Interpreting inter-model differences in regional precipitation projections

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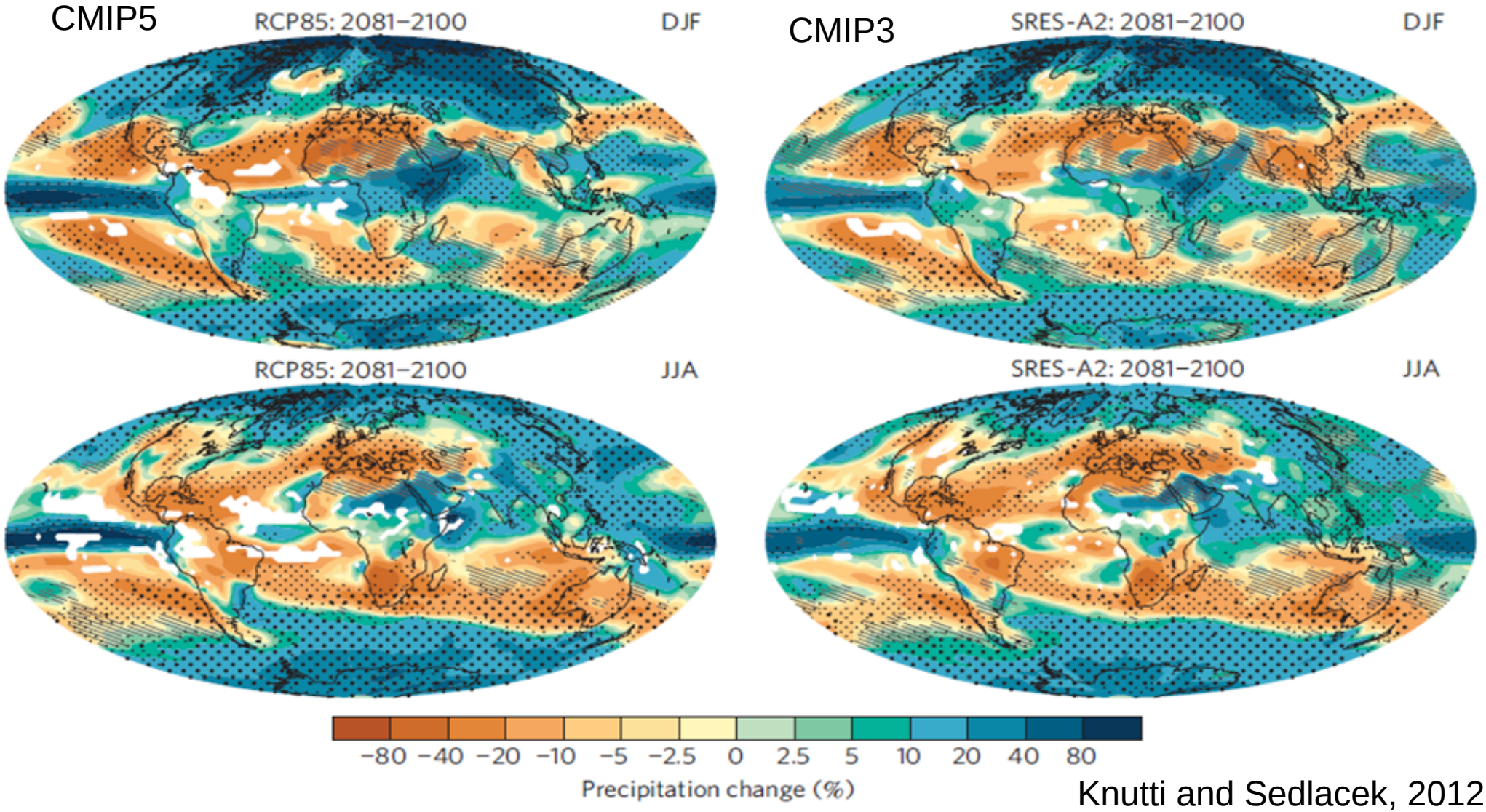
CMIP3 vs CMIP5 precipitation projections



Knutti and Sedlacek, 2012

Analysis methodology (Bony et al., 2013)

Water budget: $$P = E \underbrace{- \left[\vec{V} . \nabla q\right]}_{H_q} \underbrace{- \left[q \nabla . \vec{V}\right]}_{- \left[\omega \frac{\partial q}{\partial p}\right]}$$

ω can be decomposed as:

$$\omega = \Omega + (\omega - \Omega), \qquad \text{with} \quad \Omega(p) = \overline{\omega}\, \Phi(p)$$

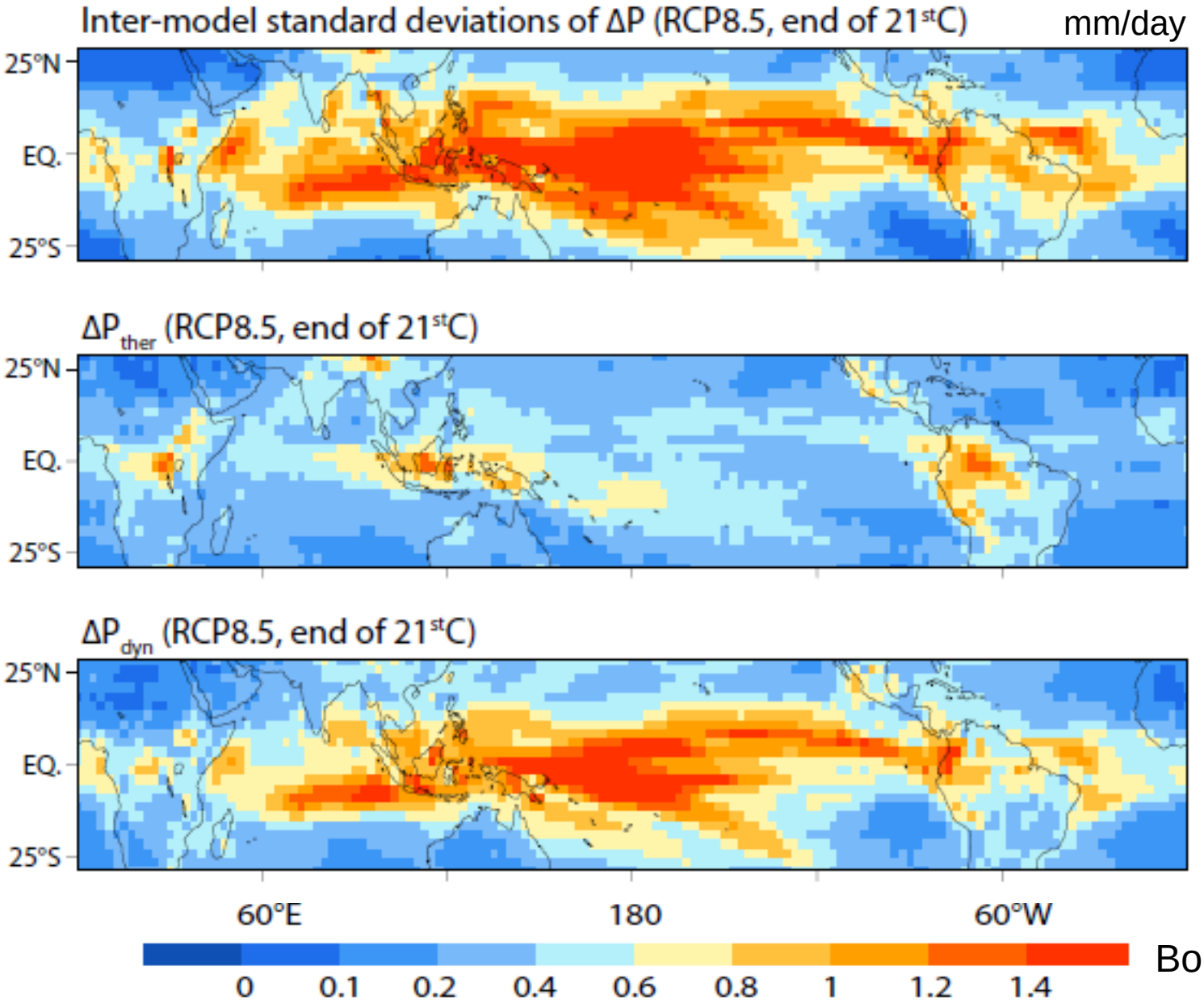
Then,

$$P = E + H_q + \overline{\omega}\, \Gamma_q + V_q^{\alpha}, \quad \text{with} \quad V_q^{\alpha} = -\left[(\omega(p) - \Omega(p)) \frac{\partial q}{\partial p}\right]$$

$$\Gamma_q = -\left[\Phi(p) \frac{\partial q}{\partial p}\right]$$

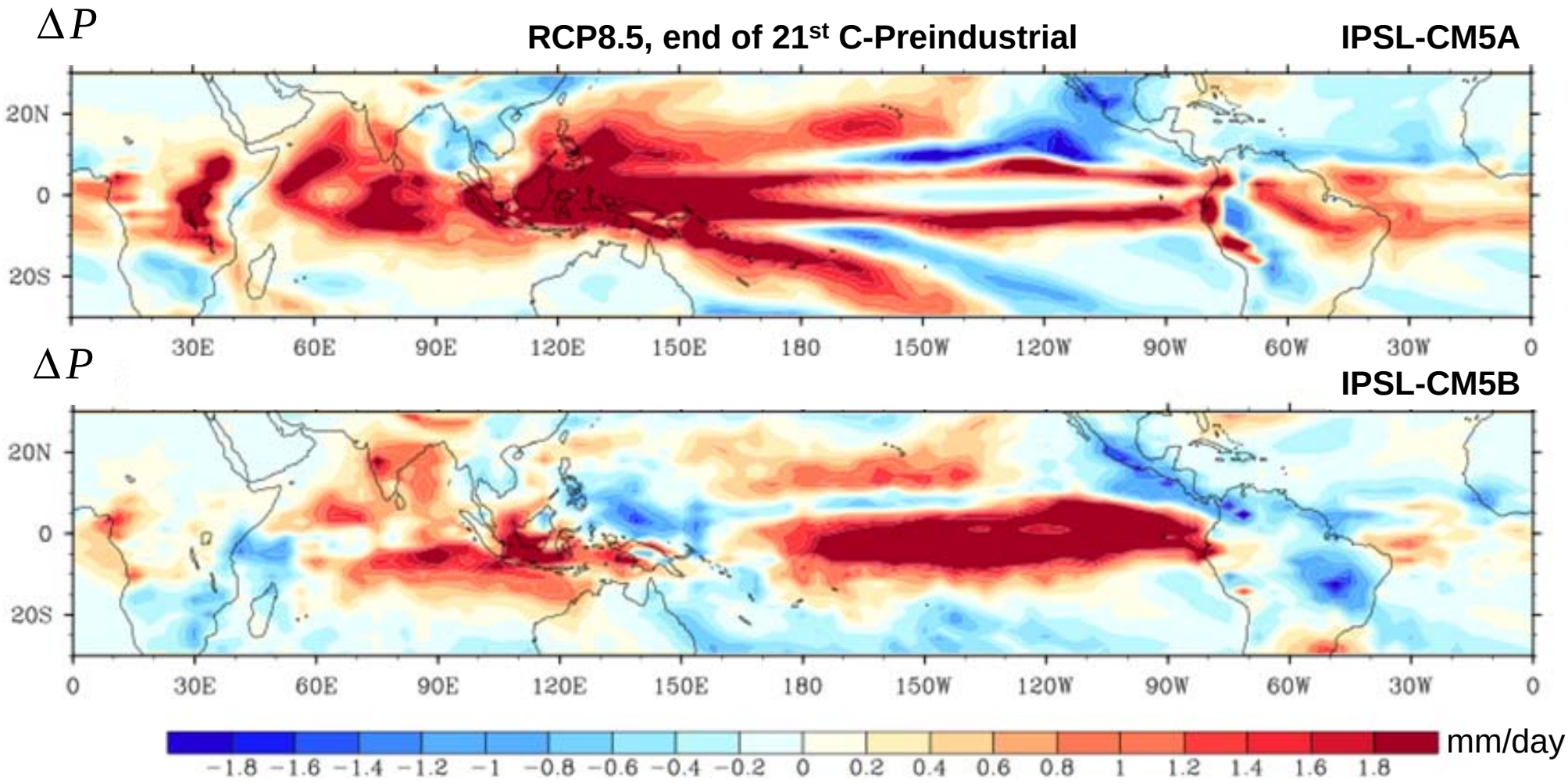
$$\Delta P = \underbrace{\Delta E + \Delta H_q + \overline{\omega} \Delta\, \Gamma_q + V_q^{\alpha}}_{\Delta P_{ther}} + \underbrace{\Gamma_q \Delta\, \overline{\omega}}_{\Delta P_{dyn}}$$

Inter-model spread in regional precipitation projections: Role of dynamic and thermodynamic processes

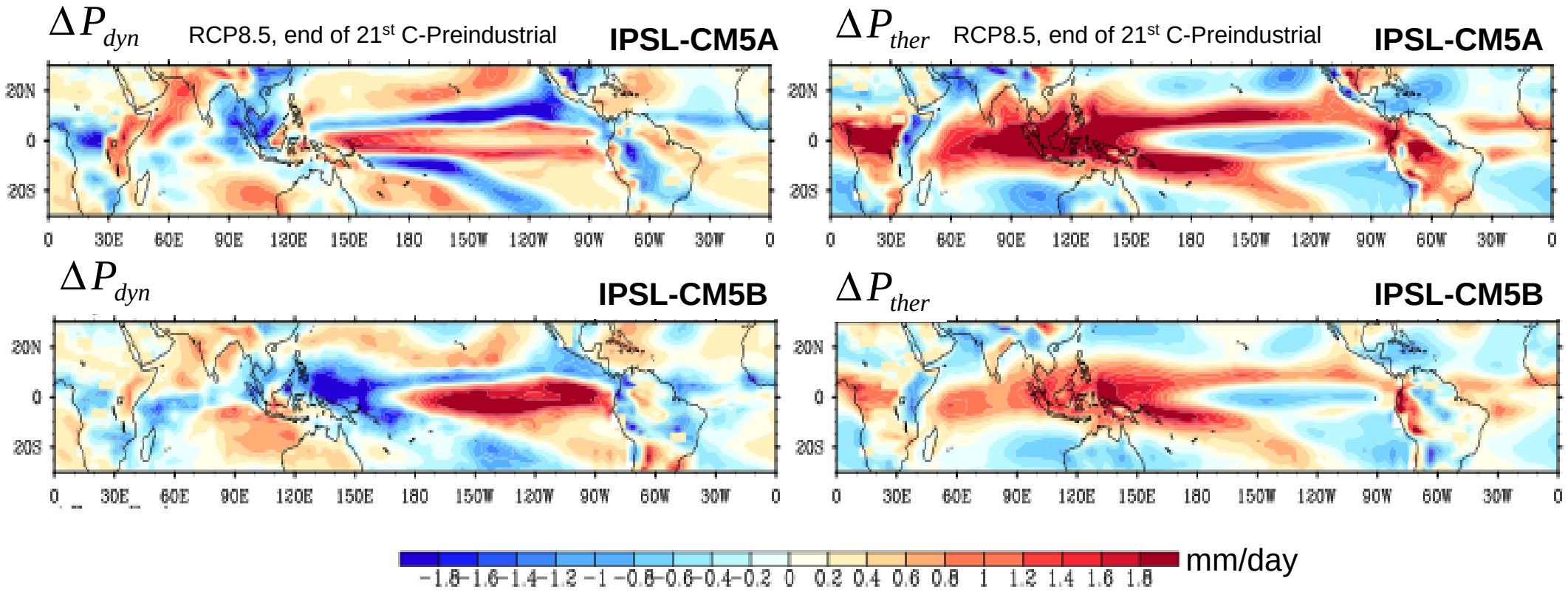


Bony et al., 2013

Inter-model spread in regional precipitation projections: IPSL-CM5A-LR vs IPSL-CM5B-LR



Inter-model spread in regional precipitation projections: IPSL-CM5A vs IPSL-CM5B

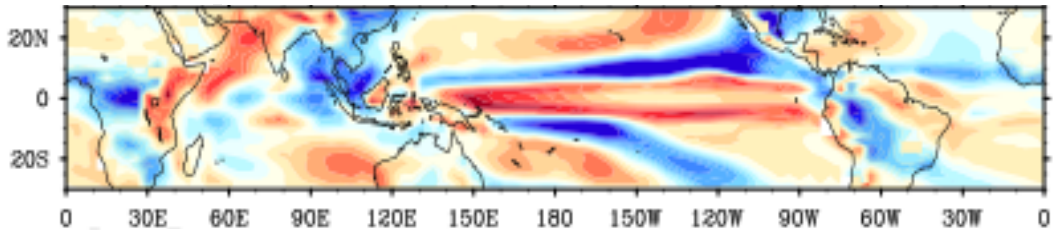


ΔP_{ther} : A wet get wetter, dry get drier regional pattern

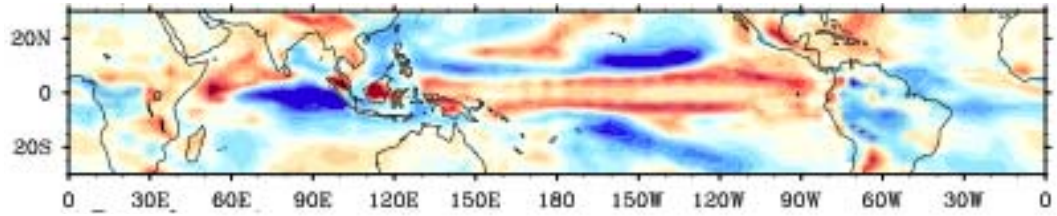
ΔP_{dyn} : A More complex pattern of precipitation changes

Inter-model spread in regional precipitation projections: IPSL-CM5A vs IPSL-CM5B

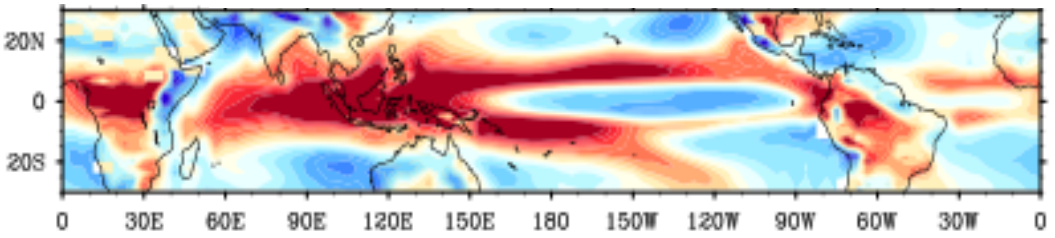
ΔP_{dyn} RCP8.5, end of 21st C-Preindustrial **IPSL-CM5A**



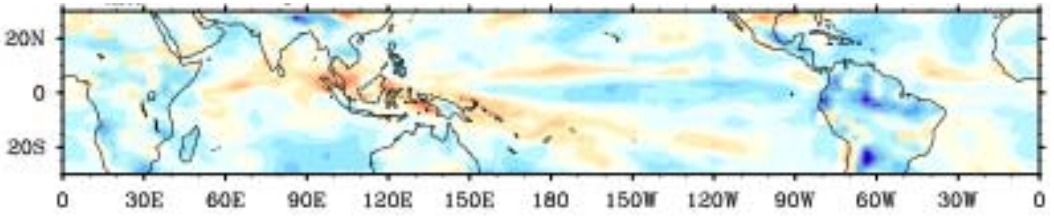
Fast response (1st year of abrupt 4xCO2)



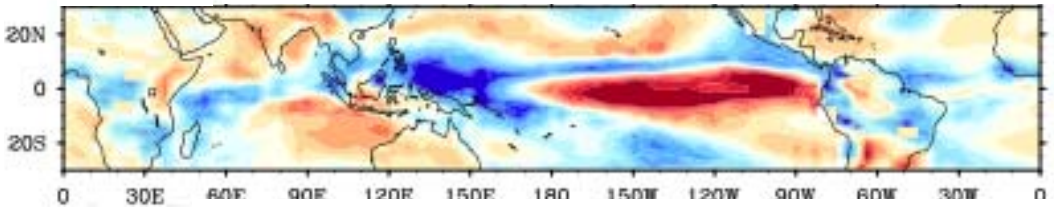
ΔP_{ther} RCP8.5, end of 21st C-Preindustrial **IPSL-CM5A**



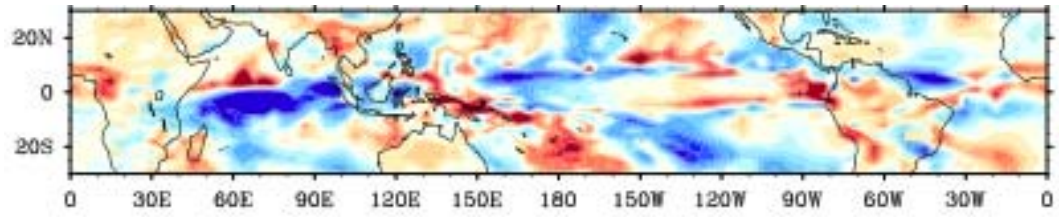
Fast response (1st year of abrupt 4xCO2)



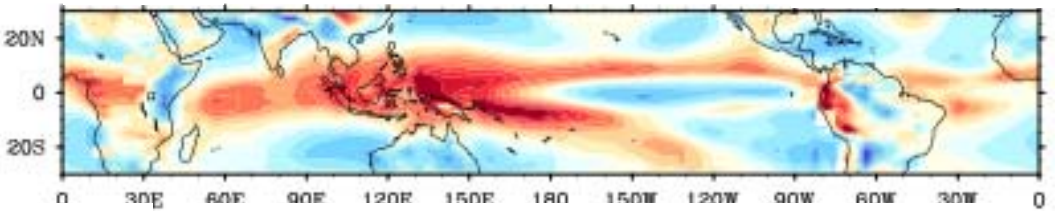
ΔP_{dyn} RCP8.5, end of 21st C-Preindustrial **IPSL-CM5B**



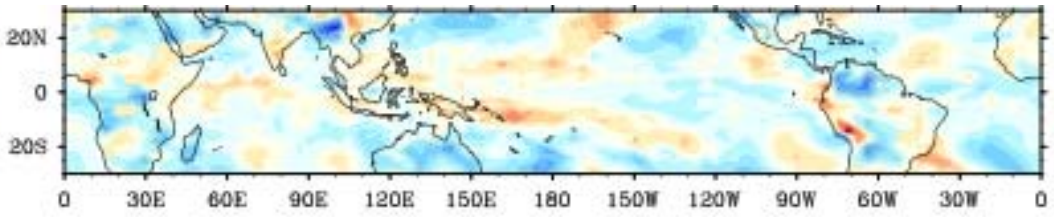
Fast response (1st year of abrupt 4xCO2)

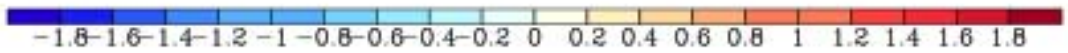


ΔP_{ther} RCP8.5, end of 21st C-Preindustrial **IPSL-CM5B**



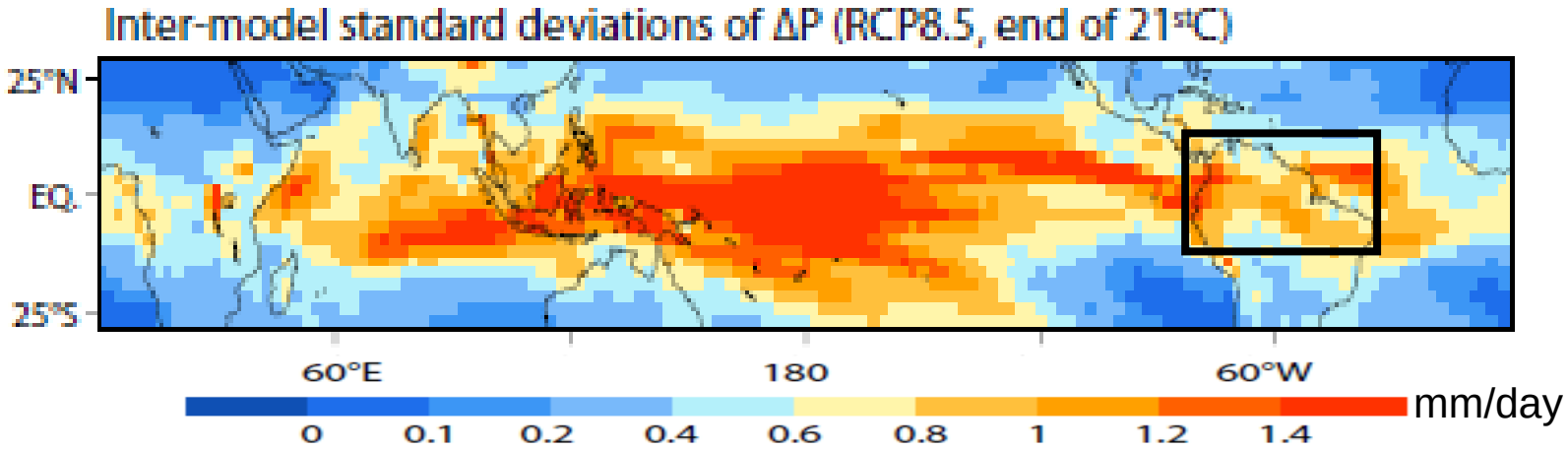
Fast response (1st year of abrupt 4xCO2)



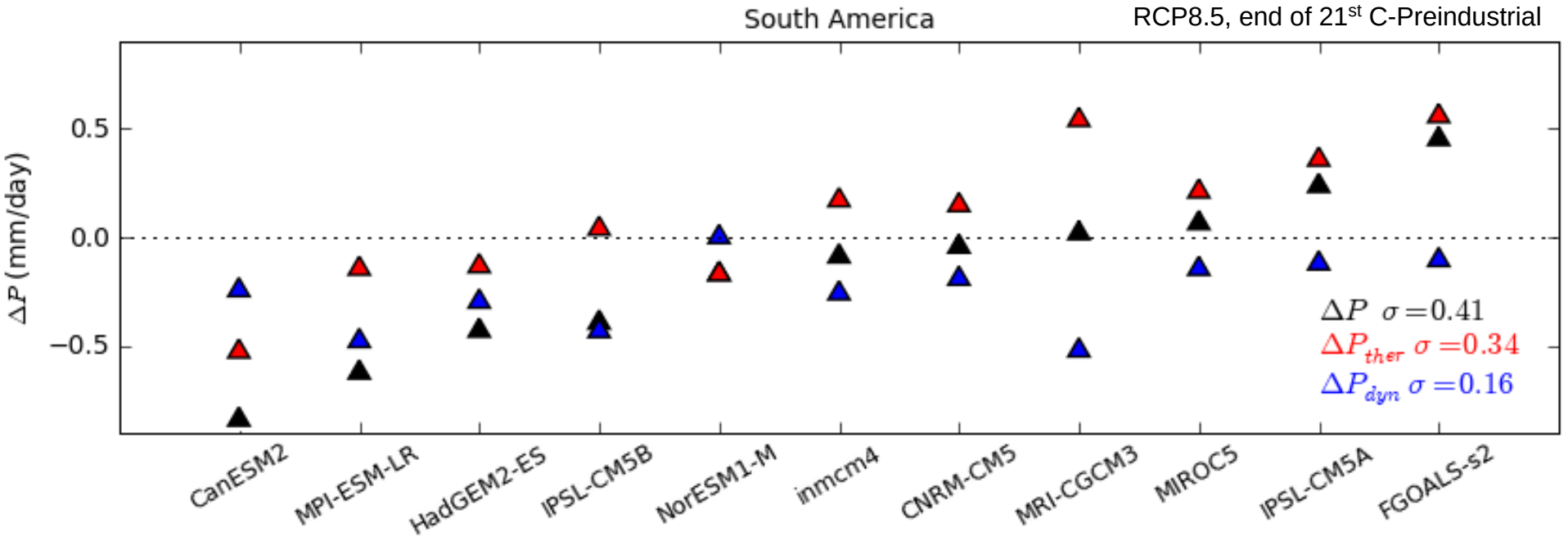


mm/day

Inter-model spread in precipitation projections in South America: A multi-model analysis

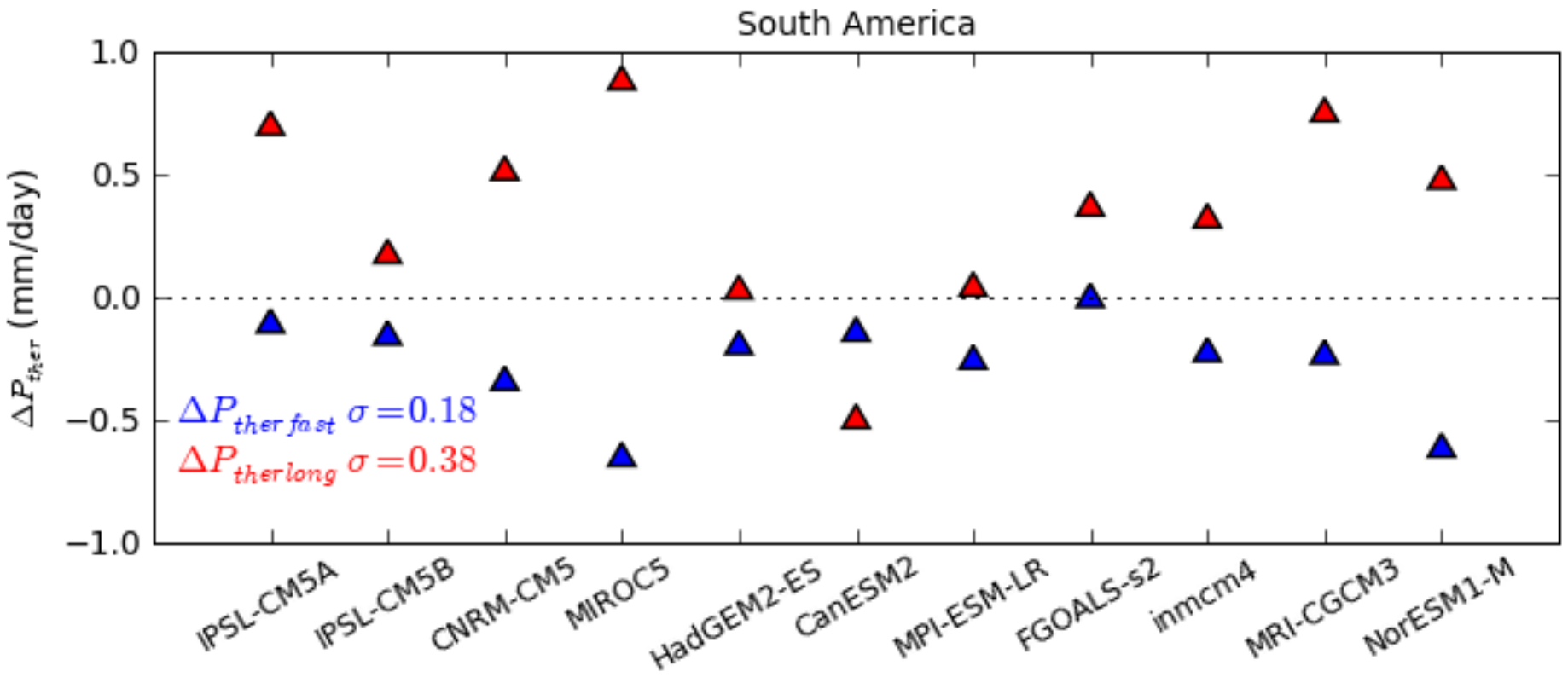


$$\Delta P = \Delta P_{ther} + \Delta P_{dyn}$$



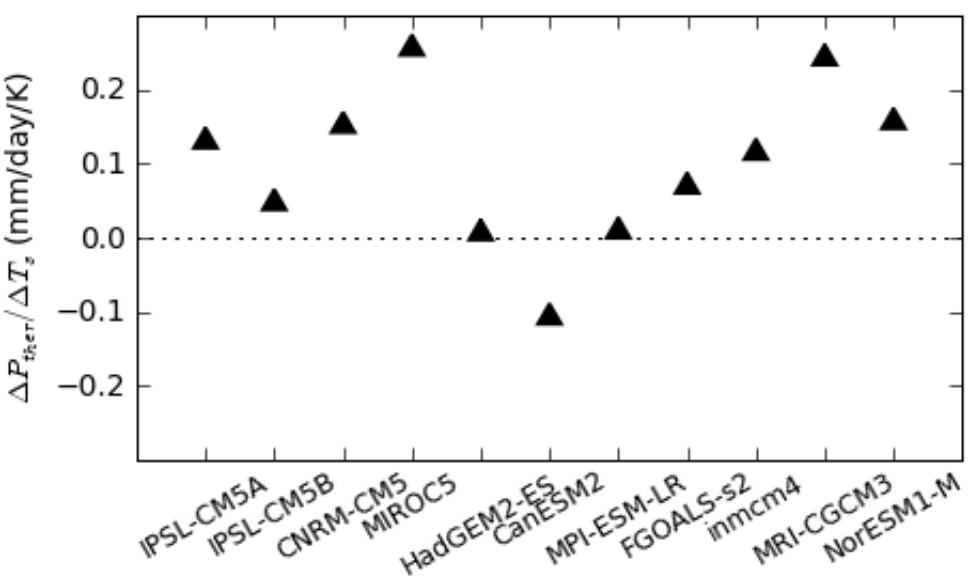
Inter-model spread in precipitation projections in South America: Role of thermodynamic processes

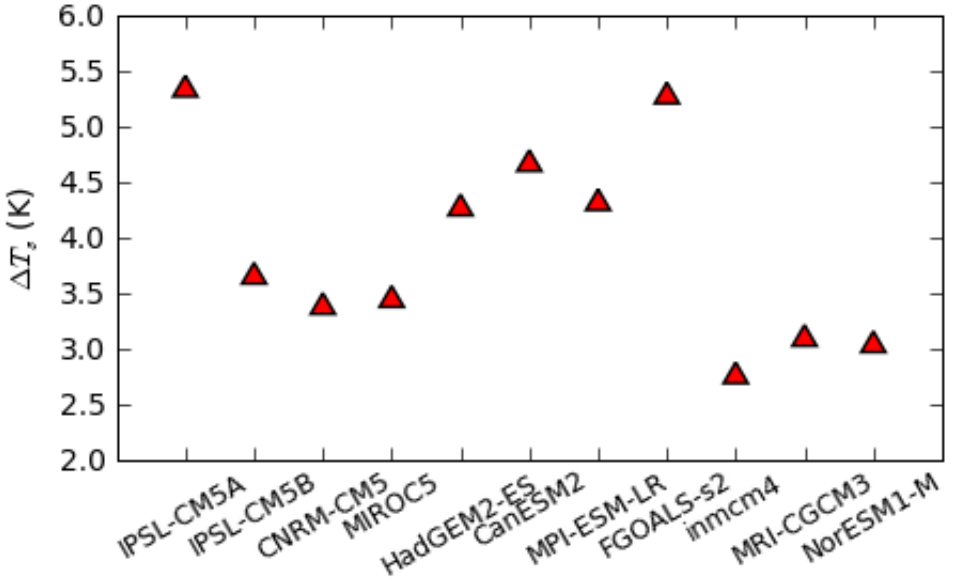
$$\Delta P_{ther} = \Delta P_{ther\ \ Fast} + \Delta P_{ther\ \ Long\ -term}$$



Inter-model spread in precipitation projections in South America: Role of thermodynamic processes

$$\Delta P_{ther} = \Delta P_{ther-Fast} + \frac{\partial P_{ther}}{\partial T_s} \Delta T_s$$



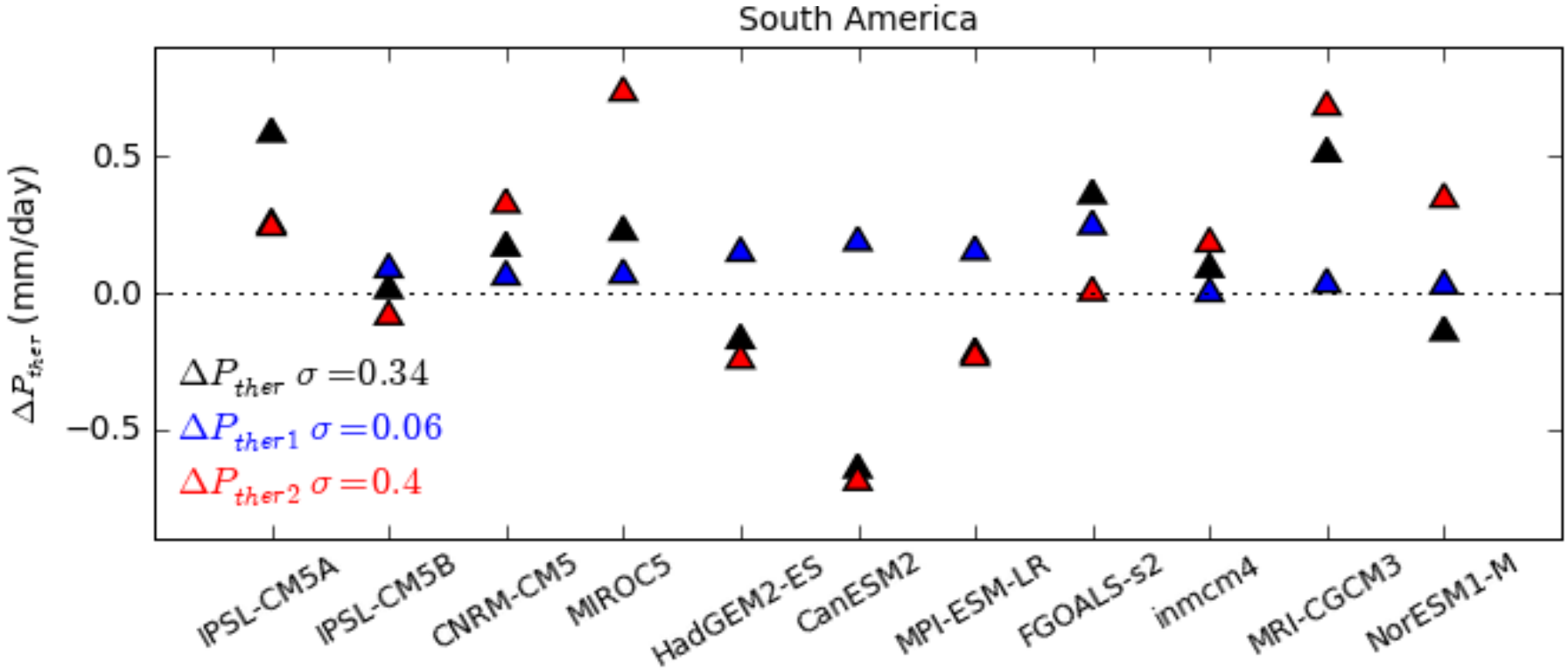


Inter-model spread in precipitation projections in South America: Role of thermodynamic processes

$$\Delta P_{ther} = \Delta P_{ther-Fast} + \frac{\partial P_{ther}}{\partial T_s}\Delta T_s$$

$$\Delta P_{ther\ 1} = [\Delta P_{ther-Fast}] + \left[\frac{\partial P_{ther}}{\partial T_s}\right]\Delta T_s, \qquad [\ ] \text{ Multi-model mean}$$

$$\Delta P_{ther\ 2} = [\Delta P_{ther-Fast}] + \frac{\partial P_{ther}}{\partial T_s}[\Delta T_s]$$



Conclusions

A methodology (Bony et al., 2013) is applied to investigate possible sources of inter-model spread in precipitation projections:

- Separate dynamical and thermodynamical processes
- Separate fast and long-term processes
- Assess quantitatively the contribution of each physical process in the spread

Different behaviours over ocean and land:

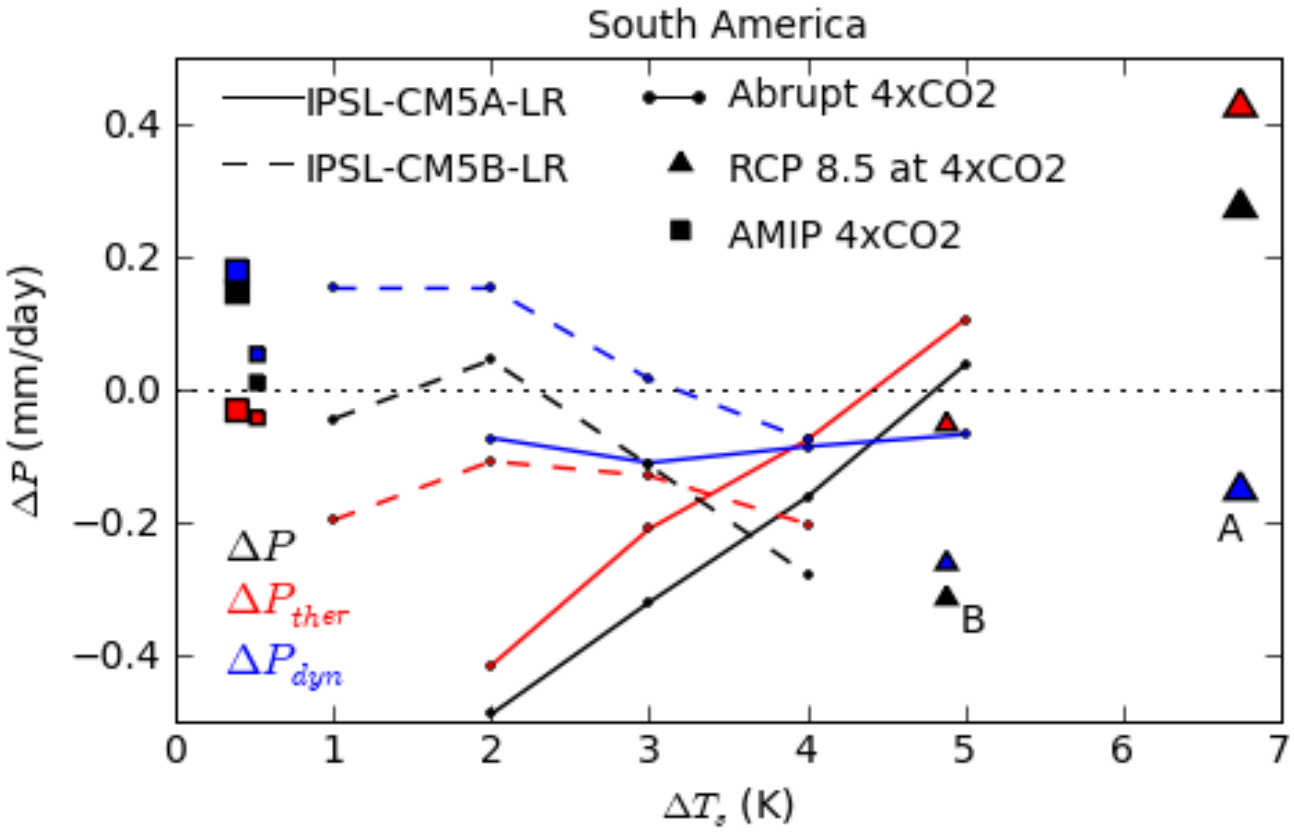
- Over ocean : A large part of the spread is explained by fast dynamical processes
- Over land (South America) : A large part is explained by long-term thermodynamical processes

Outlook

Understand the sources of spread in the thermodynamical response in South America

$$\Delta P_{ther} = \Delta P_{ther-Fast} + \boxed{\frac{\partial P_{ther}}{\partial T_s}} \Delta T_s$$

$$\Delta P_{ther} = \Delta E + \Delta H_q + \overline{\omega} \Delta \Gamma_q + V_q^{\alpha}$$



Thank you for your attention