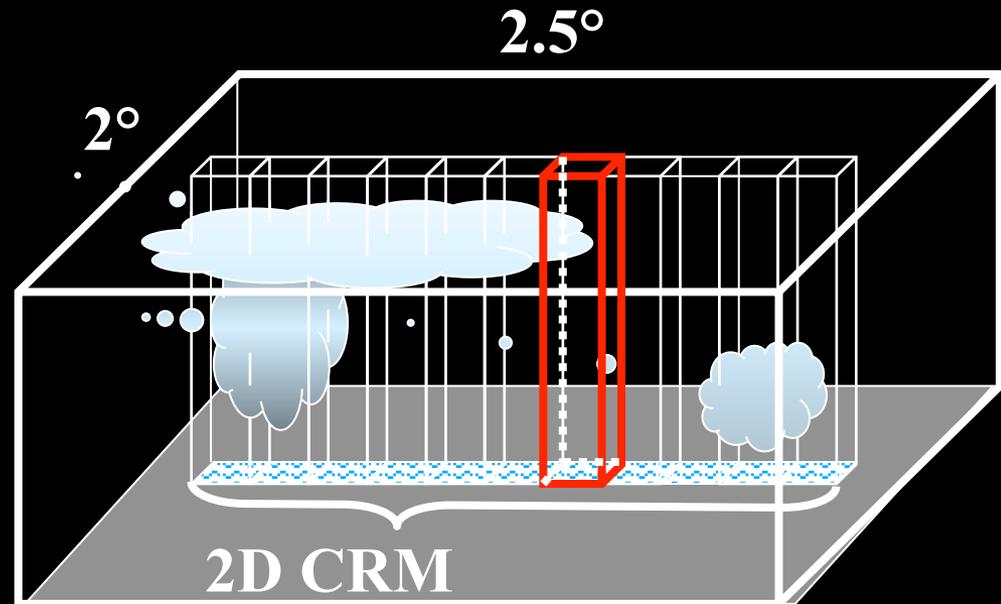


An Adaptive Vertical Grid Scheme for the Multiscale Modeling Framework

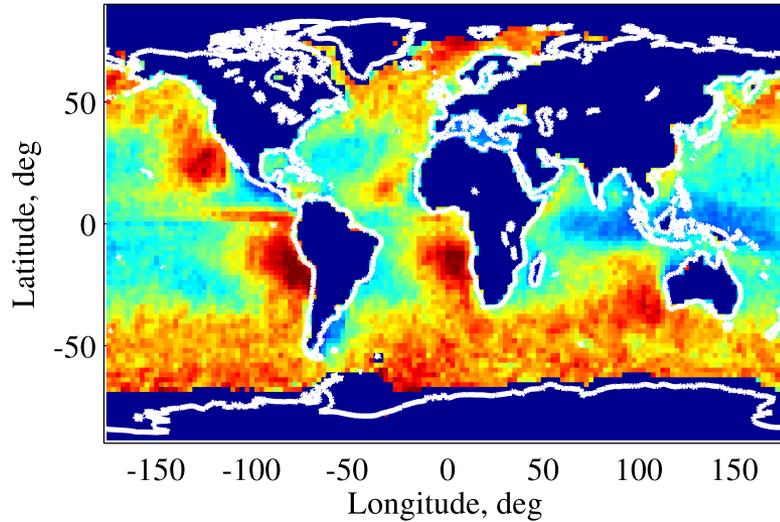
Roger Marchand, *University of Washington*

- **MMF simulations have insufficient resolution to capture “cloud-scale” motions in the boundary layer and do a poor job of capturing low clouds.**
- **Can we significantly improve CRM simulation of low clouds by adding a small number of vertical layers “just where they are needed?”**

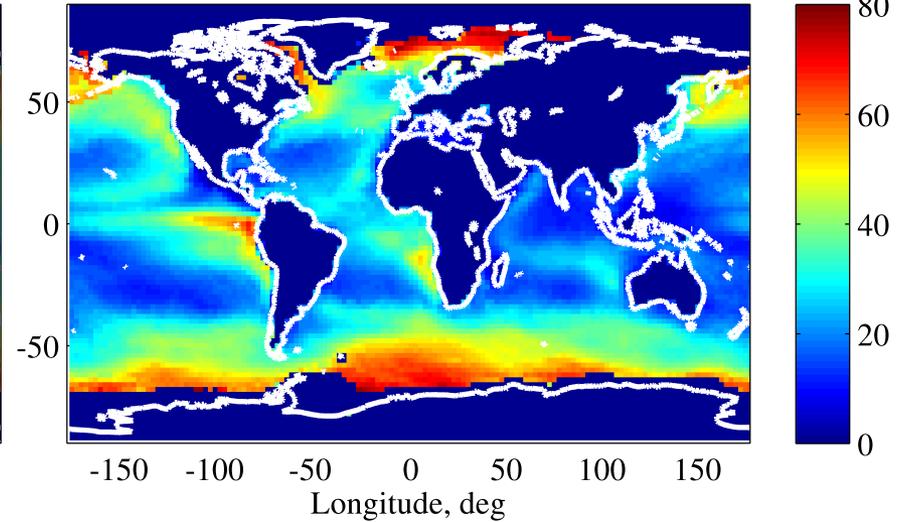


Low Cloud Cover

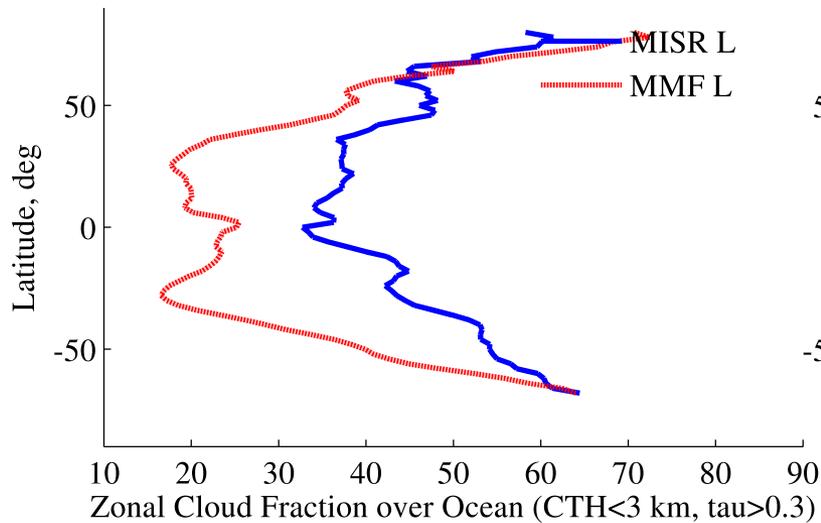
MISR L CF (CTH<3 km, tau>0.3) 2001



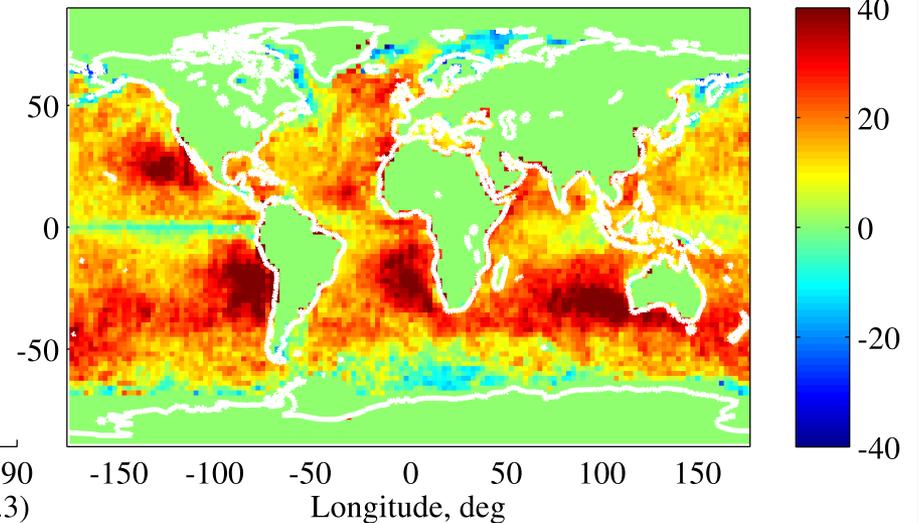
MMF L CF (CTH<3 km, tau>0.3) 2001



MISR L (43.5 %), MMF L (28.4 %)



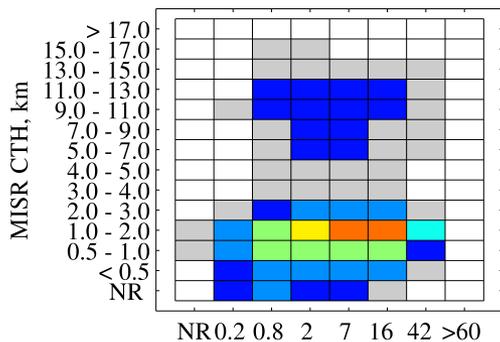
MISR L - MMF L CF (CTH<3 km, tau>0.3) 2001



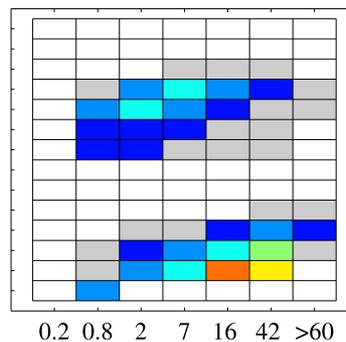
Regional CTH-OD histograms

California
Stratocumulus

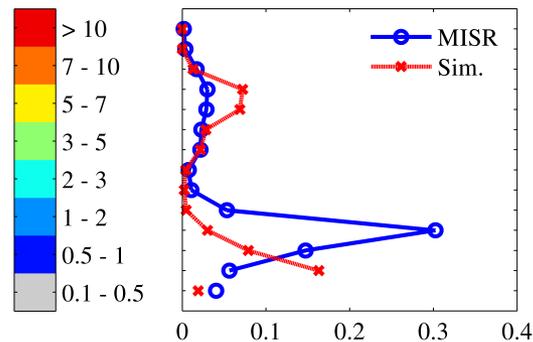
Obs. 2001, CF = 74.3% ($\tau > 0.3$)



Sim. 2001, CF = 50.6% ($\tau > 0.3$)

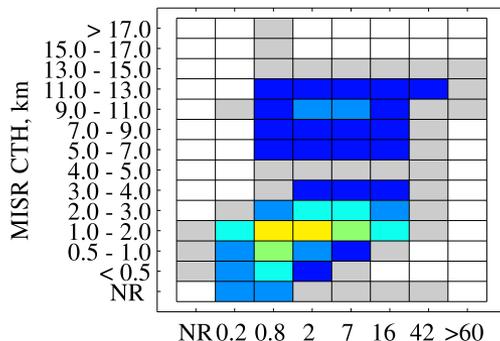


CF with Height 2001 ($\tau > 0.3$)

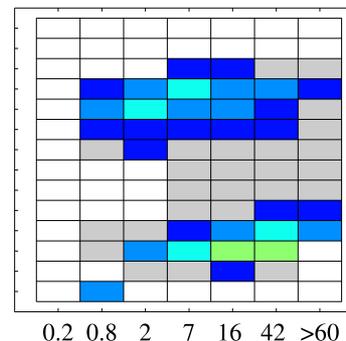


Hawaiian
Trade
Cumulus

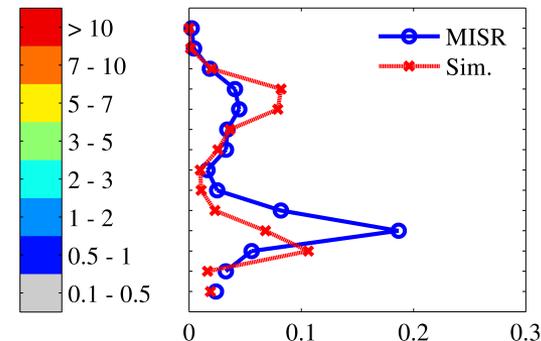
Obs. 2001, CF = 59.9% ($\tau > 0.3$)



Sim. 2001, CF = 49.8% ($\tau > 0.3$)

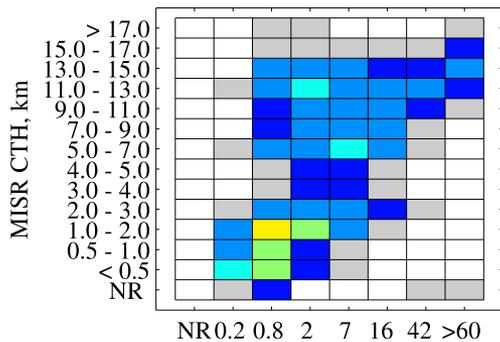


CF with Height 2001 ($\tau > 0.3$)

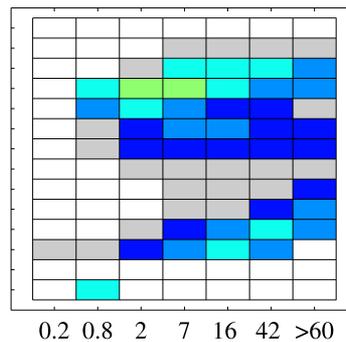


Tropical
Western
Pacific

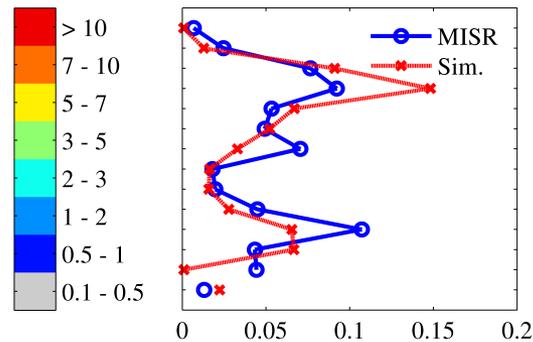
Obs. 2001, CF = 66.4% ($\tau > 0.3$)



Sim. 2001, CF = 62.0% ($\tau > 0.3$)



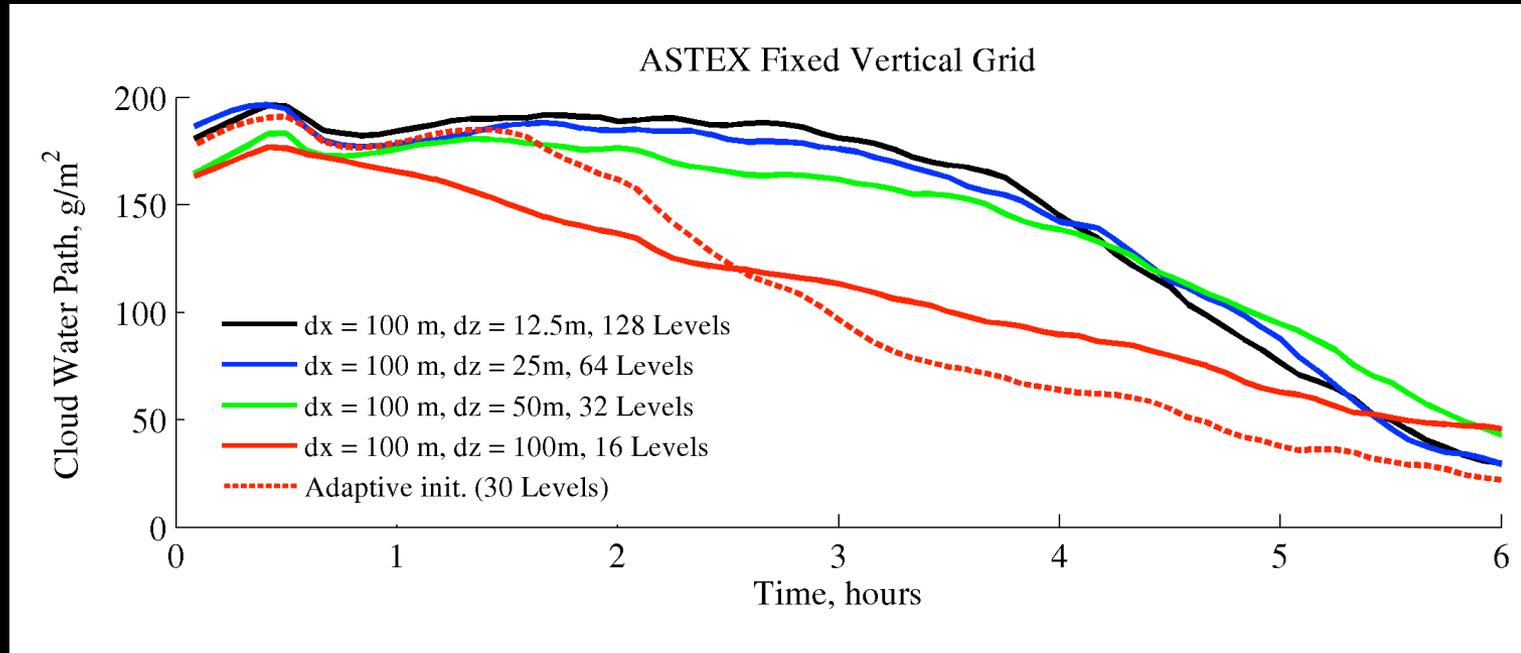
CF with Height 2001 ($\tau > 0.3$)



- **What kind of vertical resolution do we need to model stratocumulus?**

Atlantic
Stratocumulus
Transition
Experiment
(ASTEX)

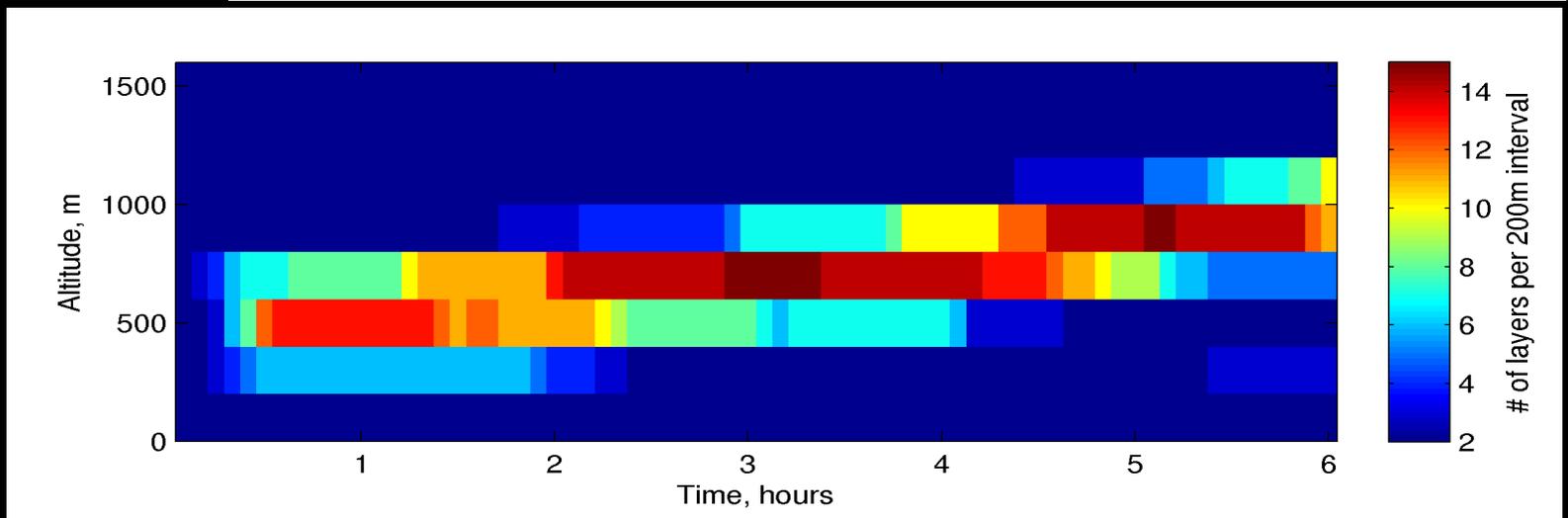
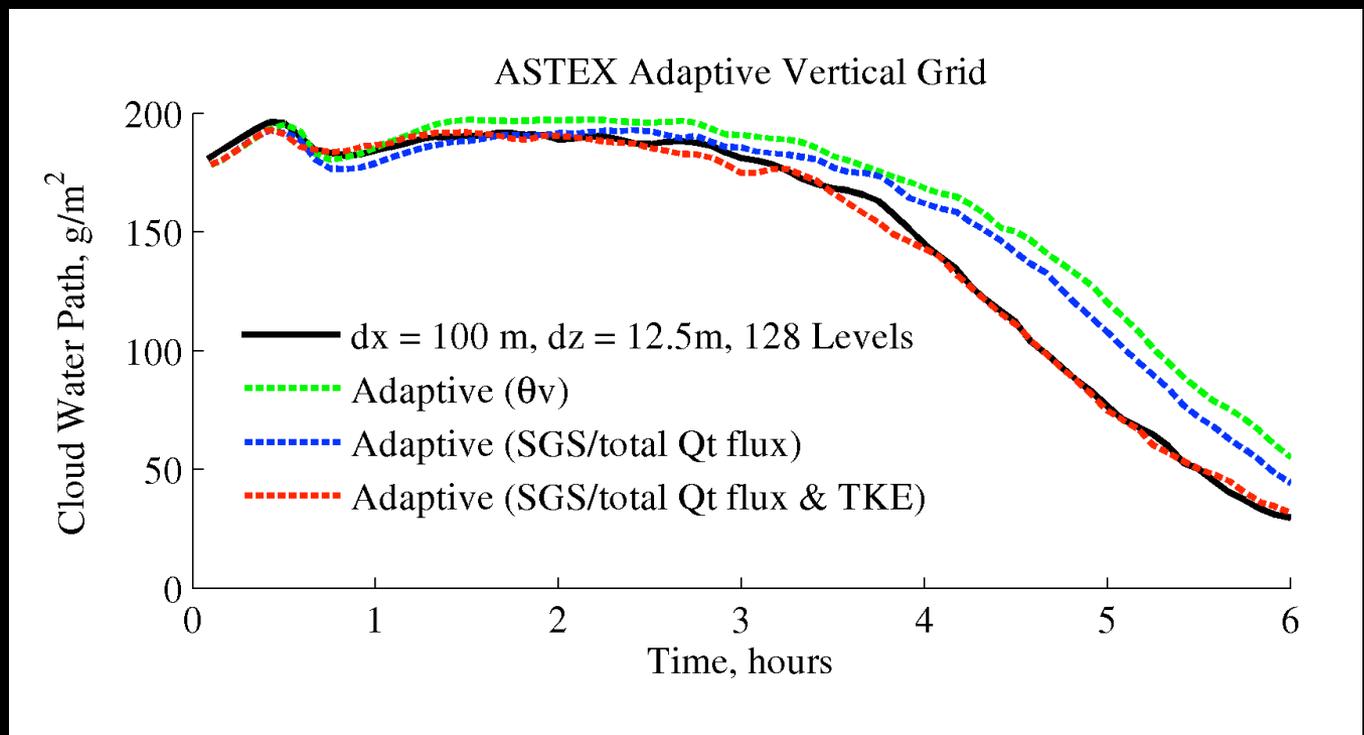
following
Duynderke et
al. (1999)



Varies from case to case, and case studies suggest ~ 25 to 10 m .

Atlantic
Stratocumulus
Transition
Experiment
(ASTEX)

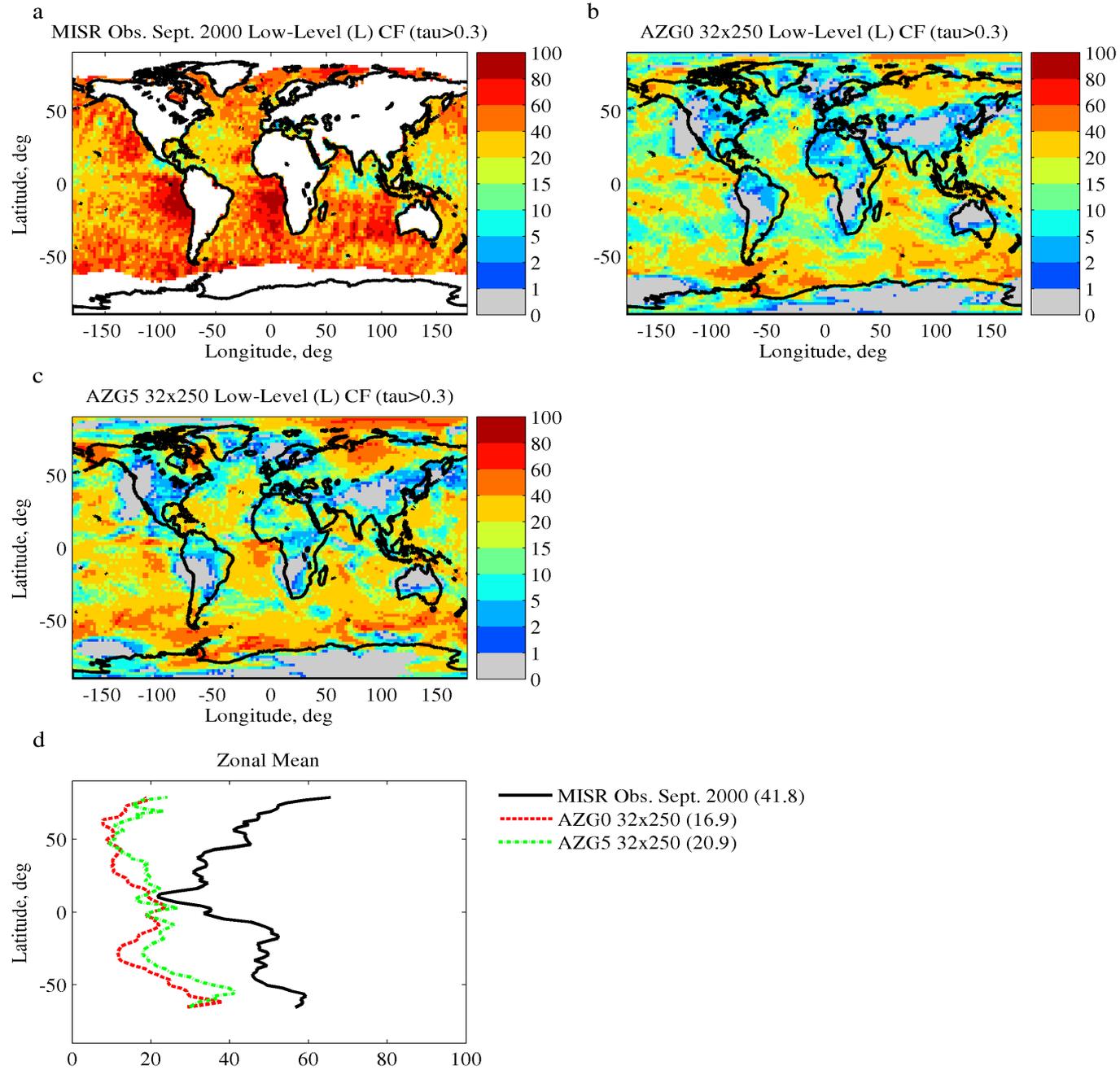
Adaptive Grid
Results



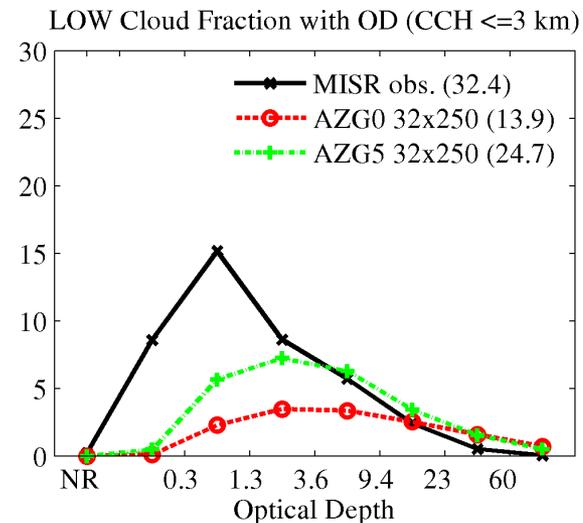
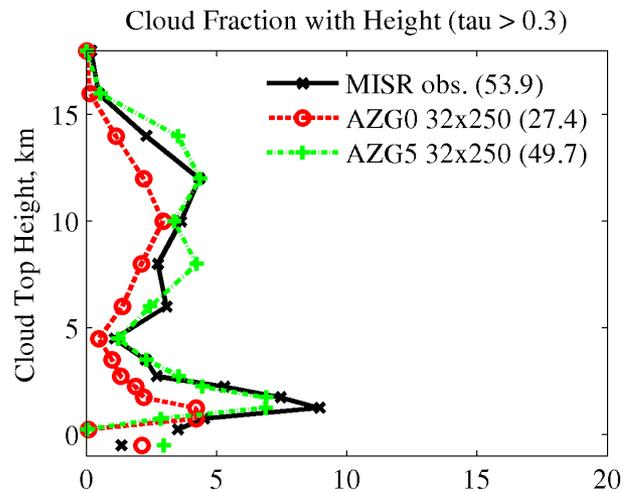
Marchand, R. and T. Ackerman (2011), A Cloud-Resolving Model with an Adaptive Vertical Grid for Boundary Layer Clouds. *J. Atmos. Sci.*, 68, 1058–1074. doi: 10.1175/2010JAS3638.1

MMF-AVG Results

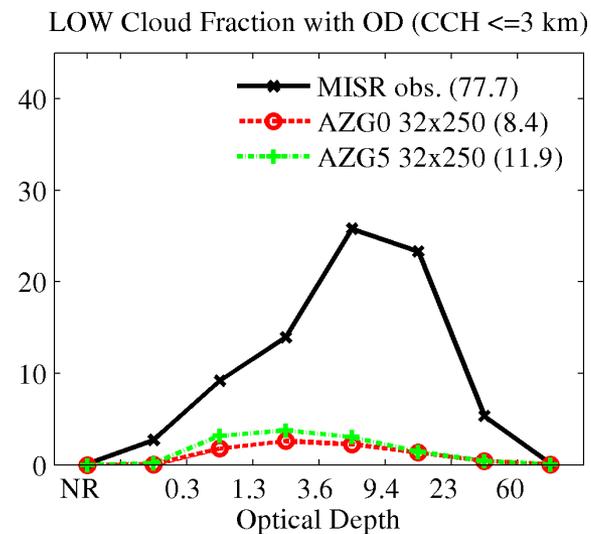
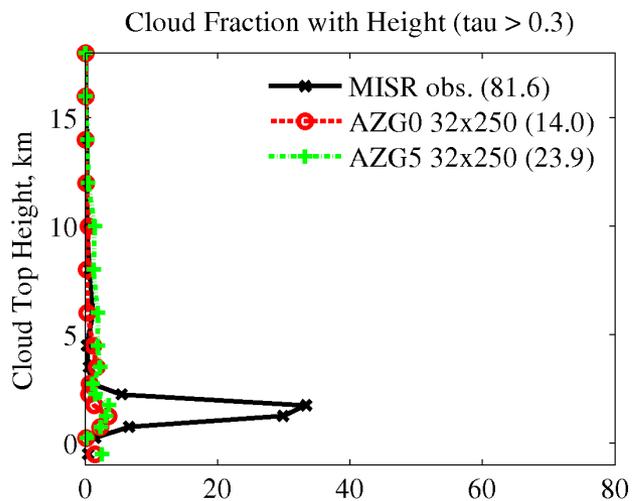
Low Cloud Cover



Hawaiian Trade Cumulus



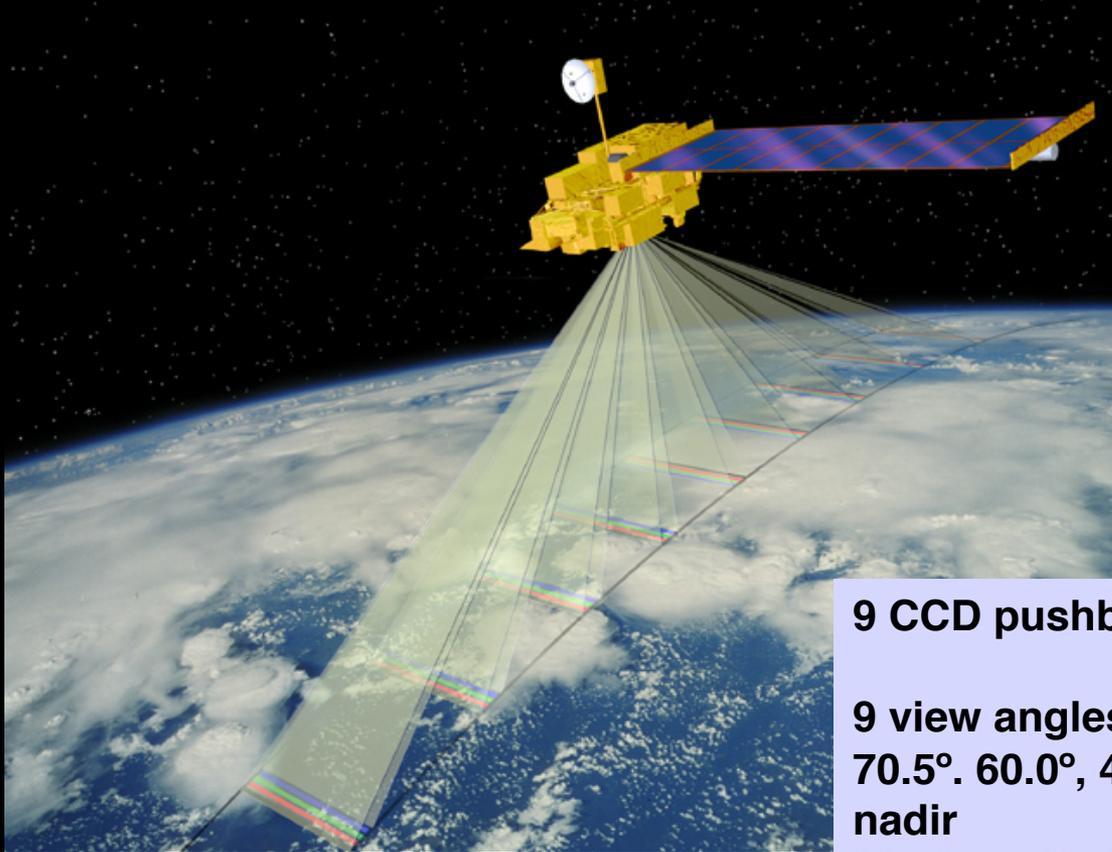
South American Stratocumulus



Closing Remarks

- **A CRM with an Adaptive Vertical Grid ((SAM –AVG 6.10) has been added to the NCAR (CAM5) MMF model.**
- **Simulations with the AVG scheme show a modest increase in low clouds.**
- **Most improvements in cloud amount and vertical structure occur in cumulus dominated regions, rather than stratocumulus regions.**
- **Why is there so little improvement in stratocumulus regions ?**
 - **1) Advection and vertical mismatch between host model and CRM**
 - **2) Insufficient vertical resolution and/or radiative coupling**
 - **3) Diffusive advection scheme (MPDATA)**

MISR Observational attributes



Polar Orbit with 400-km swath

Contiguous zonal coverage:

9 days at equator

2 days at poles

275 m sampling

**7 minutes to observe each scene
at all 9 angles**

9 CCD pushbroom cameras

9 view angles at Earth surface:

70.5°, 60.0°, 45.6°, 26.1° forward of nadir

nadir

26.1°, 45.6°, 60.0°, 70.5° backward of nadir

4 spectral bands at each angle:c

446, 558, 672, 866 nm

14-bit digitization

On-board calibration system

Stereo-imaging

- A significant advantage of the MISR CTH retrieval is that the technique is purely geometric and has little sensitivity to the sensor calibration.
- The retrieval has been the focus of several studies including Marchand et al. (2007), Naud et al. (2002, 2004, and 2005a,b), Seiz et al. (2005), Marchand et al. (2001).

