Dispersion Modeling Support at the NOAA /NWS National Centers for Environmental Prediction (NCEP) and OAR/Air Resources Lab (ARL)

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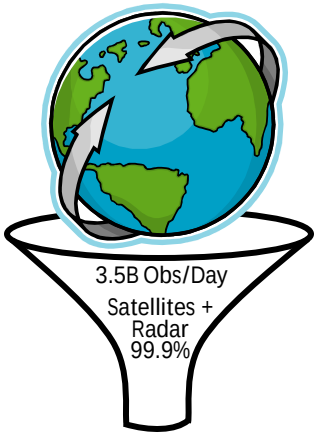
July 14, 2011

Progress with Operational Meteorological and Dispersion Model Support

- Progress towards:
  - WMO Regional Specialized Meteorological Center support
    - Run at NCEP 24/7 by Senior Duty Met (SDM)
  - Homeland Security support
    - 1.3 km nest
  - Volcanic Ash, dust, smoke global capability
- Probabilistic Prediction
  - High Resolution Meteorological Ensembles
- Evaluation Techniques
  - Concentration Evaluation
- Future Directions

NOAA's Model Production Suite



Global Data Assimilation

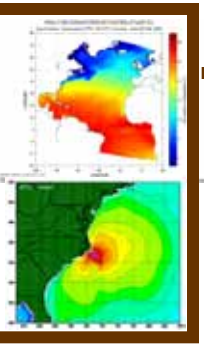
Global Forecast System

Climate
CFSv2
MOM4

Hurricane
GFDL
HWRF

Coupled

Oceans
HYCOM
WAVEWATCH III



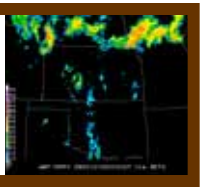
NOS PORTS
GLOFS

Chesapeake
Tampa
Delaware
ADCIRC

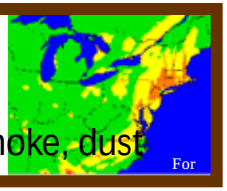
Regional DA
Regional NAM
NEMS NMM

Dispersion
ARL/HYSPLIT RSMC, Volc Ash

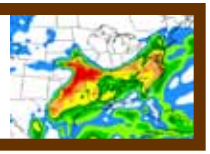
Severe Weather
WRF NMM/ARW
Workstation WRF



Air Quality
NAM/CMAQ, smoke, dust

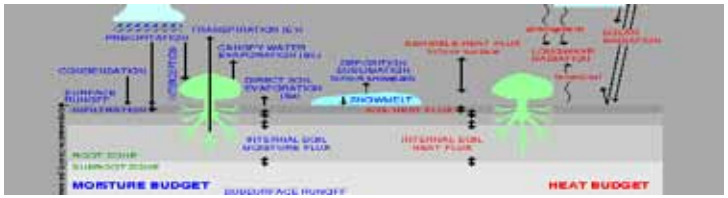


Rapid Update for Aviation



North American Ensemble Forecast System
GFS, Canadian Global Model

Regional DA
Short-Range Ensemble Forecast
WRF: ARW, NMM
ETA, RSM

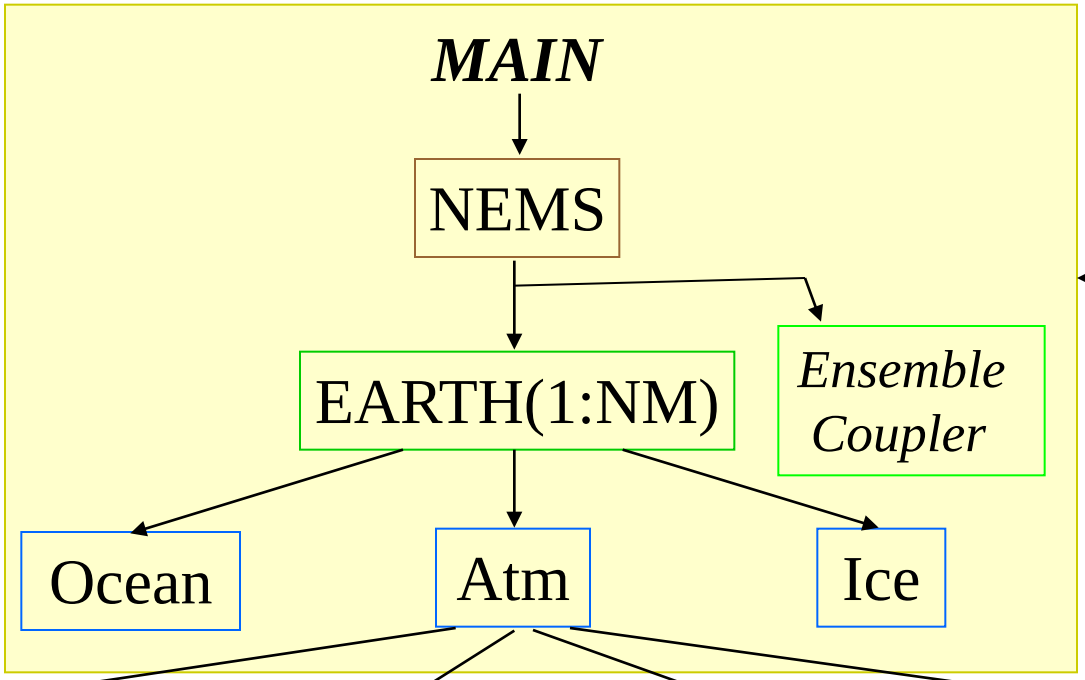


NOAH Land Surface Model

NEMS Component Structure

All boxes represent ESMF components.

Below the dashed line, the source codes are organized by the model developers.



NEMS LAYER

NMM GFS FIM ARW

Nest Domains(1:ND)

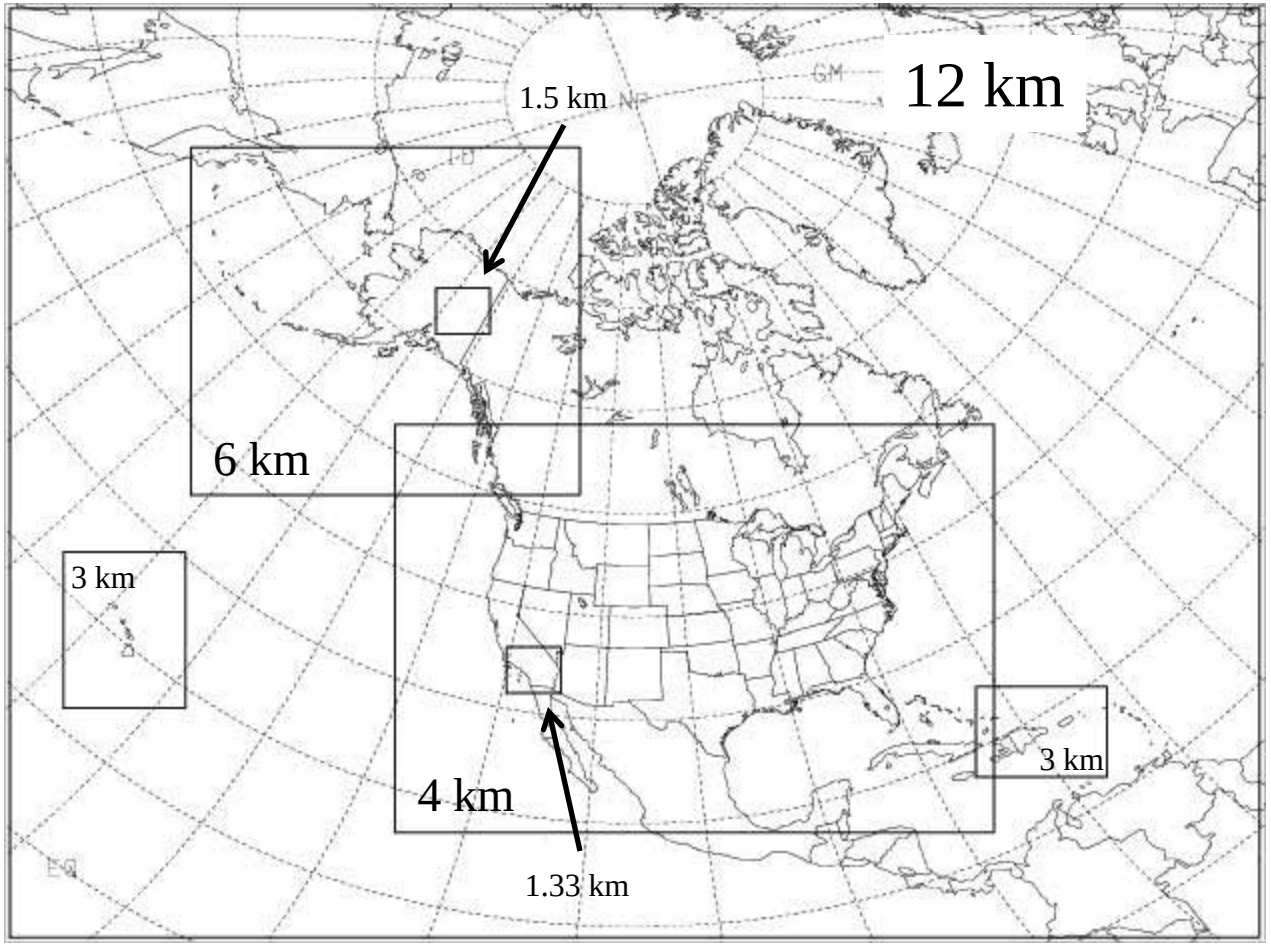
Dyn Phy Wrt — CMAQ

Dyn Phy Wrt — GOCART

Dyn Phy Wrt — WRFChem

Dyn Phy Wrt

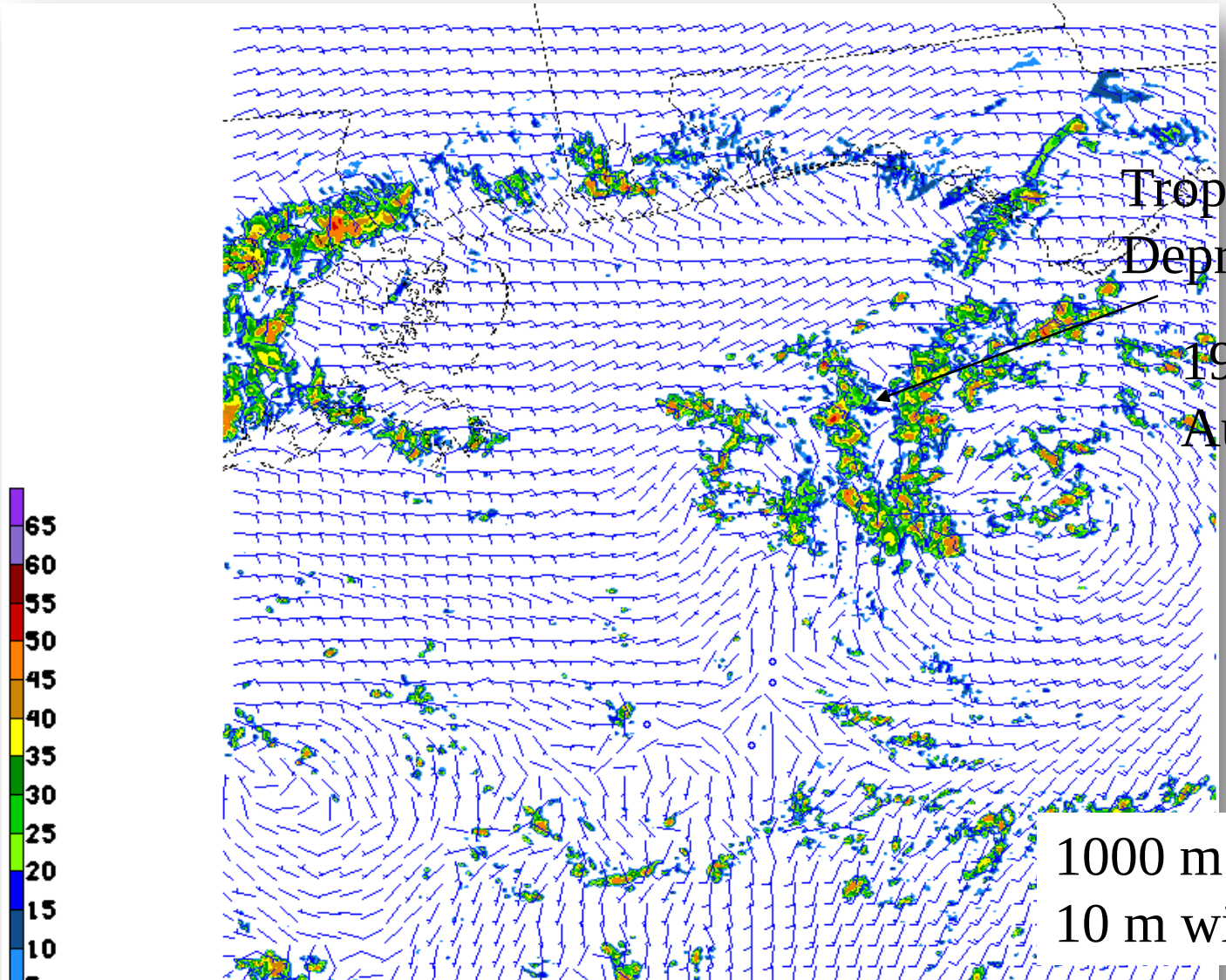
National Environmental Modeling System FY11; Q3



Parent (12 km)
– 84 hrs
Children (6, 4 & 3 km)
– 60 hrs
IMET (1.5 & 1.33 km)
– 36 hrs

Nonhydrostatic Mesoscale Model (NMM) à NonHydrostatic Multiscale Model on B grid (NMMB)
-- Physics retuned for NMMB
-- Additional data sets: Windsat, ASCAT, ACARS humidity, NOAA-19 (HIRS and AMSU-A), IASI radiances, AQUA (AMSU-A), GPS (radio occultation)

NCEP Test of Fire Wx Nest Capability
Gulf Spill 1.33 km NEMS/NMMB nest

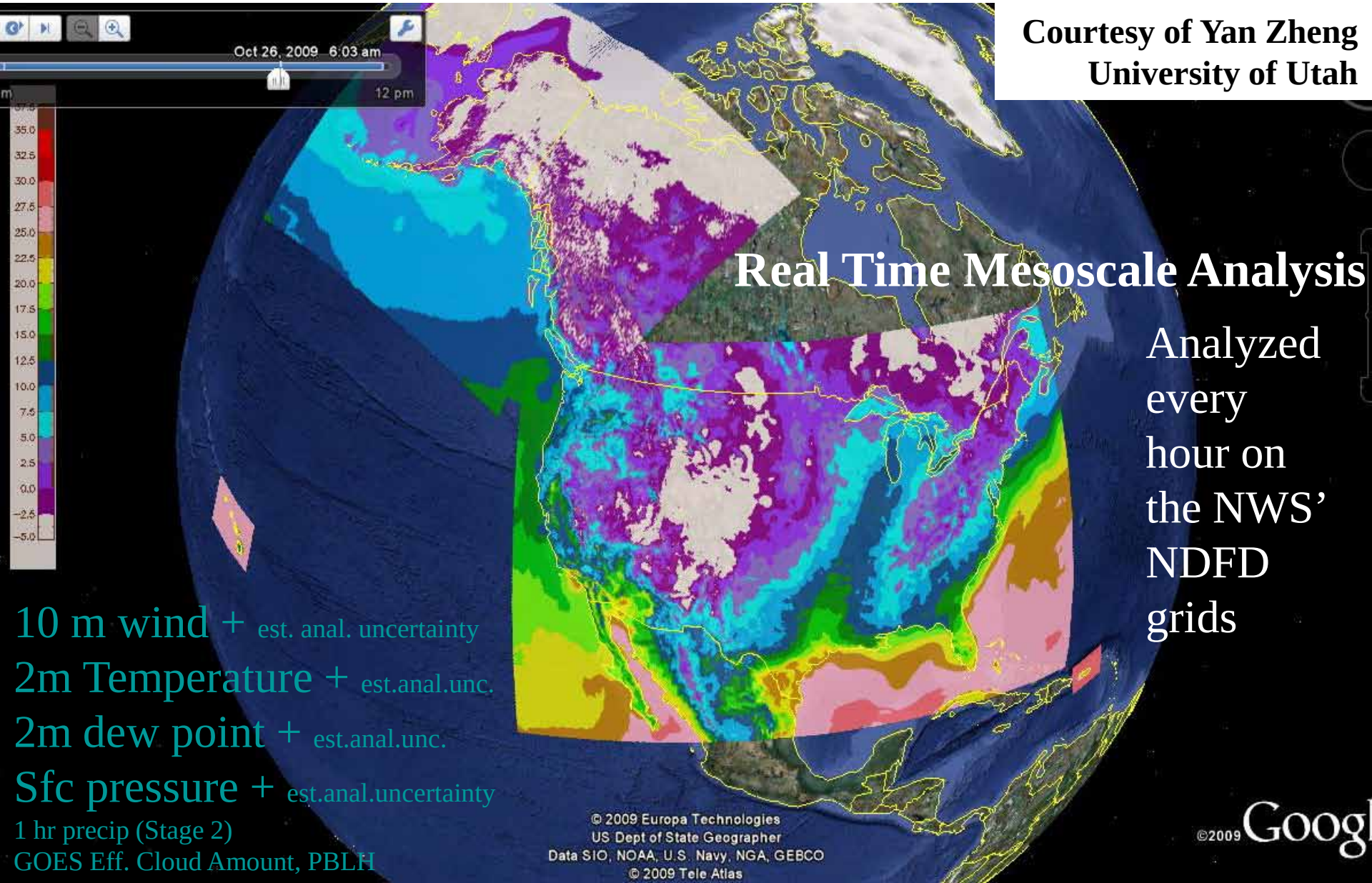


Tropical Depression 5

19Z 11 August

1000 m REFD, 10 m winds

Google Map of 4 RTMA Domains
First Phase of Analysis of Record



Courtesy of Yan Zheng
University of Utah

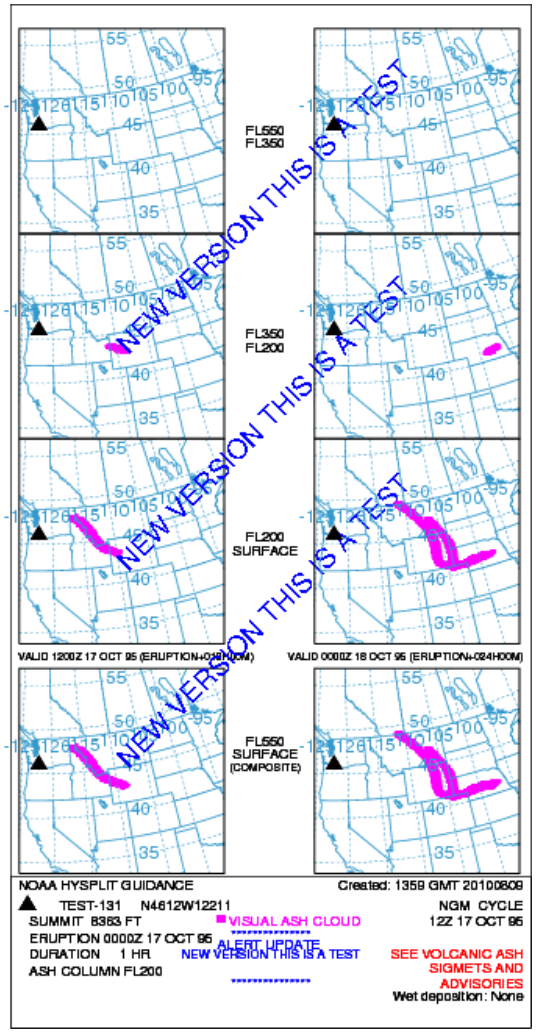
Real Time Mesoscale Analysis

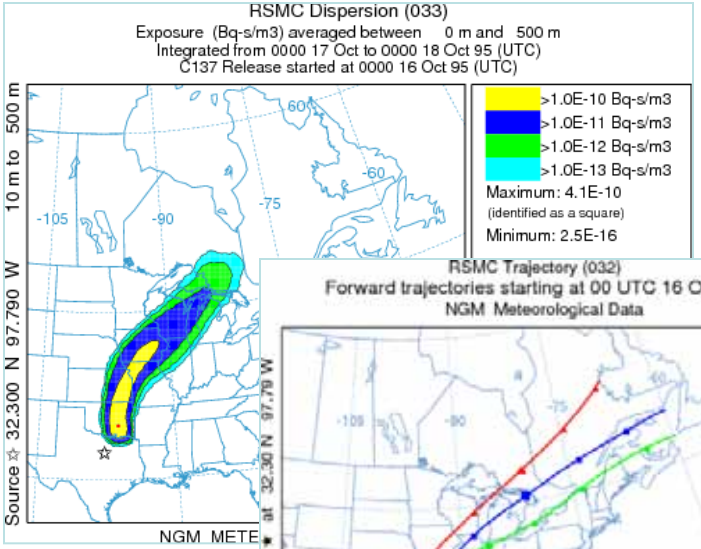
Analyzed every hour on the NWS' NDFD grids

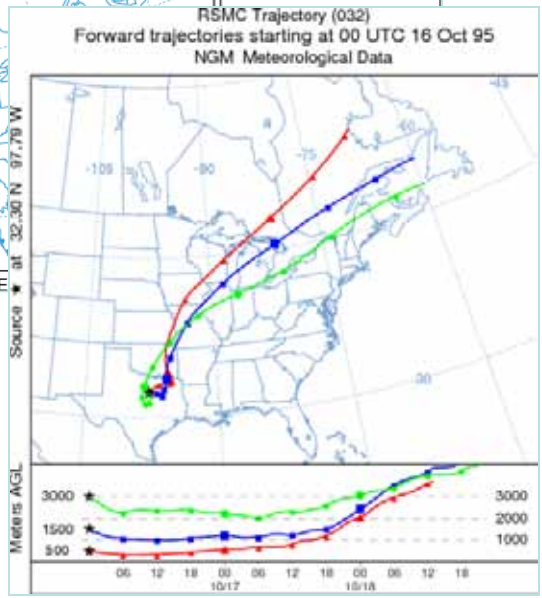
10 m wind + est. anal. uncertainty
2m Temperature + est.anal.unc.
2m dew point + est.anal.unc.
Sfc pressure + est.anal.uncertainty
1 hr precip (Stage 2)
GOES Eff. Cloud Amount, PBLH

Operational HYSPLIT

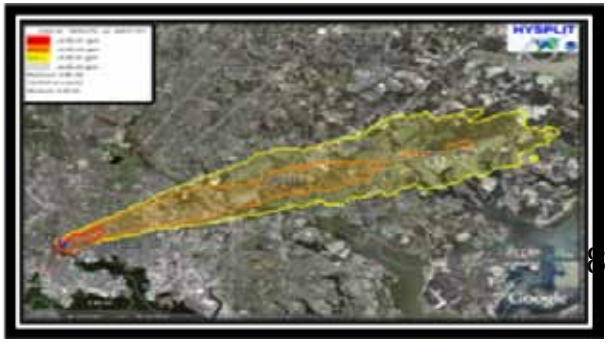
Volcano, RSMC, Homeland Security



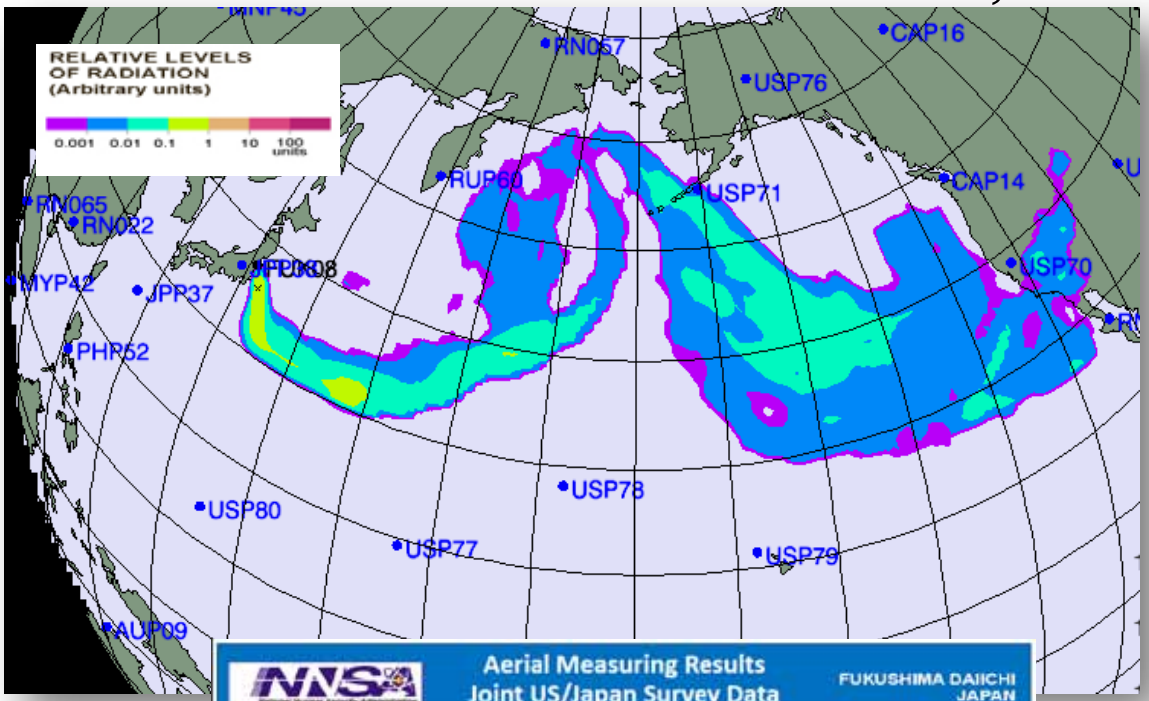


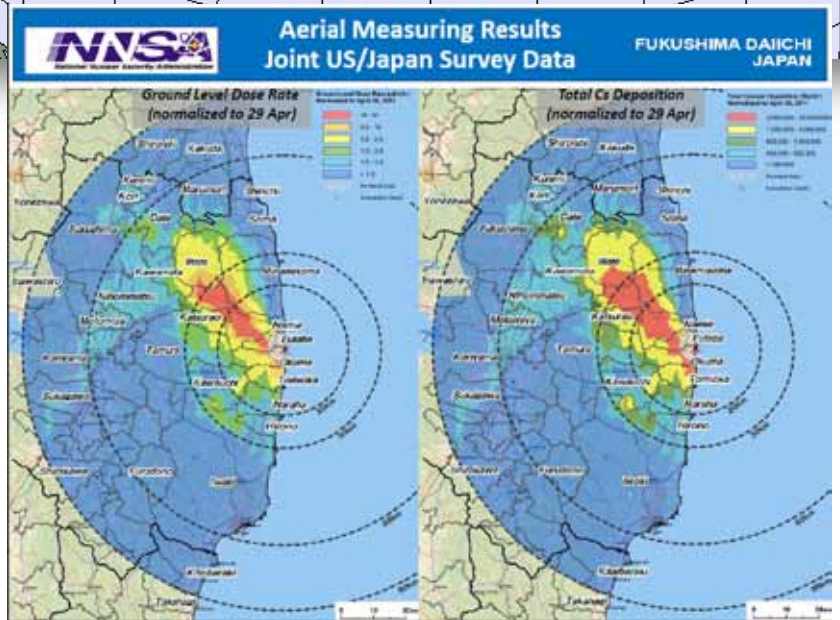


HLS



IAEA Long Range Transport Plume
New York Times March 16, 2011





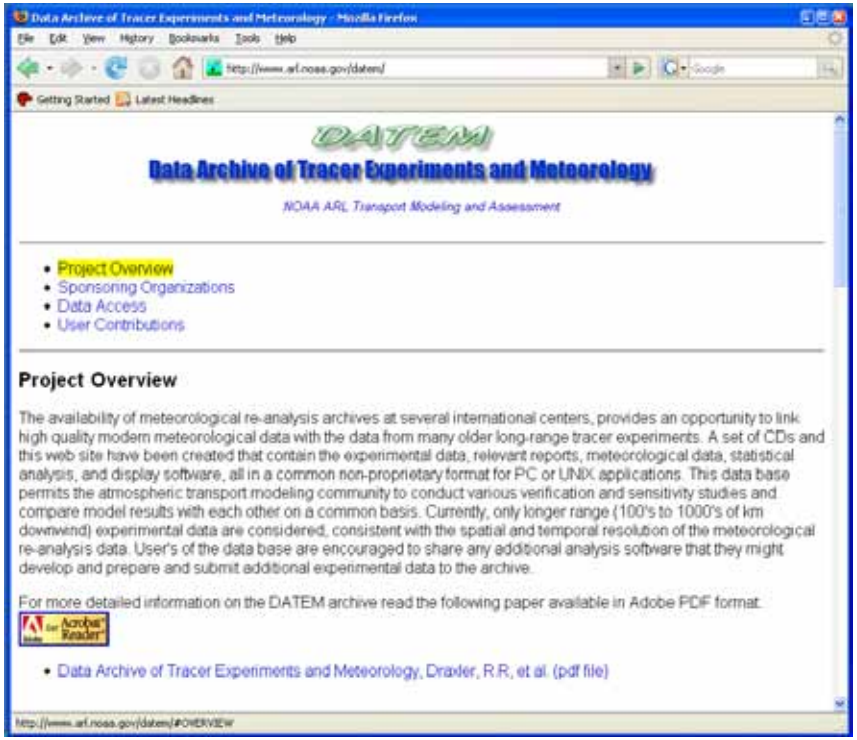
JMA estimate

10兆分の1㏃/㎡以上
1000兆分の1㏃/㎡以上
10京分の1㏃/㎡以上
4月4日15時から7日9時までの積算。
気象庁資料を加工（京は兆の1万倍）

Evaluation Techniques

Comparison to experimental data

- Archive of NOAA experimental tracer data and meteorology is on-line and in a common data format
- Meteorology comes primarily from the regional reanalysis
- WEB directory also includes all statistical programs, and the …
- model configuration used to produce tabulated results



http://www.arl.noaa.gov/DATEM.php

Comparison to experimental data, cont'd

http://www.arl.noaa.gov/DATEM_results.php

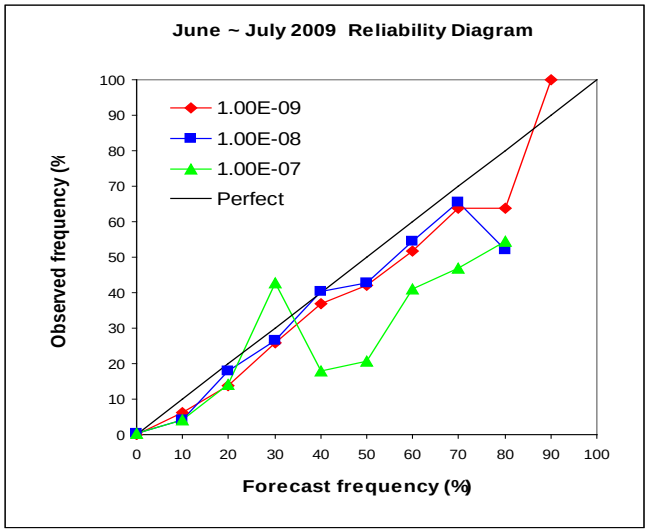
EXPERIMENT	Average	Paired
ACURATE (18 m)	3.25	1.77
ANATEX (33)	3.48	1.84
ANATEX (33)	2.66	1.63
CAPTEX (6)	3.24	1.63
[1]ETEX (1)	2.37	1.55
[1]INEL74 (2 m)	1.71	1.37
METREX (243)	2.81	1.77
METREX (243)	2.27	1.58
OKC80 (2)	2.50	1.73

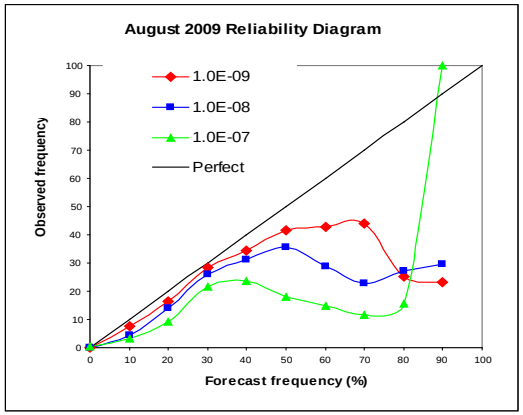
North American Regional Reanalysis:
http://nomads.ncdc.noaa.gov

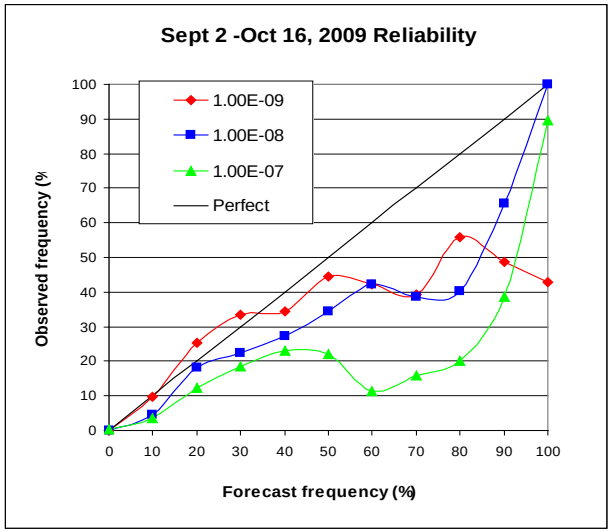
Probabilistic verification

Reliability Diagram – indicates joint bias

4 km MM5 Analysis SCIPUFF "Truth" vs 32 km SREF SCIPUFF Forecast







June-July reliability

Lower dosage show good reliability

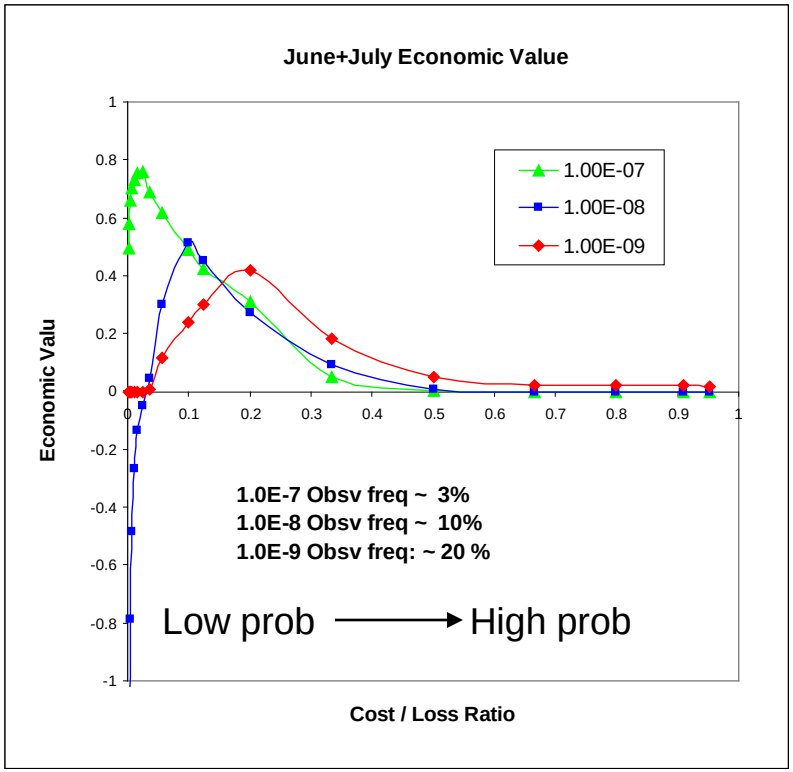
Higher dosage has positive bias over higher probability range

Aug-Sept-Oct Reliability

Overwhelmingly large positive bias over high probability range

Economic Value (EV)

Performance over different cost/loss ratio



High dosage prediction over low cost/ratio has high EV.

Answer such questions as:

If cost/loss is extremely low, e.g. loss is so high that cost can be neglected, then take action in lower probability has skill?

The answer is YES, according to EV

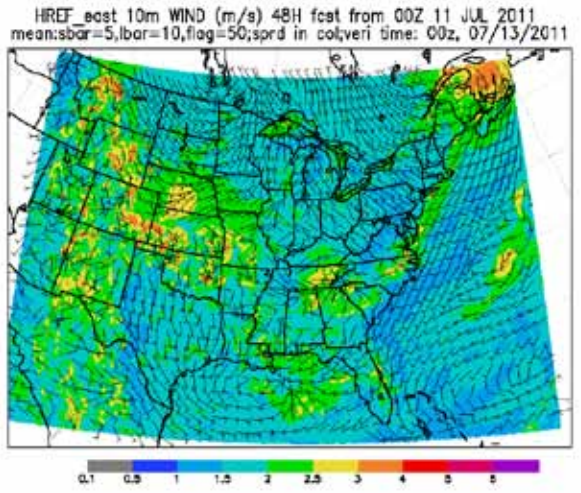
Lower probability means higher FAR

(don't care false alarm to take action)

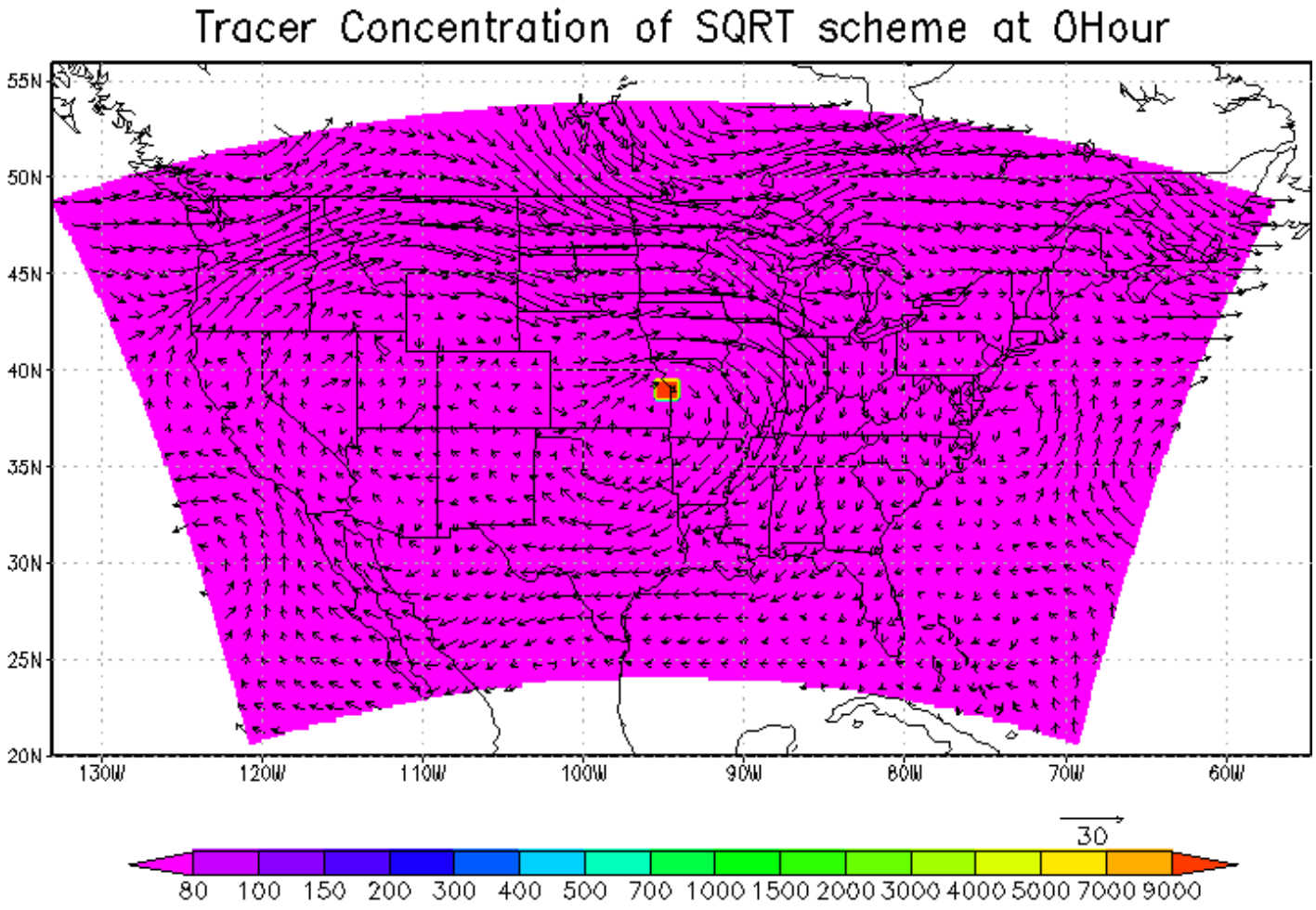
For high, less dangerous dosage, should use moderate prob thresholds

Hybrid High Resolution Ensemble Prediction

High Resolution Model	Domain	Resolution	Time lagged members	# members
NAM NEMS NMMB nest	CONUS	4 km/L35	Current, T-6, T-12h	3
NOAA/ ESRL HRRR	CONUS	3 km/L35	Current, T-1, T-2, T-3, T-4, T-5, T-6	7
WRF High Resolution Window ARW	Eastern U.S. Western U.S.	4.5 km/L35	Current, T-12	2
WRF High Resolution Window NMM	Eastern U.S. Western U.S.	4 km/L35	Current, T-12	2
NEMS/NMMB Storm Prediction Center (SPC) Configuration	CONUS	4 km/L35	Current, T-12	2



Inline Tracer Development courtesy of Youhua Tang

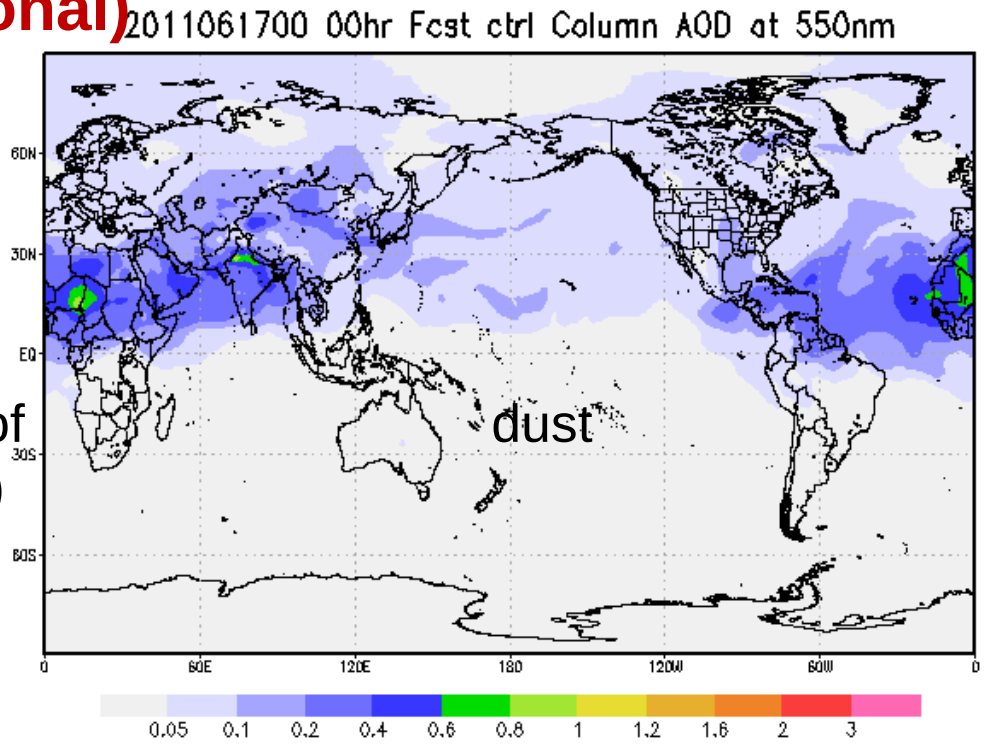


- Regional NMM-B with 3-D tracer advection (no tracer physics & diffusion)
- Tracer initialized at center of the domain from bottom to top (cuboid form)
- Zero lateral boundary conditions
- 500 hPa field shown

NMM-B tracer run with initial cuboid-shaped field

Global Dispersion Modeling

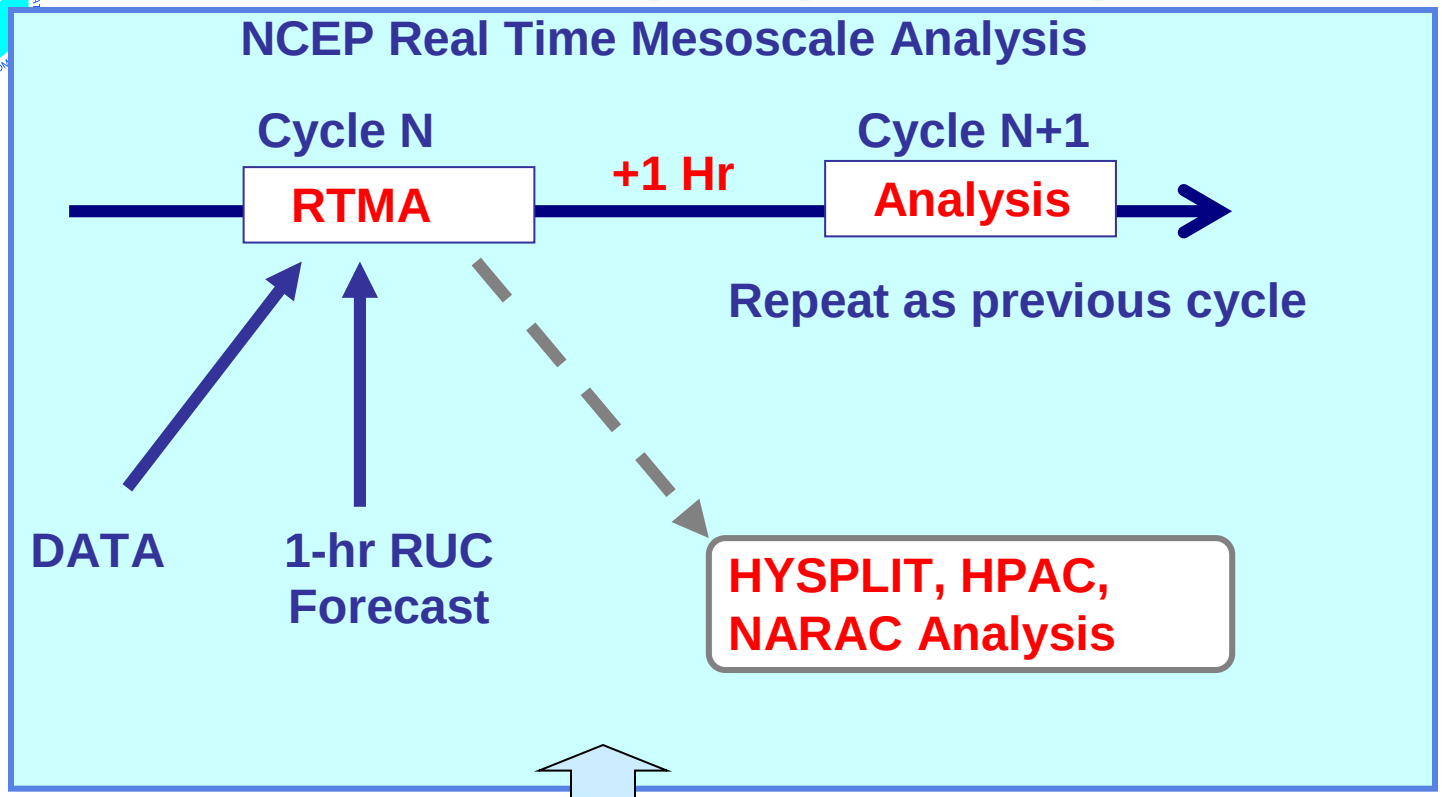
Experimental (non-operational)



dust

- Executable compiled from NEMS trunk code repository
- 120-hr dust-only forecast
- Once per day (00Z)
- 3-hourly products: 3d distribution of aerosols (5 bins from 0.1 – 10 μm)
- Automatic output archive, post processing and web update since June 11, 2011
- Same physics and dynamics as operational GFS with the following exceptions:
  - Lower resolution (T126 L64)
  - Use RAS with convective transport and tracer scavenging
  - Aerosol-radiation feedback is turned off

Boundary Layer Analysis

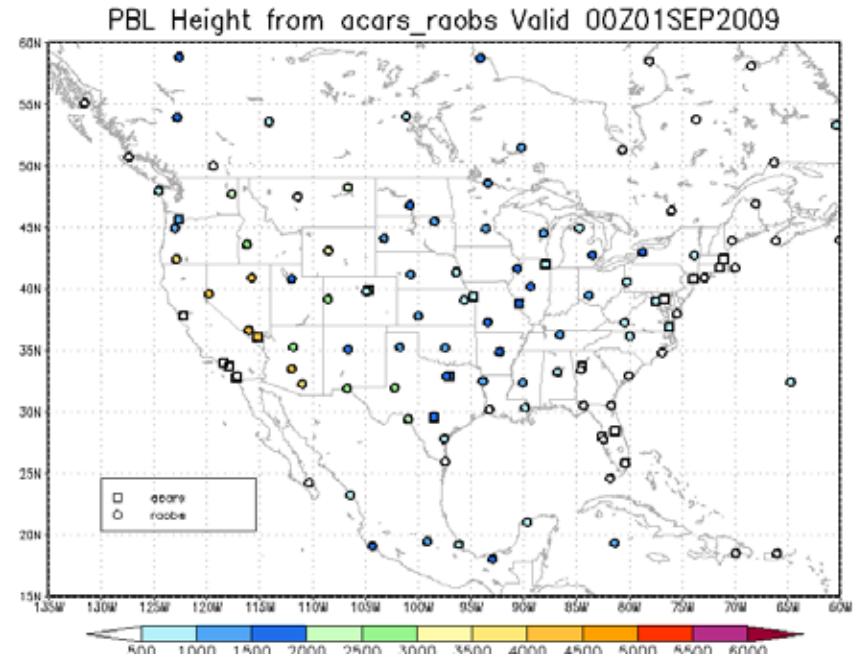


National PBL Products

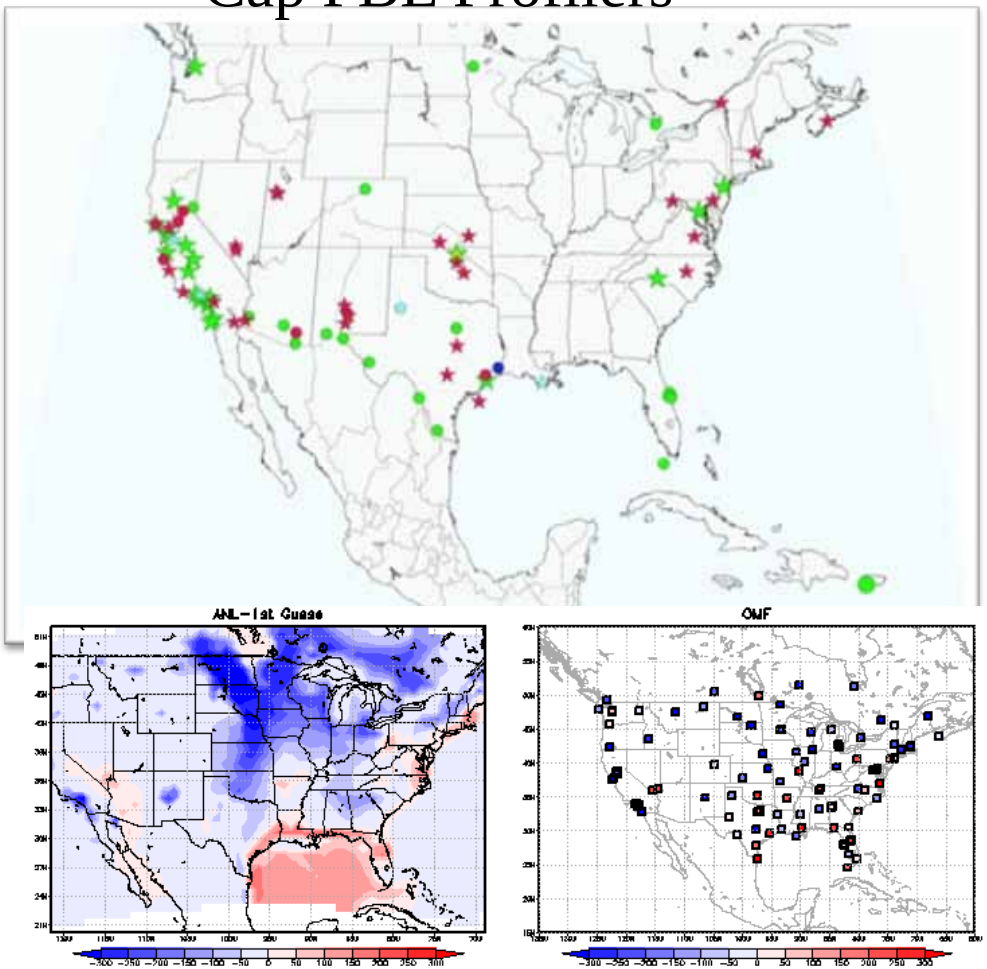
Verification:
Calipso products
NCAS lidar, ESRL Profilers

NASA GPS RO (COSMIC) data
+ Sonde/ACARS data
+MPLNET lidar + NexRad data

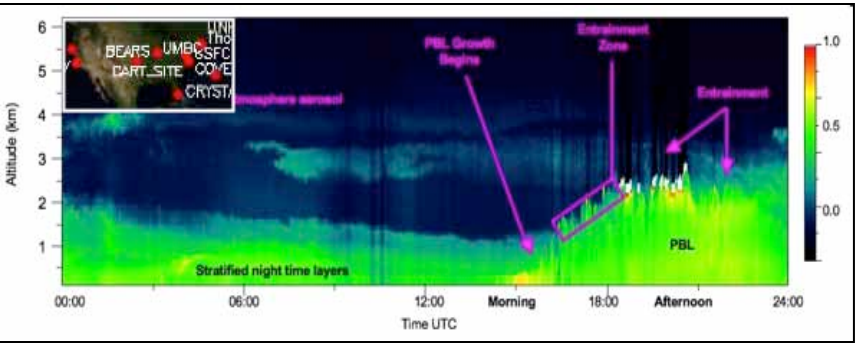
Improved Boundary Layer Analysis



Cap PBL Profilers



MPLNET Lidars



Need more observations for analysis to have an impact
Need more independent observations for verification

Lessons Learned & Recommendations

- Need for NRT relocatable, global operational high resolution NWP – Atmospheric Dispersion modeling capability w/ data assimilation
  - WMO/RSMC à Most useful for long rang transport (GFS-HYSPLIT)
  - NMCs coordination thru RSMC process (information thru secure web pages)
    - Better coordination with non-NMC centers (eg: DOE, DOD…)
    - Better define & interpret model output strengths/weaknesss (long range vs near-field products)
- Enhance boundary layer measurements for evaluation, assimilation:
  - Radiosondes, field experiments, ACARS
  - PBL Profilers (e.g.: U.S., Japan, Europe)
  - Lidar (EARLINET, WMO- GALION), ASOS Ceilometers (PBLH, Aerosols)
  - Develop boundary layer reanalysis (downscale NARR, ERA ?)
- Develop and evaluate high resolution ensemble met systems
  - HRRR, Time Lagging, Composite
  - Include boundary layer uncertainty, new metrics
  - Additional products: threshold probabilities, Plume time of arrival
- Evaluate in-line dispersion within NWP modeling techniques
  - Esp for aerosol interactions w radiation/clouds (smoke, dust, ash)