Clouds in the Southern midlatitude oceans

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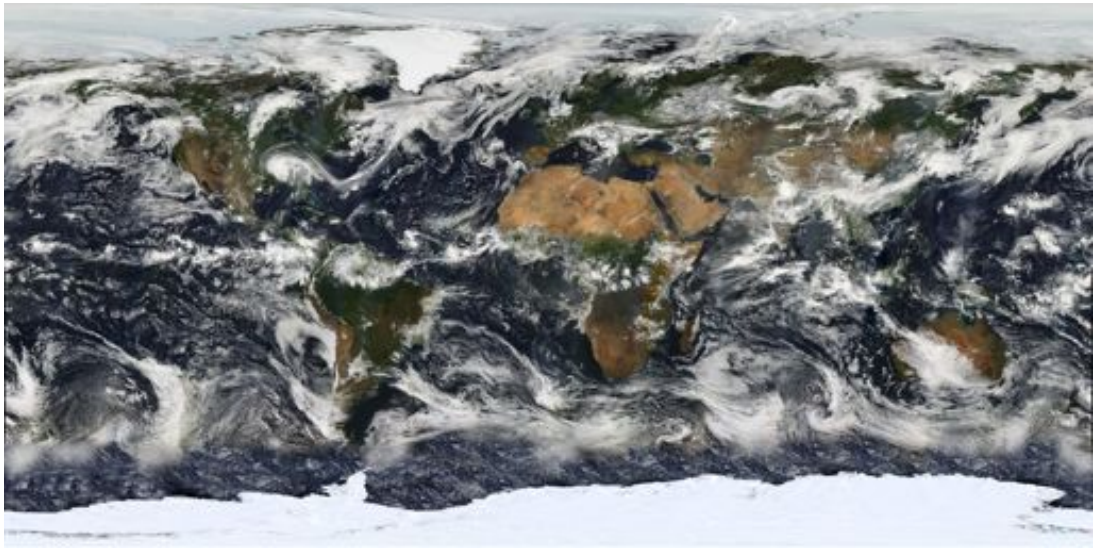
Clouds in the Southern oceans

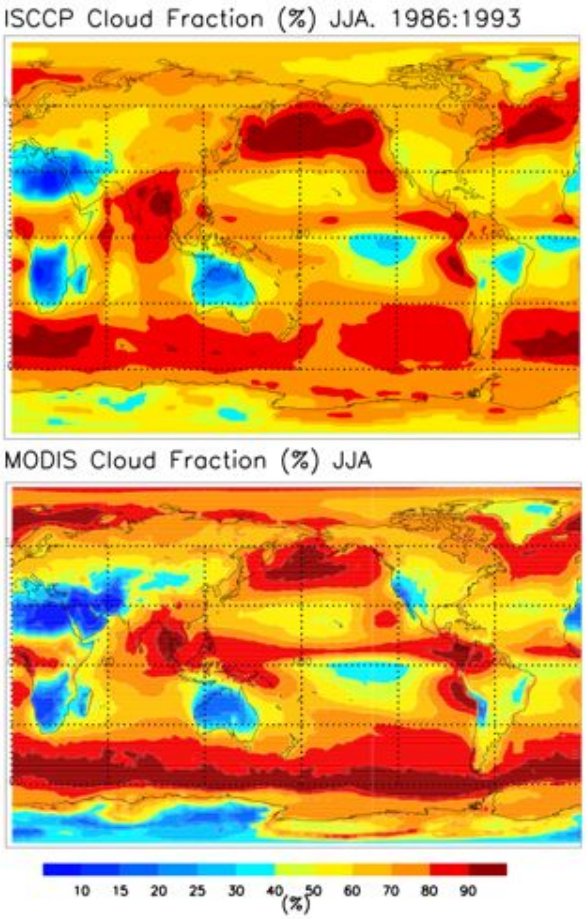
Terra July 11 2005 (+GOES for Antarctica)



- Satellites reveal large cloud cover 30-65S: ISCCP=0.79 & CloudSat=0.81 (Haynes et al., 2011), MODIS=0.82
- Recently, Mace 2010, Gordon and Norris 2010, Haynes et al 2011 find presence of low-level clouds most of the time

ISCCP vs MODIS global cloud cover

- ISCCP and MODIS fairly close despite differences in instrument sensitivity, resolution and temporal sampling.
- DJF vs JJA cloud cover: small seasonal variations in SH and at least 80% cover in 30-60S

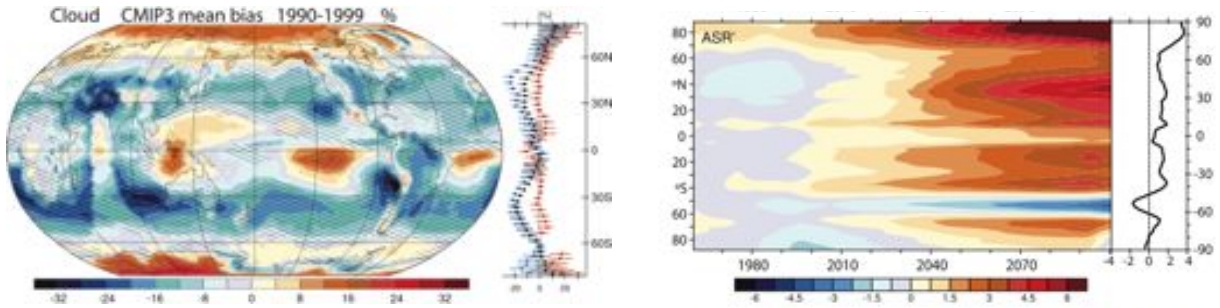


ISCCP 1986-1993 (top) and MODIS 2000-2010 (bottom) cloud fraction for the Austral Winter (JJA)

Problem in AR4 GCMs

Trenberth and Fasullo (2010):

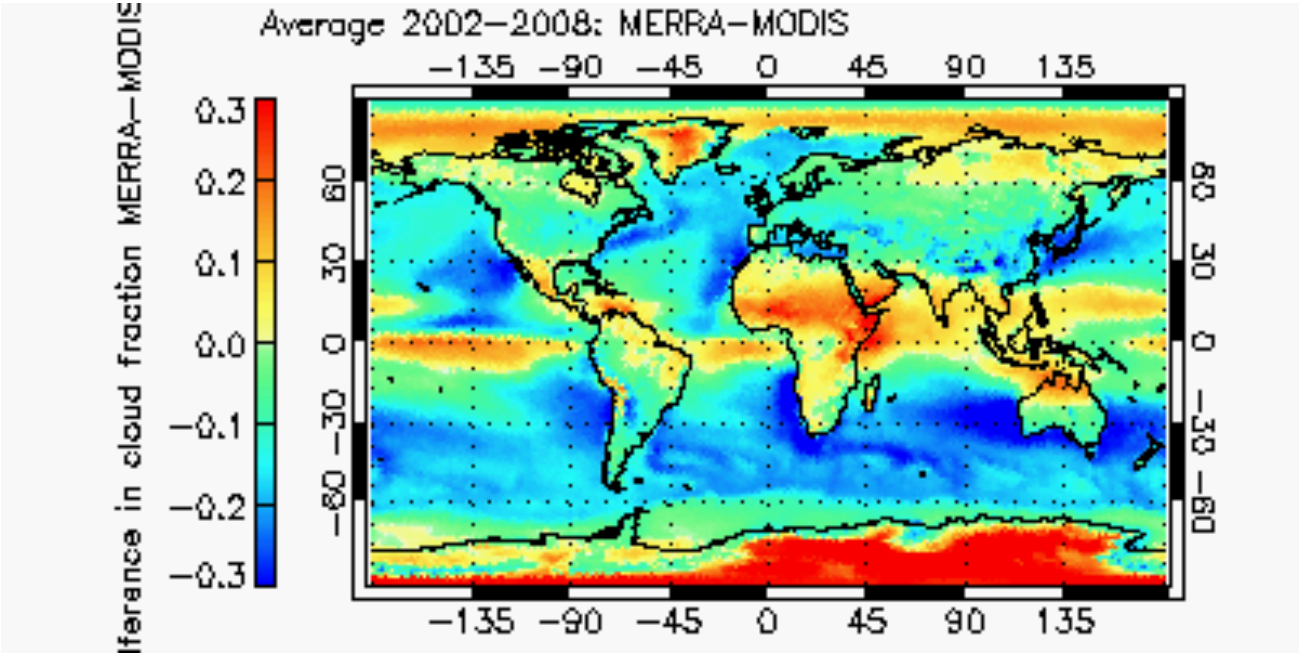
- most (AR4) GCMs overestimate absorbed solar radiation in the southern oceans = > directly related to climate sensitivity and affect long term predictions
- Cloud cover underestimate in SH oceans



Left: Biases for cloud amount in % relative to the ISCCP D2 climatology for 1990-99, where stippled (hatched) regions correspond to regions in which at least three quarters of the models share a common positive (negative) bias (Trenberth and Fasullo, 2010). Right: Latitude-time series from 1960 to 2100 of zonal average ASR in Wm^{-2} (Trenberth and Fasullo, 2009).

Underestimate in models ubiquitous

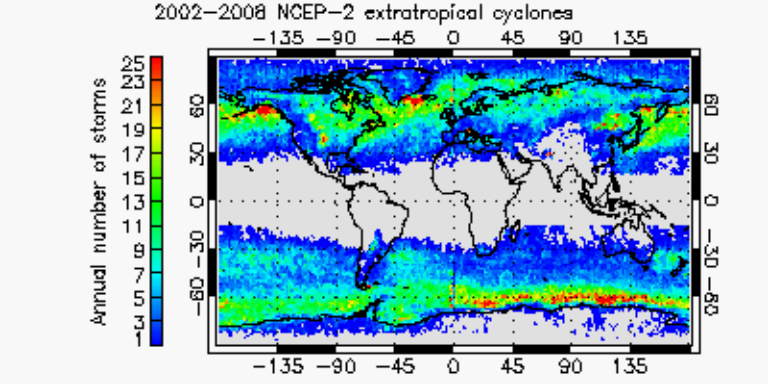
- GISS Model-E cloud fraction 30-65S =0.68 (AR4) or =0.61 (AR5)
- Problem also affects reanalysis models=> MERRA cloud cover also less than MODIS



Difference in average cloud fraction for 2002-2008 between MERRA and MODIS-Terra

How to isolate issues in GCMs?

- Cloud processes:
  - missing?
  - ill represented?

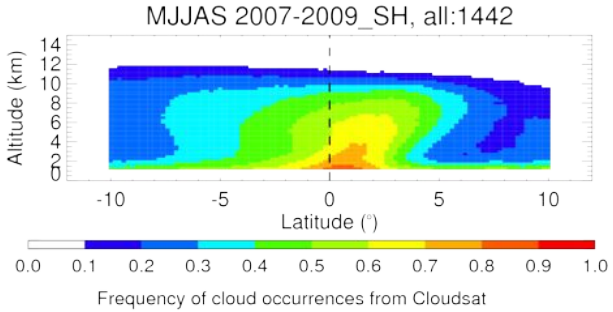


Annual number of extratropical cyclones (2002-2008)

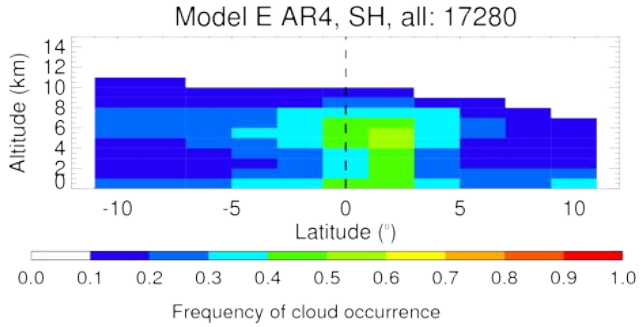
- Method: Decompose between cyclonic and non-cyclonic regions (as opposed to cloud regimes) => composite model and observations in the same manner for direct comparison in similar dynamical context
- Some examples

Previous work in extratropical cyclones

- CloudSat-CALIPSO perspective: cloud frequency of occurrence across warm fronts



distribution from warm to cold sectors (dashed line marks position of surface front)



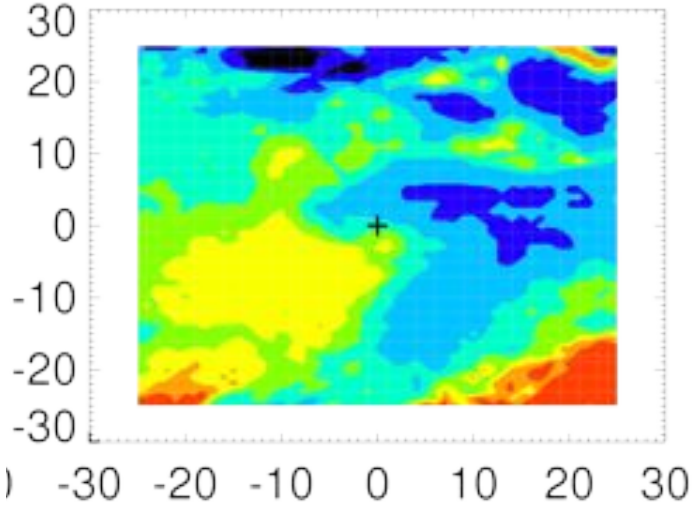
Naud et al JCLI 2010

2x2.5x40L Model E AR4-intermediate version: lower cloud fraction across warm front
=> vertical velocities too weak in Model E / lack of vertical moisture transport

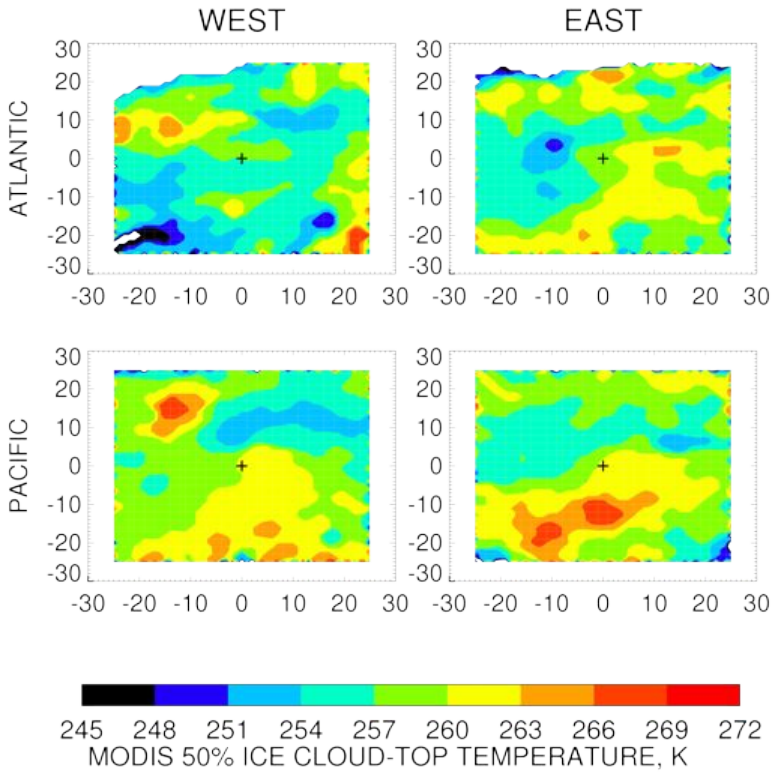
Using A-train for observational constraint

- MODIS cloud properties in cyclones: cloud top temperature (left), or cloud phase (right)

42 storms NE Atlantic ocean during winters 2002 to 2004

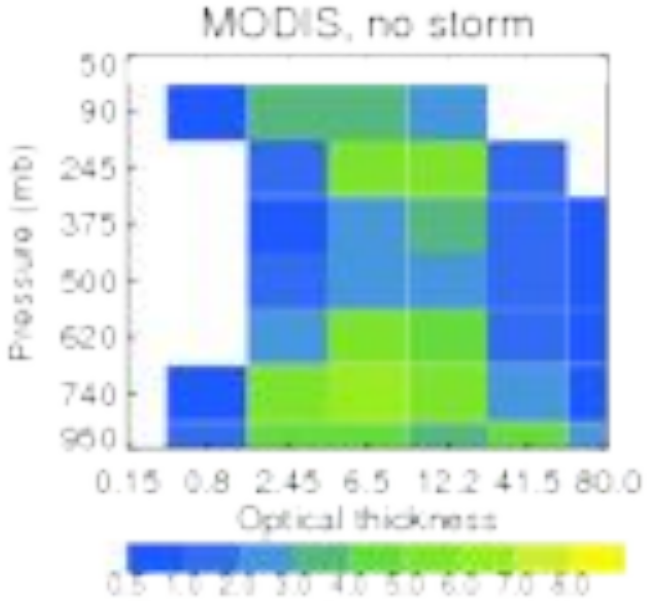


Temperature for equal probability of ice and liquid (the colder, the higher the probability of liquid at cloud top) => threshold used in GISS GCM for transition from liquid to ice should depend on vertical velocity



Outside of cyclones

- No cyclone (region at least 2000 km from low pressure center): MODIS "*ISCCP-like*" CTP vs Tau in SH oceans (2000-2010, daily files)



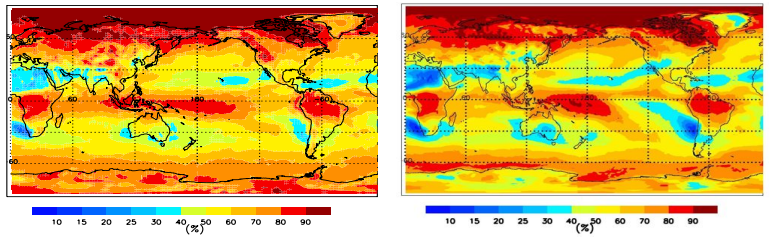
- large amount of low-level clouds, often without higher level clouds present
- Using COSP MODIS simulator: similar histogram with GCM

Future work: Terraqua project

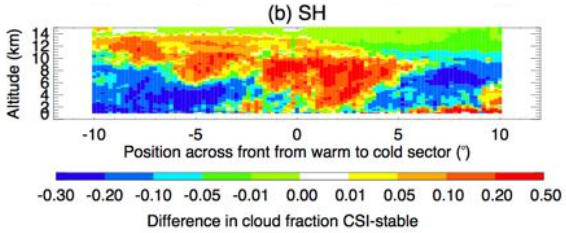
- Combine MODIS+MISR cloud properties: through cyclone lifecycle+ when no cyclone=> observational constraint
- MISR cloud top heights useful for low-level clouds
- Add AMSR-E and AIRS information + MERRA reanalysis to characterize dynamic and thermodynamic context
- Use composites to test GISS GCM and other AR5 models and possible improvements/modications

Possible changes that may impact cloudiness in cyclonic and quiescent regions

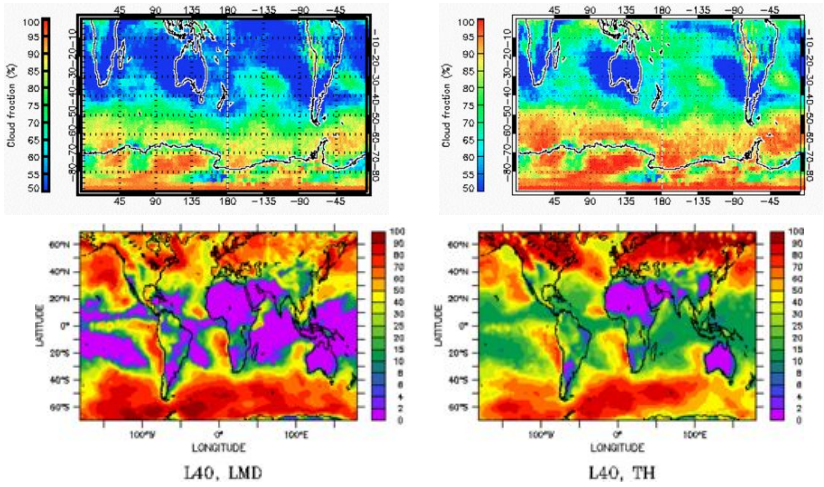
- Spatial resolution 2x2.5 => 1x1 (Jan. 1990s)
  (Cloud fraction in GISS 2x2.5 version vs Cubed Sphere – courtesy of Max Kelley)



- Conditional symmetric instability => slantwise convection
  (increase in CloudSat-CALIPSO cloud occurrence when CSI across warm fronts)



- Overlap: GISS Model-E cloud fraction with maximum-random and random-random overlap



- Thermals in BL: Jan. low-level cloud fraction in LMDz (left) and when thermals parameterization added (right)

=> To be tested with MODIS/MISR composites