OAR/ESRL/GSD

Activities

May 30-31, 2007 SSC

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(for Steve Koch)

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Overview

- Background covariance work
- Bias correction for the current GOES (12)
- Model initialization, using cloud data
- Gradient assimilation
- Summarize

Mesoscale background error covariance recovery using time-lagged ensembles

Estimating background error covariance

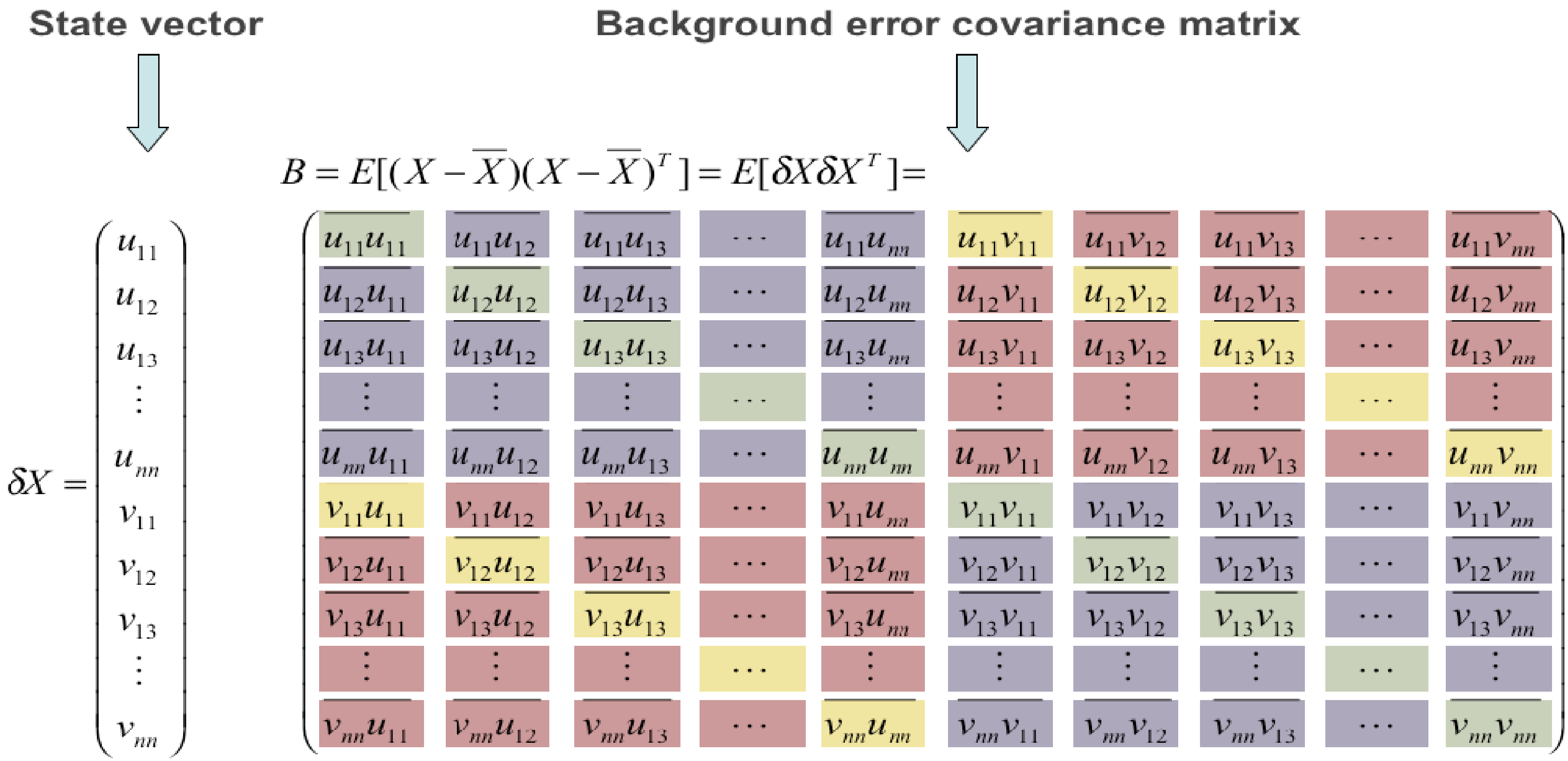
$$\begin{cases} J(\mathbf{x}) = \frac{1}{2}(\mathbf{x}-\mathbf{x}_b)^T\mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}_b) + \frac{1}{2}(\mathbf{y}-\mathbf{H}(\mathbf{x}))^T\mathbf{R}^{-1}(\mathbf{y}-\mathbf{H}(\mathbf{x})) \\ \mathbf{x}_a = \mathbf{x}_b + \underbrace{\mathbf{B}\mathbf{H}^T(\mathbf{H}\mathbf{B}\mathbf{H}^T+\mathbf{R})^{-1}}_{K}\mathbf{d} \end{cases}$$

B is crucial for the Kalman-gain matrix in data assimilation

u
v
θ
p
q

	u	v	θ	p	q
u	B_{uu}	B_{uv}	$B_{u\theta}$	B_{up}	B_{uq}
v	B_{uv}	B_{vv}	$B_{v\theta}$	B_{vp}	B_{vq}
θ	$B_{u\theta}$	$B_{v\theta}$	$B_{\theta\theta}$	$B_{\theta p}$	$B_{\theta q}$
p	B_{up}	B_{vp}	$B_{\theta p}$	B_{pp}	B_{pq}
q	B_{uq}	B_{vq}	$B_{\theta q}$	B_{pq}	B_{qq}

Fig. 1: The background error covariance matrix (right) shown against the background state vector (left). Each square is itself a matrix of zonal and meridional wind, potential temperature, pressure, and humidity.



Green: variance, Blue: spatial covariance, Yellow: cross covariance, Red: cross-spatial covariance

Time-phased model ensemble system

- Hourly runs of the 40-km RUC forecast within a 12-h cycle (previous forecast up to 12h)

- Advantages of the method:

  ① mesoscale features
  ② flow-dependent features
  ③ short-range forecast
  ④ potential large samples (e.g., multi-model ensembles)
  ⑤ on-line cycling

  ⑥ economical computing

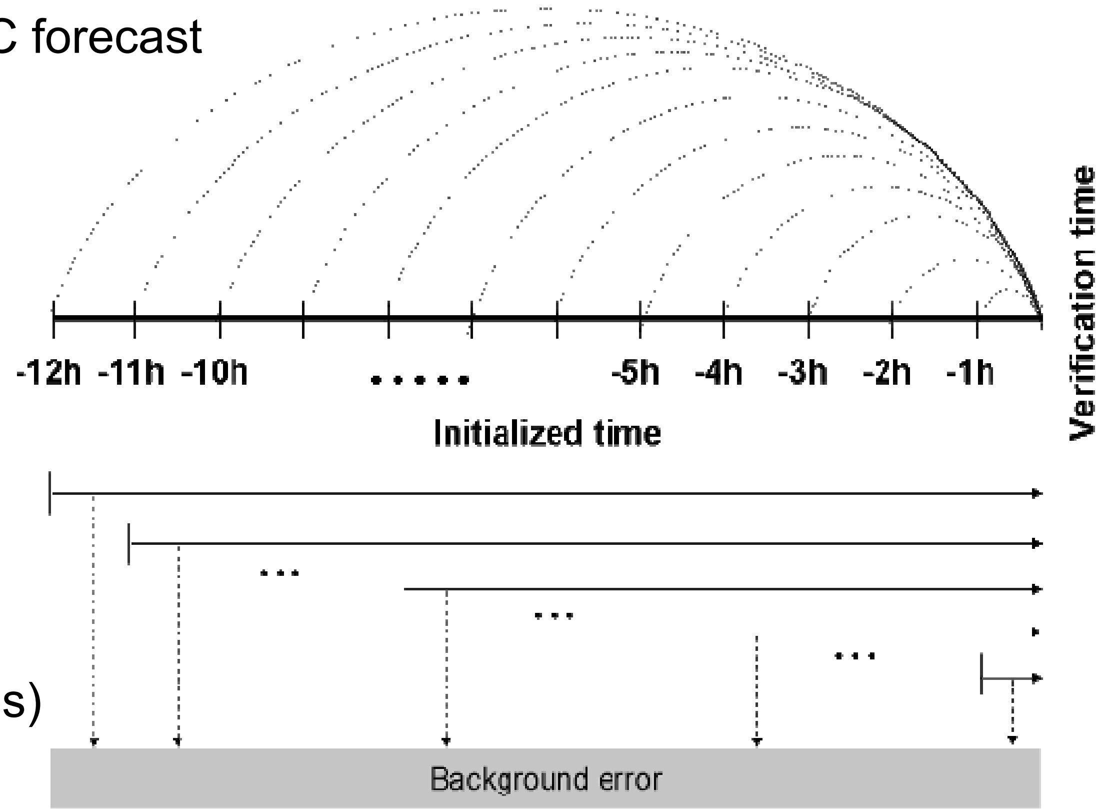
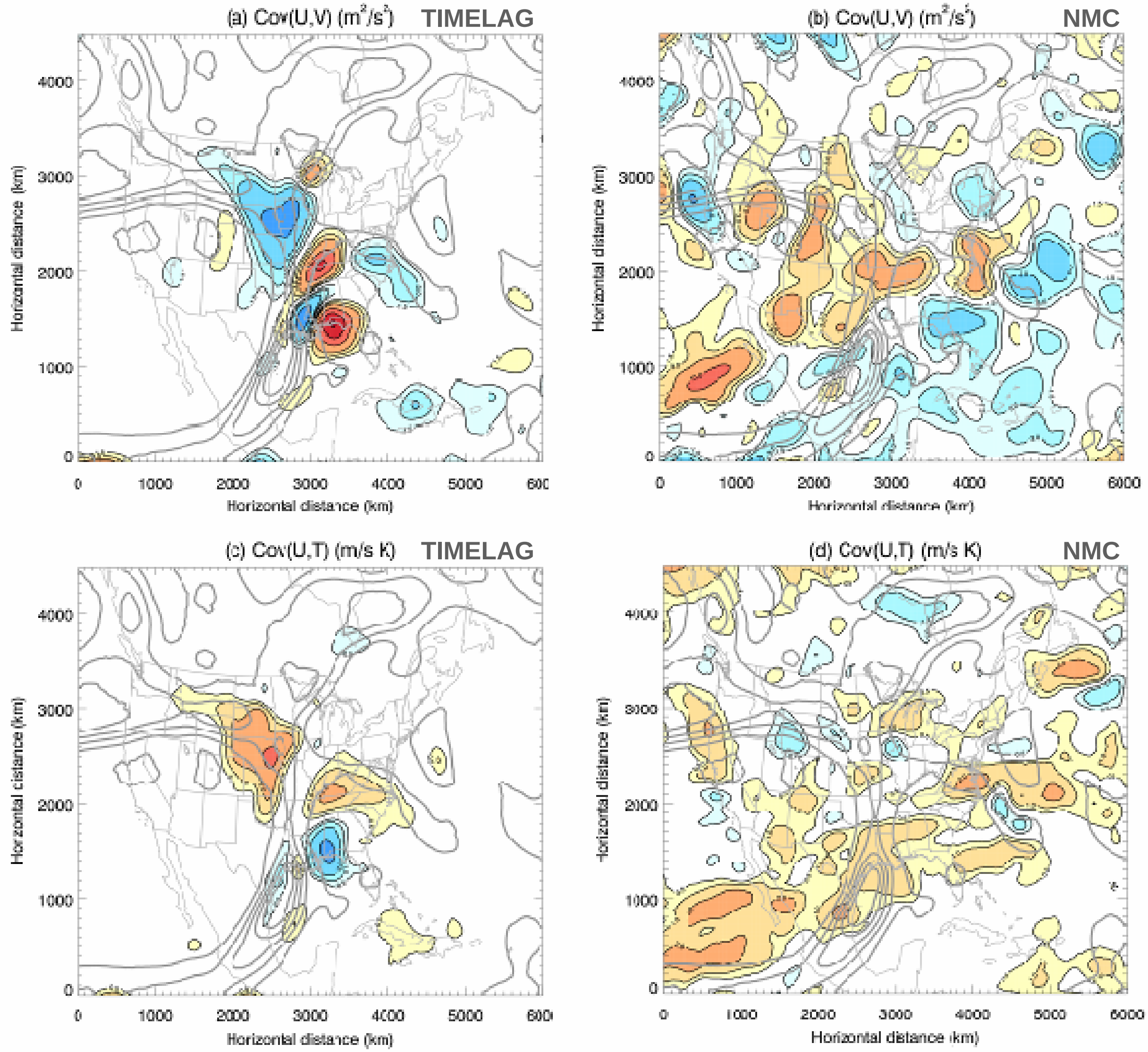


Fig. 4: Schematic illustration of time-phased ensemble method for estimating error covariance.

TIMELAG



NMC

Horizontal plot of Cov: TIMELAG vs. NMC

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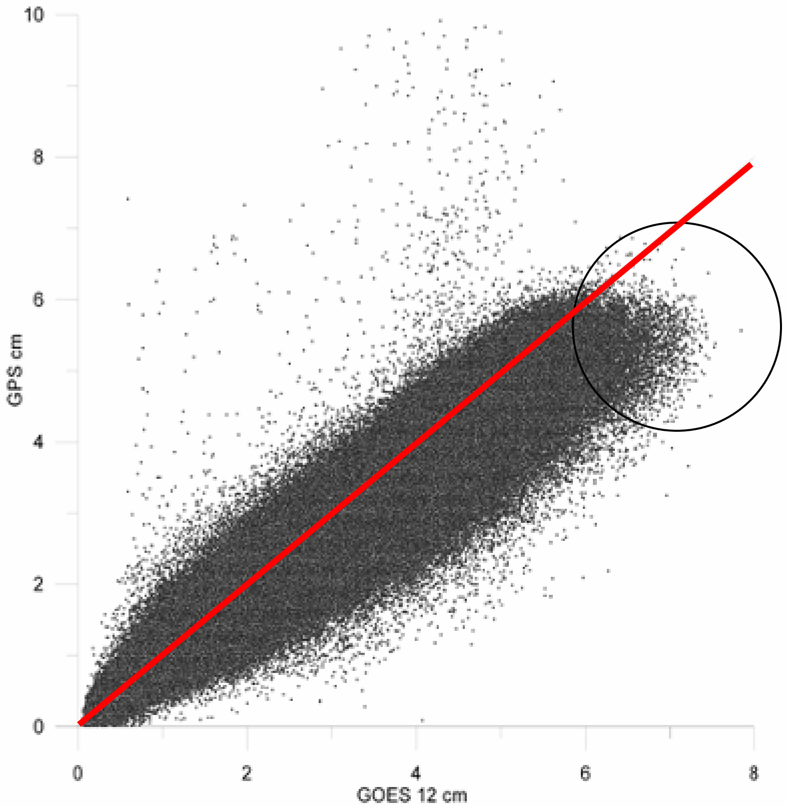
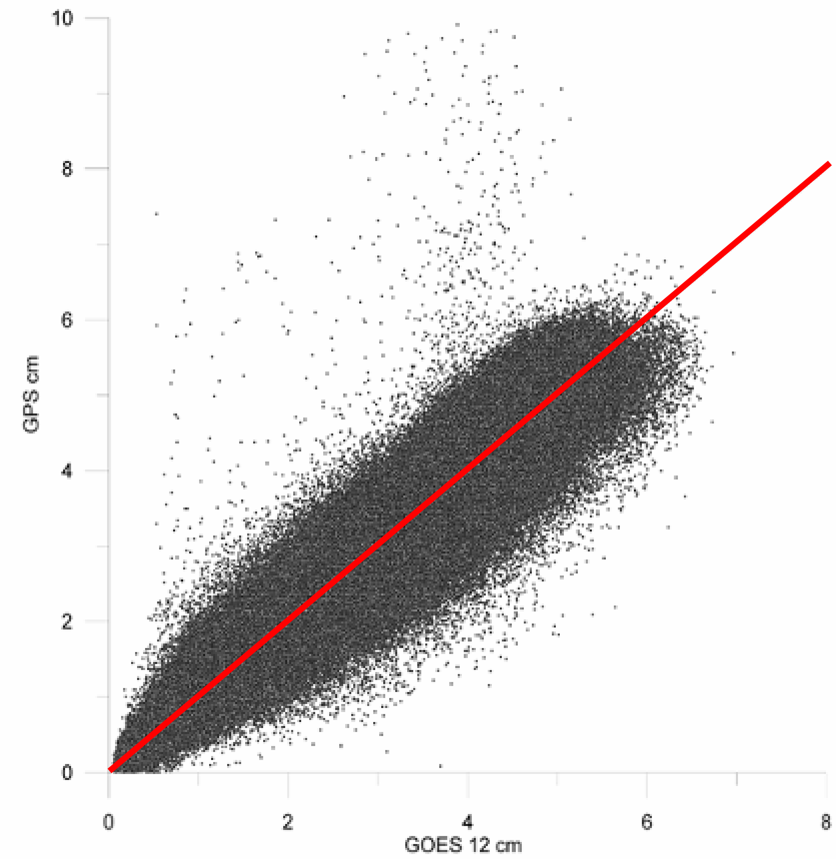


Scatter plot of raw data

Scatter plot of bias corrected data



1.8 Million Data Pairs (20min, 10km)

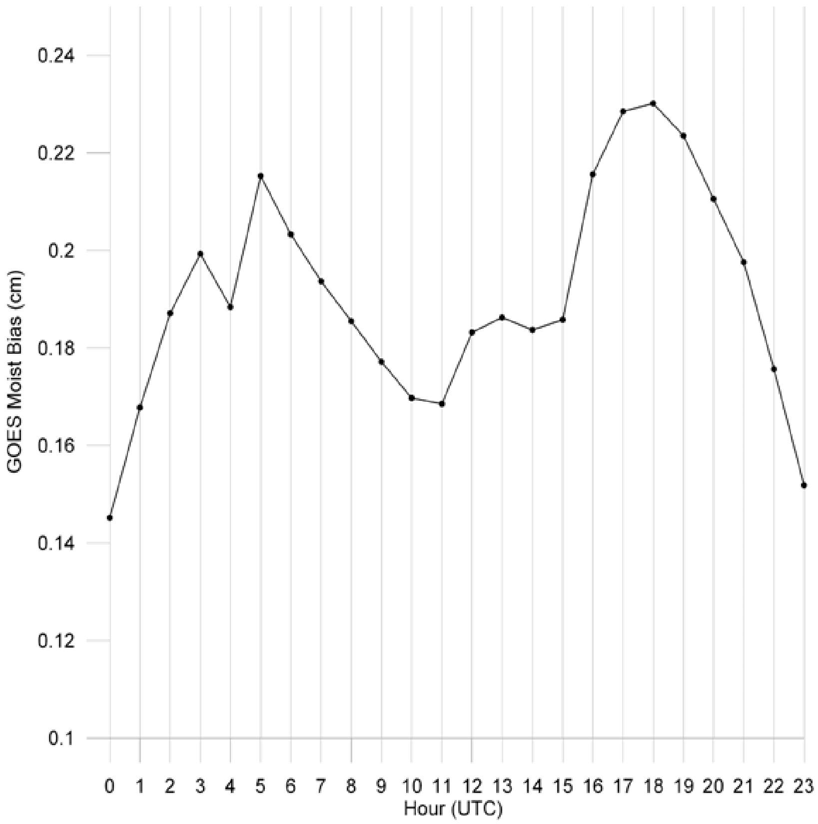
Algorithm

$$g_c = a g^b$$

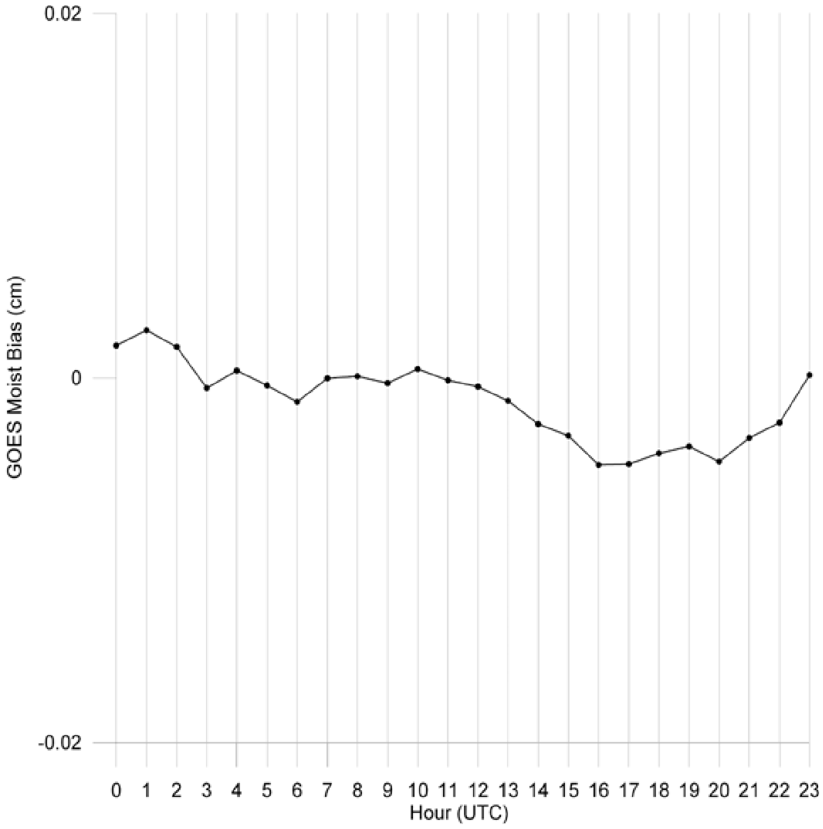
a	b	h
0.979470611	0.952045858	0
0.96386236	0.958807886	1
0.951016307	0.962379932	2
0.932851493	0.974993765	3
0.938412488	0.973992229	4
0.928518832	0.971161544	5
0.932472348	0.975237787	6
0.936737478	0.97503674	7
0.943030536	0.971995413	8
0.945574582	0.972088754	9
0.953864217	0.967487574	10
0.952823639	0.967738211	11
0.944226384	0.970142543	12

a	b	h
0.934683204	0.977410853	13
0.928368866	0.98369354	14
0.923411667	0.988313854	15
0.90421778	0.997356713	16
0.896550059	1.00138319	17
0.896099865	1.00216639	18
0.900296807	1.00008261	19
0.905209124	1.00010216	20
0.923843801	0.986412048	21
0.942986071	0.975428104	22
0.970267594	0.958948851	23

Bias Correction



RAW data



Bias Corrected

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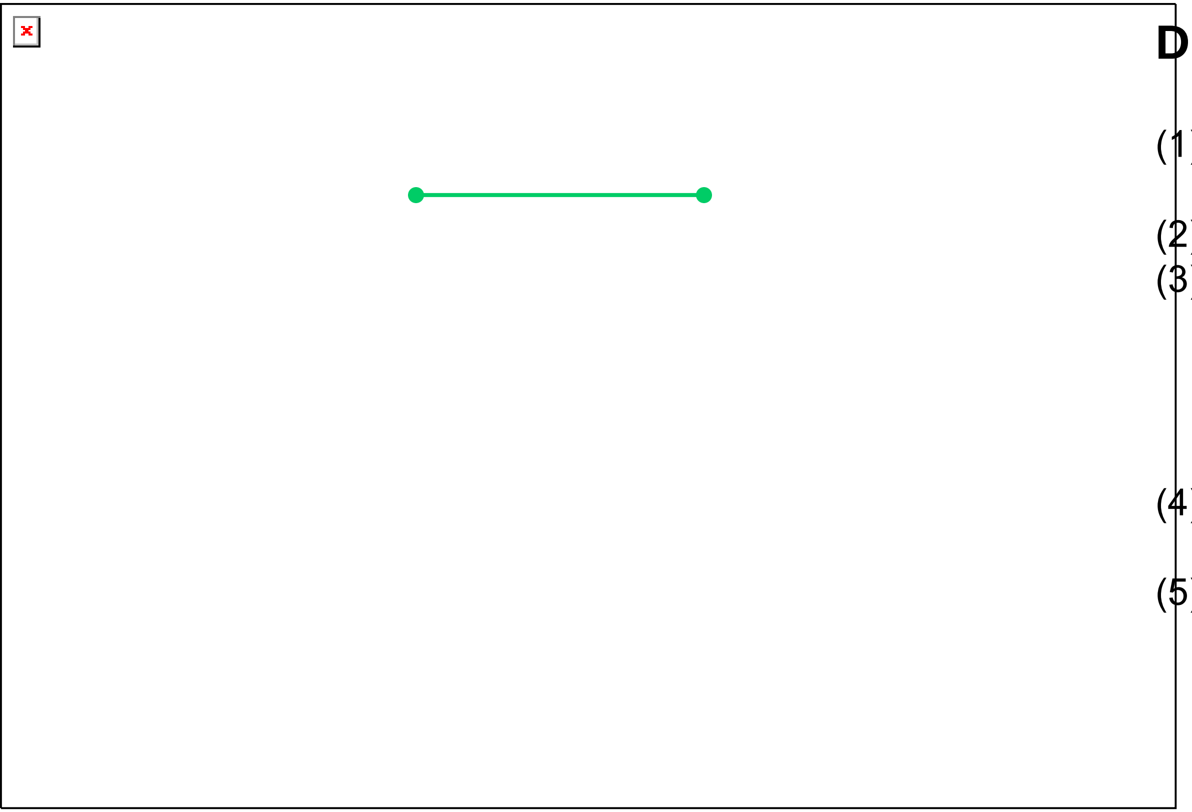
Surface Temperature and Pressure
21 UTC 2002 June 12



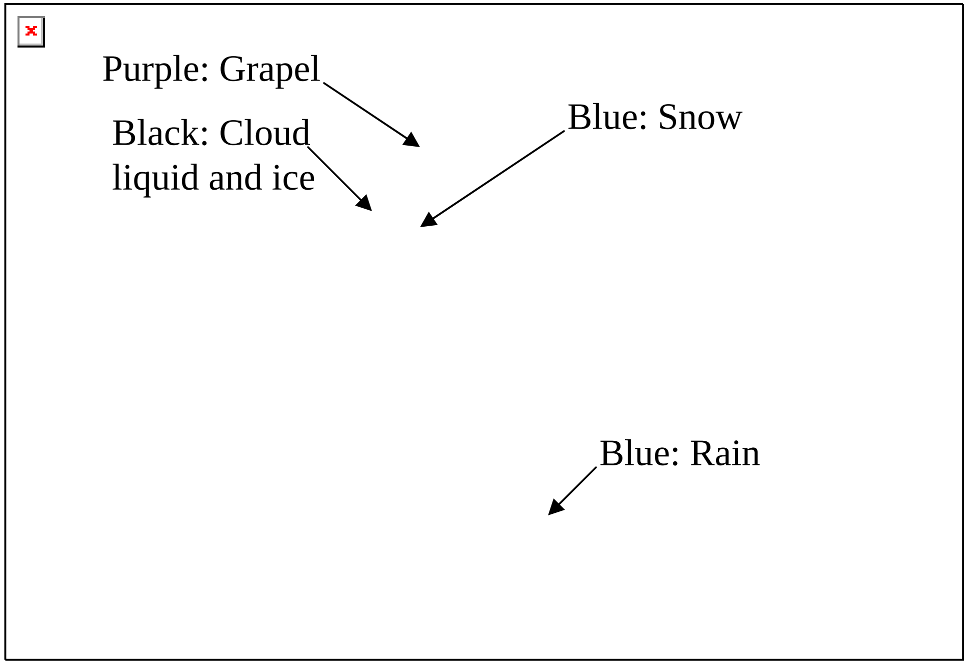
Diabatic Initialization Procedure

(1) Identify clouds in radar, **satellite**, and surface observations
(2) Determine cloud depth
(3) Assign a parabolic vertical velocity profile such that maximum vertical velocity is 10 m s^{-1} for a cloud depth of 10 km and model grid point spacing of 1 km.
(4) Set cloud relative humidity with respect to water to 110%.
(5) Compute balanced wind and pressure fields with 3D variational analysis using the continuity equation and velocity tendencies as constraints.

WRF-ARW simulation with 1-km grid increment

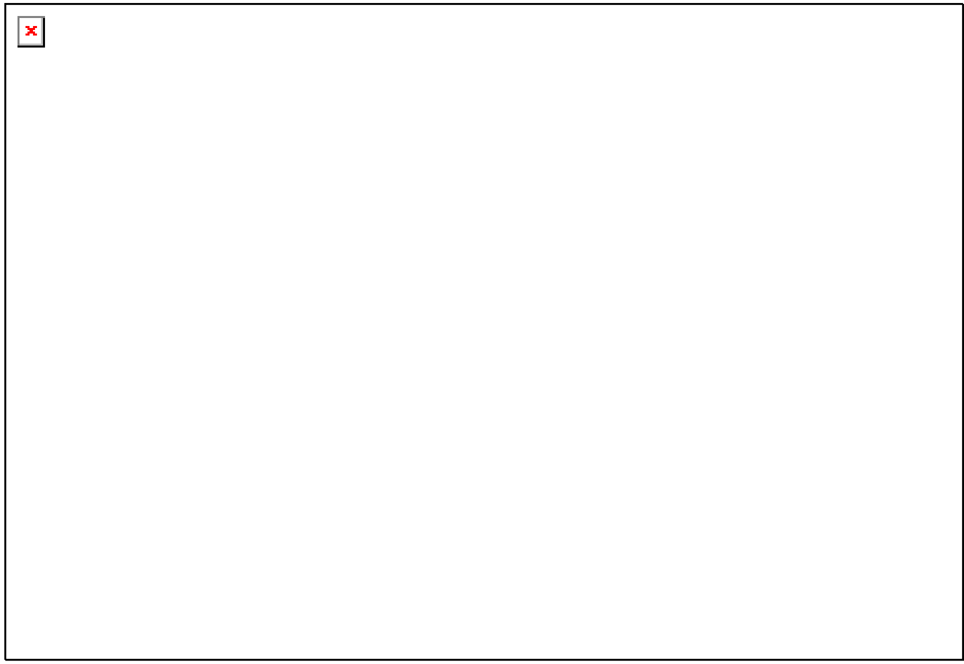
Light blue line shows the position of cross sections in subsequent slides.
It intersects a developing storm within the >60 dBZ area.

Diabatic Initialization
21 UTC 2002 June 12

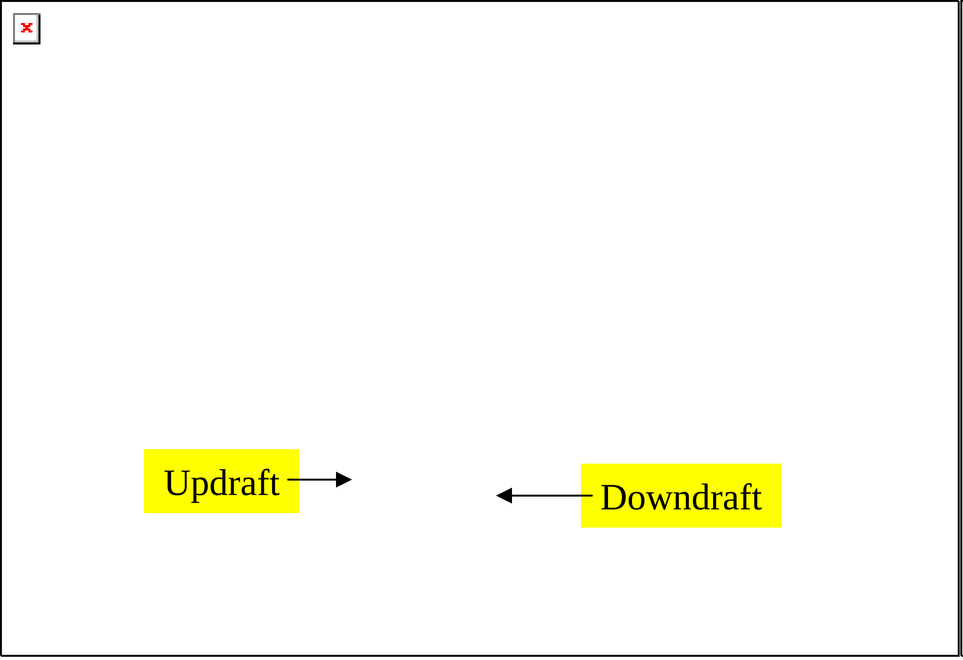


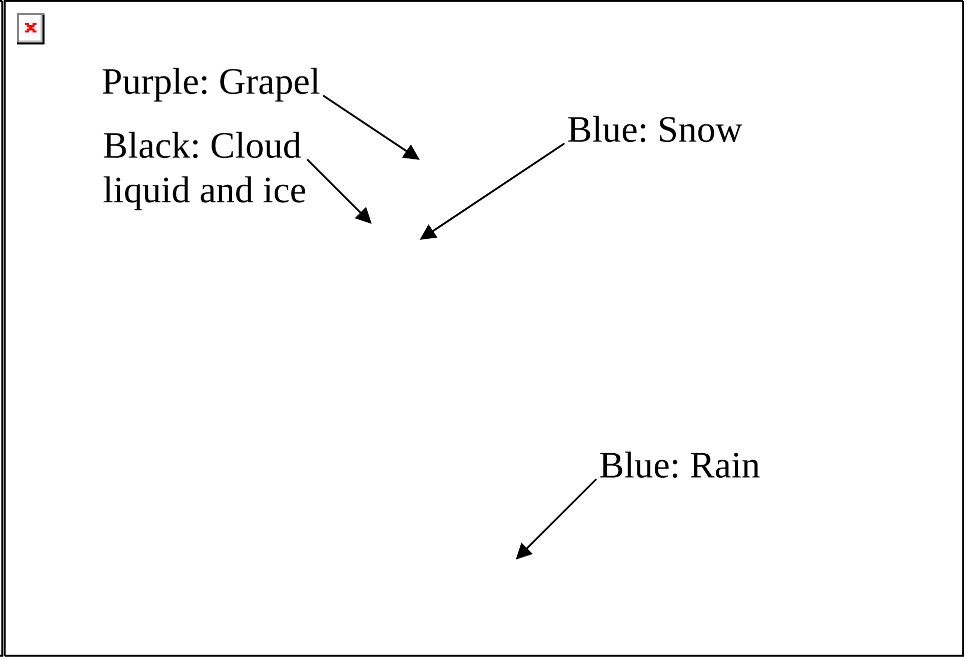
WRF initialization fields (timestep=0)

Upper Right:
Green shading is relative humidity
White contours for RH > 100% and 110%
Black contours cloud+ice mr > 0.1,0.5 g/kg
Blue contours snow mr > 4.0,8.0,12.0 g/kg
Blue contours rain mr > 0.01,0.1 g/kg
Purple contours graupel mr > 1.0,2.0 g/kg



Lower Right:
Reflectivity from Brian Colle’s equation



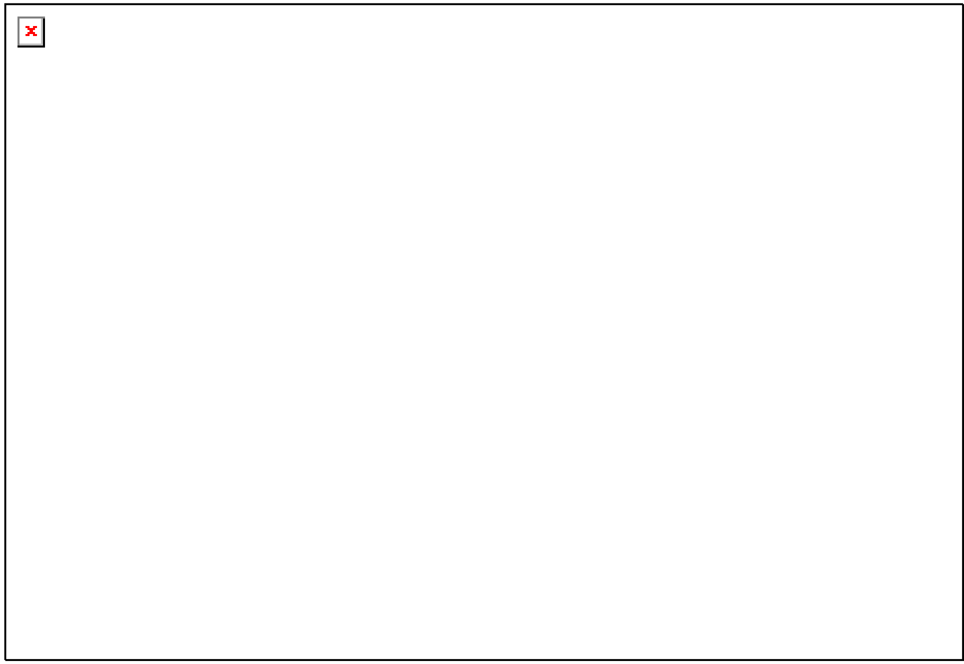


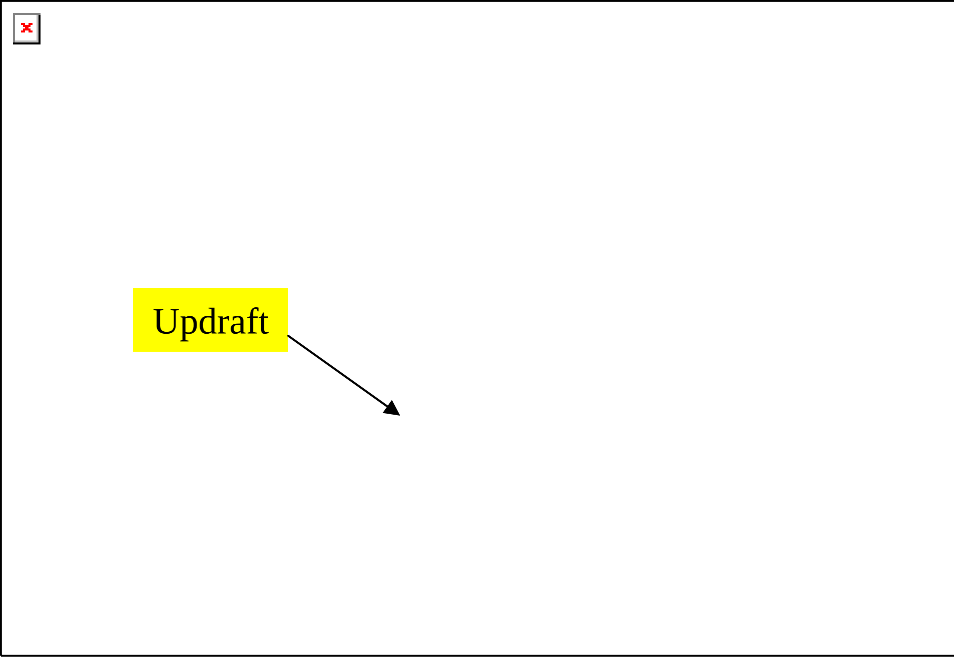
WRF 5 second fields (timestep=1)

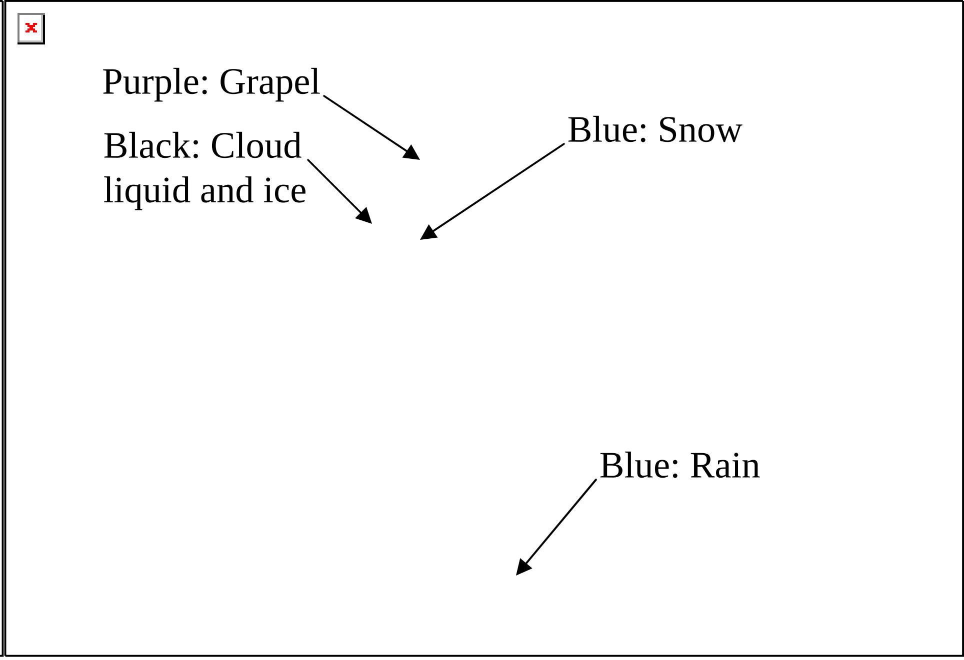
Upper Left:
Red shading diabatic heating
Blue shading is negative diabatic heating
Black contours are w > 0.2,2.0 by 0.2 m/s
Black dash contours are w < -1.0,-10.0 by 1.0 m/s

Upper Right:
Same as green scale in wrf initialization plot

Lower Right:
Reflectivity from Brian Colle’s equation





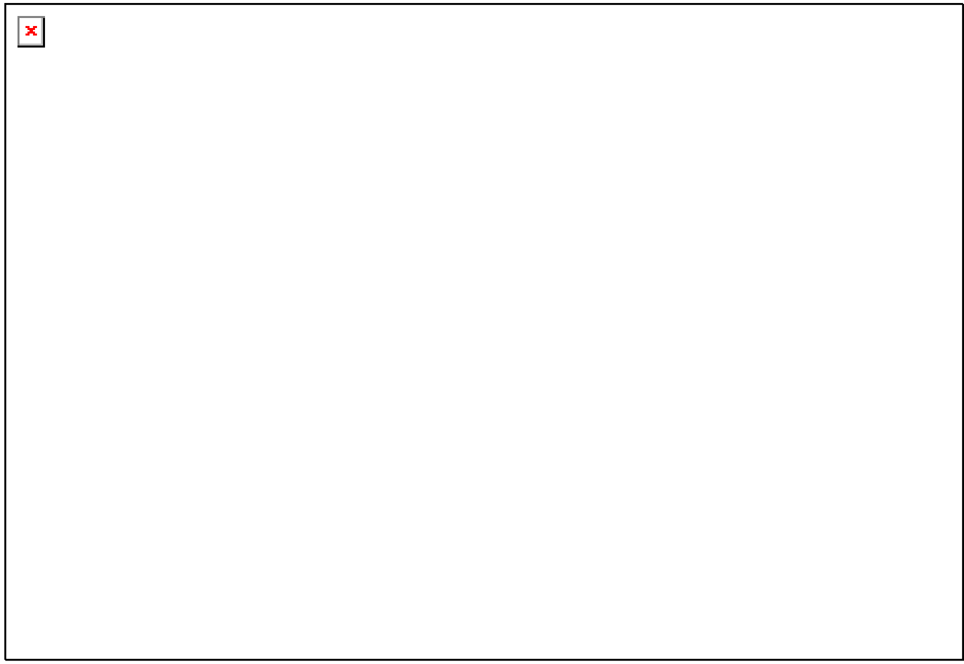


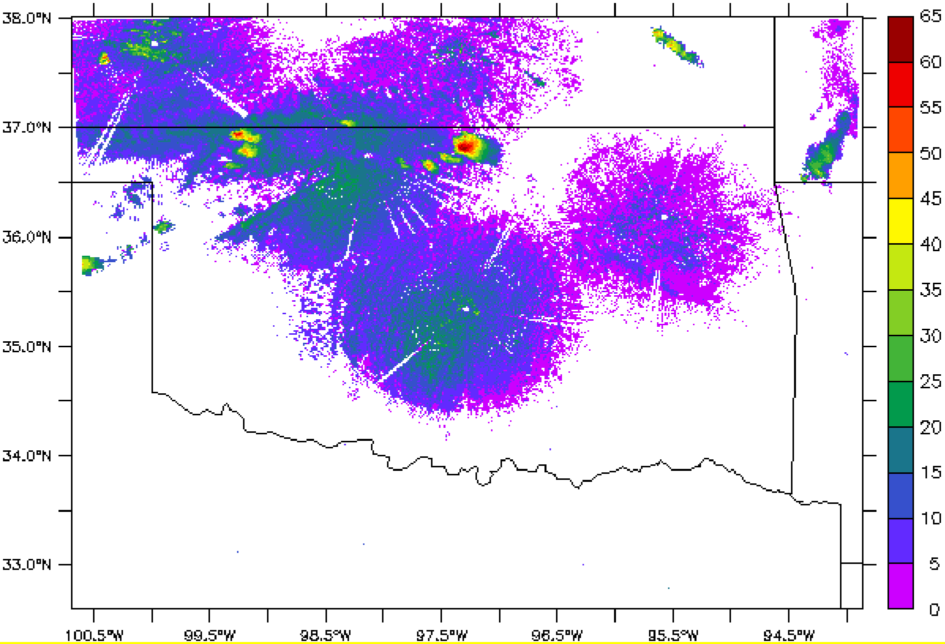
WRF 30 second fields (timestep=6)

Upper Left:
Red shading diabatic heating
Blue shading is negative diabatic heating
Black contours are w > 0.2,2.0 by 0.2 m/s
Black dash contours are w < -1.0,-10.0 by 1.0 m/s

Upper Right:
Same as green scale in wrf initialization plot

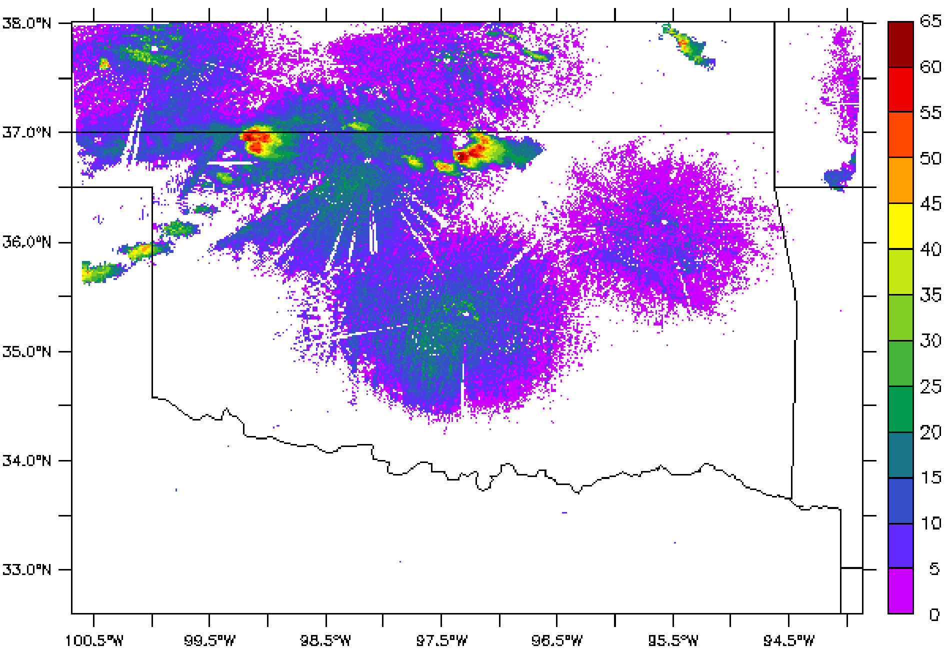
Lower Right:
Reflectivity from Brian Colle's equation





LAPS Analysis Column Maximum Reflectivity 10 minutes

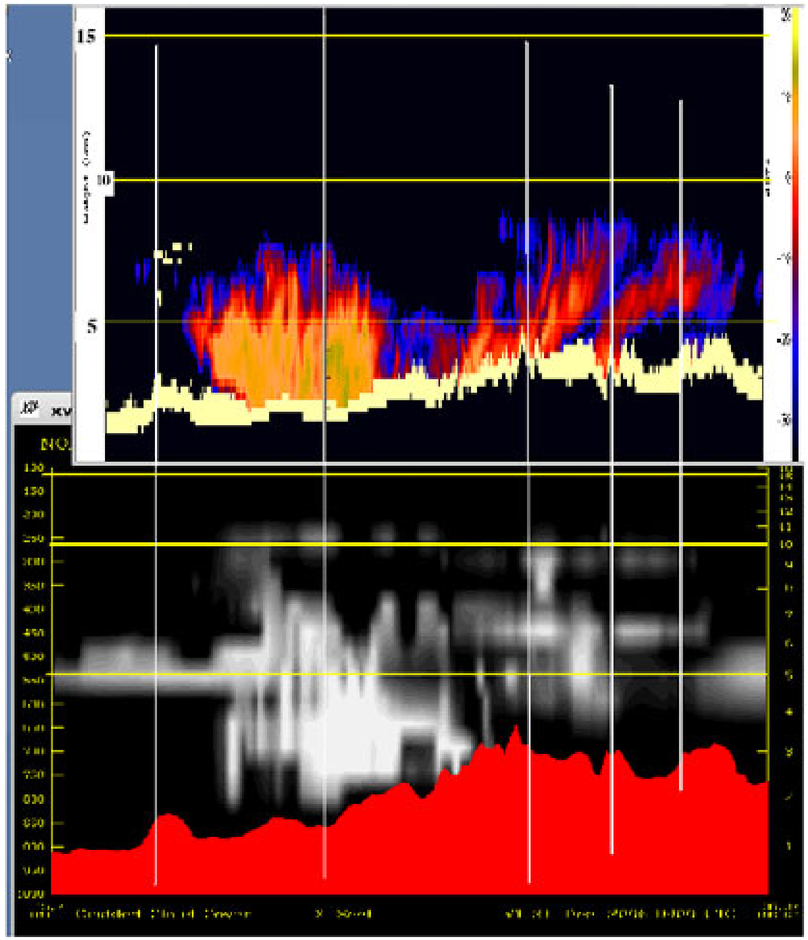
WRF Column Maximum Reflectivity 10 minutes



LAPS Analysis Column Maximum Reflectivity 30 minutes

WRF Column Maximum Reflectivity 30 minutes

CloudSat and LAPS Comparisons



CloudSat

LAPS Cloud Analysis

December 2006 Snowstorm case, Cross section running NE to SW through ROC

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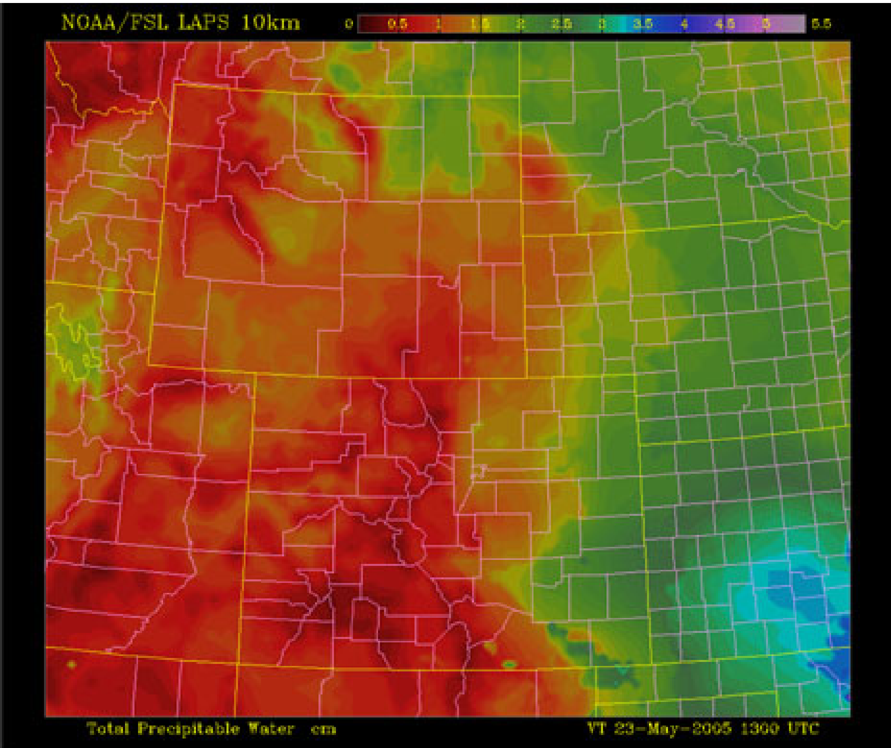
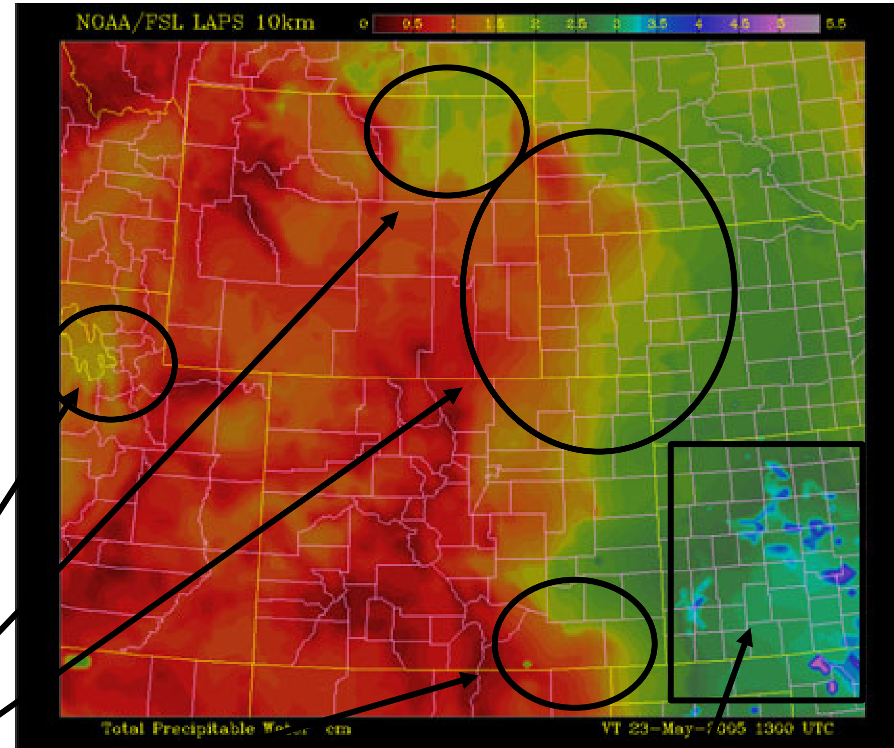
Gradient approach is to utilize only satellite gradients in the analysis





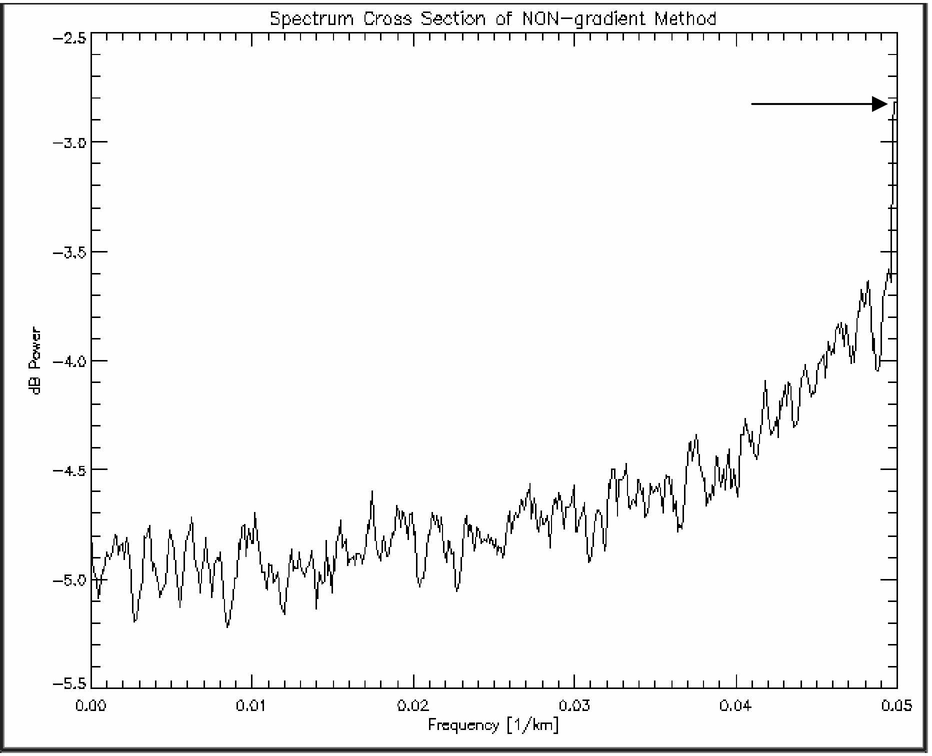
Old method

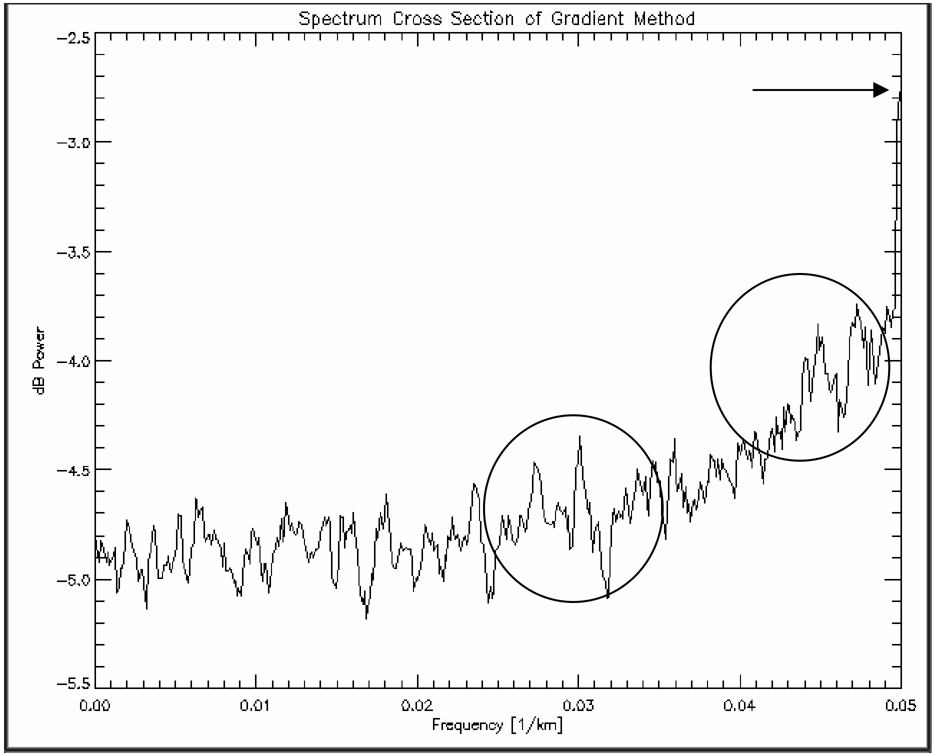
New method

Less moist bias

Better structure

Non-Gradient Method Spectra





Gradient Method Spectra

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Summary

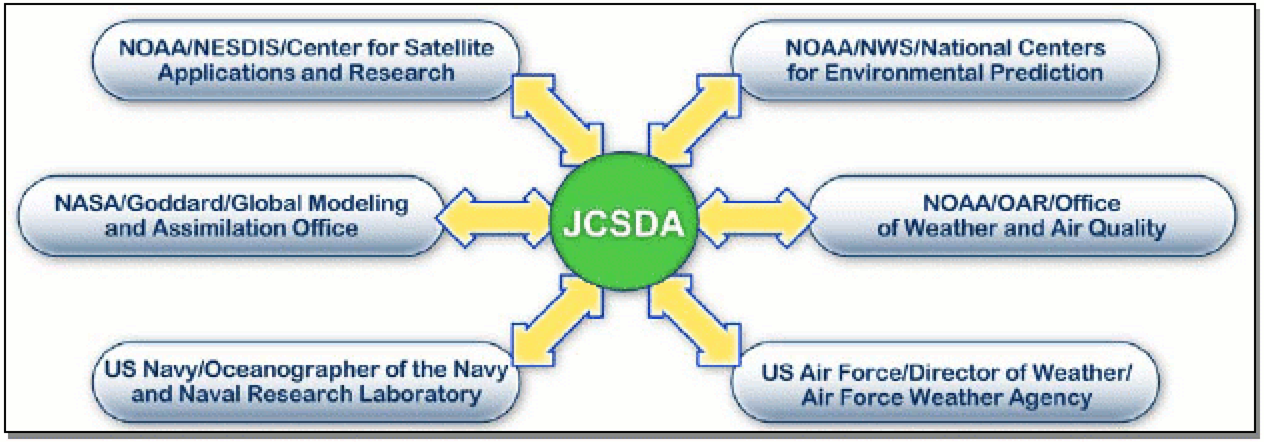
- NOAA/OAR is well positioned to work in areas of JCSDA interest.
- In order for GSD as part of OAR to continue our relationship with JCSDA, we must get more support.
- No funding was transferred to OAR from the Joint Center in 06.
- Work shown here will die on the vine unless there is some change.

It Goes Deeper than Funding Support

- Last year we prepared a comprehensive summary of cases to ascertain GOES moisture problems. This fostered little interaction.
- This year we have provided bias corrections for GOES 12 moisture to NESDIS and no action has resulted.
- We must cooperate to be successful.

From the JCSDA Strategic Plan

Inter-Agency Relationships



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