Research needs for Air Quality Forecasting from the NOAA Perspective

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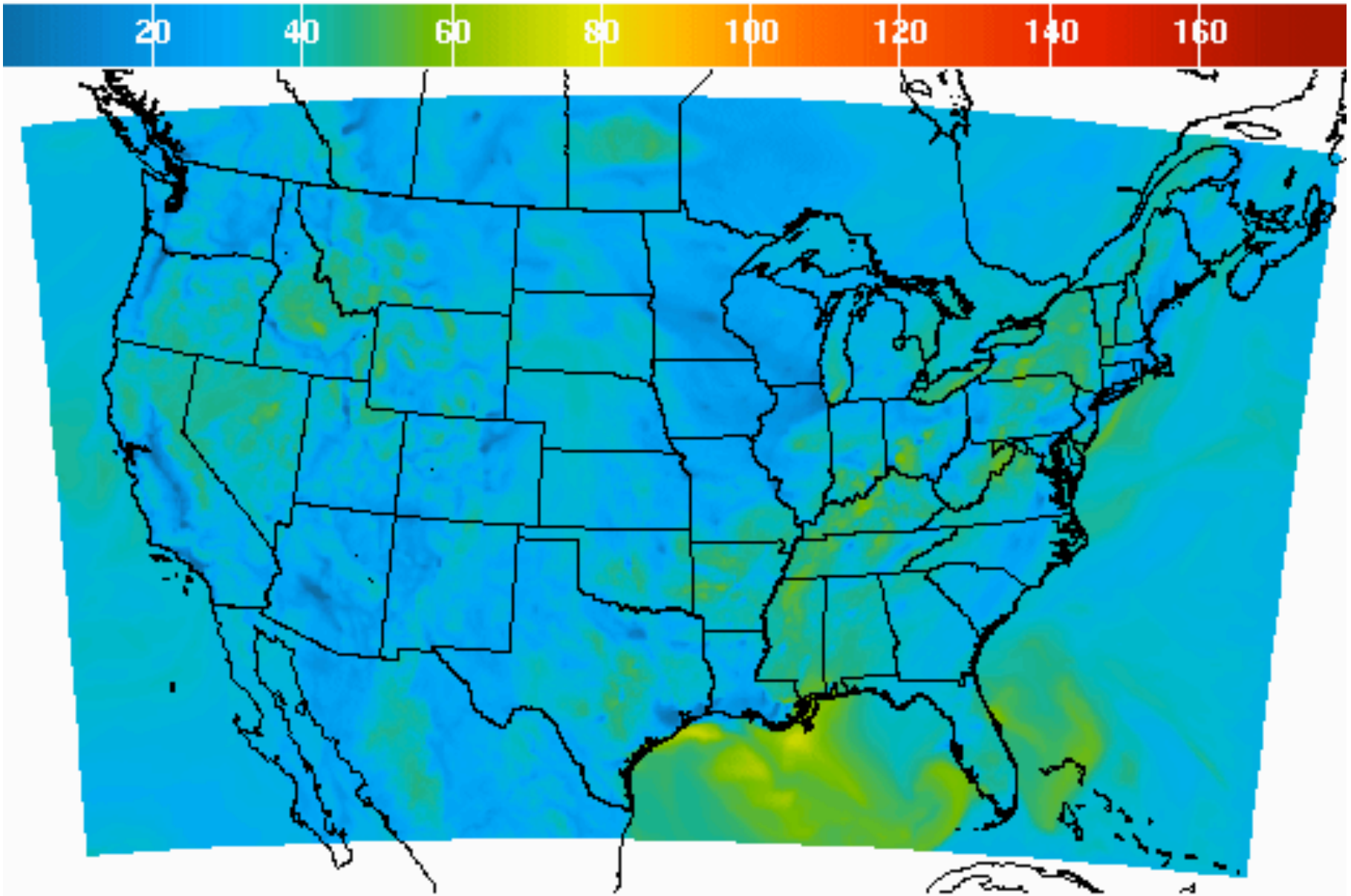
NOAA/NWS

International Workshop on Air Quality Forecasting Research, Boulder, Colorado, December 2, 2009


20
40
60
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1Hr Avg Ozone Concentration(PPB) Ending Thu Sep 20 2007 10AM EDT
(Thu Sep 20 2007 14Z)
National Digital Guidance Database
06z model run
Graphic created-Sep 20 7:23AM EDT

Outline

1. NAQFC – mission and capabilities, recent progress
2. Forecast challenges
3. Approach
4. Research needs and opportunities
5. Summary/ Way ahead

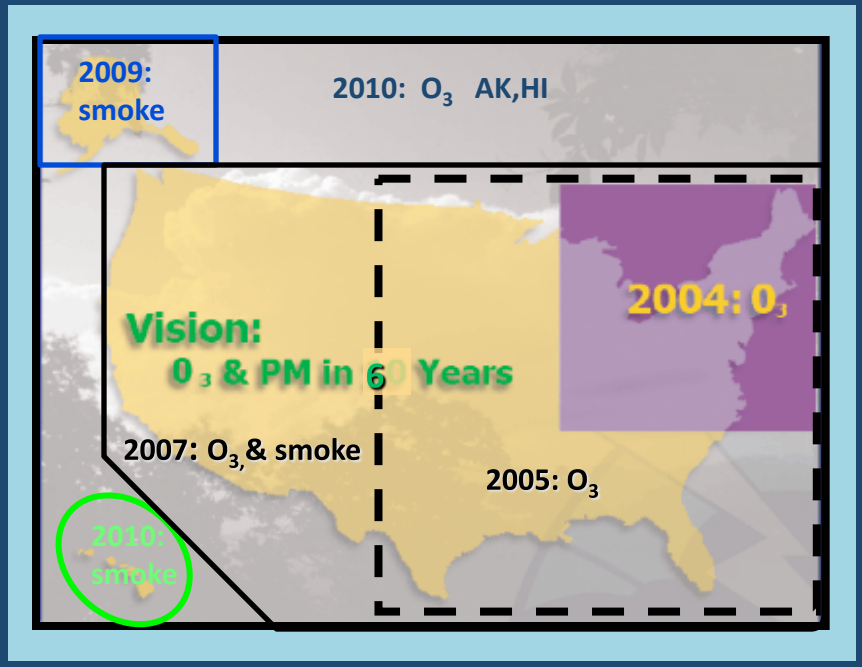
National Air Quality Forecast Capability

- Poor AQ responsible for losses each year in the US:
  - > 60,000 premature deaths
  - > $100B in health costs
- Vision: protect lives and property by providing accurate and timely AQ predictions for the US
- Strategy: work with EPA, State and Local AQ agencies and private sector to develop end-to-end AQ forecast capability for the US
- Benefits: hourly predictions available to local and state AQ forecasters, decision makers, general public

National Air Quality Forecast Capability
Current and Planned Capabilities, 12/09

FY09 Prediction Capabilities:

- **Operations:**
  - Ozone, expanded from EUS to CONUS, 9/07
  - Smoke implemented over CONUS, 3/07 and AK, 9/09
- **Experimental testing:**
  - Ozone upgrades
  - Smoke predictions over HI
- **Developmental testing:**
  - Ozone over AK and HI
  - Components for particulate matter (PM) forecasts



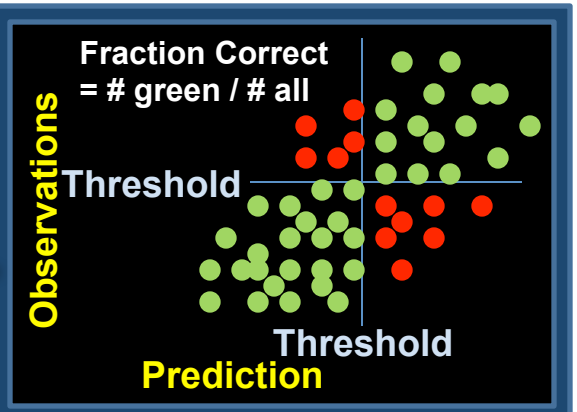
Near-term Operational Targets:

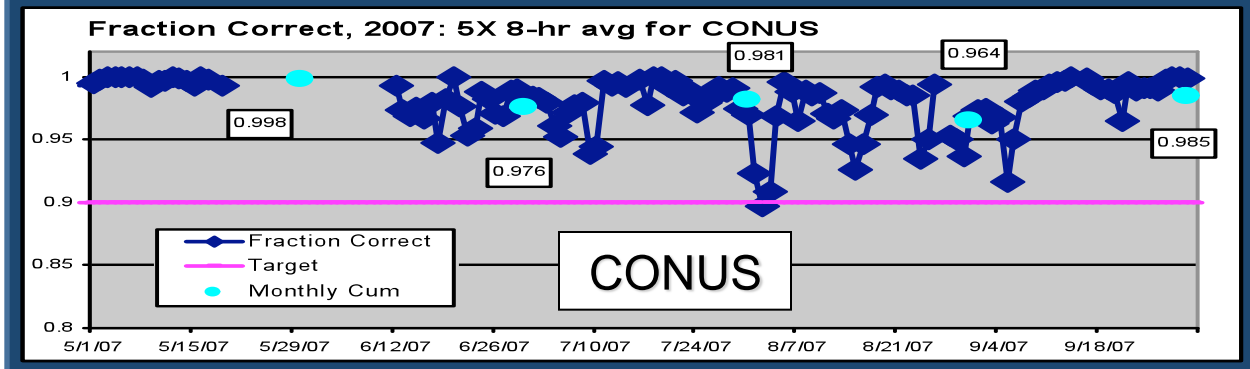
- Ozone, smoke coverage extended Nationwide
- Higher resolution prediction (4km)

Longer range:

- Quantitative fine particulate matter (PM2.5) prediction
- Extend air quality forecast range to 48-72 hours
- Include broader range of significant pollutants

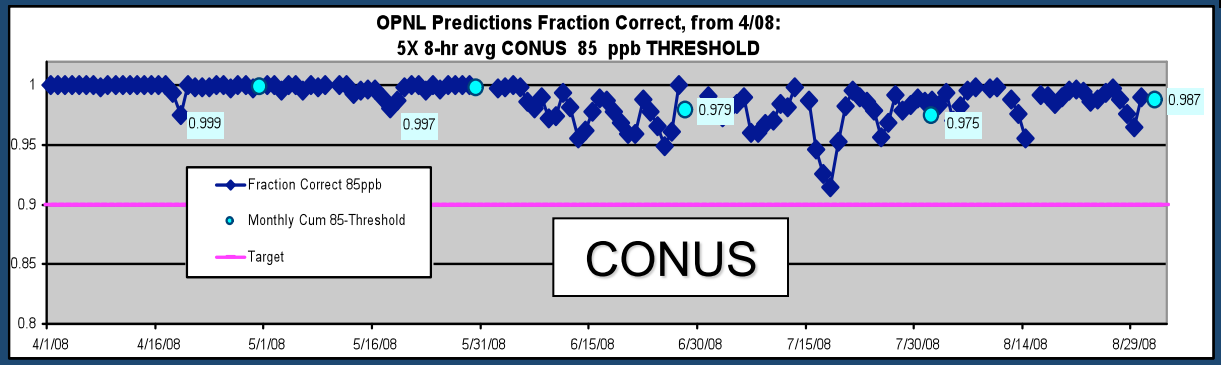
Ozone performance





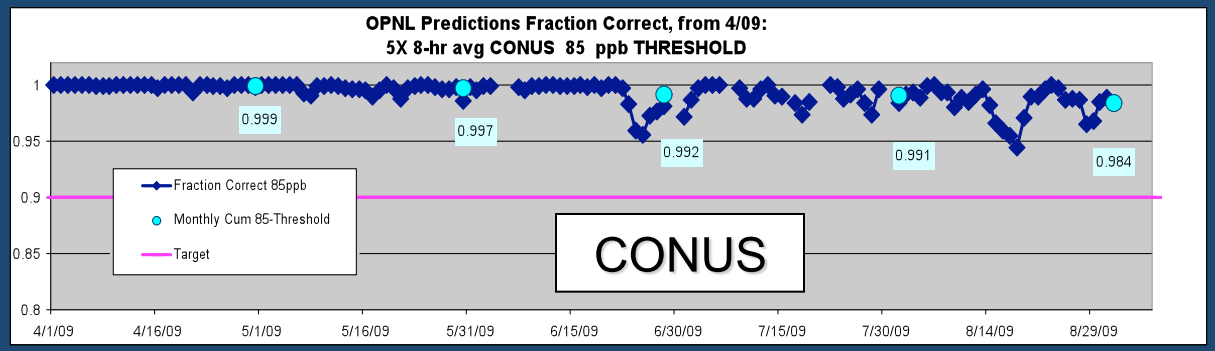
2007 Experimental

Contiguous US (CONUS) wrt 85 ppb threshold
Implemented 9/07



2008 Operational

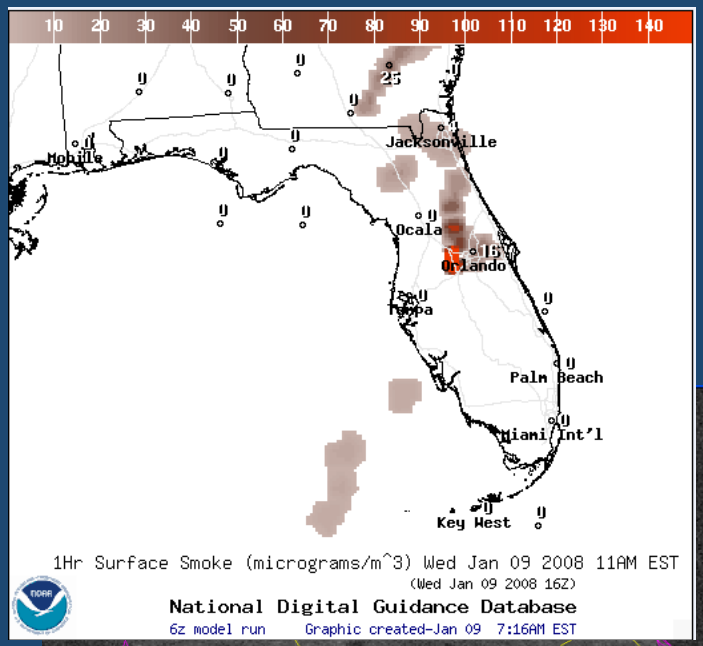
CONUS, wrt 85ppb Threshold

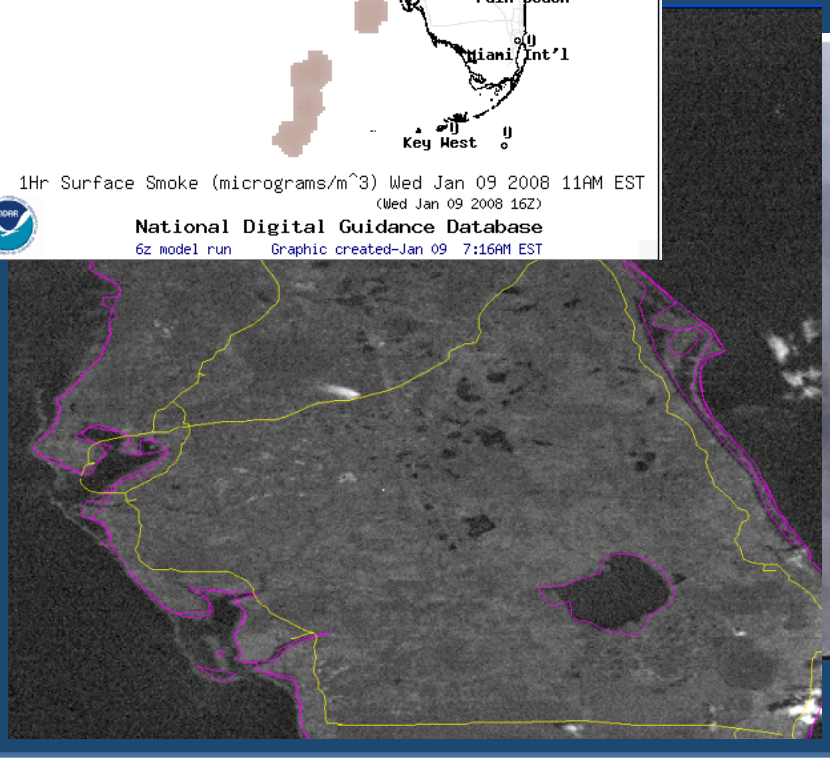


2009 Operational

CONUS, wrt 85ppb Threshold

Florida smoke





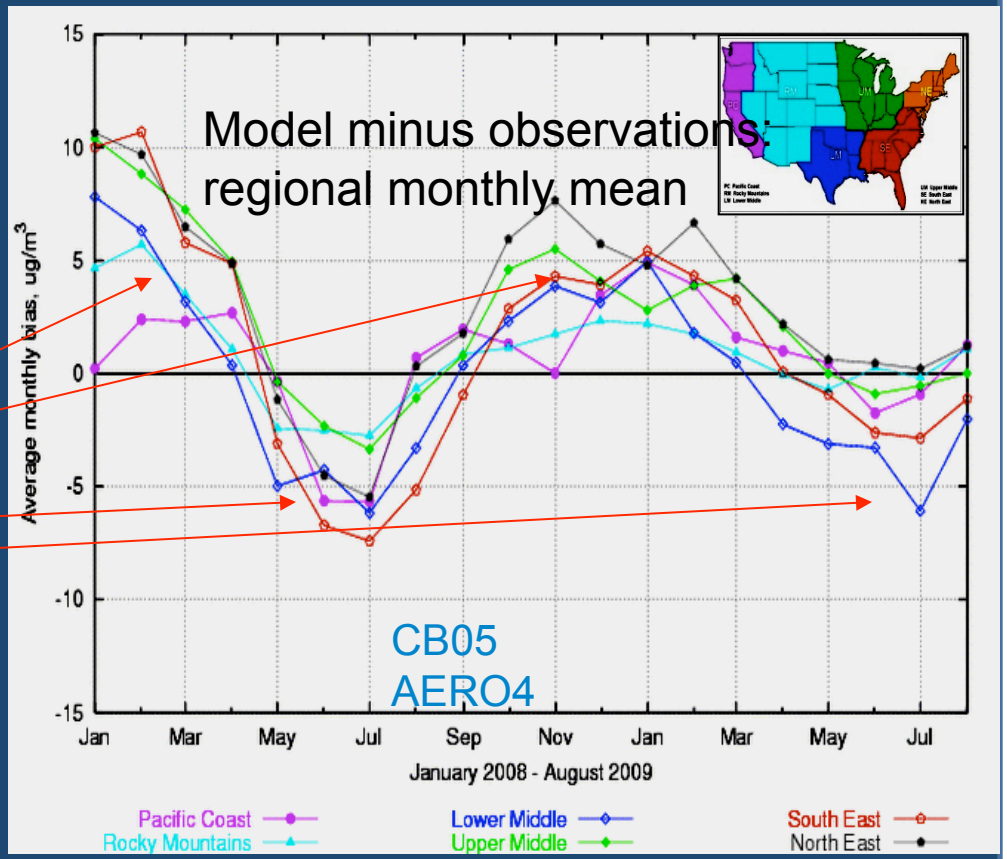
Florida, 1/09/08

- Dense morning smoke predicted near Orlando
- Accident on I-4 caused 50-vehicle crash with 3 fatalities
- Evacuation concerns for PM exposure: senior citizen facilities

Quantitative PM performance

Forecast challenges

- Aerosol simulation using emission inventories:
  - Show seasonal bias-- winter, overprediction; summer, underprediction
- Chemical boundary conditions/trans-boundary inputs
- Intermittent sources
- Impacts of 2-way chem-met coupling



Approach towards quantitative PM prediction

PM components

- Dust
- Smoke
- Chemical Boundary Conditions
- Chemical data assimilation
- Advanced Chemical Mechanism
- Emissions Inventory Inputs

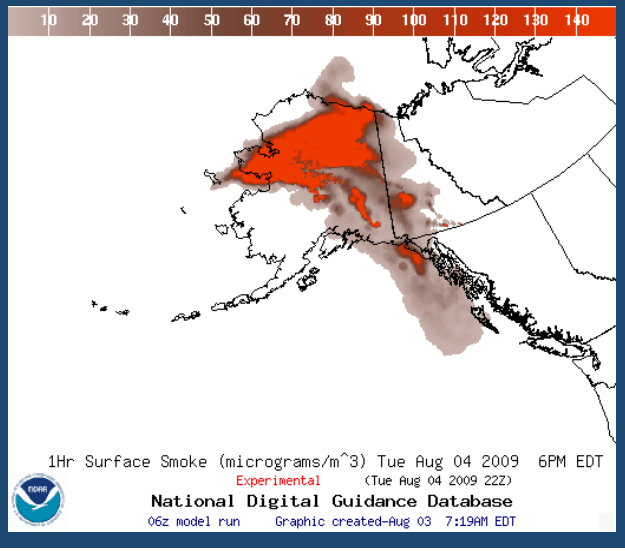
Integrated PM

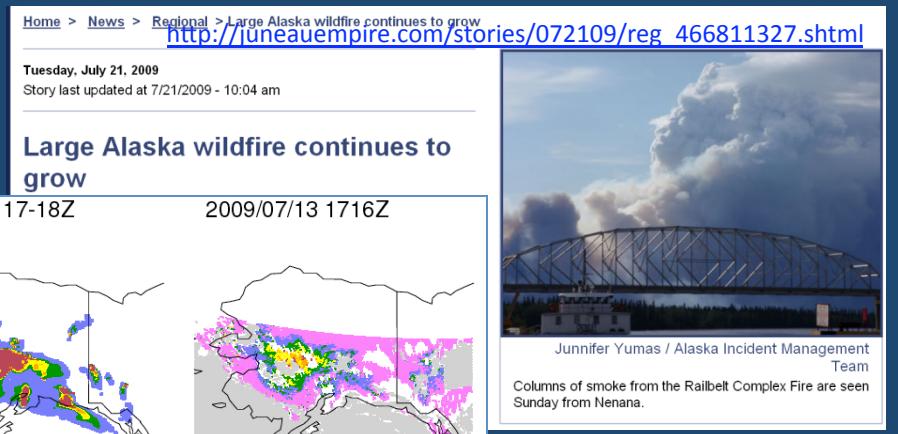
Progress on NOAA's PM2.5 Modeling for AQ Predictions

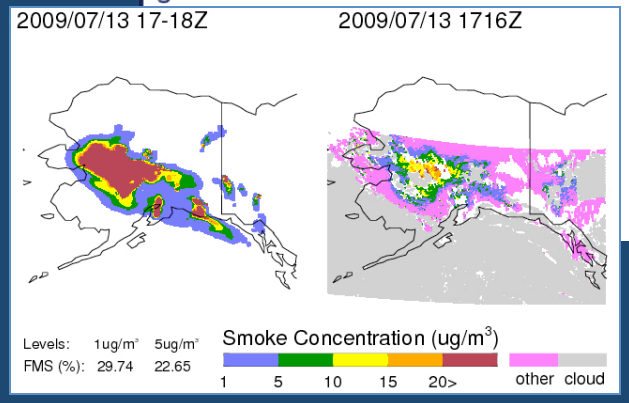
- Better representation of intermittent events (dust storms, forest fires)
- Dynamic boundary conditions
- Quantitative prediction of reactive components, especially secondary organic aerosols (SOA)
- Advanced chemical mechanisms: gas phase, aqueous phase
- Wet/dry deposition

Wildfire smoke

- Smoke forecasting system (Rolph et al 2009)
- Fire detection
- Plume rise (Stein et al 2009)
- Transport
- Impact on PM2.5 and ozone
- Modeling fire behavior
- Surface and profile observations of smoke



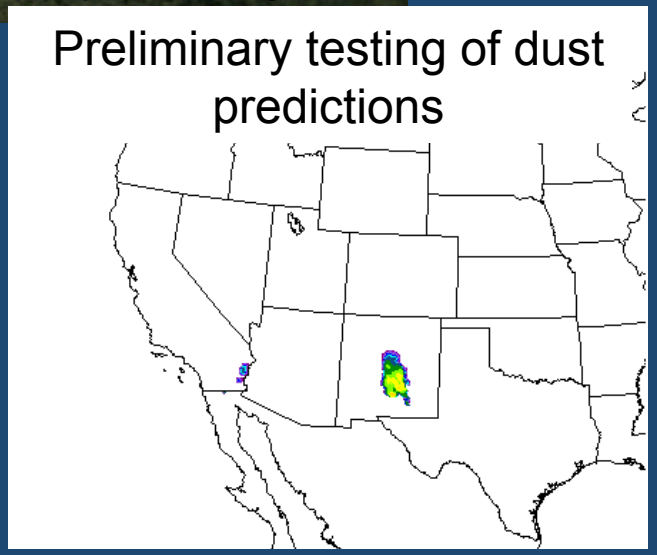




Dust storms

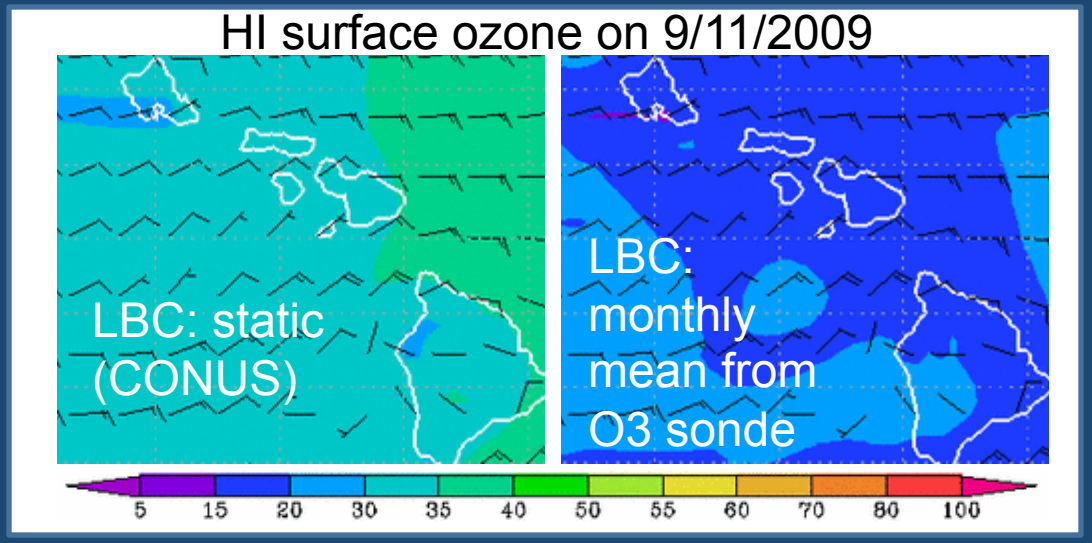
- Dust emission
  - soil type
  - wetness
  - roughness
  - wind speed
  - particle size distribution
- Transport (Draxler, in prep)
- Deposition
- Surface and profile observations

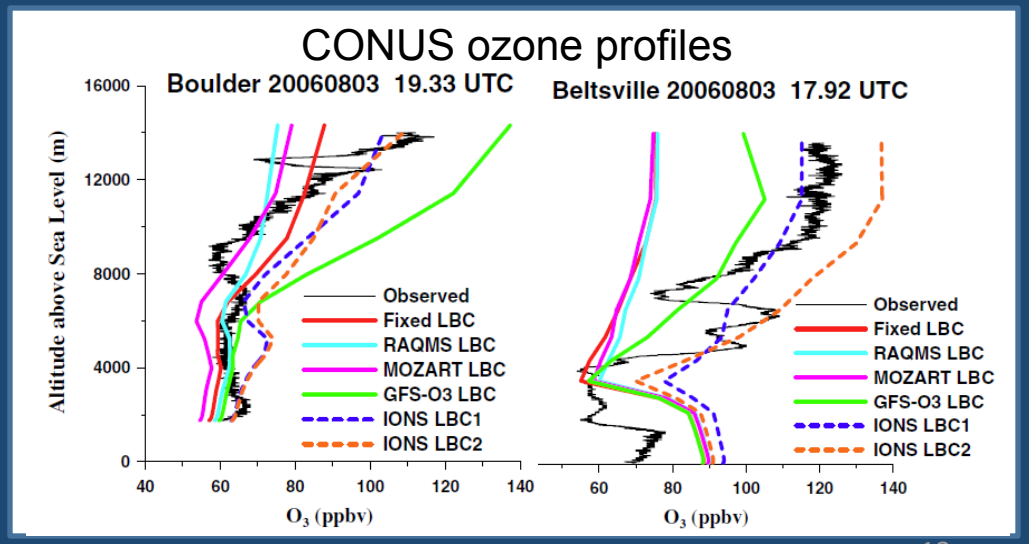
Dust storm approaching Stratford, Texas. Dust bowl surveying in Texas. NOAA George E. Marsh Album, www.photolib.noaa.gov



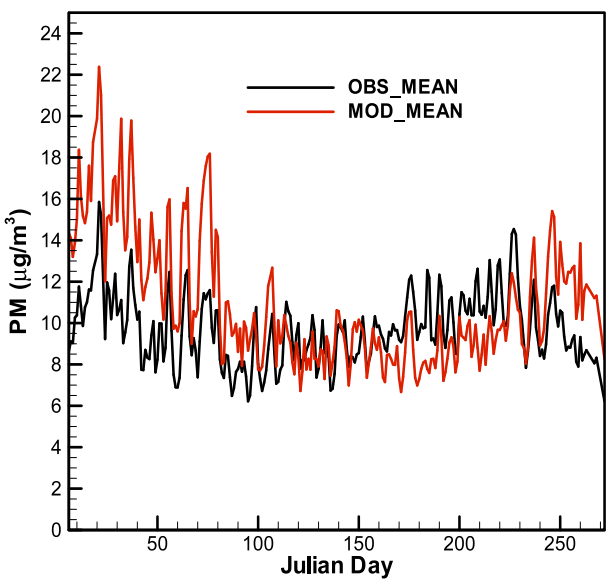
Chemical boundary conditions

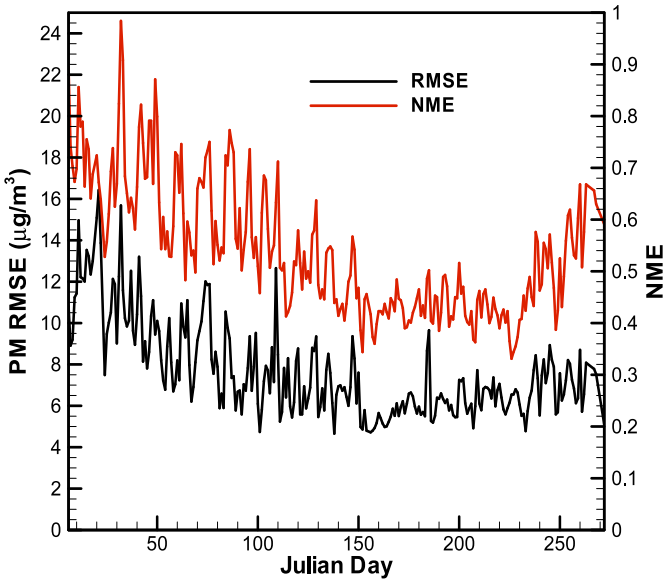
- Improved climatology (Hawaii ozone)
- Global models (ozone: Tang et al 2009, dust: Huang et al 2009)
- Global chemical data assimilation





Quantitative prediction of reactive components





- Aerosols: 2009 mean of daily developmental predictions for CONUS/ AIRNow data (Byun)
- (CB05/Aero4, Daily Max), emissions inventories inputs
- Improvement to chem. mechanism & inputs in progress

Chemical data assimilation

- Methods (3D-Var, 4-D Var, ensemble methods)
- Observations (in situ, remotely sensed)
- Distribution of integral increments (e.g. AOD, total PM2.5) into species, profiles
- Observed or retrieved variables
- Background and observation error covariance modeling, inclusion of model error
- Errors in emissions, non-random errors
- Infrastructure

Research needs for AQ Forecasting: Near Term

- Improved reactive chemical transport of species involved in production, transport, transformation, & removal of PM2.5
- Chemical boundary conditions
- Chemical data assimilation technology and infrastructure; improved modeling and analyses of emissions inputs
- Advanced chemical mechanisms, wet/dry deposition
- Continue improvement of atmospheric simulations of near-surface conditions

Research needs for AQ Forecasting: Longer-Term

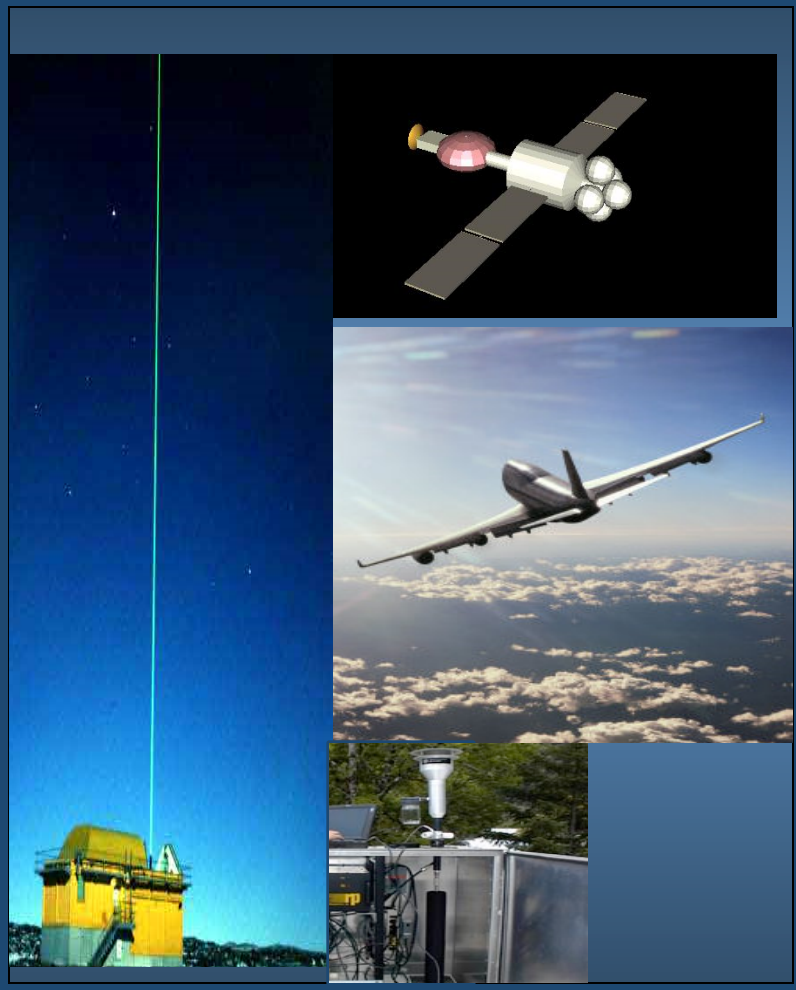
- Assimilation of new chemical observations
- Modeling of additional pollutants
- Coupling to broader range of environmental models

Additional, related research:

- AQ prediction will benefit from related advances in meteorological/ environmental modeling and ensemble generation, post-processing, atmospheric chemical observations

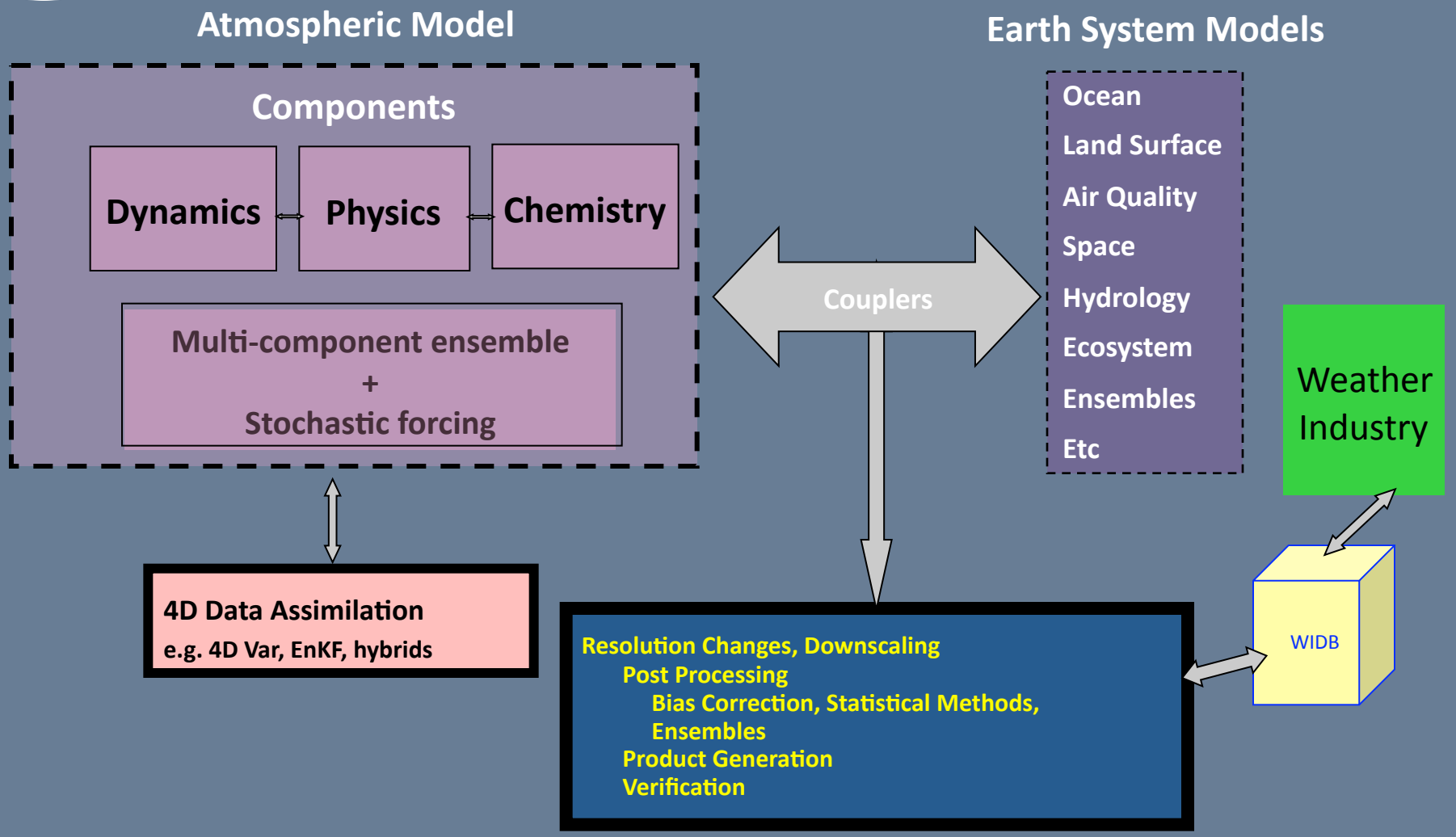
Integrated observations

- Speciated PM – need to be able to verify and constrain PM components
- Profiles – vertical distribution needed domain-wide
- Timeliness – for assimilation and for near-real-time verification



Chemical-meteorological model coupling

Integrated Environmental Modeling System Vision



National Air Quality Forecast Capability: Current Operational Links: Ozone

Numerical Weather Prediction

Real-time Weather Obs: Monitoring, Rem Sensed

Weather Data Assimilation

Boundary Conditions From Global Weather Model

Mesoscale Weather Model

Atm Chemical Data Assimilation: 3-D or 4-D

QC/QA

Real-time Chem Observations: In-Situ Monitoring, Rem Sensed

R-T Boundary Conditions, Trans-boundary transport Especially: Dust, Fires

Emissions Preprocessing

Pollutant Emissions Inventory

Numerical Chemistry Prediction

Chem Transport Model: PM + Ozone

Chem Transport Model: Ozone

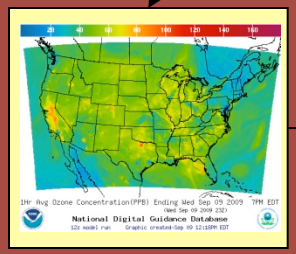
Product Generation

Verification

Continuous SCIENCE/TECH Infusion

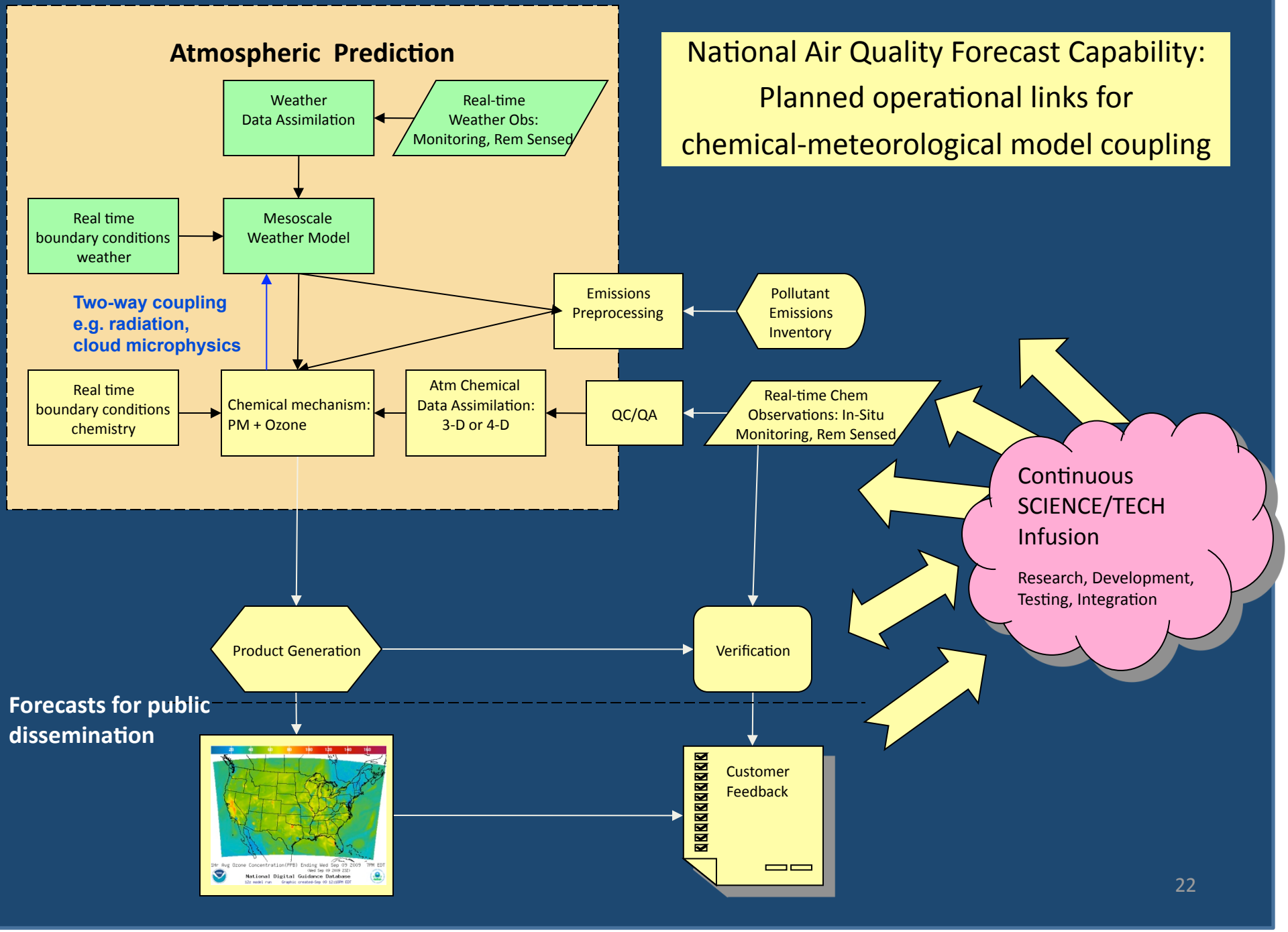
Research, Development, Testing, Integration

Forecasts for public dissemination



Custome r Feedback

National Air Quality Forecast Capability: Planned operational links for chemical-meteorological model coupling



Summary

- Operational ozone (CONUS) and smoke (CONUS, AK) prediction
- Completing nationwide prediction coverage
- Forecast challenge: quantitative PM2.5 prediction
- Approach: concurrent development of system components towards an integrated capability

Summary of Research needs

- Modeling PM, advanced chemical mechanisms
- Chemical boundary conditions
- Chemical observations and data assimilation
- Improved emissions inputs
- Coupling to other environmental models
- Modeling of additional pollutants