2nd NOAA Climate Test Bed Science Advisory Board Meeting

Silver Spring, MD, June 28-29, 2006

Written Report

Executive Summary

The Climate Test Bed project is clearly in close alignment with the mission and goals of NOAA. Sub seasonal and seasonal climate prediction is central to the mission of NOAA, and is strongly supported by CTB activities. The CTB is working with a world-class coupled prediction model and is producing routine forecasts that are valued by the user community. However in order to emphasize the Test Bed aspect more specifically, and in order to promote operational aspects that will benefit users in the shortest possible time, the SAB makes the following recommendations.

The CTB has an opportunity to significantly increase the potential utility of seasonal forecasts by introducing a Multi-Model Ensemble (MME) forecast product. Since it has been demonstrated that MME gives a significant improvement over single model ensembles, providing an MME-based forecast to users relatively quickly should be a high priority. To provide an MME forecast sooner, CTB should adopt a simple linear combination algorithm to begin with, and introduce further improvements, perhaps including weighted combinations, later. CTB should also reduce the size of the required hindcast data set, so that MME can be started more quickly with less up-front investment and, in addition, more nimbly incorporate improvements in individual modeling systems as they occur. In order to pursue MME forecasts more quickly and effectively, scientific staff with the necessary expertise and interest should be dedicated full time to this project over and above the current 1.5 FTE's.

CTB should explore possible international collaborations in MME forecasting with APCC and EUROSIP. These organizations make operational forecasts and have considerable expertise and experience. Increased iteration likely will lead to mutual benefit.

The CTB would benefit NOAA more if there were more effective communication and collaboration between CPC and EMC. Also important is ongoing engagement between EMC and the external community – scientific and users. Resources should be provided for greater external engagement.

The metric for S-I forecast validation currently being used in the GPRA process is unsatisfactory. It is a good measure of neither the accuracy or the utility of S-I forecasts. Further it does not provide a useful basis for either promoting scientific understanding or communicating with the community that utilizes the forecasts. Additional metrics that advance scientific understanding and are more appropriate for users should be adopted. WMO has recommended standard metrics for use by forecast producers (see WMO WWW web site), while CCl under WMO has been examining metrics for users (Simon Mason at IRI is the contact point).

The process by which computer resources are allocated and the evaluation of the effectiveness of this usage deserve additional management attention. The return on allocated resources should be monitored.

A clearer vision of the strategy for providing decision support is needed, including the allocation of resources to this effort. Currently 9.5 FTE's are classified as dedicated to development of the Decision Support strategy within the CTB, yet the SAB has been provided with limited information on this activity, its projects, its objectives and its intended outputs. The SAB would like to receive a full project plan covering this area and the linkages between this area and the model/MME areas.

A clearer vision of the project management structure is needed that shows the outputs of projects and how they support the overall goal.

The SAB looks forward to a response to these recommendations, in which CTB indicates which recommendations will be accepted, what actions will be taken in response to these recommendations, and indicates why specific recommendations were rejected. At some later time, but prior to scheduling the next formal SAB meeting, the SAB would like an interim report on the progress that has been made on the actions that CTB agrees to take.

A. Introduction

The SAB wishes to acknowledge the efforts by Wayne Higgins and CTB colleagues for the series of presentations and open communication at the 2nd meeting of the CTB SAB. Going into the SAB meeting, the CTB requested feedback from the SAB on the following questions:

Science Priorities

- Does the CTB have a credible science plan and implementation strategy?
- Does the CTB implementation strategy link science priorities and resources?
- What is the appropriate balance between CFS improvements and multi-model ensemble efforts?

Community Involvement

- Are collaborations and partnerships with organizations outside NCEP developing properly?
- What is the appropriate partition between in-house transition work and external research?
- Do CTB human and computational resources meet community needs?

Model Output Access and Distribution

- Does the CTB Data Policy meet the needs of the community?
- Does the CTB have effective hardware and software tools for disseminating products?
- What has been the most important research or development result that has been transferred to operations? customers?

SAB Structure and Meetings

- How often should the SAB meet and why? What about the OB?
- How should CTB meetings be increased (SAB meeting; workshop sessions; PI meetings)?
- Does the SAB recommend any changes to its membership?

Future Directions for CTB

- What are our strengths?
- What weaknesses do we need to address?
- What opportunities should we pursue?
- What impediments do we face when working with NCEP? NCPO? The external community?
- How well are we aligned with the NOAA Mission Goals & 5-year plan?

Overall, the SAB was pleased to note the reorganization of the Transition Project teams and the shared access to model data output in response to the summary of the 1st SAB meeting. As it pertains to the science of the CTB, and as discussed below, the SAB believes that the CTB needs to implement a Multi-Model Ensemble (MME) approach forthwith. NCEP is already lagging behind sister international centers and consortia that have implemented MMEs for seasonal climate forecasts. Given limited resources, the SAB believes this is the best strategy for achieving near term results for the CTB. The SAB remains concerned that the CTB science plan and priorities have not been aligned sufficiently with these limited CTB resources. In future meetings, the SAB would prefer to concentrate on setting scientific priorities and objectives of the CTB, instead of devoting attention to administrative issues.

B. Science Priorities

The SAB remains concerned with the science plan. The goals of the science plan are appropriate, but the implementation plan is less so because it is too broad in scope and is largely based on previously existing activities. The SAB suggests the need for more detailed and coordinated science and implementation plans, enumerating the "how", the "why", and identifying the constraints and the trade space the CTB is working within. Then these should be vetted within the CTB organization, its partners, and the SAB. Currently the CTB science is conducted in a too ad-hoc manner. It would be desirable to have a clearer project management structure within the context of an implementation plan. What the specific outputs of each projects are, and how they support the overall goal, should be agreed upon.

The current implementation strategy is not well linked to the relatively small CTB resources. It would be helpful to establish a more realistic prioritization. The current strategy emphasizes fairly uniformly each of three components: (1) CFS improvement, (2) multi-model ensemble prediction efforts, and (3) decision support. However the uniformity of the strategy is not mapped appropriately into resources. Given present budget levels, uniform emphasis will result in only slow progress in each area. **The SAB suggests that the multi-model ensemble (MME) effort be elevated to the highest priority,** given that it has been established that this results in higher forecast skill and probabilistic reliability. The CFS improvement, while critical, is a basic in-house task that would be pursued regardless of the CTB or any other external association. Decision support activities are important, and should also be considered as being part of NCEP's basic work of communicating with and serving its customers and their intermediaries. Nonetheless, the near-term need should be focused on improving forecast skill and the SAB believes the quickest way to achieving this is via a MME approach. As it pertains to the broadening of decision support efforts made possible by CTB, a clearer vision of the strategy, and a corresponding allocation of resources, should be established. One specific recommendation by the SAB is that forecast skill metrics be used or developed that are more appropriate for managers' and users' climate-related risk management needs than the Heidke score (the WMO Standardized Verification System is suggested as a starting point).

A MME approach appears to be a promising route toward better forecasts for users, but benefits are not being pursued as rapidly as would seem possible and practical. A start in this direction would be to simplify the requirements for producing useful MME forecasts in the near term. Specifically, relaxation of the large hindcast requirement from 25 years, all seasons, and a moderately large ensemble size, would enable a workable approximation of the originally conceived system, and on a significantly sooner timetable. Thus, to accelerate progress, initial experiments could use as few as six ensemble members per model for individual model calibration, and then simple pooling (equal weighting) for probability forecasts, and just for four seasons. Experience in programs such as DEMETER has shown that the benefit of the more complex and rigorous consolidation approach using variable weighting, relative to a simple averaging MME scheme, is small, but its costs are large. The SAB believes that this strategy will promote also enhanced community engagement.

The simplification of the MME effort is one example of a broader need to emphasize more forcefully the test bed notion for the CTB. This can be accomplished by relaxing operational restrictions upfront in order to accelerate near term progress toward testable systems. Once

tested, the workable aspect of system development can then become increasingly gradated and otherwise refined, as it is embedded into the operational suite. However, at present the operational constraints are preventing near-term progress in implementing a MME approach.

In summary, the SAB recommends that:

The CTB should have an FY08 milestone for having in place at least a four-model multi-model ensemble using equal weighting, of the CFS, GFDL, GMAO, and NCAR models.

In support of the above, resources allocated to the MME effort need to be enhanced. In order to realistically implement a MME approach, there need to be more FTEs, plus possible redistribution of current FTEs. The emphasis here is on full-time (not fractional) support dedicated to the MME work. To enhance progress in planning and developing the MME system, possible international collaborations in MME forecasting should be explored with APCC and EUROSIP.

C. Enhancing Scientific Community Involvement

A close working relationship between the CTB and the scientific community outside NCEP is essential for achieving the Testbed's goal of accelerating the transfer of the latest research results to operations. In our judgment, the current level of collaboration with the outside community is inadequate and/or inappropriate to achieve the goal of improving NCEP's seasonal forecasting capabilities. We are recommending several specific actions to enhance PI-level contributions and to improve collaborations with other centers. We think that taking these actions, as part of our overall recommendation to make a concerted effort in Multi-Model Ensemble (MME) prediction, will more effectively leverage outside resources to support NCEP's forecasting mission.

PI-level collaborations with individual researchers at universities and other research centers are a key element of bringing outside innovations to NCEP. Currently these appear to be limited to those collaborations supported through the small Announcement of Opportunity. The success to date of the JCSDA has demonstrated the importance of a competitive AO activity. At present, the CTB AO is at a sub-critical level of funding. Obviously, every effort should be made to increase this funding, but recognizing that obtaining adequate funding may require additional NWS and CPO investment, and this will take time, we recommend:

(1) **That the allocation of existing resources (the AO) be modified as soon as possible to support the recommended priority in MME forecasting**. Up to now there has been no engagement from the SAB in setting priorities for this funding. Current awards concentrate on model development—an area with existing strengths at EMC and one we judge to be of lesser priority for the CTB—while the current announcement focuses on the applications area.

(2) **That the CTB take more aggressive steps to engage and leverage activities funded by other agencies** (e.g., MAP program at NASA, Climate Process Teams or their follow-on at NSF) and NOAA AOs (NAME CPT, etc.). This approach is mentioned in the Implementation Plan, but little has been done to carry it out.

Center-level collaborations are discussed in the Implementation Plan, but in our judgment they are being developed too slowly to adequately support the recommended priority in MME. Currently there is an active collaboration (at a fairly low-level) only with GFDL. Collaborations with NASA and NCAR/COLA appear to be only in the planning stages. If our recommendation to begin experimental MME forecasting involving the main national models within the next two years is accepted, this schedule will have to be greatly accelerated. To this end, we recommend:

(3) **That the CTB take leadership in developing an interagency initiative to create a Joint MME Experimentation Facility**. This would involve sub-seasonal and seasonal forecast systems (both models and assimilation systems) at NCEP, GFDL, NASA-GMAO, and NCAR/COLA. Having the centers working together in such a facility will greatly facilitate both the MME development and its later transition to operations.

(4) **That the CTB adopt a two-step approach to the implementation of MME forecasting: An experimental collaborative project, followed by a deliberate transition to operations.** In working with the other centers, the CTB must distinguish between experimental activities, which can be much more freewheeling, and operational practices. Placing a very high, operational bar on the collaborations with research centers will invariably act to deter, rather than encourage, the flow of innovations.

International partnerships are another form of collaboration that the CTB needs to pursue more aggressively. Ongoing MME activities in Europe and Asia (DEMETER, APCC) are already at or near operational capability. A US MME forecast could profit from and contribute to these activities. We recognize that NCEP is already involved to some extent with APCC. Strengthening this and developing a European connection should be priorities. Politically this may be difficult, but the benefits of such an expansion of the pool of models used should make the effort worthwhile. Finally, we note that international collaboration may be easier once a viable in-house MME activity exists in the US.

Stakeholder Involvement. The SAB noted that, in terms of FTEs, the largest resource is placed in the development of decision tools. However little detail was provided to the SAB on the use of this resource, the projects under way and planned, and the outcomes expected. The only item referenced was with regard to the drought project, although few details were provided. While the SAB understands that considerable planning has been required for the CSF and MME components of the CTB, the SAB also feels that full planning requires appropriate consideration of outputs from the MME towards the lower end of the funnel to ensure, as far as possible, that these are tuned to the maximum extent possible. The SAB feels that this is an important area of the CTB that requires further attention at an early stage, and requests that a detailed description of current activities, and an enhanced strategy for the future, be provided ahead of its next meeting.

Potential users of NCEP results have varied views on additional data and products that could be made available, in some cases with relatively little trouble and in other cases requiring development activities. To obtain a cross section of such views, participants in the NOAA RISA

(Regional Integrated Sciences and Assessments) Program were polled. Mel Gelman described the Climate Test Bed during one of the monthly RISA PI teleconferences. During the subsequent teleconference on May 26, 2006 Kelly Redmond (also a RISA participant) solicited feedback on information that RISA participants would like to see made more available from NCEP. This was organized into a short document that was supplied to Test Bed participants at the June review.

The most common theme to emerge from these comments was a desire for greater regional specificity and information at smaller and more usable scales. Another related theme was a desire for a fuller suite of weather elements, beyond just temperature, precipitation, and pressure patterns. These included spatial fields and daily and hourly time series of wind (scalar and vector properties), humidity, solar radiation, and cloud cover. Other properties of interest included lower atmospheric and boundary layer profiles along with inversion information.

As expected, another common desire was for better forecasts. The RISA participants generally desired more and better partnering with universities, with more frequent and sustained interactions.

Users, the public, and even many climate researchers have in recent years been exposed to a large number of identified or proffered "oscillations." There is much interest in understanding the existence (in some cases), properties, roles, linkages, and physical mechanisms behind each of these apparent patterns. Among these are ENSO (there are still aspects we don't know well), PDO, NPO, AMO, SOI, AO, NAO, MJO, Antarctic Circumpolar Wave, and perhaps others. Any contribution from the Climate Test Bed toward resolution of this confusion would be welcome.

Products and capabilities that addressed disciplinary connections were of particular interest as well. Many real-world problems involve climate interacting with other phenomena. For example a number of suggestions were offered that relate to hydrology, coastal issues, air quality, ecological health, energy, and drought.

Drought is of special interest, given the recent emphasis on NIDIS (National Integrated Drought Information System) within NOAA and other agencies. The Climate Test Bed has been mentioned a number of times as potentially playing a significant role in the development of NIDIS, including at the NOAA Drought Retreat July 31 - August 3 in Santa Fe NM. The exact form of the interaction will require that the specific activities that NIDIS will sponsor or encourage be better identified. But as those things clarify, there may be identified needs for targeted efforts to produce better forecasts in particular geographic or seasonal settings, or of particular components of the local water balance(s), or to express the output in forms more amenable to use by natural resource managers. Interactions between managers and climate scientists, within the NIDIS framework, would help identify tractable and practical issues where progress actually seems feasible. The Climate Test Bed should stand ready to be closely involved as NIDIS comes into sharper focus.

Shortly after the SAB meeting, Climate Test Bed participants provided an initial response to the RISA "wish list" outlining actions that were deemed relatively painless, moderately difficult, and

requiring careful thought, and pledging to move forward on several items. Such responsiveness was appreciated, welcomed and left open a door for other forms of dialogue.

D. Computing and Data Access

The Climate Test Bed (CTB) has several large challenges before it in the area of computing and data access, some of which have been adequately addressed and some of which will require considerable further planning. The issues of managing the shared computing resource and managing the shared model output and other data resources are discussed separately below.

Shared Computing Resource

The CTB currently enjoys a sizable computing resource, which is about to undergo an upgrade to a much larger resource. The research computing resource available to the CTB is currently sufficient to provide 120 units per wallclock-year of Climate Forecast System (CFS) coupled model integration, where each unit is defined as 10 years of simulated time with the Global Forecast System (GFS) atmospheric general circulation model run at T126L64 resolution coupled to the Modular Ocean Model (MOM) ocean general circulation model run at the standard hindcast resolution. Based on the increase in the number of processing units and the relative speed of the individual processors in the prospective upgraded research computer, it is anticipated that the resource will be sufficient to provide about 1,000 of the same units per wallclock-year. This is a very large resource dedicated to dynamical seasonal prediction. In response to the question on computing resources, we feel that one-third of the research machine should be adequate to the CTB community needs. Since the allocations on this machine are accessed by the three main users (CTB, Joint Center, and the other testbeds) in a fairly informal way, it is important that the CTB be well organized in scheduling quality work and fully utilize its share of this machine. Additional resources will probably be required for hindcasts with outside models; but since it is not clear from the CTB reports how comprehensive such hindcasting will have to be to allow a system into an operational ensemble, we cannot comment at this time on what would be an appropriate mix of existing and new resources.

Because the external, Announcement of Opportunity based component of the CTB is just getting underway, there has been little external usage of the CTB research computer. More generally, the National Centers for Environmental Prediction (NCEP) have little experience in using or managing a computing resource that is shared with the outside community. To obtain maximum benefit from the transition to a shared computing environment that will be useful to both the internal and external CTB scientists, it will be necessary to reexamine NCEP research computing strategies. In particular, the CTB Science Advisory Board (SAB) recommends that a coherent strategy be developed for the allocation, monitoring, administration, and evaluation of usage of the shared computing facility. To facilitate the development of such a strategy, the SAB recommends that the CTB invite experts from other centers that have long experience in operating and managing shared computing resources to provide advice. In particular, since the CTB already has plans to use the multi-agency Climate Simulation Laboratory (CSL) as a model for managing the shared computing resource, the SAB recommends that experts from the Scientific Computing Division of the National Center for Atmospheric Research (host institute for the CSL) be asked to advise the CTB on how best to manage this resource.

Shared Model Output Data Resources

The SAB found the CTB to be highly responsive to the needs of the climate modeling research community in its willingness and the timeliness of its provision of model output from the Climate Forecast System (CFS) hindcast data sets. The CTB responded to requests from researchers for the monthly mean and daily model output by assembling, quality controlling, and serving the data sets via systems that had to be cobbled together. The data policy that has been established to regularize the provision of data sets to the research community is quite clear and reasonable. Also, the hardware and software that have been put in place appear to be adequate for the needs of the modeling research community, although, as always, online storage capacity is in short supply and should be given priority in future hardware acquisitions. The SAB commends the CTB for its forthright and proactive developments in this area.

For the future, the needs of at least two other communities should be addressed in additions and refinements to the data policy. First, there is a large ocean community with vigorous research programs that depend on ocean observations and objective analyses. The Global Ocean Data Assimilation System (GODAS) data sets that are being produced in support of the CTB would be invaluable to the ocean community. The SAB recommends that a high priority be given to adding the GODAS data sets to those already being served and included in the CTB data policy. Second, there is likewise a large and diverse community of stakeholders and regional and sectoral specialists that seek to use climate model simulations and predictions in support of decision-making. Producing decision-support tools and data sets is one of the four concentration areas in the CTB science and implementation plan. The recent addition of regular posting of validation statistics is of great value to the decision-support community, and the plan to provide access to model output data in GIS format will likewise be very helpful for the integration of model data and data bases that are currently in GIS format such as demographic data. However, it is not clear if the data policy is sufficient to cover the needs of the decision-support community. The SAB recommends that the CTB review the needs of the stakeholder and applications community to determine if the data policy adequately addresses those needs.

The SAB was specifically asked to identify “the most important research or development result that has been transferred to operations [or] customers.” The SAB was not provided with sufficient information to make an informed judgment on this question, and would welcome in future reports a list of results that have been transferred. More generally, a vision needs to be articulated for how best to transfer results to the greatest benefit of the customer communities. One important aspect of this transfer is how to measure success. The current application of the seasonal prediction GPRA metric is not representative of the full range of CTB activities, nor is it a particularly useful or appropriate measure of the value of CTB contributions. The display of highly technical information, e.g., Heidke skill scores, is considered to be uninformative to the decision support community and Congress. The SAB recommends that additional metrics be considered that measure the accuracy, reliability and scope of CTB contributions. There are several sources that could be used to define these metrics, including the Standardized Verification System of the World Meteorological Organization on seasonal prediction metrics and the recent report from the National Academy of Science on climate change metrics.

E. SAB Structure and Meetings

The SAB had some serious discussions on its mandated role in CTB plans and activities. The primary focus of future SAB meetings should be placed on addressing scientific issues facing CTB. We posed the not so hypothetical question, "Are we wasting our time?" and will hold that answer in abeyance pending the CTB response to this report. The SAB is concerned that the vast majority of the SAB presentations and deliberations continue to be in the domain of the Oversight Board (OB). In this regard, the SAB sees a need for the OB to be more engaged in the oversight of the CTB as a whole. In the next SAB meeting, at least one-half day should be devoted to CTB science, in keeping with the fact that the SAB is a *Science* Advisory Board. The topic of this science session should be the scientific strategy and accomplishments of the CTB MME priority. At future SAB meetings, we would like to see each and every science presentation begin with an opening slide that presents a scientific hypothesis statement for the science to be presented. In addition, there should be an annual presentation on the internal CTB science selection decisions and justification for such decisions. The SAB also sees the need for a separate Annual CTB Science Team Meeting involving all internal and external scientists supporting the CTB. Individual members of the SAB expressed an interest and willingness to attend on a time available basis.

Communication and interaction between CTB and the SAB should be enhanced regarding the science priorities and SAB recommendations. The SAB would like to receive a CTB response to the current set of SAB recommendations. This would consist of what actions will be taken, which will not be, and for what reasons. There should be a follow-up progress report on accepted actions taken in response to the SAB recommendations. Upon receipt of this SAB summary, the SAB would like to be informed when it would be reasonable to expect delivery of such a CTB progress report. Once the SAB has received this progress report it will be in a better position to determine if a subsequent SAB meeting is warranted. Should there be another SAB meeting, early summer seems like an appropriate time. As discussed, the Climate Diagnostics Workshop (CDW) is not the right forum for an SAB meeting. However, the SAB is interested to receive copies of, or website access to, CTB presentations at the CDW or CPAS meetings. In the future, the SAB would prefer to determine the agenda and timing of the SAB meeting based on a list of issues for which the CTB requests input. For the June, 2006 meeting, the SAB found it very helpful to have had a list of issues for the SAB in advance of the meeting. Lastly, the CTB needs to coordinate better their presentations. Once again there was too much repetition by CTB personnel, and poor timing of the engagement and discussion with the SAB.

Agenda for 2nd CTB Science Advisory Board Meeting

Hilton Silver Spring
Silver Spring, MD
June 28-29, 2006

Meeting Objectives:

(1) To discuss CTB FY06 progress
(2) To obtain independent expert advice on CTB short-term (FY07-FY08) and long-term (next 5 years and beyond) science priorities and implementation strategy.

Expected Outcome:

(1) SAB written report with advice and recommendations.

Wednesday, June 28, 2006

8:00 a.m. Continental Breakfast (SAB only)
8:00 a.m. SAB Executive Session (closed)
9:45 a.m. Break
10:00 a.m. Welcome by Louis Uccellini
10:15 a.m. Introductions and Meeting Objectives – Mel Gelman
10:30 a.m. Overview of the CTB – Wayne Higgins
11:00 a.m. Technology Transfer / CFS next – Hualu Pan
11:30 a.m. Open Discussion
12:00 p.m. Lunch
1:00 p.m. Science Plan & Implementation Strategy – Wayne Higgins
1:30 p.m. CTB Annual Planning Cycle for Proposals – Ming Ji
1:45 p.m. CST Chairs Report – Kingtse Mo & Siegfried Schubert
2:00 p.m. Scientific Results - Briefings by CTB Transition Project Teams
3:00 p.m. Open Discussion
3:30 p.m. Break
4:00 p.m. SAB Caucus to discuss day's presentations
5:30 p.m. Adjourn for the day

Thursday, June 29, 2006

8:00 a.m. Continental Breakfast (SAB only)
8:30 a.m. Management and Operations Plan – Wayne Higgins
9:00 a.m. Open Discussion
9:30 a.m. Break
10:00 a.m. SAB Writing / Executive Session (Closed) – Lunch (provided to SAB)
1:30 p.m. SAB Feedback to CTB Management Team
3:00 p.m. Adjourn