Analysis of CGILS results for LMD/IPSL model

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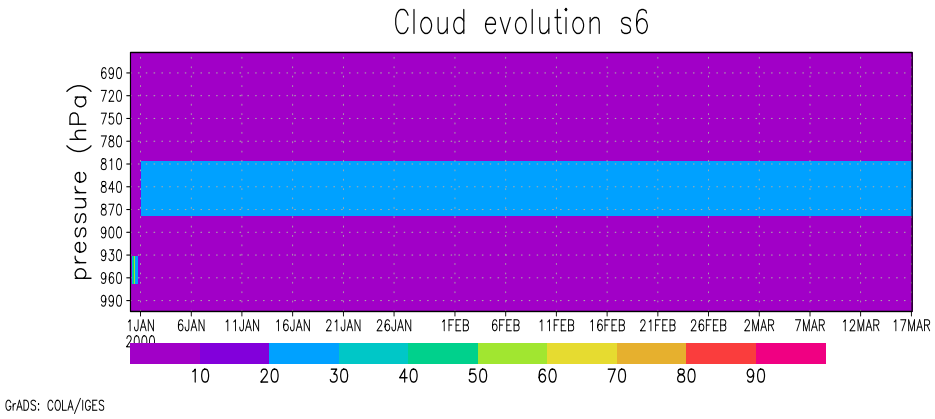
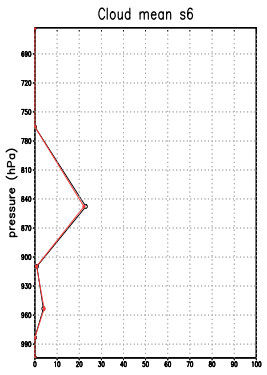
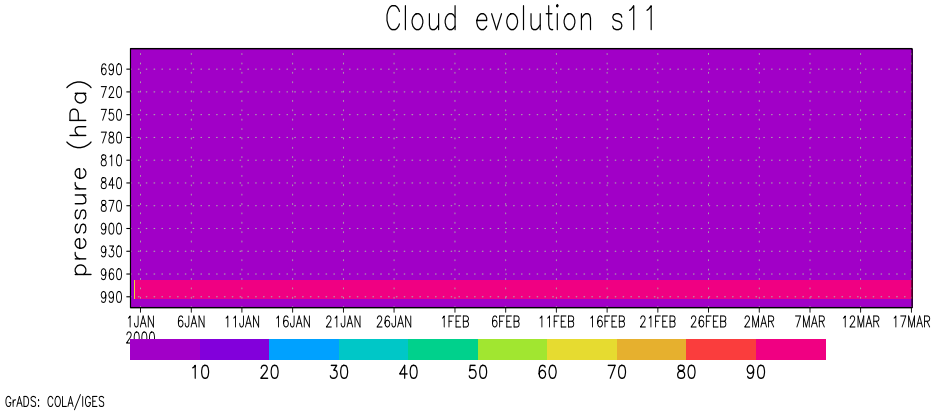
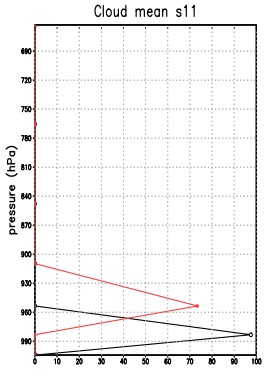
September,30th 2010

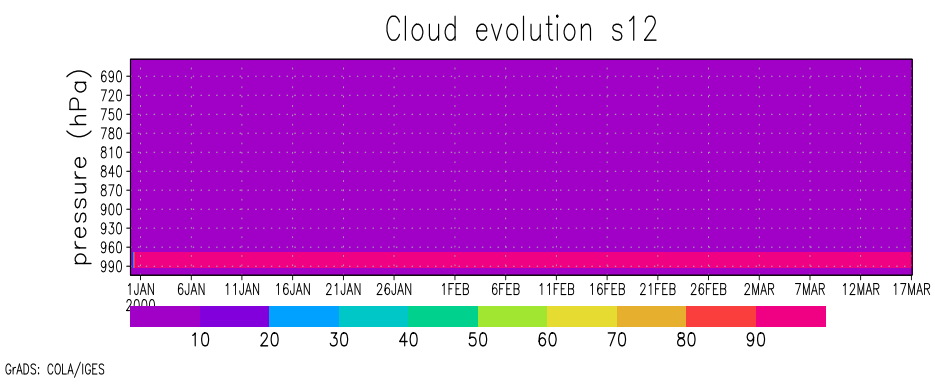
LMD/IPSL model : CGILS results L19

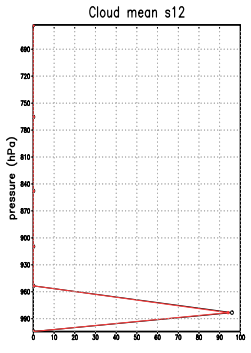






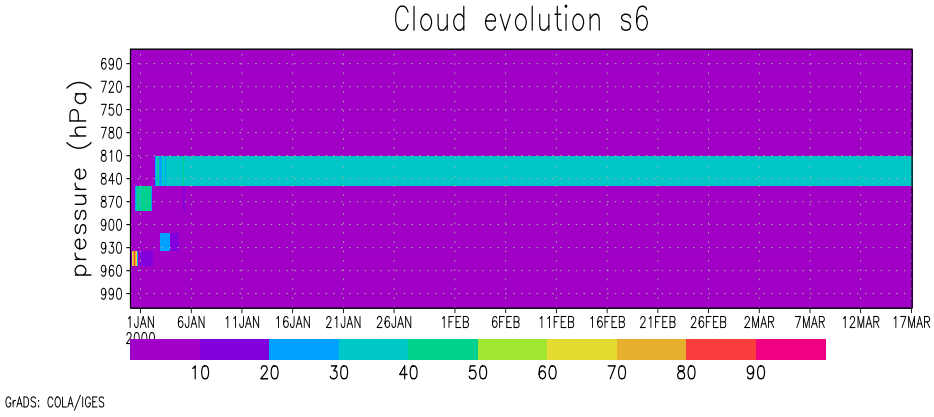


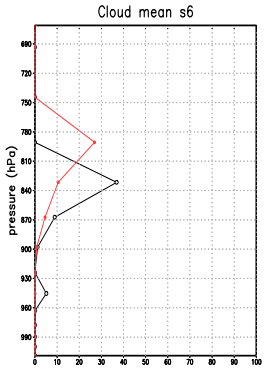


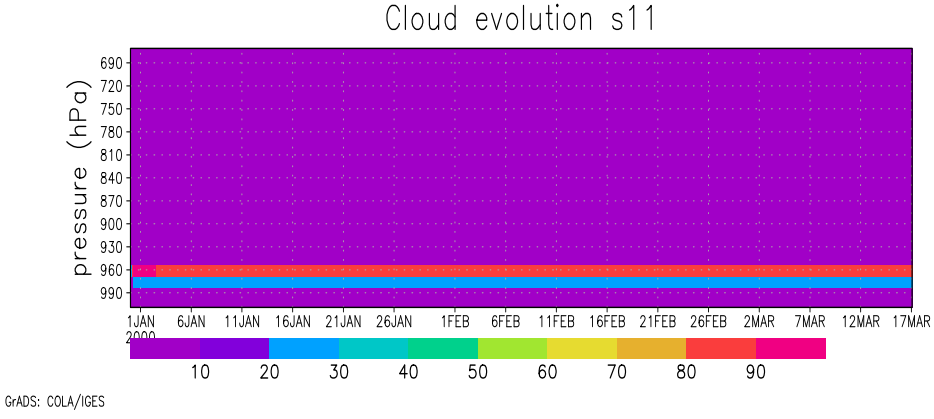


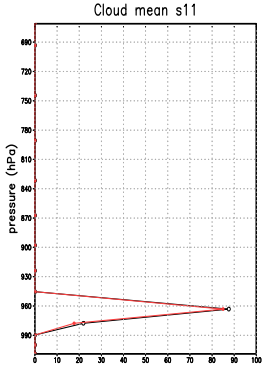
- 19 layers - Using AR4 physics
- s6 : 2 cloud layers : 950 hPa (5%) and 750 hPa (25%). No reaction for +2K case ($\neq$ old CGILS results)
- s11 an s12 : cloudiness sup 90% - Lesser and higher cloud for s11 for +2K

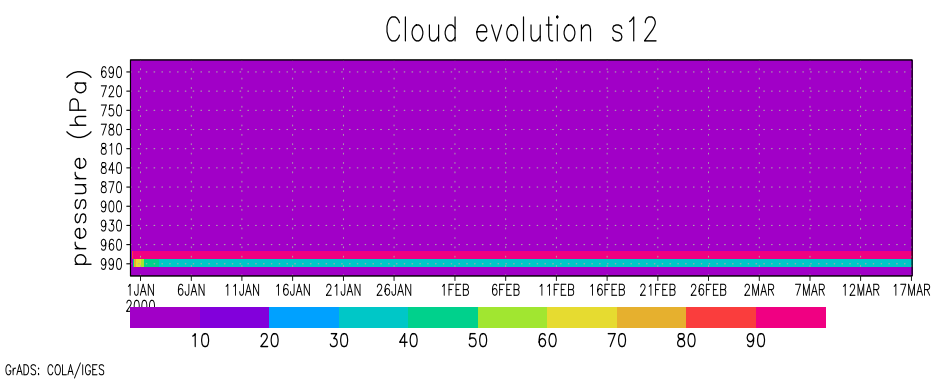
LMD/IPSL model : CGILS results L39

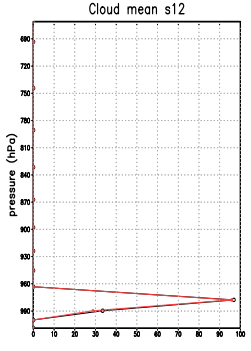








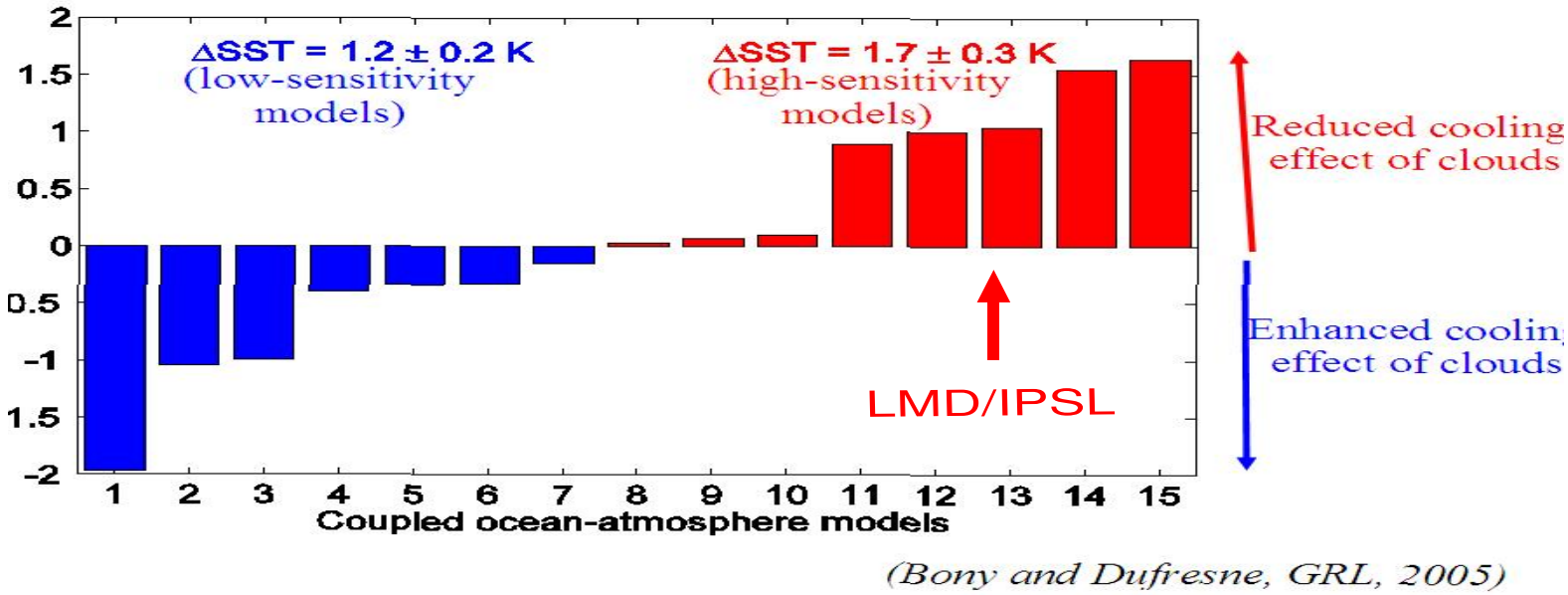




- 39 layers - Future CMIP5 resolution + AR4 physics
- s6 : Vertical developement of s6 case with less cloud (similar to LES cases)
- s11 and s12 : cloudiness sup 90% - no reaction for +2K exp
- Main difference 1st and 2nd forcing + Difference L19/L39

What about 3D-LMD/IPSL model ?

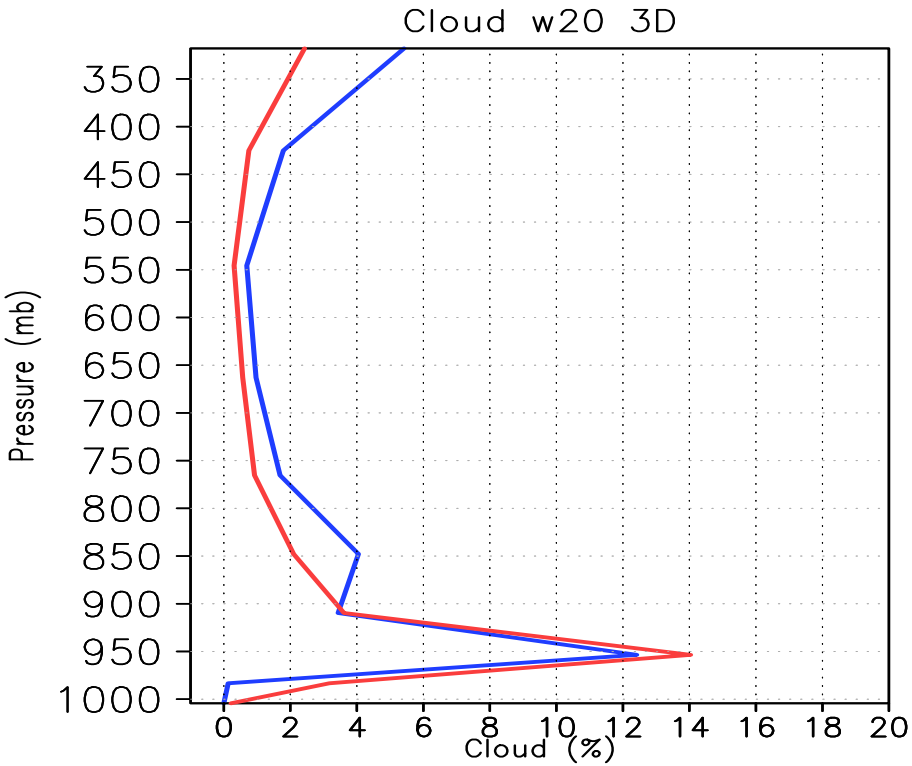
LMD/IPSL model : 3D sensitivity

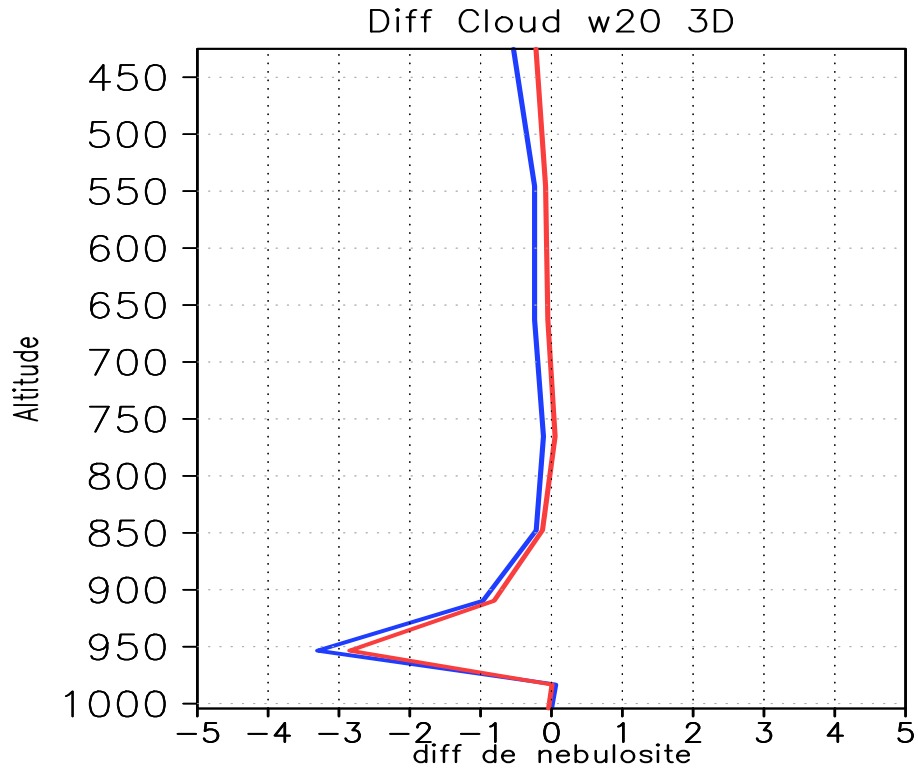


(Bony and Dufresne, GRL, 2005)

- LMD/IPSL model has a strong radiative response for tropical clouds (+ 1.0 W/m^2).
- **This feedback primarely results from the PBL cloud response in areas of weak subsidence (ω_{500} = 20 hPa/d)**
- How cloud profil looks like in this regime ?

LMD/IPSL model : 3D analysis

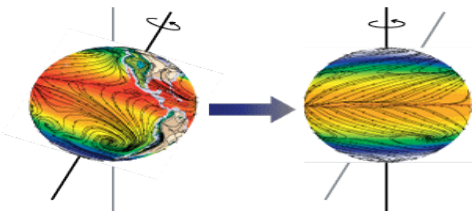


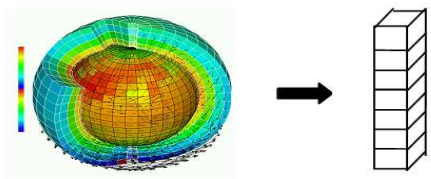


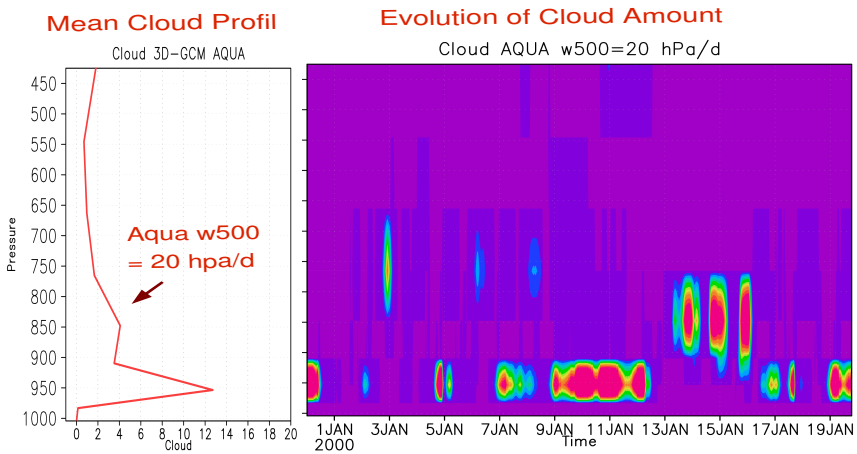
- LMD/IPSL Earth-like and Aquaplanet cloud profil for ω_{500}=20hpa/day.
- Maximum Cloud fraction and response in 950hPa. Same behaviour AQUA and Earth ($\rightarrow$ Explain tropical feedback)
- Are CGILS experiments a good framework to understand IPSL/GCM cloud feedback ?

Comparaison between 3D/1D for ShCu case

s6 case can be considered as an analogue of moderate subsidence (s6 $\simeq \omega_{500}$=20 hPa/day) and a good case for understanding cloud feedback. Same results as 3D moderate subsidence ?







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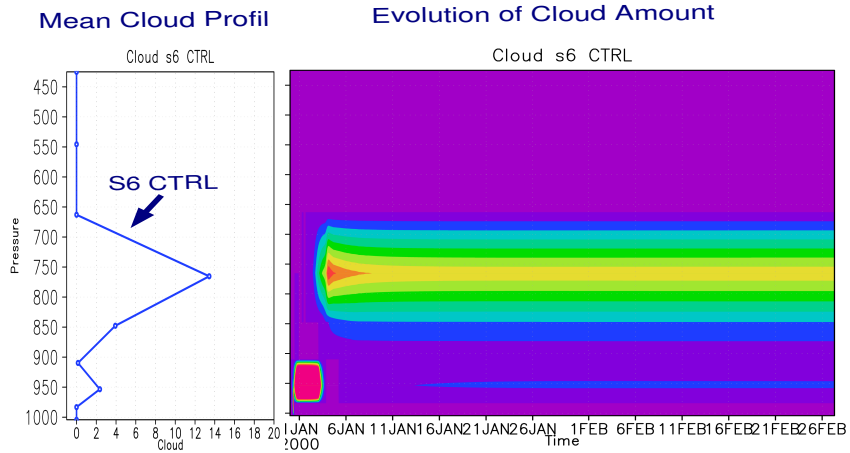
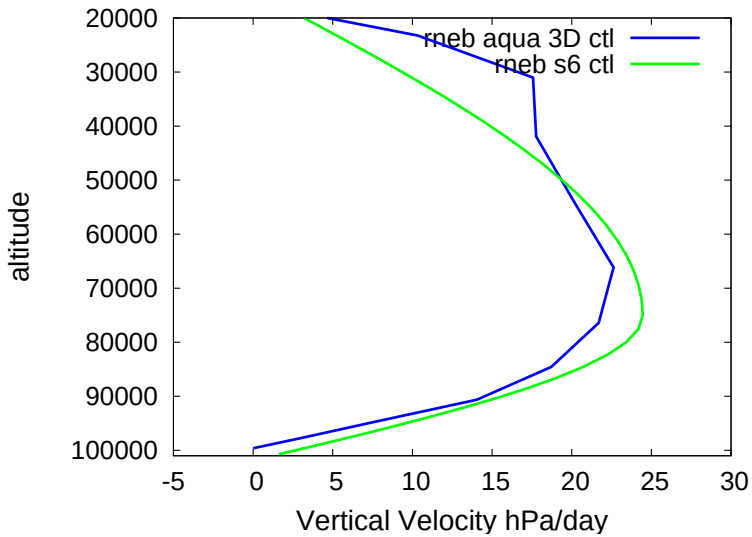
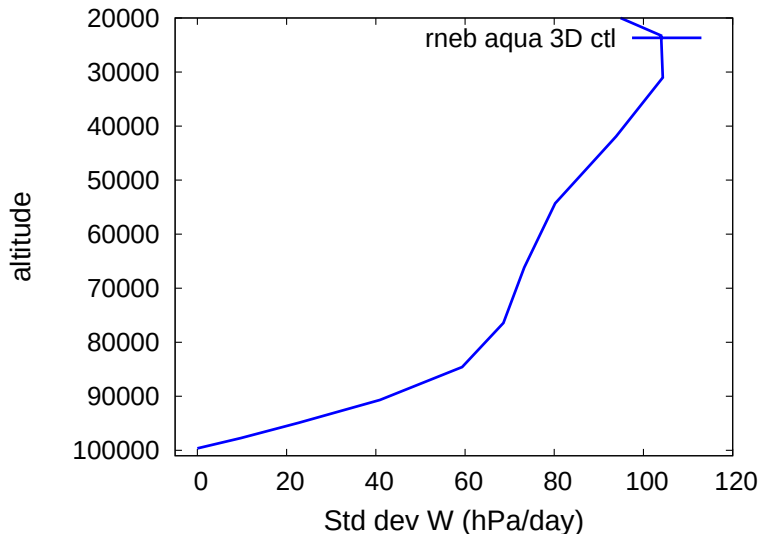


- 3D/1D : Substantially different. Why ?

Comparaison between 3D/1D for ShCu case

Comparaison between Aquaplanet-ω_{500}=+20hPa/day regime and s6 CGILS.

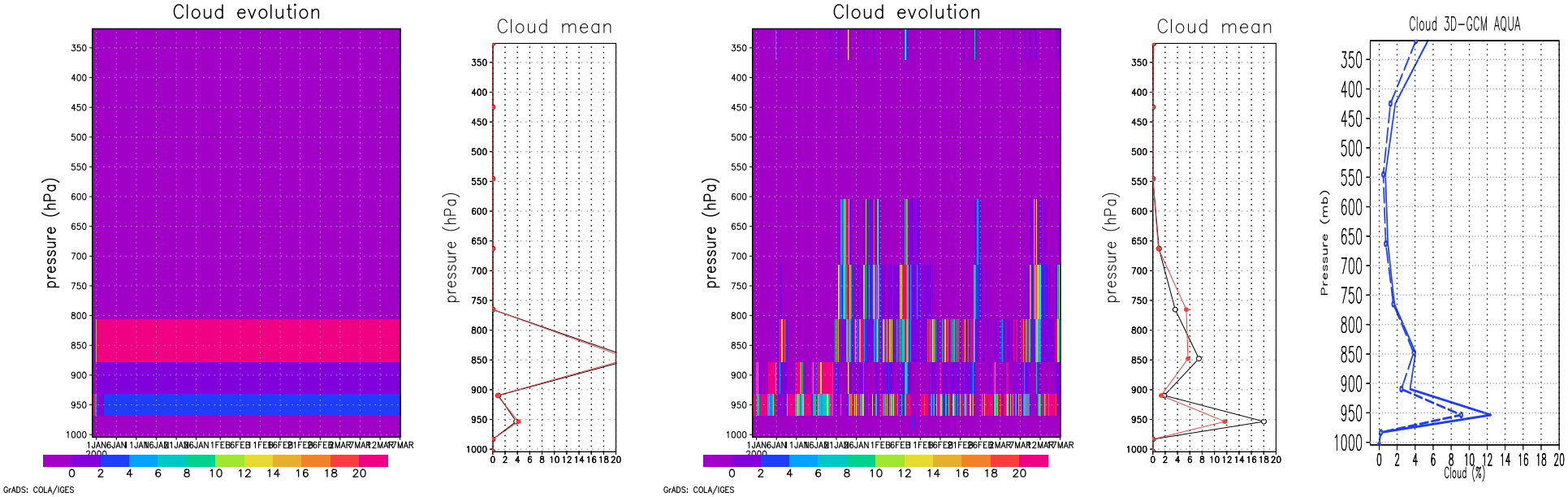




- Same profil of Vertical Velocity : maximum in 700hPa
- 3D variance calculated by 6hour model output from an aquaplanet simulation (until 5x ω mean)
- Applying stochastic variation on s6 CGILS case

Impact of high frequency stochastic variation

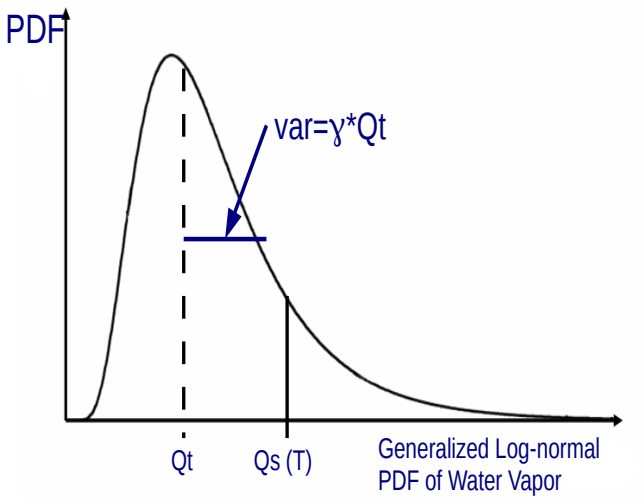
s6 CGILS case ———————— s6 ω-stochastic (σ=σ_{GCM}) —— 3D

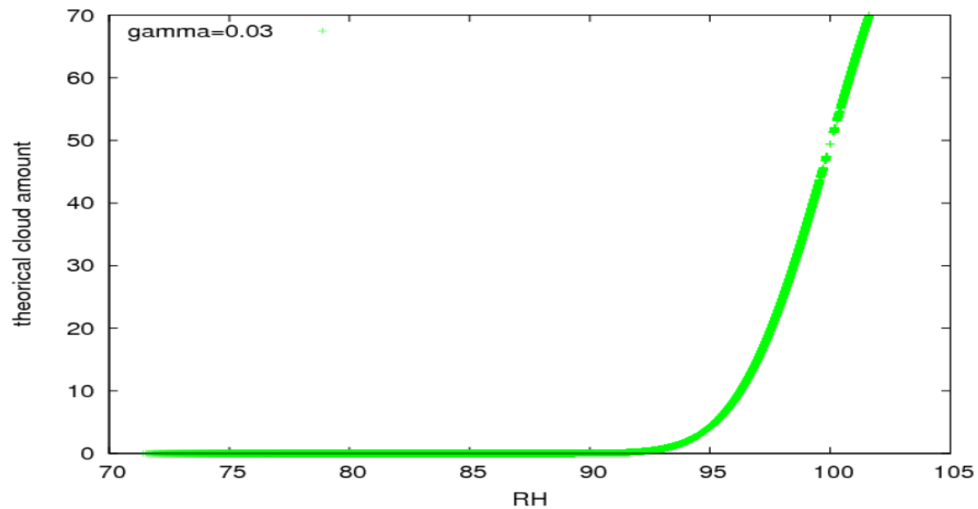


- Improvements with the application of variation on vertical velocity (f_{950mb}=12% (3D) against 18% and 4% with and without ω-variation) +similar profil
- +2K s6 with stochastic forcing is able to reproduce the time average +2K GCM exps (decrease of 950hPa cloud layer)
- s6 can help to understand physical processes involved in the climate change response to +2K in the GCM ?

How might the GCM cloud feedback relate the statistical scheme ?

Cloud Amount versus Relative Humidity for AR4 normalized variance (γ) using our statistical scheme.





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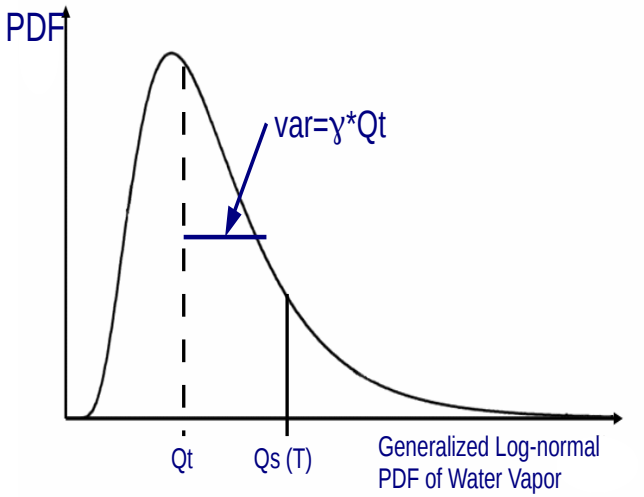
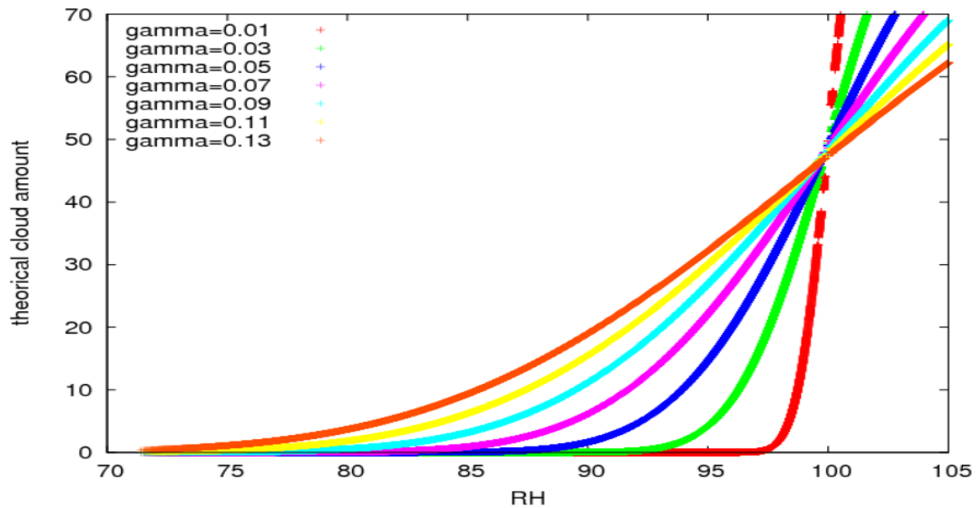
How might the GCM cloud feedback relate the statistical scheme ?

Cloud Amount versus Relative Humidity for differents assumptions about subgrid-scale variability (γ)



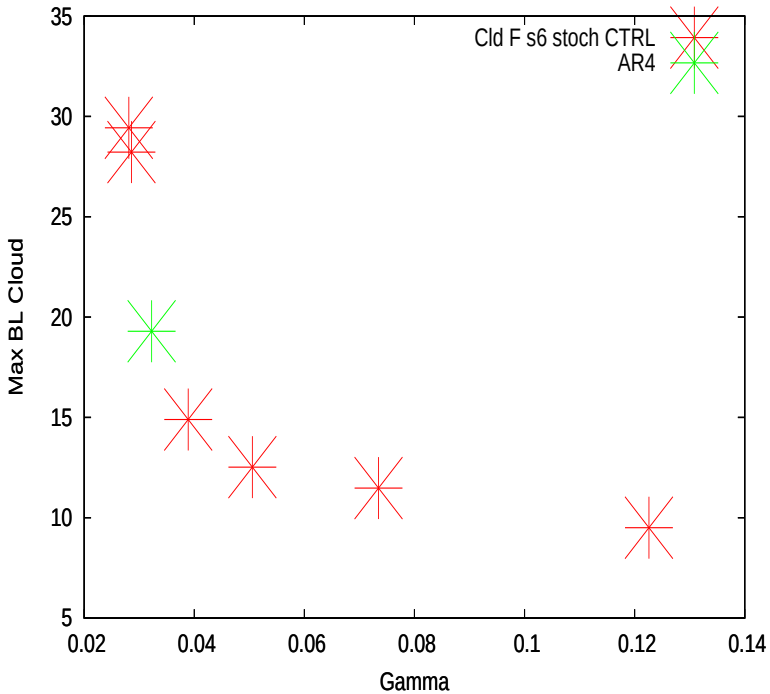


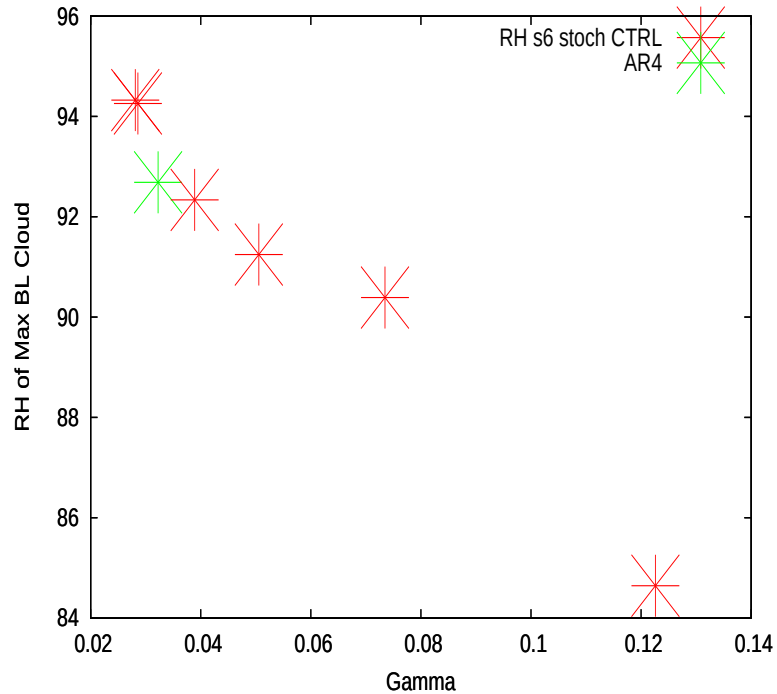
- $\gamma \nearrow$ (increasing of subgrid scale variability : min in red, max in orange)
- $\frac{\delta f}{\delta RH}$ depends on mean RH and γ

$\longrightarrow$ Tests using s6 CGILS case

Sensitivity to statistical scheme (1D)

1st exp : ωstoch-s6 case. Differents Gamma vs Max BL cloud (left) and RH of the layer (right). SCM with AR4 physics in green

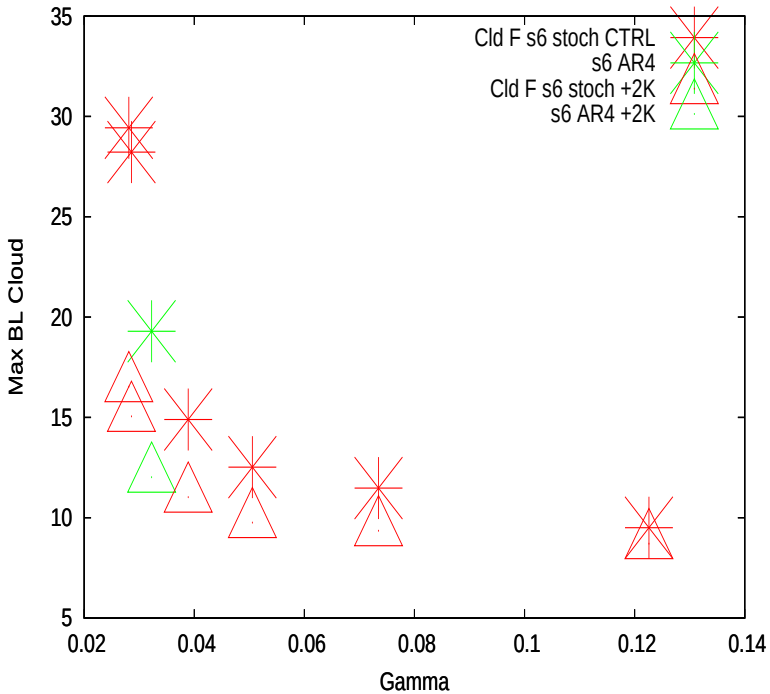




- Cloud $\searrow$ when γ $\nearrow$
- RH $\searrow$ when γ $\nearrow$
- Strong influence of Cloud parameterization on f_{BL} and mean RH.

Sensitivity to statistical scheme (1D)

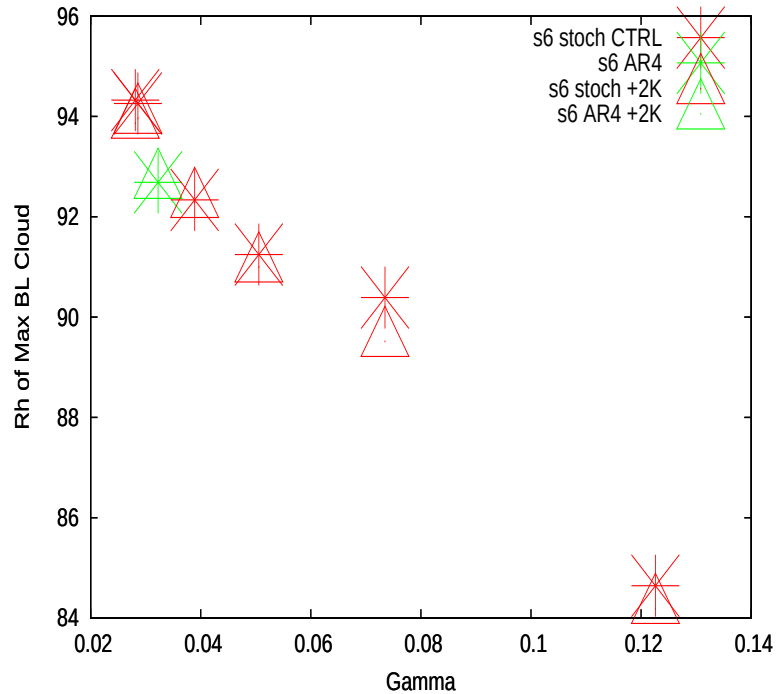
2st exp : +2K ωstoch-s6 case ($\triangle$). Differents Gamma vs Max BL cloud (left) and RH of the layer (right). AR4 physics in green



$*$

$\downarrow$

$\triangle(+2K)$

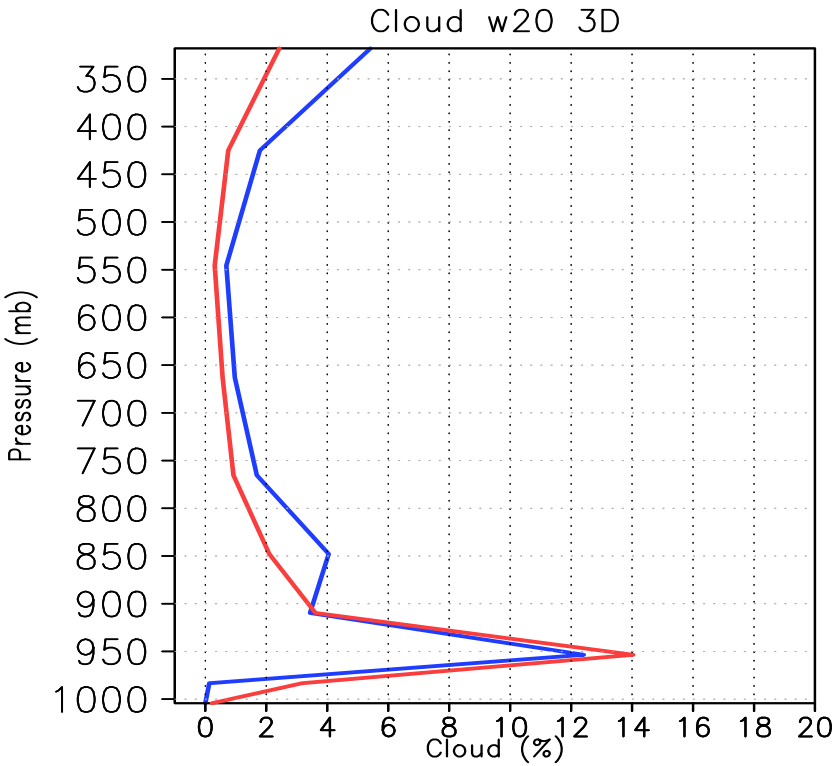


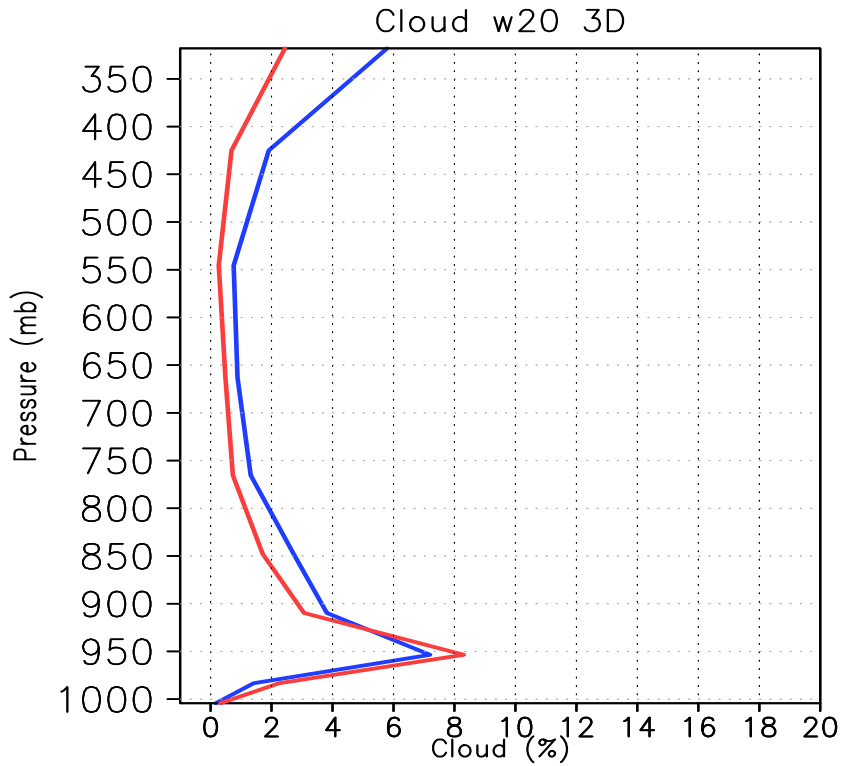
- Positive Feedback in all case (Cloud $\searrow$)
- Cloud sensitivy $\searrow$ when γ $\nearrow$ (ΔCloud $\searrow$)
- Influence of γ in 3D model ?

Sensitivity to statistical scheme (3D)

Control Cloud Cover for Earth-Like and Aquaplanet

Applying a γ=10*γ_{AR4}



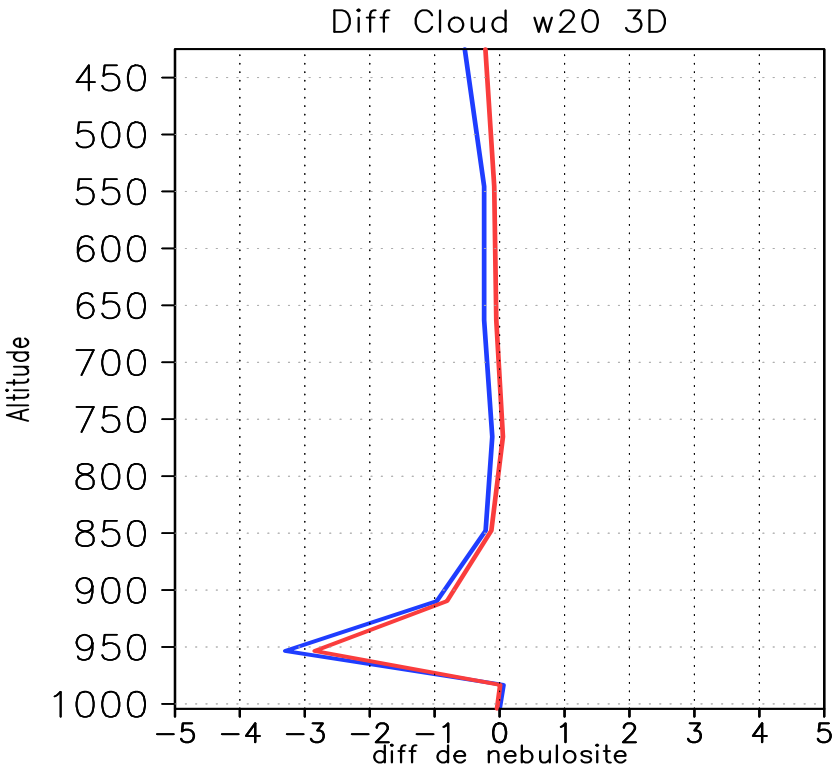


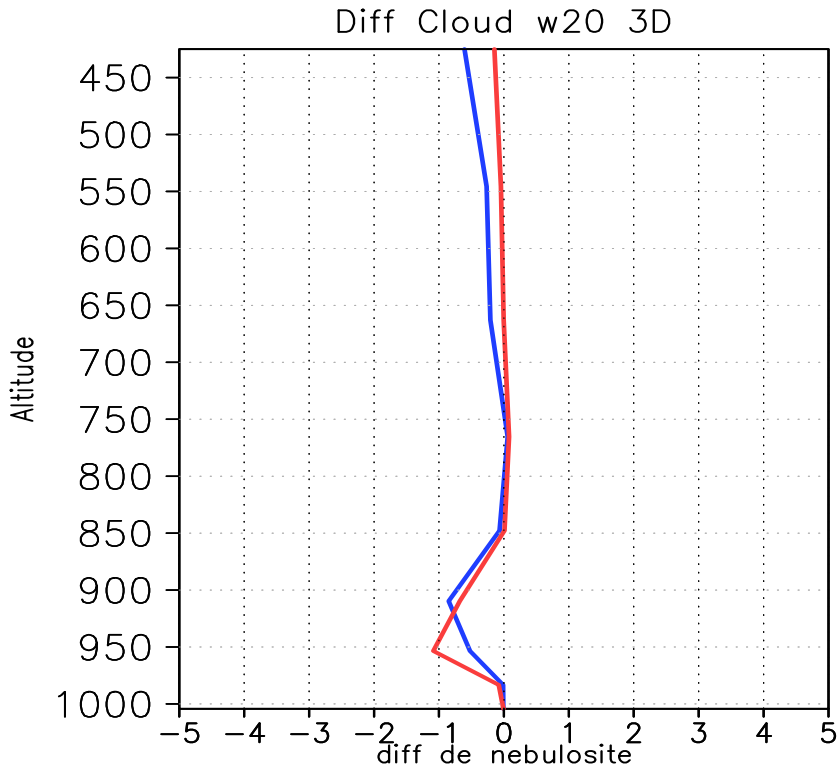
- As in CGILS case, increasing γ decrease f_{BL}
- Same effect in GCM than in Aquaplanet
- What about cloud feedback ?

Sensitivity to statistical scheme (3D)

Cloud response to +2K for Earth-Like and Aquaplanet

Applying a γ=10*γ_{AR4}





- As in CGILS case, increasing γ weakens the +2K cloud response (less positive cloud feedback : ΔCRF_{trop} +3.6 to +1.2 $W.m^2$)
- Same effect in GCM than in Aquaplanet

Conclusions

- New s6 case still differs from 3D results in regimes of moderate subsidence.
- Sensitivity exps on CGILS cases (using a stochastic forcing) allows us to reproduce with the SCM a cloudiness consistent with that predicted by the 3D GCM, in regimes of weak subsidence, both in the control and +2K cases
- The most critical parameters for the GCM cloud feedback can thus be identified at 1st order through sensitivity studies.
- Understanding the processes that control the cloud response in the ω-stoch s6 CGILS case allows us to anticipate the tropical mean cloud feedback in the GCM.
- Comparing the physical processes that control the cloud cover in s6 case in LES and in SCM will be an important component of the evaluation of cloud feedback in the GCM

Suggestions of SCM CGILS study

by Sandrine Bony and Florent Brient

- Encouraging each group to compare 3D/1D (in particular moderate subsidence regime)
- Make 4xCO2 experiences with unchanged LS forcing (fast cloud response to CO2 forcing ? Explanation of AMIP/Aqua difference)
- Cloud feedback sensitivy tests of "tuning" terms for each models (Bjorn Stevens's idea during EUCLIPSE meeting).
- s6 LES seems not having cloud feedbacks (or little). Maybe adding a stochastic forcing (on ω) will change it.

Thank You

Sensitivity to statistical scheme (1D)

2st exp : +2K ωstoch-s6 case ($\triangle$). Differents Gamma vs Max BL cloud (left) and CRFSW of the layer (right). AR4 physics in green