THE WHITE HOUSE

WASHINGTON

June 14, 1990

MEMORANDUM FOR JOHN H. SUNUNU

FROM: D. ALLAN BROMLEY

SUBJECT: SEA LEVEL CHANGE AND ENVIRONMENTAL MATTERS

Like all else in the global warming arena the calculation of sea level change is much more complicated than it appears. First some general comments:

1. Assuming for the moment a rise in atmospheric temperature there are two determining constants at work. First is that at the atmosphere-ocean interface, i.e., how much thermal energy is transferred to the water and at what rate? Second is that of the internal ocean transport mechanisms that carry this thermal energy into the bulk ocean.

2. Considering the Atlantic, as an example, thermal energy transferred to the Gulf Stream is carried northward and in the Greenland-Iceland region it splits with something like 90 percent remaining on the surface and continuing its clockwise surface circulation. This involves the upper 100-200 meters at most. The remainder (about 10%) is carried downward and flows again southward at much greater depth. What this means is that the thermal expansion of the ocean from the bulk of the ocean—depths greater than 100-200 meters— is delayed by something between 50 and 100 years as compared to that of this 100-200 meter surface layer.

3. It is important to note that for salinity greater than 24.7 permil, the density of sea water increases with decreasing temperature all the way to the freezing point, i.e., there is no maximum in the liquid density <u>vs</u> temperature plot as is the case with fresh water. Also counterintuitively, the coefficient of thermal expansion of sea water <u>increases</u> with increasing pressure i.e., depth.

4. The simple minded expansion calculation—in zeroth order follows from the hydrostatic equation

$p = \rho g h$ where p = pressure, $\rho$ = density
g = acceleration due to gravity
h = depth

and $a = \frac{-1}{\rho}\frac{d\rho}{dT}$ where T is the temperature and
a is the thermal expansion coefficient

5. As water expands the sea levels rises but $\partial p = 0$

$\partial p = \partial \rho g h + \rho g \partial h = 0$ so

$a \rho h \partial T = \rho \partial h$ and $\partial h / \partial T = a h$

Here in the zeroth order we simply take an average depth <h> ~3800 m on the assumption (wrong!) of complete thermal equilibrium and set

a (T, p, s ) ~ (10 to 20) x$10^{-3}$/°C where s is the salinity, and so find

$\partial h / \partial T \sim 60 cm/°C$

6. From this we see that a 0.10C rise in temperature corresponds to 6 cm sea level rise as indeed would a 0.4 C rise in the top 1000m and no temperature change in the lower levels. But this is a very crude model.

7. In the IPCC WG 1 report that predicts an effective CO2 doubling by 2030, the predicted sea level rise is 18cm. This is composed of the following contributions

(a) Thermal expansion--10 cm. The report discusses in some detail an up-to-date box diffusion model that does take into account the variations of salinity and of temperature. The authors of this particular section of the report are publishing a book later this year on their calculation and perhaps reflecting that, their discussions in the IPCC report are not as clear as they might be in places. Indeed one could (as I did) read the policymaker's summary as suggesting that the 10 cm figure came from a linear extrapolation of historical data on sea levels to the 2030 temperature predicted by the GCM models. I find however that the more complex box model calculations were actually used.

(b) Melting of land based glacier ice—7 cm. Here I am quite confident that this number results from simple linear extrapolation of the recent historical data on the retreat of mountain glaciers.

Note: Such extrapolations are on shaky grounds. The association of past historical behavior with the atmospheric temperature—on a single parameter basis—has very little justification. Similarly, there is little justification for linear extrapolations. The global circulation models give static, point-in-time predictions but no insight into the path from one of these states to the next. The historical record suggests substantial fluctuations about any average. Finally, my earlier memo on the carbon cycle raises its own questions regarding the assumption of effective doubling in 2030.

(c) Melting of the Greenland ice cap—2 cm. All GCM's predict that polar regions will experience greater greenhouse warming than equatorial ones in any warming scenario.

(d) Sequestering of water in Antarctica—(-1) cm. Because of its much greater area and predicated increased snowfall it is anticipated that Antarctica will actually

sequester water in a warming scenario. It bears noting that melting of 0.1% of the Antarctic ice corresponds roughly to a 1 meter change in global sea level.

Adding up all these contributions then leads to the quoted 18 cm prediction for sea level rise in 2030.

What we really need is a solid scientific look at this entire question, recognizing that it is difficult and that many of our input data are fuzzy. I am hoping to interest NOAA and NSF in doing such a study. We can do better!

I share your concern, and Dick Darman's, that by focussing on the anthropogenic greenhouse gas sources and sinks in the policymaker's summary--and the executive summary--and by omitting much mention of the 20 times greater natural fluxes, the authors end up with a distorted perspective even though both anthropogenic and natural fluxes are treated quite well in the body of the main report--which relatively few people will ever read!

I am also concerned that if we appear to accept IPCC WG 1 as ultimate truth then to some extent we have been effectively coopted into accepting the recommendations of the IPCC WG 2 and 3 which may well be substantially different from what we had in mind.

Let me turn then to a different topic.

The June 8 UNEP and RSWG (IPCC WG 3) meetings in Geneva, in my opinion, were particularly important in demonstrating that we are increasingly seen as occupying a centrist position with the EC (Netherlands, FRG, etc.) as the extremists. It will be important for us to continue fostering this view as more and more nations begin to recognize that they were overly hasty and even emotional in their willingness to sign up for targets and timetables last November in Noordwijk. Sanityis returning slowly to this field!

I believe that the President's leadership in this entire global change area is increasingly being recognized--albeit reluctantly in some communities--and that by injecting economics directly into the discussions at the White House Conference we have achieved much more than the international press was prepared to admit at the time.

It will be very important for us to develop our positions in the entire global change and environmental areas as soon as possible because in the face of the rather ridiculous number of conferences, workshops, ministerials, etc., upcoming, in the absence of such firm and generally agreed upon positions, we tend to get ratcheted toward positions that are not in our best interests.

Your suggestions and comments would be most welcome.

6/13/90

Dr. Bromley:

On the memo on sea level rise, I have a couple of specific comments.

a. The 90%/10% split on Gulf Stream surface and deeper water may not be correct - I would not use percentages. It would be better to say most of the water stays on the surface while a small percentage is carried down...

b. I checked with Watson and he said that while Tom Spence's analysis might be right that the text of the Policymaker's Summary may ( incorrectly) imply that the thermal expansion of the ocean was derived from extrapolation from historical data, he doublechecked and, indeed, the thermal expansion numbers are the result of the most up-to-date box diffusion model which takes special account of the salinity and temperature changes under such conditions. In fact, the two main authors (modelers) of this section are writing a major book on sea level rise which would be out now except that they have been spending all of their time on the IPCC report over the past year.

I have attached pertinent pages of the IPCC Chapter on Sea Level Rise - I have clipped several pages which describe the model.

c. While I agree with what you have said on page 5 about better science needed on the issue, (and I do recognize the theological constraints under which you are operating here) I think that we may want to go easy on the IPCC report and, at the same time, call for better science on the subject.

How about something like the following instead of the paragraph marked "C":

While the authors have worked hard to provide predictions based on what scientific information is available at this time, it is obvious that we really need better and more solid scientific analysis at the entire question. In fact,I am hoping to interest NOAA and NSF in doing such a study. So that we are not PERCEIVED as backing away from the President's (and other Administration) previous statements on the IPCC report, we should probably publically respond to the IPCC report as a good first start at summarizing the status of knowledge and then use the IPCC as a springboard from which we, the US, want to FURTHER REFINE THE SCIENCE.

[DAB: It is important that we as a country are not SEEN as backing off or undercutting the IPCC process because of the many, many Presidential and Administration statements that we are supporting the IPCC process and its reports. We have, in fact, used this argument vehemently to keep us from other more radical committments on the greenhouse question.

If we PUBLICALLY distance ourselves from this report, we will do significant further damage to our and the President's credibility in the national and international global change area. We will be seen as rejecting the report because we don't like the results. Bull's eye in the old foot again]

d. Darman's point about focussing so heavily on the anthropogenic greenhouse gas emissions sources and sinks - and no proper perspective - IS INCORRECT.

I have attached a copy of Section I "Greenhouse Gases and Aerosols" in which each gas is discussed in detail - including composition, feedbacks, sources, sinks, etc. Natural sources, sinks, fluxes etc are covered in great detail.