NOAA Climate Working Group Meeting

Climate Research and Modeling (CRM) Program

Response to the CWG Review

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November 24, 2008

NOAA's Climate Goal

Understand climate variability and change to enhance society's ability to plan and respond

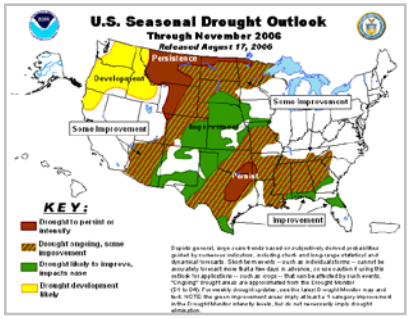
Program	Performance Objective	Outcomes
 Climate Observations and Monitoring	Describe and understand the state of the climate system through integrated observations, monitoring, and data management	A predictive understanding of the global climate system on time scales of weeks to decades to a century with quantified uncertainties sufficient for making informed and reasoned decisions.
 Climate Research and Modeling	Understand and predict climate variability and change from weeks to decades to a century	
 Climate Service Development	Improve the ability of society to plan for and respond to climate variability and change	Climate-sensitive sectors and the climate-literate public effectively incorporating NOAA's climate products into their plans and decisions.

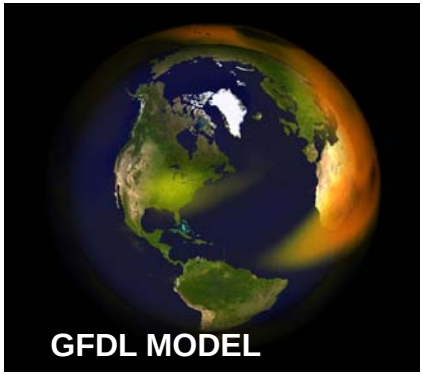
CRM: Advance Predictive Understanding and Skill about the Future State of Climate

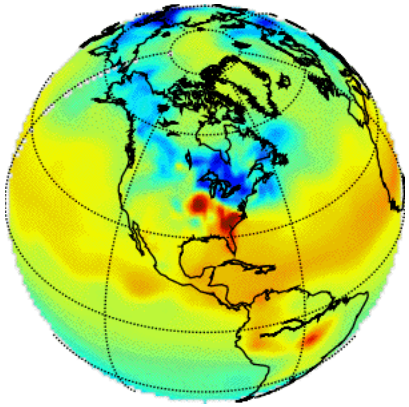
- **Understanding Climate Processes -**
  - NOAA's Research Laboratories,
  - Centers, and Cooperative
  - Institutes
  - Competitive Grants

- **Earth System Modeling, Predictions, and Projections -**
  - GFDL and NCEP coupled climate models
  - Earth system model development

- **Analysis and Attribution -**
  - Reanalysis
  - Emerging focus on Integrated Earth System Analysis and attribution







Capturing the global distribution of the short-lived Aerosols spreading out from the source regions

Genesis of CRM

- 3 August 2007: NEP/NEC approves Climate Goal restructure.
- Climate Research and Modeling program is born.
- Includes three capabilities:
  - * Understanding Climate Processes;
  - * Earth System Modeling, Predictions and Projections
  - * Climate Attribution and Analysis
- Reviewed by CWG in March 2008
- Began planning and prioritizing for FY11-15 in April 2008

Responses to comments/recommendations:

Comments

- CRM producing “important, useful, and interesting research…major contribution to the extremely important and now highly visible world-wide enterprise of climate research….”
- NOAA scientists: “many world-class contributions to the scientific investigation of the Earth’s climate and global change.”
- NOAA: “superb contributions to recent international assessment are particularly noteworthy…information on climate variability and impacts… on society are also commended…”
- “A key challenge for the future is to improve the overall design and cooperative interactions of the many institutional components involved in the CRM Program.”

Response:

- We thank the Review Panel for their efforts on this review and for acknowledging CRM’s and NOAA’s contributions to climate science—an undertaking we all agree is an extremely important one for society.
- We will develop a Strategic Plan for CRM to address many of the key challenges put forth in the report.

Responses to comments/recommendations:

➔**Overarching recommendation: CRM must develop a comprehensive and in-depth Strategic Plan…**

➔ Response: CRM will develop, over the next 8 months, a Strategic Plan (SP) document that will articulate the:

- **Vision, Mission, Goals and Objectives**
- **Roles of Labs., Centers, Institutes**
- **Roles of Grant Programs**
- **Intramural and extramural interactions**

Responses to comments/recommendations:

- **Focus on planning of the science necessary to achieve the CRM objectives**

➔**CRM Charter (March, 2008).**

"An overarching goal of climate research and modeling is to develop, understand and improve the capability to make intra-seasonal, seasonal, decadal, and centennial-scale predictions of climate variability and projections of future climate change on global to regional scales. This will enable regional and national managers to better plan for the impacts of climate variability and provide climate assessments and projections to support policy decisions with objective and accurate climate change information."

Responses to comments/recommendations:

"Big Picture"

- **Objectives of NOAA's Climate Goal**
- **NOAA's 5-year (FY09-14) Strategic Plan**
- **Linking the elements to the NOAA proposal for a National Climate Service ➔**
  - **Climate Observations+Monitoring (COM)**
  - **Climate Research+Modeling (CRM)**
  - **Climate Service Development (CSD)**

Responses to comments/recommendations:

Scope

- **Planning specific research thrusts with definite aims and outcomes.**
- **Near- (~3 years) and longer-term horizon (5-10 years).**
- **Expectations to be consistent with anticipated growth in knowledge AND demands for applications and operations.**
- **Consider explicitly overlaps with other environmental impact areas.**
- **Collaborations with other Federal agencies, academic and other partners, and international institutions.**

Responses to comments/recommendations:

Scope

- **Role of *Grant Programs*:**

  => An important resource that supports all key research areas

  => Important synergies with the external community

- **Guided by priorities which, in turn, are derived from science issues and key questions posed by stakeholders/customers.**

- **Capitalizing and building on existing strengths in NCEP, ESRL, GFDL and other NOAA Labs., Centers and Cooperative Institutes.**

Responses to comments/recommendations:

Areas to be covered

- Understanding Climate Processes
- Reanalyses, data assimilation and Carbon Tracking
- Intraseasonal-to-interannual variability and predictability
- Earth System Modeling Predictions and Projections
- Decadal-scale variability and predictability
- Grant program activity
- Integration: between, across Programs; and with other Goals
- Synthesis → information, products, services

Responses to comments/recommendations:

Important cross-linkages

- NOAA Labs. and Operational centers
- CIs and other academic centers
- Advances made through Grant Programs
- Integration with other Programs
- Collaborations with other Federal agencies
- International partnerships
- National and International Assessments
- National Academy of Sciences study: "America's Climate Choices"

Responses to comments/recommendations:

Other points

- **Logistics: resources availability, timely allocations**
- **"Young" CRM needs to "mature" *wisely***
- **Management challenges:**
  - **Augmenting resources for Grant Programs**
  - **Relevant collaborative research at the constituent institutions**
  - **Increased frequency of interactions through Workshops, Seminars**
- **Transitioning from Research to Operations and Applications**
- **Measures to gauge impacts**

Responses to comments/recommendations:

Strategic considerations → Alternatives

- **Urgency, relevance, readiness, balance etc.**
- **Underscoring specificity, reflecting the priorities, and with an integrative outlook**

→ **Development of Alternatives (*e.g., FY11-15*)**

*** Building upon the previous years**

*** Span a diverse range in terms of addressing key climate science issues**

*** Representing the collective potential of NOAA, and external partners**

Be mindful of other strategic plans and factors underway or in the making

Responses to comments/recommendations:

Recommendation: Management should emphasize better coordination between measurements and modeling and a between small scale process modeling and large scale prediction.

Response:

- GFDL has selected an ARM (Atmospheric Radiation Measurement) fellow to explicitly address ARM observations in the context of model development.
- GFDL has selected, with NOAA CPPA funding, a post-doc to accelerate development of LES (large-eddy simulation)-based stratiform cloud parameterization.

Responses to comments/recommendations……

- Recommendation: Need for better coordination of chemical and physical sciences in NOAA.

Response:

- The Strategic Plan will address issues of coordination across CRM.
- Collaborative interactions between ESRL and GFDL:
  - Aerosol observations and modeling, leading to quantification of forcing
  - Aerosol-cloud interactions (site studies and model diagnostics)
  - Tropospheric ozone process studies with emphasis on transport
  - Tropical tropopause ozone change and climate

Responses to comments/recommendations

- Recommendation: Need for better coordination of chemical and physical sciences in NOAA.

Response:

- Interactions between NCEP and GFDL:

  ➔ Build upon the strengths of the two institutions

  - Commitment for continuity in the transition of Ocean models: both the framework and the deployment for operational purposes [*Letter of Agreement, under draft*]
  - GFDL model in MME
  - Exchanges involving seminar speakers (already begun)
  - Proposals for joint postdocs
  - Annual workshop proposed
  - Co-chairing sessions at national Conferences proposed

Responses to comments/recommendations:

Recommendation: CRM's ocean modeling activities need more focus and organization. Panel not convinced ocean modeling within CRM is coordinated and headed in the same direction…

Response:

- A strategy for coordination between GFDL and NCEP on ocean modeling will be developed as part of the upcoming Strategic Plan. NCEP's focus is on ocean data assimilation for short-term prediction, and GFDL's focus is on ocean physical processes (example: overflows, mixed layers, mixing) and their impact on long-term climate change.
- GFDL has developed two world-class ocean climate models which represent these key processes differently (i.e., not redundant models). Comparison between these models will be a major CRM contribution to IPCC AR5.
- One code base will contain the essential features of both current GFDL ocean models (2-year time frame).
- A challenge: merging real-time data assimilation (NCEP) with an up-to-date ocean model code base suitable for climate studies (GFDL). This will require additional resources to accomplish.

Responses to comments/recommendations:

Comment: Ocean modeling science and algorithms developed in the large community filter into the GFDL ocean models more slowly than they should.

Response:

- Perhaps this was true 10 years ago, but is demonstrably not true today. Many parameterizations developed by, or in conjunction with, the larger community have been incorporated into the code, evaluated, and adopted; others have been tested but not adopted.
- IPCC AR4 simulations included the following externally developed key parameterizations: mixed layer, lateral viscosity, bottom boundary layer, tracer advection schemes, and tripolar grid. Key parameterizations developed in collaboration with the external community include: partial-cell bottom topography, real free surface height, and eddy-induced advection.

Responses to comments/recommendations:

Comment: NCEP is now investing in HYCOM, so GFDL and NCEP should collaboratively perform an evaluation of HYCOM's performance as an ocean model

Response:

- Although the standard version of HYCOM does conserve total mass, it does not conserve heat or salt, and is thus not appropriate for use as a climate model for long-term integrations.
- HYCOM works for NCEP for the real-time now-casting and short-term (up to 10 days) prediction problems because non-conservation problems are not a significant issue on those time scales.
- A key challenge for the future is building a real-time data ingest and data assimilation system encompassing GFDL's new ocean modeling capabilities.

Responses to comments/recommendations:

Recommendation: Additional targeted Climate Process Teams (CPTs) to take advantage of the wealth of Earth system observations, process modeling, and theory to improve all aspects of CRM modeling…Additional funding is needed for this.

Response:

- We agree that the CPT paradigm has proven very valuable for improving climate models, and that additional targeted CPTs should be formed.
- The role of CPTs and formation of additional ones will be addressed in the upcoming Strategic Plan. We agree that additional funding would be needed to accomplish this recommendation.
- CRM scientists (Donner, Legg) on the US CLIVAR Process Studies and Model Improvement Panel have drafted recommendations for future CPTs.

Responses to comments/recommendations:

Recommendation: Development of the ESM will require additional resources and Strategic Plans to take advantage of collaborations across the larger community

Response:

- The ESM Alternative for FY11-15 includes significant resources to attack the biogeochemical feedbacks on climate problem. This includes funding for five FTEs to focus on the terrestrial carbon cycle, 2 FTEs for ocean carbon/acidification modeling, and requests for additional computing for ESM development.
- We agree that NOAA and CRM will need to develop an ESM strategy, for example on what ESM problems get attacked and where. Our view is that taking on too much of the ESM problem at once would likely overwhelm model development efforts. This is a difficult problem requiring long-term funding support and a strategic focus that is reviewed and updated periodically as the science continues to develop.
- Though not yet published, the ESM development efforts to date at GFDL are quite encouraging and innovative. We anticipate that NOAA's new ESMs that are now being refined and tested will be a major CRM contribution to the IPCC AR5.

Responses to comments/recommendations:

Recommendation: A strategic plan is needed to integrate Carbon Tracker more thoroughly with NOAA assets…An effort should be made to include ESM component models in the Carbon Tracker

Response:

- The upcoming strategic plan will further address the integration of Carbon Tracker with other NOAA assets.
- As a step toward including ESM component models, a collaborative effort between Carbon Tracker and GFDL ESM developers has recently been launched, following some cross-lab visits and seminars by key collaborating scientists. Carbon Tracker group will help evaluate modeled carbon fluxes in the new land model. The recent review of Carbon Tracker will be of further assistance in this regard.

Responses to comments/recommendations:

Recommendation: GFDL needs to formulate a Strategic Plan as to whether and how it wants to take a lead role, nationally and internationally, in ESM development.

Response:

- This will be addressed in the upcoming CRM Strategic Plan. GFDL's ESM model development efforts may appear to be trailing, but that's not accurate. As declared at the review, this is a principal objective as models (and questions) now extend beyond the physical climate system into interactive atmospheric chemistry and biogeochemistry.
- While key ESM publications are just starting to appear (owing to the intense focus on pre-AR5 model development), GFDL's new ESMs are poised to make substantial contributions to the IPCC AR5.

Responses to comments/recommendations:

Comment: GFDL's land-model development activity includes dynamic vegetation, subgrid heterogeneity, and river routing. While some parts are innovative, the bulk of the modeling effort does not appear to be at the cutting edge. Land-ice modeling is a crucial area for future development.

Response:

- We agree that land-ice modeling (e.g., modeling of ice sheets and their impact on sea level rise) is a key area requiring improvement. The FY11-15 ESM alternative includes proposed funding for FTEs and post-doctoral researchers to focus on ice sheet modeling and ice-shelf/ocean interactions.This activity is getting an additional boost through interest from Princeton University (CICS, others).
- We disagree that the bulk of the land modeling effort is not cutting edge. The review is vague on what is meant here. The comments are not specific on what processes are missing from our new LM3 and why it is important to include these processes (i.e., how does the model fail by not including them?). For clarification, a brief summary of the features that have been incorporated in LM3 are given on separate slides.

Responses to comments/recommendations:

Recommendation: NOAA management should determine if, when, and how, the Coupled ensemble filter Data Assimilation (CDA) should transition to the Climate Forecast System (CFS), and if not, why it should continue at GFDL. No plan was presented for inclusion of CDA in a Multi-Model Ensemble (MME).

Response:

- CDA being developed and refined at GFDL is a crucial component of the future decadal prediction system, and thus is necessary activity at GFDL. Seasonal/interannual hindcasts obtained using the CDA and CM2.1 have been performed at GFDL and given to NCEP for the MME evaluation. Transition of CDA to the CFS would require additional resources. Further assessment of the relationship between GFDL and NCEP (as well as other inter-lab and lab-external relationships in CRM) will be addressed in the CRM strategic plan.

- Progress at NCEP towards an International MME.

- Product development for the longer timescales by CPC.

Responses to comments/recommendations:

Recommendation: The CFSRR needs an External Advisory Board."

Response:

- The CFSRR already has an External Advisory Board. There is a record available of the first meeting. The Board is chaired by Jeff Anderson. Half of its members are from various NOAA agencies, the other half is from universities and include ECMWF. In addition, CPC (as a primary user of the CFSRR) is devoting major resources to monitoring and evaluating CFSRR results as they are being generated.

Responses to comments/recommendations…….

Recommendation: There is a need for far more attention to the planning, funding, acquiring, and operation of a robust computational infrastructure to support the links between research, applications, and operations.

Response:

- NOAA has in place an Administrative Order for Management and Governance of High Performance Computing, establishing that the NOAA Environmental Modeling Program (EMP) will manage NOAA's HPC as a corporate asset through an HPC Board to meet NOAA's goals and subgoals. End-to-end HPC activities, from planning through operation, are now managed by this Board.
  - **These activities include partnering with other Federal agencies, including DOE with whom NOAA had signed an MOU for a grant of computing cycles at three DOE Leadership Computing Facilities.**

Responses to comments/recommendations

- NOAA Senior Management has approved a High Performance Computing Strategic Plan and Roadmap that identifies a new Target Architecture for NOAA HPC. This Architecture recognizes the need for, among other things,
  - **High availability for both clock-driven generation of weather products and calendar-driven generation of products from decadal-to-centennial climate models and environmental research**
  - **Maximizing the efficiency of the transition of research to operations and the return to research of operational improvements**

Responses to comments/recommendations:

Recommendation: NOAA should undertake a strategic planning exercise towards (possible) operational decadal predictions. Concerns are that NOAA lacks an agency-wide plan for transforming research progress in operational decadal prediction and for providing necessary resources. Also, need to consider Pacific, polar regions, southern oceans, as well as AMOC. Cryospheric and hydrologic processes need more focus. Coodination between labs and other research sectors will be important.

Response:

- We agree with the panel that a key hurdle is to establish whether or not there is useful predictability at decadal scales. Beyond the issue of predictability, formidable challenges exist. These include initialization strategies, systematic model bias and error, and the formulation of what predictions are meaningful. Accurate initial conditions for the global ocean are especially important, but remain a major challenge for assimilation techniques and the observing system. The initial strategic aspects of a decadal prediction system (e.g., coordination between GFDL and NCEP) will be addressed in the CRM Strategic Plan.
- Meanwhile, the FY10 decadal budget request, FY11-15 decadal prediction alternative, FY11-15 ESM alternative and FY11-15 request for revitalizing NOAA supercomputing are addressing many of the concerns of the panel, with additional focus on Arctic sea ice and climate changes, ice sheet modeling, decadal predictability of extreme events, coastal ocean ecosystem responses, terrestrial and oceanic carbon cycle modeling, and computational/human resources for development and evaluation of decadal prediction models and data assimilation systems. New LM3 contains relevant enhanced land modeling capability (see LM3 slides).

Responses to comments/recommendations:

Recommendation: See several comments and recommendations on p. ES6-ES7 on planning, prioritizing, balancing, budgeting, engaging policy scientists, coordination, ESRL representation, integrated budget planning, ARCs, Joint Institutes, Cooperative Institutes, National Climate Service, customer involvement, etc.

Response:

- To be more fully addressed in the Strategic Plan.
- Time not available during review to discuss all elements (e.g., relevant PMEL, ARL, besides many ESRL and GFDL activities).
- Interactions with COM include: climate model and data portal; Carbon Tracker; GOOS; upper tropospheric water vapor analyses; IESA; assessment processes.

Responding to CWG Review of Climate Research and Modeling Program: CPO Perspectives

Overarching recommendation: Need to coordinate/integrate climate research and modeling across NOAA labs, cooperative institutes/centers, and competitive grants programs. A strategic plan would provide a basis for this integration.

Key comments from Review related to CPO

- "Each CPO program seems to have its own, idiosyncratic approach to identifying gaps in near-term priorities, and balances between program elements. A more unified strategy would improve effectiveness."
- "The CPO ought to take care to balance the funding of internal NOAA research groups and Cooperative Institutes with those of the external community…"
- "The development of integrative, strategic directions requires addressing fundamental issues of organizational culture and structure."

Realigning CPO programs

- *CPO Program Managers to become focal points for integration across labs/centers/grants*
  - Will require restructuring of CPO programs to better align with major thrusts in climate observations and monitoring, climate research and modeling, and climate services development
  - "Re-organization is not an adequate response to achieve more effective integration..": mechanisms to integrate across new CPO structure still required
  - Will require requests for proposals from external community to be better integrated with activities in labs/institutes
  - Pros/cons of realignment options being considered, along with need to represent new structure in strategic plans for CRM, COM, and CSD

In Response to CRM Review Panel Recommendations for Reanalysis of the 20th Century

1. Formed international Atmospheric Circulation Reconstructions over the Earth (www.met-acre.org) initiative with Rob Allan (UK Hadley Centre) as Project Manager.

   Working Groups specifically addressing CRM Panel concerns including User Requirements and Applications (chair: Roger Stone, U. of Southern Queensland)

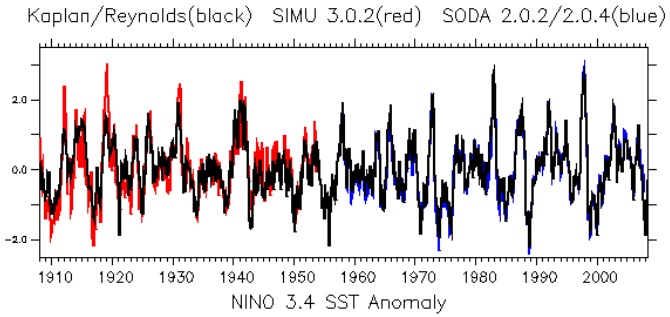
   Verification and Validation (chair: Gil Compo, U. of Colorado/NOAA ESRL)

2. Coordinating with NCDC and NCAR to release data 1891-present data during generation. Version 1 (1908-1958) has user-requested online fields since June 2008

   ftp://ftp.cdc.noaa.gov/Public/gcompo/20th_Century_Reanalysis .

   Coordinating with NCDC, NCAR, ESRL for broad release of Version 1 soon.

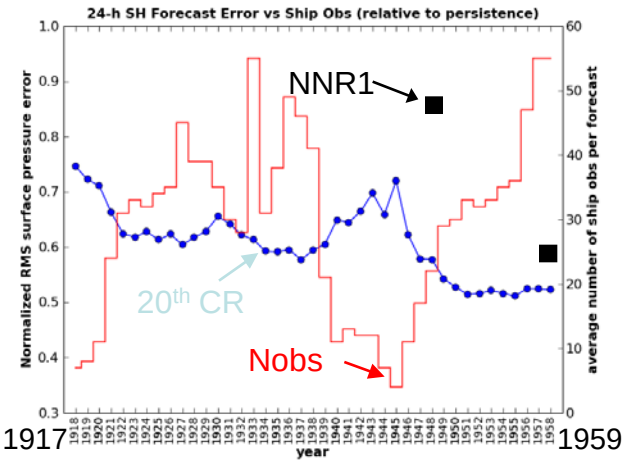
3. Coordinating with GFDL on coupled Decadal assimilation.



Assessing Tropics: POP Ocean model Simulation forced by 20th Century Reanalysis fields (SIMU) compares well with reconstruction of Kaplan et. al. but with more variance similar to present day (Giese et al 2008).

Assessing Southern Hemisphere:

Forecast skill at 24 hours is better than Persistence and improves upon NCEP-NCAR Reanalysis fields.



Back-up Slides

Responses to comments/recommendations:

Comment: The panel was not briefed on the use of cloud-resolving models to test or improve parameterizations.

Response:

- Time constraints unfortunately prevented CRM from covering many topics that deserved more attention. Here we summarize a few relevant points that could have been covered in detail, given more time:
  - GFDL has integrated cloud system resolving models (CSRMs) WRF, Zetac for most GCSS cases. Analysis is underway of CSRM features relative to GCM cumulus parameterizations.
  - The ARM CSRM distribution of vertical velocities agrees reasonably well with 'Donner' GCM cumulus parameterization.

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Responses to comments/recommendations:

Recommendation: The state of understanding of the interactions among coastal upwelling, advection, nutrient cycling, river inputs, and estuarine biogeochemistry and sedimentation remains poor. Progress in this area will likely require experiments at very high resolution in collaboration with experimentalists and data from field campaigns.

Response:

- We generally agree with the above assessment.
- A key uncertainty impeding our ability to predict how these systems will change in the future is our inability to represent these coastal systems in models of global climate change. Whether through explicit representation or through downscaling techniques, such representation is a critical focal point of future research.
- Of note, the new LM3 land model has the capability of tracer transport by rivers (for future biogeochemical model development). An FY11-15 augmentation for the FY10 Decadal Prediction request contains funding for simulations of the coastal ecosystem response to climate variability and change using a high resolution regional ocean modeling downscaling approach (a joint ESRL/PMEL/NOAA Fisheries activity).

Responses to comments/recommendations:

Recommendation: NOAA should continue to push the resolution envelope, at least for decadal-scale modeling…For physical and biological systems, improved resolution of coastal systems is vital.

Response:

- We agree that increasing resolution is desirable, although this will require additional computational resources. Substantial computing resources been requested through the FY10 budget request (decadal) and FY11-15 alternatives.
- Exploratory high-resolution decadal simulations are planned on DOE off-site systems. However, a dedicated, sustained NOAA-based computing augmentation remains essential.
- The FY11-15 decadal predictions alternative augmentation includes a coastal ocean regional downscaling component (coordinated across several NOAA labs and centers) focused on biological responses in coastal regions.
- To facilitate future ocean model downscaling activities, including two-way nesting between ocean climate models and regional models, funding for a new ocean model backbone is proposed (4 FTE and $200K/yr).
- Note that high-resolution are likely a necessary, but do not ensure a sufficiency, element. Process parameterizations and interactions amongst processes at the high spatial resolutions could prove to be a critical factor as well.

Responses to comments/recommendations:

Comment: The panel is concerned that the influence of water, nitrogen, and phosphorous cycles on the carbon cycle are not receiving enough attention within the ESM effort.

Response:

- Currently in the LM3 land model, the carbon and water cycles are coupled on both short-term and long-term time scales.
- A paper under review describes a new plant-soil nitrogen model intended for integration into the land model. Improved hydrology features, including better soil physics, river routing, and lake representations are now part of LM3 and will enable further developments in biogeochemical modeling.
- The ESM alternative proposed for FY11-15 includes proposed funding for 5 additional FTEs for modeling various aspects of the terrestrial carbon cycle, including nitrogen/phosphorous soil-vegetation modules, and biogeochemistry models for wetlands, surface waters, and rivers.

LM3 Land Model Characteristics……

- Sub-grid-scale variability represented by tiling, which has dynamic and efficient data structure for tile management (crucial infrastructure for future model development).

- Tiling describes differing histories of disturbance of vegetation and distinguishes lakes, ice sheets, and dry land.

- Within tile: single layer vegetation canopy, vertically resolved snow pack, vertically resolved substrate (soil, lake, ice sheet)

- General landscape-based solution for groundwater flow: parameterizes horizontal fluxes of water and sensible heat from the soil substrate. Fraction saturated yields “riparian sources” for runoff production. Source-area element of the model is equivalent conceptually to the VIC (variable infiltration capacity) model. Water in individual layers or soil or lake freezes and thaws as thermodynamics dictates.

LM3 Land Model Characteristics

- Dynamic or prescribed vegetation; carbon in vegetation and soil are optionally modelled. Vegetation drivers: climate, weather, CO2 concentration, land use, and fire. Stomatal control of transpiration and plant root uptake of soil water: soil water balance intimately connected to plant physiology.
- Direct and diffuse IR and visible radiation balance: single layer canopy interacting with substrate (soil, snow, lake, glacier) having band-specific reflectances derived from MODIS satellite data products.
- Surface water model includes between-cell horizontal transports of water and heat. Network of river reaches extend over all land cells. Major lakes are represented and connect hydrologically and thermodynamically to the rivers. Surface water-atmosphere exchange of water and energy managed through tiling system. Rivers have the capability to transport tracers (for future biogeochemical model development). Lakes are vertically resolved, can stratify, and can form ice.

Responses to comments/recommendations:

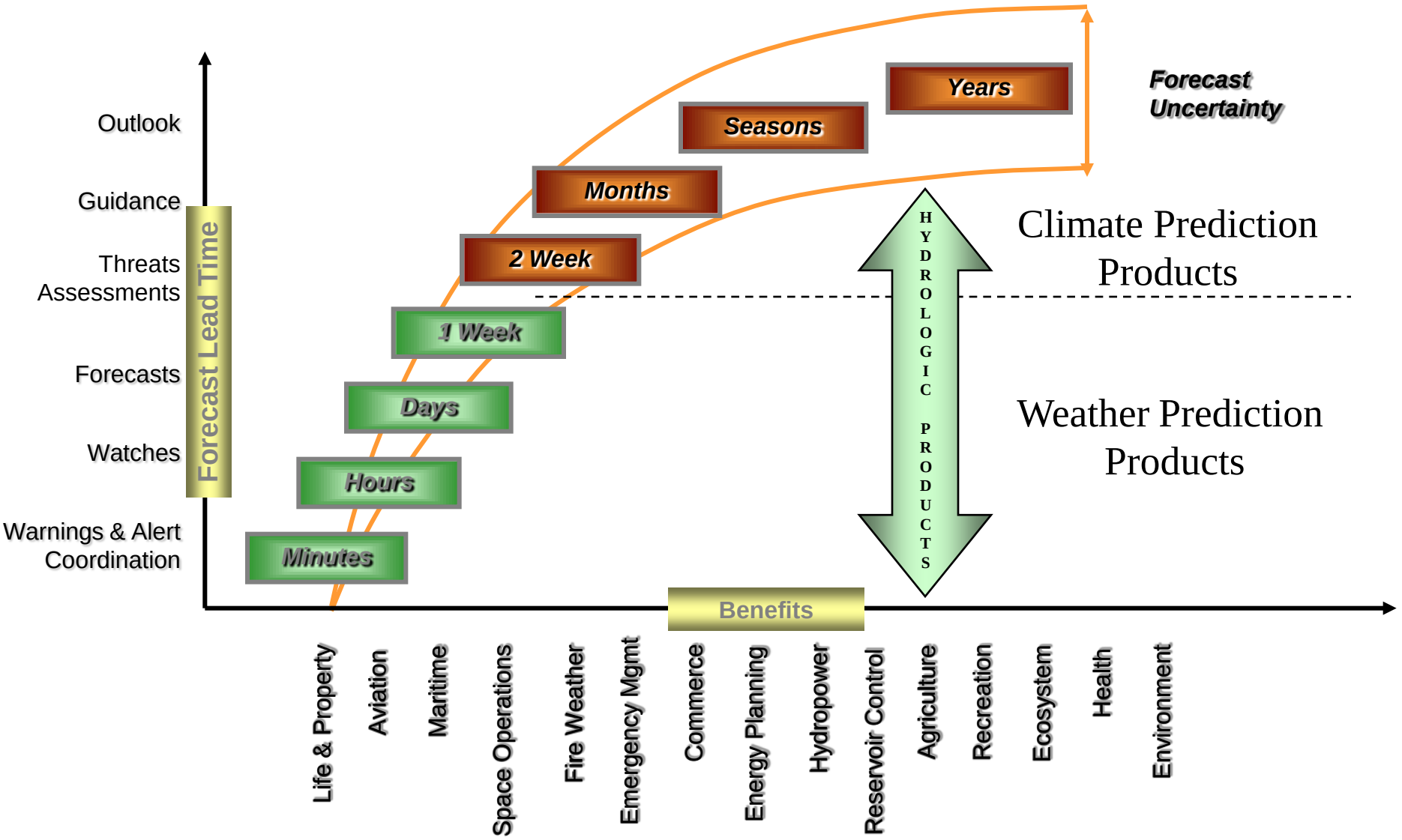
Recommendation: Transfer of research products from labs to operations needs to be managed more effectively: Evaluation of readiness? Operational needs influence research program priorities and funding decisions? Implementation plan that bridges gap between research, operations, and applications?

Response:

- The CRM Strategic Plan will address the inter-relationships between research labs and operations. A series of workshops and seminars is being planned to enhance communication and collaboration between GFDL and NCEP, for example.

- The ESRL work on Finite Volume Icosahedral dynamics is well coordinated with EMC. There are frequent telecons on global model dyanmics improvements. Time constraints at the review prevented elaborate discussions regarding this particular model.

NOAA Seamless Suite of Forecast Products Spanning Climate/Weather/Water



Current CPO program structure

- Climate Observations Division

Arctic,

- Climate Research Division

CPPA, CVP, CCDD, CDEP, GCC, AMOC/Abrupt Climate Change, Reanalysis, Climate Testbed

- Climate Assessments and Services Division

RISA, SARP, TRACS

CPPA Response to CWG Review

- Research to Operation Transition (R2O)

  - We appreciate that CWG has noticed CPPA current efforts on R2O transition. The current focus on land/hydrology is due to historical CPPA-GEWEX connection.

  - CPPA has started to expand its R2O transition into atmospheric component by working with NCEP/EMC modelers. An integration between CPPA Core Project and Climate Test Bed (i.e., an expanded CTB) would be a natural step to for CRM Program to have comprehensive R2O transition in all areas including ocean/atmosphere/land/hydrology components.

  - The expanded CTB should take a systemic approach to decide priorities for transitions and to evaluate readiness of research results for transitions into operations.

- Operation to Research Transition (O2R)

  As CWG review pointed out, it may not be obvious how NOAA's operational needs influence the research program priorities and funding decisions. However, there are some efforts in this area:

  - During the last few years, there was annual CPO-NWS Dialogue Meeting. The purpose of the meeting is to improve communication between CPO research and NWS operational needs.

  - CPPA program managers communicate with EMC, OHD, and CPC directors and chief scientists for their inputs on CPPA future research priorities in annual calls for proposals.