DTC Science Advisory Board

Meeting report and summary of recommendations

11/3/2014

The Developmental Testbed Center (DTC) Science Advisory Board (SAB) met in Boulder during 10-12 September, 2014. As usual, SAB teams consisting of subject-matter experts are aligned with DTC task areas. Discussion was broken into sessions within each team, and the entire SAB. The SAB expressed positive feedback on the meeting format allowing internal team discussion preceding broader SAB discussion.

Among the broad discussion, both within the SAB and between the SAB and the DTC, several clear themes emerged. Much of the discussion revolved around ways for the DTC to improve or augment existing activities aimed at facilitating the two-way flow of innovation, information, and technology between research and operations. Recommendations to improve tracking help tickets and downloads, for example, were aimed at least partially at the DTC improving its knowledge of operationally relevant research activities in the community. These themes extended topics that dominated during past SAB meetings, when specific science or technical activities were the primary foci.

The shift in attention reflects progress the DTC has made in establishing relationships with staff at NCEP and OAR laboratories including HRD, and continued positive relationships with AFWA staff. Although building and maintaining links with the operational centers is an ongoing process, the DTC is now in a position to strengthen its reach back into the research community in certain areas. The result would be improved readiness within the DTC for facilitating emerging O2R opportunities.

The SAB expects continuous, evolving, challenges and pressures that will force DTC to regularly re-evaluate its position and role. But it is clear that development and maintenance of strong links with both operations and the broad talent in the research community are critical for the DTC to meet its mission of bridging the historic gulf between research and operations in the U.S.

A few general recommendations, spanning multiple task areas and underpinning several other activities, emerged from the task-oriented discussions amongst the SAB with DTC staff consultation. These include:

1. Continue emphasis on support and development of a functionally similar operational environment for the NARRE and HRRRE, in line with current workflow management systems development.
2. Consider shifting the current organization of task areas to a modeling technology (e.g. convective scale, hurricanes, and global) or by software (e.g. NEMS, NITE, MET, etc.).

3. Establish an email helpdesk ticketing system for helpdesk activities addressing all O2R task areas, providing a foundation for tracking community support efforts and a database for tracking community research activities.
4. Improve DTC awareness of operationally relevant research community efforts, especially those with a diverse set of researchers working on multiple aspects of a single topic.
5. Revise the visitor program with an eye toward flexibility to rapidly pull in promising research efforts.
6. Improve community awareness of DTC efforts and software, through e.g., requests for acknowledgements in publications and presentations, and increased conference participation and organization of AMS short-courses.

The next five sections report specific SAB discussions and recommendations, organized by the current DTC task area structure. In the following sections, no attempt has been made to prioritize recommendations. The SAB has agreed that next year, a decision about whether to prioritize recommendations should be made before or at the SAB meeting, allowing prioritization while meeting in person.

Mesoscale Modeling Task Area (SAB members: G. Lackmann, D. Novak, J. Trapp)

The SAB recommends that the DTC moves forward to develop NMMB support. The NMMB tutorial and documentation tasks are labor intensive, and will require a significant commitment from EMC. A major challenge is to stimulate sufficient research community interest in the NMMB/NEMS modeling framework to yield meaningful R2O opportunities. However, the SAB recognizes that this is necessary in order to increase the probability of such exchanges. Given that it is not realistic to assume that a large fraction of the research community will switch from the WRF-ARW to the NMMB framework, the DTC should also seek to leverage R2O transfer opportunities from investigators using a variety of other modeling systems, including WRF-ARW. For science problems relevant to DTC priorities, the development of transferrable diagnostic methods (e.g., the use of "updraft helicity" for the identification of supercell thunderstorms in convection-permitting forecasts) offer opportunities for *cross-platform R2O*. The visitor program can help to facilitate the translation of cross-platform results to the NMMB framework.

The SAB recommends that the DTC continue to emphasize convective-scale NWP and ensembles through the NARRE workflow management systems and links to the HRRR/HRRRE. In the operational and research communities, grid lengths in the 2-4 km range are both useful and feasible. There are several important convective-scale problems for which DTC could help to leverage research results into high-resolution operational models, such as the HRRR. For example, MCS cold pools and stratiform regions are difficult NWP challenges that could be addressed by the convective storms research community.

The NARRE/HRRRE framework is recognized by the SAB as an important entryway into the high-resolution operational ensemble realm. To maximize research community

interest, it is important to maintain a flexible structure, including the ability to control resolution, run length, and dynamical core selection. While the HRRRE presents a moving target in terms of model development, the research community is already using the WRF-ARW framework extensively, increasing the likelihood of useful R2O opportunities. The DTC is well positioned to facilitate this transfer by providing a modeling system framework that is directly compatible with operational systems. Progress has been made in the past year in engaging with ESRL scientists, and the SAB strongly encourages the DTC to continue and expand upon these efforts.

Although the research community is using the same dynamical core and modeling system that forms the basis of the HRRR, the diabatic filter initialization provided by this operational system is highly valuable for high-resolution convective storm research and other NWP problems. Further, these high-resolution (3-km grid length) initial conditions are not easily available to the research community at large. DTC has an opportunity to provide these enhanced initial and lateral boundary conditions to the research community through the MMET case-study library. This activity would increase the value of MMET, as users could replicate the operational configuration, as well as stimulate research community use of this resource.

The DTC T&E efforts should be expanded to include process-based evaluation efforts. The MET package offers powerful capabilities for testing and evaluation of NWP output. Its use in conjunction with MMET cases and other operational model runs should emphasize processes, diagnosis of error sources, and subsequent evaluation of efforts to correct or reduce these error sources. The visitor program presents an ideal opportunity to leverage collaborative research in identifying and correcting model error sources. Proactive, targeted visitors could greatly facilitate this activity.

The SAB reached a consensus that modest investments should be made by the DTC to position itself in the global modeling realm. With the advent of MPAS and similar modeling systems, and an increased emphasis on global modeling (e.g., recent NOAA RFP), the time is opportune for DTC to get involved with global modeling. This relates to several other DTC initiatives, including scale-aware physics. With high-resolution global models now available (e.g., GFS at ~13 km effective resolution starting fall 2014), the scale-separation boundary between global and mesoscale modeling is blurring.

The DTC is encouraged to continue its development and support of operationally compatible software environments, which may be accomplished with the NITE effort. This recommendation parallels the support of the NARRE software environment to the community. This would facilitate the ability of at-large researchers to run operationally consistent systems in research mode.

The contribution of coupled Thompson microphysics and RRTMG radiation to the NMMB framework represents a significant transfer of capability from WRF-ARW to the NMMB. Additional physics porting and coupling, for example the provision of aerosol-aware microphysics to the NMMB, should be encouraged. While resources for this activity are limited, the SAB recognizes the value of this work, and encourages the DTC

to seek resources to allow it to continue. Continued collaborations with Greg Thompson and others in NCAR/MMM are essential to this effort.

The SAB views the wide variety of DTC tasks as being somewhat disjointed. Building around a common theme, such as high-resolution ensemble prediction, would help to bring these tasks together towards a unified goal.

Some general observations and recommendations emerged from the mesoscale modeling team. The DTC needs to increase its recognition. More careful monitoring of downloads and use of products and services, along with requests for acknowledgement in journal publications and presentations, should be a priority. Increased advertising of MMET and other DTC activities should be prioritized, including announcement of opportunities via email lists, short courses, and publications (BAMS or EOS). These could include activities at the AMS WAF/NWP or Annual Meeting.

The DTC should become aware of how MMET cases and tools are being used by the wider community, such as by universities in graduate and undergraduate courses. Tracking downloads, registering users, and requesting acknowledgement, are reasonable expectations given the excellent opportunities provided by the DTC.

Significant opportunities exist for DTC to gain increased recognition by doing more to inform the research community of what it has to offer. The MMET project, for example, hasn't gained the kind of utilization that is needed, and this may be due in part to a lack of advertising. Once HRRR initial condition data have been provided on MMET cases, email announcements to the Albany MAP list would be appropriate. If a hurricane MMET case is added, a message sent to the Tropical Cyclones email list would be appropriate.

Following the discussion above, observations and recommendations from the mesoscale team are summarized below:

1. The DTC is encouraged to move ahead with developing support for NMMB via tutorials and documentation.
2. The DTC supports NARRE workflow management to the research community in order to facilitate the use of operationally consistent ensembles.
3. MMET cases should provide HRRR IC/BC data to replicate the operational configuration and increase capability for explicit convection NWP research.
4. The DTC should continue to develop its productive relation with the HRRR/HRRRE efforts at ESRL.
5. The DTC T&E efforts should be expanded to include process-based evaluation efforts.
6. The DTC should take steps to position itself for the rapid emergence of high-resolution global modeling.
7. DTC is encouraged to continue its development and support of operationally compatible software environments.

8. Additional physics porting and coupling, for example the provision of aerosol-aware microphysics to the NMMB, should be encouraged.
9. The Mesoscale Modeling, Ensemble, and Data Assimilation tasks could synergize around the theme of high-resolution mesoscale model ensemble systems.
10. More careful monitoring of downloads and use of products and services, along with requests for acknowledgement in journal publications and presentations, should be a priority.
11. Increased advertising of MMET and other DTC activities should be prioritized.

Ensemble Task Area (SAB members: C. Reynolds, G. DiMego, E. Kuchera)

Currently there is a push towards higher-resolution ensembles at operational centers as well as a keen interest in convection-allowing (1-4 km horizontal resolution) simulations in the research community. At the same time, there are many unanswered questions about high-resolution ensemble design and utility. Given these priorities, the DTC will be well-positioned to facilitate O2R and R2O through the development of a functionally similar operational environment (FSOE) for the North American Rapid Refresh Ensemble (NARRE), with the capability to be extended to higher resolution (similar to the High-Resolution Rapid Refresh Ensemble, HRRRE). Specifically, we recommend that the DTC continue the development of the NARRE FSOE system using the ROCOTO workflow management system with the following enhancements:

- Periodically (e.g. 6-hourly) extend forecasts to 84 h (as in SREF)
- Reconfigurable to higher resolution (3 km or finer, to mimic HRRRE capabilities)
- Configurable to add nests to NARRE members (i.e. HRRRE within NARRE)
    - Nesting must be possible for not only CONUS, but also Alaska, Hawaii and Puerto Rico
- Allow configuration flexibility to facilitate research

Development of this system should be aligned with and facilitate mesoscale model development goals (e.g., multi-parameter or multi-parameterization ensembles may guide mesoscale model development).

We also encourage close collaboration with the data assimilation group, as both operational centers and the research community move towards ensemble-based (and hybrid) DA systems. Specifically, we encourage work on the next generation hybrid ENVAR DA (e.g., the two-way hybrid for NARRE) and the challenge of using dual dynamic cores.

Our recommendations for testing and evaluation include continued evaluation of multi-parameterization/multi-model configurations within NAM & RAP with an emphasis on identification of stable/unstable physical parameterization combinations. In addition, we strongly recommend testing of stochastic approaches. Given that the field of stochastic representation of model uncertainty is rapidly evolving, we recommend that the DTC canvass the operational and research communities concerning methods of accounting for

model uncertainty, with particular emphasis on stochastic approaches and very high resolution applications.

We did not prioritize the six different ensemble areas of concern (configuration, initial perturbations, model uncertainties, statistical post-processing, products and evaluation), as we recognize that all these components are important and therefore we recommend a balanced approach. There was no consensus opinion of the SAB ensemble sub-group on dynamic downscaling, the reforecast challenge, or neural network physics. Practically speaking, the DTC must work on those aspects for which it has (or has easy access to) personnel with a sufficiently high skill set.

There is high interest in the research community on post-processing techniques and high interest in the user community for probabilistic products, so we encourage the DTC to engage with the research community on these topics. In addition to the close collaboration with the mesoscale and data assimilation efforts, mentioned above, we also encourage a strong collaboration with the verification effort, which may also be closely tied to post-processing research. There is some community pull for an ensemble dataset interrogation toolkit, therefore we recommend that the DTC ensemble sub-group poll the broader community to identify the types of tools that would be most helpful, and examine existing ensemble toolkits (such as from ECMWF) as potential examples. The DTC ensemble sub-group should also remain aware of efforts in ensemble prediction in the DTC hurricane sub-group, and advancements under both groups should be leveraged by each other as much as possible.

Our recommendations for the DTC are summarized here:

1. Continue the development of the NARRE FSOE system using the ROCOTO workflow management system with the enhancements detailed above. Collaborate closely with the mesoscale group in this effort.
2. Collaborate closely with the data assimilation group, specifically focusing on the next generation hybrid ENVAR DA (e.g., the two-way hybrid for NARRE) and the challenge of using dual dynamic cores.
3. Continue testing and evaluation of multi-parameterization/multi-model configurations within NAM & RAP with an emphasis on identification of stable/unstable physical parameterization combinations.
4. Canvass the operational and research communities concerning methods of accounting for model uncertainty, emphasizing stochastic approaches and very high resolution applications. Test and evaluate stochastic approaches as appropriate.
5. Engage the research community on post-processing techniques and probabilistic products. Collaborate with the verification effort, which may also be closely tied to post-processing research.
6. Poll the broader community to identify the types of tools that would be most helpful in an ensemble toolkit, and examine existing ensemble toolkits.
7. Remain aware of efforts in ensemble prediction in the DTC hurricane sub-group. Advances under both efforts should be leveraged as much as possible.

Hurricane Task Area (SAB members: R. Fovell, S. G. Gopalakrishanan, K. Corbosiero)

With respect to the hurricane task, the DTC occupies an important position between EMC and the user and development community outside of NOAA. They provide user support for the operational and experimental HWRF system, which is growing in both usage and complexity. User support includes helpdesk activities, code management, documentation, and the operation of tutorials. They also support HWRF developers and assist operations with relevant testing and evaluation, and thus assist in the transfer of research to operations.

For the hurricane task alone, this is a sizable undertaking, and it is important to all involved that the DTC's role and position be mutually agreed upon and its activities receive necessary and appropriate resources, as well as a proper amount of recognition. Greater appreciation for the role played by DTC regarding model developers could result if interactions with them were better tracked. This could also facilitate better understanding of who the developers are and what they are doing, permitting DTC staff to improve efficiency.

As an example, in the near future, HWRF will incorporate an ocean wave prediction component (WAVEWATCH III), and it is expected that DTC will provide code management, documentation and user support for this package. This will be a time-consuming effort, but one necessary to the HWRF system user and development communities. Work is continuing on HWRF model physics interoperability and the basin-scale capability, both seen as crucial to further improvement of the operational model. Along with user support, these major priorities claim a large fraction of DTC staff resources. Owing to this, extending support to NMM-B development for hurricane applications appears premature.

Indeed, the magnitude of HWRF support needs in the past has left relatively little resources available for scientific research, including interaction with DTC visitors. It was discussed that involving outside subject-matter experts, such as HFIP awardees and also other NOAA and NCAR scientists, in DTC projects would enhance scientific activities. The visitor program could be reorganized to include "targeted invitations", instead of only relying on responses to opportunity announcements, with EMC given a role in visitor selection. Furthermore, it is recognized that a reorganization of resources and priorities would be necessary to permit DTC staff sufficient time to interact meaningfully with these visitors.

There was discussion of, and support for, evolving DTC's scientific efforts from large-scale testing and evaluation (T&E) to more targeted research on case studies, forecast failures, and outliers, with a focus on development of more comprehensive diagnostics and evaluation tools. This represents recognition that EMC's access to resources has improved dramatically in the recent past, such that some of the large-scale T&E efforts undertaken by DTC in the past are no longer needed as much.

Specific research areas that hold promise for bringing about operational improvements include work on scale-aware model physics, the phenomena of rapid intensification, secondary eyewall formation and eyewall replacement cycles (which impact intensity forecast skill, in particular), and model initialization issues, including data assimilation, vortex initialization, and model "hot starts".

These specific recommendations and observations summarize our discussion:

1. Support for the HWRF system to the user and developer communities must continue, even as the system is expected to increase in scope and complexity;
2. DTC should consider focusing on a smaller number of high-priority projects within the hurricane task, to utilize scarce resources more effectively.
3. Focus topics should include development of diagnostics beyond track and intensity, and systematic analyses of forecast failures and outlier cases;
4. Additional focus topics can include scale-aware physics parameterizations, rapid intensification, and eyewall behavior (secondary eyewall formation, and replacement cycle);
5. Scientific research would benefit from teaming DTC staff with subject matter experts. The visitor program can be used to invite experts to work with DTC staff on priority projects, with EMC involvement, and could include HFIP grantees.
6. DTC staff would need to be given sufficient time to effectively interact with visitors.

Data Assimilation Task Area (SAB members: J. Hacker, J. Evans, S. Majumdar)

Past SAB reports have repeatedly emphasized the need for a comprehensive system that closely replicates operational data assimilation cycling. That system should be used in all model testing, focus on regional self-consistent cycling with an eye toward the future of storm-scale data assimilation.

Some progress toward that capability is evident under the 2014 Annual Operating Plan; progress in community support for ensemble-GSI hybrids using the Global Ensemble Forecast System (GEFS) covariances is notable. A few obvious gaps still exist. Concurrent to focusing on closing those gaps, some recommendations are aimed at encouraging the DTC to focus on the academic community with the ultimate goal of enabling more effective R2O.

Our first recommendation is to provide observation access capability to replicate, as closely as possible, the capability at NCEP. It includes several components. The SAB recognizes that its execution is complex, and will require thorough scoping. We propose a couple of specific recommendations that may aid DTC execution of this goal. First, the DTC should establish a community liaison to NCEP. A liaison term would begin with a familiarization visit to EMC, with the goal of understanding both the details of the QC/QA in the prepBUFR stream, what observations may be available for community use, and how to advise the community on obtaining those observations. Second, the DTC should provide support to the community for replicating the QA/QC in the prepBUFR

stream, and consultation on observation access and data preparation for data assimilation researchers in the community. This may involve some development work at DTC aimed at improving and generalizing QC algorithms available in the GSI.

The DTC should continue to build capability and support for the ensemble-GSI hybrid in development for NCEP. The work addresses future operational data assimilation systems, and complements use of covariances from global models in current regional systems at NCEP. The O2R effort of supporting regional GSI-based hybrid systems is a necessary step toward enabling broader research in the community, which can in turn accelerate work on storm-scale hybrid data assimilation.

A system should be put in place to track operationally relevant data assimilation research. This results from the recognition that operationally relevant data assimilation research has been growing in the broader community. The DTC R2O mission demands that the DTC have a good understanding of that research, including PIs, topics, and maturity of effort. Implementation of a comprehensive helpdesk tracking system, as recommended in the introduction, will provide the information needed to track DTC staff distribution of effort, to identify return customers and to track the progress of users through various stages of engagement in DTC-relevant research. This information can be used by DTC staff to motivate relationships with groups engaging in promising research, and to focus solicitations for the visitor program.

The DTC should facilitate a community-driven effort to refactor (modularize and modernize) the GSI code. This recommendation comes from the belief that broad community engagement in GSI code refactoring lowers the barrier to entry for interested researchers and engineers. The specific recommendation is to assemble a diverse group of academics, including atmospheric scientists, computer scientists, and others with interest in guiding or participating in a refactoring effort. One outcome should be a white paper mapping a recommended pathway to refactoring that enables community engagement in the process. Refactoring will lead to code sufficiently different from current versions. Researchers who are using the GSI now, or who plan to in the near future, will need to make a significant leap to adopt this new code base. Engaging the research community, and the authors of the current GSI code, in the process encourages earlier entry.

Specific recommendations from the data assimilation team are summarized below:

1. Overcome the barriers to the community by providing the full observation database and prepBUFR capability to directly replicate that used at NCEP.
2. Continue to work toward supporting regional cycling ensemble-GSI hybrid systems.
3. Track community data assimilation research that may be relevant to AFWA or NCEP operations in the future.
4. Facilitate initial steps toward community participation in GSI code refactoring.

Data assimilation recommendations reflect past SAB recommendations, and acknowledgement of recent progress. Before effective and substantial R2O can occur, a broader community of operational code users must be involved. Efforts and building that community will accelerate future DTC R2O efforts.

Verification Task Area (SAB members: M. Stoelinga, H. Brooks, K. Mahoney)

The SAB's discussions on verification centered around two main themes: Improving the "marketing and adoption" of DTC's verification tools (primarily the Model Evaluation Tools, or MET, software package) across the weather research and forecasting community; and capability enhancements to those tools.

a. Marketing and adoption

It is the SAB's perception that in recent years, the primary challenge of DTC in its support of model verification has *not* been the capabilities of the tools offered, but rather the degree to which DTC's offerings are known and adopted across the research and operational forecasting communities.

With regard to this point, it was recognized that there are three primary user communities for MET: (1) DTC itself; (2) US operational forecast centers (NCEP, AFWA); and (3) the broader community, including academic, national lab, and private sector users. Unique challenges and recommendations for each of these three separate communities were discussed and are summarized here.

SAB recognizes that DTC itself is the most frequent and most important user of the MET software package. Indeed it would be difficult for DTC to carry out many of its mission goals without the availability of a comprehensive verification software package. MET serves this purpose, and for this reason continued maintenance and ongoing development of MET are recognized as an important part of DTC's mission.

MET use at the operational forecast centers, particularly at NCEP, has had a sporadic history, and there are fundamental challenges to widespread use of MET at the centers. These include concern at the centers about operational reliability of the code, and long-established familiarity and comfort with the metrics and graphics produced by the centers' own internal verification codes. However, there are several things DTC can do to try to bring more unity to verification efforts at DTC and NCEP. DTC should work with NCEP/EMC to acquire current EMC verification codes, understand their capabilities, and see what MET is missing. DTC has made some inroads, and should continue to seek opportunities to introduce MET to other NCEP centers in addition to EMC (e.g., AWC, CPC, NHC, SPC, WPC). Increased familiarity with MET across NCEP centers may accelerate usage throughout NCEP. DTC should look for opportunities to encourage early adoption of MET in new initiatives related to R2O and operational forecasting. These include integrating MET into the NWP Information Technology Environment (NITE), which DTC has already made plans to do; as well as becoming more engaged with, and encouraging the use of MET in the verification efforts associated with HIWPP and NGGPS. DTC should familiarize itself with and implement in MET the various "scorecard" verification metrics that are used at different operational centers and NOAA labs. Related to that, DTC should work more closely with other R2O centers, notably

NOAA/ESRL, to become familiar with their verification efforts and look for opportunities to collaborate and combine methods and codes.

Within the broader user community (academia, national labs, and the private sector), the SAB's opinion is that "getting the word out" and forming a community of users, particularly among educators and students, is a key to broader adoption of MET and to greater realization of the benefits of MET for community-wide R2O success. As with most community-supported codes (such as WRF), there is a synergy between broad community use of a code and its continued development and robustness, and this can happen with MET. DTC can foster broader community familiarity with, and usage of, MET through a variety of outreach efforts. These include:

1. Conference presentations
    a. DTC should have at least a poster at all relevant conferences (WRF Workshop, AMS NWP/WAF, etc.)
    b. DTC should organize an AMS Short-course with MET and MMET focus in conjunction with a relevant AMS conference, as in Phoenix 1998.
2. Workshop
    a. SAB again recommends holding a Verification Workshop in the coming AOP.
    b. The workshop should strike a balance between exploring verification innovations and addressing the current T&E needs of the operational community.
3. Tutorials
    a. These are a standard DTC offering, and should continue.
    b. DTC should integrate MMET cases into the tutorial
    c. It would be a good idea to try to couple a tutorial with a DTC visit to EMC during next AOP
4. Other ideas to educate the user community on MET use and capabilities
    a. Establish an email list-serve or user forum
    b. Present well-publicized webinars
    c. Launch university "road shows"

Another helpful effort would be to seek out collaborations with specific user communities that have unique verification challenges, and for which the solutions to these challenges may have broader applicability. Specific examples that were brought up include challenges in severe weather forecasting with verification of "swath predictions" (hail, convective winds, tornadoes, tropical cyclones); aviation-specific forecasting; and hurricane-specific needs such as tools to verify RI/RW and QPF for landfalling and inland TCs.

Finally, one recommendation that was made more generally for DTC, but would be of particular help for visibility and justification of the verification support efforts at DTC, is improved tracking and reporting of the support that DTC provides for the NWP verification community. Such tracking could include official requests for researchers to acknowledge DTC and MET in publications and presentations; tracking and public reporting of downloads of DTC's verification code (MET); and a ticketing system that facilitates tracking and reporting of support interactions with members of the user community.

b. Testing and evaluation capabilities

The SAB also has a set of recommendations for new or enhanced capabilities within the MET package:

1. Cycled DA outputs (innovation, analysis residual, and analysis increments): Although this was not explicitly acted upon after last year's SAB recommendation, it became clear in this year's SAB discussions that this is essentially already, or very close to being, a capability. GSI provides these fields as outputs, and MET should be able to ingest them with limited additional work. Perhaps the only remaining question is, does the user community want to make use of these fields, and is MET the vehicle by which they want to do it?
2. Forward operators: Many nonconventional observations (e.g., radar reflectivity, satellite radiance) could be verified directly if the appropriate forward operators (which convert standard model output to fields that mimic nonstandard observations) were available in MET. There is an opportunity here for synergy with the DA community, for which forward operators are an essential piece of modern DA systems.
3. Point time series: MET would benefit from better tools for working with observed and modeled time series at a point (e.g., distributions, lag correlations, diurnal and seasonal error characteristics, etc.)
4. Generalized regridding: Many new datasets could become more accessible in MET with a generalized regridding capability that interpolates data from any observation or analysis grid to any model grid (or both to some third common grid).
5. Global models: Although SAB believes that retooling of MET for any specific global model is premature, there are certain general technical issues that will arise regardless of what the NGGPS actually ends up looking like. These include logistical issues associated with domains that cover the globe instead of a portion of it (e.g., handling the poles and the dateline); as well as exploring general challenges of irregular grids, which the NGGPS is highly likely to have. DTC should begin the planning process for dealing with these issues (e.g., software specifications).
6. MET Viewer: DTC has a versatile visualization capability for MET output called MET Viewer, which is currently only intended for internal DTC use. With some additional software effort, MET Viewer could be made sufficiently portable and user-friendly to allow for community release and support. This effort would help users, and could further the goal of increasing MET adoption across the community.