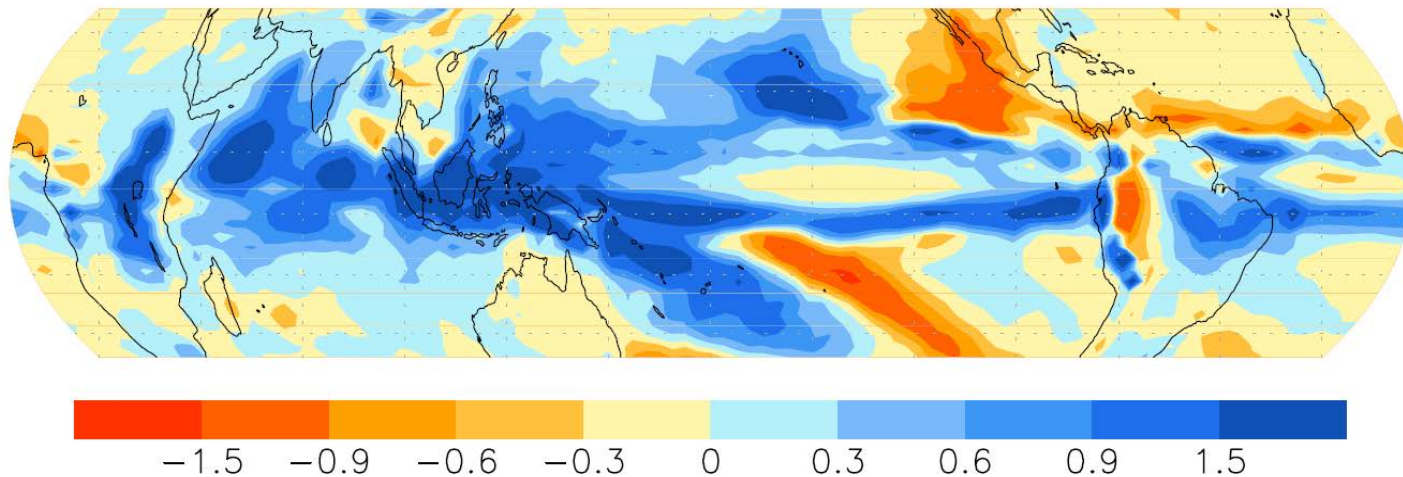


Analysis of the tropical precipitation response to global warming predicted by the IPSL-CM5A OAGCM (and in other CMIP GCMs)

Sandrine Bony (LMD/IPSL, Paris)



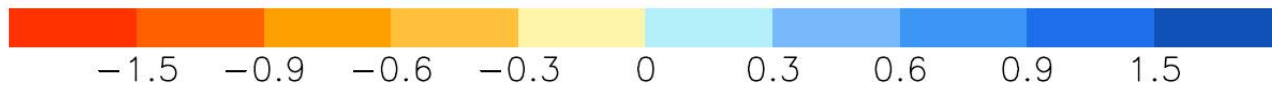
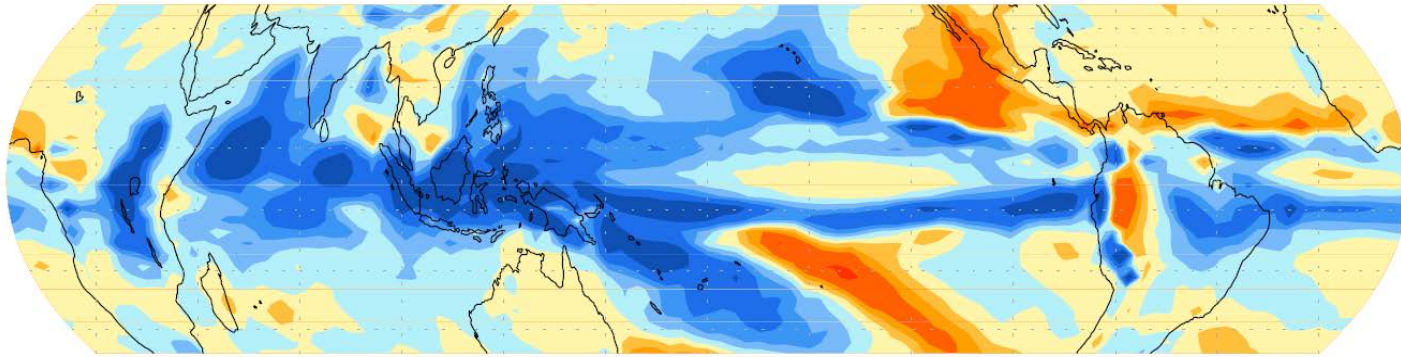
- What controls the response of tropical precipitation to climate change ?
 - What is the impact of cloud-radiative effects on precipitation change ?
- Decomposition of regional precipitation changes into :
- thermodynamical and dynamical components
 - analysis of each component using water and moist static energy budgets

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

CMIP5 IPSL-CM5-LR OAGCM :

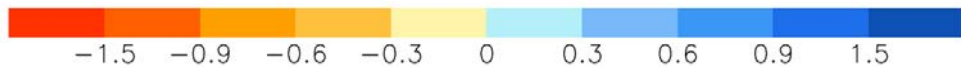
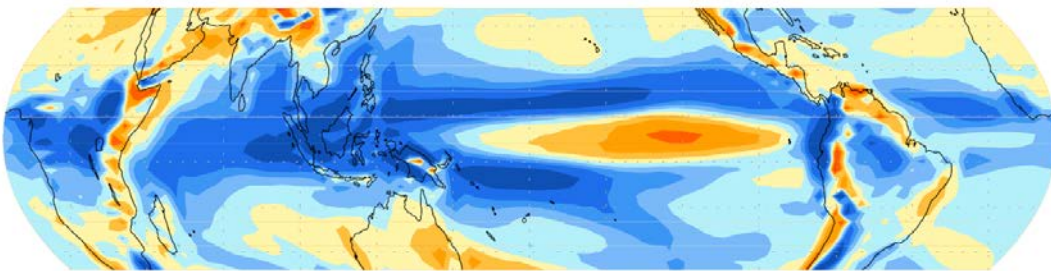
$$\Delta P = \Delta E + \bar{\omega} \Delta \Gamma_q + \Delta H_q + \Delta V_q^\alpha + \Gamma_q \Delta \bar{\omega}$$

delta P: total change



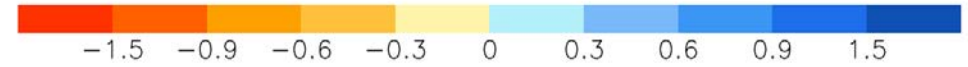
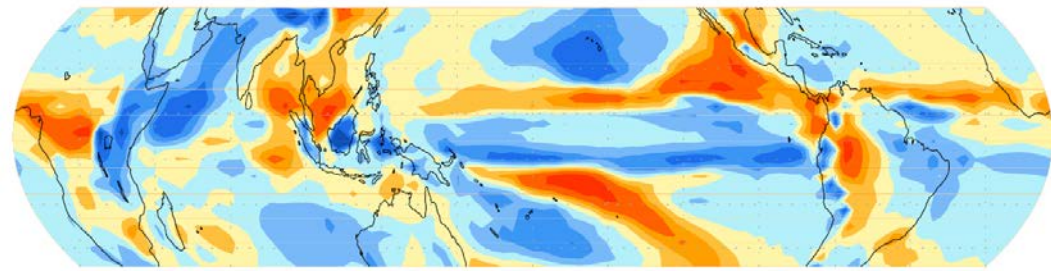
$$\Delta E + \bar{\omega} \Delta \Gamma_q + \Delta H_q + \Delta V_q^\alpha$$

delta P: thermodynamical component



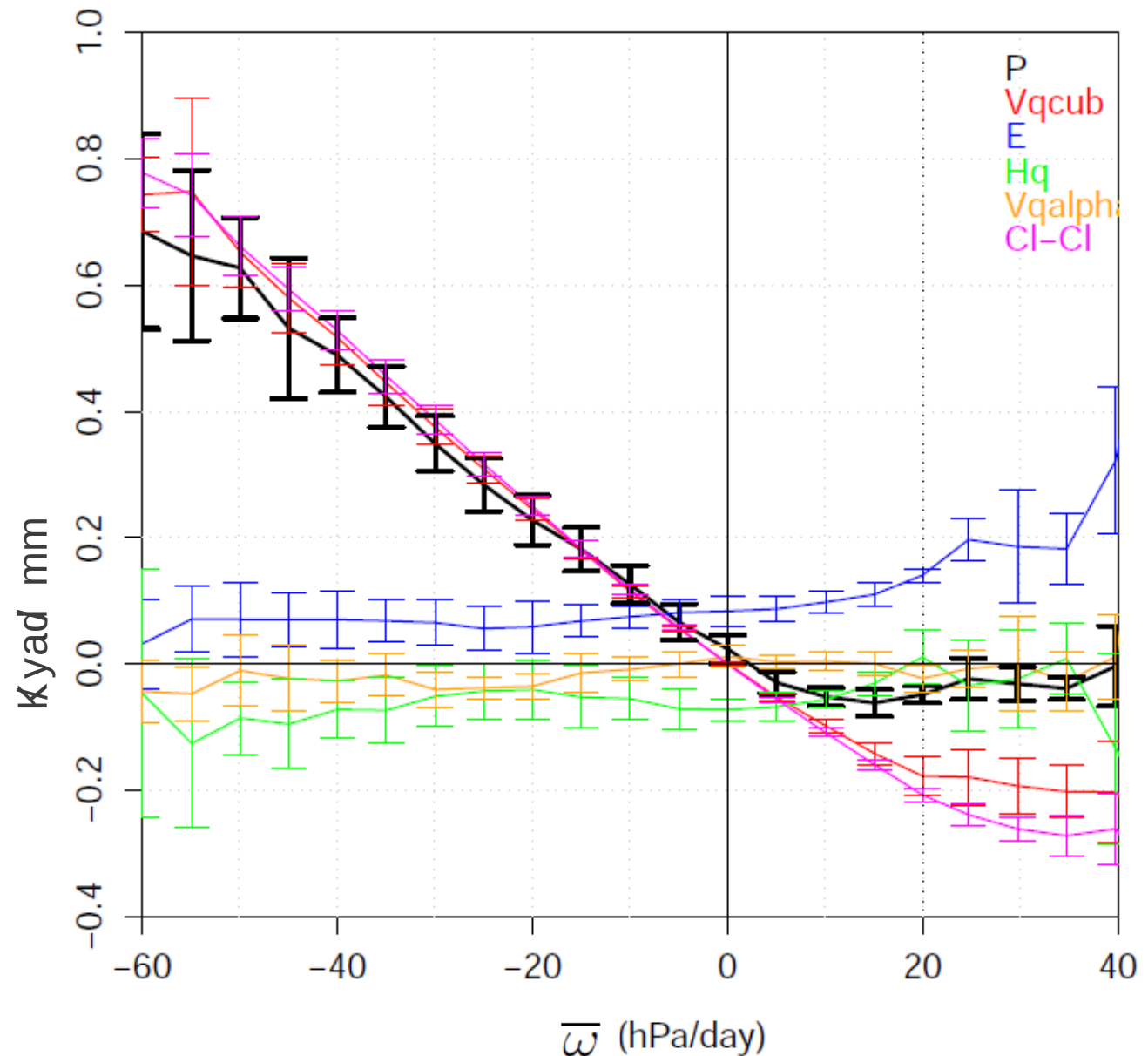
$$\Gamma_q \Delta \bar{\omega}$$

delta P: dynamical component



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

CMIP3 multi-model dP/dTs



- “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

$$\Gamma_q \Delta \bar{\omega}$$

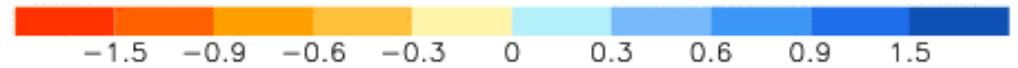
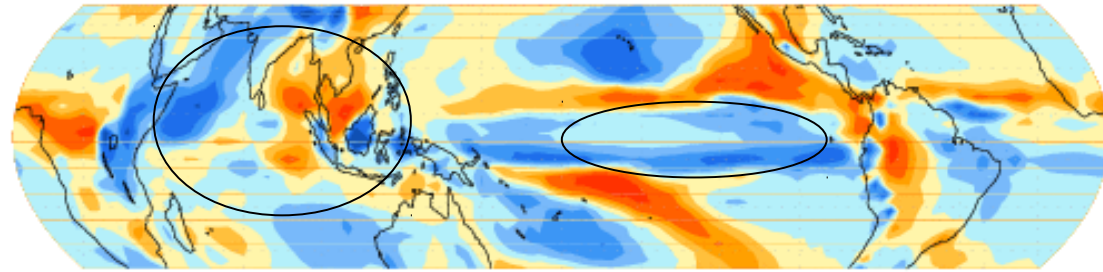
=

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

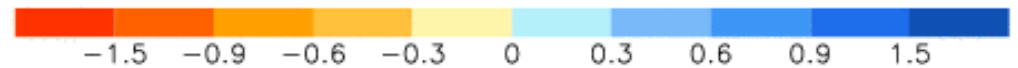
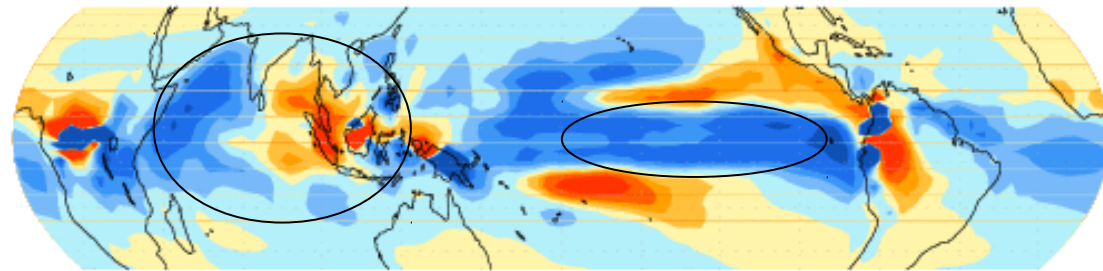
+

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

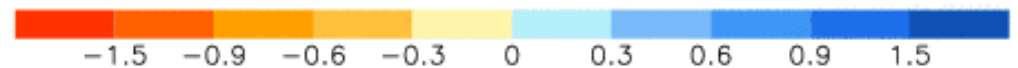
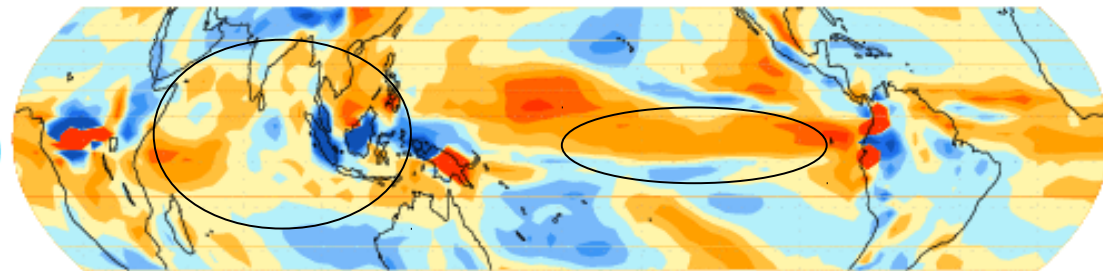
delta P: dynamical component



delta P: dynamical component due to change in ACRF



delta P: dynamical component due to other diabatic changes



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