Ministerio del Ambiente

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Atmospheric physics and microphysics research project in the Central Peruvian Andes. A multilateral approach.

Yamina Silva, Daniel Martínez-Castro, Aldo Moya-Álvarez, René Estevan, José Flores Rojas, and Shailendra Kumar

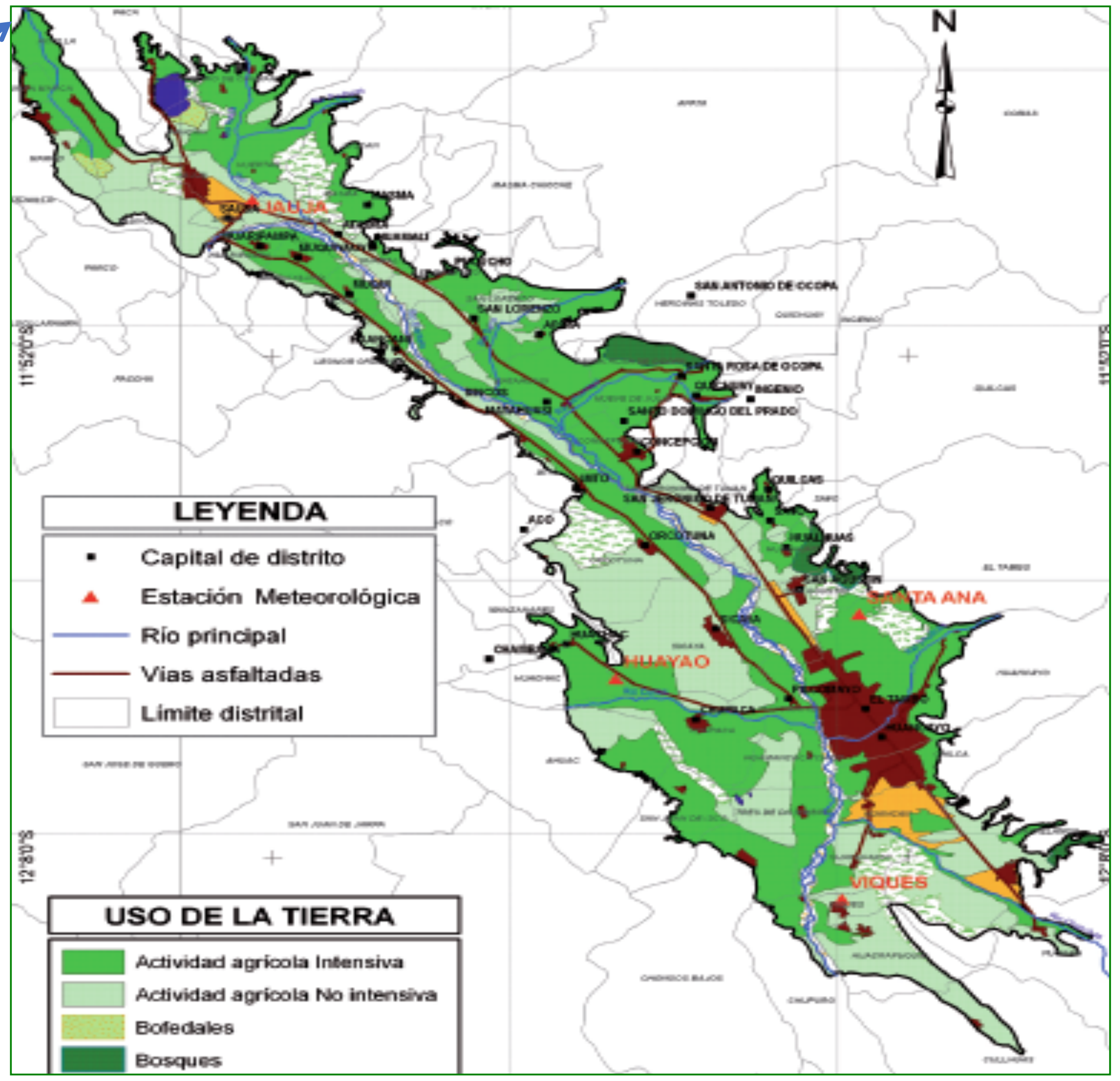
The region of study: Mantaro Basin

- The Mantaro hydroelectric power station supplies with almost 30 % of the demand of the National Interconnected System.

- The Mantaro valley has a great agricultural production that provides food to the capital (almost 10 million population)
- Over then 80% of agriculture depends directly of rainfall (no irrigation system)

Mantaro basin

Mantaro valley



The main climate features in the Mantaro

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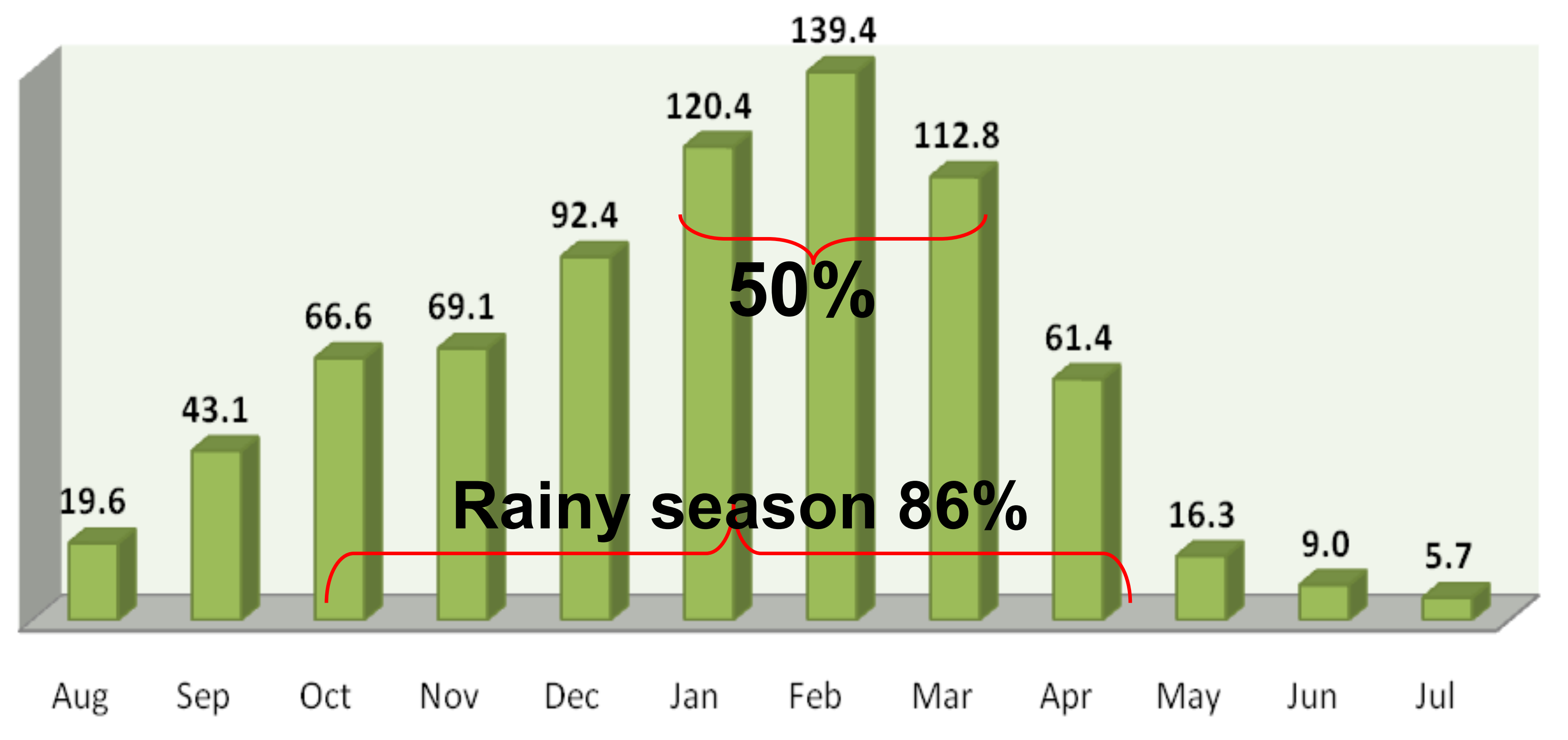
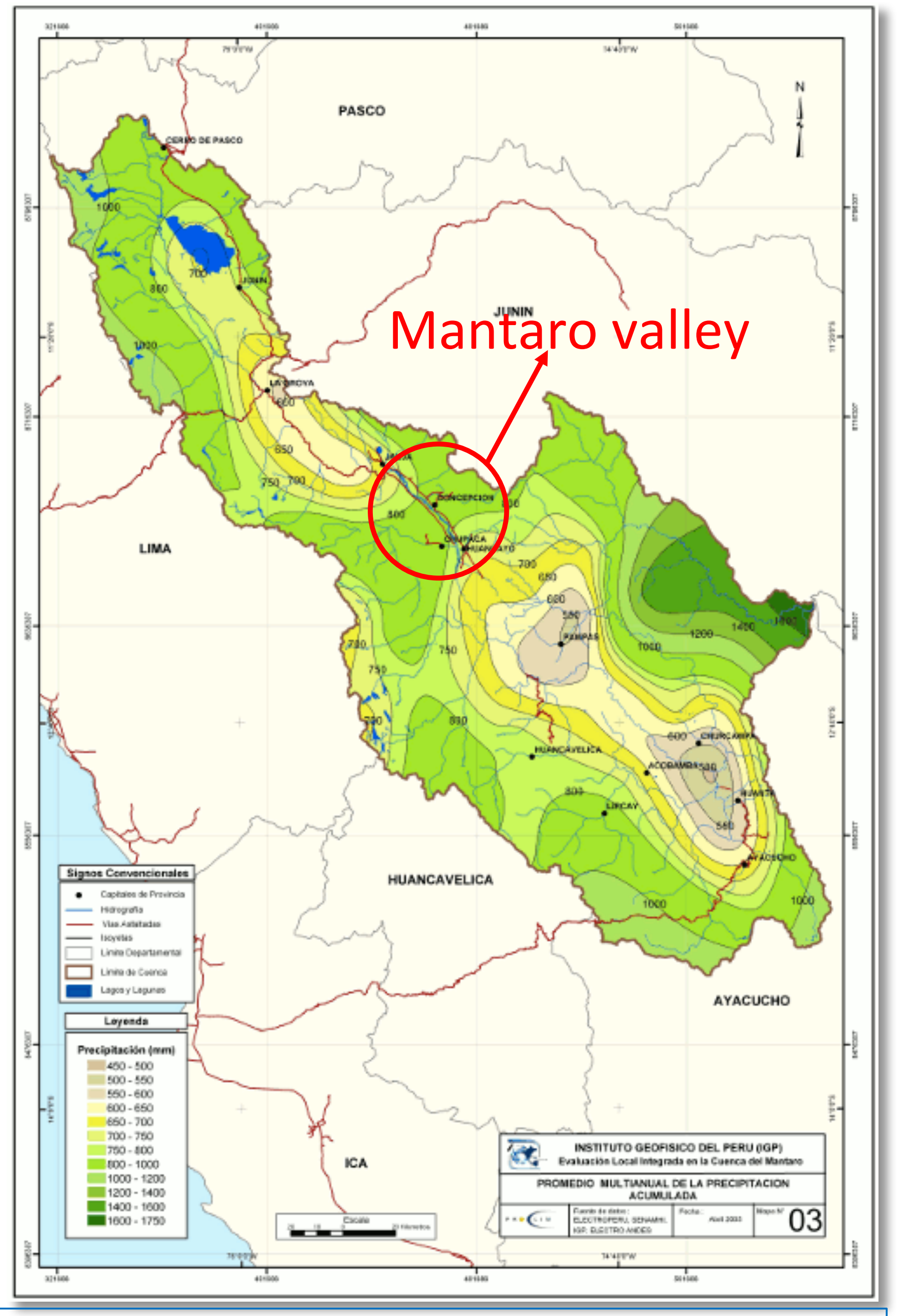
Monthly precipitation in the Mantaro valley (mm/month)

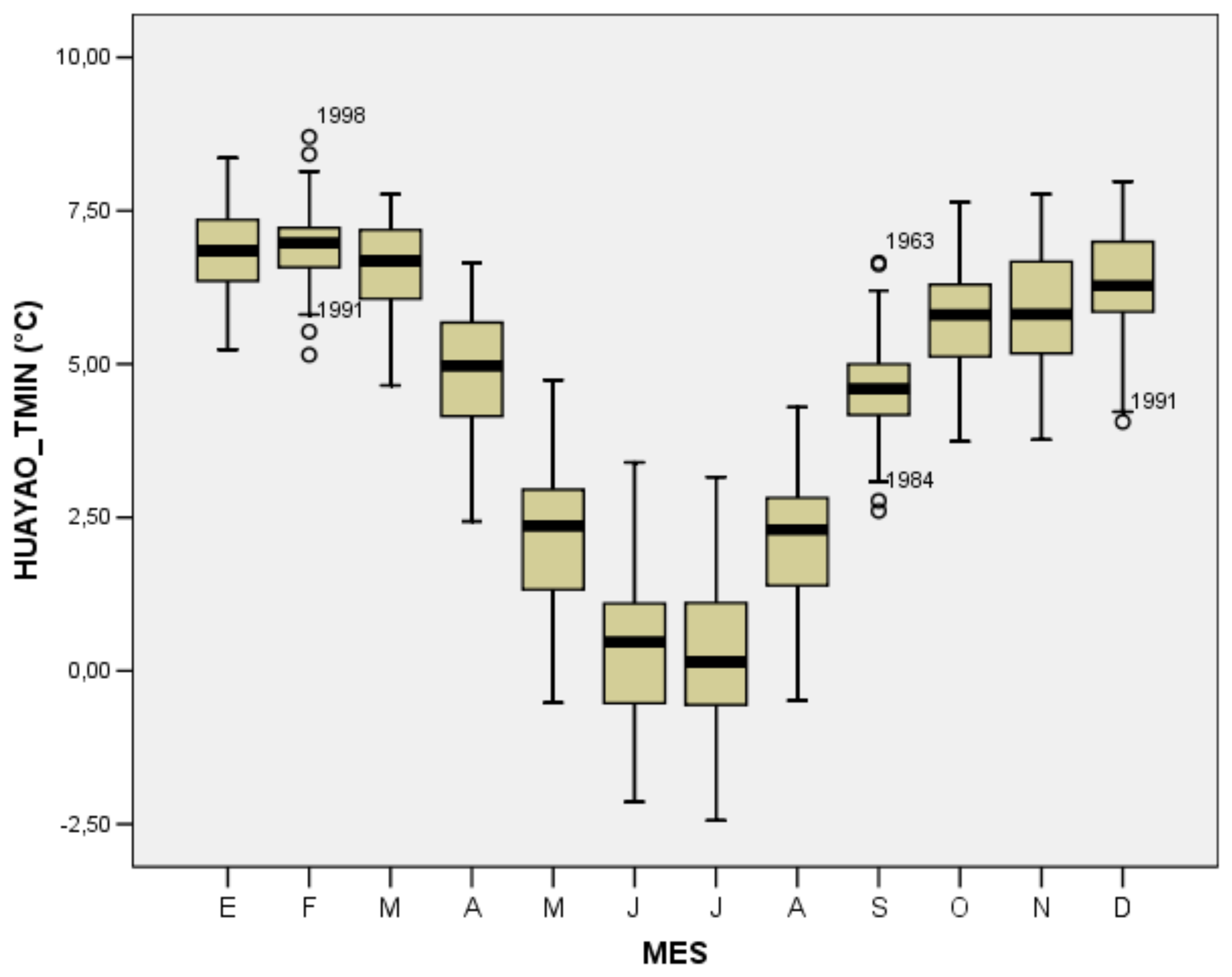


The climate of the Mantaro basin has high spatial and temporal variability, with the rainiest months in January-March, where about 50% of annual precipitation occurs. The Mantaro Valley has an average annual rainfall of 750 mm, which allows it to develop important agriculture activities for the region.

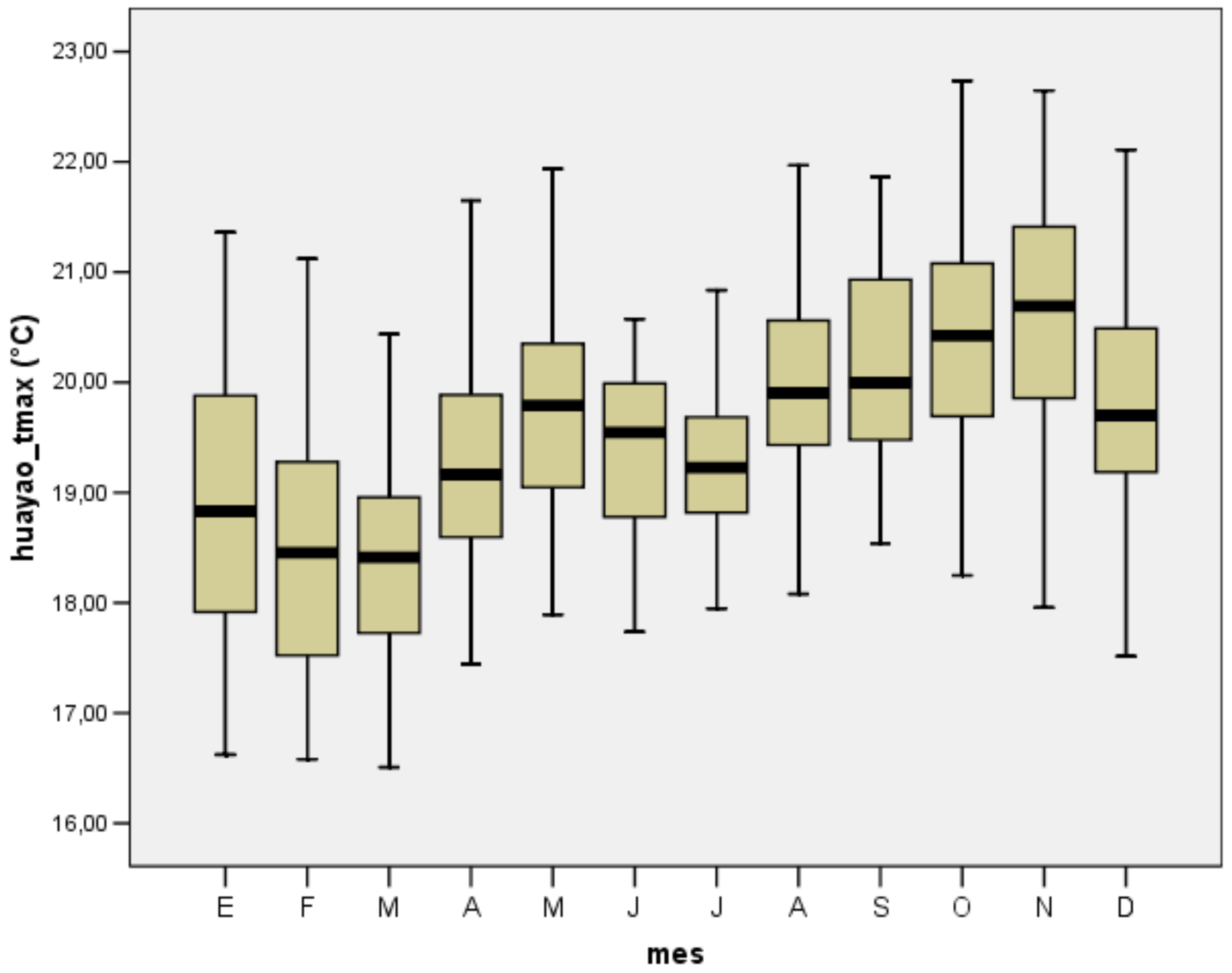
Annual precipitation (mm/year)



Minimum temperature (ºC)



Maximum temperature (ºC)



[IGP, 2005](#)

Due to the importance of the Mantaro basin for the country's economy, various research projects have been carried out to better understand the climate variability at different time scales, including climate change. Several of these projects were led by IGP.

Timeline of the IGP's projects in Mantaro basin

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Climate change

Netherlands Gobernament

2003-2005

[IGP, 2005](#)

Integrated local assessment in the Mantaro river basin

Seasonal variability

World bank

2007-2009

[IGP, 2010](#)

Seasonal climate forecast for application in agriculture in the Mantaro Valley

Extreme events

IRDC (Canada)

2009-2011

[IGP, 2012](#)

Risk management extreme weather event

Main results from previous studies:

- In 90 years the maximum temperature in Huancayo has increased in 0.85°C (1.2°C/decade).
- From the 80s the number of hot days and hot nights have increased as well as the cold days and clold nights have decreased.
- The frost events starts early (February-March) from 60s.
- From the 80s the heavy rainy events and rainy intensity has decreased.
- The rainy season is shorter in about 12 days.

Timeline of the IGP’s projects in Mantaro basin

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2014-2016

- Could & precipitation radar (MIRA) Innóvate Perú
- Aerosols USAID FROM THE AMERICAN PEOPLE

2015-2017

- Atmospheric microphysics Innóvate Perú
- Wind & precipitation UHF profiler (CLAIRE) Innóvate Perú

2017-2020

- **Magnet:** “Strengthening the research line on Atmospheric Physics and Microphysics” CONCYTEC FONDECYT

Recent projects

Since 2014 the IGP has developed various projects mostly with national funds, which allowed it to create new capacities in instrumentation and research on the climate of the Andes. This has allowed the implementation of a laboratory to carry out studies on the climate and its variability in the central Andes of Peru.

In this session we will present the main results of the **Magnet** project **:** “Strengthening the research line on Atmospheric Physics and Microphysics”, which was funded by FONDECYT-CONCYTEC.

The IGP´s Magnet project was part of the financial scheme ”Atracción de investigadores" executed by CONCYTEC in 2015.

Research in atmospheric physics and microphysics

Main objective:

Generate knowledge, skills and tools in atmospheric physics and microphysics, to increase the capacities of prevention and mitigation impacts of adverse weather events in the Peruvian Andes.

Research topics:

1. **Clouds and precipitation.** The aim is to evaluate the formation, structure and evolution of clouds and rainfall in the Mantaro valley;

2. **Radiation and aerosols**. The aim is to evaluate physical and chemical properties of atmospheric aerosols and its relation with solar radiation;

3. **Dynamics and atmospheric modeling**. The aim is to evaluate the physical and dynamical processes of the atmosphere in the Mantaro basin using WRF and ARPS models.

Laboratory of Atmospheric Microphysics and Radiation- LAMAR

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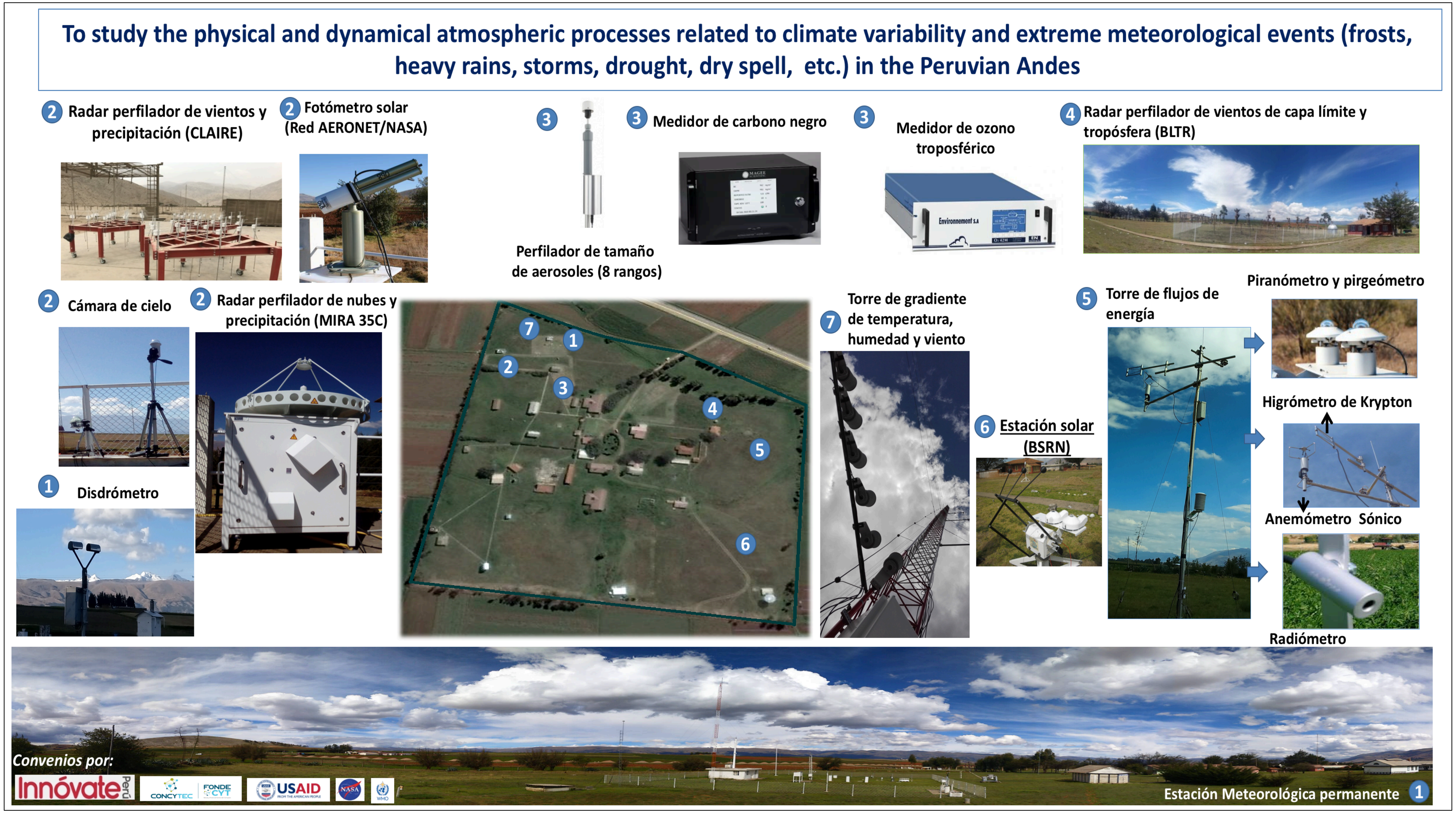
To achieve the objectives of the project, data generated in LAMAR (Martínez[1]) and the field campaigns measurement during the rainy season were used; as well as the HPC-Linux cluster from the Geophysical Fluid Dynamics Laboratory (LDFG) of IGP.



1. [D3386 | EGU2020-12664] Laboratory of Atmospheric Microphysics and Radiation (LAMAR): a set of sensors for the study of extreme meteorological events in the Central Andes of Peru.

1. Clouds and precipitation

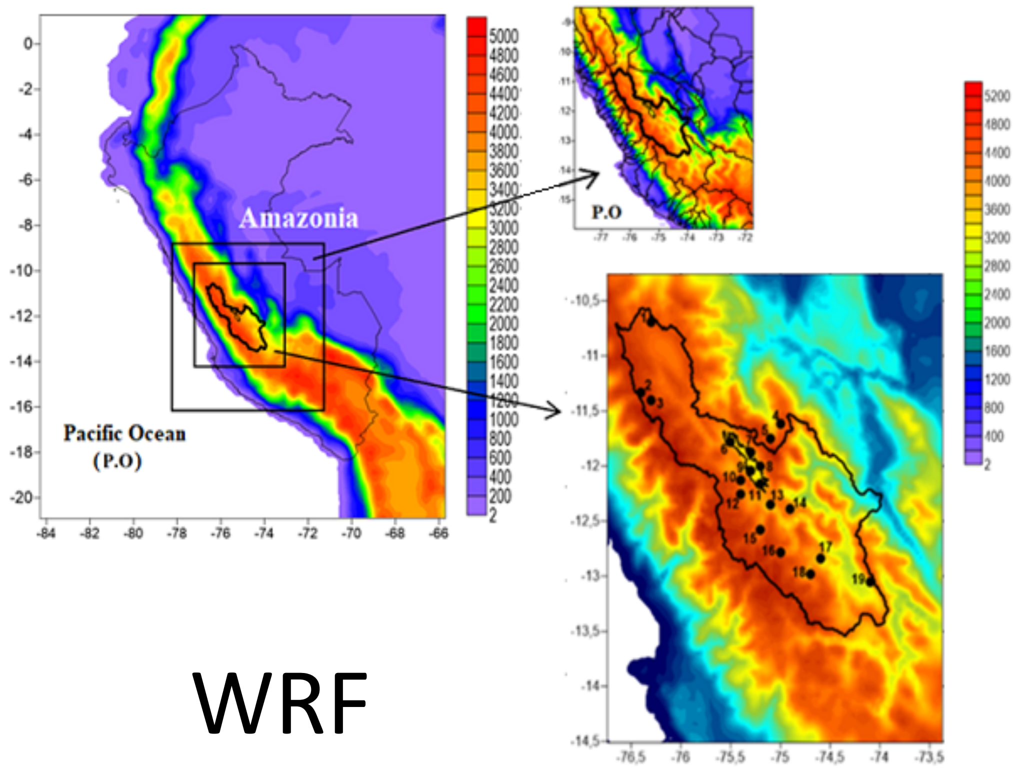
<u>The aim of this research line was</u>:

•Characterize the structure of the convective systems that are developed on the Huancayo Observatory using radar data

•Find the size distribution and phase composition of the precipitation particles at the Huancayo Observatory, using radar and disdrometer information.

•Characterize the diurnal cycle of precipitation for the Mantaro basin.

•To characterize the dynamics and microphysics of convective storms that develop over the Mantaro Basin from high resolution numerical simulation.



WRF

MIRA 35 C

Parsivel 2

1.1 The Impact of Microphysics Parameterization in the Simulation of Two Convective Rainfall Events over the Central Andes of Peru Using WRF-ARW

Martínez-Castro D., Kumar S, Flores Rojas J. L., Moya-Álvarez A.,. Valdivia-Prado J. M, Villalobos-Puma E., Del Castillo-Velarde C., Silva-Vidal Y.

DOI: 10.3390/atmos10080442

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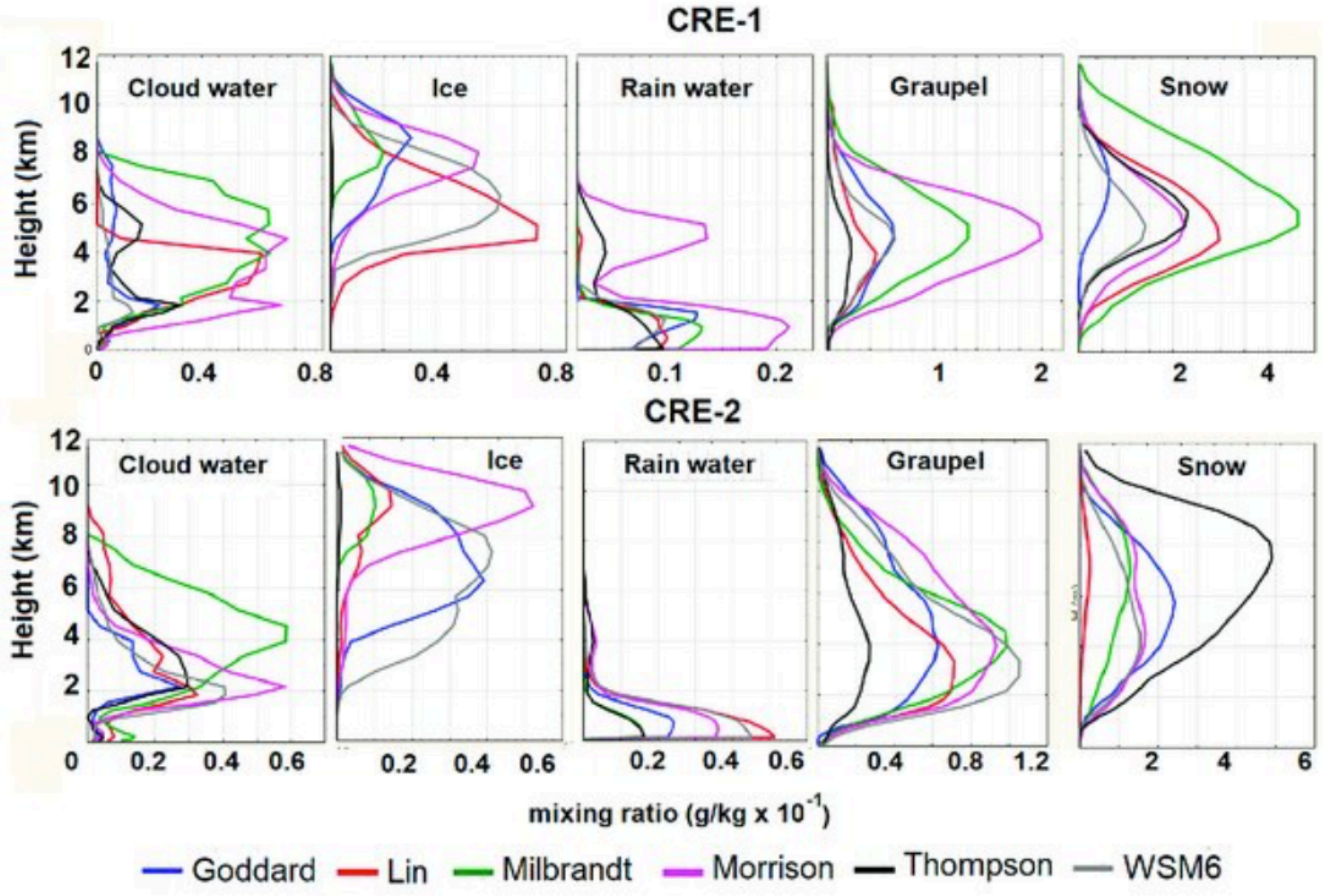
- **The main results:**
- The Morrison and Lin configurations reproduced the general dynamics of the development of cloud systems for the two case studies.
- The vertical profiles of the hydrometeors simulated by different schemes showed significant differences.
- The best performance of the Morrison scheme for both case studies may be related to its ability to simulate the role of graupel in precipitation formation.
- The analysis of the maximum reflectivity field, cloud top distribution, and vertical structure of the simulated cloud field also shows that the Morrison parameterization reproduced the convective systems consistently with observations.



Average vertical profile of hydrometeors simulated by WRF model microphysics schemes for CRE1 (upper panels) and CRE2 (lower panels) for the six tested parameterization schemes.

1.2 Diurnal Cycle of Raindrops Size Distribution in a Valley of the Peruvian Central Andes

Villalobos-Puma, E., Martinez-Castro, D., Flores-Rojas, J. L., Saavedra-Huanca, M., & Silva-Vidal, Y.

https://doi.org/10.3390/atmos11010038

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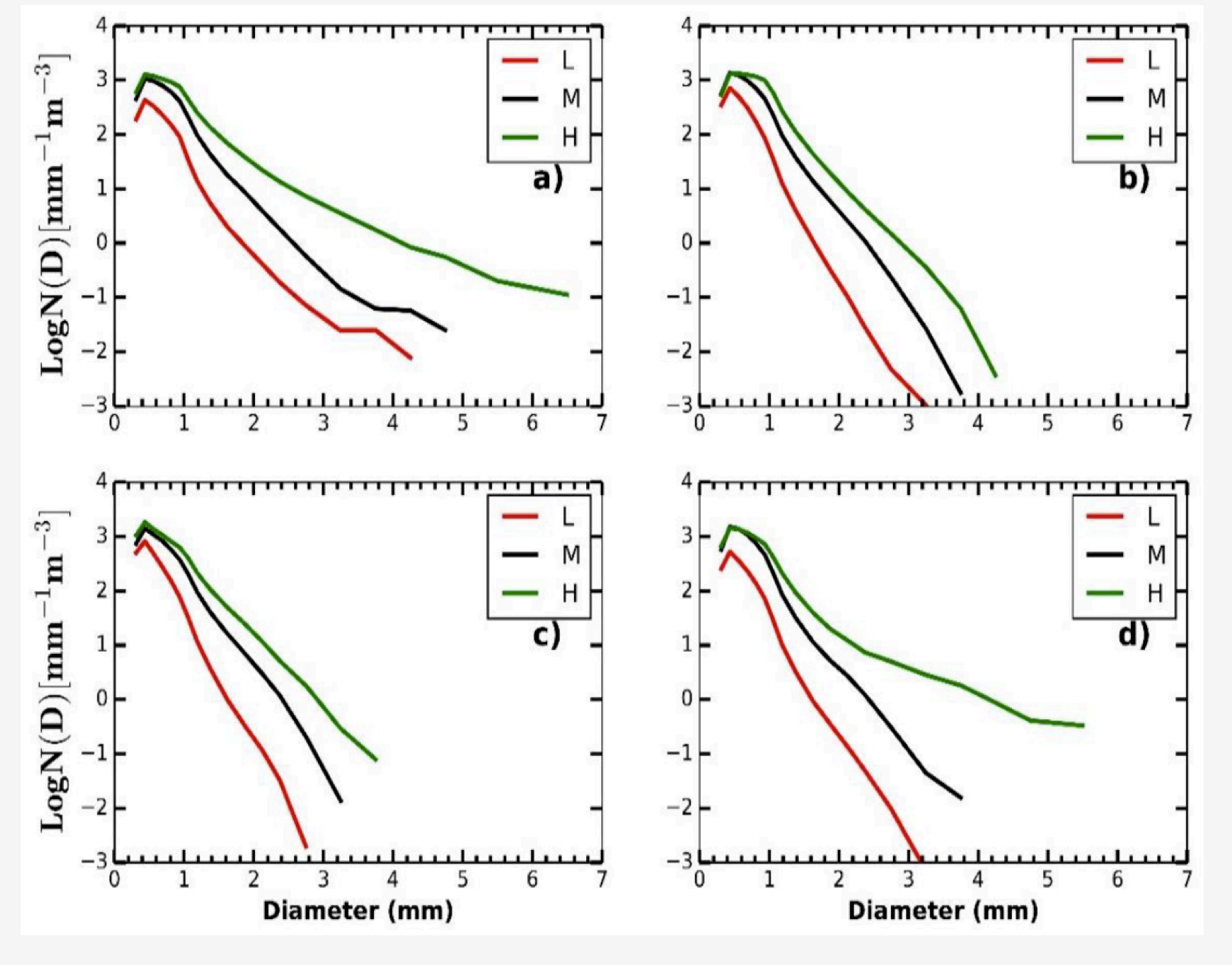
•**The main results:**

•The mass-weighted mean diameter Dm and the Nw parameter present respectively high and low values, in the interval of 15–20 LST (local standard time), wherein deeper and more active clouds appear.

•The events including convective rainfall contribute 67.5% of the accumulated total, wherein 92% corresponds to the 15–20 LST interval.

•The spectral variability of the RSD is strongly controlled by the cloudiness configuration field developing over the west (convection over highlands) and east (convection over Amazon) sides of the valley.

•In the afternoon, clouds develop and drift to the east, over the Andean valleys and towards the Amazon, intensified by local orographic circulation. The opposite happens at night, when the stratiform rainfall is dominant and it is controlled by clouds, located in the Inter-Andean valley, generated by the convection fields formed over the Amazon forest.



Diurnal variation of the RSD spectra in function to rainfall classes (light rainfall, medium rainfall, and heavy rainfall), (**a**) 15–20 LST, (**b**) 21–02 LST, (**c**) 03–08 LST, (**d**) 09–14 LST.

1.3 Rainfall Characteristics in the Mantaro Basin over Tropical Andes from a Vertically Pointed Profile Rain Radar and In-Situ Field Campaign.

Shailendra Kumar, Carlos Del Castillo-Velarde, Jairo M. Valdivia, José Luis Flores, Stephany M. Callañaupa, Aldo S. Moya, Daniel Martinez-Castro and Yamina Silva

https://doi.org/10.3390/atmos11030248

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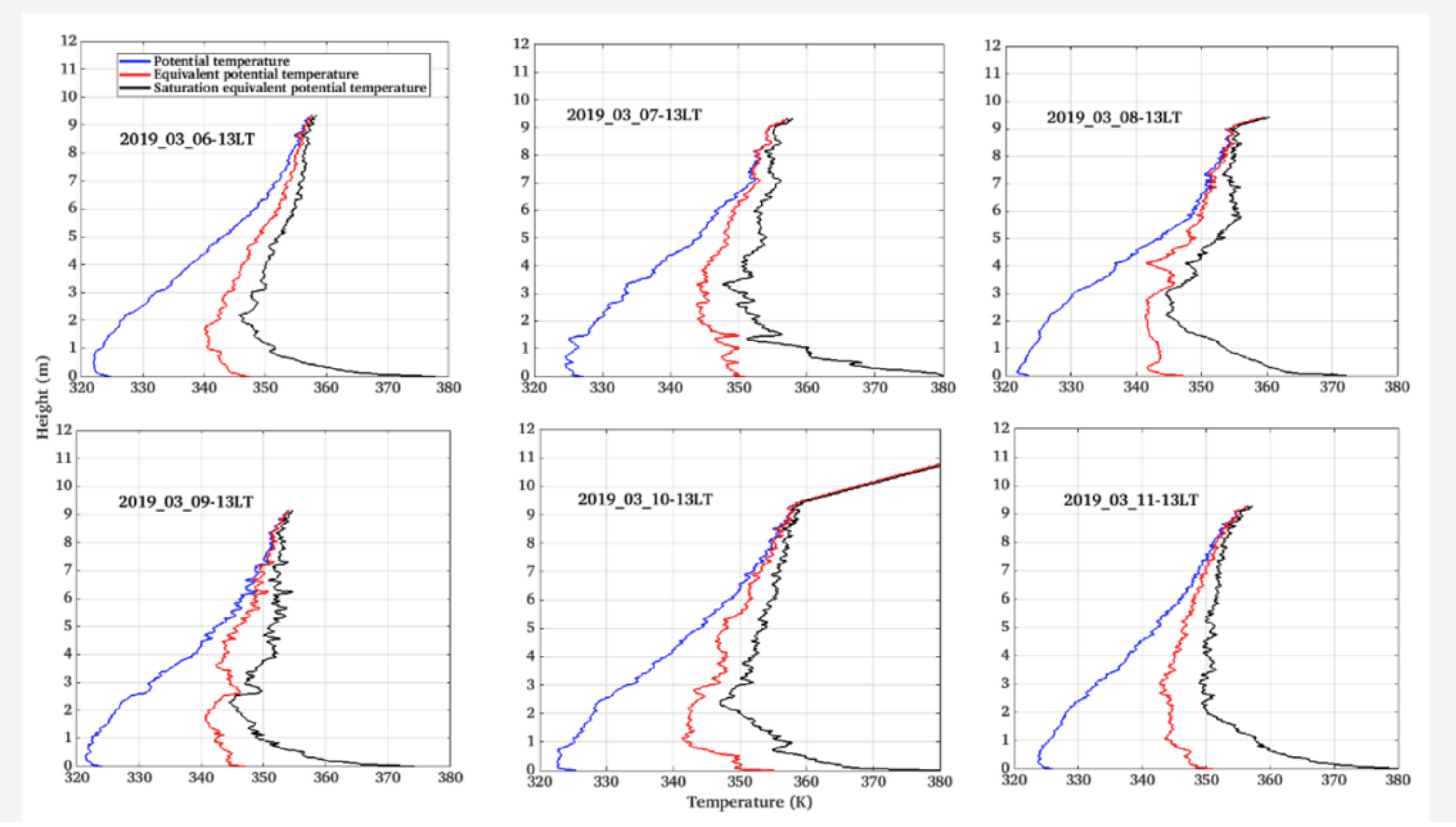
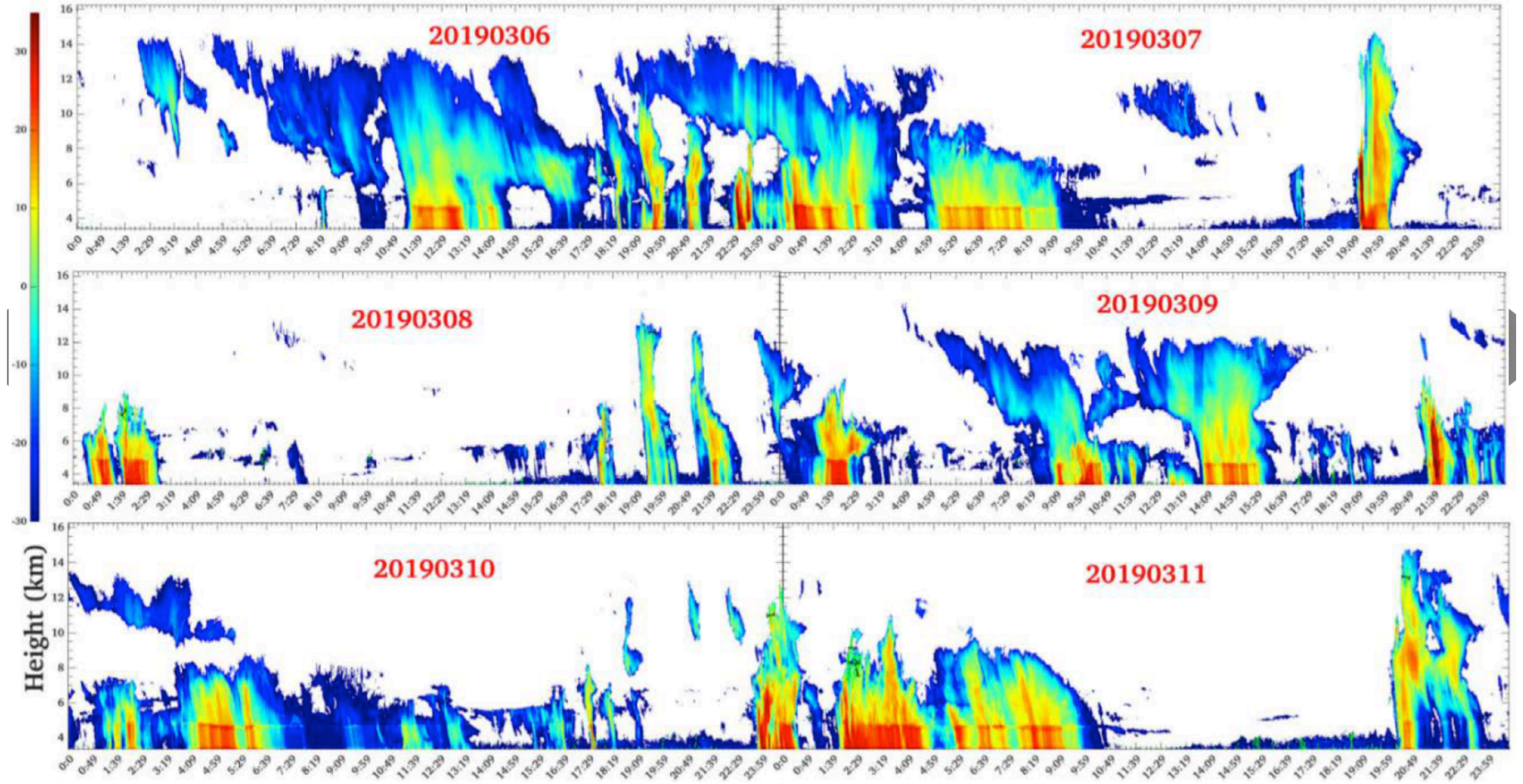


Equivalent potential temperature, saturation equivalent potential temperature and potential temperature calculated from the radiosonde data for 06–11 March at 13 LT.

- **The main results**:
- A bimodal pattern is observed in precipitation and bright band height with local maxima during after-noon and overnight. This is partially attributed to the diurnal cycle of surface temperature in the tropical Andes.
- The average Z_e profiles show the gradient near the freezing height due to the melting layer and for the higher near-surface RR, Z_e decreases sharply above the freezing height. Rain rate and LWC show the different vertical variations below and above the 6 km altitude. The DSD variation shows the higher concentration of larger sized of drop for higher near-surface rain rate below the ML. Although the dominant mode of drop size is less than 1 mm for most of the near-surface rain rate.
- The rainfall characteristics during campaign periods reveal the convective organization with higher precipitation. However, stratiform precipitation was more common and exist for the longer periods, but with less accumulated surface rainfall.



Vertical profiles of radar reflectivity (Ze) during the wet spells (6 March to 11 March 2019) from vertical profile of rain radar (VPRR).

1.4 Effect of the surface wind flow and topography on precipitating cloud systems over the Andes and associated Amazon basin: GPM observations.

Shailendra Kumar, Yamina Silva-Vidal, Aldo S. Moya-Álvarez, Daniel Martínez-Castro

https://doi.org/10.1016/j.atmosres.2019.03.027

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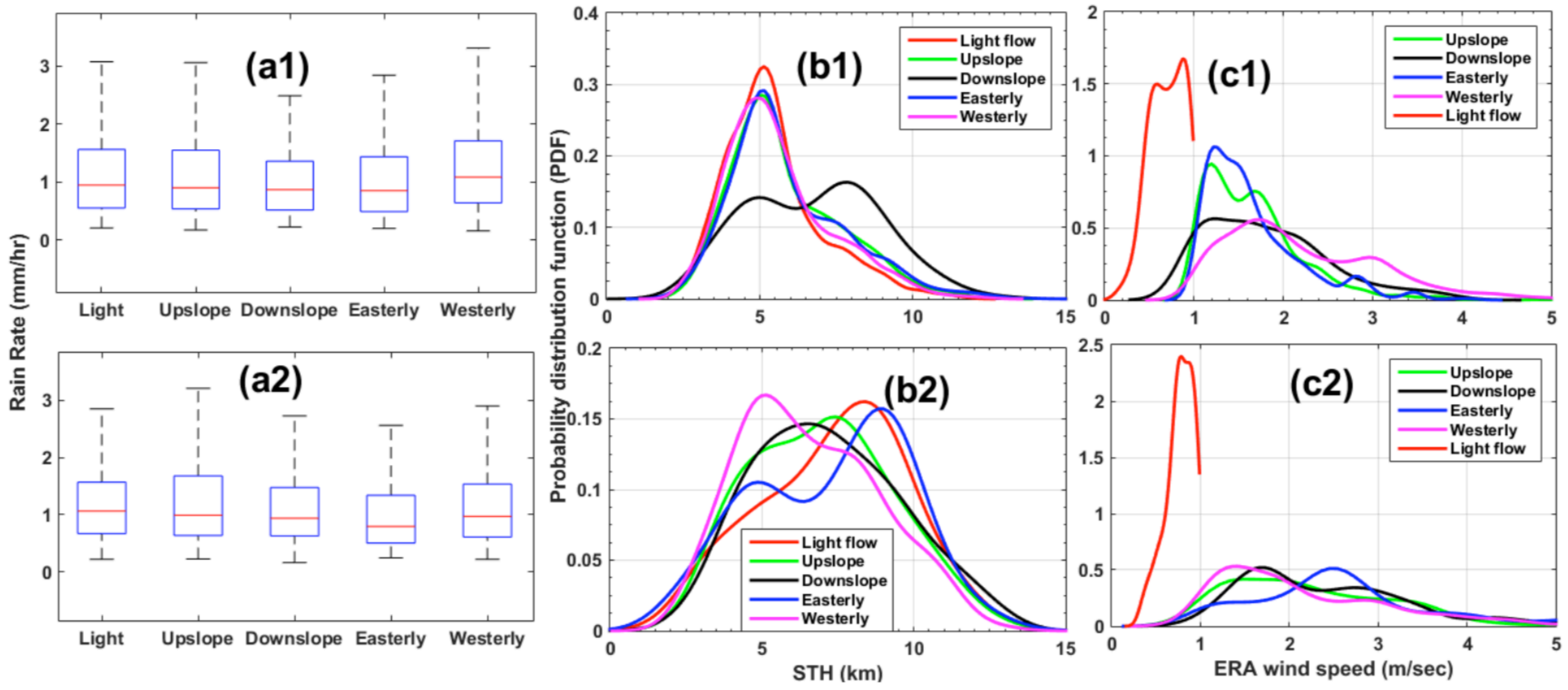
The main results:

- Orography also modulates the precipitation characteristics under different directional flow over the Andes mountain.
- Eastern slope of Andes has higher rain rate compared to western slope of Andes in most of the directional flow.
- Orographically forced moisture loaded flow, over the eastern slope of Andes causing the higher rain rate, drop radius and droplet concentration in northern Andes.
- At the low lands, effective drop radius and droplet concentration show the opposite characteristics, and effective drop radius (concentration) is least (highest) excluding the downslope flow in over northern Andes.
- The results of DSD parameters along with rainfall intensity show the microphysical evolution of the precipitation under the complex orography over the Andes mountain.



Probability density function of (a1,a2) rain rate, (b1,b2) storm top height (c1, c2) average wind speed for the precipitating cloud systems for different classes of flow for Toporeg1 (upper row) and Toporeg2 (bottom row).

1.5 Seasonal and Regional Differences in Extreme Rainfall Events and Their Contribution to the World's Precipitation: GPM Observations.

Kumar S., Silva Y., Moya-´Alvarez A. S., and Martínez-Castro D.

https://doi.org/10.1155/2019/4631609

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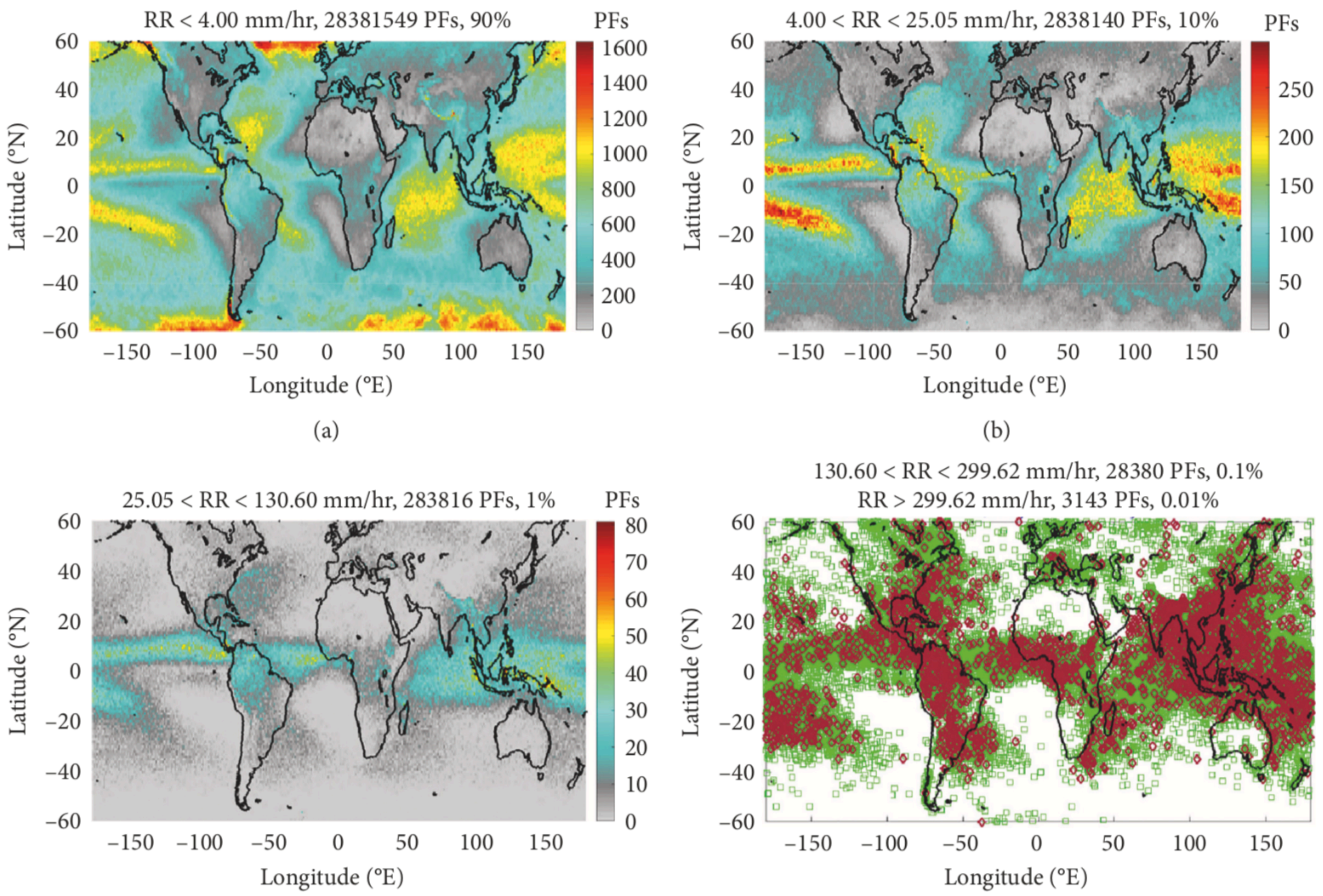
The main results:

- On the regional and seasonal scale, South Asia (SAsia) and South America (SA) nearly show common features, as oceanic and land areas consist of largest and deepest EREs, respectively, and contribute to higher precipitation.
- Subtropical latitudes over South America, including Sierra de Cordoba and La Plata basin, consist of deepest and intense EREs and match with those of the Indo-Gangetic plain over South Asia, which also shows the similar characteristics.
- EREs based on various parameters are strongly linked over SAsia compared to SA. For example, the largest top 10% EREs have a higher probability to be part of the top 10% deepest and intense EREs over SAsia.
- The seasonal and regional water budget reveals different characteristics, as in the southern hemisphere, the deeper EREs contribute to the higher fraction of rainfall, but over SAsia, the shallower EREs could also contribute to significant rainfall.



Spatial distribution of intense extreme rainfall events (in mm h−1) over the globe based on the rainfall rate. (a–c) The distribution of intense extreme rainfall events in each 1° × 1° box; (d) the actual geographical locations of intense extreme rainfall events. Color bar in (a)–(c) shows the number of extreme rainfall events. (d) The green color refers to the top 0.1% intense extreme rainfall events, whereas magenta refers to the top 0.01% intense extreme rainfall events.

2. Radiation and aerosols

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<u>The aim of this research line was</u>:

- To classify different types of aerosols present in the Mantaro Valley, and their relationship to source regions.
- To characterize radiative forcing and its dependence on different types of aerosols.
- To evaluate the behavior of the Integral Content of Water Vapor (CIVA) measured with a solar photometer.

CIMEL CE-318 Solar Photometer
Spectral measurement of solar and sky irradiance, to determine the Aerosol Optical Depth (AOD) and Angstrom Coefficient. Part of NASA-AERONET. Uses 8 wavelengths (340, 380, 440, 500, 675, 870, 1020, 1640 nm). Automatic sun-tracking. Precision: 0.003°.

BSRN Station. (Baseline Solar Radiation Network). Measurement of Surface short wave and long wave solar radiation.

2.1 First two and a half years of aerosol measurements with an AERONET sunphotometer at the Huancayo Observatory

Estevan, R., Martínez-Castro, D., Suarez-Salas, L., Moya, A., Silva, Y.

https://doi.org/10.1016/j.aeaoa.2019.100037

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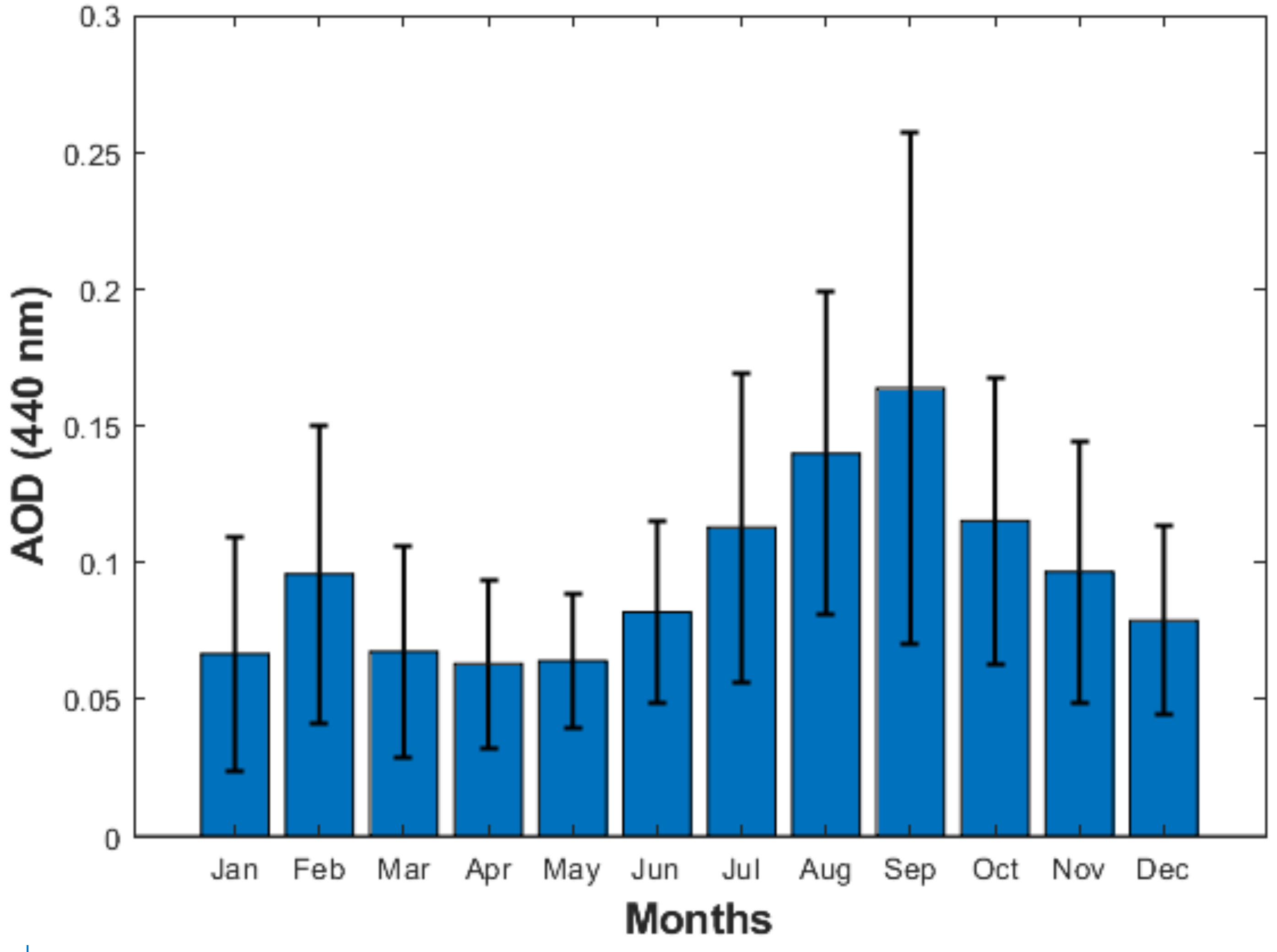
The main results:

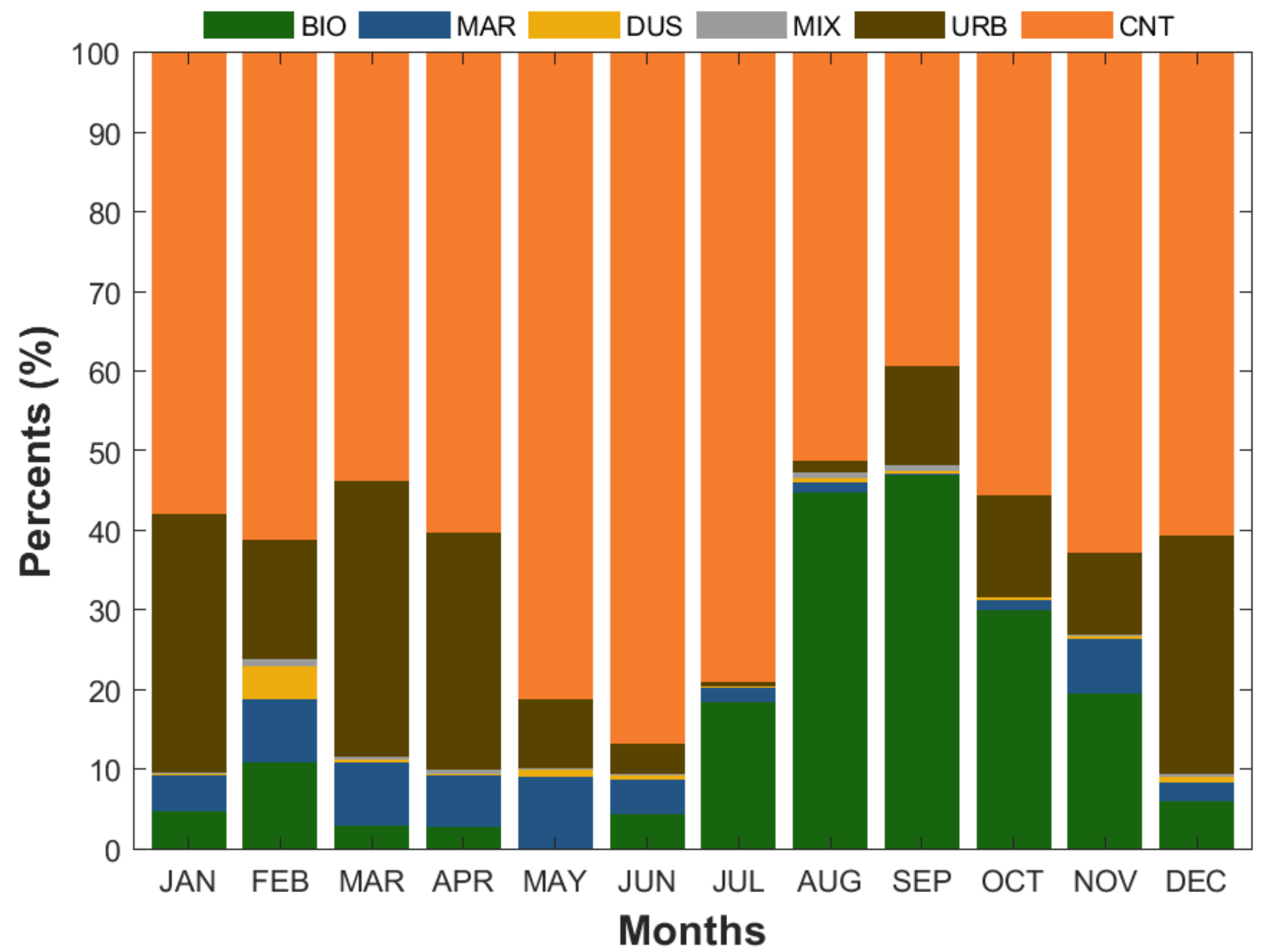
Characterization and classification of atmospheric aerosols at Huancayo Observatory

- The average AOD at the Huancayo Observatory (HYO) is 0.10 ± 0.07, which shows that the background conditions prevail.
- September is the month with the highest AOD and standard deviation values.
- Six types of aerosols (continental, biomass, maritime, dust, urban and mixed) has been defined.
- An important result is the establishment of biomass-burning periods that are related to the increase of registered AOD in the HYO.
- These periods cover from July to October of each year and consider September as the month of the maxima.
- During these months, the background conditions are disrupted by the presence of biomass-burning aerosols, coinciding with the greater occurrence of forest fires, both in Peru and in neighboring countries.
- The arrival of biomass-burning aerosols generated by forest fires that take place in Brazil and Bolivia has been evidenced.
- The biomass aerosols are the main party responsible for the increase of AOD in the Mantaro Valley and take the second place in all aerosols registered in HYO (18.2%).

AOD monthly mean values (march 2015 to august 2017) and standard deviation.



Monthly percentages of aerosol presence for six aerosols types. The biomass aerosol type modulates the monthly behavior of AOD in HYO



2.2 Effects of atmospheric aerosols over solar radiation at Huancayo Observatory

Estevan, R., Martínez-Castro, D., Suarez-Salas, L., Moya, A., Silva, Y.

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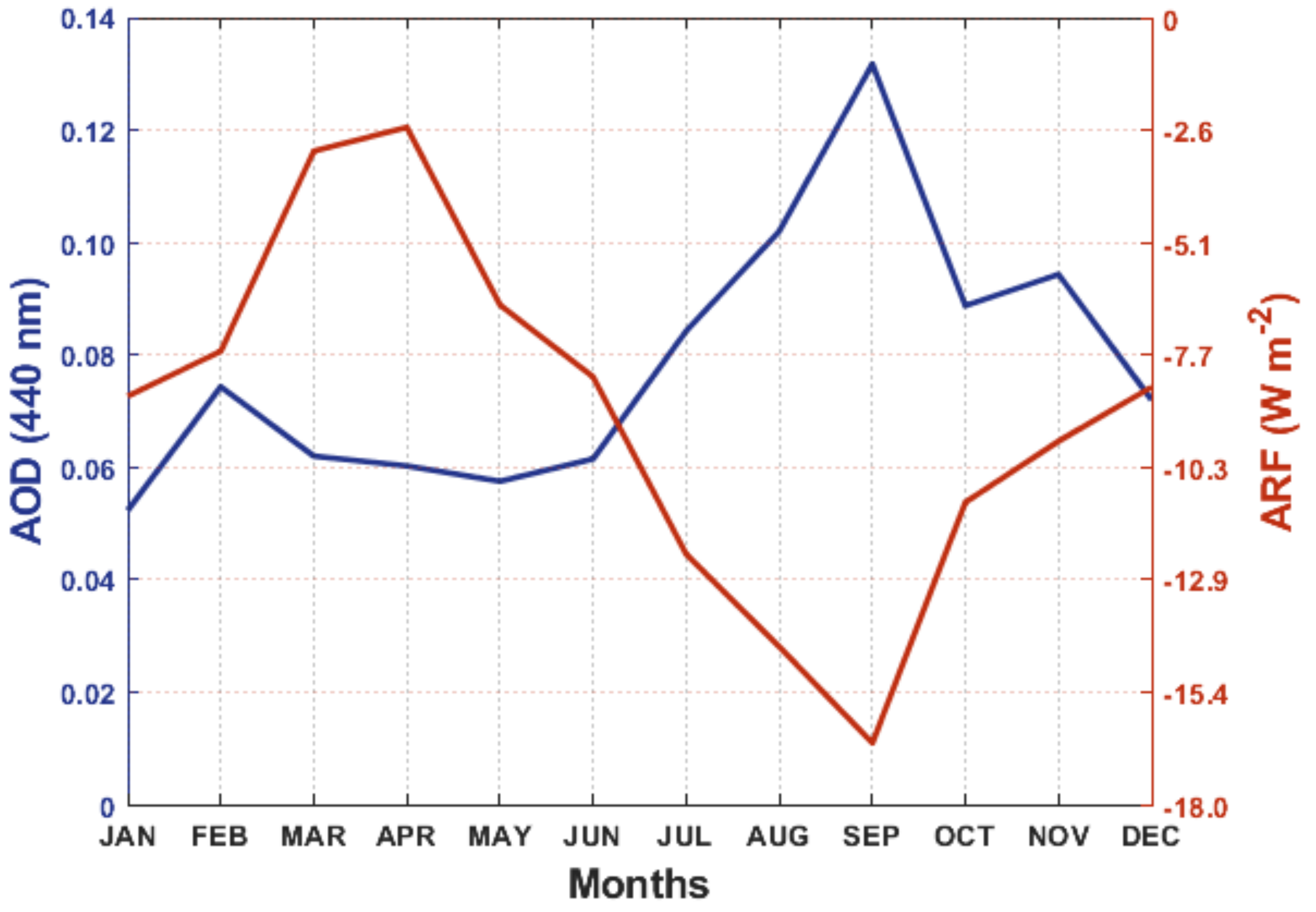
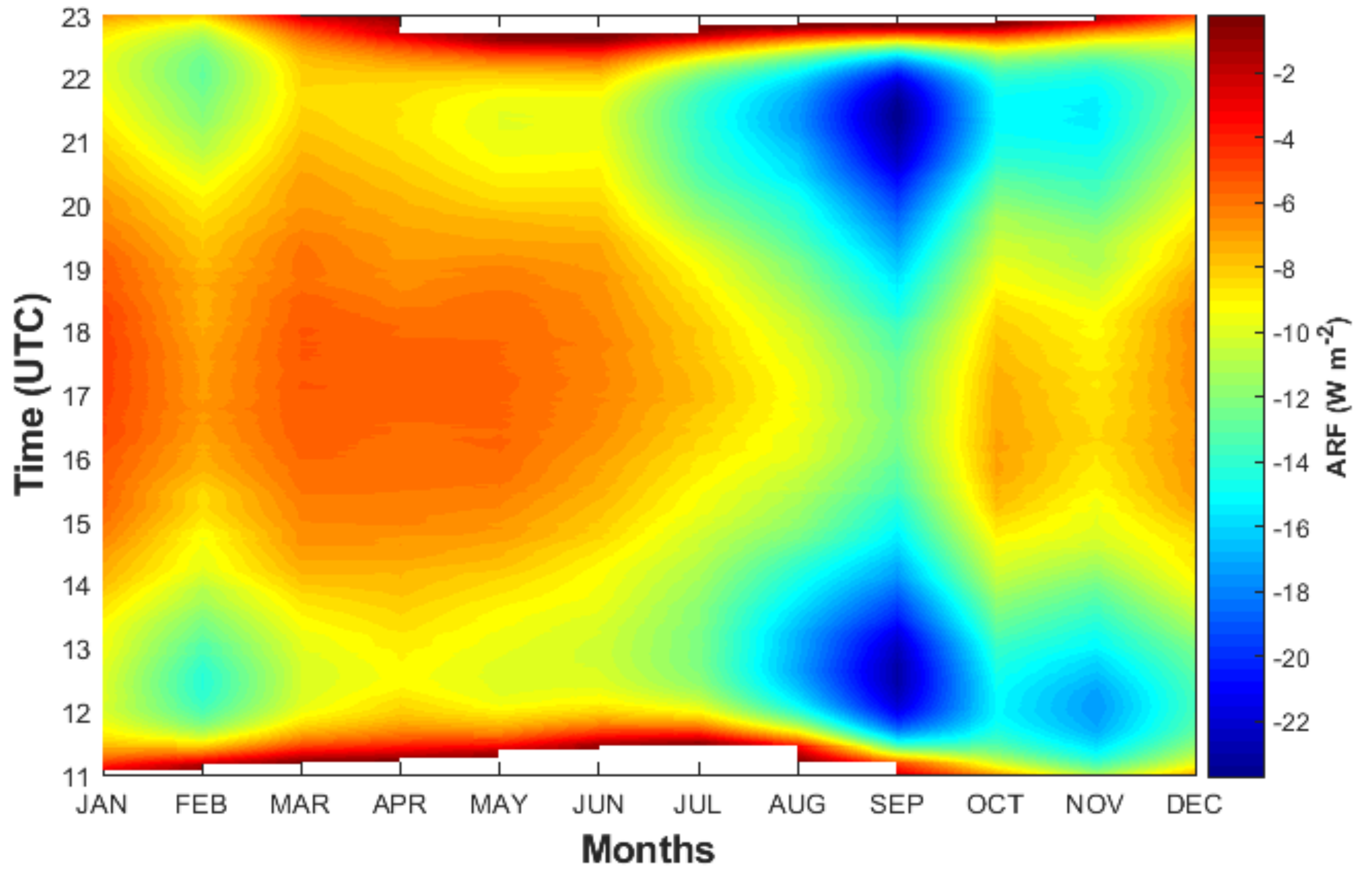
The main results:

- The highest Aerosol Radiative Forcing (ARF) values correspond to biomass burning aerosols with an instantaneous maximum value of -73.68 W m^{-2}, which took place on September 14, 2016 at 12:46 UTC, date on which the absolute maximum value of AOD was also recorded.
- This aerosol type modulates the monthly AOD means behavior and consequently the behavior of the monthly means of the ARF.
- This is corroborated by the high correlation coefficient (R = -0.84) between monthly averages of AOD and ARF.
- This correlation between AOD and ARF is inverse. The quarter July to September records the highest values of ARF (-13.19 W m^{-2}) coinciding with the biomass burning season in the Amazonia, and September the month with maximum mean ARF values of -16.59 W m^{-2}.
- The highest ARF values are recorded between July and October and in the morning and afternoon as can be seen in the right figure.
- The highest values appear in September and take place in the morning between 12 and 13 UTC. A second maximum takes place in the afternoon between 21 and 22 UTC. The lowest ARF values occur in the month of April, around noon.

Monthly Aerosol Radiative Forcing averages and AOD_{440nm} for the period from March 2915 to October 2018.



Average values of the Aerosol Radiative Forcing by months and hours for the period between March 2915 to October 2018.



2.3 Studies of Integral Content of Water Vapor derived from Huancayo AERONET site

Estevan, R., Martínez-Castro, D., Suarez-Salas, L., Moya, A., Silva, Y.

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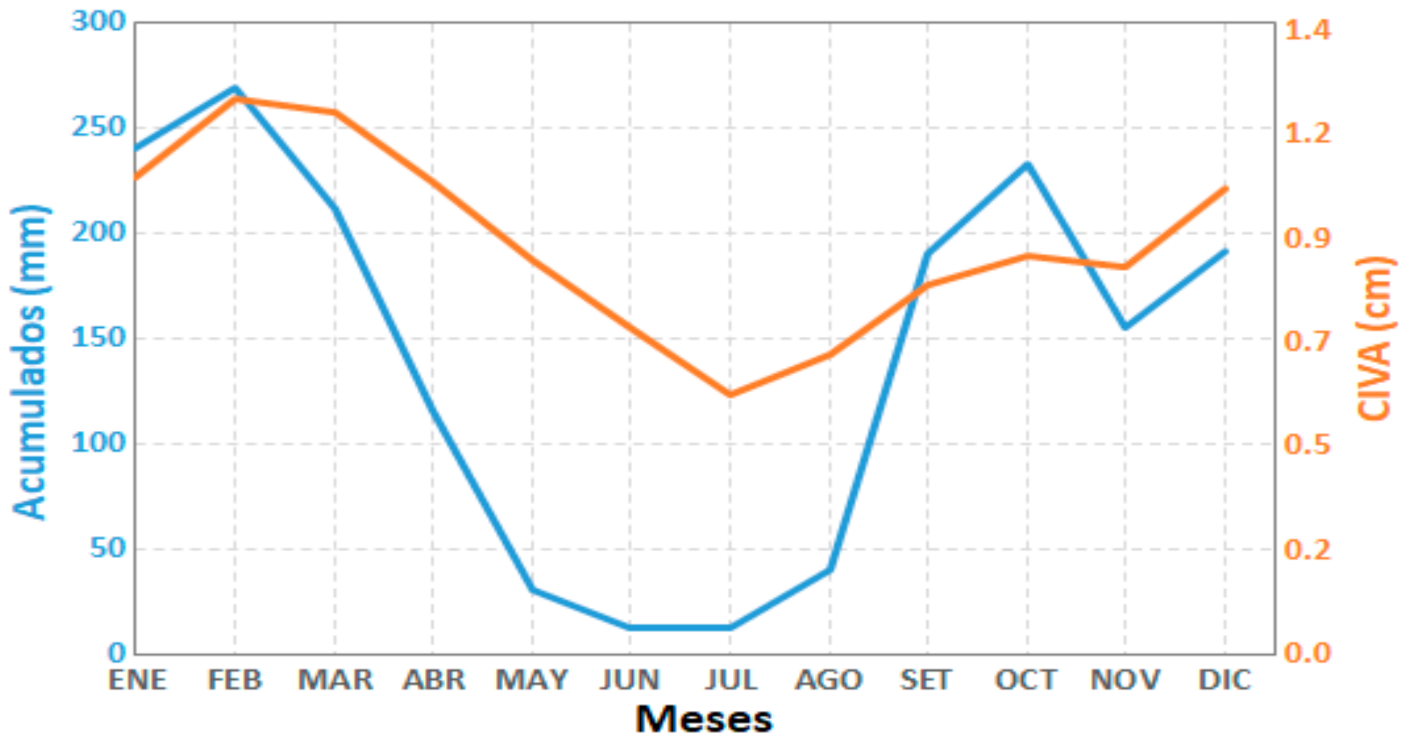
The main results:

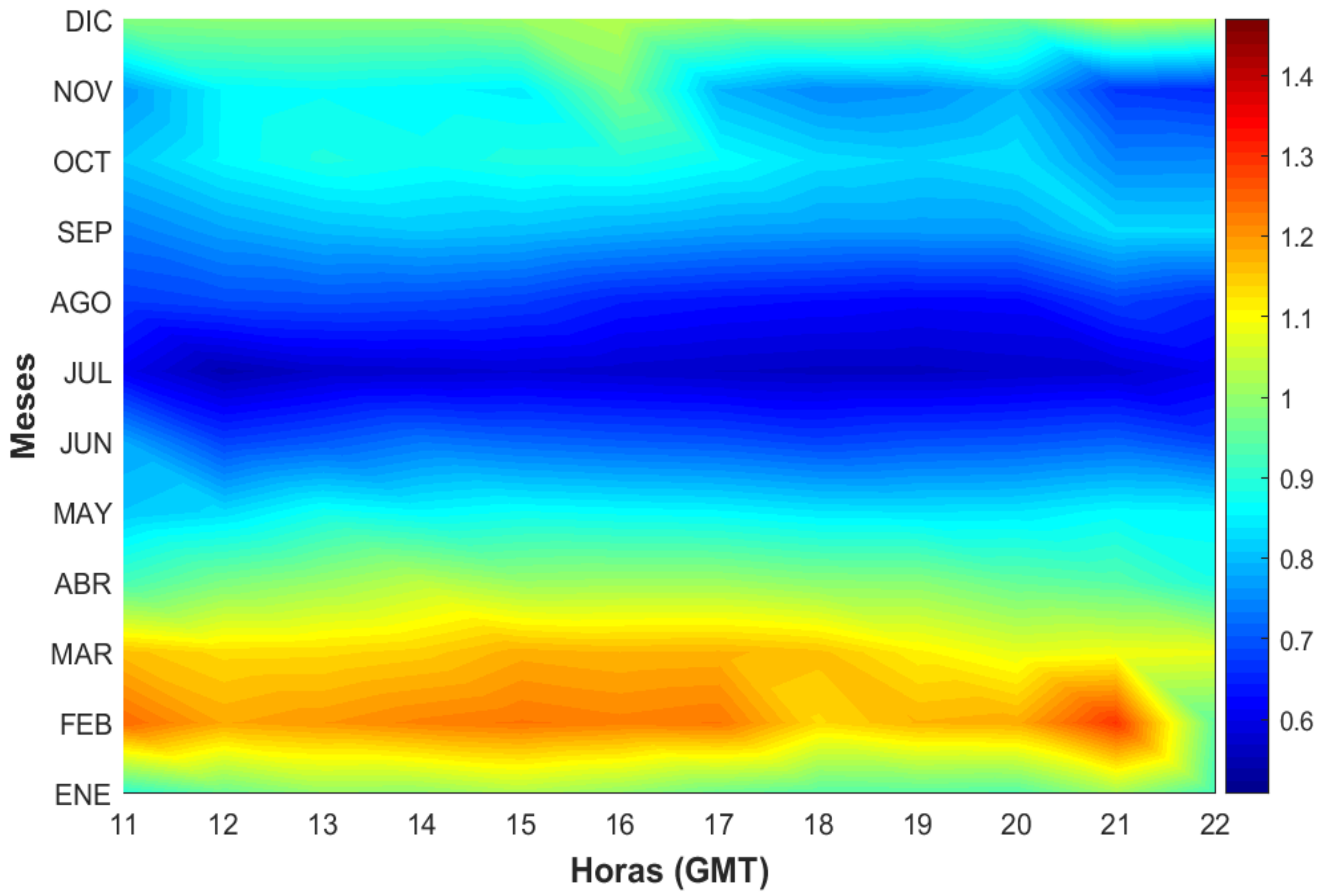
- There is a good correlation (R = 0.77) between the Integral Content of Water Vapor (ICWV) and the accumulated rainfall (figure left). February is the month where the maximum values of both variables are recorded. In the case of ICWV, a secondary maximum occurs in March, while in the case of precipitation, October is the month with the secondary maximum precipitation. In both variables, there is an accelerated decrease from March, in the case of ICWV until July and in the case of precipitation until May. In both cases, the minimum value is recorded in July. It can also be seen in the correct figure.

- The figure on the right shows the ICWV monthly and hourly averages. There are no big variations in the hourly averages of the ICWV unlike what happens with the monthly averages. February is the month with maximum ICWV values and the time of 21 GMT where the maximum value of this month is recorded. March and April follow to February, as months with high ICWV values. On the other hand, July is clearly the month with the minimum vapor content values, surrounded by the months of June and August.

Comparison between the monthly averages of IWVC and the monthly accumulated rainfall, for the period 2015-2018.



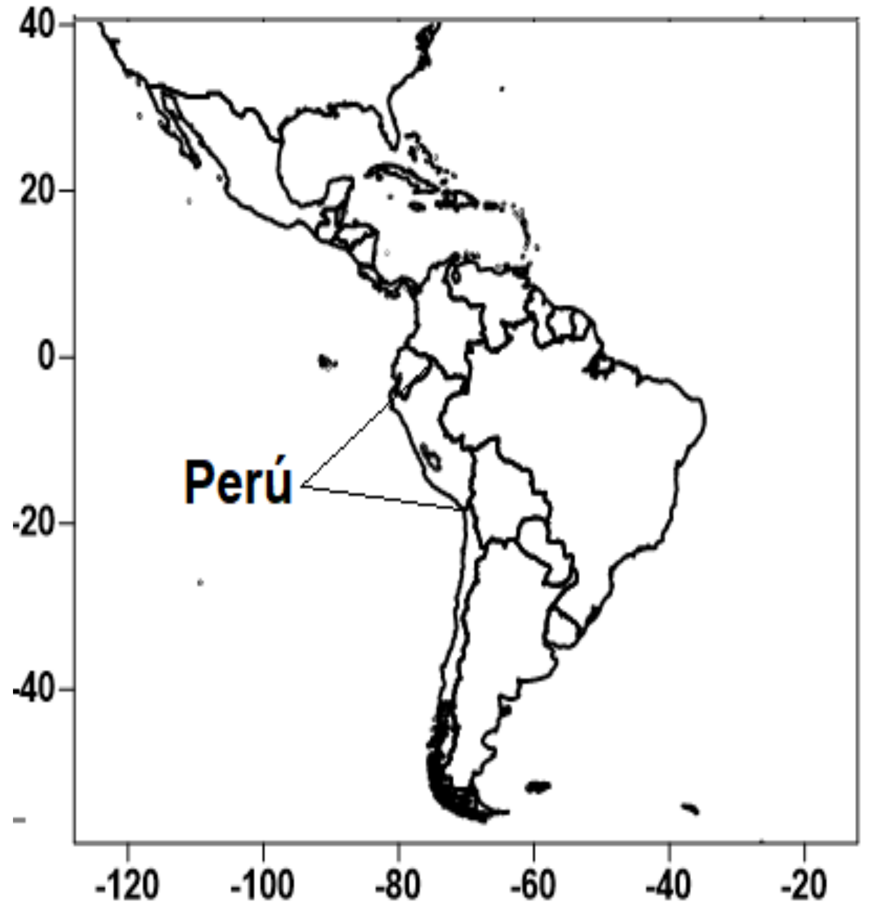
Behavior of monthly and hourly averages of ICWV for the period 2015-2018.

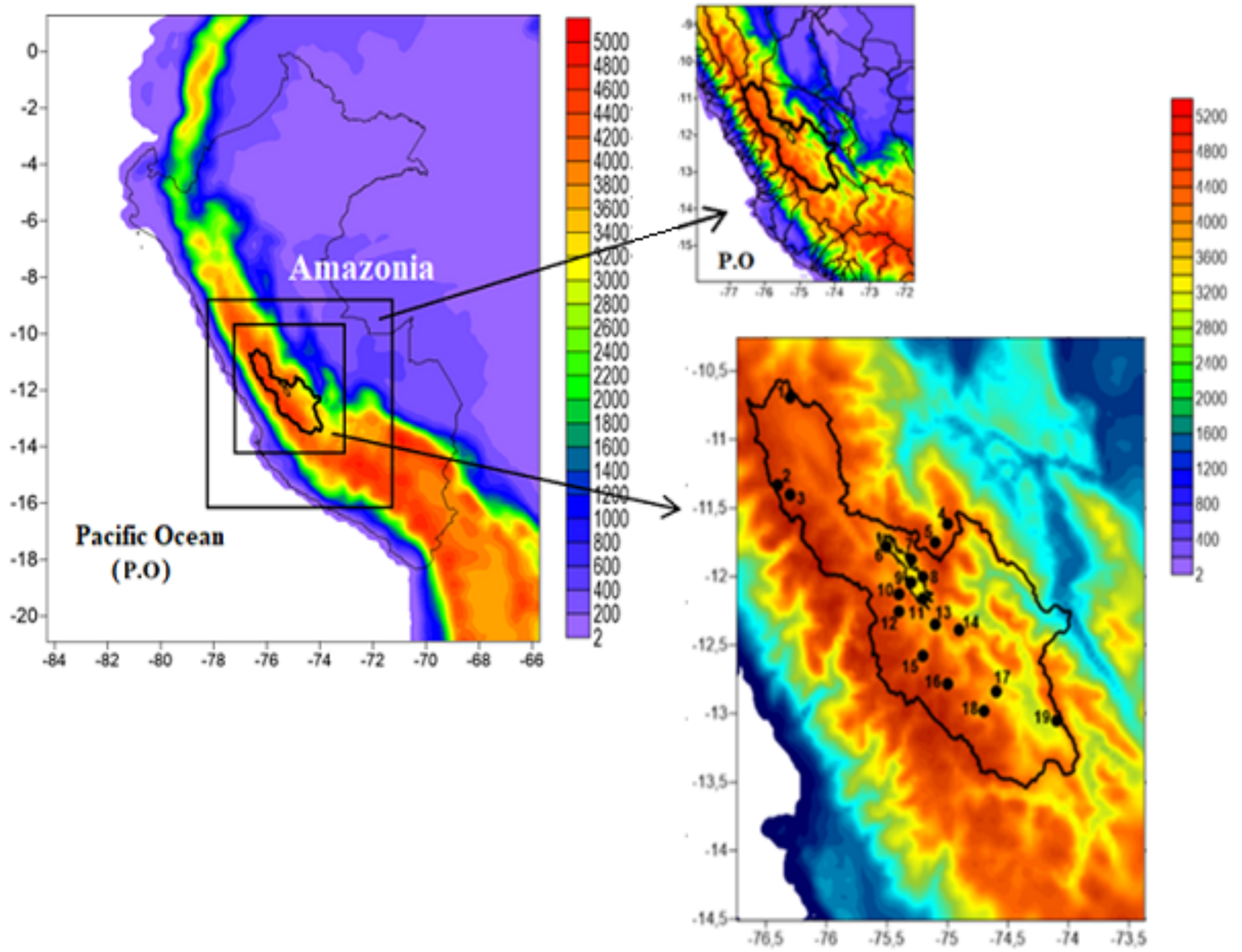


3. Dynamics and atmospheric modeling in the Peruvian Andes

<u>The aim of this research line was</u>:

- To implement, validate, and perform coordinated simulations with the WRF and ARPS models.
- To Study the influence of turbulent energy processes on the development of convective storms in the Mantaro basin.
- To determine the atmospheric circulation patterns at a regional and local scale that influence weather conditions in the Mantaro basin.
- To develop a storm forecast model for the Mantaro valley.





Multiple simulations were performed using different configurations, domains with different resolutions for the WRF and ARPS models.

3.1 Sensitivity Study on the Influence of Parameterization Schemes in WRF_ARW Model on Short- and Medium-Range Precipitation Forecasts in the Central Andes of Peru

Aldo S. Moya-Álvarez, Daniel Martínez-Castro, José L. Flores, Yamina Silva

https://doi.org/10.1155/2018/1381092

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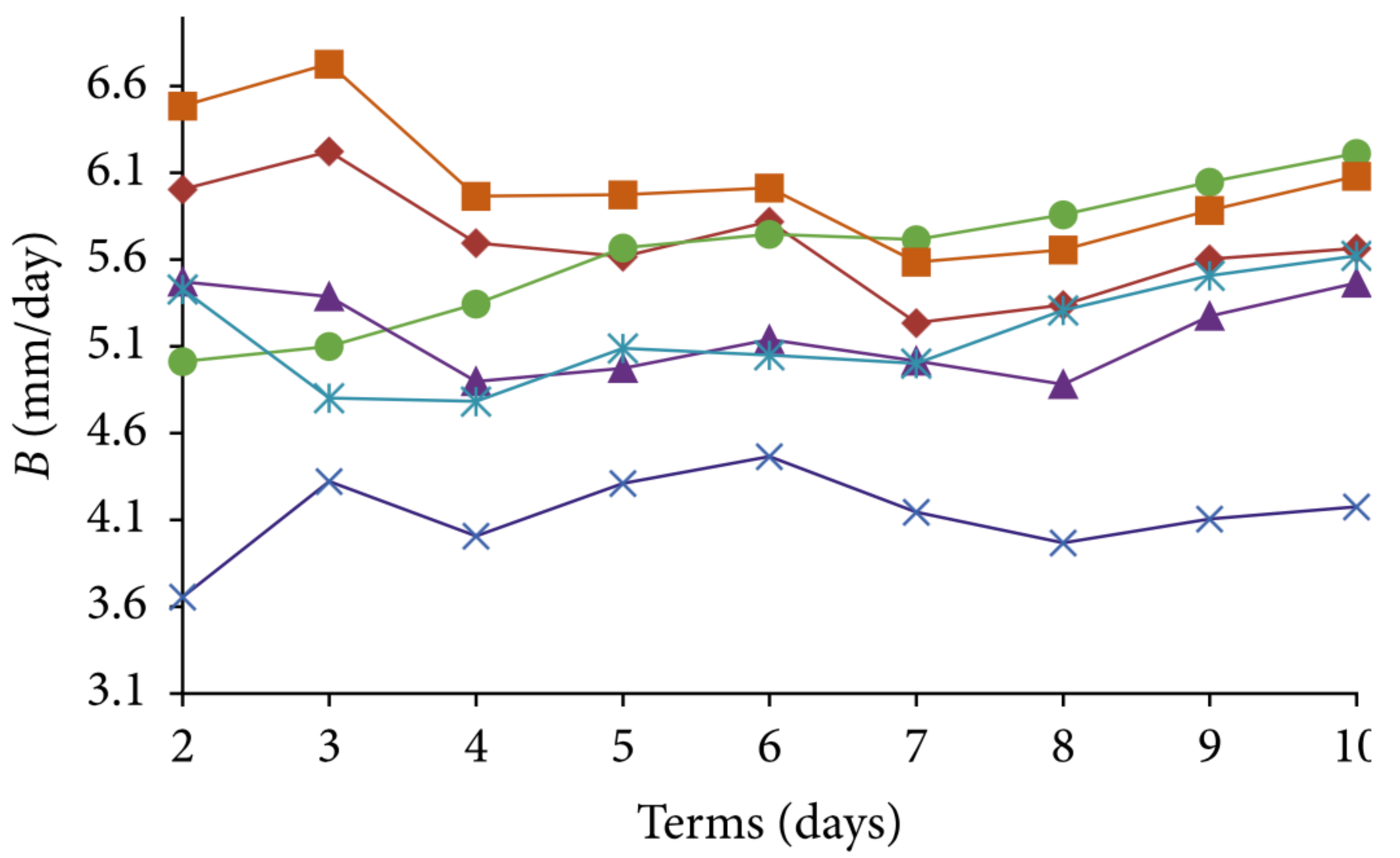
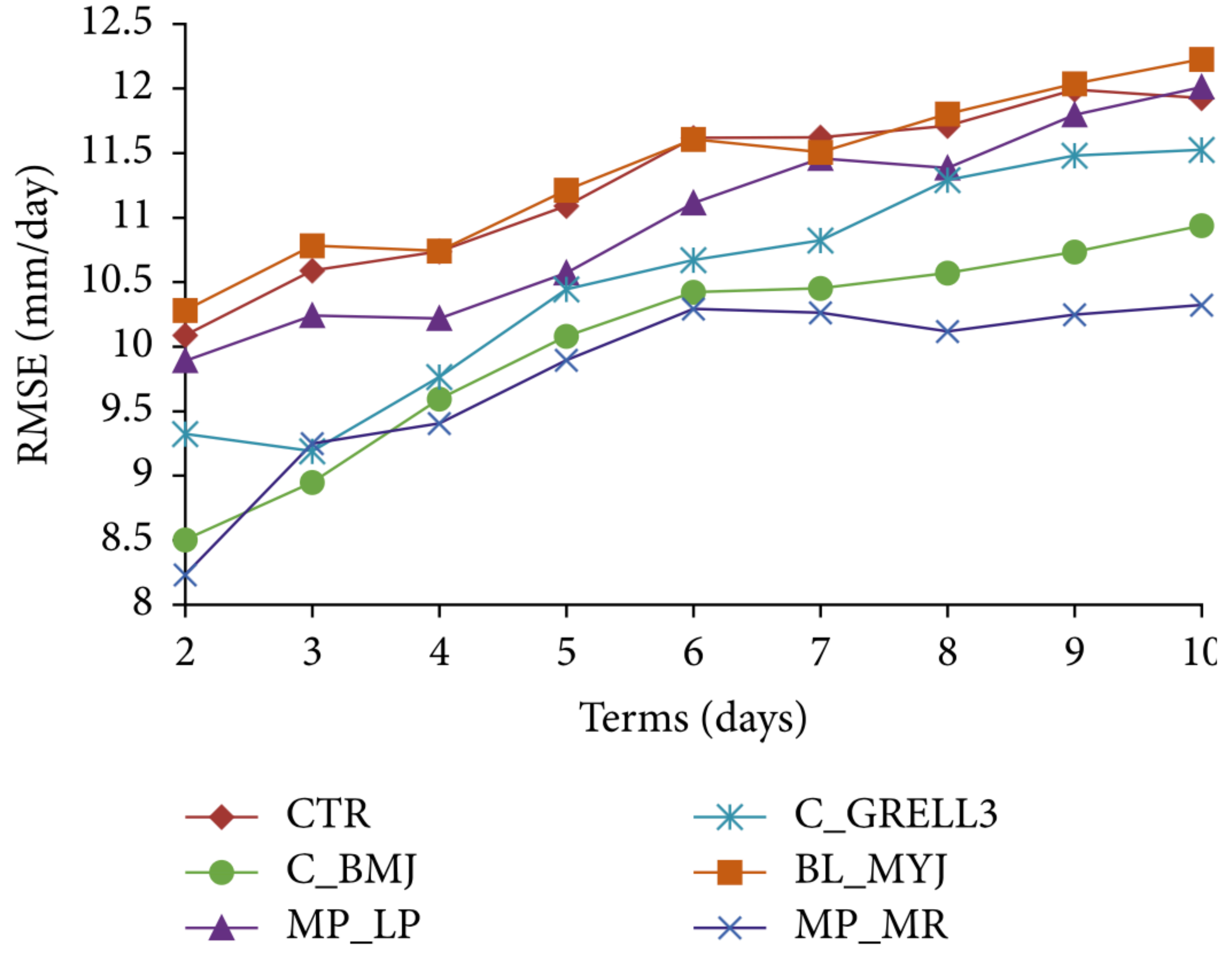
The results:

- The model predicts more precipitation than occurs in the region.
- The best result was obtained using the Grell-Freitas cumulus scheme and the Morrison scheme for microphysics.
- The configuration using the Grell-Freitas cumulus scheme and the Morrison scheme for microphysics is recommended for short- and medium-term rainfall forecasting tasks in the Central Andes of Peru and particularly in the Mantaro basin.
- The results of a special sensitivity experiment showed that the activation or not of cumulus parametrization for the domain of 3 km resolution is not relevant for precipitation forecast in the Mantaro basin.



Evolution of the average bias “B" of domains 2 and 3 with each configuration, for 10 days simulation horizon.



Evolution of the “RMSE” average of domains 2 and 3 of all stations with each configuration scheme used, for 10 days simulation horizon.

3.2 Response of the WRF model to different resolutions in the rainfall forecast over the complex Peruvian orography.

Aldo S. Moya-Álvarez, Daniel Martínez, Shailendra Kumar, René Estevan & Yamina Silva

https://doi.org/10.1007/s00704-019-02782-3

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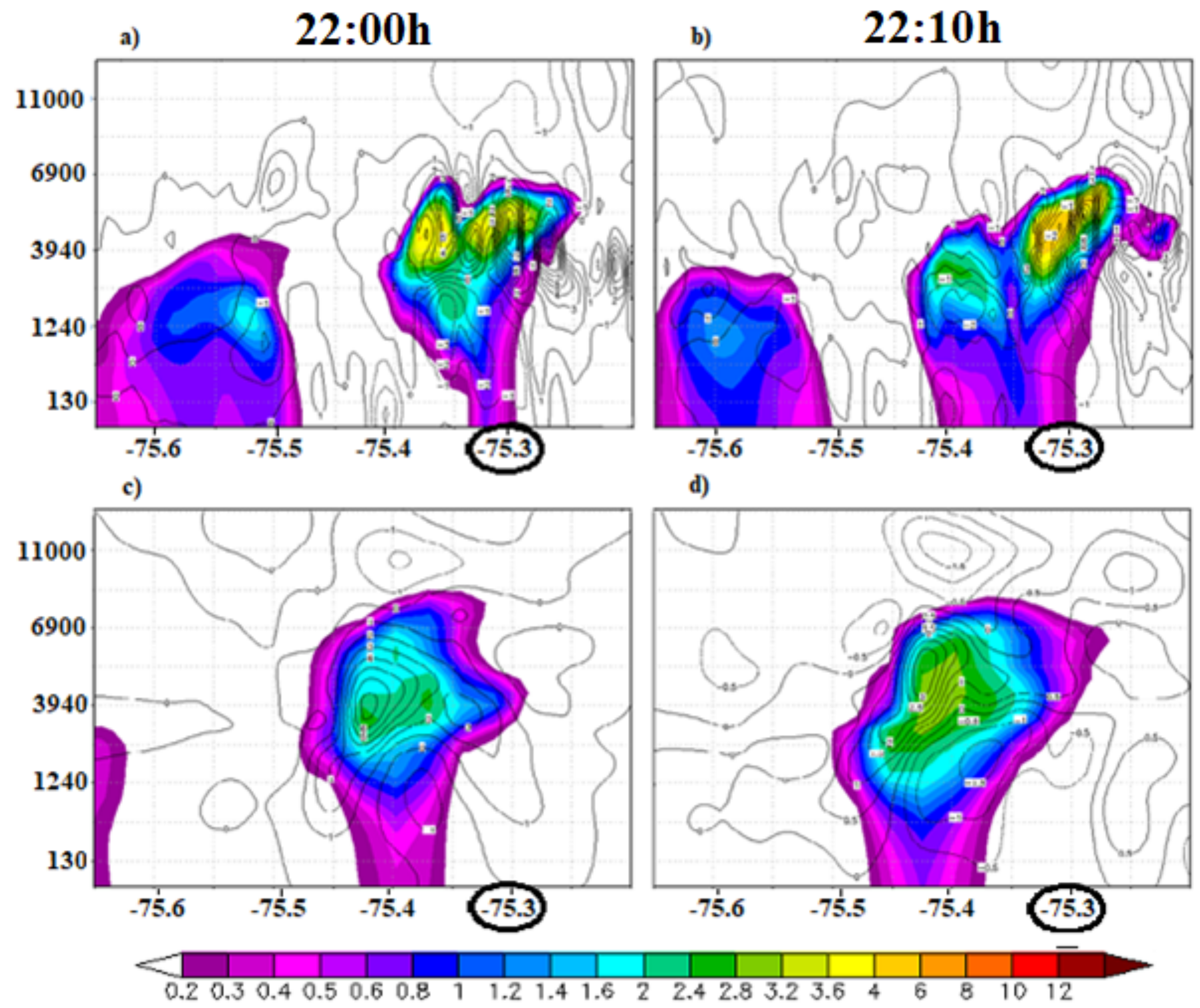
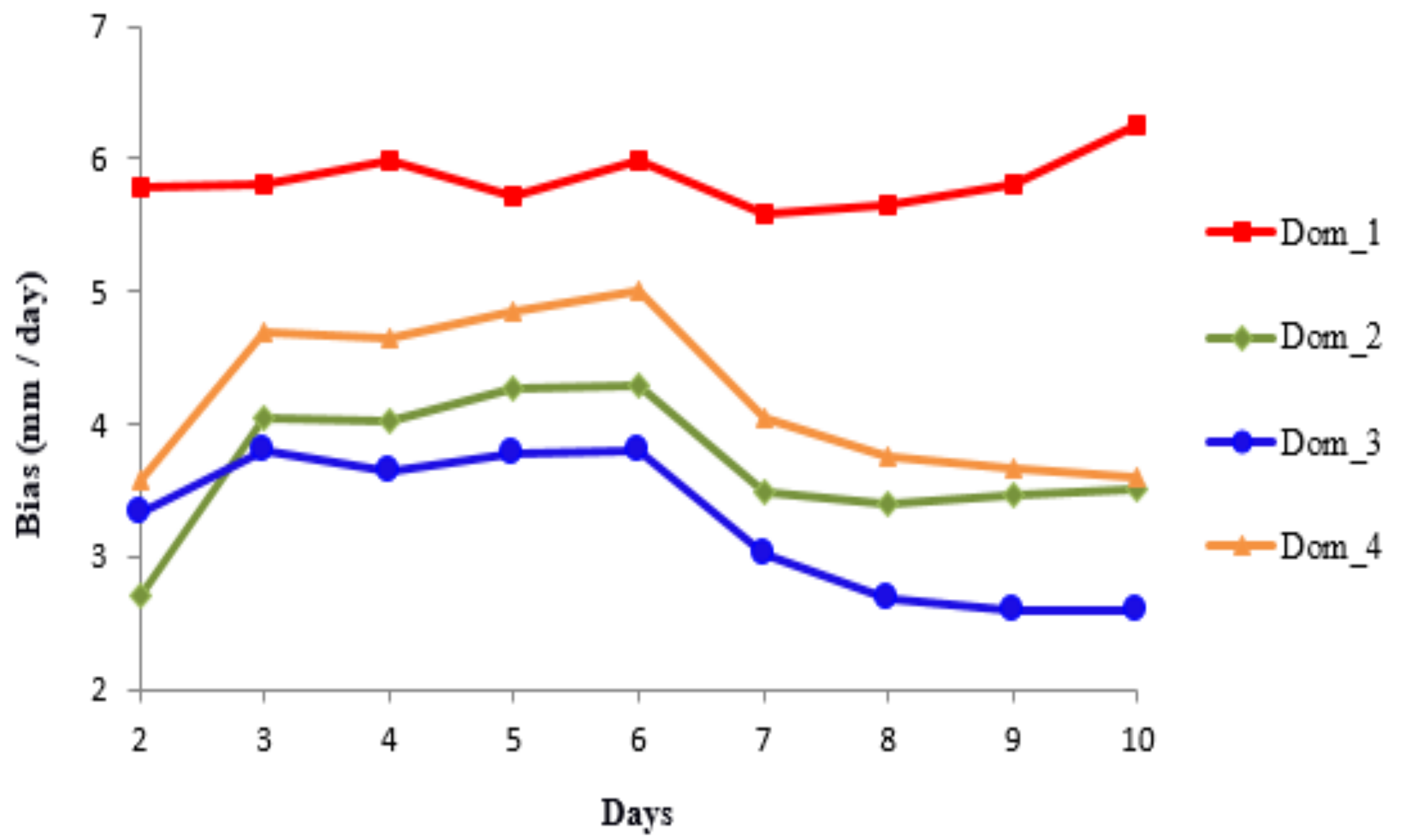
The results:

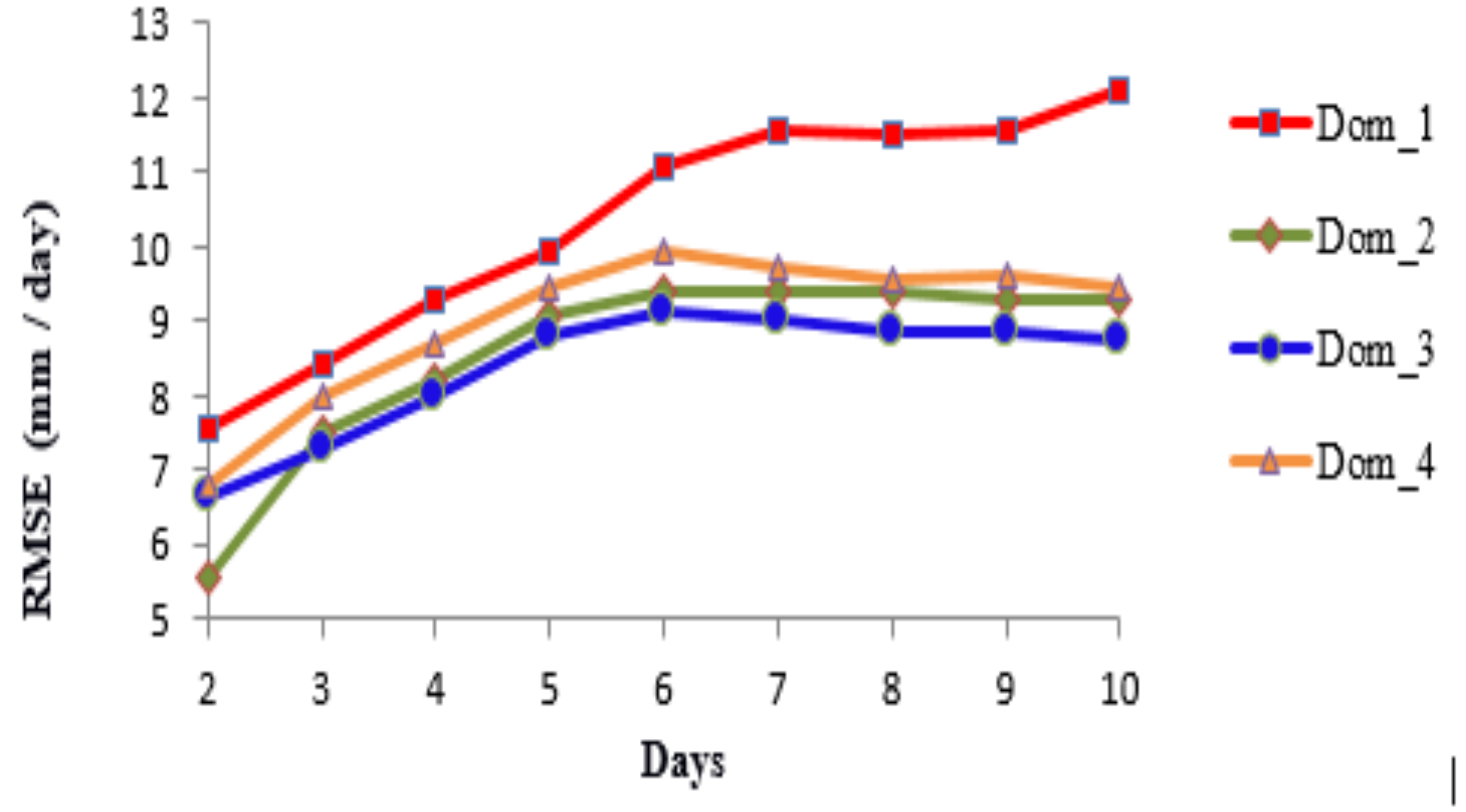
- It is generally believed that increasing the domain resolution always improves the forecast results- Not so, but…
- Does it mean that you don't need to use thinner domains?
- Fine domains will better represent very local rainfall events, which can sometimes be very intense.



Domain 3: 2 km

Domain 4: 750 m





3.3 Extreme Rainfall Forecast with the WRF-ARW Model in the Central Andes of Peru.

Aldo S. Moya-Álvarez, Gálvez José, Holguín Andrea, Estevan René, Kumar Shailendra, Villalobos Elver, Martínez-Castro Daniel & Yamina Silva

https://doi.org/10.3390/atmos9090362

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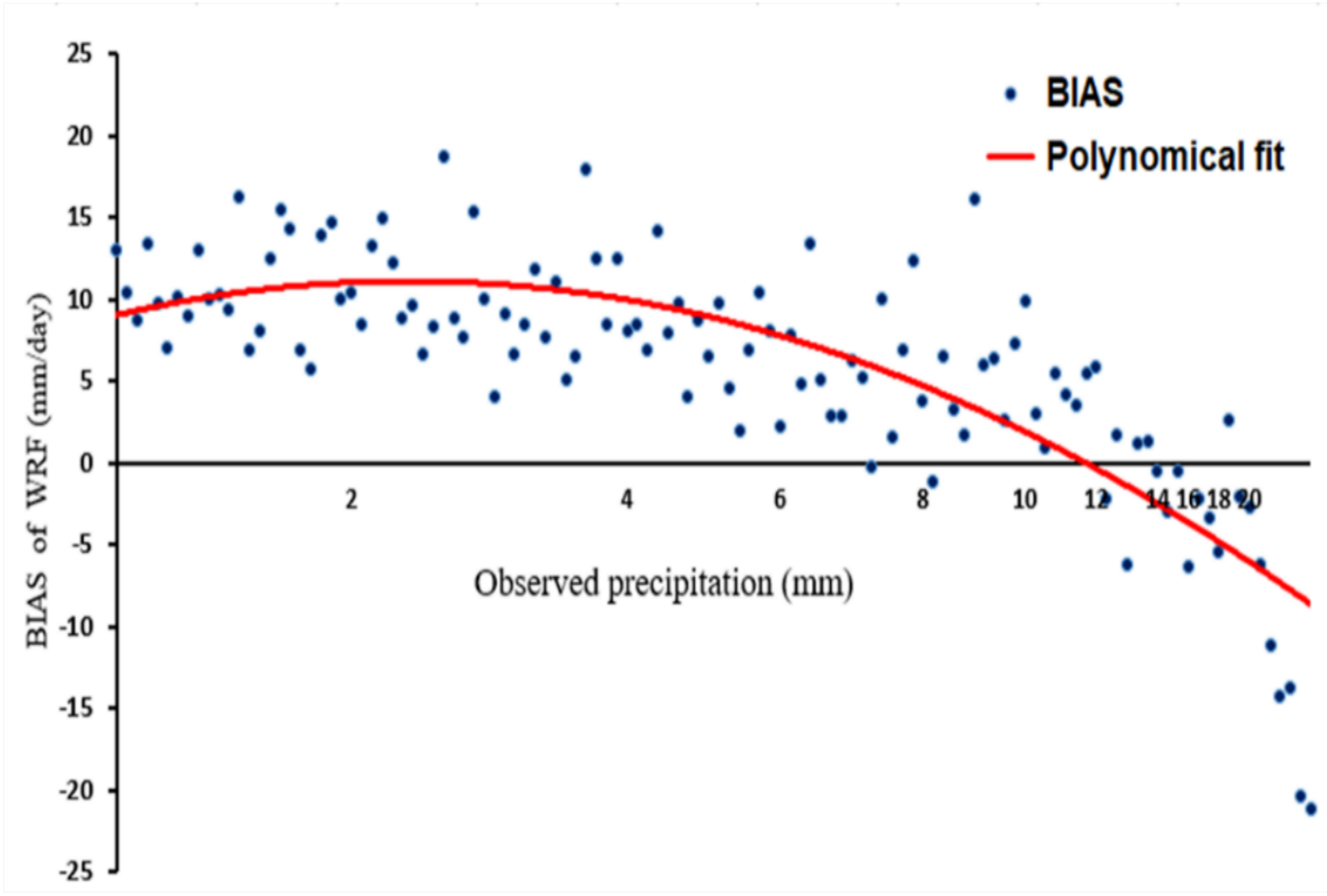
The main results:

- The WRF underestimate precipitation over than 12 mm/day.
- This is an important contribution, until now it was thought that the WRF always overestimates the rain in this region.
- The analysis of two case studies shows that the underestimation by the model is probably due to three reasons: inability to generate convection in the upstream Amazon during early morning hours, apparently related to large scale processes; limitations on describing mesoscale processes that lead to vertical movements capable of producing extreme rainfall; and limitations on the microphysics scheme to generate heavy rainfall.



Bias curve of the Weather Research and Forecasting (WRF) model relative to observed precipitation. The red line shows its second-order polynomial fit curve.

3.4 Influence of PBL parameterization schemes in WRF_ARW model on short - range precipitation's forecasts in the complex orography of Peruvian Central Andes

Aldo S. Moya-Álvarez, René Estevan, Shailendra Kumar, Jose L. Flores Rojas, Joel J. Ticse, Daniel Martínez-Castro & Yamina Silva

https://doi.org/10.1016/j.atmosres.2019.104708

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The main results:

- The model generally overestimated rainfall in the northern basin, underestimated in the center, and in the south some schemes overestimated and others underestimated.
- The boundary layer is more stable in the model than in the observations.
- The schemes that generated the most rainfall were those that generated a more unstable boundary layer with weaker wind speeds, at least with easterly winds.
- The height of the boundary layer for rainy days in the region at 18 UTC oscillates around 1000 m and that, generally, the wind's velocity changes very little or decreases within the boundary layer and increases above it.

Statistics of evaluation the influence of boundary layer schemes on precipitation forecast.

Statistic	ACM2	BL	BP	GBM	MYJ	M25	M30	QNSE	SH	YSU
					(mm)					
BIAS	-1.62	0.72	-2.15	0.59	-0.13	-1.72	-1.86	-1.42	-0.85	-0.92
MAE	9.67	9.78	9.56	11.25	9.64	9.51	9.25	9.68	9.39	9.37
RMSE	12.19	12.34	12.17	15.08	12.23	11.88	11.53	12.12	11.90	11.85
					(%)					
BIAS	-12.7	5.7	-16.8	4.6	-1.0	-13.5	-14.5	-11.1	-6.6	-7.2
MAE	78.3	79.2	78.2	92.6	77.9	75.9	74.4	78.1	75.9	75.3
RMSE	99.9	100.5	100.2	125.8	99.5	95.0	92.6	98.5	95.6	95.6

The best performing PBL schemes were those of Mellor Yamada Nakanishi(M30) and Mellor Yamada Janjic (MYJ).

3.5 Statistical characterization of vertical meteorological profiles obtained with the WRF-ARW model on the central Andes of Peru and its relationship with the occurrence of precipitation on the region.

Aldo S. Moya-Álvarez, Daniel Martínez-Castro, Shailendra Kumar, Jose L. Flores Rojas, René Estevan, Miguel Saavedra-Huanca & Yamina Silva

https://doi.org/10.1016/j.atmosres.2020.104915

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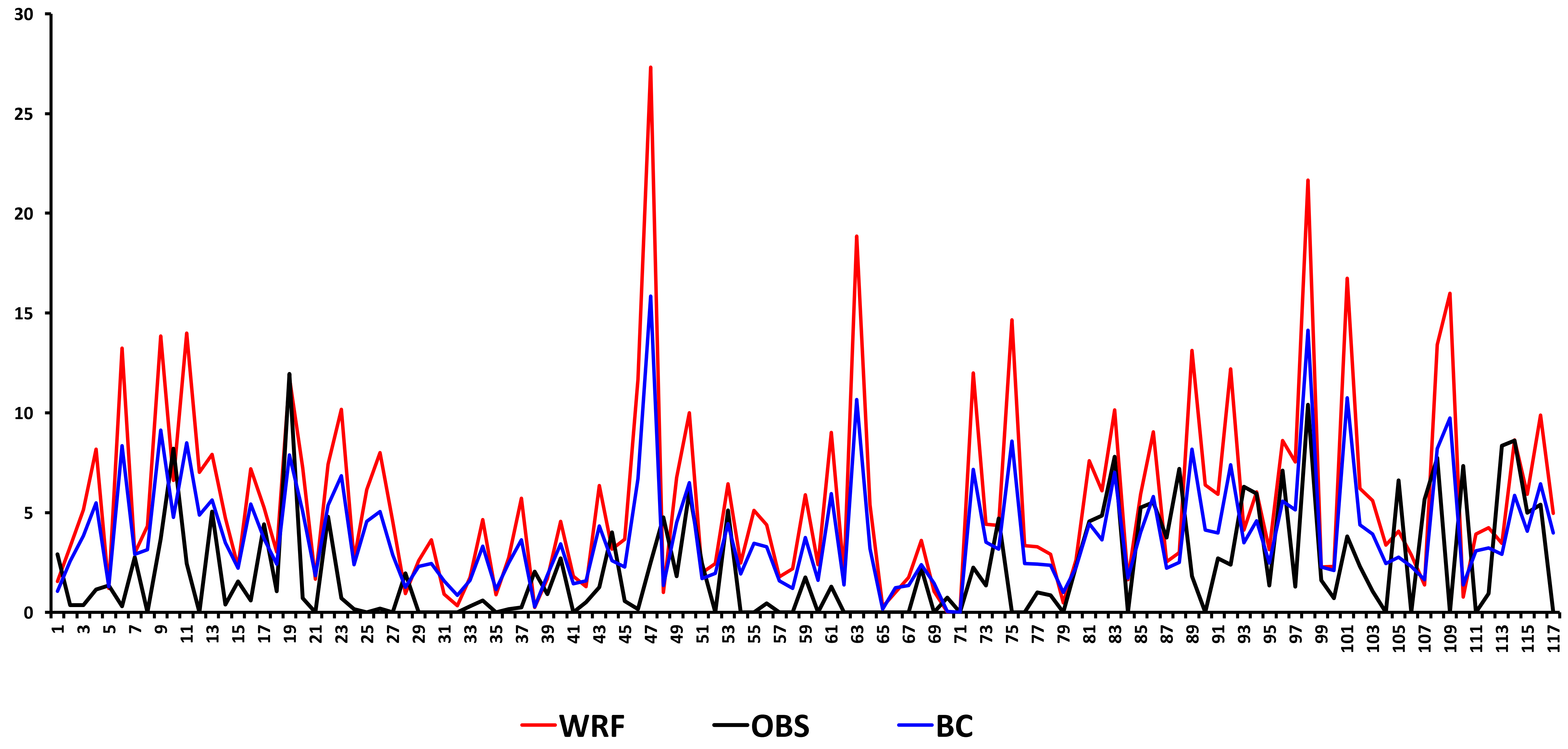
The main results:

- The use of thermodynamic indices usually improves the forecast of rainfall, however good results were not obtained in the forecast of extreme rains.
- The level of condensation was always higher in the dry period, in which the lower troposphere was also more stable.
- The parameters that were most informative to precipitation forecasting in rainy period were the precipitation predicted by the model WRF, the average relative humidity of the 600–400 hPa layer and the water vapor mixing ratio in the layer itself.
- The case study showed that in general, the thermodynamic parameters analyzed for each day, responded to the fact of a rainy day in relation to another dry day.



3.6 Analysis of Possible Triggering Mechanisms of Severe Thunderstorms in the Tropical Central Andes of Peru, Mantaro Valley

José Luis Flores Rojas, Aldo S. Moya Alvarez, Shailendra Kumar, Daniel Martínez Castro, Elver Villalobos Puma and Yamina Silva Vidal

https://doi.org/10.3390/atmos10060301

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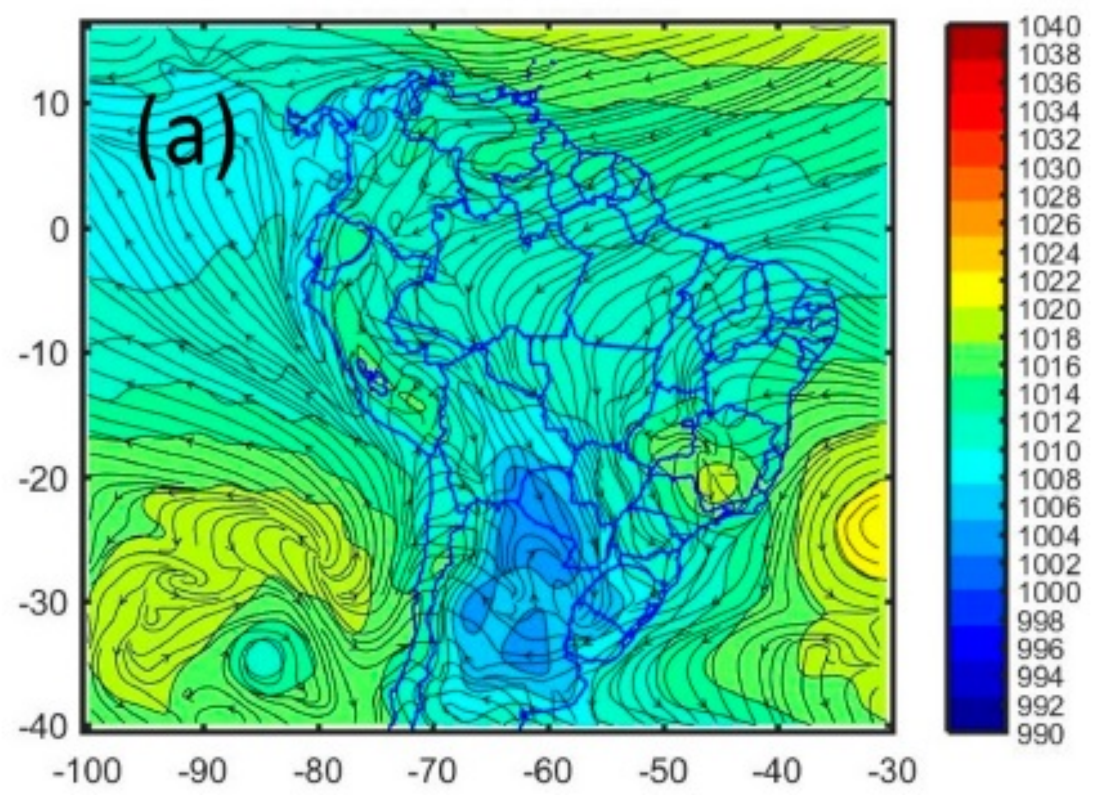
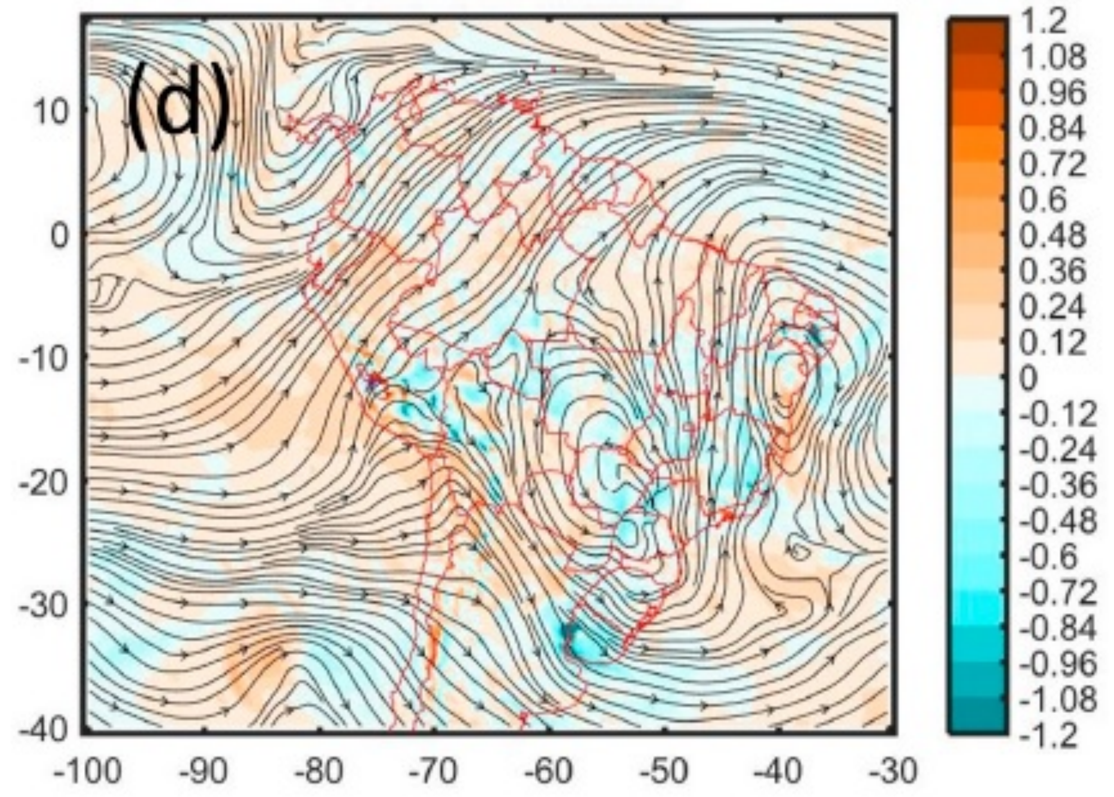
The main results:

- At synoptic scale, the TSs are characterized by the southern displacement of the South-east Pacific Subtropical Anticyclone up to latitudes higher than 35°S.
- Also the weakening and south-eastern displacement of the Bolivian high–North east low system.
- The intrusion of westerly winds along the west side of the central Andes at upper and medium levels of the atmosphere.
- At meso-scale, apparently, two important moisture fluxes from opposite directions are filtered through the passes along the Andes: one from the north-west and the other from the south-east directions converge and trigger the deep convection into the Mantaro valley.

Resolution: 18 km



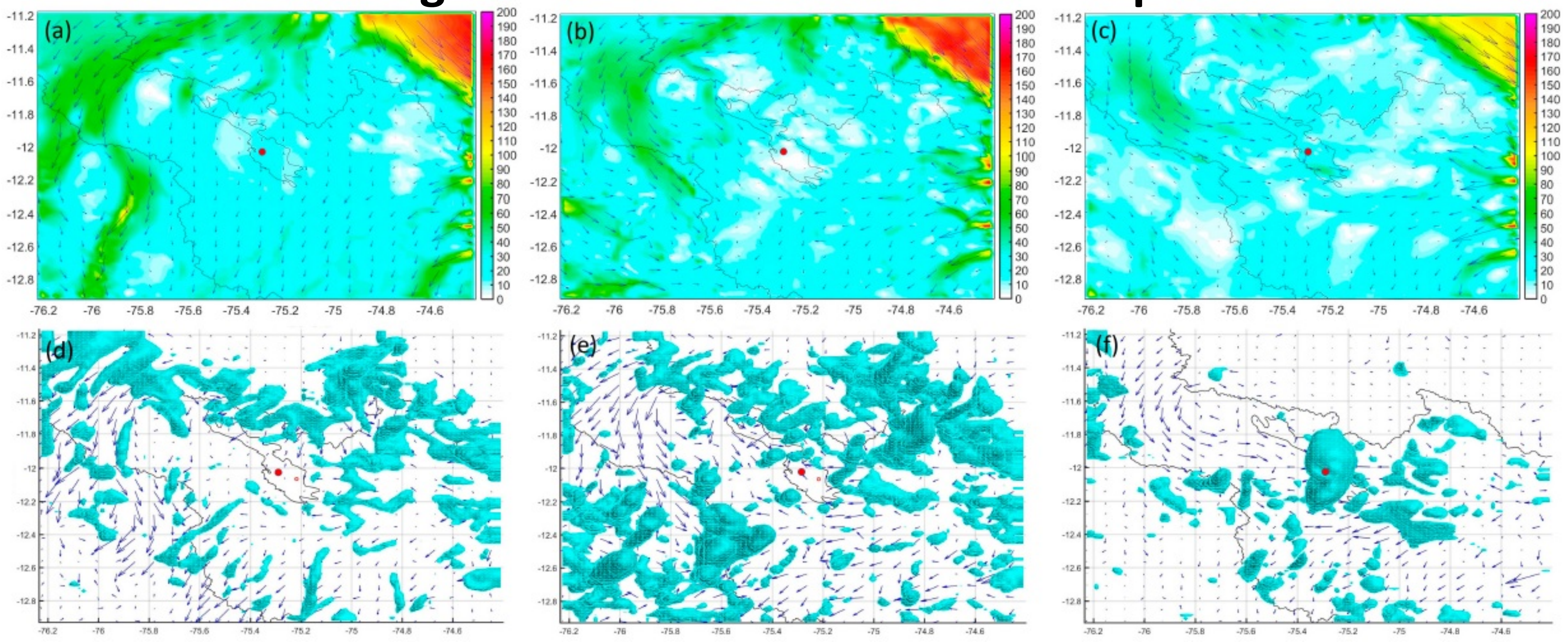
Wind streamlines and reduced pressure at sea level (1000 hPa)



Wind streamlines and vertical velocities at 300 hPa

Resolution: 2 km

Integrated total column of water vapor flux



Combined issosurface of cloud, ice, rain and hail mixing ratios

3.7 Seasonal and Diurnal Cycles of Surface Boundary Layer and Energy Balance in the Central Andes of Perú, Mantaro Valley

José Luis Flores Rojas, Cuxart J., Piñas-Laura M., Callañaupa S., Suárez-Salas L., Kumar Shailendra, Moya Álvarez Aldo & Silva-Vidal, Y.

https://doi.org/10.3390/atmos10120779

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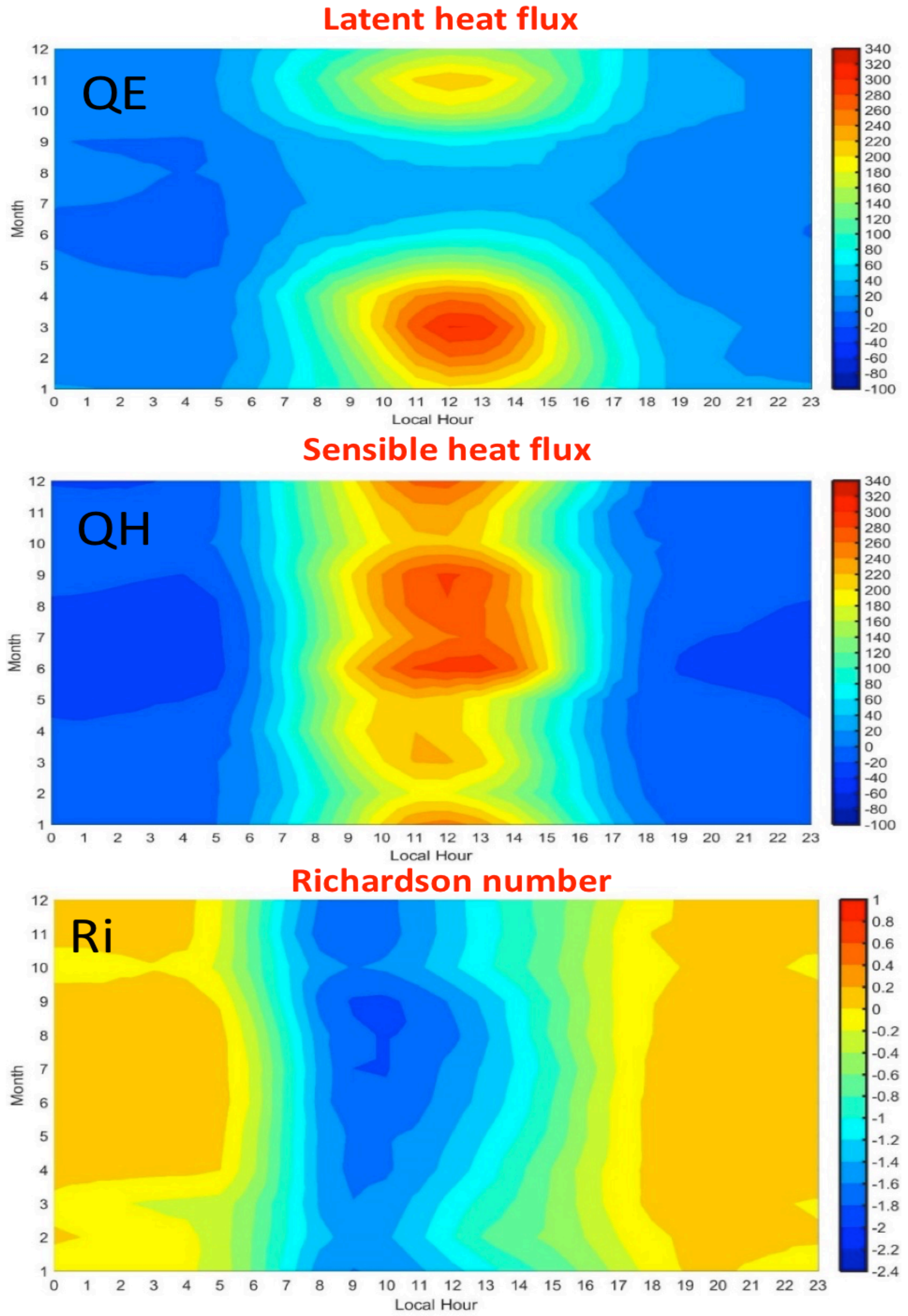
The main results:

- The results show minimum mean monthly temperatures and more stable conditions were observed in June and July before sunrise.
- Maximum mean monthly temperatures in October and November and more unstable conditions in February and March.
- From May to August inverted water vapor profiles near the surface were observed (more intense in July) at night hours, which indicate a transfer of water vapor as dewfall on the surface.
- The comparison between available energy and the sum of *QE* and *QH* fluxes shows a good level of agreement with important imbalance contributions after sunrise and around noon, probably by advection processes generated by heterogeneities on the surface around the Huancayo observatory and intensified by the mountain–valley circulation.



3.8 On the dynamic mechanisms of intense rainfall events in the central Andes of Peru, Mantaro valley

José Luis Flores Rojas, Aldo S. Moya-Alvarez, Jairo M. Valdivia-Prado, Manuel, Piñas-Laura, Elver Villalobos-Puma, Daniel Martínez-Castro, Shailendra Kumar, Yamina Silva

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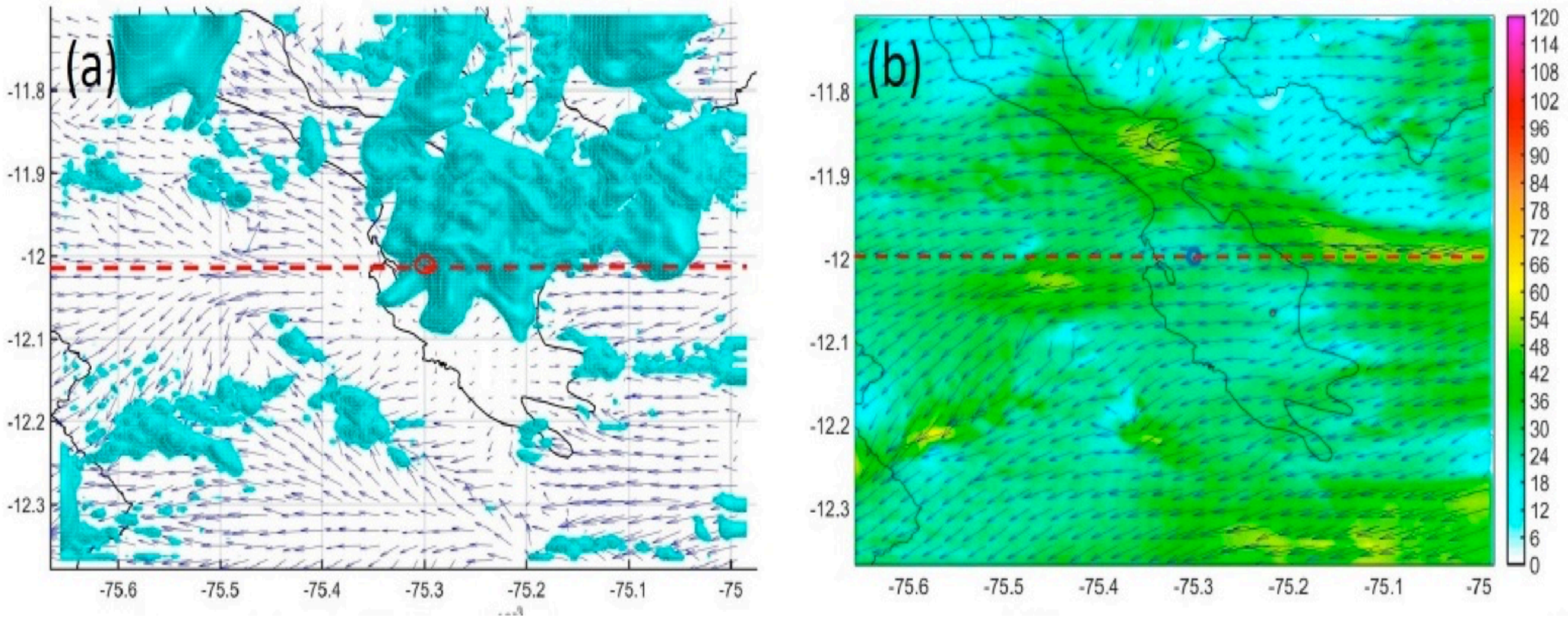
The main results:

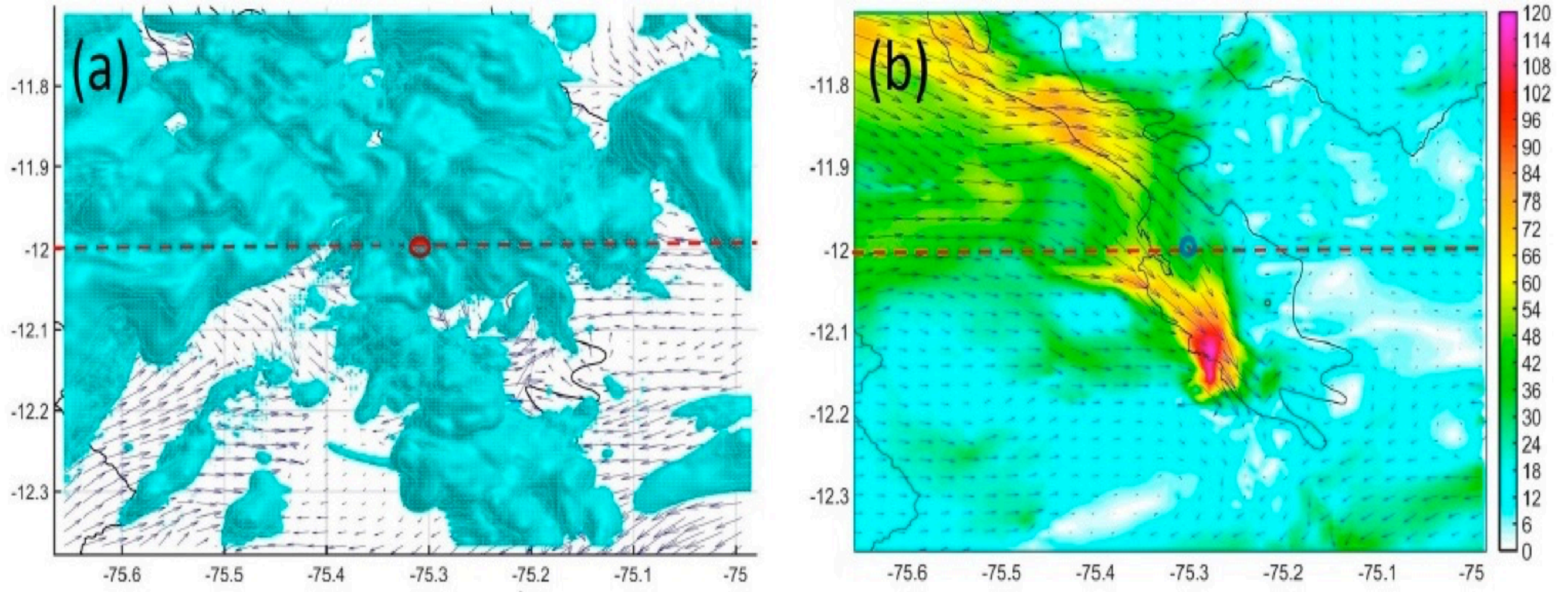
- The results showed that all intense rainfall events are associated with the presence of thermal meso-scale circulations that transport moisture fluxes through the passes with gentle slopes along both sides of the Andes.
- The easterly moisture fluxes coming from the South America Low Level Jet (SALLJ) and the westerly moisture fluxes coming from the Pacific Ocean.
- At synoptic scale, the results show that the rainfall events can be separated into two groups:
- The first one associated with easterly circulations (EC) at mid and upper levels of the atmosphere generated by the intensification of the anticyclonic Bolivian high-North east low (BH-NE) system.
- The second one associated with westerly circulations (WC) at mid and upper levels of the atmosphere generated by the weakening and eastern displacement of the BH-NE system.

Easterly circulation events **Resolution: 0.5 km**



Combined issosurface of cloud, ice, rain and hail mixing ratios and Integrated total column of water vapor flux

Westerly circulation events **Resolution: 0.5 km**



Combined issosurface of cloud, ice, rain and hail mixing ratios and Integrated total column of water vapor flux

Summary

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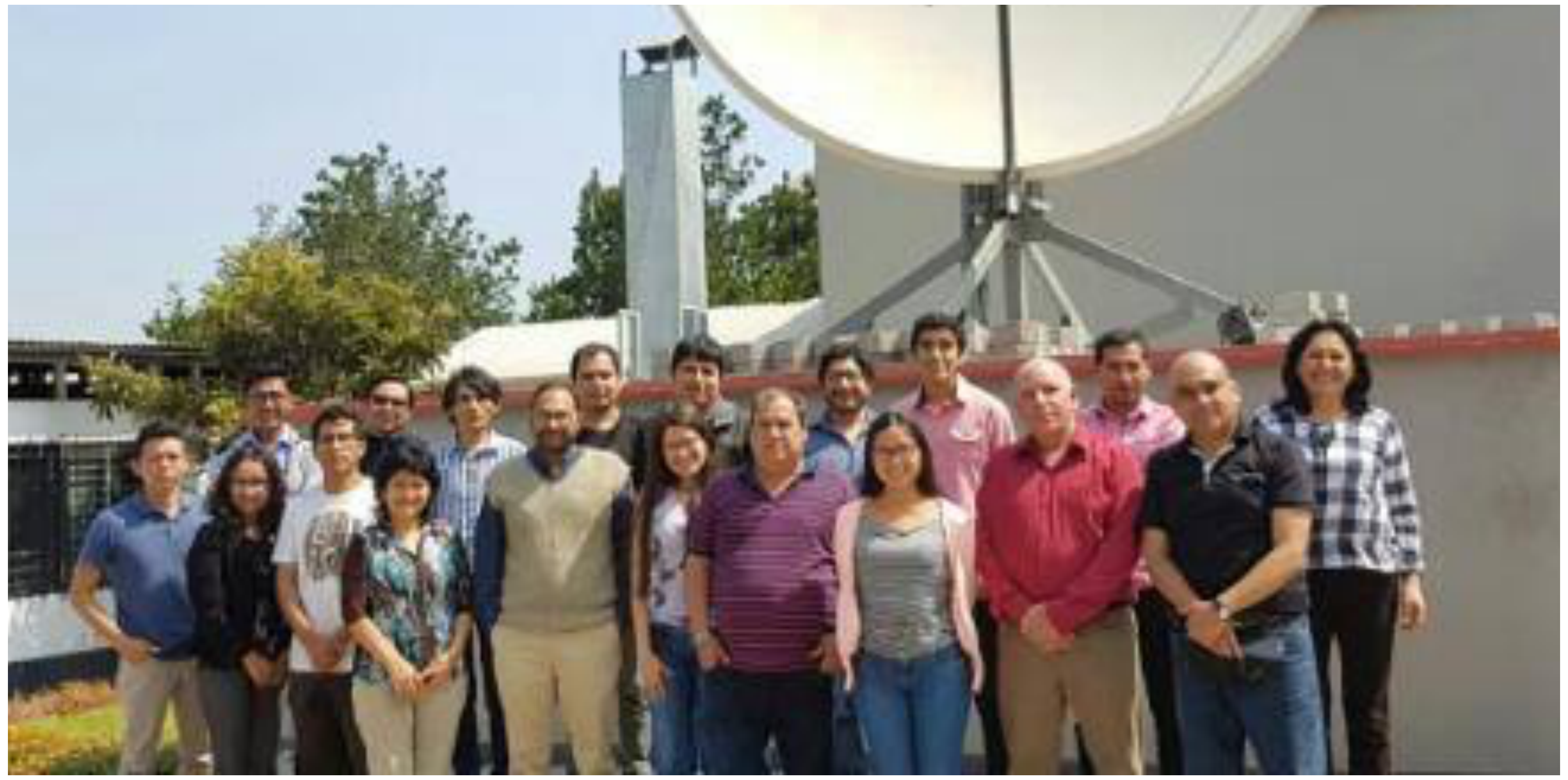
- Obtaining and applying methodologies for use of satellite data from Global Precipitation Measurement System (GPM) and in particular its double wavelength radar to study morphological and dynamic characteristics, life cycle depending on the diurnal cycle, and its dependence on the orographic conditions and the local wind of the cloud systems that produce precipitation and storms over the South American continent and, in particular, over Peru. This provides mastery of an additional tool for research on weather and climate forecasting methods.
- Development of methods for using the MIRA 35C radar information to study the precipitation systems that are developed over the Mantaro Valley.
- Experimental determination of rain drop size distributions for different types of rain in the Mantaro valley, highlighting the differences between convective and stratiform rain, which allows the identification of these types of rain with satellite parameters through the normalization of the distributions.
- Determination of the influence of parameterization of the microphysical processes on the capacity of the WRF model to reproduce convective systems in the Mantaro basin. This is one of the procedures that allows optimizing the WRF model for the very short-term forecast of these phenomena.
- Availability of database from the Laboratory of Atmospheric Microphysics and Radiation- LAMAR for future projects.

- The project has published 17 preview papers;
- Five (5) papers are under review;
- Two (2) Ph.D. Thesis are in progress;
- Seven (7) master thesis: Five are already finished;
- Three (3) undergraduate thesis ared finished.

Project researcher´s team



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- Aldo Moya
- Daniel Martínez
- Shailendra Kumar
- José Luis Flores

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The Huancayo Observatory of IGP (3330 masl)

THANK YOU!

Ciencia para protegernos,
ciencia para avanzar.