Hazard Prediction with Nowcasting

Overview of Mesoscale Meteorological Modeling for Dispersion Applications at the Naval Research Laboratory

Science and Technology for Chem-Bio Information Systems Conference
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- **Description:** Develop capability to use high-resolution (~1 km) COAMPS®* atmospheric forecasts as input for DoD dispersion models, and quality check the results.
- **Performers**

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- 2005 Objectives:
  - Develop high-resolution (~1 km hz grid spacing) atmospheric prediction capability to support DoD WMD forecasts.
  - Incorporate predicted battle space environment variables into improved chemical/biological dispersion models (JEM, HPAC, VLSTRACK).
  - Demonstrate the quality of the atmospheric and dispersion forecasts.
- 2006-07 Objectives:
  - Develop surface analysis package for COAMPS®/NAVDAS
  - Boundary layer/surface flux parameterizations

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2005 Milestones:

- Generate COAMPS® forecasts for Dipole Pride 26 field project and store results in a database.
- Develop interface for JEM using HPAC as a surrogate.
- Generate HPAC, VLSTRACK, and JEM forecasts using the COAMPS® forecasts.
- Demonstrate the quality of the JEM forecasts in comparison with the HPAC and VLSTRACK forecasts using the full suite of atmospheric forecast fields.

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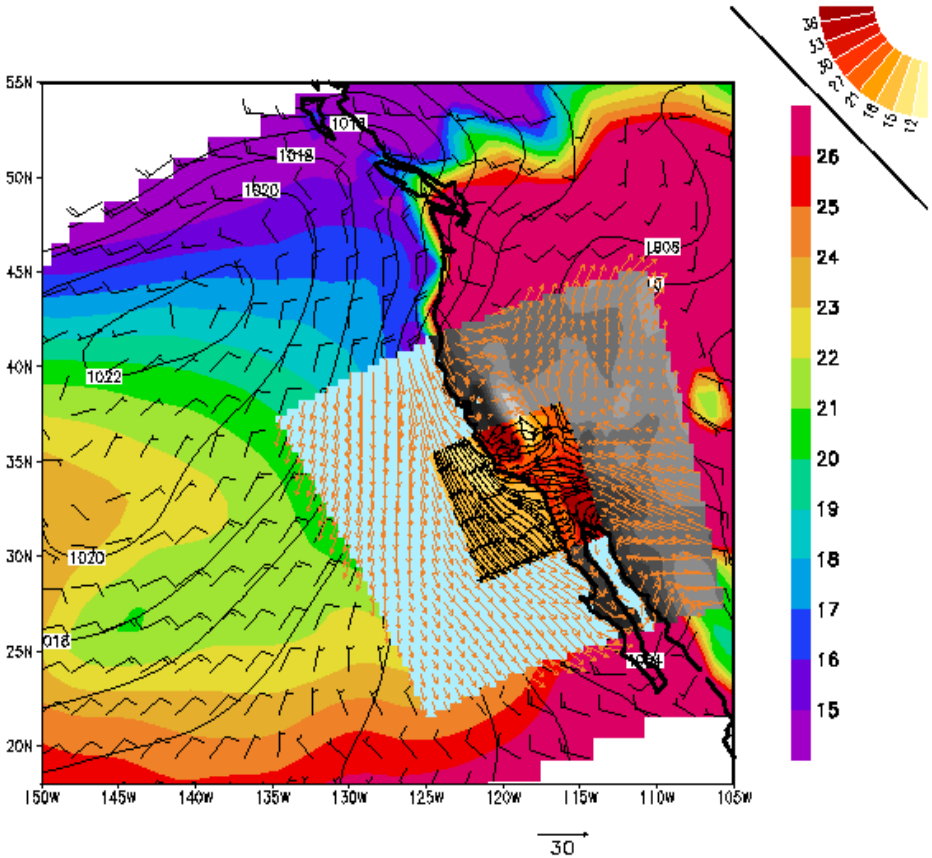
COAMPS-OS® is a globally re-locatable atmospheric data assimilation and forecast system



- Highly automated, limited area, multi-scale, local control
- NCODA/NAVDAS Ocean/Atmosphere analyses
- Nonhydrostatic Mesoscale forecasts generated from the COAMPS® model using MPI for scalability
- Automatically transforms output into dynamic web graphics
- Digital data in TEDS and flat files for interface to other applications
- Web-based interface

*COAMPS-OS® is a registered trademark of the Naval Research Laboratory

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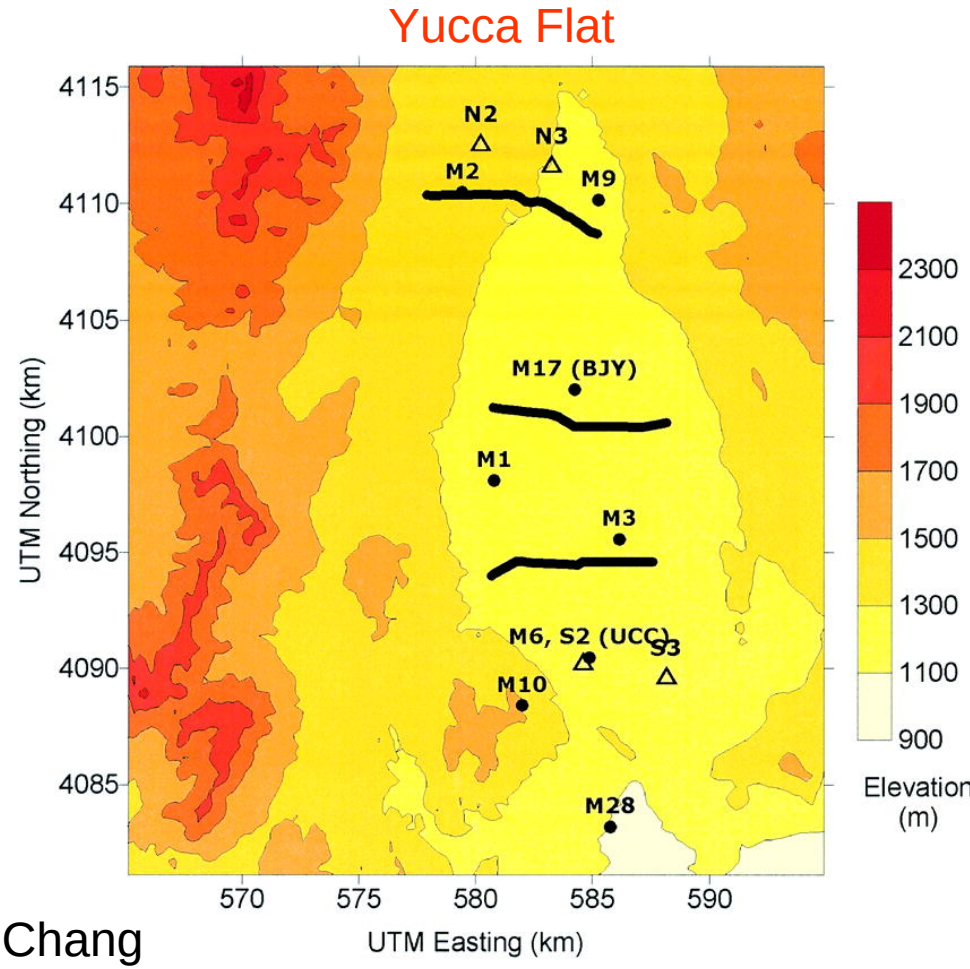
Dipole Pride 26:

- November 1996
- 17 field trials over 14 days
- Observed plumes (SF_6) tracked over mesoscale (~30 km) areas
- 15-minute contaminant measurements from 3 sampling lines
- 15-minute surface observations from 25 MEDA stations
- 3-hourly upper air measurements
- Chang et al. 2003 Study



From Chang et al. 2003

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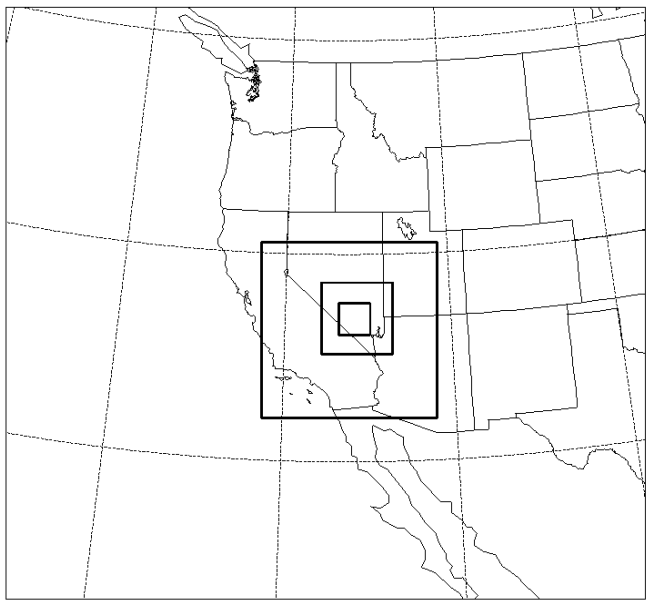
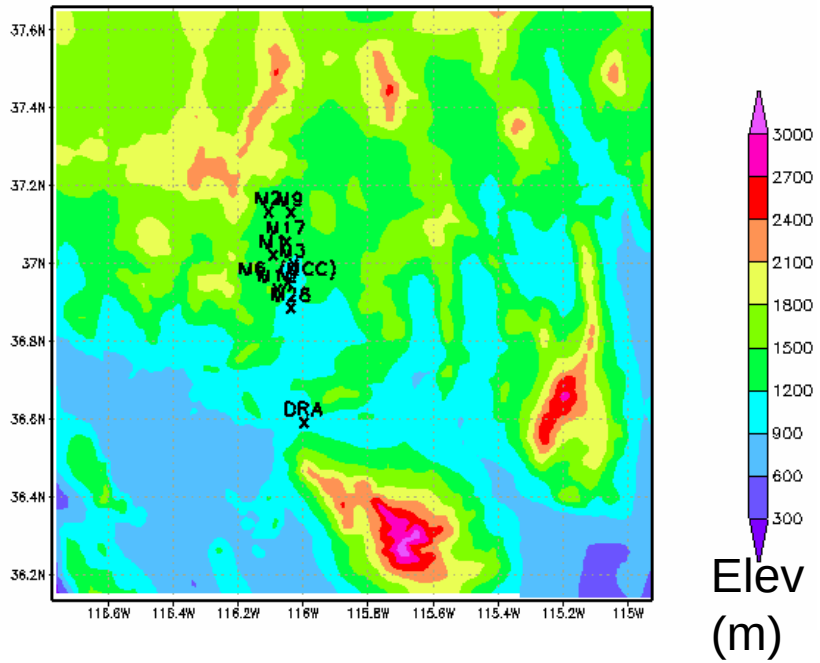
COAMPS® simulations:

- 18-hour forecasts
- 60 vertical levels, 15 layers within lowest 1500 m
- Nonhydrostatic, full physics suite
- 6-hour NOGAPS boundary forcing



Nest 4 Topography



Four nests: 27 km, 9 km, 3 km, 1 km

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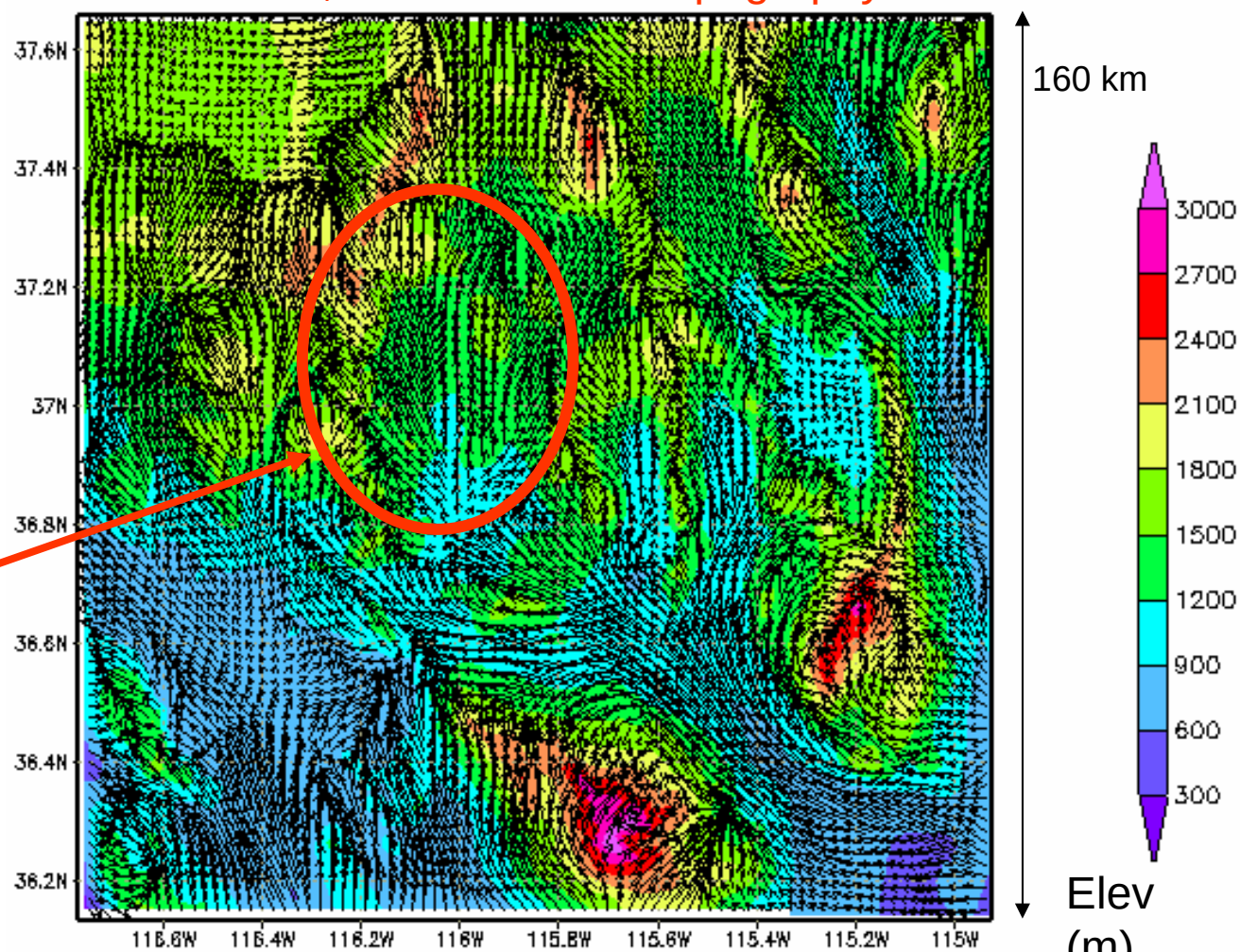
COAMPS® simulations:

- Evolving 3-D flow
- Highly variable
- Mesoscale terrain-forced circulations
- Validation required

Dipole Pride 26

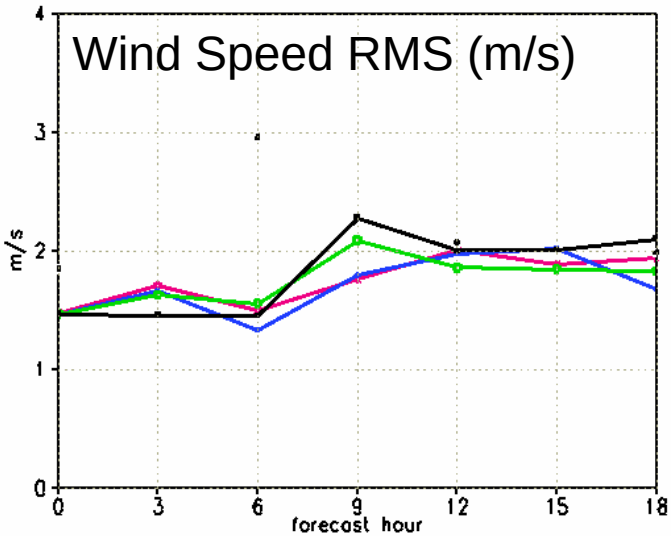
Nest 4, 10m wind and Topography

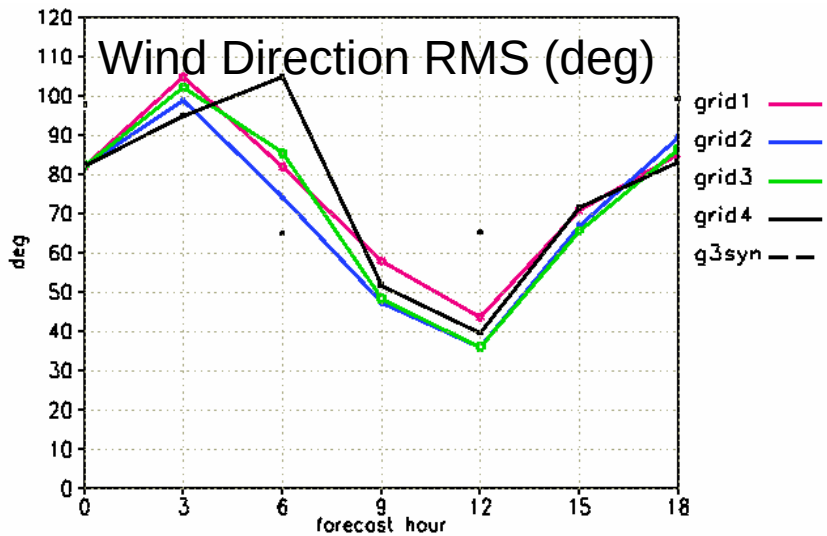


12-hr FCST valid 1600 PST 21 Nov 1996

7 m/s

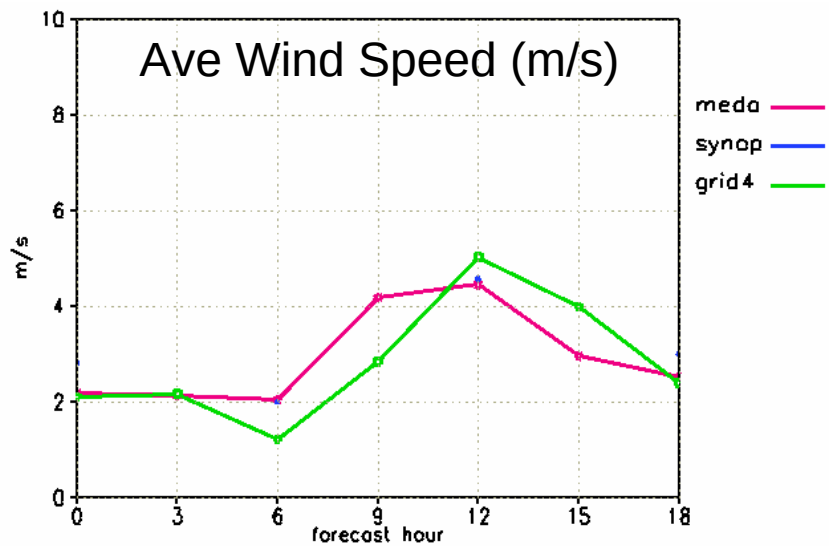
Hazard Prediction with Nowcasting



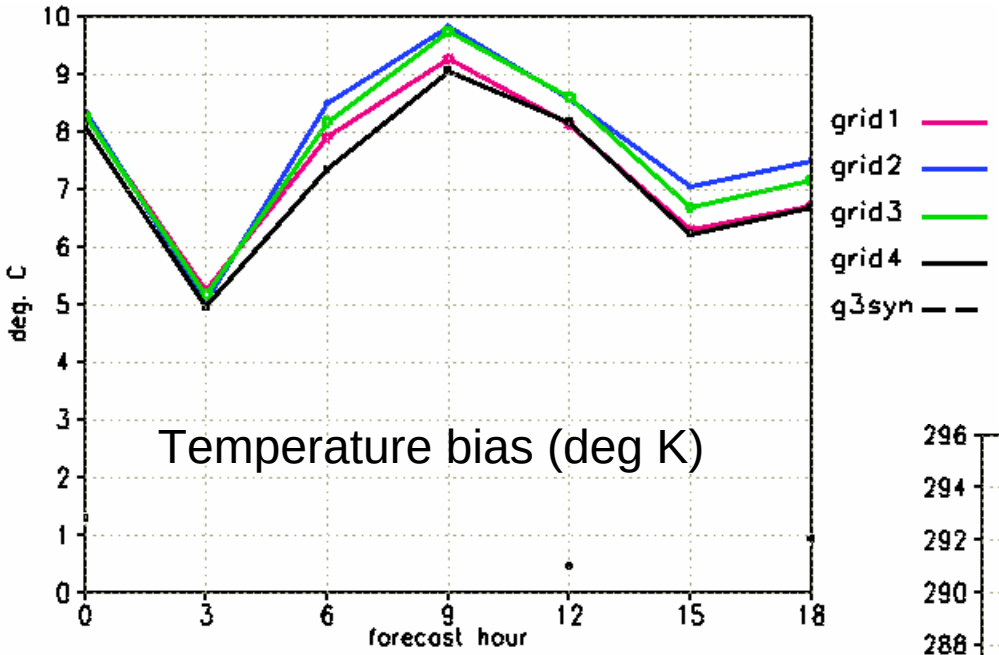


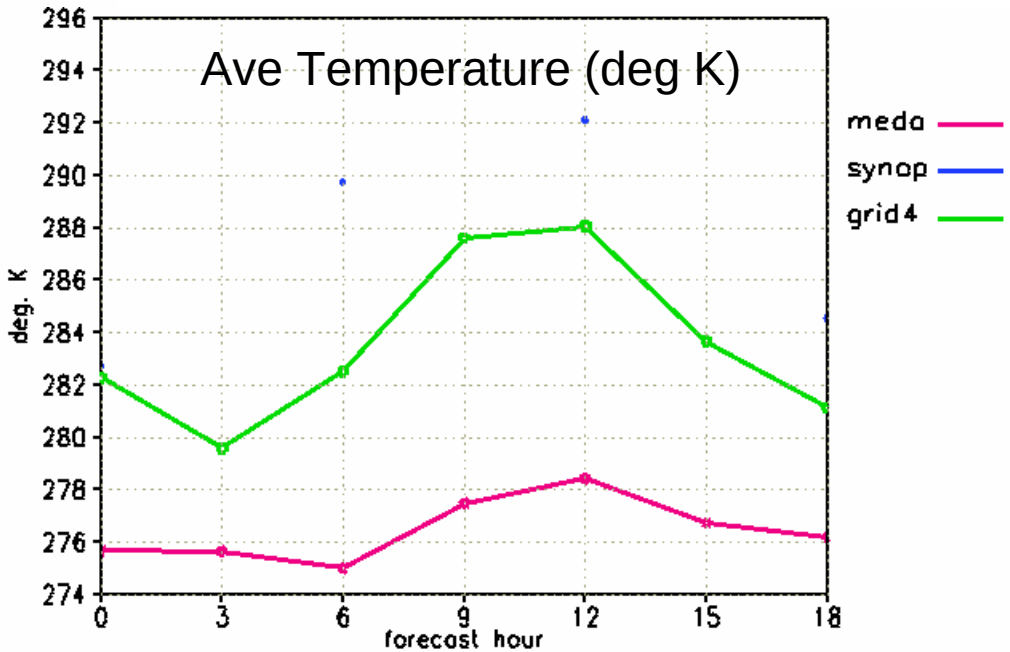
COAMPS® 10 m Statistics:

- Sanity check against MEDA and SYNOP stations
- Direction errors decrease with increasing wind speed
- Little dependence on grid spacing



Hazard Prediction with Nowcasting





10 m Temperature Statistics:

- Intercomparison between forecast, MEDA and SYNOP stations reveals MEDA station error
- COAMPS® analysis serves as cross reference check

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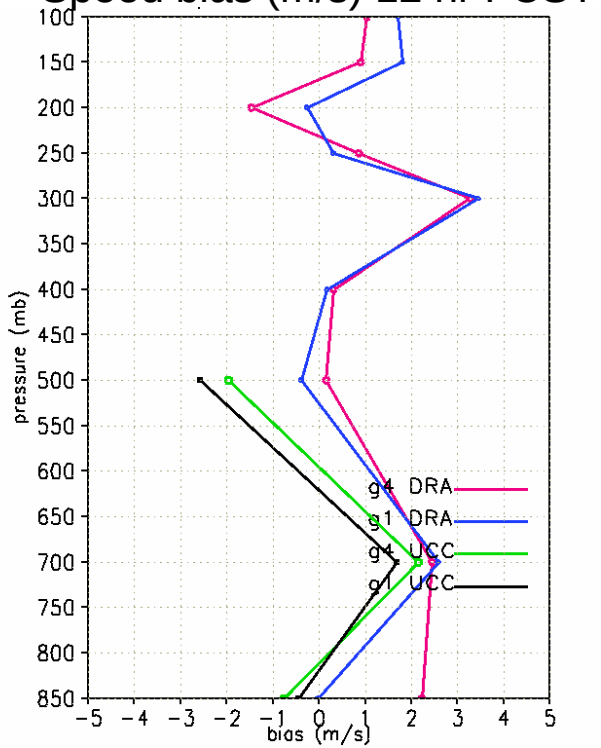
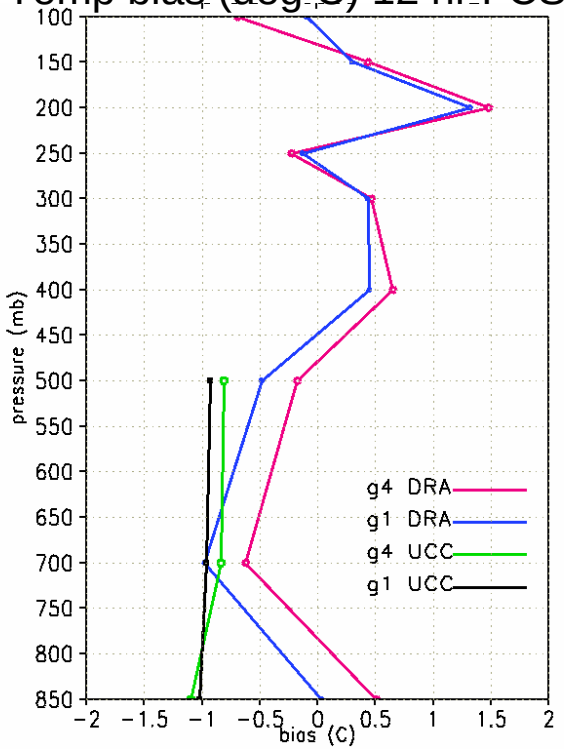
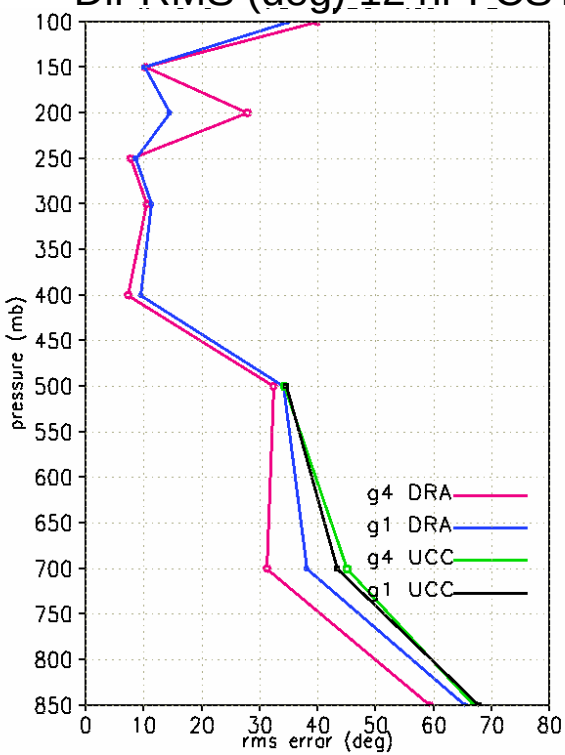
Speed bias (m/s) 12 hr FCST



Temp bias (deg C) 12 hr FCST



Dir RMS (deg) 12 hr FCST



Upper Air Statistics:

- Direction errors decrease with height
- Temperature biases less than 1 deg. C
- Little dependence on grid spacing

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COAMPS-OS® Interface for JEM:

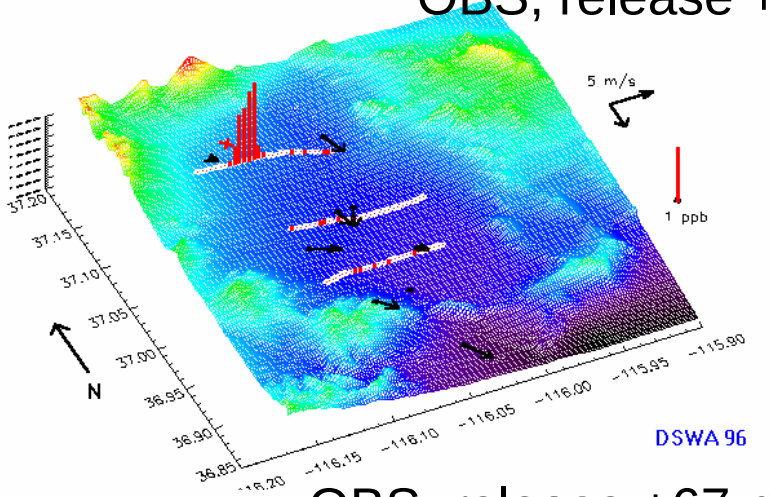
- HPAC interface created as surrogate for JEM
- Provided COAMPS® grib files to Kyle Dedrick (ATK-MRC/DTRA) for import into the MDS.
- Standard (30-level) and high-resolution (60-level)
- Upgrading VLSTRACK capabilities to accept 60-level forecast input
- COAMPS-OS® will be ready for JEM

Hazard Prediction with Nowcasting

11 November 1996 test case

Test - 05 11/11/96 04:52:30 PST

OBS, release +52 min



OBS, release +67 min

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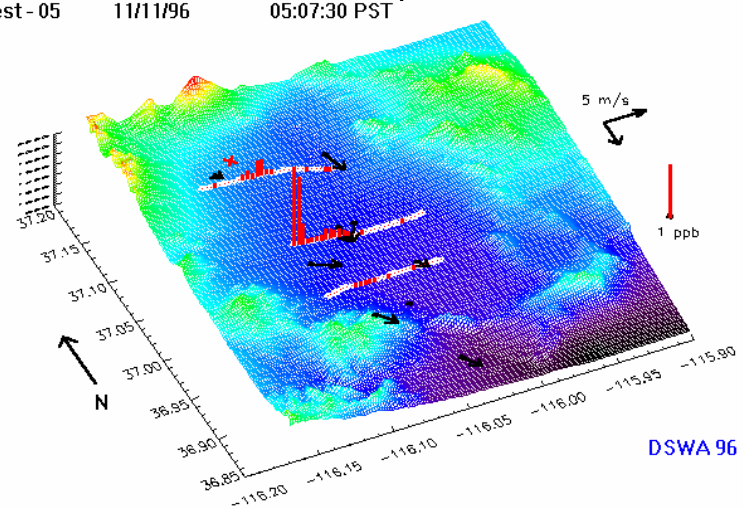
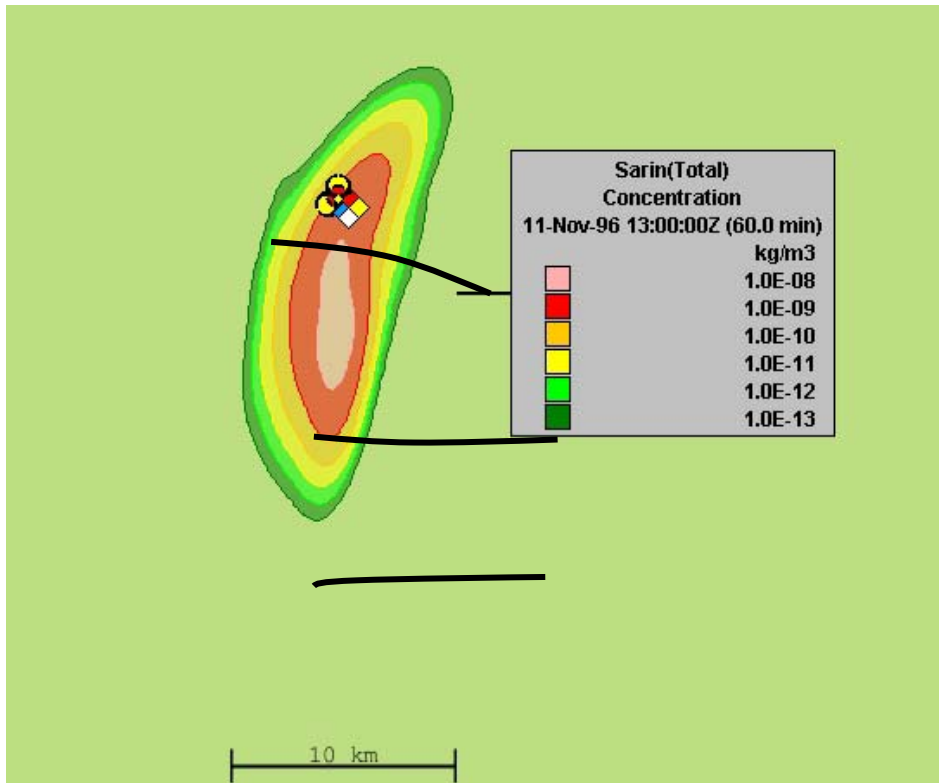


Ongoing tests show good qualitative agreement between obs and COAMPS-driven HPAC.

HPAC 1-hr FCST



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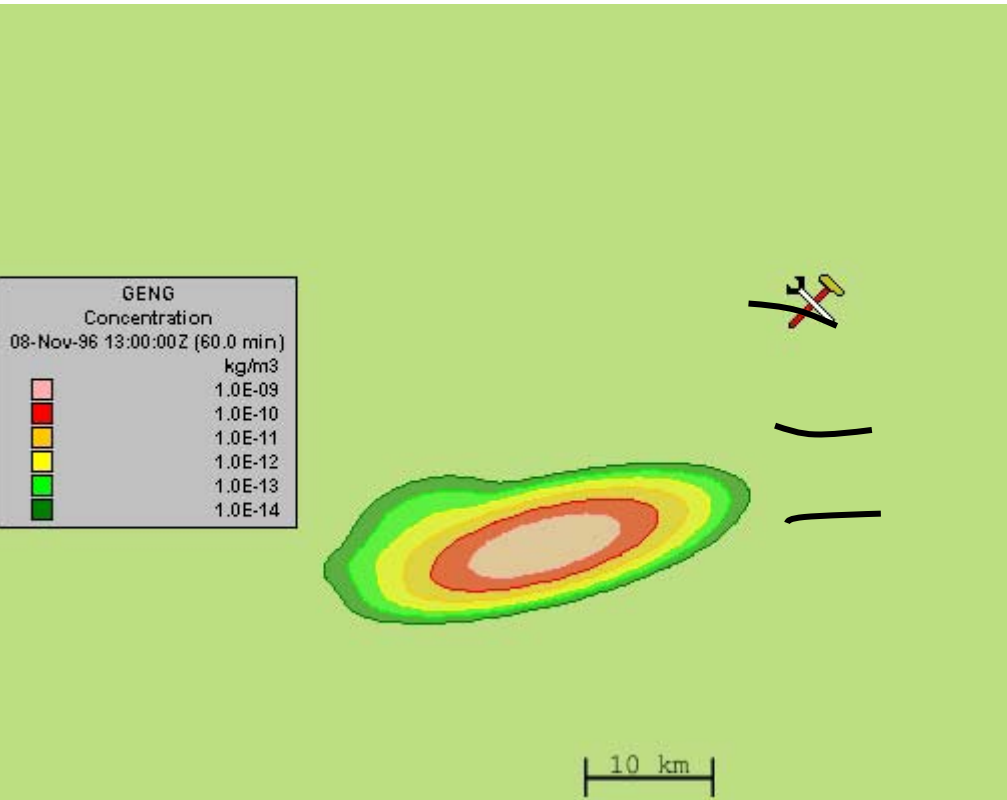
8 November 1996 test case

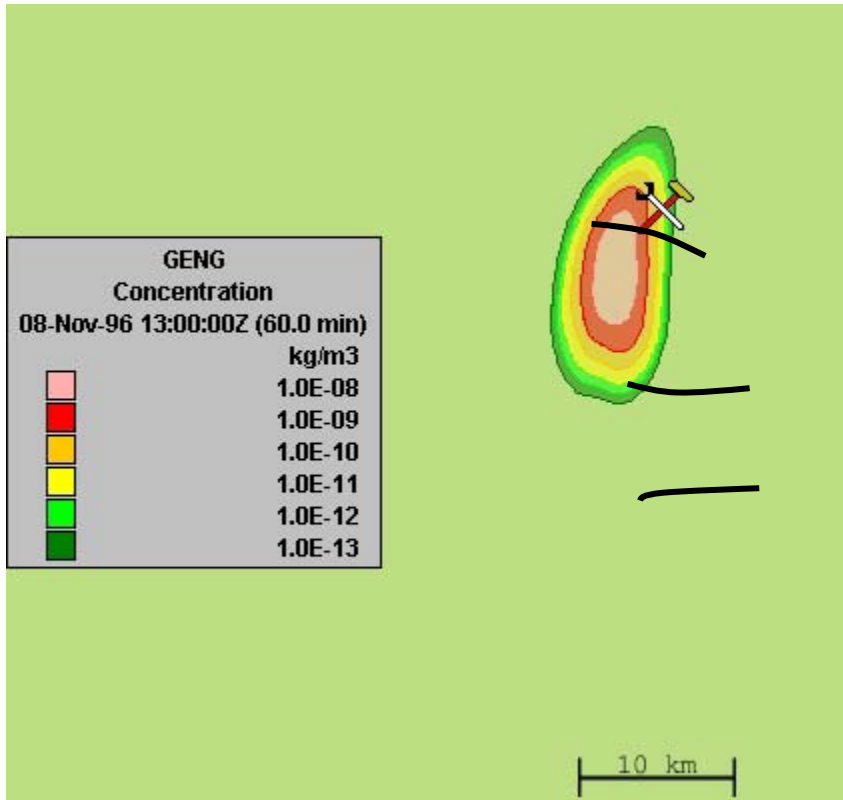
Contaminant trajectories are strongly dependent on nest resolution

HPAC 1-hr FCSTS Valid 13 UTC 8 November 1996

27 km COAMPS Forcing



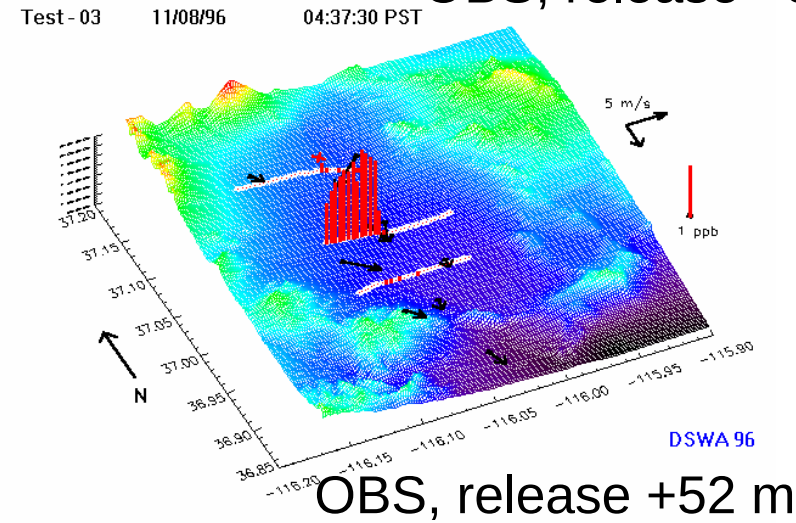
1 km COAMPS Forcing



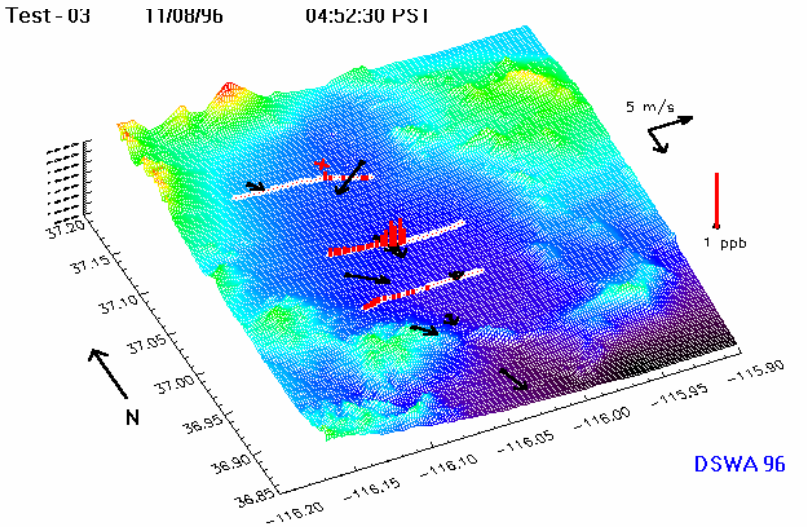
Hazard Prediction with Nowcasting

8 November 1996 test case

OBS, release +37 min

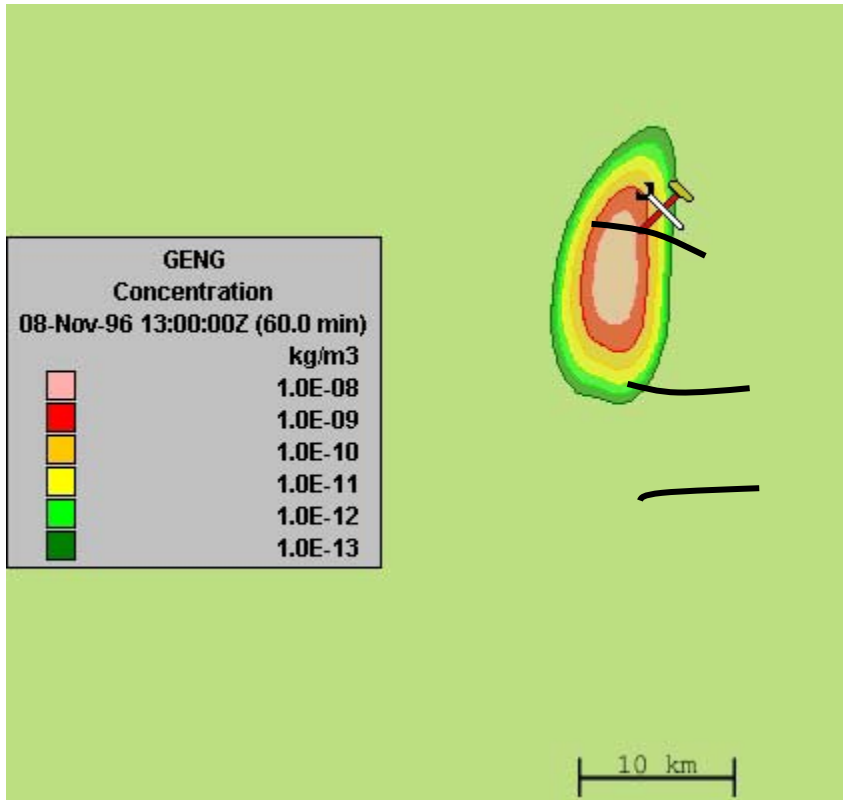


OBS, release +52 min



1km forcing shows better qualitative agreement

1 km COAMPS Forcing



Hazard Prediction with Nowcasting

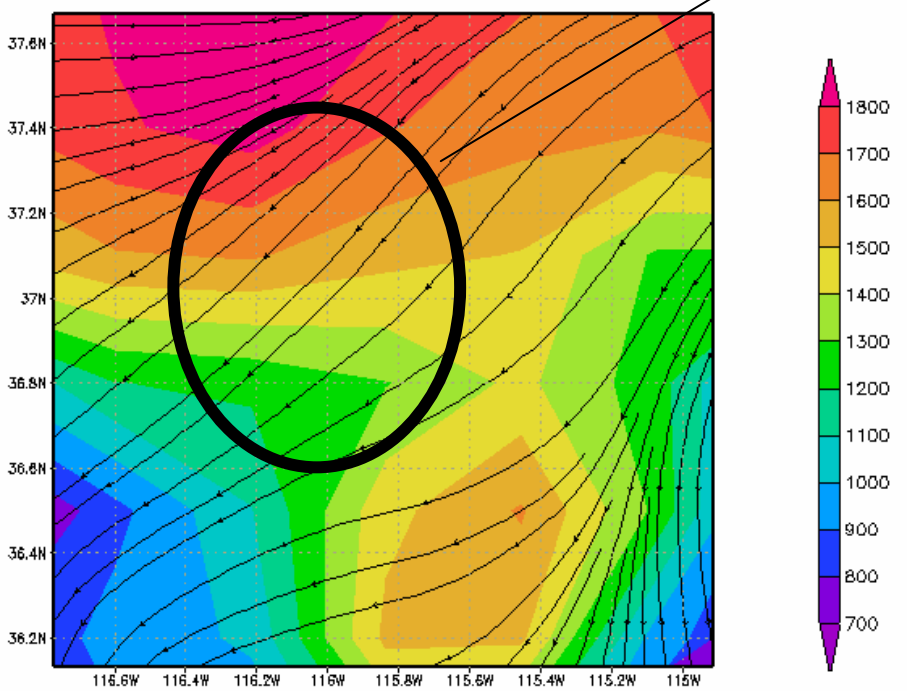
8 November 1996 test case

1km forcing shows more realistic flow structure

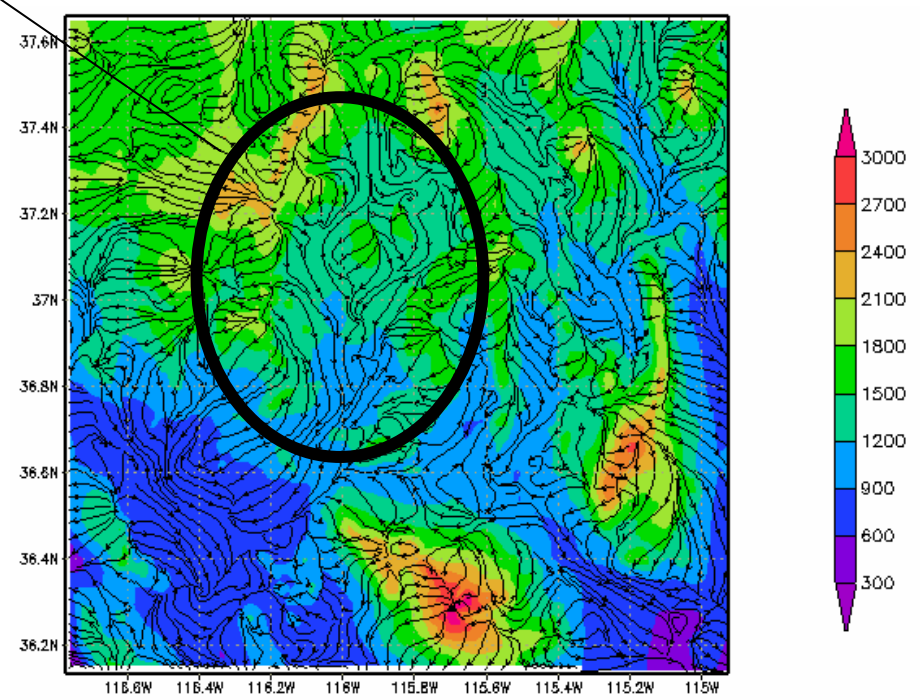
COAMPS® 12-hr FCSTS Valid 12 UTC 8 November

DP26

27 km Winds, Topo



1 km Winds, Topo



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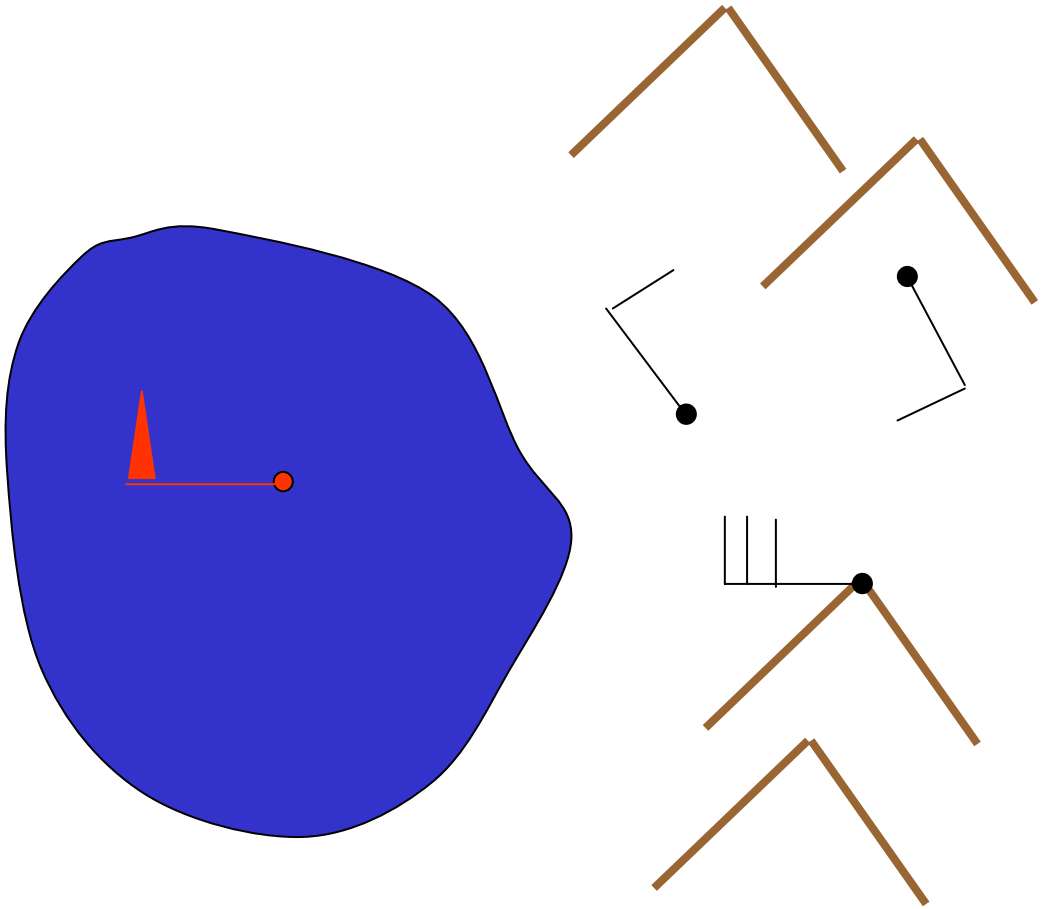
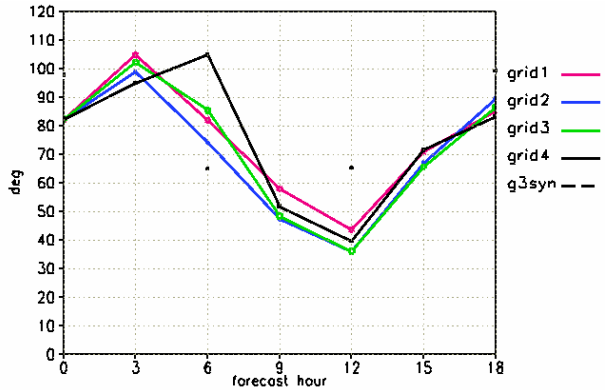
High-Resolution Lower Tropospheric Data Assimilation





Want to reduce error while maintaining physically consistent 3-D structure.

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Northern SF Bay Landsat Image

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NAVDAS

- **NAVDAS is a modern 3-D variational analysis for COAMPS®**
  - Pre-Ops testing at FNMOC prior to operations (Oct-Dec 2005).
  - Much of the code shared with global version for NOGAPS
- **NAVDAS uses the actual pressure level of each observation in analysis**
  - Uses all mandatory and significant level observations from soundings, aircraft data, satellite feature-rack winds, satellite temperature retrievals; MVOI only mandatory pressure levels
  - Applies correct surface pressure for surface marine observations; MVOI assigns surface data to 1000 mb level for analysis.
  - Currently land surface data at elevs above 50m not used.
- **NAVDAS can define background covariance in different vertical coordinates - pressure or potential temperature.**
- **NAVDAS has improved upper-air and surface marine wind and temperature analyses.**

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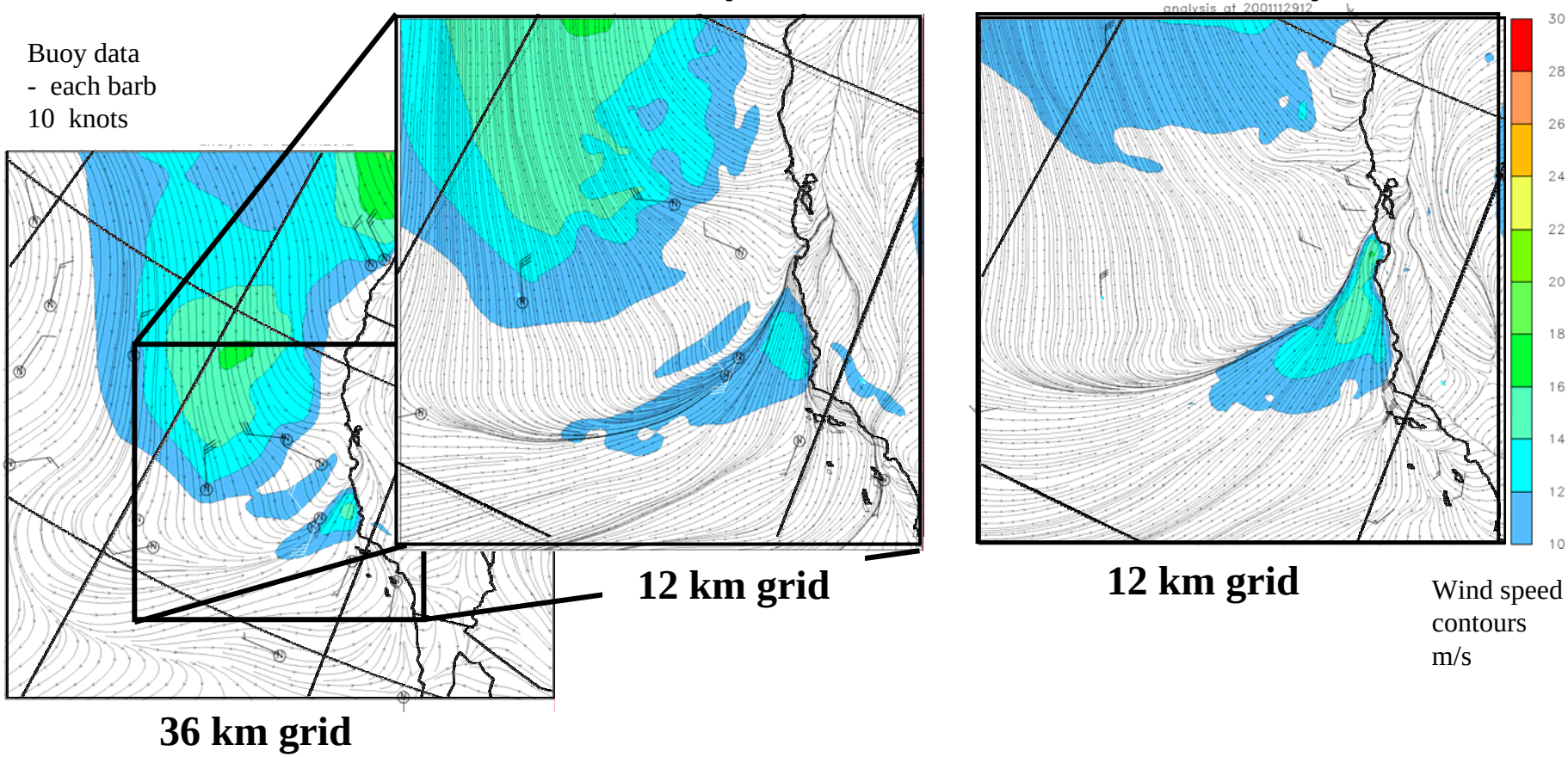
10 m wind analysis; NAVDAS vs. MVOI valid 2001112912

NAVDAS analysis

MVOI analysis



- **NAVDAS uses a single multi-grid analysis (with actual pressure levels)**
- **NAVDAS analysis more consistent between grids and better fit to buoy wind observations**

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NAVDAS Surface Data Analysis Plans

- **Independent 3-D lower tropospheric analysis in terrain following coordinates**
  - Use surface observations of temperature, humidity and wind over land.
  - Use satellite temperature and moisture retrievals, satellite skin temperature retrievals produced by global NAVDAS 1dvar radiance code over land.
  - Currently such surface data at elevations above 50m over land are not used by NAVDAS.
- **Hourly surface analyses**
  - Use COAMPS forecast as background at asynoptic hours and update NAVDAS analyses at synoptic hours
- **Native COAMPS sigma-height coordinate defines boundary layer background correlation function**
  - Modified to account for differences in terrain and potential temperature
- **Full 3-D boundary layer structure at high resolution**

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Conclusions:

- Gridded COAMPS forecast fields can be used to produce useful contaminant forecasts.
- High-resolution model output show improved performance in HPAC despite RMS errors.
- COAMPS® output will be ready for JEM.

Current/Future Work:

- Complete quantitative DP26 study using COAMPS® fields in VLSTRACK, HPAC and JEM.
- Improve boundary layer and surface flux parameterizations
- 3DVar data assimilation at high-resolution with high-frequency updates
- Mesoscale validation techniques specifically targeted for coastal applications

EXTRA SLIDES

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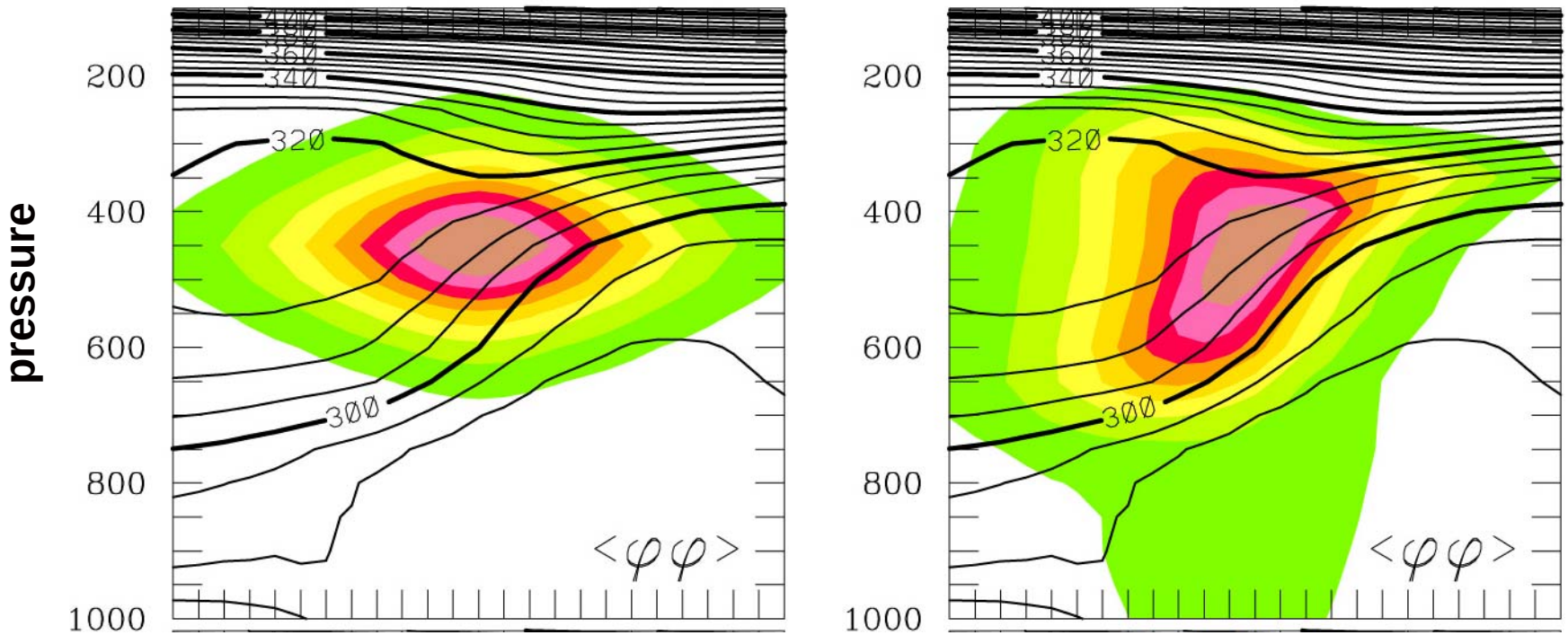
Correlation Function for Background Error

Geopotential Height correlation in NAVDAS can use different vertical coordinates:

Standard pressure coordinate **or** **Isentropic vertical coordinate**



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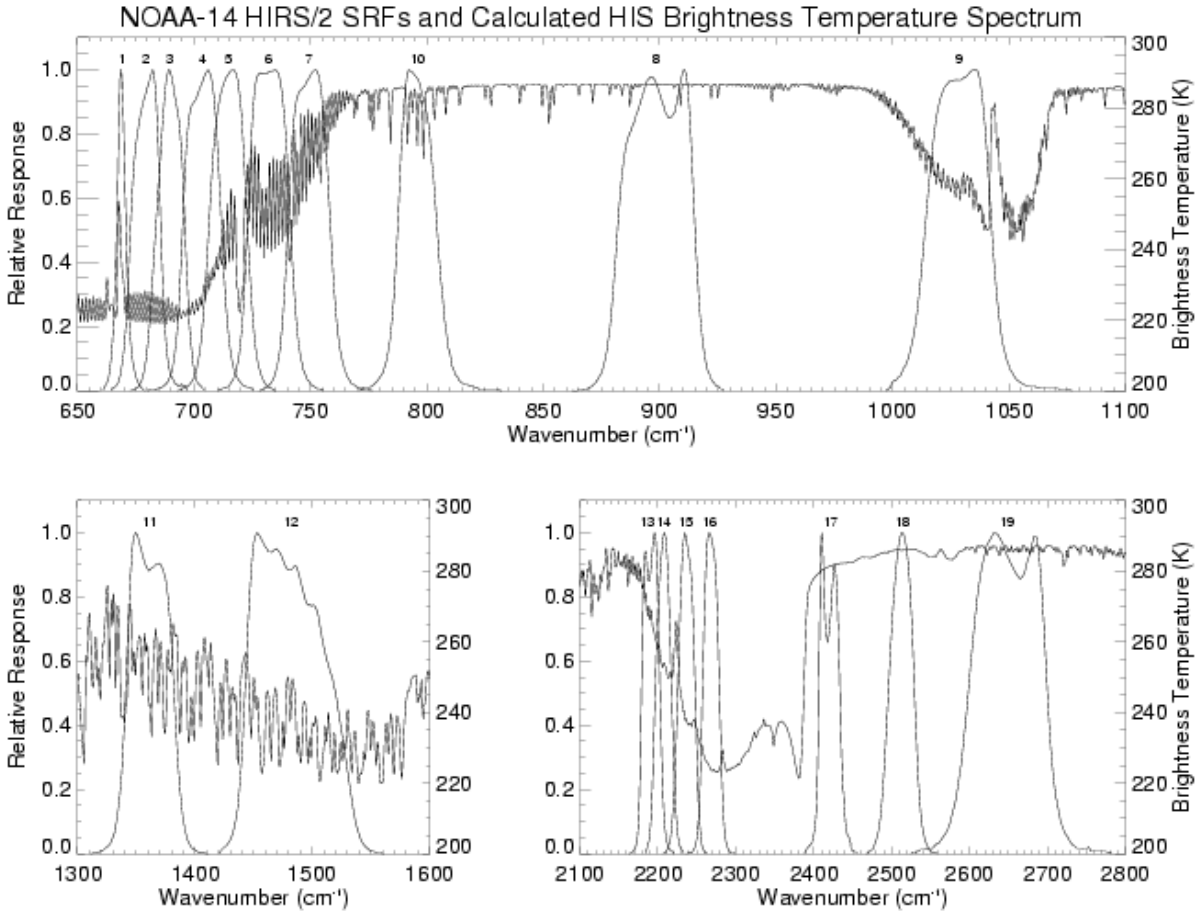
HIRS Channel Response vs. US Std. Atmos. Emission Spectra



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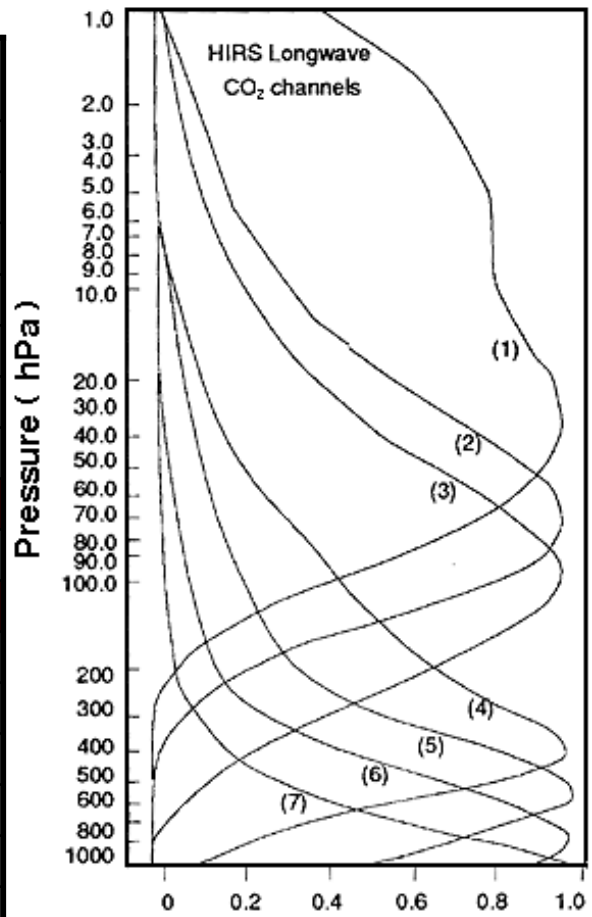
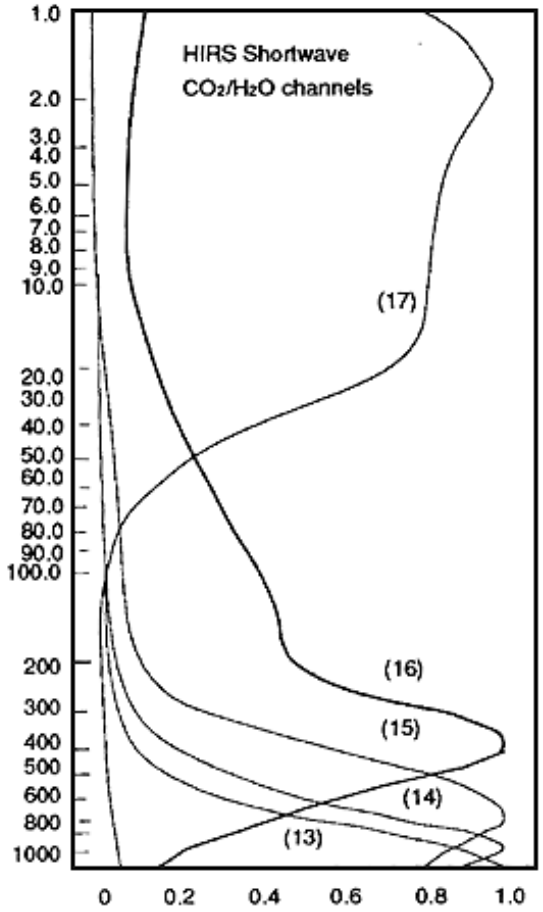
HIRS Sounding Channel Temperature Weighting Functions

Channel	Wavenumber (cm^{-1})	Wavelength (μm)
1	669	14.95
2	680	14.71
3	690	14.49
4	703	14.22
5	716	13.97
6	733	13.64
7	749	13.35
8	900	11.11
9	1030	9.71
10	802	12.47
11	1365	7.33
12	1533	6.52
13	2188	4.57
14	2210	4.52
15	2235	4.47
16	2245	4.45
17	2420	4.13
18	2515	4.00
19	2660	3.76





gray = water vapor

red = “window” channels

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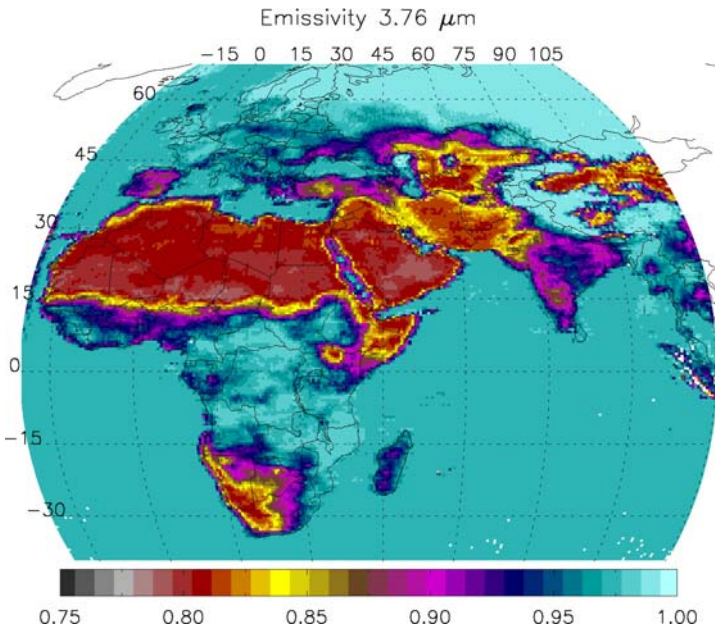
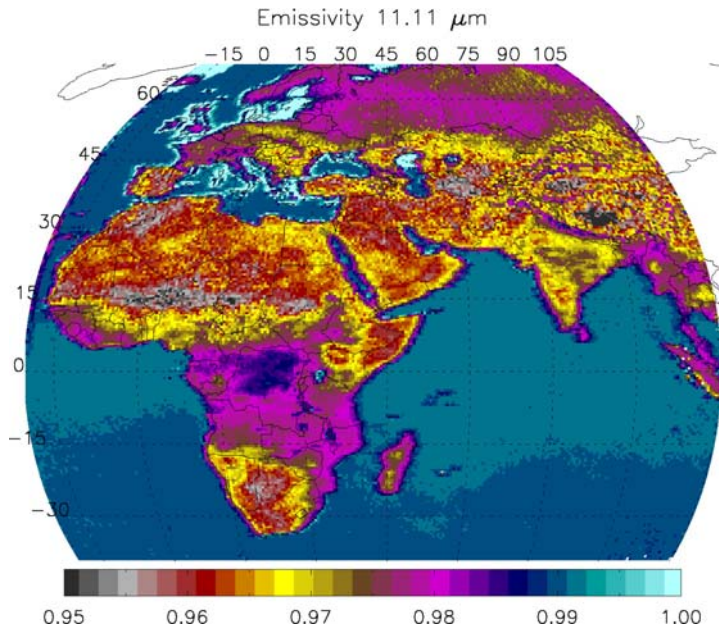
Surface Emissivity Means *(Mar/Apr 2003)*





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Satellite Temperature Retrievals Show Positive Impacts in Boundary Layer *(Sep 2004)*