



Andean Highlands

Implications of climate change

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SANREM CRSP

Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

Adapting to Change in the Andean Highlands: Practices and Strategies
to Address Climate and Market Risks in Vulnerable Agro-Eco Systems

- promotes stakeholder empowerment and improved livelihoods through knowledge - based sustainable agriculture and natural resource management systems.
- emphasis on developing economies

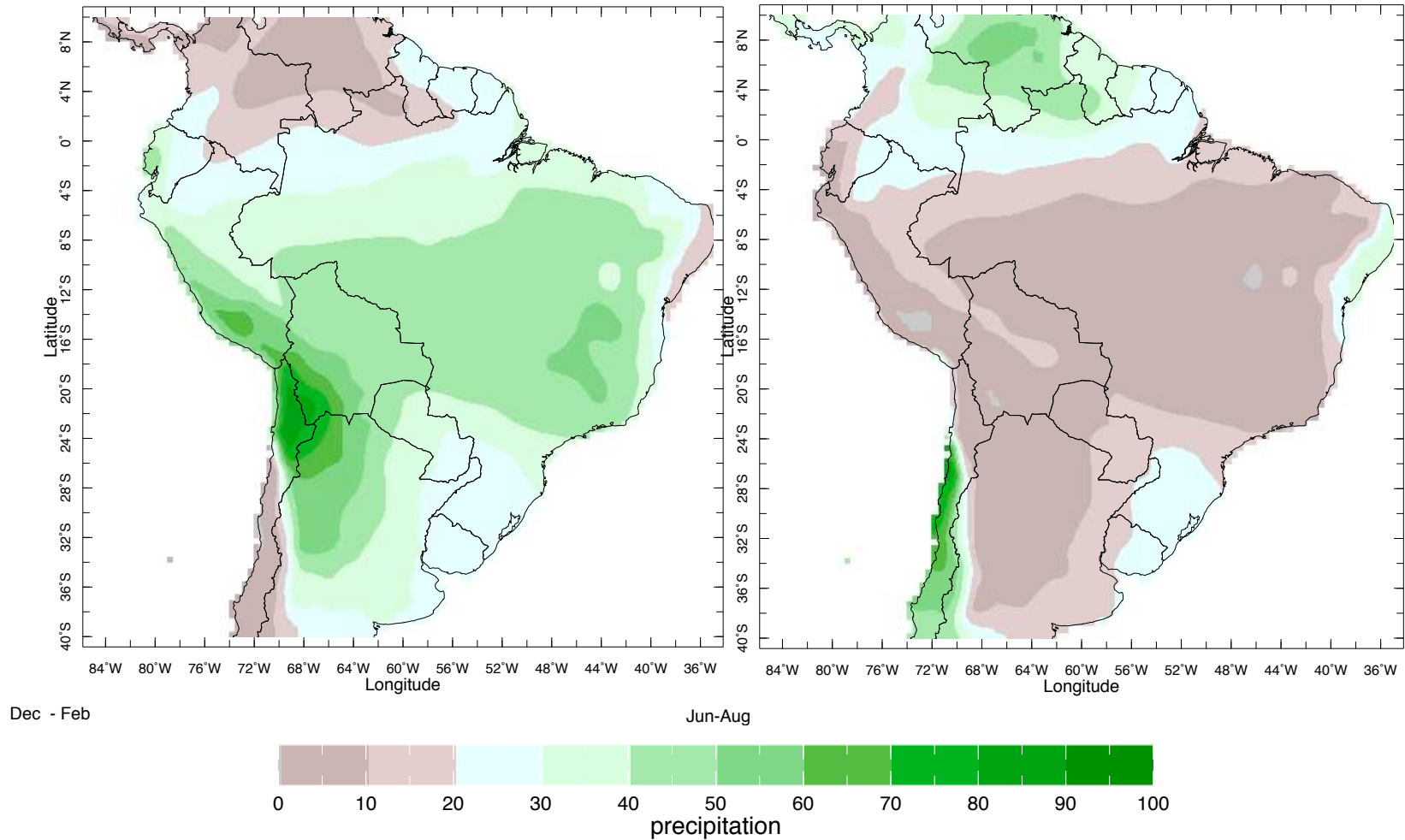


Andean Highlands



Altiplano Climate

Fraction of annual precipitation: DJF, JJA



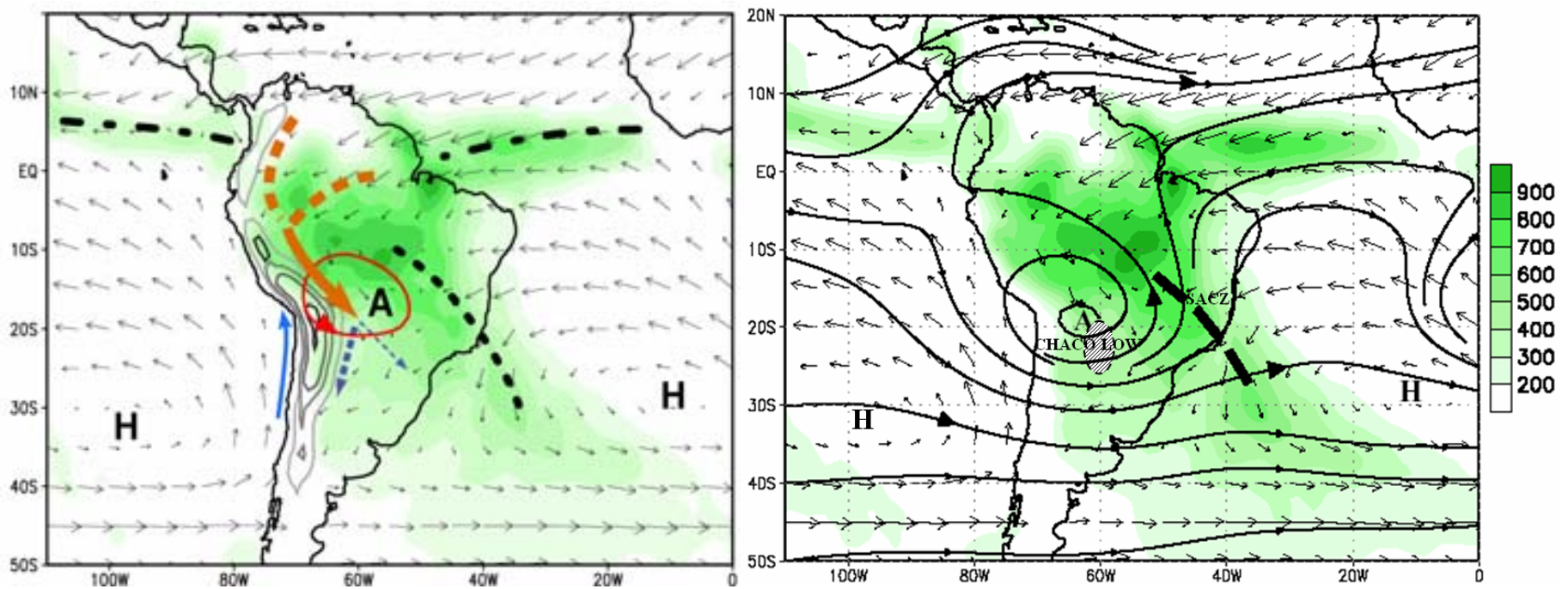


Overview

- SANREM CRSP Background
- Altiplano climate - mean
- Altiplano climate - variability
- Altiplano climate - projections
- Discussion

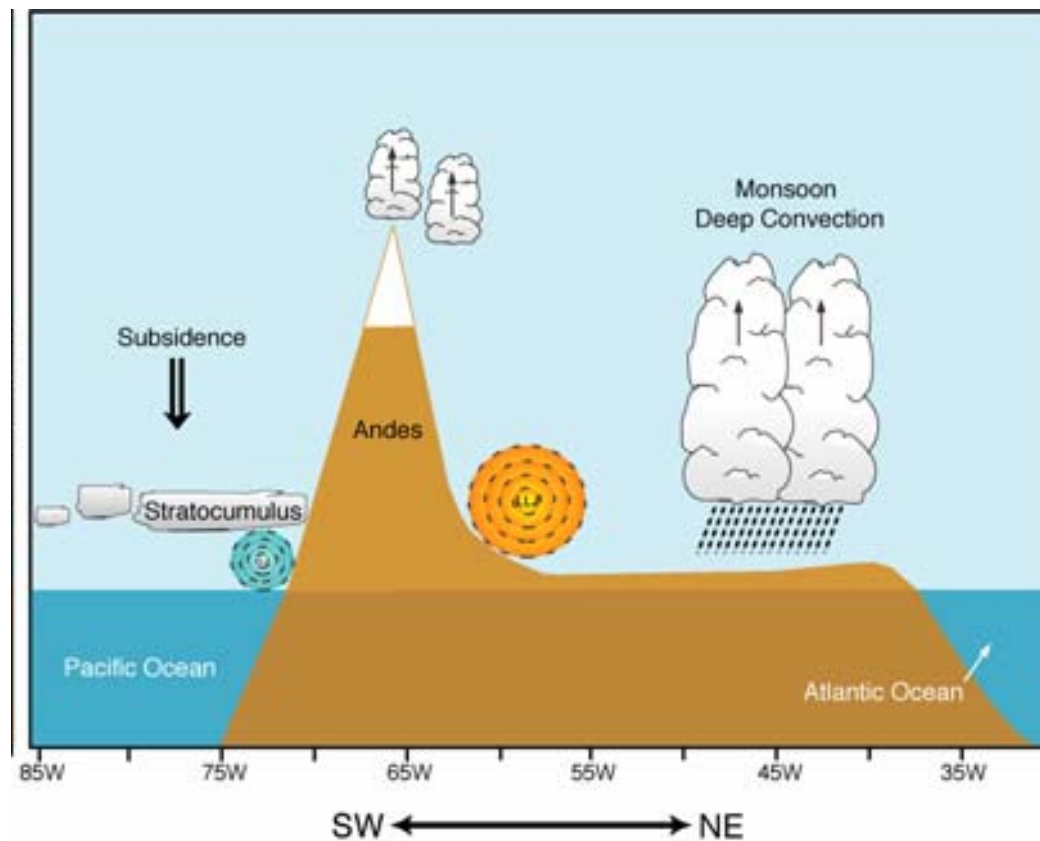
Altiplano Climate

Features of South American Warm Season Rains

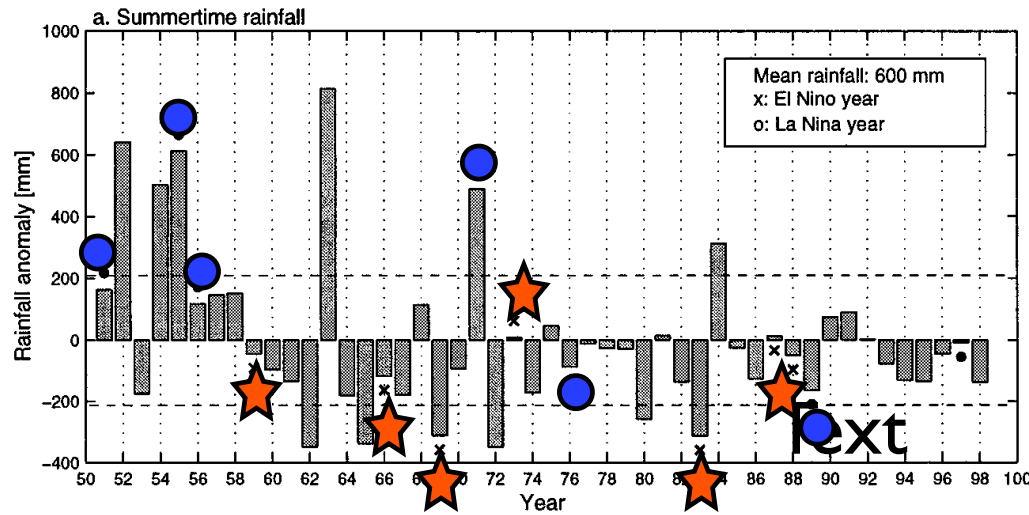


Altiplano Climate

Features of South American Warm Season Rains



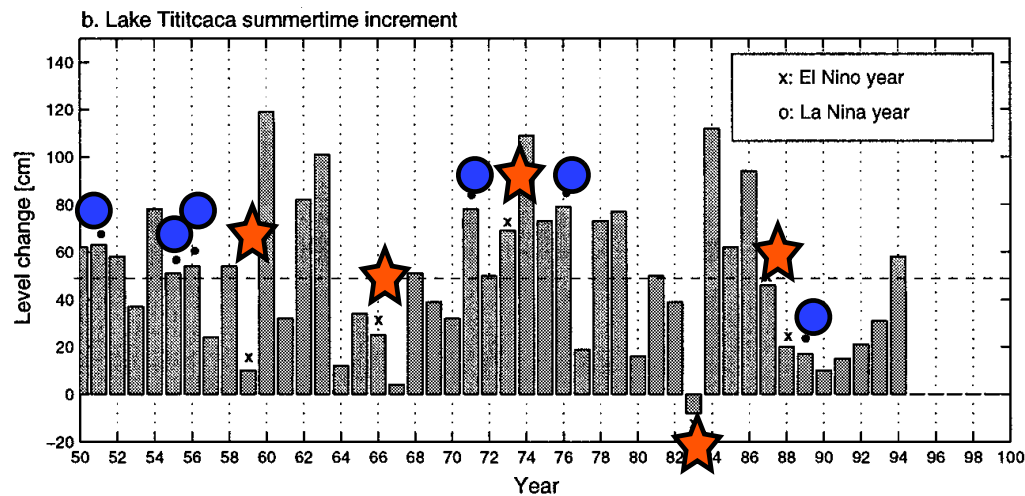
Altiplano Variability



Garreaud & Aceituno, 2001

Summer Rainfall Anomalies
Gridded precipitation from
CRU/Dai

El Nino - Dry?
La Nina - Wet?



Lake Titicaca summertime
increment

Altiplano Variability

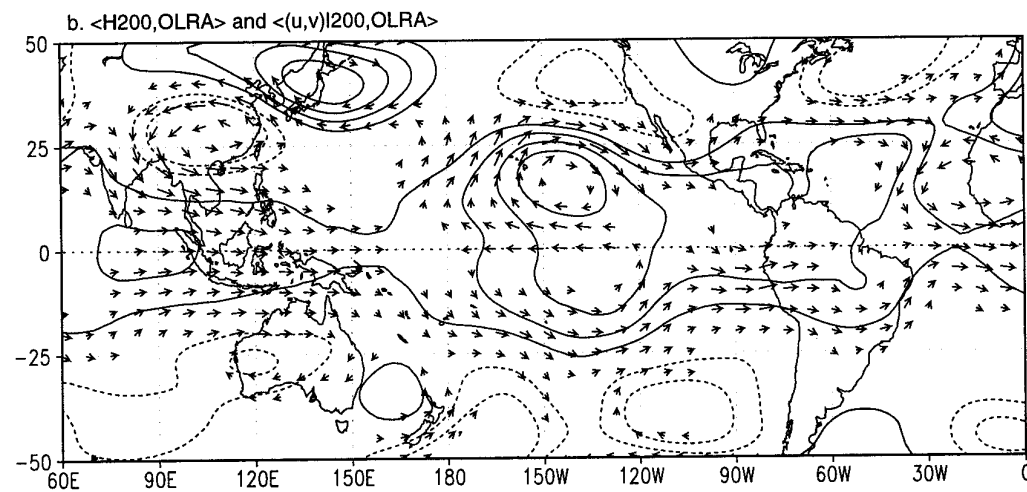
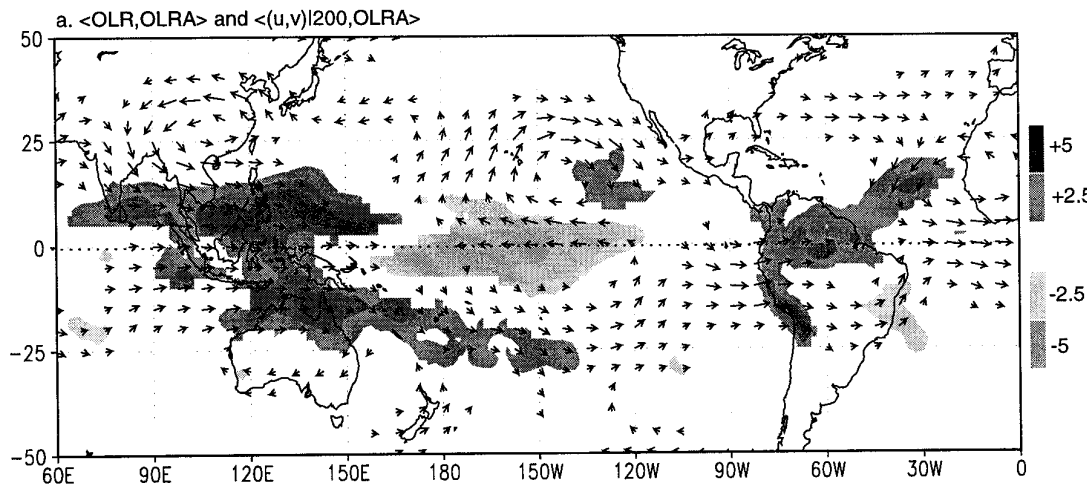
Garreaud & Aceituno, 2001

Summer rainfall anomalies
upper tropospheric winds
and tropospheric
temperatures

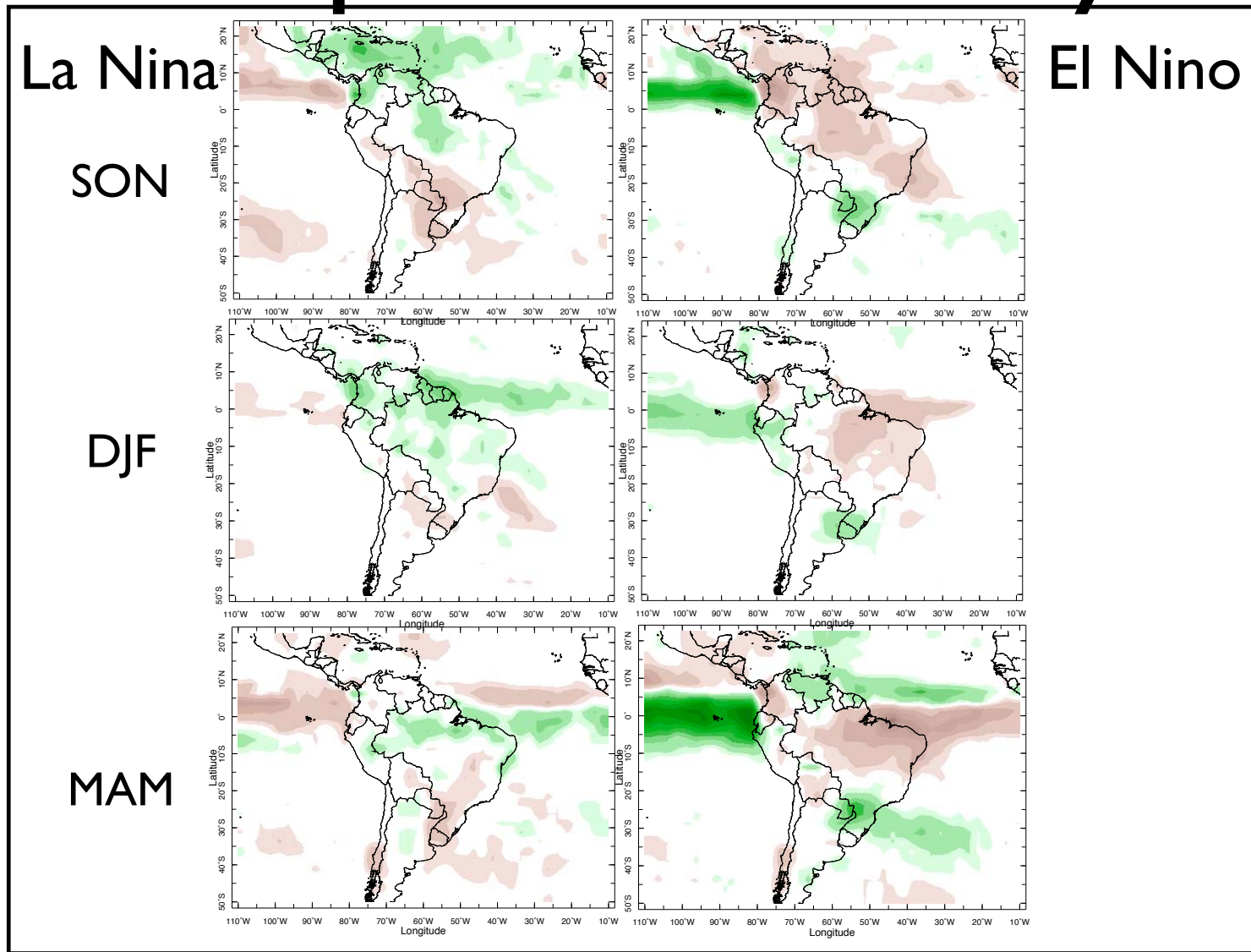
Dry - upper level westerlies
and warm troposphere

Wet - easterlies and cooler
troposphere

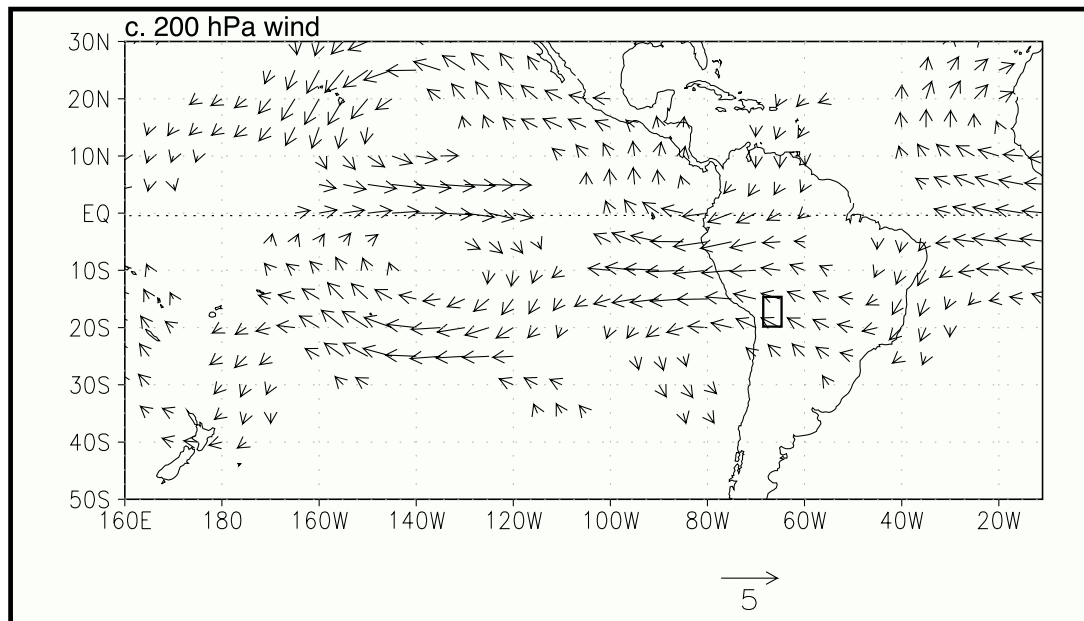
Sensitive to latitude of
enhanced westerlies



Altiplano Variability



Altiplano Variability



Garreaud & Aceituno, 2001

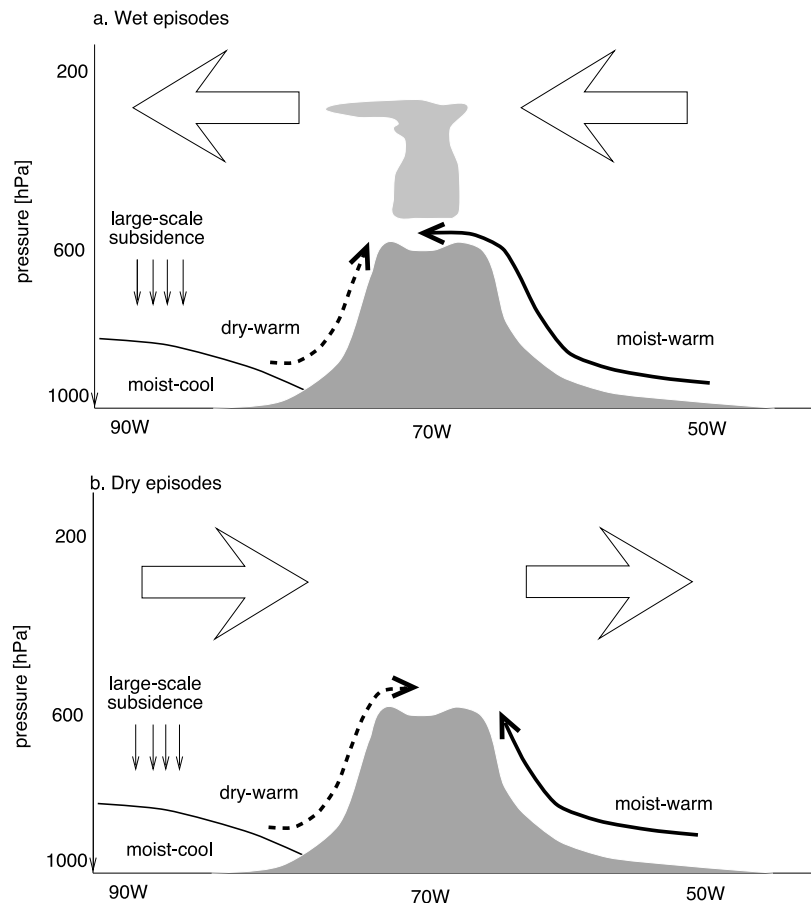
Summer rainfall anomalies
upper tropospheric winds

Dry - upper level westerlies

Wet - easterlies

Altiplano Variability

R. Garreaud et al. / *Palaeogeography, Palaeoclimatology, Palaeoecology* 194 (2003) 5–22

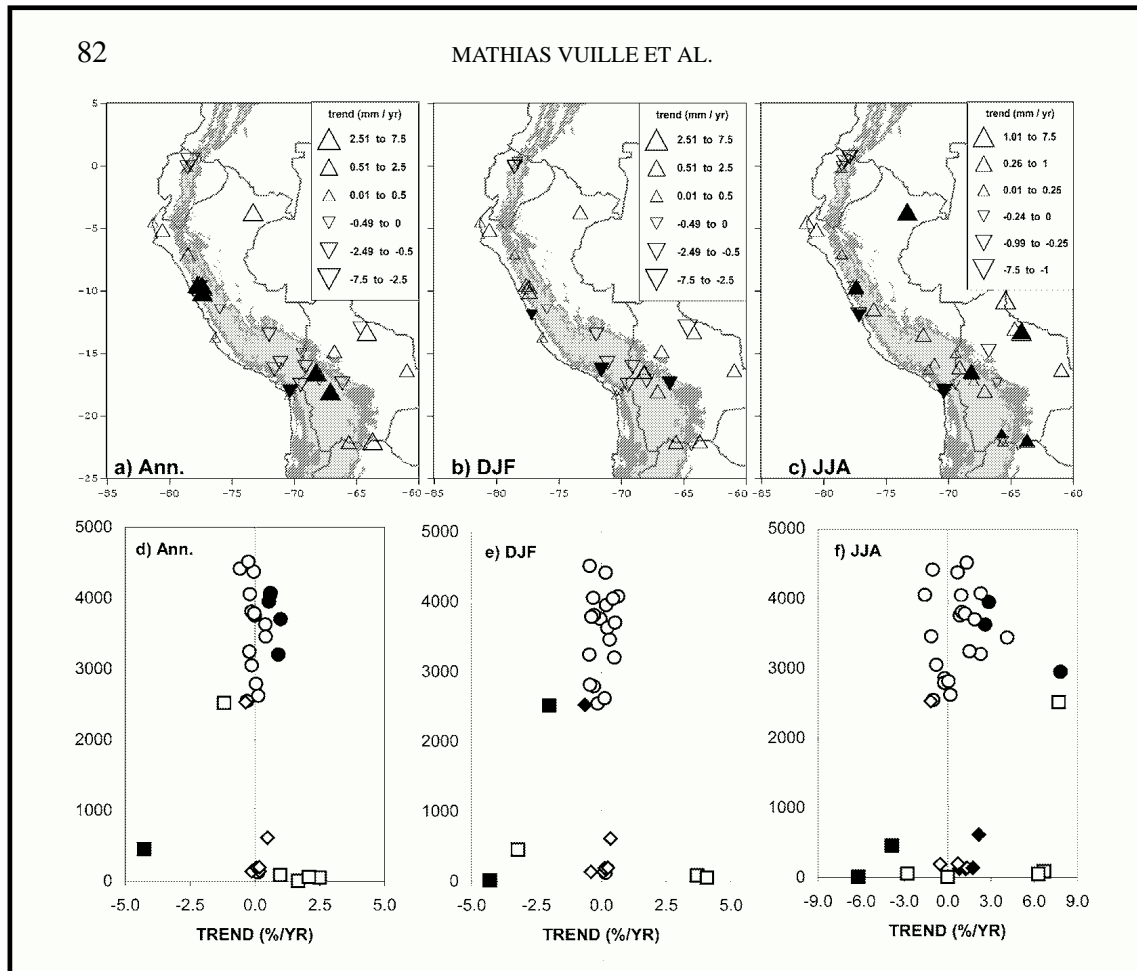


Garreaud et al., 2003

Summer rainfall related to direction of upper tropospheric winds at

- intraseasonal
 - annual cycle
 - interannual
 - interglacial?
- timescales.

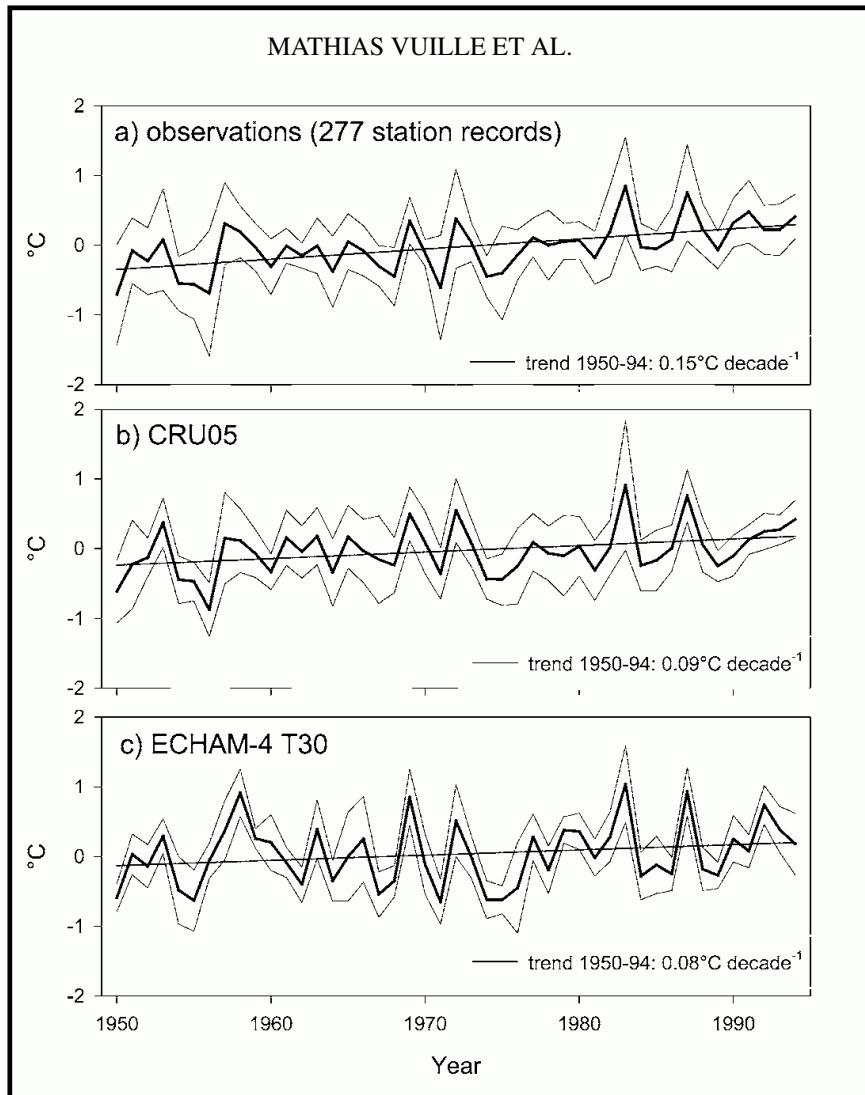
Altiplano Trends



Vuille et al., 2003

Precipitation trends are minor and cannot explain observed retreat of glaciers.

Altiplano Trends

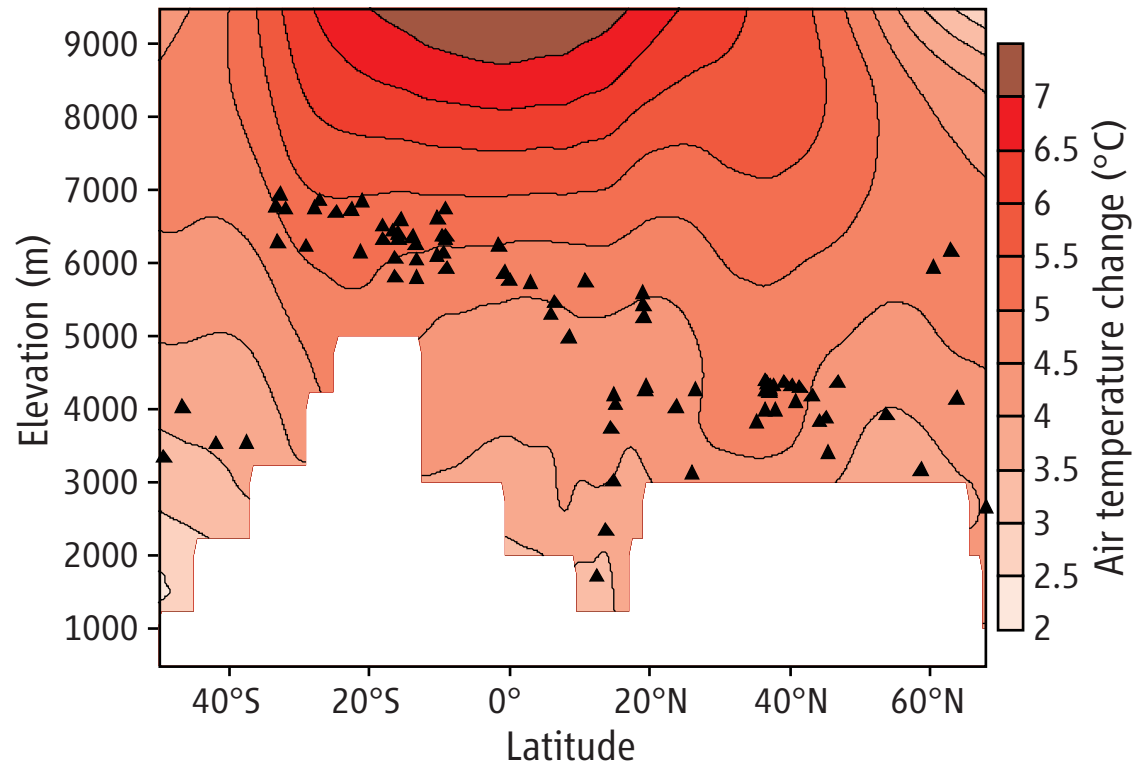


Vuille et al., 2003

Temperature trends are substantial, and are a likely cause of glacial retreat.

Trend is larger on the western slope of the Andes.

Altiplano Projections



Threats to Water Supplies in the Tropical Andes

Raymond S. Bradley, Mathias Vuille, Henry F. Diaz, Walter Vergara

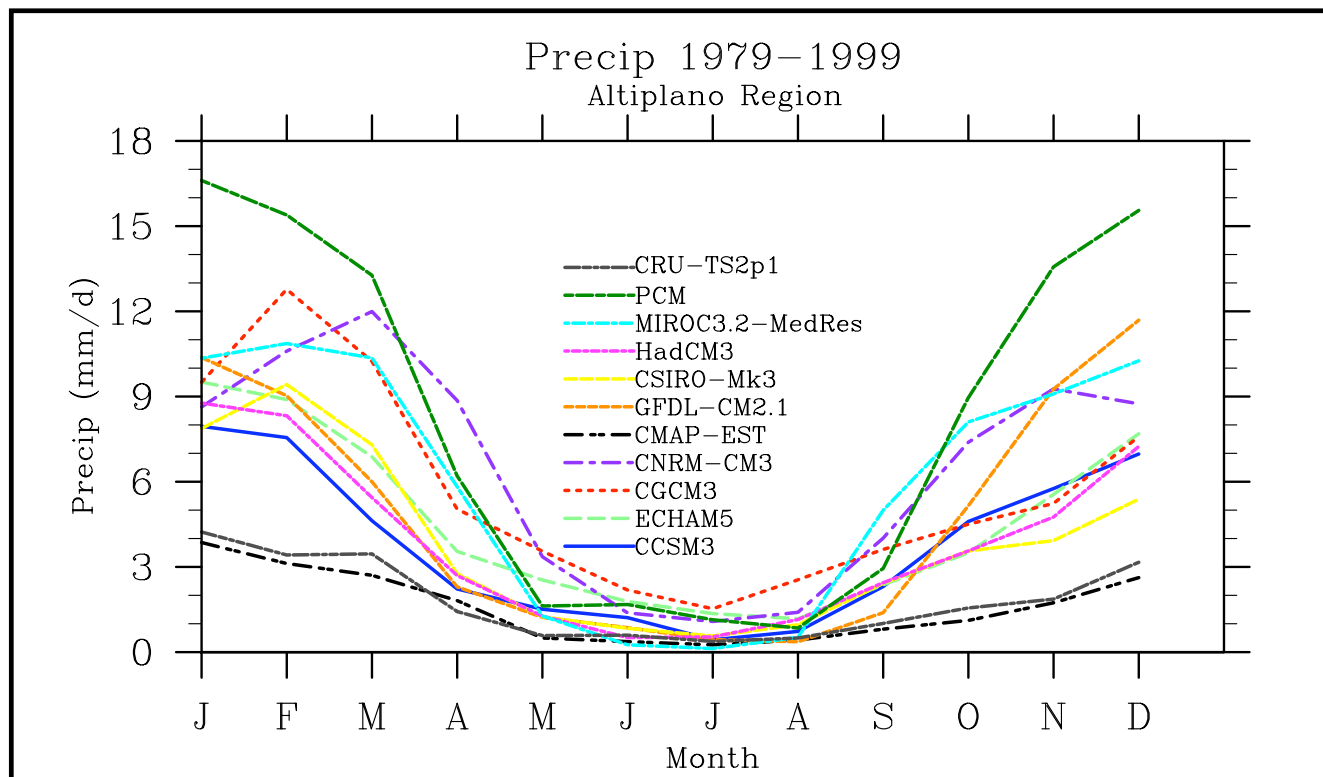
Hypotheses

Anticipated Changes

- Climate Variability -
- Climate Change - precipitation, frost days, heat waves

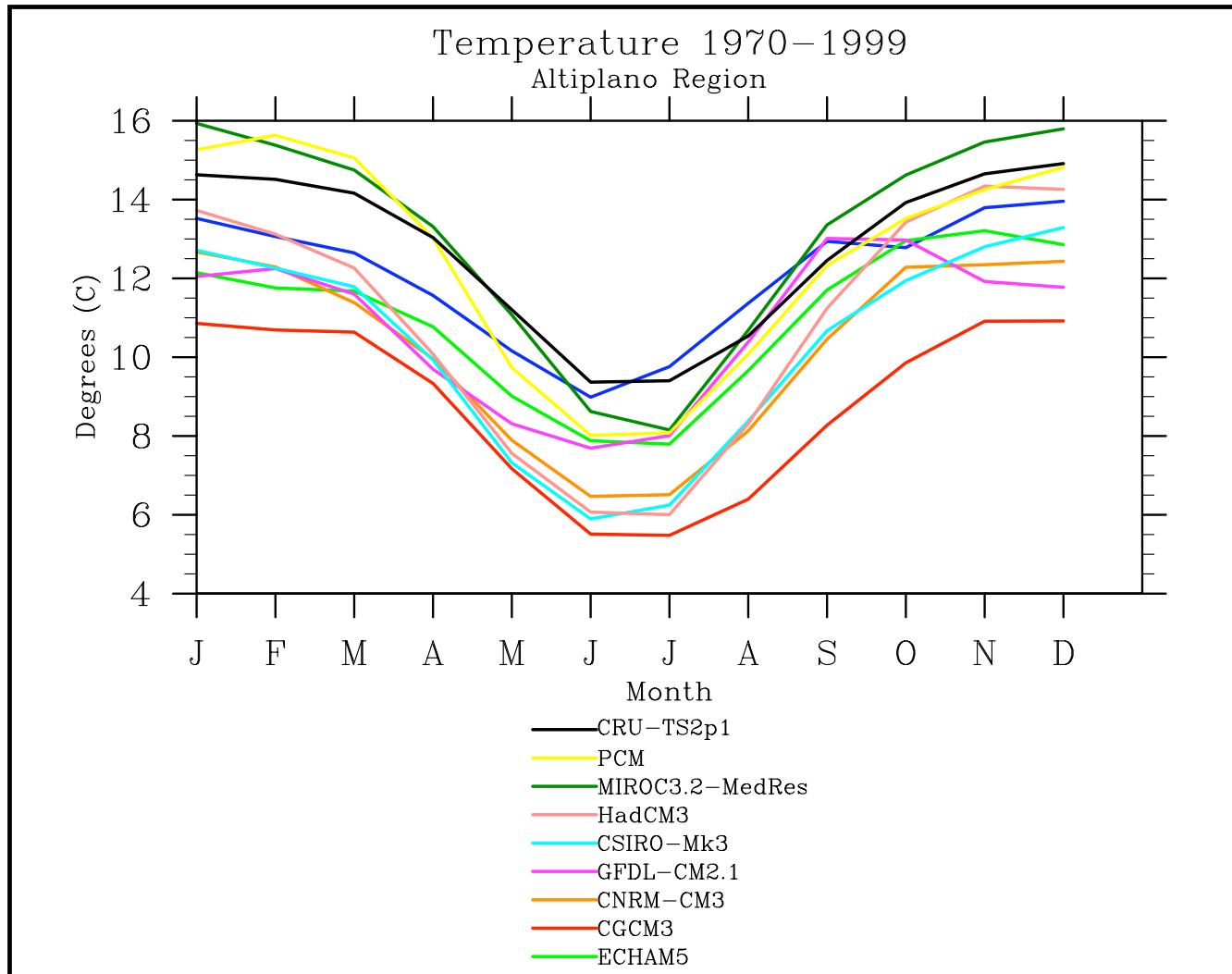
Altiplano Climate

Precipitation - Obs, AR4 Models



Altiplano Climate

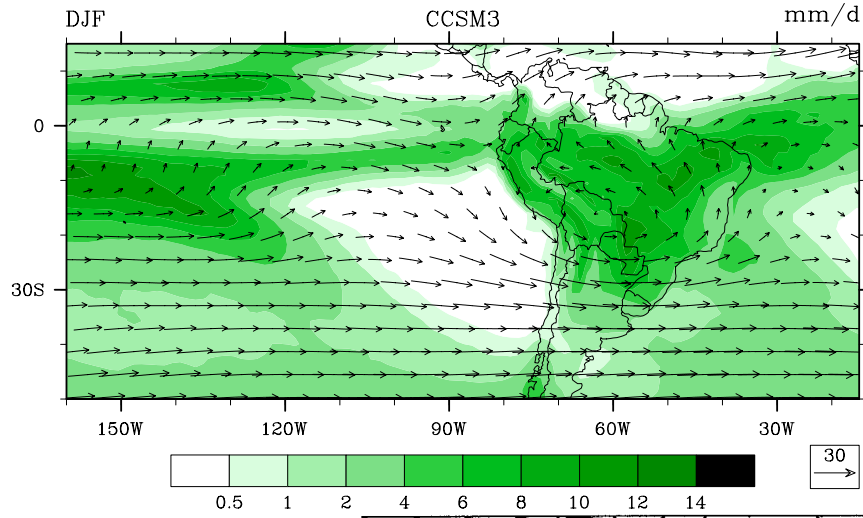
Precipitation - Obs, AR4 Models



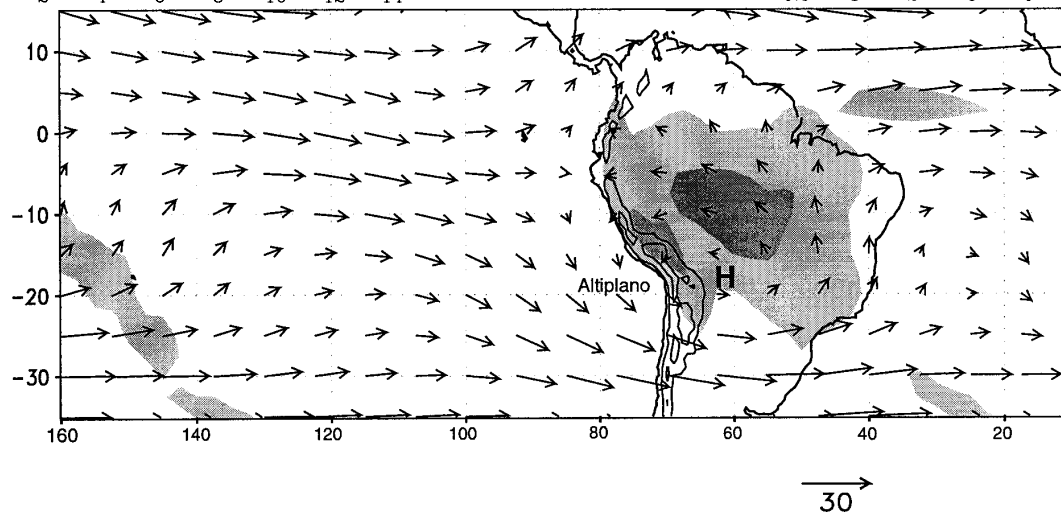
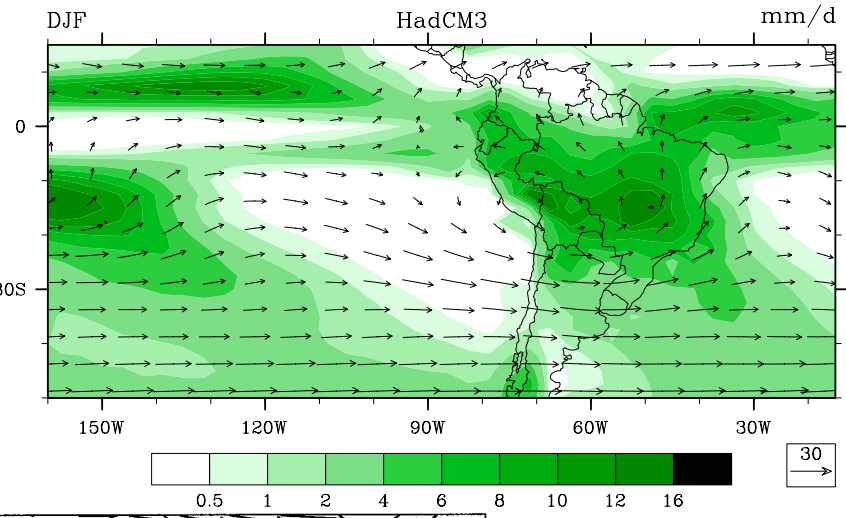
Altiplano Climate

Precipitation & 200 hPa Wind - AR4 Models

Precipitation & 200 HPa Winds 1970-1999



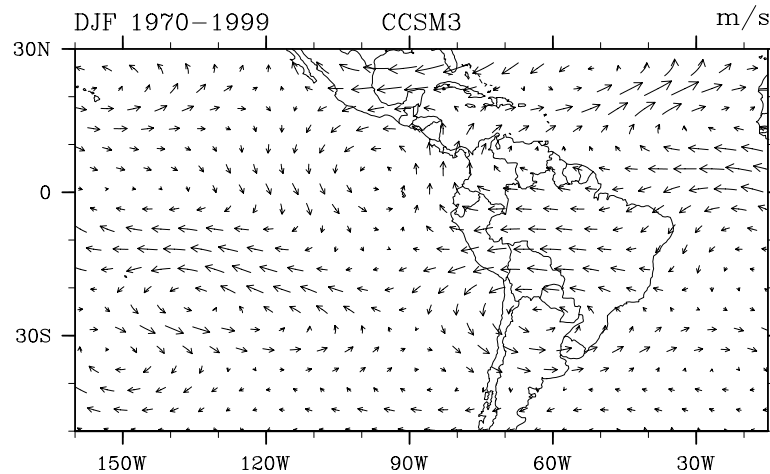
Precipitation & 200 HPa Winds 1970-1999



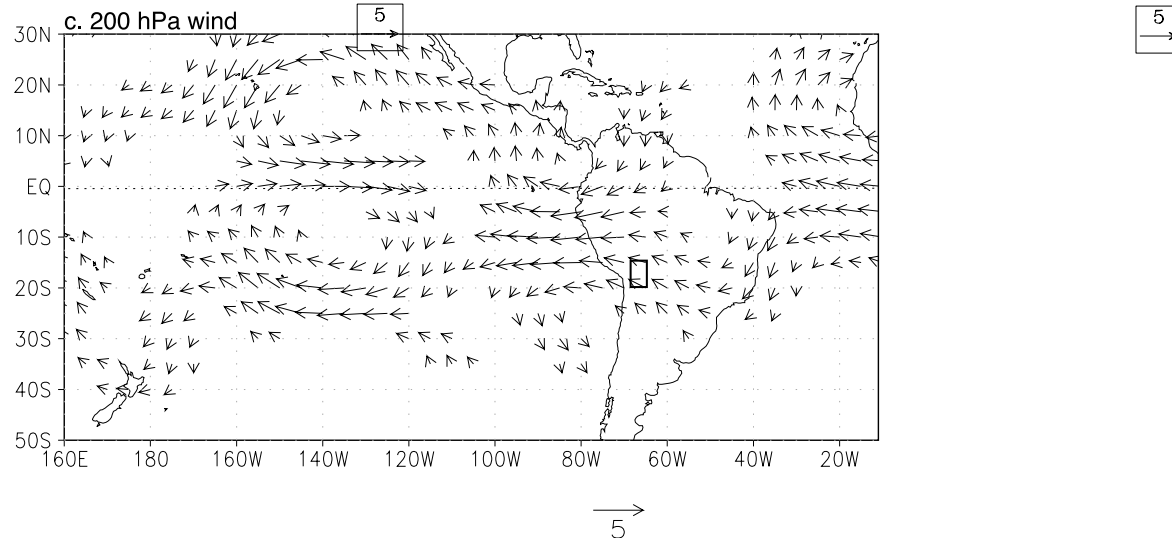
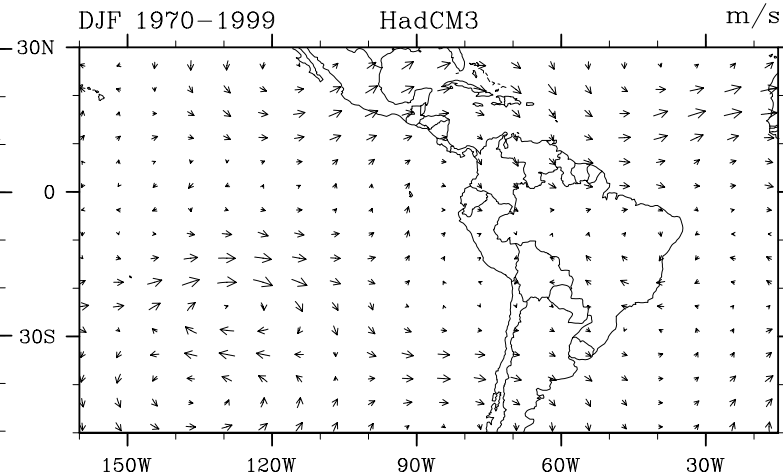
Altiplano Variability

Precipitation & 200 hPa Wind - AR4 Models

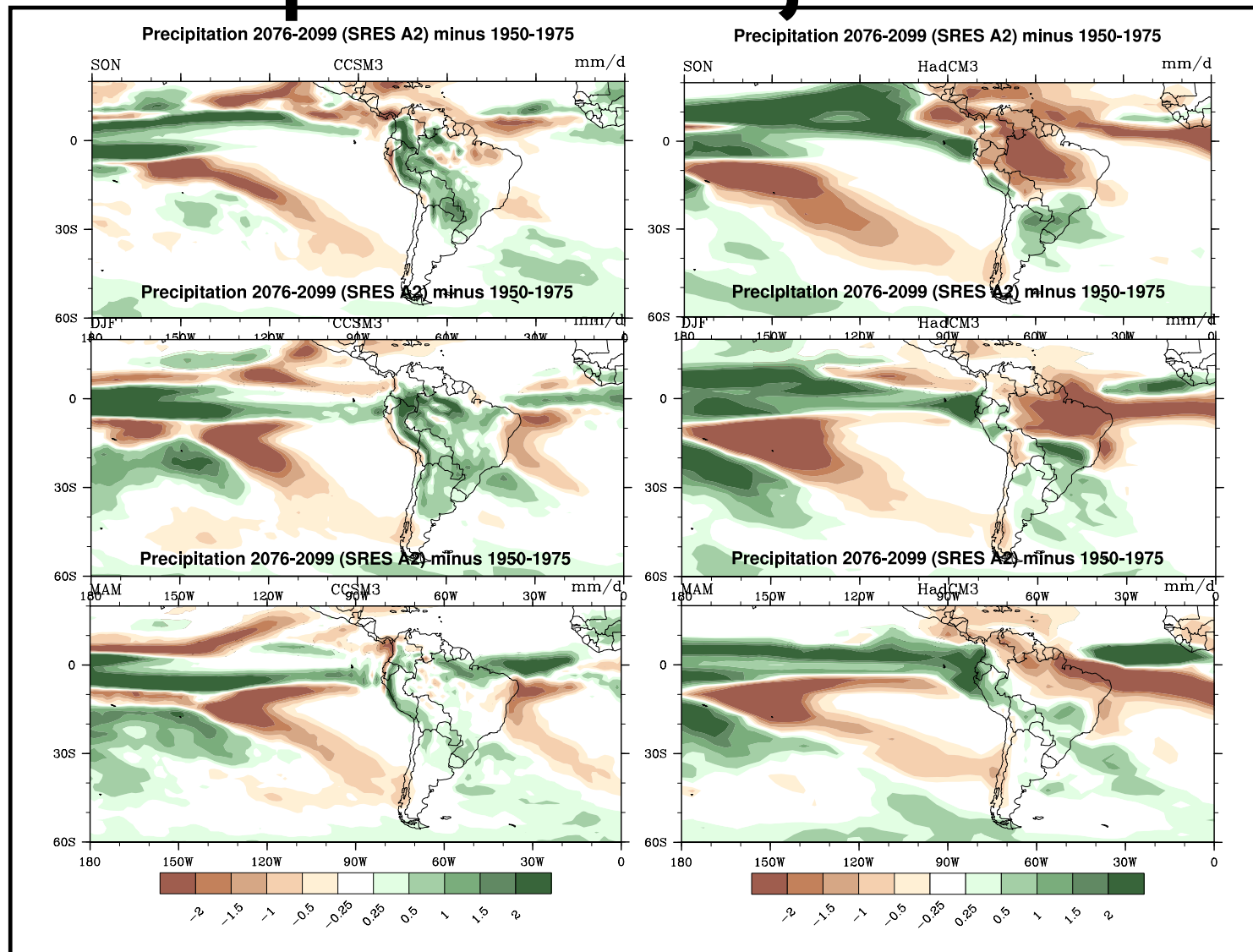
200 HPa Winds v. Altiplano Precipitation 1970-1999



200 HPa Winds v. Altiplano Precipitation 1970-1999



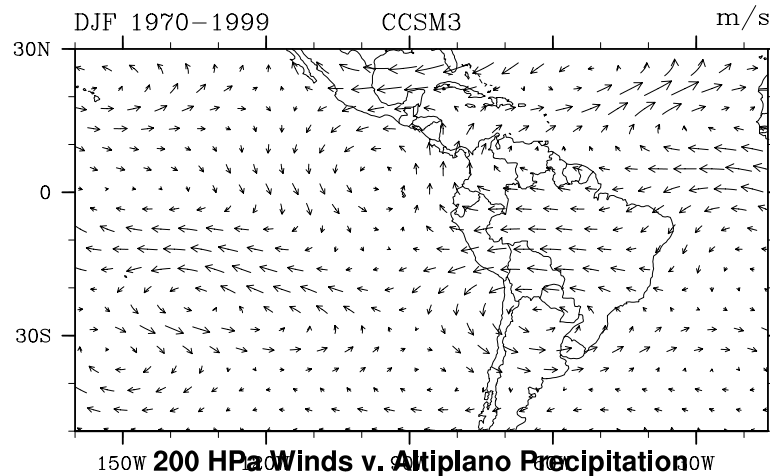
Altiplano Projections



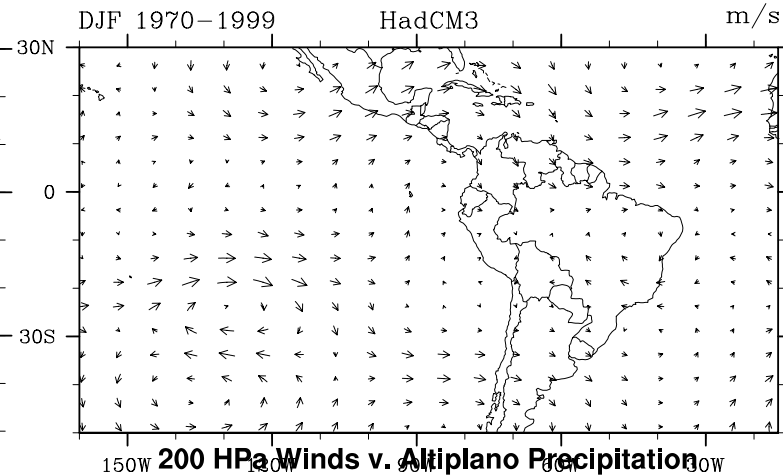
Altiplano Projections

Precipitation & 200 hPa Wind - AR4 Models

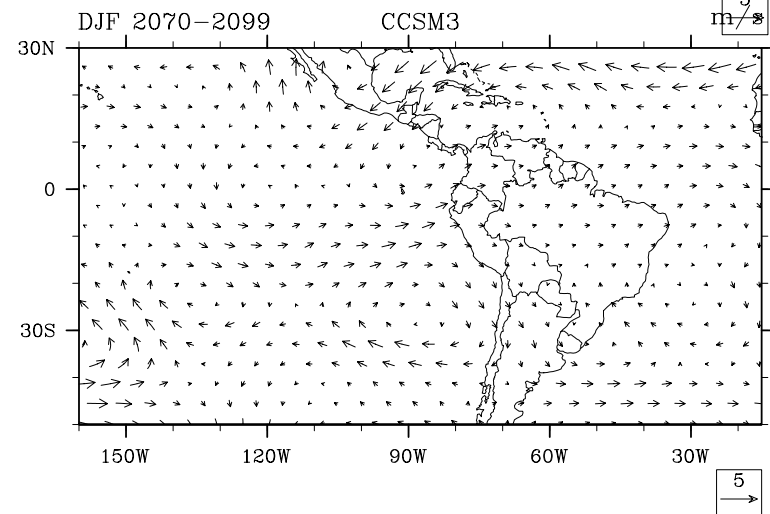
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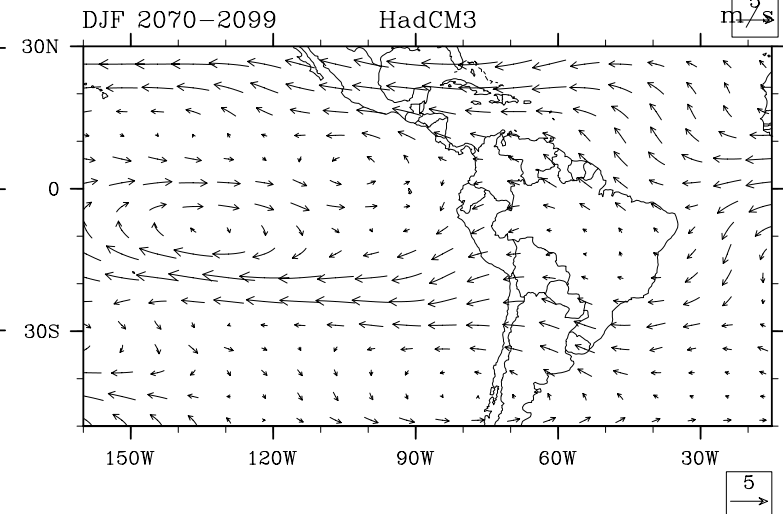
200 HPa Winds v. Altiplano Precipitation 1970-1999



200 HPa Winds v. Altiplano Precipitation



200 HPa Winds v. Altiplano Precipitation

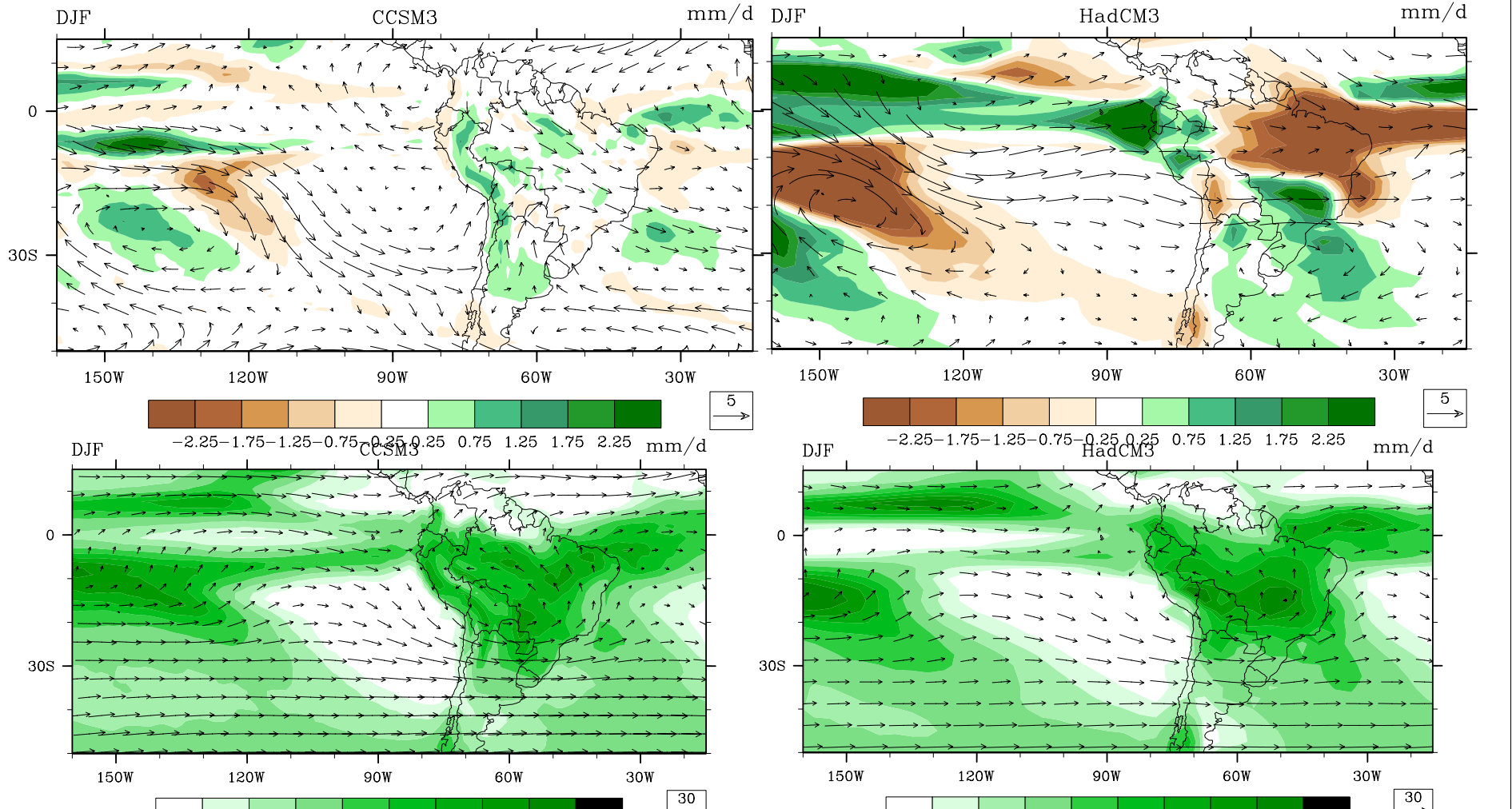


Altiplano Variability

Precipitation & 200 hPa Wind - AR4 Models

Precip & 200 HPa UA 2070-2099 - 1970-1999

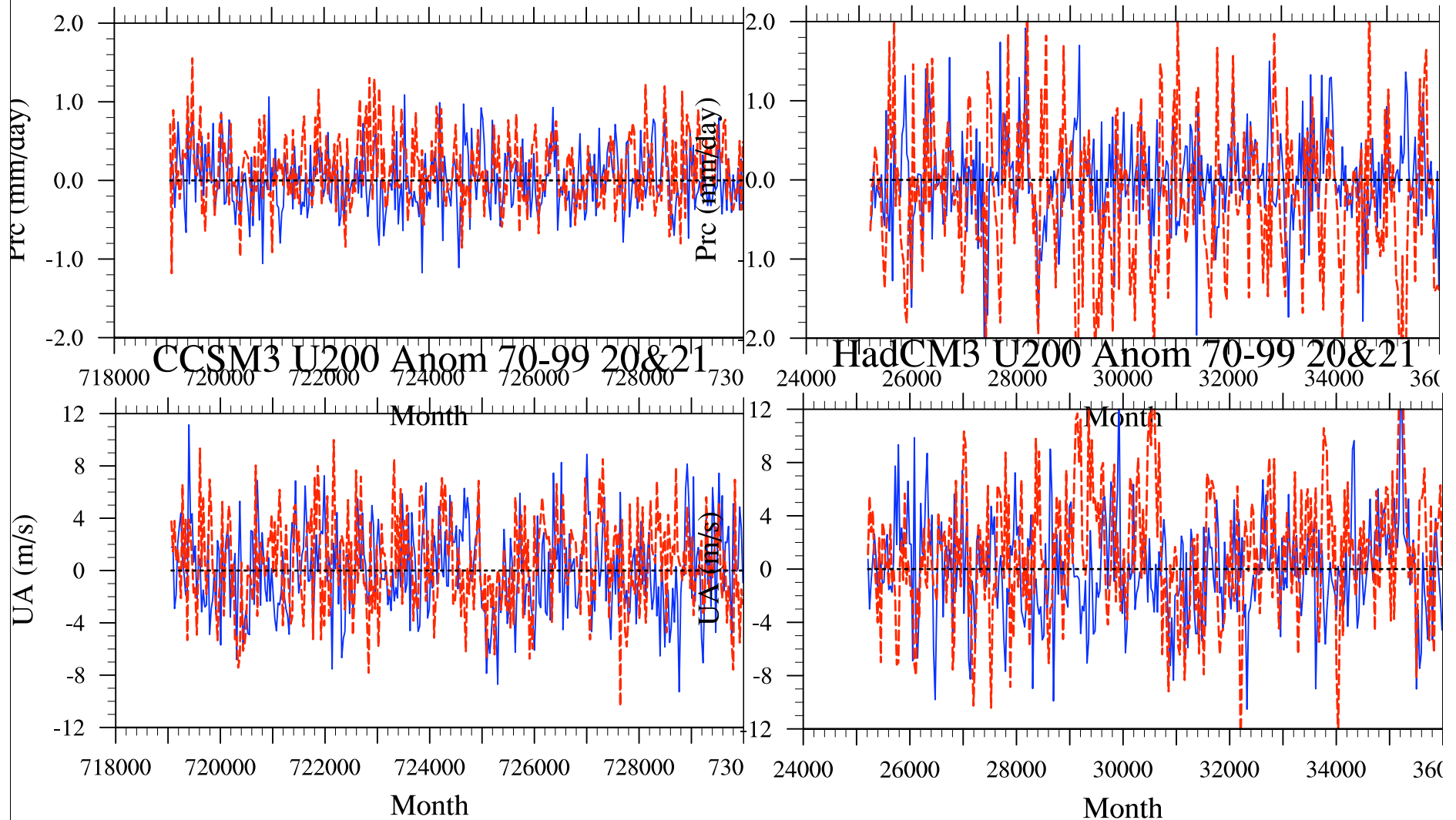
Precip & 200 HPa UA 2070-2099 - 1970-1999



Altiplano Variability

CCSM3 Prec Anom 70-99 20&21

HadCM3 Prec Anom 70-99 20&21



Discussion

- The upper tropospheric zonal wind hypothesis...
- The models appear to simulate this mechanism in the present
- The models respond quite differently in 21st Century climate - is there a change in the mechanism relating precipitation to upper level zonal wind?

Acknowledgments



University of Connecticut



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University of Missouri-Columbia



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