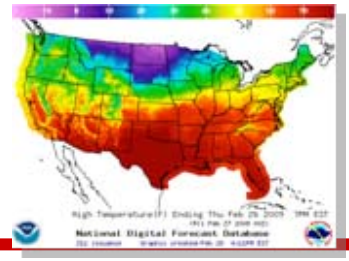


NWS Science and Technology Roadmap… Enabling the Future

Don Berchoff
Director, Office of Science and Technology
National Weather Service
National Oceanic and Atmospheric Administration

National MIC/HIC Conference—20 April, Leesburg, Va

Outline

- Science & Technology Imperatives
- Mission-Limiting Science & Technology Issues
- Science and Technology Vision
- Strategies/Plans/Actions
- Moving Research into Operations
- Partnerships
- Implementation Challenges
- Summary

Science and Technology Imperatives

Drivers	Over the Horizon Challenges
Operational Environment is changing	• Keeping pace with decision-maker expectations for more precise, consistent and timely impact-based forecasts and warnings
Rapid advances in S&T	• Getting ahead of the power curve to provide forecasters the best observations, models, applications, tools and equipment
Huge data explosion on the horizon	• Will become too cost prohibitive to transmit everything, everywhere…how to prevent forecaster saturation
US industry reliance on "foundational" weather data is increasing	• Soaring expectations/demand on NWS systems as weather data becomes integral to industry's business decisions and productivity
Federal deficits and resource constraints	• Maintaining world class capabilities

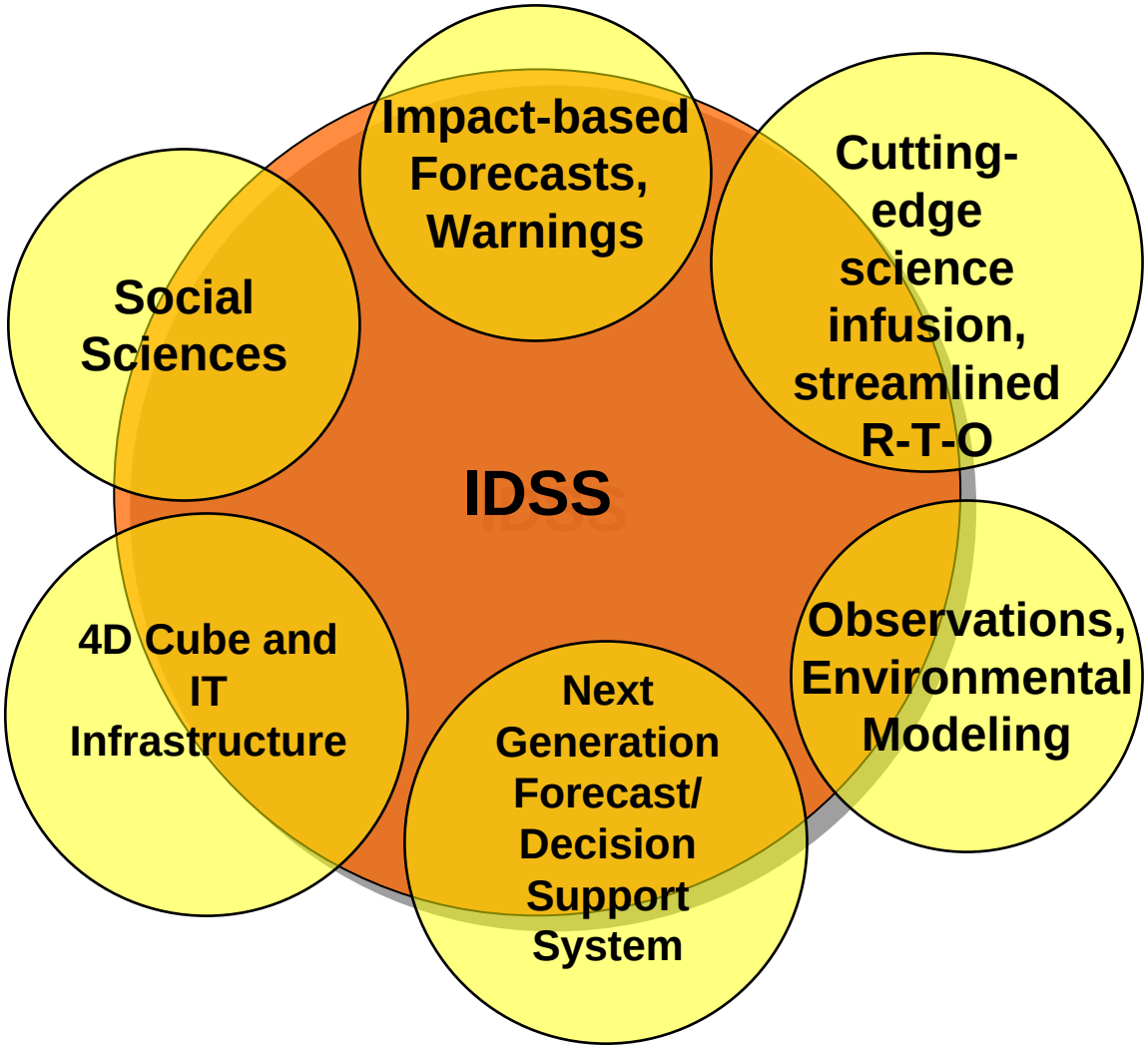
"Weather is an uncontrolled customer…"
Rick Day, MIC/HIC Conference 2010

Mission-Limiting Science & Technology Issues

- Stovepipe observation systems, PBL measurements gaps
- Inadequate short-range, neighborhood-scale models/guidance
- Multiple IT platforms, lack of interoperability, flexibility
- Software not arrayed for agile, rapid S & T insertion
- Saturated IT and communication systems
- Inadequate dissemination/collaboration capabilities
- Lack of high resolution ensemble/uncertainty guidance
- Lack of social science integration in system design, DSS
- Stovepipe field innovation R-T-O and O-T-R

Science & Technology:

Enabling Change



- Comprehensive, networked observations, situational awareness
- Neighborhood-scale, short-range through seasonal forecast guidance
- Forecast assistance tools -- free forecasters for most cerebral tasks
- Decision-assistance tools / technology to enable DSS
- Smart Push / Pull IT and communications arch-- efficiency, interoperability
- Social science in system design & communicating uncertainty

Strategies/Plans/Actions

Links to NOAA/NWS Strategic Plans

Social Sciences

Enabling Capabilities

IT/Communication Infrastructure

NWS Strategic Goals (Draft)	Cutting-edge Science Infusion
Impact-based Forecasts and Warnings	✓ Air quality ✓ Fire weather ✓ Marine weather ✓ Severe weather ✓ Tropical weather ✓ Tsunami ✓ Winter Weather ✓ Hydrology—flooding ✓ Space Weather
Improved water services	✓ Hydrology—water resources
Enhance Climate Services	✓ Climate
Expand Sector-Relevant Services	✓ Aviation ✓ Emerging area: energy, health
Integrated Environmental Services	✓ Emerging area: ecosystems

Transform Dissemination/ Outreach/ Feedback Technologies

Integrated Observations/ Analysis

4D Data Cube

Integrated Environmental Modeling:
- **Data Assimilation**
- **Models**
- **Uncertainty**

Next Generation Forecast and Decision Support System

Strategies/Plans/Actions

High-Impact Forecasts/Warnings

Service Area	Goals
Hydrology	Dependable Street-Scale Probabilistic Warnings
Aviation	Initiation of Convection: 30 mins LT
Severe Weather	Warn on Forecast, LT > 1hr
Winter Weather	High-Res User-Defined Thresholds
Marine	Probabilistic Warnings, LT> 5 days
Tropical Weather	Track/Intensity errors reduced by 50%
Climate	Accurate 6mo+ LT on forcing events
Air Quality	Accuracy >85% out to day 5
Space Weather	>90% accuracy, out to day 2
Tsunami	< 5 mins after triggering event
Energy (Wind)	1km resolution, 5min updates
Fire Weather	>24hr LT Red Flag Warnings, 95% POD

<u>Societal Benefits:</u> reduce loss of life, property, and mitigate economic impacts

Goals to rally research/development efforts across Weather Enterprise

Strategies/Plans/Actions

Aviation Example

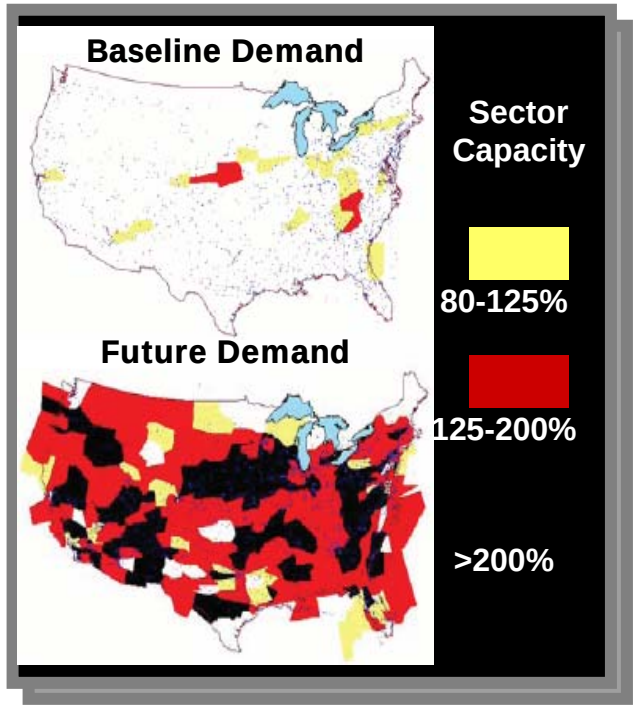
Goal: 30 min LT: initiation, evolution, dissipation, of convection

- Delays cost $41 billion in 2007
- 70% were weather related

  NextGen 2022 goal:

  – Improvements to forecast LT for initiation of storm-scale convection and its effects

  – More accurate hail, turbulence, icing, crosswinds, microburst potential etc



Science and Technology Needs:

- **Increased surface, sub-surface and boundary layer observations**
- **3km probabilistic prediction system**
- **Forecaster Assistance Tools—situational awareness, rapid updates**
- **Decision Support Tools—interoperability, threshold alerts**
- **Effective Social Sciences integration—communicate uncertainty**

Strategies/Plans/Actions

Links to NOAA/NWS Strategic Plans

Social Sciences

Enabling Capabilities

IT/Communication Infrastructure

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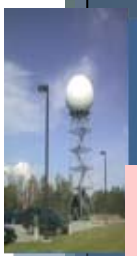
Next Generation Forecast and Decision Support System

Strategies/Plans/Actions

Integrated Observation/Analysis System



Current

Individual Systems

Public, Private. Universities

Radar, Satellite Surface; in-Situ, Upper Air….

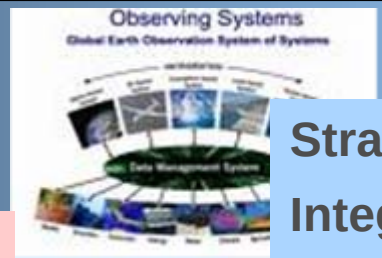
Analysis

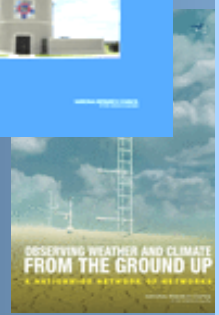
Inventory & Assess:

Systems, Metadata

Gaps

Needs





Strategies

Integration

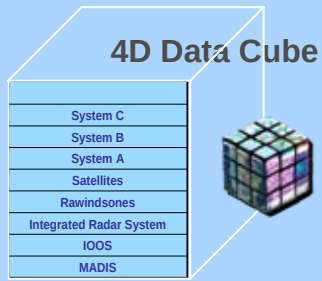
Networked

Optimization

Standards, Architectures, Protocols

Fusion Algorithms

Future



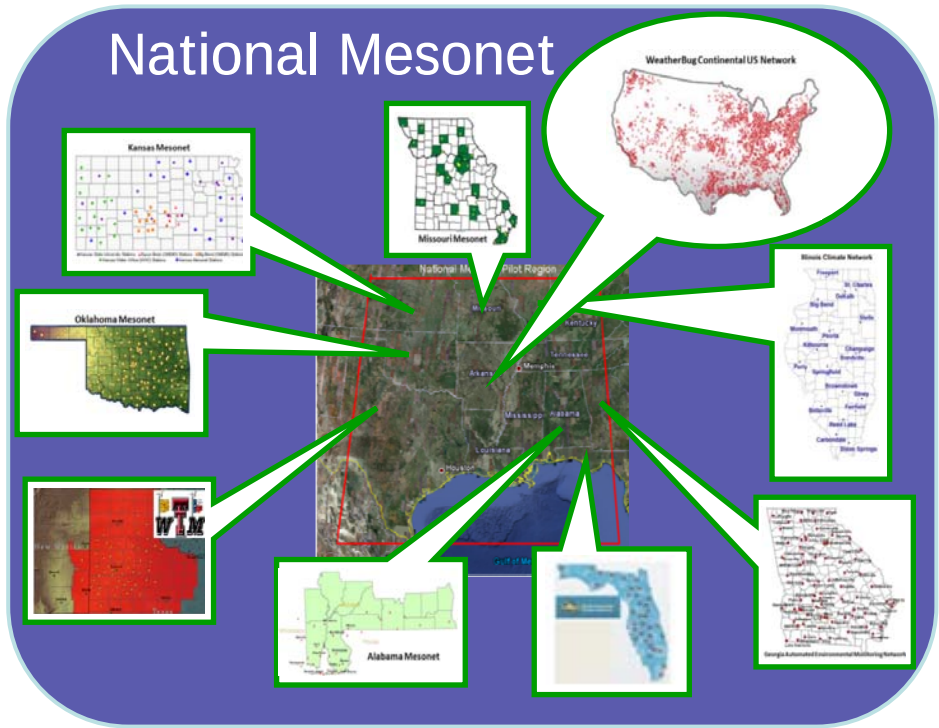
Open Architecture

Strategies/Plan/Actions

Integrated Observations/Analysis

Next Five Years

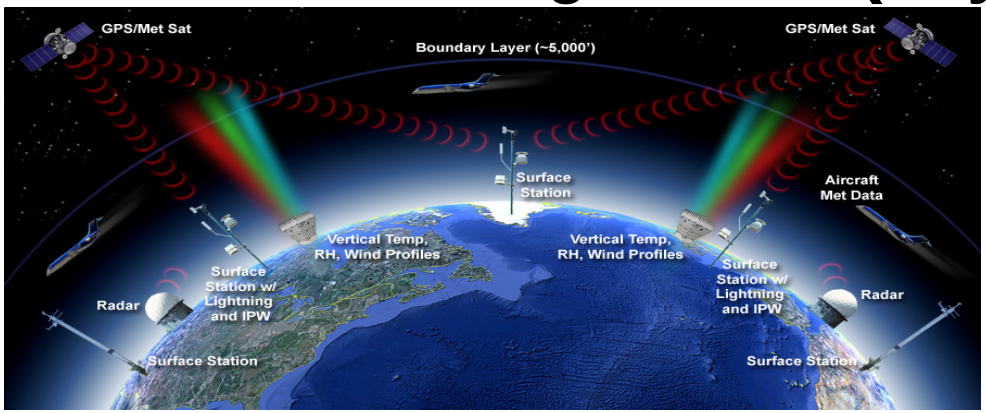
- **Improved situational awareness/ neighborhood scale model precision:**
  - **Radar: Dual Pol deployed; research/test/demo MPAR and gap-fillers**
  - **Satellites:**
    - DCVER (replace ACE): space warnings
    - COSMIC II: water vapor and space warnings
    - OSVW: GCOM data possibilities, partnerships
  - **Close surface observations gaps:**
    - Severe weather belts, coastal, mountains
    - Build Network of Networks
  - **Evaluate/test/demo boundary layer capabilities**



Strategies/Plans/Actions

Integrated Observations/Analysis

Longer Term (Beyond 5 Years)

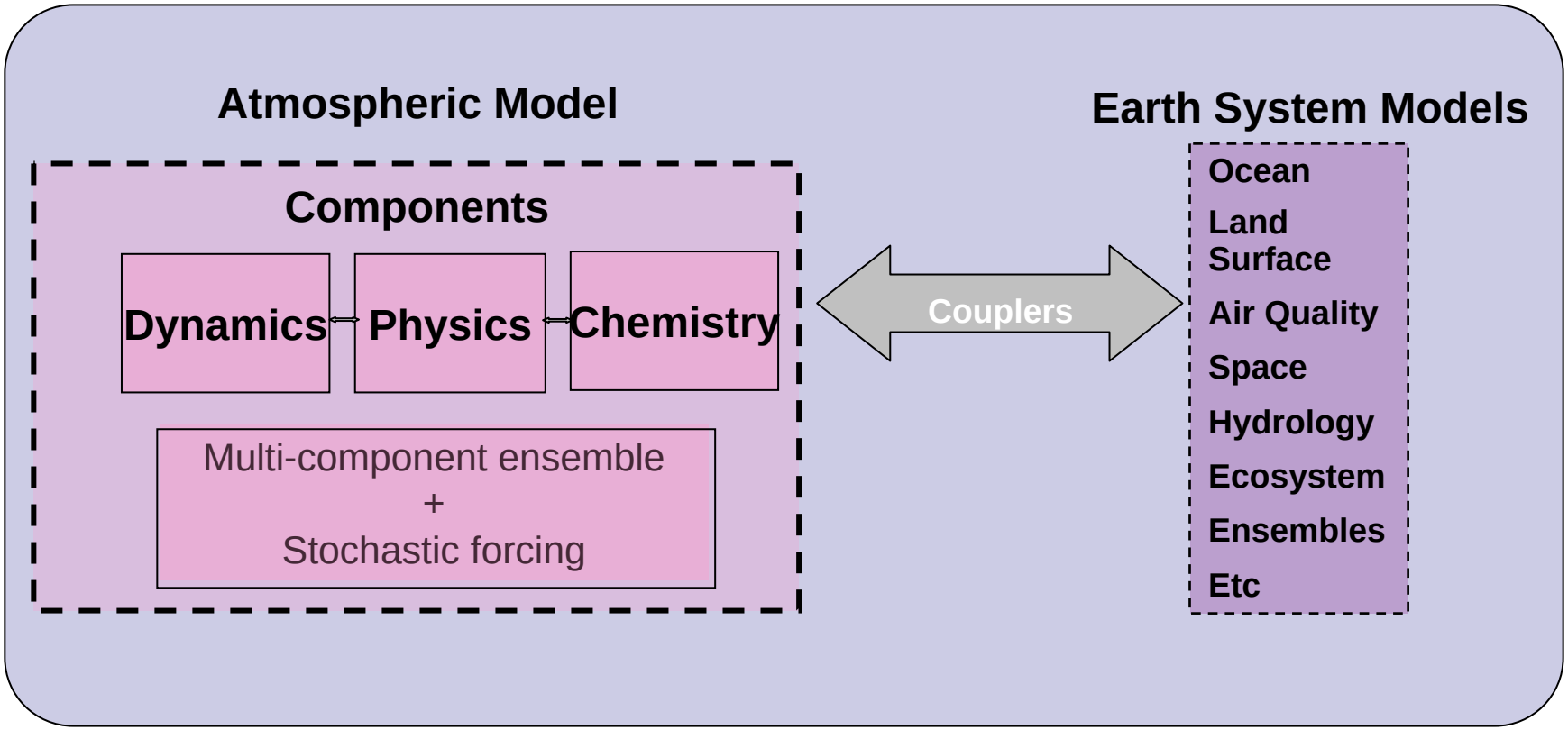


Extending through boundary layer critical for forecast improvements

- **Forecaster Assistance Tools:** Fused, single observational picture, multi-sensor algorithms
- **Networked Observations:** Network of Networks, Integrated Ocean Observing System, Global Earth Observing System of Systems, GIS compatible
- **Neighborhood-scale model precision:** Improved boundary layer in-situ and remotely sensed data
- **Situational Awareness:**
  - GOES-R—30 second spotlight, better sensors, more channels, lightning
  - Joint Polar Satellite System (formerly NPOESS) —better visual/IR sensors
  - Dual Freq scatterometer—12km ocean surface winds
  - Radar: Gap-Filling & MPAR radar capabilities (with DHS/FAA), all types

Strategies/Plans/Actions:

Integrated Environmental Modeling System



Improve R-T-O/O-T-R:
Developmental Test Center

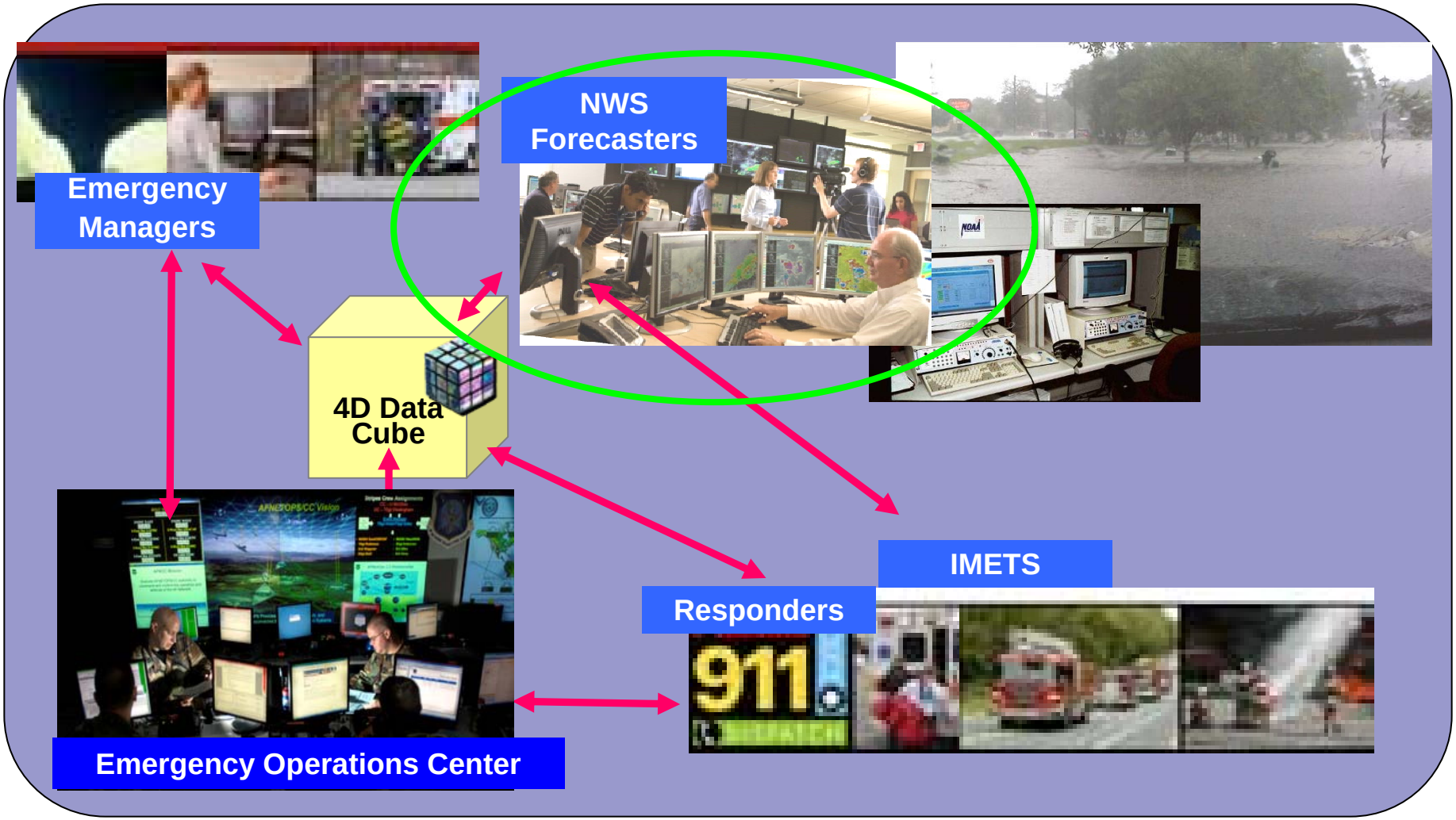
Strategies/Plans/Actions

Integrated Environmental Modeling Effects

- Improved Winter/Tropical Storm Tracks—Next Generation Global Model
- Improved inter-seasonal forecasts
- More precise/reliable neighborhood scale model
- Tropical storm intensity—Hurricane Forecast Improvement Predictions research integrated into operations, e.g. Hurricane- WRF
- Coastal flood forecasts: Storm Surge added to tides
- NOAA Ecosystem forecasts: Coupled, interdisciplinary hydrologic and atmospheric models

Strategies/Plans/Actions

Next Generation Forecast & Decision Support System

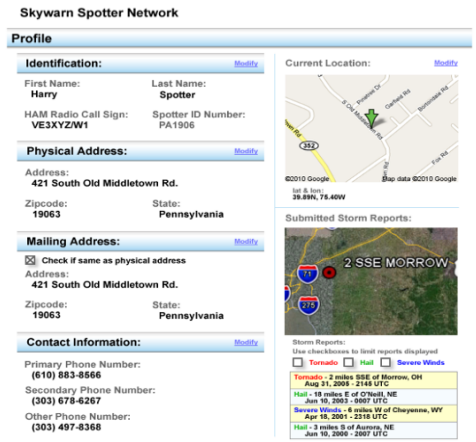


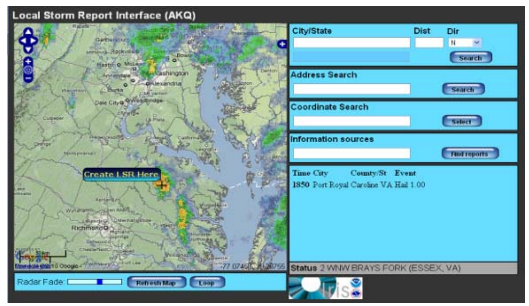
Strategies/Plans/Actions

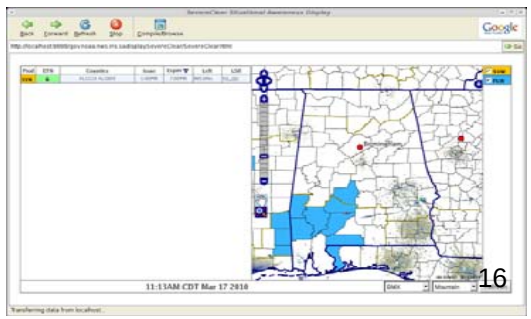
Next Generation Forecast & Decision Support System

Next Five Years

- **Forecaster Assistance Platform / Tools:**
  - AWIPS 2 – inherent development capability
  - Service back-up efficiency/effectiveness
  - Deploy Integrated Hazards Info Services
    - Combines WarnGen, RiverPro, Graphical Hazard Generator
- **DSS Assistance Tools:**
  - AWIPS Services Oriented Architecture
  - Integrated Risk Information System (IRIS) IOC, later merged with AWIPS
    - Unifying structure, location of weather and risk assessment data
    - Impact-based assistance tools
  - DSS testbed--prototype EM decision assistance tools
  - Enhanced collaboration tools—internal/external partners







Strategies/Plans/Actions

Next Generation Forecast & Decision Support System

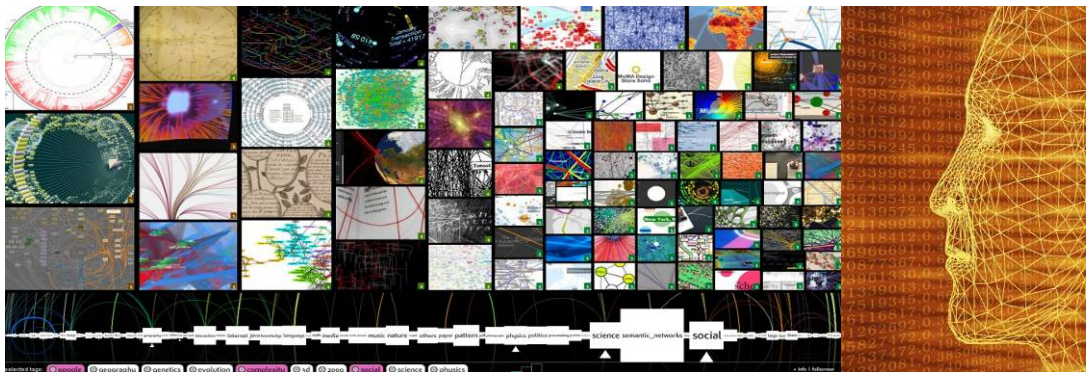
Longer Term

Advanced **Forecaster Assistance** Tools

- Data mining--enhanced situational awareness, data management
- Intelligent assistant--**what matters, where's uncertainty, where to add value**

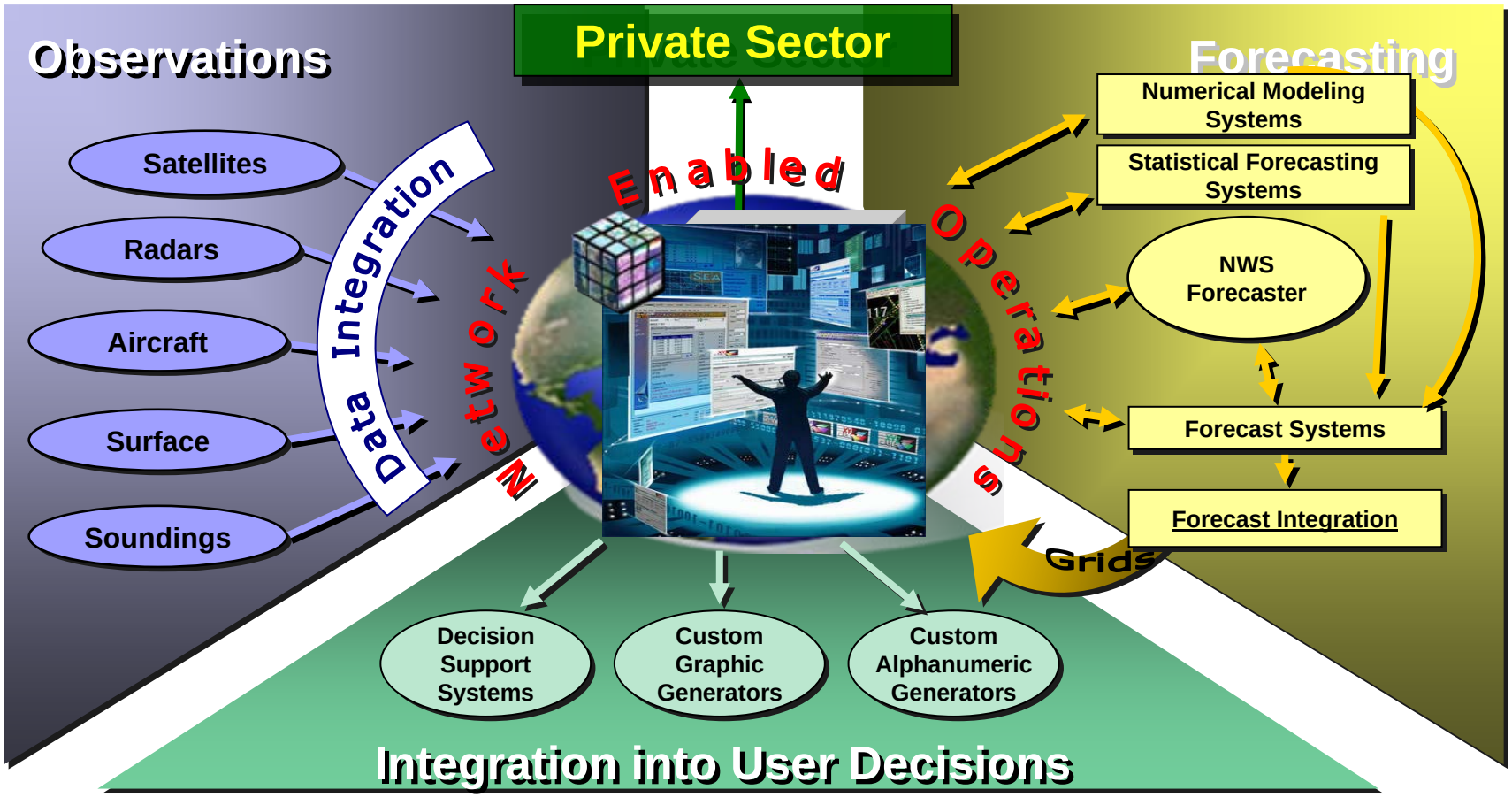
Advanced **Decision Assistance Technologies/Tools**

- Pattern recognition--thresholds recognized/impact-generated alerts/option for automatic dial/connect to decision-maker
- Voice recognition activation for efficiency/timely customer contact
- Integrated common operating picture with customer databases
- Next Generation Field Office Design—cameras, hand gesture interfaces



Strategies/Plans/Actions

4D Data Cube



NOMADS, MADIS, NDFD data/information ready

Strategies/Plans/Actions

4D Data Cube

Next Five Years

2013

- Smart Push/Pull IT and Communications Arch
  - Product/Data discovery and access, demonstrated, ready
  - Select data sets available
    - Icing, turbulence, winds, thunderstorms and CIG/VIS
  - NEXGEN and aviation services applications tied to cube
- Neighborhood Scale Precision/Reliability in cube
  - 3km High Resolution Rapid Refresh guidance

Strategies/Plans/Actions

4D Data Cube

Longer Term

2016

- Single authoritative source capability
- Neighborhood scale probabilistic data sets
- Service Oriented Architecture access for all users—public, private, academia
- More inclusive sensible weather data sets
  - Continuously updated weather/water observations

2022

- Inclusive of all weather, water, climate data

Strategies/Plans/Actions

Transform Dissemination/Outreach/Feedback Technologies

Next Five Years

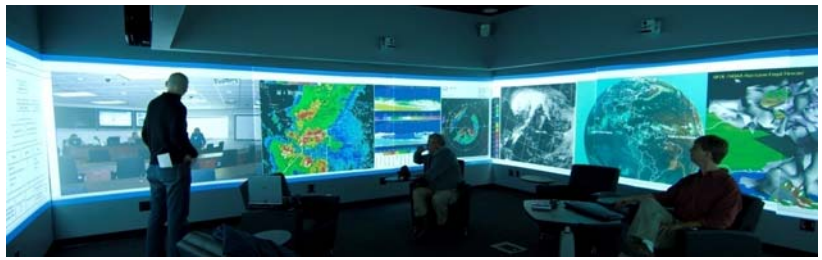
- Decision assistance tools/technologies
  - Move iNWS (WR prototype) into operations
    - Alerts to PDAs, cell-phones; user decision thresholds/areas
  - Hands-free technologies prototyped at DSS testbed
- Agile infusion of dissemination technologies
  - DSS testbed--build, prototype, test, field
  - Rennaissance Computing Institute (Renci) as partner
- Push/Pull IT and communications infrastructure
  - NWS Satellite Products User Readiness team defining what/how needs to be delivered
  - Ramping up bandwidth: 2X current

Strategies/Plans/Actions

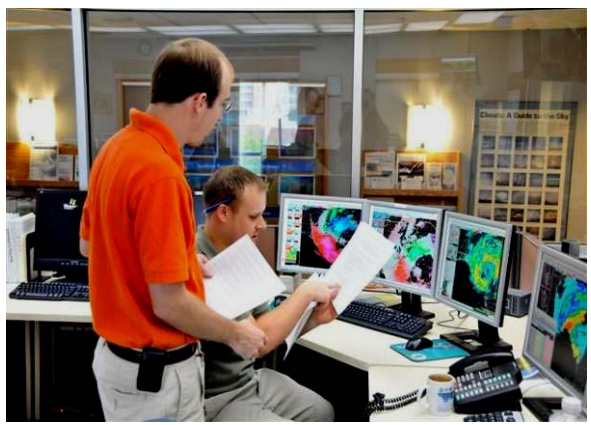
Transform Dissemination/Outreach/Feedback Technologies

Longer Term

- Decision Assistance Tools/Technology
  - Support advanced visualizations
  - Advanced collaboration technology



- Smart Push/Pull IT and communication infrastructure--ramping up ~10X current by 2016
  - Accommodate bandwidth for next generation field office—cameras, streaming video feeds, etc
  - Prototype cloud computing—select centralized software applications



Strategies/Plans/Actions

Social Sciences

Next Five Years

- Improving communication of uncertainty icons, text of point forecasts
- Partner w/Renci to test methods to illicit the appropriate user responses
- Develop WFO/CWSU/RFC/Center operational proving ground
  - Systems design; NOAA/NWS internal collaboration/interoperability
  - OAR/NWS "convective initiation" demonstration project: also improves evolution, dissipation

Longer term

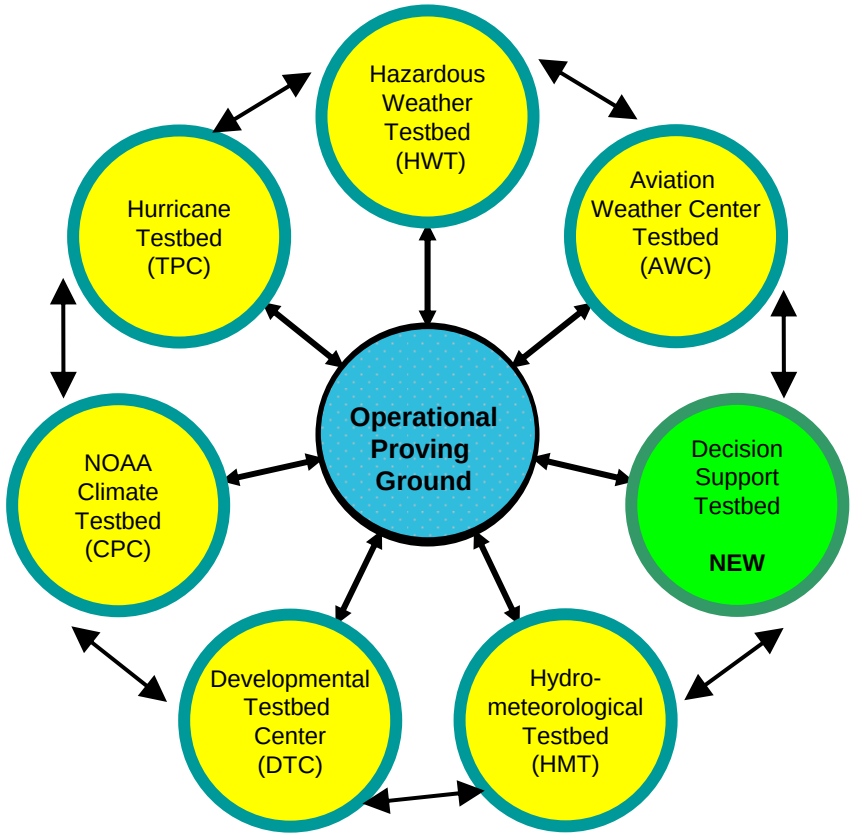
- Social sciences integral in developing future:
  - Forecaster assistant and decision support tools
  - System designs—collaborative technologies

"If we do not change behavior based on the forecast,
we did not pass the "so what" test"…Greg Fugate, FEMA, MIC/HIC Conf 2010

Moving Research into Operations

Framework for Improving R2O/O2R

- Testbed system of systems
  - working overarching governance model, interoperability
- Accelerate agile, rapid software/tech insertion
  - More Prototyping
- Develop Operations Proving Ground
  - experimental testing in ops setting
- Streamline field innovation into operations
  - Innovation Advisory Board
  - Research and Innovation Transition Team



Field is integral to transition process -- AWIPSII facilitates

Partnerships

- Must do better infusing good ideas, research, capabilities into NWS
- Benchmark: HFIP
- US leads world in research, but not necessarily in ops
- Focus on closer partnerships, leveraging capabilities
- Eliminate hurdles

Primary Federal Agencies:

- **Department of Energy**
- **Air Force**
- **Navy**
- **Department of Transportation**
- **Environmental Protection Agency**
- **Department of Interior**
- **NASA**

NOAA Agencies

- **NOS**
- **OAR**
- **OFCM**
- **NESDIS**
- **NOAA Climate Service**

Other Partners:

- **AMS**
- **Private Industry**
- **Academia**
- **NCAR**
- **UK**
- **Canada**
- **RENCI**
- **State Climatologists**

Implementation Challenges

- Resources...
  - High Performance Computing
  - Satellite costs
  - Closing boundary layer, surface, coastal, river, sub-surface observational gaps
  - Mesonet development—federal, local, state, academia and private sector partnership challenges
- Infusing local innovations into enterprise system
- IT security keeping pace w/cutting-edge technologies
- Streamlined R2O/O2R--always a challenge
- Culture—not invented here syndrome
- Priorities...

Summary

- We have a strategy to enable NWS future
  - More, integrated networked observations
  - Better models—weather, water, climate
  - Impact-based DSS tools/applications with smart forecast assistance
  - 4D Data Cube
  - Advances in IT infrastructure/communications, interoperability
  - Social Science— in communicating uncertainty and in systems development
- Improving R2O/O2R with more rapid, agile S&T insertion, more prototyping, and streamlining infusion of field innovation

Discussion

Backup

Roadmap

Science Service Stretch Goals

Science Service Area	Key Products / Services	S&T Goal Examples	Research Needs and Opportunities: Examples
Fire Weather	Red Flag Warning	>24hr Lead Time (LT) with 95%	Simulations (high-resolution) of eather / behavior
Hydrology	Inundation F		hydrologic models and
Aviation	Convection I evolution and		olution of convection
Severe Weather	Tornado War		standing of tornado vere weather
Winter Weather	Winter Storm		ation and snow intensity
Marine	Storm Warni	days	odel physics from shelf to shore
Tropical Weather	**Hurricane Track, Intensity Forecasts**	**Errors reduced by 50%**	**Causes of rapid intensity changes**
Climate	**Seasonal / IA Forecasts**	**Accurate, probabilistic 6 month+ LTs on extreme events**	**Earth system modeling with ensemble prediction and uncertainty**
Air Quality	**Air Quality Predictions**	**Accuracy >85% out to day 5**	**Advanced simulations of generation and reactive chemical transport of airborne particulate matter**
Space Weather	**Geomagnetic Storm Warnings**	**>90% accuracy, out to day 2**	**Data Assimilation: Ionosphere, Magnetosphere, and Solar Wind**
Tsunami	**Tsunami Warnings**	**<5 mins after triggering event**	**Enhanced observations and models**
Emerging Areas/ Surface Wx	**Wind Forecasts**	**1km resolution, 5 min updates**	**Meteorological influences on renewable and sustainable energy systems**

Aviation

Key Products:

- **Convection Initiation**

2025 Stretch Goal:

- **30 minute lead time**

Research Needs/Oppty Examples:

- **Initiation, evolution of convection**