The Impacts of Atmospheric Rivers on Precipitation over the west coast of South America

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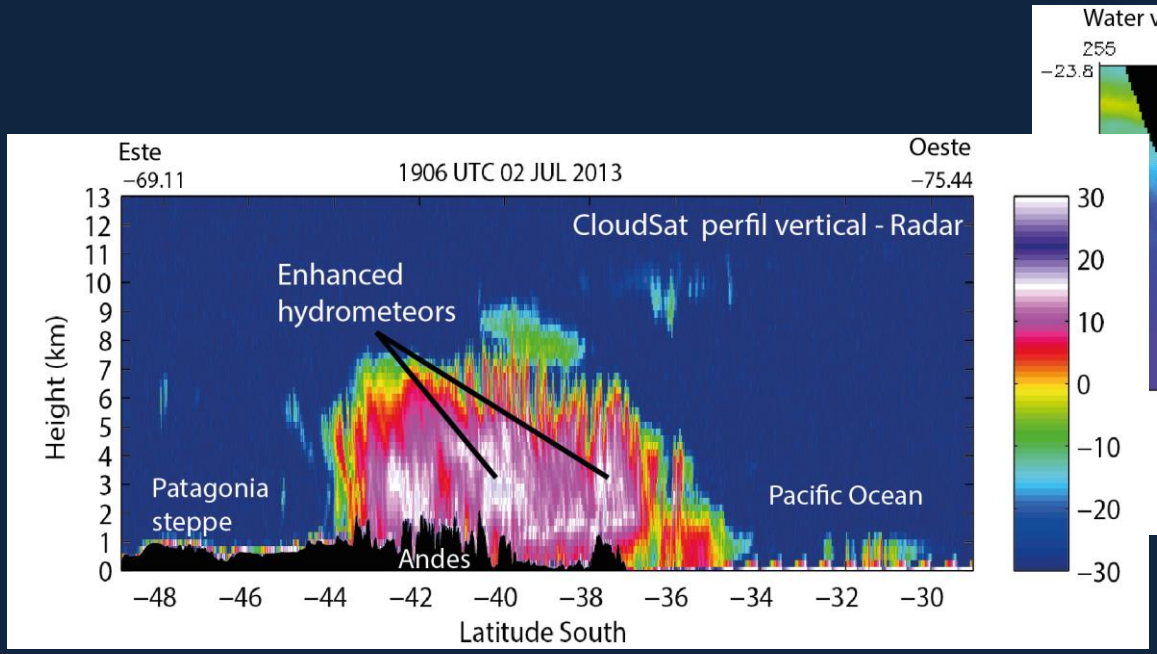
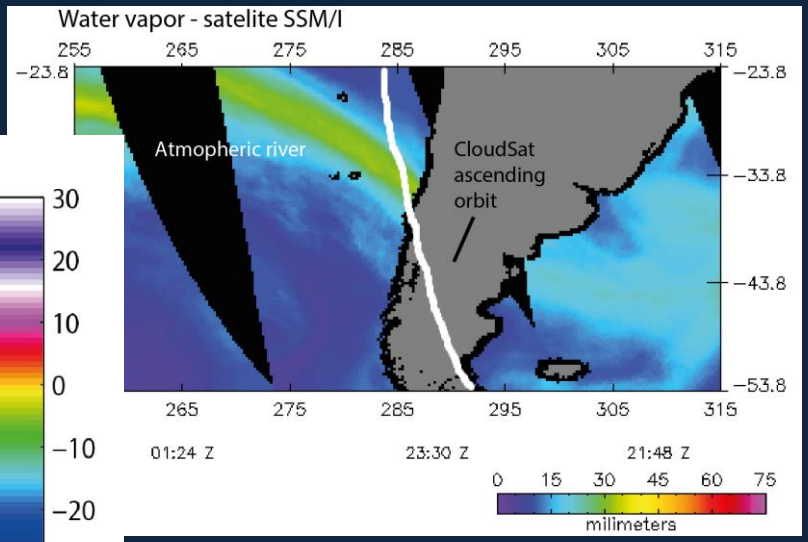
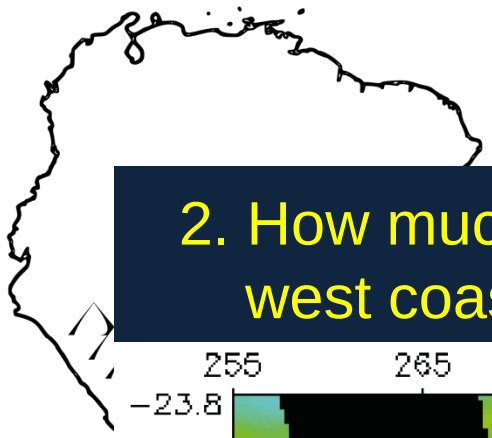
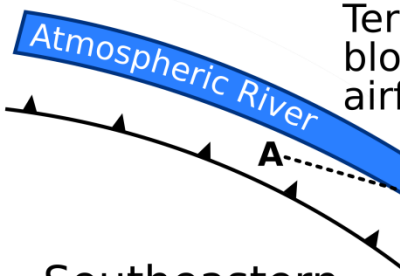




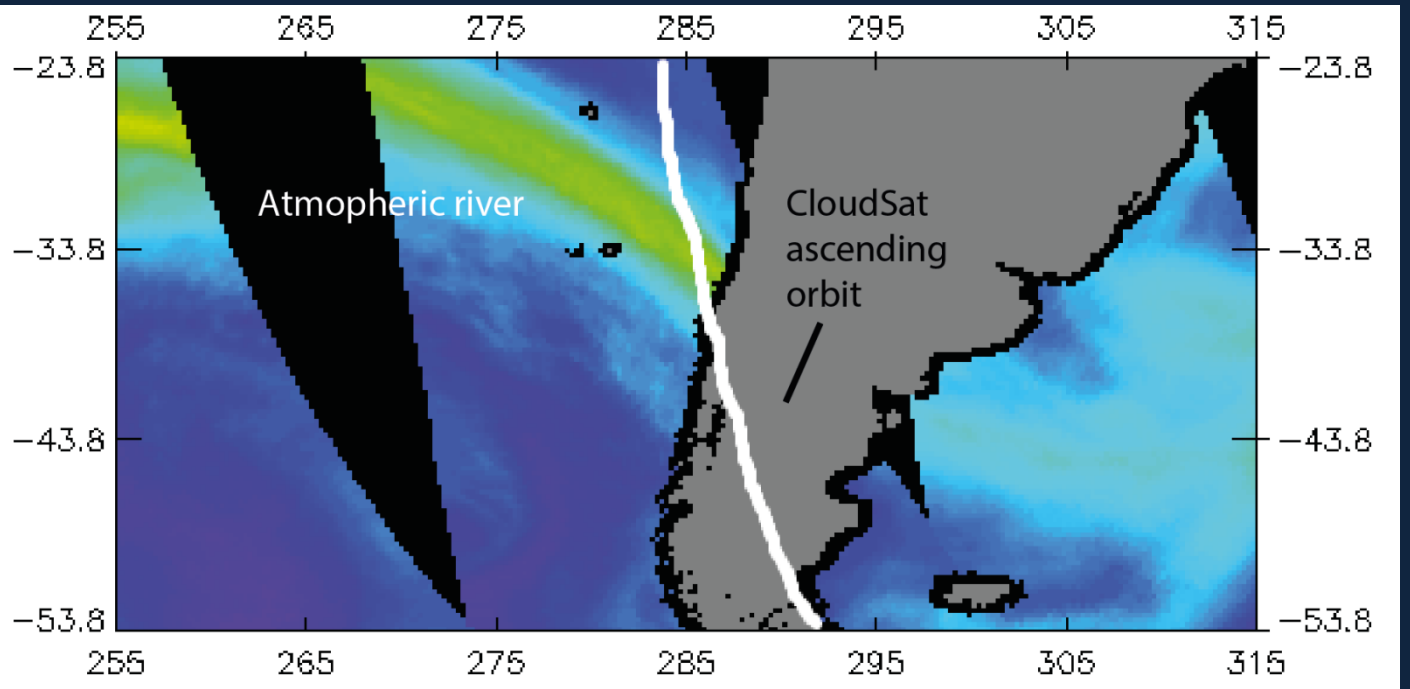
Main motivating questions…

1. How often do ARs made landfall on the west coast of South America?





2. How much Precipitation do ARs leave on the west coast when they move equatorward?



My talk has three main topics

1. Introduce the main findings of ARs and orographic precipitation in South America

Mostly on the subtropical west coast (36º-30ºS)

[*Viale and Norte WAF (2009), Viale and Nuñez JHM (2011), Viale et al. MWR (2013), Viale and Garreaud JGR(2015)*]

2. Atmospheric rivers topic is just starting in South America

Brief description of a just-started project on the southern Andes (35º-55ºS)

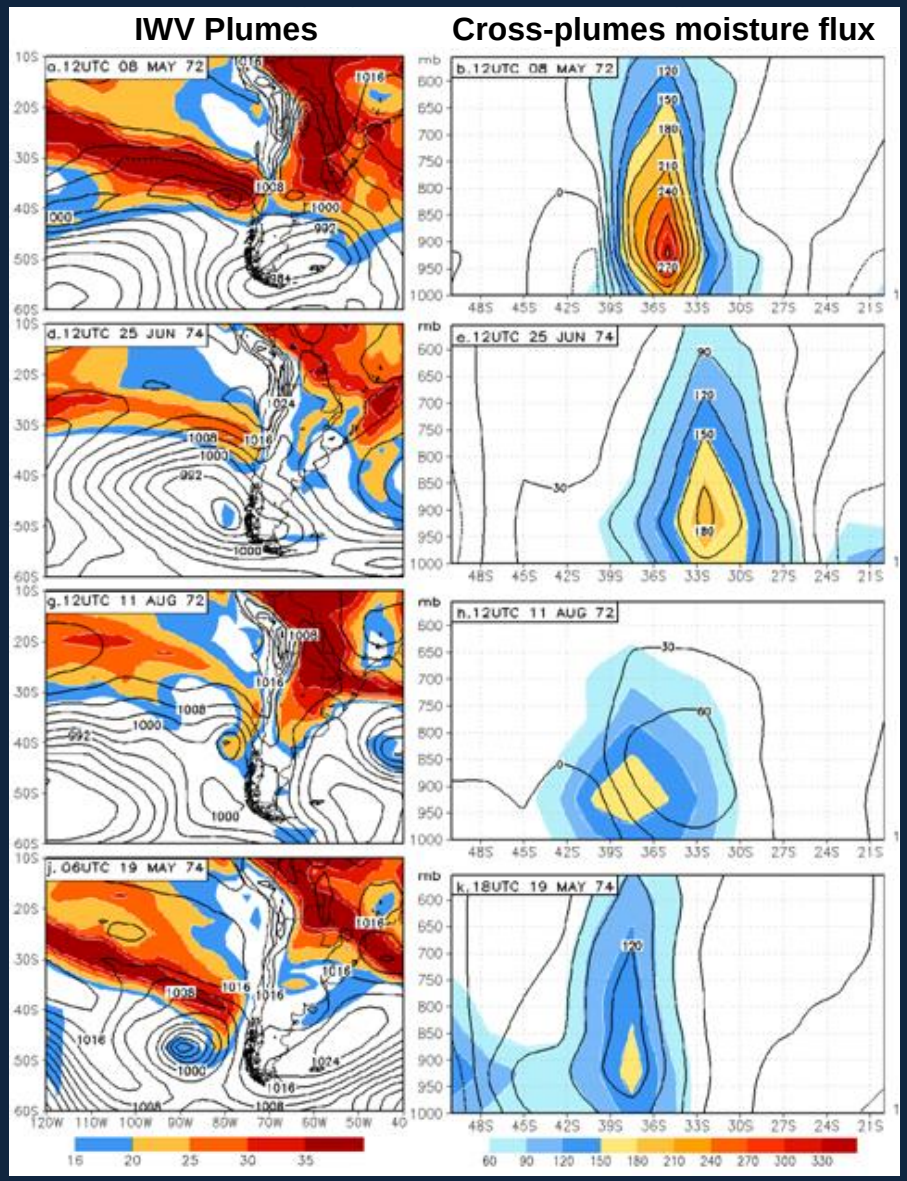
3. Climatological results of the Impact of ARs on precipitation on the west coast of SA

Further discussions are expected all the week in the ARConf 2016

Few significant Precip events that account for most of annual total on the 'Subtropical sector (36º-30ºS)' are linked to ARs

40 of the 46 (87%) heaviest precipitation events in a 7-yr period were linked to Atmospheric Rivers

Four examples of events linked to Atmospheric Rivers producing flood and casualties in Chile

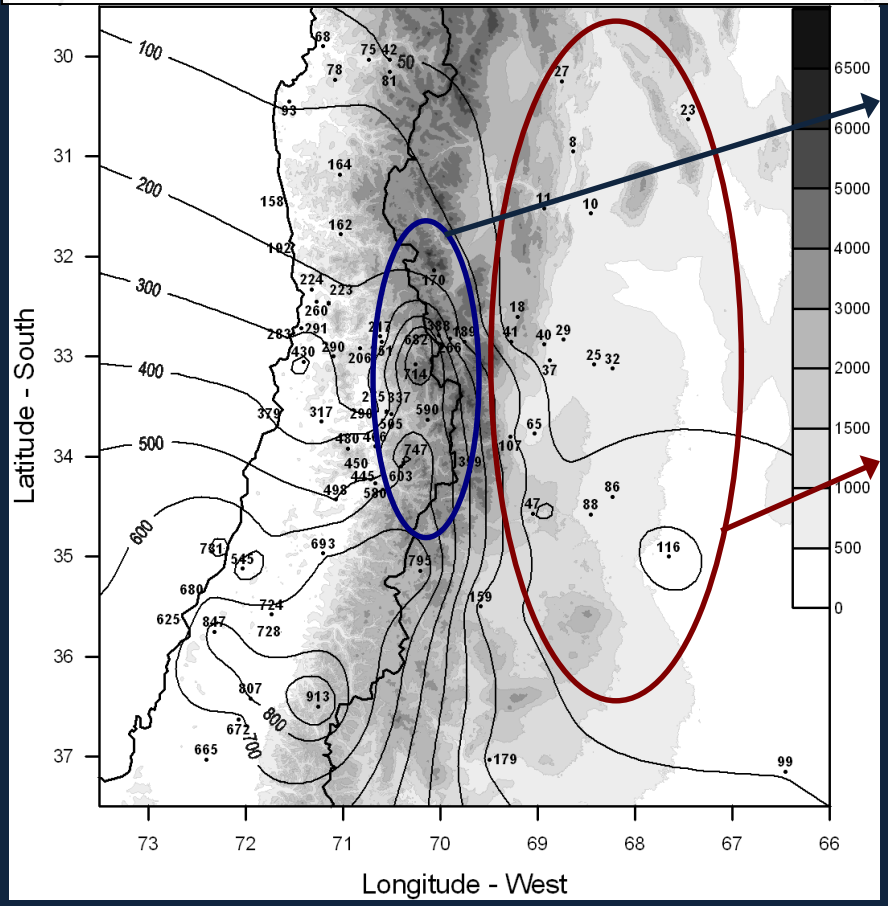


Viale and Nuñez JHM 2011

Most of the moisture carried by ARs are removed through orographic processes on the high subtropical Andes

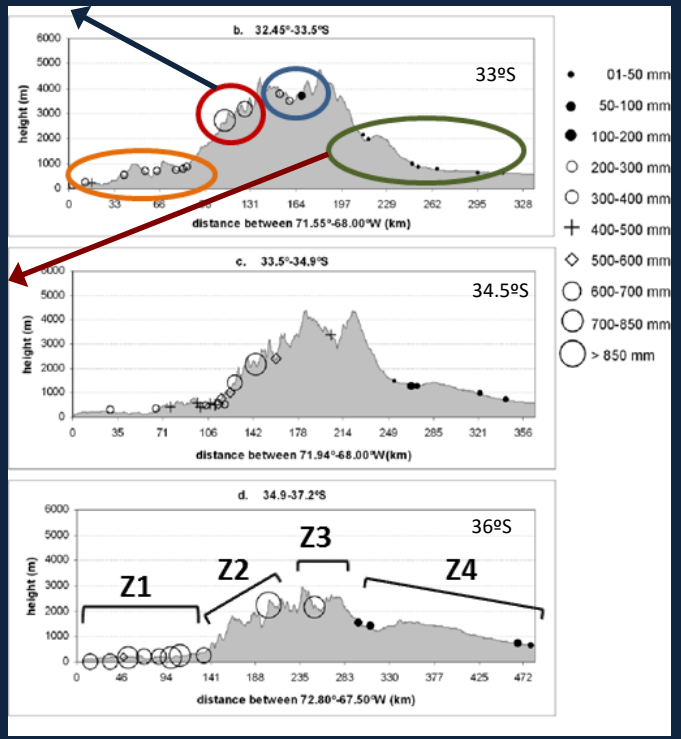
Subtropical Andes (30º-37ºS)

Mean Orographic precipitation pattern



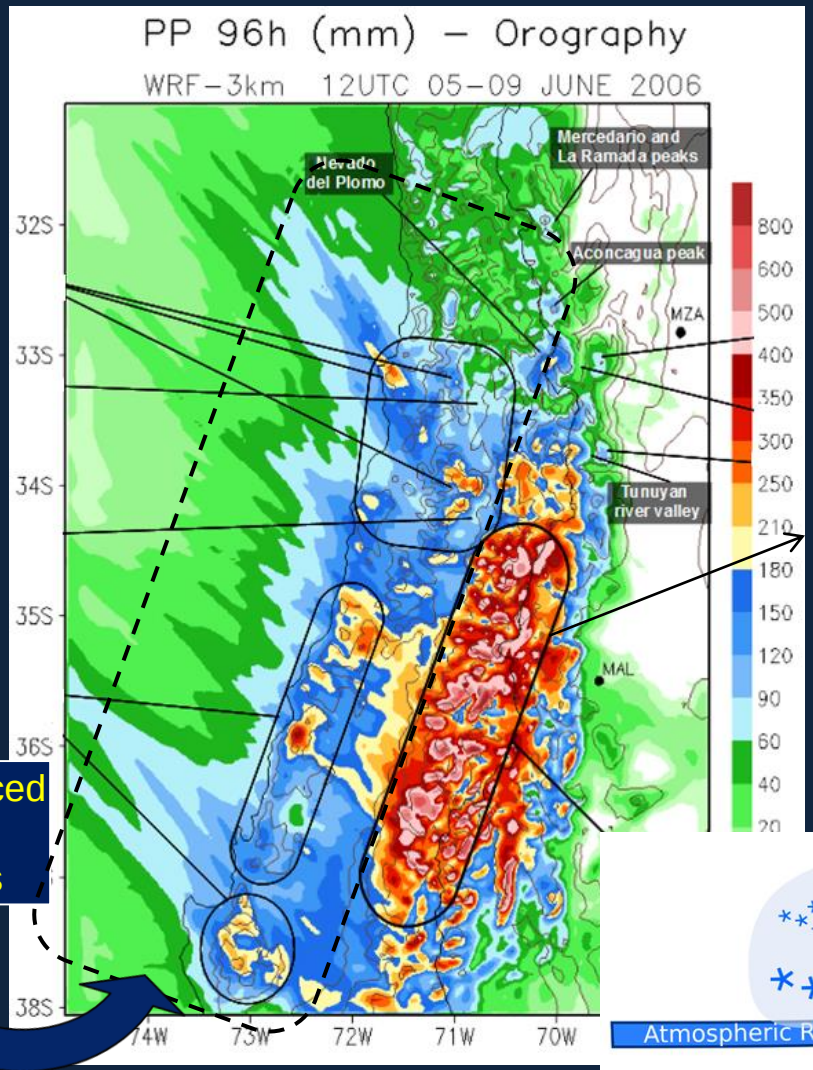
Precipitation enhancement

Prominent Rain shadow effect



Viale and Nuñez JHM 2011

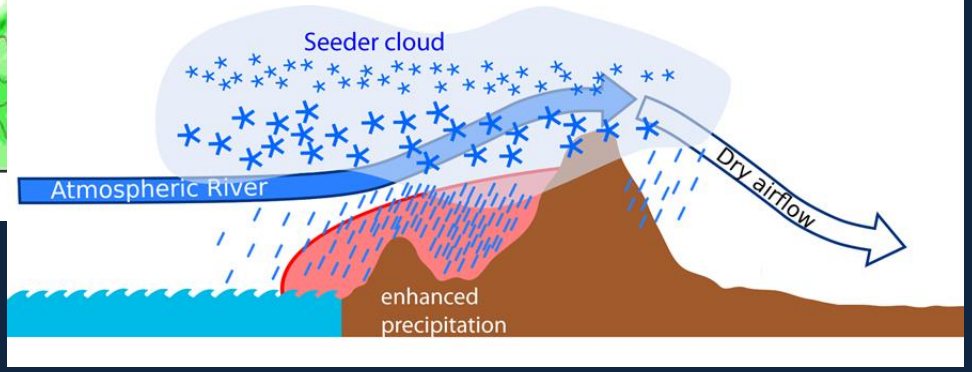
The high Subtropical Andes block low-level flow of ARs and lead to upstream orographic precipitation enhancement



Main orographic precipitation on the Andes

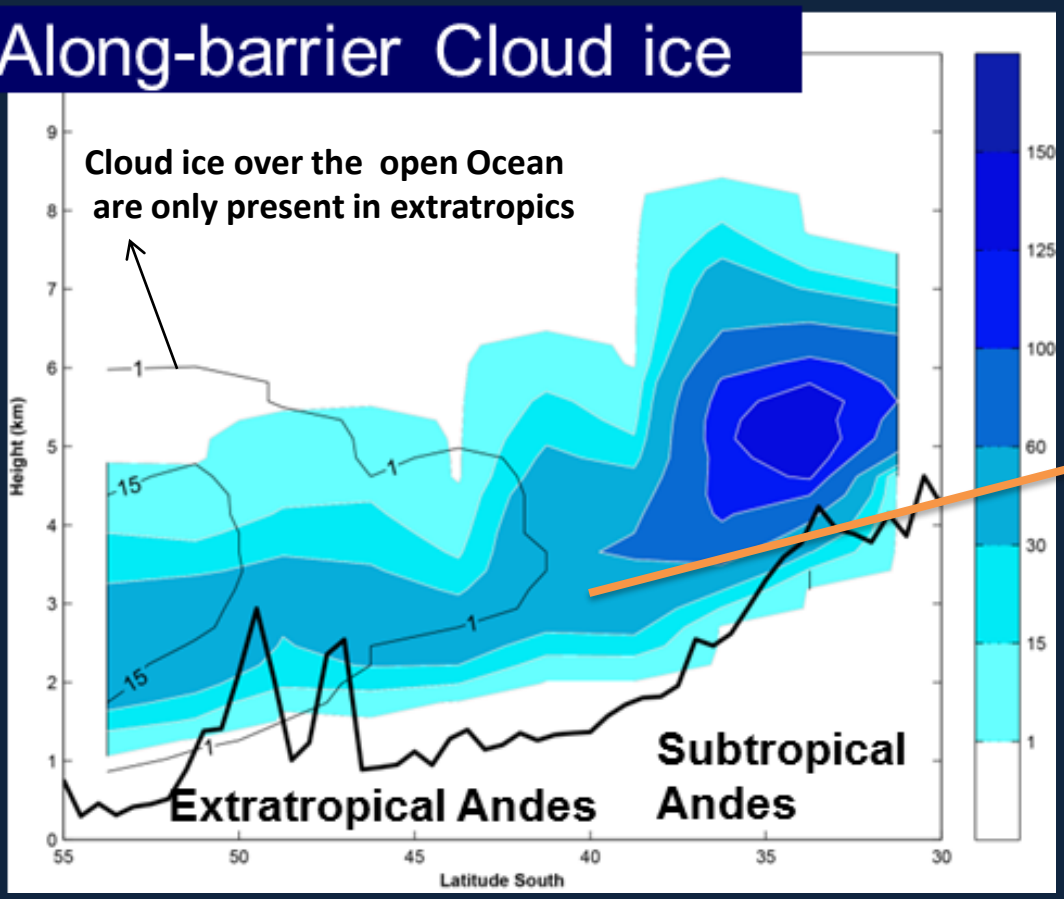
Precipitation enhanced upstream of the subtropical Andes

Cross-barrier view



Viale et al. MWR (2013)

Orographic effects of extratropical Andes accelerate precipitation growth in the existing clouds rather than originate new clouds as occurs over the subtropical Andes



Ice content in clouds over the windward slopes of the Andes

Climatology of precipitating clouds derived from CloudSat data

Viale and Garreaud JGR 2015

A just started project on the ARs and Orographic Precipitation over the southern Andes

Orographic Precipitation over the southern Andes (35º-45ºS): the impacts of ARs and precipitating clouds properties

The project is financed by CONICYT Chilean Agency and receive collaboration from the IANIGLA Institute from Argentina

The main goals are:

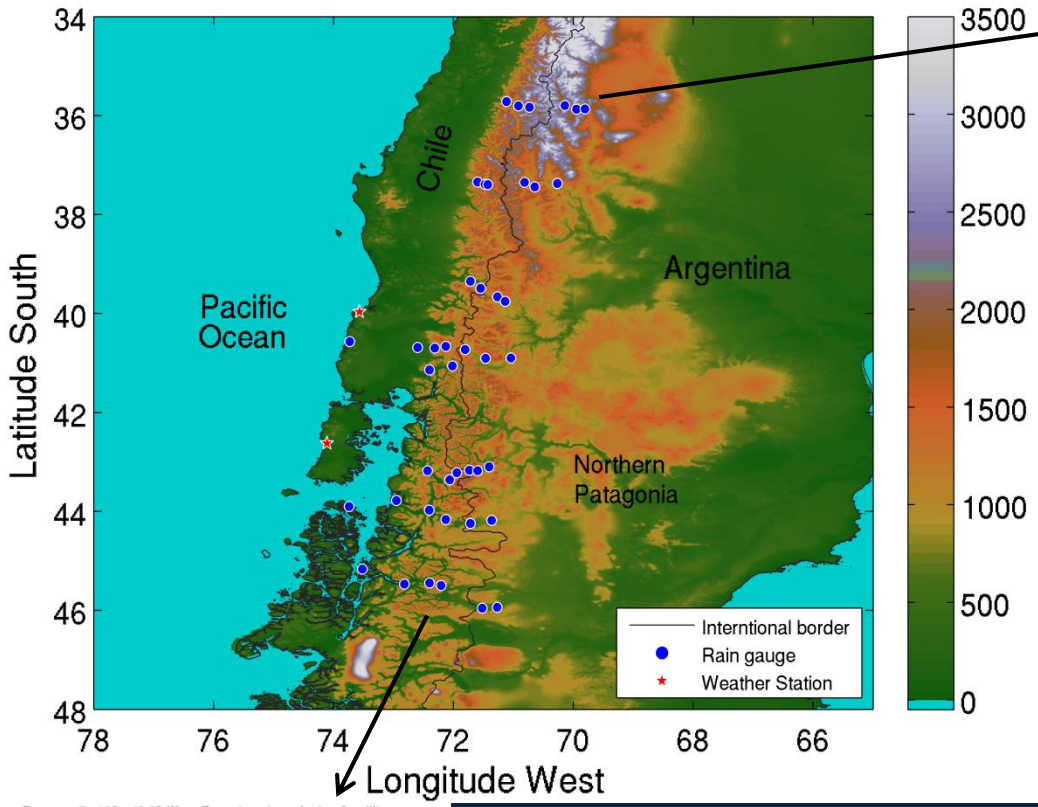
1. Estimate the impacts of ARs on Precipitation, Water resources and flooding events along the west coast of South America and across the southern Andes

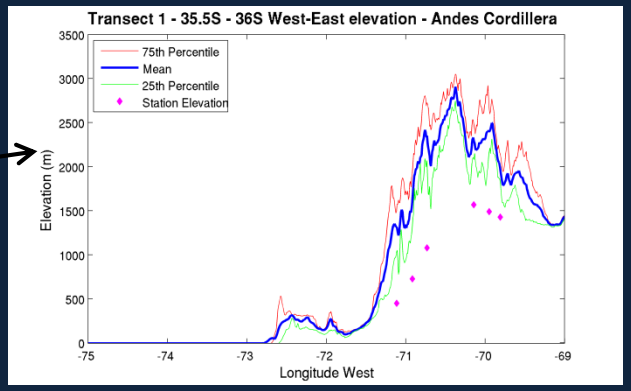
2. Identify synoptic characteristics of AR storms and their possible latitudinal variations along the west coast of SA (30º-50ºS).

3. Characterize micro- and macro-physical properties of precipitating clouds at different cross-barrier and latitudinal zones

The Project efforts to deal with limited observations in the region

7 transects of rain gauges extend from 35°S to 45°S

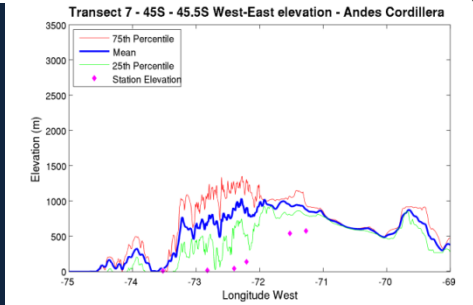




A total of 45 rain gauges was installed along mountain passes

Sensors do not transmit the data. It is collected every 6 month.

The fun part… travel a lot



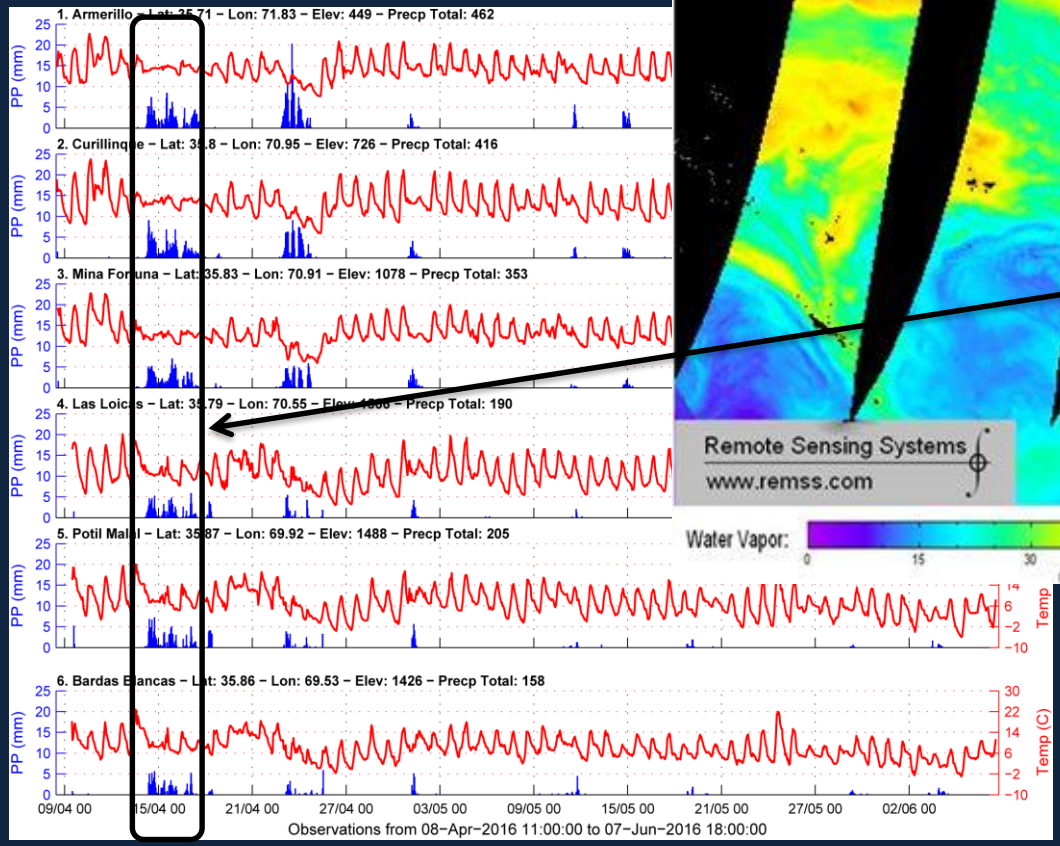
Interesting data from the Project will be analyzed soon

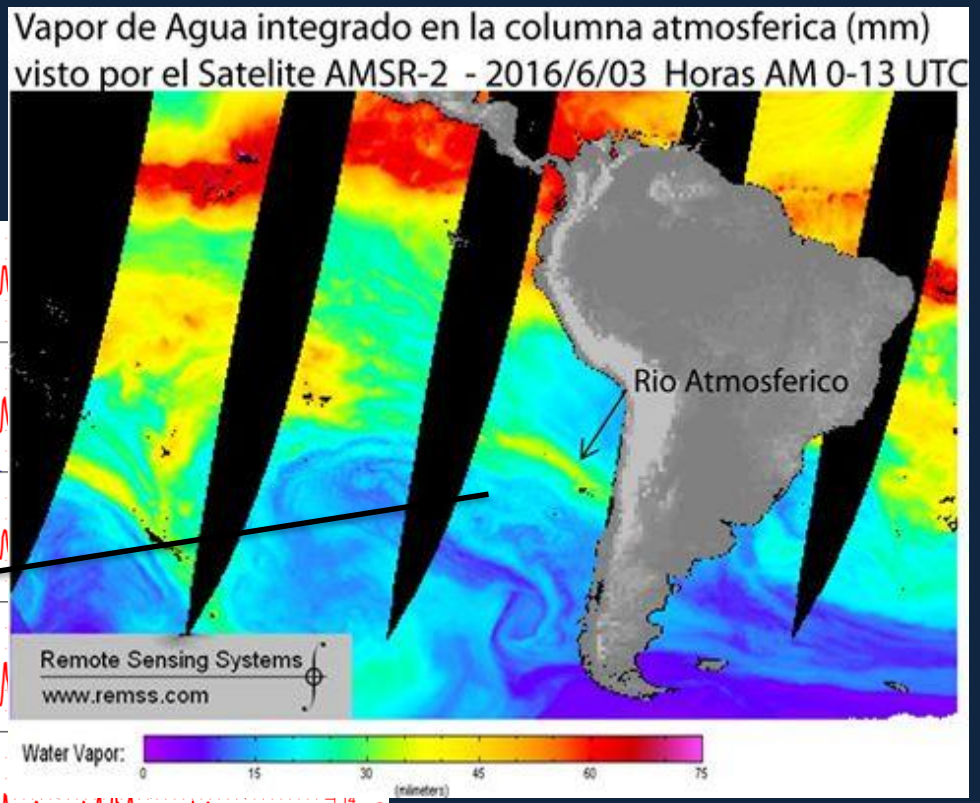
Atmospheric River occurred in early fall of 2016 that caused flooding

Data from the northernmost transect at 35ºS

Westernmost station

Easternmost station





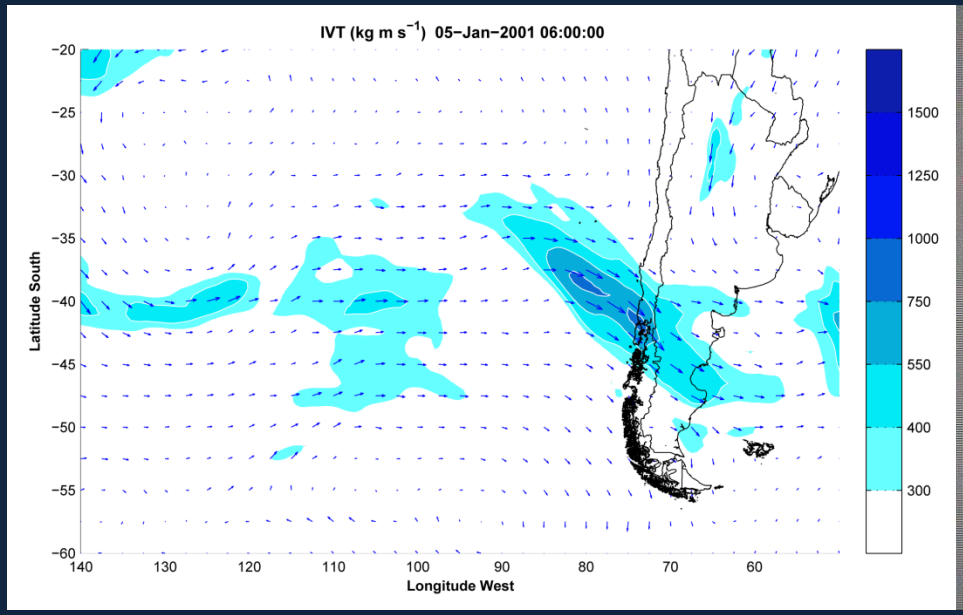
The method to detect “Landfalling ARs”

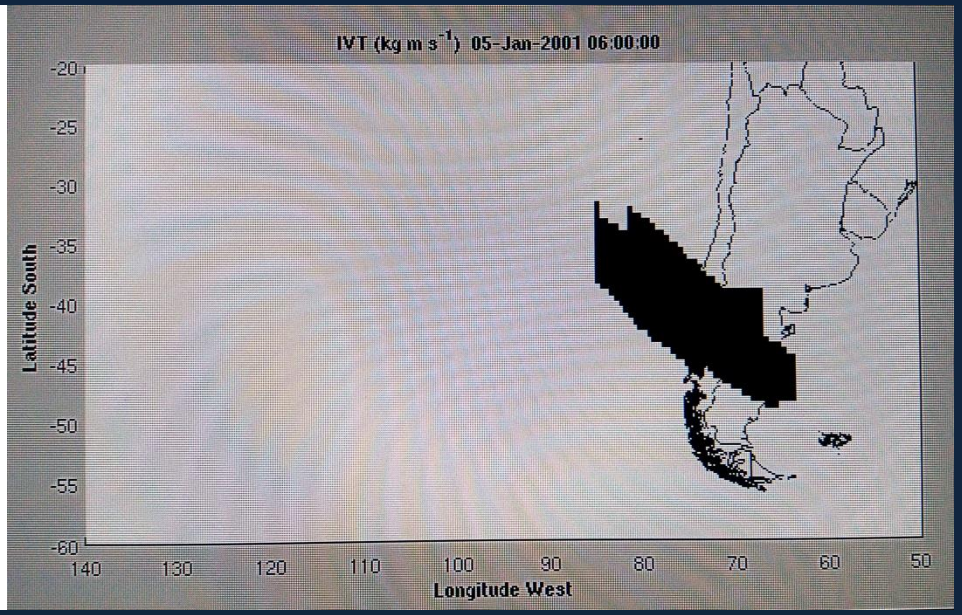
By using 6-hourly gridded reanalysis CFSR data from 2001 to 2012, we applied the following steps:

1. Detect several contiguous costal grid point in the north-south direction with IVT > 300 km m^{-1} s^{-1} (i.e., a candidate of AR making landfall)
2. Identify contiguous objects with IVT>300 extending to the Ocean and to the continent
3. Analyze the “length” and “width” of the contiguous objects (i.e., AR candidate) following the criterion proposed by GW2015

- ✓ Determine the Axis of the objects as the consecutive IVT maximum values
- ✓ Determine if length is >2000km, calculated as the sum of the distance between the axis points
- ✓ Determine if the ratio of the area of the object to its length is < 2 (i.e., the width)

An example of one detected landfalling ARs

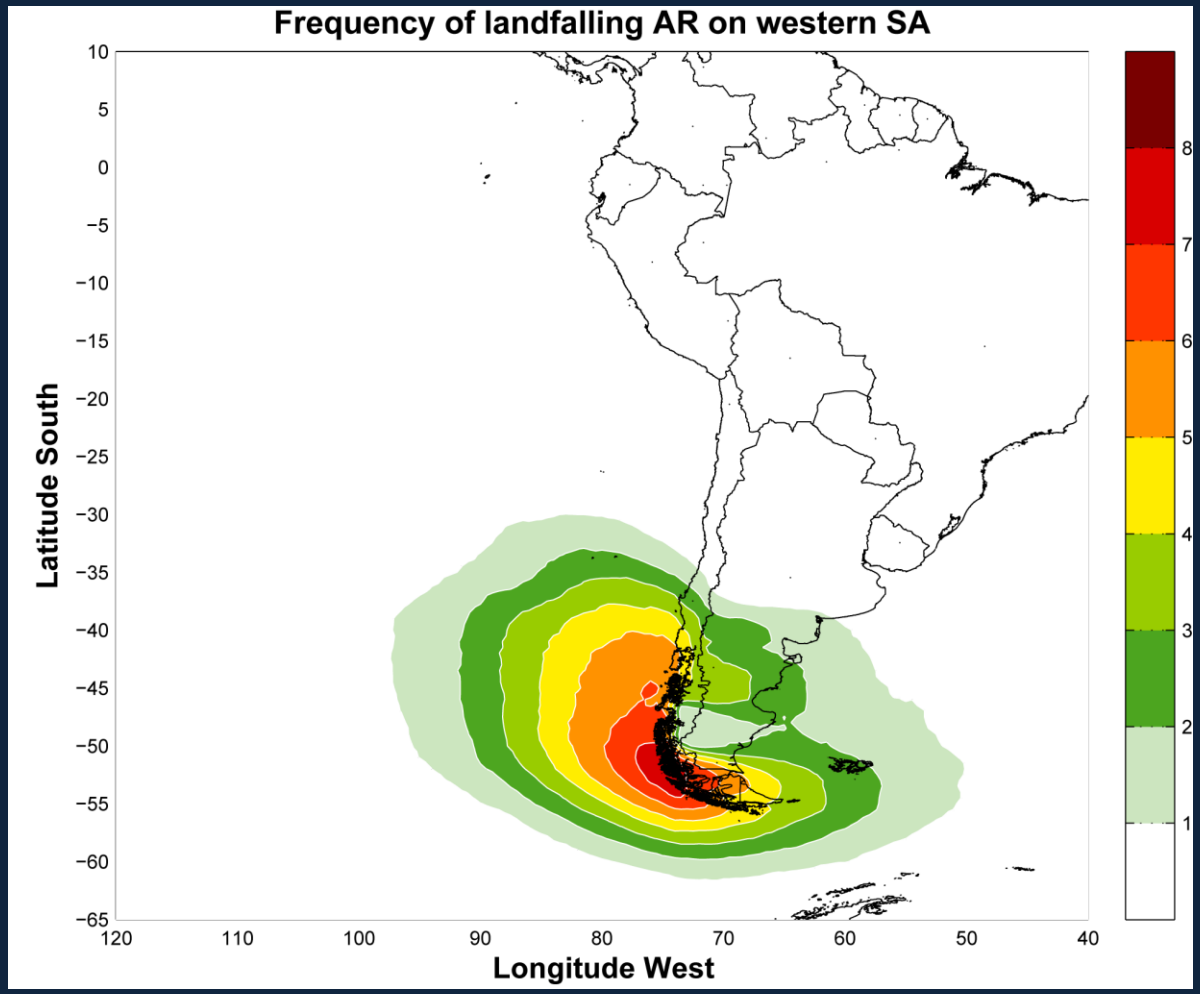




Not interested in the geometry, only in the area enclosed by the AR to associate it with Precipitation

We associated daily Precipitation with one AR if at least, in one of the 4 times of the reanalysis CFSR, the area of the AR enclosed the surface rainy station

Frequency of ARs on the west coast of SA on annual scale



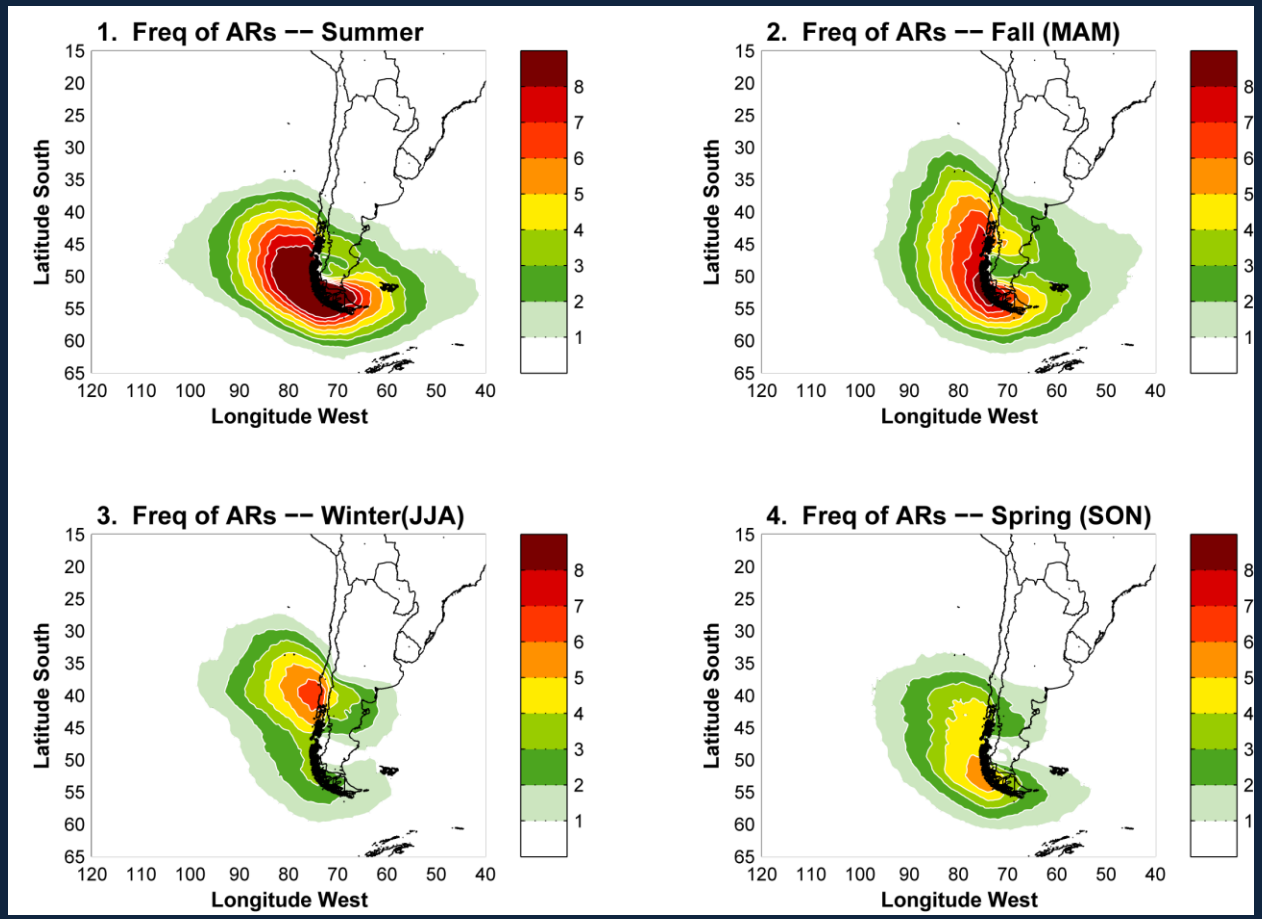
Limited to the South of 30ºS

Maximum freq. on the southern tip of the continent (50º-57ºS)

Seasonal changes in the Frequency of ARs on the west coast of SA follows the storm tracks seasonality

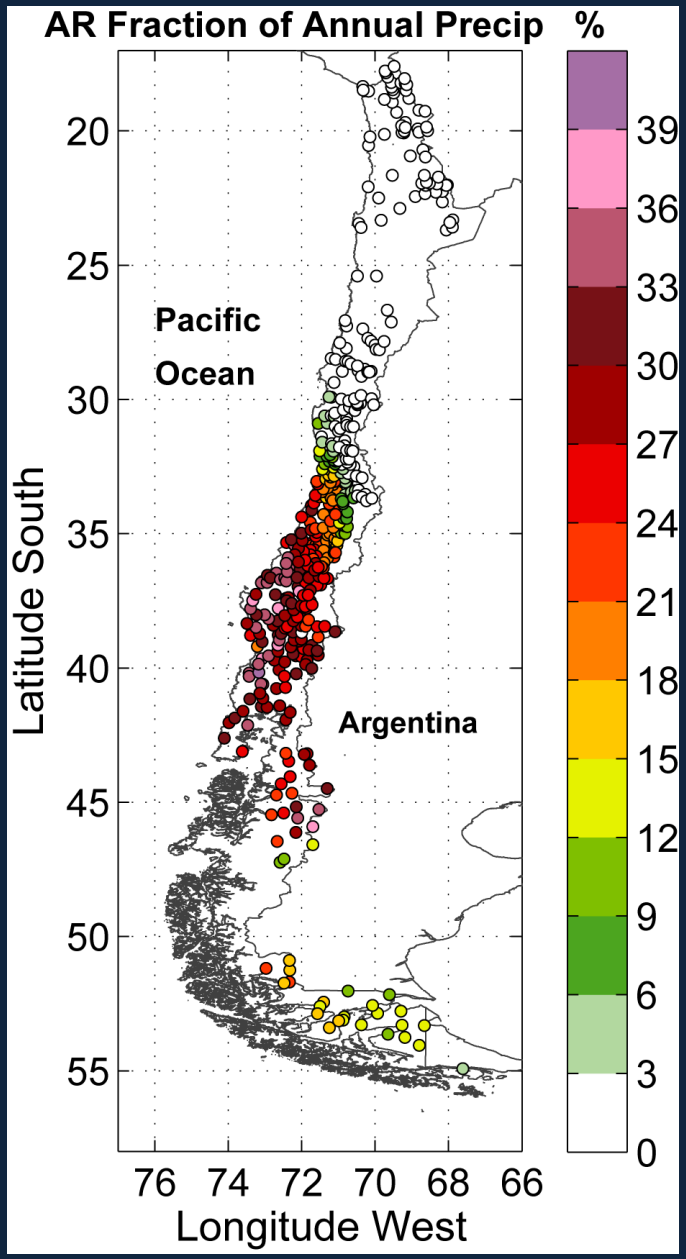
In summer, the highest freq are linked with IVT threshold

In fall, the ARs are actives all along the coast



In winter, Higher Freq. of ARs displaced equatorward between 35ºS and 45ºS

ARs account for 25%-35% of annual precipitation between 35ºS and 45ºS linked to higher freq. in winter



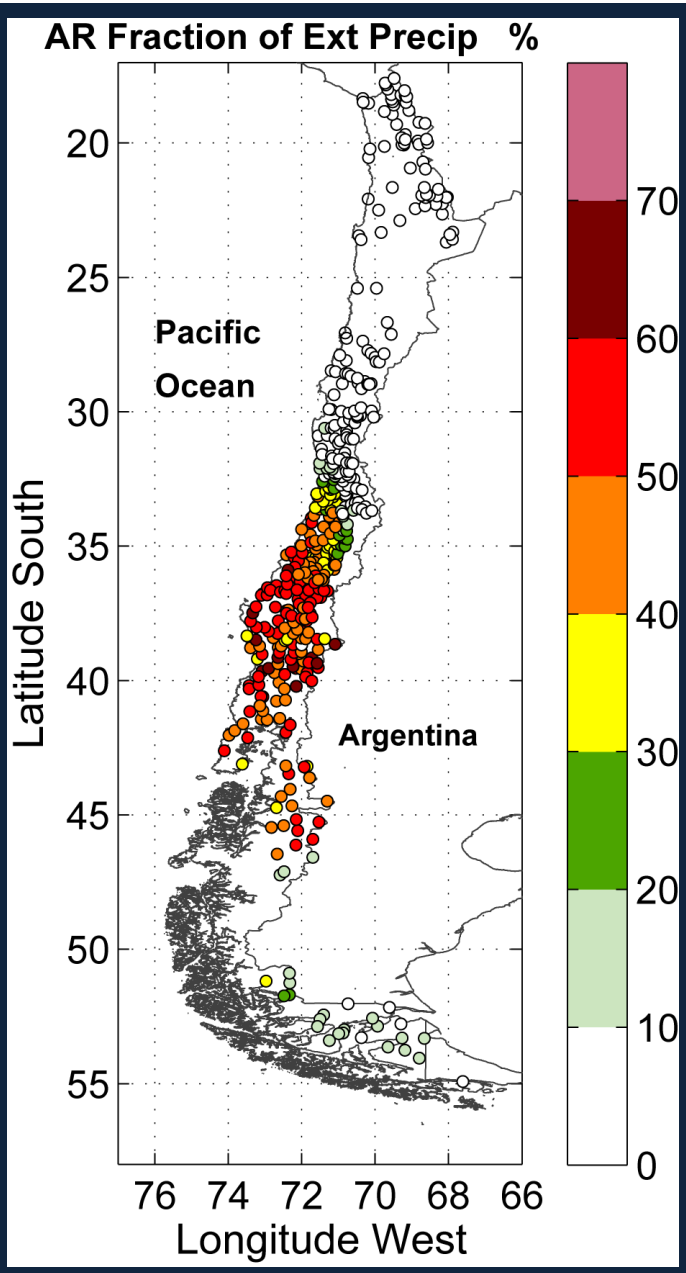
Further details …

The impacts of ARs on precipitation seems to reduce over the foothills of the Andes

The impacts of ARs is reduced on the southern tip of the continent despite its maximum freq.

Reduced orographic effects?

ARs account for 40%-65% of top-decile precipitation between 35ºS and 45ºS linked to higher freq. in winter there



The impacts of ARs on extreme precipitation is minimal on the southern tip of the continent, which also suggest that orographic effects are reduced there.

CONCLUSIONS

1. Atmospheric River topic is just starting in South America

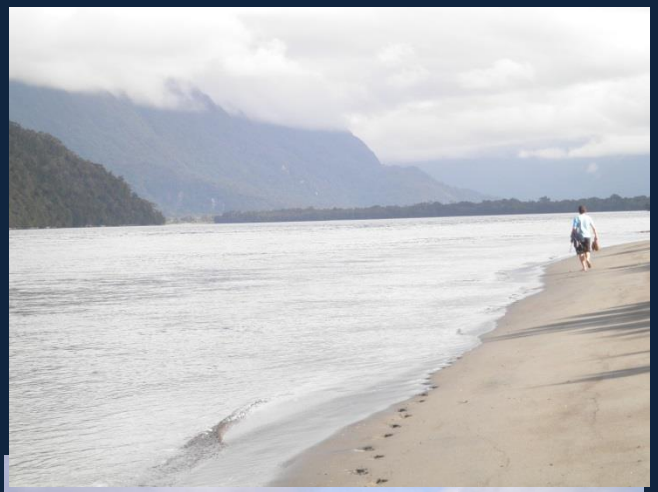
   Few studies focused on the subtropical west coast (36º-30ºS)

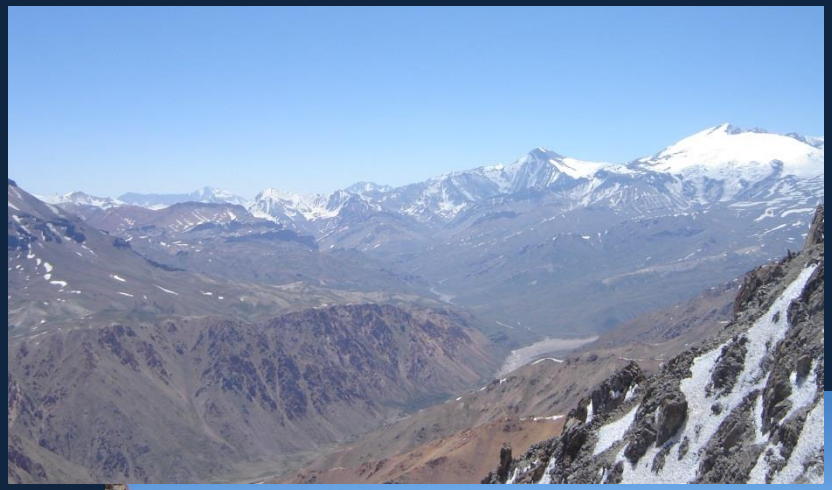
2. The Andes Cordillera exert an strong control on ARs impacts and Precipitation along the west coast of South America

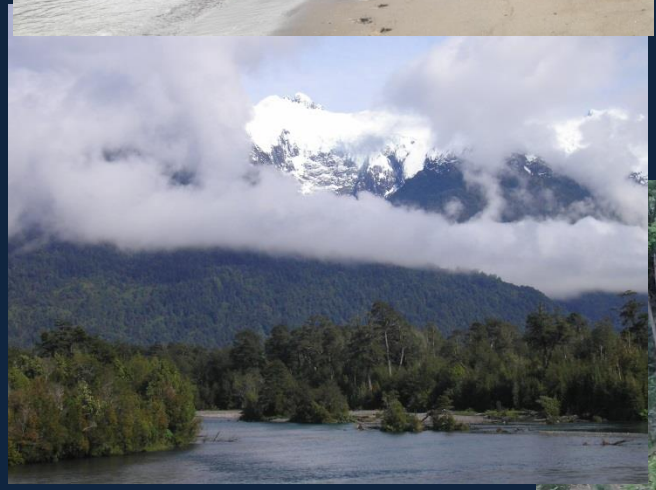
3. Atmospheric river have strong effects on precipitation, water resources and risky flooding events on the west coast of South America

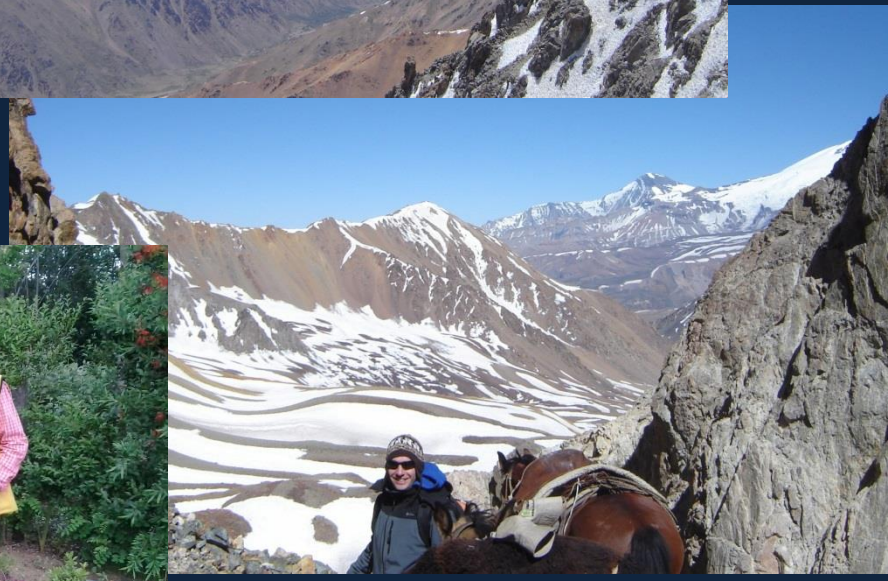
Fruitful discussions with all of you are expected in the AR Conf 2016

Thanks for your attention!









Wet and low Extratropical Andes

Dry and high Subtropical Andes