How Do the Variational Analysis and SCMs/CRMs Respond to a Reduced ARM SGP Network?

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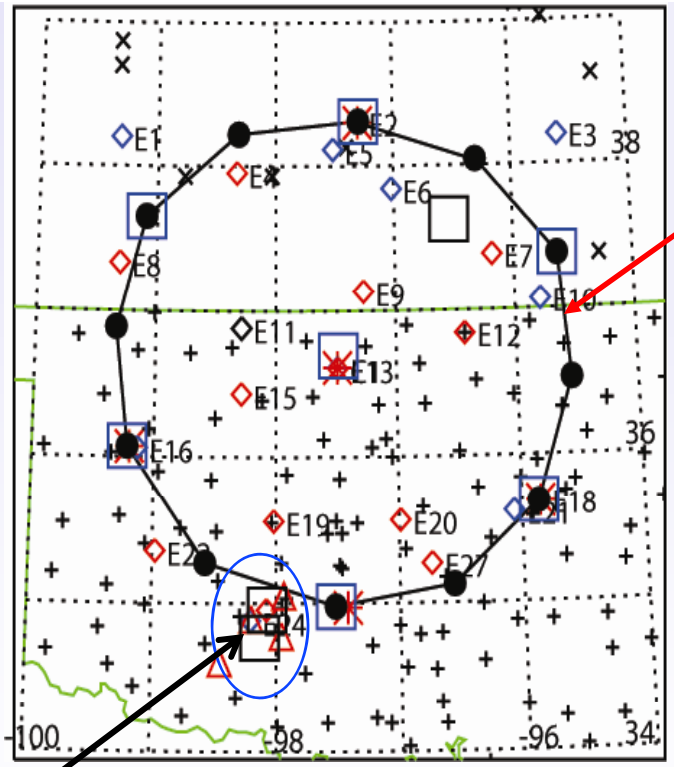
A Little Background

ARM
Atmospheric Radiation Measurement

Current ARM SGP Observation Network



Variational Analysis Domain

Δ CASA IP1 Radar Network

□ NOAA wind profilers

□ ARM wind profilers

● Analysis grid points

* Sounding stations

\+ Oklahoma mesonet

X Kansas mesonet

◊ ARM EF

~3.5 x 3.5 degree

~ 23 ARM Extended Facilities (EFs)

- ***Radiative fluxes***
- ***SH, LH***
- ***Precipitation***
- ***Other surface Meteorology fields (e.g., Ts, Ps)***

~14 EFs equipped with EBBR (Red)

~9 EFs equipped with ECOR (Blue)

~4km WSR-88D Radar precipitation well covers the domain

Issues with Current SGP Network

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- ***SGP Domain size (~3.5 x 3.5 deg) vs. a typical GCM grid box (~2.0 x 2.0 deg)***
- ***Can't resolve well the mesoscale variability shown in many important meteorology fields***
- ***Continuously maintaining the 23 EFs at their current locations is expensive***

Ideas

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- ***Shrink SGP to 2 x 2 (deg) or less***
- ***Redistribute the EFs to the reduced SGP domain***

➔ ***Have a better chance to get 3d clouds for a smaller domain***

How do the variational analysis and SCMs/CRMs respond to a reduced SGP domain?

Two Revised Surface Networks Used in the Study

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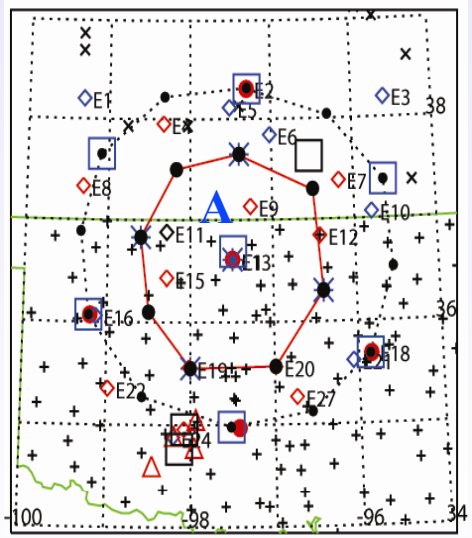
Option A:

Shrink SGP to ~ 2 x 2 deg, centered at CF

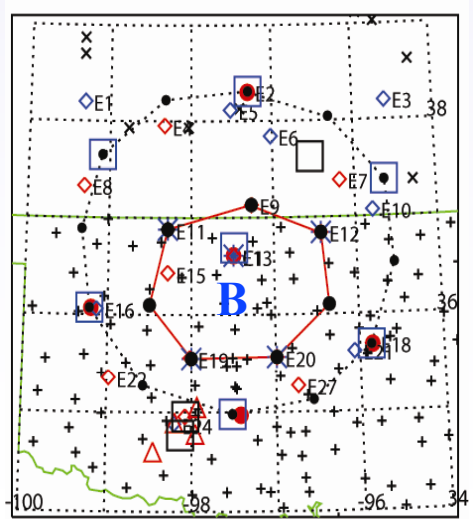
Analysis Domain A



Option B:

Shrink SGP to ~ 1.5 x 1.5 deg, domain enclosed by the 6 closest EFs, the CF not at the center

Analysis Domain B



Pros:

- ***2 x 2 or 1.5x1.5 (deg) ~ A typical climate model resolution***
- ***6 EFs +CF within the new domain***
- ***More evenly distributed surface mesonet stations***

Cons:

- ***CASA radars and both ARM and NOAA wind profilers are outside the reduced domains***
- ***Eliminate most ECOR stations (except for CF)***

Mean Surface Precip Rates Over CLASIC IOP

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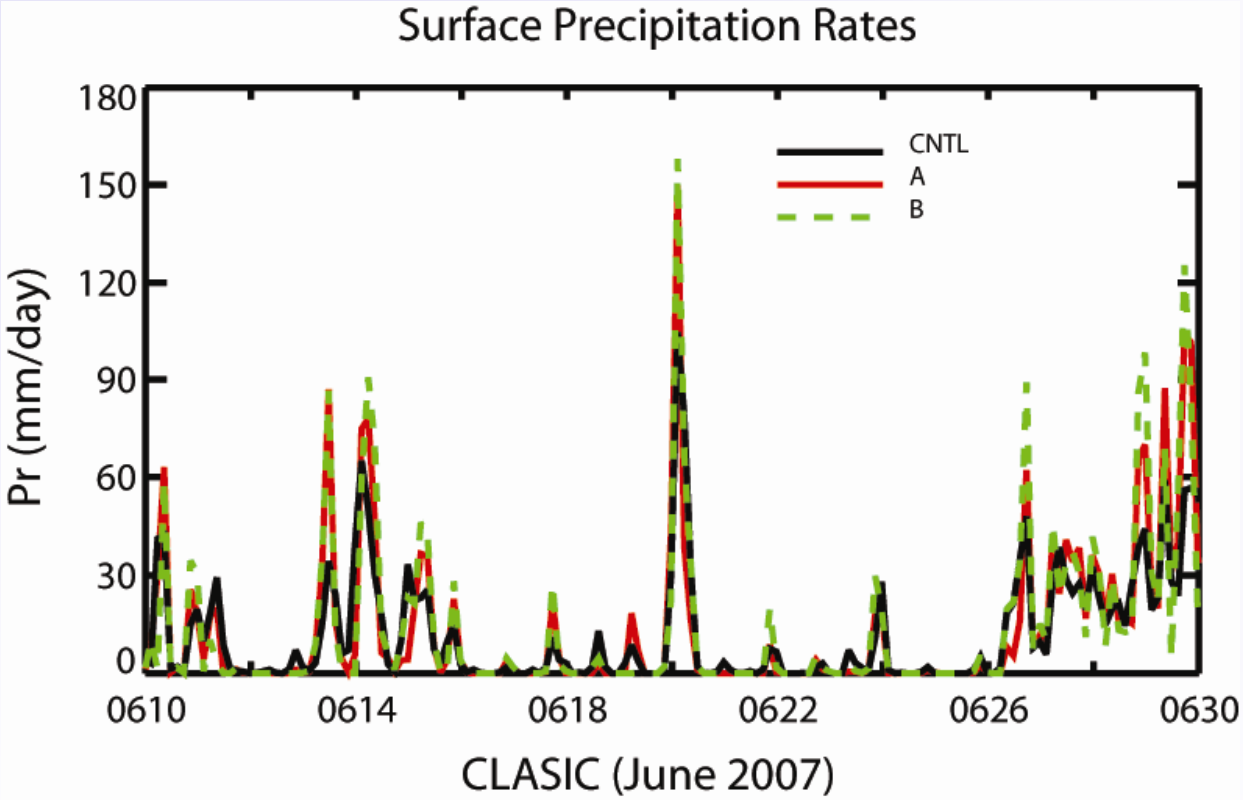


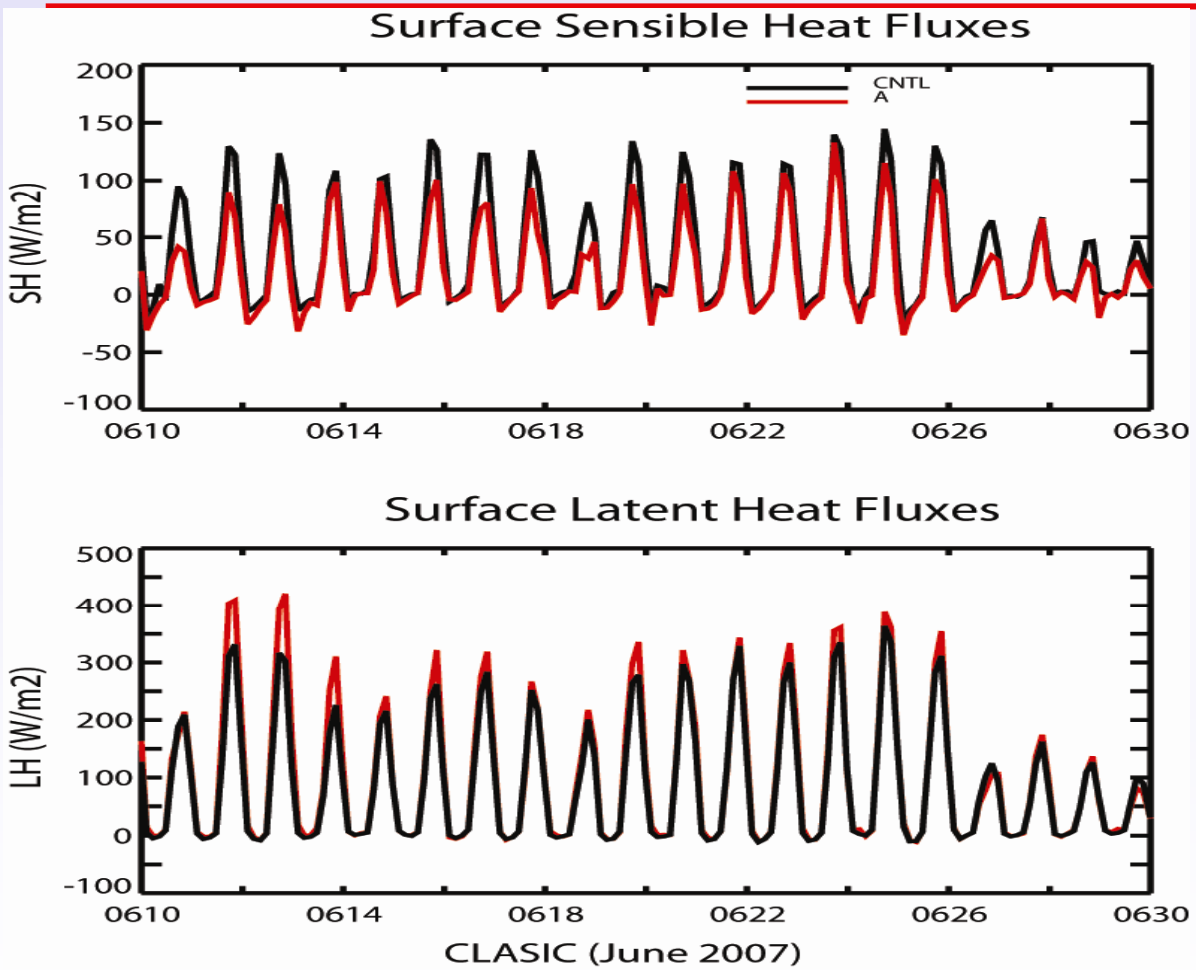
- ***Smaller domain shows stronger surface precipitation***

CNTL : Original domain

A: Domain A

B: Domain B

Mean Heat Fluxes

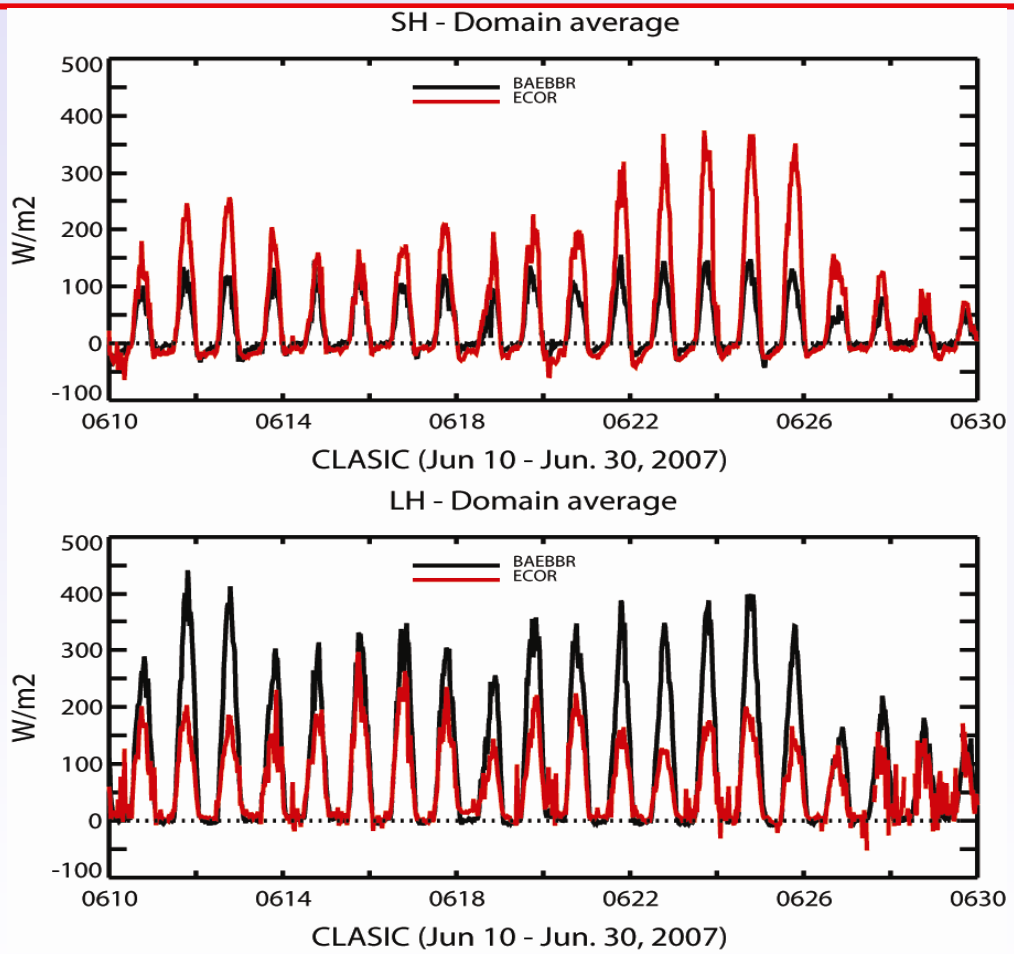


CNTL : Original domain

A: Domain A

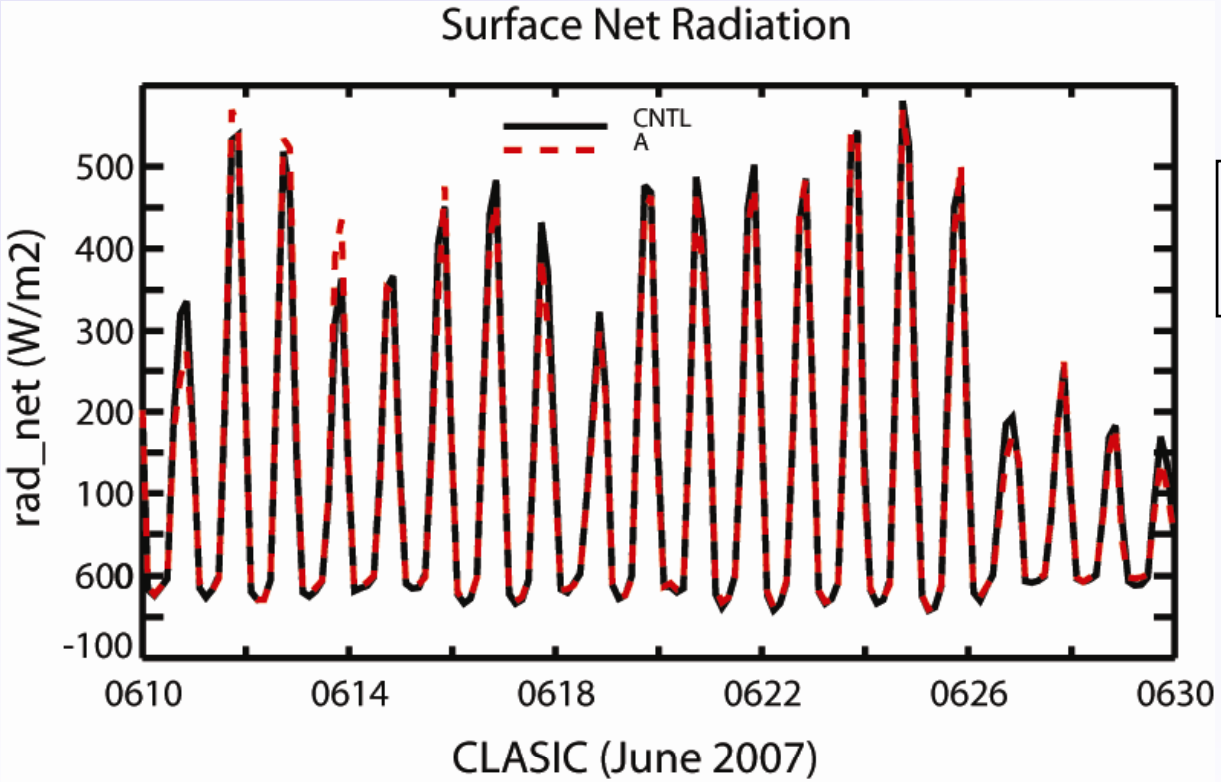
- ***The differences are mainly due to the elimination of the ECOR stations (see next slide for more information)***

EBBR vs. ECOR



- ***ECOR has larger SH and smaller LH than EBBR***

Mean Surface Radiation



- ***Minor impact on surface radiation fluxes***

CNTL : Original domain

A: Domain A

Variational Analysis

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- ***Three runs over the ARM CLASIC IOP:***

  CNTL: original domain

  A: domain A (2x2 degree)

  B: domain B (1.5x1.5 degree)

- ***Upper air data from RUC analyses***
- ***Surface and TOA constraints are averaged over corresponding domains***

Derived Large-Scale Forcing Field

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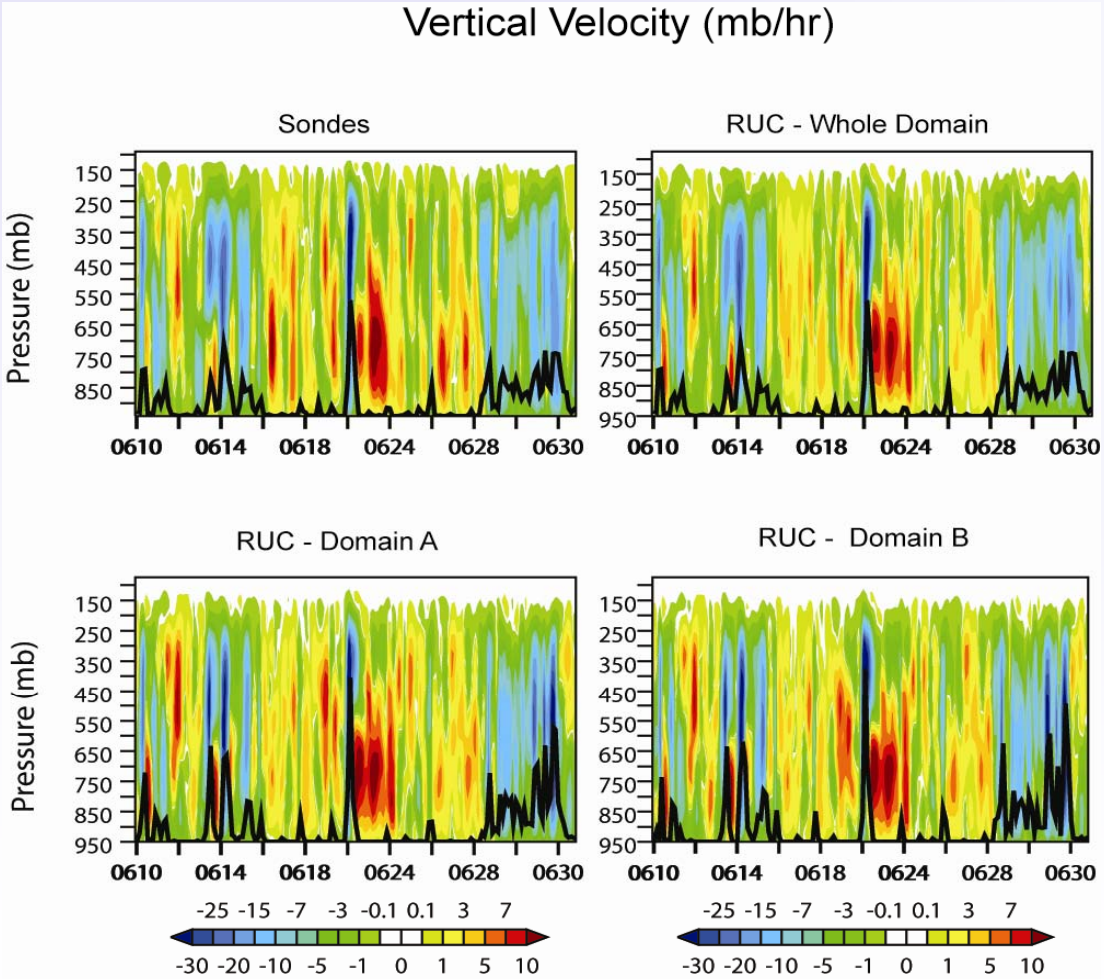

- ***Analysis is stable***
- ***Forcing strength just responds to the new surface and TOA constraints, especially surface precipitation***

Vertical Omega Profiles Averaged over wet and dry periods

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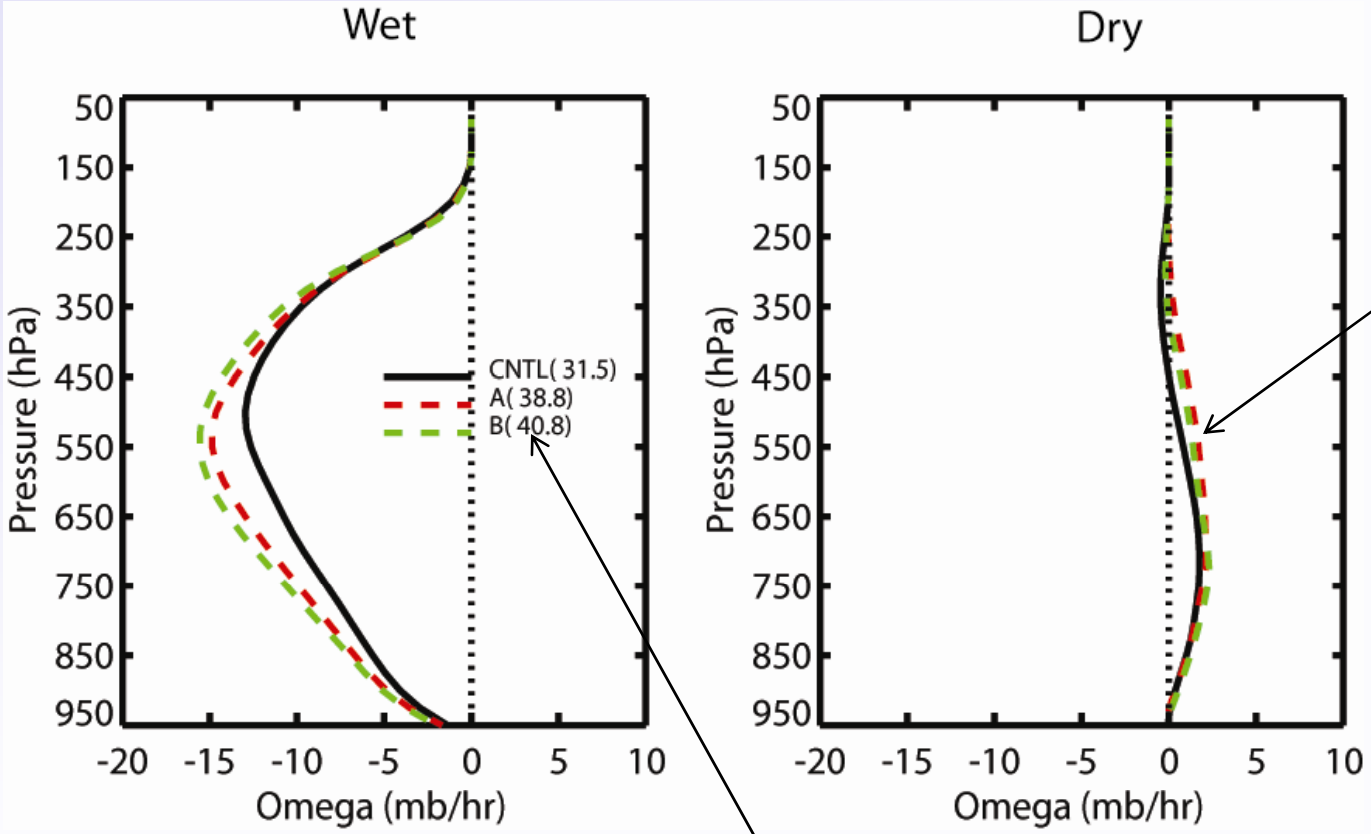
Atmospheric Radiation Measurement



Stronger subsidence for smaller domain

- ***Stronger forcing with stronger Pr***
- ***The level of maximum omega is lower for smaller domain***

Averaged surface precipitation Rates (mm/day)

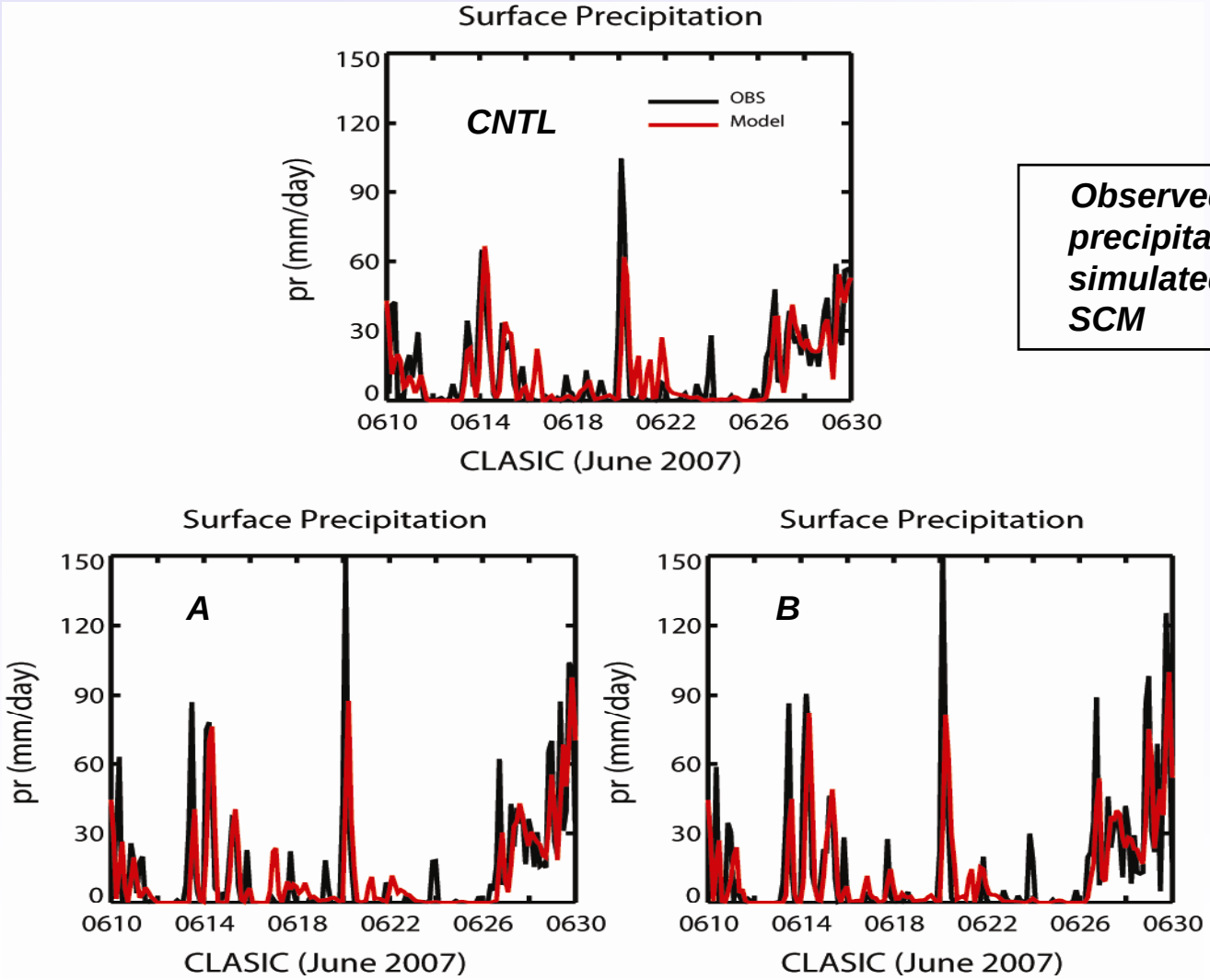
SCM/CRM Tests

Atmospheric Radiation Measurement

- ***NCAR CAM3 SCM (Shaocheng Xie)***
- ***ISU CRM (Xiaoqing Wu)***

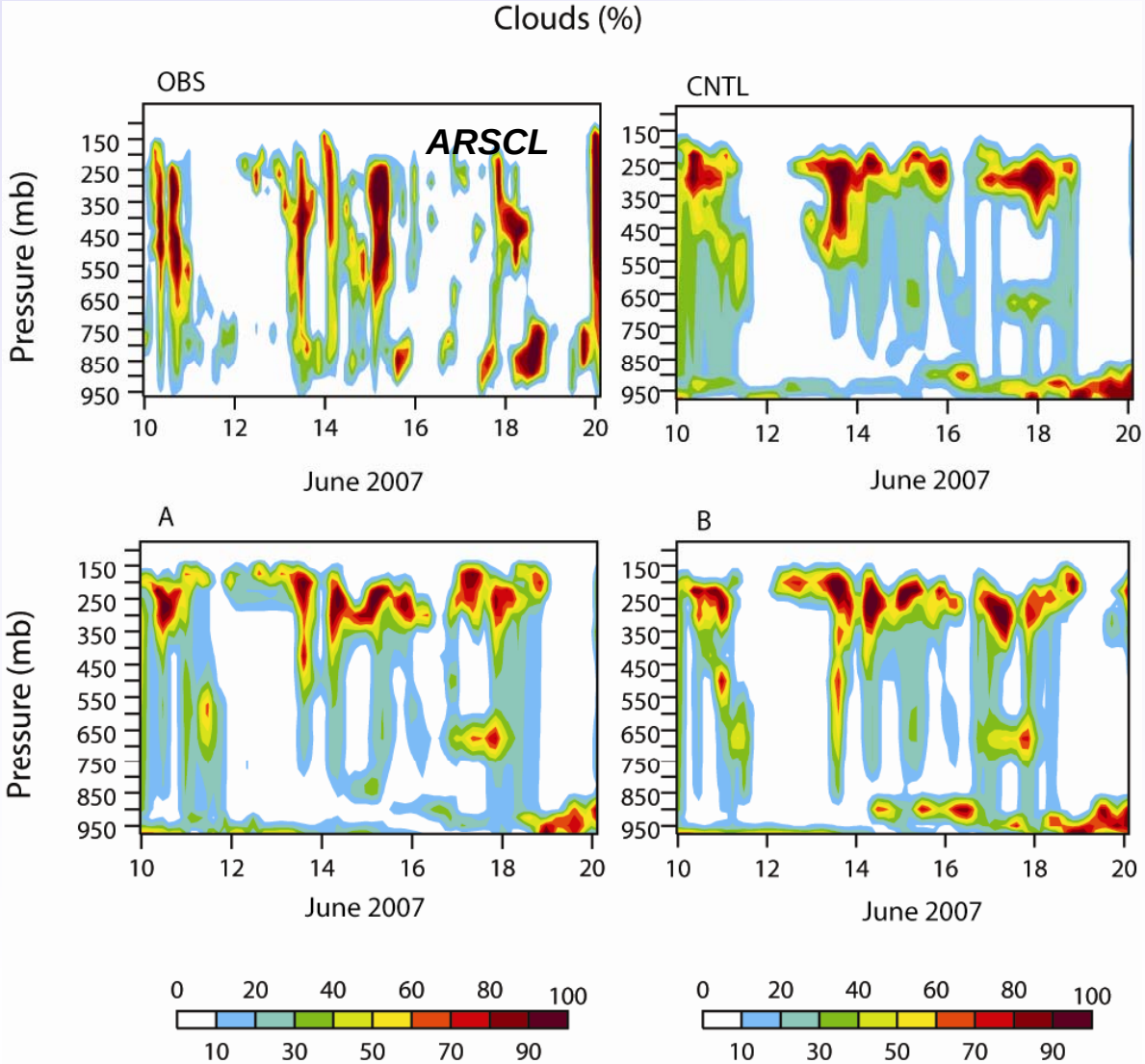
SCM responds well to the smaller scale forcings

Atmospheric Radiation Measurement



Observed surface precipitation rates are well simulated by the NCAR SCM

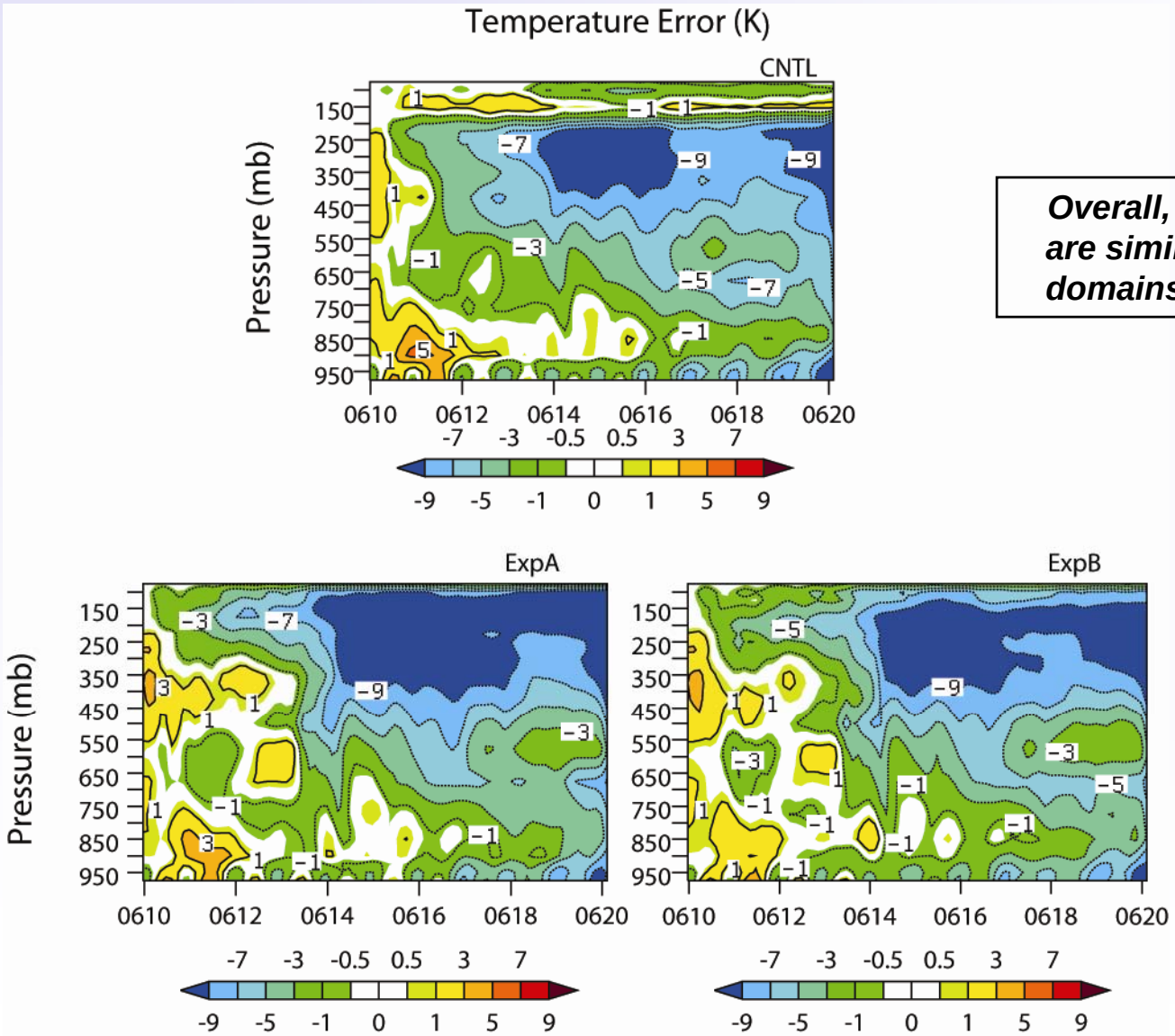
Simulated Clouds



Smaller domain helps capture better the temporal variability and low-middle level clouds observed at CF

Temperature Errors

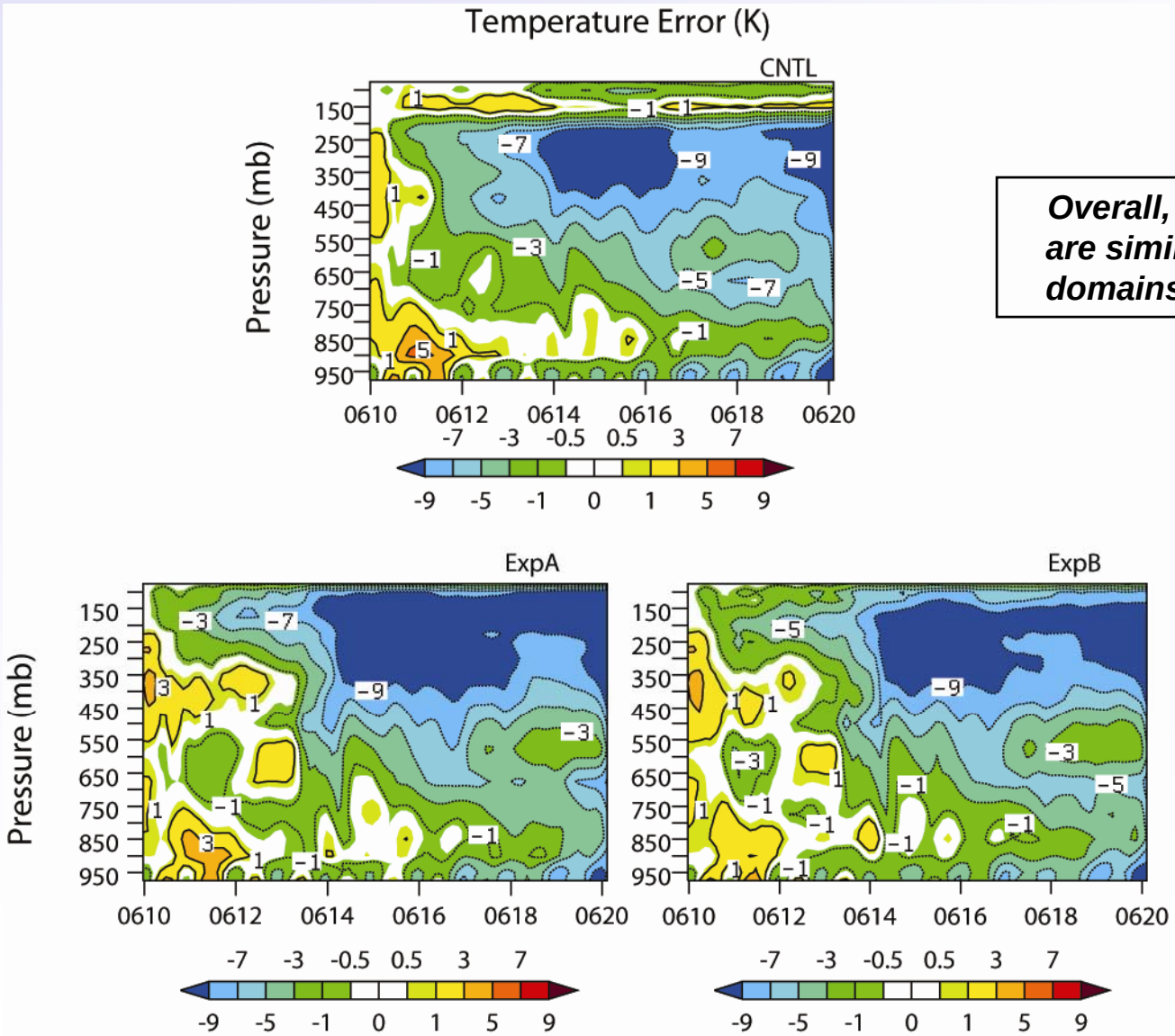
Atmospheric Radiation Measurement



Overall, model errors are similar for the three domains

Temperature Errors

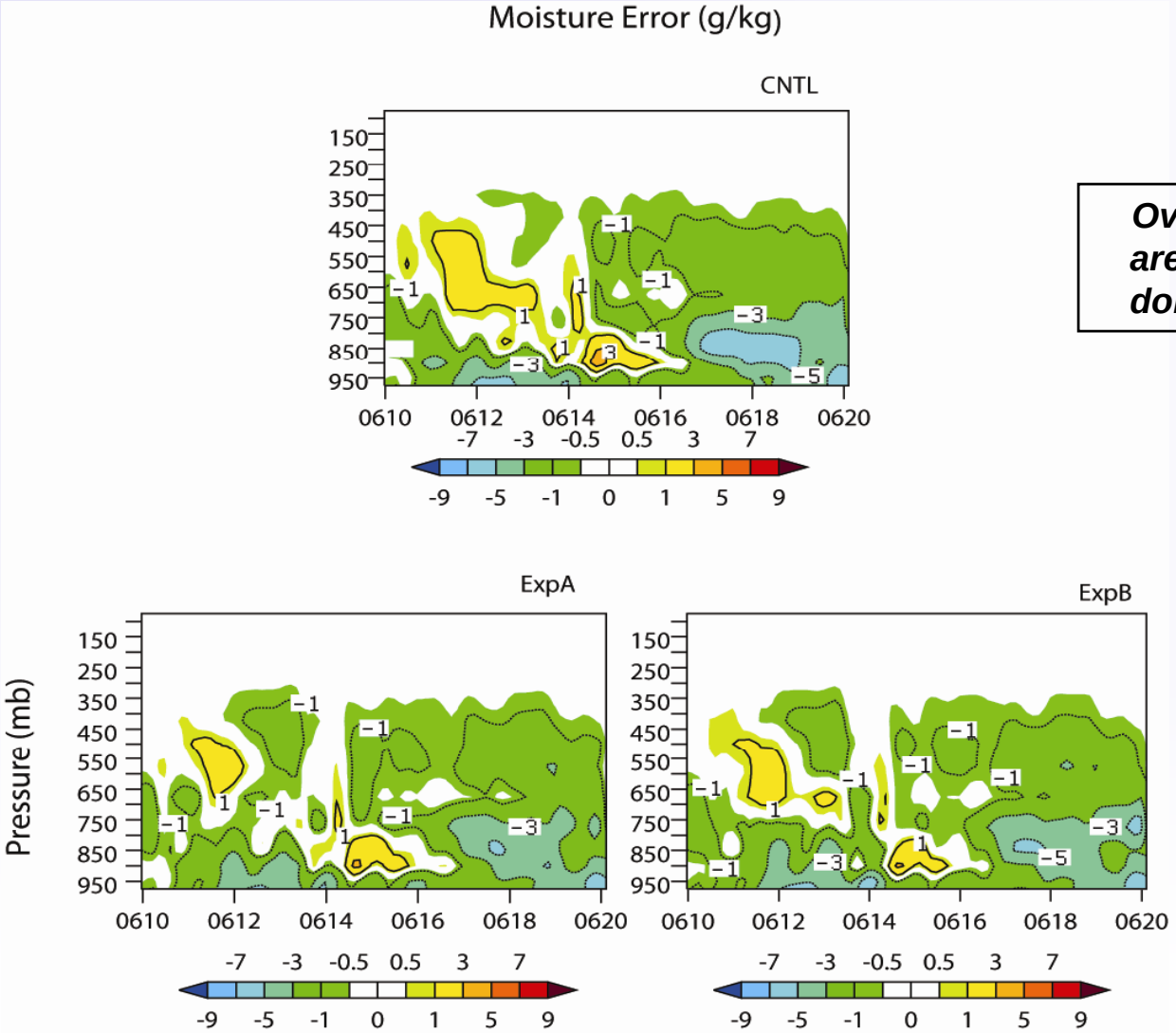
Atmospheric Radiation Measurement



Overall, model errors are similar for the three domains

Moisture Errors

Atmospheric Radiation Measurement

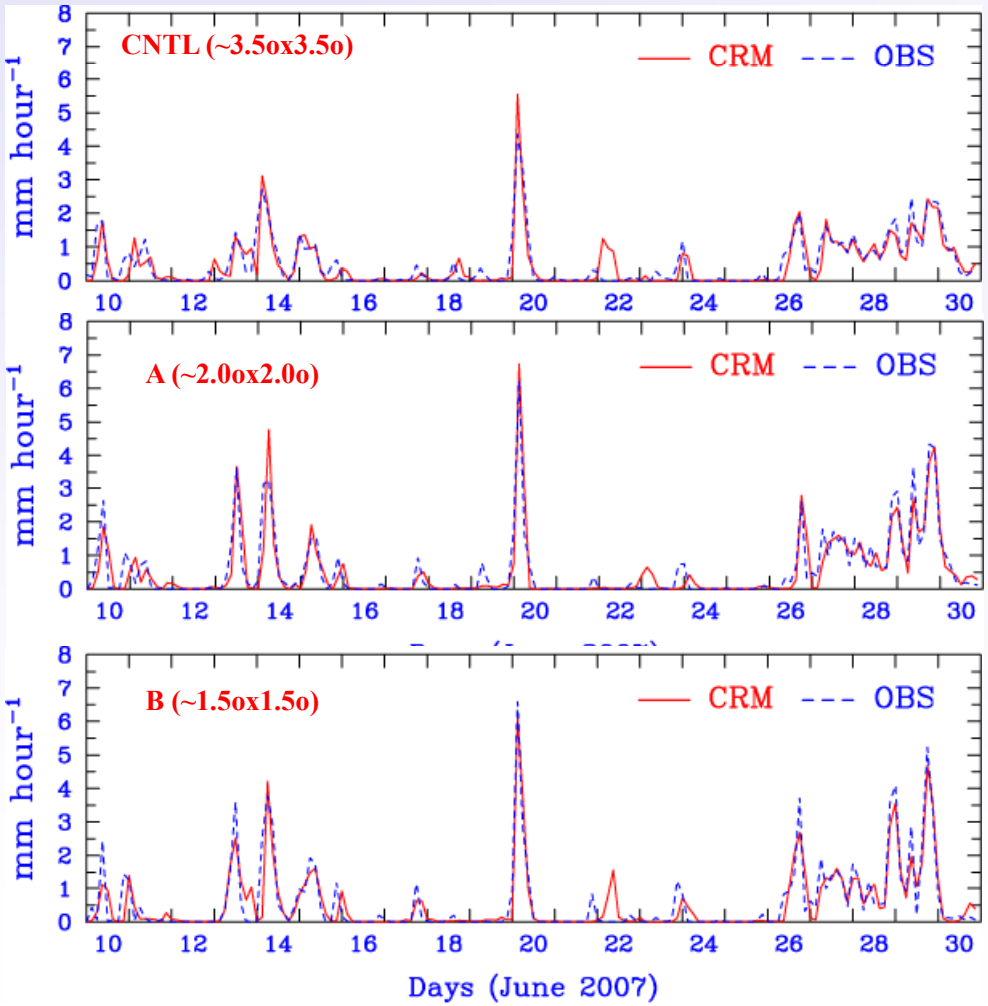


Overall, model errors are similar for the three domains

Small domain is not an issue for ISU CRM

Atmospheric Radiation Measurement

3-hourly precipitation



Observed surface precipitation rates are well simulated

(*Courtesy of Xiaoqing Wu*)

T, q biases are slightly larger with smaller domain forcing

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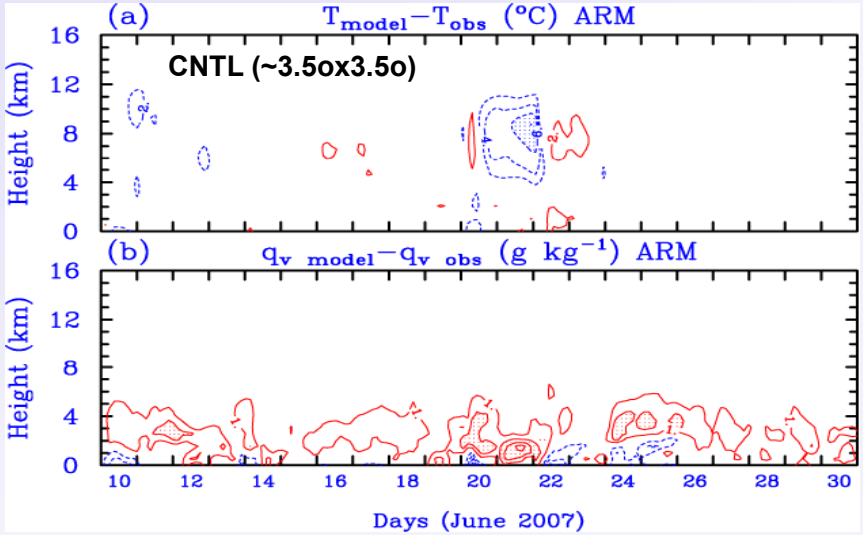
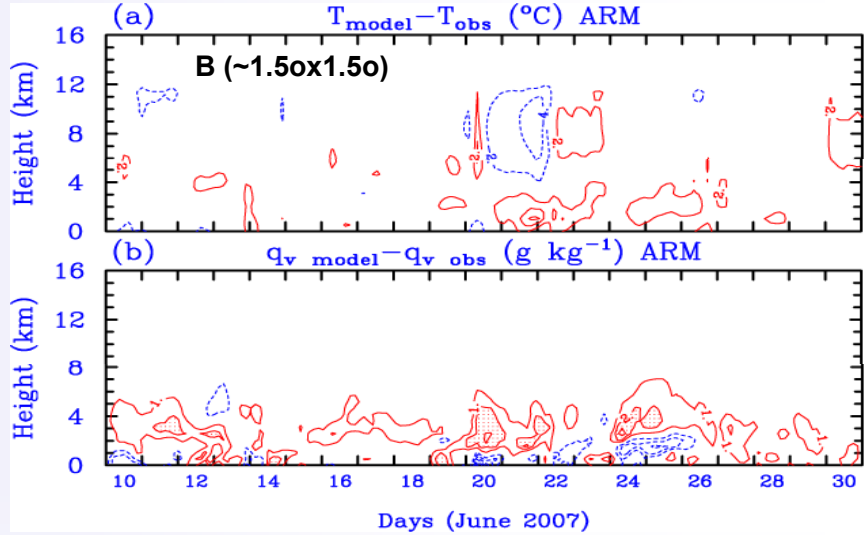
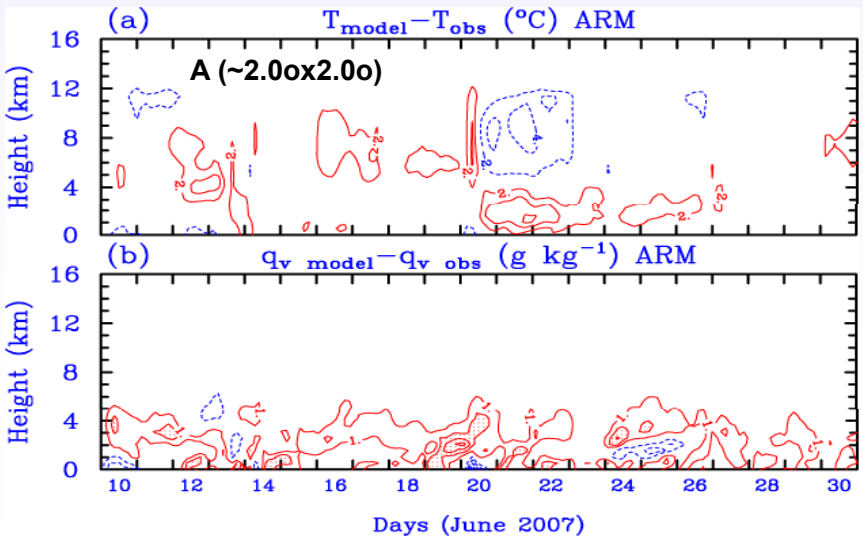
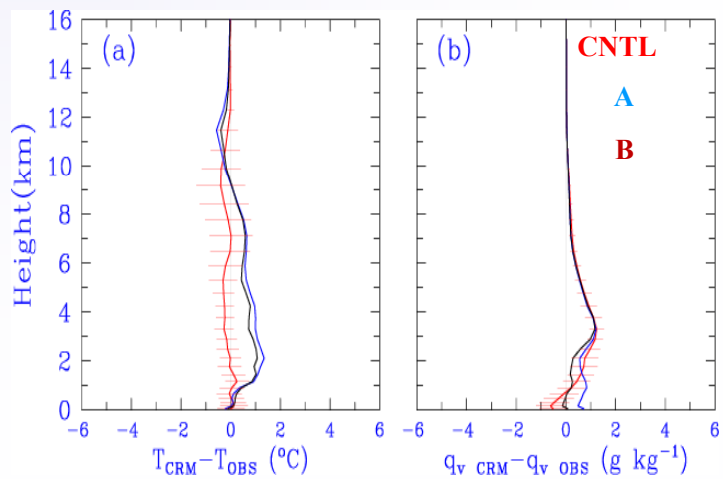
Atmospheric Radiation Measurement







21-day mean T and q biases



(*Courtesy of Xiaoqing Wu*)

Summary

Atmospheric Radiation Measurement

A reduced 2x2 (or 1.5x1.5) degree domain is comparable to a typical GCM grid box used in current climate models. Impact on the variational analysis is small and SCM/CRM respond well to the smaller scale forcing for both revised domains.

Pros:

- ***Save money for ARM***
- ***Better resolve the subgrid scale variability in clouds and other important atmospheric fields with potentially denser network if the outside EFs are moved into the smaller domain***
- ***Have the potential to get 3-d clouds***
- ***Improve the comparison between models and data observed at CF***
- ***Surface mesonet stations are more evenly distributed***

Cons:

- ***CASA radars and both ARM and NOAA wind profilers are outside the revised domain ~ could be a loss***
- ***Eliminate most ECOR stations (except for CF)***

Summary

Atmospheric Radiation Measurement

Suggestions:

- ***Prefer Domain B (1.5x1.5) ~ smaller than domain A (2.0x2.0) but larger enough for SCMs and CRMs.***
- ***Keep the 6 EFs and CF within the reduced domain unchanged so that we can maintain long-term consistent measurements at those stations***
- ***Move those outside EFs into the reduced network to increase the density of surface stations, especially for those stations equipped with the ECOR system***
- ***Move CASA radars into the new domain if ARM is going to maintain the CASA radars***
- ***Move ARM wind profilers***
- ***NOAA wind profilers? – the data has been used in the variational analysis so missing the NOAA wind profilers could be a loss, but this can be probably tolerated based on the test results from this study and using interpolated wind profiler data.***

Questions and Comments?