Comprehensive cloud evaluation in GCMs

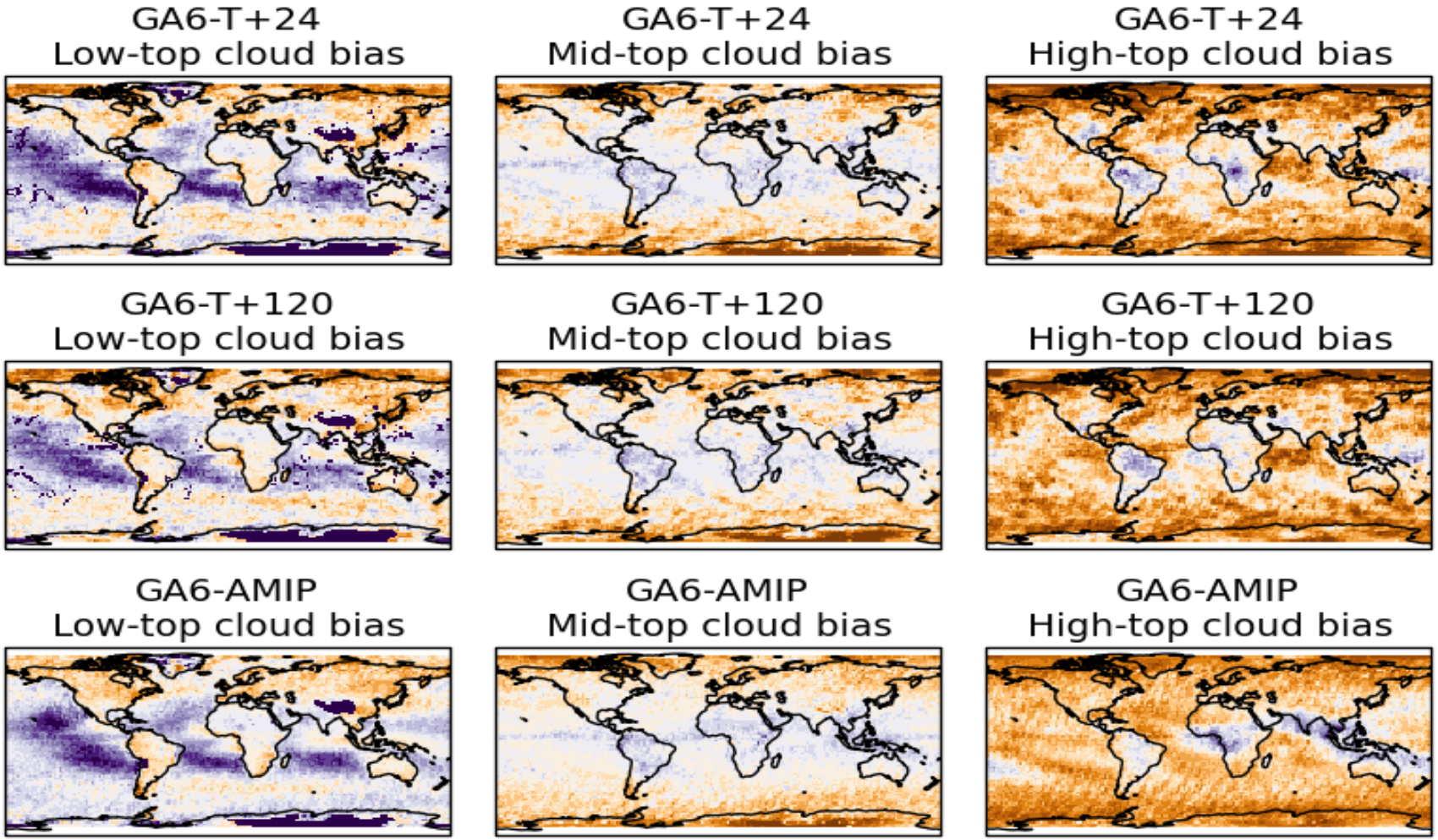
Keith Williams & Alejandro Bodas-Salcedo

CFMIP, 08/06/15

Aims of the project

- Use a range of observational data and diagnostic techniques to provide a thorough evaluation of cloud.
- This is illustrated through the evaluation of:
  - The GA6 configuration of the Unified Model (currently operational at the Met Office).
  - Prototype GA7 configuration (#136.5), which contains numerous cloud changes. GA7 will be operational from spring 2016 & will underpin UKESM1 – the UK's submission to CMIP6.

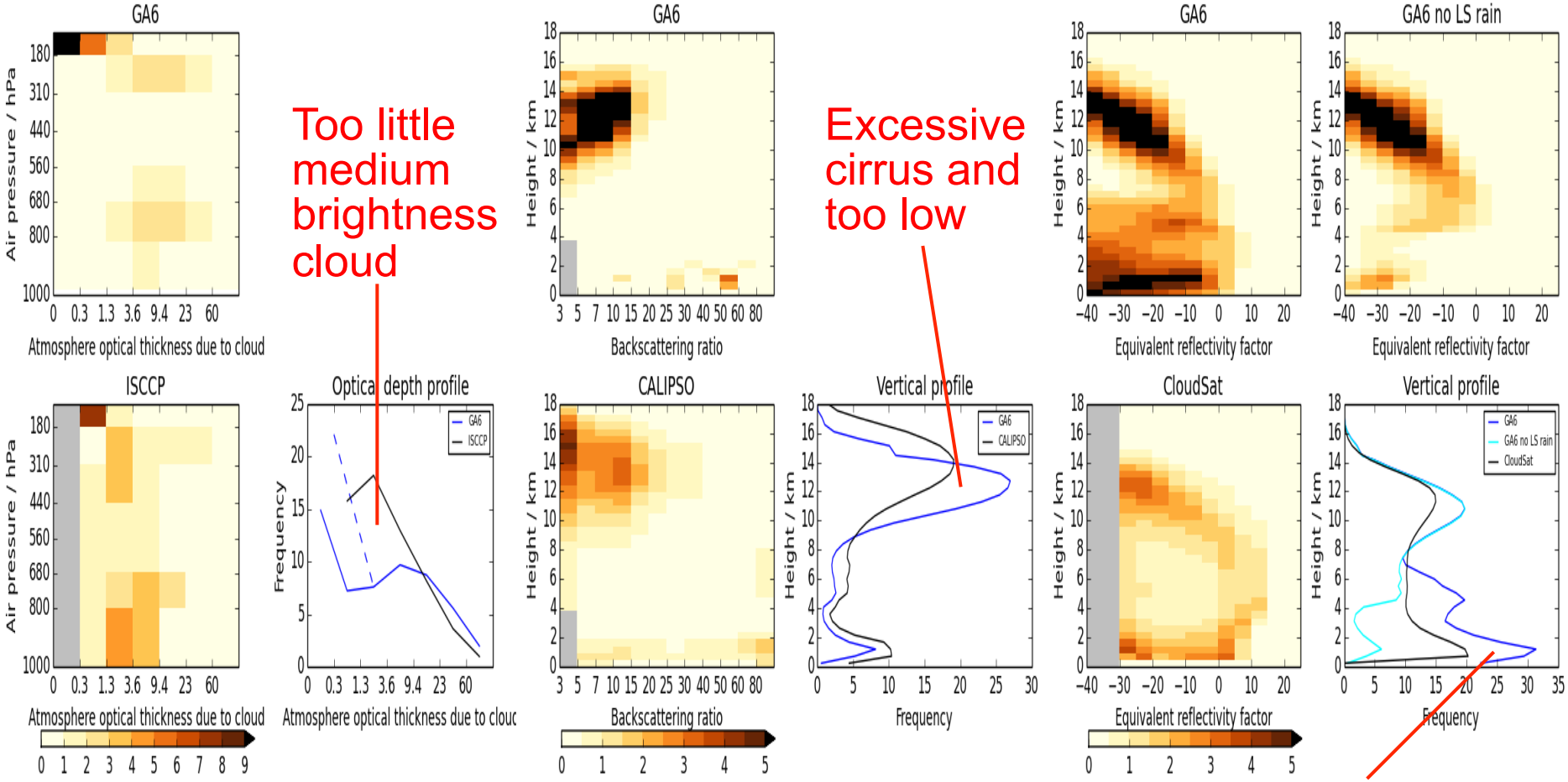
Bias in cloud cover
(against CALIPSO)



Tropics

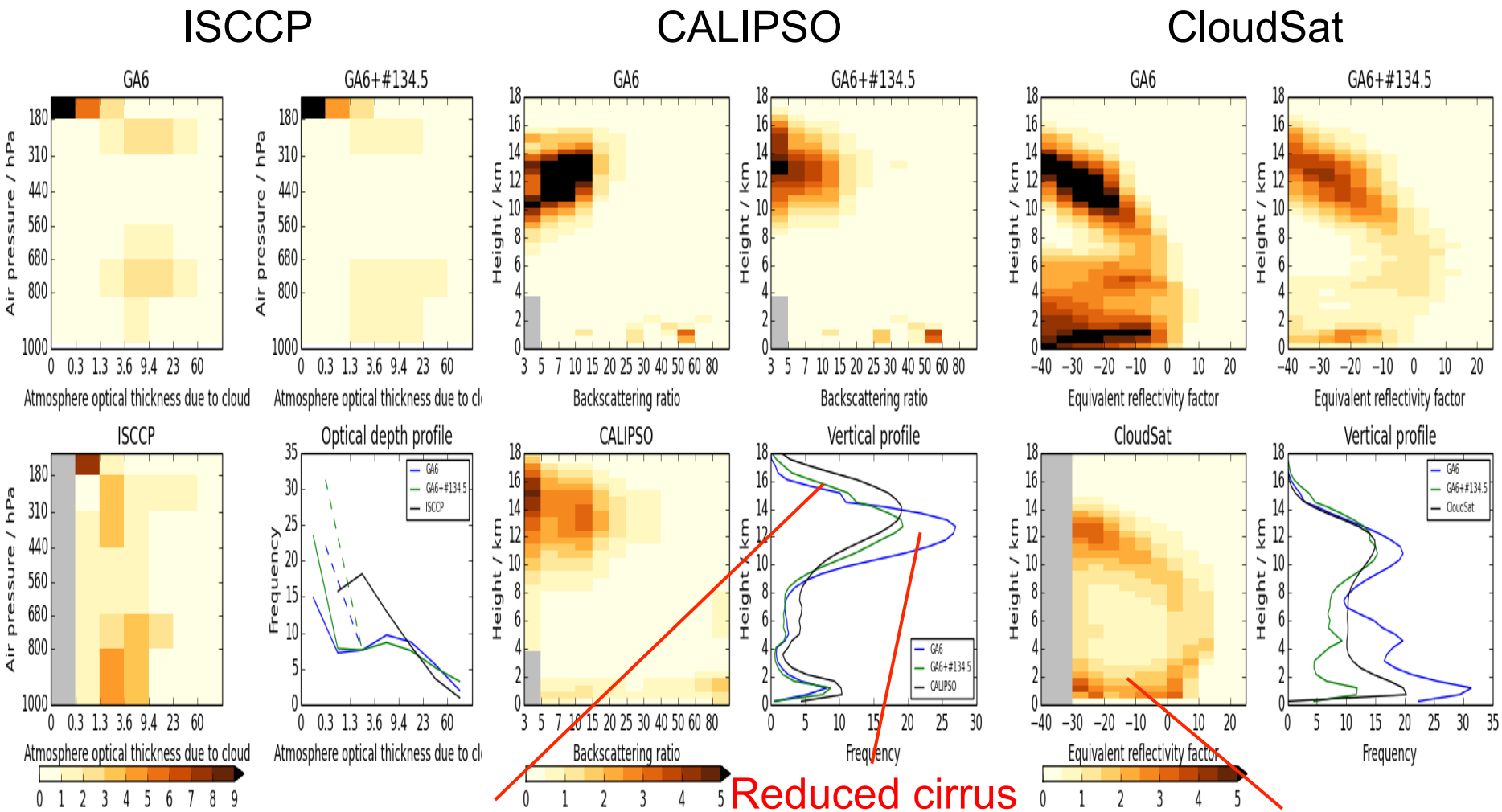
Comparison against satellite data over the tropics

ISCCP CALIPSO CloudSat



Excess "drizzle" (<0.005mm/hr)

Comparison against satellite data over the tropics

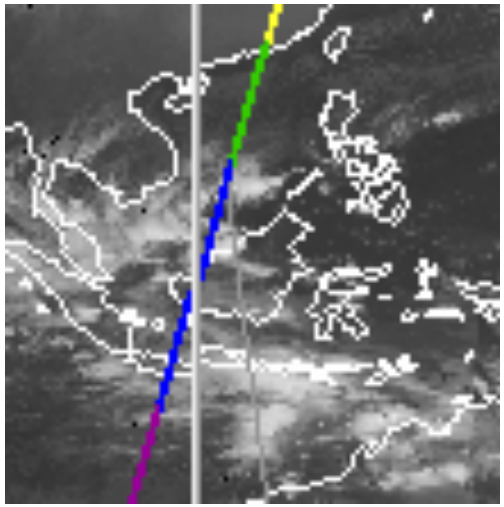


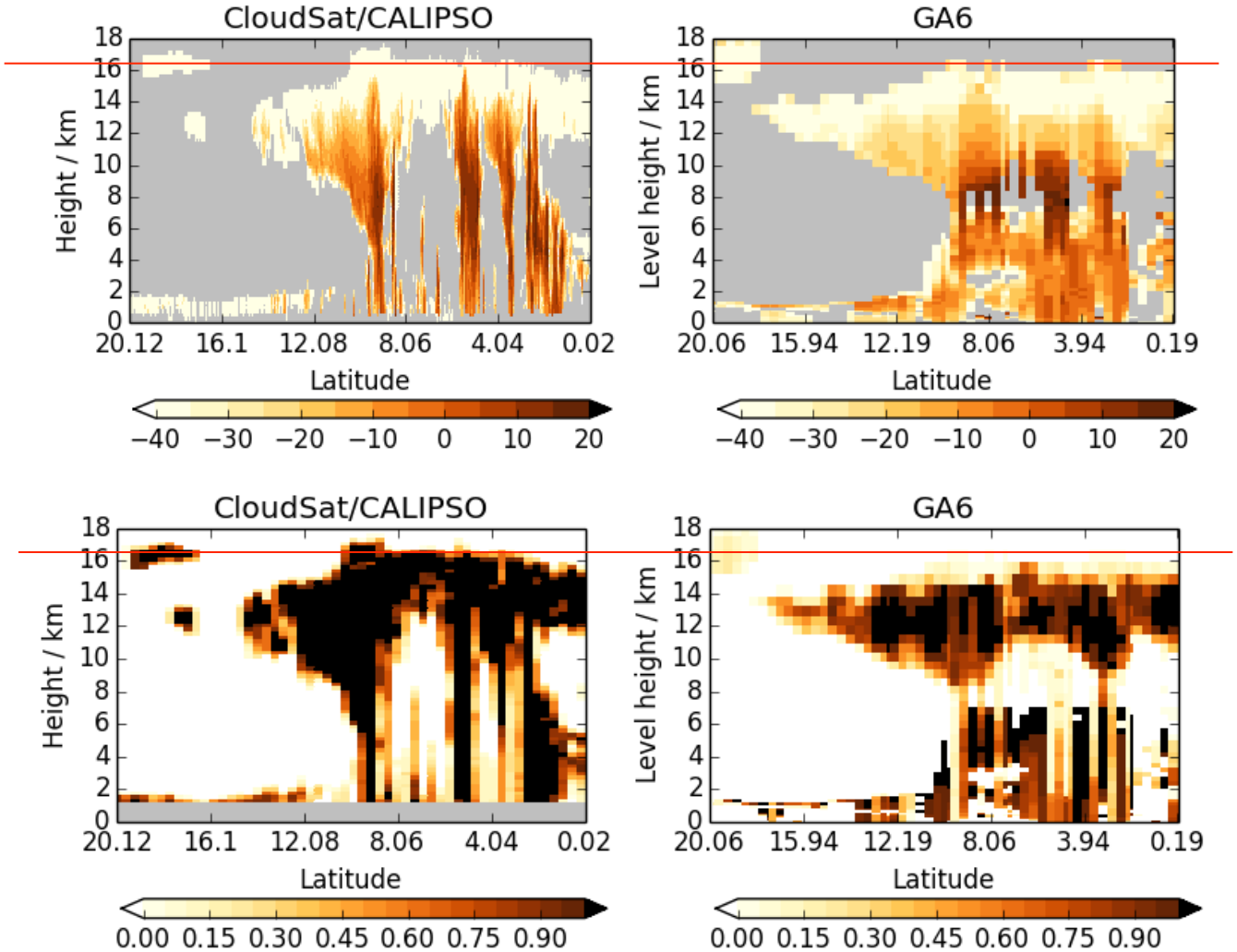
Reduced cirrus spreading rate

6A convection

Warm rain microphys

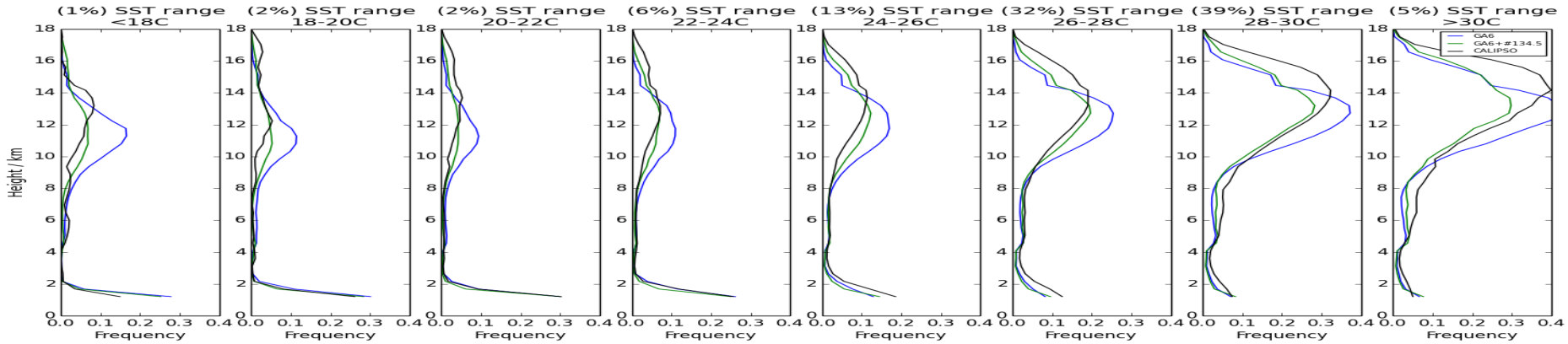
Case study
VT: 18Z 17/12/2010 (T+6)





CALIPSO composites
(mean over tropics)

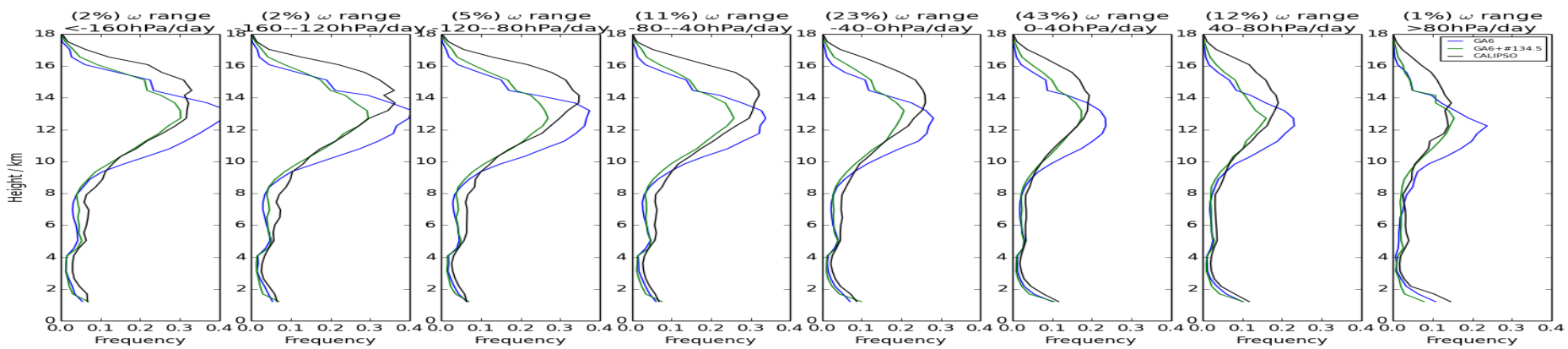
By SST:



← Cool

Warm →

By vertical velocity:



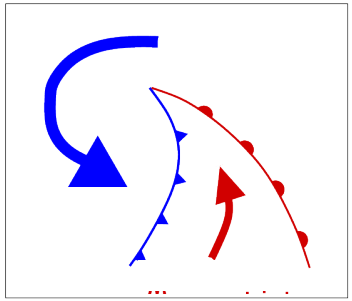
← Strong ascent

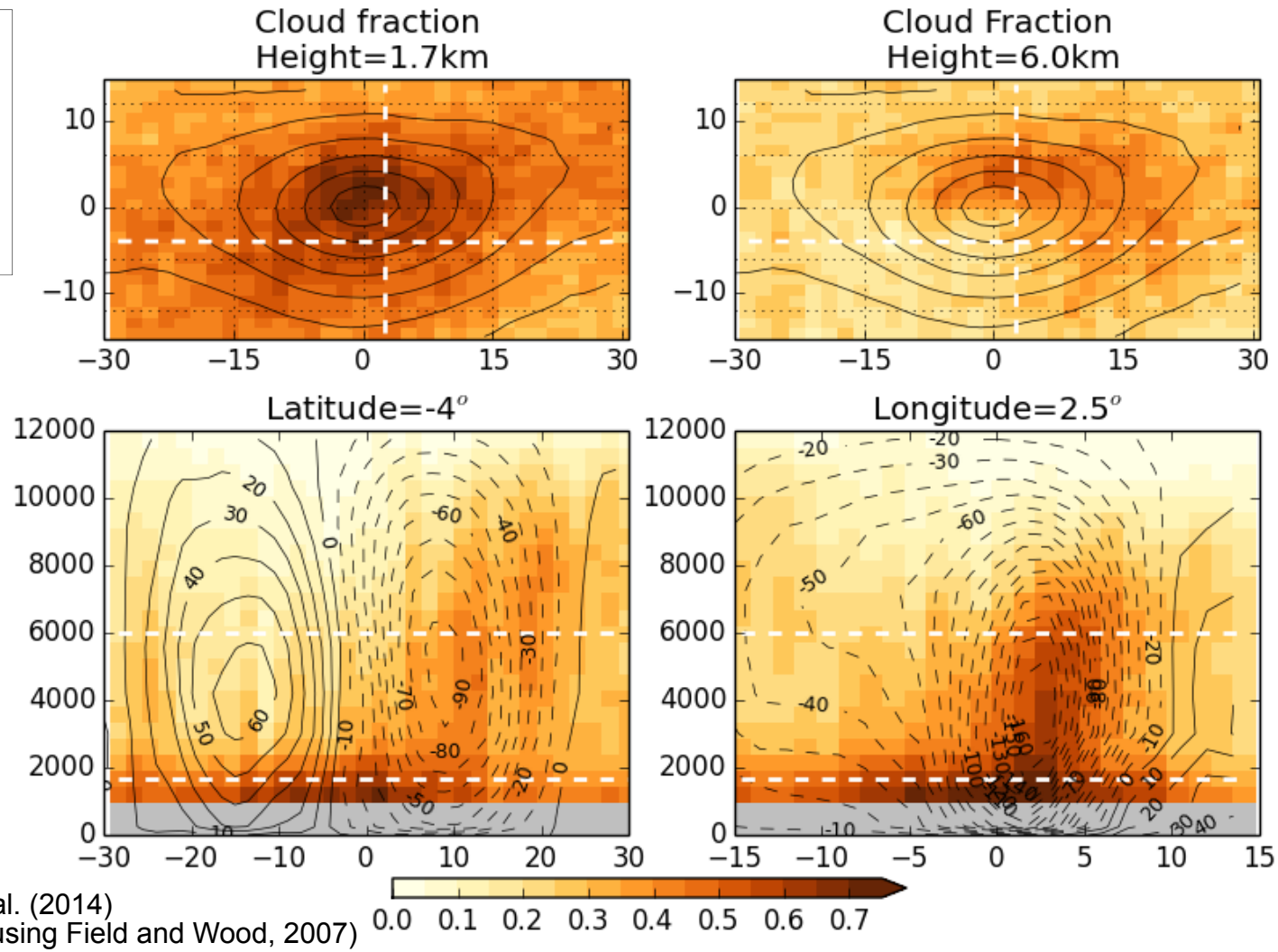
Strong subsidence →

Mid-latitude storm tracks

Composite cyclone: RL-GEOPROF hydrometeor frac.

Northern hemisphere winter

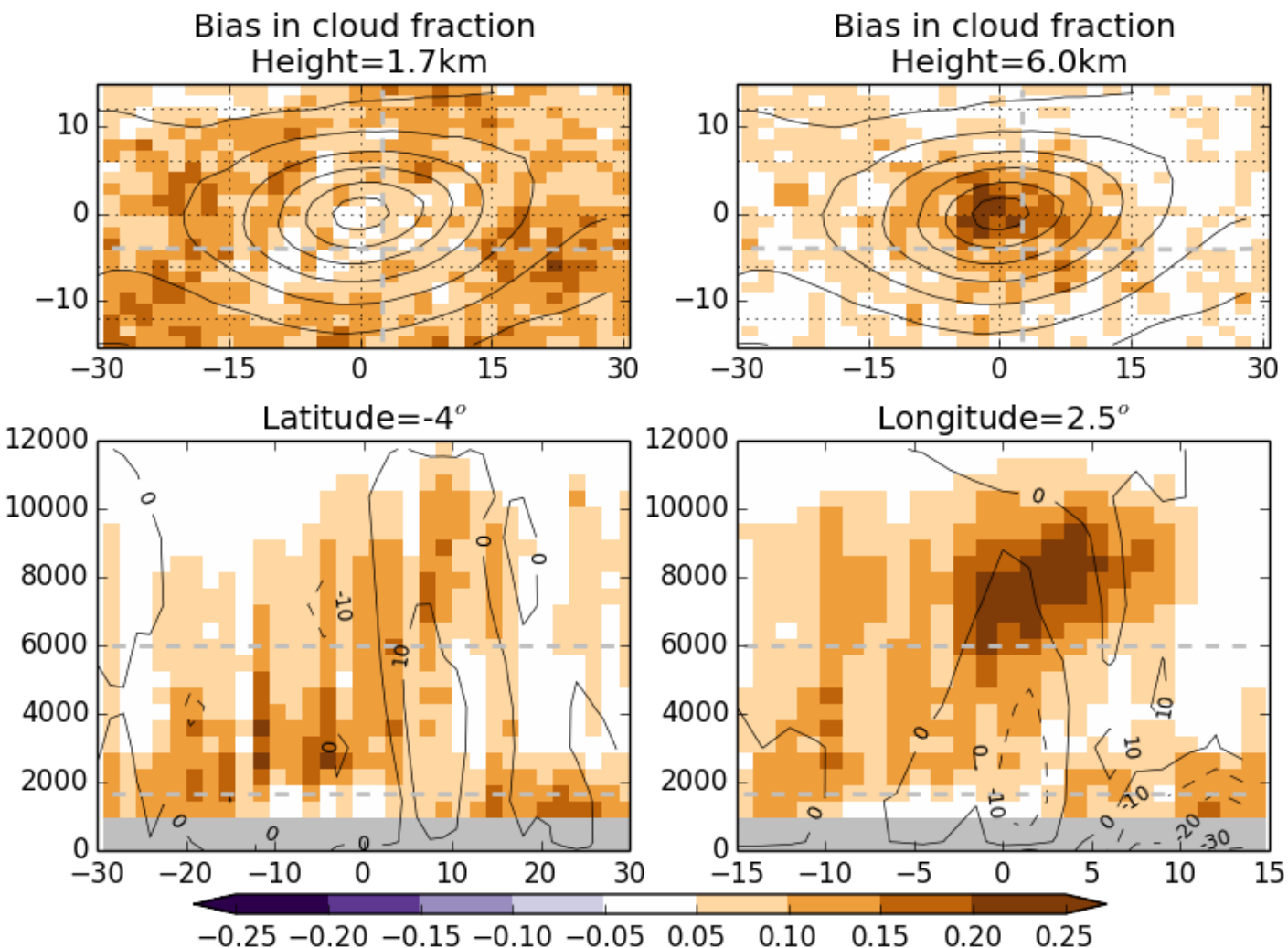




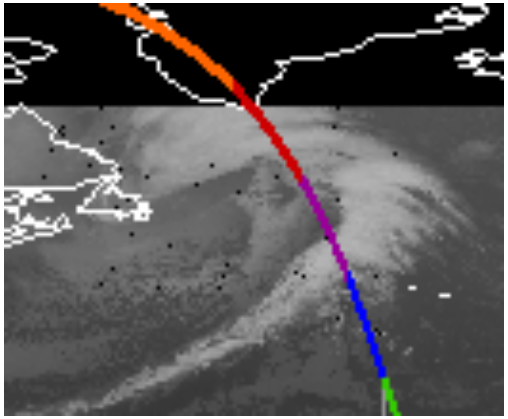
Following Govekar et al. (2014)
(cyclone compositing using Field and Wood, 2007)

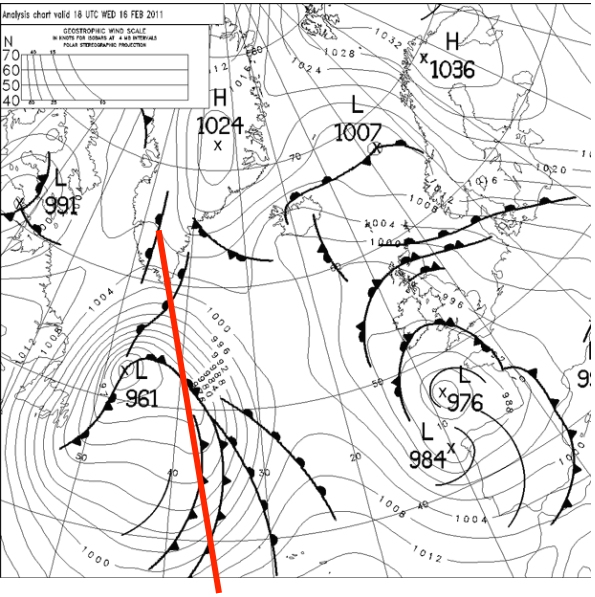
Composite cyclone: GA6 hydrometeor frac bias

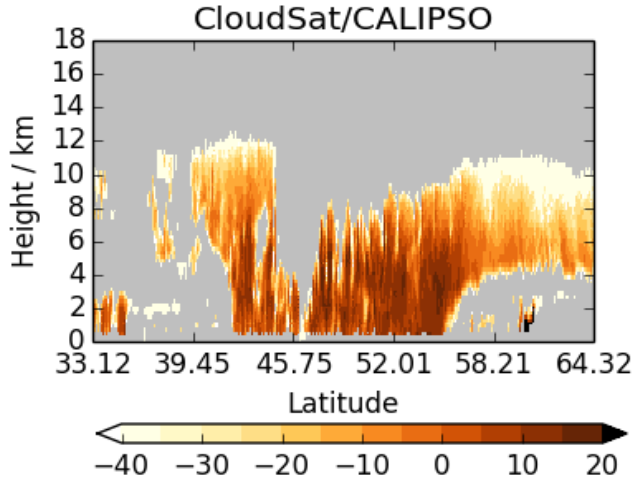
Northern hemisphere winter

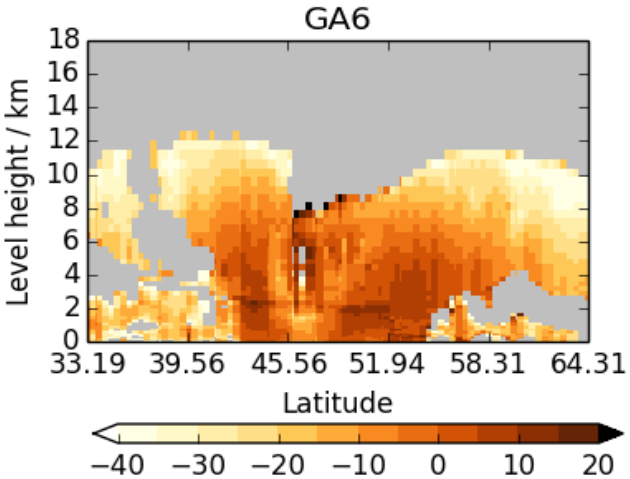


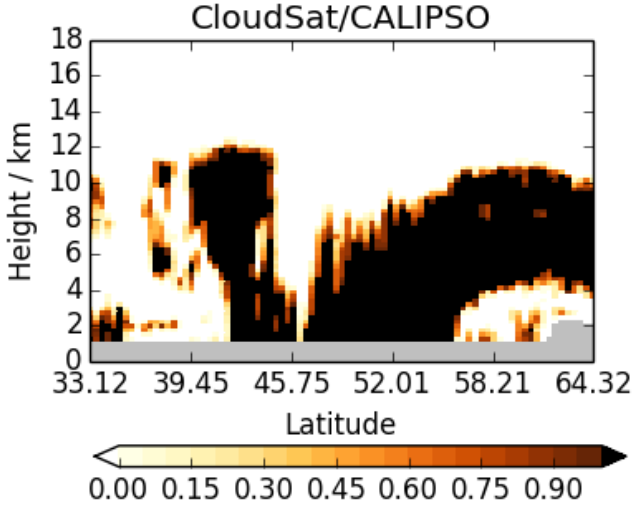
Case study
VT: 15Z 16/02/2011 (T+27)

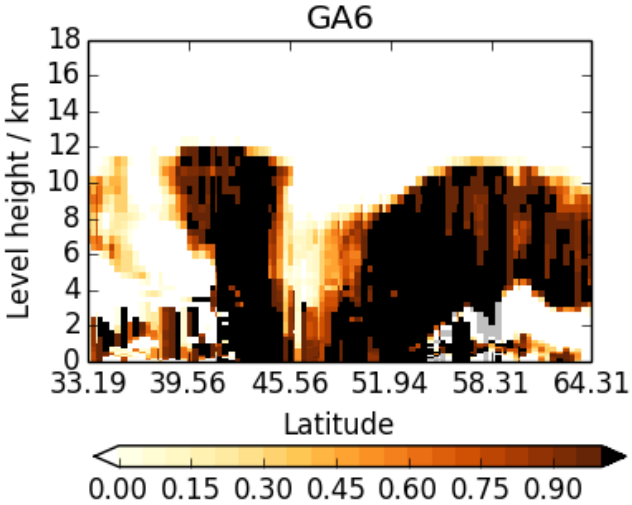








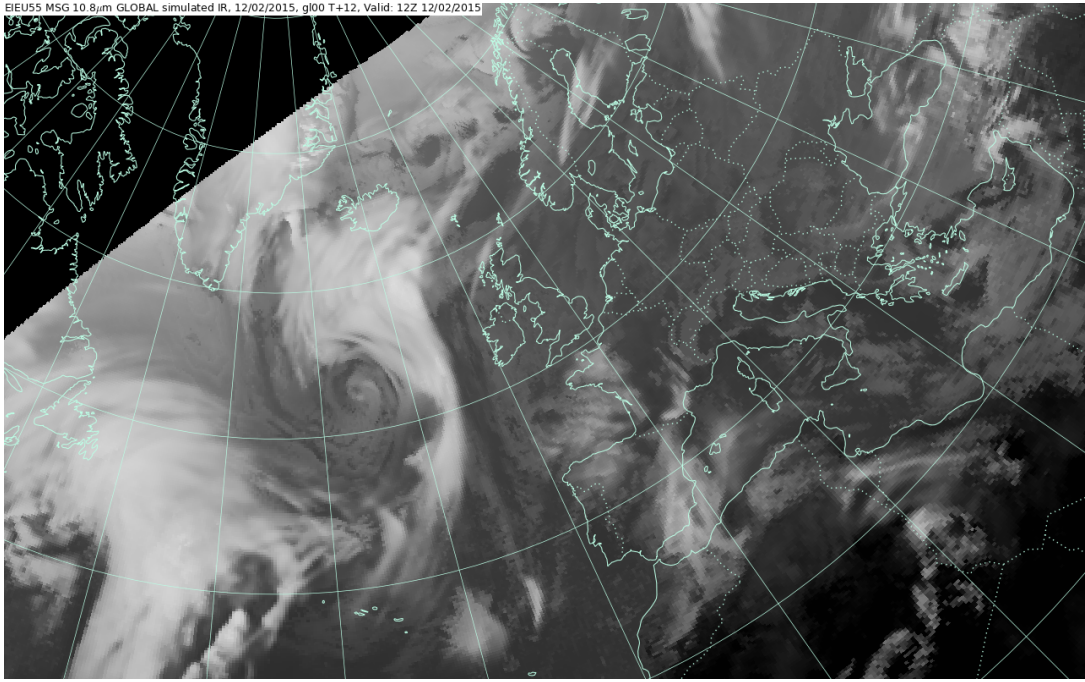


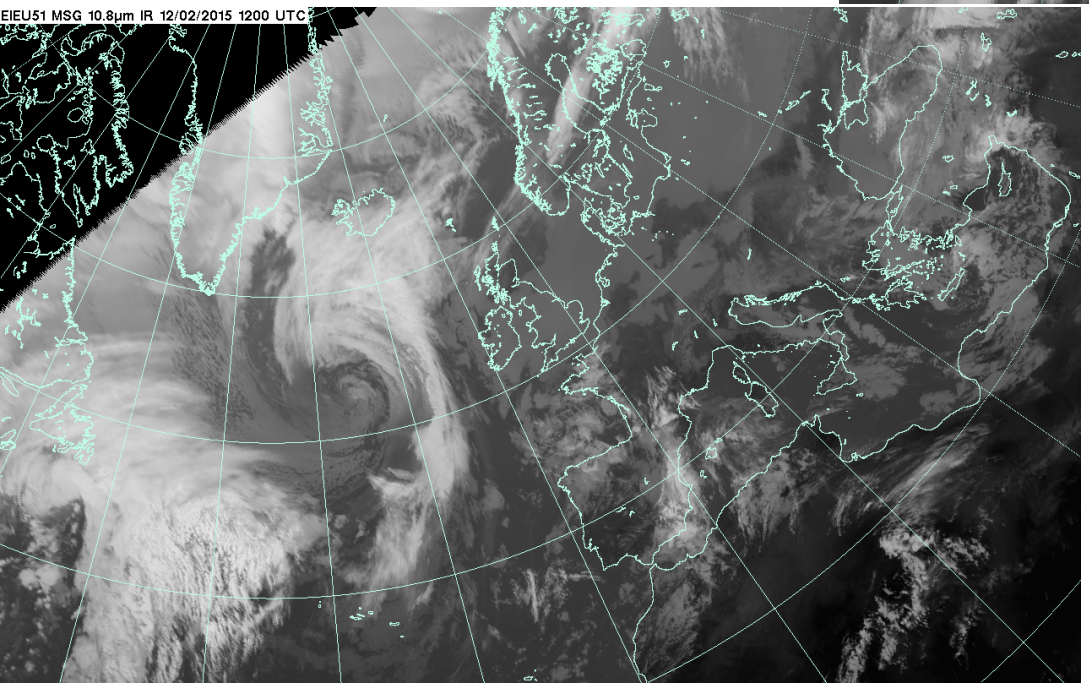


GA6

Simulated imagery

VT: 12Z 12/02/15 (T+12)



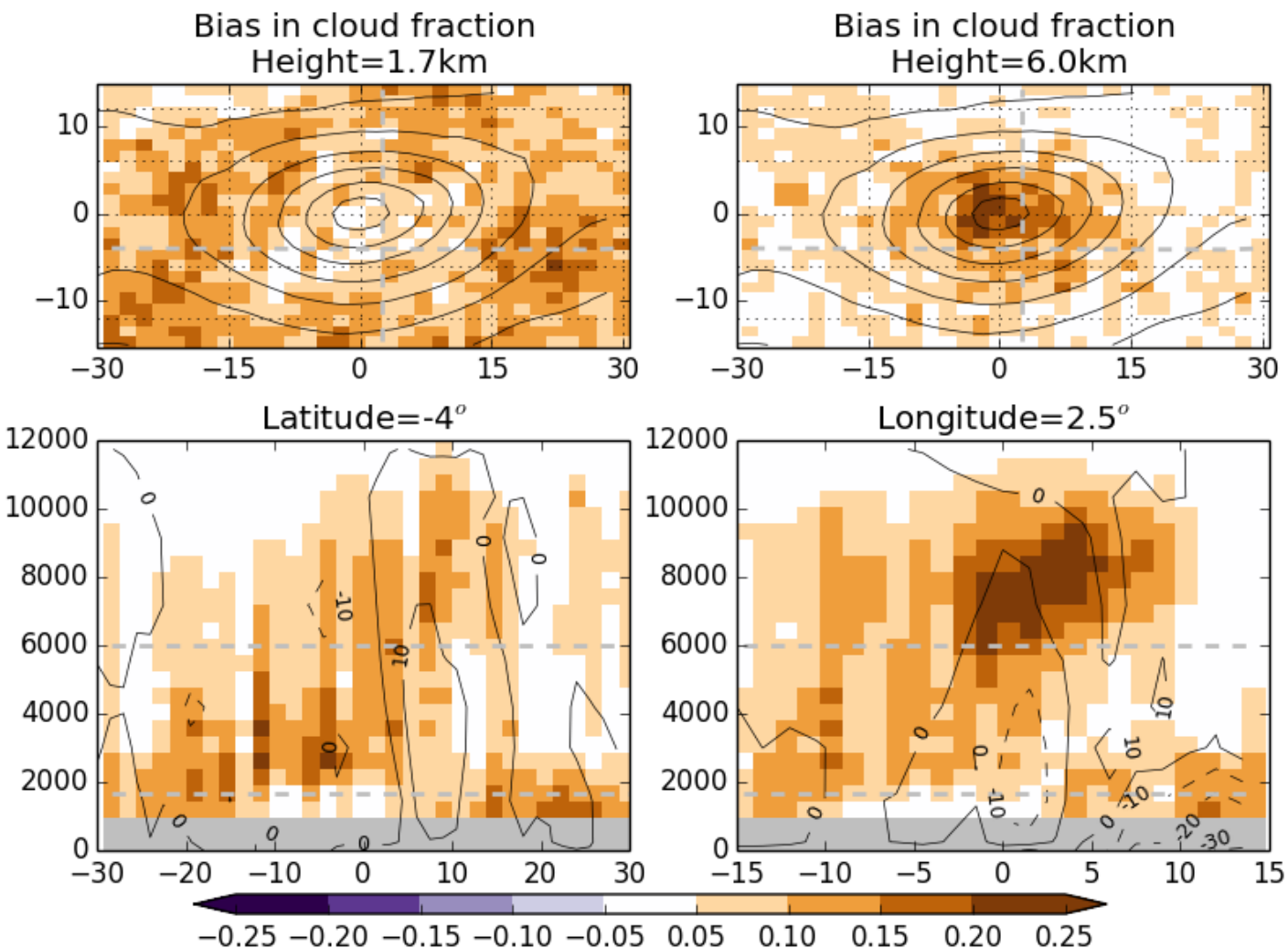


Satellite

Tom Blackmore

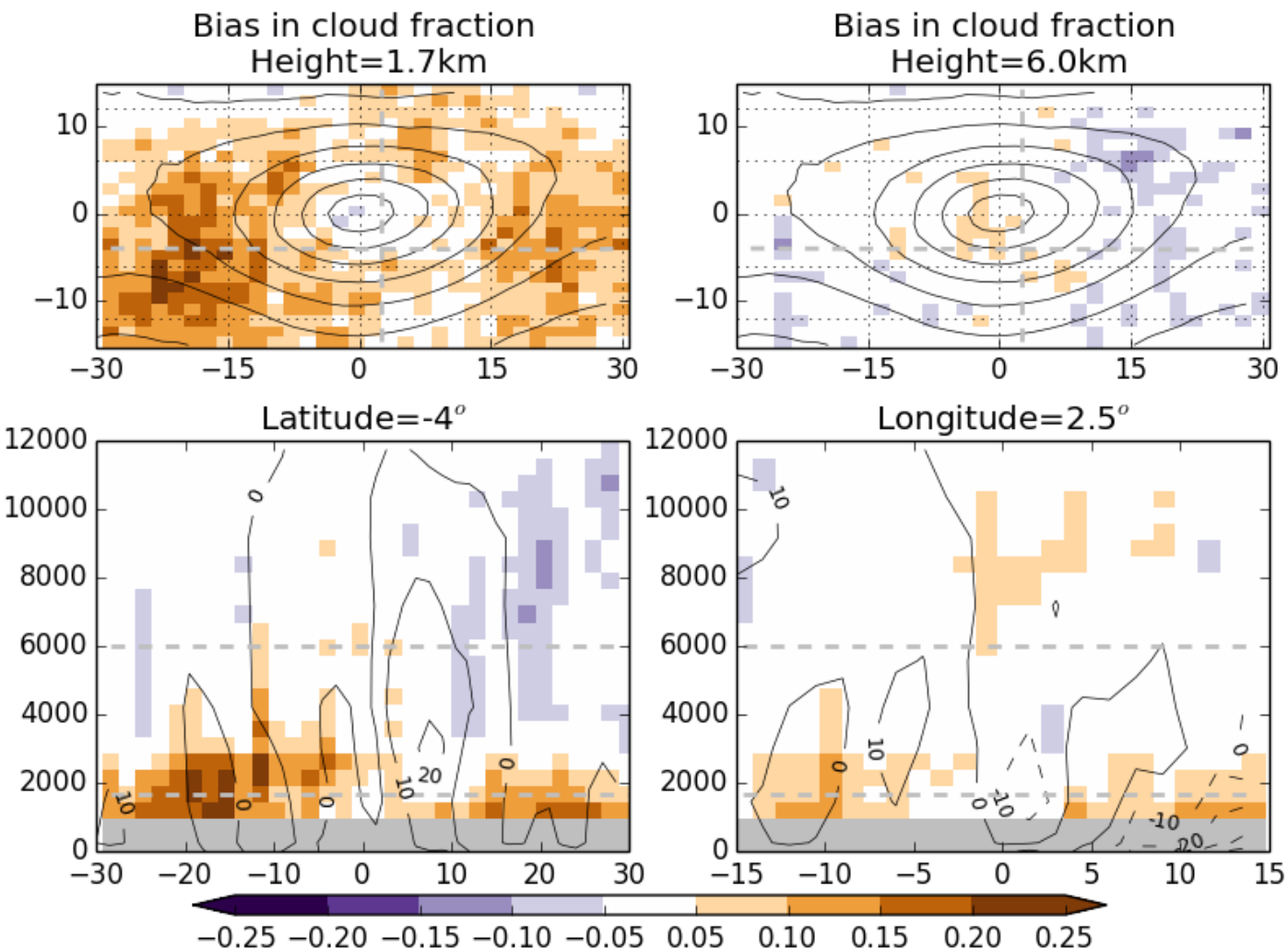
Composite cyclone: GA6 hydrometeor frac bias

Northern hemisphere winter



Composite cyclone: #134.5 hydrometeor frac bias

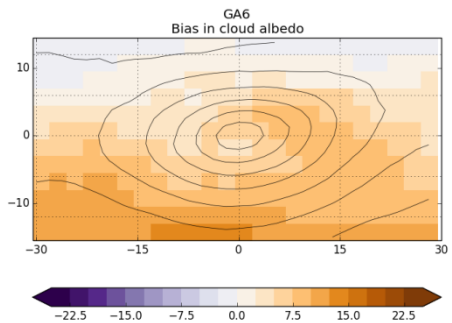
Northern hemisphere winter



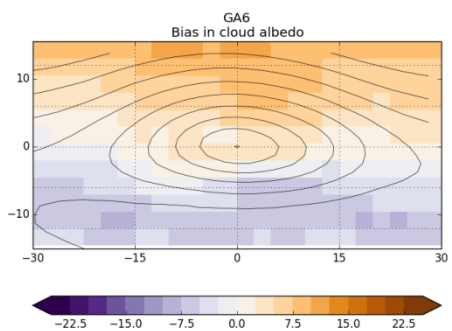
Composite cyclone: GA6 cloud albedo bias

Winter

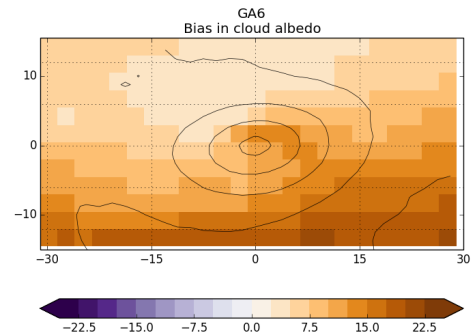
Northern hemisphere:

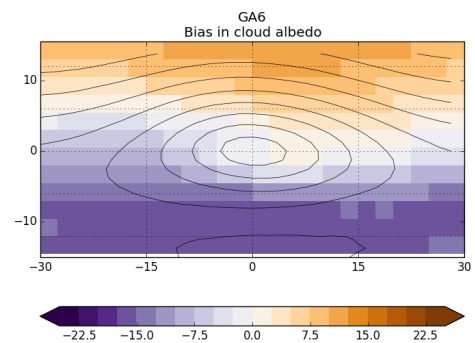


Southern hemisphere:



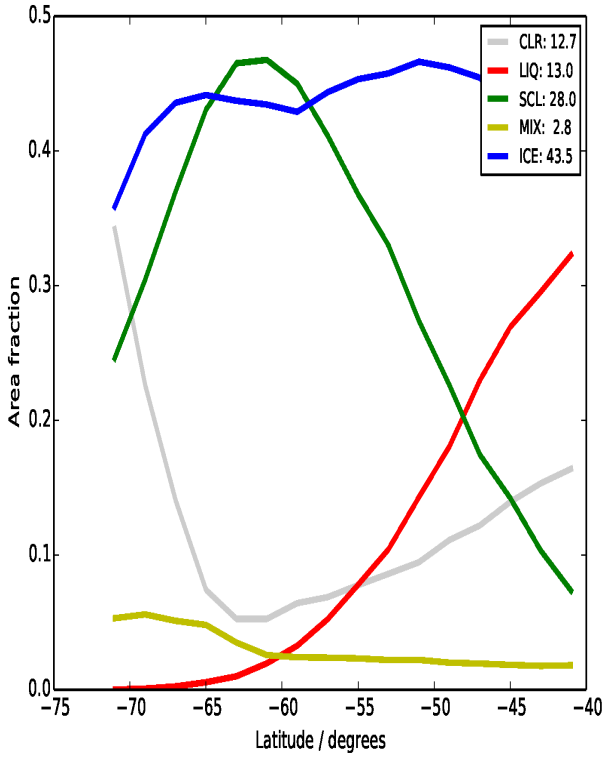
Summer





Possible causes of albedo bias

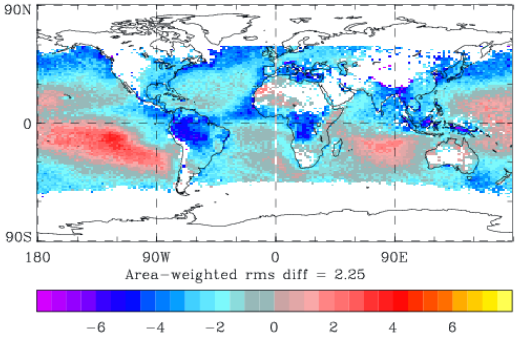
Cloud phase:



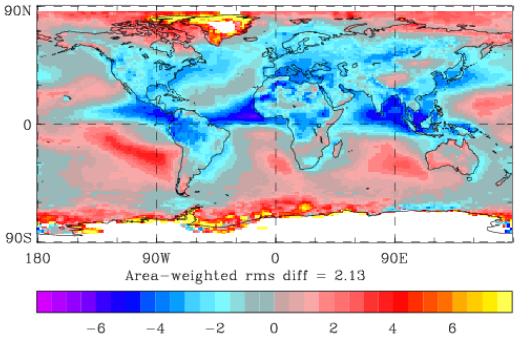
c/o Alejandro Bodas-Salcedo

Aerosol interaction:

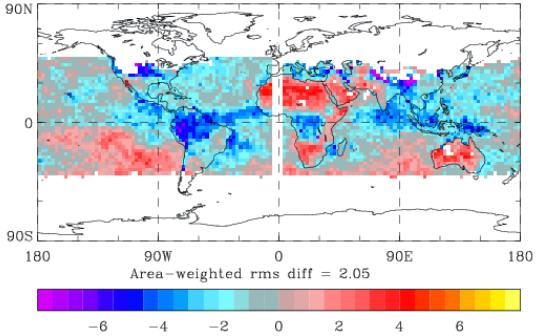
re bias vs Kawamoto



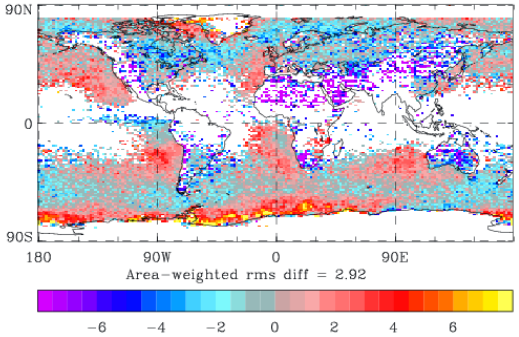
re bias vs ATSR



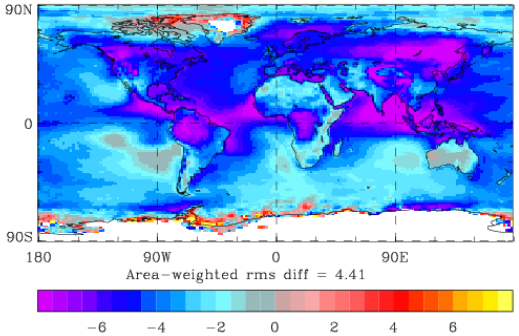
re bias vs Han



re bias vs POLDER



re bias vs CERES-MODIS



Comparison with ground-based observations

Comparison with ground-based (CloudNet) sites

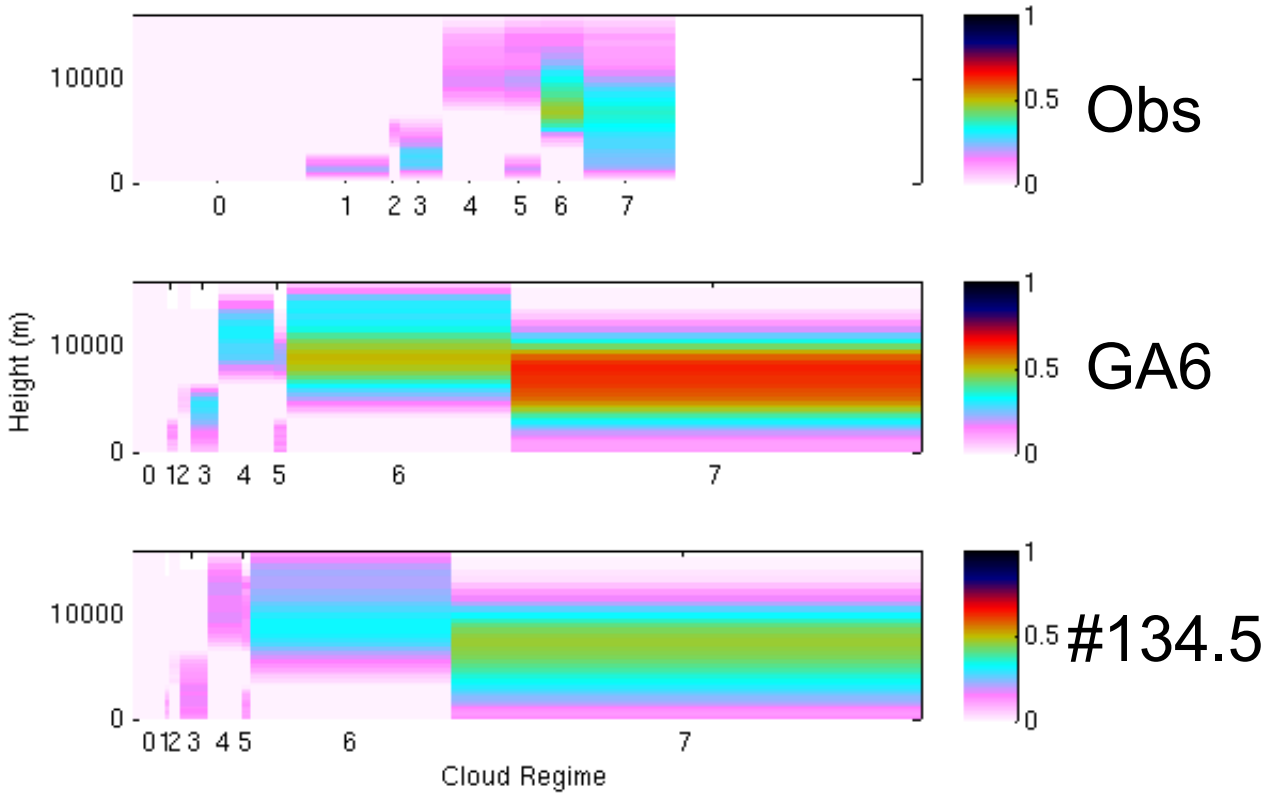
(Chilbolton, Lindenberg, Darwin, SGP and Murgtal)

c/o Cyril Morcrette and Kwinten Van Weverberg

- Excess high cloud in GA6 improved in #134.5
- Low cloud too infrequent (not seen in satellite comparisons)

0	clear sky
1	low cloud
2	mid-level
3	low and mid
4	high
5	high and low
6	high and mid
7	low and mid and high

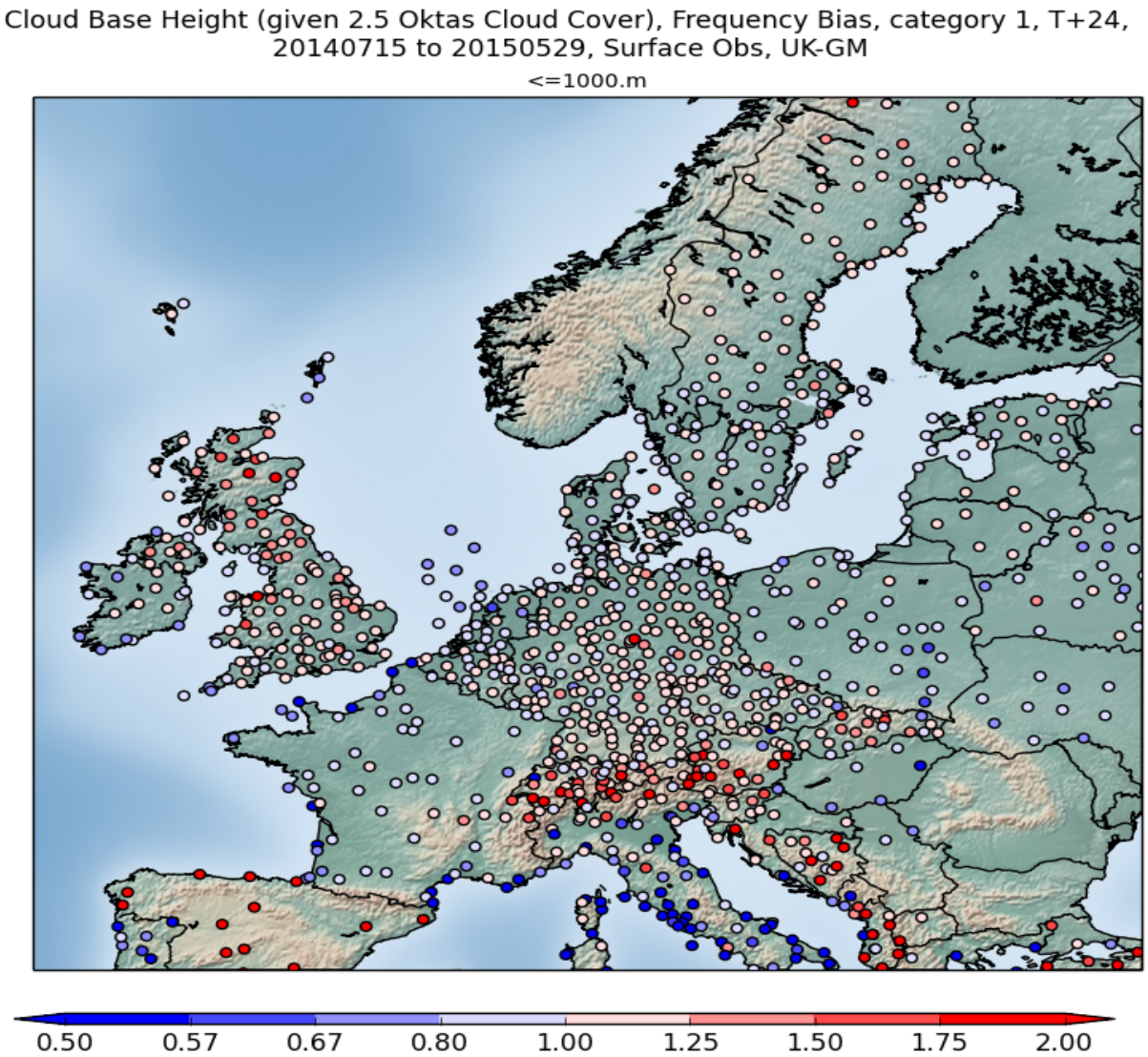
Width = frequency of occurrence
Shading = cloud cover profile



CAUSES - http://portal.nersc.gov/project/capt/CAUSES/

Bias in freq. CBH<1km (T+24)

(when amount >2.5okta)

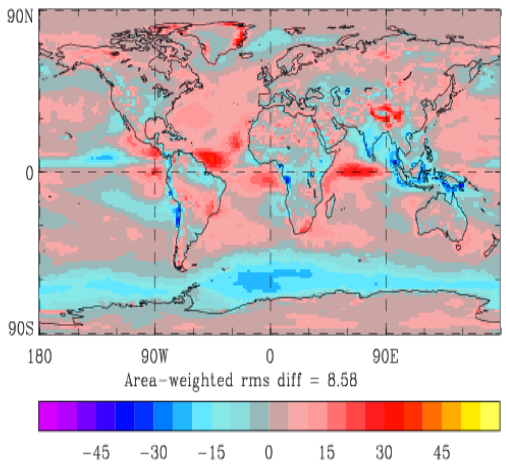


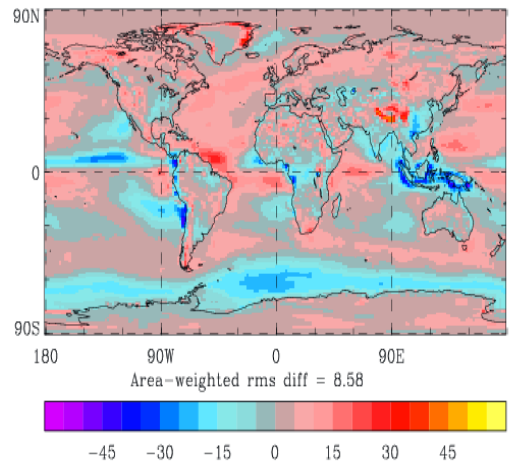
Mean radiation bias

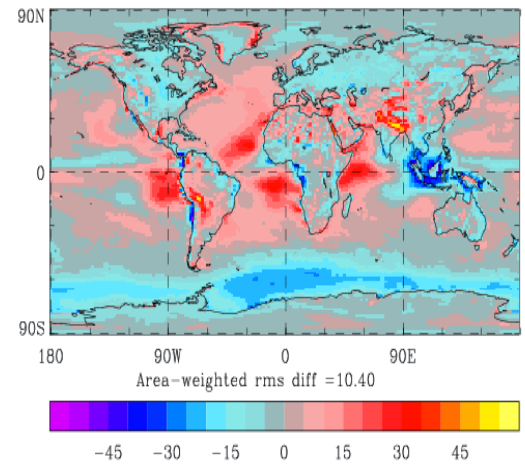
TOA radiation bias

GA6 | #134.5 | HadGEM2

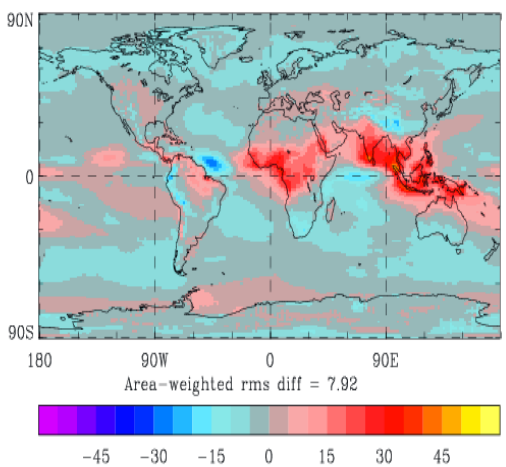
RSW

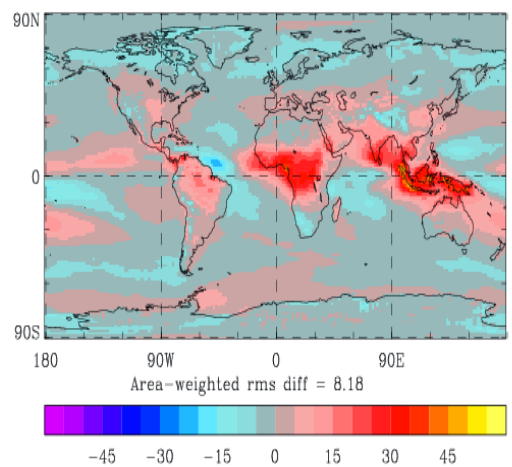


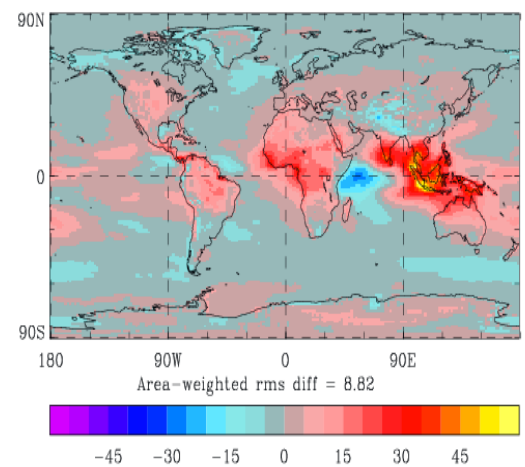




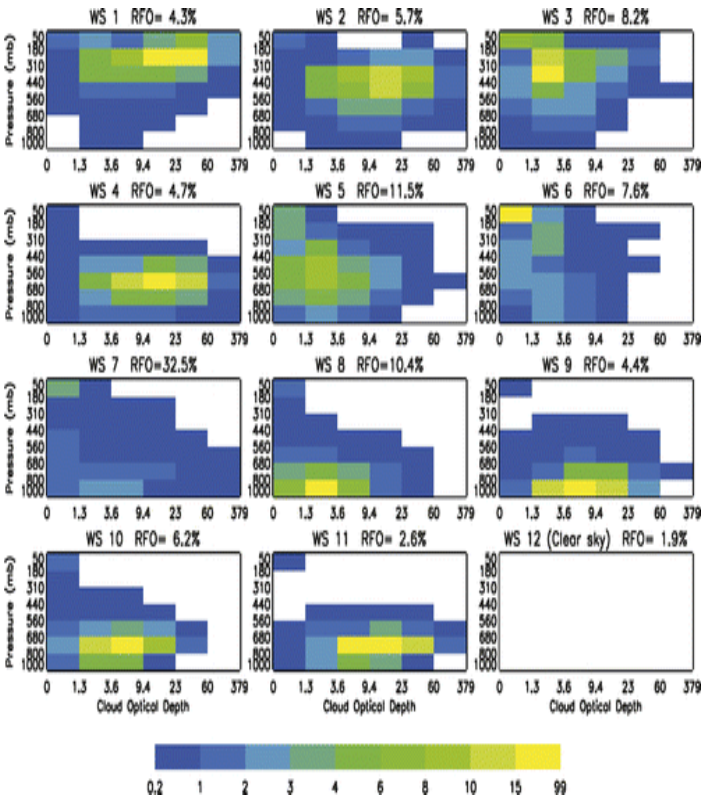
OLR



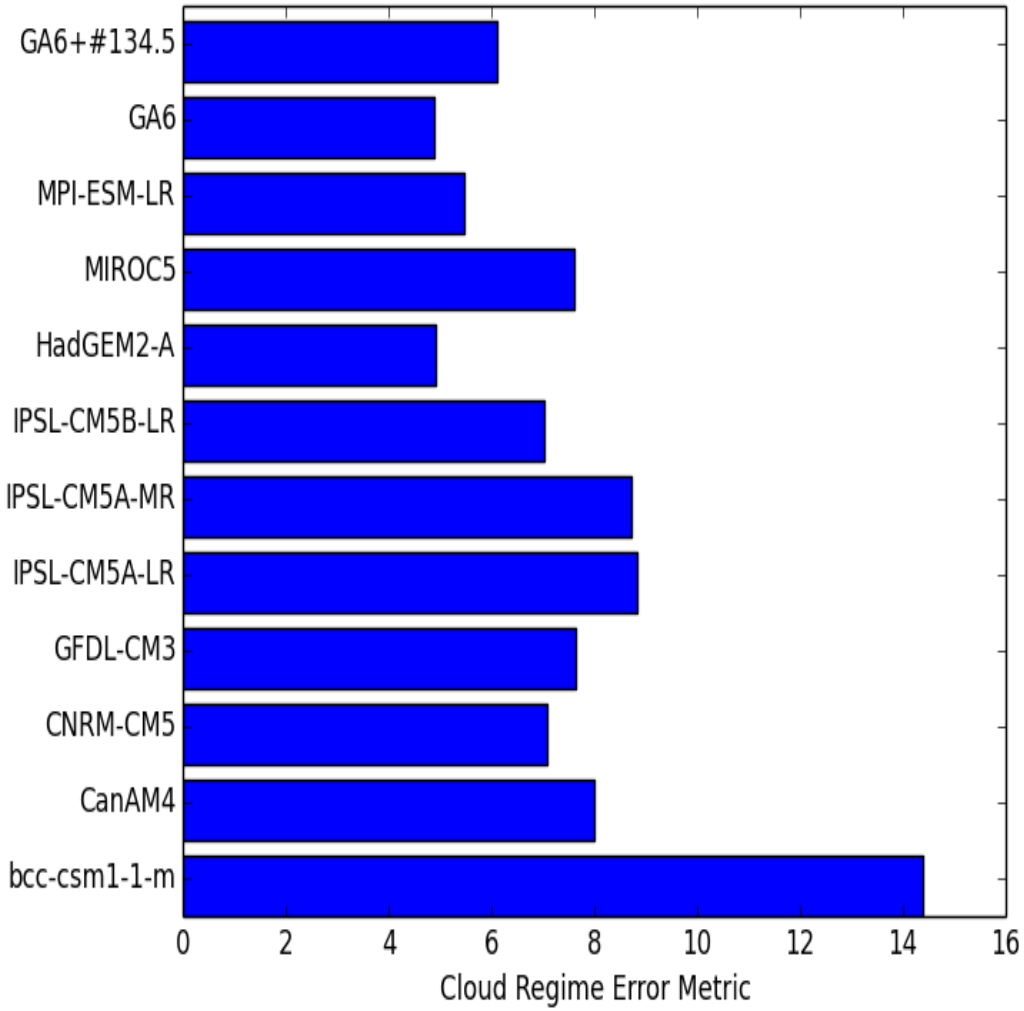




Cloud regime error metric
(Williams and Webb, 2009)



ISCCP cluster centroids from Tselioudis et al. (2013)

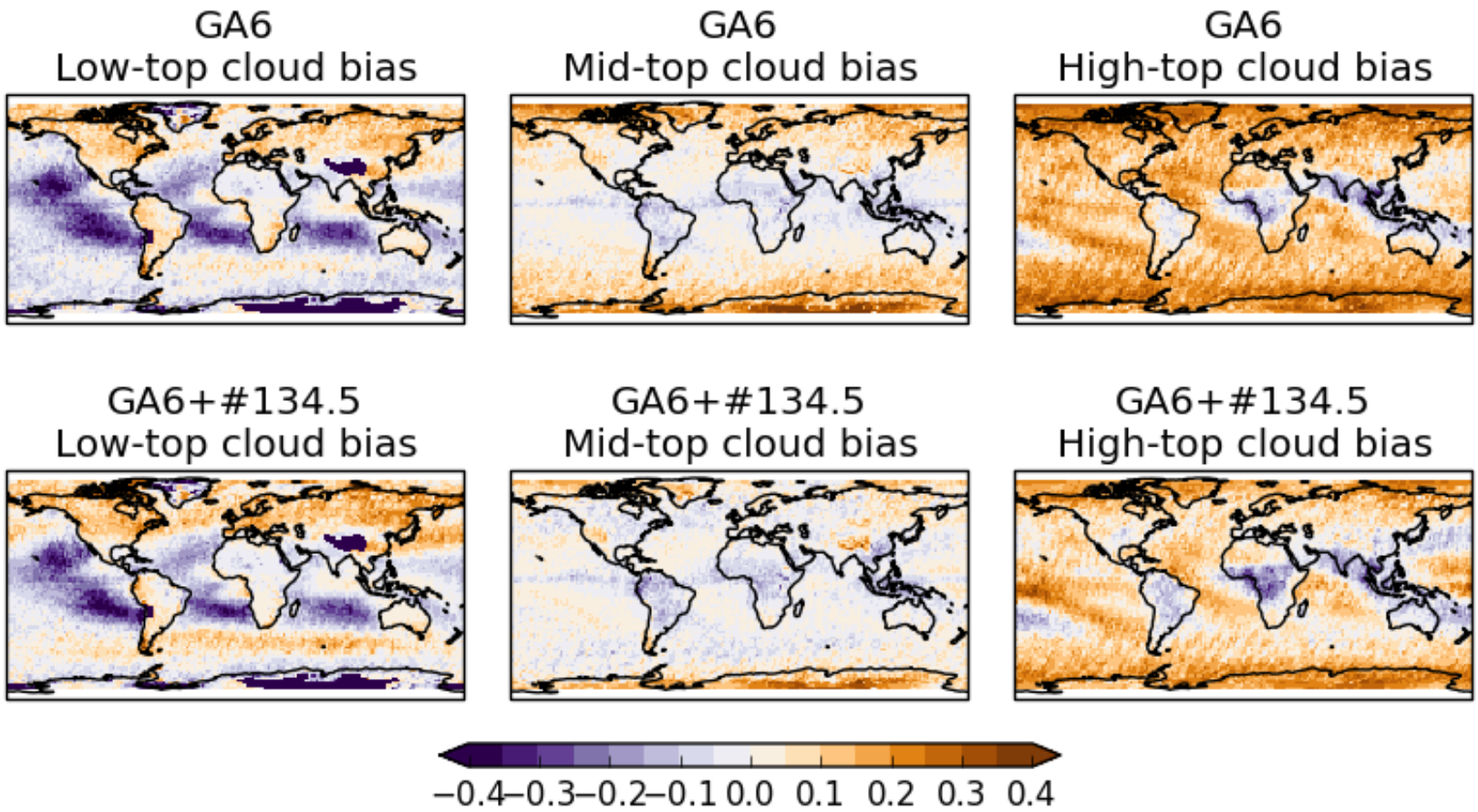


Conclusions

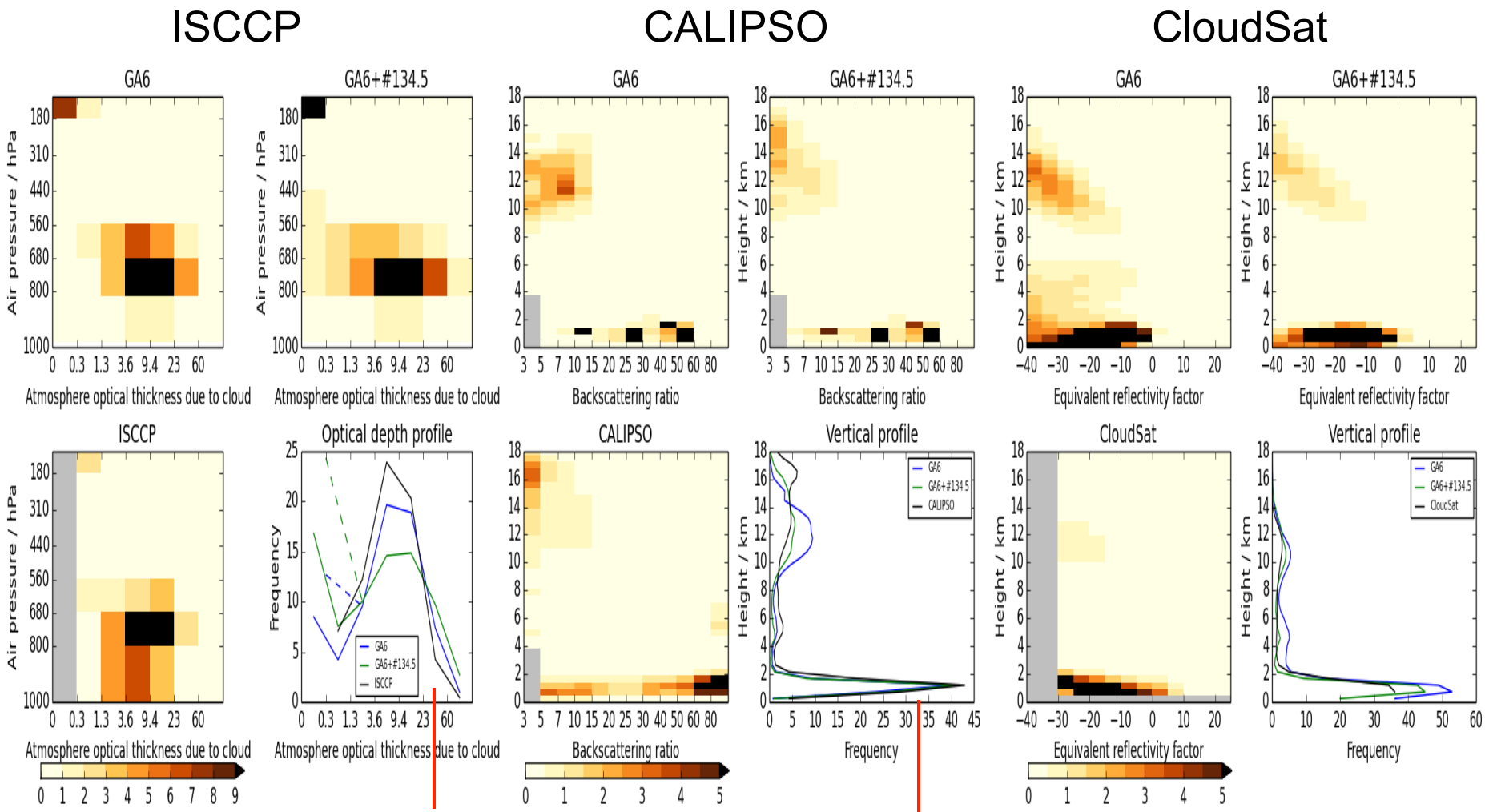
- It is easy to draw the wrong conclusion on model performance when just using one dataset/diagnostic technique/timescale.
- Use of a range of observational data (each to its own strengths) and various diagnostic techniques has permitted a comprehensive evaluation of cloud in the model.
- Overall cloud amount reasonably well simulated in the global UM although:
  - GA6 has excessive amounts of sub-visual cirrus which is corrected in proto-GA7.
  - Indications of slightly too much boundary layer cloud and/or drizzle in northern mid-latitudes.
- Main outstanding error is the cloud is too reflective in the northern hemisphere (esp. equatorward side of cyclones), and not reflective enough in the southern hemisphere (esp. poleward side of cyclones).

Met Office

Bias in cloud cover
(against CALIPSO)



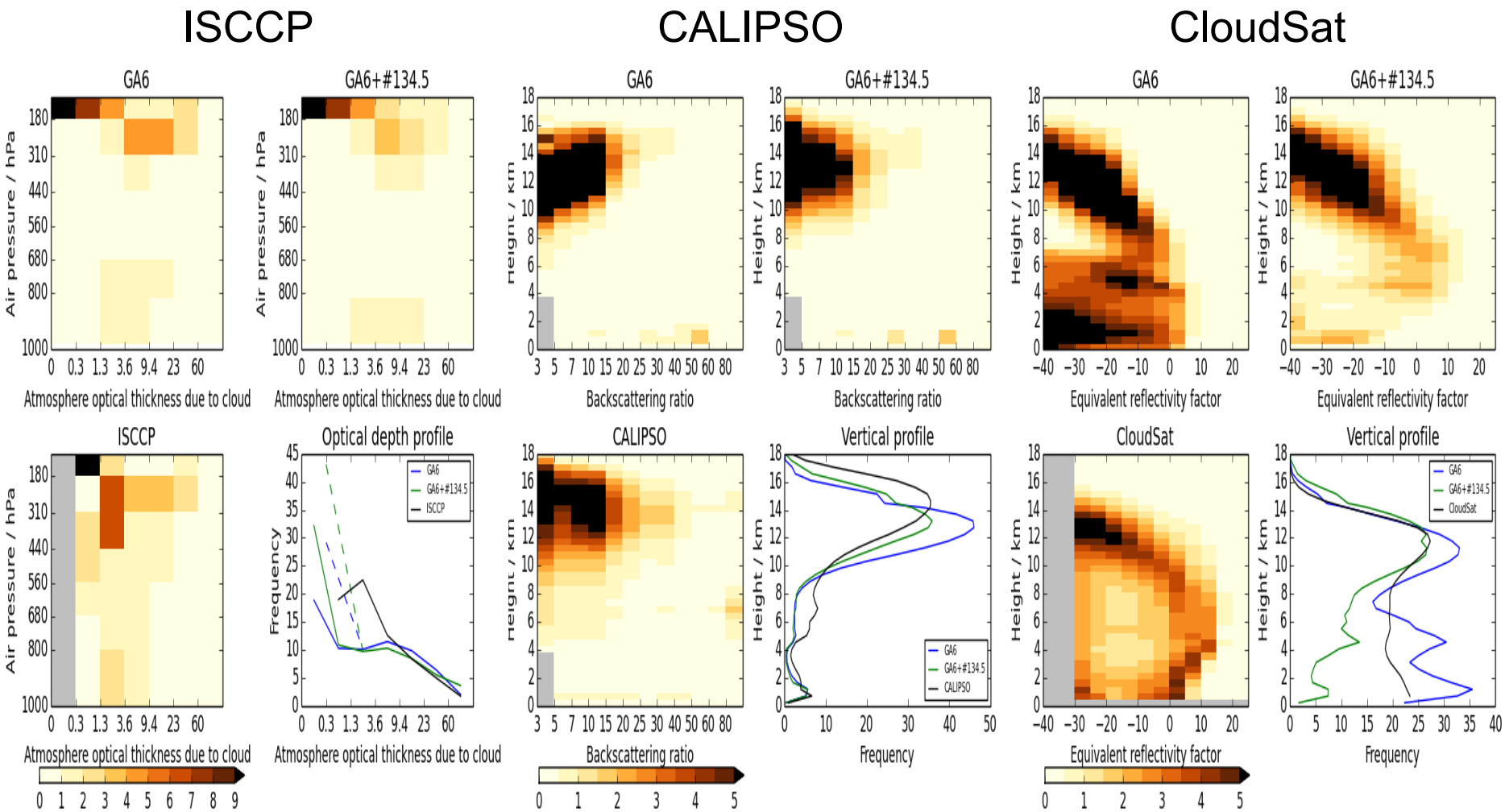
Comparison against satellite data over sub-trop stratocu



Cloud too bright (esp. #135.4)

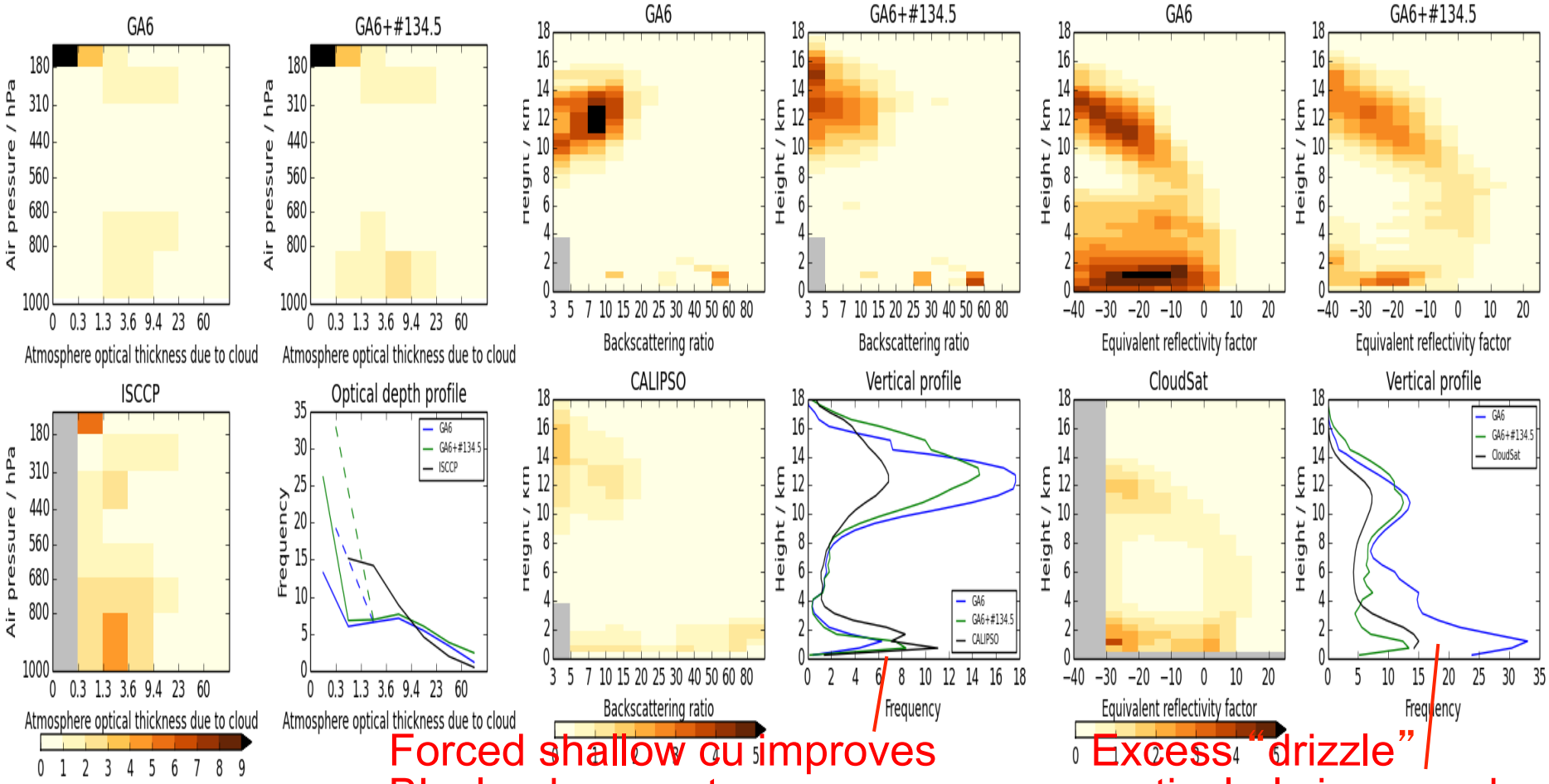
Cloud amount is excellent!

Comparison against satellite data over the warm pool



Comparison against satellite data over the trade region

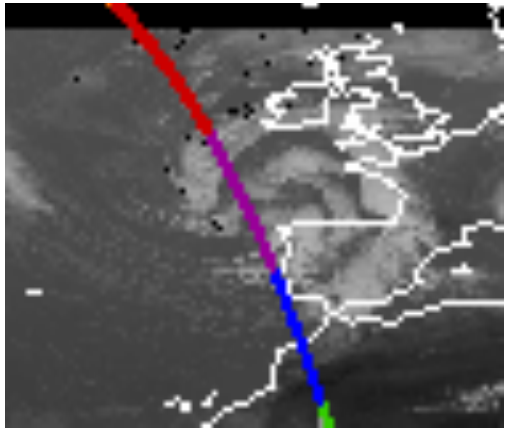
ISCCP | CALIPSO | CloudSat

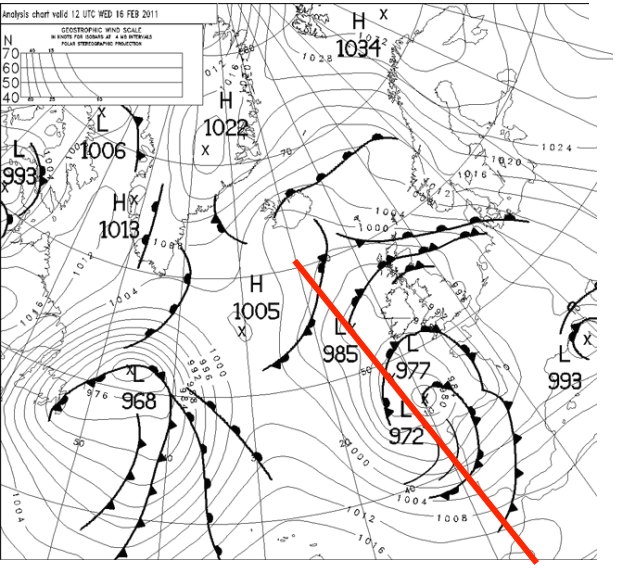


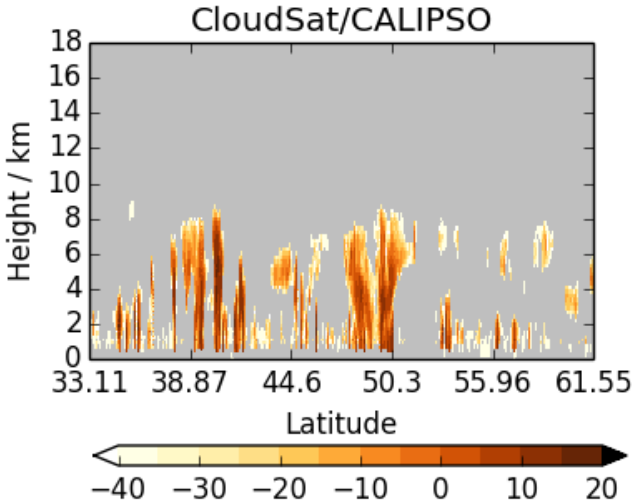
Forced shallow cu improves BL cloud amount

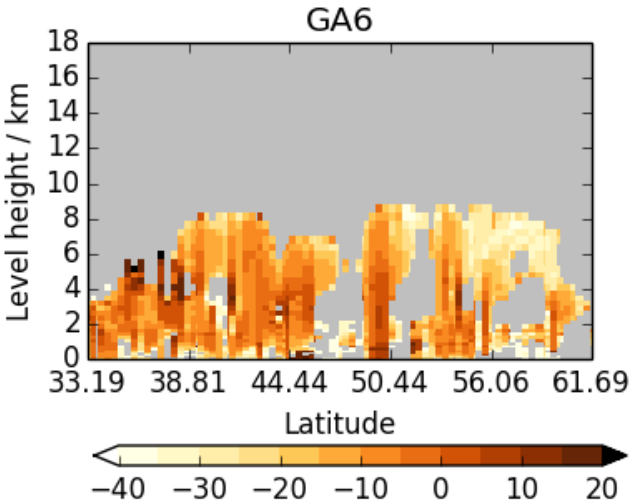
Excess "drizzle" particularly improved

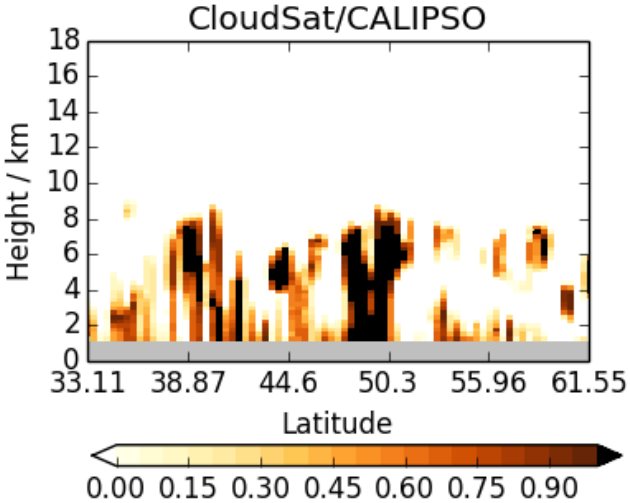
Case study
VT: 12Z 16/02/2011 (T+24)

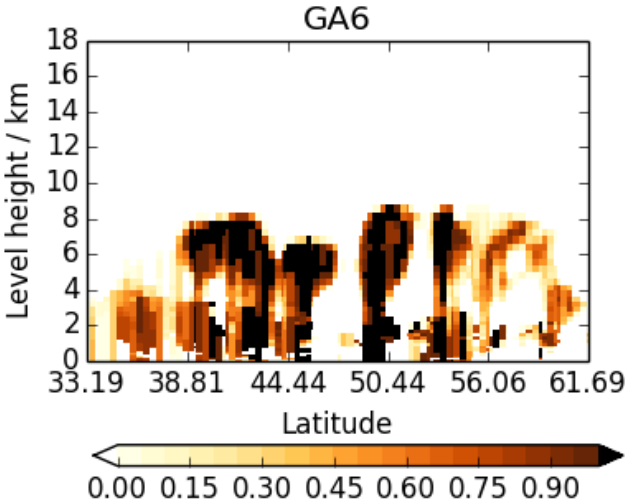








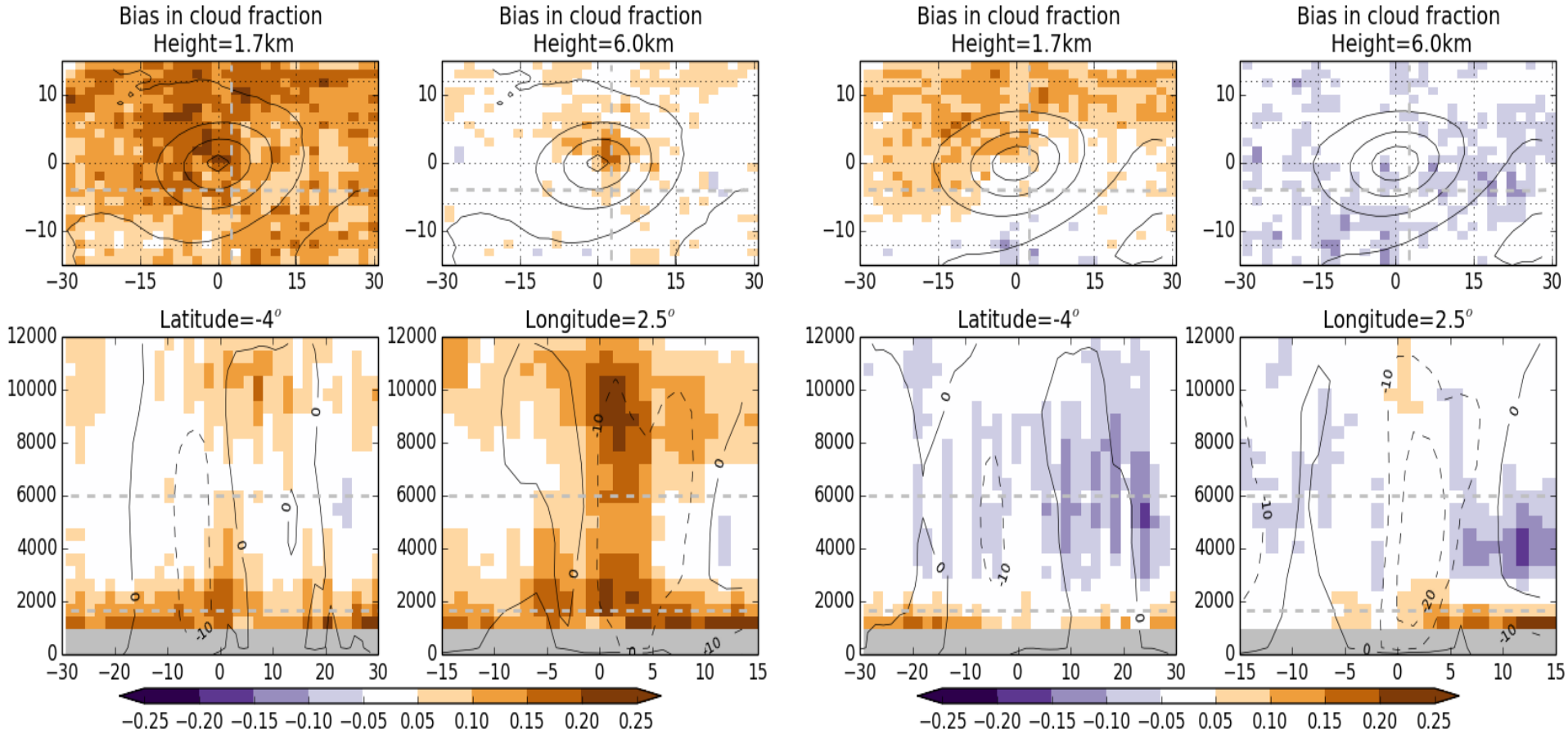




Composite cyclone: Hydrometeor frac bias

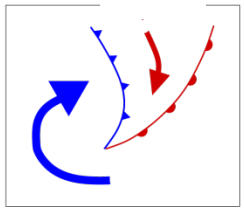
Northern hemisphere summer

GA6 #134.5



Composite cyclone: Hydrometeor frac bias

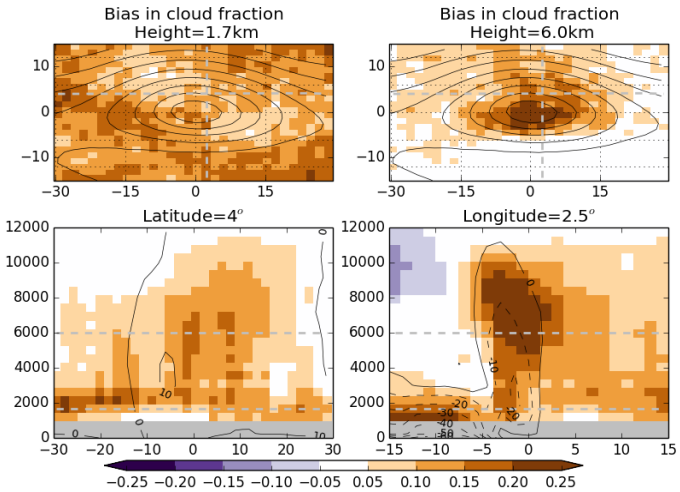
Southern hemisphere

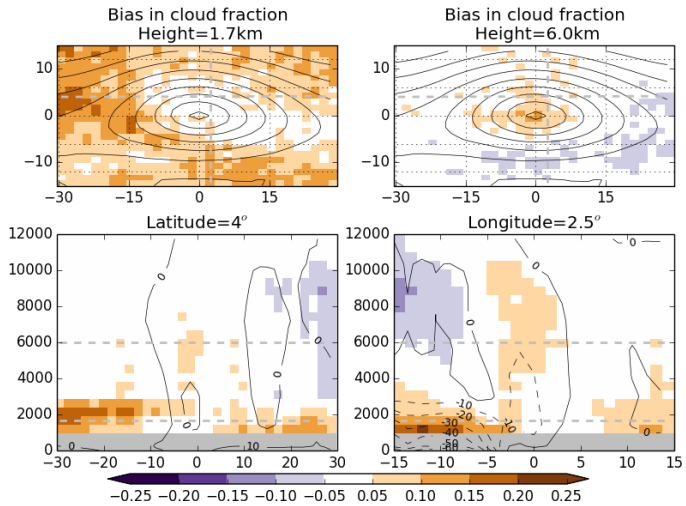


GA6

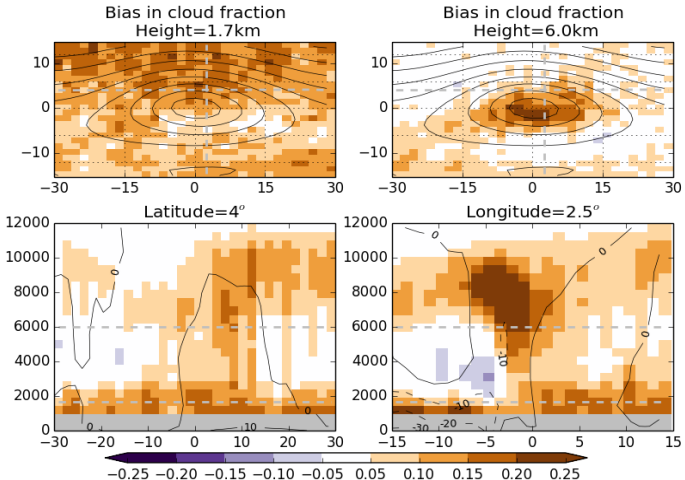
#134.5

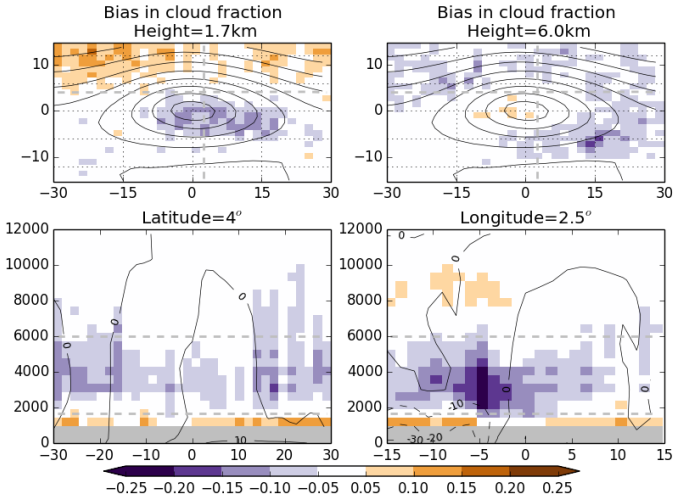
Winter





Summer





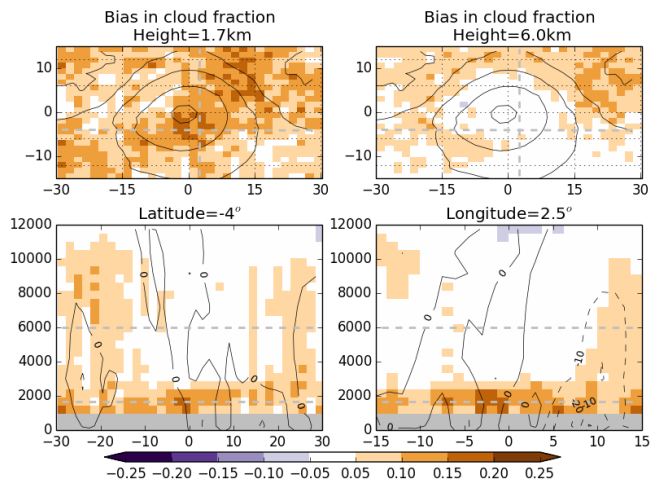
Composite anti-cyclone: Hydrometeor frac bias

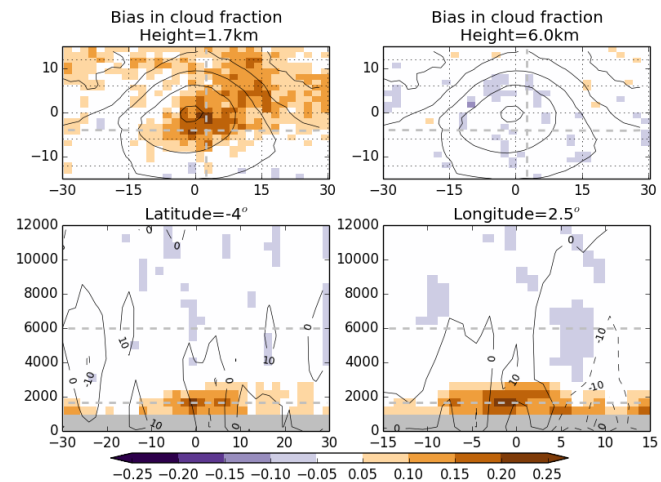
Northern hemisphere

GA6

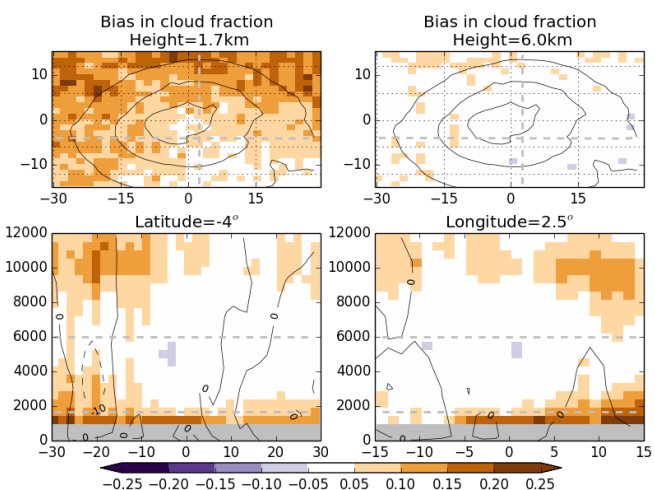
#134.5

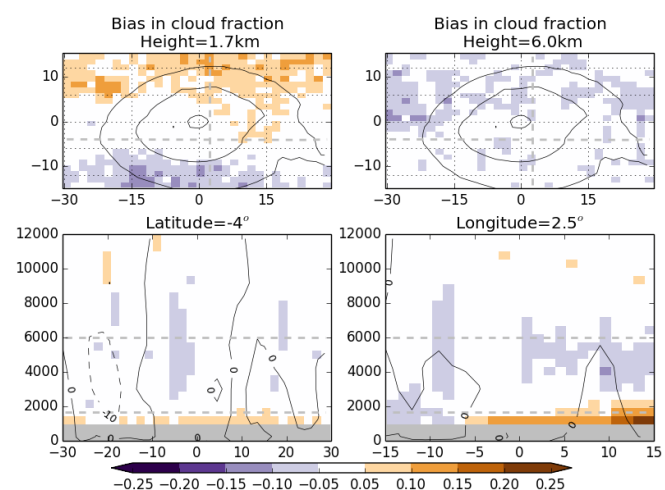
Winter





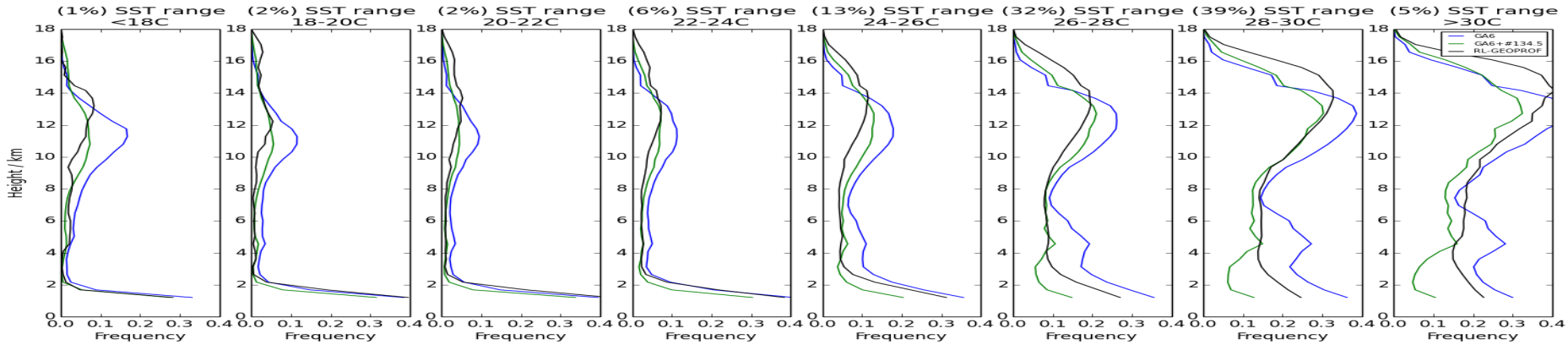
Summer





RL-hydrometeor composites
(mean over tropics)

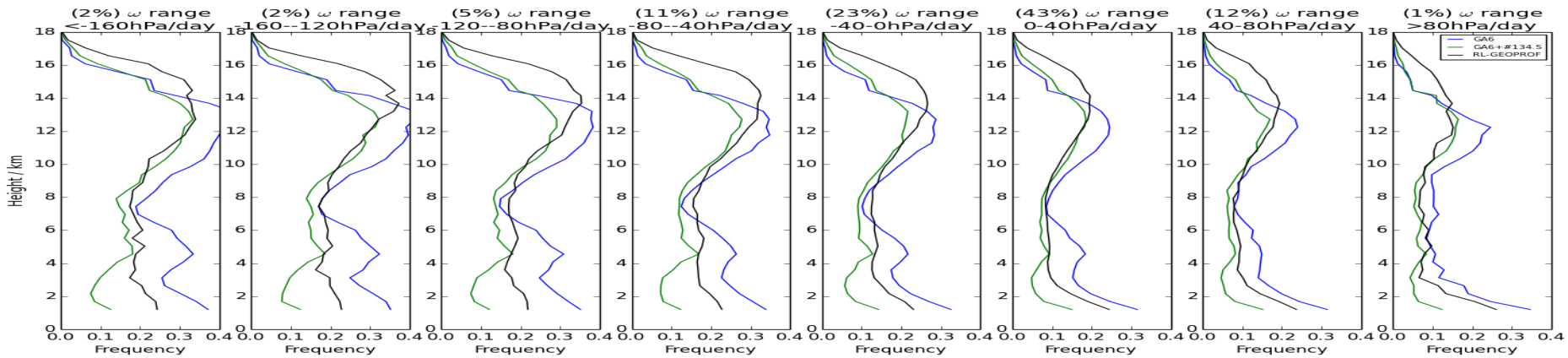
By SST:



← Cool

Warm →

By vertical velocity:



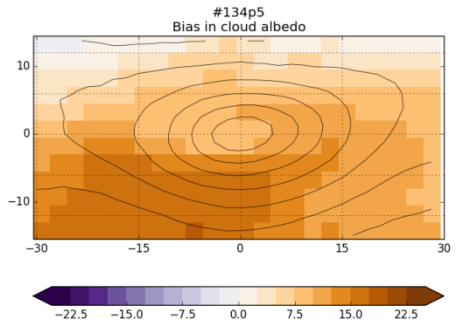
← Strong ascent

Strong subsidence →

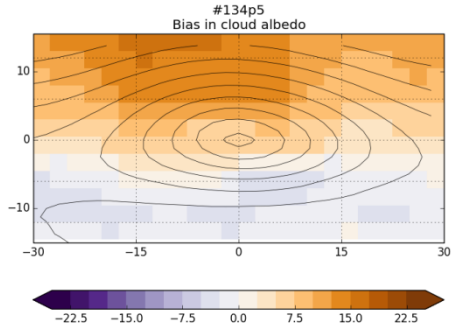
Composite cyclone: #134.5 cloud albedo bias

Winter

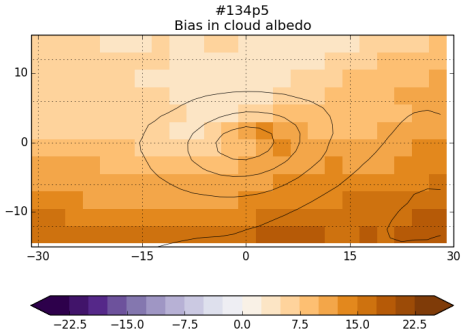
Northern hemisphere:

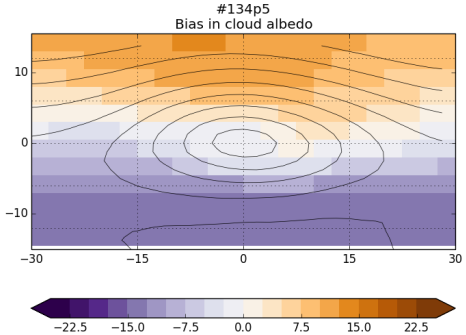


Southern hemisphere:



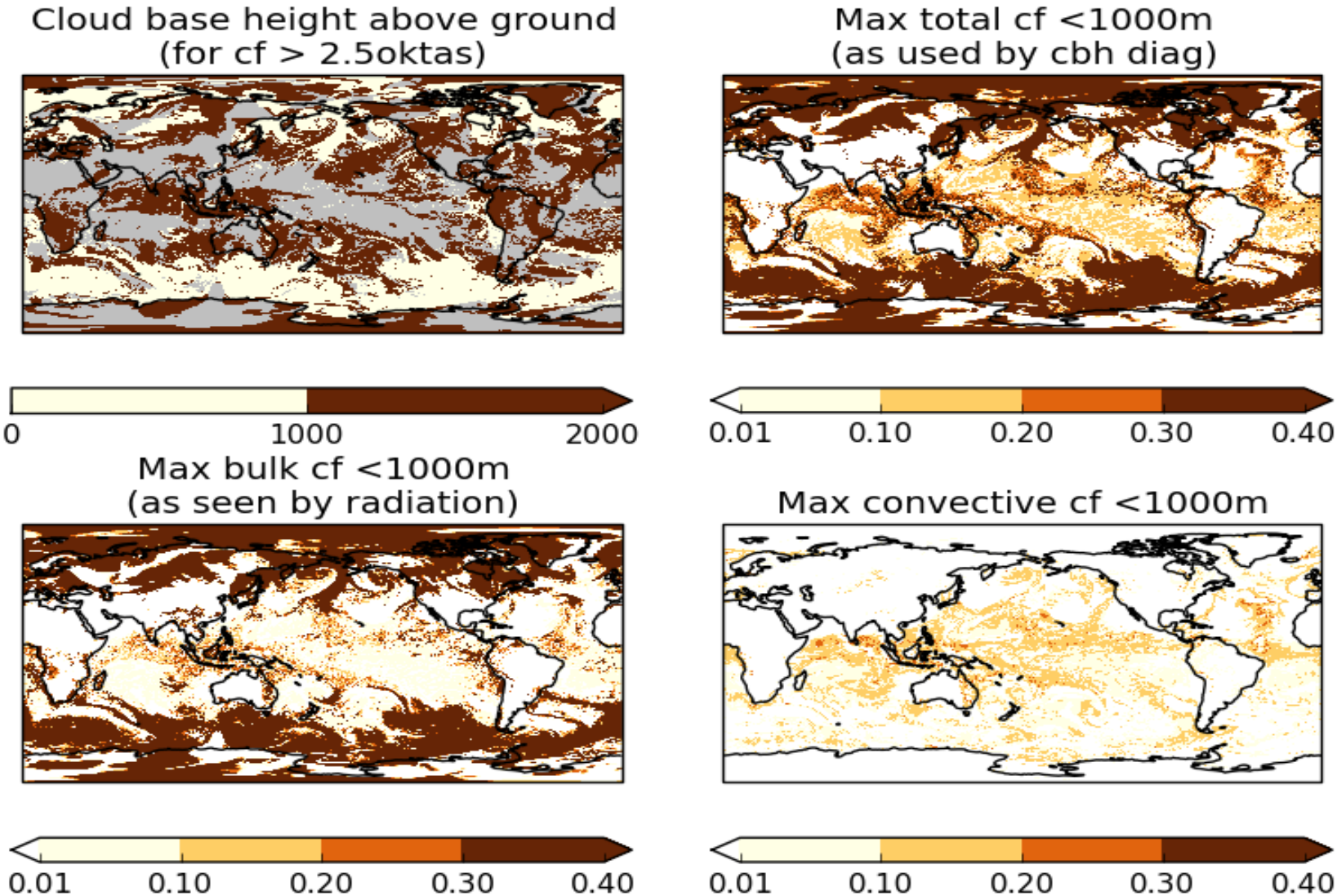
Summer





Case study

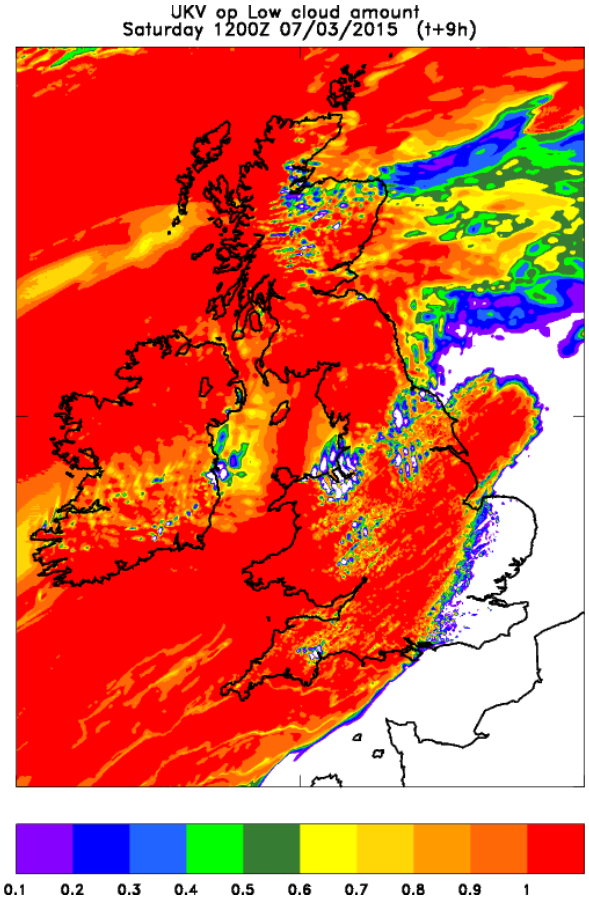
VT: 12Z 02/12/2010 (T+24)



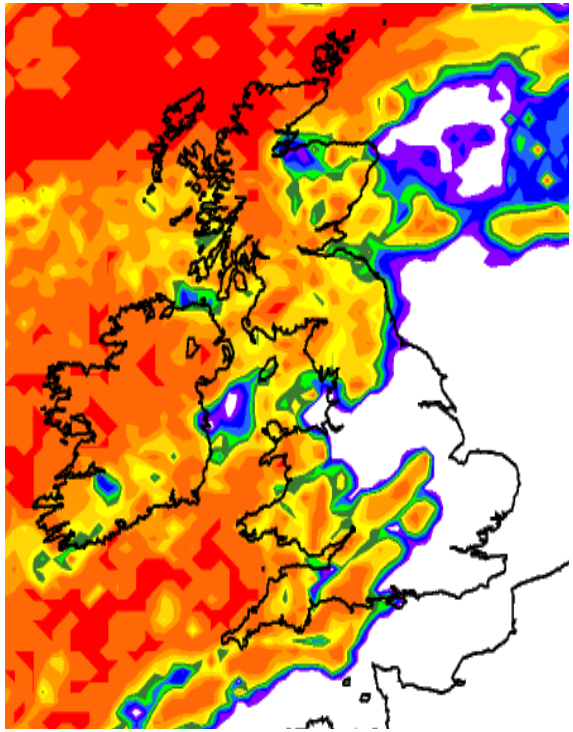
Case study – low cloud amount

VT: 12Z 07/03/15 (T+12)

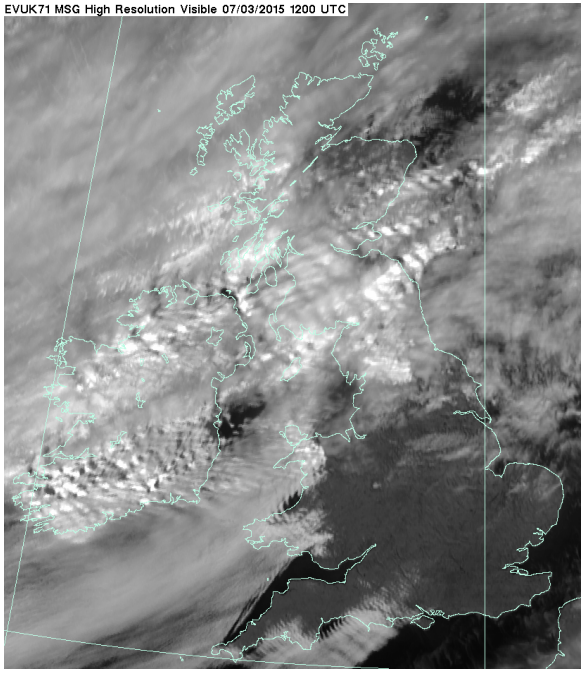
UKV



Global



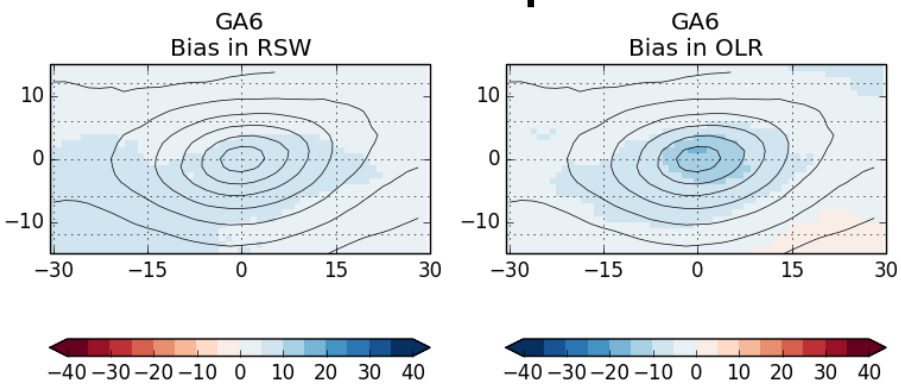
Satellite



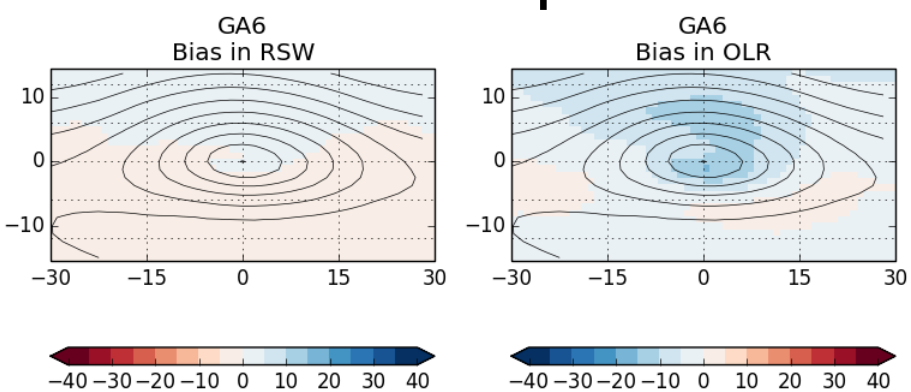
Composite cyclone: GA6 radiation bias

Winter

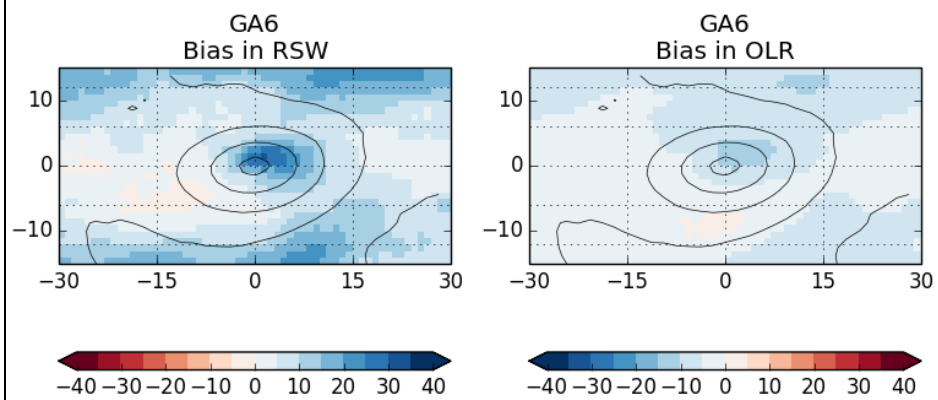
Northern hemisphere:

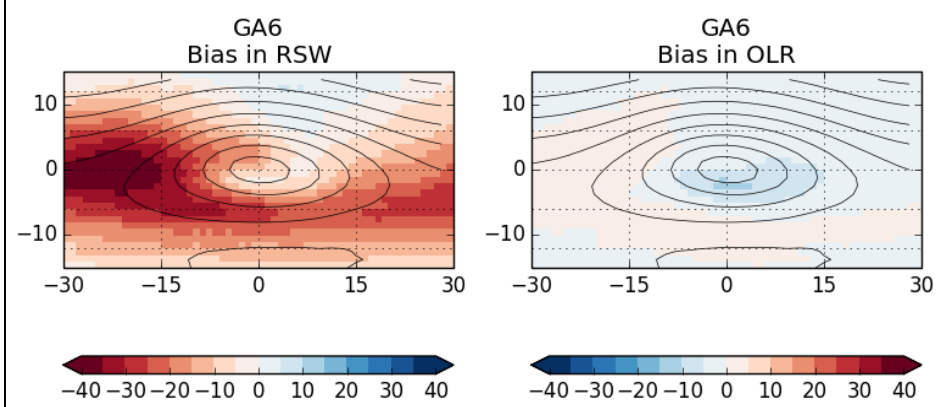


Southern hemisphere:



Summer

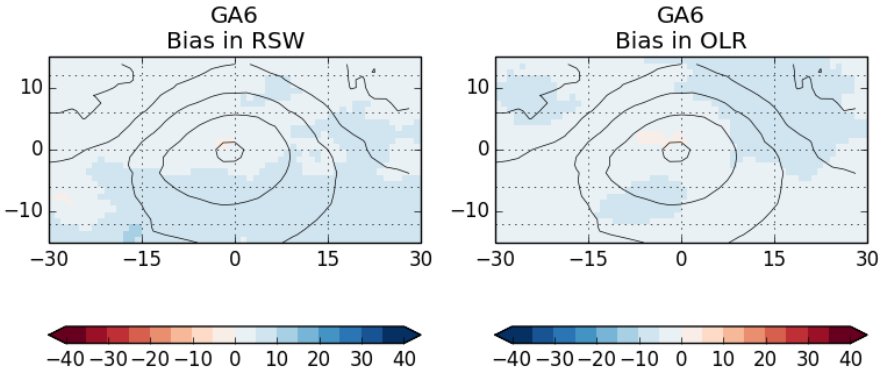




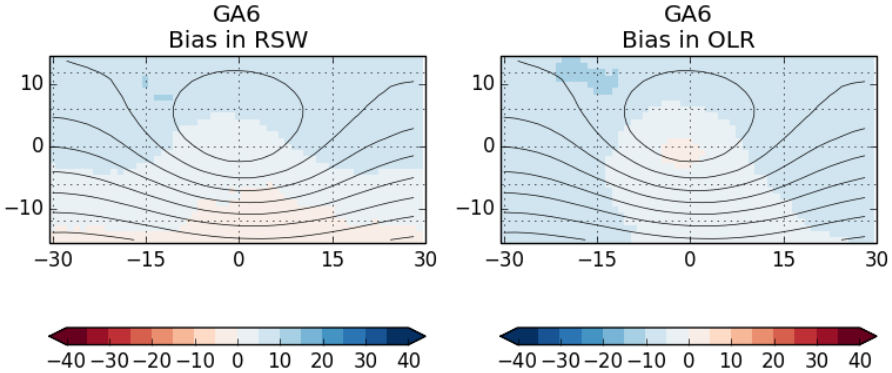
Composite anti-cyclone: GA6 radiation bias

Winter

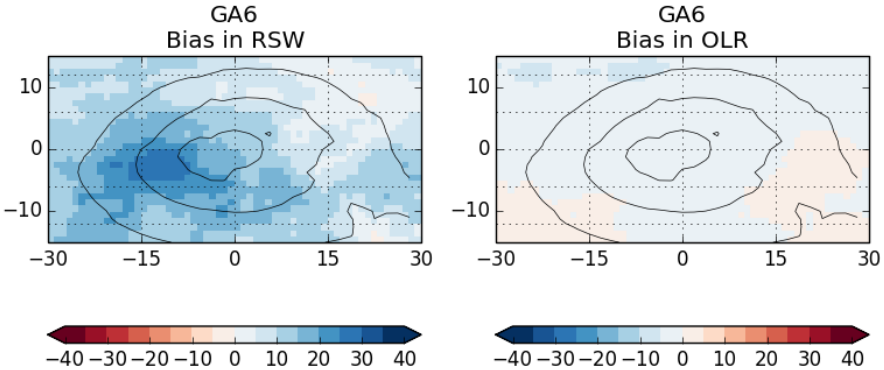
Northern hemisphere:

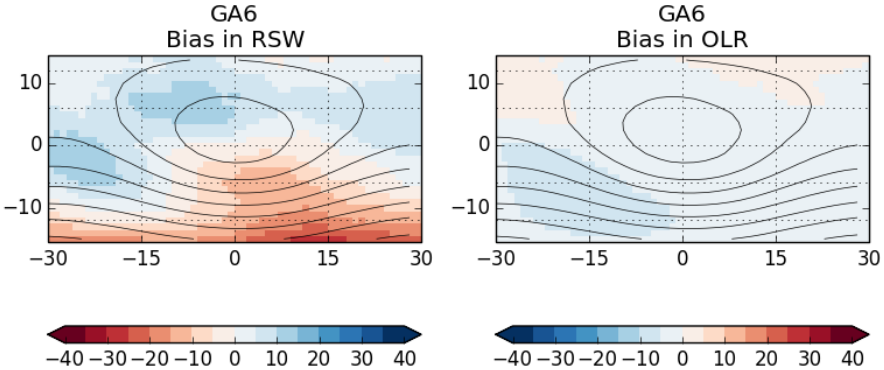


Southern hemisphere:



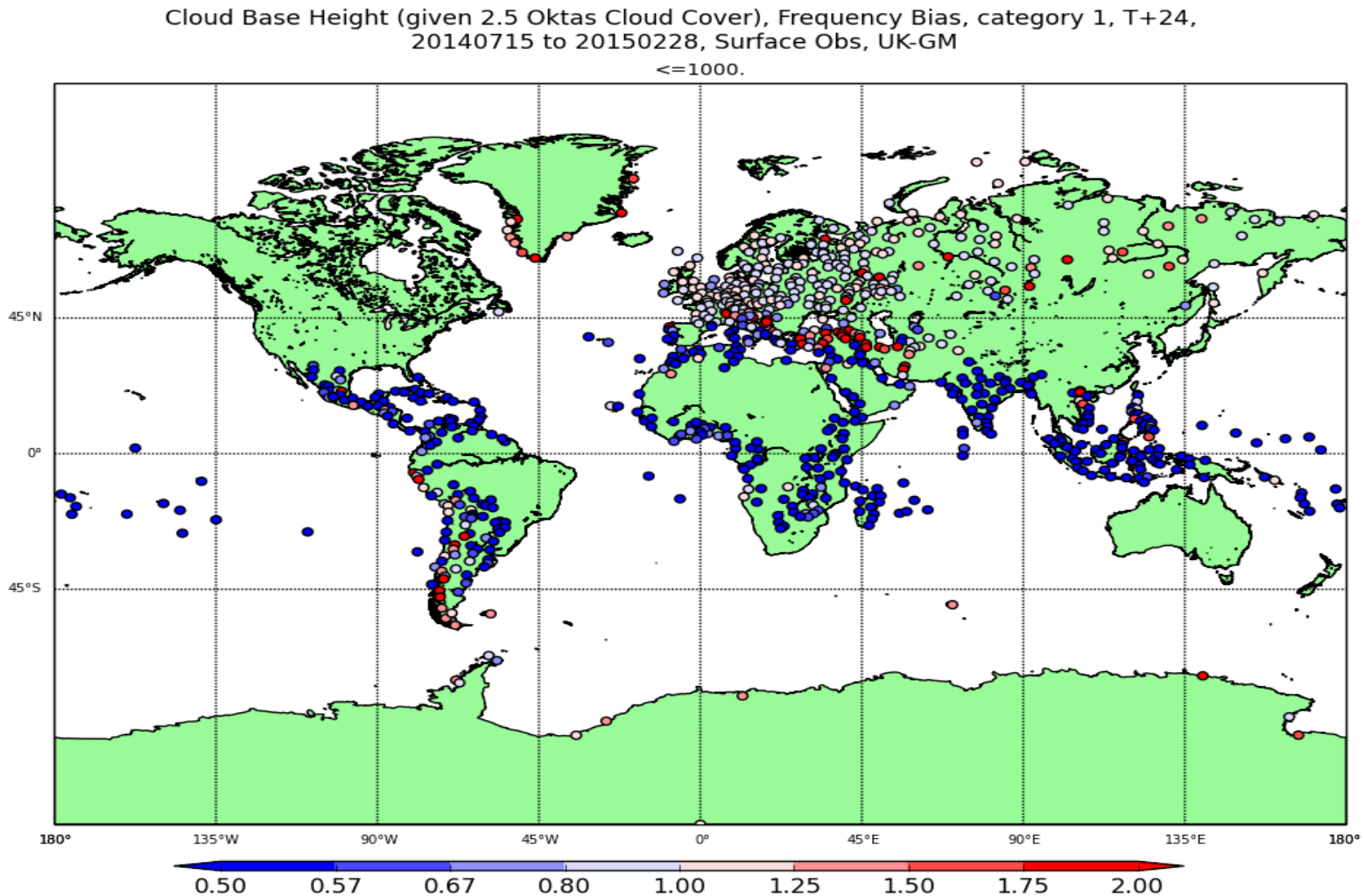
Summer



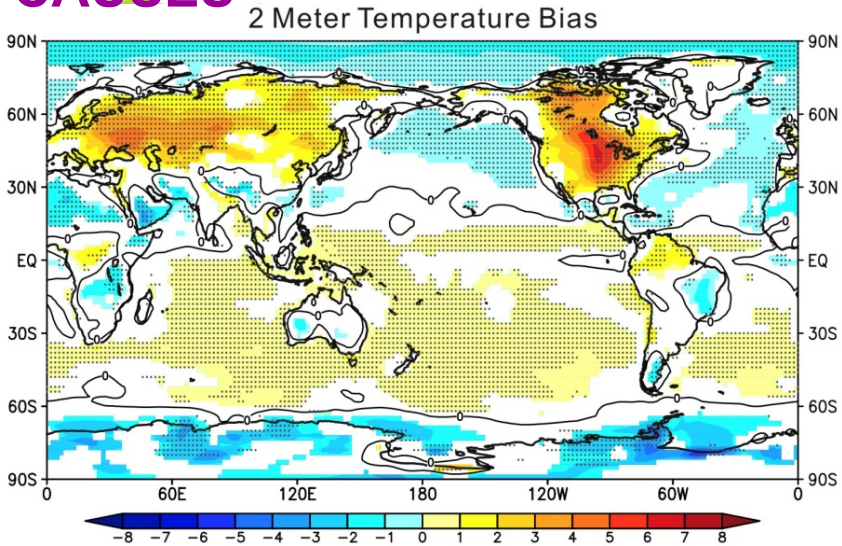


Bias in freq. CBH<1km (T+24)

(when amount >2.5okta)



CAUSES



The warm bias over the US in summer is common to many GCMs.

It is seen in several climate models' long-term climate mean and it also shows up as a bias within a *few days* when running climate models from analysis in NWP mode.

Aims:

A joint GASS/ASR comparison project aiming to evaluate clouds, radiation and precipitation in several weather and climate models using ground-based observations to better understand the reasons for the surface temperature error.

diagnostics required is available from CAUSES website:

http://portal.nersc.gov/project/capt/CAUSES/

GASS GEWEX WCRP Global Atmospheric System Studies ASR Atmospheric System Research Met Office PCMDI RGCM