Attributing the shortwave bias in the trade cumulus regime

Mixed signals from ground-based MWR retrievals, satellite retrievals and first-guess brightness temperature departures

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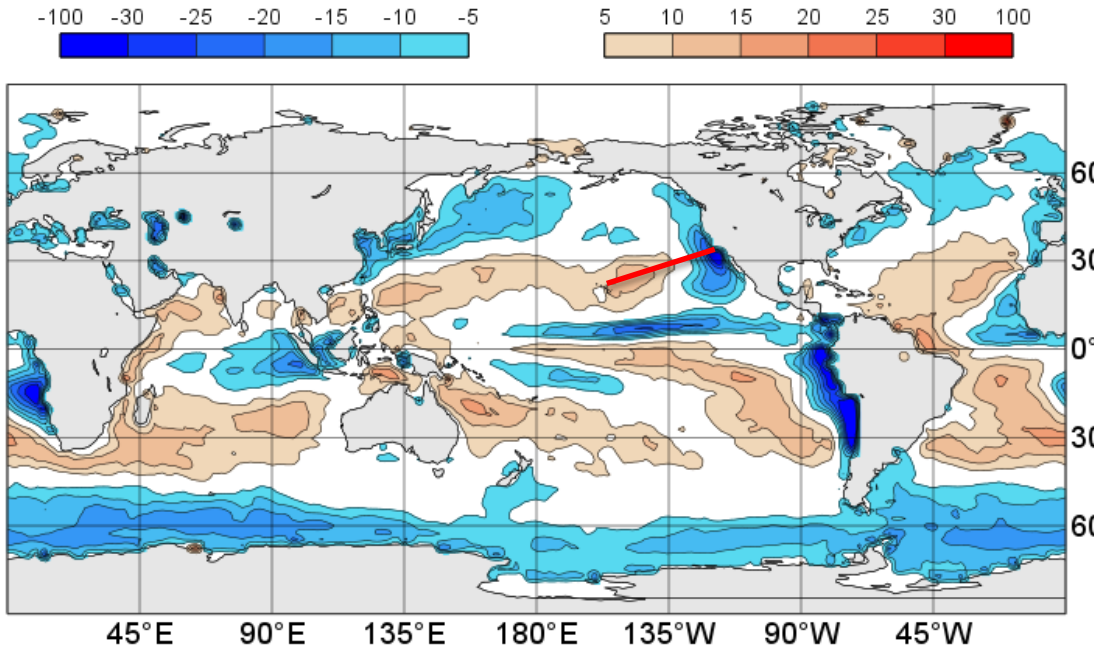
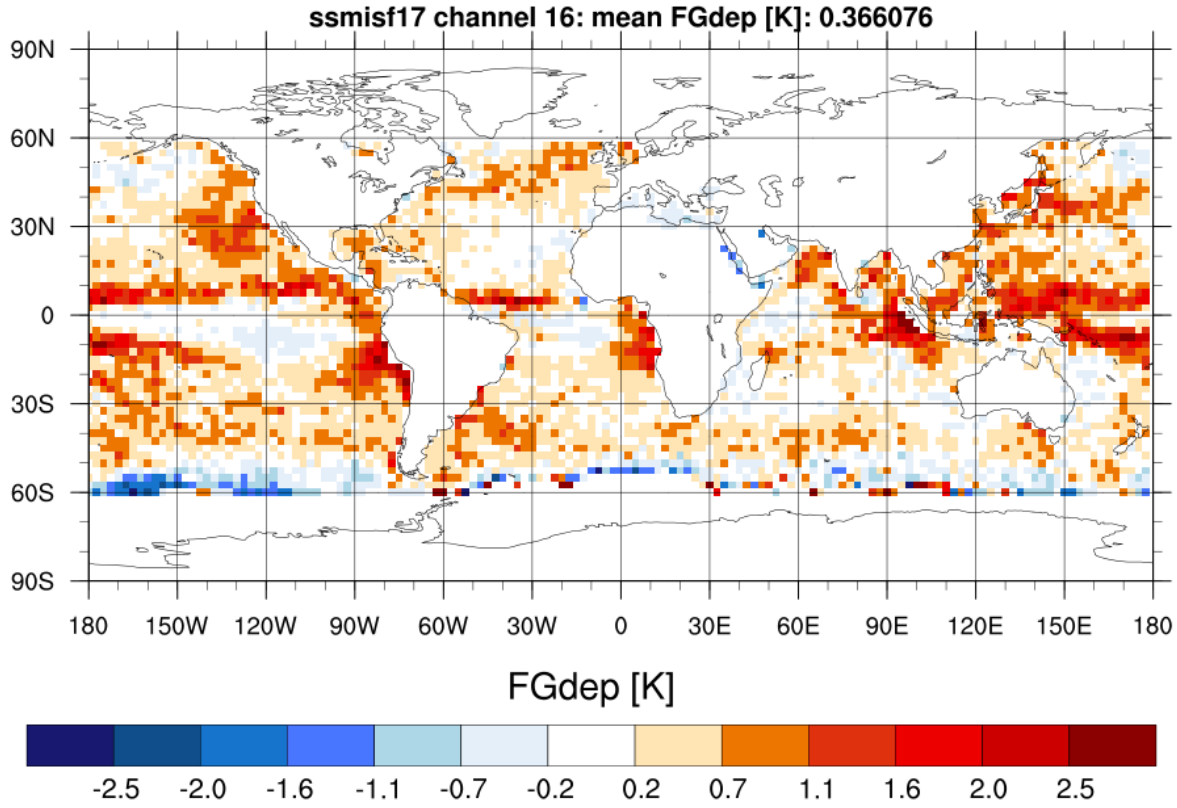
The problem: “Too bright, too few” trade cumulus clouds. Cause: unknown



37 v GHz

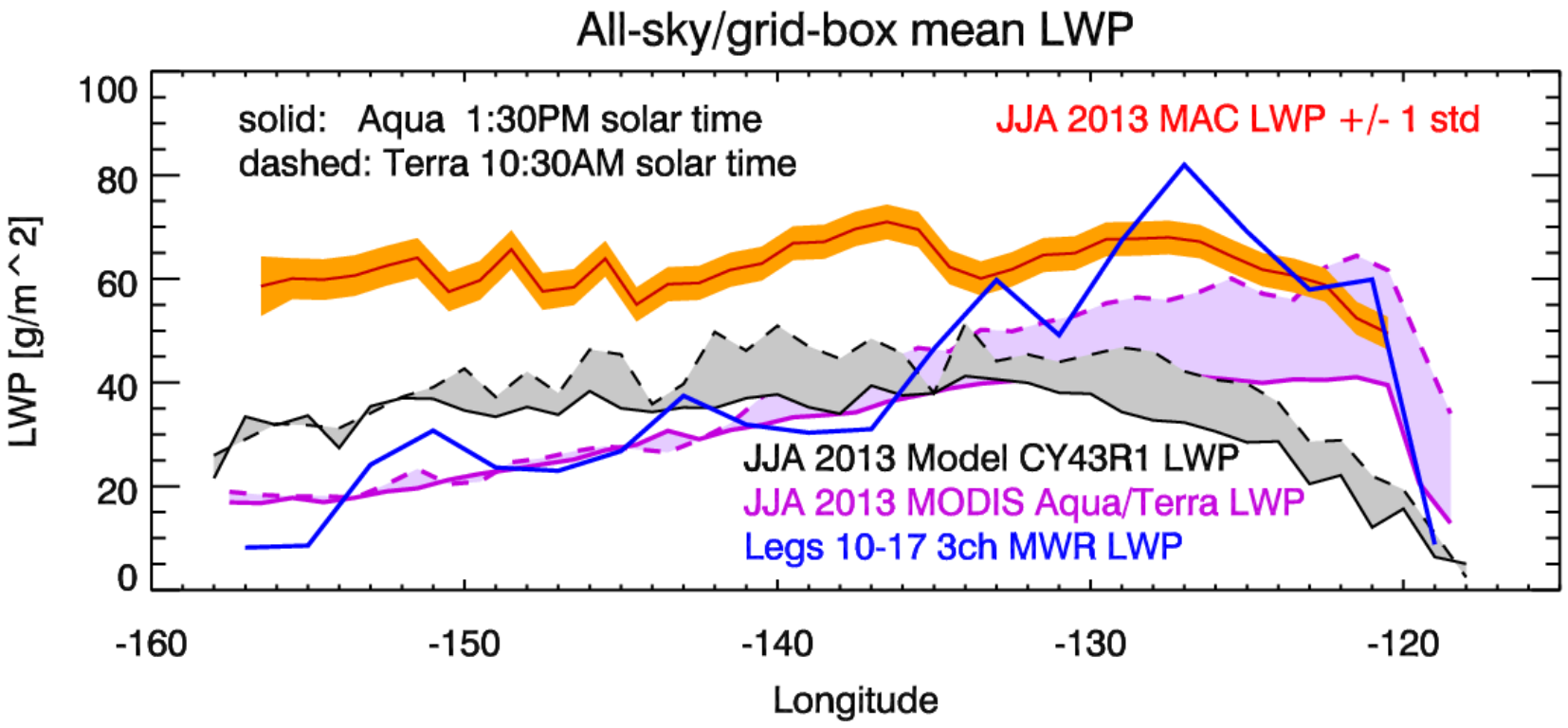


Cumulus areas too reflective (red)
Stratocumulus areas not reflective enough (blue)

Brightness temperature first-guess departures from SSMI/S:
Not enough liquid in the column everywhere (red)

CALIPSO: not enough cloud cover → daytime cloud cover in trade cumulus regions actually ok

Liquid Water Path observations along the MAGIC transect (JJA2013)



Findings consistent with Painemal et al. 2016:

Wentz retrieval of MW LWP overestimates water path – no gradient

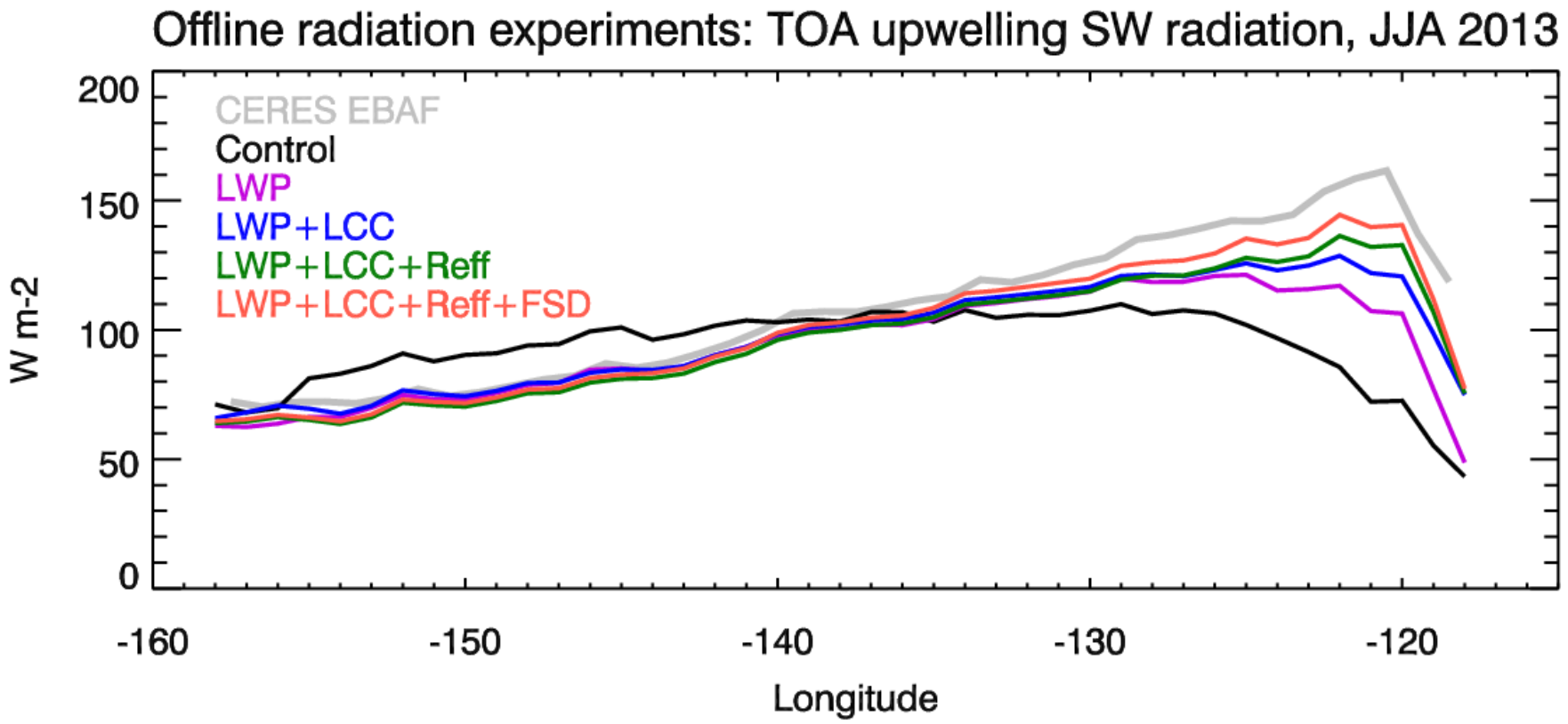
MAGIC 3-ch MWR suggests gradient in all-sky LWP

MODIS/CERES LWP retrieval in better agreement with 3-ch MWR

Relative to CERES/MODIS and ground-based observations, model overestimates LWP in the trade cumulus regime

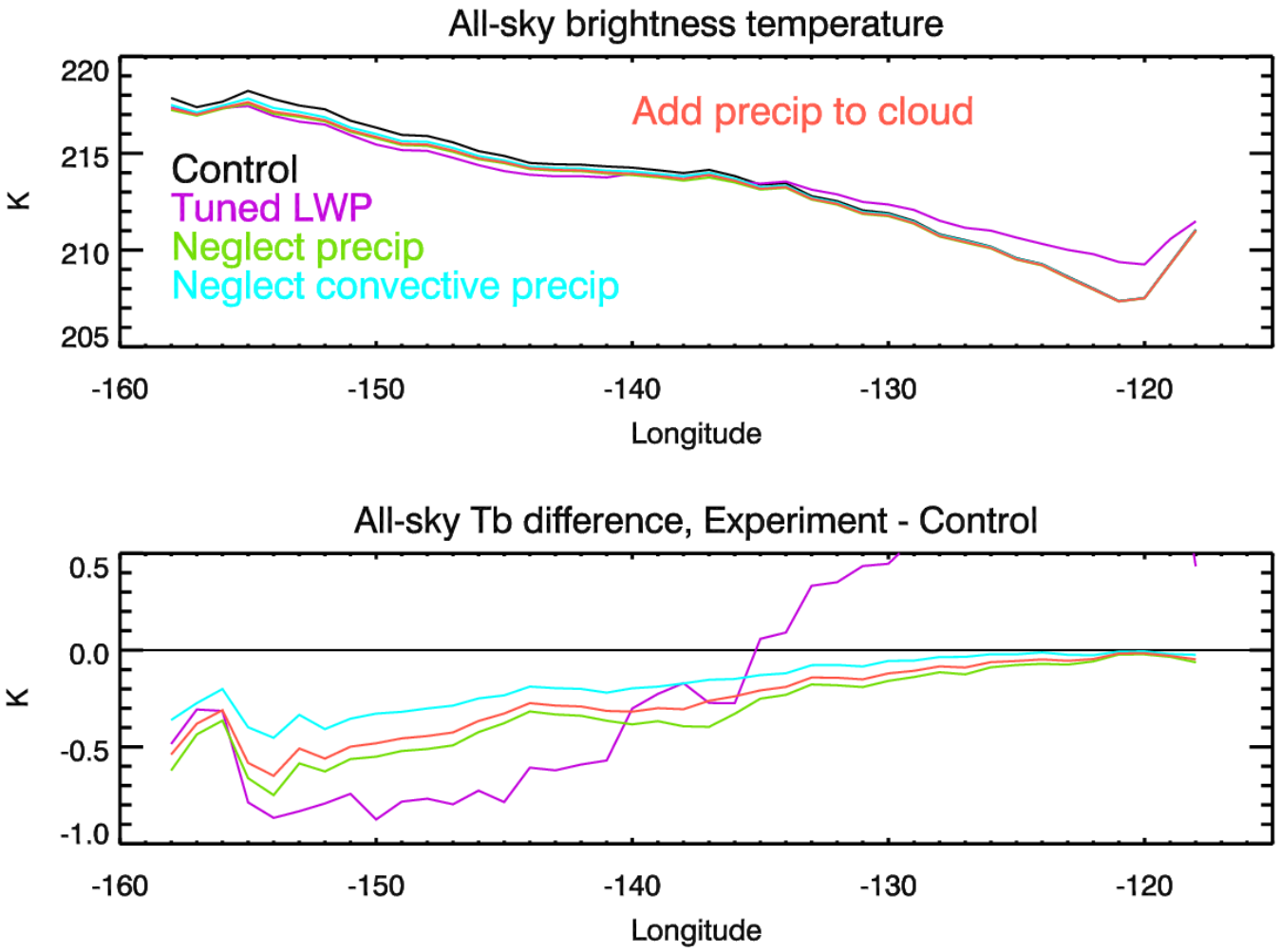
Cross-over of model bias lines up well with crossover of SW radiation bias – quite suggestive!

Hypothesis: LWP bias primary cause of SW error in Trades



Hypothesis confirmed with offline radiation experiments – tuned LWP “fixes” SW bias.
All other assumptions secondary (effective radius, cloud heterogeneity, overlap, 3D radiative effects)

What about first-guess departures?



RTTOV scatt offline experiments:

Daytime-only departures approx. neutral, but model LWP is too large!

Tuned LWP leads to reduction of Tb ~0.8K

Inconsistency remains:
When LWP “fixed”, Tb departures still suggest lack of water in column on the order of 1K

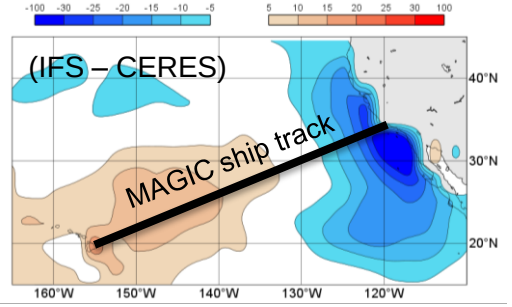
Possible culprit: forward modelling of precipitation in RTTOV scatt, or amount of precip in the column

Conclusions

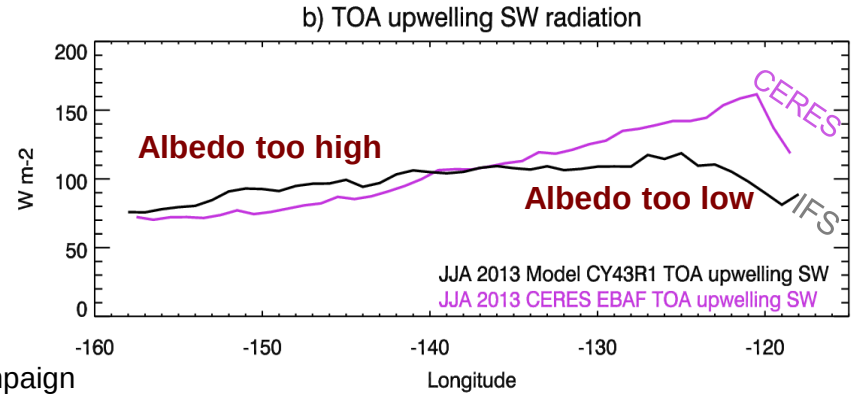
- SW bias in the Trades in the IFS caused by overestimate of all-sky LWP. Daytime cloud cover ok, and other assumptions (heterogeneity, Reff, overlap, 3D radiative effects) all secondary.
- Satellite microwave is misleading; neither retrieval nor forward modelling (RTTOV scatt) give results consistent with ground-based observations and SW bias *in the (broken cloud) trade cumulus regime* (this conclusion applies *only* to this one regime)
- Review of RTTOV scatt is ongoing (i.e. could model lack precip in the column, rather than cloud water? How does that fit with the typical light-precip-too-frequently issue in global models?)
- Very important to consider overpass times of satellites (something an online simulator might do, but offline simulator does not!). Beware of evaluating with all-day mean products if looking into SW bias.

Subtropical marine shortwave radiation bias

SW radiation



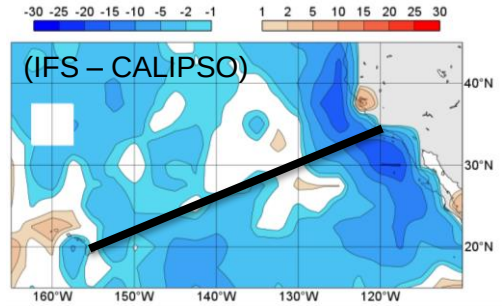
MAGIC – ASR/ARM observational ship campaign

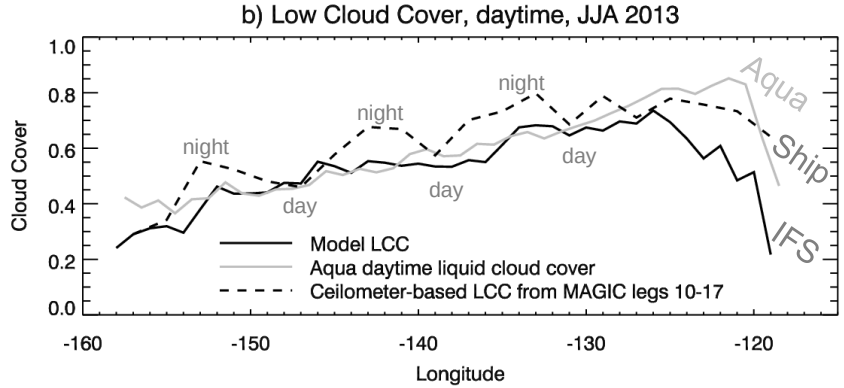


IFS albedo too high in trades

IFS albedo too low in stratocumulus

Cloud cover

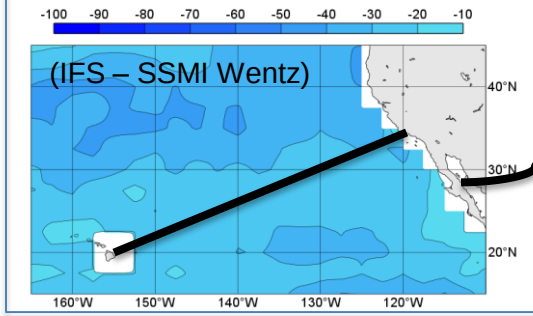


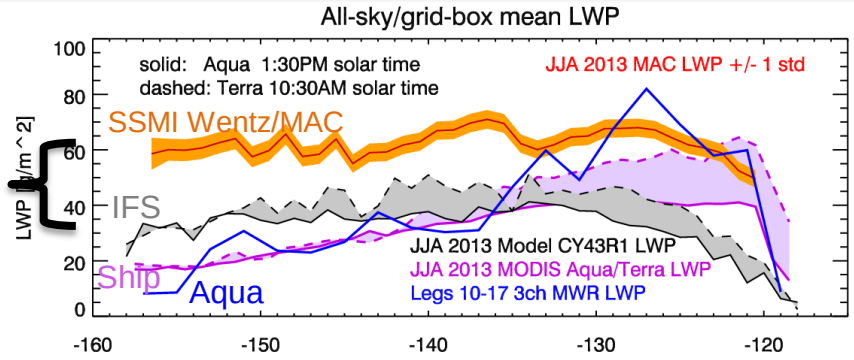


IFS cloud cover good in day

IFS cloud cover too low at night

Liquid water path





IFS LWP too low vs widely used satellite microwave retrievals *(Painemal et al 2016)*

..but IFS LWP too high versus ship MWR and MODIS !

Ahlgrimm, Forbes et al (2018, in prep. – see poster2.45)