Assessment of GPM IMERG satellite precipitation estimation and its dependence on microphysical rain regimes over the mountains of south-central Chile

Yazmina Rojas, Justin Minder

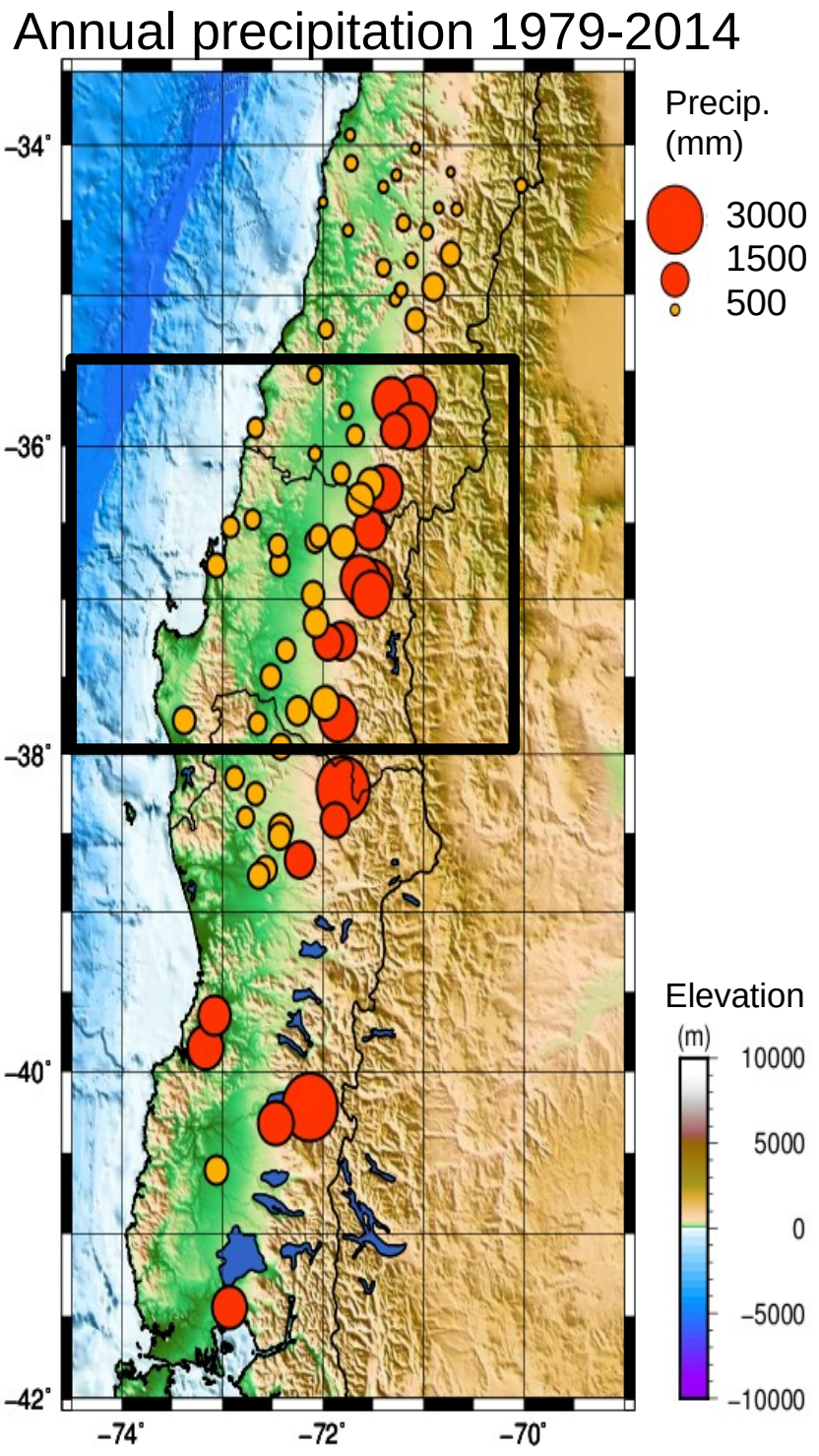
University at Albany, State University of New York

Acknowledgment: Adam Massmann, Leah Campbell, Rene Garreaud

Becas Chile 72180485

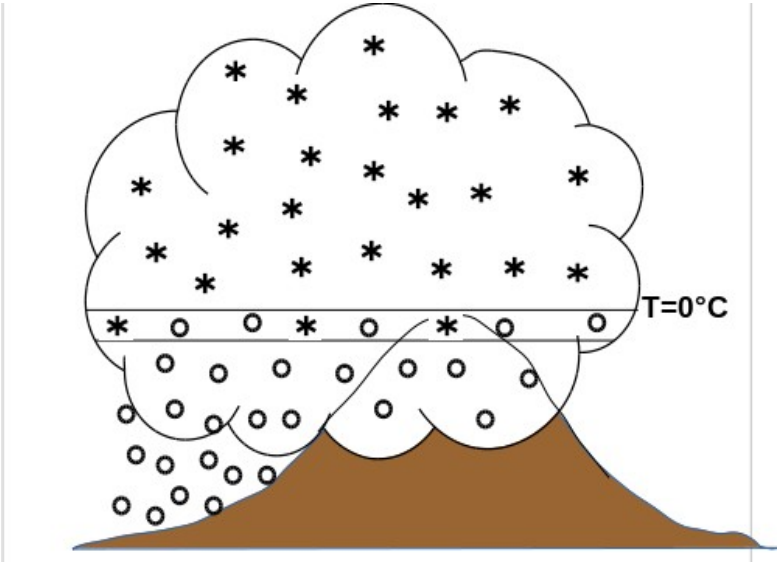
Motivation

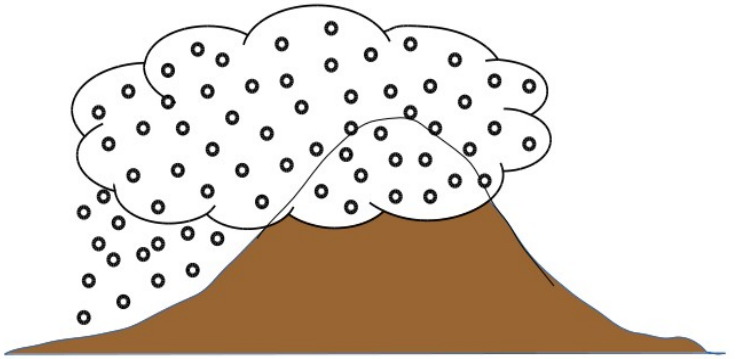
- Precipitation is largely concentrated in the austral winter (May-September) produced by frontal systems.
- Enhancement of precipitation in the windward side and snow accumulation over the Andes:
  - *Key factor in the water resources of south-central Chile.*
  - *Can lead to hydrometeorological disasters.*
- Satellite data provides vital information for this complex terrain site with lack of:
  - *Long term precipitation records*
  - *High elevation data*
  - *Radar coverage*



Motivation: Microphysical regimes

Ice – initiated and warm rain periods





Ice-initiated rain: Characterized by:

- A well defined melting layer, produced by melting processes from aloft.
- Fewer and bigger drops

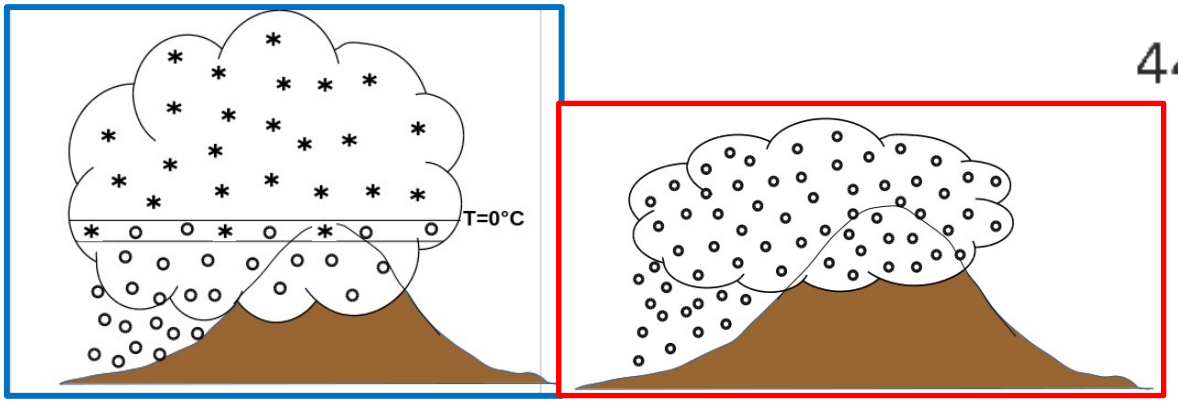
Warm rain: Characterized by:

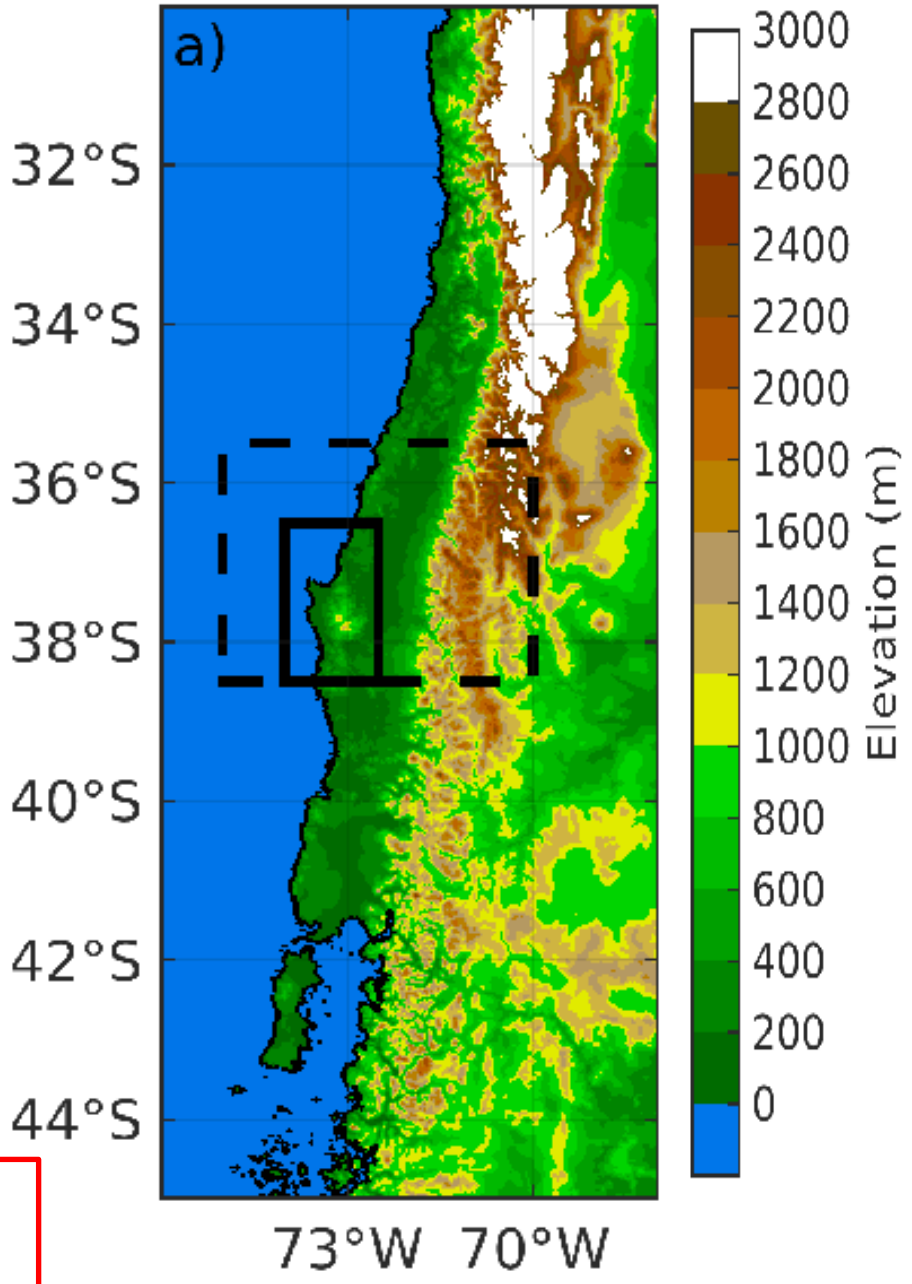
- The absence of a melting layer in low-level warm processes.
- More numerous and smaller drops

Martner et al. (2008), Massman et al. (2017), White et al. (2003)

Objective

Investigate the skill of Integrated Multi-SatellitE Retrievals for GPM (IMERG) in the estimation of precipitation over the mountains of south-central Chile using observational data from two field campaigns, including ice-initiated versus warm rain periods differences.

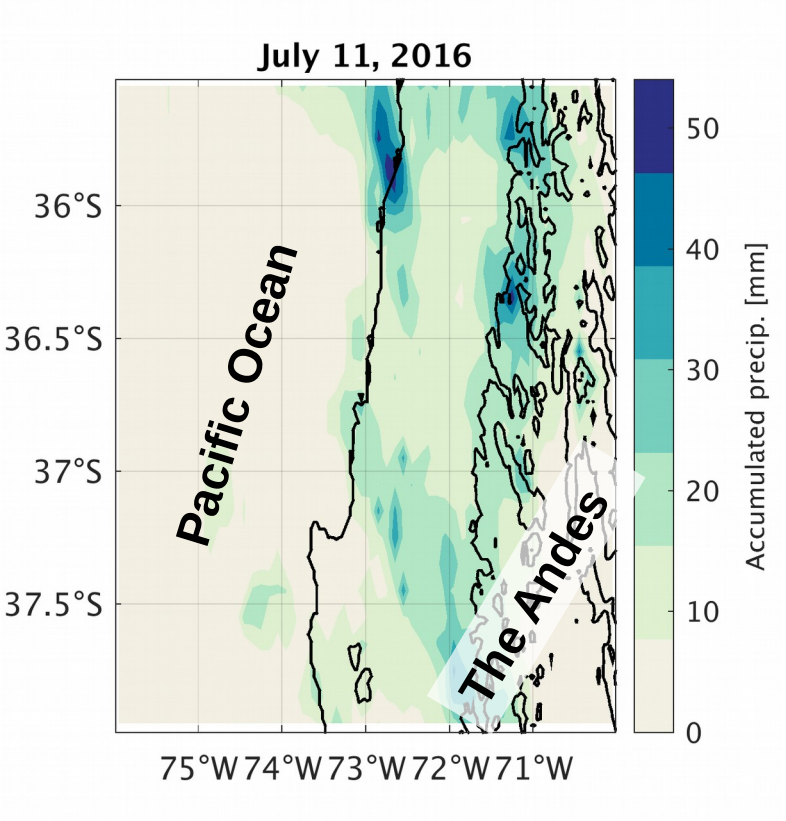




Data and Methods

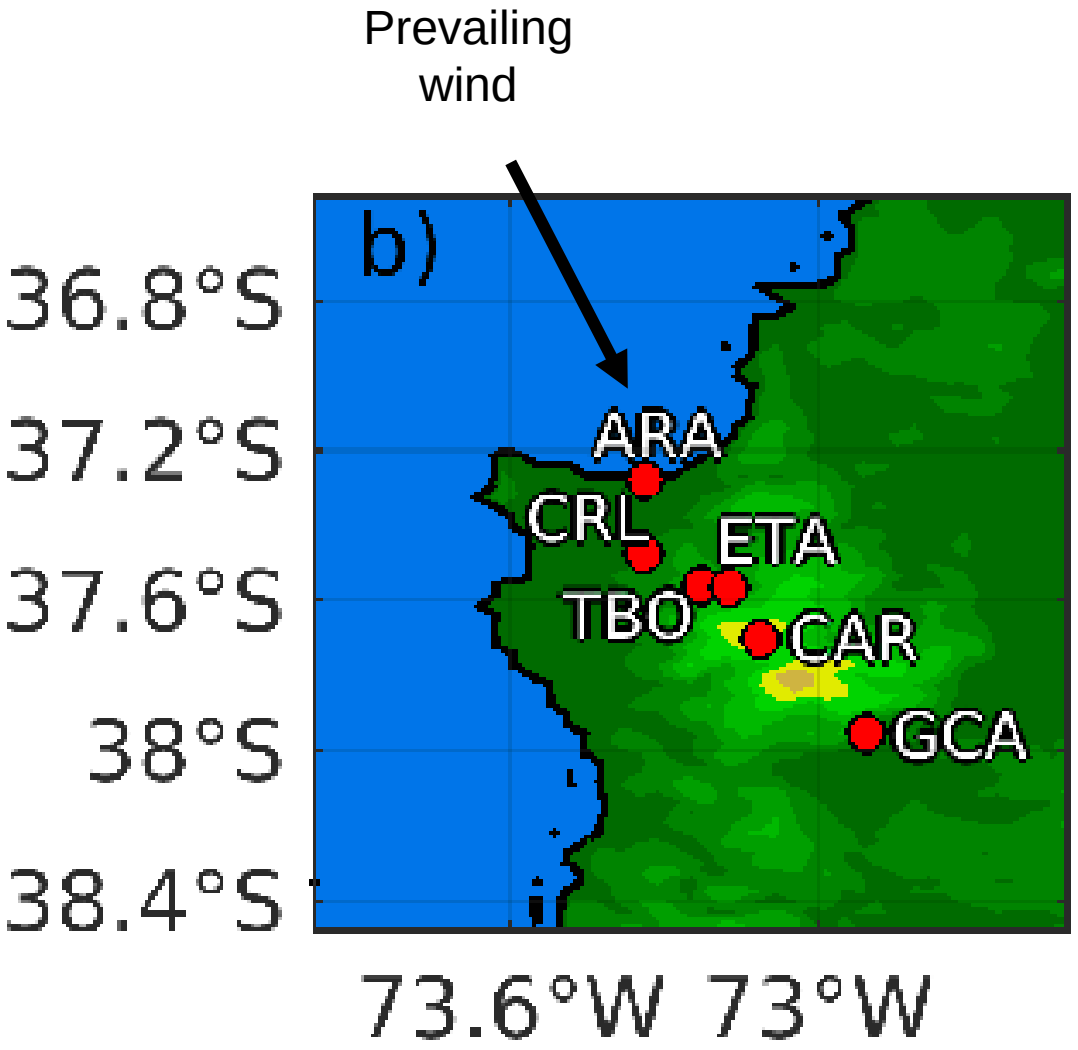
Data: GPM IMERG

- **GPM IMERG version 6.0 – Late run**
- **GPM core:** GPM Microwave Imager (GMI)
- Dual frequency Precipitation Radar (DPR)
- ***IMERG*** *intercalibrate, merge and interpolate:*
  - *Satellite microwave precipitation estimates*
  - *MW-calibrated infrared satellite estimates*
- **Spatial resolution**: 0.1°
- **Spatial domain:** 60°N - 60°S
- **Temporal resolution:** 30 minutes
- **Time domain:** 1998 – present



Contours: Elevation every 1000 m

Data: CCOPE



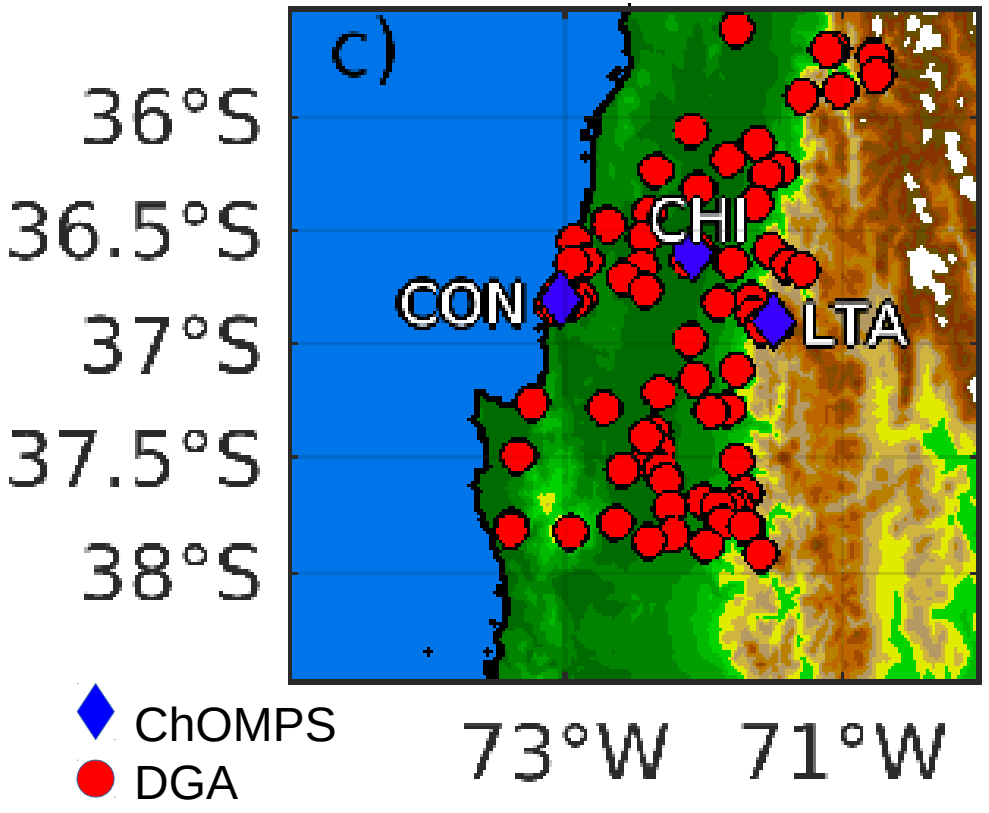
(Massmann et al. 2017)

- CCOPE: The Chilean Coastal Orographic Precipitation Experiment. (Massmann et al. 2017)
- May 22 to August 15, 2015
- Rainfall measurements from tipping bucket range gauge at: ARA, CRL, TBO, ETA, CAR and GCA
- K-band Micro Rain Radar (MRR) at Curanilahue (CRL)

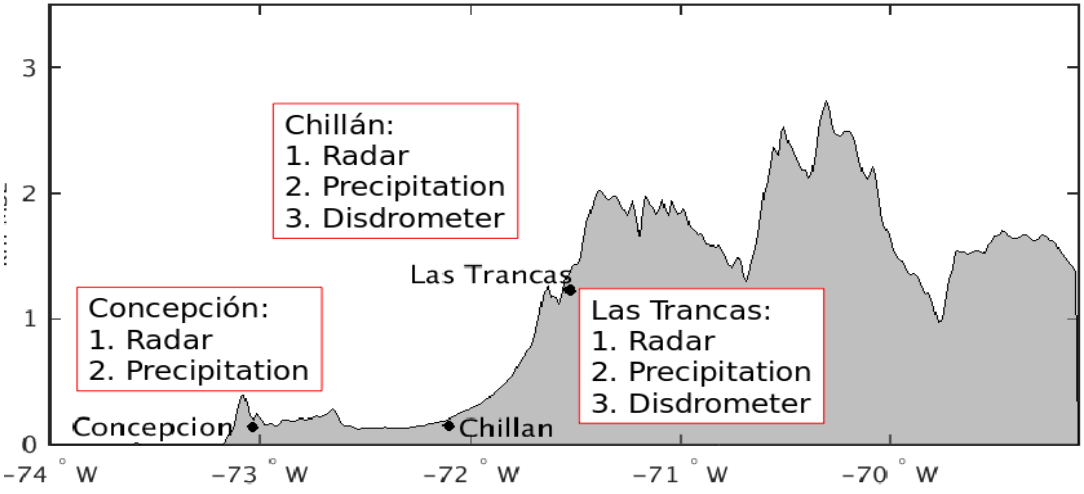
Frequency:
24 GHz
Temporal resolution:
2s
Vertical resolution:
200 m

Data: ChOMPS

ChOMPS: The Chilean Orographic and Mesoscale Precipitation Study



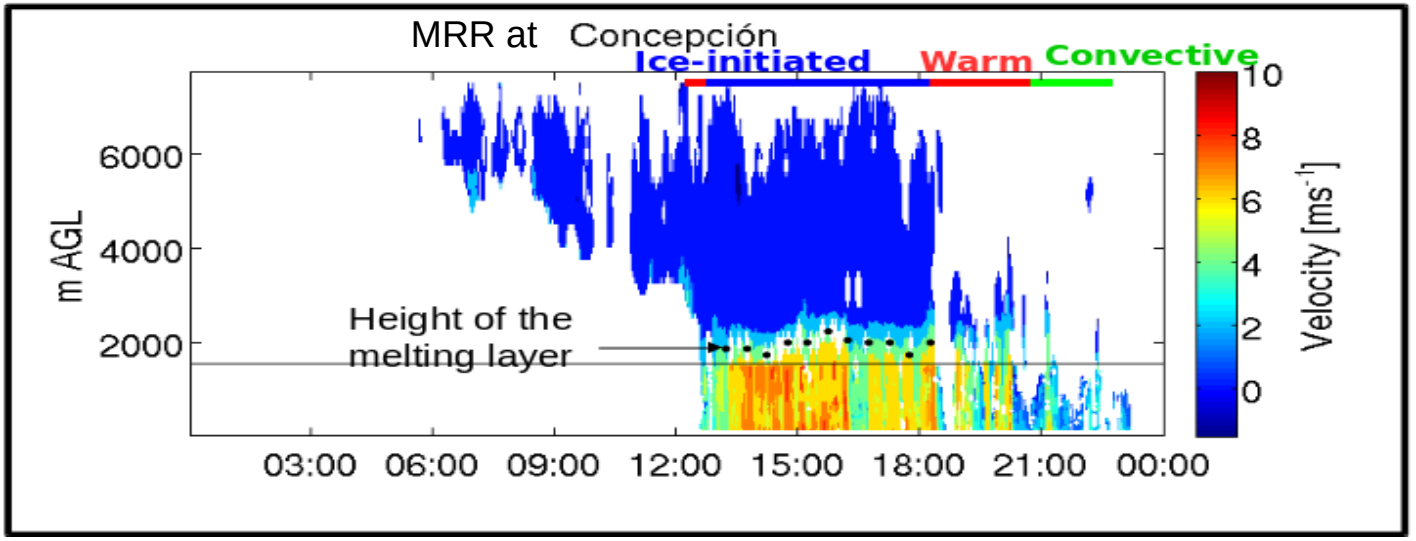
- May 15 to October 7, 2016



- Daily rainfall measurements from The Chilean Directorate of Water Resources (DGA)

- 0.2 mm per tip, tipping bucket rain gauge in all stations except Las Trancas (Weighing precipitation gauge with 0.01 inch accuracy)
- MRR at 3 sites (24Ghz every 2s, resolution: 50m and 250 m)
- Parsivel disdrometer measuring drop size and velocity every 10 s

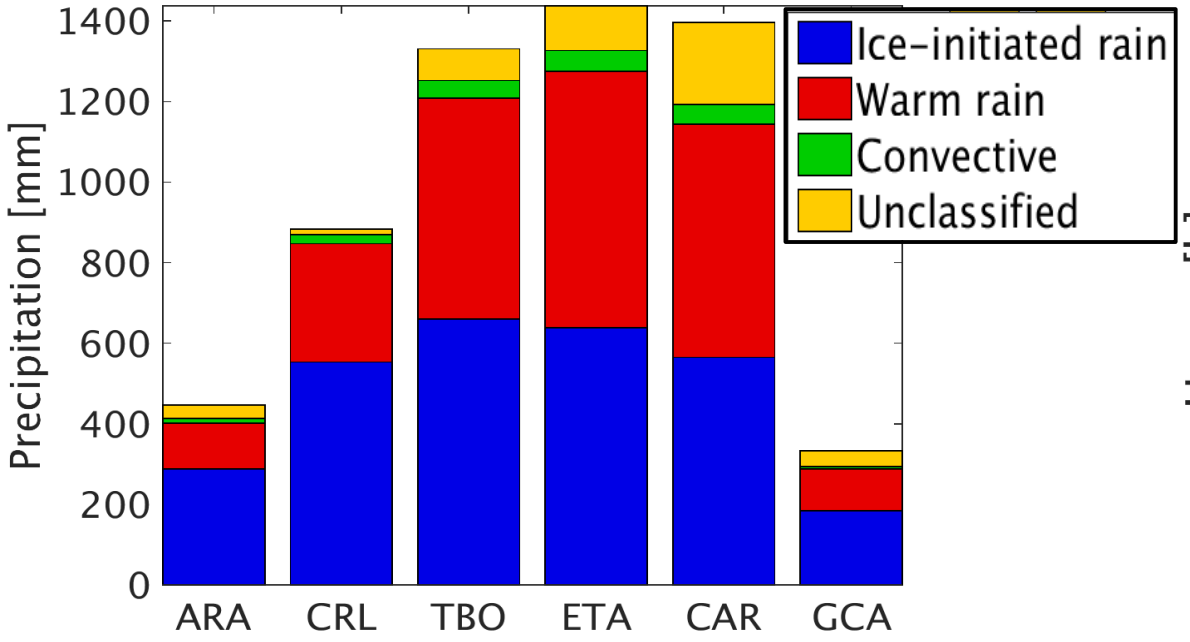
Methodology:
Classification of microphysical regimes

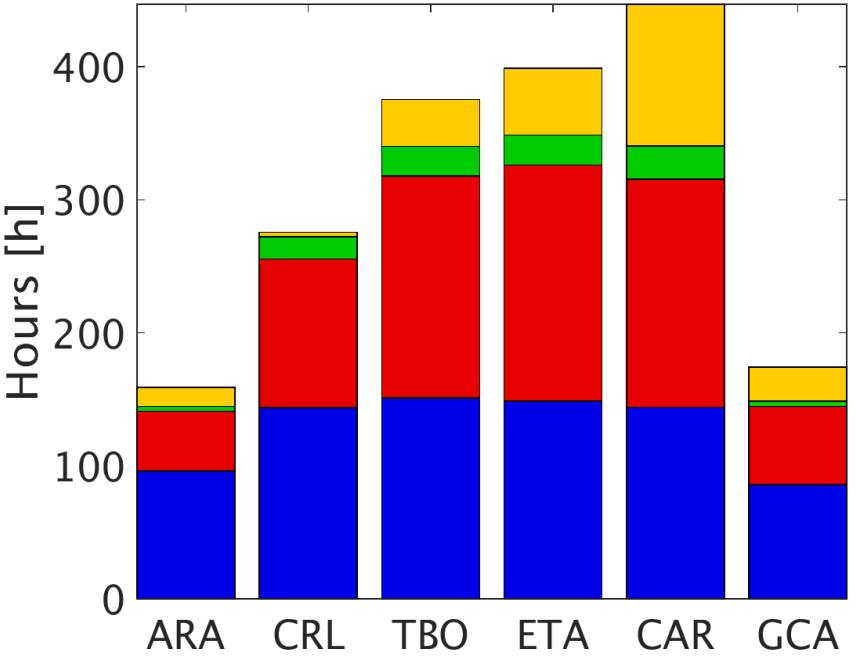


- **From profiling radar data and following White et al. (2003) and Massmann et al. (2017):**
- For every half an hour sample we classified:
  - **Convective rain**: Highly variable and sporadic echoes
  - **Ice-initiated rain**: Detected melting layer associated with a Doppler velocity gradient
  - **Warm rain**: Absence of a melting layer.
- These classifications are applied to rain gauge and IMERG data

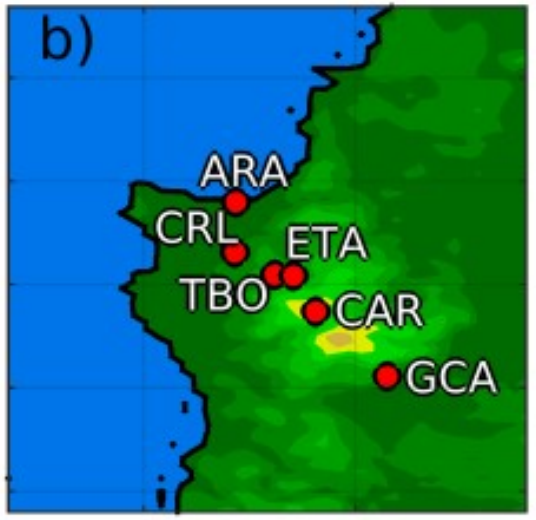
Results

Ice-Initiated versus Warm rain: CCOPE

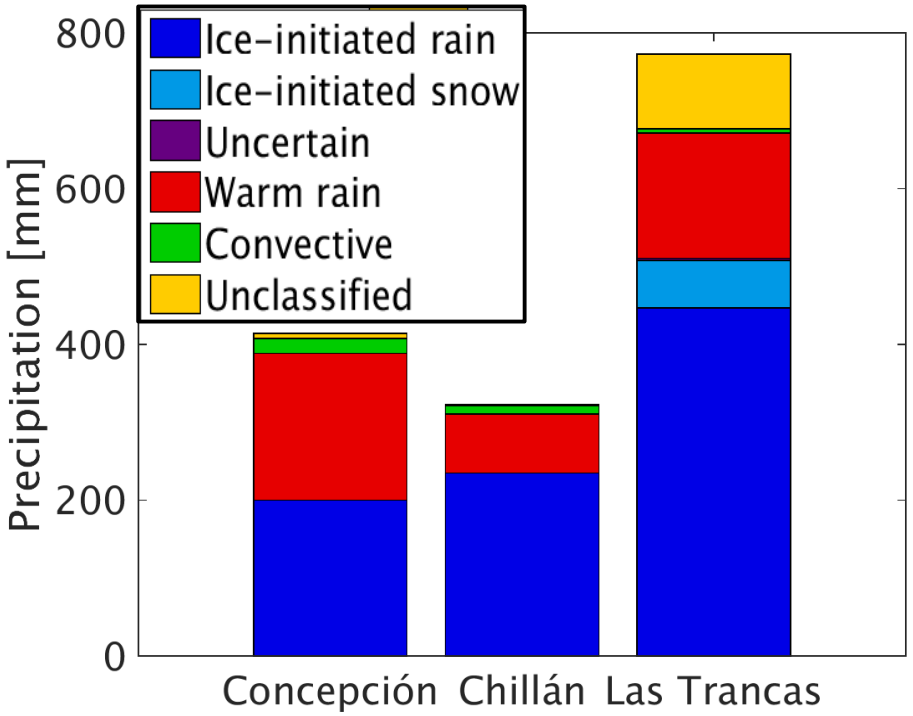


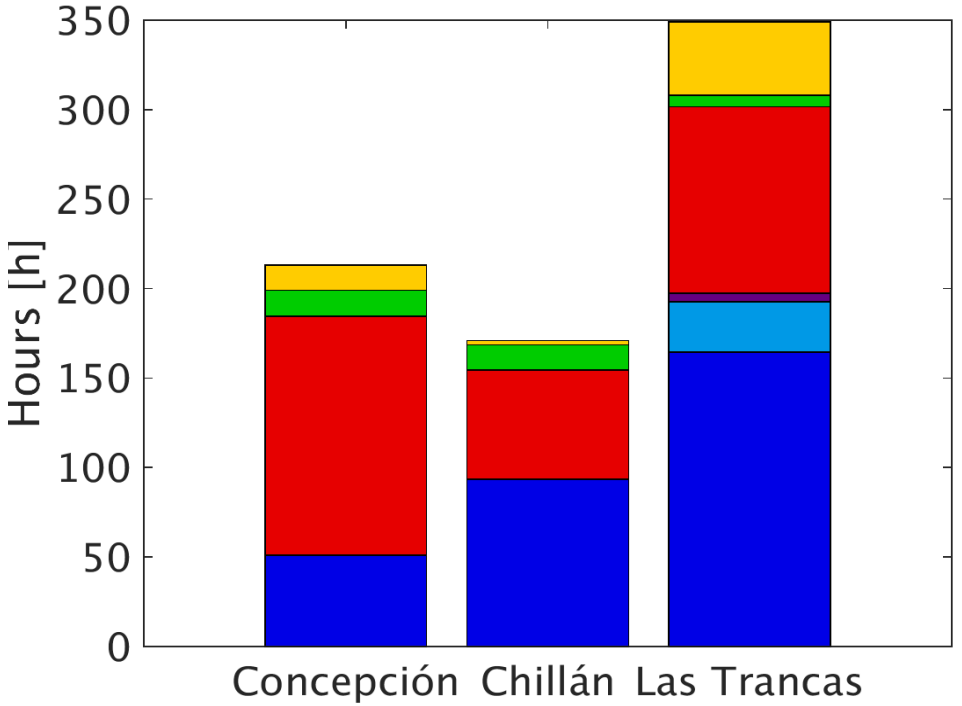


- Accumulated precipitation increases toward the coastal mountain range and decreases on the lee side:
  - *Increasing ice-initiated rain and warm rain.*
- Bigger intensity of precipitation during ice-initiated periods.
- Warm rain represent ~35% of total at CRL.

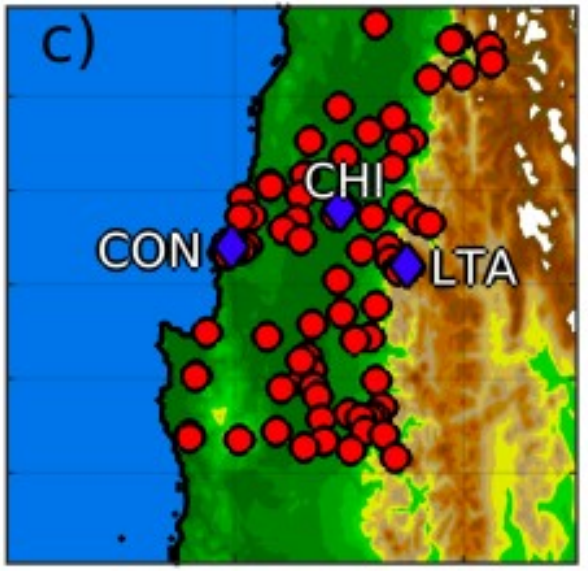


Ice-Initiated versus Warm rain: ChOMPS

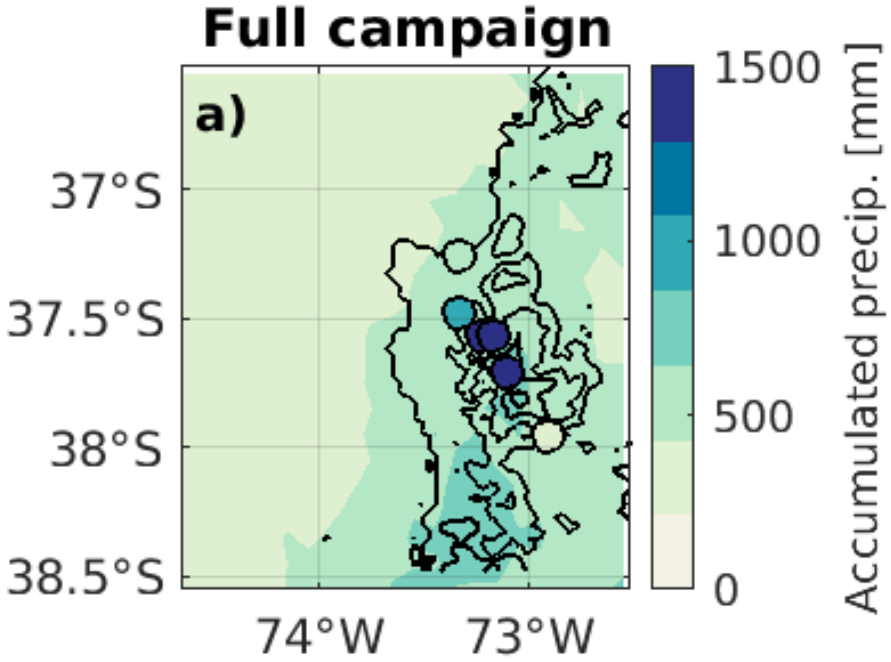




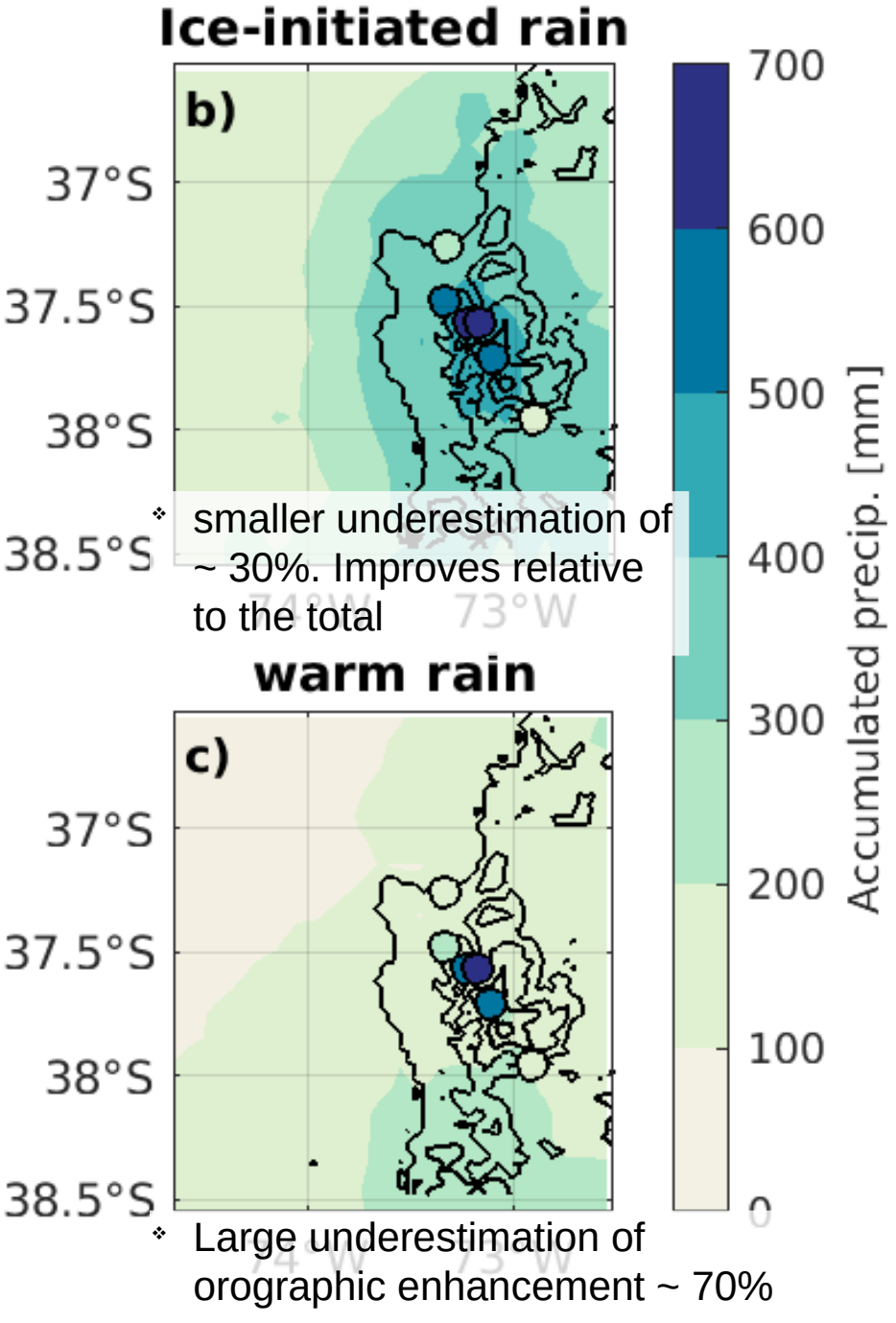
- Orographic enhancement at the coast and the
- Andes
- Ice-initiated rain increases toward the Andes in amount and duration
- Warm rain is bigger at the coast
- Ice-initiated rain is more intense than warm rain



Evaluating GPM-IMERG: CCOPE

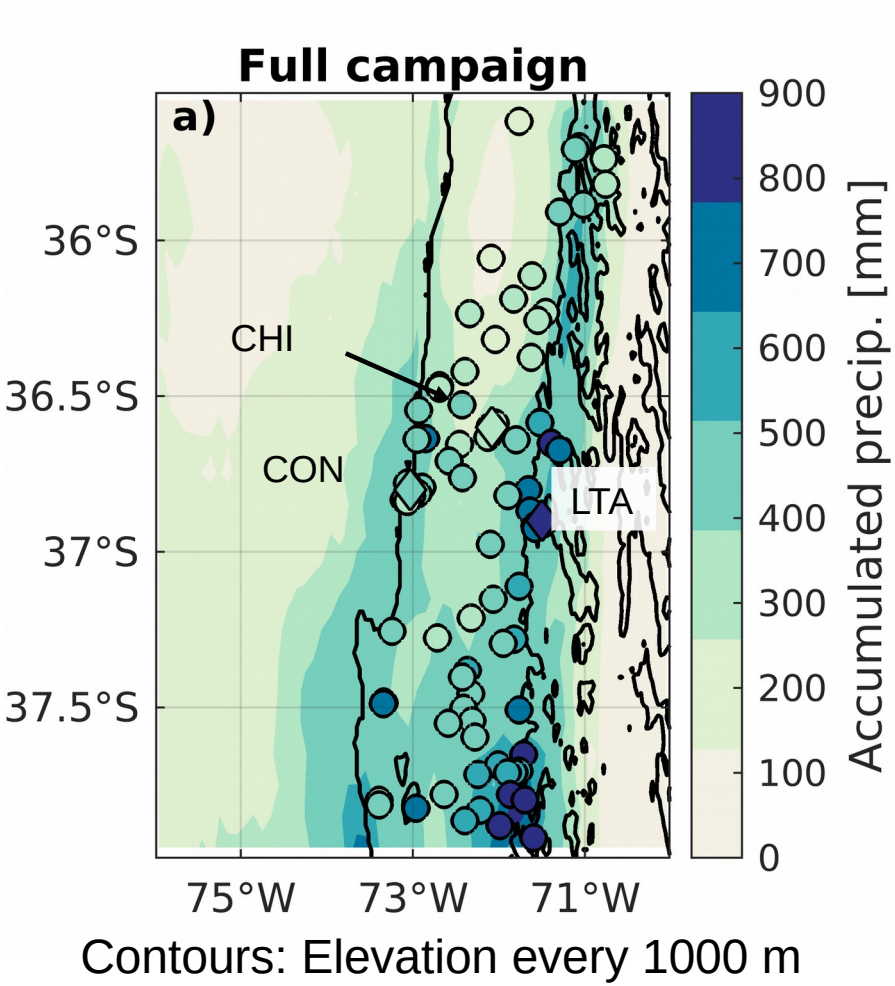


- IMERG exhibits orographic enhancement
- Underestimates the amount of precipitation ~ 50% at higher elevations



- smaller underestimation of ~ 30%. Improves relative to the total
- Large underestimation of orographic enhancement ~ 70%

Evaluating GPM-IMERG: ChOMPS



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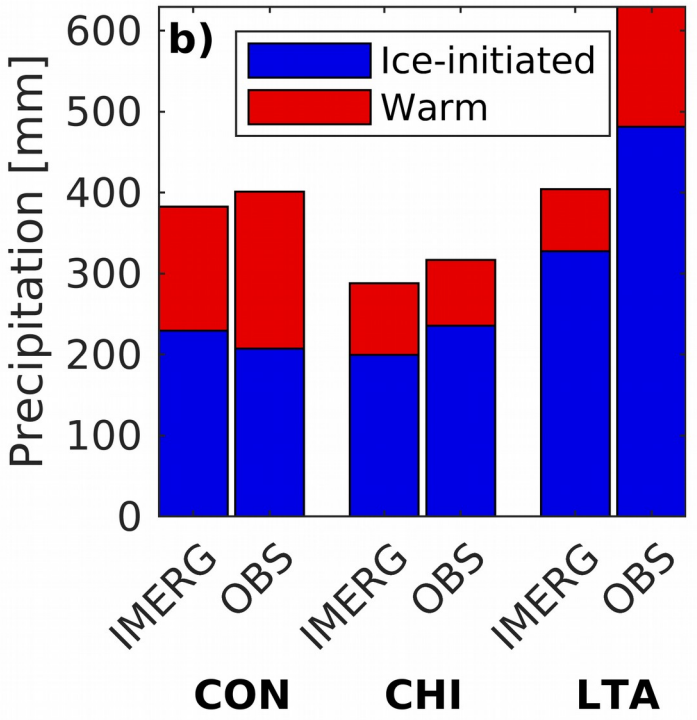

- IMERG shows orographic enhancement but underestimates the magnitude.
- Better agreement for northern sites
- CON: good estimation of ice-initiated but underestimation of warm rain
- CHI: good performance
- LTA: Underestimation of ~32% during ice-initiated and ~48% during warm rain periods

Discussion

- **GPM exhibits underestimations on the full rainfall field that may be due to:**
- Ground clutter contamination
- Inaccurate interpolation algorithms
- Inaccurate combination algorithms of IR and MW to estimate precipitation
- **Underestimation errors are more pronounced during warm rain periods**
  - Shallow orographic clouds poorly detected by satellite sensors:
    - errors in estimated cloud top temperature (brightness temperature)
    - weak or absent ice scattering signature

Conclusions

- IMERG exhibits orographic precipitation enhancement over the coastal mountains and The Andes of south-central Chile but underestimates the magnitude
- Assessment of IMERG against observations shows a large bias during warm rain periods
- Underestimations by ~30-70% at high elevation is consistent with previous studies in US west coast (~50%)