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Reconciling Ground-Based and Space-Based Estimates of the Frequency of Occurrence and Radiative Effect of Clouds

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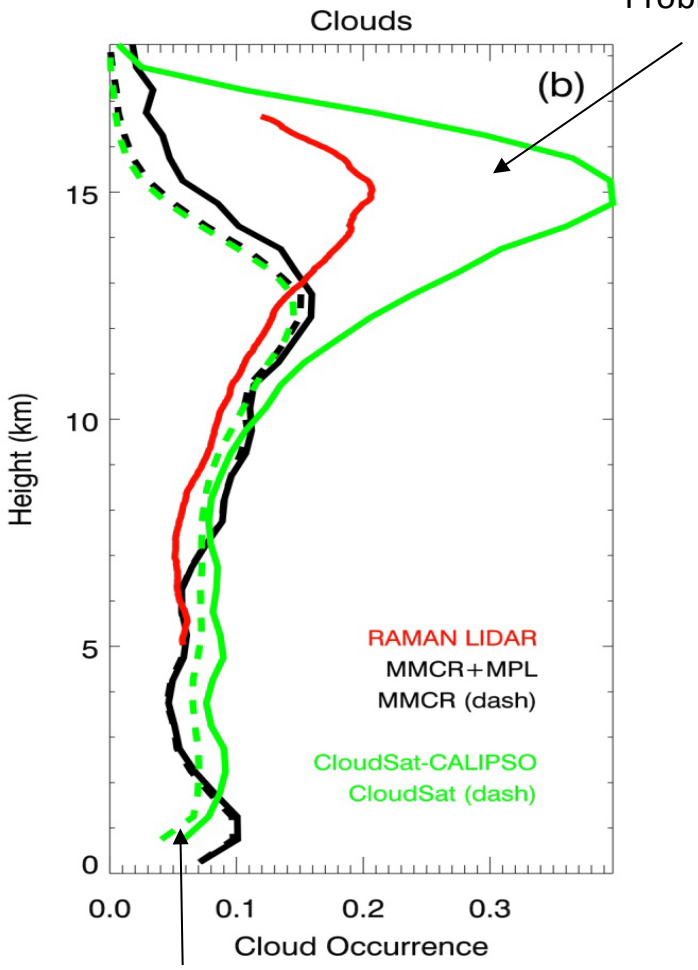
Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

CSIRO

More details in our Protat et al. poster
Ground – satellite comparisons at Darwin

Statistical comparisons of cloud frequency of occurrence (CFO) and associated radiative fluxes and heating rates over Darwin, using CloudSat-CALIPSO and ARM data + radiative transfer.



Problem for satellite radiation budget ?

Problem for ground-based radiation budget ?

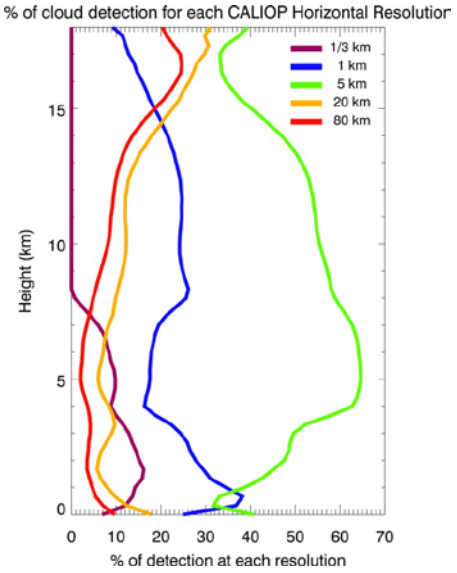
This statistical comparison has already been extensively used to evaluate CloudSat calibration, CloudSat and CALIPSO microphysics over Darwin → details in Protat et al. (2009, 2010).

Basically : 200 km radius around GB site, +- 1 h around overpass

Reasons ?

CALIPSO multi-resolution processing :
can't be the reason (max effect is 0.05)

Low / high cloud cover overlap :
high cloud cover 61%,
low / high overlap 19.8%
→bias in CFO of 0.198*0.61 = 0.12
Does not explain the MPL bias (0.3)
Explains most of the Raman lidar bias

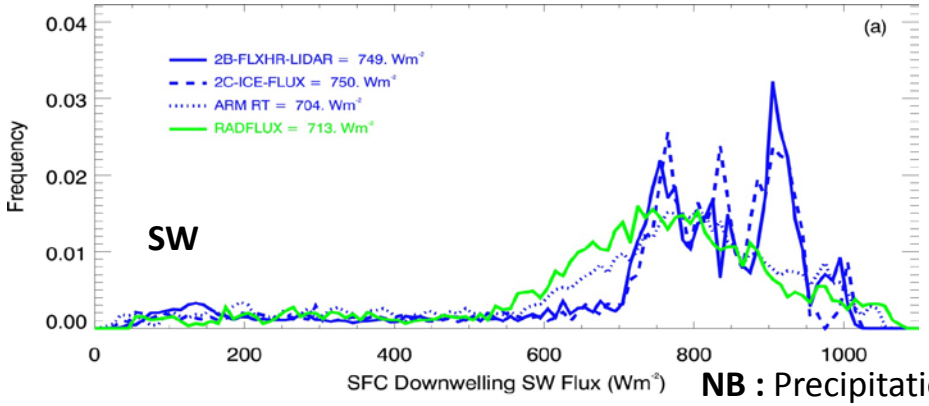


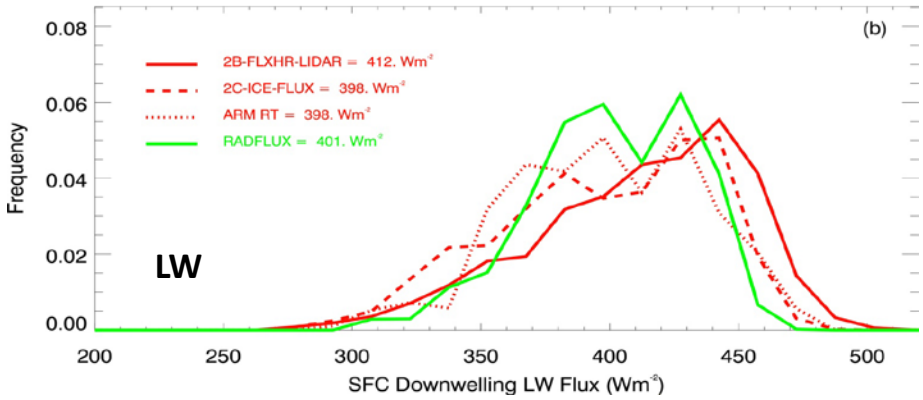
Conclusion: not much more we can do from ground to mitigate that bias !
Conditional sampling for model evaluation (eg, Thorsen et al. 2012, AGU)

More details in our Protat et al. poster

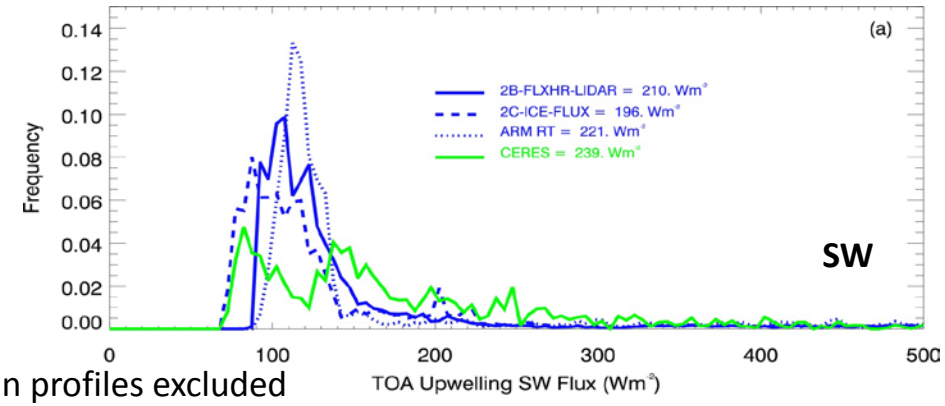
Impact on radiative budgets at SFC and TOA

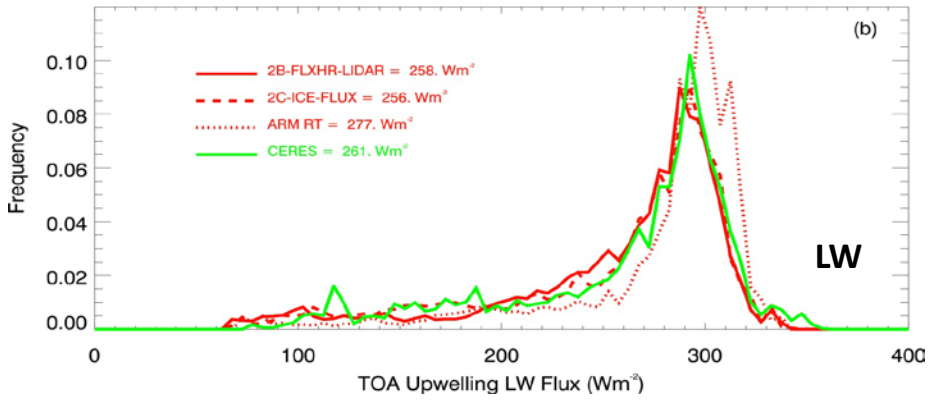
SFC Downwelling Radiative Fluxes





TOA Upwelling Radiative Fluxes





NB : Precipitation profiles excluded

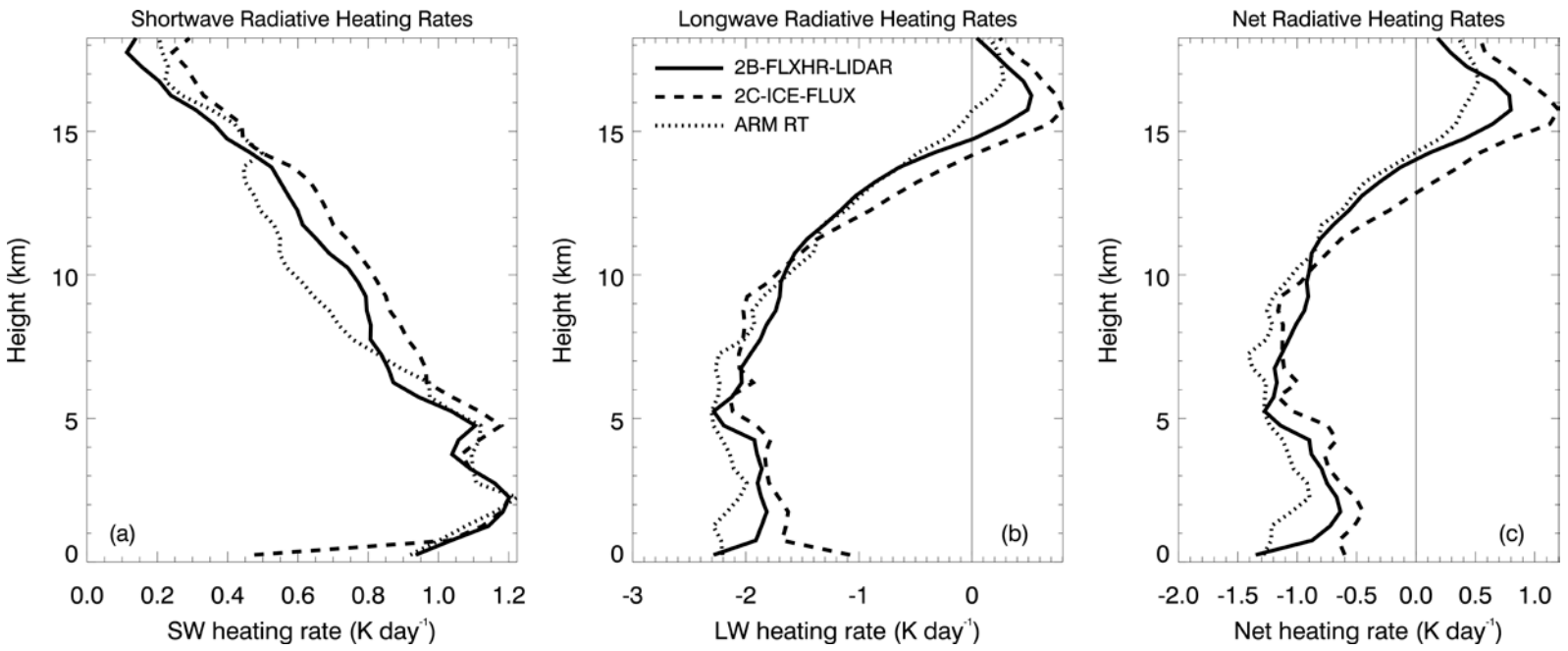
SW flux PDF : ARM RT underestimates (9 Wm^{-2})
Satellite products largely overestimate (36-37 Wm^{-2})
Cumulus occurrence and microphysics (550-700 Wm^{-2})

LW flux PDF :
ARM RT and 2C-ICE OK, 2B-FLXHR-LIDAR high (11 Wm^{-2}).
Same reason (LW >450 Wm^{-2})

SW flux PDF : Bimodal PDF not captured !
Due to land-ocean variability. CERES-CC agree better over ocean (smaller peak).

LW flux PDF : Satellite excellent (3-5 Wm^{-2}).
ARM RT too high (16 Wm^{-2}) – cirrus detection !

More details in our Protat et al. poster
Impact on radiative heating rate profiles



Main results:

Underreported tropical cirrus produce LW radiative heating biases of 0.4-0.8 K day^{-1}.

Differences between satellite products (microphysics) produce 0.4 K day^{-1} LW differences as well

Level of net zero heating rate differs by 1 km : impact on tropospheric / stratospheric exchange studies

Satellite SW differences are largest in ice phase (0.1-0.15 K day^{-1} between satellite products, due to microphysics , and up to 0.35 K day^{-1} between ground and satellite).

Implications for QUICR & ASR

Using ARM cloud microphysics retrievals, radiative transfer and radiative closure to evaluate and improve retrievals is a very good idea, but caution should be exercised that we are not missing radiatively-important clouds (thin tropical cirrus like here over Darwin)

Cloud microphysics retrievals are still all over the place (Zhao et al. 2012, Comstock et al. 2013) – we urgently need to use the QUICR strategy to improve this.

CloudSat-CALIPSO can be used to check that over other ARM sites.

More generally for ASR : we should move away from ARM climatologies and use conditional sampling for model evaluation and improvement – low cloud cover / high cloud cover overlap introduces biases much larger than (I) expected. Here a factor 2 in ice cloud occurrence at 15 km !