

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

Collection/Record Group: Clinton Presidential Records
Subgroup/Office of Origin: Council on Environmental Quality
Series/Staff Member: Kathleen (Katie) McGinty
Subseries:

OA/ID Number: 2897
FolderID:

Folder Title:
Clouds Hearing - Pre-Hearing Memos from Tony Socci (Katie Memo)

Stack:	Row:	Section:	Shelf:	Position:
S	61	6	3	1

MEMORANDUM

FOR: SENATOR GORE
FROM: MIKE NELSON
RE: FUNDING FOR GLOBAL CHANGE RESEARCH

October 6, 1991

At Monday's hearing, it is likely that both Administration witnesses and others will bring up the need for additional Federal funding for global change research. This could prove somewhat embarrassing since both this year and last Congress has cut the Administration's request for increased funding for global change research at NSF, NASA, and NOAA. The House and Senate Appropriations Committee has agreed on figures for NOAA, NASA, and NSF, but the conference reports must still be approved by both Houses.

FUNDING FOR GLOBAL CHANGE RESEARCH (in millions of dollars)

Agency	FY91	FY92 request	Congressional action
NASA	\$651.6	\$772.6	Earth sciences req. cut 4.7% (11.6% over FY91) EOS cut 25.7%, additional funding for TRMM, Earth Probes, and Climsat (new) Total NASA budget cut \$15.75 B to \$14.35 B (8.9% cut, 3.5% over FY91)
NSF	87.1	118.5	Total NSF research budget cut 4.3%, 10.9% over FY91 The 36.1% increase for global change will likely be reduced. (to 15% or so)
NOAA	47.0	78.0	Cut to \$47.0 million
TOTAL	\$953.7	\$1,185.5	No new money for NOAA, Modest (5-10%) increases (after inflation) for NSF, NASA

Funding for NASA and NSF research programs was cut to provide full funding (\$2,029 billion, 6.8% increase over FY91) for the Space Station which the Administration said was it's number one priority.

Despite the Congressional budget cuts, there is still new money for NASA and NSF global change research programs (just not as much as the Administration requested). We cannot be sure of the actual funding levels for NSF and NASA until the bill is signed and the agencies determine their FY92 budget. (global change research is not a line item at either NSF or NASA). About 50% of total global change research budget is for work on climate and hydrologic systems (including cloud research) with about 70% of money going to NASA.

United States Senate

WASHINGTON, DC 20510-4202

M E M O R A N D U M

DATE: October 5, 1991

TO: Al, Tony, Mike

FROM: Katie

SUBJECT: Lindzen's "Convective Tower" argument and questions to pose to him on this subject:

THE QUESTION: Does the increased convection expected in a warmer climate produce a POSITIVE or a NEGATIVE feedback?

LINDZEN'S ANSWER: A NEGATIVE feedback will result due to the following process:

As air rises, it cools. This cooling wrings out much of the moisture (which then falls back to the surface as rain). The dried air continues to rise and fill the upper troposphere. As CO2 increases and warms the atmosphere, this convection-driven conveyor belt will run faster and more efficiently so that it will carry more and even drier air to the upper troposphere. Since what goes up must come down, (in the jargon, this is called SUBSIDENCE) this cold dry air will come back down to the surface -- and drag with it some of the moisture that was in the upper troposphere. The overall result -- less moisture in the upper troposphere (that part of the atmosphere where the molecule-for-molecule greenhouse forcing of water vapor is most intense) -- and therefore overall less greenhouse forcing.

AN ACID TEST: If Lindzen is correct then it should be the case that, in warmer geographical locations, in warmer seasons, and in areas of strong convective coupling (i.e., the Western Pacific), the upper troposphere should be relatively dry.

THE RESULTS: Lindzen's hypothesis does not pass the test.

SUGGESTED QUESTIONS

1. Dr. Lindzen, could you please explain your "convective tower" theory? (Al it is important here to rein him in -- you are not asking him about global warming in general or about the state of the gcm's -- stick to his theory).

2. So, Dr. Lindzen, the crux of your theory is that, with greenhouse warming you would expect the upper troposphere to dry. Is that correct?

3. Dr. BETTS, what do you think about that conclusion?

A: In his testimony, Betts says "This idea is wrong".

4. Dr. TRENBERTH, would you agree with Dr. Lindzen's conclusion?

A: T says in his statement: "Any model convection scheme that "rains out" all the moisture in these clouds and which does not detrain a fraction fails to come closed to reproducing observed moisture concentrations. The vertical moisture transport by convection is vital in forming the observed tropical moisture concentrations in the atmosphere which, in turn, has a strong greenhouse effect." If I'm reading this right, this clearly says -- contrary to Lindzen -- that convection does not dry out the troposphere.

① Trenberth
has
data

3. Dr. Lindzen, it would seem that we should be able to test that theory -- get real data on it. Would it follow from your theory, Dr. Lindzen, that atmospheric warming in the summer months -- and the consequent increase of moist convection in those months -- would lead to a decrease in the amount of moisture in the upper troposphere compared to the moisture content of the upper troposphere in the cooler months of the year when, presumably, convection would not be as strong?

A: He should say yes. If he gets cute and tries to deny it, you should ask CESS if he agrees that that would be a fair expectation to draw from Lindzen's theory. CESS will say yes.

4. Dr. Lindzen, do you have any observational data that supports this conclusion?

A: If he's honest, he has to say no.

5. Dr. Cess are you aware of any data that would be relevant to this point?

A: Yes. He will point to recent work done by David Rind of NASA Goddard (colleague of Jim Hansen -- note that ROSSOW can also speak to this; he also is from Goddard):

Cess will
speak
to satellite
data

See #11 -- Rind has data, too

Rind's MODEL predicts an INCREASE in the water vapor in the upper and middle troposphere due to CO2 warming -- a POSITIVE feedback. In his recent work (February 1991), Rind VALIDATES HIS MODEL PREDICTION:

Rind used SATELLITE generated water vapor data (SAGE II) to compare summer and winter moisture values in regions of the middle and upper troposphere. CONCLUSION -- "as the hemispheres warm, INCREASED CONVECTION LEADS TO INCREASED WATER VAPOR ABOVE 500 mbars (this is approx. 5.5 km) in approximate quantitative agreement with the results from current climate models."

6. Dr. Lindzen, I believe I just heard Dr. Cess say that satellite data -- real/live evidence -- shows that upper tropospheric moisture INCREASES with atmospheric warming. That would be contrary to your ideas wouldn't it?

7. Dr. Lindzen, I believe I also heard Dr. Cess say that the satellite data measures water vapor above 500 mbar -- i.e., approximately above 5.5 km. Is that right?

A: Yes.

But, Dr. Lindzen, didn't you say in your testimony that "Water vapor is not monitored above 6-9 km"? What did you mean by that? Clearly the SAGE satellite instrument DOES MEASURE water vapor in that region. (In fact, Al, Rind has told us that he has data up to 40 km!! BUT, NOTE HERE THAT LINDZEN IS BEING CUTE -- HE SAID "MONITOR" -- I UNDERSTAND THAT THE SAGE DATA IS NOT CONTINUOUS (thousands of data sets, but not a continuous record) -- SO, TECHNICALLY, IT COULD BE ARGUED THAT LINDZEN IS RIGHT.)

8. Dr. Lindzen, wouldn't it also follow from your theory that areas where there is strong convection should have relatively dry upper atmospheric moisture levels?

A: Yes.

9. Do you have any observational evidence to support this conclusion?

A: No.

10. Do we have observational evidence that is relevant to this point?

A: Again, the answer is yes -- this was the second conclusion reached by Rind in his satellite analysis.

11. Dr. Lindzen, it also seems to me that we could fairly test your theory by determining the upper tropospheric water content in areas with warm sea surface temperatures and comparing them with moisture levels in relatively cooler areas. Dr. RAMANATHAN, is there any data relative to this point?

A: Yes. Ramanathan and Raval (1989) used satellite data over different oceanic locations (with the different sea surface temps of the different locations providing a surrogate for global warming) and showed more moisture in the warmer locations. NOTE HERE THAT LINDZEN SAYS THIS STUDY WAS FLAWED and you will want to give Ram an opportunity to defend it because it is a critical study -- it "proved" that water vapor feedback is positive. Lindzen's criticism: "That result (i.e. positive water vapor feedback) is significantly due to a faulty assumption in their analysis -- namely, that the shape of temperature profiles are independent of surface temperature."

M E M O R A N D U M

DATE: October 1, 1991

TO: Senatore Gore, Katie and Greg

FROM: Tony Socci (ADS)

SUBJECT: Clouds Hearing

In preparation for this hearing I thought I might work down the list of panel members, discussing each person/their work, in turn, beginning with Richard Lindzen who, in my view, and that of many other scientists, is an icon/sophist whose real interest in the so-called greenhouse debate is just that, the latest grounds and arena for debate for the sake of argument alone. The above notwithstanding, his theory on convectively dried, cold, descending air masses within tropical regions has been the source of much discussion and debate within climate and water-modeling circles, as well as in the press.

Richard Lindzen:

As you can see from his credits in the list of panel members, he holds an endowed professorship at MIT. His position is this: he contends that whereas most climate models (GCM's) predict elevated sea-surface temperatures, this should theoretically result in an increase in the supply of water vapor to the atmosphere, and at increased rates as well. This, he argues, brings about increased/invigorated atmospheric convection, the result of which is the transport of water vapor/water into higher, cooler regions of the atmosphere, specifically, the upper troposphere. As this water vapor moves into the upper atmosphere the air mass cools, the water condenses and falls as rainfall, leaving the upper atmosphere devoid of water vapor (dry). And since what goes up must come down, the convected, water-laden air mass, now stripped of water/water vapor, descends as a cool dry air mass. The net effect of this, Lindzen contends, is a reduced greenhouse effect due to the loss of water vapor/drying in the upper atmosphere (water vapor being the most efficient greenhouse gas) resulting from increased convection driven by elevated sea-surface temperatures.

Lindzen further argues that this hypothetical phenomenon would yield global warmings only 1/2 to 1/5 of the values cited in most GCM's with predicted greenhouse warming on the order of 2 to 5 degrees C as a consequence of a doubling of atmospheric CO-2. In fact, Lindzen has also offered that this negative water-vapor feedback mechanism

could result in an overall cooling as opposed to a warming, changing the sign of the climate change as well. Most, if not all GCM's, presently show water vapor as a positive feedback to warming, the vast bulk of which is to the greenhouse effect of water vapor.

Permit me to labor this hypothetical mechanism in the interest of laying it out more clearly. Warming has at least two effects: it increases the water vapor present at low elevations, increases the rate at which this water vapor rises, while producing more and deeper (thicker cumulus clouds and therefore, higher rising clouds) cumulus convection. The result of course, is the drying out of the upper troposphere where these thicker clouds now extend, theoretically. Warming leads to drying of the atmosphere above 5 km, as opposed to the moistening which is called upon by most GCM's, and leads to the elevation of the altitude at which convected heat is deposited. Lindzen points out that this effect, increased convection, of heat in this instance, reduces greenhouse absorption (negative feedback to warming) as opposed to increasing warming (the greenhouse effect), by a factor of 3, as most GCM's predict.

I might also add or emphasize that Lindzen's effect requires that warming has already, somehow come about. How and why, and what is the minimal warming required to produce this effect in the first place?)) ✓

It would be very useful for you to become acquainted with the core of Lindzen's argument/proposed mechanism for vastly reduced or negative greenhouse effects due to increases in anthropogenic greenhouse gas emissions. Figure 7 of Lindzen's now classic paper, "Some Coolness Concerning Global Warming", is his mechanism in a nut shell. I shall make a copy of this figure for your use at the clouds hearing and otherwise.

Lindzen's paper is a short paper which would be extremely useful to read in its entirety. It also happens to be very readable. Lindzen does have a knack for finding simplicity in complexity. In this respect he lends himself to being understood by a broader spectrum of people hence, I suspect, part of his attractiveness to many who often find the average scientist completely undecipherable.

Other notable Lindzen caveats (from the paper cited above):

1. After all fossil fuel is burned we may expect the gradual return of CO-2 concentrations to their preindustrial levels. (This would not necessarily mitigate the greenhouse effect of CO-2 which might persist even after anthropogenic CO-2 is stripped from the atmosphere after a natural

residence time of appx. 220 yrs. There is no consideration of the non-linearity of many aspects of the climate system, and the fact that all of the above constitutes an extremely precarious experiment in progress, at best).

2. CO-2 might also stimulate the growth of vegetation. → ✓

3. As far as we know, there is no direct adverse effect on human beings arising from increases in CO-2 on the order of those anticipated (however uncertainly) over the next few centuries. Certainly, much higher concentrations are found in normal indoor environments.)

4. Lindzen suggests that it is not clear that our network of surface-temperature measurements is adequate to eliminate sources of uncertainty in calculating or estimating temperature trends on the order of 100 years or so, particularly for temp. changes less than 1 degree C. He cites the possibility that such small changes in temp. could be due to inadequate and improper sampling, in addition to having temperature recording stations at fixed locations on land only, most of which are in cities. (Tom Wigley suggests that one could eliminate urban effects or eliminate suspect stations from one's calculations).

5. On the basis of the records available, the best estimate for the global temperature change that has occurred over the industrial period does not significantly vary from 0, suggesting that current models are probably exaggerating expected warming.

6. The interpretation of this record, (temp. record) in terms of a linear trend, seems highly inappropriate. (Who has calculated this trend to be linear?).

7. It is currently believed however, that the cooling effect (of stratiform clouds) slightly exceeds the warming effect (Ramanathan et al., 1989). (To my knowledge Ramanathan said much more than this, including the possibility for significant positive feedbacks due to cloud phenomena - I will double check this).

8. The British Meteorological Office climate model had predicted a 5 degree C warming accompanying a doubling of CO-2. Very recently they reported that the simple matter of changing the ice content of layer clouds had reduced this value to under 2 degrees C, a reduction of 60% (Mitchell, et al., 1989). (David Rind, a colleague of Jim Hansen's at NASA (GISS), has informed me that what Mitchell and others had later discovered was that in cold continental regions as the temp. warms, cloud optical thickness increases leading to regional/local cooling phenomena. Everywhere else, globally, according to Rind, clouds warm but optical

thickness decreases resulting in a net positive feedback or warming by appx. 1 degree C. Thus it appears that Mitchell et al. had originally thought the cold continental cloud phenom applied everywhere and revised their warming estimates downward accordingly as Lindzen reported. Subsequent knowledge has shown that revision downward to have been much too great. I presently have a call into Mitchell at the British Meteorological Office, and to Rind as well.).

9. Certainly the possibility of greenhouse warming remains for the present.

10. Oddly enough though, despite all the uncertainty, there is one thing that is surprisingly clear right now; it is difficult to envision any practical action that will make much difference to the final outcome. (Why then did Lindzen get into this discussion in the first place? For the sake of a good argument/discussion of course.).

11. However, according to the most pessimistic models, much of the predicted warming is already in the pipeline- delayed only by ocean heat absorption. Because of the logarithmic dependence of warming on CO-2, large changes in CO-2 emission (20%-40%) will, at most, reduce warming by a fraction of a degree. (Again, if so then why embrace the discussion in the first place if the whole thing is a non-problem? Broecker, on the other hand, or by contrast, states: "I fear that the effects of the rise in concentration of the greenhouse gases will come largely as surprises. But the greater our knowledge, the greater the wisdom that will be brought to bear if surprises do come." Senator, Broecker understands the uncertainties of climate turns and twists and the subtleties upon which they turn, as well as the unimagined rates at which such events can proceed even from slow, sometimes imperceptible beginnings. Lindzen is virtually completely unaware of the historical record of this planet's climate, and the rates at which those changes can occur, and did occur, altering our thinking each time.

More on Lindzen:

I cannot emphasize any one thing more than the fact that Lindzen's convection-reduced water vapor phenom/negative feedback to predicted warming, is a concept. It is an idea in his head. To my knowledge Lindzen has no data addressing this idea one way or another. If he has, he has not shown it to anyone (word has it that he has approached Broecker for some sea-surface data). On the other hand, the vast majority (all?) of GCM's show a positive feedback resulting from water vapor effects largely, contrary to the idea of Lindzen, which is not to say that Lindzen's effect is an impossibility.

Lindzen has also not put his idea in the form of a working model which shows his hypothesized negative feedback to warming.

Subsidence is a local phenomenon, much as Lindzen had depicted it in Fig. 7. However, according to Rind and others, there are no subsidence cells of the type described by Lindzen which extend beyond 200 km (I will double check numbers) in diameter. In other words Lindzen has described a local phenomenon, as if it accounted for the worldwide distribution of water vapor, and its impact. However, when pressed on this point at times he has suggested that he was referring to a worldwide, largescale circulation phenomenon like the circulation of the Hadley cell. Again, according to Rind and others, there is no indication on the part of any model, of what would happen, if anything, to Hadley-scale circulation.

There is no historical climatic evidence for the existence or manifestation of the water vapor mechanism alluded to by Lindzen, for which he has no data.

Furthermore, as Rind and others have again pointed out, if we have less water vapor in the upper atmosphere during warmer times, according to Lindzen's mechanism, in glacial times we should have had more water vapor in the upper atmosphere, a position which no one is apparently willing to defend. If it were so, for example, how would Lindzen, or others, propose that it gets there since its presence is coupled to increased convection driven by heat?

In short, Lindzen is a debator Senator, and will drift in all directions if allowed to do so, as his paper clearly shows.

Well, this will do for now. I shall leave some papers for you to read. I shall continue tomorrow.

ADS

MEMORANDUM

DATE: October 1, 1991

TO: Senatore Gore, Katie and Greg

FROM: Tony Socci (ADS)

SUBJECT: Clouds Hearing

In preparation for this hearing I thought I might work down the list of panel members, discussing each person/their work, in turn, beginning with Richard Lindzen who, in my view, and that of many other scientists, is an icon/sophist whose real interest in the so-called greenhouse debate is just that, the latest grounds and arena for debate for the sake of argument alone. The above notwithstanding, his theory on convectively dried, cold, descending air masses within tropical regions has been the source of much discussion and debate within climate and water-modeling circles, as well as in the press.

Richard Lindzen:

As you can see from his credits in the list of panel members, he holds an endowed professorship at MIT. His position is this: he contends that whereas most climate models (GCM's) predict elevated sea-surface temperatures, this should theoretically result in an increase in the supply of water vapor to the atmosphere, and at increased rates as well. This, he argues, brings about increased/invigorated atmospheric convection, the result of which is the transport of water vapor/water into higher, cooler regions of the atmosphere, specifically, the upper troposphere. As this water vapor moves into the upper atmosphere the air mass cools, the water condenses and falls as rainfall, leaving the upper atmosphere devoid of water vapor (dry). And since what goes up must come down, the convected, water-laden air mass, now stripped of water/water vapor, descends as a cool dry air mass. The net effect of this, Lindzen contends, is a reduced greenhouse effect due to the loss of water vapor/drying in the upper atmosphere (water vapor being the most efficient greenhouse gas) resulting from increased convection driven by elevated sea-surface temperatures.

Lindzen further argues that this hypothetical phenomenon would yield global warmings only 1/2 to 1/5 of the values cited in most GCM's with predicted greenhouse warming on the order of 2 to 5 degrees C as a consequence of a doubling of atmospheric CO-2. In fact, Lindzen has also offered that this negative water-vapor feedback mechanism

Lindzen doesn't argue the water
vapor is a neg. feedback - he only says
atmosphere will lose H₂O vapor &
will cool.

could result in an overall cooling as opposed to a warming, changing the sign of the climate change as well. Most, if not all GCM's, presently show water vapor as a positive feedback to warming, the vast bulk of which is to the greenhouse effect of water vapor.

Permit me to labor this hypothetical mechanism in the interest of laying it out more clearly. Warming has at least two effects: it increases the water vapor present at low elevations, increases the rate at which this water vapor rises, while producing more and deeper (thicker cumulus clouds and therefore, higher rising clouds) cumulus convection. The result of course, is the drying out of the upper troposphere where these thicker clouds now extend, theoretically. Warming leads to drying of the atmosphere above 5 km, as opposed to the moistening which is called upon by most GCM's, and leads to the elevation of the altitude at which convected heat is deposited. Lindzen points out that this effect, increased convection, of heat in this instance, reduces greenhouse absorption (negative feedback to warming) as opposed to increasing warming (the greenhouse effect), by a factor of 3, as most GCM's predict.

I might also add or emphasize that Lindzen's effect requires that warming has already, somehow come about. How and why, and what is the minimal warming required to produce this effect in the first place?

It would be very useful for you to become acquainted with the core of Lindzen's argument/proposed mechanism for vastly reduced or negative greenhouse effects due to increases in anthropogenic greenhouse gas emissions. Figure 7 of Lindzen's now classic paper, "Some Coolness Concerning Global Warming", is his mechanism in a nut shell. I shall make a copy of this figure for your use at the clouds hearing and otherwise.

Lindzen's paper is a short paper which would be extremely useful to read in its entirety. It also happens to be very readable. Lindzen does have a knack for finding simplicity in complexity. In this respect he lends himself to being understood by a broader spectrum of people hence, I suspect, part of his attractiveness to many who often find the average scientist completely undecipherable.

Other notable Lindzen caveats (from the paper cited above):

1. After all fossil fuel is burned we may expect the gradual return of CO-2 concentrations to their preindustrial levels. (This would not necessarily mitigate the greenhouse effect of CO-2 which might persist even after anthropogenic CO-2 is stripped from the atmosphere after a natural

residence time of appx. 220 yrs. There is no consideration of the non-linearity of many aspects of the climate system, and the fact that all of the above constitutes an extremely precarious experiment in progress, at best).

2. CO-2 might also stimulate the growth of vegetation.

3. As far as we know, there is no direct adverse effect on human beings arising from increases in CO-2 on the order of those anticipated (however uncertainly) over the next few centuries. Certainly, much higher concentrations are found in normal indoor environments.)

4. Lindzen suggests that it is not clear that our network of surface-temperature measurements is adequate to eliminate sources of uncertainty in calculating or estimating temperature trends on the order of 100 years or so, particularly for temp. changes less than 1 degree C. He cites the possibility that such small changes in temp. could be due to inadequate and improper sampling, in addition to having temperature recording stations at fixed locations on land only, most of which are in cities. (Tom Wigley suggests that one could eliminate urban effects or eliminate suspect stations from one's calculations).

5. On the basis of the records available, the best estimate for the global temperature change that has occurred over the industrial period does not significantly vary from 0, suggesting that current models are probably exaggerating expected warming.

6. The interpretation of this record, (temp. record) in terms of a linear trend, seems highly inappropriate. (Who has calculated this trend to be linear?)

7. It is currently believed however, that the cooling effect (of stratiform clouds) slightly exceeds the warming effect (Ramanathan et al., 1989). (To my knowledge Ramanathan said much more than this, including the possibility for significant positive feedbacks due to cloud phenomena - I will double check this).

8. The British Meteorological Office climate model had predicted a 5 degree C warming accompanying a doubling of CO-2. Very recently they reported that the simple matter of changing the ice content of layer clouds had reduced this value to under 2 degrees C, a reduction of 60% (Mitchell, et al., 1989). (David Rind, a colleague of Jim Hansen's at NASA (GISS), has informed me that what Mitchell and others had later discovered was that in cold continental regions as the temp. warms, cloud optical thickness increases leading to regional/local cooling phenomena. Everywhere else, globally, according to Rind, clouds warm but optical

but phoki
pests, etc...

has paper that
has determined such
problems & still
get 0.50C yr

Rind
assuming
linearity?

Wigley
data call
unreliable
X also
more satellite
Sen
signature
temp.

Note
that urban
CO2 not
a proxy
such growth
warming
over land
expected.

why? esp. if have ↑ water content?

thickness decreases resulting in a net positive feedback or warming by appx. 1 degree C. Thus it appears that Mitchell et al. had originally thought the cold continental cloud phenom applied everywhere and revised their warming estimates downward accordingly as Lindzen reported. Subsequent knowledge has shown that revision downward to have been much too great. I presently have a call into Mitchell at the British Meteorological Office, and to Rind as well.).

? = anything published??

9. Certainly the possibility of greenhouse warming remains for the present.

10. Oddly enough though, despite all the uncertainty, there is one thing that is surprisingly clear right now; it is difficult to envision any practical action that will make much difference to the final outcome. (Why then did Lindzen get into this discussion in the first place? For the sake of a good argument/discussion of course.).

11. However, according to the most pessimistic models, much of the predicted warming is already in the pipeline- delayed only be ocean heat absorption. Because of the logarithmic dependence of warming on CO-2, large changes in CO-2 emission (20%-40%) will, at most, reduce warming by a fraction of a degree. (Again, if so then why embrace the discussion in the first place if the whole thing is a non-problem? Broecker, on the other hand, or by contrast, states: "I fear that the effects of the rise in concentration of the greenhouse gases will come largely as surprises. But the greater our knowledge, the greater the wisdom that will be brought to bear if surprises do come." Senator, Broecker understands the uncertainties of climate turns and twists and the subtleties upon which they turn, as well as the unimagined rates at which such events can proceed even from slow, sometimes imperceptible beginnings. Lindzen is virtually completely unaware of the historical record of this planets climate, and the rates at which those changes can occur, and did occur, altering our thinking each time.

More on Lindzen:

I cannot emphasize any one thing more than the fact that Lindzen's convection-reduced water vapor phenom/negative feedback to predicted warming, is a concept. It is an idea in his head. To my knowledge Lindzen has no data addressing this idea one way or another. If he has, he has not shown it to anyone (word has it that he has approached Broecker for some sea-surface data). On the other hand, the vast majority (all?) of GCM's show a positive feedback resulting from water vapor effects largely, contrary to the idea of Lindzen, which is not to say that Lindzen's effect is an impossibility.

Lindzen has also not put his idea in the form of a working model which shows his hypothesized negative feedback to warming.

Subsidence is a local phenomenon, much as Lindzen had depicted it in Fig. 7. However, according to Rind and others, there are no subsidence cells of the type described by Lindzen which extend beyond 200 km (I will double check numbers) in diameter. In other words Lindzen has described a local phenomenon, as if it accounted for the worldwide distribution of water vapor, and its impact. However, when pressed on this point at times he has suggested that he was referring to a worldwide, largescale circulation phenomenon like the circulation of the Hadley cell. Again, according to Rind and others, there is no indication on the part of any model, of what would happen, if anything, to Hadley-scale circulation.

There is no historical climatic evidence for the existence or manifestation of the water vapor mechanism alluded to by Lindzen, for which he has no data.

Furthermore, as Rind and others have again pointed out, if we have less water vapor in the upper atmosphere during warmer times, according to Lindzen's mechanism, in glacial times we should have had more water vapor in the upper atmosphere, a position which no one is apparently willing to defend. If it were so, for example, how would Lindzen, or others, propose that it gets there since its presence is coupled to increased convection driven by heat?

In short, Lindzen is a debator Senator, and will drift in all directions if allowed to do so, as his paper clearly shows.

Well, this will do for now. I shall leave some papers for you to read. I shall continue tomorrow.

ADS

United States Senate

WASHINGTON, DC 20510-4202

M E M O R A N D U M

DATE: October 2, 1991

TO: Senator Gore

FROM: Tony Socci - ADS

SUBJECT: Preparation/review for clouds hearing, part 2.

V. Ramanathan:

He is, I believe, the agreed-upon foremost authority on the role of clouds in climate change, including the effects of water vapor, particularly in tropical cumulus clouds, and ocean-atmosphere interactions. Ramanathan is one of the few people in the world, if not the sole individual (along with colleagues), who has actually compared or tested cloud-climate-water model predictions against actual observations using radiation (and other?) data from the ERBE (Earth Radiative Budget Experiment) satellite program. In part, for these reasons, the actual testing of some models (often with Cess), renders him one of the most knowledgeable on the topic of clouds. He has models and real, observational data, both of which give him tremendous authority on the subject at hand, in stark contrast to Lindzen, for example, who is at the other end of the spectrum in terms of data, model construction, and testing.

In 1989 Raval and Ramanathan, in a paper known as "Observational determination of the greenhouse effect", they compared model calculations against ERBE data, drawing the following conclusions:

1. The greenhouse effect is found to increase significantly with sea-surface temperature. Thus if global warming ensued as a consequence of increased CO-2 emissions and other gases as is expected, the increased heating is predicted to warm or elevate sea-surface temperature which, in turn, will increase water vapor which, in turn, will lead to a positive feedback to warming in-progress.

2. As a consequence to 1, there is compelling evidence for a positive feedback between sea-surface temperature (surface temp.), water vapor, and an enhanced greenhouse effect, based upon ERBE data and model calculations used to test the above hypothesis.

In 1989 again, this time with Cess and others, Ramanathan published the much heralded "Cloud-Radiative forcing and climate: results from the Earth Radiation Budget

*this is the
TLC to
Lindzen?*

* Need to expand what R has to say directly to Lindzen — does R refute the idea that the upper trop. will dry out?

Experiment" paper, the results from which were presented at your hearing on Climate Surprises (5/8/91). In summary Ramanathan's conclusions were:

1. Clouds have two competing effects on climate: they trap heat, produce a greenhouse effect, and reflect sunlight, thus cooling as well. It depends on cloud type, thickness etc., realizing of course, that one cloud type can evolve into another, or thicken, thereby changing its radiative and other properties completely, with obvious but unclear climatic consequences. The number of possibilities and solutions are seemingly, nearly endless. There are, however, apparent limits, temp. perhaps being one of them, as shall become more clear as you read on.

Do get positive feedback up to a point.

2. The greatest/largest heat-trapping effect of clouds is found in upper level clouds prevalent in tropical oceans and in the mid-latitude oceans frequented by storms and cyclones.

brings up by warmer air?

3. Globally, the greenhouse effect of clouds is greater than the effect of a 100-fold increase in the atmospheric CO₂ concentration. It suggests that trace gas-induced warming of the ocean can lead to more extensive coverage of heat-trapping type clouds as described in 2.

4. With respect to the albedo/reflectance/shading/cooling effect of clouds, the largest such effect is due to the bright, low-lying stratus and storm track cloud systems over the mid- to high-latitude oceans and also due to the upper level cloud systems in the tropical regions.

5. What the experiment attempted to answer was the following: do clouds heat or cool the planet? Globally-averaged data reveal that the shading/cooling effect of clouds will offset the greenhouse warming. However, Ramanathan et al made the following important point, a point which Lindzen precludes from citing (see item 7 of my first note to you regarding Lindzen), and that is, that the fact that clouds have a net cooling effect on the present-day climate does not necessarily imply that clouds will offset greenhouse warming.

? = thought 13% GCM say small to signif

6. If, for example, the system of storm-track and low-lying cloud systems retreat poleward due to any warming, one loses the cooling effect of these clouds, which could result in amplification of global warming as a result of clouds.

Why would my retreat?

7. During spring and summer, clouds reduce sunlight which otherwise would have heated soil. If trace gas warming leads to a reduction, or even disappearance of this cooling cloud system, as suggested by some models, the sun's energy absorbed by this region will increase by as much as 25 to 50

? = Why would a reduction in clouds over landmasses occur?

is this the TRO to Lindzen?

watts per square meter, a factor of 10 to 20 times larger than the direct heat trapping effect of the trace gases.

8. Tropical convective cloud systems contain a mixture of cumulus, cumulonimbus, and cirrus anvils. Ramanathan et al could not determine whether the reflective cloud forcing of the cumulus clouds or the heating effect of the cirrus is dominant in the tropics. His data showed that these effects essentially, nearly cancelled over the thickness or height of the entire cloud column. GCM's however, had predicted this effect.

9. The clouds described in 8 however, can play a substantial role in climate change for these reasons: i) the height of cloud tops largely governs the LW (long wave - positive) cloud forcing, but the water and ice content determine the shortwave (SW - negative) forcing, and ii) surface temp. influences the cloud height, but low-level convergence governs the water content. So, for example, warming could increase cloud height and therefore, LW cloud forcing as well, hence, increased warming.

Why
and you're
all the forcing
long-wave - all
in IR?

10. A drought event (drying) would appear to cause a significant decrease of the SW (negative) cloud forcing since drying causes decreased cloudiness.

In his most recent work Ramanathan (and Collins, 1991), "Thermodynamic regulation of ocean warming by cirrus clouds deduced from observations of the 1987 El Nino", drew the following conclusions:

1. Water vapor and clouds are the dominant regulators of the radiative heating of the planet (at what rates and timescales?).

2. There could be a seasonal temp. cap at temps. above 303K due to cirrus cloud shielding. In other words, as warming occurs (thus warming the ocean surface as well) as, for example, in the case of an El Nino event (cessation or shift in the zone of upwelling of deep ocean waters offshore, as in the case of the 1987 event), it is accompanied by an increase in the greenhouse effect of the atmosphere and consequently clouds (cirrus clouds with anvils in the upper atmosphere to be exact - the cirrus eventually become so thick and therefore, so highly reflective that it blocks further sunlight from reaching the oceans). Thus, the negative warming effect produced by the presence of the cirrus clouds (albedo) exceeds the warming effect and thus ends up regulating the temp. of the ocean surface in this region (this mechanism will not permit the ocean surface temps. here to exceed a certain value, in this case the limiting temp. is 305K). Thus senator, as Schneider has pointed out, this may explain why there is no evidence for

my section
clouds over
the oceans
specifically
over the tropical
oceans &
specifically
only over the
Western Pacific &
other convective
regions?

① Ramanathan may be wrong - or at least offered only local
② " is right, Rindgen.com & Cooper

the operation of a Lindzen-type phenomenon. The system shuts down, is self regulating, and never reaches the temp. necessary, in theory, to set off a Lindzen type mechanism which, if one believes Lindzen, would bring about a negative water feedback effect resulting in cooling or significantly reduced global warming. - but this effect also & global warming.

bring this out in?

3. For very warm ocean temperatures, and in the region where cumulous clouds are generated (appx. 10% of Earth's surface) there may well be a strong negative feedback, which would help explain why the positive water vapor-greenhouse feedback of Raval and Ramanathan has not caused larger climatic variations over the geologic past.

4. However, as Schneider again has pointed out, such a strong negative feedback on surface temp. in the vicinity of highly reflective cirrus clouds in the tropics, would not significantly reduce the global average sensitivity to CO-2 doubling, for example, since most of the Earth is not covered by such clouds (appx. 10 % of the globe is covered by such clouds).

5. Thus, from Ram's perspective the interactions between the sea-surface temp., deep ocean convection, large-scale transport of moisture, and cirrus formation, are responsible for the observed negative feedback effect of cirrus.

6. Again, these results represent further testing of models by Ram, using actual data (sea-surface temp measurements taken during the 1987 El Nino event, and ERBE satellite observations of cloud radiation).

7. These processes are suggested to involve convective forces of the Hadley and Walker circulation cells, which these processes help drive as well. It is a self-regulating system.

then would be a global phenomenon - not just tropics

8. Thus the feedback between convection, greenhouse effect and planetary brightness (albedo) limits the temp. in the warmest regions of the Earth to 305K, a negative feedback to warming. (How would this explain Cretaceous warming of over 10 - 14 degrees C?).

convert to °C & °F

9. According to Ram, it would take an order of magnitude increase in atmos. CO-2 to increase the max. sea-surface temp. by a few degrees, in spite of significant warming outside the equatorial region (this may effectively counter's one of Stephen Schneider's earlier contentions cited above - it depends on the geographic extent of the phenomenon, a point which Ram is not exactly clear on - he almost has it both ways as I read it).

∴ Ram only gets as a ⊕ - but v. ltd. ⊕ feedback??

10. One of the bottom lines here as well is that this precludes the operation of a Lindzen-type negative feedback to the water vapor effect. In addition, there is still a positive temp. - water vapor feedback in operation here since this mechanism produces water vapor. In Ram's model the water vapor produced what he called a "super greenhouse effect" since water vapor amplifies the combined other effects of aerosol heating.

But limited

? - what produces clouds over landmasses?

11. Let me also add to the above by stating that it appears that cloud thickening above cold continental landmasses due to warming, tend to produce a net cooling via albedo effects as the cloud gets thicker with more heating, which increases its albedo effect. However, in most regions of the world, according to Rind, low level, thin clouds predominate. Such clouds, by virtue of their thinness, are not effective in reflecting sunlight and thus do not produce a negative feedback to warming, but rather allow radiative heating. On the other hand, I'm not certain that Ram and colleagues would agree.

Need to find out //

Robert Charlson:

Charlson will discuss the formation/nucleation of clouds by way of a variety of cloud condensation nuclei (CCN), aerosols with an affinity for water vapor. Such things serve, presumable as the basis for cloud seeding/formation. Various sulfur oxides of both an anthropogenic and a non anthropogenic variety (the latter being DMS - dimethylsulfide (a gaseous precursor of CCN) emitted from the carcasses of dying or dead plankton) serve as cloud condensation nuclei hence, the assertion on the part of many of the virtues of the cooling effects of acid rain (sulfurous emission, some of which seeds clouds which, in turn, block sunlight, and thus lead to cooling). Paul Crutzen also made it clear that the burning of biomass (i.e., forests) produces some particulate carbon which also serves as cloud condensation nuclei - thus rendering carbon with a dual role, cooling and warming, depending upon the form of the carbon involved, as well as the volume.

Regarding DMS, Charlson will point out that, independent of the rate of phytoplankton production in the oceans, the warmest, most saline, and most intensely illuminated regions of the oceans have the highest rate of DMS emission to the atmosphere. Hence, one would expect higher, preferential DMS production, and hence, CCN and therefore, cloud production in such regions, and thus a negative feedback to warming - a biotic or biogeochemical feedback as well. However, according to ice core records spanning the last glacial cycle, DMS (and hence, CCN and cloud formation I presume) production is inversely

What is the destruction here?

correlated with temperature or climate. DMS production appears to have been highest during cooler/colder climates and lowest during the warmest times/climates. Why? Good question.

a time lag?

However, Charlson has a very powerful punch line/message which is slightly outside the realm of clouds per se, but no more so perhaps than water vapor. His recent data on the volume and distribution of anthropogenic sulfur gases being injected into the atmosphere will not, as many have already concluded, result in compensatory global cooling in the face of global warming resulting from greenhouse gas emissions. He will show instead that SO₂ coolings effects are quite localized geographically, thus any cooling due to SO₂ emissions will hardly have anything remotely close to a global cooling effect.

both anthropogenic & natural? why does anthropogenic sulfur have effect - doesn't get globally dispersed? what about Pinatubo?

In addition to the above, others have shown (theoretically and practically, I believe) that atmospheric pollutants can alter cloud optical properties and the effect therefore of clouds on the Earth's radiation budget. There is evidence that the overall effect of pollution is to make clouds brighter (more reflective - a negative feedback to warming).

Robert Cess:

Cess is a close associate of Ramanathan and one of the few people in the world to analyzed differences among cloud/climate circulation model predictions. He notes, in having compared 14 such models recently, that in the absence of cloud feedback data in these models, the climate predictions were quite similar from model to model. However, upon entering cloud feedback into these same 14 GCM's, the compatibility vanished leaving a threefold variability in climate sensitivity within this suite of GCM's. The cloud feedback ranged from modest negative to strong positive feedback (to warming that is). He cites the hydrologic cycle as a key variable in such models. Such models did not also account for equator-to-pole temp. gradients., which would have an important impact on the position and movement of clouds. The bottom line was that the models produced a broad spectrum of cloud-climate feedbacks.

19?

? again, just modeling CO₂?

Cess was second author with Ram on the landmark paper on the radiative effects of clouds on the Earth's radiation budget. Cess has also done a great deal of climate modeling involving albedo (snow-climate) feedbacks, as well as desert-albedo feedbacks and biosphere (vegetation)-albedo feedbacks, on glacial-interglacial scales, in addition. He has tremendous depth and experience as a climate modeler.

Cess has also been very outspoken in favor of the existence of a positive temperature-water vapor feedback mechanism which amplifies warming. He has spoken out against Lindzen's notion of a negative temp.-water vapor feedback which leads to climate cooling (see accompanying reading materials).

has he published on that question?

Albert Arking:

Arking has a wide breadth of knowledge on the radiative effects of clouds on climate, as well as the capacity to discuss such matters as the sensitivity of clouds to pollutants, cloud condensation nuclei and dimethylsulfide phenomena. Arking's work has also emphasized the difference in cloud sensitivity (the differential response of top-of-the-atmosphere fluxes to changes in cloud cover parameters - i.e., optical thickness, water content, brightness, reflectivity, etc.) in cloud-climate models. He has suggested that observational data at are presently insufficient to yield more than rough estimates of this important feedback - cloud sensitivity. Arking is the closest individual we have to an authority on the micro-physics and properties of clouds, and their impact upon climate.

Arking has also co-authored with many of the panel members present, and was even one of the reviewer's on Lindzen's epic paper. In addition, like most cloud-climate modelers, Arking too considers water vapor to be the largest of the cloud-climate feedbacks. He clearly believes the burden of proof is squarely on Lindzen in demonstrating a negative water vapor-temp. feedback, and thus cooling in the face of warming. Arking, I think it is fair to say is a proponent of the temp.-water vapor positive feedback school of thought among modelers. He advocates more research in upper tropospheric water/convection phenomena.

Below are a list of other Arking caveats:

1. There is a wide discrepancy among cloud-climate models presently.
2. The effects of SO₂-induced aerosols on clouds is unknown.
3. Cirrus clouds have a large effect on infrared radiation, while the total effect is opposite in sign to low and middle level clouds.
4. The best way to study cirrus is with lidar(?).

? but Cess 19 show "excellent agreement"

? which is C? which is C?

5. Present cloud monitoring program (ISCCP-International Satellite Cloud Climatology Project) is not good enough. Comparisons among ISCCP data sets show wide scatter, especially with regard to cloud height and optical thickness data. Cloud parameters presently retrieved from current satellite measurements leave appx. 10 W/m (squared) unexplained in net flux at the top of the atmosphere, implying insufficient info, regarding cloud parameters. Additional parameters such as total column liquid water, liquid water density near cloud top, and an estimate of cloud base for boundary layer clouds could also be retrieved.

6. Mission to Planet Earth should also include a radiometer with channels optimized for the remote sensing of cloud parameters and a lidar system for studying cirrus and multi-layered clouds.

7. There is presently not enough emphasis on clouds in the EOS program.

8. Need to equip EOS with cloud monitoring equipment specifically for cloud measurements, and uniquely so.

9. Arking suggests that there is also newer instrumentation which could go into EOS satellites instead of 1989 vintage technology.

Arking will round out the discussion.

Alan Betts:

If there is a sleeper in this crowd I would put my money on Betts (and perhaps Charlson but for different reasons). Betts works out of his home in Vermont, not unlike Lovelock has worked out of his home. Yet at the same time, should this seem undaunting, Betts' research and brightness are held in extremely high esteem (see letter from his recent grant reviews). He also happens to be an expert on tropical upper atmosphere boundary layer phenomena, including the role of convective processes and water vapor. Furthermore, he was the first to respond in the literature, quite negatively, to Lindzen's hypothetical mechanism for a negative temp. water vapor feedback. Betts has been, and remains to be, one of Lindzen's most outspoken and fiercest critics, and on substantive grounds as well as far as I am able to see. Betts is presently in Europe testing and developing convective climate circulation models which will address the role of water vapor and the feedbacks. I gather that he also has some real data to work with.

whose is this
IGBP?

? = he is a
satellite guy
Can he add to
Rind's satellite
observations?

Betts is a staunch proponent of the existence of a positive temp.-water vapor feedback among GCM's, perhaps moreso than Cess. However, I repeat that his strength here, among other things, is his brightness and his expertise in tropical convective phenomena in the upper atmosphere, including the role of water vapor. He can directly and knowledgeably address Lindzen's theoretical mechanism. Betts may prove to be a tremendous panelist. He will certainly not be silent, by all accounts (see Betts' response to Lindzen, and reply from Lindzen).

? = what
data
models?
satellite?

William Rossow:

Rossow is a colleague of Jim Hansen who felt that he would make a very excellent addition to this panel discussion, even moreso than himself. His work essentially overlaps that of many of the above in many respects, but not in all. One of his most recent works, Global patterns of cloud optical thickness variation with temperature, is co-authored with David Rind, whom I have referred to often above. The focus of Rossow's most recent work is cloud optical thickness on low level clouds globally. His findings are the following:

1. On a planetary scale, clouds in the colder higher latitudes are found to be optically thicker than clouds in the warmer, lower latitudes (optically thicker clouds are more reflective and therefore have a net cooling effect, in general).

2. On the seasonal scale, winter clouds are generally optically thicker than summer clouds (positive feedback to winter cooling generally making winter cooler).

3. On the basis of having analyzed info. on northern hemisphere clouds in 1984, Rossow found (drew the conclusion beyond the data set at hand, de facto) that in cold continental clouds, optical thickness increases with temp. (as temp goes up this phenom turns on the ac by increasing reflectivity).

4. In warm continental and in almost all maritime clouds, however, optical thickness decreases with temp. (as temp. increases opt. thickness decreases and thus a warming effect.).

5. The temp. dependence of the optical thickness-temp. relationship (inverse relat.) stays the same regardless of whether the temp. variations are driven by seasonal, latitudinal or day-to-day changes.

Negative feedback
on cold, continental
clouds... how?
also... CO₂ proxy
paper?

this
is gone
as well
as Lindzen

6. Another way of looking at this is the following, however, overly simplistic it may be: thinner clouds (holding vertical extent, particle size and water phase of clouds relatively constant by focusing on low-lying clouds alone) allow light/heat/energy to pass through and thus heat what's below as opposed to shading. One can often see hazy sun through such clouds so you know intrinsically that they are not opaque to light and heat. On the other hand, optically thicker clouds (in essence a measure of cloud albedo/reflectivity mostly based upon a complex function of cloud microphysical properties such as the volume of the relative phases of water present, cloud brightness [often due to presence of pollutants and CCN] the amount and type of cloud condensation nuclei present, the diameter of those nuclei, etc. - as you can see from this list, optical thickness may be just a ballpark estimate at this stage of our knowledge - refer back to notes on Arking in this letter) are more opaque to light and therefore more prone to reflect light and hence, produce cooling.

clouds aren't
justly hazy -- just a
? of how much they
cool??

7. Rossow has offered that the reason for the inverse effect cited above is that for the most part, there is an increase in precipitation efficiency at higher temperatures relative to condensation. What does that mean? Just this, I think, precipitation is, or brings about the removal of water from clouds/the atmos., whereas condensation however, is a change in water phase, not the removal of water from clouds. So in warm places clouds contain more water vapor which, in turn, leads to increased precipitation efficiency and thus increased transparency/reduced or negligible albedo hence warming below these clouds. Those clouds with increased water content due to condensation, among other things, are more reflective and opaque to sunlight and thus lead to cooling.

why this not
a confirmation
of Arking
↑ temp →
↑ water content →
↑ precip →
↓ albedo

Rossow also advocates a positive water vapor-temp. feedback, as opposed to the operation of a Lindzen-type effect resulting in a negative feedback to warming.

Kevin Trenberth:

Kevin is the head of climate analysis at NCAR, and consequently, by virtue of that fact alone, should add immensely to the discussion and even broaden it considerably, should we wish to push the envelope out some. He has worked on decadal and interdecadal climate oscillations in the northern hemisphere, explored the origins of the 1988 drought in North America (which also included studying El Nino effects), studied/explored distributions and redistributions of atmospheric mass, surface pressures and water vapor variations/humidity, keeps records on global monthly ground and sea-surface

temperatures, has analyzed the frequency and effects of El Nino events and much more. His wide-ranging interests and background are real additions to this panel. He may also be one of the few people present who has addressed the role of humidity in clouds/climate in some detail, moreso than anyone else on this panel to my knowledge, including Lindzen.

7 = what will he say on this?

need to know!
I believe Kevin also advocates a positive water vapor-temp. effect, as most (all) GCM's show or predict.

Agency administrative witnesses:

Shelby Tilford:

He will be present to discuss/lay out the EOS (Earth Observing System) satellite project and its bearing on investigations into clouds. He should also be ready to discuss ERBE (Earth's Radiation Budget Experiment) and other relevant projects such as TRMM, the Tropical Rainfall Measurement Mission.

Mike Hall:

As head of NOAA's global change program he will be ready to discuss/present such initiatives as TOGA (the Tropical Ocean-Global atmosphere program) and GEWEX (Global Energy and Water Cycle Experiment program), in particular. The former is a joint program with NSF. He can also address ISCCP, the International Satellite Cloud Climatology Project (see Arkings remarks about this program).

U. S. Air Force Colonel Ronald Townsend:

As of today the Air Force has agreed to have Townsend present (he holds a Ph. D. in meteorology as well) to discuss the sharing of potentially useful data bases with climate modelers.

This then senator, along with associated reading materials which I have made available to you (today as well), will constitute my briefing of you for the clouds hearing. I will also get a list of questions to you by this evening or tomorrow morning at the latest. I believe you will be in good shape after having digested this material. I will also be available to you over the weekend should you feel the need to chat. I can be reached at (202) 362-9198 (home), and (202) 224-9360, my office in the Hart building. It's a complex topic.

United States Senate

WASHINGTON, DC 20510-4202

M E M O R A N D U M

DATE: October 4, 1991

TO: Senator Gore

FROM: Tony Socci

SUBJECT: Questions and short bits for clouds hearing.

*Katie: The latest
of Jester. It still
needs a final "Push"
P.*

General Introductory Questions

1. Would you provide us with a general overview on clouds and their role in determining or establishing climate?
(Perhaps Ramanathan might be the best person to do this).
2. What is the present state of knowledge regarding the role of clouds in climate/climate change?
3. How do clouds form and how do they regulate climate?
4. What do climate models presently tell us about the possible role of clouds in an atmosphere wherein greenhouse gases might double, triple or even quadruple?
5. What are the major weaknesses in the predictive capabilities of the present generation of cloud-climate models, and how does that presently affect their capacity to predict what the role of clouds will be in the face of climate change, an anthropogenically-induced warming, for example?
6. How would you characterize the resolving power of this present generation of climate models?
7. What do we know about clouds and their impact upon climate?
8. Where are the gaps in our present knowledge regarding the role of clouds in climate?
9. By the same token, what are the shortfalls in the present generation of climate models in terms of their predictive capabilities, and the reliability or resolution of those predictions?
10. How good or reliable is our present information on clouds?

United States Senate

WASHINGTON, DC 20510-4202

M E M O R A N D U M

DATE: October 4, 1991

TO: Senator Gore

FROM: Tony Socci

SUBJECT: Questions and short bits for clouds hearing.

General Introductory Questions

1. Dr. Ramanathan, would you provide us with a general overview on clouds and their role in determining or establishing climate?
2. What is the present state of our knowledge regarding the role of clouds in climate and climate change? Furthermore, how does that knowledge compare to our understanding of other Earth systems (oceans, terrestrial, biogeochemical and planetary) and the linkages between these systems [Drs. Ramanathan and/or Cess]?
3. How do clouds form and how do they regulate climate [Dr. Ramanathan]? What are the most climatically significant or sensitive components of clouds [Drs. Rossow, Arking or Ramanathan]?
4. Where are the gaps in our present knowledge regarding the role of clouds [Drs. Arking, Ramanathan or Betts]? What additional knowledge would render cloud-climate models useful for policy decision-making and societal planning [Drs. Ramanathan, Betts and Cess]?
5. What are the major weaknesses in the predictive capabilities of the present generation of cloud-climate models, and how does that presently affect their capacity to predict what the role of clouds will be in the face of climate change, an anthropogenically-induced warming, for example [Drs. Cess, Ramanathan, Betts or Lindzen]?

Dr. V. Ramanathan

1a. Does the present distribution of clouds on Earth bring about a net cooling or net warming effect? [Ans. cooling].

1b. How were you able to determine that ? [Ans. by the use of ERBE (Earth Radiation Budget Experiment) satellite observations on radiation - satellite data compare with ground monitoring stations for accuracy].

1c. Would it be fair to say that global warming global warming greenhouse gas emissions would, in the absence of clouds, lead to even greater warming? [Ans. yes].

2a. Would you explain the fact that some clouds have a greater affinity for trapping heat radiated from the Earth, while others have a greater affinity for reflecting incoming solar radiation? What determines whether a cloud will have a greater reflective capacity versus a greater heat-trapping capacity? [Ans. all clouds do both but typically net greenhouse effect or net cooling effect - many things: transparency, opacity, cloud thickness, density, phase of water, cloud condensation nuclei (CCN), kind of nuclei, packing of nuclei, brightness or dullness, etc., determine properties of cooling or warming].

2b. Is it possible for a cloud to start out with an affinity for warming, later evolving into a cloud with an affinity for cooling, and vice versa? [yes, I believe, but I would like to know the answer for my own edification - if yes then clouds are even more complex and their behavior more difficult to predict, I would imagine].

→ 3a. In May of this year, the New York Times had an article on some of your research indicating that there is a feedback between clouds, sea-surface temperature and water vapor that seems to set an upper limit for ocean temperatures in the tropics. Would you explain the operation of that system? [Ans. NYT writer suggested that clouds might cool greenhouse warming globally, citing the temperature regulating mechanism in the tropics which Ram had referred to - he is angry with NYT's because they mistated him - his mechanism applies only in tropics and may have nothing to do with greenhouse warming [it will not cool planet in face of warming- temp. regulatating mech. is this: tropical sea-surface warms due to heating, feedback is production of more water vapor above sea surface, convective rise of water vapor forming cirrus clouds with anvils which lead to cooling below, thus regulating temp. of sea surface below - puts cap of 31 degrees C on water temp here]'

Dr. Ramanathan Continued

- 3b. Would you elaborate on the significance of these feedbacks, and the sign of these feedbacks, in terms of their combined impact on climate in the face of increasing greenhouse gas emissions/further warming? [Ans. sea surface temp. elev. leads to water vapor prod. therefore, positive feedback to warming because water vapor is one of most effic. greenhouse warmers].
- 3c. I take it therefore, that this work was based upon model calculations or predictions and observations and/or real-world data? [positive sea surface temp.-water vapor feedback was predicted by GCM's - Ram and others then collected data on sea surface temps. for 1987 El Nino event and tested the observations against the predictions with good correlations].
- 3d. Am I correct in assuming therefore, that this effect or mechanism is confined to the tropics due to the relatively high sea-surface temperatures involved? [Ans. yes - area of tropics is appx. equivalent to roughly 10% of the Earth's surface, or is it global - it can only logically, theoretically be confined to the oceanic sites of cirrus cloud production].
- 3e. If cirrus cloud phenomena are confined to the tropics, would it be fair to conclude that cirrus cooling in the tropics would not significantly reduce global average sensitivity to a CO-2 doubling, for example? [Ans. it will not presently reduce onslaught of greenhouse-induced warming].
- 3f. Even in the event that cirrus cloud formation in the tropics might lead to an upper limit (305 degrees K, appx. 31 C) on sea-surface temperatures globally, would this not still leave much latitude for climate warming resulting from increased greenhouse gas emissions, before such a mechanism might come into play in the first place? [I do not know answer to this- I wanted to know - Schneider wanted to know as well].
- 3g. What climatic impact do pole-to-equator thermal gradients have on the operation of this cirrus cloud-sea surface temperature regulation mechanism, and on clouds in general? [changes in gradient should result in movement of clouds - in tropics if tropical clouds were to move further n and s of equator due to change in thermal gradient, tropics may warm in absence of no net cloud-heating or cooling effects presently].

Dr. Ramanathan Continued

— 3h. Would the operation of the cirrus-sea-surface temperature regulation mechanism preclude any negative water vapor-temperature feedbacks due to say convective drying in the upper atmosphere [Lindzen's theory], insofar as you are able to determine? [Ans. I would think so, or at least place starting point at new Lindzen's mech. at higher temp.].

3i. Is the cirrus cloud-sea surface temperature regulation mechanism based upon a model calculation, actual observations/data, or both? Would you explain? [Ans. based on model prediction's of GCM's which predicted positive water vapor feedback with temp. in a warming scenario - doubling of CO-2- they then collected real sea-surface temp. records for 1987 El Nino event in order to test GCM predictions against real records of temp. - good correl. between prediction and raw data].

Dr. Robert Cess

1. What are the results of your comparisons among cloud-climate models? [Ans. compared 14 cloud-climate models - without clouds all models similar predictions- with clouds - when clouds added fair amount of variation in climate scenarios with doubling of CO₂ - found range of feedbacks from slightly neg. to high positive - one of the 14 models predicted slight neg. feedback to greenhouse warming - all others positive].

2. According to your models, calculations and/or observations, is there a positive (climate warming) feedback between temperature and water vapor? Would you explain? [Ans. resoundingly positive - this guy has done most of the model testing and comparisons among models].

Dr. Robert Charlson

1. Would you explain the results of your research on cloud condensation nuclei and dimethylsulfide (DMS), and their climatic implications? [Ans. DMS given off by phytoplankton, preferably in warm, illuminated saline ocean settings - it later reacts to become cloud condensation nuclei (CCN) which seeds clouds].

2. Is it fair to say that dimethylsulfide (DMS) is a biotic control on cloud formation and the entire climate system? [Ans. yes - we are laying ground for entry of biogeochemical feedbacks to climate/clouds - want this on record].

3. If the warmest, most saline and most intensely illuminated regions of the oceans have the highest rate of DMS emissions to the atmosphere how do you account for the fact that ice core records spanning the last glacial to interglacial climate cycle appear to indicate that DMS production was higher when it was climatically cooler, and the glacial oceans were more saline? [Ans. I don't know, he may not have a clean ans.]

→ 4. Much has been said recently about the apparent climate cooling effect of SO₂ emissions, presumably predicated upon the correlation between sulfur emissions and cloud formation [see accompanying doc.]. What, in fact, do your recent findings on anthropogenic SO₂ emissions indicate in terms of this alleged sulfur-driven global cooling in the face of a global warming due to rising levels of greenhouse gases? [Ans. cooling effects of SO₂ are localized - it will not act as global air conditioning to global warming].

Dr. William Rossow

1a. What is the climatic significance of low-lying clouds over continents, and their counterparts over oceans? [Ans. clouds over cold conts., when heated increase in optical thickness, block sun and cool below - low clouds elsewhere outside cold continental regions, including oceans, appear to thin when heated, become more efficient at releasing water through precipitation, leading to heating below - reason: less opt. thickness and light/heat passes through] through].

1b. How much is really known regarding clouds over landmasses, their properties and climatic significance, relative to our knowledge of clouds over oceans? [Ans. almost nothing - his study is one of the few that deals with cont. clouds.].

2. According to your calculations and/or observations, is there a positive or a negative water vapor feedback to climate warming? [Ans. positive].

3. Is there any evidence of for a negative feedback to elevated temperatures and water vapor due to convective drying, as Dr. Lindzen has suggested? [Ans. no].

Dr. Albert Arking

1a. Are the results of your observations and calculations on the radiative effects of clouds similar to the results of Dr. Ramanathan, Dr. Cess and others? [Ans. yes if candid - he also does a great deal of detailed measurements on cloud microphysical properties].

1b. According to your calculations or observations, is there a positive feedback to climate warming due to temperature-water vapor effects? [Ans. yes, if he has info of his own - otherwise he has no info. and cannot say - he will however say the burden of proof is on Lindzen].

1c. Are you aware of any evidence for the existence of a negative feedback to warming resulting from convective drying as Lindzen has suggested? [Ans. no].

2a. What, in your estimation, would improve the sensitivity, resolution and reliability of cloud-climate models? [Ans. more measurements on cloud microphysical properties, proper cloud-monitoring equip. on board EOS satellites, and new er tech. instruments on EOS].

2b. How sensitive are the predictive capabilities of the present generation of cloud-climate models? [Ans. he will say bad on microphysical properties, better elsewhere - overall fair but needs lots of improvement].

Dr. Alan Betts

1a. On the basis of your modeling of tropical convective systems, as well as your observational data, is there a positive temperature-water vapor feedback to climate warming? [Ans. yes].

1b. What does your work tell us about the role of water vapor and tropical convective processes resulting from greenhouse warming, for example? [Ans. lots of water vapor and ice injected into upper troposphere during convection in tropics where Lindzen claims it's dry - relative humidity high up in tropics is approx. 40% - his models shows 2-3 degree C temp. rise in tropics due to doubling of CO₂].

2. Is there any evidence for the existence of a negative feedback to climate warming resulting from convective drying as Dr. Lindzen has suggested? [Ans. No - The idea is wrong and Lindzen's model is implausible].

Kevin Trenberth

1a. What's the role of water vapor during climate warming, according to your calculations or observations? [Ans. it should be that it reinforces warming - otherwise no info.].

1b. Are you aware of any evidence for a negative feedback to climate warming due to convective drying in the upper troposphere as Dr. Lindzen has suggested? [Ans. no - there is moisture in mid-to-upper troposphere contrary to Lindzen and therefore, there must be a pos. feedback to climate warming - subsiding side of convective systems produce locally cloudless skies and heating below

2. Would you describe the results and climatic implications of your work on cloud patterns, tropical convection and water vapor? [Ans.- in part, he has a bone to pick with Dr. Ramanathan - Trenberth claims Dr. Ramanathan's temperature-limiting mechanism in tropics does not work everywhere and that there is a dry, hot side to these convective systems as well - so he says that although Dr. Ramanathan's mechanism produces cloud cooling in some local areas there are compensating regions of warming and drying and greenhouse water vapor effects which exceed cooling - thus no overall net cooling or temp. limiting by Dr. Ramanathan's mechanism - Trenberth says that cool dry air masses from these and other systems draw heat from ocean and limit sea-surface temp. in places - fairly uniform temps. in tropics - bottom line - higher sea surface temps. could occur with global warming].

Dr. Richard Lindzen

1a. Would you describe your idea for a negative temperature-water vapor feedback to climate warming due to convective drying in the upper atmosphere? [Ans. heating produces increase in water vapor but vapor is driven higher and faster into upper atmos. - along the way up water condenses and falls out updraft side of convective tower, leaving upper troposphere dry, thus without a means of getting water vapor into upper atmos., water vapor and warming effect of vapor not well distributed, therefore minimal warming effect, conceivably negative feedback to warming?].

1b. In the two years or so which have elapsed since you first published a sketch of this mechanism, have you set about formulating a set of physical constraints or limiting conditions to your idea so that other scientists would be better able to subject your idea to critical evaluation and testing? [Ans. nothing like that exists - however, I cannot speak to his integrity]

Isn't this the so-called scientific method?

1c. If so, would you describe what those constraints are and nature of the data upon which you have based this idea? [Ans. no constraints to my knowledge].

1d. Do you presently have any direct measurements or observational data indicating that the atmosphere and water vapor might, in fact, behave in accordance with your original idea? [no would be the honest answer].

1e. If so, would you share that information with us and explain how it supports your original idea regarding convective drying and the notion of a negative water vapor feedback to greenhouse warming?

Dr. Richard Lindzen Continued (1)

[Ans. the only way he might be able to slide out from under this is a study he did (recently submitted and presently unpublished is my guess) wherein he infers that the so-called descent of the mountain snowline during the last glaciation (whatever that is) might possibly infer the existence and operation of a negative feedback mechanism - in other words the real answer is that he has no data and no observations - from this snowline paper he states: "As to the possibility of the enhanced evaporation of cloud water or hydrometeors(?) in a colder climate, the discussion has been qualitative" - elsewhere he states - "A direct analysis of the roles of the relevant physical processes in maintaining the current water vapor distribution is impeded by the lack of good observations of water vapor in the upper-troposphere" - in other words, no data and no constraints - his evidence for his elusive model is now an inference apparently devoid of convection at all]

[Senator, we should pursue this (unpub. ?) paper of Lindzen's and it's themes and content with a series of questions - his responses are bullshit - Trenberth has lots of good tropical water vapor measurements or calculations, so does Alan Betts and so does David Rind, a colleague of Hansen's at NASA-GISS - in other words, earlier on about 1990, Lindzen's argument's against testing and characterizing his idea were that all of the data and all of the models are terrible - then with the advent of great water-vapor gathering instruments which gather water vapor up to heights of 40 kms (Lindzen in his present introductory statement says "Water vapor is not monitored above 6-9 km." - this is just not the case)]. I will prepare a suite of such questions.

1f. Is there any evidence that your original conceptual mechanism for convective drying might, in fact, almost entirely counteract warming due to greenhouse gases? [Honest answer - no, but I doubt an admission -maybe he'll refer to the paper above].

1g. Could there be variations of this concept such that the effects might also lead to a positive feedback to warming as opposed to a negative feedback? [honest answer should be yes, but I doubt an admission].

1h. What data or evidence would effectively negate your notion of a negative water vapor feedback to cooling? [Ans. I have no idea, nor do I know his response].

Note:

To my knowledge and that of others, Lindzen has no data or evidence for this mechanism and its climatic consequences, or at least one of them. It is an idea in his head.

2a. Even if such a mechanism were to exist, would it not, in fact, be a local phenomenon even by your own description and depiction? Could such a phenomenon really dry out all of the upper atmosphere? [Ans. should be yes to first ? and no to latter but I doubt he will say so].

2b. What's the approximate radius of convective columns, at their tops, as observed in nature? [Ans. the biggest size he can think of - Hadley circulation is my guess].

Dr. Richard Lindzen Continued (2)

Note:

In Dr. Lindzen's Fig. 7 (see copy), the downwelling dry air is immediately adjacent to the updraft side of this convective column. To my knowledge, no such convective towers are known to exist which have a tower-top radius in excess of 200 km. It therefore, has to be a local phenomenon.

Note:

Dr. Lindzen might respond by suggesting that he was talking about a much larger convective system such as updraft in Florida and downdraft in Peru. He might further suggest that this phenomenon (idea in his head) is on the scale of a Hadley circulation cell encompassing many tens of degrees of latitude]

3. Dr. Lindzen, I understand that there is no evidence in the historical climate record for the existence and operation of such a climate feedback mechanism. The consensus is that there must be a positive water vapor feedback to create ice ages. Would you agree that that is the present consensus? Do you have any evidence to the contrary?. [Ans. should be that he agrees, and that that is the case, but he may not agree].

4. Dr. Lindzen, if we accept your conceptual mechanism for the sake of discussion, then we should just sit back and wait for your mechanism to kick in and cool us off. But the mechanism requires heating to turn itself on in the first place! How much heat is needed? 2 degrees C? 5 degrees C? So what should we do in the interim while we are waiting for salvation? Are you confident enough in your hypothesis to tell Congress that we should just wait and see?

Questions Regarding Lindzen's (unpub. ?) Paper "Negative feedback of water vapor inferred from the mountain snowline record"

1. Is the above paper published?
2. Where was it submitted for publication?
3. Is there inferred effect in question a negative feedback to cooling or a negative feedback to warming?
4. What is a hydrometeor?
5. Would you explain the following series of statements from the Introduction of this work?

"A direct analysis of the roles of the relevant physical processes in maintaining the current water vapor distribution is impeded by the lack of good observations of water vapor in the upper-troposphere. The situation is improving since some water vapor data in clear sky can be obtained through satellites (Rind et al, 1991). However, even if we are able to establish a reasonable picture for the current water vapor distribution, we may still have a long way to go to understand how the increase of CO-2 perturbs this picture. Here we present a different approach, namely to infer the relevant information concerning the water vapor behavior in different climate regimes".

6. Aren't these statements nothing more than a series of disclaimer amounting to saying the following:

I cannot state what the study is about because I am not certain myself.

I cannot employ data because there is none or it's not sensitive enough.

Even if there is reasonable data available we still don't understand the problem or why we started this in the first place.

The issues involved are too complex to be subjected to data and an idea.

Therefore, we will give ourselves a license in draw inferences.

How could anyone else evaluate this if they are vague in telling you what is being done, have no data to analyze, show no raw data in the paper, yet remarkably enough,

Lindzen's Paper Continued

In other words what's really being said is:
I cannot prove this phenomenon but I just know it's there.
(Lindzen's running for cover - nearly all of his excuses
have fallen one by one as to why he cannot explain his
mechanism beyond what he has, he cannot prove it has
operated, and he now cannot afford to use data at the risk
that it may disprove his idea which he knows to be correct
and in operation anyway).

M E M O R A N D U M

DATE: October 5, 1991

TO: Senator Gore and Cloud Crew

FROM: Tony Socci

Richard Lindzen -Rebuttal

Points of Contention from Lindzen's Testimony, with Rebuttal
This is a road map for engaging Lindzen directly should you care to mix it up. [Have a good time].

Let me emphasize at the outset that after having given the matter additional thought, I have arrived at the conclusion that most of the points which Lindzen has made in his opening statement are points which most would agree upon. In fact, one wonders where Lindzen has been all this time. I can think of few scientists, and certainly not those at this table, who have not concerned themselves with these matters for quite some time. Lindzen thinks he's the first to have arrived here, when in fact, what his comments address the fact that it is he who has been the latecomer to this debate. This is probably due, in part, to the fact that his research has been in atmospheric wave phenomena (i.e., radio waves, etc.). Greenhouse and water vapor are new to him.

On the other hand I believe that Lindzen has set about distorting information at the very least, either deliberately or because of his naivete with regard to the history of this planet's climate, or a combination of both. Greenhouse also remains to be one of the largest playgrounds for debate.

1. "... the average temperature of the Earth has been in the range 18 degrees C (+/- 5 degrees) for about 4 billion years - during much of which time the atmosphere contained many times the CO-2 projected for the next several centuries (Fairbridge, 1991). The model predictions exceed this range."

Response/discussion: [refer to accompanying chart]

Lindzen would have the world believe the so-called logical and accurate conclusion to be drawn is: that the models are badly flawed because they fail to predict reality. And reality and accuracy (perhaps even integrity,

) are indeed the keys here. The real problem here is that Lindzen has either deliberately mistated the facts, or he is totally and shamefully unaware of the climate history of this planet or both.

According to Lovelock and Whitfield, and many others, including Carl Sagan (refer to accompanying figure), the range of temperatures over the surface of the Earth appears to have been confined between 5 and 40 degrees C (perhaps up to 50). The median (not the average) tempterature of the Earth's surface over the past 4 Ga (billions of years) is appx. 21 to 22 degrees C (most put the average at appx. 25 degrees C). Every GCM (general circulation model) prediction lies well within this range of surface temperatures excepting of course, those instances in which extreme values were purposely loaded into the model to examine its sensitivity and so on. An eminently logical and essential task for a modeler.

In short, Lindzen fails to show the reader the range of the data set from which the average temperature was calculated, reporting only the error bar of the average temperature as well, which is huge by the way (18 degrees, +/- 5 degrees means the data set had a great deal of scatter, as it surely does).

Thus Lindzen has set up the reader to mistrust models and modelers (in this case GCM's) by misuse and distortion of information, or unforgivable naivte.

Even more to the point, the real question or significance here is the remarkable constancy of the temperature at the Earth's surface. That does indeed warrant a real explanation.

It's remarkability stems from the fact over this same timespan of 4 billion yrs., the amount of radiation given off by the sun has increased by appx. 30%. Hence, todays' average surface temperature should be somewhere in the vicinity of 72 degrees C, far in excess of the limits of tolerance for life itself (according to Lovelock and others), as opposed to its present actual temperature of appx. 25 degrees C).

Lindzen is clearly building the base for his next caveat which is, of course, that the Earth has always been extremely capable of regulating it's own temperature so why should we be alarmed. Let's let nature do it's thing as it has for at least 4 billion years, and in the face of much higher CO-2 concentrations as well [which is true - but do not be alarmed - he does not fully grasp the full spectrum of the implications and facts here so do it for him].

How then did Earth surface temperatures remain relatively constant over the last 4 billion years when the sun was getting 30 % hotter? By the constant biogeochemical removal of carbon from the atmosphere (this is pure greenhouse - that is, add carbon to the atmosphere and the earth warms, remove it and it cools) over the last 4 billion years. Had this carbon not been incrementally removed life may well have already been eliminated from this planet according to Lovelock and many others [keep in mind that Charlson has worked with Lovelock - if you need greenhouse help go to Charlson].

And now we have arrived at the point, that point being the very basis for our concern, the impending and real threat of disrupting the very balance in nature which has so deftly regulated planetary temperatures and climate for so long, by continuing to emit greenhouse gases into the atmosphere at rates that exceed nature's so-called natural ability to handle it, thus resulting in heating and the threat of significant and as yet unknown climate. and as nature has already demonstrated, such sweeping changes can come about almost instantaneously. Thus we need complex models to analyze the compound complexity of climate controls and feedbacks. Such models will be essential in being prepared for such an eventuality [ad lib wherever you want to Senator].

One could imagine the analogy of an inflatable tire which we come along and inflate until it ruptures - let us not forget that this tire could rupture due to the added volume and/or the rate at which we inflate the tire.

2. Reply:

Another equally good point to make Senator would be that climate change is hardly synonymous with changes in temperature and/or CO-2 alone. It is a highly complex system which often turns radically on subtleties born out of complex feedbacks. Again the overriding rationale for building and tuning GCM's is that they help solve complex problems.

3. The corollary notion (to the above) which Lindzen is pushing in his opening statement, is that there have been natural variations in atmospheric CO-2 and temperature [Is Lindzen actually admitting to a link between CO-2 and temperature?] four or more times the amount of CO-2 which we are presently concerned about (and in the future as well). And the message is: life persisted and all was well. why then should we be worried about a non-problem?

Reply:

Again, what Lindzen has deliberately withheld (or simply does not know - keep in mind that he is a newcomer to this topic) is that at those times when CO-2 increased beyond the range of the present projections based on emissions, there were sweeping changes in biotic communities and a near complete melting of the polar caps, as was the case 100 Mybp, when sea-level rose by appx. 130 meters above our present sea-level. Is Lindzen suggesting that had we (people - human beings) been around then (which we were not) that there would have been no cause for alarm here, or that it was life as usual? Had we been able to anticipate such a change however we might have built boats and survive. [you take it from there Senator].

Lindzen is shamefully lulling people (unknowledgeable people at that) into a false sense of security. This is highly unethical, particularly since Lindzen's main or real interest lies in the furthurance of the debate itself.

4. Lindzen states that the average equatorial sea-surface temperatures over the past 4 billion years has been in the range of 30 degrees C (+/- 1 degree). And again, Lindzen goes on to argue that because all models GCM's) predicting large global warming predict a 2 to 4 degree C warming at the equator, they are misbehaving.

Response:

And again, the real question here is what is the range of the data set from which this average of 30 degrees was calculated? Without knowing the range of that data set, my response is as it was above, I would find it hard to believe that equatorial sea-surface temperature calculations from GCM's are not well within the Earth's historic record of equatorial sea-surface temperatures, as opposed to having to lie within the range of the average value of equatorial sea-surface temperature for the past 4 billion years. Lindzen is misleading the reader into being suspicious about models (genuine and sincere inquiry is one thing but implanting suspicions based upon half truths is another matter entirely).

5. Elsewhere Lindzen states: "Beyond the prima facie evidence that model (GCM's, I presume) predictions are inconsistent with observations". inconsistency far transcends the above examples), are there other reasons for questioning model behavior?".

Response:

How is it that Ramanathan's (and Cess's, as well as others for that matter) model predictions are inconsistent

with observations? For example, Ramanathan's models (or the models which he employed) predicted that there would be a positive water vapor feedback produced by warming (in other words warming the sea-surface would lead to increased water vapor and hence, warming). Ramanathan then tested these predictions by gathering relevant observations/instrument-recorded data on radiation and sea-surface temperature, and in that instance, found observation to be consistent with prediction beforehand, thus constituting a test of the model.

Where by contrast, is Lindzen's model, in detail, so that it might then be subjected to the same scrutiny which he relishes in the case of other peoples' models? It's easy to sit back and take pot-shots at other peoples' work as opposed to putting your neck out there so that others can then evaluate your ideas and observations through careful inquiry? Yet in over two years since Lindzen published his work paper on "Some coolness regarding global warming" he has yet to reveal any set of constraints to his idea (in other words what are the physical requirements for turning it on and off, when does it turn on, under what circumstances does it turn on, where does it happen, how does it shut down, at what temperature does it shut off. Even worse, where are Lindzen's efforts to observe his idea in operation on this planet? [It would be worth probing Lindzen with a series of such questions asking for the details of his idea as I have suggested above. Put him on the spot. Where is his evidence/proof?]. Where are his attempts to validate his own model and let others scrutinize his idea?

6. Reply:

In the timespan of over two years Lindzen provides no embellishment or clarification of his idea, nor even observational data to support it's existence to my knowledge. Over this same timespan, by contrast, Ramanathan and colleagues have taken model predictions and tested them with real data from the real world, and subjected their work to analysis [and one of the first to jump all over Ram's work, of course, is Lindzen]. The point is that Ramanathan is engaged in the art of scientific inquiry while Lindzen appears to be engaged in the art of debate. Why doesn't Lindzen do some science for a change? Or is it simply the case that he cannot afford to determine the likelihood or reality of his model since, at that point, there is no vehicle for continuing the debate?

7. In addressing the alleged mis-behavior of models, as Lindzen has put it, Lindzen makes the following statement (bottom of page 1, top of 2, of his opening statement): "... (recall that CO-2 contributes only about 1% to the

greenhouse effect and model errors are far larger than this)
..."

Reply:

Here again Lindzen is clearly, in my opinion, attempting to not only lull the reader (the uninformed mostly) into accepting, without further clarification, that these expensive circulation models are fraught with error and therefore, untrustworthy, but also to lead the reader (the non-scientist largely), into accepting that these models, because of such large errors, are completely insensitive to changes in CO-2 because there is so little CO-2, volumetrically, presently in the atmosphere (0.036 % - this number is accurate Senator) and because CO-2 contributes only about 1% to the greenhouse effect (which is not altogether true either).

In other words, Lindzen has done his best to lead one to believe that the models are totally incapable of rendering any reliable results insofar as its volume, absolute quantity and climatic effects are concerned, because all of the error completely removes sensitivity to CO-2 as I have stated.

[This is bullshit, flat out]. First of all, the error in circulation models is compound and complex. It comes from all of the variables and the interactions, etc., including measurements of data. All of that error is not attributable to CO-2 as he would clearly like to invite the reader into believing [this guy senator, is devilishly clever, but unethical]. In fact, the error associated with CO-2 values in these models might contribute very little to the overall error, contrary to his implication [bear in mind that he has not come out and said this, nor has he made these connections, he has merely left the unaware reader in a carefully designed trap - free to make the so-called obvious connections, or free to draw the obvious conclusions as one sees fit].

This would be a very interesting matter to throw before the members of this panel. My advice is to invite their comment on this and add your own. No wonder people do not understand models, modelers, and the basis for their use and existence.

8. Item 1, page 2 of his testimony: "Water vapor and layer clouds account for over ninety-eight percent of the greenhouse effect"

Response:

As Lindzen himself points out elsewhere in his own statement, "A molecule of water vapor at 12 km altitude is about 1000 times more important than a molecule at 2 km in its contribution to the greenhouse effect". In other words, the water vapor greenhouse effect is variable depending on where most of it resides. It's effect therefore, is variable. [nonetheless it is true that water vapor has an extremely large greenhouse effect].

Interestingly enough however, particularly in light of the small volume of CO-2 in the atmosphere, doubling CO-2 concentrations in GCM's leads to warming, which then triggers a positive water-vapor feedback to warming, which greatly enhances the warming. And that's precisely again what Lindzen fails to elucidate. How such a small quantity of gas can trigger a larger positive feedback to warming and greatly amplify the signal. The distortion of information here is unimaginable [again, it is clear that he has not said the above - he merely leaves those who lack the ability to evaluate such information in a minefield of conceptual traps which lead to fallacious or partial understanding.

9. Be on the lookout as well, for one of Lindzen's pet fiats which is this: he has even questioned whether there is a link between temperature and CO-2. Specifically, he has pointed to the ice-core data (Vostok and Greenland) for the last glacial/interglacial and cites others in saying that it is not clear that increased levels of CO-2 lead to an increase in temperature (he's questioning the fundamental tie between CO-2 and temperature) because some of the data show that in the beginning of the last interglacial ice-cap melting appears to have preceded and increase in CO-2. In other words, CO-2 did not lead to elevated temperatures, but rather, elevated temperatures lead to increased levels of CO-2.

Response:

Buy his argument completely. If you accept that increased temperatures lead to higher levels of CO-2, isn't that just another way of saying that the warming will be amplified by more warming, and isn't that the point? Now you have more to be concerned about. It does not get rid of any problems and his argument is totally meaningless in terms of the directions and signs of the feedbacks. There is also more than one way to heat a planet.

But more importantly senator, lurking behind Lindzen's position here is Lindzen caught questioning the existence of a greenhouse effect or again attempting to imply, or leave the reader to infer that there is no greenhouse effect. It's a conspiracy. Under any circumstance, increased CO-2 will lead to elevated temperatures.

Greenhouse effect is an established fact. Just look at Mars and Venus.

10. Elsewhere in his opening testimony Lindzen states that "Water vapor is not monitored above 6 - 9 km".

What did you mean by that statement Dr. Lindzen?

The SAGE II satellite instrument does measure water vapor in that region, all the way up to 40 km, at intervals or increments of one km. Note that Lindzen has used the word "monitor" in his statement. The Sage data is not a continuous data set because the data are spaced apart by increments of 1km.

11. Dr Lindzen, what prevents you from using the SAGE satellite measurements of water vapor since this device monitors water vapor all the way up to a height of 40 km, at increments of 1 km? [Ans. - he will probably suggest sensitivity problems- which he could not know beforehand anyway]

12. Dr. Lindzen, on the other hand, how could you then make a corollary claim, along with De-Zheng Sun, that you can infer a negative feedback of water vapor from the mountain snowline record?

13. Are you suggesting that your calculations or inferences constitute a more sensitive data set than the SAGE II satellite data on water vapor, or that the data on the mountain snowline record is also more sensitive than this satellite data on water vapor?

14. Dr Lindzen, it appears as though no data set is quite good enough to test your idea for one reason or another. Would you agree with that?

15. Dr. Lindzen, who is De-Zheng Sun?

16. Would you explain this paper's "Negative feedback of water vapor inferred from the mountain snowline record"?

17. Would you explain what this paper purports to explain, as simply as possible?

David Rind, colleague of Hansen's, has used this data to test his model predictions of a positive water vapor feedback to climate warming, including water vapor in the upper and middle troposphere, precisely where Lindzen claimed there should be no water as a result of his model - and therefore a negative water vapor feedback to global warming. Using water vapor data gathered by the SAGE II satellite Rind has

validated his model prediction - positive water vapor
feedback to warming.

M E M O R A N D U M

DATE: October 7, 1991

TO Senator Gore

FROM: ADS

SUBJECT: Clouds Road Map/Tree

Opening Statements in this order: Ramanathan, Lindzen, Arking, Cess Charlson, Rossow, Trenberth, Betts, Hall, Tilford, Townsend. If Dr. Ramanathan does not finish piece on rebut of NYT's piece let him finish in discussion.

Rules of the discussion: all speakers recognized by you. One speaker at a time.

Overview on clouds and their climatic significance: Dr. Ramanathan.

General questions.

Greenhouse/your business: Start with Dr. Charlson - ask questions marked in red only, in order in which they occur - get small cooling effect due to SO-2 on the record.

From there go on to Dr. Ramanathan: again ask questions marked in red only, in order in which they occur - 1. get positive water vapor feedback to warming on record due to relat. between increase in sea surface temp. and production of water vapor; 2. get temp-regulating mechanism on record for tropical area only.

Now the discussion begins: ask Dr. Lindzen to explain his notion of a convective tower which allagedly results in a negative water vapor feedback to elevated temperatures.

From here on out the discussion is wide open and we will have to play it by ear.

Closing Statement: Models are a sound investment for planning purposes of future generations.