Using tropical archives of precipitation isotopic composition to assess the credibility of projected changes in precipitation
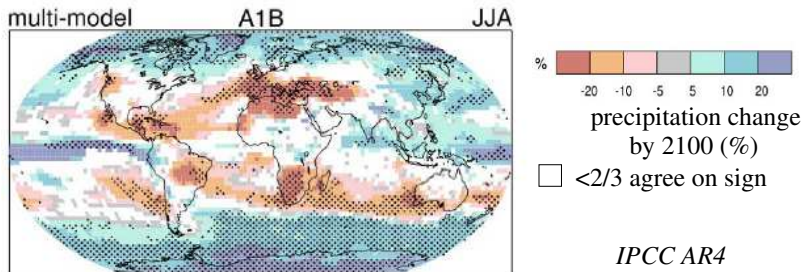
Camille Risi

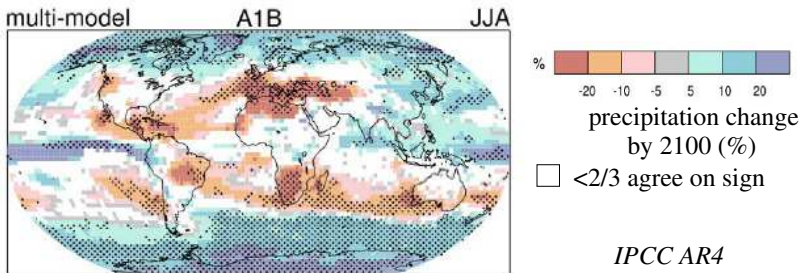LMD/IPSL/CNRS (Paris, France)

with the contribution of: S. Bony, F. Vimeux, R. Eagle, A. Tripati

AGU: 6 December 2011

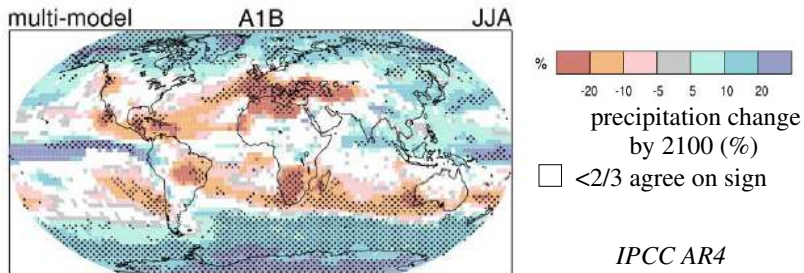# Spread in precipitation projections

precipitation change
by 2100 (%)

☐ <2/3 agree on sign

IPCC AR4

Spread in precipitation projections

multi-model   A1B   JJA

precipitation change by 2100 (%)

□ <2/3 agree on sign

IPCC AR4
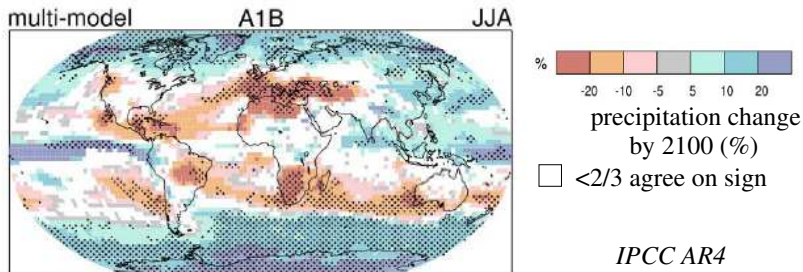
▶ Can we assess the credibility of future precip projections of tropical precip using past changes?

Spread in precipitation projections

IPCC AR4

- ▶ Can we assess the credibility of future precip projections of tropical precip using past changes?
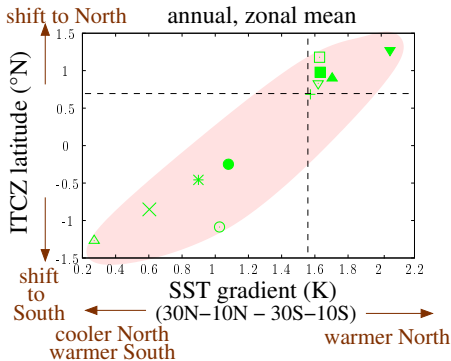   1. if a model is better for the past, is it better for the future? only if common mechanisms

Spread in precipitation projections

precipitation change
by 2100 (%)

☐ <2/3 agree on sign

IPCC AR4

▶ Can we assess the credibility of future precip projections of tropical precip using past changes?

1. if a model is better for the past, is it better for the future? only if common mechanisms
2. if robust proxy for past precip changes: $\delta^{18}O$ (ice cores, speleothems...)?
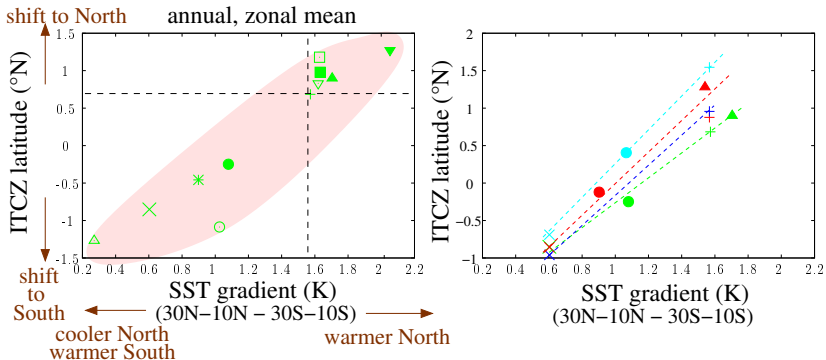
1) Past/future precipitation changes

▶ 11 climates using LMDZ GCM forced by SST anomalies

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- precipitation response depends strongly on the physics

1) Past/future precipitation changes

- 11 climates using LMDZ GCM forced by SST anomalies

- precipitation response depends strongly on the physics
- work in progress: regional scale over land?

2) What controls $\delta^{18}O$ in the tropics?

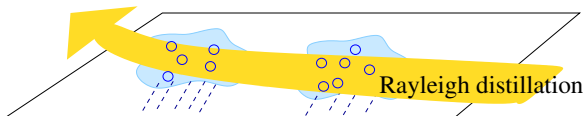- the amount effect: precip $\nearrow \Longrightarrow \delta \searrow$ (*Dansgaard 1964*)

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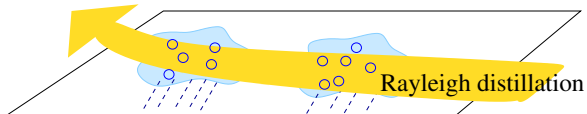- obs+modelling *(Risi et al 2008 JGR,GRL, 2010 JGRb,QJRMS)*
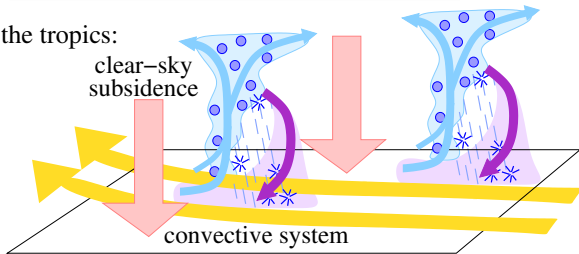
In mid/high latitudes:

Rayleigh distillation

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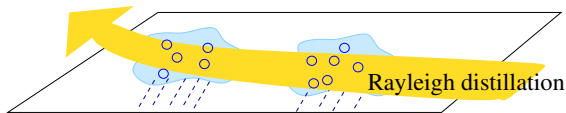- obs+modelling *(Risi et al 2008 JGR,GRL, 2010 JGRb,QJRMS)*

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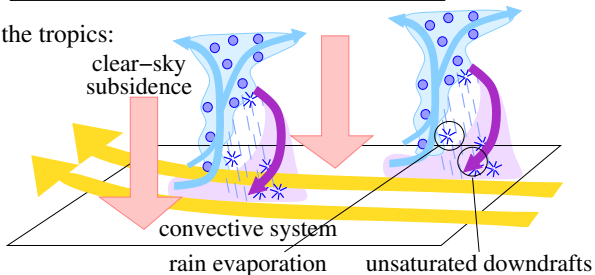
In the tropics:

clear−sky subsidence

convective system
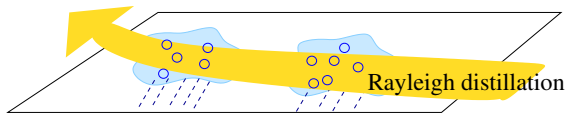
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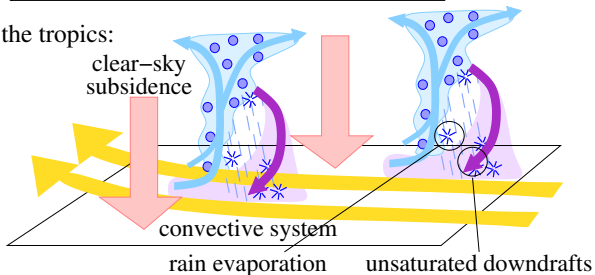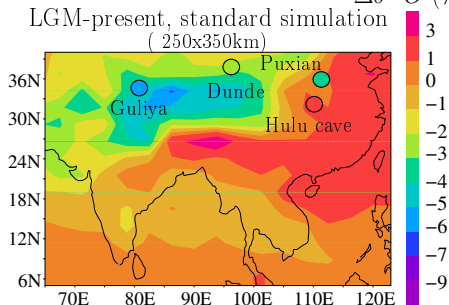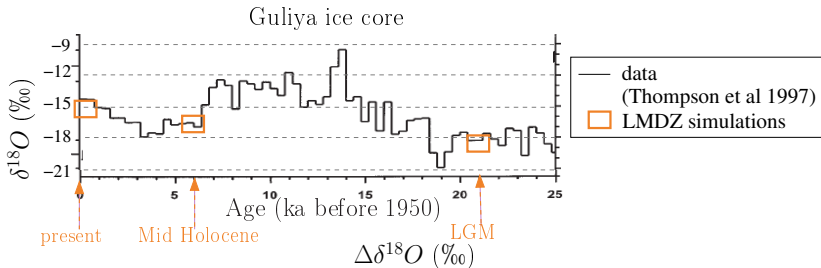convective system

rain evaporation   unsaturated downdrafts

2) What controls $\delta^{18}O$ in the tropics?

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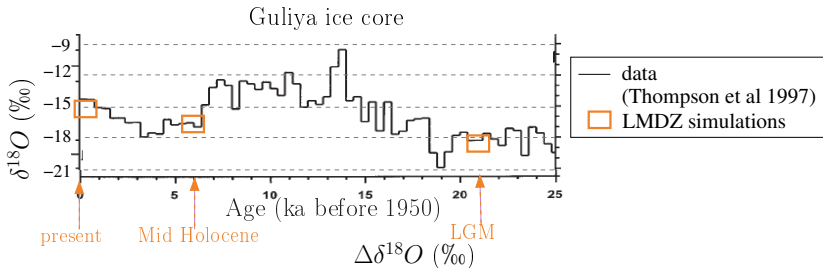- obs+modelling *(Risi et al 2008 JGR,GRL, 2010 JGRb,QJRMS)*

- Paleo time scales: precip or temperature (*Thompson et al 2000*)?
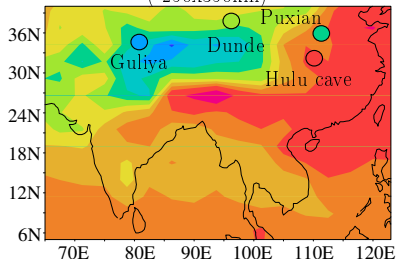$\Longrightarrow$ analysis with LMDZ-iso (*Risi et al 2010 JGRa*)

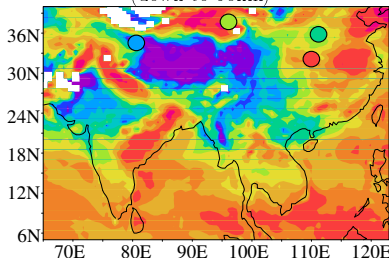# Simulated paleo $\delta^{18}O$: example in Asia

Guliya ice core

Simulated paleo $\delta^{18}O$: example in Asia

Guliya ice core

$\delta^{18}O$ (‰) vs Age (ka before 1950)

data (Thompson et al 1997)
LMDZ simulations

present   Mid Holocene   LGM

$\Delta\delta^{18}O$ (‰)

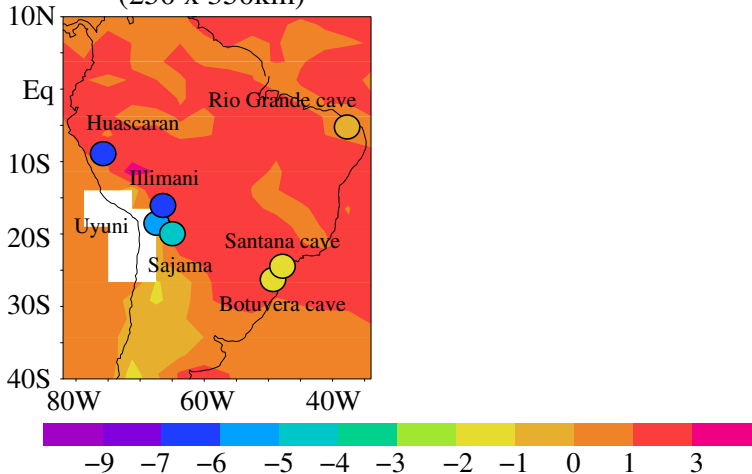LGM-present, standard simulation (250x350km)

Puxian
Dunde
Guliya
Hulu cave

LGM-present, zoomed simulation (down to 50km)
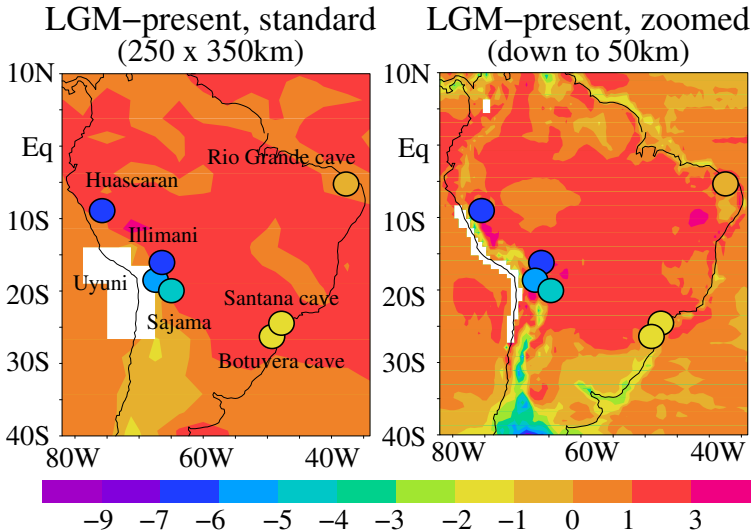
▶ high resolution -> regional circulation changes

Simulated paleo $\delta^{18}O$: South America

LGM−present, standard
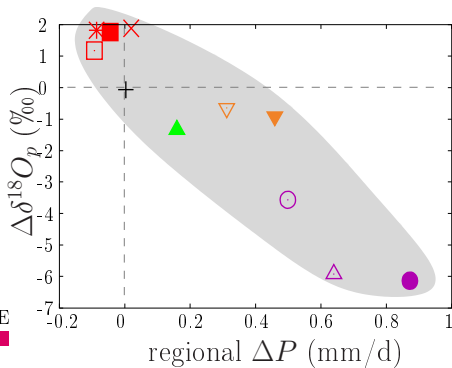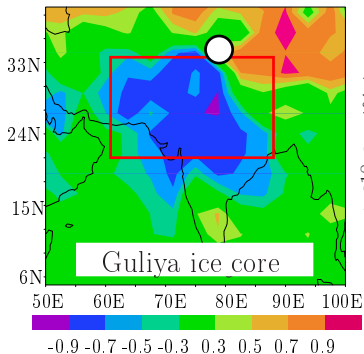(250 x 350km)

- LGM depletion=long standing problem in GCMs

Simulated paleo $\delta^{18}O$: South America

LGM−present, standard (250 x 350km) and LGM−present, zoomed (down to 50km). Locations marked: Huascaran, Illimani, Uyuni, Sajama, Rio Grande cave, Santana cave, Botuyera cave.

- LGM depletion=long standing problem in GCMs
- resolution is only part of the problem

$\delta^{18}O$ controls in LMDZ: Asia
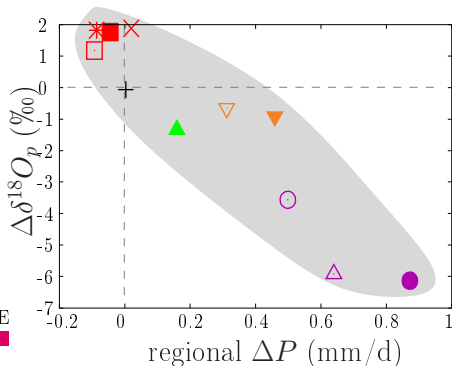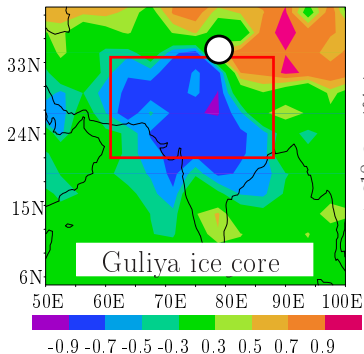

Correlation $\delta^{18}O_p$ - P

Guliya ice core

Climates:
- $+$ present-day
- $\times$ 4xCO2 IPSL
- $*$ 2xCO2 IPSL
- $\square$ 2xCO2 ECHAM
- $\blacksquare$ 2xCO2 MIROChi
- $\circ$ LGM climap
- $\bullet$ LGM IPSL
- $\triangle$ LGM IPSL THCoff
- $\blacktriangle$ MH IPSL
- $\triangledown$ Eemien IPSL
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$\delta^{18}O$ controls in LMDZ: Asia

Correlation $\delta^{18}O_p$ - P

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▶ $\delta^{18}O$ =good proxy for past regional precipitation changes

$\delta^{18}O$ controls in LMDZ: South America

Correlation $\delta^{18}O_p$ - P

Illimani ice core

$\delta^{18}O$ controls in LMDZ: South America

Correlation $\delta^{18}O_p$ - P

Illimani ice core

regional ΔP (mm/d)

$\Delta\delta^{18}O_p$ (‰)
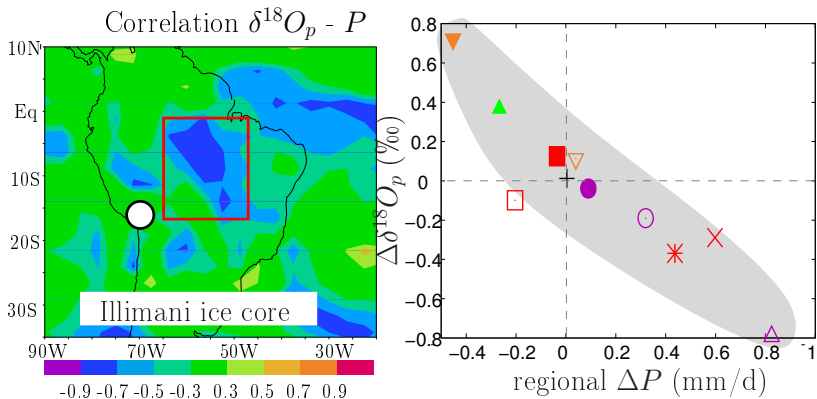
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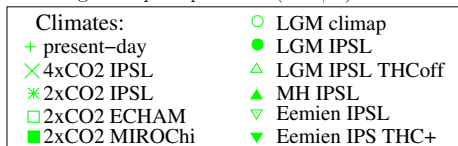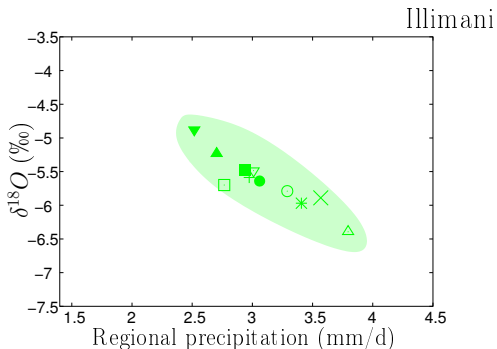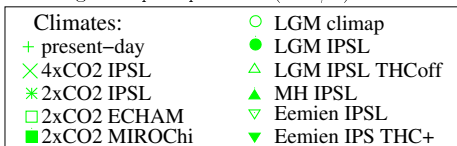
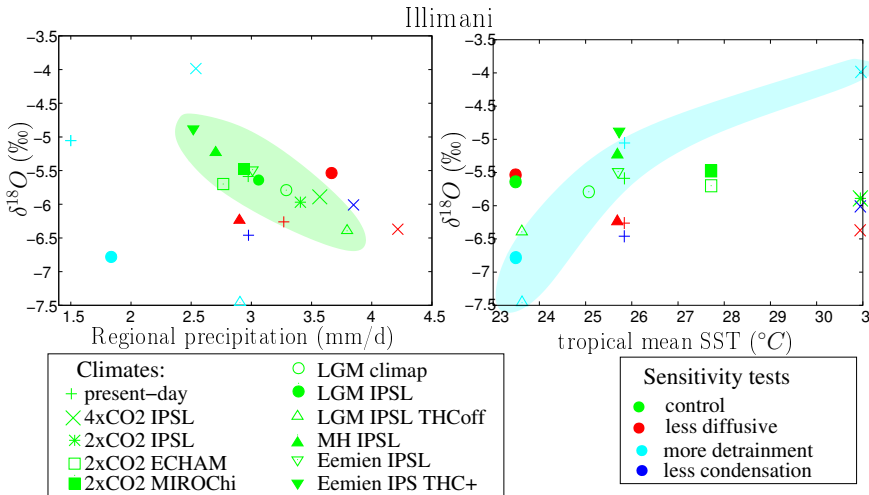# Is P-$\delta^{18}O$ sensitive to model physics?

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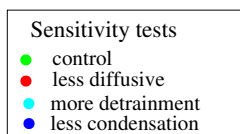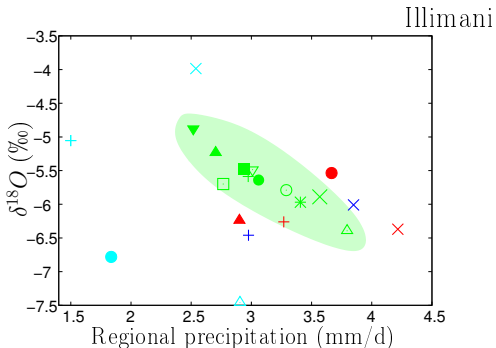
Illimani

Is P-$\delta^{18}O$ sensitive to model physics?

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Sensitivity tests
- control
- less diffusive
- more detrainment
- less condensation
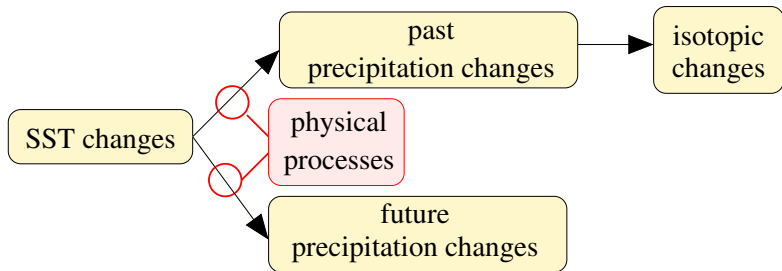
▶ depending on the physics, $\delta^{18}O$ controlled by upstream precip or by average temperature
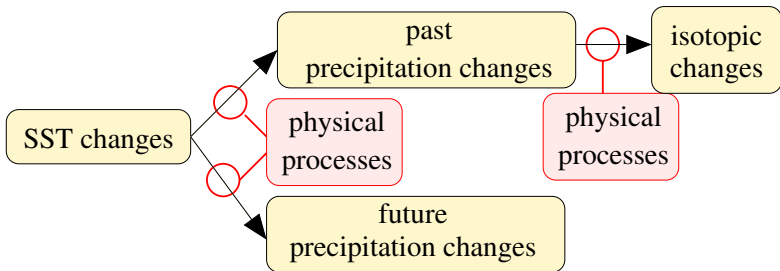
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Illimani
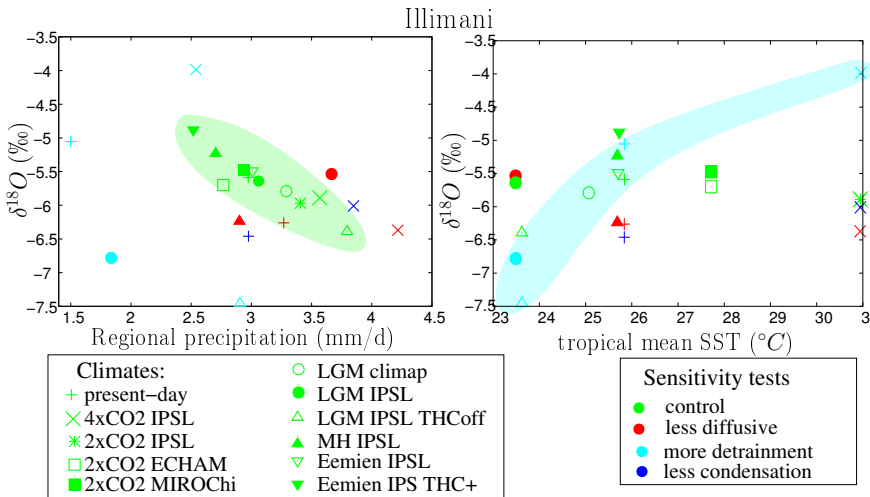
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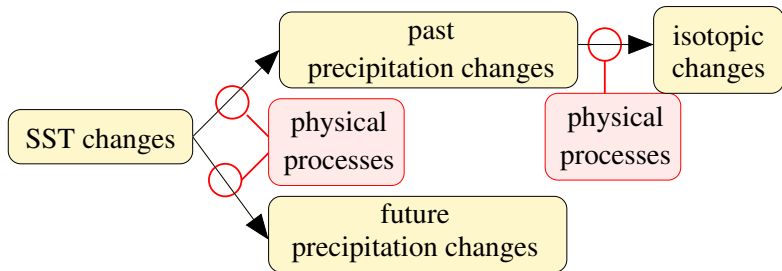- not obvious which one is most realistic

Conclusion and perspectives
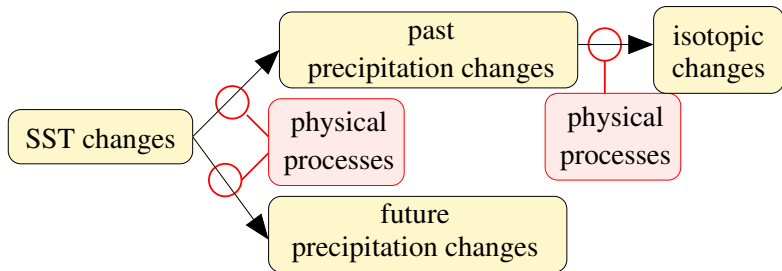
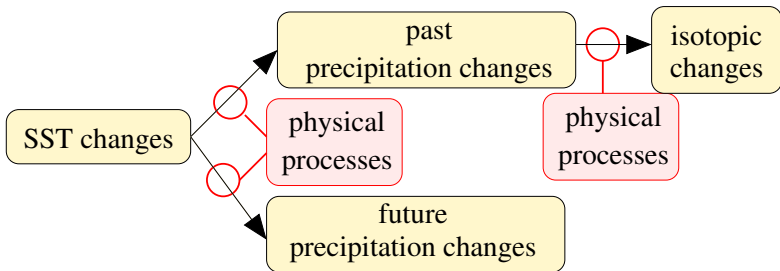# Conclusion and perspectives

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  - better understand physical processes

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  - CMIP5: link between physical processes at present, past changes and future projections (but isotopes missing)

Conclusion and perspectives

- ▶ To go further:
  - ▶ better understand physical processes
  - ▶ CMIP5: link between physical processes at present, past changes and future projections (but isotopes missing)
  - ▶ any paleo-data synthesis effort planned for $\delta^{18}O$?