Minutes
WRF Executive Oversight Board (ExOB)
Meeting 4 (2005-2)
AFWA, Offutt AFB, NE
11 August 2005

Attendees: John Lanicci (AFWA), Robert Winokur (N7C), Louis Uccellini (NCEP), Alexander MacDonald (ESRL, formerly FSL), Gloria Kulesa (FAA, via telecom), Pamela Clark (ARL), Greg Holland (NCAR), Simon Chang (NRL), Nelson Seaman, Robert Gall, Greg Mandt, Mark Surmeier, Jerry Wegiel, David Knapp, Mike Clancy, Brian Moore, Chris Finnigsmier, Calvin Naegelin, Richard Wagoner, Steve Payne, Richard Allard, Mike Howland, Capt. Brandon Alexander.

1. Briefing 1: Welcoming Remarks and Introduction:

As host, Col. John Lanicci welcomed meeting attendees to AFWA. In his opening remarks, Col. Lanicci emphasized the importance of preserving time for the scheduled executive session. He indicated that the time appears right to discuss where the WRF program has evolved differently over the past several years than anticipated in the original vision of community modeling and to begin reassessing the WRF vision to guide the future of the program.

2. Briefing 2: AFWA Command Briefing

Capt. Brandon Alexander gave the Command briefing explaining AFWA's mission: providing advanced environmental information and training and equipping the warfighter in the use of that information. AFWA's mission encompasses terrestrial, space and climate weather products. Over 800,000 individual products are delivered daily through AFWA's JAAWIN system. A key element of AFWA's effort to improve the value of its products and services is the impending replacement of the MM5 mesoscale model by the WRF system, beginning in early FY06.

AFWA currently consists of ~900 military and civilian personnel organized into five directorates: operations, communications and information, air and space science, plans and programs, and operational analysis. AFWA is resourced with a budget of $192 M/yr. In January 2006 construction will begin on a $30 M modern facility at Offutt AFB that will become the future home of AFWA. Negotiations are ongoing with NWS on a plan that would co-locate the AFWA and NCEP primary operational computer systems in the new facility, which could offer potential savings to both organizations.

3. Briefing 3: AFWA-WRF Status

Mr. Chris Finnigsmier, the AFWA program manager for WRF implementation, briefed the ExOB on the status of AFWA's **WRF implementation** efforts. AFWA currently is running

WRF-ARW four times per day in parallel with the operational MM5 as part of its pre-implementation testing and evaluations. These tests have revealed potential vorticity (PV) "streamers" (narrow bands of maximum and minimum PV) downwind of the highest peaks in the Rocky Mountain region. These streamers exist in both MM5 and WRF-ARW and, when triggered by high terrain in the interior of model domains, they appear to correspond to features that can be observed in the atmosphere. However, in some cases the models seem to generate spurious strong streamers in the vicinity of steep terrain along the models' lateral boundaries. AFWA and NCAR are attempting to correct this boundary problem prior to ARW implementation.

As part of the testing and evaluation process, AFWA is preparing to send WRF-ARW datasets to internal and external customers four times per day and twice per day, respectively, using 15-km and nested 5-km grids. Metrics have been developed to establish "exit criteria" that will signal a successful end to the testing. Model evaluations by customers are scheduled to begin in September 2005. Results from the testing and evaluations will be reviewed to reach a decision on initial operational implementation (IOC) of WRF. Following IOC, WRF-ARW will be implemented across the rest of AFWA's domains over the following 12-18 months.

AFWA will publish a formal report on the results of its WRF model testing. An unclassified version of the report will be posted on the WRF website, while classified results will be available on SIPRNET.

4. Briefing 4: WRF Program Status

Dr. Seaman began the WRF program status briefing by summarizing key **accomplishments** of the WRF program over the past 4 months. These include:

- Developed tutorial for 2 WRF modeling systems (establishes user training for operational models to be implemented at 2 U.S. OPCs);
- Released WRF Reference code v2.1 for 2 cores;
- Completed statistical evaluation of DTC Winter Forecast Experiment (DWFE);
- Conducted NSSL-SPC 2005 Spring Forecast Experiment with 2 cores on grids of 4 km and 2 km, and demonstrated ability of 2-km WRF-ARW to simulate supercell thunderstorms with "hook-echo" signatures;
- Implemented first operational WRF models (two cores) on ~5 km grids without convective parameterization;
- Established WRF as the primary mesoscale modeling system supported to the external NWP community.

The WRF program status summary for Phase 1 showed that during the past 4 months, two additional threshold metrics and one additional objective have been completed. Over the same period, two Phase 1 objectives have been elevated from "TBD" to "on track." These changes are summarized as follows:

- Goal 1a threshold metric completed: "2 WRF cores released for community use as a single reference code, with physics interoperability." *Achieved with release of WRFv2.1 reference code*.
- Goal 1a objective metric status elevated: "3 WRF cores released to community as a single reference code." *This objective was upgraded from "TBD" to "On track for FY07" based on NRL's plans to establish ESMF as the driver for COAMPS by FY07 and WRF program's plans for a technical workshop in early FY06 to develop an approach for merging WRF and ESMF. (see ESMF discussion below for details)*
- Goal 1b objective metric status elevated: "Distributed DTC becomes functional." *This objective was upgraded from "TBD" to "On Track for April 2006" based on planning begun in June 2005 for DTC/MRY and DTC/Boulder to collaborate in running and evaluating models during TREX.*
- Goal 2 objective metric completed: "WRF with grid nesting for two cores supported to community." *This objective has been (marginally) completed by availability of a beta version of WRF-NMM with one-way interactive, moveable nested grids for testing by the community. General release of two-way nested WRF-NMM as WRF Reference code is anticipated by 2Q FY06.*
- Goal 5 threshold metric completed: "Infrastructure understudy position fully functional." *Achieved by completion of training for Dr. Thomas Henderson as a second expert in the WRF software engineering infrastructure at NCAR/MMM.*

- *ESMF discussion*

A request was made for more information regarding the report that the WRF program is now on track to allow all 3 cores run under WRF-ESMF by FY07 (see above, 2nd bullet). Mr. Clancy said that reaching that goal will depend on the outcome of the WRF-ESMF infrastructure workshop planned for early FY06. Dr. Seaman agreed, but noted that the anticipated merger of the WRF and ESMF infrastructures by FY07 would likely represent only a first-stage in the merger process, because ESMF codes will be under development for at least the next five years. However, that first-stage merger is expected to be sufficient to support running all 3 cores in a common modeling infrastructure (CMI).

Dr. Chang asked if there is sufficient interest in the community to move to ESMF. Dr. Holland answered that the current version of ESMF is not fully ready to take over the range of capabilities provided by the WRF infrastructure. For example, performing physics coupling with the current ESMF could triple the run time of models now run under the WRF CMI. Mr. Clancy said that Navy has found only very small overhead associated with running under ESMF. He asked if there was experimental evidence that the performance penalty of ESMF-coupled physics is so severe. Dr. Holland replied that "running under ESMF" can have a variety of meanings depending on how extensive is the use of ESMF couplers, etc. Minimal application of ESMF to run an otherwise complete modeling system might indeed be relatively efficient, but use of ESMF to couple different physics modules may be far less efficient. Mr. Clancy noted that the NASA GEOS-5 atmospheric general circulation model was built with extensive use of ESMF coupling, with each and every subroutine in the model an ESMF component, and yet the model does yet does not suffer from loss of efficiency.

- *Dealing with complexity of the WRF CMI*:

Noting that the WRF CMI "understudy" position has been staffed at NCAR/MMM, Dr. Uccellini asked if the DTC also is capable of supporting CMI to all users. Dr. Gall replied that currently there is no such position at the DTC. Dr. Chang asked if there has been any feedback on whether the WRF infrastructure documentation is sufficiently detailed or not. Dr. Seaman said that there has been little direct feedback, but that assessing the sufficiency of the documentation has been included for action in the charge written to the WRF-ESMF infrastructure workshop. Dr. Uccellini said that it is important to determine whether all the WRF partners are approaching a satisfactory level of comfort with the infrastructure. Dr. Holland pointed out that reaching that state requires tapping the expertise of the wider user base, not relying solely on one or two individuals. Dr. Uccellini pointed out that the complexity of the WRF CMI is the primary reason that NCEP was forced to delay operational implementation of WRF as the replacement for Eta. Dr. Holland noted that lessons learned along the way at individual centers can be used to ease the implementation at other centers. Referring to Dr. Seaman's report that NCAR had spun-up a 2nd software engineer with broad expertise in the WRF infrastructure, Dr. Chang asked if having only 2 such individuals can be considered sufficient. Drs. Gall and Seaman replied that there are now quite a few others scattered in the community who have been gaining in-depth expertise with the CMI, including at least two at NCEP, under the direction of Geoff DiMego.

5. Briefing 5: Development Testbed Center Briefing

Dr. Gall presented the DTC briefing and highlighted its recent important accomplishments. These emphasized contributions made by DTC to both the operations and research communities through model testing, code evaluation, and community support. It was also reported that the DTC Terms of Reference had been close to completion, but review by NCAR's legal section has required that a number of modifications be introduced.

In response to ExOB Action Item 3.1-2005 (April 13, 2005), Dr. Gall presented evaluations of model results from the DTC Winter Forecast Experiment (DWFE). DWFE results revealed many detailed mesoscale structures in predicted upper-level WRF fields, precipitation and surface-layer fields. NWS forecasters participating in DWFE found it difficult to make use of many upper-level fields because of the high degree of detail produced by the 5-km WRF models. On the other hand, forecasters were very excited by instantaneous composite radar-reflectivity fields generated from WRF model predictions. The simulated reflectivity contained much mesoscale detail, similar to that found in observed Doppler radar reflectivity.

Both the DWFE WRF models (based on ARW and NMM cores) had errors in surface temperatures due to bugs later found in the radiation physics. When the bugs were corrected following DWFE, WRF-NMM produced errors very similar to those of Eta, while some larger errors appear to remain in WRF-ARW. On the other hand, WRF-NMM had somewhat lower skill for precipitation in DWFE than the WRF-ARW. However, for most variables it appears that differences in forecast skill among NMM, ARW and Eta solutions were not significant. An

exception is that both WRF models appear to have significantly higher biases than Eta for the larger thresholds of precipitation.

A final report on DWFE has been written and is undergoing review. Its formal release is expected by early September.

Lessons learned from DWFE include:

- A balanced approach needs to be established for dealing with model bugs uncovered during major real-time modeling experiments. Model developers and forecasters generally want bugs fixed immediately, while model evaluators often want codes "frozen" to preserve the scientific integrity of the experiments.
- We are able to develop several new, innovative products that can communicate to forecasters much of the important information found in very-fine-scale numerical predictions of the winter atmosphere. These products, such as simulated reflectivity, are suitable for rapid transition to operations.
- We need to learn how to more effectively isolate and present useful information contained in traditional model fields (e.g., vorticity and vertical velocity) that otherwise appear confusing due to excessive detail emerging from very-fine scale numerical predictions.
- More basic modeling research is needed on the predictability of winter mesoscale systems (e.g., lake-effect snow bands).

Dr. Gall also reviewed the final DTC budget for FY05, showing the breakdown of resources received from different organizations. The FY06 DTC budget plan also was presented. It was pointed out that in FY05 the DTC had been able to carryover prior-year funds from several sources and pay less than full-year salaries for two employees. However, those cost-saving "windfalls" will disappear in FY06 and could present DTC with serious budget challenges, even without new hires or task commitments. Projects undertaken for FY06 will be contingent on resourcing and will be prioritized with the help of the DTC Advisory Board, which will meet in September 2005.

The DTC visitor program was expanded in FY05 with new funding from NSF ($50 K) and NCEP ($25 K). For this year 88% of the visitors are from the academic community. This represents an important contribution to efforts of the WRF program to better entrain the research community in WRF testing and evaluations. Future evaluation of visitor proposals will be made with the assistance of a new DTC Advisory Board, as called for by the DTC TOR. Gloria Kulesa said that FAA is still working to identify a representative to the Advisory Board. Dr. Gall also noted that planning for the first WRF-NMM tutorial have progressed well and should be completed in time for the 27-29 September deadline. Applications were received from 62 individuals (nearly twice the available space), indicating considerable community interest. Documentation for the WRF-NMM is expected to be completed in time for the tutorial. COMET will assist by videotaping the tutorial for later preparation of a distance-learning module.

The Boulder DTC and NRL/MRY DTC have made plans to collaborate in TREX (Terrain-induced Rotor Experiment) to be held in Owens Valley, CA, in Spring 2006. COAMPS will be run in real time. WRF-ARW and WRF-NMM will probably run in near-realtime. Pam Clark added that ARL also will be running WRF at 2 km over the Owens Valley as part of TREX. This project will establish the DTC as a functioning distributed center. Meanwhile, a second joint project is being considered in which Boulder and Monterey would collaborate to develop a regular tutorial for COAMPS, possibly beginning in 3Q, FY06.

- *DTC discussion*

Dr. Uccellini said there are at least three major issues facing WRF that must be addressed with the help of the DTC: (a) What are the implications of choosing a single dynamic core for WRF? Do potential cost savings exist? What is the implication of a loss of model diversity, particularly for ensemble predictions? The DTC is positioned to help address these issues. (b) How do we successfully transition from models that rely on convective parameterizations to models that rely solely on explicit microphysics? DTC must help determine how to make explicit-microphysics configurations work well and define the resolutions where they can be used with confidence. (c) In the area of data assimilation DTC needs to develop an active relationship with JCSDA, so that research codes evaluated at DTC can be readied for transition to operations. Dr. Holland said that NCAR/MMM already has adopted the NCEP GSI 3DVar system and DTC can work with MMM on data assimilation tasks. MMM also is continuing to develop its original WRF-3DVar system in order to fulfill contracts with several customers. Dr. MacDonald said that ESRL is also interested in GSI testing because that code will be used for the Rapid-Refresh WRF.

6. Briefing 6: Status of Action Items from Meeting 3 (Meeting 2005-1)

This briefing was omitted in an effort to return to the schedule of the meeting agenda. As a result, most of the time lost due to a fire-related building evacuation was recovered. Those interested in the status of action items are referred to the PPT briefing slides.

7. Briefing 7: WRF Research Applications Board Update

Dr. Seaman reported initiatives undertaken by the WRAB to (1) obtain inputs from the community to help identify high-priority areas of atmospheric research necessary to sustain WRF as a state-of-the-science NWP system, (2) expand the opportunities for academic community participation in the WRF program, and (3) build a closer relationship with NSF with the aim of having NSF become a signatory partner in the WRF program.

- *WRAB discussion*

Dr. Chang asked if the WRAB members have surveyed scientists at each of the WRF partners for their inputs on high-priority research. The August 15 deadline for responses is quickly approaching and Dr. Chang does not know of any scientist at NRL or elsewhere who had been surveyed. Dr. Seaman replied that there was no information from the WRAB on progress to

date. WRAB members would be encouraged to move forward to contact their peers. Once the initial inputs have been collected, they will be circulated to the points of contact at each partner organization, so there can be adequate opportunity for agency review and input. The ExOB then discussed whether the academic community is over-represented on the WRAB. Dr. Seaman pointed out that this is the only WRF Board that includes academic representatives and even here, they are a minority (4 out of 9). Having an opportunity for academia to make its voice heard clearly is vital to the balance of the WRF program. It was asked whether NCAR can speak for the academic community. Drs. Gall and Seaman replied that the universities are adamant that NCAR does not represent them. Dr. Chang noted that asking passionate individuals to lead WRF working groups may cause problems if they lead in the wrong direction. Leadership needs both passion and insight about the best direction to pursue. Oversight is needed to make sure that the directions promoted make sense. Dr. Uccellini stressed that it is vitally important that WRF find a way to achieve full NSF participation, including representation on the ExOB.

Regarding the WRAB briefing's request for a rapid-response fund, Dr. Chang asked who would administer the fund. Dr. Wegiel said that it could be managed through the DTC, which has an interagency Advisory Board. Dr. Uccellini said funding is unlikely to appear because agencies can no longer have unassigned funds in their budgets. Budget assignments are already nearing completion for FY08. Dr. Kulesa said that FAA, as other agencies, has no flexibility on how funds are directed. It can reprioritize existing funds, but the FY08 budget will be locked down within the next several weeks.

8. Briefing 8: WRF Operations Requirements Board Update

Dr. Wegiel reviewed the purpose of the WORB, referring to the board's charge that was approved in 2003. Its primary duties are to review coding and documentation standards and to identify requirements WRF must meet to be supported in operations. So far, WORB has met only by telecom and has not been able to review any WRF documentation.

The following recommendations were made to the ExOB on behalf of the WORB: DTC should...

- be charged with responsibility to establish, sustain and maintain the official unified set of WRF Reference codes, including operations codes, and their documentation.
- develop a cost estimate to perform the duties outlined in the first bullet. (Probably ~2 FTE.)
- formulate and maintain an integrated suite of standardized numerical tests that the operational and research communities can apply to various configurations of WRF codes.
- become the primary test facility for the unified WRF Reference (baseline) codes.

Dr. Chang requested that Roger Stocker or an alternative at FNMOC be fully integrated into the planning efforts of the WORB. Dr. Wegiel readily agreed to do so. It was also reported that WRF is now being used by at least 5 OPCs, including some outside the U.S. Dr. Wegiel asked if

the foreign OPCs should be formally integrated into the WRF management. A number of the ExOB expressed concern that that could raise security issues that are currently difficult to address.

9. Briefing 9: WRF-ESMF Integration Update

Dr. Seaman reported that agreement has been reached on the form of a technical workshop for WRF-ESMF integration. A charge to workshop participants has been drafted and the WRF partner points-of-contact have been asked to review the charge and to provide comments and suggestions. They also have been encouraged to provide their agency's perspective on desired outcomes of WRF-ESMF integration as supplemental guidance to the workshop. The workshop is expected to be held at NCAR in November. Following the workshop, a target of Jan-Mar 2006 is expected for producing a draft report on WRF-ESMF integration. The report will need to be reviewed by the WRF partners, revised and adopted, with a target for completion by June-July 2006. This schedule reflects advice from the ExOB that earlier targets are probably unrealistic. Also, Dr. Payne requested that BEI be kept in the loop as the WRF-ESMF process goes forward. Dr. Seaman readily agreed.

10. Briefing 10: Battlespace Environments Institute Update

Dr. Allard, the BEI Staff Project Manager, gave the briefing. The goals of the BEI are:

- Integrate earth and space modeling,
- Support battlespace decision making,
- Enable a whole-earth modeling approach,
- Transition non-DoD technologies to DoD applications.

Some of the extensions to ESMF that will be developed under BEI were explained and specific goals for FY06 were discussed. ESMF coupling of COAMPS to the Navy Coastal Ocean Model (NCOM) is expected to be completed by 4Q FY06. BEI also expects to use ESMF coupling to link WRF and HYCOM by Q2 FY06.

11. Briefing 11: Joint Numerical Testbed Plan

Dr. Seaman presented an **analysis of current gaps in capabilities** of the WRF DTC in Boulder that limit its ability to perform model testing and evaluations, support WRF codes to the community, and slow the transition of tested codes to operations. The deficiency analysis is the motivation for what is tentatively called the Joint Numerical Testbed (JNT), which encompasses the present DTC plus some code-transition functions of an operational testbed. Specific areas of expertise that require different skill sets than those of current DTC scientists were identified. It was estimated that 4.0 FTE are required for the Boulder DTC to provide the range of **developmental testing and support services** presently expected by the partner organizations.

In addition, experience has demonstrated that important code-transition tasks are not covered under the original DTC plan, but are necessary for an efficient flow of codes to and from the operational centers. Those code transition functions have long existed between NRL and FNMOC, for example, but do not exist between DTC-Boulder and either AFWA or NCEP. In addition to the obvious interest that operations centers have in transitioning code from research to operations, there is also a need to pass operational model codes to the DTC, where they must be tested and supported to the community. The JNT plan lists 2 FTE for **code transition to/from operations** and 0.5 FTE for **testing of operational codes** returned to the DTC. The primary task of operational code testing is to continuously run and evaluate WRF operational systems provided by the operational centers on a common domain. (Also see JOMES discussion below.)

- *JNT discussion*

Dr. Chang asked whether the Environmental Modeling Center and NCEP Central Operations already serve as NCEP's JNT. Dr. Seaman replied that this is true for codes developed internally at EMC, but in the WRF era many additional codes will be coming from the external community. For operational centers like NCEP and AFWA to take advantage of innovations developed externally and tested by the DTC, a new capability must be established to transition those external codes for OPC applications. Assignment of existing EMC personnel to JNT transition activities is included as part of the JNT plan, but corresponding personnel are needed on sight in Boulder, where the majority of external code testing will take place at DTC. Dr. Uccellini confirmed that a better way is needed to get externally developed codes ready for use by the operations community.

Ensuing discussion revealed that there was some confusion about what the JNT proposal entails, including how it would be governed. First, by filling the gaps in present DTC staffing, DTC will become better constituted to serve the needs of all the partners. It was explained that extension of DTC to become JNT (by including code transition functions and operational model testing) does not necessarily require inclusion of all partner organizations, but is it open to those who benefit from its services. For example, EMC already has offered to assign an FTE for transitioning codes for operations. In actuality, there is no need to change the name of DTC to do this and governance descriptions to cover the additional transition tasks probably can be accommodated with fairly minor changes to the current DTC TOR draft. Dr. Uccellini pointed out that, without the necessary code-transition capabilities, NCEP will face difficulties adapting to the stream of codes beginning to flow from the research community to operations. Without these OTC functions, an efficient flow of new science and technology between the branches of the community cannot be achieved, thus losing one of the major advantages of the WRF program.

The discussion turned to the specific new positions proposed for the JNT, what services they would perform and where they would be located. At least one transition position would be at NCEP/EMC. Most (but not necessarily all) of the others would be in Boulder. Dr. Chang said that NRL was worried about changing the name of DTC and diluting the effort of the WRF program. The WRF Program Office should make WRF work within the current organizational structure, which has only been established recently, instead of setting up a new organization. Dr.

Seaman replied that, as shown in the briefing, the objective is to complete the unfinished bridge between research and operations communities, in the same way NRL and FNMOC now constitute a complete bridge for Navy. Rather than dilute WRF efforts, the plan recognizes the need to the shift emphasis of the WRF from program from initial code development and implementation to sustaining and improving WRF. This is consistent with the declared three-phase strategy, wherein we are approaching completion of Phase 1 and must lay the basis for Phase 2 to be successful. Changing the name to "JNT" is not necessary, and it may be preferable to retain the name "DTC."

Dr. Uccellini pointed out that in the DTC concept figure (see slides 4.11.2, 4.11.5, and 4.11.7), the lower green arrow, representing the flow of operational codes to the research community, does not exist at present. It's time to recognize we need to complete the boxes representing the bridge and make it work in both directions. So far, many people on the "outside" still think the WRF program is mostly "vapor." Completing an effective two-way bridge between research and operations is essential to make the WRF program work. Mike Clancy agreed that the WRF program hasn't matured yet. Dr. Chang asked if it's simply a matter of asking EMC people to work with DTC. Dr. Uccellini answered that NCEP/EMC would explore how resources could be allocated to transition tasks under the JNT plan, but filling the identified gaps requires going well beyond that and might require additional resources. This is much more than a name change. It replaces the idea of separate developmental testing and code transition efforts performed by disconnected organizations by recognizing they are handled most efficiently by as a continuous flow in a tightly-managed organization.

- *JOMES Discussion*

JOMES, the proposed Joint Operational Mesoscale Evaluation System, was the next focus of discussion. Dr. Uccellini agreed that this is a necessary role of the JNT because it establishes the "green arrow" shown on the DTC slides that represents the return of tested operational codes supported to the research community. Dr. Uccellini also pointed out that the proposed JNT personnel will enable testing of WRF-based ensembles, which is essential if we are to have adequate answers about how to maximize diversity within mesoscale ensembles. Dr. MacDonald cautioned that balance needs to be maintained in any reorganization of the DTC/OTC concept. If operations centers exert excessive control over JNT, that could make it more difficult for NSF to participate significantly in the WRF program. Dr. Wagoner concluded by explaining NCAR's concept for its own internal JNT, in which the NCAR-DTC node is a part. NCAR envisions building partnerships with other organizations external to the WRF partnership, especially in the private sector, who can become important supporters for many of the positions and capabilities that have been identified as deficiencies in the current DTC. Many private-sector organizations recognize their need for such services, so the benefits of collaboration and leveraging of investments can be shared by private and public sectors.

12. Executive Session

Col. Lanicci began by listing the major issues currently facing the WRF ExOB:

- What is the definition of community modeling at this time?
- What is the best way to organize and resource modeling testbeds?
- How can the WRF program make best use of its large user base?
- How can the WRF program be best organized for the future?

- *Community modeling*

Col. Lanicci launched the discussion by saying that WRF began with the concept of a single dynamical model core, a single data assimilation (DA) system and multiple physics packages. Despite the original intent, we now have multiple dynamical cores and DA systems, in addition to multiple physics packages. Is this a situation with which we should be satisfied or do we need to push toward further convergence? This is at the heart of defining what we mean by "community modeling."

Dr. MacDonald replied that there are compelling arguments that the evolution of WRF as a multi-core system in a CMI is actually an advantage. The goal of WRF should be a system that provides the best forecast products, which necessarily will require an ensemble approach having broad model diversity. The evidence strongly implies that multiple cores are critical to achieving the necessary diversity. Mr. Clancy agreed that broad diversity is best attained in systems that support diversity through multiple DAs, physics and cores. Dr. Chang added that current evidence also indicates that broadly based ensemble diversity, including multiple cores, is advantageous for improving forecasts of tropical storm tracks.

Dr. Uccellini said it's important to recognize that the current WRF system, with multiple components in a CMI, is especially well designed to support ensemble modeling, as well as deterministic modeling. This is a concept he strongly endorses to Gen. Jack Kelly of NOAA. WRF soon will allow NCEP to replace four entire modeling systems (Eta, RUC, GFDL and Regional Spectral Model, thus reducing its operational code maintenance burdens. So, while WRF presents challenges, NCEP is satisfied that its advantages greatly outweigh its problems.

Dr. Holland mentioned that most atmospheric model users are not engaged in operations, but rather are focused on research. Therefore, "community modeling" also means bringing research and operations users together in a way that both can make contributions that move the entire community system forward. The diversity within the WRF system can be a positive factor to facilitate such progress.

Mr. Surmeier commented that AFWA had entered the WRF program based on the need to reduce its costs. The cost of developing and running ensembles is a very significant part of overall costs, so these developments are not inconsistent with AFWA's goals. Air Force strategy is to avoid changing directions too often, which creates risks and drives up costs. So, while AFWA agrees that a plan for eventual consolidation of NCEP's GSI and NCAR's 3DVar DA systems is a good long-term strategy, the ability to stick with the NCAR system for now is an advantage. Insisting on immediately choosing a single DA system might place AFWA's investments at risk.

At this point Col. Lanicci concluded that there appears to be a consensus that having multiple cores and data assimilation systems in WRF is not necessarily a bad outcome (at least for the near term) and it may provide certain advantages.

- *Model Testbeds*

Dr. Uccellini began by saying that the current DTC funding profile (essentially, by NOAA and NCAR alone) is not sustainable. Meanwhile, the issue of multiple DA systems raises the question of how WRF should take advantage of the Joint Center for Satellite Data Assimilation (JCSDA). AFWA's intent to implement the NCAR 3DVar DA system means that, at least initially, it will be the only major OPC in the world that will not use satellite radiance data (except through global model products). The need to do so has motivated the current efforts to re-converge the two WRF DA systems. To make that happen, NCAR needs to become a partner in the JCSDA. Mr. Surmeier pointed out that it had always been AFWA's intent that its operational DA system would use satellite radiances. It was through a series of oversights leading to a divergence in the DA development program that AFWA will not have that capability immediately. Dr. Uccellini said that it's to our advantage that we find a solution that manages to bring everyone back together again.

Col. Lanicci said that AFWA must continuously look for ways to collaborate with others to stretch its limited resources. The community approach, including joint testbeds, is the only way AFWA can operate today. Its strongest collaboration remains with NCAR. Mike Howland asked if the WRF program has lost sight of the community approach to science. In what areas are we collaborating to develop and use the best science in the WRF system? Dr. Uccellini replied that we are better positioned to do that today than we ever have been before. However, NSF is the key missing player in order to make the best progress. Unfortunately, in the past NSF has backed away from supporting WRF. It is time to re-engage NSF to determine if their position has changed.

- *Future Organization of the WRF Program*

Dr. Uccellini and Bob Winokur began by saying that the ExOB needs to hold a meeting to develop a new funding strategy for WRF. That will likely require a new management plan for the WRF program. Pam Clark asked if the ExOB had considered certain other programs, such as NPOESS, as a model. NPOESS uses an MOA as the basis for its management plan. Others suggested that a WRF MOA could be developed that would build on the foundations laid by the current AIP and WRF CONOPS framework. A MOA would cover both resourcing and management, defining what *will be done* under WRF.

Dr. Bob Winokur suggested that the ExOB hold a telecon to develop a plan for resourcing and program management and/or devote more time in the next meeting to discuss resourcing issues. Drs. Gall and Seaman can be charged with soliciting options from the individual ExOB members, which could be distributed prior to a telecon. This approach would make the telecon more effective by providing a preview of the positions of the ExOB members. The ExOB members requested this be captured as an action item, with a target of about September 15 for the telecon.

13. Action Items from Meeting 4 (2005-2)

Action Item 4.1-2005: The Program Coordinator and DTC Director will plan for and conduct a teleconference of the WRF Executive Oversight Board to discuss options for establishing a more firm management plan to sustain the WRF Program, including resourcing for the WRF DTC. The PC will solicit and organize initial thoughts from the ExOB members, and distribute them prior to the telecom as a starting place for discussion. The target date for the telecon is about September 15th.

Action Item 4.2-2005: Dr. Greg Holland will prepare a brief report on how to actively engage the research community with NSF in a partnership to support WRF developments that can flow to research and operations, including the potential for NSF to become a member of the WRF ExOB.