Submission to the

House of Representatives Industry, Science and Innovation Committee

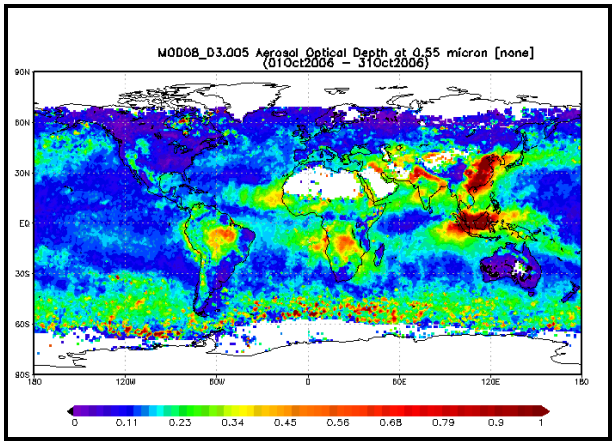
Inquiry into Long-term Meteorological Forecasting in Australia

by

Keith Potts

Particulates

(Solid and/or Liquid Particles Suspended in the Atmosphere)



Two Images showing Particulates in the Atmosphere

Left from the NASA Terra satellite shows the particulates plumes in the atmosphere Note the two large plumes to the north of Australia in October 2006.
(Blue denotes low to zero particulates, yellow and red high particulate loadings)

Right from the USA Geological Survey shows the eruption of Mount Pinatubo which ejected an estimated 11 cubic kilometres of tephra into the atmosphere.
(Tephra is defined as the material explosively ejected into the atmosphere & includes particulates)

CONTENTS

Executive Summary

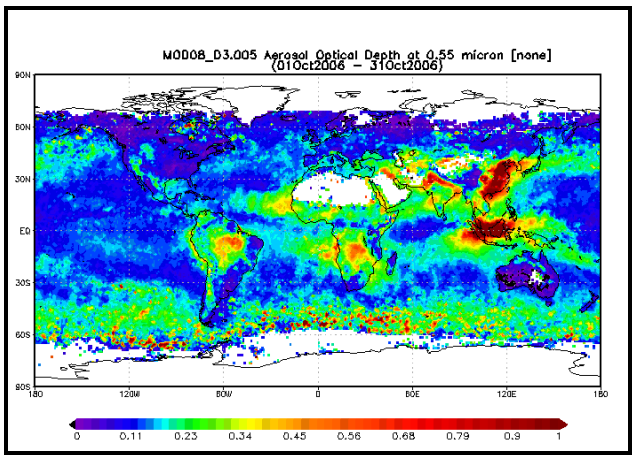
Based on my research papers, presented at the AGU Fall Meeting in San Francisco 2008 [1] and the AMOS meeting in Melbourne in 2009 [2], and reports from the Intergovernmental Panel on Climate Change (IPCC) and the USA Climate Change Science Program (CCS Program) which reports to the President and Congress in that country I submit that:

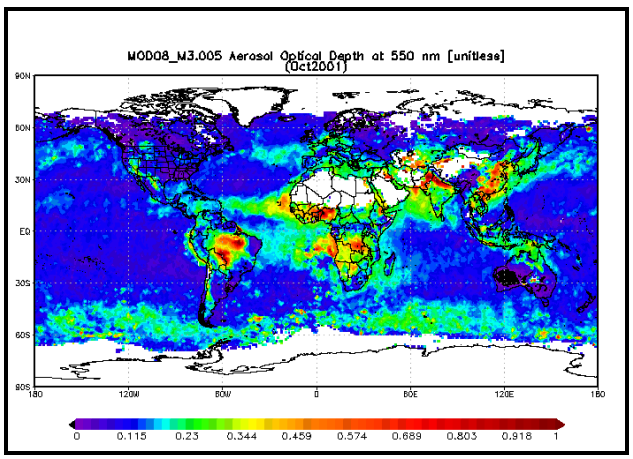
- Climate models do not currently represent accurately the combined effects of carbon dioxide and continental scale particulate/smoke plumes on the global and regional climates as the sensitivity of the models to changes in these agents varies significantly (CCS Program) and many models do not include all particulate/smoke species (IPCC fourth assessment report). Hence any forecast made using such models may be inaccurate even if they have reproduced the global temperature change during the twentieth century (CCS Program). **Reliance on such forecasts is therefore at least questionable and at worst fatally flawed.**

- Particulates in the atmosphere (commonly smoke from agriculture, deforestation, industry and volcanoes) are now understood to have large effects on the global and regional climates. Australia is just to the south of Indonesia and Papua New Guinea, the most intense source of volcanic particulates in the world and also one of eight major sources of biomass burning and other anthropogenic particulates/smoke. It is now relatively easy to demonstrate a connection between the particulate plumes over this area and drought in south eastern Australia. **Efforts should therefore be immediately made to implement programs to reduce the emission levels of biomass burning particulates to the north of Australia which have a far greater effect on our rainfall than carbon dioxide ever will.**

I enclose two images from the NASA Giovanni system [3] which shows the particulate plumes to the north of Australia in October 2006 (left image) as the red, yellow and green area over Indonesia, Papua New Guinea and China, a month when little or no rain fell in south eastern Australia and, in contrast, data from October 2001 (right image) when there were lesser plumes and no drought.

In the appendix I have also included two sets of images, one showing the evolution of the continental scale particulate plumes over a single year and the second showing the inter annual variation of some plumes. Both sets of images are referenced to Table 2 in the appendix which lists the eight continental scale particulate plumes which now occur each year.





Scope of this submission

This submission addresses items 1, 2 and 5 of the Terms of Reference of the Inquiry, and commences with some background information on myself and particulates in the atmosphere.

Background

I am a geophysicist and, at my own expense over the last three years, I have been researching the effects of continental scale particulate plumes on regional climates. I have presented two research papers on the subject at the AGU conference in San Francisco in December 2008 and at the AMOS conference in Melbourne in February 2009. NASA defines particulates as "solid and/or liquid particles suspended in the atmosphere". They are referred to in some technical reports as "aerosols". My research demonstrates that such particulate plumes have a significant effect on the climates of Australia, Europe, the Sahel and the Arctic. The Member for Barker, Patrick Secker MP, was kind enough to table a report I wrote on the subject in the House of Representatives on February 19th 2008 which you will, no doubt, be able to access.

United States Climate Change Science Program

Since writing the report for Mr Secker a new series of reports to the President of the USA and the Congress have become available from the United States Climate Change Science Program ("CCS Program"). The CCS Program has, inter alia, addressed the effects of particulates on regional and global climates and has come the same conclusions as I have:

- ***That the IPCC reports have focused largely on the long-lived greenhouse gases;***
- ***That particulates have a significant effect on the climate and are a major driver of climate change;***
- ***That particulate distribution is highly inhomogeneous at the global and annual scales and particulate effects cannot therefore be assessed using simple global averages;***
- ***That climate change forecasts using current climate models may be inaccurate.***

I note here that the IPCC states that most models used for their Fourth Assessment Report do not include carbonaceous particulates which, I would suggest, renders their modelling worthless in the Australian context as the plume shown in the executive summary in the October 2006 image over Indonesia is mainly composed of carbonaceous particulates from biomass burning caused by deforestation.

The CCS Program reports are written for the non-scientist and provide an excellent foundation on the science of climate change and particulates. The CCS Program web site is at:

http://www.climatescience.gov/

with two reports which focus on particulates available at:

Report 3.2 - Atmospheric Aerosol Properties and Climate Impacts

http://www.climatescience.gov/Library/sap/sap3-2/final-report/sap3-2-final-report-all.pdf

Report 2.3 - Climate Projections Based on Emissions Scenarios for Long-Lived and Short-Lived Radiatively Active Gases and Aerosols

http://downloads.climatescience.gov/sap/sap2-3/sap2-3-final-report-all.pdf

I commend both reports to you as easily readable reports from eminent scientists in the field which were recently delivered to the President and the Congress in the USA.

Particulates and Rainfall

Even the IPCC fourth assessment report released in 2007, which as the CCS Program reports focused on long lived greenhouse gases, states:

- ***"In particular, changes in aerosols*** [particulates] ***may have affected precipitation and other aspects of the hydrologic cycle more strongly than other anthropogenic forcing agents."***

Which raises the interesting question "If the IPCC states that particulates may have affected rainfall more than the other human induced agents including carbon dioxide – why are we focused on carbon dioxide as the only solution to drought in Australia?" You may like to investigate this further!

The CCS Program also states in report 3.2 in relation to particulates that:

- ***"by the year 2100 short-lived gases and particles may account for as much as 40 percent of the warming over the summertime continental United States"***
- ***"It is noteworthy that the simulated climate response to these pollutants is not confined to the geographical area where they are released."*** and
- ***"Changes in pollutant levels, primarily over Asia, may significantly increase surface temperature and reduce rainfall over the summertime continental United States."***

Since Australia is much closer to Asia than the USA the third point above should draw your attention to the need for an immediate investigation of the effects of Asian particulates on rainfall in Australia!

Late Winter and Spring Rainfall in South Eastern Australia

In south eastern Australia there has been a significant decrease in rainfall in late winter and spring in recent years. This rainfall deficit has had a serious effect on agriculture by destroying grain and other seed crops before they mature and are harvested. I am personally involved in the seed production industry as a director and chairman of Pristine Forage Technologies, a new technology start-up company which develops new plant varieties for broad acre agriculture. Our production of medic and balansa seeds for the production of forage crops in the wheat sheep zone has been severely impacted by this rainfall deficit in recent years.

As you will see below there is an explanation for this rainfall deficit which is not based on carbon dioxide levels which requires immediate attention.

Particulates and Surface Temperature Increases by Regional Dimming

I draw your attention to the little known fact that particulate plumes can also increase the regional surface temperature at great distances from the plume which is a totally counter intuitive result in that particulates reduce the level of solar radiation reaching the Earth's surface and would be expected to have a cooling effect. The CCS Program however states that

- ***by the year 2100 short-lived gases and particles may account for as much as 40 percent of the warming over the summertime continental United States***

My own research demonstrates that the particulate plume emanating from West Africa has a warming effect in Europe due to its modification of the global circulation system in its vicinity. This effect which I call Regional Dimming is also reported by the IPCC which states:

- ***"Simulations also suggest that absorbing aerosols, particularly black carbon, can reduce the solar radiation reaching the surface and can warm the atmosphere at regional scales, affecting the vertical temperature profile and the large-scale atmospheric circulation."***
- ***"Modelling studies and data comparisons suggest that mid- to high-latitude circulation patterns are likely to be affected by some forcings such as volcanic eruptions….."***

and the CCS Program:

- ***However, since aerosol forcing is much more pronounced on regional scales than on the global scale because of the highly variable aerosol*** [particulate] ***distributions, it would be insufficient or even misleading to place too much emphasis on the global average. Also, aerosol RF*** [Radiative Forcing] ***at the surface is stronger than that at TOA*** [Top of Atmosphere] ***, exerting large impacts within the atmosphere to alter the atmospheric circulation patterns and water cycle. Therefore, impacts of aerosols on climate should be assessed beyond the limited aspect of globally averaged radiative forcing at TOA.***

Such Regional Dimming causes an increase in temperature by modifying the large scale atmospheric circulation as suggested by the IPCC and CCS Program which results in anomalous persistent and static high pressure systems in the higher latitudes which alter the wind systems. In areas where the winds blow preferentially from the tropics due to the anomalous high pressure system the surface temperature rises as the wind is anomalously warm.

To demonstrate this, consider two days in Adelaide in summer, one day may be over 40 degrees and the next under 30. In these circumstances the sun is in effectively the same position and the only significant change is that on day one the wind blows from the tropical north and is hot and on day two the wind blows from the southern ocean and is cooler. Hence changing the wind systems can change the climate immediately and my research demonstrates that a plume such as that seen in the October 2006 image in the executive summary will produce an effect in south eastern Australia within a few days of its creation and will maintain that effect until it disappears or is extinguished.

Particulates and Population

A scan of the images in the appendix which show the evolution of the particulate plumes in 2006 shows that a majority occur in the tropics in South America, Africa and Asia. The emissions of particulates from these areas has increased significantly in recent decades as the UN statistics show that the population in these areas increased by a factor of three to four times since 1950 – resulting in more mouths to feed, more slash and burn tropical agriculture and therefore more particulates!

Responses to the Terms of Inquiry

1. The efficacy of current climate modeling methods and techniques and long-term meteorological prediction systems

2. Innovation in long-term meteorological forecasting methods and technology

I provide three quotes from the CCS Program reports which I believe to be accurate and which demonstrate that current long term climate modelling leaves much to be desired:

- ***"Despite a wide range of climate sensitivity (i.e. the amount of surface temperature increase due to a change in radiative forcing, such as an increase of CO2) exhibited by the models, they all yield a global average temperature change very similar to that observed over the past century."***
- ***"This agreement across models appears to be a consequence of the use of very different aerosol forcing values, which compensates for the range of climate sensitivity. For example, the direct cooling effect of sulfate aerosol varied by a factor of six among the models. An even greater disparity was seen in the model treatment of black carbon and organic carbon. Some models ignored aerosol indirect effects whereas others included large indirect effects. In addition, for those models that included the indirect effect, the aerosol effect on cloud brightness (reflectivity) varied by up to a factor of nine. Therefore, the fact that models have reproduced the global temperature change in the past does not imply that their future forecasts are accurate. This state of affairs will remain until a firmer estimate of radiative forcing by aerosols, as well as climate sensitivity, is available."***
- ***"The results reveal the necessity for explicit and consistent inclusion of the short-lived pollutants in assessments of future climate."***

I believe these quotations speak for themselves and would only emphasise that until such models are significantly improved to include all particulate species at adequate temporal (monthly) and geographic (5 degrees of latitude and longitude or less) resolution any major decisions such as the implementation of a carbon pollution reduction scheme based on their forecasts are at least questionable and at worst ill founded and without any credible scientific basis.

5. Strategies, systems and research overseas that could contribute to Australia's innovation in this area.

Just to the north of Australia is an area bounded by latitude 10S to 10N and longitude 90E to 160E and shown in green on fig 1 from Google Earth – the South East Asian Plume Area ("SEAP Area"). My research demonstrates that the anthropogenic particulate plume over the SEAP Area has a significant effect on late winter and spring rainfall in south eastern Australia and I provide Table 1 to demonstrate this noting that a more scientifically rigorous demonstration of the connection is presented in the report attached to this submission.

Table 1 shows the average rainfall in Adelaide from 1977 to 2007 during August to October – the months in which the anthropogenic South East Asian Plume exists and then shows the average rainfall in Adelaide in the three years since 2000 when the particulate levels in the SEAP Area were highest (2002, 2004 and 2006) and the rainfall in the years when the particulate levels were lowest (2000, 2001 and 2005). In the years when the particulate level was highest the total rainfall was 43% BELOW the long term average and in the years when the particulate level was lowest the total

rainfall was 44% ABOVE the long term average. The figures for October are even greater at -75% and +81% respectively as this is the month when the SEAP particulate plume is at its greatest Aerosol Optical Depth ("AOD" – the technical measurement of the quantity of particulates in the atmosphere) and geographic extent – just before the onset of the local wet season in the SEAP Area.

From this recent data which demonstrates a connection between drought in south eastern Australia and particulates in the SEAP Area it is then an obvious deduction that historic droughts in Australia, before the anthropogenic plume became so large and intense, might have been caused by the natural particulates ejected by volcanoes in the SEAP Area. The SEAP area is the most volcanically active area on the earth's surface with 17% of the volcanic eruptions since 1800 in 3% of the global surface area. The area also includes 33% of the continuously erupting volcanoes in the world over the last 30 years. I present:

> Figure 2: a Google Earth image with the Global Volcanism Program [4] overlay of volcanoes, each red triangle is one, or at this scale a group of, volcanoes;
>
> Figure 3: a scatter plot of the inflows into the River Murray [5] during April to October (the southern wet season) from 1892 to 2006 plotted against the volume of particulates (technically "tephra") ejected by the volcanoes in the SEAP Area in the same months which shows that as the level of particulates increases the inflows into the River Murray drop. In this plot the data is segmented by tephra level and then averaged for both tephra and inflows.

The Global Volcanism Program database of volcanic eruptions shows that there has been a 92% increase in volcanic eruptions in the SEAP area in the decade 2000 to 2010 between April and October relative to the average of the decades from 1920 to 2000 coinciding with a decade of significant drought in Australia.

Figure 3 demonstrates conclusively that particulates in the SEAP area affect rainfall and hence inflows into the River Murray in south eastern Australia as it is logically impossible to form any other conclusion since volcanoes erupt due to deep earth geological processes alone.

My research also demonstrates that volcanic particulates in the SEAP Area are the cause of historic El Nino events by changing the large scale atmospheric circulation systems, specifically the Walker Cell over the Pacific Ocean, and that anthropogenic particulate plumes in the same area together with an increase in volcanic and tectonic activity in the SEAP Area are therefore the cause of the recent spate of El Niño events.

Hence to provide improved long term meteorological forecasts it is essential that anthropogenic and volcanic particulates are incorporated into climate models. This will require some input data from Indonesia specifically which is responsible for much of the increase in anthropogenic particulates from August to November in the SEAP area due to rainforest clearing and therefore for the reduction in late winter and spring rainfall in south eastern Australia.

Conclusions

The recommendations from the CCS Program report 3.2 are to further investigate:

1. The projection of future human-caused emissions for the short-lived gases and particles;
2. The indirect and direct effects of particles and mixing between particle types;
3. Transport, deposition, and chemistry of the short-lived gases and particles;
4. Regional climate forcing vs. regional climate response;
5. Sensitivity studies of climate responses to short-lived gases and particles.

I suggest these recommendations be implemented forthwith in Australia as they are important in understanding climate change in Australia and two in particular are crucial:

2. The direct effects of particulates over Asia and south eastern Asia on rainfall in Australia on a monthly basis;

4. Climate forcing in the Australian region by particulates vs. the Australian regional climate response on a monthly basis.

Note that this research must be focused on a monthly time resolution as annual averaging, as used in the IPCC reports, will, as suggested by the CCS Program miss the devastating effects of these short term particulate plumes.

I have included my contact details at the end of this submission.

Further Evidence

Should the committee require more information I would welcome the opportunity to present the results of my research personally.

I have provided an update of the report tabled by Mr Secker with this submission.

Keith Potts
Adelaide
April 2009

Contact Details

Keith Potts,
4 Bowyer Crescent,
Cumberland Park,
South Australia 5041

Phone: (08) 8297 3274
Email: Keith.Potts@bigpond.com

Appendix

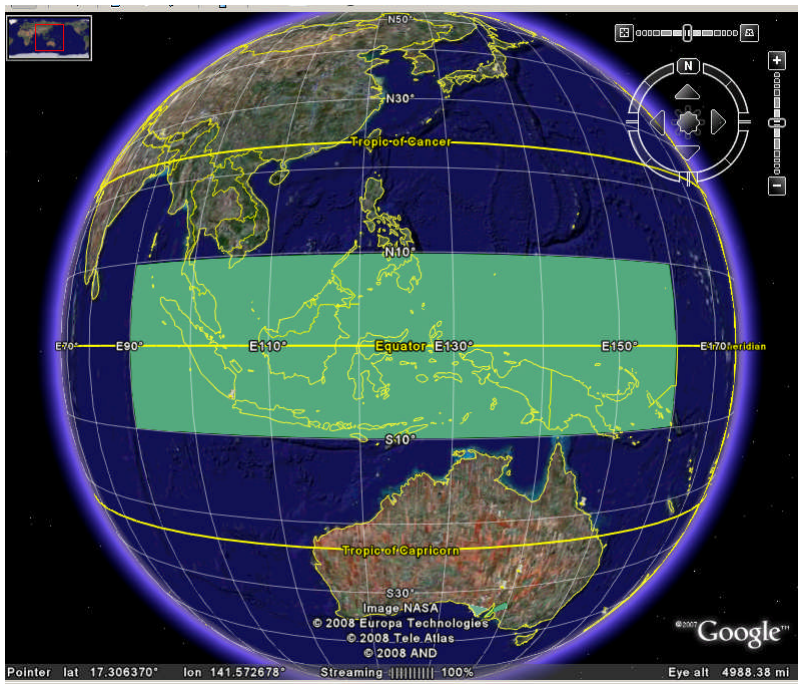


Fig One: South East Asian Plume Area – Google Earth

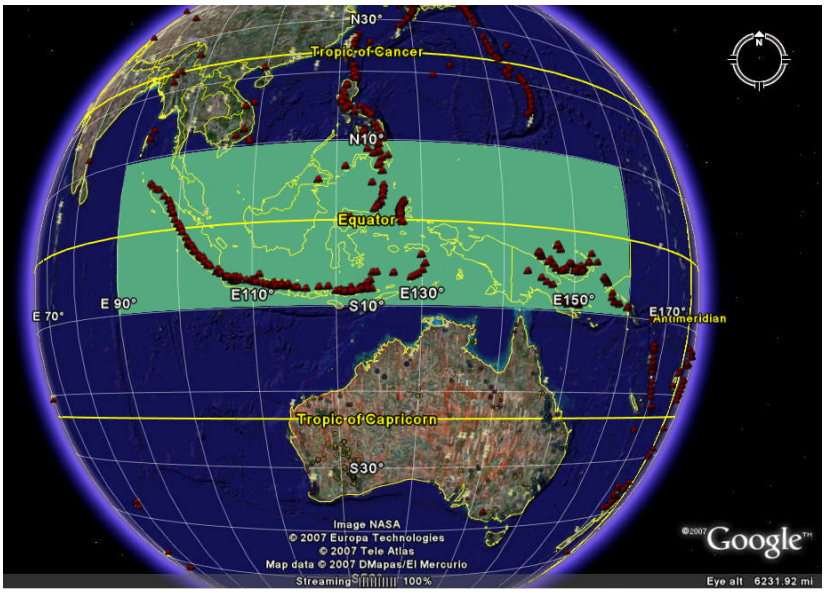


Fig Two: South East Asian Plume Area – Google Earth with the Global Volcanism Program overlay

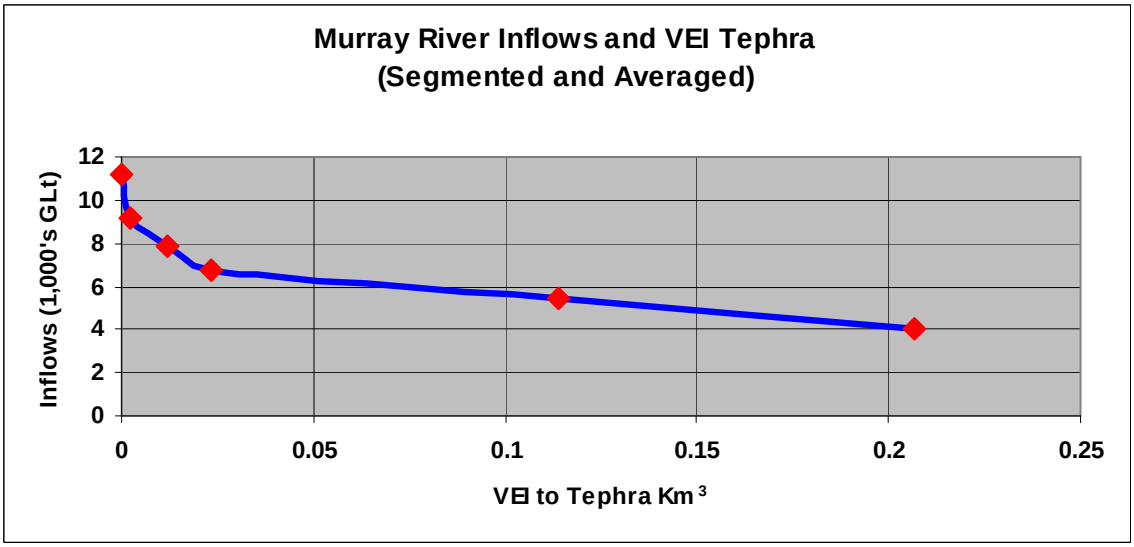


Fig Three: Volcanic Particulates (VEI to Tephra) in the South East Asian Plume Area – and inflows into the River Murray from 1892 to 2006. Data is segmented and averaged.

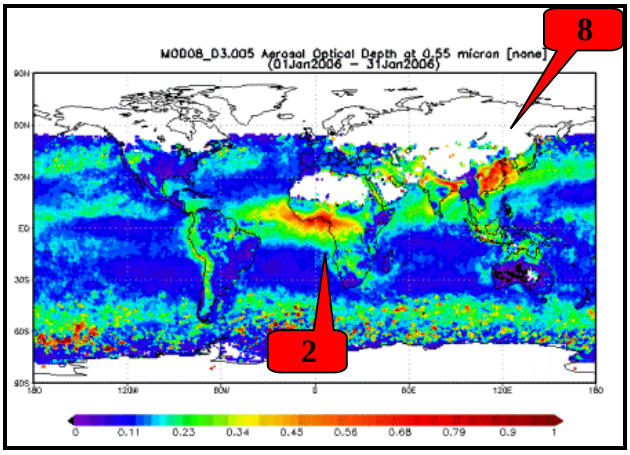
Rainfall mm	August	Sept	October	Total
Av 1977 to 2007	66	62	46	174
HIGH Oct AOD (2002, 2004, 2006)	44	43	11	99
Low Oct AOD (2000, 2001, 2005)	80	88	84	251
%age Difference				
HIGH Oct AOD (2002, 2004, 2006)	-34%	-30%	-75%	-43%
Low Oct AOD (2000, 2001, 2005)	20%	43%	81%	44%

Table 1: Rainfall Adelaide High Oct AOD and Low October AOD in the SEAP Area

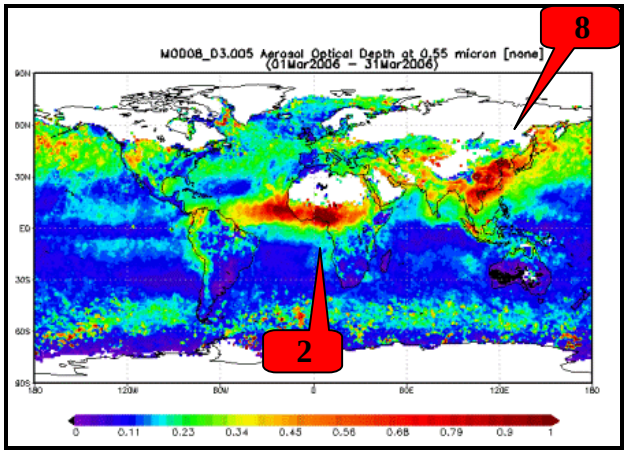
Plume Name/Location	Occurs
1. South American	August - November
2. West African	November - April
3. Mali / Chad	May - October
4. Central African	July - October
5. Middle East	May - October
6. India/Pakistan	May - October
7. South East Asian	July - November
8. East Asian	All Year

Table 2: The Eight Great Aerosol Plumes

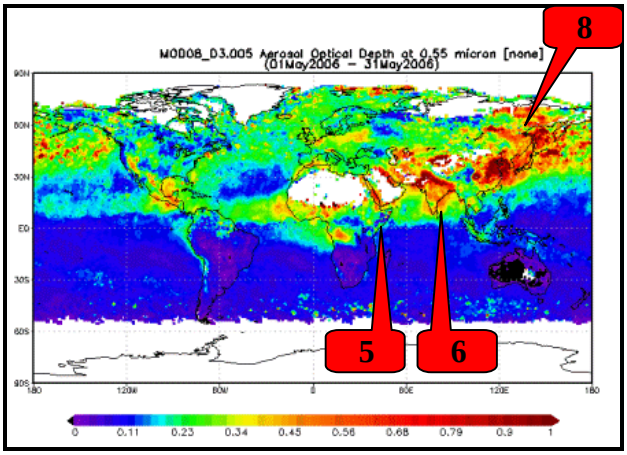
Evolution of the Global Particulate Plumes through 2006



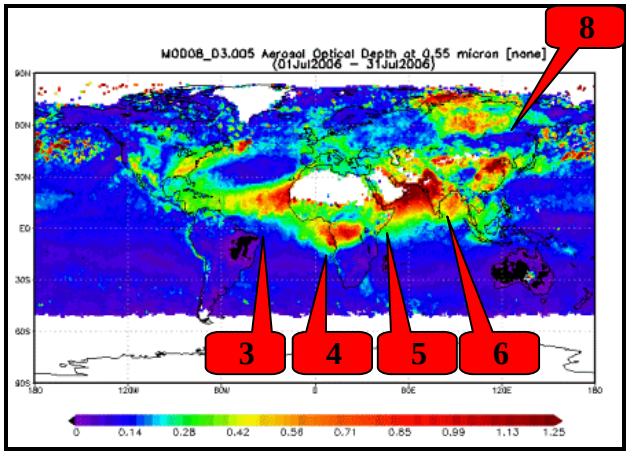
January 2006



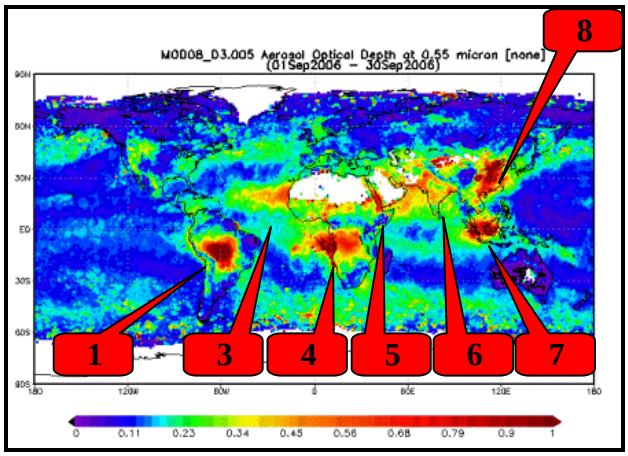
March 2006



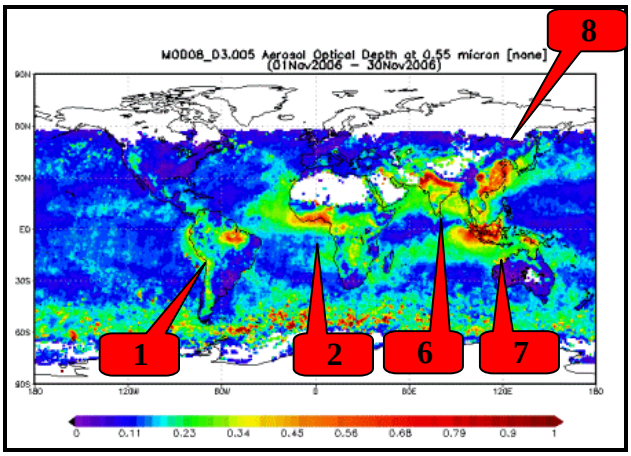
May 2006



July 2006



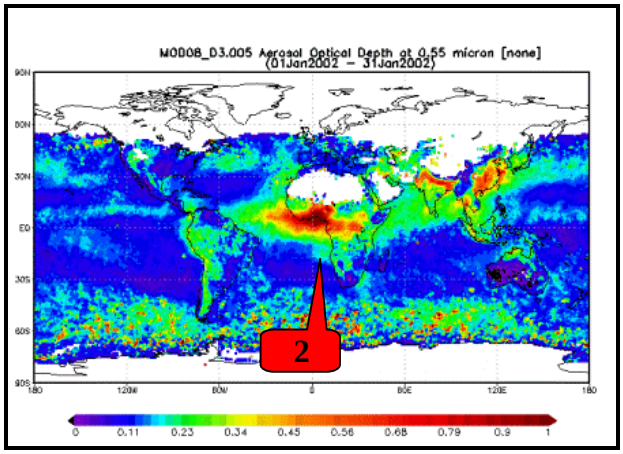
September 2006

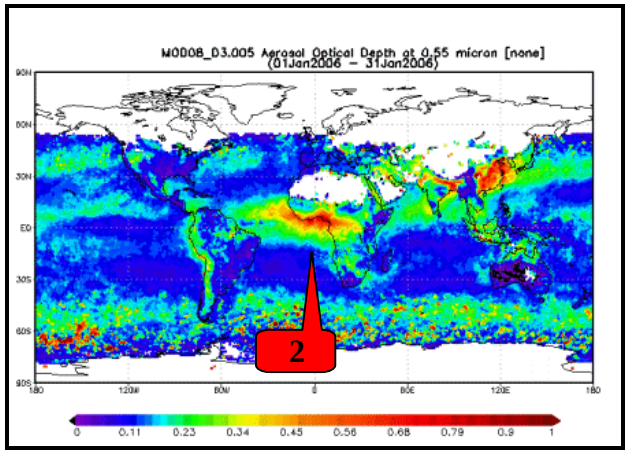


November 2006

Red Callout numbers refer to Table 2

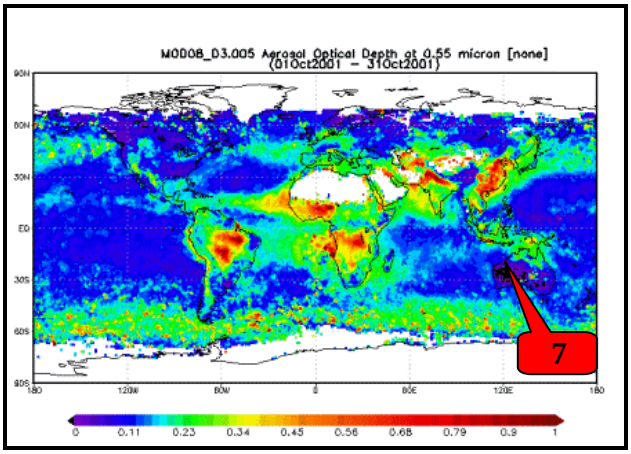
Inter Annual Variation of Specific Plumes

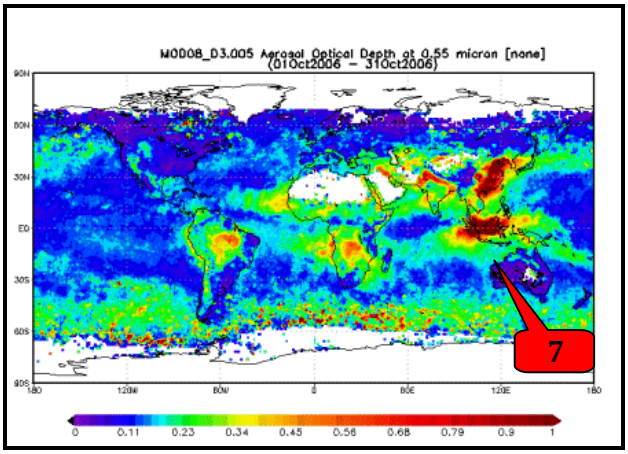




January 2002 **January 2006**

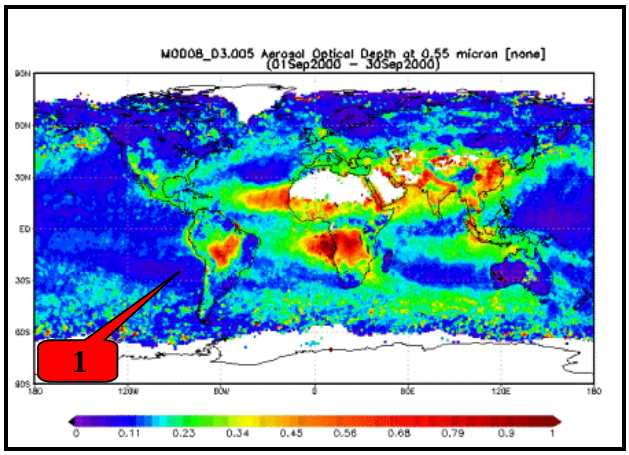
Note: The West African Plume (2) is larger and more intense in 2002

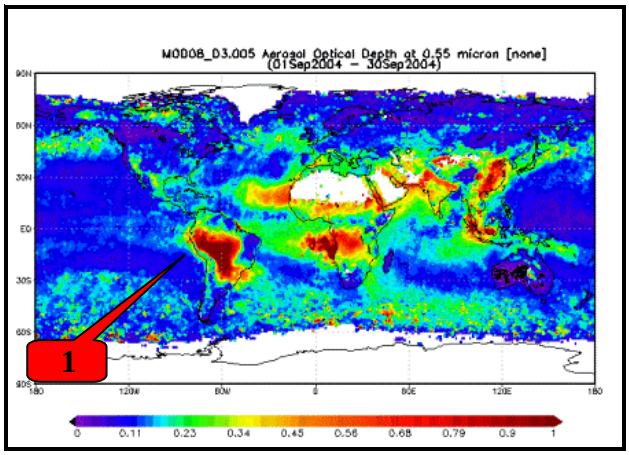




October 2001 **October 2006**

Note: The South East Asian Plume (7) is larger and more intense in 2006





September 2000 **September 2004**

Note: The South American Plume (1) is larger and more intense in 2004

References

1. **American Geophysical Union Fall Meeting, December 2009, San Francisco. Abstract at http://adsabs.harvard.edu/abs/2008AGUFM.A13B0258P**

2. Australian Meteorological & Oceanographic Society at the 9th International Conference on Southern Hemisphere Meteorology and Oceanography.

3. Analyses and visualizations used in this paper were produced with the Giovanni online data system, developed and maintained by the NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC) at http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=MODIS_MONTHLY_L3

4. Global Volcanism Program at http://www.volcano.si.edu/ L. Siebert, T. Simkin (2002-). Volcanoes of the World: an Illustrated Catalog of Holocene Volcanoes and their Eruptions. Smithsonian Institution, Global Volcanism Program Digital Information Series, GVP-3, (http://www.volcano.si.edu/world/eruptioncriteria.cfm).

5. Murray Darling Basin Commission 51 Allara St, Canberra City, ACT, Australia 2601 http://www.mdbc.gov.au/. Supplied the Murray River Inflow data.

Terms of Reference for the Inquiry

The Minister for Innovation, Industry, Science and Research requested that the committee inquire into and report on long-term meteorological forecasting with particular reference to:

1. The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems;

2. Innovation in long-term meteorological forecasting methods and technology;

3. The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism;

4. Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries; and

5. Strategies, systems and research overseas that could contribute to Australia's innovation in this area.