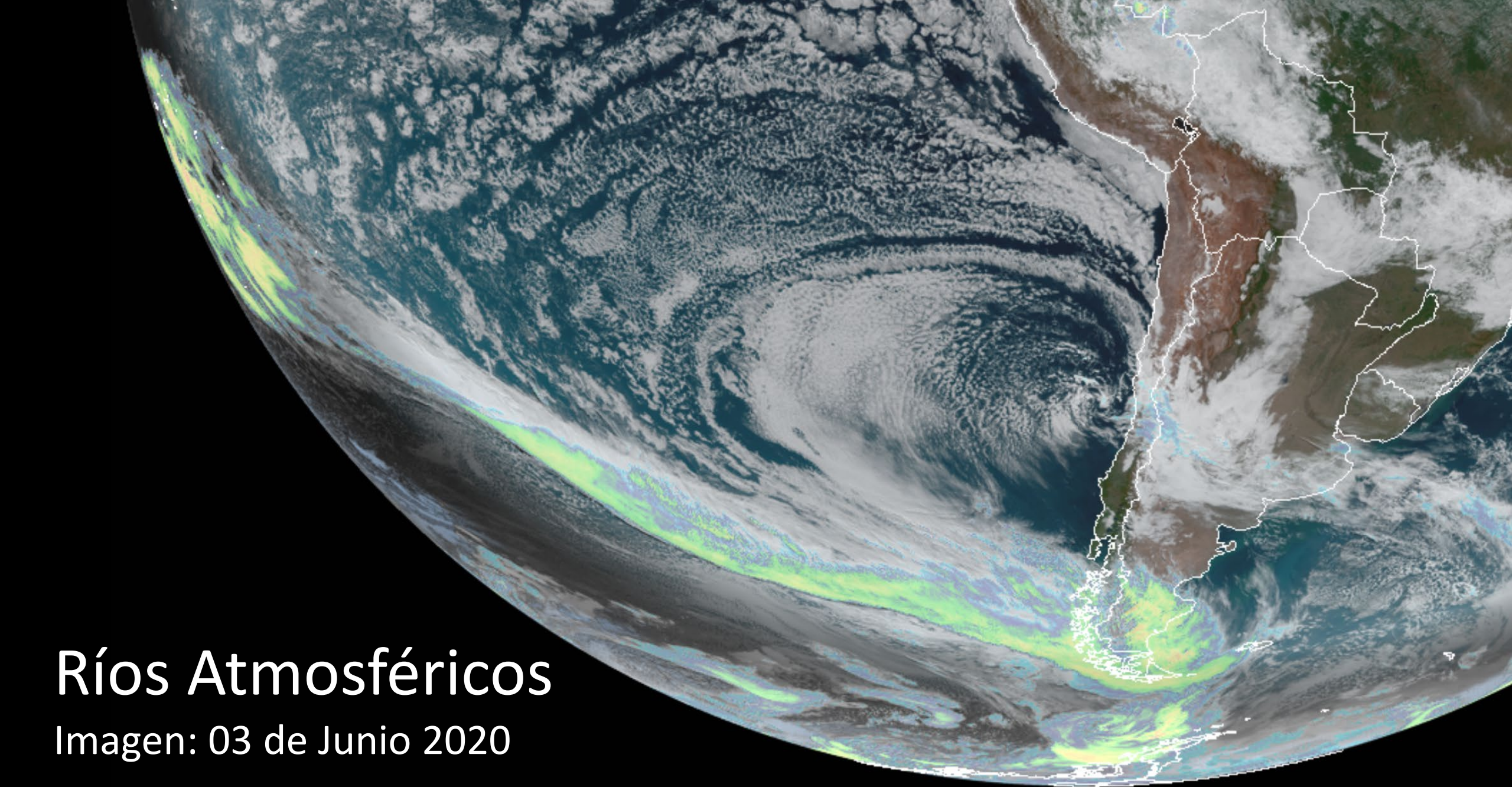




Ríos Atmosféricos

Imagen: 03 de Junio 2020

Se vienen las lluvias y ola polar: Revisa el pronóstico para la zona centro sur

Publicado:

Jueves, 27 de Abril de 2023 a las 11:28hrs. Autor: [Cooperativa.cl](#)

El académico del Centro de Investigación y Transferencia en Riego y Agroclimatología (Citra) de la Universidad de Talca, **Patricio González**, explicó que "el sistema frontal que se aproxima es un río atmosférico, es decir, que un **canal de nubes se desprendió de la zona ecuatorial, la cual se caracteriza por sus fuertes lluvias**".

"Estos ríos atmosféricos se deben al cambio climático y **generan más perjuicios que beneficios**, pues **no se alcanza a acumular el agua en los suelos, embalses o a producir la nieve**, por ende, ayudan muy poco a la agricultura. Lo ideal son aquellas lluvias que duran más de cuatro días", afirmó González.

Veo, veo...que ves?

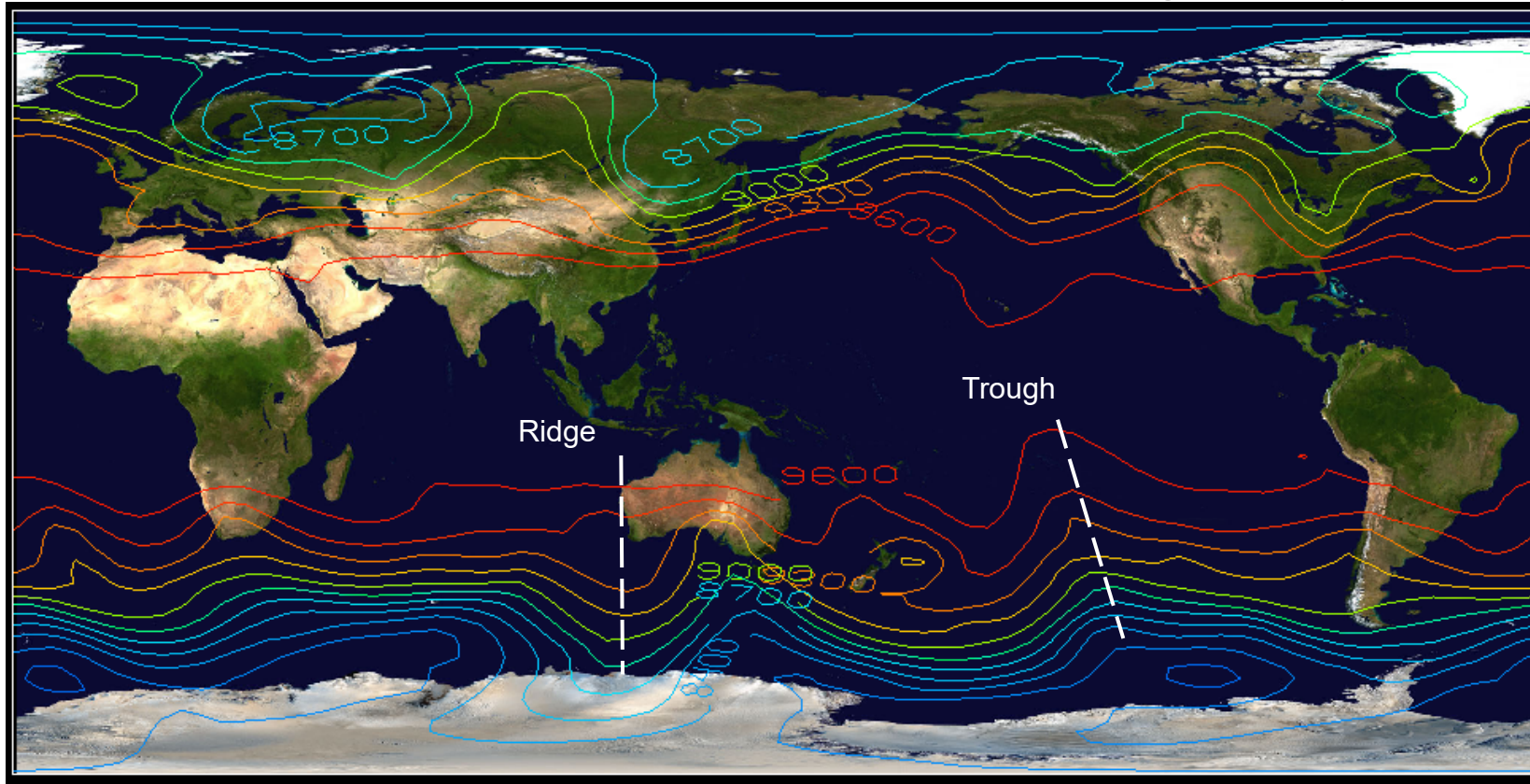
Que son los RA?

Que relación tienen con ciclones y frentes?

Como se definen e identifican?

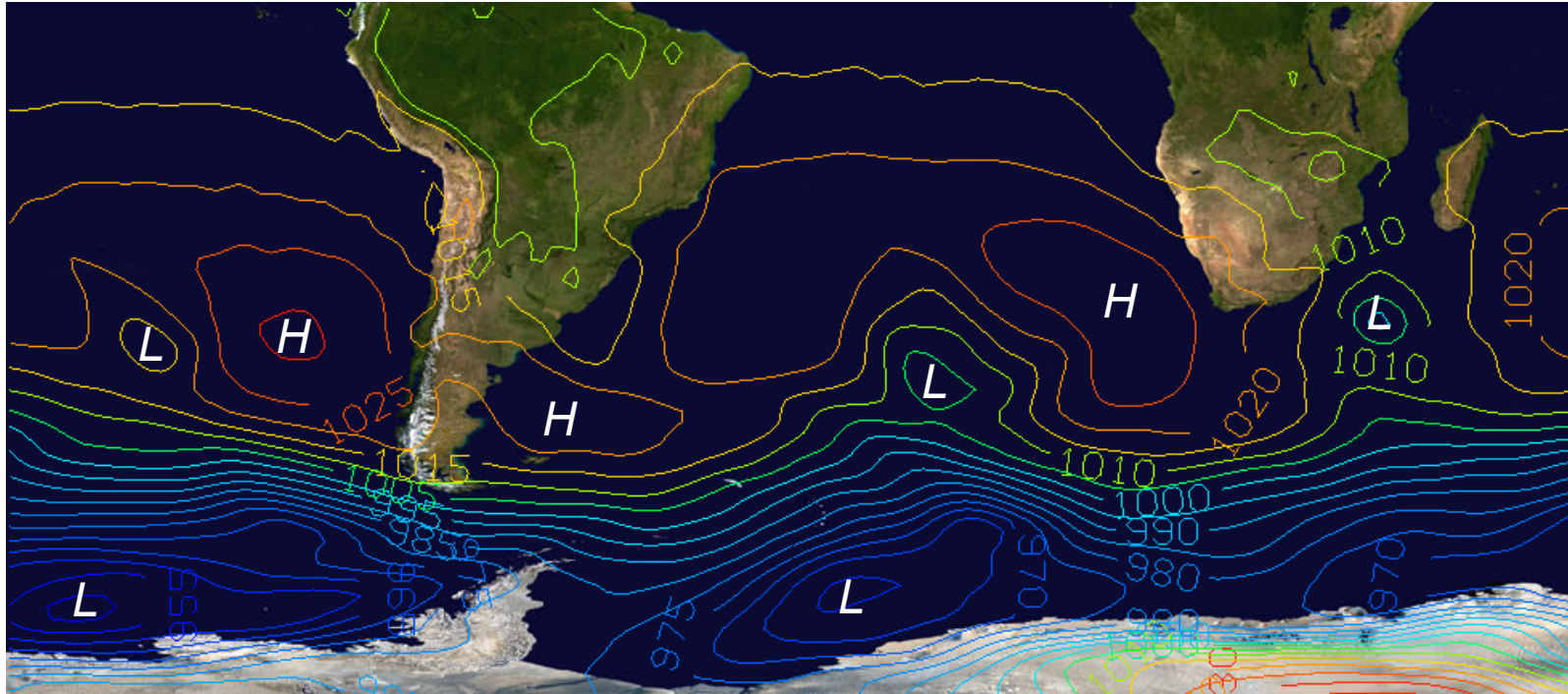
XX: Lines of constant geopotential height at a given pressure level
Trough: relative minimum pressure. Ridge: relative maximum pressure
In both cases “relative” looking at a same latitude

Z @ 300 hPa (9000 m ASL)



Isobars: lines of constant pressure at a given level
(e.g. sea level pressure chart) and time (snapshot).

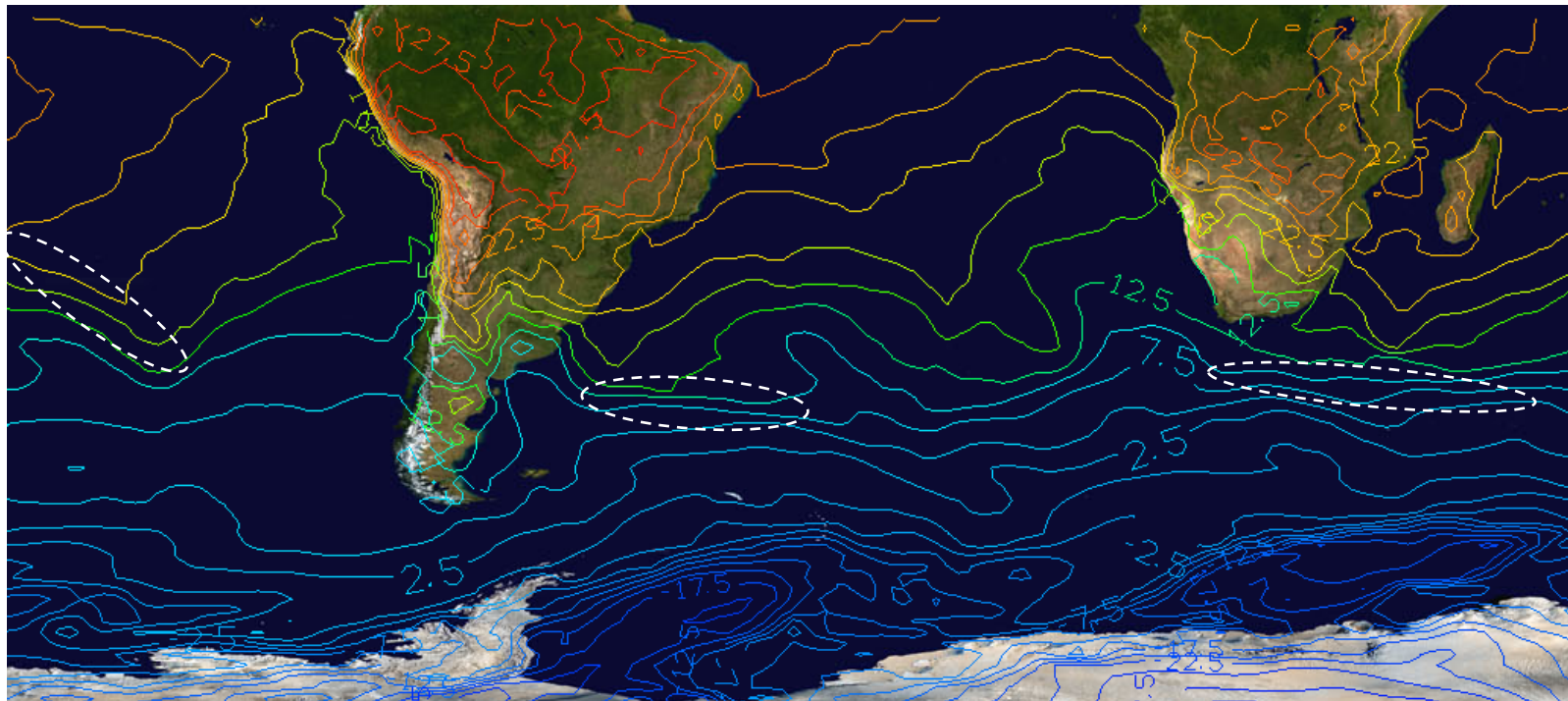
High (anticyclones) and **L**ow (cyclones) pressure centers.



SLP map, October 17 2010

Isotherms: lines of constant air temperature at a given level
(z or p) and time (snapshot).

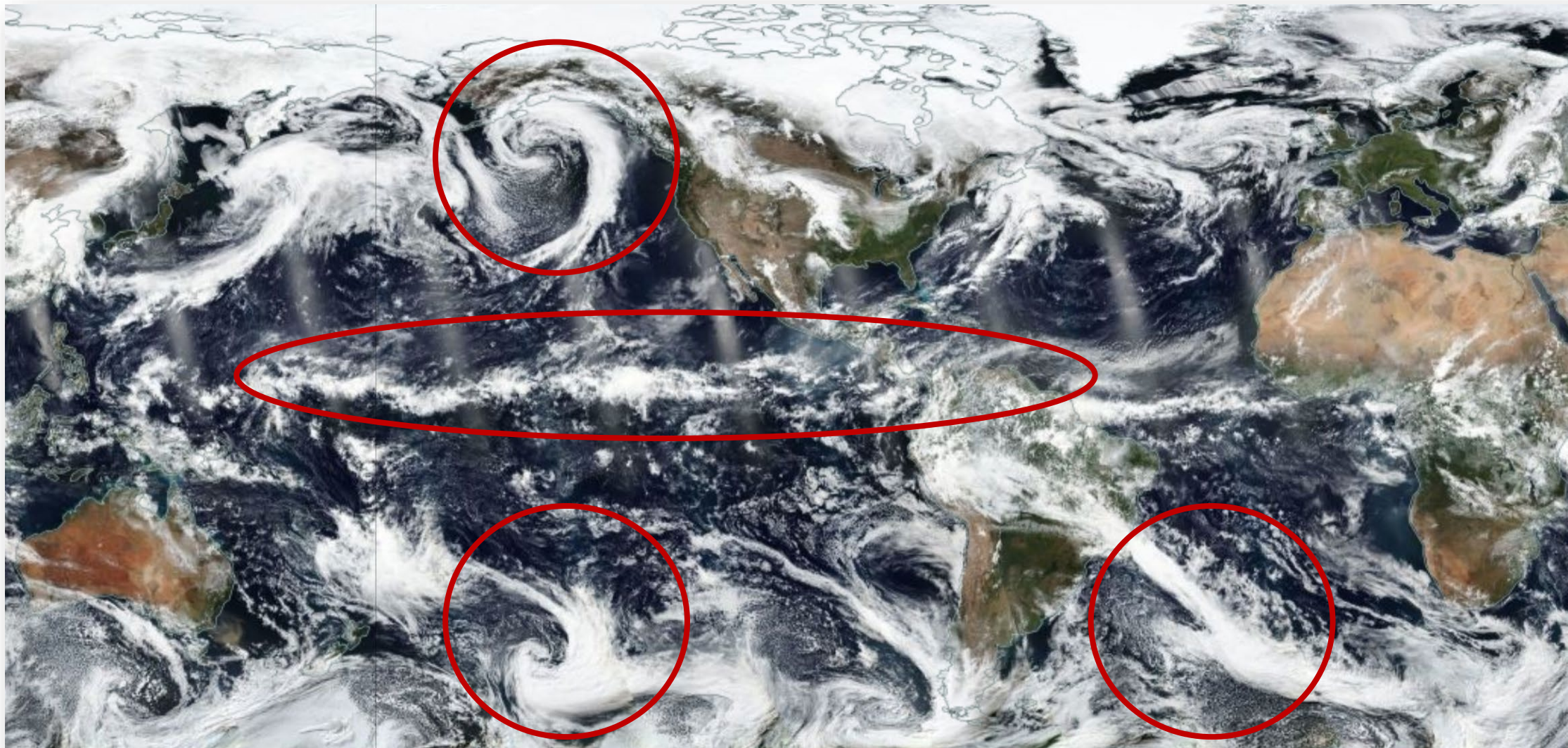
The temperature field usually decreases poleward and often exhibits
elongated bands of strong thermal gradient (baroclinicity) called fronts



T @ 850 hPa (1500 m ASL)
October 17, 2010

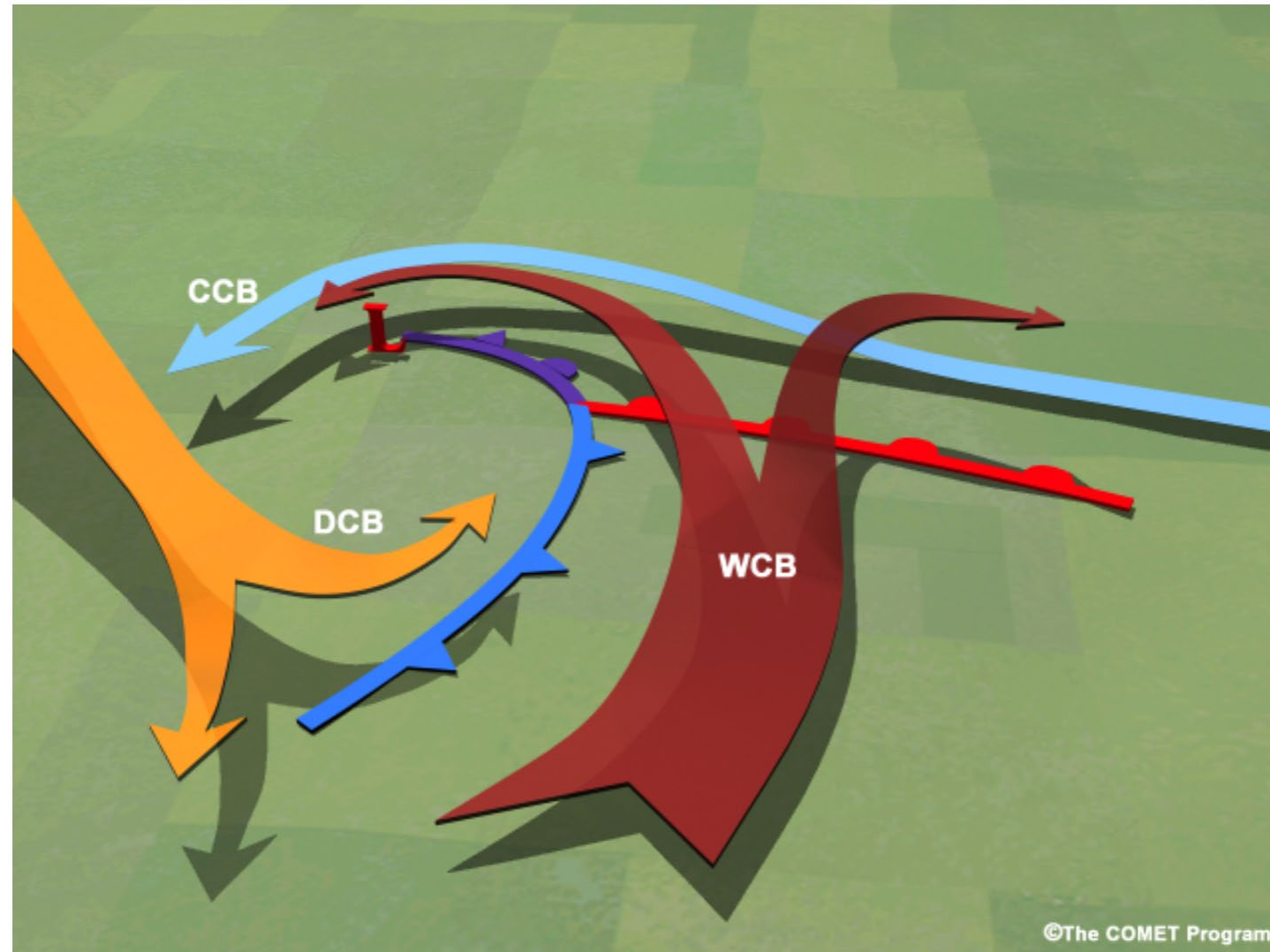
IMAGEN VISIBLE

<https://worldview.earthdata.nasa.gov/>

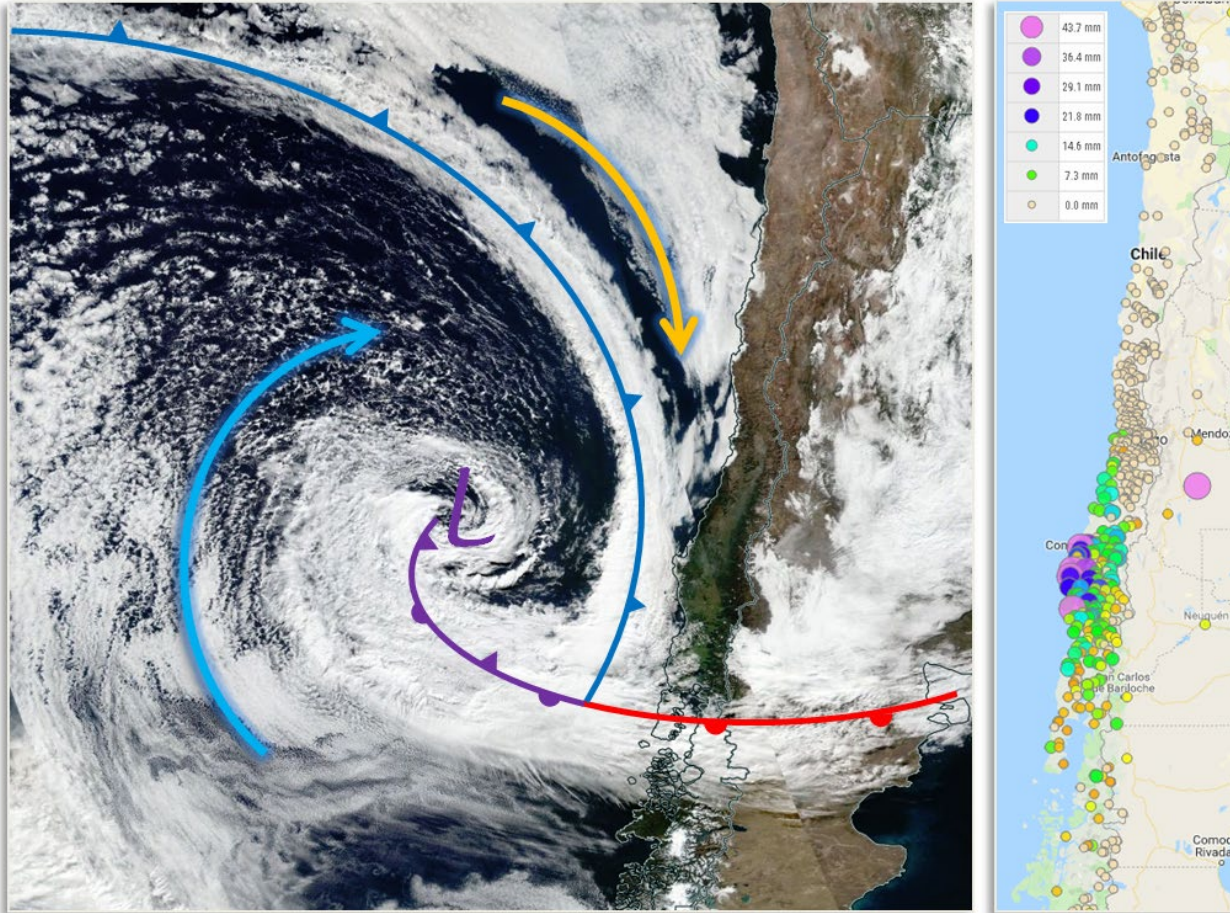


There are three types of conveyor belts as defined by [Carlson](#) (1980):

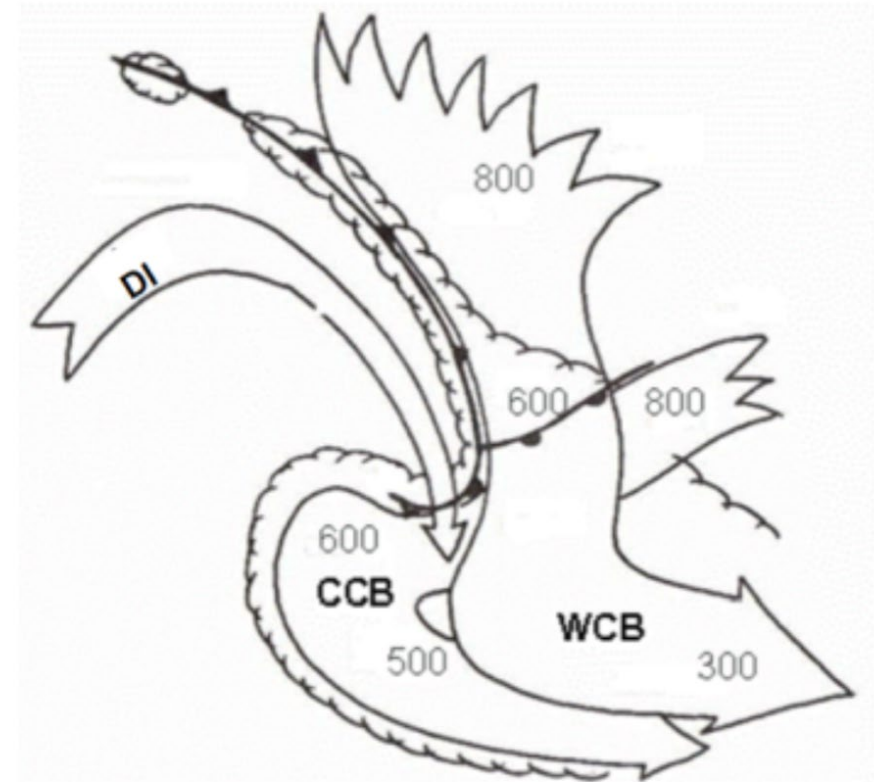
- Warm conveyor belt (WCB; relatively high θ_w)
- Cold conveyor belt (CCB; relatively lower θ_w) and
- Dry conveyor belt (DCB; originally called the dry stream; lowest θ_w values).



Synoptic environment during winter storms in central Chile



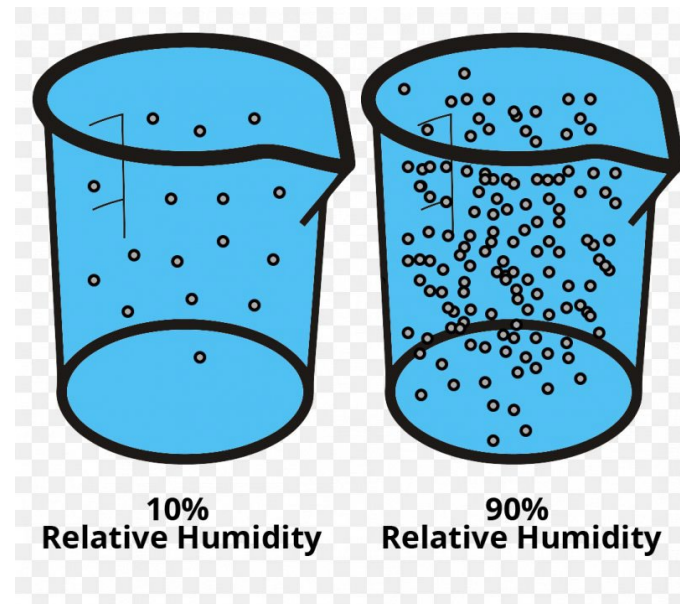
Schematic distribution of conveyor belts. Numbers correspond to pressure levels expressed in hPa.



Transmisiones microondas afectadas por el contenido de **vapor en la atmósfera**.
Problema = Oportunidad



Se puede estimar el contenido de vapor (agua en estado gaseoso) en la columna atmosférica

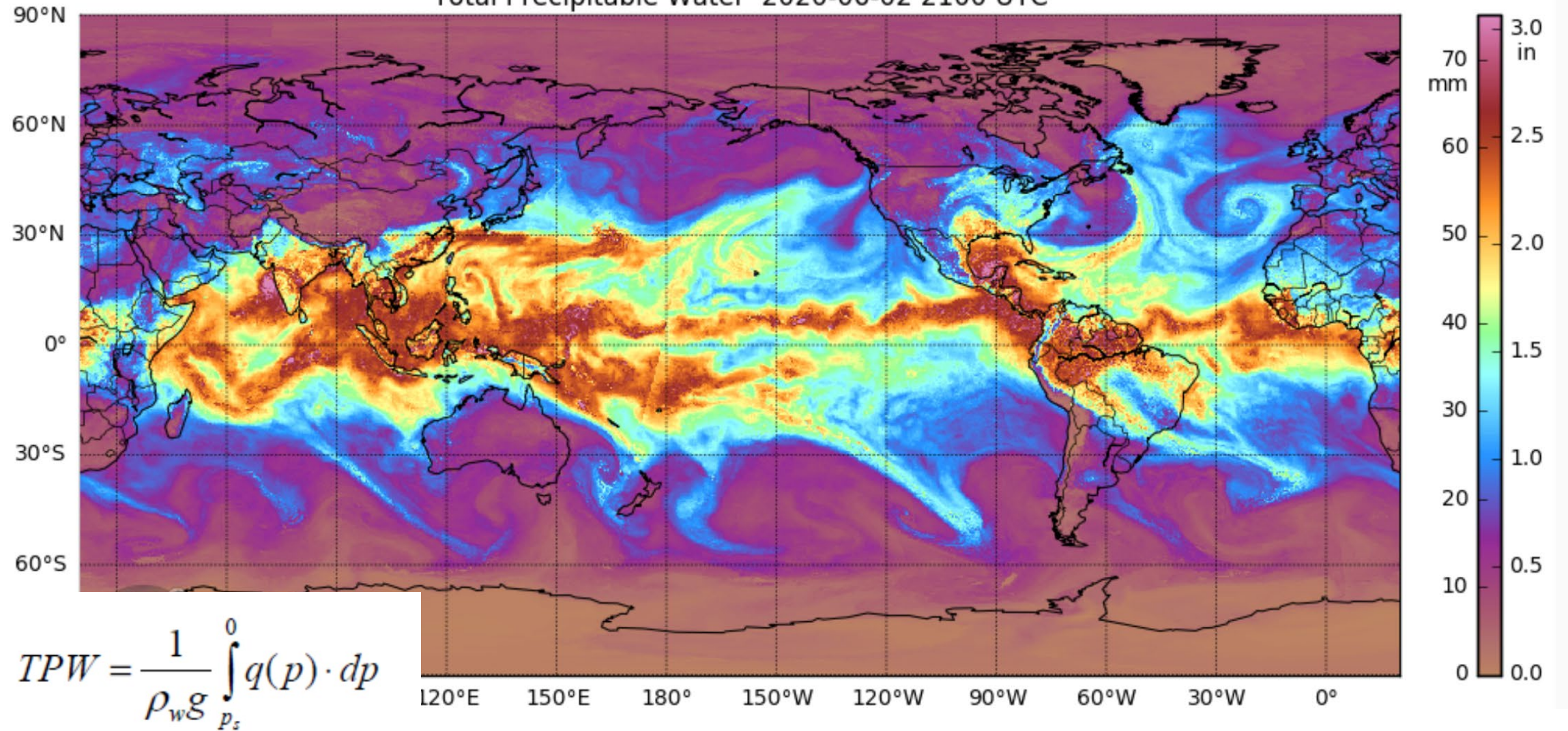


Agua precipitable (PW)
Se expresa en mm (equivalente en agua líquida al estrujar el aire)



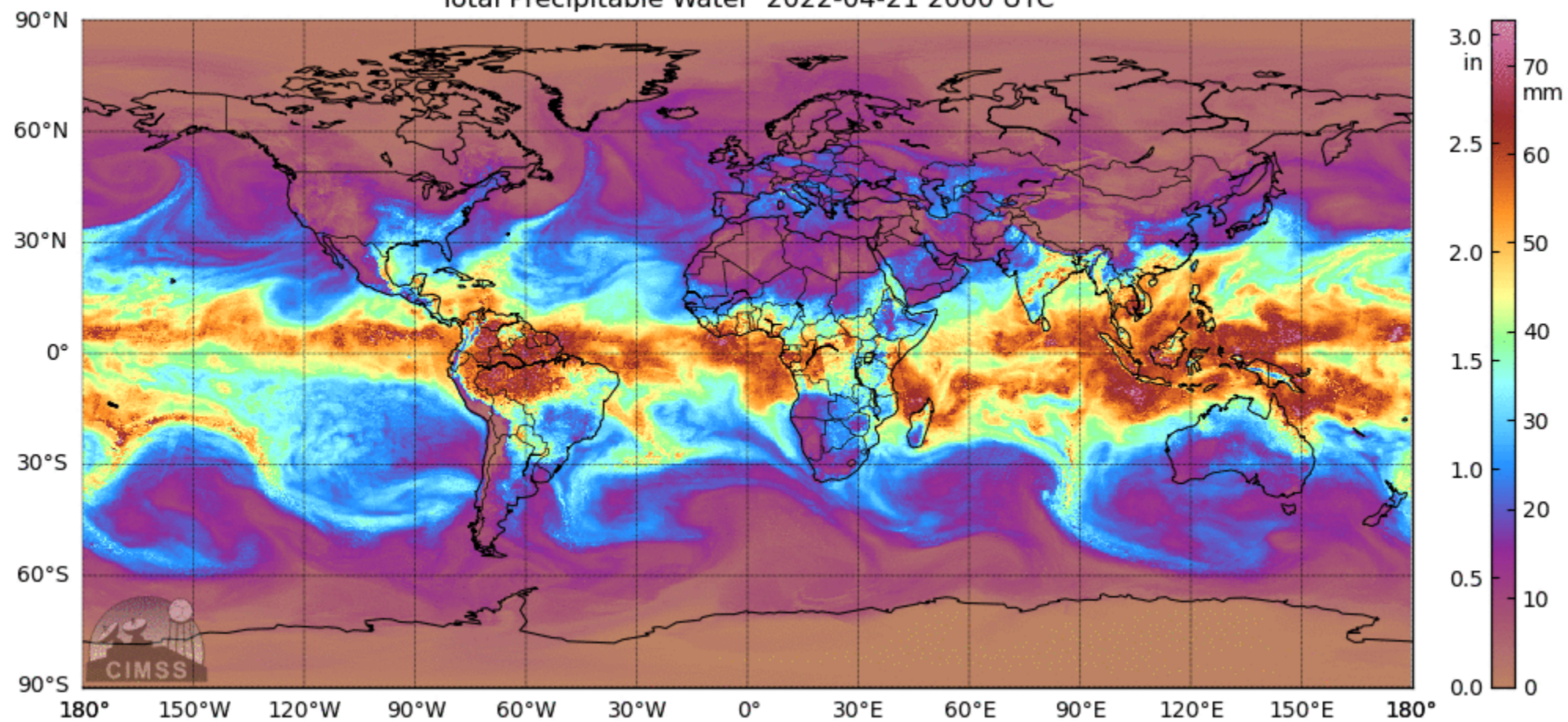
$$TPW = \frac{1}{\rho_w g} \int_{p_s}^0 q(p) \cdot dp$$

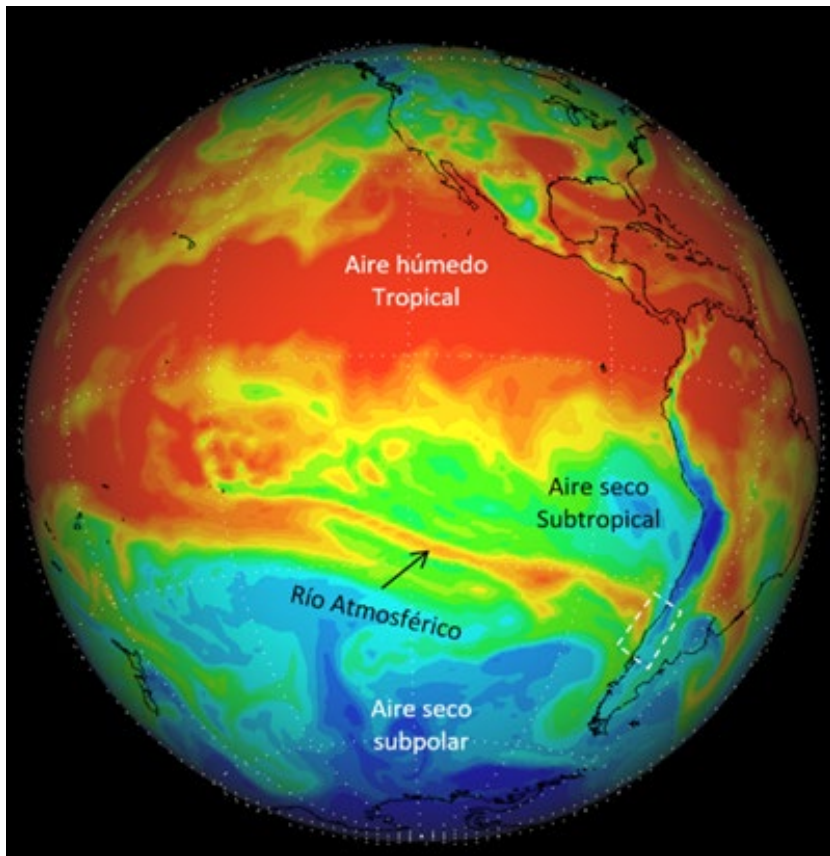
Total Precipitable Water 2020-06-02 2100 UTC



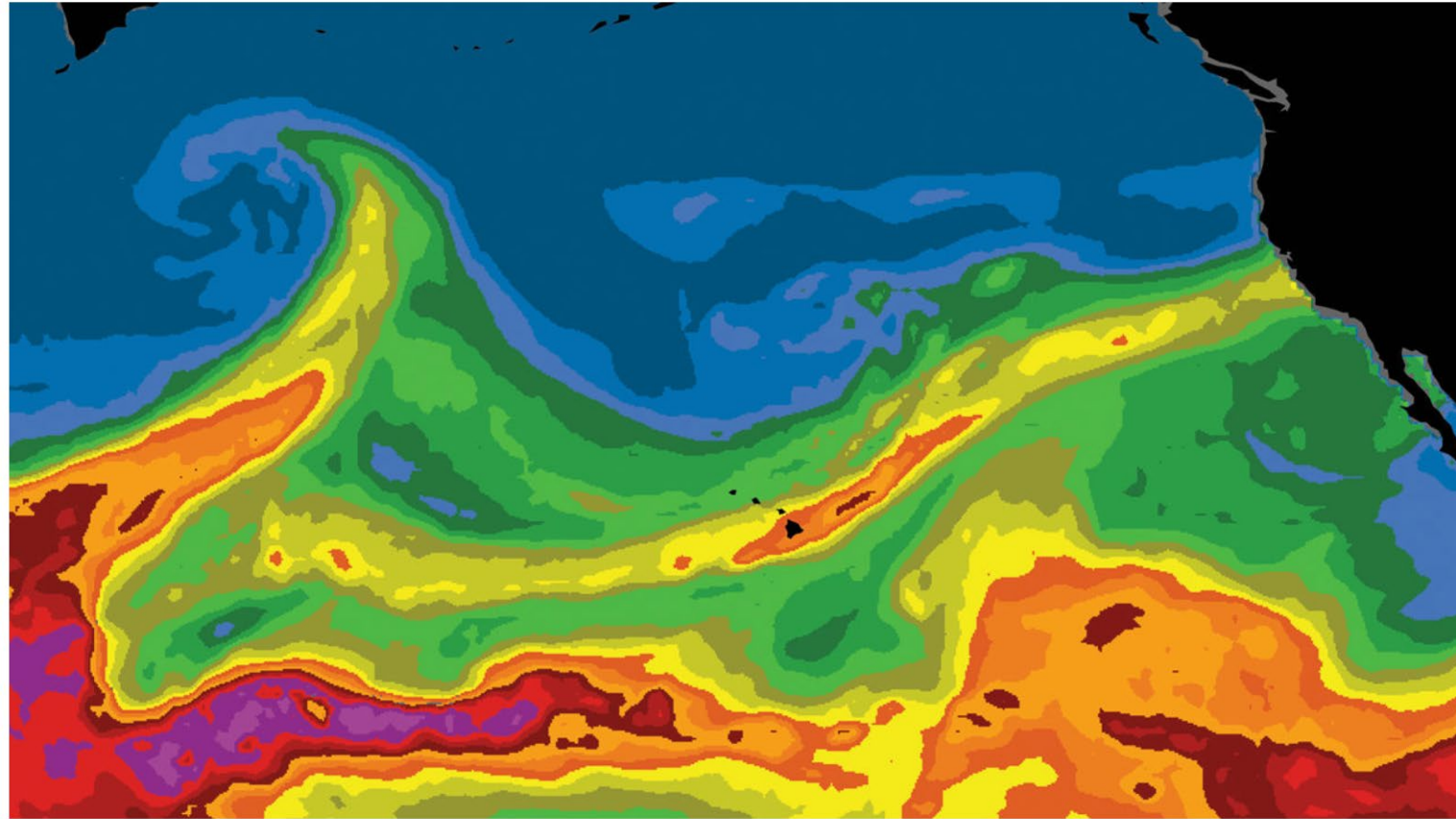
<http://tropic.ssec.wisc.edu/real-time/mtpw2/>

Total Precipitable Water 2022-04-21 2000 UTC





$$TPW = \frac{1}{\rho_w g} \int_{p_s}^0 q(p) \cdot dp$$



On 7 February, water vapor streamed from Hawaii on an atmospheric river called the Pineapple Express. NOAA EARTH SYSTEM RESEARCH LABORATORY PHYSICAL SCIENCES DIVISION

The science behind atmospheric rivers

An atmospheric river (AR) is a flowing column of condensed water vapor in the atmosphere responsible for producing significant levels of rain and snow, especially in the Western United States. When ARs move inland and sweep over the mountains, the water vapor rises and cools to create heavy precipitation. Though many ARs are weak systems that simply provide beneficial rain or snow, some of the larger, more powerful ARs can create extreme rainfall and floods capable of disrupting travel, inducing mudslides and causing catastrophic damage to life and property. Visit www.research.noaa.gov to learn more.

A strong AR transports an amount of water vapor roughly equivalent to 7.5–15 times the average flow of water at the mouth of the Mississippi River.

ARs are a primary feature in the entire global water cycle and are tied closely to both water supply and flood risks, particularly in the Western U.S.

On average, about 30–50% of annual precipitation on the West Coast occurs in just a few AR events and contributes to the water supply — and flooding risk.

ARs move with the weather and are present somewhere on Earth at any given time.

ARs are approximately 250–375 miles wide on average.

Scientists' improved understanding of ARs has come from roughly a decade of scientific studies that use observations from satellites, radar and aircraft as well as the latest numerical weather models. More studies are underway, including a 2015 scientific mission that added data from instruments aboard a NOAA ship.

3/2015

WATER
VAPOR
COOLS

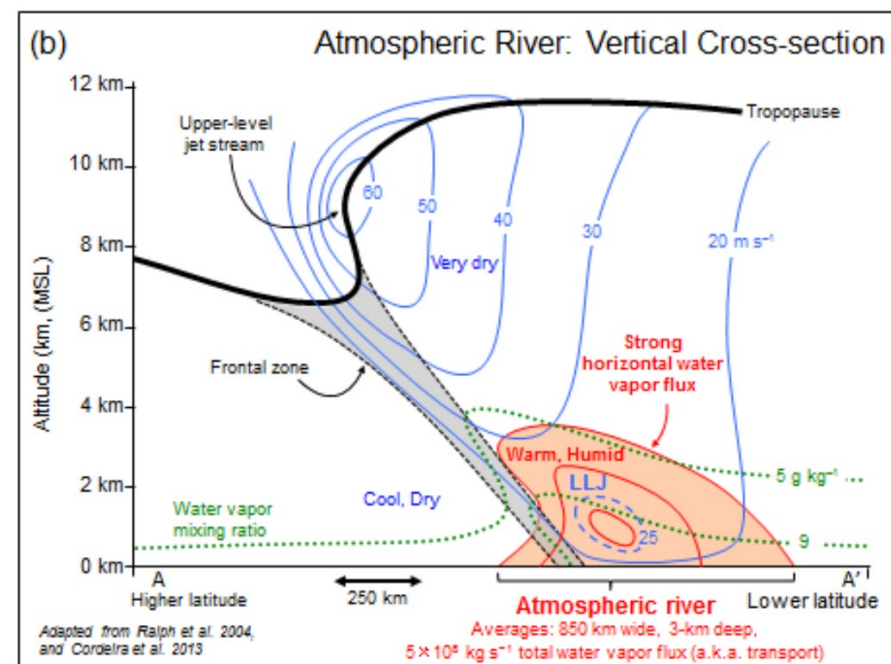
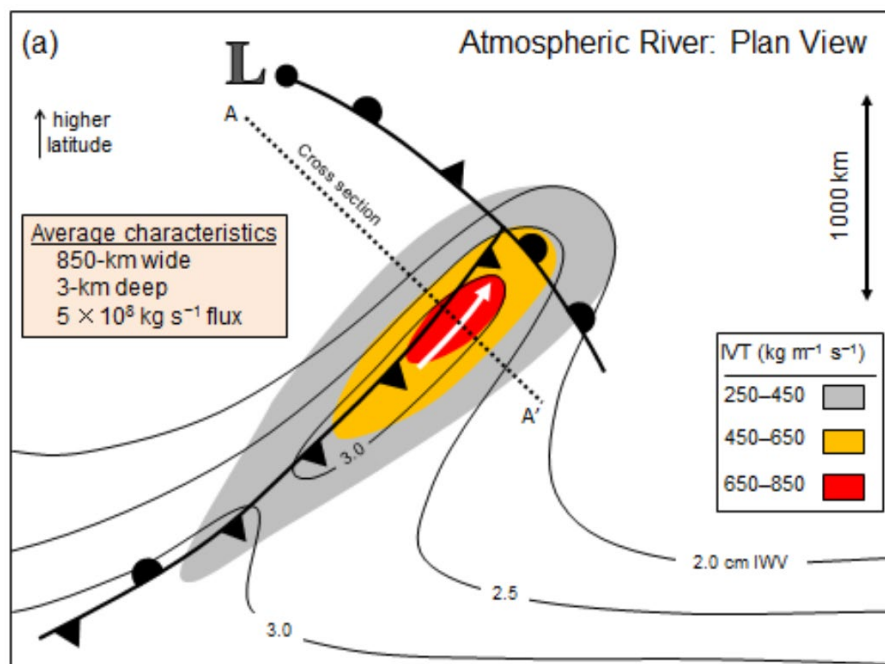
CALIFORNIA

Image not to scale.



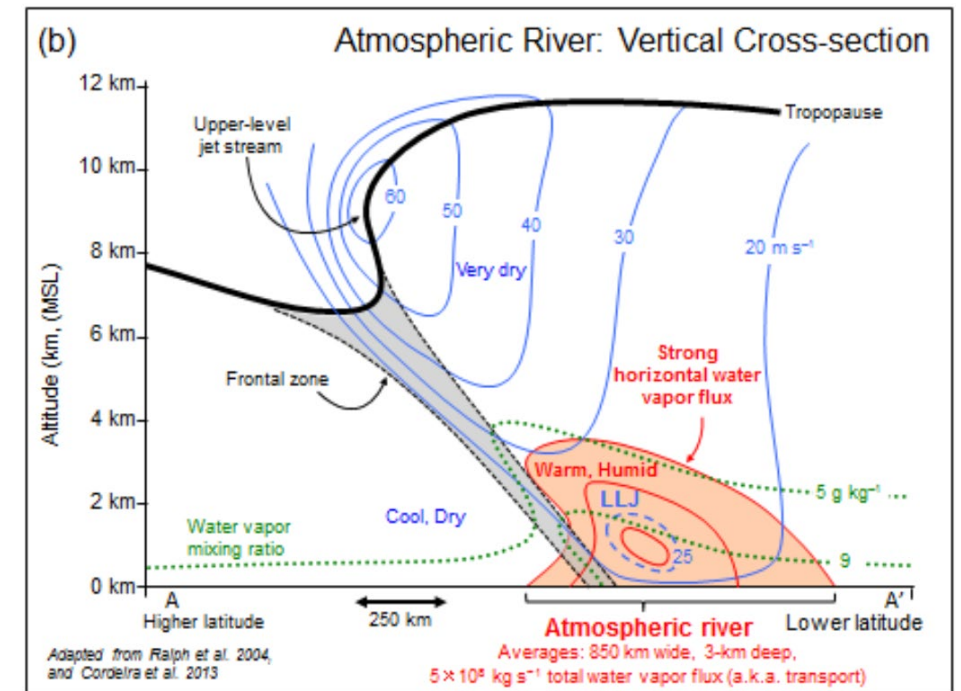
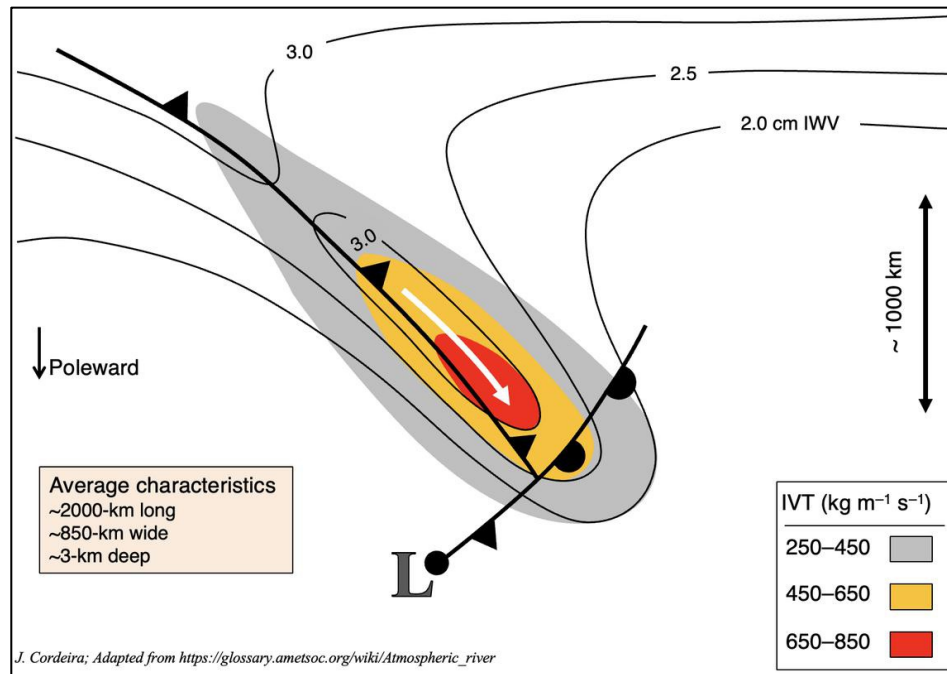
atmospheric river

A long, narrow, and transient corridor of strong horizontal **water vapor** transport that is typically associated with a **low-level jet** stream ahead of the **cold front** of an **extratropical cyclone**. The water vapor in atmospheric rivers is supplied by tropical and/or extratropical moisture sources. Atmospheric rivers frequently lead to heavy **precipitation** where they are forced upward—for example, by mountains or by ascent in the warm conveyor belt. Horizontal water vapor transport in the midlatitudes occurs primarily in atmospheric rivers and is focused in the lower **troposphere**. Atmospheric rivers are the largest "rivers" of fresh water on Earth, transporting on average more than double the flow of the Amazon River.



atmospheric river

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$$\vec{\text{IVT}} = \frac{1}{g} \int_{p_{\text{sfc}}}^{100\text{hPa}} q \vec{\mathbf{V}} dp,$$

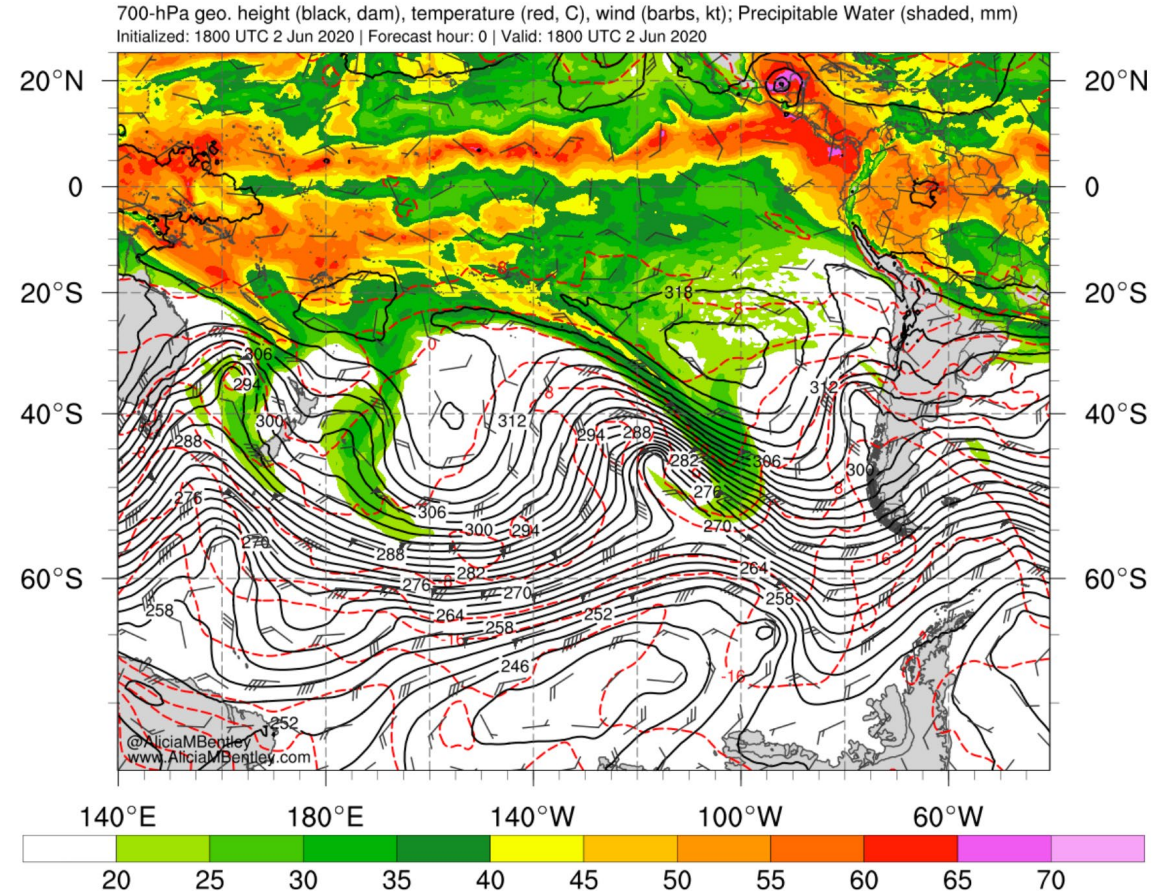
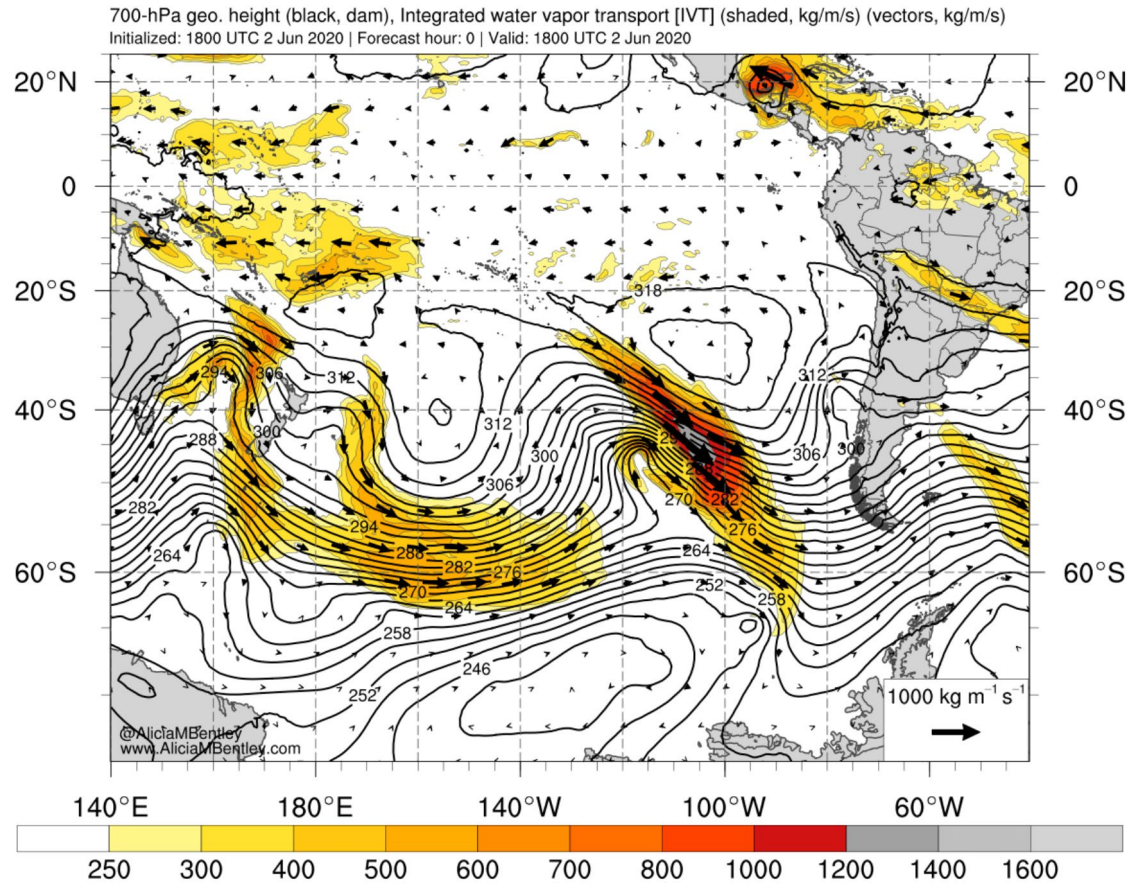
Integrated Water Vapor Transport (kg/m/s)

that is explained below. To calculate the IVT vector at each grid cell, the following formula was used:

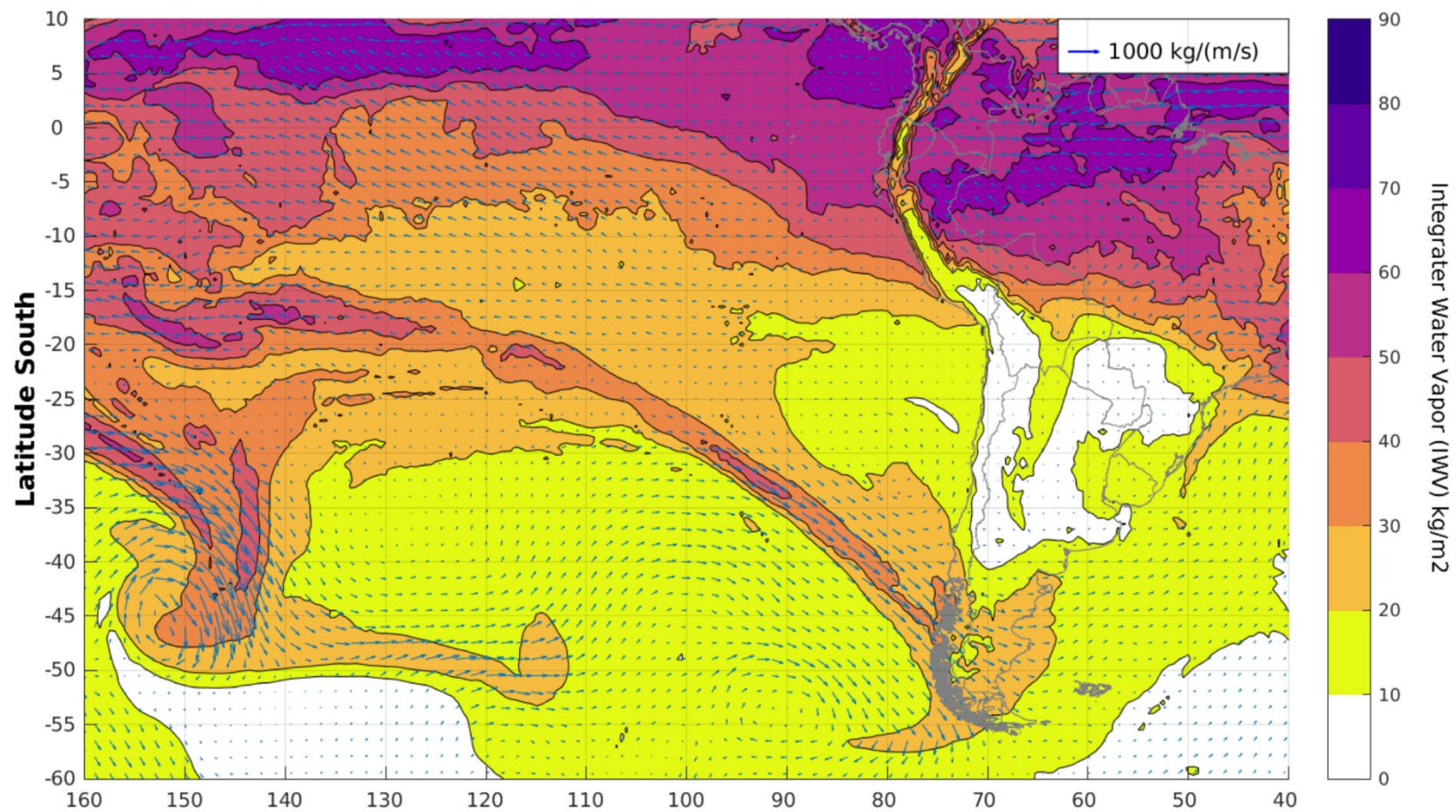
$$\overrightarrow{\text{IVT}} = \frac{1}{g} \int_{p_{\text{sfc}}}^{100\text{hPa}} q \overrightarrow{\mathbf{V}} dp, \quad (1)$$

where $\mathbf{V} = (u, v)$ is the horizontal wind vector determined by its meridional and zonal wind components, q is the specific humidity, p_{sfc} is the surface pressure, p is the pressure level, and g is the gravitational acceleration. The integration is done using data

Identificación de RA: IVT o PW...mejor IVT



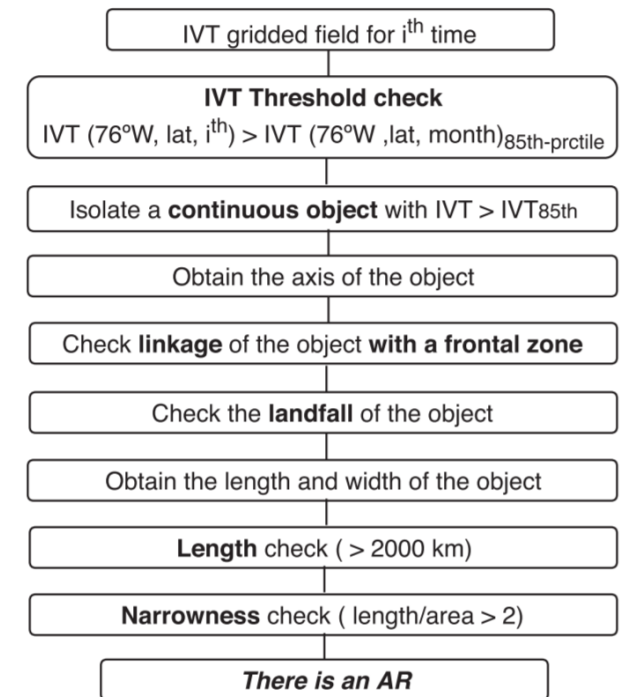
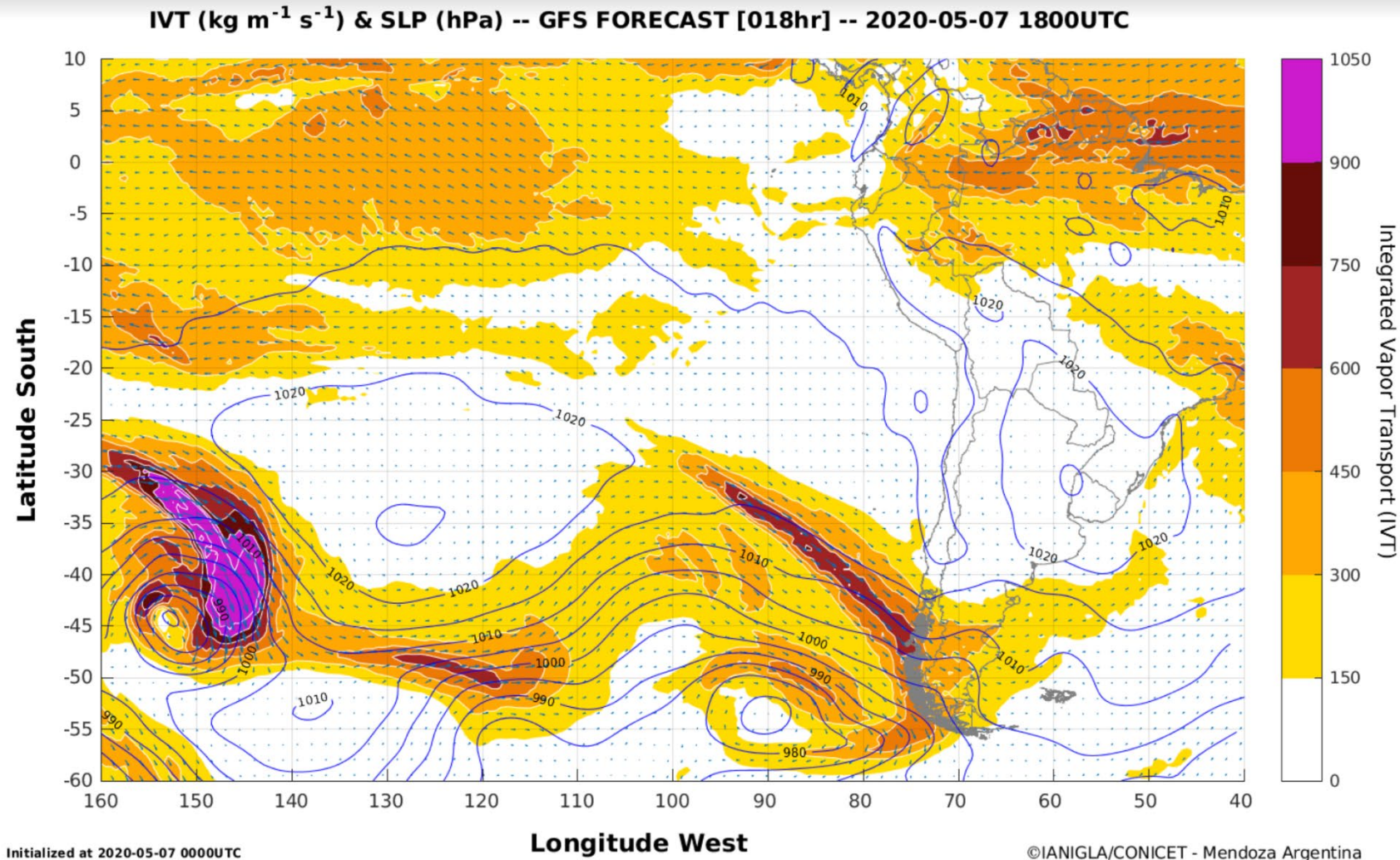
IWV (kg m^{-2} , shaded) & IVT ($\text{kg m}^{-1} \text{s}^{-1}$, vector) -- GFS FORECAST [018hr] -- 2020-05-07 1800UTC



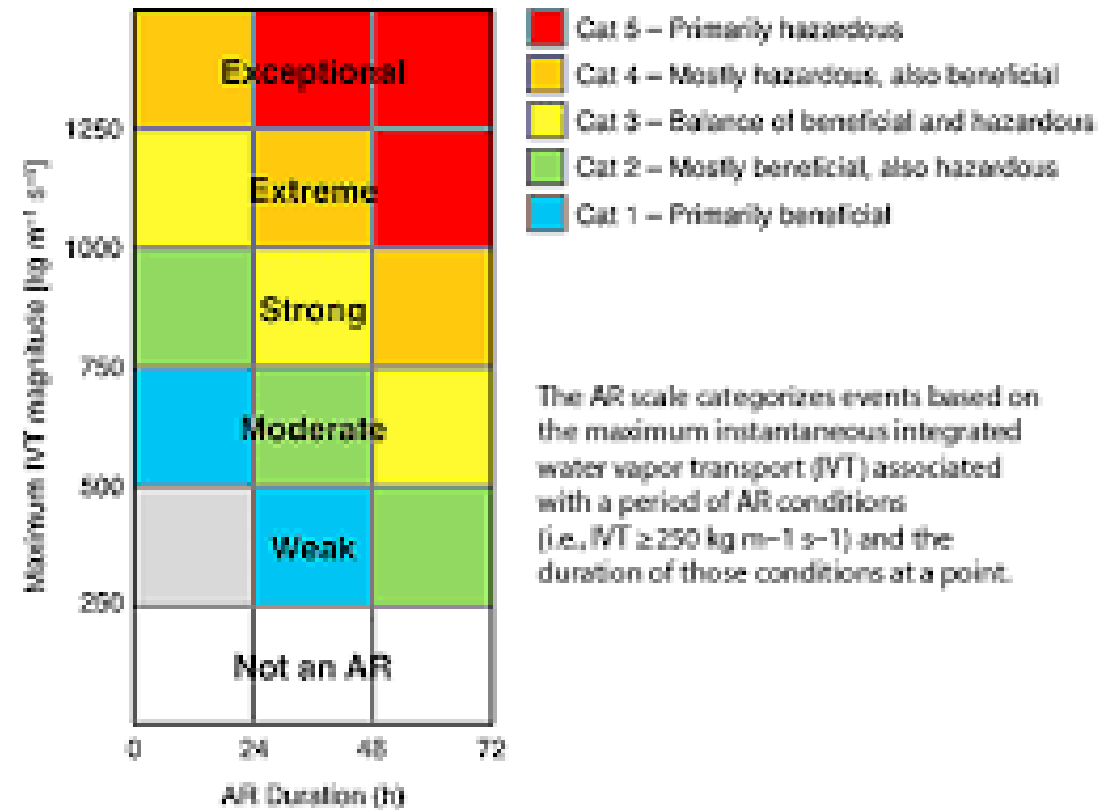
Initialized at 2020-05-07 0000UTC

©IANIGLA/CONICET - Mendoza Argentina

Usualmente se emplea $IVT > 250 \text{ kg/m/s}$ mas criterios geométricos (largo y angosto, continuo....)



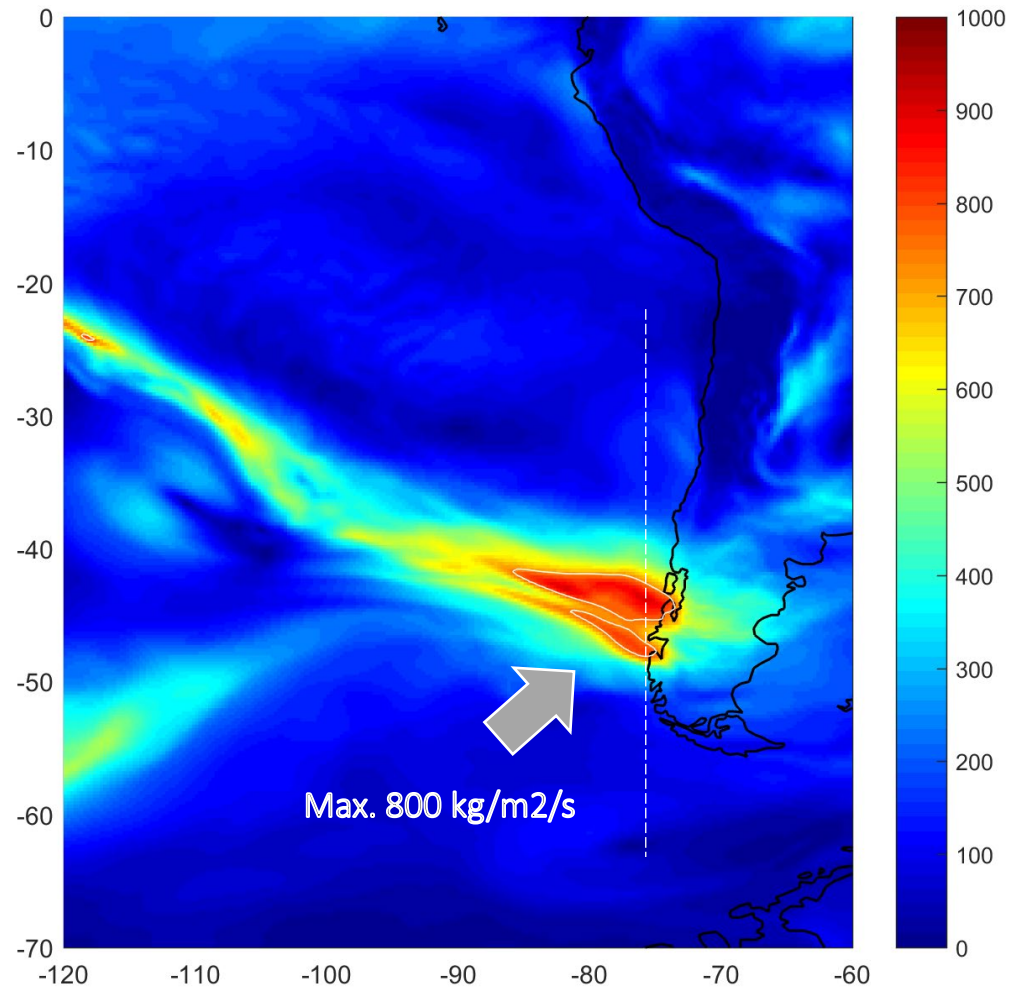
Ralph et al.2019: IVT + duración definen la categoría de un AR y su potencial impacto (bueno o malo)



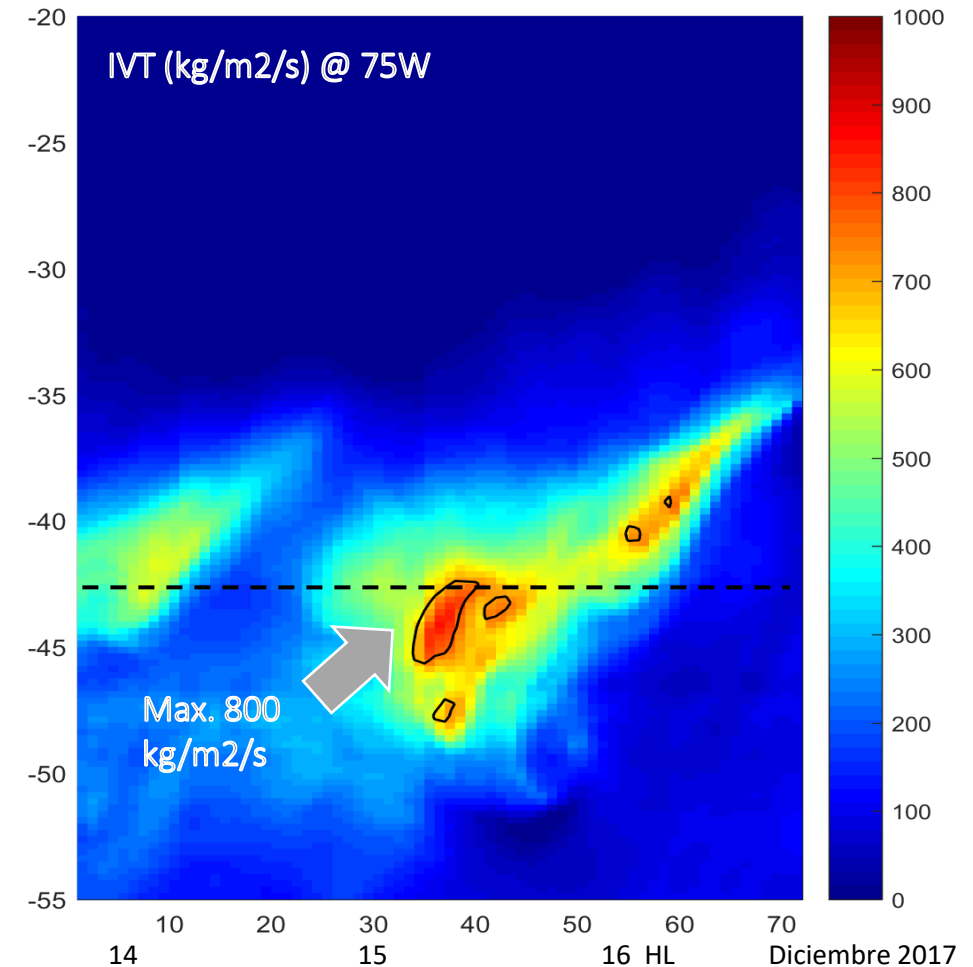
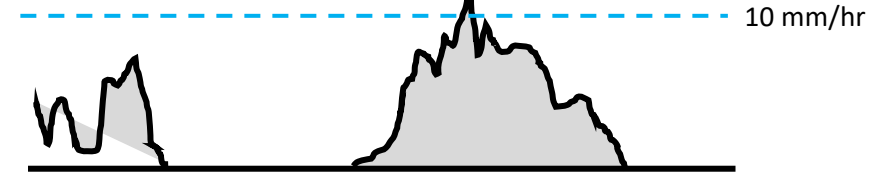
Pero en el caso de Chile la orientación importa mucho...

Necesitamos validar la escala propuesta de RA...casos de estudio

Transporte integrado de vapor de agua: IVT
15 Diciembre 2007, 12 UTC



Precipitación Villa
Santa Lucia



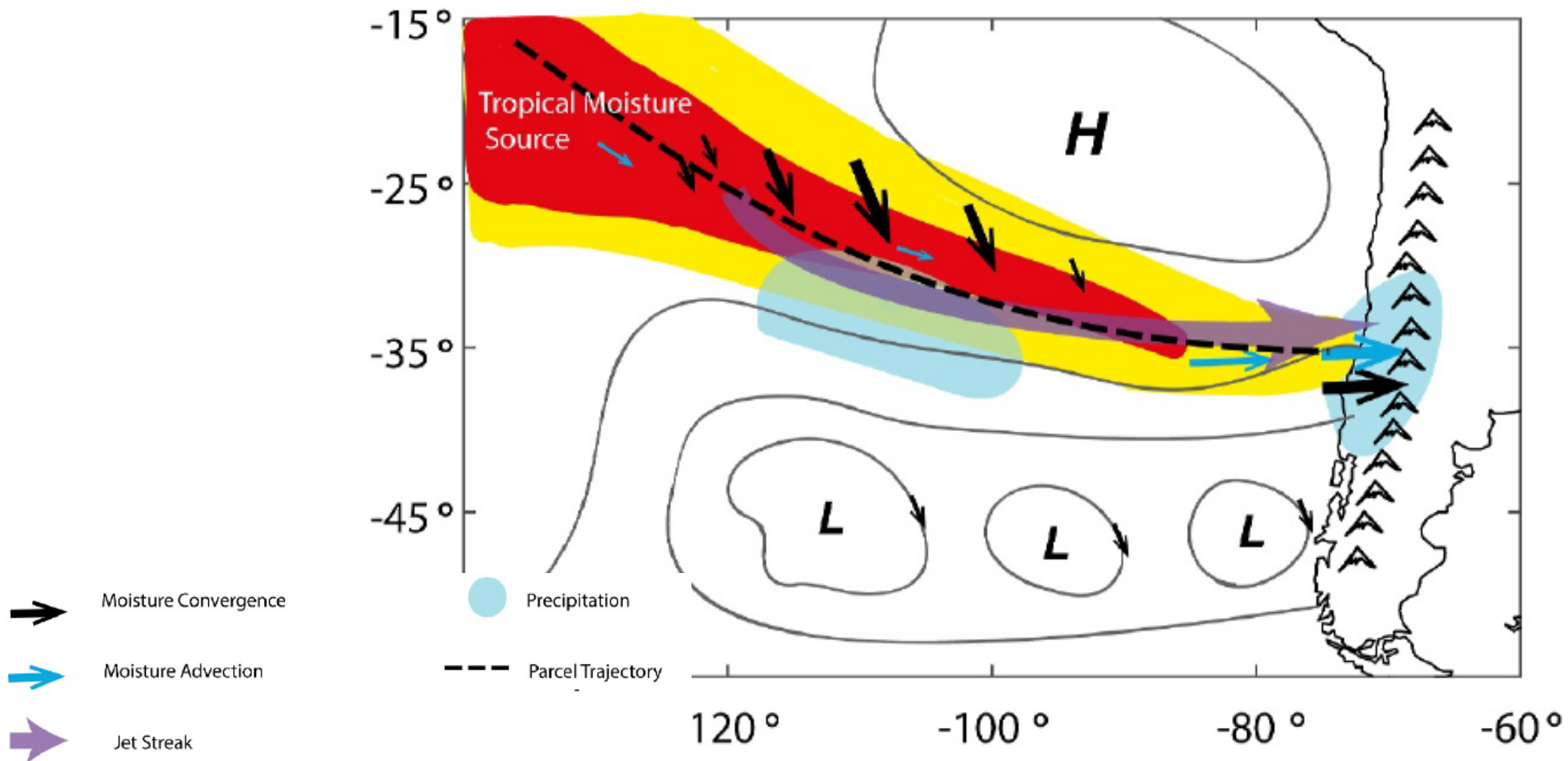
15 de Diciembre 2017: Claramente no un Cat-3!



Origen del vapor en un RA

Unraveling the Dynamics of Moisture Transport During Atmospheric Rivers Producing Rainfall in the Southern Andes

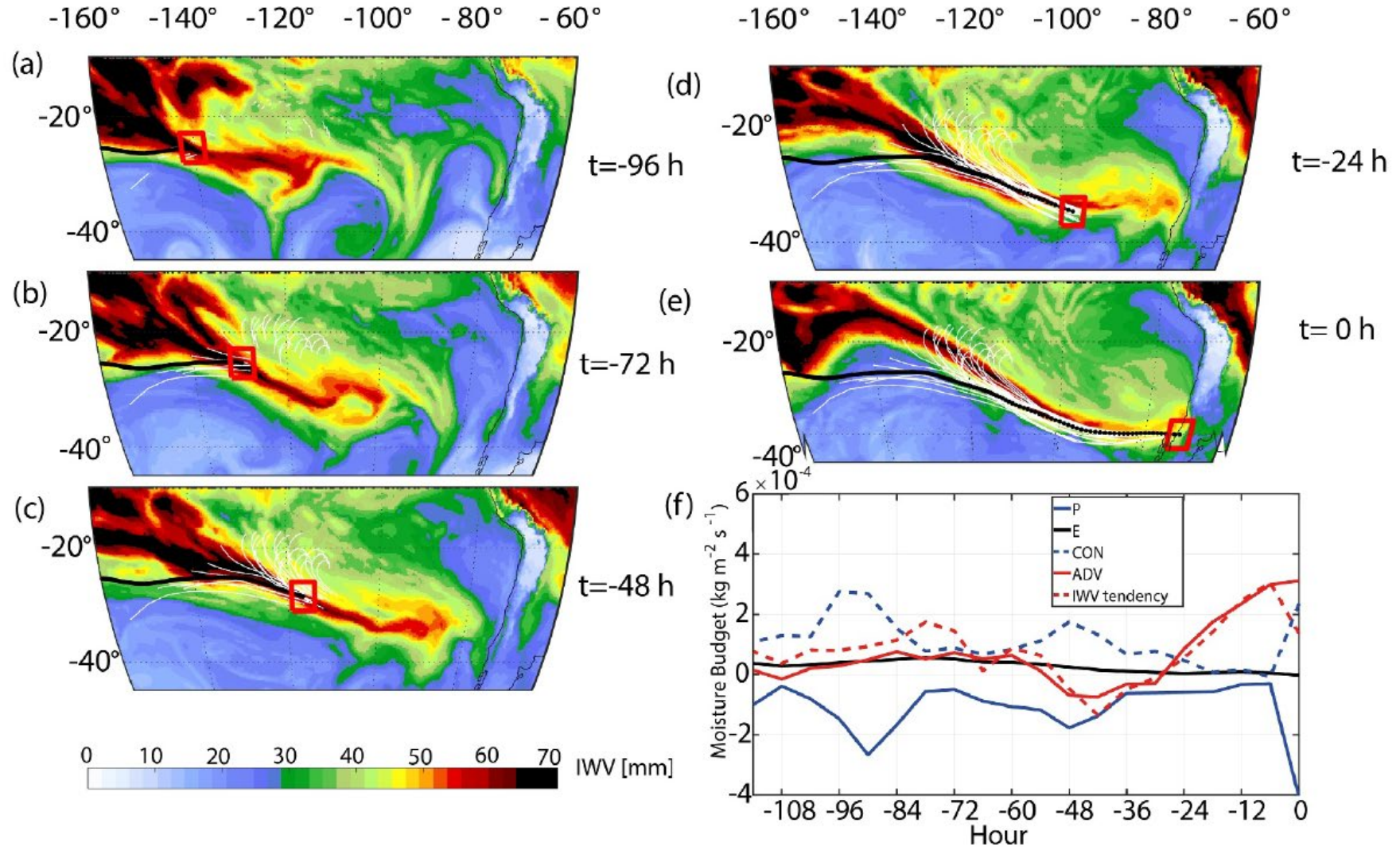
Dipjyoti Mudiar^{1,2} , Roberto Rondanelli^{1,2} , Raul A. Valenzuela^{2,3}, and René D. Garreaud^{1,2} 



Unraveling the Dynamics of Moisture Transport During Atmospheric Rivers Producing Rainfall in the Southern Andes

Dipjyoti Mudiari^{1,2} , Roberto Rondanelli^{1,2} , Raul A. Valenzuela^{2,3}, and René D. Garreaud^{1,2} 

$$\frac{1}{g} \frac{\partial}{\partial t} \int_{p_t}^{p_s} q dp = -\frac{1}{g} \int_{p_t}^{p_s} (\vec{V} \cdot \nabla q + q \nabla \cdot \vec{V}) dp - \frac{1}{g} \int_{p_t}^{p_s} \vec{V}_s \cdot \nabla p_s + E - P$$



Cuidado....los AR se ven como un canal que transporta agua. Pero (1) el canal se mueve y (2) hay entradas y salidas de agua desde el canal. Mejor la analogía de la carretera....



Linking Atmospheric Rivers and Warm Conveyor Belt Airflows

H. F. DACRE

Department of Meteorology, University of Reading, Reading, United Kingdom

O. MARTÍNEZ-ALVARADO

National Centre for Atmospheric Sciences, Reading, United Kingdom

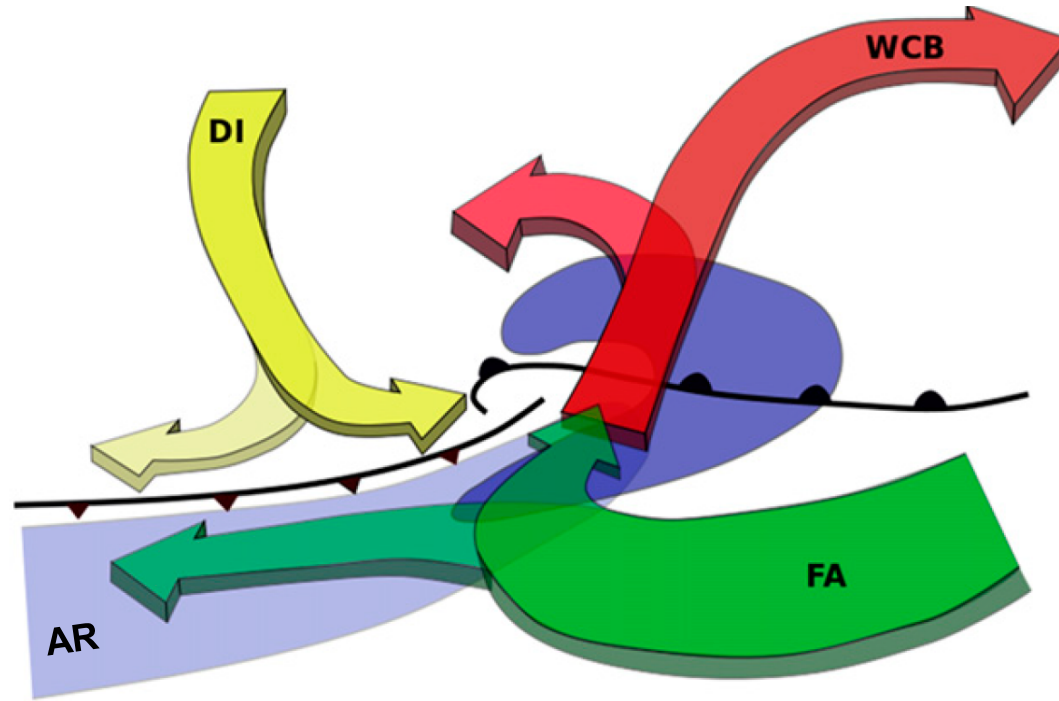


FIG. 7. Schematic of cyclone-relative airflows overlaid on cyclone surface features. Cold and warm front (black), precipitation (dark blue shading), and high TCWV (light blue shading). Ascending warm conveyor belt (WCB; red), split into lower cyclonically turning and higher anticyclonically turning branch. Low-level rearward flowing feeder airstream (FA; green), split into lower cyclonically turning and higher anticyclonically turning branch. Descending dry intrusion (DI; yellow), split into lower anticyclonically turning branch and higher cyclonically turning branch.

Climatología Global de RA

Global ARs: Seasonal Cycle

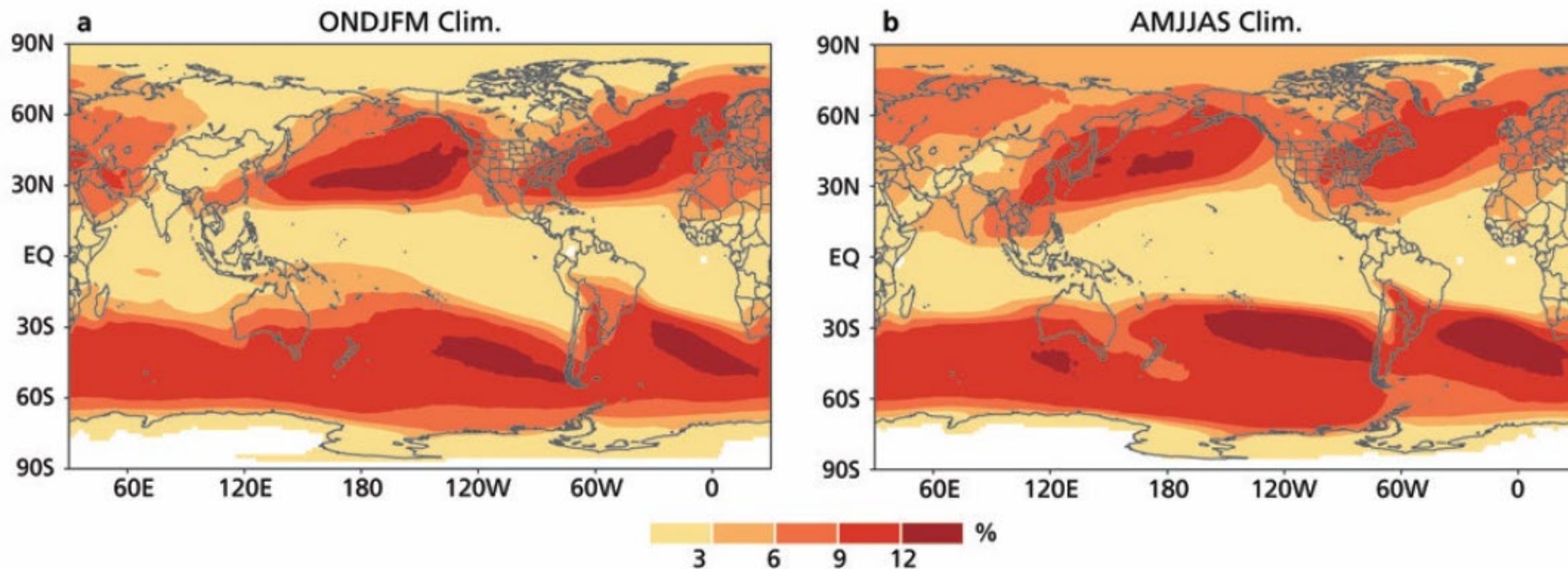
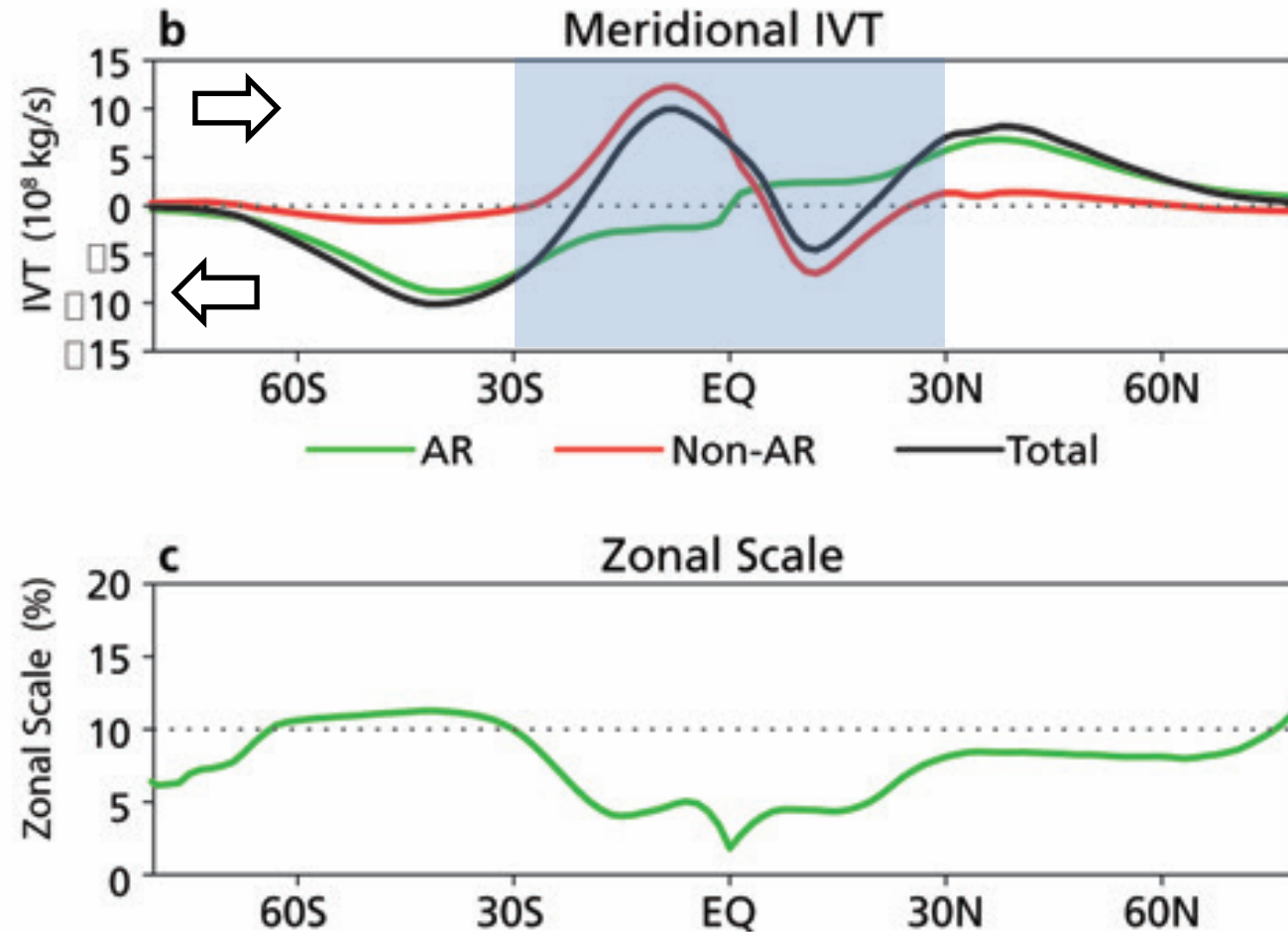


Fig. 4.7 AR frequency (percent of time-steps) in **a** ONDJFM and **b** AMJJAS for the period of 1979–2015

Global ARs: How much moisture transport?



Updated from Guan and Waliser 2015

Global ARs: How long? How Juicy?

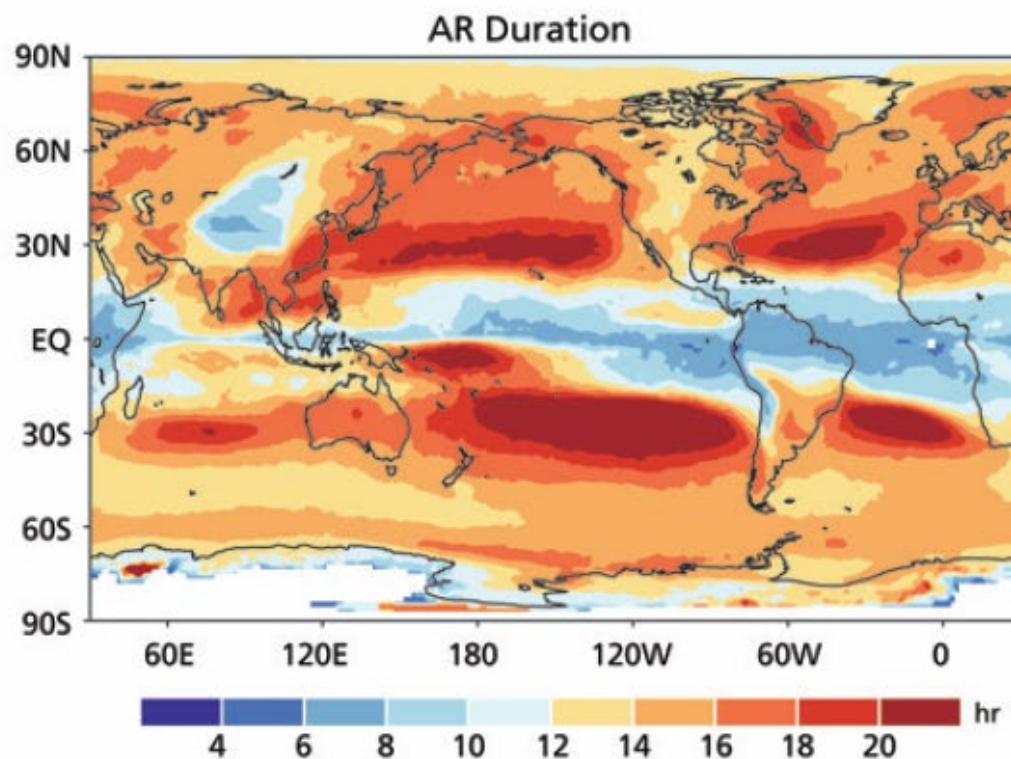


Fig. 4.4 Mean duration (hour) of ARs at each grid cell. Calculations are based on all months of 1979–2015. (Updated from Guan and Waliser 2015)

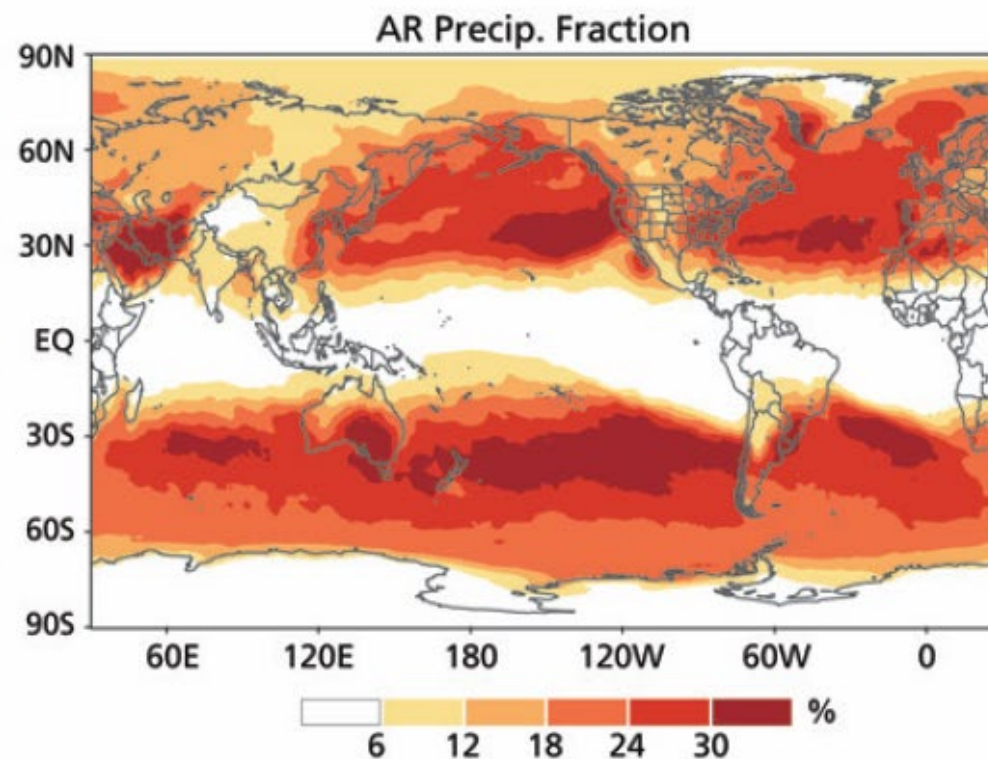


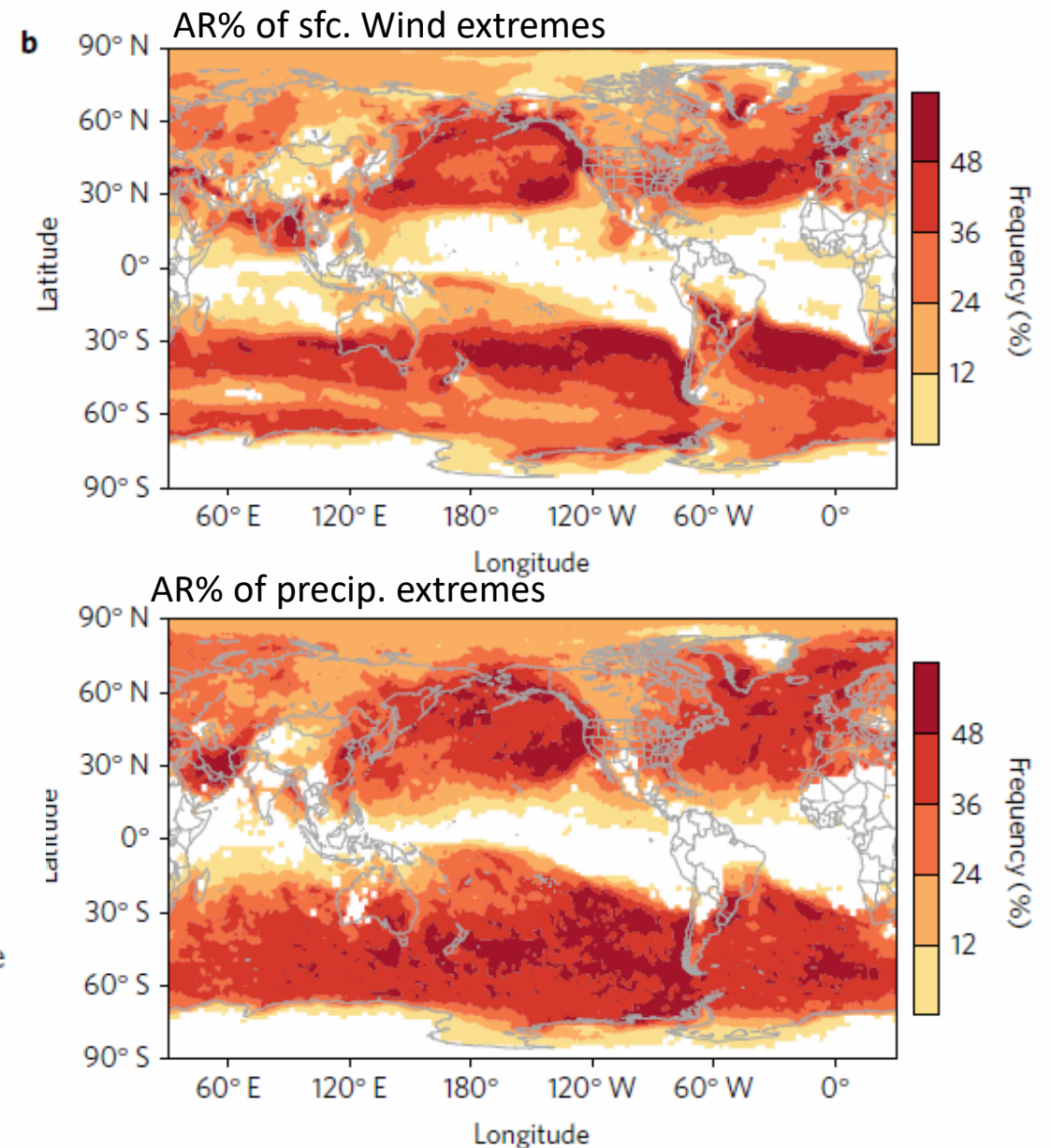
Fig. 4.5 Mean AR fractional contribution to total precipitation over the period of 1997–2015, for which precipitation data from Global Precipitation Climatology Project version 1.2 (Huffman et al. 2001) are available. (Updated from Guan and Waliser 2015)

Global ARs: How bad?

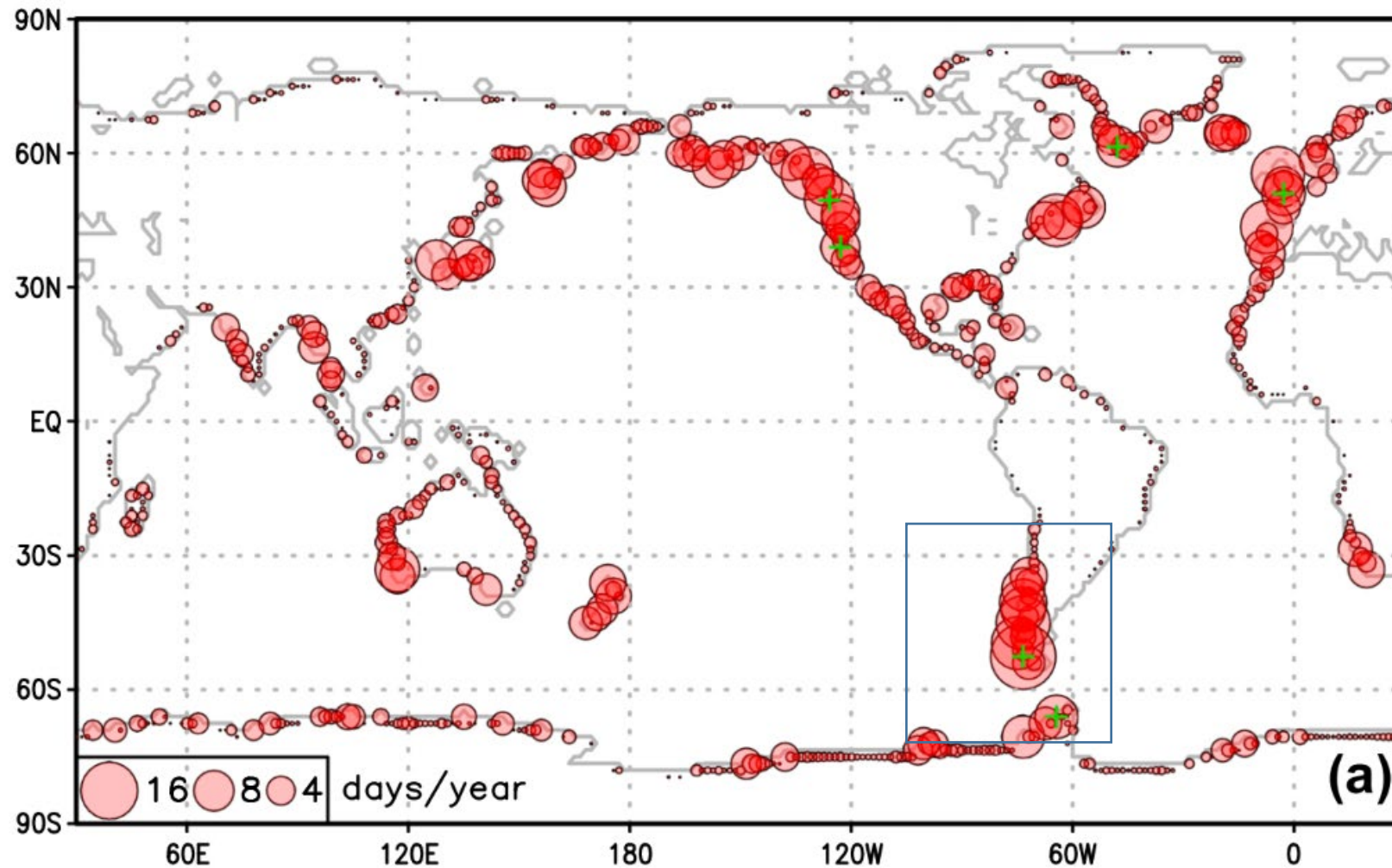
Extreme winds and precipitation during landfall of atmospheric rivers

Duane Waliser^{1*} and Bin Guan²

Figure 1 | AR fractions among wind and precipitation extremes. **a**, Map reflecting the frequency of global occurrence of AR events out of all time steps (that is, considering the entire distribution of wind/precipitation, including times with zero precipitation/wind)¹⁴. **b,c**, Global maps showing the frequency (% of times) that ARs are associated with surface (10 m) wind extremes (**b**) and surface precipitation extremes (**c**). In each case, extremes are defined as those exceeding the 98th percentile of non-zero values at a given grid cell. Note different colour scale for **a**. In **b** and **c**, values are shaded only if statistically significant at the 99% level; see Methods for details.



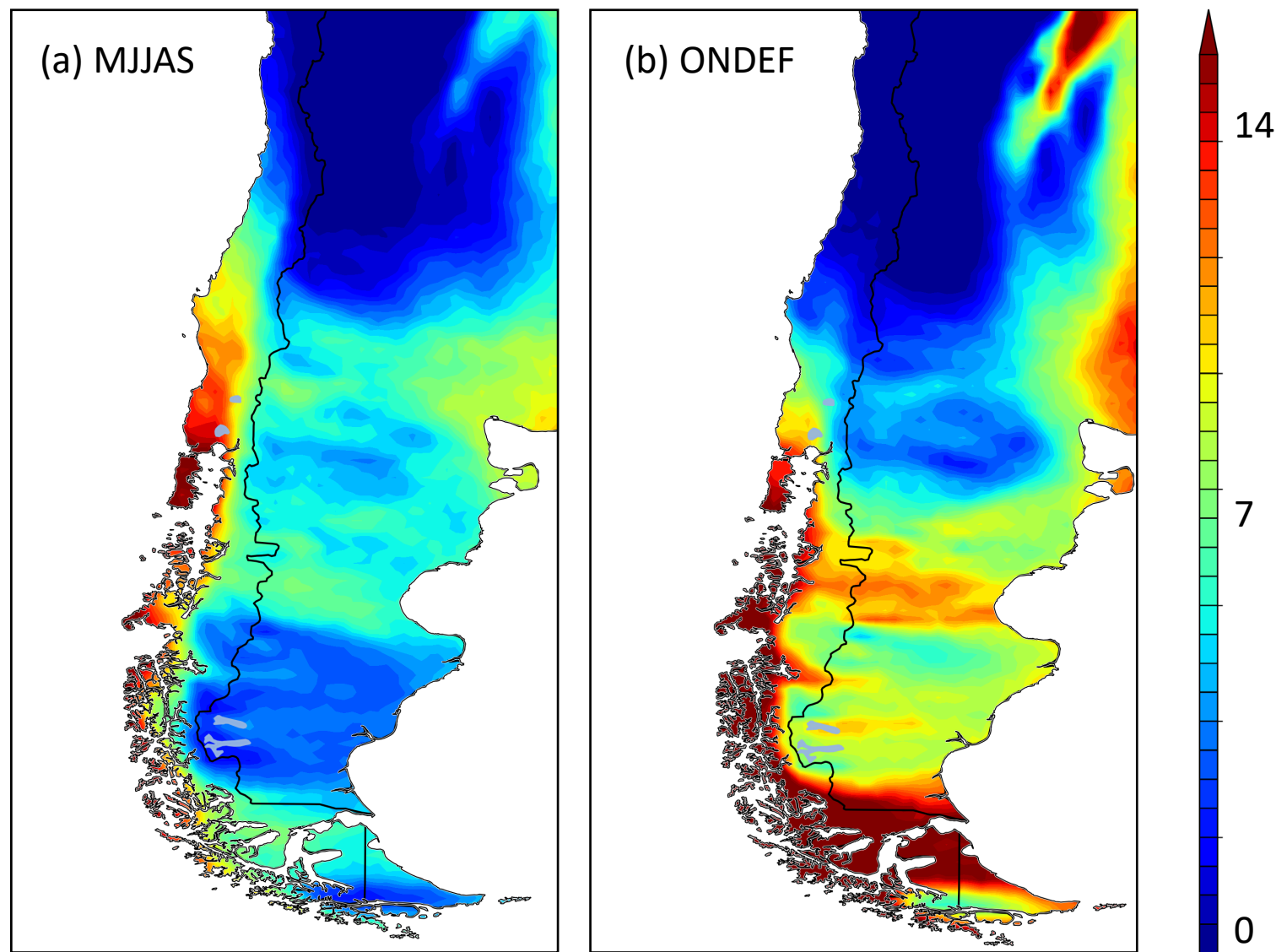
Landfalling AR – Global Survey



Guan and Waliser
(2015)

Climatología Regional de RA

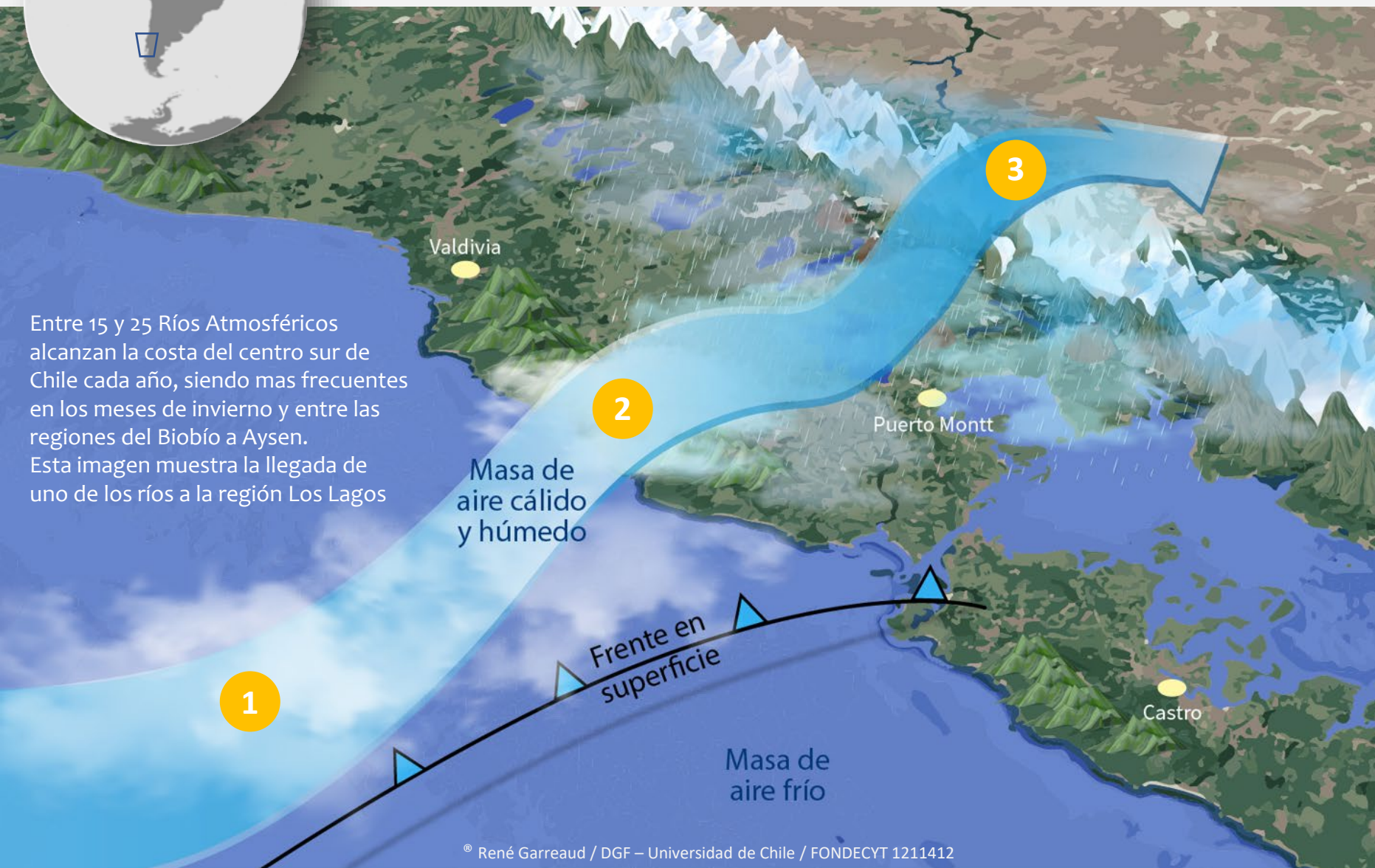
Número promedio de ríos que llegan en cada estación del año
(Gentileza de Jorge Eiras-Barca)



Un Río Atmosférico aterrizando en la Región de Los Lagos, Chile



Entre 15 y 25 Ríos Atmosféricos alcanzan la costa del centro sur de Chile cada año, siendo mas frecuentes en los meses de invierno y entre las regiones del Biobío a Aysen. Esta imagen muestra la llegada de uno de los ríos a la región Los Lagos



1

El vapor de agua en la atmósfera viaja desde los océanos tropicales hacia las latitudes medias y se concentra en filamentos que se extienden por miles de kilómetros en la horizontal. Estos filamentos generalmente se ubican inmediatamente al norte de un frente frío y cuando el transporte es intenso se denominan Ríos Atmosféricos.

2

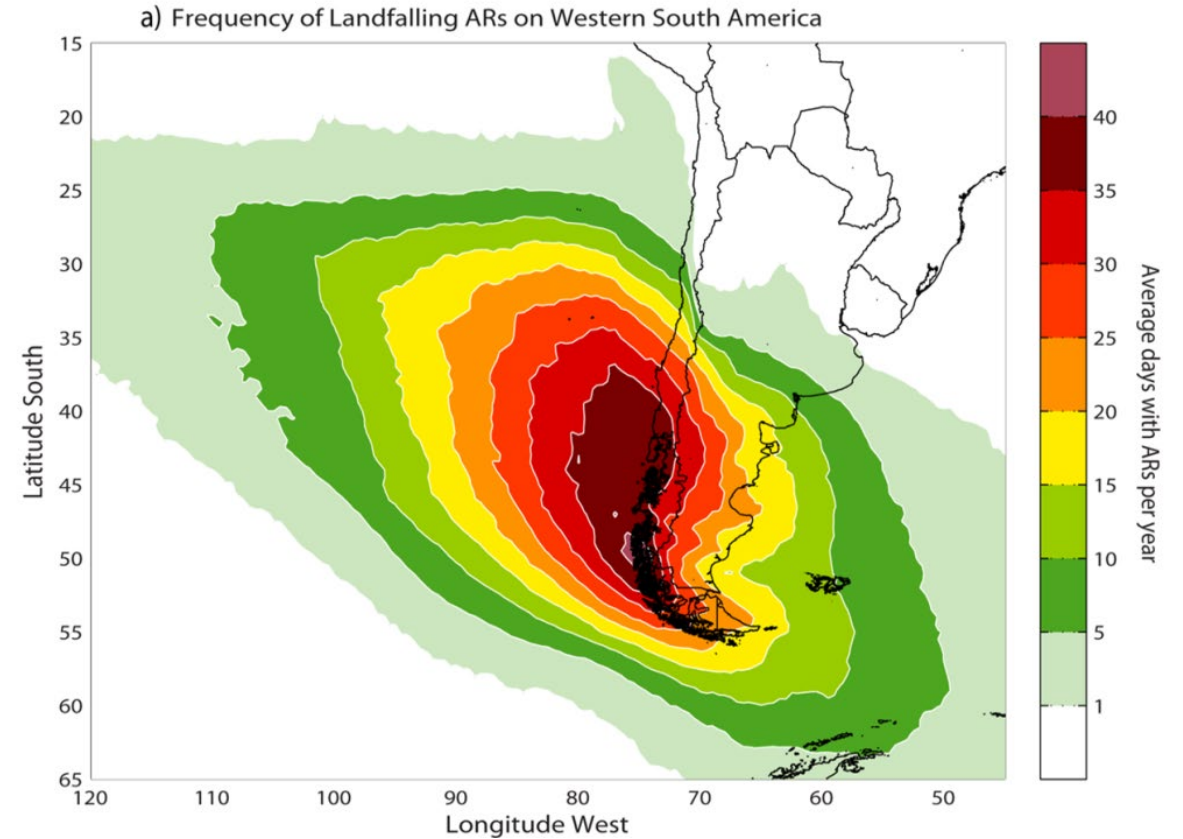
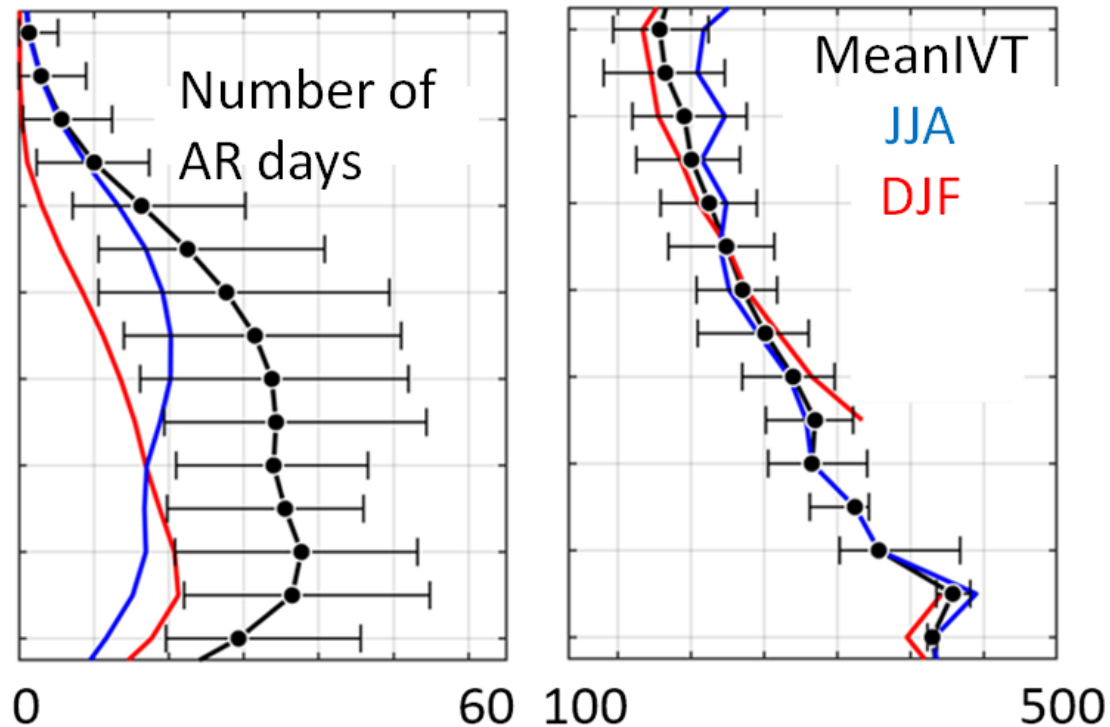
El transporte de vapor es máximo en torno a los 2 kilómetros de altura sobre el nivel del mar, pues mas arriba en la tropósfera el aumento de la magnitud del viento se compensa con una disminución de la humedad.

3

Cuando el vapor contenido en estos Ríos Atmosféricos asciende sobre un frente o cadena montañosa se condensa, dando origen a nubes y precipitación. Si el río se orienta en dirección este-oeste, como el que se muestra aquí, el ascenso sobre la cordillera de la costa y los Andes es muy intenso, resultando en copiosas precipitaciones.

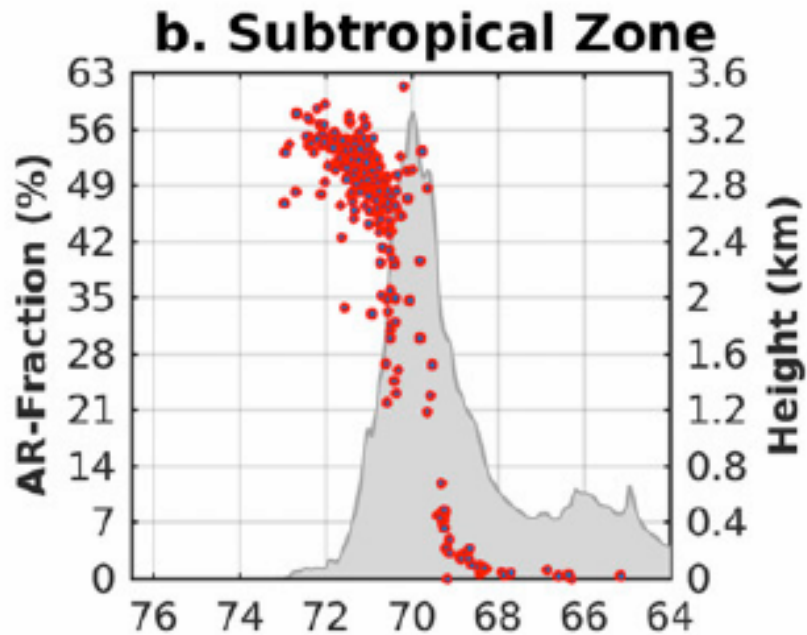
15 year landfalling AR climatology

Viale et al. 2018

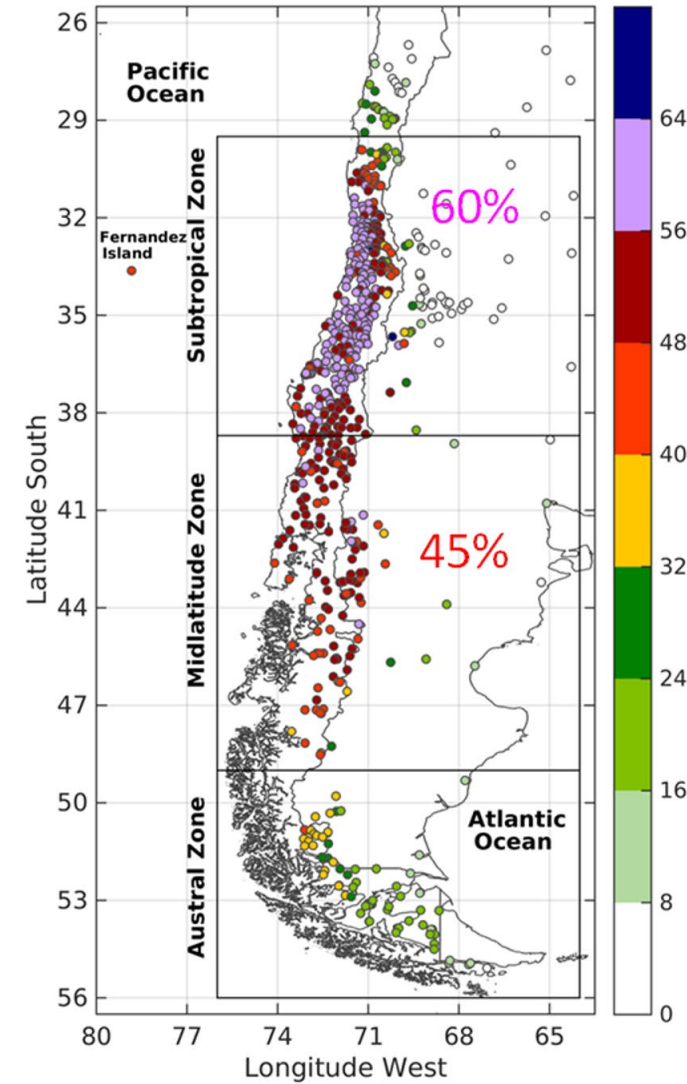


15 year landfalling AR climatology

Viale et al. 2018

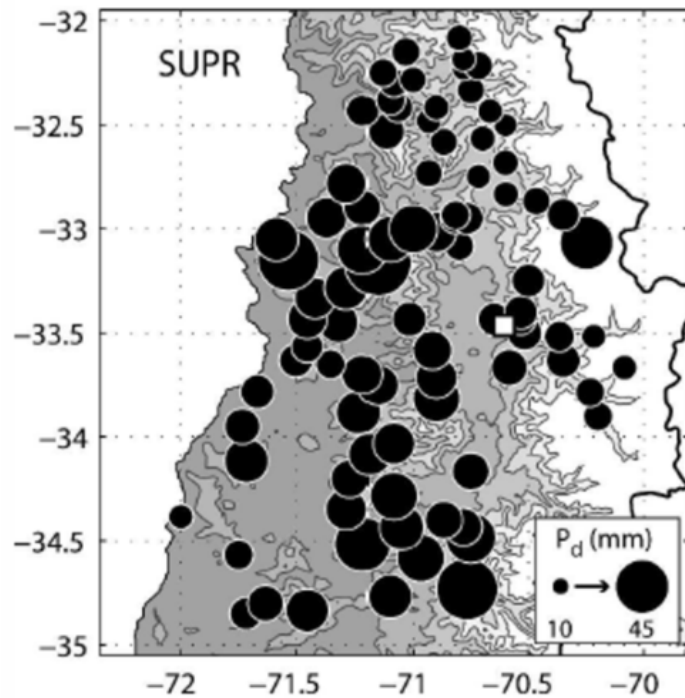


AR contribution to
annual rainfall

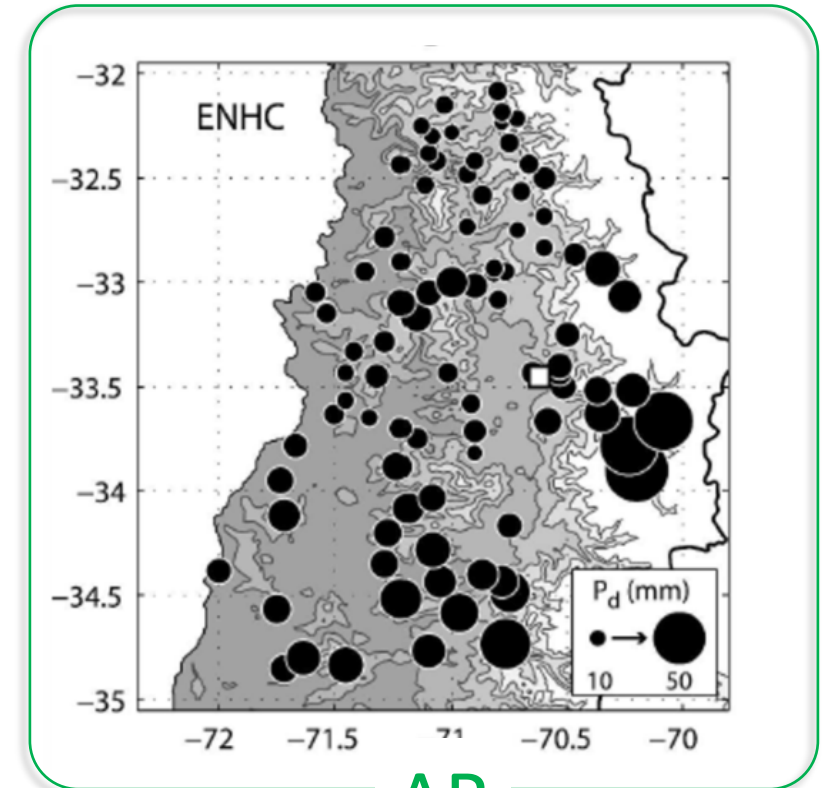
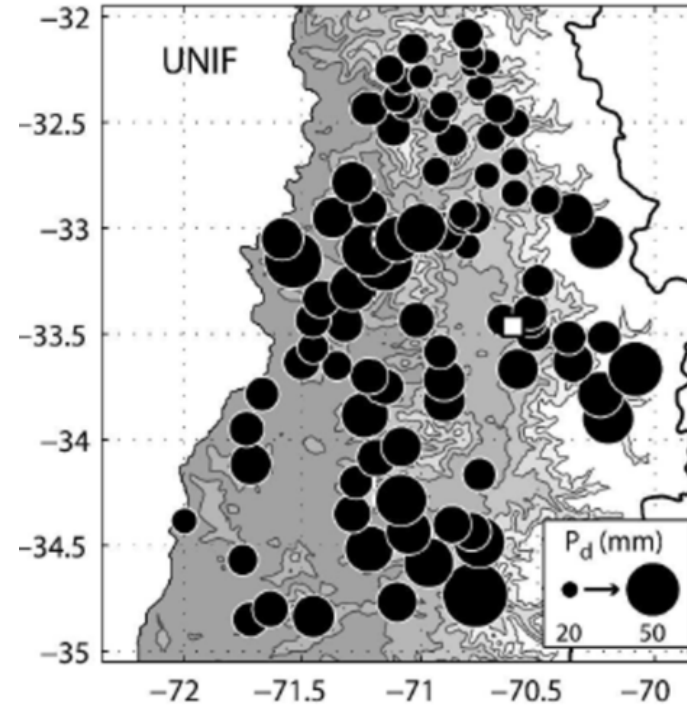


Orographic enhancement and ARs

Falvey and Garreaud 2007

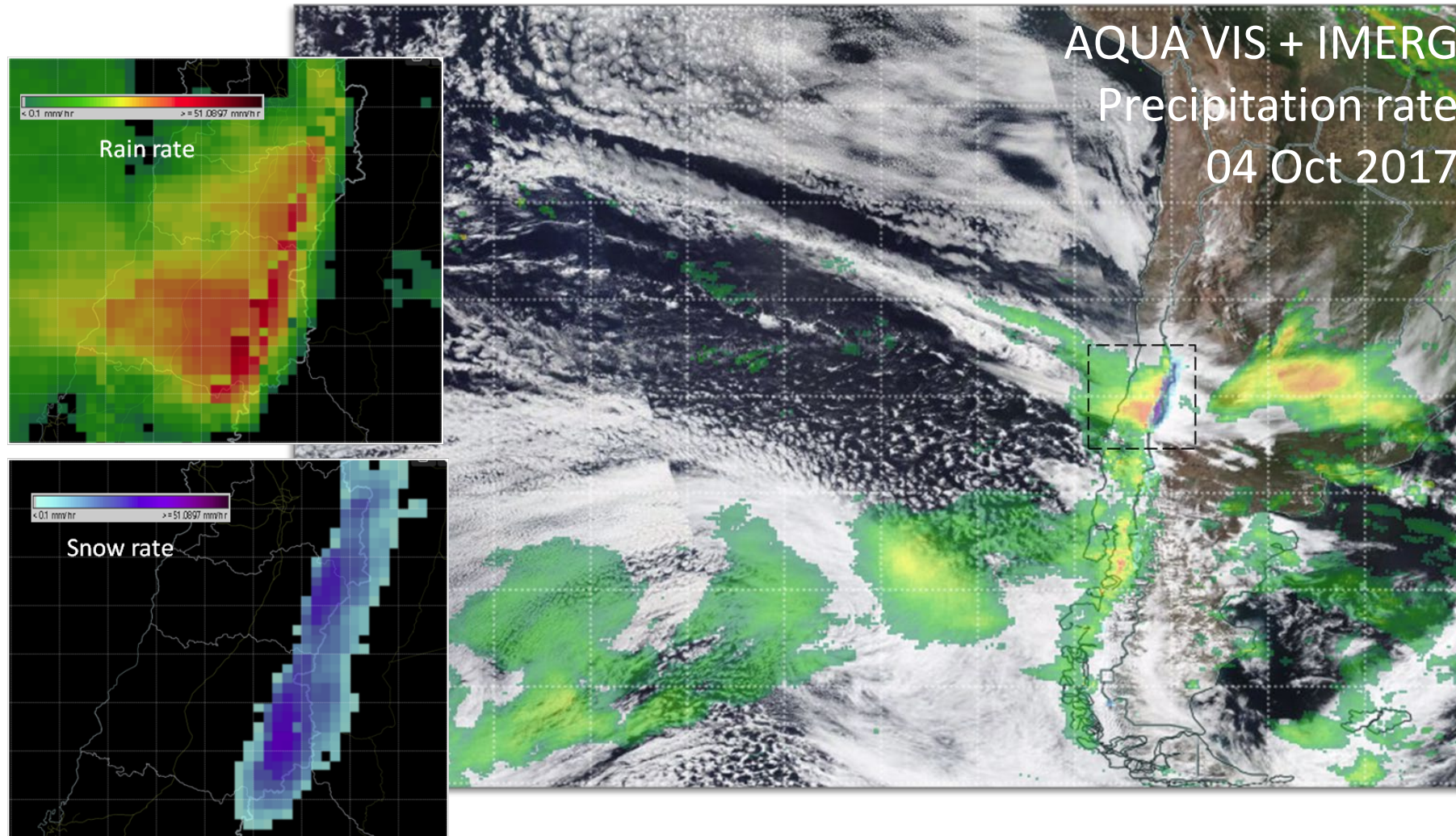


Non-AR



AR

ARs: Rain and Snow



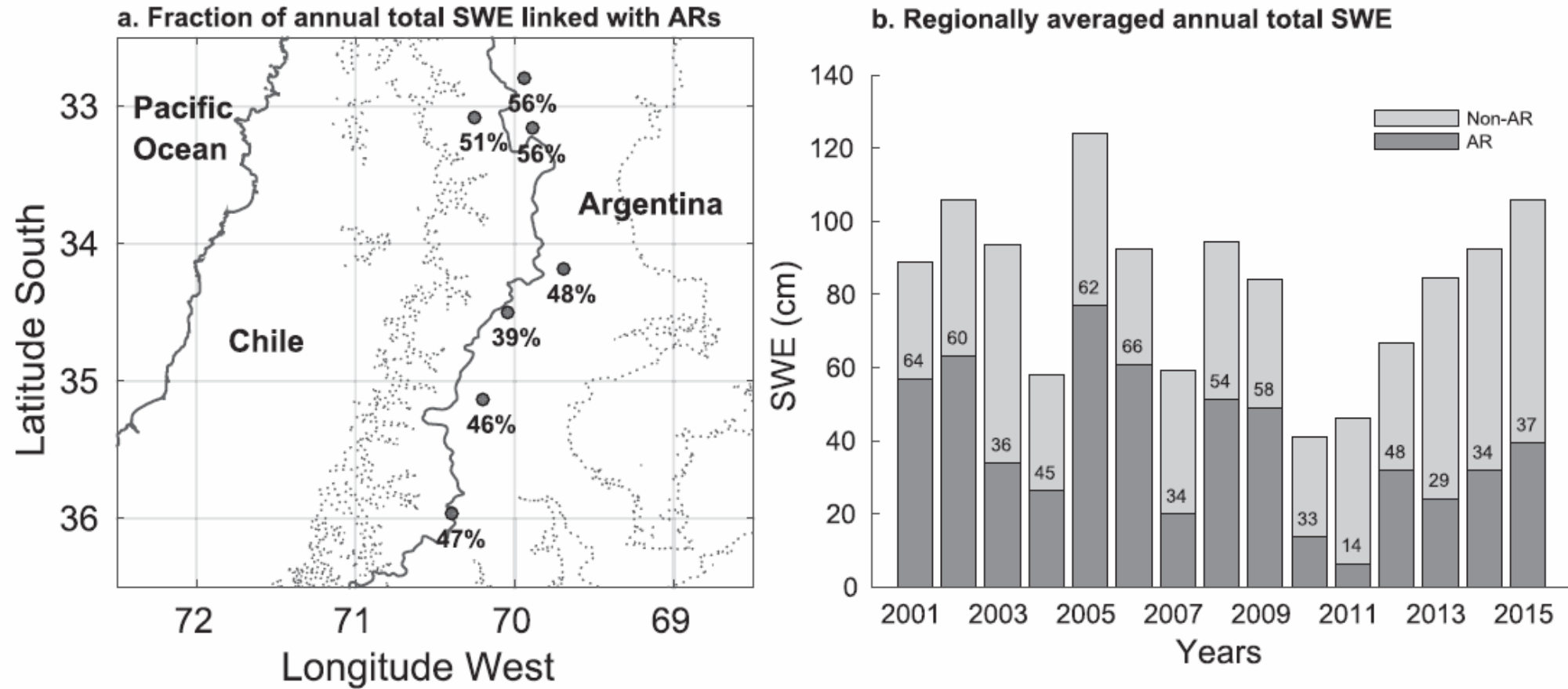


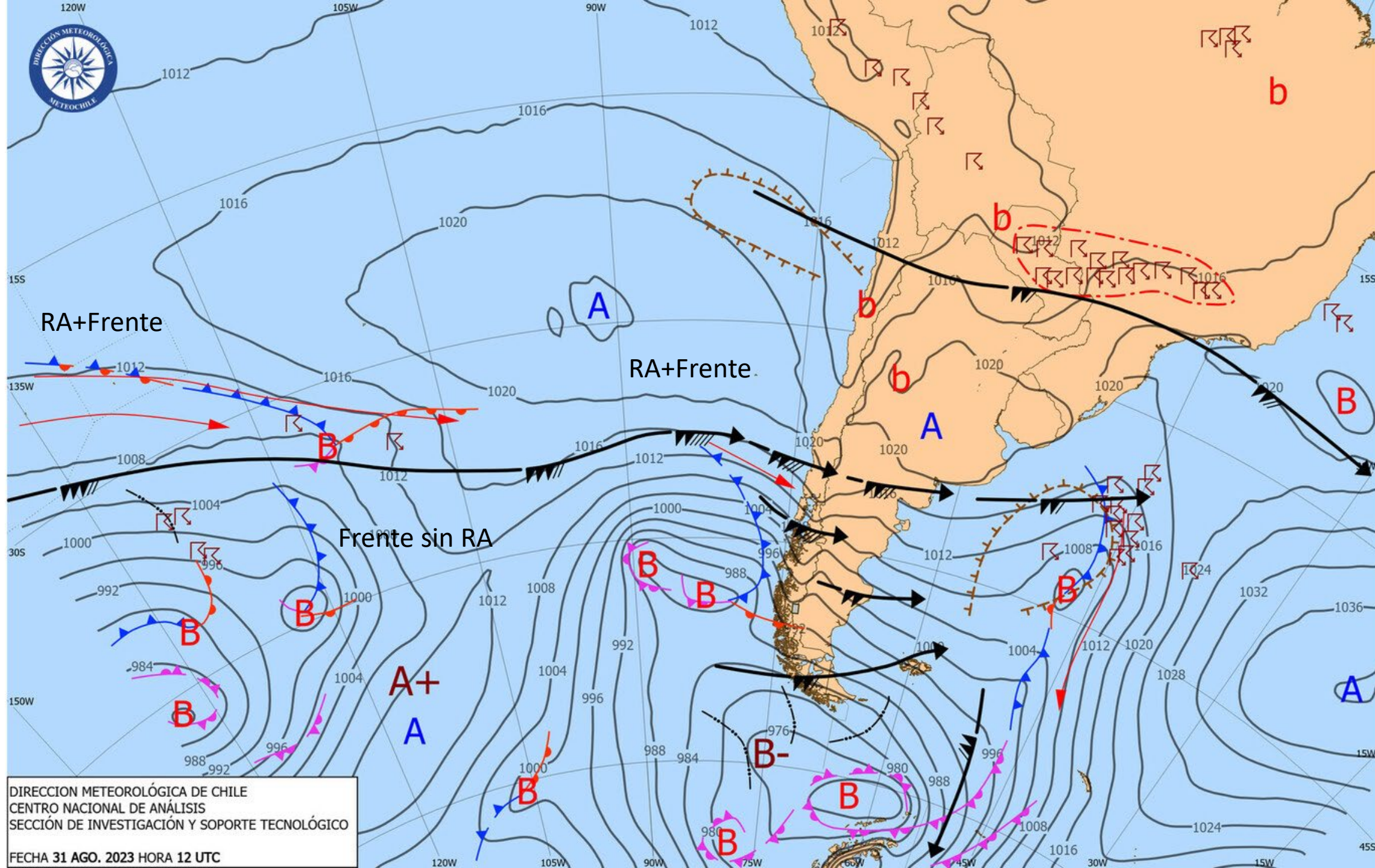
FIG. 9. (a) Fraction of snow total precipitation associated with ARs at snow pillow locations over the 2001–15 period. Fractions are multiplied by 100 to express the results in percentage. The topographic line of 1500 m (dotted line) and the Argentina–Chile border line (solid line) are plotted as references. (b) Regionally averaged annual contribution of ARs to total annual snow over the 2001–15 period, calculated using the seven SWE sites shown in (a). The numbers within each bar correspond to the percentage of the annual contribution of ARs to total annual snow for each year.

Preguntas importantes

¿Todos los frentes fríos tienen asociado un río atmosférico?

¿Todos los ríos atmosféricos están asociados a un frente frío? ¿Y a una depresión?

¿Un RA intenso produce más precipitación?

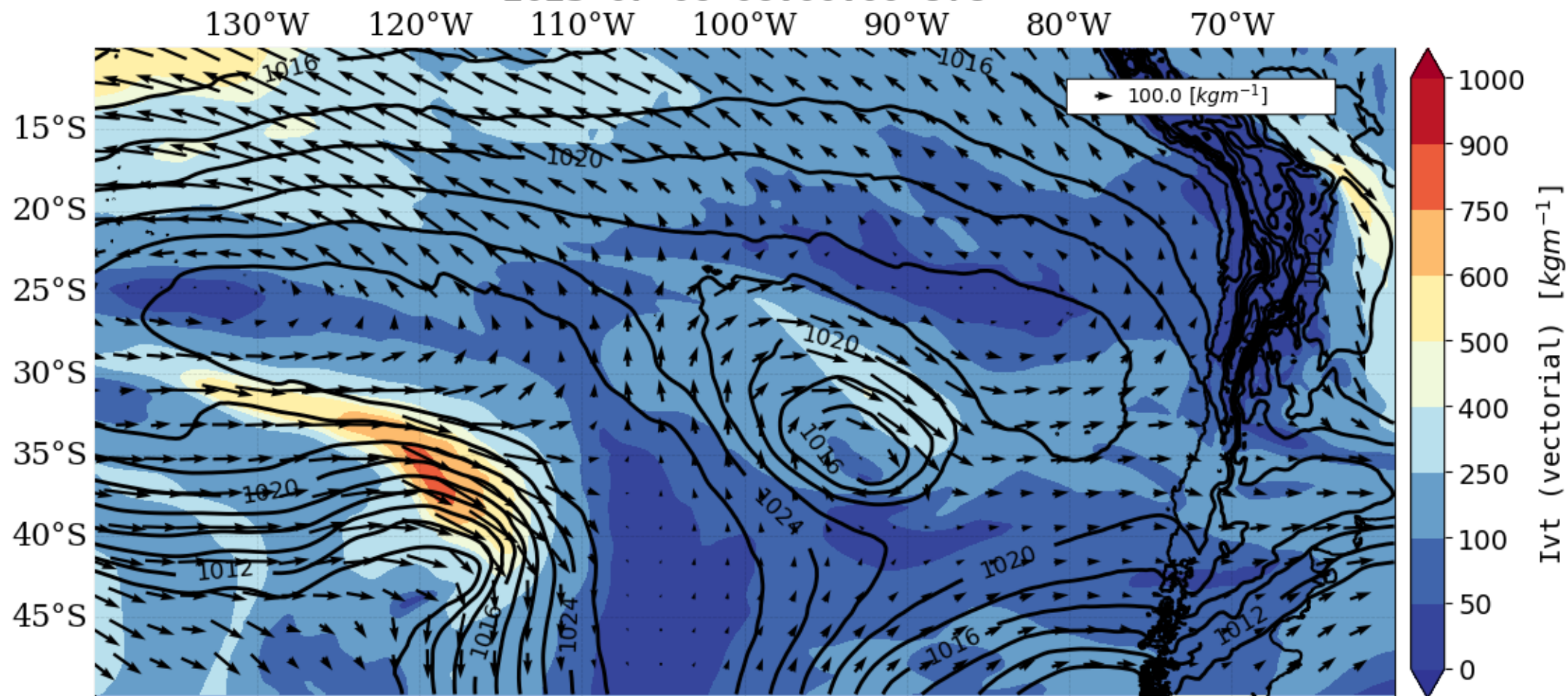


Sombreado: ivt (vectorial) [kgm^{-1}]

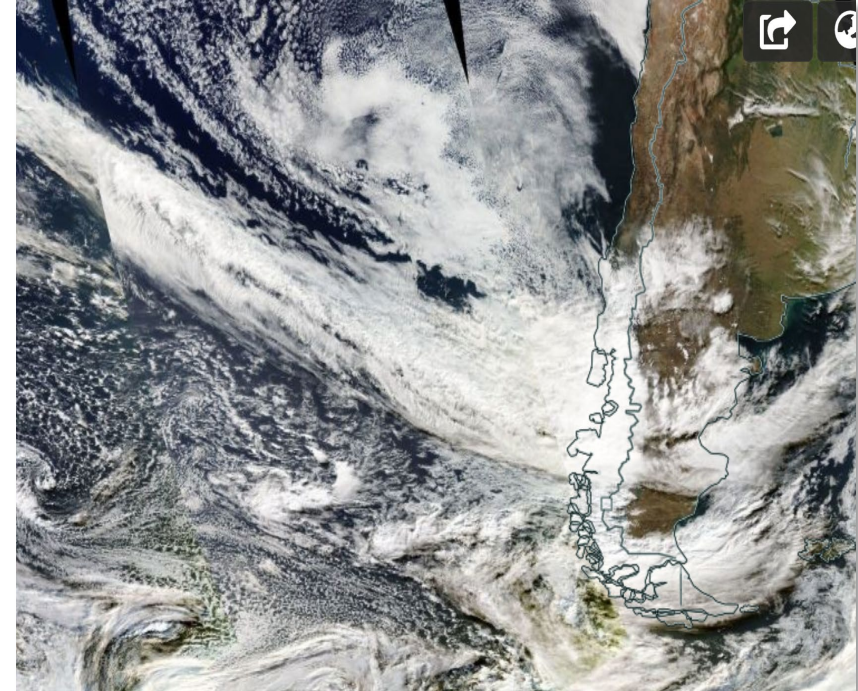
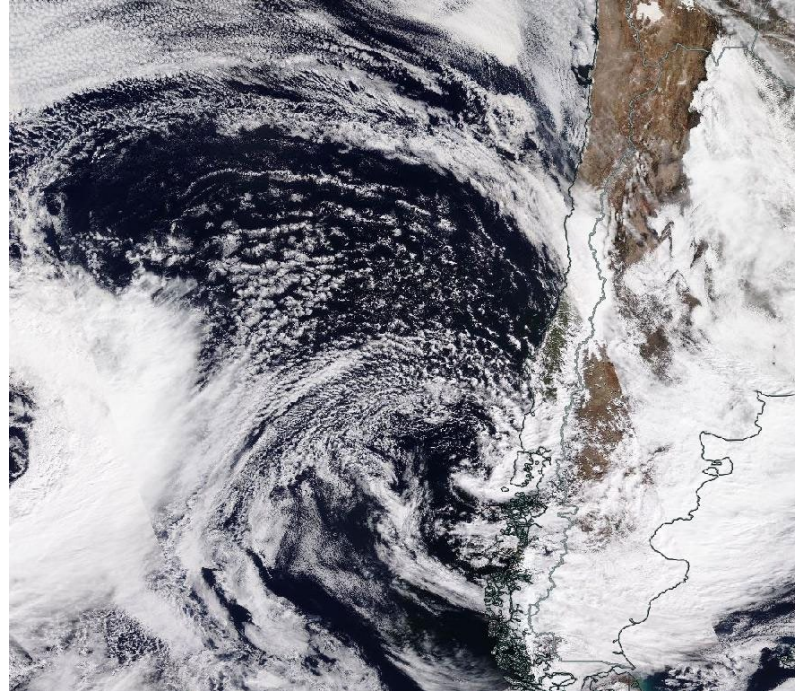
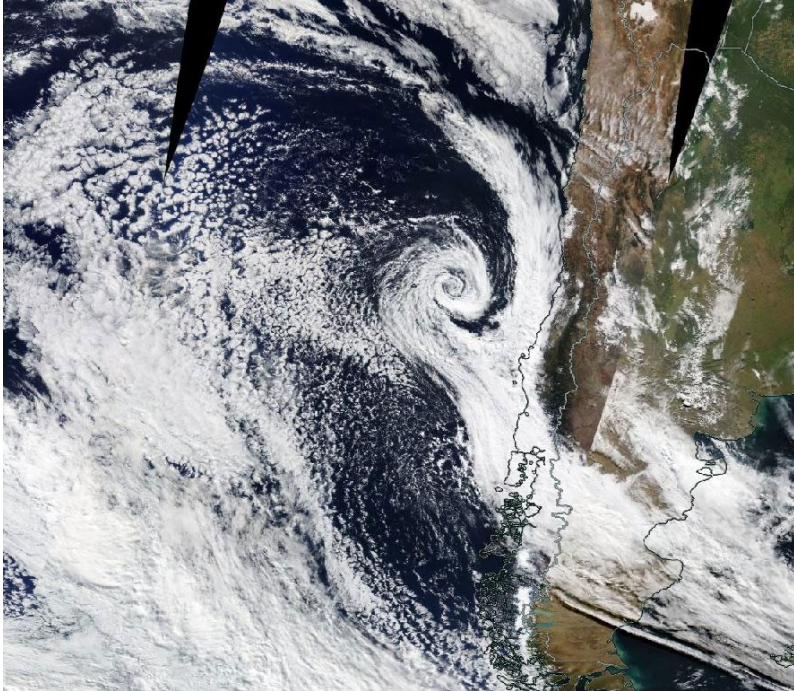
Contornos: presión a nivel del mar [hPa]

Vectores: ivt (vectorial) [kgm^{-1}]

2023-07-06 06:00:00 UTC



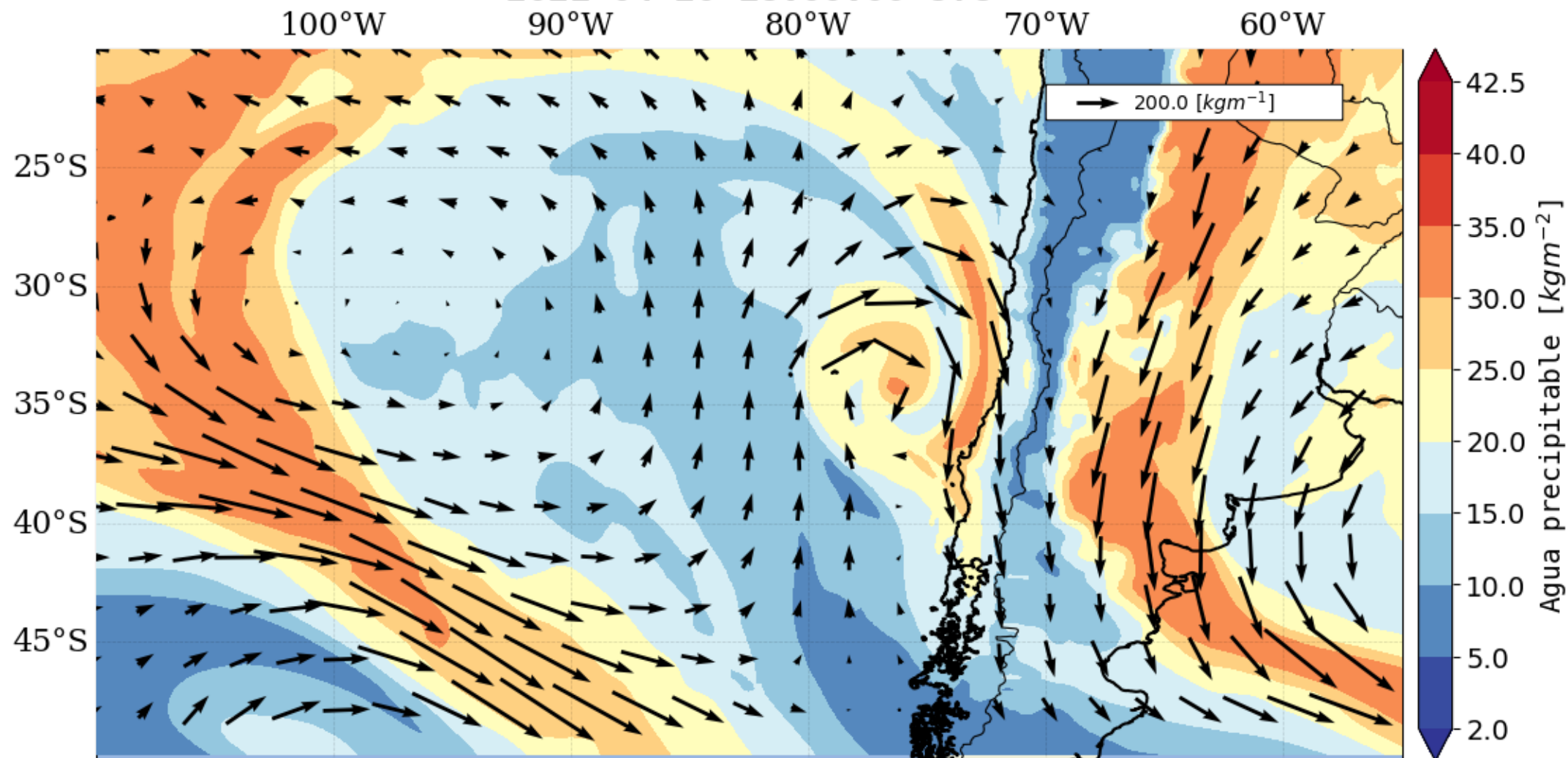
¿Cuál se ve más amenazante?

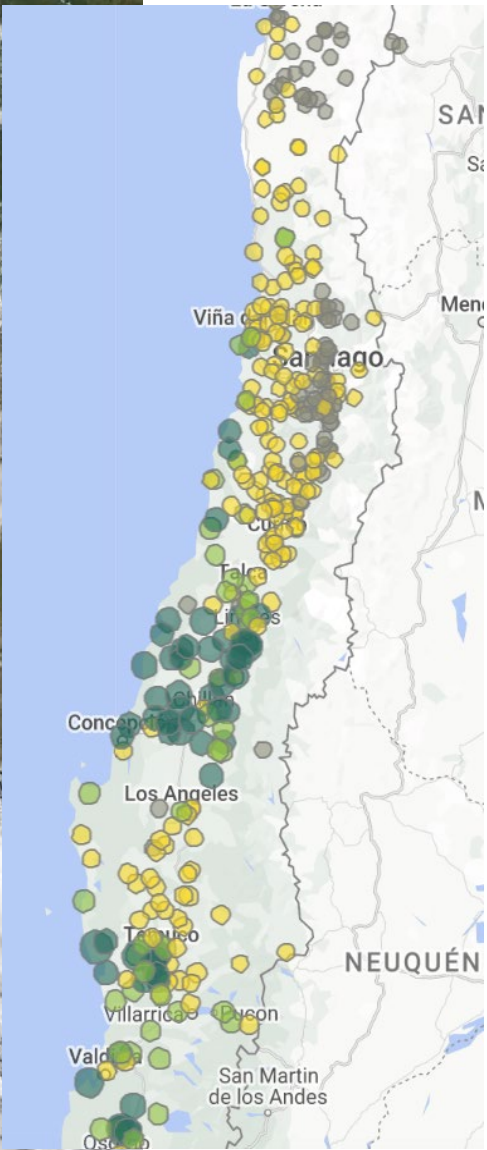
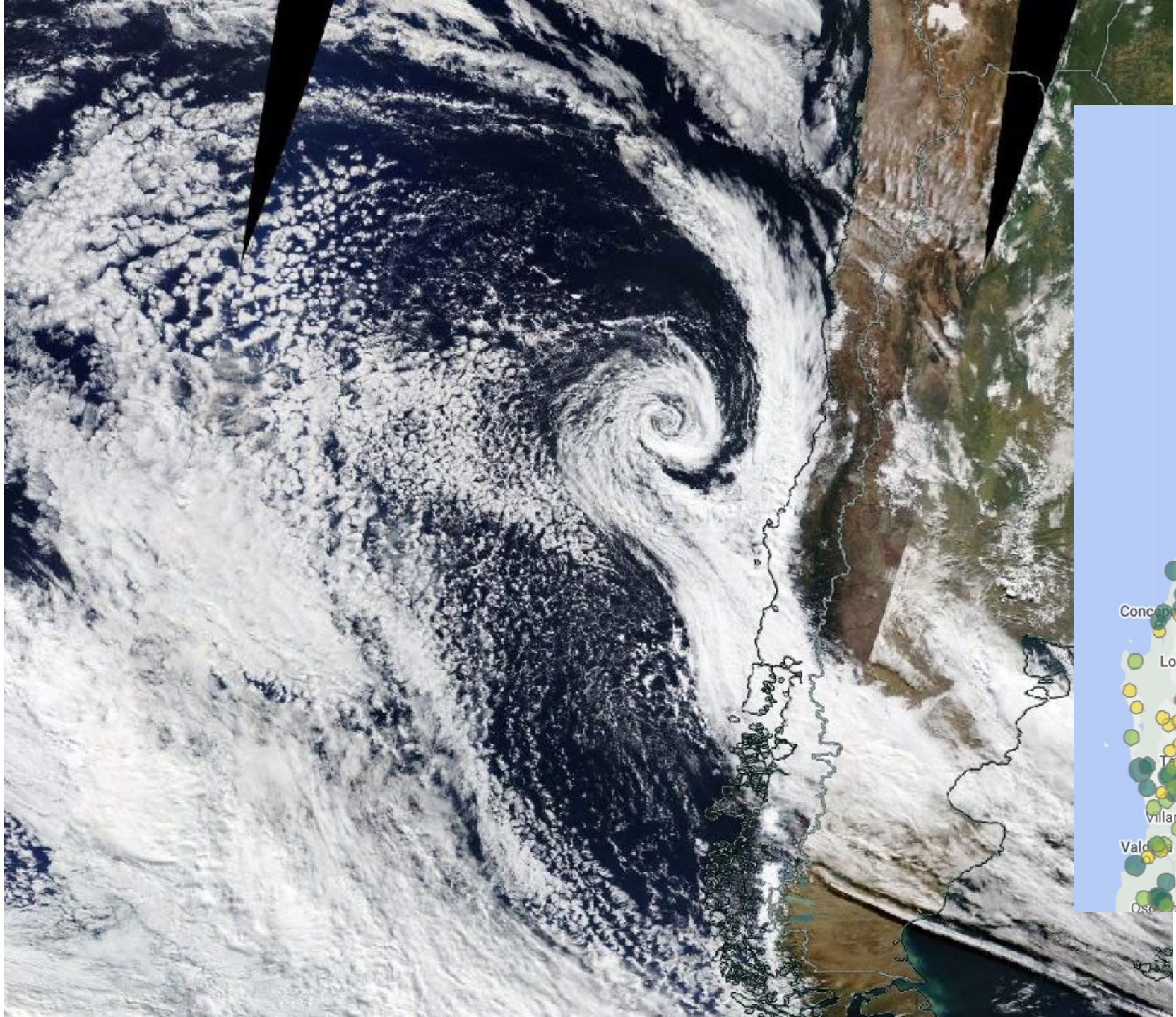


Sombreado: agua precipitable [kgm^{-2}]

Vectores: ivt (vectorial) [kgm^{-1}]

2021-04-20 18:00:00 UTC

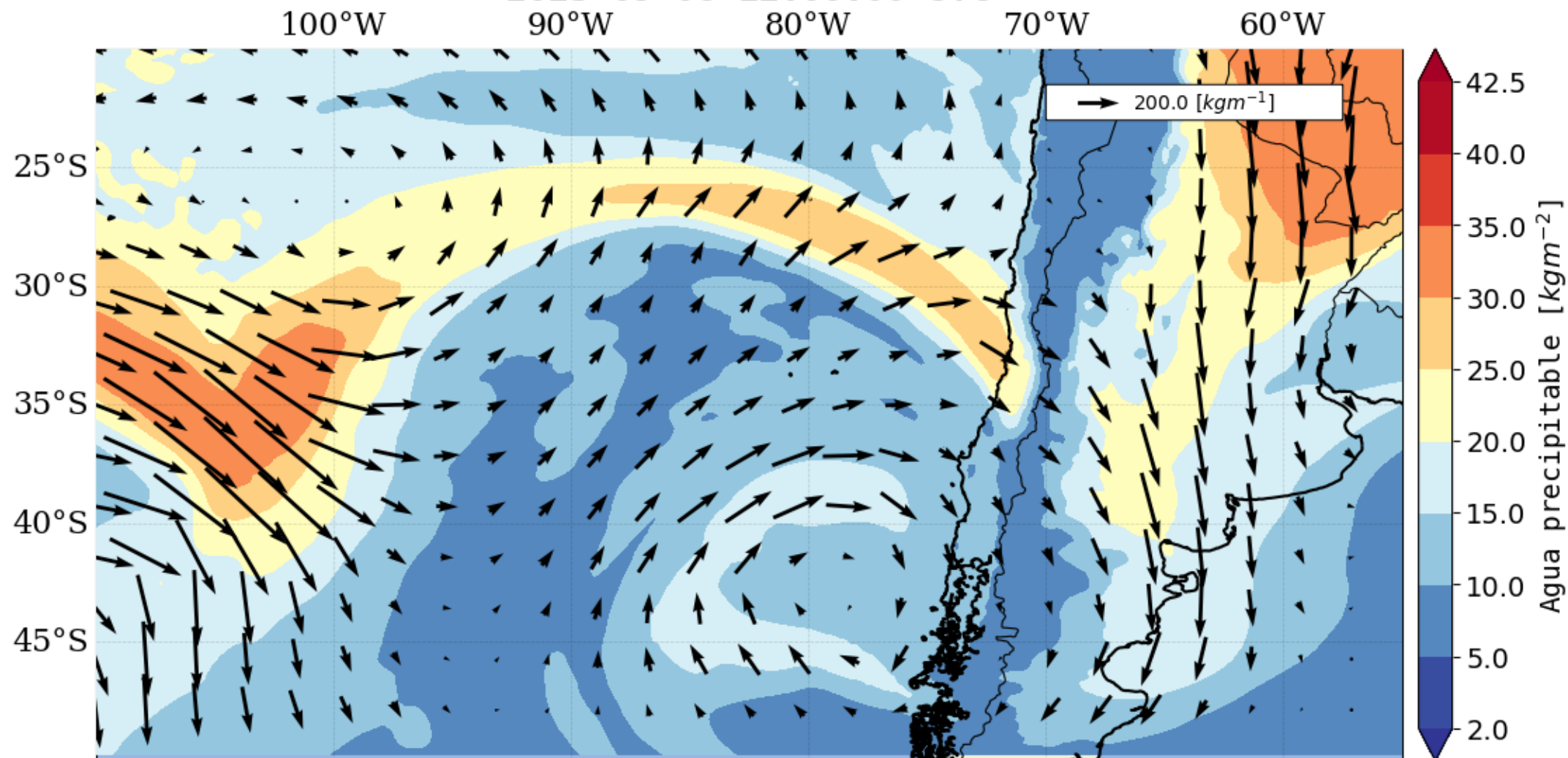


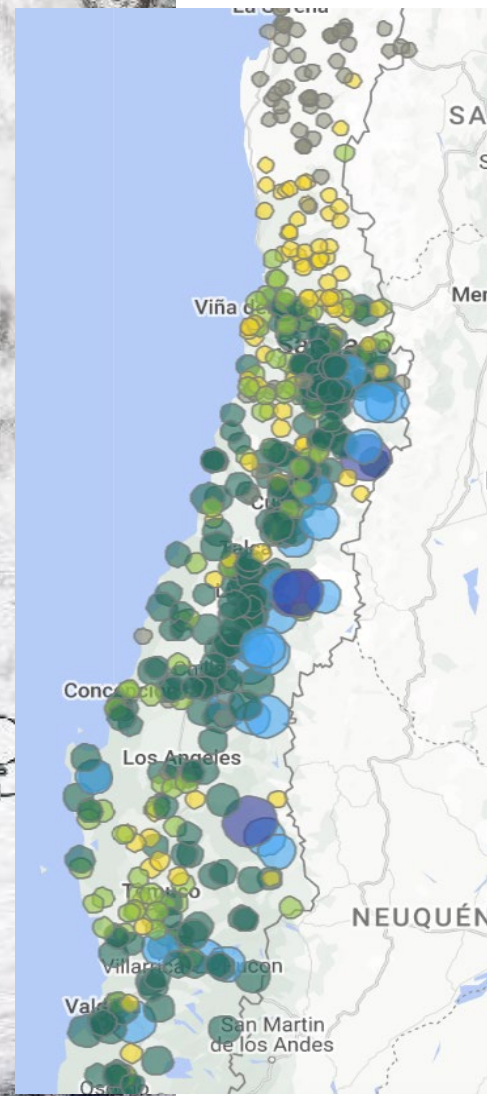
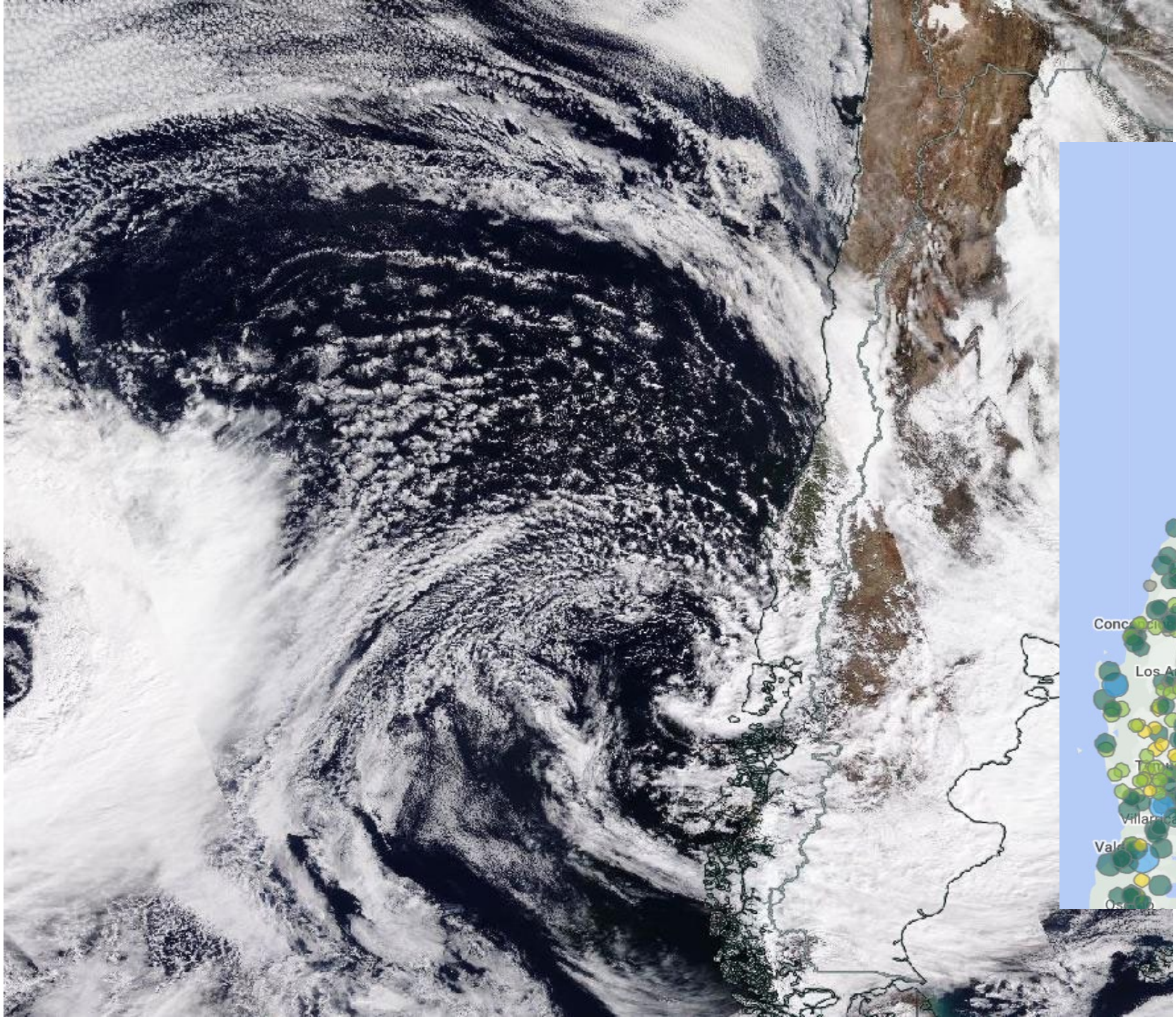


Sombreado: agua precipitable [kgm^{-2}]

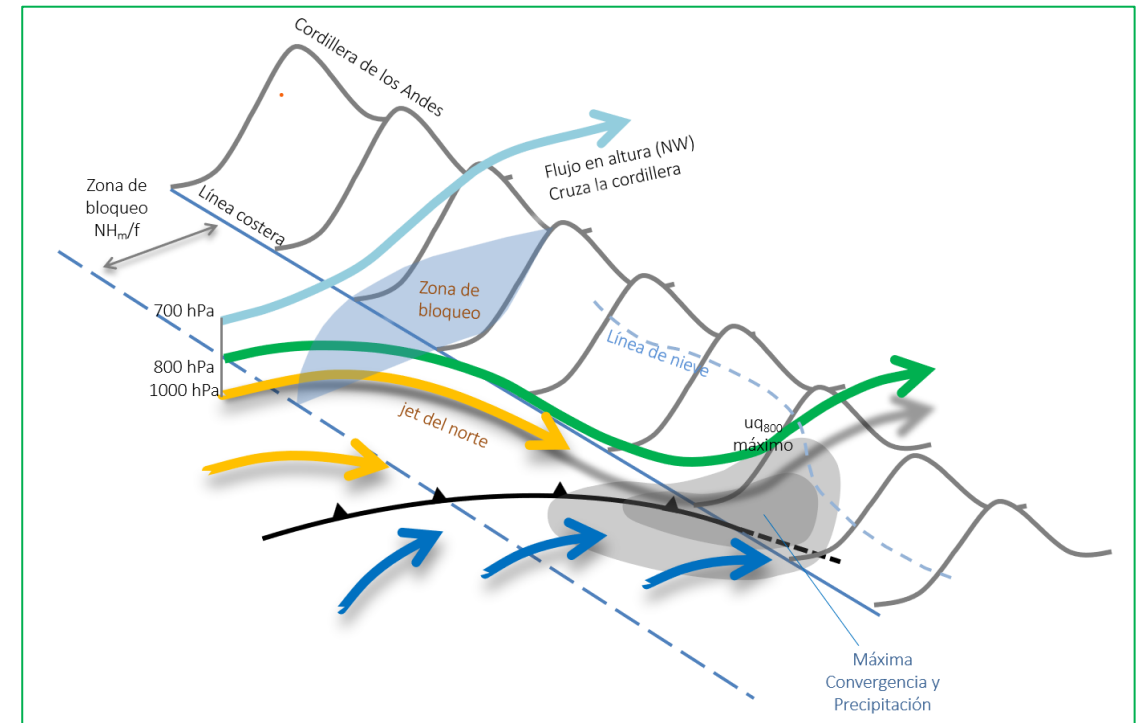
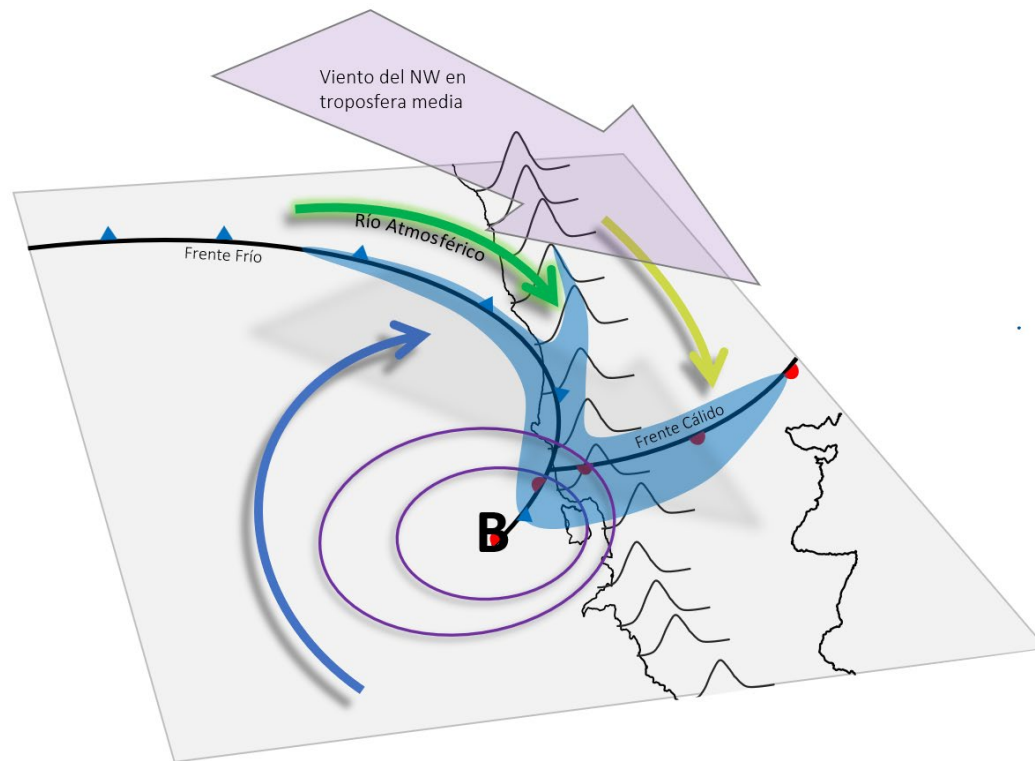
Vectores: ivt (vectorial) [kgm^{-1}]

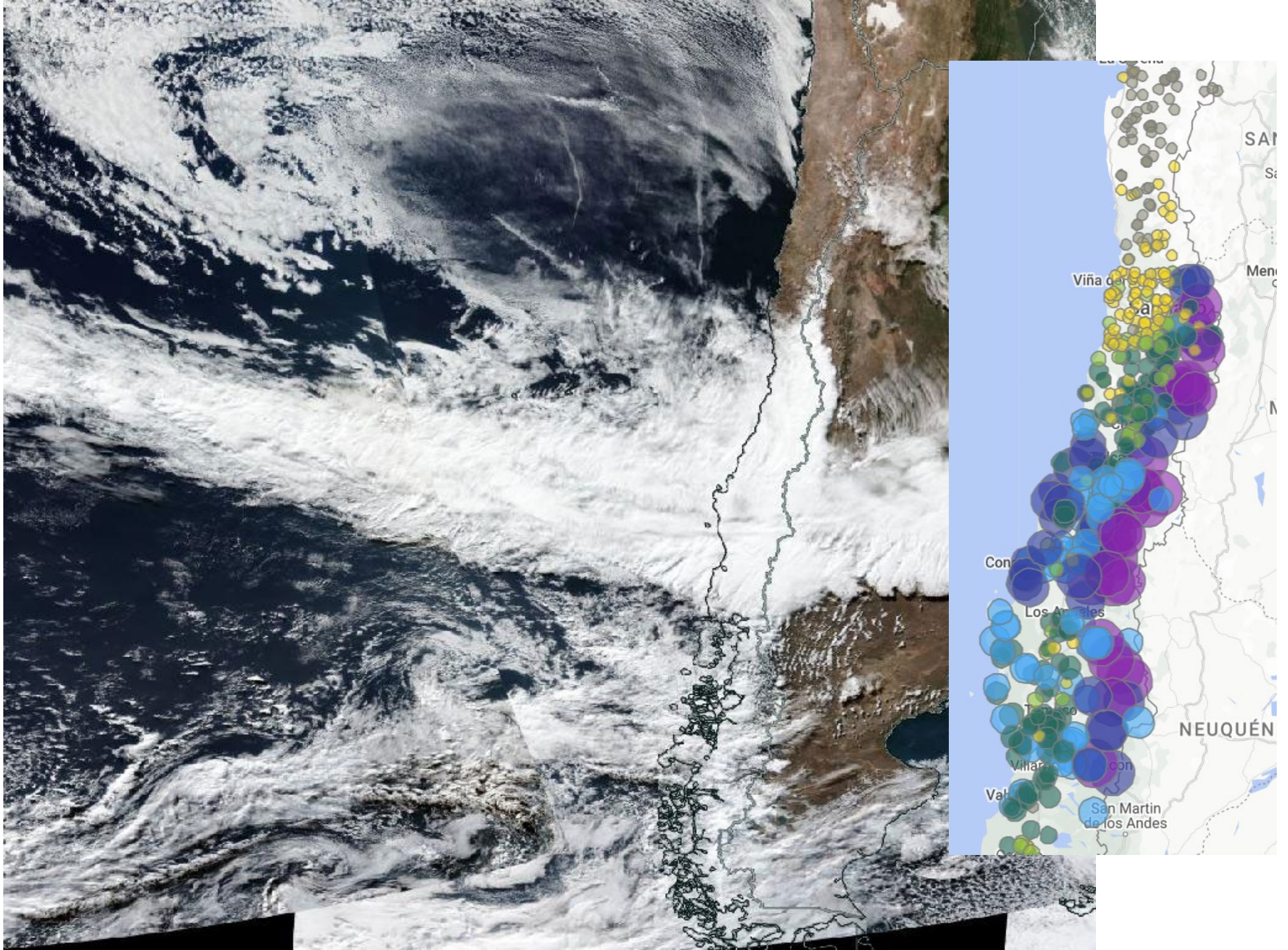
2023-09-06 12:00:00 UTC





Río atmosférico inclinado delante de un frente frío

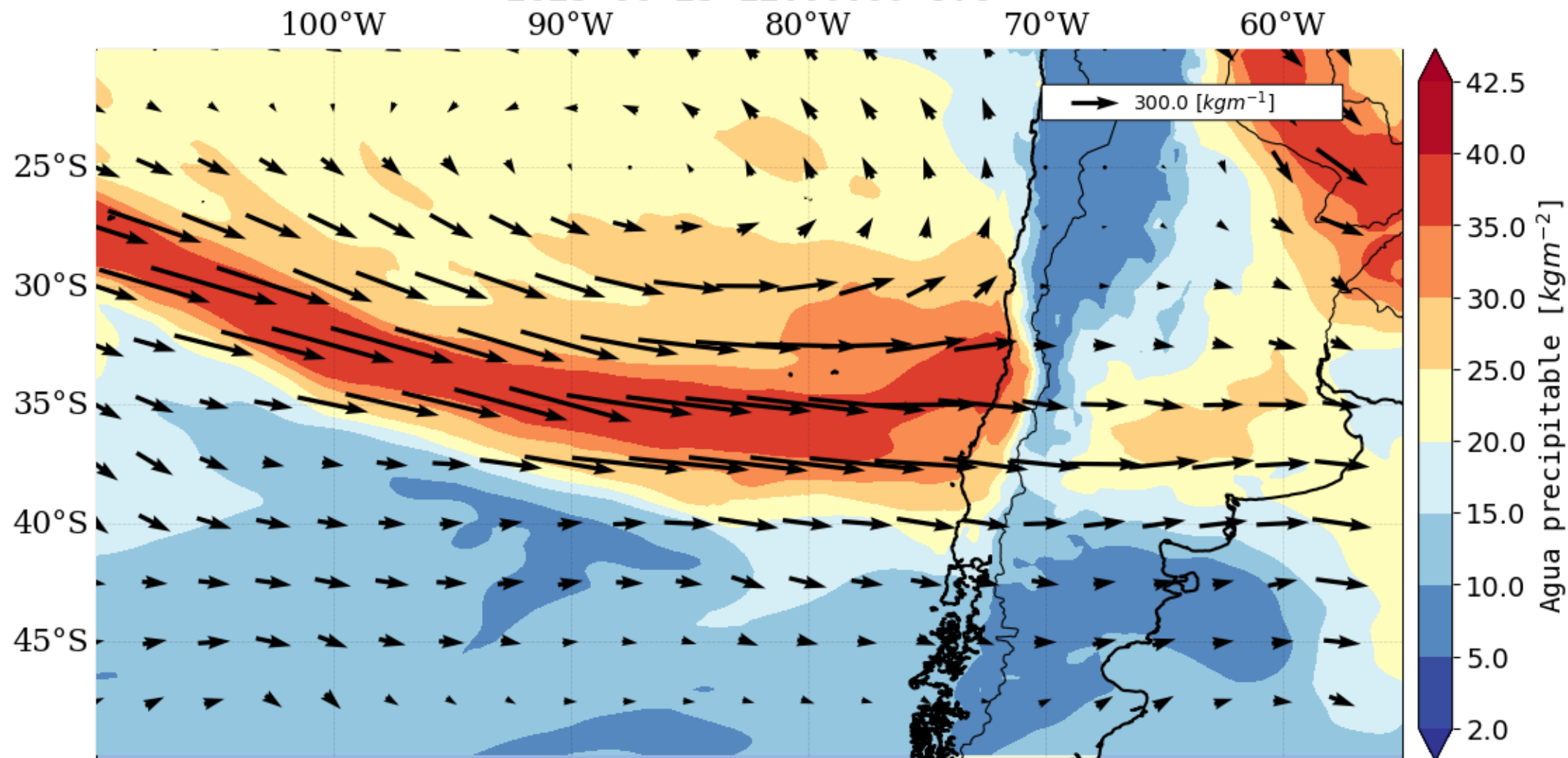




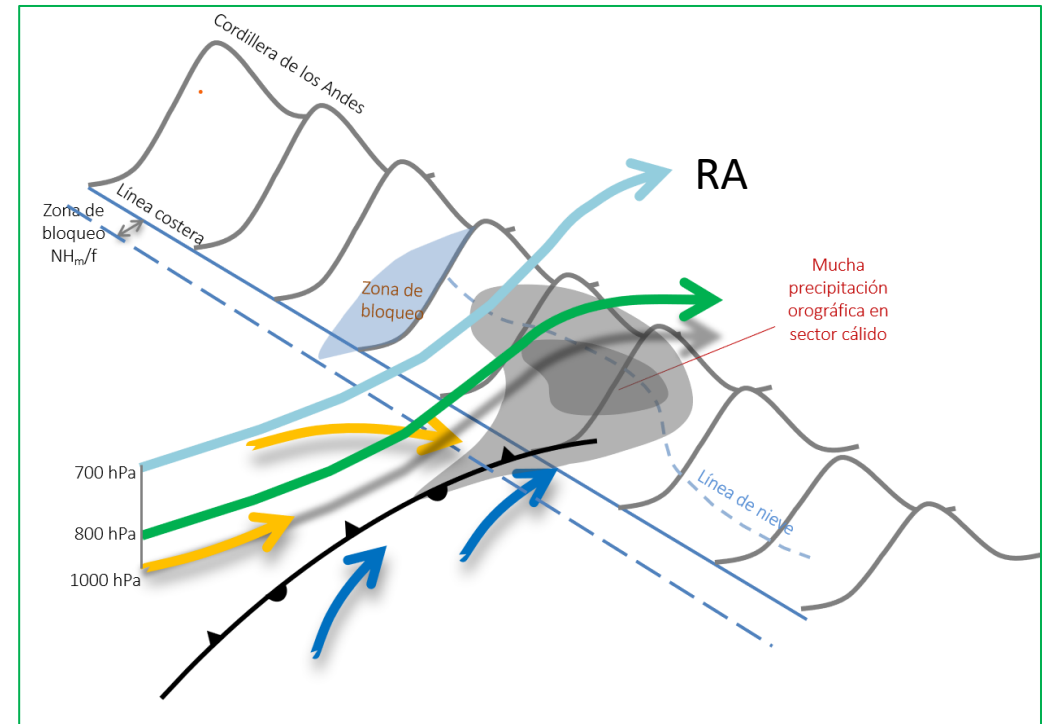
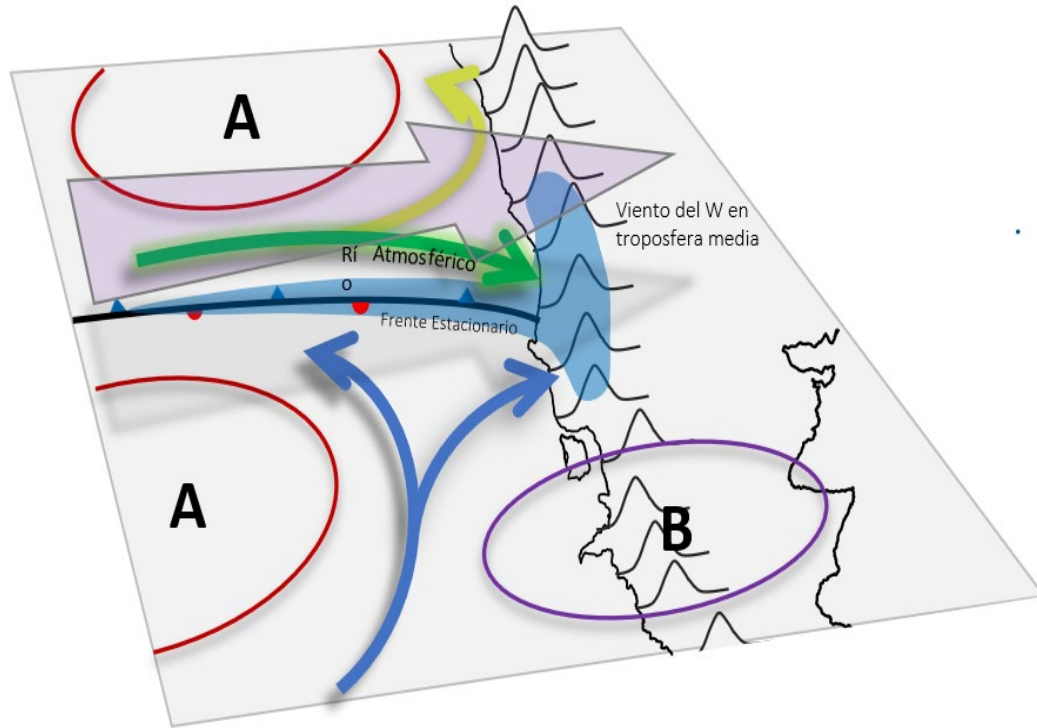
Sombreado: agua precipitable [kgm^{-2}]

Vectores: ivt (vectorial) [kgm^{-1}]

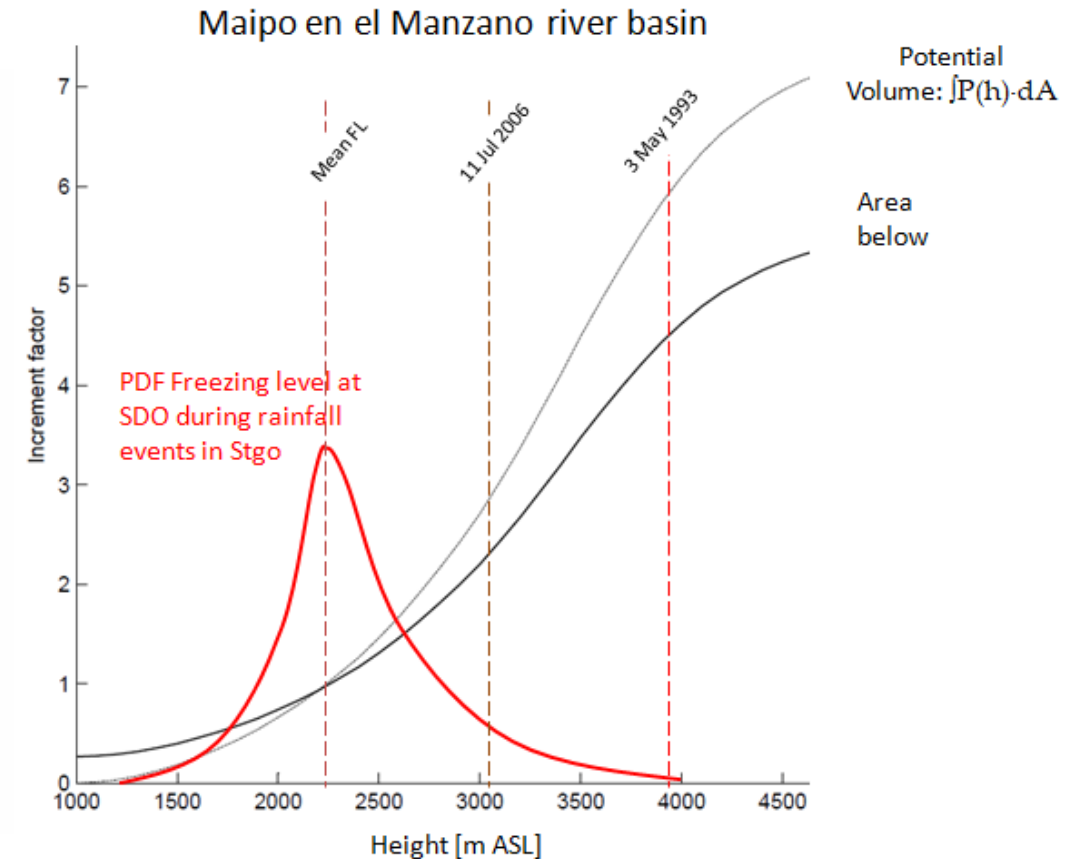
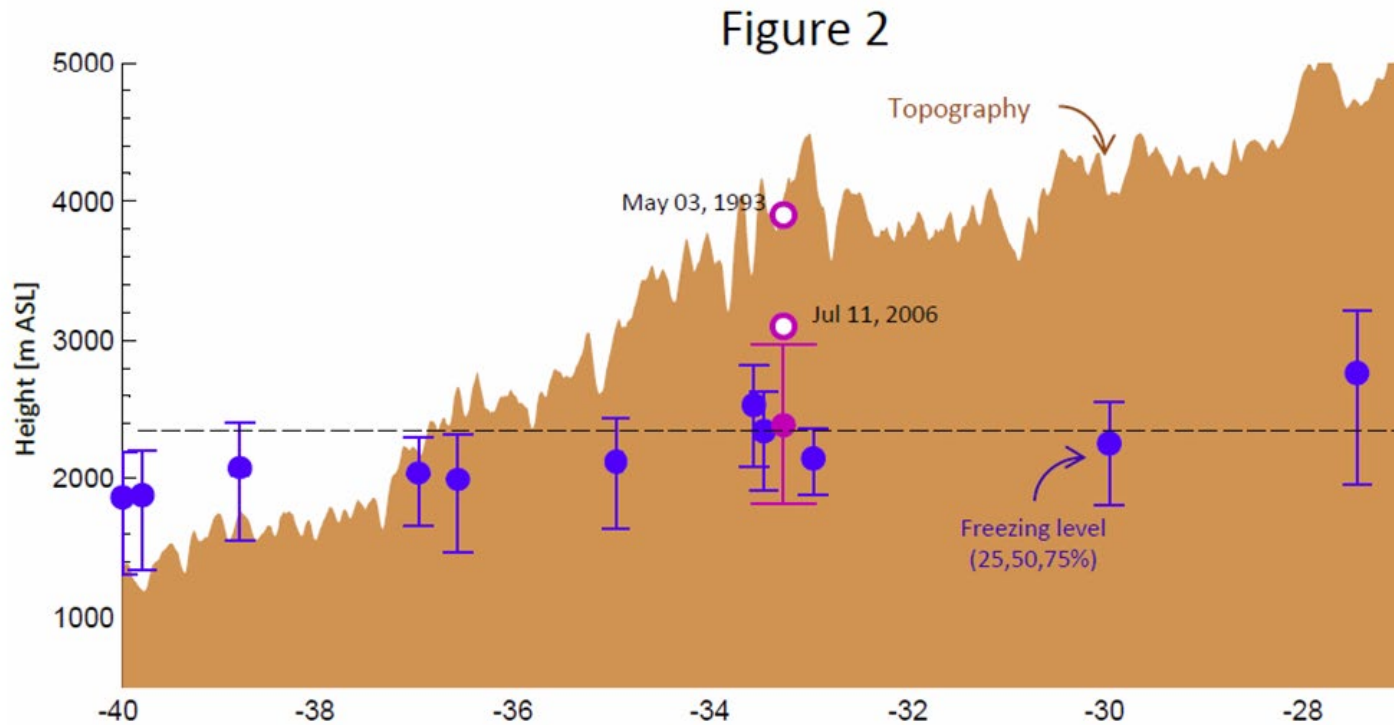
2023-06-23 12:00:00 UTC



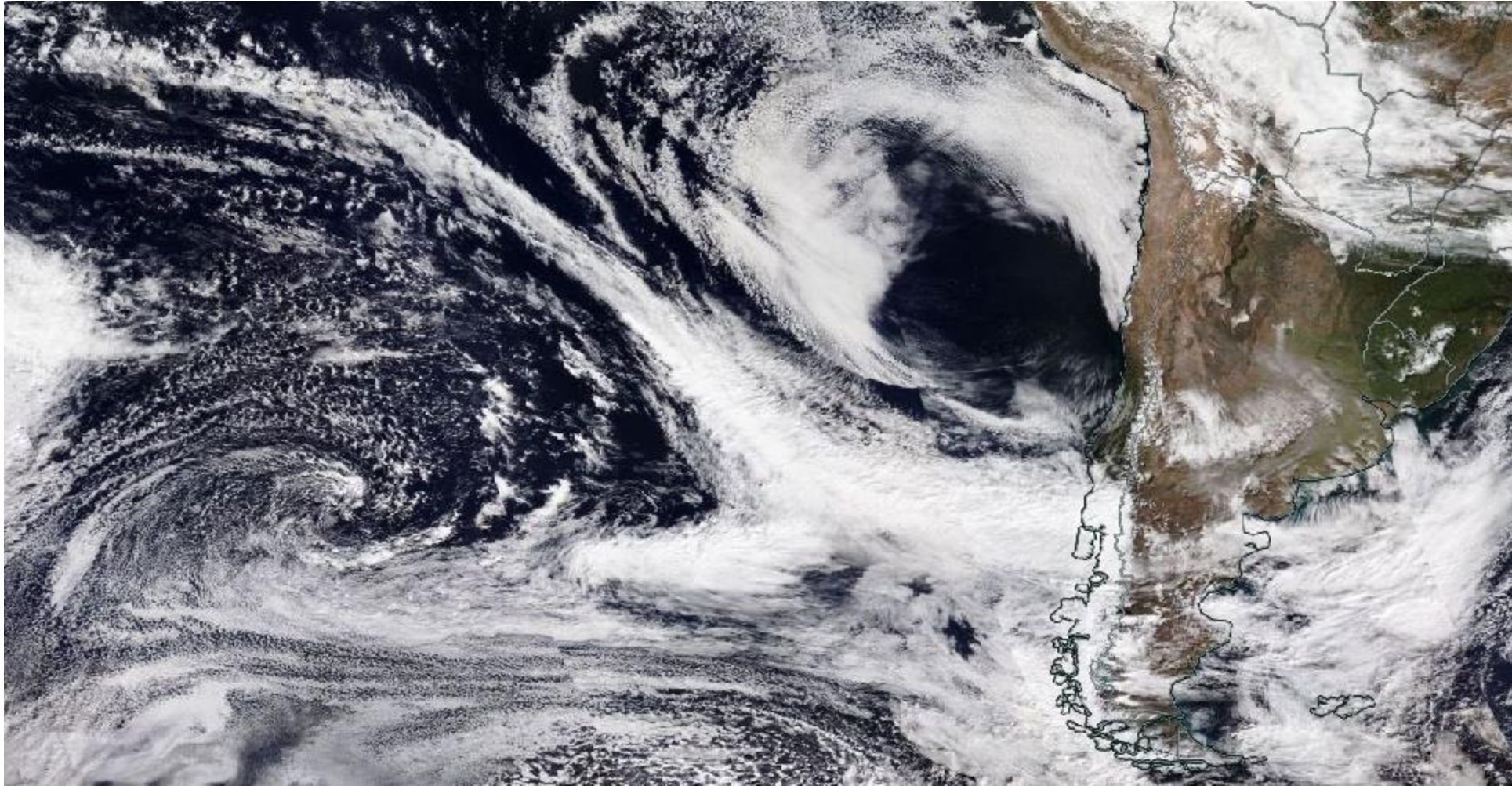
Río atmosférico zonal delante de un frente estacionario (ZAR)



Hydrological impacts – Not only precipitation matters!

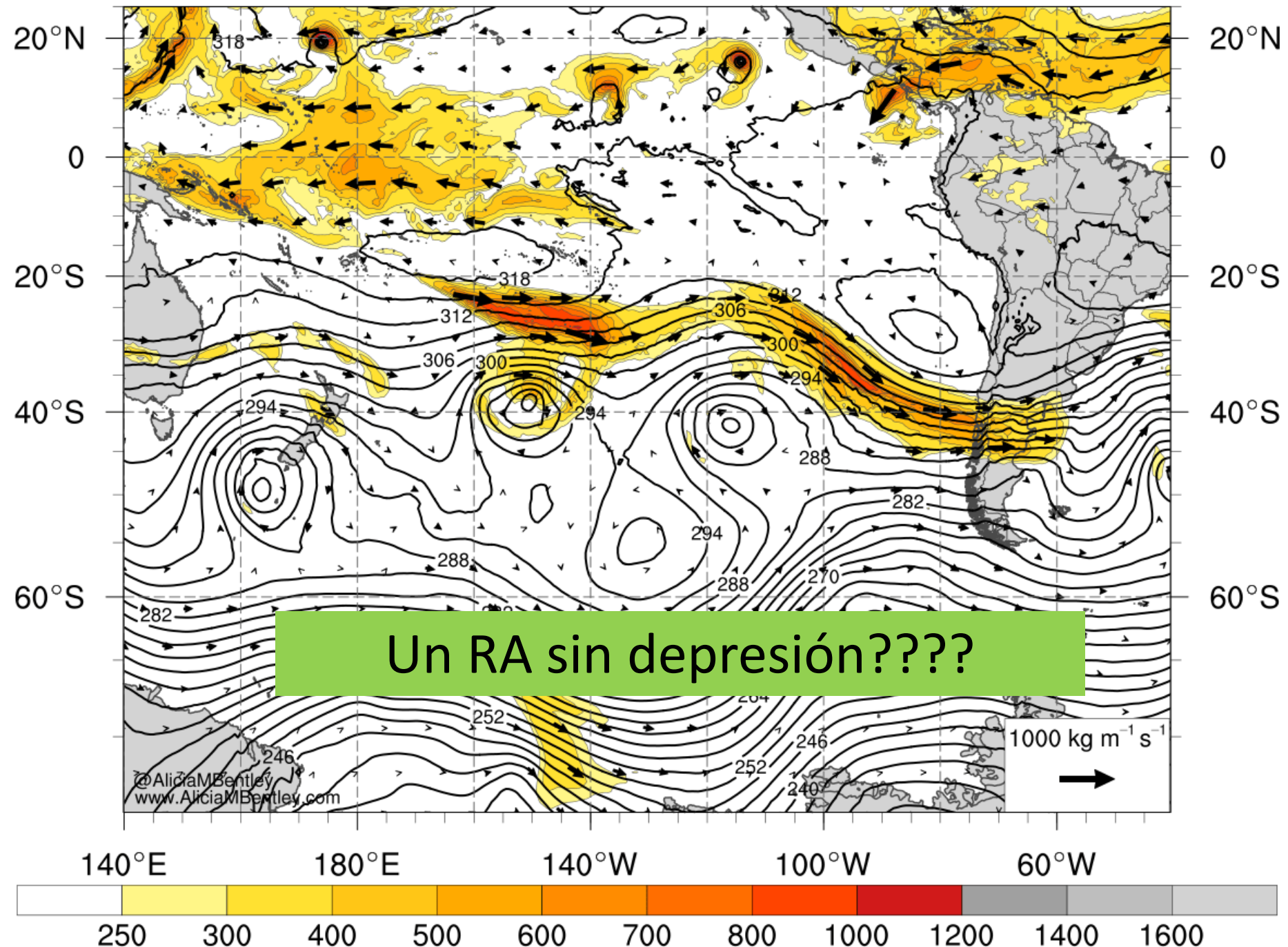


Un RA largo y sin depresión????

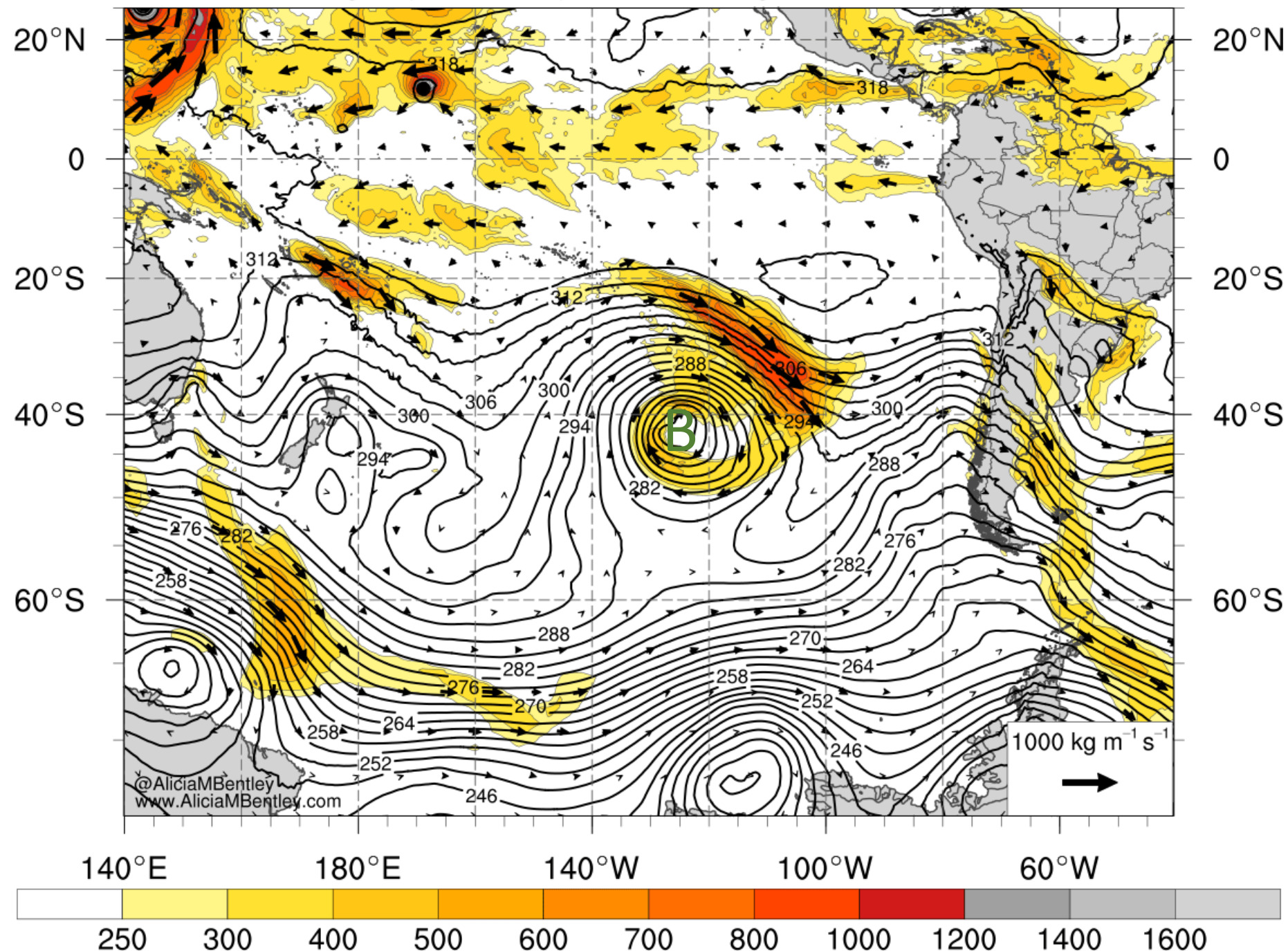


700-hPa geo. height (black, dam), Integrated water vapor transport [IVT] (shaded, kg/m/s) (vectors, kg/m/s)

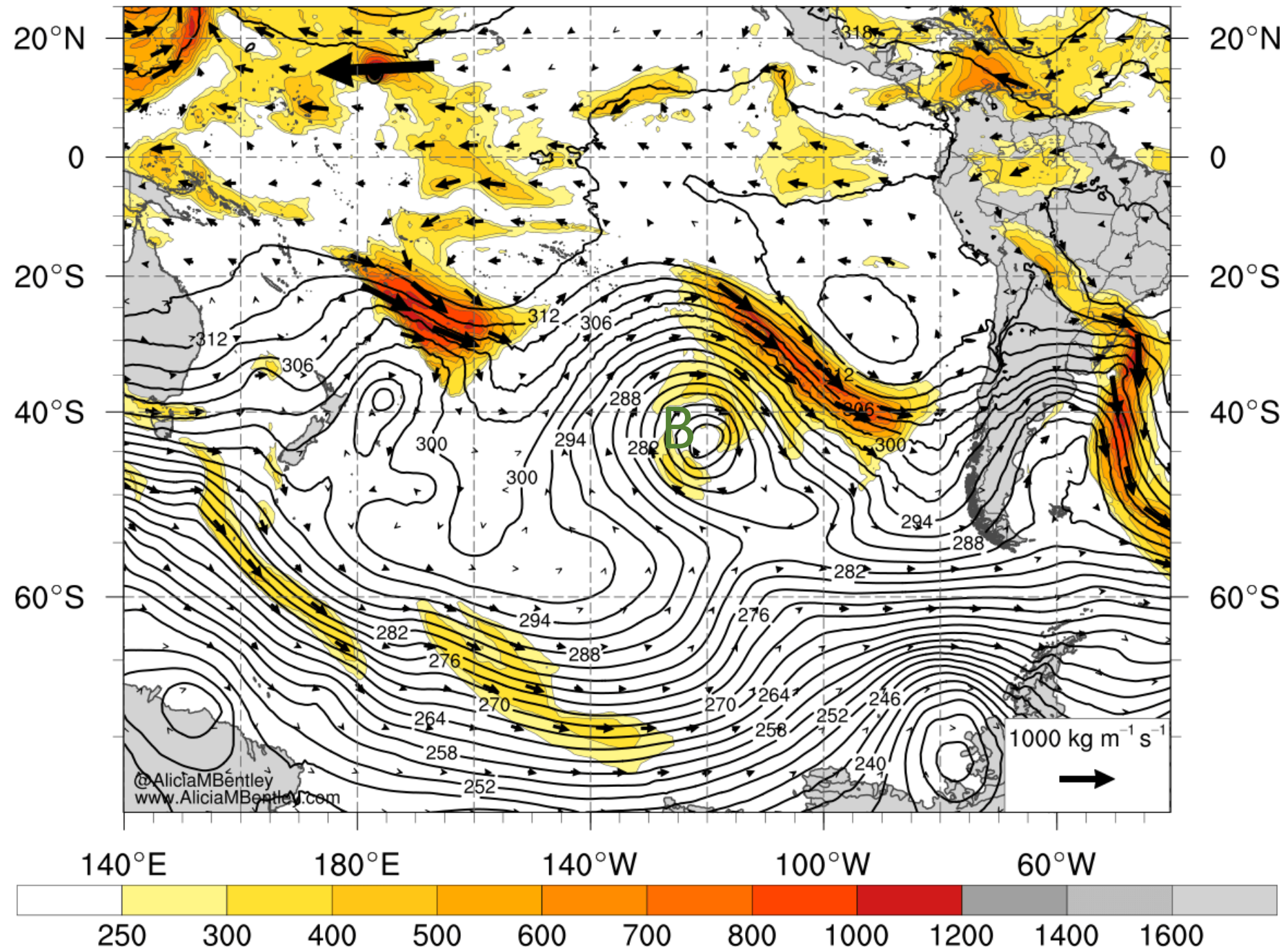
Initialized: 1200 UTC 12 Aug 2023 | Forecast hour: 24 | Valid: 1200 UTC 13 Aug 2023



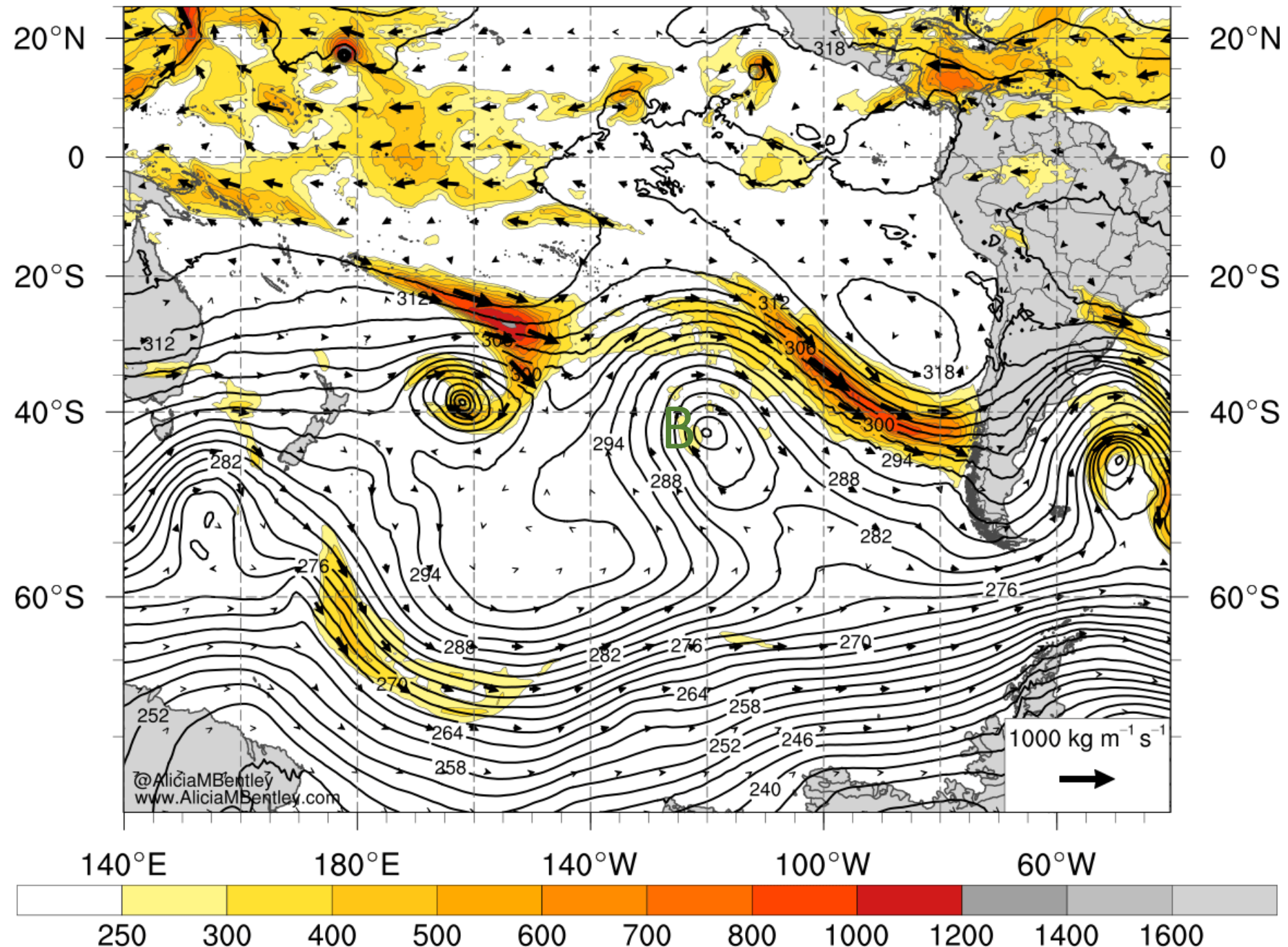
700-hPa geo. height (black, dam), Integrated water vapor transport [IVT] (shaded, kg/m/s) (vectors, kg/m/s)
Initialized: 0600 UTC 10 Aug 2023 | Forecast hour: 0 | Valid: 0600 UTC 10 Aug 2023



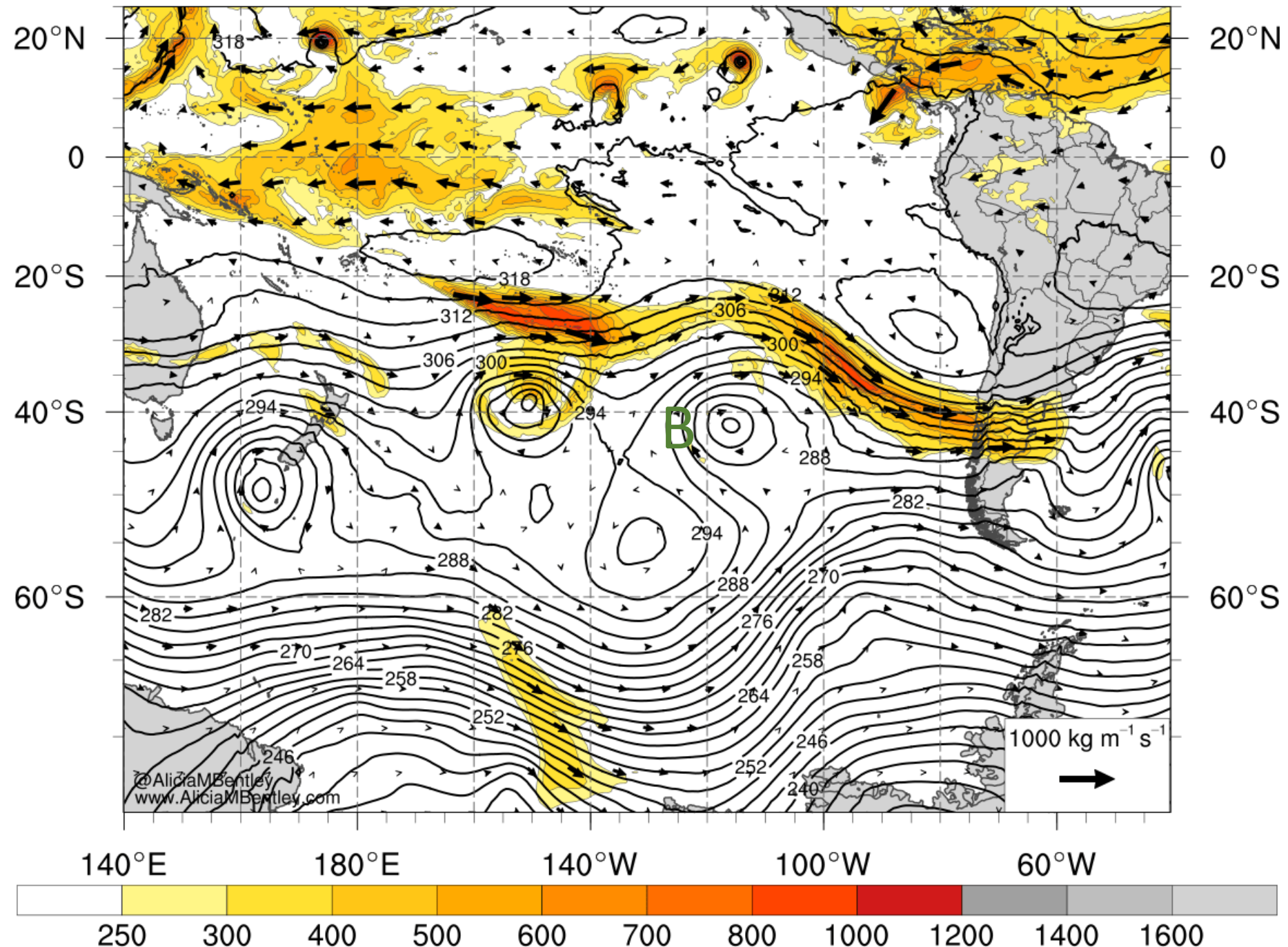
700-hPa geo. height (black, dam), Integrated water vapor transport [IVT] (shaded, kg/m/s) (vectors, kg/m/s)
Initialized: 1200 UTC 11 Aug 2023 | Forecast hour: 0 | Valid: 1200 UTC 11 Aug 2023



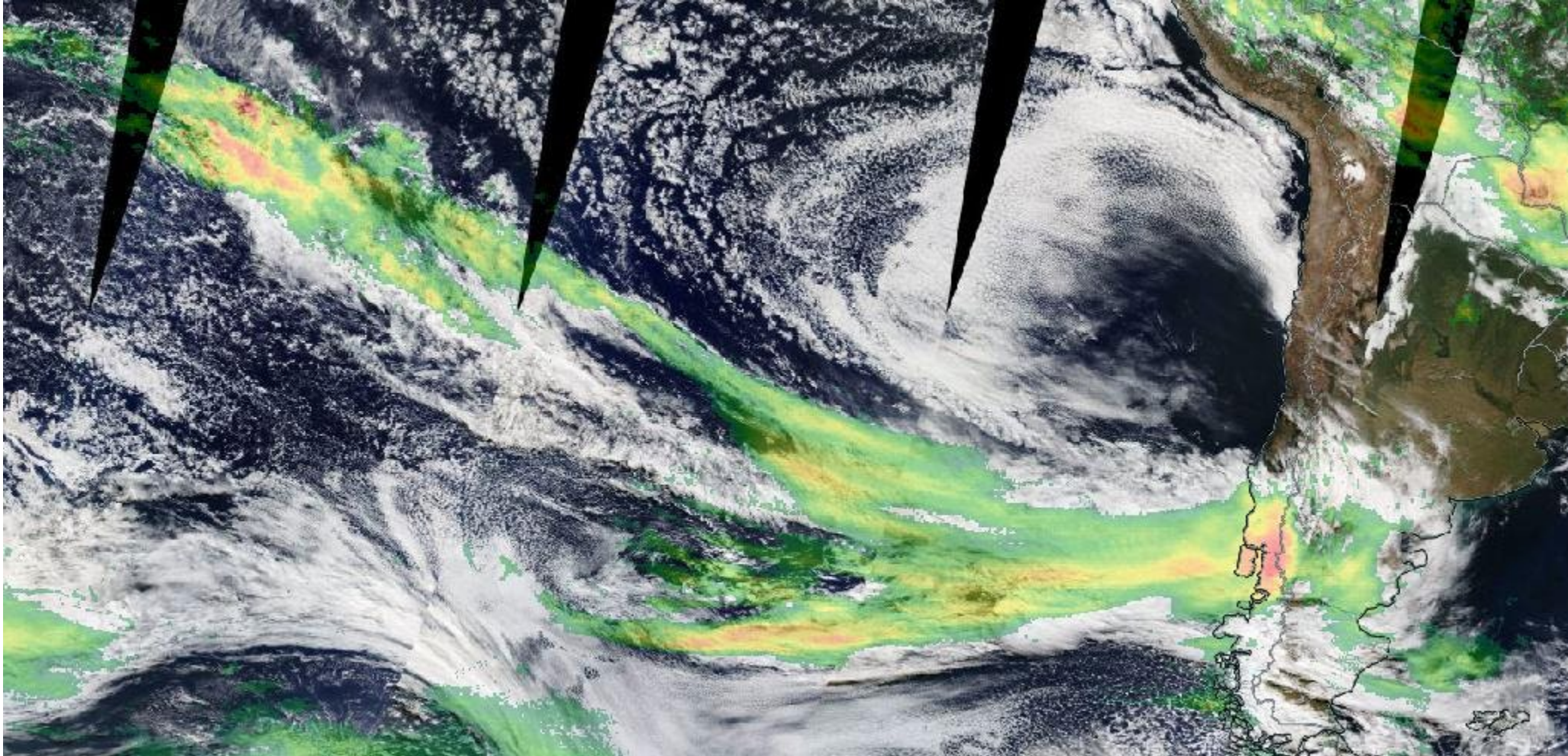
700-hPa geo. height (black, dam), Integrated water vapor transport [IVT] (shaded, kg/m/s) (vectors, kg/m/s)
Initialized: 1200 UTC 12 Aug 2023 | Forecast hour: 0 | Valid: 1200 UTC 12 Aug 2023



700-hPa geo. height (black, dam), Integrated water vapor transport [IVT] (shaded, kg/m/s) (vectors, kg/m/s)
Initialized: 1200 UTC 12 Aug 2023 | Forecast hour: 24 | Valid: 1200 UTC 13 Aug 2023



El misterio del río trabajador (01-Mayo-2019)

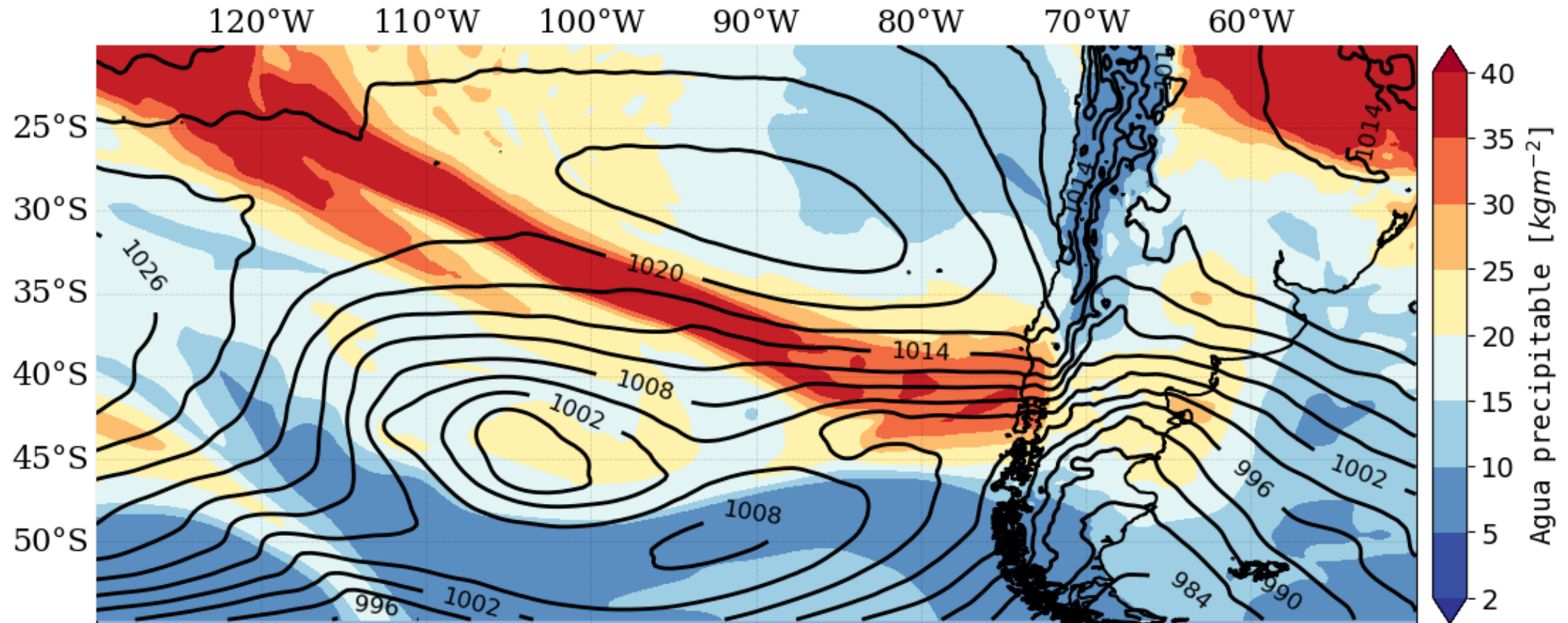


El misterio del río trabajador (01-Mayo-2019)

Sombreado: agua precipitable [kgm^{-2}]

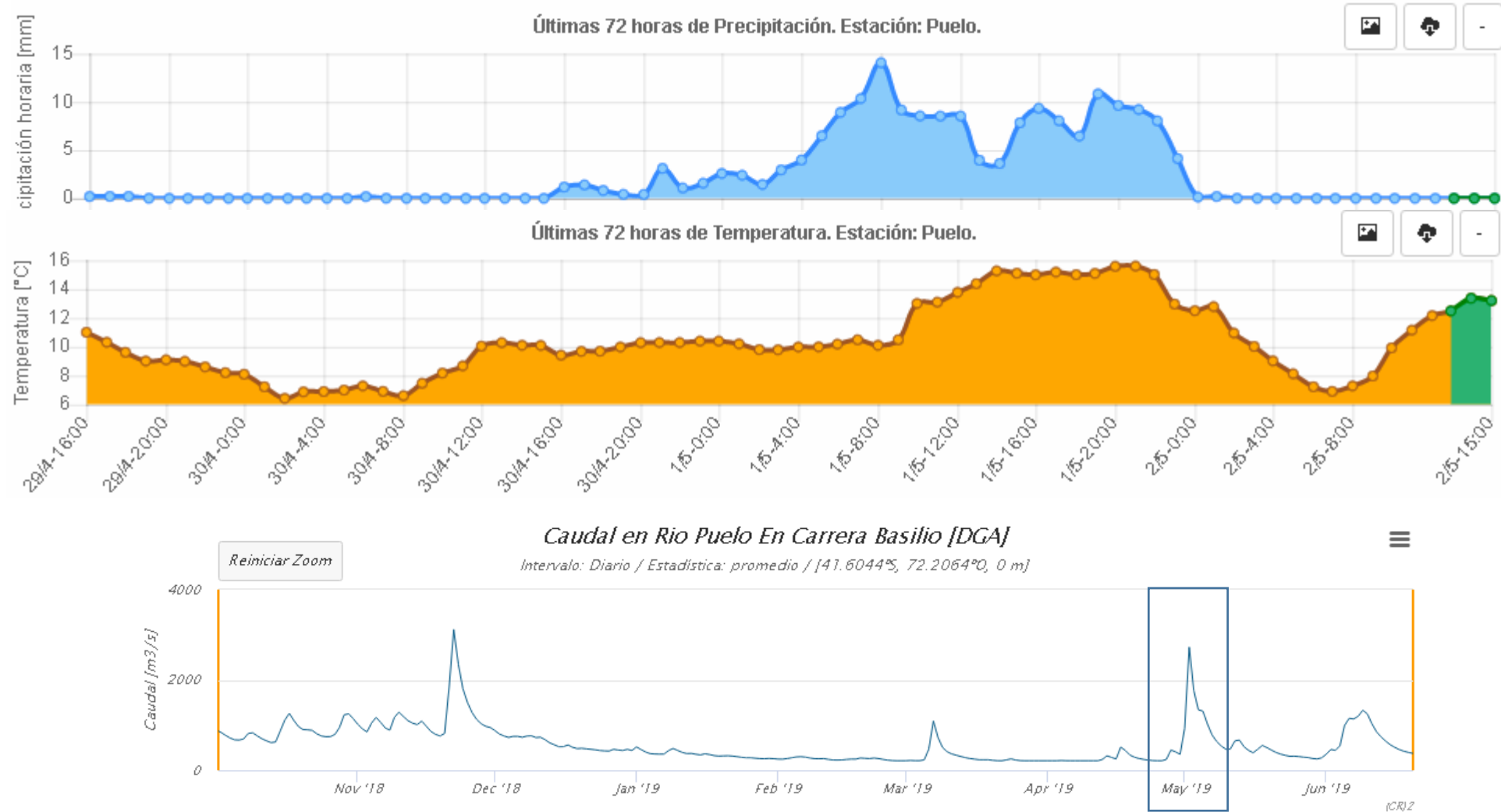
Contornos: presión a nivel del mar [hPa]

2019-05-01 18:00:00 UTC



R-Explorer | (CR)2 - Universidad de Chile | Datos ERA5

Zonal Atmospheric River / Warm Storm ☹️



Another example....May 1st 2019

Alerta roja en Puerto Montt: Desborde de río, dos muertos y clases suspendidas por temporal

La Onemi también informa además que hay 81 personas damnificadas en la Región de Los Lagos producto de las precipitaciones.

Temporal en Los Lagos deja 477 damnificados, 64 viviendas con daños y conectividad es el área más afectada

El subsecretario del Interior, Rodrigo Ubilla, además aclaró que los fallecidos reportados ayer "no tienen relación directa con las emergencias climáticas".

02 de Mayo de 2019 | 10:52 | Redactada por Juan Peña, Emol

NACIONAL

Onemi convoca comité de emergencia por intenso temporal en la Región de Los Lagos

La gran cantidad de agua acumulada ha generado problemas en la zona de Cochamó.

01 de Mayo de 2019 17:16

por ENRIQUE FUENZALIDA



Credito: Twitter: @Saesa_



Uno de os sectores afectados en Cochamó.



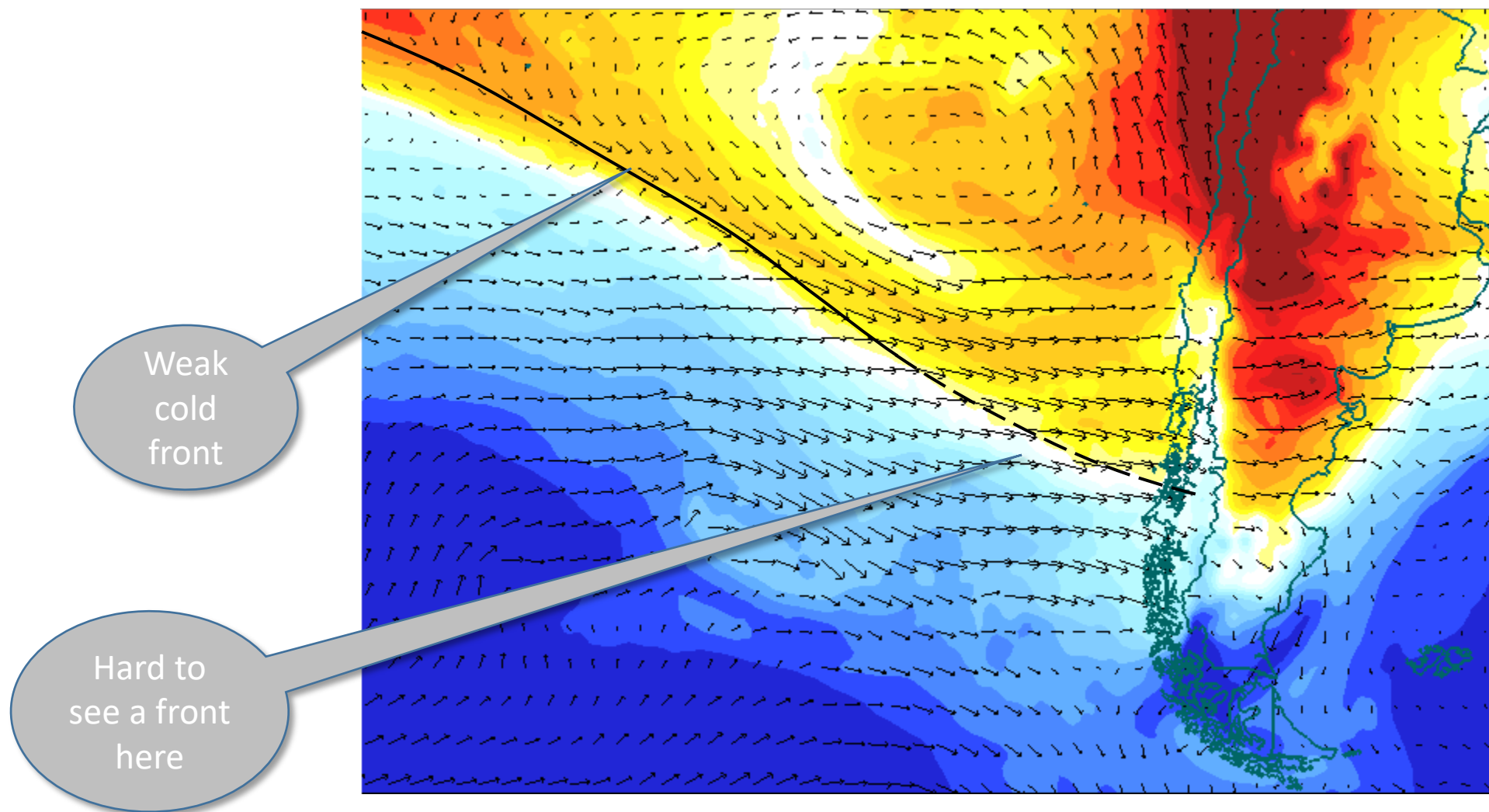
Twitter MOP Los Lagos



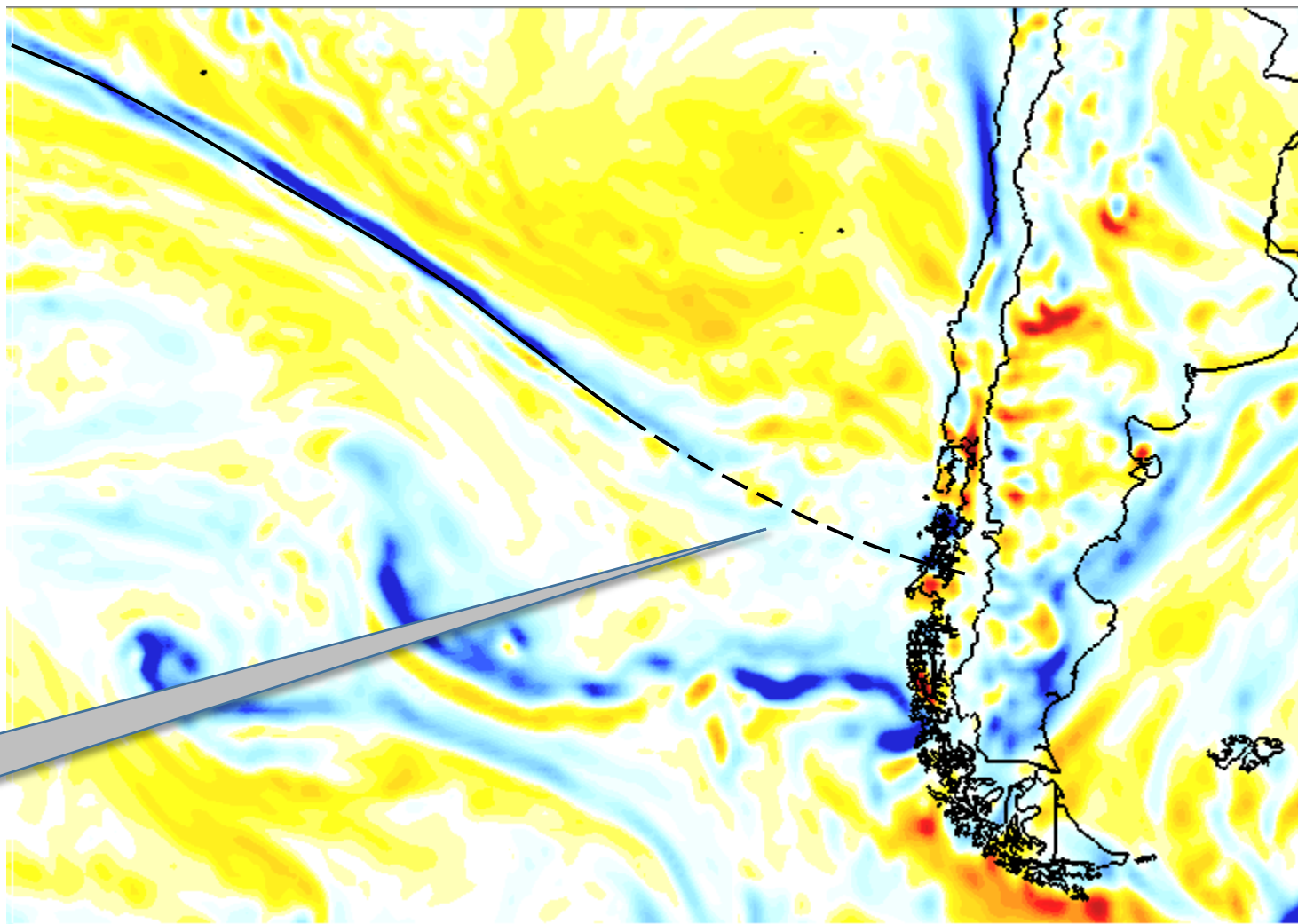
Anegamientos y diversos deslizamientos de tierra ha producido el temporal que afecta a la Región de Los Lagos durante la jornada de este miércoles.

La Oficina Nacional de Emergencia (Onemi) conformó un comité de emergencia en la ciudad de Puerto Montt para enfrentar la compleja situación que se vive en la zona.

950 hPa wind vectors and air temperature (0 – 20°C)

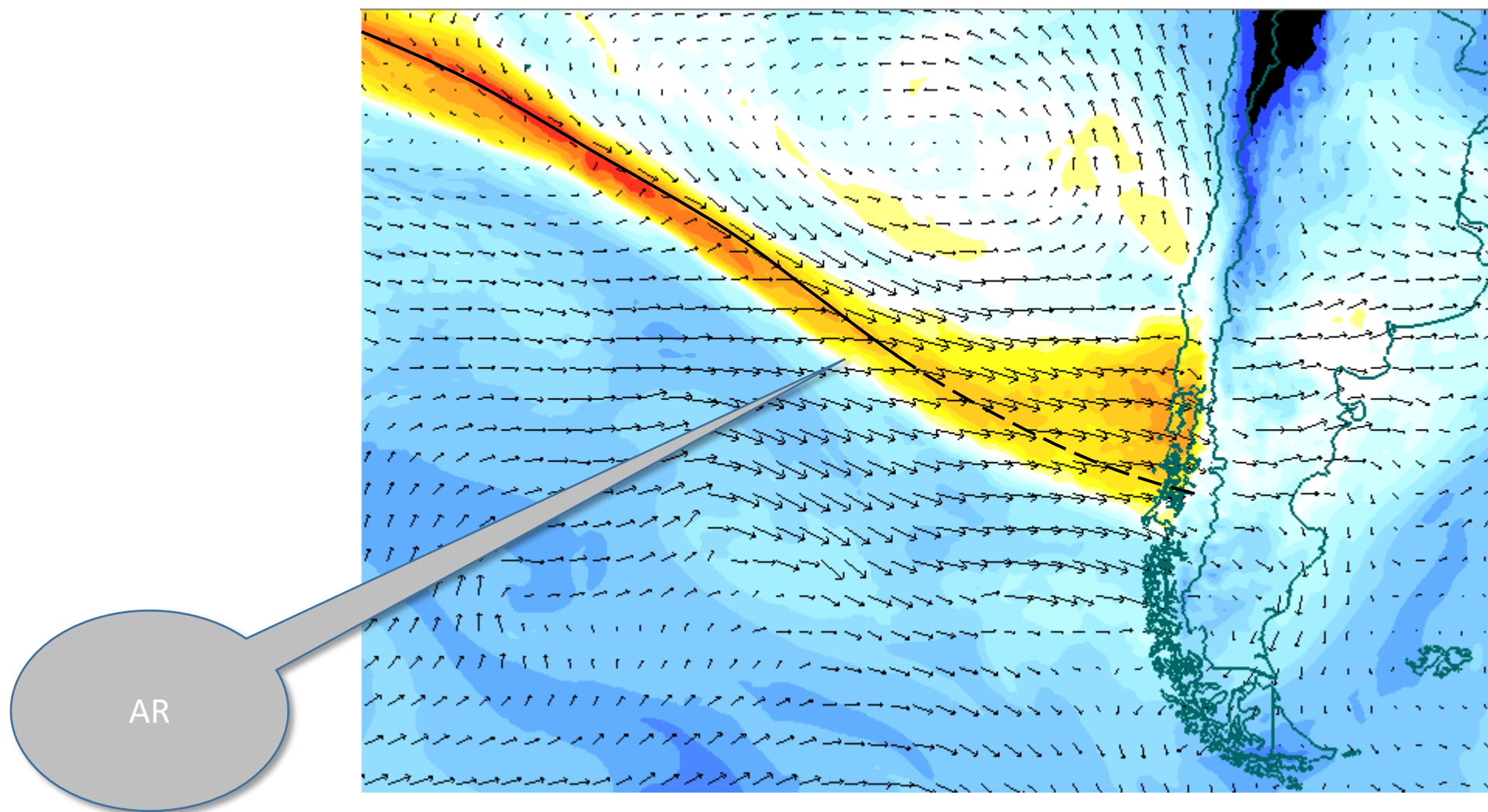


950 hPa relative vorticity ($\pm 1.5 \cdot 10^{-6} \text{ s}^{-1}$)

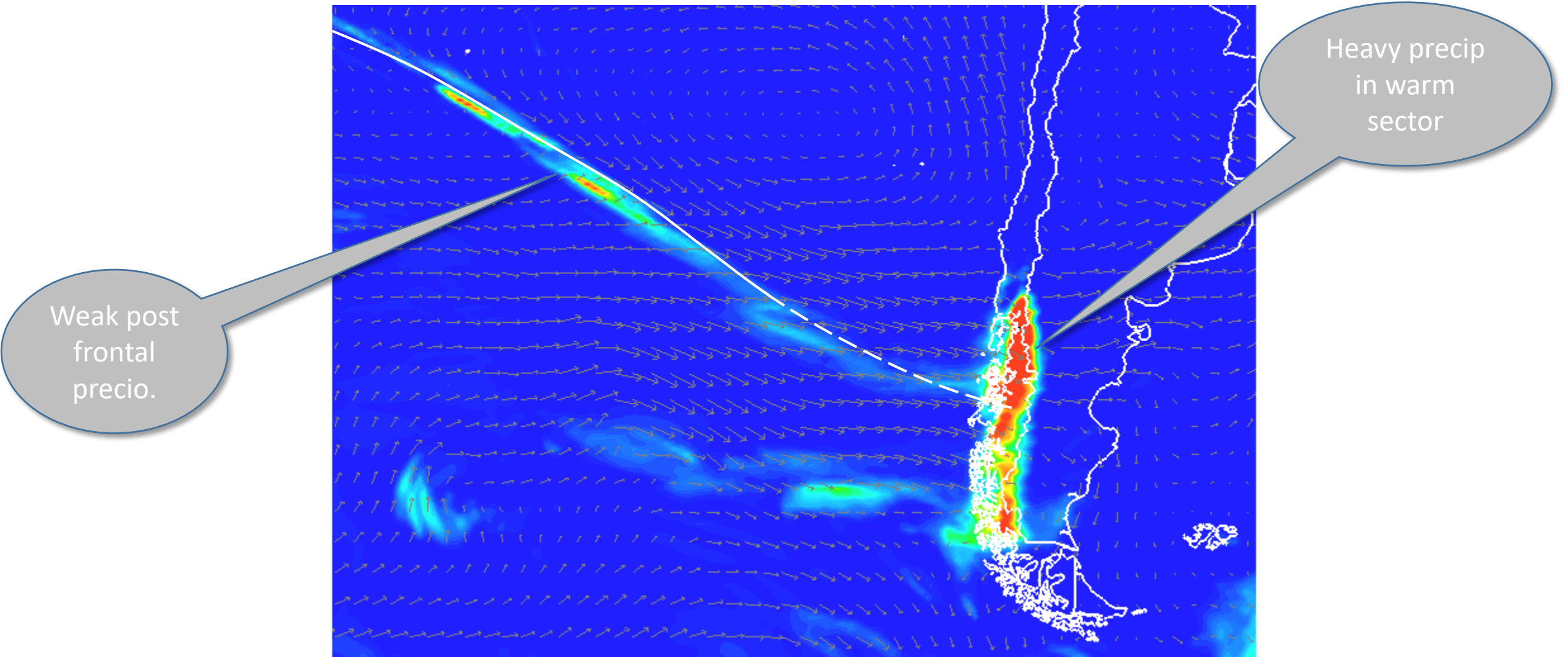


Hard to
see a front
here...

950 hPa wind vectors and precipitable water (0 – 50 mm)



950 hPa wind vectors and 6 hr accumulated precipitation (0-25 mm)

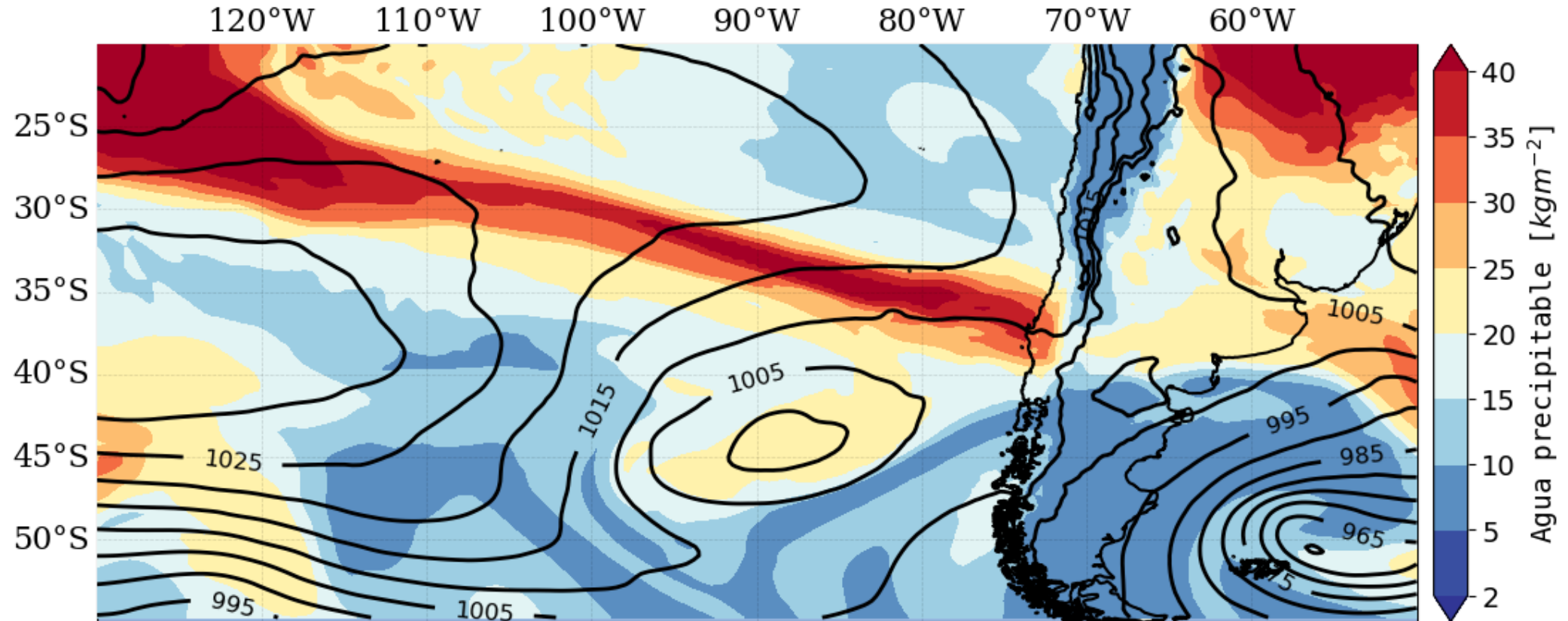


Seguimos con el río trabajador....como se arma un ZAR???

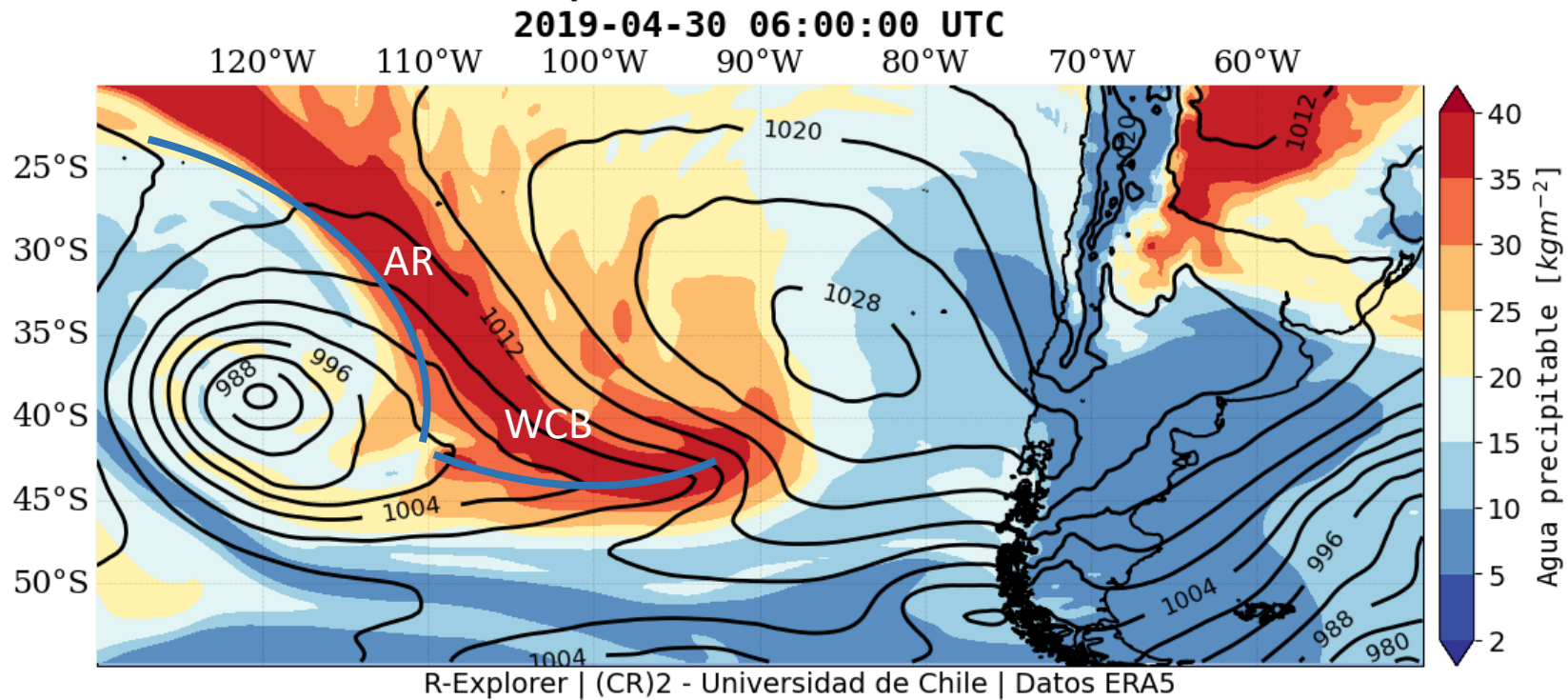
Sombreado: agua precipitable [kgm^{-2}]

Contornos: presión a nivel del mar [hPa]

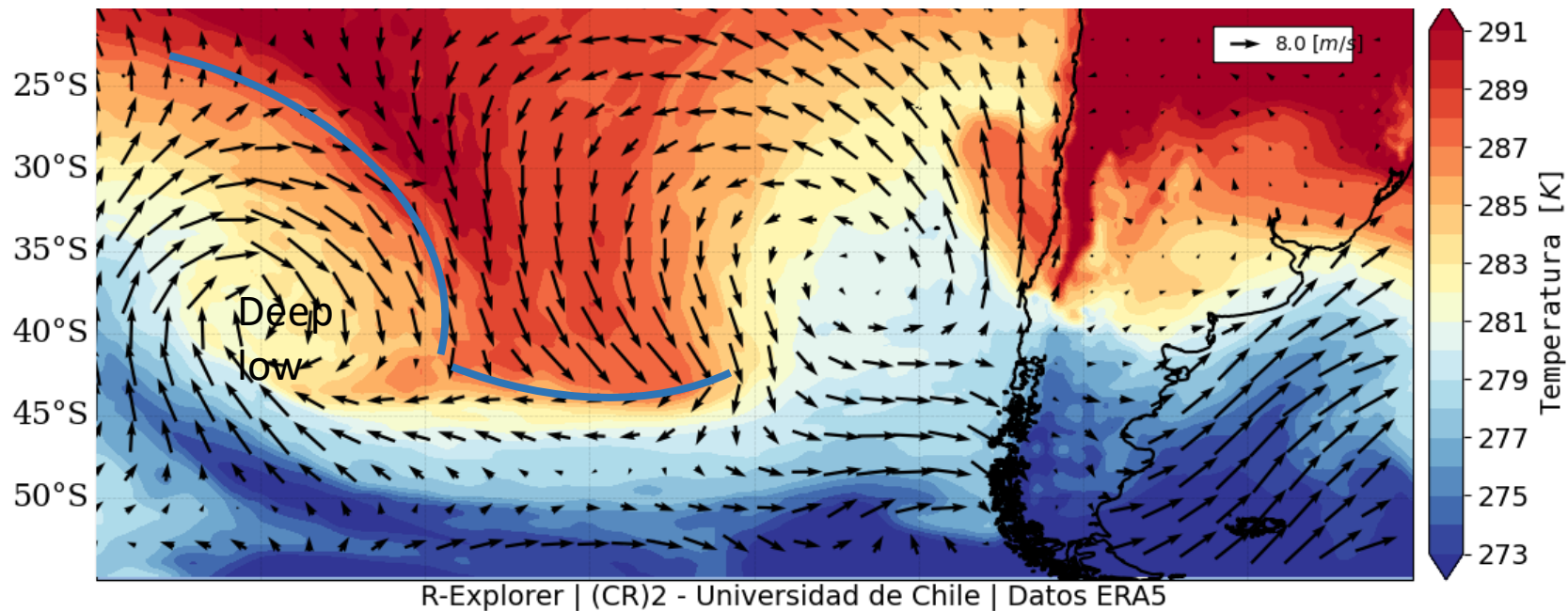
2019-05-02 18:00:00 UTC



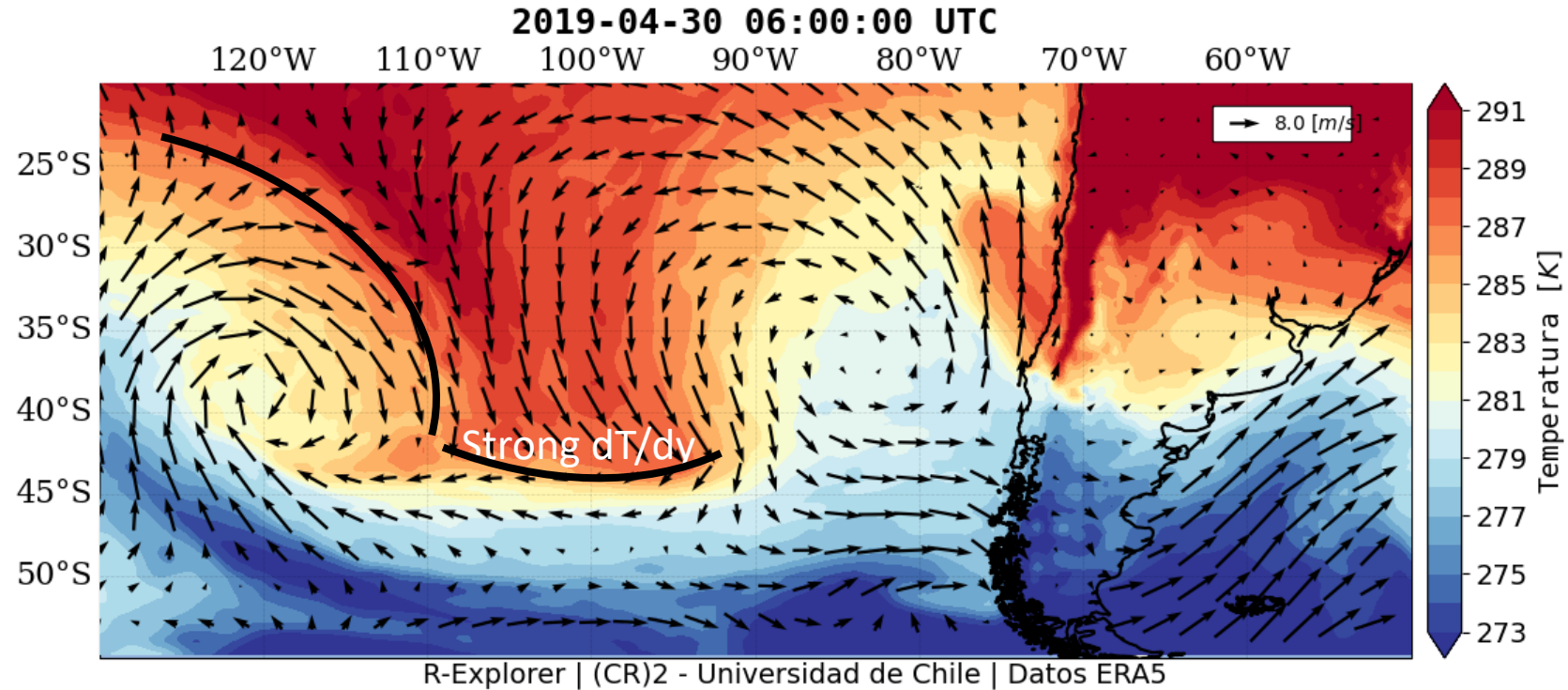
R-Explorer | (CR)2 - Universidad de Chile | Datos ERA5



Does the
moisture ascend
and precipitate
over warm
front?

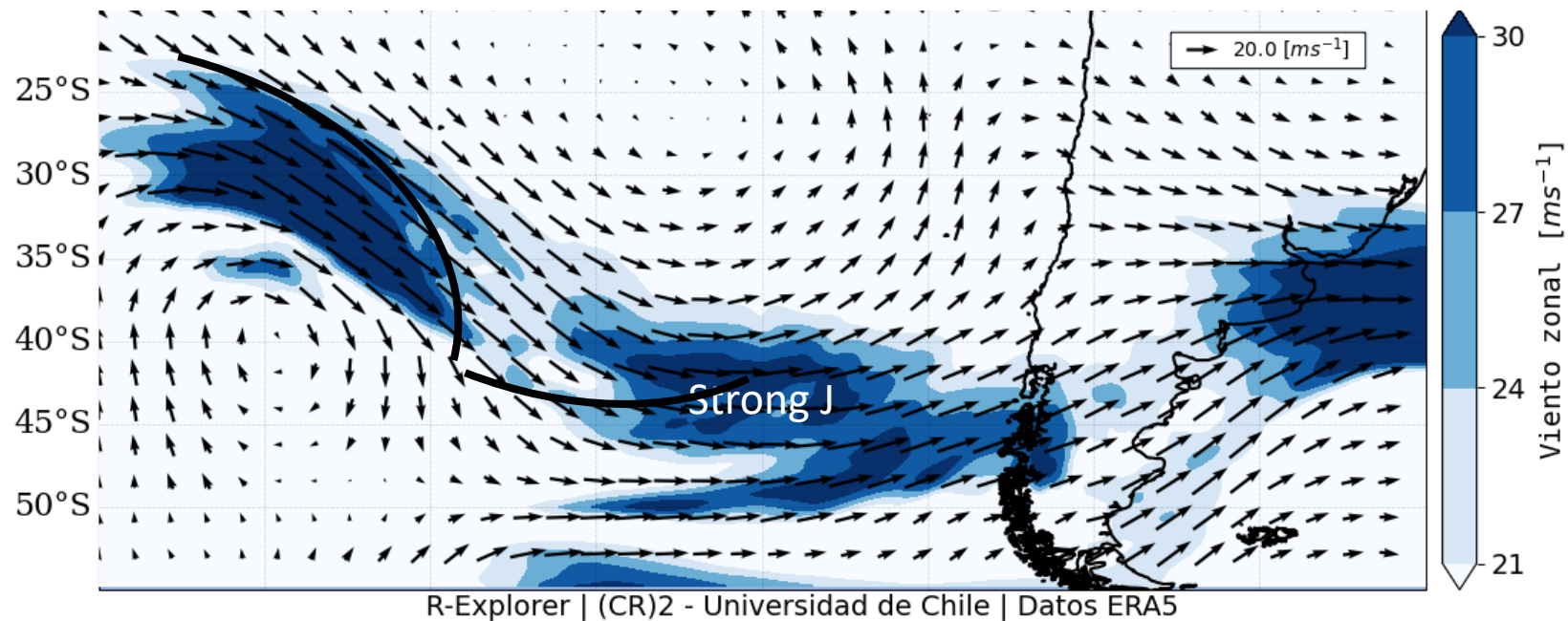


925 hPa



925 hPa

Strong dT/dy at
low levels
enhanced mid
level westerly jet
that foster ZAR

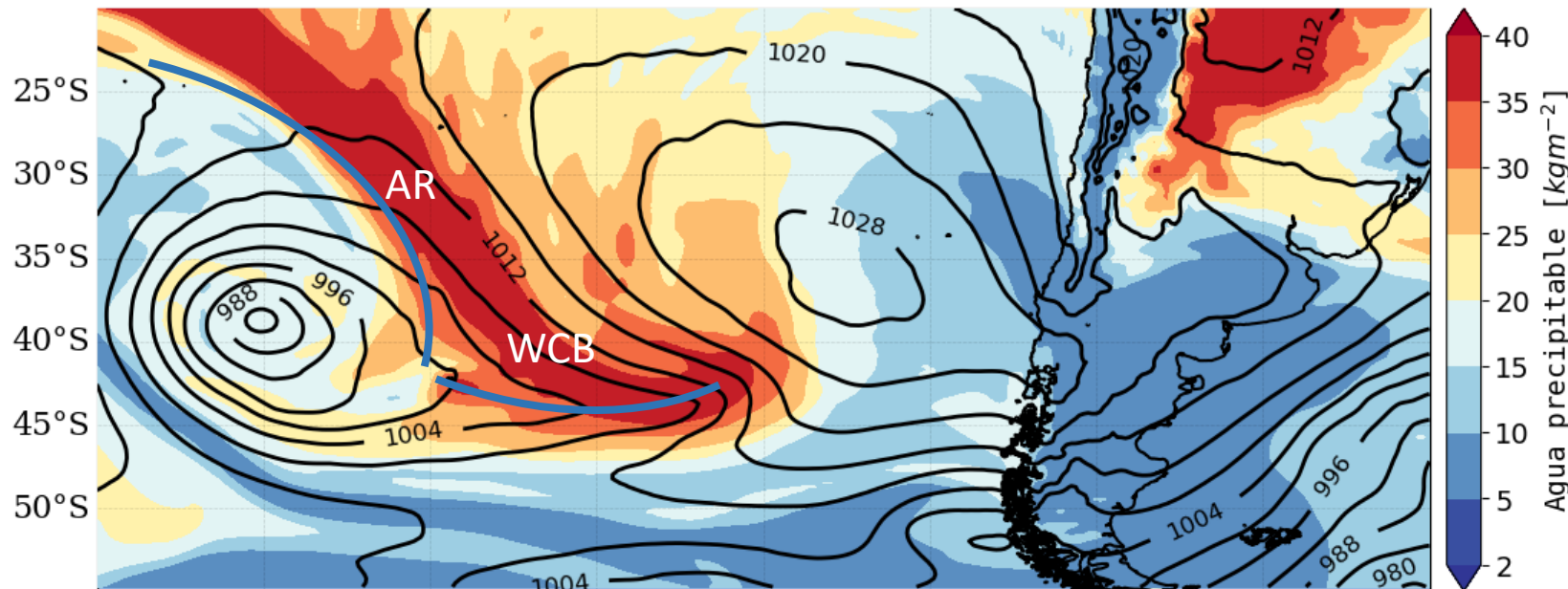


500 hPa

2019-04-30 06:00:00 UTC

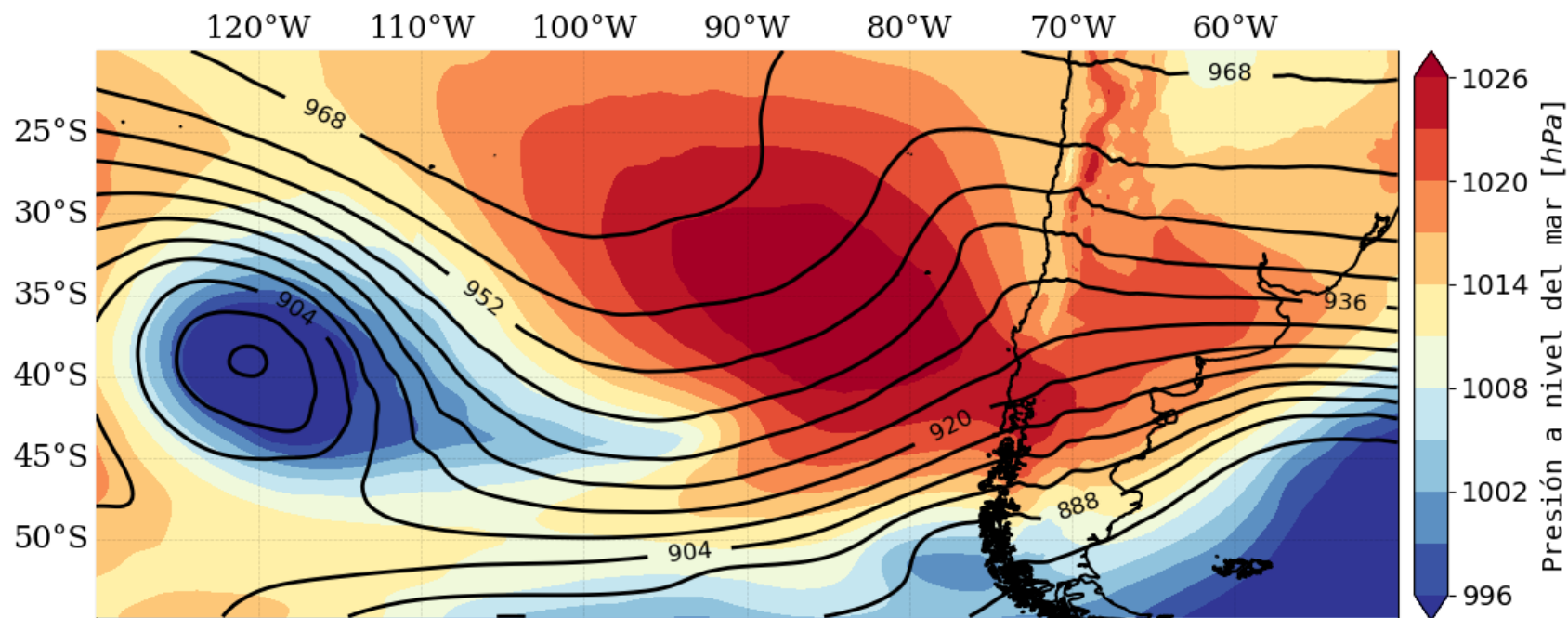
120°W 110°W 100°W 90°W 80°W 70°W 60°W

Why we have
an slow cyclone
rapid AR
(SCRAR)



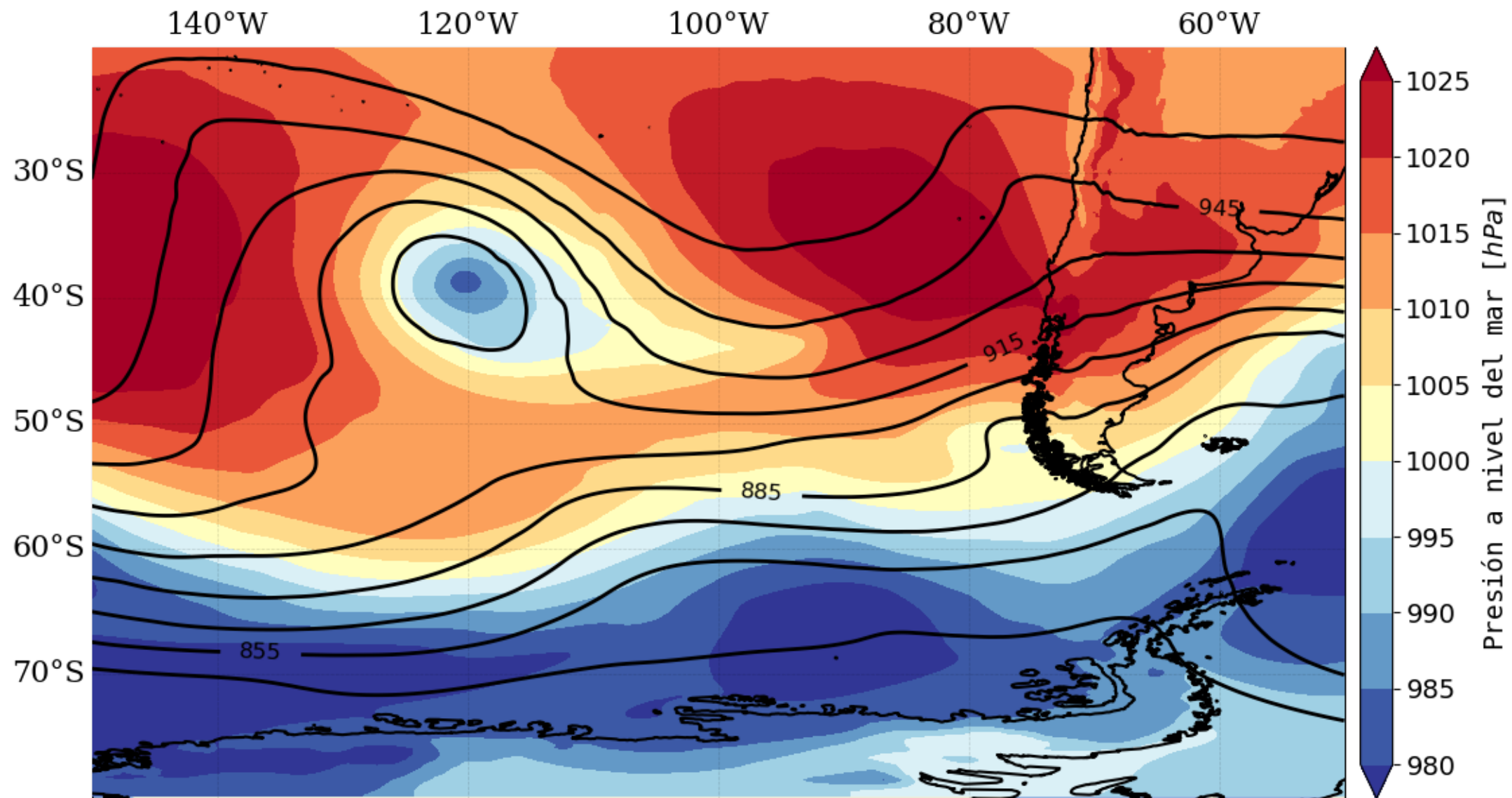
R-Explorer | (CR)2 - Universidad de Chile | Datos ERA5

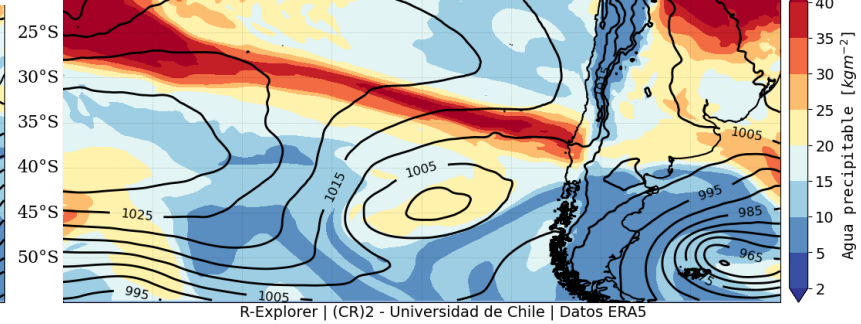
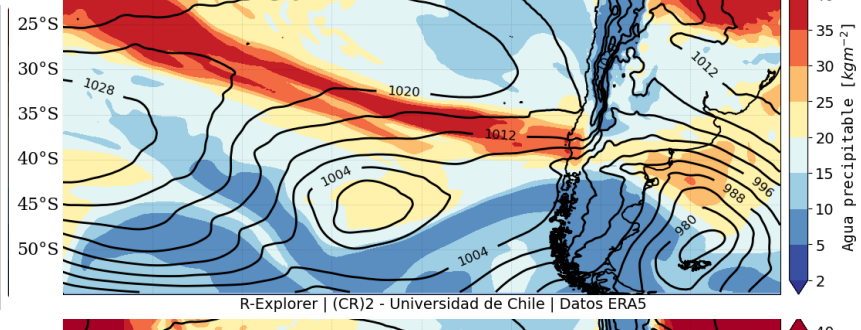
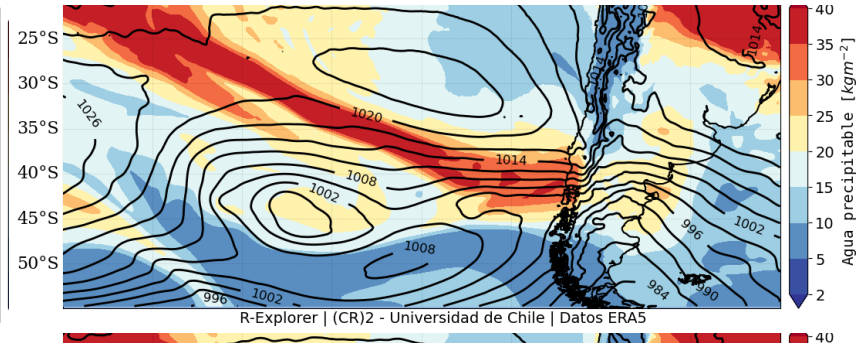
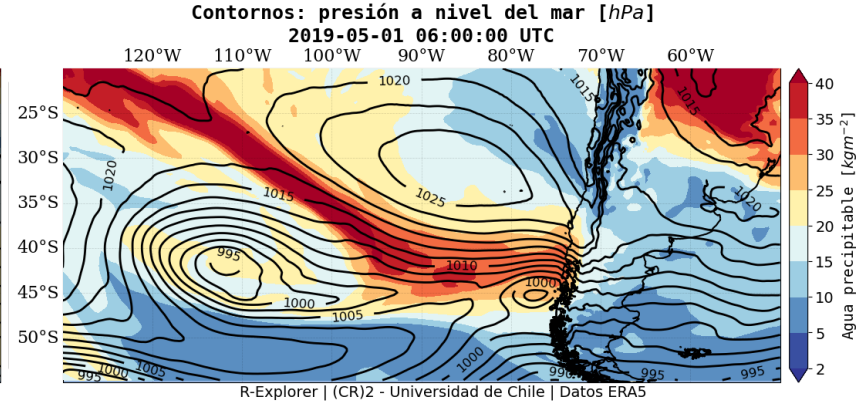
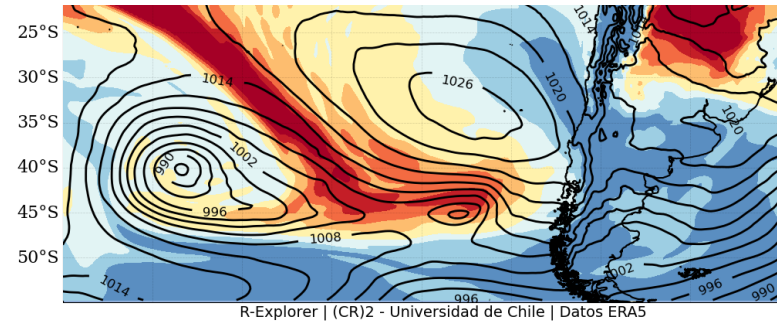
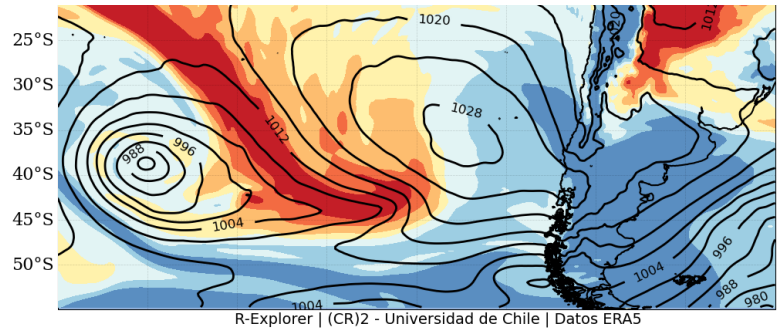
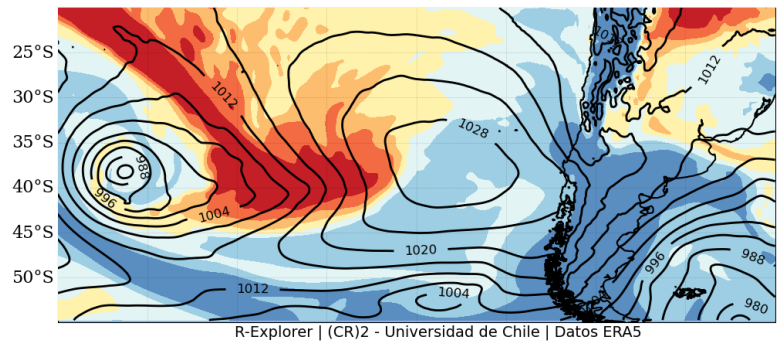
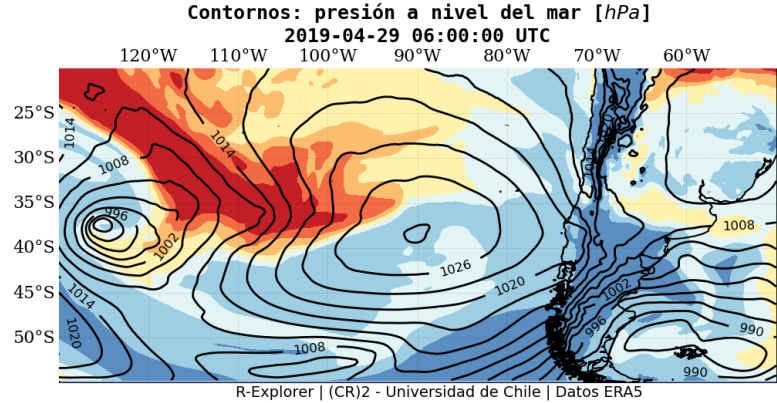
Note upper
level cyclone
(300 hPa) just
over surface
low....lysis?



R-Explorer | (CR)2 - Universidad de Chile | Datos ERA5

Sombreado: presión a nivel del mar [hPa]
Contornos: altura geopotencial [dm] a 300 [hPa]
2019-04-30 06:00:00 UTC

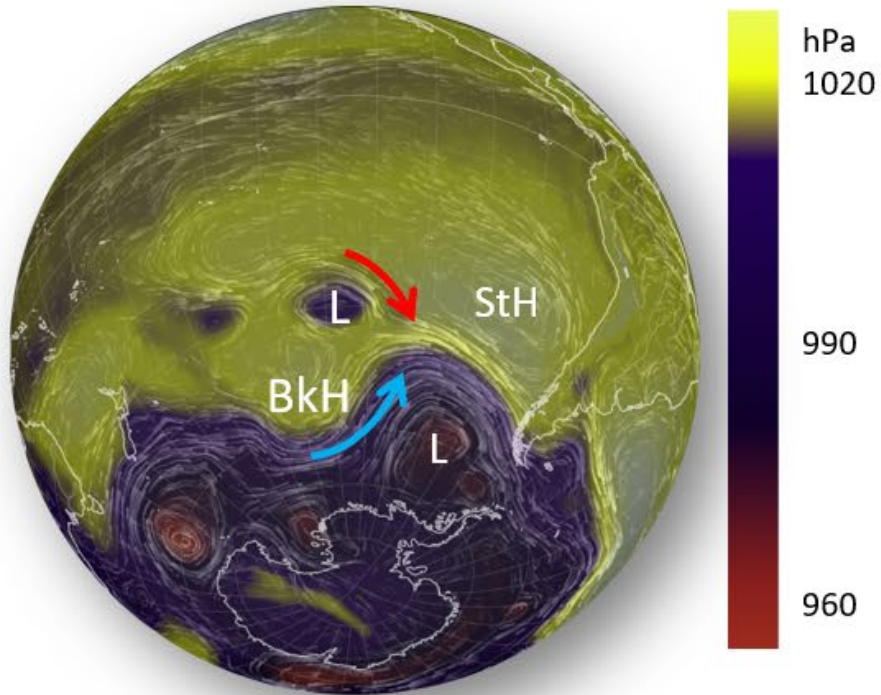




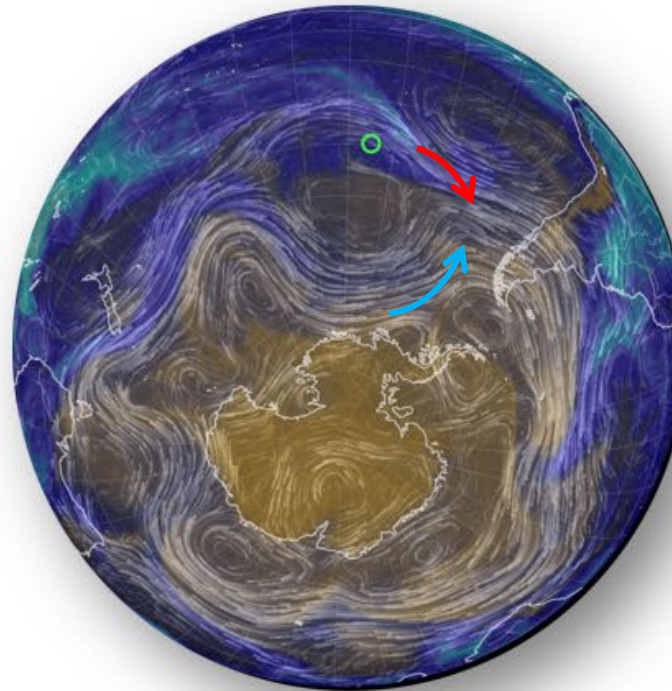
Precedent conditions: 24 January 2021

Slow moving high latitude anticyclone (blocking high) + closed cyclone to the north

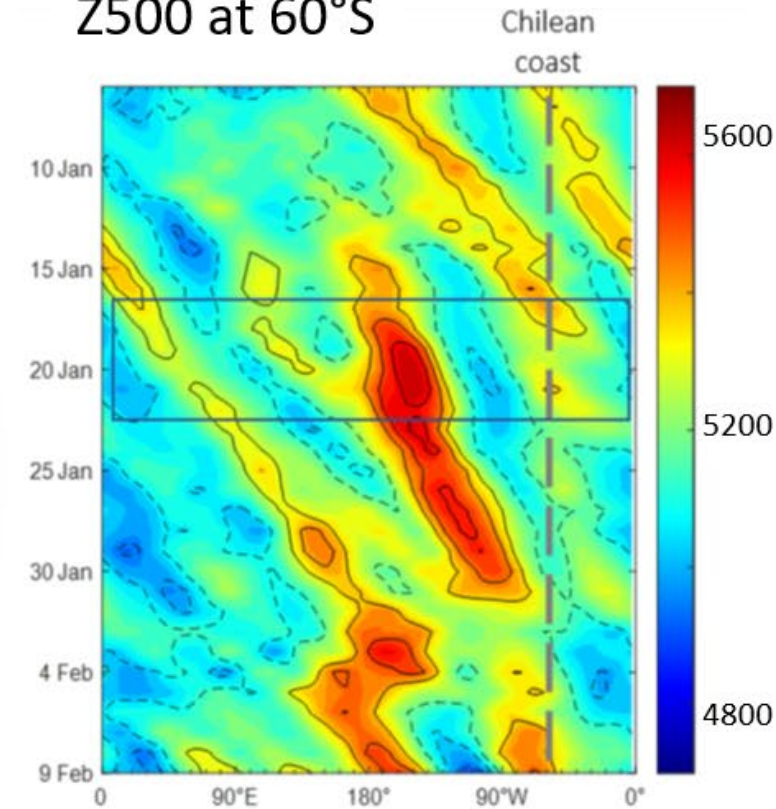
SLP + 700 hPa Wind



PW + 500 hPa wind



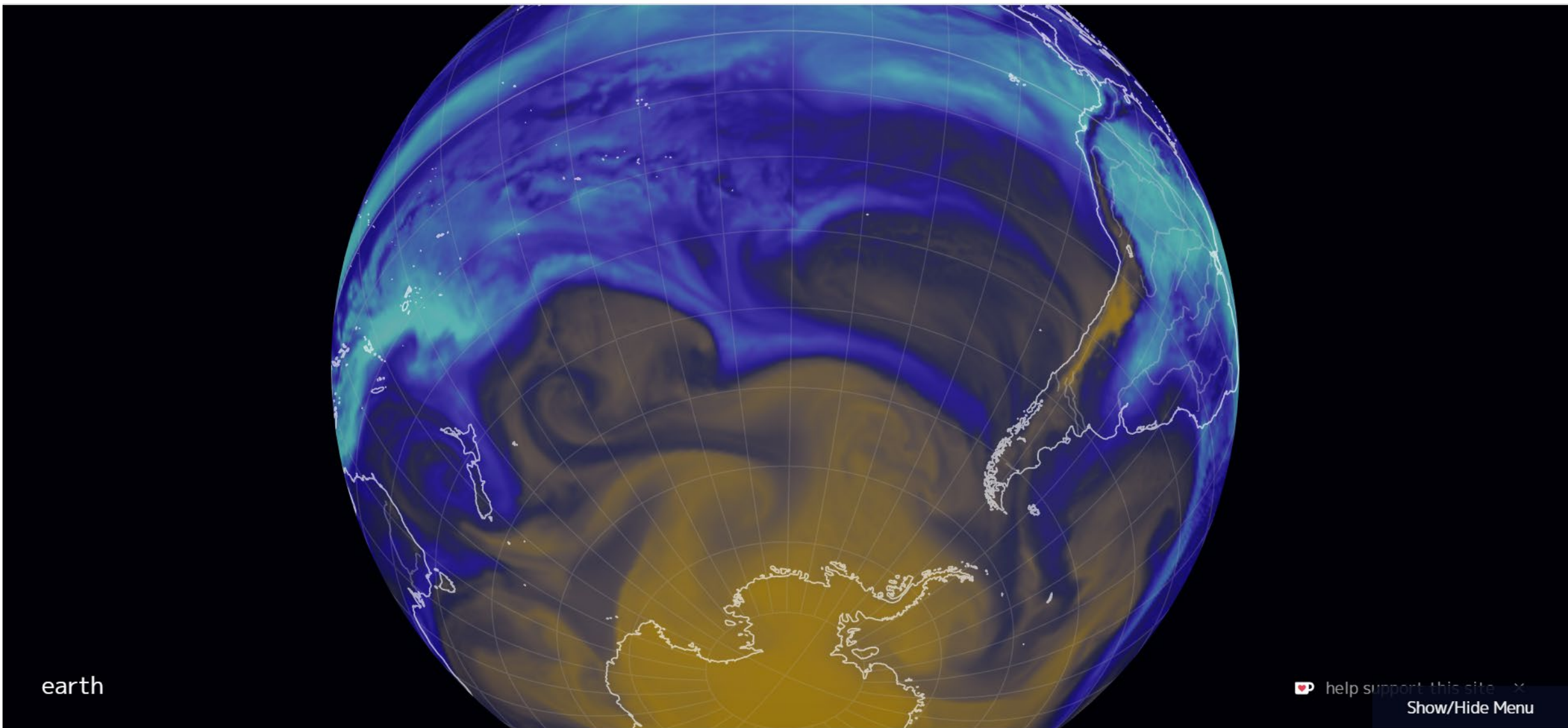
Z500 at 60°S



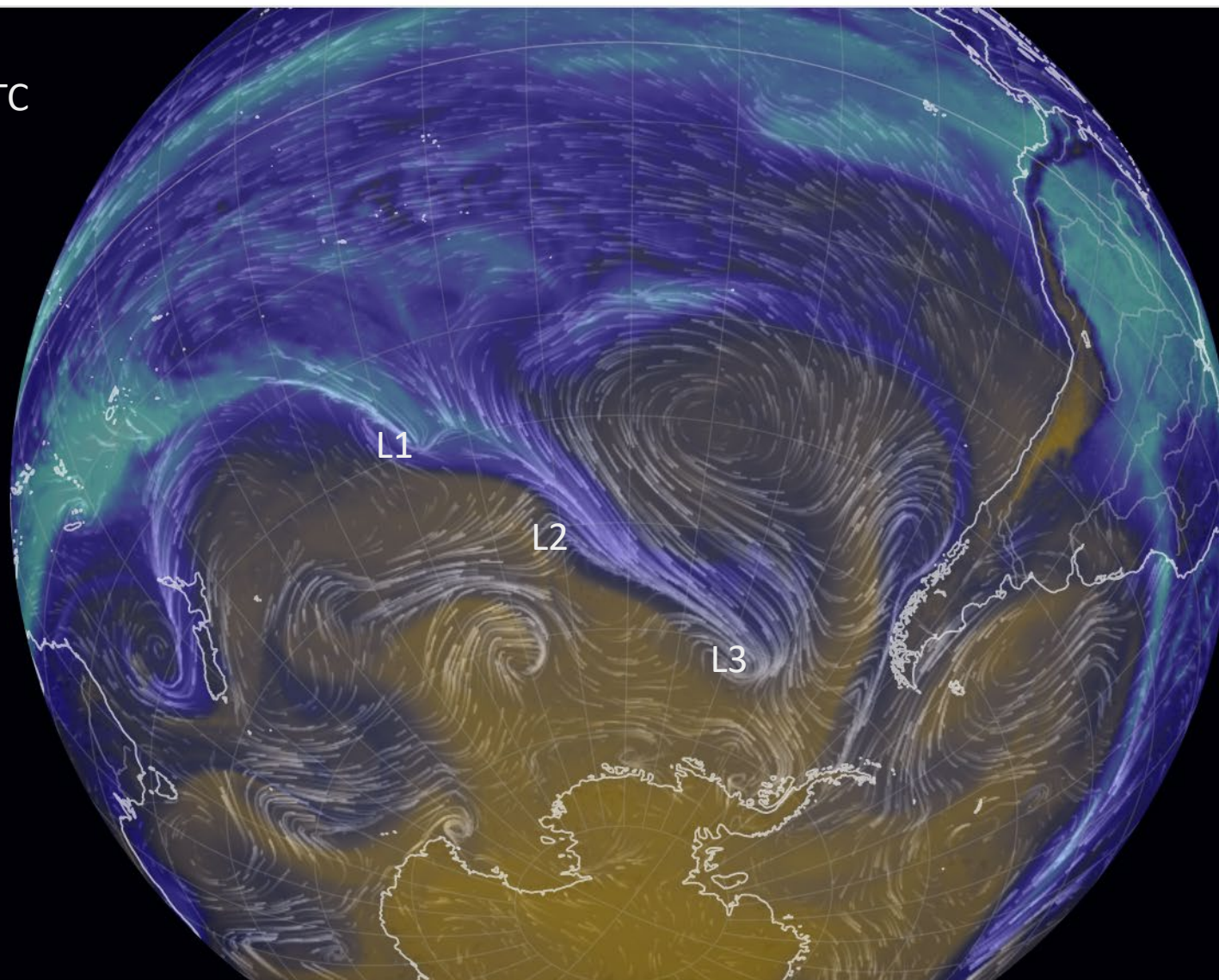
Entonces se puede generar un ZAR con un slow-low/strong jet

Otra forma de generar un ZAR

Cyclone chain...

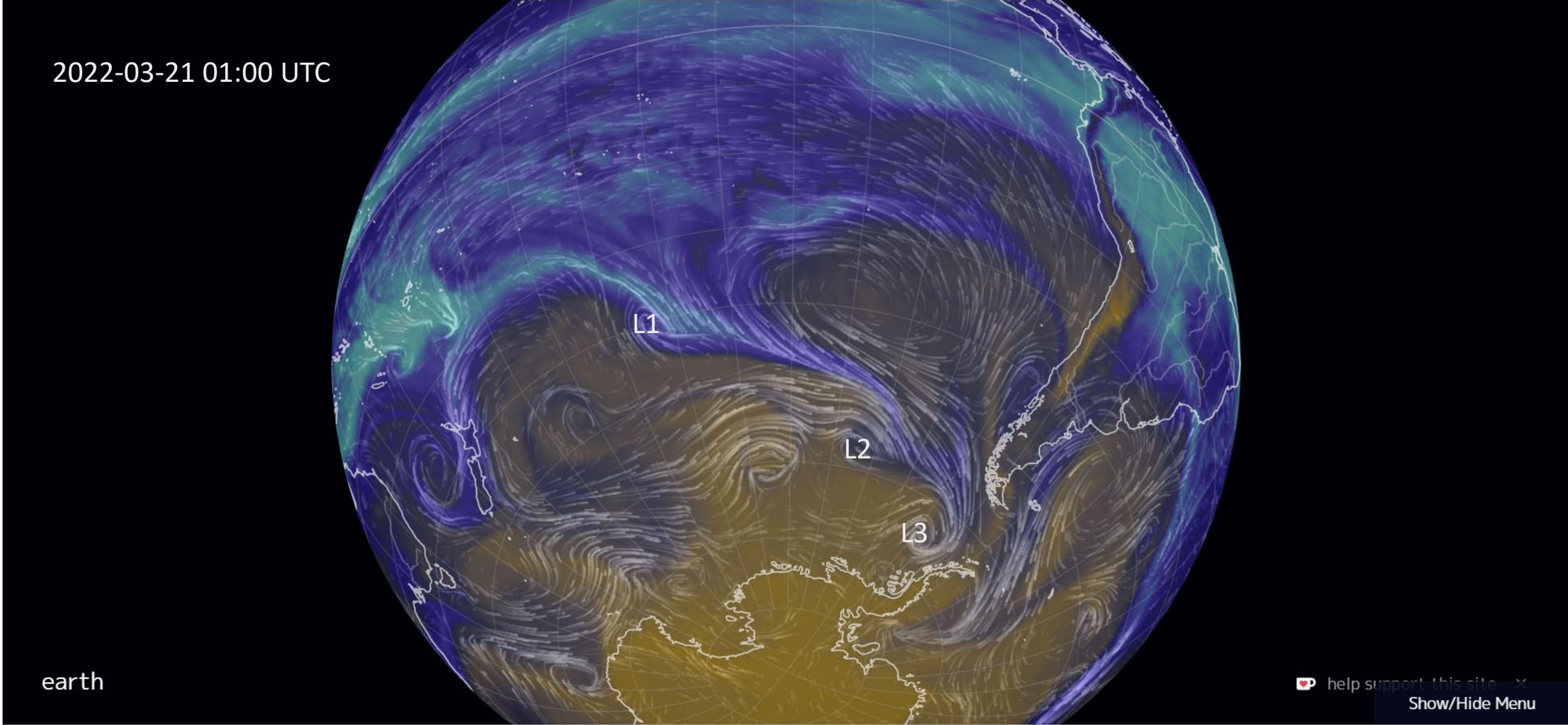


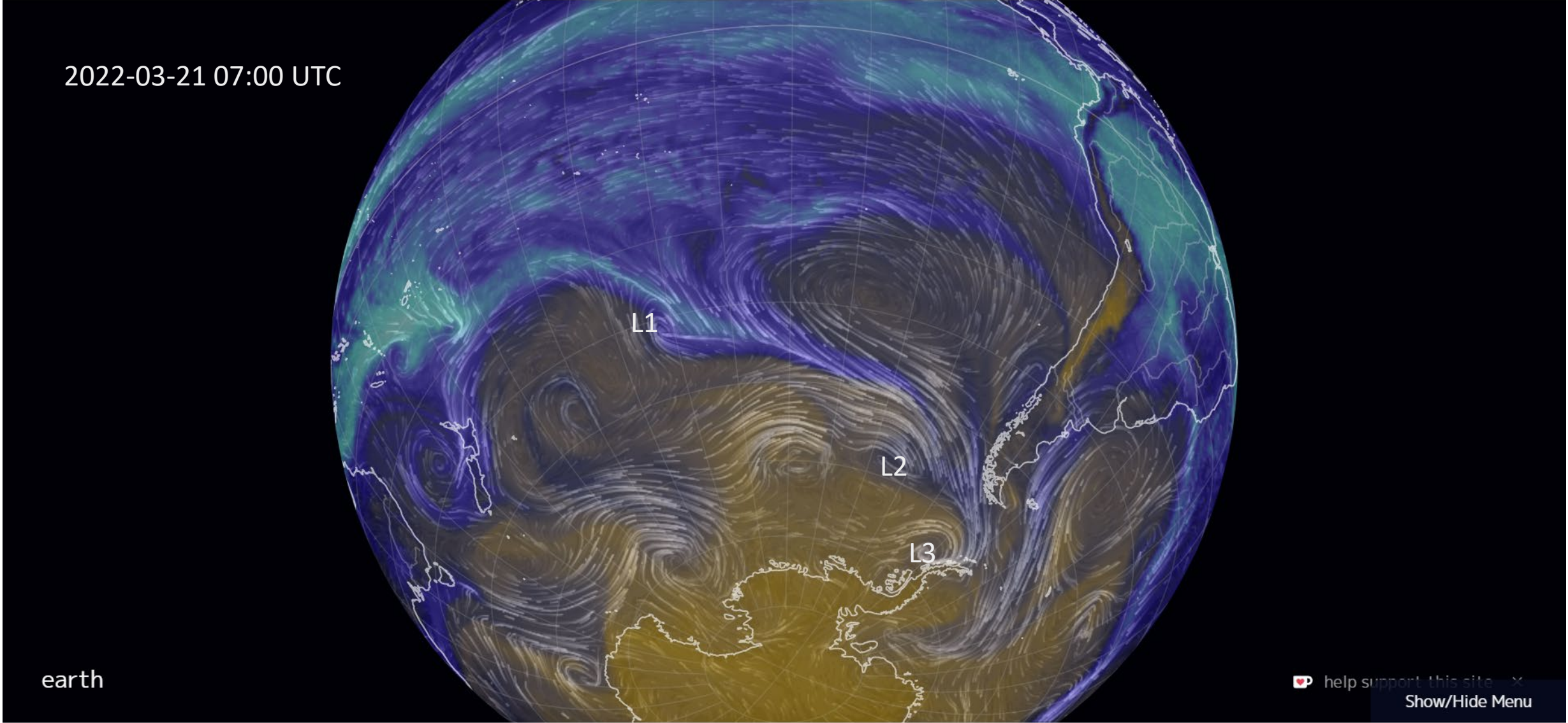
2022-03-20 09:00 UTC



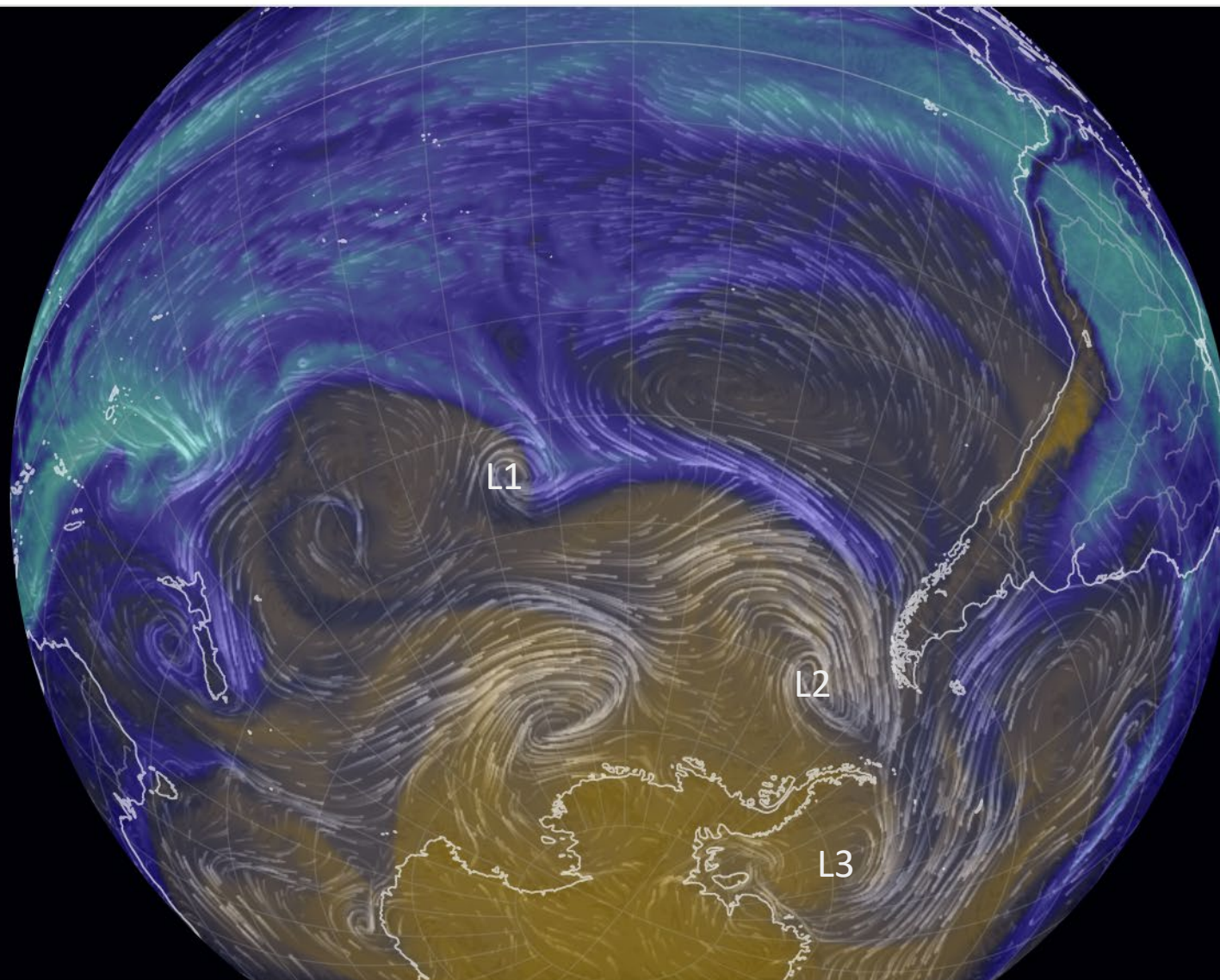
earth

help support this site x



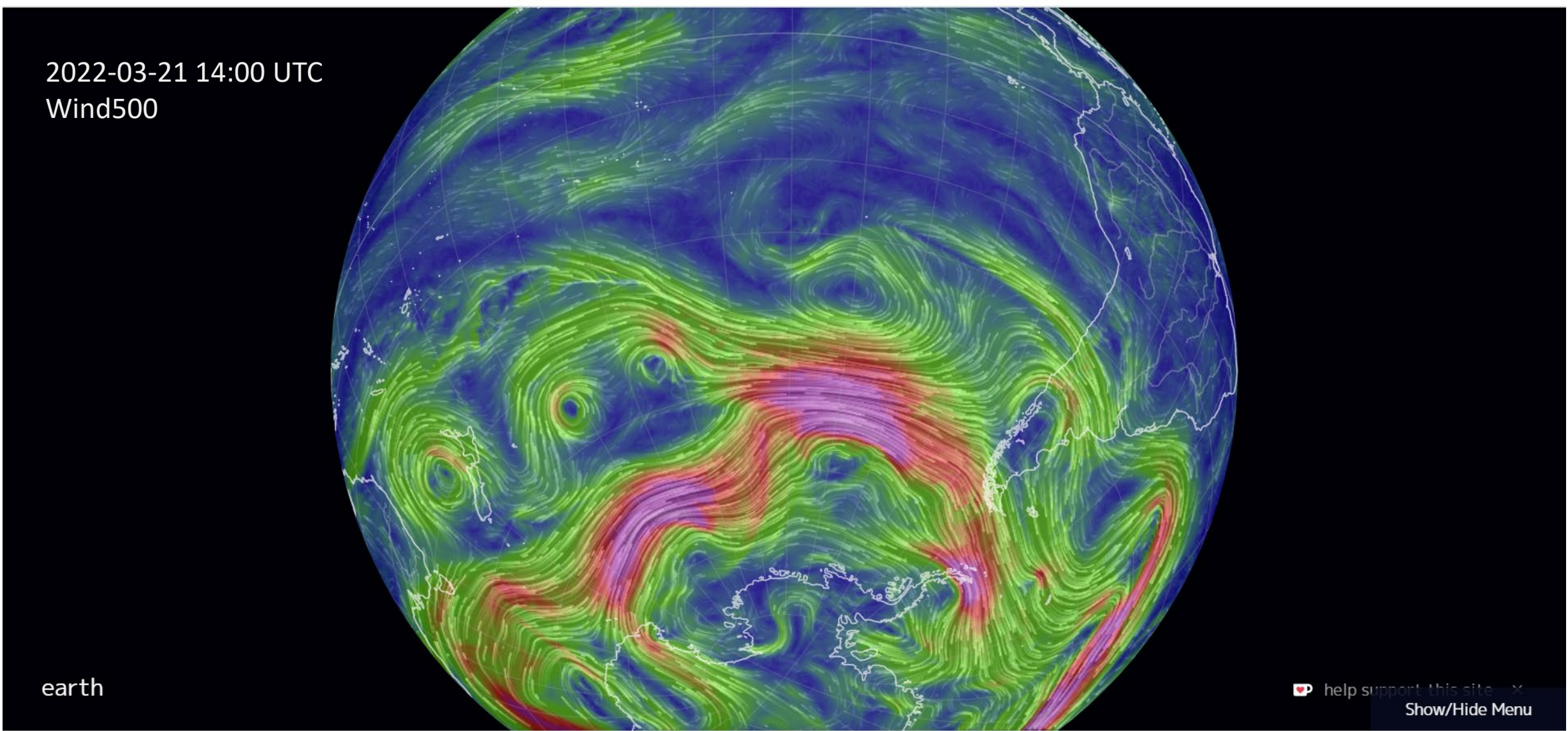


2022-03-22 01:00 UTC
PW + u1000



earth

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Show/Hide Menu



Otra forma de generar un ZAR

