



# Evaluation of clouds in CMIP5 models using precursor data sets

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Met Office  
Hadley Centre

# Motivation

- Clouds are associated with important feedbacks which provide one of the largest sources of uncertainty associated with estimating climate sensitivity and its spread across models.
- It is clearly crucial to evaluate cloud processes in climate models thoroughly – to improve models & projections of future climate.
- A wide range of satellite observations currently available & want to make best use of these.
- Model evaluation is a key focus for both CFMIP & EUCLIPSE.



# Choice of precursors – 1

- ISCCP provides a long record of cloud properties (1983 onwards) & similar parameters to the cloud CCI, although it is not suitable in all cases.
- Directly comparable diagnostics will be available in the CMIP5 models as part of CFMIP.
- In addition we can use ISCCP data together with other information – radiation budget from CERES and other cloud data sets, e.g. MODIS, SSM/I & CloudSat.
- Long time series permits evaluation of interannual variability as well as climatology (e.g. ENSO).



## Choice of precursors – 2

- Can find good match-ups between proposed CCI products and what is currently available & used for assessing climate models.
- So we can examine the potential utility of the CCI products.
- Can also compare with new observations such as CloudSat, which are already widely used by modellers.
- Challenge for the CCI is to determine where it can add value to what is currently being used by the modelling community.

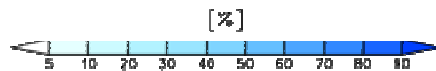
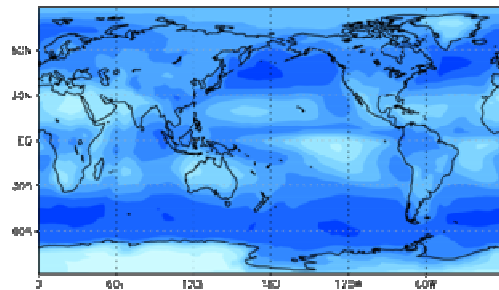


# Models simulations

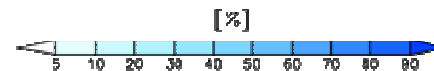
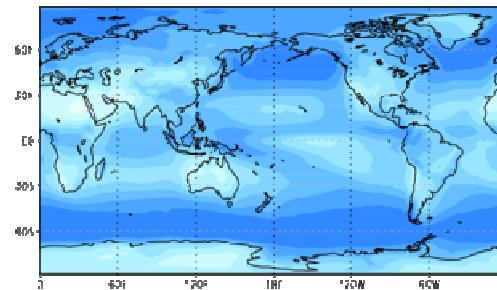
- Models: HadGEM2-A, CNRM-CM5, MPI-ESM-LR, MIROC5, CanAM4 & MRI-CGCM3
- AMIP simulations: models forced with observed SSTs and sea ice for 1979-2008.
- These models are chosen because they have already submitted the required diagnostics.
- Comparison with a variety of satellite data sets.
- Monthly means – most results shown here use long-term averages.

# Cloud amount & cloud albedo: CMIP5 multi-model mean

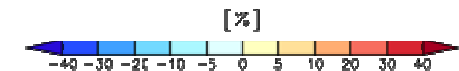
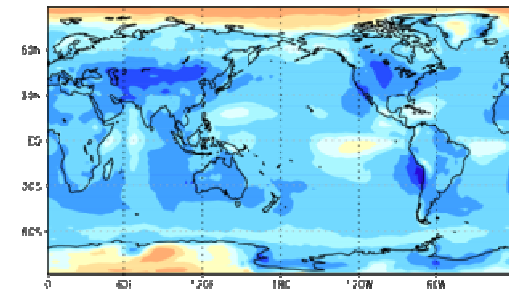
ISCCP Cloud Amount: OBSERVATIONS



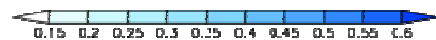
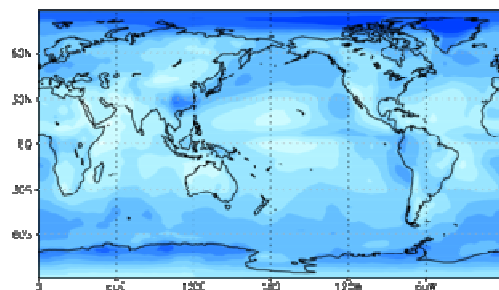
ISCCP Cloud Amount: MULTIMODEL MEAN



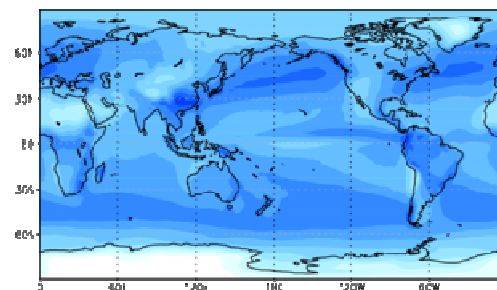
MODELS - OBSERVATIONS



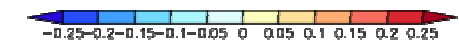
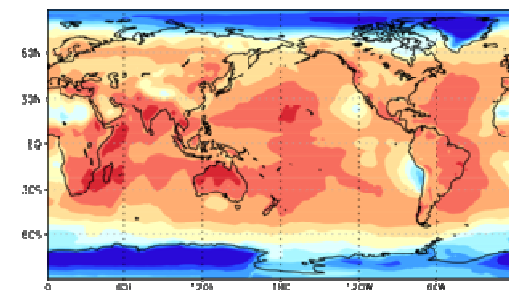
ISCCP Cloud Albedo: OBSERVATIONS



ISCCP Cloud Albedo: MULTIMODEL MEAN

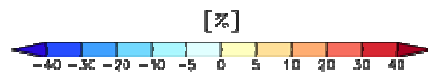
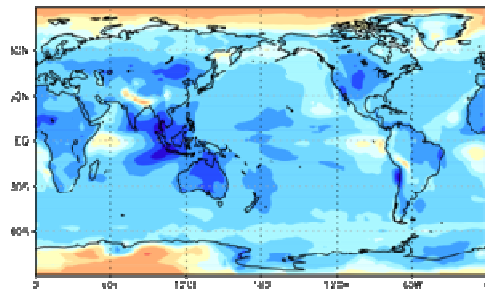


MODELS - OBSERVATIONS

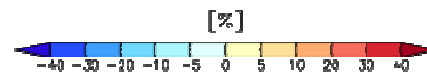
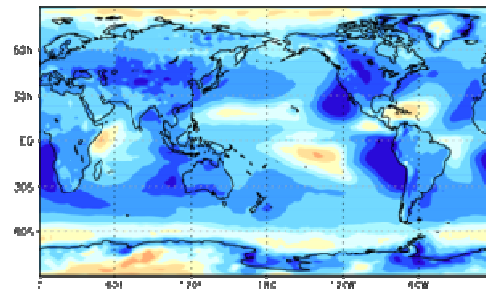


# Cloud amount: Models - Obs

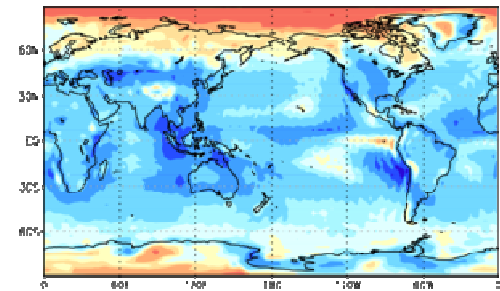
ISCCP Cloud Amount: HadGEM2-A



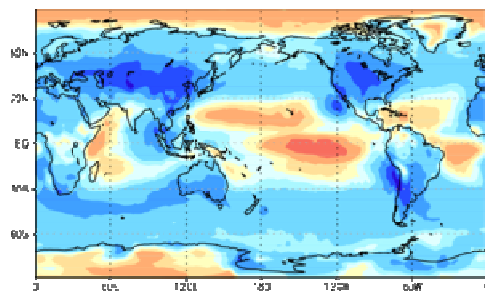
ISCCP Cloud Amount: CNRM-CM5



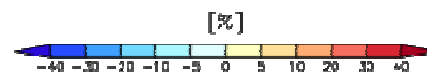
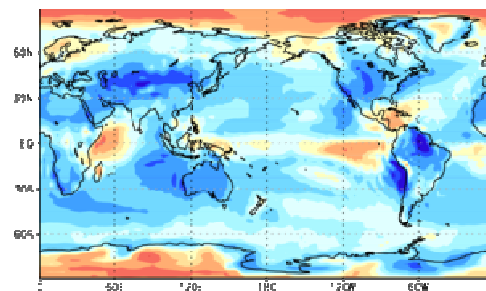
ISCCP Cloud Amount: MPI-ESM-LR



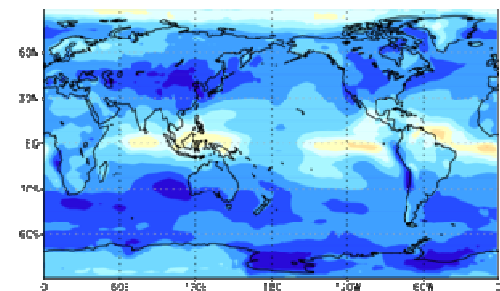
ISCCP Cloud Amount: MIROC5



ISCCP Cloud Amount: CanAM4

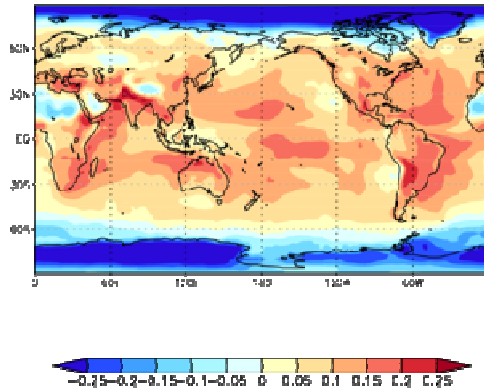


ISCCP Cloud Amount: MRI-CGCM3

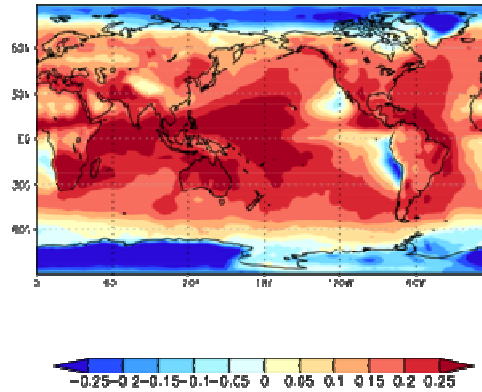


# Cloud albedo: Models - Obs

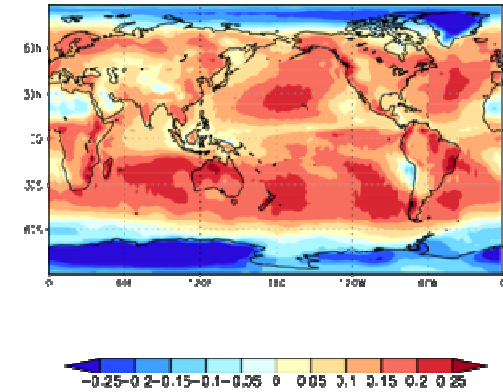
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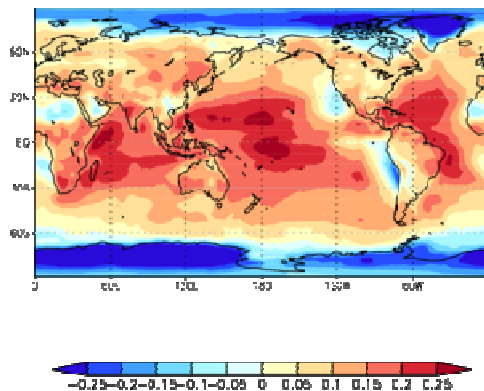
ISCCP Cloud Albedo: CNRM-CM5



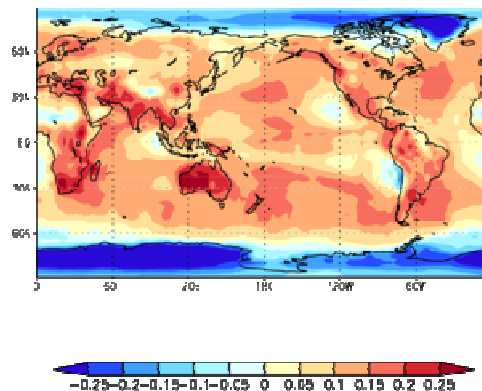
ISCCP Cloud Albedo: MPI-ESM-LR



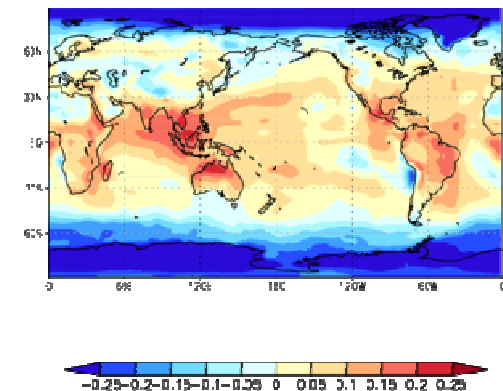
ISCCP Cloud Albedo: MIROC5



ISCCP Cloud Albedo: CanAM4



ISCCP Cloud Albedo: MRI-CGCM3



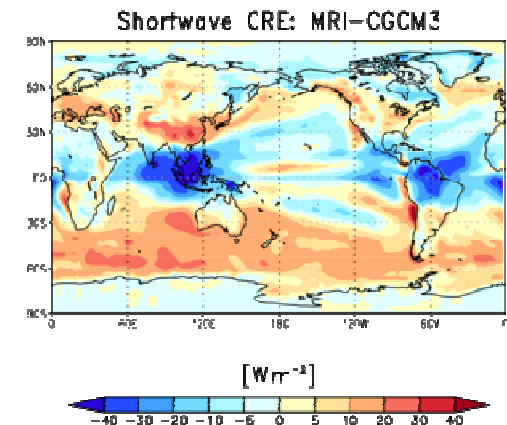
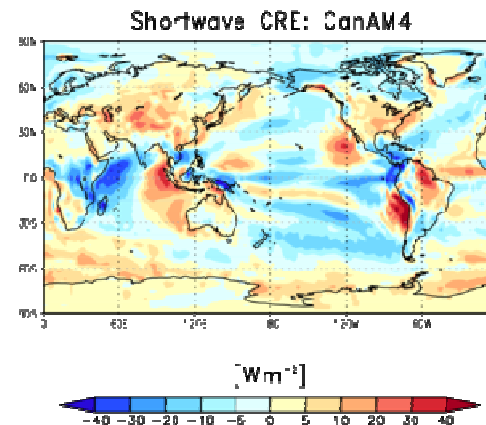
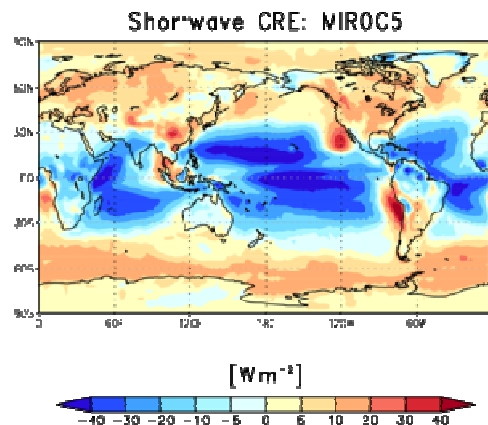
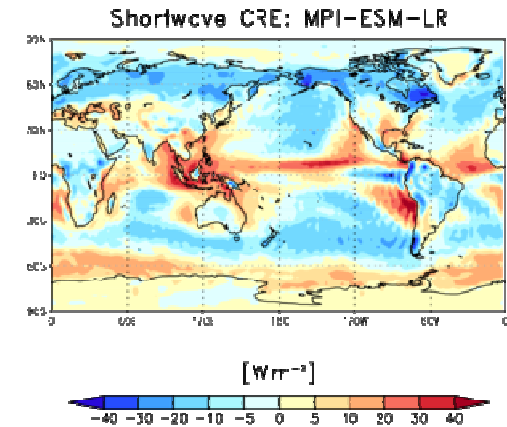
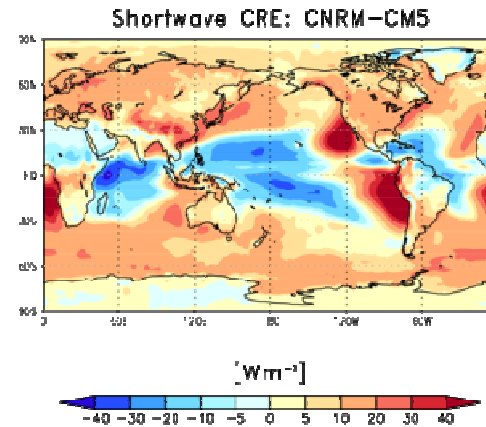
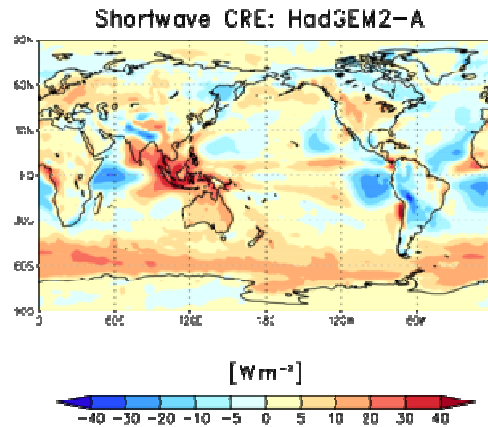




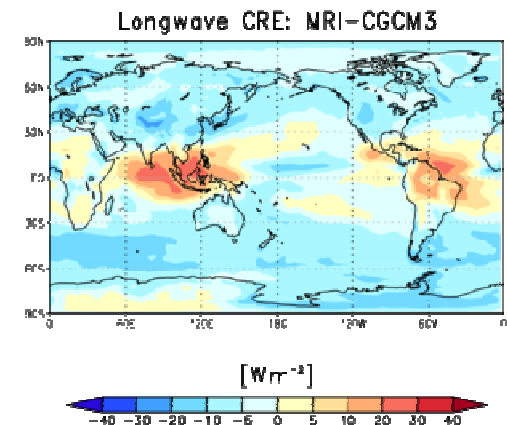
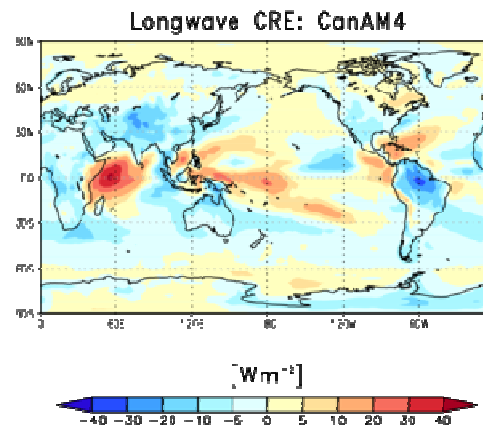
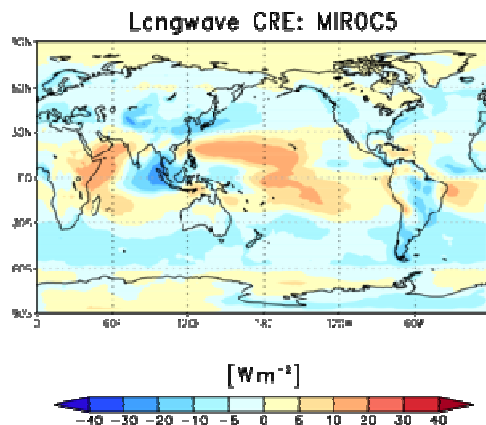
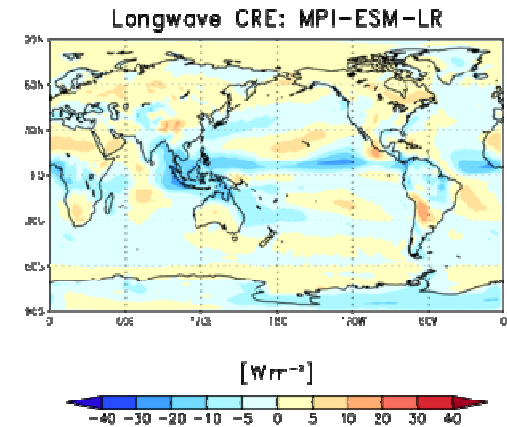
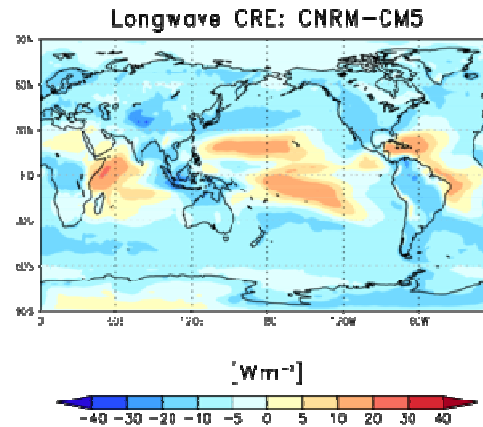
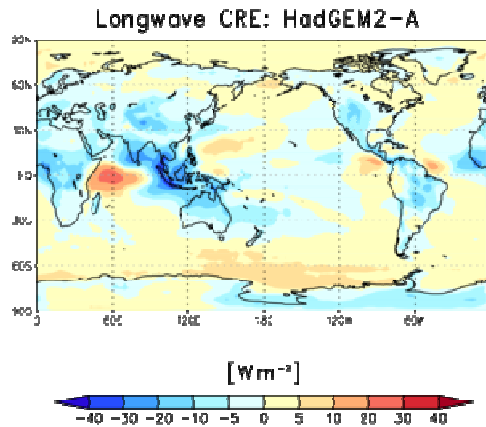
## Why might this be relevant to cloud feedbacks?

- Observations indicate close to 100% cloud coverage over the Southern Ocean but models have much less (75%)
- Possibility of unrealistic feedback due to increasing cloud in models in response to warming (cf Trenberth & Fasullo 2010)
- Can also imagine similarly unrealistic feedback responses if cloud water/albedo is overestimated (cf Stephens 2010)

# Shortwave cloud radiative effect at top-of-atmosphere: CERES

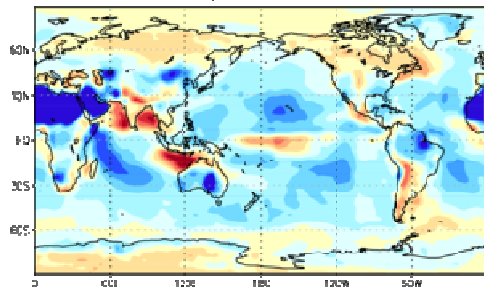


# Longwave cloud radiative effect at top-of-atmosphere: CERES

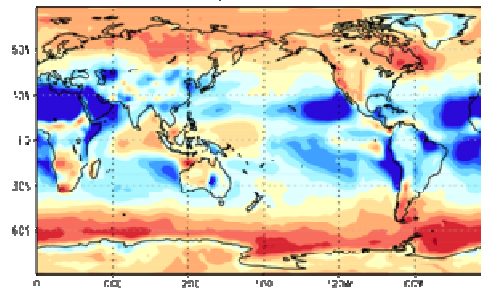


# Cloud top pressure: ISCCP

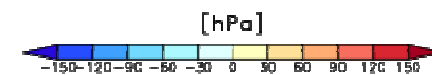
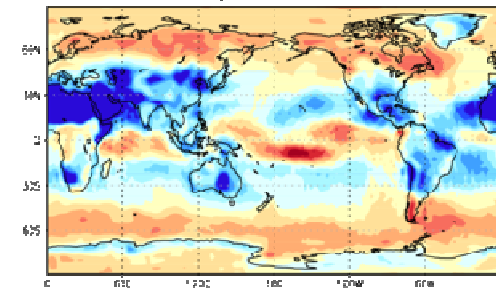
ISCCP Cloud Top Pressure: HadGEM2-A



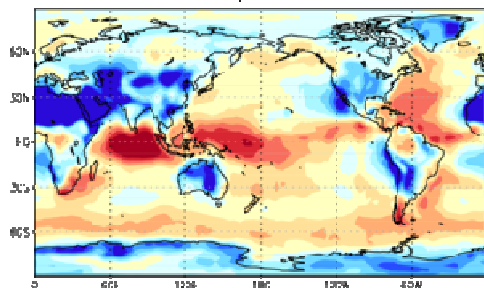
ISCCP Cloud Top Pressure: CNRM-CM5



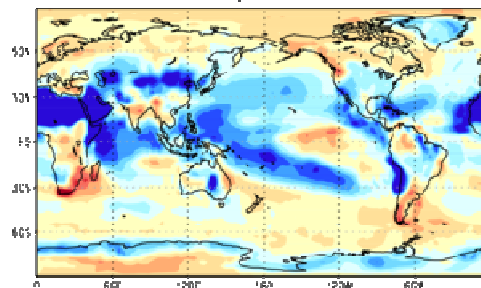
ISCCP Cloud Top Pressure: MPI-ESM-R



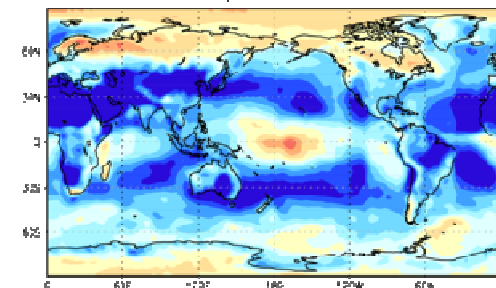
ISCCP Cloud Top Pressure: MIROC5



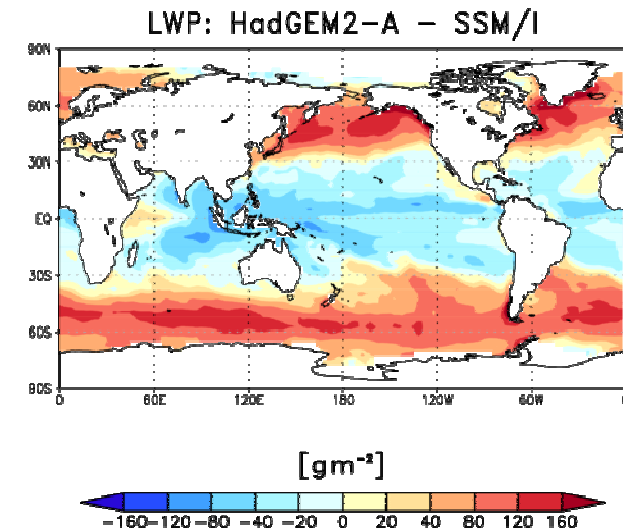
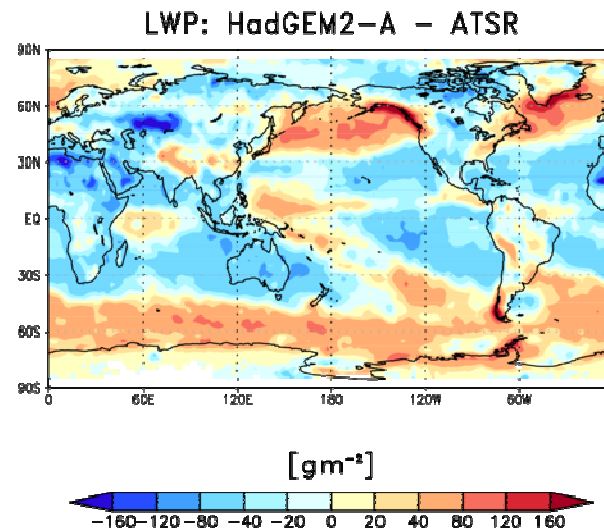
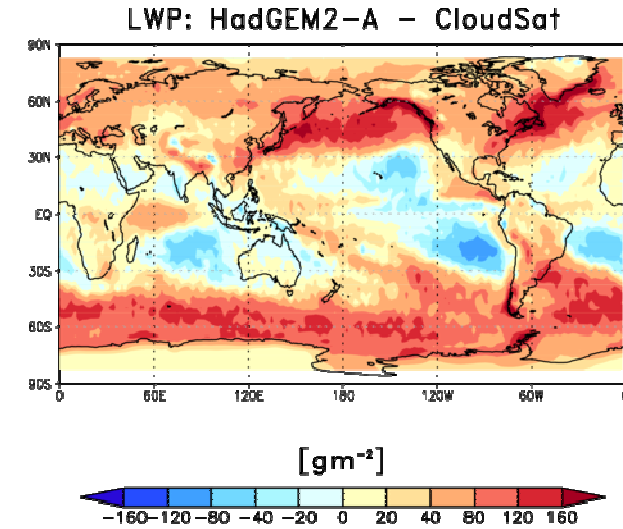
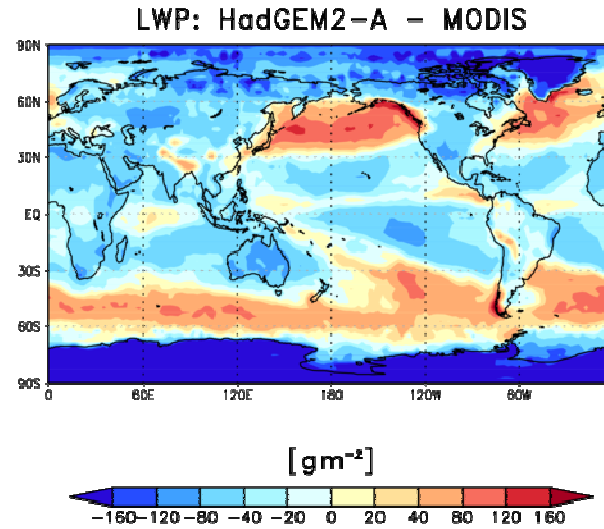
ISCCP Cloud Top Pressure: CarAM4



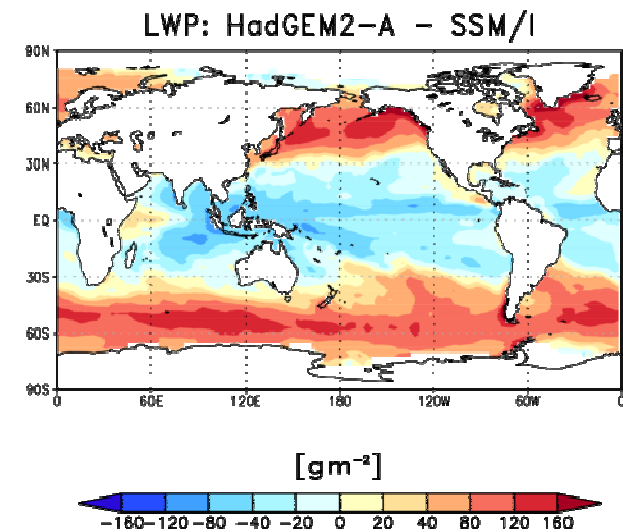
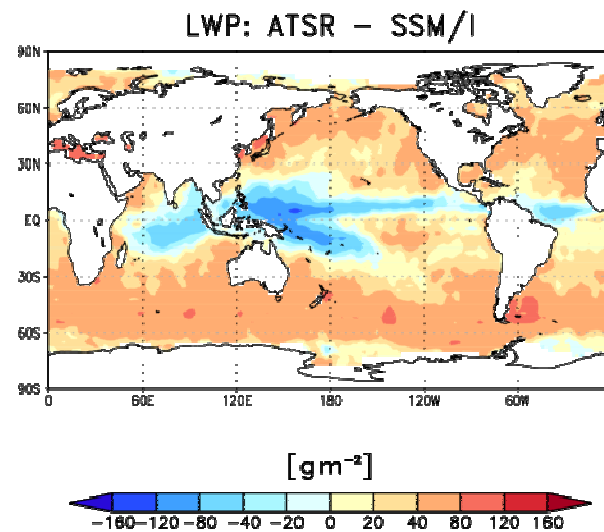
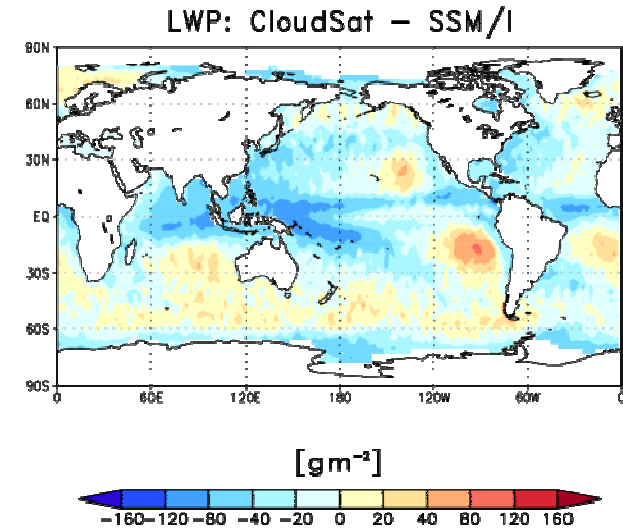
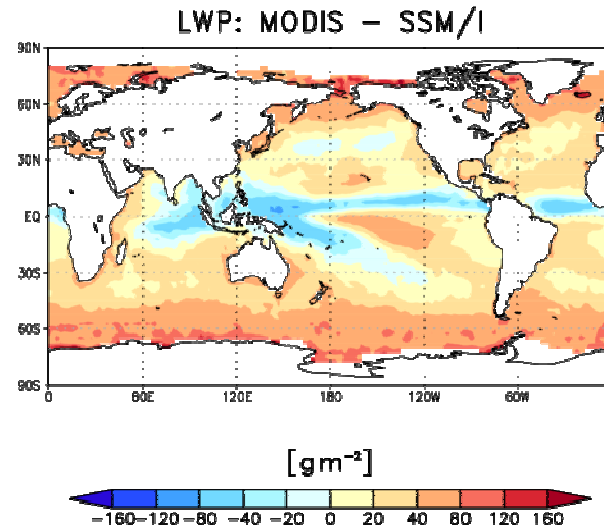
ISCCP Cloud Top Pressure: MRI-CGCM3



# Cloud liquid water path: HadGEM2

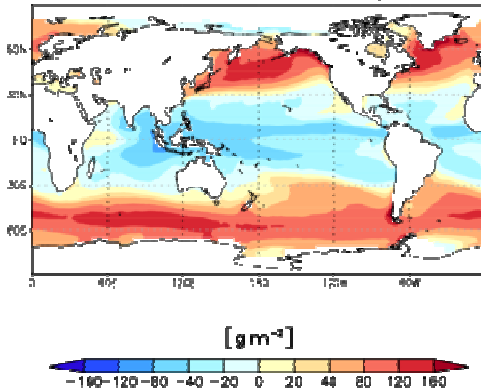


# CLWP: Observations comparison

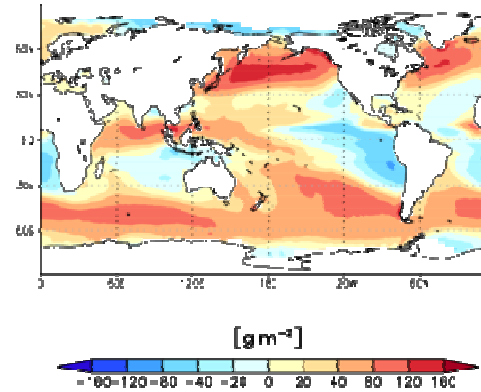


# Cloud liquid water: CMIP5 Models vs. SSM/I

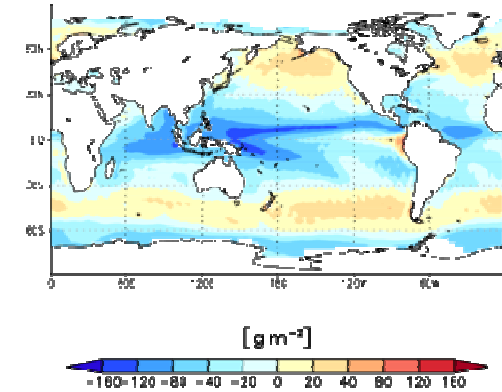
LWP: HadGEM2 - SSM/I



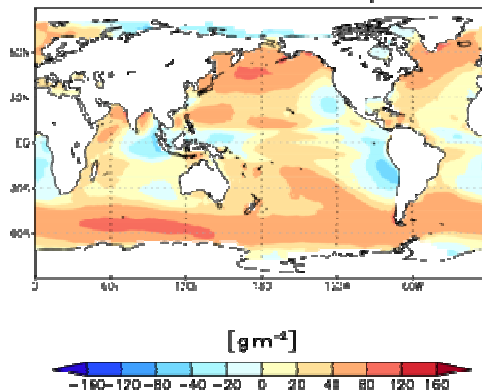
LWP: CNRM - SSM/I



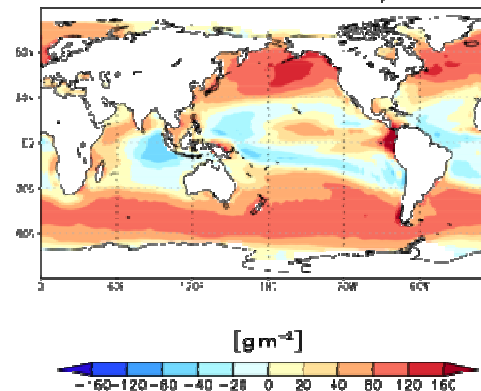
LWP: MPI - SSM/I



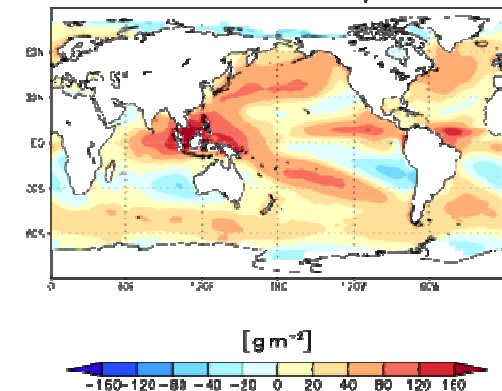
LWP: MIROC5 - SSM/I



LWP: CanAM4 - SSM/I

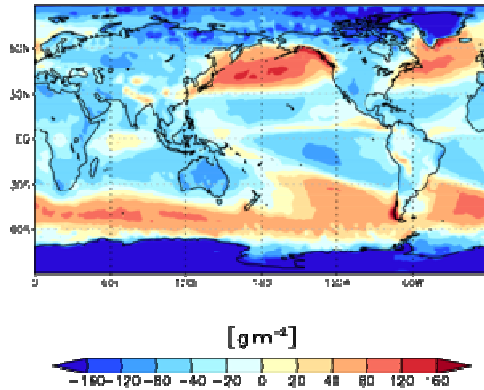


LWP: MRI - SSM/I

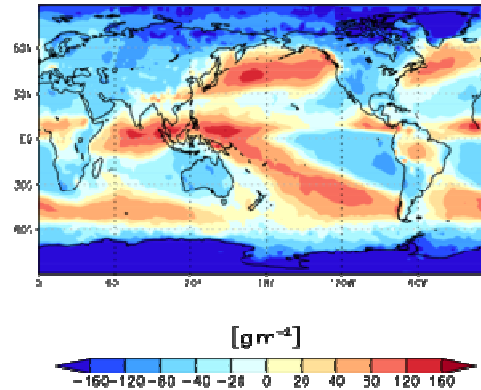


# Cloud liquid water: CMIP5 Models vs. MODIS

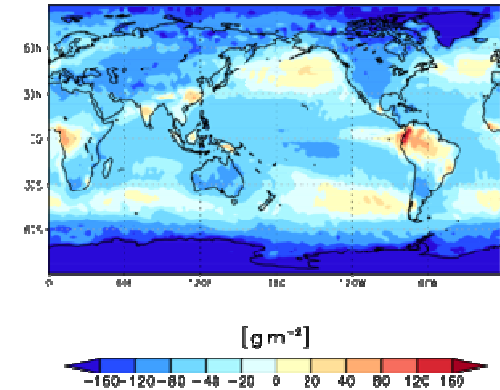
LWP: HadGEM2 - MODIS



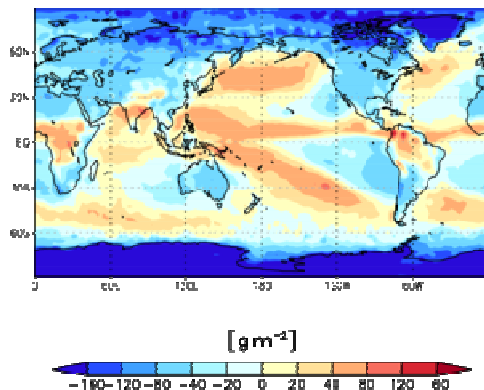
LWP: CNRM - MODIS



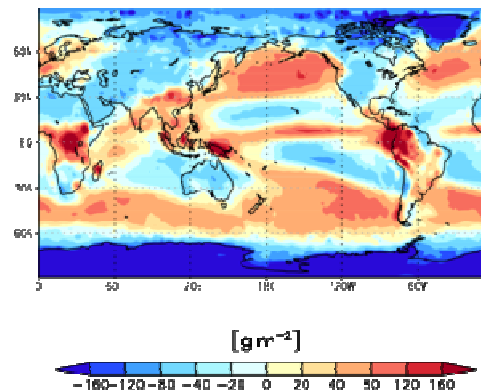
LWP: MPI - MODIS



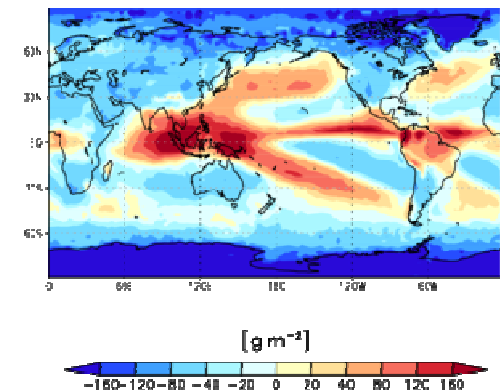
LWP: MIROC5 - MODIS



LWP: CanAM4 - MODIS

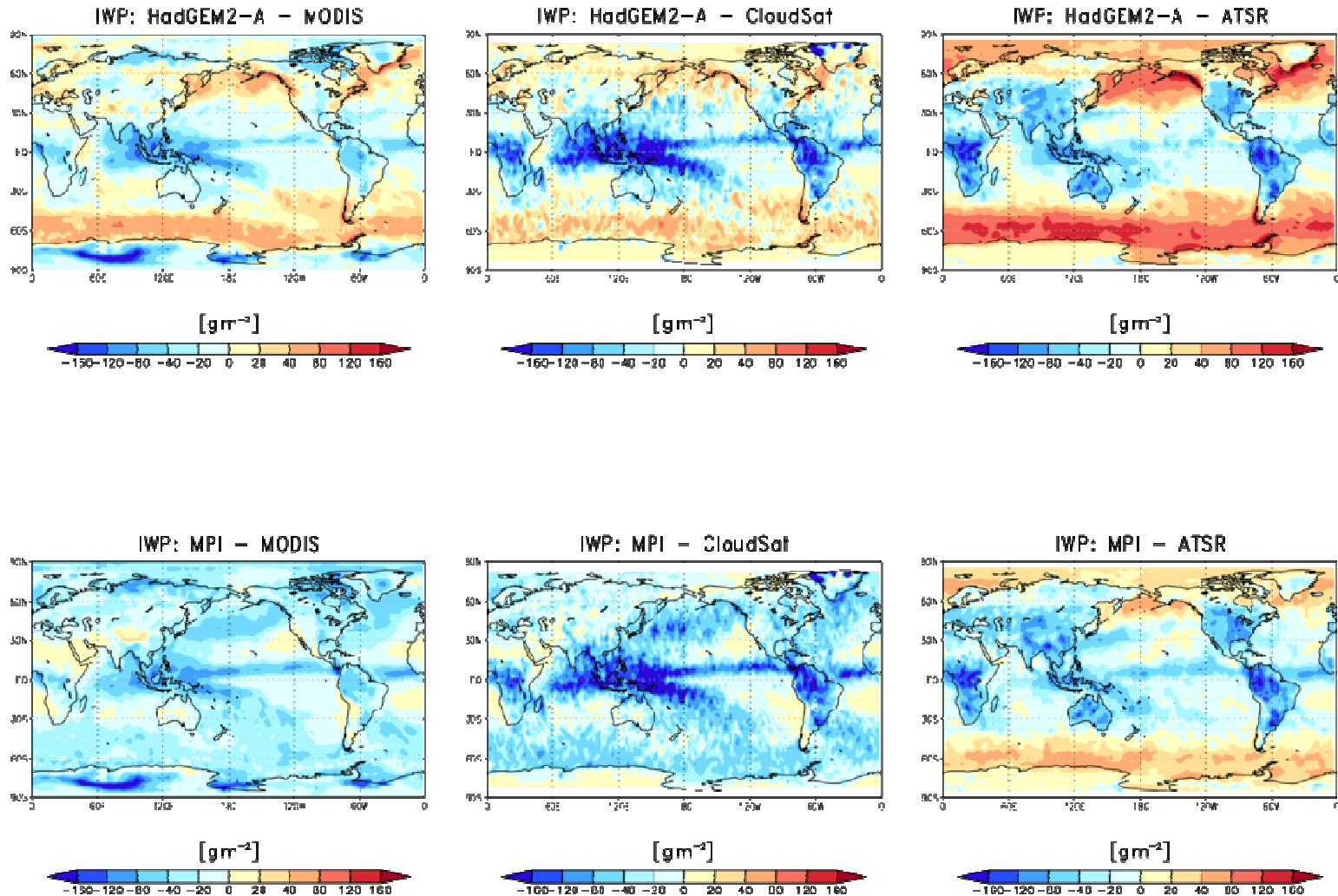


LWP: MRI - MODIS



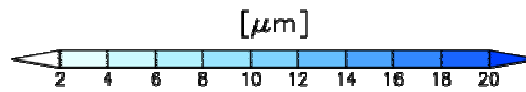
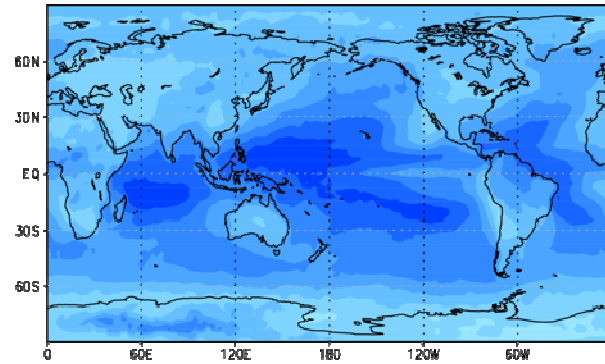


# Cloud ice: HadGEM2 & MPI models vs. observations

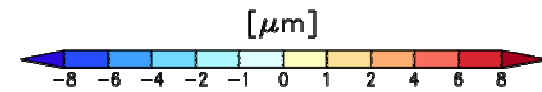
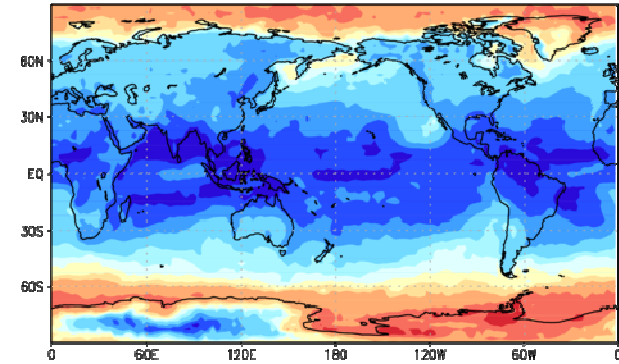


# Cloud droplet size: HadGEM2

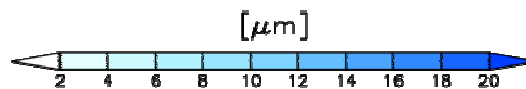
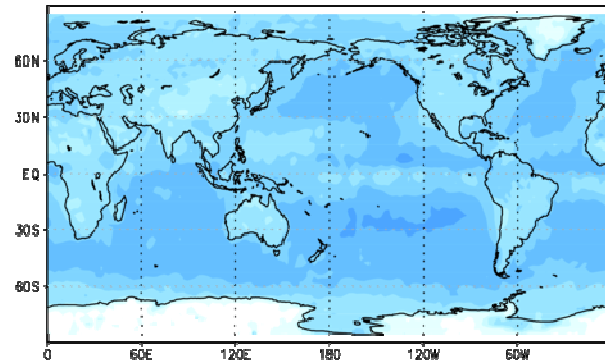
reff: MODIS



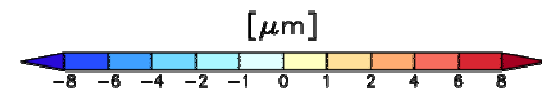
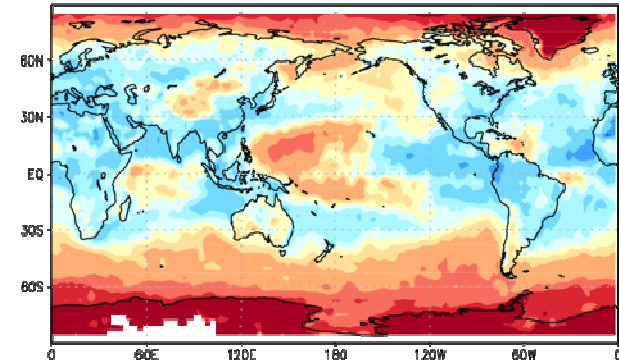
reff: HadGEM2 – MODIS



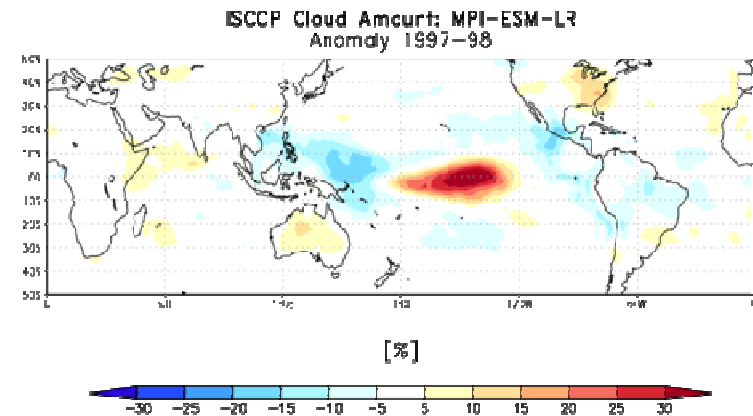
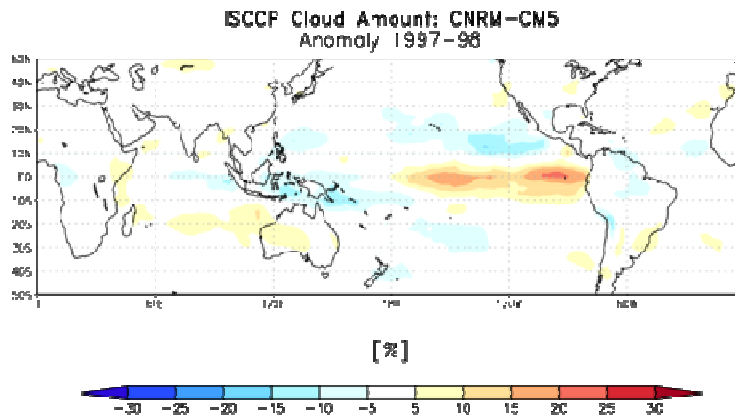
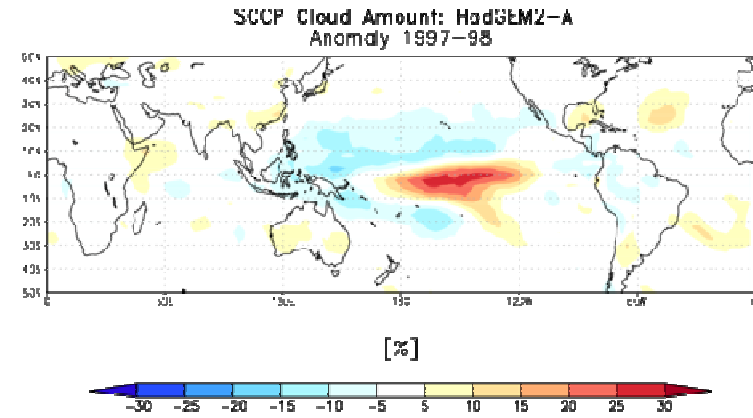
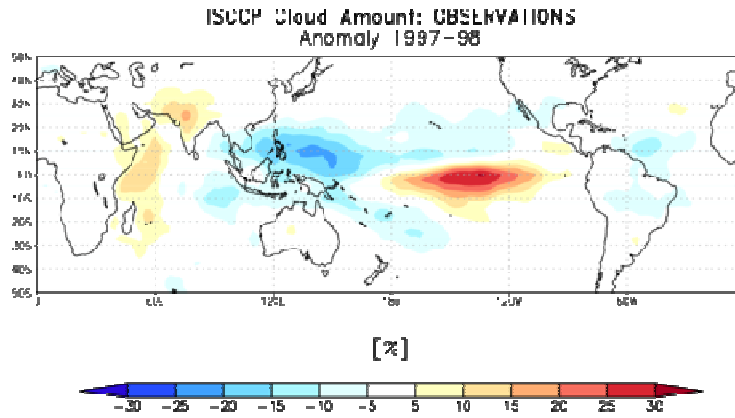
reff: ATSR



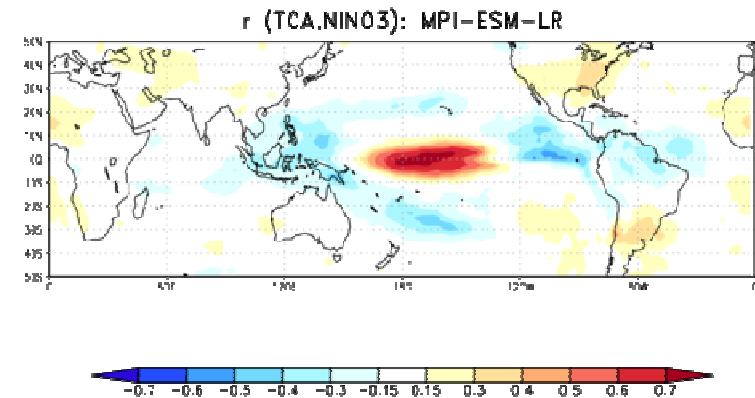
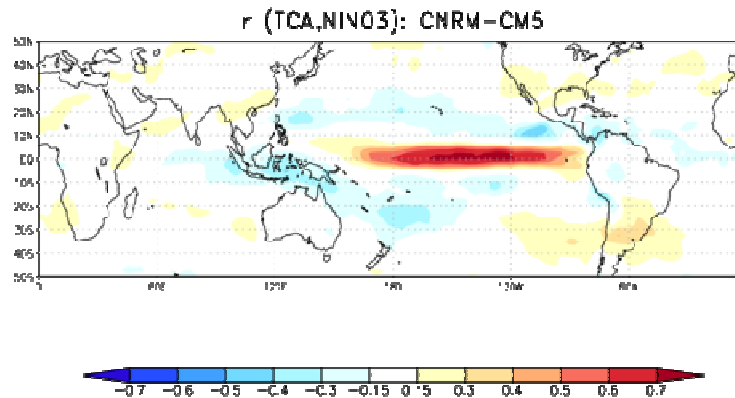
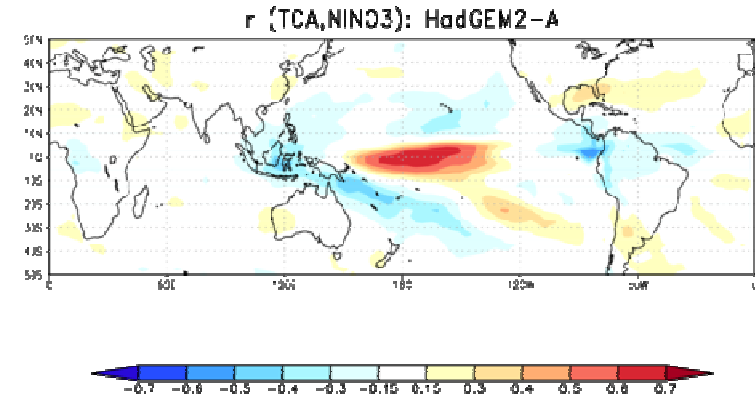
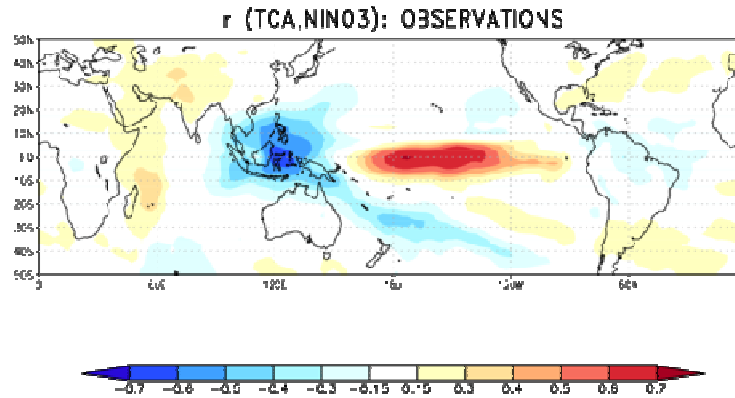
reff: HadGEM2-A – ATSR



# Cloud amount anomalies: 1997-98 ENSO



# Correlation with Niño-3 SST: Anomalies 1983-2008





# Current & future work

- More detailed use of ISCCP data: e.g. CTP-TAU histograms and comparisons with MODIS, MISR, etc
- Process studies using CloudSat (radar) and CALIPSO (lidar)
- Cirrus and sub-tropical marine stratocumulus
- More on seasonal & interannual variability
- Impact of increasing resolution
- And ultimately...how do all of the above – and more – relate to feedbacks under climate change?



# Concluding remarks

- Modellers use a range of observations for evaluation of clouds – there isn't a single precursor data set.
- Need to determine where CCI fits in and how it compares to what's currently used – e.g. LWP, IWP c.f. SSM/I or CloudSat.
- Value will probably come from long-term record – plausible estimates of variability and trends – and provision of reliable error estimates.