Climate and climate variability along the extratropical Andes cordillera (western slope)

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Climate and climate variability along the extratropical Andes cordillera (western slope)

- Present day climate (rainfall)
- Present day climate variability: ENSO
- Present day climate variability: Longer-time
- Future scenarios (work in progress)
The big picture… storm track over the South Pacific
Satellite (TRMM, SSMI data)
Mean Annual Rainfall. Chilean stations.

- **Coastal desert**
- **Altiplano**
- **Frontal**
- **Frontal + orographic**

For elevations:
- **h < 2000m ASL**
- **h > 2000m ASL**
A closer look over Central Chile
Wintertime (MJJAS) precipitation – 93 stations – 10 years

Rainfall pattern dominated by N-S gradient in rainfall...mostly due to southward increase in the number of rainy days
Rain shadow

\[ \frac{\Delta R/R}{\Delta H/H} \sim 3/10 \]

\[ \frac{\Delta R/R}{\Delta F/F} \sim 3/1 \]

Orographic Enhancement (1:3) Intensity?
Lack of surface precipitation data… what about remote sensing?

TRMM: State of the art in rainfall RS (forget GPI)
TRMM mean wintertime rainfall (2002-2003)

Nice below 2000 m (despite of lack of data)

Sadly bad above 2000 m….calibration algorithm not suitable for solid precipitation
Lack of surface precipitation data… what about regional models?

Met. Models currently used in many institutions for numerical weather prediction…

\[
\Delta x \sim \Delta y \sim 1\text{-}25 \text{ km} \quad \Delta z \sim 50\text{-}200 \text{ m} \quad \Delta t \sim 3\text{-}180 \text{ segundos}
\]

\[
L_x \sim L_y \sim 100\text{-}5000 \text{ km} \quad L_z \sim 15 \text{ km}
\]
MM5-DGF

3 Dominios Anidados

Condición inicial y las condiciones de los bordes de pronostico global de NCEP

15 km de resolución horizontal
MM5-DGF mean wintertime rainfall (2002-2004)

Nice N-S gradients

Too much (?) precipitation in the lee slope
Summary

Even in a densely populated area (as Central Chile) we do not know actual precipitation over the Andes. Remote sensing + Models can help, but more ground truth is needed…
Interannual variability - Major ENSO impacts

Stronger upper-Level ST Jet

Weakened ST High

Blocking High

Drier/Warmer DJF

Wetter-OND

Wetter-JJA

Drier-DJF

Colder

EN years Storm Track

Climo. Storm Track
ENSO Impacts on Rainfall

We know look for inter-event variability

Rainfall stations

Rainfall Index: JJA<br>\(<\text{RI\&N}\text{34}>=0.63\)

Rainfall Index: ON<br>\(<\text{RI\&N}\text{34}>=0.60\)

Rainfall Index: JFM<br>\(<\text{RI\&N}\text{34}>=-0.44\)
Longer-time variability (Trends, shifts, oscillations) in the XX Century:

<table>
<thead>
<tr>
<th>Required data</th>
<th>Annual means</th>
<th>Monthly means / annual cycle</th>
<th>Extreme events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sfc. Air Temp. (Tx,Tn)</strong></td>
<td>90%</td>
<td>10%</td>
<td>70%</td>
</tr>
<tr>
<td><strong>Upper air Temp. (0ºC Height)</strong></td>
<td>80%</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Rainfall / snowfall</strong></td>
<td>80%</td>
<td>30%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Enviromental variables (e.g., river flow,...)</strong></td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
Maximum air temperature (annual means):

Arica – Iquique - Antofagasta

Copiapó – Vallenar – La Serena

Stgo – Curicó-Chillán - Concepción

Temuco – Valdivia - Osorno

Fuente de datos : DMC
T. mínima anual

Indice 3: Stgo - Curicó - Chillán - Concepción
Figure 1. Trend maps of annual values of cold nights (a) and warm nights (b) indicated in [days/dec] over 1961-2003. Upward (black) and downward (gray) pointing triangles indicate positive and negative trends, respectively. Size of triangles is proportional to the magnitude of the trend.

Villarroel et al, 2006
Fig. 4 Annual (●), winter (▲) and summer (■) mean of the altitude of the 0°C air temperature (ZIA) in central Chile as derived directly from the radiosonde data at Quintero station. Lines across the annual and seasonal data correspond to the secular trends after applying an exponential filter (Rosenblüth et al., 1997).

Ref: Quintana, 2004
Frequency of days with precip. in the upper tercile in **southern Chile**

**Periodo de referencia: 1930 – 2000**
Promedio móvil sobre periodos de 10 años.

Ref: Quintana, 2004
Future Scenarios

Use high-resolution Regional (area-limited) Climate Models (MM5, Precis, etc) laterally forced by coarse-resolution GCM outputs (e.g., HadCM, CCM3, ECHAM).

GCMs are run under using CO$_2$, other greenhouse gases and aerosol concentrations in the near future (2000-2100) as projected for different scenarios (A2, B2, etc.) defined by IPCC.

Some issues of concern:

• Garbage in – Garbage out. Check GC and Reg. Models against current climate…climate variability (e.g., ENSO) even more important than mean values
• Model parameterizations
• No CO$_2$ effect in regional models (at least until now)
B2 – Baseline Annual Precipitation

(a) Precip. Difference (mm)  
(b) Precip. Diff. wrt Baseline (%)
Conclusions

- Current climate rainfall distribution over the Andes is mostly unknown (educated guesses only). Temperature distribution is better known (more easily extrapolated). Surface network is needed.

- Basic knowledge of ENSO impacts on rainfall. Focus now in inter-event variability.

- 20th Century climate history partially described (in the lowlands). Need for a more comprehensive, broader analysis (ANILLO).

- Regional climate simulation for future scenarios in progress (ANILLO)