Updates to Operational HYSPLIT Dispersion Predictions

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CCB

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HYSPLIT

HYSPLIT operational applications at NCEP:

- Meteorology prep (WOC)
- Smoke prediction
- Dust prediction
- “Canned” dispersion prediction (WFO/HAZMAT)
- “On-demand” prediction
  - Volcanic ash
  - Radiological (RSMC)
  - WFO/HAZMAT (backup to WOC)
- CTBTO (also on-demand, but different job)

•Single dispersion executable and common library for all HYSPLIT applications.

Charter Overview

Overview of Changes in Version 7.4

- **ALL** – Update unified HYSPLIT code and libraries to a more current ARL version
  wet deposition; several post-processing program minor changes
- **CTBTO** – Enhanced graphics for SDM (Google Earth)
- **RSMC** – operational RSMC Washington web page (vs. non-operational ARL)
  – updated wet deposition (final update compared to 7.3.2 bugfix)
  – grib2 and time of arrival products sent to RSMC web page
- **Volcanic Ash** – updated wet deposition as RSMC
- **Canned/Hazmat** – new, lake-effect trajectories
- **Meteorology** – GFS half-degree, change specific humidity to RH
  – NAM CONUS nest 4 km extend forecast from 24 to 48 hr.
- **Volcano trajectories** – new, transferred from ARL to NCEP

- Technical changes
  – **CTBTO -** Rename WCOSS directory name of 30-day gdas archive to facilitate automated cleanup
  – **RSMC, Volcanic ash, Hazmat** – script filename changes for clarity
  - Option to use 4 km CONUS nest
  – **Smoke/Dust -** Unified CONUS, HI, AK smoke scripts
  -grib2 output produced directly, not grib1

Charter Overview

Expected Benefits to End Users

- **WMO-IAEA-RSMC**

  – Products available on *operational* web site, including new sending of grib2 concentration/deposition file and time-of-arrival product

  – Much more accurate wet deposition forecasts; minimal change in input files (CONTROL).

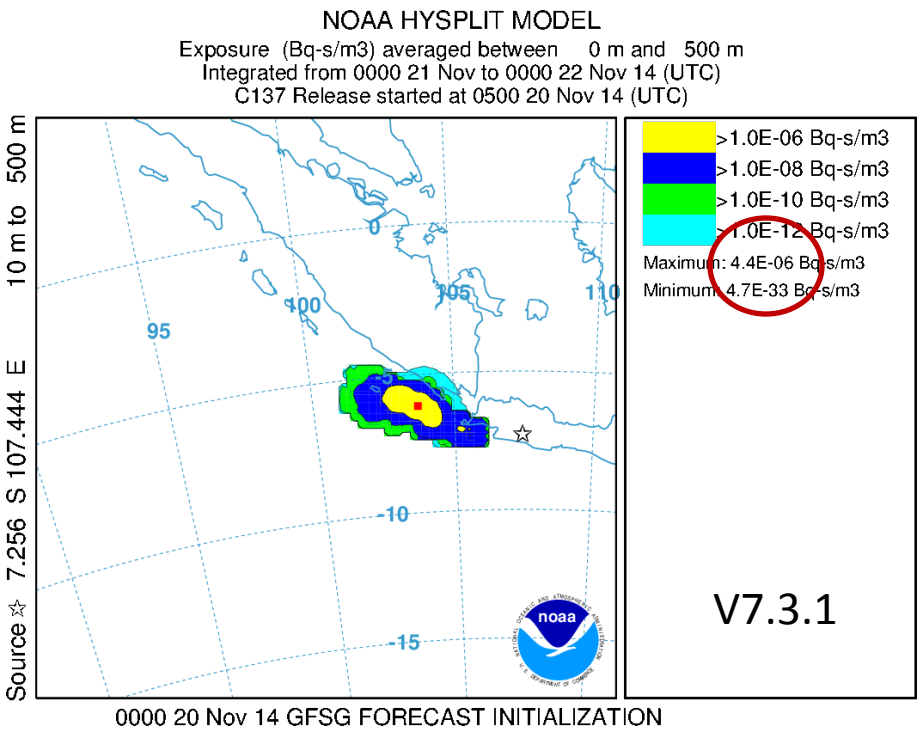
- **NWS Alaska and USGS** - Volcano trajectories – operational
- **ARL users -** GFS half-degree - some ARL users prefer direct use of RH instead of specific humidity
- **USFS –** CONUS nest 4 km extended from 24 to 48 hr.

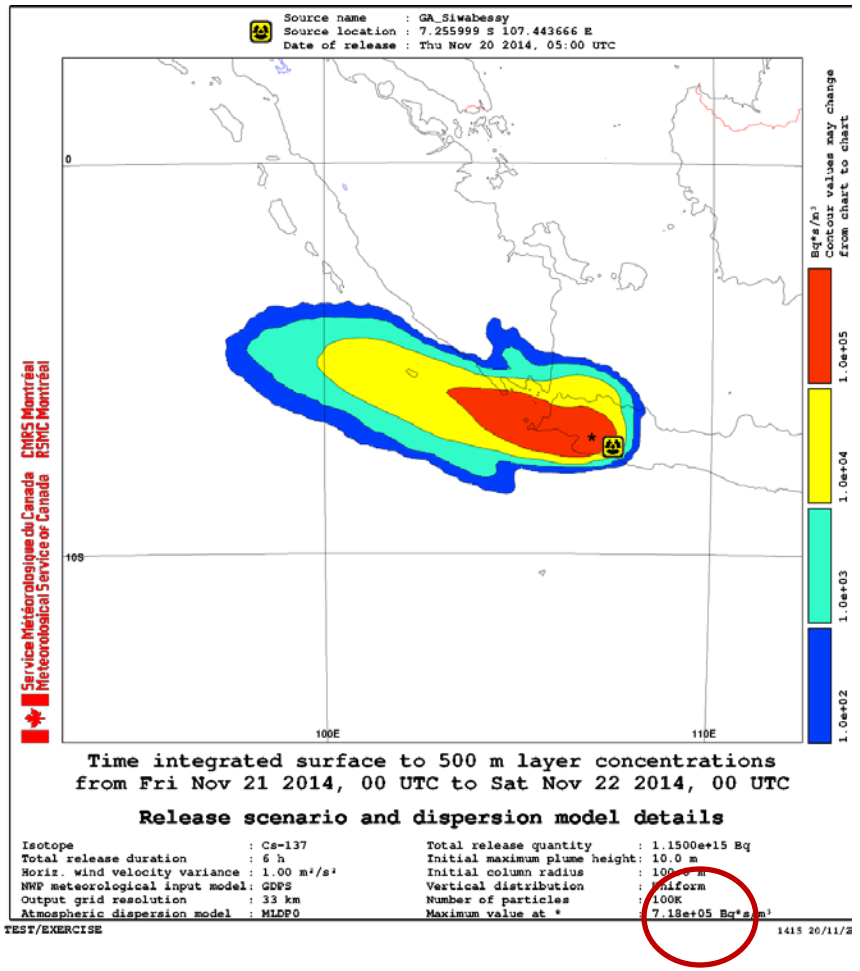
Expected Benefits within NOAA

- **SDM**
  - Can better review the CTBTO graphics
  - Can run RSMC/VA/HAZMAT with 4 km CONUS nest
- **NCO**
  - Save WCOSS disk space for GDAS (only 1 month back vs. all years)
  - Smoke/dust – directly output on grib2 (no grib1 to grib2 conversion)
- **WFO** - Lake effect trajectories – provide guidance to WFO

Wet deposition problem noticed
November 2014, RSMC/IAEA exercise

Release location: Indonesia

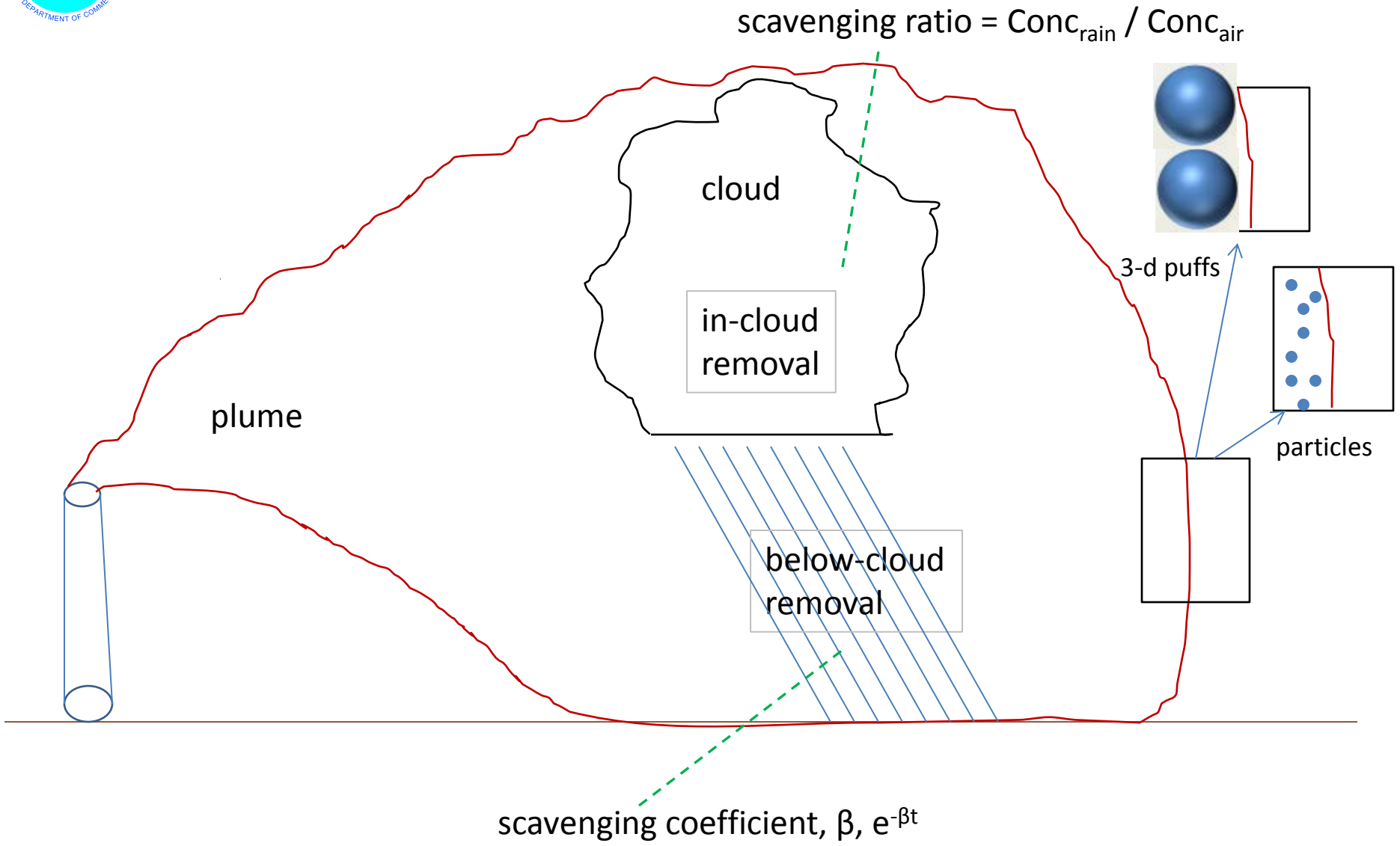




Maximum values:
Washington: 4.4E-6
Montreal: 7.2E+5

IAEA = International Atomic Energy Agency

Wet-deposition schematic



Particles

- In-cloud
  - Scavenging ratio is the ratio of pollutant's concentration in water to that in air (these values for different particles are set in a fix file, note they are >1)
  - Wet removal time constant is the scavenging ratio (S) times the precipitation rate (P) divided by the depth of the pollutant or cloud layer (Δz), $\beta_{in\text{-}cloud} = SP/\Delta z$

V7.3.2 (ops) (Through a bug fix)

vs.

  - Scavenging coefficient can be directly defined as a time constant, $\beta_{in\text{-}cloud} = KP^{0.79}$, K=constant (value <1, set in fix file), P=precipitation rate (mm/h)

V7.4 (new)

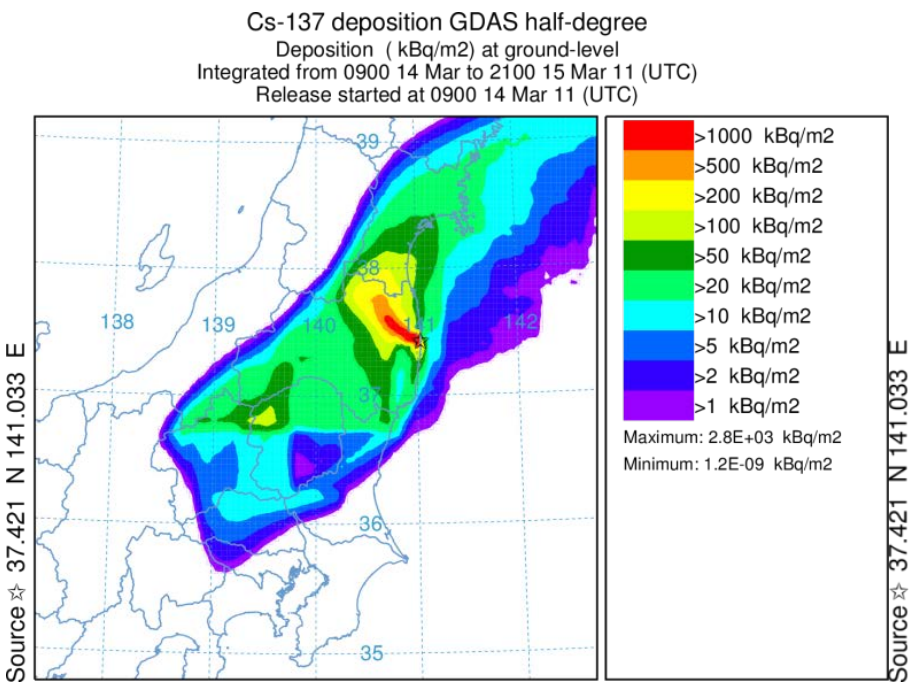
- Below-cloud
  - A scavenging coefficient is expressed as a time constant (in the fix file), hence
  - Wet removal time constant below cloud is independent of the precipitation rate, $\beta_{below} = 1 \times 10^{-6}$

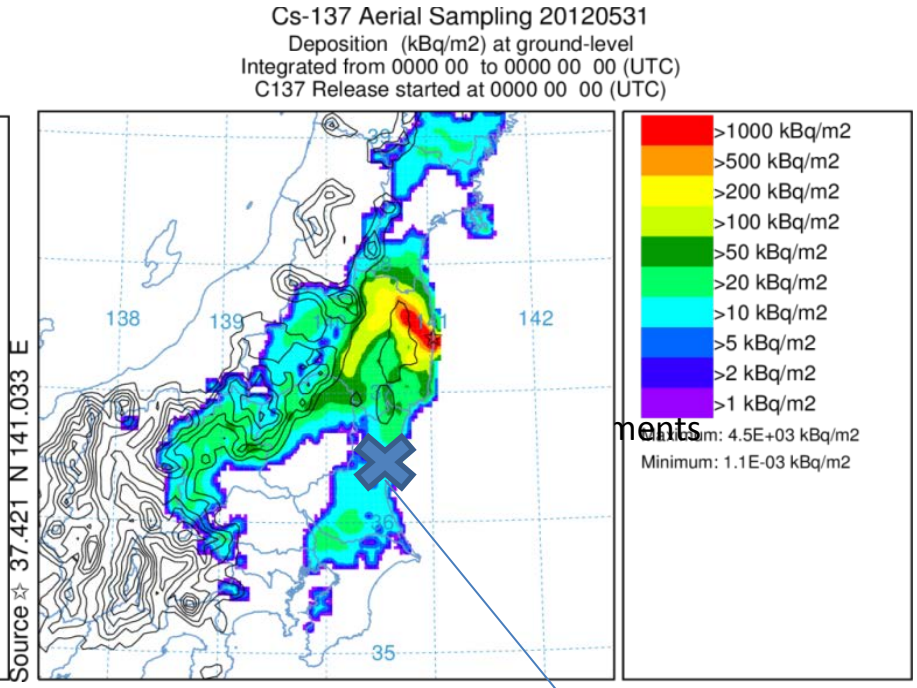
no change

Units of β are s^{-1}

On-demand runs – Radiological

Deposition from Fukushima nuclear power plant, 2011





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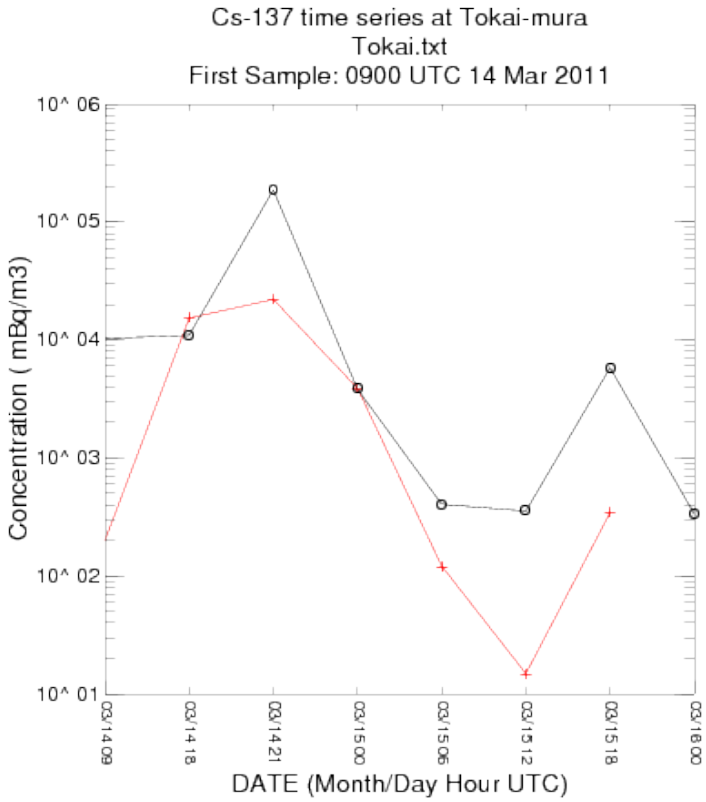
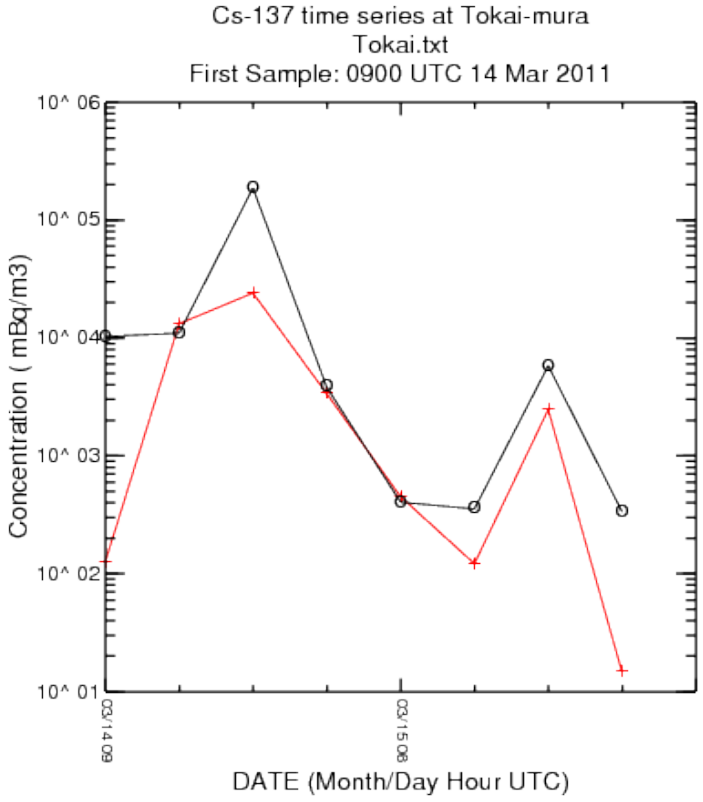
Tokaimura station

Air concentrations 7.3.1 vs 7.4.0





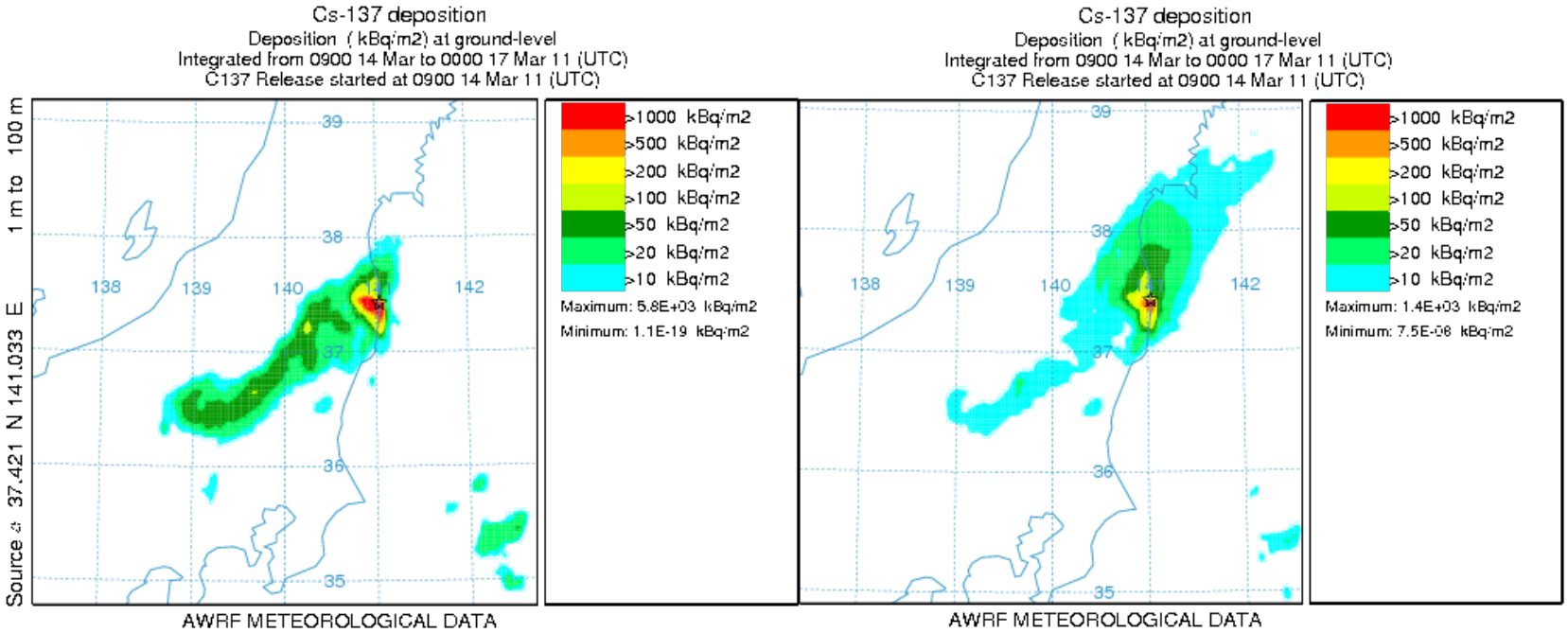
On-demand radiological evaluation

	V7.3.2	V7.4.0
Correlation Coefficient	0.91	0.94
Fractional Bias	-1.36	-1.33
Figure of Merit in Space	87.5	100.0
KSP*	50.0	38.0
Rank	2.53	2.85

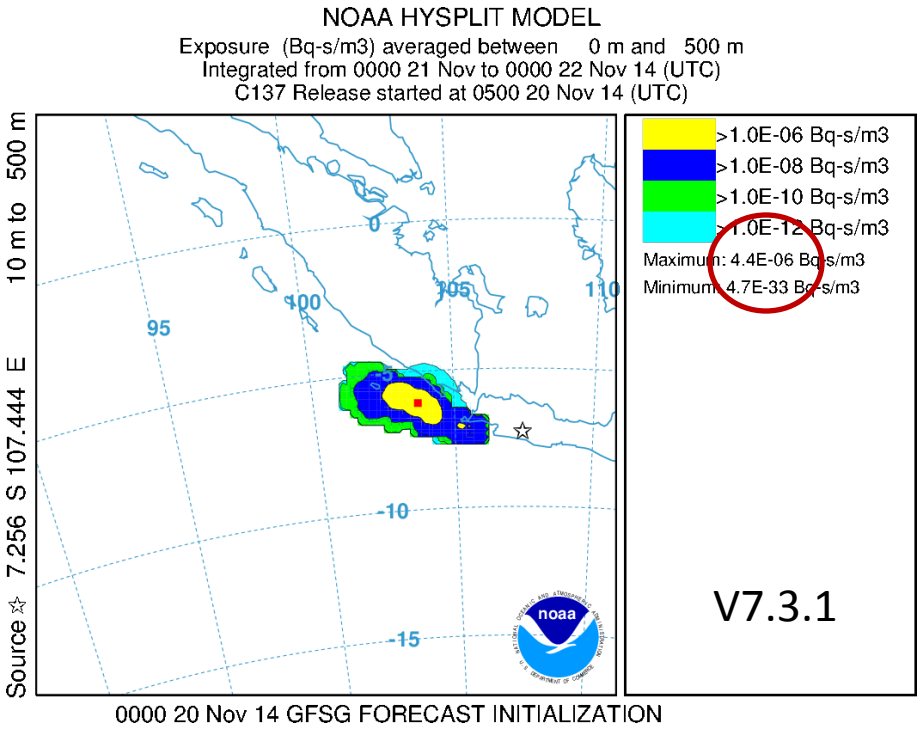
The "rank" score is based on the correlation coefficient, fractional bias, Figure of Merit in Space, and a measure of the cumulative concentration distribution. Rank varies from 0.0 to 4.0 (best). Differences of 0.1 or less are not significant. Tracer experiment information available at http://www.arl.noaa.gov/DATEM.php

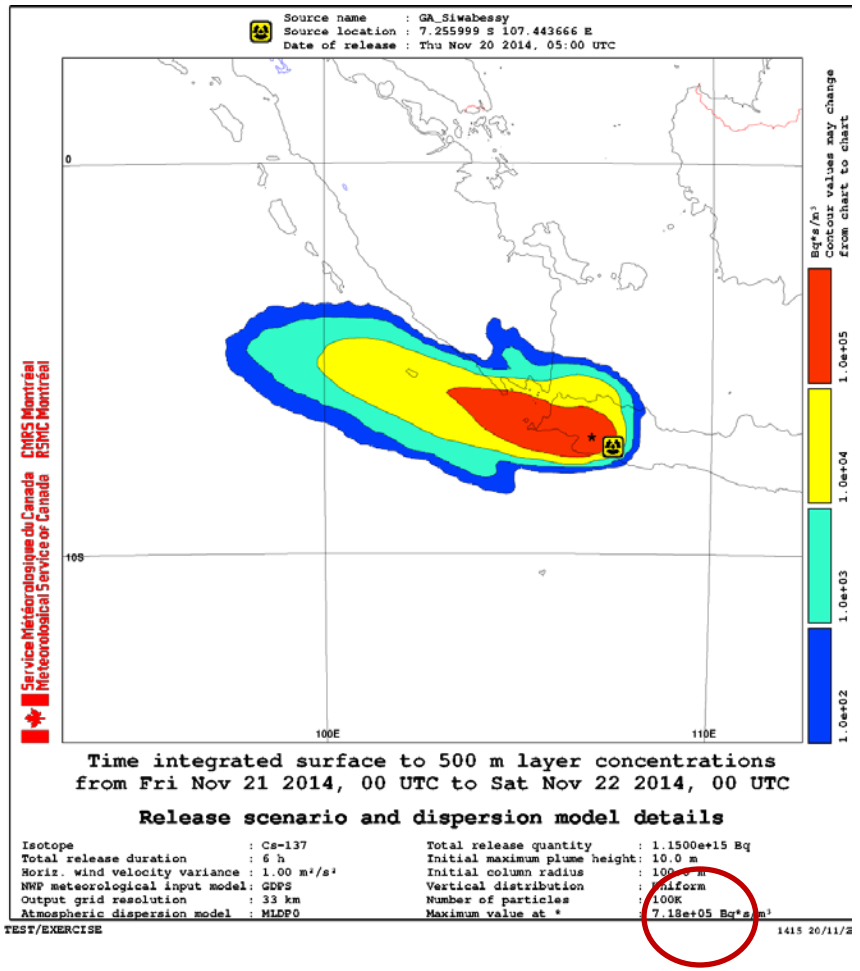
KSP = Kolmogorov-Smirnov Parameter

Deposition 7.3.1 vs. 7.4.0



Version 7.3.1

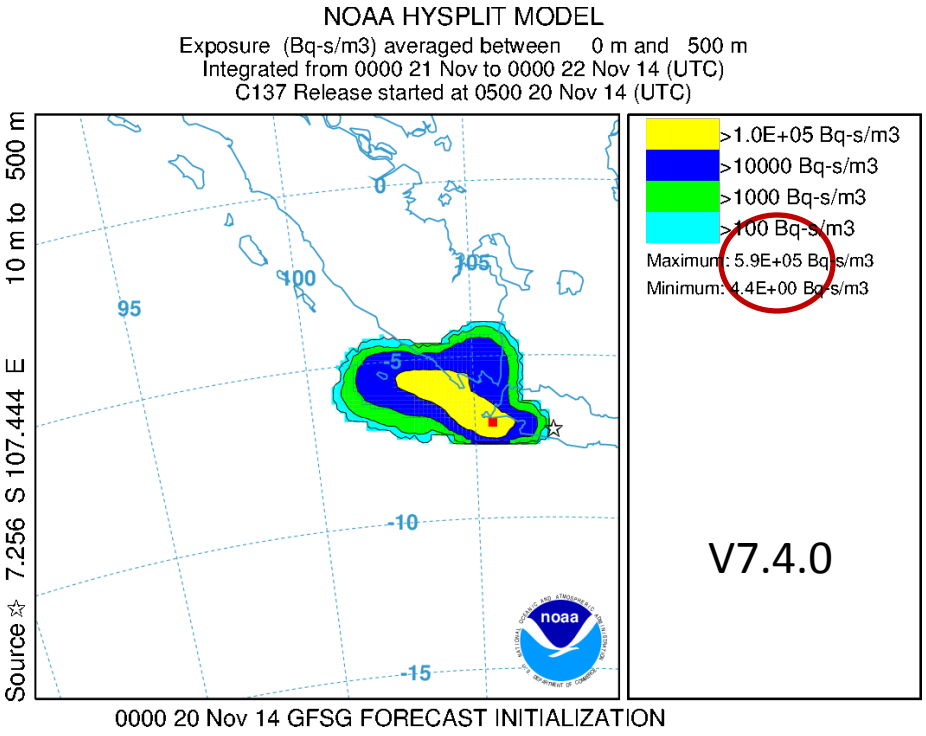


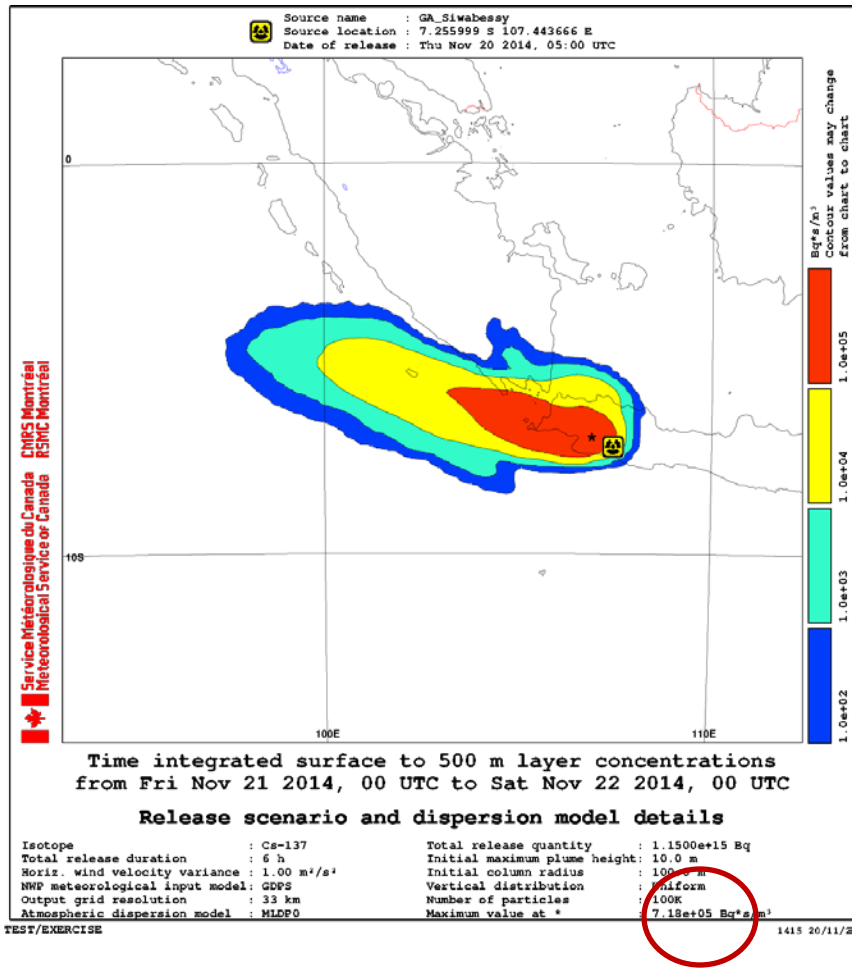


Maximum values:
Washington: 4.4E-6
Montreal: 7.2E+5

GFS1 to GFS0P5
Meteorology layer

Version 7.4.0





Maximum values:
Washington: 5.9E+5
Montreal: 7.2E+5

Cloud layer
Scavenging coefficient

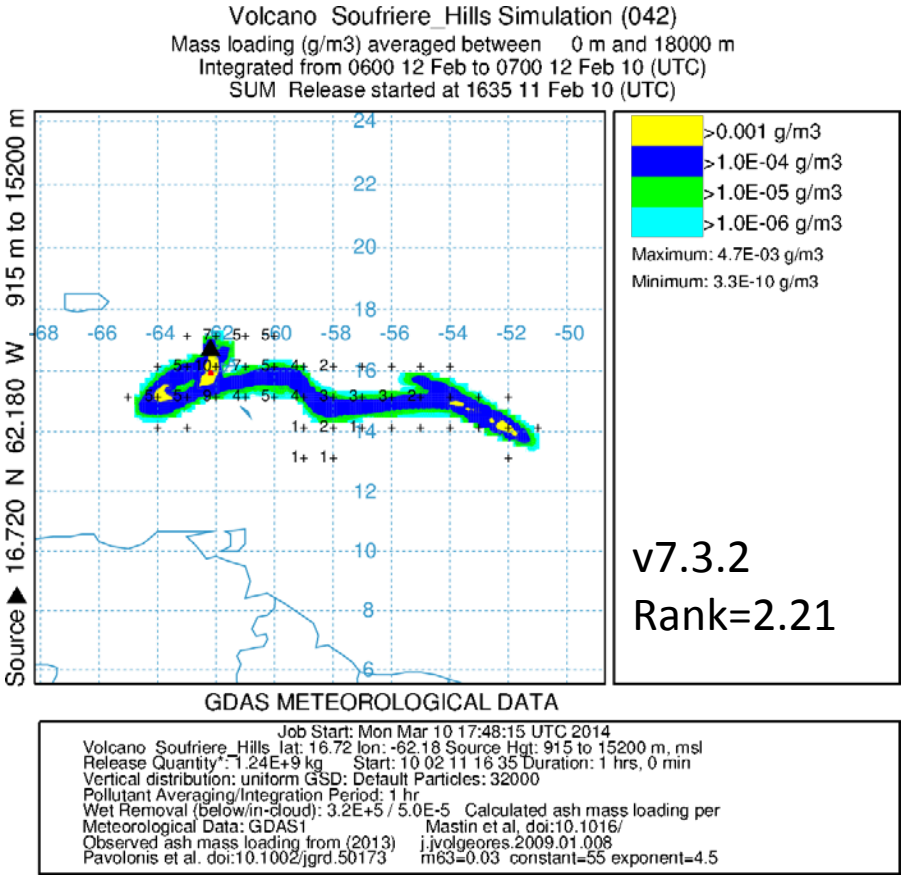
RSMC exercises' maximum values for the 2nd 24-h period

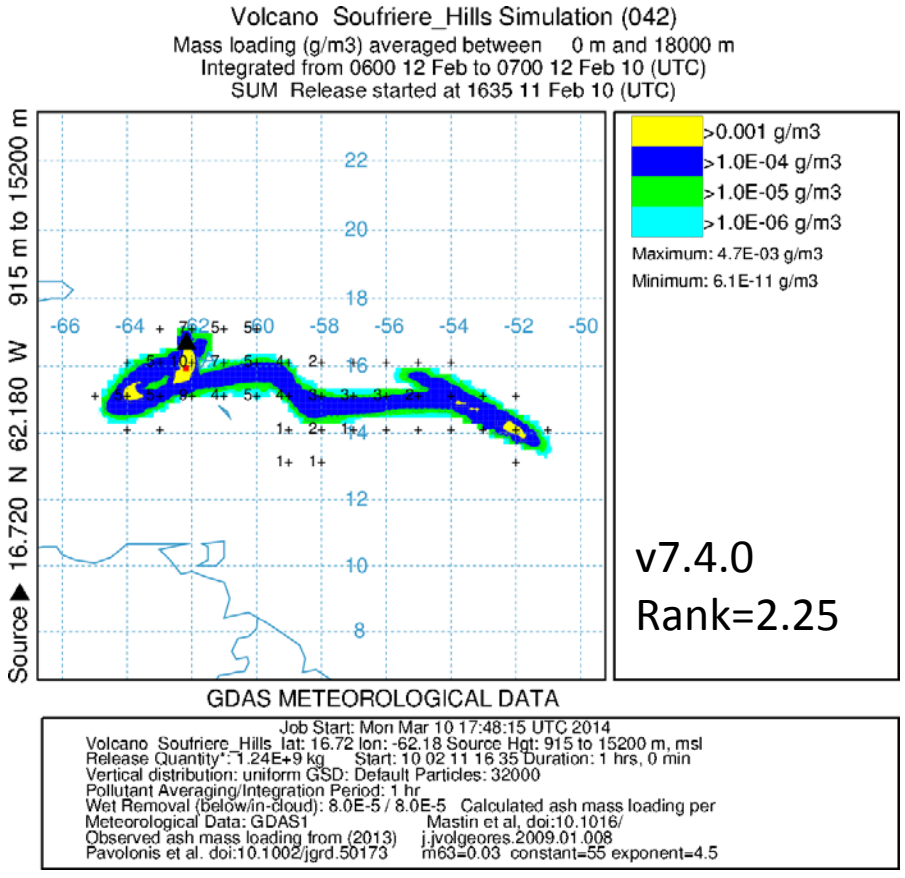
Date		V7.3.1 (old)	Canadian	V7.4.0 (new)	Precipitation
20141009	exposure	1.2E+08	8.1E+07	Same as v7.3.1	No
	deposition	2.4E+06	7.7E+05	Same as v7.3.1	
20141120	exposure	4.4E-06	7.2E+05	5.9E+05 ✓	Yes
	deposition	4.9E-10	3.6E+05	1.8E+05 ✓	
20141125	exposure	2.2E-09	1.8E-09	Same as v7.3.1	No
	deposition	3.7E-11	1.1E-11	Same as v7.3.1	
20141211	exposure	3.3E-10	2.7E-10	6.6E-10 ✓	Yes
	deposition	1.1E-10	8.2E-12	6.5E-12	
20150108	**exposure	*0.0	1.2E-10	1.1E-09	Yes
	**deposition	*1.4E-10	1.6E-11	4.2E-11	

*re-run with no wet deposition: 2.2E-12, 2.9E-11
** 3rd 24-h period

On-demand runs – Volcanic Ash

Volcanic ash – 2010 Soufriere Hills, Montserrat





- Very similar results for updated and operational HYSPLIT

Volcanic ash Evaluation

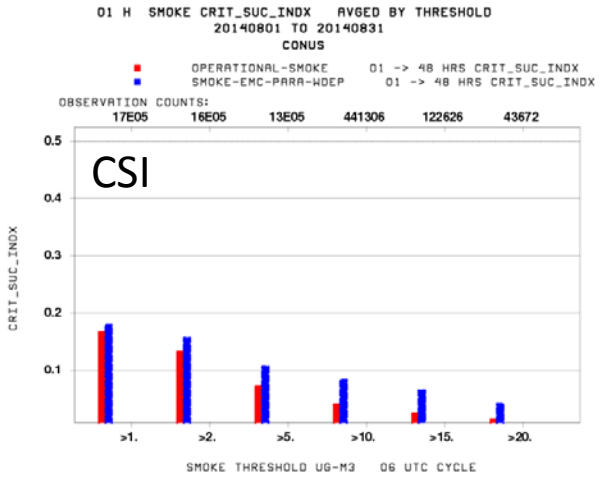
Soufriere Hills, 2010, Montserrat, West Indies

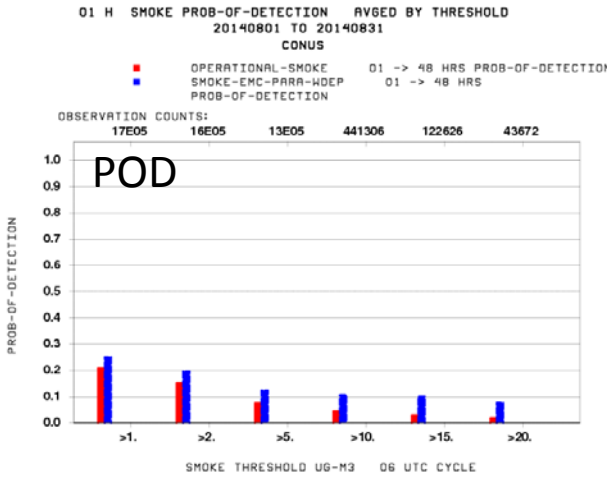
- Statistical comparison against satellite-based mass loadings show no significant differences.

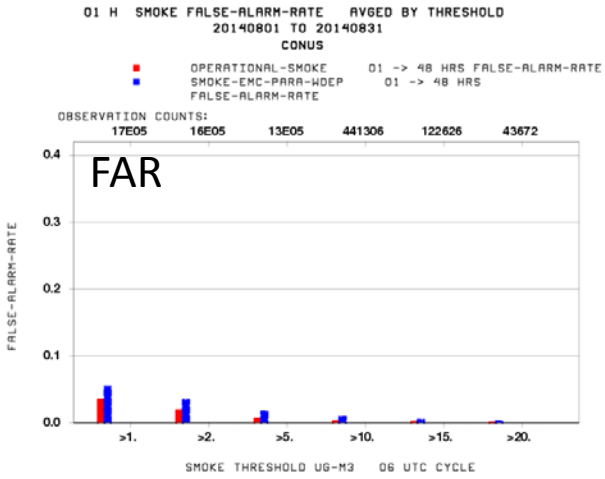
	V7.3.2	V7.4.0
Correlation Coefficient	0.33	0.36
Fractional Bias	0.25	0.24
Figure of Merit in Space	48.15	48.15
KSP*	26.00	24.00
Rank	2.21	2.25

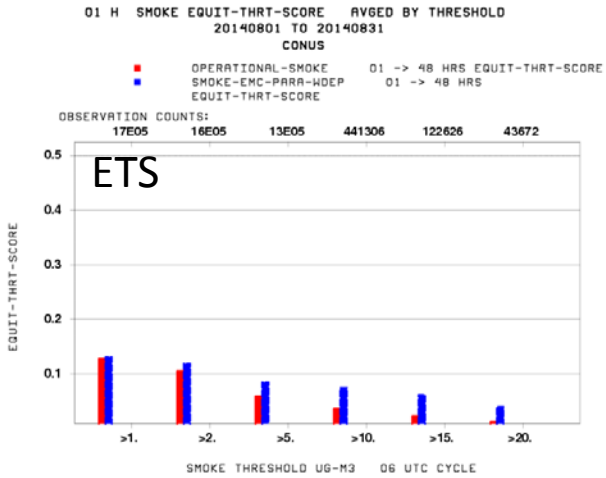
Verification period : 08/01-08/31 2014

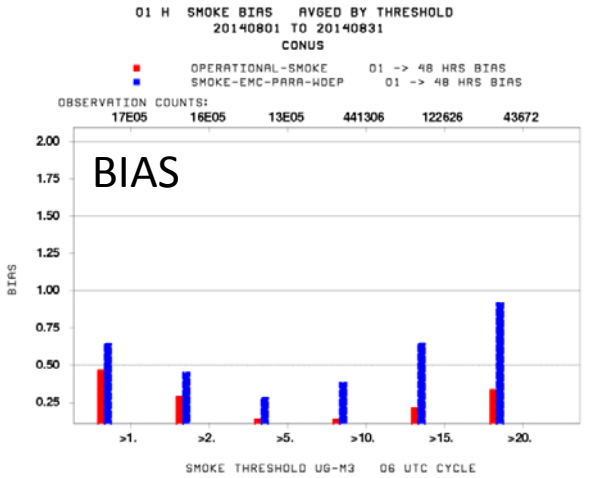
Better or no impact on HYSPLIT smoke forecasting

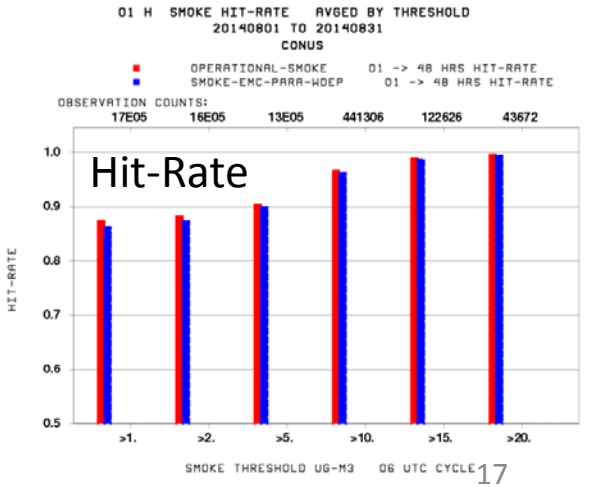






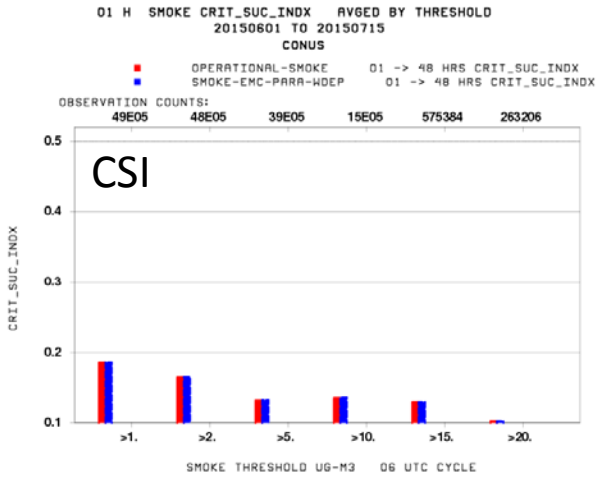


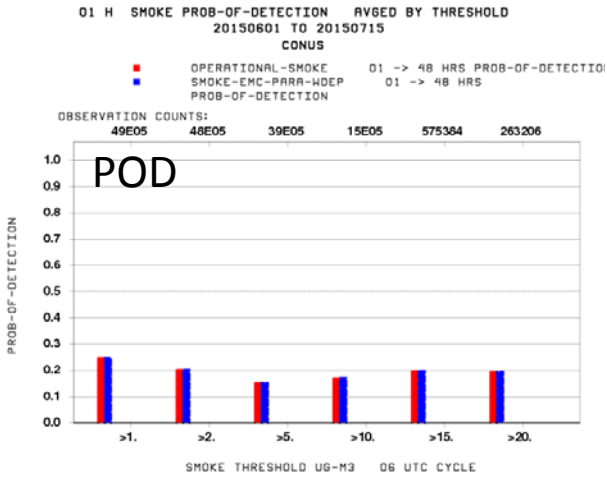


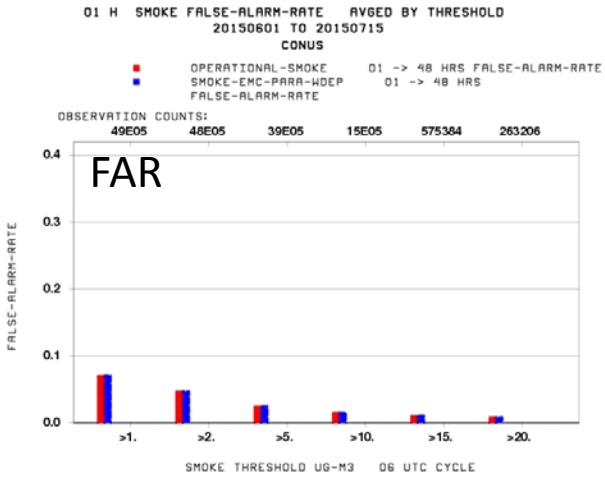


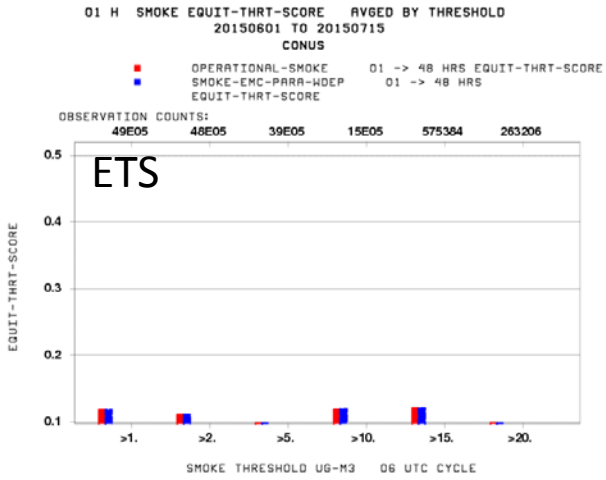
Verification period : 06/01-07/15 2015

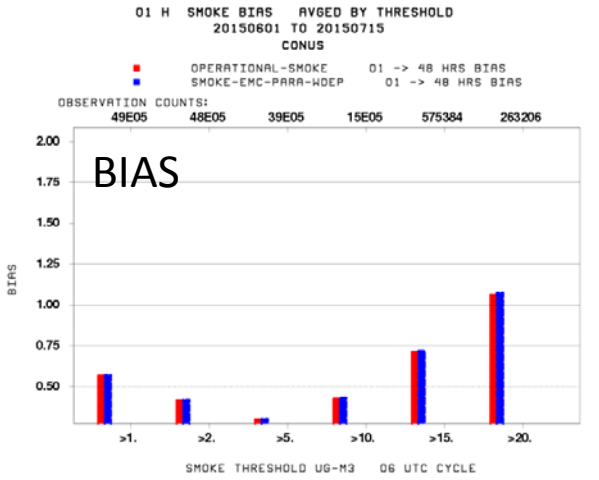
Nearly no impact on HYSPLIT smoke forecasting

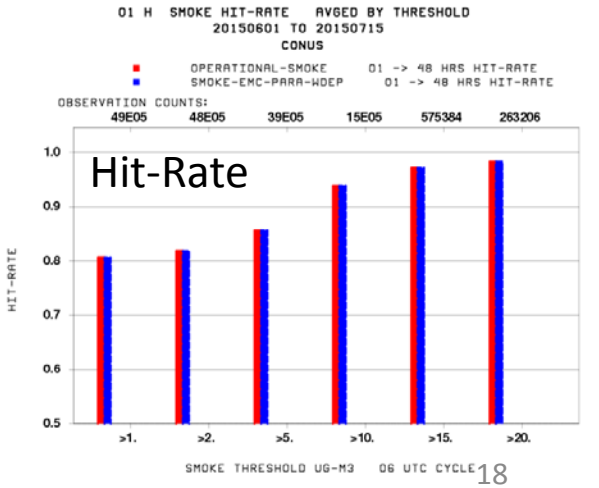






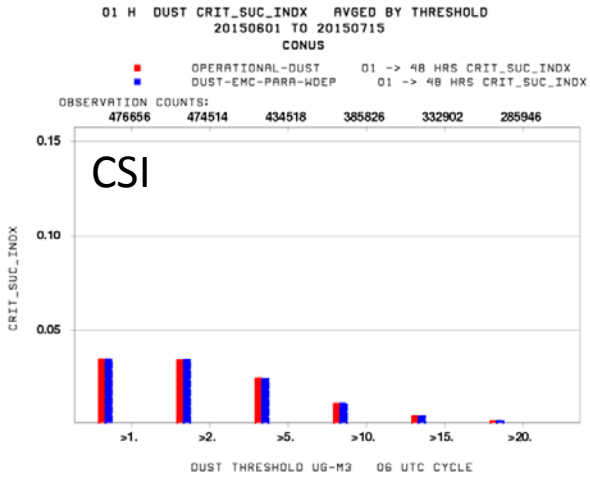


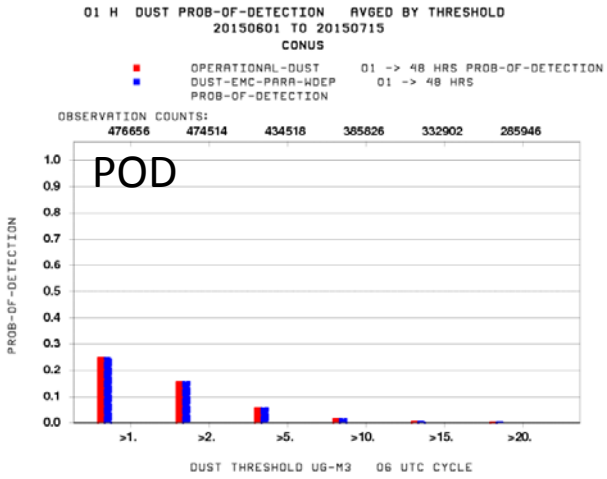


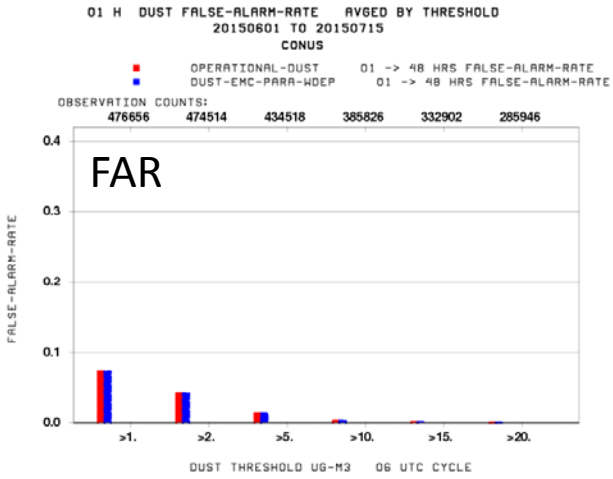


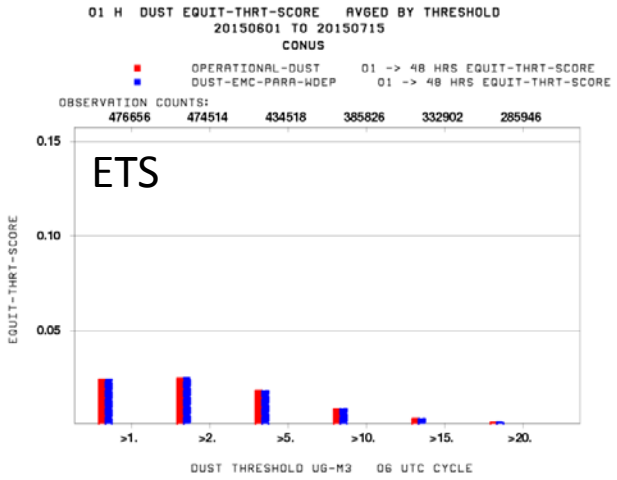
Verification period : 06/01-07/15 2015

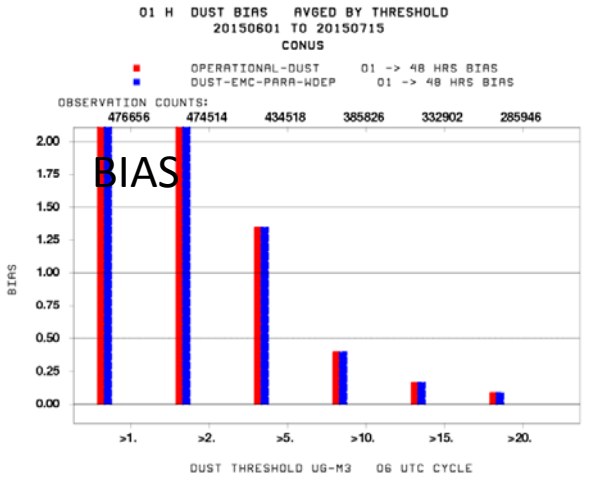
Nearly no impact on HYSPLIT dust forecasting

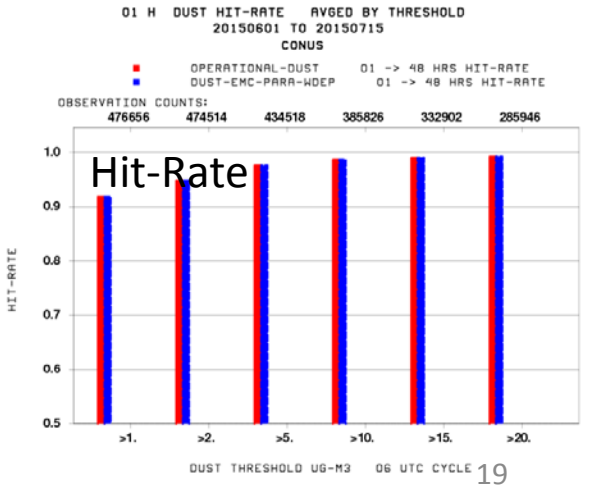












Verification using historical tracer experiments

Compare statistics (Rank score) of HYSPLIT new vs. operational for many boundary-layer tracer-release field experiments.

Experiment	Number of tracer releases	Sampler distance from release	Meteorology
ACURATE (March, 1982-Sept. 1983)	near-continuous	300 - 1100 km	NARR
ANATEX_GGW (1987)	33 (every 2.5 days)	500 - 3000 km	NARR
ANATEX_STC (1987)	33 (every 2.5 days)	500 – 2000 km	NARR
CAPTEX (1983)	6	300 – 1100 km	WRF and NARR
ETEX	1	200 – 1500 km	Reanalysis
INEL74 (Jan- May, 1974)	near-continuous	~1200-1800 km	Reanalysis
METREX_8h_MDVA (Nov 83 – Dec 84)	~ 275	< 50 km	MM5
METREX_8h_MtVernon (Nov 83 – Dec 84)	~ 275	< 50 km	MM5
OKC80 (1980)	2	100 km, 600 km	NARR
SRP76 (March 1975 – Sept. 1977)	near-continuous	< 150 km	Reanalysis

Tracer Experiments test

	v7.4 (new)	v7.3.2 (operations)
ANATEX_GGW	3.05	3.05
ANATEX_STC	2.60	2.60
CAPTEX	3.35	3.35
ETEX	2.66	2.66
INEL74	2.37	2.37
METREX_30d_MDVA	2.75	2.93
METREX_30d_MtVernon	2.18	2.33
OKC80	2.52	2.57
SRP76_weekly	2.17	2.17

Time interpolation for high resolution grids

Overall impact

- smoke/dust : June-July 2015, no impact
- volcanic ash : 2010 Soufriere Hills: small positive impact
- Radiological/RSMC/HLS: significant positive impact
- Tracer experiments: No impact except negative impact in high resolution urban experiment.

PROPOSED EVALUATION TEAM

Organization	Recommended	Individual	HYSPLIT Applications
NCEP Centers	EMC NCO	Ho-Chun Huang Steven Earle	ALL : smoke, dust, volcanic ash, Radiological & RSMC, Hazmat, CTBTO
NCEP Service Centers	SDM AWC	Patrick O'Reilly *E; Leitman*	Ash, RSMC, CTBTO, Hazmat RSMC, Ash?
NWS Region / WFO	ER CR SR WR AR Pac WFO BGM	*Jeff Waldstriker* *Jeff Craven* *Andy Edman* *Neil Petreskew* *Roger Edson* Mike Evans	Hazmat, Smoke, Dust Hazmat, Smoke, Dust Hazmat, Smoke, Dust Hazmat, Smoke, Dust, Ash? Ash, Smoke Ash? Lake-effect trajectories
Other NWS or NOAA components	ARL OST NESDIS/SAB (Washington VAAC) NWS/AAWU (Anchorage VAAC)	Glenn Rolph? Ivanka Stajner Jamie Kibler Don Moore	Hazmat, Ash, RSMC, CTBTO, Traj. Smoke, Dust, Ash Ash, Volcano trajectories
External Customers / Collaborators	CTBTO USFS WMO? Canadian Met Center USGS	Monica Krysta Susan O'Neill Rene Servranckx? Dov Bensimon Hans Schwaiger	CTBTO Smoke RSMC RSMC Volcano trajectories

Names in Italics from last upgrade, NCEP please confirm

Extras…

HYSPLIT originated as a puff model

- puffs grow with time and split based on puff size with respect to the meteorological grid size
- wet deposition based on horizontal and vertical dimension of puff

HYSPLIT default transitioned to particle model

- HYSPLIT.v7.3.0 used depth of meteorological layer(s) for in-cloud wet deposition calculation, however then the deposition was dependent on the depth of meteo layers, meaning different meteo datasets could give different deposition *(noticed this for RSMC, one-degree pressure level to half-degree native hybrid level GFS)*
- HYSPLIT.v7.3.2 uses meteorological cloud-layer depth (defined by RH) *(current operational)*
- HYSPLIT.v7.4 will extend the use of the below-cloud scavenging coefficient method for in-cloud wet deposition