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

Jean-Louis Dufresne

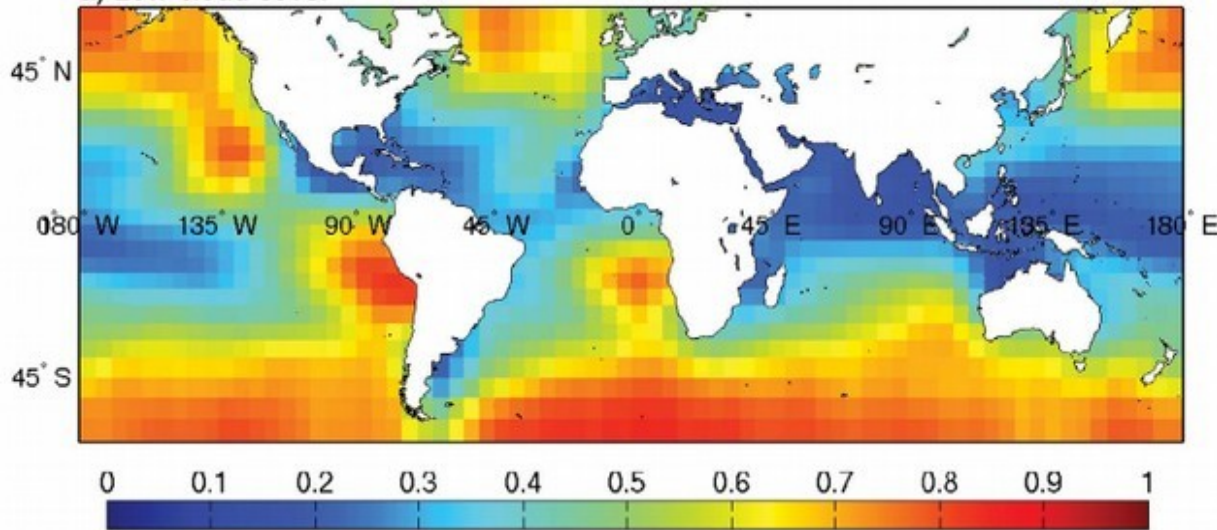*Laboratoire de Météorologie Dynamique*

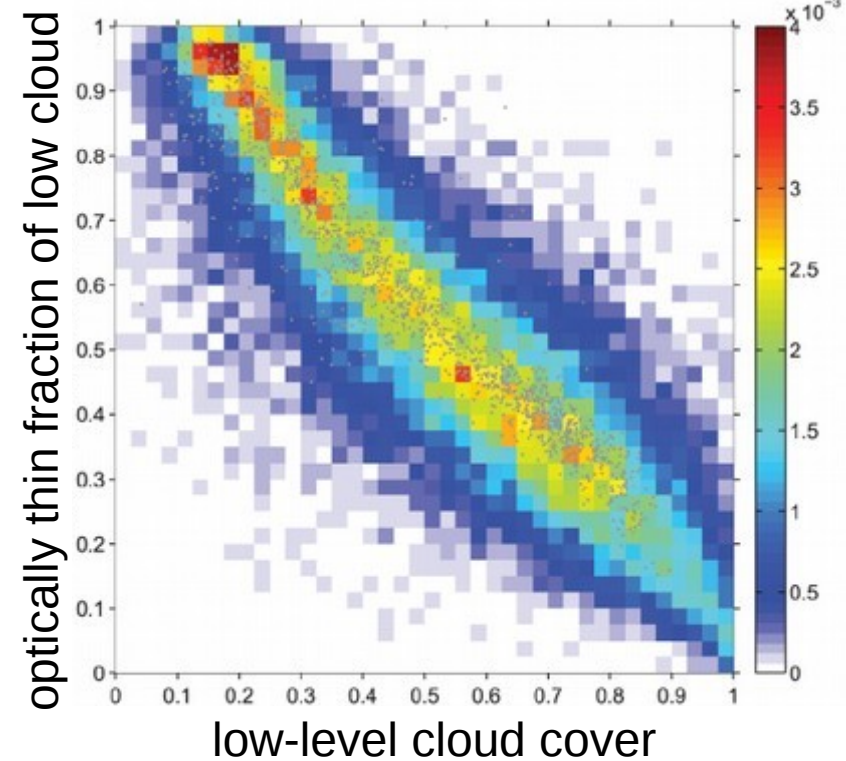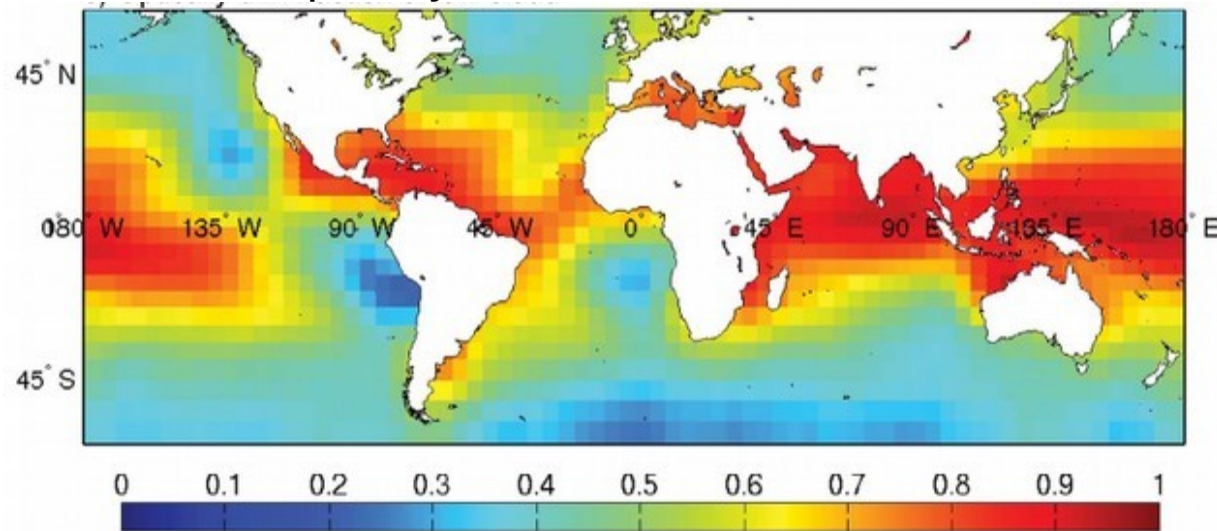*Institut Pierre Simon Laplace*

Importance of *optically thin low-level clouds* over oceans
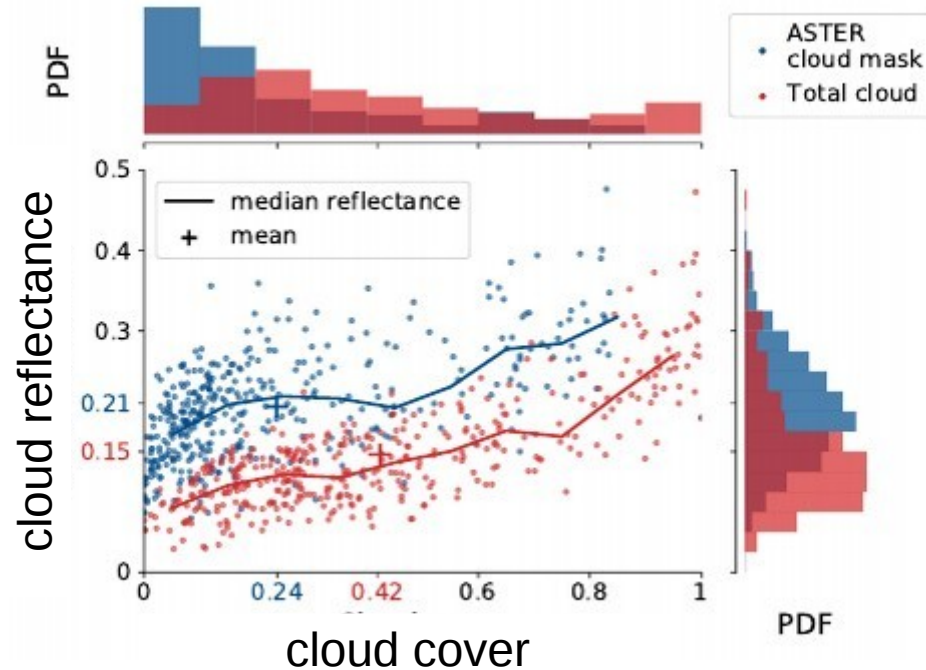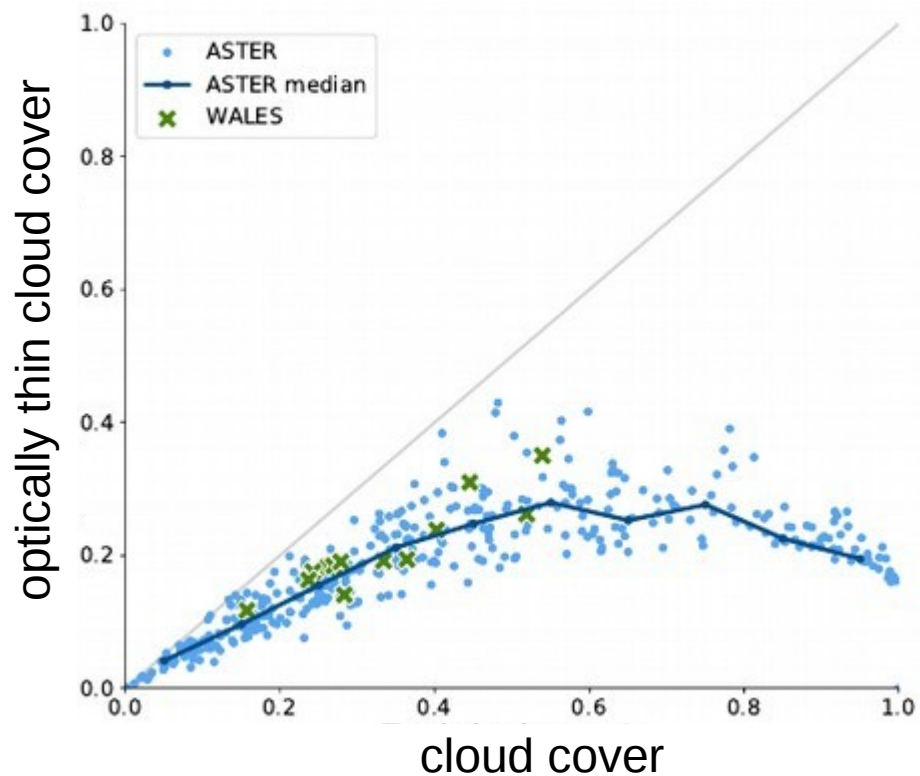
From Calipso night measurements

low-level cloud cover

optically thin fraction of low cloud

[Leahy et al., JGR, 2012]

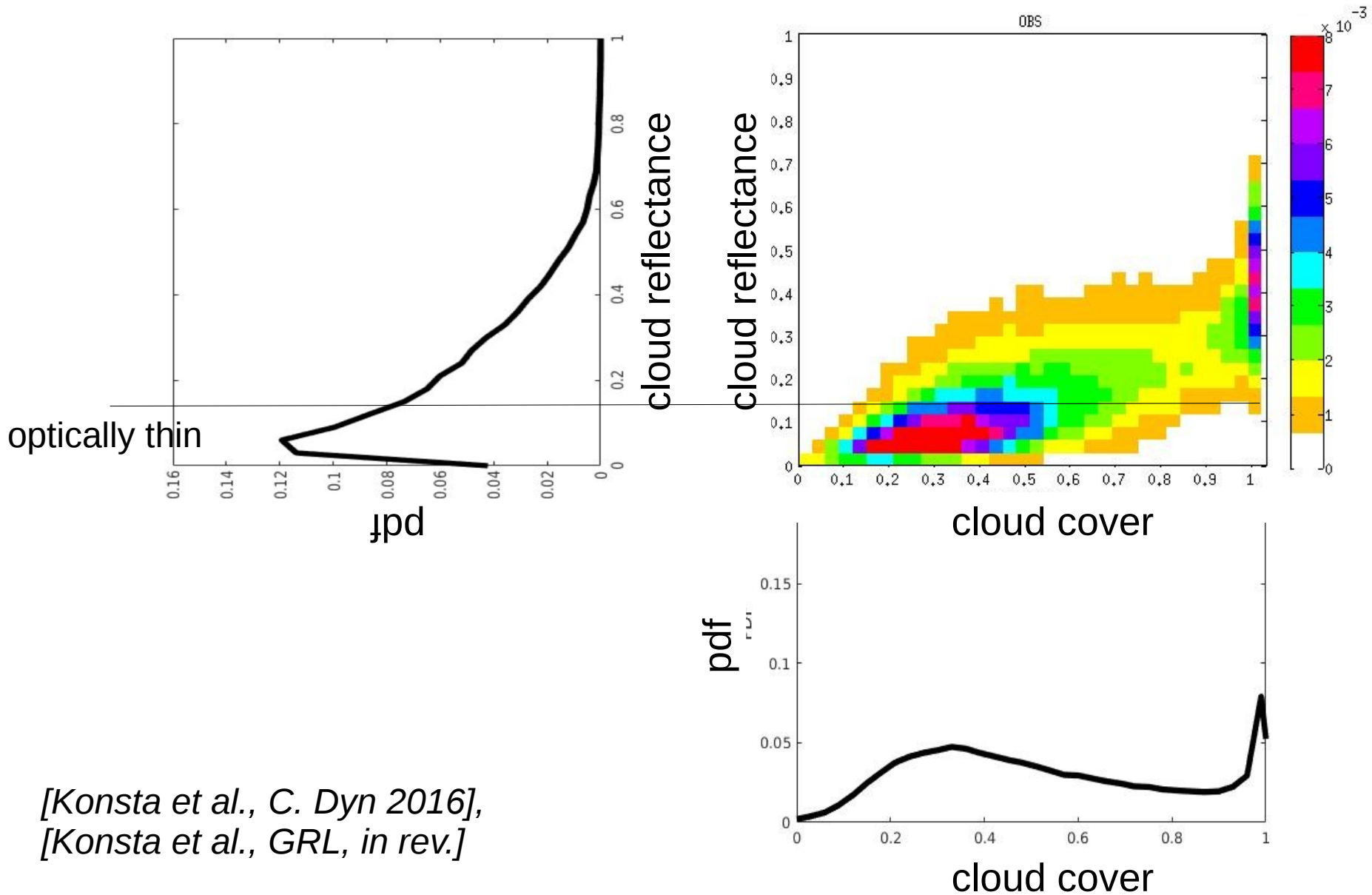# Importance of *optically thin low-level clouds* over oceans

trade cumulus cloud fields
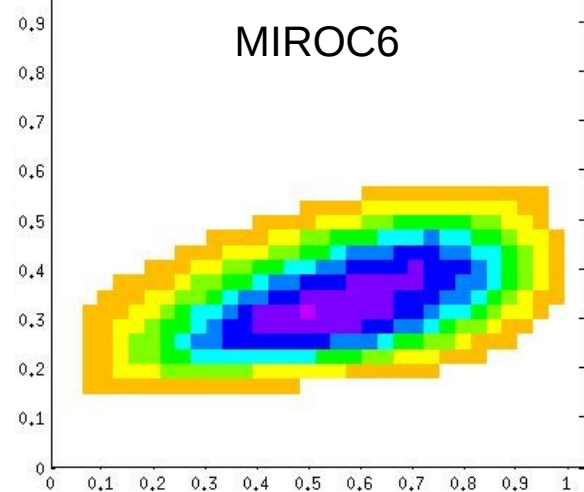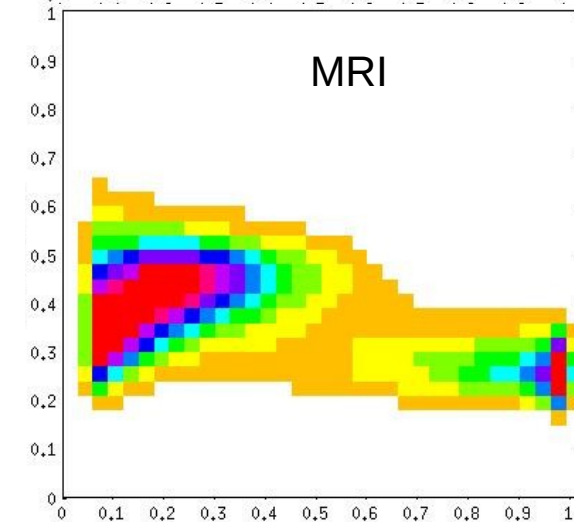
high-resolution ASTER satellite radiometer (& WALES lidar)
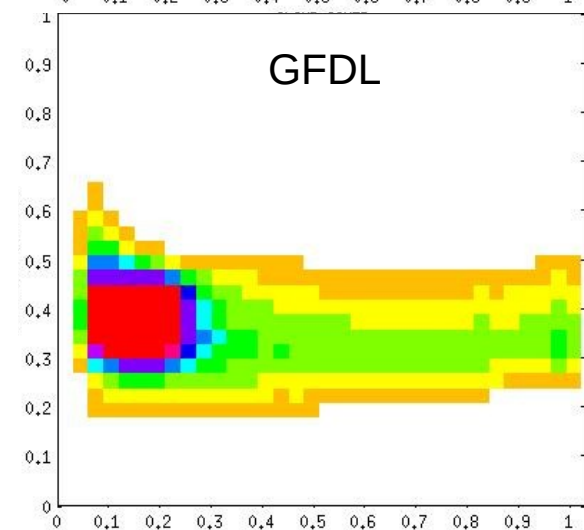

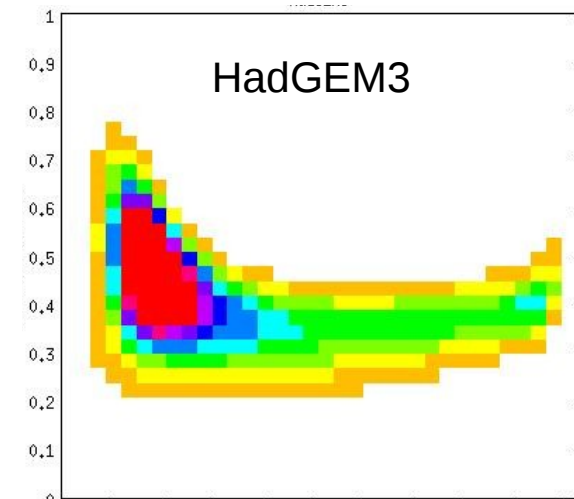*[Mieslinger, ACP, in review]*

Low-level clouds reflectance versus cover

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

optically thin

pdf

cloud reflectance

cloud reflectance

OBS

cloud cover

pdf

cloud cover

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

Observations

reflectance

cover

IPSL-CM6

CNRM

HadGEM3

GFDL

MRI

MIROC6

reflectance

cover

OBS	
IPSL	
CNRM	
HadGEM3	
MRI	
MIROC6	
GFDL	
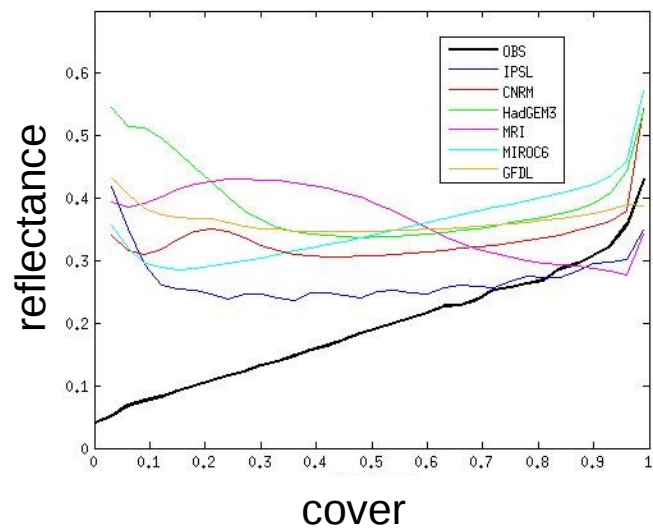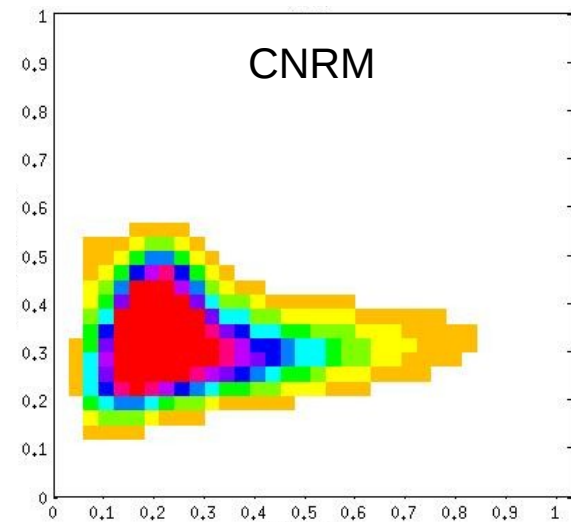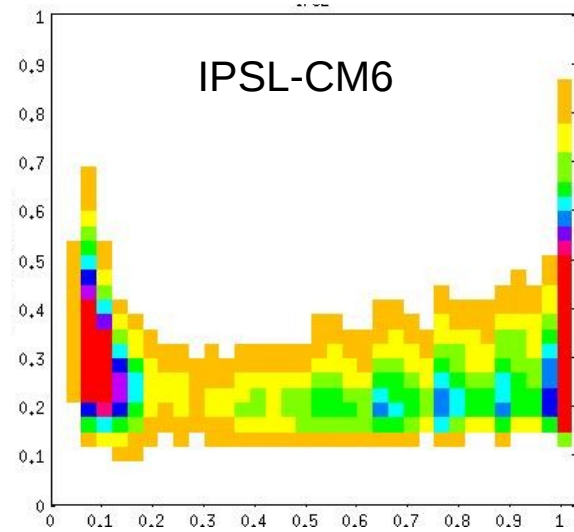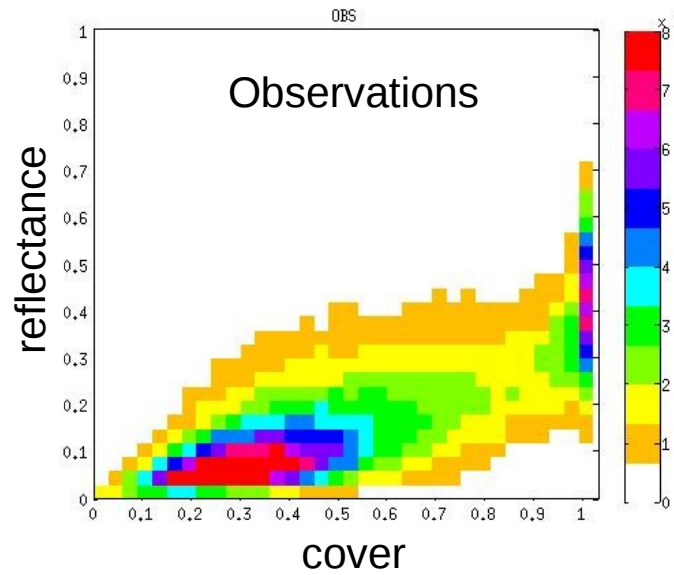
Sensitivity of low-level clouds to their environments

Low-level cloud cover increases with low troposphere stability (LTS) in both observations and models
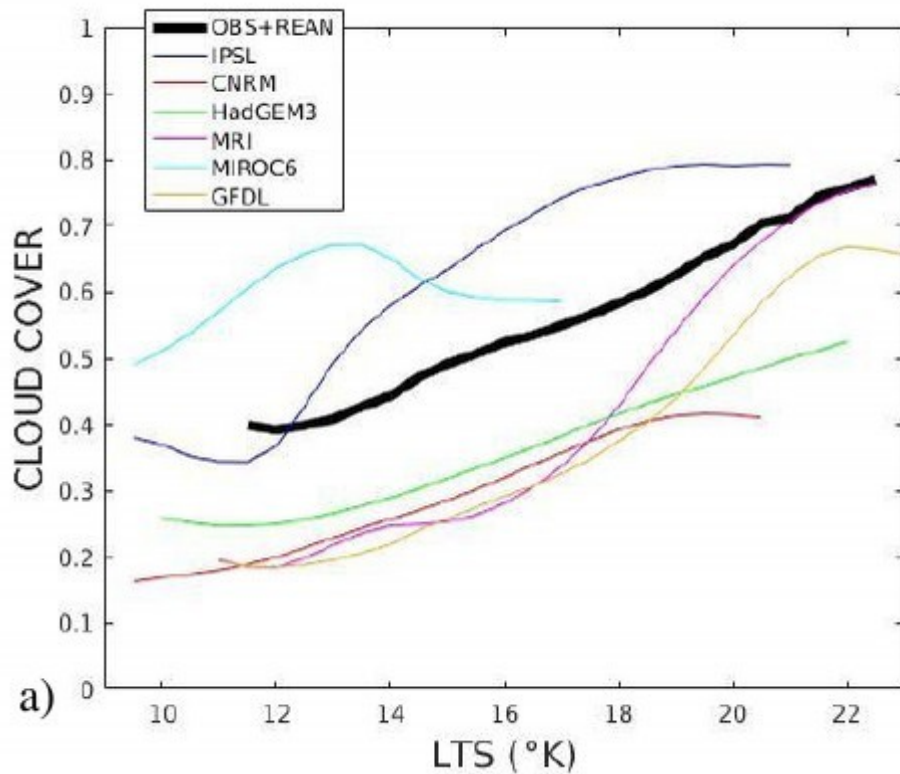
Low-level cloud reflectance increases with low troposphere stability (LTS) in observations but not in models
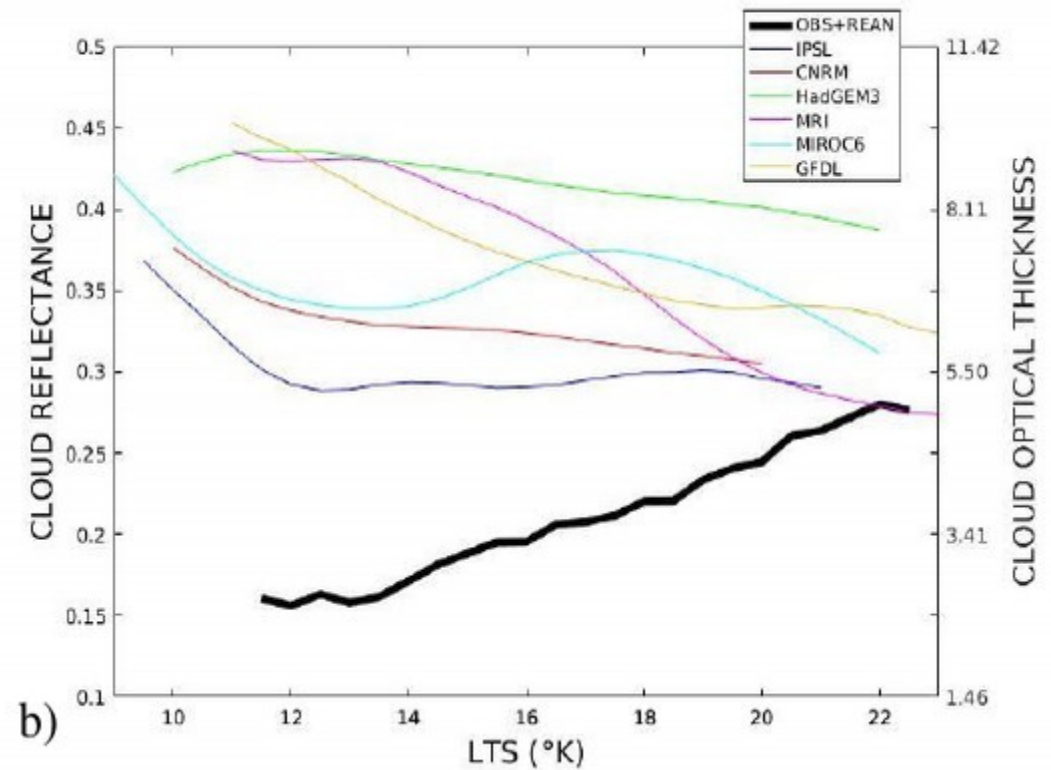
Current GCMs do not simulate optically thin clouds

Hypothesis:

- They do not simulate *thin veil clouds* beneath the trade inversion

- They do not simulate the *vertical heterogeneity* of cloud fraction

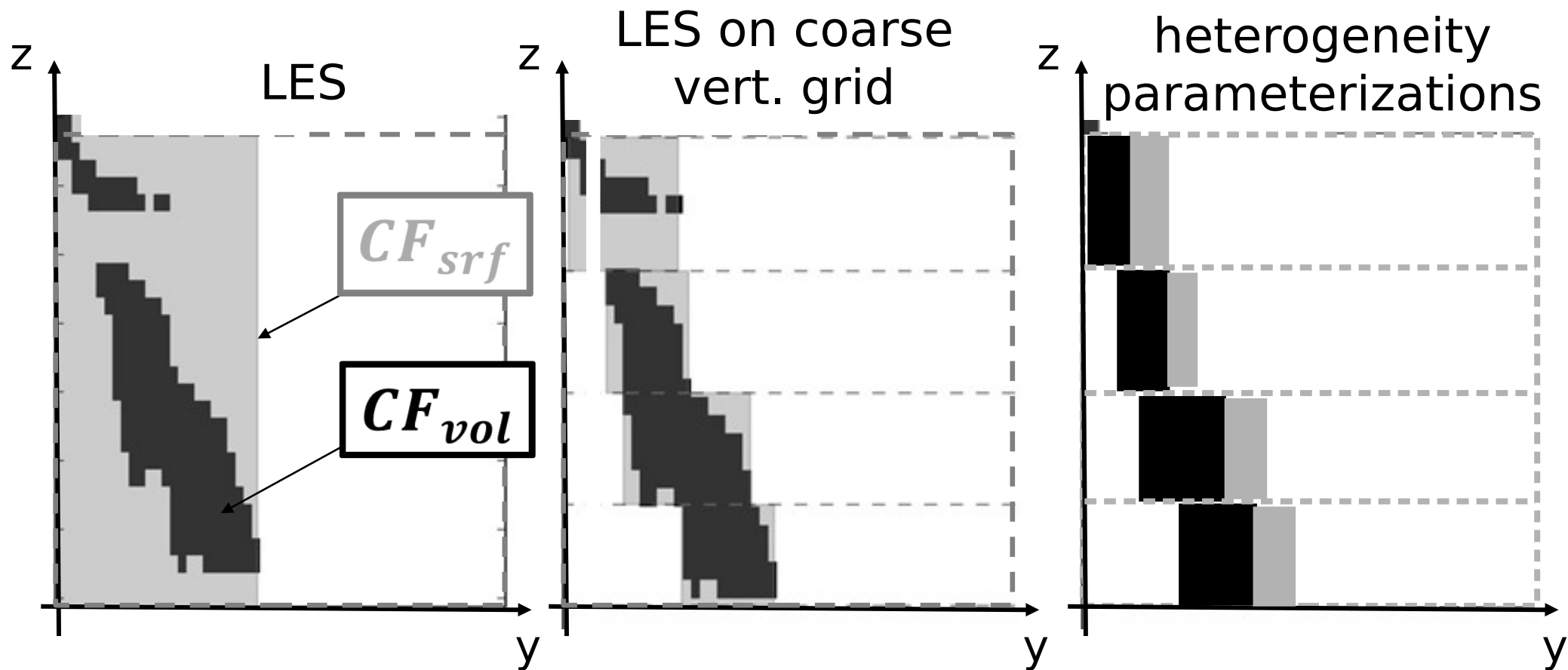# Clouds in models are too "compact"

z   LES

CF_{srf}

CF_{vol}

z   LES on coarse vert. grid

z   model with common parameterizations

y

y

y
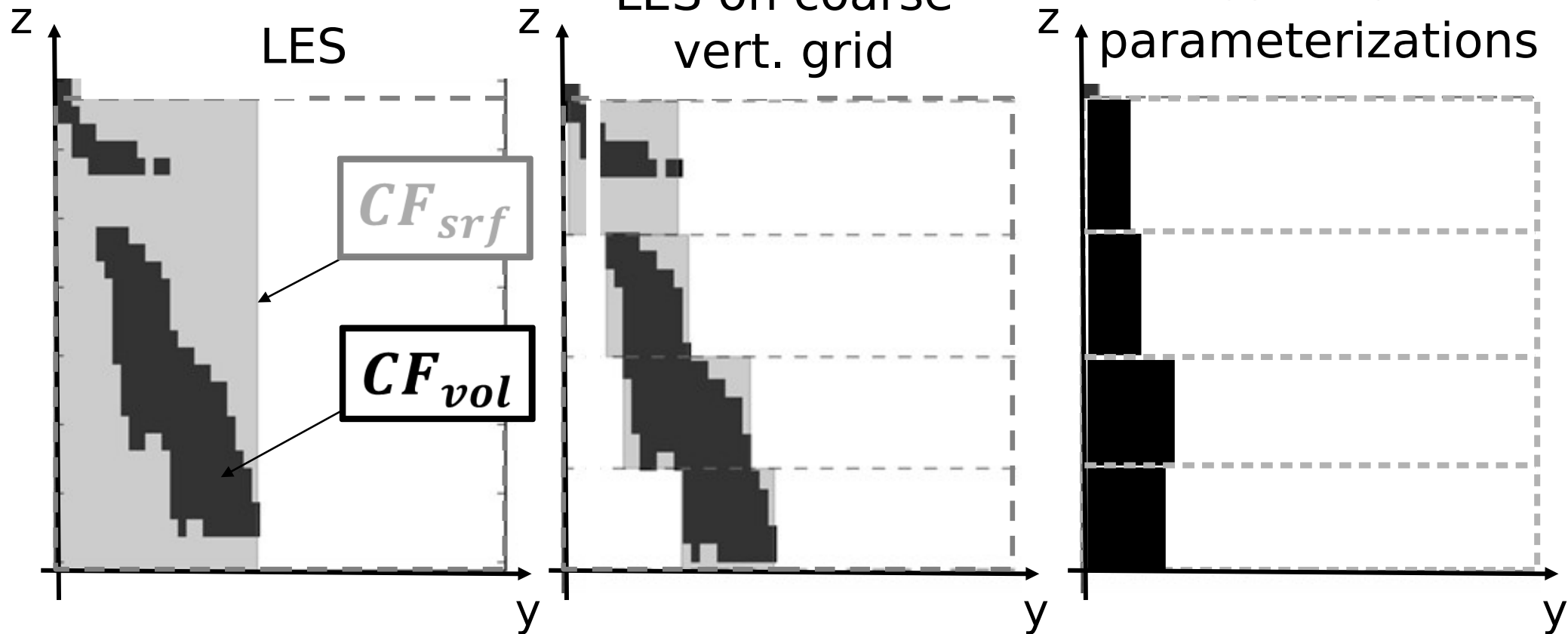
Parameterizations:

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

Clouds in models are too "compact"

CF_{srf}

CF_{vol}

LES

LES on coarse vert. grid

model with heterogeneity parameterizations

z

z

z

y

y

y

Parameterizations for:

- *Sub-grid variability:* differentiate between the surface fraction and the volume fraction
- *Cloud overlap:* partly random, not only maximum
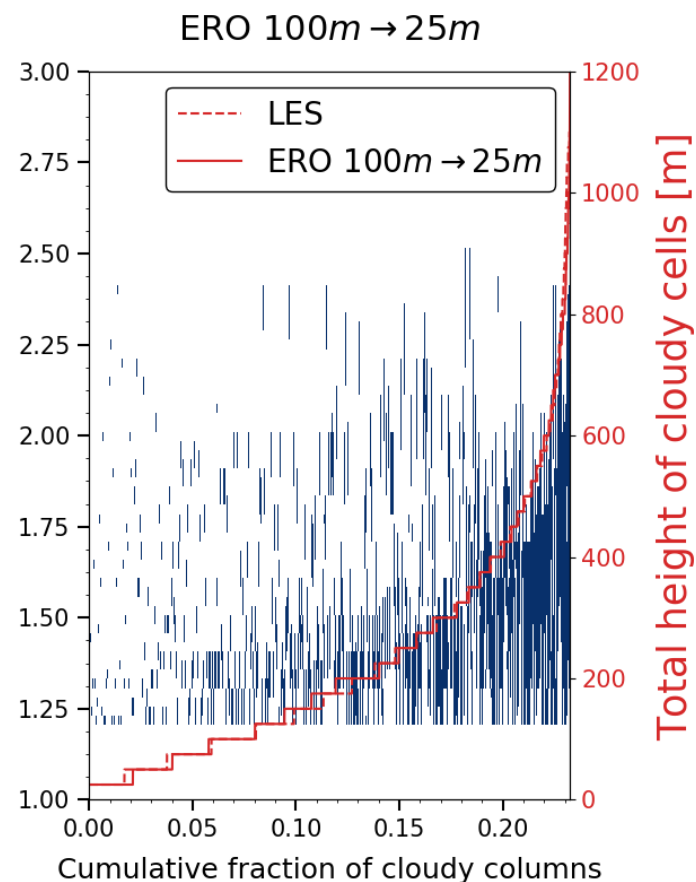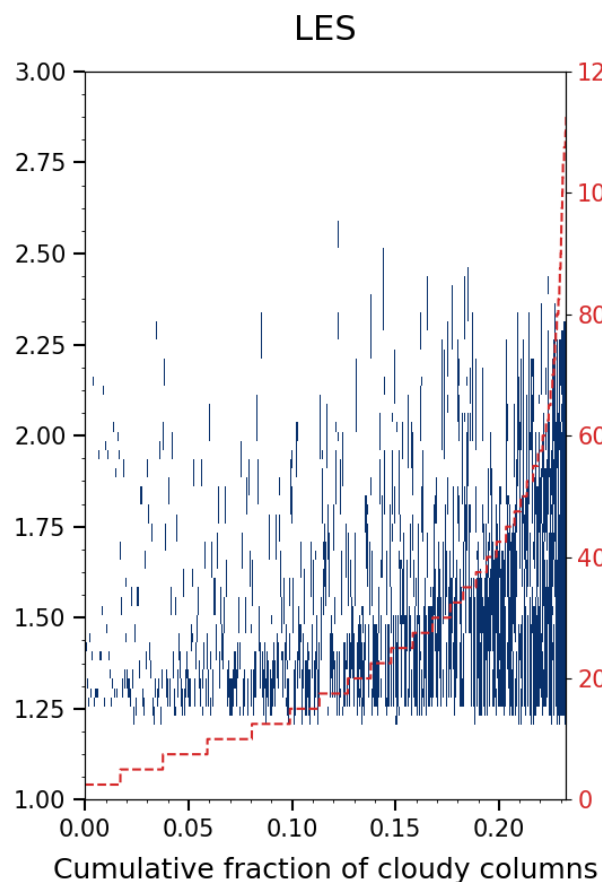
Impact of sub-grid heterogeneity and cloud overlap
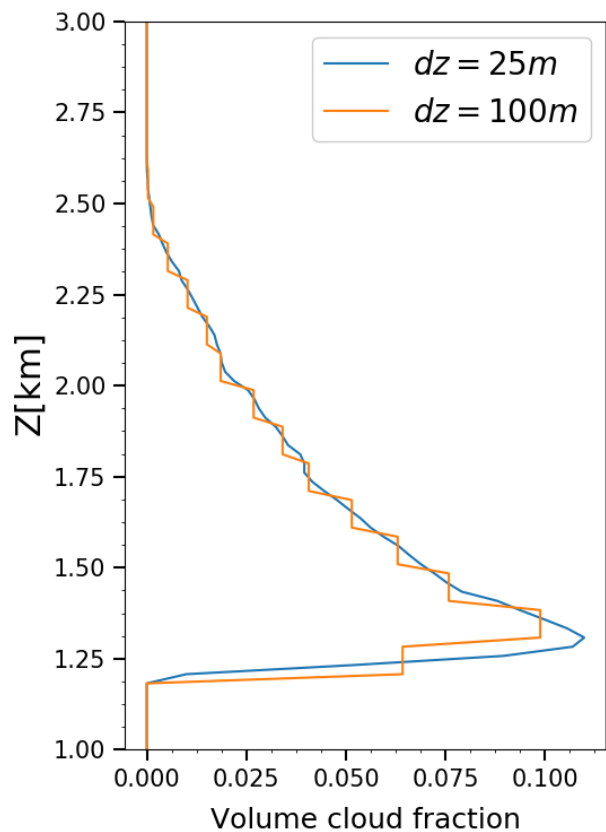
LES simulation with MESO-NH 6.4x6.4x4 km, dx=dy=dz=25m

ARM cumulus cloud case

Vertical distribution of clouds within the domain

Horizontally averaged

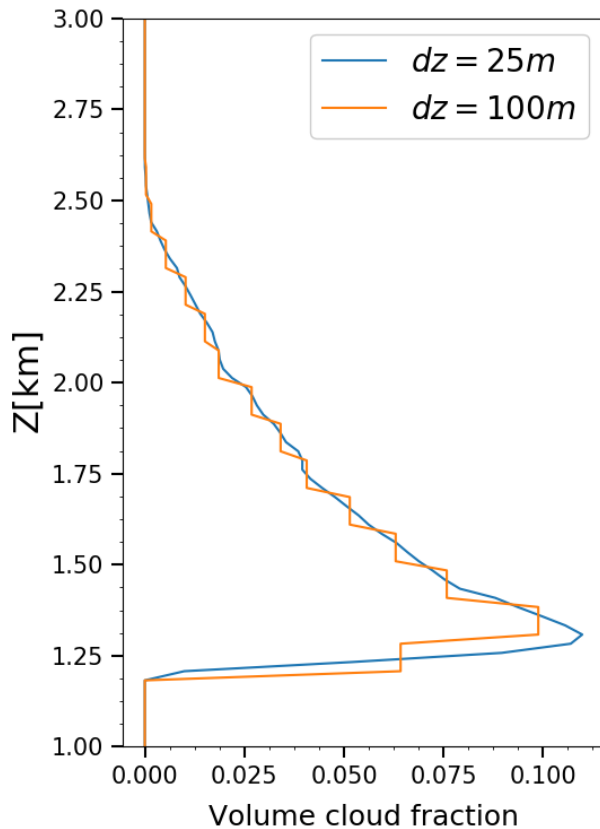Horizontal statistical distribution (sub-columns)

[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
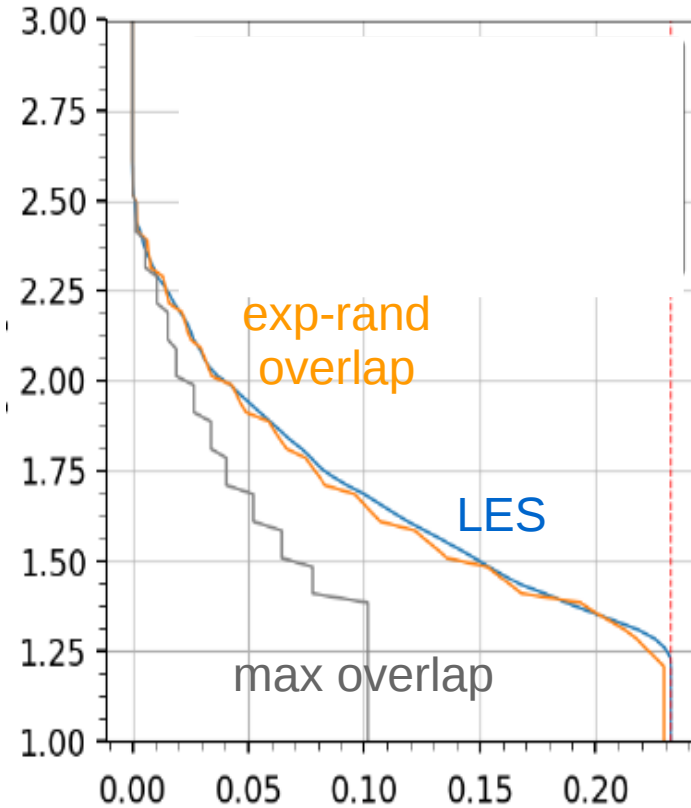
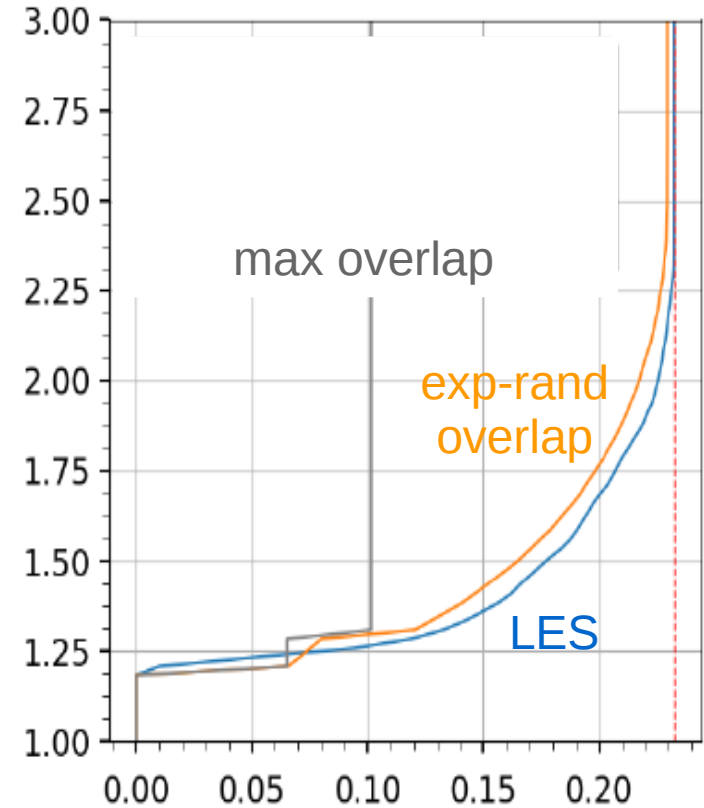## ARM cumulus cloud case

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

Earth Care will give new opportunities:
- better detection of 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)