

Mr Grant Harrison
Secretary
Joint Standing Committee on Treaties

Dear Mr Harrison

Further to my letter of 25 August and with apologies for the lateness, I enclose a Bureau of Meteorology submission to the Committee's Inquiry into the Kyoto Protocol.

I also confirm telephone arrangements that the Bureau will be represented at the hearing in Melbourne on 13 September by:

Dr Susan Barrell (Executive and International Affairs Branch)
Ms Mary Voice (National Climate Centre)
Dr Bryant McAvaney (Bureau of Meteorology Research Centre)

I apologise for the inability to participate myself. I have been committed since some weeks ago to giving a National Press Club presentation on greenhouse in Canberra on the same day.

Yours sincerely

(J W ZILLMAN)
DIRECTOR OF METEOROLOGY

6 September 2000

JOINT STANDING COMMITTEE ON TREATIES INQUIRY INTO THE KYOTO PROTOCOL

SUBMISSION BY THE BUREAU OF METEOROLOGY

SUMMARY

The scientific basis for expecting global warming as a result of increasing atmospheric concentrations of greenhouse gases is well understood and widely accepted in the relevant expert scientific community.

It is virtually certain that the world has warmed significantly over the past century and there is now a high level confidence in the expert climate community that at least a large part of the observed warming is due to the enhanced greenhouse effect. While alternative explanations for the observed warming (and other observed changes in climate) have been examined and may have made some contribution, it is now considered unlikely that they have been of more than minor significance relative to greenhouse warming.

While presently unforeseeable influences such as a period of sustained volcanic activity or the onset of major instabilities in ocean circulation or the Antarctic ice sheet cannot be entirely ruled out, these are currently seen by the scientific community as very low probability events and the main influence on global climate over the next century is considered almost certain to be the enhanced greenhouse effect resulting from the continued build up of atmospheric concentrations of greenhouse gases. Year to year fluctuations will still be dominated by natural climate variability, including the El Niño and Southern Oscillation phenomena. Although it is not possible to predict the magnitude of the future global warming (or other associated changes of climate) in the absence of confident knowledge of future emissions, the expert science community are able to provide fairly confident projections of future warming for any of a wide range of greenhouse gas emission scenarios.

The Intergovernmental Panel on Climate Change (IPCC) which was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) is aimed at providing governments with the most informed, up-to-date and objective assessment possible of the current state of knowledge of the science of climate change. The IPCC is not a particular group of scientists, it is not a research organisation and it has no policy agenda. It is an intergovernmental mechanism which is designed to enlist the expert scientific community to produce balanced and widely credible assessments of the science in an understandable and policy-relevant form. Although still widely seen as an experiment in science-policy interaction, the experience so far suggests that the IPCC process is capable of providing a fully objective view of the science. The IPCC's Third Assessment Report on the science of climate change, is due for finalisation in January 2001.

INTRODUCTION

The Commonwealth Bureau of Meteorology is the National Meteorological Service for Australia with responsibility under the Meteorology Act 1955 (Attachment A) for observation, understanding and prediction of Australian weather and climate. Its staff includes some 300 professional meteorologists with expertise in climate science and it operates both the National Climate Centre (NCC) which is responsible for continuous monitoring of the state of Australia's climate and the Bureau of Meteorology Research Centre (BMRC) which includes, inter alia, internationally recognised experts in both the monitoring and modelling of long term climate change.

2 The Director of Meteorology is the Permanent Representative of Australia with the World Meteorological Organization (WMO), the UN organisation which established and cosponsors (with UNEP) the Intergovernmental Panel on Climate Change (IPCC). He is also the representative of the SW Pacific on the 8-member Bureau of the Science Working Group of the IPCC and a member of the writing team of the Summary for Policymakers of the IPCC's forthcoming Third Assessment Report (TAR).

3 Bureau of Meteorology officers have participated in all sessions of the Conference of the Parties (COP) to the Framework Convention on Climate Change (FCCC) in their capacity as experts on climate science, as well as at all sessions of the COP Subsidiary Body for Scientific and Technological Advice (SBSTA).

4 In its role as the national climate authority since Federation, the Bureau of Meteorology:

- maintains an ongoing record of the state of the Australian climate (eg see the Annual Climate Summary for 1999 at Attachment B);
- carries out research into the mechanisms and behaviour of Australian and southern hemisphere climate (eg see pp 18-23 and 33-35 of Attachment C);
- provides overall coordination of Australian linkages to and participation in the global climate observing, research and application programs of the World Meteorological Organization (eg see the recent issue of 'Climate Activities in Australia 1999' at Attachment D).

5 Against this background, the Bureau is pleased to offer a short submission providing a factual status report on the current state of climate change science as it relates to that part of the Committee's second term of reference that deals with "the veracity of conflicting current scientific theories on global warming...".

SCIENTIFIC BACKGROUND

3 It is assumed that the Committee is aware of the general meteorological background on the mechanisms of climate and the role of the so-called 'greenhouse effect' of the naturally occurring radiatively active trace gases such as carbon dioxide and methane in maintaining the earth's surface at temperatures some tens of degrees warmer than it would otherwise be. Although mathematically complex, the physical processes that maintain the three dimensional temperature structure of the atmosphere are generally well understood and reproducible with numerical models.

6 The particular mechanism that keeps the earth's surface relatively warm (about 15°C, globally averaged, compared with the -18°C that it would be if there were no atmosphere) relative to the much cooler atmosphere above can be explained, with little loss of rigour, in terms of the radiative 'blanketing' effect of a layer of greenhouse gases. Adding some more layers by increasing the greenhouse gas concentrations makes the surface warmer but at some point the surface heat is all 'trapped' and adding more and more 'layers' makes only a very small additional difference. Among the many simple diagrammatic explanations of the mechanism of the greenhouse effect is that in the box on page 10 of the 1995 Australian Joint Academies Report on Climate Change Science at Attachment E.

7 It is also assumed that the Committee is aware of the most recent authoritative international scientific assessment of the state of knowledge of climate change science, the 572 page 1995 Second Assessment Report (SAR) of the IPCC, the Summary for Policymakers of which is at Attachment F. Attachments E and F represented the 'state of the science' at the time of negotiation of the Kyoto Protocol.

8 The international climate science community has been working since 1997 on the preparation of the IPCC's Third Assessment Report (TAR) the essential scientific content of which has been largely agreed amongst its lead authors but the Summary for Policymakers (SPM) of which will not be formally agreed and approved for release until January 2001.

9 A recently prepared (August 2000) attempt to summarise the current state of the science in terms that are broadly consistent with what seems likely to emerge from the IPCC TAR is at Attachment G.

TERMINOLOGY

10 It is important to realise that there are highly significant differences of terminology between the Climate Convention and climate science communities which, if not allowed for, can lead to unnecessary confusion in debates over the reality of climate change.

11 In the Framework Convention on Climate Change, "climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

12 To the climate science community and, in particular, in IPCC (Intergovernmental Panel on Climate Change) usage "climate change" refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change, in the IPCC meaning of the term, may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

13 It is similarly important to recognise the distinction (mostly adhered to in the scientific community) between 'global warming' which refers to an actual globally averaged increase in

temperature (from whatever cause) and ‘greenhouse warming’ which refers to the physical process through which increasing greenhouse gas concentrations are expected to cause surface temperature increases, other things being equal.

THE ISSUES

14 The scientific questions involved in assessing ‘the relevance of conflicting current scientific theories on global warming’ can be formulated from either of two perspectives:

- (1) The existence of global warming over (say) the past century can be taken as an established (ie observed) fact with the question then becoming how to explain the observed warming and in particular, how to determine whether it is due to natural processes or whether it is due to the enhanced greenhouse effect or some other human influenced process;
- (2) The scientists’ assertions that the enhanced greenhouse effect of increasing atmospheric concentrations of radiatively active trace gases should be producing global warming can be tested by examining the records of the observed climate to see if the expected warming signal can be identified and unambiguously attributed to the enhanced greenhouse effect.

15 Both perspectives have been adopted in recent scientific and public debates and both represent valid approaches to the science of the issue. To facilitate consideration from either perspective, some summary information on the current international scientific perspective will be provided below on each of the following:

- (3) the evidence for global warming in the observed records over the past century;
- (4) the scientific basis for expecting global warming from an enhanced greenhouse effect;
- (5) the basis for attributing the observed warming to the enhanced greenhouse effect;
- (6) the possibility that the observed warming could be due to some influence or influences other than an enhanced greenhouse effect;
- (7) the objectivity and integrity of the process through which the forthcoming IPCC assessment is being carried out.

EVIDENCE FOR GLOBAL WARMING

17 The observational evidence that global mean surface temperature has risen over the past century is overwhelming. Some charts which summarise the essential data both globally and for Australia are shown in Figures 1 and 2. While there are various other independent compilations of the global data, each using slightly different approaches to allow for the effects of missing, erroneous or unrepresentative observations, all analyses lead to the same conclusion that although the rate of warming has not been uniform the average global surface air temperature has increased by approximately 0.6°C (± 0.2°C) over the past century.

18 Some elaborative comments can be offered:

- (1) It is virtually certain that the observed warming is not due to the contamination of the record by local effects such as the so-called urban heat island effect;

- (2) Alleged inconsistencies between the fairly large surface warming trend and a weak or non-existent warming trend evident in lower tropospheric (ie the layer 1.5 to 8 km above the surface) satellite data do not in any way invalidate the surface trend for several reasons:
- (1) the satellites are ‘measuring’ the temperature of a different layer of the atmosphere from the human observers - at levels where the warming trend would be expected to be different;
 - (2) the length and continuity of the satellite record are not sufficient to confidently identify any long term trends.
- (8) The warming trend that is clearly evident in Figures 1 and 2 is neither spatially uniform (some small areas of the globe have cooled over the past century) nor is it equally evident in day-time maximum and night-time minimum temperatures. For the most part night time minima have risen faster than day-time maxima. The spatial pattern of change of both maximum and minimum temperatures over Australia over the past 90 years are shown in Figure 3.

SCIENTIFIC BASIS FOR EXPECTING WARMING

19 While intuitive considerations clearly suggest that if the greenhouse effect makes the earth’s surface some tens of degrees warmer than it would otherwise be, a stronger greenhouse effect would make it warmer still, allowance has to be made for the many (positive and negative) feedbacks and thresholds in the global climate system. The only feasible approach for predicting what should be the result of an enhanced greenhouse effect is to simulate the process through scientifically based and validated models of the global climate system.

16 The methodology of the modelling process for ascertaining the effects of additional greenhouse gas concentrations is shown schematically in Figure 4, the observed increase of carbon dioxide over the past century which would be expected to lead to warming is at Figure 5 and one model’s estimates of the warming trends that would be expected are shown in Figure 6. Evaluations of coupled climate models, both through the IPCC process and through other inter-comparison experiments, confirm the increasing credibility with which the models can simulate climate on continental scales but highlight continuing uncertainties in regional scale modelling.

17 Despite uncertainties about the strength of some of the ‘feedbacks’ that operate in the global climate system and are built into the models, all the scientifically sound and credible global climate models developed in the past few decades indicate the virtual certainty of a significant contribution to global surface warming from increasing greenhouse gas concentrations. However the warming:

- (9) would not be expected to be spatially uniform over the globe;
- (10) could be offset to some extent by cooling agents such as sulphate haze or dust veils from volcanic eruptions;
- (11) would be expected to leave a characteristic ‘fingerprint’ on the structure of the atmosphere including especially a significant cooling in the stratosphere.

ATTRIBUTION OF THE OBSERVED WARMING

19 Five years ago, at the time of the IPCC Second Assessment Report, a considerable scientific controversy developed over the level of confidence with which the observed global mean warming (which virtually all reputable scientists accept as ‘real’) can be attributed to the enhanced greenhouse effect of the observed increased carbon dioxide (and other greenhouse gas) concentrations in the atmosphere. The applications of a range of established signal detection techniques to the global warming data (and other characteristics of the observed changes in climate over the past century) suggested the high probability of cause and effect relationship but the final IPCC formulation for Policymakers was that ‘The balance of evidence suggests a discernible human influence on global climate’.

20 Over the past five years, the linked scientific problems of description of the global warming trend (and other changes in climate) and its explanation in physical terms have been investigated much more extensively and it is now fairly widely (though still not universally) believed in the expert scientific community that it is highly likely that most, if not all, of the observed warming is due to the enhanced greenhouse effect. Experiments with the best climate models now available which allow for the enhanced greenhouse effect and a range of other modifying influences (such as the offsetting cooling effects of sulphate aerosols, fluctuations in the incoming energy from the sun and so on) have been able to ‘predict’ the observed pattern of global warming extremely well, eg see Figure 6.

21 Although some scientists are yet to be fully convinced that the cause and effect relationship has been established beyond doubt, the vast majority accept that the evidence for the link is now much stronger than five years ago.

THE POSSIBILITY OF OTHER EXPLANATIONS

22 Among the other possible explanations (ie other than greenhouse warming) that have been advanced for the observed global warming are the following:

- (1) The urban heat island effect: that the warming in the observational records is not a large scale global warming, but rather the contamination of the observations by the local effects of city build-up etc, near the observing stations;
- (2) Changes in solar radiation: that the observed warming is ‘real’ but is due to increased input of energy from the sun;
- (3) Natural internal variability of the climate system: that the steady warming trend in the second half of the twentieth century is simply the rising limb of a natural century or longer time scale fluctuation of the coupled atmosphere-ocean climate system - essentially a continuing manifestation of ‘recovery’ from the ‘Little Ice Age’ of the 14th to 18th centuries;

26 All of these possible explanations have been very carefully examined by the scientific community through the general climate research literature and as part of the IPCC assessment process. The present assessment of each may be summarised as follows.

Urban Heat Island and related effects

23 The urban heat island effect is undoubtedly real, but great care has been exercised in excluding stations whose records might be contaminated by local warming or other non-representative effects from the global database. The fact that broadly similar warming trends are evident in both land and sea surface temperature (and other proxy) data adds weight to the belief that the global temperature data sets are genuinely representative.

24 One line of argument used in support of the proposition that the observed warming is not real has been based on an apparent inconsistency between the observed surface warming and the temperature trends that have been detected from satellite sensing of the lower half of the atmosphere over the past twenty years. The satellite data have been interpreted as suggesting little or no significant warming. The ‘discrepancy’ has not yet been fully reconciled. However:

- (12) the two sets of measurements are not measures of the same thing (surface versus lower troposphere) and, given that greenhouse warming should decrease with height in the atmosphere and change to cooling around 10-15km, they would not be expected to be the same;
- (13) there are many uncertainties in the satellite data, not least due to the fact that they derive from a number of different satellites and absolute calibration of the individual satellite sensors has not been possible;
- (14) the period of observation since 1979 is too short to separate out the expected long term warming ‘signal’ from the ‘noise’ of natural variability.

25 While the remaining discrepancies remain the subject of intense study, the weight of international scientific opinion is that the satellite data do not significantly reduce the high level of confidence in the reality of the observed surface warming.

Changes in solar output

26 While there is no doubt that the earth’s climate responds sensitively to changes in incoming energy from the sun and that past changes in climate on the time scales of tens to hundreds of thousands of years can be linked to changes in solar energy input, the changes in incoming solar energy over the past hundred years or so appear to have been far too small to be able to explain any significant part of the observed warming.

27 Earlier studies that linked the warming to changes in the length of the solar cycle have not stood up to subsequent scientific scrutiny and have been largely discredited.

Natural variability

28 A great deal of research has been carried out over the past 5-10 years using both long term instrumental data and paleo data (eg from tree rings and ice cores) to gain a better estimate of how large the natural variability of global climate system might be on the time scales of interest in the context of greenhouse warming. The natural variability results from internal processes in the dynamics of the atmosphere and ocean as well as influences such as the cooling effect of stratospheric dust veils from volcanic eruptions. It can be simulated and studied in climate models.

29 While the possibility cannot be totally discounted that the observed warming is due to some, as yet, unrecognisable source of large scale, long term, natural fluctuations in the climate system, the very strong scientific consensus emerging among the scientists involved in the preparation of the IPCC TAR is that it is highly unlikely that the observed warming can be explained through natural variability.

INTEGRITY OF THE IPCC ASSESSMENT PROCESS

30 The Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (the UN Specialised Agency for meteorology and operational hydrology) and UNEP in 1988 as a mechanism for providing broadly-based and objective assessment of the current state of knowledge of the science, impacts and response options for human-induced climate change.

31 The IPCC is not a research organisation, it is not a particular group of scientists and it does not have a policy agenda. It is a mechanism for making the considered results of scientific research into climate change accessible to the policy community in an intelligible and useable way. To the extent that it has no precedent in international science-policy interaction, it is still viewed as an experiment. Its nature and modus operandi may be understood in terms of the charts at Figures 7-10.

32 Figure 7 shows the IPCC as an intergovernmental body established by two UN system agencies (WMO and UNEP) as an interface between the international climate research and monitoring work of the World Climate Programme (and other related research programmes under both governmental and non-governmental sponsorship) on the left and the political processes of the FCCC on the right. The IPCC itself is thus an intergovernmental body managed by Member Governments working according to UN system rules (eg that every country has an equal voice) to reach decisions. Its Bureau of 30 is elected, partly on a country basis and partly on the basis of personal expertise. Its three working groups are intergovernmental bodies with decisions taken in formal intergovernmental sessions.

33 Figure 8 shows that the work of the three working groups (and an additional task force on invention) is based on the work of individual scientific experts as contributors, authors and reviewers.

34 The main steps in the preparation of an IPCC Assessment Report are as follows:

- (1) Countries and participating international organisations are invited to put forward the names of scientists who are expert in the subject of the assessment who might be considered for the role of Lead Author, Contributing Author or Reviewer;
- (2) The Bureau of the IPCC or the appropriate Working Group reviews all the available nominations (usually some thousands) and assembles proposals for a team of Lead Authors (typically 150) with a balance of background, expertise, country of origin etc. After an intensive process of review this is formally approved by the Working Group;
- (3) The Lead Authors prepare the draft assessment on the basis of the available literature and input from all scientists who are willing to contribute (typically up to 2000). The draft material goes through at least two rounds of expert peer review and at least one round of review in which IPCC member governments provide comment on the draft report. The

Lead Authors are bound to consider and respond to all comments but the judgement on which suggestions they accept remains theirs (albeit Review Editors must satisfy themselves that all comments have been properly considered).

35 The draft IPCC report is then submitted for approval and acceptance by IPCC governments in formal session. The approval/acceptance process takes place at several levels as follows (cf Figure 9 which indicates the structure of the forthcoming Third Assessment Report).

- (1) The Working Group negotiates line by line the text of a 5-8 page 'Summary for Policymakers' (SPM) on the understanding that negotiated text is only approved if the Lead Authors certify that it is consistent with the science in the body of the underlying report. The negotiated text is approved by consensus with various mechanisms put in place for ensuring the transparency of the process and the balance of the text in situations where complete consensus is unachievable;
- (2) Once the SPM has been approved, the Working Group 'accepts' a 30-50 page Technical Summary and the underlying scientific report on the understanding that it is still fully the work of the Lead Authors but that they will incorporate any changes needed to bring the text into line with any statements that they have agreed to in the approved SPM;
- (3) In the case of major assessment reports, such as the forthcoming Third Assessment Report (TAR), there may be a fourth level of integration through a Synthesis Report as shown in Figure 9.

36 The various steps in the process are shown in Figure 10 for the Science Working Group preparation of the Third Assessment Report.

37 The IPCC assessment process is aimed at providing policymakers with an objectively and transparently prepared statement of current scientific knowledge focussed on the points on which there is widespread scientific agreement but highlighting also the areas where there are different views and where the state of knowledge is considered inadequate. Although some Working Group and Panel sessions have been characterised by intensive negotiations in which one or more governments have argued from what appeared to be a national interest rather than scientific perspective, the IPCC working procedures have so far succeeded in ensuring that the end products remain scientifically objective documents.

38 In summary, experience so far suggests that the IPCC processes are sufficiently robust and sufficiently widely acceptable to ensure the integrity and objectivity of the content of IPCC Assessment Reports.

List of Attachments to Bureau of Meteorology Submission (sent under separate cover)

Attachment A The Meteorology Act 1955

Attachment B Annual Climate Summary 1999

Attachment C Researching Sea and Sky (Bureau of Meteorology Research Centre)

Attachment D Climate Activities in Australia 1999

Attachment E Climate Change Science: Current Understanding and Uncertainties

ment F Summary for Policymakers, Climate Change 1995 – The Science of Climate Change

ment G The Science of Climate Change: An Update (J W Zillman, 2000)