Smoke Forecast Tool for Alaska:

New Guidance in National Air Quality Forecast Capability

Operational Readiness Summary

September 29, 2009

Outline

- **Background**
  - *Air Quality Forecast Program Goals, Planned Capabilities*
  - *Implementation Schedule*
- **Review operational readiness**
  - *Readiness Criteria (OST)*
  - *Objective verification (NCEP)*
  - *Subjective feedback (OCWWS)*
  - *Production readiness (OCIO)*
  - *Summary (OST)*
- **Deployment Recommendation and Implementation**

Background

National Air Quality Forecast Capability

Vision and Strategy

Vision

National Air Quality Forecast Capability which provides the US with ozone, particulate matter and other pollutant forecasts with enough accuracy and advance notice to take action to prevent or reduce adverse effects

Strategy

Work with EPA, State and Local Air Quality agencies and private sector to develop end-to-end air quality forecast capability for the Nation

National Air Quality Forecast Capability
Current and Planned Capabilities, 8/09

FY09 Prediction Capabilities

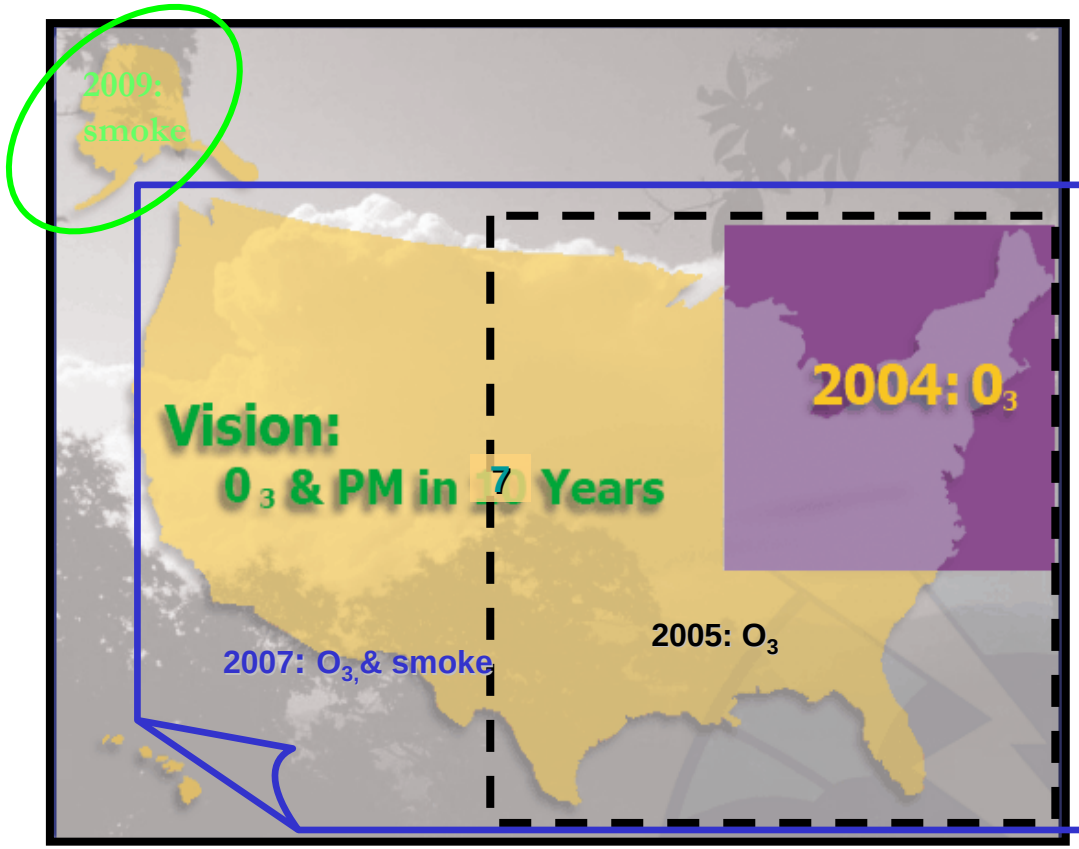
- Operations:
  Ozone and smoke for CONUS,

Near-term Operational Targets:

- Ozone, smoke coverage extended Nationwide

Longer range:

- Quantitative $PM_{2.5}$ prediction
- Extend air quality forecast range to 48-72 hours
- Include broader range of significant pollutants



Smoke Forecast Tool for Alaska:
A step toward quantitative PM predictions

- ***Required for particulate matter (PM) forecasts***
  - **Fire emissions significant source of fine particle pollution (PM2.5)**
  - **Direct (e.g. soot) and indirect (from secondary reactions) contributions**
  - **Large fires locally dominate PM**
  - **Challenges: how much and how far do fire emissions contribute to PM2.5?**
- ***Real-time information on fire emissions essential***
  - **Inventory-based aerosol component tests for PM forecasting during summer fireseason consistently underpredict: errors ~ 2-5 X**
  - **Wildfire smoke sources too large and variable for success with inventory-based, climatological approximations**
- ***Effectively leverages existing capabilities***
  - **NOAA/NESDIS observations of fire locations, extent**
  - **USFS estimates for wildfire smoke emissions based on vegetation cover**
  - **NOAA/OAR expertise in dispersion prediction: HYSPLIT**
  - **Scalable for CONUS, AK, HI, North American and global domains as needed**

Smoke Forecast Tool for Alaska
End-to-End Capability

Model Components: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

- NCEP mesoscale NWP: WRF-NMM
- NOAA/OAR HYSPLIT dispersion for smoke transport

Observational Input:

- NWS real-time weather observations
- NESDIS fire locations/extent

Gridded forecast guidance products

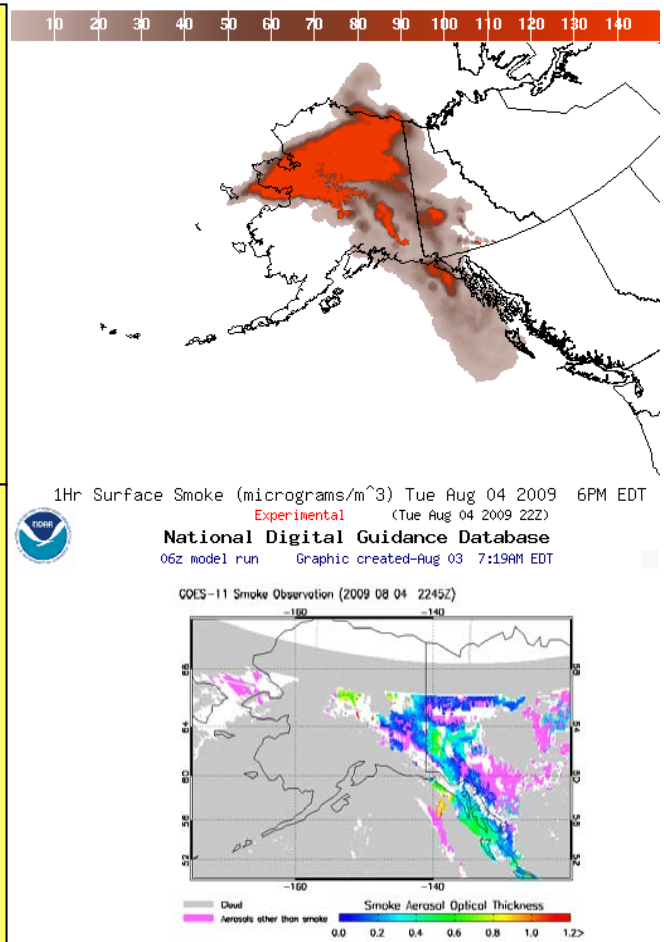
- On NWS Telecommunications Gateway and NDGD
- Updated each day, 6Z cycle, available by 13Z

Routine verification basis

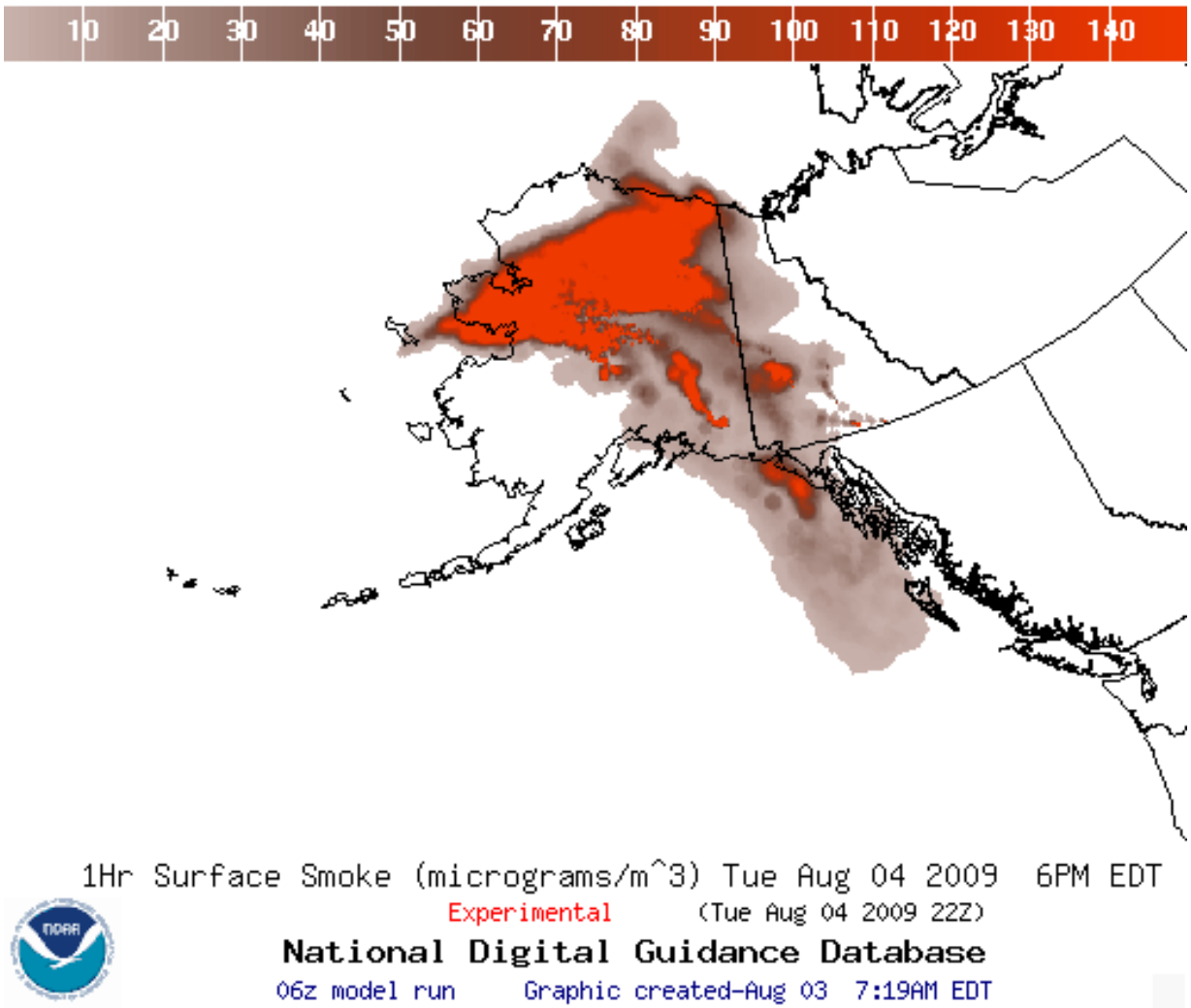
- Near real-time NOAA/NESDIS smoke-column product

Customer outreach/feedback

- NOAA/NWS field forecasters
- State&Local AQ forecasters, coordinated with EPA
- Public and Private Sector AQ constituents



Sample smoke forecast guidance for Alaska



- **Experimental Testing: from August, 2009**
- **Fire Locations and verification based on satellite observations**
- **Fire emissions estimates from USFS (BlueSky)**
- **HYSPLIT/WRF-NMM transport**

Verification Approach: Alaska Smoke

Objective verification product developed for NWS:

- **First real-time verification for wildfire smoke in Alaska in daily use**
- **Based on NOAA/NESDIS satellite imagery:**
  - *GOES Aerosol Smoke Product (GASP)*
  - *Smoke from identified fires only*
- **Filtered for interference:**
  - *Clouds, surface reflectance, solar angle, other aerosol*
- **"Footprint" comparison:**
  - *Threshold concentration (1 μg/m³) for average smoke in the column*
  - *Tracking Threat scores, or Figure-of-merit statistics:*

    (Area Pred ∩ Area Obs) / (Area Pred. U Area Obs)

Initial skill target set at 0.08 checked with independent analysis in earlier methods:

  - *Analysts isolate smoke in GOES-based NESDIS Hazards Mapping System (HMS)*

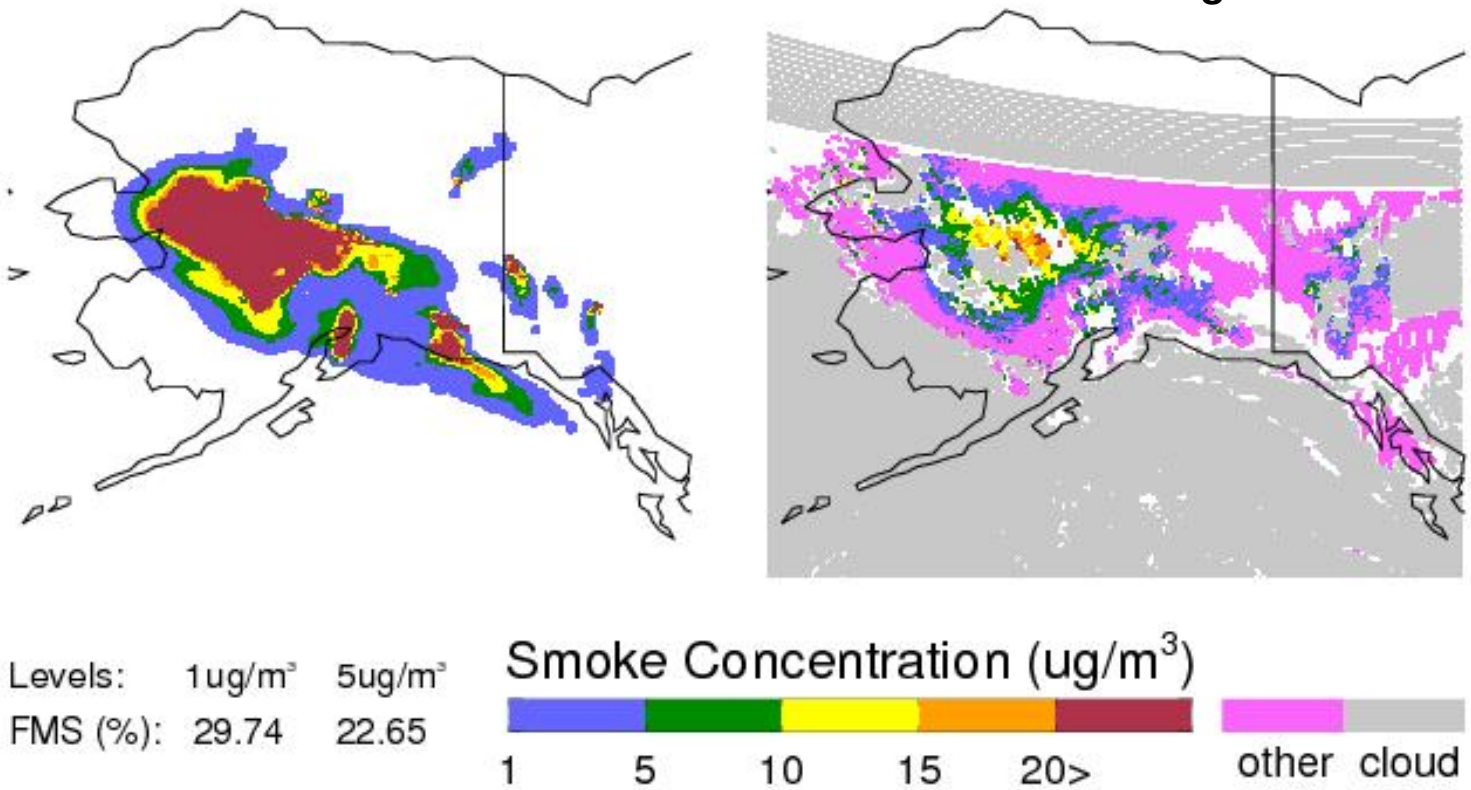
Sample Smoke Verification:
July 13, 2009

7/13/09, 17-18Z, Prediction:

7/13/09, 17-18Z, Observation:

GOES smoke product: Confirms areal extent of peak concentrations

FMS = 30%, for column-averaged smoke > 1 ug/m^3



Review of Operational Readiness

Smoke Forecast Tool for Alaska:
Operational Readiness Criteria Summary

Criterion	Lead	Metric	Dates	Status 9/09
Objective Evaluation: Accuracy	*NCEP*	*> 8%*	*5/27/08 – 8/14/09*	C
Subjective Feedback	*AR, OCWWS*	*Positive on balance*	*5/1/09 – 8/14/09*	C
Production Readiness	*OCIO, NCEP*			C
On-time delivery		*> 95 %*	*5/1/09 –8/14/09*	C
Back-up		*In place*	*5/1/09*	C
Data retention		*In place*	*5/1/09*	C
Near-real time verification*	*NCEP*	*In place*	*5/1/09 (at OAR)* *TBA (at NCEP)*	C
Final go/no go decision	*NWS*		*Review date*	G

* NESDIS automated (objective) product

Key	Complete	On schedule	At risk	Remedial Action Required

Objective Verification (NCEP, OAR)

Criterion	Metric	Dates	Status
Objective Evaluation: Accuracy	Prediction overlap (FMS) > 8 % for 24-hr prediction that smoke concentration ≥ 1 µg/m³ in total column	5/1/09 – 8/14/09	C

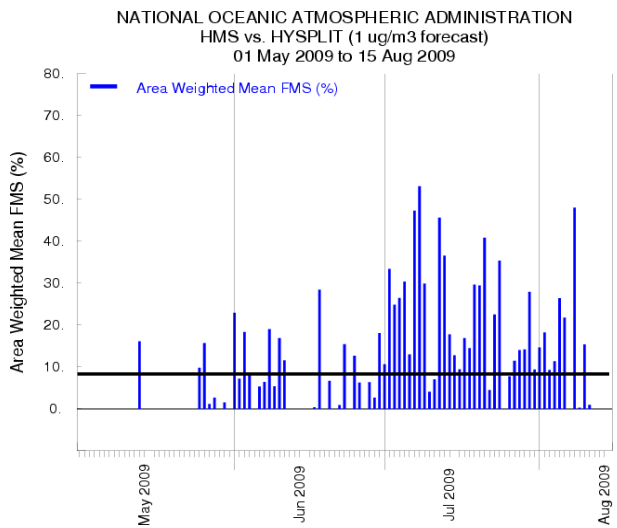
Summary Performance, based on new GASP-based product, 7/1/09 – 8/14/09

- **Automated product provides objective basis for daily verification**
- **Exceeds target 40/ 45 days. Wildfire activity curtailed 8/14 (weather change)**
- **Cumulative FMS (>1 ug/m^3)= 16 %**

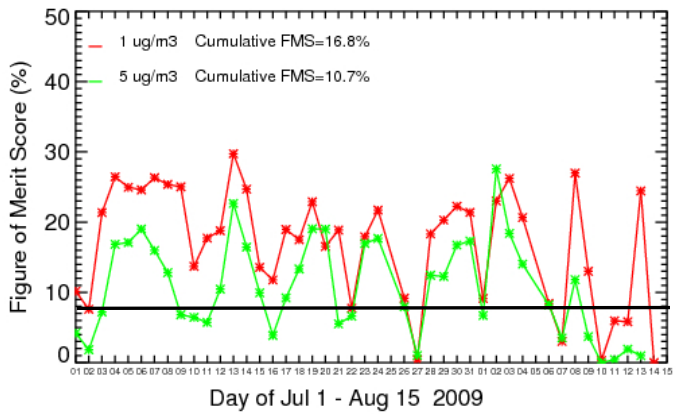
Comparison with daily HMS analysts' product :

- **Comparison to HMS: slightly lower FMS, but higher during periods of active fires**

Comparison with HMS analysis



GASP Smoke-based Verification



Subjective Feedback (AR, OCWWS)

Criterion	Metric	Dates	Status
Subjective Feedback	*External feedback from State/Local AQ forecasters support product as helpful.* *Other feedback: internal, constituent, general public: On Balance, positive*	*6/1/09 – 8/15/09*	C

Feedback Sources:

- **Feedback link from NDGD**
- **State and Local AQ forecasters**
- **NWS field forecasters**
- **Constituent group**
- **Other responses/comments on experimental products**

Subjective Feedback:
Other responses/comments on experimental products

Responders represented a mix of public, AQ forecasters, and researchers from a dozen states including all NWS CONUS Regions.

Sample Comments:

- ***"I** of course love all guidance products for Alaska! We tend to focus too much on CONUS issues… this is an important step forward in smoke guidance for Alaska users."*

- *"Alaska Region supports moving forward for operational deployment of the Alaska smoke forecast tool."*

No negative comments received

Production Readiness

Criterion	Lead	Metric	Dates	Status 8/09
On-time delivery	OCIO	Forecast guidance available by 1300 UTC (primary) > 95%	5/1/09 – 8/14/09	C
Ftpserver	OCIO		5/1/09 – 8/14/09	C
NDGD server	OCIO, MDL		5/1/09 – 8/14/09	C
Back-up	OCIO	In place	5/1/09	C
Product archiving	OCIO	In place	5/1/09	C
Near-real time verification	NCEP	In place	5/1/09 (at OAR)	C

Production Readiness (OCIO, NCEP)

On-time delivery

Criterion	Metric	Dates	Status
On-time delivery	Forecast guidance available by 1255 UTC > 95%	5/1/09 – 8/14/09	C
Guidance availability on NDGD	Forecast guidance available on NDGD by 1300 UTC > 95%	5/1/09 – 8/14/09	C
Guidance Back-up	NCEP backs up as part of NCEP model backup	5/1/09	C
NESDIS fire locations product delivered on time	Delivered to NCEP/NCO daily: target 10 UTC	5/1/09	C
NESDIS GASP observation product delivered on time	Delivered to NCEP/NCO in near real-time*: target within 1 hr of satellite pass	9/15/09	G
IT infrastructure Back-up	NESDIS ,CCS, TOC and interfacility communications links fully backed up. Reliability of comms links > 99.99%.	5/1/09	C

* Running pre-operationally at NESDIS from 8/4/09

Experimental Smoke Data Availability

- **Monitored Data Flow Receipt from the TOC To NWS Web Farm**
  - *Data flow tracked from 5/1/09 – 8/14/09*
  - *Reviewed forecast guidance availability from system logs, graphical interface displays*
- **Availability must meet program criteria: Forecast guidance available by 1300 UTC > 95%**

  STATUS

  - *Availability at TOC FTP Server:* **GREEN**
  - *Data Archive at NCDC:* **GREEN**
  - *Guidance Availability at NDGD:* **GREEN**
  - *Timely Display on the NWS Web Farm:* **GREEN**

Production Readiness (NCEP)

Near-real time verification

Criterion	*Metric*	*Dates*	*Status*
Near-real time verification	***Daily; for 24-hour forecast interval 0700-0600 UTC by 48 hours after end of forecast interval.***	***5/1/09 (at OAR)***	C

- ***Verification Statistics:*** *Compiled and maintained by NCEP. Updated daily*
- ***Availability:*** *Model developer group*
- ***Seasonal summary:*** *Available on AQ program web site (public)*
- ***Weekly verification:*** *Reports on operational performance measures provided by NCEP to OST PM*
- ***NESDIS tailored GASP product:*** *Formatted as gridded WMO standard GRIB files*

  Sent daily to NCEP for model verification; future assimilation

Summary:
Experimental Production of AQ forecast guidance for IOC

- **September 2009 Status: ……general…**
  - *HYSPLIT predictions capture smoke transport from fires -- especially for agricultural, prescribed and large wildfires*
  - *Timing/location of plumes predicted; little quantitative concentration verification available other than column-wide*
- **Objective verification:** G
  - *Accuracy performance targets achieved*
- **Subjective feedback:** G
  - *Generally positive*
  - *Focus group forecasters providing additional feedback; additional feedback links posted on graphical display sites*
- **Production readiness:** G
  - *Forecast guidance available on time*
  - *Backup, data retention and verification demonstrated*

Future Science Infusion

NOAA planning for improvements to the smoke forecast capability

- Addition of reactive transport of all estimated fire species within particulates forecast testing
- Global inputs from fires to be incorporated in GFS

Continuing R&D required

- OAR working actively with NWS to provide prototype capabilities for pre-operational development, testing experimental production, and implementation
- USFS improvements to operational fire emissions estimates (Bluesky) ongoing

Assuring quality with science peer reviews:

- Design review of major system upgrades (initial, yearly upgrades)
- Diagnostic evaluations with field campaigns and evaluations
- Publication of T&E in peer-reviewed literature
  - ***Prados, A et al.,J. of Geophys. Res., 112, D15201, doi:10.1029/2006JD007968, 2007***
  - ***Kondragunta. S., et al., J. of Applied Meteorology and Climatology, doi:10.1175/2007JAMC1392.1, 2008***
  - ***O.Neill, et al., Developments in Environmental Science Series, Vol. 8, Elsevier, 499-534, 2008***
  - ***Christopher, S., et al., IEEE J. of Selected Topics in Applied Earth Sciences and Remote Sensing, accepted, 2009***
  - ***Rolph et al., Weather and Forecasting, Volume 24, pp 361-378, 2009.***
  - ***Stein et al., Weather and Forecasting, Volume 24, pp. 379-394, 2009.***

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Deployment

Recommendation:

Based on demonstrated acheivement of operational readiness criteria, NWS deploy smoke forecast guidance for Alaska as a new air quality component of operational product suite

Approved: OST, AR, NCEP, OCWWS, OCIO

Implemented into operations: 29 Sept 2009

Backup

Smoke Forecast Tool for Alaska

Major Components

NWP Model

NAM / WRF-NMM

NOAA / NWS

Weather Observations

NWP Post-processors for AQ Modules

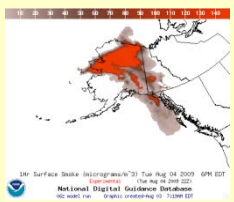
NESDIS HMS Fire Locations

HYSPLIT Module:

NOAA / OAR

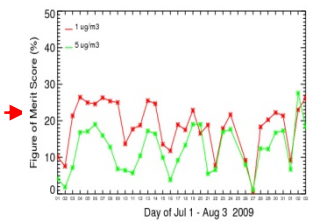
USFS's BlueSky Emissions Inventory:

USFS



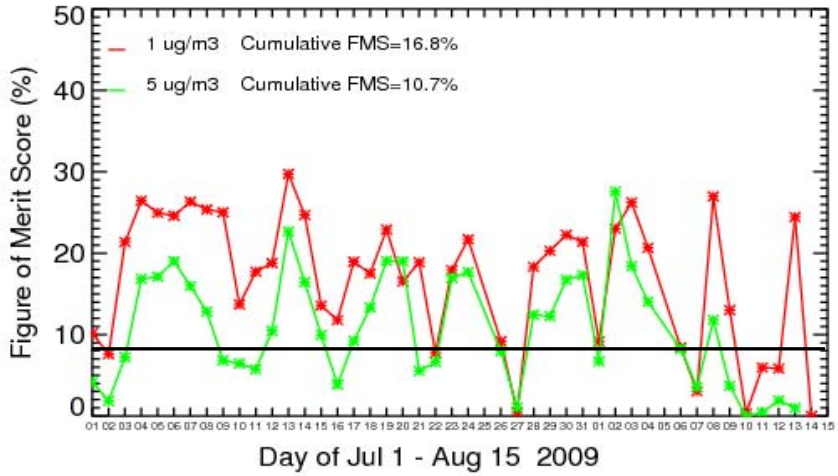
Verification:

NESDIS/GASP Smoke

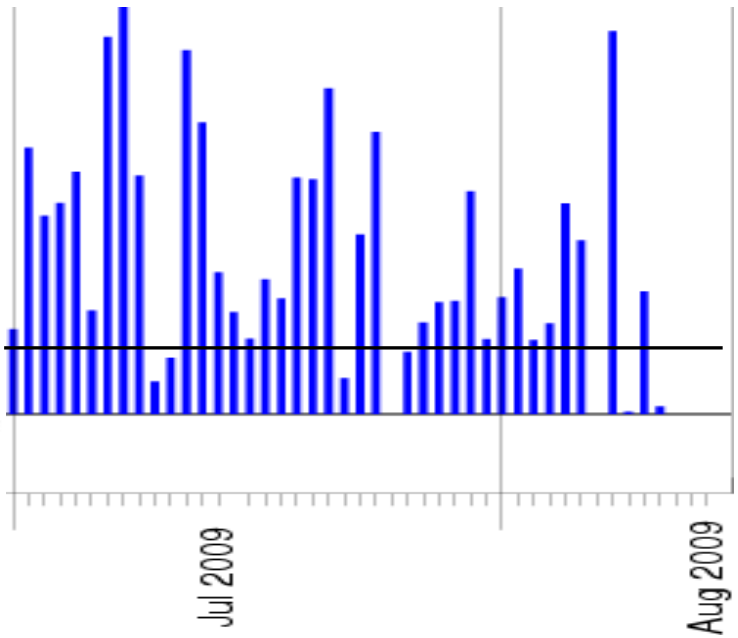


Comparison Statistics:

Automated and Analyst-Provided Smoke, 7/1-15/09



Predictions vs automated GOES Smoke Observations



Predictions vs HMS Analysis

Average of Hourly Threat Scores (1 ug/m3, area weighted)