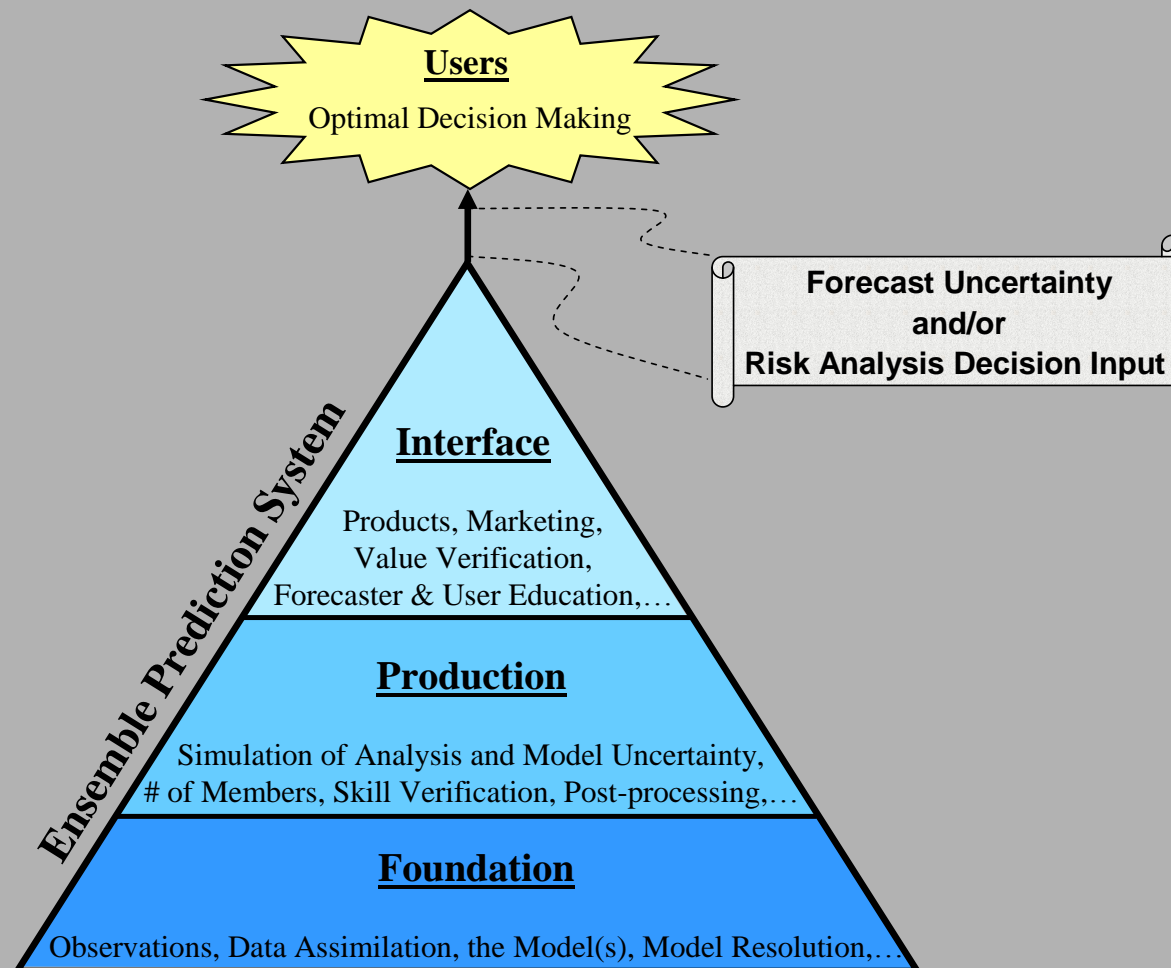


Integrating Efforts for an Improved National Ensemble Prediction System

...a key initiative in the NWS Science and Technology Roadmap

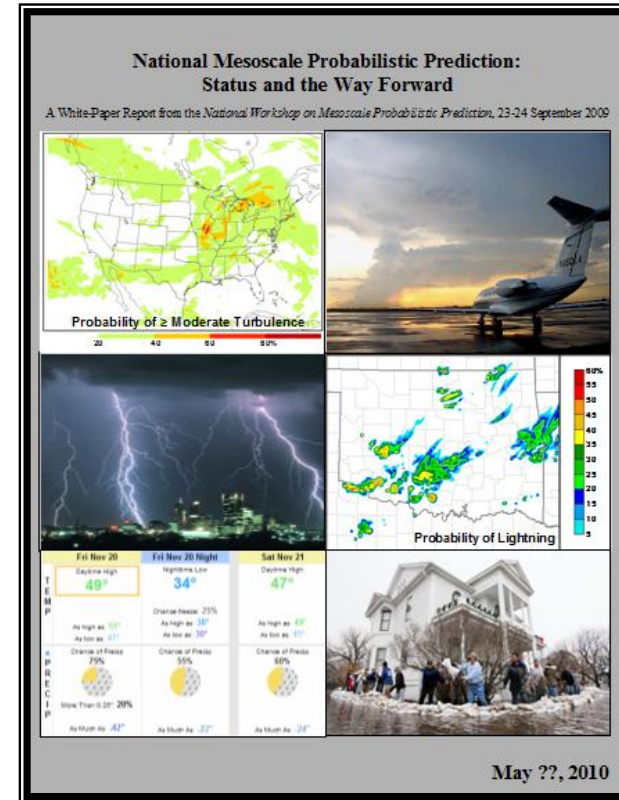


Presentation Outline

- **The S&T Roadmap national EPS initiative**
 - **Overview**
 - **Ties to NOAA and NWS Strategic Plan**
 - **Details**
- **Alignment with existing ensemble efforts**
 - **NCEP/EMC**
 - **ACUF**
 - **NFUSE**
 - **HFIP**
 - **TIGGE**
 - **NUOPC**
 - **NAEFS**
 - **DoD: AFWA & FNMOC**
 - **Universities**

Overview of the Initiative

- *National Workshop on Mesoscale Probabilistic Prediction*
 - Boulder, Colorado, 23-24 September 2009
 - Examined current state of US mesoscale probabilistic prediction and discussed how to expedite progress
 - 100 attendees from government, industry, academia
 - Sponsored by NCAR and NWS
 - White paper: ***“National Mesoscale Probabilistic Prediction: Status and the Way Forward”***
 - Supporting document to NWS S&T Roadmap
 - Complementary to ACUF Plan



The Goal

By 2015, the US will implement a radically upgraded national capability for mesoscale probabilistic prediction to support current and future decision-making needs and return the US to world leadership in numerical weather prediction.

NOAA'S NATIONAL WEATHER SERVICE STRATEGIC PLAN

Vision

A healthy, safe planet, where society thrives in robust, productive communities, economies, and ecosystems, and avoids the adverse impacts of environmental events.

Long-Term Goals

Deliver comprehensive decision support services for environmental events that threaten safety, health, the environment, economic productivity, or homeland security.

Americans use impact-based forecasts, warnings, and risk information from the NWS that enable everyone to make better decisions to organize their daily lives and take valuable actions to minimize adverse risks.

Improve sector-relevant services for energy, transportation, telecommunications, and agriculture in support of economic productivity and national security.

S&T Roadmap

Risk Analysis optimizes decisions and productivity.
Take Action when $Risk > Risk\ Tolerance$

Objective
Forecast Uncertainty
&
Probabilistic Weather

- - - - -
- - - - - **Robust EPS generates high-utility risk information, enabling optimized decisions...**

Details of the Initiative

- Initiate coordinated, efficient, and effective enterprise-wide effort
 - Promote collaboration
 - Integrate existing efforts
 - Tap into unrealized resources and reduce any overlapping research activities
 - Build conduit for state-of-the-art techniques into operations
 - **Developmental Testbed Center (DTC)**
 - Formalize testing and evaluation procedures
 - Use NOAA Environmental Modeling System (NEMS) for NCEP compatibility

- **National Advisory Committee**
 - Standing governing body for R&D of nation's probabilistic forecast capability
 - Members: NOAA, NCAR, DOD weather, academia, private sector, FAA
 - Establish a standing council under the AMS ACUF
 - Appoint working groups to carry out specific studies and make recommendations
 - *Ensemble Design* (# of members, resolution, methods to simulate uncertainty, ...)
 - *Post-processing* (correction of systematic error, downscaling, ...)
 - *EPS Interface* (communication of uncertainty, education, verification of value, ...)
 - *Testing* (establish prototype EPS, prioritize and judge EPS techniques,...)
 - *Business Case* (prove EPS pays for itself many times over)

Details of the Initiative

Challenge: Promote research→operations, and fill R&D gaps

- Assess current efforts and transition capabilities into ops. **Examples:**
 - **CAPS & Univ of OK:** assimilation of radar for short-range forecast
 - **HFIP & ESRL:** global mesoscale ensemble with EnKF ICs
 - **MDL:** post-processing (ensemble/gridded MOS, LAMP, etc.)
 - **NRL:** stochastic parameterizations
 - **Univ of WA:** fine-scale EnKF, post-processing, communicating uncertainty
 - **Penn State:** rapid refresh modeling, fine-scale ensembles
 - *many others...*

- Determine key research not currently funded. **Examples:**
 - Optimal ensemble configuration to meet NOAA customers' needs
 - Boundary layer modeling improvements
 - Post-processing issues
 - meteorological consistency
 - seamless (spatial and temporal) results
 - Social sciences issues
 - misinterpretation of probability expressions
 - impact of probabilistic forecasts on user trust

Details of the Initiative

Challenge: HPC resources for both **R&D** and **real-time operations**

- For R&D
 - Existing HPC: DTC, NCEP backup @ Gaithersburg (for transition to ops), DoD Supercomputing Resource Centers (DSRC), DOE systems, university/NSF systems, ...
 - Find HPC cycles (from existing and/or new systems) to support needed R&D
- For Operations, need extensively more HPC than currently available or planned
 - Ensemble design factors that impact computer demand:
 - Model resolution (horizontal and vertical)
 - Number of members
 - Forecast length
 - Domain size
 - Forecast update frequency
 - Forecast timeliness
 - Method of initializing the ensemble
 - Method(s) for simulating model uncertainty
 - Domain interaction (1-way or 2-way nesting)
 - Must balance effort devoted to each factor based on best service to users' decision-making needs--- *a key research question*
- Mitigating Factor: Moore's Law for computing costs (cpus/\$ doubles every 2 years)

Current and Proposed EPS Plans

- NCEP/EMC Ensemble Implementation Plan
 - **GEFS** (Global Ensemble Forecast System)
 - **Current:** 21 Members, global, ET ICs, stochastic model perturbations, T190 (~75 km grid), 384 h, 4 cycles/day
 - **2011:** T254 (~55 km grid)
 - **SREF** (Short-Range Ensemble Forecast)
 - **Current:** 21 Members, N. America, Breeding & ET ICs, multi-model, 32-35 km, 87 h, 4/day
 - **2011:** 22 km grid, drop Eta & RSM, add NEMS-NMMB w/ stochastic parameterizations
 - **2013:** 12 km grid, ET ICs, 2 model (NEMS-NMMB and NEMS-ARW) w/ stochastic param.
 - **NARRE** (North American Rapid-Refresh Ensemble, *focused on aviation forecast*)
 - **2014:** 6 Members, 3 km grids over CONUS and AK, 24 h, 24 cycles/day
 - **HRRRE** (High-resolution Rapid-Refresh Ensemble, *focused on high-impact weather*)
 - **2014:** 6 Members, 1 km grid, small relocatable domain, 24 h, 24 cycles/day
- S&T Roadmap proposes that more is needed (*and possible*) to meet user needs
 - **GEFS:** higher resolution (~15 km) to support regional EPS and medium-range forecast
 - **SREF:** higher resolution (≤ 4 km) to resolve convection and terrain effects
 - **NARRE** (+ HRRRE): 20 members, and run hourly on 1 km grids over CONUS and AK
 - May also need a separate TC ensemble

unfunded

Proposed Target for 2015

Name	Model	Domain	Resolution		Forecast Length (h)	Update Frequency (h)	# of Members
			Grid	Levels			
GEFS	GFS	Global	T1000 (~14 km)	90	84	6	20
			T399 (~35 km)	40	84-360	12	20
SREF	NMMB	N. America	4 km	55	48	3	20
NARRE	NMMB	CONUS and AK	1 km	90	12	1	20
?	cyclone?	Relocatable	TBD	TBD	TBD	TBD	TBD

Notes

- Work within current modeling frameworks, and include enhancements based on DTC testing (e.g., EnKF ICs, stochastic parameterizations, ocean ensemble coupling)
- No change in NCEP model domains or production schedules (i.e., products on time and cover same regions as current NCEP requirements)

ACUF

(AMS Ad Hoc Committee on Uncertainty in Forecasting)

- **Mission:** Formulate a cross-enterprise plan to provide forecast uncertainty information to the Nation
- **Membership:** *67 volunteers from across the enterprise*
- **ACUF Plan** (May, 2010): *A guide for enterprise partnership, and not a prescriptive program plan (does not define cost, schedule, and performance information)*
 - **Use and Benefits of Forecast Uncertainty Information**
 - **Vision**
 - **Strategic Goals**
 - 1) **Understanding** the nature of forecast uncertainty
 - 2) **Generating** reliable uncertainty data, products, services, and information
 - 3) **Communicating** uncertainty and **Assisting** users in application to decision making
 - 4) **Enabling** development and acquisition of necessary infrastructure
 - **Proposed Enterprise Partners' Roles and Responsibilities**
 - **Implementation Roadmap**
 - **Objectives:** Current capabilities/gaps, performance measures/targets, proposed solution strategy, specific tasks and sector leads
 - **Tasks:** Specific actions for short-, mid-, and long-term periods over next decade
 - **Monitoring Progress**

NFUSE

(NOAA/NWS Forecast Uncertainty Steering Team)

- **Mission:** Advise/coordinate NWS activities related to development, implementation, and evolution of forecast uncertainty products, services, and information
- **Membership:** OST, OCWWS, OHD, SPP, NCEP, NWS Regions/WFOs, OAR/ESRL, OAR/NSSL
- **Funding:** FY12-16 PPBES alternative submitted within Decision Support Services (DSS) capstone alternative
- **Shared R&D Interests:**
 - Planning -- seeking funding, and coordinating with other efforts (e.g., ACUF)
 - Post-Processing -- coordinating efforts within NCEP, OAR, and MDL to build **NWS Unified Ensemble Post-processing System** (NUEPS)
 - Forecast Process -- defining forecasters' role within DSS paradigm. (i.e., How can forecasters help bridge the gap between ensemble output and optimized user decisions?)
 - Products and Services -- working to improve communication of forecast uncertainty through innovative products with input from social sciences
 - Training -- currently researching training needs and seeking NSTEP funding support to develop new training

HFIP

(Hurricane Forecast Improvement Program)

- 10-year (2007 - 2017) NOAA effort to improve NWP guidance to National Hurricane Center forecasters
 - Focused on 1-5 day TC track/intensity forecast accuracy
- **Membership:** *AOML, EMC, ESRL, NRL, GFDL, DTC/TCMT, NHC, AOC, NESDIS/CIRA, NCAR, Universities (PSU, FSU, URI, SUNY Albany, UWisc)*
- **Funding:**
- **Shared R&D Interests:**
 - Global & Regional Model/Physics Development -- improve EPS foundation with better physics for TC forecasts, which also improves general aspects of NWP forecast
 - Data Assimilation -- improvement to EPS foundation, plus EnKF for ensemble ICs
 - Ensemble Development -- making excellent progress in both global and regional
 - Verification -- general tools for ensemble forecast evaluation
 - Applications Development and Diagnostics -- communicating uncertainty
 - Ocean/Wave Coupled Model -- critical to simulating forecast uncertainty in an EPS