High resolution ***Global*** atmospheric modeling.

Plans?
Questions?

Discussions and/or Assistance

NCAR/CGD/AMP Group ….

NASA GSFC: Myong-In Lee, Max Suarez, Wei-Kuo Tao

High resolution ***Global*** atmospheric modeling.

Plans?
Questions?

Discussions and/or Assistance

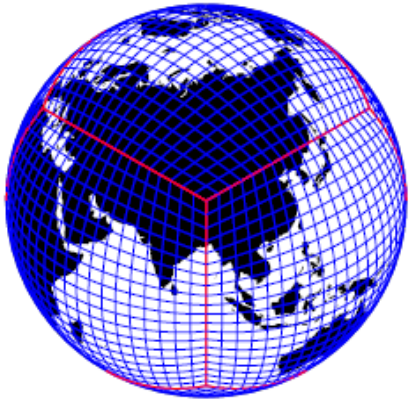
NCAR/CGD/AMP Group ….

NASA GSFC: Myong-In Lee, Max Suarez, Wei-Kuo Tao

Δx ~ 10 to 50 km

Lat-lon grid

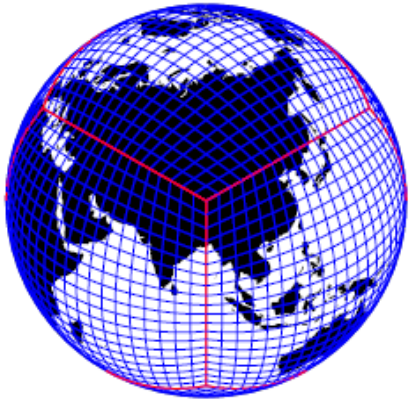
- CAM-HOMME (High-Order Method Modeling Environment, Thomas and Loft 2005):
  - Based on local spectral element method
  - For each element: Mass-conservative to machine precision and total energy conservative to the truncation error of the time integration scheme
  - Discretized on cubed-sphere
  - Highly scalable!
  - Currently being tested in 'AMIP mode' (Contact Mark Taylor for details).



Lat-lon grid

Filters needed to preserve stability at poles interfere with scalability

- CAM-HOMME (High-Order Method Modeling Environment, Thomas and Loft 2005):
  - Based on local spectral element method
  - For each element: Mass-conservative to machine precision and total energy conservative to the truncation error of the time integration scheme
  - Discretized on cubed-sphere
  - Highly scalable!
  - Currently being tested in 'AMIP mode' (Contact Mark Taylor for details).

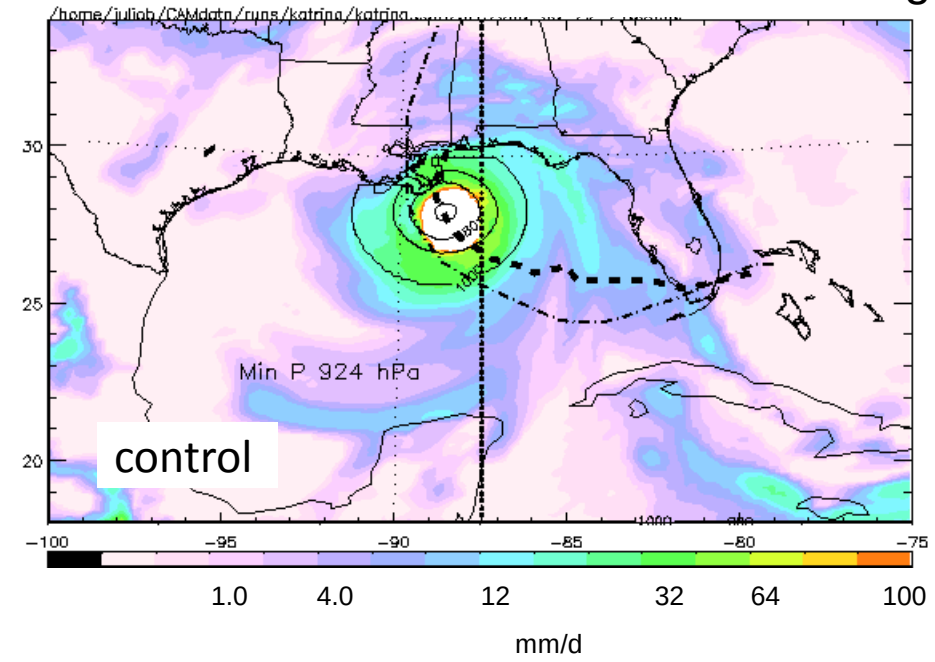


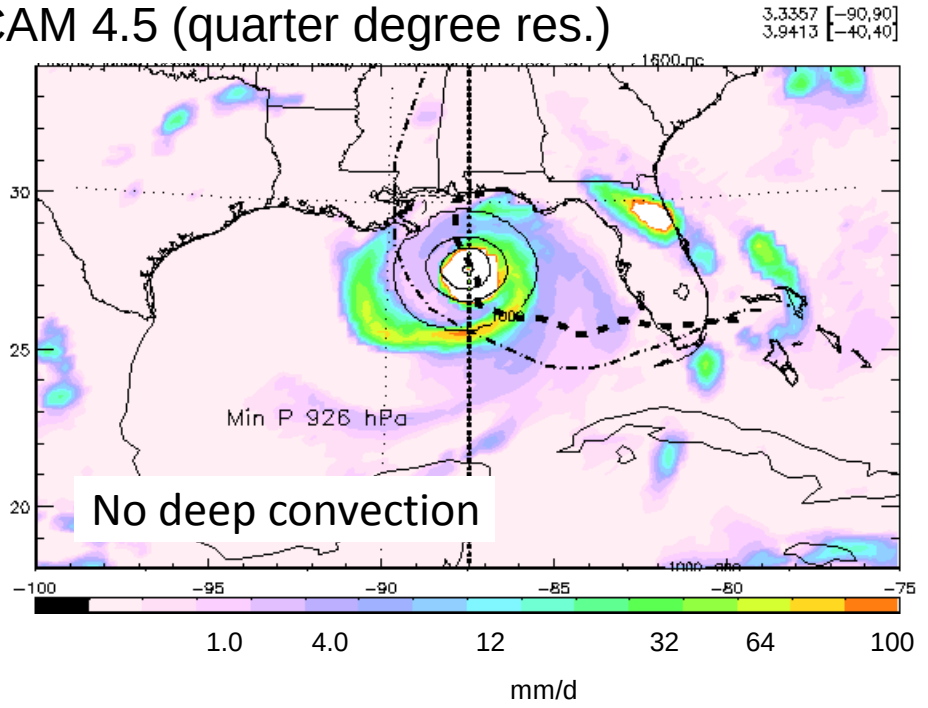
5-day Katrina forecasts using CAM 4.5 (Track 5)

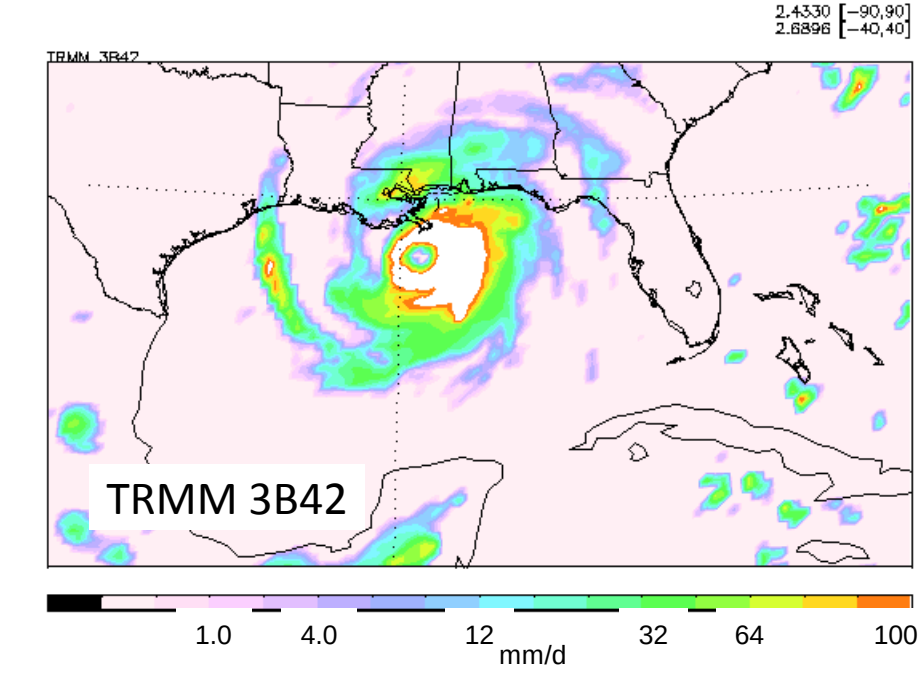
0.23x0.28 degree resolution (“quarter degree”)

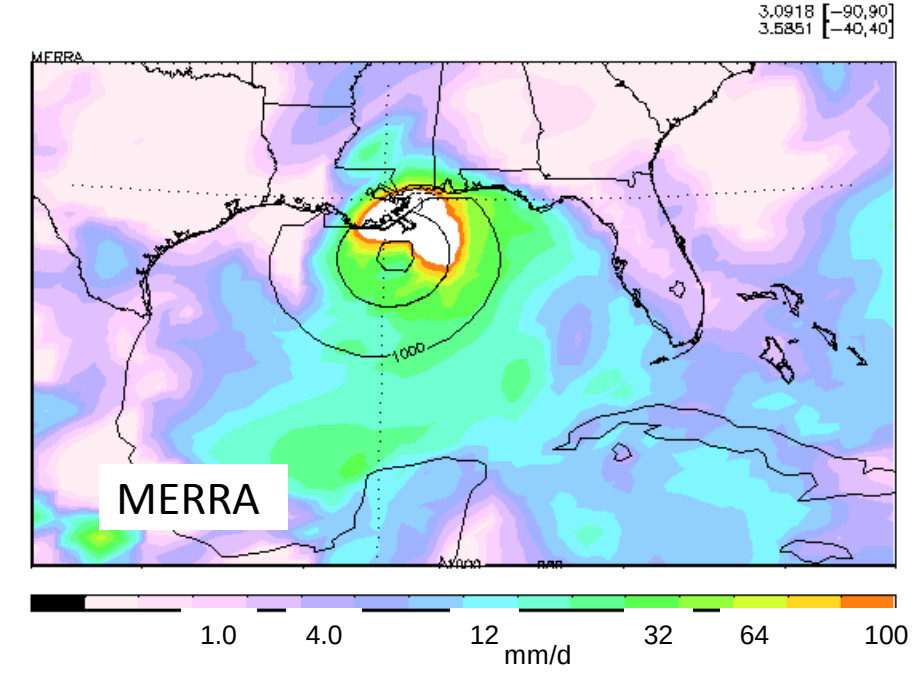
Initialize 12Z 25 Aug 2005 using MERRA reanalyses

96 hour forecasts using CAM 4.5 (quarter degree res.)

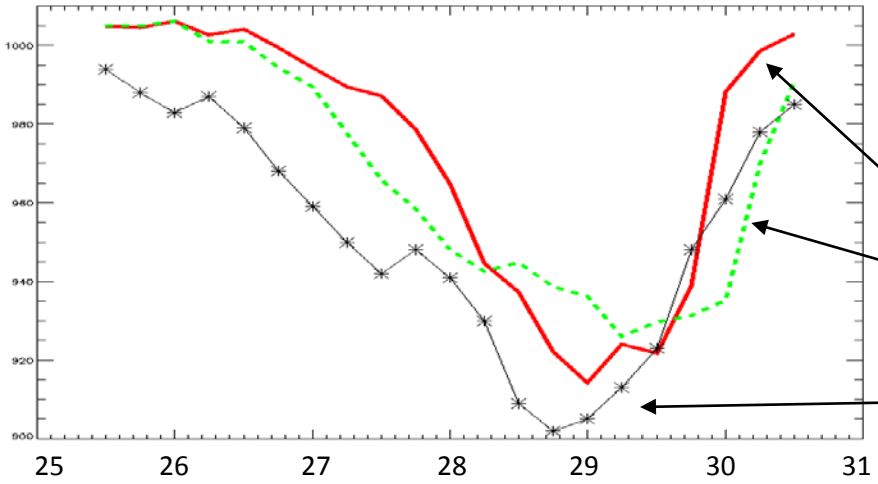








Minimum Surface Pressure



control

No Deep Conv

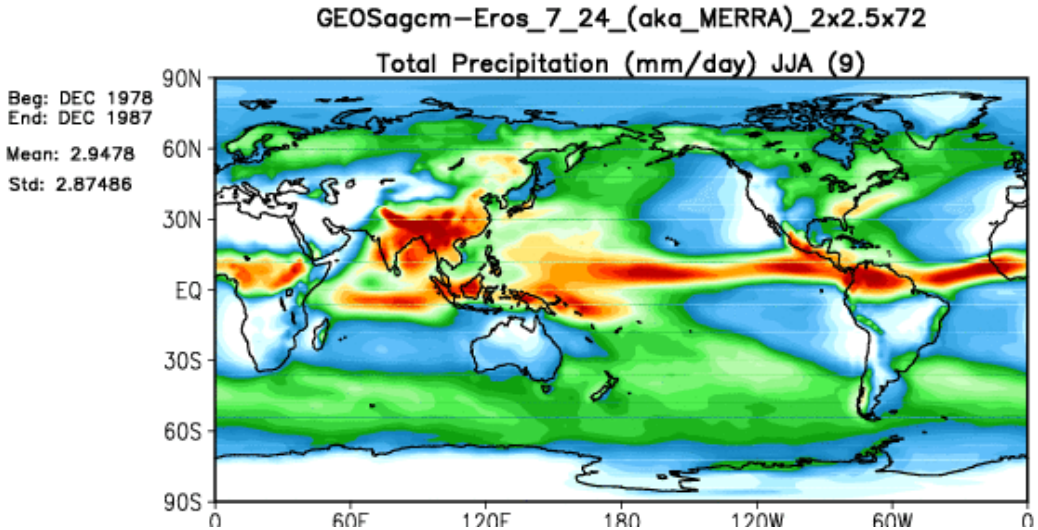
Hurricane Center Analysis

Day of Aug 2005

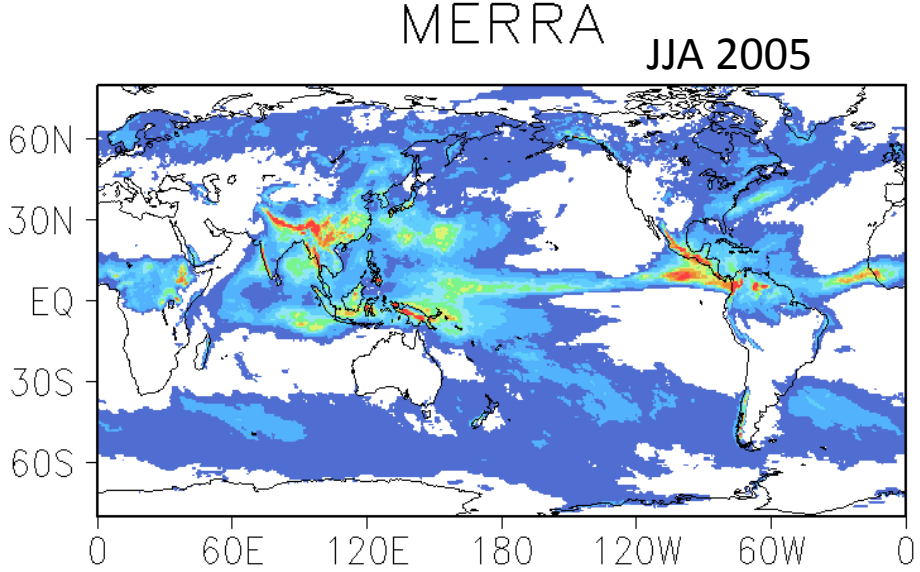
Short term NWP clearly improves with higher resolution

Mesoscale organization begins to show up in some situations

Resolution is not a Panacea



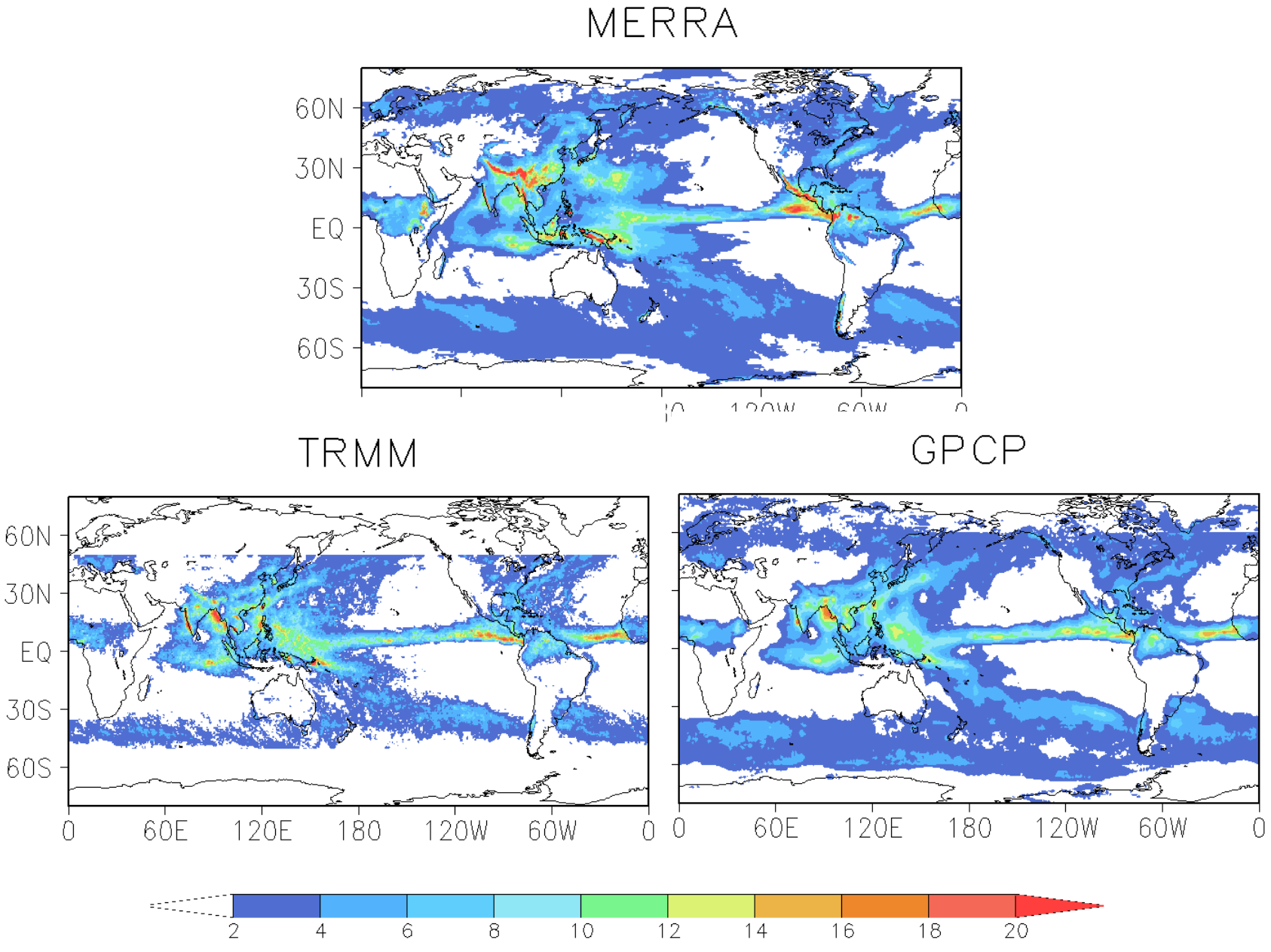
2.5x2.0

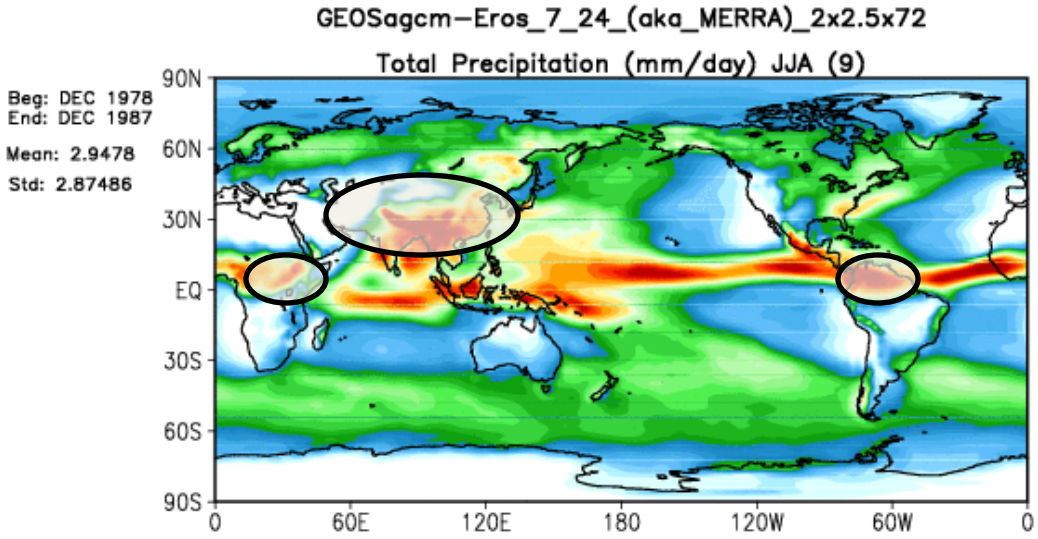


0.33x0.25

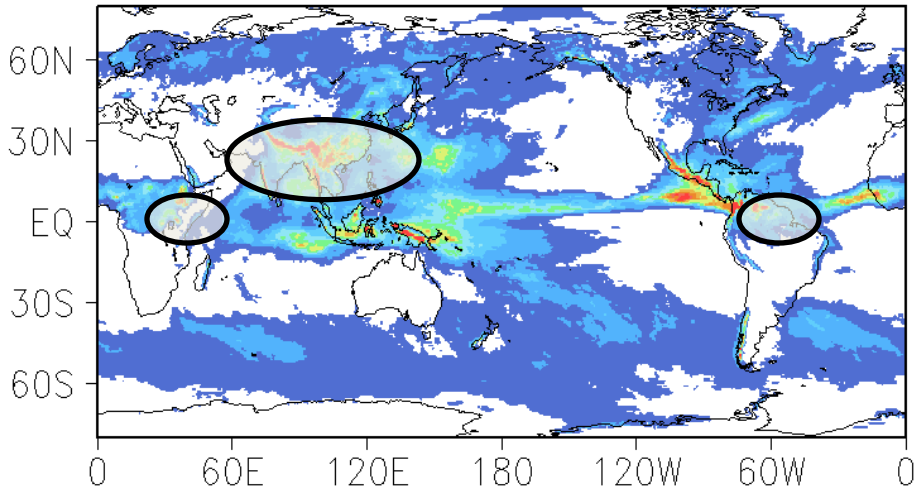
8 fold increase in resolution!!

Time-Mean Precipitation (JJA 2005)

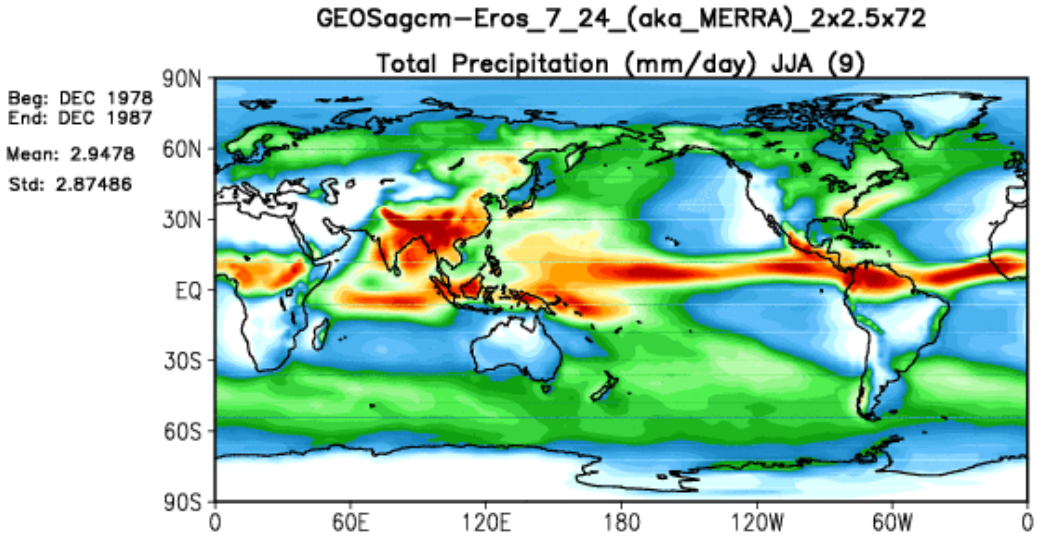




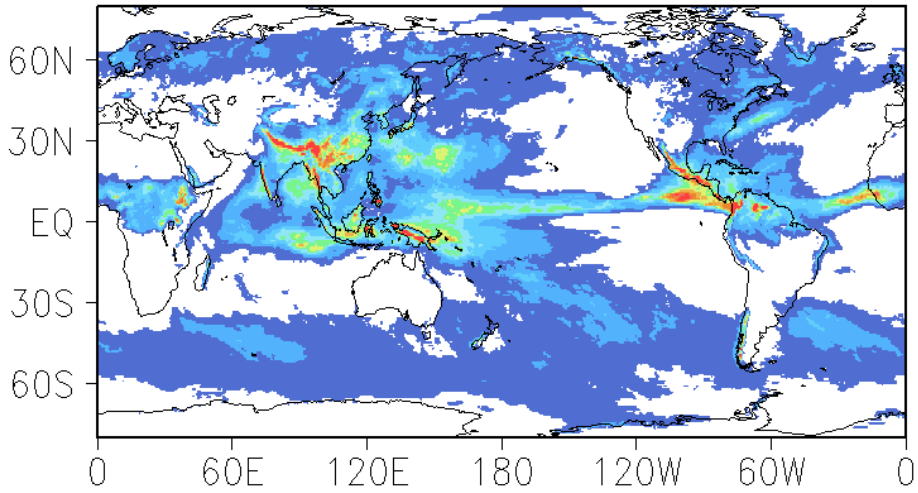
MERRA



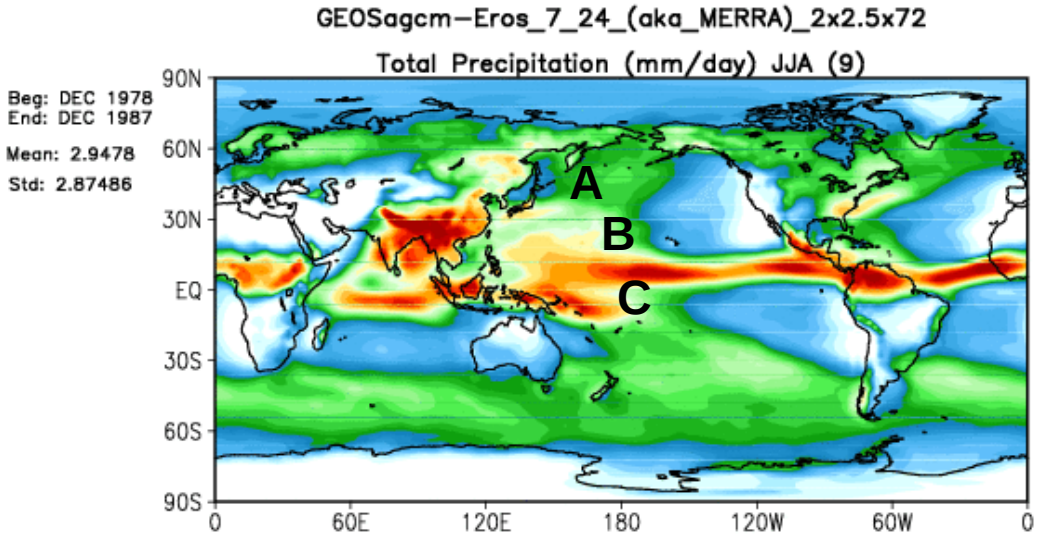
Some improvement in orographic precipitation biases. Size of large bias region is reduced but magnitude of bias is similar.



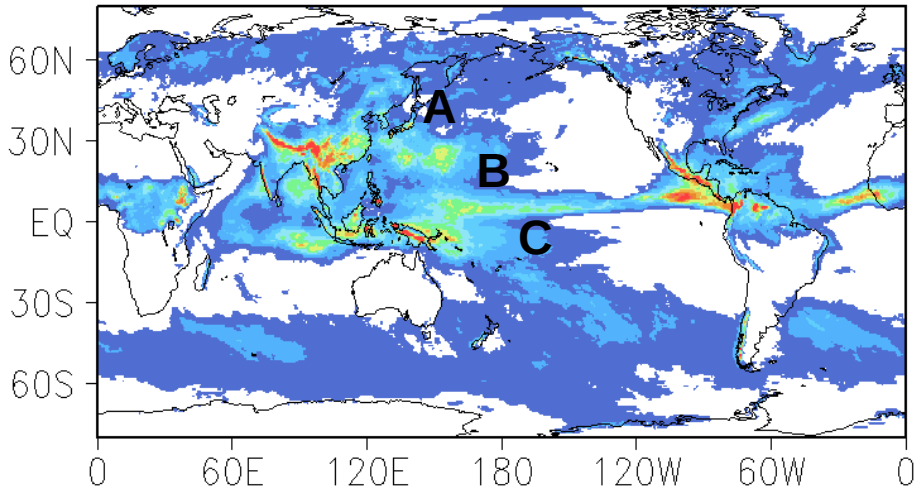
MERRA



Some improvement in orographic precipitation biases. Size of large bias region is reduced but magnitude of bias is similar.



MERRA



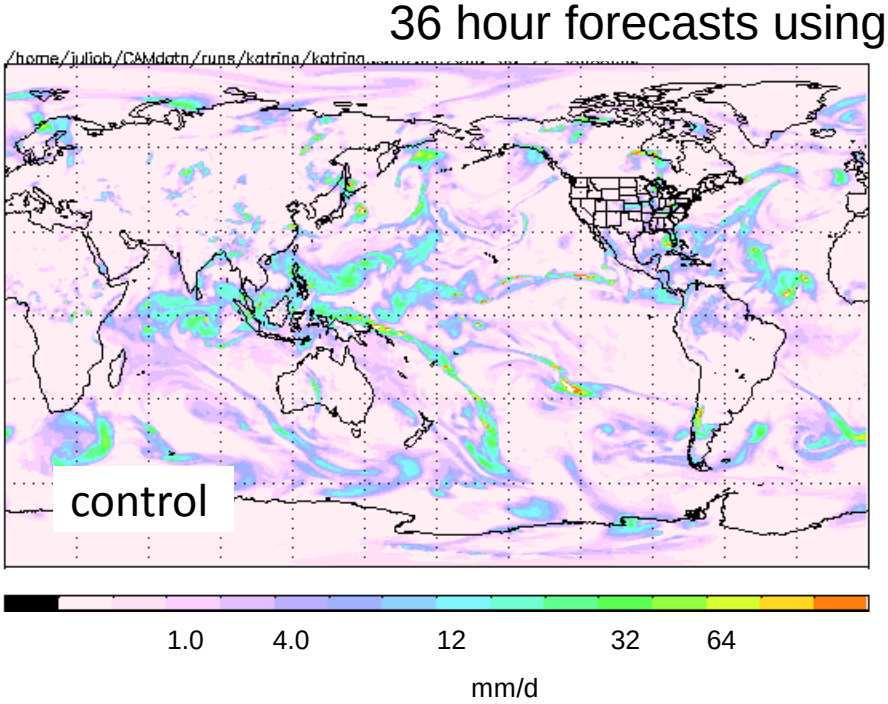
Large scale precipitation patterns across Pacific Ocean are not significantly improved by 8-fold increase in resolution.

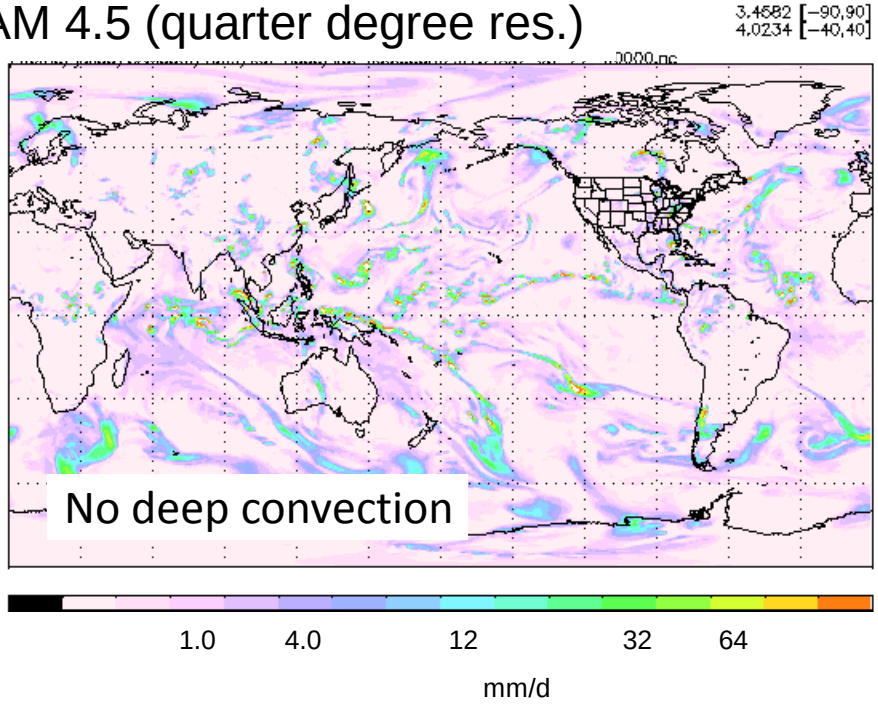
Biases are similar or worse, e.g.; **A)** weak N Pacific storm track; **B)** excessive precip west of Hawaii; **C)** excessively strong ITCZs in both hemispheres.

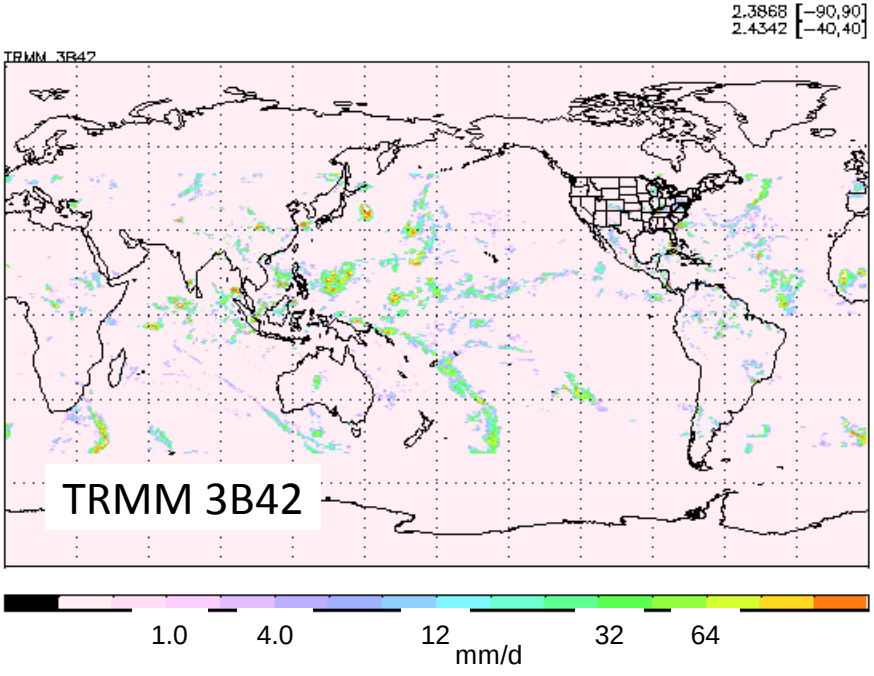
Diurnal cycle over land, MJO biases also recalcitrant

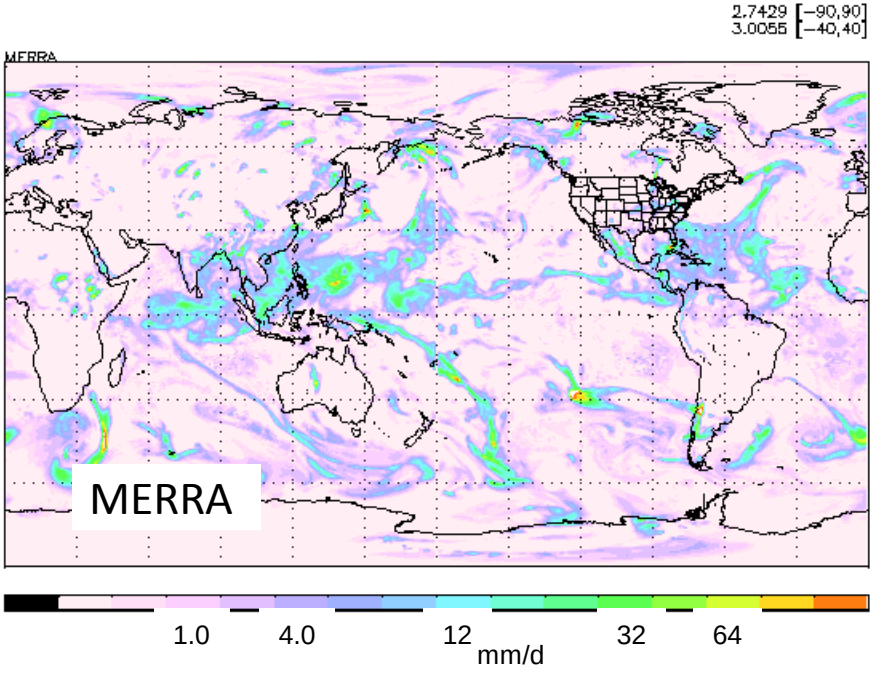
Why isn’t resolution a Panacea ??

36 hour forecasts using CAM 4.5 (quarter degree res.)

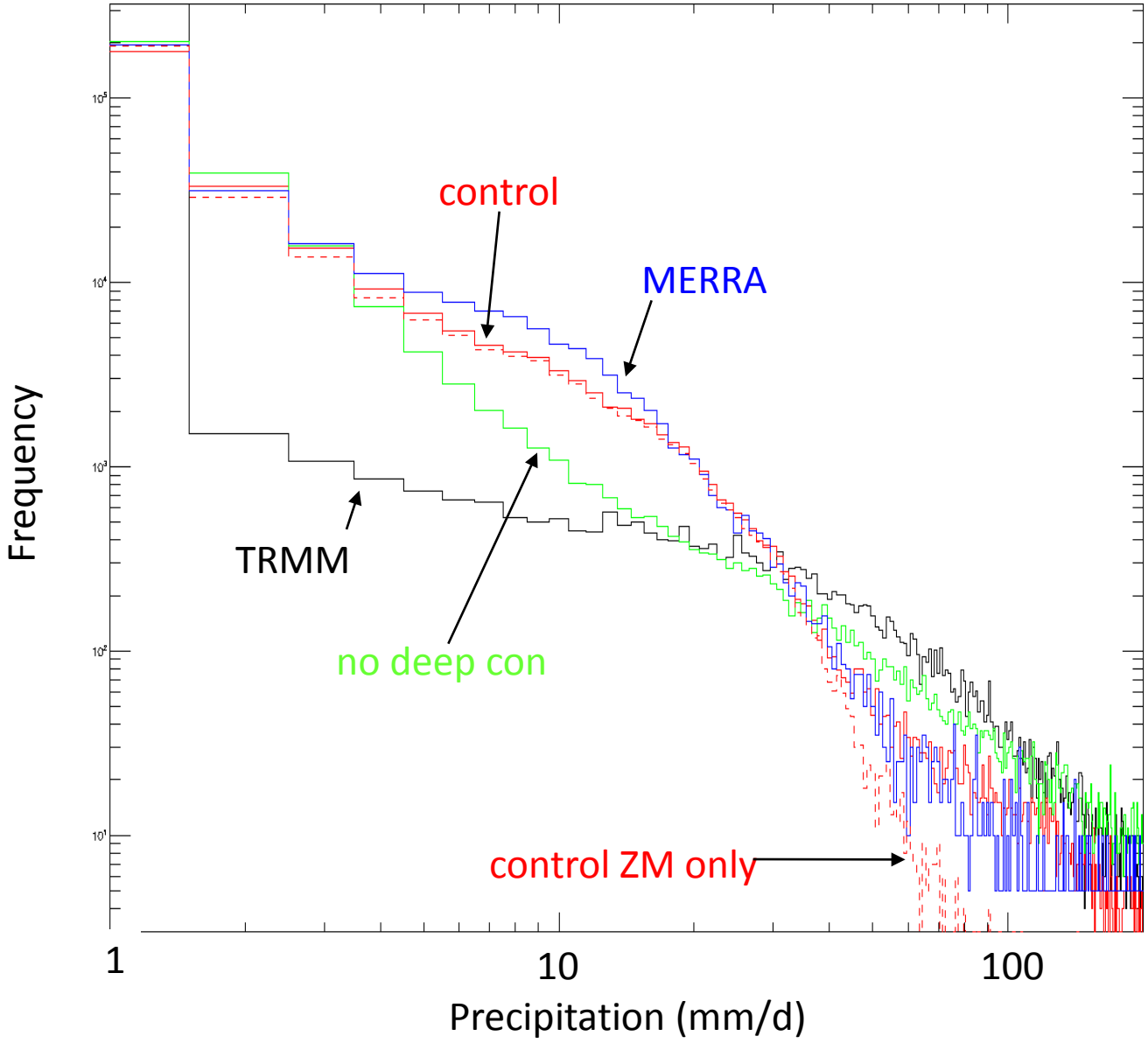








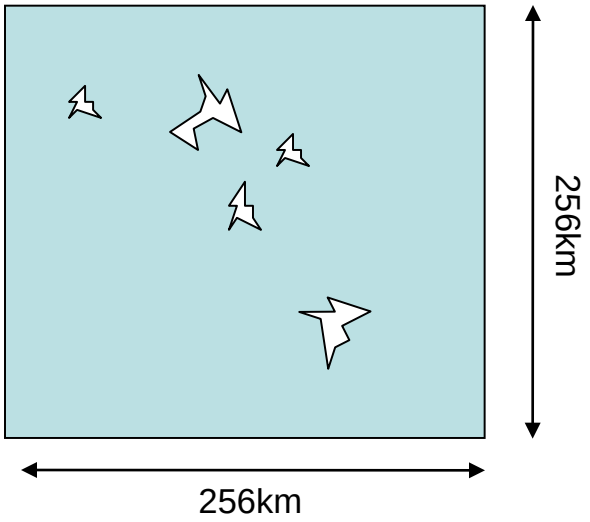
PDFs of precipitation intensity (log-log) 30S - 30N

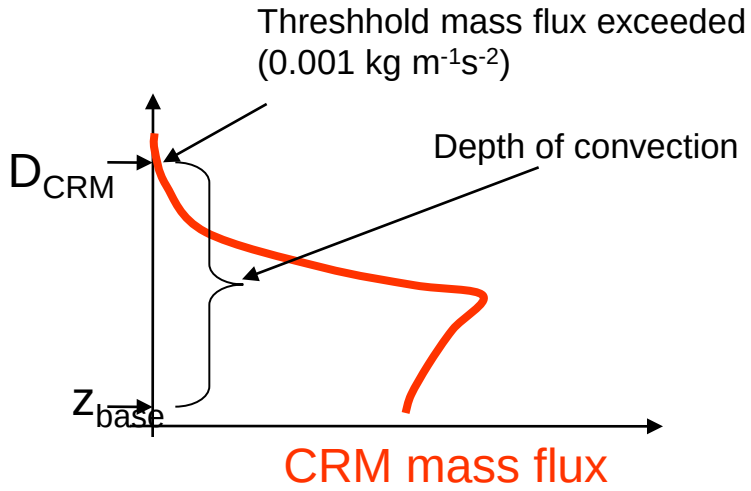


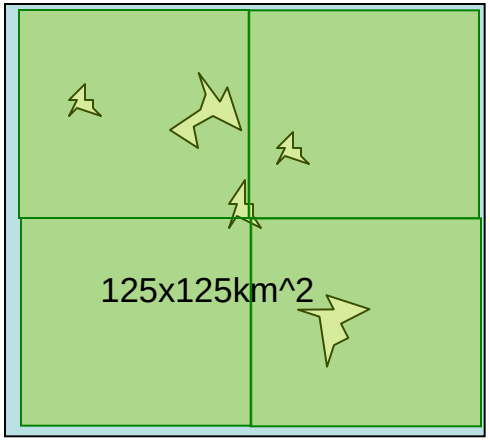
~60 days of 1km x 1km, hourly CRM simulation results (Tropical Ocean)

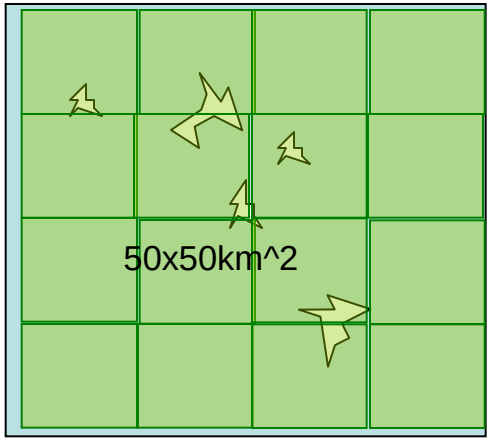
CRM domain is divided into smaller subdomains

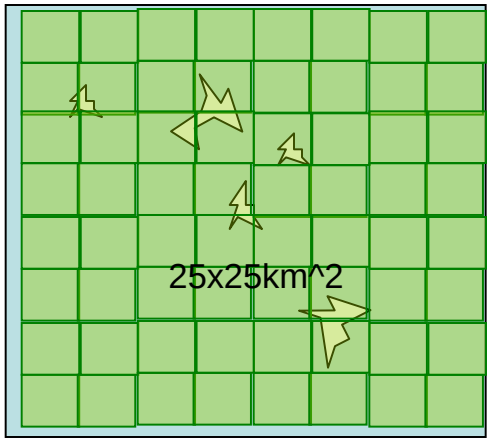
Vertical updraft mass fluxes and meteorological profiles are calculated in each subdomain for each hour



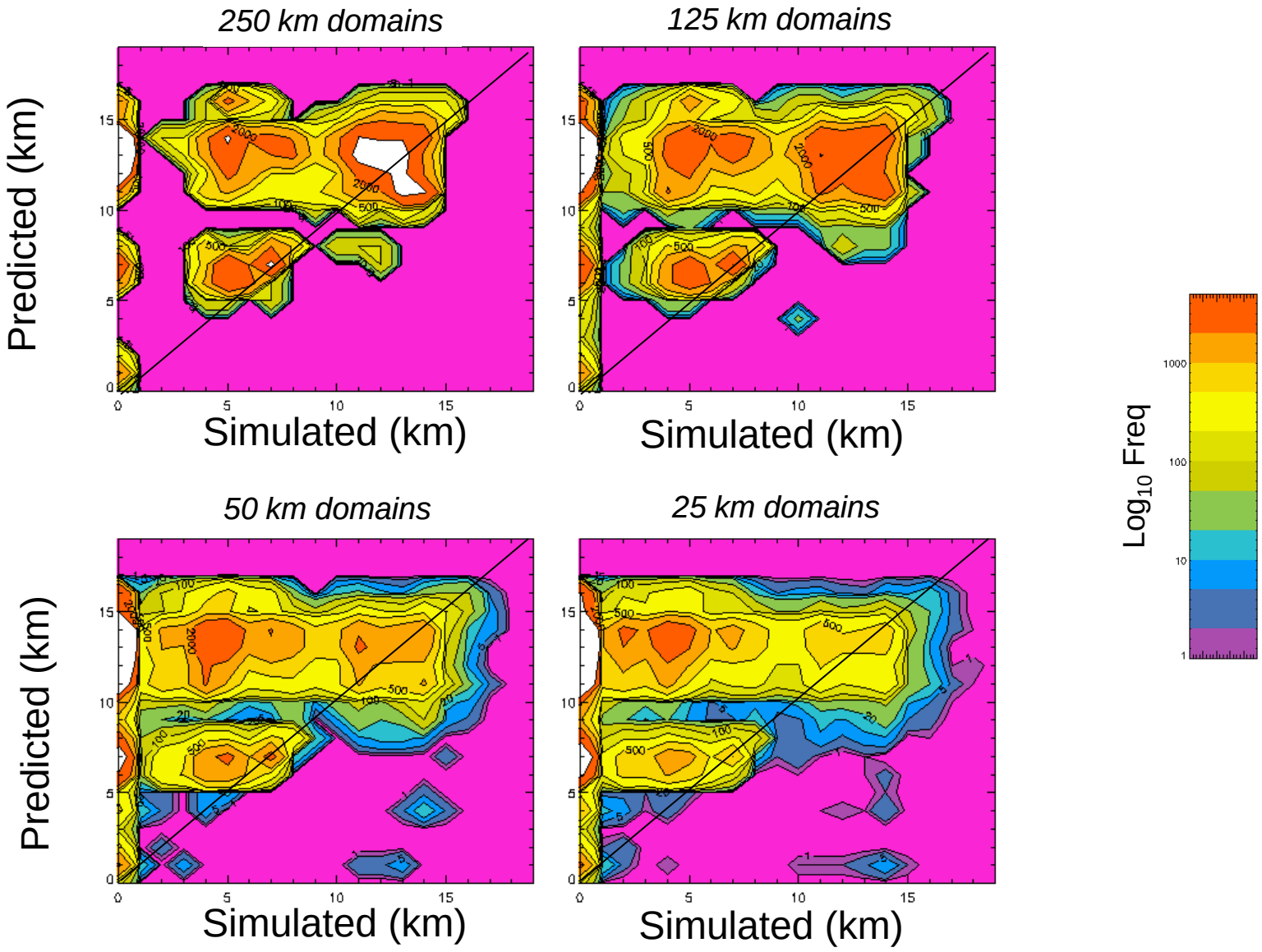




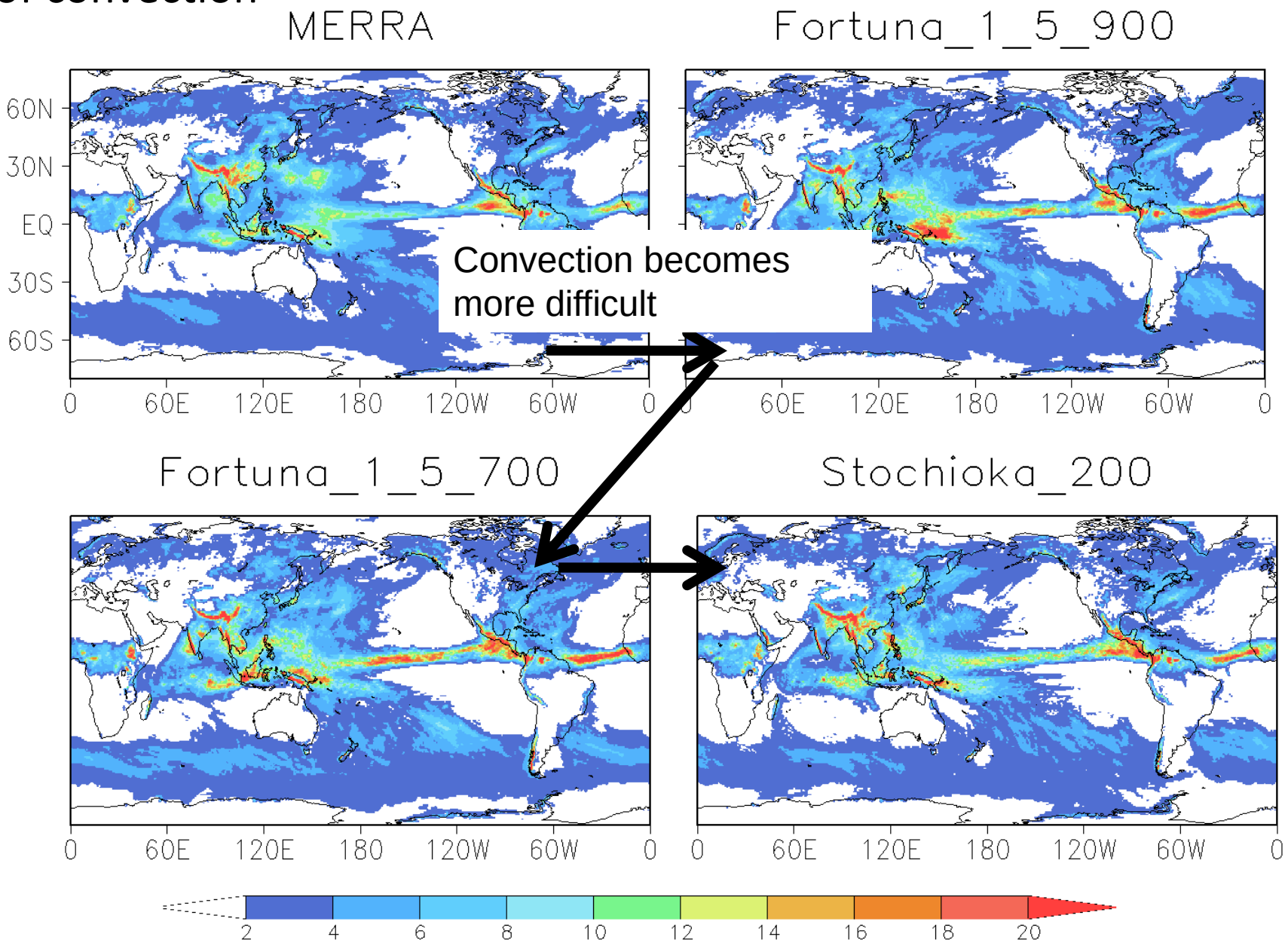




Vertical = grid-box mean **prediction** of convective cloud height
Horizontal = CRM **simulated** convective cloud height



Time-Mean Precipitation (JJA 2005). Effect of stochastic triggering of convection



First Conclusion

Benefits from increased horizontal resolution may be limited without significant modifications to convection parameterization schemes.

Tempting to conclude that some of the climate scale biases in precipitation are related to its high-frequency statistics

Options
Stochastic/other triggers applied to existing ZM/NR scheme.

Mesoscale schemes, e.g., Kain-Fritsch

Entirely new schemes: (B. Mapes, Sungsu Park, Aiguo Dai)

Sub-column generation

Use statistical description of cloud and condensate fields to synthesize subgrid-scale variability within GCM grid-boxes – *Poor man's super-parameterization*

Objective: Port CRM-style microphysics to GCM without modifications.

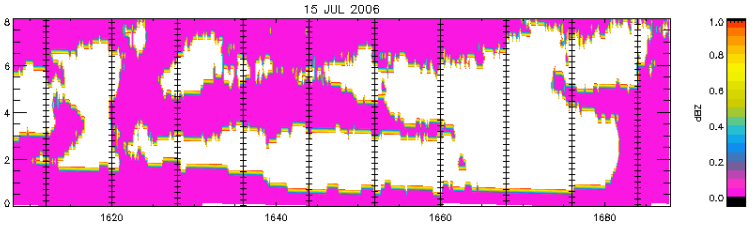
(Andrew Gettelman, Vince Larson)

Synthesized 0/1 cloud field consistent with mean fraction (50 sub-columns, max.random overlap)

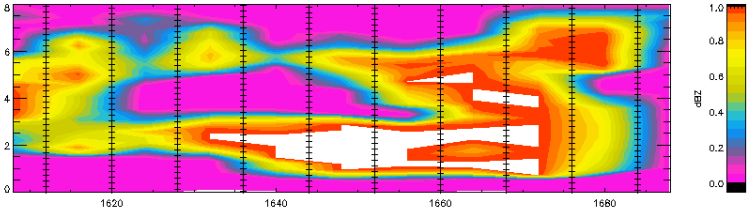
Grid mean cloud fraction

500 km

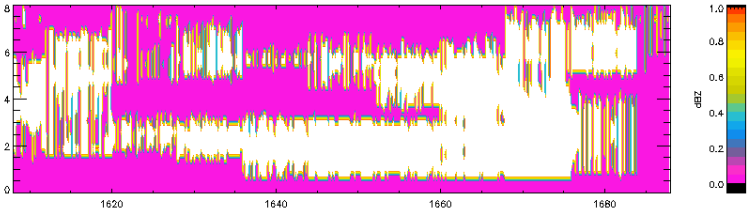
CloudSat obs
1 where > -25 dBZ
Δx=1km



50 km gridded version of above.



Synthetic cloud field at original resolution



Sub-column generation

Condensates can also be consistently sampled from some assumed PDF to generate statistically realistic sub-grid fields.

Issues

Determining PDFs (multivariate *w, q, T*)

Cost

(Andrew Gettelman, Vince Larson)

Plans

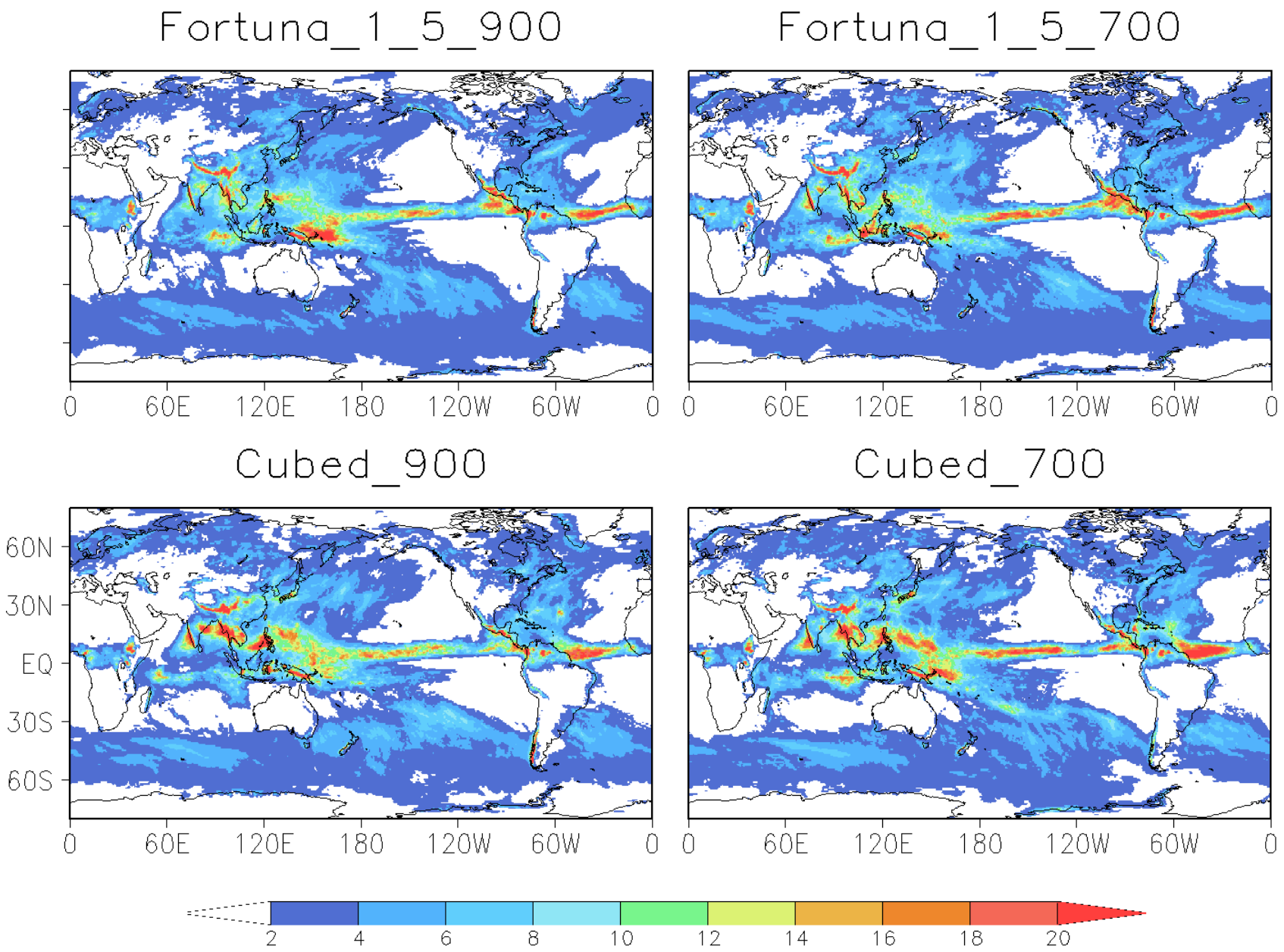
New dynamical core on grid without pole problem.

Physics??

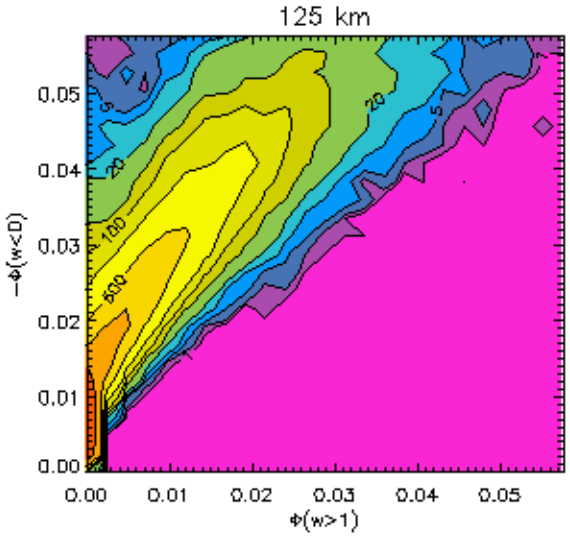
New or re-tuned convection scheme(s) need to be evaluated at high resolution

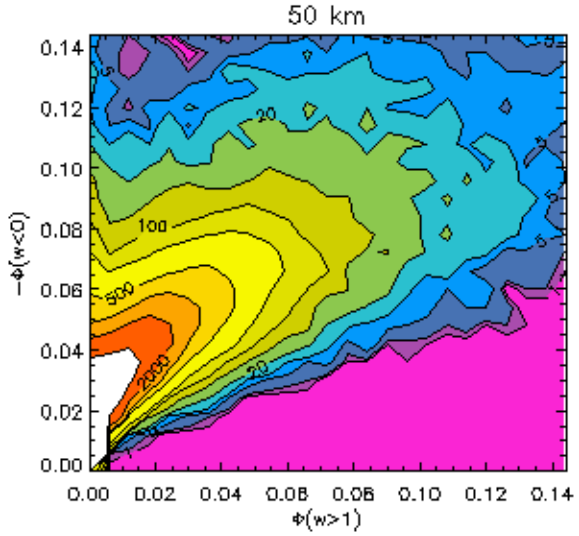
Cloud microphysics and other subgrid physics could exploit a subcolumn generation scheme

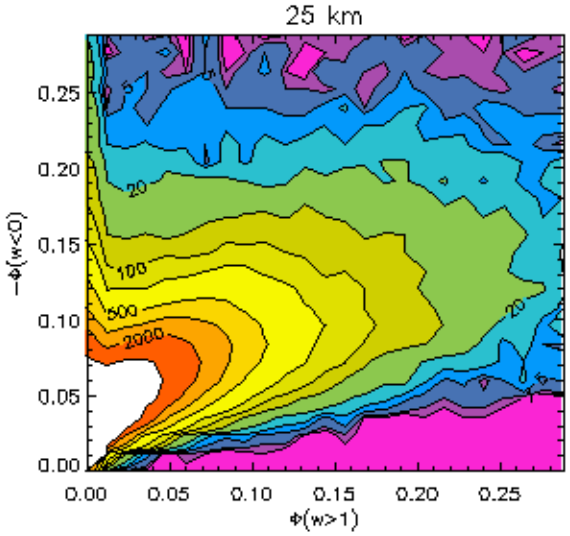
Time-Mean Precipitation (JJA 2005): *Sensitivity to grid/dycore*



The End


125 km
0.05
0.04
0.03
0.02
0.01
0.00
−Φ(w<0)
0.00
0.01
0.02
0.03
0.04
0.05
Φ(w>1)
5
20
100
500


50 km
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−Φ(w<0)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Φ(w>1)
5
20
100
500
2000


25 km
0.25
0.20
0.15
0.10
0.05
0.00
−Φ(w<0)
0.00
0.05
0.10
0.15
0.20
0.25
Φ(w>1)
5
20
100
500
2000