Constraining future precipitation changes in South America using paleoclimate archives: 1) CMIP5 analysis 2) isotopic modeling

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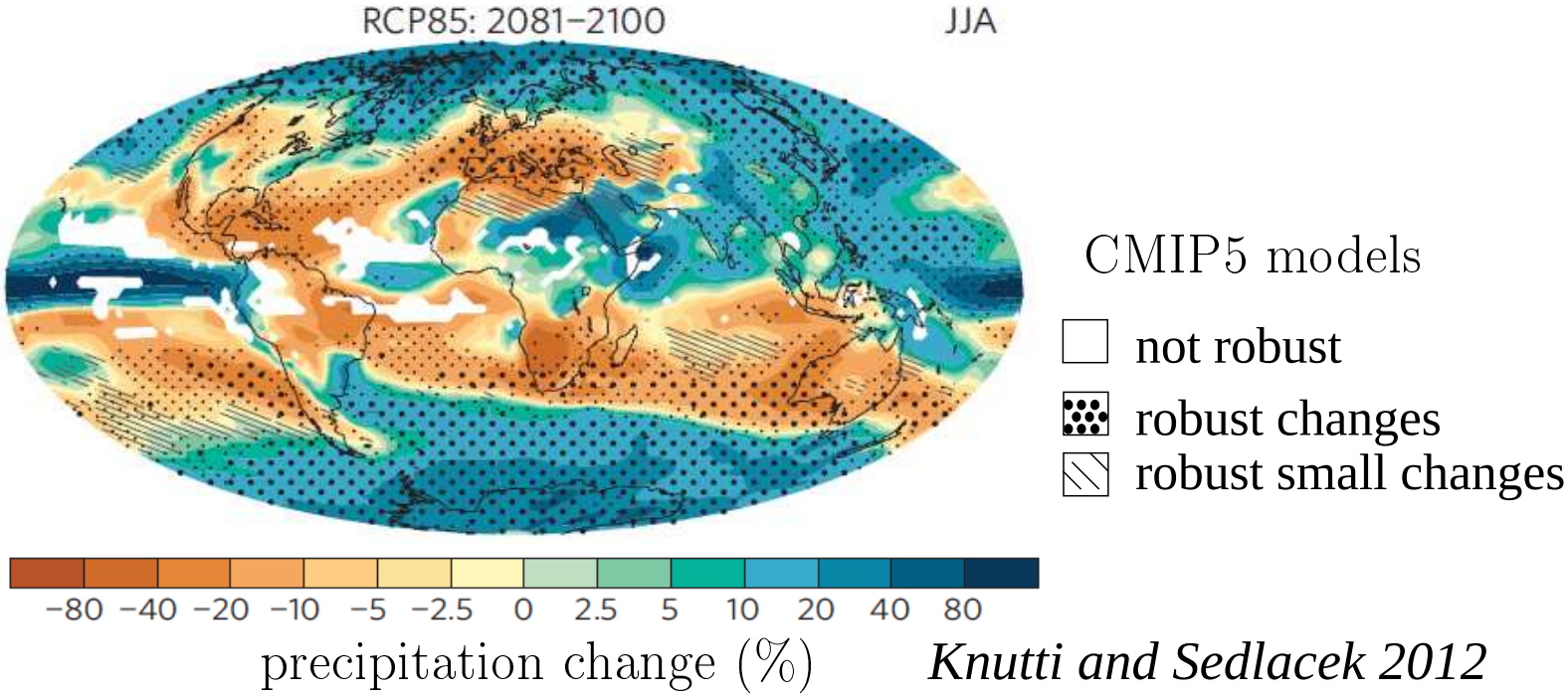
Informal seminar at University of Stockholm

29 July 2013

Spread in precipitation projections



Knutti and Sedlacek 2012

- Can we assess the credibility of projections of South American precip using past changes?
  If a model is good for the past, do we expect it to be good for the future?

Assesing future precip projections using CMIP5 analysis

Conditions to constrain projections using the past:

1. link between projected and past behavior
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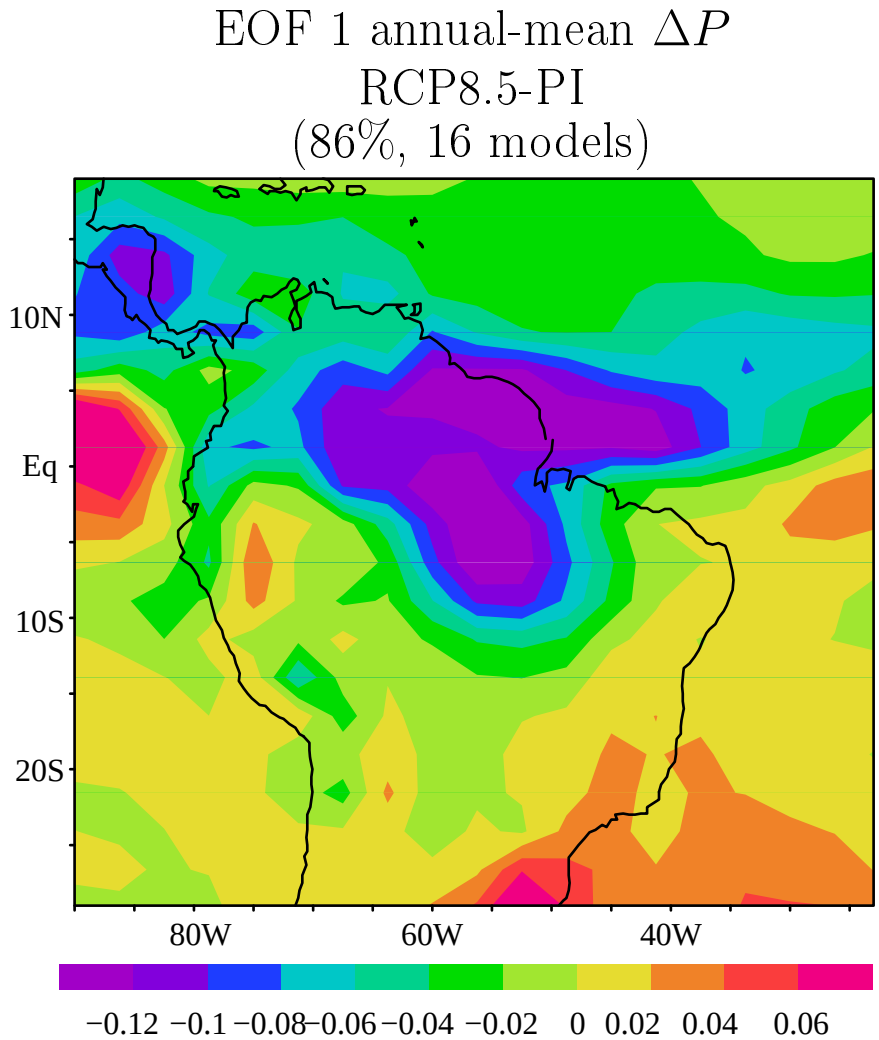
CMIP5:

- 4 models for LGM
- 9 models for MH $\Longrightarrow$focus on MH
- RCP with same models
- Idealized simulations -> role of SSTs, CO2

Multi-model EOF of future precip changes



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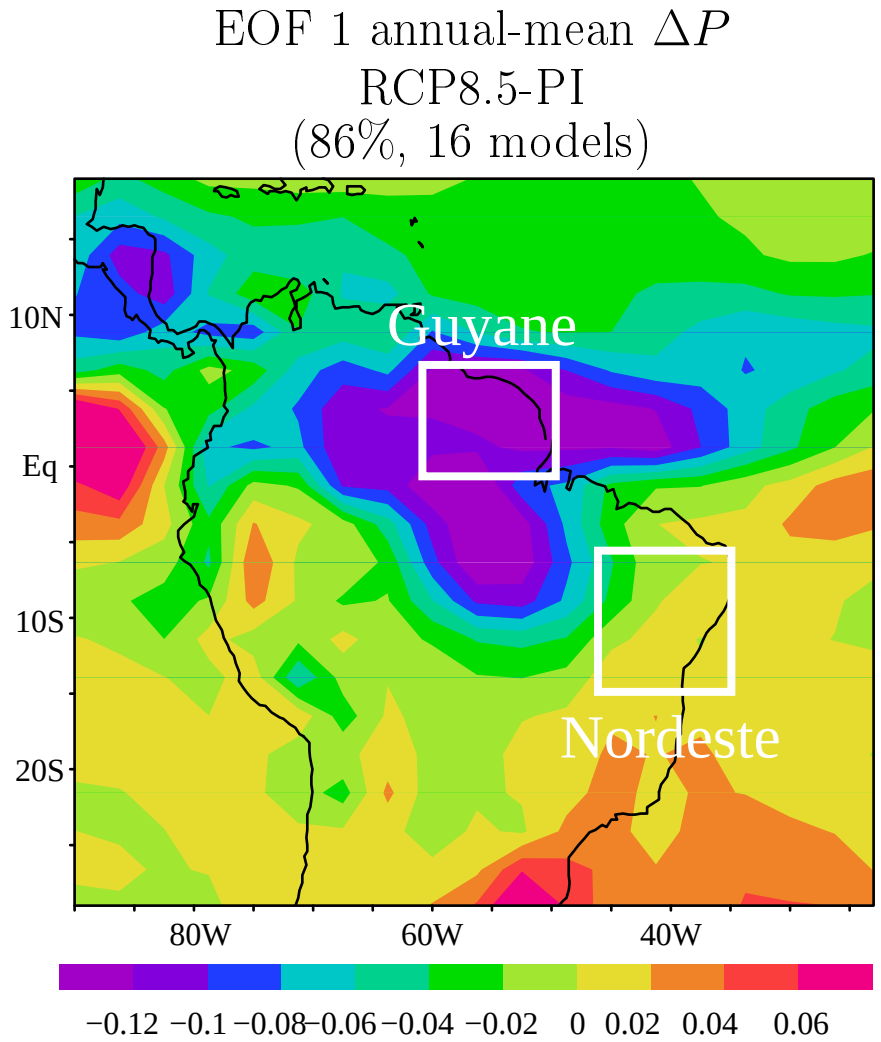
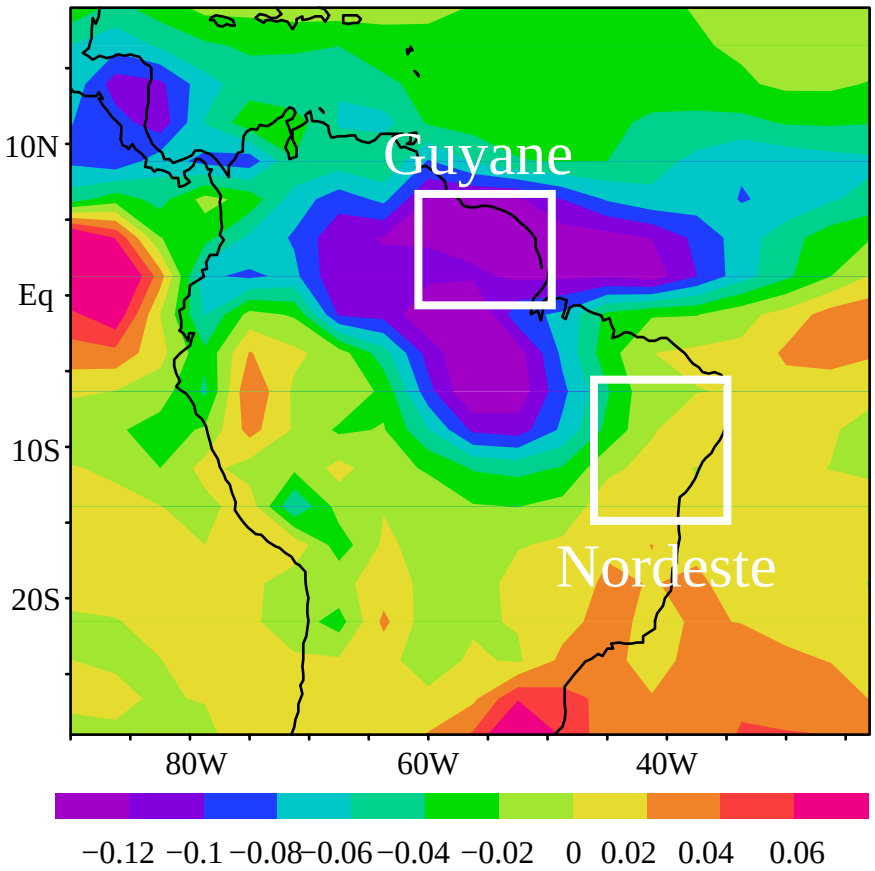
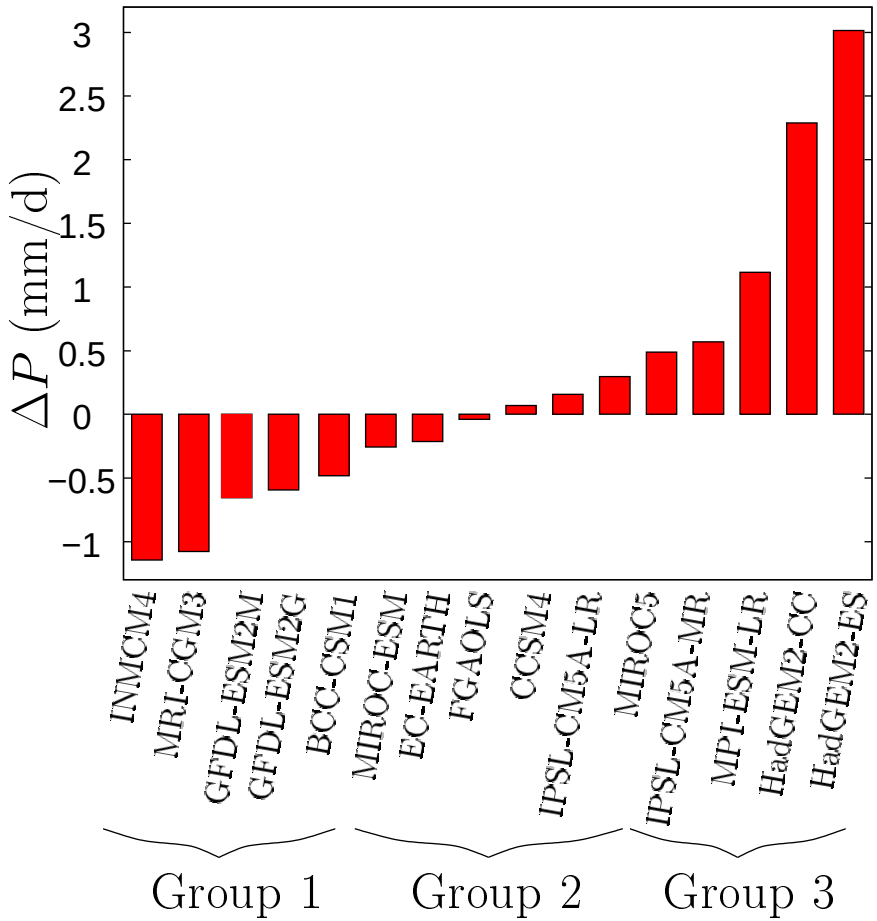


Multi-model EOF of future precip changes

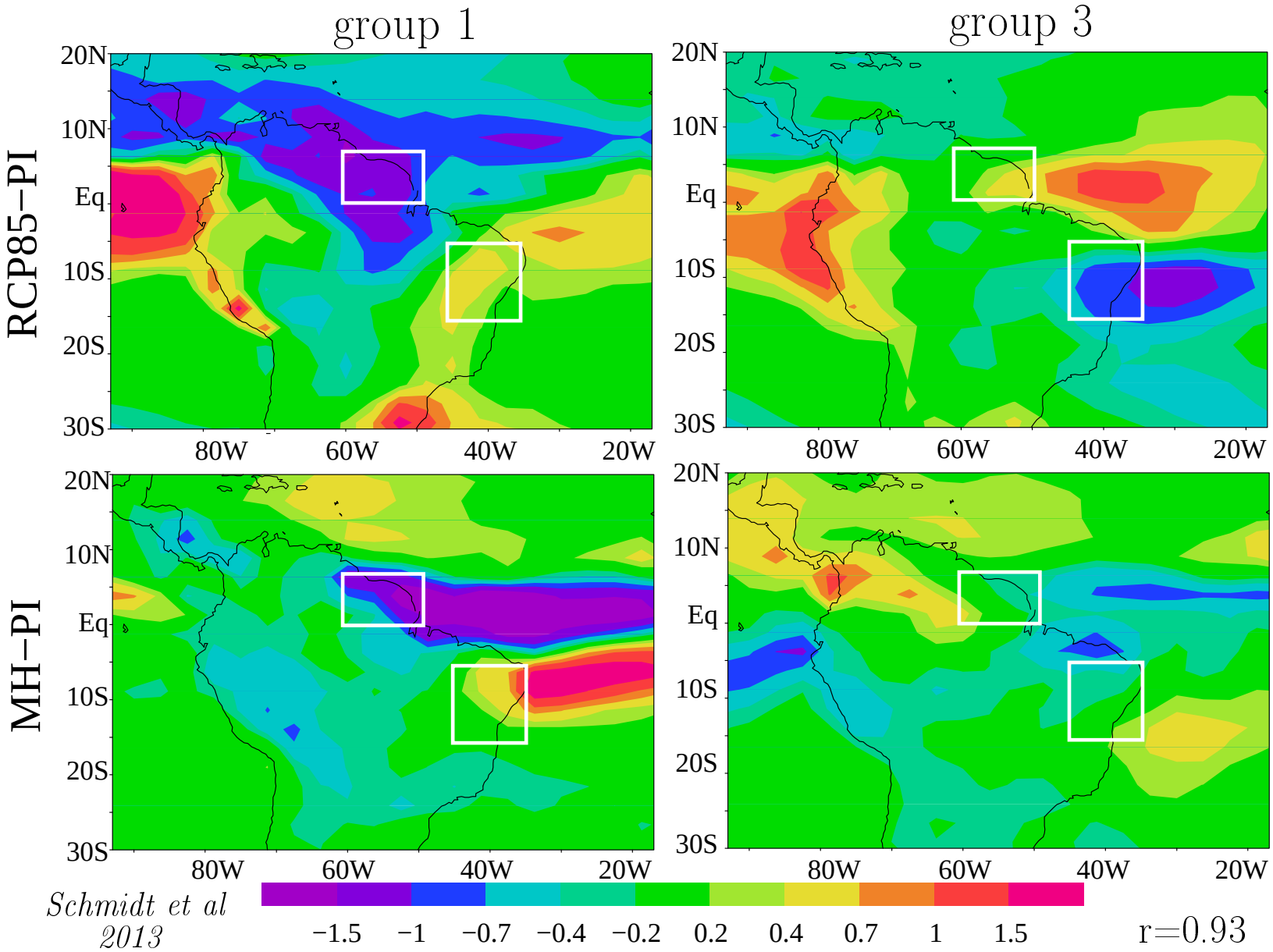
EOF 1 annual-mean ΔP
RCP8.5-PI
(86%, 16 models)



Guyane-Nordeste
RCP8.5-PI precip change



Link between future climate and MH



Link with response to SST, CO2, present-day biases

In models where precip decreases in Guyane and increases in Nordeste in RCP8.5:

- similar precipitation dipole in MH (r=0.93) ⇒Potential for constraining future projections using paleo data

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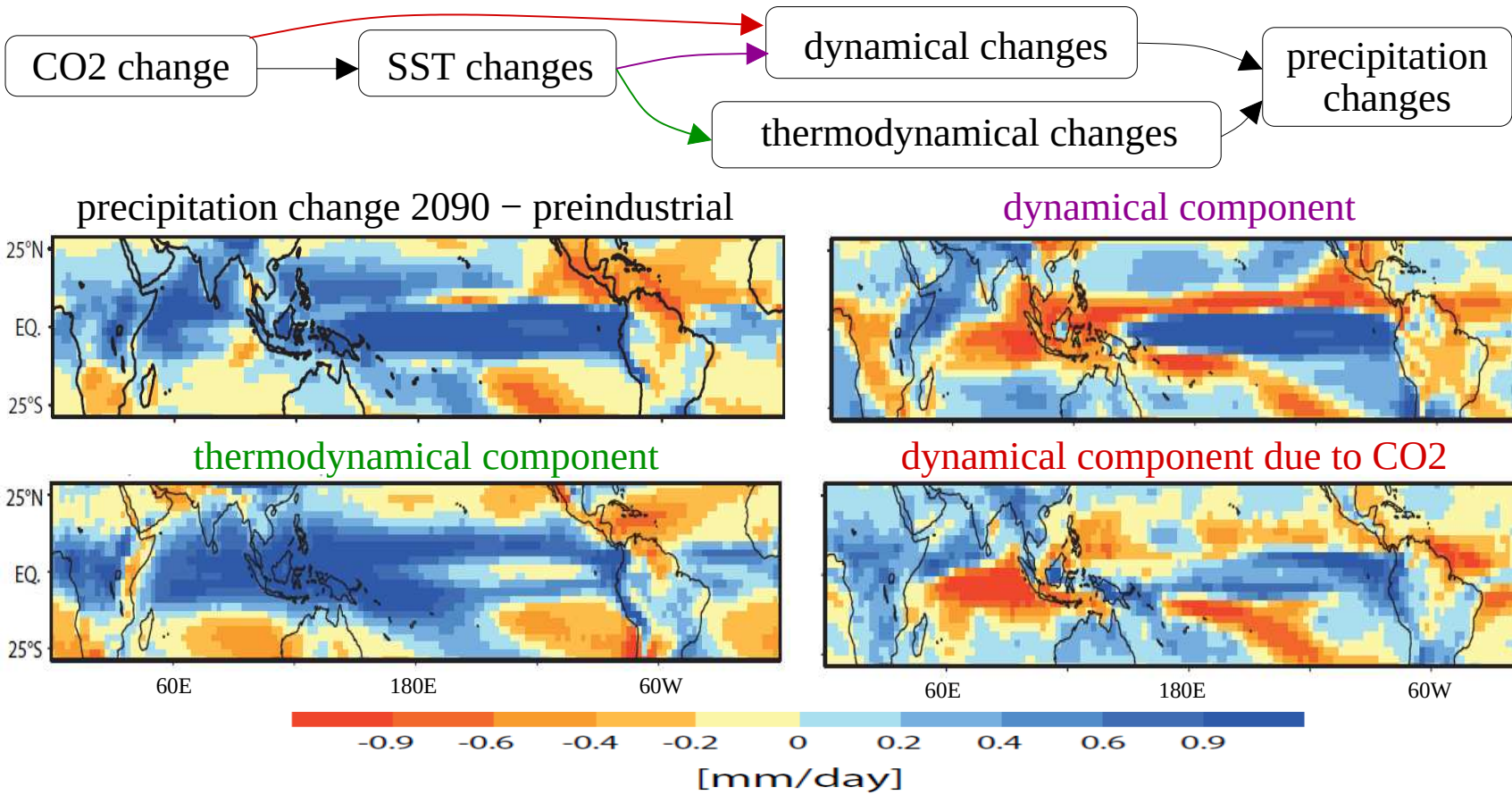
- the double ITCZ problem is less frequent (r=-0.66) ⇒link with present day biases

Perspectives on CMIP5 analysis

- Work in progress to understand mechanisms in future, MH:

Bony et al 2013: decomposition of future precip changes:



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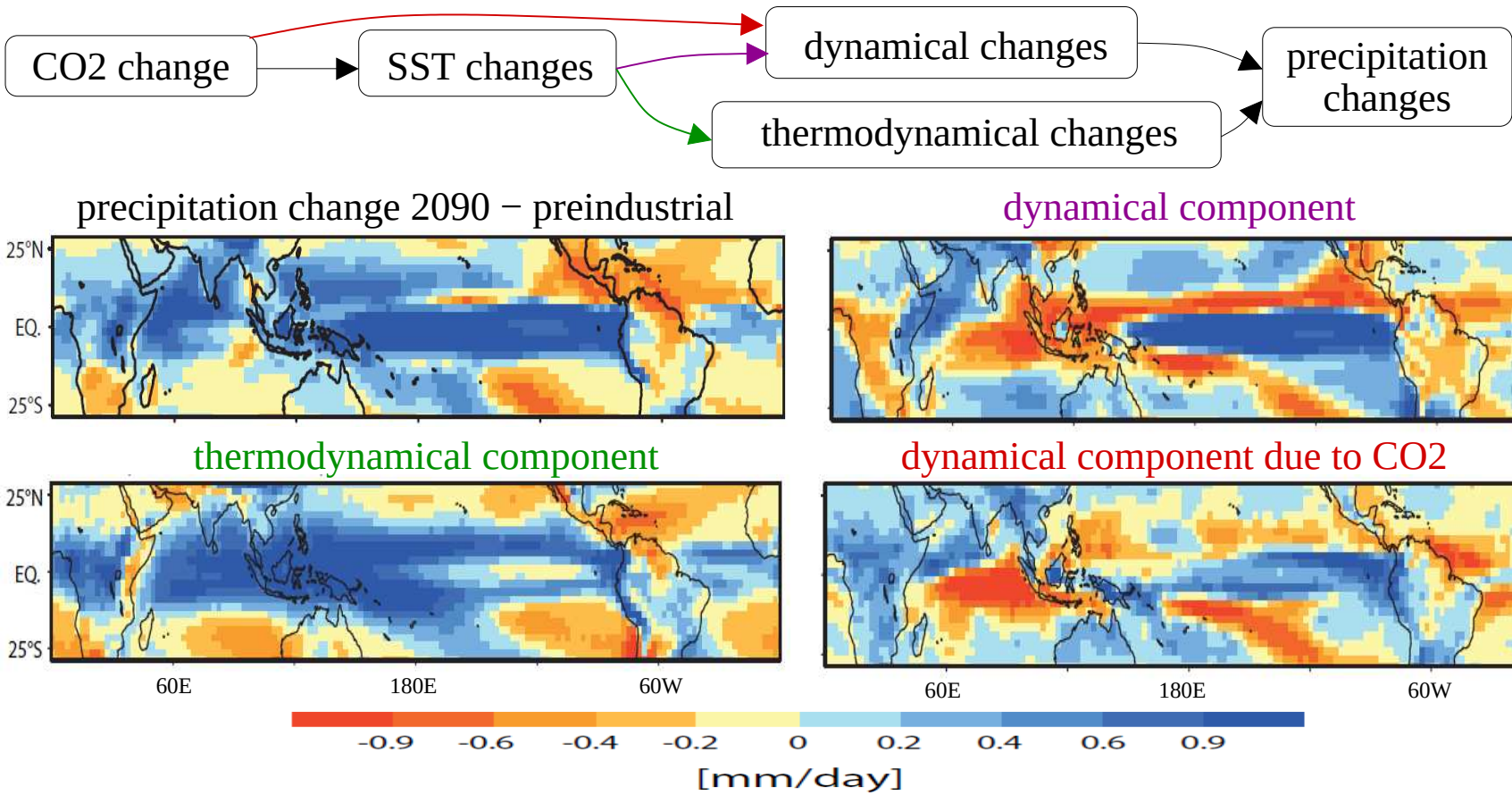
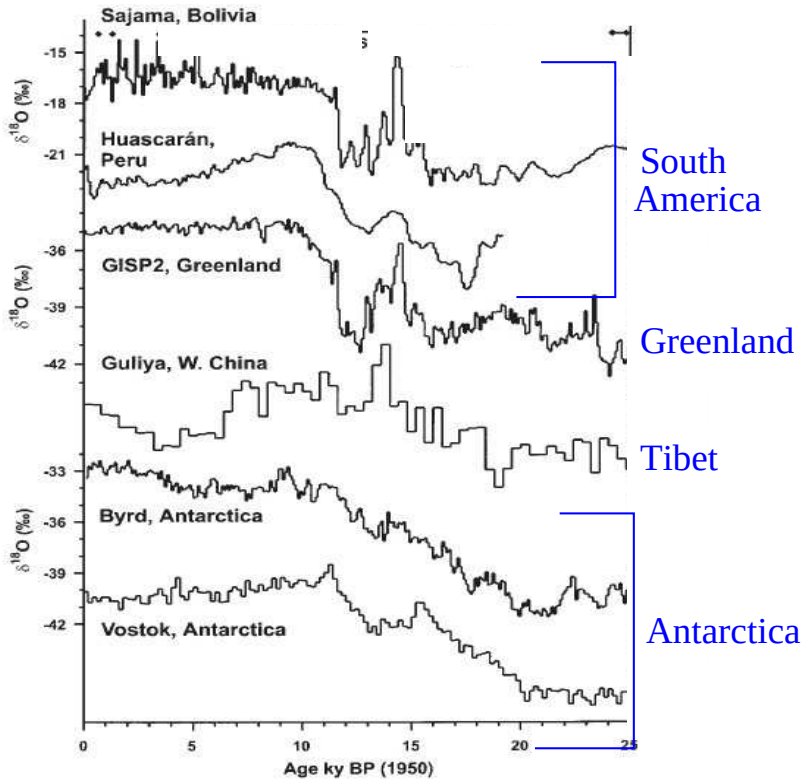


- Actually using paleo constrains: ex: water isotopic archives?

What does $\delta^{18}O_p$ records?

- Thompson et al 2000 $\rightarrow$ proxy de temperature



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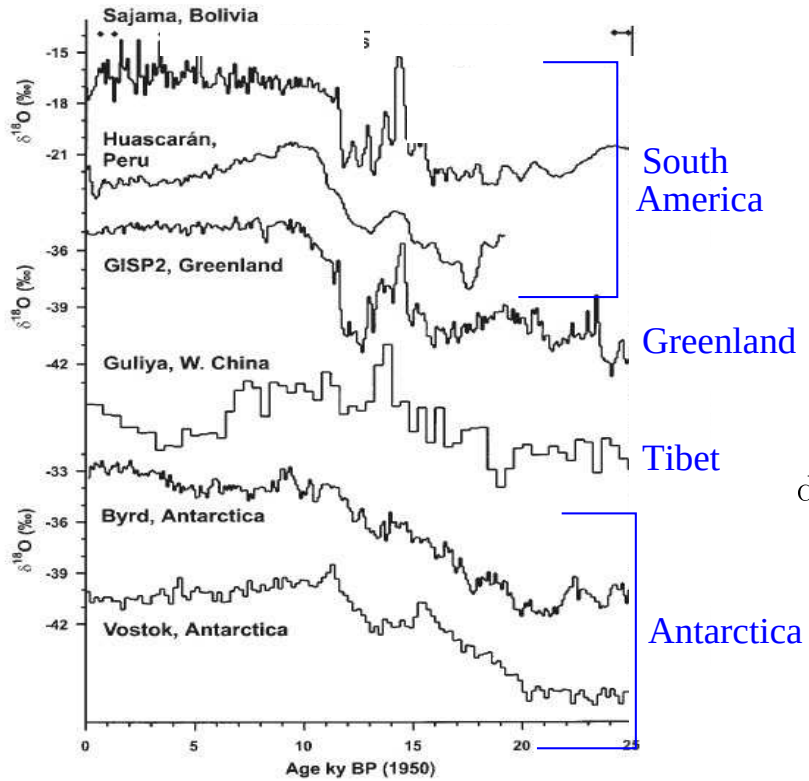

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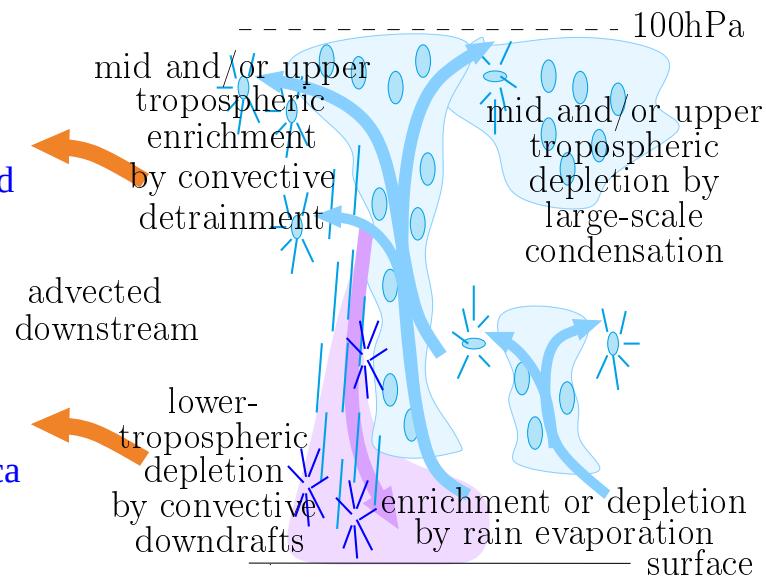

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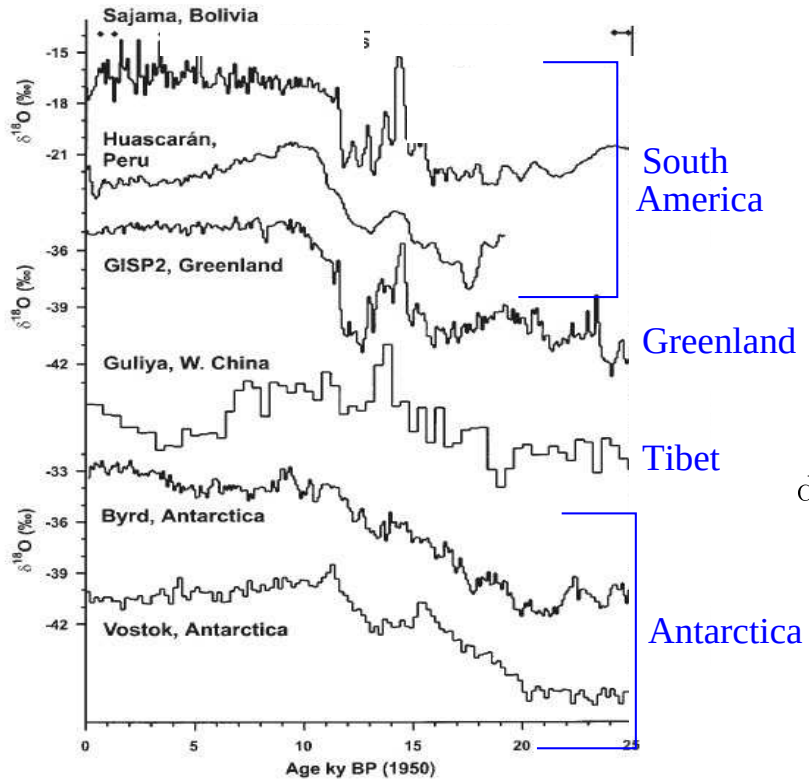

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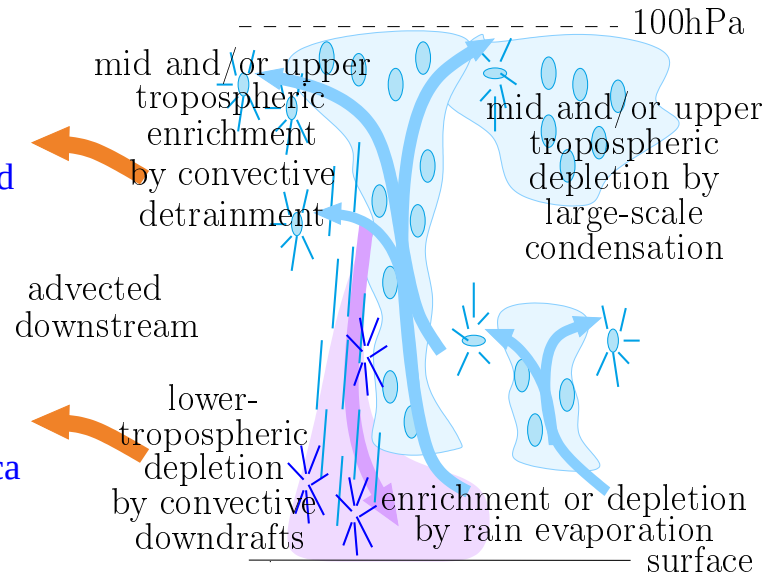
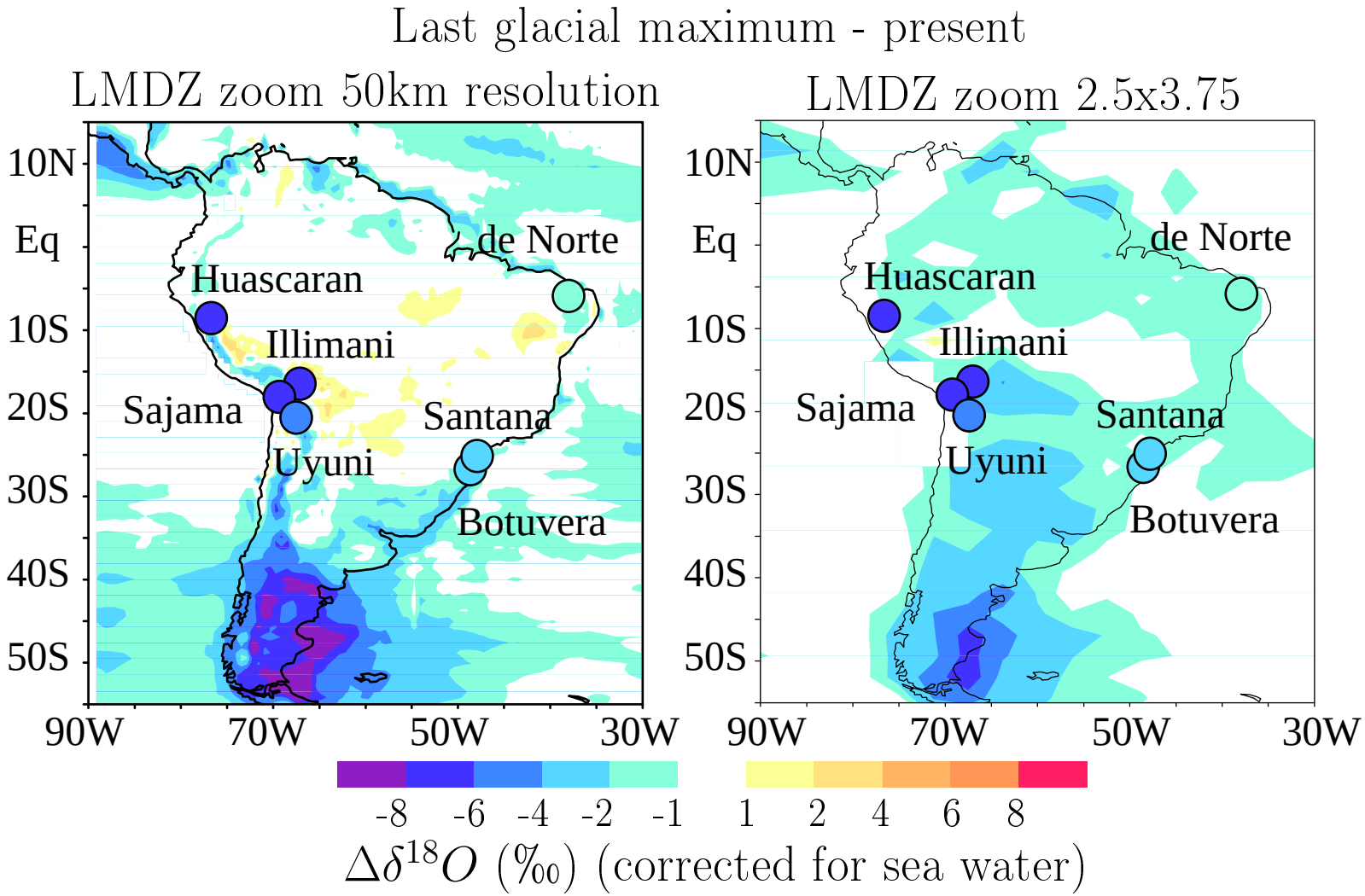


Risi et al 2008

$\Longrightarrow$ Use LMDZ with isotopes:
11 different climates (e.g. LGM, MH); 4 different model physics

Paleo simulations with LMDZ-iso



- underestimate of LGM depletion= frequent problem in GCMs
- improvement with resolution

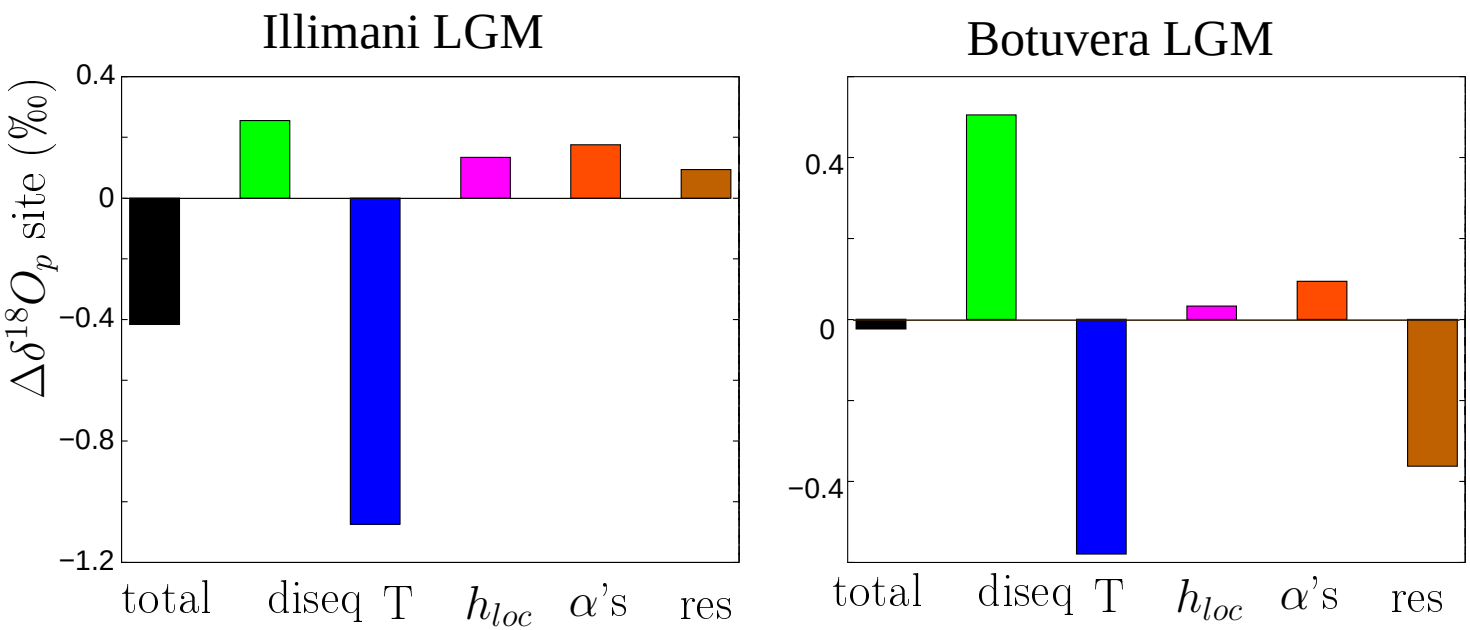
Causes of $\delta^{18}O_p$ changes at LGM?

$$R_p = R_v + (R_p - \alpha_{loc} \cdot R_v) + (\alpha_{loc} \cdot R_v - R_v)$$

vap-cond diseq

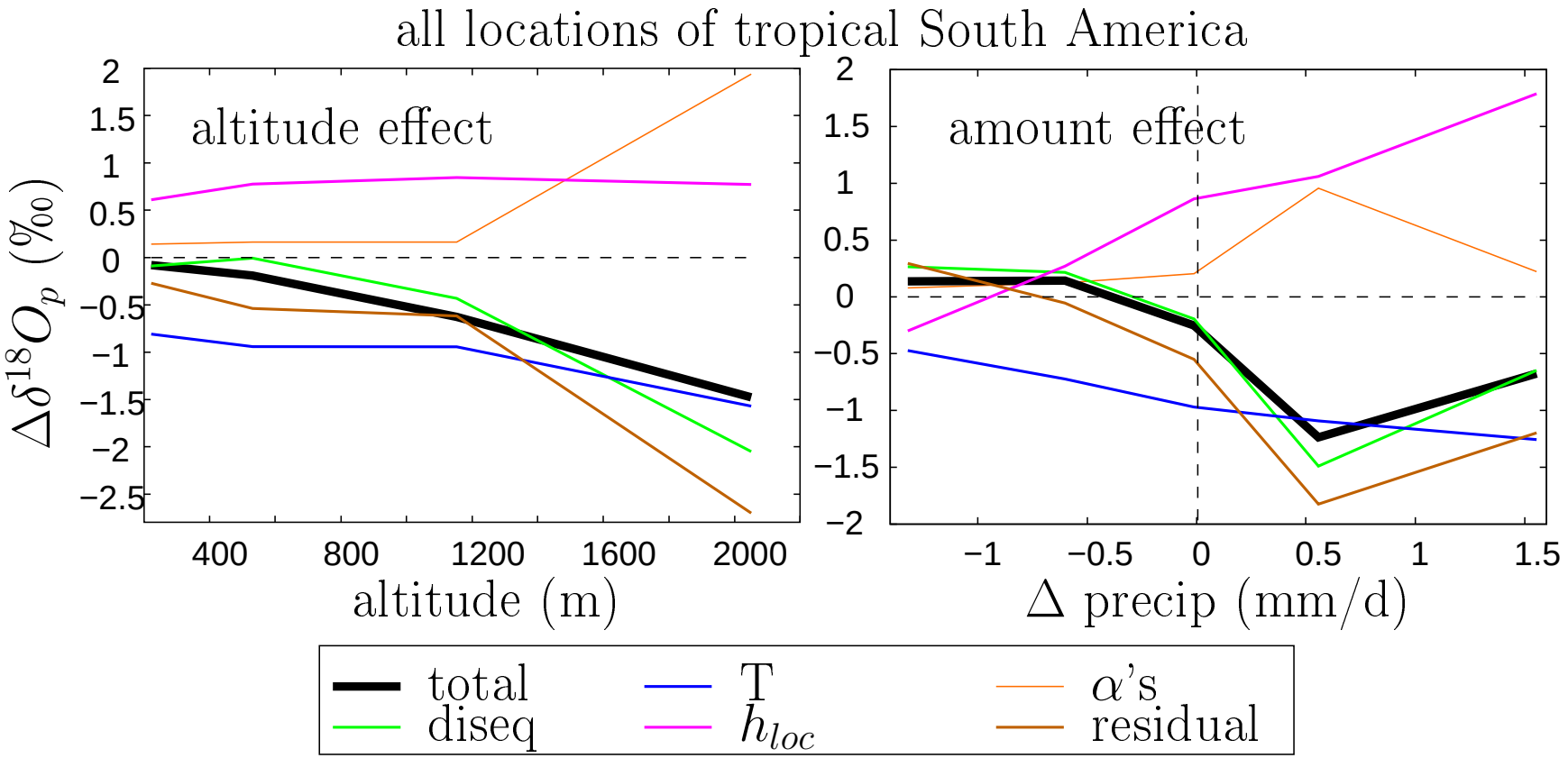
$$R_v = \frac{R_{oce}/\alpha_i}{\alpha_K \cdot (1-h_i) + h_i} \cdot \left(\frac{h_{loc} \cdot q_s(T_{loc})}{q_s(T_i)} \right)^{\alpha_{loc}-1} + \text{residual}$$

initial vapor | distillation | e.g. upstream convection



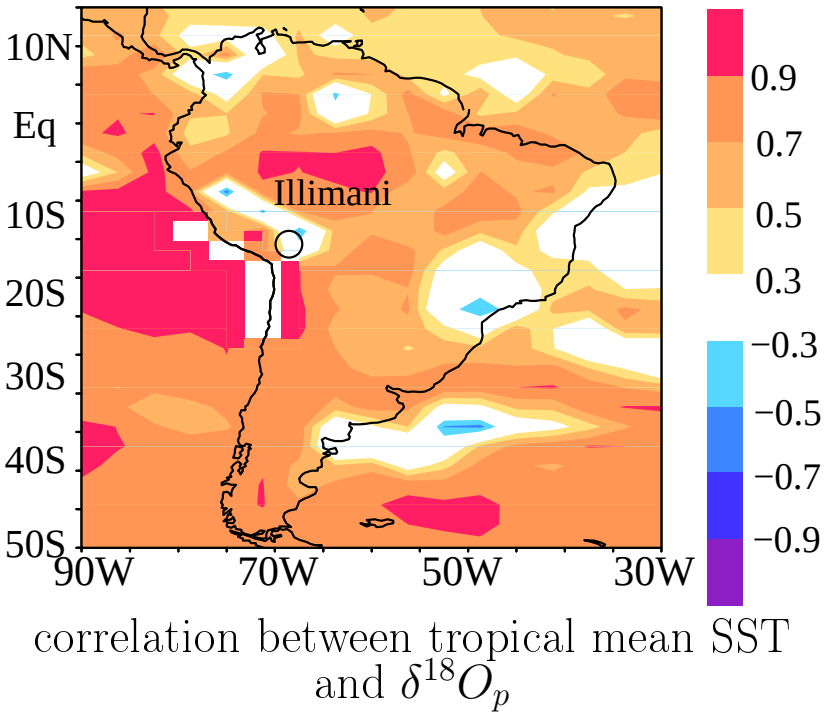
- importance of temperature effect

Temperature and amount effects at LGM

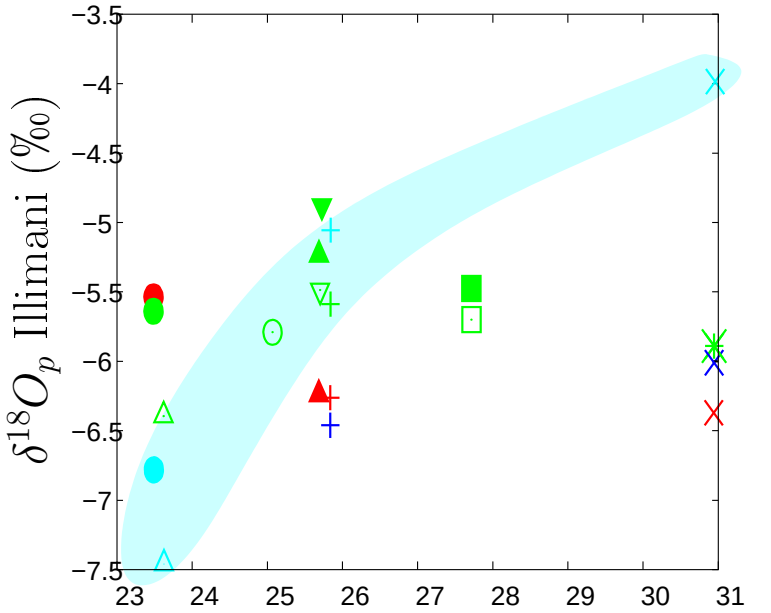


- temperature effect over land + slight amplification with alitude, compensated by changes in α's
- amount effect due to rain-vapor desequilibrium + residual ($\Rightarrow$upstram convection), compensated by changes in h_{loc}

Is $\delta^{18}O_p$ a proxy for temperature?



correlation between tropical mean SST and $\delta^{18}O_p$



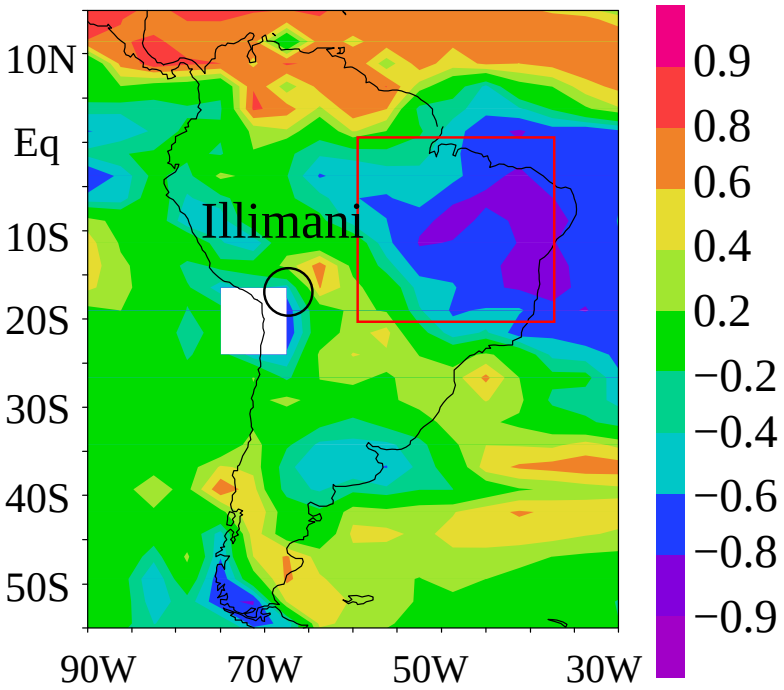
tropical-mean (30°S-30°N) SST (°C)

Climates:
- + present−day
- × 4xCO2 IPSL
- ✳ 2xCO2 IPSL
- □ 2xCO2 ECHAM
- ■ 2xCO2 MIROChi
- ○ LGM climap
- ● LGM IPSL
- △ LGM IPSL THCoff
- ▲ MH IPSL
- ▽ Eemien IPSL
- ▼ Eemien IPS THC+

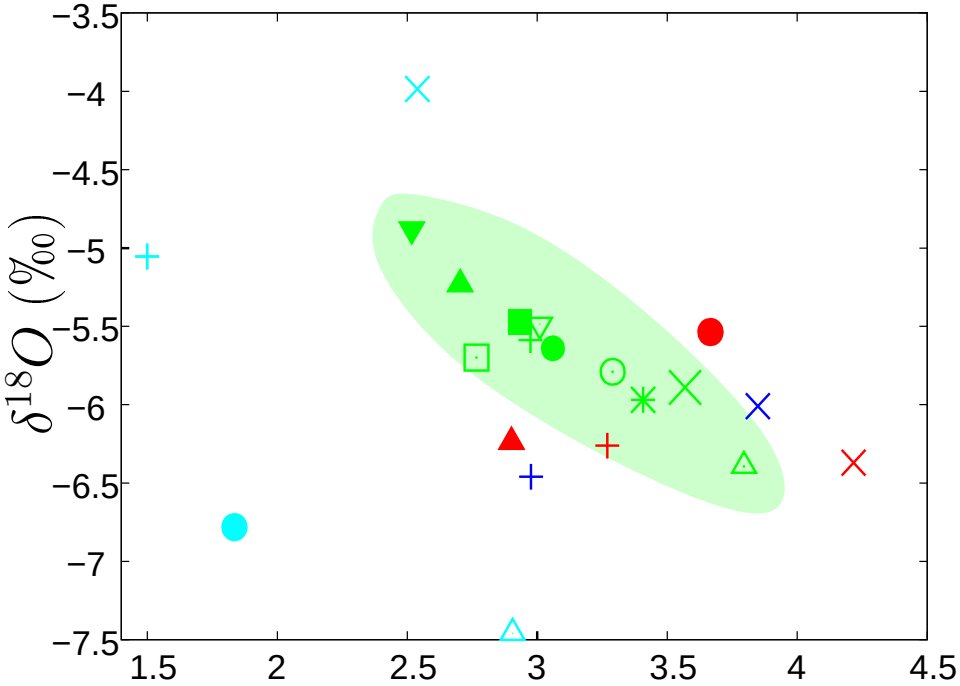
Model versions
- control
- less diffusion
- more detrainment
- less condensation
- 50 km resolution

- temperature = significant control at paleo time scales
- but sensitive to model physics

Is $\delta^{18}O_p$ a proxy for precipitation?



correlation between $\delta^{18}O_p$ at site and precipitation around



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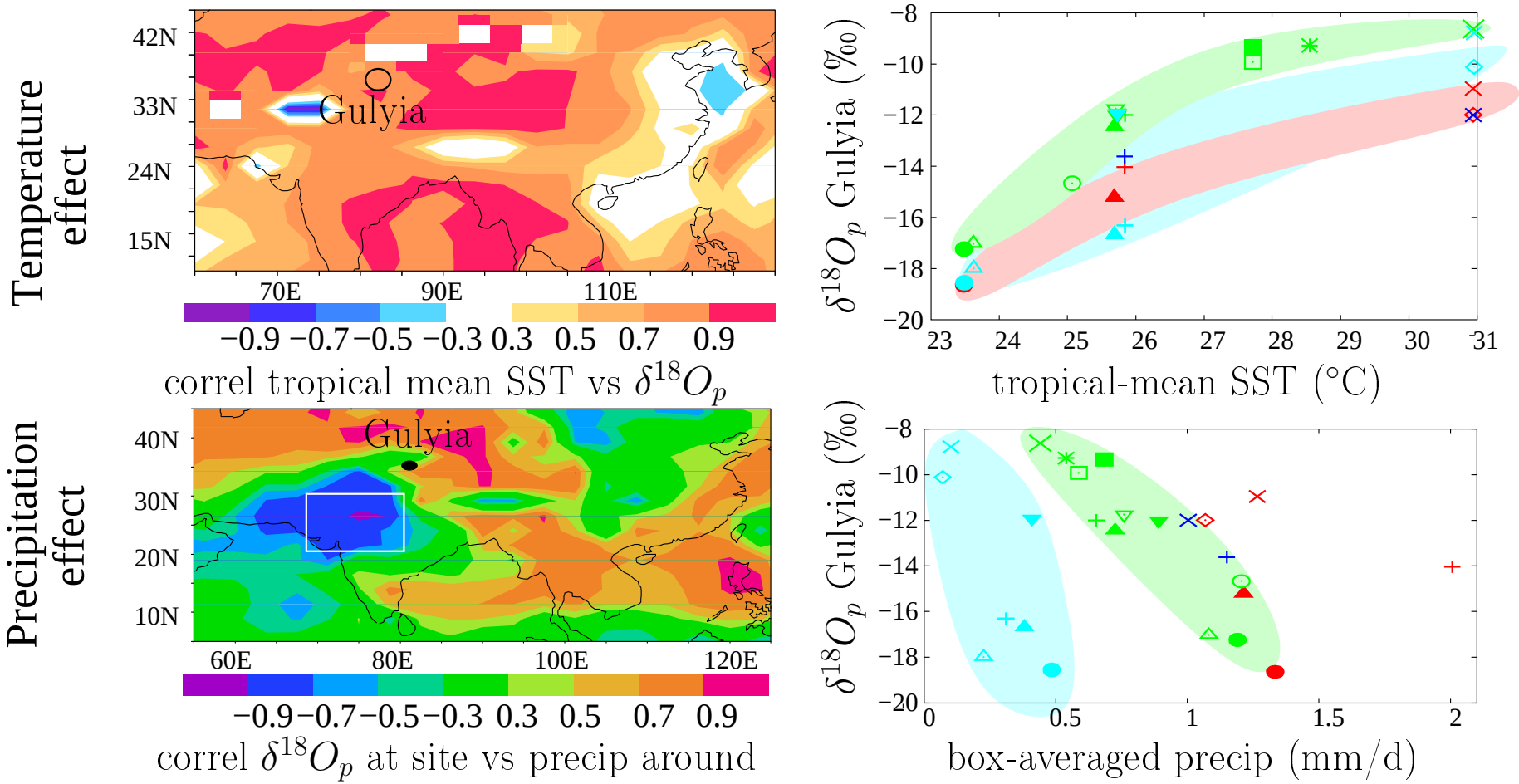
- $\delta^{18}O_p$ influenced by past regional precipitation changes
- but sensitive to model physics

Summary on isotopic paleo records in South America

- LMDZ can reproduce several aspects of past $\delta^{18}O$ changes, but underestimates depletion at LGM
- At paleo time-scales and especially during LGM, temperature is a major control in LMDZ
- Also significant relationship with upstream precip
- But sensitive to the model physics

Comparison with the Tibetan Plateau



- Temperature effect, stronger, more robust to model physics, stronger amplication with altitude
- Relationship with upstream precip, sensitive to model physics

Perspectives (1/2)

- Why does LMDZ underestimate $\delta^{18}O$ changes at LGM?
  - more data synthesis needed for paleo $\delta^{18}O$ to evaluate models
  - temperature or precip effects underestimated? missing process?
  - how common is it among models?

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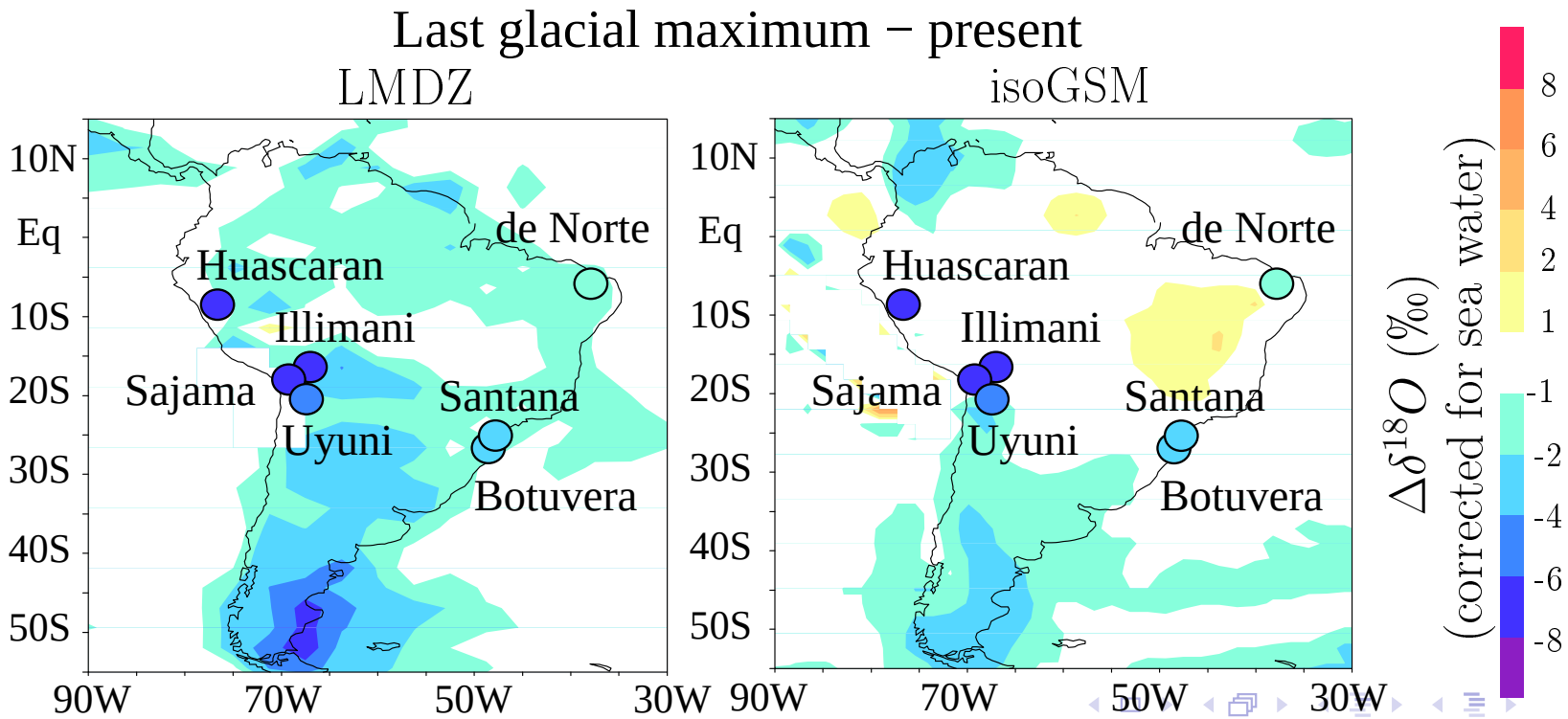

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    - in-situ data (precip, vapor)
    - satellite data: e.g. TES: 3D, weekly δD in troposphere

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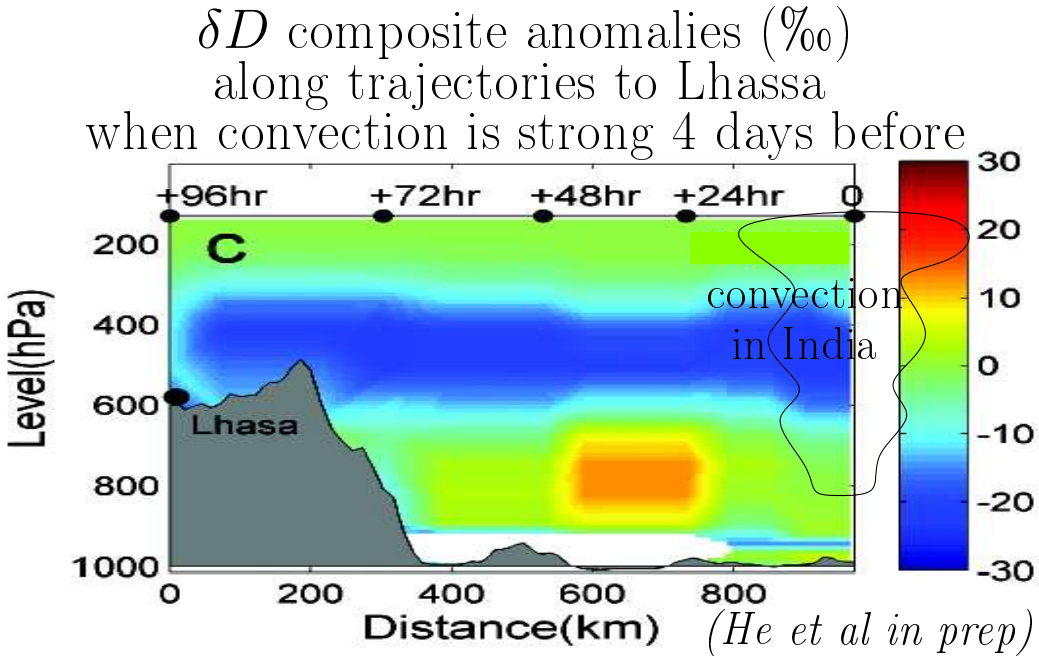

(He et al in prep)

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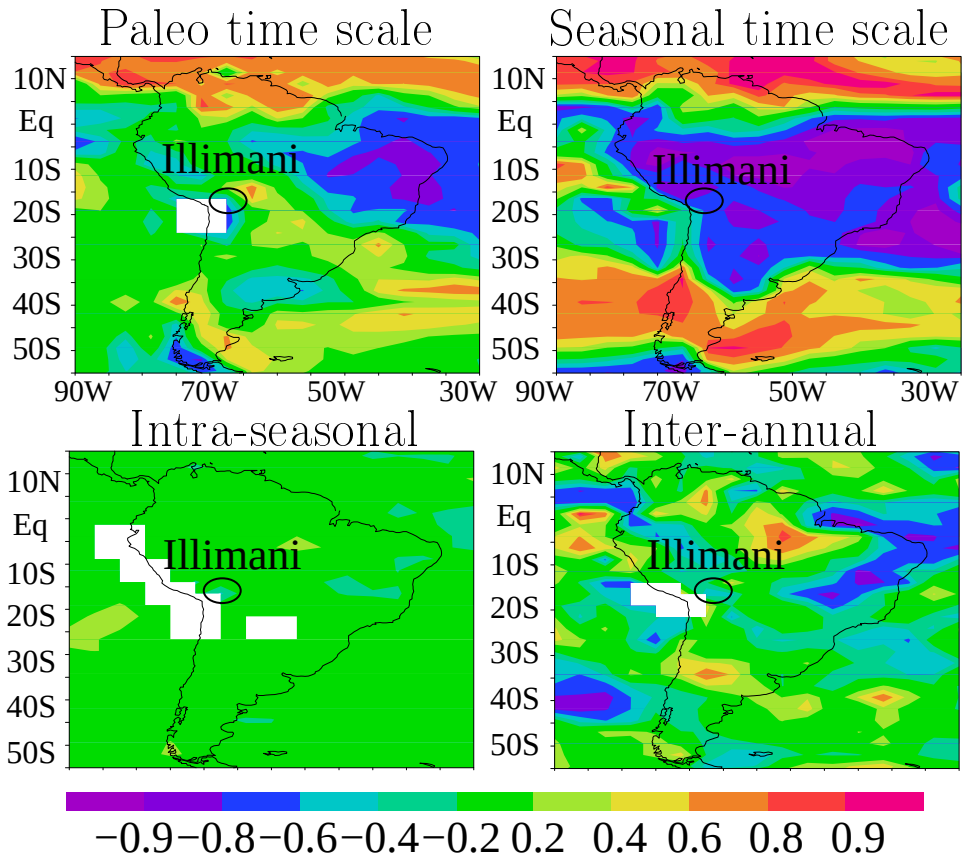

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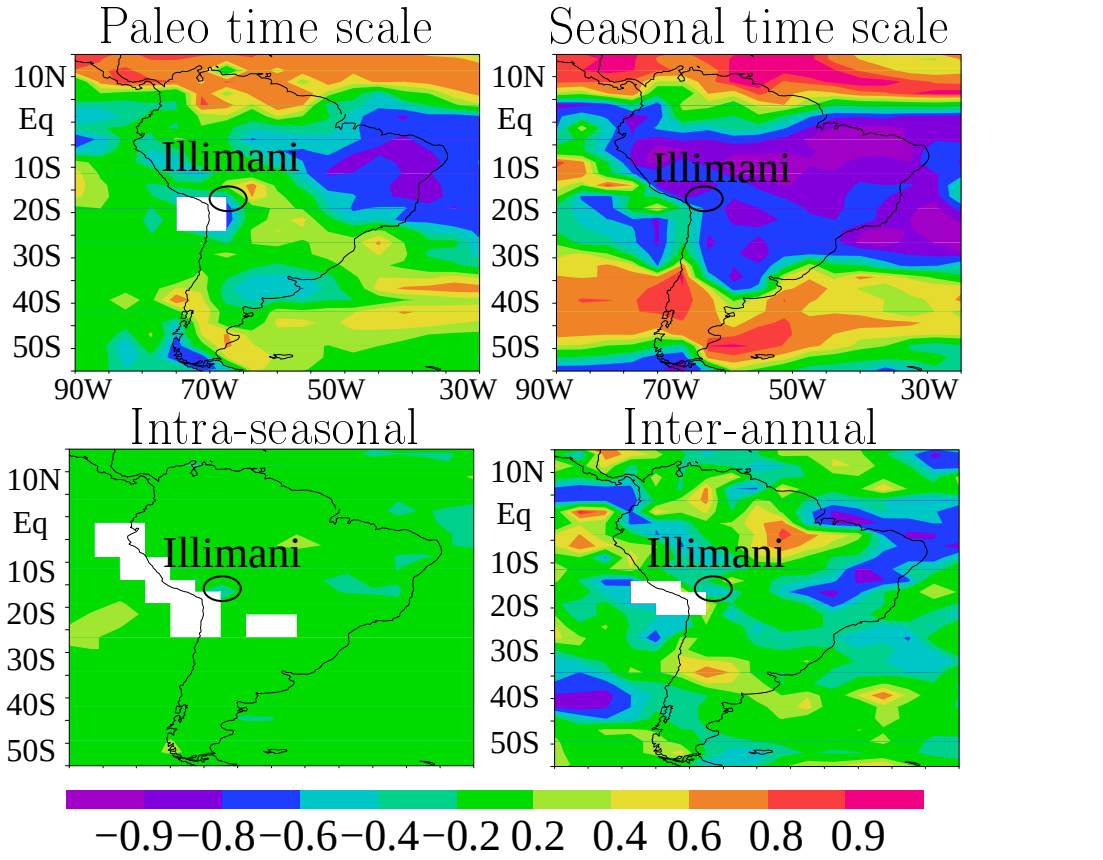

$\Longrightarrow$Understanding daily controls not enough to understand paleo controls