AN ANALYSIS OF CLOUD COVER IN THE MMF GLOBAL CLIMATE MODEL

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Simulating climate

Some things never change …

- From the ... Times
  Editoria... ugust 25, 1901
  on long... ate forecasting

And now, back to climate modeling!

As To ...

“THERE is more baldfaced faking done in this business than in any other.”

So spake the Weather Man. He was just

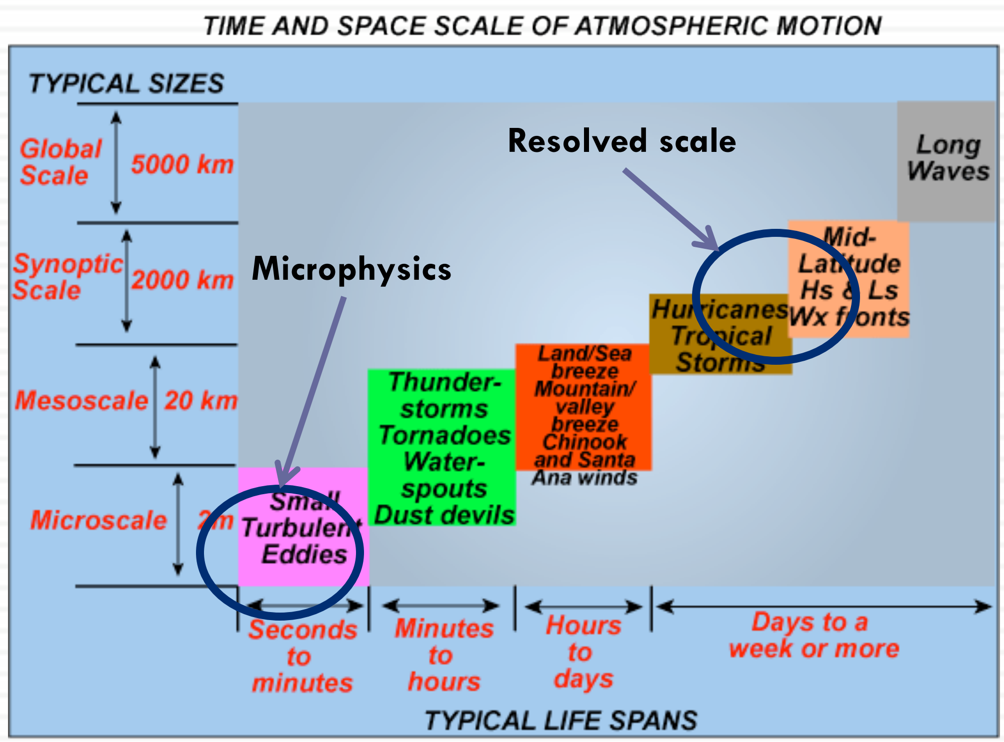
... Hence it seemed a ... rating that weather “prophets,” wi... science to hold them up, with no elaborate records to guide them, should presume to foretell months in advance just what the snow, the wind, and the rain should do.

And more …

"There are more people bunkoed by false weather prophets than lose their money on nebulous mining schemes. If it were not for the unending desire of some American people to be fooled, not a single man outside of the Weather Bureau maintained by the Government would be able to make a livelihood on 'weather prophecies' in the United States."

Aerosol indirect effects in climate models

- Huge mismatch between resolved scale and microphysical processes
- Parameterizations largely divorce microphysics from relevant dynamical motions and environmental conditions
- Tendency to get out what you put it *

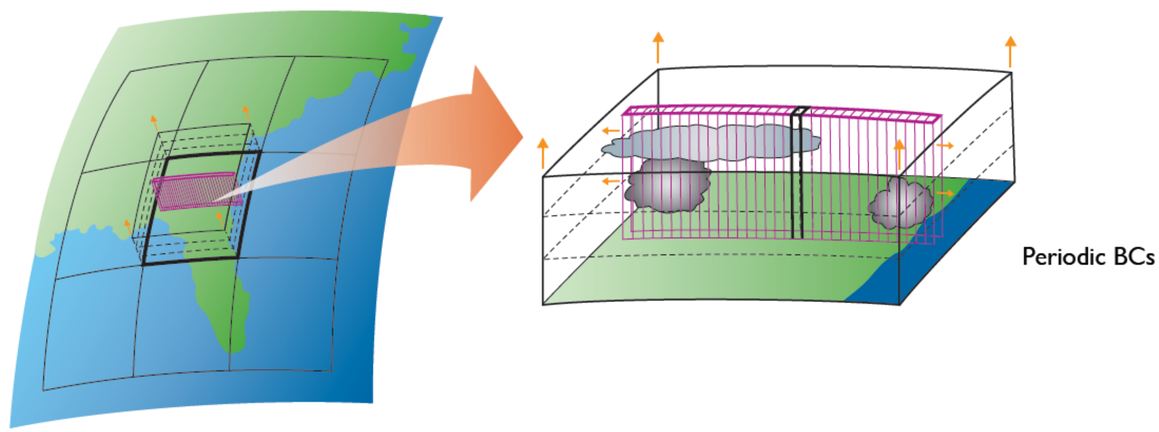


* Okay, this is a *little* dramatic, but there is a lot of truth in this statement

So what's the MMF and can it help?

Super-Parameterization

(a.k.a. the Multiscale Modeling Framework, or MMF)



A super-parameterized climate model is about 250 times slower than a conventional GCM with climate resolution.

It is more flexible and less expensive, but also more complicated, than a global cloud-resolving model.

Borrowed from Dave Randall, CSU

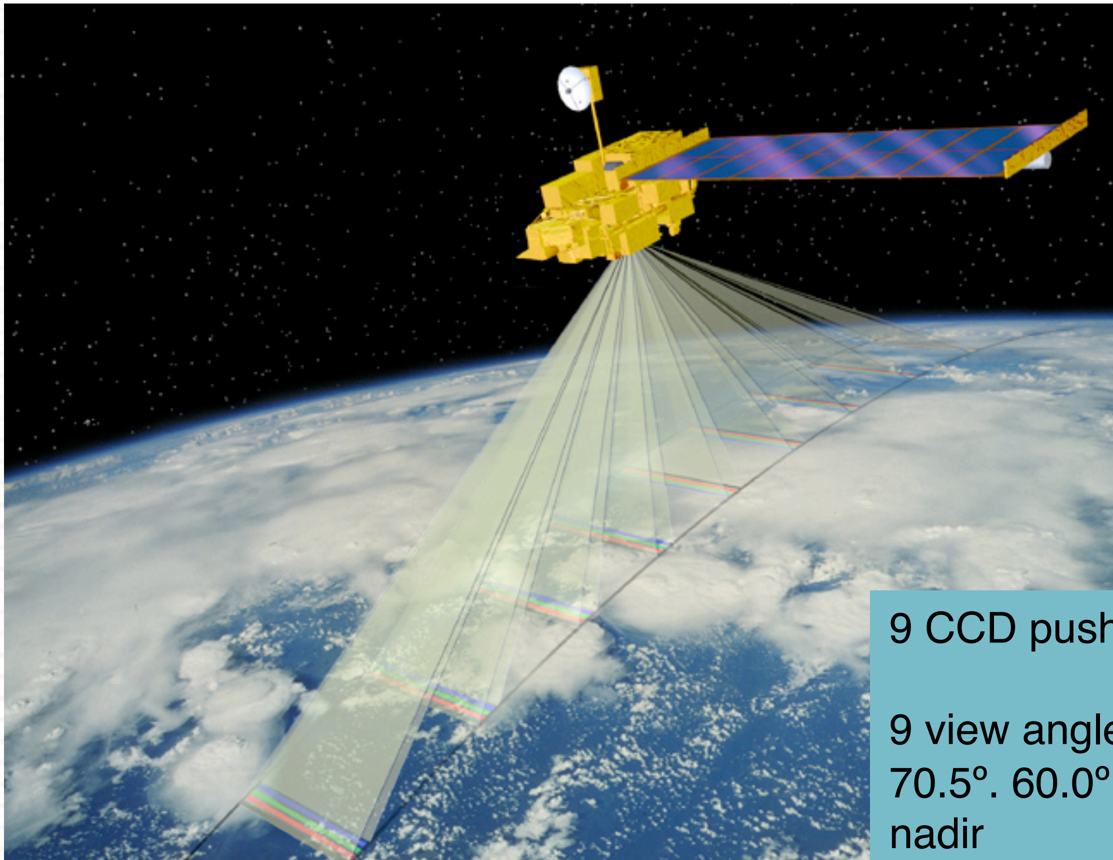
Why use the MMF?

- Computes cloud-scale (okay, sort of cloud scale) motions explicitly
- Requires no cloud parameterizations (does require turbulent closure)
- Can include more co plex microphysical schemes directly (Morris oment microphysics)
- Can p tly into the mi
- Explo current GCMs

Is this true for boundary layer clouds?
What horizontal resolution is needed for CRM?

Evaluating low clouds in the MMF

MISR Observational attributes



Polar Orbit with 400-km swath

Contiguous zonal coverage:
9 days at equator
2 days at poles

275 m sampling

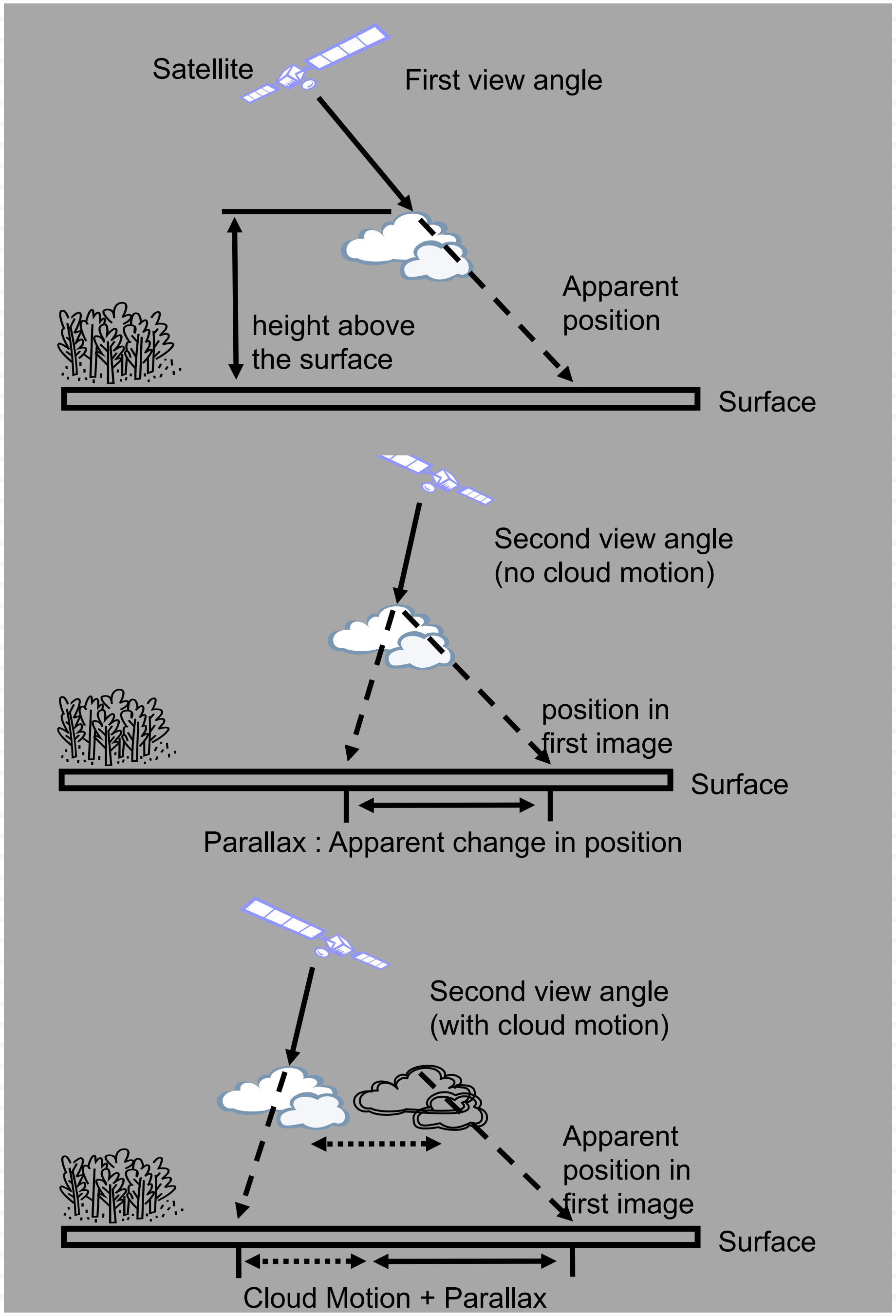
7 minutes to observe each scene at all 9 angles

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:
446, 558, 672, 866 nm

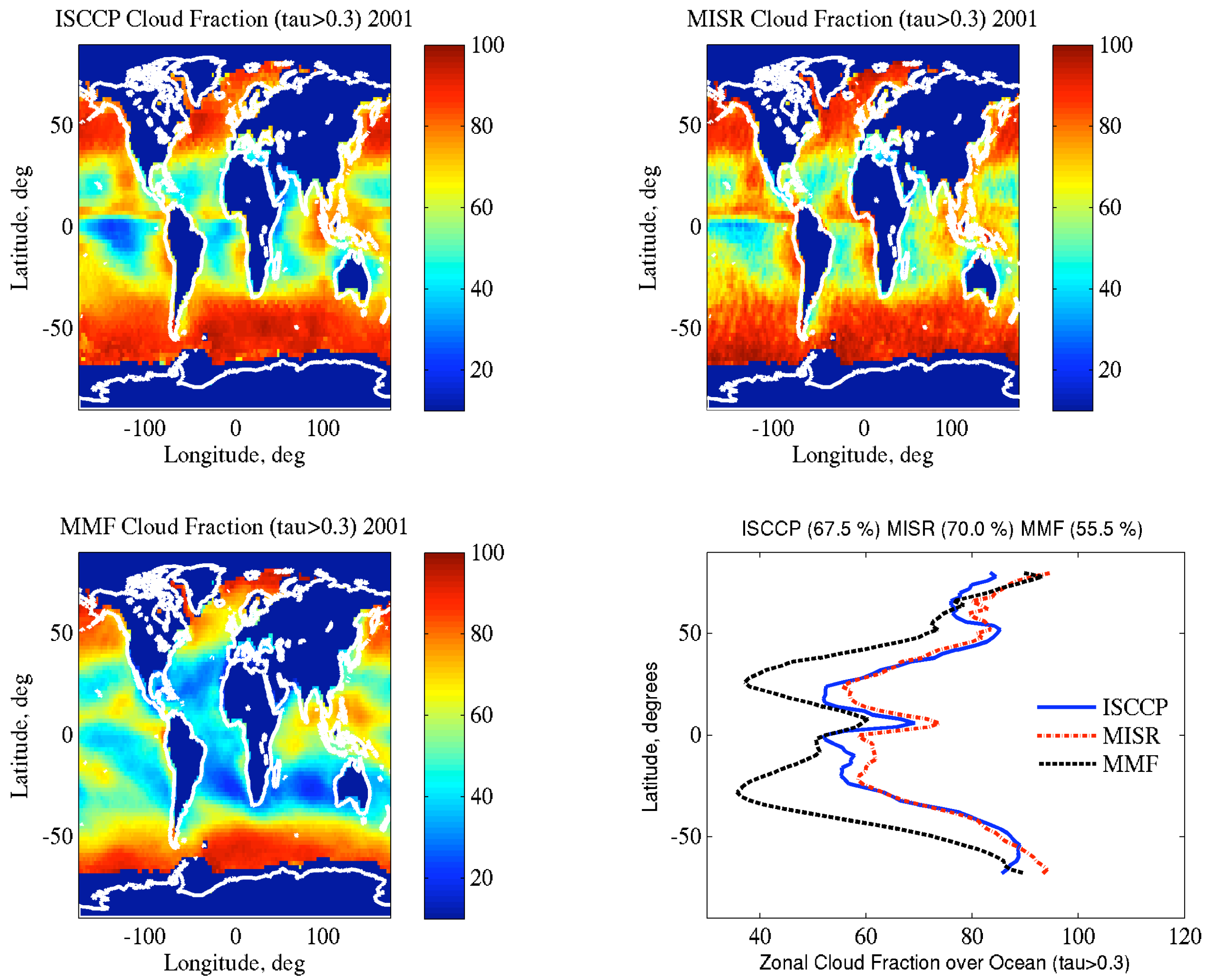
14-bit digitization
On-board calibration system



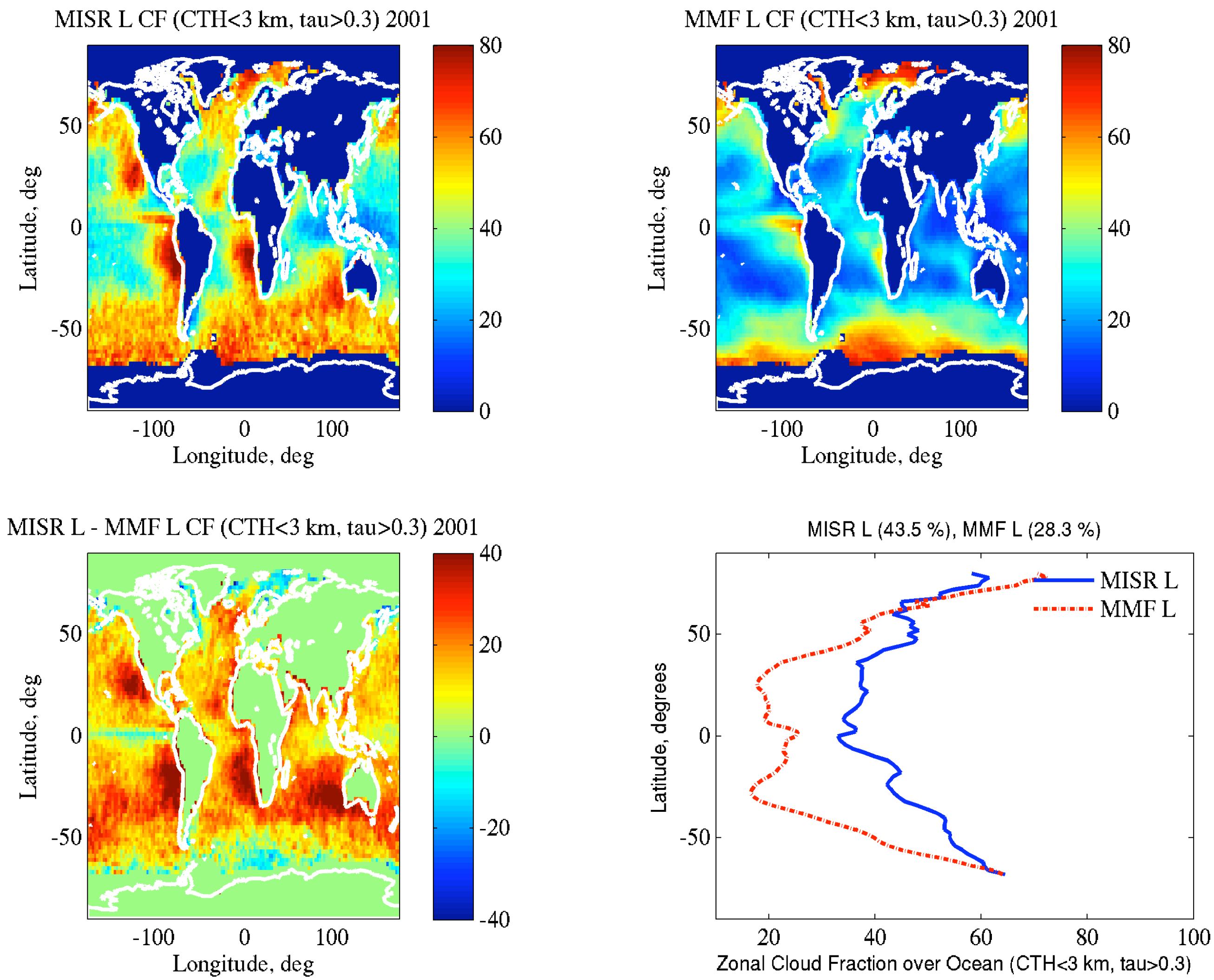
Stereo-imaging

- MISR CTH retrieval is purely geometric; little sensitivity to sensor calibration
- Very good for low clouds (strong contrast helps pattern recognition algorithm)
- References:
  Marchand et al. (2007),
  Naud et al. (2002, 2004, 2005a,b)
  Seiz et al. (2005),
  Marchand et al. (2001).

Total Cloud Cover (annual)



Low Cloud Cover (annual)

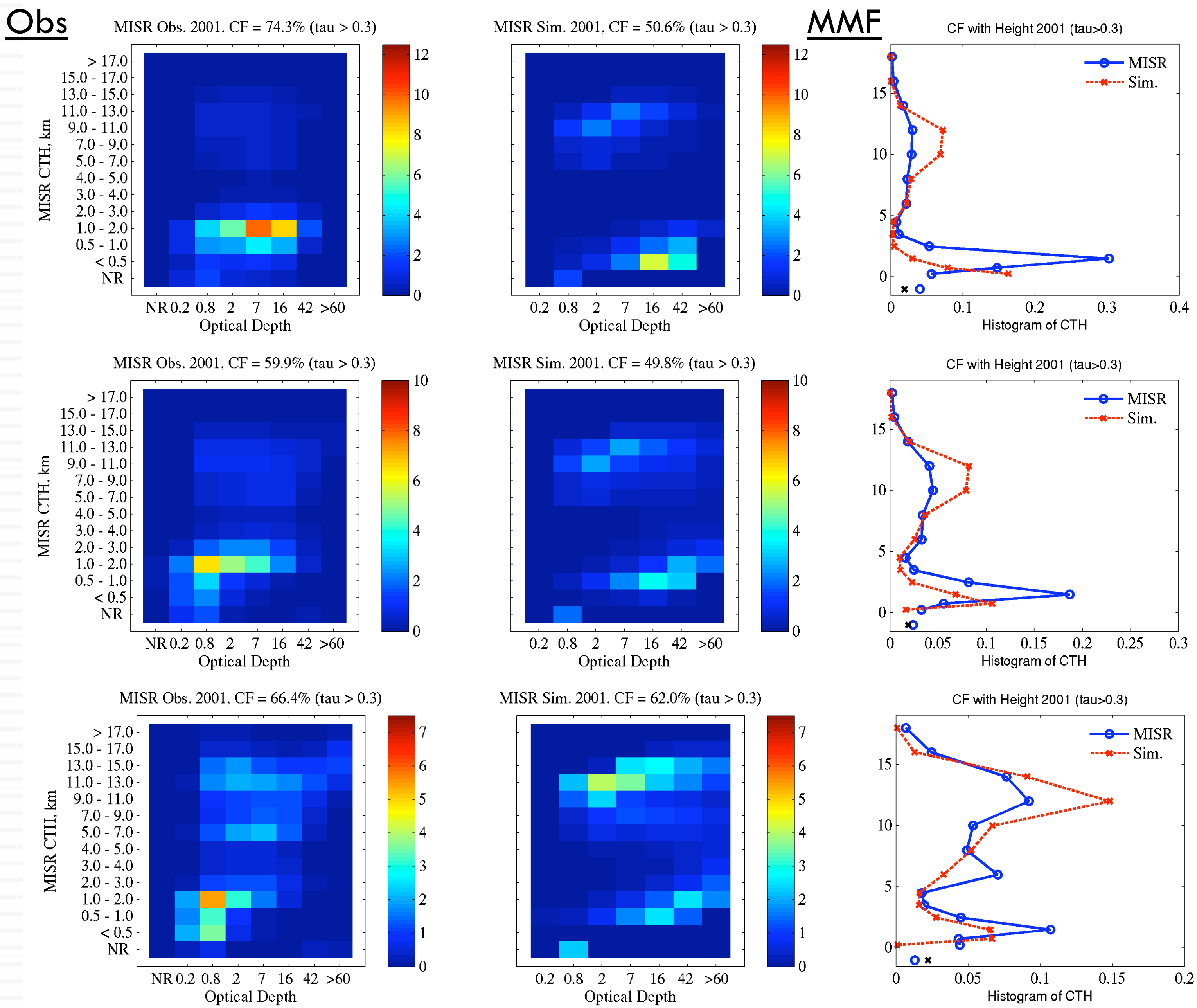


Regional CTH-OD histograms (annual)

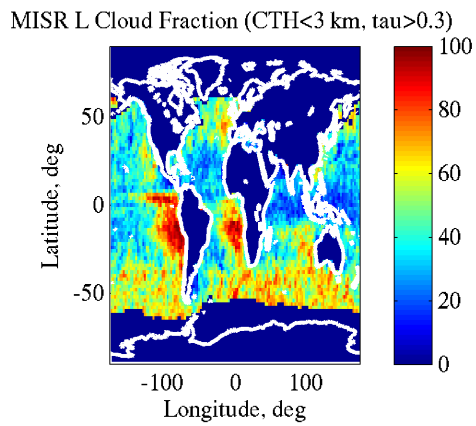
California Stratocumulus

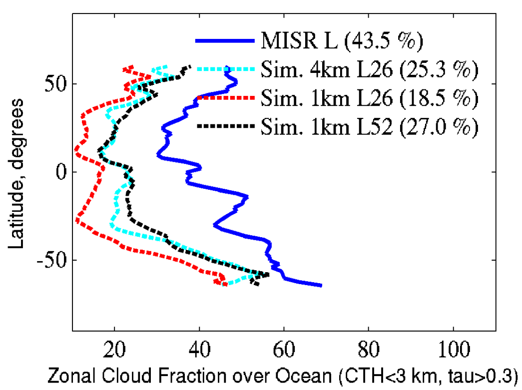
Hawaiian Trade Cumulus

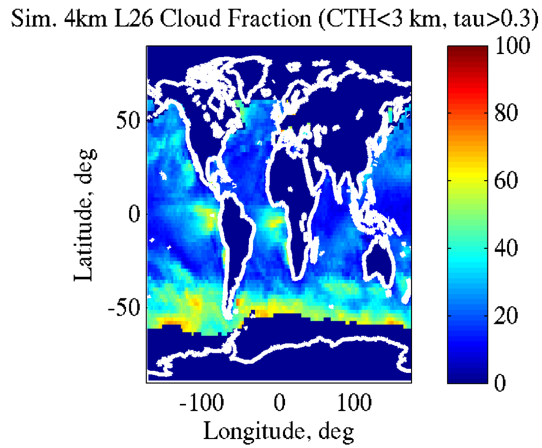
Tropical Western Pacific

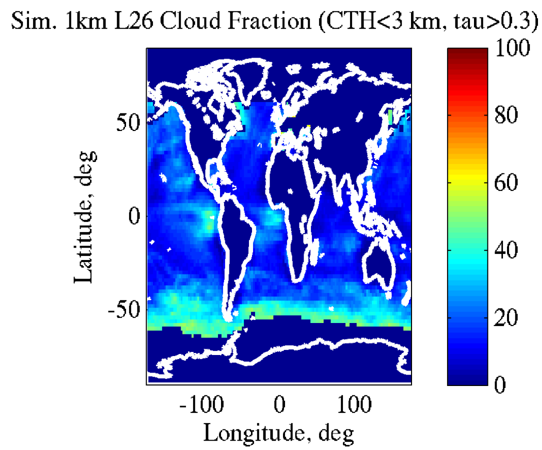


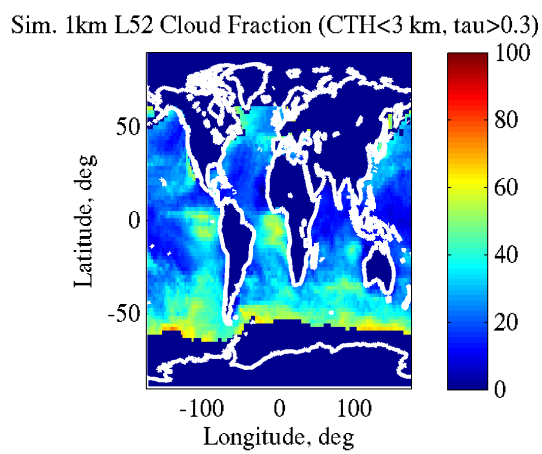
Sensitivity of low cloud amount to CRM resolution









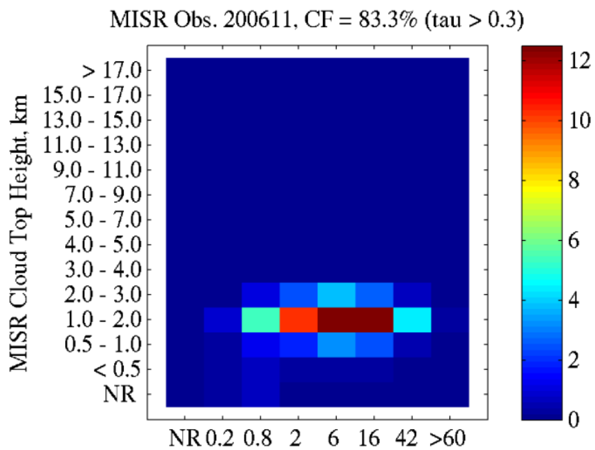


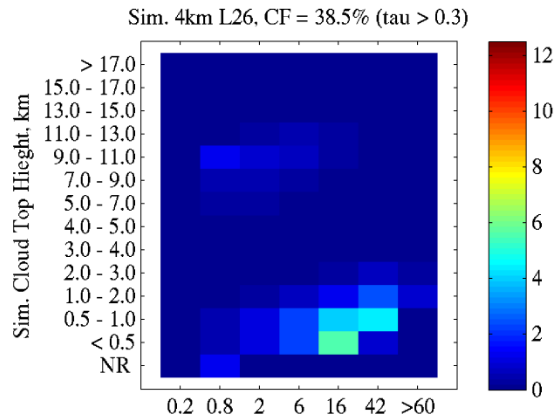
Control
- 4 km horizontal
- 64 columns
- 26 vertical layers

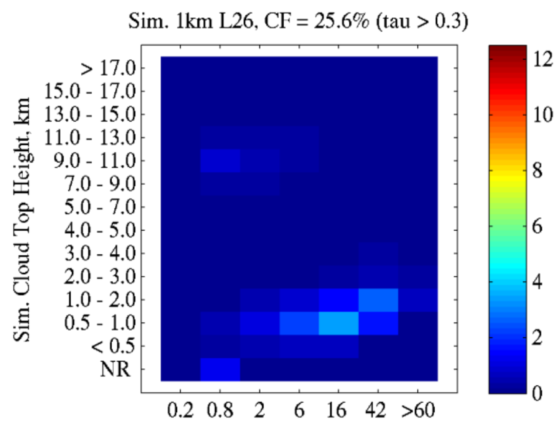
- Test A
  - 1 km horizontal
  - 64 & 128 columns
  - 26 vertical layers

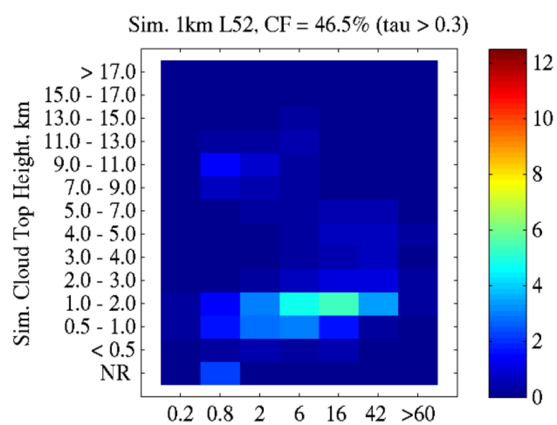
- Test B
  - 1 km horizontal
  - 64 columns
  - 52 vertical layers

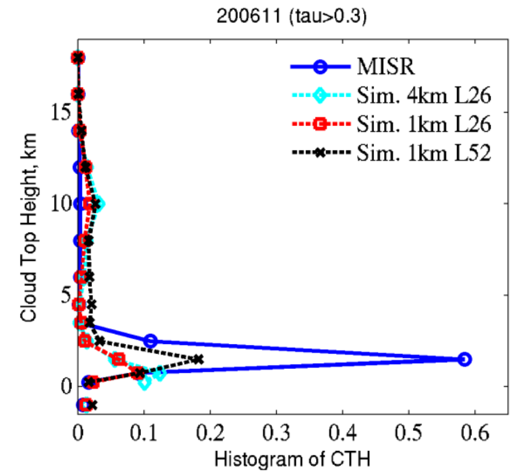
South American Stratocumulus

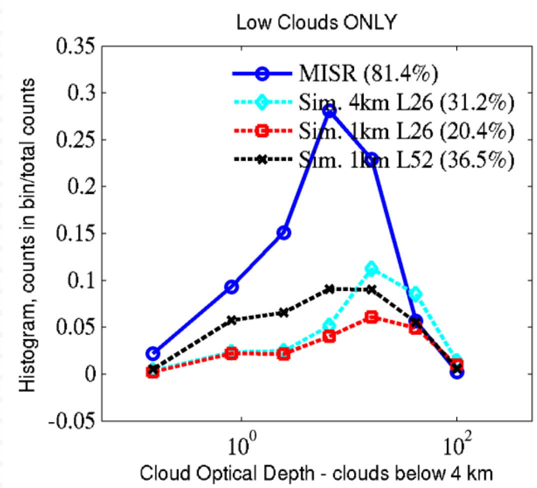




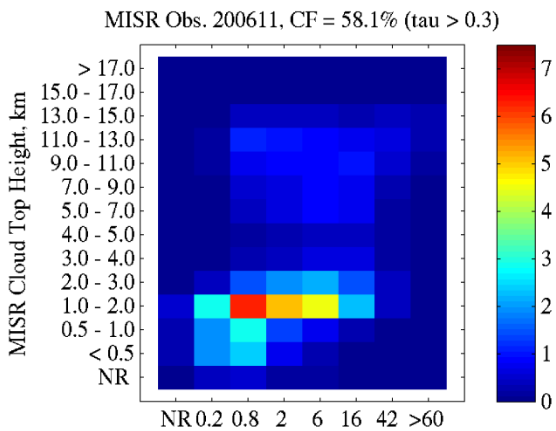


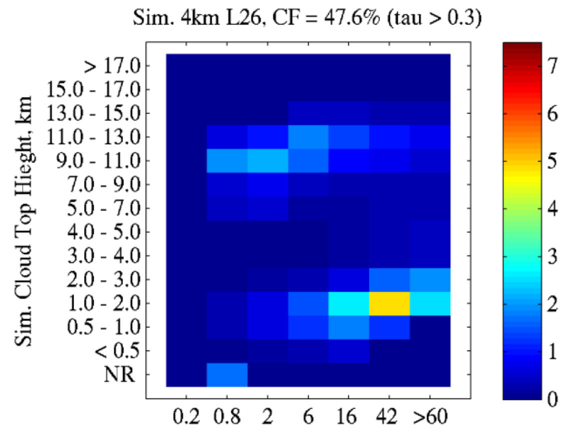


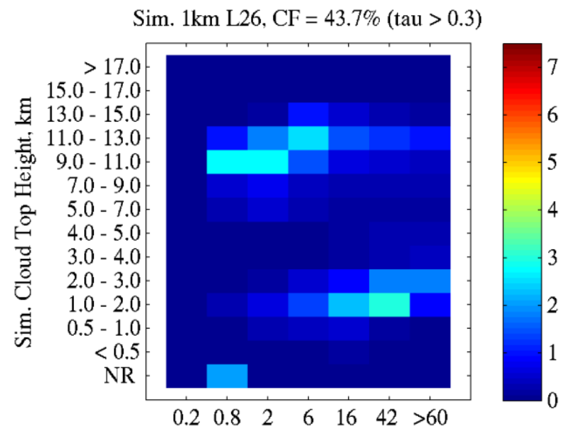


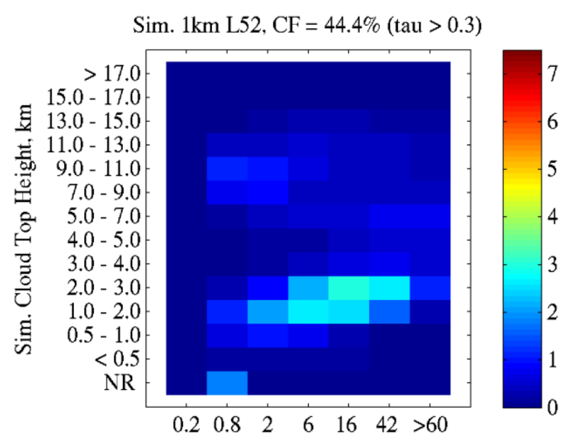


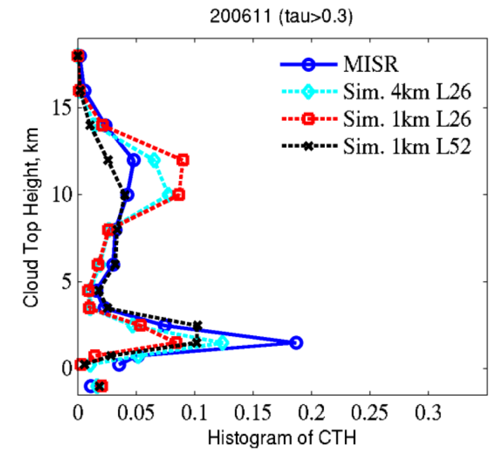
Hawaiian Trade Cumulus

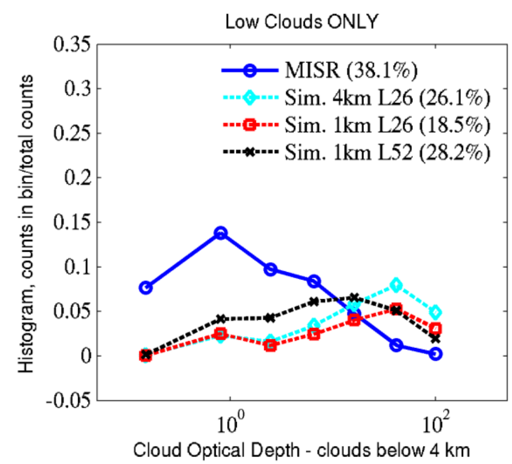












What now? Improve the MMF!

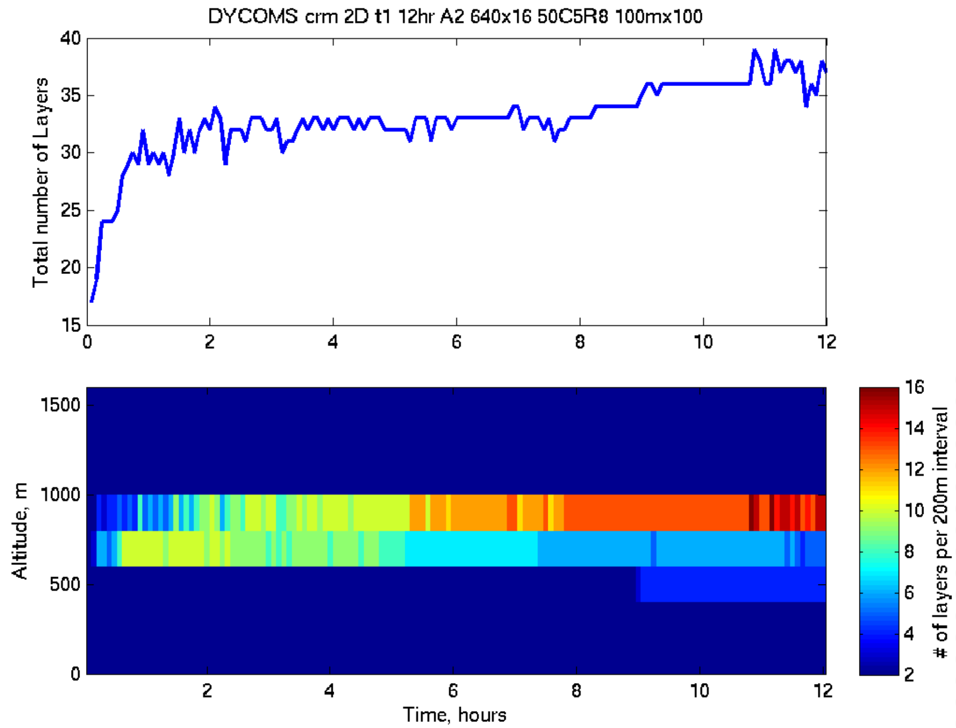
- Brute force
  - Can we actually get a reasonable simulation of BL clouds with an MMF if we go to sufficiently high CRM resolution?
  - UW group (Marchand, Blossey, Bretherton, Ackerman) running simulation at 250 m and 52 vertical levels *
  - Can only afford to run 1+ month on NSF Teragrid computer (Purdue Steele: 893 dual quad-core Dell 1950 compute nodes, running Red Hat Enterprise Linux; run on 512 so far)
  - Intended as proof of concept at this point
- Subtle approach – adaptive vertical grid in SAM (Marchand)

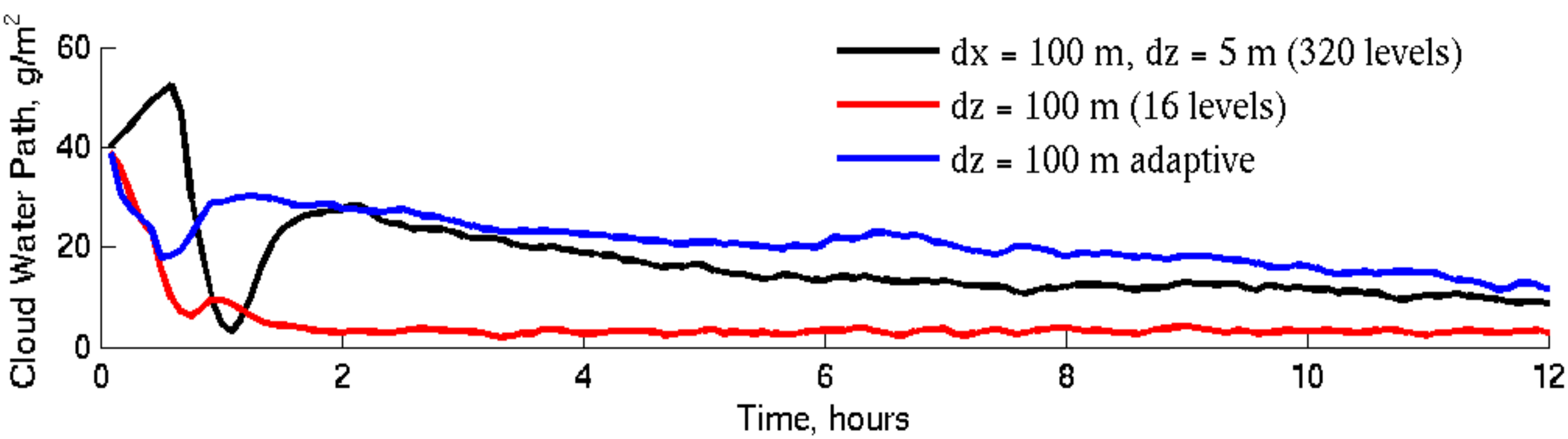
* Computer time and support courtesy of CMMAP at CSU

Adaptive Vertical Grid Simulation of DYCOMS-II

Modified SAM:

- Vertical layers are addressed by an index array (data can be stored vertically in any order)
- Layers are added or removed (mass and energy are conserved).
- Criteria: Using ratios of subgridscale to total vertical fluxes – work in progress (threshold to add << to remove)





Testing SAM versions

- Versions: (1) Morrison microphysics, (2) adaptive grid, (3) high spatial resolution grid (1 km, 250 m)
- Test SAM in 3D and 2D for short-term forcing data sets like ARM 97 SGP and TWP-ICE
- Run 2D versions for a year using SGP ARM forcing data set and ECMWF in TWP
  - Evaluate with ARM data
- Run MMF with 2D CRF selected by testing
  - Evaluate with ARM data, CloudSat, MISR, ISCCP

And what about the aerosol …

- Aerosol physics being implemented in MMF by Steve Ghan and colleagues at PNNL
- Explicit Clouds – Parameterized Pollutants
  - Compute cloud properties with CRM in MMF
  - Use grid cell mean properties from CRM to drive pollutant processing by clouds and radiation effects at large grid cell
  - Want to know more? Talk to Steve
- Implement this scheme into improved CRM

Our other project - Classification

- Sort atmosphere into dynamical regimes or states using NWP re-analysis fields using neural net
- Identify clouds associated with each state using ground-based mm-wavelength radar (composite profiles) and ultimately CloudSat (A-Train)
- Sort model fields into same states and compare composite cloud profiles (use radar simulator)
- Scheme works at SGP; research underway at TWP
- Happy to discuss this with anyone interested
- R. Marchand, N. Beagley, T. Ackerman, 2009: Evaluation of Hydrometeor Occurrence Profiles in the Multiscale Modeling Framework Climate Model Using Atmospheric Classification, J. Climate, 22, 4557


Thank you for your attention!