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Tropical and sub-tropical cloud transitions: ISCCP and weather/climate models

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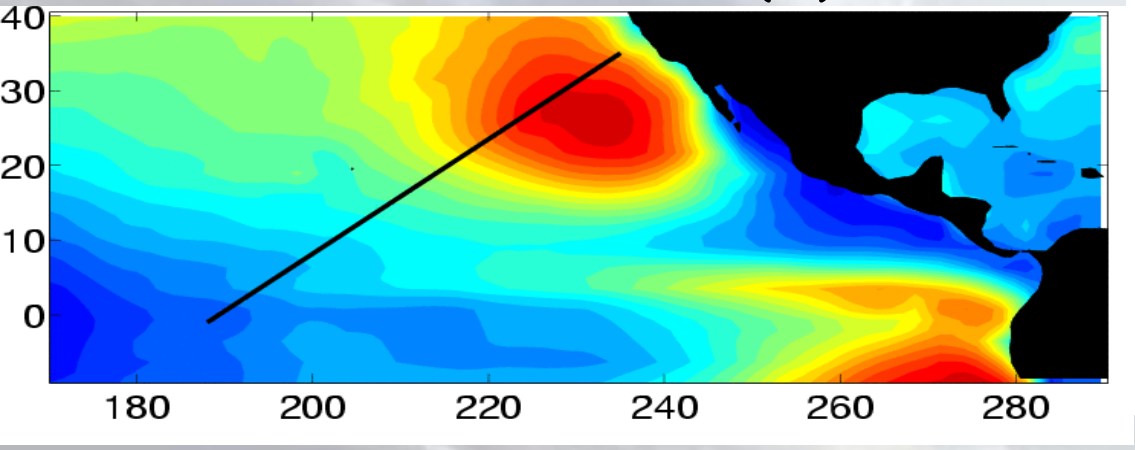
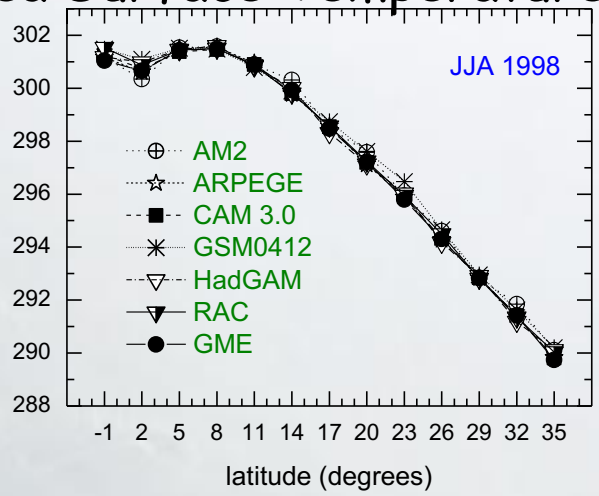
GCSS Pacific Cross-section Intercomparison

ISCCP Low Cloud Cover (%)



Courtesy C. Hannay

Sea Surface Temperature



GCSS/WGNE Pacific Cross-section Intercomparison (GPCI) is a working group of the GEWEX Cloud System Study (GCSS)

Models and observations are analyzed along a transect from stratocumulus, across shallow cumulus, to deep convection

Models: GFDL, NCAR, UKMO, JMA, MF, KNMI, DWD, NCEP, MPI, ECMWF, BMRC, NASA/GISS, UCSD, UQM, LMD, CMC, CSU, GKSS

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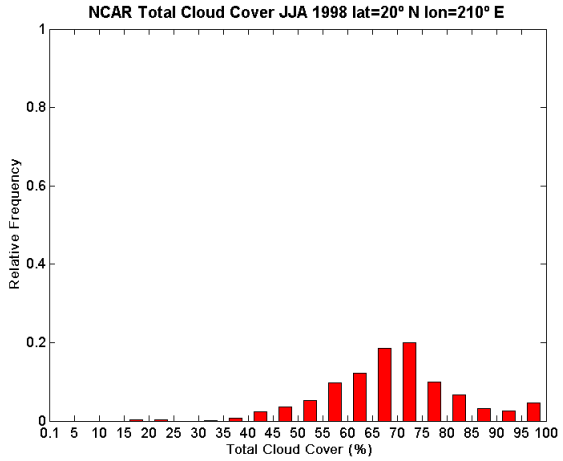
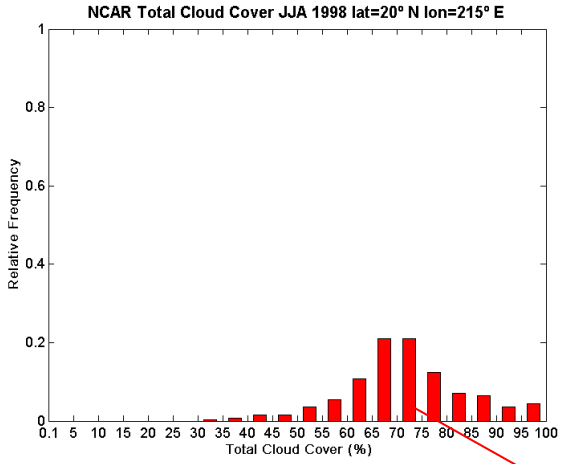
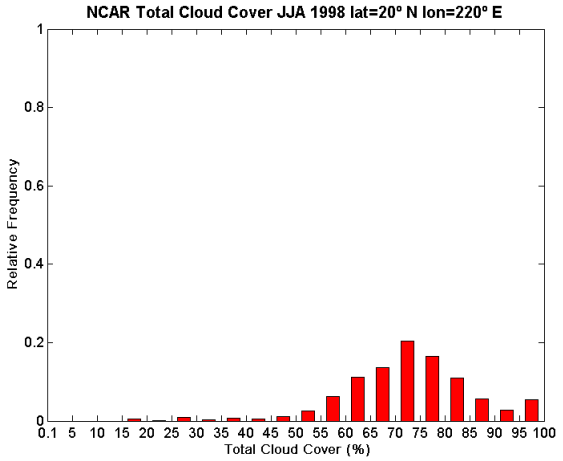
How representative is the cross-section? Total cloud cover histograms



20 N, 210 E



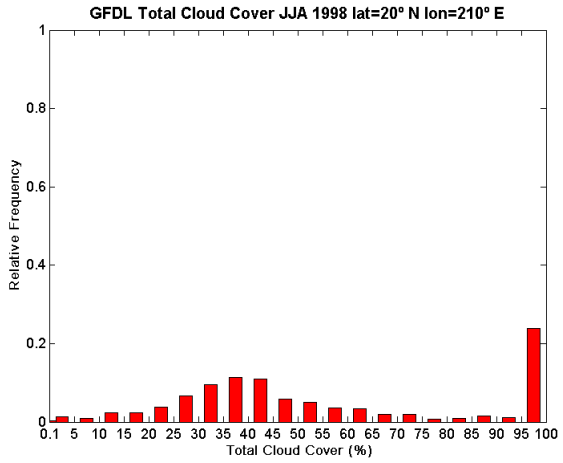
NCAR, 20 N, 215 E



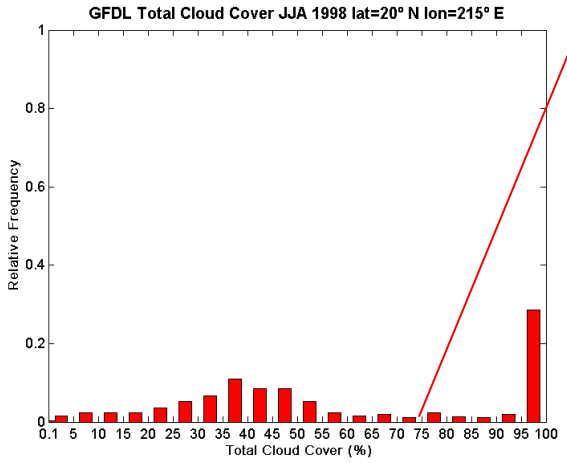
20 N, 220 E

1 peak .vs. 2 peaks

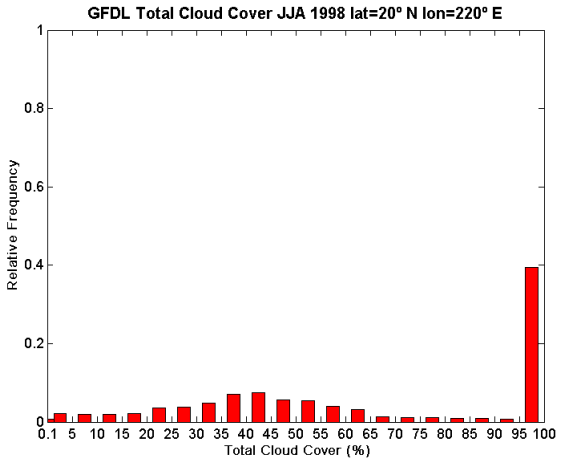
20 N, 210 E



GFDL, 20 N, 215 E



20 N, 220 E



Results from adjacent points are similar. Models are more different.

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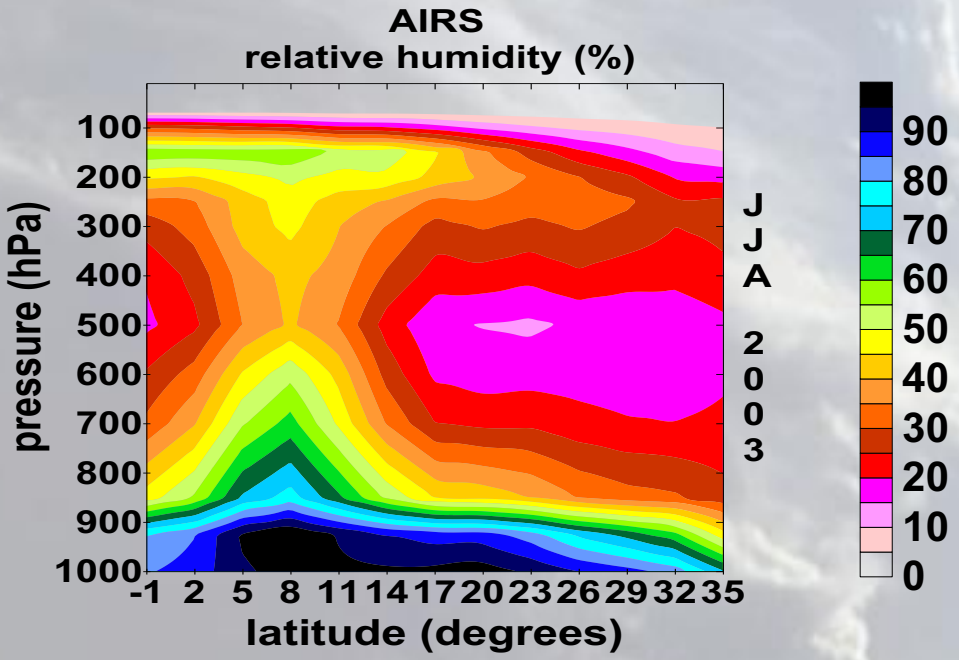
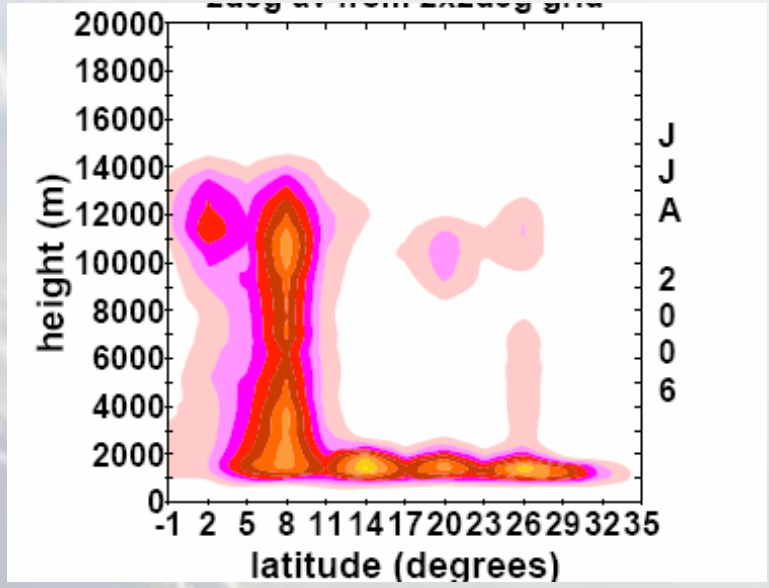
Subtropics to tropics transition: satellite observations of mean relative humidity and cloud occurrence

AIRS relative humidity JJA 2003



CloudSat cloud occurrence JJA 2006



Satellites show transition from subtropical PBL clouds to deep tropical convection … these observations did not exist when we started planning for the cross-section.

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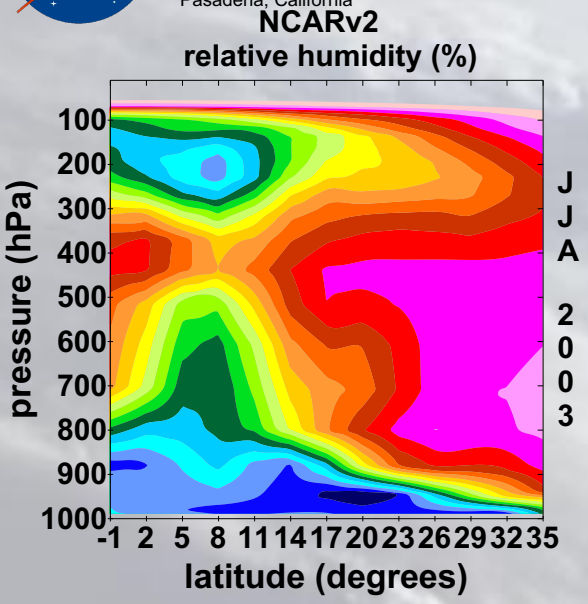
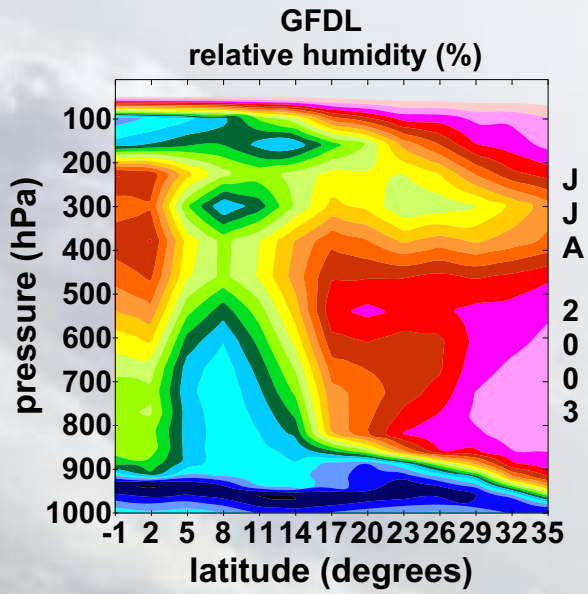
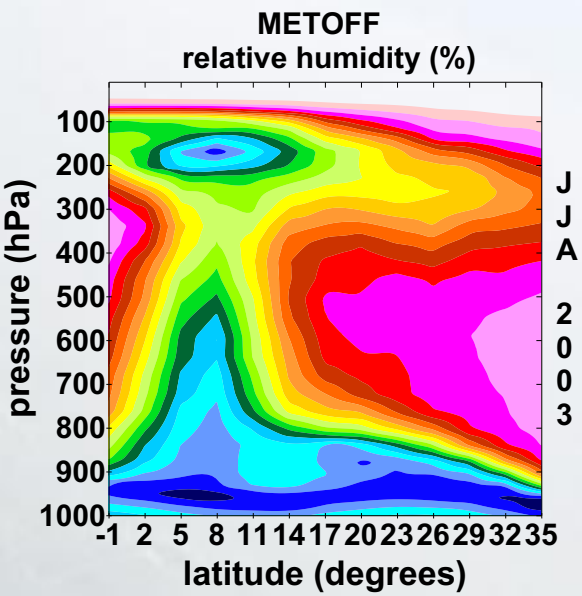
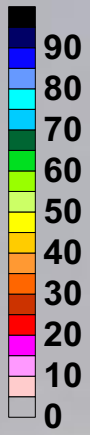
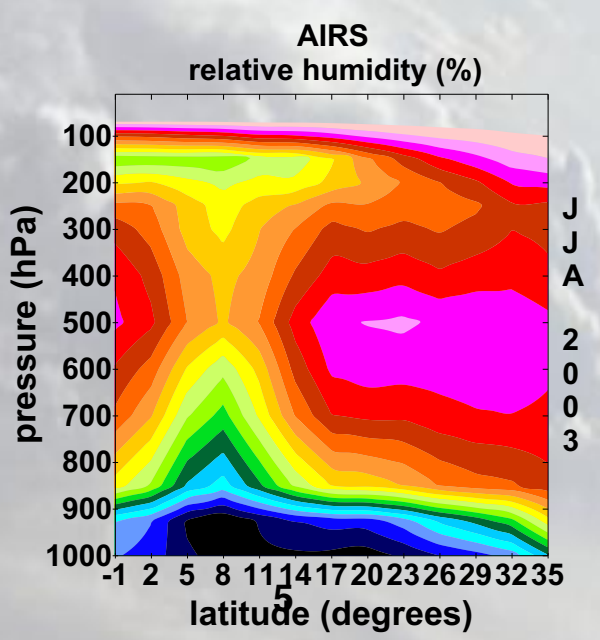
GPCI mean relative humidity – JJA 2003

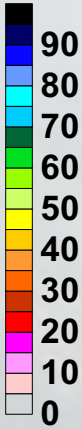












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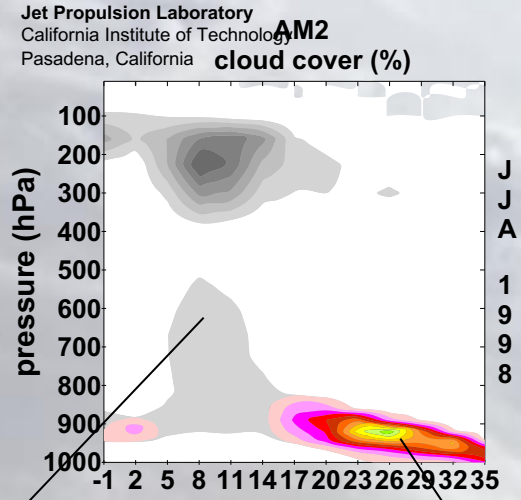
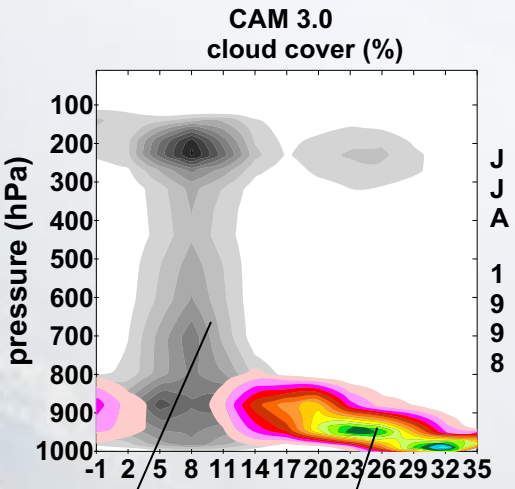
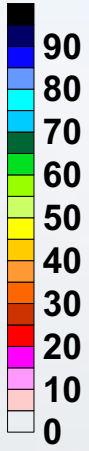
Cloud Cover along GPCI



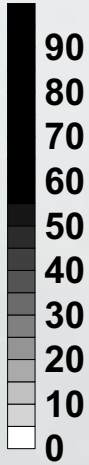


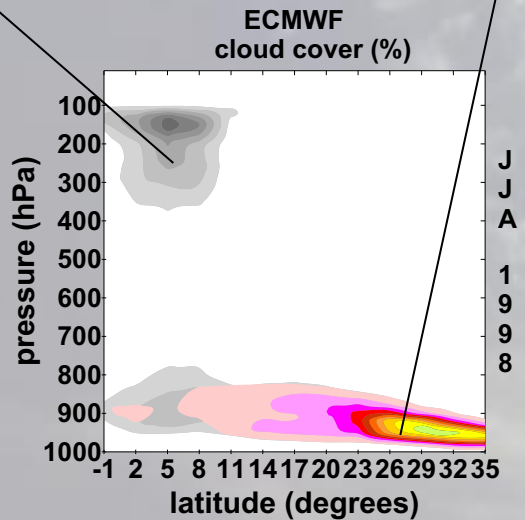


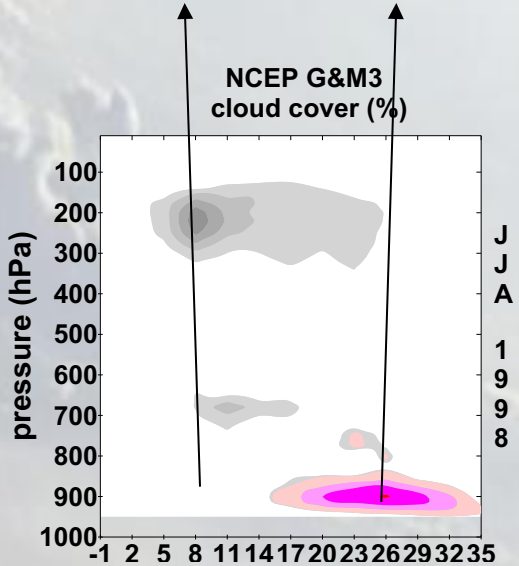
Deep convection clouds

Boundary layer clouds

Large differences in clouds between models







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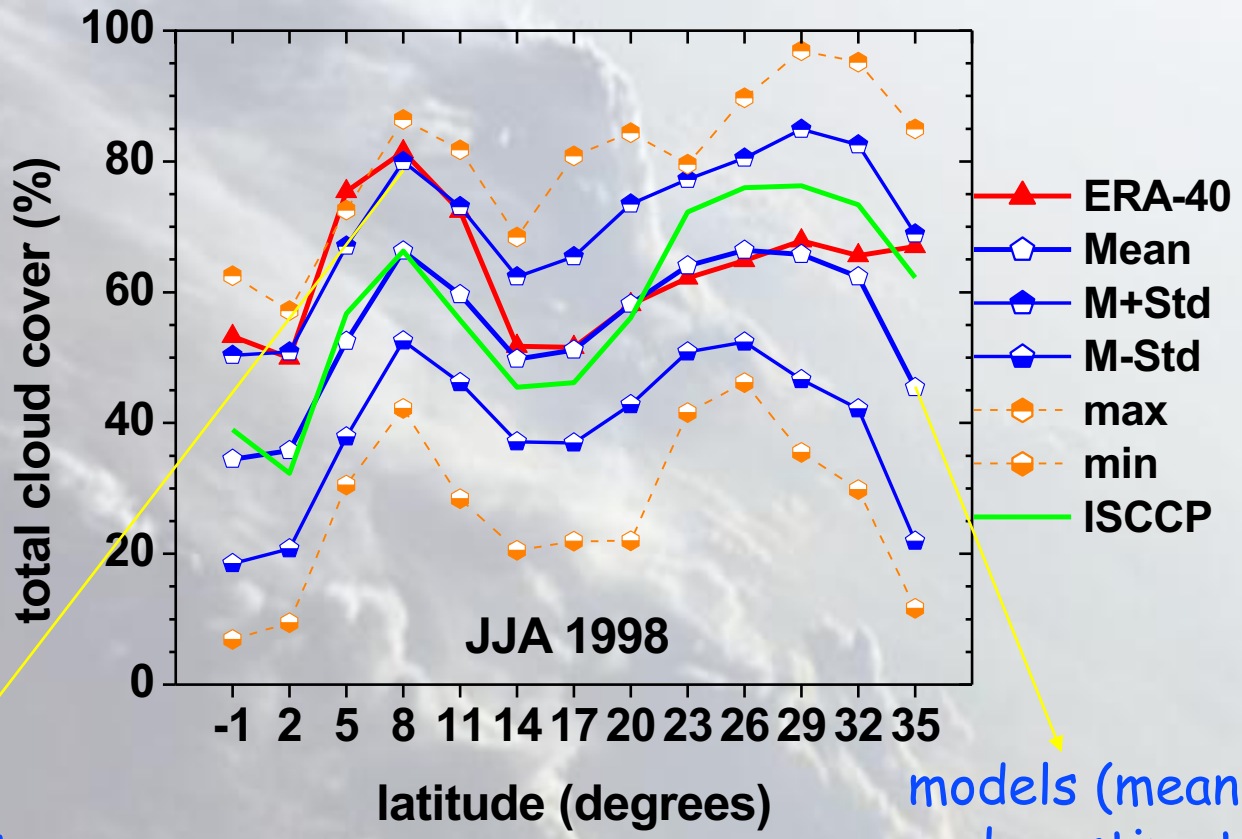
Total cloud cover (JJA98) along GPCI



ERA40 underestimates stratocumulus and overestimates clouds in ITCZ

models (mean) still underestimate stratocumulus with large stand. deviation between them

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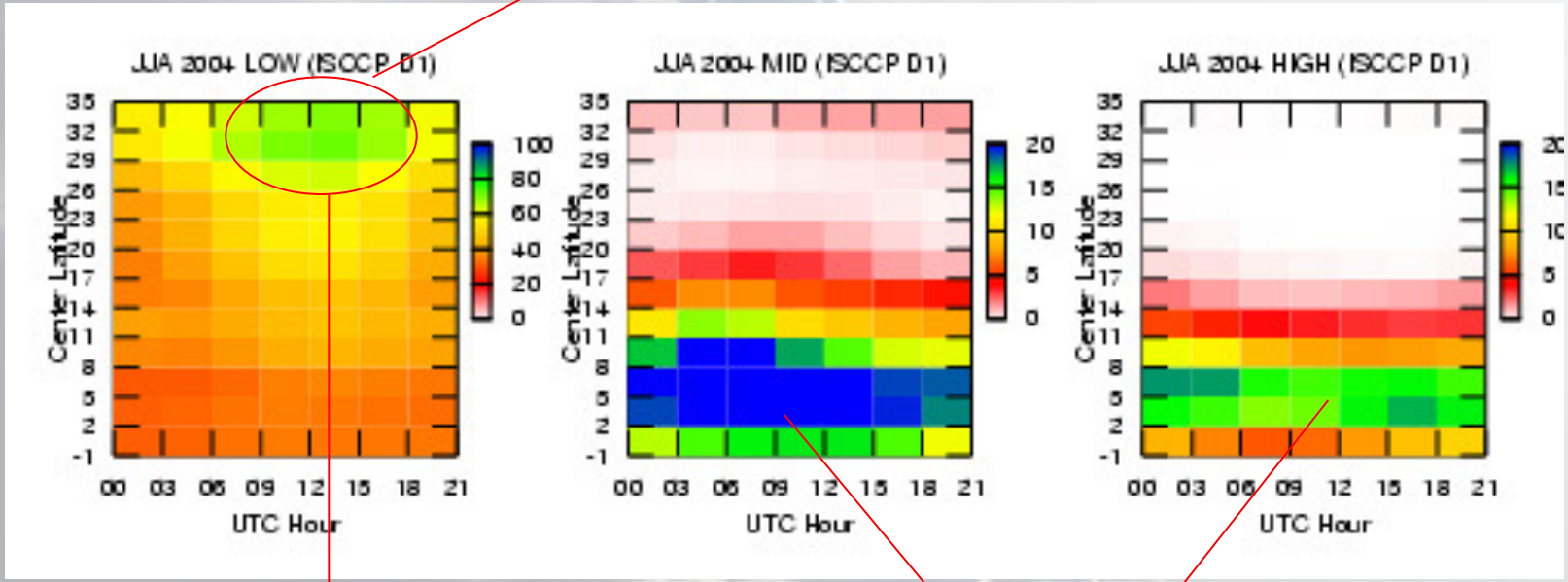
Mean diurnal cycle: ISCCP cloud cover

peak values of Sc cloud cover around 32-35 N



Diurnal cycle: max in (early) morning local time

peak values of mid/high clouds close to ITCZ

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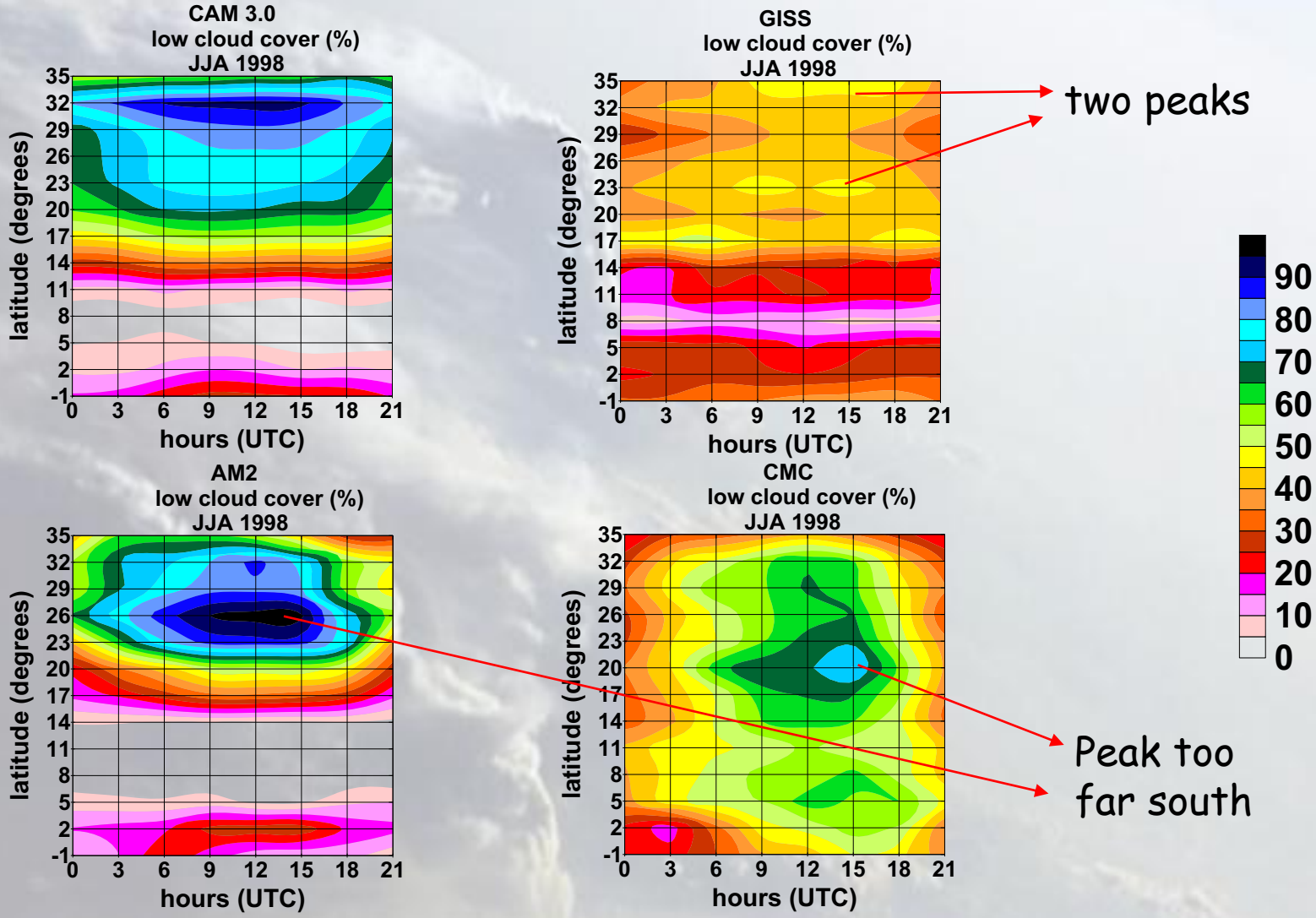
Diurnal cycle: model low cloud cover



Models have different diurnal cycles of LCC

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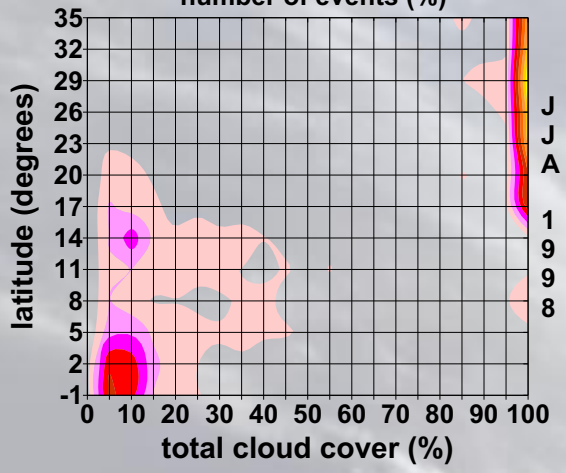
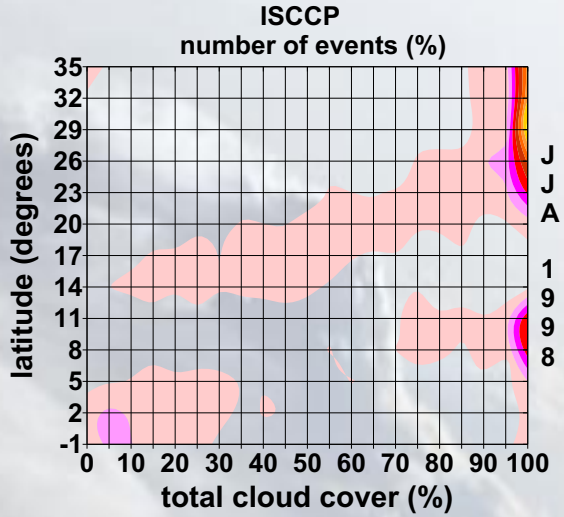
Characterizing the transition: histograms of cloud cover

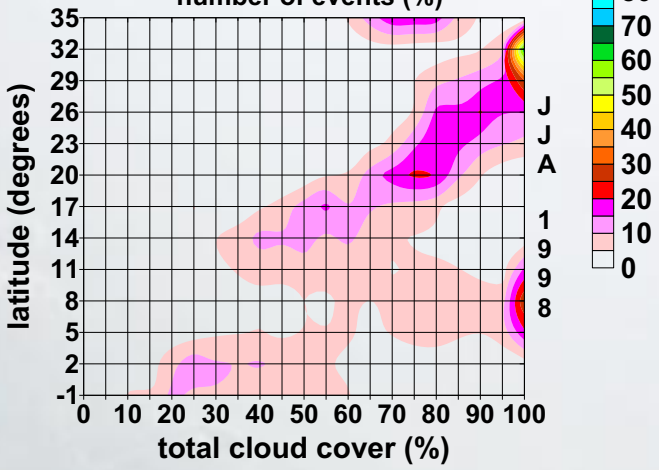
UKMO





ISCCP is between continuous and bimodal

NCAR



- NCAR low cloud parameterization is partly based on climatology => continuous transition
- UKMO (and partly GFDL) cloudy-PBL parameterizations are based on the idea of distinct-regimes => discontinuous transition
- ISCCP suggests that none of these two "extreme" concepts is fully valid => relevant for parameterization development

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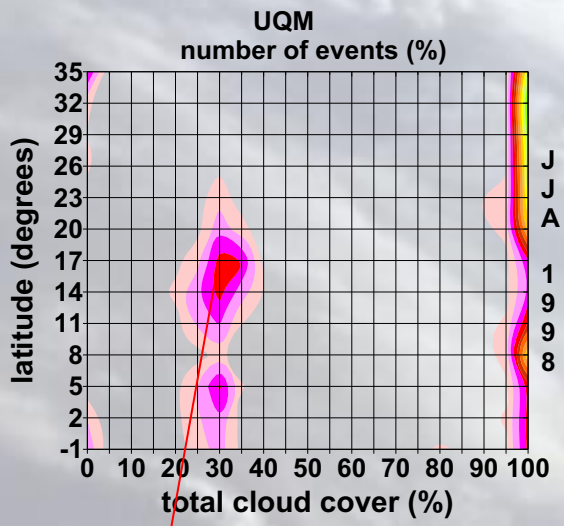
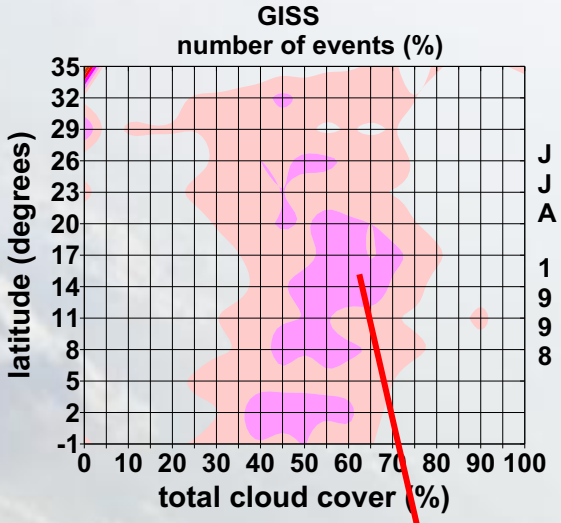
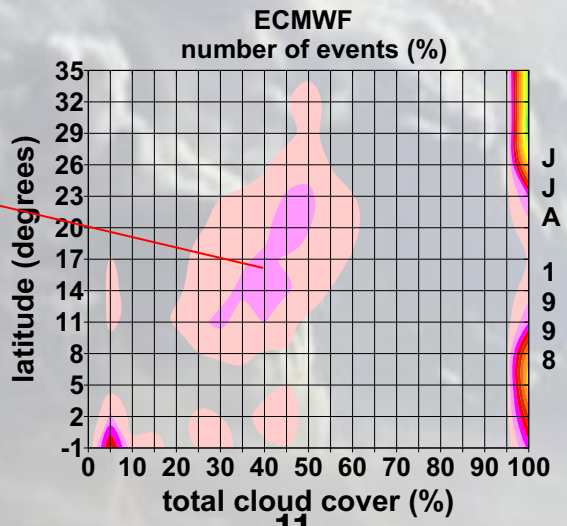
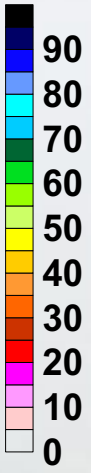
Histograms of total cloud cover









Third peak

No apparent transition

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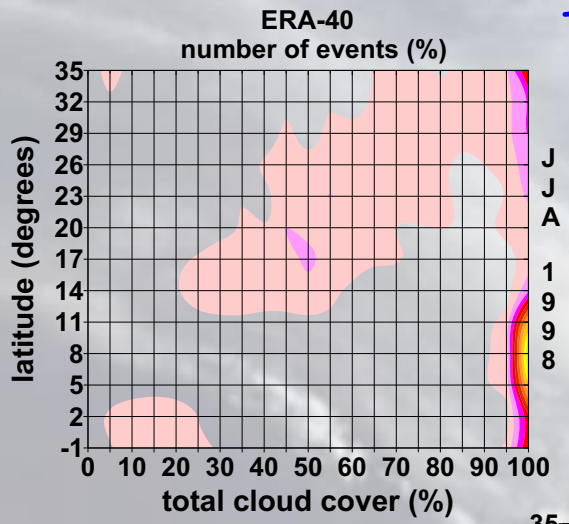
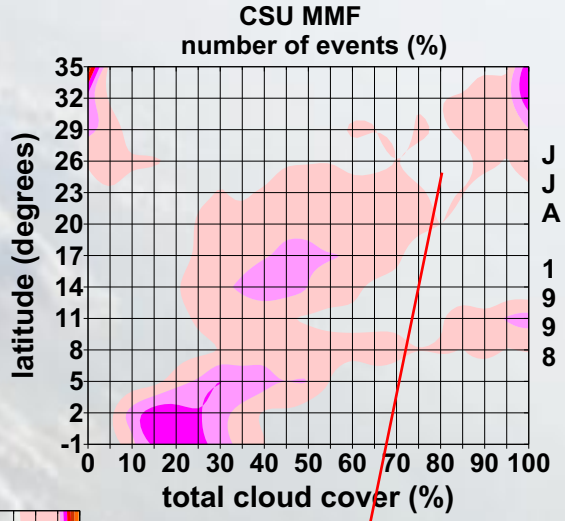
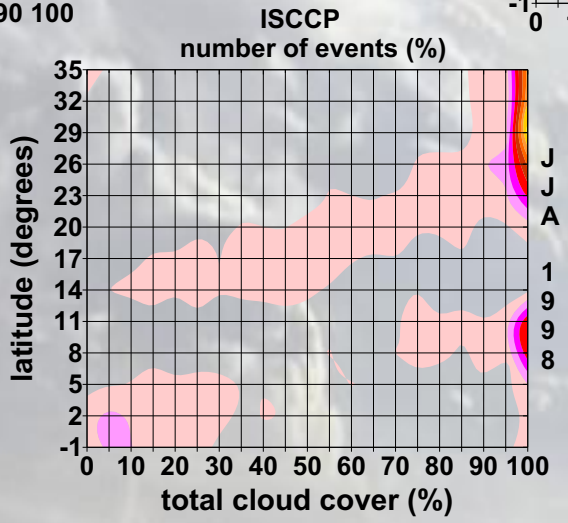
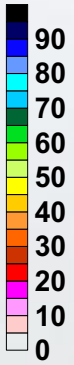
Histograms of TCC: ISCCP, ERA40 and MMF

ERA40 and MMF are the closest to ISCCP …









..But still with a significant underestimation

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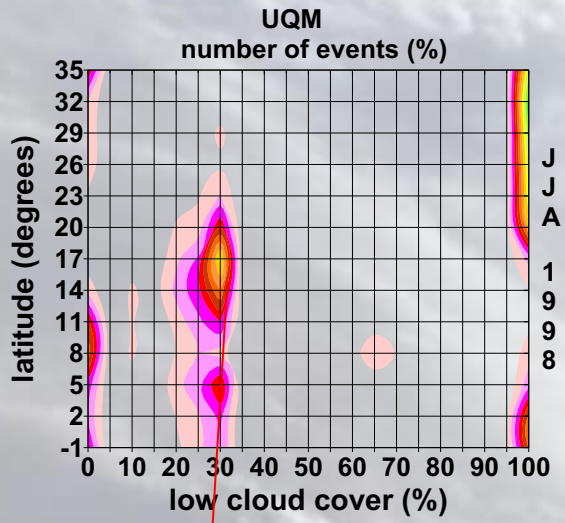
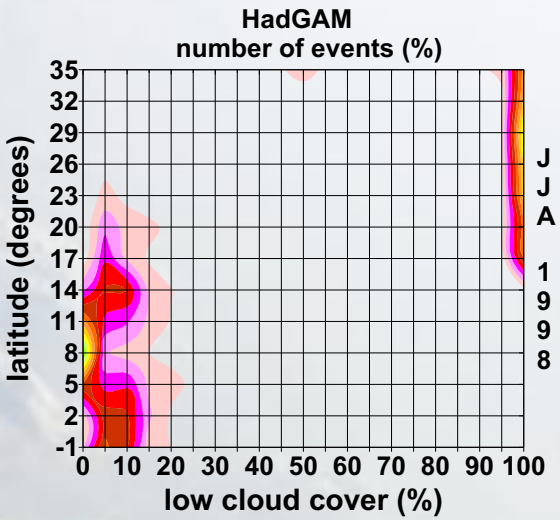
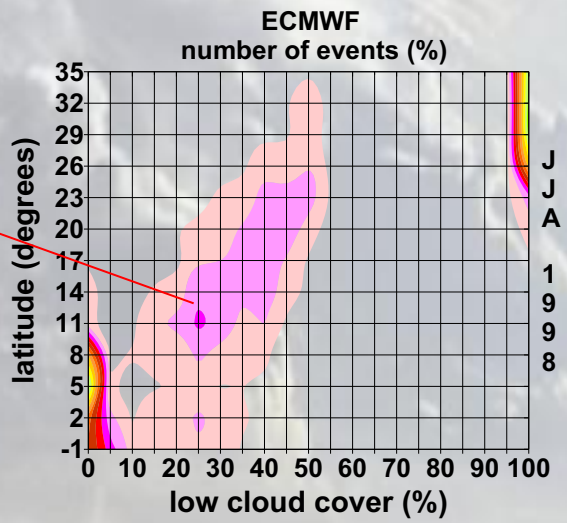
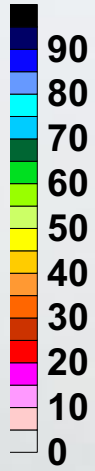
Histograms of low cloud cover









This third peak is in PBL

Bi-modal distribution

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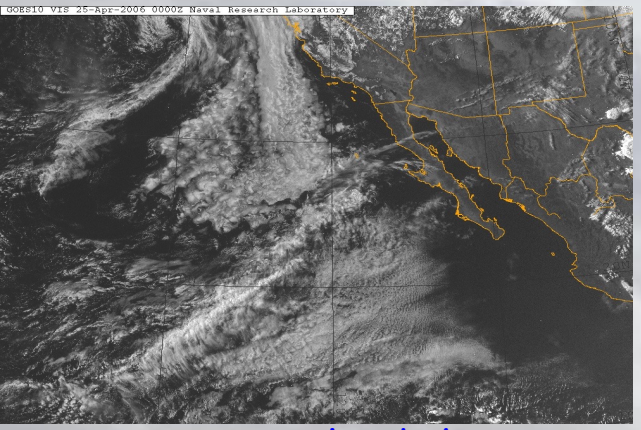
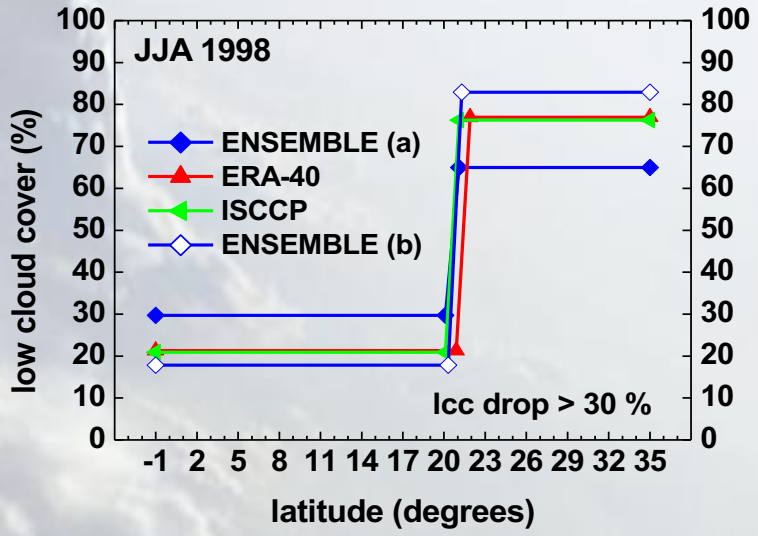
Alternative statistics to estimate mean LCC: assume existence of at least 1 sharp gradient of LCC

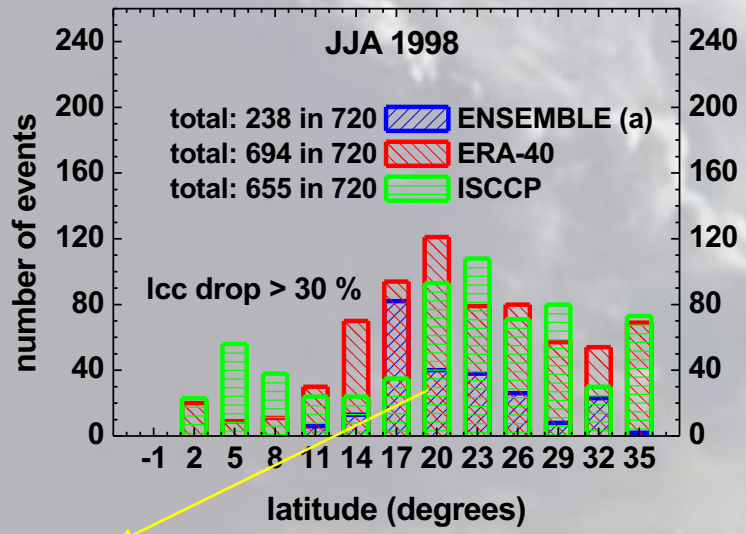


instantaneous clouds have sharp gradients in space

Method: 1) Find location of strong gradient of LCC;

2) keep LCC constant to the NE and SW of this location.





Models: location of gradient similar to ISCCP but very different LCC values

ERA40: location of gradient different from ISCCP but similar LCC values

Different histograms between ERA40 and ISCCP

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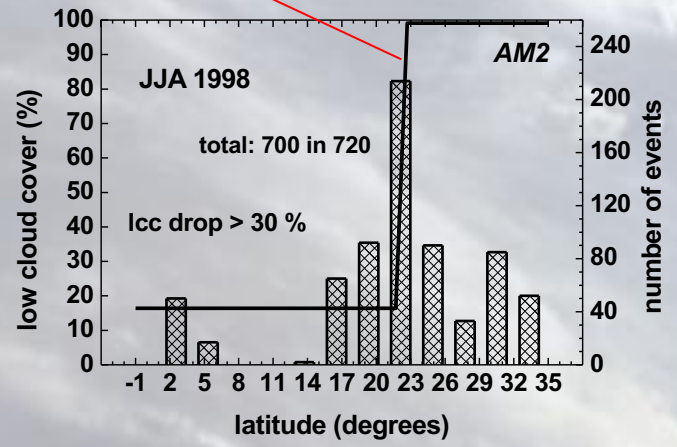
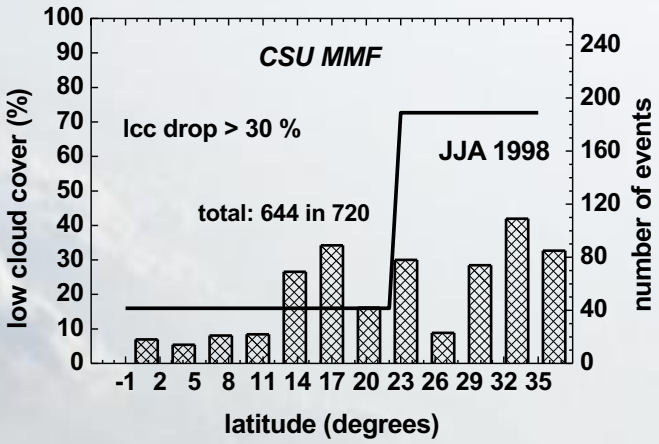
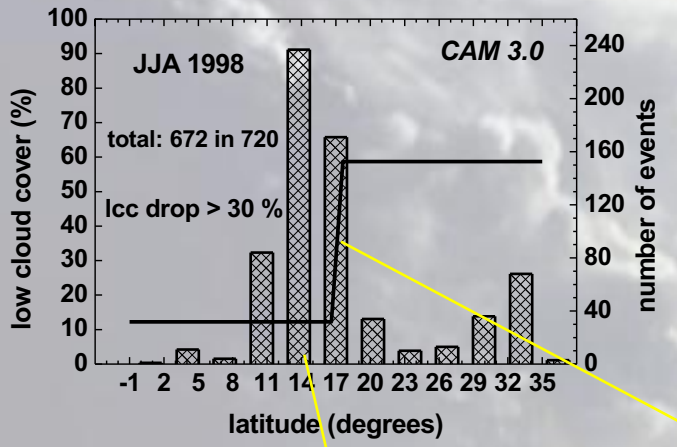
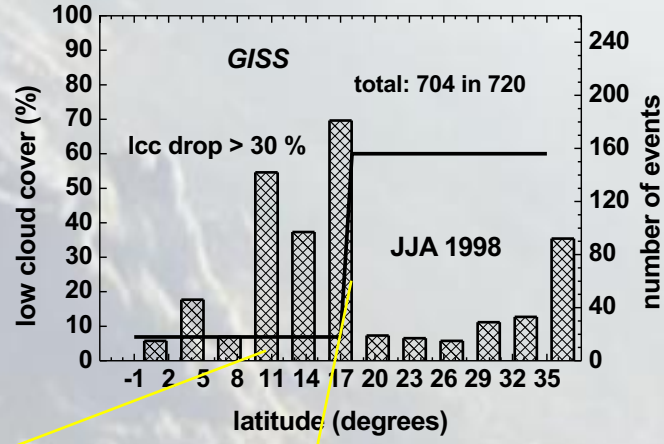
"Sharp gradient" averaging of LCC: Model results along GPCI

large gradient









Histogram peak too far to the south

Weak mean gradient

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DIME/GPCI models and observations webpage

- GPCI model results for GPCI were assembled/organized (with the help of the DIME webmaster) on DIME website: http://gcss-dime.giss.nasa.gov/gpci/modsim_gpci.html.
- GPCI/DIME webpage dynamic features: interactive selection of model data, dynamic plotting and model comparisons
- Observations on webpage: ISCCP, TOVS, SSM/I, GPCP - soon add AIRS T, q, RH

Gridded Data

ISCCP D1/DX

TOVS Atmosphere Gridded Data Product

SSM/I Daily Data Product

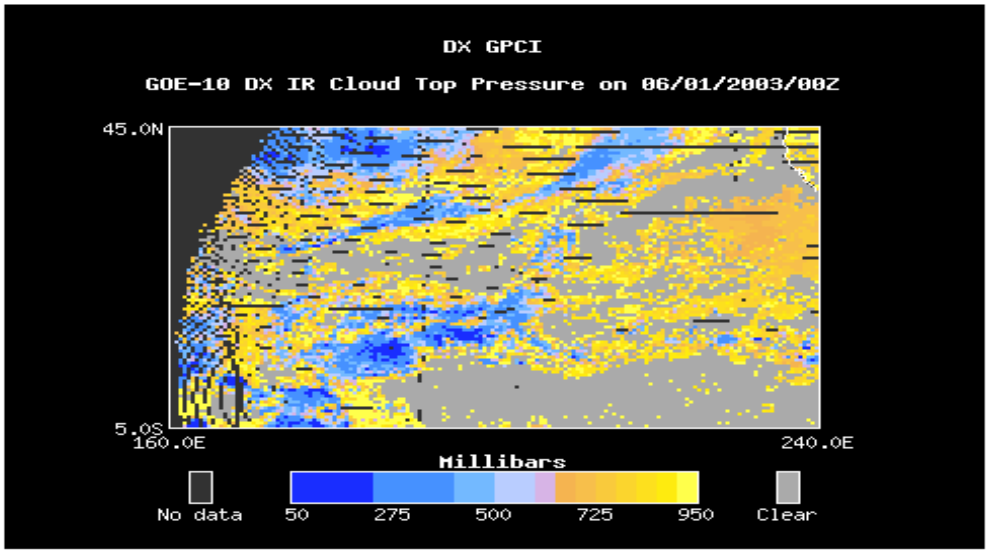
NCEP Reanalysis

GPCP 1-Degree Daily Precipitation Data

Cross-section PCTAU Plots

Point Data

Rawinsonde Observations



GCSS-DIME HOME | GPCI HOME

Webmaster: GCSS-DIME Webmaster

http://gcss-dime.giss.nasa.gov/gpci/lsobs_gpci.html

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GCSS Pacific Cross-section Intercomparison (GPCI) – the next steps

A driving question: What determines the variability and the transitions of clouds and convection along the GPCI cross-section?

Tasks

1) To characterize this variability and transitions along GPCI in climate models and satellite data

2) To study how various models (Climate, LES, CRM) respond to a variety of large-scale and surface forcings

Our initial efforts have been concentrated on Task 1 – Characterization

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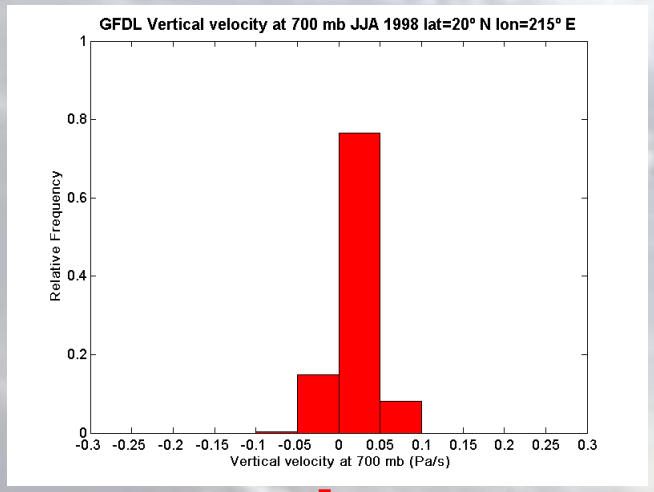
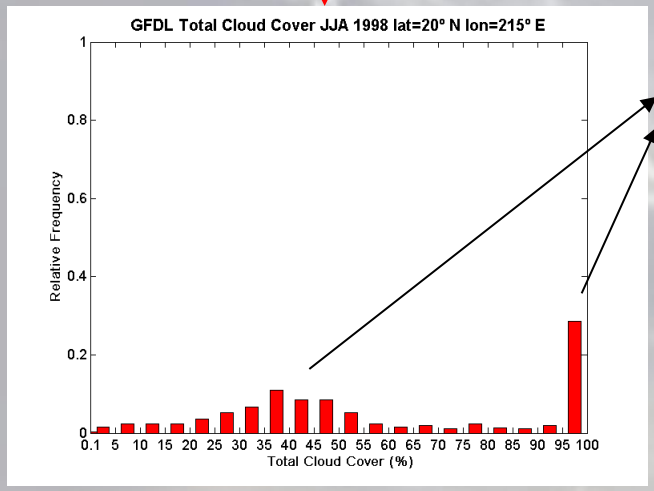
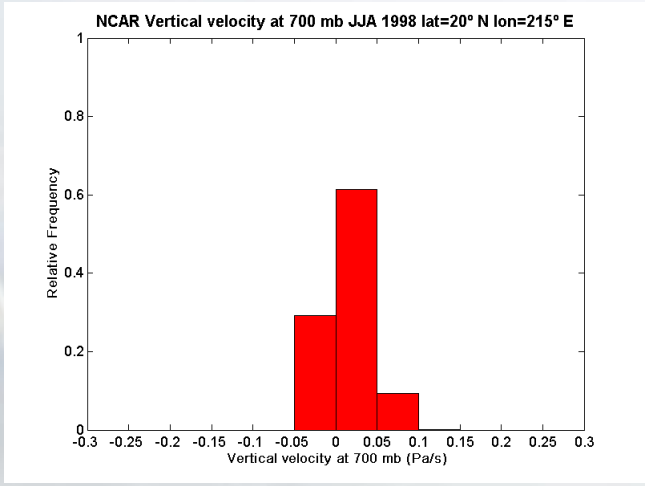
What is the response of clouds to variability in subsidence? histograms of vertical velocity (700 hPa) and total cloud cover (20 N, 215 E)

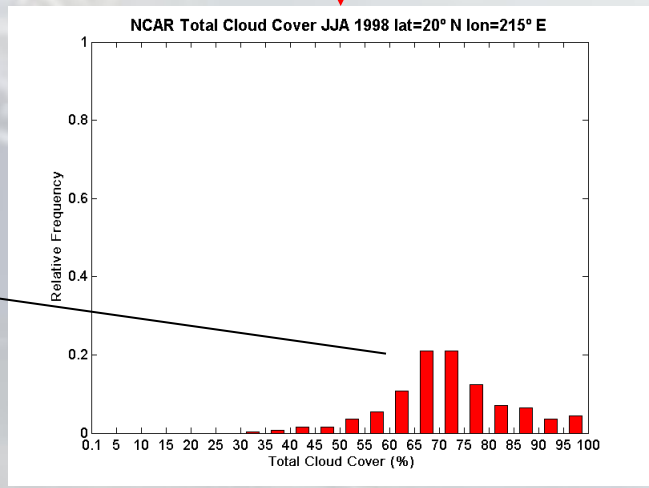
GFDL





two peaks .vs. one peak





NCAR

'Similar' histograms of subsidence lead to different cloud cover histograms

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Summary

- Tropical and subtropical cloud transitions are important for weather and climate (e.g. cloud-climate feedbacks)
- GPCI: models and observations are analyzed along a transect from stratocumulus, across shallow cumulus, to deep convection
- Overall satellite observations can characterize in a fairly comprehensive manner cloud regime transitions (e.g. subtropics to tropics transition)
- ISCCP can be used to successfully analyze a variety of characteristics of these cloud transitions (e.g. diurnal cycle, GPCI cloud histograms)
- Weather and climate models still suffer from serious problems to represent tropical and subtropical cloud transitions

ISCCP data has played a key role in model evaluation