Evaluation of low-level marine tropical clouds in CMIP6 models: the ‘too few too bright’ bias

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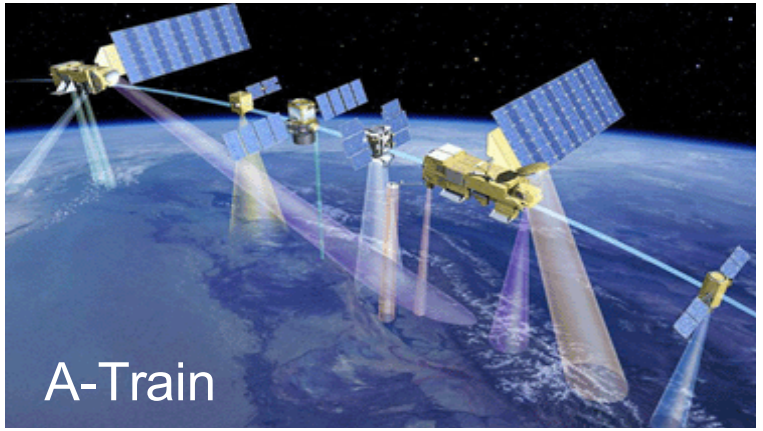
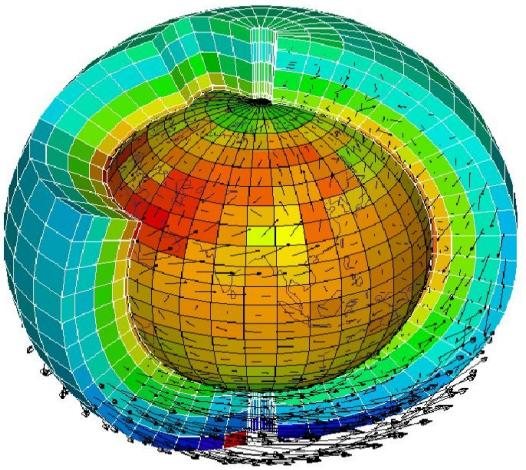
Clouds in Models, 14 April 2021

Method of evaluating clouds in climate models





Radiometer PARASOL
→ Cloud Optical Depth (cloud reflectance 6km, in 1 constant direction: θv=30°, φv=320°)

Lidar CALIPSO – GOCCP *[Chepfer et al., 2010]*
→ Cloud Fraction (330m), Cloud Vertical Distribution (30m)

CMIP6 models :
- IPSL-CM6A
- CNRM-CM6
- HadGEM3
- MRI
- MIROC6
- GFDL

+ COSP simulator

Objective
→ is the too few too bright bias still present in CMIP6 models ?
→ is there a common origin of this bias?

Method of evaluating clouds in climate models

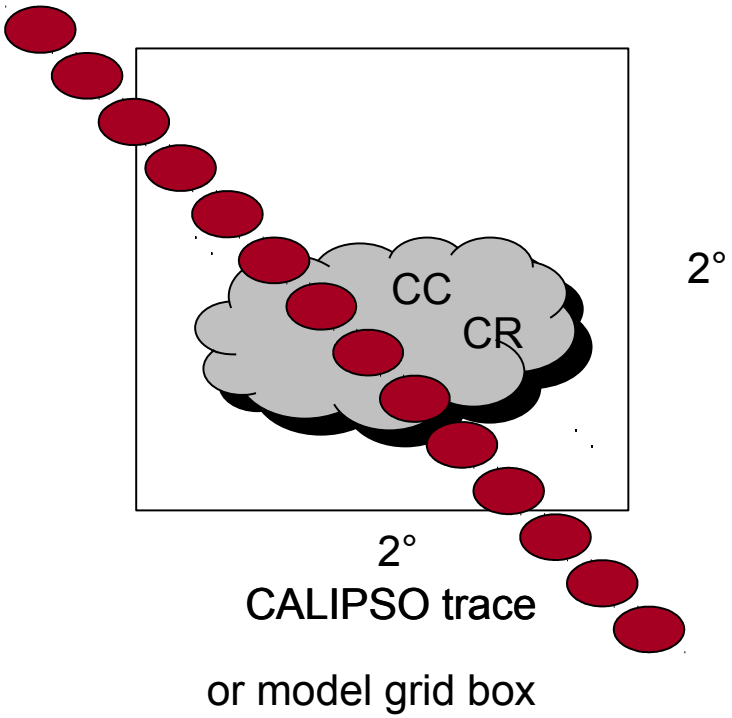
Variables under study
Cloud Cover and Cloud Reflectance (a proxy of Cloud Albedo)

Region of study
Tropical Oceans (30 °S – 30 ° N)

Situations of dominant low-level clouds
Criterion : CClow > 0.9 * CC

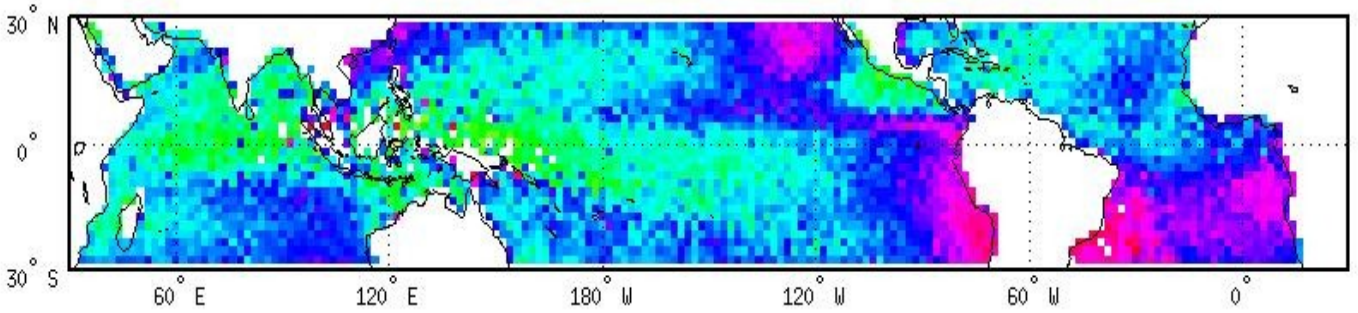
Temporal resolution
Daily (the highest possible giving a view of models' parameterization)

4 years climatology (2007 – 2010)

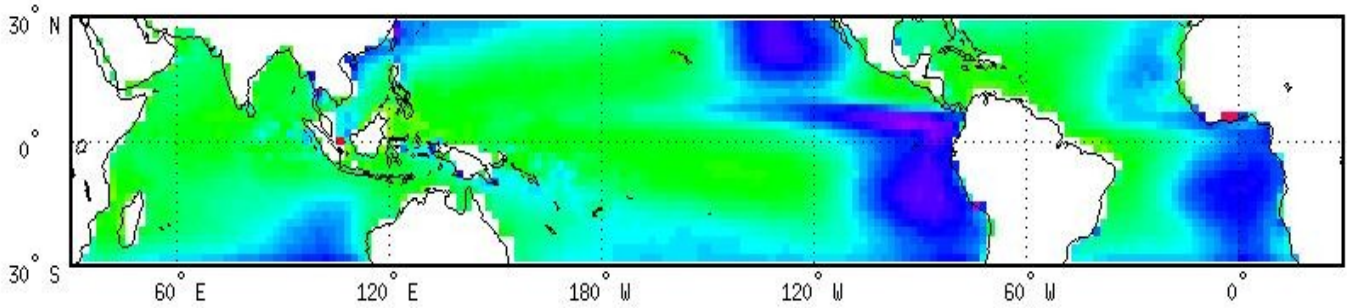


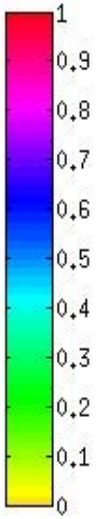
Cloud Cover

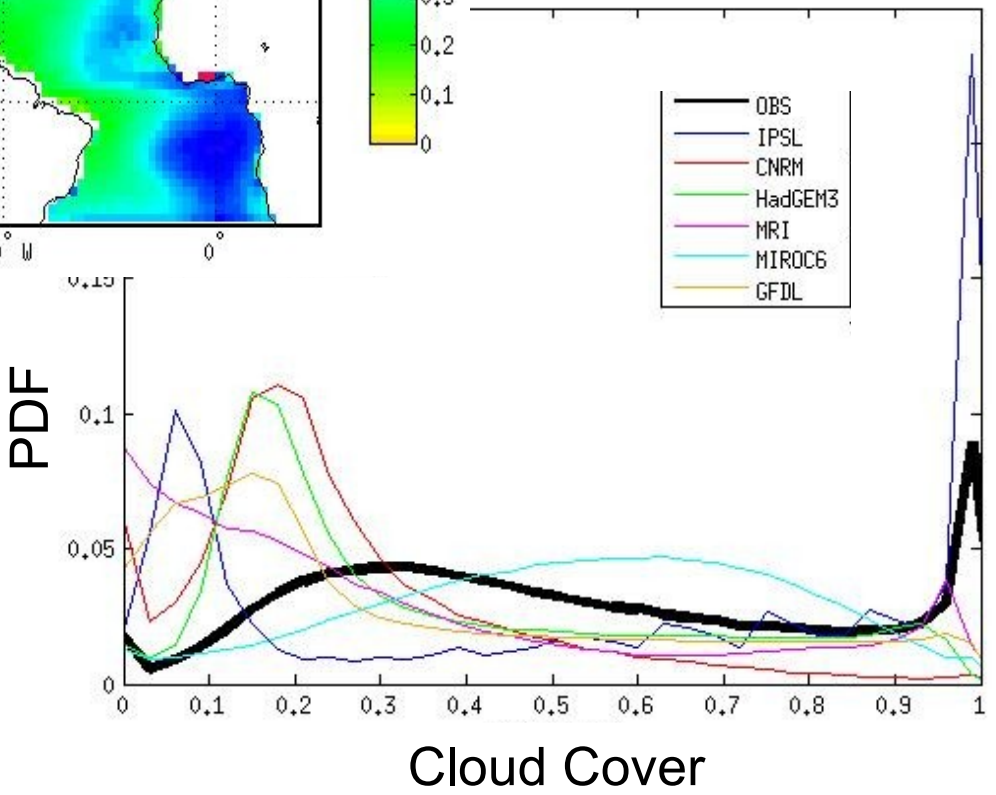
GOCCP observations



6 CMIP6 model mean



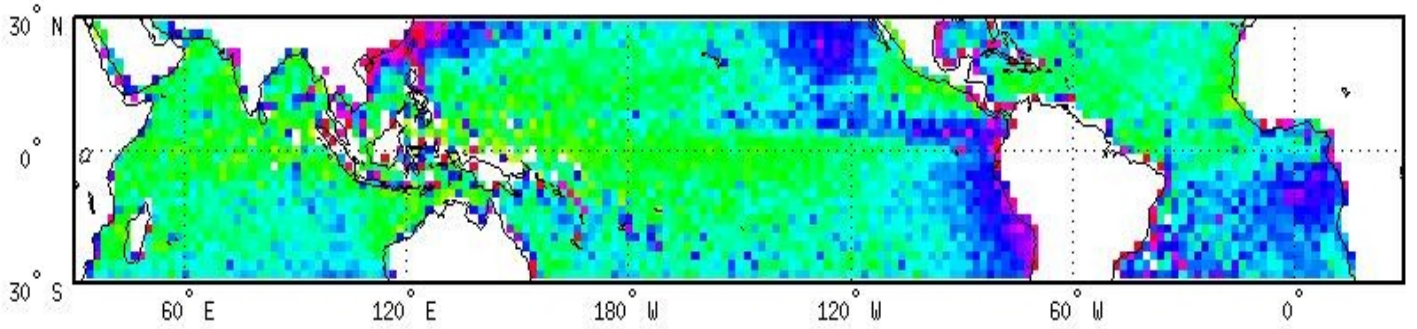


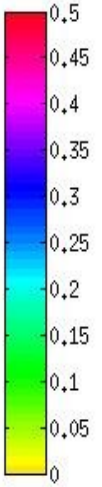


→ Difficulty of models to simulate low-level clouds with high CC

Cloud Reflectance

PARASOL observations





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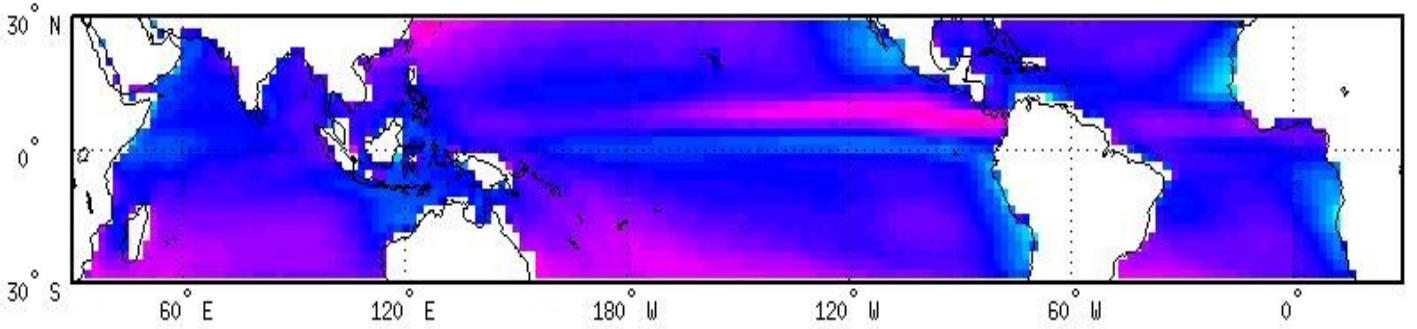
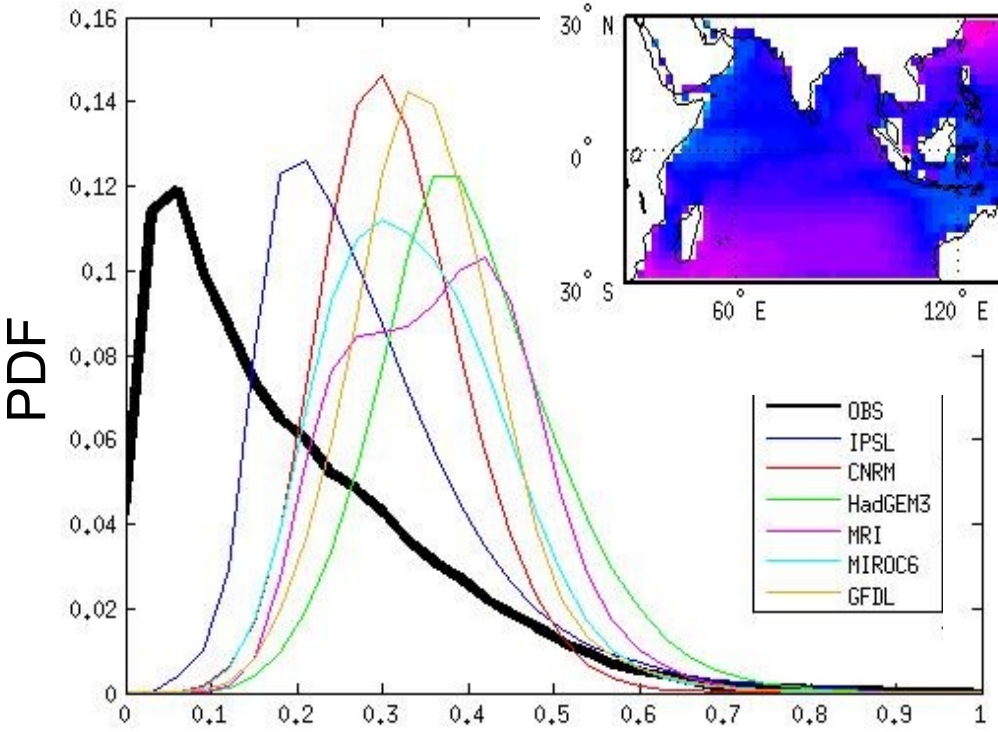
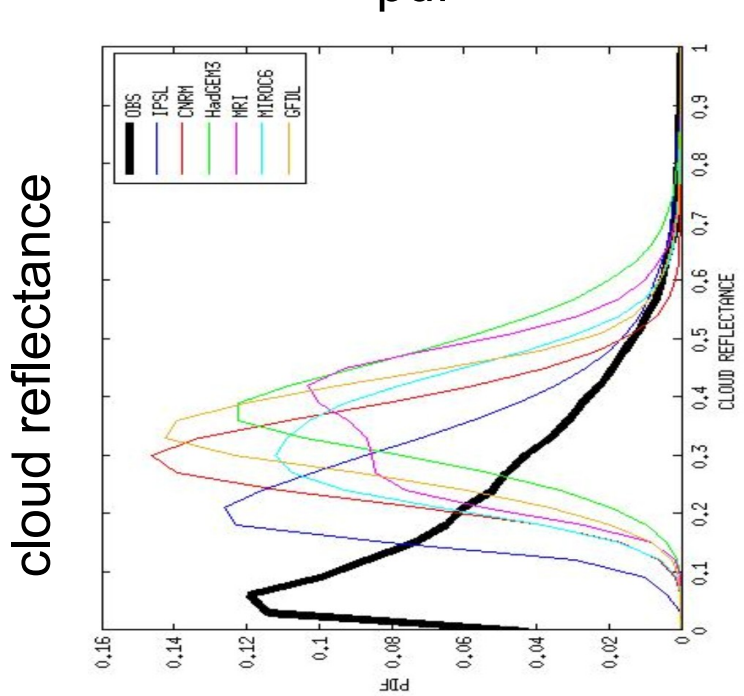


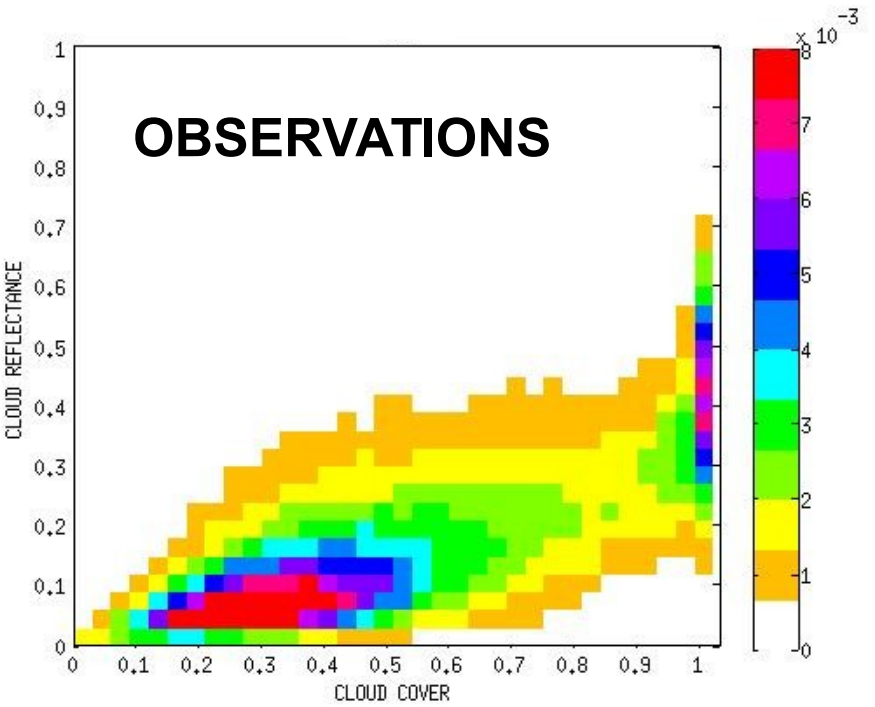


→ Mean CR
~ 0.15 for obs
~ 0.35 for models

Relation between Cloud Cover and Cloud Reflectance

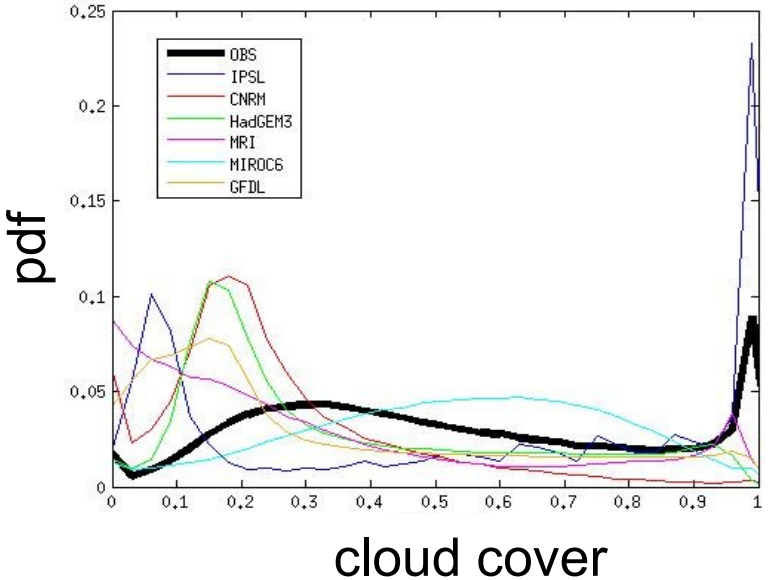
pdf



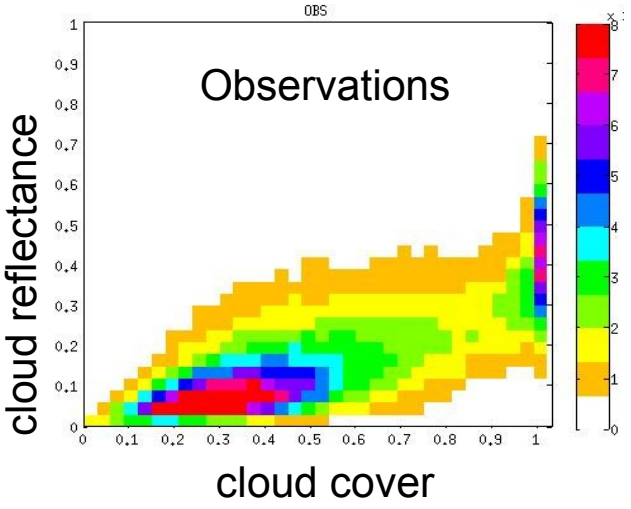


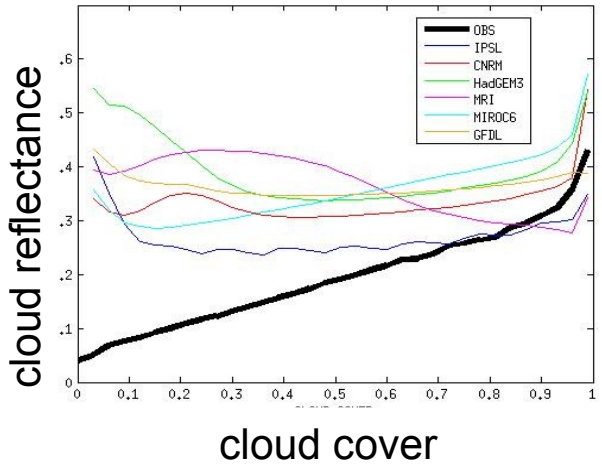
→ two cloud populations : cumulus type and stratocumulus type clouds

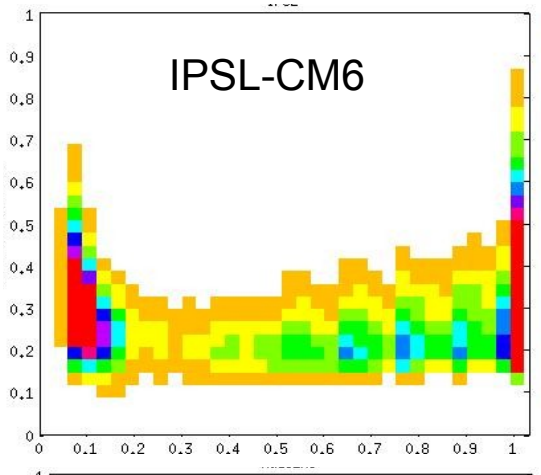
→ cloud reflectance increases with increasing cloud cover

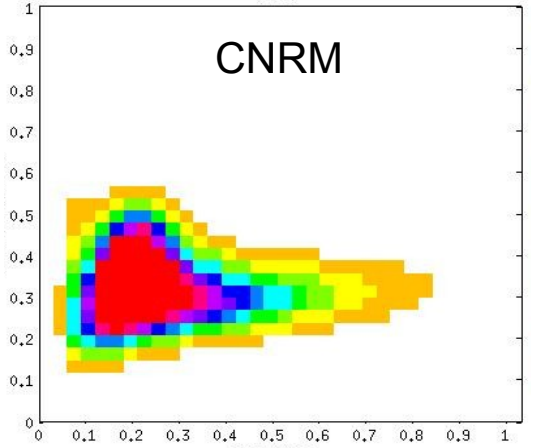


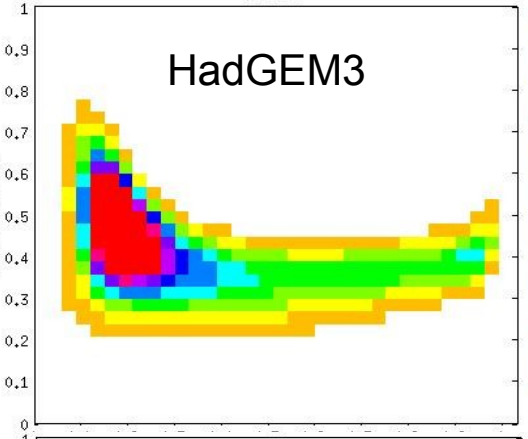
Relation between Cloud Cover and Cloud Reflectance

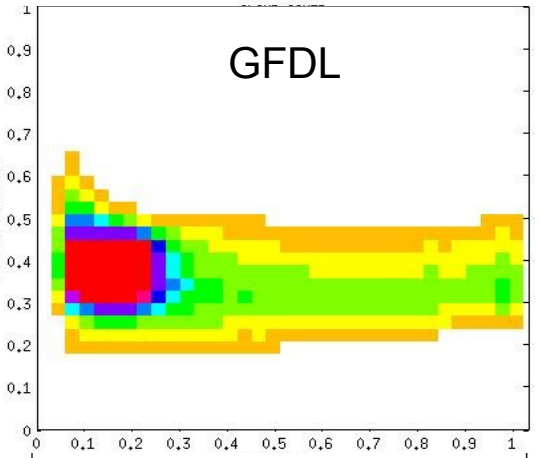


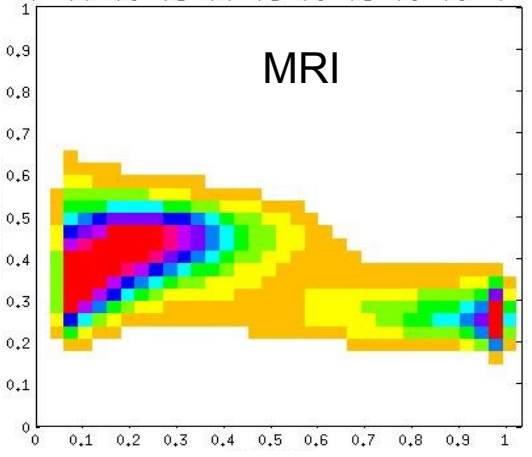


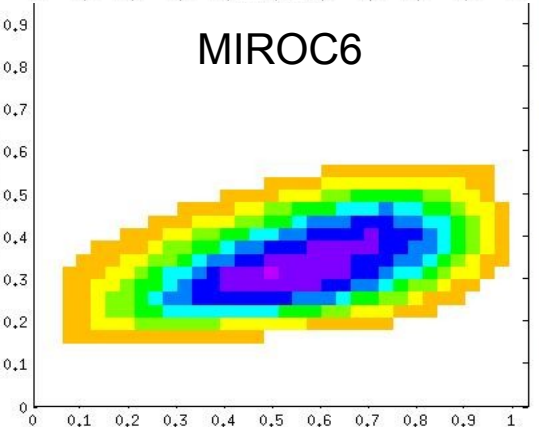




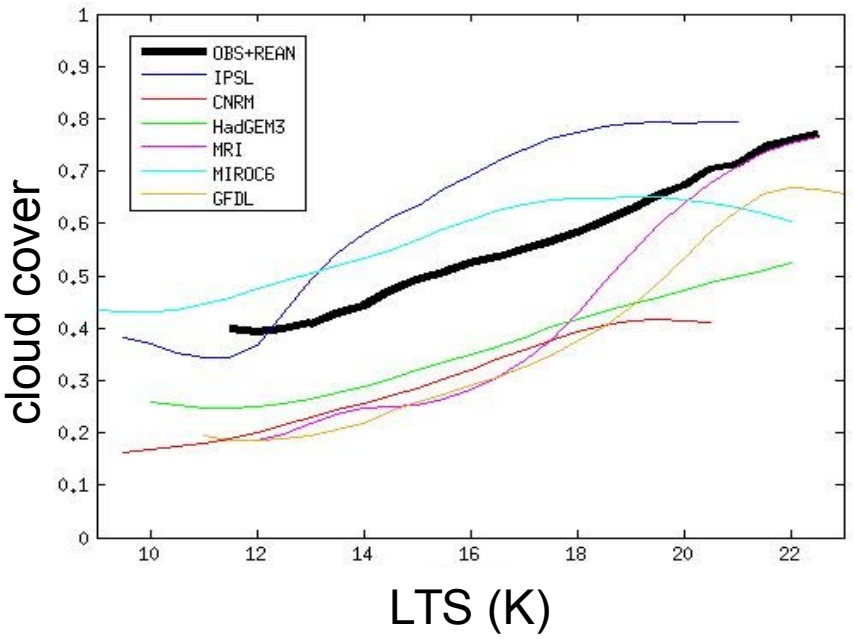


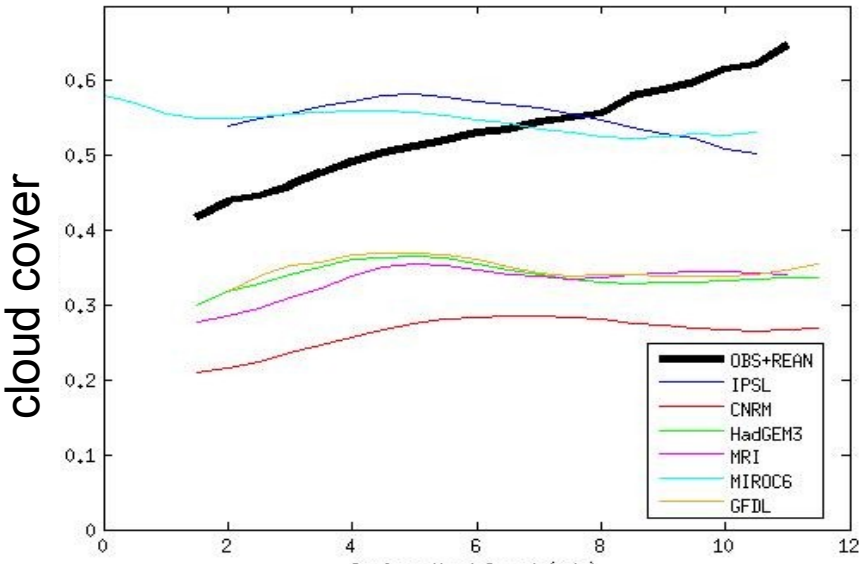


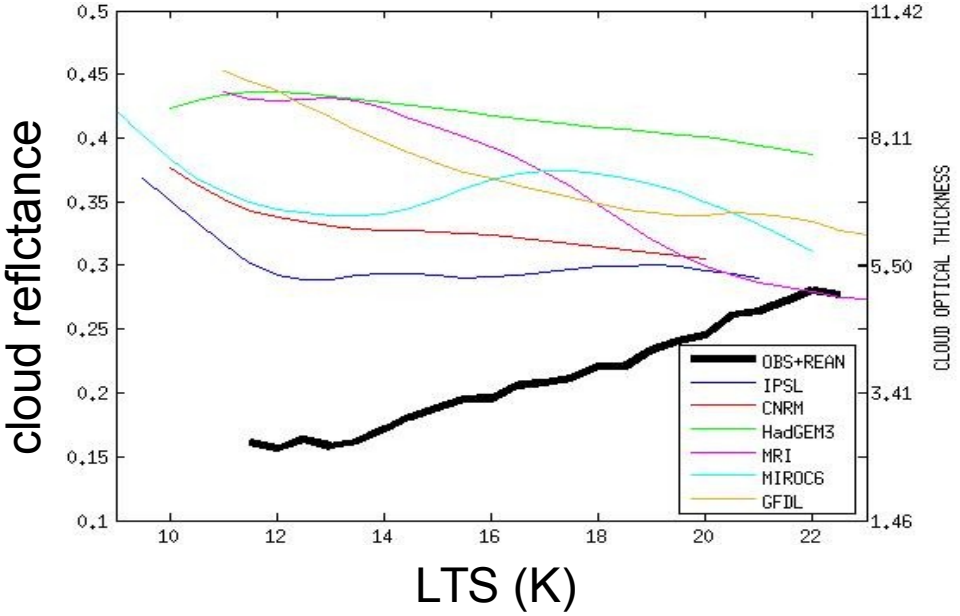




Variation with the environement





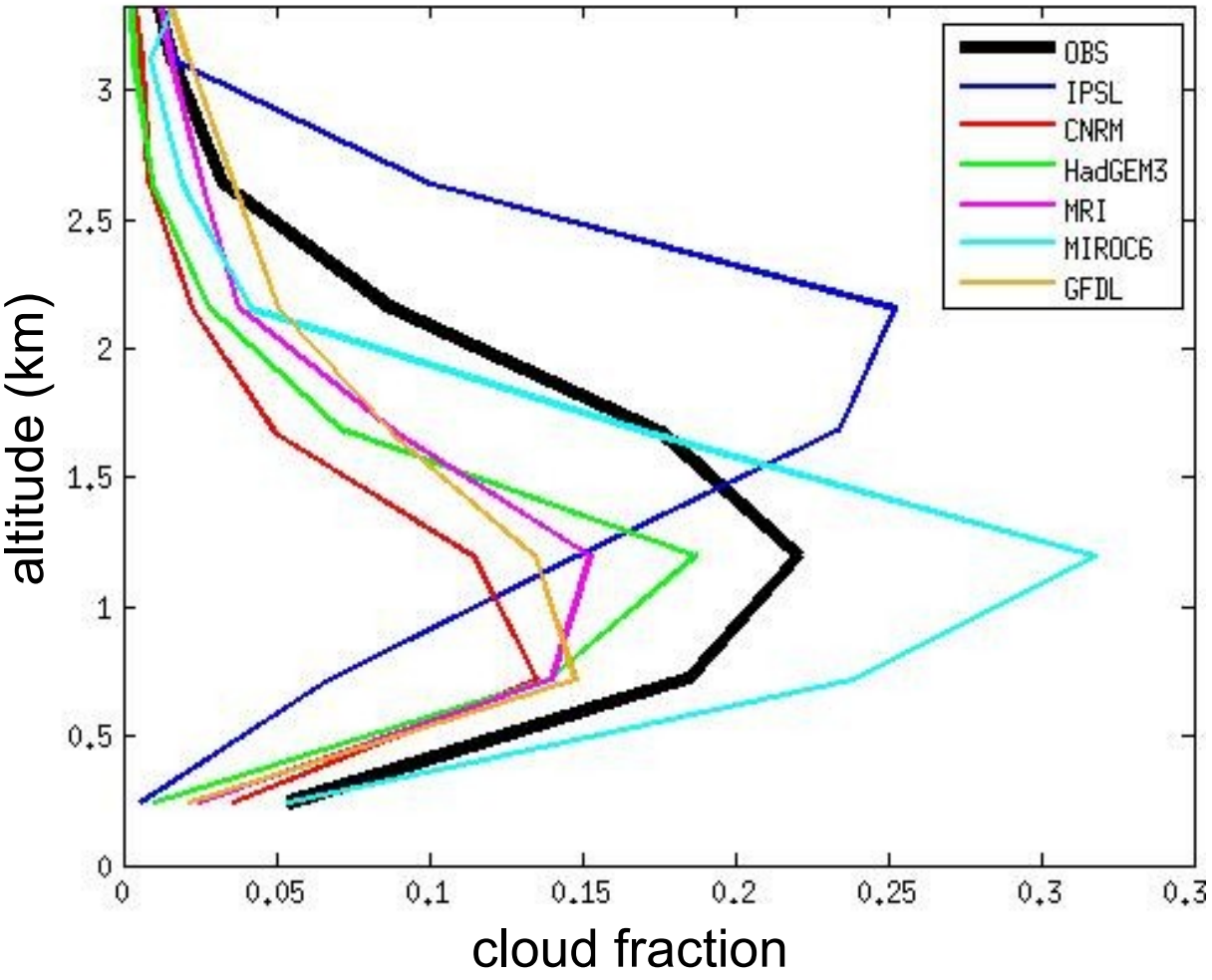


→ CC increases when LTS increases in models and obs

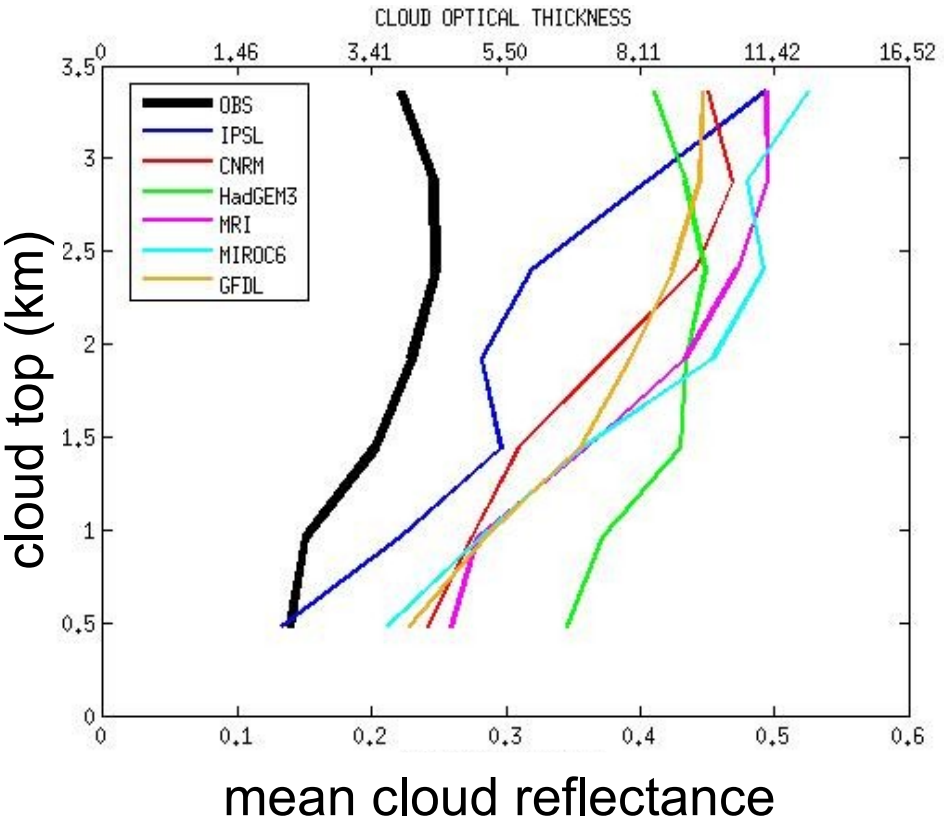
→ obs show that CR increases with LTS opposite to the simulations

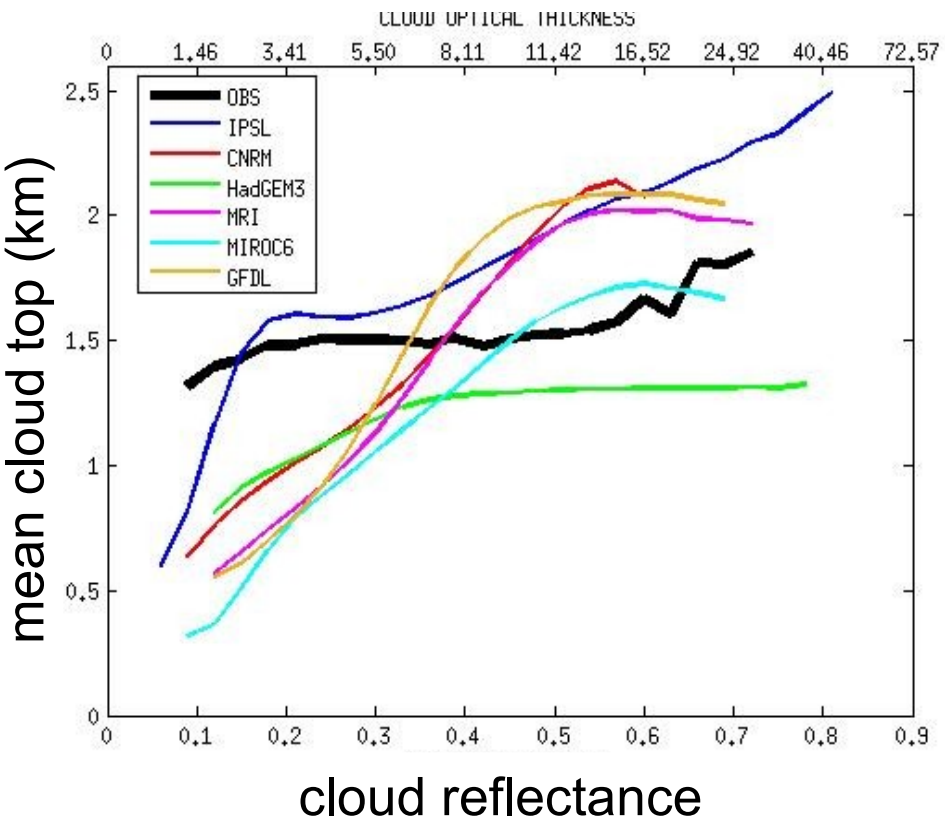
→ obs show increase of CC with surface wind speed, no dependence for the models

Vertical structure



Variation with Cloud Top Height





→ CR increases as clouds rise (greater increase simulated + bias of CR)

→ Models show a much stronger dependence of the CR on cloud geometric thickness

Conclusion

→ **The too few and too bright bias still present in CMIP6 models for low level clouds**

Biases in the simulation of cloud properties :

- **Strato-cumulus clouds on the eastern coast of the oceans are absent or underestimated in many models**

- **CR decreases with CC in obs, models show inverse or no dependence**

- **CR increases with LTS in obs but not in models**

- **CTH is too low for optically thin clouds and increases with CR much faster in models than in obs**

→ **Can we infer some common origin of this bias among the different climate models?**

Hypotheses :

- **models simulate too often small cumulus clouds (low CC and high CR) and lack of a variety of low-level cloud types**

- **lack of taking into account the sub-grid heterogeneity of cloud properties in the models**


Thank you !