MMFhr

Do high resolution MMF simulations give better boundary layer cloud?

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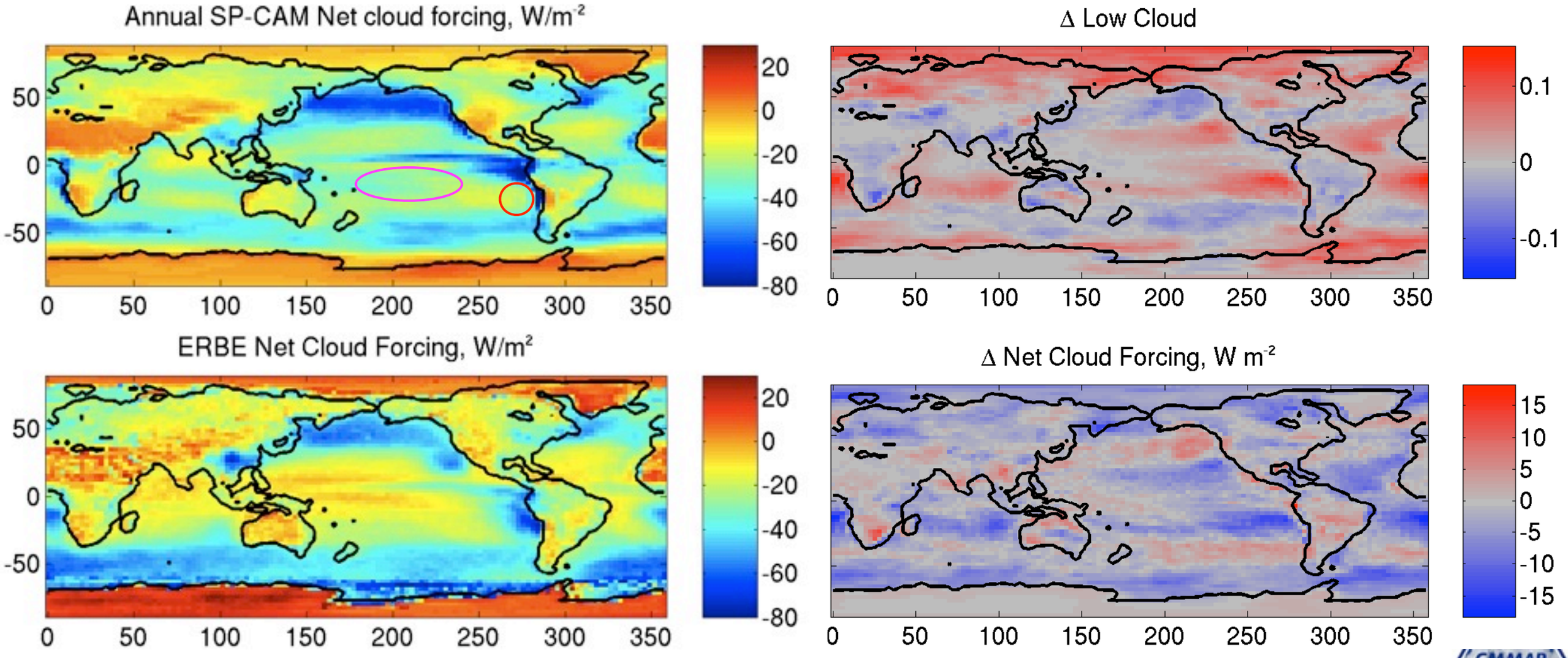
SP-CAM cloud climatology

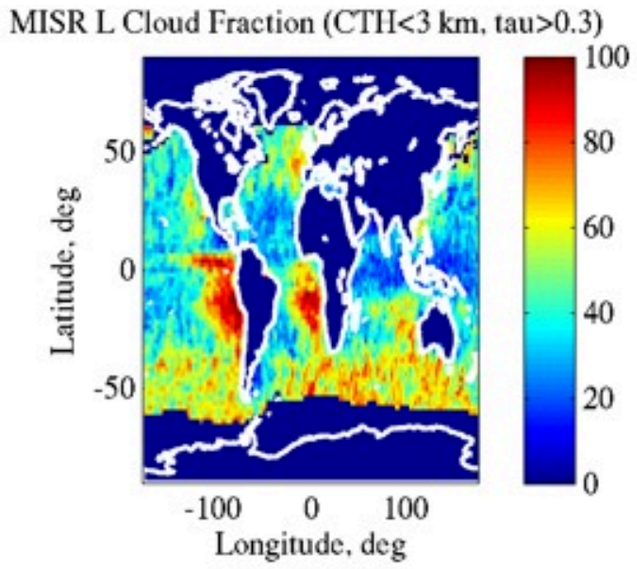
SP-CAM MMF: 30 levels, Δx = 4 km

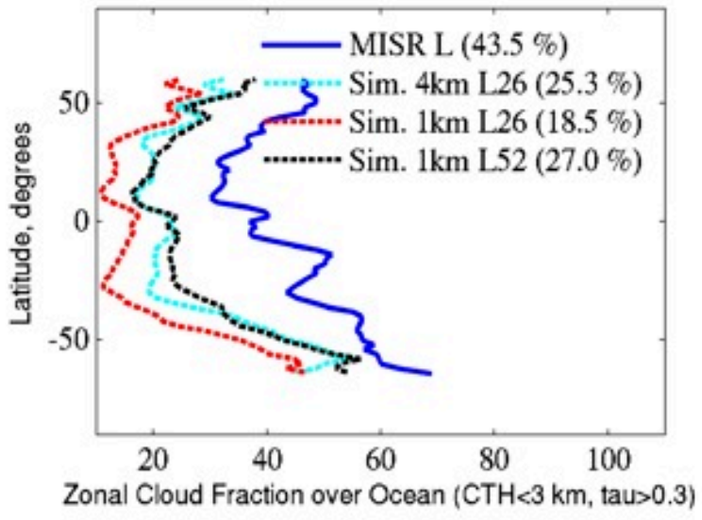
- Under-resolves boundary-layer Cu & Sc
- Climatological bright trade Cu/dim Sc bias
- Strong increase in low cloud for a 2K SST increase

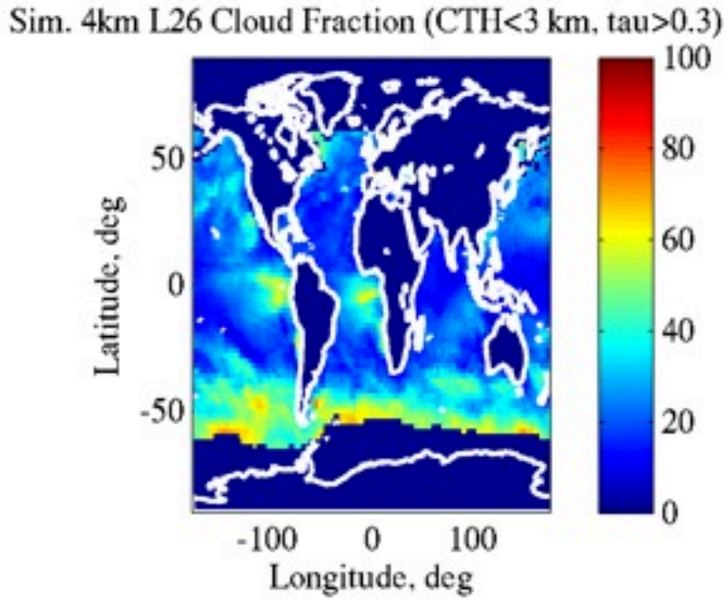


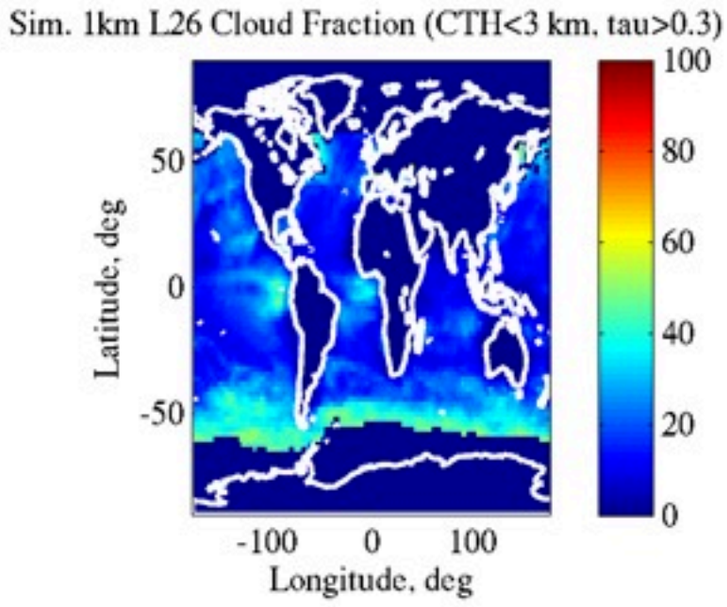
How do we get more realistic cloud fields in SP-CAM?

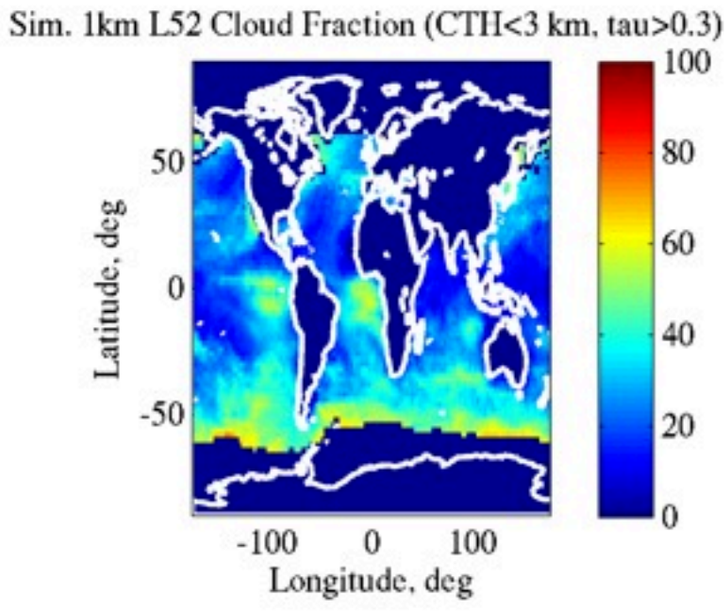
Sensitivity of low cloud amount to CRM resolution











Control
- 4 km horizontal
- 64 columns
- 26 vertical layers

- Test A
  - 1 km horizontal
  - 64 & 128 columns
  - 26 vertical layers

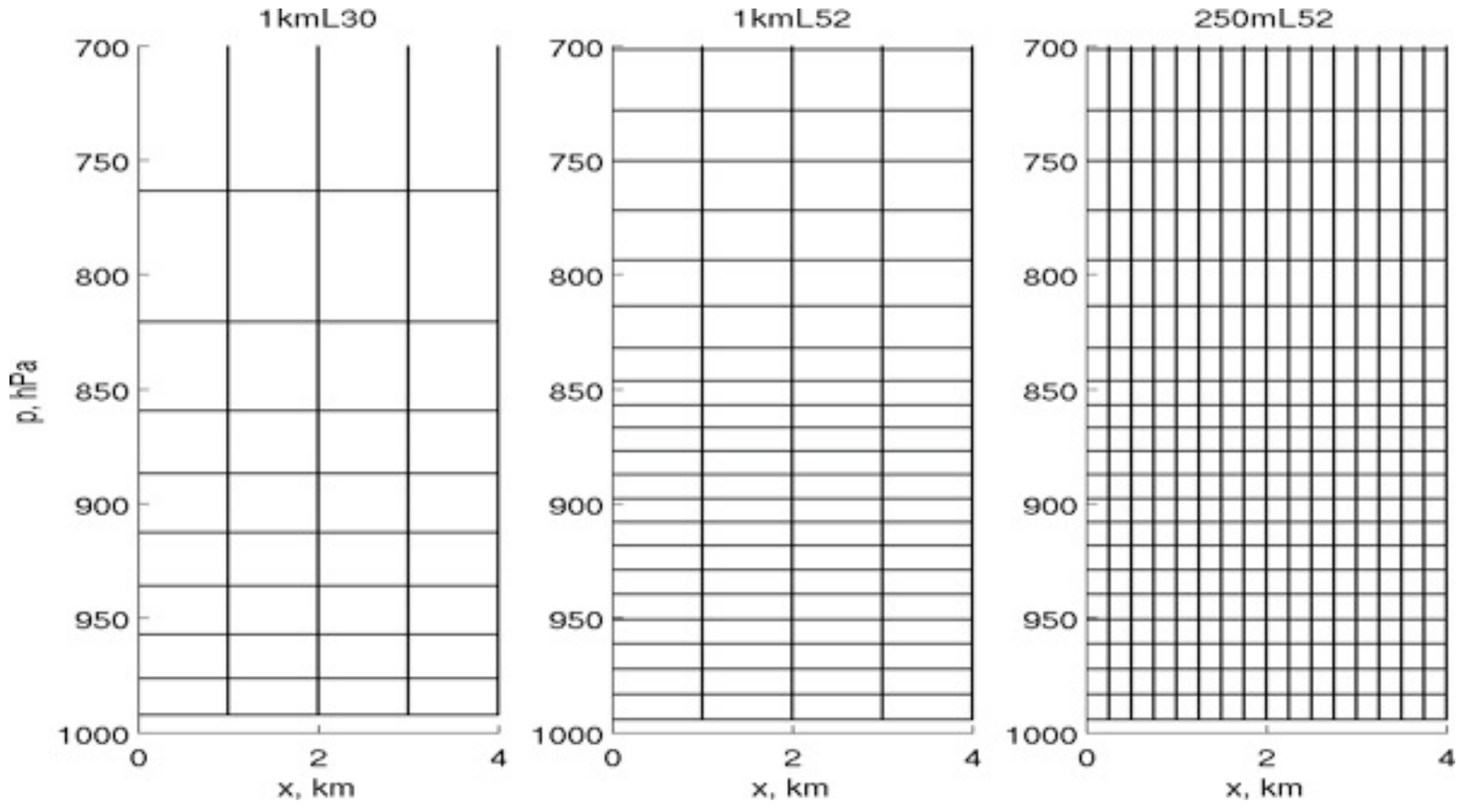
- Test B
  - 1 km horizontal
  - 64 columns
  - 52 vertical layers

Could further resolution improvement help?

- For trade Cu, LES suggests Δx, Δz = 250,100 m adequate
- For Sc, sharp inversion requires $\Delta z << 5$ m or kluges in SAM.

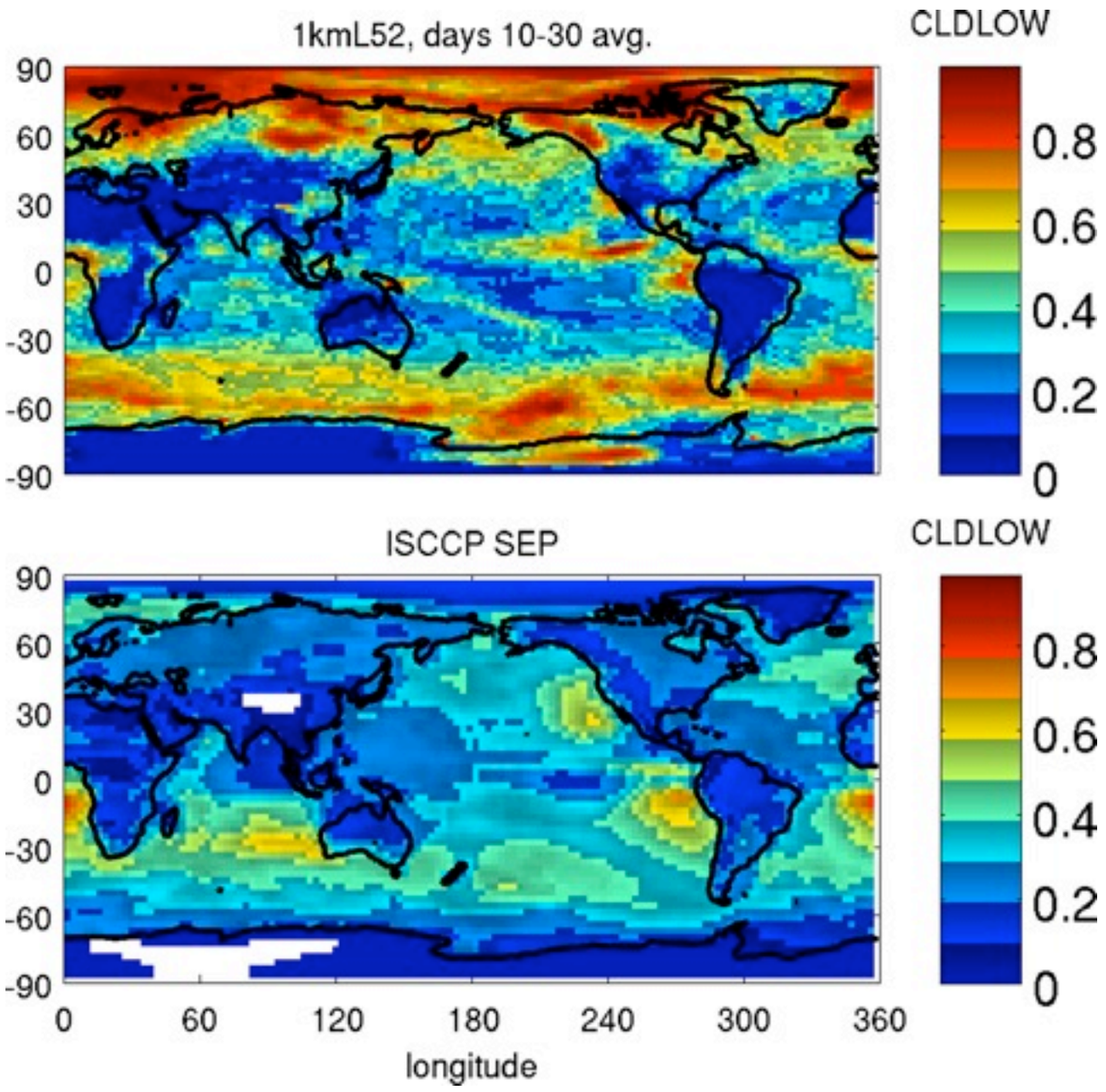
$\Rightarrow$ Goal: Better trade Cu in MMF

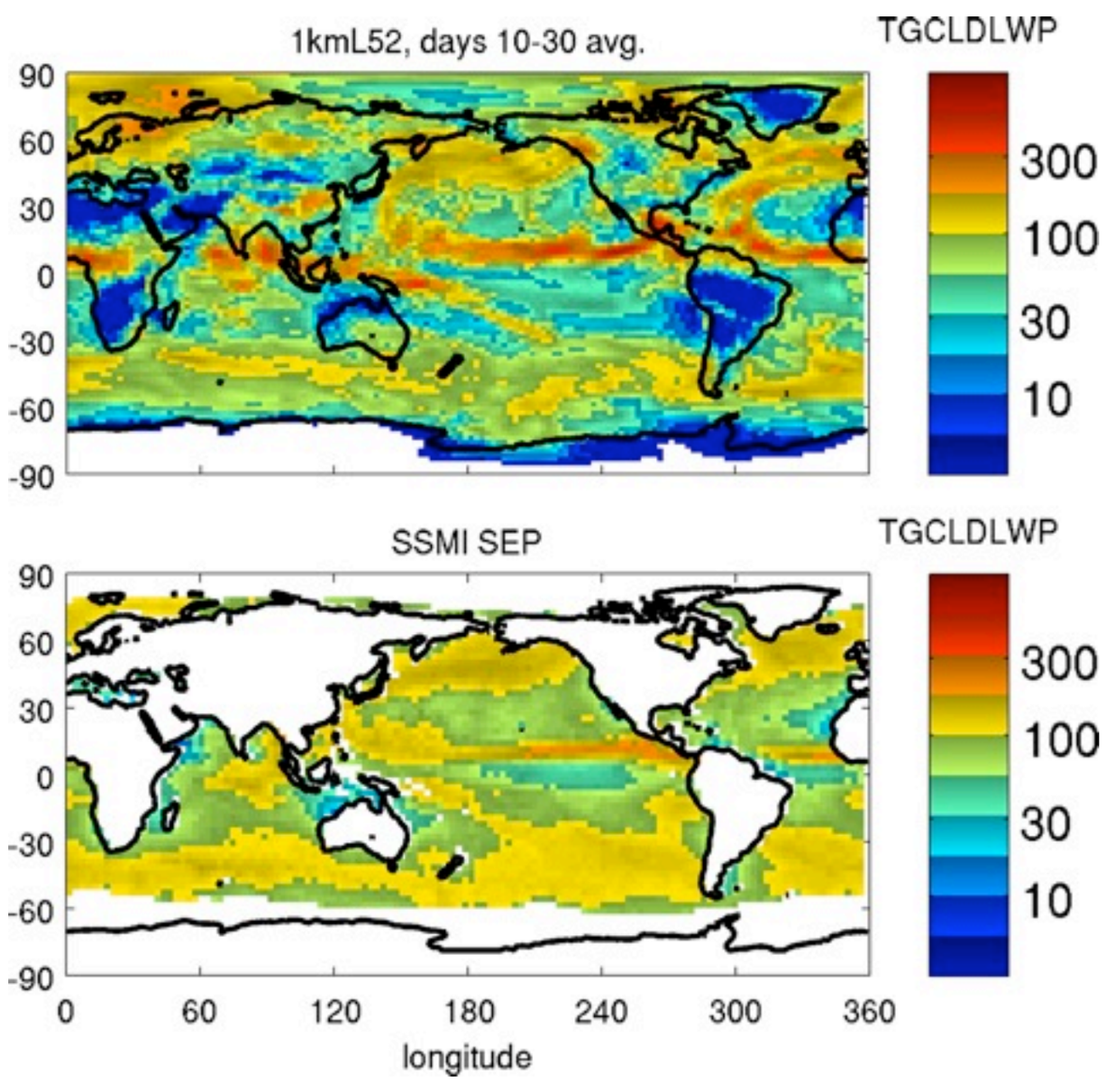
Experiment	N_x x N_y
1kmL30	64
1kmL52	64
250mL52	256
250mL52(3D)	32x32



- Each simulation is one month long (September).
- Parallel efficiency largely limited by output of CRM fields, which happens through serial CAM I/O routines.

Analysis strategy



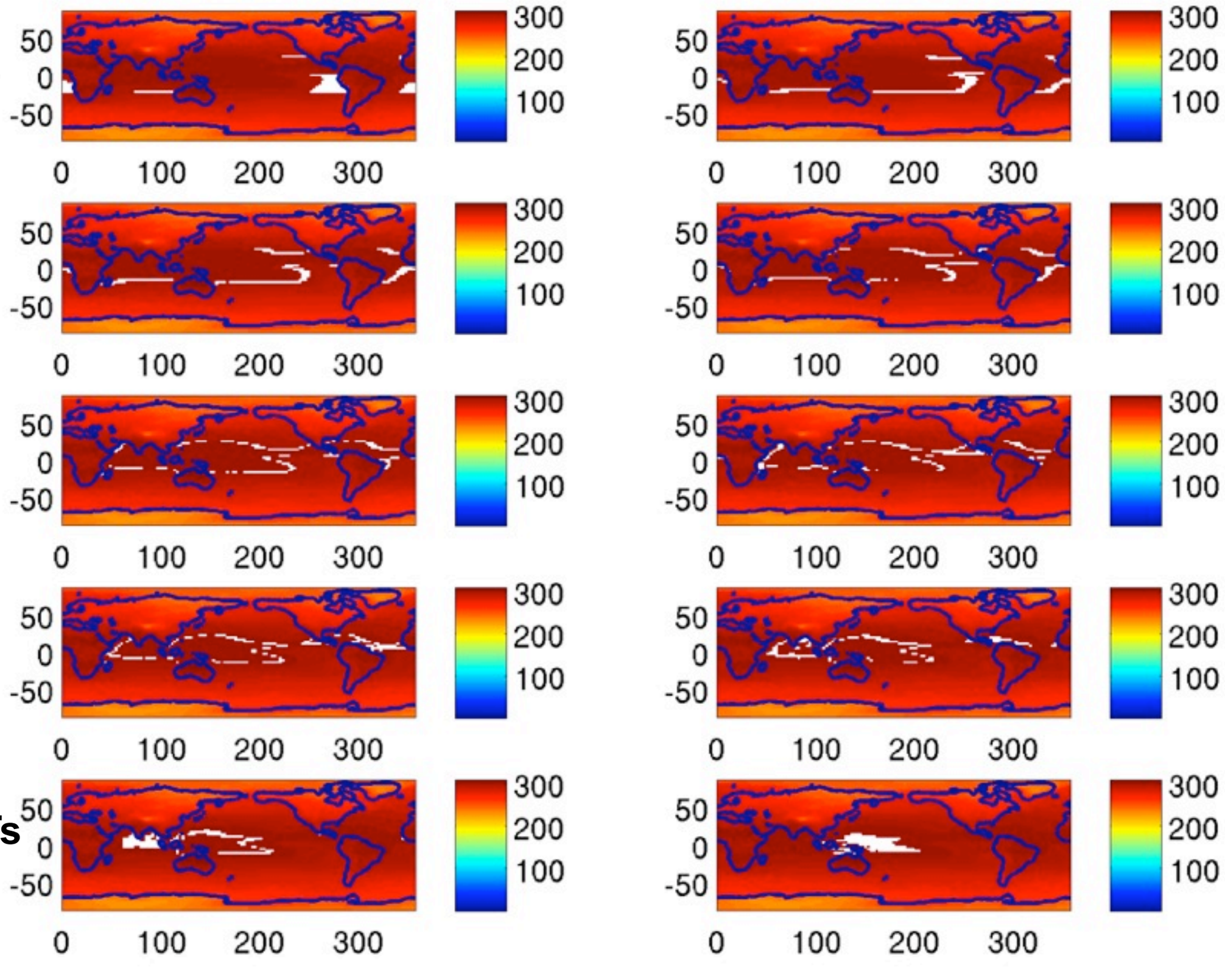


Low cloud field is noisy and synoptically modulated in these single month simulations, so:

- Average over deciles of SST over oceans in 25S-25N.
- Look at global/regional cloud climatology w/MISR simulator

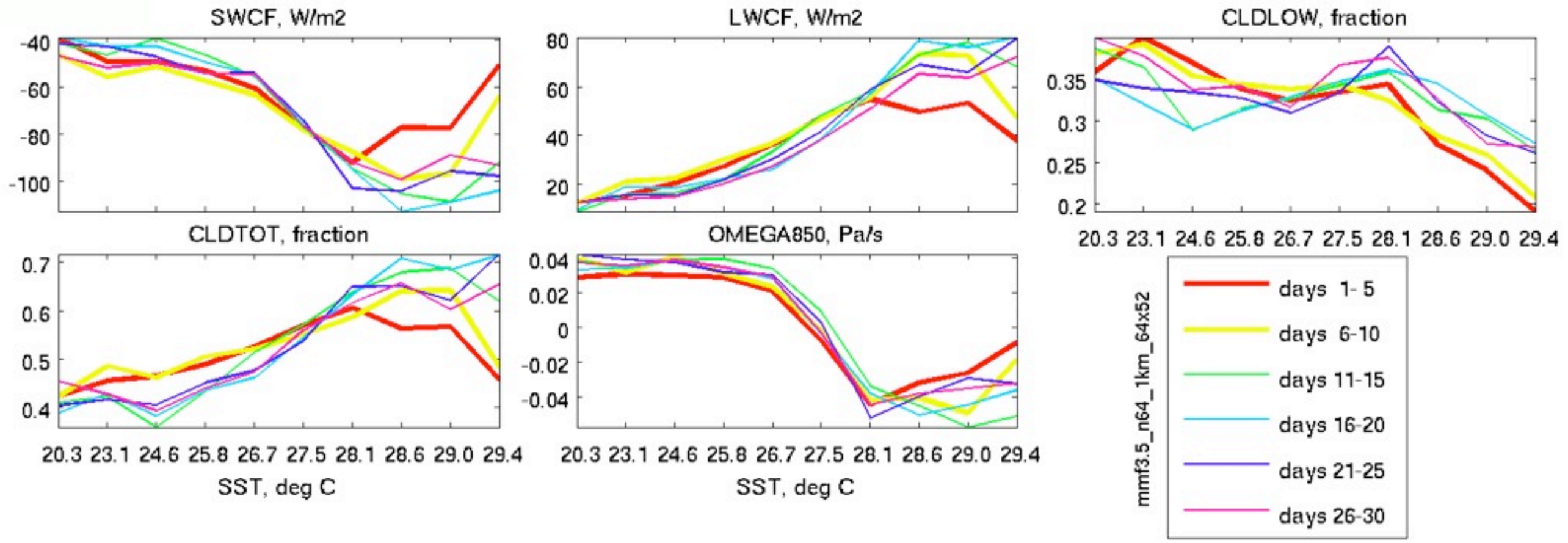
Locations of SST Bins

Cool SSTs



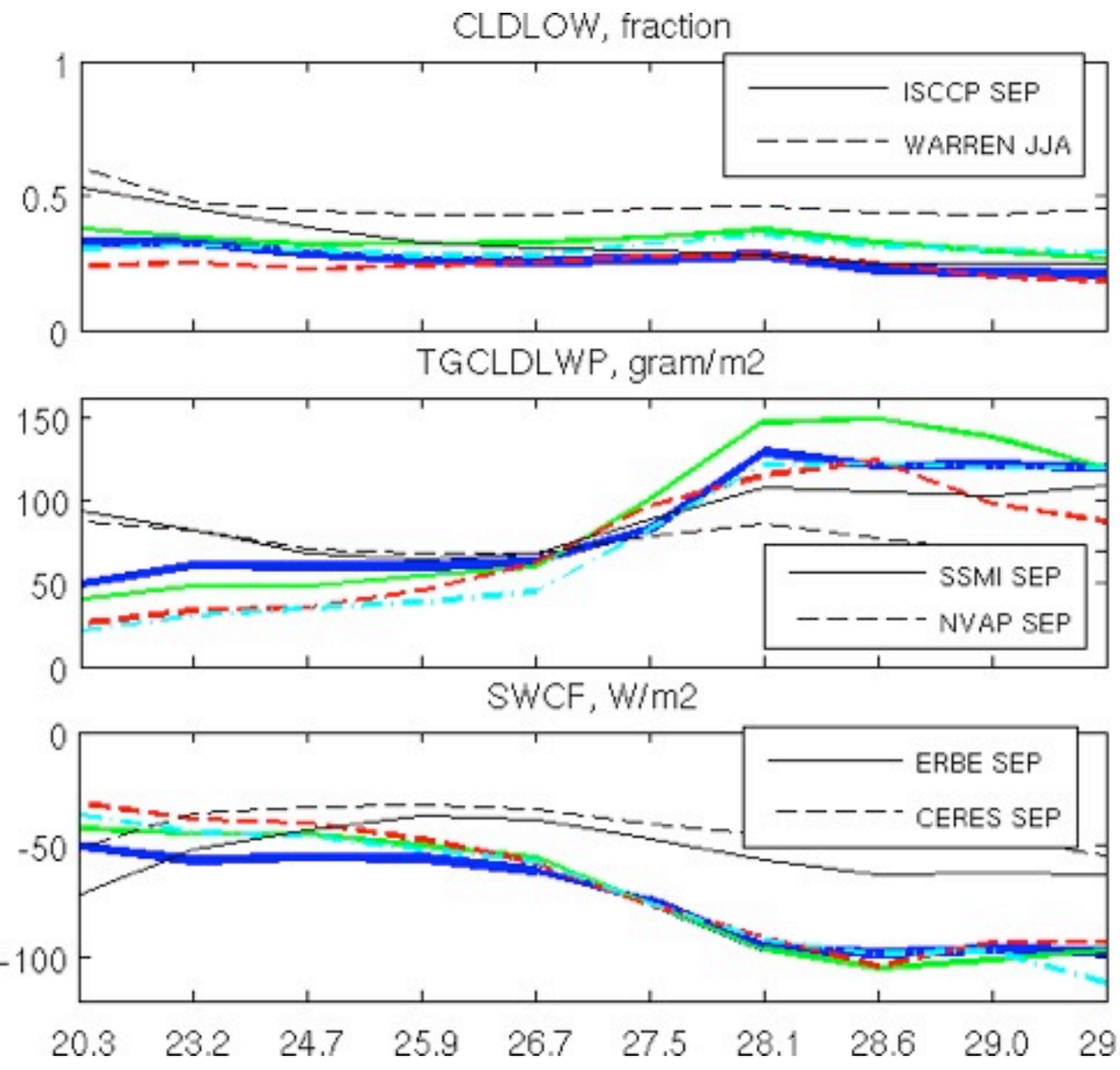
Warm SSTs

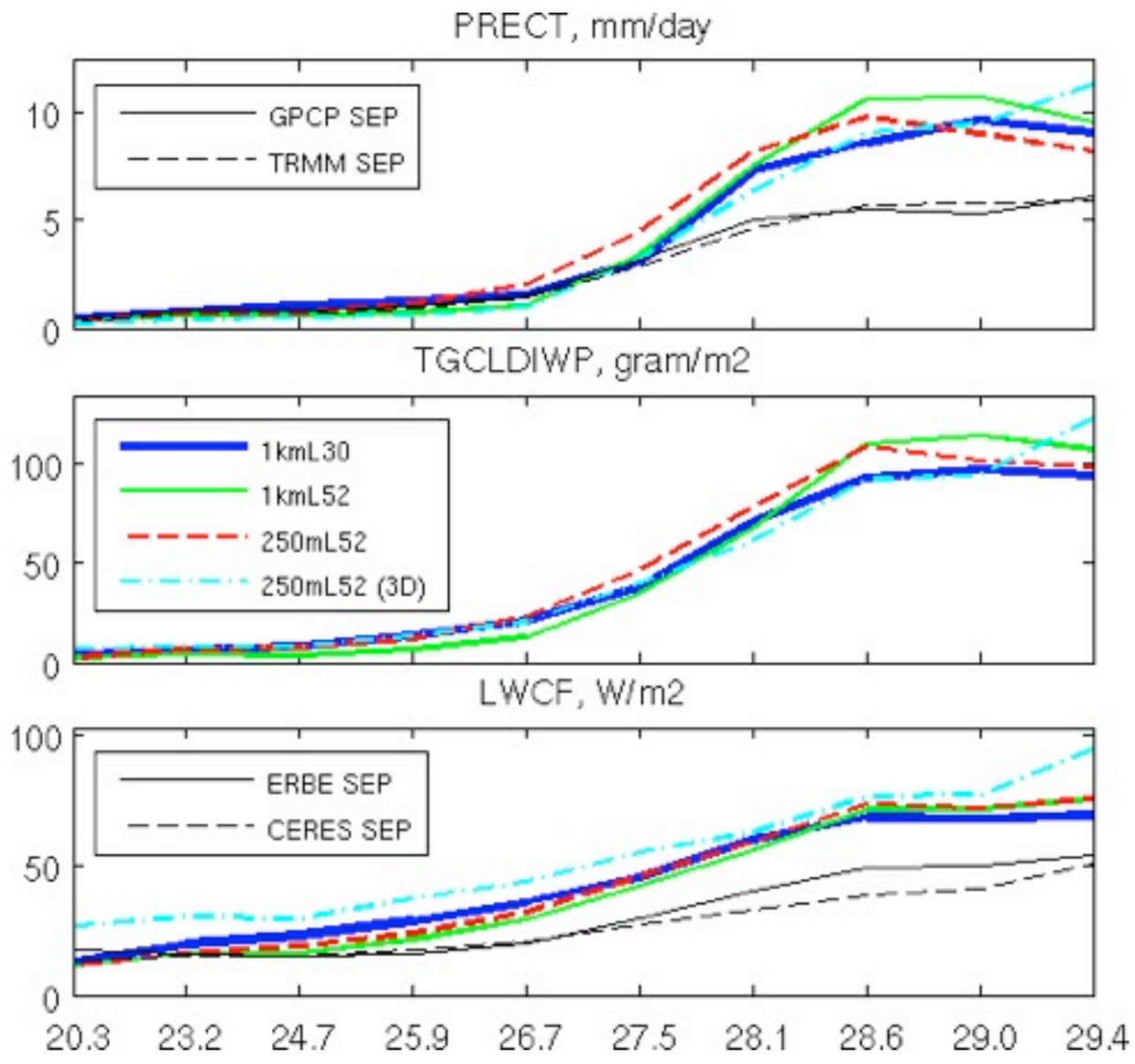
5-day averages from SST-binned 1kmL52



- Cloud statistics spin up rapidly.
- From here on, we compare day 11-30 averages.
- Compare w/September climatologies from observations.

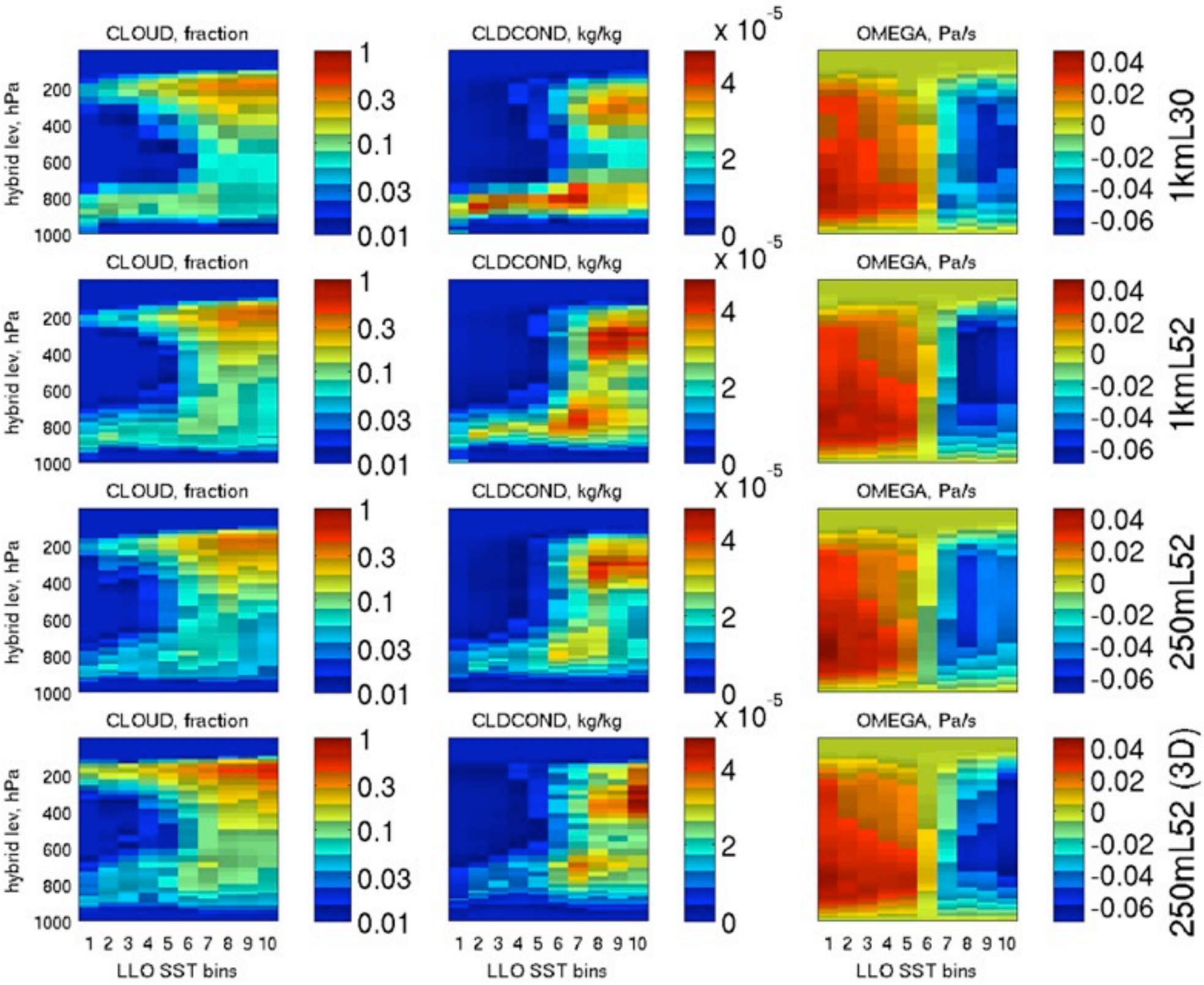
Time-mean resolution comparison





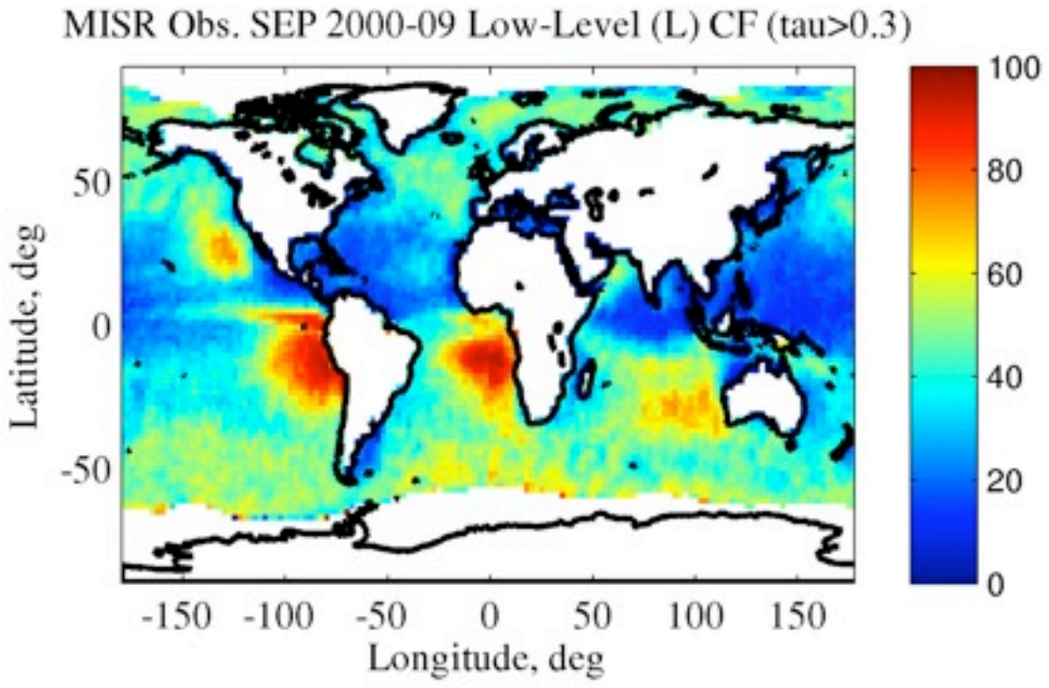
- Smaller Δx decreases LWP in subsidence regimes.
- No runs exhibit a clear stratocumulus low cloud max at low SST.
- Over warmest SSTs, all runs too rainy w/too strong LWCF & SWCF.
- LWCF systematically larger in 3D run (domain size issue?).

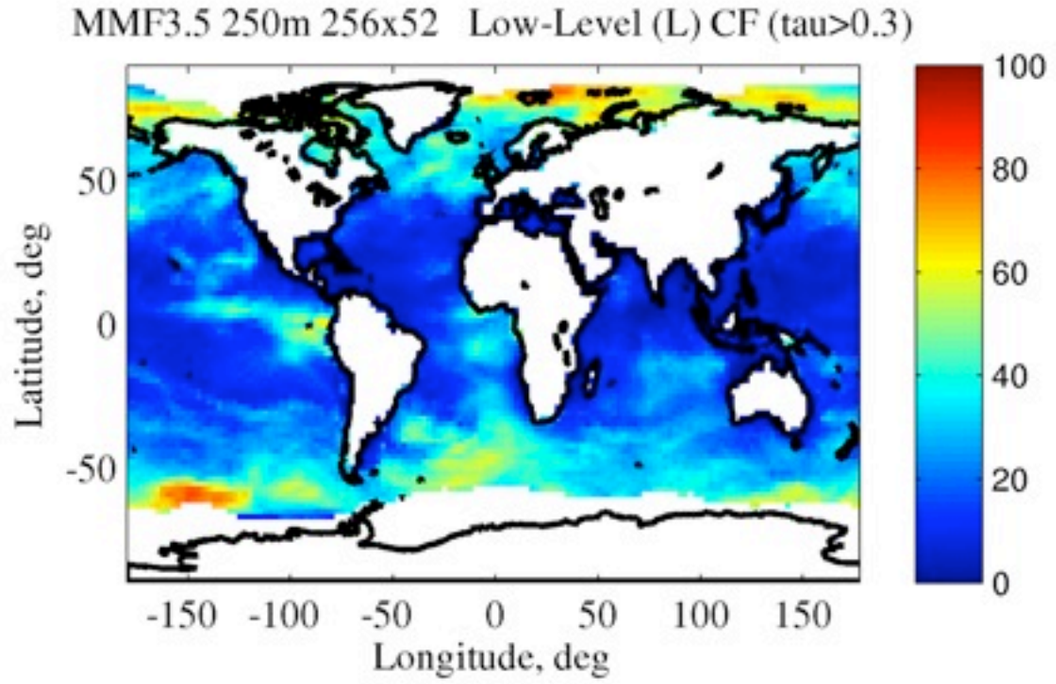
SST-binned vertical structure comparisons

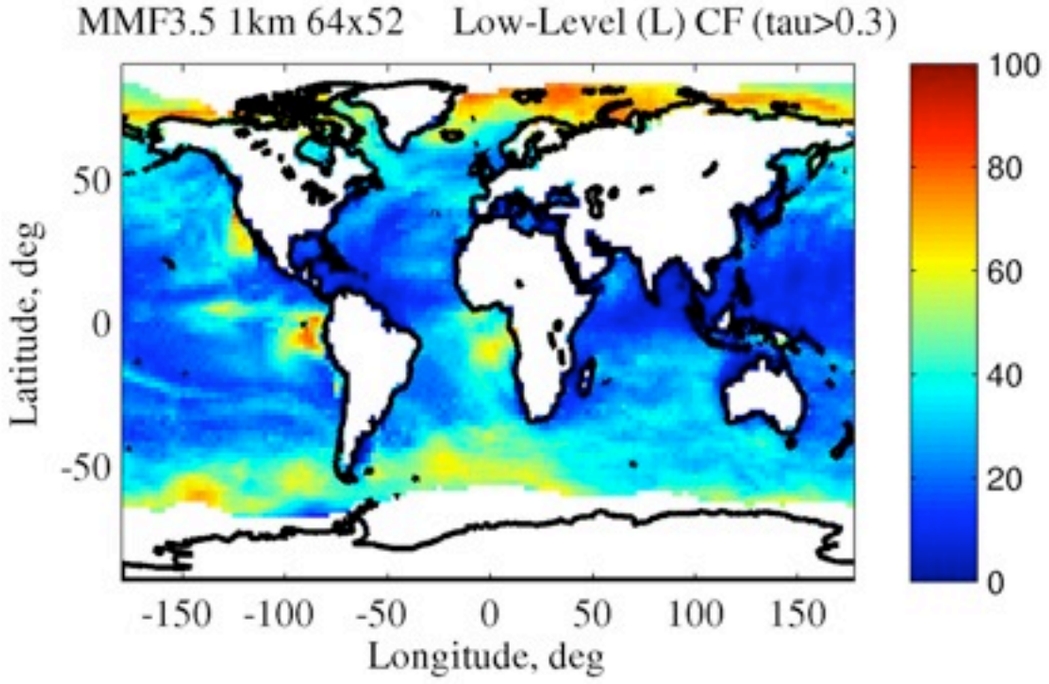


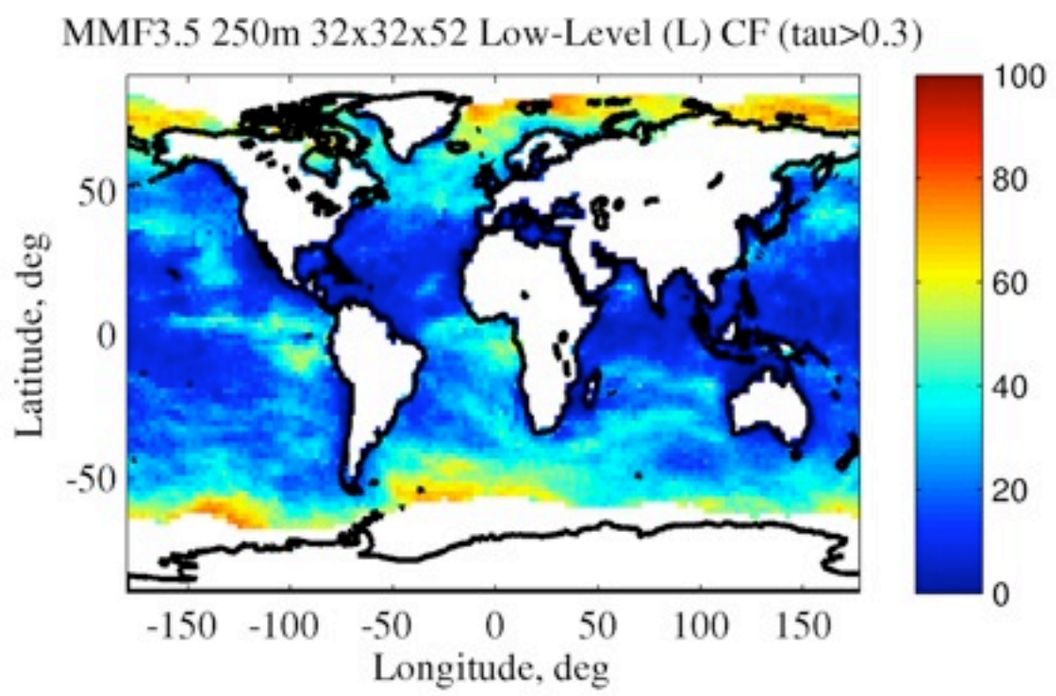
- 250m runs: less low cloud and less condensate,
- 250m 3D run shows hint of cloud fraction max near trade inversion
- 52 levels allows BL to deepen more naturally over warmer SSTs in subsidence regions.

MISR Simulator Low Cloud Fraction





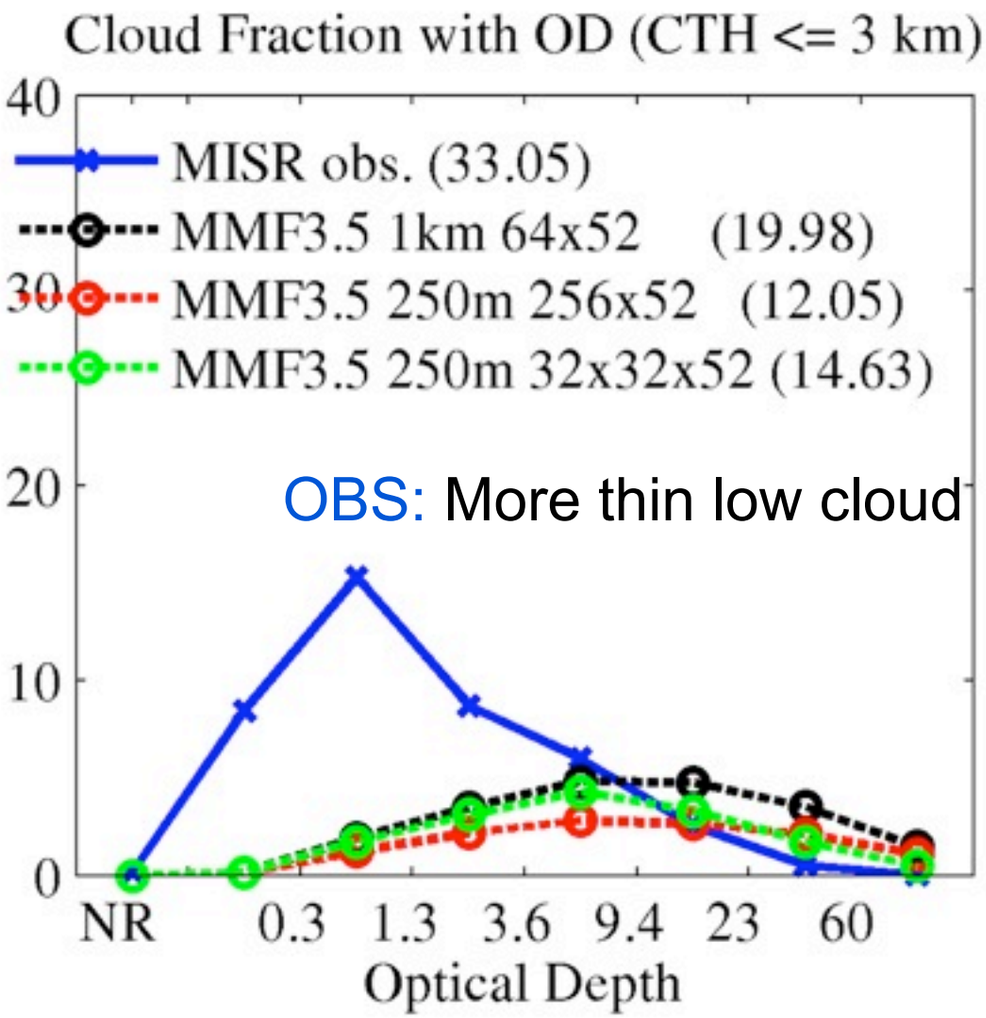


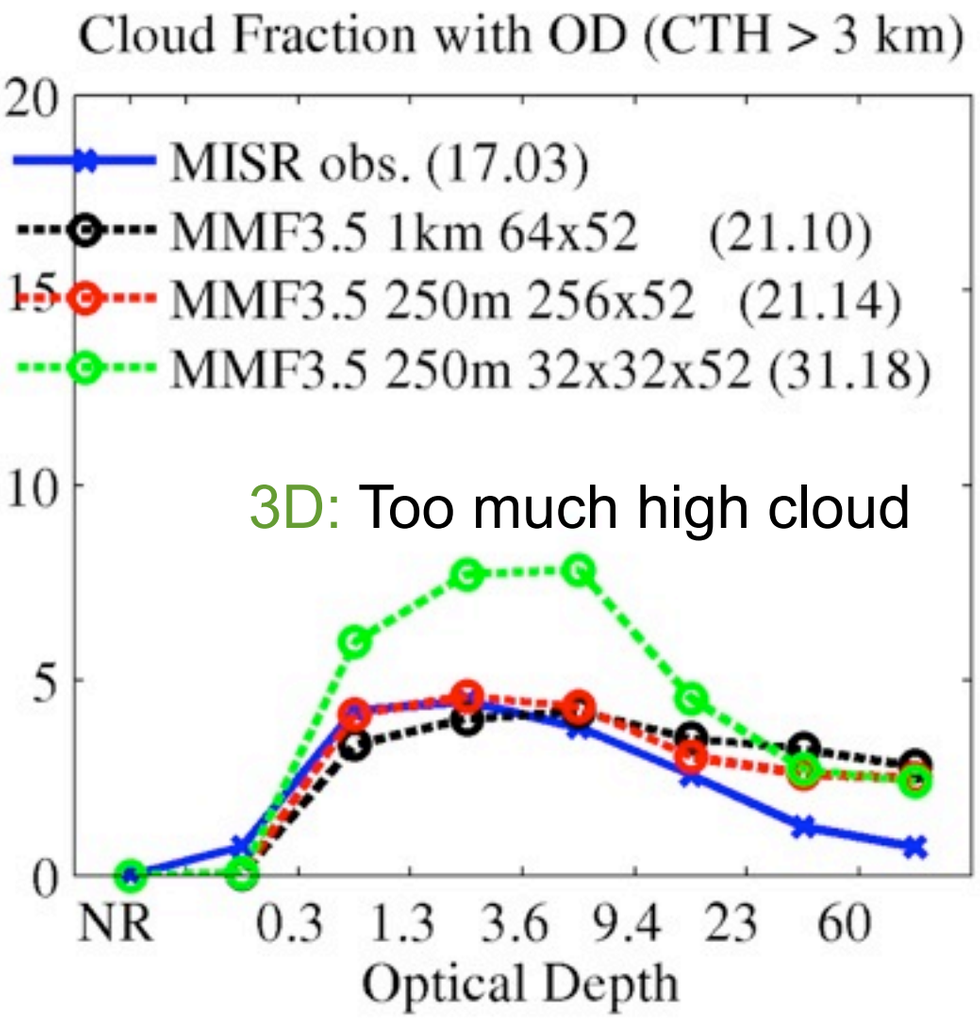


- No significant Sc in MMF runs.
- Low cloud in TradeCu regions doesn't improve w/resolution.

Cloud Optical Depth Histograms (MISR)

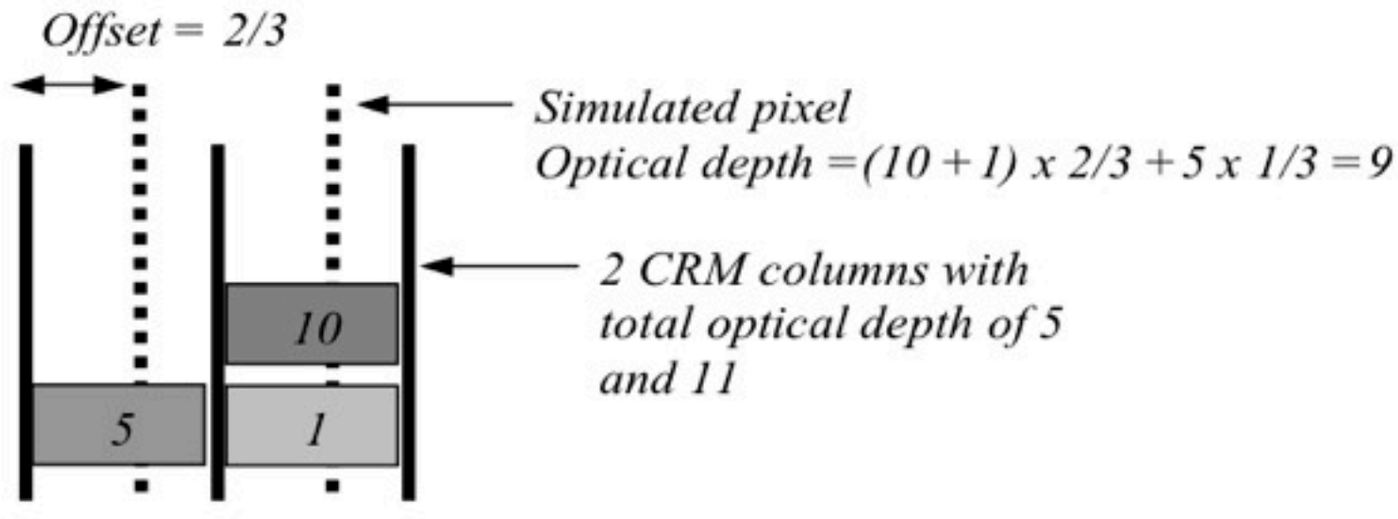
Hawaiian TradeCu Region



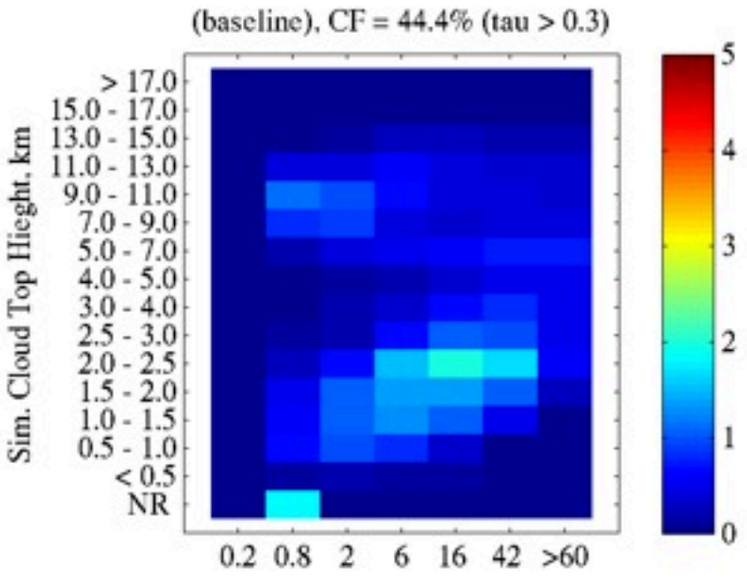


- Good: Amount of high optical depth low cloud decreases.
- Not as good: Low optical depth low cloud doesn't increase as expected.
- Small domain 3D run (8km x 8km w/dx=250m) has excessive high cloud.

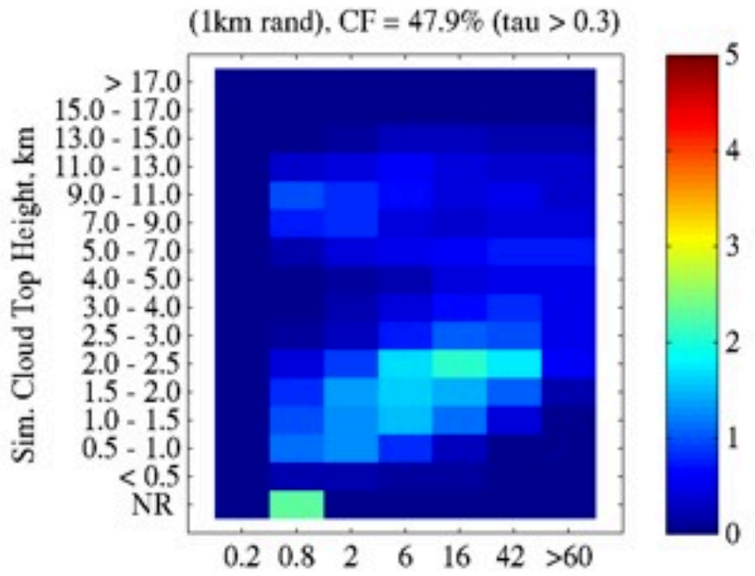
Sensitivity of MISR Simulator to "Pixel" Alignment and Size

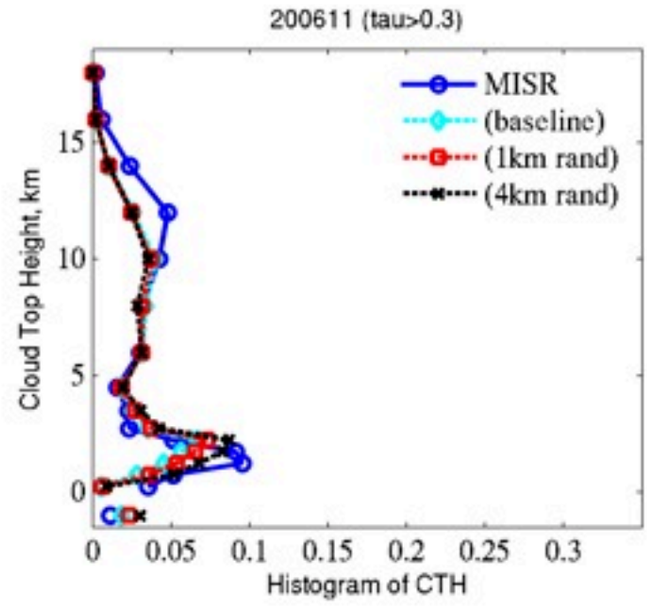


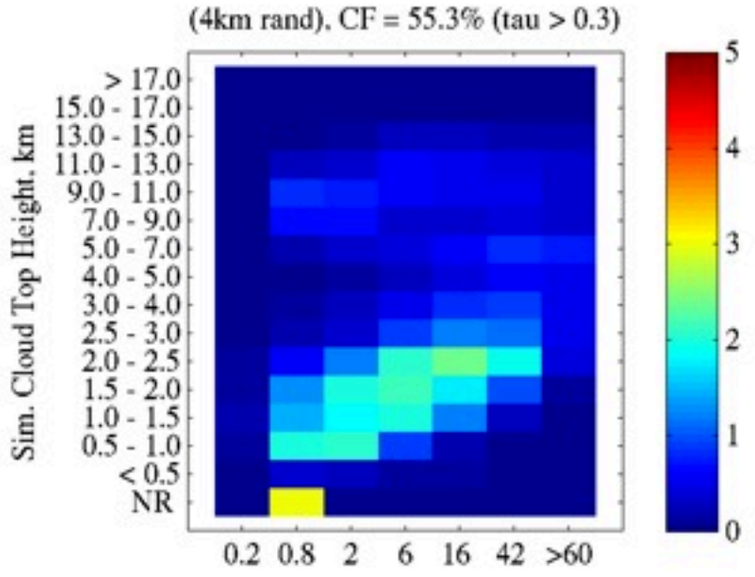
- Not accounted for in data shown previously.
- Might explain some of the lack of thin low cloud in 250m simulations.
- MISR pixel ~ 1km.

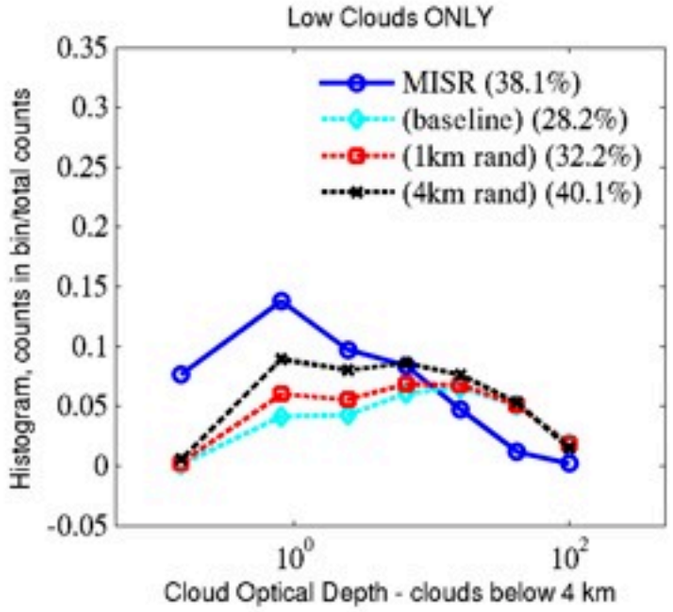


See also Zhao & Di Girolamo (GRL 2006)









Conclusions

- MMFhr pilot experiments show some sensitivity of low cloud to resolution, with less unrealistic thick low cloud in trade cumulus regions.
- Vertical structure of cloud and condensate seems more realistic at higher vertical/horizontal resolution.
- Little Sc present at higher horizontal resolution, but cautious optimism on improvements in trade cumulus.
- Little improvement in ‘bright trades’ problem (too large optical depth, SWCF in trades) with resolution.
- Still more work to understand results fully. However, improvements in vertical resolution might be more fruitful, especially in Sc regions.