



THE HON DANNA VALE MP
FEDERAL MEMBER FOR HUGHES



26 March 2010

Senator the Hon Kim Carr
Minister for Innovation, Industry, Science and Research
Parliament House
CANBERRA ACT 2600

Dear Minister,

CSIRO/BoM "State of the Climate" Report

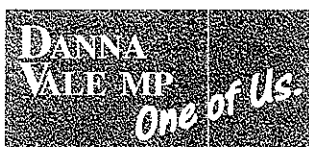
Further to my previous correspondence I write to raise another important issue with you regarding the State of the Climate Report.

The keynote statement in the State of the Climate Report: "There is greater than 90% certainty that increases in greenhouse gas emissions have caused most of the global warming since the mid-20th century", appears to be grossly misleading.

As the responsible Minister I am confident you will see the need to investigate this matter promptly and ensure that the CSIRO and Bureau of Meteorology issue any necessary corrections.

In their research paper {"How Much More Rain Will Global Warming Bring?" by Frank J. Wentz, Lucrezia Ricciardulli, Kyle Hilburn & Carl Mears (May 2007)} Wentz et al. note "Of significance is the fact that E, P and V all exhibit similar magnitudes for interannual variability". A perusal of the charts in Wentz et al. (Fig. 2) makes apparent the fact that for the water cycle in the real world evaporation (E), precipitation (P) and atmospheric water vapour (V) not only increase, but also decrease by about the same percentage and this interannual relationship is proved repeatedly over the 20-year period of the study. Fig. 2 also shows that for the virtual water cycles built into the major global climate models (GCM) increases and decreases in precipitation and hence evaporation, while similar in timing and duration to what was happening in the real world, are severely constrained to be only a small fraction (about a quarter) of the increases and decreases in atmospheric water vapour.

This factual discrepancy is so significant that it destroys the historical integrity of the joint CSIRO and Bureau of Meteorology GCM. The evaporation phase of the water cycle provides three times (78 Watts per square metre) as much cooling of the earth's surface as the net cooling (26 W/sqm) provided by radiation at wavelengths affected by greenhouse gases. Since at least the late eighties until now the water cycle in the real world has provided negative feedback and reduced any temperature increases caused by anthropogenic greenhouse gas emissions. In contrast the virtual water cycle built into the joint CSIRO/BoM GCM has erroneously provided positive feedback since the late



eighties and this amplification of any temperature increases caused by anthropogenic greenhouse gas emissions is grossly misleading.

Question 1: - Before publishing their report did the CSIRO/BoM run a version of their GCM which had been corrected to replicate the actual behaviour of the water cycle in the real world by having "E, P and V all exhibit similar magnitudes for interannual variability" since the late eighties or earlier?

The CSIRO/BoM are certain that, although "E, P and V all exhibit similar magnitudes for interannual variability" since at least the late eighties until now, increases and decreases in evaporation (E) from now on will be only a small fraction (about a quarter) of the increases and decreases in atmospheric water vapour (V). The discussion below recognises that the CSIRO/BoM are therefore likely to use a GCM, in which they severely constrain evaporation from now on, for the purposes of predicting future changes in the climate.

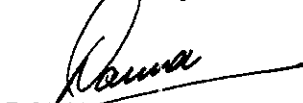
The CSIRO/BoM validated their GCM by comparing their GCM's calculation of the past with historical data. However, this procedure presupposes that the virtual water cycle built into their GCM faithfully replicates the behaviour of the water cycle in the real world. For the period from the late eighties until now, as noted above, the behaviour of the virtual water cycle built into their GCM provided positive feedback, but in contrast the water cycle in the real world provided negative feedback. Consequently, their validation process was hopelessly compromised and was a misleading exercise in curve-fitting. No one, including the CSIRO/BoM, can have any confidence in predictions of future changes in the global climate produced by a GCM validated in this way.

Question 2: - Will the CSIRO/BoM correct their GCM so that "E, P and V all exhibit similar magnitudes for interannual variability" since at least the late eighties and revalidate their GCM?

Question 3: - Will the CSIRO/BoM then re-run their GCM to produce forecasts of future climate change, which are not hopelessly compromised?

Having regard to the widespread publicity accompanying the recent publication of "State of the Climate", I trust that you will on behalf of the people of Australia, seek a prompt answer from CSIRO/BoM.

Yours faithfully



DANNA VALE MP
FEDERAL MEMBER FOR HUGHES



PARLIAMENT OF AUSTRALIA
HOUSE OF REPRESENTATIVES

THE HON DANNA VALE MP
FEDERAL MEMBER FOR HUGHES



16 March 2010

Senator the Hon Kim Carr
Minister for Innovation, Industry, Science and Research
Parliament House
CANBERRA ACT 2600

Dear Minister, *Kim*

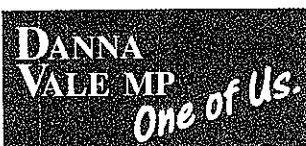
RE: CSIRO FEBRUARY 2010 ANALYSIS PAPER

Further to my letters of 15 March 2010 and 14 December 2009, I would be grateful if you could obtain further details for me on some matters relating to the CSIRO's February 2010 'analysis paper'.

I would like to provide a considered response to the CSIRO's 'analysis paper' and these further matters in due course.

Both Paltridge et al. and Wentz et al. anticipated the purported testable, hard science rebuttals set out in the CSIRO's 'analysis paper'. Both teams of scientists included anticipatory counter-rebuttals in their respective research papers. The CSIRO's 'analysis paper' did not have any new science. Consequently it appears that the CSIRO and indeed the whole of the global warming scientific community have made no progress in the last year (Paltridge) and three years (Wentz). Not only is the CSIRO unable to prove that the empirical discoveries made by Paltridge et al. and Wentz et al. respectively are false, it is not even able to provide testable, hard science responses to those authors' anticipatory counter-rebuttals. It is therefore of great concern that the CSIRO is still using its structurally unsound GCM to provide exaggerated forecasts of catastrophic anthropogenic global warming.

Many of the matters raised specifically below were also raised in my letter to you of 14 December 2009 and, as noted above, in the research papers by Paltridge et al. and Wentz et al.



Shop 1, 9-15 East Parade, Sutherland 2232
Tel: (02) 9521 6262 Fax: (02) 9545 0927
Email: danna.vale.mp@aph.gov.au Web: www.dannavale.com.au
PO Box 1014, Sutherland, NSW 1499

Parliament House, Canberra 2600
Tel: (02) 6277 4866
Fax: (02) 6277 8555

Paltridge et al. 2009

1. The tropopause which marks the transition from the troposphere to the stratosphere typically occurs at an altitude of 17 km (mid-latitudes) to 20 km (tropics) and 7 km (polar). Paltridge used radiosonde data only from the tropics and mid-latitudes and from below 8 km.

In their 'analysis paper' (page 1) the CSIRO refers to "the lower 1-2 kilometres of the troposphere". The CSIRO goes on to say "Paltridge et al. find a decreasing trend in humidity in the upper troposphere".

Question:- In referring to Paltridge's empirical discovery does the CSIRO use the term "upper troposphere" to refer to all of the troposphere from 1-2 km to 17-20 km or to just the upper half of the troposphere above say 8 km?

The CSIRO says further on "Many studies.....have concluded that radiosonde data are highly uncertain in the upper troposphere".

Question:- In referring to the above conclusions does the CSIRO use the term "upper troposphere" to refer to all of the troposphere from 1-2 km to 17-20 km or to just the upper half of the troposphere above say 8 km?

2. In their paper Paltridge et al. make the point that while some radiosonde humidity readings are unreliable a sub-set of radiosonde humidity readings is reliable. Paltridge et al. then evaluate all radiosonde humidity readings and restrict their analysis to a sub-set of radiosonde readings that they have determined to be reliable.

Question:- What reasons does the CSIRO have for concluding that the sub-set of radiosonde readings used by Paltridge et al. is unreliable?

3. In their paper Paltridge et al. make the point that based on climate theory an increase in CO₂ and global temperature will cause the long term trend increase in the temperature of the troposphere, around the height of the convective boundary layer, to be greater than the long term trend increase in temperature of the lower levels.

Question:- Does the CSIRO/BoM GCM comply with this theory?

4. In their paper Paltridge et al. find the NCEP data shows the long term trend increase in the temperature of the troposphere, around the height of the convective boundary layer, is in fact greater than the long term trend increase in the temperature of the lower levels.

Question:- Does the CSIRO/BoM accept these real world observations?

Question:- Does the CSIRO/BoM GCM comply with these real world observations?

5. The finding referred to in No. 4 above holds for the tropics, northern mid-latitudes and southern mid-latitudes.

Question:- Does the CSIRO have an explanation for why these three sub-sets of what the CSIRO may deem to be unreliable radiosonde data, separated as they are by geography, gave trends which were consistent for all three sub-sets and were also in accordance with climate theory?

6. In their paper Paltridge et al. make the point that based on climate theory the greater long term trend increase in temperature around the height of the convective boundary layer “implies a tendency for the upward flux of water vapor through the top of the layer into the middle troposphere to be reduced.”

Question:- Does the CSIRO/BoM GCM comply with this theory?

7. Paltridge et al. (Fig. 4) shows that for a number of standard pressure levels, above the convective boundary layer, the NCEP data shows a negative long term trend in relative humidity for the tropics, northern mid-latitudes and southern mid-latitudes.

Question:- Does the CSIRO have an explanation for why these many subsets of what the CSIRO deems to be unreliable radiosonde data, separated as they are by geography, gave trends which were consistent and were also in accordance with climate theory?

8. The CSIRO says that “the theory continues to be consistent with other peer reviewed observational evidence.”

Question:- Is the “other peer reviewed observational evidence” relating to long term trends in the amount of water vapour, above the convective boundary layer, limited to satellite data?

Wentz et al. 2007

9. Generally, the major GCMs do not use a scientific simulation to predict precipitation. Rather they predict precipitation using a computer modelling technique known as parameterisation. In parameterisation, model users set up equations which incorporate control values known as parameters. These parameters determine the predictions of precipitation made by their GCM. So then it is up to the model user to choose which set of equations and which set of parameters gives the most reasonable or useful result.

Question:- Does the CSIRO follow general practice and use parameterisation rather than scientific simulation to predict precipitation?

10. The CSIRO notes Liepert & Previdi opine that “global precipitation changes in a given 20-year period may not be representative of the changes that will occur on longer time scales.”

Wentz et al. argue that “although two decades may be too short for extrapolating trends, it may indeed be long enough to indicate the observed scaling relationships will continue on a longer time scale.”

The fact that the CSIRO’s GCM fails to replicate long term trends in “global precipitation changes” is consistent with it being structurally unsound. But the point has been made previously that this is not the reason it is structurally unsound. It is structurally unsound because it has built into it the assumption that precipitation increases and decreases by only one quarter of the percentage increases and decreases in atmospheric water vapour. In

contrast, Wentz et al. note "Of significance is the fact that E, P and V all exhibit similar magnitudes for interannual variability".

A perusal of the charts in Wentz et al. (Fig. 2) makes apparent the fact that evaporation, precipitation and atmospheric water vapour not only increase, but also decrease by about the same percentage and this interannual relationship is proved repeatedly over the 20-year period of the study.

Question:- What scientific explanation does the CSIRO have for the fact that Wentz et al. showed the major GCMs replicated the direction of the interannual increases and decreases in precipitation, but calculated the magnitude of GCM increases and decreases to be only a small fraction of the real world interannual increases and decreases?

Question:- What empirical evidence is there, which gives the CSIRO a scientific basis for its certainty (it has left its GCM unchanged) that over the next say 20-years the magnitudes of the interannual increases and decreases in evaporation and precipitation will be only around one quarter of the interannual increases and decreases in atmospheric water vapour?

11. The CSIRO says " it is now well established that this discrepancy arises from the fact that the global water cycle is constrained by the atmospheric energy balance ". However, Wentz et al. discovered and Liepert & Previdi confirmed real world data has shown repeatedly that the above "discrepancy" does not exist in the real world because " E, P and V all exhibit similar magnitudes for interannual variability".

Question:- What empirical evidence does the CSIRO have which shows that the global water cycle is constrained so that percentage increases and decreases in evaporation per 1°C increase or decrease in temperature are only **one quarter** of the increases and decreases in atmospheric water vapour?

12. It was well established a long time before the first major GCM was built that the huge amount of energy transferred mainly (86%) from the oceans to the atmosphere by evaporation provides the majority of the energy needed to drive the global weather system, which transports warm moisture laden air to colder altitudes and geographic regions, where precipitation takes place (the global water cycle). Therefore the global water cycle is fundamentally constrained by the amount of evaporation taking place, which is itself driven mainly by sea surface temperatures, and the atmosphere adjusts in consequence to achieve energy balance.

Question:- Does the CSIRO accept that the empirical discovery made by Paltridge et al. (2009), once accepted, would provide one obvious means by which the atmosphere does in fact adjust to achieve energy balance?

13. A 6°C increase in temperature will cause atmospheric moisture to increase by around 40% (6.5% x 6). The major GCMs typically predict that this will cause precipitation to increase by only around 10% (1.7% x 6). Simple mathematics shows that for this discrepancy to hold true the average time taken for the

global weather system to transport warm moisture laden air from the point of evaporation to the point of precipitation would have to increase by around 25% (10.5-days to 13-days). Following a 6°C increase in temperature the amount of sensible heat, latent heat and radiative energy delivered into the global weather system would increase very substantially. It therefore seems highly implausible that following a 6°C increase in temperature in the real world the global weather system would slow down by a **huge 25%**. In fact Wentz et al. noted that as global temperatures increased by 0.2°C per decade "ocean winds exhibited a small increase of 1.0% decade⁻¹" (1% per decade).

Question:- What explanation does the CSIRO have, in a scenario where a very substantial amount of additional energy is being fed into our energy powered global weather system, for it slowing down by a **huge 25%**?

Question:- What empirical evidence does the CSIRO have, which shows that a warming trend causes the global weather system to slow down?

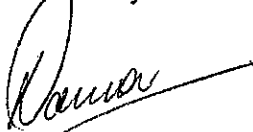
14. A GCM which has been set up to constrain the increase in evaporation to say 1.7% per 1°C rise in temperature might predict that a doubling of CO₂ would lead to a 3°C to 6°C increase in temperature. The Wentz empirical discovery implies that such an increase in temperature would require prodigious (approx. 15 to 30 Watts per square metre) amounts of energy to be transferred mainly from the oceans to the atmosphere and hence pose oceanic and atmospheric energy balance issues.

However, a GCM which complies with the Paltridge and Wentz empirical discoveries will forecast a barely perceptible temperature increase of 0.2°C to 0.5°C spread over a century. This would require only 1.0 to 2.5 Watts per square metre in additional latent heat of vapourisation to be transferred to the atmosphere.

Question:- Is the CSIRO able to explain how this level of transfer of energy would be constrained by energy balance limits?

I trust that you will obtain and forward the CSIRO's response to these matters well before the Rudd government presses on in May with its ill conceived attempt to foist its disastrous CPRS legislation on the people of Australia.

Yours faithfully



DANNA VALE MP
FEDERAL MEMBER FOR HUGHES



PARLIAMENT OF AUSTRALIA
HOUSE OF REPRESENTATIVES

THE HON DANNA VALE MP
FEDERAL MEMBER FOR HUGHES



15 March 2010

Senator the Hon Kim Carr
Minister for Innovation, Industry, Science and Research
Parliament House
CANBERRA ACT 2600

Dear Minister, 

RE: CSIRO/BoM GCM STRUCTURALLY UNSOUND

Thank you for your letter of 22 February 2010 in response to mine of 14 December 2009 regarding the above and recent empirical scientific discoveries by Paltridge et al. and Wentz et al. in relation thereto. Thank you also for attaching the analysis paper from the CSIRO and for the offer of an oral briefing by the CSIRO.

Paltridge and Wentz each made separate empirical discoveries based on separate real world observational data. Notwithstanding your assertion to the contrary, the plain fact is that each of their empirical discoveries **does prove** unequivocally and to date irrefutably that the global climate model (GCM) managed jointly by the CSIRO and Bureau of Meteorology is structurally unsound and its climate forecasts are grossly exaggerated. The CSIRO's refusal to accept either of these two empirical discoveries does not change this fact. The CSIRO obviously presumes and is undoubtedly hopeful that someone, somewhere, at some time in the future will prove both of these two empirical discoveries are false, but unless and until that happens their GCM remains structurally unsound.

Your letter confirms that, notwithstanding one year (Paltridge) and three years (Wentz) of "rigorous review" by the whole of the global warming scientific community, these empirical discoveries made by Paltridge and Wentz respectively are still in force. This means of course that the CSIRO's forecasts of catastrophic anthropogenic global warming are most likely plainly wrong and are at best severely compromised. In consequence the recommendations in the Garnaut Review (2007) and the Rudd government's CPRS legislation are also most likely plainly wrong and are at best severely compromised.



Shop 1, 9-15 East Parade, Sutherland 2232
Tel: (02) 9521 6262 Fax: (02) 9545 0927
Email: danna.vale.mp@aph.gov.au Web: www.dannavale.com.au
PO Box 1014, Sutherland, NSW 1499

Parliament House, Canberra 2600
Tel: (02) 6277 4866
Fax: (02) 6277 8555

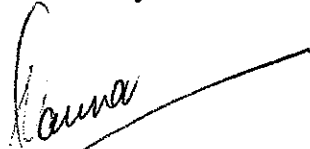
The CSIRO has now advised you in writing that they are unable to disprove either of these empirical discoveries and are therefore basing their forecasts of catastrophic anthropogenic global warming on presumption.

With great respect, as the responsible Minister you will by omission mislead the parliament and the people of Australia if you do not inform them that each of the empirical discoveries made by Paltridge and Wentz respectively **does prove** that the joint CSIRO/BoM GCM is structurally unsound and the CSIRO is unable to prove that either of these empirical discoveries is false.

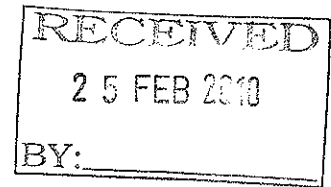
Parliament needs to know this, the people of Australia need to know this and you as Minister have a duty to inform them.

I will write to you again shortly in respect of the analysis paper from the CSIRO. Hopefully the CSIRO can be convinced that, sooner rather than later, it is in their interests to bow to the inevitable and make their GCM compliant with the empirical discoveries made by Paltridge and Wentz respectively.

Yours faithfully



DANNA VALE MP
FEDERAL MEMBER FOR HUGHES



SENATOR THE HON KIM CARR

**MINISTER FOR INNOVATION, INDUSTRY,
SCIENCE AND RESEARCH**

The Hon Danna Vale MP
Federal Member for Hughes
PO Box 1014
SUTHERLAND NSW 1499
Dear Ms Vale

22 FEB 2010

Thank you for your letter of 14 December 2009, concerning CSIRO-Bureau of Meteorology climate models and your concerns about apparent discrepancies with the work of Paltridge *et al.* (2009) and Wentz *et al.* (2007).

I would like to reaffirm the statement in my previous letter that the observations cited in these two papers do not disprove the underlying theories on which the Global Climate Models (GCMs) are based nor do they invalidate the outputs from those models. I also confirm that this statement has the endorsement of the CSIRO's Chief Executive, Dr Megan Clark.

In summary the primary science concerns raised in your letter appear to be that:

- The papers by Paltridge *et al.* (2009) and Wentz *et al.* (2007) report observations that contradict contemporary theory of the feedbacks between global warming, due to increasing levels of atmospheric carbon dioxide, and atmospheric water content.
- The existing GCMs including those used in preparation of the Garnaut Review (2007) are based on contemporary theories of climate and atmospheric physics and so may be in error if the interpretations of Paltridge *et al.* and Wentz *et al.* are correct.
- The GCMs are based primarily on assumptions that have not been tested against empirical evidence.

CSIRO has provided a detailed analysis of each of these matters in the enclosed document which I commend to you. In summary their analysis notes that:

- The inconsistencies cited in Paltridge *et al.* (2009) and Wentz *et al.* (2007) were substantially qualified with caveats by the authors and alone do not provide consistently convincing evidence sufficient to overturn the findings of the many other peer-reviewed papers published in the climate science literature. Indeed both papers contain substantive observational results that are consistent with the theoretical underpinnings of current GCMs.
- There is no observational data in either of the two papers that categorically disproves the underlying theories on which the CSIRO's GCMs are based, or would invalidate outputs from those models. It would thus be inappropriate to re-configure the contemporary GCMs on the basis of these two publications as their results are arguably inconsistent *in places* with the majority of evidence-based theory and the wealth of other research that has informed these models and which has been used repeatedly to test their assumptions and predictions.

- There generally is very good agreement between predictions of theories of the atmospheric water cycle in a warming environment and published empirical evidence.
- Outputs from GCMs are regularly tested against available observational evidence. Further the ability of GCMs to replicate an extremely wide range of observed features of past and current climate and climate variability is continually reported in the peer reviewed literature, along with analyses of model – data differences and the quality of the observed datasets themselves.

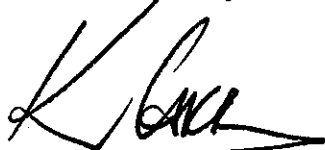
Climate change and the uncertainties surrounding it are subject to much public and scientific debate. It is not unusual for new scientific studies to report findings that are to some degree at odds with the majority of available, rigorous evidence and this appears to be the case with the papers by Wentz *et al.* and Paltridge *et al.* It is a normal part of the testing and challenging of established scientific theory that contributes to the rigor of the scientific method. However science does not advance on the result of a few inconsistent findings alone and the overturning of existing theory only occurs after a rigorous review of such observations to ensure that they are sufficiently robust to justify a change in theory. The role of CSIRO scientists in providing rigorous peer reviewed science is important in providing decision makers with the best available scientific knowledge, advancing the underpinning science and continually improving model performance.

Wentz *et al.* has attracted considerable subsequent examination but this has not resulted in a re-writing of the theoretical underpinnings of GCMs because the review process has not verified that the partial differences from other observations are sufficiently robust to overturn existing theory. Paltridge *et al.* will no doubt receive similar rigorous examination in the peer reviewed literature in due course and any tested and substantiated implications for GCMs would be taken into consideration at that time as part of the systematic evolution of GCMs.

In addition to the enclosed analysis by CSIRO of Paltridge *et al.* and Wentz *et al.* I would encourage you to read CSIRO's review of common climate change science questions at <http://www.csiro.au/resources/Climate-questions-science-facts.html> which includes references to published, peer-reviewed papers on this important topic.

If it would be helpful, CSIRO staff would be able to give you an oral briefing on these issues. Please contact Kimberley Shrives on 02 6276 6682 or at Kimberley.Shrives@csiro.au if you'd like to arrange a meeting.

Yours sincerely



Kim Carr

Paltridge *et al.* (2009) and Wentz *et al.* (2007) and the validity of Global Climate Models (GCMs)



Introduction

The papers referred to by the Hon Danna Vale, MP in her letter of 14 December 2009 are:

"Trends in middle and upper-level tropospheric humidity from NCEP reanalysis data" by Paltridge, G., Arking, A. and Pook, M., *Theor. Appl. Climatol.* (2009), 98, 351 - 359

"How much more rain will global warming bring" by Wentz, F.J., Ricciardulli, L. and Mears, C. *Science* (2007), 317, 233 - 235.

The primary concerns of science raised by Ms Vale's letter appear to be as follows:

- Papers by Paltridge *et al.* (2009) and Wentz *et al.* (2007) report observations that contravene contemporary theory of the feedbacks between global warming, due to increasing levels of atmospheric carbon dioxide, and atmospheric water content.
- Existing Global Climate Models (GCMs) including those used in preparation of the Garnaut Review (2007), are based on contemporary theories of climate and atmospheric physics and so may be in error if the interpretations of Paltridge *et al.* and Wentz *et al.* are correct.
- It is also suggested that the GCMs are based primarily on assumptions without test against empirical evidence.

Responses to each matter follow.

Observations

Water vapour feedback and humidity in the atmosphere (Paltridge *et al.* 2009)

The paper by Paltridge *et al.* relates to the water vapour feedback, whereby global warming will lead to increased humidity in the atmosphere which, in turn could cause further warming because water vapour itself is a greenhouse gas. If this is occurring, then there should be an increasing trend of water vapour, measured as specific humidity, in the troposphere (the lower 10 or so km of the atmosphere).

The results from Paltridge *et al.* confirm this for the lower part of the atmosphere; finding that the trend in specific humidity over the 35 years from 1973 to 2007 is "*significantly positive below 850 hPa in all three zones, as might be expected in a mixed layer with rising temperatures over a moist surface*". This confirmation is consistent with other observed data sets and demonstrates that the water vapour feedback is occurring as expected in the lower 1 - 2 kilometres of the troposphere. This is consistent with current climate theories.

Paltridge *et al.* find a decreasing trend in humidity in the upper troposphere, based on analysis of balloon-borne radiosonde measurements. They note that this result is inconsistent with satellite-based observations and importantly they provide the caveat that "*radiosonde-derived humidity data must be treated with great caution, particularly at altitudes above 500 hPa*". This caveat acknowledges that analyses of trends in upper troposphere moisture based on radiosonde observations alone are highly uncertain, a point that is well documented in the climate science literature.

Many studies in the peer-reviewed scientific literature (for example: Spencer and Braswell, 1997; Allan *et al.*, 2003) have concluded that radiosonde moisture data are highly uncertain in the upper troposphere, due to a range of factors including: i) poor instrument response at very low humidities; ii) changes in instrumentation over time, and iii) the extremely poor spatial coverage over the globe - for example, the Southern hemisphere is mostly ocean and so poorly sampled by

balloon-borne radiosonde sensors. These data are therefore unreliable for analysing even the *mean* climate of the upper tropospheric humidity, and so any analysis of *trends* will be highly uncertain.

The conclusions of such studies are summarised well by the IPCC Fourth Assessment Report (Working Group I, p. 273) where it is stated that “*In general the radiosonde trends are highly suspect owing to the poor quality of, and changes over time in the humidity sensors. Comparisons of water vapour sensors during recent intensive field campaigns have produced a renewed appreciation of random and systematic errors in radiosonde measurements of upper tropospheric humidity...*”.

Thus, the result from Paltridge *et al.* for the upper troposphere is not alone sufficient to falsify current water vapour feedback theory, and the theory continues to be consistent with the other peer reviewed observational evidence.

Further, the current state of the science with regard to drying in the upper troposphere is well presented by both the IPCC Fourth Assessment Report (see Chapter 8 of Working Group 1), and the recent paper by Dessler and Sherwood (2009) published in *Science*. Dessler and Sherwood's main points are:

- The water vapour feedback is controlled by humidity changes in the tropical upper troposphere (see also Held and Soden, 2000), where humidity levels are forced mostly by large-scale wind and temperature fields. As climate models predict these large-scale fields well, using the fundamental equations for fluid mechanics and thermodynamics, there is much less uncertainty in their predictions of the sign of the water vapour feedback.
- While climate models may vary to an extent in their predictions of the magnitude of the water vapour feedback effect due to differences in predicted warming, the net feedback magnitude is relatively insensitive to these model differences (Soden and Held, 2006).
- Crucial observational evidence has been hampered by acknowledged limitations of radiosondes to accurately measure humidity levels in the upper troposphere (as explained above). Observational evidence for the upper troposphere and ocean regions is therefore based mostly on satellite data. Studies (for example Soden *et al.*, 2002 and 2005; Forster and Collins, 2004; Dessler *et al.*, 2008; Inamdar, 1998) have analysed both long-term trends (over the ~ 20 year satellite record) and shorter-term responses of atmospheric humidity to climate variations that arise from natural causes such as El Nino or volcanic eruptions to demonstrate “atmospheric humidity changing in ways consistent with those predicted by global climate models” (Dessler and Sherwood, 2009).
- Quoting from Chapter 8 (Section 8.6.3.1.2) in the IPCC Fourth Assessment Report, based on papers such as those listed above: “*Confidence has also increased in the ability of GCMs to represent upper-tropospheric humidity and its variations, both free and forced. Together, upper-tropospheric observational and modelling evidence provide strong support for a combined water vapour/lapse rate feedback of around the strength found in GCMs.*”

These points are based on a large volume of peer-reviewed literature and are not inconsistent with the findings of Paltridge *et al.*, who also demonstrate the need to develop and maintain a high quality record of atmospheric humidity in the upper troposphere.

Indeed Paltridge *et al.* do not conclude that their radiosonde observations disprove a positive water vapour feedback effect, stating in their Abstract that the inconsistency found in their analysis should be explored to “... *establish what (if any) aspects of the observed trends survive detailed examination of the impact of past changes of radiosonde instrumentation and protocol within the various international networks*”.

Global precipitation (Wentz *et al.* 2007)

The goal of this paper by Wentz *et al.* is to investigate whether the global water cycle is intensifying i.e. whether the observed rates of global precipitation and evaporation are increasing. Using a combination of satellite and rain gauge observations (for the global precipitation) and model estimates (for evaporation) for the decade from 1987 to 2006, their goal was to quantify

the size and sign of the trend in the global water cycle and compare this to predictions from the GCMs used in the IPCC's Fourth Assessment.

The motivation for the study is the apparent discrepancy between the response of atmospheric humidity to global warming and the response of the water cycle to global warming. Climate models, theory and observations all agree that specific humidity increases at 5 - 7% per degree Kelvin of global warming (referred to as the Clausius-Clapeyron, or C-C, rate). Climate models, however, predict that global mean precipitation and evaporation change at the much slower rate of about 1–3% per degree Kelvin of global warming. This issue is widely reported and discussed in the climate science literature (see for example not just Wentz *et al.* but also Held and Soden, 2006; Liepert and Previdi, 2009; Soden and Held, 2006). As a result it is now well established that this discrepancy arises from the fact that the global water cycle is constrained by the atmospheric energy balance and not the availability of moisture (i.e. atmospheric water vapour which must increase at the rate dictated by the Clausius-Clapeyron equation) - see Mitchell *et al.* (1987); Allen and Ingram (2002); Feichter *et al.* (2004); and John *et al.* (2009).

The Wentz *et al.* analysis shows that the observed trend in global precipitation from 1987 to 2006 is close to the C-C rate. For the slightly shorter period (1987 – 2001), the GCMs predicted an increasing but smaller trend, and a dampening of the inter-annual variability. They conclude that “*the reason for the discrepancy between the observational data and the GCMs is not clear*” and suggest it could result from:

1. the time period chosen may be too short for extrapolating trends; and/or
2. errors in the observed data set due to problems with satellite retrievals; and/or
3. the possibility that the climate models are in error.

Analyses of long-term trends in global precipitation from observations do have uncertainties, as noted in numerous peer-reviewed papers (see for example Liepert and Previdi, 2009, Adler *et al.*, 2008, Stephens and Ellis, 2008) and in the IPCC Fourth Assessment Report.

There have been many papers published citing Wentz *et al.* 2007 (65 citations on ISI) that shed further light on the reasons for the apparent discrepancy between the response of atmospheric humidity to global warming, and that of the observed and predicted global water cycle.

For example, Liepert and Previdi (2009) analyse the trend in global mean precipitation for the same decade as Wentz *et al.* (July 1987 to August 2006), using two observed datasets. They find an increase of $1.4\% \pm 0.50\%$ per decade and $1.14 \pm 0.65\%$ per decade, which confirms Wentz *et al.* (2007) and is “*close to the Clausius-Clapeyron rate that describes the dependence of water vapour saturation pressure on temperature.*” Their analysis of global ocean evaporation rates is consistent with this observed increase in global precipitation. The predictions of eight GCMs analysed in their study underestimate this observed increase in precipitation, however the difference was not always statistically significant. They conclude that the GCMs used in the IPCC Fourth Assessment Report are able to predict the increasing trend in the global water balance, but over larger time scales and that global precipitation changes in a “*given 20-yr period may not be representative of the changes that will occur on longer time scales*”. These conclusions are consistent with the caveat stated by Wentz *et al.*

These papers suggest that the discrepancy identified by Wentz *et al.* (2007) does not point to an error in the GCMs. Some of the factors cited are:

- The large inter-decadal variability in the sensitivity of the global water cycle to warming in GCMs, especially for 20th century simulations. This partly arises because of differences in the nature of the climate forcing i.e. changing greenhouse gas concentrations compared to aerosols or volcanic emissions. The decade 1987 to 2006 analysed by Wentz *et al.* includes several volcanic eruptions that are likely to have affected the observed precipitation response.
- It is possible that the dampened response of precipitation and evaporation may arise from systematic changes in surface wind, humidity and temperature (Richter and Xie, 2008).

- Ongoing concerns about the quality of the long-term observations of the global hydrological cycle, as already noted (e.g. Liepert and Previdi, 2009, Adler *et al.*, 2008, Stephens and Ellis, 2008).

Based on the current science, there is no consistent and substantive evidence of a model error that would invalidate the projected climate change stated in the IPCC Fourth Assessment or the more recent Garnaut Report.

In summary, given the uncertainties in observed global precipitation trends and the recent analyses by Liepert and Previdi (2009) and others, the paper by Wentz *et al.* does not invalidate contemporary theory behaviour of the atmospheric water cycle and its response to atmospheric warming.

The Global Climate Models

The GCMs referenced in the IPCC Fourth Assessment Report and those used in the preparation of the Garnaut Review are based on contemporary climate theory, developed on the bases of a long history of climate observations and fundamental theories of physics. GCMs routinely are run to produce outputs covering historical periods (as well as future projections) and the outputs for the past tested against empirical evidence from the same periods to verify that the models credibly mimic the available empirical evidence. The cycle of model refinement, prediction, and test against observations is a robust, rigorous and peer-reviewed process that ensures that the custodians of GCMs are constantly accountable to earth system observations.

The papers of Paltridge *et al.* (2009) and Wentz *et al.* (2007) contain substantive observational results that are consistent with the theoretical underpinnings of current GCMs. The cited inconsistencies of some of their observations with predictions of current theory are substantially qualified with caveats by the authors and are not consistent with the majority of equally rigorous and peer reviewed publications describing observations and upon which contemporary climate models are based. There is no observational data in either of the two papers that categorically disproves the underlying theories on which the existing GCMs are based, or would invalidate outputs from those models. Re-configuring the contemporary GCMs on the basis of two publications with results arguable inconsistent in places with the majority of evidence-based theory would be to ignore the wealth of other research with which those GCMs are consistent.

Outputs from GCMs are regularly tested against available observational evidence and their skill in replicating an extremely wide range of observed features of past and current climate and climate variability is continually reported in the peer reviewed literature along with analyses of model – data differences and the quality of the observed datasets themselves.

Summary

The papers by Paltridge *et al.* (2009) and Wentz *et al.* (2007) do not provide consistently convincing evidence sufficient to overturn the findings of many other peer-reviewed papers.

There generally is very good agreement between predictions of theories of the atmospheric water cycle in a warming environment and published empirical evidence.

Outputs from GCMs are regularly tested against available observational evidence and their skill in replicating an extremely wide range of observed features of past and current climate and climate variability is continually reported in the peer reviewed literature along with analyses of model – data differences and the quality of the observed datasets themselves.

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