Evolving Climate in the NWS’ Weather-Ready Nation
National Climate Services Meeting

Dr. Louis W. Uccellini
Director, National Weather Service
NOAA Assistant Administrator for Weather Services

National Climate Services Meeting- Silver Spring, MD
May 9, 2016
Outline

• Building a Weather-Ready Nation
• Restructuring NWS Budget, HQ, Governance: What Does it Mean to You?
• Improving Climate Prediction
  – Addressing the Climate-Weather “Grand Challenges”
  – Embracing the Multi-Model Approach to Numerical Climate Prediction
Increase in Extreme Events
“Average” Year and Trends in the U.S.

- 650 Deaths
- $15B in Losses
- 26,000 Severe Thunderstorms
- 6 Atlantic Basin Hurricanes
- 1,300 Tornadoes
- 5,000 Floods

Increasing Vulnerability

- Improved forecasts of extreme events 4-8 days in advance
- Connecting forecasts to decision-makers is basis for building a Weather-Ready Nation
- Increasing population
- More infrastructure at risk
- Signs of sea level rise

*Munich Re NatCatSERVICE*

**Loss events in the U.S. 1980 - 2015**

<table>
<thead>
<tr>
<th>Number of events*</th>
<th>*Excludes last week of December 2015</th>
</tr>
</thead>
</table>

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Becoming a Weather-Ready Nation is about building community resiliency in the face of increasing vulnerability to extreme weather, water and climate events.

“Ready, Responsive, Resilient”

- Requires NWS to produce:
  - Better forecasts and warnings
  - Consistent products and services
  - Actionable environmental intelligence

- NWS needs to address the “last mile” that connects forecast to critical national, state and location decisions
  - Provide Impact-based Decision Support Services (IDSS)
  - Deliver through multiple and reliable dissemination pathways
  - Work with partners, including embedding NWS in Emergency Operations Centers and incorporating Social Sciences, to gain public’s needed response

Involves entire US Weather, Water and Climate Enterprise WORKING TOGETHER to achieve national preparedness for weather, climate and water events.
NWS Strategic Outcome: Weather-Ready Nation

NWS Strategic Goals

• Improve **Weather** Impact-Based Decision Support Services
• Improve **Water** Forecasting Services based on “Total Water Prediction”
• Enhance **Climate** Services and adapt to climate-related risks
• Improve sector-relevant information in support of **economic productivity**
• **Enable** environmental forecast services supporting healthy communities and ecosystems
• Sustain a highly skilled, professional **workforce** equipped with training, tools, and infrastructure to meet mission

**Prediction is what makes NOAA/NWS unique and indispensable**
What Does it Mean to the NWS?

Building a Weather-Ready Nation will change the way we work—and change the nature of our products:

• Becoming more oriented toward Earth System Sciences (atmosphere, ocean, land, cryosphere)
• Social Science - ensure message delivered = message received for desired outcomes (e.g. How to describe and display “storm surge?”)
• Understanding decision makers and their “shifting risk preferences” before/during/after an event
  • “Organized” – Government
  • “Loosely Coupled” – Social Organizations
  • “Organic” – Individuals
• Connecting observations/forecasts/warnings to “Key Decision Points” in all service areas
• How we measure success: determining intrinsic value of the forecast and IDSS

The NWS must evolve to complete these goals
“First, it should be understood that forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts.”

“What is a Good Forecast? An Essay on the Nature of Goodness in Weather Forecasting”

– by Allan H. Murphy; Weather and Forecasting (June 1993)
Realizing Intrinsic Value

Intrinsic Value is realized through providing Impact-Based Decision Support Services (IDSS)

Generating forecasts and warnings + Connecting those forecasts/warnings with impacts = IDSS

Practice, practice, practice!

The best hydrometeorological forecasting in the world

Develop relationships/ know partner needs

“Ready, Responsive, Resilient”

Trust

Embed
January 2016 Blizzard & Costal Storm: Connecting All of the Pieces

<table>
<thead>
<tr>
<th>Jan 15 - 18</th>
<th>Jan 19</th>
<th>Jan 20</th>
<th>Jan 21</th>
<th>Jan 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Range products begin identifying snowstorm threat for the end of next week</td>
<td>Confidence increasing</td>
<td>Partner Coordination/Briefings</td>
<td>Fed./state/local govts make critical decisions <strong>before</strong> the snow begins</td>
<td>Snow begins in the Mid-Atlantic</td>
</tr>
<tr>
<td>NWS offices begin briefing partners on potential storm</td>
<td>Partner Coordination/Briefings</td>
<td>Media interviews</td>
<td>Snow forecast adjusted to include NYC in Blizzard Warning</td>
<td>Snow forecast adjusted to include NYC in Blizzard Warning</td>
</tr>
</tbody>
</table>

**Blizzard Watches Issued**

**Blizzard Warnings Issued**

1 pm: Press Briefing

- **State of Emergency Declared:**
  - North Carolina
  - Virginia
  - West Virginia
  - District of Columbia
  - Maryland
  - Pennsylvania
  - New Jersey
  - New York

**Schools/Govt Close**

**Flights Canceled**

**Roads Closed**

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[Image of weather map and news coverage]
Connecting All the Pieces

2013 Snowstorm

The Past

Pennsylvania Turnpike

Long Island Expressway

2016 Snowstorm

With NWS Decision Support

Without NWS Decision Support
Planning & Budget Structure Increases Transparency and enhances Service Delivery

**Observations**
Joe Pica
- A focused effort on sustaining & integrating all observations supporting the NWS mission and ensuring continuous situational awareness.

**Central Processing**
David Michaud
- Fully integrating the central and distributed computing system from central computer to AWIPS/AHPS

**AFS**
Andrew Stern
- Analyze, Forecast, Support includes all NWS forecast offices:
  - Working toward “fully integrated field structure” providing consistent products & services
  - Supports local/national IDSS, outreach, & social science integration *(nature of work will change)*

**Dissemination**
Luis Cano
- Better managed, reliable, centralized, and more responsive network, especially during high impact events.

**STI**
Ming Ji
- Accelerates numerical model advances, supports forecaster training/development
  - Provides a centralized development environment to enable Research to Operations (R2O) & a visible “catcher’s mitt” for the rest of the research community interested in the R2O process (e.g., CSTAR, SOO/DOH …)

**Facilities**
Deirdre Jones
- Make sustaining all of the NWS facilities a fundamental part of the NWS mission execution
## FY2016 NWS President’s Budget Request Composition by Portfolio

### Funds Breakdown

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Funds* (in thousands of dollars)</th>
<th>Full Time Employees (FTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations ORF</td>
<td>204,876</td>
<td>804</td>
</tr>
<tr>
<td>Observations PAC</td>
<td>16,720</td>
<td>-</td>
</tr>
<tr>
<td>Central Processing ORF</td>
<td>87,902</td>
<td>134</td>
</tr>
<tr>
<td>Central Processing PAC</td>
<td>64,000</td>
<td>22</td>
</tr>
<tr>
<td>Analyze, Forecast and Support ORF</td>
<td>489,845</td>
<td>3,058</td>
</tr>
<tr>
<td>Dissemination ORF</td>
<td>46,743</td>
<td>82</td>
</tr>
<tr>
<td>Dissemination PAC</td>
<td>45,743</td>
<td>-</td>
</tr>
<tr>
<td>Science and Technology Integration ORF</td>
<td>134,197</td>
<td>517</td>
</tr>
<tr>
<td>Facilities PAC</td>
<td>8,650</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,098,878</strong></td>
<td><strong>4,617</strong></td>
</tr>
</tbody>
</table>

* In thousands of dollars

**Total Forecasters:** 1,624
Within AFS: Climate Services Program
One of 11 National Service Programs

• Aviation Weather
• **Climate**
• Fire Weather
• Marine Weather
• Public Weather

• Severe Weather
• Space Weather
• Tropical
• Tsunami
• Water Resources
• Winter Weather

NWS Climate Services
End-to-end approach to climate services: from observations to prediction to user outreach at national and local levels
Within STI: Challenge of R2O and O2R

The R2O Funnel

- Path for transfer of scientific advances and technology into operational and information services
- NOAA operational requirements and concepts to inform research priorities atop the funnel

- Forms the basis of our MOU and Service Level Agreements (SLAs) with OAR for supporting our mission delivery research and transition needs

To accelerate R2O, need to support O2R and provide research access to operational observations, data assimilation and modeling system (Being applied to the development of the Next Generation Global Prediction System, NGGPS)
FY16 NWS-OAR Service Level Agreement

- Includes 48 projects, based on OAR/CPO competitive and non-competitive funding
- Positions the Climate Test Bed as a major authority in the R2O/O2R paradigm
**Mission:** Advancing operational climate monitoring, models, and prediction capabilities at subseasonal to seasonal and interannual timescales.

- Accelerate **research-to-operations (R20)** transition to improve NCEP operational climate prediction
- Provide **operations-to-research (O2R)** support to the climate research community with access to operational models, forecast tools and datasets

**Climate Test Bed Priorities:**
1. Multi-model ensembles
2. Climate Forecast System (CFS) improvements
3. Climate forecast tools and products
4. Climate monitoring tools and products (new)

New website: [http://www.nws.noaa.gov/ost/CTB](http://www.nws.noaa.gov/ost/CTB)
Seamless Suite of Forecasts: Increasingly Based on Multi-Model Ensembles

Spanning Weather and Climate

Forecast Lead Time

- Minutes
- Hours
- Days
- 1 Week
- 2 Week
- Months
- Seasons
- Years

Forecast Uncertainty

Benefits

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

Outlook

Guidance

Threats Assessments

Forecasts

Watches

Warnings & Alert Coordination

Benefits

- North American Ensemble Forecast System
- Climate Forecast System—NMME
- Global Ensemble Forecast System
- Global Forecast System
- Global Dust
- Short-Range Ensemble Forecast
- Wave Ensemble
- North American Mesoscale
- Fire Wx
- Regional Hurricane
- Rapid Refresh/HRRR
- SSEO (Storm Scale Ensemble of Opportunity)
- Dispersion (smoke)
Climate Forecast System (CFS)

- Numerical model that couples atmosphere, ocean, land and sea-ice components
- Provides sub-seasonal (multiple weeks) to seasonal (~9 months) forecasts
- Focus on prediction of US temperature and precipitation, as well as large-scale features such as MJO and ENSO (El Niño/La Niña cycles) tied to various weather patterns over the U.S. and worldwide
- Future: Include aerosol dust/chemistry and ocean wave model components; Incorporate new observational data sets for all six components
48 Month Running Mean of Heidke Skill Score
Seasonal Temperature

Each point is a 48 month average

- **CFS Implementation**
- **CFSv2 Implementation**

- **GPRA Goal**
- **Actual Skill**
- **El Niño winters (darker=stronger)**
- **La Niña winters**
- **Significant –ve AO**
"The Grand Challenge"
Addressing the weather/climate linkage

Weather Modeling
*Hours to 1-2 weeks*
Highly sensitive to initial conditions

**SKILL GAP**
Needs both

Climate Modeling
*Seasonal to Decadal*
Sensitive to boundary conditions related to coupling of ocean, land, ice, and atmosphere

Presented to OSTP/OMB/White House in summer 2014 as a major forecast imperative

Shapiro et al (BAMS, 2010)
CPC Update

Week 3-4 Forecast and Verification for April 16 – 29

Temperature Forecast

Precipitation Forecast

Temperature Verification

Precipitation Verification

Temperature Forecast

Precipitation Forecast

Weeks 3/4 Temperature Hit/Miss Forecast Issued 01Apr2016

Heidke (No EC) = 60.7639
Heidke = 44.7347
RPSS (No EC) = 0.0988434
RPSS = 0.072297

Weeks 3/4 Precipitation Hit/Miss Forecast Issued 01Apr2016

Heidke (No EC) = 33.7461
Heidke = 8.89796
RPSS (No EC) = 0.0506902
RPSS = 0.0136677
Temperature Verification

Mean Non-EC grids: +57.9
Mean All grids: +36.4
Mean Forecast coverage: 64%

Temperature Heidke Skill Score

Mean = +61.4
How is CFS doing?
High Priority Cross-NOAA Activities

- Addresses the Grand Challenge/climate-weather linkage
  - Implement NMME seasonal forecast system
  - Incorporate “Next Generation Model” into CFS
  - Incorporate updated reanalysis/reforecasts

- Linkages to other areas/applications
  - Water
  - Ecological forecasts
  - Health vectors/related decisions
  - Fisheries

NMME

Ranked probability skill scores of 6.5-month sea surface temperature forecasts
Grand Challenge: Unified Global Coupled System (UGCS) for Weather, Water and Climate Prediction

- UGCS will include fully-coupled components of the Earth system, namely Atmosphere, Land-Hydrology, Ocean, Sea-Ice, Waves & Aerosol, both for data assimilation and model forecasts
- Use NEMS/ESMF software
- **Atmosphere** will comprise of a new dynamic core, new physics, higher resolution in the horizontal and vertical, accompanied by an advanced 4D EnVAR data assimilation system
- **Ocean** component will be MOM6 and HYCOM model systems with updated physics and bio-geochemistry and an ensemble based coupled data assimilation system
- **Land-Hydrology** component will be Noah Land model with upgrades to land surface physics and an upgraded ensemble based Land Information System that assimilates new data sources
- **Sea-Ice** component will be CICE and SIS2 model systems with an ensemble-based coupled sea-ice data assimilation system for sea-ice cover and thickness
- **Wave** component will be Wavewatch III that will be fully coupled to the atmosphere and ocean, with a new ensemble-based coupled data assimilation for assimilating significant wave height observations, etc
- **Aerosol** component will be GOCART and will also have a ensemble-based coupled data assimilation to incorporate AOD and other sources of data
- Will unify the GFS, GEFS and CFS models under a single unified modeling system for:
  - **Weather (GFS):** ~10 days, 10 km, 128 levels, 3 year reanalysis & hindcasts, implement every year
  - **Sub-seasonal (GEFS):** ~45 days, 30km, 128 levels, 20 year reanalysis & hindcasts, implement every 2 years
  - **Seasonal (CFS):** ~12 months, 50km, 128 levels, 40 year reanalysis & hindcasts, implement every 4 years

S. Saha, H. Tolman, M. Ek et al/NCEP/EMC
VISION: Scientific excellence and innovation driving water prediction to support decisions for a water resilient nation

BENEFITS:

- State-of-the-science modeling for global to street level predictions (from 6,000 forecast locations to 2.7 million stream reaches)
- Operations Center to establish common operating picture within NOAA and among water agencies; decision support for floods to droughts (flood mapping to street level)
- Proving ground to accelerate research to operations; partnerships with research communities (e.g. CHUASI, National Flash Flood Interoperability Experiment)
- Data integration and service backup
National Water Model (NWM) 
IOC Experimental Output (FY16)

• Hydrologic Output
  – River channel discharge and velocity at 2.7 million river reaches
  – Surface water depth and subsurface flow (250 m CONUS+ grid)

• Land Surface Output
  – 1km CONUS+ grid
    • Soil and snow pack states
    • Energy and water fluxes

• Data Services
  – Public-facing NWC website
  – Data feed to River Forecast Centers
  – NOMADS data service
One NOAA Collaboration for Ecological Forecasting

- **NOS** models run on NOAA/NWS operational supercomputer
- HAB, Hypoxia, Vibrio prediction in Gulf of Mexico **led by NOS**
- HAB: Real-time prediction in Great Lakes by NOS/OAR-GLERL
- The 5th NWS Strategic Goal “Enable environmental forecast services supporting healthy communities & ecosystem”:
  - Gulf of Mexico (status: operational)
    - **NWS**: WFOs Tampa and, new in 2015, Miami and Key West, capable of issuing Beach Hazard Statements for high respiratory irritation from HAB
  - Lake Erie (status: experimental)
    - **NWS**: WFO Cleveland hosts Lake Erie HAB web page;
    - New in 2016:
      - WFO CLE provides decision support [dashboard](#) to NOS HAB analysts
      - OHRFC to provide HAB analysts CFS 45-day flow forecasts for 2 points on Maumee River
      - WFO CLE/OHRFC provide River Forecasting 101 webinar for Ohio state agencies, GLERL, and NOS HAB analysts

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**Success is based on TRUST and recognition that we all could gain in serving this predictive need**
Summary

• Working towards building a Weather-, Water- and Climate-Ready Nation

• NWS working closely with all NOAA line offices (especially OAR/CPO) to establish a framework for effective R2O/O2R and improved service delivery

• Climate services programs (collocated within AFS) touch a large portion of the NWS management infrastructure

• Many strategic opportunities exist (especially the “grand challenge”) based on a unified global-coupled system (UGCS) for weather, water and climate prediction, including application to health vectors, fisheries and other strategic areas