Sensitivity of the IPSL-CM5a low cloud feedback to physical parameterizations : *Can CGILS help us to predict and understand it ?*

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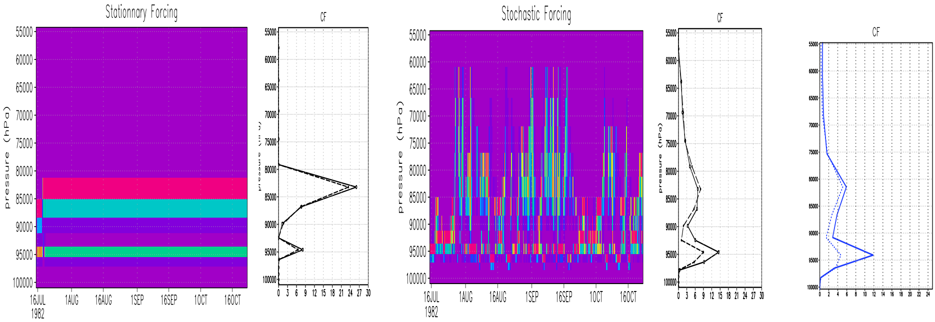
CGILS framework for IPSL model

s6 CGILS case ——————————— s6 ω-stochastic ($\sigma = \sigma_{GCM}$) —— **3D**



- SCM able to reproduce cloud profil in both present and future climat only by adding of a ω-stochastic forcing using s6 CGILS methodology
- Which physical parameters influence the most the cloud feedback ? Is it possible to anticipate the intensity of the 3D feedback by using 1D experiments ?

"Tuning" Parameters

"Tuning terms" are parameters which allows us to ajust a climate model for avoiding drifts (zero Net TOA budget) and giving a GCM climate not to far away from the real climate.

Those terms have a impact on many physical mechanisms (convection, clouds, circulation...) : Obvious effect on present climate.
EUCLIPSE Meeting (Utrecht) : What about climate sensitivity ?

Using 1D model with s6 CGILS experiments allows us to test the influence of each of those parameters. Three are selected :

- Sub-grid scale cloud parameterization (1 parameter)
- Impact on Liquid Water Content (2 parameters)

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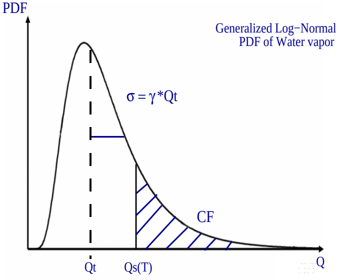
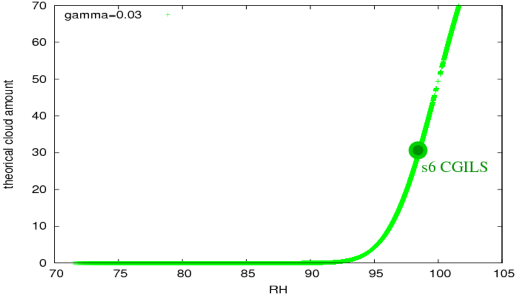
- Impact on Liquid Water Content

GCM sensitivity to cloud statistical scheme ?

Cloud Amount versus Relative Humidity for CMIP5 normalized variance (γ) using our statistical scheme.

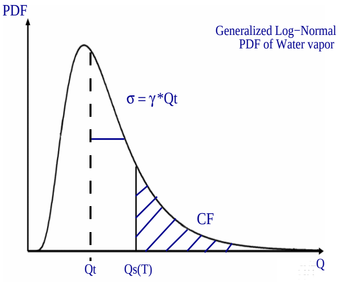


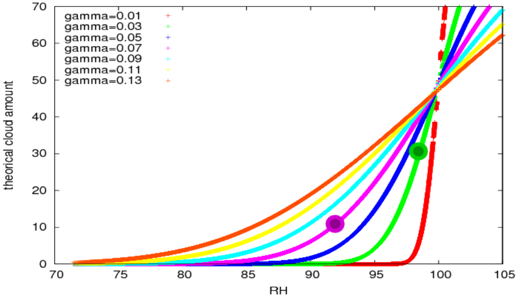


- SCM : $\gamma \nearrow$ (increasing of subgrid scale variability : min in red, max in orange) $\overline{RH} \searrow$ CF $\searrow$
- Mean atmospheric state depends on γ but owing to the influence of γ on $\overline{RH}$
- ΔCF function of γ ?

GCM sensitivity to cloud statistical scheme ?

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





- *SCM* : $\gamma \nearrow$ (increasing of subgrid scale variability : min in red, max in orange) $\overline{RH} \searrow$ CF $\searrow$
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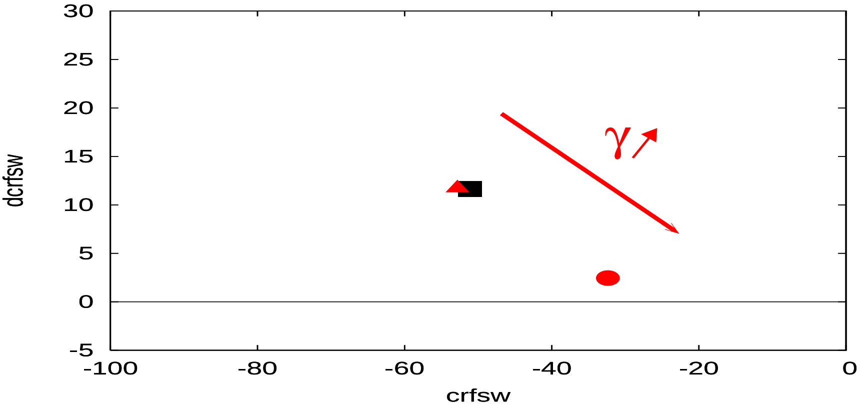

- +2K-Ctrl SCM Experiments (s6 CGILS)
- |SWCRF| ↘ when γ ↗ (because CF_{950mb} decreases)
- Cloud sensitivity correlated to the present climate

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- Impact on Liquid Water Content (LC1 and LC2)

GCM sensitivity to cloud LWC ?

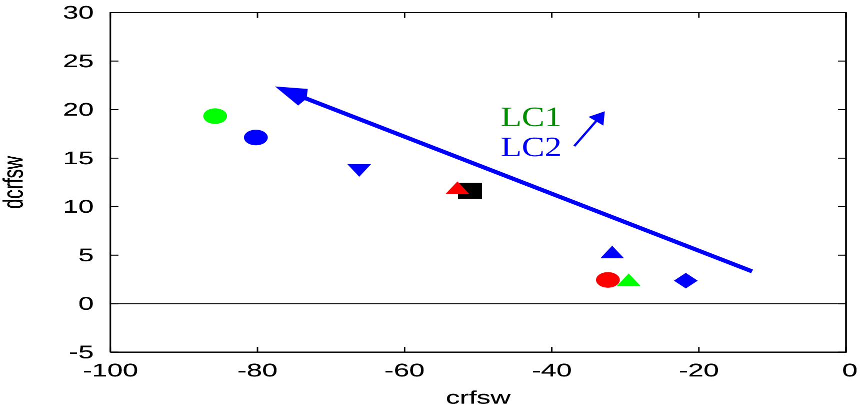
Tuning of precipitation efficiency depending of two LWC parameters :

$$\left(\frac{\partial q}{\partial t}\right)_{precip} = \frac{q_{cond} - q_{crit}}{\tau}$$

- A LWP constant which defines a threshold of precipitation (LC1)
- A time constant for the elimination of liquid water content by precipitation (LC2)

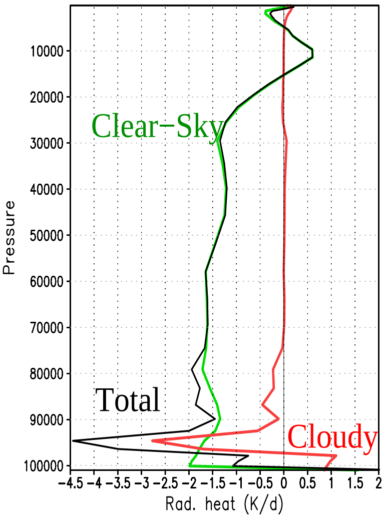
LC1 $\nearrow$: More LWC for a defined cloud fraction (threshold increases, less precipitation)
LC2 $\nearrow$: More LWC for a defined cloud fraction (precipitation efficiency decreases)

GCM sensitivity to cloud LWC ?



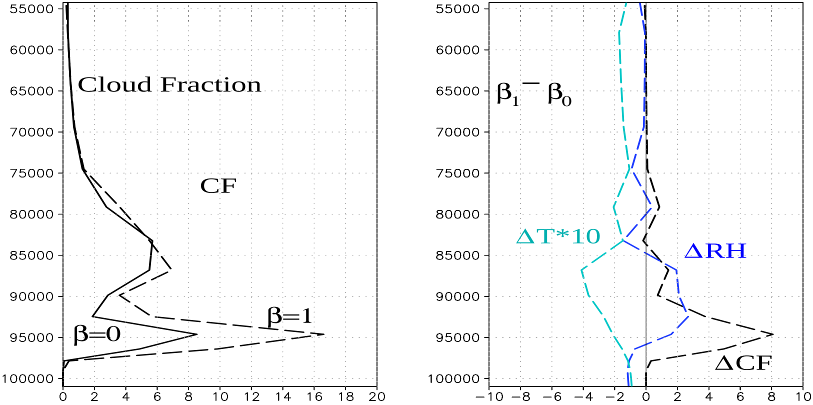
- Precipitation efficiency influences present-day low cloud fraction
- Cloud sensitivity highly correlated to the cloud fraction in the present climate.
- What processes are involved in this mechanism ?

Radiative feedback



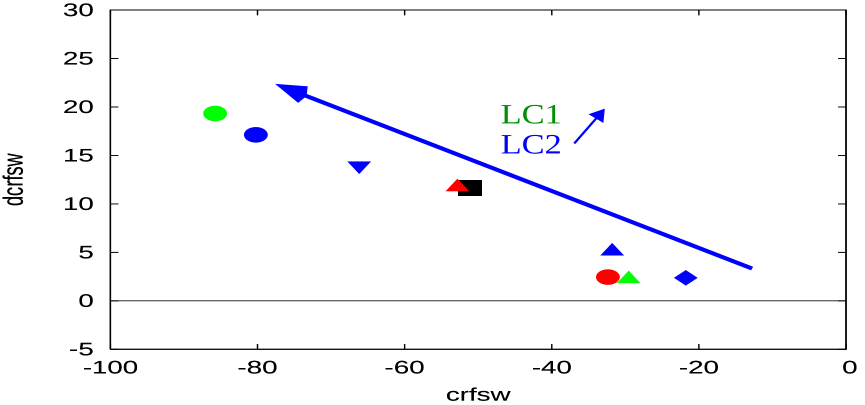
- Total Radiative cooling(z) = Clear-Sky Radcool(z) + $\beta\, CRF_{atm}(z)$
- β=1 if Control (test $\beta = 0$)

Radiative feedback (1D)



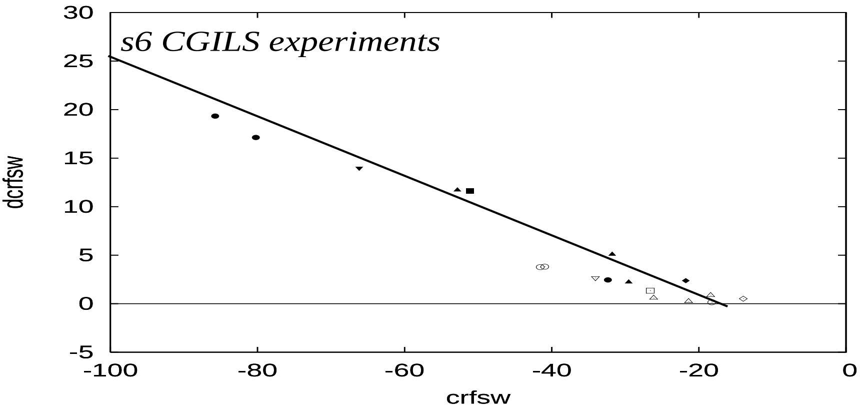
- Positive radiative feedback between LW radiative Cooling, Temperature, Relative Humidity and Cloud (so-called β feedback)

Radiative feedback (1D)



- Decreasing Precipitation efficiency (LC $\nearrow$) enhances β feedback
- Always Positive cloud feedback to a global warming (robust mechanism) : SCM experiments gives a linear relation
- Are s6 CGILS sensitivity tests able to anticipate 3D feedback ?

Summary of 1D results



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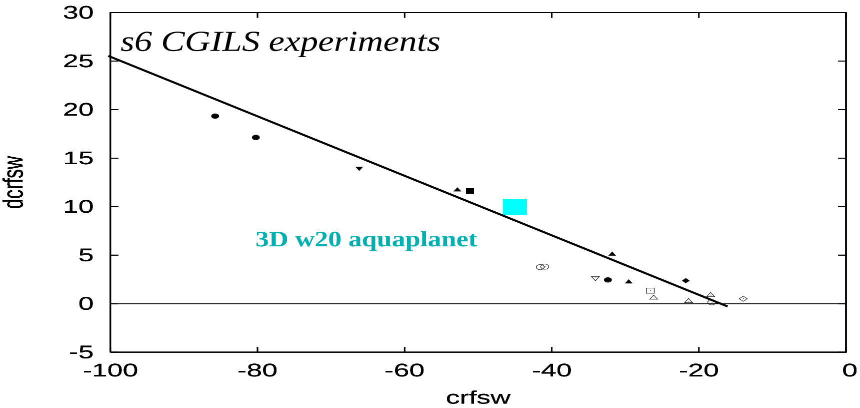
Application on 3D aquaplanet



- Blue Square : A +4K-Ctrl aquaplanet experiment for w_{500}=20hPa/day
- 3D on the same linear relation than SCM experiments
- s6 CGILS allows us to anticipate GCM cloud feedback sensitivity on "tuning" parameters

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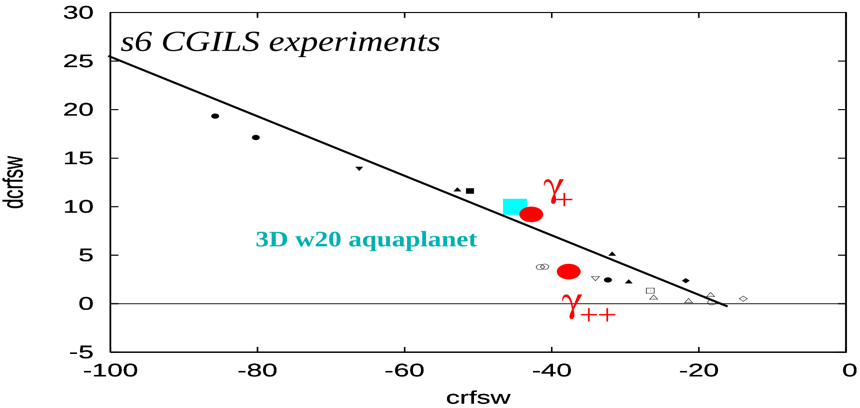

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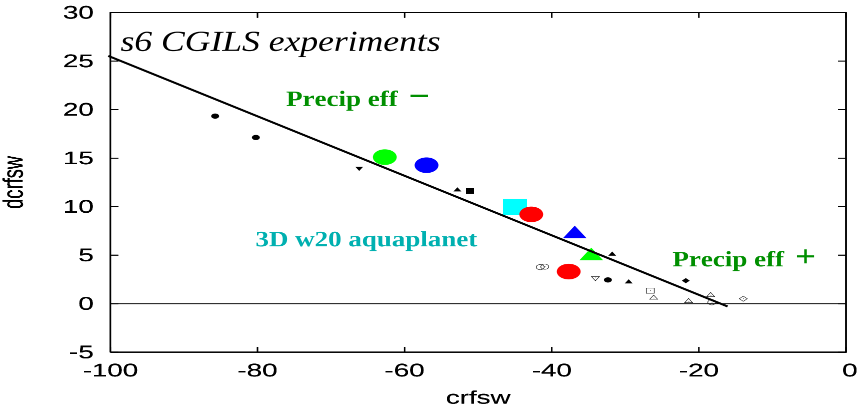

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Conclusions

- The s6 CGILS experiments with a ω-stochastic forcing allows us to anticipate the tropical mean cloud feedback seen in the GCM (focus on a subset of paramaters which has a local physical influence)
- Linear relation between the present-day cloud fraction and the cloud sensitivity in our model.
- Boundary Layer positive radiative feedback between LW radiative cooling, RH and Cloud (β feedback) responsible of this relation
- β feedback contributes to the strong amplitude of the positive cloud feedback in the IPSLCM5a model

Thank You