National Earth System Prediction Capability (National ESPC)

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Information Brief
**Subcommittee on Disaster Reduction**
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What Is the National ESPC?

- An integrated National Capability meeting the U.S. Federal need for Earth System Prediction for the provision of **_operational_** products and services
  - For the protection of life and property in the US
  - For the economic development, aviation, maritime, shipping, agriculture of the US
  - National defense and homeland security (World Wide)
  - Strategic decision making
- Includes:
  - Near term, medium range and extended range weather (< 90 days)
  - Seasonal and inter-annual climate (90 Days+)
  - Sub-decadal to decadal
- Leverages *existing* and *planned* Agency operational capabilities, and research and development programs and projects
- ***Strong need identified for Inter-Agency Coordination***

Efforts are broadly consistent with WMO Plans for Seasonal-to-Subseasonal Prediction and High-Impact Weather (HiW).

Weather and Climate Modeling
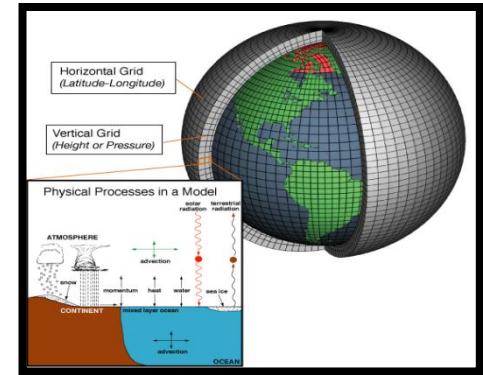# Need for Improved Skill
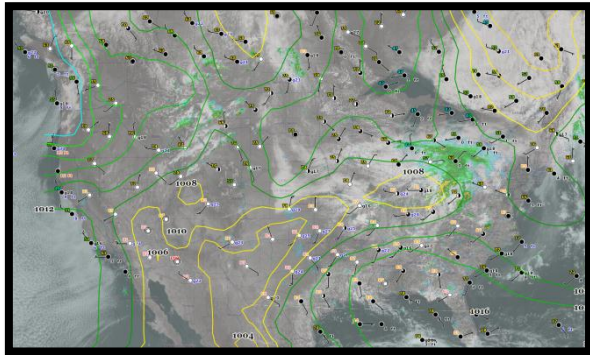
Weather Modeling
Hours to 1-2 weeks

SKILL GAP

Needs both

Climate Modeling
Seasonal to Decadal

Highly sensitive to initial conditions

Sensitive to boundary conditions related to coupling of ocean, land, ice, and atmosphere.

Bridging the Gap

operational products   strategic decision support

0 10^0 10^1 10^2 10^3 10^4

7d   16d   30d   1yr   30yr

weather   seasonal   decadal

Skill Gap
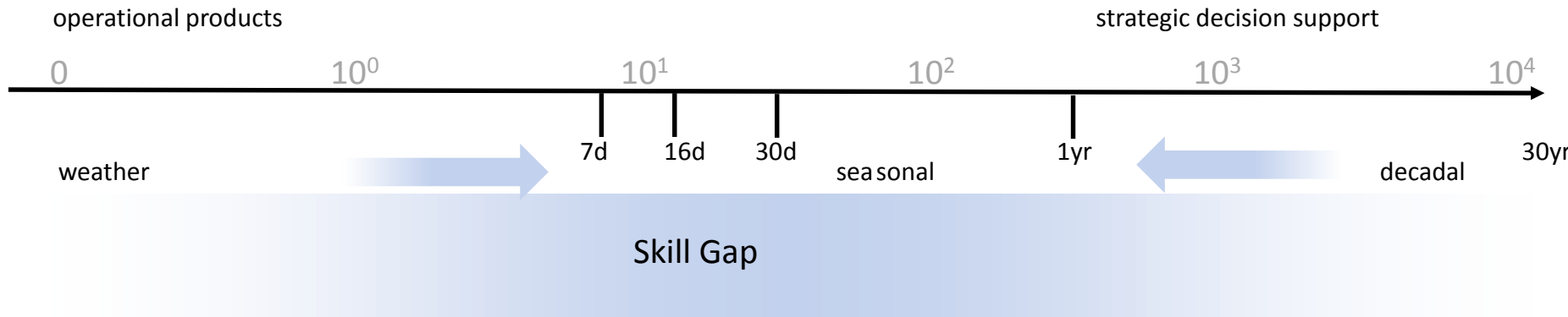
- To extend weather skill past traditional weather scales:
    - Fully coupled air-ocean-land-ice modeling systems needed
    - Multi-model ensembles
    - Improved data assimilation techniques, particularly for ocean-land-ice

- To improve climate model skill at subseasonal scales:
    - Data assimilation, reanalysis/reforecast
    - Process representation

Needed across time scale:
- Improved HPC utilization, incl. advanced architectures
- Common model architectures
- Multi-model ensemble management
- Uncertainty depiction; metrics suited for longer time scales
- Product creation

- Research agencies: work within mission expertise to improve skill
- Operational agencies: exploit the research for skill improvements
- *Need strategic-level coordination of issues*

Need for Improved Skill
Exploit Sources of Extended Range Predictability
Global Coupled Modeling
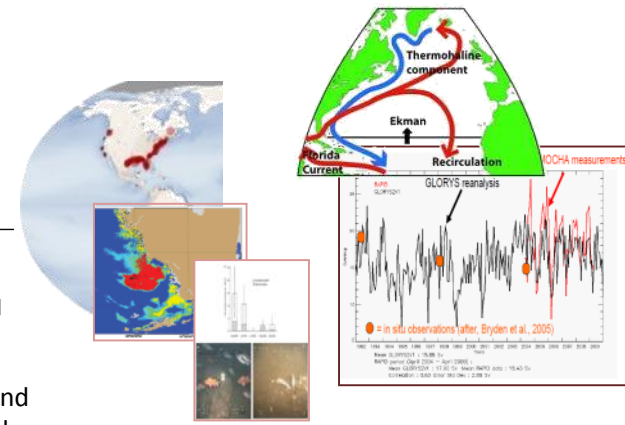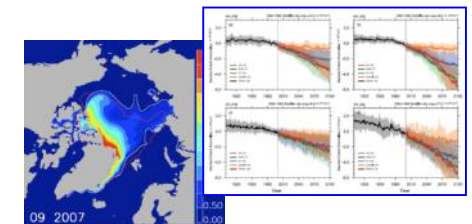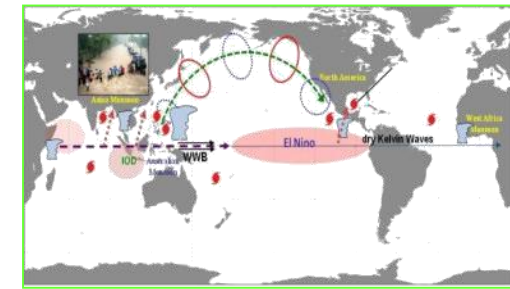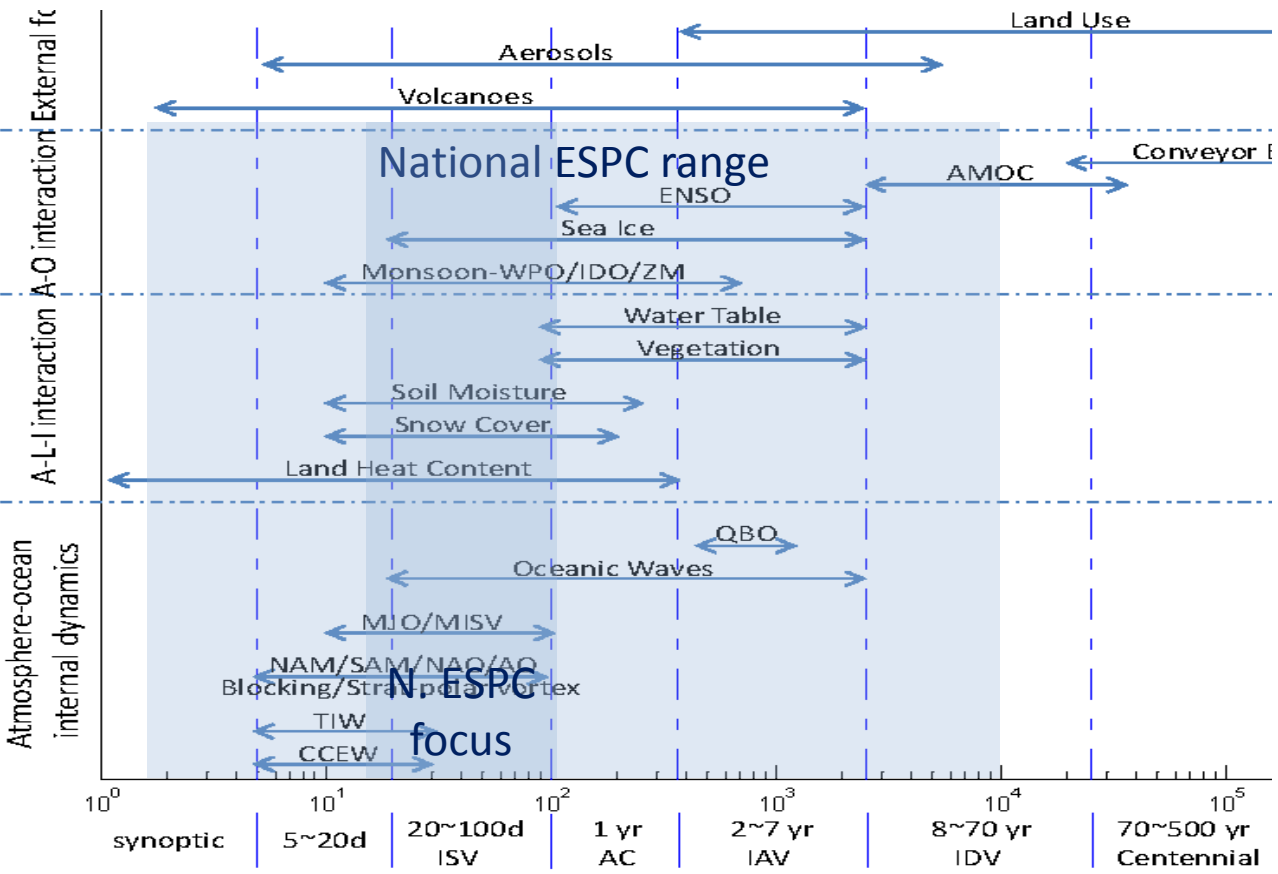
Assessment of Intraseasonal to Interannual Climate Prediction and Predictability, 2010, THE NATIONAL ACADEMIES PRESS •500 Fifth Street, NW • Washington, DC 20001
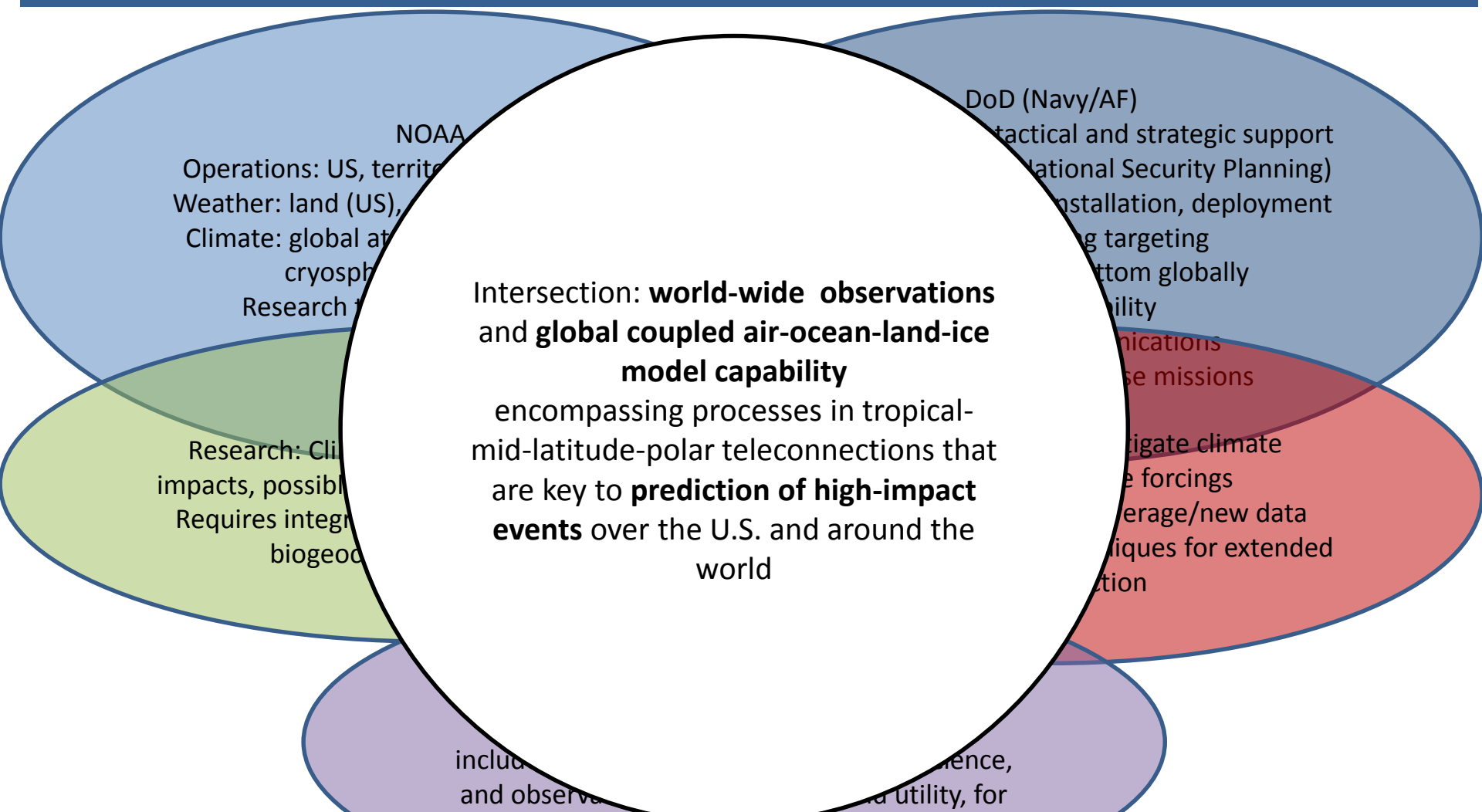
Building a National ESPC

- Develop and implement a common or coordinated prediction technology through

  – An affiliation of existing Programs, Projects, Laboratories, Centers

- Cooperative effort of the participating federal environmental research <u>and</u> environmental operational guidance agencies

  – Multiple offices and laboratories within each agency

  – Application of significant internal & external research and development funding

- Focus on meeting needs of user community through existing and planned agency operational numerical prediction capabilities through coordinated R&D and Operations

<div style="border:1px solid red; text-align:center; color:red; font-weight:bold;">
Coordination of Existing and Planned Agency Capabilities
</div>

Agency Roles and Responsibilities

- NOAA – Mission/Operational Requirements, Research, Demonstration, Development, Implementation, Operations - US

- Navy – Mission/Operational Requirements, Research, Demonstration, Development, Implementation, Operations – World-wide

- Air Force – Mission/Operational Requirements, Implementation, Operations - World-wide

- NASA – Observations, Research, Demonstration

- DOE – Research, Demonstration

- NSF - Research

Agency Roles and Responsibilities

NOAA
Operations: US, territo...
Weather: land (US),
Climate: global at...
cryosph...
Research t...

DoD (Navy/AF)
tactical and strategic support
...ational Security Planning)
...nstallation, deployment
...g targeting
...ttom globally
...ility
...nications
...se missions

Research: Cli...
impacts, possibl...
Requires integr...
biogeo...

Intersection: **world-wide observations**
and **global coupled air-ocean-land-ice
model capability**
encompassing processes in tropical-
mid-latitude-polar teleconnections that
are key to **prediction of high-impact
events** over the U.S. and around the
world

...tigate climate
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...erage/new data
...iques for extended
...ction

includ... ...ence,
and observa... ...utility, for
NSCI-driven next generation HPC architectures

Where we are

- Operational Global Weather Ensemble
  - 63 member, multi-model, > 80 variables, out to 16 days, with skill at 11+ days, at 1 degree resolution -   going to ½ degree, adding variables, will do extended runs to 32 days

- Operational Multi-model Ensemble for Sub-seasonal and Seasonal Prediction

- Earth System Modeling Framework - Common Model Architecture

- In-place Coordinating Structure – Project Office
  - Executive Steering Group
  - Multiple committees - agencies regularly interacting to solve problems in a common way.

Ongoing Activities

1. Collect and validate Mission and Operational Requirements for an operational Earth System Prediction Capability

2. Identify Priority Research Needs for skillful prediction addressing mission requirements
   - NRC Study "Developing a U.S. Research Agenda to Advance Subseasonal to Seasonal Forecasting" (report out soon)*

3. Coordinate Development and Implementation of Operational Modeling Systems
   - Integrated Modeling Roadmap
   - Common Data and Data Assimilation
   - Joint/Common post-processing development
   - Components of the operational modeling systems

4. Coordinate Operations
   - Modeling Systems, including post-processing
   - Products and Services

5. Demonstrate Capability (continued assessment of the operational system)

*http://dels.nas.edu/Study-In-Progress/Developing-Research-Agenda/DELS-BASCPR-13-05?bname=basc

NRC Study "Developing a U.S. Research Agenda to Advance Subseasonal to Seasonal Forecasting"

- **Statement of Task***

- An ad hoc committee will conduct a study that will identify opportunities to increase forecasting skill on subseasonal to seasonal (S2S) timescales based on the 2010 NRC report Assessment of Intraseasonal to Interannual Climate Prediction and Predictability and progress since. The report will describe a strategy to increase the nation's scientific capacity for research on S2S forecasting. The committee will develop a 10-year scientific research agenda to accelerate progress on extending prediction skill for weather and ocean forecasts at spatial and temporal resolutions to aide in decision making. The committee's report will cover:

  * Identification of potential sources of predictability and assessment of their relative value for advancing predictive skill;
  * Identification of process studies for incorporating new sources of predictability into models;
  * Application and advancement of ocean-atmosphere-ice-land coupled models;
  * Key observations needed for model initialization and verification of S2S forecasts;
  * Uncertainty quantification and verification of probabilistic products;
  * Approaches to communicating this type of prediction in a way that is useful to and understandable by decision makers; and
  * Computational and data storage and visualization infrastructure requirements.

*http://dels.nas.edu/Study-In-Progress/Developing-Research-Agenda/DELS-BASCPR-13-05?bname=basc

Proposed Demonstrations of Predictive Skill

- Cross-selection of phenomena affecting extended range predictability

- Focus on physical processes tied to user needs
  - Provide process-based feedback to research
  - Emphasize underlying consistency between agencies having differing mission needs

- Organized reach back to research community to support prediction improvements

- Pursue:
  - Blocking
  - Tropical Cyclones
  - Arctic ice

- Enable:
  - HABs/Hypoxia
  - AMOC

Issues and Challenges

- Need for Comprehensive Identification of User Need
- Need for Improved Operational Prediction Skill at longer time scales
  - Identifying sources of predictability
  - Predictability beyond 2 weeks
- Need for Inter-Agency Coordination
  - Complementary Missions and Mission Capabilities
  - Technological Capability Integrations
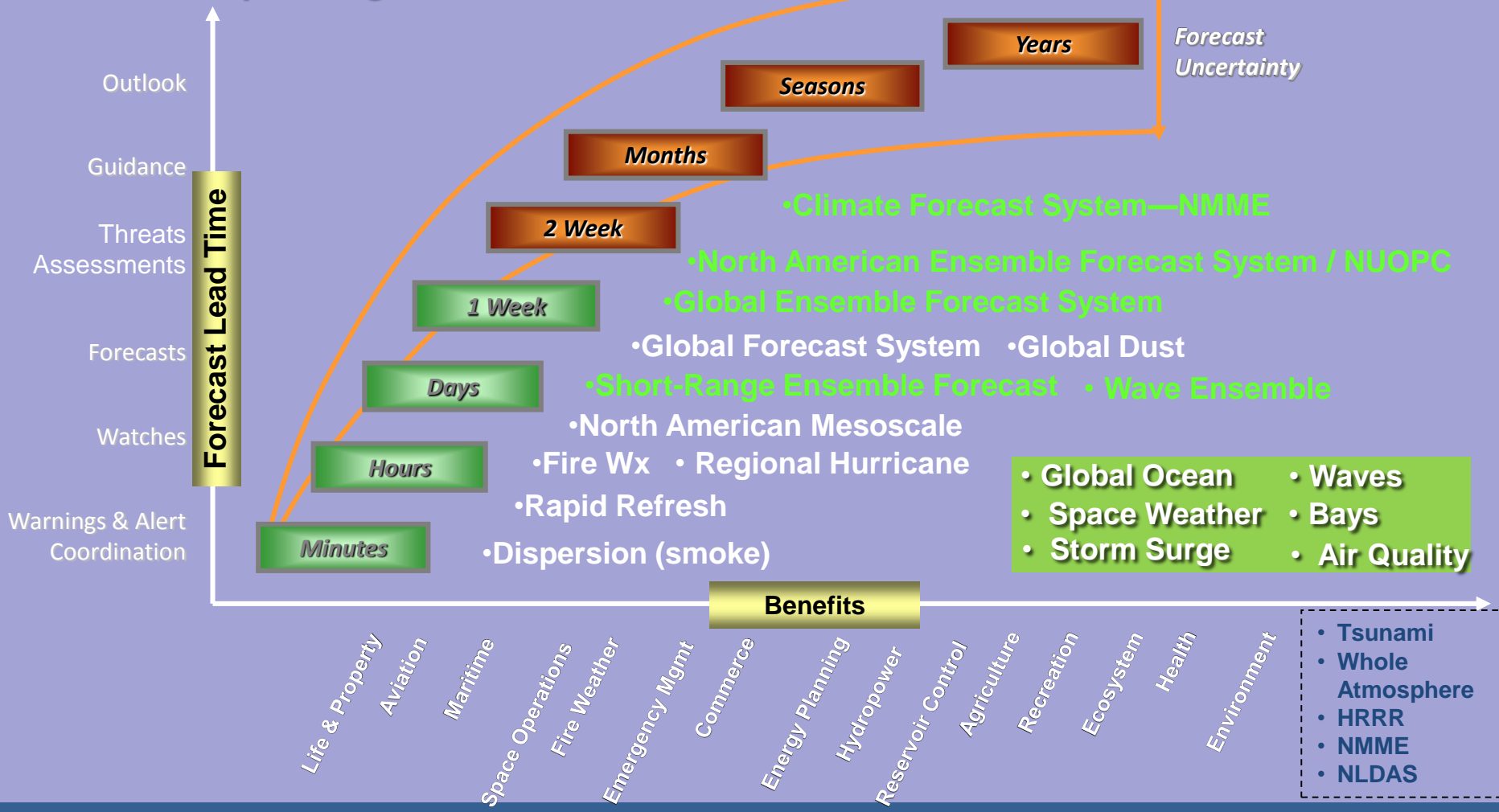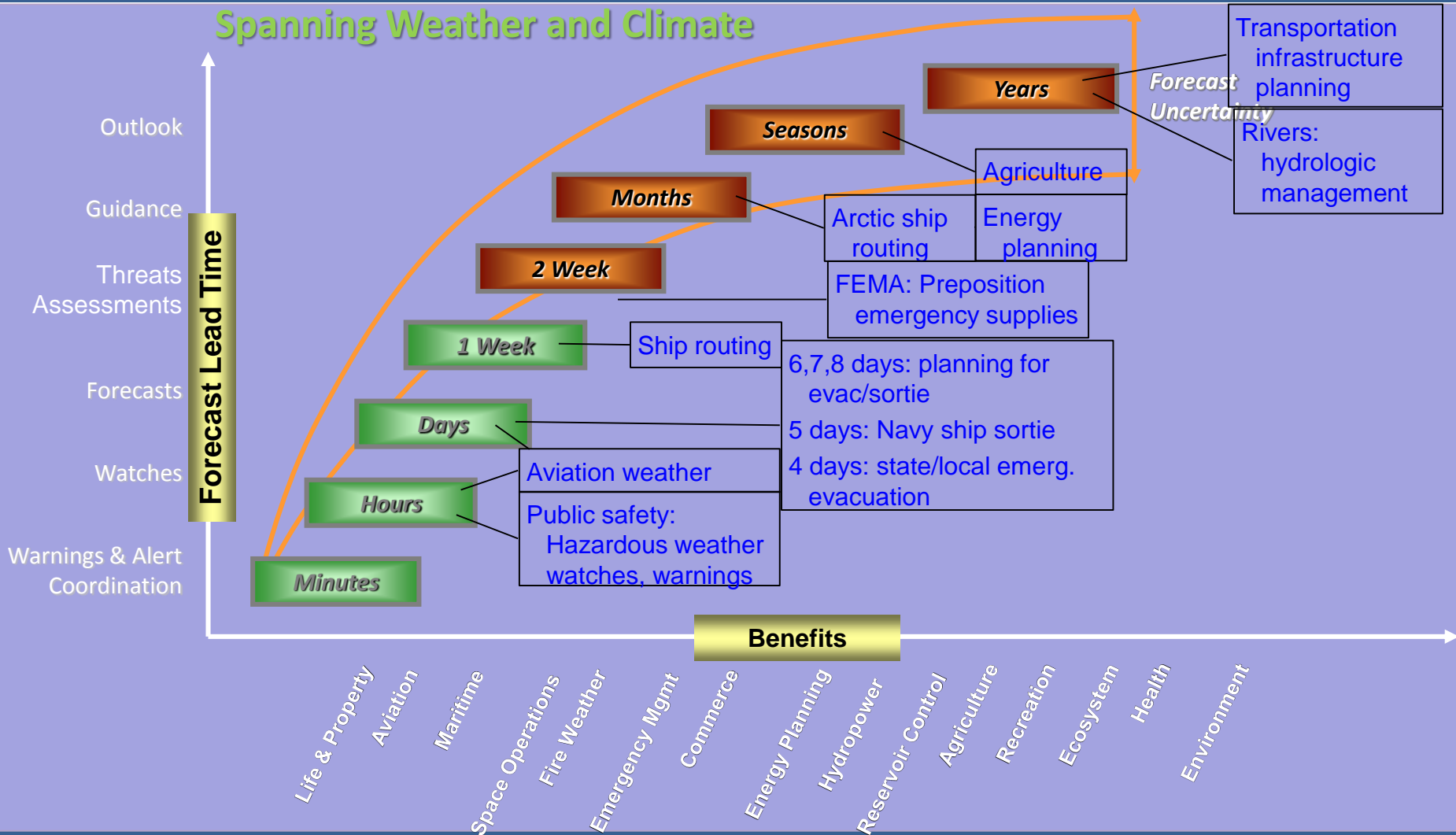 - Connectivity to Interagency Coordination Committees

Questions?

Vision:
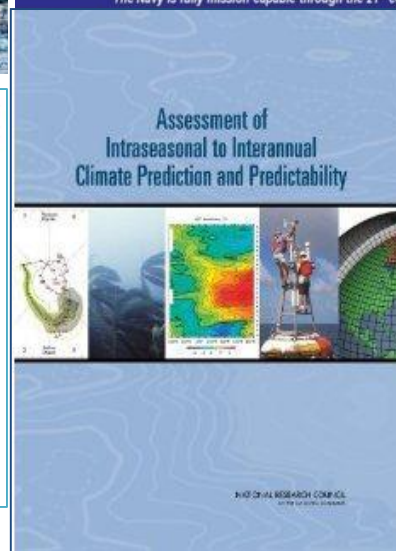# Multi-model ensemble system across scales

Spanning Weather and Climate

Forecast Lead Time

- Outlook
- Guidance
- Threats Assessments
- Forecasts
- Watches
- Warnings & Alert Coordination

Years

Seasons

Months

2 Week

1 Week

Days

Hours

Minutes

Forecast Uncertainty

- •Climate Forecast System—NMME
- •North American Ensemble Forecast System / NUOPC
- •Global Ensemble Forecast System
- •Global Forecast System   •Global Dust
- •Short-Range Ensemble Forecast   • Wave Ensemble
- •North American Mesoscale
- •Fire Wx   • Regional Hurricane
- •Rapid Refresh
- •Dispersion (smoke)

- • Global Ocean   • Waves
- • Space Weather   • Bays
- • Storm Surge   • Air Quality

Benefits

Life & Property, Aviation, Maritime, Space Operations, Fire Weather, Emergency Mgmt, Commerce, Energy Planning, Hydropower, Reservoir Control, Agriculture, Recreation, Ecosystem, Health, Environment

- • Tsunami
- • Whole Atmosphere
- • HRRR
- • NMME
- • NLDAS

Decision Time Scales
## Need for "Seamless" (Internally Consistent) Forecasts

Interagency Effort: Result of Community and Agency Calls to Action

- An Earth-System Prediction Initiative for the Twenty-First Century (Shapiro et al. 2010)

- Collaboration of the Weather and Climate Communities to Advance Subseasonal-to-Seasonal Prediction (Brunet et al. 2010)

- Assessment of Intraseasonal to Interannual Climate Prediction and Predictability (Weller, 2010)

- A National Strategy for Advancing Climate Modeling (NRC Press, 2012)

- Arctic Security Considerations and the U.S. Navy's Roadmap for the Arctic (Titley and St. John, 2009)

- The Uncoordinated Giant: Why U.S. Weather Research and Prediction are not Achieving their Potential (Mass, 2006)
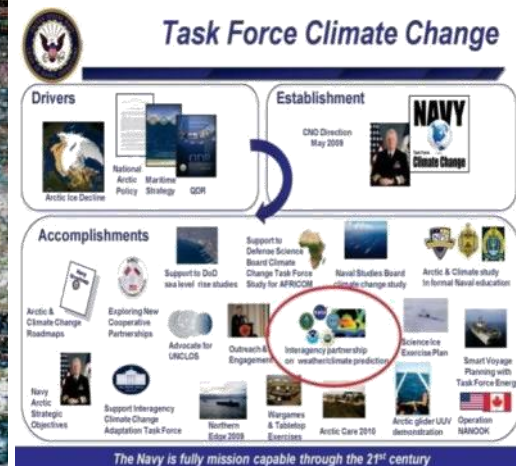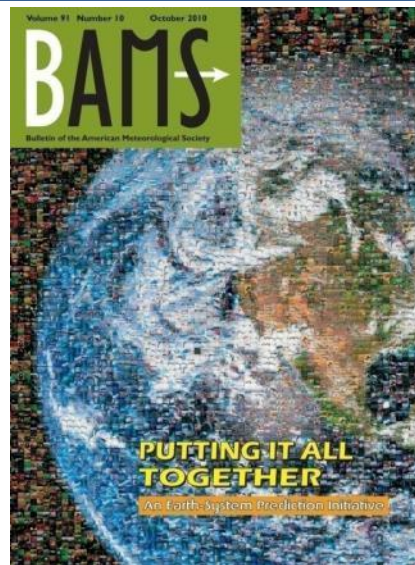
Scientific rationale: same documents call for

- Holistic approach
  - Obs, models, DA, HPC
- Seamless weather-to-climate systems, including uncertainty
- Multi-model ensembles
- Improve representation of processes, esp. convection
- Air-ocean-land-ice coupling
- Exploit sources of predictability in system
  - MJO, ENSO, Arctic ice, monsoon variability
- Common shared software infrastructure
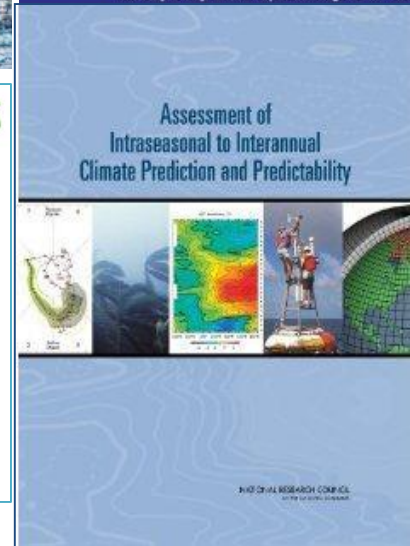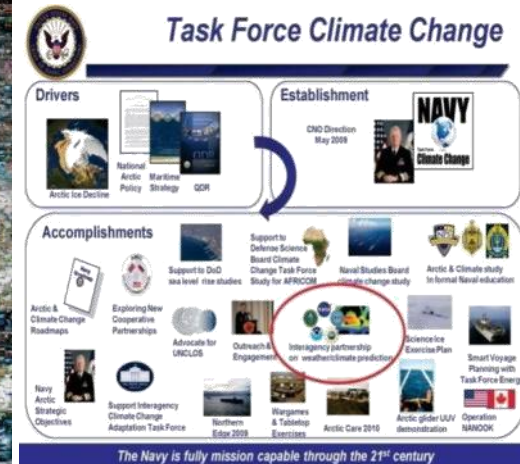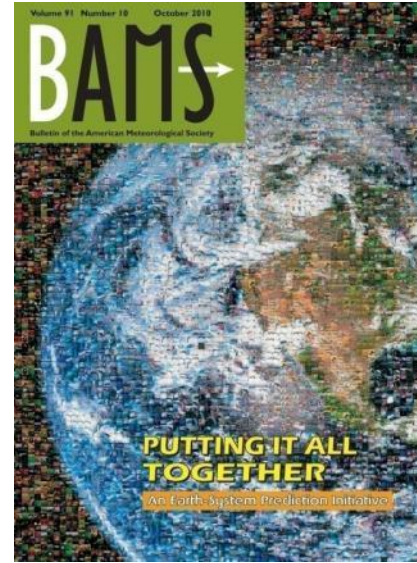
Legacy Structures

- **National Unified Operational Prediction Capability**
  - NOAA, Navy, Air Force Partnership
  - Coordinated Operations with coordinated Transition to Operations and Coordinated Research and Development
  - NWP Global Ensemble Weather Forecast Systems

- **Earth System Prediction Capability**
  - NOAA, Navy, Air Force, NSF, DOE, NASA Partnership
  - Weather, Seasonal, Inter-annual and Decadel Climate Prediction
  - Primarily Research

Gaps/Overlaps of Existing Coordinating Organizations