

Altiplano Climate

Making Sense of 21st century Scenarios

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Overview

- Coupled Model Intercomparison Project (CMIP3)
- How do models represent Altiplano climate?
- What do models project for 21st century?
 - Changes in annual cycle of temperature, precipitation
 - Changes in extremes
- Caveats and Cautions

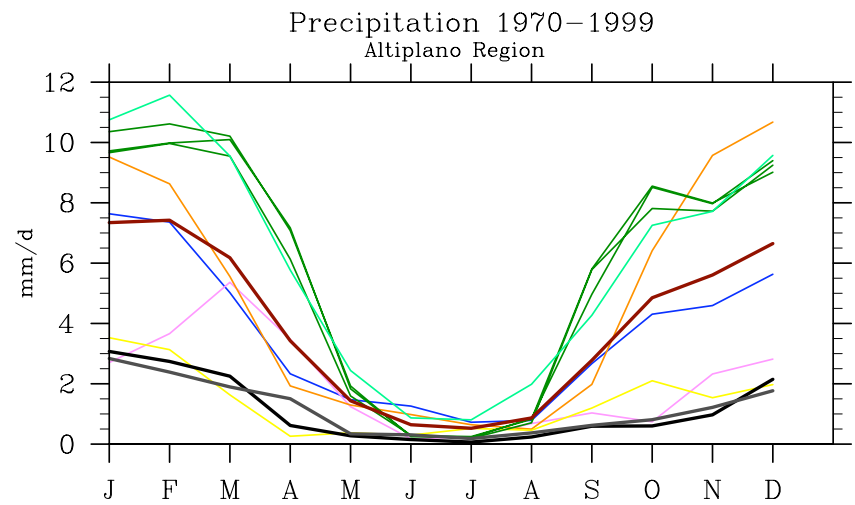
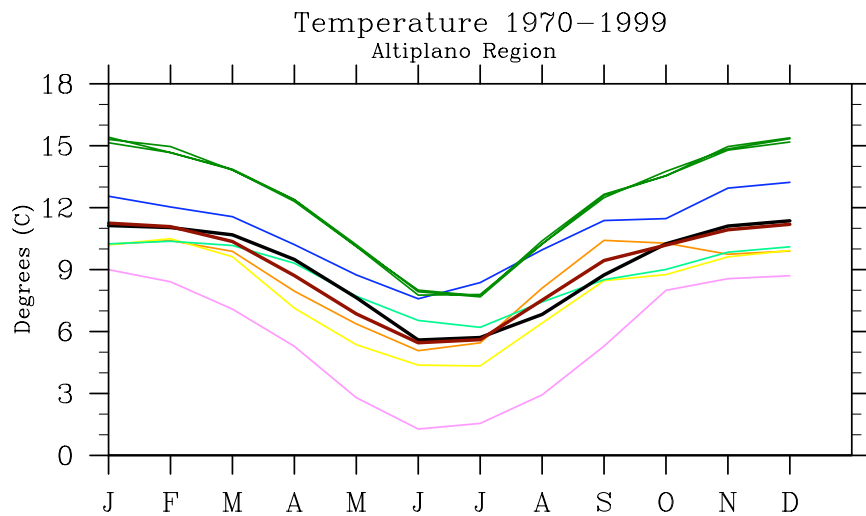
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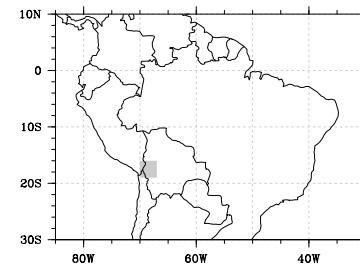
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Simulated Altiplano Climate



- Model Average
- CRU-TS2.1
- MIROC3.2-HiRes
- MIROC3.2-MedRes(3)
- MIROC3.2-MedRes(2)
- MIROC3.2-MedRes(1)
- GFDL-CM2.0
- GFDL-CM2.1
- CNRM-CM3
- CCSM3



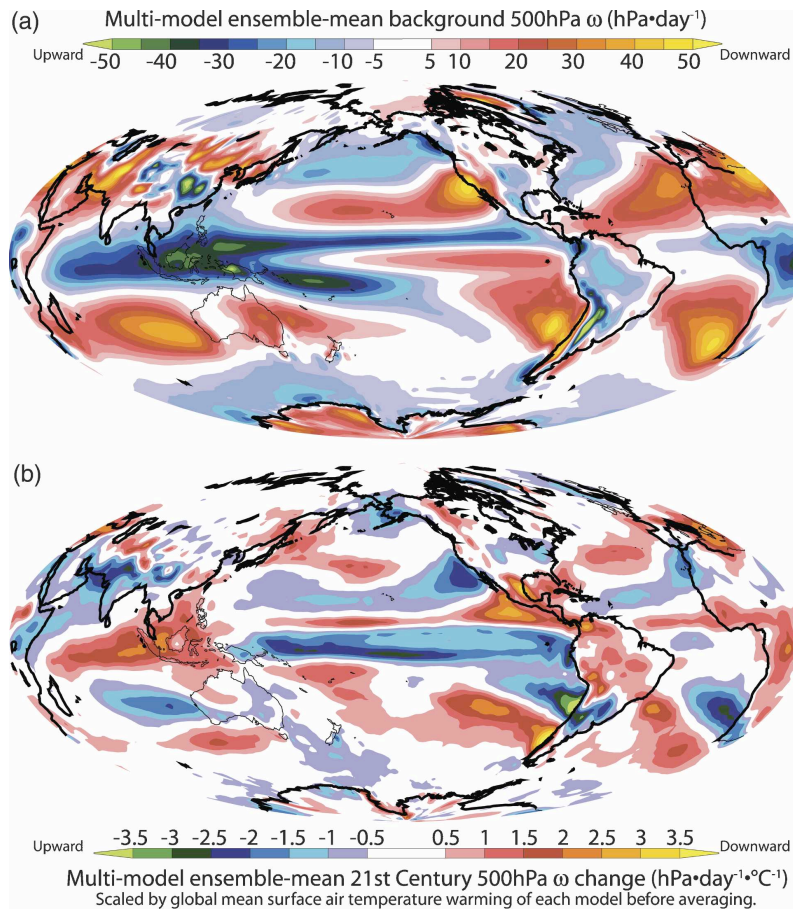
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Analysis for South America

- South American Monsoon analysis
 - Vera *et al.*, *Geophys. Res. Lett.* 2006
 - Li *et al.*, *J Geophys. Res.* 2006
 - ➔ much disagreement among models for Amazon
- Large scale circulation changes:
 - Vecchi and Soden, *J Climate* 2007
 - Neelin *et al.*, *PNAS* 2006
 - ➔ some coherent large scale changes

Large scale changes?



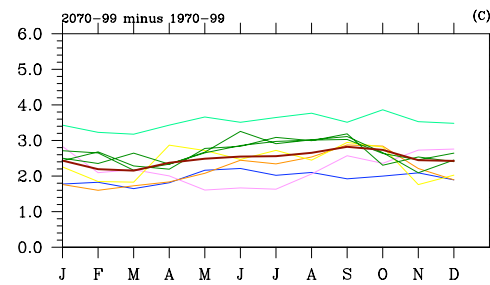
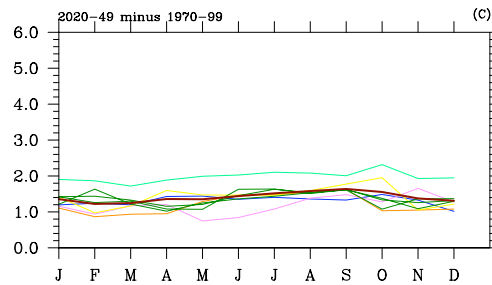
- weakening of tropical circulation via reduction in strength of Walker Circulation
- strengthened, poleward shifted sub tropical highs
- “upped ante” e.g., Neelin et al 2006

from Vecchi and Soden, *JClimate* 2007

Projected Temperatures

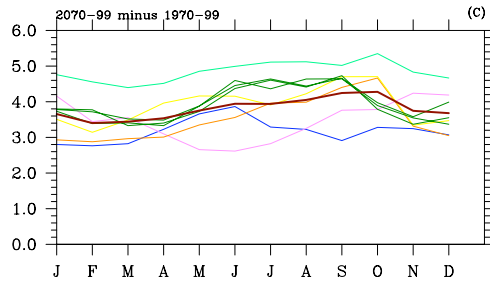
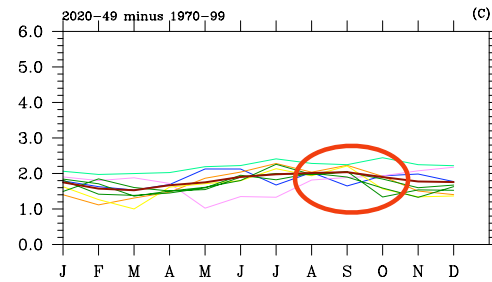
2020-49

BI: low

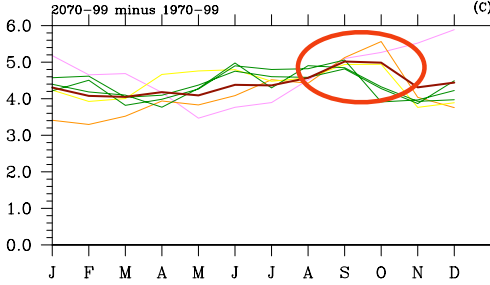
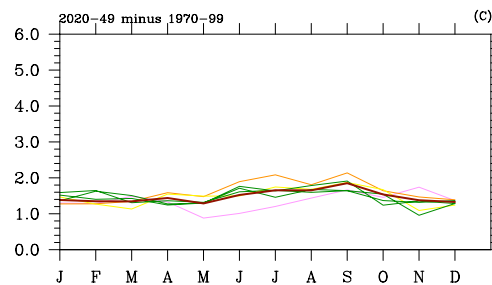


2070-99

A1B: medium



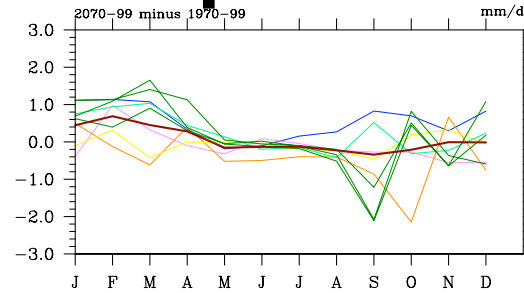
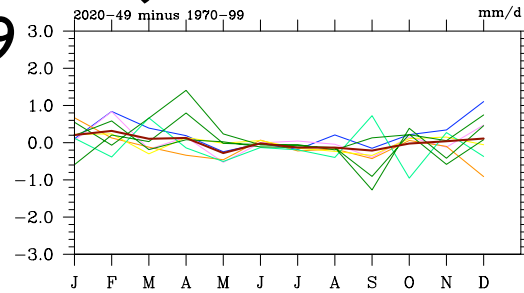
A2: high



Projected Precipitation

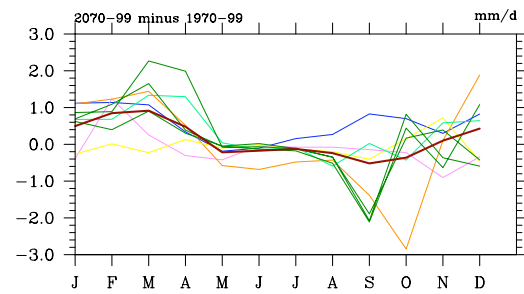
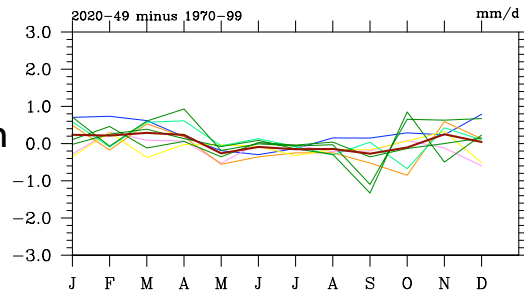
2020-49

BI: low

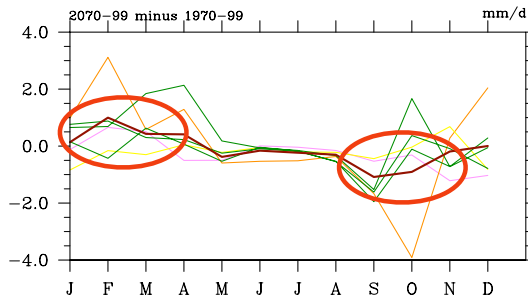
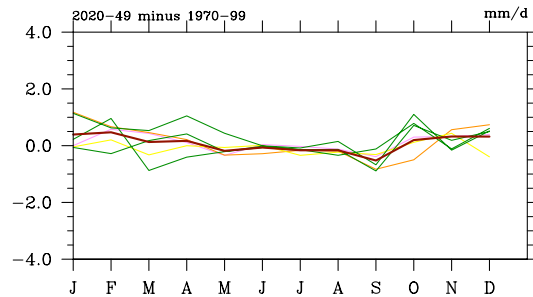


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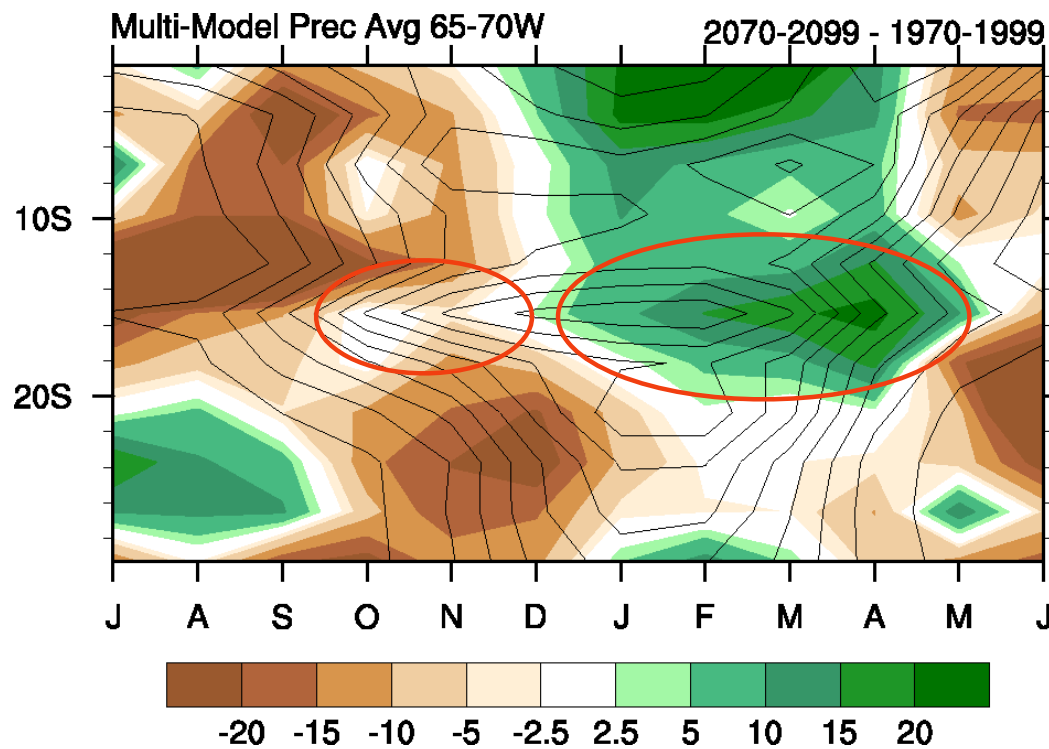
A1B: medium



A2: high



Annual Cycle Precipitation



- Drier early season
- Wetter peak season
- Is this believable?

Seth, Garcia & Thibeault, 2008: GRL, submitted

Overview

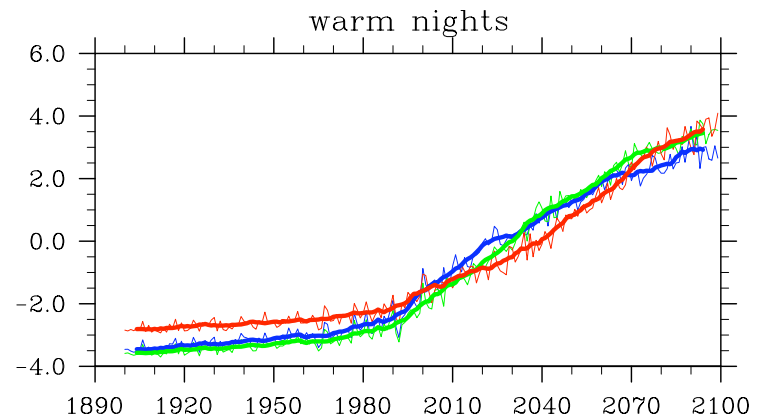
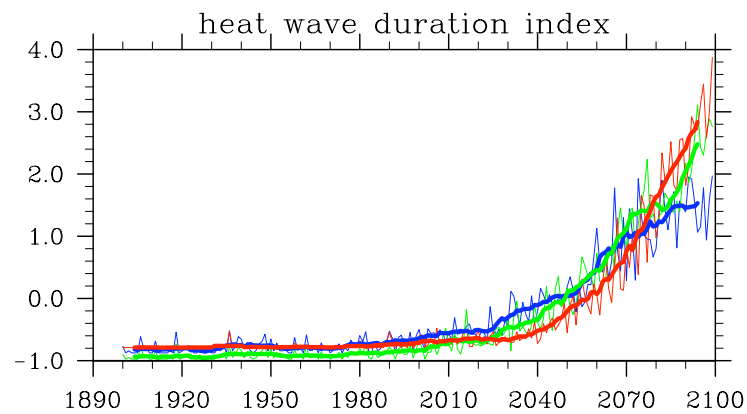
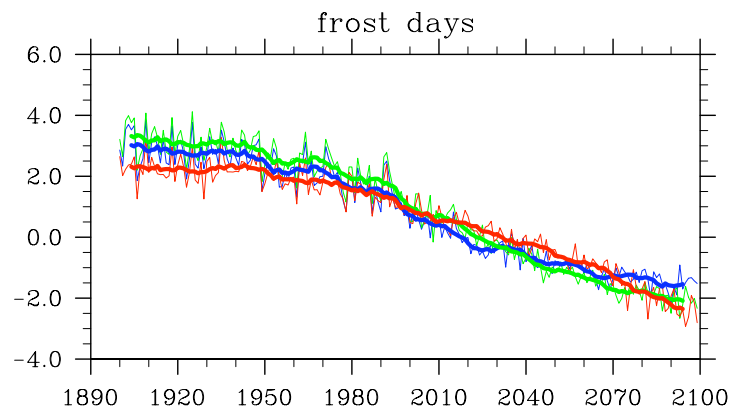
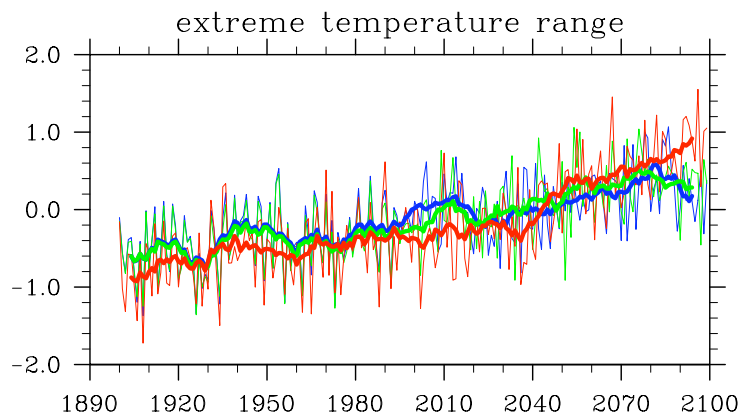
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 - **Changes in extremes**
- Caveats and Cautions

Extreme Indices

Table 1. Ten indicators of climate extremes *Frich et al.* [2002] *Tebaldi et al.* [2006] .

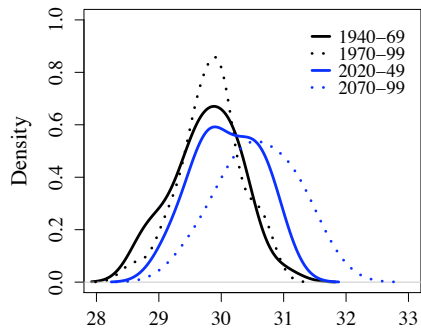
| Indicator | Definition | Units |
|--------------------------------------|--|-------------|
| Extreme temperature range (ETR) | Difference between the highest and lowest temperature observations within a given year | K |
| Frost days (FD) | Total number of days with minimum temperature $< 0^{\circ}$ C | days |
| Growing Season Length (GSL) | Number of days between the first period when mean $T_{day} > 5^{\circ}$ C for > 5 d and the first period when mean $T_{day} < 5^{\circ}$ C for > 5 d | days |
| Heat wave duration index (HWDI) | Max. period of at least 5 d when $T_{max} > 5^{\circ}$ C above the 1961-1990 daily T_{max} average | days |
| Warm nights (Tn90) | Percent of time in a year when $T_{min} > 90^{th}$ percentile of minimum temperature for a particular calendar date | % |
| Precip > 10 mm (R10) | Number of days with precip. ≥ 10 mm d^{-1} | days |
| Consecutive dry days (CDD) | Maximum number of consecutive dry days ($R_{day} < 1$ mm) | days |
| 5 day precipitation (R5d) | Maximum 5-day precipitation total | mm |
| Precip $> 95^{th}$ percentile (R95T) | Fraction of total annual precipitation from events $>$ the 1961-1990 95^{th} percentile | % |
| Precipitation intensity (SDII) | Annual total precipitation divided by the number of days with precip. ≥ 1 mm d^{-1} | mm d^{-1} |

Temperature Indices



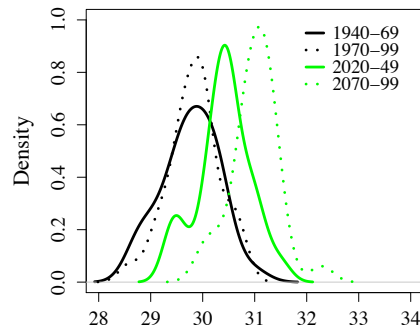
Shifts in PDFs (Probability Distribution Functions)

extreme temperature range (B1)



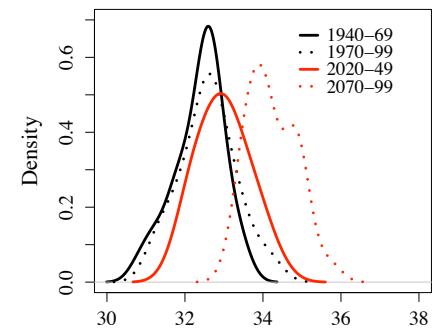
(C)

extreme temperature range (A1B)



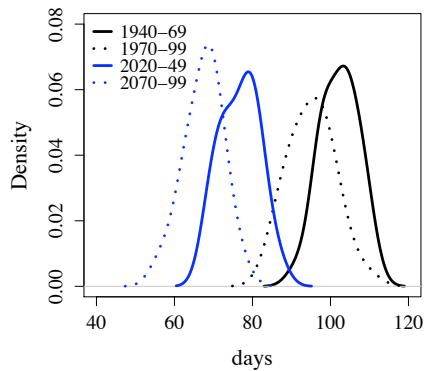
(C)

extreme temperature range (A2)

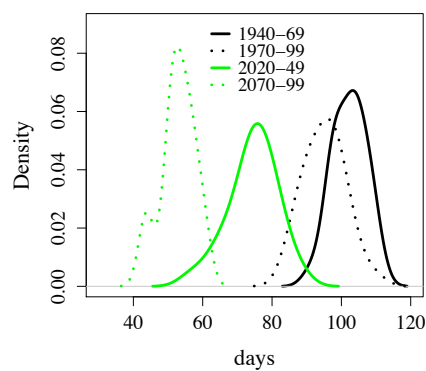


(C)

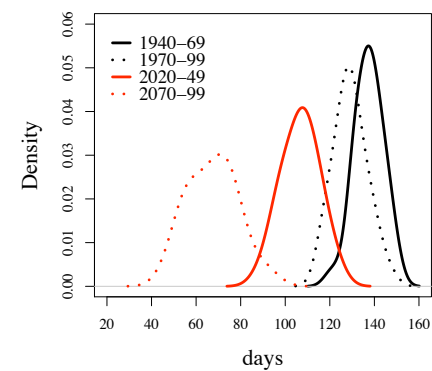
frost days (B1)



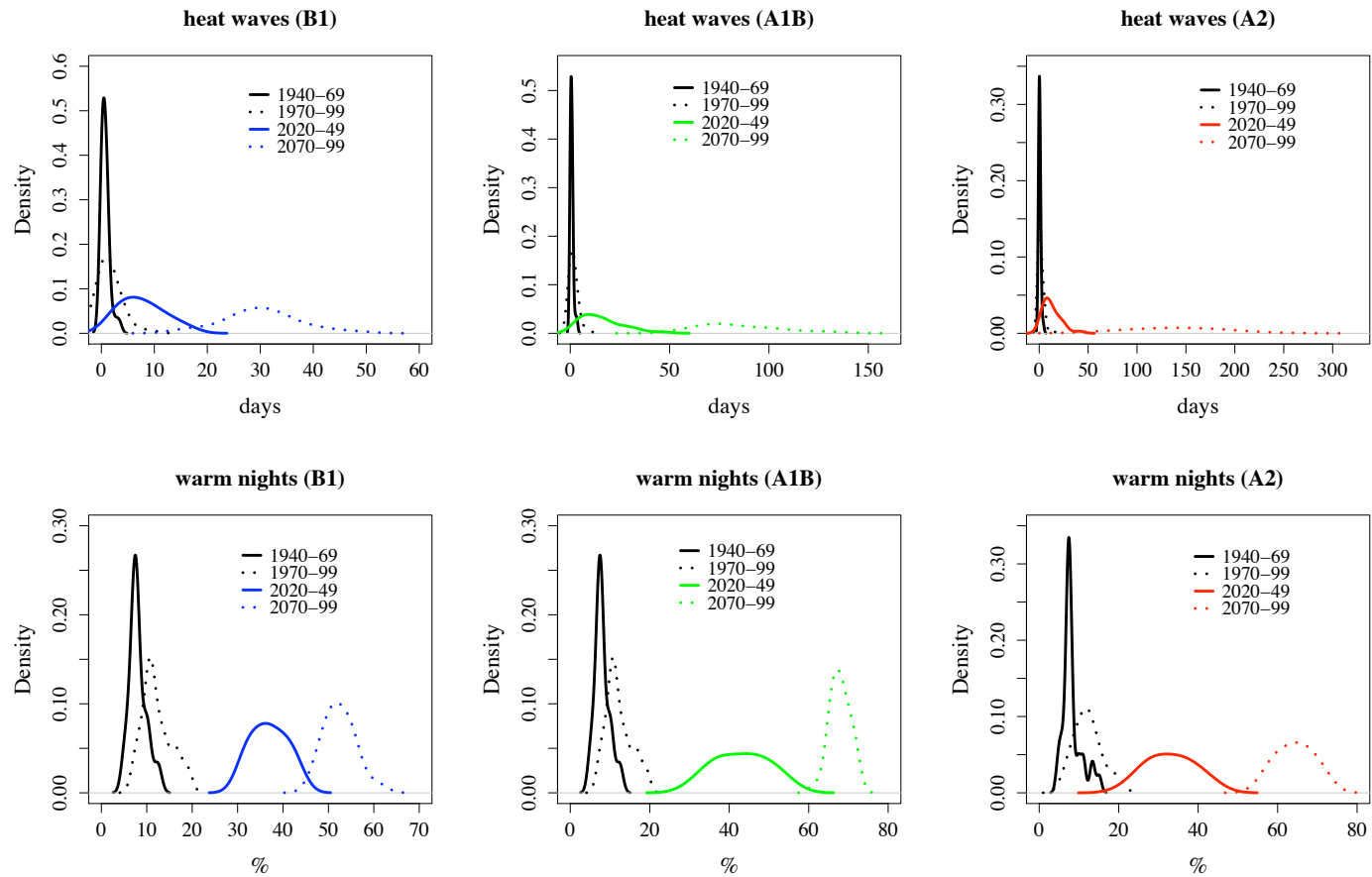
frost days (A1B)



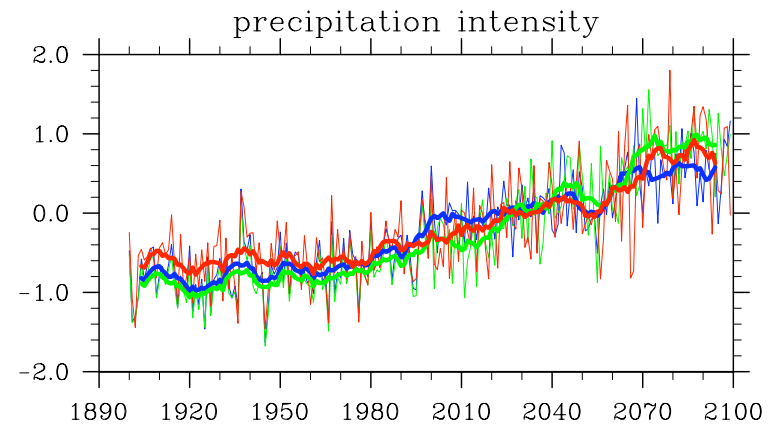
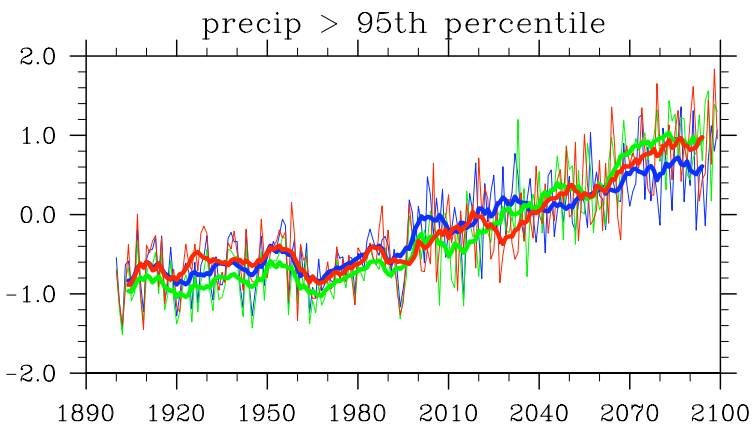
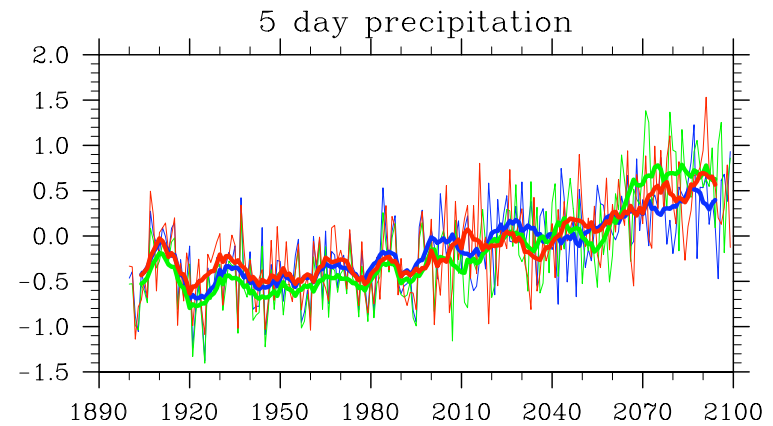
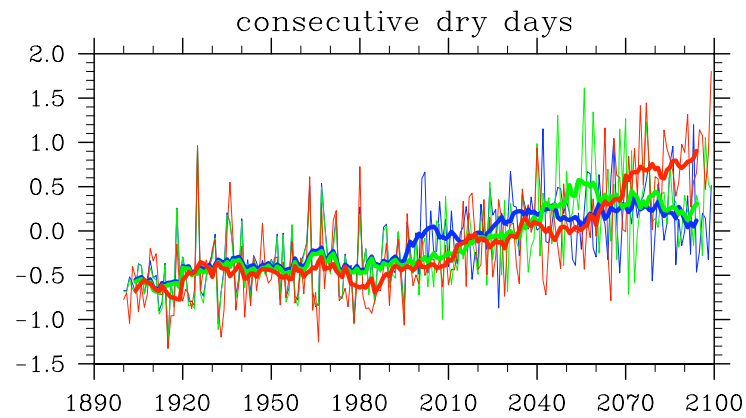
frost days (A2)



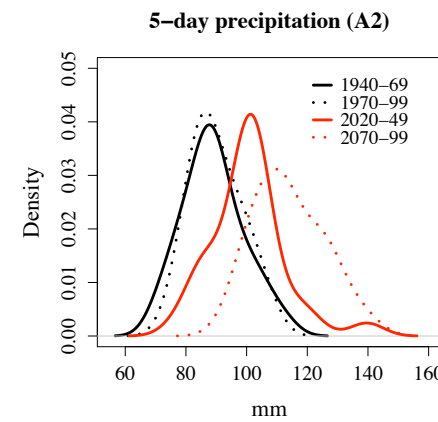
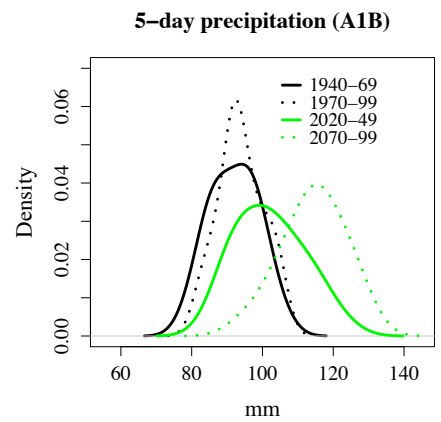
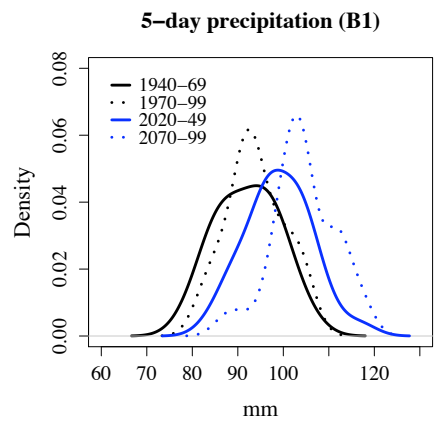
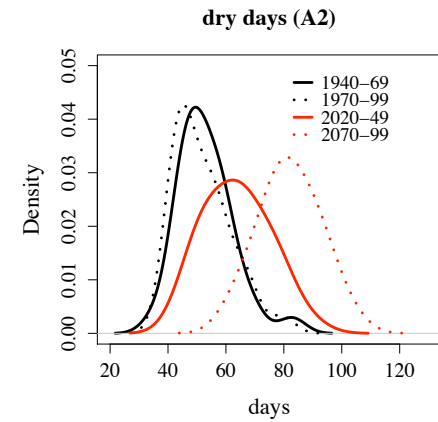
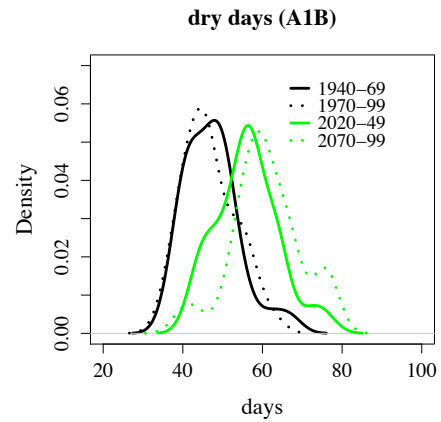
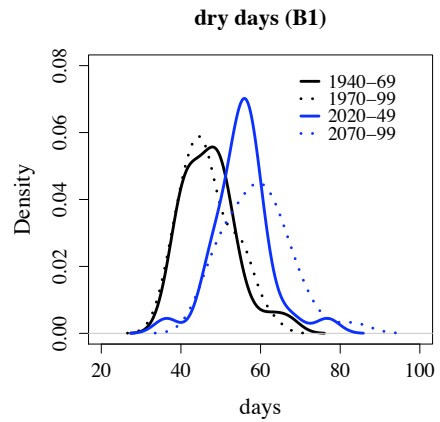
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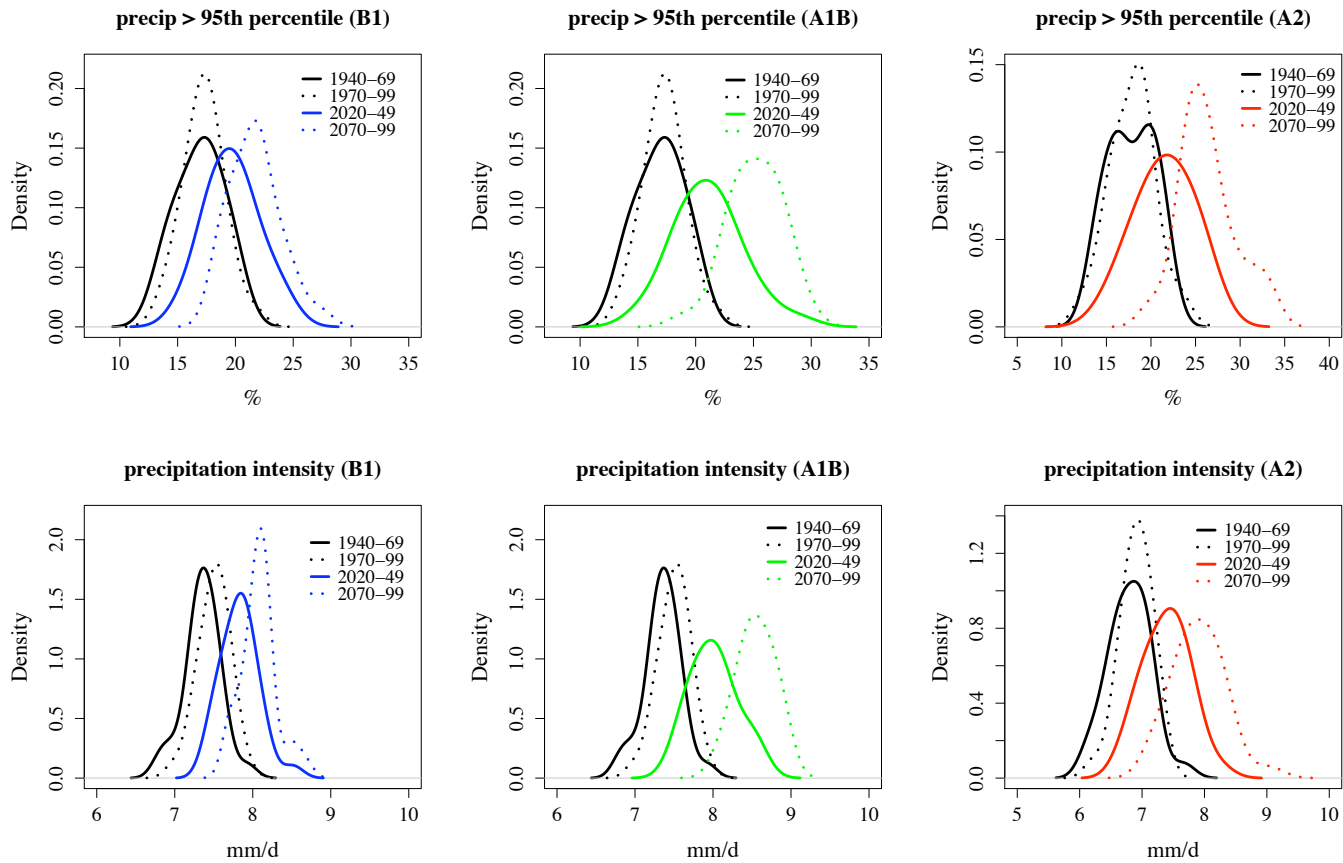
Precipitation Indices



Shifts in PDFs

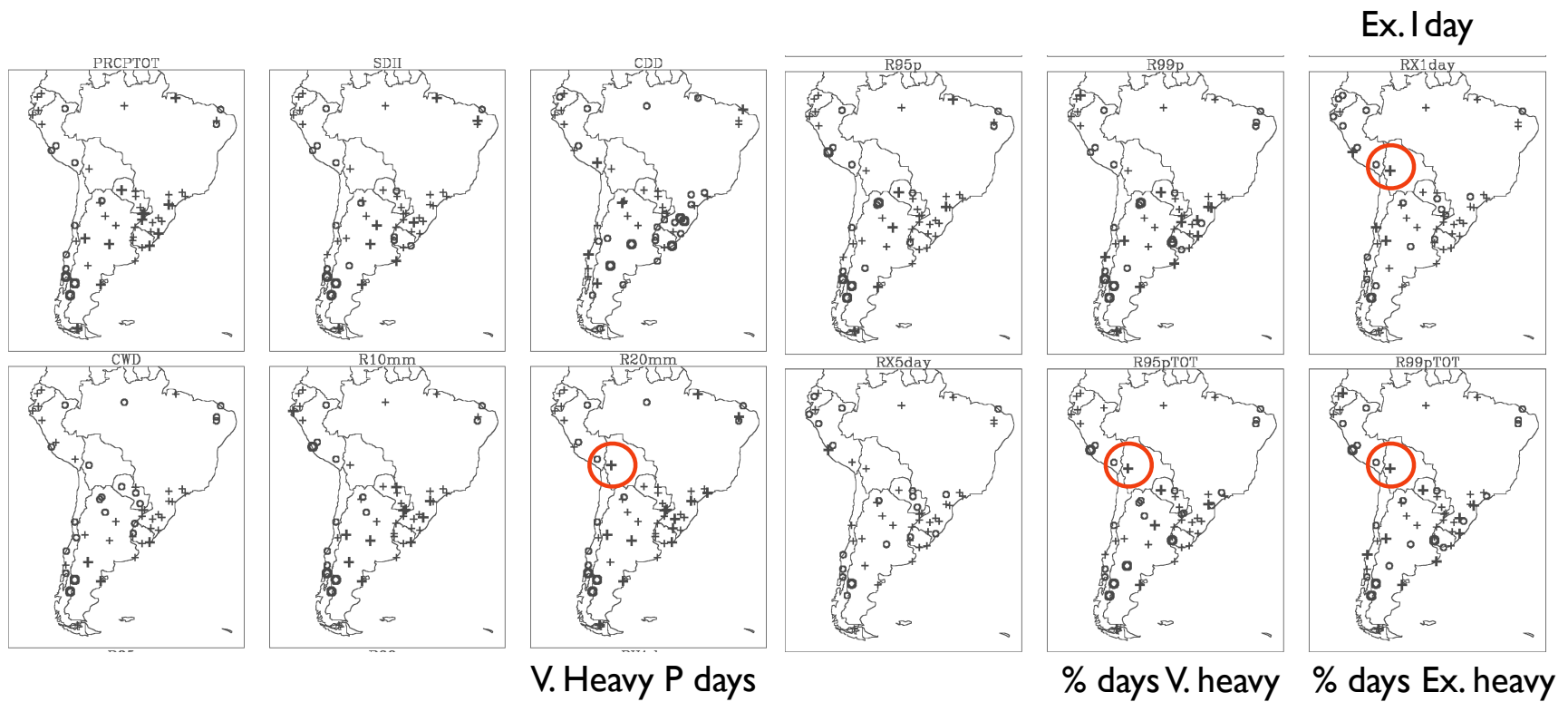


Shifts in PDFs



Observed trends

from Haylock et al., *JClimate* 2006



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Caveats and Cautions

- Caveats

- Climate models are currently low resolution. Do not capture elevations of Altiplano, too much moisture from Amazon.

✳ *Discussion ongoing about generation of climate scenarios will be higher resolution for improved regional evaluation. IPCC AR5*

- Climate models include evolution of oceans and atmosphere. Ocean dynamics have important impact on South America and are the causes of differences between models.
- Still disagreement about changes in ENSO, important for variability!

Caveats and Cautions

- Changes in Annual Cycle?
 - Temperature: 1.5 - 2 C increase in mean by mid century. 4-5 C increases by end of century
 - * *unless global mitigation strategies are implemented.*
 - Precipitation: possible small decrease in SON, increase in DJF. Both larger by end of century.
 - * *Dependent on large scale changes in Pacific Ocean and South American monsoon.*

Caveats and Cautions

- Changes in Extremes?
 - Temperature: increases in Extreme Temp Range and Warm Nights.
 - Decrease in Frost Days *not reliable due to warm bias and low elevation in the models.*
 - Increase in Heat Waves - *will be more meaningful with new calculation using percentile rather than threshold.*
 - Precipitation: increases in Dry Days, Max 5 day, Simple Intensity, and Heavy precipitation - in accordance with Patacamaya. *Work with SENAHMI to verify recent period.*