Influence of regional processes in convection over an inter-Andean valley in Colombia

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VI Convection-Permitting Climate Modeling Workshop

Thursday 8th - 2: South American high resolution modeling research activities

7-9 September 2022, C. A. Buenos Aires, Argentina

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viCPCMW Buenos Aires city, 2022 Sep. 7-9th Convection-Permitting Climate Modeling Workshop

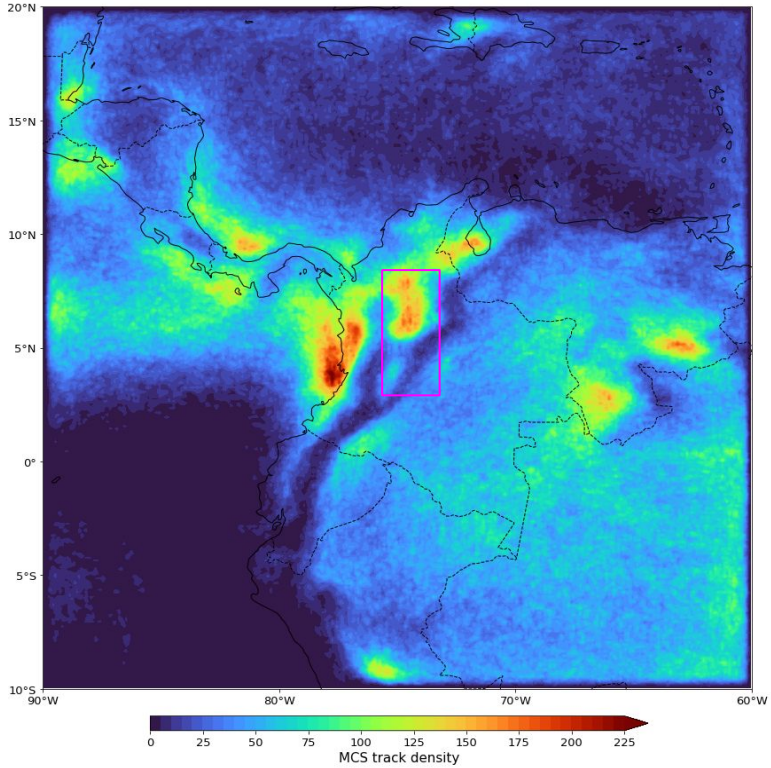
Introduction

-NW South America is characterized by its intense convective activity and complex terrain. [e.g. Houze et al 2015, Zuluaga and Houze 2015]

-Several convection hotspots there: Amazon, Pacific coast, Maracaibo Lake, Caribbean flatlands, and **Magdalena River Valley - MV (an inter-Andean valley)** [e.g. Gómez-Rios 2020, Robledo et al 2022]

Different diurnal cycle of rainfall (and convection) in each region; in MV late-night peak. [e.g. Hernández-Deckers 2021]

MV is the most populated and economically relevant area in Colombia



Frequency of MCSs tracks in NW South America. Robledo et al, 2022, (in prep.)

Introduction

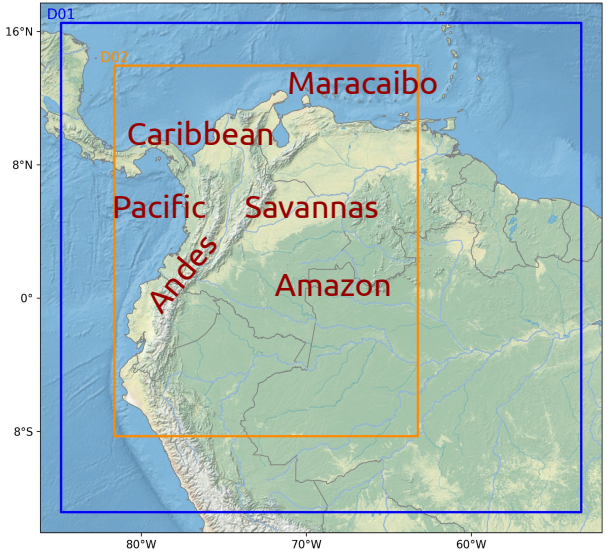
Main Goal

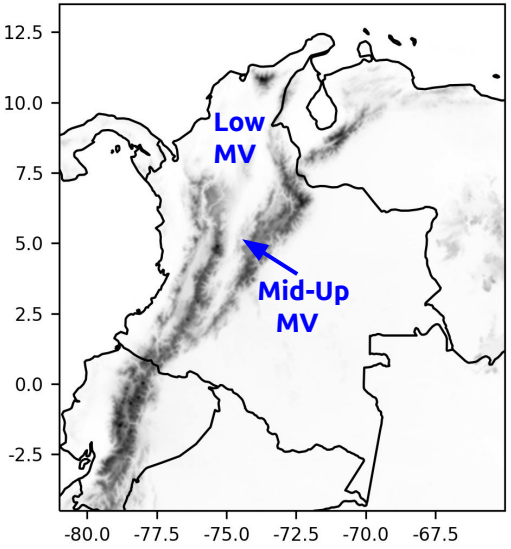
Elucidate possible relationships between regional-scale atmospheric processes in northwestern South America and convection in the Magdalena Valley (MV)

Frequency of MCSs tracks in NW South America. Robledo et al, 2022, (in prep.)

Methods and Data

WRF Convection-permitting high resolution simulations* (4km inner domain). ERA5 boundary conditions





Methods and Data

WRF Convection-permitting high resolution simulations* (4km inner domain). ERA5 boundary conditions

2 one-month periods in 2019

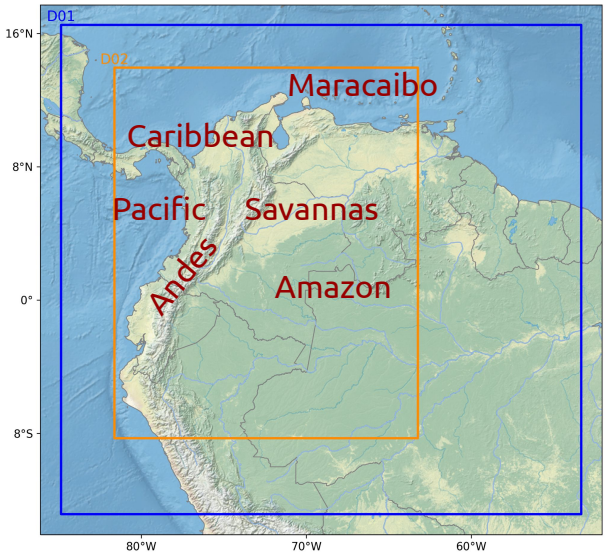
Jul 12-Aug 12 **JA**

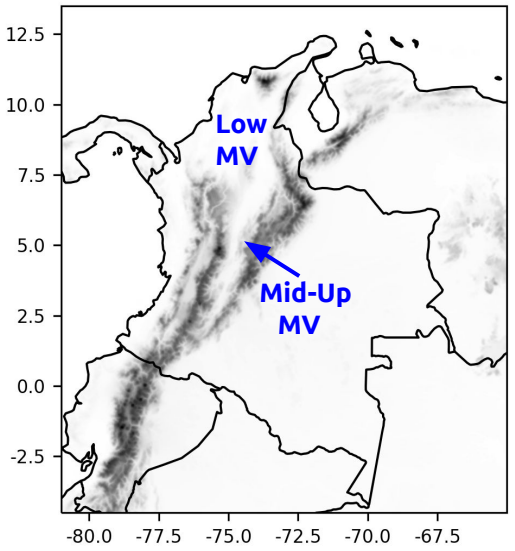
Sep 18-Oct 18 **SO**

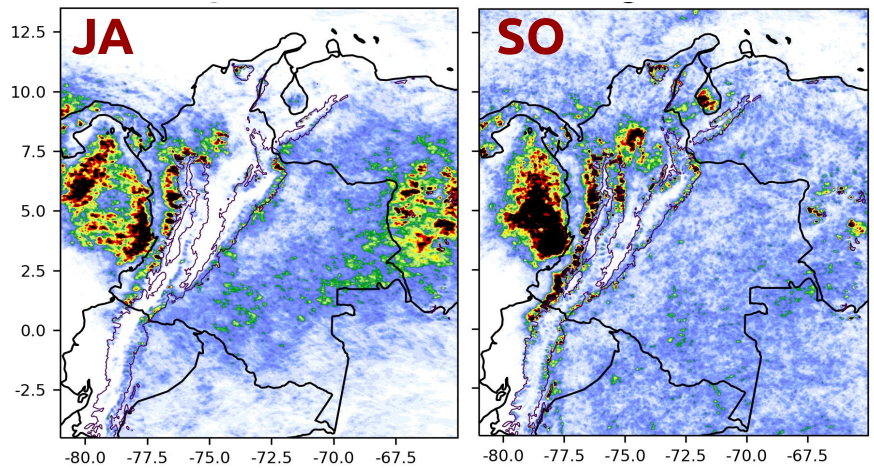
Periods of intense convective activity in the MV

Consider Low and Middle-Upper MV

*Comparison between model and observations, in Rendón et al (2021) and Hernández et al (2022). We use here the same model configuration.







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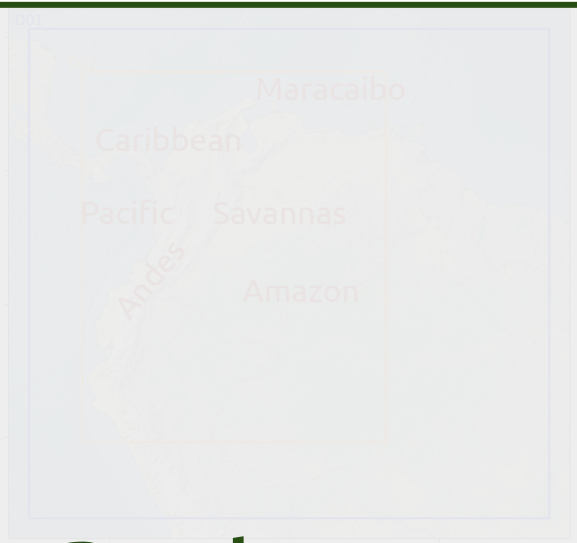
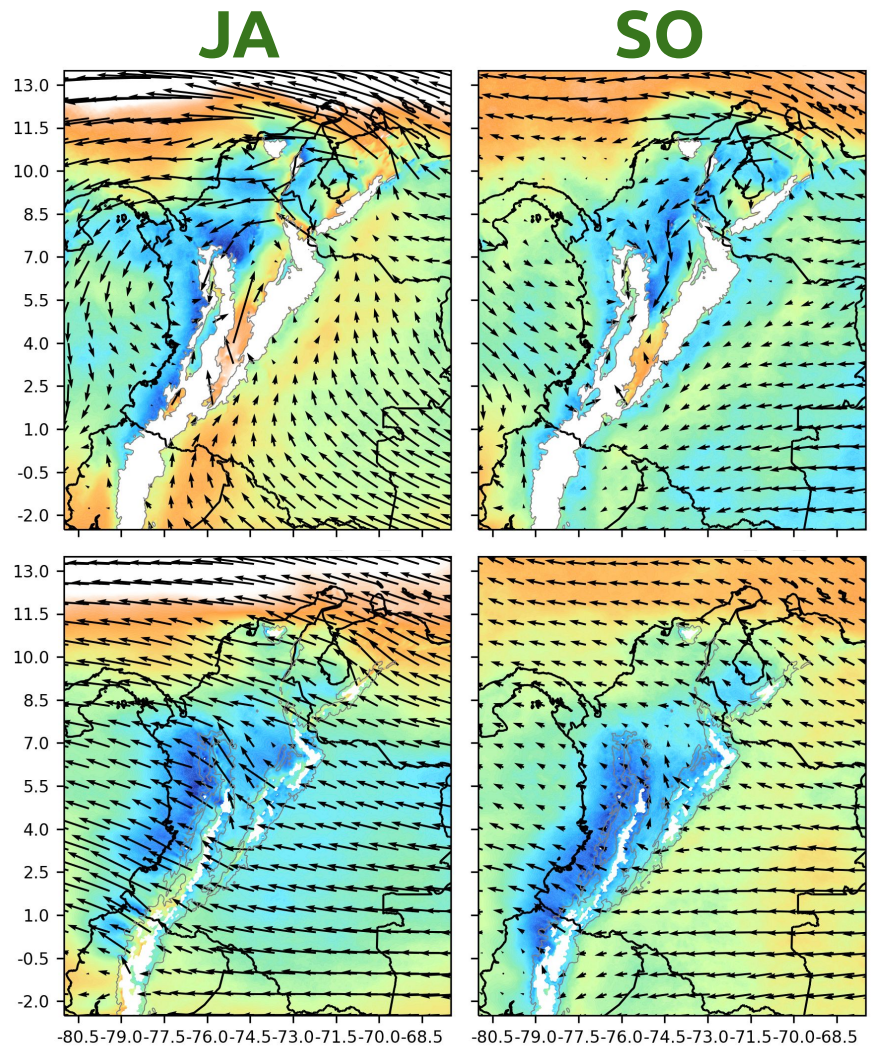


Results

Synoptic context

WRF circulation and mixing ratio

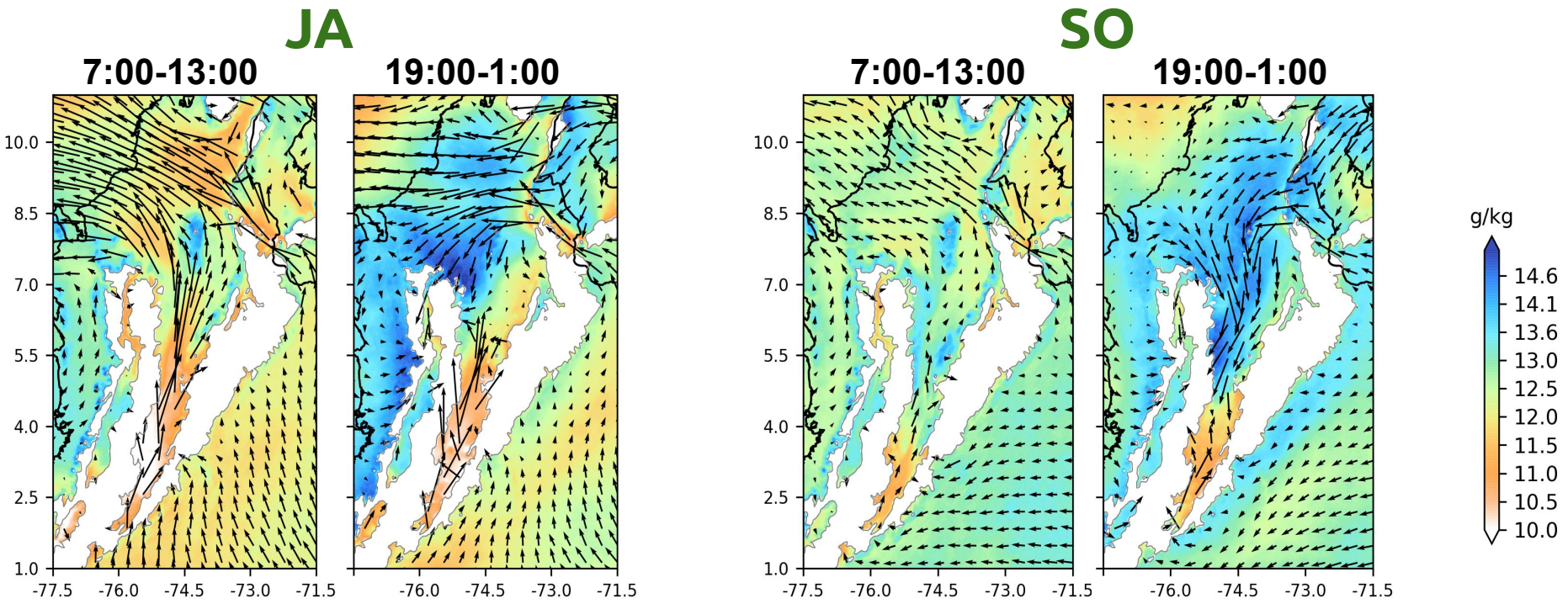


Southeasterly (JA) and easterly (SO) flow from Amazon

Caribbean and Chocó LLJ

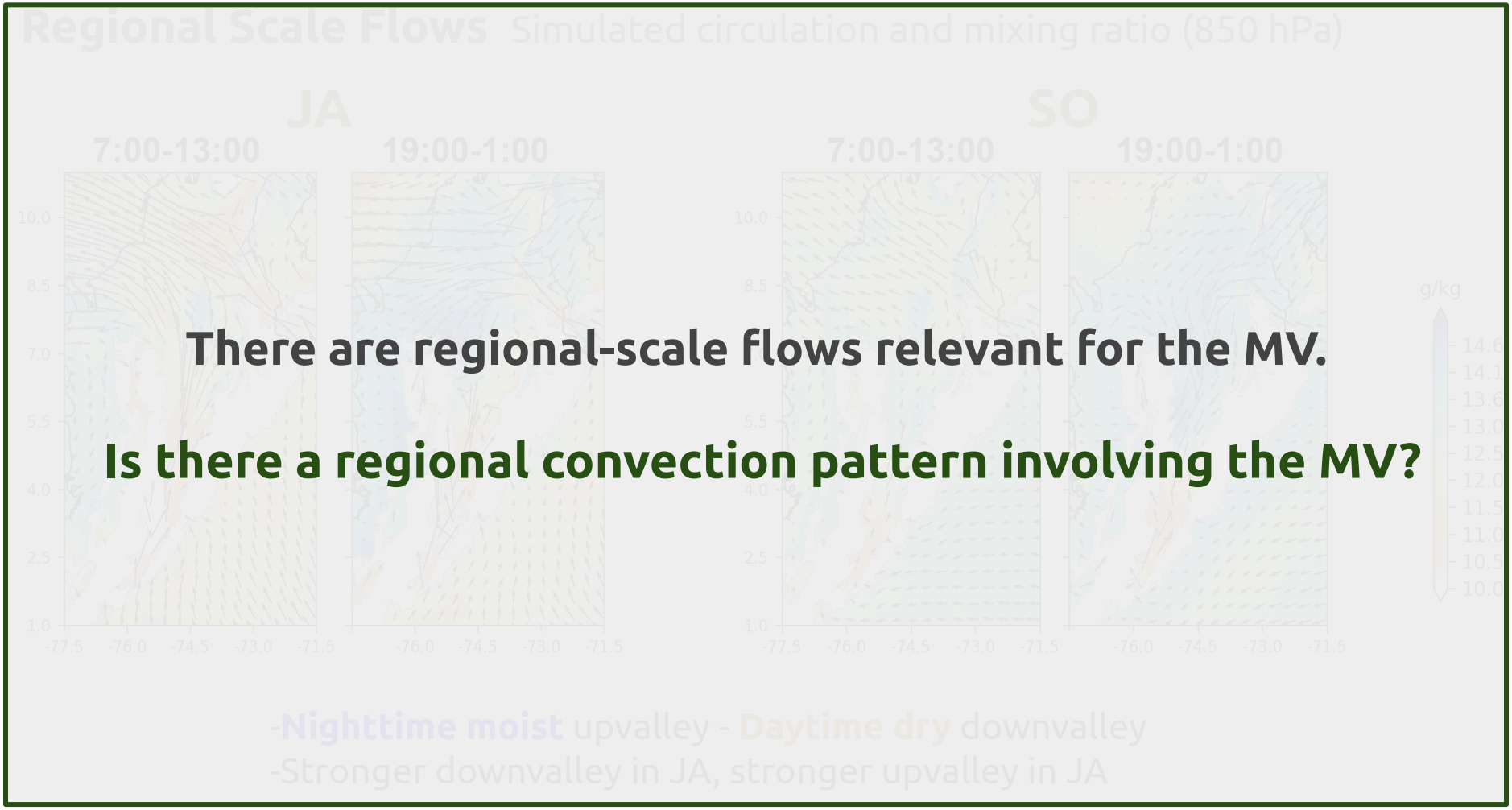
Prevailing easterlies at 700 hPa and above (with southerly component in JA)

Regional Scale Flows Simulated circulation and mixing ratio (850 hPa)



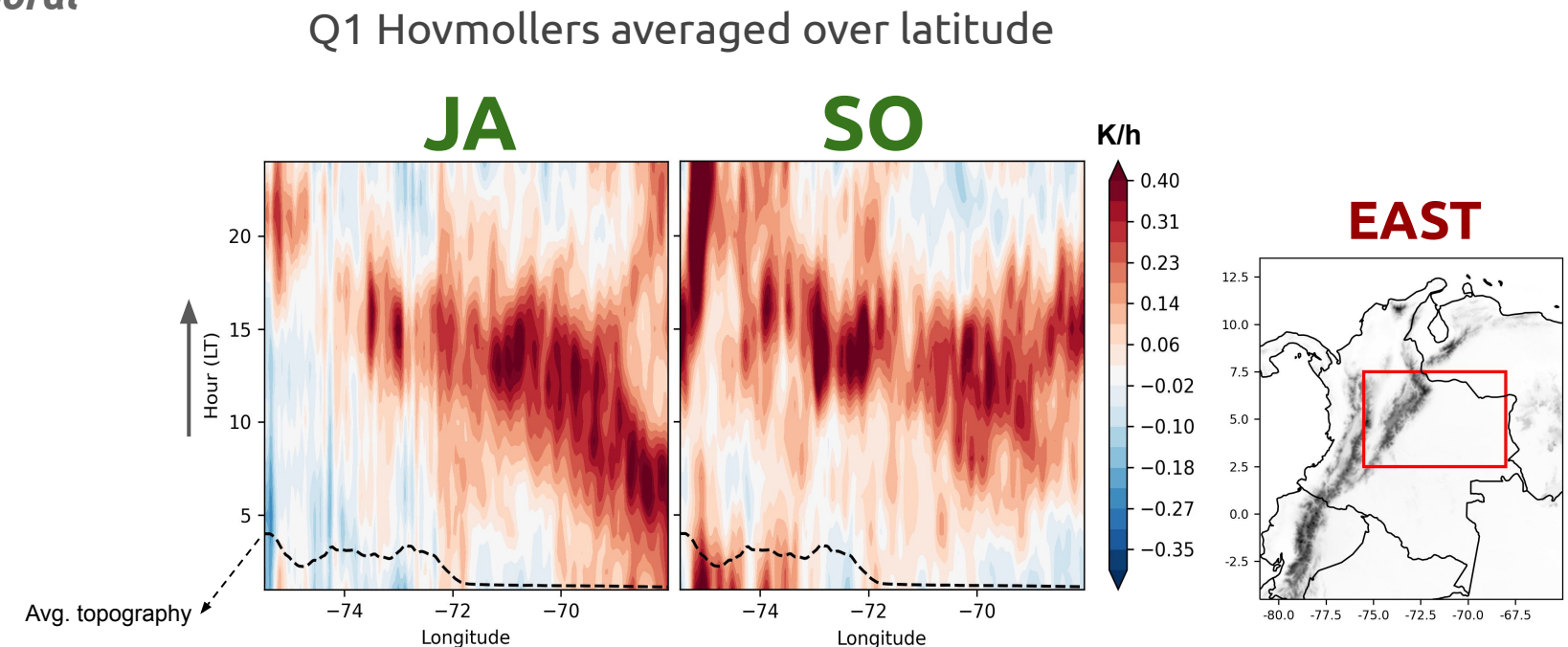
-**Daytime dry** downvalley - **Nighttime moist** upvalley

-Stronger downvalley in JA, stronger upvalley in SO


There are regional-scale flows relevant for the MV.
Is there a regional convection pattern involving the MV?

Diurnal Cycle of Average 700-450 hPa diabatic heating

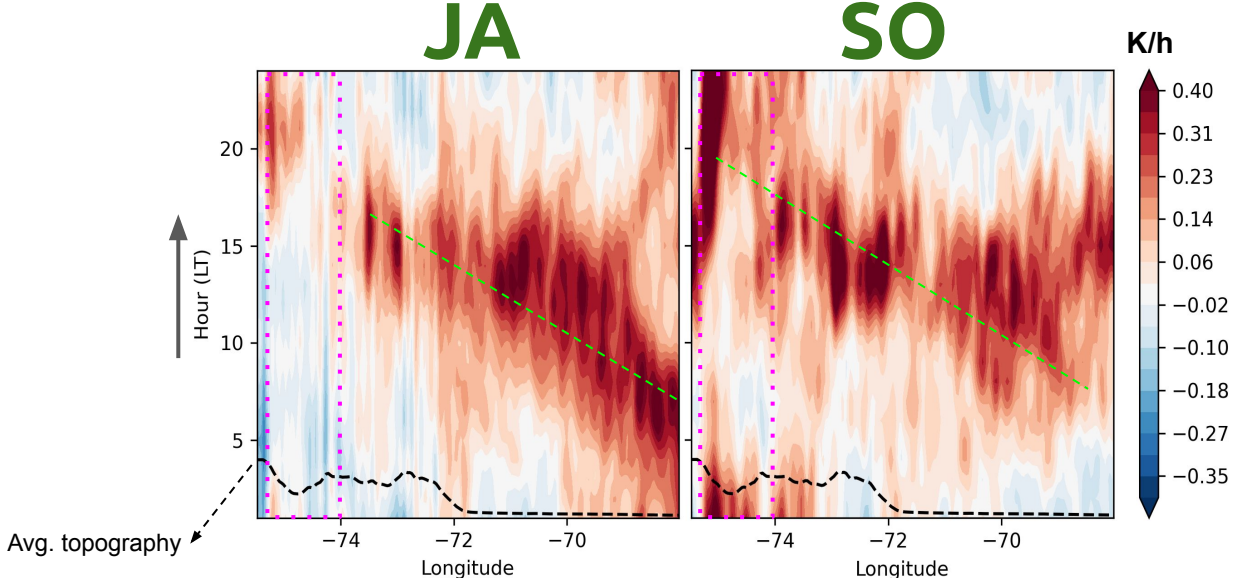
Spatio-temporal evolution

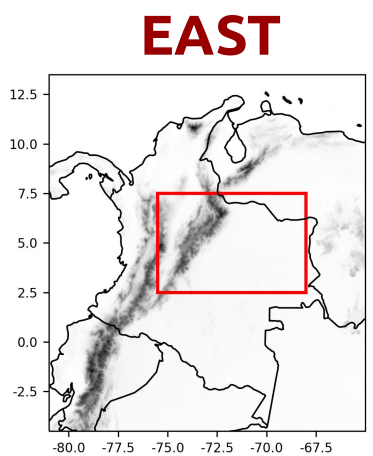


Diurnal Cycle of Average 700-450 hPa diabatic heating

Spatio-temporal evolution

Q1 Hovmollers averaged over latitude

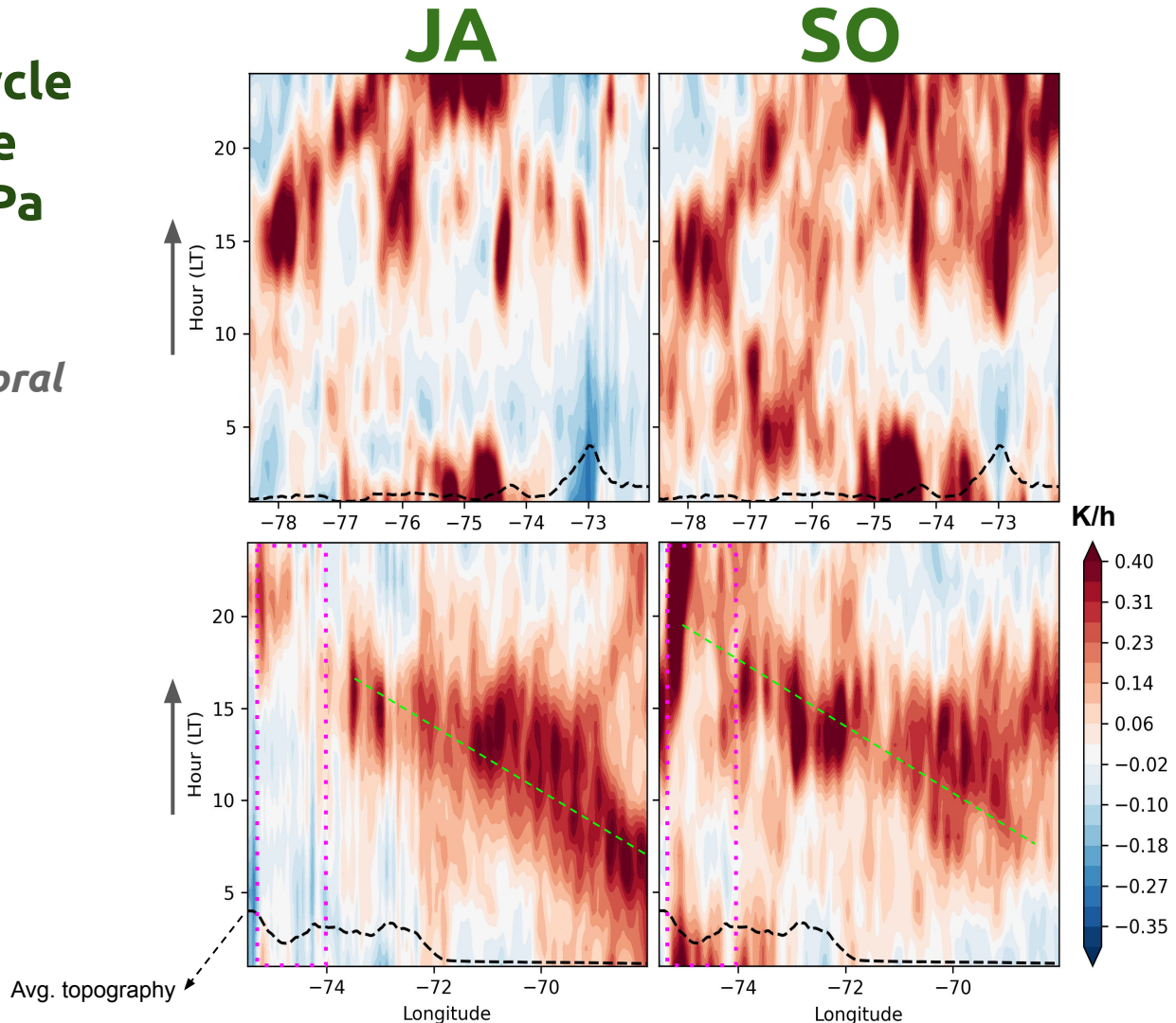


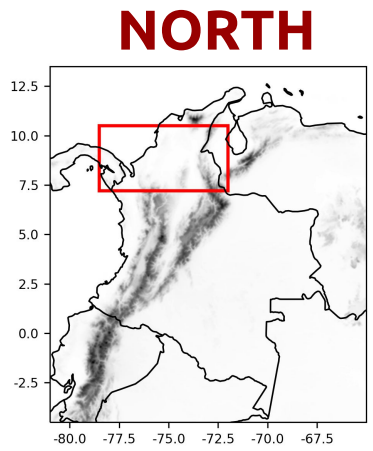


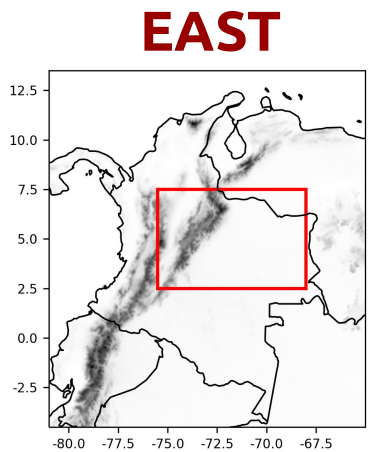
Easterly spatio-temporal evolution from Amazon to MV

Diurnal Cycle of Average 700-450 hPa diabatic heating

Spatio-temporal evolution







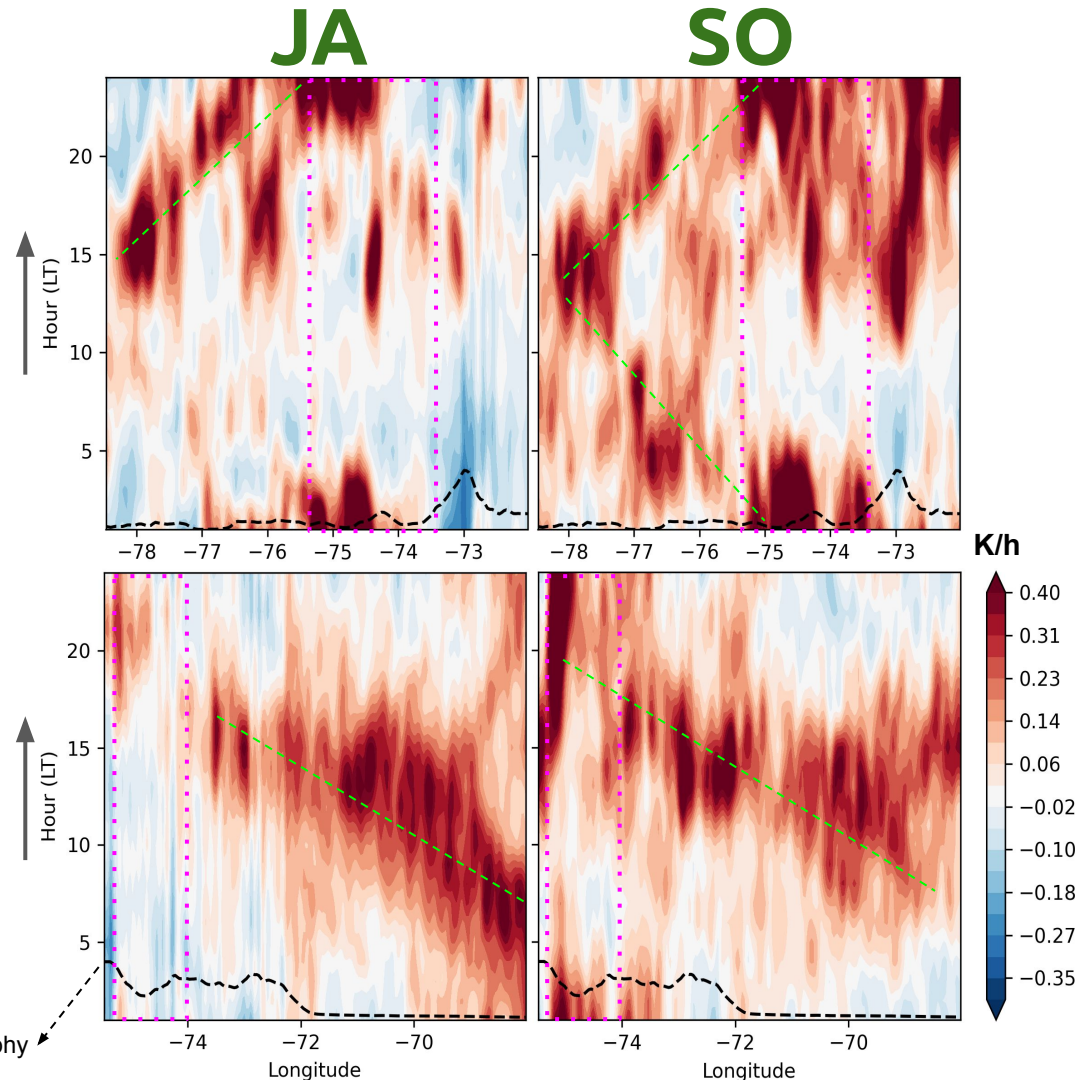
Easterly spatio-temporal evolution from Amazon to MV

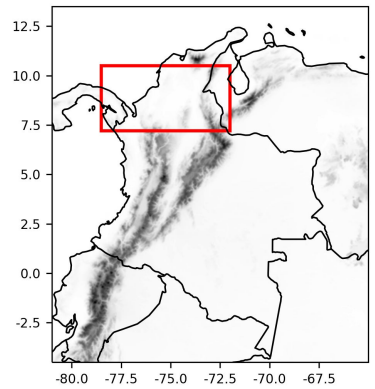
Diurnal Cycle of Average 700-450 hPa diabatic heating

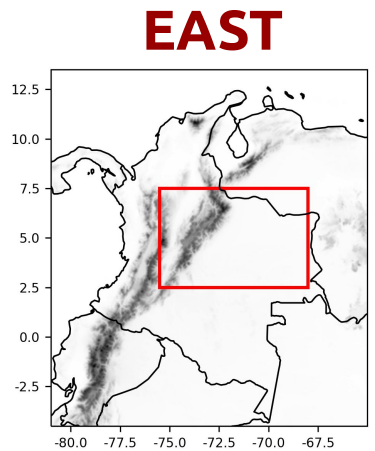
Spatio-temporal evolution

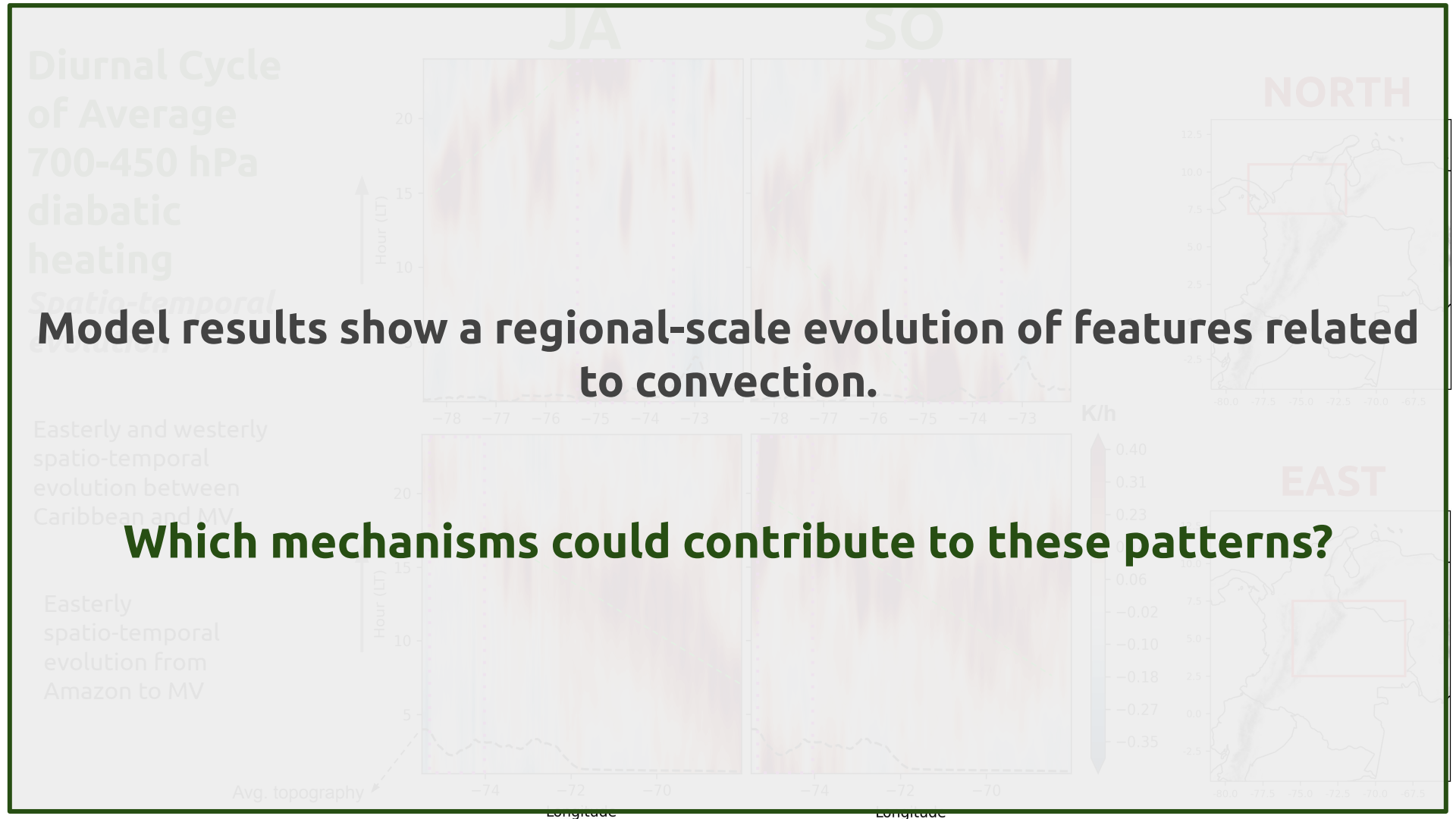
Easterly and westerly spatio-temporal evolution between Caribbean and MV

Easterly spatio-temporal evolution from Amazon to MV







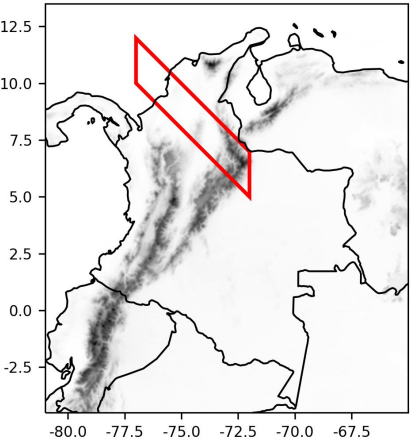

Diurnal Cycle of Average 700-450 hPa diabatic heating
Spatio-temporal
JA
SO
NORTH
EAST
Hour (LT)
K/h
Easterly and westerly spatio-temporal evolution between Caribbean and MV
Easterly spatio-temporal evolution from Amazon to MV
Avg. topography
Longitude
Model results show a regional-scale evolution of features related to convection.
Which mechanisms could contribute to these patterns?

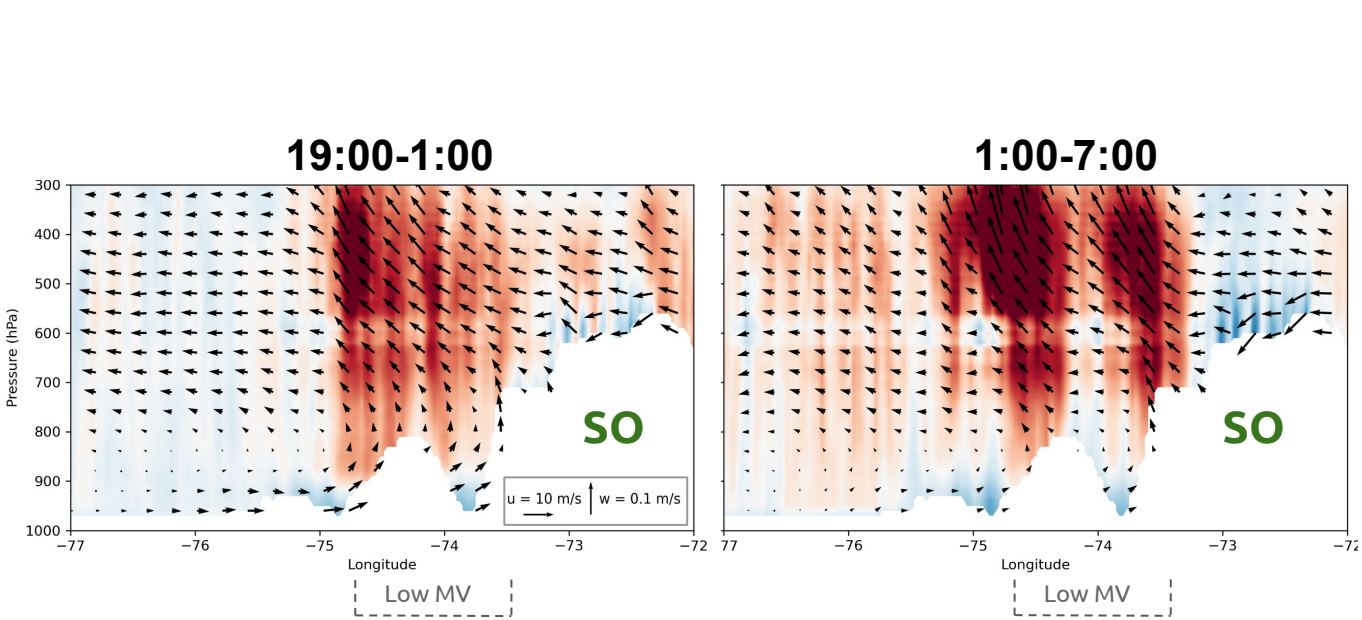
Diurnal Cycle of diabatic heating and circulation

Cross section from the Caribbean coast to the Low MV.

LL flow from Caribbean may contribute to afternoon and early night **westerly** evolution of c.a.

Easterlies at and above 700 hPa may transport heat that contributes to late-night **easterly** evolution of c.a.



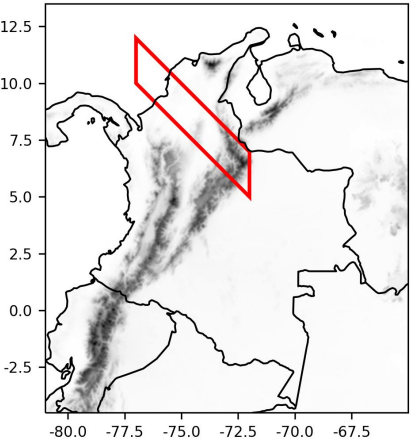


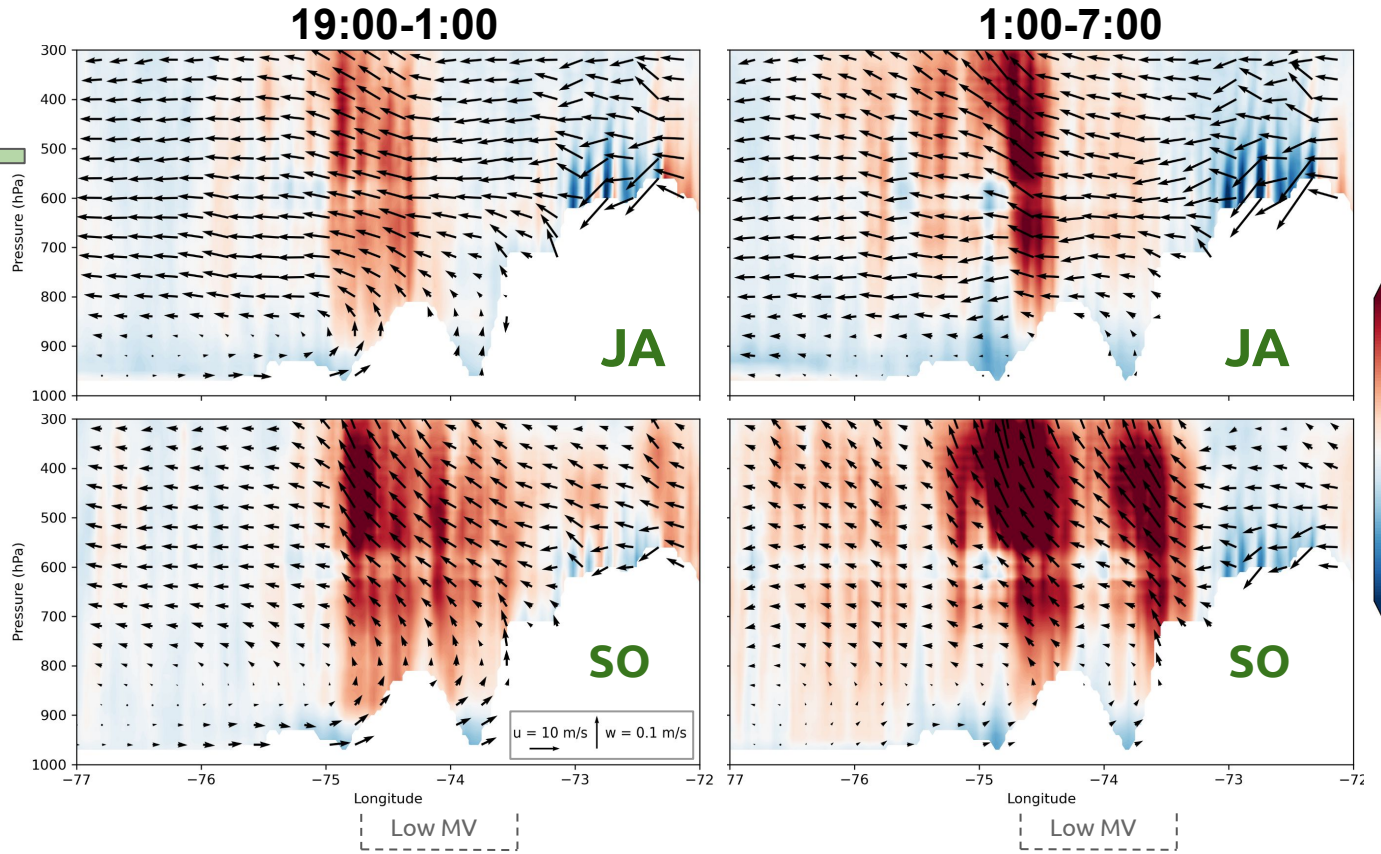
Diurnal Cycle of diabatic heating and circulation

Cross section from the Caribbean coast to the Low MV.

Possible contribution of flow from Caribbean to **westerly** evolution of c.a.

Despite easterly flow, weak **easterly** evolution of c.a. Possible role of strong cooling over the range.



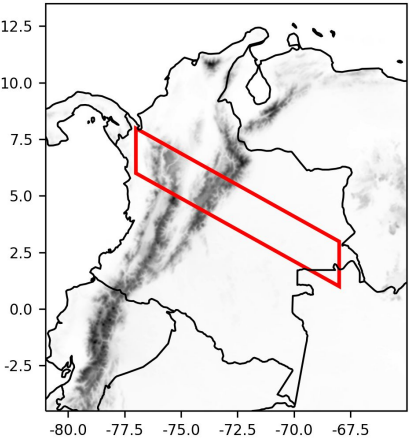


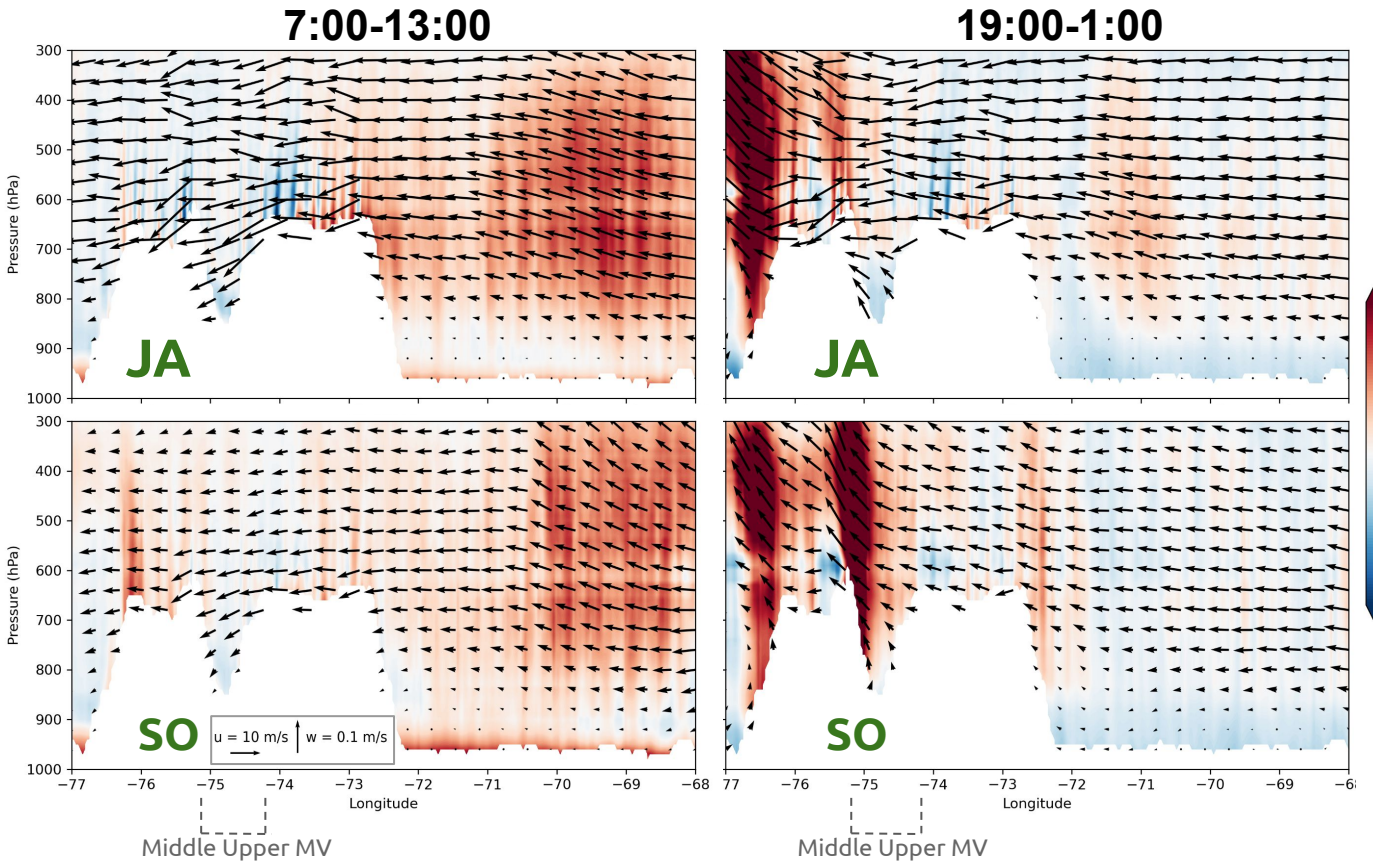
Diurnal Cycle of diabatic heating and circulation

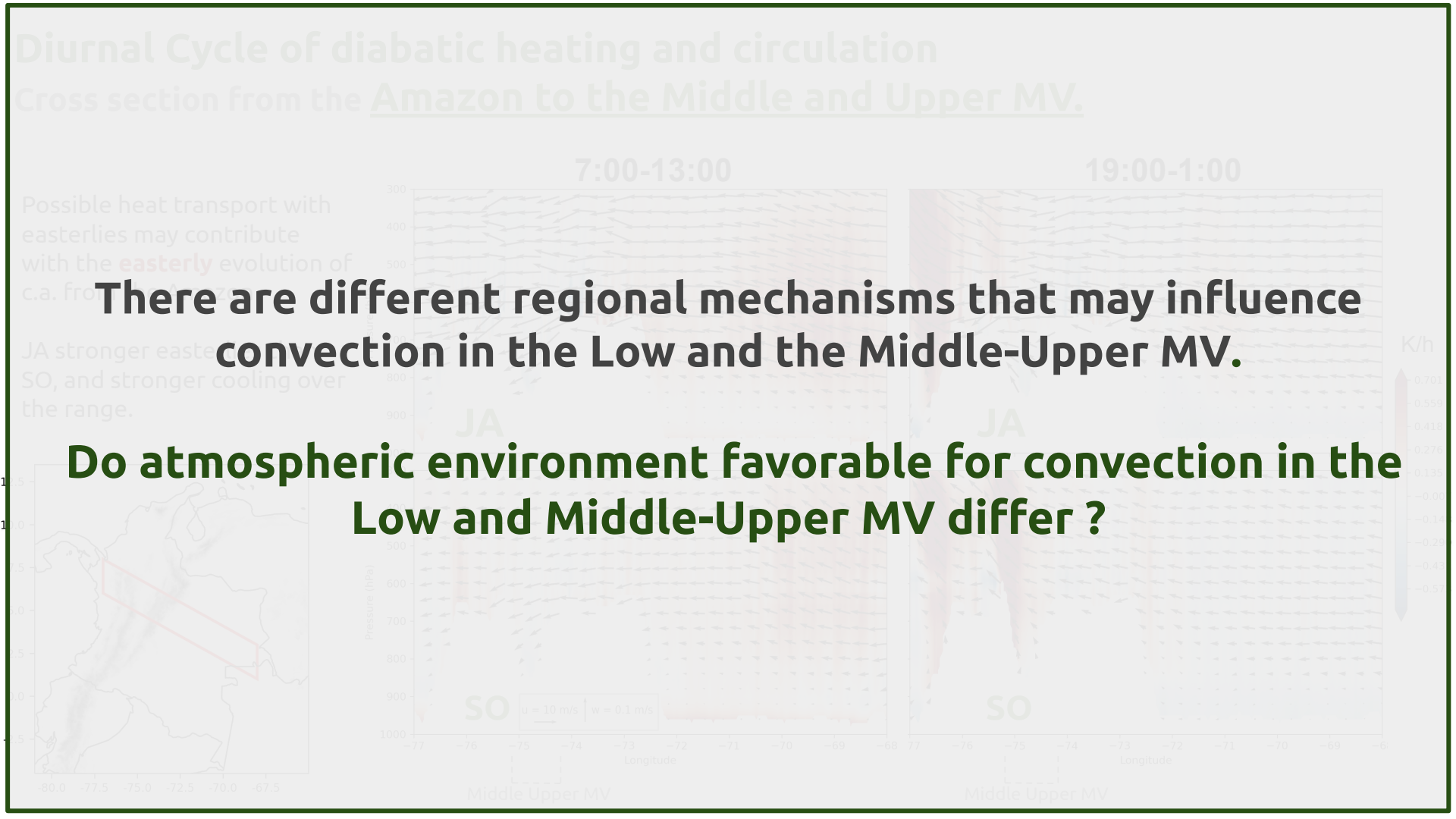
Cross section from the Amazon to the Middle and Upper MV.

Possible heat transport with easterlies may contribute with the **easterly** evolution of c.a. from the Amazon

JA stronger easterlies than SO, and stronger cooling over the range.

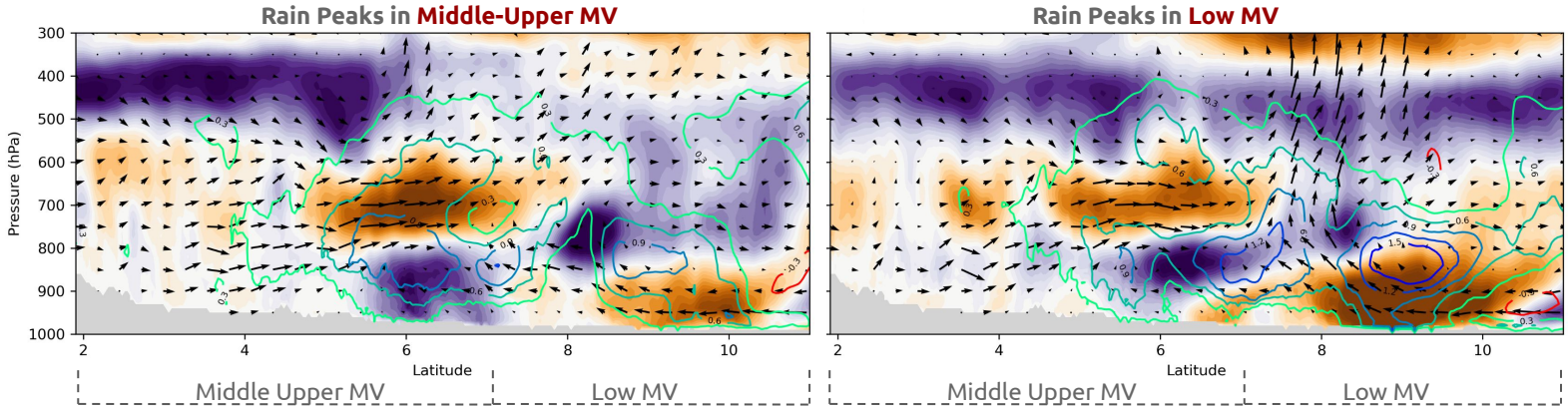


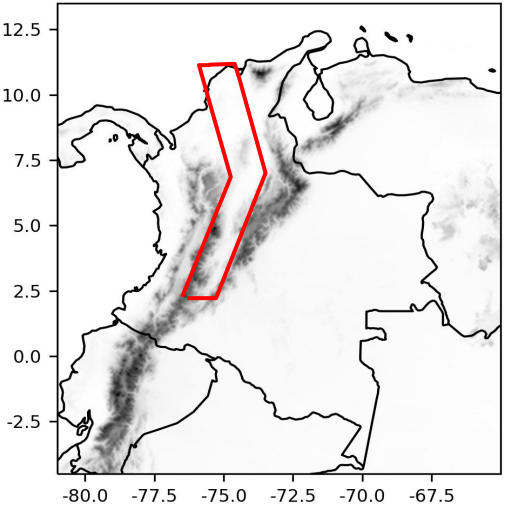



Diurnal Cycle of diabatic heating and circulation
Cross section from the Amazon to the Middle and Upper MV.
7:00-13:00
19:00-1:00
Possible heat transport with easterlies may contribute with the easterly evolution of c.a. fro
JA stronger easte
SO, and stronger cooling over the range.
There are different regional mechanisms that may influence convection in the Low and the Middle-Upper MV.
Do atmospheric environment favorable for convection in the Low and Middle-Upper MV differ ?
JA
SO
u = 10 m/s
w = 0.1 m/s
Pressure (hPa)
Longitude
Middle Upper MV
K/h

Atmospheric Environment Along MV in rain peaks. Comp. of *u* anomalies respect to the period average; of v,w, and mixing ratio anomalies.

JA





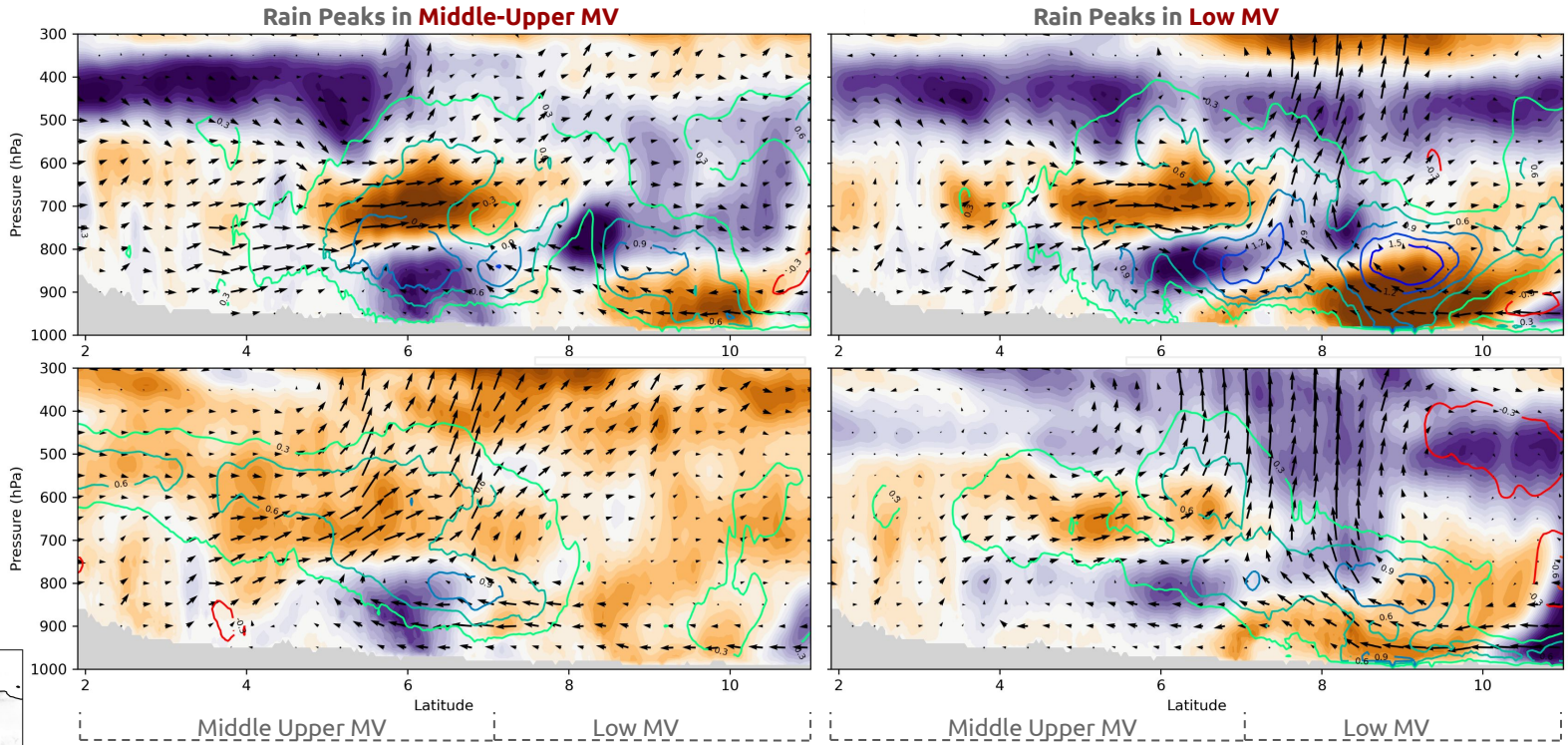
Similar atmospheric setups favorable for convection in both Low and Middle-Upper MV

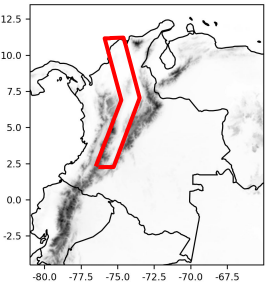
Enhanced easterlies above 600 hPa
Stronger low level westerly component in the north.

Atmospheric Environment Along MV in rain peaks. Comp. of *u* anomalies respect to the period average; of v,w, and mixing ratio anomalies.

JA

SO





In **SO**, contrasting atmospheric setup for convection in Low and Middle-Upper MV (Unlike **JA**!)

e.g. For Middle-Upper MV, **weaker easterlies** above 700hPa. In Low MV, **enhanced easterlies**

Final remark

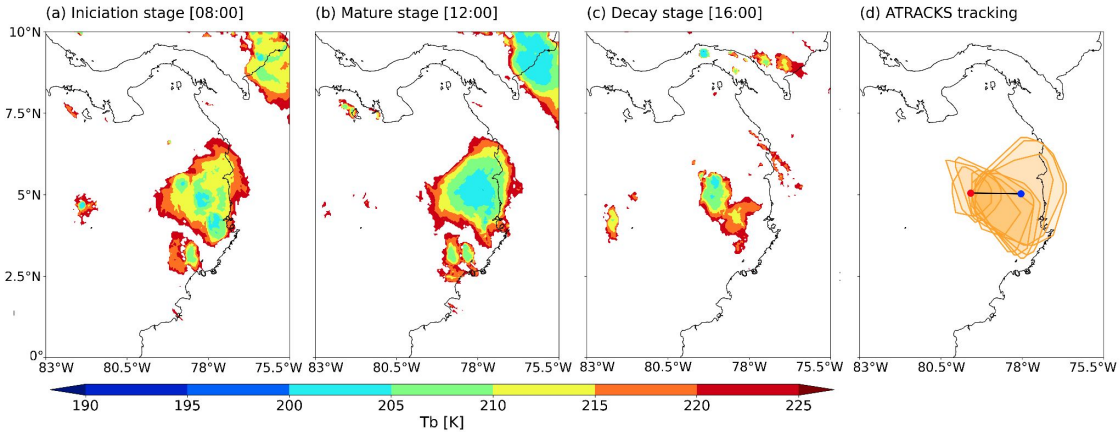
WRF CP simulations suggest that there are possible regional-scale mechanisms that relate the convective activity in the MV and adjacent convection-hotspots. Main candidate mechanisms are easterly mid-level heat transport from Amazon and eastern Colombia, and Caribbean onshore flow that interacts with the valley complex orography. However, conjunction with dynamics along valley have to be considered, as processes related to convection differ in the portions of the MV.

A final ad

-For more about convection in northwestern South America with WRF CPM, please visit poster **P.2.3 Hernández et al.** *Mechanisms behind the occurrence of convective systems in Northwestern South America: results from a cloud-resolving simulation abstract.*

-**Algorithm for Tracking Convective Systems (ATRACKCS)**

https://github.com/alramirezca/ATRACKCS/



Thanks!

Questions?

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Acknowledgments: This research was funded by the Colombian Ministry of Science, Technology and Innovation (MINCIENCIAS) through the project : "*Implementación de un sistema de investigación y pronóstico meteorológico de corto plazo con el modelo WRF, para apoyo a sistemas de comando y control de la Fuerza Aérea Colombiana*" (code 1115-852-70955) with funds from "*Patrimonio Autónomo Fondo Nacional de Financiamiento para la Ciencia, la Tecnología y la Innovación, Fondo Francisco José de Caldas*"

Thunderstorm in *La Mojana*, Low Magdalena valley.
Credit: @El Carromato: medium.com/@elcarromato

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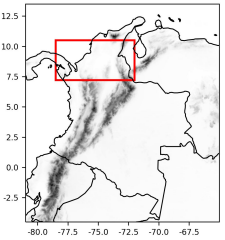
- Gómez Ríos, S. (2019). *Orographic control over convection in an Inter-Andean Valley in Northern South America.* Universidad Nacional de Colombia.
- Robledo V., Rendon, A., Henao, Juan J., Hernandez, K.S., Gomez, S., Ramirez-Cardona, A. and Mejia, John F. (2022) Climatological characteristics and large scale environments of deep convection in northwestern South America. *In prep.*

Additional Slides

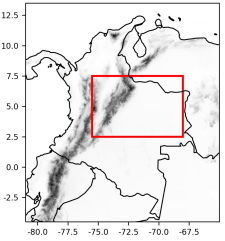
For specific questions

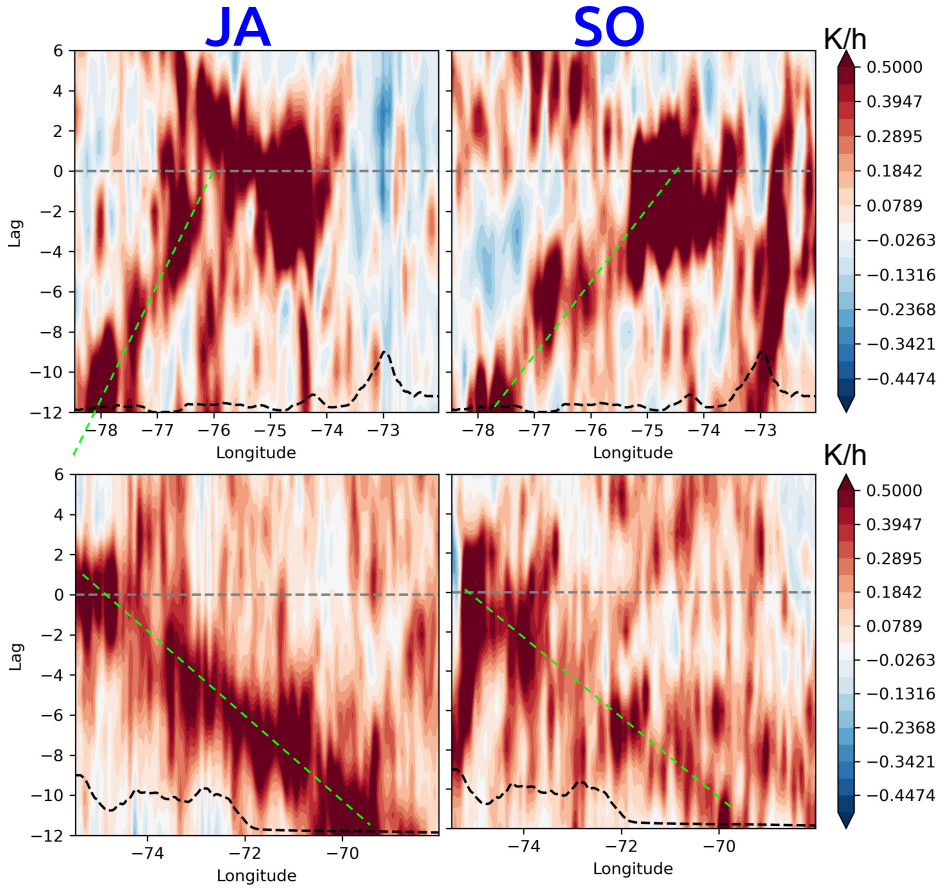
Composites of Average Mid-level diabatic heating around rain peaks

NORTH

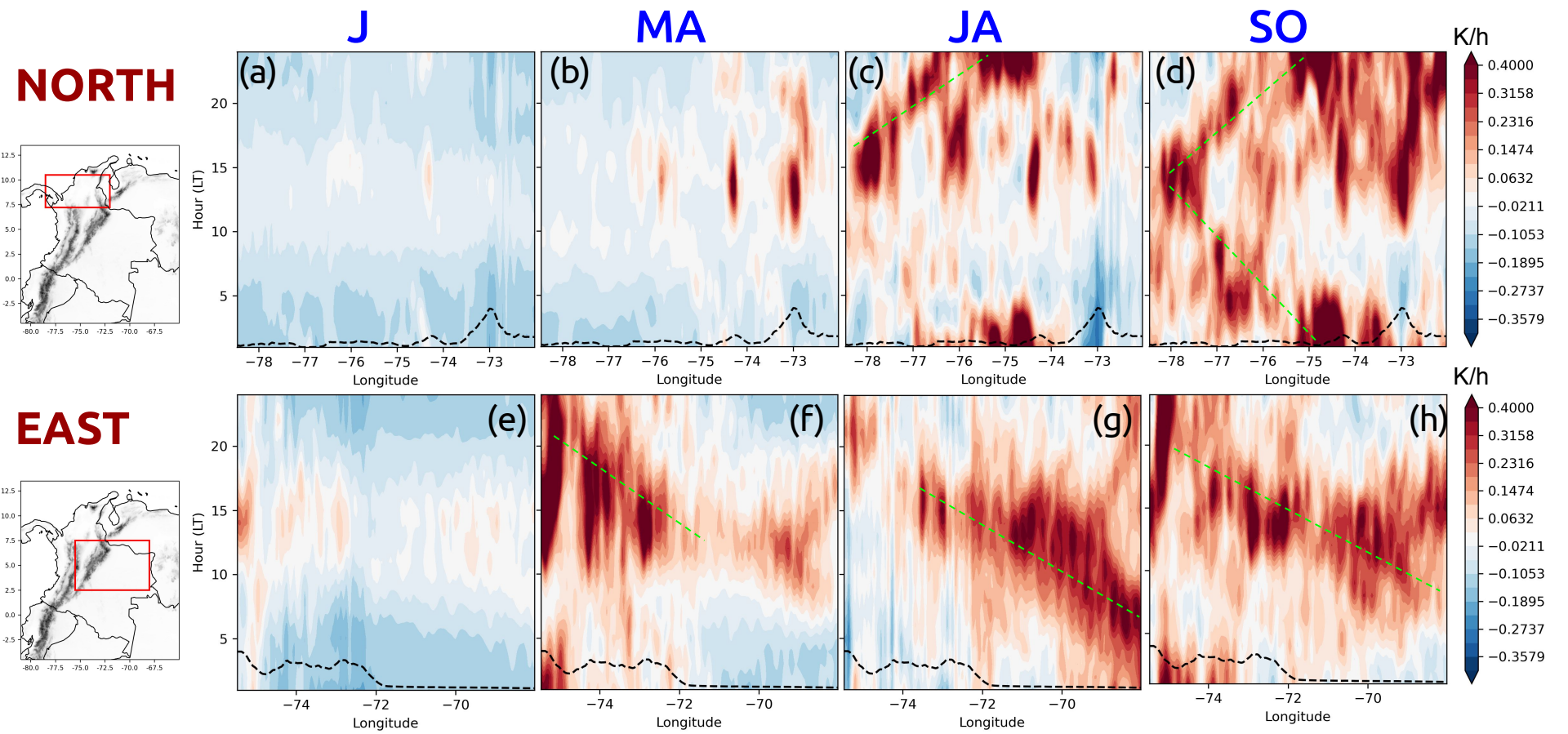


EAST

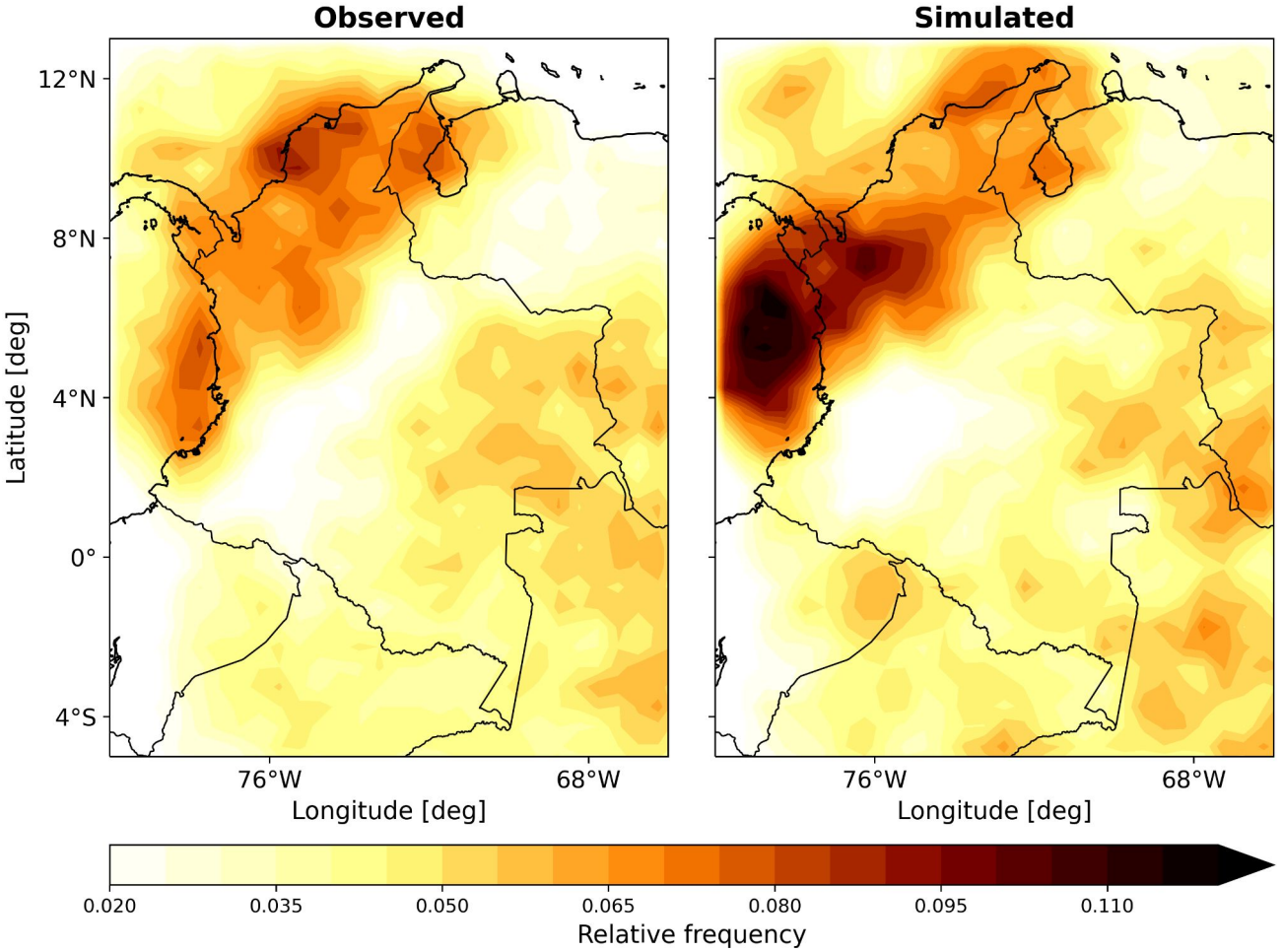




Diurnal Cycle of Average 700-450 hPa diabatic heating

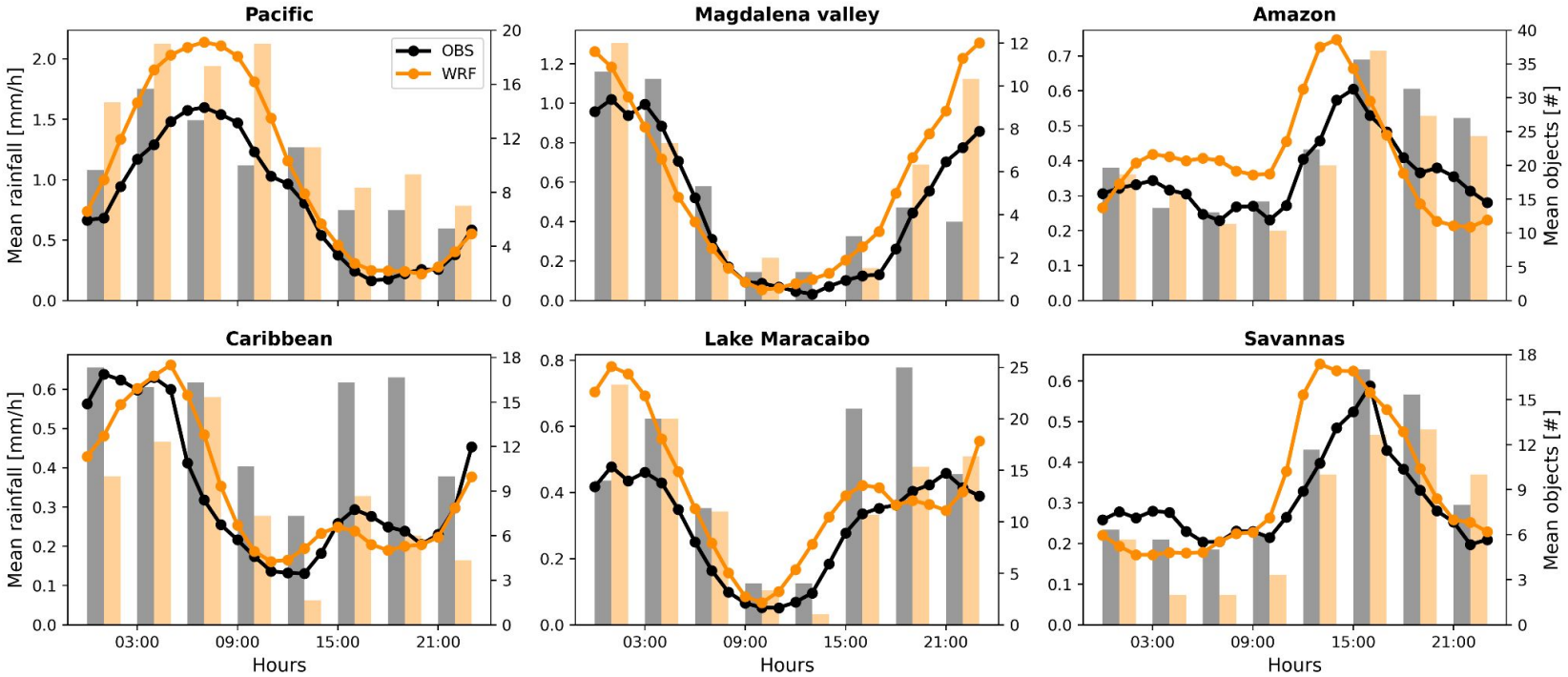


Observed and simulated frequency of tracks of convective systems



Hernández et al, 2022

Observed and simulated number and main rainfall of convective systems



Hernández et al, 2022