NWS Science and Technology Roadmap

Air Quality Forecasting

Team Composition

- Paula Davidson, NWS—Team Leader
- James Meagher, OAR/ESRL—Contributor
- Steve Fine, OAR—Contributor
- Daewon Byun, OAR—Contributor
- James Wilczak, OAR—Contributor
- Ivanka Stajner, NWS—Contributor

Vision/Benefits/Impacts

- **Focus Area Team Vision:**
  - Protect lives and property by providing accurate and timely AQ predictions to the Nation
- **Benefits**
  - People limit exposure to poor AQ based on accurate predictions of onset, severity and duration of poor AQ in cities, suburbs, rural areas alike
  - Local and state AQ forecasters use NWS' AQ predictions as improved basis for issuing AQ alerts
  - Basis for decision makers to take measures to protect AQ; e.g. action days for encouraging mass transit
  - Basis for power companies to switch to cleaner fuels

- **Impacts:**
  - Lives saved: reduction in >60,000/yr premature deaths due to poor AQ
  - Savings of >$500M from reduction of 0.5% in >$100B/yr in health cost of poor AQ

Goals/Targets:
Customer Needs

Goal	Outstanding Issues
Extend current ozone and smoke predictions nationally	Smoke and ozone predictions are in developmental and experimental testing for AK & HI
Quantitative predictions of fine particulate matter (<2.5 µm diameter; PM 2.5)	Further development of model components needed for quantitative prediction of PM2.5
Extend to at least 2 days (up to 5 days)	Meteorological predictions available for up to 5 days. Improve accuracy of AQ predictions. Better representation of interregional transport.
Prediction of additional pollutants of concern	EPA assessment of health and welfare impacts to date has focused on ozone and PM2.5
Higher resolution prediction information (as fine as 2.5 km) will capture increasing resolution of operational meteorological models	Current resolution is 12 km. Preparing for testing at 4 km resolution.

Goals/Targets:
Emerging Science & Technology

Goal/Target	Outstanding Issues
Sufficient accuracy in modeling of PM2.5 components to allow accurate prediction of total PM2.5	Quantitative prediction of reactive components, especially secondary organic aerosols. Better representation of intermittent events (dust storms, forest fires) and boundary conditions.
Assimilation of expanding atmospheric chemistry observations	Capability for assimilation of chemical constituents and aerosols needs to be developed.
Increasing accuracy of AQF (for PM and ozone) for weakly forced meteorological conditions, where sensitivity to small variations in predicted meteorological parameters is very high	In coordination with modeling enabling and observational capabilities. Focus on conditions with weak forcing e.g. stagnations and boundary layer structure in transition zones. Meteorological models under conditions conductive to poor AQ (winds, stagnant boundary layer) need improvement.
Inform observing system design to improve AQF	Advanced data assimilation methods and infrastructure needed for observing system sensitivity analyses.
Quantify uncertainty	Computational capacity. Technique for generating uncertainty estimates.
Prediction of volcanic ash	Operational prediction in aviation weather.

Key Information Gaps

Gap	Solution Alternative	Impact
1 Quantitative prediction of PM2.5	1.1 Extend ozone and smoke prediction capability to provide PM2.5 prediction 1.2 Leverage other countries' capabilities 1.3 Implement extended capability without increasing NCEP computing resources 1.4 Status quo	1.1 Nationwide prediction 1.2 Prediction over limited area 1.3 Adverse impact on availability or timeliness of AQ or weather prediction 1.4 No prediction
2 Extend prediction to at least 2 days (up to 5 days)	2.1 Infuse new science to improve chemical simulation and meteorological forecast to allow current prediction accuracy over longer timescales 2.2 Use existing technology and extend forecast range.	2.1 Meet customer driven accuracy requirement. Extend application to additional customers (e.g. power industry). 2.2 Reduced accuracy over extended forecast range

Key Information Gaps

Gap	Solution Alternative	Impact
3 Prediction of additional pollutants of concern	3.1 Add predictive capability for additional species beyond current capability 3.2 Add derived variables (e.g. regional haze) to current predictive scheme 3.3 Report additional species from the existing scheme	3.1 Additional health and/or welfare guidance available to the public and decision makers 3.2 Haze: reduced losses to tourism 3.3 Specific impact will depend on species of concern
4 Higher resolution prediction information (as fine as 2.5 km)	4.1 Improve physics and chemistry to represent processes on finer scales 4.2 Use existing parameterizations for capturing finer scale variability	4.1 Provides information to help pinpoint places/times with poor AQ. 4.2 No ability to improve simulation of local-scale processes that can have major influence on AQ like thunderstorms
5 Quantifying societal benefits from improved AQF	5.1 Design and fund scientific studies to quantify the impacts. 5.2 Rely on existing and planned studies.	Better targeted investments for improving AQF.

Research Needs and Opportunities

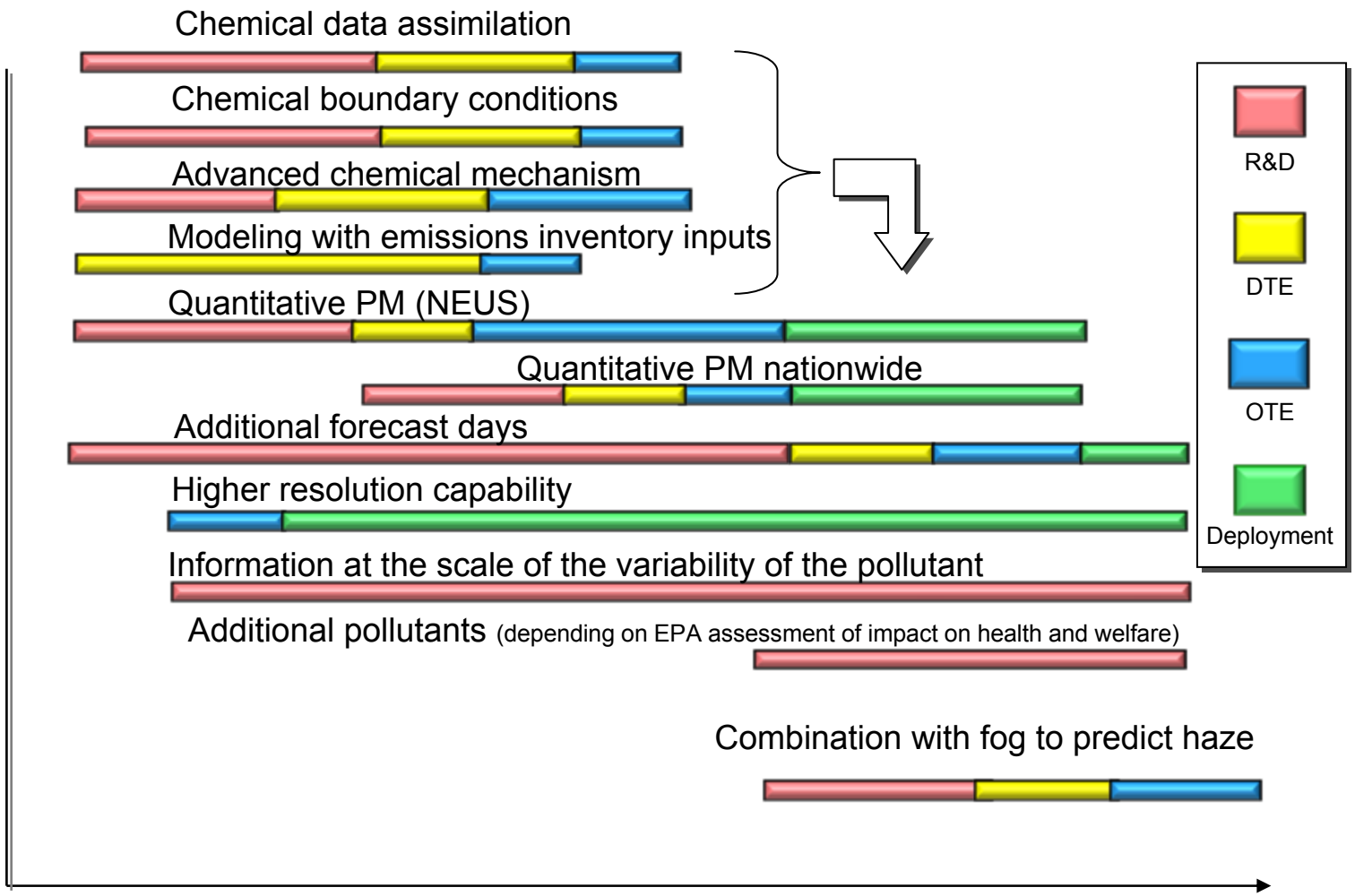
- **Near-term**
  - Modeling PM2.5
  - Chemical boundary conditions
  - Chemical data assimilation technology and infrastructure
  - Advanced chemical mechanisms, wet/dry deposition
  - Improved modeling and analyses of emissions inputs
  - Continue improvement of atmospheric simulations of near-surface conditions
- **Long-term**
  - Chemical data assimilation of new chemical observations
  - Modeling of additional pollutants
  - Coupling to broader range of environmental models
- **Additional outstanding research needed**
  - AQF will benefit from related advances in meteorological simulations, fire behavior, observation, etc.

AQF Alternative Solutions

Observations
Data Assimilation

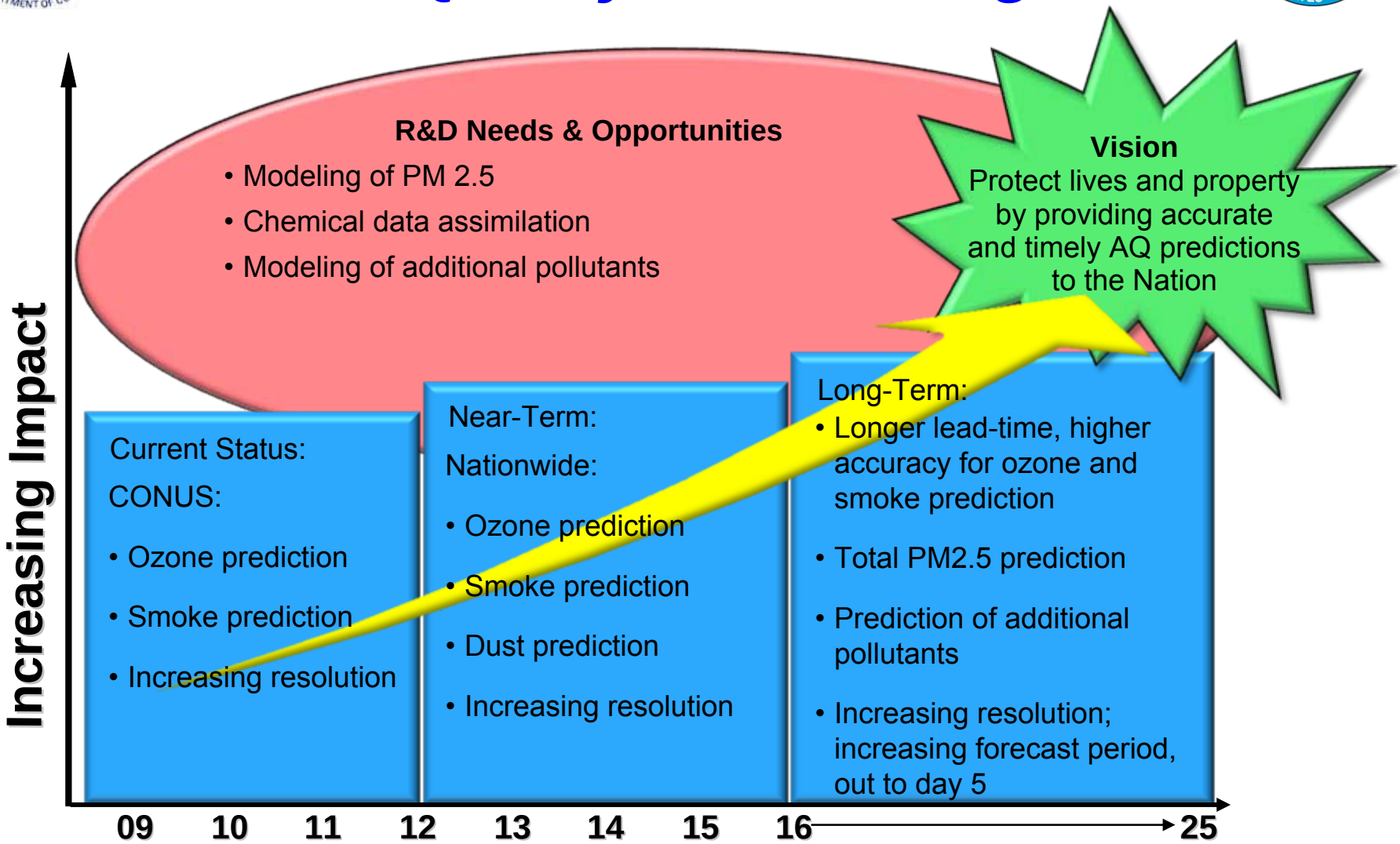
Forecasting:
Model

Decision Support
Services



AQF

Focus Area Team Summary: Air Quality Forecasting



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AQF Team Additional Information

Target Performance Measures: AQF

Proposed	Current (2009)	FY 2016 Target Example	FY 2025 Target Example
Ozone prediction accuracy	90% based on warning level	90% based on warning level	95% based on warning level
Ozone on-time delivery	95% on-time delivery	95% on-time delivery	95% on-time delivery
PM2.5 components prediction accuracy	Smoke: 8% FMS score for concentration >1µg		
PM2.5 components on-time delivery	95% on-time delivery		
Total PM2.5 prediction accuracy	None	90% based on warning level	93% based on warning level
Total PM2.5 on-time delivery	None	95% on-time delivery	95% on-time delivery

*Verification is based on EPA real-time air quality monitoring data. Accuracy is based on confirming prediction above/below EPA's health based warning threshold.

Target Performance Measures: AQF

Proposed	Current (2009)	FY 2016 Target Example	FY 2025 Target Example
Extended forecast (days 2-5) prediction accuracy	None	Day 2: 90% based on warning level	Day 5: 85% based on warning level
Extended forecast (days 2-5) on-time delivery	None	Day 2: 95% on-time delivery	Day 5: 95% on-time delivery
Other pollutants of concern (TBD) prediction accuracy	None	None	90% based on warning level
Other pollutants of concern (TBD) on-time delivery	None	None	95% on-time delivery

*Verification is based on EPA real-time air quality monitoring data. Accuracy is based on confirming prediction above/below EPA's health based warning threshold.

Backup

Target Quantitative PM Prediction Capability

Program Requirements	FY09	Note	FY10	FY11	FY12	FY13	FY14	FY15	FY16
PM:Components									
Smoke	CONUS O&M, Begin ET&E HI 3Q	HI Q3 AK Q4	Nation: 48 hr						
Dust	Begin ET&E CONUS		CONUS: 48 hr						
Chemical Boundary Conditions							ET&E CONUS 3Q		
Data Assimilation									
Advanced chemical mechanism						Begin ET&E NEUS			
Emissions inventory inputs						Begin ET&E NEUS			
PM: Integrated Capability									
Quantitative PM IOC (NEUS)					Initiate PM DT&E	Initiate PM ET&E	NE: 24 hr	NE:O&M; CONUS ET&E	CONUS
Quantitative PM: Nationwide							AK, HI	Nation ET&E	Nation: 24 hr

R&D	Research & Development
DT&E	Developmental Testing/Evaluation
E T & E	Experimental (Pre-Operational) Testing/Evaluation
O & M	Operations & Maintenance

Target Quantitative PM Prediction Capability

Program Requirements	FY09	Note	FY10	FY11	FY12	FY13	FY14	FY15	FY16
PM Components									
Smoke	CONUS O&M Begin ET&E HI 3Q	HI 3Q AK Q4	Nation: 48 hr						
Dust			CONUS: 48 hr						
Chemical boundary conditions							ET&E CONUS 3Q		
Data assimilation									
Advanced chemical mechanism						Begin ET&E NEUS			
Emissions inventory inputs						Begin ET&E NEUS			
PM: Integrated Capability									
Quantitative PM IOC (NEUS)					Initiate PM DT&E	Initiate PM ET&E	NE: 24 hr	NE: O&M CONUS ET&E	CONUS
Quantitative PM: Nationwide							AK, HI	Nation: ET&E	Nation: 24 hr

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Enabling Capability Linkage Items

1. Meteorological models performance (especially planetary boundary layer)
2. Chemical-meteorological model coupling
3. Integrated observations (speciated PM2.5, vertical profiles are needed for assimilation and verification)
4. Data assimilation methods and infrastructure
5. Global model coupling: chemical boundary conditions for AQF