Discussion Paper for the UNFCCC Experts Meeting on the Brazil Proposal, 28-30 May, 2001

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Introduction

This report adds some clarifications and additional information to the matters included in my presentation at the meeting. Additional material includes a discussion and evaluation of several aspects of the Brazil Proposal and a modification of my Framework concept that implements the normalization process discussed at the Workshop. Recommendations for future work, mentioned briefly in my talk, are amplified and clarified. Some of the points made in my oral presentation and transparencies are reformulated here for clarity.

Evaluation of the proposal by Brazil

As I understand the Brazil Proposal (BP), it has several components. Overall it amounts to a new conceptual approach to allocation of the burden of climate change mitigation. The components include a method for attributing responsibility based on climate indicators, using temperature change as an example, a reduced form "Policy Maker" (PM) model for computing attribution, a method for translating computed responsibilities into future obligations, and examples of application of those procedures. The present comments deal only with technical and methodological aspects of the attribution method and the PM model. I will not comment on the policy suggested for allocating future burdens except to point out that there are other possible policies for allocating burdens that could be based on the methods of the BP for attribution of past responsibility.

The PM Model.

The BP and subsequent UNFCCC discussions have considered the PM model as an example and considered the possibility that other models might be used for that purpose. Also, it was made clear that improved an improved PM model has been developed by Luiz Gylvan Meira Filho, as described at the Meeting. My comments here will pertain only to that later version of the PM model as I understand the model from the January 2000 Note and his description at the meeting.

I have not reviewed the quantitative formulae in the January 2000 Note that documents the model to check their accuracy in detail. However, from what I understand about its structure, the model has been greatly improved and now treats the nonlinear aspects of radiative forcing for the principal greenhouse gases, the delays in warming due to the ocean thermal inertia, and a detailed model of the carbon cycle that includes nonlinear effects associated with feedbacks from a warming environment. It also predicts other climate indicators such as sea level rise and rate of change of temperature. It appears to me that this should, in principle, enable the model to be a state-of-art reduced form model, subject to verification that the model is able to mimic the behavior of major GCMs. Questions have been raised about verification by other authors, but I have no independent information on verification.

One issue that was raised at the meeting was validation of the carbon cycle model now used in the PM. Although that model is derived from a model developed by carbon cycle scientists, some participants believe (as I understand their argument) that it contains assumptions about environmental feedbacks that go beyond the formulations in other models and that have not been, and probably cannot be validated from observed data. Although I am not an expert on the carbon cycle, I will make a few general remarks about that situation. A general principle of model validation is that one usually cannot validate a model's performance in a range of values of the input variables that lie outside of observed data. It should be pointed out that that caveat also applies to all other models of global change, although sometimes that caveat is more constraining on reduced form models then on more detailed process models that incorporate process representations that can be validated on a small scale. In the latter case, it may be possible to use the detailed models to validate the reduced form models. It should also be pointed out that if the PM carbon cycle model remains the same as that used by Joos, perhaps the latter will be validated outside the UNFCCC context. What is not clear to me is how much the Joos models differs from other representations under conditions where there is relevant observed data and whether that data is sufficient to distinguish between the models with and without feedbacks.

In any case, the major point to be made is that if global warming continues to increase substantially, then environmental conditions later this century or next conceivably might reach levels where carbon cycle feedbacks would become important. In that case, if reduced form or even detailed GCM models lacking a representation of those feedbacks are used to project climate warming, they would miss such feedbacks and perhaps give a poor representation of actual results. Hence, a key question for policy applications is whether the Joos representation is likely to give a better or worse approximation of results than other representations, given the current state of scientific knowledge; i.e., which one represents the best guess (or can't we say)?

The BP Attribution Method

The original BP utilized a linear PM model that made attribution straightforward. With the new non-linear PM model, as well with alternative non-linear climate system models, attribution doe not appear to be as straightforward. The framework for attribution proposed and discussed below addresses this aspect of the BP. It also provides for an extension of climate indicators to include climate damages, also mentioned in the BP, or surrogates for damage that are non-linear functions of climate indicators.

In brief, the Framework can be applied to the new PM model, other reduced form models, or even large GCMs and linked systems of atmospheric chemistry, GCM, and impact models, given sufficient resources to make numerous model runs. (Essentially one must make one run for each distinct combination of emitted greenhouse gas and time period, say about a decade, for which emission weighting factors are required.) Thus the Framework provides a systematic method for carrying out the stated intent and conceptual methodology of attribution proposed in the Brazil Protocol.

Description of General Framework for Attribution

An updated description of the framework is provided as an attachment, "A Framework for Attributing Climate Damages". That description of the framework includes an implementation of a normalization procedure along the lines discussed and recommended by other experts at the meeting, especially by M. Prather, as interpreted by me and translated into the framework formulation. Additional remarks and explanations were made in my presentation. Key points made in the presentation and the subsequent discussion, but not treated in the Framework paper are summarized in the following paragraphs.

- In order to be useful and credible for policy applications, any scheme for attributing responsibility should be reasonably robust against artifacts of any particular model, modest variations in future scenarios, small errors in emission data, and other uncertainties or arbitrary assumptions in the attribution methodology.
- The effect of different attribution schemes and their robustness may vary with characteristics of the policy to which the schemes are applied. For example, application to a *polluter pays* scheme as a basis for setting emission tax rates requires absolute estimates of the marginal change rates with a high degree of accuracy and credibility. In contrast, application to a policy involving sharing of a fixed burden only requires relative estimates of responsibility; errors that affect all parties about the same may be negligible.
- Attribution based on climate effects essentially creates differential weights for historical emissions of globally well-mixed gases in terms of time of emissions and type of gas. (In contrast, emission of shorter-lived, regionally important precursors conceivably might result in differential weights for different geographic regions.) The proposed Framework treats differences among greenhouse gases integrally, effectively replacing GWPs with a more precise differential weighting scheme that varies with time of emission.
- Non-linear processes in the climate system and in the relationship to climate impacts (damages) would play a major role in determining the differential weighting of emissions with time. The "sub linear" non-linearity involving radiative forcing of CO_2 tends to result in heavier weighting of earlier emissions than later ones. In contrast, non-linearities that are "super linear" would tend to increase the importance of later emissions. They conceivably might result, for example, from positive climate/carbon cycle feedbacks or climate impacts that increase sharply with the degree of climate warming.
- Since the effect of different process assumptions and the choice of climate "indicator" (i.e., measure of performance) potentially could reverse the temporal bias in emission weighting, those assumptions have to be made with great care. The whole purpose of employing a climate system effects based approach, rather than just counting cumulative emissions as a simple alternative, might come into question if the assumptions in the methodology cannot be justified.

Future Areas of Work

I see a need for the following future work:

1. The framework discussed above should be improved and made more credible if it is to be used in further development of the Brazil Proposal and application to UNFCCC policies. A more rigorous justification for the basic assumptions and formulae should be provided, including use of the normalized marginal change (differential) attribution and identification of alternative formulations, if any. It appears that such justification could be accomplished by invoking scientific and policy-oriented criteria that an attribution should satisfy.
2. Examine possible damage functions or alternative climate indicators for use as a measure of performance. A survey of the literature and consultation with experts might establish at least the functional form for damages, if not absolute values, which might suffice for relative attribution purposes. It might be useful to identify partial damage functions for particular sectors of special importance, such as important human and natural resource sectors. (Policy makers often make decisions based on protection of particular resources of great significance to the public, such as scenic resources and endangered species.)
3. Candidate damage functions should be plugged into a quantitative test of attribution and compared with alternative measures of performance such as delta T, time derivative of delta T, and sea level rise. A comprehensive analysis should include systematic variations of other components of the problem, including alternative time-preference weighting, alternative climate models (e.g., including the new PM model with nonlinear carbon cycle representations and alternatives), and alternative scenarios of future emissions such as a range of IPCC scenarios. Outputs of those analyses would primarily be a range of emission weighting schemes and evaluation of how the schemes vary with the alternative assumptions described above.
4. More policy-oriented analyses could take the alternative emission weighting schemes derived in 3 and apply them to real and/or prototypical emissions of individual countries or groupings of countries to see how they differentially affect their total attributions of responsibility. An additional variation would examine how cutting off historical emissions at some date in the past would affect outcomes. Also, one might want to examine how application of the attribution methodology would affect outcomes when extended to the near future. I.e., suppose the policy application involved counting past emissions through 2020 or 2030 for application to emission allocations at subsequent dates. After all, it may be that the Brazil Proposal might not get implemented until a later time frame. Of course, those are highly policy sensitive analyses and perhaps would not be carried out under UNFCCC auspices. But eventually such analyses would be needed so that negotiators of a protocol would be able to understand the implications of choosing to implement a policy based on the Brazil Proposal concept.

5. An additional, more policy-oriented task concerns examination of the implications of alternative policies for burden sharing that are based on alternative attributions of historical emission responsibilities, i.e., the final logical link in the Brazil Proposal. That undoubtedly goes beyond the current mandate of the experts working group. It would still be within the scope of the Brazil Proposal if the BP is interpreted to encompass alternative schemes for linking burdens to responsibilities. Note that burdens may be interpreted differently under different types of control policies, including burdens expressed as financial obligations as well as those expressed in terms of emission limitations.