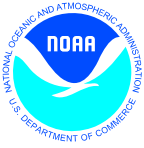


Smoke Forecast Tool for Hawaii: New Guidance in National Air Quality Forecast Capability

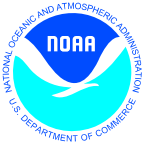
**Operational Readiness Review
February 16, 2010**

**Paula Davidson
NWS Manager,
Air Quality Forecast Capability**



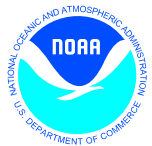
Purpose of Readiness Review

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

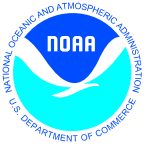


Outline

- **Background**
 - *Air Quality Forecast Program Goals, Planned Capabilities*
 - *Smoke Forecast Tool for Hawaii*
- **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

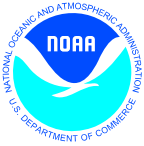


Vision

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

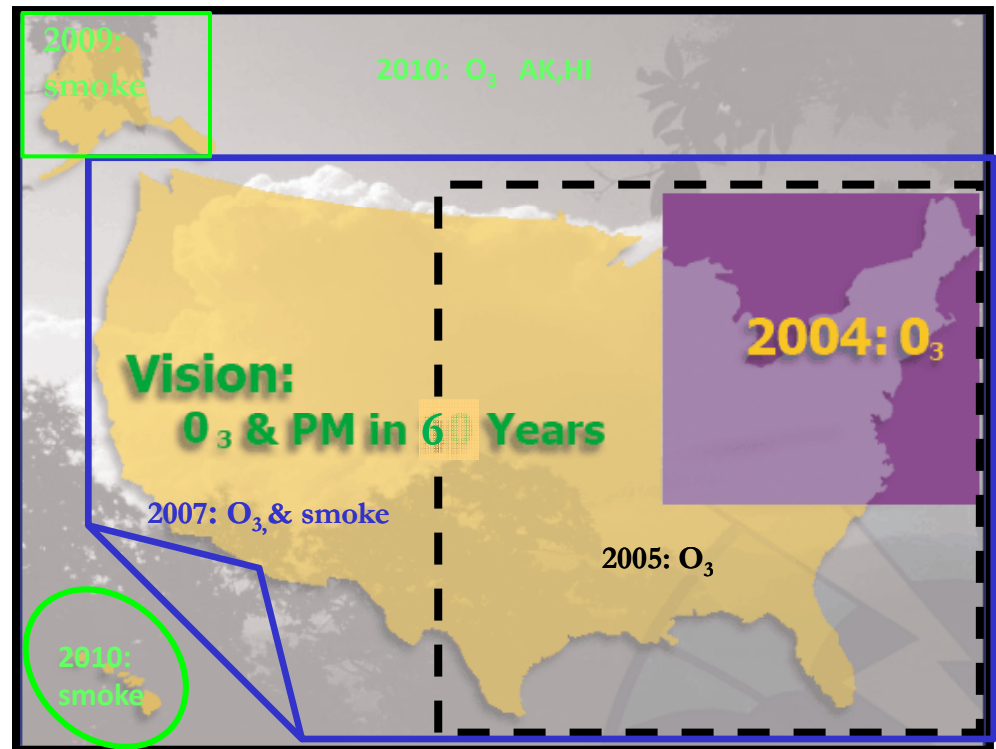
- Operations: *Ozone and smoke for CONUS; smoke also for AK*

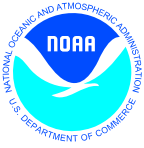
Near-term Operational Targets:

- 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



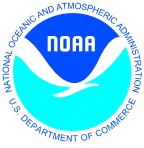


Smoke Forecast Tool for Hawaii:

A step toward quantitative PM predictions



- ***Required for particulate matter (PM) forecasts***
 - Fire emissions significant source of fine particle pollution (PM_{2.5})
 - 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 PM_{2.5}?
- ***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

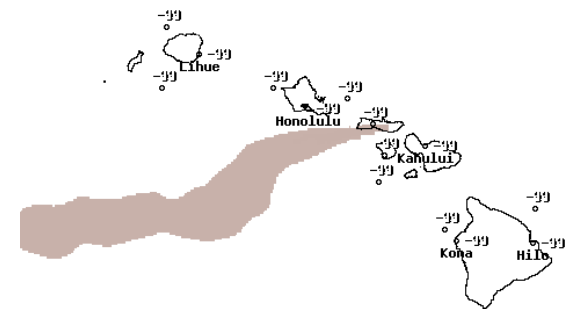
Near real-time NOAA/NESDIS smoke-column product

Customer outreach/feedback

NOAA/NWS field forecasters

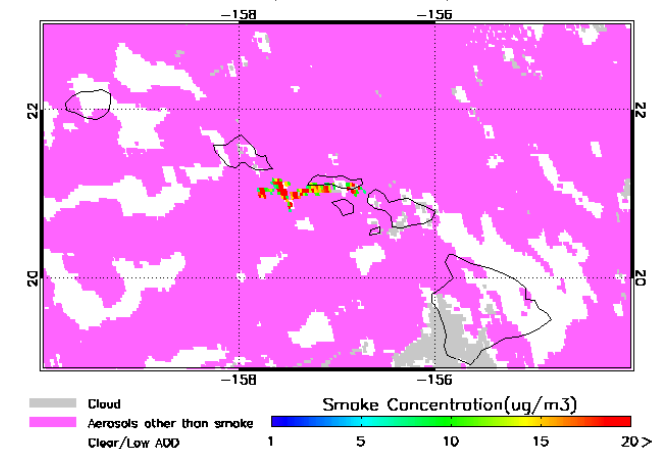
State&Local AQ forecasters, coordinated with EPA

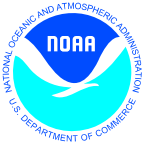
Public and Private Sector AQ constituents



1Hr Vertical Smoke (micrograms/m³) Sun Aug 30 2009 9PM HST
 Experimental (Mon Aug 31 2009 07Z)
 National Digital Guidance Database
 06Z model run Graphic created-Dec 16 10:15AM HST

COES-11 Smoke Observation (2009 08 31 0245Z)





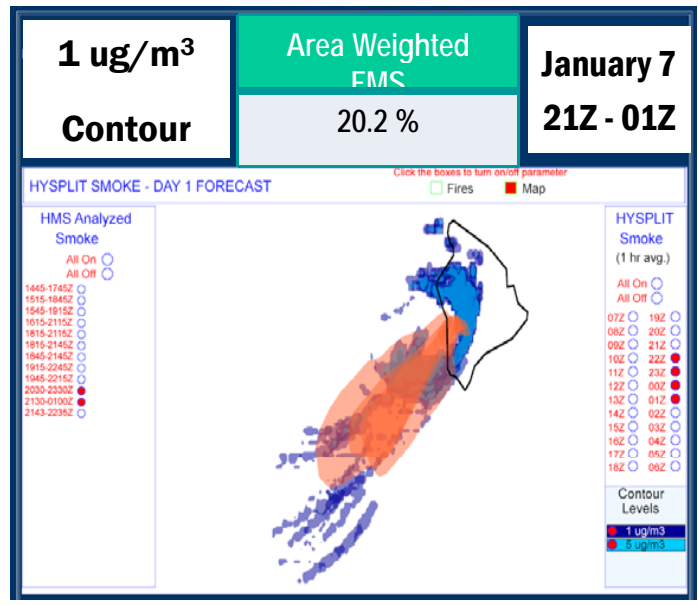
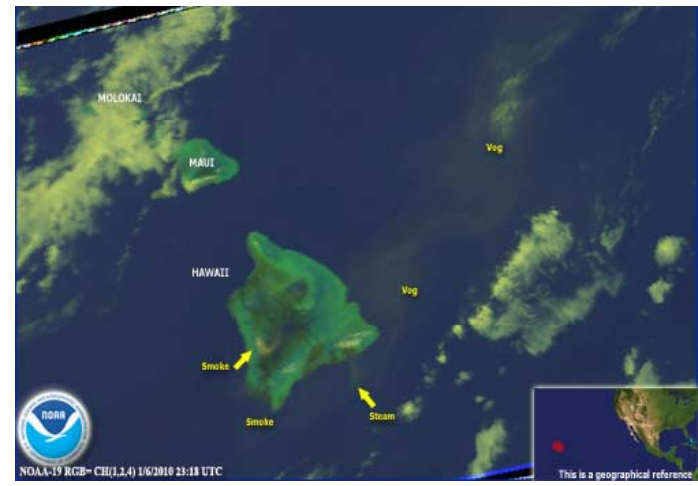
Hawaii smoke forecast guidance: *January 7, 2010*

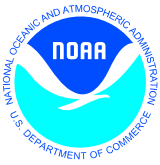


- Brush fire near Kona on the Big Island of Hawaii (~1800 acres).
- smoke initially drifted east on Jan 4-5, shifting to SW, Jan 6-8; a very small plume observed Jan 10.
- HYSPLIT (blue) captured the wind shift; predicted plumes somewhat larger than analysts showed (orange).

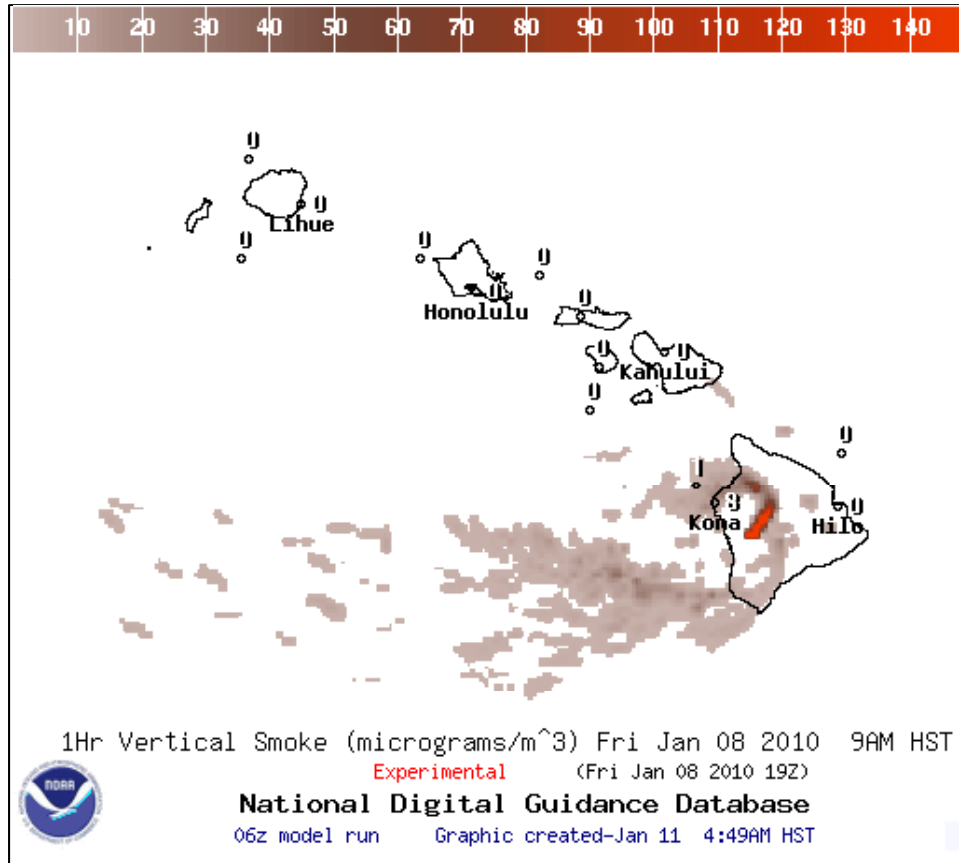
Kona fire update Posted on 07 January 2010. UPDATED, 1:30 a.m. Friday, Jan. 8
MEDIA RELEASE
This is Fire Chief Darryl Oliveira of the Hawaii Fire Department with a brush fire update for Thursday January 7, 2010 at 4:00 p.m.
 Hawaii Fire Department firefighters, along with personnel from various ranch 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/>





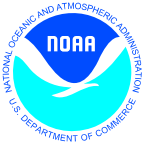
Hawaii smoke forecast guidance: *January 8, 2010*



- Fire Locations and verification based on satellite observations

- Fire emissions estimates from USFS (BlueSky)

- HYSPLIT/WRF-NMM transport



Hawaii Smoke Forecast Guidance: *Verification Approach*

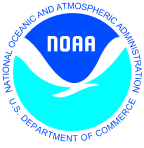


Adaptation of NESDIS verification product for CONUS:

- **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 $\mu\text{g}/\text{m}^3$, for average smoke in the column*
 - *Tracking threat scores, or figure-of-merit statistics:*
$$(\text{Area Pred} \cap \text{Area Obs}) / (\text{Area Pred} \cup \text{Area Obs})$$

Initial skill target 0.08, as for CONUS

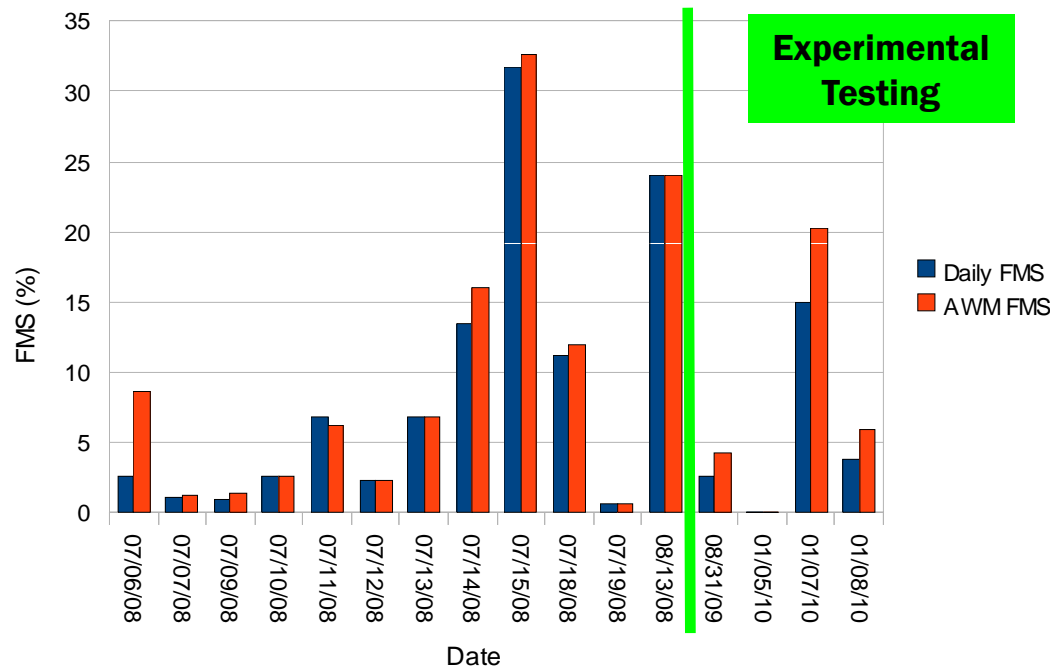
- **checked with independent analysis, based on GOES imagery**
- **NESDIS Hazards Mapping System (HMS) analysts isolated smoke**



Hawaii Smoke Forecast Guidance: *Comparison with HMS analyst's product*

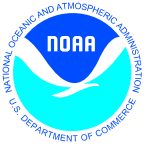


July 1, 2008 – January 13, 2010



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

- Testing with experimental configuration since July 2008
- Transitioned into experimental production April 2009
- Increased resolution 4X of smoke aggregation grid to 5km 12, Jan 2010

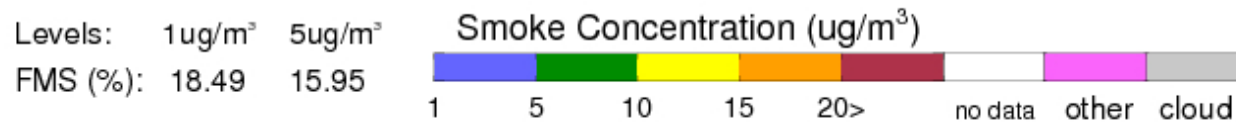
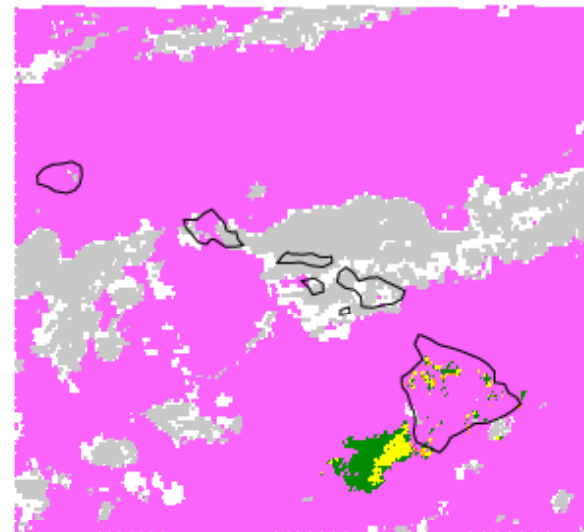
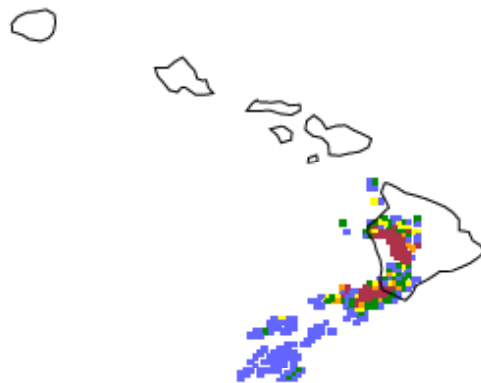


Hawaiian Smoke Forecast Guidance: *Verification with GASP*

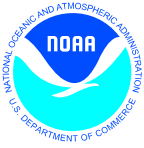


NOAA/ARL
HYSPLIT Smoke Forecast
2010/01/07 20-21Z

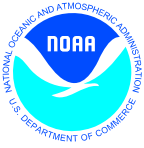
NOAA/NESDIS
GOES-11 Smoke Observation
2010/01/07 2045Z



- **Challenges: retrievals over ocean (dark) contrast**
- **Working to analyze earlier cases**



Review of Operational Readiness



Smoke Forecast Tool for Hawaii: Operational Readiness Criteria Summary

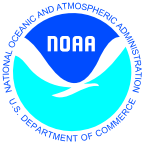
Criterion	Lead	Metric	Dates	Status 9/09
Objective Evaluation: Accuracy	NCEP	> 8%	4/15/09 – 2/1/10	C
Subjective Feedback	PR, OCWWS	Positive on balance	10/1/09 – 2/1/10	C
Production Readiness	OCIO, NCEP			C
On-time delivery		> 95 % (98%+)	10/1/09 – 2/1/10	C
Back-up		In place	4/15/09	C
Data retention		In 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
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Objective Verification (NCEP, OAR)



Criterion	Metric	Dates	Status
Objective Evaluation: Accuracy	Prediction overlap (FMS) > 8 % for 24-hr prediction that smoke concentration $\geq 1 \mu\text{g}/\text{m}^3$ in total column	7/1/08 – 1/10/10	C

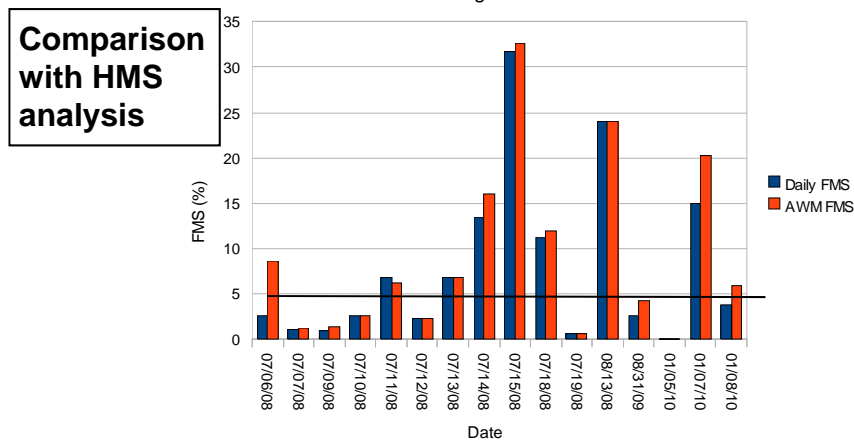
Summary Performance, based on new GASP-based product

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

Comparison with daily HMS analysts' product :

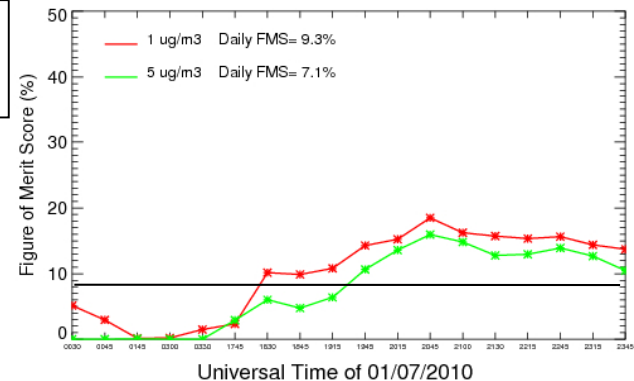
- Exceeds target 6/16 days, with an average area weighted FMS of 9.1%

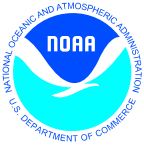
Hawaii Smoke Verification using HMS
1 ug/m3 Forecast



GASP -based Verification

Objective Verification, GASP 01/07/09





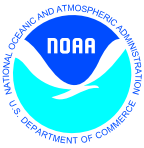
Subjective Feedback (AR, OCWWS)



Criterion	Metric	Dates	Status
Subjective Feedback	<i>External feedback from State/Local AQ forecasters support product as helpful.</i> <i>Other feedback: internal, constituent, general public: On Balance, positive</i>	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



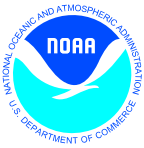
Subjective Feedback: *Other responses/comments on experimental products*

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 (OCIO, NCEP)



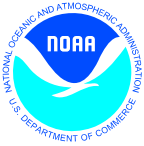
Criterion	Lead	Metric	Dates	Status 8/09
On-time delivery	OCIO	Forecast guidance available by 1300 UTC 95 %	10/1/09 – 2/1/10	98%+
Ftpserver	OCIO		10/1/09 – 2/1/10	
NDGD server	OCIO, MDL		10/1/09 – 2/1/10	
Back-up	OCIO	In place	10/1/09	
Data Retention	OCIO	In place	5/1/09	
Near-real time verification*	NCEP	In place	4/15/09 (at OAR)	

Notes:

* NESDIS automated (objective) product

+ Actual on-time delivery rate

Key	Complete	On schedule	At risk	Remedial Action Required
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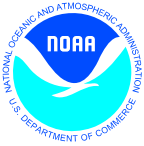
Production Readiness (OCIO, NCEP)

On-time delivery, backup, data retention



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
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
Backup			
Guidance Back-up	NCEP backs up as part of NCEP model backup	10/1/09	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
Data retention	Archive at NCDC in place	4/1/09	C

* Running pre-operationally at NESDIS



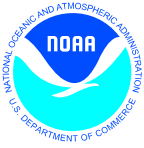
Production Readiness (NCEP)

Near-real time verification






Criterion	Metric	Dates	Status
Near-real time verification	<i>Daily; for 24-hour forecast interval 0700-0600 UTC by 48 hours after end of forecast interval.</i>	<i>4/15/09 - 2/1/10 (at OAR)</i>	C

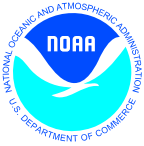
- Verification Statistics:** *Compiled and maintained by NESDIS STAR. Updated daily. Transitioning to NCEP 4/1/10.*
- Availability:** *Model developer group*
- Seasonal summary:** *Available on AQ program web site (public)*
- Weekly verification:** *Reports on operational performance measures provided 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 smoke forecast guidance for HI

- **February 2010 Status:**general...
 - *HYSPLIT predictions capture smoke transport from wildfires*
 - *Timing/location of plumes predicted; little quantitative concentration verification available other than column-wide*
- **Objective verification:** 
 - *Accuracy performance targets achieved*
- **Subjective feedback:** 
 - *Generally positive*
 - *Focus group forecasters providing additional feedback; additional feedback links posted on graphical display sites*
- **Production readiness:** 
 - *Forecast guidance available on time*
 - *Backup, data retention and verification demonstrated*



Future Science Infusion



NOAA planning for improvements to the smoke forecast capability

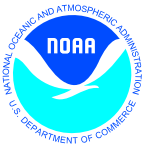
- Addition of reactive transport for fire species within particulates prediction testing
- Global inputs from fires to be incorporated in GFS

Continuing R&D required

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

Assuring quality with science peer reviews:

- Design review of major system upgrades (yearly)
- 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, Vol. 2, No. 3, 163-175, September 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.*



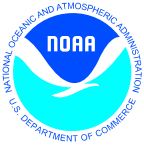
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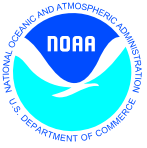
Key	Complete	On schedule	At risk	Remedial Action Required
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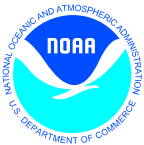
Deployment Recommendation

Recommend:

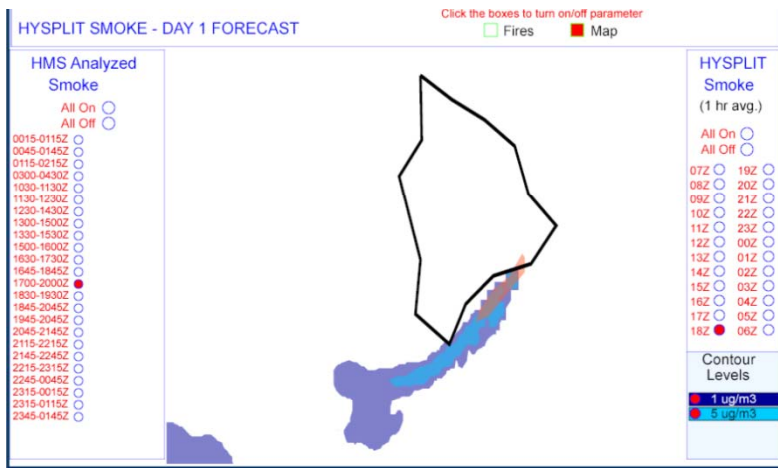
NWS deploy smoke forecast guidance for Hawaii as a new air quality component of operational product suite



Backup

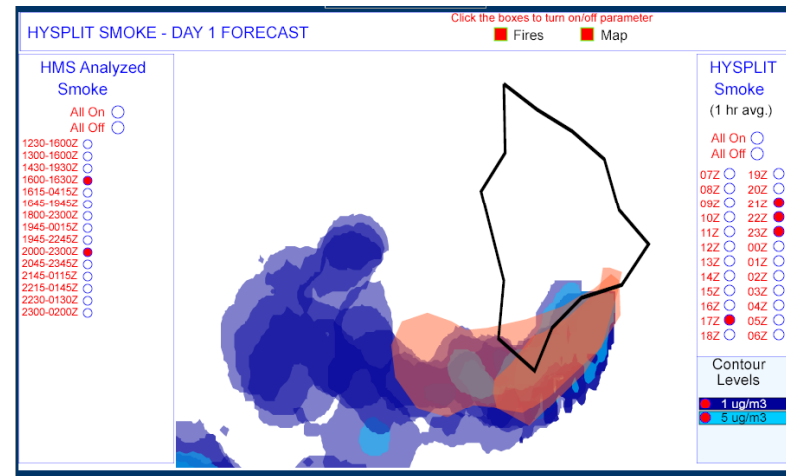


Example comparisons with daily HMS analysts product



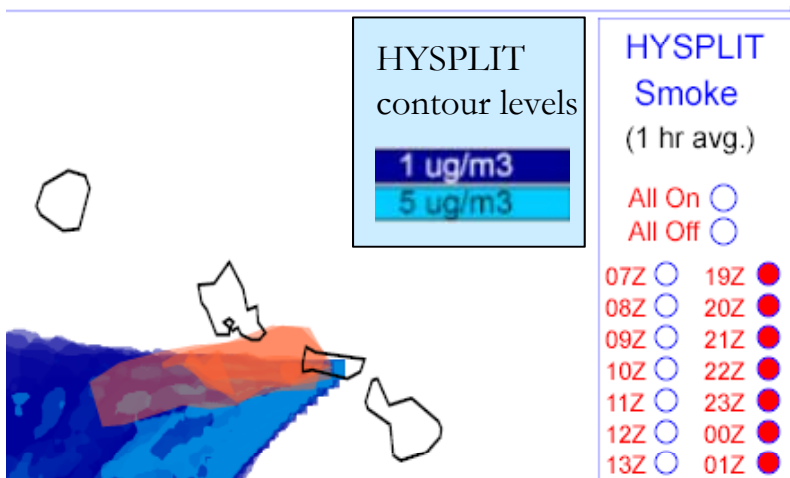
July 13, 2008

1 ug m⁻³ FMS = 6.8%



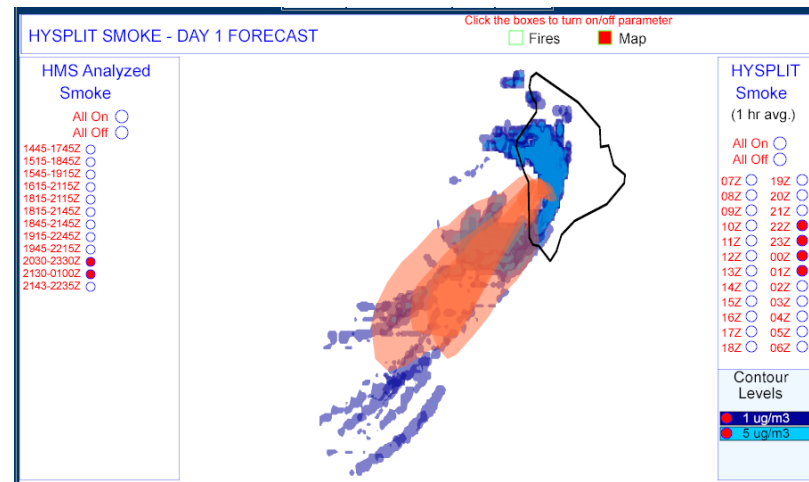
July 15, 2008

1 ug m⁻³ FMS = 31.8%



August 31, 2009

1 ug m⁻³ FMS = 2.6%



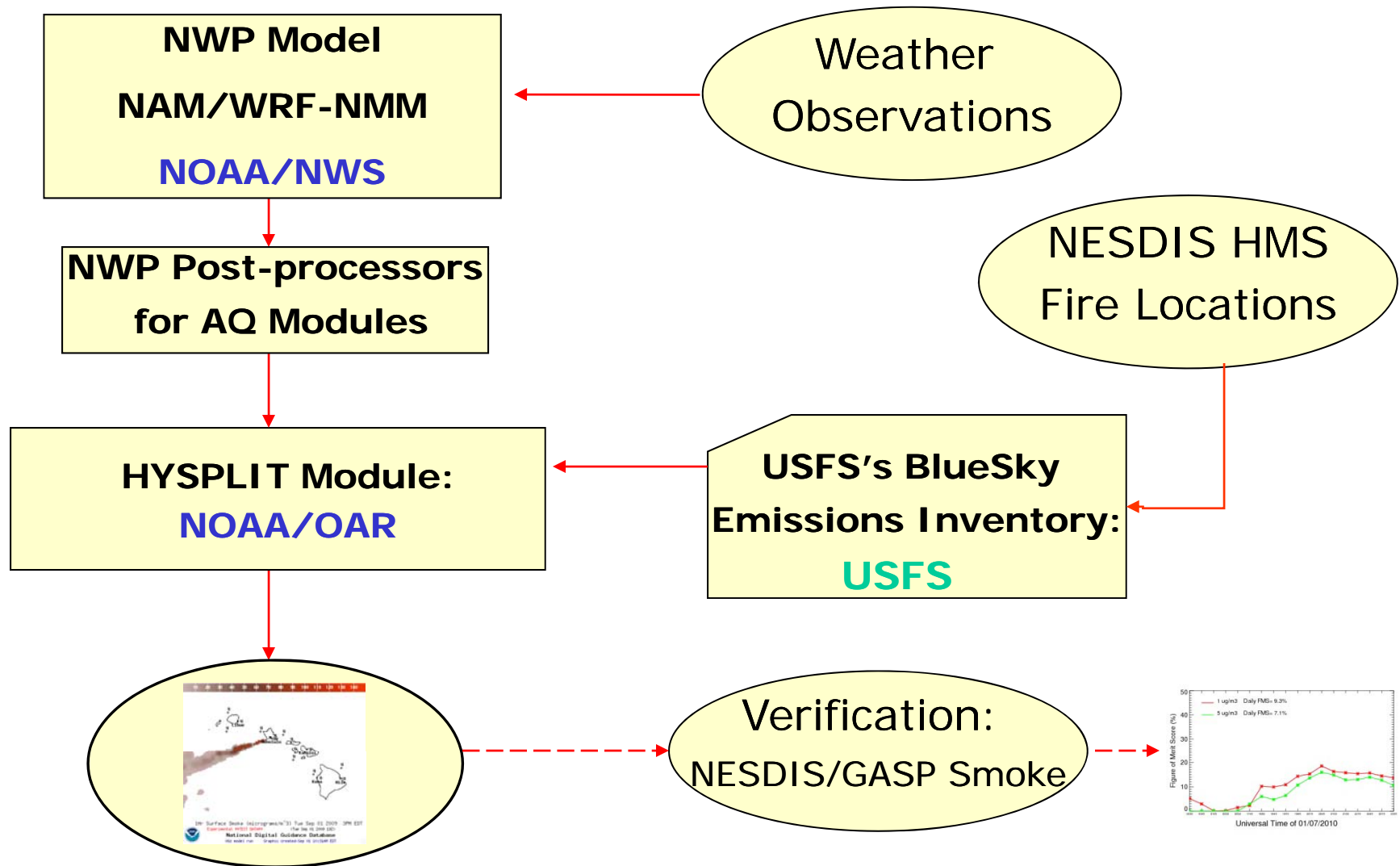
January 7, 2010

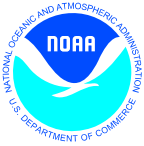
1 ug m⁻³ FMS = 15.0%



Smoke Forecast Tool for Hawaii

Major Components





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

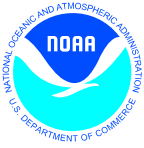
- USFS' BlueSky algorithm for emitted PM2.5

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

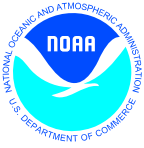


HI configuration

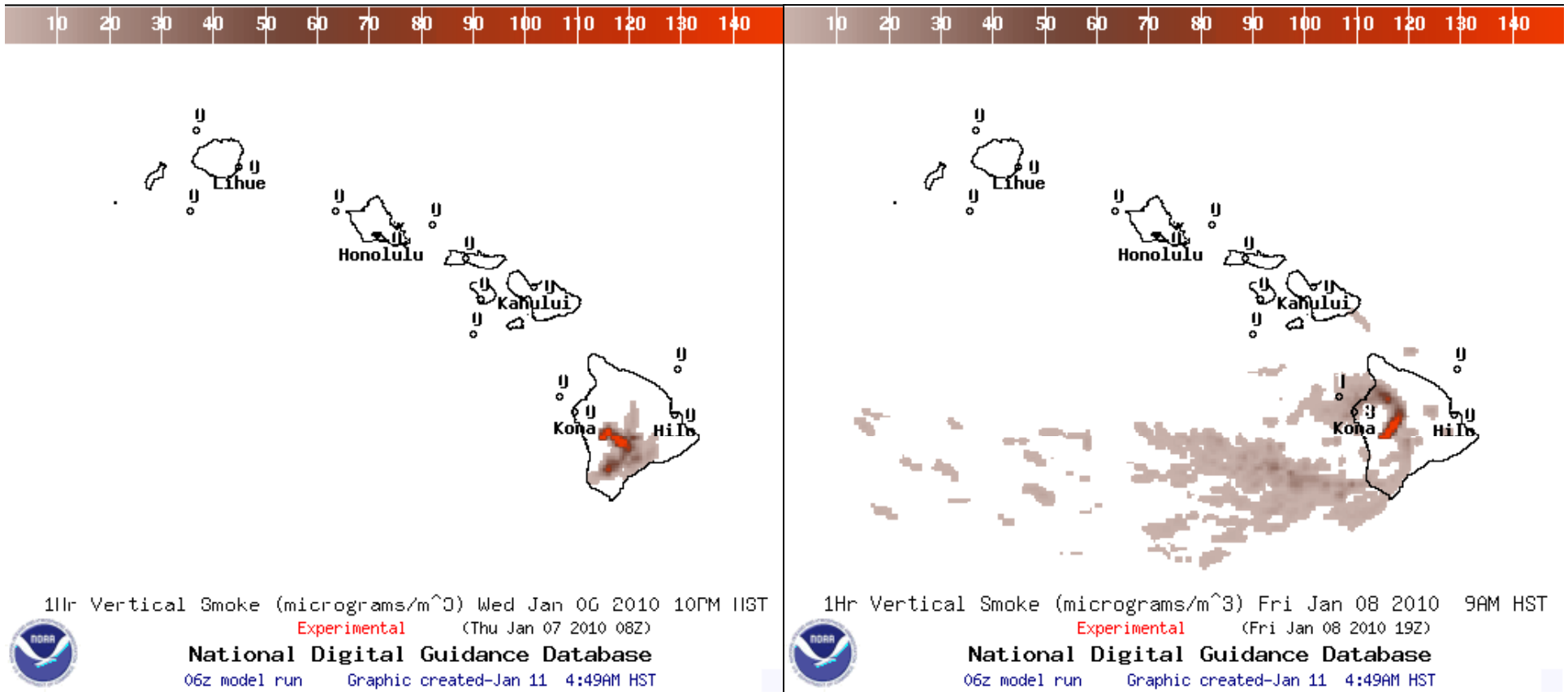
The Hawaii smoke prediction relies on the smoke forecasting tool, which is currently operational over CONUS and Alaska.

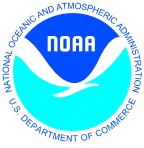
For Hawaii, HYSPLIT transports smoke from HMS-detected fires with visible smoke. The Hawaii smoke run was updated to use a 5 km aggregation grid in the fires pre-processor.

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.



HI smoke predictions: Examples





Production Readiness:

Experimental Smoke Data Availability

- **Monitored data flow, receipt from 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*