Stony Brook University
School *of* Marine and Atmospheric Sciences

Developing a 3D Constrained Variational Analysis Method to obtain Gridded Vertical Velocity and Advective Tendencies

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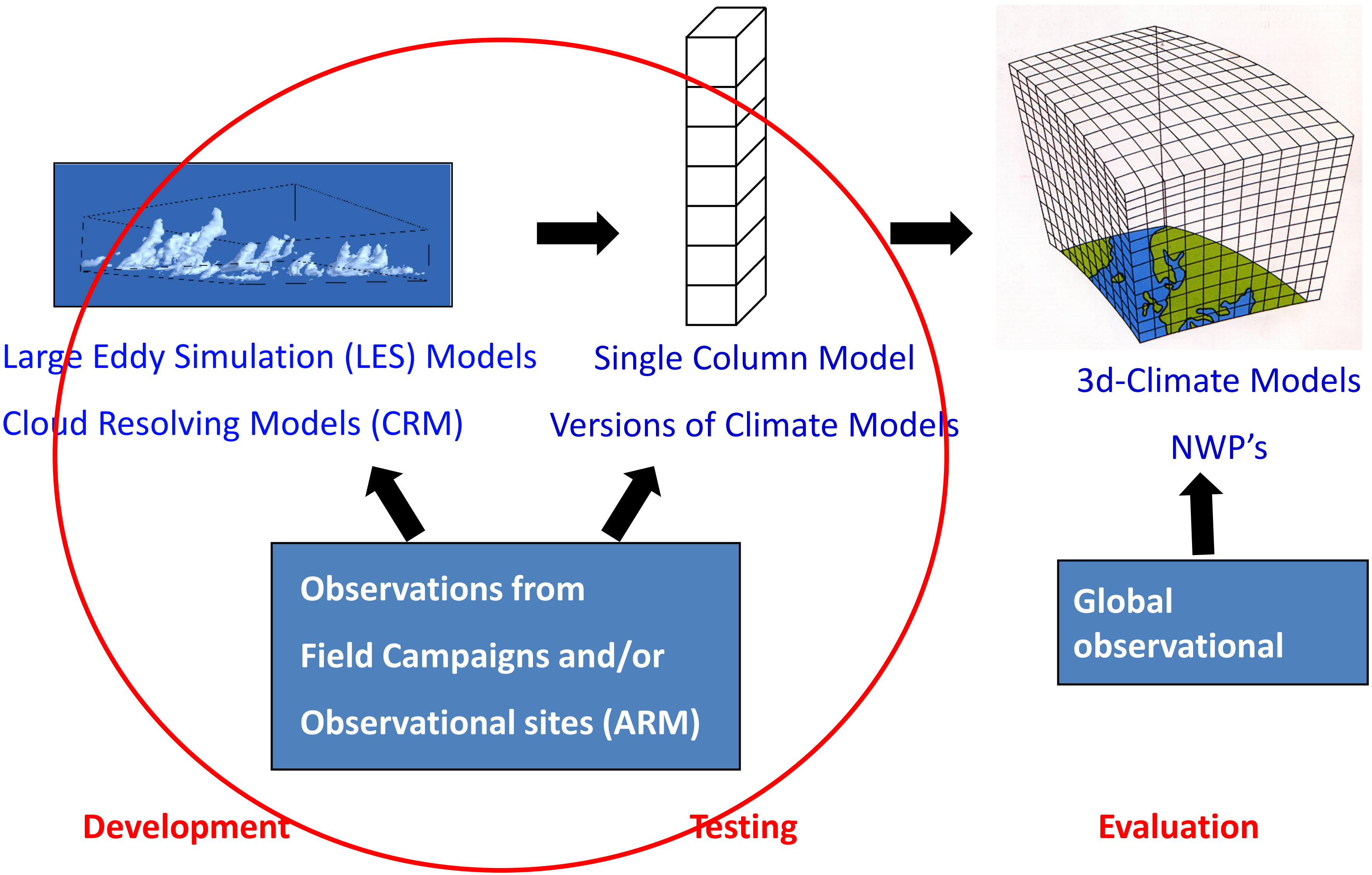
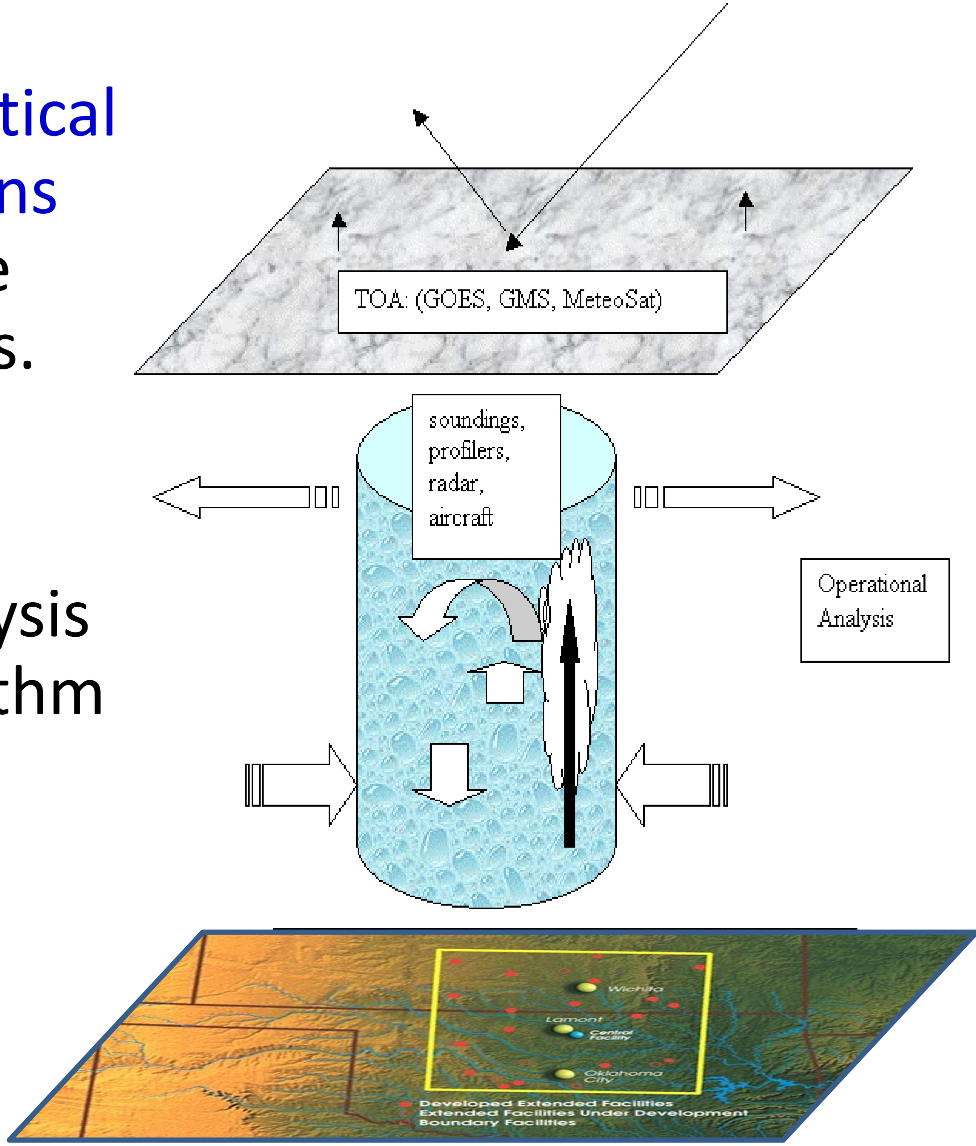
Working Strategy of GCSS (Pier Siebesma)

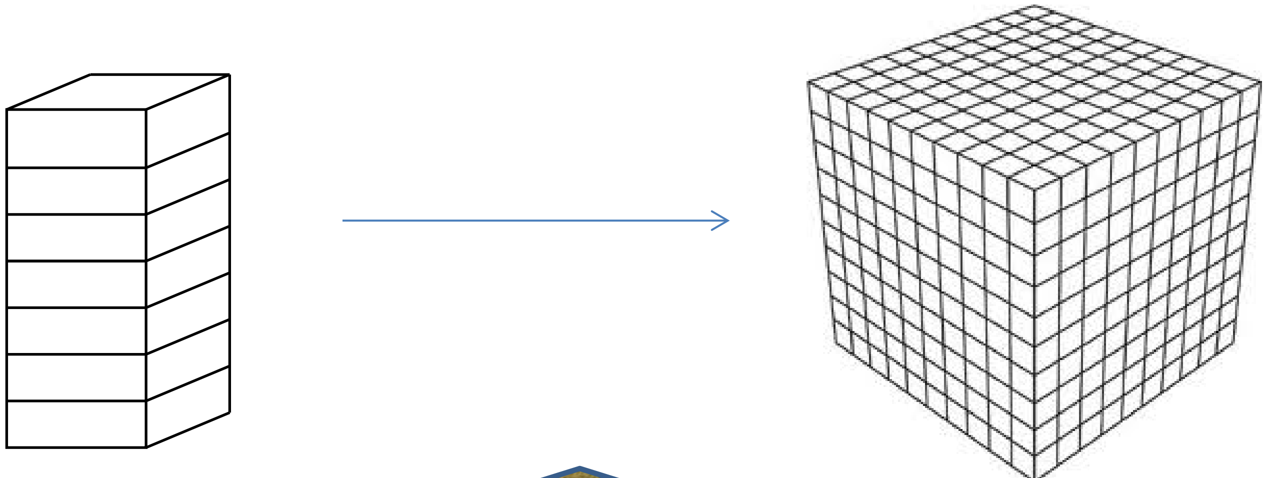


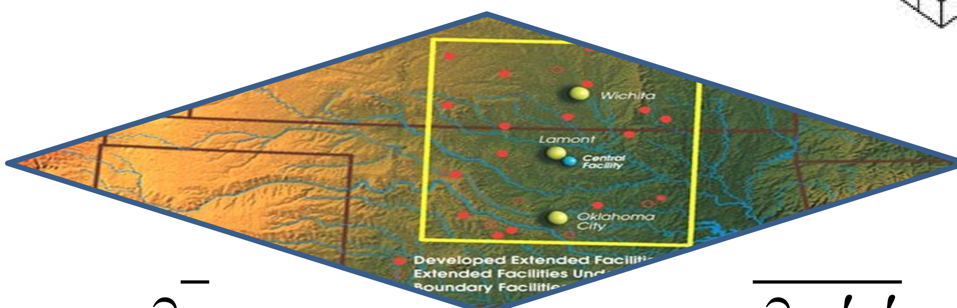
• Previous research and new requirements

- Large-scale forcing data (vertical velocity, horizontal advections of heat and water vapor) are needed to drive SCMs, CRMs.
- ARM has been using a constrained variational analysis (Zhang and Lin, 1997) algorithm to derive 1D forcing data
- New need for higher resolution models
- 3D cloud data



- An experimental version of 3D Constrained Variational Analysis (3D CVA)





$$Q_1 = \frac{\partial \bar{s}}{\partial t} + \bar{\vec{V}} \cdot \nabla \bar{s} + \bar{\omega}\frac{\partial \bar{s}}{\partial p} = Q_{rad} + L_v\left(c - e\right) + \overline{\frac{\partial \omega' s'}{\partial p}}$$

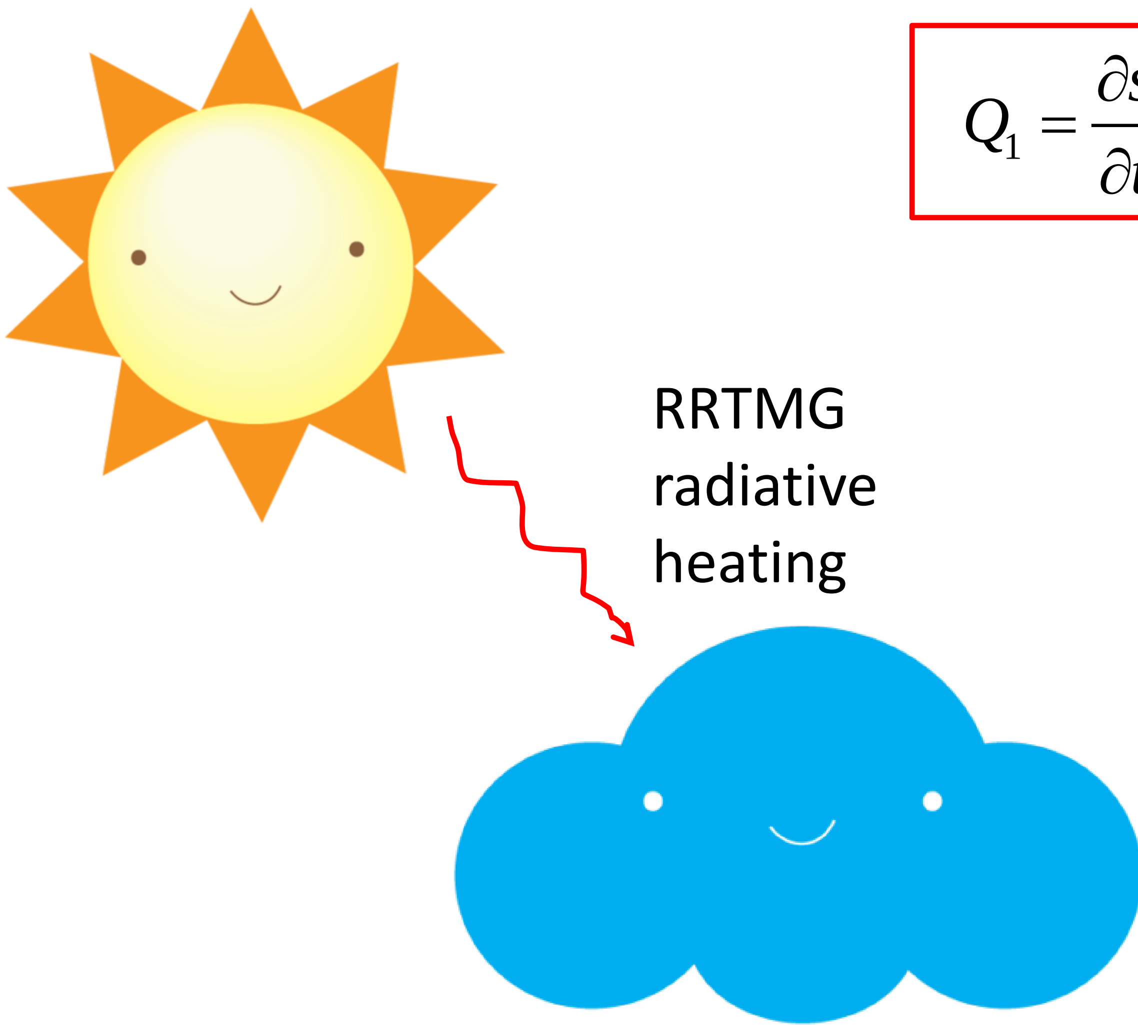
dry static energy

$$s = C_p T + gz$$

$$Q_2 = -L_v\left(\frac{\partial \bar{q}}{\partial t} + \bar{\vec{V}} \cdot \nabla \bar{q} + \bar{\omega}\frac{\partial \bar{q}}{\partial p}\right) = L_v\left(c - e + \overline{\frac{\partial \omega' q'}{\partial p}}\right)$$

(Yanai et al. 1973)

Additional Constraints above observed Cloud top

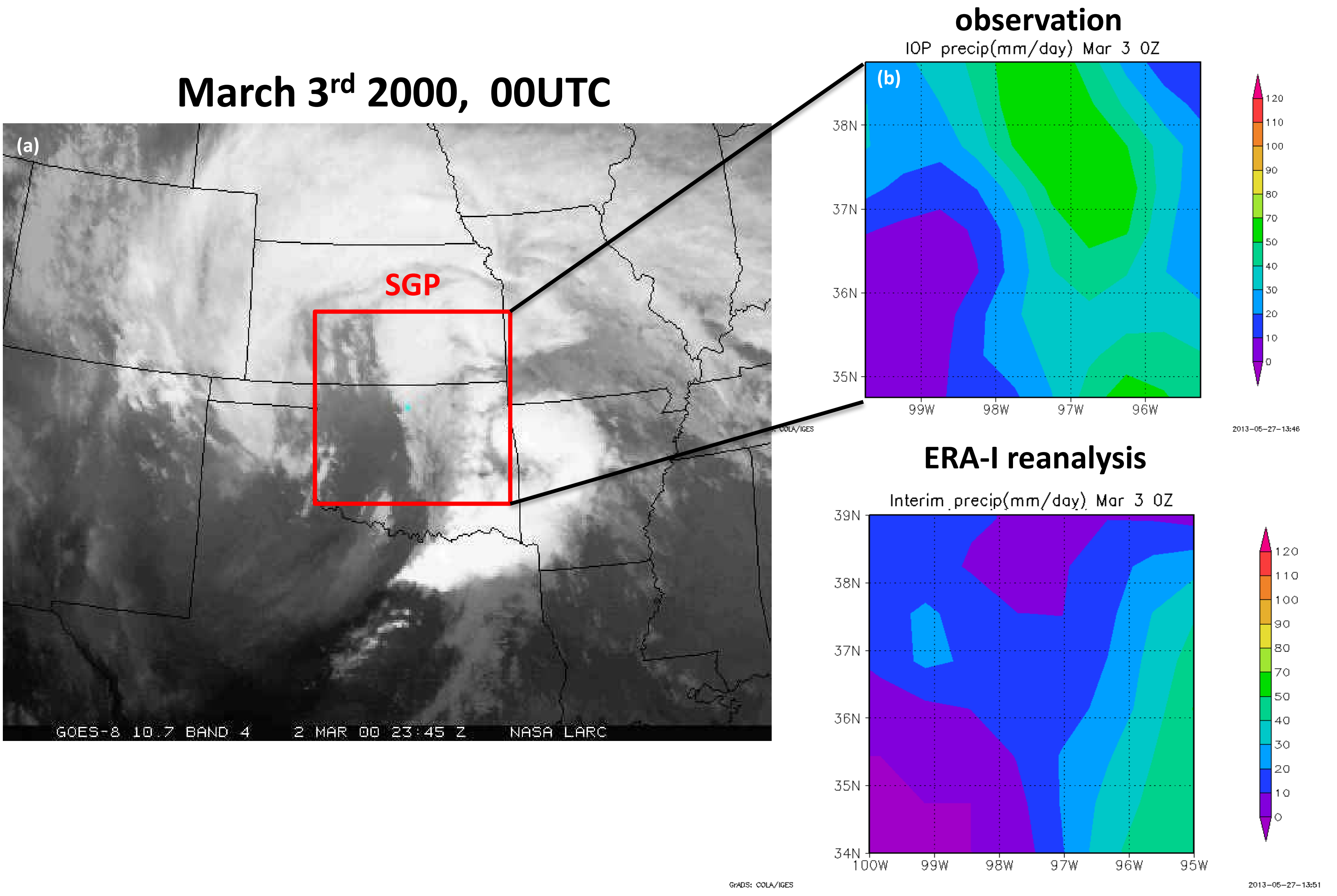


$$Q_1 = \frac{\partial s}{\partial t} + \overline{\vec{V}} \cdot \nabla \overline{s} + \overline{\omega} \frac{\partial \overline{s}}{\partial p} = Q_{rad}$$

to ensure no condensation, evaporation and sub-grid scale transport above cloud top

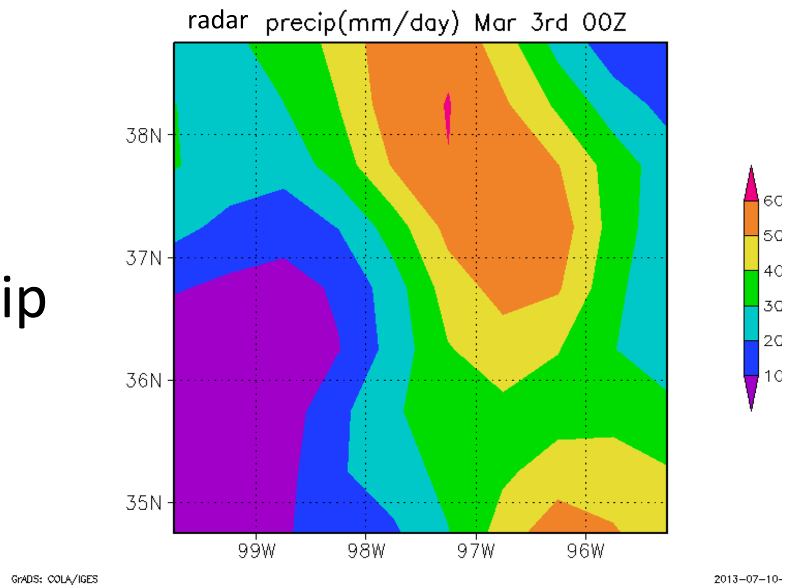
- A Case Study: March 2000 SGP IOP

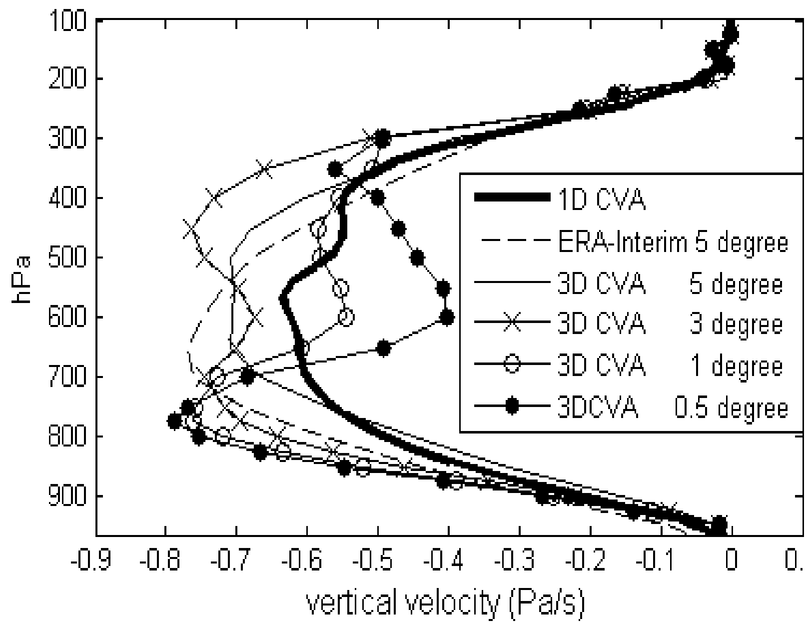
March 3rd 2000, 00UTC



- Resolution dependency and improvements to reanalysis

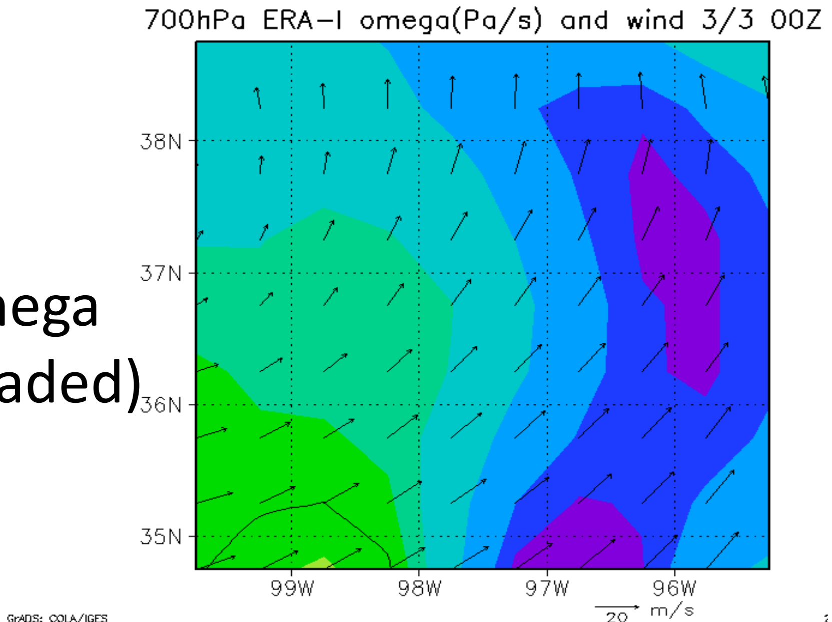
Precip



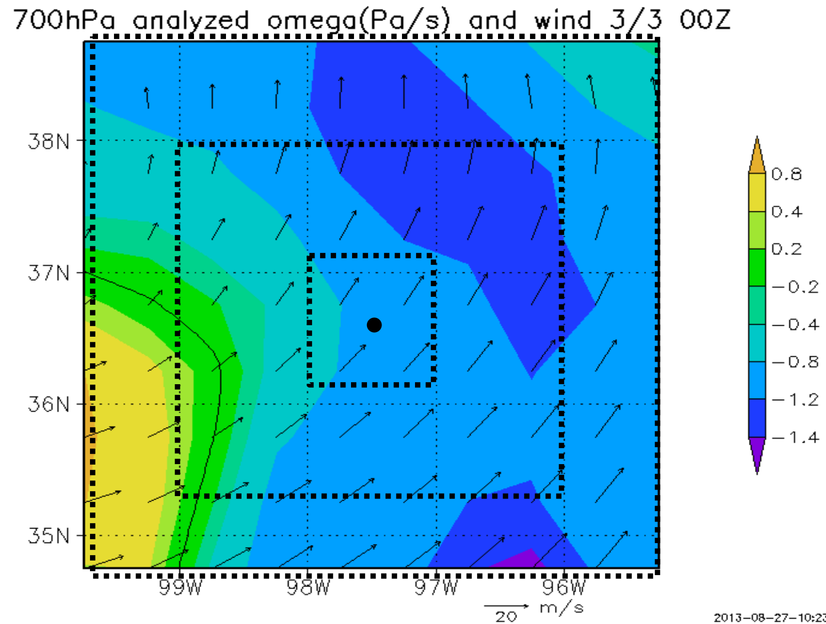


Omega (shaded)

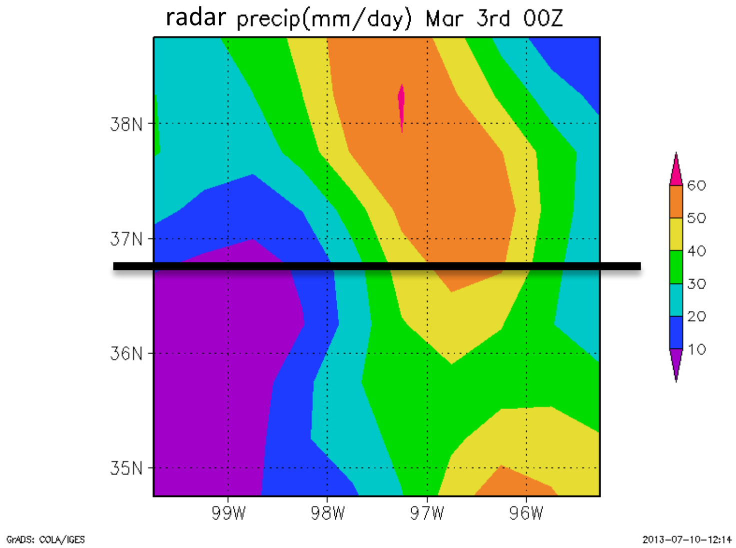
ERA-Interim



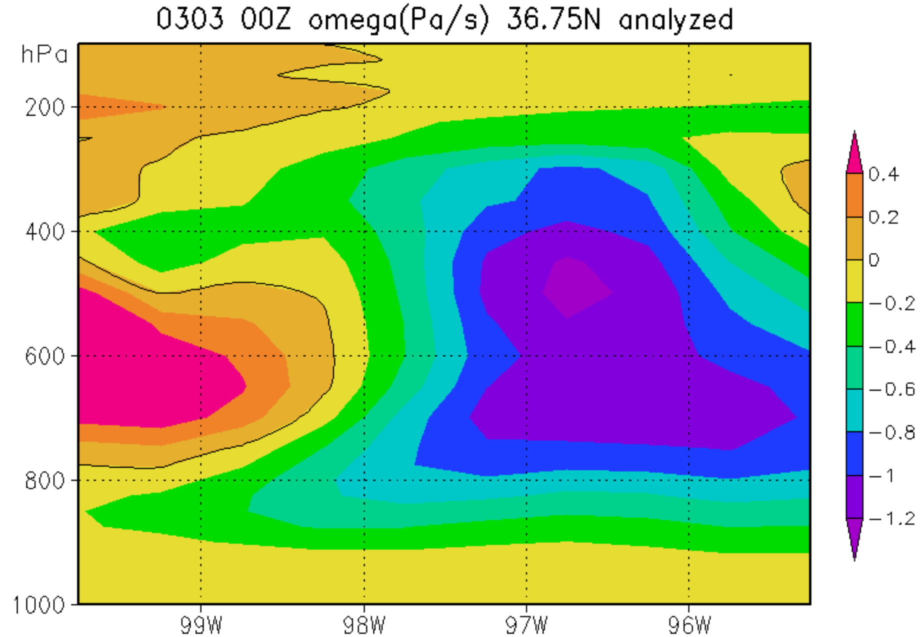
3D CVA



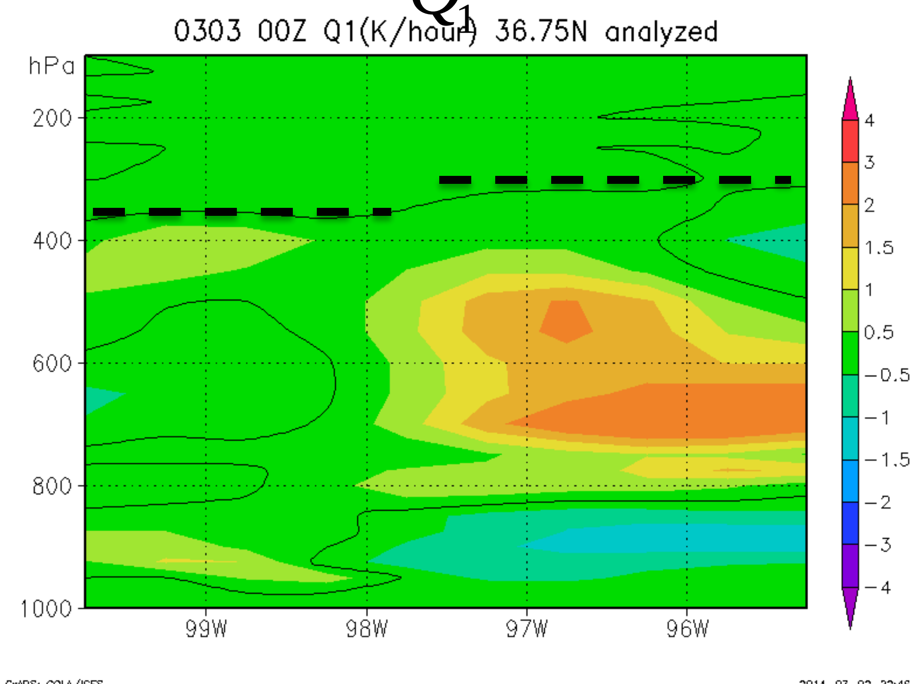
Cross section: 36.75N



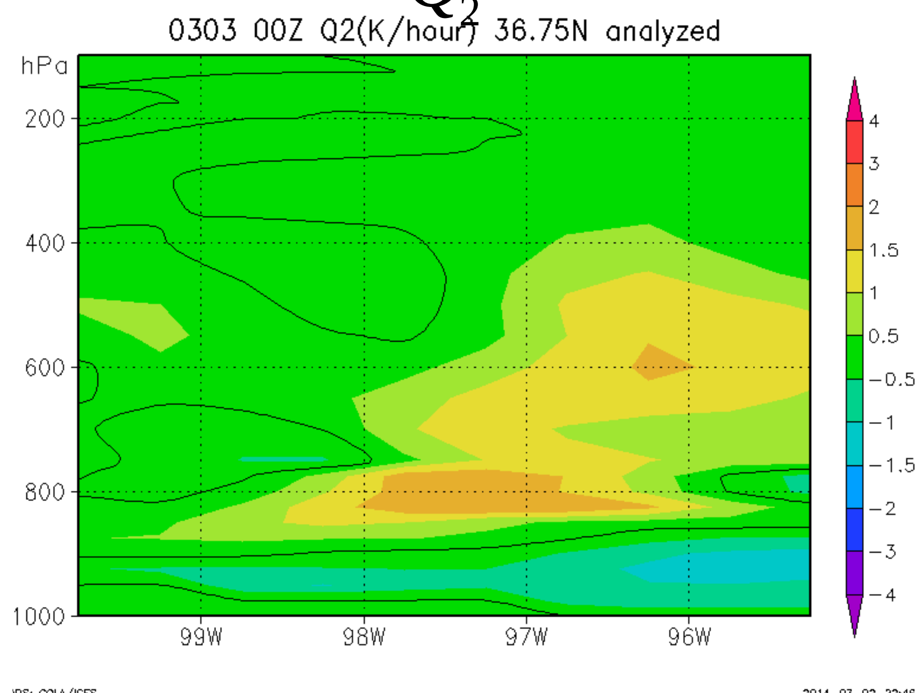
omega



Q_1



Q_2



Sensitivity Study

- 1. Sensitivity to background data
- 2. Sensitivity to error covariance matrix
- 3. Sensitivity to constraint variables

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Domain averaged vertical velocity

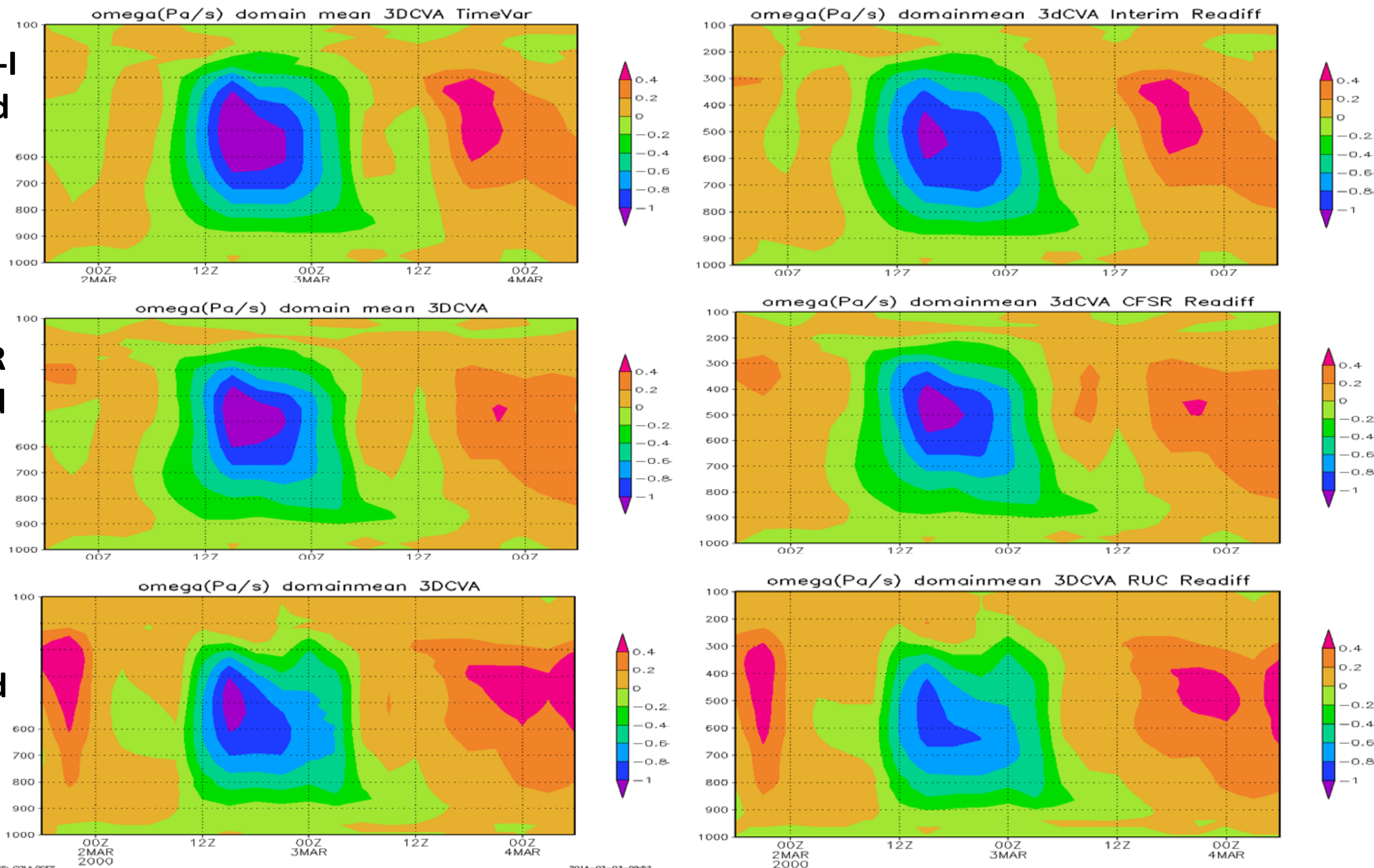
Covariance from **time variance**

Covariance from **CFSR – ERA-I**

ERA-I bkgd

CFSR bkgd

RUC bkgd



Summary and Future Work

- We have developed and are improving a 3D Constrained Variational Analysis method to derive large-scale forcing data to improve upon existing operational analysis and reanalysis products

- Generally speaking, the result pattern is similar among different background data and different covariance matrix. The difference among background data is larger than difference among covariance matrix.

- We are doing more test on the algorithm and will use SCM/CRM to evaluate the data. Our further plan is to apply it on more ARM experiments (RACORO, MC3E, etc.) so as to provide realistic gridded large-scale forcing data.

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