Interpreting inter-model spread in regional precipitation projections

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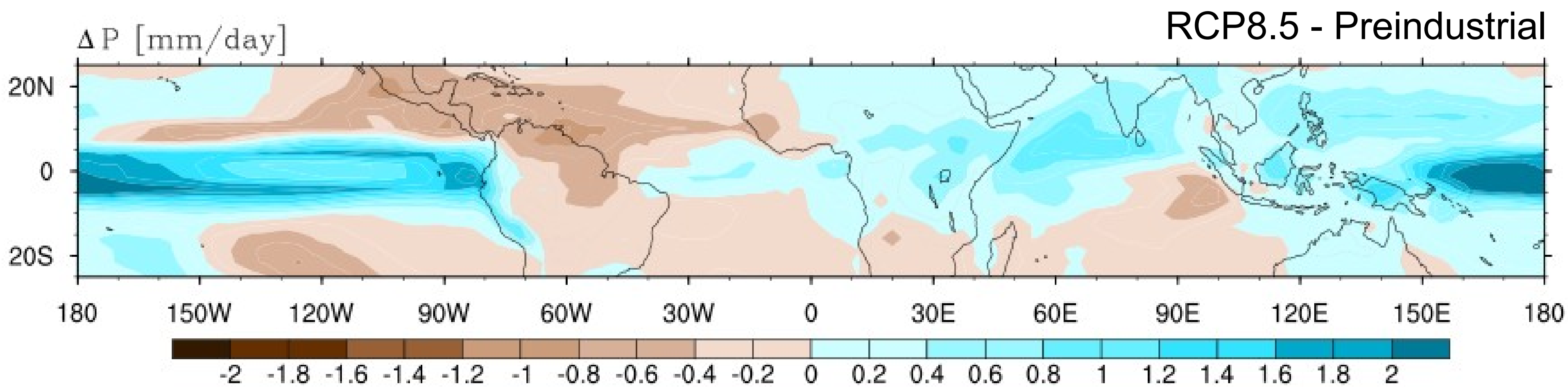
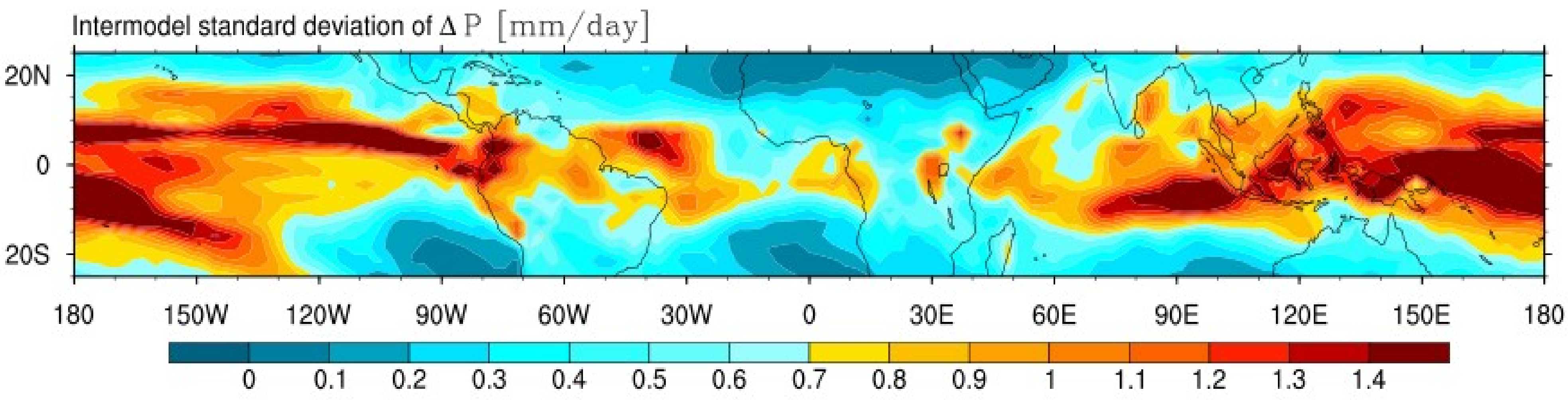
Annual mean precipitation : Changes and Spread





Models : IPSL-CM5B-LR, CNRM-CM5, MPI-ESM-LR, IPSL-CM5A-LR, MIROC5, CanESM2, HadGE2-ES, FGOALS-s2, MRI-CGCM3, NorESM1-M, inmcm4

Analysis methodology (Bony et al., 2013)

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

ω can be decomposed as:

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

Then,

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

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

Role of dynamic and thermodynamic processes

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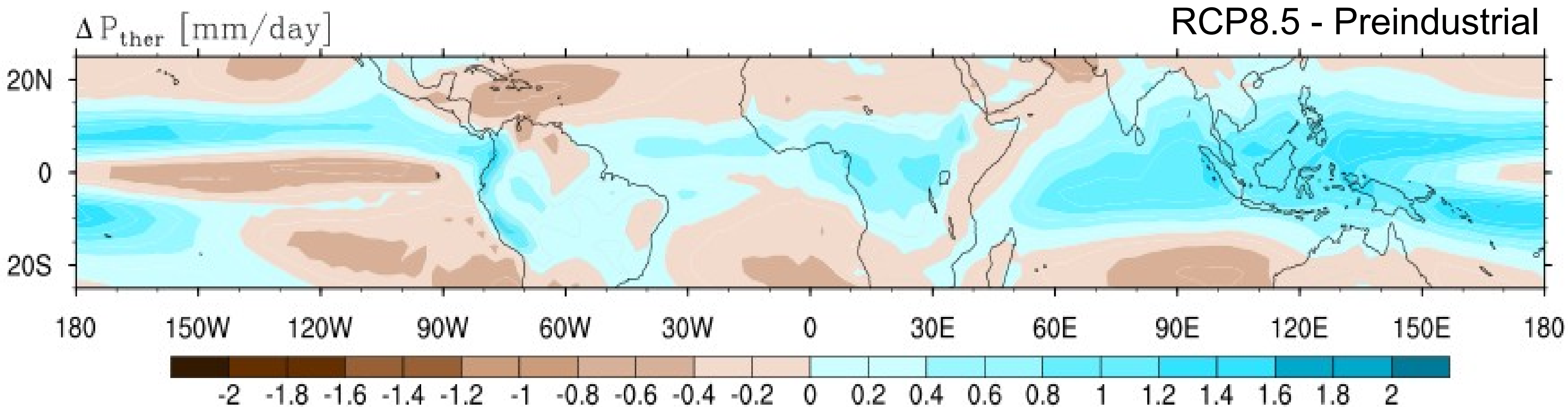
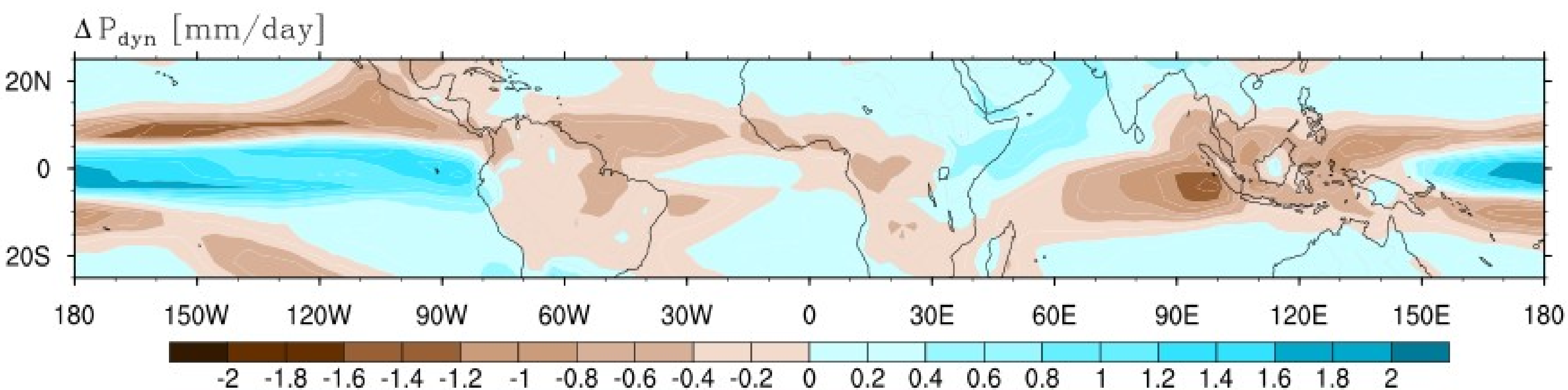
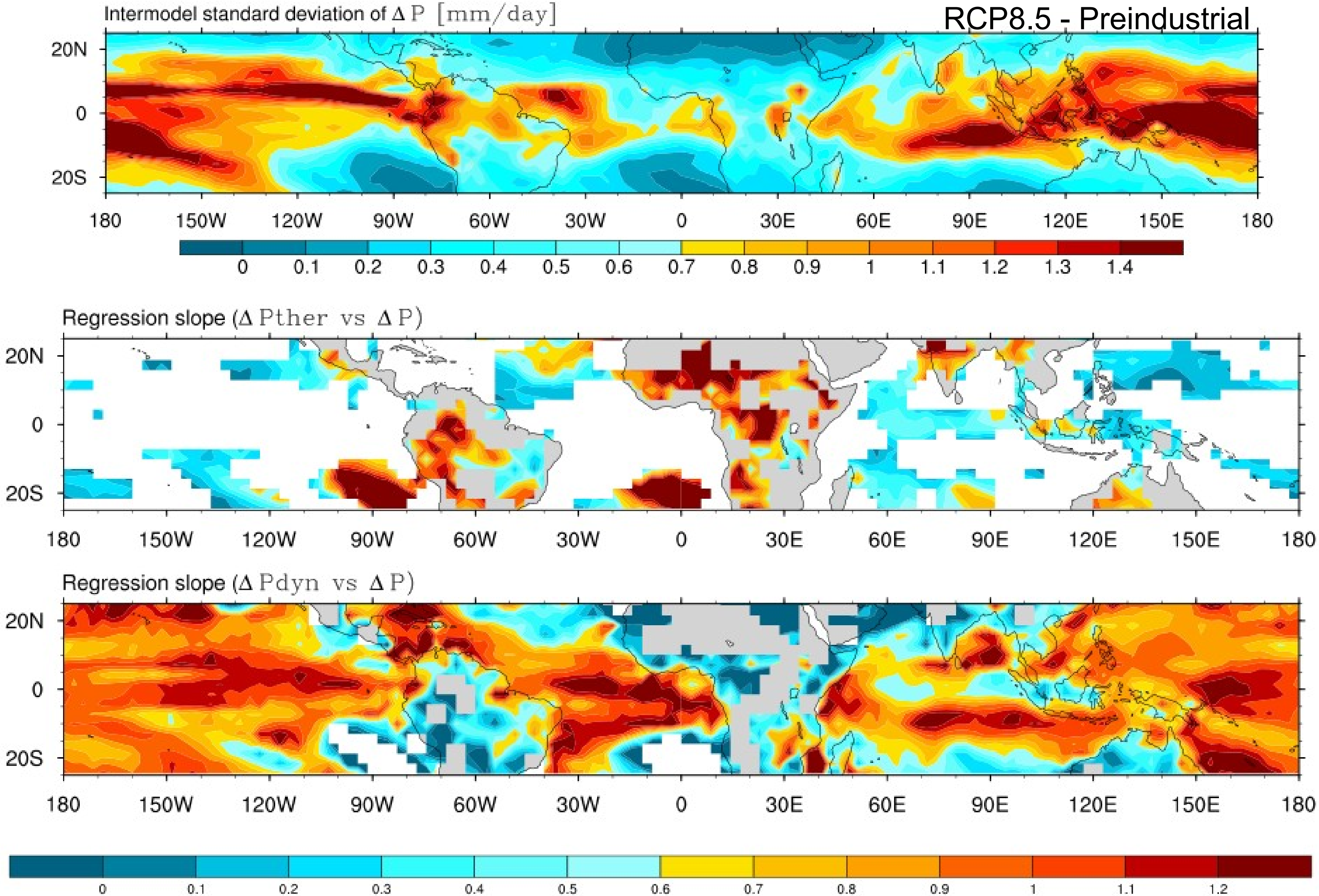




Role of dynamic and thermodynamic processes

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



Fast vs Long-term processes

$$\Delta P_i = \Delta P_{i-Fast} + \frac{\partial P_i}{\partial T_i}\Delta T_s$$

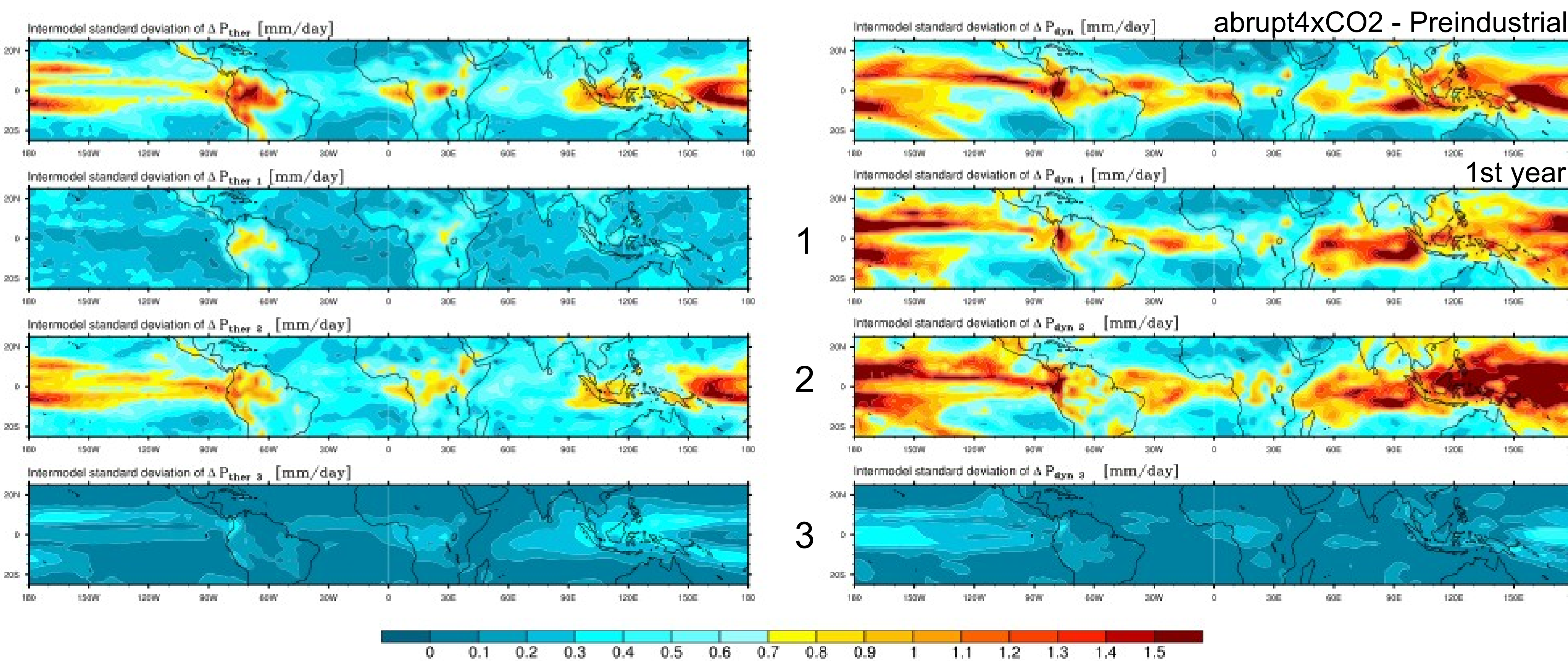
[ ] Multi-model mean

i : ther ou dyn

$$\Delta P_{i1} = \Delta P_{i-Fast} + \left[\frac{\partial P_i}{\partial T_i}\Delta T_s\right]$$

$$\Delta P_{i3} = [\Delta P_{i-Fast}] + \left[\frac{\partial P_i}{\partial T_i}\right]\Delta T_s$$

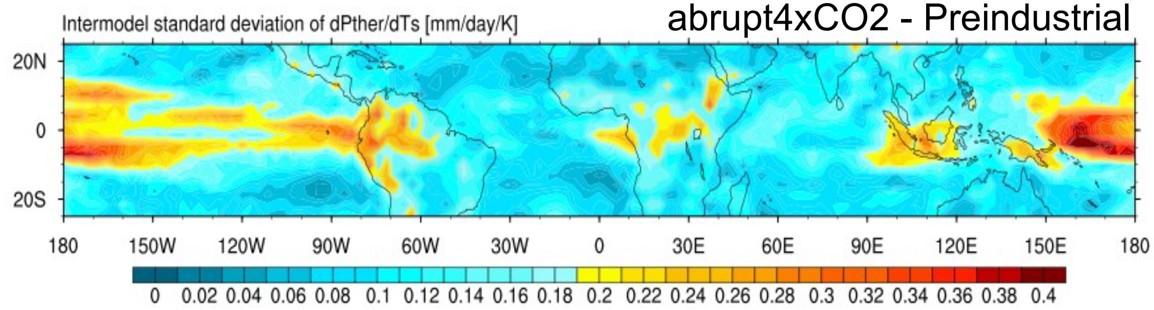
$$\Delta P_{i2} = [\Delta P_{i-Fast}] + \frac{\partial P_i}{\partial T_i}[\Delta T_s]$$

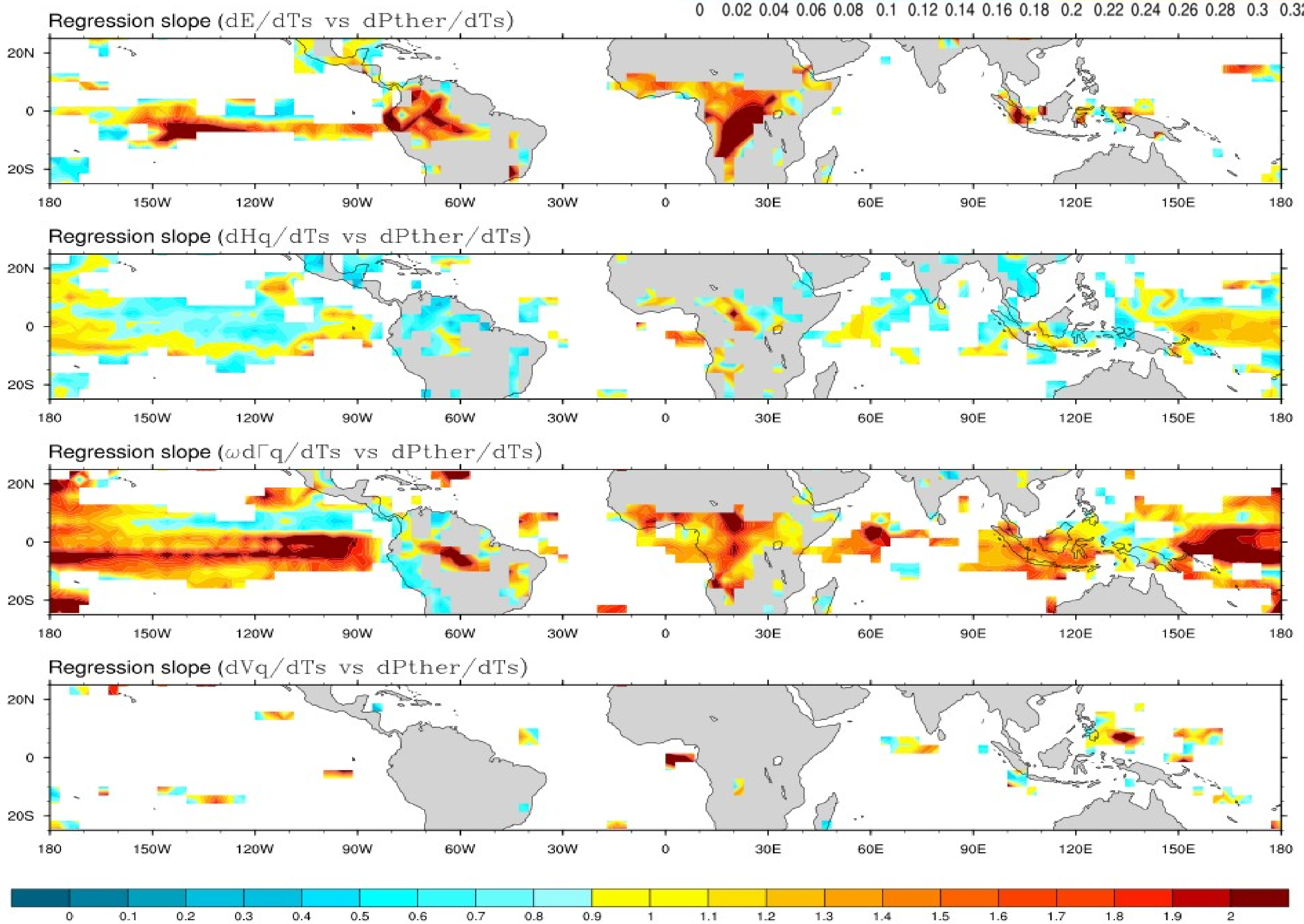


Interpretation of the thermodynamic component (dPther/dTs)

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

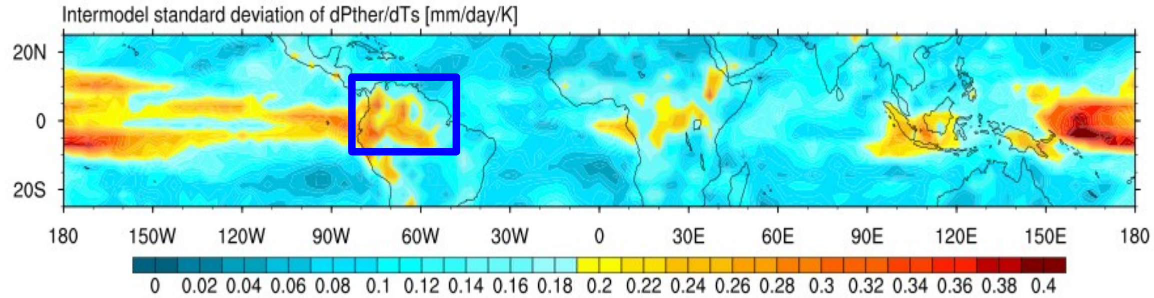
abrupt4xCO2 - Preindustrial

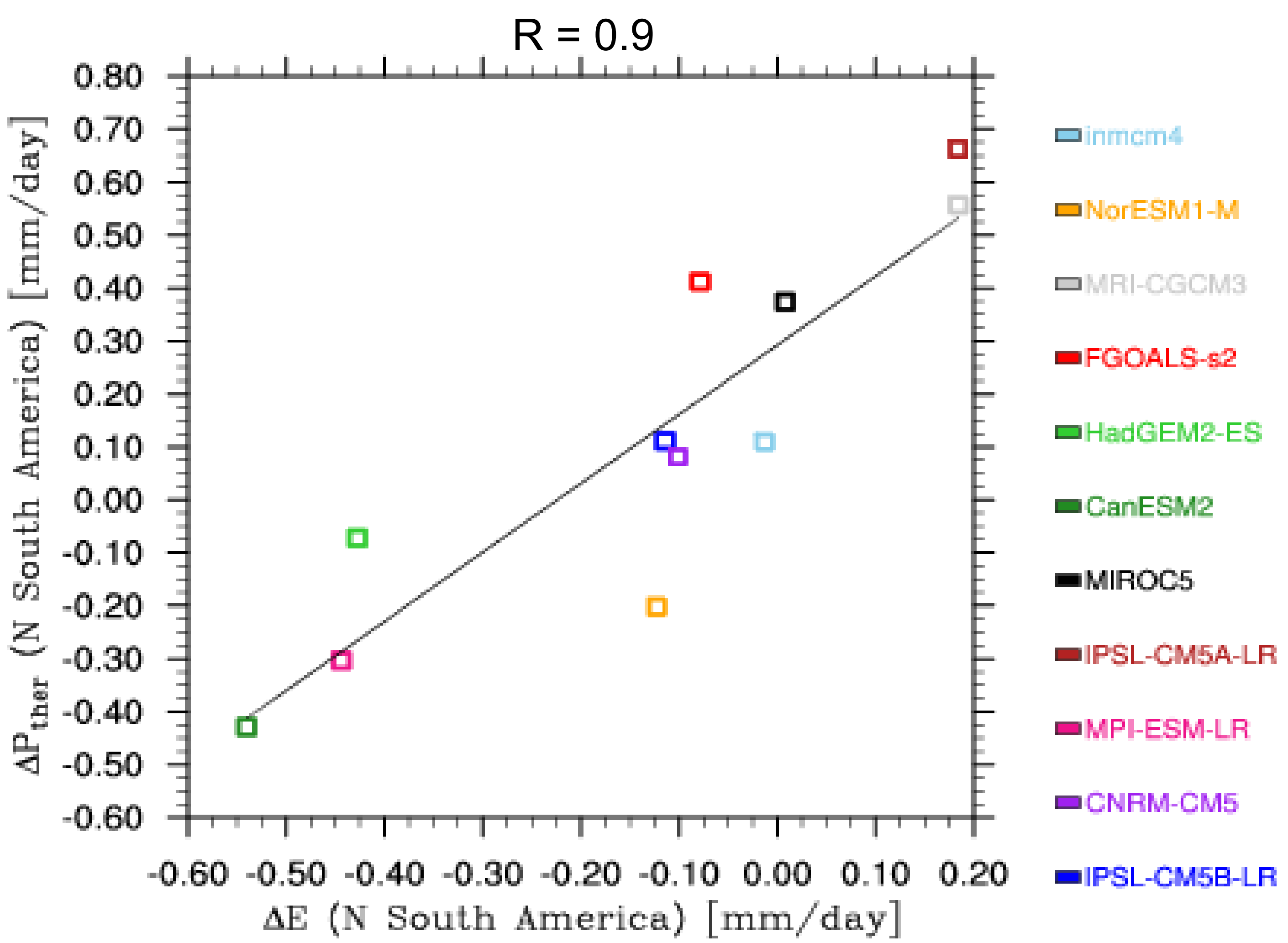




Interpretation of the thermodynamic component

Role of evaporation





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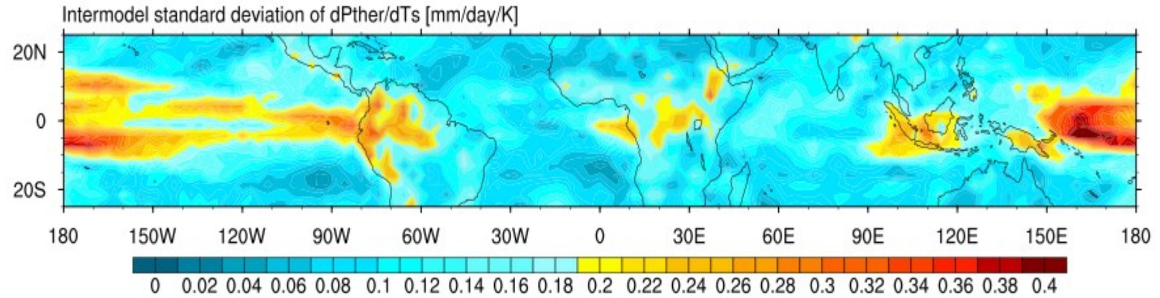
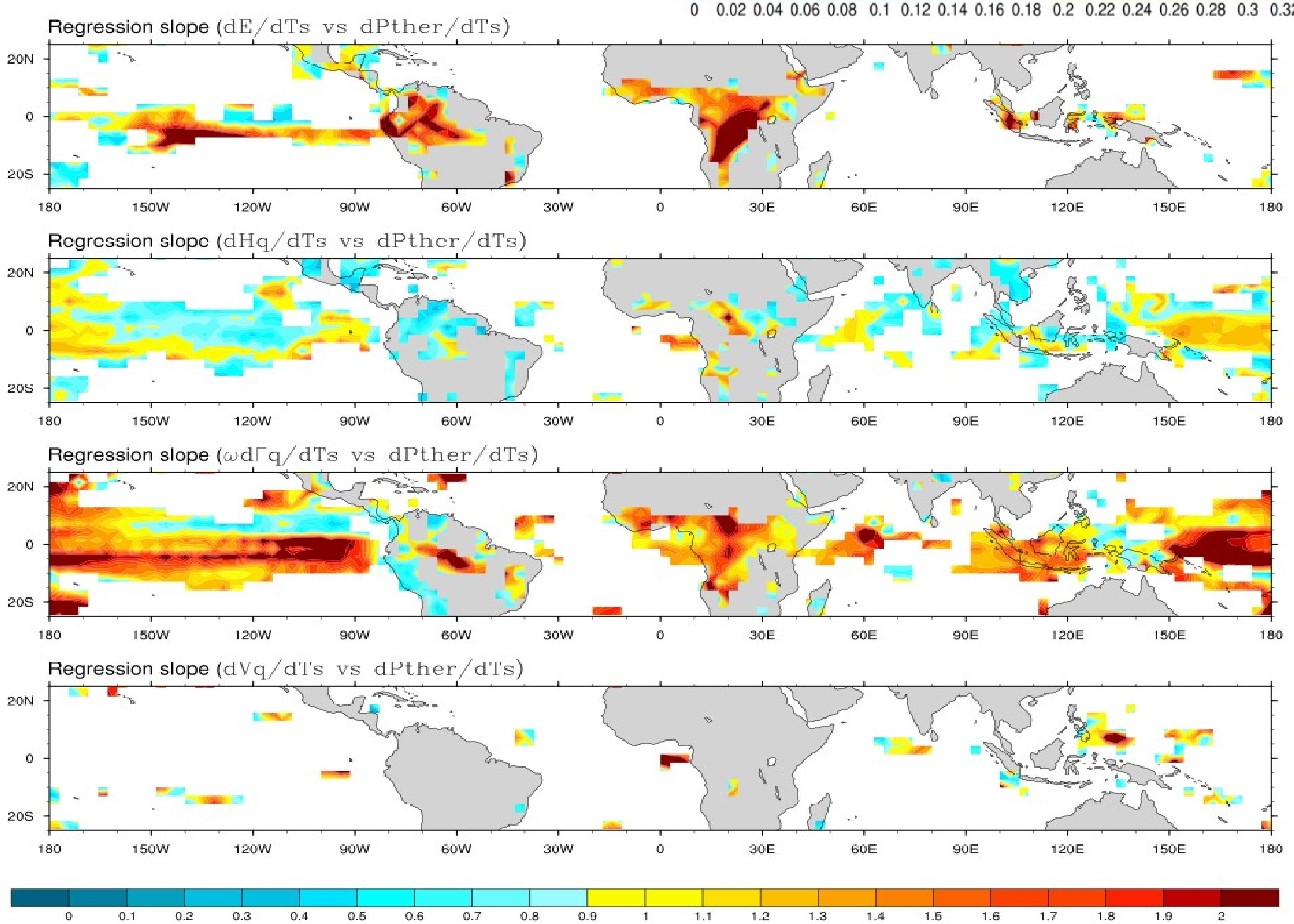
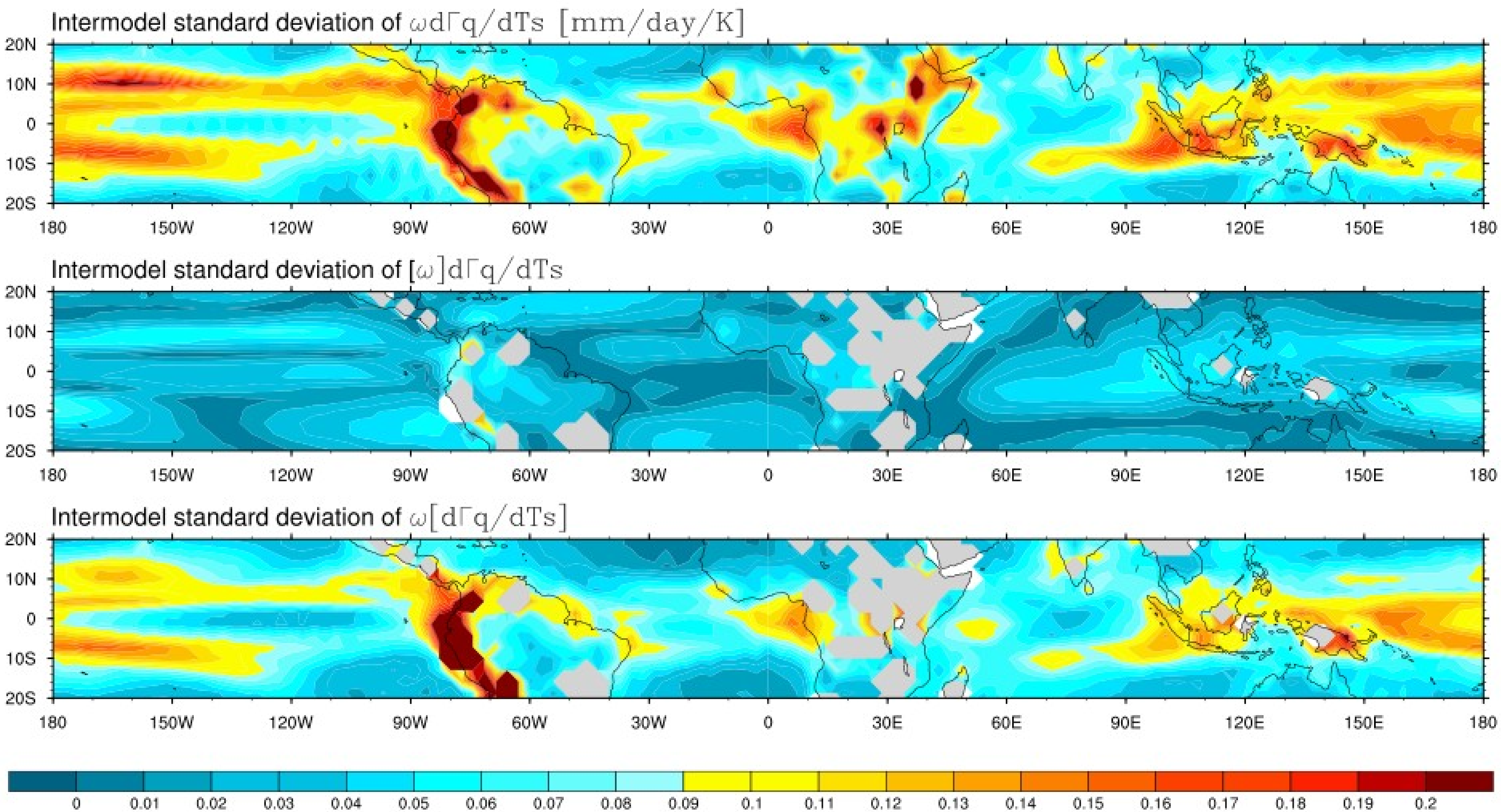




Interpretation of the thermodynamic component

Role of climatology

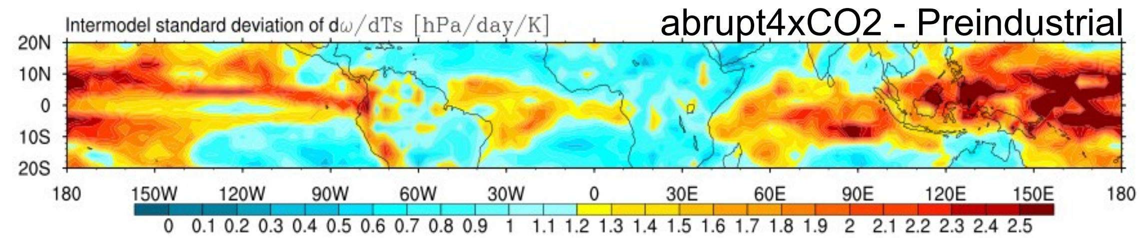
$$\overline{\omega}\Delta\Gamma_q \rightarrow [\overline{\omega}]\Delta\Gamma_q$$
$$\overline{\omega}\Delta\Gamma_q \rightarrow \overline{\omega}[\Delta\Gamma_q]$$

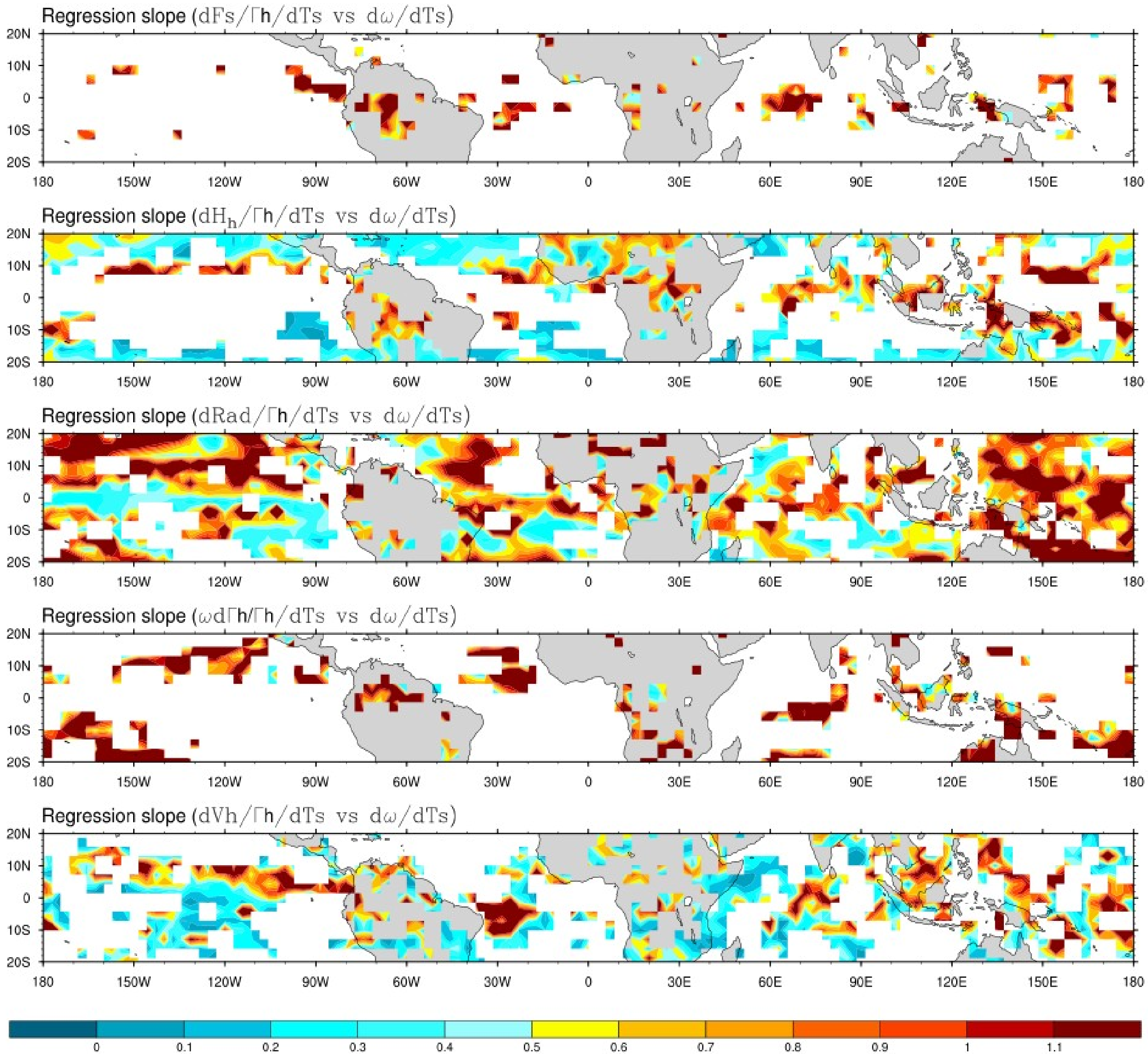


Interpretation of the dynamic component (dPdyn/dTs)

$$F_s + Rad + \overline{\omega}\Gamma_h + V_h^{\alpha} + H_h = 0$$

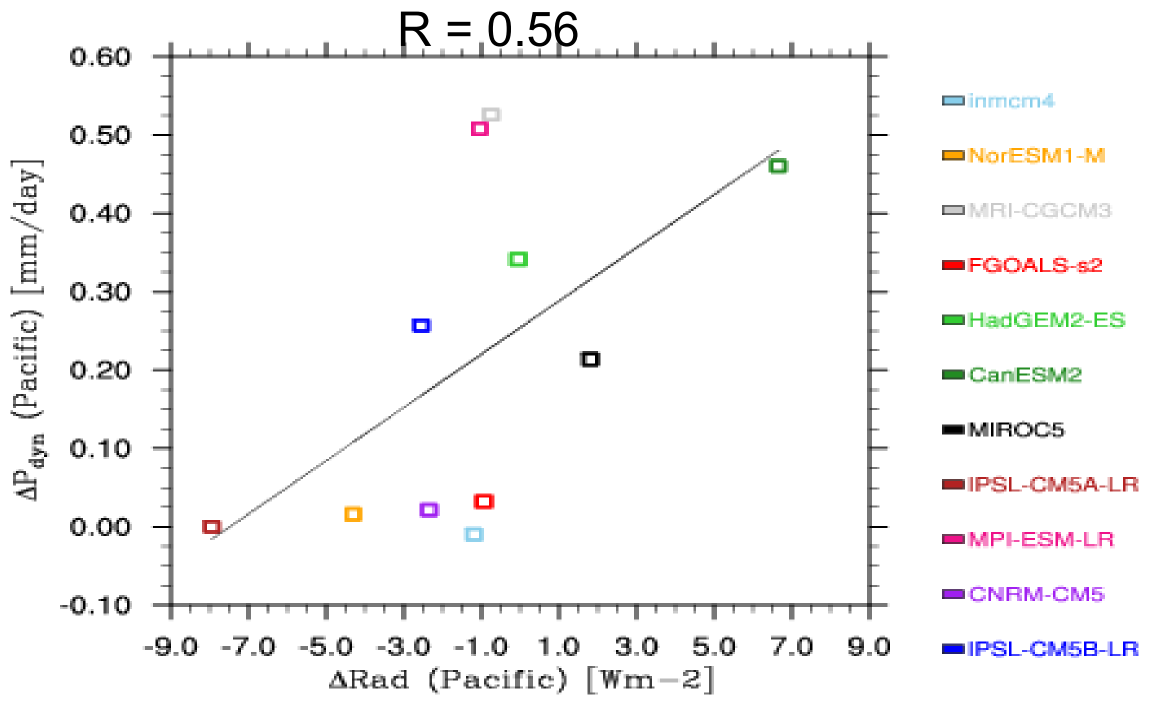
$$\Delta\overline{\omega} = -\frac{1}{\Gamma_h}\left(\Delta F_s + \Delta Rad + \overline{\omega}\Delta\Gamma_h + \Delta V_h^{\alpha} + \Delta\overline{\omega}\Delta\Gamma_h\right)$$

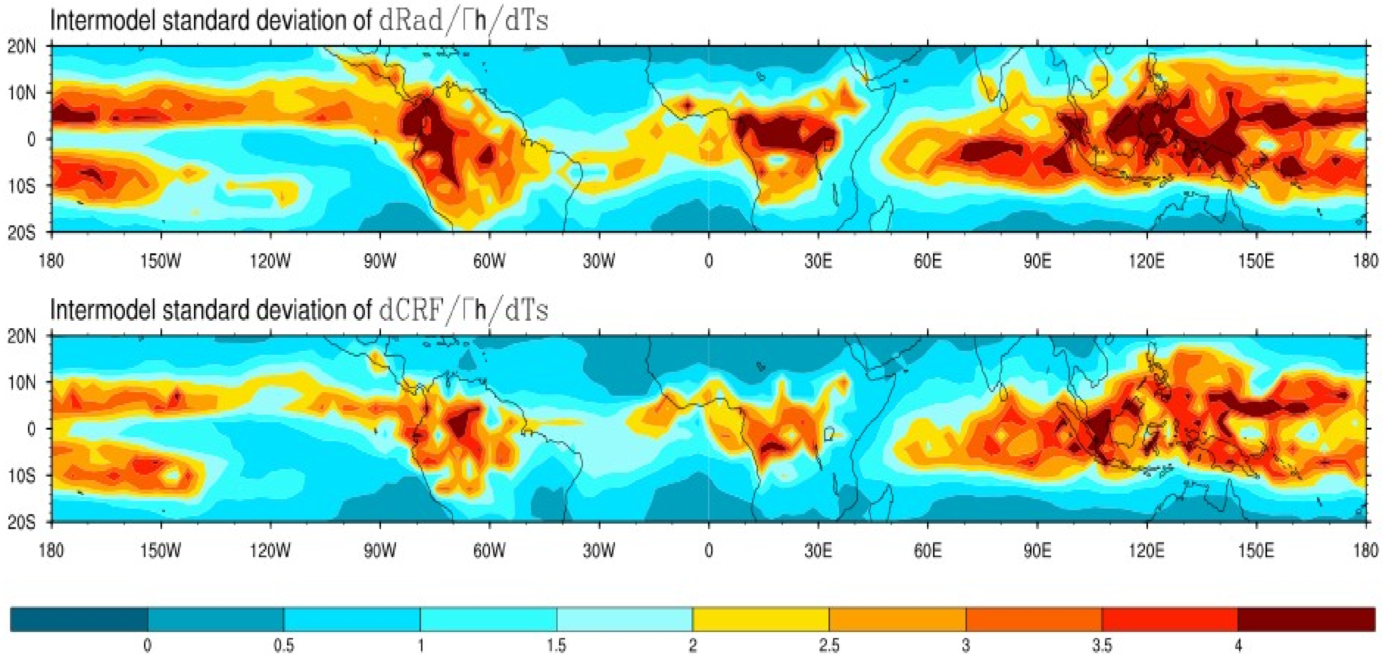




Interpretation of the dynamic component

Role of radiative cooling and cloud radiative effect



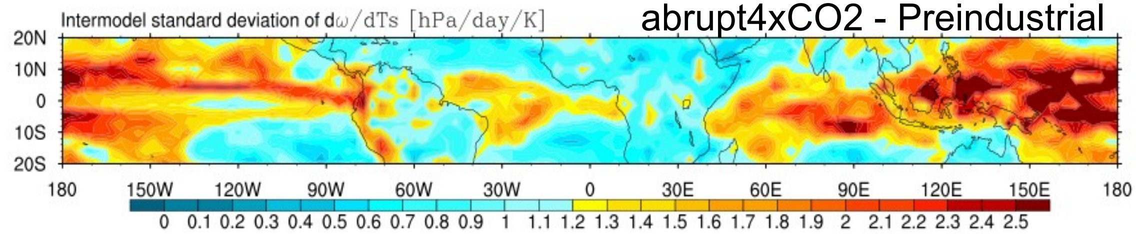


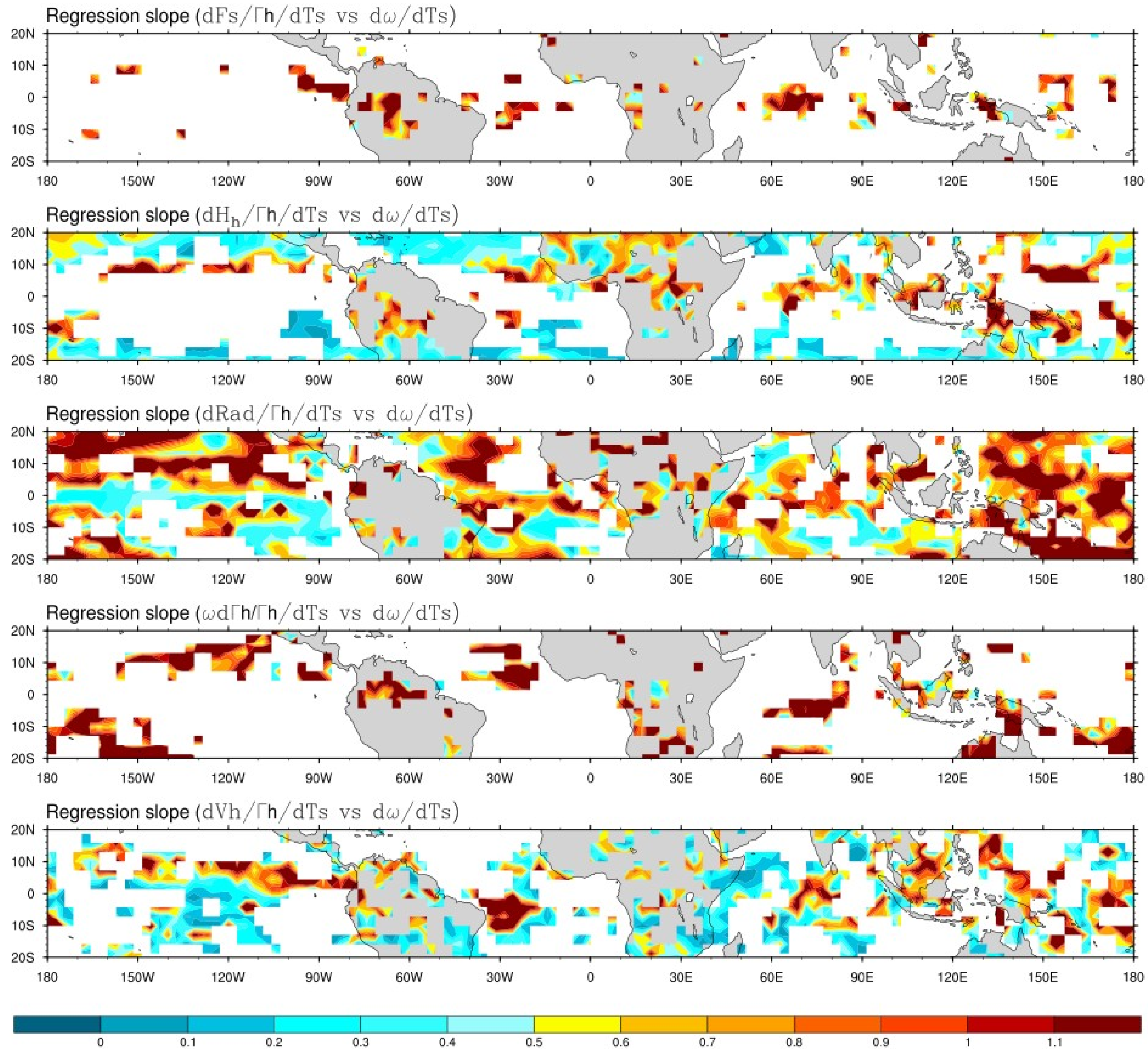
Interpretation of the dynamic component (dPdyn/dTs)

$$F_s + Rad + \overline{\omega}\Gamma_h + V_h^\alpha + H_h = 0$$

$$\Delta\overline{\omega} = -\frac{1}{\Gamma_h}\left(\Delta F_s + \Delta Rad + \overline{\omega}\Delta\Gamma_h + \Delta V_h^\alpha + \Delta\overline{\omega}\Delta\Gamma_h\right)$$

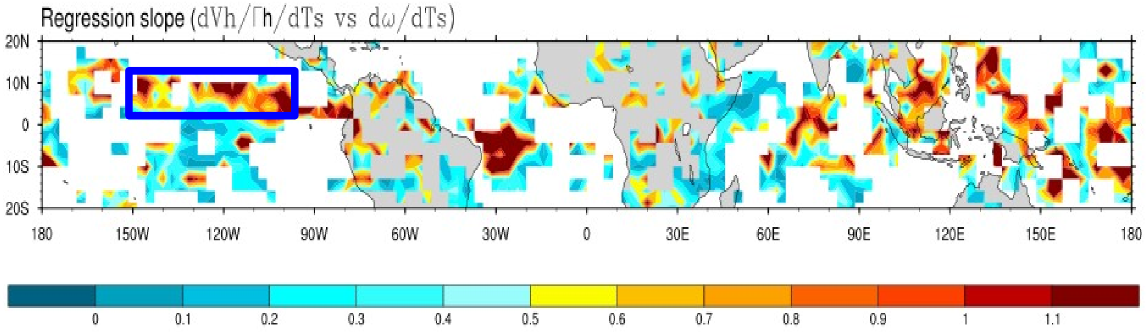
abrupt4xCO2 - Preindustrial

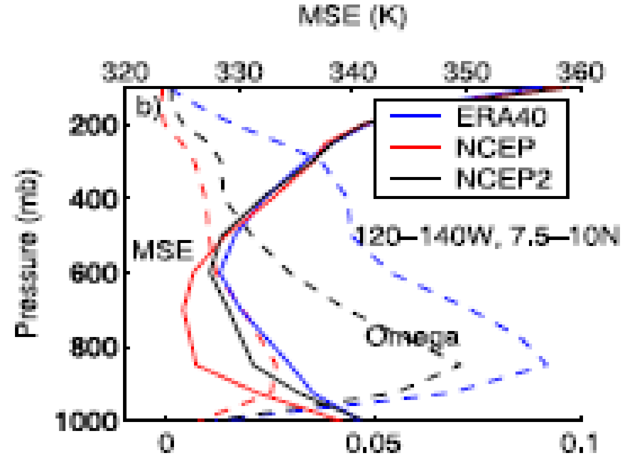




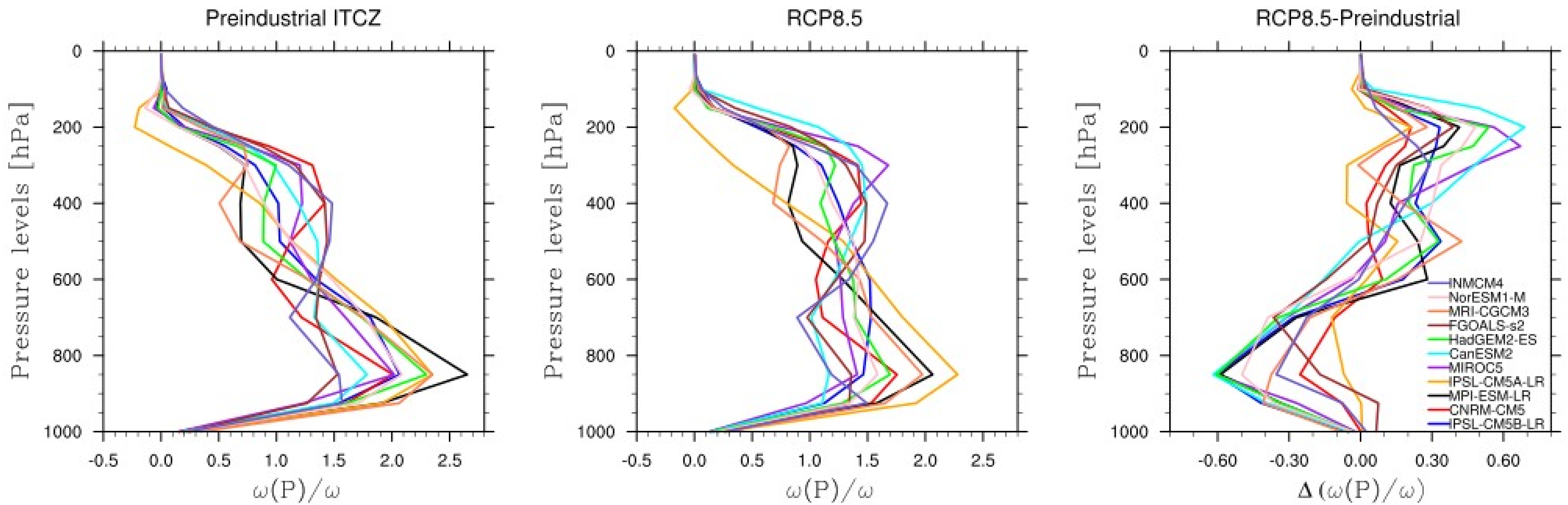
Interpretation of the dynamic component

Role of w vertical profile



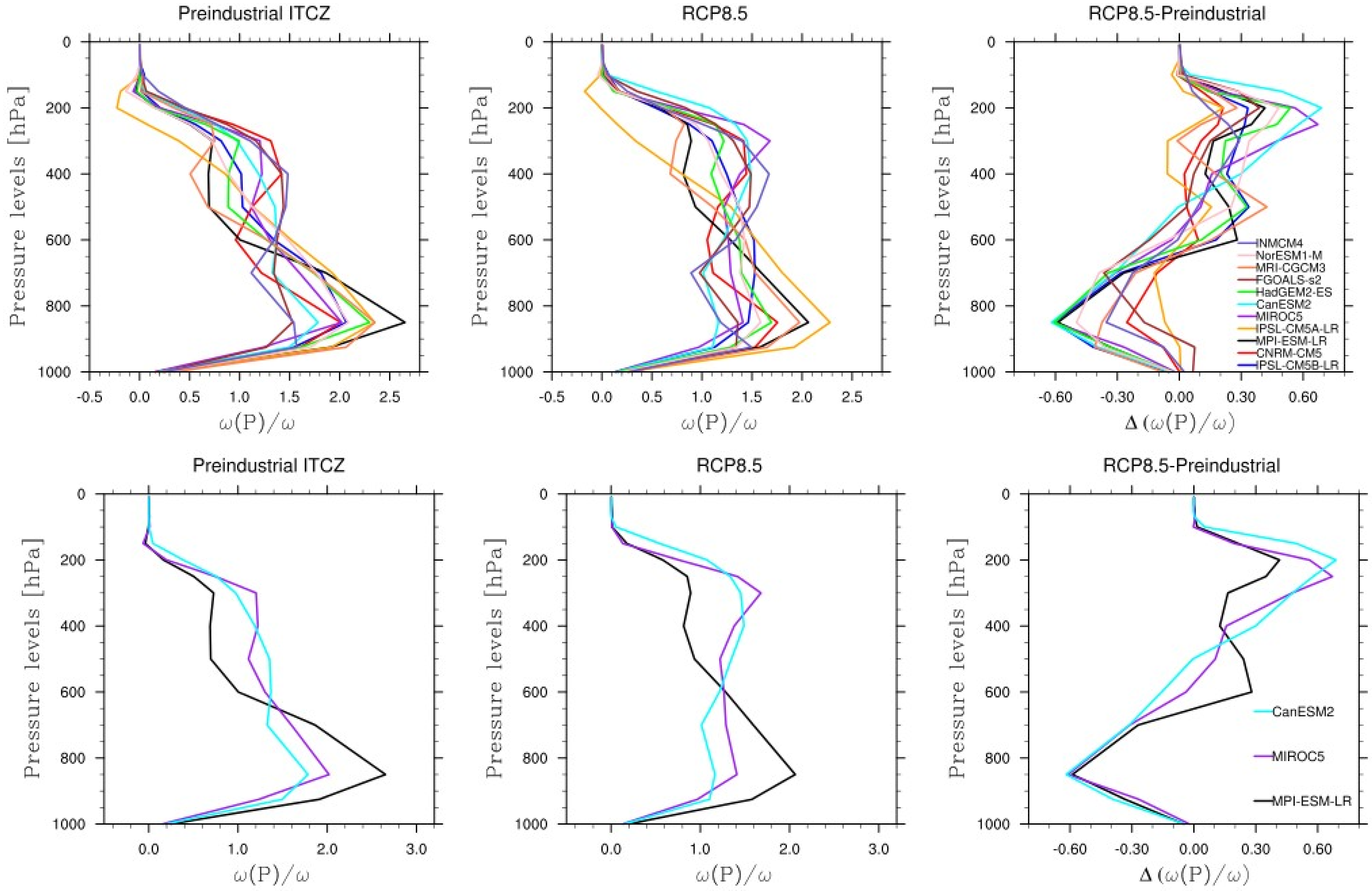


Back and Bretherton (2006)



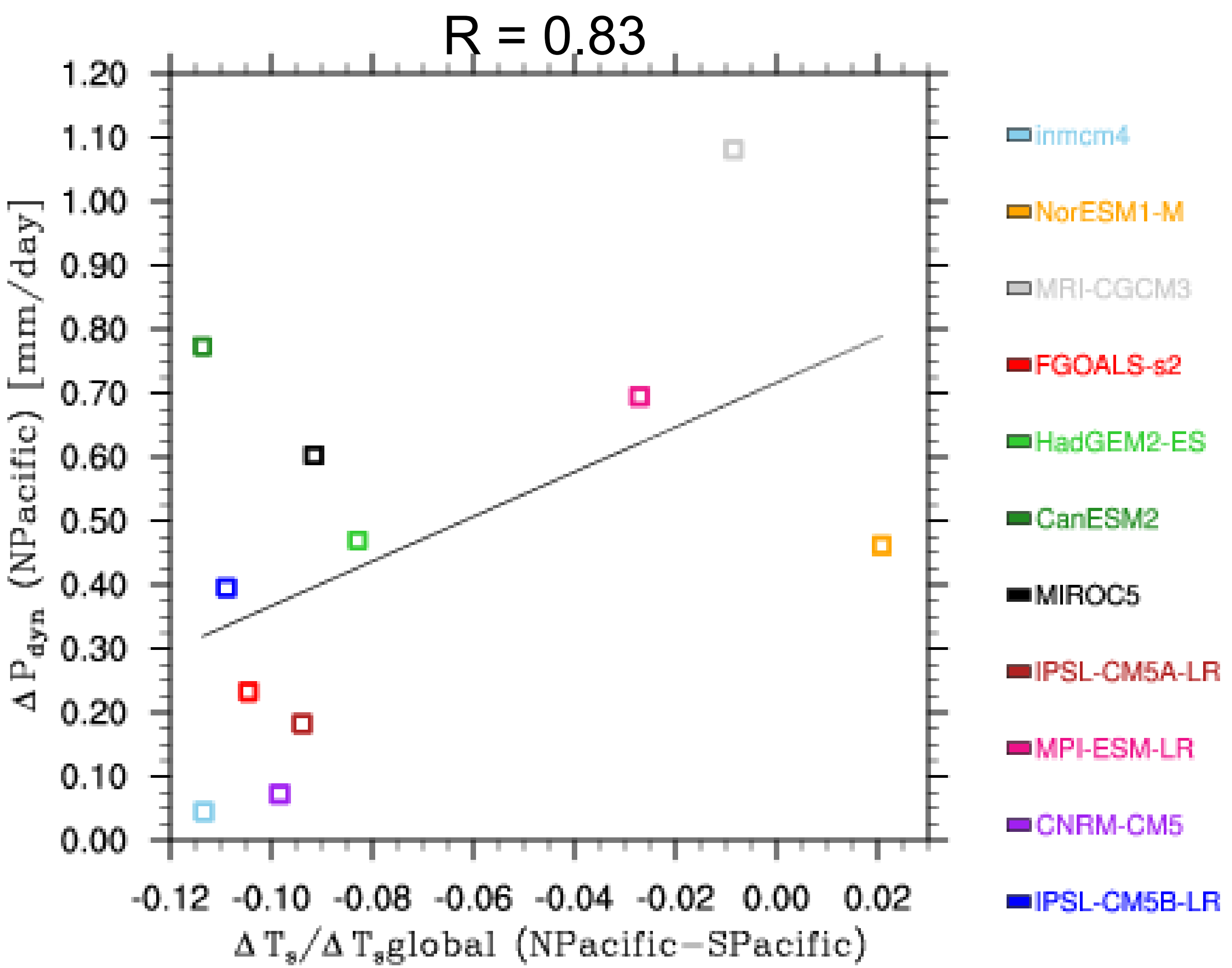
Interpretation of the dynamic component

Role of w vertical profile



Interpretation of the dynamic component

Role of SST gradients on w vertical profile



Conclusions

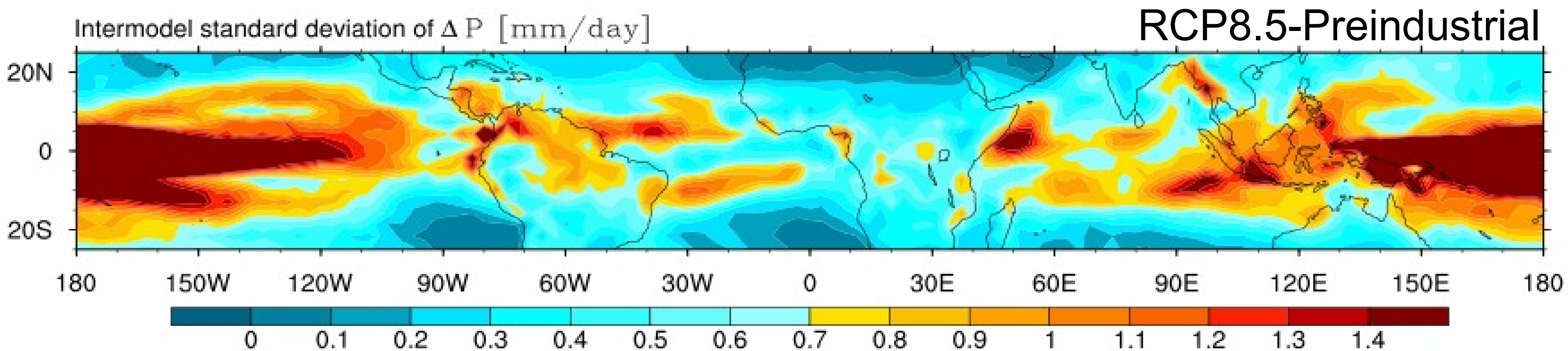
The present study investigates possible sources of intermodel spread in precipitation projections:

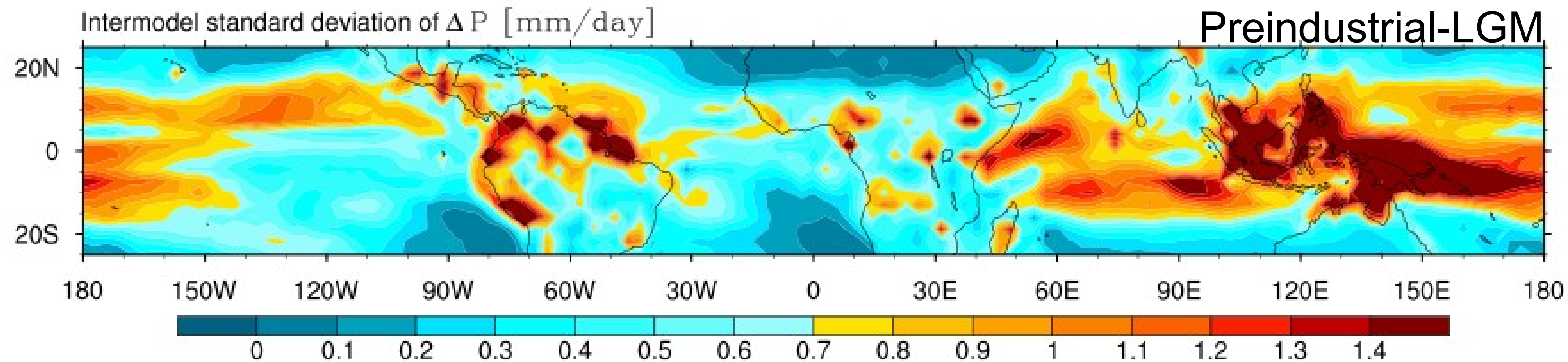
- The dynamic component dominates over oceans and along continental coasts through the spread in CRE and w vertical profile

- The thermodynamic component dominates over continental interiors through the spread in evaporation and w climatology

Outlook

Comparison with paleoclimate simulations (Last Glacial Maximum, Mid-Holocene)

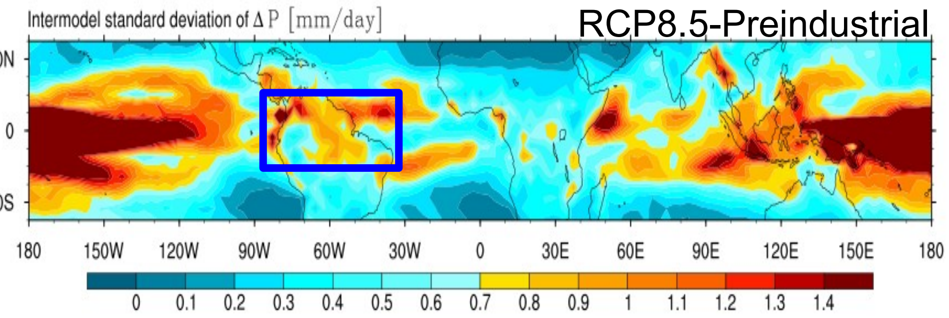


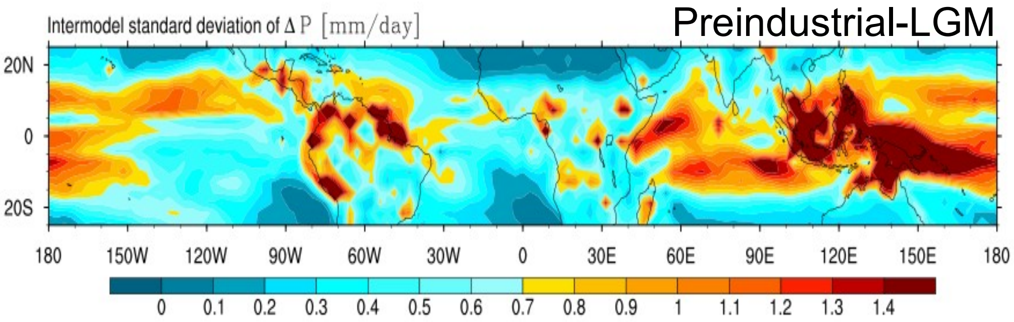


Models: FGOALS-g2, CNRM-CM5, MIROC-ESM, MRI-CGCM3, GISS-E2-R, CCSM4, MPI-ESM-P

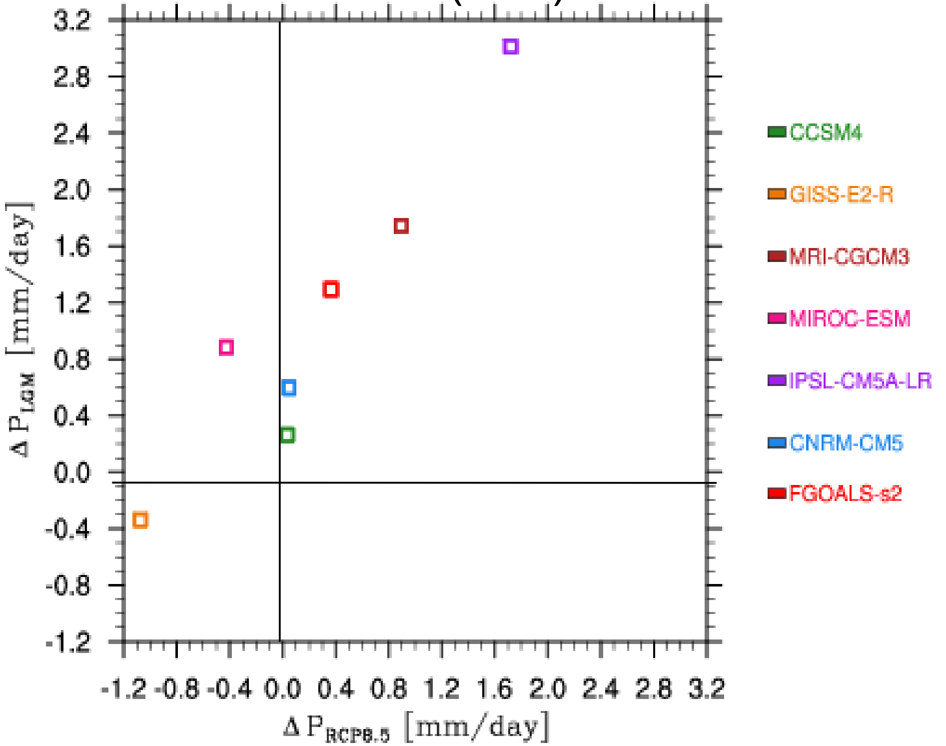
Outlook

Comparison with paleoclimate simulations (Last Glacial Maximum, Mid-Holocene)





R=0.9 (DJF)



Thank you for your attention

Relative changes in annual mean precipitation

RCP8.5 - Preindustrial