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Senator the Hon Arthur Sinodinos AO
Minister for Industry, Innovation and Science
PO Box 6100
Senate
Parliament House
Canberra ACT 2600

9 August 2017

Dear Minister,

I am writing to provide you with additional information as requested regarding a number of questions raised by Senator Roberts in a meeting between his office, your advisers and CSIRO scientists on 26 July 2017.

Specifically, the Senator and his team raised three questions relating to three specific research papers. My team have provided further information outlining our position on those matters which I have attached to this letter.

I affirm that the information attached has been prepared in accordance with the Government's expectations that CSIRO conduct its activities with integrity and impartiality and maintain high standards of scientific practice.

Thank you for the continued support we have received from your office during our engagement with the Senator on this important field of study.

Yours sincerely,

Dr Larry Marshall
Chief Executive, CSIRO

Att

Response to issues raised with references at the 26 July 2017 briefing

This document responds to questions raised by Senator Roberts and his team in relation to references presented by CSIRO at the Climate briefing on 26 July 2017.

1. Marcott et al. (Science, 2013)

In relation to claims made in blog posts regarding the integrity of the Marcott study, and the questions raised regarding this research, it should be noted that there are currently 265 published papers in the peer-reviewed literature citing Marcott et al (2013), and there is no published study that draws the temperature reconstruction into question for the period for which sufficient proxies are available (~11,300 BP to 1800 CE).

We further note that reference [1] derives a 12,000-year record of Arctic temperatures that extends to the year 2009 CE, with 25-year resolution, and concludes that the recent rate of Arctic temperature change is unprecedented in the entire Holocene.

CSIRO reaffirms the scientific rigour of the Marcott et al. (2013) study and the conclusion that the rate of recent warming of global mean temperature is unprecedented in the past 10,000 years.

Studies published after Marcott et al. (2013), using a variety of data sets and analysis methods and covering various time periods, support the conclusion that recent rates of warming are unprecedented [e.g. 1-5].

The conclusion drawn by CSIRO and by the Marcott study is based on a comparison of recent temperatures *as measured by instruments* to past temperatures *inferred from proxy data*. Neither Marcott, nor CSIRO, make any conclusions based on the "uptick" part of the temperature record.

This approach is used because the best information we have about recent temperatures are those made by instruments measuring temperature (thermometers measure temperature more accurately than tree rings, ice cores, or plankton preserved in sediments).

There is no scientific evidence in any other climate variable to support the supposition that there may have been periods of rapid warming and cooling in the past that were missed by Marcott's reconstruction method, nor has a plausible physical mechanism been identified that could have driven such spikes in warming and cooling. In addition, it can be demonstrated that the Marcott method could have detected periods of rapid warming/cooling in the past, had they occurred.

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2. Harries et al. (Nature, 2001)

CSIRO reaffirms its conclusion that changes in radiative spectra provide direct empirical evidence of an enhanced greenhouse effect.

Studies published since 2001 confirm that less energy is leaving the top of the atmosphere in the wavelengths absorbed by carbon dioxide and other greenhouse gases [e.g. 6-8], and more energy is reaching the surface in these wavelengths [e.g. 9-10]. These measurements provide further direct empirical evidence of the enhanced greenhouse effect.

The more recent studies confirm and extend the conclusion reached by Harries et al. (2001). These studies use new data sets and methods that are not subject to limitations noted by the original Harries et al. study. Specifically, the new studies use improved instruments and satellites, span the spectral range of the main CO_2 absorption band, and most are based on continuous measurements from single instruments (satellite or ground-based), which avoids introducing uncertainties or errors that might potentially arise as a result of intercalibrations between different sensors/satellites.

3. Mann, Bradley and Hughes (1998)

Senator Roberts referred to a paper published two decades ago by Mann et al. (1998). This study was not used by CSIRO in its briefing and is not relevant to the present discussion.

Highlighting available data sets of global mean surface temperatures in the late 20th – early 21st century

Over the past twenty years, multiple studies have used a variety of methods and data sets to reconstruct past temperatures over various time periods. These studies have consistently shown that global mean surface temperatures in the late 20th – early 21st century are unusual in the context of the past 1000 years (the period covered by Mann et al., 1998). The data sets underpinning these studies are publicly available [5].

Based on an assessment of the published literature available by 2013, reference [2] concluded "For average annual NH temperatures, the period 1983–2012 was very likely the warmest 30-year period of the last 800 years (high confidence) and likely the warmest 30-year period of the last 1400 years (medium confidence)."

References:

1. Lecavalier B. S., et al. High Arctic Holocene temperature record from the Agassiz ice cap and Greenland ice sheet evolution, Proceedings of the National Academy of Sciences (2017). DOI: 10.1073/pnas.1616287114,
2. Masson-Delmotte, V., M. Schulz, A. Abe-Ouchi, J. Beer, A. Ganopolski, J.F. González Rouco, E. Jansen, K. Lambeck, J. Luterbacher, T. Naish, T. Osborn, B. Otto-Bliesner, T. Quinn, R. Ramesh, M. Rojas, X. Shao and A. Timmermann, 2013: Information from Paleoclimate Archives. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, US,
3. PAGES 2k Consortium (2013). Continental-scale temperature variability during the past two millennia. Nature Geoscience, Vol. 6, pp. 339-346 (data publicly available at https://www.ncdc.noaa.gov/paleo-search/study/14188)
4. North, Gerald R.; Biondi, Franco; Bloomfield, Peter; Christy, John R.; Cuffey, Kurt M.; Dickinson, Robert E.; Druffel, Ellen R. M.; Nychka, Douglas; Otto-Bliesner, B.; Roberts, N.; Turekian, K.; Wallace, J. (22 June 2006), Surface temperature reconstructions for the last 2,000 years, Washington, D.C.: National Academies Press, ISBN 0-309-10225-1. (data publicly available at https://www.ncdc.noaa.gov/paleo-search/study/14188)
5. PAGES2k Consortium (2017). A global multiproxy database for temperature reconstructions of the Common Era, Scientific Data 4, Article number: 170088 (2017) doi:10.1038/sdata.2017.88
6. Chapman, D.; Nguyen, P.; Halem, M., 2013. A decade of measured greenhouse forcings from AIRS. Proc. SPIE, 8743, 874313.
7. Griggs, J. A.; Harries, J. E., 2007. Comparison of spectrally resolved outgoing longwave radiation over the tropical Pacific between 1970 and 2003 using IRIS, IMG, and AIRS. Journal of Climate, 20, 3982-4001.
8. Worden, H. M.; Bowman, K. W.; Worden, J. R.; et al., 2008. Satellite measurements of the clear-sky greenhouse effect from tropospheric ozone. Nature Geoscience, 1, 305-308.
9. Philipona, R; Durr, B; Marty, C; et al., 2004. Radiative forcing - measured at Earth's surface - corroborate the increasing greenhouse effect. Geophysical Research Letters, 31, L03202.
10. Feldman, D. R., W. D. Collins, P. J. Gero, M. S. Torn, E. J. Mlawer & T. R. Shippert , 2015. Observational determination of surface radiative forcing by CO2 from 2000 to 2010. Nature, 519, 339–343, doi:10.1038/nature14240.

References and abstracts

1. Lecavalier B. S., et al. High Arctic Holocene temperature record from the Agassiz ice cap and Greenland ice sheet evolution, Proceedings of the National Academy of Sciences (2017). DOI: 10.1073/pnas.1616287114.

   Reconstructions of past environmental changes are important for placing recent climate change in context and testing climate models. Periods of past climates warmer than today provide insight on how components of the climate system might respond in the future. Here, we report on an Arctic climate record from the Agassiz ice cap. Our results show that early Holocene air temperatures exceed present values by a few degrees Celsius, and that industrial era rates of temperature change are unprecedented over the Holocene period (~12,000 y). We also demonstrate that the enhanced warming leads to a large response of the Greenland ice sheet; providing information on the ice sheet's sensitivity to elevated temperatures and thus helping to better estimate its future evolution.

2. Masson-Delmotte, V., M. Schulz, A. Abe-Ouchi, J. Beer, A. Ganopolski, J.F. González Rouco, E. Jansen, K. Lambeck, J. Luterbacher, T. Naish, T. Osborn, B. Otto-Bliesner, T. Quinn, R. Ramesh, M. Rojas, X. Shao and A. Timmermann, 2013: Information from Paleoclimate Archives. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, US,

   [No abstract. Excerpt from the Executive Summary. The full chapter can be accessed at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter05_FINAL.pdf]

   For average annual NH temperatures, the period 1983–2012 was very likely the warmest 30-year period of the last 800 years (high confidence) and likely the warmest 30-year period of the last 1400 years (medium confidence). This is supported by comparison of instrumental temperatures with multiple reconstructions from a variety of proxy data and statistical methods, and is consistent with AR4. In response to solar, volcanic and anthropogenic radiative changes, climate models simulate multi-decadal temperature changes over the last 1200 years in the NH, that are generally consistent in magnitude and timing with reconstructions, within their uncertainty ranges.

   Continental-scale surface temperature reconstructions show, with high confidence, multi-decadal periods during the Medieval Climate Anomaly (950 to 1250) that were in some regions as warm as in the mid-20th century and in others as warm as in the late 20th century. With high confidence, these regional warm periods were not as synchronous across regions as the warming since the mid-20th century. Based on the comparison between reconstructions and simulations, there is high confidence that not only external orbital, solar and volcanic forcing, but also internal variability, contributed substantially to the spatial pattern and timing of surface temperature changes between the Medieval Climate Anomaly and the Little Ice Age (1450 to 1850).

3. PAGES 2k Consortium (2013). Continental-scale temperature variability during the past two millennia. Nature Geoscience, Vol. 6, pp. 339-346 (data publicly available at https://www.ncdc.noaa.gov/paleo-search/study/14188)

   Past global climate changes had strong regional expression. To elucidate their spatio-temporal pattern, we reconstructed past temperatures for seven continental-scale regions during the past one to two millennia. The most coherent feature in nearly all of the regional temperature reconstructions is a long-term cooling trend, which ended late in the nineteenth century. At multi-decadal to centennial scales, temperature variability shows distinctly different regional patterns, with more similarity within each hemisphere than between them. There were no globally synchronous multi-decadal warm or cold intervals

that define a worldwide Medieval Warm Period or Little Ice Age, but all reconstructions show generally cold conditions between ad 1580 and 1880, punctuated in some regions by warm decades during the eighteenth century. The transition to these colder conditions occurred earlier in the Arctic, Europe and Asia than in North America or the Southern Hemisphere regions. Recent warming reversed the long-term cooling; during the period AD 1971–2000, the area-weighted average reconstructed temperature was higher than any other time in nearly 1,400 years.

4. North, Gerald R.; Biondi, Franco; Bloomfield, Peter; Christy, John R.; Cuffey, Kurt M.; Dickinson, Robert E.; Druffel, Ellen R. M.; Nychka, Douglas; Otto-Bliesner, B.; Roberts, N.; Turekian, K.; Wallace, J. (2006), Surface temperature reconstructions for the last 2,000 years, Washington, D.C.: National Academies Press, ISBN 0-309-10225-1.

   [No abstract. Report available at https://aamboceanservice.blob.core.windows.net/oceanserviceprod/education/pd/climate/teachingclimate/surftemps2000yrs.pdf]

5. PAGES2k Consortium (2017). A global multiproxy database for temperature reconstructions of the Common Era, Scientific Data 4, Article number: 170088 (2017) doi:10.1038/sdata.2017.88

   Reproducible climate reconstructions of the Common Era (1 CE to present) are key to placing industrial-era warming into the context of natural climatic variability. Here we present a community-sourced database of temperature-sensitive proxy records from the PAGES2k initiative. The database gathers 692 records from 648 locations, including all continental regions and major ocean basins. The records are from trees, ice, sediment, corals, speleothems, documentary evidence, and other archives. They range in length from 50 to 2000 years, with a median of 547 years, while temporal resolution ranges from biweekly to centennial. Nearly half of the proxy time series are significantly correlated with HadCRUT4.2 surface temperature over the period 1850–2014. Global temperature composites show a remarkable degree of coherence between high- and low-resolution archives, with broadly similar patterns across archive types, terrestrial versus marine locations, and screening criteria. The database is suited to investigations of global and regional temperature variability over the Common Era, and is shared in the Linked Paleo Data (LiPD) format, including serializations in Matlab, R and Python.

6. Chapman, D.; Nguyen, P.; Halem, M., 2013. A decade of measured greenhouse forcings from AIRS. Proc. SPIE, 8743, 874313.

   Increased greenhouse gasses reduce the transmission of Outgoing Longwave Radiation (OLR) to space along spectral absorption lines eventually causing the Earth's temperature to rise in order to preserve energy equilibrium. This greenhouse forcing effect can be directly observed in the Outgoing Longwave Spectra (OLS) from space-borne infrared instruments with sufficiently high resolving power [3, 8]. In 2001, Harries et. al observed significant increases in greenhouse forcings by direct inter-comparison of the IRIS spectra 1970 and the IMG spectra 1997[8]. We have extended this effort by measuring the annual rate of change of AIRS all-sky Outgoing Longwave Spectra (OLS) with respect to greenhouse forcings. Our calculations make use of a 2°x2° degree monthly gridded Brightness Temperature (BT) product. Decadal trends for AIRS spectra from 2002-2012 indicate continued decrease of -0.06 K/yr in the trend of CO2 BT (700cm^{-1} and 2250cm^{-1}), a decrease of -0.04 K/yr of O3 BT (1050 cm^{-1}), and a decrease of -0.03 K/yr of the CH4 BT (1300cm^{-1}). Observed decreases in BT trends are expected due to ten years of increased greenhouse gasses even though global surface temperatures have not risen substantially over the last decade.

7. Griggs, J. A.; Harries, J. E., 2007. Comparison of spectrally resolved outgoing longwave radiation over the tropical Pacific between 1970 and 2003 using IRIS, IMG, and AIRS. Journal of Climate, 20, 3982-4001.

The observation of changes in the earth's spectrally resolved outgoing longwave radiation (OLR) provides a direct method of determining changes in the radiative forcing of the climate system. An earlier study showed that satellite-observed changes in the clear-sky outgoing longwave spectrum between 1997 and 1970 from the Infrared Interferometer Spectrometer (IRIS) and Interferometic Monitor of Greenhouse Gases (IMG) instruments could be related to changes in greenhouse gas composition. The authors present a new study that extends this to 2003, through the first use of a new, independent source of global atmospheric infrared spectra, from the Atmospheric Infrared Sounder (AIRS) experiment. AIRS is a dispersion grating spectrometer, while the other two were Fourier transform spectrometers, and this is taken into account in the analysis. The observed difference spectrum between the years 2003 and 1970 generally shows the signatures of greenhouse gas forcing, and also shows the sensitivity of the signatures to interannual variations in temperature. The new 2003 data support the conclusions found in the earlier work, though, interestingly, the methane (CH_4) Q branch centered at 1304 cm^{-1} exhibits more complex behavior, showing a decrease in intensity in the difference spectrum between 1997 and 2003. Sensitivity analysis indicates that this is due to changes in temperature structure, superposed on an underlying increase in CH_4. Radiative transfer calculations based on reanalysis data are used to simulate the changes in the OLR spectrum; limitations in such data and possible variations that could account for several observed effects are discussed.

8. Worden, H. M.; Bowman, K. W.; Worden, J. R.; et al., 2008. Satellite measurements of the clear-sky greenhouse effect from tropospheric ozone. Nature Geoscience, 1, 305-308.

   Radiative forcing from anthropogenic ozone in the troposphere is an important factor in climate change[1], with an average value of 0.35 W m^{-2} according to the Intergovernmental Panel for Climate Change[1] (IPCC). IPCC model results range from 0.25 to 0.65 W m^{-2}, owing to uncertainties in the estimates of pre-industrial concentrations of tropospheric ozone[1, 2, 3], and in the present spatial and temporal distributions of tropospheric ozone[4, 5, 6, 7, 8], which are much more variable than those of longer-lived greenhouse gases such as carbon dioxide. Here, we analyse spectrally resolved measurements of infrared radiance from the Tropospheric Emission Spectrometer[9] on board the NASA Aura satellite, as well as corresponding estimates of atmospheric ozone and water vapour, to obtain the reduction in clear-sky outgoing long-wave radiation due to ozone in the upper troposphere over the oceans. Accounting for sea surface temperature, we calculate an average reduction in clear-sky outgoing long-wave radiation for the year 2006 of 0.48±0.14 W m^{-2} between 45° S and 45° N. This estimate of the clear-sky greenhouse effect from tropospheric ozone provides a critical observational constraint for ozone radiative forcing used in climate model predictions.

9. Philipona, R; Durr, B; Marty, C; et al., 2004. Radiative forcing - measured at Earth's surface - corroborate the increasing greenhouse effect. Geophysical Research Letters, 31, L03202.

   The Intergovernmental Panel for Climate Change (IPCC) confirmed concentrations of atmospheric greenhouse gases and radiative forcing to increase as a result of human activities. Nevertheless, changes in radiative forcing related to increasing greenhouse gas concentrations could not be experimentally detected at Earth's surface so far. Here we show that atmospheric longwave downward radiation significantly increased (+5.2(2.2) Wm^{-2}) partly due to increased cloud amount (+1.0(2.8) Wm^{-2}) over eight years of measurements at eight radiation stations distributed over the central Alps. Model calculations show the cloud-free longwave flux increase (+4.2(1.9) Wm^{-2}) to be in due proportion with temperature (+0.82(0.41) °C) and absolute humidity (+0.21(0.10) g m^{-3}) increases, but three times larger than expected from anthropogenic greenhouse gases. However, after subtracting for two thirds of temperature and humidity rises, the increase of cloud-free longwave downward radiation (+1.8(0.8) Wm^{-2}) remains statistically significant and demonstrates radiative forcing due to an enhanced greenhouse effect.

10. Feldman, D. R., W. D. Collins, P. J. Gero, M. S. Torn, E. J. Mlawer & T. R. Shippert, 2015. Observational determination of surface radiative forcing by CO2 from 2000 to 2010. Nature, 519, 339–343, doi:10.1038/nature14240.

    The climatic impact of CO_2 and other greenhouse gases is usually quantified in terms of radiative forcing[1], calculated as the difference between estimates of the Earth's radiation field from pre-industrial and present day concentrations of these gases. Radiative transfer models calculate that the increase in CO_2 since 1750 corresponds to a global annual mean radiative forcing at the tropopause of 1.8 ± 0.19 W m^{-2} (ref. 2). However, despite widespread scientific discussion and modelling of the climate impacts of well-mixed greenhouse gases, there is little direct observational evidence of the radiative impact of increasing atmospheric CO_2. Here we present observationally based evidence of clear-sky CO_2 surface radiative forcing that is directly attributable to the increase, between 2000 and 2010, of 22 parts per million atmospheric CO_2. The time series of this forcing at the two locations—the Southern Great Plains and the North Slope of Alaska—are derived from Atmospheric Emitted Radiance Interferometer spectra[3] together with ancillary measurements and thoroughly corroborated radiative transfer calculations[4]. The time series both show statistically significant trends of 0.2 W m^{-2} per decade (with respective uncertainties of ±0.06 W m^{-2} per decade and ±0.07 W m^{-2} per decade) and have seasonal ranges of 0.1–0.2 W m^{-2}. This is approximately ten per cent of the trend in downwelling longwave radiation[5–7]. These results confirm theoretical predictions of the atmospheric greenhouse effect due to anthropogenic emissions, and provide empirical evidence of how rising CO_2 levels, mediated by temporal variations due to photosynthesis and respiration, are affecting the surface energy balance.

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DEPARTMENT OF INDUSTRY, INNOVATION AND SCIENCE

CSIRO BRIEFING WITH THE HONOURABLE SENATOR MALCOLM ROBERTS

PRESENT: **HELEN CLEUGH**
STEVE RINTOUL
PETHER BOBROFF
LEON ASHBY
SEAN BLACK
JACK STEELE
PETER MAYFIELD
KATE CHAPPLE
GEOFF MASON

LOCATION: **ROOM MG 62, PARLIAMENT HOUSE**

DATE: **WEDNESDAY, 26 JULY 2017**

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MR G. MASON: Welcome all. Just a note that this meeting is being recorded. The transcript will be made available to all parties attending. It will also maybe being made available via a Senate Estimates process. For context, this meeting has been convened in response to a request from Senator Roberts' office to discuss climate science analysis produced by CSIRO. This is the third meeting convened on the subject in addition to questions raised by Senator Roberts during Senate Estimates. To ensure the recording reflects the complete discussion today, CSIRO will be repeat past presentation made to Senator Roberts. CSIROs presentation will have minor clarifications made to reflect additional information requested by Senator Roberts in past meetings, for example, source reference material.

The agenda for today is as follows. We will have a brief introductory statement from Senator Roberts and CSIRO. CSIRO will then present their climate science analysis. Following on from that, Senator Roberts' office will present additional climate analysis. We will then work through a structured discussion based on the queries raised by both parties. I will ask that only clarifying questions are asked during presentations and can we please note key points of difference or discussion for the structured discussion at the end. Can we please do just a brief introduction around the table for the purpose of the recording so that they're able to capture the names of who is attending. Perhaps if we start with you, Helen, and then work our way around.

DR H. CLEUGH: Certainly. Helen Cleugh, Climate Science Centre Director, CSIRO.

DR S. RINTOUL: Steve Rintoul, CSIRO.

MR P. BOBROFF: Pether Bobroff, private citizen.

THE HON. SENATOR M. ROBERTS: Malcolm Roberts, Senator for Queensland.

MR L. ASHBY: Leon Ashby, assistant to Malcolm Roberts.

MR S. BLACK: Sean Black. Thank you. I work for Malcolm Roberts.

MR J. STEELE: Jack Steele, Director of Science Impact and Policy, CSIRO.

DR P. MAYFIELD: Peter Mayfield, Executive Director of Environment, Energy and Resources, CSIRO.

MS K. CHAPPLE: Kate Chapple, advisor to Minister Sinodinos.

MR G. MASON: Geoff Mason, senior advisor to Minister Sinodinos. On that note, Senator Roberts, would you like to provide an opening statement from your side first?

MR ROBERTS: Sure. I covered the opening statement last time. In my opening statement last time I mentioned the very high cost of climate policies and energy policies that have emanated directly from claims that carbon dioxide from human activities affects global climate and needs to be decreased, so they're extensive, they're ongoing and they're getting worse and getting very, very much higher and they're costing taxpayers and citizens enormously. So we have a right and a duty to the citizens that we represent, our constituents, to investigate this. I have investigated it for 10 years prior to becoming a senator. Others in my team have investigated it for equally long period.

We're very concerned at the presentation of – or the lack of data that we have seen indicating carbon dioxide from human activity affects climate. And so the first thing I did after being sworn in as a senator was to write a letter to the chief executive requesting a presentation. We didn't get a response and I gave the chief executive over two weeks' notice. Didn't get a response. Two days before the desired date for the presentation, my staff contacted the chief executive. His office indicated they would make a presentation on the day. The next day, the day before the presentation, we received notice that we would not get a presentation. We then pursued that through the ministers and eventually got a presentation in Sydney. And then we weren't happy with that presentation.

We were pleased that CSIRO had made the presentation. We still didn't see any evidence, empirical evidence, proving that carbon dioxide from human activity affects global climate detrimentally and I then made a response. I think that was in November. My written response, I then asked in Senate Estimates if I would get a response to my written response because we challenged and rebutted the material that CSIRO had presented. The chief executive, at Senate Estimates, of the CSIRO said that we would not be getting a response. Minister Sinodinis, to his credit, who I must compliment throughout this whole process for being open and wanting to investigate the science because that is the only basis for good policy, he said we would get a response. To date, we have not had that response.

At the same time, or not long after, I made a copy of my response to the CSIRO as part of evidence to a dissenting report that I structured to a committee report in the Senate. The CSIRO then presented its response to my dissenting response and, quite frankly, that was very, very disappointing. That was a deplorable – scientifically deplorable statement. Then we had another presentation from the CSIRO on 10 May. We still haven't been convinced at all that there is any empirical evidence proving carbon dioxide from human activity needs to be abated. So that's what we are looking for now and we will be responding to the CSIRO today.

MR MASON: Thank you, Senator Roberts. Helen.

DR CLEUGH: So, at the last meeting that we had here, CSIRO explained their role in climate research and in this ongoing consultation process, so I would like to repeat that same opening statement here. CSIRO undertakes its own research into understanding climate variability and change. That includes undertaking

observations, analysing those observations and observations from other agencies, undertaking studies into climate processes and developing, testing and using weather and climate models, utilising CSIROs own research as well as the research that's reported in the peer-reviewed literature. To be specific, CSIRO wants to be clear about our role and a few points.

So, firstly, just to reiterate that the scientific method underpins all of our research and we're committed to ensuring that the research that we do and the research that we use has been rigorously peer-reviewed. CSIROs research aims to understand the factors that are causing current and past climate variability and analysing long-term climate trends. That includes measurements of atmospheric greenhouse gases, ocean observations and analyses of ocean processes and analyses of the global carbon cycle, and we collaborate with other research agencies in the pursuit of our own research.

CSIRO also develop and use climate models. We develop our own and we use other climate models to pursue providing assessments and projections of likely future climates, and that includes assessments of the impacts of climate change across many sectors of the Australian economy. And CSIRO provide information based on the science to a wide range of users who use that information in their decision-making and we also provide the science and information to the broader Australian community via publications obviously in the peer-reviewed literature but also in publications such as the State of the Climate. So, as I said at the last meeting, that sets the scope for today's discussion and I will hand over to Steve, Geoff, if that's okay, for his presentation.

MR MASON: Yes, that's fine. Just for the record, CSIRO will present – Steve will be presenting CSIROs presentation for them.

DR RINTOUL: Firstly, I apologise for the state of my voice. We will see if I can last. It's a bad case of laryngitis. So I will repeat the presentation as well as I can from last time because we're asked to address a specific question. Showing here on the screen, I will address the first part before I address the question. I should just point out that whether something is unprecedented or not is not in this case a particularly relevant question in the sense that something doesn't have to be unprecedented to be significant or important. So the world does not have to be warmer than it ever was for warming to potentially cause impacts that we might better avoid. But, taking the question as posed – what, if anything is unprecedented in the climate record of the last 10,000 years – there are a number of things.

One thing that's unprecedented is the rate of rise in global mean temperature. So temperatures were warm in the early part of the Holocene, then cooled until the Industrial Revolution and then have risen rapidly since then. So the temperatures at the moment, according to this study, are not unprecedented in the last 10,000 years, but they are warmer than 82 per cent of measurements over similar ..... means over the Holocene and global temperature has risen from near the coldest to the warmest levels of the Holocene within the last century, reversing the long-term cooling trend

that began 5000 years ago. Carbon dioxide concentrations in the atmosphere today are unprecedented over the last 10,000 years and indeed over at least the last 800,000 years. The same is true for many other greenhouse gases. There are many other things that we can point to, including the rate of sea level rise, but there are aspects of the climate system that are indeed unprecedented in the time scale of the last 10,000 years.

The second part of the question you asked us to address is what proves it is caused by carbon dioxide from human activity. The presentation in May, or the first presentation, set out several lines of evidence that humans have caused climate change. The first point was about carbon dioxide is a greenhouse gas in the sense that it absorbs and radiates infrared radiation. I think we reached agreement on that fact. The second was that carbon dioxide concentrations in the atmosphere have increased - - -

MR ROBERTS: We have reached agreement on the fact that it absorbs and emits but not on the term "greenhouse gas", but that's minor. We just need to clarify that.

DR RINTOUL: Carbon dioxide concentrations in the atmosphere have increased since the Industrial Revolution. The red curve here shows CO2 largely stable for the 1000 to about 1800 at values of about 280 and are now up in excess of 400 parts per million. So they have increased by about 40 per cent since pre-industrial times. And we also reached agreement that CO2 levels have risen since 1800. The third point in the argument was that the extra carbon dioxide in the atmosphere comes from human activities. There were several lines of evidence shown in the original presentation to support this. One involves the isotopic composition of carbon dioxide in the atmosphere. So just if I go backwards because this plot makes it easier to see.

The red line here was the increase in CO2. The black line is the decrease in the ratio of – in the carbon 13 ratio – 13 to carbon 12 ratio. That decrease in C13 is obviously a large departure from anything seen in the previous thousand years and it's consistent with burning of fossil fuels because fossil fuels drive plants and plants have a preference for the lighter isotopes of carbon and that is carbon 12. Therefore, as we burn fuels, we put more carbon 12 in the atmosphere and that depletes the atmosphere of lowest ratio of carbon 13 to carbon 12. A similar argument holds for carbon 14. So that's one piece of the argument. Another piece of the argument was that oxygen concentrations in the atmosphere have declined and have declined at the rate expected from burning carbon-rich fuels. As we burn carbon-rich fuels, that consumes oxygen. Oxygen concentrations are lowering consistent with the rate at which carbon dioxide is rising, assuming – as has made it from burning of fossil fuels.

The third piece of evidence is that the CO2 in the atmosphere has increased as human emissions have increased, physical correlated – that is, we have a very good feeling for how much carbon dioxide has been introduced to the atmosphere by industrial activities because we know quite a lot about the industries that we operate. So the emissions of fossil fuel CO2 are well-known and the increase in CO2 in the

atmosphere has followed that increase in the use of fossil fuels. The alternative in natural sources and sinks can explain the 40 per cent rise in atmospheric CO2. It is inconsistent with the fact that the natural sinks had actually increased over time so that nature has absorbed more CO2 than it has emitted alleviating some, compensating for some, but not all of the human emissions.

The fourth point in the line of evidence was that the additional carbon dioxide added to the atmosphere by human activities has enhanced the greenhouse effect, that is, less energy is leaving the top of the atmosphere in the wavelengths are absorbed by carbon dioxide and other greenhouse gases. This is an empirical measurement. One example is the study by Harries et al. It shows the difference in the amount of radiation leaving the top of the atmosphere in particular wavelengths – wavenumbers, and what you see is that there's less leaving in the spectra bands where CO2 and other greenhouses gases are absorbed. There were several questions that were raised by you in response to this plot. The first, do we agree, that the paper reference above seems to show there was no significant change? No, we don't agree. The plot shows the difference between 70 and 97.

MR BOBROFF: Yes. We understand where I misunderstood that.

DR RINTOUL: CSIRO agree that the CO2 absorption spectra extends down to wavenumber 630 and, yes, we agree that the absorption spectra extends to lower wavenumbers. These are indeed measured by satellites. They're not shown in this graph because the spectra ..... in that wavenumber band. It's just not as clear. Third, the CSIRO agree that the greenhouse effect of CO2 is mostly ..... by 50ppm with little increase by 300ppm and virtually none at 400ppm. No, we don't agree. The figure shows direct empirical evidence that this is not true. In that sense, the CO2 effect is not saturated.

This statement is based on a misunderstanding of the physics of radiation in the atmosphere. Adding more CO2 means that heat leaves the Earth's atmosphere at higher elevation where temperatures are cooler. The colder the air, the less heat is radiated. Adding greenhouse gases warms climate by reducing how much heat escapes into space, as the empirical observations show. We will come to another empirical observation, that at the same time that – just as measuring the amount of infrared radiation leaving the top of the atmosphere is one empirical measure of an enhance greenhouse effect, measuring the amount of radiation returning to the surface being emitted by greenhouse gases is another measure, and we will come to that in a minute.

Does CSIRO agree that even a two per cent variation in the atmosphere of water vapour will equal the total amount of supposed greenhouse effect of all human CO2 production? No, we do not agree. Water vapour in the atmosphere is set by temperature. Warmer air means warmer water vapour. Thus water vapour acts as a positive feedback roughly doubling the warming expected from the change in CO2 alone. The point is that it is not possible to simply change the amount of water vapour in the atmosphere without changing the temperature. The two are very

tightly linked. The water vapour responds to the change of temperature and provides a feedback that provides the cause and spread of warming.

So there is empirical evidence, as I mentioned, of increased radiation at the surface as a result of increased atmospheric CO2 concentrations. The study shows measurements of the spectra of radiation measured at the surface at two locations in the US, one on the Great Plains and one in Alaska. Again, it shows the total amount of – in the wavenumber bands covered by CO2 which shows the amount of radiation being received at the surface between the year 2000 and 2011 or '12. What you see is that both curves go up and that is a direct measure of the increase in infrared radiation reaching the surface of the Earth as a result of the 22ppm increase in atmospheric CO2 between those two dates. It's also a seasonal cycle and that reflects the changes in CO2 in that atmosphere due to photosynthesis and respiration enrichment.

This plot on the right, that spectra in the middle box on the upper row, shows the measured spectra as a function of wavenumber with the brown band corresponding to CO2, the green band corresponding to ozone, the yellow band corresponding to methane and the blue corresponding to water vapour. Where this change happens is on the flanks of the CO2 band and that's shown in the plot on the upper right. This wavenumber is just less than 600 and between about 750 and 800 so-called PNR bands are where the absorption bands due to CO2 are not saturated and there is capacity to increase the absorption capacity in the atmosphere, and that is precisely what has happened and what these measurements show as a result of the increase in CO2.

The fourth point: the Earth has warmed as a result of the enhanced greenhouse effect. So we've shown there's more CO2 in the – the CO2 acts as a greenhouse gas. There's more of it in the atmosphere. The additional CO2 came from us and that additional CO2 has caused an enhanced greenhouse effect. The fifth point is that the Earth has actually responded to that enhance greenhouse effect and there are many measures of this. The surface temperature measurements – here are the four different global climatologies showing the land and ocean temperatures. There's measurements of the above the surface and the lower troposphere measured by satellites or by radio sounds. There's measurements of ocean heat content which provide some of the most reliable metric of changes in planetary energy balance because more than 93 per cent of the extra heat stored by the Earth over the last 50 years is found in the oceans. There are other examples I could point to like melting of glaciers or retreat of Arctic Sea ice.

You posed several questions on temperature change, saying: do you accept that the Earth has warmed since the Little Ice Age but it's still cooler than the Roman Warm Period and much cooler than the Holocene Thermal Maximum? This statement that modern global average temperatures are cooler than the Roman Warm Period is not supported by the scientific evidence. As an example, the study states that the global warming that has occurred since the end of the 19th century reversed a persistent long-term global cooling trend. I showed that in one of the first plots. There were no

globally-synchronous multi-decadal warm or cold intervals that define a worldwide Medieval Warm Period or Little Ice Age, but all reconstructions show generally cold conditions between AD50 and AD1880. Recent warming reversed the long-term cooling. In the period AD71 to 2000, the area-weighted average reconstructed temperature was higher than at any other time in nearly 1400 years. This plot I had showed earlier just illustrating the - - -

MR ROBERTS: Just mark it – yes, mark it.

DR RINTOUL: Yes. Point 6: observed changes in the climate system are consistent with an enhanced greenhouse effect. Other forcings, for example, volcanoes, the sun or internal variability cannot explain the magnitude, timing and distribution of observed trends. For example, enhanced greenhouse four sink causes warming of the lower atmosphere and cooling of the upper atmosphere as observed. Increases of solar energy reaching the Earth will warm both the upper and lower atmosphere. These plots, all of which show latitude on the X axis with south on the right and north on the left and elevation on the Y axis, so a cross-section for the atmosphere average around the Earth, shows how the atmosphere responds to changes in solar radiation, volcanoes, greenhouse gases, ozone, sulphate aerosol or the sum of those five.

MR ROBERTS: So that's simulated by model.

DR RINTOUL: Yes. This is using the BCM model. So this activity, it's one way to illustrate the changes that one would expect given the changes in each of each of these forcings. What you see is that greenhouse gases are the only – one of the signatures of increased greenhouse gas four sink other than enhanced greenhouse effect is cooling of the stratosphere, shown in the second plot down on the left side. It shows cooling in the stratosphere in blue and warming of the lower troposphere in red. What has been observed? Well, the satellite measurements and radio sounds are consistently showing that the stratosphere has cooled and the lower troposphere has warmed. The changes ore not monotonic of course in time. There are other things happening. In particular, those warm events in the stratosphere are caused by major volcanic eruptions that warm the stratosphere and cool the surface.

I should say there was a request that some of the figures that I have used, they were from the IPCC. I haven't changed them because the idea was to present the same evidence. You asked for information on the sources. They ..... all those IPCC figures and that's here.

MR ROBERTS: Thank you, Steve.

DR RINTOUL: So, to recap, the second point in your question was to show us that humans have something to do with the climate change and so we raised and provided direct empirical evidence to support six points, that carbon dioxide is a greenhouse case, that carbon dioxide concentrations in the atmosphere have increased, that extra carbon dioxide in the atmosphere comes from human activities, the additional carbon

dioxide added to the atmosphere by human activities has enhanced the greenhouse effect, less energy is leaving the top of the atmosphere in wavelengths absorbed by carbon dioxide and other greenhouse gases and more energy is reaching the surface in those wavelengths.

The Earth has warmed as a result of the enhance greenhouse effect. There ae multiple lines of robust independent empirical evidence that that is the case. Six, observed changes in the climate system are consistent with enhanced greenhouse effect. Other forcings, for example, volcanoes, the sun, internal variability cannot explain the magnitude, timing and distribution of observed trends. That later statement is supported both by empirical observations of the – looking at the response of the climate system to volcanoes or to the sun or documenting internal variability as well as theoretical considerations and models.

The final part of your question was to show that such carbon dioxide output needs to be cut, that is, the human production of carbon dioxide is dangerous or indicates impending catastrophe. There are many signals and/or observed impacts of – there are multiple lines of evidence that climate has warmed and there are also multiple lines of evidence that many aspects of the climate system have responded to that warming. Some of those observed impacts of climate change include the rise in sea level causing an increase in the frequency and magnitude of extreme coastal flooding events. Warming which has caused an increase in frequency, magnitude and duration of heatwaves has changed the probability and distribution of temperature in a way that values exceeding any particular temperature threshold are both more likely to occur, exceed the threshold by a larger amount and last longer. We have observed increased in fire risk in Australia and we have observed ocean warming in increased coral bleaching risk and incidence. There are many others.

I then went on to show some of the – to put things in a global context and in an Australian context showed you some slides from the State of the Climate 2016 published by the Bureau of Meteorology and CSIRO. This plot shows global temperatures between 1950 and 2015. It shows that global temperatures vary year to year and they are typically warmer during El Niño and cooler during La Niña or after a major volcanic eruption as heat is moved around the climate system. The overall increase in ocean temperatures means that a La Niña year now is warmer than an El Niño year in the 1960s. I have already shown you a picture of ocean heat content. The rise in ocean heat content since the 1970s continues. It goes up and down a little bit with volcanic eruptions, but has continued unabated over the last four to five decades. Sea levels also continue to rise, and the rate of sea level rise during the – averaged over the 20th century was about 1.7 millimetres per year. The sea level has risen at a faster rate since 1993. Why 1993? 1993 is the launch date of satellite altimeters that allow us to measure sea ..... from space globally and accurately. The green line here is the tide gauge data. Tide gauges are good, but they're very sparse. Their main benefit is that they go further back in time. The satellite and tide gauge records agree with each other quite well, as you can see in the figure.

A recent study by the CSIRO has shown that even over the satellite period, the rate of sea level rise has accelerated and the rise over the last decade is more rapid than the rise over the previous decade, consistent with increased melt of Greenland inferred from other sources. ..... Australian temperature shows the changes – the Australian temperature record from 1910 to 2014 or '15 – I can't remember – shows that Australia's climate has warmed since 1910. It's also consistent with warming in the surrounding oceans. That's useful because if you did happen to have concerns about the continental temperature record, it's hard to suggest that they're the same bias as the ocean temperature record. The ocean temperatures here are shown in blue, the land temperatures in red – the surface air temperature is in red.

What are the consequences of that increase in temperature? One of the consequences has been an increase in the frequency of extreme heat events. That's shown here from about 1920 up to the present, and you can see that the number of extreme days has been increasing over that time period. In terms of fire weather, fire weather conditions are worsening, particularly in the south and east. Fire weather is calculated as a function of drought factor, which takes into account both recent rainfall and rainfall over a preceding time period, taking into account how much moisture is in the soil, as well as a function of temperature and windspeed.

There's a – Leon, you asked about the source of this. I've got a paper here that – or the reference for that paper. It's also in the State of the Climate report, which I believe you have a copy of. It's something that has been used since the 1960s. So what – moving back to what has caused changes since 1750, this plot shows the radiative forcing, that is, the forcing on the climate system, due to various factors. And I will work through them - - -

MR ROBERTS: Is that empirical or - - -

MR RINTOUL: These are measured.

MR ROBERTS: All of those are measured?

MR RINTOUL: The sources are in the document I just passed to you.

MR ROBERTS: Okay. Thank you.

MR RINTOUL: Each of the figures are derived from empirical observations of things related to, for example, stratospheric water vapour, solar cycle, tropical ozone and the amount of greenhouse gases in the atmosphere. That's the empirical measurement. The radiative forcing is calculated using a radiative forcing model, not a climate model, if that makes that more clear for you. The orange is sulphur. The thin black line is black carbon on snow and contrails. The thin blue line – I'm working down from top to bottom of these plots. Each one – the width of each coloured line is proportional to its contribution to the net radiative forcing. The blue line is stratospheric water vapour. The dark green line is tropospheric ozone. The light green colour are other well-mixed greenhouse gases. The grey bar is carbon

dioxide. All of those factors have a positive effect on radiative forcing. They warm the Earth. And they've all increased with time.

The bottom of the graph are those factors that cool the Earth. One is aerosol-radiation interactions. That's in the red. Aerosol-cloud interactions are shown in the orange. Both of those act to cool. Those are the major factors causing cooling in the Earth. Green is land use. Stratospheric ozone is shown as a cooling effect as opposed to stratospheric water vapour. Volcanoes are shown in the spiky green line. The sum of all those forcings is shown in black, and the sum of all the anthropogenic forcings is shown in red.

What this plot shows you is that these changes since 1750 in each of these climate drivers have increased in time. The positive factors have increased and the negative factors have generally increased in time. The volcanoes, on the other hand, are very episodic. The solar is largely cyclical. But there are stronger increases in the positive forcings than there are in the negative forcings, and that's driving the warming of the Earth. This also gives you a direct visual impression of the relative magnitude of the response of the climate system, the amount of warming that's caused by variations in solar output, or any of the other factors shown on the plot.

This plot shows a temperature record on the upper left in black. It happens to be the head three observations. The four other coloured lines are estimates of the warming of the Earth by adding up the contributions supplied by various different factors, including El Niño, the second bar down, volcanoes, third bar down, solar, fourth bar down, and the fifth bar down is the anthropogenic and the last one is the Atlantic meridional oscillation, one example of internal variability.

There are several points to make here. One is that if we take into account the climate response to each of these forcing factors and sum them up, we get something that's very close to the observed temperature record, that is, the curves in the upper plot agree pretty closely. Again, the only one of these plots that has a trend is the anthropogenic forcing. There's no significant trend in El Niño activity driving an increase in global mean temperature. There's no trend in volcanic forcing that's significant. There's no trend in solar forcing of – no trend in solar forcing. The only thing that goes up over time like the global temperature record is the anthropogenic forcing. So it makes the same point as I've made in several other plots before.

One point that has been raised in discussion is the question of whether CO2 causes temperature change or temperature change causes changes in CO2. A recent study has looked at this issue, and one of the results is shown in this plot. The blue line shows changes in global average temperature from 22,000 years ago at the last glacial maximum through to the Holocene period and up to 7000 years ago, and it shows the warming as we came out of the glacial period and into the interglacial. The red line shows temperatures in Antarctica which lead those global temperatures. It warms up first in Antarctica. The yellow lines show global carbon dioxide concentrations increasing from about 180 at the last glacial maximum to close to 280 during the Holocene.

What you see is that the change in CO2 leads the change in global temperature. The yellow dots increase before the blue curve does. It's largely synchronous in the Antarctic. But in terms of what's driving what, more than 90 per cent of the warming of the Earth coming out of the last glacial happens after the increase in CO2. The initial trigger are changes in the Earth's orbit, but that trigger then sets off a chain of events within the Earth system that leads to release of CO2 and amplifying effects.

So if we take another look at that figure from the same paper but the change in temperature over that time period into latitude bands. If you look at the purple line, the purple line is the furthest north, 60 to 90 north. In 19,000 years ago, it was warming in the northern part of the Earth, between 60 and 90 north. It then cooled again. Then the southern latitude started to warm. Those orange and red lines increased, as well as the tropics. The northern latitude – warmings in the northern part of the northern hemisphere lagged. They didn't start to increase until about 15,000 years ago.

So what does this say? What's happening here? Well, one explanation is that the Earth's orbital cycles trigger the initial warming starting approximately 19,000 years ago, which is first reflected at highest latitudes because that's where the changes in insulation as a result of the changes in orbit are felt first and strongest. So that's where we expect to see the first signal, and that is the time when we expect to see the first signal, if, indeed, it's due to orbital changes. And that's what causes the purple line to go up in 19,000 years ago. The second step, that warming causes a melting of large quantities of ice. Remember we're talking about the ice age. There are huge ice sheets in the northern part of the northern hemisphere. That warming starts causing ice sheets to melt, and that freshwater floods into the ocean.

Third step, that influx of freshwater disrupts ocean currents. It disrupts the Atlantic meridional overturning circulation, which consists of sinking at high latitudes in the North Atlantic and of global circulation that you – I'm sure you know. The influx of freshwater makes it difficult for water to sink because that freshwater is buoyant. That slows down the overturning circulation. That slows down the heat transport to the North Atlantic. More heat accumulates in the Southern Hemisphere, and the Southern Hemisphere starts to warm about 17 to 18 thousand years ago. Fourth step, that warming Southern Ocean releases CO2 into the atmosphere starting around 17,5000 years ago, which in turn caused the entire planet to warm ..... enhanced greenhouse effect because that carbon dioxide is rapidly mixed around the global atmosphere.

Next topic, temperature measurements at the ground compared to satellite and bloom measurements in the troposphere and stratosphere. I showed you this plot earlier, suggesting that one of the signatures we might look for in terms of empirical evidence of an enhanced greenhouse effect is cooling in the stratosphere and warming in the lower troposphere. This plot shows temperatures. It's about a – what is it – a 50 year long record. The stratosphere is in the upper part of the plot, the surface is at the bottom, and the intermediate curves are at different levels ascending

in the atmosphere. And what we see is cooling in the stratosphere and warming in the lower troposphere as well as at the surface. Furthermore, there are several studies that suggest there is no longer a significant discrepancy between surface measurements and satellite radiosonde observations. Why do I say that? As one example, there's a report that's a decade old co-authored by John Christy at the University of Alabama in Huntsville saying that:

> *Previously reported discrepancies between the amount of warming near the surface and higher in the atmosphere have been used to challenge the reliability of climate models and the reality of human-induced global warming. This significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected. New data sets have also been developed that do not show such discrepancies.*

MR ROBERTS: That a peer reviewed paper?

MR RINTOUL: Yes, it is.

MR ROBERTS: So it's a report to - - -

MR RINTOUL: I will get you the reference. Apologies for not including it in there ..... it's ..... John Christy, whose record has been the one that has agreed least well with other satellite records and with the surface temperature record. He is an author on this report and agrees with that conclusion.

MR ROBERTS: And he had been very critical of the IPCC.

MR RINTOUL: This is not relevant to the IPCC. This is about a discrepancy between two sets of empirical observations. They don't agree. It has been an issue. The reason they haven't agreed is because of errors in the satellite data. Furthermore, starting in 2011, it was concluded that there was no reasonable evidence of a fundamental disagreement between troposphere temperature transfer models and observations. When ..... both are accounted for. Another study from 2011:

> *This further confirms our finding for our data set that unambiguously resolving the diurnal drift effect correction and its impacts is likely to be a key determinant in reducing the uncertainty in long-term tropospheric temperature changes from MSU and AMSU records.*

I should also point out that there's a study that's accessible on the web – it's ..... general of climate – which uses a new method of accounting for the drift in satellites. The problem with the satellite measurements is that due to drag and friction on the satellites as they orbit, they start to slow down a little bit and they change their orbit. As they change their orbit, that changes the time at which they make their measurement on the Earth. So these satellites are designed to measure each point of

the Earth at the same time every day – or every time they come back to that point so that you can ..... detect a trend in temperature.

If you're making the temperature at noon and then you make it a little later the next day, a little later the next day, that adds a spurious temperature trend. That's the issue with the satellite measurements. Removing that ..... is not a trivial thing, and that's why the community has been wrestling with it for more than a decade. The most recent study published coming out in the Journal of Climate shows that not only is the satellite record showing warming, but the warming of the lower troposphere slightly exceeds the rate of warming at the surface. But the most important point is that these measurements are consistent and they both show warming of the Earth.

Another way of looking at temperature records, including the discrepancy or otherwise between satellite and ground-based measurements, is that when we take into account variability due to ENSO, volcanoes and solar forcing, the agreement between the records is very close. So the plot on the left shows five temperature curves. The three above are surface temperature records. The two lower ones are the satellite and lower troposphere records. And the curves are offset by .2 degrees just to make them easier to follow. They actually agree with each other very well, but not exactly.

You will note that the two curves on the bottom, the yellow and – the orange and red curves, are a bit noisier, they're a bit spikier, and that's because the lower troposphere responds more sensitively to things like El Niño, so the big positive peak in 1998, there was a big El Niño in 1998, and they cool more – cool by a larger amount in response to volcanic eruptions than the surface temperature. So we can – if we remove from that ..... from each of those five records the change in temperature due to El Niño, the change in temperature due to volcanoes and the change in temperature due to solar forcing and then plot them again on top of each other, you get the curve on the right, which shows that after removing those signals that have a different expression in each of those records, the curves agree with each other very well.

MR ROBERTS: Just a point there, Steve, 1998 El Niño, which was very high, is easily seen on the satellite and not so easily seen on the ground base. Just an observation. Doesn't need - - -

MR RINTOUL: That's – and that's well understood.

MR ROBERTS: Okay.

MR RINTOUL: Yes. That's because of the adiabatic lapse rate in the lower troposphere. It's basically the signals are amplified in the lower troposphere above what you see – above the level that you see in ..... I was also ..... to touch on the question of the quality of the Australian temperature record. Changes in the location of a weather station and other factors can introduce biases in the surface temperature

record. The raw data are adjusted to correct for these factors, for example, by comparison in the nearby reference stations with reliable records.

There are several things to note about this: (1) the size of the trend in Australian mean temperature is large when compared to estimates of natural variability, and this holds true whether you use – regardless of which historical reconstruction is used, for example, ACORN-SAT, the Bureau's adjusted data record, the AWAP, the Bureau's unadjusted temperature record, or global datasets like ASIGIS or HadCRUT; (2) the size of the trend is large compared to the uncertainty estimates for annual values of Australian mean temperature; (3) the various methods of preparing the data show the most differences in the early part of the record, and this is a result of the sparser observing network at that time; (4) two independent expert reviews, one international and one Australian, have found that the Bureau's practices in preparing temperature data are sound and amongst the best in the world.

Which difference does it make? This plot from the Bureau, the light blue line is the adjusted data, the red line is the ACORN-SAT data. There are some differences in the earliest part of the record. The overall trend is quite similar in the two records, and after about 1960, the difference between the two is very little. An important point is that the fact that the two agree might be reassuring to some, but there's no scientific reason for believing that unadjusted temperatures are superior to ..... temperatures. It's exactly the reverse. How do the Australian records compare to other global records? Basically there's very little difference between them.

One last point about homogenisation of temperature records or correcting for biases. The process of homogenisation for global land ocean temperature has actually reduced the overall trend in global mean surface temperature. Contrary to the suggestion by some that these adjustment processes are leading to a spurious trend in surface temperatures, the adjustments actually reduce that trend. It's biggest in the ocean adjustments, and those adjustments are made because in the early part of the period when people measured surface temperatures, they took a canvas bucket, they lowered it over the side of the ship, they raised it onto the deck, they measured the temperature. Wet canvas evaporates pretty well. And the cooling of that by evaporation in the canvas bucket led to a uniform bias in those temperature measurements.

MR ROBERTS: So not only was it biased, but very sparse in the oceans as well.

MR BOBROFF: It varied a lot.

MR ROBERTS: Yes.

MR RINTOUL: Sure. So there's no question that as we go further back in the historical record, data observations both on land and in the ocean become more and more sparse. And that was the end of the presentation that I gave last time.

MR ROBERTS: Thank you very much.

MR MASON: Thanks, Steve. If we could swap the equipment around so that we can have the presentation from Senator Roberts' office, please.

MR BOBROFF: Here's a one-page overview of where we're - - -

MR ROBERTS: .....

MR BOBROFF: Where we're doing – what we're talking about, the major points. If anyone would like a full set of what we're talking about to make notes on on the way through – if anyone would like that, they're – do you want to hand those around? We concentrated very much on what we think are just the critical points. Some of the points we pushed off into appendices.

MR MASON: Mr Bobroff, I will ask you to just - - -

MR BOBROFF: Yes. All right.

MR MASON: - - - set the equipment up first, and then we will - - -

MR BOBROFF: Yes. Yes. Yes.

MR MASON: Then you can start. Is the technology working for us?

MR BOBROFF: I will try and get the thing cloned, which is not the case at the moment, but failing that, I will point at the screen and put it up on there. Just give us a minute to see whether it will be - - -

MR MASON: All right. Thank you.

MR BOBROFF: - - - around the right way.

MR ROBERTS: We're ahead of schedule, too.

MR MASON: We are. I appreciate everybody - - -

MR BOBROFF: So we need a few - - -

MR MASON: - - - working to a tight schedule.

MR BOBROFF: We need a few delays to get back on schedule. Well, not yet. It looks like I will talk to the – in that direction. On the way through, we've mentioned a few appendices. Their issue is somewhat tangled with the main points, but I think we should probably not talk about them. We don't want to raise them. But if – there are 10 copies of appendices which are free to pick up later on. Metadata about one of the data sets and - - -

MR MASON: I was going to raise it at the end. If we can just get digital copies of everything and any additional materials which are provided today to come through to myself, I will then distribute to everybody as a pack.

MR BOBROFF: Yes. Yes. We can do that.

MR ROBERTS: They can also take paper copies with them when they leave.

MR BOBROFF: Well, Jeff sent an email not too long ago drawing our attention to the CSIRO Act of 1949 and CSIROs Code of Conduct, so we thought we better have a look at that. You obviously didn't send it to us idly. So in the Act, all that we could find that was of interest was that CSIRO carries – well, the functions of CSIRO are "(a) carry out scientific research for any of the following purposes". The one that most interested us was "(iv) any other purpose determined by the Minister". We would be quite interested to see what directions CSIRO had received from the ministers from various governments over the last 20 years.

MR MASON: So that's a significant request.

MR BOBROFF: Yes, it is. It is. It is. And I'm just sort of floating the idea.

MR MASON: I suggest that we take that – I suggest that we raise that as a separate request outside of this session.

MR BOBROFF: Yes. That's right. That's something - - -

MR ROBERTS: Yes. Just take it on notice. Yes.

MR BOBROFF: That's - - -

MR MASON: Well, no. We will take that as a separate request.

MR BOBROFF: Yes. Yes.

MR MASON: We won't take that on notice in this meeting because that's a significant request which would need to come through proper channels.

MR ROBERTS: Okay.

MR BOBROFF: Yes. We just - - -

MR ROBERTS: So you just mean outside the meeting.

MR MASON: Yes.

MR BOBROFF: Yes.

MR ROBERTS: Okay.

MR BOBROFF: And then we looked at the Code of Conduct and sorted out some of the points in the Code. There are some of them which seem to entrench a CSIRO position, which I can understand. Organisations can't have people running off in different directions. And "must act in the best interests of CSIRO". Not of Australia necessarily, but of CSIRO. "Ensure all publications are peer reviewed and approved by the CSIRO." So presumably don't have too many dissenting publications coming out on issues where CSIRO has a position. "Alert managers where research findings" – or whatever, continuing on and on.

And a couple of really positive rules in the Code of Conduct, "be politically impartial and neutral", so no tacking on, no agenda 21 slides on the end of climate briefings and things like that. Glad – we don't see that very often any more. "Provide frank, honest, comprehensive, accurate, timely advice." Well, what could be better? It would be interesting to see what processes ensure that that occurs. And then a number about peer review, "impartial, rigorous, formal peer review, best available science and scientific techniques, robust peer review, open about areas of uncertainty and gaps in our knowledge, independent peer reviewed research". Who would argue with that? Okay. On to the - - -

MR ROBERTS: You've included the copies there of – or links to Dr Cleugh responding to questions at Senate estimates on peer review.

MR BOBROFF: Have I?

MR ROBERTS: Is that underlined there?

MR BOBROFF: Yes. It could be. It could be, though I've forgotten what those links are. So what's unprecedented in the climate record for the last 10,000 years? Well, temperature and carbon dioxide. So - - -

MR ROBERTS: So the green is CSIRO, red is our response.

MR BOBROFF: Yes. And if there's anything in black other than on a slide, that's sort of neutral stuff that has just been quoted from somewhere.

MR ROBERTS: It's usually just cut and paste; right?

MR BOBROFF: Yes. That's right. So it is Marcott – here's the slide that we're responding to, Marcott ..... science 2013. So here's Marcott's – a similar slide from Marcott's - - -

MR ROBERTS: Do you want to let people read the red?

MR BOBROFF: Yes and no.

MR ROBERTS: Okay.

MR BOBROFF: I will go back to the red. Here's Marcott's PhD thesis, which used the same 73 proxies. There's no uptick. So presumably CSIRO – well, it shows Marcott because of the 20th century uptick. Otherwise, it wouldn't be showing unprecedented temperature at all. It would show a slow decline to about the Holocene.

MR RINTOUL: Would you prefer me to respond as we go?

MR BOBROFF: No. I think that wasn't the direction, was it, or - - -

MR RINTOUL: Fair enough.

MR MASON: Sorry?

MR BOBROFF: You want - - -

MR RINTOUL: ..... no. It's okay. I wasn't sure if we wanted - - -

MR MASON: That's all right. If it's - - -

MR ASHBY: I think we're happy for a response afterwards - - -

MR MASON: Yes. So, look - - -

MR ASHBY: - - - in a formal way, but - - -

MR MASON: Yes.

MR ASHBY: - - - not today.

MR MASON: No. Look - - -

MR ASHBY: You know, we expect there will be time needed for a response to this.

MR MASON: That's right. So, look, just to kind of recap, if there's something which you just want to ask some clarification on during the presentations, if we could do that and then note any key areas of concern or interest for a discussion at the end.

MR BOBROFF: Well, the peer reviewed literature would have given CSIRO no cause for concern; however, the lead author, Marcott himself, admitted:

> *The 20th century portion of our paleotemperature stack is not statistically robust and cannot be considered representative of global temperature changes.*

Well, that's in the public domain. The uptick has been repudiated by the author. Here's the response, and there's the critical bit that I've quoted there, also the paragraph before and after.

MR ROBERTS: So he's saying that's the - - -

MR BOBROFF: That there was an outcry when Marcott 2013 came out and eventually Marcott responded with a set of questions and answers on the site RealClimate, and that was the central bit. So there's - - -

MR ROBERTS: So just read that one out. Just get it into the transcript.

MR BOBROFF: This one here?

MR ROBERTS: Yes.

MR BOBROFF:

> *Thus, the 20th century portion of our paleotemperature stack is not statistically robust, cannot be considered representative of global temperature changes, and is therefore is not the basis of our conclusions.*

That's Marcott.

MR RINTOUL: Read the next sentence.

MR BOBROFF:

> *Our primary conclusions –*

Well, we're not really interested in their conclusions. We're just interested in the temperature record, really.

MR MASON: Sorry, Steve. Was there a point that you just needed to clarify there?

MR RINTOUL: Well, just to be clear, our use of Marcott does not use any of their "20th century uptick", in quotes, any more than Marcott's paper did. The point is in the sentence I suggested you read out that:

> *Our primary conclusions are based on a comparison of the longer term paleotemperature changes from our reconstruction with the well-documented temperature changes that have occurred over the last century, as documented by the instrumental record.*

That is, the 20th century information we're comparing to the historical information is from the observations, not from Marcott's uptick.

MR BOBROFF: That's not what – he doesn't say the - - -

MR RINTOUL: That's what that second ..... sentence says there, sir.

MR BOBROFF: No. The point we're making is he has repudiated the 20th century data. And what caused that? What changed from his PhD thesis which used exactly the same 73 cores to the paper using the same 73 cores again? Well, the different was that two extra authors joined him, Dr Peter Clark, who was the lead author of an IPCC report, and Jeremy Shakun, and they converted – they redated the upticks, the core top of some of the alkenone ones. There weren't many of the series that went through into the 20th century. They were all published in their own peer reviewed papers, and those – the researchers who produced the 73 cores dated the core tops. The core tops were changed by the four authors here, and that wasn't clearly brought out in the body of the paper. So – and when subject to the criticism, they repudiated the uptick.

MR ROBERTS: That was the public criticism, but it survived peer review - - -

MR BOBROFF: Yes. That's right. It was - - -

MR ROBERTS: - - - in the Journal of Science.

MR BOBROFF: It survived peer review. It has been cited 200 times presumably because of the uptick. It has not been withdrawn. It has not been corrected. So we wonder why the CSIRO have used this particular paper. So that was all on temperature. So it is 300 peer – the list of 300 peer reviewed papers saying that temperature is not unprecedented. So we're not saying that we're citing each one of these. We're just saying there's a great body of literature, hundreds of papers that say temperature is not unprecedented.

MR RINTOUL: Just to clarify, we did not say the temperature was unprecedented.

MR BOBROFF: Well, that was the question.

MR RINTOUL: We said – we were asked to identify what things were unprecedented, and we said the rate of temperature rise is unprecedented.

MR BOBROFF: The rate of temperature rise is unprecedented.

MR ROBERTS: Based on how many points.

MR BOBROFF: Yes. Yes. Yes. Good point. Good point. But you didn't plot the rate of temperature rise here.

MR RINTOUL: No. I didn't plot it ..... but that's the point. That's exactly – the rate of rise in global mean temperature. That's what the slide said.

MR BOBROFF: Well, when we get on to the CO2, there's an observation that will bear upon that. There's a good deal more on Marcott in an appendix. Now, the CO2 one - - -

MR ROBERTS: So you've got a copy of the appendix here?

MR BOBROFF: Yes. There's a bunch of copies ..... anyway ..... copies of that. The current carbon dioxide levels are unprecedented. Well, if you look at these graphs, you could conclude that they're unprecedented. However, we note that the time resolution on the first one is 570 years.

MR ROBERTS: Five copies of the appendix.

MR BOBROFF: And the second part, the Vostok data, is the 1000 years. So the modern change is 90 parts per million in 60 years, and we're trying to detect changes that have occurred like that, sampling once every 570 years or 1000 years. So certainly we agree that you haven't found anything that - - -

MR RINTOUL: Sorry. Just to clarify – perhaps the slide wasn't clear. The text with the arrow that says "CO2 concentration today as measured in air" is the measurement from stations like Mauna Loa or Cape Grim of the CO2 concentration in the air at present. It's not from the ice core record. It's a comparison again - - -

MR BOBROFF: You're comparing it – but the ice core record is up there to show that it hasn't occurred in the past.

MR RINTOUL: Right. So the ice core record is the best evidence we have of what happens in the past.

MR BOBROFF: Yes. True. But it samples every 570 years or 1000 years. So the chances of detecting a 90 part per million uptick in 60 years is zero. So the data doesn't allow you to comment on - - -

MR RINTOUL: .....

MR BOBROFF: We agree that Law Dome was a resolution of 12 years – may well show that there has been ..... CO2 is unprecedented for 2000 years. But certainly I don't think the data is up to any statement about what CO2 upticks have been like over the last 10,000 years.

MR RINTOUL: So just to clarify, your suggestion is that at times in the past, CO2 has been .....

MR BOBROFF: No.

MR RINTOUL: So we don't know anything about past CO2 levels. Is that what - - -

MR BOBROFF: We know what can be known by sampling every 570 years or every 1000 years. So you miss a lot - - -

MR RINTOUL: Or 12.

MR BOBROFF: - - - by sampling only every 1000 years.

MR RINTOUL: Or 12.

MR BOBROFF: Sorry?

MR RINTOUL: Or 12.

MR BOBROFF: Yes. Yes. Agree. Law Done takes you back to 2000 with a much better resolution. So what – CO2 as a greenhouse gas, well - - -

MR ROBERTS: That's CSIROs claim.

MR BOBROFF: Yes.

MR ROBERTS: Statement.

MR BOBROFF: Statement. We agree that it absorbs and emits longwave radiation.

MR ROBERTS: We don't agree with the term, but we agree - - -

MR BOBROFF: Yes. But we're not - - -

MR ROBERTS: - - - with the underlying statement.

MR BOBROFF: Not going to make any fuss about it.

MR ROBERTS: It emits long – absorbs and emits longwave radiation.

MR BOBROFF: Carbon dioxide has increased since the Industrial Revolution. Yes. Probably true. At no great – it seems to have increased slowly since 1850 and a bit faster since 1950. No objection there. Extra carbon dioxide comes from human activities. The isotropic concentration shows that it has come from burning fossil fuels. Well, there was this paper, Munshi 2016, that provides an alternative explanation that it's from the – can be explained by the decay of bomb debris.

MR ROBERTS: From the atomic bomb tests.

MR BOBROFF: Yes. We're not, though. He says it fits the data, it's consistent. We're not really confident to say one way or the other. Just there is a paper that says there's another alternative consistent - - -

DR CLEUGH: Can I ask a point of clarification. Is the Munshi data – is the Munshi paper – sorry – in the peer reviewed literature?

MR BOBROFF: Yes. Yes. Yes. Yes. Munshi 2016 gets you - - -

DR CLEUGH: Which journal is it?

MR BOBROFF: It may well be a link. I think – yes. It looks like it's a link. SSRN.com ..... something or other. Well, have a look. If you - - -

DR CLEUGH: It's not a journal I'm familiar with.

MR BOBROFF: There's a fascinating site that has just come online that provides almost real-time, three hour delay CO2 concentration at the surface. So I imagine it's the latest satellite. And you can step back in three hour jumps or one day jumps.

MR ROBERTS: What is the source of the data?

MR BOBROFF: It's a – well, it has obviously got to be a satellite.

MR ROBERTS: No. But I mean who provides it?

MR BOBROFF: NASA GMAO GEOS-5, which sounds like it must be a satellite, and there's a link to that. This just happened to be when I looked at it one evening, and there's an even higher resolution mode you can put it into, and the white is high CO2 concentrations and the black is low CO2 concentrations. And apart from a few little places – the pointer disappears over the image – Japan frequently has high CO2 concentrations, as does California and a little bit on the east coast of the US, but what's going on in the Democratic Republic of Congo I have no idea. And it also pops up in the lower part of South America, where there's – in neither of those two places is there any major industrial activity going on, I suspect.

MR ROBERTS: So just in your perusing of the data, you've found that it varies from, say, 349 parts per million, which is 0.034 per cent in northern China - - -

MR BOBROFF: That was up in here.

MR ROBERTS: Yes. Where human activity is usually pretty big. To .04 per cent in the Democratic Republic of Congo, where human activity seems to be small. And you've also said in the past and last night when we watched this same data that it changes quite significantly within hours.

MR BOBROFF: As the sun goes over. You can see – well, I imagine it's plant activity or people waking up. I'm not too sure what. But it changes significantly.

MR ROBERTS: So the CO2 levels are sometimes highest in areas where there are few humans and no human industrial activity.

MR BOBROFF: There's no change – or very little change in the broad Northern Hemisphere belt up here of low CO2. The difference is big. I mean, it's 100 parts per million between the high CO2 areas and the low CO2 areas.

DR CLEUGH: So we can pick this up in the discussion, but just as a point of clarification, this is – as I said, it will be a satellite image, so presumably its time resolution is more or less instantaneous, it's not averaged - - -

MR BOBROFF: They come out every three hours.

DR CLEUGH: Yes. Okay. Thank you.

MR BOBROFF: So - - -

DR CLEUGH: Well, we will talk about that at the end.

MR BOBROFF: Yes. Yes.

DR CLEUGH: But just to say that there is a lot more than just human activities that are both emitting and taking up CO2 that contribute to - - -

MR BOBROFF: Yes.

MR ROBERTS: Yes. Yes.

MR BOBROFF: Yes. Yes. That's right.

DR CLEUGH: - - - high fluctuations in atmospheric CO2 concentrations - - -

MR BOBROFF: Yes. Absolutely.

MR ROBERTS: Exactly.

DR CLEUGH: - - - as you would see from a satellite.

MR ROBERTS: Exactly.

MR BOBROFF: But it's certainly not just the – it doesn't mean the well-mixed gas, so it's the same all over the globe, and the Scripps Institute cites a specific – don't seem to be measuring where it's all changing and happening.

DR CLEUGH: But, again, I make the point this is essentially an instantaneous measurement.

MR BOBROFF: Yes. Yes. That's right. And you would need to integrate over the whole lot and do all sorts of interesting things to – the oxygen concentrations have declined at the rate expected from burning carbon rich fuel.

MR ROBERTS: So that's CSIROs statement. That's in green.

MR BOBROFF: Yes. That's right. The data was available from 1989 onwards. I looked quite hard to see whether I could find changes in oxygen concentrations over the Holocene, and I could find some spot ones that were not – that were mainly to do with the processing of ice cores and what was happening at the top of ice cores. No one was sort of really interested in systematically getting data on what oxygen concentrations are in the Holocene. What I was looking for there was has it declined like this before when human fossil fuels weren't burning, and I couldn't find anything to suggest that you could answer that question. CO2 in the atmosphere has increased as human emissions have increased. The two are correlated.

MR ROBERTS: That's the CSIRO statement.

MR BOBROFF: Yes. Up there. Well, they're only correlated when they're not uncorrelated. There's CO2 emissions in gigatons per year, and here's the CO2 parts per million.

MR ROBERTS: Just before you go from that, in 2009, we had the recession around the world and carbon dioxide from human activities was lower than in 2008 – the production was lower than in 2008, and yet the carbon dioxide level in the atmosphere continued increasing. And the same for the period from 1910 roughly to 1940s. Carbon dioxide – human production was relatively flat, but it continued increasing in the atmosphere.

MR BOBROFF: Yes. So sometimes it's correlated and sometimes it doesn't respond like that at all.

MR MASON: What are the measurement points which they use for that?

MR BOBROFF: Well - - -

MR MASON: So when you're talking about that impact, are they looking at industrial or are they looking at consumer output?

MR ROBERTS: Peter will get onto that.

MR MAYFIELD: Yes. We will get onto that in - - -

MR ROBERTS: It's quite surprising.

MR MASON: Just quickly, I just wanted to come back in because I – just since the question had been raised around SSRN. That article – that Munshi article is not peer reviewed. It's a submission website. Is that correct?

MR BOBROFF: So it's not of the quality of Marcott 2013.

MR MASON: It's not. Okay.

MR BOBROFF: Right. I see.

MR MASON: Okay. All right. Sorry. I just jumped online to have a look since it raised.

MR ROBERTS: Good. Thank you.

MR BOBROFF: In recent decades, nature has absorbed more CO2 than it has emitted, it's alleged. So natural .....

MR ROBERTS: So that's CSIROs statement.

MR BOBROFF: Yes. Yes. So including that the data on natural resources appears to be a bit weak, particularly the land sink data. What you showed us was two graphs, one with two human sources, burning fossil fuels and land use change, and the land and ocean sinks. So we went to CDIAC, which was probably the site where you got yours from, and here we put them together. So here we go from 1850 or – yes – 1850 on to here. So we've got human fossil fuel and cement production, land use changes. The blue one is ocean sink. The light blue and the dark blue is the land sink. The red one is atmospheric growth. What flows of CO2 in and out of the atmosphere would have to have occurred in order to make the concentration change? And this is – you notice that is an extraordinarily smooth graph – or smooth plot, the atmospheric growth.

Well, looking a little bit bigger as to where this data came from, it was stated that nature has apparently absorbed more than it has emitted since 1850. So here's where the measurements have come from. Fossil fuel and cement production is obviously not a measurement, as such. I mean, there's no dial that you can read. It's an estimate, the typical sort of economist's estimate, I suppose. The more recent ones here have come from CDIAC itself, some from BHP.

MR ROBERTS: BP.

MR BOBROFF: Sorry. BP. And the stuff in the past seems to have come from the US Geological Survey. So those estimates are as good as you give them credit for. The atmospheric CO2 growth rate directly from atmospheric CO2 concentrations, that's an easy calculation if you assume everything uniform over the Earth. And we, you know, can see that that one is based upon measurements. We don't really dispute the Scripps stuff terribly much.

MR ROBERTS: Even though it may not represent what's happening around the world - - -

MR BOBROFF: Around the world. At least it seems to be relatively consistent. And the ocean sink is the combination of global ocean biochemistry models, so it's

not a measurement at all. It's an output of models. The land sink is estimated as a residual of the other things. So there's no measurements, no estimate, nothing of the land sink. The land sink is the term for everything that we don't know, and we've called it land sink.

MR ROBERTS: It's done by addition and subtraction.

MR BOBROFF: Yes. Just adding and subtracting the others in the way you would expect. So basically - - -

MR ROBERTS: Including the model data – model - - -

MR BOBROFF: Including the model ocean data. Yes. So the land sink data is worthless. So there's more – CDIAC has data coming from it looks like 1958. But here the atmospheric growth has not been so heavily smoothed. So if you take the same calculations back to get the land sink data with the unsmooth CO2, what you get is the land sink at this year – I don't know – 1987, is the source of one gigaton per year into the atmosphere, and a few years later, it's 15 gigatons coming out of the atmosphere. For such a huge change in flow, surely someone would have noticed something happening in the forests or the ocean or the tundra or something to support such huge changes in what's called the land sink. So basically we conclude that the land sink data is not plausible at all.

Now, in the northern latitudes, CO2 changes are particularly seasonal. So here we're looking at not too far north. This is La Jolla. If you go further north to Alert Point or Barrow, the changes are even much greater. So here's what's happening seasonally with the CO2 concentrations, big changes, and they turn around extraordinarily rapidly and go back up again. Now, you can only get that if big flows of CO2 are going in and out of the atmosphere. Now, if you apply a simplistic, somewhat naïve calculation to that using the same factor that was used on the smooth longer-term data, you get gigantic flows going in and out of the atmosphere, hundreds of gigatons per year. I'm sure you can quibble with the naïve factors that I've used, but if you reduce the 400 to 100, it's still 10 times greater than any human effect. So if these huge flows – huge natural flows are at all even slightly temperature dependent, everybody has to think again.

MR ROBERTS: And that includes the oceans, which are temperature dependent, and the solubility of carbon dioxide in water is temperature dependent.

MR BOBROFF: So that slide about the sinks and sources, we accept some of the data, but strongly contest some of the other parts. So we're now on to the additional carbon dioxide added to the atmosphere by humans has enhanced the greenhouse effect and less energy is leaving the top of the atmosphere in the wavelengths absorbed by carbon dioxide and other greenhouse gases. And here it is. Well, the first time we looked at that, I didn't see the delta and jumped to the wrong conclusions that you had only presented one point in time and how could it have changed from that, but I freely admit my error. Unfortunately – this is figure 1C

from Harries. Figure 1A is the data from the satellite. Figure 1C is the component of the simulated spectrum which is not defined but includes only the effects of trace-gas changes between 1970 and whatever, omitting temperature and humidity changes to aid interpretation.

So this is not the empirical data off the satellite. It has been heavily massaged and moved to a interpretation. It hasn't been spectrally integrated to bring it out into watts per square metre. You could compare it with other fluxes and things. Here's the data off the satellite. This is Harries figure 1A of the two satellites, I think the earlier one IMG and the later one IRIS. So it has gone up in some areas, gone down in other areas, but it doesn't include the main CO2 absorption band, which is a bit odd. You're setting out to prove that more or less CO2 is leaving the atmosphere and you don't include the main CO2 absorption band. That would seem to be a bit odd. And it would seem that the data is not available. If you believed what I said here, you would have been wrong because there was an erratum that came out a couple of months after that and these labels are around the wrong way, so that what was up is down and what was down is up.

MR ROBERTS: So it was erratum from – on the paper.

MR BOBROFF: Yes. Yes. The satellites that were used were quite different. One could measure a footprint of 100 kilometres, the other one a footprint of eight kilometres. The decision to stop the investigation at 710 per centimetre was based on a recommendation of one of the satellite working groups. So it's almost like saying, "I lost my keys in the carpark, but I'm searching under the streetlight because the light is better." That's what it seems to me. Is - - -

MR ROBERTS: What's that – no. That's okay. Did you want to talk about MODTRAN or ..... later?

MR BOBROFF: Well, there's the MODTRAN changes showing just from no carbon dioxide, 400 and 1000. So most of the activity occurs here, and that was excluded from the Harries paper.

MR ROBERTS: So the significant portion of the wavelength has been excluded from the Harries paper.

MR BOBROFF: Now, the heading should have been, I think, "excluding the land absorption band of CO2, less energy is leaving the top of the atmosphere in other wavelengths absorbed by carbon dioxide and greenhouse gases. Well, that still would have – that would then have been a technically correct statement. Excluding the main absorption band to us seems ludicrous. Going further on - - -

MR ROBERTS: Just 3.7.7?

MR BOBROFF: This one? Yes. Yes.

MR ROBERTS: Harries draws - - -

MR BOBROFF: Draws the conclusion on two data points 27 years apart. Now, here's – looking at the NOAA outgoing longwave radiation satellite at the same lat/long box that Harries used for the same month, and this is how it changes over 40 years. So Harries picked two points 27 years apart. So what statistician would arbitrarily pick two points on a time series and jump and down and say things have changed?

MR ROBERTS: It's ludicrous.

MR BOBROFF: It just depends on what points you pick.

MR ROBERTS: It's ludicrous.

MR BOBROFF: It might have been a valiant effort back in 2001 when there wasn't any data, but now there's 40 years of data from the NOAA series of satellites that measure the outgoing longwave radiation at the top of the atmosphere since 1979. They have the same series of instruments as opposed to dissimilar instruments. The data about that satellite is included in the appendix. So this is really what's happening – happened for 40 years for the outgoing longwave radiation at the top of the atmosphere. And I don't see any significant trend or not enough to get me to lose any sleep at.

MR ROBERTS: So it's basically flat.

MR BOBROFF: Yes. You can start to run all sorts of statistical tests on it, but - - -

MR ROBERTS: So the amount of longwave radiation leaving the top of the atmosphere hasn't changed.

MR BOBROFF: Yes. As CO2 has been rocketing up since 1979, there has been no change in the outgoing longwave radiation at the top of the atmosphere. And for naïve people like us, discussing it – the black box at the top of the atmosphere seems the simplest way of looking at the whole system. Stuff comes in, stuff comes out at the top of the atmosphere. And if CO2 is trapping more, less has got to come out, unless the sun is changing, but we didn't – we have that data, but we thought that would cloud the issue. So we don't find Harries 2001 very convincing at all. So the Earth has warmed as a result of the enhanced greenhouse effect.

MR ROBERTS: That's the CSIRO claim.

MR BOBROFF: Yes. That's right. And here are some graphs to suggest that the Earth has warmed. In this section 5, there's no evidence provided to link any warming to any enhanced greenhouse effect. I guess the reliance has totally been on Harries 2001. So at the moment we would - - -

MR ROBERTS: So it's just an opinion.

MR BOBROFF: Yes. I mean, this is – in this section here, this is an opinion with no evidence behind it at all. The CSIRO statement doesn't claim that dangerous or even significant warming has resulted from the enhanced greenhouse effect. The statement that the Earth has warmed as a result of the enhanced greenhouse effect is so vague that it's almost impossible to falsify or confirm. The world's big academic body, the InterAcademy Council, condemned similar statements in IPCCs AR4. So there's a whole lot of peer reviewed papers that are relevant to this subject.

MR ROBERTS: Do you want to just go through them for the transcript?

MR BOBROFF: Yes. I won't go through them in huge detail, but - - -

MR ROBERTS: No. I mean just the - - -

MR BOBROFF: Yes. Yes.

MR ROBERTS: - - - six lists you've got.

MR BOBROFF: Yes. 60 peer reviewed papers on low climate sensitivity, which basically says CO2 doesn't do much. Here's 285 papers that say we're all cooling and we're going to freeze and die, so we're not warming at all. These are all peer reviewed papers, I believe, or virtually all. I haven't gone through every one of them. Some of the lists have the primary graph brought out. Some have just an abstract and a graph. Some just have an abstract. They all have links to the papers, so you can easily follow them up. I think – no net warming during the 20th century – I've got a feeling I got – confused that with sea level change, but you did talk about sea level change. Natural variability dominates climate. Another 20 papers. Forecasting cooling coming up. Another 31 papers suggesting we're cooling rather than whatever.

So we have quite a few secondary concerns on whether the Earth has warmed or not, the Global Historical Climate Network and those sorts of things, but we've pushed all those off into an appendix. I think that would clog the issue too much if we were to start discussing that. The observed changes in the climate system are consistent with an enhanced greenhouse effect and it can't be explained by anything else. Well, there was no – this was just a statement. I mean, I guess this was posed as a briefing. I guess you can make statements as a briefing. But we sort of really see this as you making a case against CO2, and it's our job to cross-examine it and to see whether there's even a prima facie case against it. So making statements like that, as far as we can see, is not making a case at all. We need to see, you know, a causal chain with its papers.

MR MASON: Just to be clear, CSIROs role here is to provide the information and advice to government and analysis, which is what they've done. They've gone out of

their way to ensure that they provide information that's relevant to past discussions. Their position is not to create a case or to present a position for your - - -

MR BOBROFF: Well, someone needs to create a case.

MR MASON: For your benefit.

MR BOBROFF: And it needs to be cross-examined.

MR MASON: That's not the discussion which we're here to have today.

MR BOBROFF: Well - - -

MR MASON: The discussion was specifically designed today to be about climate analysis. I suggest that we halt this discussion until Senator Roberts is able to come back into the room, since we've drifted off subject since he left.

MR BOBROFF: All right.

MR MASON: If we can just ask this to hold.

MR ASHBY: Yes. I think he will be about five minutes. It's an interview.

MR MASON: Terrific. That's all right. Perhaps now is a good time just to take a five minute break, and we will come back when Senator Roberts is ready.

ADJOURNED **[11.31 pm]**

RESUMED **[11.38 am]**

MR MASON: Mr Bobroff, I will let you continue - - -

MR BOBROFF: Okay.

MR MASON: - - - noting that we're keeping focused on the subject.

MR BOBROFF: Certainly. So we're now – the observed changes in the climate system are consistent with an enhanced greenhouse effect, we call that at 6(a), and other forces cannot explain the magnitude and timing of the observed trends at 6(b). Well, 6(a) seems to be an opinion unsupported by any empirical evidence or papers. So I'm not too sure which – it might be this 200 and something papers.

MR ROBERTS: So you have 282 peer-reviewed papers - - -

MR BOBROFF: Papers - - -

MR ROBERTS: - - - which contest the opinion?

MR BOBROFF: Yes, contest the opinion. Going on to the next one, other forcings, internal variability can't explain it, whatever, again, just an opinion with no supporting stuff. So there's lots of papers on this.

MR ROBERTS: So 1000 peer-reviewed papers which appeared - - -

MR BOBROFF: Yes.

MR ROBERTS: - - - to discuss this topic.

MR BOBROFF: Yes.

MR ROBERTS: And we've long known that there has been many peer-reviewed papers contradicting the conclusion that CSIRO and NASAs Goddard Institute for Space Studies has come up with.

MR BOBROFF: So as far as we can tell, there's nothing unprecedented in global temperatures. There's no prima facie case that the carbon dioxide from human activities has affected global temperatures because no evidence has been provided on critical points of opinion. To the One Nation question, what in the 2000 year climate record indicates impending danger, CSIRO refused to ascribe danger and said, "You probably best ask the Minister" if he has done that.

MR ROBERTS: That was in - - -

MR BOBROFF: So I guess couldn't take that on notice.

MR ROBERTS: That was in Sydney.

MR BOBROFF: Yes.

MR ROBERTS: We asked the questions of CSIRO – I will get it up for you.

MR BOBROFF: Yes. "What's dangerous", and CSIRO said, "Not our job". Well, they weren't the exact words. It's up to the Minister, up to politicians, people or something, but it's not CSIROs job to ascribe any danger to it.

MR ROBERTS: So what I said was, "That needs to be statistically valid to have proof of – okay. Good. All right". And then I said, "Peter, you've already asked this question, and you gave me – gave it to me earlier. What is – what in the 2000 year climate record indicates impending danger?" And Steve said, "I don't believe I've said anything about danger". I then said, "No, but we're asking the question. Is

there anything that indicates impending danger?" And then Alex – I don't know his second name.

DR STEELE: Wonhas.

DR CLEUGH: Wonhas.

MR ROBERTS: Wonhas. Yes. Said, "I mean, it depends on your definition of danger. I think it's actually, again, coming back to our roles. Danger is quite an emotive word, and so, again, what are we actually trying to do? What – what we are actually trying to do is present the data as it is, try to provide the evidence base, try to provide the causation chain. I think how we then interpret this data and what we perceive as dangerous or not dangerous, I think that is ultimately a question for the people of Australia to decide." So then I said, "Well, Greg Hunt" – and I was looking at Alex, who was from Greg Hunt's department. I believe Greg had responsibility for the environment at the time, and possibly CSIRO. And I'm – that's correct. CSIRO at the time?

MR .....: No.

DR CLEUGH: At the time it was in – when was that meeting?

MR MASON: He was the Science Minister at the time.

DR CLEUGH: Okay. Yes.

MR ROBERTS: Yes.

MR MASON: Yes.

MR ROBERTS: So he had responsibility for CSIRO and also for the environment and climate.

DR CLEUGH: No.

MR ROBERTS: Not at – well – so I said, "Well, Greg Hunt" – and I'm looking at Alex here, who was a member – who was one of the Minister's staff, not for an - - -

MR BLACK: Beg your pardon. CSIRO staff.

MR ROBERTS: No, Alex actually came from the Minister's - - -

MR BLACK: No, I don't think so.

MR ROBERTS: Sorry. Not – sorry. Alex was – yes. Alex – there were two Alex's, weren't there?

MS .....: There's an Alex Caroly who worked on Minister Hunt's staff who was an advisor.

MR ROBERTS: Was he in Sydney with us?

MS .....: I don't - - -

MR YOUNG: That was Alex Cooke - - -

MS .....: Alex Cooke.

MR MASON: It was Alex - - -

MR YOUNG: - - - who was at the Minister's office at the time.

MS .....: Okay. Alex Cooke was with the Minister.

MR ROBERTS: Yes. So a - - -

MS .....: So there were three Alex's, and two of them were in the room.

MR ROBERTS: So I remember turning to him. He was on the right on the other side of Leon, I believe. So I said, "Well" – I'm looking at Alex from Greg Hunt's department here not for an explanation, but just to emphasise that Greg Hunt in particular has said that his climate policies rely entirely on the CSIRO, the Bureau of Meteorology, and the IPCC. And so he's saying, "We will end up in danger unless we do something to cut the use of hydrocarbon fuels". And so if he relies upon the CSIROs advice, is that where he's getting his imminent danger from? And Alex Wonhas said, "So you have seen the type of advice that we're generally providing to – that we are generally providing to, frankly, the Australian public, or sent to the Minister." So I said then, "So the Minister has drawn those conclusions".

MR MASON: Can I just for a second, Senator Roberts, I don't mean to interrupt you. You're reading from a transcription of a meeting - - -

MR ROBERTS: Yes.

MR MASON: - - - which took place under a prior Minister; is that correct?

MR ROBERTS: Correct.

MR MASON: Is - - -

MR ROBERTS: Correct.

MR MASON: Has everybody got a copy of that? Has - - -

MR ROBERTS: It was recorded.

MR YOUNG: That was the - - -

MR MASON: That was the - - -

MR YOUNG: - - - transcription we discussed after the first - - -

MR MASON: Okay. Terrific. So I'm just making sure that – I was just clarifying that this is a transcription which everybody had got a copy of. Okay.

MR ROBERTS: So you've seen the type of – Alex from CSIRO said, "So you've seen the type of advice that we are generally providing to, frankly, the Australian public and also to the Minister", and I said, "So the Minister has drawn these conclusions about danger, not – not the CSIRO. He has done it independently of the CSIRO. So the CSIRO has presented him with the temperature changes and the causal analysis and he has gone, 'Oh my God, we've got to do something". And Alex from CSIRO said, "You're probably best to ask the Minister if he has done that". So, yes, the point I'm making is that CSIRO denied any comment about whether or not there was danger from the climate records, and that was then pointed to the Minister at the time.

MR MASON: Sorry.

MR ROBERTS: That's all I was wanting to clarify.

MR MASON: Yes. Okay.

MR BOBROFF: So I guess we're interested, does the current Minister consider imminent danger - - -

MS CHAPPLE: That's not for the - - -

MR MASON: Again, this is – this is – this is something which is not on the table to discuss today.

MS CHAPPLE: No.

MR BOBROFF: No. True, true, true. Well, that's the end of the - - -

MR MASON: No. Thank you, Mr Bobroff.

MR ROBERTS: So summarising, then, the Marcott paper has serious questions about it. It seems to have relied upon one – correct me if I'm wrong here in the summary – one data point.

MR BOBROFF: Yes. There's one data point on there.

MR ROBERTS: And there's a significant - - -

MR BOBROFF: If you look at the alkenones, there's data points going right down that – it's in the – I can probably bring it up.

MR ROBERTS: So there's no change in – there's nothing unprecedented about that until the two IPCC authors got involved - - -

MR BOBROFF: Yes. The - - -

MR ROBERTS: - - - with the – with Marcott.

MR BOBROFF: There's the alkenone.

MR ROBERTS: Can you get it up there?

MR BOBROFF: I – yes, yes. I'm talking to myself. That is just the alkenones from Marcott. Look at all the data points going ..... and there's just the one from the - - -

MR ROBERTS: So, if anything, it shows cooling.

MR BOBROFF: You can - - -

MR ROBERTS: And there's one data point, and that is – what did you say, Peter – cooler than 80 per cent of the – the Holocene.

MR BOBROFF: Yes.

MR ROBERTS: Keep going through the rest of this.

MR BOBROFF: Well - - -

MR ROBERTS: We've got plenty of time up our sleeve because we haven't used our time yet.

MR BOBROFF: - - - there's the time series from just the alkenones with and without the core top redating. So from - - -

DR CLEUGH: So just, again, to be clear, this document that you've got on the screen here at the moment is his Masters - - -

MR BOBROFF: It's not a peer review, no.

DR CLEUGH: No. I'm just checking - - -

MR BOBROFF: No. Yes.

DR CLEUGH: - - - it's a PhD thesis, or Master's thesis?

MR BOBROFF: No.

DR CLEUGH: No. Okay.

MR BOBROFF: No. It's just someone who looked – who looked at - - -

MR MASON: All right. So it's incredibly - - -

MR BOBROFF: - - - the alkenones – got Marcott's data and looked at - - -

MR MASON: - - - important that the information you present here today and the information which you ask CSIRO to look at as part of that raising has been peer reviewed - - -

MR BOBROFF: No, it's not.

MR MASON: - - - and has gone through a process - - -

MR BOBROFF: It's not important at all.

MR ROBERTS: What it shows here - - -

MR BOBROFF: A peer review allows crap like - - -

MR MASON: It is – it is.

MS CHAPPLE: It is from CSIROs point of view.

MR MASON: It is important because that's - - -

MS CHAPPLE: It is from CSIROs point of view.

MR BOBROFF: You can distinguish the - - -

MR MASON: - - - the rules which CSIRO needs to engage in.

MR ROBERTS: Hang on. Let him finish.

MR BOBROFF: Yes. That's – CSIRO can put their head in the sand for this if they want to, but - - -

MR MASON: It's unfair to make statements like that, they're putting their head in the sand. CSIRO has got a defined set of boundaries which they can exist in.

MR BOBROFF: They're self-imposed. The code of conduct – CSIROs code of conduct.

MR ROBERTS: Hang on. Hang on, Peter. It has to rely on peer reviewed papers.

MR MASON: Yes.

MR ROBERTS: And I heard Dr Cleugh respond to my questions on peer review. CSIROs peer reviewed papers from her own answers indicate that they're not strong. Now, what we're raising here is serious issues – serious issues. I'm questioning CSIROs reliance on peer review because that Marcott paper is dodgy.

MR MASON: Okay. And I would pass to - - -

DR STEELE: Senator, could I just ask you to clarify what you meant a moment ago.

MR MASON: Can I get you to just do a quick introduction for yourself at the same time. Yes.

DR STEELE: Sure. Jack Steele. Could I ask you to clarify the question or the assertion you just made a moment ago that - - -

MR ROBERTS: Yes.

DR STEELE: - - - CSIROs evidence – Dr Cleugh's evidence that estimates - - -

MR ROBERTS: Her responses to my questions - - -

DR STEELE: - - - was in some way not strong.

MR ROBERTS: Yes. It didn't give me - - -

DR STEELE: Could you clarify what the sentence meant.

MR ROBERTS: That's why we've got the responses in – access to this.

DR STEELE: I have them already in front of me.

MR ROBERTS: Good. Perhaps you could read them out, because - - -

DR STEELE: What was the question that you were raising in relation to the transcript, and what was your conclusion from it, is my question to you.

MR ROBERTS: The conclusion is that CSIROs reliance on peer review is not scientifically robust, and is not robust itself.

DR STEELE: So for what it's worth, Senator, as I read the transcript, I didn't come to that conclusion at all from the evidence.

MR ROBERTS: I did.

DR STEELE: There we go.

MR ROBERTS: That's right. We differ. We differ.

DR STEELE: We've got a difference of opinion about the evidence.

MR ROBERTS: Yes. And what we're showing here is valid evidence that raises serious questions about Marcott, and, in fact, we don't have to rely upon the evidence, even, because the author himself admits that under peer – under scrutiny from his peers in the public domain.

DR STEELE: So I was asking a question - - -

MR ROBERTS: Could you acknowledge that?

DR STEELE: No, no. Senator, I was asking a question generically about your question in relation to the evidence. The evidence that was given in the estimates wasn't specifically to that paper. I'm happy for my colleagues to talk to that paper if we're at that point in the debate.

MR ROBERTS: Correct. It wasn't about this paper, but it was about the peer review in general.

DR STEELE: And the evidence that was given was that CSIRO – as, indeed, is consistent with the code of the conduct – when it publishes its scientific output it goes through both an internal peer review process, and also it puts its output into scientific journals that conduct their own independent and then subsequent, therefore, peer review process, and that's the expectations that come from the code of conduct. That's what we do.

MR ROBERTS: So what I'm presenting here through Peter's work is that raising questions about why CSIRO is relying on a particularly bad paper, because the author himself has come out publically under public scrutiny and admitted that it doesn't stand up. The author himself – the lead author, sorry.

DR STEELE: And I believe, Steve, you wanted to make a comment in response to that.

DR CLEUGH: So I think we should - - -

MR MASON: Just - - -

DR CLEUGH: Just before Steve – yes. I think we should put the paper card back up.

MR MASON: On the list of discussion because that will be - - -

DR RINTOUL: Well - - -

MR MASON: - - - finished on the - - -

DR RINTOUL: - - - the points – it's interesting that you're so keen on the Marcott paper. None of the conclusions that I spoke about - - -

MR ROBERTS: Well, excuse me, we're keen on the Marcott paper because you raised it as the only piece of evidence showing that there's unprecedented warming.

DR RINTOUL: No. There are many records, as you know, that – and, first, I did not say that the present temperatures are unprecedented. I said that according to that study - - -

MR ROBERTS: So are they or are they not?

DR RINTOUL: - - - the rate of rise in temperature is unprecedented. The temperature - - -

DR CLEUGH: Which is why I wanted the slide to be put back up, because it's very clear in the heading that Steve's point was that it was the rate of - - -

MR ROBERTS: We're happy to have it back up.

DR CLEUGH: - - - temperature change.

DR RINTOUL: What the plot shows is a comparison of the instrumental record for the 20th century to the past record from Marcott. The conclusion that the rise in temperature in the 20th century is – that rate of rise is unprecedented in the previous 10,000 years – the question you asked – is based on comparing recent measurements – the instrumental record of temperature rise – to the best information we have about past temperature rises.

MR BOBROFF: Well, I suspect that - - -

DR RINTOUL: It's completely – it has nothing to do with the uptake, zero.

MR BOBROFF: I suspect that we will find that the sample interval over the - - -

DR RINTOUL: So all of - - -

MR ROBERTS: Hang on. Hang on. Let him finish.

DR RINTOUL: - - - the questions that you've raised about the Marcott paper are irrelevant to the discussion we've had here today. None of our conclusions depend on that uptake in any way.

MR BOBROFF: Well, you haven't presented any other evidence, and - - -

DR RINTOUL: That slide that I presented showed the instrumental record for the last 200 years.

MR ROBERTS: Let's go back to that slide.

MR BOBROFF: Well, we can't – I can pull it up.

MR MASON: I think - - -

MR BOBROFF: Yes.

MR MASON: Can I just, kind of – just to, kind of, keep the proceedings in line here, have we completed - - -

MR ROBERTS: Peter, have you finished?

MR BOBROFF: Yes, yes.

MR MASON: - - - the presentation from that side. All right. So, look, can I just – just so I've got a sense of, kind of, gauging with the time that we've got left and the amount of discussion to participate – so we do have – fortunately, we are running a bit ahead of time, which is useful. Are there key areas or key points that either party would like to discuss as a priority? Obviously the Marcott is the starting point. Is there any other areas which – perhaps starting with .....

DR RINTOUL: There's points of clarification I would like to raise.

MR MASON: Okay.

MR ROBERTS: The Harries paper.

MR BOBROFF: I don't think we need to raise anything. We just respond to - - -

DR MAYFIELD: Can I just ask one other question. So, Peter Mayfield. So at the last meeting there was a presentation that you wanted to make and Leon and Peter started part of that. Is there anything that would have been presented there that we could see?

MR BOBROFF: No, no. We realised that the only way of making any progress is to narrow down on just the core questions. So we've - - -

MR ASHBY: Yes. Some of that other evidence is peer reviewed and not peer reviewed, and because you're, sort of, saying that - - -

DR MAYFIELD: Okay. Yes. I just wanted to confirm.

MR ASHBY: - - - you want to keep it peer reviewed, we've kept it to that one.

DR MAYFIELD: Thank you.

MR BOBROFF: And we really want to focus down on just the - - -

MR MASON: All right. So Marcott is obviously the starting point. Steve, have you got a few areas?

DR RINTOUL: I – yes. Mostly one or two liners.

MR MASON: All right. So - - -

DR RINTOUL: But I can run through them, anyway.

MR MASON: - - - we can perhaps just start with this discussion here and then work through any questions which Steve has got on his side. All right. Terrific. Thank you.

MR ROBERTS: So here's your – here are your comments on the Marcott paper:

> *Our results indicate that global mean temperate for the decade* - - -

DR RINTOUL: This is the quote from the paper, yes.

MR ROBERTS: That's your quote:

> *…has not yet exceeded the warmest temperatures of the early Holocene.*

So they're not unusual that way. They're not unprecedented:

> *These temperatures are, however, warmer than 82 per cent of the Holocene distribution. In contrast, the decadal mean global temperature of the early 20th century 1900 to 1999 was cooler than 95 per cent of the Holocene. Global temperature, therefore, has risen from near the coldest to the warmest levels of the Holocene within the past century, reversing the long term cooling trend that been two thousand and – 5000 – approximately 5000 years before the present.*

MR BOBROFF: Well, the first thing I would look at - - -

DR RINTOUL: Yes. And that's in the text that you showed on the screen - - -

MR BOBROFF: Yes. The first thing I would look at - - -

DR RINTOUL: - - - the second sentence that you read.

MR BOBROFF: - - - would be the sample intervals.

MR ROBERTS: And also the - - -

DR RINTOUL: But it's not - - -

MR ROBERTS: - - - point itself.

MR BOBROFF: You're talking about rates of change. You need to see fine sampling so that you can see rates of change over short periods. I don't think - - -

DR RINTOUL: So - - -

MR BOBROFF: - - - the data will probably support that.

DR RINTOUL: - - - the statement is that based on the science that we have today, that the rate of rise in global mean temperature is unprecedented in the last 10,000 years. The published literature supports that statement.

MR BOBROFF: If the sample intervals are too long, it doesn't matter whether it's the best available or not. You can't find data on a 20 hertz signal by sampling it at 10 hertz.

DR CLEUGH: So, just to reiterate, the point of our meeting today and the last time was to present the best available science that's in a peer reviewed literature, and this is a - - -

MR BOBROFF: Possibly so, but we're not – we're here - - -

DR CLEUGH: If you've got some more analyses that you feel you wish to do then that's not the point of today's discussion, really.

MR BOBROFF: What, we're supposed to sit here and - - -

MR MASON: No. So the best and most possible way to get this sort of information in front of CSIRO is to – you've obviously done considerable work into this – is to potentially have that information put forward and put through a peer review process - - -

MR BOBROFF: You're joking.

MR MASON: - - - which means that they can then consider it.

MR ROBERTS: Hang on. Hang on. He has presented a number of papers here – hundreds of papers - - -

MR MASON: I'm aware.

MR ROBERTS: - - - that show that there's nothing unusual. In fact, he has covered four or five topics – five topics, I think, and there are papers out there showing that there's nothing unusual going on with temperature. And we've got data sets – access to data sets that show that there's nothing unusual going on too.

MR BOBROFF: I mean, putting that – you would have to go through a peer review process. If you pull some data out of a peer reviewed data set and display it – pull it out of a grid set and show it - - -

MR ROBERTS: Doesn't anyone raise any concerns about the use of this paper, that the PhD student put up, and then two IPCC people came and joined and then changed dramatically? Doesn't that raise any questions at all within CSIRO?

DR RINTOUL: As I - - -

MR BOBROFF: Yes. But we .....

MR ROBERTS: Doesn't that raise any questions?

DR RINTOUL: - - - mentioned, the uptake has nothing to do with the conclusions we have raised with this paper.

MR ROBERTS: Doesn't that raise anything at all with the quality of the - - -

MR BOBROFF: They're redated the core tops without declaring it in the paper.

MR ROBERTS: That - - -

DR RINTOUL: Shall I – would you like me to show you a different temperature time series for the last 10,000 years? They're all the same. They're all very similar.

MR ROBERTS: The point here - - -

DR RINTOUL: The rate of rise is clearly unprecedented in the last - - -

MR BOBROFF: But there's – and most of the series that go back run out of proxies before you get to the present.

MR ROBERTS: Steve, the - - -

DR RINTOUL: Your second point was that - - -

MR ROBERTS: - - - temperatures in the 1880s/1890s, according to some of the Bureau of Meteorology data, were warmer then than they are today.

DR RINTOUL: There are only a few stations that are all in the south-east part of the country. There's no way to say what Australian - - -

MR ROBERTS: That's the best available data there is.

DR RINTOUL: But there is no estimate of Australian mean temperatures in the 1880s. It doesn't - - -

MR BOBROFF: In the what?

MR ROBERTS: The temperature stations - - -

DR RINTOUL: It doesn't exist.

MR ROBERTS: Can you pull up your rural and city.

MR BOBROFF: Yes. I was just looking for the – there's some Holocene temperatures, just to - - -

DR CLEUGH: So, again, can I ask where these data are from, please, just for clarification.

MR BOBROFF: Yes. All PhD – all – apart from - - -

DR RINTOUL: The only - - -

MR BOBROFF: - - - Marcott's PhD one, all the rest are peer reviewed papers.

DR RINTOUL: Which ones are those with global mean temperatures?

MR BOBROFF: Well, now, I suspect that this - - -

DR RINTOUL: That's precisely the problem.

MR BOBROFF: Still, global mean is - - -

DR RINTOUL: We're talking about whether the globe is warm.

MR ROBERTS: Can you get on to your - - -

MR BOBROFF: Well, that's another issue that – on which we need two hours to describe, whether the global mean temperature is of any use to anybody other than .....

MR ROBERTS: Can you get on to the rural and urban.

MR BOBROFF: Well, we're off into – yes. We're down in this ..... which we - - -

MR ROBERTS: This is from which data set?

MR BOBROFF: Well, this is global historical climate at work – the 7000 stations that feed into all the major thermometer data sets. There are – in the metadata on each station, there are two fields that can take the value, rural, urban or suburban, and in response – well, taking the idea from a peer reviewed paper, I looked at the – the fully rural ones that were rural in both fields against the fully urban ones in both fields. And the fully rural stations showed decline. The fully urban ones go up. And the ..... land global is much closer to the fully urban. I would have thought the rural stations are more representative of the earth than the urban stations, and yet - - -

DR RINTOUL: No.

MR BOBROFF: Do I have to go through a peer reviewed paper to do that?

MR ROBERTS: We're raising serious questions about CSIROs peer review.

DR RINTOUL: Well, the research that's important is because the peer reviewed and published studies that have done exactly the same thing show nothing like this.

MR BOBROFF: They do.

DR RINTOUL: So when you put the plot - - -

MR BOBROFF: I can quote you a – Soon, Connolly and Connolly go through exactly this.

DR RINTOUL: It's not the – it's not my understanding of the state of the science, but I stand to be corrected, but - - -

MR ROBERTS: Peter just said - - -

DR RINTOUL: - - - a similar - - -

MR ROBERTS: - - - Soon, Connolly and Connolly, a peer reviewed paper.

MR BOBROFF: They define the technique and produce some evidence from it using that technique.

DR RINTOUL: And they get that plot?

MR BOBROFF: No, no.

MR ROBERTS: Peter has done the data himself.

DR RINTOUL: That's the point.

MR BOBROFF: They concluded that the GHCN was useless and, for the purposes that they wanted, they found what they thought were three really high quality, long term data series – one in China, one in India – one in Ireland, and one somewhere else.

DR CLEUGH: But I guess I come back to the key point that Steve is - - -

MR ROBERTS: Hang on. Can Peter just finish that.

DR CLEUGH: Sorry.

MR ROBERTS: Can Peter just finish that.

MR BOBROFF: Well, no, that was the finish, that they have been - - -

DR CLEUGH: Yes. I thought you had finished.

MR BOBROFF: Yes.

DR CLEUGH: I just want to come back to the key point that Steve just made a few minutes ago. Firstly, we were looking at the last 10,000 years and unprecedented rates of temperature rises – this is in global temperatures – and we haven't seen a plot that you've provided that had demonstrated a difference - - -

MR BOBROFF: But you haven't provided a plot of rises either – of rates of rise. We have to infer that from an uptick.

DR CLEUGH: We've already addressed that question through the discussion about the Marcott paper. The point here about the instrumental records through the – over the last 100 years, again, it's important to be looking at the global temperature record.

MR BOBROFF: Well, it's simplistic - - -

MR ROBERTS: But we're looking - - -

MR BOBROFF: It's simplistic, and suitable politically.

DR CLEUGH: Whereas you talked about – just then about a paper that has looked at data from India or China or wherever you – and I just want to come back to the point that we're talking about global climate – global anthropogenic climate change.

MR ROBERTS: Does it not bother people with the – with what we've shown about Marcott? The peer review has got to be called into question with that when the author himself says that it doesn't stack up. I mean, that's staggering, and I'm confronted by faces here - - -

DR RINTOUL: The author himself made exactly the same point as I've made – as in the text that Peter read out for us, helpfully.

MR ROBERTS: I'm staggered that people I'm looking at now will accept that an author has contradicted his own paper after the IPCC got involved and changed it significantly. I mean, that's serious stuff.

DR RINTOUL: I reiterate that the so-called uptick had nothing to do with the conclusions that we're drawing here today.

MR ROBERTS: I'm talking about the author of a paper that you're siding on – the sole paper that you're relying upon to provide unprecedented – or evidence of unprecedented warming, he has contradicted his own paper publically after scrutiny by the public.

MR BOBROFF: If you - - -

MR ROBERTS: That is just staggering.

MR BOBROFF: - - - had used Marcott's PhD thesis paper you wouldn't have quoted it, because it didn't show any unprecedented rise.

DR RINTOUL: To reiterate, what we're comparing is our best estimate of recent temperatures, which is based on the instrumental record, to our best estimate of past temperatures, which is based on a series of proxies.

MR BOBROFF: I don't think Marcott's paper spliced instrumental record on the end of this settlement record.

DR RINTOUL: What did the text that you read out say?

MR BOBROFF: It certainly didn't suggest that they had spliced recent thermometer records on the end of it.

DR RINTOUL: So it draws – makes a comparison between past changes inferred from the proxy records with recent changes inferred from the instrument records.

MR BOBROFF: I think we're going to have to sit down to a subcommittee or something here, aren't we?

MR ROBERTS: Yes. Because that's - - -

MR BOBROFF: See our way forward.

MR ROBERTS: So we're comparing instrumental records with proxy records.

DR RINTOUL: Yes. The only way to say anything about – you're the one who had raised the issue about what's unprecedented. To talk about what's unprecedented about some time interval that goes beyond the instrumental record, we have to compare paleo proxy records with the - - -

MR ROBERTS: Well, let's compare the proxies all the way through and see what that does. That's the original data. If you put up his – the graph you showed not long ago, Peter, with the - - -

MR BOBROFF: With the alkenones that - - -

MR ROBERTS: Yes. This is the author himself comparing proxies with proxies. There it is.

MR MASON: Hold on. This is coming back to the same chart which I've previously said we can't consider.

MR ROBERTS: But that's the data from the peer reviewed papers.

MR MASON: I understand.

MR BOBROFF: So you can't ask for the data from a peer reviewed paper, plot it, and - - -

MR MASON: The same - - -

MR BOBROFF: - - - and bring it in public.

MR MASON: - - - logic which you're using here to say you can't do that logic – CSIRO has got the same in reverse. They've got specific boundaries that they operate in and today's discussion, in particular, as laid out by the arrangements which were put in place, CSIRO could only look at and can only consider peer reviewed papers. If we began taking into consideration every person's analysis and personal thoughts and considerations as part of this, CSIRO would have to be one of the largest organisations in the world to undertake the proper analysis and consideration to be able to provide relevant - - -

MR ROBERTS: We accept that.

MR MASON: - - - analysis to government.

MR ROBERTS: We accept that, Geoff.

MR BOBROFF: We accept that. We accept that.

MR ROBERTS: But what we want to know is why did CSIRO use such a bad paper that has shown remarkable changes without substantiation on a PhD student's thesis to this publically released paper, which the author himself – the prime author himself has criticised and shows the 20th century doesn't stack up. It has been fabricated out of that. Did you know about the outlier?

DR RINTOUL: Yes, indeed. I know exactly about the criticisms that have been raised on both sides of this paper. The point here is that if you have published results that show that the rate of rise in temperature is not unprecedented in the last 10,000 years, I would love to see it.

MR BOBROFF: You don't have – I suspect that you don't have data that can show any sharp rises if the data going back – well, these aren't too bad, are they? They're fairly close to the points. I haven't looked at the sample intervals on that.

MR ROBERTS: So we asked you to come up with something unprecedented, and you're relying on a paper that the author himself has criticised and says doesn't stack up.

DR CLEUGH: Well, can I just reiterate the point that Steve has made, that he's using this data and the peer reviewed literature as the best available science to show the rate of temperature rise over the last 10,000 years to compare with warming over the 20th instrumental record.

MR ROBERTS: So you're comparing – you're using a paper that the author himself has criticised publically after being questioned publically, and you're comparing proxy data with instrumental data. That just doesn't stack up. Both those things don't stack up. How the CSIRO can continue to rely on Marcott after what the author himself has said is beyond me. It raises questions about the voracity of your peer review process.

MR MASON: All right. We are beginning to - - -

MR ROBERTS: The author himself - - -

MR MASON: - - - go around a little bit of a loop on this one. I might bring that to an end. Do you want to go through a couple of items, Steve?

DR RINTOUL: Yes. Sure. Just on some of the other points you raised, you offer 300 papers that said unprecedented global warming is disputed, and just to reiterate, we did not say that global temperatures are unprecedented. We said the rate of rise of temperature is unprecedented, as well as the amount of CO2 in the atmosphere, etcetera.

MR BOBROFF: But the .8 of a degree - - -

DR RINTOUL: You made a comment about - - -

MR BOBROFF: No. Hang on.

DR RINTOUL: - - - the time resolution of the - - -

MR ROBERTS: Yes. Can he answer that.

MR BOBROFF: Yes. The point – you're suggesting .8 of a degree per century is unprecedented?

DR RINTOUL: In the last 10,000 years, yes.

MR BOBROFF: In the last 10,000 years.

DR RINTOUL: Which was the question you asked us to address.

MR BOBROFF: Yes, yes, yes. Okay.

DR RINTOUL: Now, in terms of current carbon dioxide levels being unprecedented, you raised issues about the time resolution. Just to reiterate that we were comparing recent measures in the atmosphere – our best estimate of what the CO2 concentration in the atmosphere is to past Law Dome iScores because that's the best information we have about the past records. So if we want to look, compare CO2 levels in the past with CO2 levels in the present, that's what we need to do.

MR BOBROFF: Even those that can't a 90 degree – a 90 part per million rise in 60 years – the past records.

DR RINTOUL: If - - -

MR BOBROFF: It could have occurred hundreds of times and they wouldn't be shown in the past records.

DR RINTOUL: There is no evidence of any type - - -

MR BOBROFF: Yes.

DR RINTOUL: - - - to support those kinds of rises in the past.

MR BOBROFF: Nor - - -

DR RINTOUL: If they had occurred the climate would have responded in other ways and - - -

MR ROBERTS: Steve, that's very misleading, in my view, because you're saying that a – you're putting forward a record whose resolution can't show that, and you're saying there is no evidence. That's - - -

DR RINTOUL: The best - - -

MR ROBERTS: - - - staggering.

DR RINTOUL: I'm putting forward the best information we have because that's all I can do.

MR ROBERTS: And what I'm saying is - - -

MR BOBROFF: But it's not good enough to make any statement about it.

DR RINTOUL: And so if you're asking me whether CO2 concentrations today are higher or lower than in the past - - -

MR ROBERTS: Steve, if the resolution that - - -

DR RINTOUL: - - - and you want me to go back 10,000 years I need to go to an iScore.

MR ROBERTS: If the resolution is not there there will never be the evidence.

DR RINTOUL: And the Law Dome iScore, as you have shown, as you have conceded - - -

MR BOBROFF: You can go back – yes – 2000 years. Yes.

DR RINTOUL: - - - shows that over the period of the Law Dome record that the values today are unprecedented, and in the Law Dome record there is no evidence of the imaginary large swings that you're proposing - - -

MR BOBROFF: Well, you see – yes.

DR RINTOUL: - - - there's no – it's a hypothetical.

MR BOBROFF: 2000 years is not long in the – it's only a quarter of the Holocene, let alone the 8000 year – 800,000 year record you've put up which doesn't - - -

DR RINTOUL: Sure. And statistically the odds that over 800,000 years the observed record would never hit one of those peaks if they had occurred is quite low.

MR BOBROFF: Well, I'm not sure about that. I wouldn't take that - - -

MR ROBERTS: No.

MR BOBROFF: - - - statement on face value.

MR ROBERTS: I won't accept that.

DR RINTOUL: If someone takes a time series and randomly sample it, then you can have a go. You're good at that stuff.

MR BOBROFF: Sample it every 1000 years and detect - - -

DR RINTOUL: Make up a time series - - -

MR BOBROFF: Well - - -

DR RINTOUL: - - - that has spikes that are five years long, 10 years long.

MR ROBERTS: We want to rely on the empirical evidence.

MR BOBROFF: Well, it depends upon what happens in the ice. I'm not confident that say what happened in the ice - - -

DR RINTOUL: I'm giving you the empirical evidence.

DR CLEUGH: We've provided the best empirical evidence that there is, just to reiterate.

MR ROBERTS: But it's not adequate to make – we're talking about billions – tens of billions of dollars being paid for by taxpayers, and this evidence is not at all adequate. And, in fact, CSIRO won't even say that there is any danger and says that's the Minister's call. So the Minister - - -

DR CLEUGH: So - - -

MR ROBERTS: - - - is calling that there's danger here, and we're saying there's nothing that shows it.

MR MASON: Sorry. Just to clarify, the Minister has not made that statement.

MR ROBERTS: Sorry. You're correct. But it didn't come from CSIRO. So we want to know where it's coming from that we're facing unprecedented danger.

MR ASHBY: To put that – be more precise, I think, I would like to say why is the government acting if there hasn't been something with the word "danger", or something with – what wording has been used and what - - -

MR MASON: Okay. So this is, again, is raising it's a subject for - - -

MR ASHBY: That's right. We will deal with that – another matter. But that is important to us, yes. Right.

MR MASON: Your next point.

MR ROBERTS: So our - - -

DR RINTOUL: So - - -

MR ROBERTS: - - - conclusion there, Steve, is that you may say it's the best available evidence, but it is not adequate evidence for making the conclusions that you now put forward from it.

DR RINTOUL: The reason I just suggested about the statistical likelihood of completely missing every spike if there had been spikes – my scientific judgment is that the evidence from the published literature is extremely strong that CO2 levels today are unprecedented over the last 800,000 years at least. I'm going to leave it that.

MR ROBERTS: With respect to your scientific judgment - - -

DR RINTOUL: High 40 per cent.

MR ROBERTS: - - - and with respect to you, your scientific judgment is relying upon a paper and elsewhere on Marcott that the author himself has admitted is - - -

DR RINTOUL: We're not talking about Marcott here. We're talking about CO2. You keep - - -

MR ROBERTS: But we're now – you've raised the topic of your scientific judgment, and that is the Marcott paper.

MR MASON: No, no. So we've - - -

DR RINTOUL: If you would like to question my credibility - - -

MR MASON: No. So, Steve, this is not the - - -

MR ROBERTS: I think you are questioning your credibility by relying on Marcott.

MR MASON: - - - discussion which I'm going to allow to continue on talking about individuals' credibility in the room.

MR ROBERTS: It is important that the case is substantiated.

DR RINTOUL: So the Munshi - - -

MR MASON: I - - -

DR RINTOUL: That's – the Munshi evidence that you presented, it's not from a peer reviewed paper. It's from a paper from a website where one can load papers. There's no peer review.

MR BOBROFF: Well, fine.

DR RINTOUL: And, of course, if the decline – if the dilution of the CO2 – of the C14 in the atmosphere was due to – came from the bomb spike, that would not explain the reduction in the ratio of C13 to C12 which is not affected by the bomb spike.

MR BOBROFF: Yes. We will put that down, and we will have a look at that.

DR RINTOUL: You mentioned the 2009 recession. Emissions did decrease, but they didn't reverse, and CO2 levels in the atmosphere did continue to increase because we were continuing to emit CO2 in the atmosphere.

MR ROBERTS: Say that again for me.

DR RINTOUL: You mentioned that during the 2009 recession that CO2 levels continued to increase in the atmosphere. It's true that emissions declined, but emissions were not negative. We didn't remove CO2 from the atmosphere during the recession and, hence, CO2 levels continued to increase.

MR ROBERTS: That doesn't refer to the period in the fifties – sorry – was it the forties where they were basically flat and cut - - -

DR RINTOUL: No. I was just speaking about the 2009 recession and the point that you raised.

MR ROBERTS: That's correct, but what it shows there – there's the graph that really needs to be discussed. We show, in fact, accelerating CO2 levels, and yet the carbon dioxide from human production is variable.

DR RINTOUL: The CO2 levels in the atmosphere - - -

MR ROBERTS: And in fact it went down.

DR RINTOUL: - - - does respond to both human and natural factors, as we've shown.

MR BOBROFF: Yes. Agreed.

DR RINTOUL: And so you don't expect a perfect one to one correlation.

MR BOBROFF: No. Agreed.

DR RINTOUL: But it's also true that the scientific evidence is overwhelming that much of the – that the 40 per cent increase in CO2 since pre-industrial times is overwhelmingly driven by human sources.

MR BOBROFF: Yes. Well, which evidence was that?

DR RINTOUL: Should I start over?

MR ROBERTS: Where is this, Steve?

MR BOBROFF: We're not happy with broad statements like that. List the chain of events and the papers.

DR CLEUGH: Well, that's the presentation - - -

DR RINTOUL: That is what the presentation that I have - - -

DR CLEUGH: - - - that Steve has already taken you through – took you through those logical steps to that calculation.

MR BOBROFF: Well, we must have missed it.

MR ROBERTS: We then analysed the land sinks and the other sinks and sources, and they're calculated.

DR CLEUGH: So just as a point of clarity on the carbon budget and the land sinks and ocean sinks and the sources, the Global Carbon Project which publishes the global carbon budget every year has a fully set – full set of peer reviewed publications that detail the methodology behind coming up with those terms. It's not correct to claim that – I can't remember the words you used - - -

MR BOBROFF: The land sink was estimated as a residual - - -

DR CLEUGH: That the land sink had no – so it does explain the residual and how it's calculated, but it's not correct to say that it has fabricated or whatever language you used, because there are observations and models with those observations to substantiate the kind of magnitude of land sinks that have been reported in the budget.

MR BOBROFF: List them.

MR ROBERTS: But, Dr Cleugh - - -

DR CLEUGH: As I said, they're in the peer reviewed literature.

MR ROBERTS: - - - the variability just in the northern hemisphere alone of the actual measured carbon dioxide level in the atmosphere far exceeds the human production. So, in other words, nature is overwhelming, and we've shown - - -

DR CLEUGH: There are very large natural flows, as Steve has already presented in, I think, the last two presentations, of CO2 into and out of the land surface and the oceans as a result of natural processes. What humans are doing are adding a perturbation on those naturally large sinks and sources of CO2, and that is - - -

MR ROBERTS: We want to see the evidence of that.

DR CLEUGH: Well, that was the presentation this morning.

MR ROBERTS: No. We didn't see the evidence for that, Dr Cleugh. We didn't see the evidence that human production of carbon dioxide is making something – making a perturbation that is unusual. We didn't see that. It's – the human signal is lost.

DR CLEUGH: It's the multiple lines of evidence that when you combine that information with things like the chemical analysis of the isotope that we've demonstrated, carbon 13, the change in oxygen, that are consistent with the increase in CO2 being as a result of emission of fossil fuel from human activity.

MR BOBROFF: Yes. None of this is top quality science. Top quality science requires prediction into the unknown future, and it's either confirmed or falsified, and climate science we can't aspire to top quality science because everything goes too long and it takes decades before we get anywhere and it's extremely complicated. So we've got to rely on lesser quality science, and it boils down to scientists arguing possible theories to explain what might have happened, and there's arguments about the data as well. So that's the sort of soup we're in at the moment.

DR CLEUGH: Just for the record, I would refute that climate science is – no. Let me rephrase that. I would stand by the quality of the climate science which is based on the scientific method and the peer review and the independence that comes with that and the objectivity in that the scientific method is about posing a question, testing a theory with observations, with theories, and that's the science that climate science is using.

MR BOBROFF: Well, true, but I don't see that happening here, and I can't see how it can happen here.

DR CLEUGH: Well, I'm just making it a clear statement that in my view the scientific method that has been used - - -

MR BOBROFF: Can you show us the predictions that have been made into the future and whether - - -

DR CLEUGH: Of course.

MR BOBROFF: - - - they succeeded or failed.

DR CLEUGH: Well, we haven't got to the future yet.

MR BOBROFF: So there haven't been any predictions far enough into the future which have succeeded or failed?

DR CLEUGH: The work that - - -

DR RINTOUL: Arrhenius predicted that Earth would warm as a result of increased CO2 in the atmosphere.

MR ROBERTS: Arrhenius, within a very short time of his first paper, radically downgraded that – radically downgraded. They didn't know what they were doing at that time.

DR CLEUGH: There were peer reviewed publications in the 1980s – I'm going off my memory here – that were saying that with a doubling in CO2 we expect to see a warming of – I think it was – of water a couple of degrees. So, if you would, there's a prediction - - -

MR BOBROFF: There were hundreds of peer review papers to say that we're cooling. We're - - -

DR CLEUGH: - - - and that's – we're on that trajectory.

MR BOBROFF: So what about the hundreds of peer reviewed papers that said that we're heading for cooling and trouble in the 1970s? Are they all wrong? What happened to the peer review of those? What happened to the reviewers? Have they all been retracted?

MR ROBERTS: See, you rely upon - - -

DR RINTOUL: Can I return to some of the points that you've raised.

MR ROBERTS: - - - two papers – Harries and Marcott – in particular for significant conclusions, and they're both not sustainable.

DR RINTOUL: So with regard to Harries, I did show you evidence from Feldman, which is very similar in spirit.

MR BOBROFF: Which one?

DR RINTOUL: Feldman.

DR CLEUGH: Feldman.

MR BOBROFF: What about the NOAA satellites that's - - -

DR RINTOUL: If you look at the CERES data – which is the most accurate data we have for outgoing longwave radiation – there's a trend between 2000 and 2013 of minus .3 watts per square metre per decade.

MR BOBROFF: Well, table it. Let's have a look at it and compare it to the 40 years of the NOAA satellites.

MR ROBERTS: Because there's no trend on the NOAA satellites, and we see enormous variability - - -

DR RINTOUL: The trend in outgoing long wave radiation is small. It's tenths of a watt per square metre on top of a signal which is of hundreds of watts per square metre. So if you just plot - - -

MR BOBROFF: Tenths of a watt?

DR RINTOUL: That's all it takes over years and years and years to warm the Earth.

MR ROBERTS: There's no trend in that data that Peter presented.

DR RINTOUL: You can't see a trend in that data.

MR BOBROFF: Yes. No. I wouldn't assert that there's no trend one way or the other. It's not - - -

DR CLEUGH: And, again, can I remind us that we're meant to be here making commentary around peer reviewed data or interpretations of those data and that - - -

MR BOBROFF: Well, you keep saying that, but we keep seeing evidence that peer review is anything but a guarantee of truth.

MR ROBERTS: And you're relying upon a paper, again, that the author has admitted is not sustainable.

DR CLEUGH: No, no.

MR MASON: So - - -

DR CLEUGH: We're not talking – we're talking about the Harries and the Feldman work.

MR ROBERTS: That's right. And we've gone beyond Harries with the NOAA satellite data.

DR RINTOUL: Have a look at the CERES data. You can download it from the NASA website and have a look.

MR BOBROFF: Right.

DR RINTOUL: CERES.

MR BOBROFF: From - - -

DR RINTOUL: You mentioned that – it's the CERES satellite from NASA.

MR ROBERTS: CERES.

DR RINTOUL: You said the ocean sink was not observations. That's not true. It comes from ocean observations and an ocean transport model because that's the best and most accurate way to estimate the total amount of CO2 in the ocean. You talked about seasonal flows of CO2 being large, and that's true. The – again, it is well understood. In fact, you look outside - - -

MR BOBROFF: Are you sure about that statement "well understood"?

DR RINTOUL: Well, in the northern hemisphere, most trees are deciduous. They grow in summer, and they lose their leaves in winter.

MR BOBROFF: Well, what do they do in winter with CO2? Nothing?

DR RINTOUL: Organic material rots, and it gives off CO2.

MR BOBROFF: Gives CO2. So we could expect to see more CO2 – if we go back in the winter, we should see more CO2 in this - - -

DR RINTOUL: This plot that you're showing is not the way to look at these problems because CO2 sources and things vary with time and the atmosphere stores that are – so looking at that plot, you wouldn't expect to see sources of CO2 with areas of high CO2. It would unusual temperature.

MR BOBROFF: Well, we do see some points or - - -

DR RINTOUL: The atmosphere is moving.

MR BOBROFF: We do, and we can see the winds. You can plot the winds on that at any level. Yes. It doesn't look like it's well understood to me at all.

DR RINTOUL: So moving along, you stated that there was no evidence – I presented no evidence of the enhanced greenhouse effect. Feldman is direct empirical evidence of that. You haven't offered any material to suggest any questions for that, so I gather that's accepted. The - - -

MR BOBROFF: So you present just that one, or - - -

MR ROBERTS: We - - -

DR CLEUGH: No. We – it was in Steve's presentation. It's Feldman. I did - - -

MR BOBROFF: Presentation – Feldman.

DR RINTOUL: It was in the presentation in May and there was no comment made, and it was in the presentation today and there was no comments made.

DR CLEUGH: It shows ground measurements made at the surface of infrared radiation through time increasing through time, but Steve – it was in the slide pack, so you can look at it.

MR BOBROFF: Right.

DR RINTOUL: And as I say, I suggest you have a look at the CERES data for evidence of a trend in outgoing long wave radiation. We do have few measurements of that at the top of the atmosphere from which we can detect trends because the trend is small relative to the total amount of outgoing long wave radiation, but it's of the magnitude that matches the warming rate of the Earth. That's it for me.

MR MASON: All right.

MR ROBERTS: The temperature graphs that you had showed comparing satellite and the ground base, Steve, they're only from 1958, which I understand why the - - -

MR BOBROFF: .....

DR RINTOUL: And we say - - -

MR ROBERTS: No. I understand why, because the radio science started in '58.

MR BOBROFF: Yes, yes.

MR ROBERTS: But that is not a basis for saying that there is something unusual going on.

DR RINTOUL: No. I said that both independent of platform – the question that that was addressing was whether there was any discrepancy between satellite and surface based observations.

MR BOBROFF: Yes. But we're not arguing that there's - - -

MR ROBERTS: Not arguing that, but you made the point that there is warming there, and I'm saying that from '58 to current times that's not – there's nothing unusual going on.

DR RINTOUL: Well, define "unusual".

MR BOBROFF: .....

MR ASHBY: Well, I think the IPCC has - - -

MR ROBERTS: Tell us what it is. Yes.

DR RINTOUL: Say what you – I don't know what question you're asking.

MR ROBERTS: There's nothing unusual – you said there's warming there.

DR RINTOUL: Yes.

MR ROBERTS: There is warming, but there was cooling from the thirties to '76 when the Great Pacific climate change – Great Pacific climate shift occurred.

DR RINTOUL: The overall warming trend over the past century is positive. That's clear.

MR ROBERTS: You say it's .8 of a degree. Other peer reviewed papers say it's .4 of a degree. There's nothing unusual in that. If you remove the urban heat island effect there's nothing unusual.

DR RINTOUL: That's not what the published literature .....

MR ROBERTS: What some of the published literature says. There are others, as Peter showed, that were approaching a – forecasting a cooling. There are others that show all of the changes that we've seen and the natural variation that we've seen is explicable by solar and other factors. There are peer reviewed papers saying that. So how can you make the claim?

DR RINTOUL: Yes. I think an important point here - - -

MR ROBERTS: Can you acknowledge that.

DR RINTOUL: I acknowledge the fact that not every - - -

MR MASON: So given – sorry. Can I just ask a quick question here. Were those references which you're discussing – were they provided prior into the lead up to this meeting?

MR ROBERTS: No.

MR MASON: No. They weren't. So just for - - -

DR CLEUGH: They are the ones that you've tabled - - -

MR ROBERTS: I just want him to acknowledge - - -

MR MASON: Just - - -

MR ROBERTS: - - - that I've said that, and that Peter has - - -

MR MASON: Yes. All right.

MR ROBERTS: - - - provided peer reviewed papers to that effect.

MR MASON: That's okay.

MR ROBERTS: That's all I want. I don't want a rebuttal of it.

MR MASON: That's fine.

DR RINTOUL: The point to keep in mind here – and I'm not suggesting that every peer reviewed study says exactly the same thing and reaches exactly the same conclusion. Of course, that's not how science works. But our confidence in the validity of a finding is based on the type, amount, quality and consistency of the evidence. And that evidence may be data and may the mechanistic understanding of how things work and may be a theory or the principles of laws of nature. It may be models based on those laws of nature. It's based on the type, amount, quality, consistency, and the degree of agreement.

So if there are 1000 published studies and there are five that suggest a different conclusion, of course, we have to look hard at that. But do we throw out the evidence from the other 995? No, we do not. So the way science – the way that our assessments of, and our confidence in the climate science – where it's derived from is precisely that.

MR ROBERTS: Steve, what my - - -

DR STEELE: And that's consistent with the evidence and the estimates last time.

MR ROBERTS: Well, I beg to differ with that, Jack. My understanding is that CSIRO has been investigating climate, but has not dismissed peer reviewed papers that have come up and said the opposite of what CSIROs position is. CSIRO has basically a blue team. There is no red team within CSIRO, and I would expect when we're talking about tens of billions of dollars of taxpayer funds CSIRO would have a strong red team arguing with a strong blue team, but I don't see that.

MR MASON: Can I refer that to the .....

DR RINTOUL: My - - -

MR MASON: To have a conversation about, please.

DR STEELE: So the expectation in CSIRO is not that there's either a blue or a red team, just to be really clear. The manifestation of the code of conduct that you referred to at the start is it's an inquiry for a truthful – that is, to say, an inquiry that is not driven by a pre-determined motivation. It's an open inquiry into what the situation truly is, and then an interpretation of that. And, therefore, it is not motivated by hunting for evidence to support a pre-determined policy outcome - - -

MR BOBROFF: Well, it certainly looks like it to us.

DR STEELE: - - - or a – sorry.

MR BOBROFF: It certainly looks like it to us.

DR STEELE: I'm perfectly fine for people to take their own views about it. I'm just describing what goes on in CSIRO, as was the request, and, also, because you had made some comments in relation to the code of conduct earlier on and asked a question about it, taking the opportunity to explain how you should interpret the code of conduct that you drew attention to at the start of your presentation.

MR ROBERTS: Jack, I just – in response, I would say, first of all, thank you for saying that. In response, we have now been having close on four decades of the claims that carbon dioxide from human activity affects global climate and needs to be reduced. We have had people from very senior positions in the IPCC reject the IPCC, leave, and condemn the IPCC for being political. We've had eminent scientists come out and say – Nobel Prize winners come out and say they just swallowed it at first, and then when they started questioning it they found that there was nothing there. We've had serious climate scientists, climatologists dispute it all the way along.

If there had been – it's just so startling that outside of the CSIRO there is a vibrant group within the scientific community – a substantial group within the scientific community that completely contradicts the CSIROs constant claims. Why is that possible? They are not funded – the CSIRO is funded by governments that have been pushing a policy. We know that. We have got people from – former CSIRO senior officers who are saying that CSIRO is driven politically because it is dependent on funds. The people who are contradicting this - - -

MR MASON: Can I just - - -

MR ROBERTS: - - - are not funded and are outside the CSIRO.

MR MASON: I just want to catch that point there. There has been discussion around the point you just raised around the politicisation of CSIRO in the past.

CSIRO doesn't provide input to government policy. CSIRO provides analysis, and governments on all sides of the spectrum, including people from Opposition and other parties, use the evidence provided by CSIRO to develop their own policies. So I just want to be clear there, that CSIRO doesn't provide input to government policy.

MR ROBERTS: We've recently had the chief scientist in answer to a question from Senator Macdonald from North Queensland – Senator Macdonald asked the chief scientist in Senate Estimates two questions amongst other questions. The first was, "Is it true that carbon dioxide from human activities in Australia constitute about 1.3 per cent of the carbon dioxide produced by humans around the world?" The chief scientist agreed that that is correct. And then Senator Macdonald said, "What would be the impact if we shut down all production of carbon dioxide from Australia?" and the chief scientist went around and dodged the question that – Senator Macdonald brought him back to that and the chief scientist said "virtually nothing".

DR STEELE: So, Senator, can I - - -

MR ROBERTS: Virtually nothing. So the chief scientist is disagreeing with you in his conclusion.

DR STEELE: - - - make a response to your comments, first of all.

MR ROBERTS: Sure. Yes, yes.

DR STEELE: For clarity, I'm not going to make any reflection upon the healthy exchange which occurred in Senate Estimates with the chief scientist. That's not the purpose of this meeting, from our perspective. I just reiterate, Senator, it's absolutely the case that you're in a position to form your own views, and do analysis. We're in no doubt about that. We just make the point that the expectation inside CSIRO is that we are doing science to try and identify a thing which is – it's difficult to get the phrase correct, but I'm going to use the word "truth".

That is to say, to be truthful about the analysis that we do to try and unearth the truth with the intention that the scientific process will put that to a contest – an open contest in the scientific community, and you will find out whether it was not the truth through that process. And that's what we expect is going to occur, and that's the process that we expect that we conduct inside CSIRO as well. So we don't do our science in order to back and fall behind a particular policy position. We don't do our science to try and drive government to come to a particular policy position.

Our ability to do anything for the benefit of the Australian community is absolutely dependent upon us making sure that we do the scientific analysis for the best scientific process, put it through the right peer reviewed process both internally and outside CSIRO. And in that sense, we – sometimes we double handle the issue. We overdo the peer review by doing it twice, but we do that very deliberately in order to have a clear outcome and, as best we can, contribute to the state of knowledge and the use of knowledge in Australia.

MR ROBERTS: In - - -

MR BOBROFF: Well, that sounds – I will just jump in quickly.

MR ROBERTS: Sure.

MR BOBROFF: That sounds really good, mate.

MR ROBERTS: Yes.

MR BOBROFF: We would hardly take any exception to that except talking to a retired deputy CEO of CSIRO some years ago he said, "CSIRO would never make a public statement that threatened its funding".

MR ROBERTS: And .....

MR BOBROFF: And I believe he was serious.

DR STEELE: So - - -

MR MASON: Can I just say that's a reflection of that particular person once they had left the organisation, and that's - - -

MR BOBROFF: Yes, yes, yes. I agree.

DR STEELE: I don't even know it's correct, by the way. I'm not doubting - - -

MR BOBROFF: No, not – yes. I agree. You have to - - -

DR STEELE: - - - what you're – I'm not doubting your statement.

MR BOBROFF: Yes. But that's partly why - - -

DR STEELE: I'm certainly not persuaded in my mind - - -

MR BOBROFF: Yes, yes. No. But that's what makes us a bit sceptical - - -

DR STEELE: - - - that it's an accurate statement of the situation.

MR BOBROFF: - - - of the good statements that you made then.

DR STEELE: But there will be the occasional moment where people will be sceptical about us. I accept that. We see that our name is used quite frequently in the newspapers when former officers of CSIRO continue to make contributions to the public debate and, you know, that's not unreasonable. My point is inside CSIRO we have processes to try and make sure we're doing things at a very high standard.

MR ROBERTS: And what I'm saying is that we question those processes, with all due respect, and I'm not accusing anyone in this room of fraud, and I'm not raising that to try and, by association, use that, but we know humans are capable of group think, and that has long plagued this climate industry. Now, I gave my – Steve made his presentation in Sydney. I gave my response. At Senate Estimates I asked the chief executive if we would get any response because I raised serious concerns about that with peer reviewed data, and the chief executive said no. That is hardly the position of an eminent scientific body.

The Minister then, to his credit – your Minister, Geoff, Minister Sinodinos, then said there will be a response. I have not received that response, and instead we got this. If that is the response from the CSIRO – it didn't come to me. It came in response to my submitting my response to CSIRO to a committee. That is an indictment of the CSIRO submitting something like that. That is just highlighting CSIROs lack of science, Jack.

DR STEELE: So, Senator, just for clarity, what is the document you're holding up?

MR ROBERTS: It's called CSIROs Response to One Nation Board on Climate, CSIRO Lacks Empirical Proof.

DR STEELE: And that was provided to another Senate committee, was it?

MR ROBERTS: Correct.

DR STEELE: Okay. All right. Thank you. So, yes, and since the - - -

MR ROBERTS: We have not had - - -

DR STEELE: No, no.

MR ROBERTS: - - - formal response from the CSIRO.

DR STEELE: But we have had three meetings now in which there has been quite a bit of exchange of discussion around the scientific content, so - - -

MR ROBERTS: Well, this is the first one where there has been quite a bit of exchange.

DR STEELE: Okay. All right. Well, there has been certainly sharing of views in relation to the scientific content.

MR ROBERTS: And what we're doing is we're questioning why an organisation that claims to be pretty eminent would rely upon a paper – peer reviewed, albeit – that the lead author or the head author says is not robust in itself – why they rely – why you rely upon Harries et al, and why you didn't show the whole picture with Harries et al. And we show – we say, again, that there is no empirical evidence

proving carbon dioxide from human activity affects global warming and has to be cut.

DR STEELE: And, Senator, my observation of this meeting so far is you're correct, those questions have been raised. A response has been made, and I'm sure the transcript will be coherent in that regard.

MR MASON: All right. I think we've hit the end of the line on that particular subject. Steve, did you have - - -

DR RINTOUL: Just one – at the risk of following that thread, a recent paper published in Nature two weeks involving CSIRO authors is an example of the even-handedness, I guess, if you might like. You know, any suggestion that we only do work that supports a view that climate change is real is false. We do the science.

MR ASHBY: Can I just correct you. It's manmade climate change, not the climate change.

DR RINTOUL: So, for example, there was a recent study in Nature that suggested that the air system's sensitivity might be higher than previous assessments had suggested. And this work with CSIRO and other authors, kind of, fall on that study bringing the air system sensitivity numbers back to where we have thought they had been for a while. So, you know, it's just an example of – in the title of that Commenting Over Estimate of Committed Warming, referring to the earlier study. So it's just an example, that CSIRO does follow the science. It's not following an ideology.

MR BOBROFF: There have been a couple of examples lately. I'm quite surprised.

MR ROBERTS: There's another – are you aware of, and what will you be doing about, Michael Mann's – was it Mann, Bradley, Hughes paper in 1998 and, I think 1999 – who, after presenting that data – sorry – after presenting the paper, has refused to release the data – refused to release it to the government of Virginia, the Attorney-General responsible for funding that paper and the research, and now in Canada he has sued Professor Tim Ball for defamation, and, in response, Professor Tim Ball has rightfully requested the data, and that is not forthcoming. Tim Ball, as I understand it, is now holding him – what is the word – in - - -

MR BOBROFF: Well, contempt of court, it is.

MR ROBERTS: - - - contempt of court, and that is a very serious accusation. That was a key paper that you and IPCC relied upon in its 2001 report. Never, ever been subject to public scrutiny, scientific scrutiny. Refused to do that. Does that not raise questions within CSIRO? Does not the - - -

MR BOBROFF: Well, not CSIRO. CSIRO do really good things.

DR STEELE: Just for clarity, because other people will read this transcript, that's not a data set that CSIRO had an involvement in. Correct.

MR ROBERTS: No. What I'm saying is that was a landmark paper that Al Gore used, the IPCC used. CSIRO has told us in Sydney that it relies upon the IPCC. It refused to say that it did any due diligence on the IPCC, refused to say that it did any due diligence on NASA. It just has good grounds for accepting what they say. What I'm saying is that a key part of the UN claimed position is now under scrutiny in the courts in Canada. And that man has refused to release his data. That is fundamental science. That should be raising alarm bells everywhere within the CSIRO. Are you aware?

DR STEELE: Indeed. And I'm not aware of the details of the case.

MR ROBERTS: Michael Mann.

DR STEELE: When you say that something is involved in a court case in a foreign jurisdiction, my observation would be that's almost invariably a complex situation that's difficult to make a sensible comment about from a distance. I know that's not quite what you're asking for, Senator, but for - - -

MR ROBERTS: It is not complex – it is not complex at all to know that this key paper – the Mann, Bradley, Hughes paper, I think in nineteen eight – 1998 or 1999 – was the poster paper, and it has never been subjected to peer review outside.

DR STEELE: But - - -

MR ROBERTS: Never.

DR STEELE: - - - still, Senator, I'm not sure we can give a more coherent answer to your question - - -

MR ROBERTS: Well - - -

DR STEELE: - - - other than to make the observation that it's conspicuously complex, and when I see something that's in relation to a foreign jurisdiction in a legal case I usually try and steer away from.

MR ROBERTS: Jack, it's not a foreign – it's not a – that sounded like a political response rather than a scientific response. This Mann, Bradley, Hughes paper was the centrepiece around the world in the media, the governments, Al Gore's movie, Al Gore's statements, and the IPCC, and yet he will not disclose his data. It has been completely torn apart. We will not reveal his data. IPCC, peer review process, and no one in the CSIRO is raising an eyelid. Instead we've got Jack defending it because it's in a court system.

MR MASON: I don't think Jack is - - -

DR CLEUGH: I don't think Jack is defending it.

MR ROBERTS: No, defending the lack of scrutiny of that. I'm raising a serious issue - - -

DR CLEUGH: Well, there may be a reason why there's a lack of scrutiny. If it's being litigated there may be issues around IP, for example. We don't know, and it may be a completely different reason as to why it has not been released.

MR ROBERTS: Well, he has had almost 20 years – we've had almost 20 years, Kate, to scrutinise that, and it has been publically disclosed that he has not disclosed the data.

DR CLEUGH: Yes. But if it's the subject of litigation there may well be other factors that are impacting on the reason why it has not been released.

MR ROBERTS: We've had 18 years to - - -

DR CLEUGH: Well - - -

MR ROBERTS: Without litigation on that paper, and the CSIRO – despite the enormous controversy around the world, the CSIRO has never questioned Mann, Bradley, Hughes.

DR CLEUGH: We're entirely speculating because we don't know. So we can't ask - - -

MR ROBERTS: So I ask you - - -

DR CLEUGH: - - - these people to respond to something that we don't know the facts about.

MR ROBERTS: Well, I would ask you, have you done any scrutiny of the Mann, Bradley, Hughes paper, and are you at all concerned that Mann, Bradley, Hughes would not release their data to public and scientific scrutiny?

DR CLEUGH: Well, I mean, I think Jack responded to that.

DR STEELE: I don't know further detail to make a further response. I would make the observation that it's difficult to be the arbitrator of all of these matters on a global basis, Senator, as we previously discussed at a - - -

MR ROBERTS: I'm asking a specific paper.

DR STEELE: No. Look, I've got that point.

MR ROBERTS: Because, see, Jack, it's important to recognise that in Sydney the CSIRO presented – did not say that they had done due diligence on the Bureau of Meteorology. They accepted their data without that. They also said there has been no due diligence on the IPCC. They accepted that, because they're – whatever. They said they did not do due diligence on NASAs Goddard Institute for Space Studies.

DR STEELE: And, Senator, I did notice earlier on in the presentation that Steve gave that there was commentary made on the fact that there had been, by other parties – appropriately so, not by CSIRO – a review of the Bureau of Meteorology and its handling of data. So we make no further comment, but you can see we've made that – we've drawn that to your attention, as you've raised that question before.

MR ROBERTS: We're aware of that, and people are just amazed that that's the case, because there are people – scientists investigating the Bureau of Meteorology's work. So I'm just raising it in response that we're not happy with that answer. We don't accept it.

MR MASON: All right. I think we've come to an end on that. Steve, have you got any more matters?

DR RINTOUL: Just the statement that the suggestion that it's just an opinion that other factors can't explain observed warming and that we haven't cited papers is simply not true. The references were provided.

MR MASON: Okay.

MR ROBERTS: Say that again, please.

DR RINTOUL: The statement was made by Peter that it was just our opinion that other factors could not explain warming.

MR MASON: And that's where I cut the conversation short, and I will cut it short again on that one as well.

MR ROBERTS: Well - - -

MR MASON: This is just after you stepped out of the room - - -

MR ROBERTS: Why can't you - - -

MR MASON: - - - because we're not here to be talking about – we're here to focus on the discussion at hand.

MR ROBERTS: You're wanting to cut that short. Why?

MR BOBROFF: Well, I'm happy that this is not the best place to address point by point in detail. I'm only too happy to have Steve's point by point stuff come back so we can look at it.

DR RINTOUL: Well, I've provided the references already. They're already in the presentation.

MR BOBROFF: Well, I will dig around and see if I can find something there, but we were hoping in the future that when you make the statement that the stuff was right underneath it.

DR RINTOUL: I believe you will find they are.

MR ROBERTS: Well, Steve, let me test my memory. Last time you made a presentation and we raised questions about the IPCC material, you had referenced the IPCC only, and then we asked for the papers that the IPCC in fact relied upon. Referencing the IPCC does not help your credibility. The IPCC is a political organisation and a highly politicised organisation, and that's the point we were making at the time.

DR RINTOUL: I've provided the original sources.

MS CHAPPLE: That's that document there, isn't it?

DR CLEUGH: That has been provided. Yes.

DR RINTOUL: Yes.

DR CLEUGH: And others have been provided.

MR MASON: All right. If there's no other specific issues - - -

MR ASHBY: Yes. The thing I would like to raise is the fact that in doing that PowerPoint I was doing previously, my attempt was to look at the reasoning within CSIRO and the IPCC for various conclusions to then internally argue, well, if this was the case where's the – where does that lead to, and, therefore, has things been consistent and there's a coherent table that comes together point of view. I would like to be able to – now, there's a difficulty because in saying that everything had to be peer reviewed, I have the question that a lot of that stuff from the IPCC and a lot of data and stuff is not necessarily peer reviewed. It's collated. Sometimes it's used, but I don't necessarily know that it's always peer reviewed. For example, you know - - -

DR RINTOUL: No. It's - - -

DR CLEUGH: Excuse me. Can we clarify something here.

MR ASHBY: Yes.

DR CLEUGH: Steve, you go.

MR ASHBY: Yes, please.

DR CLEUGH: You say it.

DR RINTOUL: IPCC is solely based on peer reviewed science, and the chapters – the assessments are also fully peer reviewed.

MR ASHBY: Okay. So if I was - - -

MR BOBROFF: I would question that - - -

MR ROBERTS: Excuse me, excuse me. Just - - -

MR BOBROFF: - - - on some detail. On AR4, I analysed all chapters of all whatevers, found what was peer reviewed, what wasn't peer reviewed, and by the time you get to working groups – the second and third working groups – hardly any of it is.

DR CLEUGH: So - - -

DR RINTOUL: I think you will find in working group 1 that they. 5 at least it's - - -

MR BOBROFF: It's a bit more. It's not all peer reviewed by any means.

DR CLEUGH: So just to be very clear, the science that we draw from the IPCC is primarily from – not always, but primarily from the fifth assessment, and the fifth assessment had 800 lead authors and received over 140,000 comments that were all individually responded to and only used peer reviewed literature.

MR ROBERTS: Dr Cleugh, I know of a - - -

MR BOBROFF: Well, there must have been a new exchange since AR4, and I don't believe there was.

DR CLEUGH: I just made that comment about AR5 which was a - - -

MR ROBERTS: Dr Cleugh, I know of a New Zealand scientist – a research scientist who had 60 years' experience in research science, and he has reviewed every IPCC report. In the 2007 report he made – I think, from memory – over 570 comments, and not one response – not one. So I don't know where you're getting your figures from.

DR RINTOUL: For the AR5, all - - -

MR ROBERTS: AR4.

DR RINTOUL: - - - one hundred and - - -

DR CLEUGH: All of them.

MR ROBERTS: I'm talking about AR4, Steve.

DR RINTOUL: Wait, there's no – we don't need to talk about history. What we're talking about here is - - -

MR ROBERTS: Jeez - - -

MR ASHBY: But the process should be the - - -

DR RINTOUL: The point that Leon then was talking about is the IPCC process and this is based on peer reviewed science.

MR ASHBY: Okay.

DR RINTOUL: AR5 is based on peer reviewed science. Written responses have been made to all 140,000 review comments and those are publically available.

MR ROBERTS: And the Mann, Bradley, Hughes, that was the centrepiece of the IPCCs AR3 in 2001 refused to disclose its evidence – its data. It was torn apart by people including eminent statisticians externally. That doesn't raise warning bells – warning alarms in this room. Marcott's own comments that the head author of that paper contradicting the 2013 Marcott report, that has not raised alarms.

DR CLEUGH: So just to be clear, we were commenting on Leon's – we wanted to clarify Leon's comment about the IPCC process.

MR ROBERTS: You - - -

DR CLEUGH: That was the point of the statement that we made.

MR ROBERTS: And what I'm saying, Dr Cleugh, is that you're relying upon a peer reviewed process that has got holes in it. You're relying upon an IPCC that repeated both of those, and that has got holes in it. Mann, Bradley, Hughes is enormous holes. So what raises – well, the question it raises with me is what due diligence do you do to check peer reviewed papers? Having checked the other papers you rely upon we've already found problems with Marcott. We've found problems with the way you have presented Harries to us. I mean, these are significant questions that raise enormous doubts in our mind.

Do you understand the significance of variations seasonal, cyclical? Do you understand the difference between inherent natural variation and process change variation, because I see very little talk – even though we put up peer reviewed paper graphs showing enormous variation in carbon dioxide, enormous variation in temperature. So I'm wondering why there has been no due diligence on the IPCC, on NASAs Goddard Institute for Space Studies, on the Bureau of Meteorology. And Jack says, "We rely upon an investigation", that just skimmed the surface with the Bureau of Meteorology. What is going on?

And now we've got taxpayers facing tens of billions of dollars needlessly because no one has provided us with any statement or – and CSIRO has, in fact, been at lengths to paint that they are not claiming danger from carbon dioxide from human activity. So why are we doing all this?

DR STEELE: Senator, a small technicality. The transcript will show that I didn't use those words. I made the observation that other people had reviewed the Bureau.

MR ROBERTS: Correct. Well, let me make it clear then that I understood that other people had reviewed it, but you cited that.

DR STEELE: In the presentation today we made the observation that that had happened.

MR ROBERTS: Yes. And that was not really an adequate investigation.

MR MASON: All right. So - - -

DR STEELE: I don't make any comment on that statement.

MR MASON: No.

MR ROBERTS: And I don't ask you to make any comment on that.

MR ASHBY: So can I get back to where I was at?

MR MASON: Yes.

MR ASHBY: Okay. So I would like to be able to present to CSIRO my slides, but with the knowledge that not everything is going to be able to be backed by peer review because for whatever reason some of the data is new. Some of it is, you know – let's say, for example, John Christy's, sort of, analysis that he presented to the US government. I would like to present that as evidence because he's one of the scientists that's, you know, eminent in this work. I would like to be able to do that, knowing that CSIRO would take that on board as looking at the logic of the whole climate debate of how carbon dioxide interacts or doesn't interact with temperature.

That's what I would like you to – I didn't do it today because I knew that it wasn't precisely peer reviewed. I just would like to ask for permission for that to be able to be tabled - - -

MR MASON: So - - -

MR ROBERTS: We will discuss that first, Leon.

MR ASHBY: - - - at some stage.

MR MASON: Requests can come through.

MR ROBERTS: Yes, a request; yes. And, also, there is material from a scientist who is also an engineer, worked extensively on this for many years, and he has shown how the NASA Goddard Institute for Space Studies has corrupted the data and misadjusted the data. And I wrote to the NASAs Goddard Institute for Space Studies director, Gavin Schmidt, and in reply to me he inadvertently admitted that the NASA data, the NOAA data are not independent. They're basically the same. So we have been told by Steve Rintoul that there are four different data sets around the world. We understand that they're really just one. We understand also that the – okay. They're different data sets.

They come from one core piece of data, different interpretation. And we have seen – we're very concerned about adjustments in that data, and that's what I would like to present as well, because CSIRO has admitted they didn't do their due diligence on NASAs Goddard Institute for Space Studies.

MR MASON: I don't think that CSIRO would agree with that statement.

MR ROBERTS: Okay.

MR MASON: If we don't have any other matters to bring forward, I thank everybody for travelling today, because I know that a lot of the people who are here today had to come travel to Canberra and it's particularly cold. A reminder that the recording will be made available to all parties in a timely manner.

MR ROBERTS: What do you expect that to be?

MR MASON: Days to a week - - -

MR ROBERTS: Okay. That's good.

MR MASON: - - - is the expectation. I'm going to look at departmental staff to get a sense of – yes. So not a prolonged - - -

MR ROBERTS: So that's the transcript?

MR MASON: That's the transcript, yes.

MR ROBERTS: Okay. That's good. Thank you.

MR MASON: If there were any unresolved issues, I will take them on notice. If there are any other requests, that can come through to the office, and we can deal with that way. Can I request a digital copy of all of the materials that were presented today from all sides. I just note that there's quite a substantial block there, so - - -

MR BOBROFF: The links are all within the presentation.

MR MASON: You've got – okay.

MR BOBROFF: And I will send you a PDF of the three sections of the presentation.

MR MASON: Terrific. That's okay. That's fine. So just a copy of any of the materials that were presented here today so I can turn that into a pack for distribution so that everybody has got a copy of that sitting there. All right. In that case, we might draw this to a close. Thank you.

MR ROBERTS: Can I – yes.

MR MASON: Sorry. Yes. That's all right.

MR ROBERTS: Once you've closed it – sorry.

MR MASON: Yes. I will just draw this to a close. End the recording. Thank you.

MATTER ADJOURNED at 12.52 pm ACCORDINGLY

Climate Science Briefing

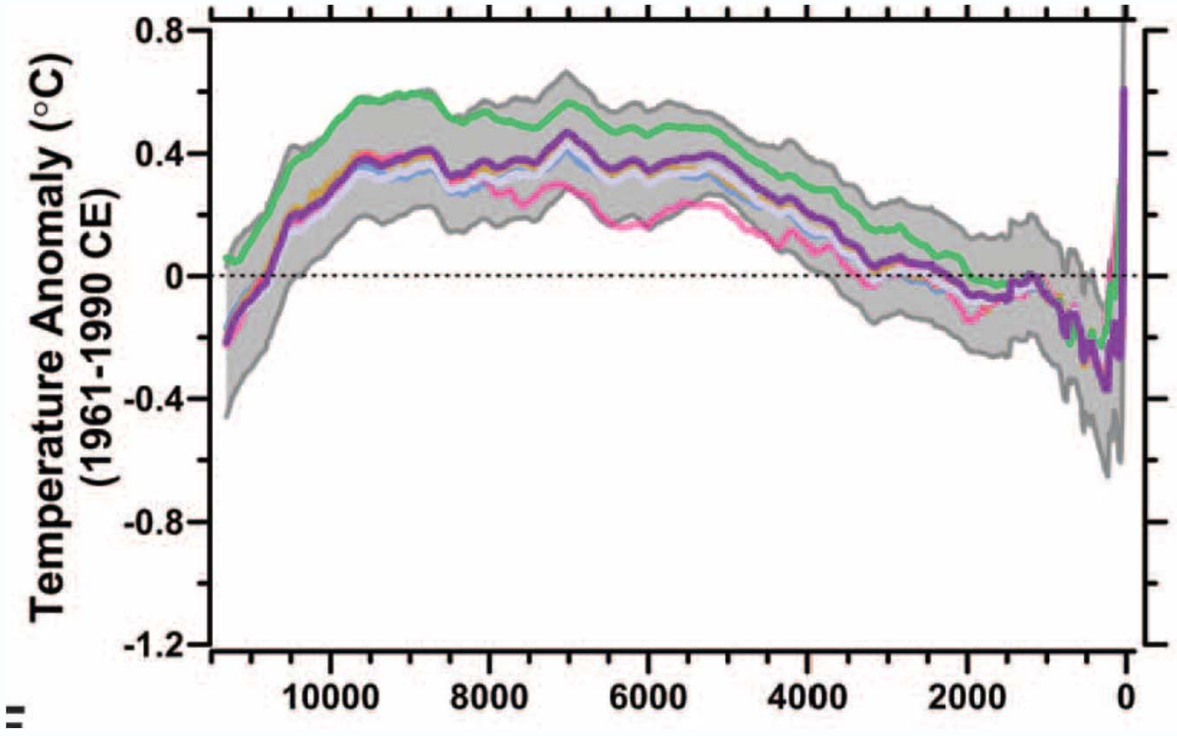
Dr Stephen Rintoul (CSIRO Fellow)

Dr Helen Cleugh (Director, CSIRO Climate Science Centre)

10 May 2017

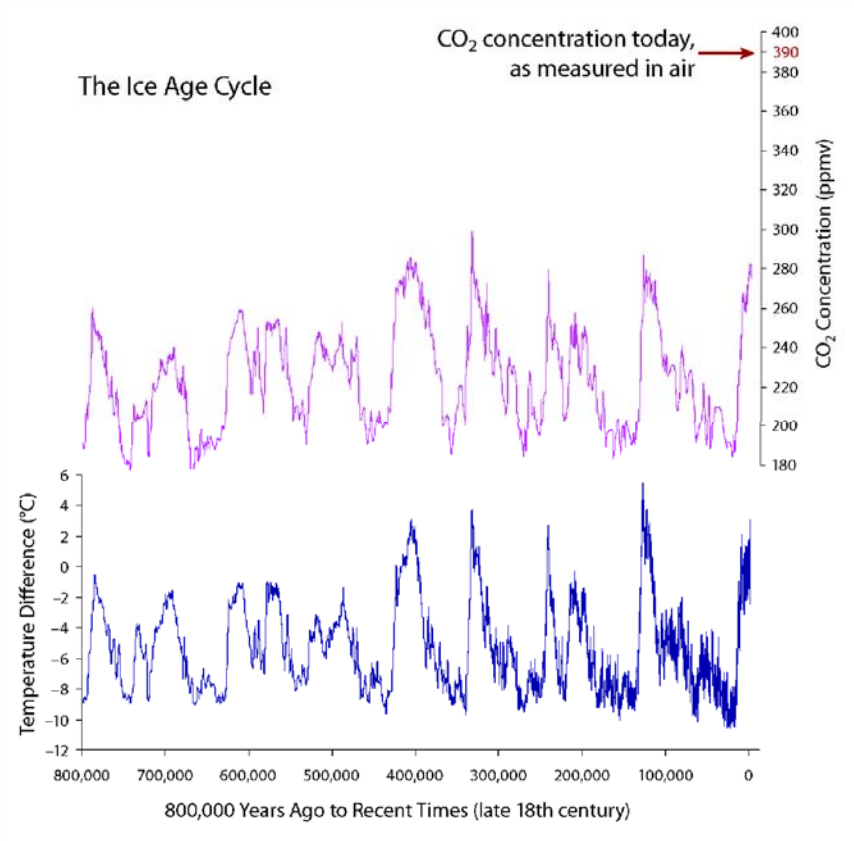
"What, if anything, is unprecedented in the climate record of the last 10,000 years and, if something is unprecedented, what proves it is caused by carbon dioxide from human activity and that such carbon dioxide output needs to be cut. i.e., the human production of carbon dioxide is dangerous or indicates impending catastrophe?"

Rate of rise in global mean temperature is unprecedented in past 10,000 years



"Our results indicate that global mean temperature for the decade 2000–2009 has not yet exceeded the warmest temperatures of the early Holocene (5000 to 10,000 yr B.P.). These temperatures are, however, warmer than 82% of the Holocene distribution. … In contrast, the decadal mean global temperature of the early 20th century (1900–1909) was cooler than >95% of the Holocene distribution. … Global temperature, therefore, has risen from near the coldest to the warmest levels of the Holocene within the past century, reversing the long-term cooling trend that began ~5000 yr B.P."

Marcott et al., Science, 2013



Carbon dioxide concentrations in the atmosphere today are unprecedented over at least the past 800,000 years.

The same is true for many other greenhouse gases.

Figure from National Research Council (2011).

Source for top image: Lüthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, and T. F. Stocker. 2008. High-resolution carbon dioxide concentration record 650,000-800,000 years before present. Nature 453(7193):379-382, doi: 10.1038/nature06949.

Source for bottom image: Jouzel, J., V. Masson-Delmotte, O. Cattani, G. Dreyfus, S. Falourd, G. Hoffmann, B. Minster, J. Nouet, J. M. Barnola, J. Chappellaz, H. Fischer, J. C. Gallet, S. Johnson, M. Leuenberger, L. Loulergue, D. Luethi, H. Oerter, F. Parrenin, G. Raisbeck, D. Raynaud, A. Schilt, J. Schwander, E. Selmo, R. Souchez, R. Spahni, B. Stauffer, J. P. Steffensen, B. Stenni, T. F. Stocker, J. L. Tison, M. Werner, and E. W. Wolff. 2007. Orbital and millennial Antarctic climate variability over the past 800,000 years. Science 317(5839):793-797.

"What, if anything, is unprecedented in the climate record of the last 10,000 years and, if something is unprecedented, what proves it is caused by carbon dioxide from human activity and that such carbon dioxide output needs to be cut. i.e., the human production of carbon dioxide is dangerous or indicates impending catastrophe?"

Evidence that humans have caused climate change

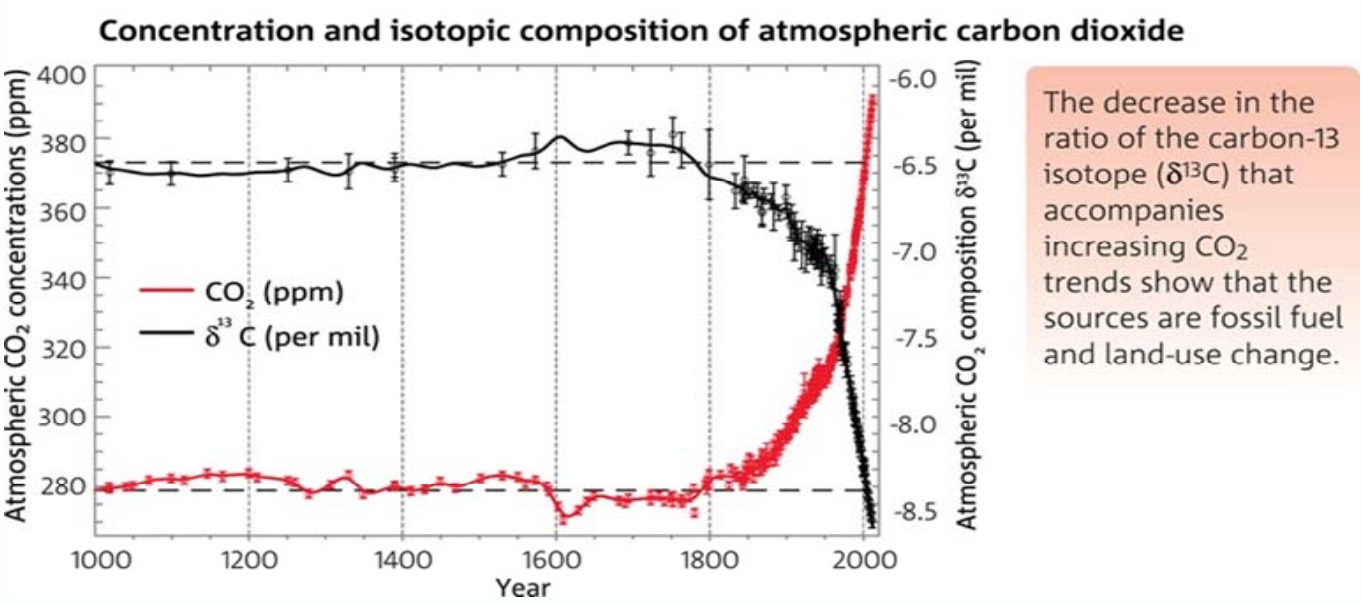
1. **Carbon dioxide is a greenhouse gas.**

The natural greenhouse effect makes the planet habitable: the average temperatue of the earth is 33°C warmer than it would be in the absence of greenhouse gases.

Laws of physics and direct measurements confirm that carbon dioxide is a greenhouse gas.

Evidence that humans have caused climate change

2. Carbon dioxide concentrations in the atmosphere have increased since the industrial revolution.



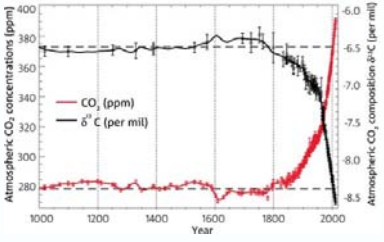
Atmospheric carbon dioxide levels have increased by more than 40% since pre-industrial times.

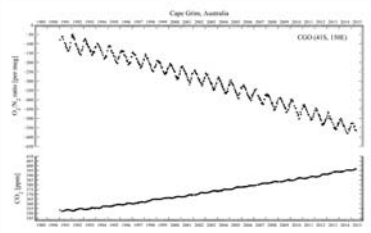
Source: State of the Climate 2014 (CSIRO and Bureau of Meteorology)
Data source: CSIRO
Data available at: - http://www.csiro.au/greenhouse-gases/ and http://ds.data.jma.go.jp/gmd/wdcgg/
Atmospheric concentration of CO_2 (red line, ppm) and carbon-13 isotope ratio in CO_2 ($\delta^{13}C$, per mil) as measured in air bubbles in ice cores and atmospheric samples at Cape Grim.

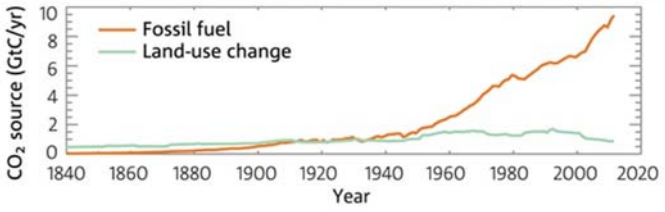
Evidence that humans have caused climate change

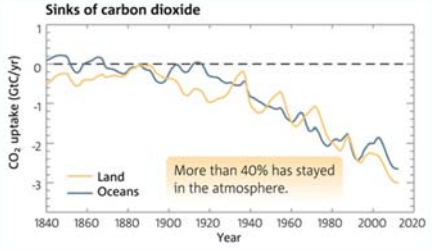
3. The extra carbon dioxide in the atmosphere comes from human activities.

- The isotopic composition of CO_2 in the atmosphere shows that the CO_2 added to the atmosphere has come from burning fossil fuels.
- Oxygen concentrations in the atmosphere have declined, at the rate expected from burning carbon-rich fuels.
- CO_2 in the atmosphere has increased as human emissions have increased (the two are correlated).
- In recent decades, nature has absorbed more CO_2 than it has emitted, so natural sources cannot explain the observed increase in the atmosphere.



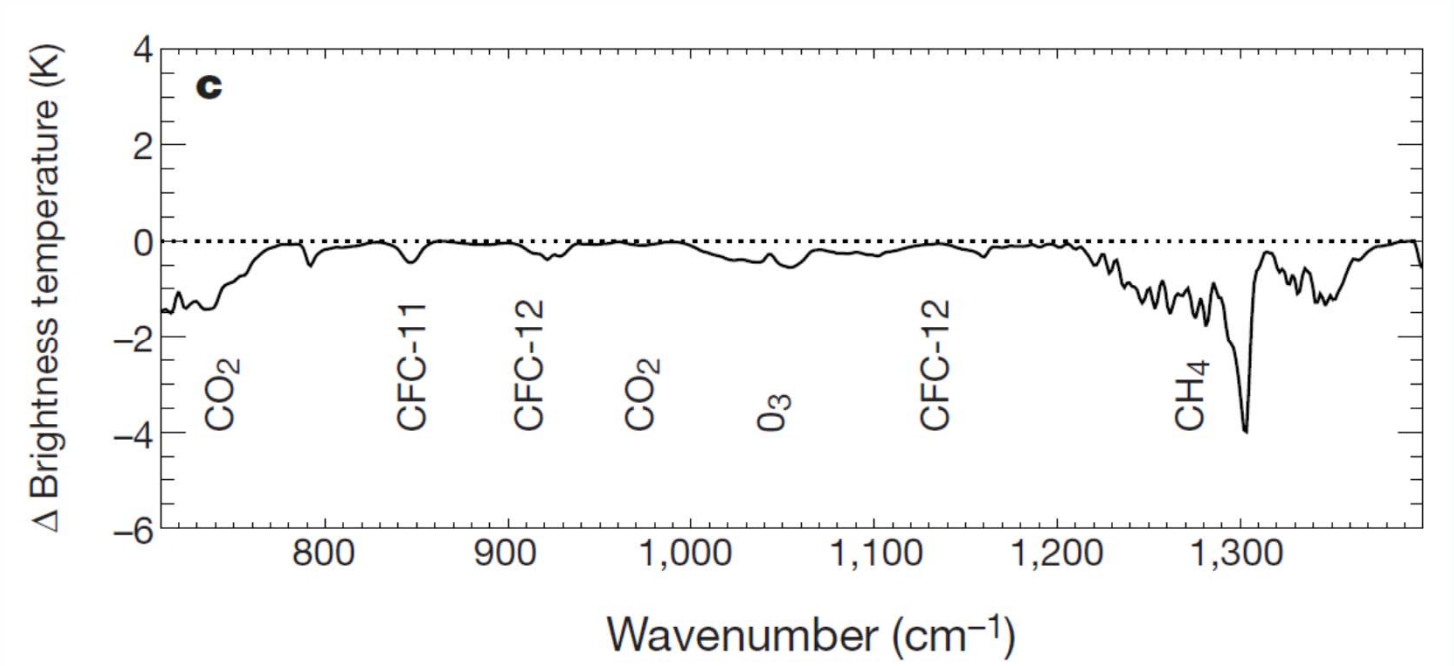






Evidence that humans have caused climate change

4. The additional carbon dioxide added to the atmosphere by human activities has enhanced the greenhouse effect: less energy is leaving the top of the atmosphere in the wavelengths absorbed by carbon dioxide and other greenhouse gases.



Harries et al., Nature (2001)

Questions from Senator Roberts re changes in the energy leaving the top of the atmosphere

Does CSIRO agree that the paper referenced above seems to show there was no significant change from 1970 to 1997?

No: the plot shows difference between 1970 and 1997.

Does CSIRO agree that the CO2 absorption spectra extends down to wavenumber 630 so the IMG and IRIS satellites do not adequately address CO2 as a greenhouse gas?

We agree that the CO2 absorption spectra extends to lower wavenumbers. These are measured by the satellites. They are not shown in this graph of the contribution from CO2 and other greenhouse gases because the spectra are noisier in that wavenumber band.

Questions from Senator Roberts re changes in the energy leaving the top of the atmosphere

Does CSIRO agree that the greenhouse effect of CO2 is mostly finished by 50ppm, with little increase by 300ppm and virtually none at 400ppm?

No. The figure shows direct empirical evidence that increasing concentrations of CO2 in the atmosphere reduce the energy leaving the atmosphere: the CO2 effect is not “saturated.”

This statement is based on a misunderstanding of the physics of radiation in the atmosphere. Adding more CO2 means that heat leaves the earth’s atmosphere at a higher elevation, where temperatures are cooler. The colder the air, the less heat is radiated. Adding greenhouse gases warms climate by reducing how much heat escapes to space, as the empirical observations show.

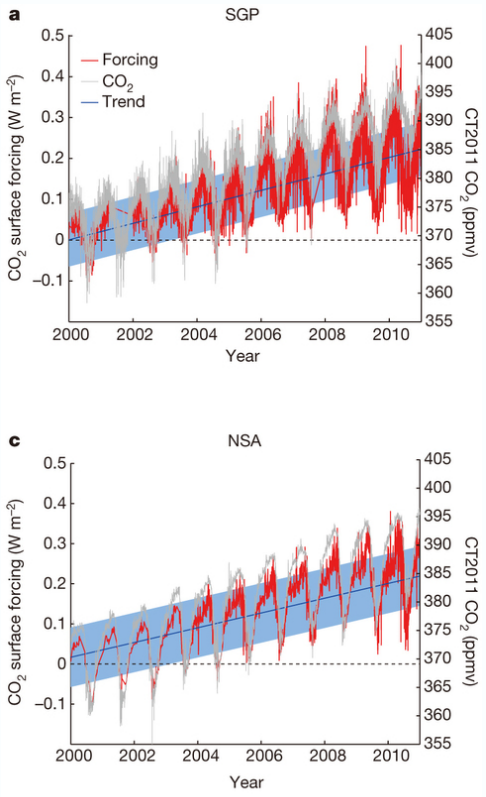
Questions from Senator Roberts re changes in the energy leaving the top of the atmosphere

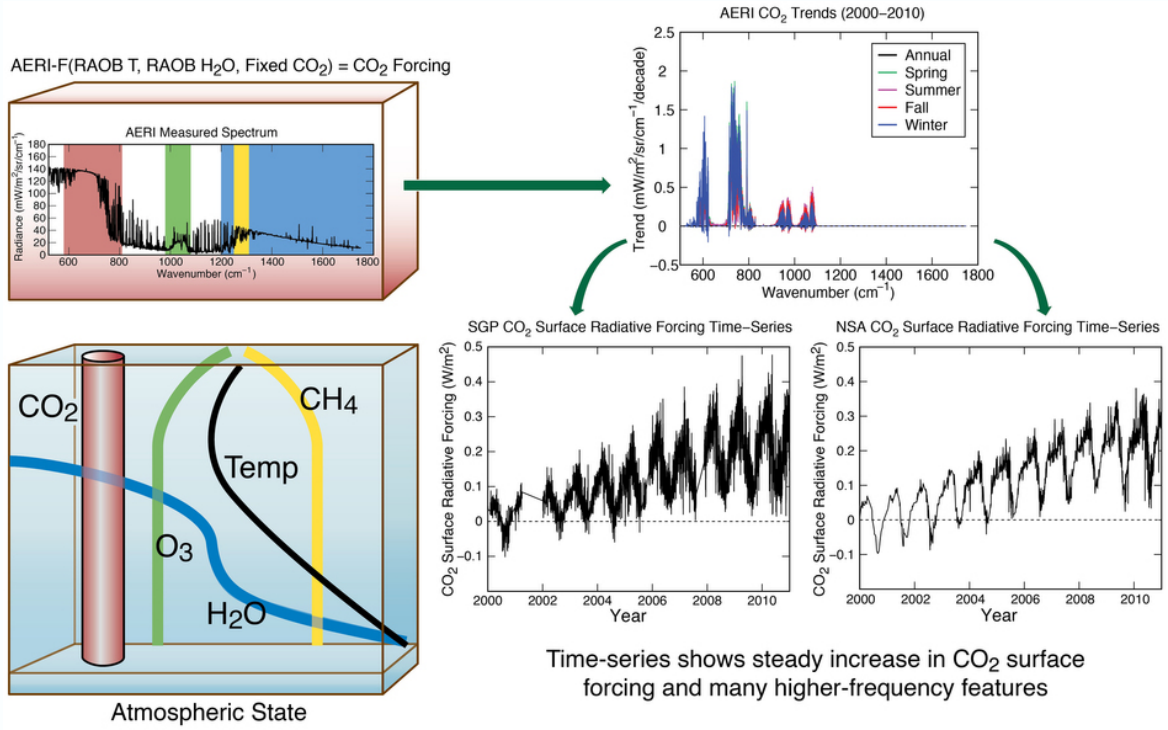
Does CSIRO agree that even a two percent variation in atmospheric water vapor will equal the total amount of supposed greenhouse effect of all human CO2 production?

Water vapour in the atmosphere is set by temperature: warmer air means more water vapour. Thus water vapour acts as positive feedback, roughly doubling the warming expected from the change in CO2 alone.

Empirical evidence of increased radiation at the surface as a result of increased atmospheric CO2 concentrations

Time series of observed spectrally integrated (520–1,800 cm^{-1}) CO_2 surface radiative forcing at SGP (in red) with overlaid CT2011 estimate of CO_2 concentration from the surface to an altitude of 2 km (grey), and a least-squares trend of the forcing and its uncertainty (blue).



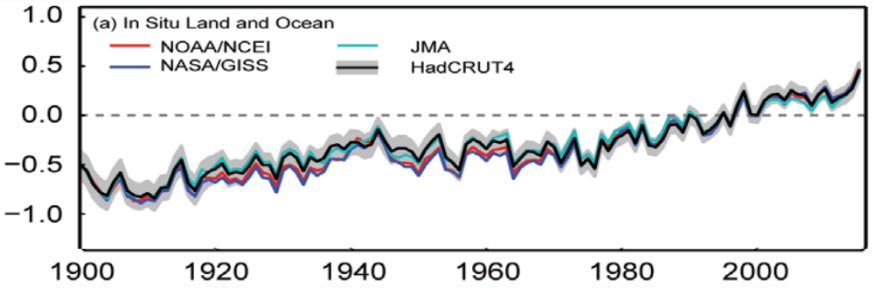


Feldman et al., Nature, 2015

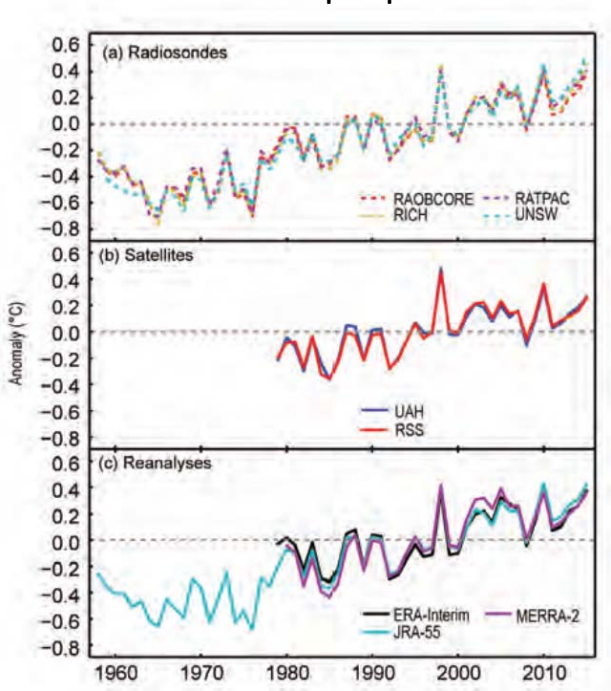
Evidence that humans have caused climate change

5. The earth has warmed as a result of the enhanced greenhouse effect.

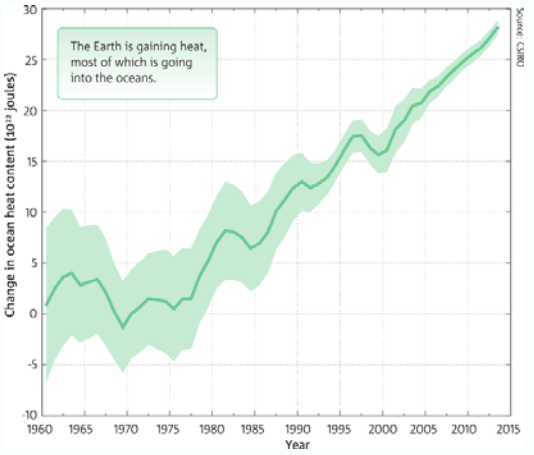
Surface temperature (°C)



Lower troposphere



ocean heat content



Source: Surface air and lower troposphere temperature: Bulletin of the American Meteorological Society, State of the Climate 2015, supplement to Vol. 97, No. 8, August 2016
Ocean heat content: http://www.cmar.csiro.au/sealevel/thermal_expansion_ocean_heat_timeseries.html

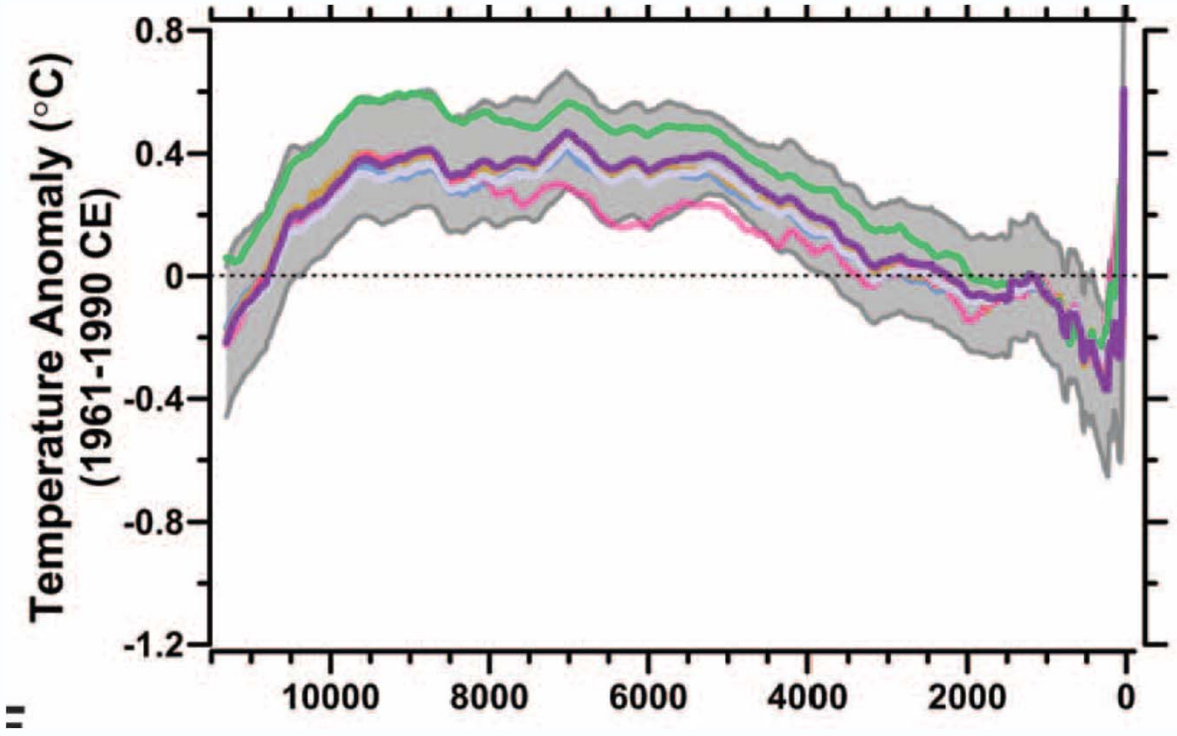
Questions on temperature change

"Accepted that the earth has warmed since the Little Ice Age but is still cooler than the Roman Warm Period and much cooler than the Holocene Thermal Maximum" (Senator Malcolm Roberts, https://checkvist.com/checklists/583700)

The statement that modern global average temperatures are cooler than the Roman Warm Period is not supported by the evidence.

"the global warming that has occurred since the end of the nineteenth century reversed a persistent long-term global cooling trend …. There were no globally synchronous multi-decadal warm or cold intervals that define a worldwide Medieval Warm Period or Little Ice Age, but all reconstructions show generally cold conditions between ad 1580 and 1880 …..*Recent warming reversed the long-term cooling; during the period ad 1971–2000, the area-weighted average reconstructed temperature was higher than any other time in nearly 1,400 years*."

(PAGES 2k Consortium, Nature Geosciences, 2013)



"Our results indicate that global mean temperature for the decade 2000–2009 has not yet exceeded the warmest temperatures of the early Holocene (5000 to 10,000 yr B.P.). These temperatures are, however, warmer than 82% of the Holocene distribution. … In contrast, the decadal mean global temperature of the early 20th century (1900–1909) was cooler than >95% of the Holocene distribution. … Global temperature, therefore, has risen from near the coldest to the warmest levels of the Holocene within the past century, reversing the long-term cooling trend that began ~5000 yr B.P."

Marcott et al., Science, 2013

Evidence that humans have caused climate change

6. **Observed changes in the climate system are consistent with an enhanced greenhouse effect. Other forcings (e.g. volcanoes, the sun, internal variability) cannot explain the magnitude, timing and distribution of observed trends.**

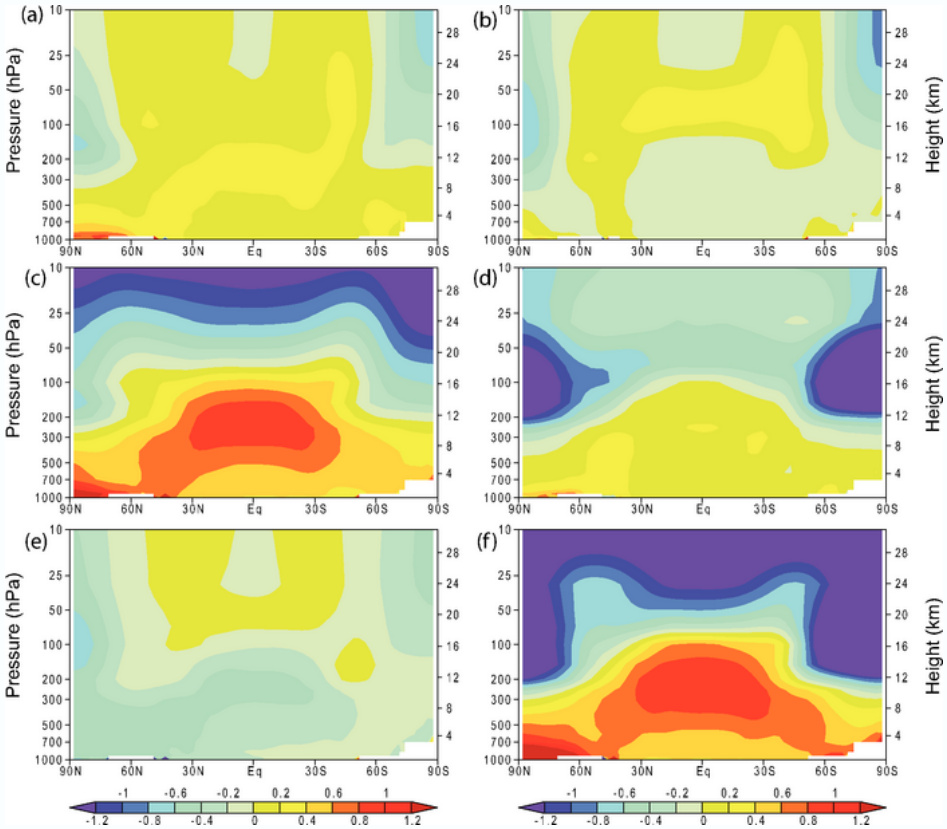
For example, enhanced greenhouse forcing causes warming of the lower atmosphere and cooling of the upper atmosphere, as observed. Increases in solar energy reaching the earth would warm both the upper and lower atmosphere.

How do different climate drivers affect atmospheric temperature change?

SOLAR

GH GASES

SULPHATE AEROSOL



VOLCANOES

OZONE

SUM

Figure 9.1. Zonal mean atmospheric temperature change from 1890 to 1999 (°C per century) as simulated by the PCM model from (a) solar forcing, (b) volcanoes, (c) well-mixed greenhouse gases, (d) tropospheric and stratospheric ozone changes, (e) direct sulphate aerosol forcing and (f) the sum of all forcings. Plot is from 1,000 hPa to 10 hPa (shown on left scale) and from 0 km to 30 km (shown on right). See Appendix 9.C for additional information. Based on Santer et al. (2003a).

IPCC AR4 Fig 9.1

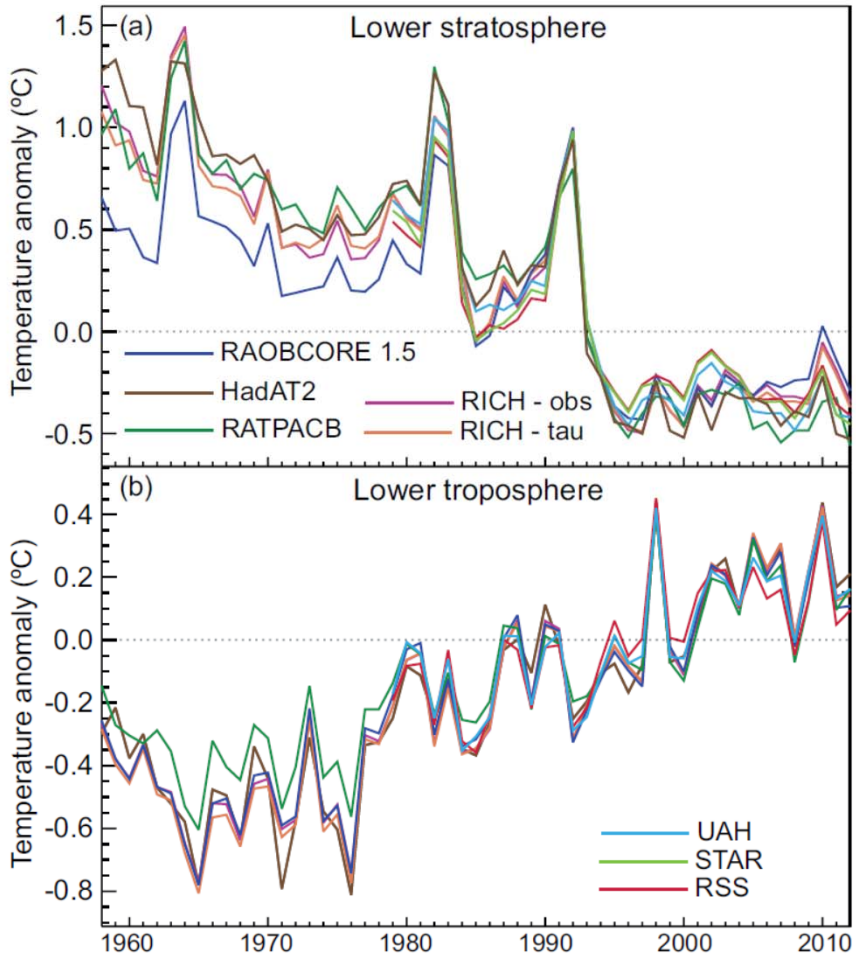


Figure 2.24 | Global annual average lower stratospheric (top) and lower tropospheric (bottom) temperature anomalies relative to a 1981–2010 climatology from different data sets. STAR does not produce a lower tropospheric temperature product. Note that the *y*-axis resolution differs between the two panels.

IPCC AR5 Fig 2.24

Evidence that humans have caused climate change

1. Carbon dioxide is a greenhouse gas.
2. Carbon dioxide concentrations in the atmosphere have increased.
3. The extra carbon dioxide in the atmosphere comes from human activities.
4. The additional carbon dioxide added to the atmosphere by human activities has enhanced the greenhouse effect: less energy is leaving the top of the atmosphere in the wavelengths absorbed by carbon dioxide and other greenhouse gases.
5. The earth has warmed as a result of the enhanced greenhouse effect.
6. Observed changes in the climate system are consistent with an enhanced greenhouse effect. Other forcings (e.g. volcanoes, the sun, internal variability) cannot explain the magnitude, timing and distribution of observed trends.

"What, if anything, is unprecedented in the climate record of the last 10,000 years and, if something is unprecedented, what proves it is caused by carbon dioxide from human activity and that such carbon dioxide output needs to be cut. i.e., the human production of carbon dioxide is dangerous or indicates impending catastrophe?"

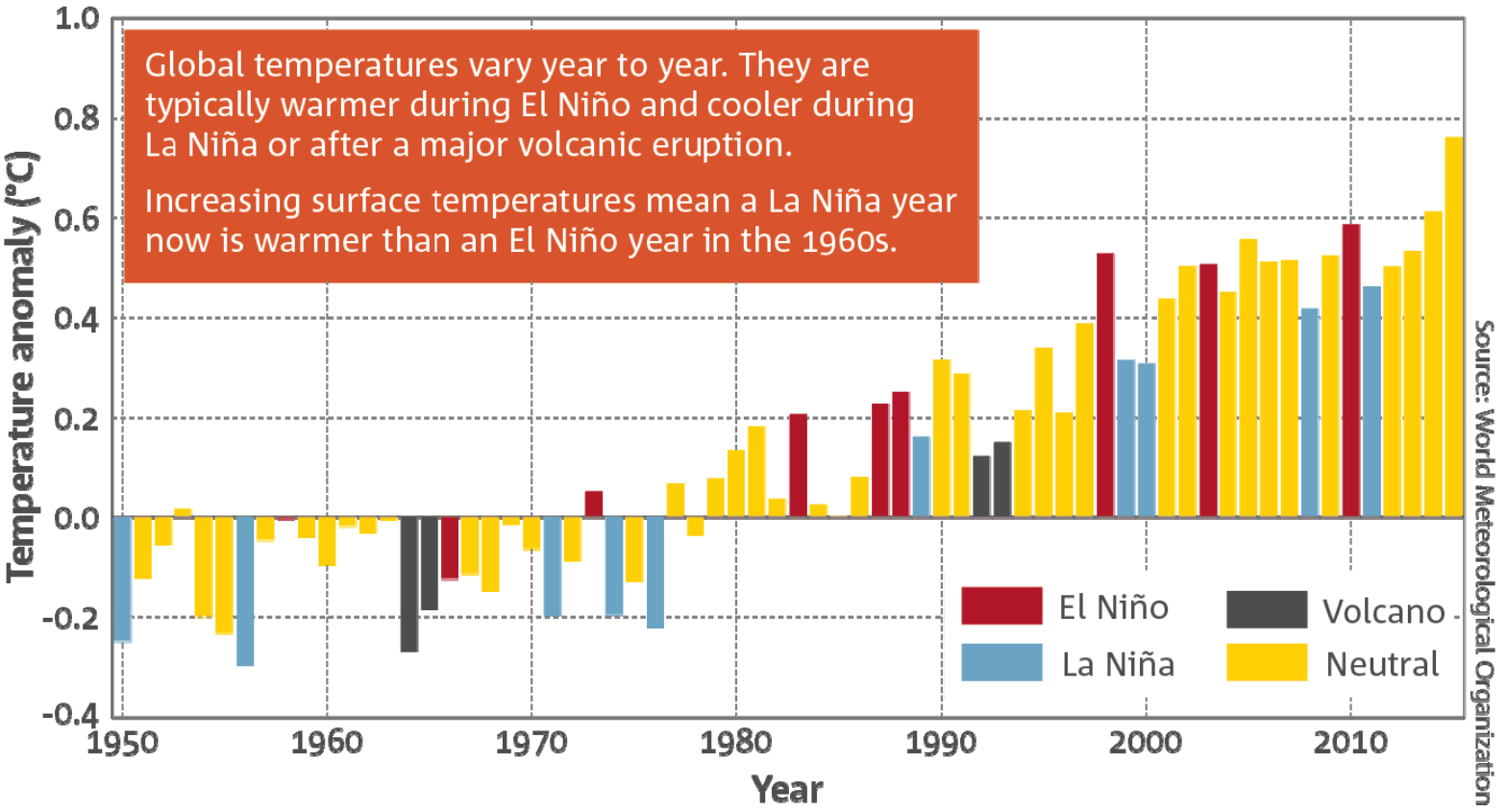
Impacts of climate change

Observed impacts of climate change include:

- Rise in sea level, causing an increase in the frequency and magnitude of extreme coastal flooding events
- Warming, causing an increase in frequency, magnitude and duration of heat waves
- Increases in fire risk in Australia
- Ocean warming and increased coral bleaching risk

Global

Global temperature, 1950 - 2015



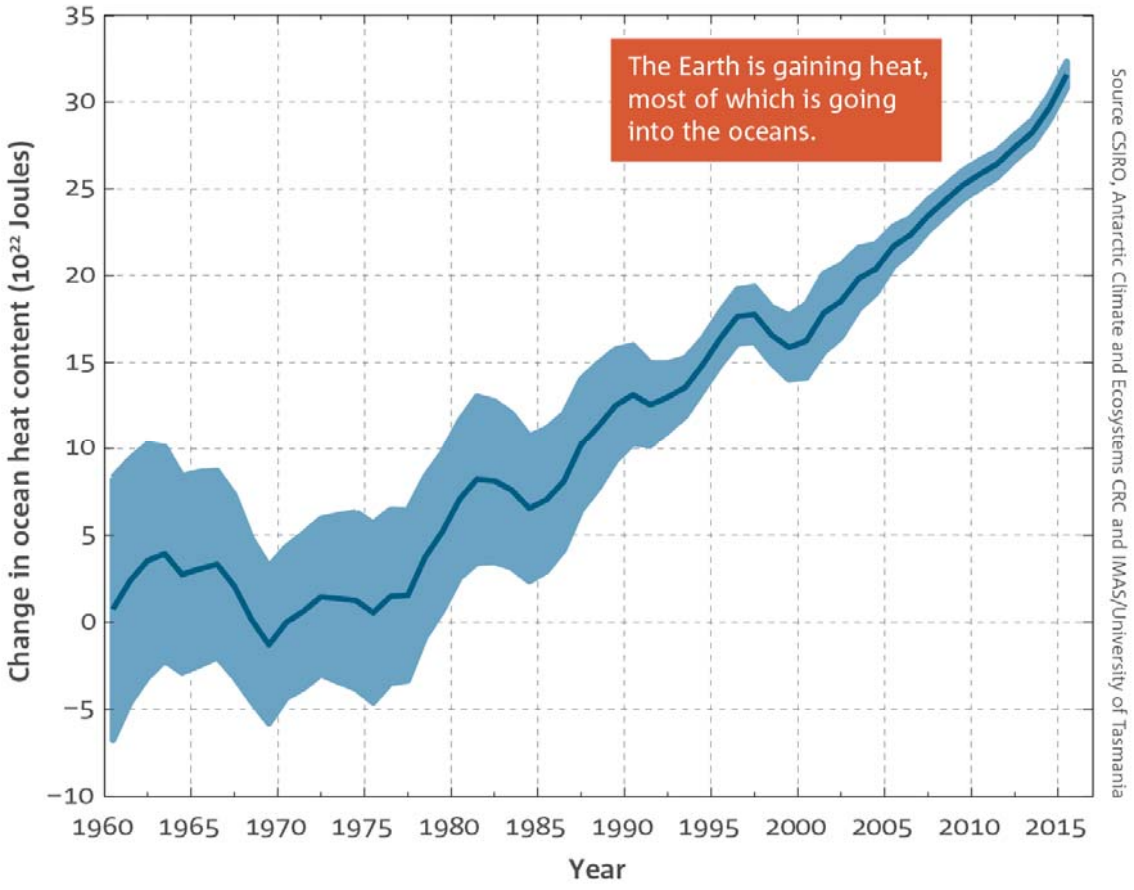
State of the Climate 2016 (Bureau of Meteorology and CSIRO)

CSIRO

Australian Government
Bureau of Meteorology

Oceans

Ocean heat content

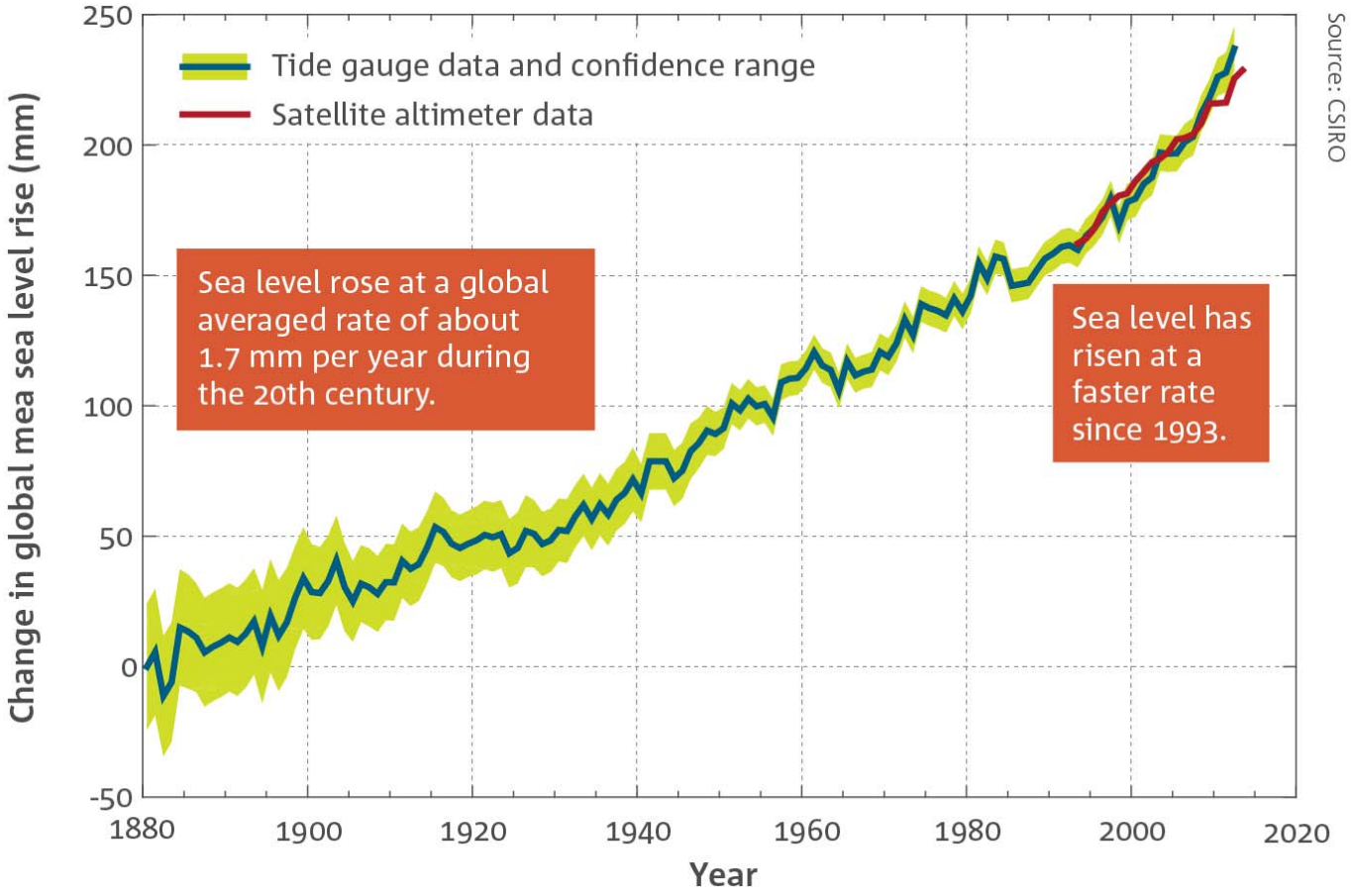


CSIRO

Australian Government
Bureau of Meteorology

Oceans

Sea level

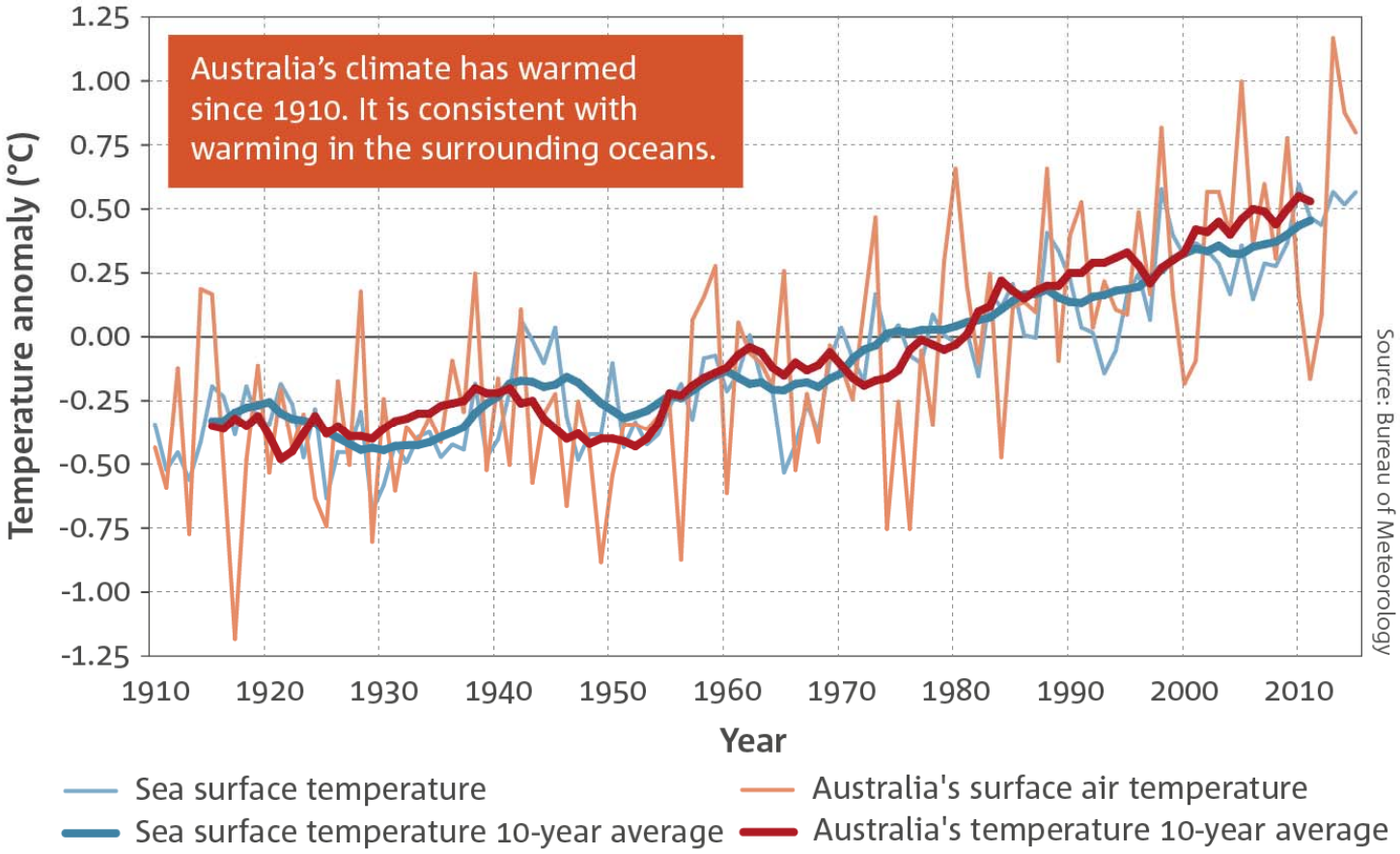


CSIRO

Australian Government
Bureau of Meteorology

Australia's changing climate

Temperature

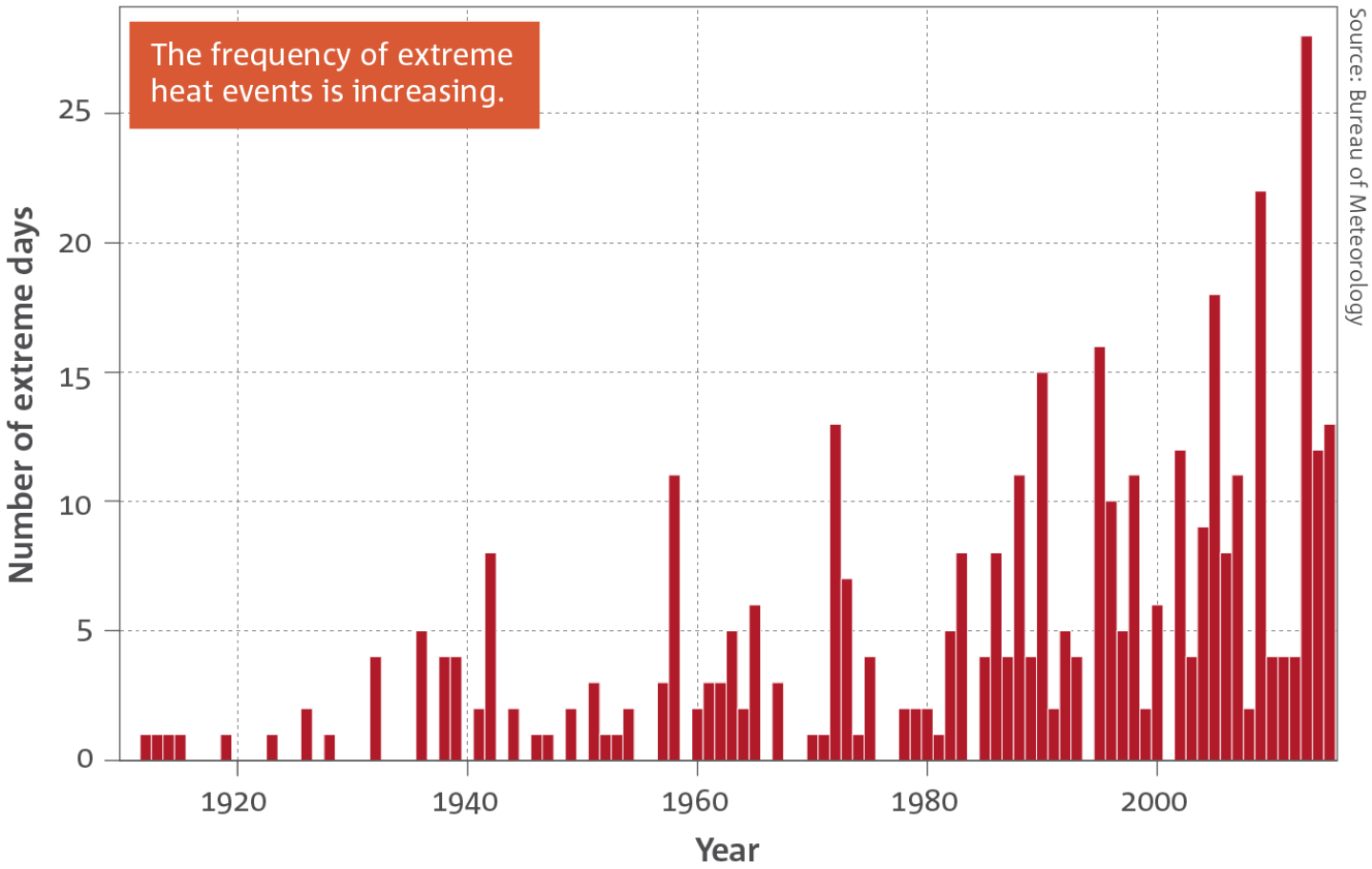


CSIRO

Australian Government
Bureau of Meteorology

Australia's changing climate

Extreme heat events



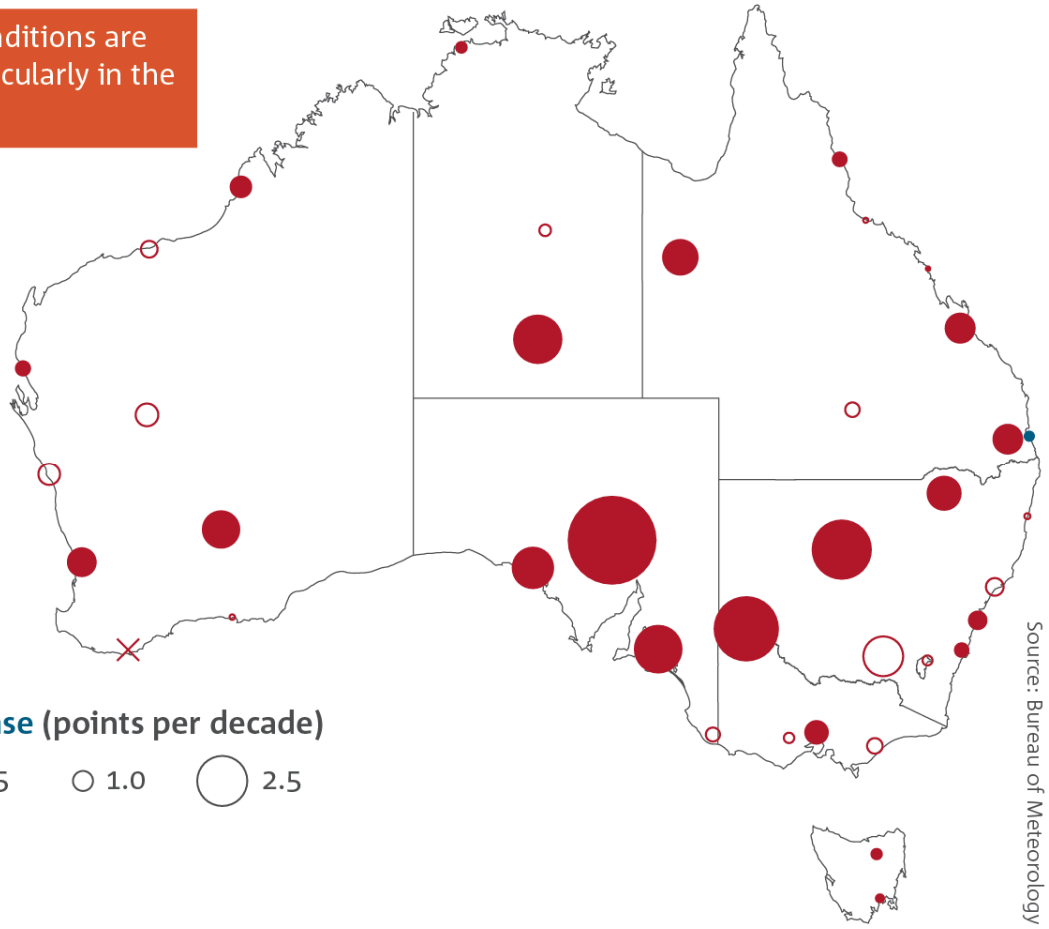
CSIRO

Australian Government
Bureau of Meteorology

Australia's changing climate

Fire weather

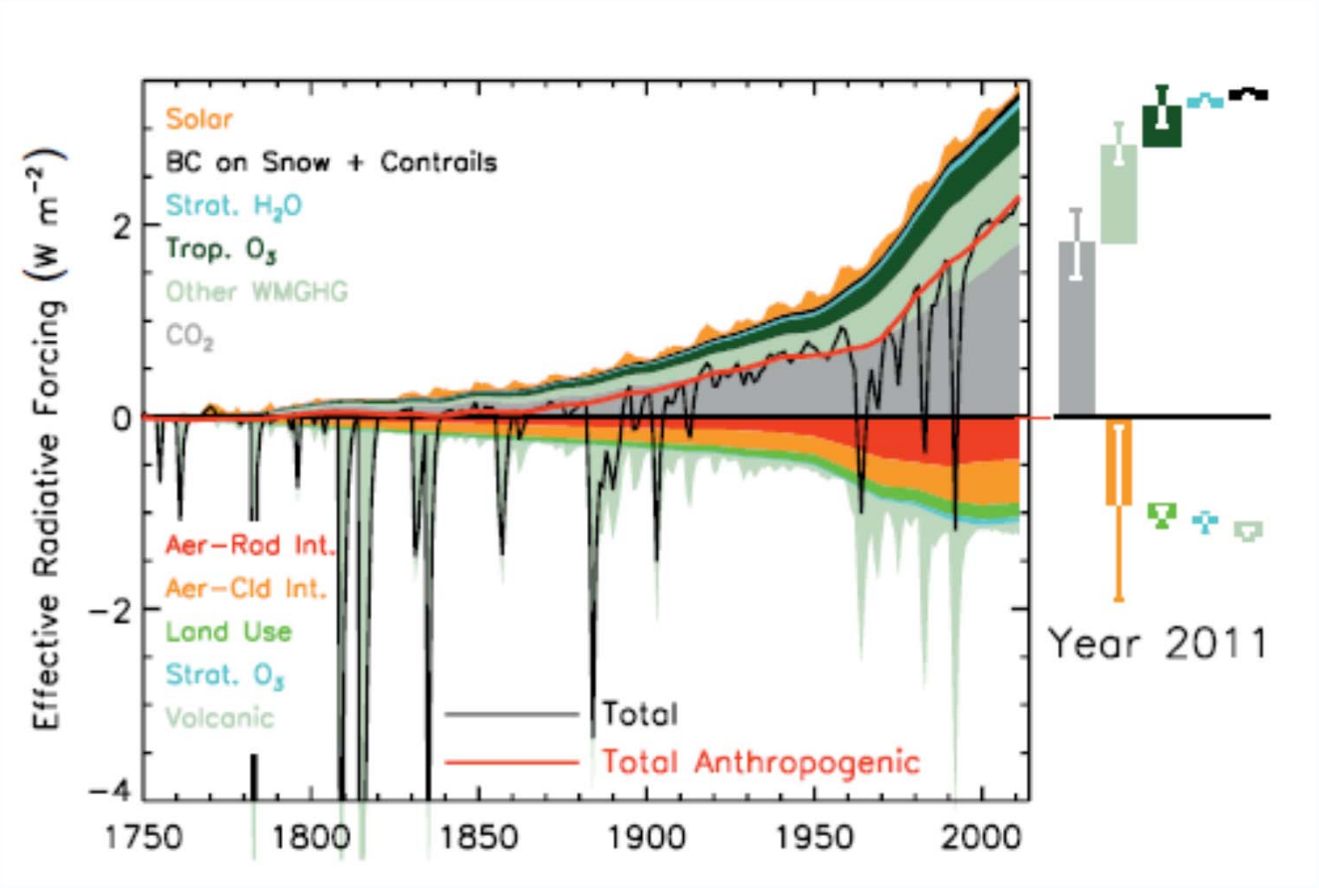
Fire weather conditions are worsening, particularly in the south and east.



CSIRO

Australian Government
Bureau of Meteorology

Climate drivers since 1750



IPCC AR5 Fig 8.18

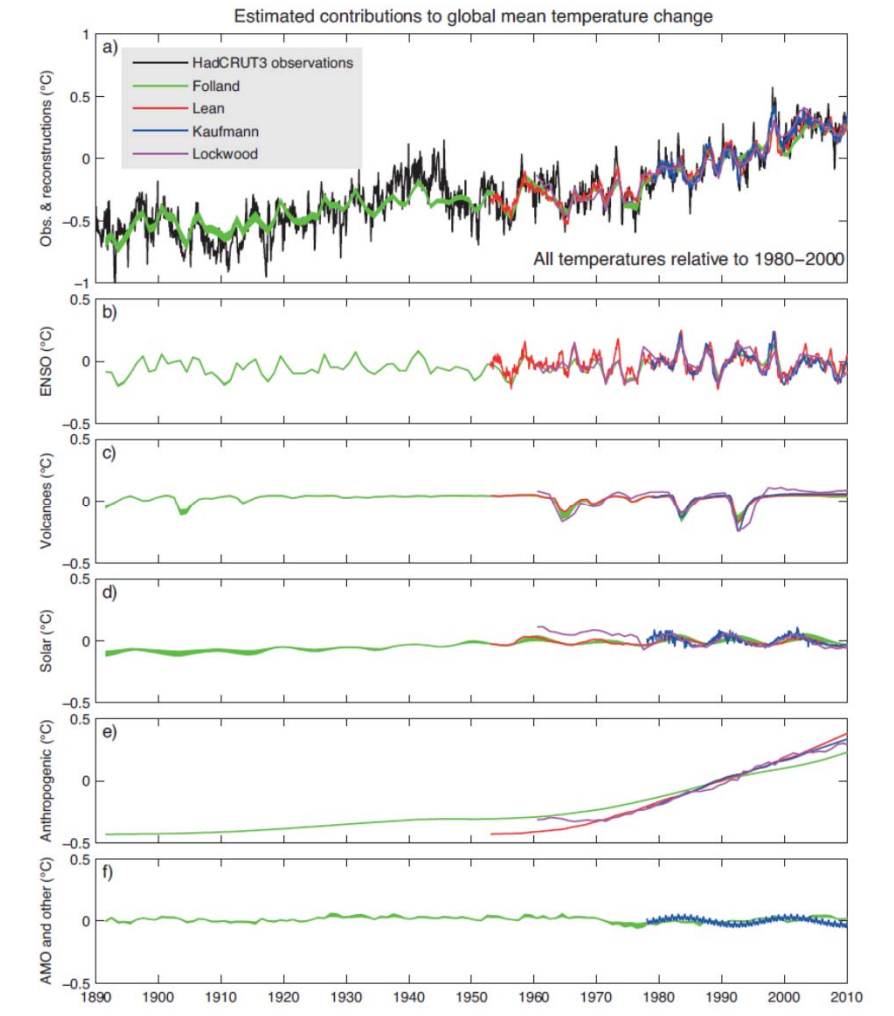
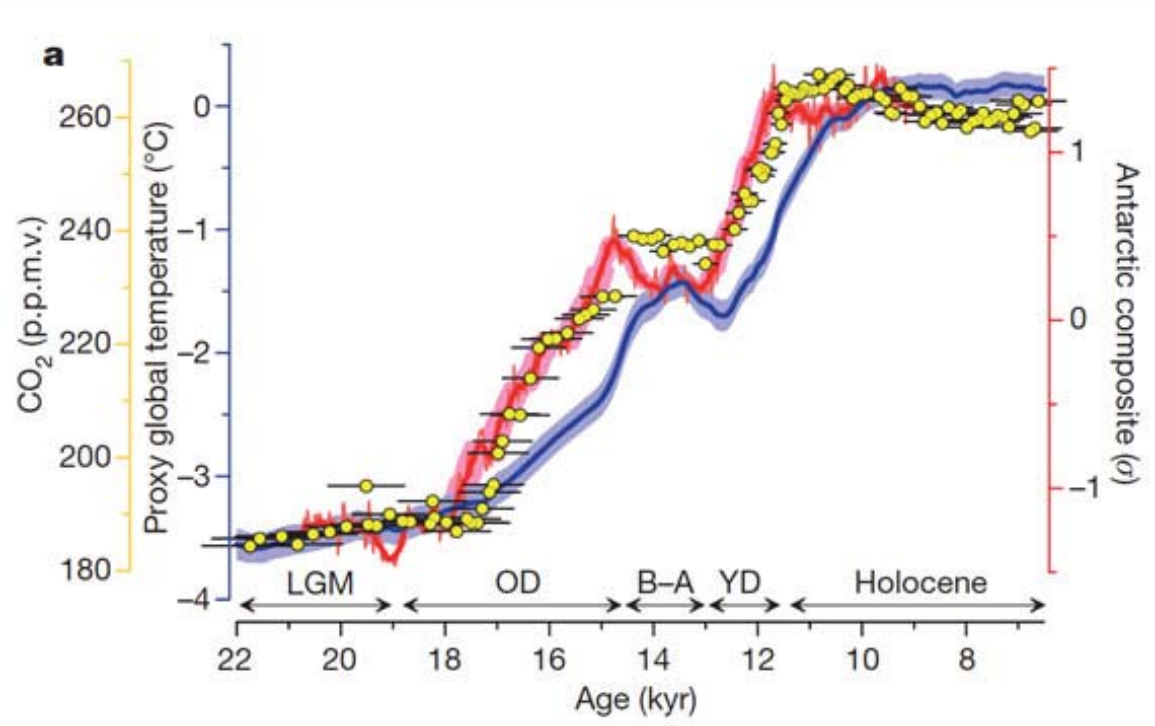


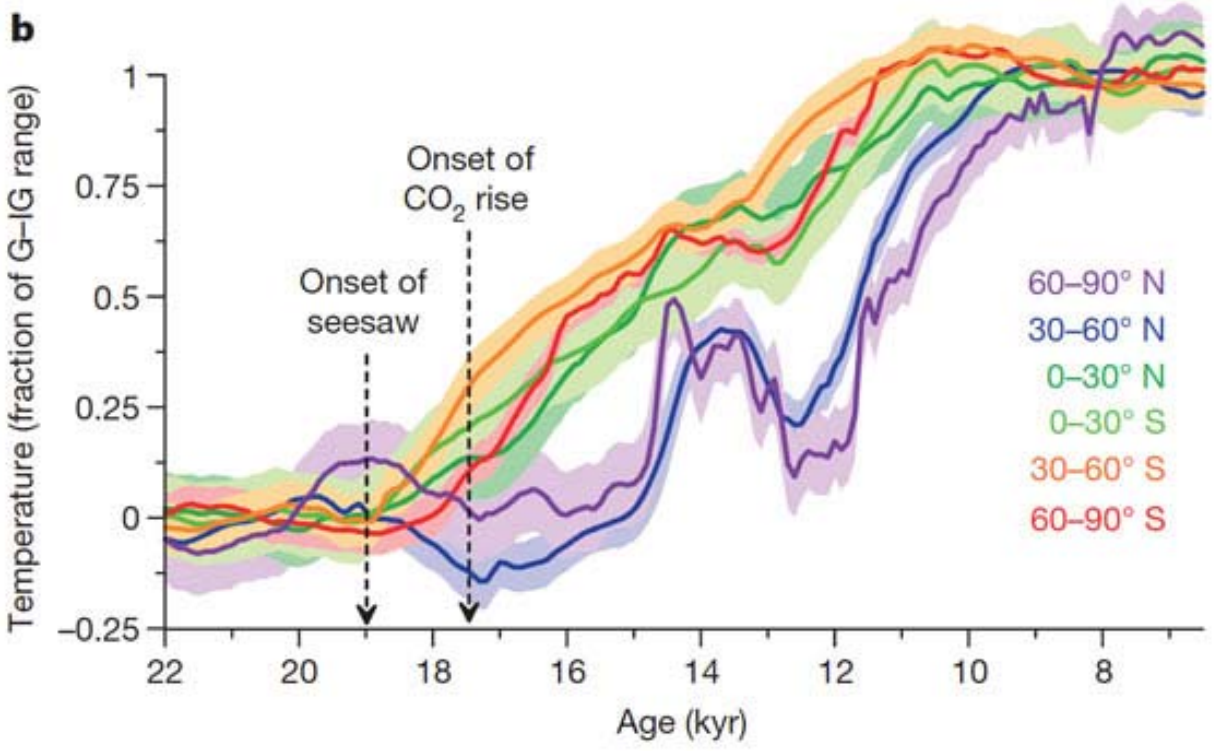
Figure 10.6 | (Top) The variations of the observed global mean surface temperature (GMST) anomaly from Hadley Centre/Climatic Research Unit gridded surface temperature data set version 3 (HadCRUT3, black line) and the best multivariate fits using the method of Lean (red line), Lockwood (pink line), Folland (green line) and Kaufmann (blue line). (Below) The contributions to the fit from (a) El Niño-Southern Oscillation (ENSO), (b) volcanoes, (c) solar forcing, (d) anthropogenic forcing and (e) other factors (Atlantic Multi-decadal Oscillation (AMO) for Folland and a 17.5-year cycle, semi-annual oscillation (SAO), and Arctic Oscillation (AO) from Lean). (From Lockwood (2008), Lean and Rind (2009), Folland et al. (2013) and Kaufmann et al. (2011), as summarized in Imbers et al. (2013).)

Change in CO_2 leads change in global temperature during transition from last glacial maximum to Holocene



The global proxy temperature stack (blue) as deviations from the early Holocene (11.5–6.5 kyr ago) mean, an Antarctic ice-core composite temperature record (red), and atmospheric CO2 concentration (yellow dots). The Holocene, Younger Dryas (YD), Bølling–Allerød (B–A), Oldest Dryas (OD) and Last Glacial Maximum (LGM) intervals are indicated. Error bars, 1-sigma; p.p.m.v. = parts per million by volume.

Shakun et al., Nature, 2012



Proxy temperature stacks for 30° latitude bands with 1-sigma uncertainties. The stacks have been normalized by the glacial–interglacial (G–IG) range in each time series to facilitate comparison.

1. The Earth's orbital cycles trigger the initial warming (starting approximately 19,000 years ago), which is first reflected at the highest latitudes (i.e. Greenland and the Arctic - see "Onset of seesaw" in Figure).

2. This Arctic warming melted large quantities of ice, causing fresh water to flood into the oceans.

3. This influx of fresh water then disrupted the Atlantic meridional overturning circulation (AMOC), in turn causing a seesawing of heat between the hemispheres. The Southern Hemisphere and its oceans warmed first, starting about 18,000 years ago.

4. The warming Southern Ocean then released CO2 into the atmosphere starting around 17,500 years ago, which in turn caused the entire planet to warm via the increased greenhouse effect.

Shakun et al., Nature, 2012

TEMPERATURE MEASUREMENTS AT THE GROUND COMPARED TO SATELLITE AND BALLOON MEASUREMENTS IN THE TROPOSPHERE AND STRATOSPHERE

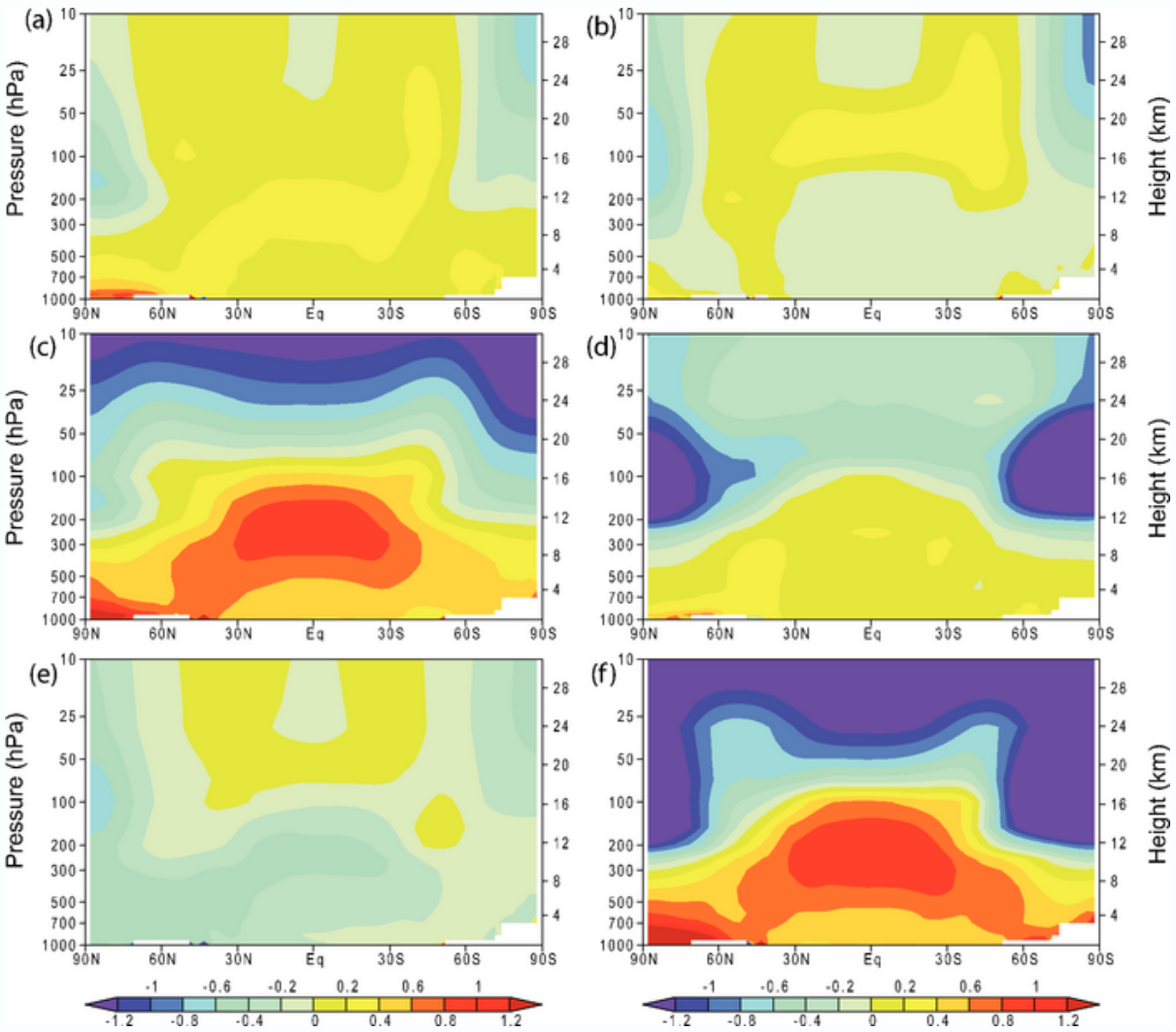
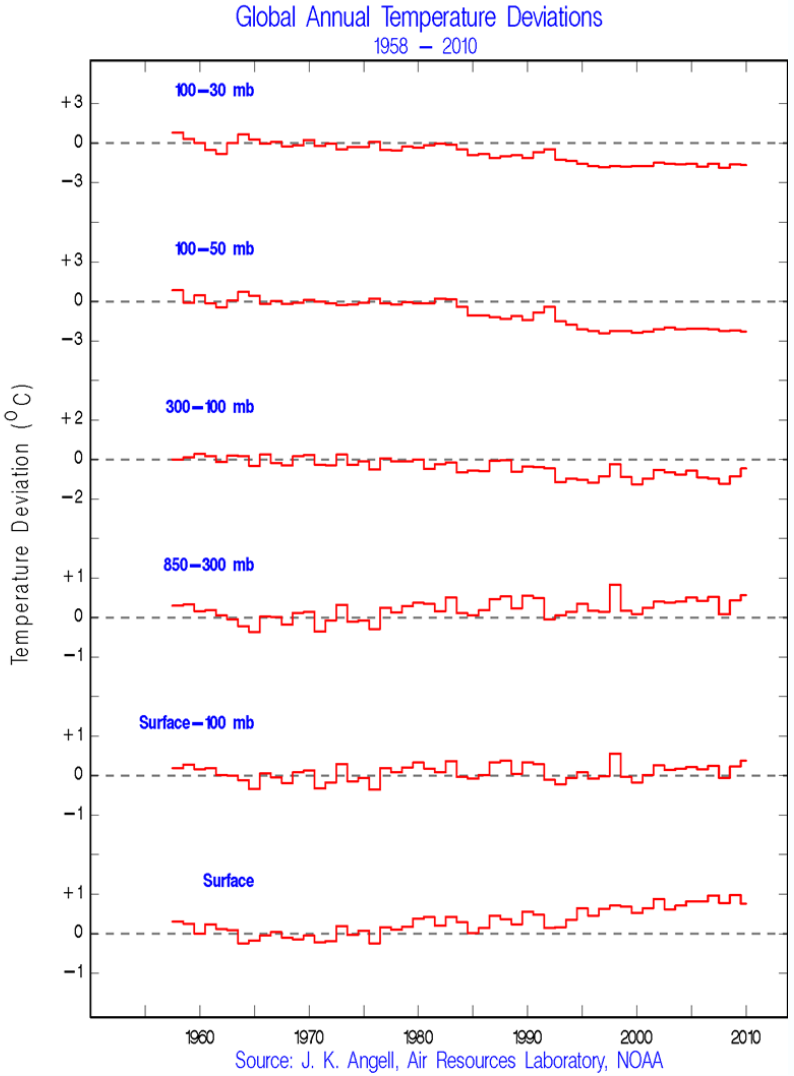


Figure 9.1. Zonal mean atmospheric temperature change from 1890 to 1999 (°C per century) as simulated by the PCM model from (a) solar forcing, (b) volcanoes, (c) well-mixed greenhouse gases, (d) tropospheric and stratospheric ozone changes, (e) direct sulphate aerosol forcing and (f) the sum of all forcings. Plot is from 1,000 hPa to 10 hPa (shown on left scale) and from 0 km to 30 km (shown on right). See Appendix 9.C for additional information. Based on Santer et al. (2003a).

IPCC AR4 Fig 9.1



Angell, J.K. 2011. Global, hemispheric, and zonal temperature deviations derived from radiosonde records. In Trends Online: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. doi: 10.3334/CDIAC/cli.005

There is no longer a significant discrepancy between surface measurements and satellite/radiosonde observations

"Previously reported discrepancies between the amount of warming near the surface and higher in the atmosphere have been used to challenge the reliability of climate models and the reality of human-induced global warming... This significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected. New data sets have also been developed that do not show such discrepancies."

Temperature Trends in the Lower Atmosphere - Understanding and Reconciling Differences (2006)

Convening Lead Author: Tom M. L. Wigley, NSF NCAR
Lead Authors: V. Ramaswamy, NOAA; J.R. Christy, Univ. of AL in Huntsville; J.R. Lanzante, NOAA; C.A. Mears, Remote Sensing Systems; B.D. Santer, DOE LLNL; C.K. Folland, U.K. Met Office

"It is concluded that ***there is no reasonable evidence of a fundamental disagreement between tropospheric temperature trends from models and observations*** *when uncertainties in both are treated comprehensively."*

Thorne, P. W., Lanzante, J. R., Peterson, T. C., Seidel, D. J. and Shine, K. P. (2011), Tropospheric temperature trends: history of an ongoing controversy. WIREs Clim Change, 2: 66–88. doi:10.1002/wcc.80

"This further confirms our finding for our data set that unambiguously resolving the diurnal drift effect correction and its impacts is likely to be a key determinant in reducing the uncertainty in long term tropospheric temperature changes from MSU/AMSU records."

Mears, C. A., Wentz, F. J., Thorne, P., & Bernie, D. (2011). Assessing uncertainty in estimates of atmospheric temperature changes from MSU and AMSU using a Monte-Carlo estimation technique. *Journal of Geophysical Research: Atmospheres (1984–2012)*, *116*(D8).

When variability due to ENSO, volcanoes and solar are removed from all records, the agreement is very close

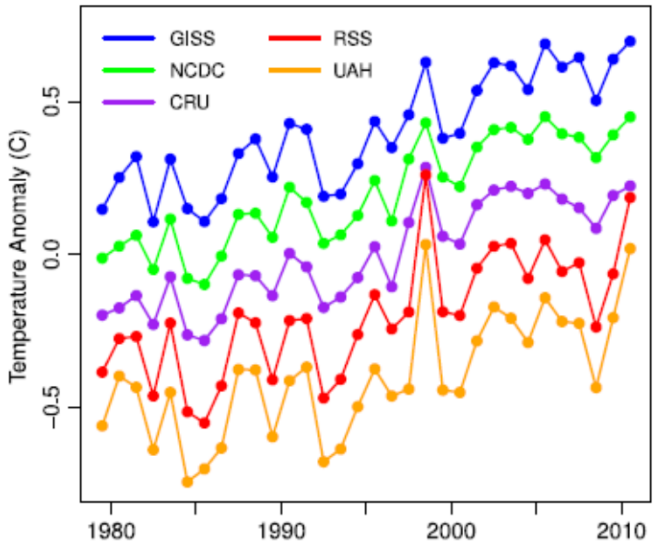


Figure 1. Five major global temperature records.

Curves offset by 0.2˚C

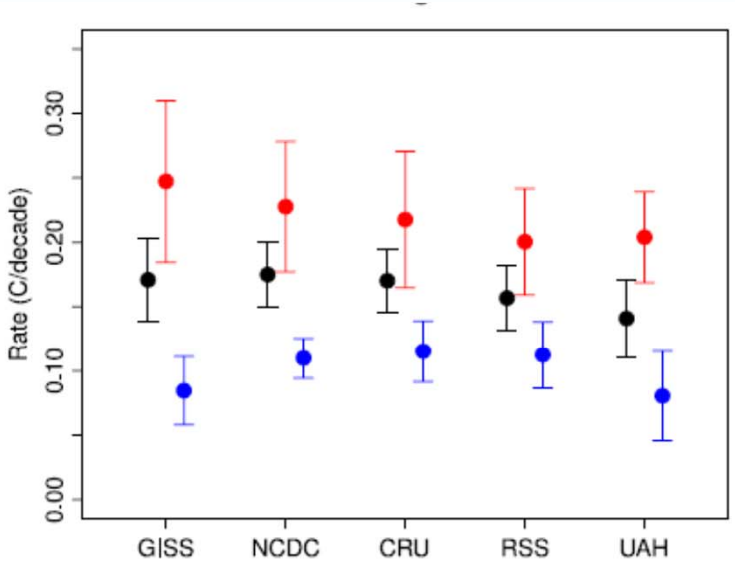


Figure 2. Estimated warming rates. Black dots are for global temperature, red for the northern hemisphere, blue for the southern hemisphere. Error bars are 2-σ.

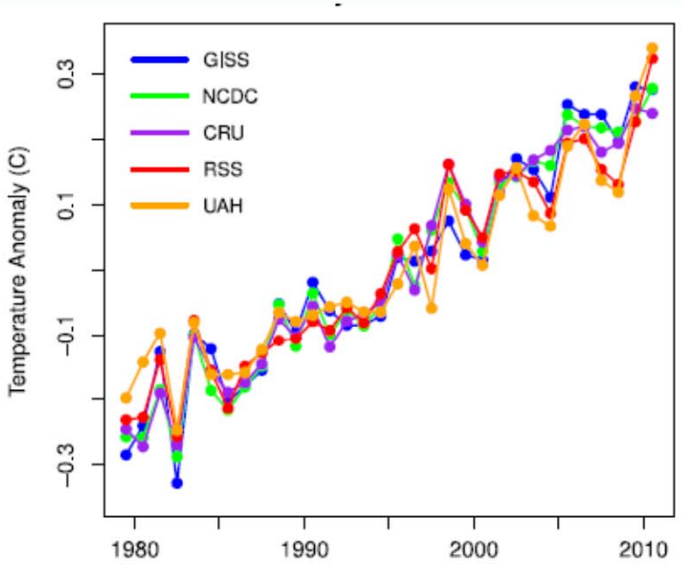


Figure 5. Annual averages of the adjusted data.

Foster and Rahmstorf (ERL, 2011)

Available at www.ncdc.noaa.gov/cmb-faq/anomalies.html.
Available at www.cru.uea.ac.uk/cru/data/temperature/#datdow.
Available at www.remss.com/msu/msu data description.html#zonal anomalies.
Available at http://vortex.nsstc.uah.edu/public/msu/t2lt/uahncdc.lt.
Available at www.esrl.noaa.gov/psd/people/klaus.wolter/MEI/table.html.
Available at http://data.giss.nasa.gov/modelforce/strataer/.

Ensuring a high quality Australian temperature record

Changes in the location of a weather station and other factors can introduce artificial biases in the surface temperature record. The raw data are adjusted to correct for these factors, e.g. by comparison to nearby reference stations with reliable records.

Note that:

1. The size of the trend in Australian mean temperature is large when compared to estimates of natural variability — and this holds true regardless of which historical reconstruction is used (eg, ACORN-SAT (adjusted), AWAP (unadjusted), NASA-GISS, HadCRUT etc).

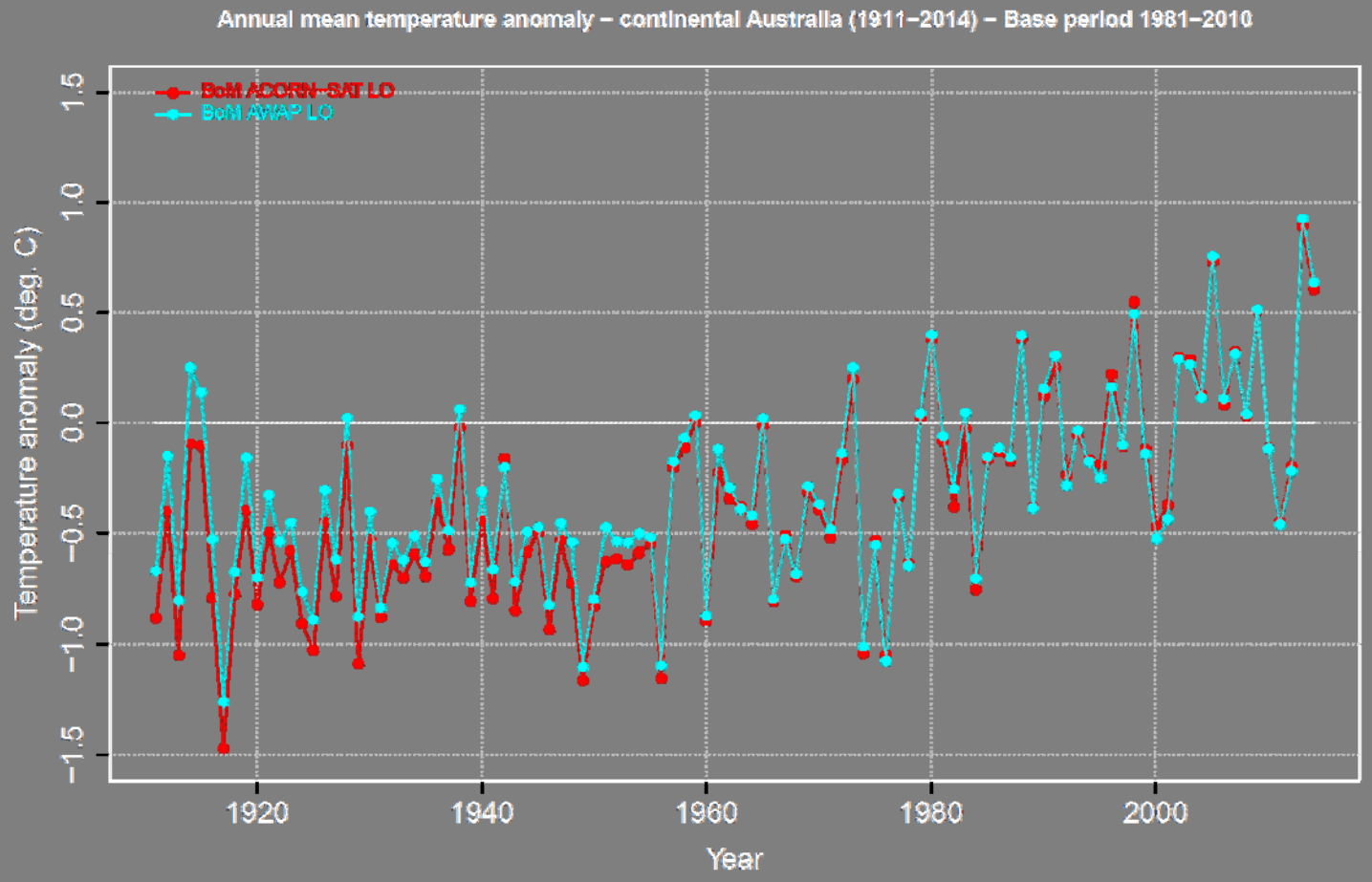
2. The size of the trend is large compared to the uncertainty estimates for annual values of Australian mean temperature.

3. The various methods of preparing the data show the most differences in the early part of the record, and this is a result of the sparser observing network at that time.

4. Two independent expert reviews, one international and one Australian (organized by the federal government) have found that the Bureau's practices in preparing temperature data are sound, and amongst the best in the world.

More information can be found at: http://www.bom.gov.au/climate/change/acorn-sat/#tabs=FAQs

Adjusted versus unadjusted Australian-mean annual temperature

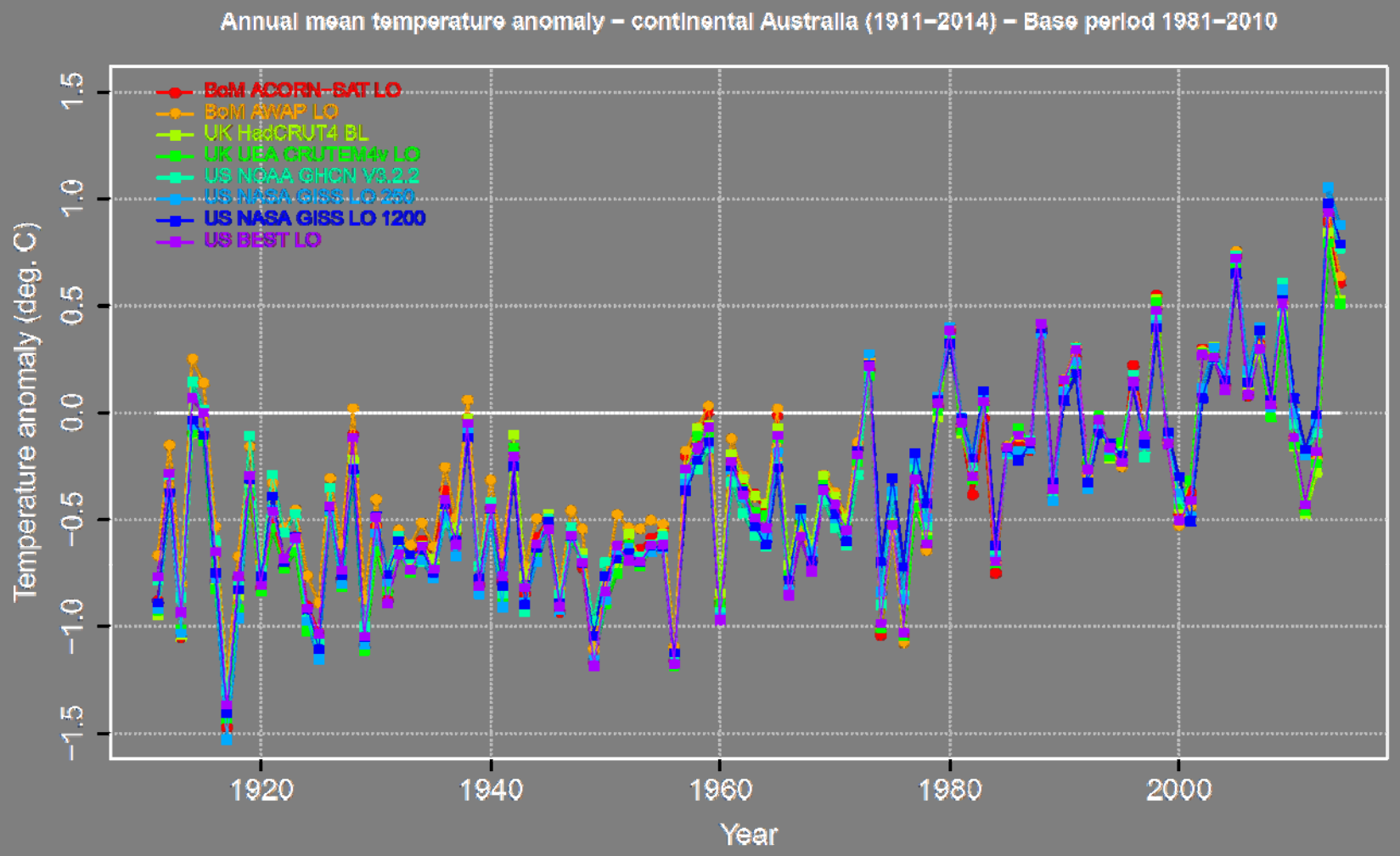


The differences are mainly in the early period of record, when the observing network is sparser.

There is no scientific reason for believing that unadjusted temperatures are more accurate.

The opposite is true.

Australian-mean annual temperature trends estimated from multiple independent methods and networks



Homogenisation has *reduced* the overall trend in global-mean surface temperature

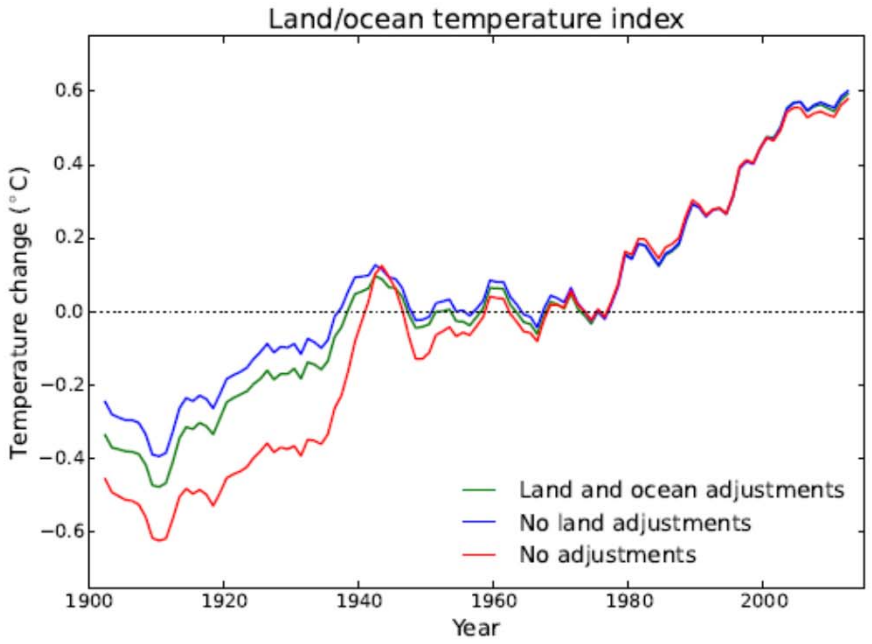


Figure 2.2: The impact of homogenization of land data alone and of both land and ocean data. Land temperature data from GHCN, sea surface temperatures from HadSST3 (Kennedy, Rayner, Smith, Parker, & Saunby, 2011).

Cowtan (2015)

Paper available here: http://www-users.york.ac.uk/~kdc3/papers/homogenization2015/homog.pdf

Computer code available here: http://www-users.york.ac.uk/~kdc3/papers/homogenization2015/methods.html