A01 Earth – Evolution at the dry limit

Universität zu Köln

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Moisture transport into the Atacama

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1. Daily Moisture transport into the Atacama

Observations from our station network show that the there is a very regular circulation between the coastal mountains and the slope of the Andes mountains. During daytime there are strong westerly winds with higher moisture whereas during night we observe easterly winds with lower moisture. But while this wind pattern can also observed at most eastward stations at the slope of the Andes, they do not show the humidity variation (Schween et al. 2020). This means that the circulation transports moisture into the desert. To investigate how this circulation connects to the moist oceanic boundary layer and where the moisture remains we planned several runs of the turbulence resolving model ICON-LEM. A first test run allows investigation of the performance of the model and first insights into the moisture transport.

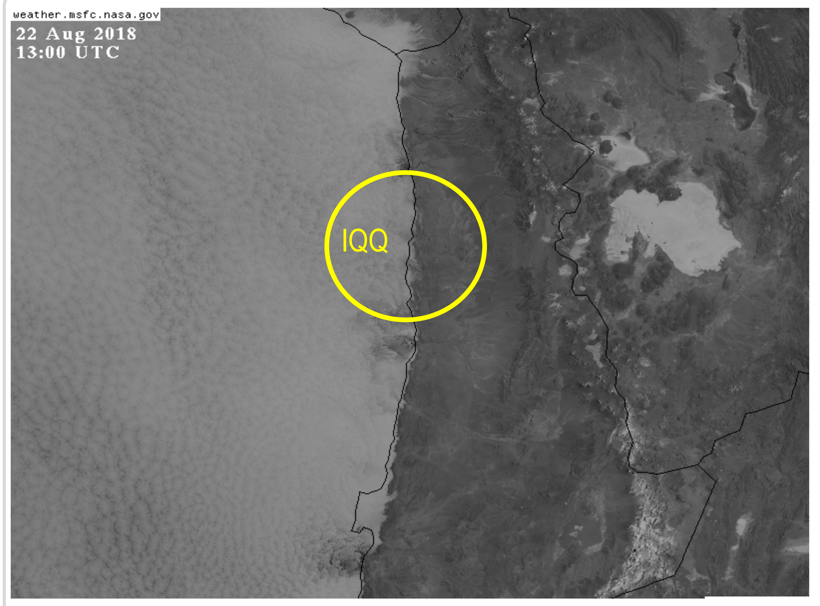


Fig. 1: Satellite view of the Atacama coast with location of IQQ and model domain in yellow.

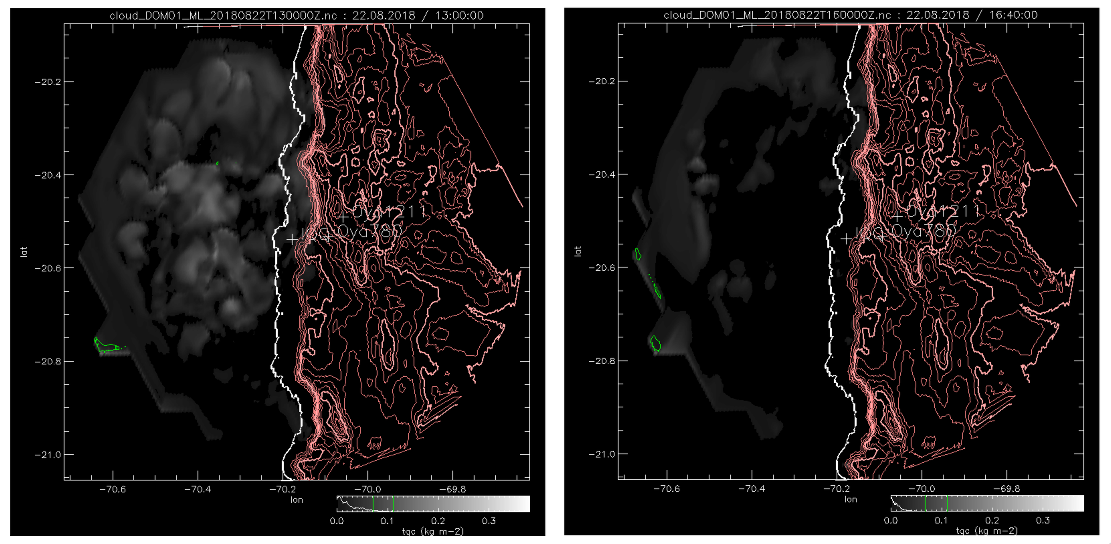


Fig. 2: Vertically integrated water vapor content in the model.

2. First results from the ICON-LEM run

- 22.8.2018, a typical winter day.
- Homogenous SC deck over the ocean.
- Gaps developing in morning hours, closing in the afternoon – evening.
- 100km around IQQ airport.
- Resolution: dx=628m dz=20m..500m.
- Forced by ICON global (presented here) and ECMWF – IFS.

3. Comparison with remote sensing at IQQ

- Inversion not as sharp and lower than observed by Radiosonde and Microwave radiometer.
- less and rather broken clouds,
  but noon gap is present.
- Cloud base higher, cloud top lower
  => cloud less thick.

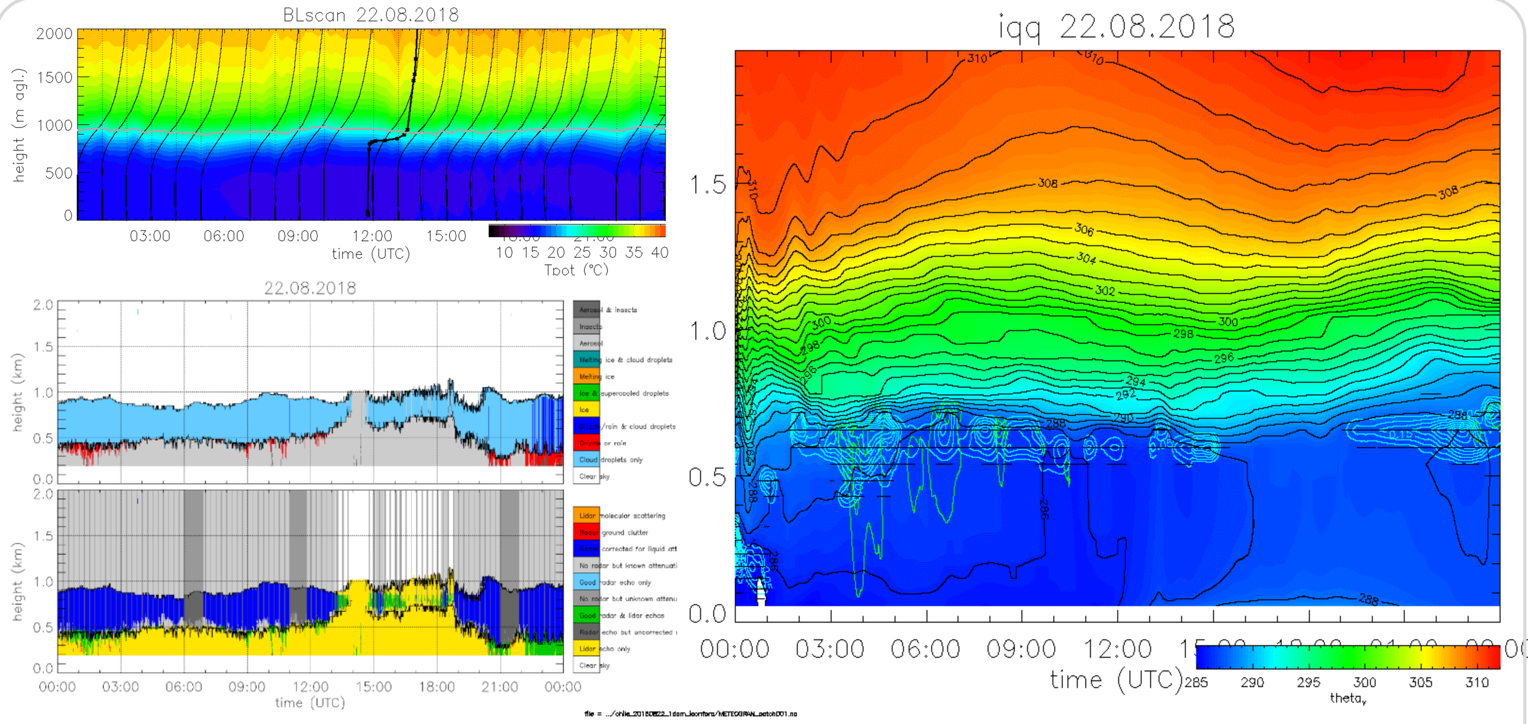


Fig. 3: time-z sections at IQQ. As observed (left) and modelled (right).

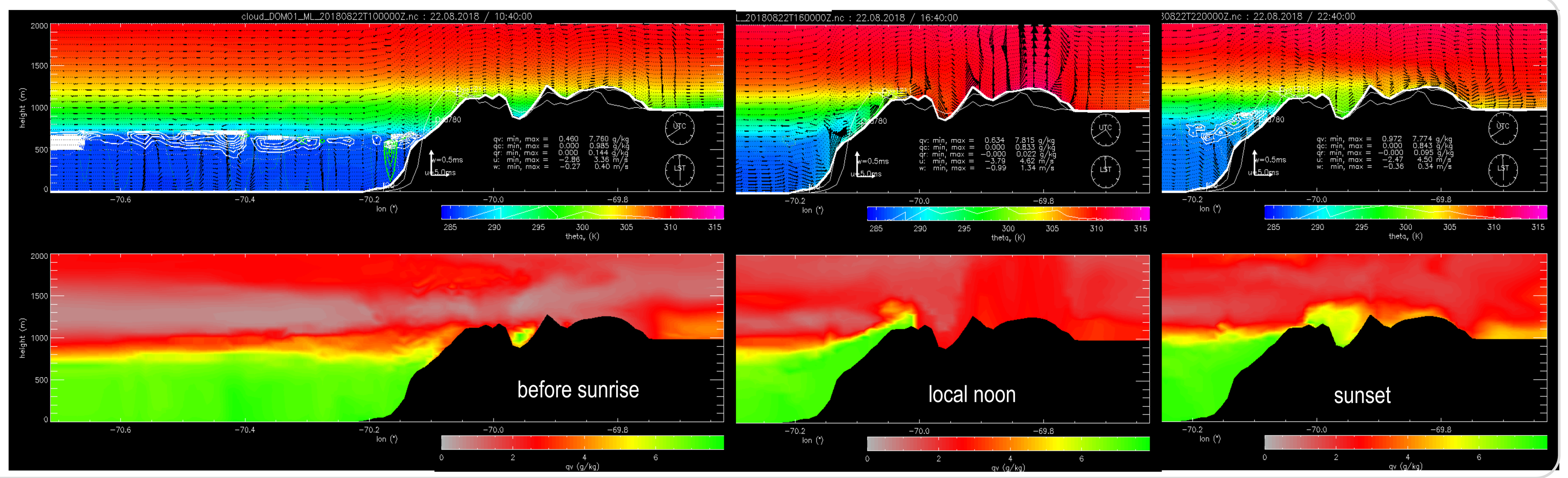


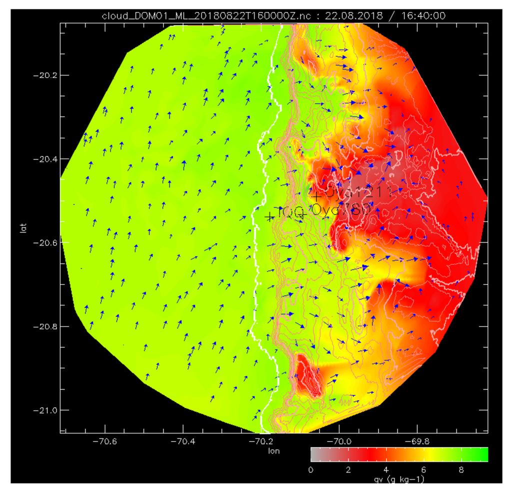
Fig. 4: x-z section through IQQ, during three times of the day with virtual potential temperature and (u,w)-wind vectors (top), and water vapor mass mixing ratio (bottom)

4. x,z-section through IQQ

- Wind develops at slope of cliff
- Transports cold and moist air into the desert
- Partly driven by mountain vents in coastal mountain range.

5. Next steps

- Extend domain to slope of Andes.
- Longer runs.
- higher resolution, also vertically to improve structure of inversion.
- Other places (Rio Loa, Paranal).



The overlooked role of westerly moisture source for summer precipitation in the Atacama Desert

José Vicencio, Christoph Böhm, Mark Reyers, Ulrich Löhnert and Susanne Crewell

1. Introduction

- Low pressure system right above marine boundary layer visible in climatology (850hPa geopotential, Fig. 1) causes northwesterly inflow (Vicencio et al. in prep.)
- Andean Pumping (Rutllant et al., 2013) advects coastal air above MBL toward the east.
- Enhanced summer time fog frequency along the Precordillera indicates frequent moisture supply (Böhm et al., 2021)
- Extreme summer precipitation events associated with low cloud/upslope fog formation and low level westerly inflow (Reyers et al., 2020)
- Daytime moisture advection toward the Andean slopes exceeds night time moisture return (Schween et al., 2020) --> Where does the moisture go?

Hypothesis: Summer precipitation, fog and clouds are triggered by moist-air advection from the west affecting even the Atacama's dry core.

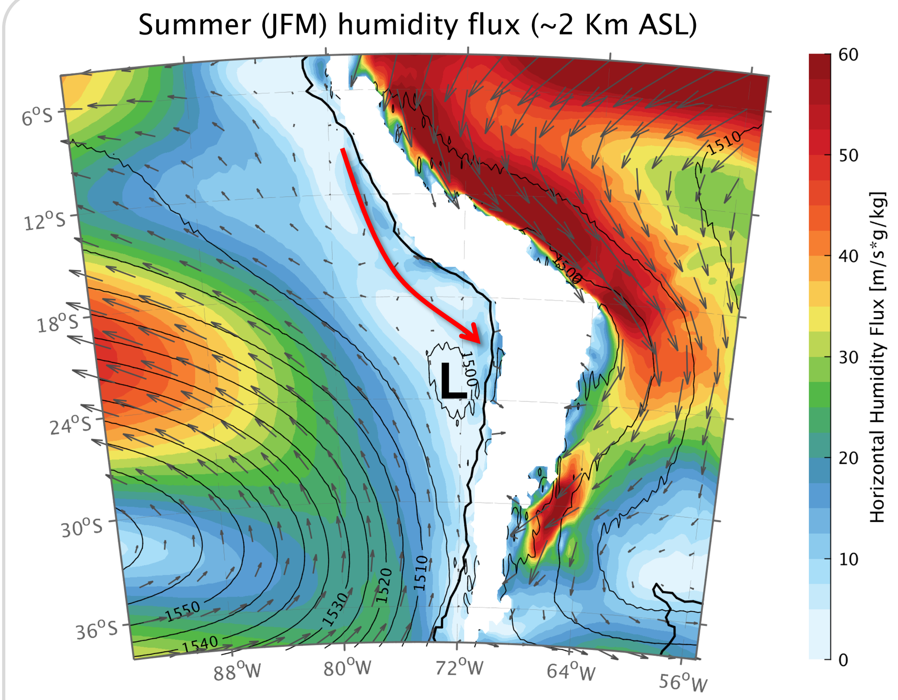


Figure 1. Summer (JFM) climatological composite (1988–2020) of the horizontal humidity flux between 750–800 hPa (aprox. ~2 Km ASL). From Vicencio et al. (In prep.).

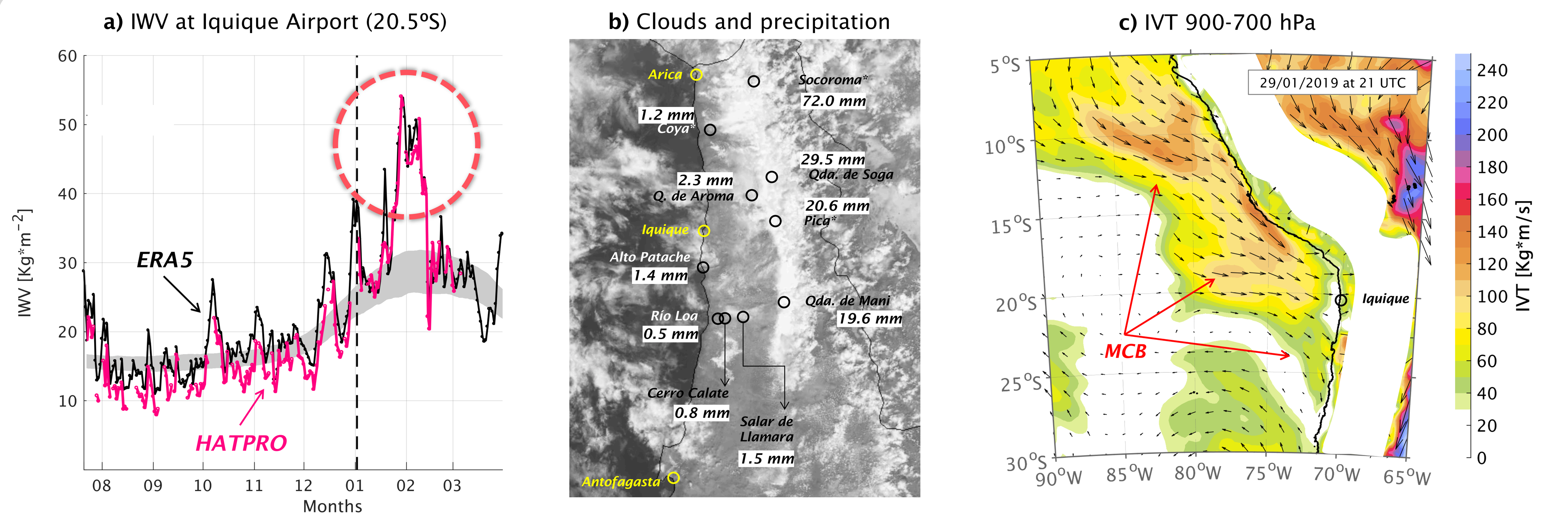


Fig. 2. (a) Time series of daily IWV at Iquique Airport from HATPRO (pink) and ERA5 (black) between August 2018–March 2019. Gray shaded polygon is ERA5's climatological interquartile (1980–2020). (b) GOES-16 visible channel on January 29th at 16:30 UTC, and 3-hr accumulated precipitation at CRC and CR2(*) stations (January 28th to 31st). (c) IVT between 900–700 hPa on January 29th, 2019 at 12 UTC (ERA5)

2. Data

CRC surface weather stations (2017–2020), CR2 weather stations (1950–2020), and HATPRO campaign (2018–2019).

Reanalysis ERA5 from 1959 to 2020. Horizontal resolution of 31x31 km.

High-resolution WRF simulations from 1991 to 2020. Horizontal resolution of 6x6 km.

3. Preliminary results: Case study

- The 1-year campaign at Iquique Airport (2018–2019) revealed a period of extreme humidity (*Fig. 2a*) during the summer of 2019, with integrated water vapor (IWVV) exceeding 54 kg/m2, which agrees with reanalysis ERA5 (*Fig. 2a*).
- Extreme precipitation was observed in the Coast, Central Valley and Precordillera (see *Fig. 2b*) between January 28th and 31st.
- The integrated water vapor transport (IVT) exhibits extreme values in a filamentary structure above the marine boundary layer (Moisture conveyor belt, MCB, Böhm et al. 2021) towards the Atacama (*Fig. 2c*).

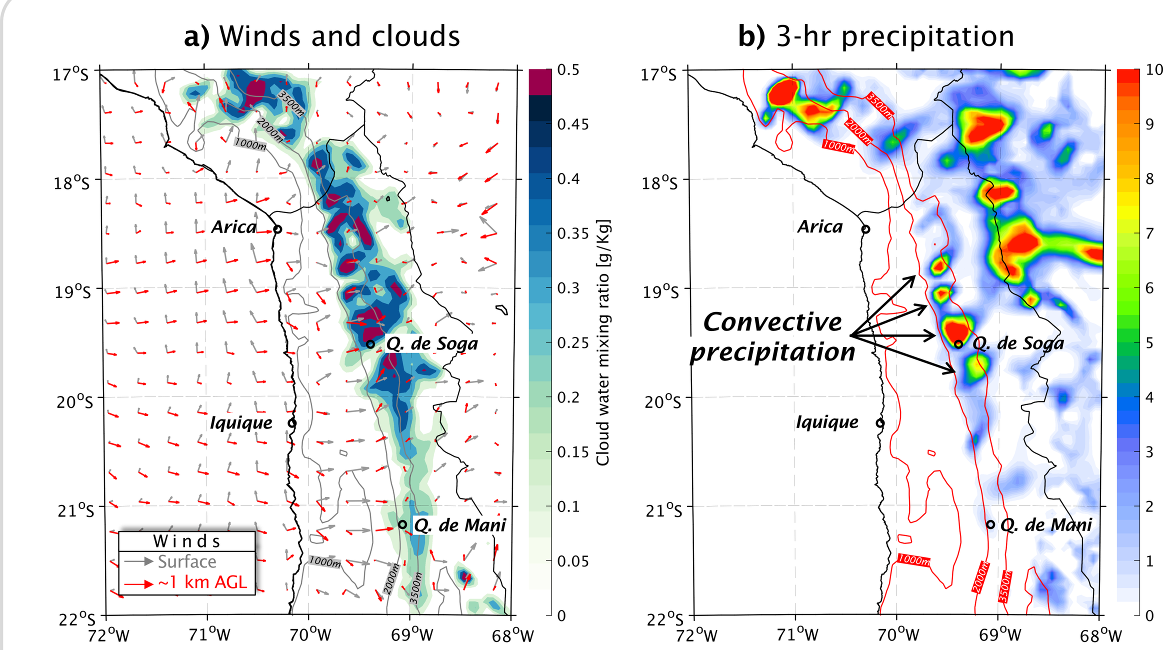


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Fig. 3. (a) Cloud water mixing ratio average (colors), surface winds (gray arrows) and ~1 km above ground level winds (AGL, red arrows), and (b) 3-hour accumulated precipitation. Data: WRF simulation on January 29th, 2019 at 21 UTC. Gray and red lines: terrain elevation of 1000, 2000 and 3500 m ASL.

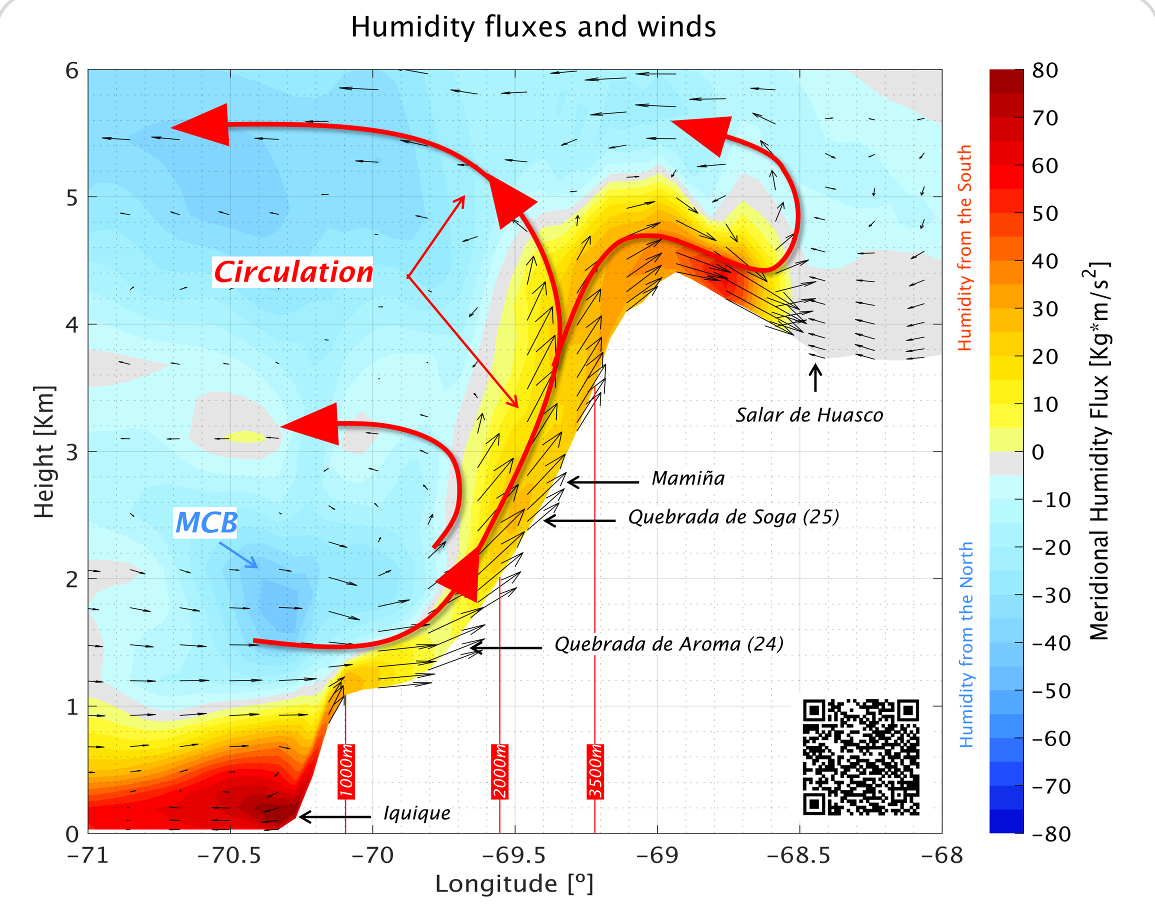

Figure 4. Cross-section (18.5–20.5°S) of meridional humidity flux (colors) and zonal-vertical winds (arrows). WRF simulation on January 29th, 2019 at 21 UTC.

- Once the humidity reaches the coast, it is transported inland by the afternoon circulation, i.e. Andean Pumping (21 UTC, *Fig. 3a* and *Fig. 4*).
- The moist air is lifted in the Precordillera, producing clouds (*Fig. 3a*) and triggering storms with heavy precipitation (>10 mm/3hr, *Fig. 3b*).
- The westerly moisture transport even reaches the Altiplano (~180 km inland, Fig. 4).
- A return flux is observed above 3 km ASL (*Fig. 4*).

4. Main conclusion

Contradictory to the previous literature, this study highlights the role of the westerly moisture sources for precipitation, fog and cloud formation.

5. Outlook

Identify all the summer westerly moisture episodes from climatology by cluster analysis using high-resolution simulations, reanalysis and observations.

Quantify the partition of precipitation, fog and clouds frequency associated with summer westerly moisture episodes.