El Clima de Patagonia: Glaciares, Rayos y Sombras

René D. Garreaud

Departamento de Geofísica Universidad de Chile
Centro del Clima y Resiliencia

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Septiembre 2016

Agenda

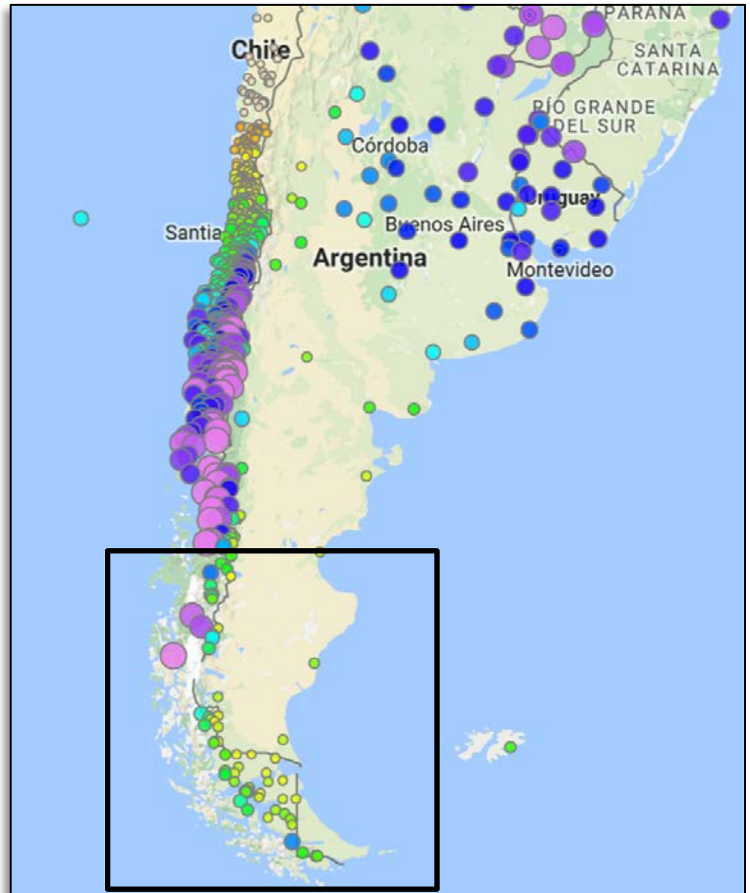
- Patagonia 101: Aspectos básicos y esotéricos
- Control de gran escala (U-P, U-T)
- Cambio climático contemporáneo
- Actividad eléctrica sobre Patagonia

Todos amamos la Patagonia.....

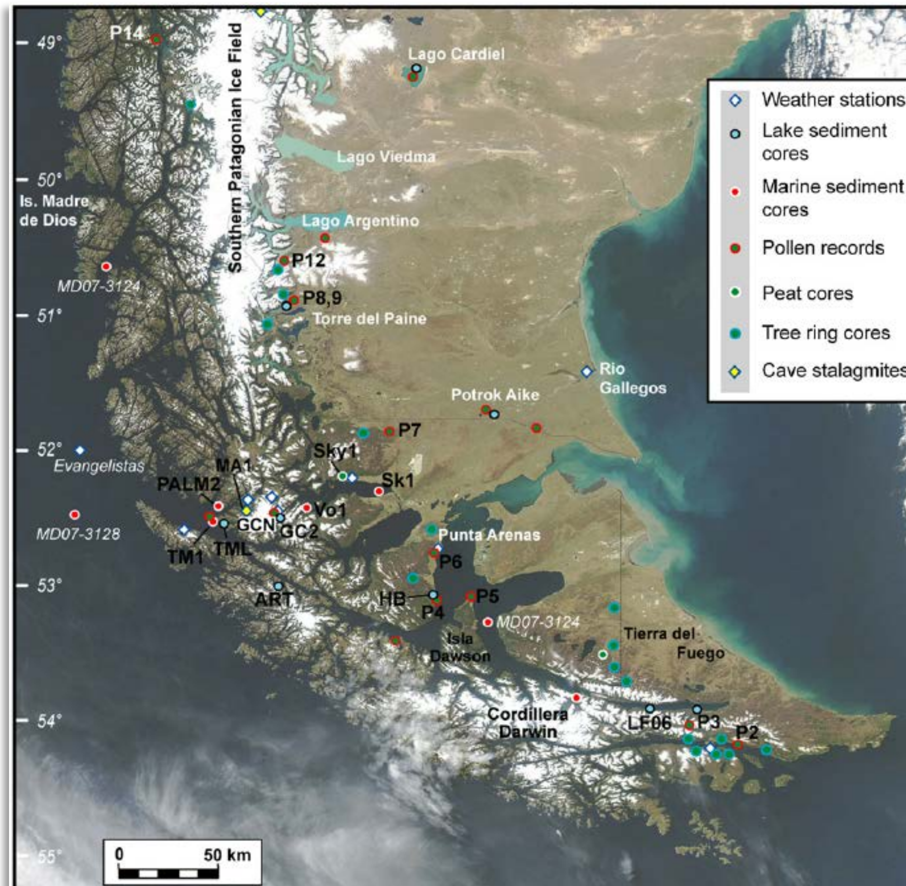
- Gran territorio con terreno complejo
- Glaciares, campos de hielo y bosques lluviosos al oeste y sobre los Andes
- Alta biodiversidad y endemismo
- Hidrocarburos, viento y dinosuarios al este
- Cambios climáticos y mediambientales
- Multiples paleo-registros
- Datos climáticos insuficientes

Comencemos con lo básico y esotérico...

Not many weather stations but plenty of Paleo records in the only SH land mass extending into the core of the westerly wind belt

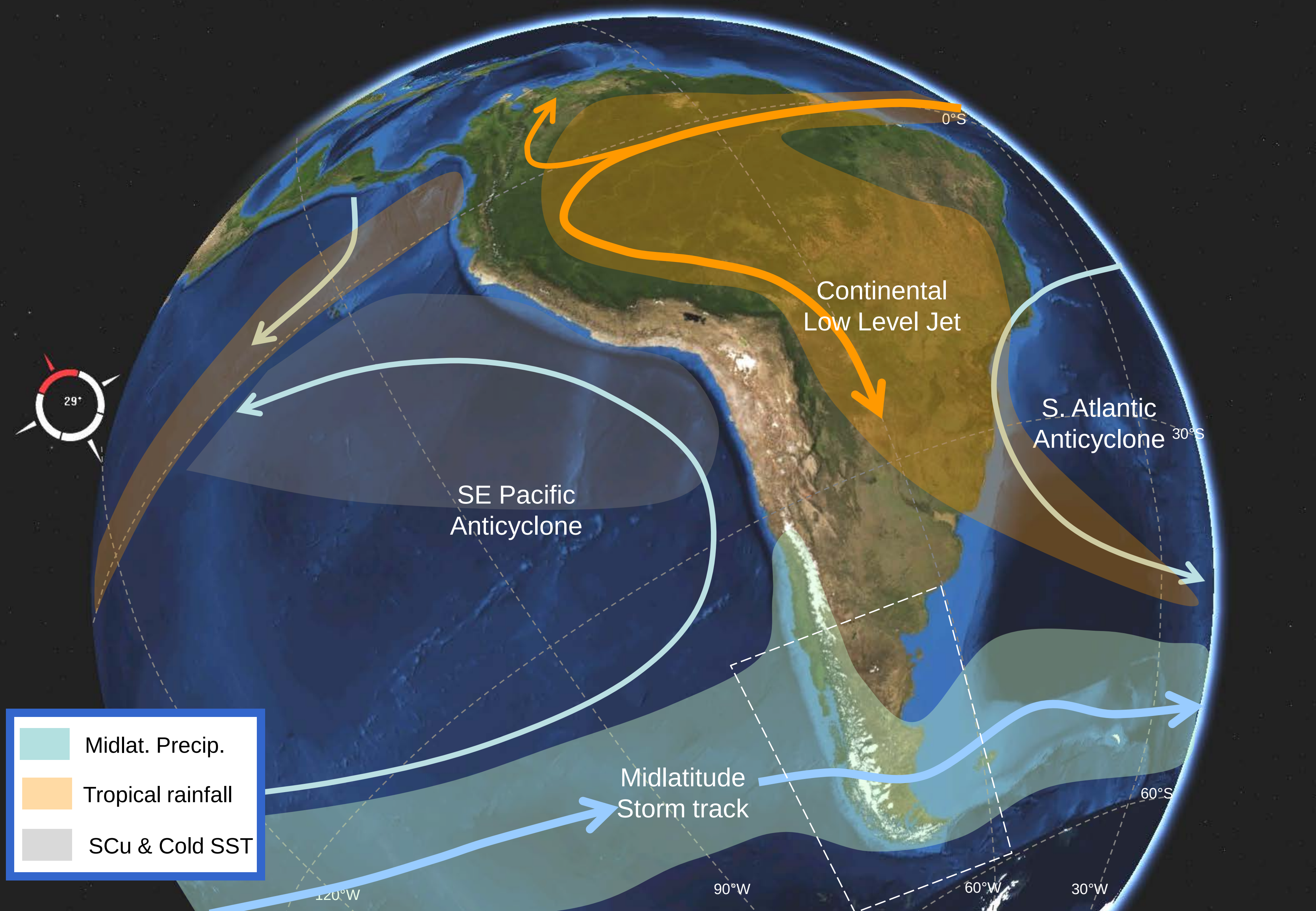


Explorador Climático

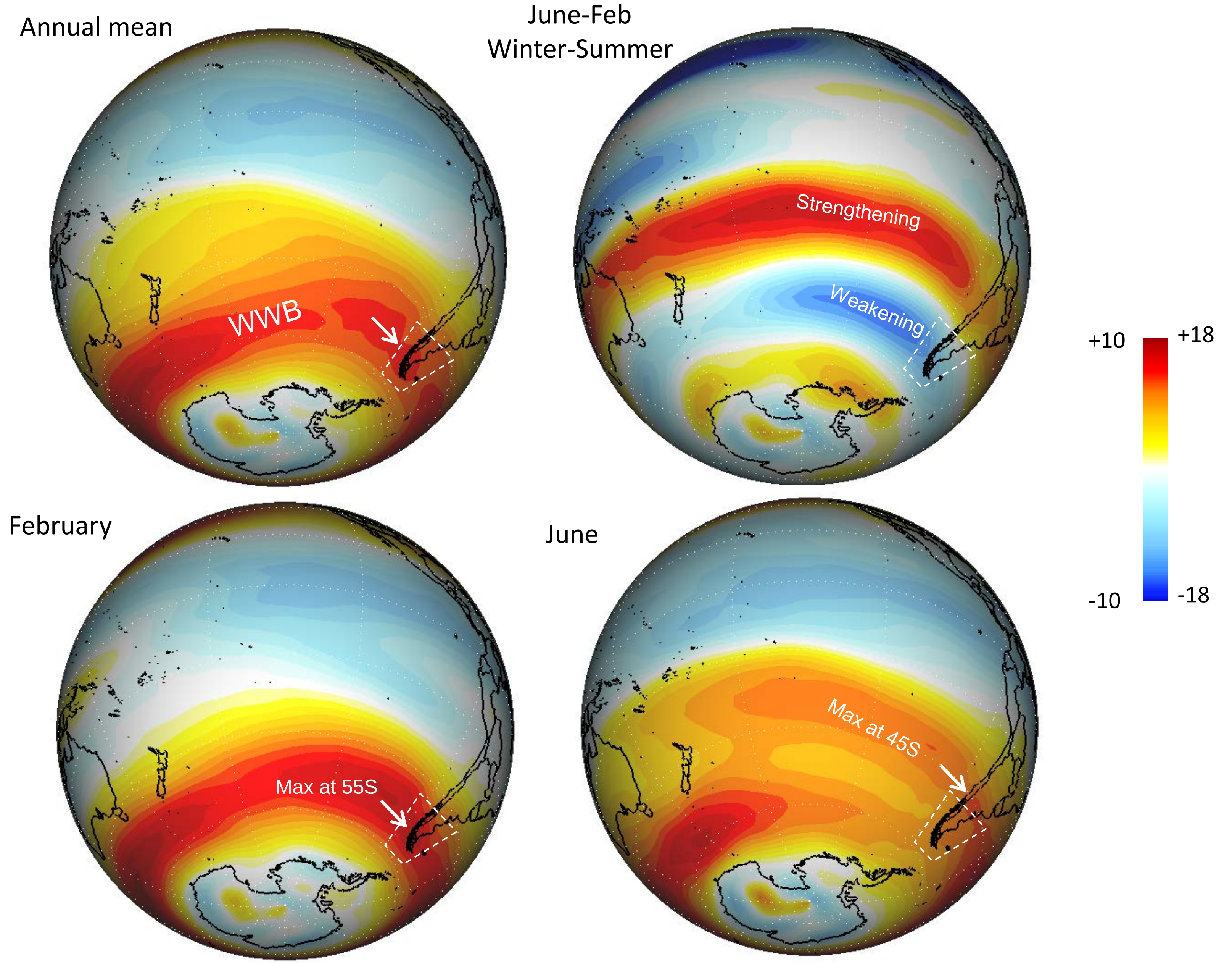


Kilian and Lamy 2012

El Panorama Continental

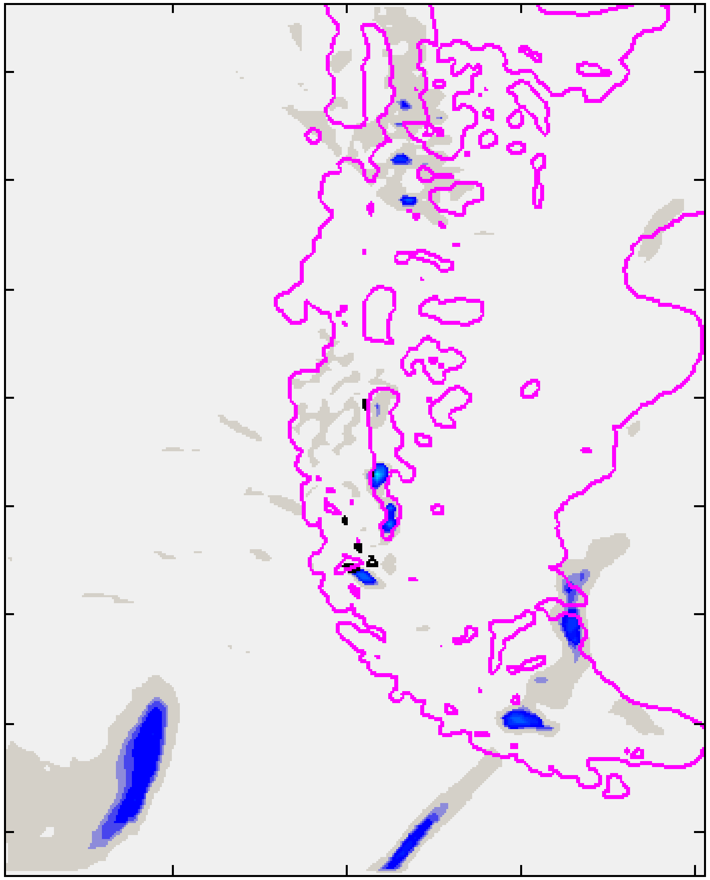


Long term mean zonal wind at 700 hPa
(best predictor of precipitation over the extratropical Andes)



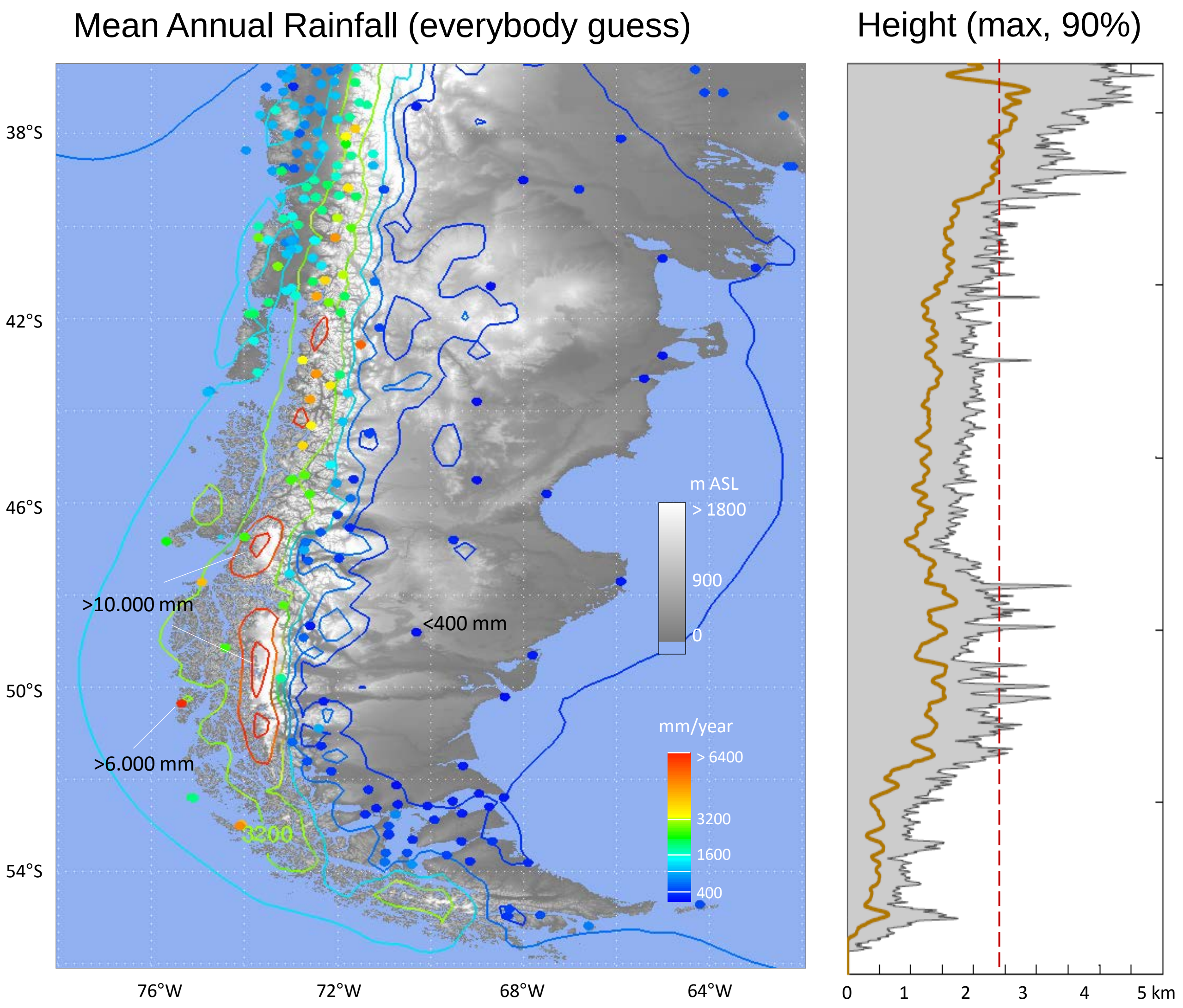
One (typical) storm simulation (WRF)

Hourly results during a 3 day period. Resolved precipitation (colors), Convective rainfall (contours) and topography



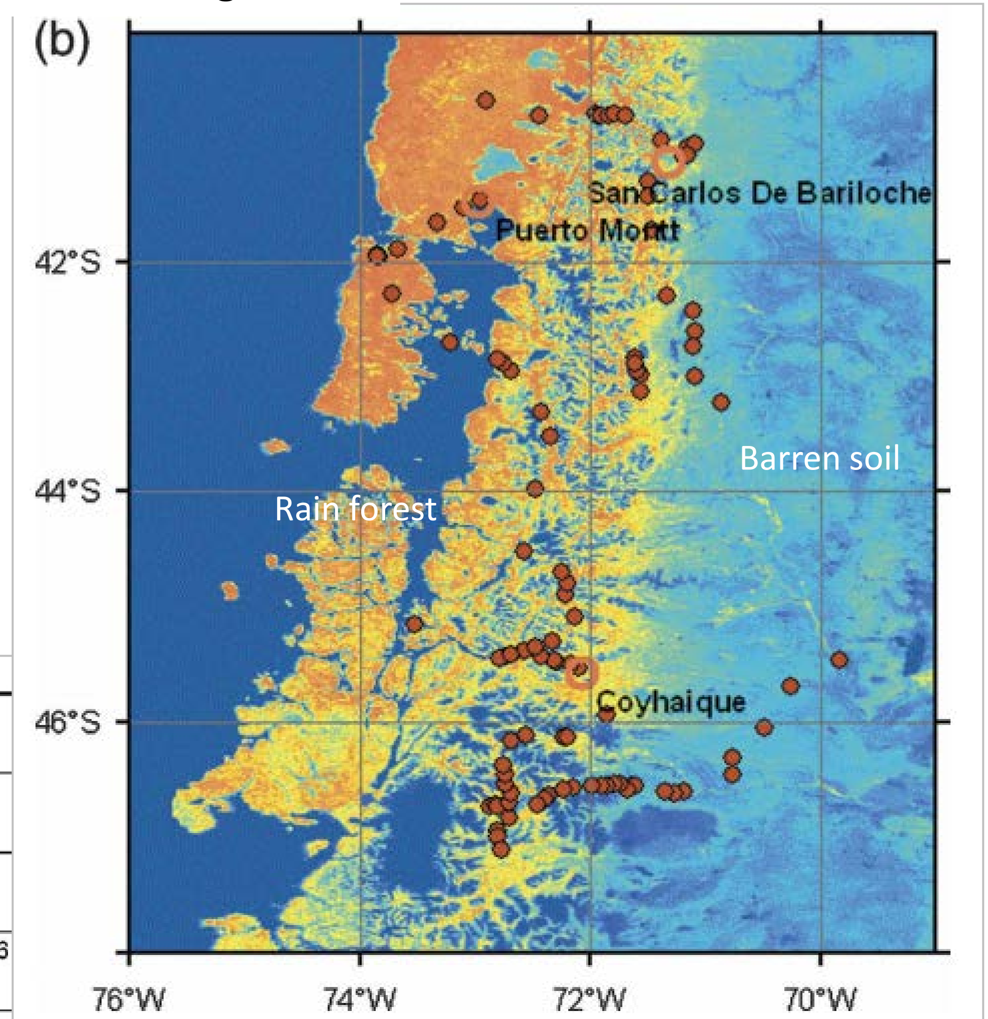
Salient features: Rainfall enhancement over the Andes windward slope, Rain shadow, Convective rainfall along the coast

Patagonia 101: Precipitation

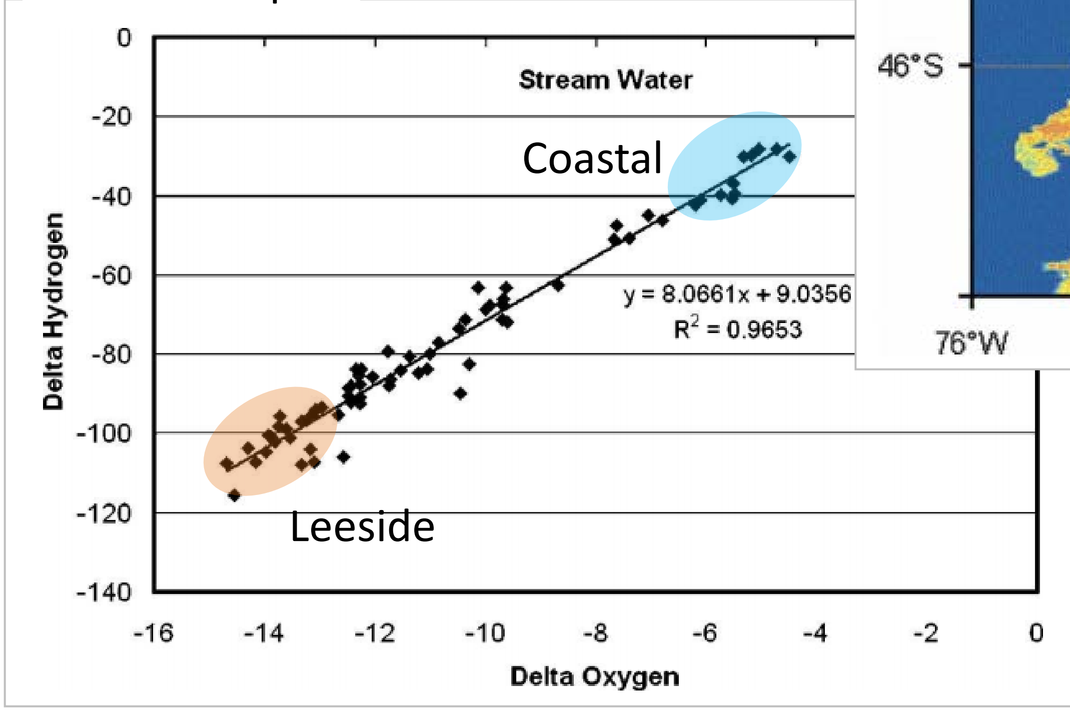


Precipitation gradient leads to other two biophysical contrasts: vegetation and isotopes

MODIS Vegetation



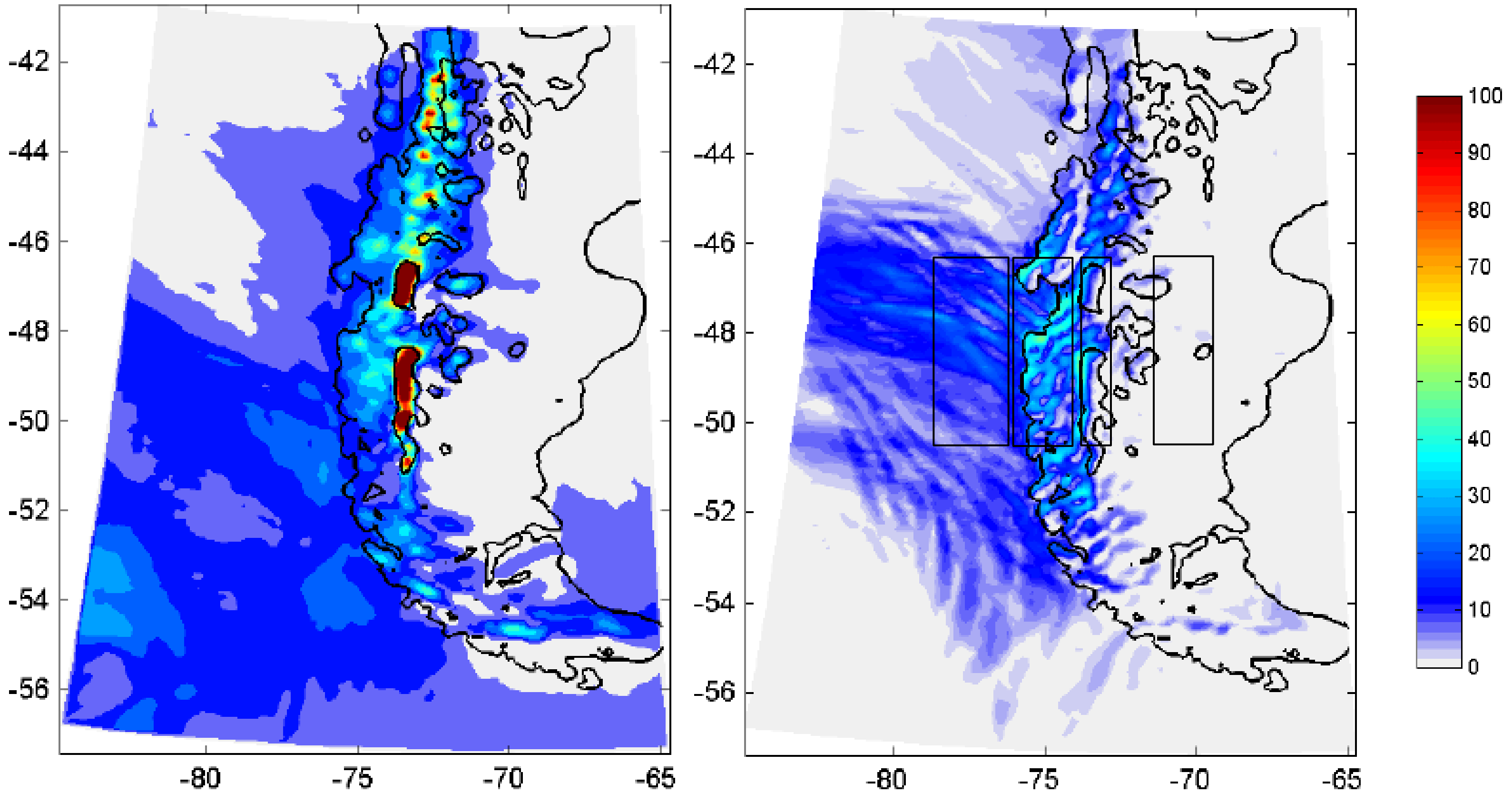
Stable isotopes



Smith and Evans 2007

Control topográfico
(relevante para el clima del pasado muy remoto)

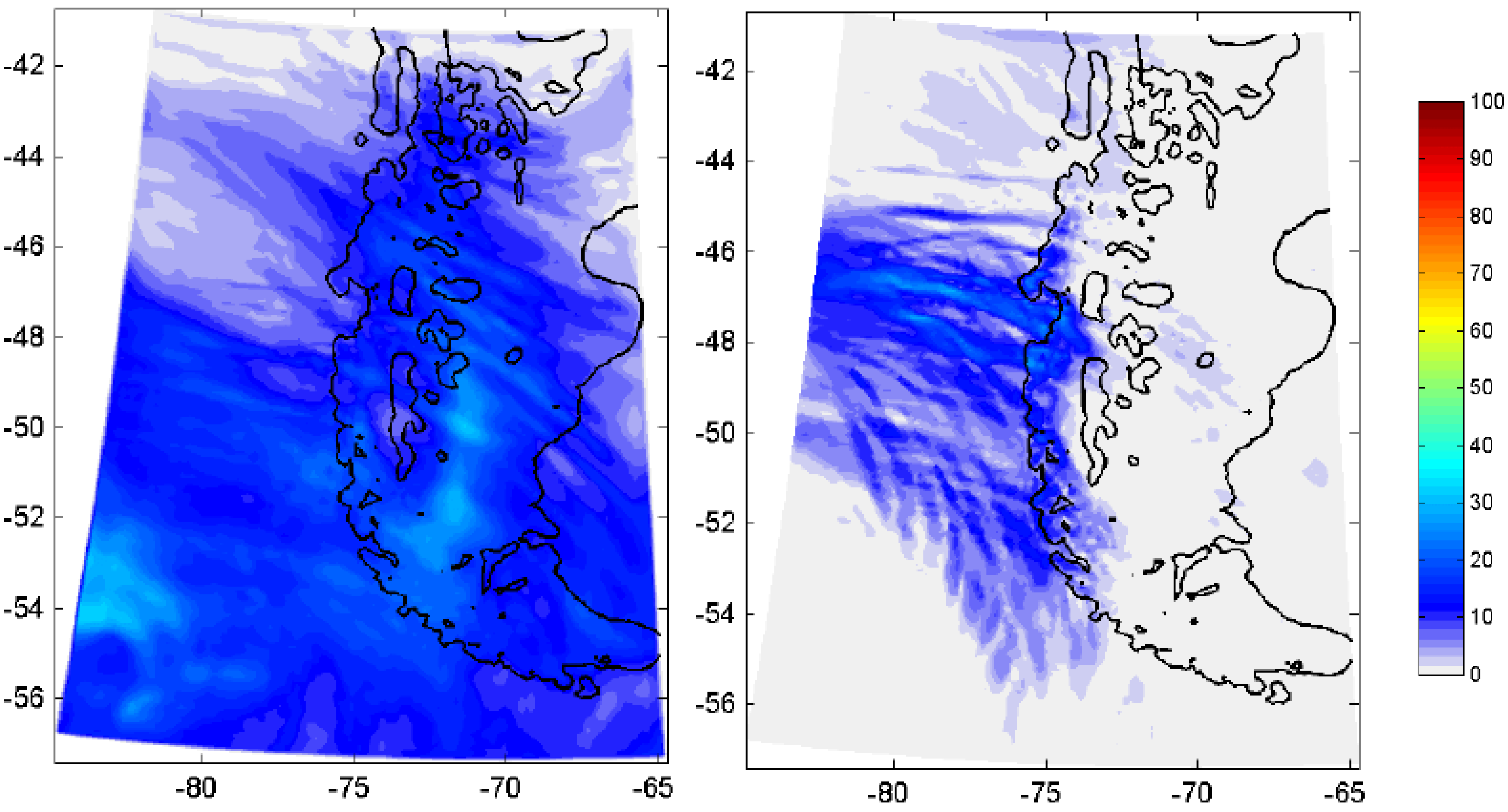
48 hr Accumulated Precip - Control Simulation



Resolved Convective

Control topográfico
(relevante para el clima del pasado muy remoto)

48 hr Accumulated Precip – No Topo Simulation

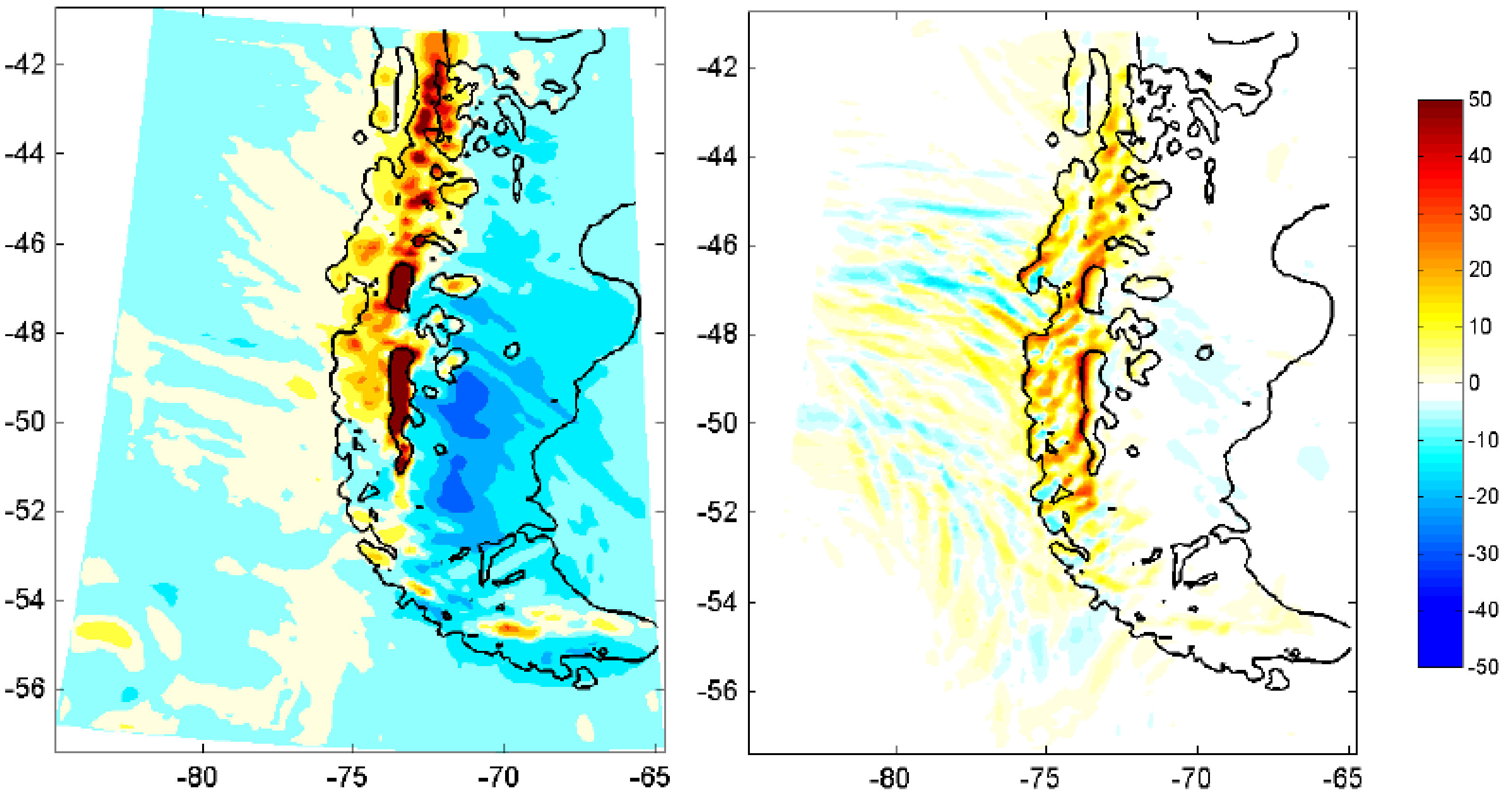


Resolved

Convective

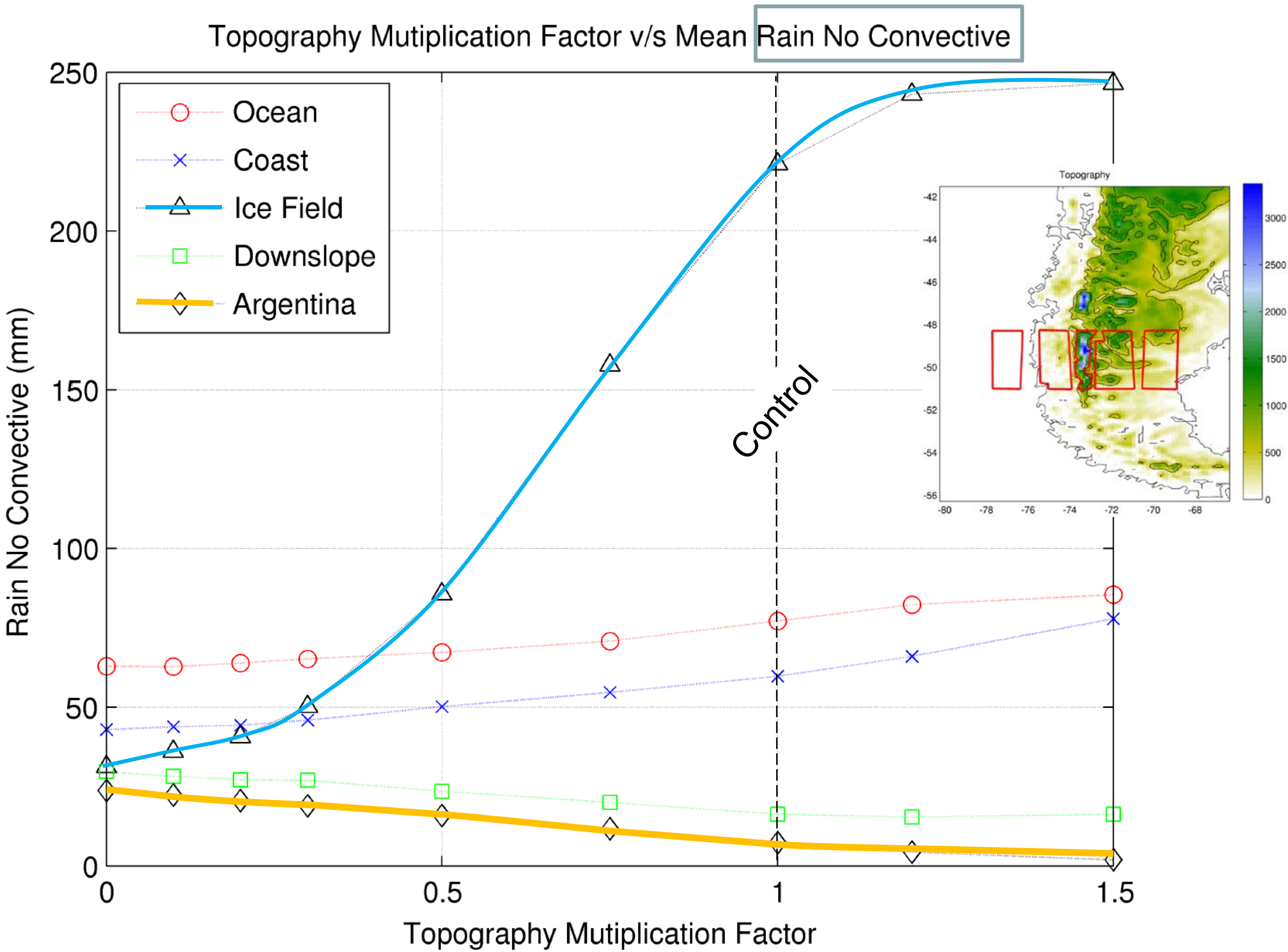
Control topográfico
(relevante para el clima del pasado muy remoto)

48 hr Accumulated Diff Precip (CTR-Ntopo)

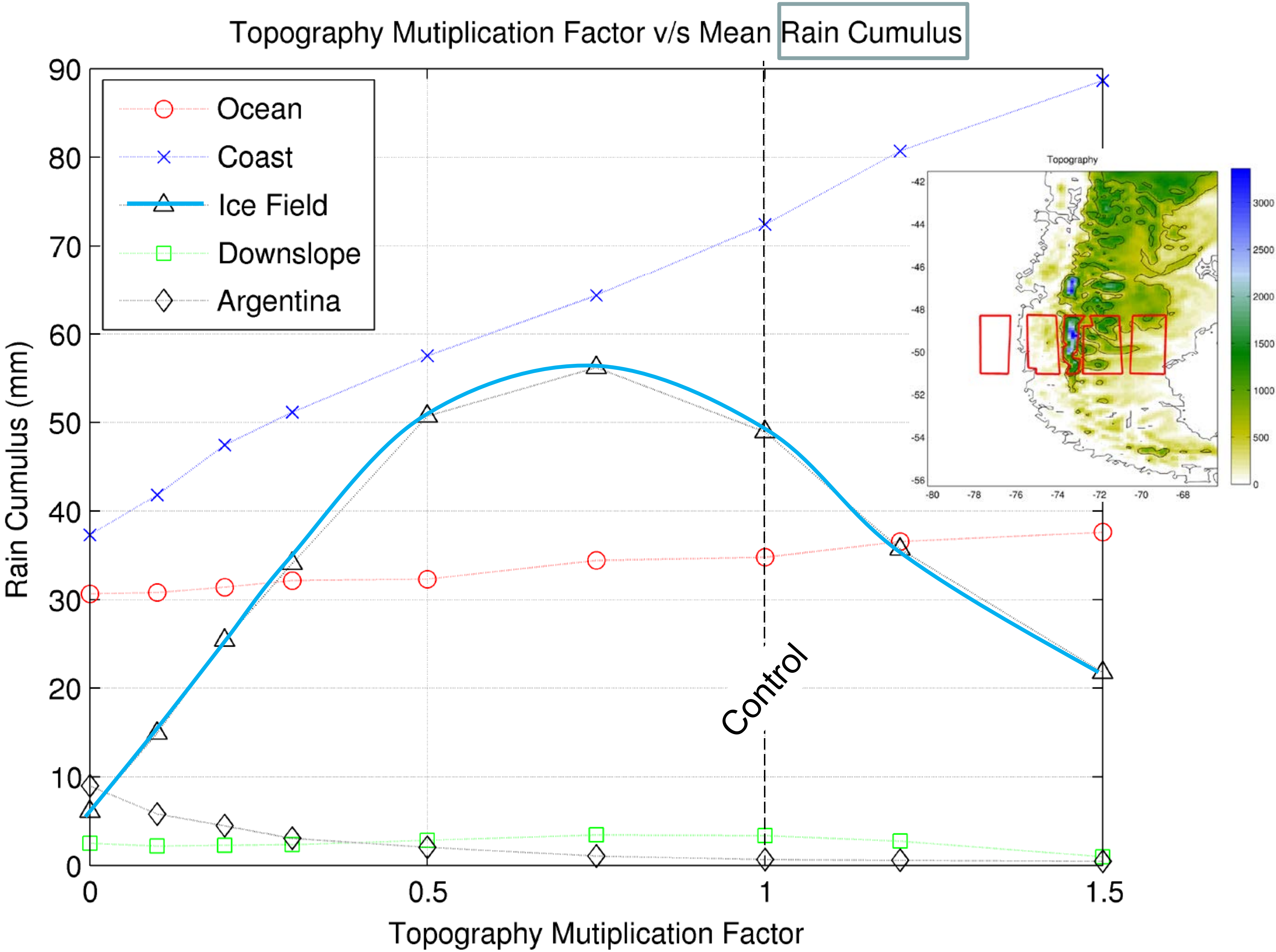


Resolved

Convective



Topography Mutiplication Factor v/s Mean Rain No Convective
Ocean
Coast
Ice Field
Downslope
Argentina
Control
Topography
Rain No Convective (mm)
Topography Mutiplication Factor
0
50
100
150
200
250
0
0.5
1
1.5


Topography Mutiplication Factor v/s Mean Rain Cumulus
Ocean
Coast
Ice Field
Downslope
Argentina
Rain Cumulus (mm)
Topography Mutiplication Factor
Control
Topography
0
0.5
1
1.5
0
10
20
30
40
50
60
70
80
90

MAT & MAP/PET

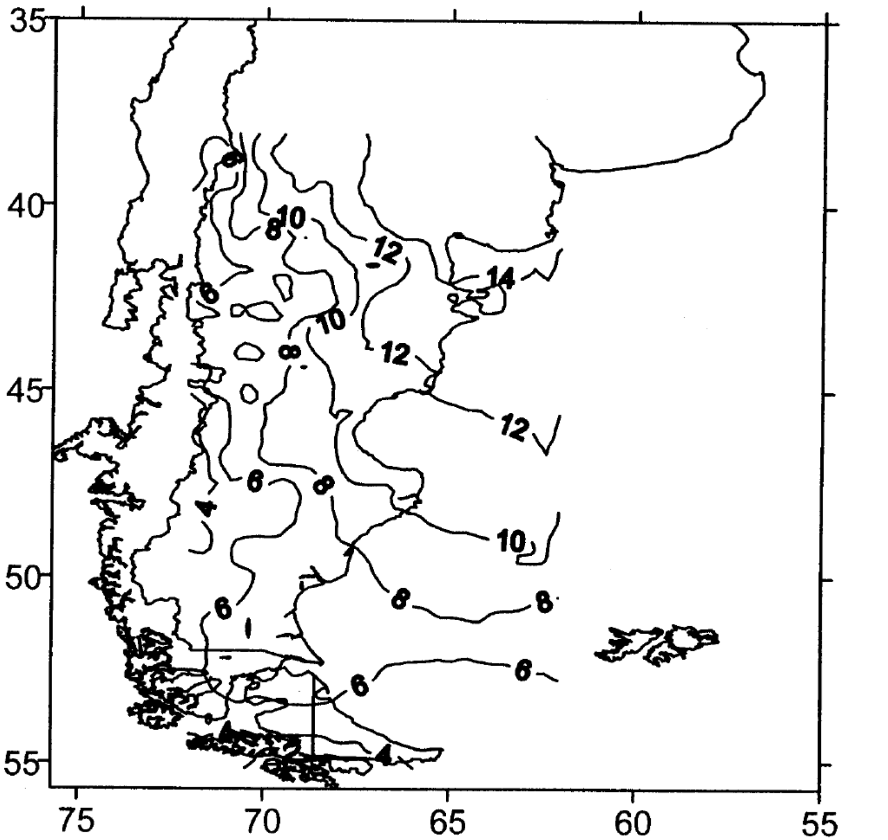


Figure 4. Mean annual temperature (MAT) of Patagonia. Data corresponded to the Leemans y Cramer (1991) database. This database has a spatial resolution 0.5x0.5 of latitud and longitude. (See Paruelo et al. 1995 for a description of the database).

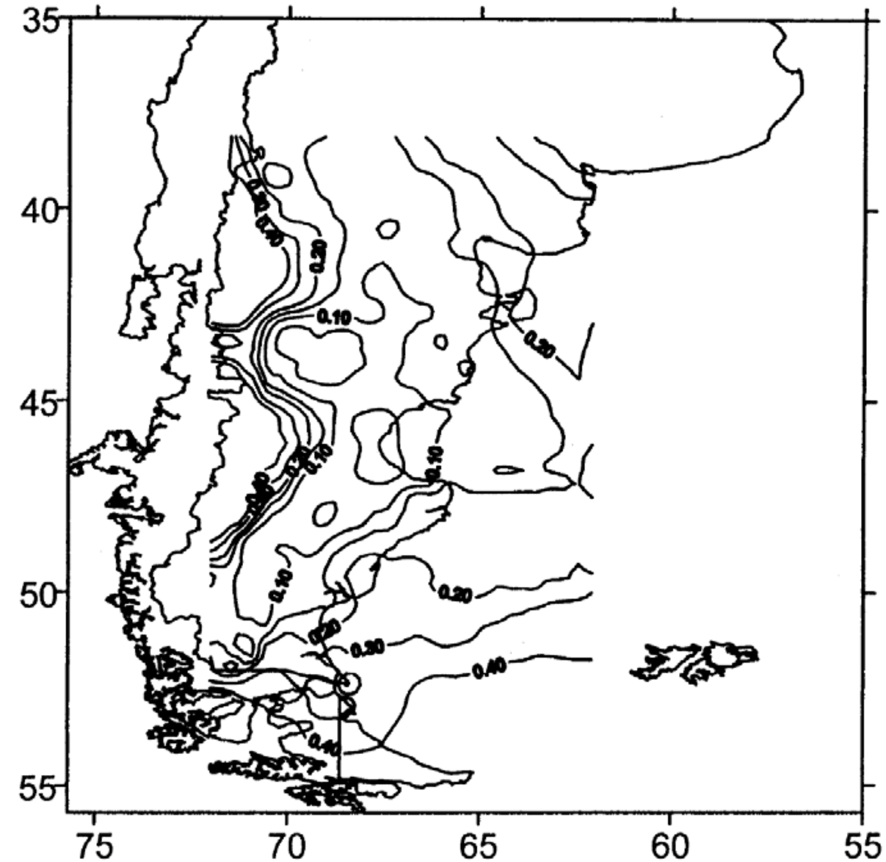
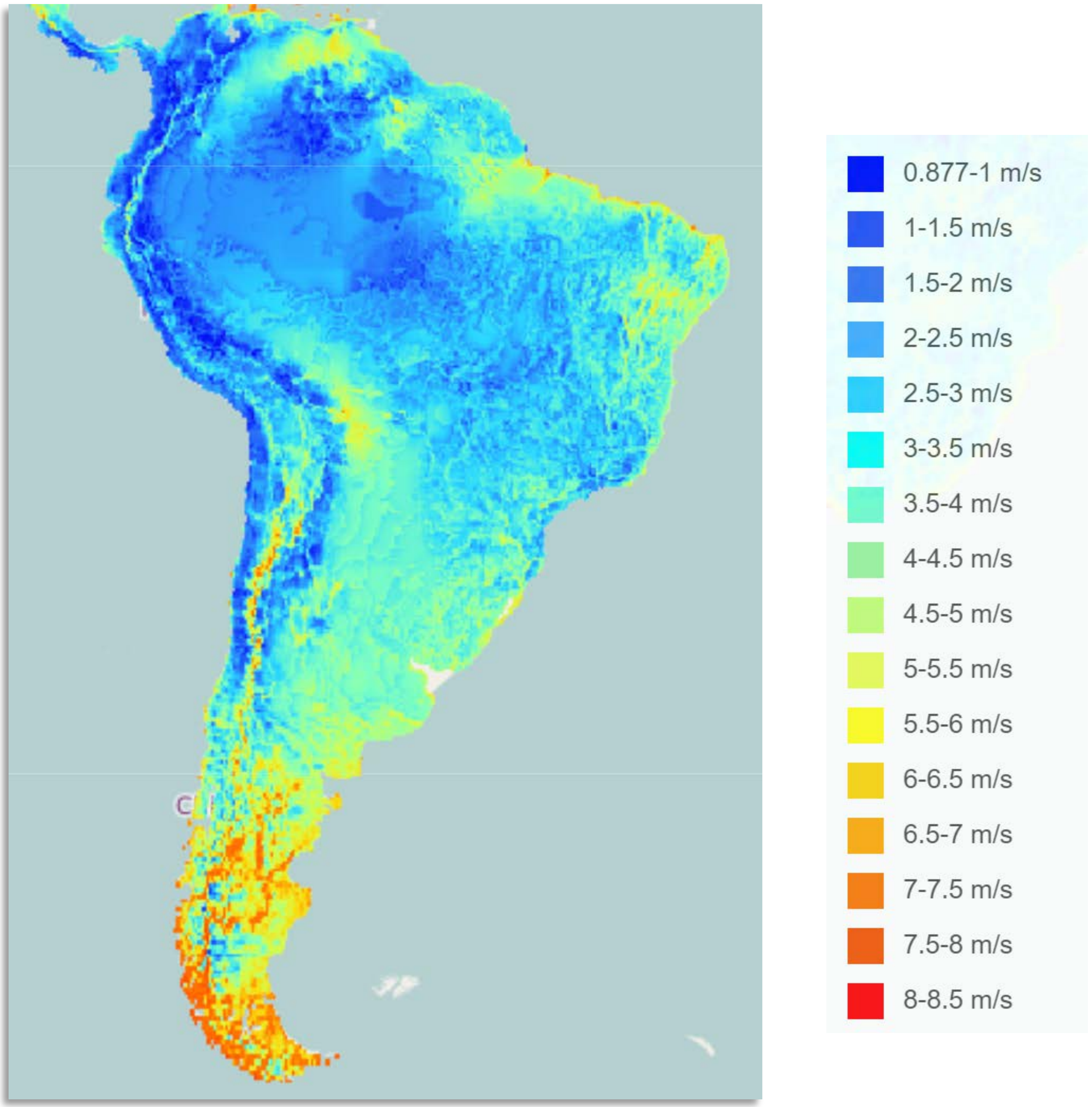


Figure 6. Aridity Index (MAP/PET) for Patagonia. MAP data corresponded to the Leemans and Cramer (1991) database. PET was calculated from mean annual temperature (Shaw et al. 1995).

The climate of Patagonia: general patterns and controls on biotic processes

José M. Paruelo [1], Adriana Beltrán [2], Esteban Jobbágy [1,3], Osvaldo E. Sala [1] and Rodolfo A. Golluscio [1]

Wind atlas by CENER (http://irena.masdar.ac.ae/)



Impactos de ENOS, PDO and SAM (AAO)

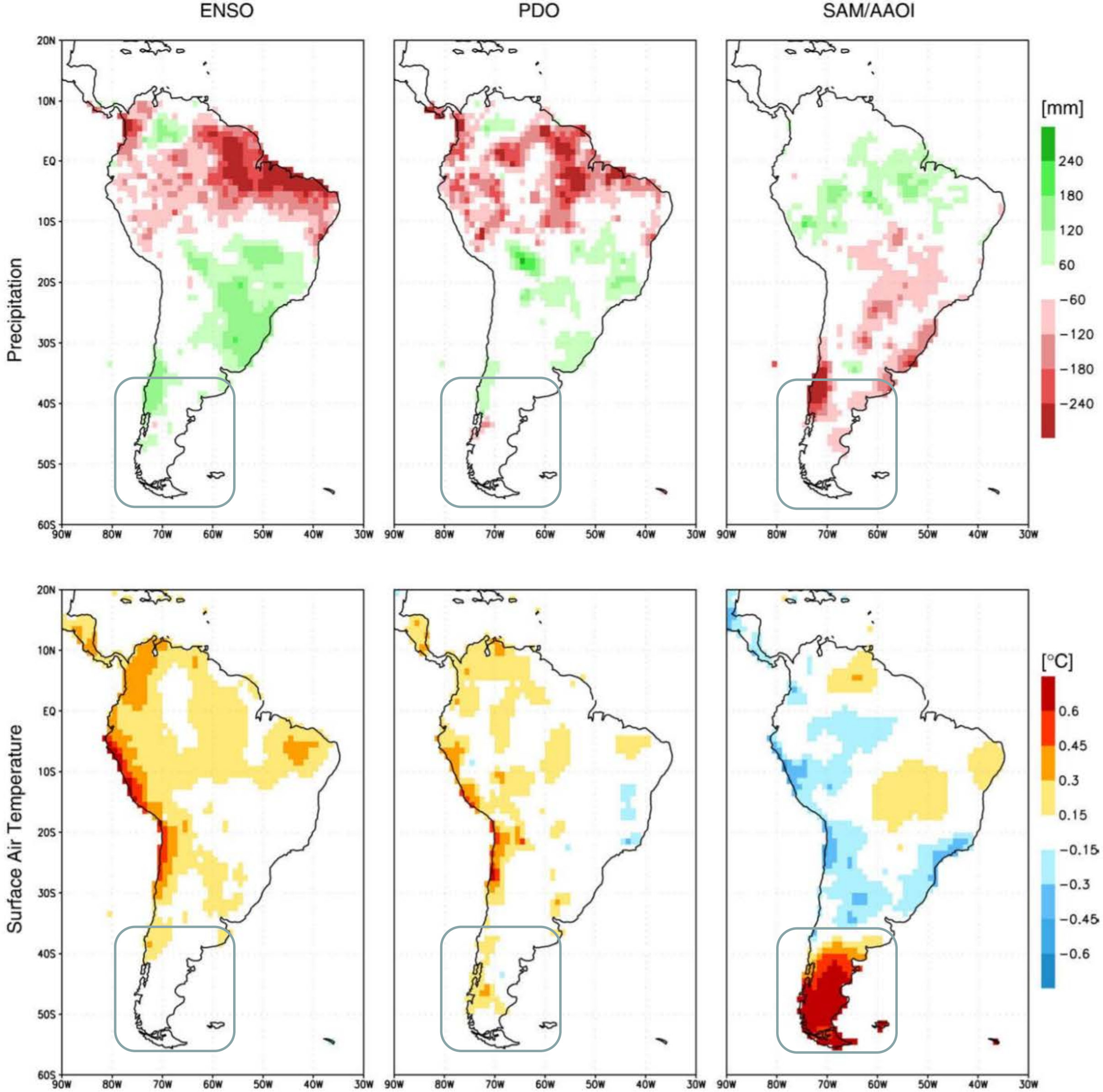


Fig. 10. Annual mean precipitation (upper row) and surface air temperature (lower row) regressed upon MEI (left column), PDO index (center column) and AAOI (right column). Precipitation and surface air temperature from University of Delaware gridded dataset.

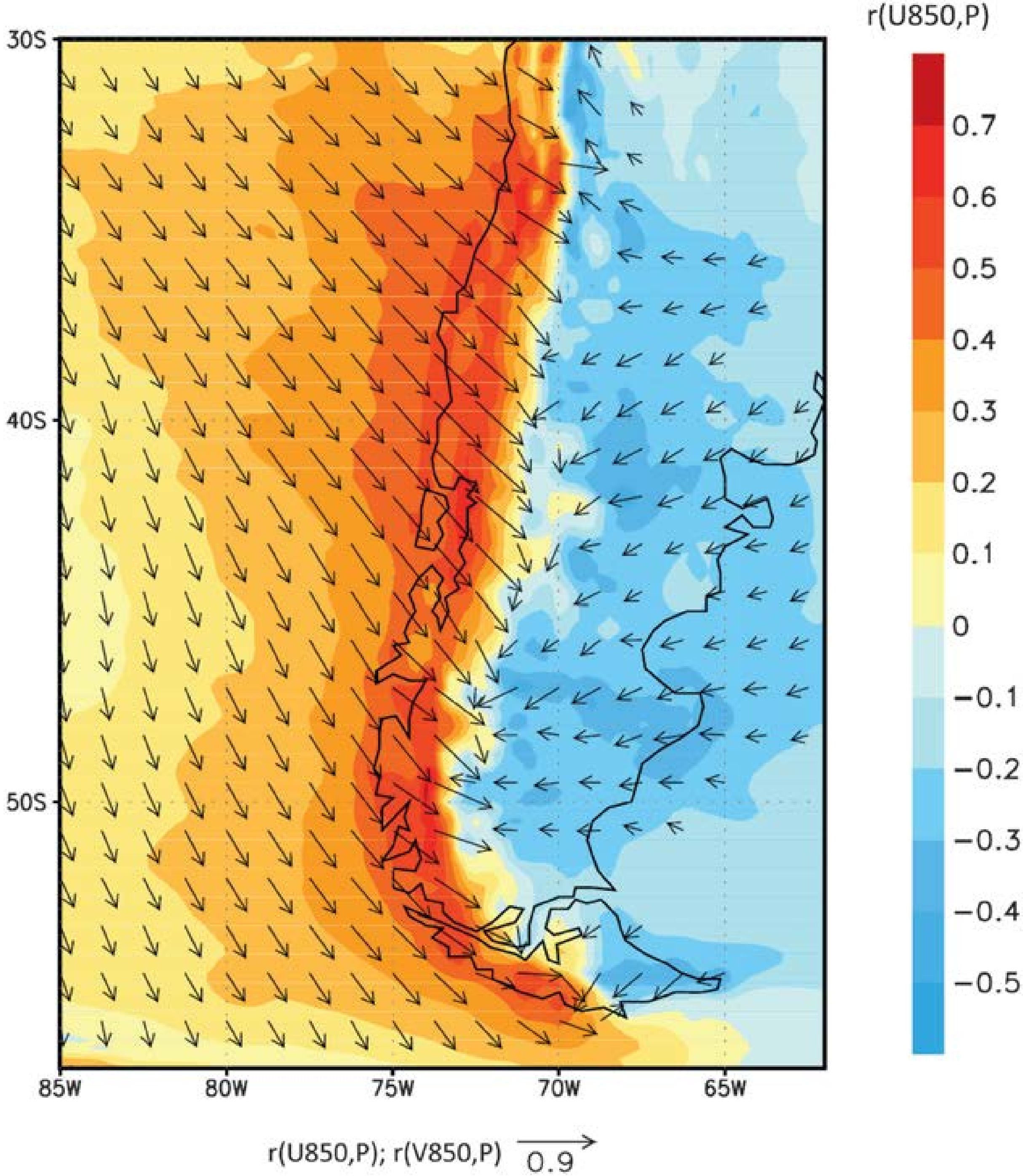
Garreaud et al. 2009

El control de gran escala en el clima de Patagonia

(Garreaud 2007; Garreaud et al. 2013)

Relacionando U con P/SAT podemos:

* Escalar hacia abajo señales de gran escala
* Escalar hacia arriba señales locales



Local (point-to-point) **correlation map between daily precipitation (P) and 850-hPa zonal and meridional wind components (U850; V850)** using PRECIS-DGF results from 1980–90. At each grid point the correlation was calculated for the sample of days with P >1 mm.

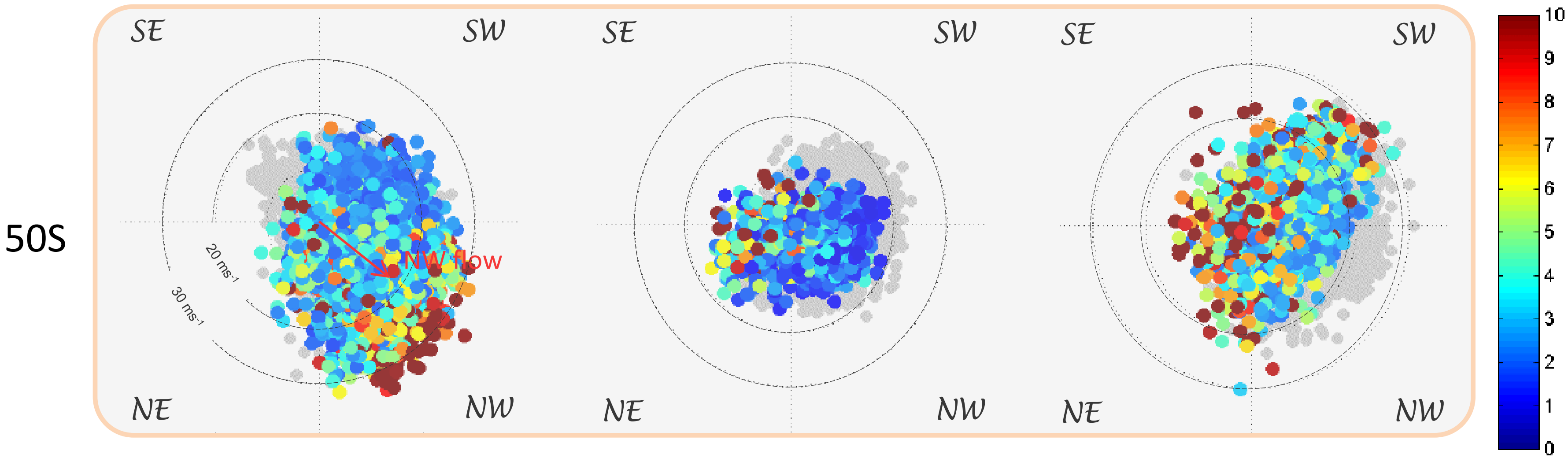
Colors indicate the P–U850 correlation.

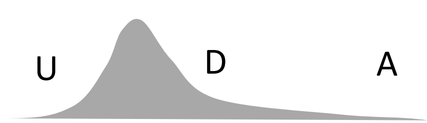
Vectors are constructed using r(P, U850) and r(P,V850) (scale at the bottom) and only shown where absolute value exceeds 0.3.

Garreaud et al. 2013

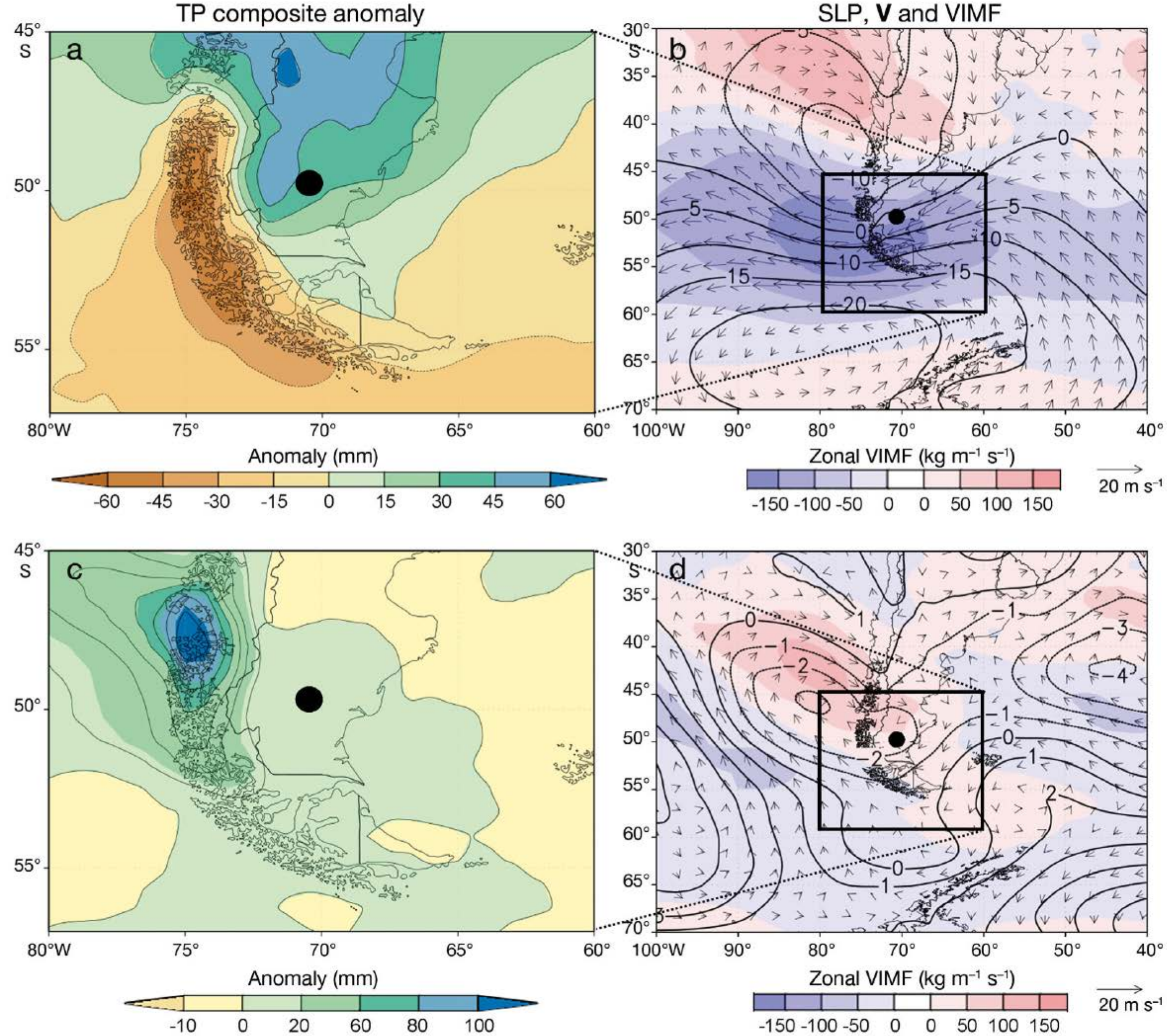
850 hPa (1500 m ASL) Wind roses for all days (grey) and rainy days (color) at selected locations in Patagonia

Upstream Downstream Atlantic seaboder



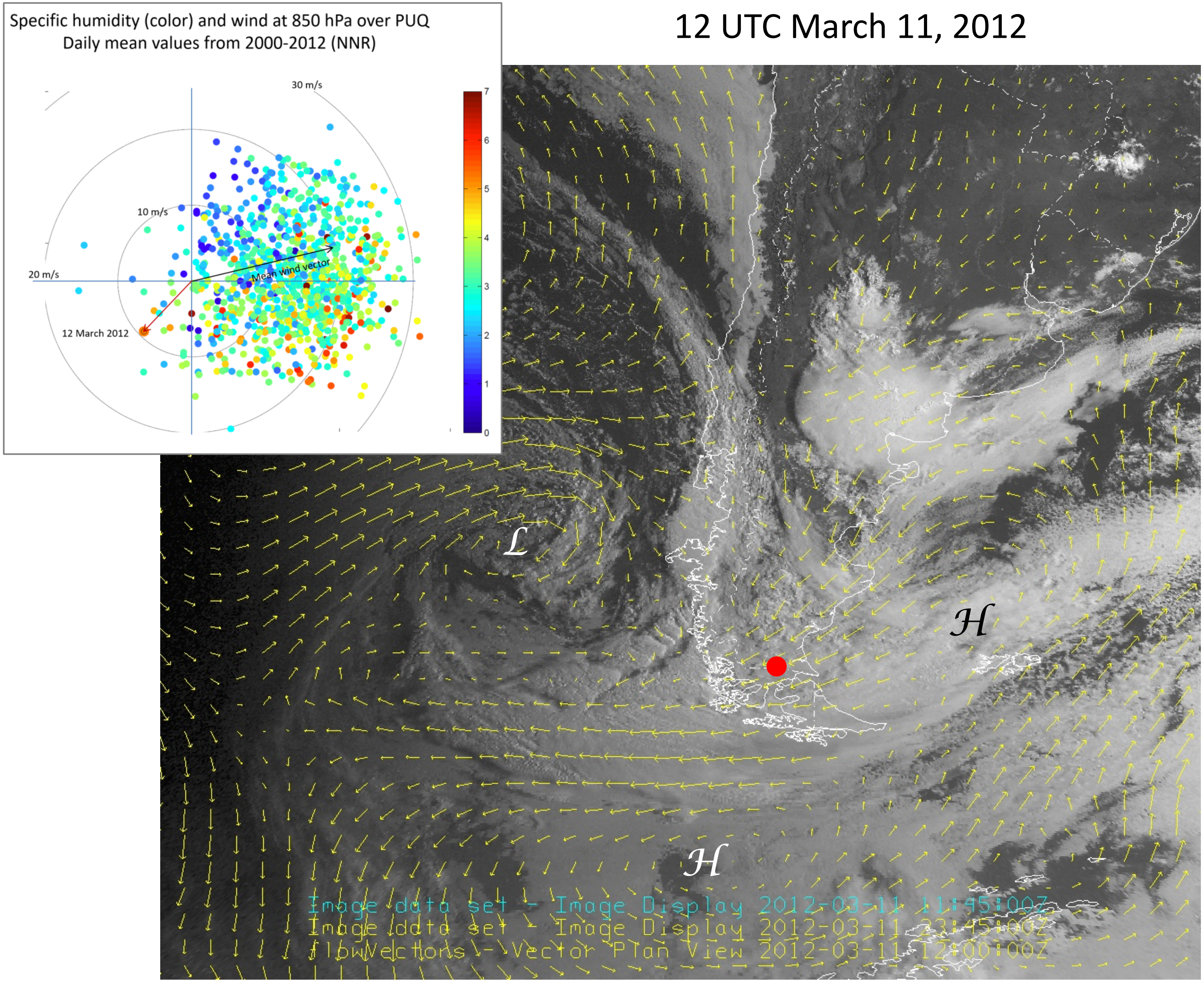


A few but intense rainfall events do occurs over Eastern Patagonia under easterly flow (Atlantic moisture source)



Agosta, Compagnucci and Ariztegui, 2015

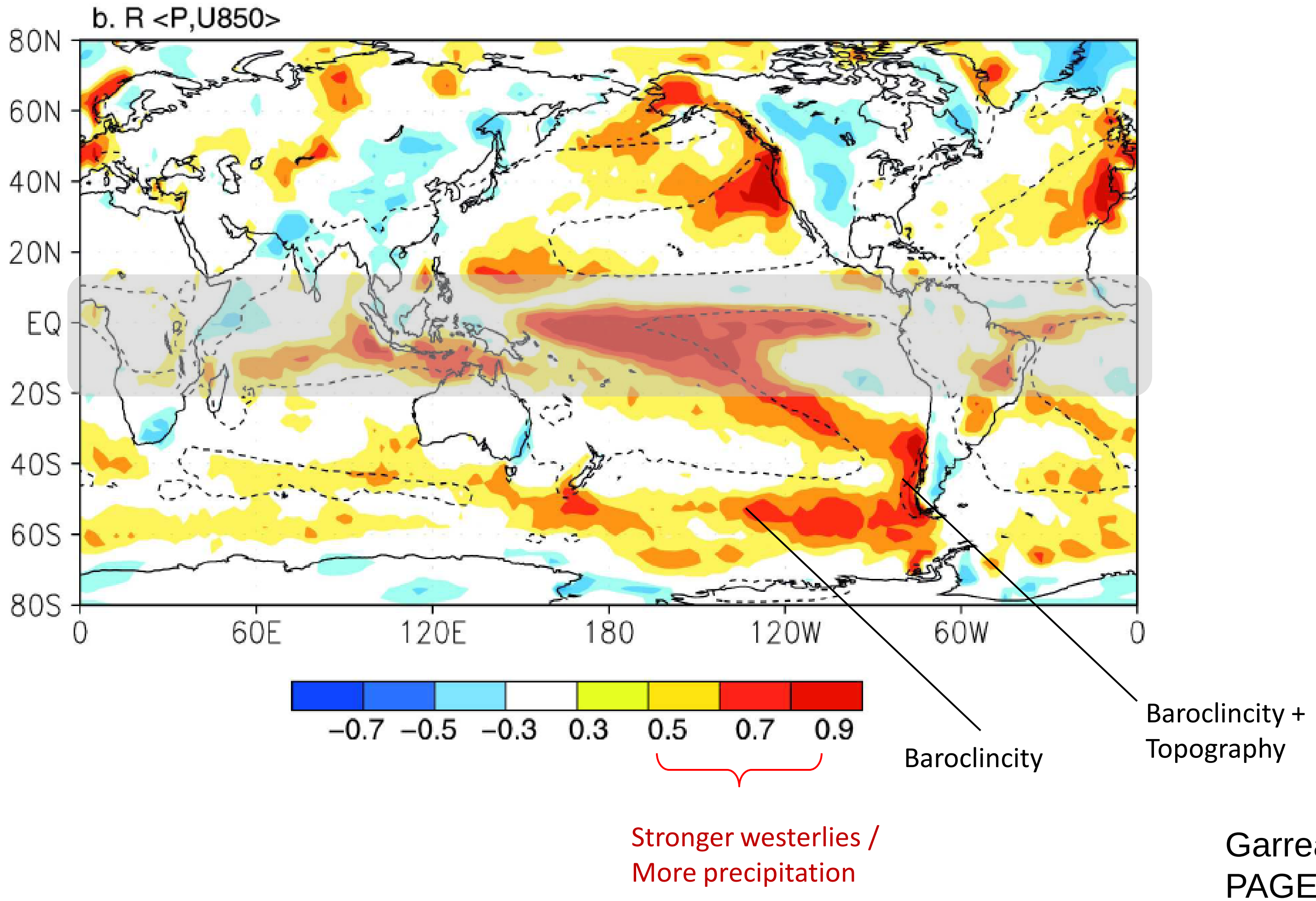
GOES-13 (VIS) and GFS winds at 850 hPa
12 UTC March 11, 2012



Co-variability of zonal wind and precipitation

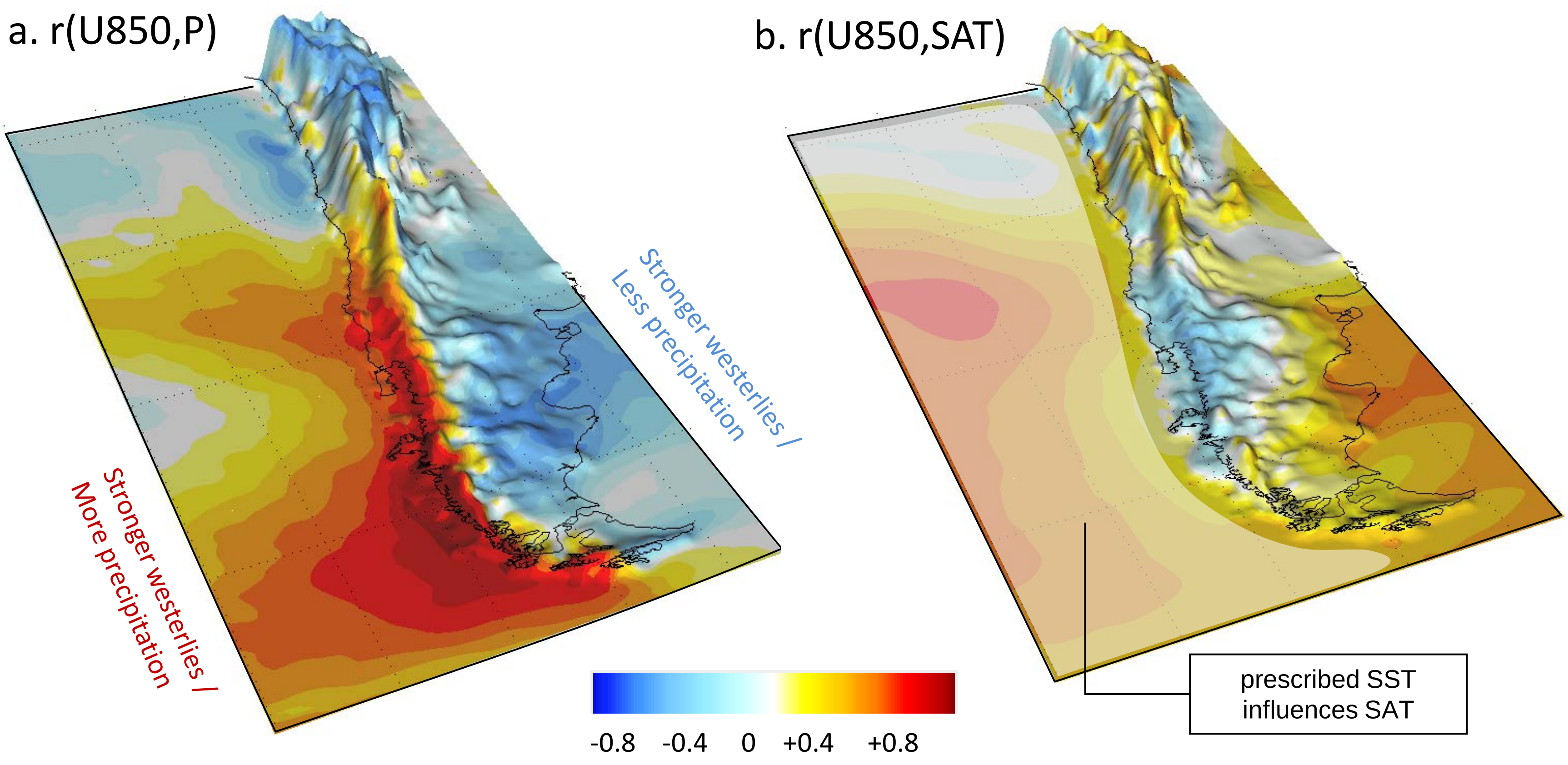
Point-to-point correlation between U850 (*NNR*) and precipitation (*CMAP*)

Both data sets 2.5º×2.5º lat-lon, **annual means, 1979-2005**

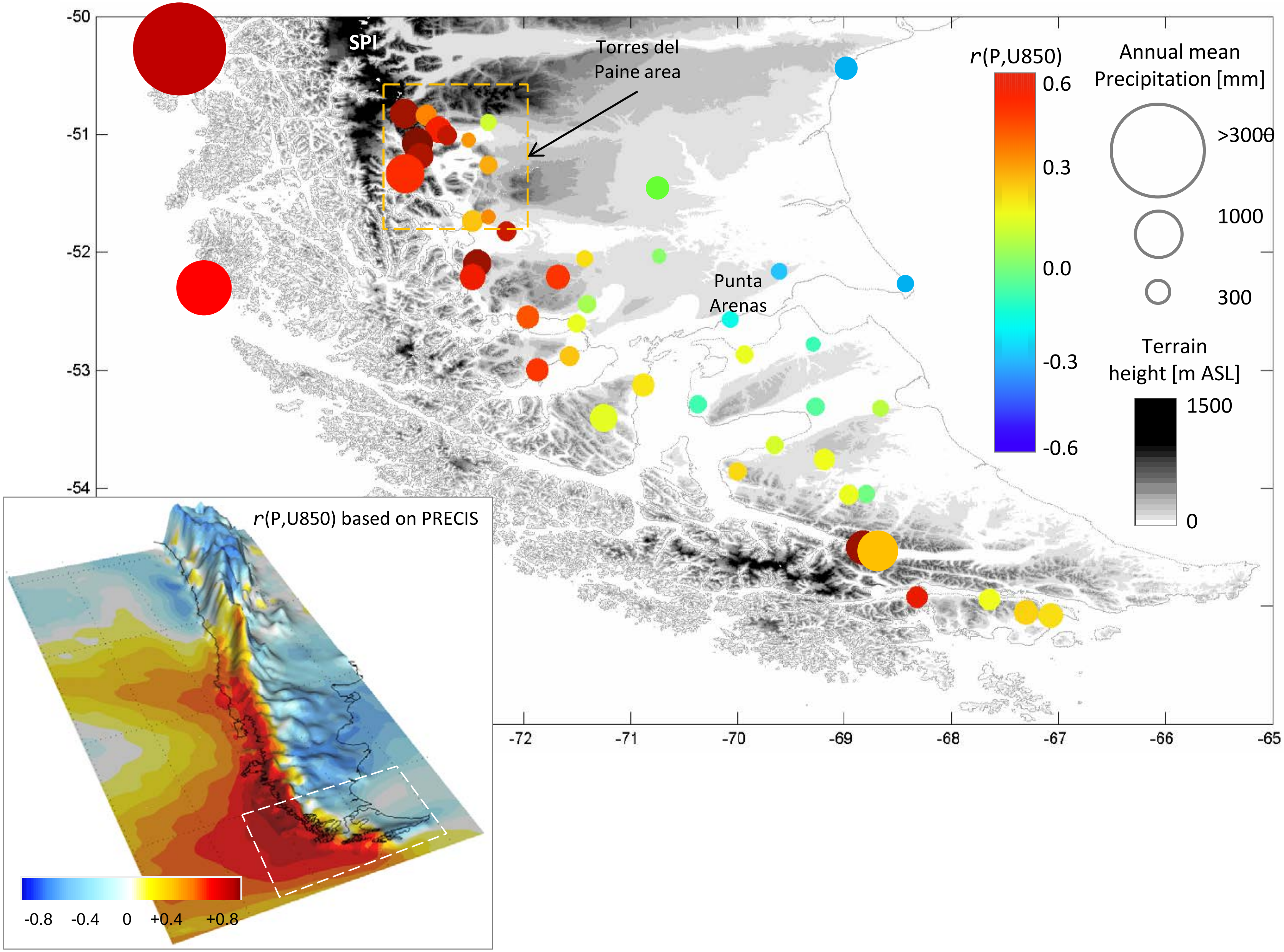


Garreaud 2007
PAGES 2006

Wind-precipitation and Wind-SAT covariability at annual timescale (year-to-year)



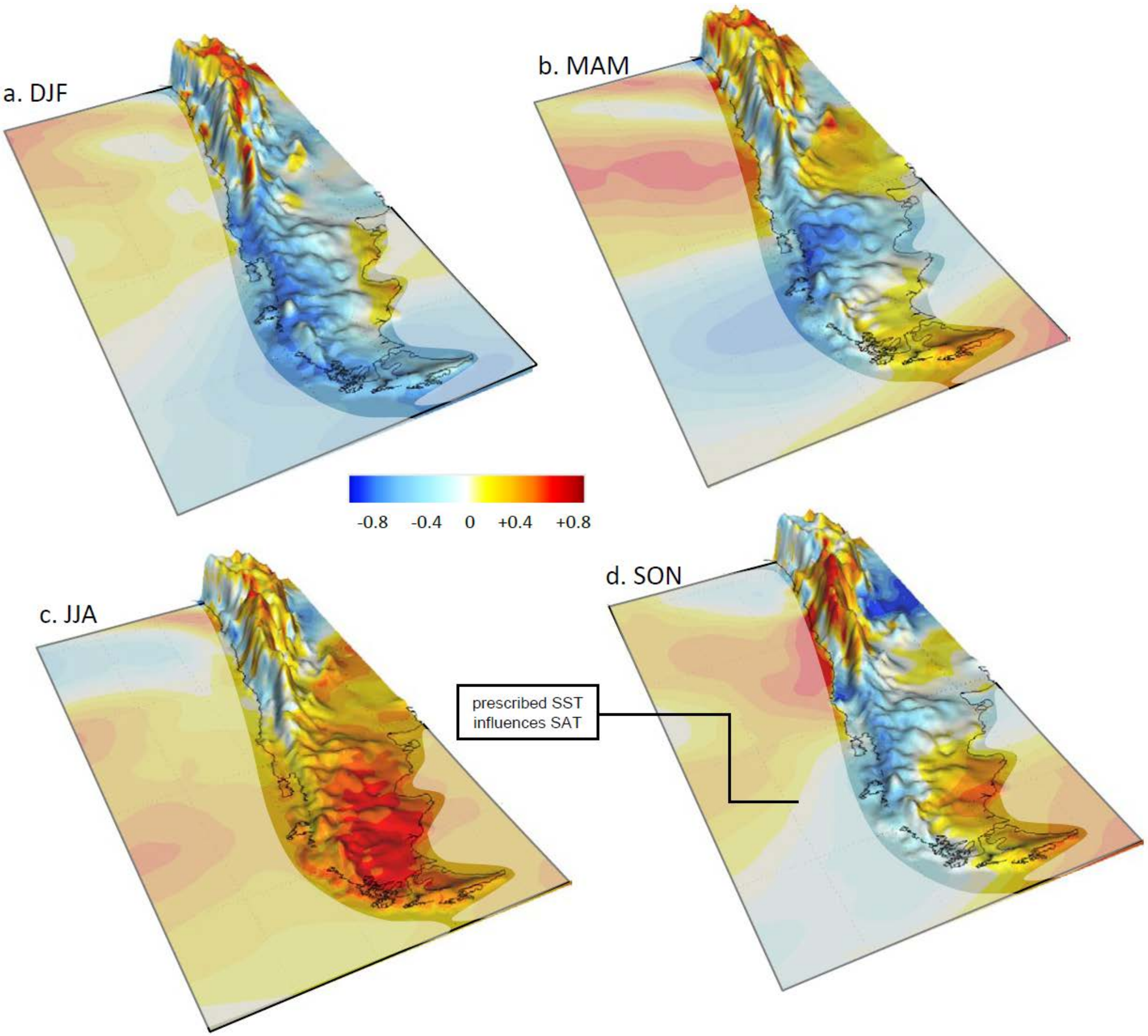
Stronger westerlies/More Precip. up to 50 km downstream of the Mnts.



Wind-SAT covariability at annual timescale

Strong westerlies
→ cold summer

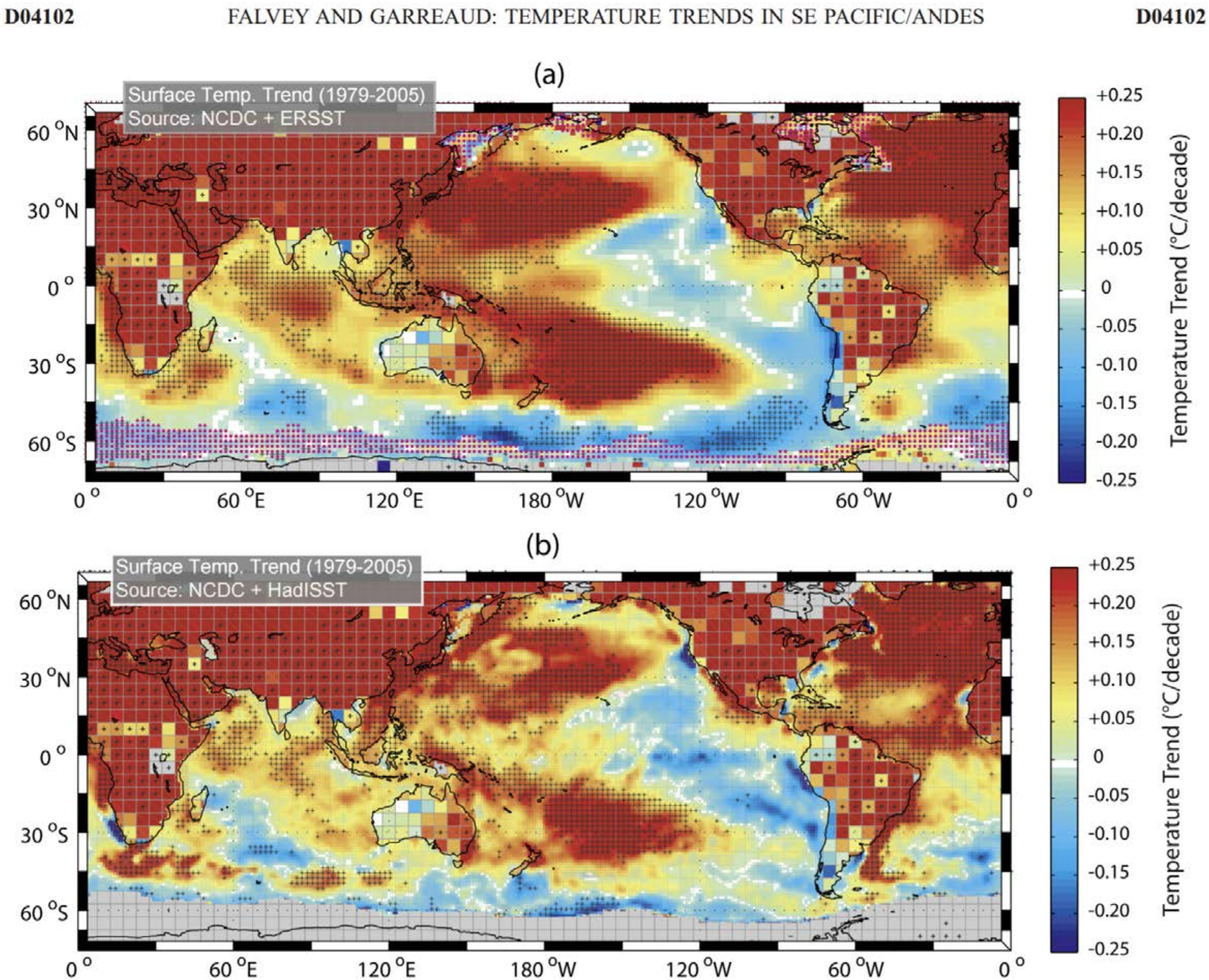
Strong westerlies
→ Warm winter



Cambio climático contemporáneo

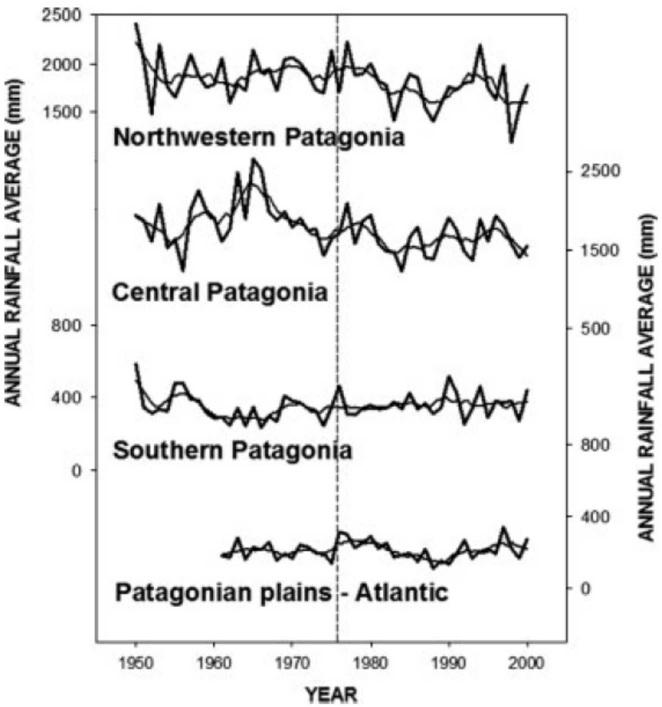
El pasado reciente y el futuro cercano

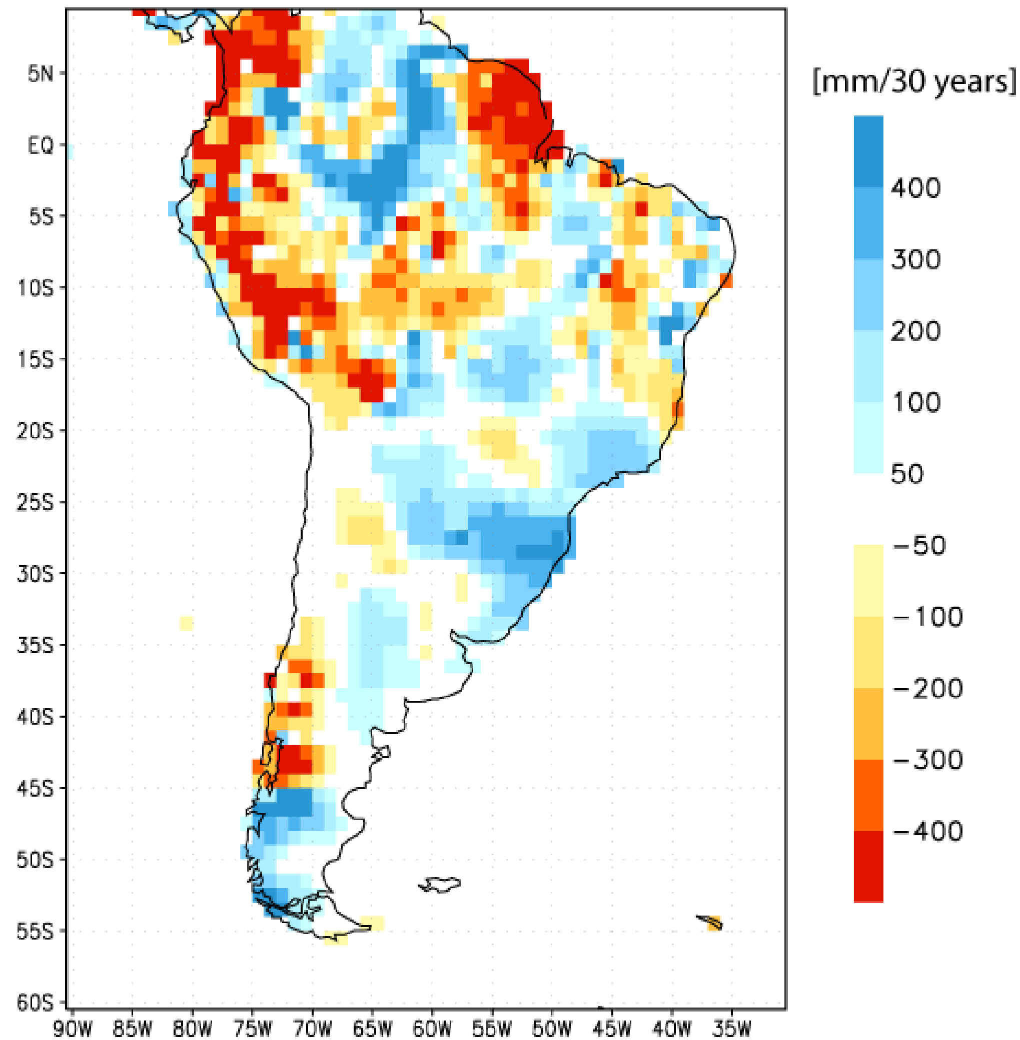
Tendencias recientes de temperatura...débiles.



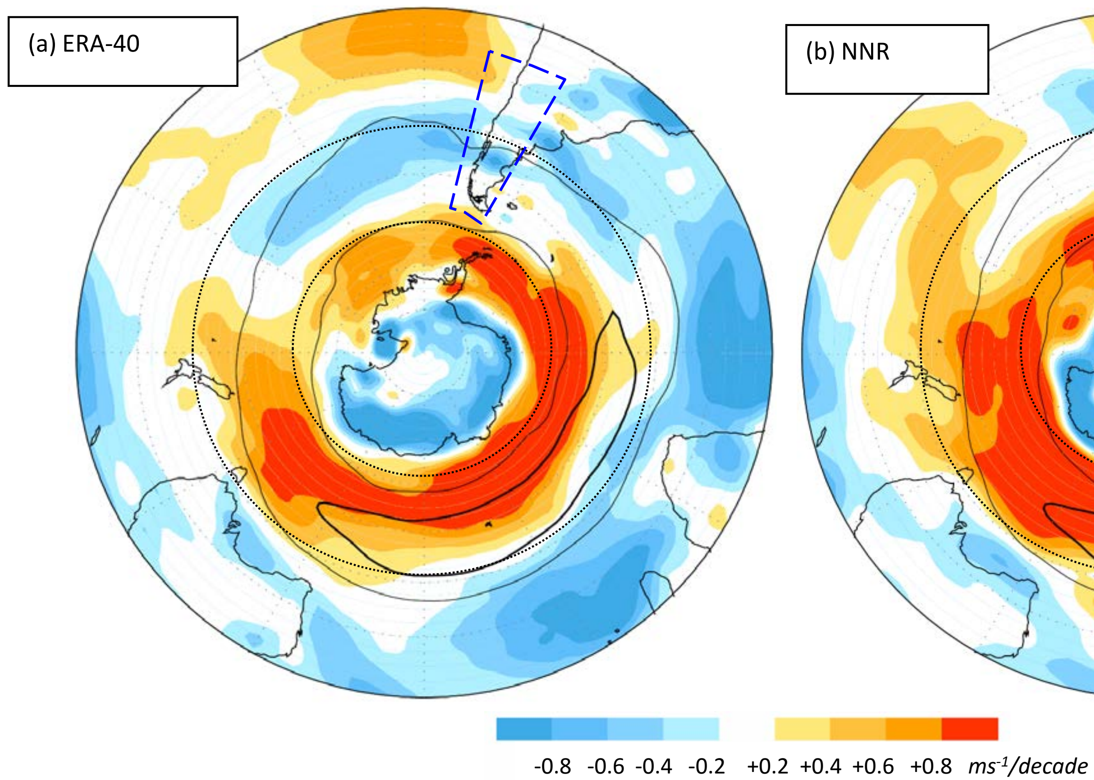
Observed (U.Delaware) Precip trend (1960-2000)

Aravena & Luckman 2010





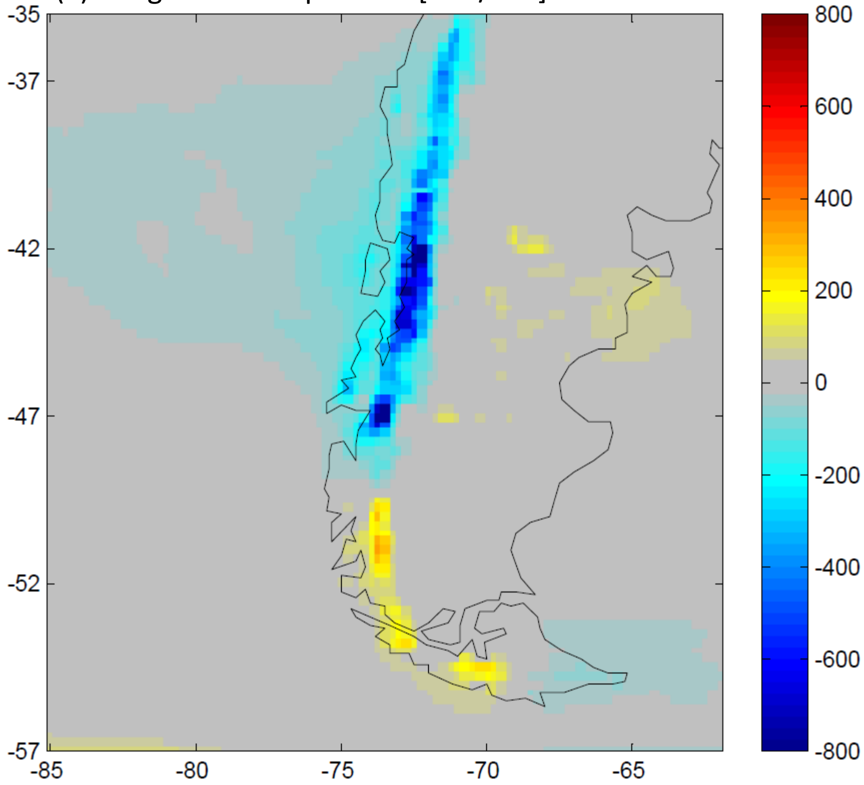
Downscale the U-P, U-SAT relationships

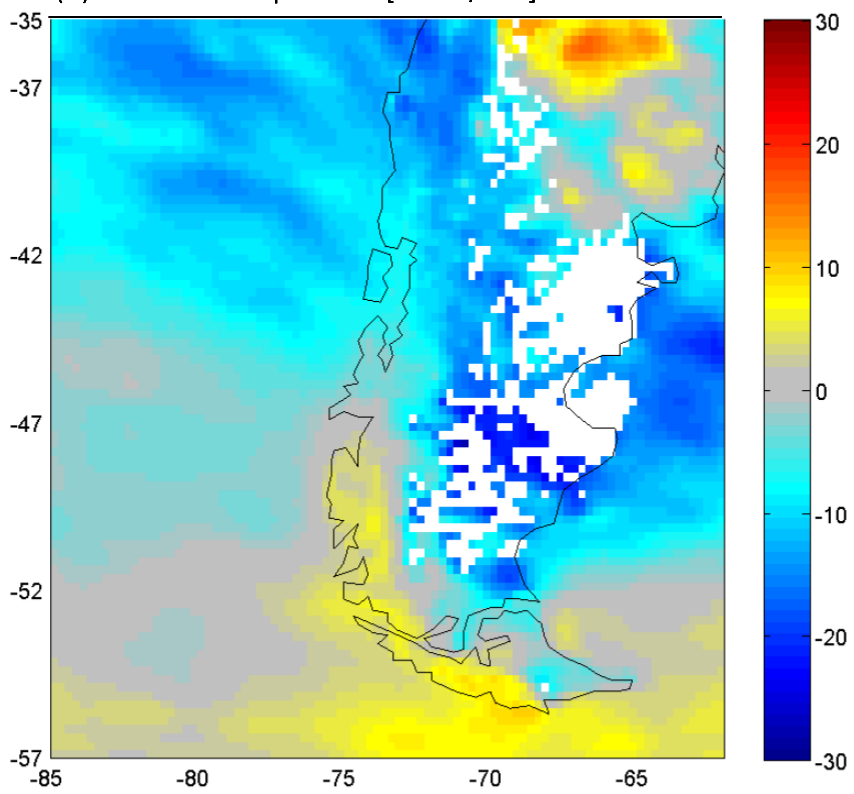


Linear trends in the annual mean zonal wind at the 850 hPa level using the (a) ERA-40 and (b) NCEP-NCAR reanalysis. **Shading indicates the change between 1968 and 2001 of a linear least squares trend fit calculated at each grid-box**

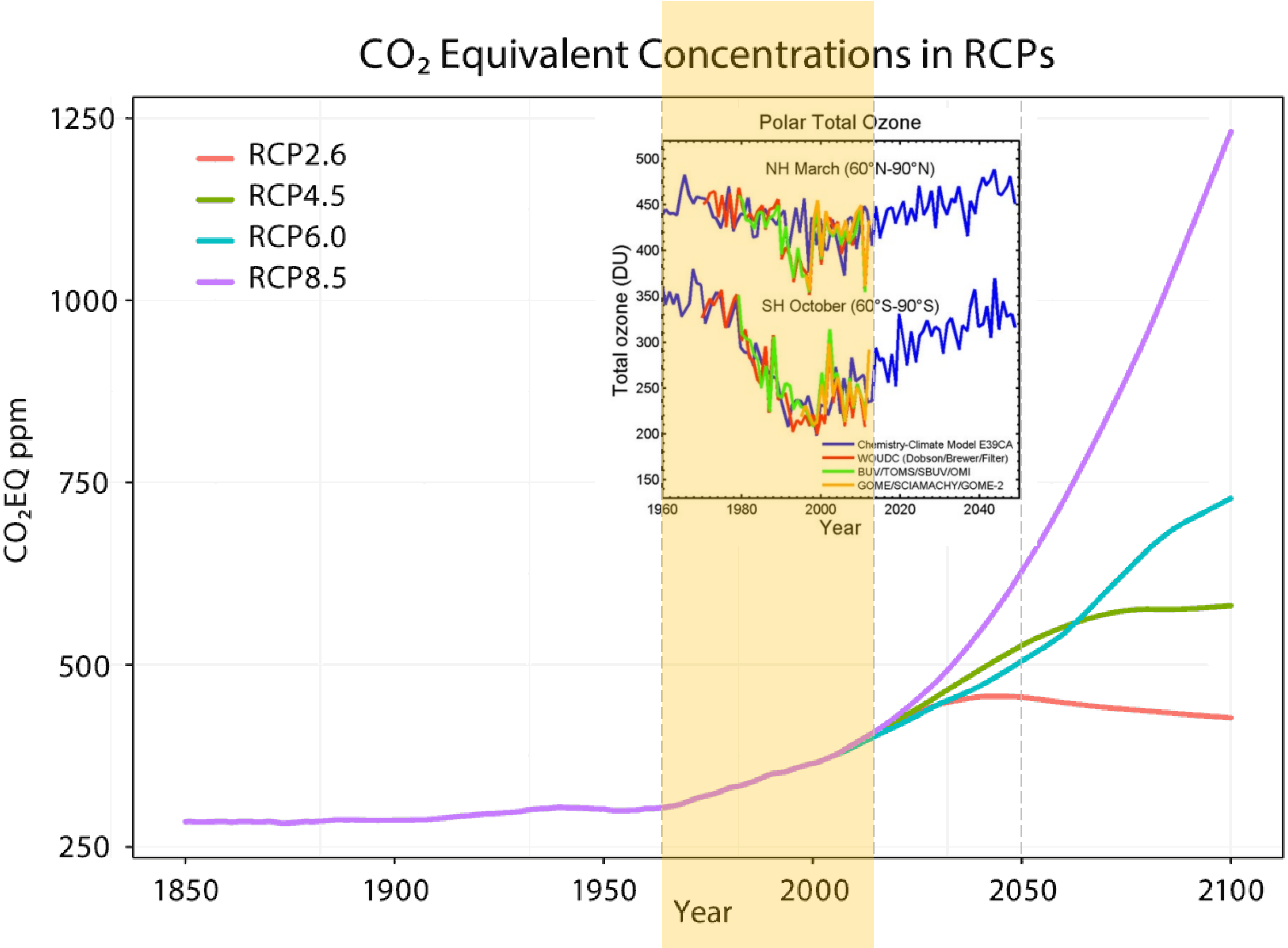
Wind-congruent precipitation trends(1968-2001)

$\Delta P^* = \beta \cdot \Delta U_{850}$

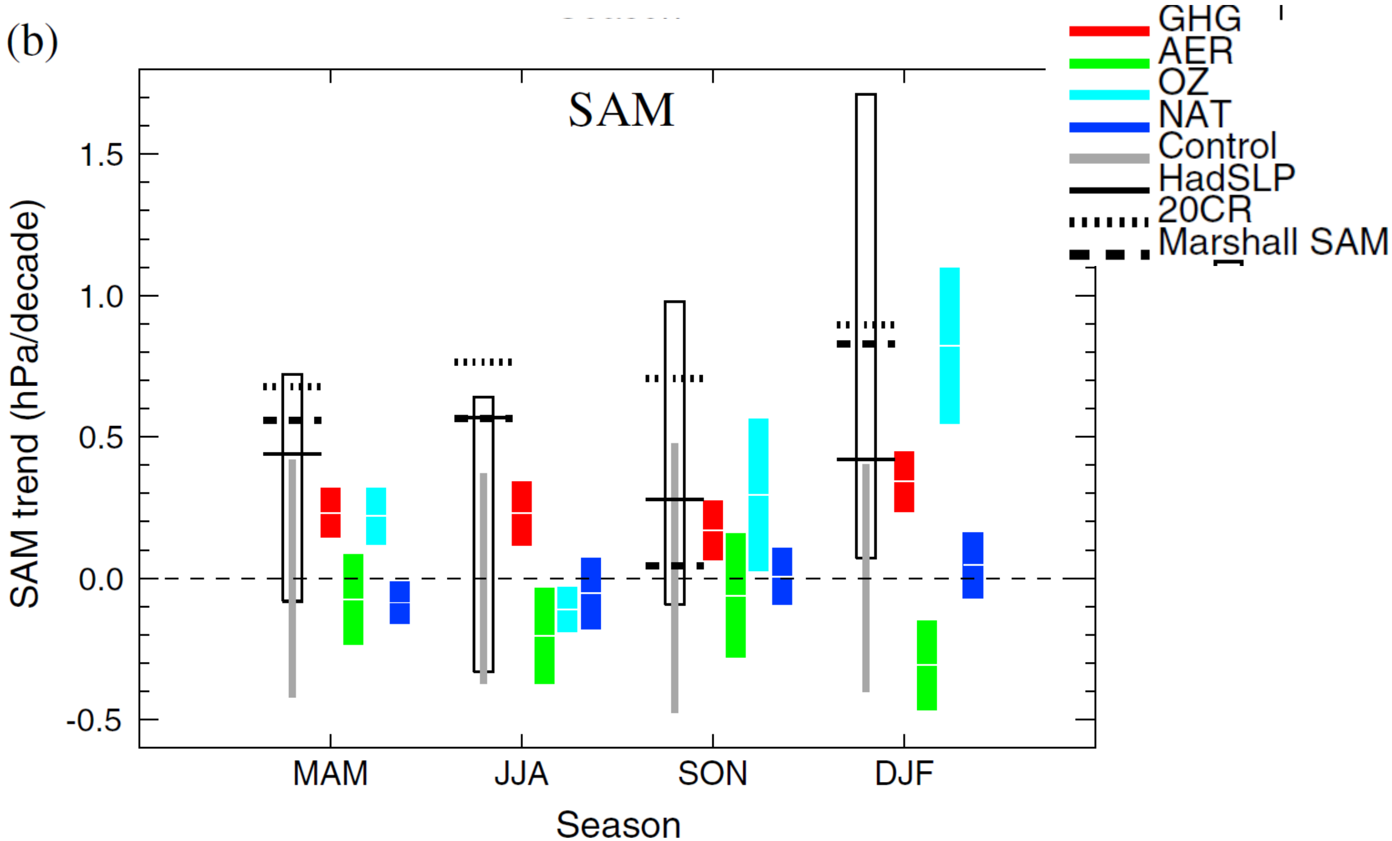




Greenhouse gases and Ozone: the main drivers of climate change



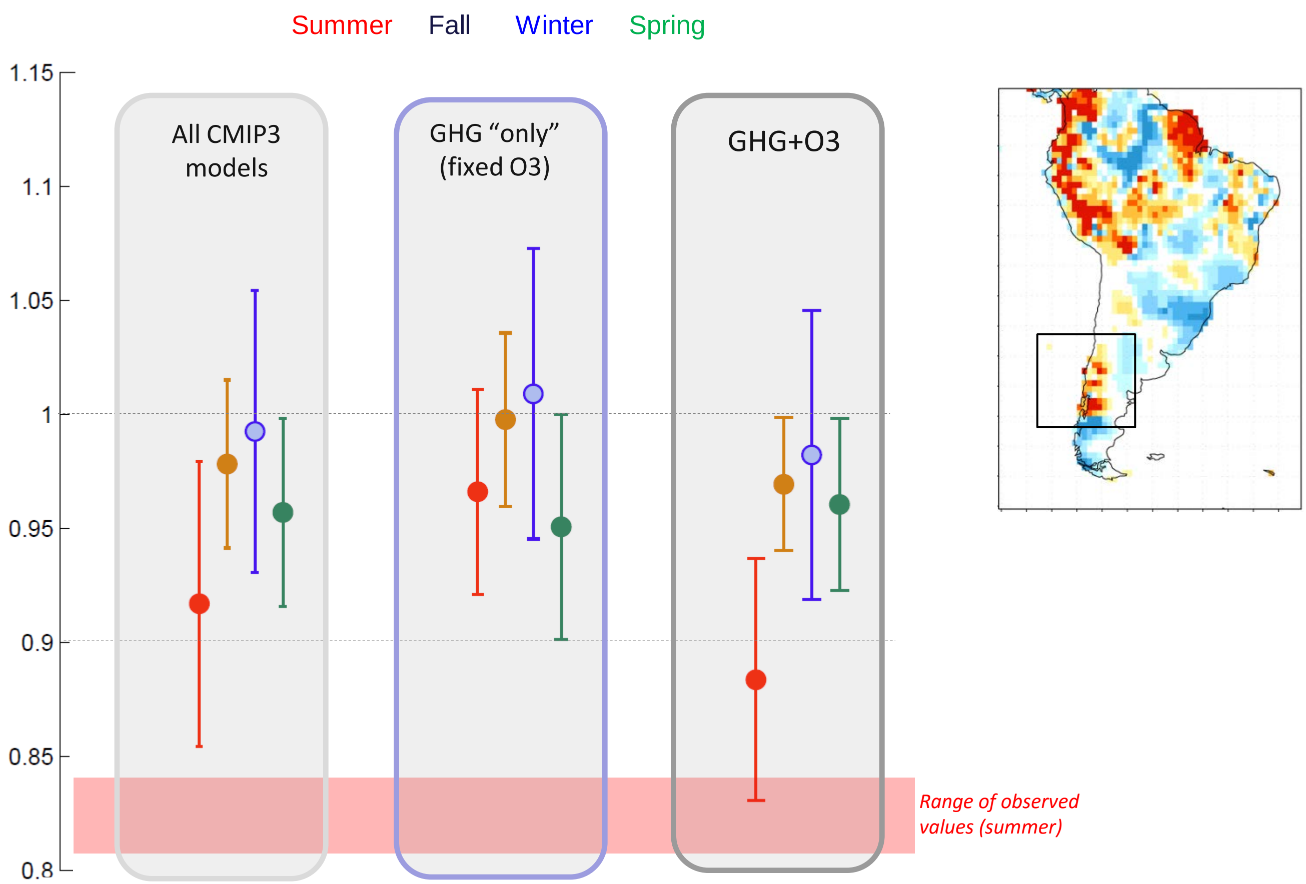
SAM trends 1950-2011: Observations and attribution

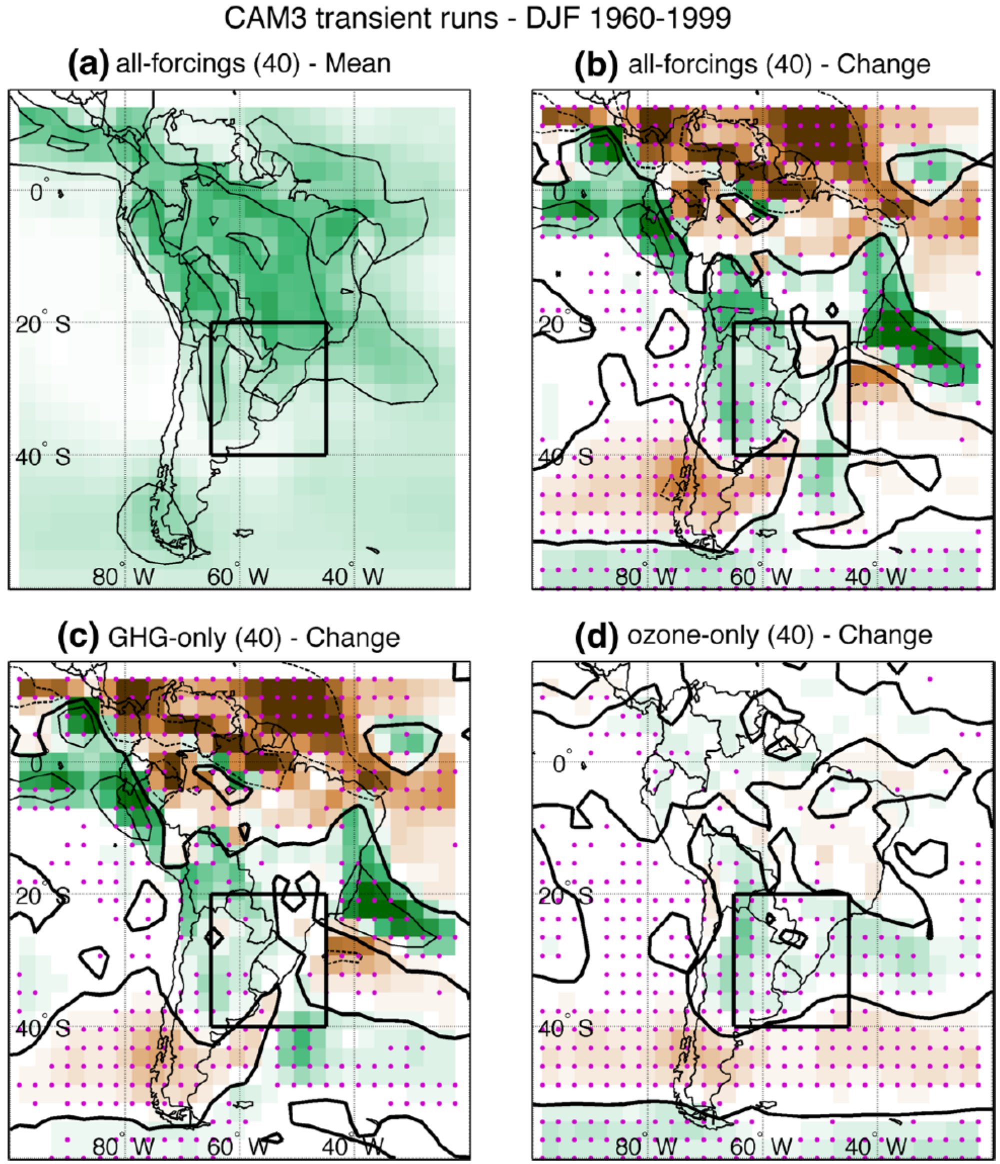


Attribution of observed sea level pressure trends to greenhouse gas, aerosol, and ozone changes

Nathan P. Gillett,[1] John C. Fyfe,[1] and David E. Parker[2]

Seasonal anomalies (P[1990-2005]/P[1960-1980])

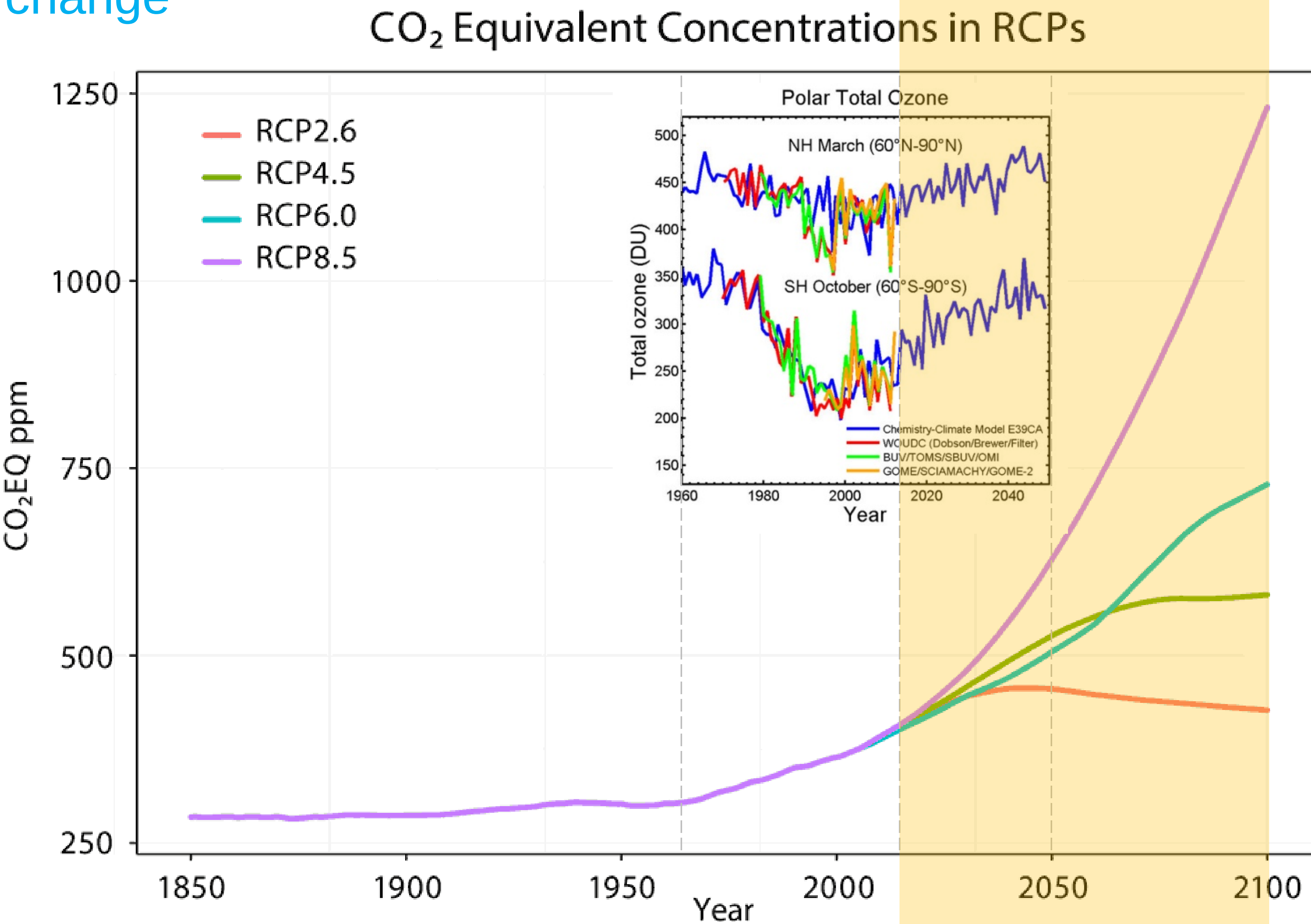




Stratospheric ozone depletion: a key driver of recent precipitation trends in South Eastern South America

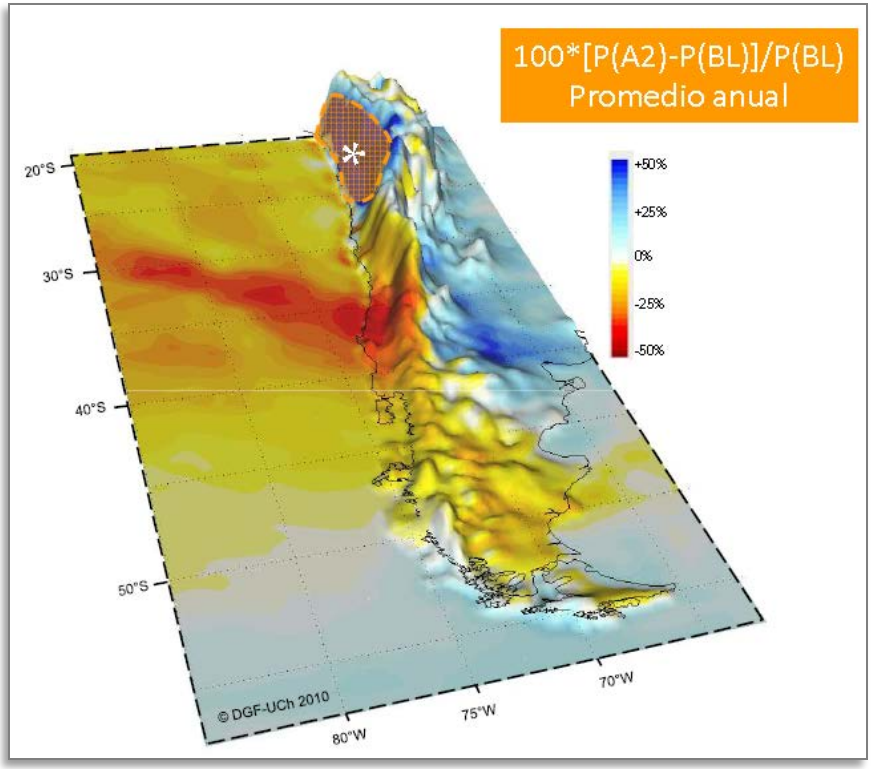
Paula L. M. Gonzalez · Lorenzo M. Polvani · Richard Seager · Gustavo J. P. Correa

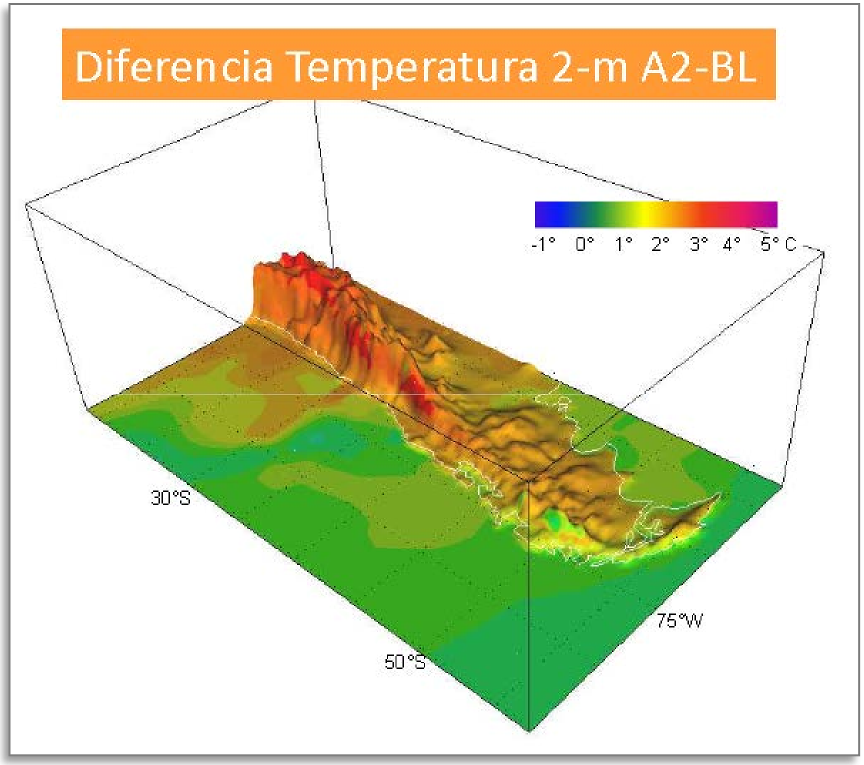
Greenhouse gases and Ozone: the main drivers of climate change



Southern SA Climate Change Projections

Towards the end of century under A2 (RCP8.5)

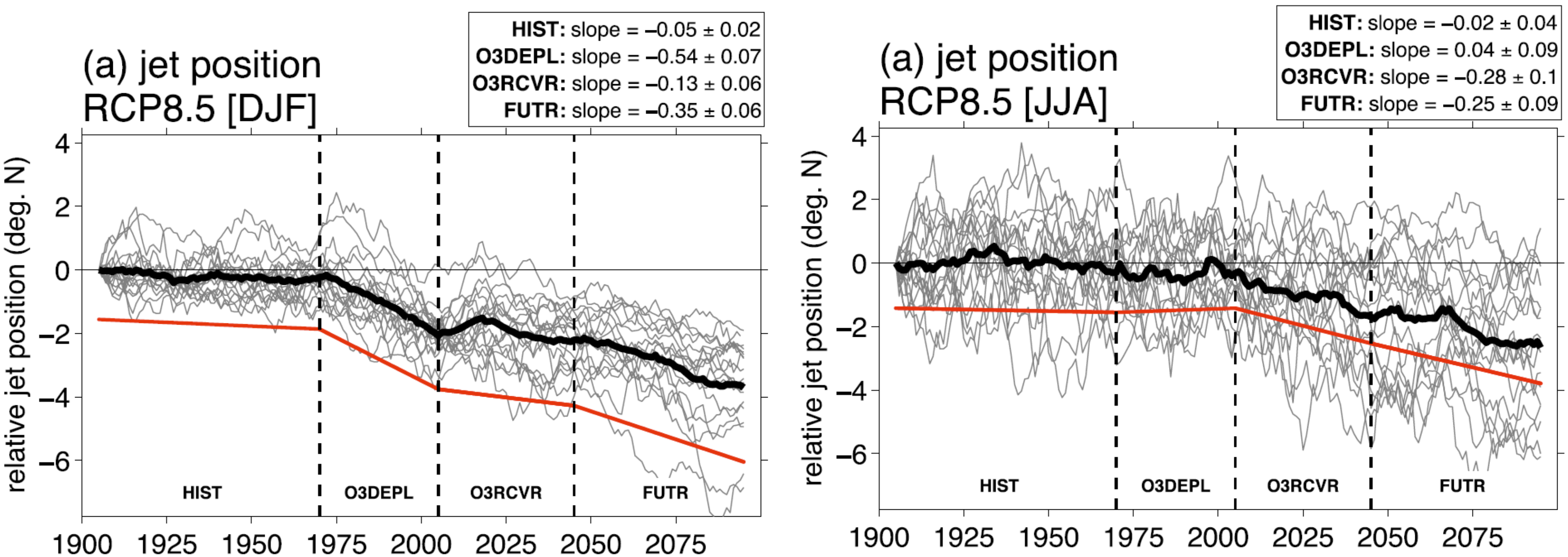




Estudio DGF/UCh-CONAMA 2007 empleando PRECIS

Projections of Jet Position

Implications for Patagonia hydro climate



Delayed Southern Hemisphere Climate Change Induced by Stratospheric Ozone Recovery, as Projected by the CMIP5 Models

ELIZABETH A. BARNES

Rayos y centellas

Evidencia de paleo-incendios en Patagonia Oeste sugiere ocurrencia de rayos en esta región

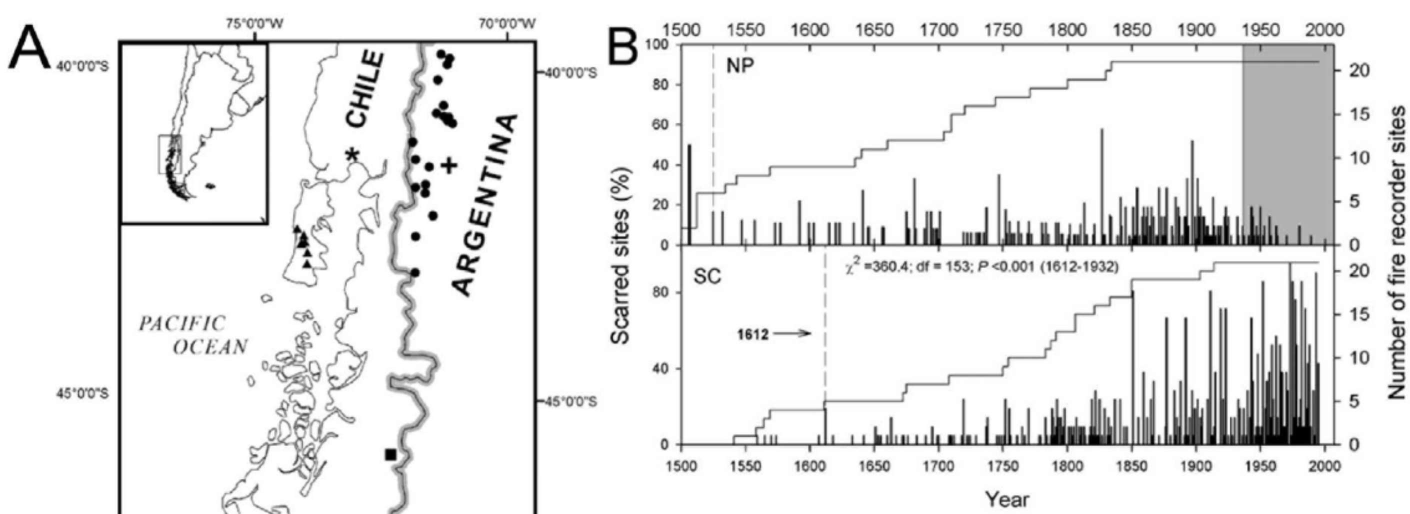


Figure 2. (a) Locations of the regional fire-chronologi[...] triangles), and of the Puerto Montt (asterisk), Bariloche ([...] (1500–2004) of all fire events and sample depth of each [...] period (post-1932) in the NP area). Chi-square and p-va[...] (≥10% of all sites in each area, with a minimum of two s[...] Vertical dashed-lines and "1612→" indicate the start year of the fire chronology and of analysis.


Palaeogeography, Palaeoclimatology, Palaeoecology 311 (2011) 82–92

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Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

The amplifying effects of humans on fire regimes in temperate rainforests in western Patagonia

Andrés Holz *, Thomas T. Veblen

Department of Geography, University of Colorado, Boulder, CO 80309 USA

World Wide Lightning Location Network (WWLLN)

It monitors the VLF radio waves (sferics) emitted by lightning and uses a time of group arrival technique to locate lightning strokes within ~5 km and <10 μs. Online data available at: http://wwlln.net/

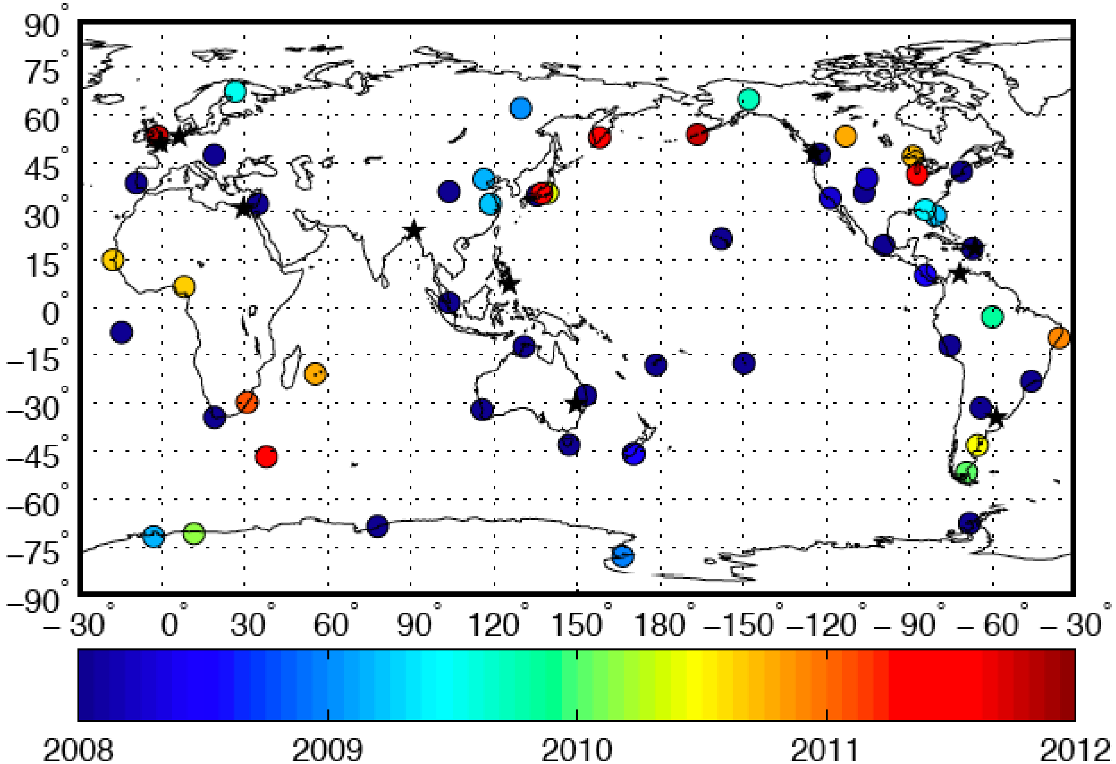
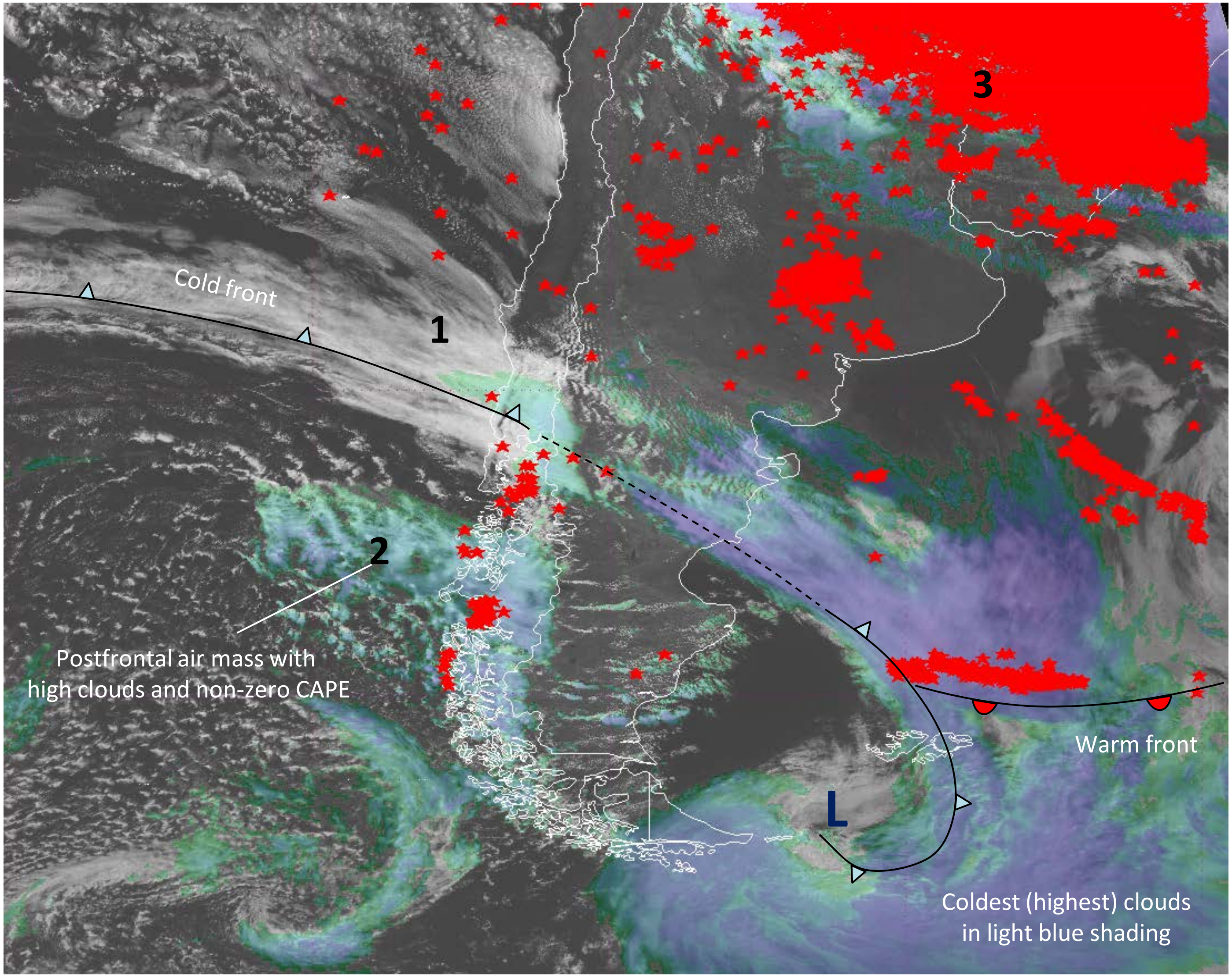


Figure 1. Location of WWLLN sensors, color-coded according to the date each was established. Stations established prior to 2008 are shown in dark blue; black stars indicate stations established 2012-present.

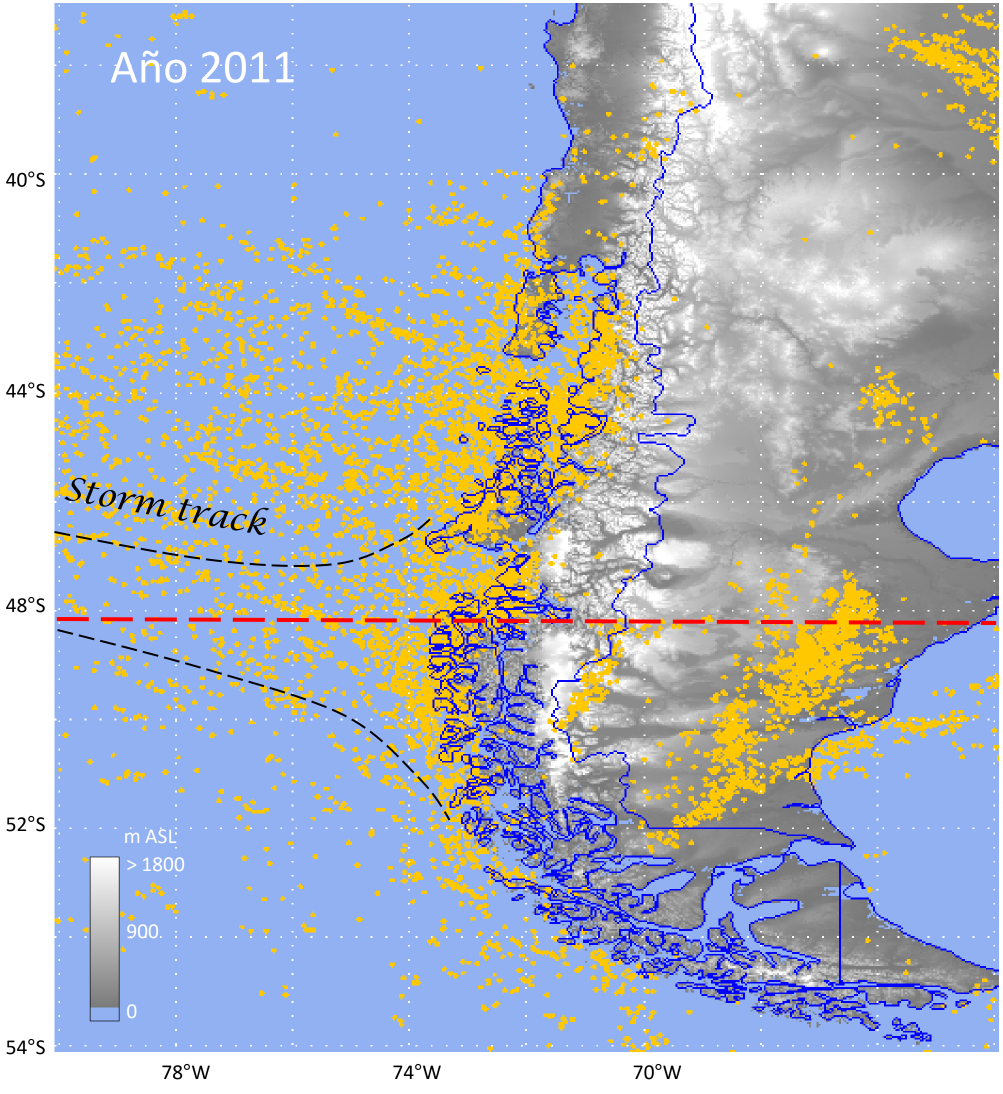
Virts et al. 2013

January 6, 2013 – 1800 UTC

GOES-13 Visible (BW) and IR4 (light shading) + WWLLN Lighting (stars)



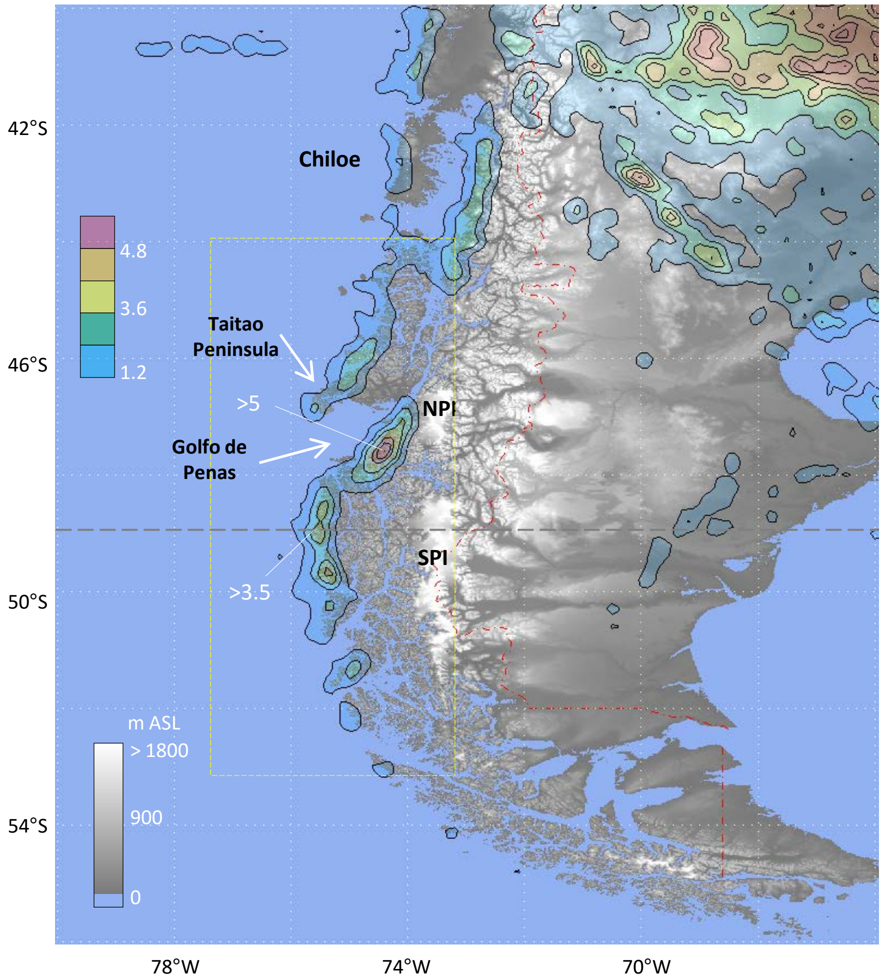
Spatial Distribution (2008-2012)



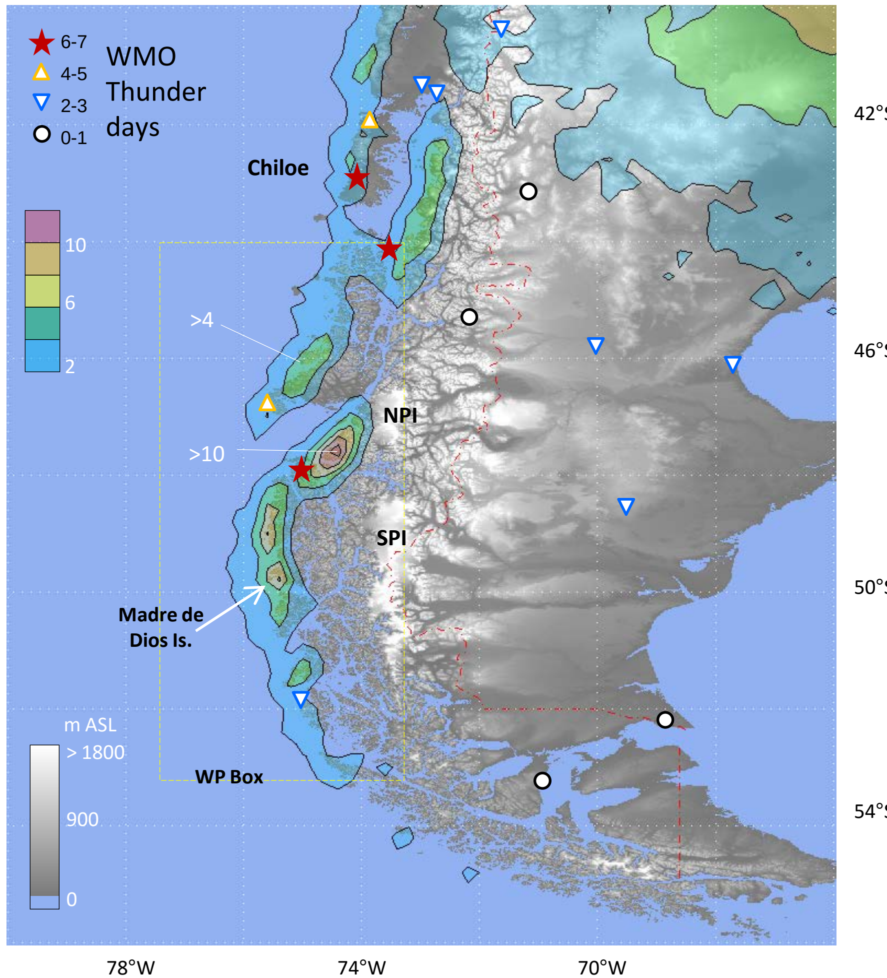
Garreaud, Nicora et al. 2014

Spatial Distribution (2008-2012)

Lightning density, 0.1×0.1 lat-lon boxes

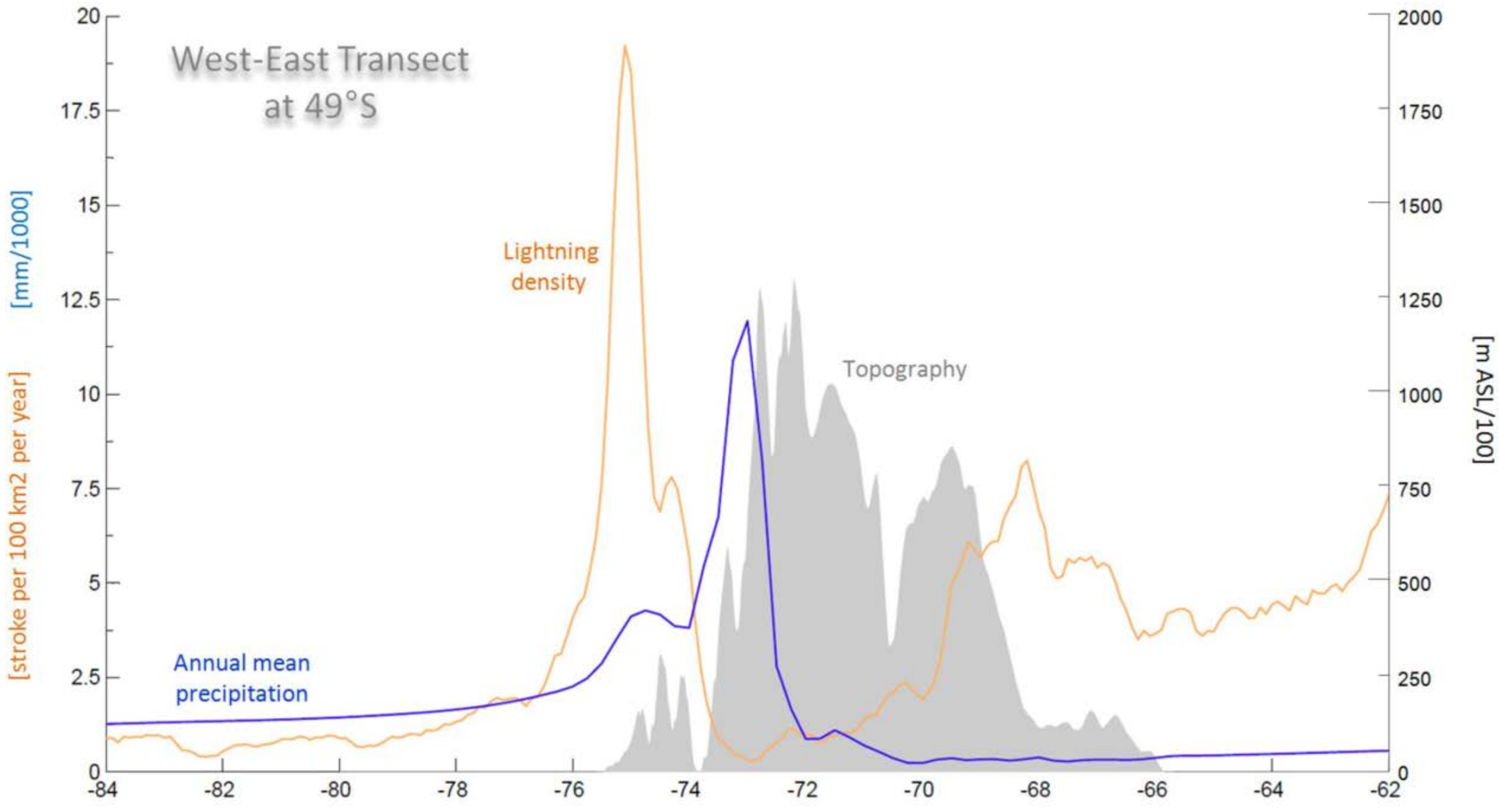


Number of lightning-days, 0.2×0.2 lat-lon boxes



Garreaud, Nicora et al. 2014

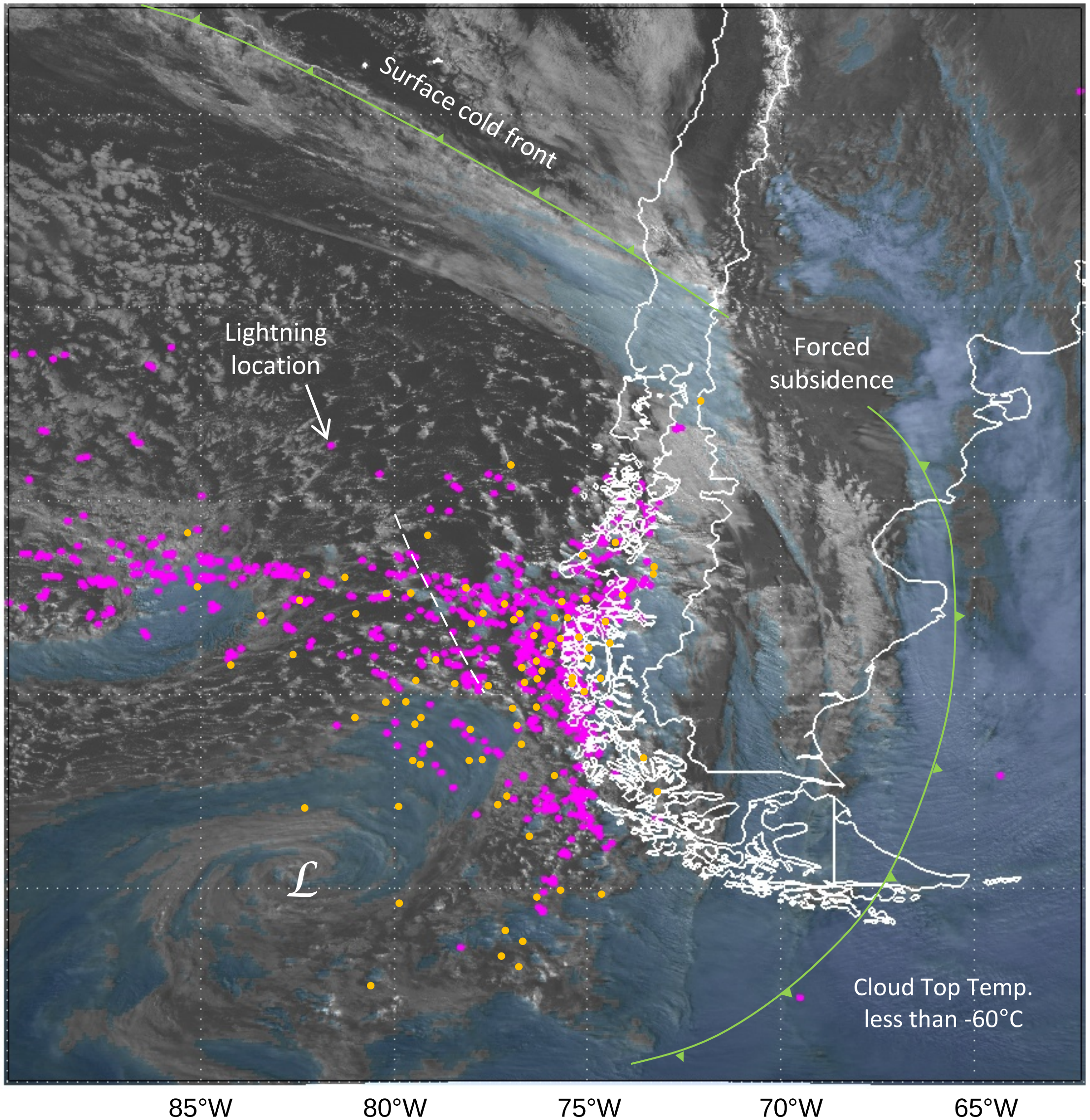
Spatial Distribution (2008-2012)



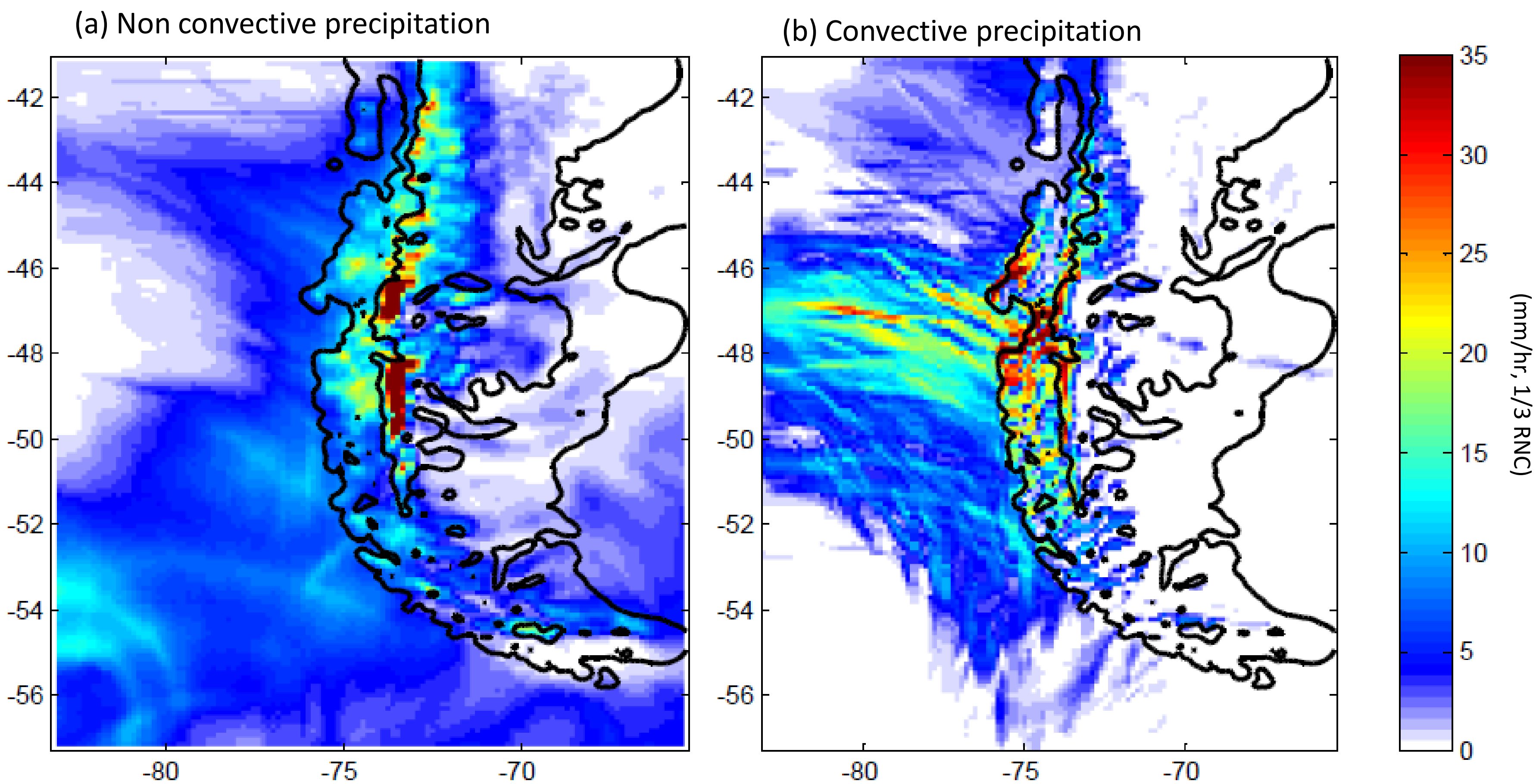
Garreaud, Nicora et al. 2014

April 30, 2012 – 1800 UTC

GOES-13 Visible (BW) and IR4 (light shading) + WWLLN Lighting (dots) + Starnet

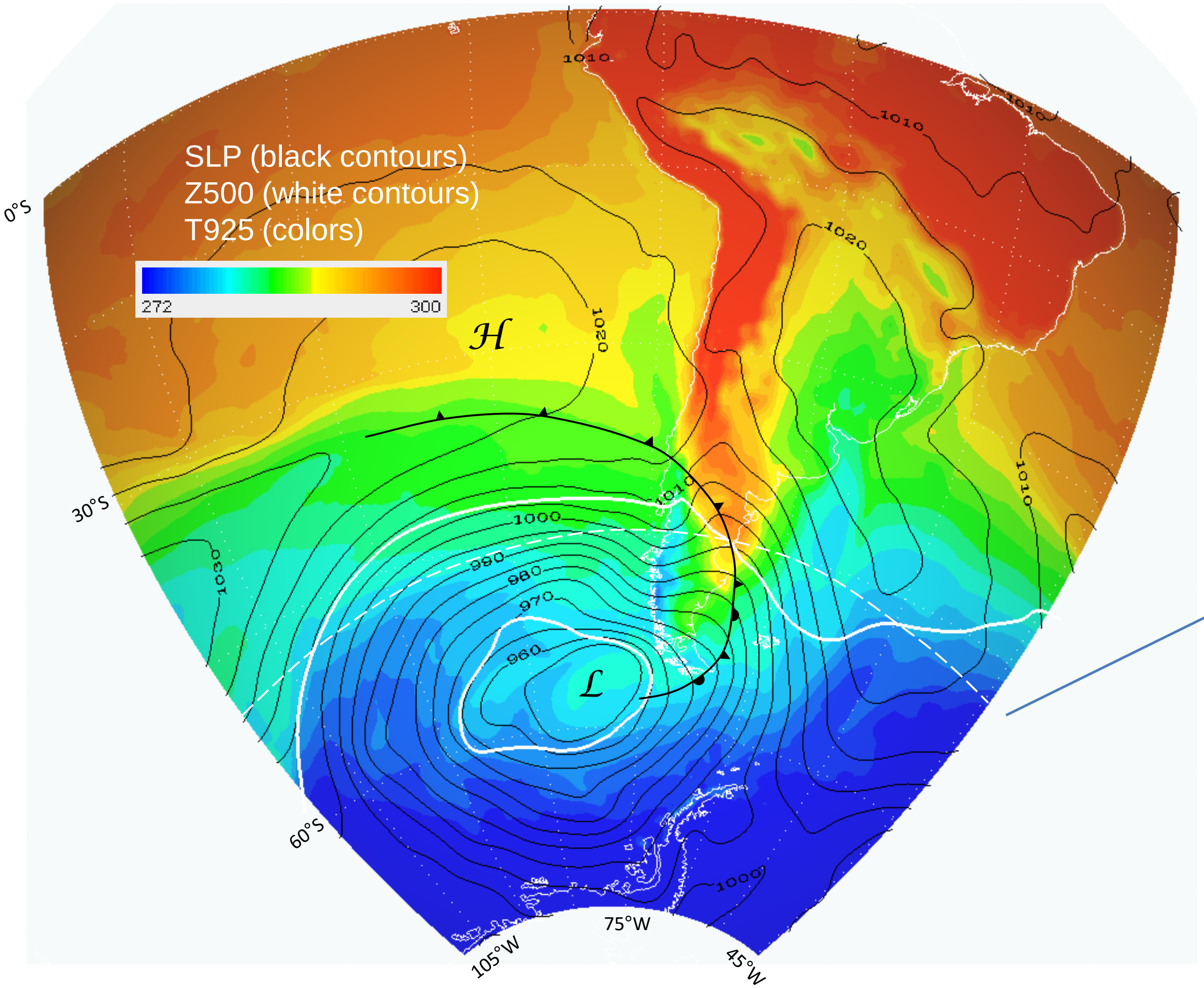


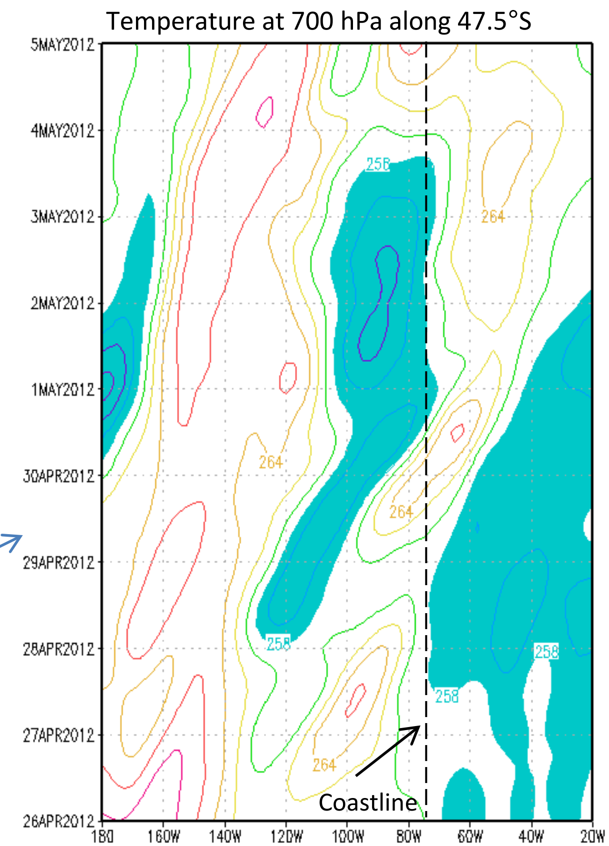
Accumulated precipitation (08 UTC, 29 April – 23 UTC, 30 April, 2012) simulated by WRF (12 km inner domain, KF-Cu Scheme)



April 30, 2012 – 1800 UTC

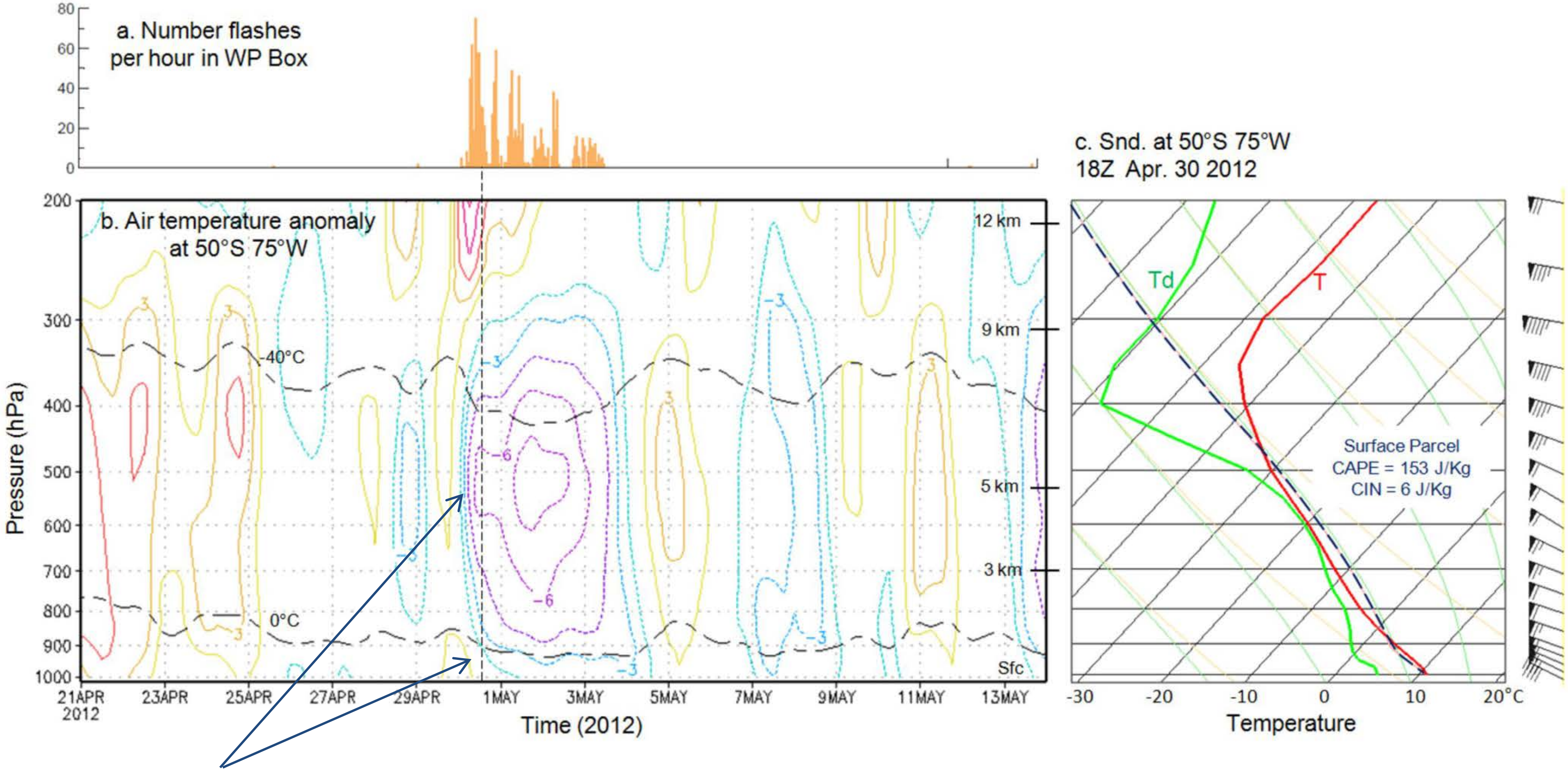
Análisis sinóptico (CFSR)





Garreaud, Nicora et al. 2014

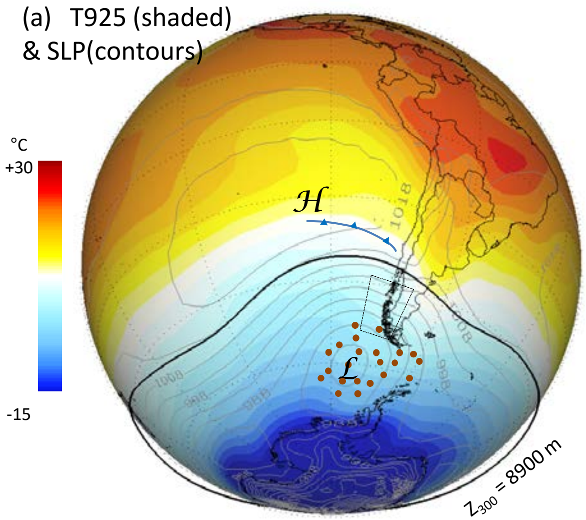
Electric activity in a slightly unstable environment and strong Westerly flow

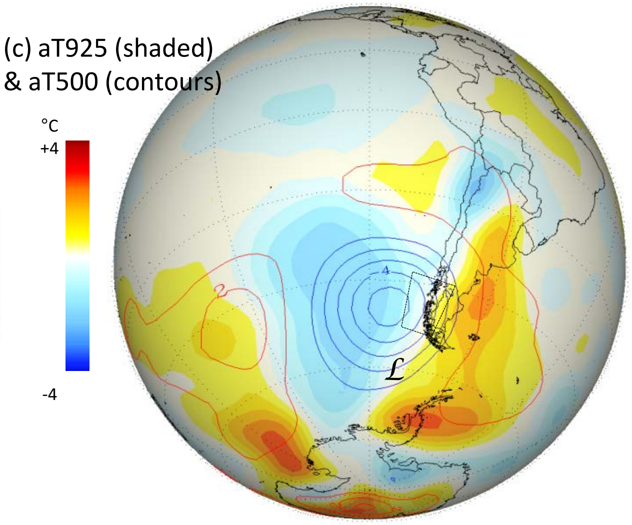


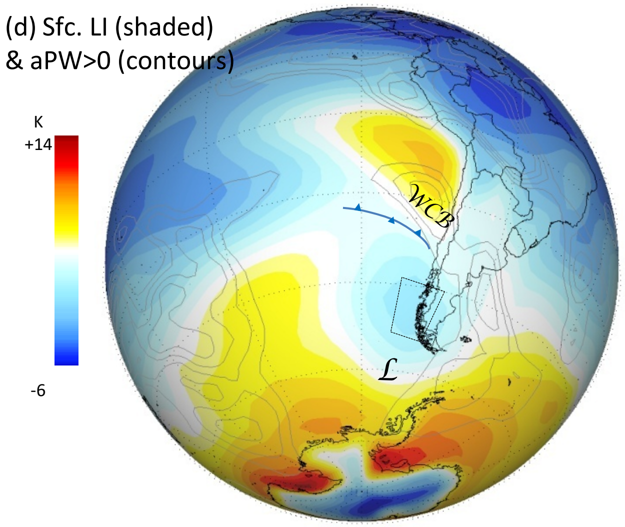
Mid level cooling stronger and before than at surface

Garreaud, Nicora et al. 2014

Compositing analysis for days with more than 50 flashed in WP Box (89 days)







1. Depresión Extratropical en etapa madura. PO en masa postfrontal

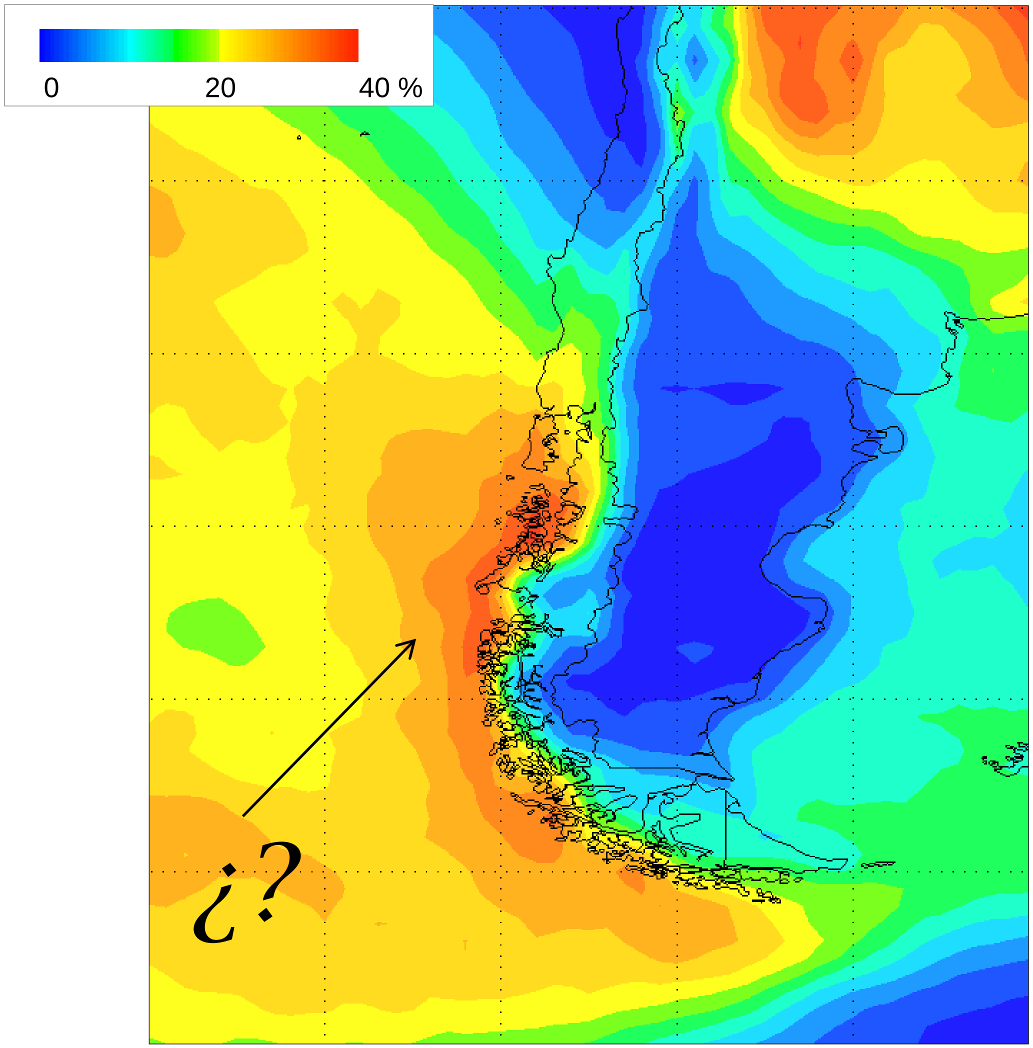
2. Enfriamiento más pronunciado en troposfera media

3. Ambiente ligeramente inestable sobre WP

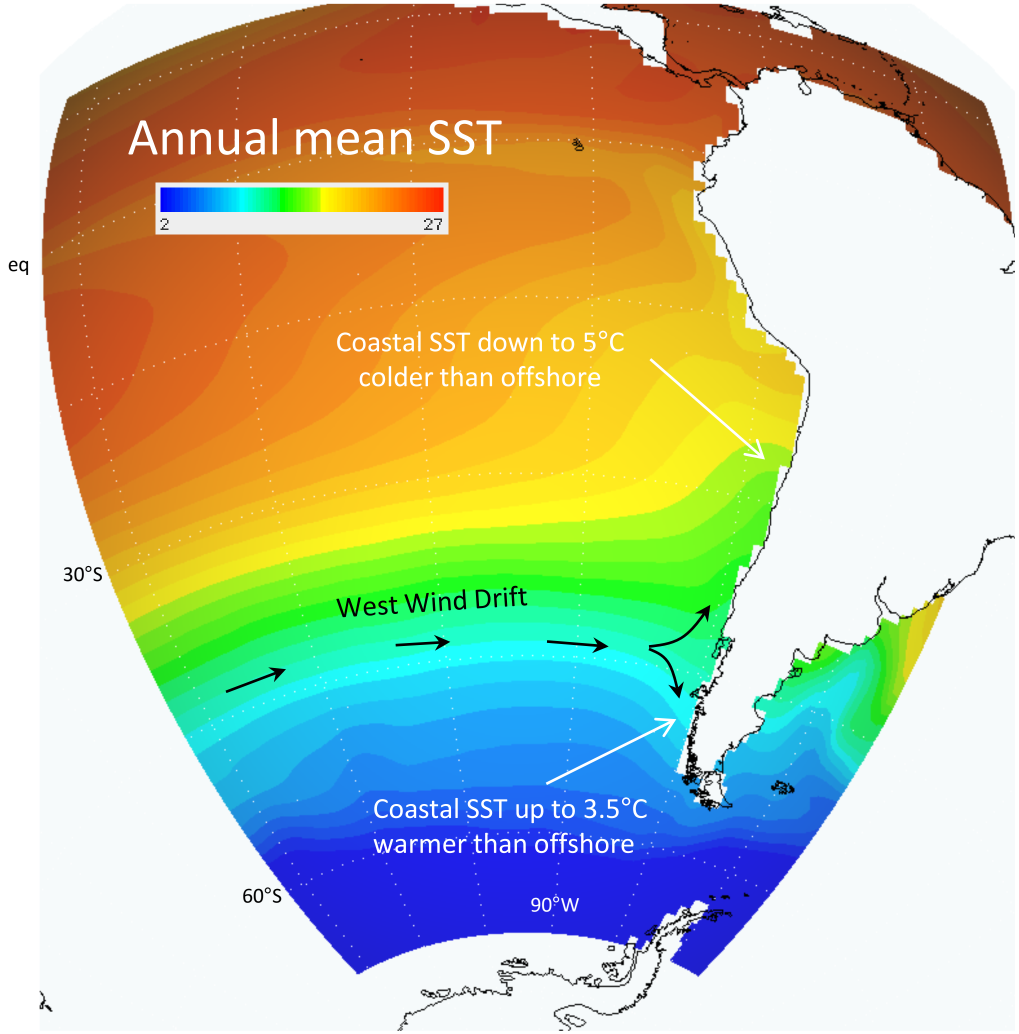
Garreaud, Nicora et al. 2014

Coastal topography forces updraft under strong westerlies.
What about unstable conditions?

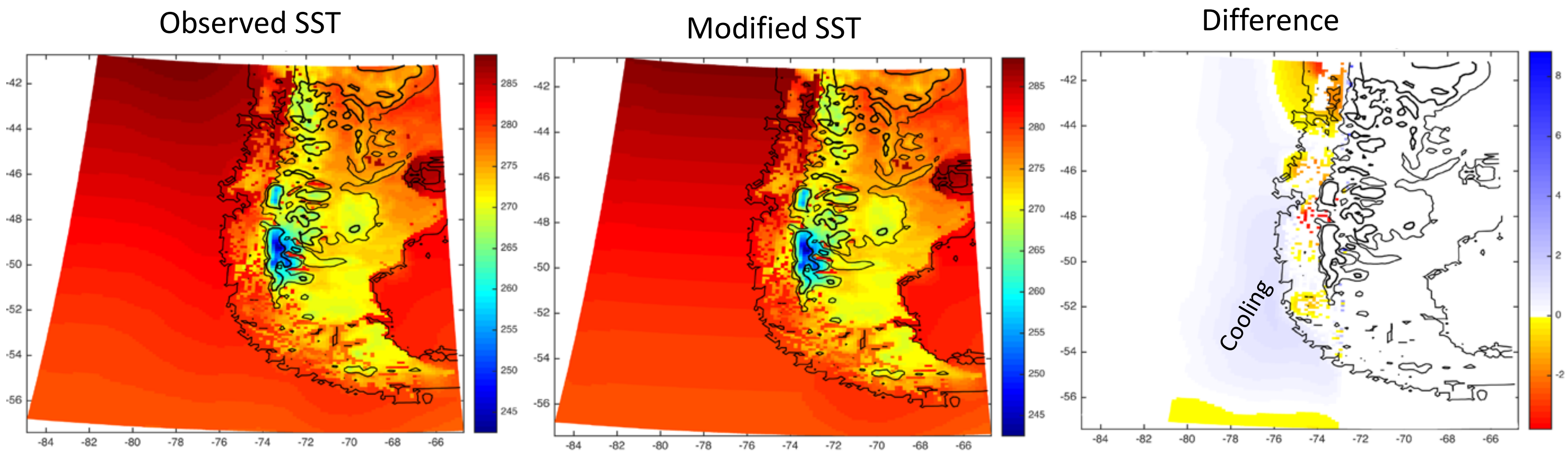
Frequency of days with CAPE > 0 (unstable conditions)

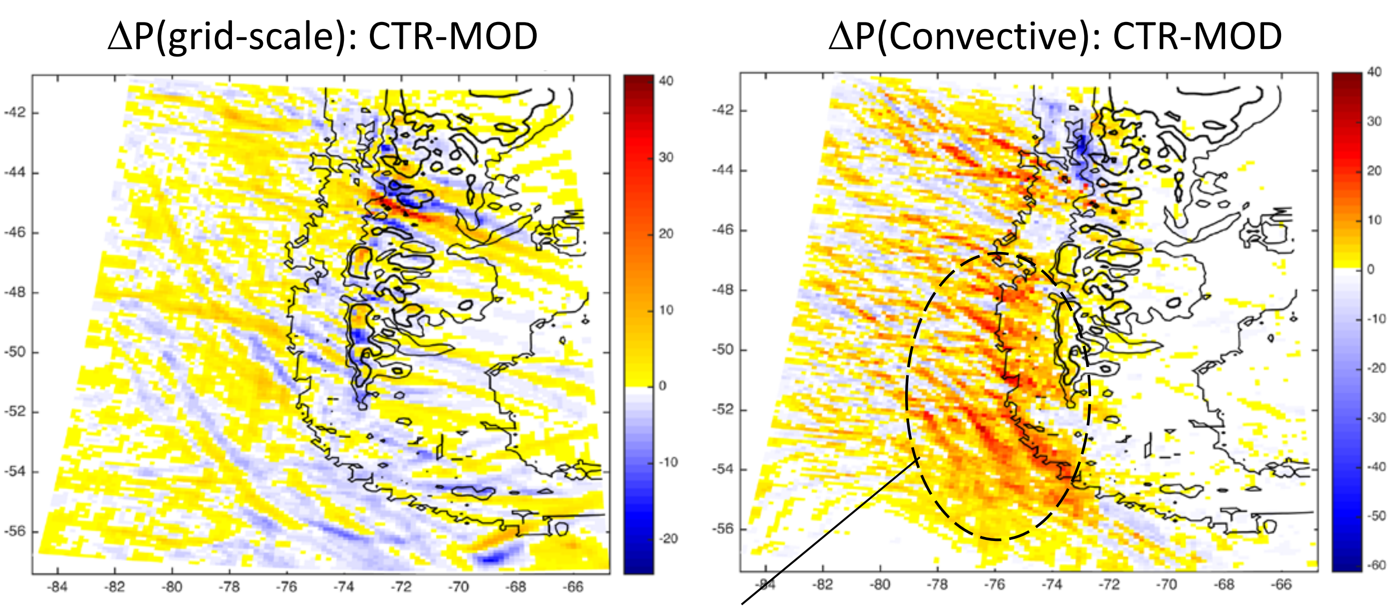


The higher frequency of unstable conditions near Patagonia maybe associated with its warmer coastal waters.



SST Experiments





Warm anomaly increases rainfall (up to 70%)

Asuntos pendientes

- Como el aumento de precipitación a barlovento y sombra a sotavento varían con la elevación de los Andes?
- Impactos de GHG y O3 en el clima de Patagonia define en gran medida el futuro de la región en las próximas décadas.
- Influencia Atlántica en el clima Patagónico, especialmente en eventos extremos.