The importance of optically thin low-level clouds and of considering small scale heterogeneity in cloud properties

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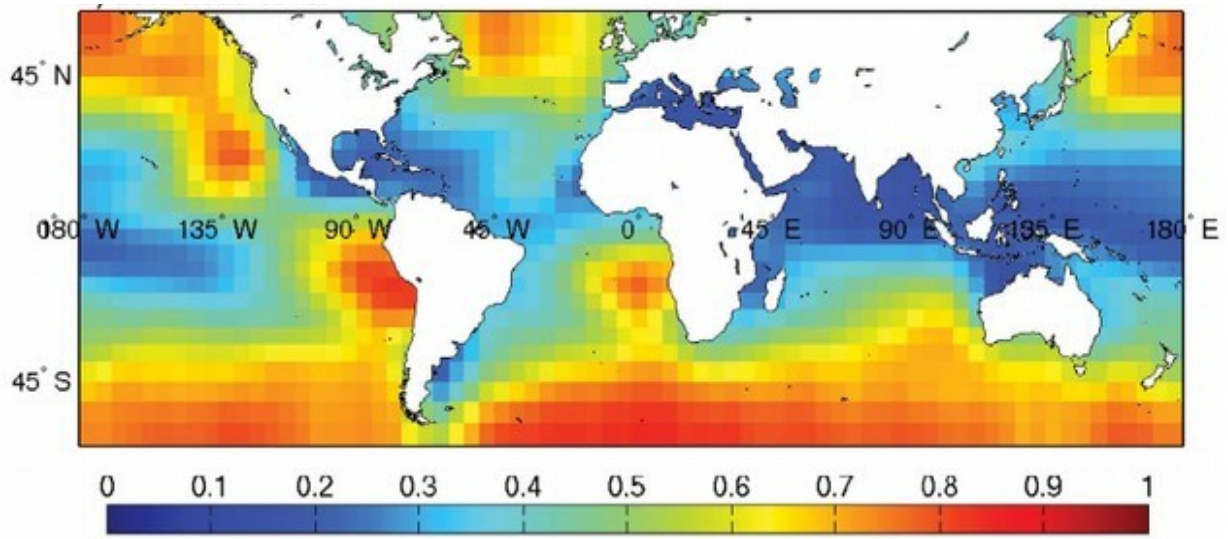
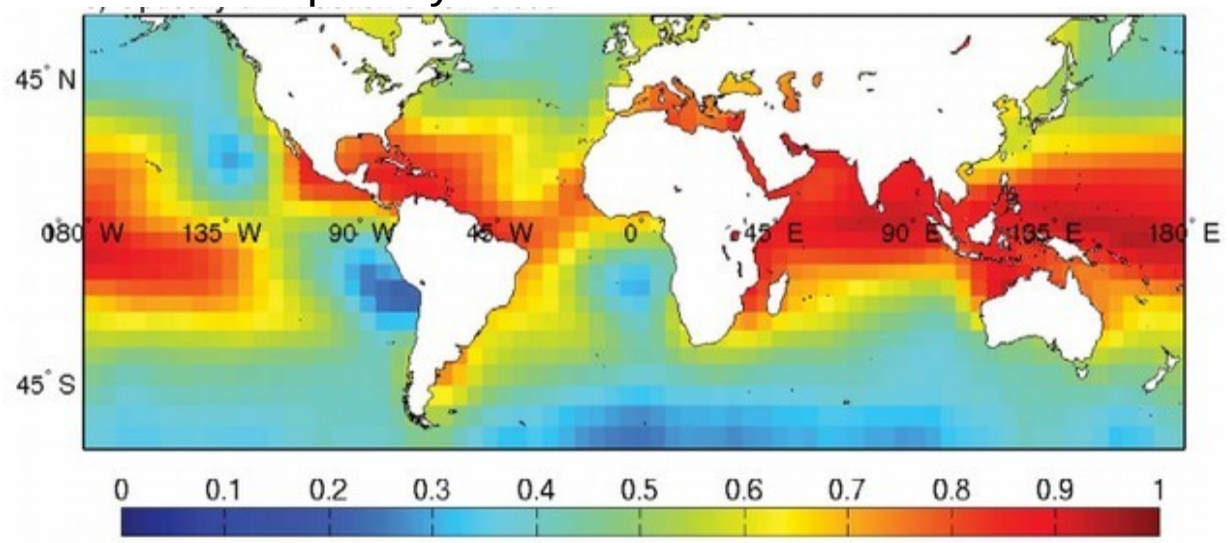
Importance of ***optically thin low-level clouds*** over oceans

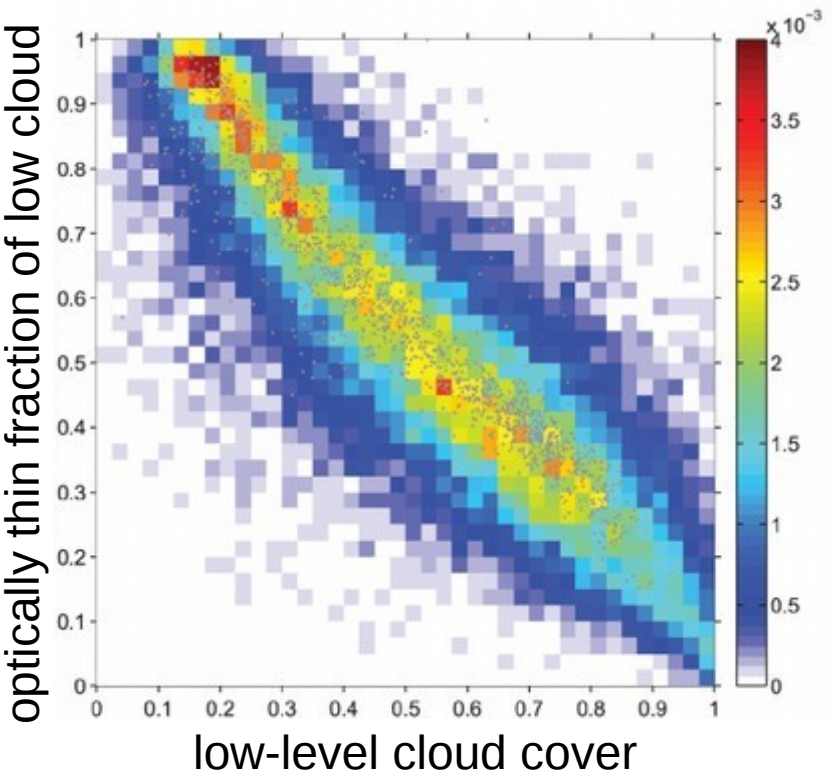
From Calipso night measurements

low-level cloud cover



optically thin fraction of low cloud



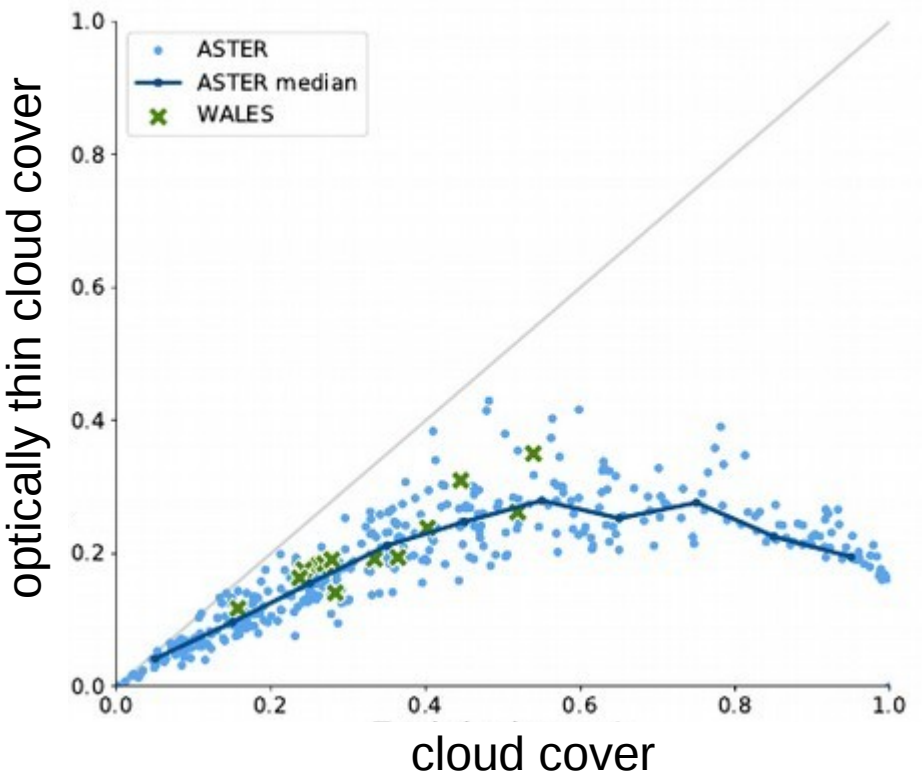


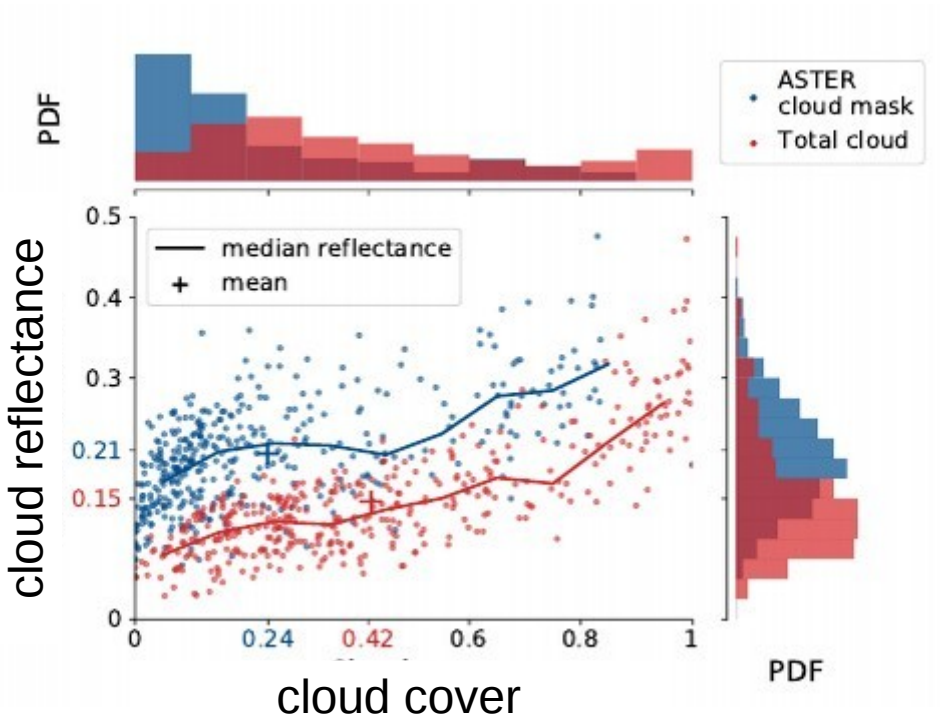
[Leahy et al., JGR, 2012]

Importance of ***optically thin low-level clouds*** over oceans

trade cumulus cloud fields

high-resolution ASTER satellite radiometer (& WALES lidar)

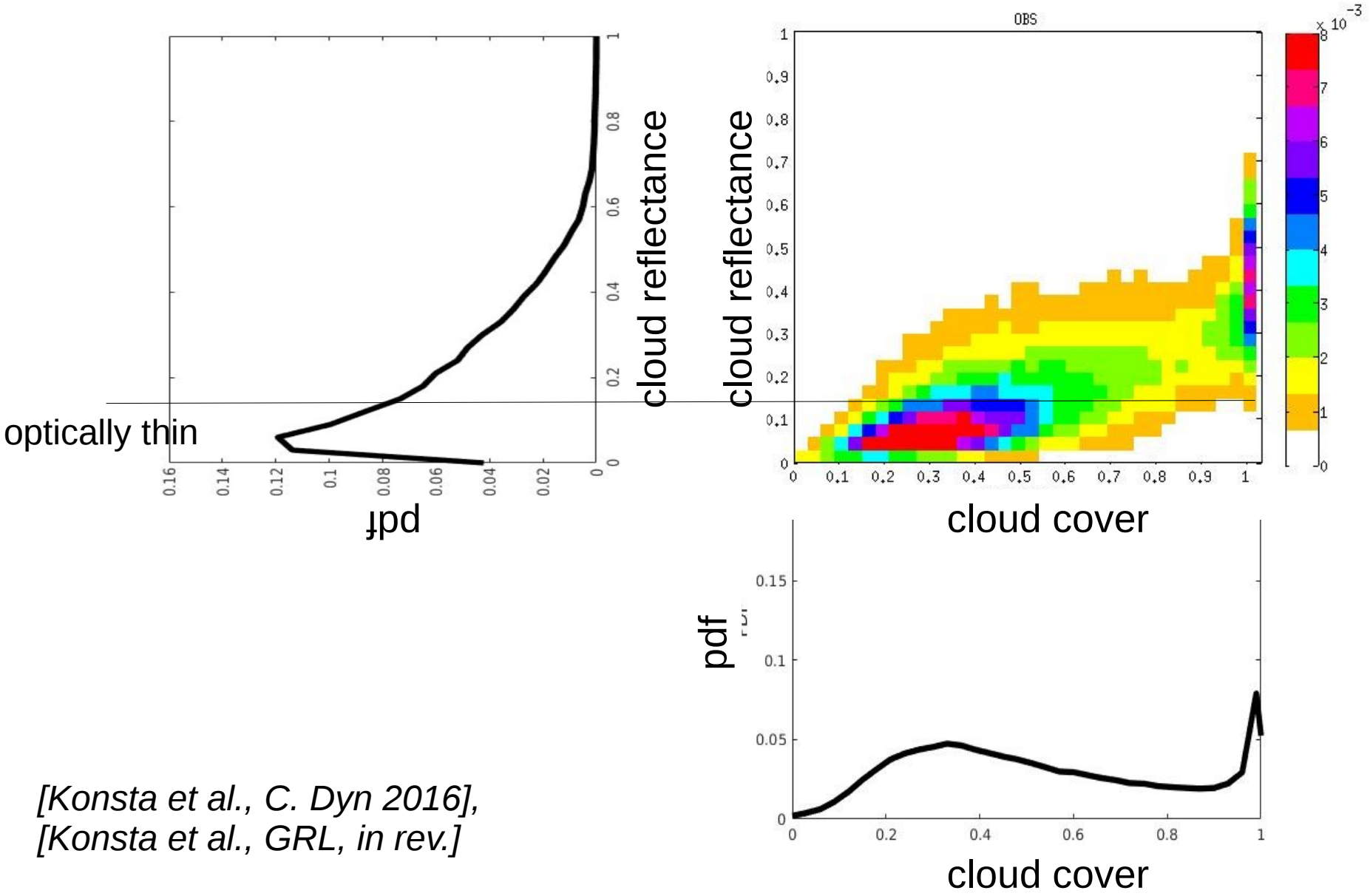




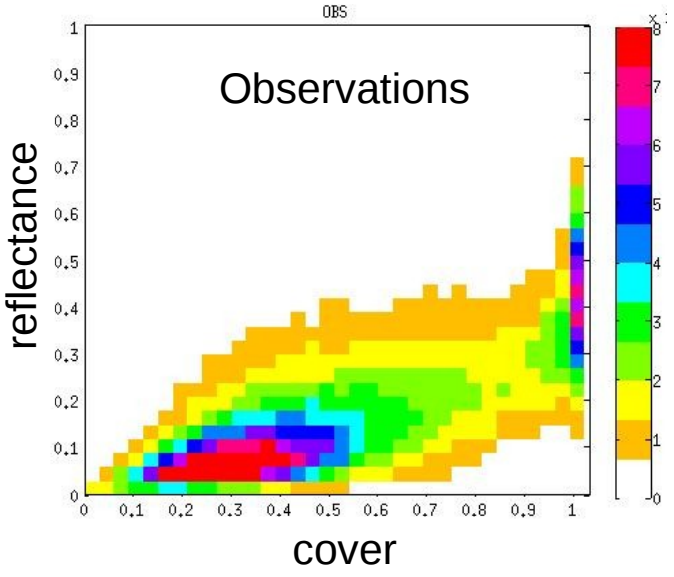
[Mieslinger, ACP, in review]

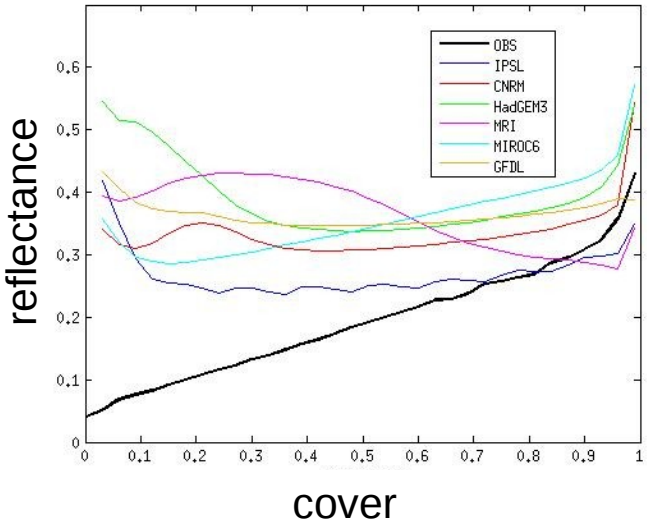
Low-level clouds reflectance versus cover

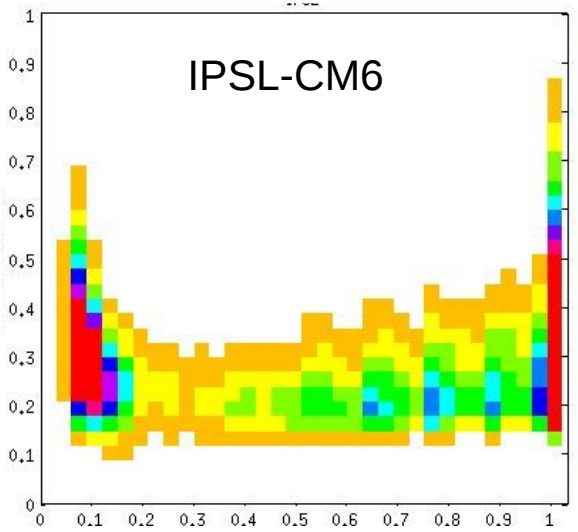
Cloud **reflectance** (PARASOL radiometer) and Cloud **cover** (CALIPSO) on a 2°x2° grid

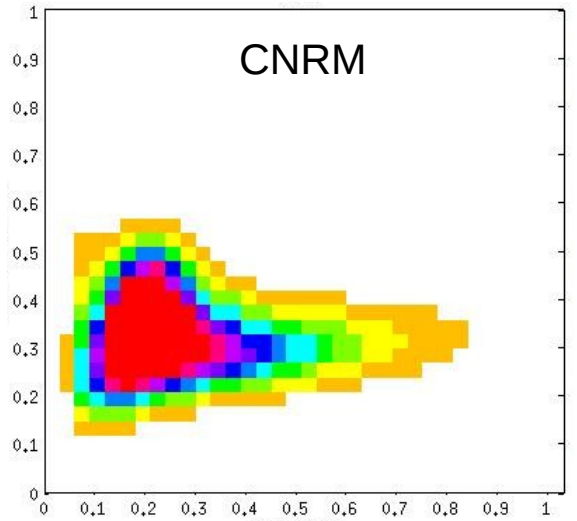


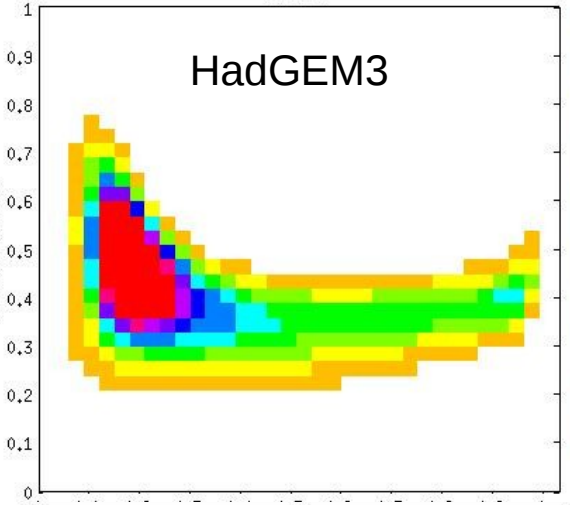
[Konsta et al., C. Dyn 2016],
[Konsta et al., GRL, in rev.]

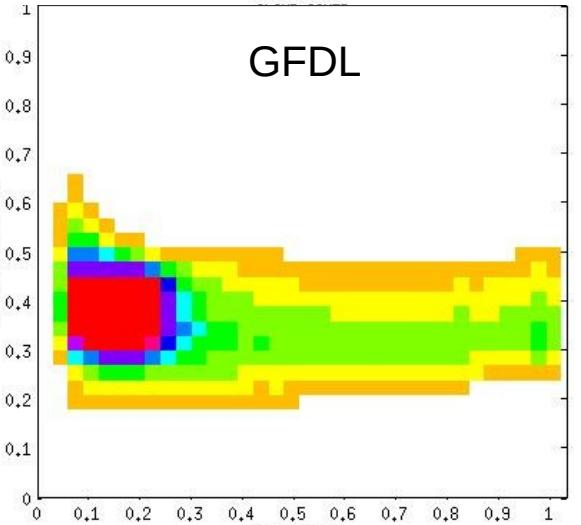

OBS
Observations
reflectance
cover

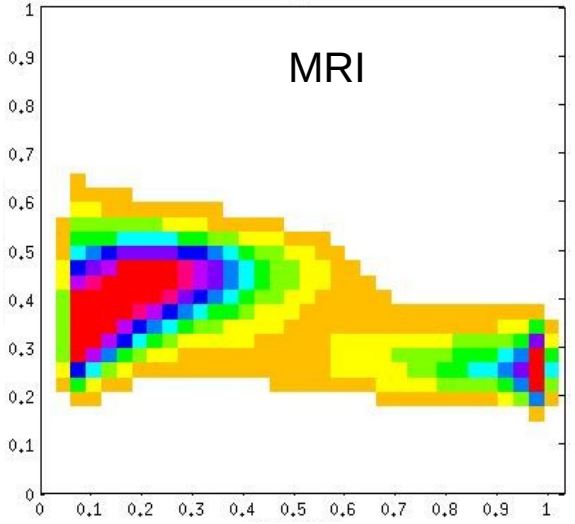

OBS
IPSL
CNRM
HadGEM3
MRI
MIROC6
GFDL
reflectance
cover

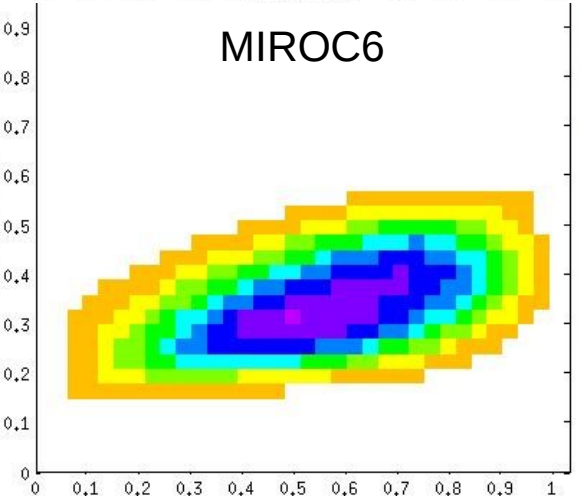

IPSL-CM6


CNRM


HadGEM3

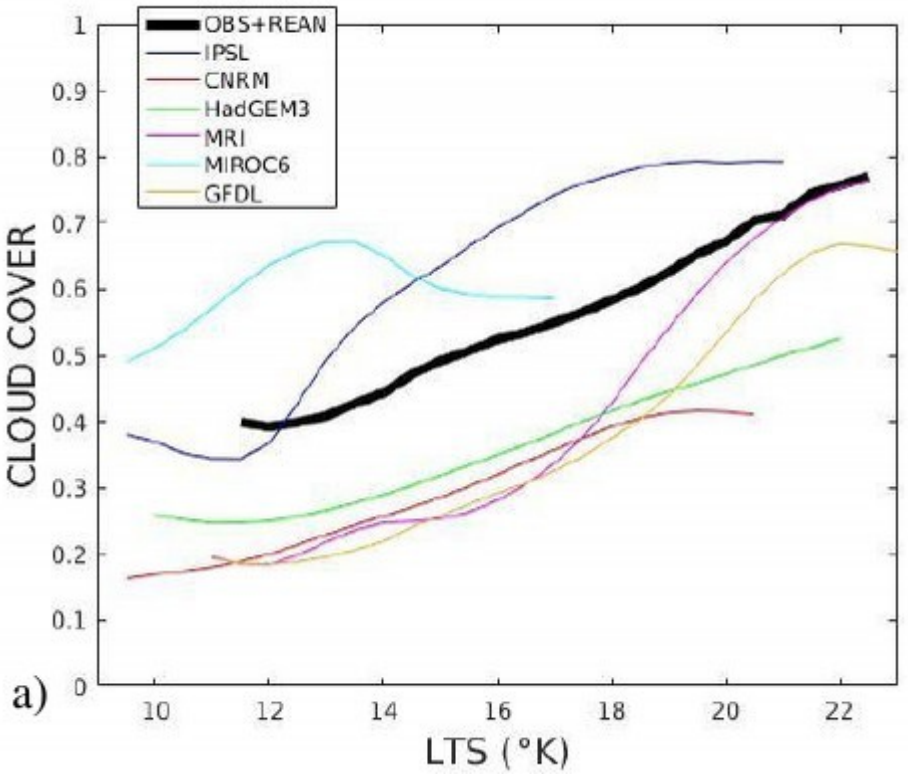

GFDL


MRI

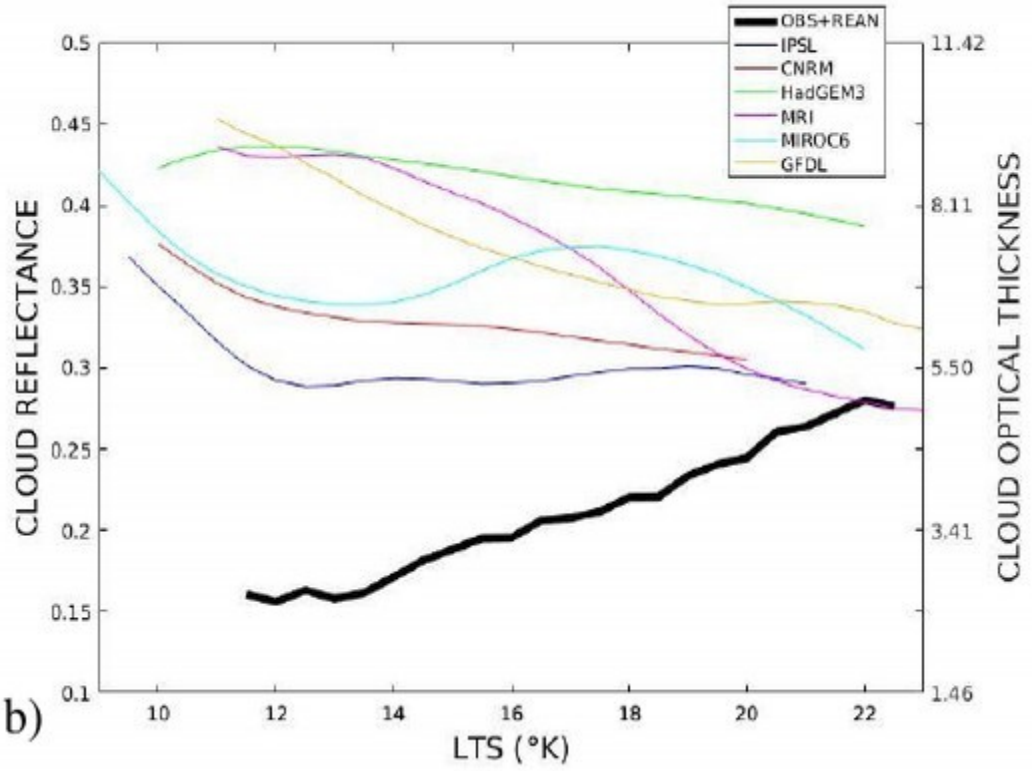

MIROC6

Sensitivity of low-level clouds to their environments

Low-level cloud cover increases with low troposphere stability (LTS)
in both observations and models



Low-level cloud reflectance increases with low troposphere stability (LTS)
in observations but not in models

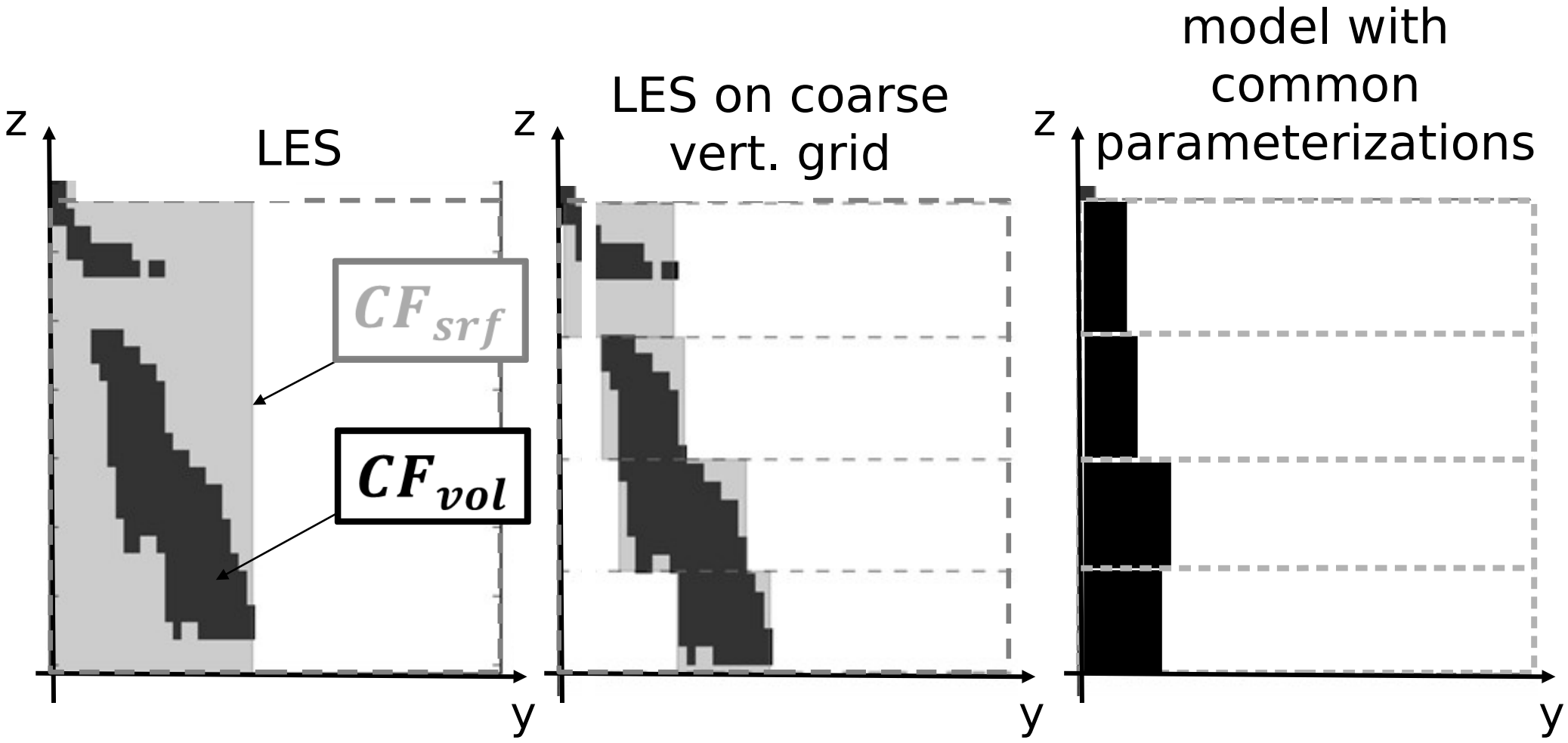


Current GCMs do not simulate optically thin clouds

Hypothesis:

- They do not simulate *thin veil clouds* beneath the trade inversion
- They do not simulate the *vertical heterogeneity* of cloud fraction

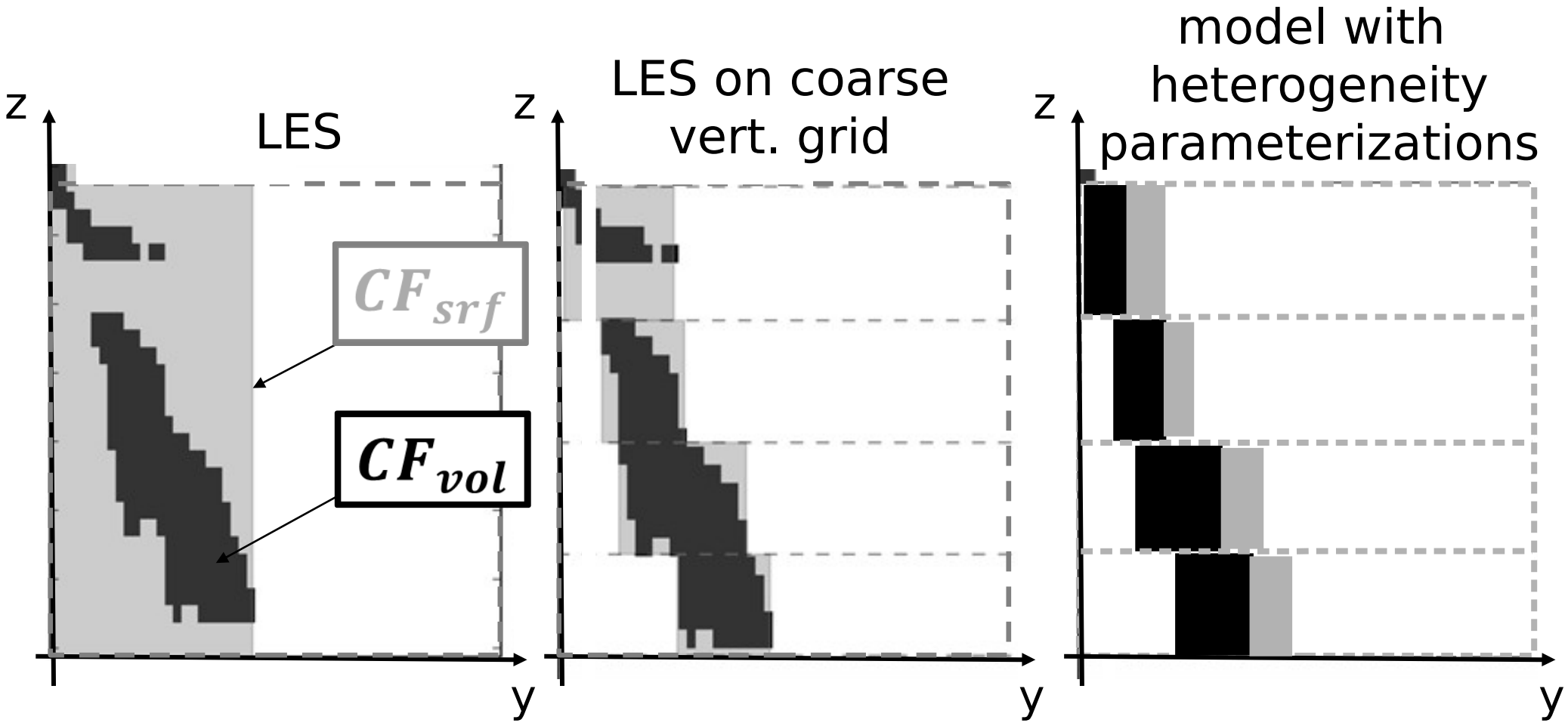
Clouds in models are too “compact”



Parameterizations:

- *No sub-grid variability*
- Cloud overlap: *maximum-random* (i.e. maximum here)

Clouds in models are too “compact”



Parameterizations for:

- *Sub-grid variability:* differentiate between the surface fraction and the volume fraction
- *Cloud overlap:* partly random, not only maximum

Impact of sub-grid heterogeneity and cloud overlap

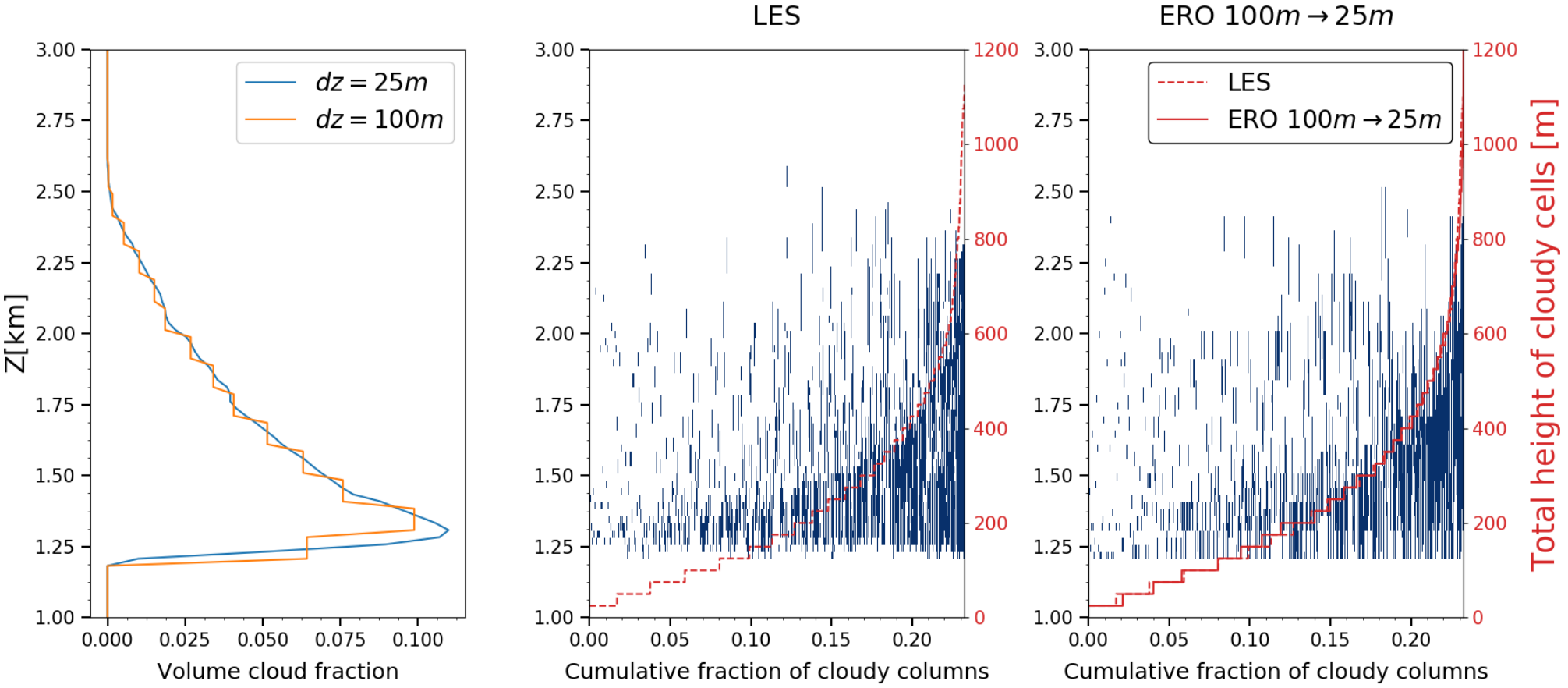
LES simulation with MESO-NH 6.4x6.4x4 km, dx=dy=dz=25m

ARM cumulus cloud case

Vertical distribution of clouds within the domain

Horizontally averaged

Horizontal statistical distribution (sub-columns)



[Lebrun et al., in prep.]

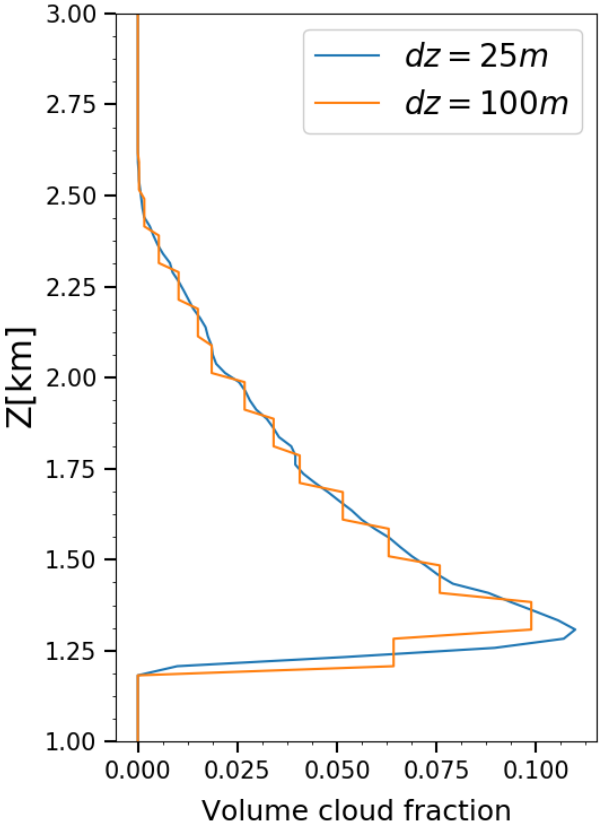
Impact of sub-grid heterogeneity and cloud overlap

LES simulation with MESO-NH **6.4x6.4x4 km**, dx=dy=dz=25m

ARM cumulus cloud case

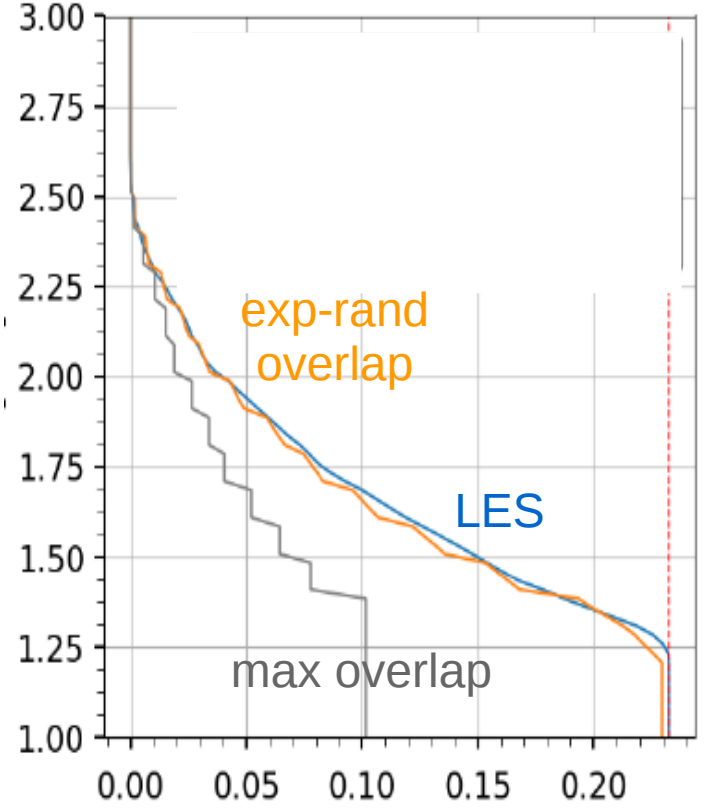
Cloud fraction

Horizontally averaged

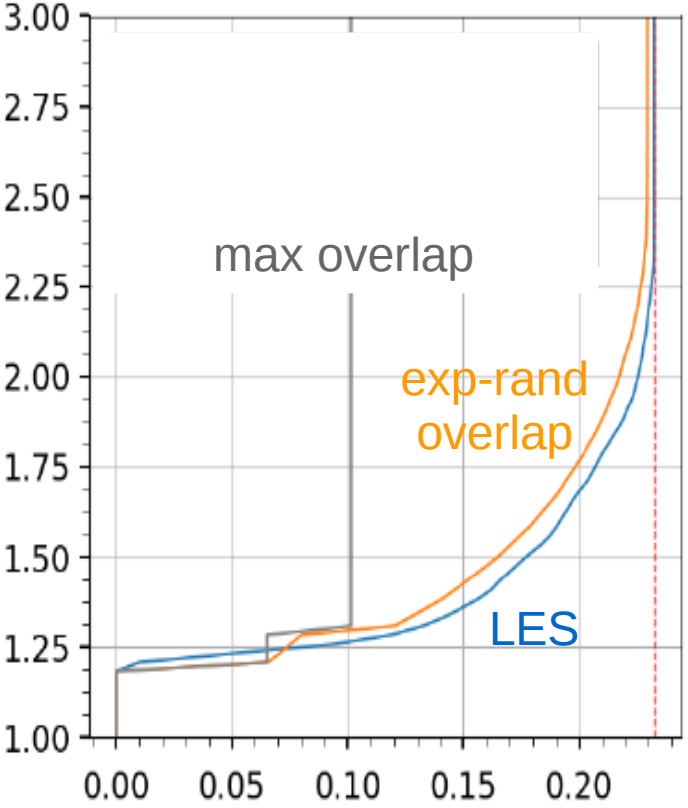


Vertical distribution of **cloud cover**

seen from **above**



seen from **below**



[Lebrun et al., in prep.]

Conclusion

For current GCM (and storm resolving models Δx > kms?)

- Improvement of *optically thin clouds* is an issue
- Low clouds *are too compact* if they do not take into account
  - The sub-grid heterogeneity
  - The vertically decorrelation of overlap
  - Importance of sub-grid variability of water content
- Heterogeneity is likely also important for high clouds

Earth Care will give new opportunities:

- better detection of optically thin clouds
- “radiative closure“ => collocated information on cloud fraction, height and radiative properties

Simulator for models:

- Sub-grid generator consistent with model’s radiative code
- Adapted to a collocated multi-instrument prospective
- Vertical resolution should be higher than COSP (480m)