Analysis of the tropical precipitation response to global warming predicted by the IPSL-CM5A OAGCM (and in other CMIP GCMs)

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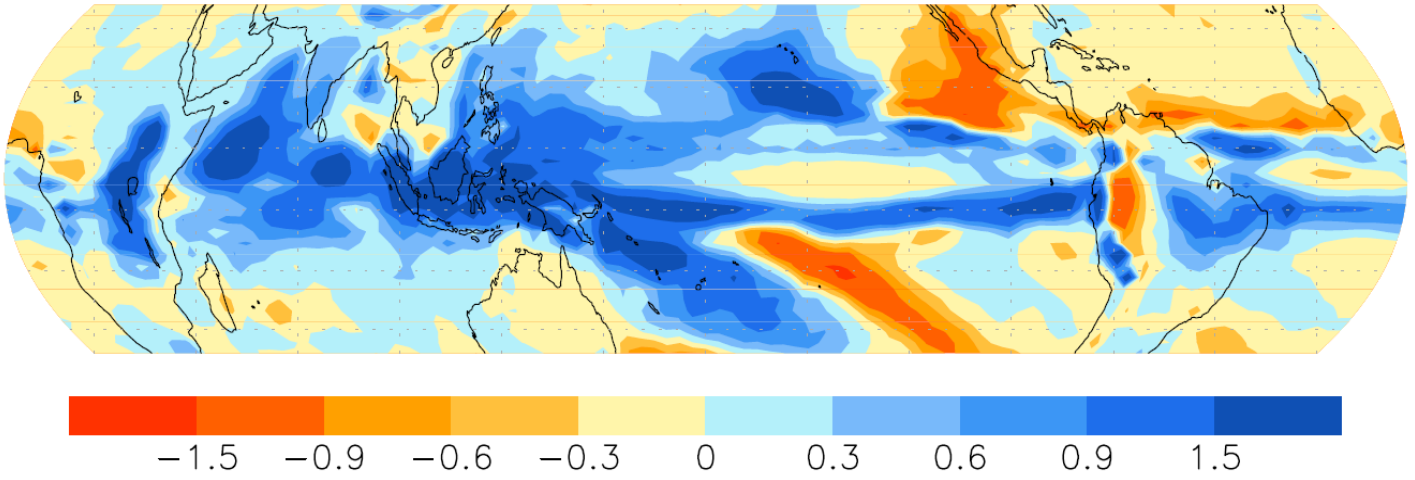


- What controls the response of tropical precipitation to climate change ?
- What is the impact of cloud-radiative effects on precipitation change ?

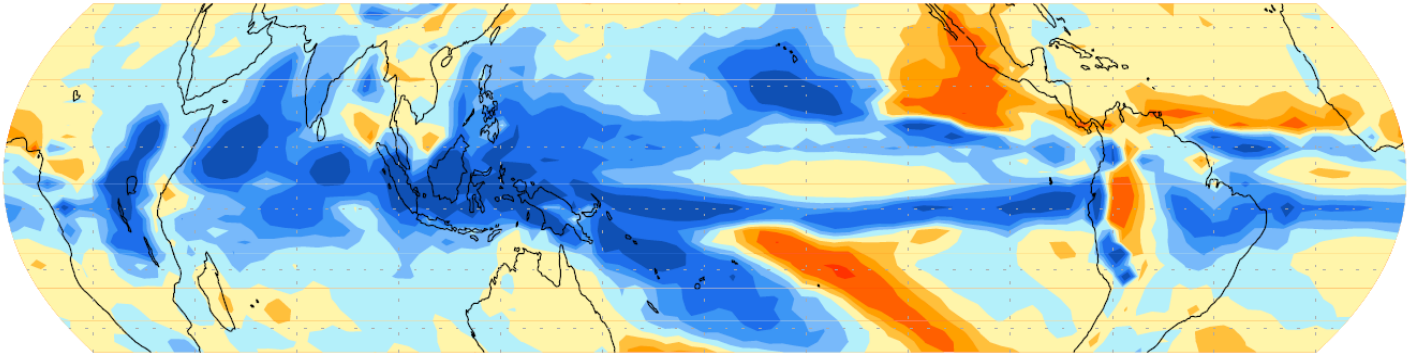
→ Decomposition of regional precipitation changes into :
- thermodynamical and dynamical components
- analysis of each component using water and moist static energy budgets

$$P = E - \left[\omega \frac{\partial q}{\partial P}\right] + H_q \quad \rightarrow \quad P = E + \overline{\omega}\,\Gamma_q + H_q + V_q^{\alpha}$$

CMIP5 IPSL-CM5-LR OAGCM :

$$\Delta P = \Delta E + \overline{\omega}\,\Delta\Gamma_q + \Delta H_q + \Delta V_q^{\alpha} + \Gamma_q \Delta\overline{\omega}$$

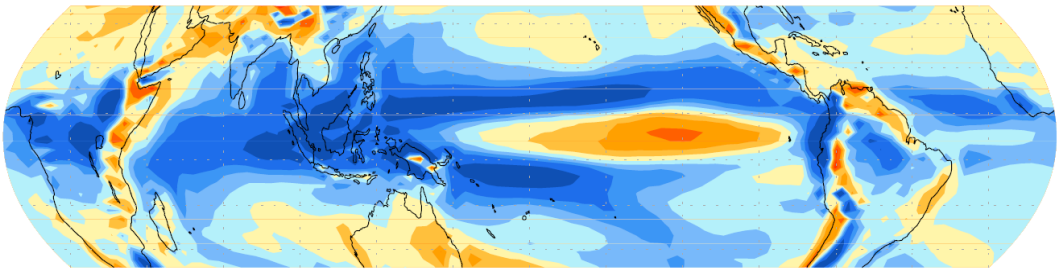
delta P: total change



−1.5 −0.9 −0.6 −0.3 0 0.3 0.6 0.9 1.5

$$\Delta E + \overline{\omega}\,\Delta\Gamma_q + \Delta H_q + \Delta V_q^{\alpha}$$

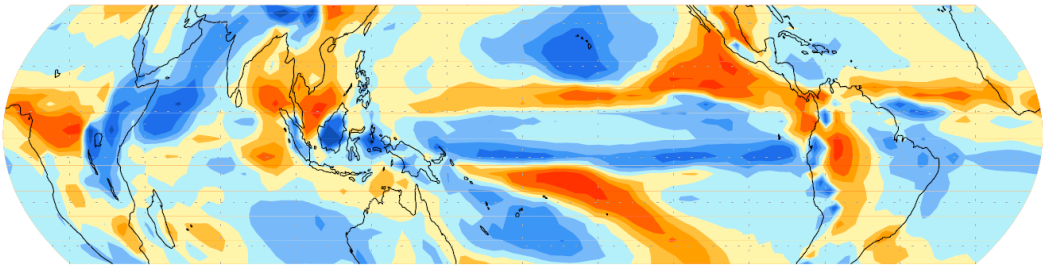
delta P: thermodynamical component



−1.5 −0.9 −0.6 −0.3 0 0.3 0.6 0.9 1.5

$$\Gamma_q \Delta\overline{\omega}$$

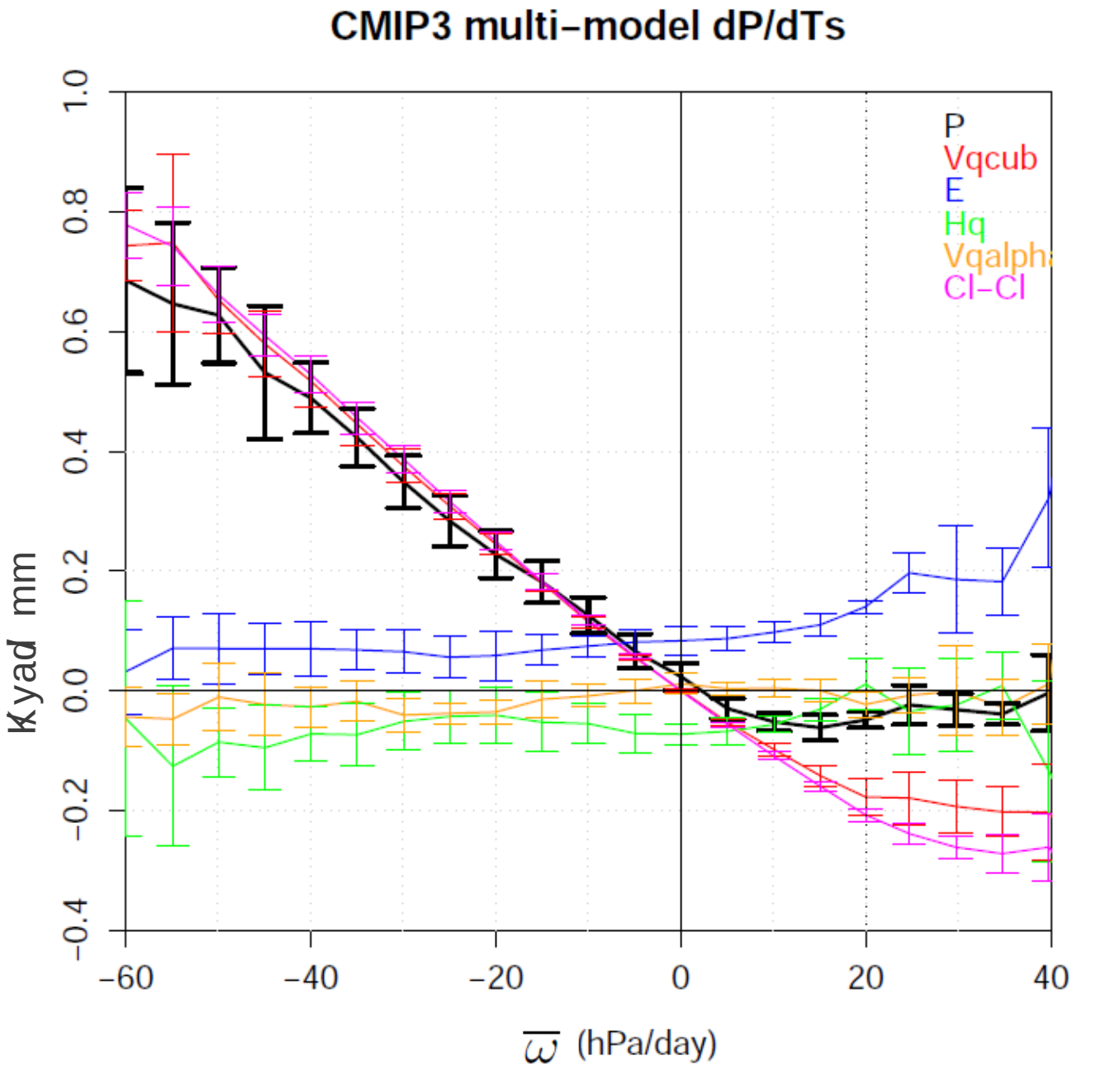
delta P: dynamical component



−1.5 −0.9 −0.6 −0.3 0 0.3 0.6 0.9 1.5

$$\Delta P/\Delta T_s = (\Delta E + \overline{\omega}\,\Delta\Gamma_q + \Delta H_q + \Delta V_q^{\alpha})/\Delta T_s$$

- "Rich get richer"
- In convective regimes : dP/dTs close to Clausius-Clapeyron
- Sign of dP/dTs robust in convective regions, less in subsidence regimes



There are regions where the dynamical change in precipitation turns out to be dominated by a cloud-radiative-dynamical feedback

e.g. Indian Ocean, eastern equatorial Pacific, tropical Atlantic

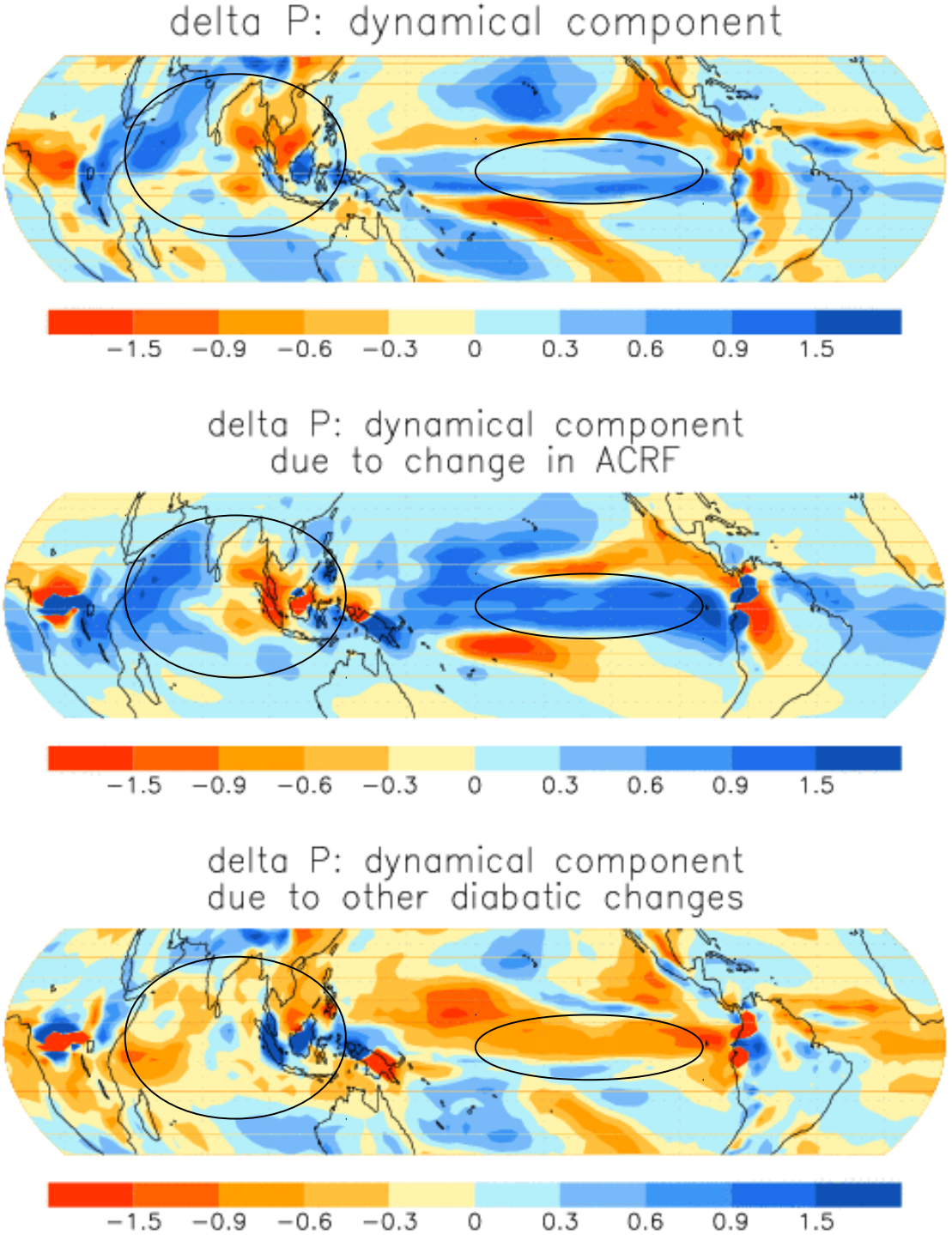
$$\Gamma_q \Delta\overline{\omega}$$

=

$$-\frac{\Gamma_q}{\Gamma_h}\,\Delta ACRF$$

+

$$-\frac{\Gamma_q}{\Gamma_h}\,(\overline{\omega}\,\Delta\Gamma_h + \Delta Q)$$



Conclusion

- A methodology is proposed to analyze regional dynamical and precipitation changes in GCMs (or in observations).

- It makes it possible to assess quantitatively the contribution of ACRF changes to regional changes in the large-scale vertical motion of the atmosphere.

- Its application to the IPSL-CM5A and CMIP3 models suggests that in some regions, ACRF changes play a substantial or even dominant role in regional precipitation changes, especially in equatorial regions.

- The response of cloud-radiative effects to global warming thus matters for much more than just climate sensitivity.

- The aim is now to apply this analysis to CMIP5 models to better understand the origin of robust and non-robust responses of clouds and precipitation to climate change.

... et si le temps le permet :

analyse de la circulation et des changements de precip en l'absence d'effets radiatifs des nuages