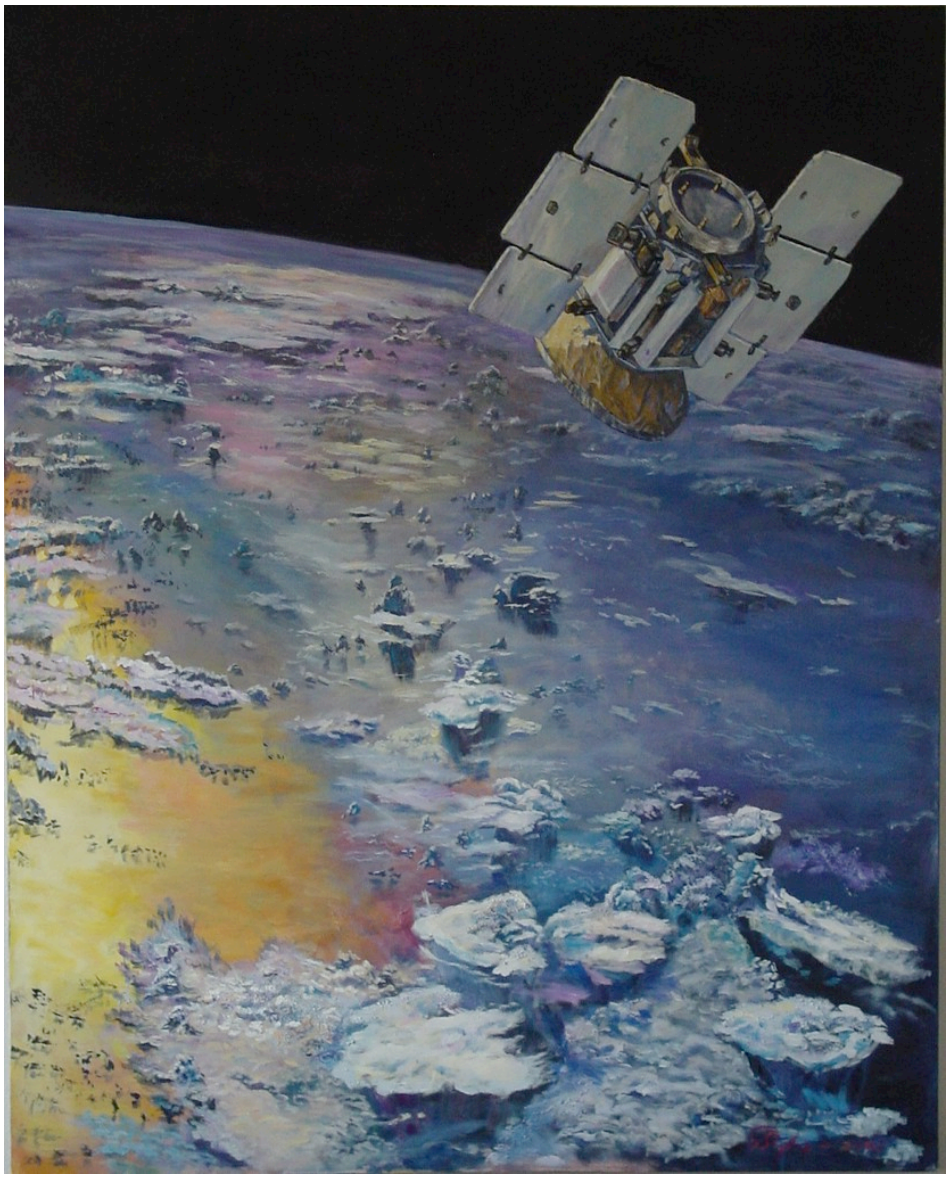
Cloud Parameterizations, future observing systems, data assimilation…

-Introduction to upcoming CloudSat and A-train experiment as relevant to cloud parameterization

Closer match between *global* observations and resolved 'cloudiness' as represented in CSRMs

- Thoughts about evaluation of model parameterization
- Thoughts about steps to cloud data assimilation

-Thoughts on the representativeness issues of super-parameterization and how satellite data might help



CloudSat and the A-train

•What (Mission Objective): Provide, from space, the first global survey of profiles of cloud physical properties, cloud and precipitation occurrence.

• **How (main features)**

➔ mm radar (CPR), nadir,500m vertical resolution, ~ -29dBZ minimum detectable signal)

➔ formation flying- 'A-train'

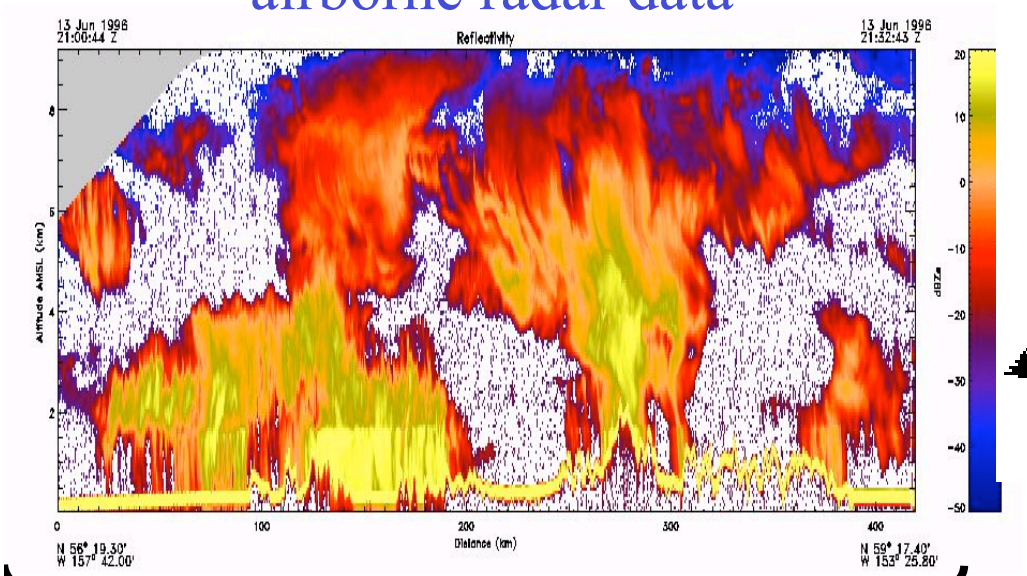
➔Cloud information comes from combinations of active and passive

• **When** Expected Launch in 2004 polar orbit, duration 2 yrs (fiscal), 5yrs (tech)

BAMS article, Dec 2002

Observe cloud & precipitation as part of single ‘weather systems’

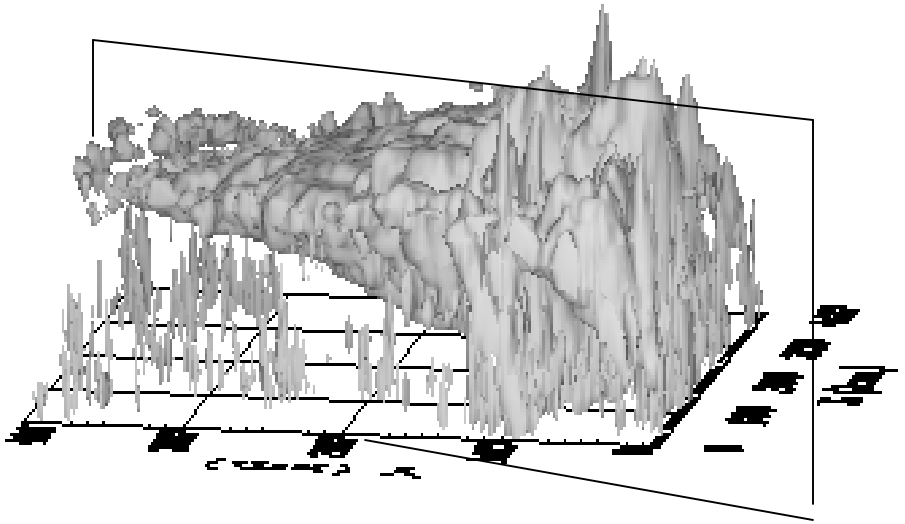
Example of DC8 airborne radar data



~200 km

CloudSat-like

CSRM simulation of a tropical MCS

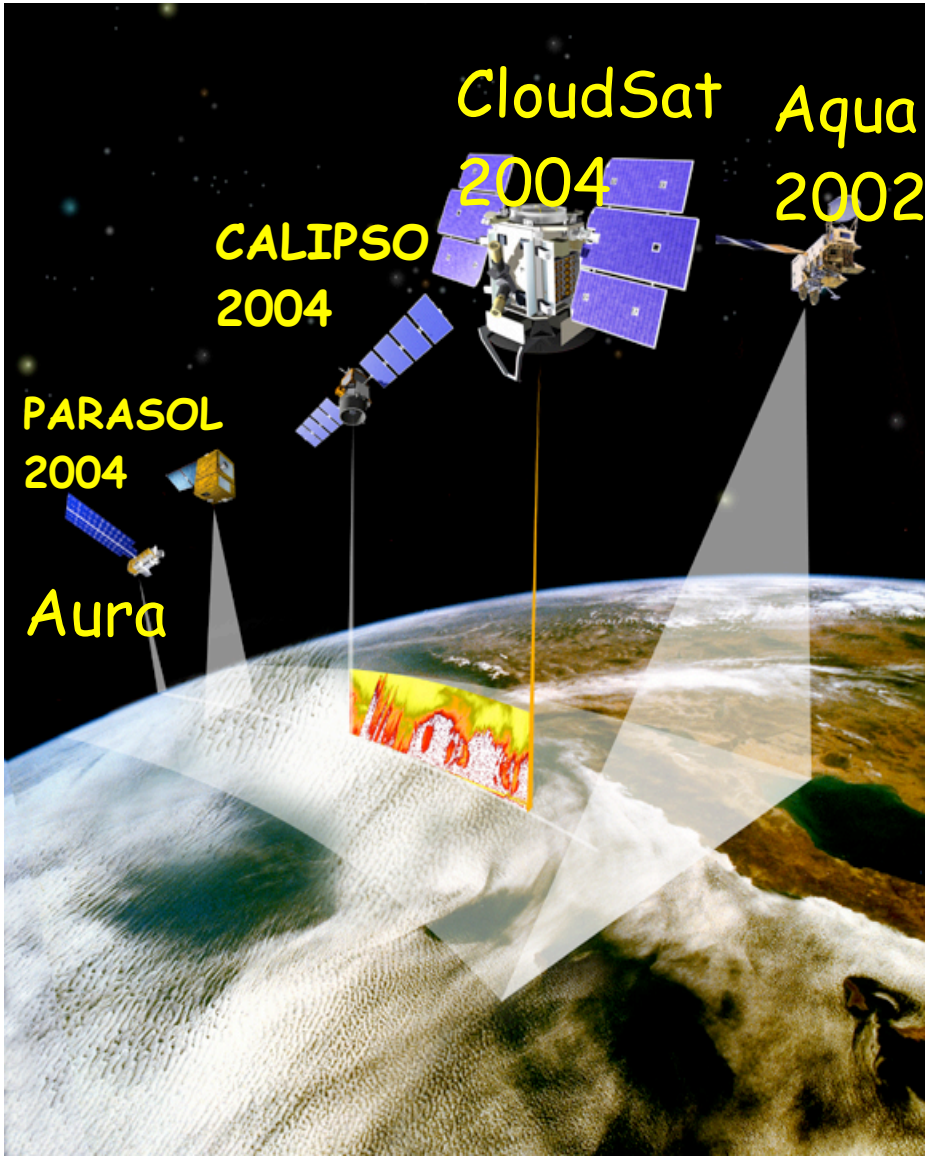


Has the sensitivity and dynamic range to observe optically thin cirrus and deep meso-scale convective complexes

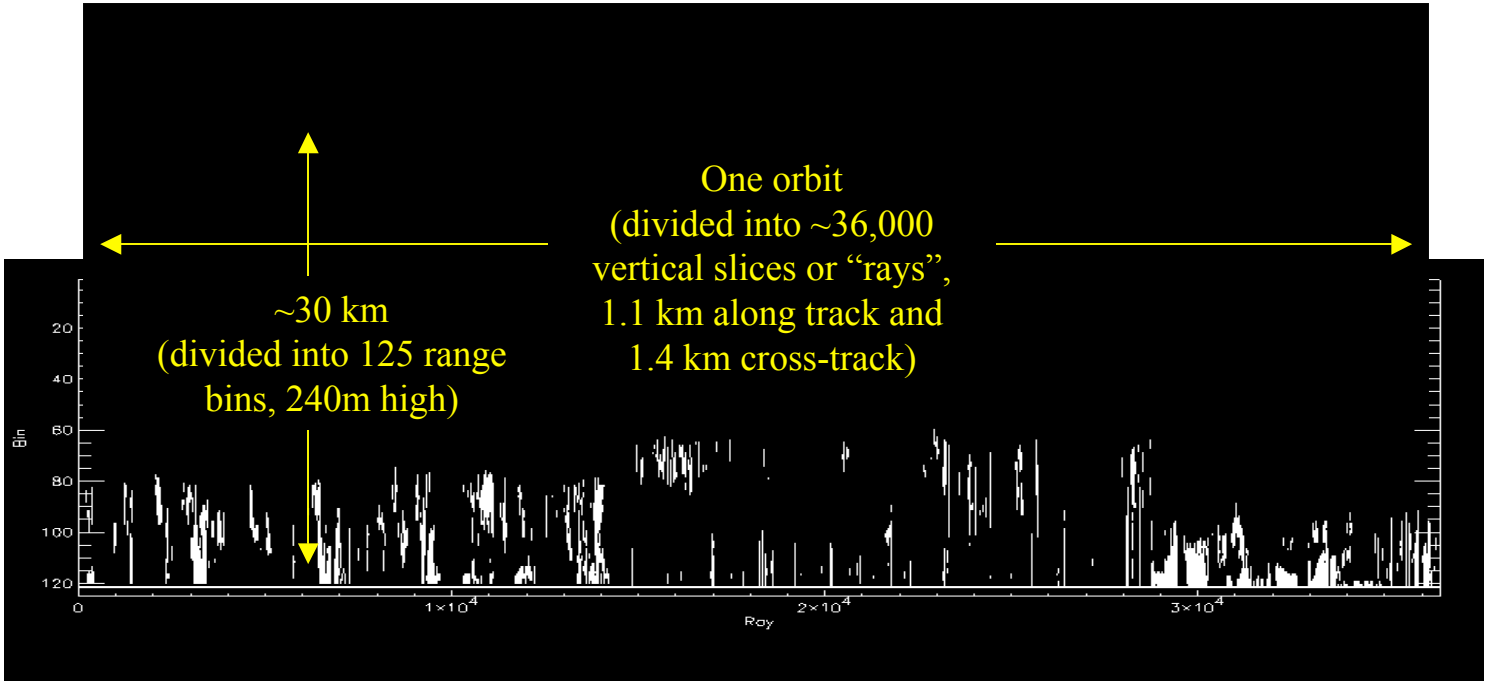
CLOUDSAT

A NASA EARTH SYSTEM SCIENCE PATHFINDER MISSION

The Aqua-train observing system (clouds, aerosol & precip)



Cloud condensate,	CloudSat 94 GHz radar
Precipitation	CloudSat, AMSR
Cloud Microphysics	CloudSat,MODIS Parasol
Aerosol optics	Calipso,MODIS, AIRS, Parasol
Radiative fluxes	CERES
Aerosol Chemistry	Aura?

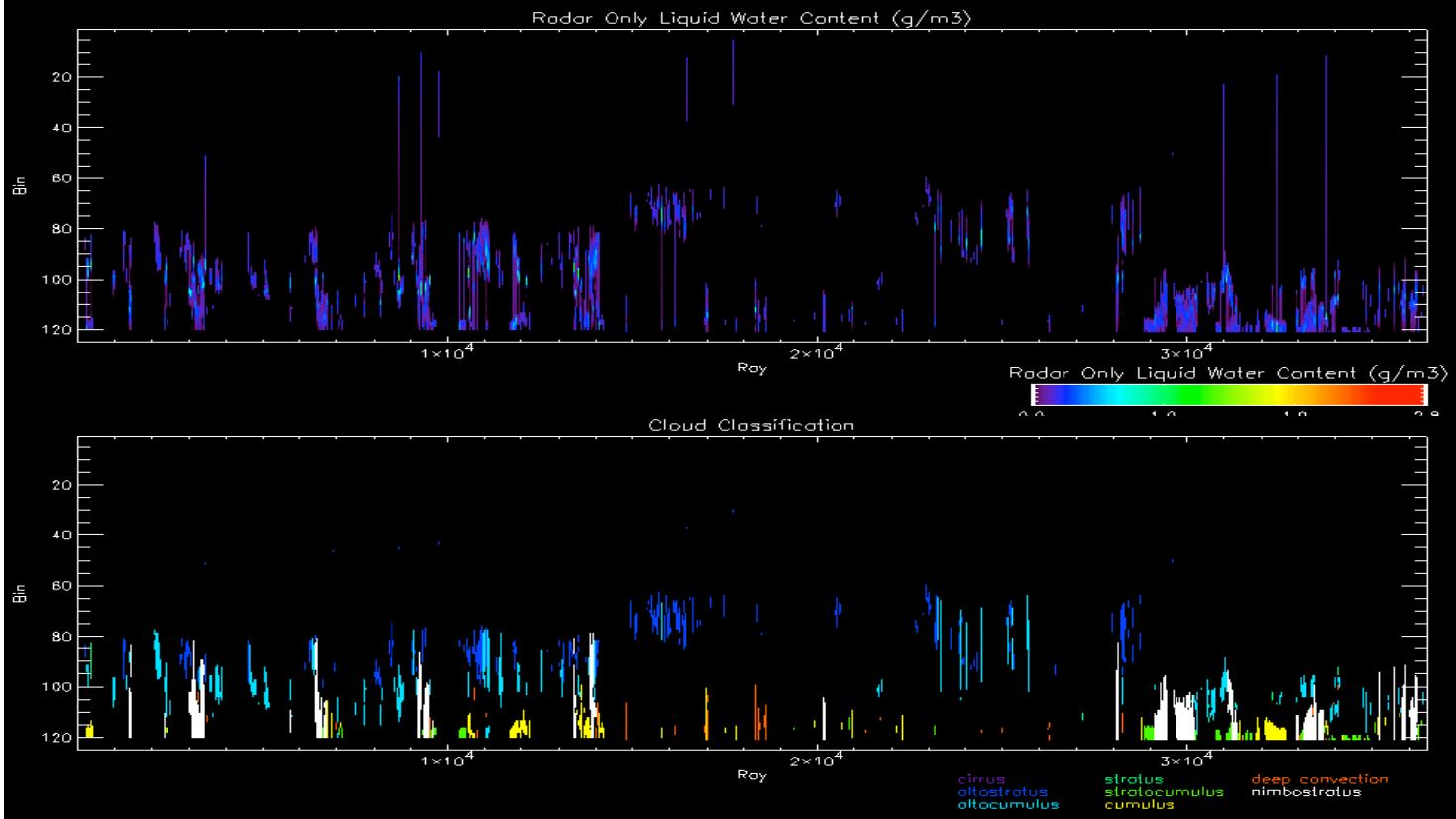


- CloudSat will gather information in the form of vertical slices through the atmosphere, 500m vertical resolution.

- These slices are to be processed into data granules, one orbit in length

Expected Information:

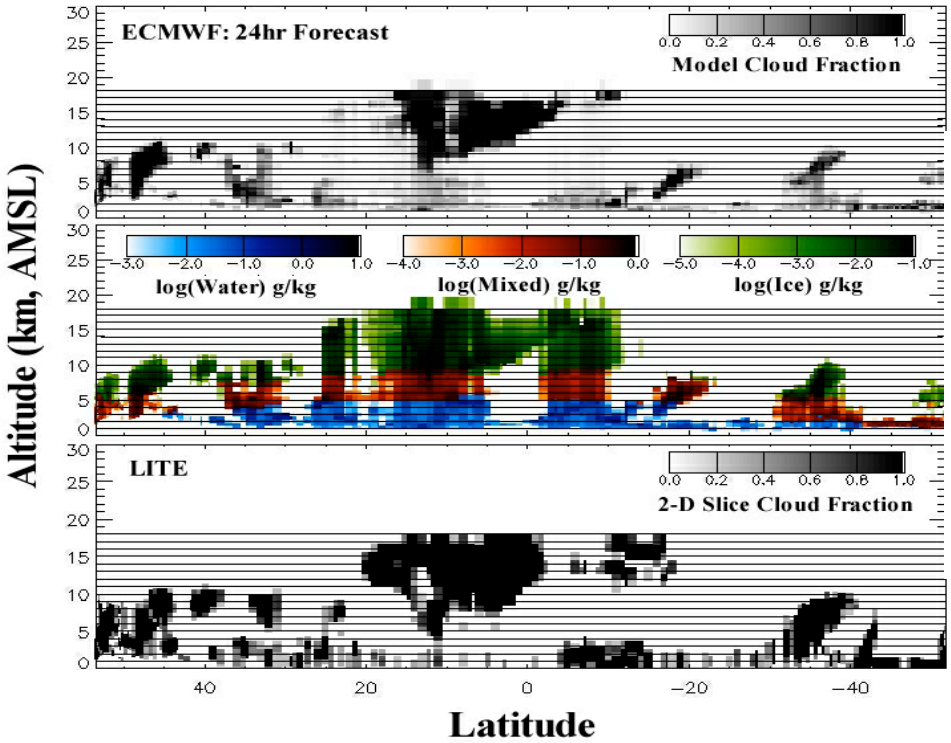
profiles of cloud & precip occurrence
ice/water content
some microphysics (N, D)
fluxes and heating rates

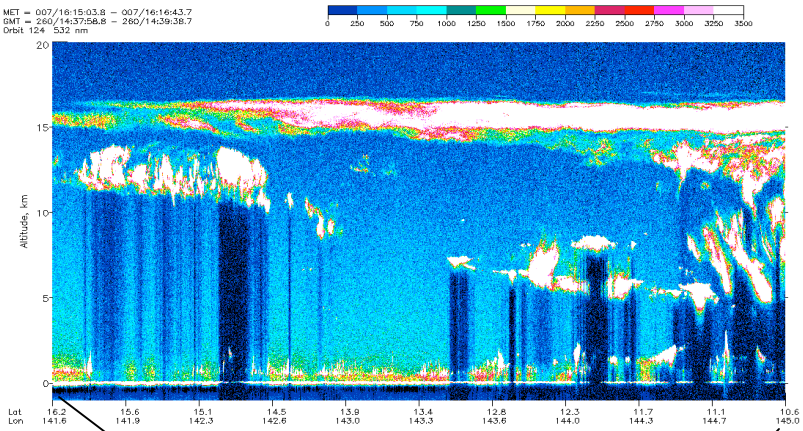


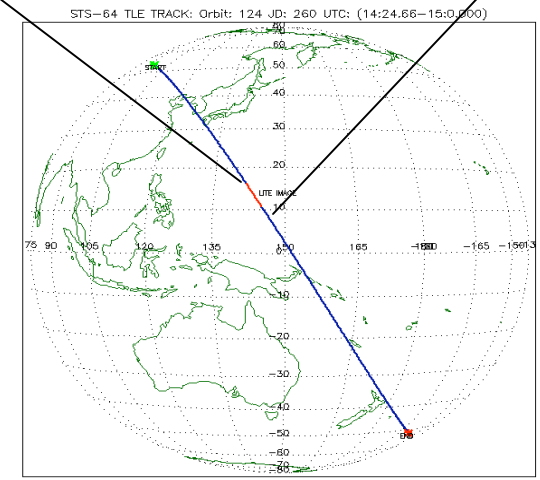
Liquid/ice
Water content

Cloud type

Thoughts on model evaluation: explicit comparison with NWP model







ECMWF/LITE correlative study Statistics for 60+ LITE Orbits, ±1 bin horizontal and vertical

Hit Rate = fraction cloudy+clear correctly forecast, =0.896

Threat Score = fraction of cloud points correctly forecast = 0.714

Probability of Detection = ratio of cloud hits to total # of obs clouds = 0.796

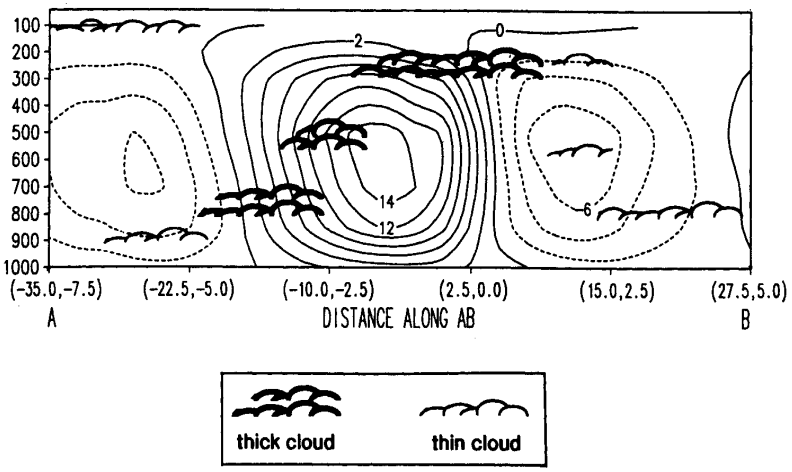
False Alarm rate = rate of forecasting cloud when clear = 0.126

Miller et al., 2000

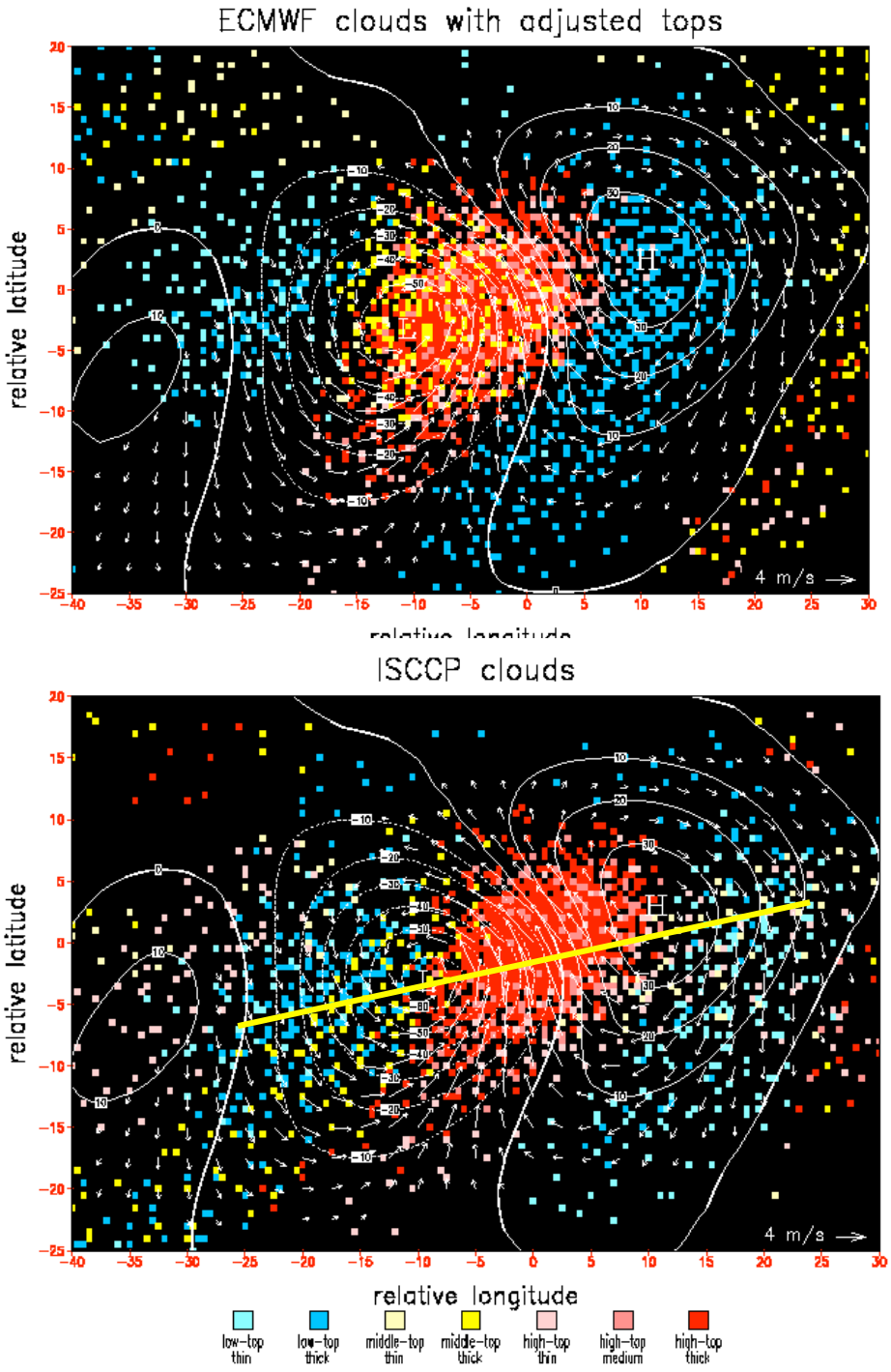
Composite Comparisons

- Stratified by cloud types
- Composited as functions of environments

example of
Lau & Crane, 1995

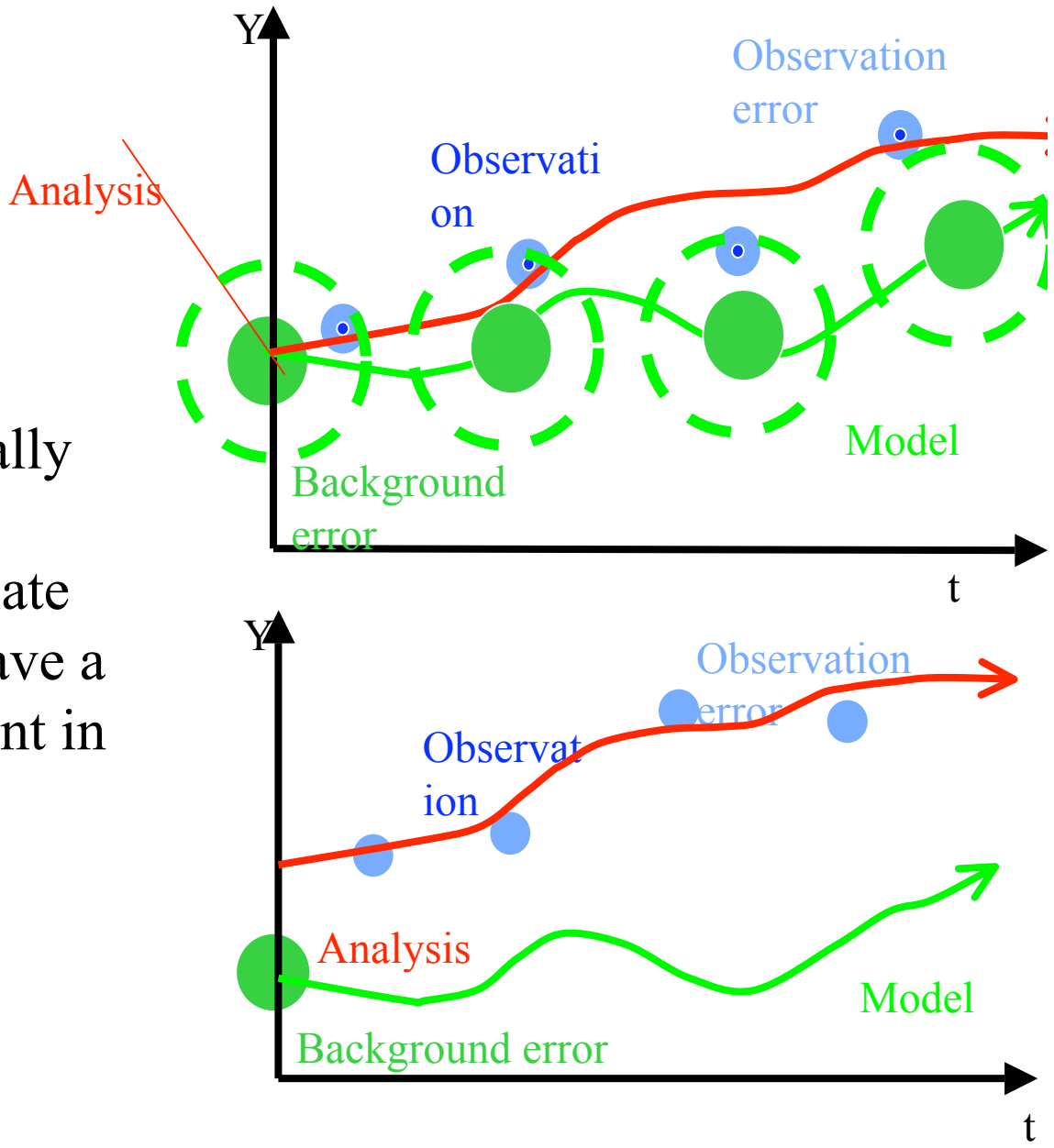


Others examples include Mace and Jacob, Miller et al., Hogan and Illingworth.



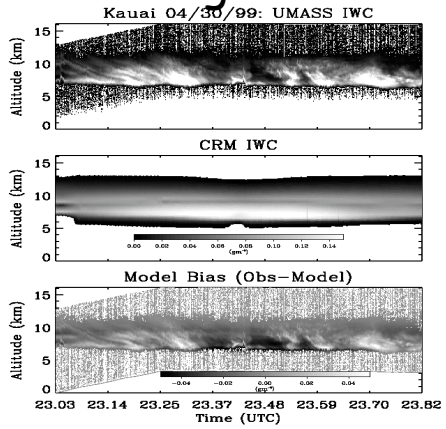
Two ways of thinking
About assimilation

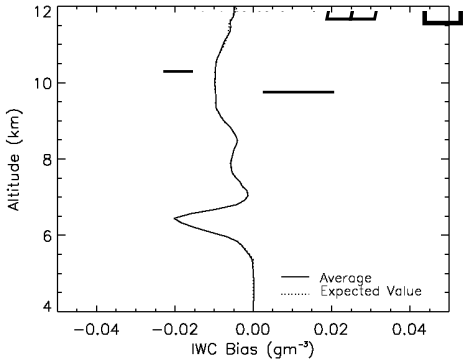
- Operational kind: Optimally constrain model trajectory – if we can successfully assimilate cloud information, then we have a Global Data resource important in its own right …….but…

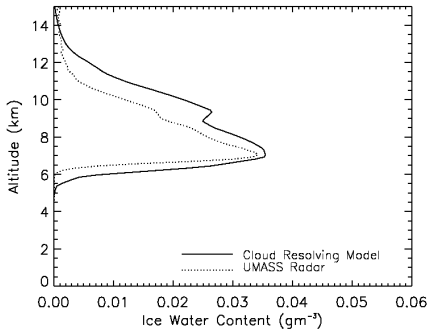


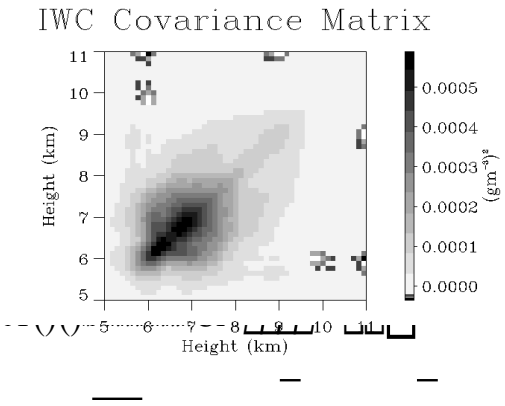
2. Science kind – assimilation provides a ‘disciplined’ approach to to comparison of model with observations, and provides a framework for interrogating the model parameterizations….

Bias and error covariance are computed performing a horizontal average over the domain

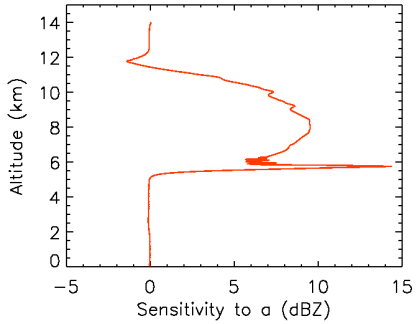


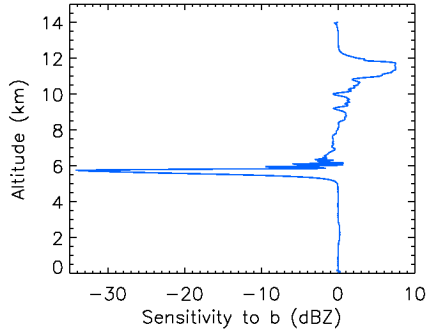






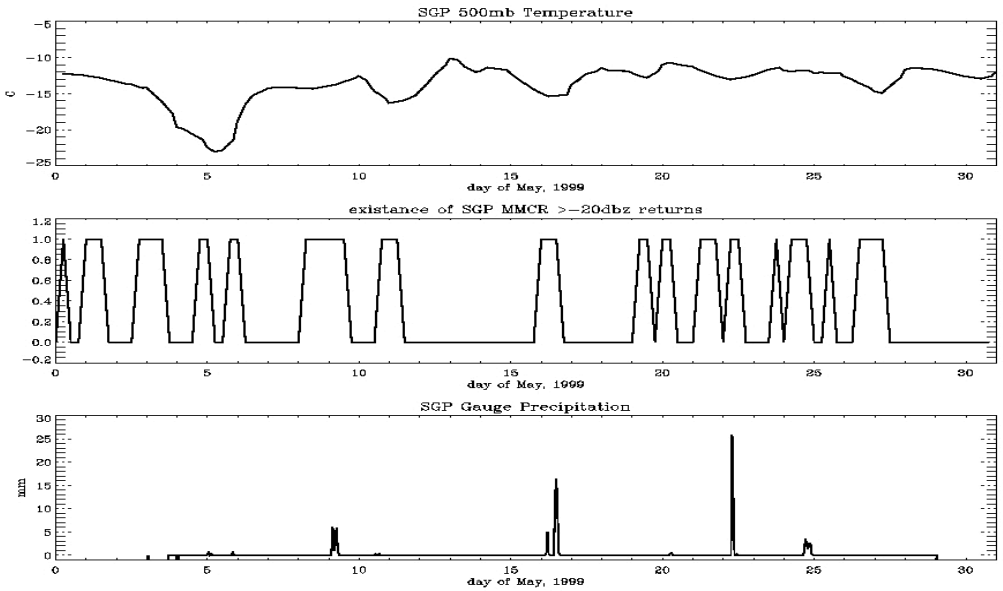
Model Sensitivity: Sensitivity of observable to a given model parameter





Benedetti & Stephens, 2002

Some Issues .



SGP 500mb temp

Cloud occurrence

Precipitation

$\Phi = [x-x_a]^T B^{-1} [x-x_a] + [y-f(x)]^T S_y^{-1} [y-f(x)]$

Seek x, such that $d\Phi/dx \to 0$

X_a = background

B^{-1} = prediction (model) error

$f(x)$= model of observation

S_y^{-1} = 'observation' error

1. How? Linear Physics?
2. What? Prognosed variables, time & space filtered?? What statistics
3. Forecast model error? How is this defined?
4. Improving & understanding observing systems

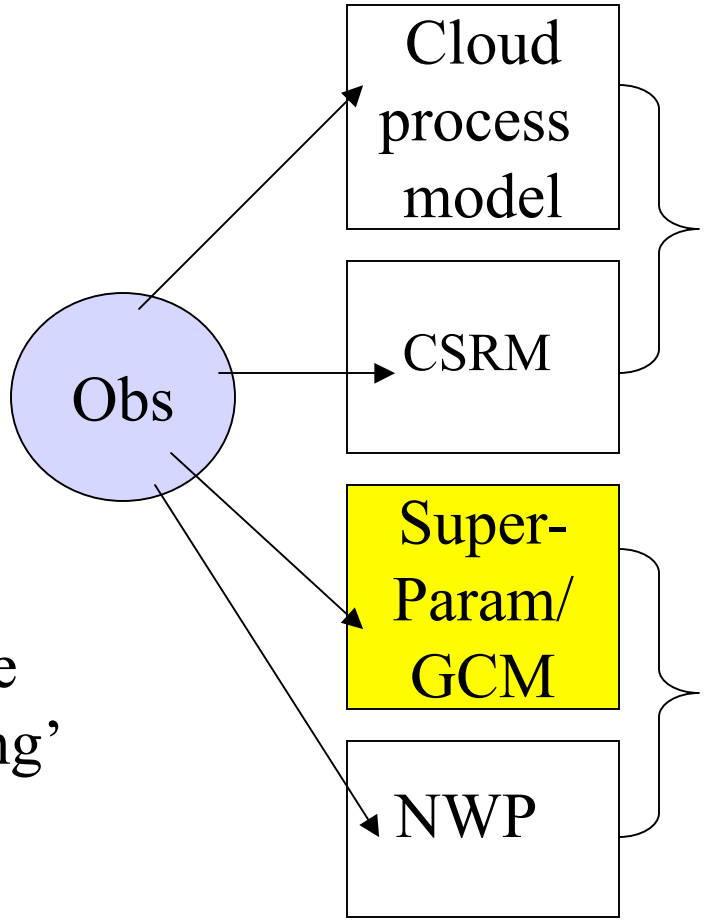
Thoughts on role of super-parameterization and cloud data assimilation:

- Assume GCM+CSRM is a significant improvement over GCM+bulk parameterization
- Consider super-parameterization as part of an imbedded hierarchy:

What assimilation Might do

Might help Constrain model Assumptions

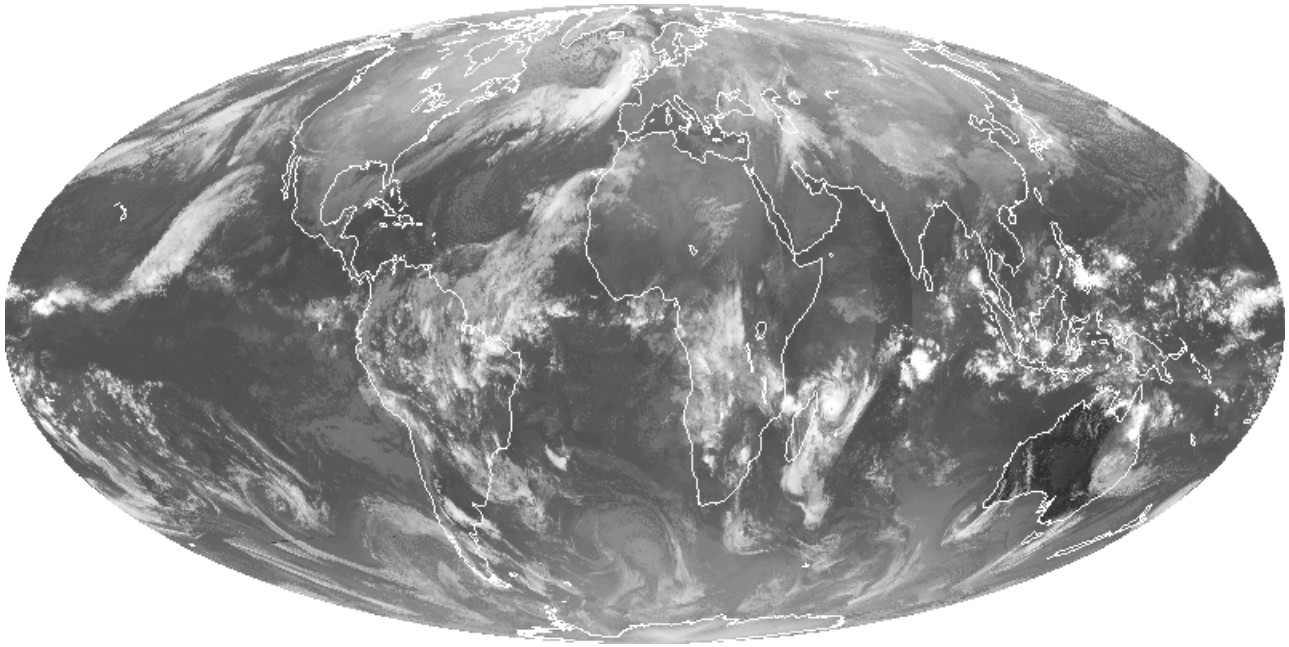
Might help to ensure Proper 'large-Forcing'



What the model Hierarchy might do

Provide a tool for researching new assimilation procedures

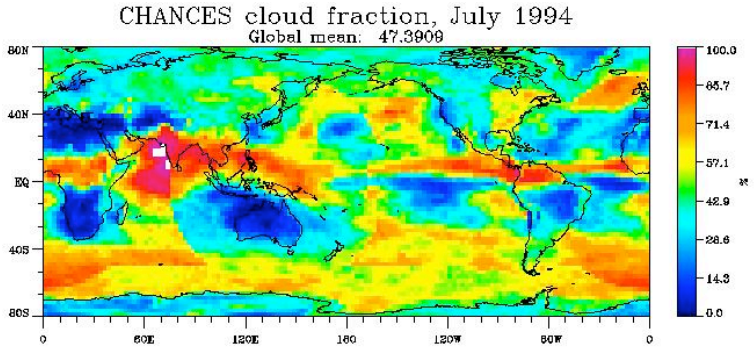
Provide a meaningful way of quantifying background error

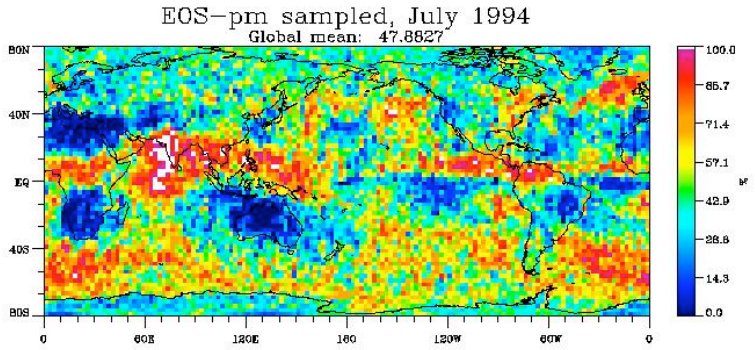


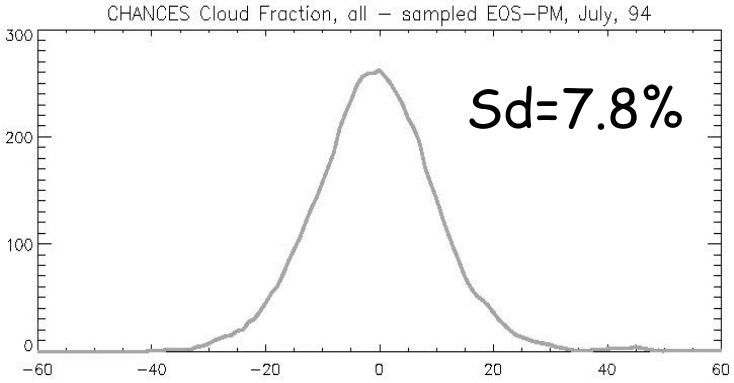
5km,hourly 'Chances' IR Tb data

Convert Tb data into proxies for:

- Precipitation
- Cloud







Evaluating errors of Representativeness

CloudSat example:

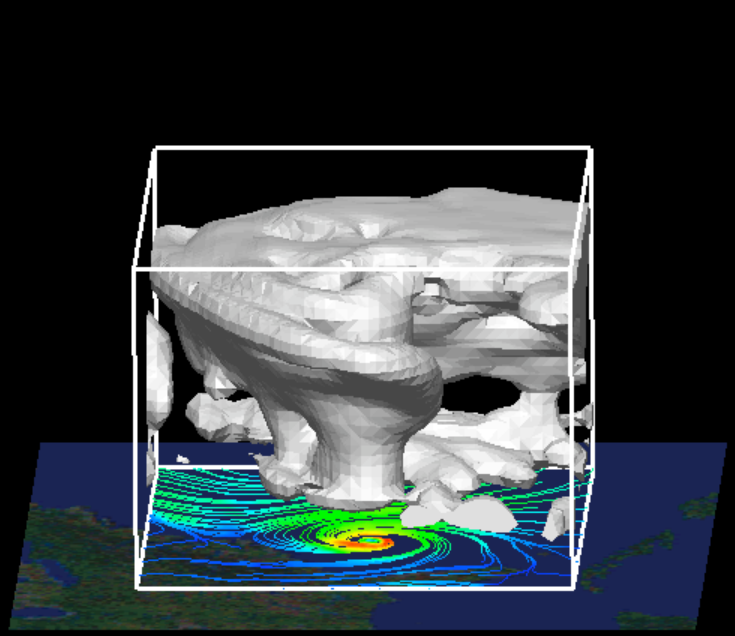
Nadir 5km pixels are sampled & Compared to full sample

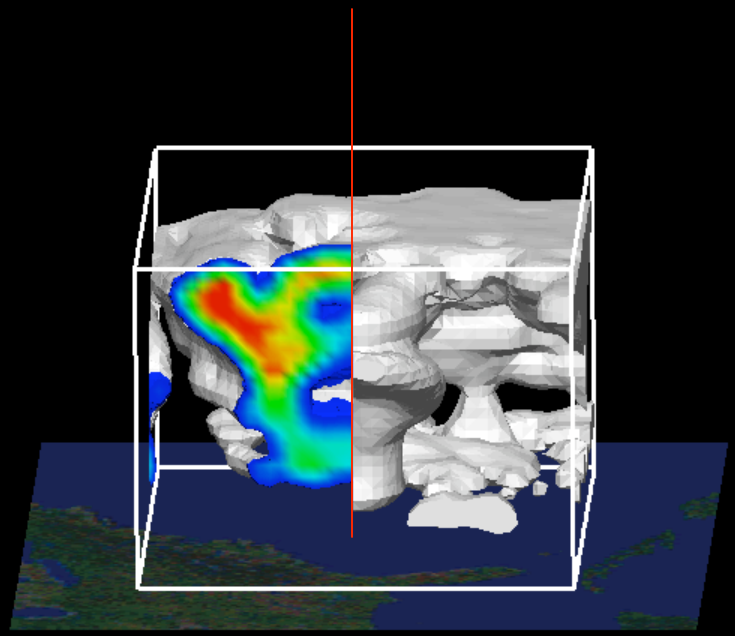
Sample errors to be O(10%) for 'synoptic mapping', montly mean

Sampling errors of super-parameterization??

Goals

1. Quantitatively evaluate the representation of clouds and cloud processes in global models





ECMWF forecast
Hurricane Bonnie