RAPID: Upper-Air Observations over the Far Eastern Pacific (OTREC; ChocoJEX II)

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German Poveda, Universidad Nacional de Colombia, Medellin, Colombia

Many collaborators from several institutions in US and Colombia.

Objective

- Extend the upper-air observation network over the far EPAC to better monitor in **real time** and characterize the **meridional extension of the tropical easterly waves** (EW); filling a surface and upper-air data sparse area.
- Provide a **diurnal and synoptic evolution baseline for the G-V flight** data over the far EPAC.
- Provide in-situ observations to characterize the thermodynamical and kinematical convection indices in relation to the observed convective activity in the region.
- Observe the strength of the shear between the easterly trade mid-level flow over the Andes and the westerly low-level flow
- Characterize the Andes-generated thermal disturbances originally introduced by Mapes at al. (2003)
- Observe the vertical convective environments and characterization of air-mass sources in support of isotopic analysis that will be performed during OTREC (OTREC- Kuang).
- Extend ChocoJEX-I efforts to observed the environment of one of the rainiest spots one Earth (Yepes et al. 2019-BAMS).
- (long term goals) Provide ground truth for comparison with modeling efforts, reanalysis products and satellite observations.

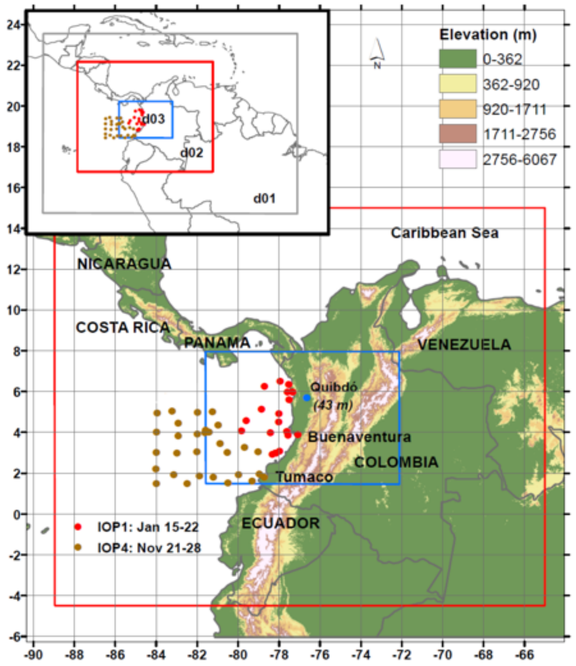


FIG. 2. Selected images of CHOCO-JEX activities: (a) launch of a radiosonde from ARC *Gorgona* in Jan, (b) shipment of personnel and helium gas cylinders by the FAC in Oct, (c) inflation of a balloon inland in Quibdó at Universidad Tecnológica del Chocó in Jun, and (d) sounding setup on board the ARC *Gorgona* in Nov.

ChocoJEX-I (2016) Legacy

- UN-Colombia | DRI | University of Miami (Mapes) | Colombian: NSF, Air Force, Navy
- Capacity building
- 4 IOPs
- Yepes, J., G. Poveda, J. F. Mejía, L. Moreno, and C. Rueda, 2019: CHOCO-JEX: A Research Experiment Focused on the Chocó Low-Level Jet over the Far Eastern Pacific and Western Colombia. *Bull. Amer. Meteor. Soc.*, **100**, 779–796, https://doi.org/10.1175/BAMS-D-18-0045.1.
- Yepes, J., J. F. Mejía, B. Mapes, and G. Poveda, 2020: Gravity waves and other mechanisms modulating the diurnal precipitation over one of the rainiest spots on Earth: Observations and Simulations in 2016. Mon. Wea. Rev., https://journals.ametsoc.org/mwr/article/doi/10.1175/MWR-D-19-

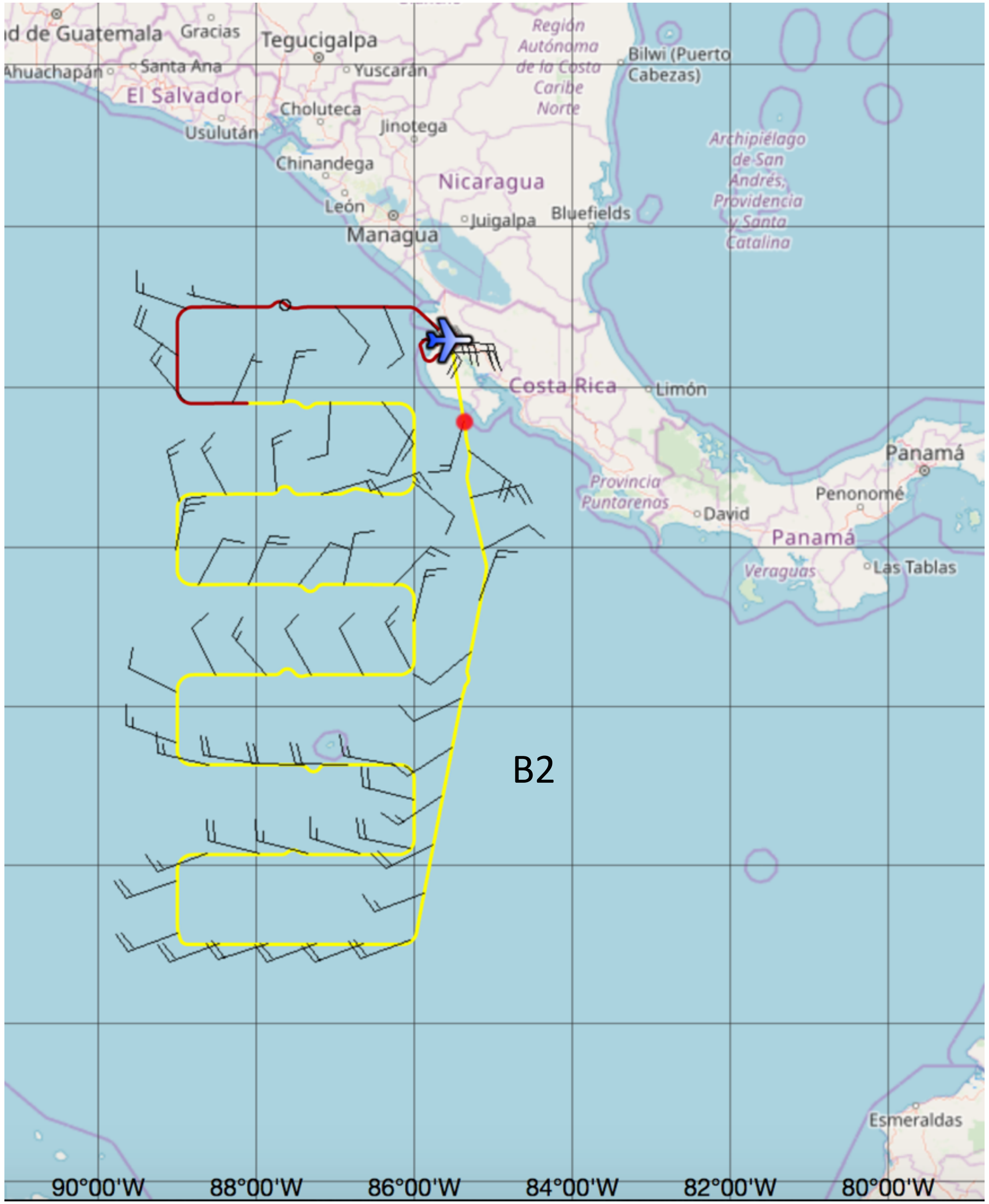
CHOCO-JEX

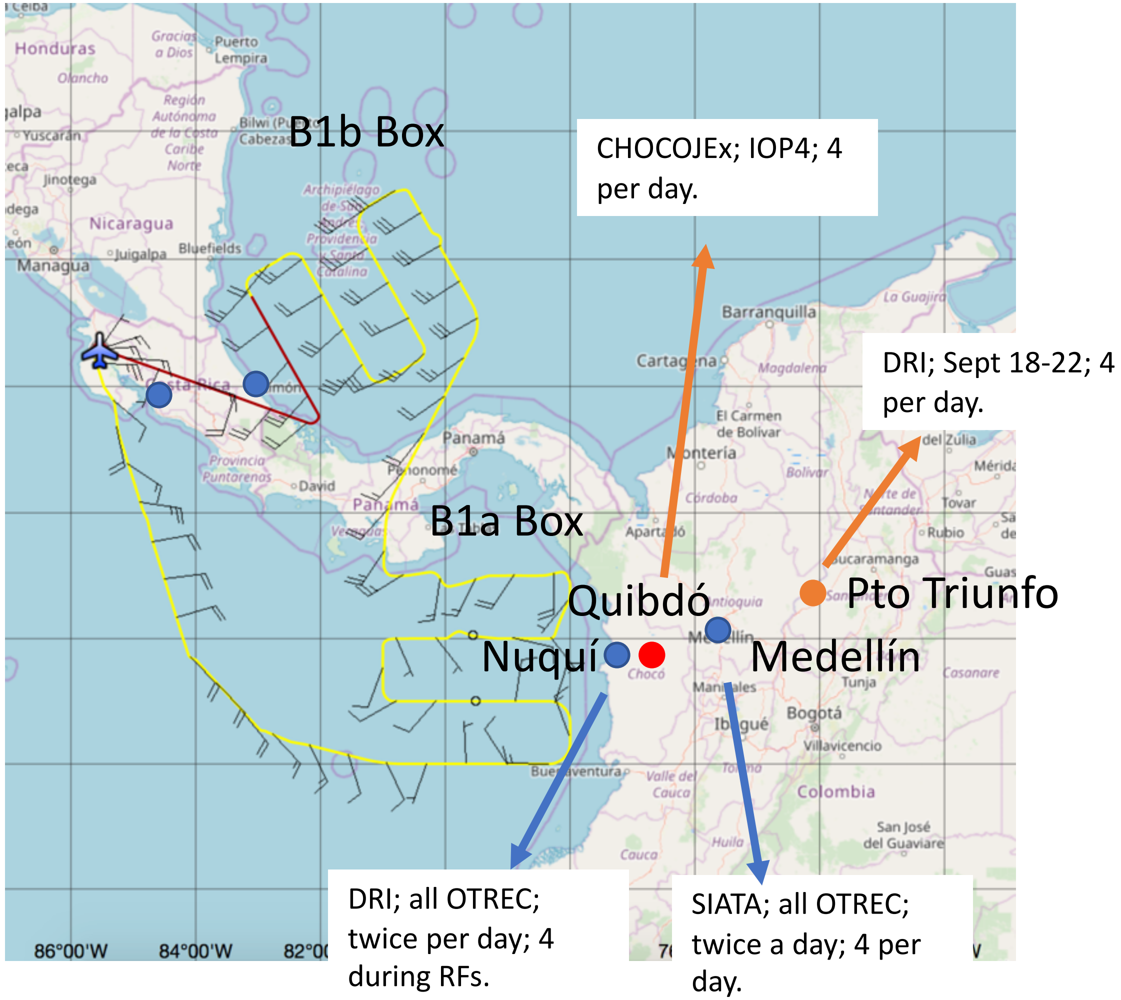
A Research Experiment Focused on the Chocó Low-Level Jet over the Far Eastern Pacific and Western Colombia

JOHANNA YEPES, GERMÁN POVEDA, JOHN F. MEJÍA, LEONARDO MORENO, AND CAROLINA RUEDA

Scientists and students from Colombia and the United States participated in CHOCO-JEX, the first field campaign to provide upper-air observations over the far eastern Pacific and western Colombia, a region that has one of the rainiest spots on Earth.

GV flight tracks and special radiosondes



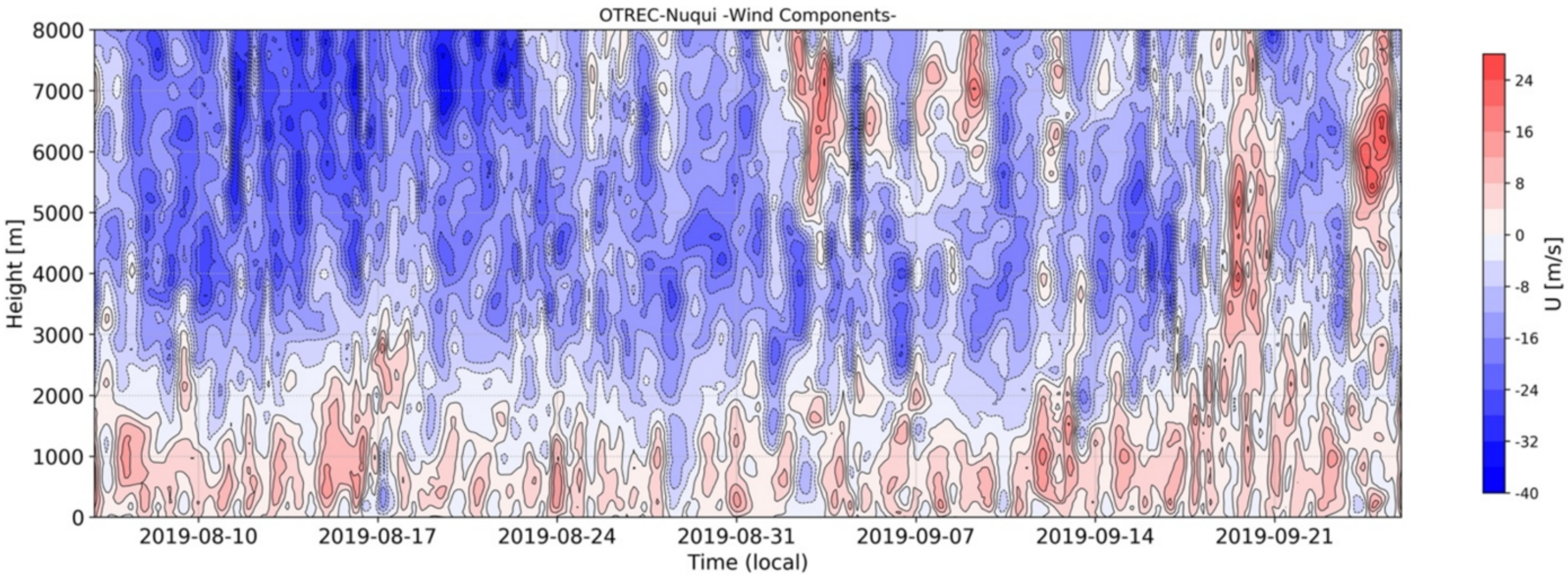


OTREC-Nuquí participants

Participant	Home Institution	Occupation	Time Sponsor	Travel Sponsor	Education and Outreach
John Mejia	DRI	Assoc. Research Prof.	NSF	NSF	PI
Johanna Yepes	UNALMED	Postdoctoral Fellow	UNALMED; G. Poveda	NSF	Collaborator
Luisa Giraldo	COLMAYOR	Undergraduate Student	COLMAYOR	NSF	RUE-Capstone
Juliana Valencia	COLMAYOR	Undergraduate Student	COLMAYOR	NSF	RUE-Capstone
Simon Restrepo	COLMAYOR	Undergraduate Student	COLMAYOR	NSF	RUE-Capstone
Manuela Velasquez	UNALMED	Graduate Student (MSc)	UNALMED; G. Poveda	NSF	MSc practical training
Manuel Salazar	UNALMED	Undergraduate Student	UNALMED; G. Poveda	NSF	Class: special topics
David Munoz	UNALMED	Undergraduate Student	UNALMED; G. Poveda	NSF	Class: special topics
Juan Jose Henao	UdeA	Graduate Student (PhD)	UdeA	NSF	PhD practical training
Manuel Zuluaga	UNALMED	Associate Researcher	COLCIENCIAS	NSF	Collaborator

OTREC Nuquí/ ChocoJEX II
Upper-air Measurements at Nuquí, Colombia

141 soundings: twice a day; 4 times a day during RF.
Outreach and education

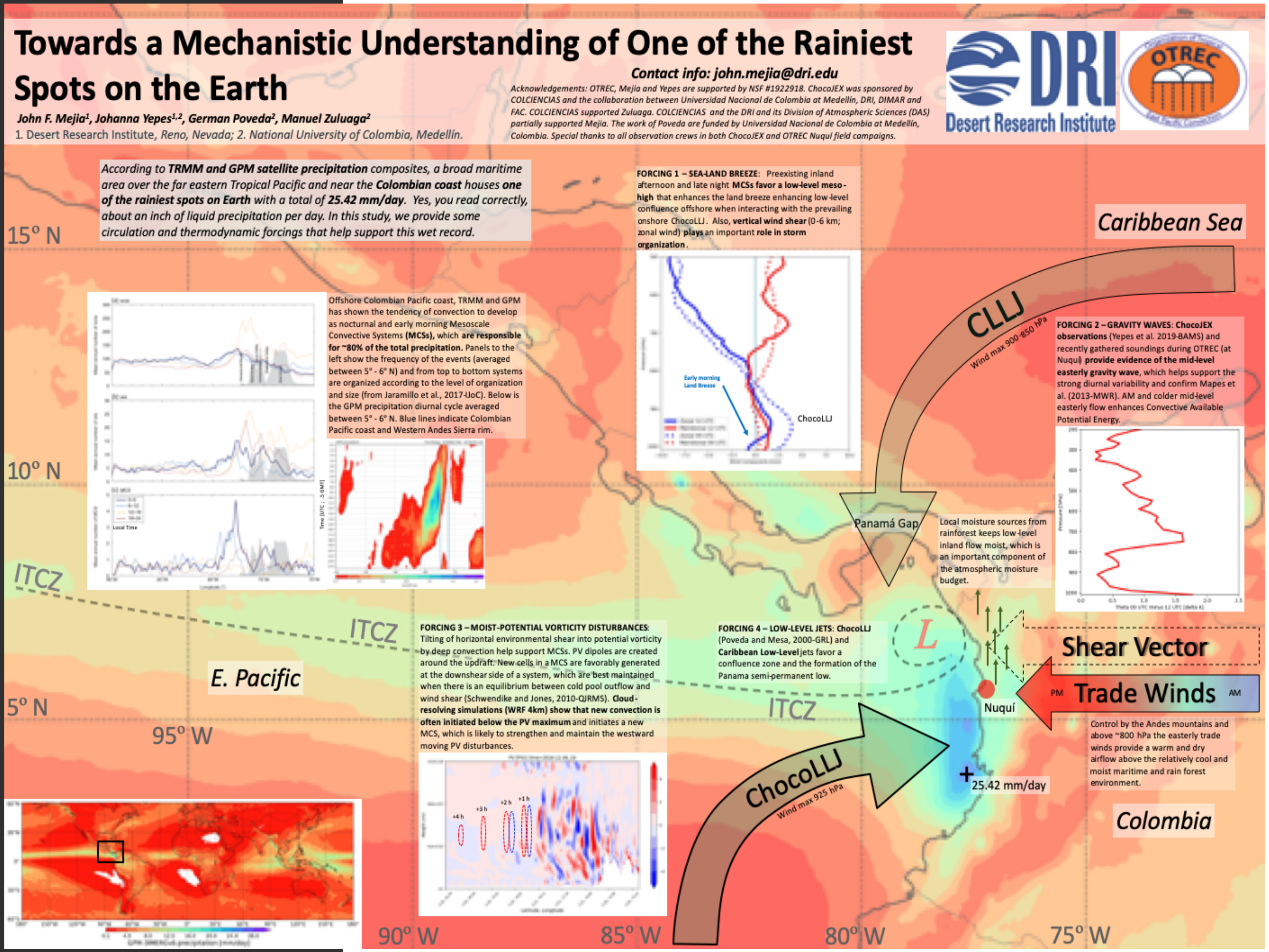


Mejia, J., Poveda, G. 2020. Upper-air Measurements at Nuquí, Colombia. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/M951-SXZK-NF0N. Accesse Date.

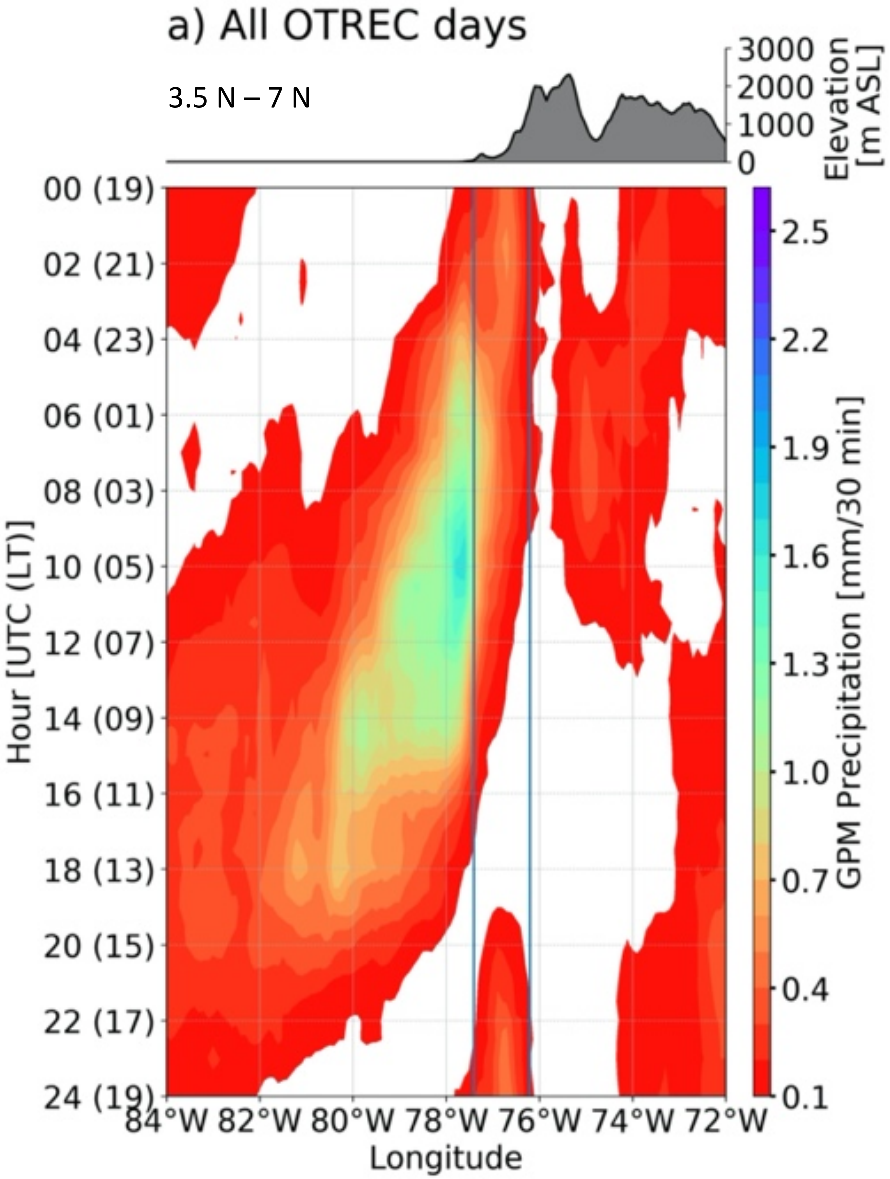
It was fun!

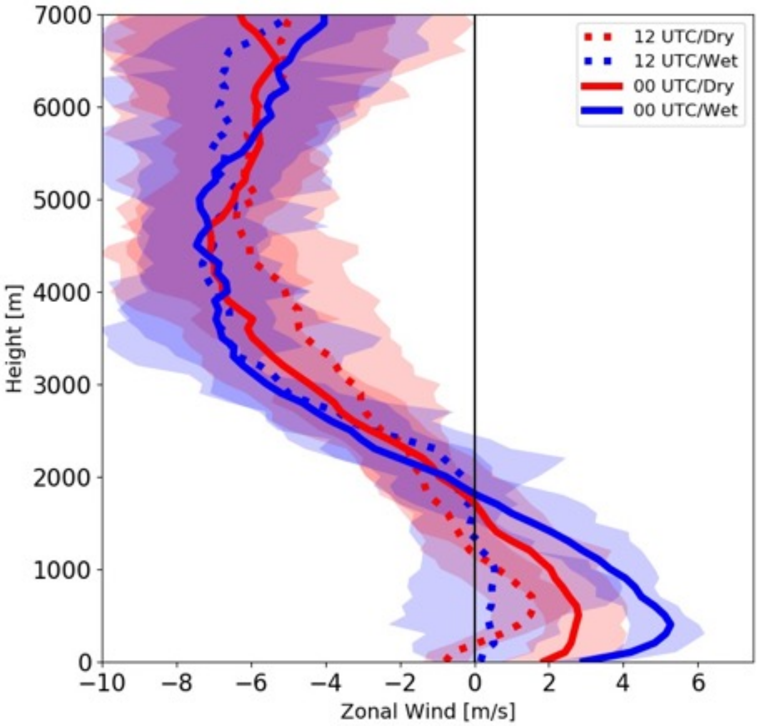
Data analysis

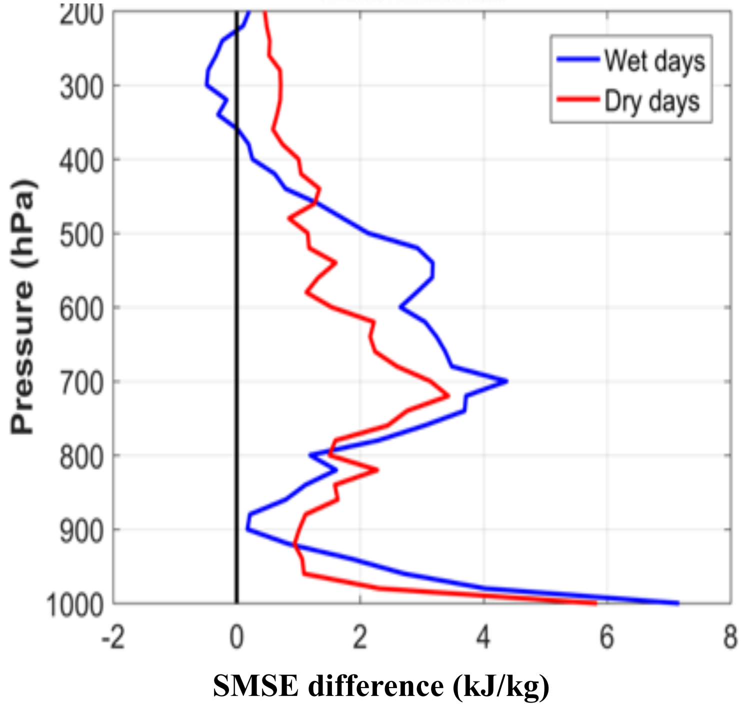
- Mejía J. F., J. Yepes, G. Poveda and M. Zuluaga (2019). Towards a Mechanistic Understanding of One of the Rainiest Spots on Earth. AGU 2019. San Francisco, USA.
- *Mejía J. F., Johanna Yepes, Juan J. Henao, Germán Poveda, Manuel D. Zuluaga, David J. Raymond, and Željka Fuchs-Stone, 2020:* Towards a Mechanistic Understanding of One of the Rainiest Spots on Earth, JGR-Atm, Under Review, https://doi.org/10.1002/essoar.10503572.1 (Discussion)
- OTREC session postponed, AMS-Tropical New Orleans to 2021

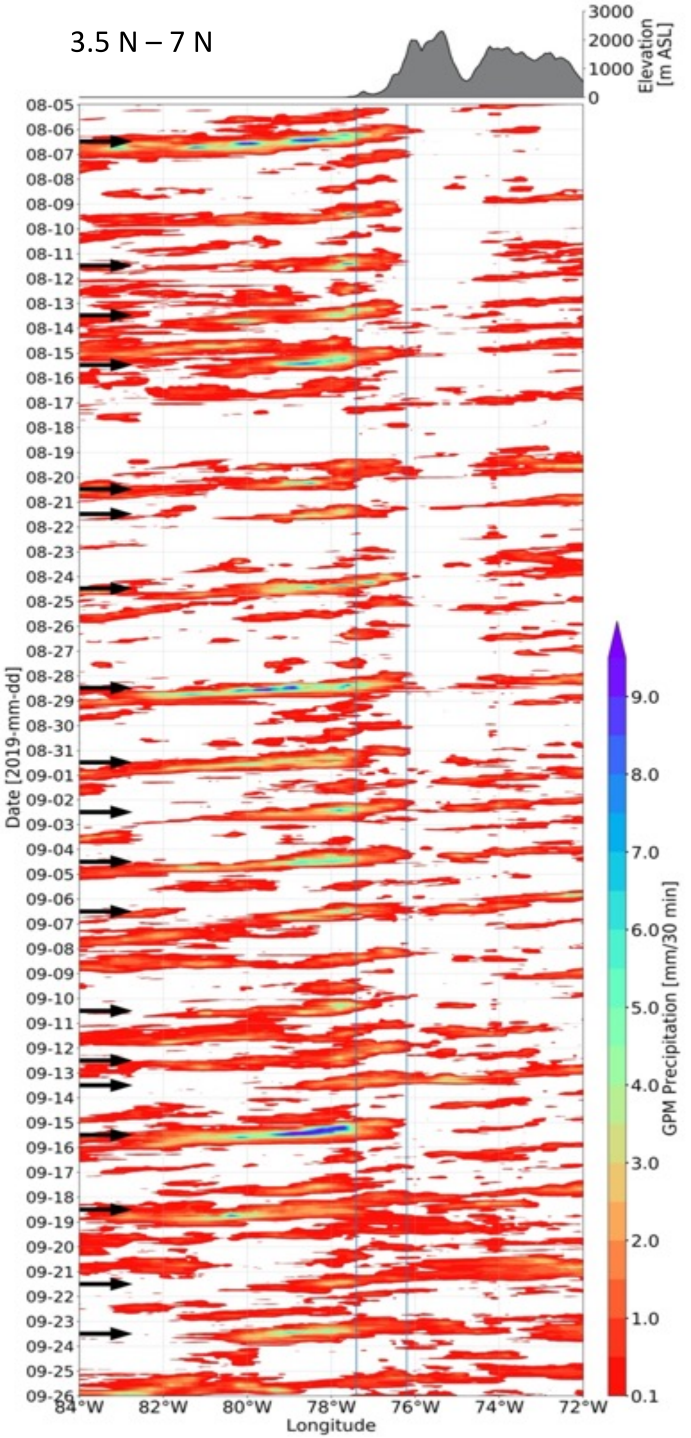


Mejia et al. (2020-JGR-Atm Under review).



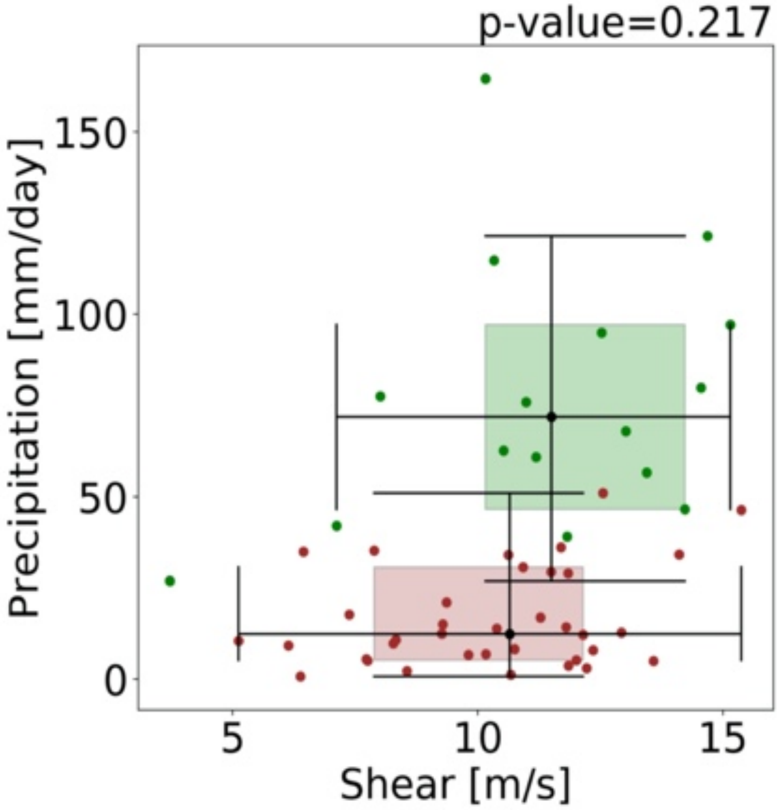


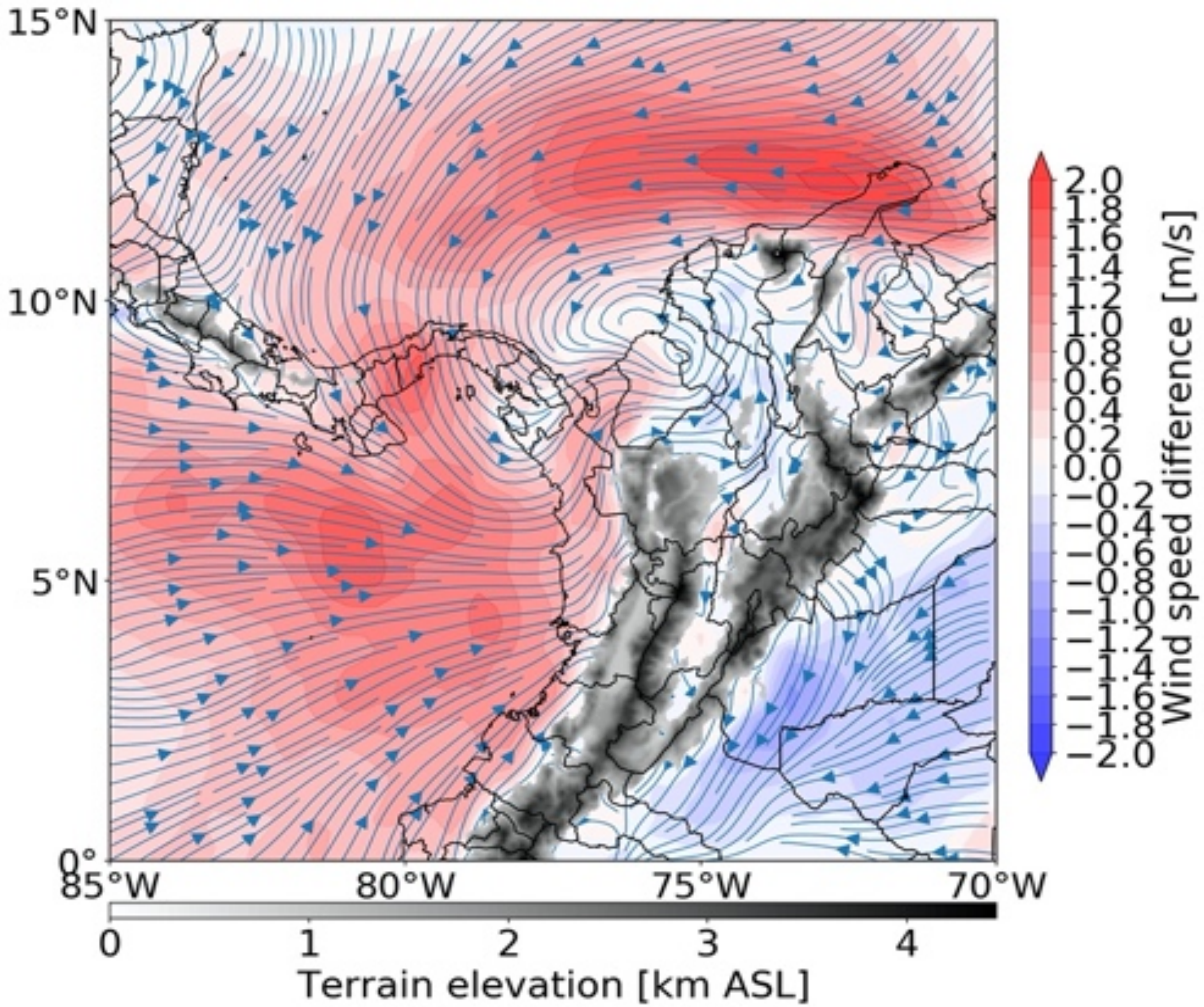


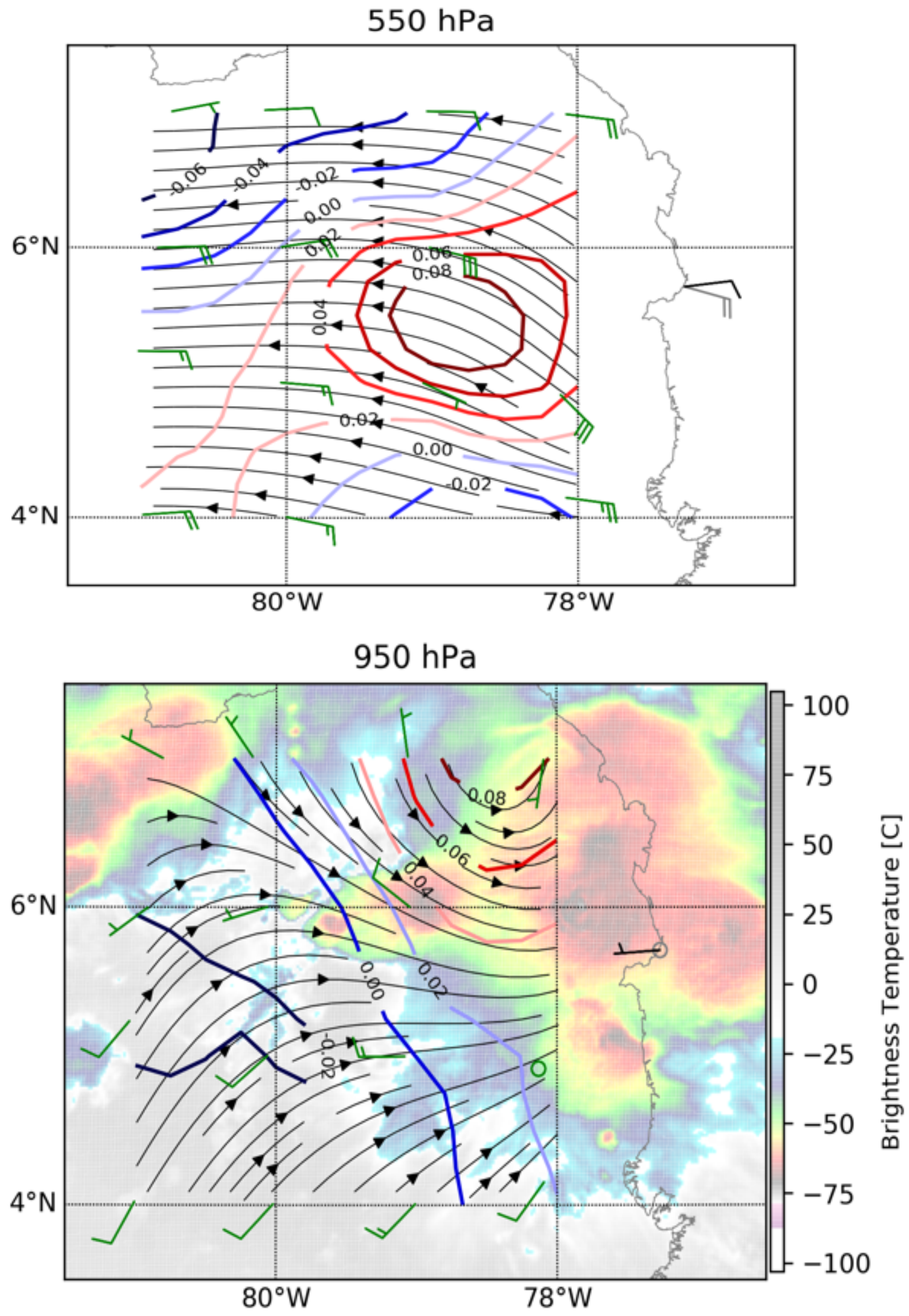


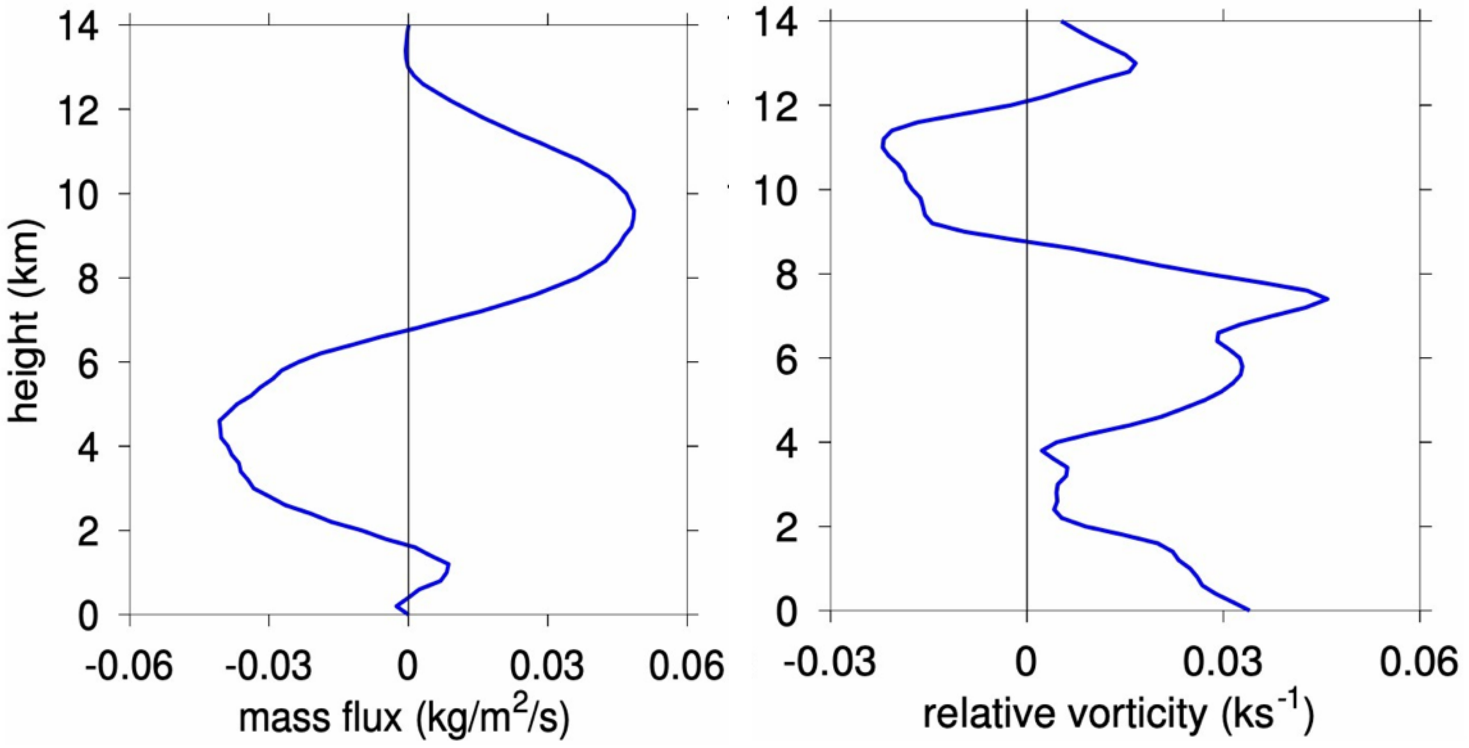
Wet minus Dry differences ERA5

OTREC-Nuquí shear 500 m - 3500 m









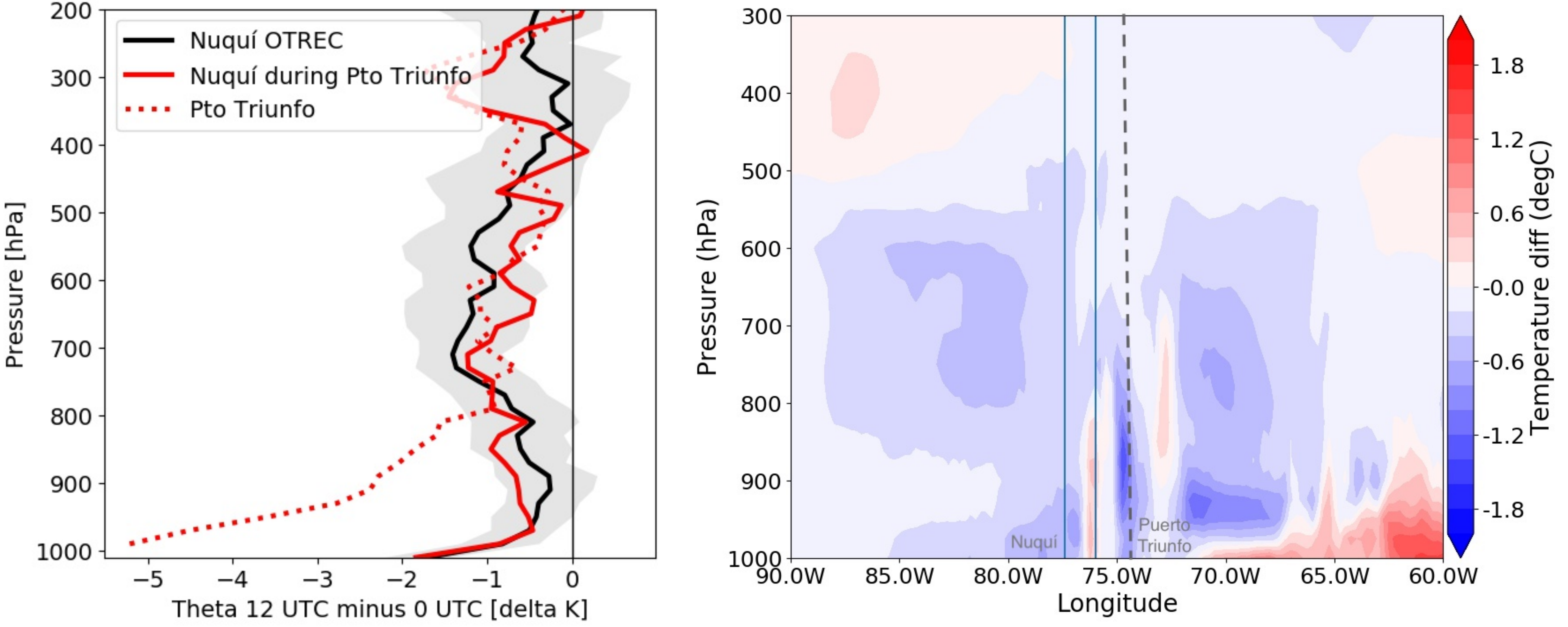
MCSs event during August 11, 2019 (GV-RF02) and 3DVAR analysis

Nuquí soundings at 12 UTC (grey) and 18UTC (black)

During MCS Days (Observable and predictable):

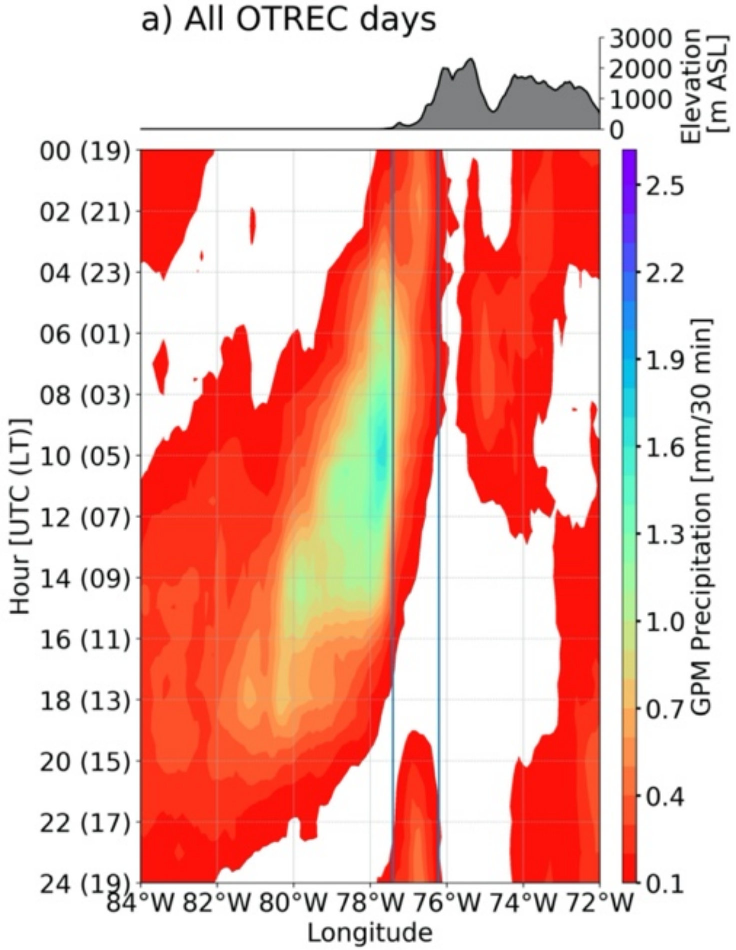
- ***ITCZ***: Enhanced low-level convergence formed by the ChocoJet and Panama gap jet. More pronounced "Panama low".
- ***Land breeze***: Land breeze favors ChocoJet deceleration offshore, enhancing the nighttime and early morning low-level convergence.
- ***Vertical wind shear***: Days with stronger shear than average correlate well with organized and persistent convective systems.
- ***Mid-level gravity wave***: During the nighttime and early morning, the cold phase of the gravity wave enhances convection potential and helps erode the inversion layer that forms in the interface of the cold and moist EPAC airmass and the drier and warmer easterly airmass that flows above the Andes
  - ***MCV***: well-organized MCV that developed during the occurrence of an MCS. This mid-level vorticity is most likely generated by stretching of ambient vorticity by the top-heavy vertical mass flux profile.
  - MCSs over the far EPAC constitute a source of local generation of mid-level vorticity that may contribute to downstream tropical cyclones development (Rydbeck et al., 2017 - JAS).

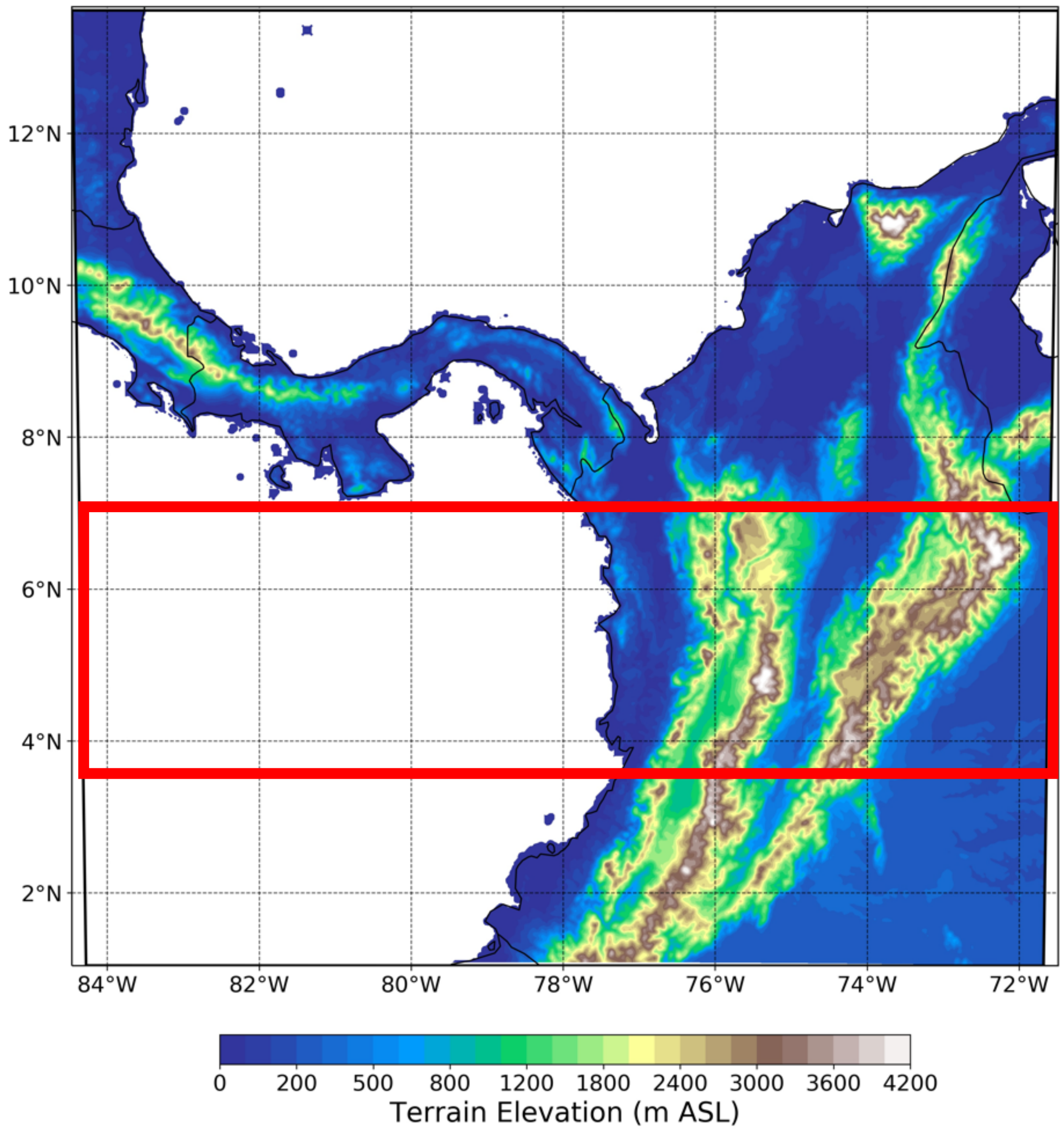
OTREC soundings and ERA5



Cloud-resolving modeling during OTREC

a) GPM-IMERG precipitation (mm/30 min) averaged between 3.5° N - 7° N during OTREC (Aug-Sept, 2019)

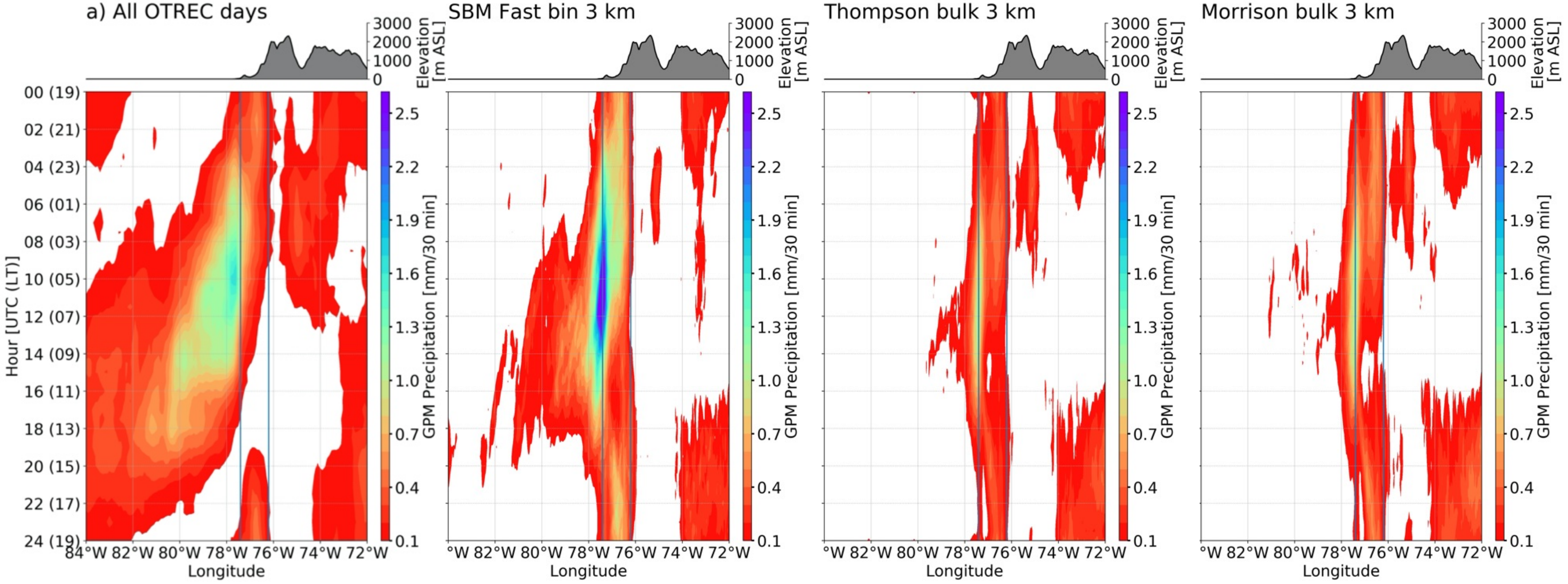




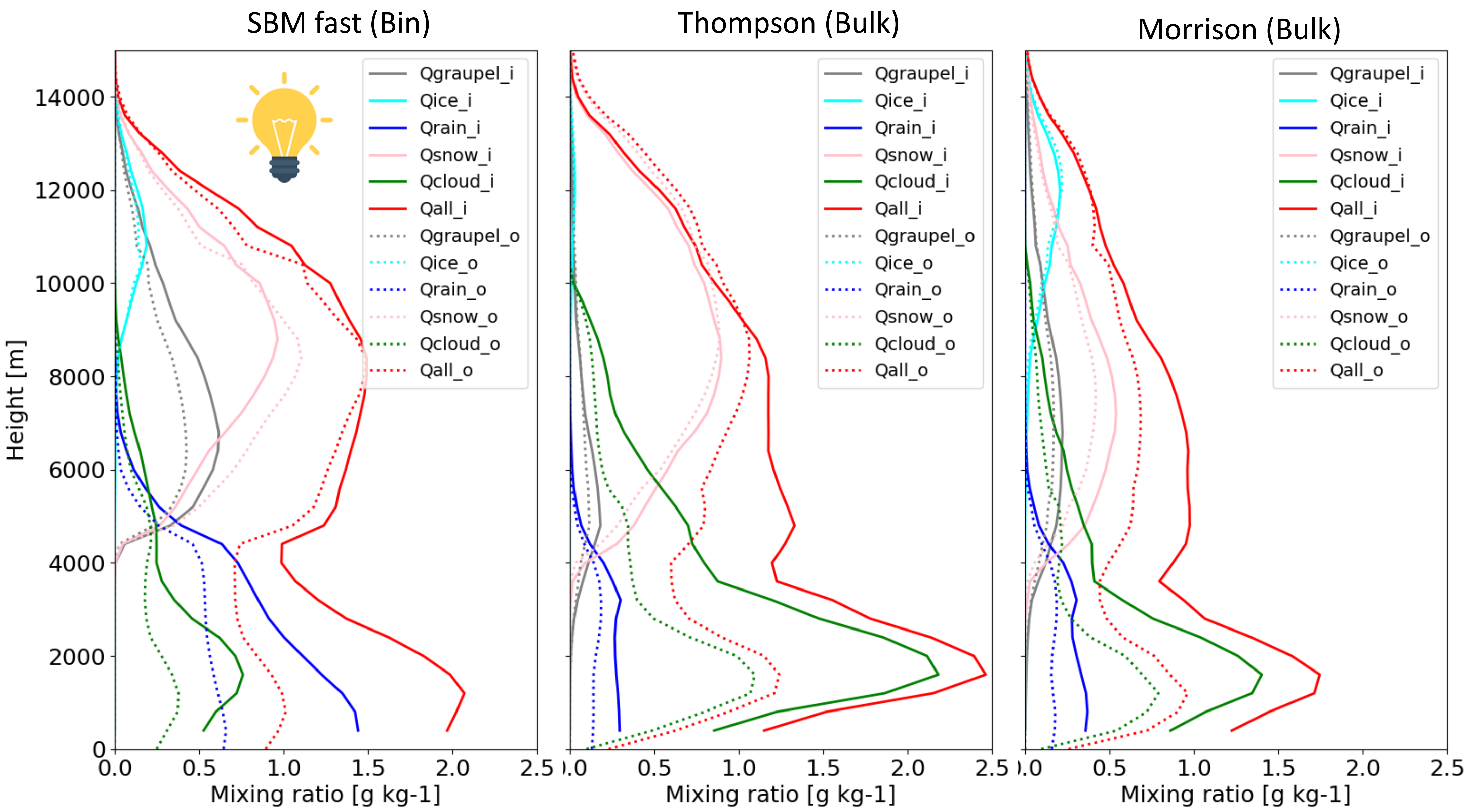
BC= ERA5
MP= {Thompson, Morrison, SBM fast}
LSM= NOAH-MP
3 km H and 71 L

Cloud-resolving modeling during OTREC

a) GPM-IMERG precipitation (mm/30 min) averaged between 3.5° N - 7° N during OTREC (Aug-Sept, 2019)



Average hydrometeor profiles: inland & ocean

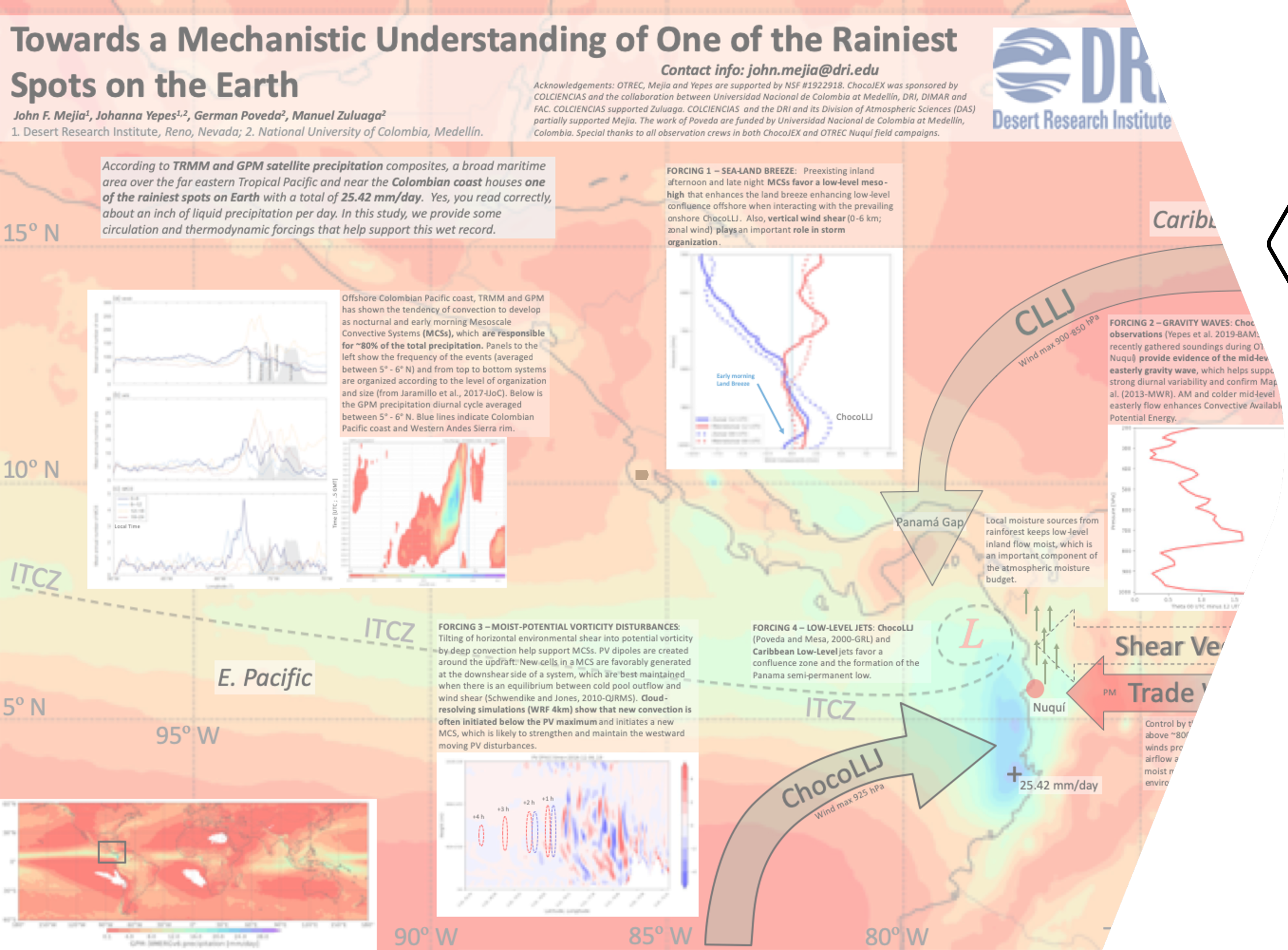


Research Questions for the "far EPAC"

1. What are the environmental conditions favoring MCSs development/propagation?
2. Can CRM develop MCSs and mayor precipitation characteristics?
3. If #2 is reasonable, then do the MCSs develop for the "right" conditions, i.e., as shown in Mapes et al. (2003), Yepes et al. (2019, 2020), Mejia et al. (2020)?
4. Use observations/model to show sources of internal variability {of vortices and energy} capable of modulating EPAC tropical cyclogenesis?

Near future

1. Develop deeper analysis Nuquí and other OTREC platforms
2. Examine nine (9) B1a RFs (3DVAR done; Thanks to NMT); several with MCSs, no MCS equally valuable.
3. Simulate using CRM and Idealized
4. Sort out dominant forces during MCSs {e.g., vorticity budgets}
5. Understand Internal Variance: diurnal to 2-day waves to TEW
6. Future: role of rainforest (surface fluxes and BVOC and inland aerosols).


Towards a Mechanistic Understanding of One of the Rainiest Spots on the Earth
Contact info: john.mejia@dri.edu
Acknowledgements: OTREC, Mejia and Yepes are supported by NSF #1922918. ChocoJEX was sponsored by COLCIENCIAS and the collaboration between Universidad Nacional de Colombia at Medellín, DRI, DIMAR and FAC. COLCIENCIAS supported Zuluaga. COLCIENCIAS and the DRI and its Division of Atmospheric Sciences (DAS) partially supported Mejia. The work of Poveda are funded by Universidad Nacional de Colombia at Medellín, Colombia. Special thanks to all observation crews in both ChocoJEX and OTREC Nuquí field campaigns.
John F. Mejia[1], Johanna Yepes[1,2], German Poveda[2], Manuel Zuluaga[2]
1. Desert Research Institute, Reno, Nevada; 2. National University of Colombia, Medellín.
Desert Research Institute
According to TRMM and GPM satellite precipitation composites, a broad maritime area over the far eastern Tropical Pacific and near the Colombian coast houses one of the rainiest spots on Earth with a total of 25.42 mm/day. Yes, you read correctly, about an inch of liquid precipitation per day. In this study, we provide some circulation and thermodynamic forcings that help support this wet record.
Offshore Colombian Pacific coast, TRMM and GPM has shown the tendency of convection to develop as nocturnal and early morning Mesoscale Convective Systems (MCSs), which are responsible for ~80% of the total precipitation. Panels to the left show the frequency of the events (averaged between 5° - 6° N) and from top to bottom systems are organized according to the level of organization and size (from Jaramillo et al., 2017-IJoC). Below is the GPM precipitation diurnal cycle averaged between 5° - 6° N. Blue lines indicate Colombian Pacific coast and Western Andes Sierra rim.
FORCING 1 – SEA-LAND BREEZE: Preexisting inland afternoon and late night MCSs favor a low-level meso-high that enhances the land breeze enhancing low-level confluence offshore when interacting with the prevailing onshore ChocoLLJ. Also, vertical wind shear (0-6 km; zonal wind) plays an important role in storm organization.
Early morning Land Breeze
ChocoLLJ
FORCING 2 – GRAVITY WAVES: Choc
observations (Yepes et al. 2019-BAMS
recently gathered soundings during OT
Nuquí) provide evidence of the mid-lev
easterly gravity wave, which helps supp
strong diurnal variability and confirm Map
al. (2013-MWR). AM and colder mid-level
easterly flow enhances Convective Availabl
Potential Energy.
FORCING 3 – MOIST-POTENTIAL VORTICITY DISTURBANCES: Tilting of horizontal environmental shear into potential vorticity by deep convection help support MCSs. PV dipoles are created around the updraft. New cells in a MCS are favorably generated at the downshear side of a system, which are best maintained when there is an equilibrium between cold pool outflow and wind shear (Schwendike and Jones, 2010-QJRMS). Cloud-resolving simulations (WRF 4km) show that new convection is often initiated below the PV maximum and initiates a new MCS, which is likely to strengthen and maintain the westward moving PV disturbances.
FORCING 4 – LOW-LEVEL JETS: ChocoLLJ (Poveda and Mesa, 2000-GRL) and Caribbean Low-Level jets favor a confluence zone and the formation of the Panama semi-permanent low.
Local moisture sources from rainforest keeps low-level inland flow moist, which is an important component of the atmospheric moisture budget.
15° N
10° N
5° N
95° W
90° W
85° W
80° W
ITCZ
E. Pacific
Caribb
CLLJ
Wind max 900-850 hPa
Panamá Gap
Shear Ve
Trade
Nuquí
ChocoLLJ
Wind max 925 hPa
25.42 mm/day
L

THANKS!

Acknowledgements

- *Support for this work was provided under NSF grant 1922918.*
- *Universidad Nacional de Colombia at Medellin, Colegio Mayor de Antioquia, and Universidad de Antioquia sponsored the time for OTREC-Nuquí participating students, while NSF funding sponsored all travel related expenses.*
- *We would like to acknowledge operational, technical, and scientific support provided by NCAR's Earth Observing Laboratory, sponsored by the National Science Foundation.*
- *Henao received funding by the Colombian Administrative Department of Science, Technology and Innovation (COLCIENCIAS) under the National Doctoral Grant 727 (2015).*
- *Poveda's work was supported by Universidad Nacional de Colombia at Medellín.*
- *Raymond and Fuchs-Stone were supported by NSF grant 1758513.*
- *Zuluaga was supported by Patrimonio Autónomo Fondo Nacional de Financiamiento para la Ciencia, la Tecnología y la Innovación, Francisco José de Caldas (ref. 80740-128-2019).*
- *Special thanks to all OTREC-Nuquí participants and to DRI administration for facilitating this international field campaign.*
- *Administration personnel from Hotel Puerta del Sol, Nuquí (Patricia Lozano and Don Ramon) for their continue logistic support during the field campaign. We also thank NASA for providing GPM dataset, and DIMAR for sharing surface station observations in the region.*