

Assimilation of MODIS Cloudy Radiances with a Hybrid Variational-Ensemble

Data Assimilation System for Convection-Permitting Forecast

Zhiqian Liu (liuz@ucar.edu), Hui-Chuan Lin, and Craig S. Schwartz

National Center for Atmospheric Research, Boulder, CO, USA

Implementation for MODIS cloudy radiance

Data (in HDF-EOS format) Processing

- Collection 51 <ftp://adsweb.nascom.nasa.gov/allData/51>
- MOD021KM/MYD021KM** (level 1 MODIS radiances, 36 channels)
- Cloud_Mask_1km info from **MOD06_L2/MYD06_L2**

GSI related developments

- Community Radiative Transfer Model (CRTM) interface for MODIS cloudy radiances (both forward and Jacobian matrices)
- Allow change of **cloud water/ice and rain** profiles by assimilating MODIS cloudy radiance
- Assimilation using 3DVAR or hybrid mode**

$$J(x_i, \alpha) = \beta_1 \frac{1}{2} (x_i - y_i)^T B_1^{-1} (x_i - y_i) + \beta_2 \frac{1}{2} \sum_{j=1}^n (\alpha^j)^T L_j (\alpha^j) + \frac{1}{2} \sum_{j=1}^n (H_j x_i - y_j)^T R_j^{-1} (H_j x_i - y_j)$$

$$x_i = x_i + \sum_{j=1}^n (\alpha^j) x_i$$

Test Case (801x616, 4km resolution over US, 2011052418)

- Background from the mean of 6-h ensemble forecasts (initialized by EnKF)
- 50 member ensemble forecast input forms flow-dependent background error covariance.

Assimilated Channels and Error Specification

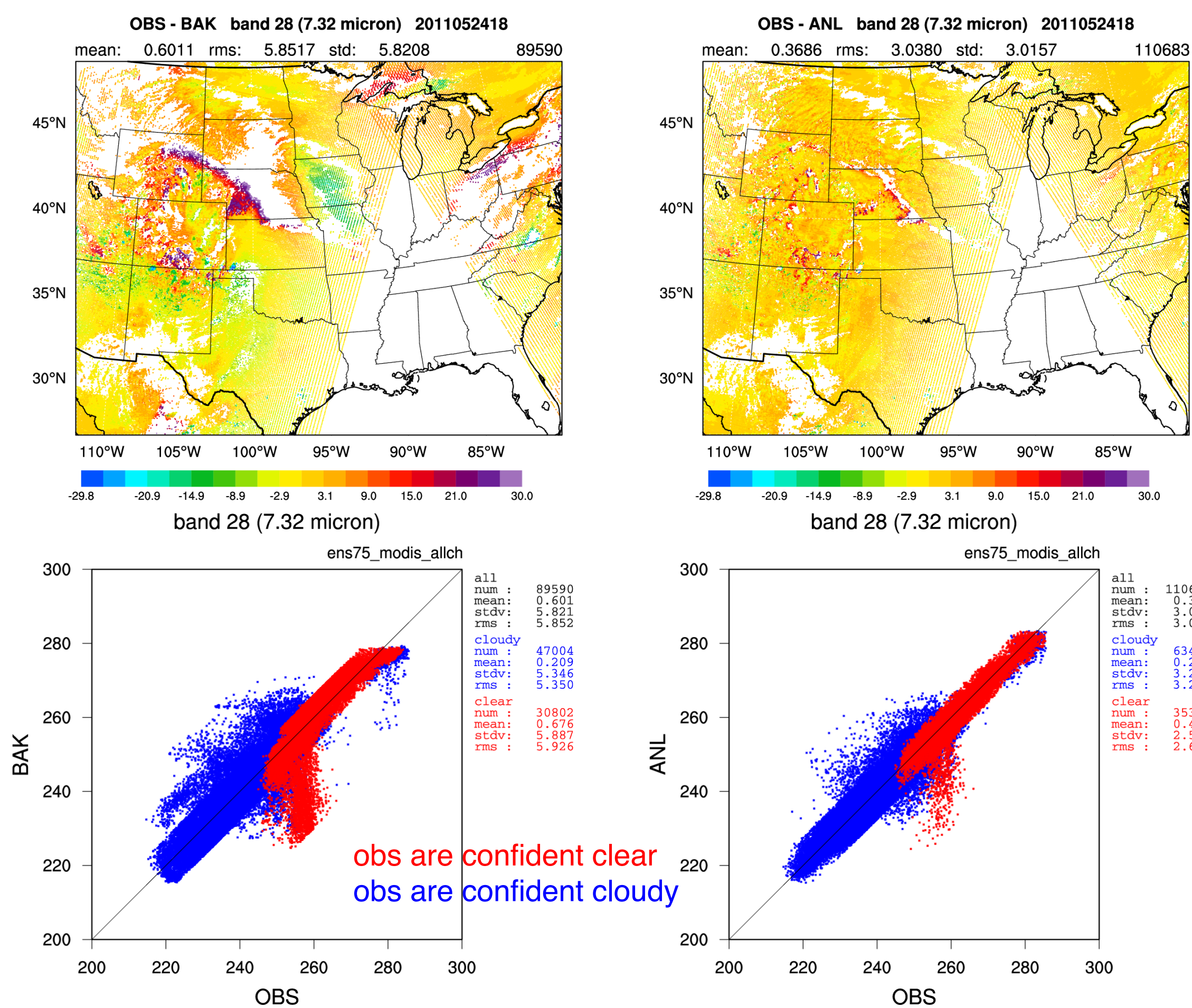
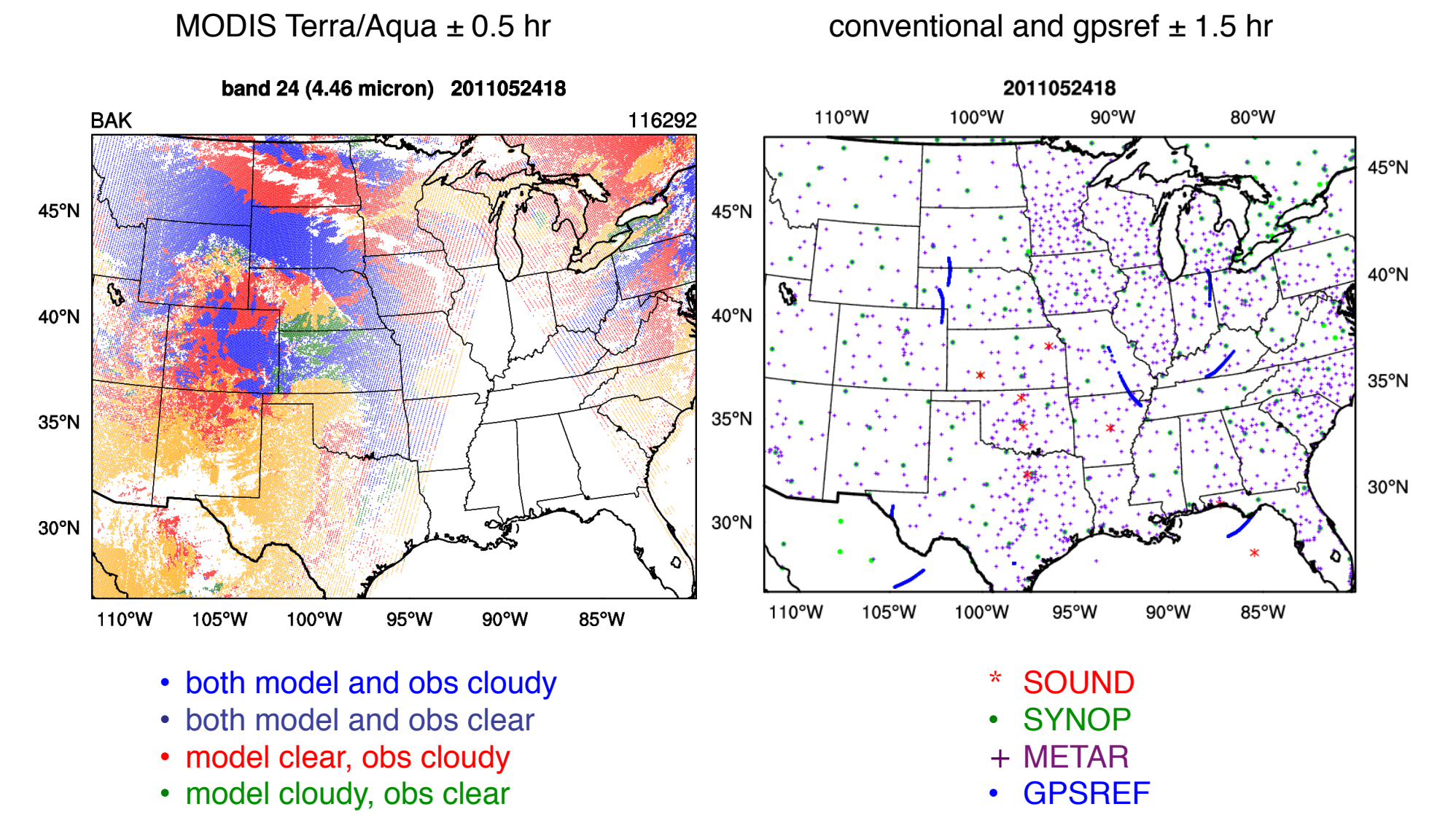
Primary Use	Band	Bandwidth (µm)	ob_err	ob_err_cld
Surface/Cloud Temperature	20	3.660 – 3.840	2	20
	21	3.929 – 3.989	2	20
	22	3.929 – 3.989	2	20
Atmospheric Temperature	23	4.020 – 4.080	2	20
	24	4.433 – 4.498	1	8
Cirrus Clouds Water Vapor	25	4.482 – 4.549	1	10
	27	6.535 – 6.895	2	5
Cloud Properties	28	7.175 – 7.475	2	10
	29	8.400 – 8.700	2	20
Ozone (not used)	30	9.580 – 9.880	2	10
Surface/Cloud Temperature	31	10.780 – 11.280	2	20
	32	11.770 – 12.270	2	20
Cloud Top Altitude	33	13.185 – 13.485	2	10
	34	13.485 – 13.785	2	10
	35	13.785 – 14.085	2	10
	36	14.085 – 14.385	2	10
	(not used)			

Conservative ob_err (3 scenarios)

- Both model and obs are clear: **error = ob_err**
- Both model and obs are cloudy: **error = ob_err_cld * 0.25**
- When model and obs do not agree: **error = ob_err_cld**

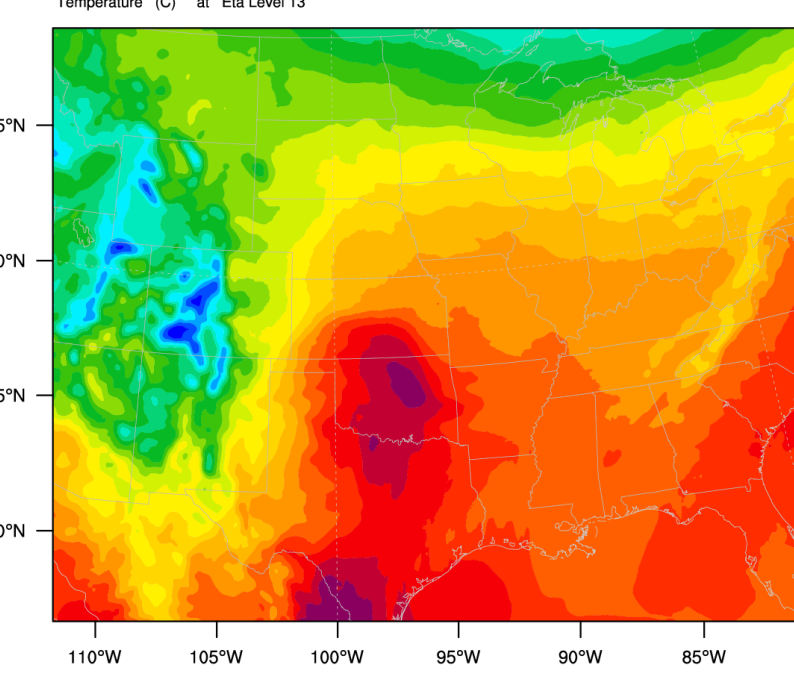
model_cld >= 0.05 considered as cloudy

Observations Coverage

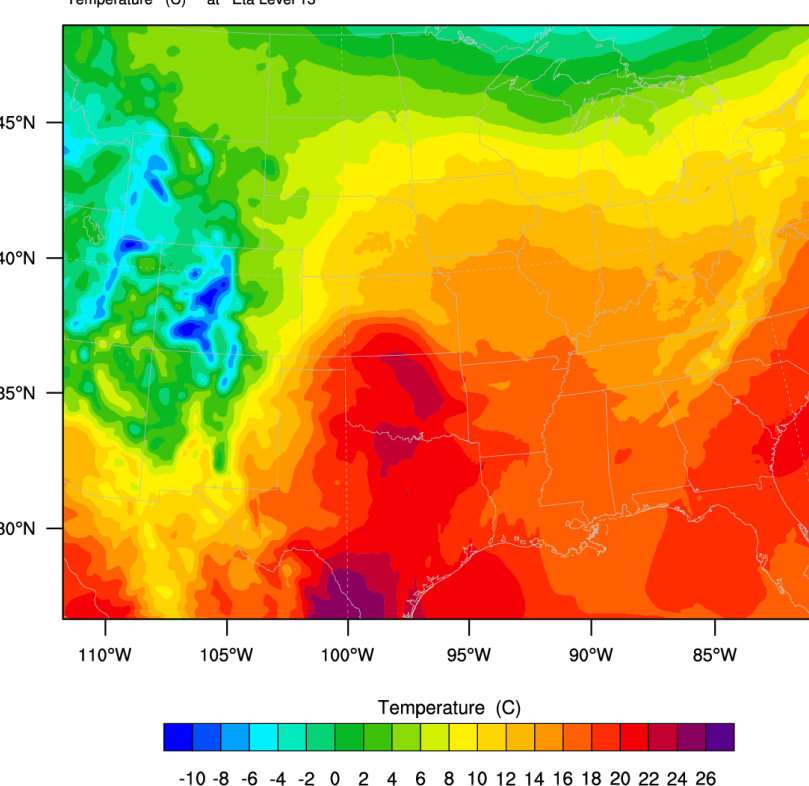


Temperature eta=0.87 (~850 hPa)

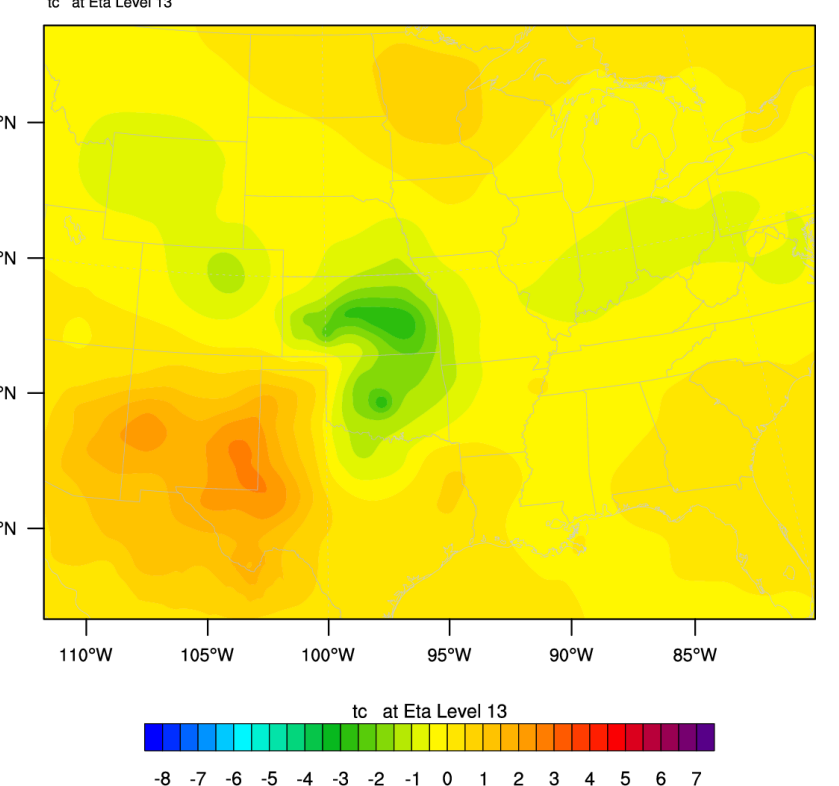
First Guess



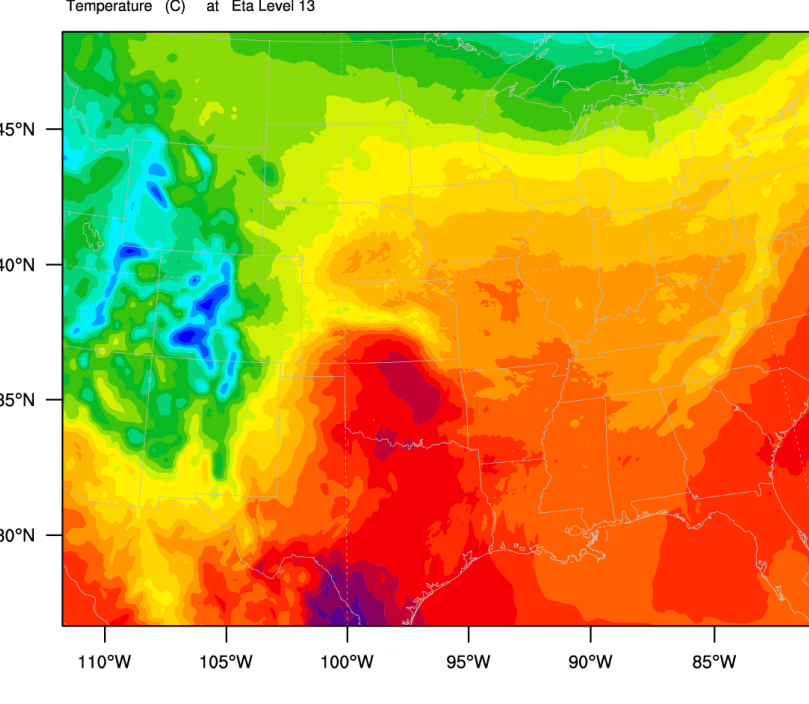
3DVAR Analysis



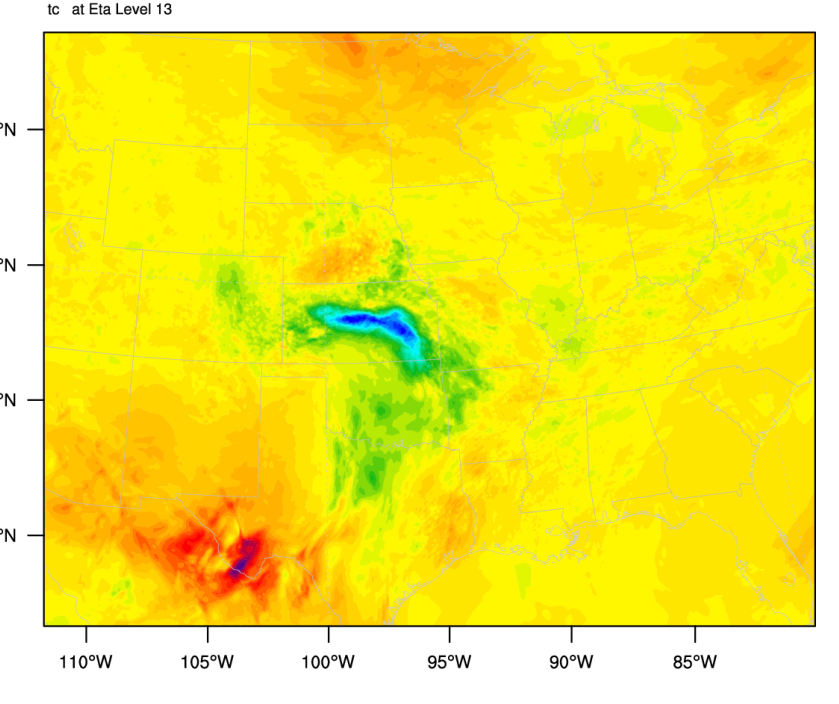
3DVAR Increment



75% Ensemble Analysis

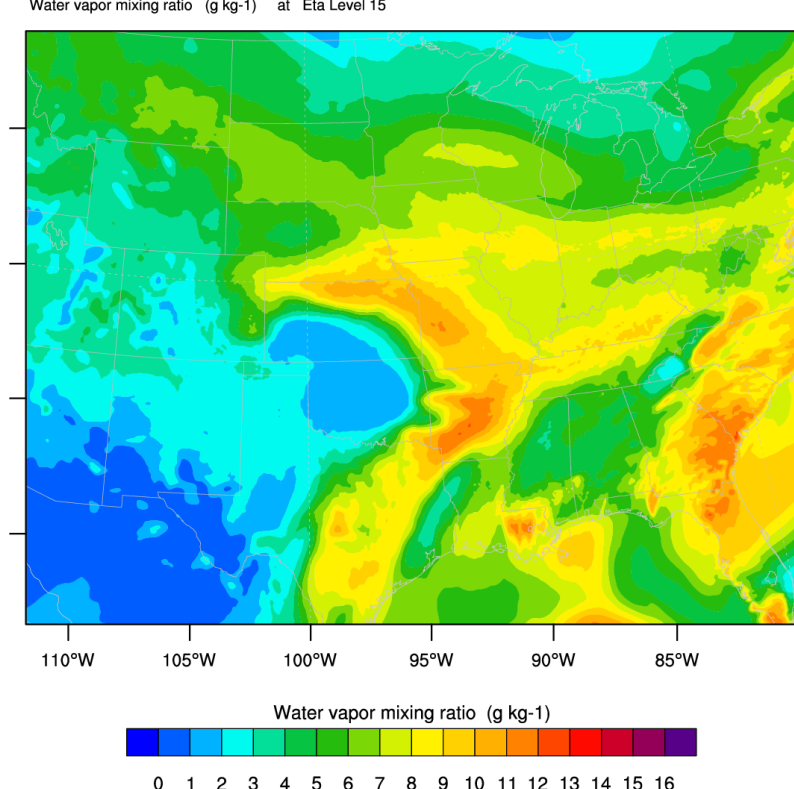


75% Ensemble Increment

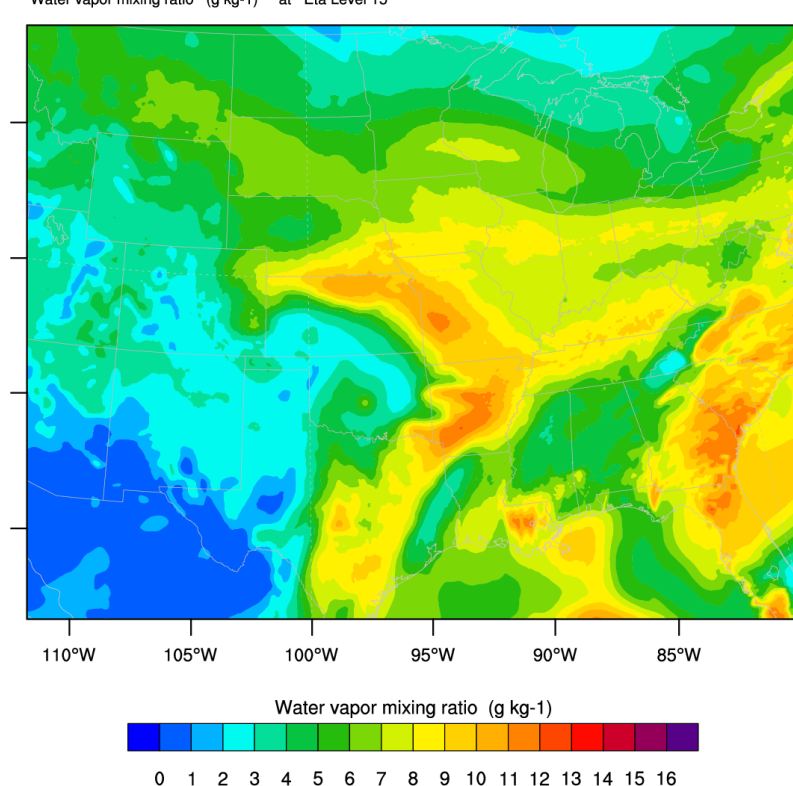


QVAPOR eta=0.82 (~800 hPa)

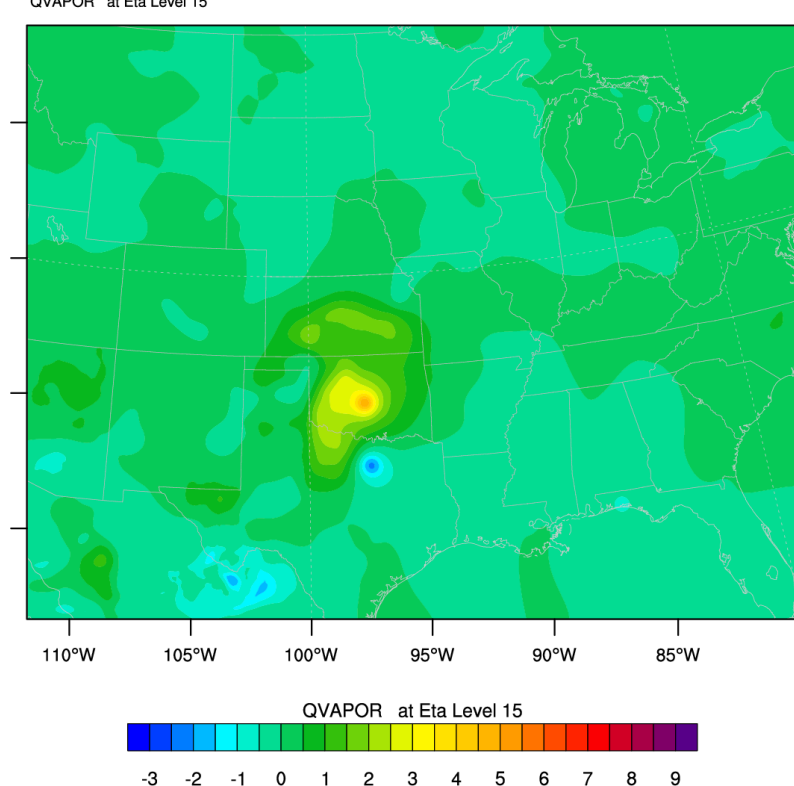
First Guess



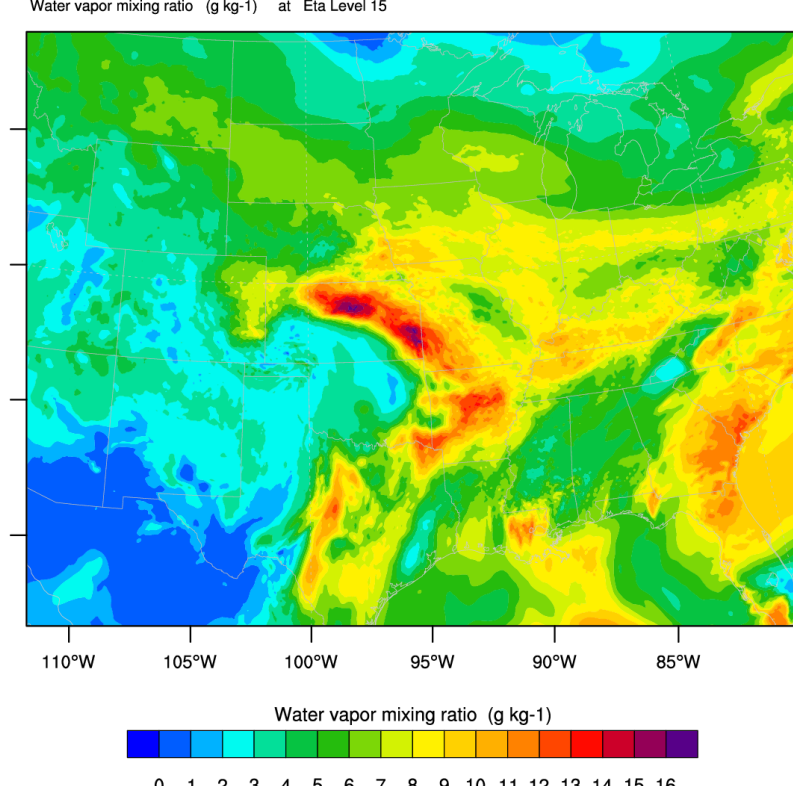
3DVAR Analysis



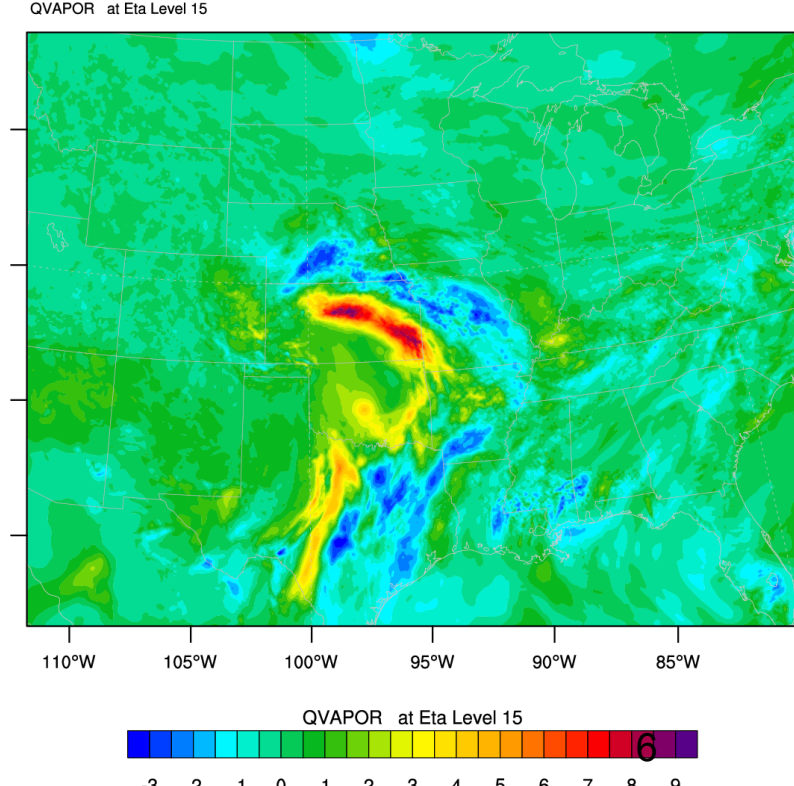
3DVAR Increment



75% Ensemble Analysis

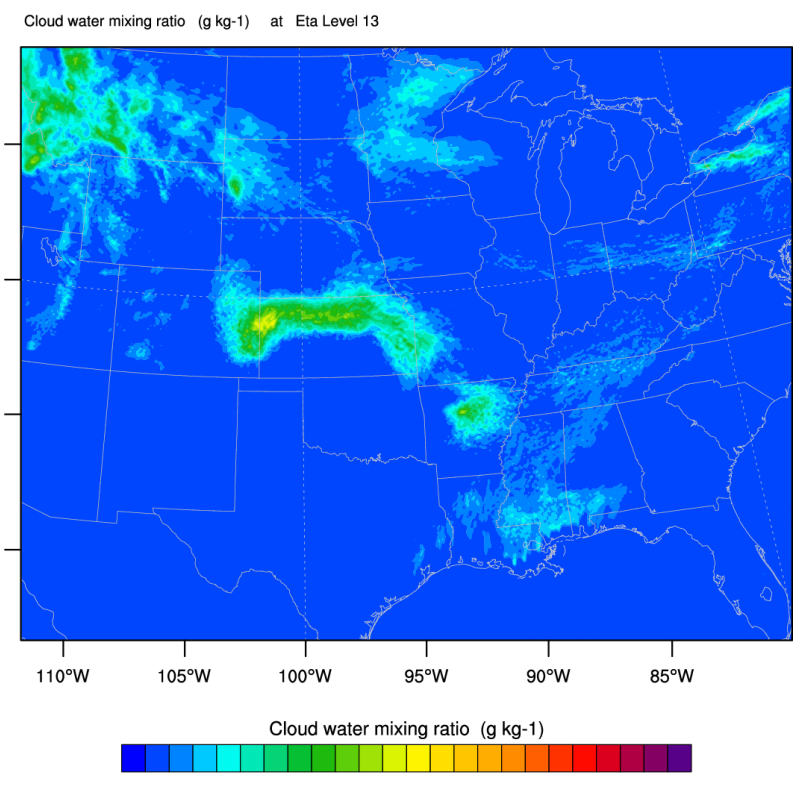


75% Ensemble Increment

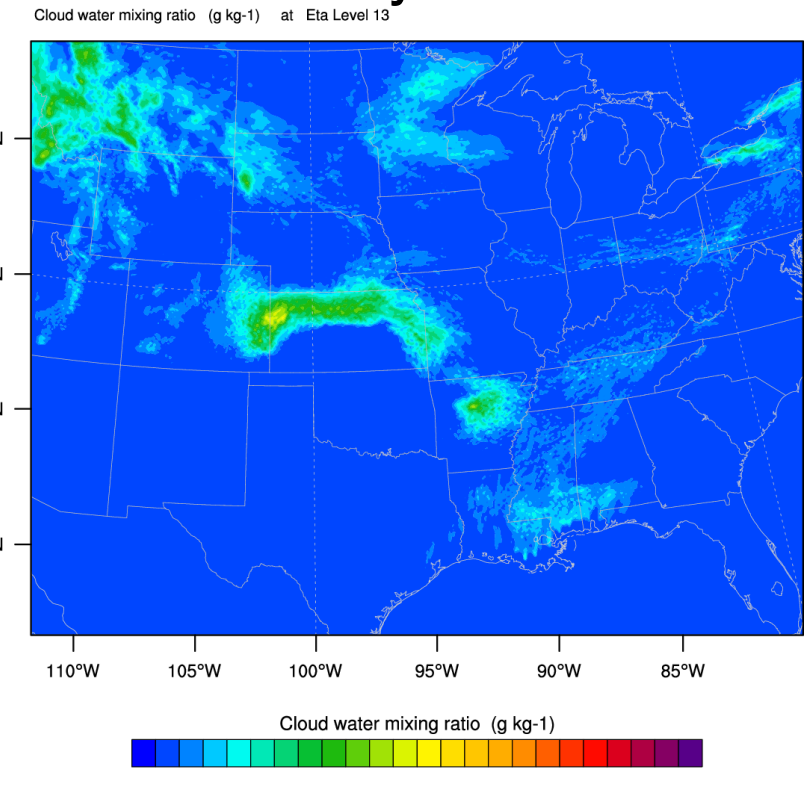


QCLOUD eta=0.87 (~850 hPa)

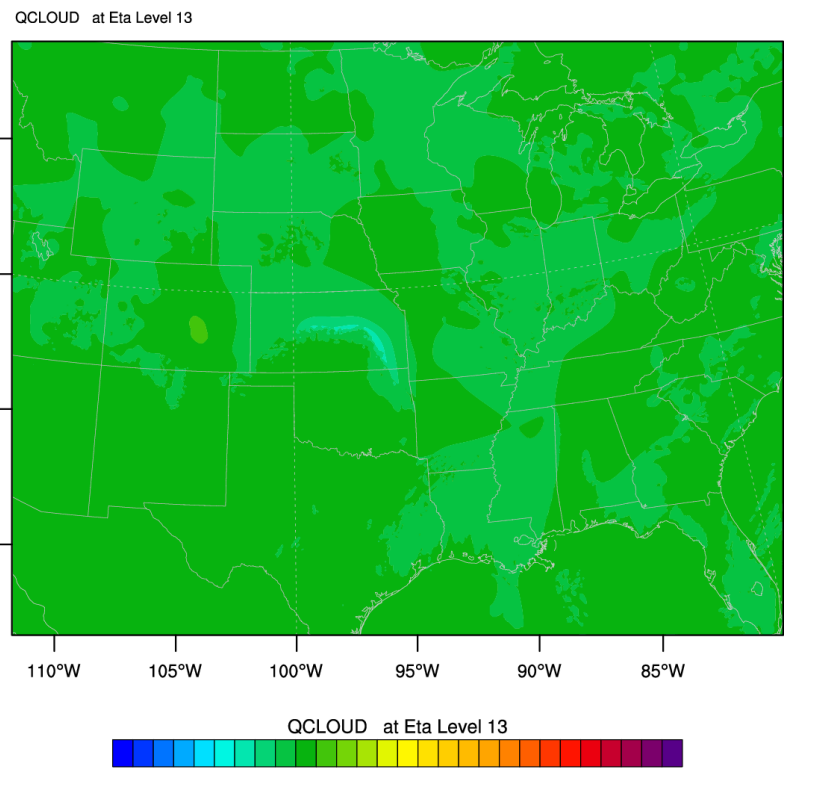
First Guess



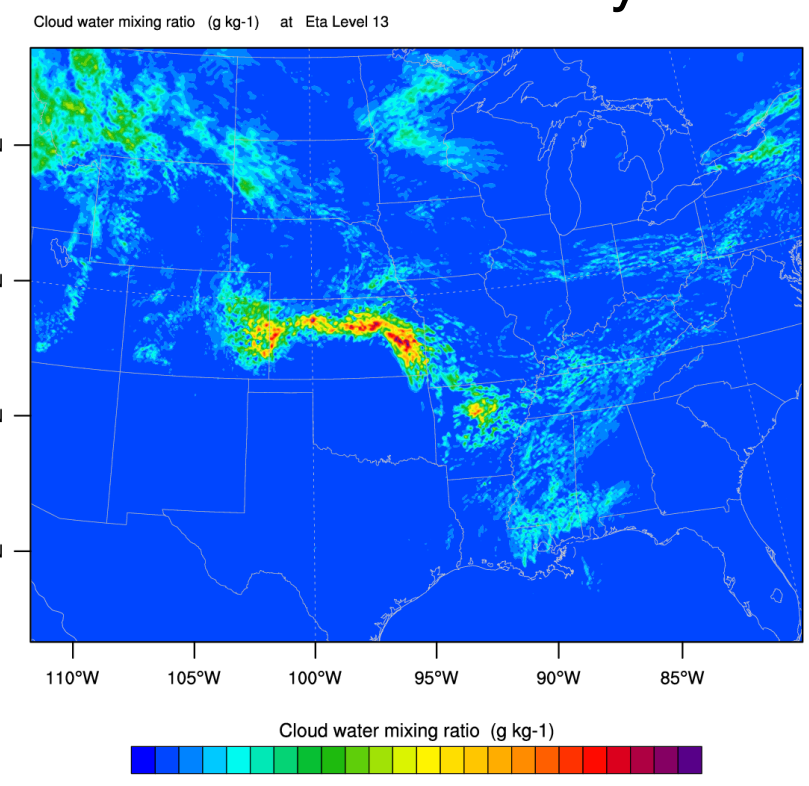
3DVAR Analysis



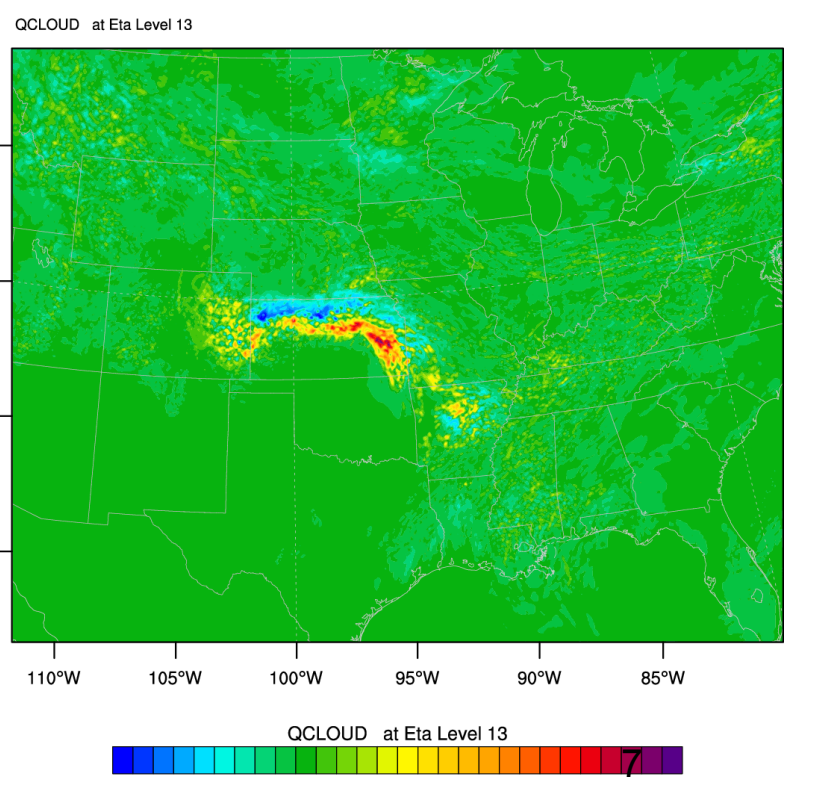
3DVAR Increment



75% Ensemble Analysis



75% Ensemble Increment



2-hr forecast

6-hr forecast

12-hr forecast

