

The diurnal cycle of cloudiness in the standard and MMF CAM

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MMF Background

- CAM3 is run with cloud-resolving model (SAM) in place of cumulus parameterization.
- 2D CRM simulation with 32 4-km horizontal grid spacing.
- vertical levels in SAM same as those used in CAM3.
- Radiative calculations performed on SAM grid. Surface fluxes computed on CAM3 grid.

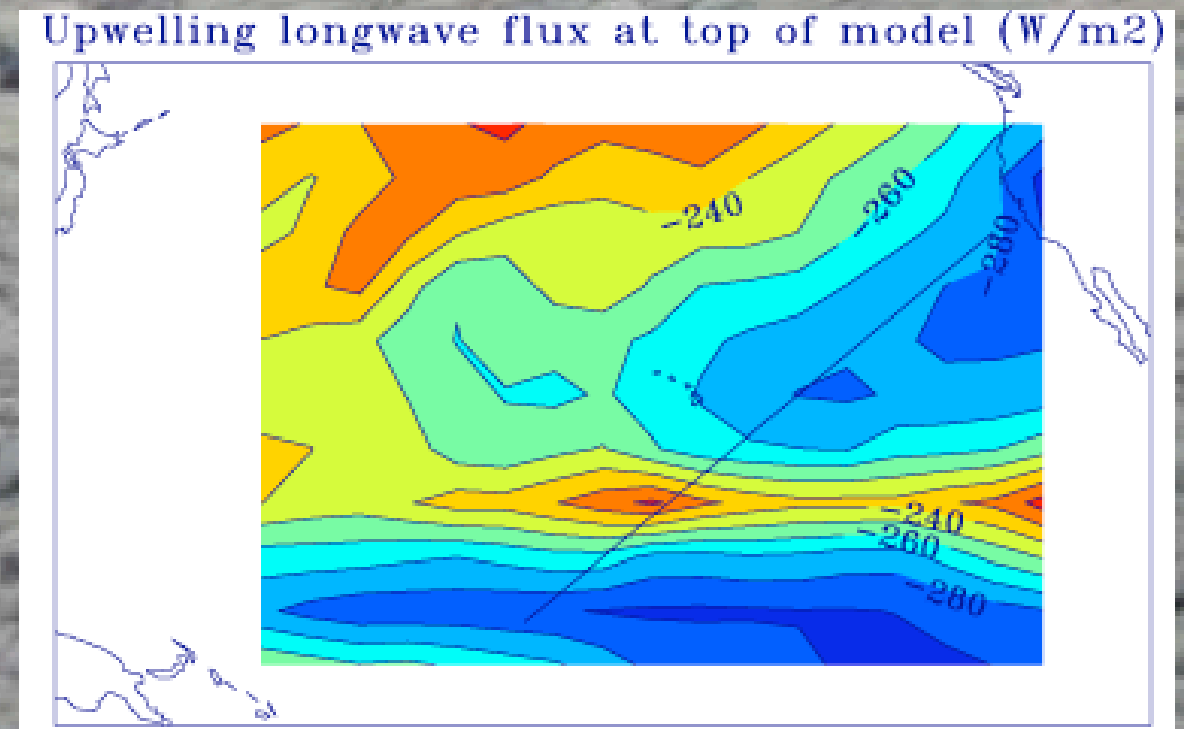
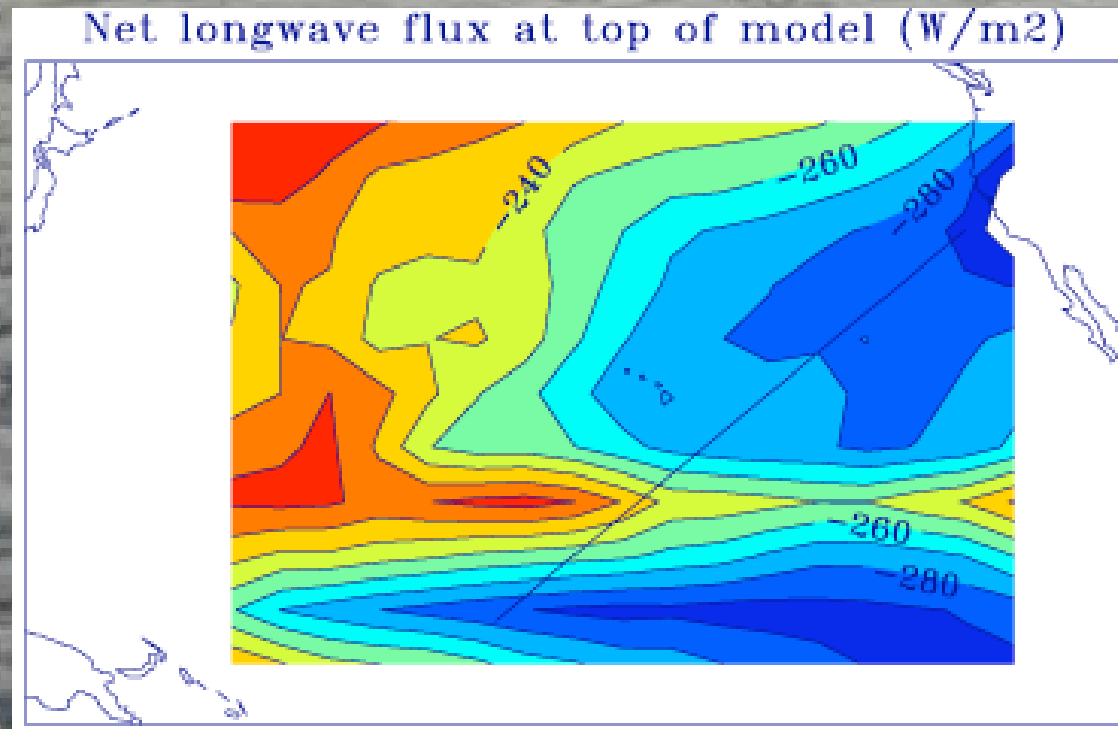
Motivation

- In the AMIP runs, SAM has been configured primarily for deep convection (4 km grid spacing) and “speed” (32 grid columns).
- Can we realistically expect to simulate marine stratocumulus with such a setup?

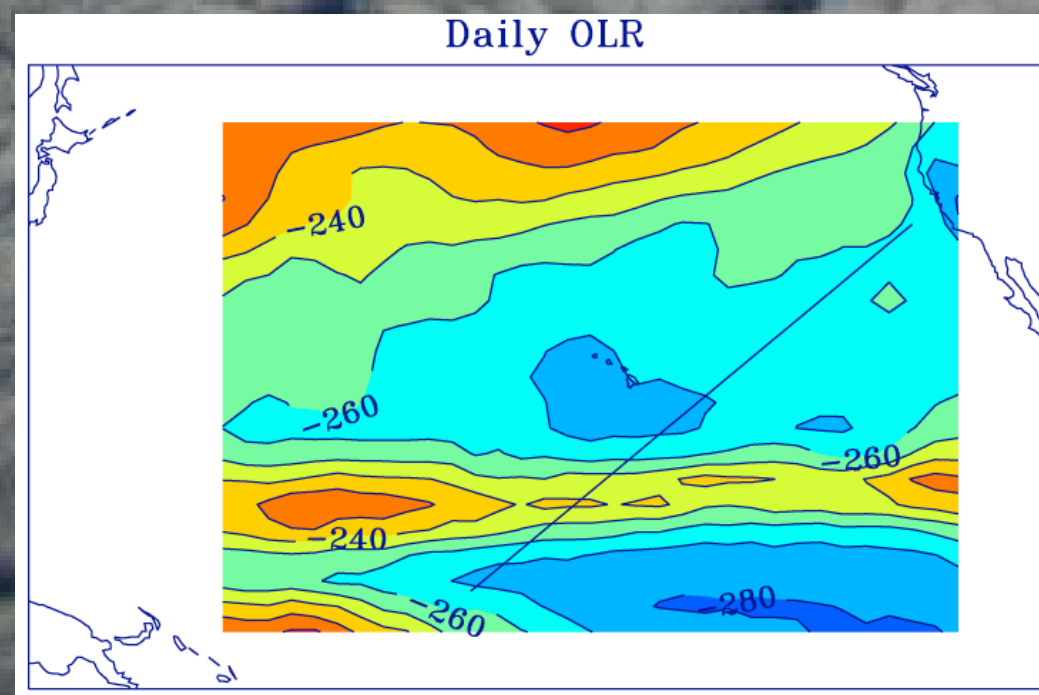
Basic comparisons - OLR 1998

CAM3

MMF



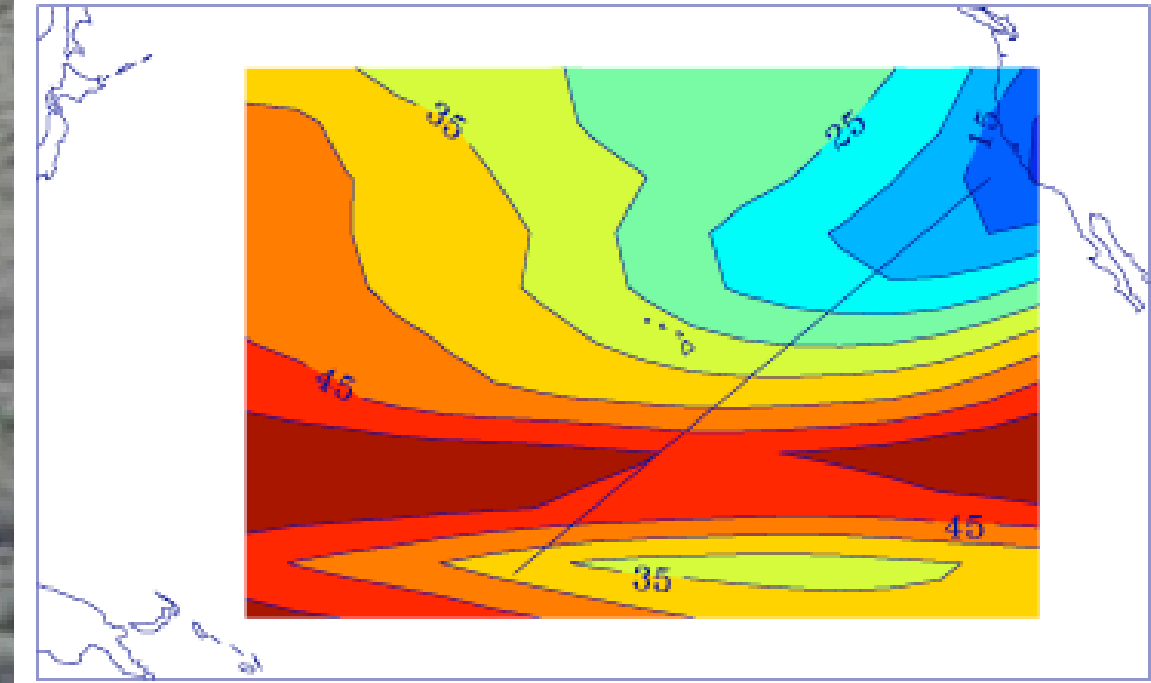
NOAA



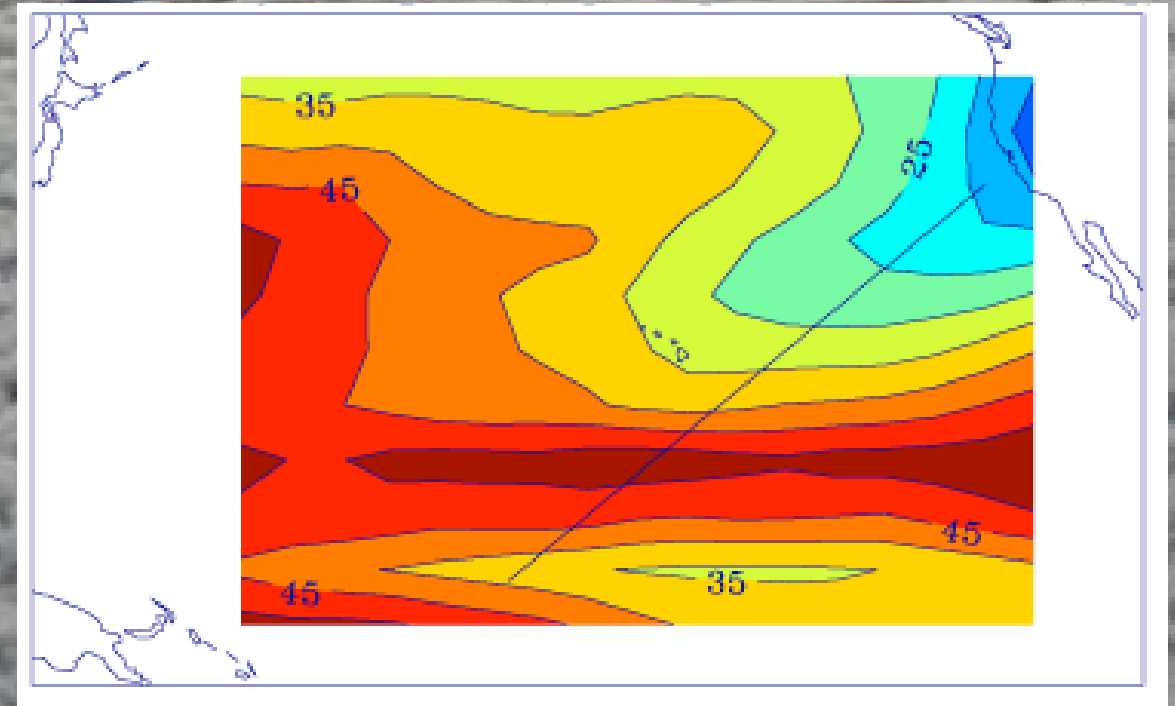
Precipitable Water (mm) - 1998

CAM3

1 (vertically integrated) precipitable water (kg,

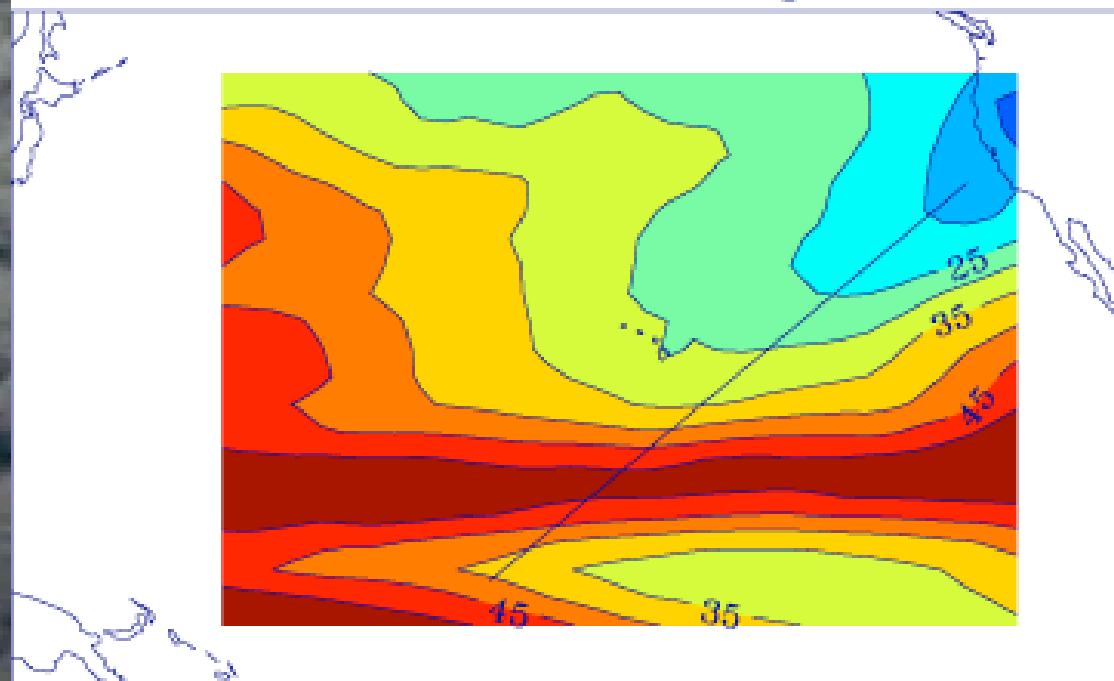


MMF



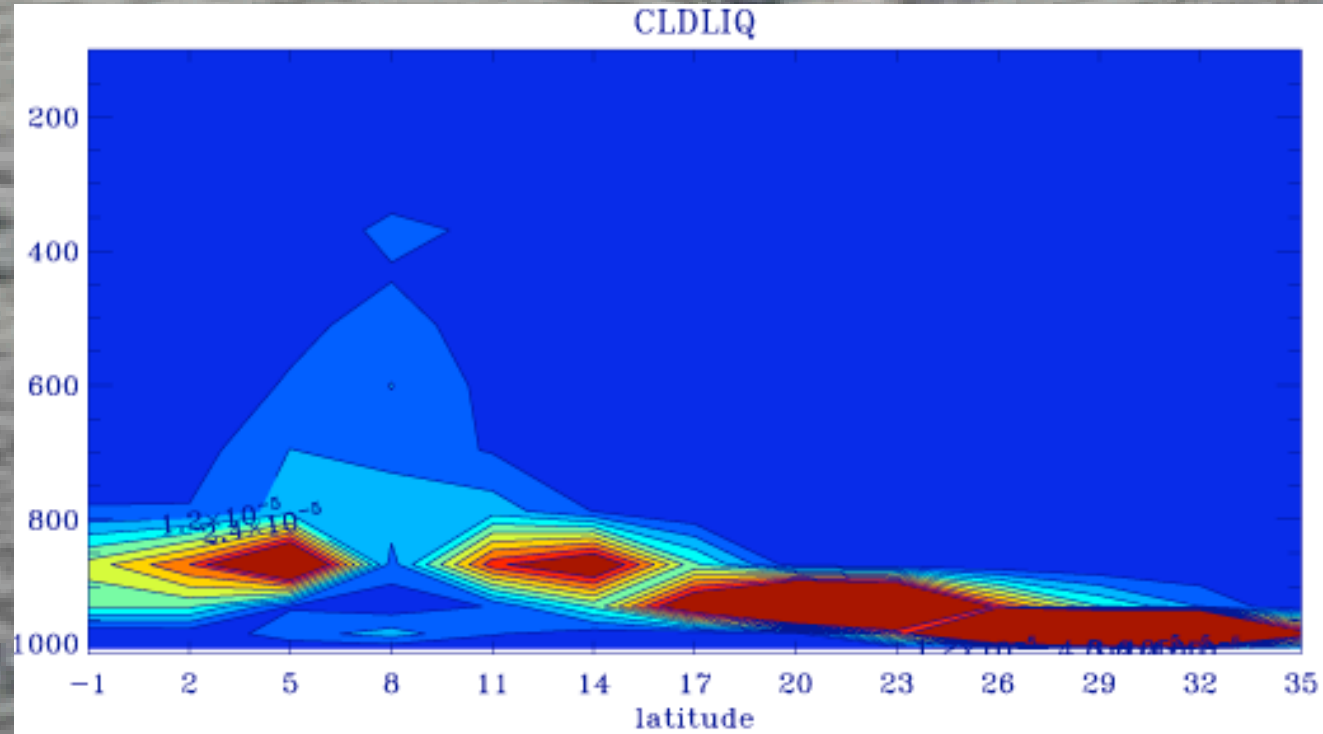
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Total column water vapour

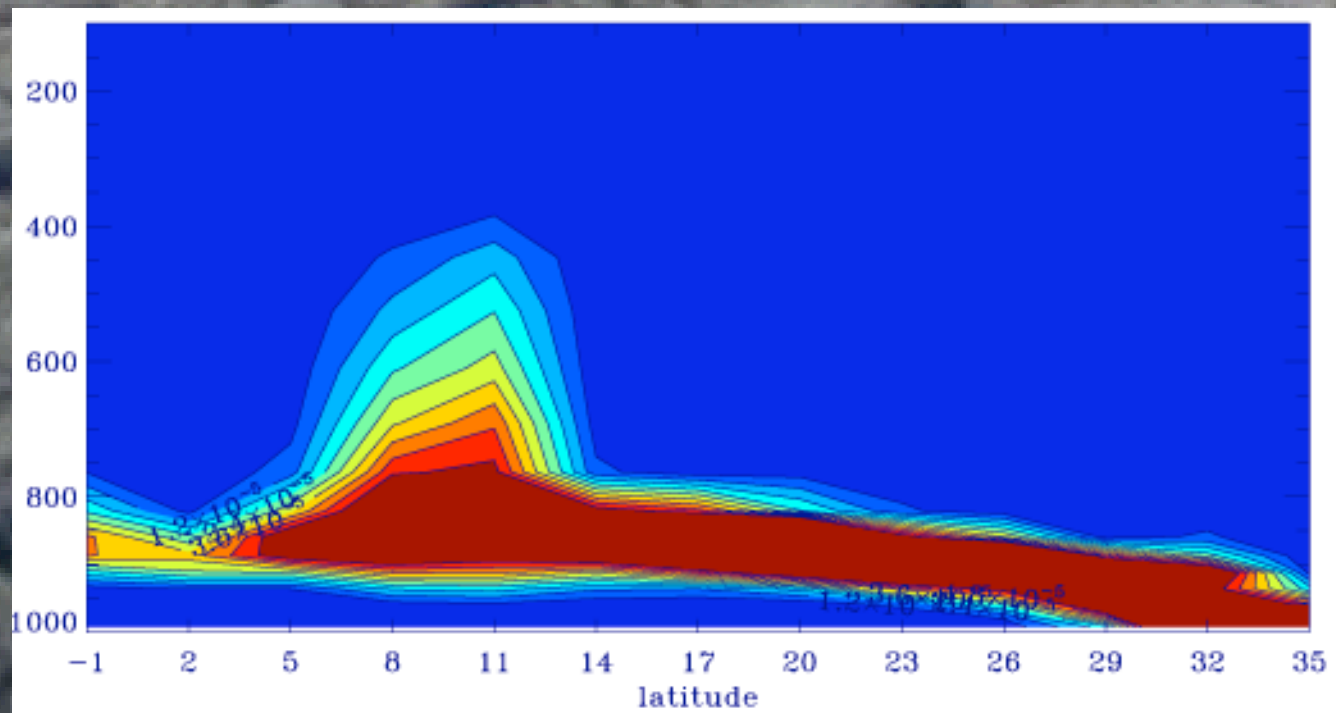


Cloud Water (kg/kg) - 1998

CAM3

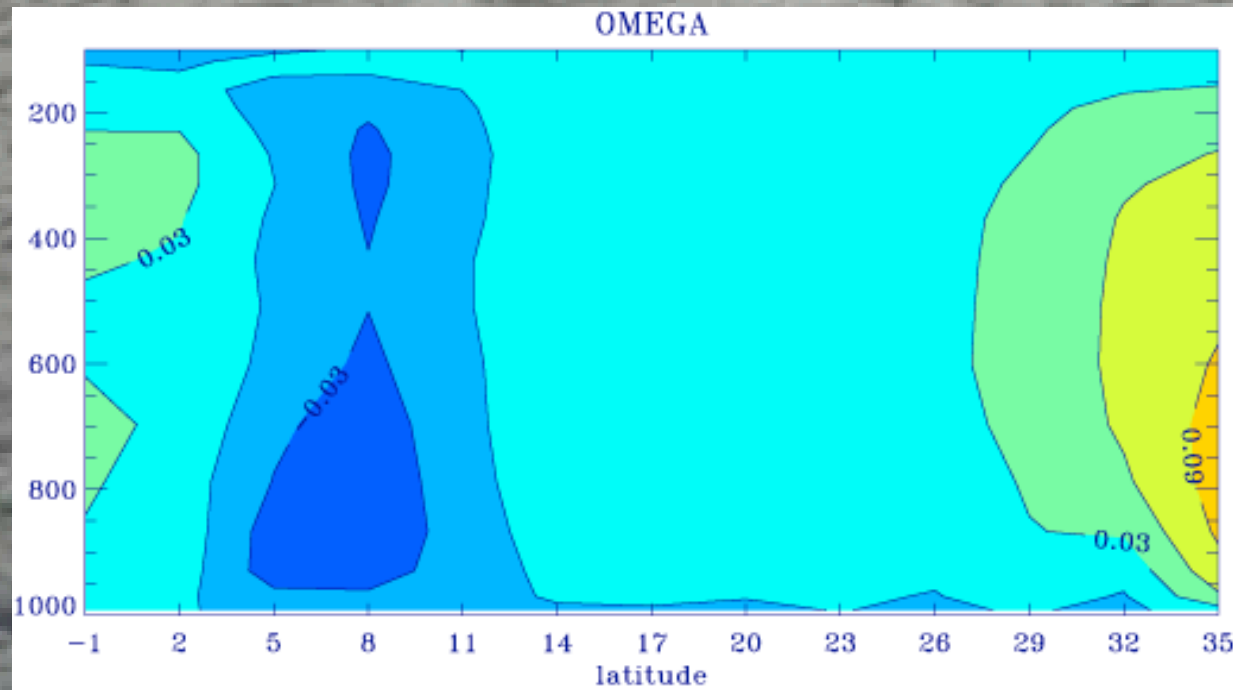


MMF

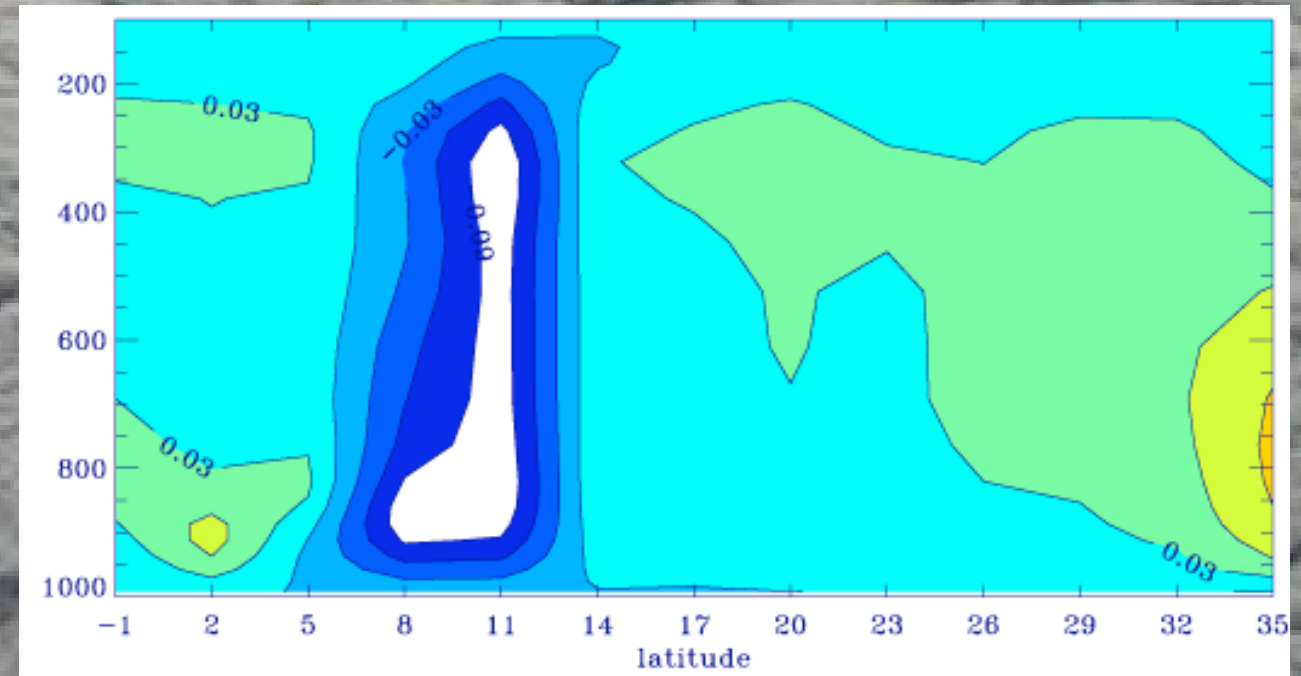


Vertical Motion (Pa/s) - 1998

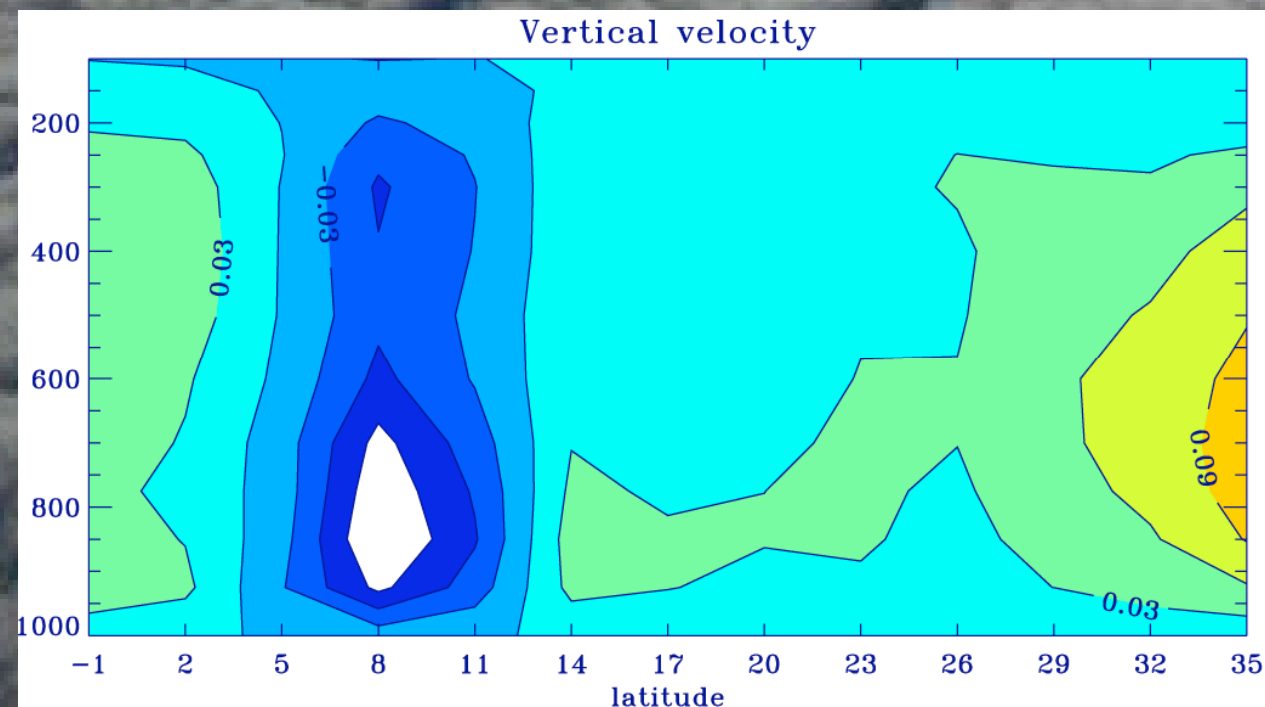
CAM3



MMF



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How do the two simulations produce marine Sc clouds?

- Standard CAM

- ▶ cloud is assumed to be located in the model layer below the strongest stability jump between 750 mb and the surface. If no two layers present a stability in excess of -0.125 K/mb , no cloud is diagnosed (after Klein and Hartmann, 1995).

- MMF CAM

- ▶ SAM is simply given surface and momentum fluxes, and left to its own devices.

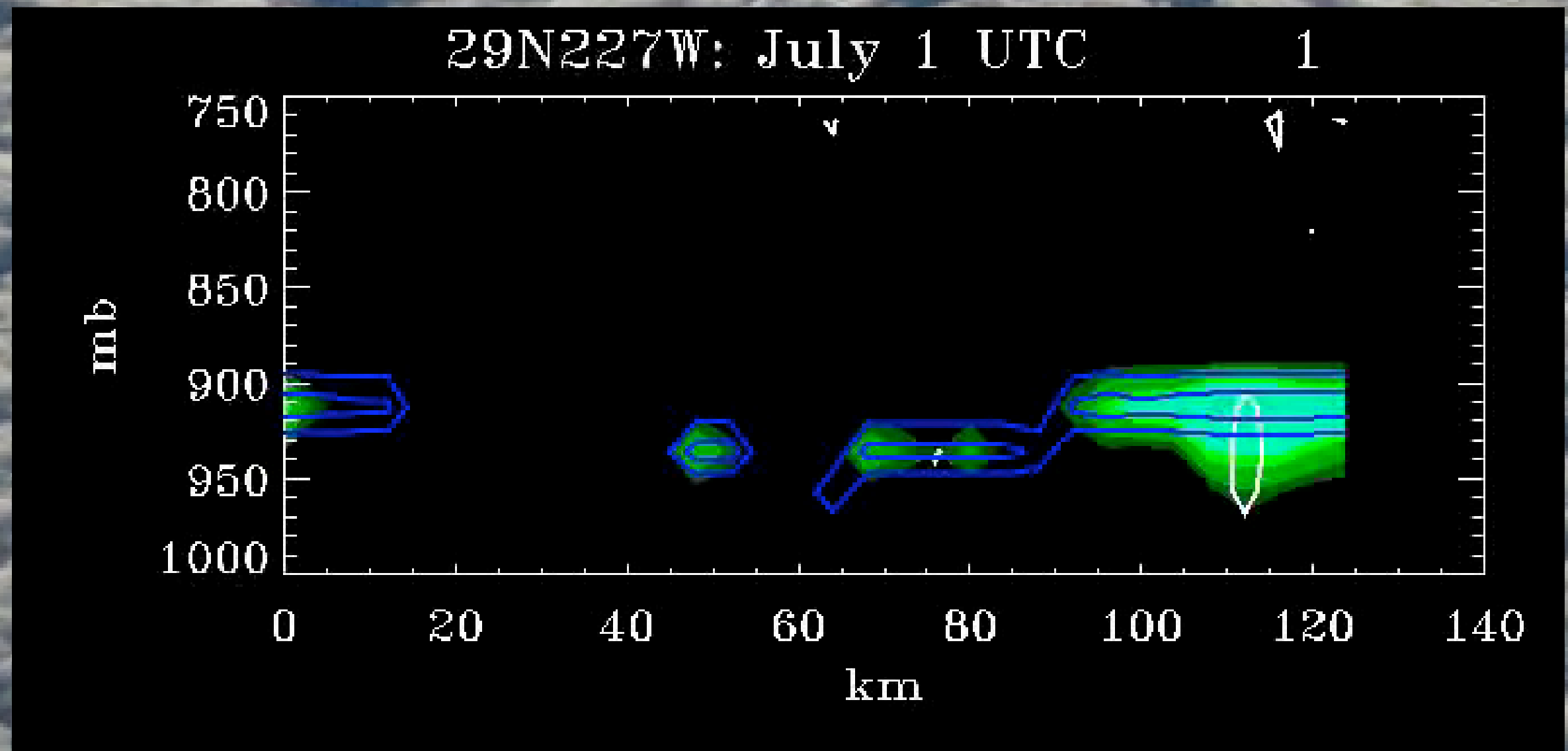
More questions about the MMF

- Does the MMF really produce stratocumulus clouds?
- Do the MMF stratus clouds behave as they do in nature?
- Does the MMF produce a transition zone between Sc and Cu clouds?

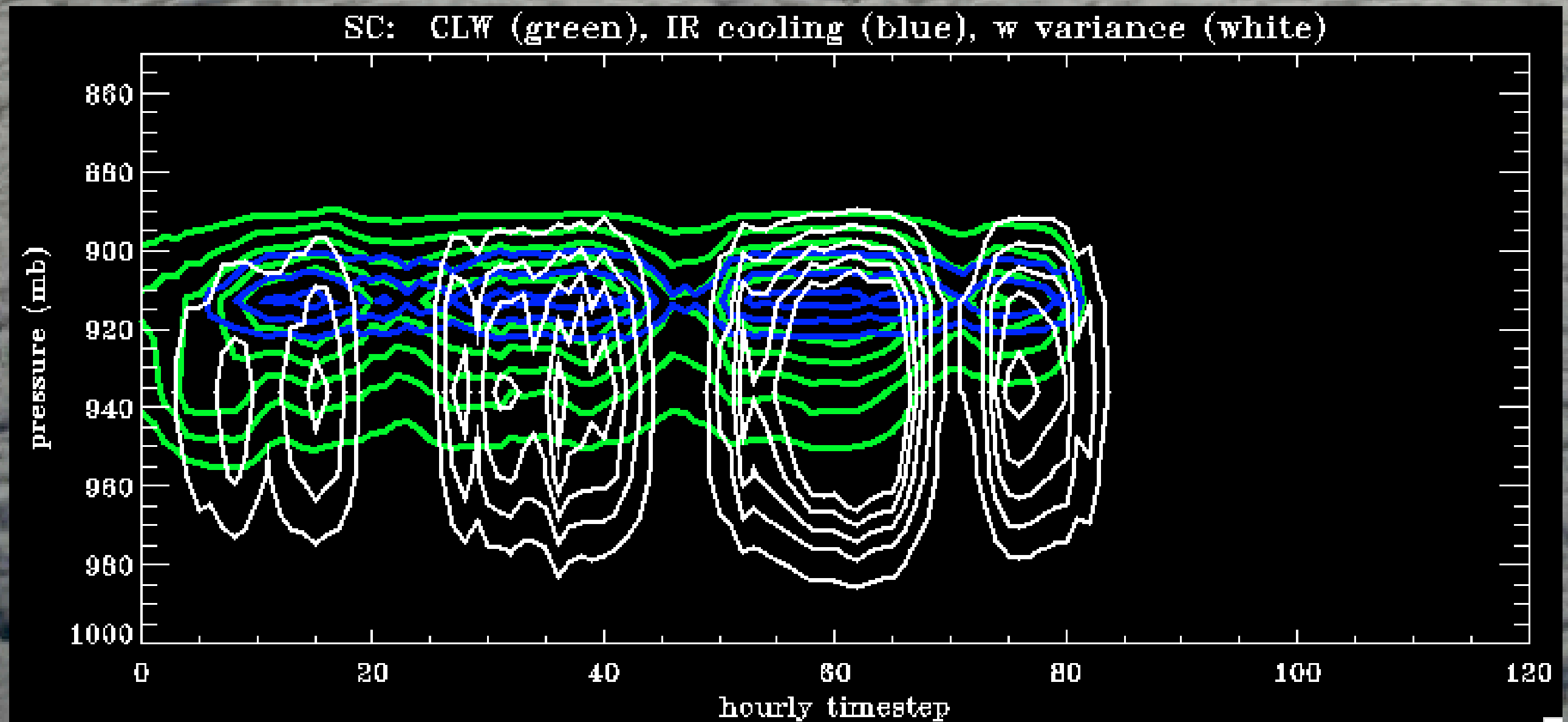
MMF fine-scale analysis

- Randomly selected a 5-day period to save hourly full-resolution SAM output
 - ▶ July 1-5, 1998
 - ▶ Saved SAM output at 32 columns x 4-km resolution x 28 vertical levels (coincident with CAM3 vertical levels).
- Examine marine Sc clouds, Sc-Cu transition clouds, and deep convective clouds along cross-section.

29N: hourly SAM output

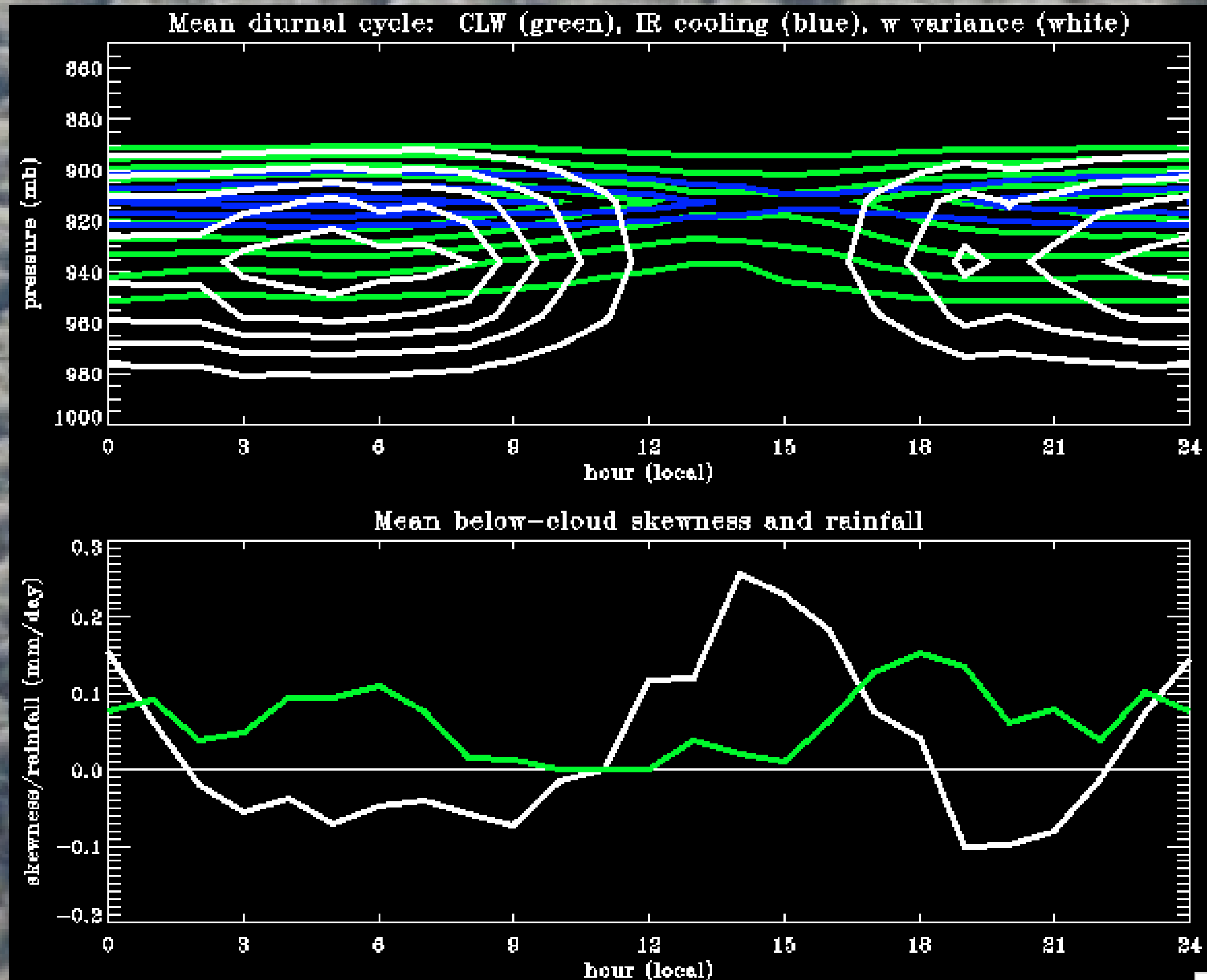


29N: an area-averaged perspective

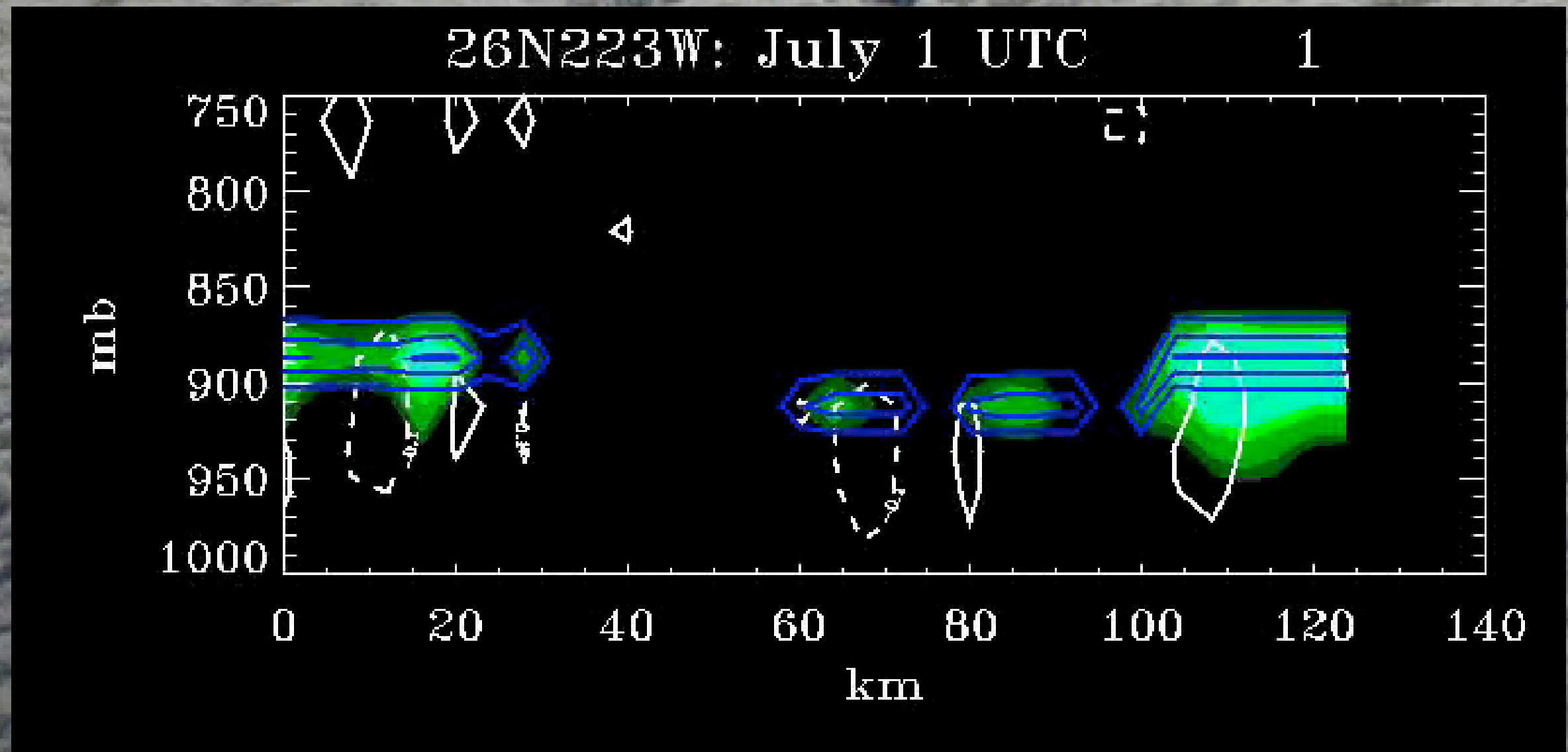


- IR cooling coincident with maximum cloud water
- w variance coincident with IR cooling
- all three vary diurnally

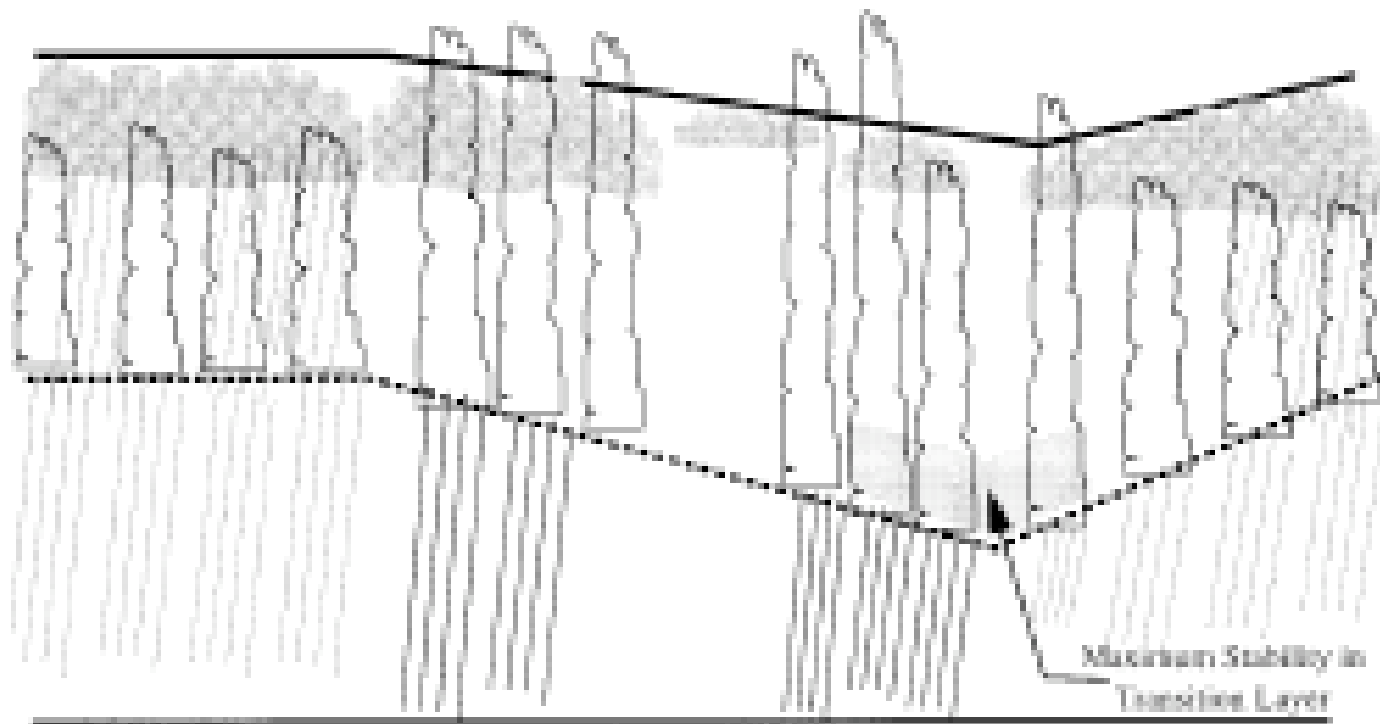
29N: what drives sub-cloud turbulence?



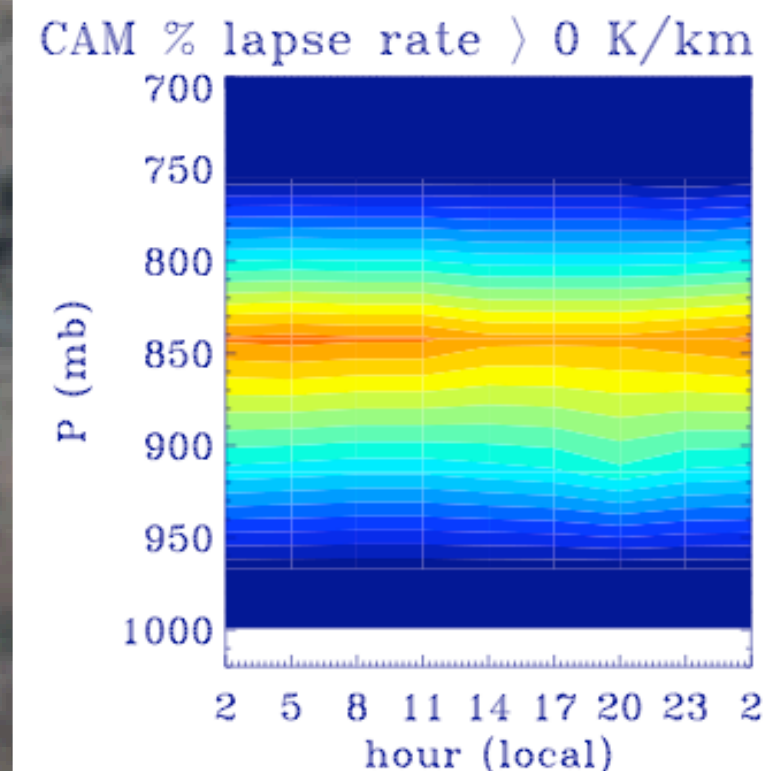
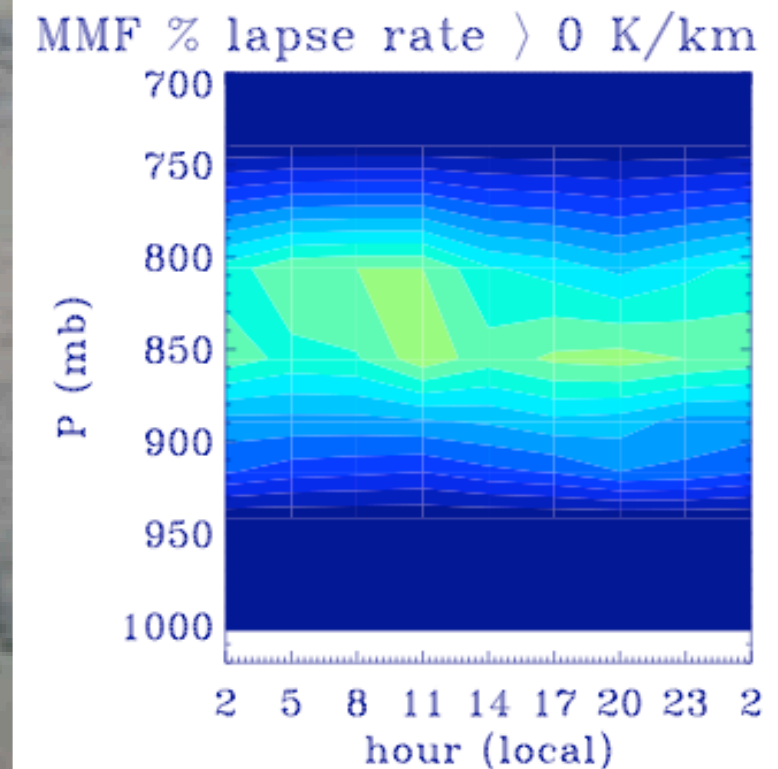
26N (transition zone) animation



26N (transition zone): mean diurnal cycle

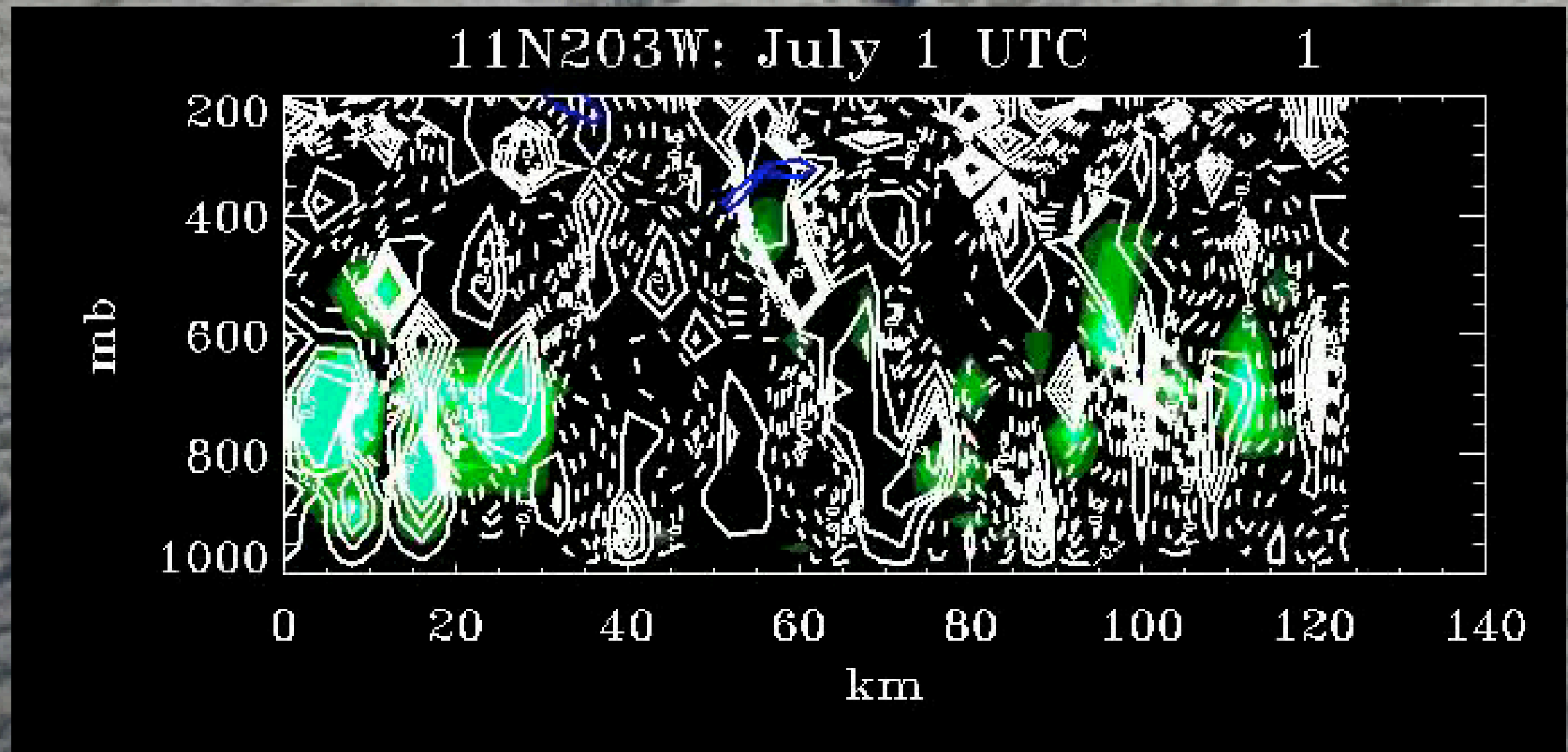


NIGHT	MORNING	AFTERNOON	EVENING
<ul style="list-style-type: none"> thick, drizzling stratocumulus shallow, weak cumulus drizzle filling subcloud layer lowest mean cloud thickness highest mean cloud base highest mean LCL 	<ul style="list-style-type: none"> drying of cloud layer warming in stratus layer beneath the inversion less numerous, increasingly vigorous cumulus highest mean cloud thickness and lowest mean cloud base due to combination of thick stratocumulus and deep cumulus measurable surface drizzle 	<ul style="list-style-type: none"> warming through most of the cloud layer increasing stability in transition layer accumulation of water vapor in the subcloud layer during late afternoon increasing CAPE in the subcloud layer deep, vigorous cumulus with mesoscale organization during late afternoon largest surface drizzle rates of the day 	<ul style="list-style-type: none"> decreasing stability in the cloud layer decreasing CAPE in the subcloud layer more numerous, weak cumulus thickening stratus drizzle in subcloud layer, not reaching surface detrainment of water vapor into the inversion layer widest range of cloud base heights



from Miller et al, 1998

ITCZ: Deep convection animation



Summary

- The good news
 - ▶ MMF appears to produce reasonable marine Sc clouds and cloud behavior despite relatively coarse resolution.
 - ▶ Transition zone PBL height variability is properly simulated.
- The bad news
 - ▶ MMF shifts ITCZ convection too far north compared to observations.