Smoke Forecast Tool for Hawaii:

New Guidance in National Air Quality Forecast Capability

Operational Readiness Review

February 12, 2010

Purpose of Readiness Review

Obtain Corporate approval for operational deployment of the smoke forecast tool for Hawaii as new forecast guidance in the Air Quality Forecast Capability

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)*
- **Recommendation**

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, 2/10

Prediction Capabilities, 2/1/10

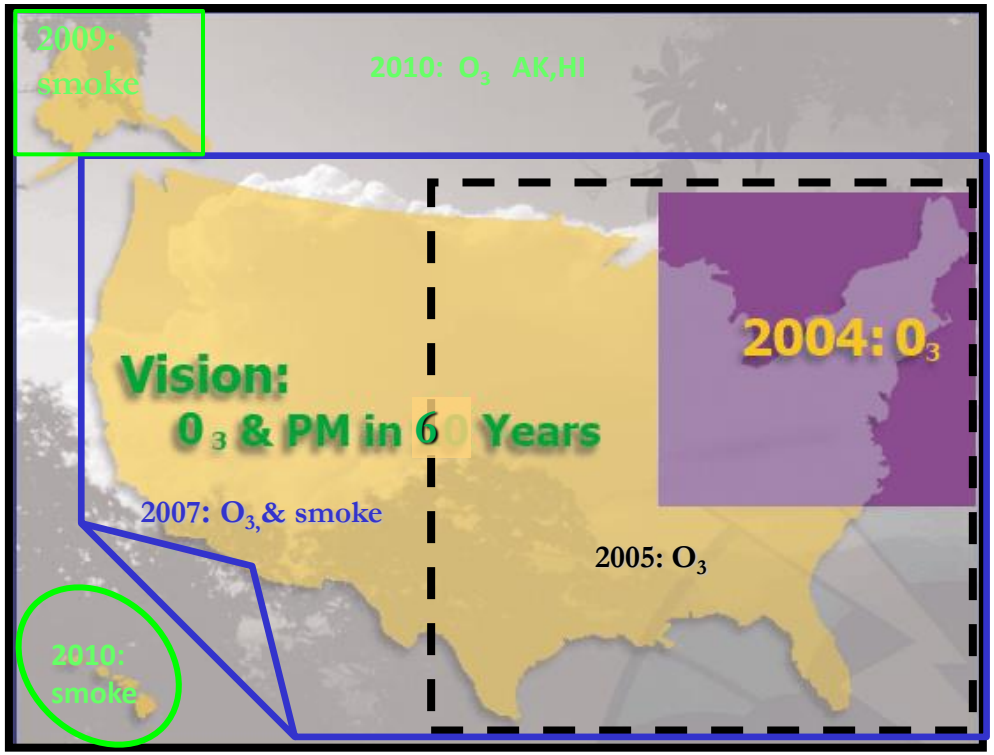
- Operations: *Ozone and smoke for CONUS; smoke also for AK*

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 Hawaii:
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***
  - **Wildfire smoke sources too 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 Hawaii

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

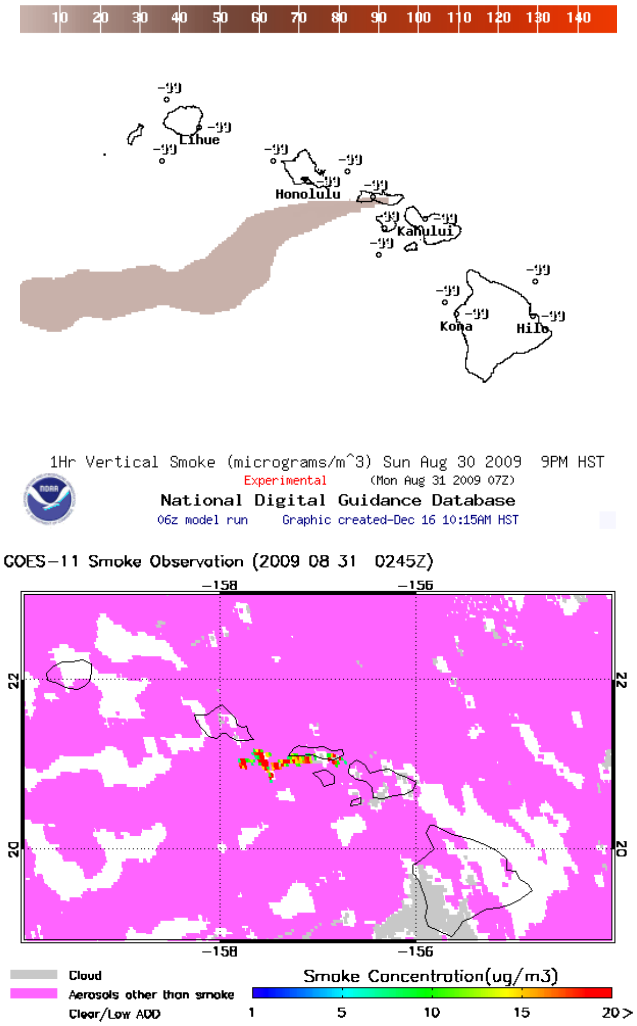
- On NWS Telecommunications Gateway and NDGD
- Updated each day, 6Z cycle, available by 13Z

Routine verification basis

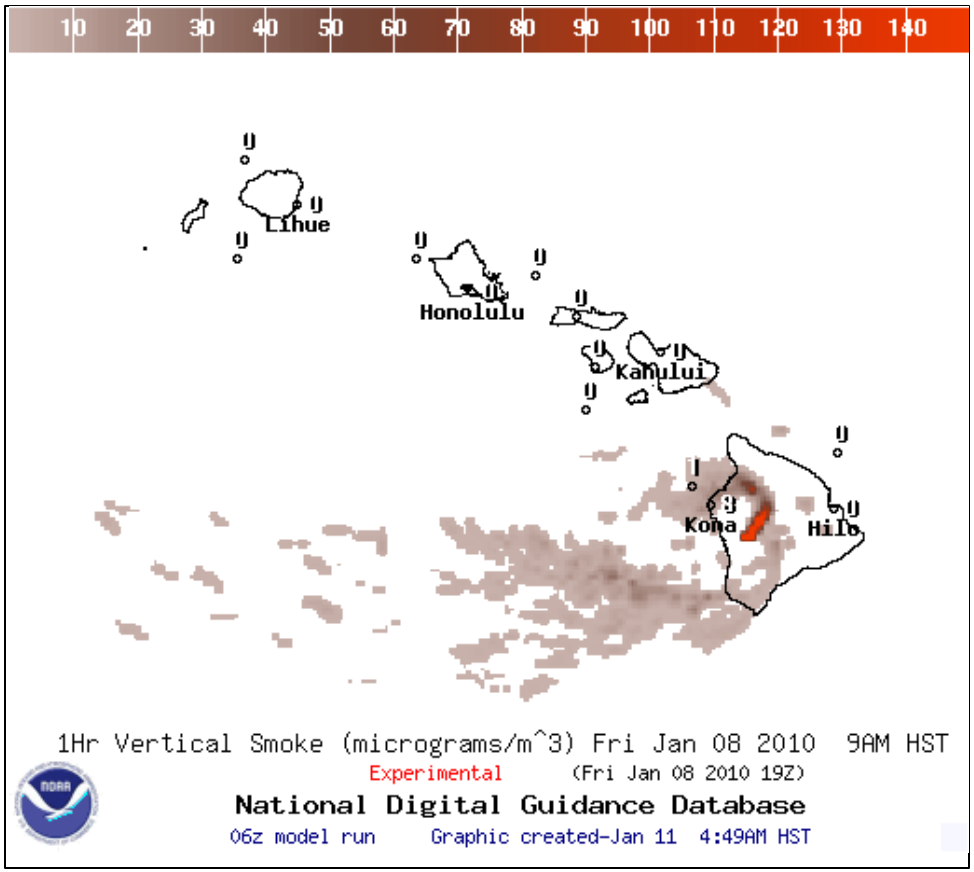
- Near real-time NOAA/NESDIS smoke-column product

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 Hawaii



- Example from January 8, 2010
- Fire Locations and verification based on satellite observations
- Fire emissions estimates from USFS (BlueSky)
- HYSPLIT/WRF-NMM transport

HYSPLIT Hawaii Forecast for January 7, 2010

The following graphics show one day of a several day period of observed smoke from a brush fire near Kona on the Big Island of Hawaii (~1800 acres).

The smoke initially drifted to the east on the 4th and 5th of January, shifting to the southwest from the 6th to the 8th. Then a very small plume was observed on the 10th. HYSPLIT was able to capture this wind shift, however the plumes tended to be somewhat larger than observed.

The orange plume is the observed HMS plume, the dark blue plume is the HYSPLIT 1 ug/m^3 contour and the lighter blue is the 1 ug/m^3 contour.

Kona fire update from Chief Oliveira

Hawaii 24/7

Posted on 07 January 2010. Tags: fire, kealakekua, south kona

UPDATED, 1:30 a.m. Friday, Jan. 8

Sen. Josh Green has asked Gov. Linda Lingle for state assistance as the Kealakekua fire is presenting health hazards.

Lingle has forwarded the request to her staff, the Department of Land and Natural Resources and state Civil Defense Director Major General Robert Lee.

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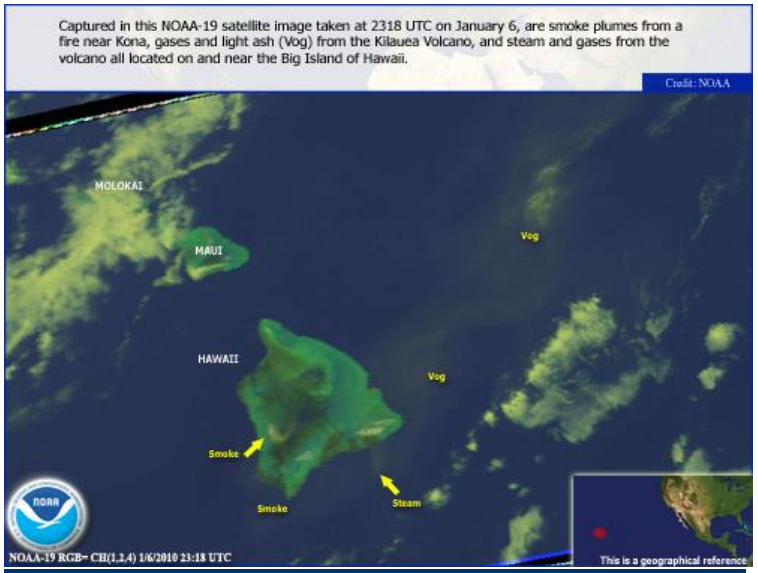
MEDIA RELEASE

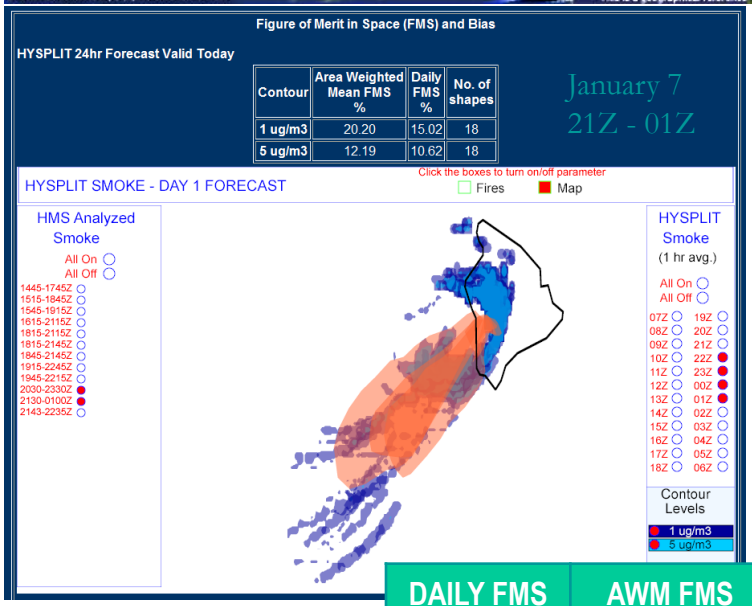
Good afternoon.

This is Fire Chief Darryl Oliveira of the Hawaii Fire Department with a brush fire update for Thursday January 7, 2010 at 4:00 p.m.

Hawaii Fire Department firefighters, along with personnel from various ranch and land owners continue fire fighting efforts on the brush fire in the Kealakekua mauka area of Kona. The fire continues to burn in an area at the approximately 4,000 foot elevation and poses no threat to property at this time. …

http://www.hawaii247.org/2010/01/07/kona-fire-update-from-chief-oliveira/





1 ug/m^3 Contour

DAILY FMS	AWM FMS
15.0 %	20.2 %

Verification Approach: Hawaii Smoke

Objective verification product developed for NWS:

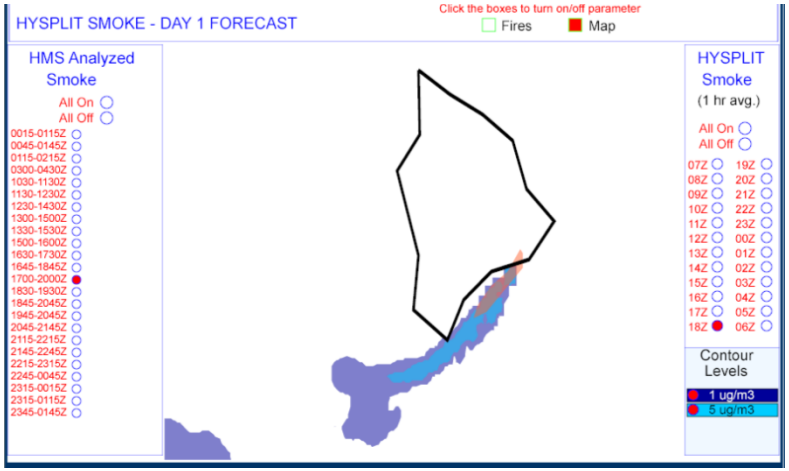
- **First real-time verification for wildfire smoke in Hawaii in daily use**
- **Based on NOAA/NESDIS satellite imagery:**
  - *GOES Aerosol Smoke Product (GASP)*
  - *Smoke from identified fires only*
- **Filtered for interference:**
  - *Clouds, surface reflectance, solar angle, other aerosol*
- **"Footprint" comparison:**
  - *Threshold concentration (1 $\mu g/m^3$) for average smoke in the column*
  - *Tracking Threat scores, or Figure-of-merit statistics:*

    (Area Pred $\cap$ Area Obs) / (Area Pred. U Area Obs)

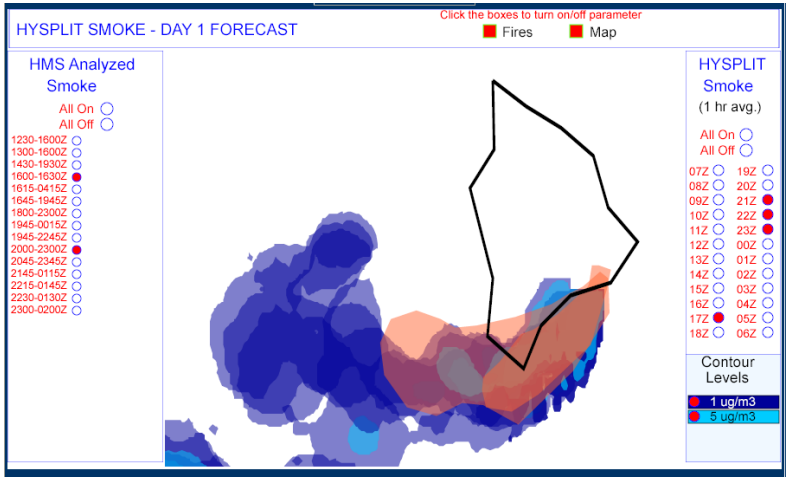
Initial skill target set at 0.08 checked with independent analysis in earlier methods:

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

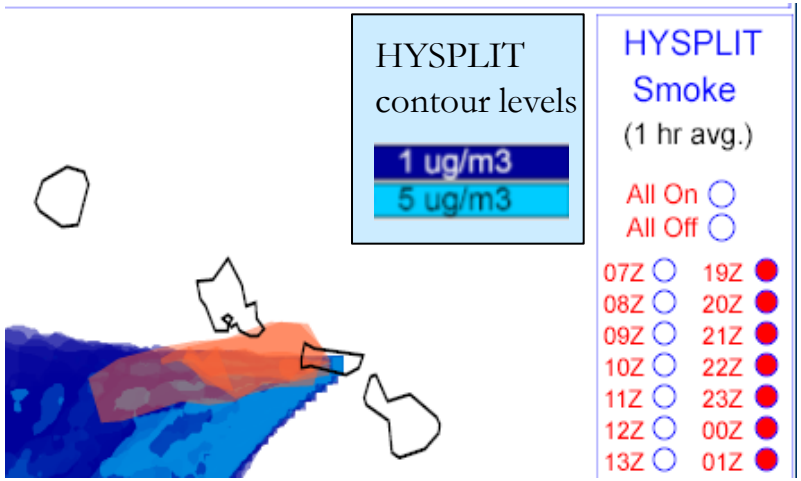
Example comparisons with daily HMS analysts product



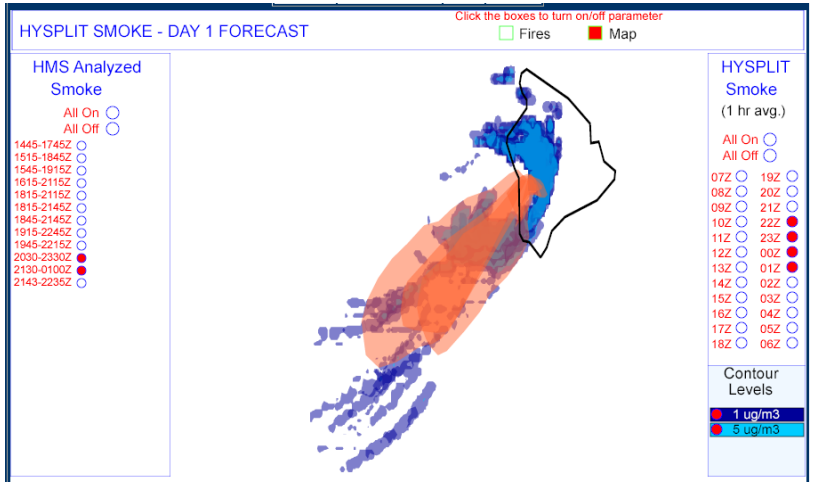
July 13, 2008 1 ug m^{-3} FMS = 6.8%



July 15, 2008 1 ug m^{-3} FMS = 31.8%



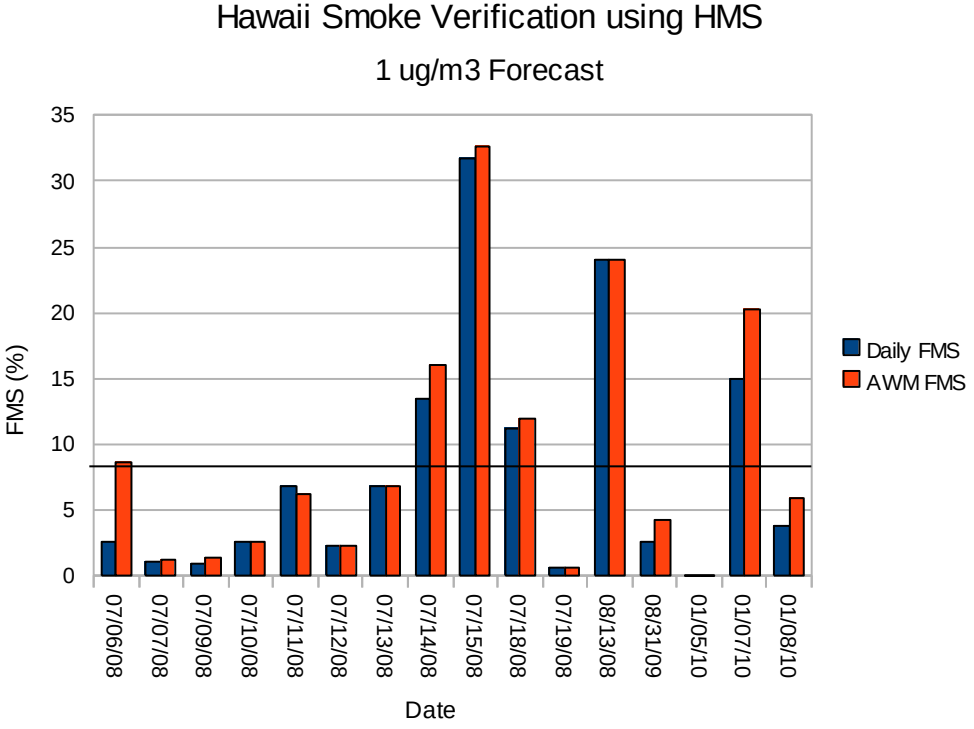
August 31, 2009 1 ug m^{-3} FMS = 2.6%



January 7, 2010 1 ug m^{-3} FMS = 15.0%

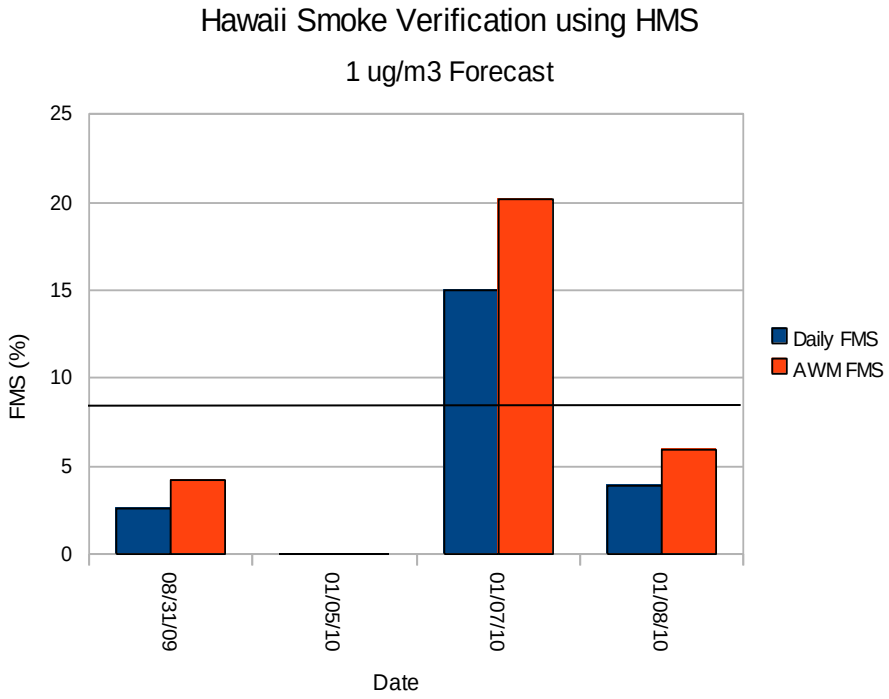
Comparison with daily HMS analysts' product

July 1, 2008 – January 13, 2010



Mean FMS	Days exceeding FMS = 8%
Area weighted: 9.1%	6 out of 16 days

Experimental Period: April 2009 – January 2010



Mean FMS	Days exceeding FMS = 8%
Area Weighted: 7.6%	1 out of 4 days

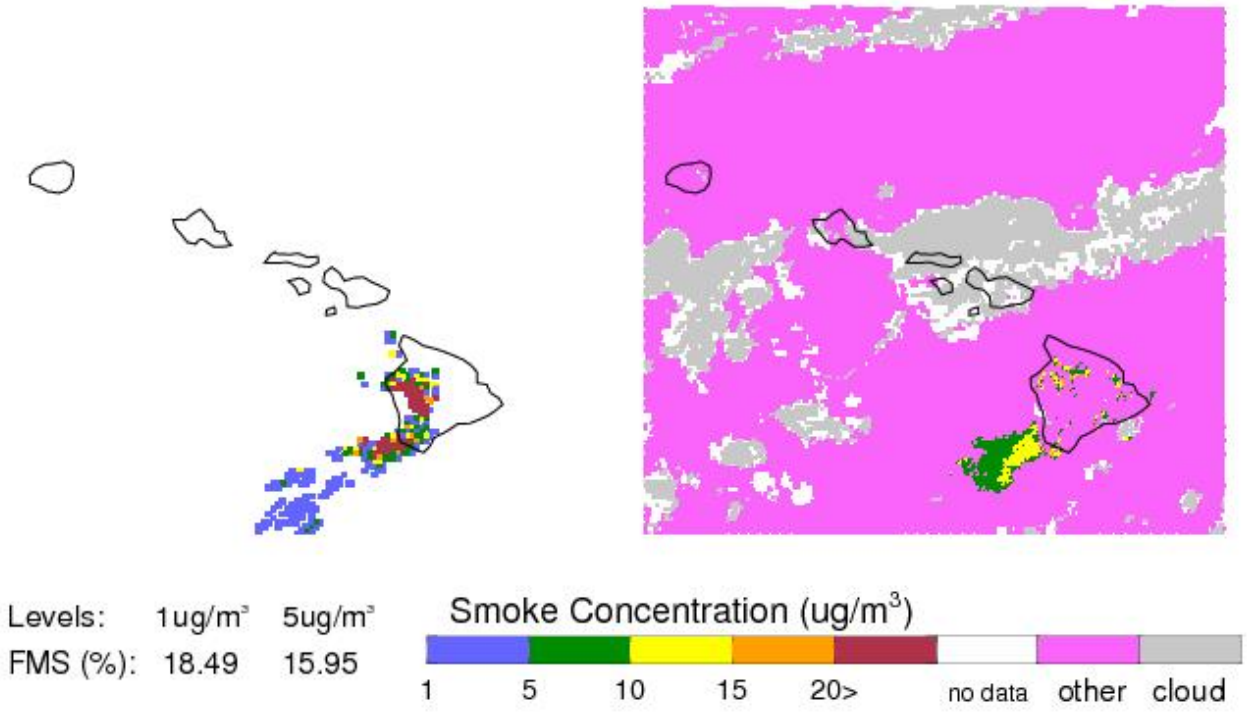
System has been running in the same configuration as the experimental system since July 2008

Verification against GASP smoke

Example for January 7, 2010

NOAA/ARL
HYSPLIT Smoke Forecast
2010/01/07 20-21Z

NOAA/NESDIS
GOES-11 Smoke Observation
2010/01/07 2045Z



Review of Operational Readiness

Smoke Forecast Tool for Hawaii:
Operational Readiness Criteria Summary

Criterion	*Lead*	*Metric*	*Dates*	*Status 9/09*
Objective Evaluation: Accuracy	*NCEP*	*> 8%*	*4/15/09 – 2/1/10*	C
Subjective Feedback	*PR, OCWWS*	*Positive on balance*	*10/1/09 – 2/1/10*	C
Production Readiness	*OCIO, NCEP*			C
On-time delivery		*> 95 % (98%+)*	*10/1/09 – 2/1/10*	C
Back-up		*In place*	*4/15/09*	C
Data retention		*In place*	*4/15/09*	C
Near-real time verification*	*NCEP*	*In place*	*4/15/09 (at OAR) Targetting 4/10 (at NCEP)*	C
Final go/no go decision	*NWS*		*Review date*	G

* = NESDIS automated (objective) product

\+ = Actual on-time delivery rate

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	7/1/08 – 1/10/10	C

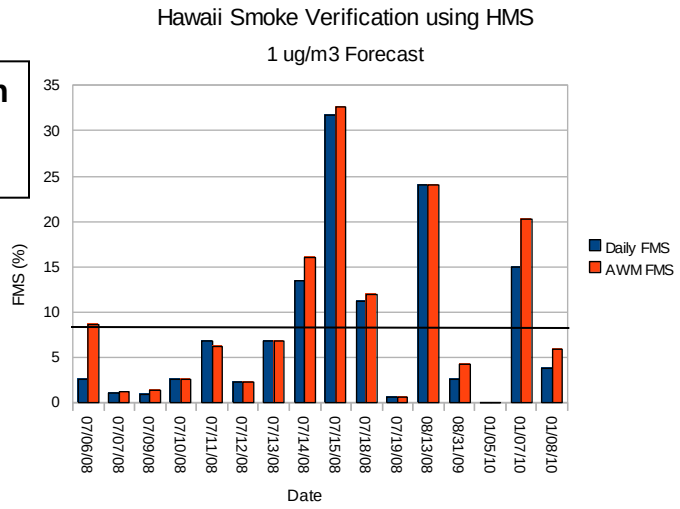
Summary Performance, based on new GASP-based product

- Automated product provides objective basis for daily verification
- For January 7, 2010 the daily FMS is 9.3%

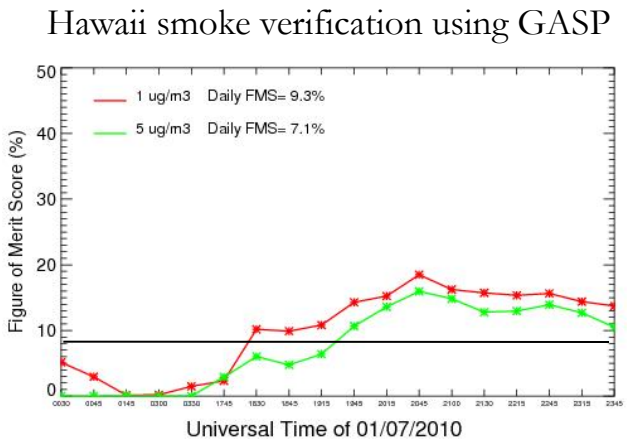
Comparison with daily HMS analysts' product :

- Exceeds target 6/16 days, with an average area weighted FMS of 9.1%

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*	*10/1/09 – 2/10/10*	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 Comment:

"We are good to go based on these tests-- especially pleased to see the Molokai fire results:", B. Ward, ESSD Chief, Pacific Region.

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 % (98%+)	10/1/09 – 2/1/10	C
Ftpserver	OCIO		10/1/09 – 2/1/10	C
NDGD server	OCIO, MDL		10/1/09 – 2/1/10	C
Back-up	OCIO	In place	10/1/09	C
Data Retention	OCIO	In place	5/1/09	C
Near-real time verification*	NCEP	In place	4/15/09 (at OAR)	C

* = NESDIS automated (objective) product

+ = Actual on-time delivery rate

Key	Complete	On schedule	At risk	Remedial Action Required

Production Readiness (OCIO, NCEP)

On-time delivery

Criterion	Metric	Dates	Status
On-time delivery	Forecast guidance available by 1255 UTC > 95%	10/1/09 – 2/1/10	C
Guidance availability on NDGD	Forecast guidance available on NDGD by 1300 UTC > 95%	10/1/09 – 2/1/10	C
Guidance Back-up	NCEP backs up as part of NCEP model backup	10/1/09	C
NESDIS fire locations product delivered on time	Delivered to NCEP/NCO daily: target 10 UTC	10/1/09	C
NESDIS GASP observation product delivered on time	Delivered to NCEP/NCO in near real-time*: target within 1 hr of satellite pass	4/1/10	C
IT infrastructure Back-up	NESDIS ,CCS, TOC and interfacility communications links fully backed up. Reliability of comms links > 99.99%.	10/1/09	C

* Running pre-operationally at NESDIS

Experimental Smoke Data Availability

- **Monitored Data Flow Receipt from the TOC To NWS Web Farm**
  - *Data flow tracked from 10/1/09 – 2/1/10*
  - *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.***	***4/15/09 - 2/1/10 (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

- **February 2010 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

Recommend:

NWS deploy smoke forecast guidance for Hawaii as a new air quality component of operational product suite

Backup

Smoke Forecast Tool for Hawaii

Major Components

NWP Model

NAM/WRF-NMM

NOAA/NWS

Weather Observations

NWP Post-processors for AQ Modules

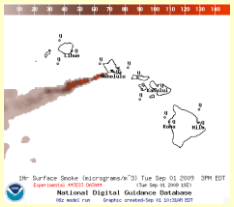
NESDIS HMS Fire Locations

HYSPLIT Module:

NOAA/OAR

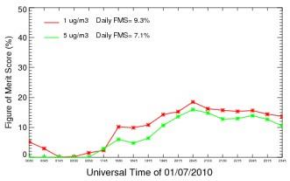
USFS's BlueSky Emissions Inventory:

USFS



Verification:

NESDIS/GASP Smoke



Smoke Forecast Tool:
What is it?

Overview

- Passive transport/dispersion computed with HYSPLIT & WRF-NAM (or GFS, OCONUS). 24-hr spin-up, 48-hour prediction made daily with 6Z cycle

Fire Locations

- NESDIS/HMS: Filtered ABBA product (only fires with observed associated smoke)

Emissions

- USFS' BlueSky algorithm for emitted PM2.5

Smoke Transport/dispersion

- HYSPLIT (Lagrangian); plume rise based on combustion heat and meteorology

Verification

- Based on satellite imagery for footprint of extent of observed smoke in atmospheric column exceeding threshold of detection

HI configuration

The Hawaii smoke prediction relies on the smoke forecasting tool, which is currently operational over CONUS and Alaska.
For Hawaii, HYSPLIT transports smoke from HMS-detected fires with visible smoke. The Hawaii smoke run was updated to use a 5 km aggregation grid in the fires pre-processor.
This allows the source location precision to be finer than the size of the smallest islands. The CONUS and Alaska runs continue to use the default 20 km resolution.

Testing of HI smoke predictions