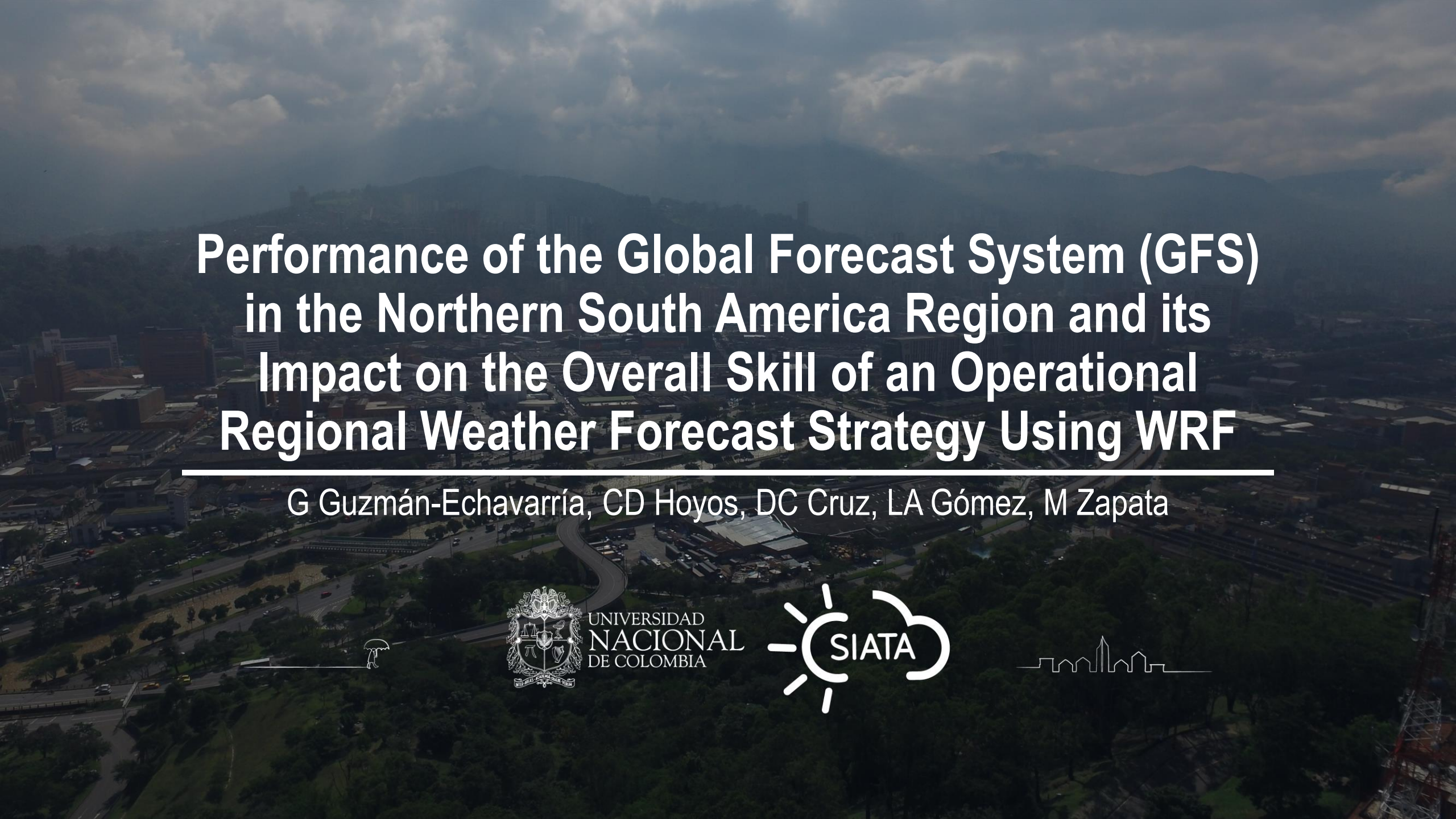
Performance of the Global Forecast System (GFS) in the Northern South America Region and its Impact on the Overall Skill of an Operational Regional Weather Forecast Strategy Using WRF

G Guzmán-Echavarría, CD Hoyos, DC Cruz, LA Gómez, M Zapata



Quality of a weather forecast from limited area models depends on:

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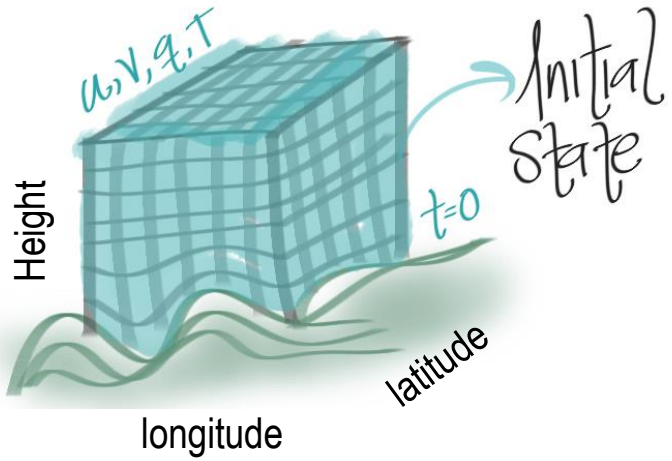
Initial conditions (IC)



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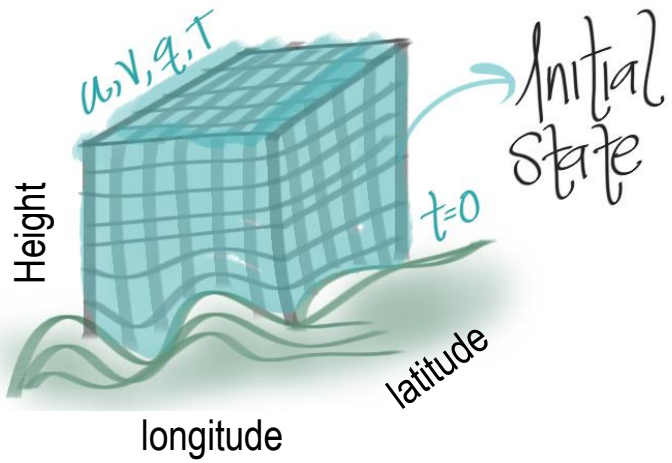

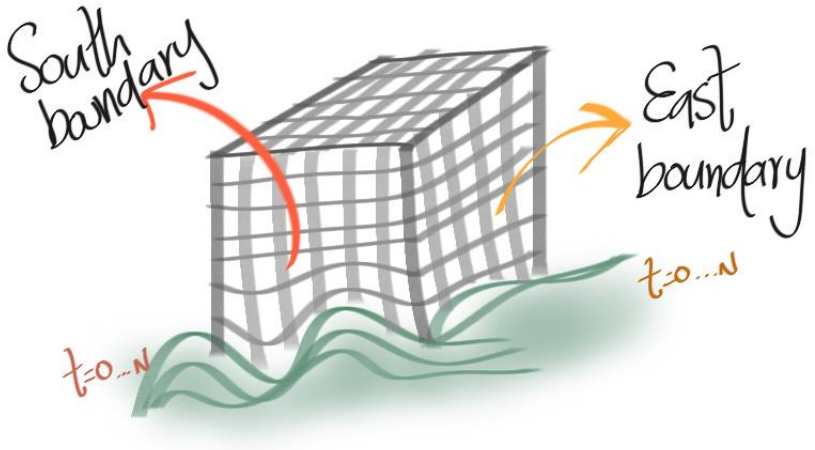

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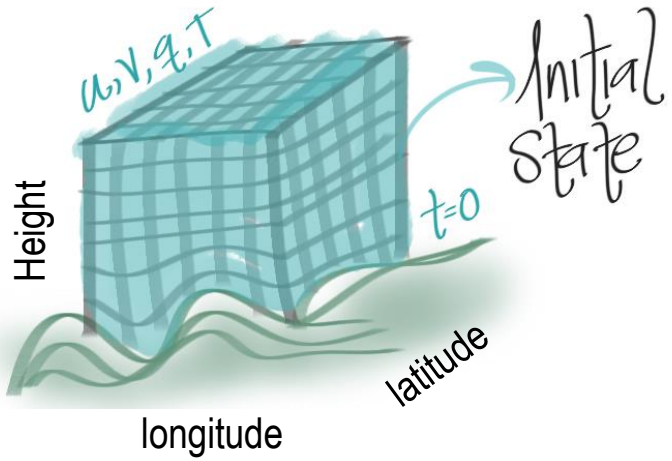

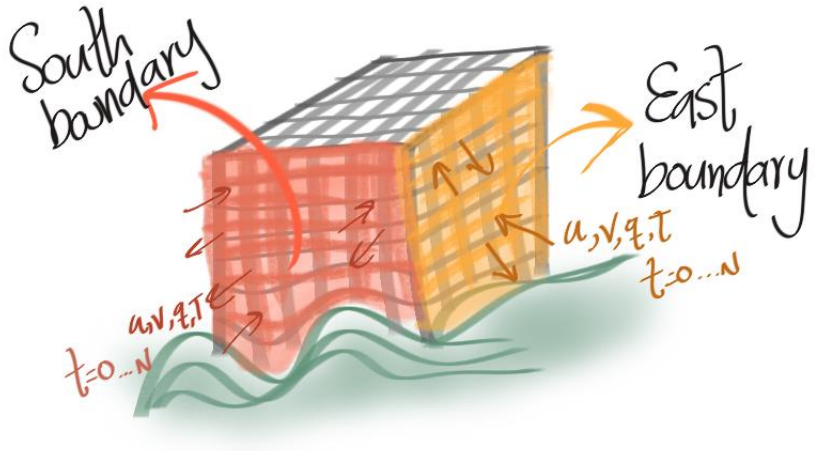

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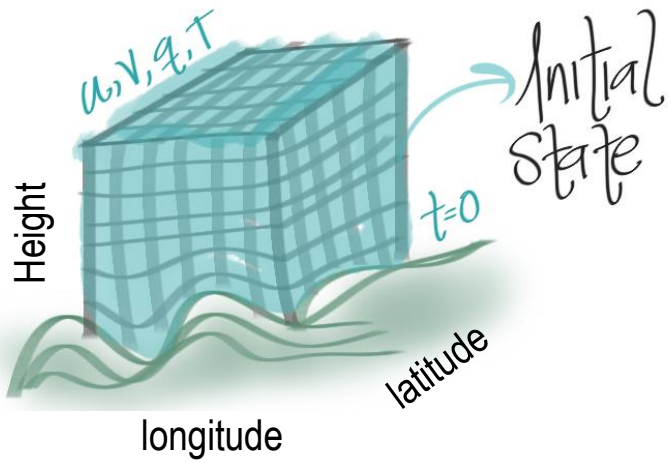
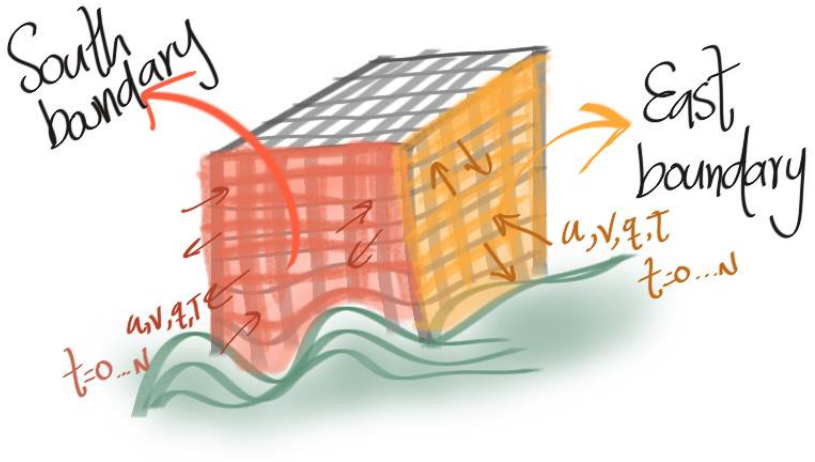
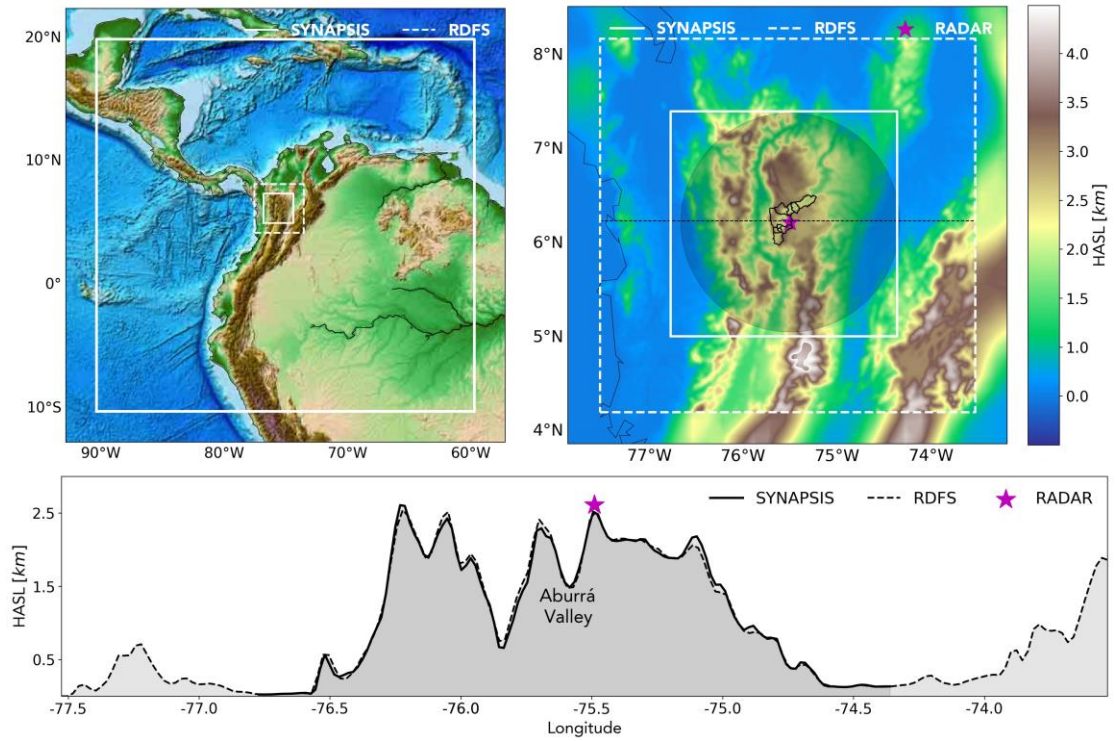




In forecast verification literature there are fewer studies that analyze the **impact of boundary conditions** in the skill of local weather forecast.

SIATA - Early Warning System of Medellín and Aburrá Valley (Colombia) Operational Weather Forecast Scheme:

2 operational strategies using WRF model, to produce skillful forecast of rainfall to risk management applications.



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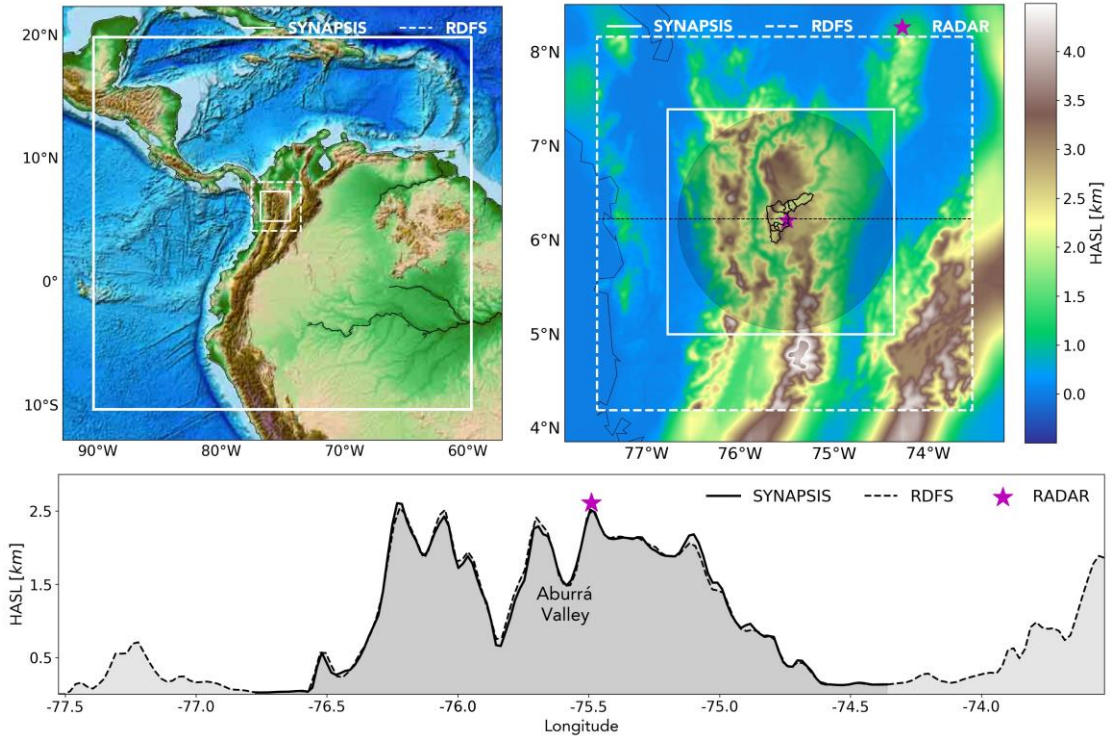
SYNAPSIS:

Medium-range forecast

Forecast lead time:	120 hours, 3 runs per day
Domain:	Triple nested domain
Microphysics scheme:	Lin (PAR02), Eta Ferrier (PAR05), Thompson (PAR08) Schemes.



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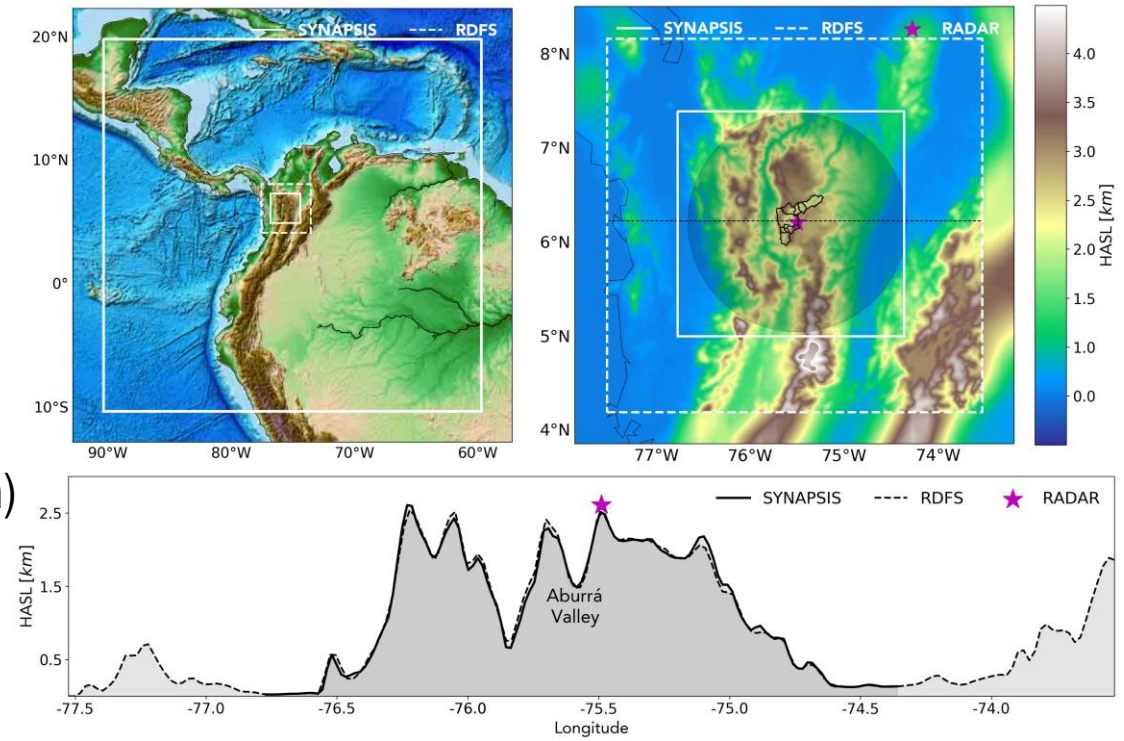
	SYNAPSIS:	RDFS:
	Medium-range forecast	**Short-range forecast**
Forecast lead time:	120 hours, 3 runs per day	30 hours , 2 runs (1run with C-band radar data assimilation)
Domain:	Triple nested domain	Doble nested domain
Microphysics scheme:	Lin (PAR02), Eta Ferrier (PAR05), Thompson (PAR08) Schemes.	Thompson Scheme



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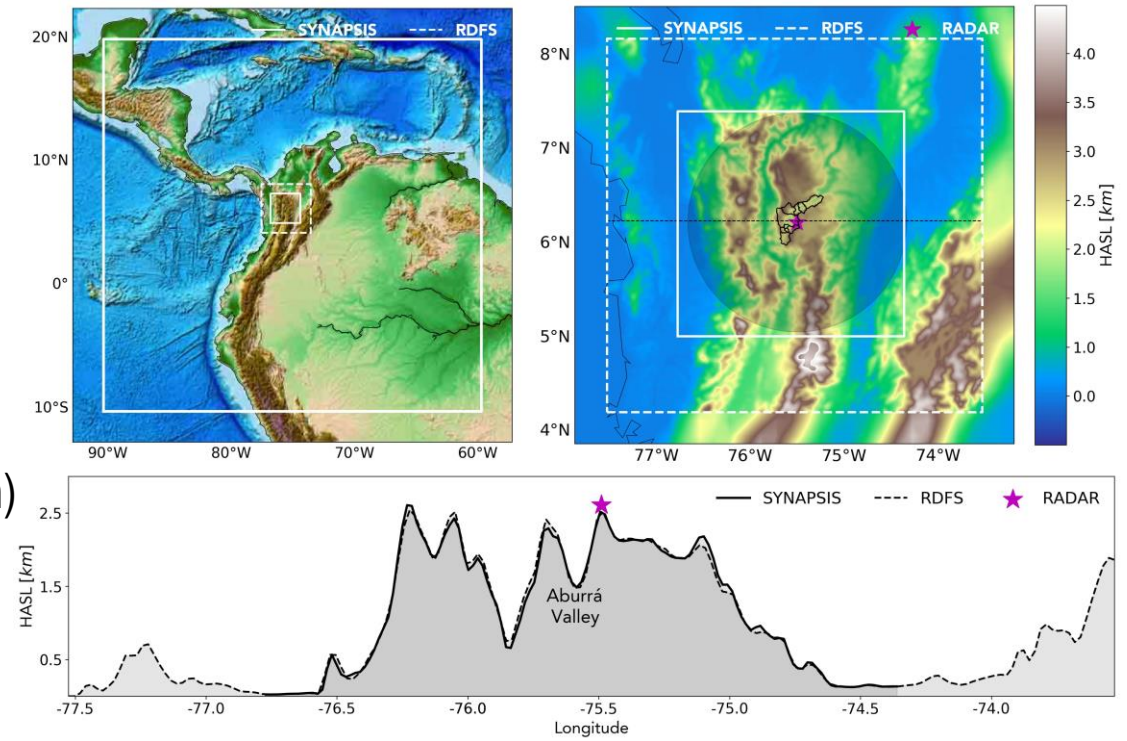
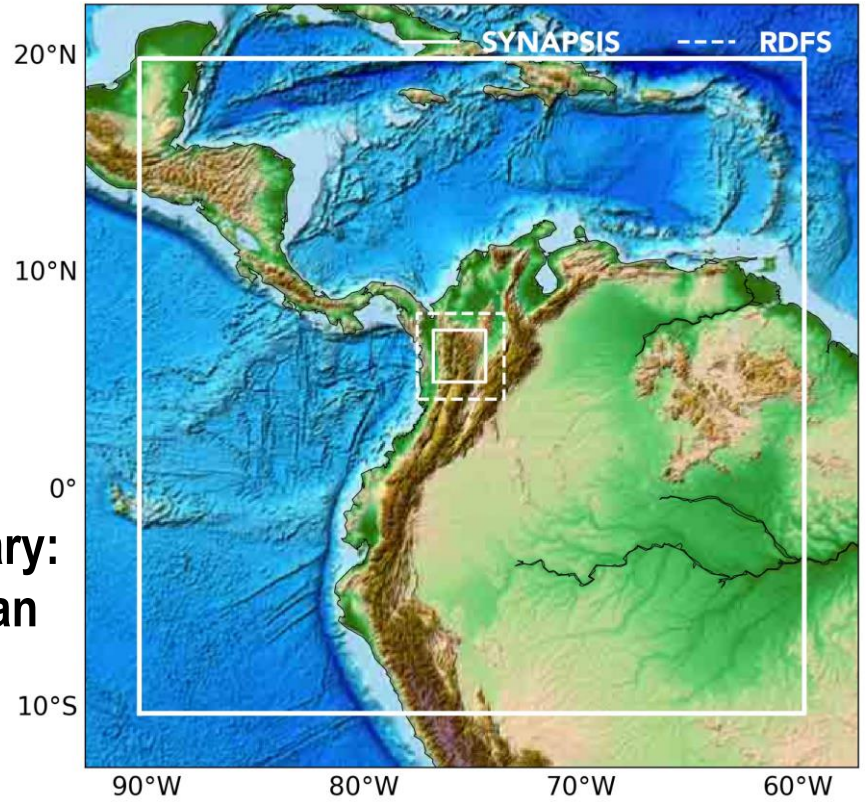


In both 3 Hourly 0.5° resolution NCEP 12 UTC GFS forecast data are used as initial and boundary condition

Outer domain: weather and climatic relevant features

North Boundary: Caribbean sea



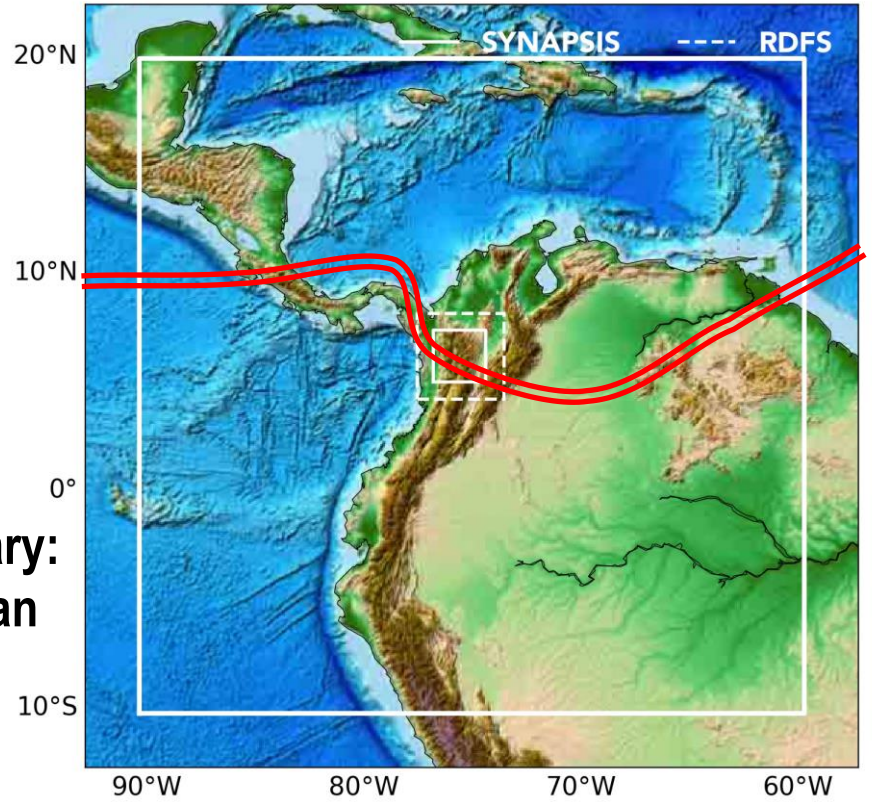
West boundary: Pacific Ocean

East Boundary: Amazonas, Caribbean sea

South boundary: Pacific Ocean, Andes and Amazonas

Outer domain: weather and climatic relevant features

North Boundary: Caribbean sea



ITCZ displacement

East Boundary: Amazonas, Caribbean sea

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Outer domain: weather and climatic relevant features

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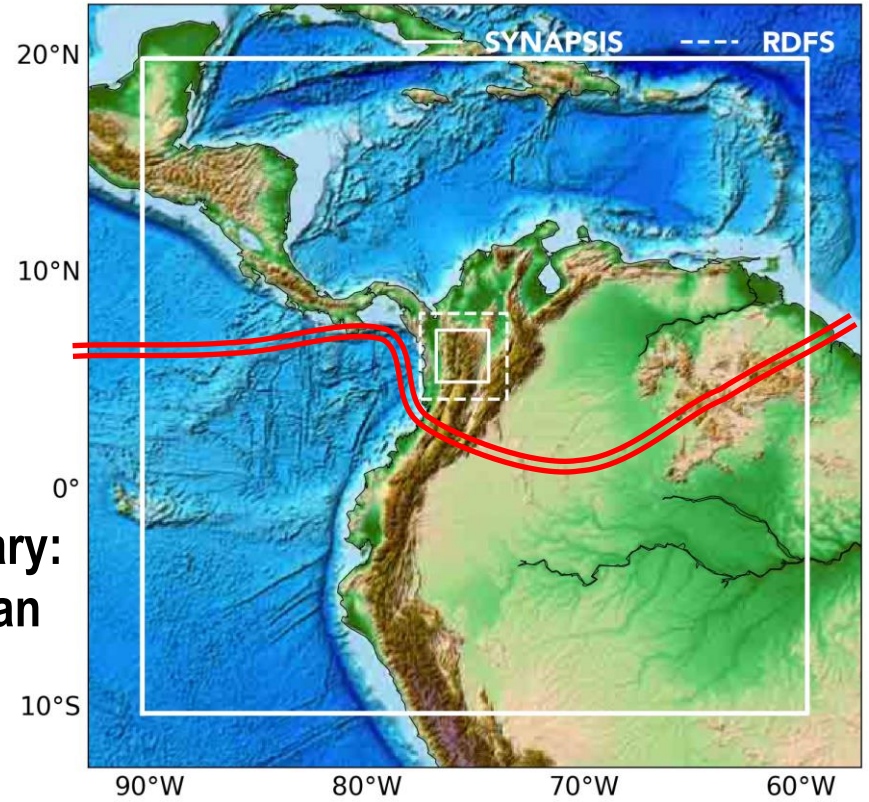

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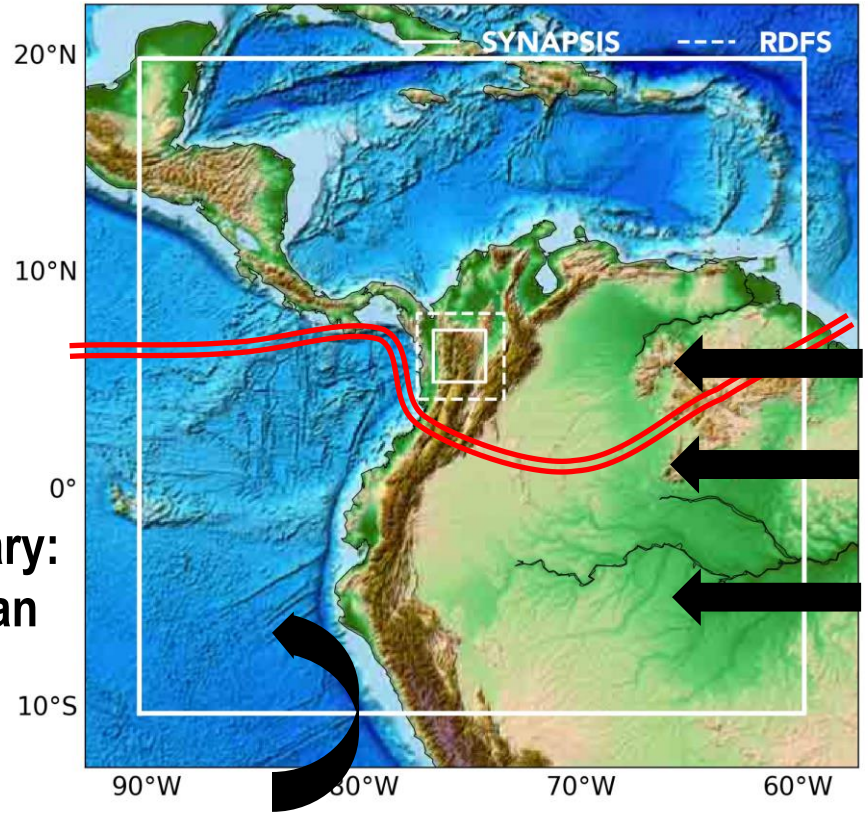

East Boundary: Amazonas, Caribbean sea

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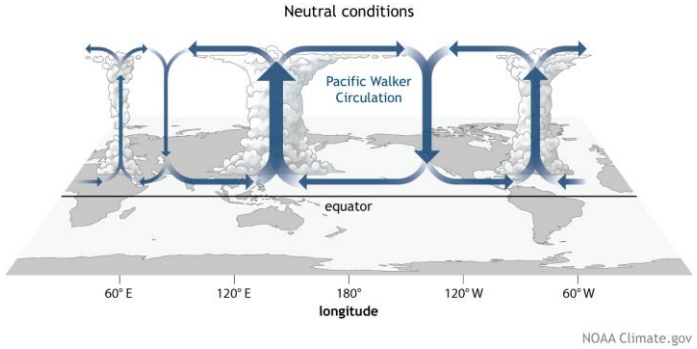
Trade winds moisture transport from Amazonas, Andes and Pacific Ocean

Outer domain: weather and climatic relevant features

Walker circulation



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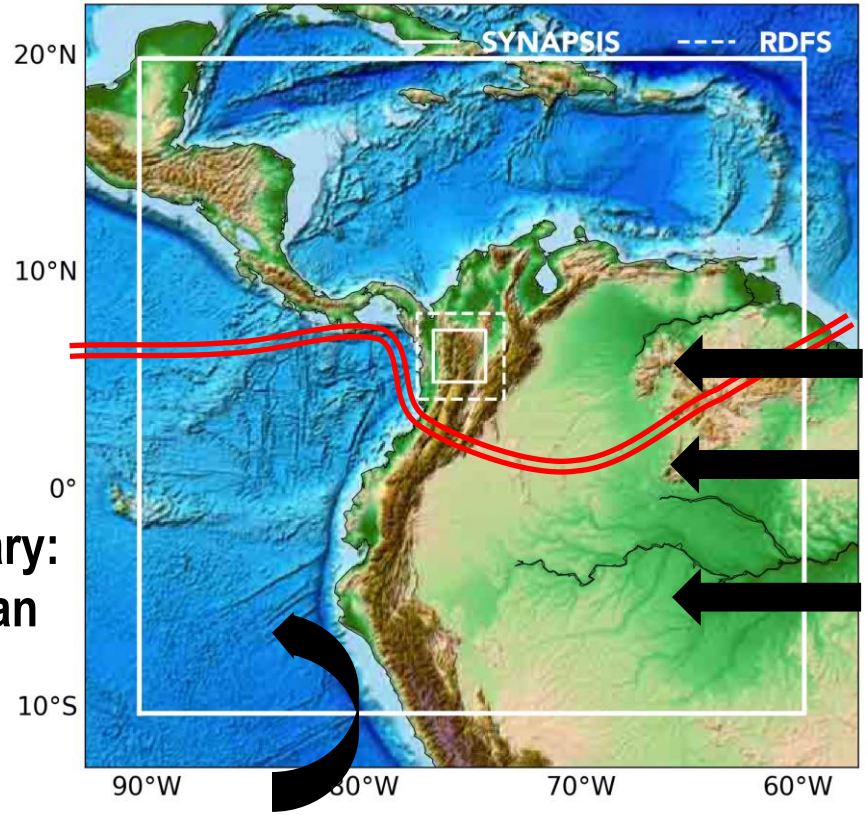

East Boundary: Amazonas, Caribbean sea

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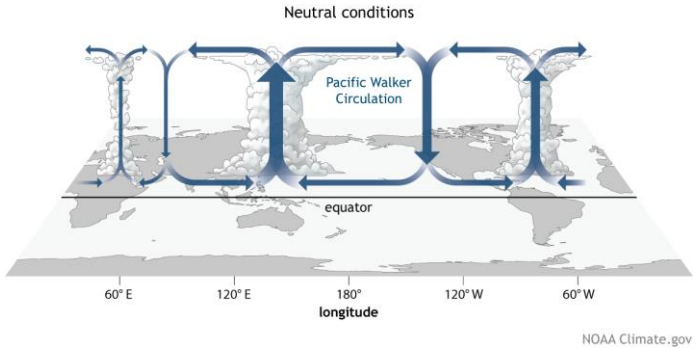
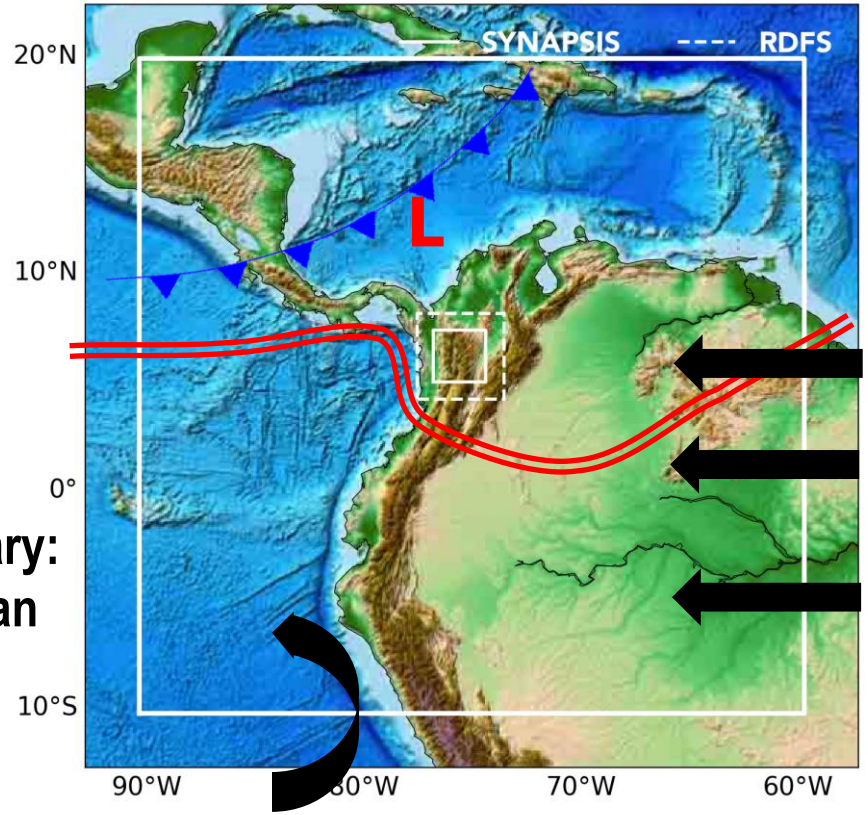
South boundary: Pacific Ocean, Andes and Amazonas

Outer domain: weather and climatic relevant features

Cold fronts that moves from North America



North Boundary: Caribbean sea



East Boundary: Amazonas, Caribbean sea

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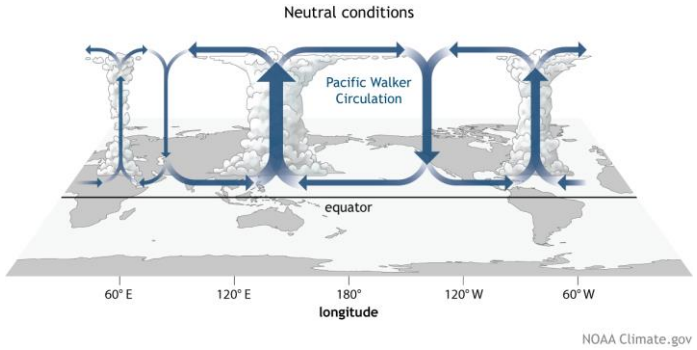
Outer domain: weather and climatic relevant features



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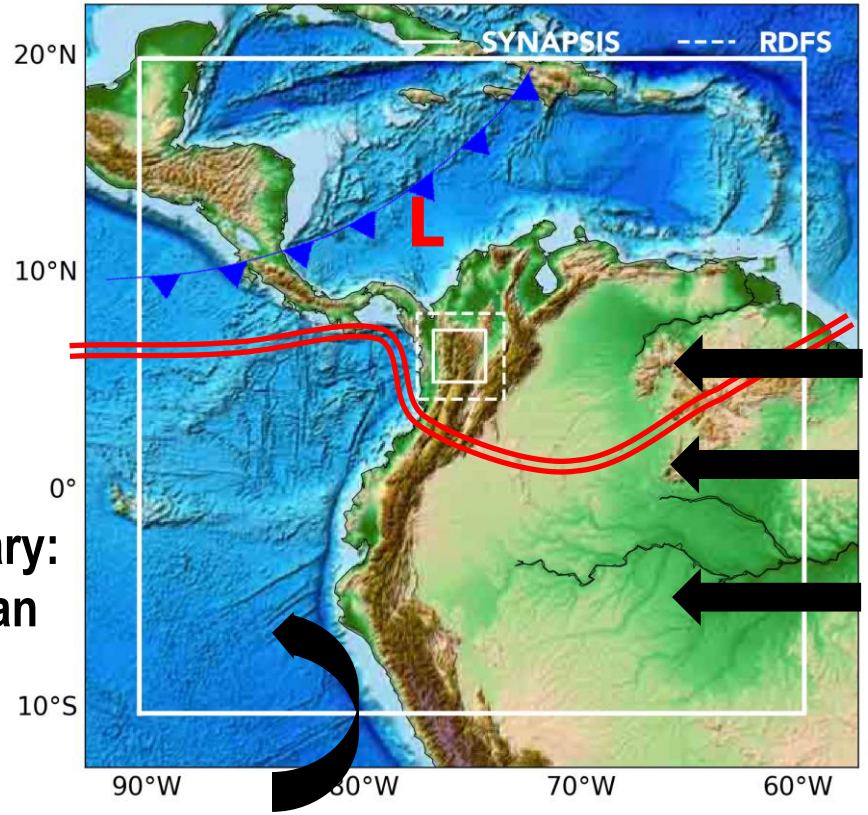

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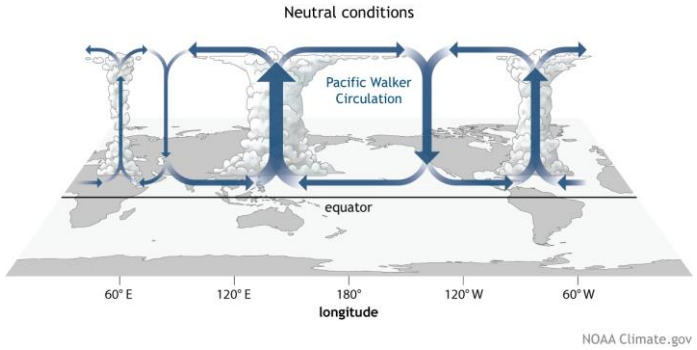

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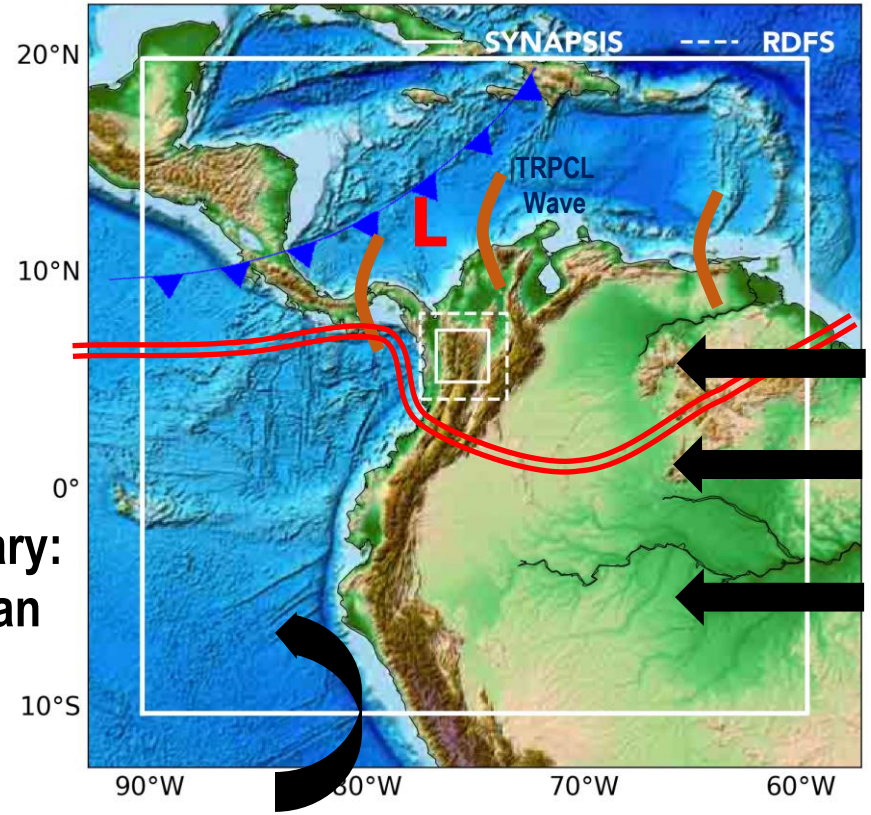
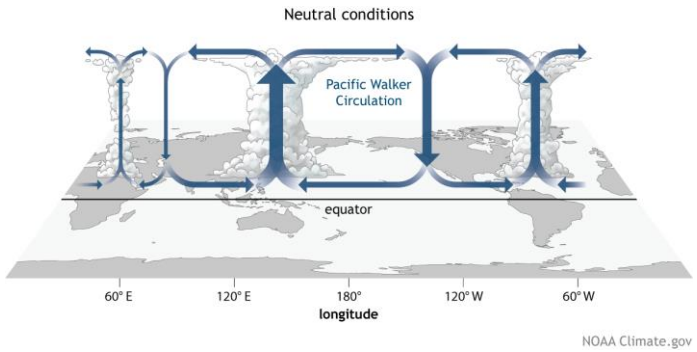


Tropical Waves

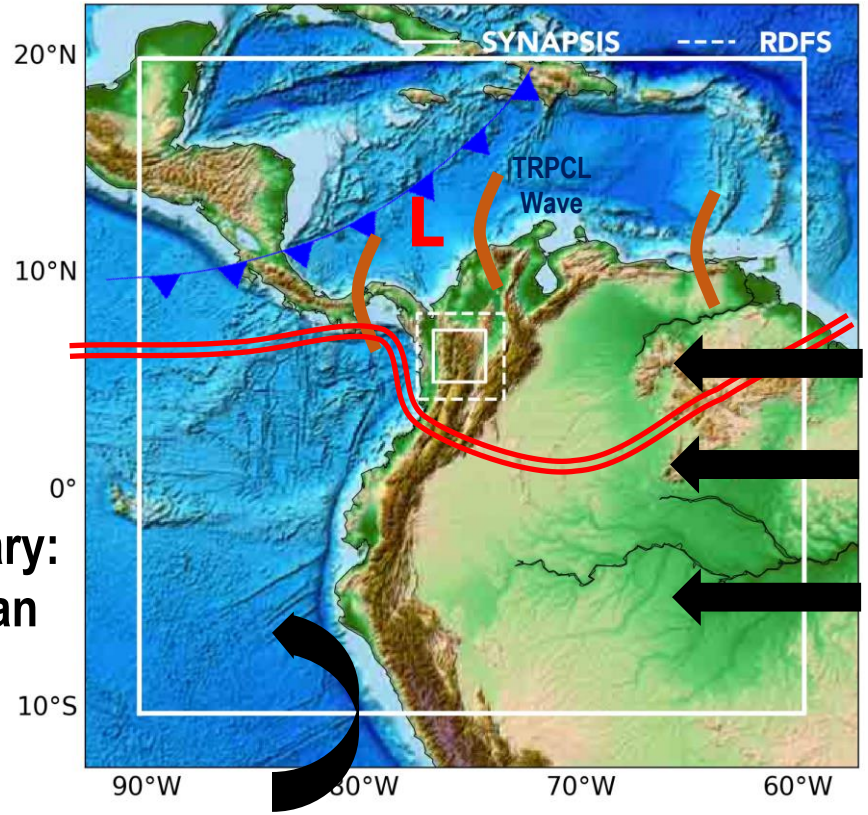
East Boundary: Amazonas, Caribbean sea

South boundary: Pacific Ocean, Andes and Amazonas

Outer domain: weather and climatic relevant features



North Boundary: Caribbean sea



East Boundary: Amazonas, Caribbean sea

West boundary: Pacific Ocean

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To make **skillful local weather forecasts** GFS must capture most of all these phenomena

Aim of this research:

Asses how much the performance of the SIATA forecast relies in the accuracy of the GFS data.

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Evaluation of GFS as boundary data in WRF
Benchmark data: QPE from C-band radar data (Sepulveda, 2015)

3. Conditional skill of WRF application per run regarding GFS errors.

Skill WRF forecast (t) = WRF model skill (t, skill GFS forecast (t))

Methodology

Errors pixel per pixel: from 2015-2019 GFS and FNL data.

Result: Maps of Root Mean Square Error (RMSE) and BIAS per boundary.

Variables: Temperature, Specific humidity, zonal and meridional winds

1. Spatial Skill of GFS forecast at the boundaries

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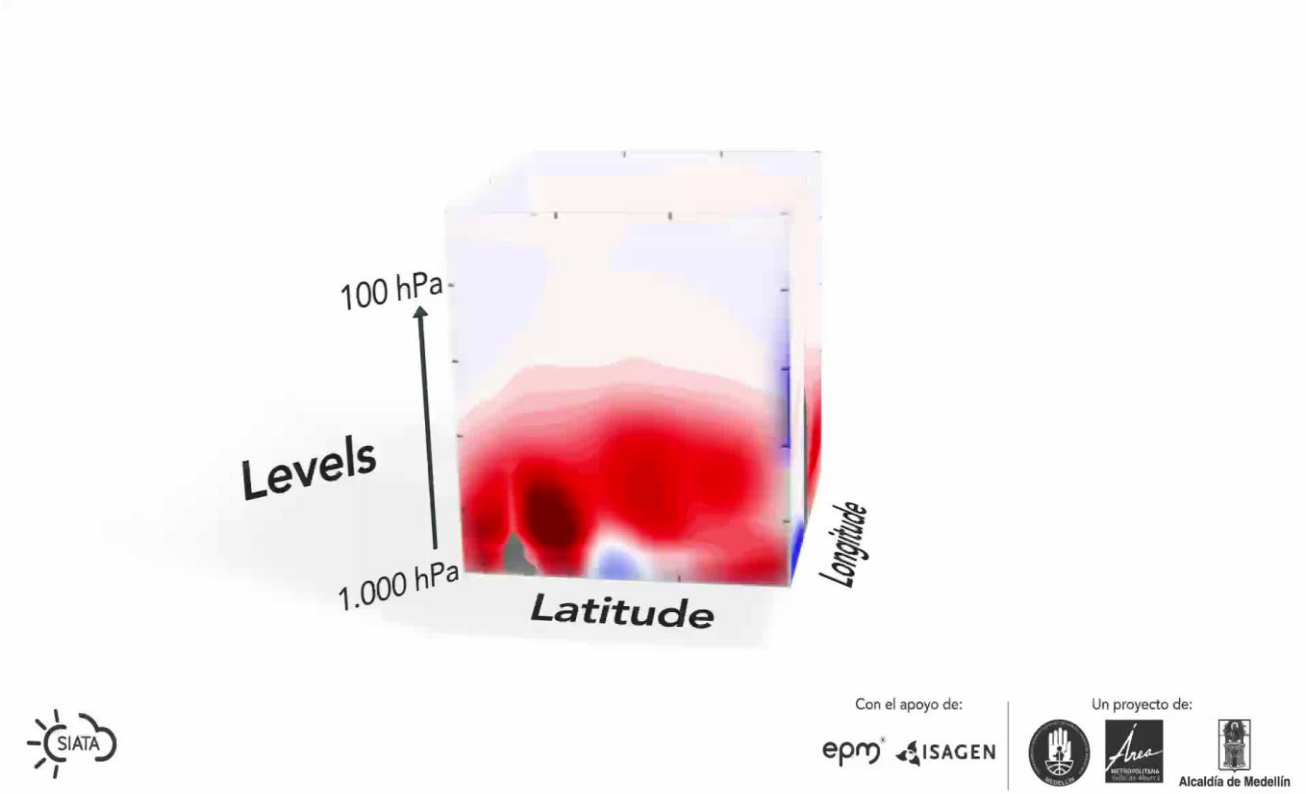

Con el apoyo de:
Un proyecto de:
Alcaldía de Medellín

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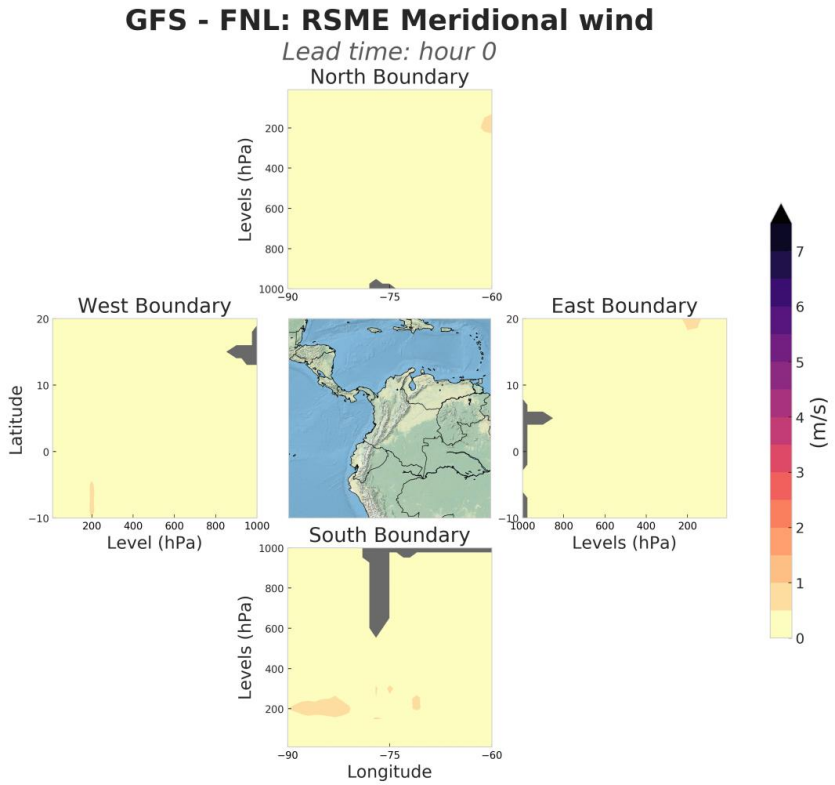
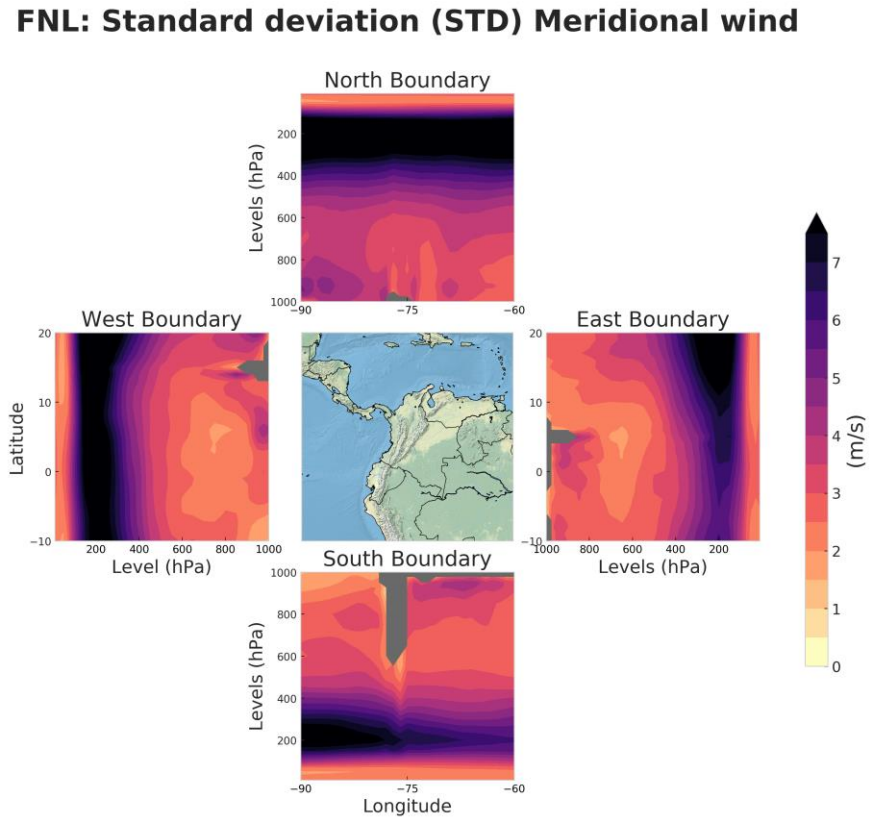
1. Spatial Skill of GFS forecast at the boundaries

Spatial skill of GFS at the boundaries

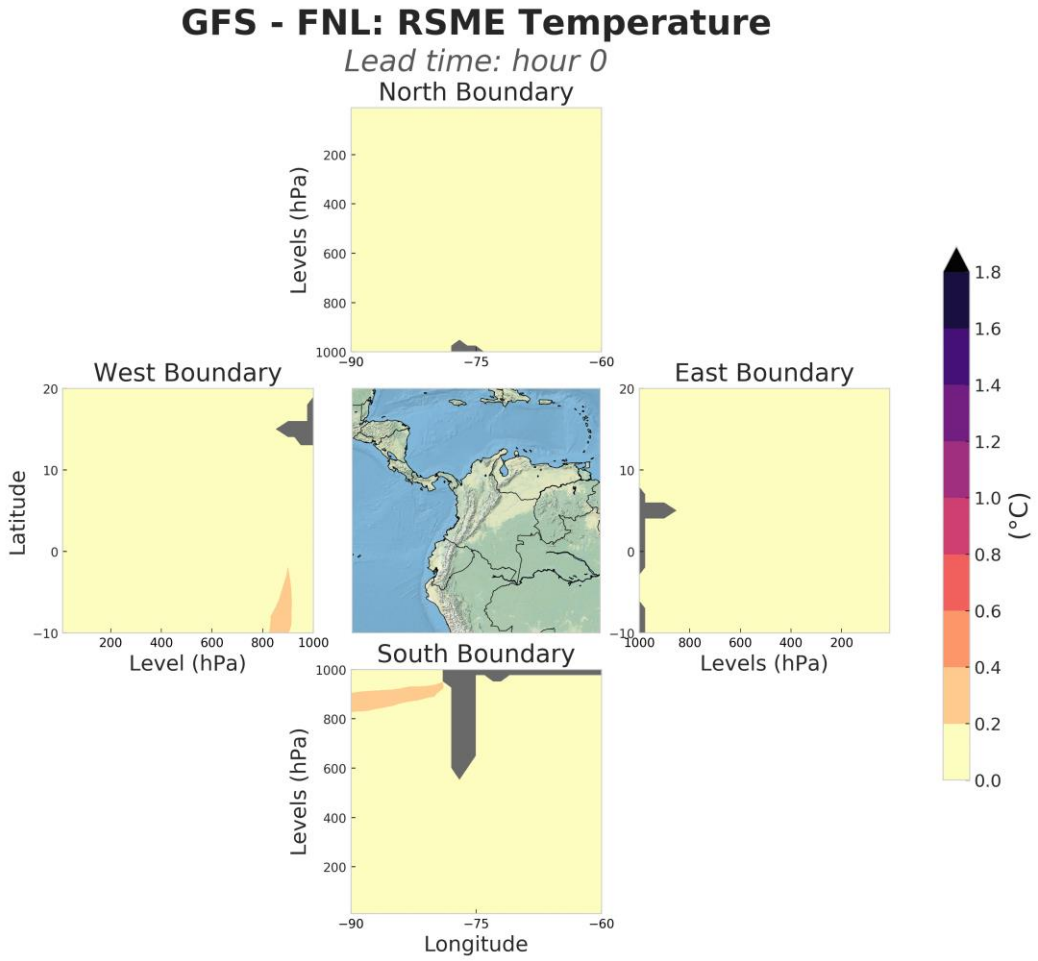




Errors in all variables increase sharply with the forecast lead time, but only the RMSE in **meridional winds** reach to exceed the standard deviation of FNL data

Spatial skill of GFS at the boundaries

Temperature



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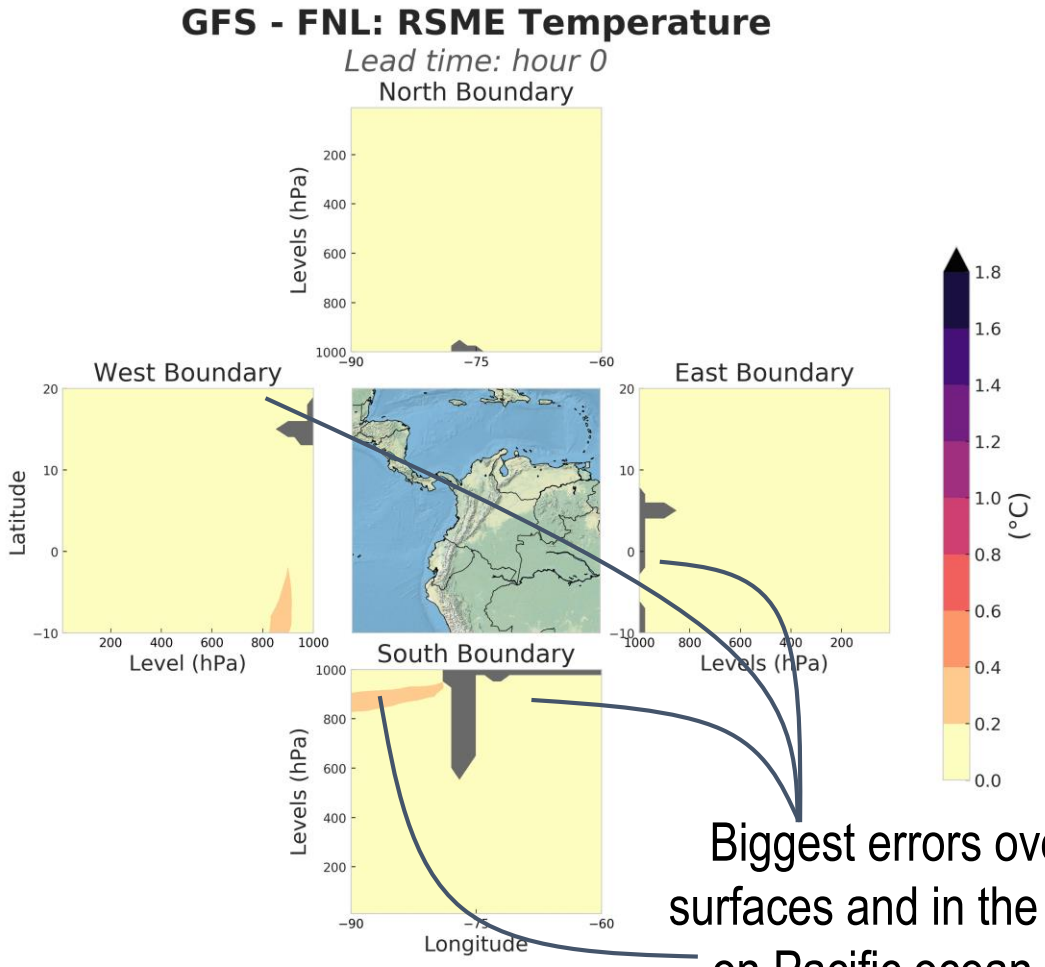
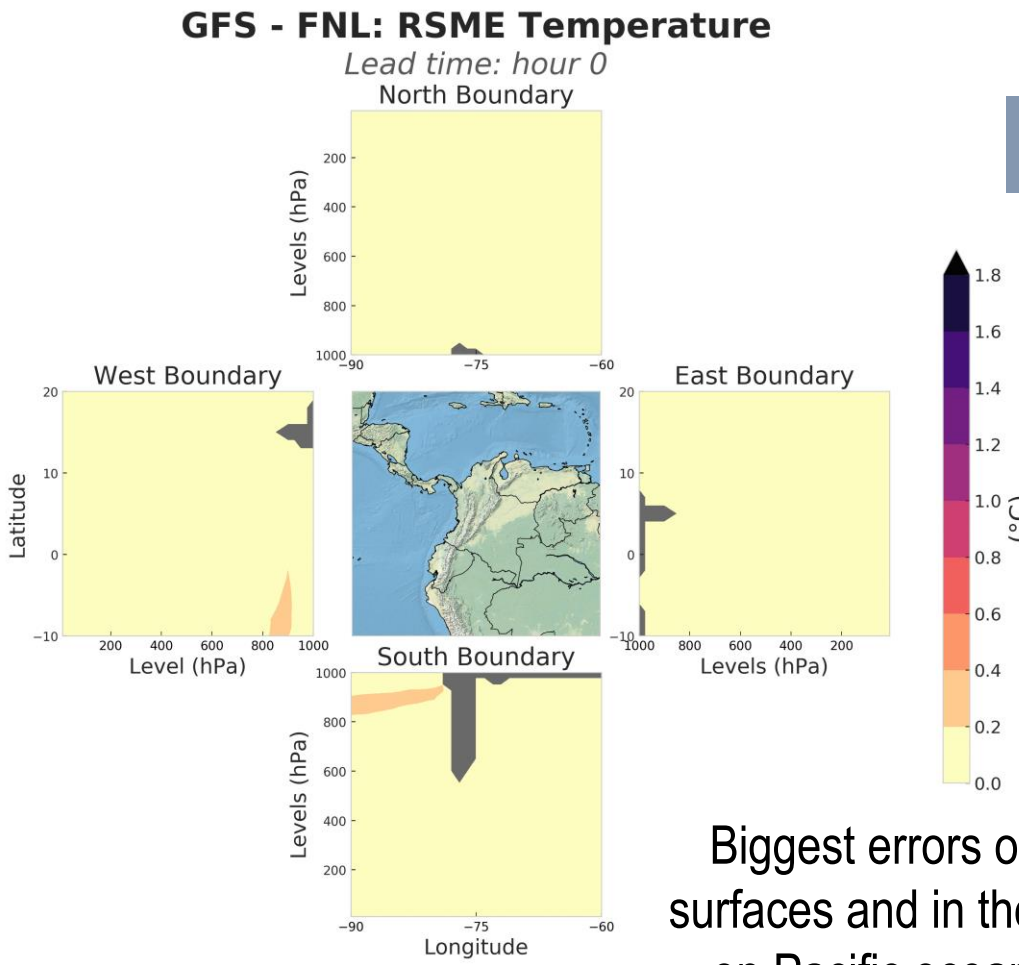


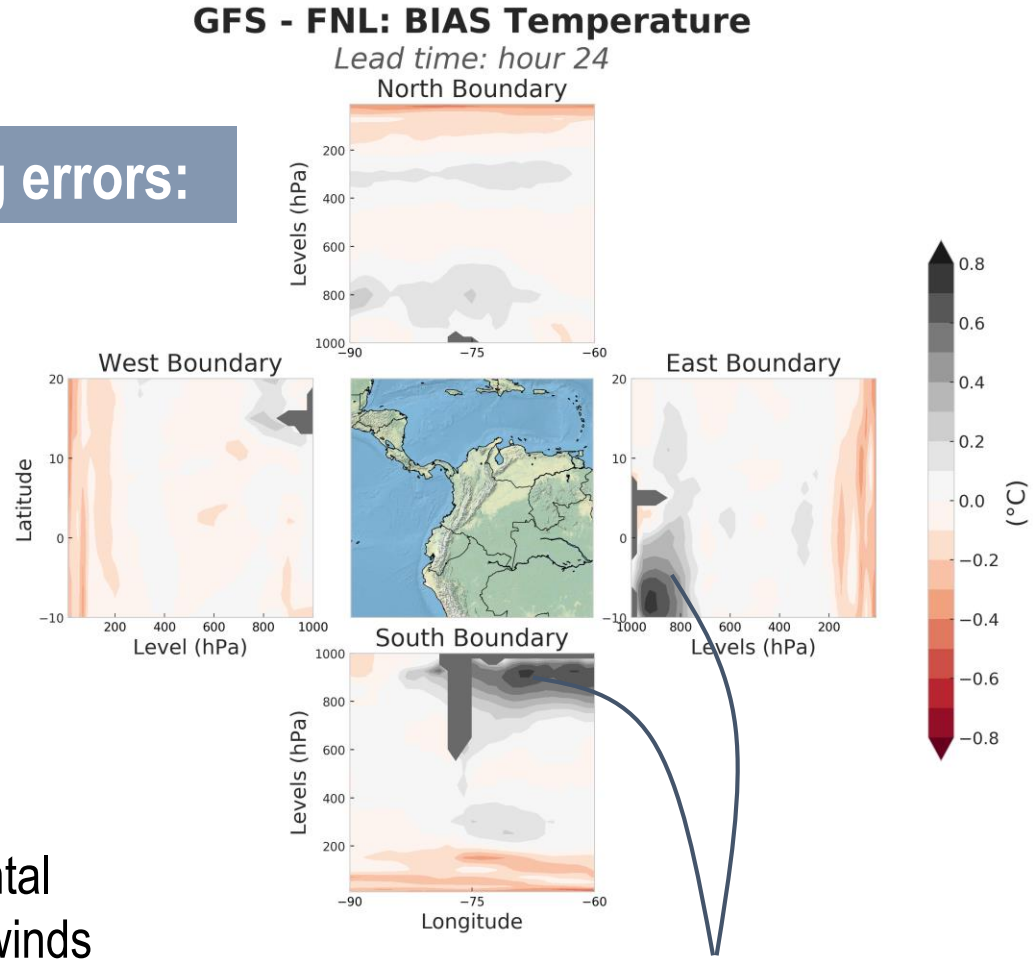
Biggest errors over continental surfaces and in the low-level winds on Pacific ocean close to Perú

Spatial skill of GFS at the boundaries

Temperature



Morning errors:

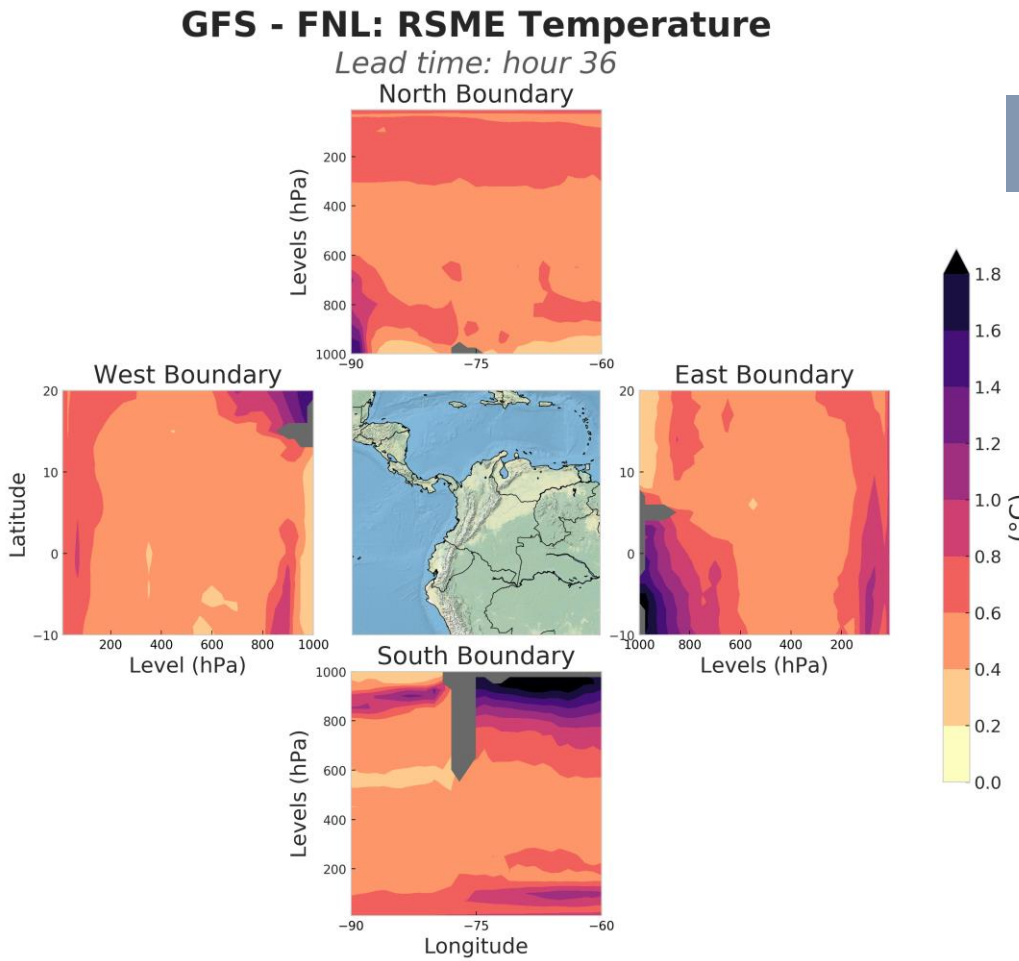


Biggest errors over continental surfaces and in the low-level winds on Pacific ocean close to Perú

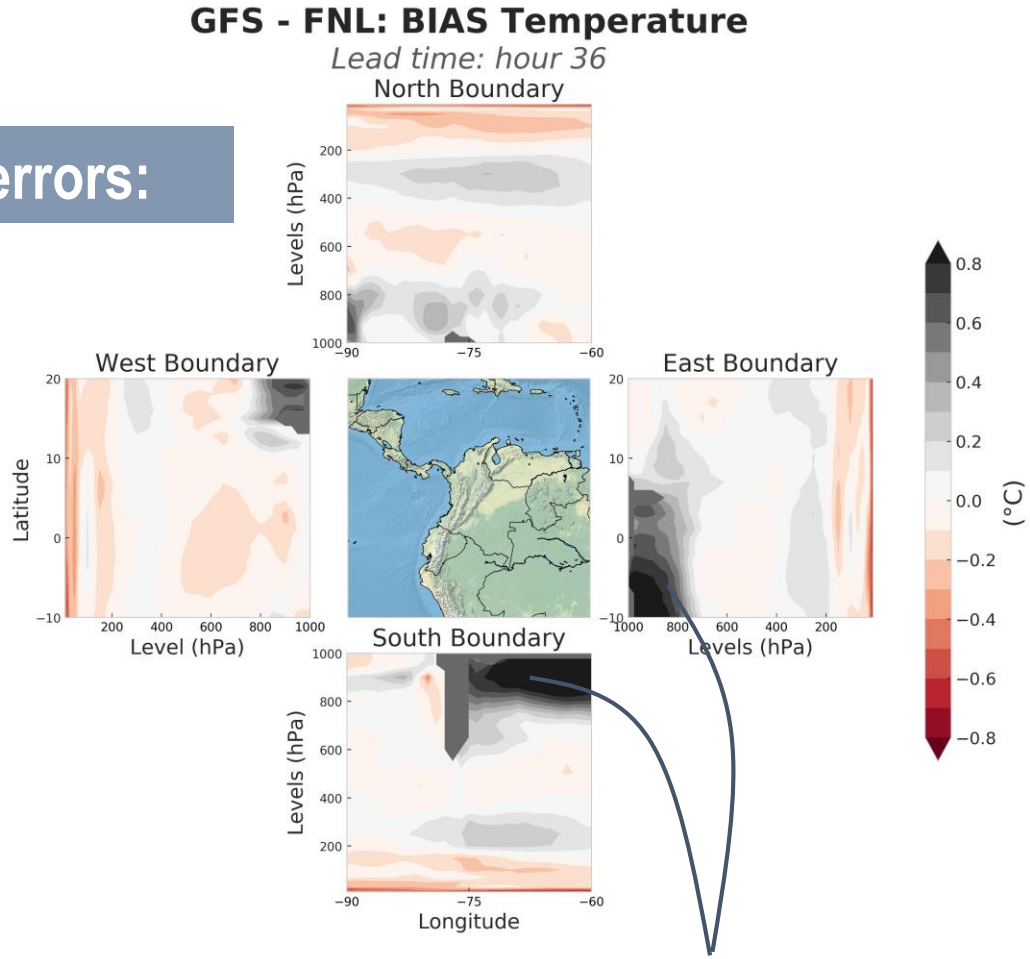
Lower troposphere **warm bias** over continental land

Spatial skill of GFS at the boundaries

Temperature

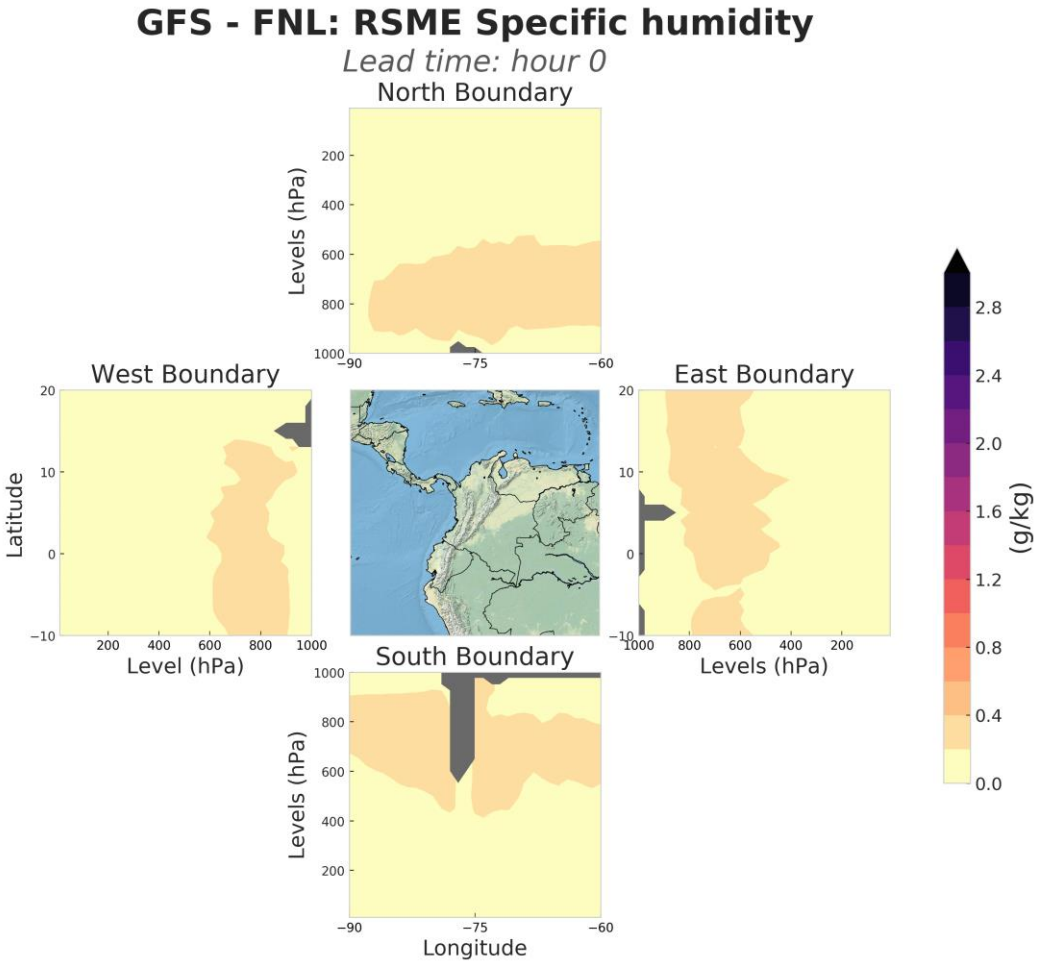


Night errors:



Lower troposphere **warm bias** over continental land

Specific Humidity



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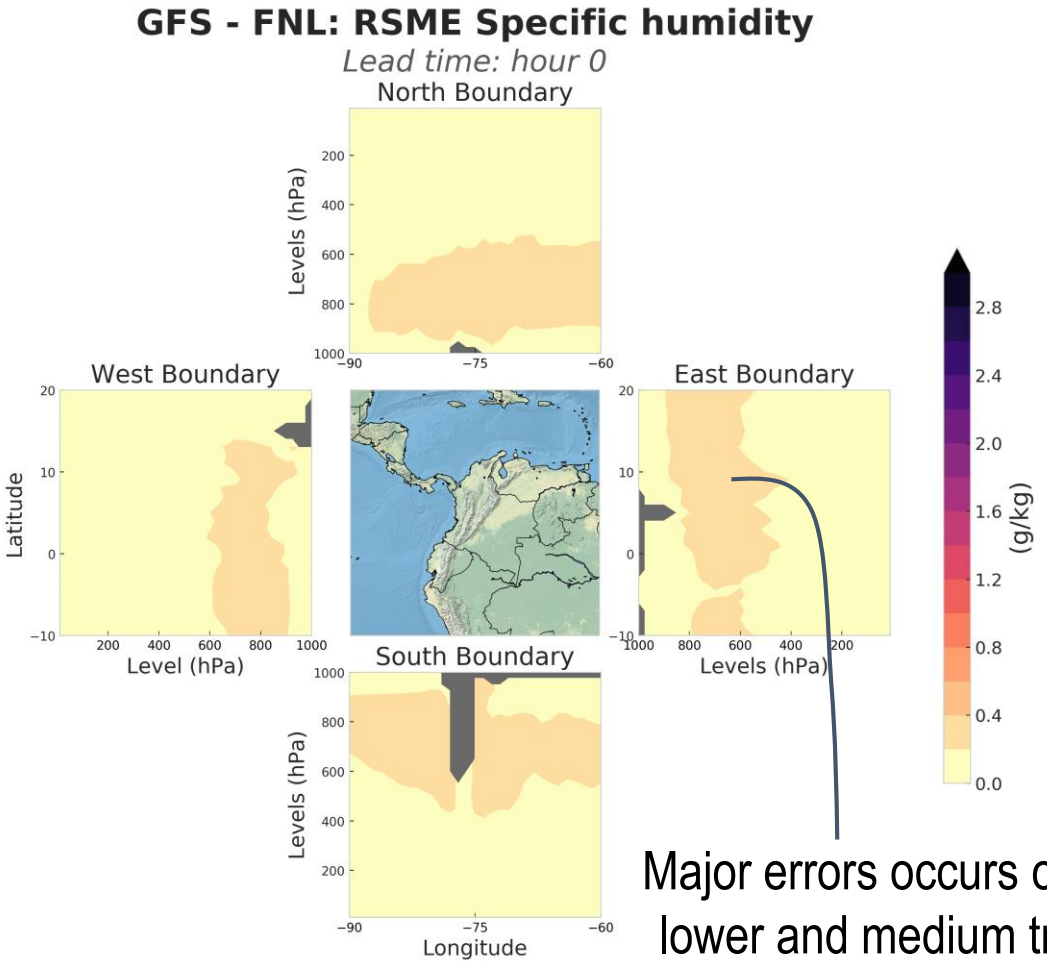
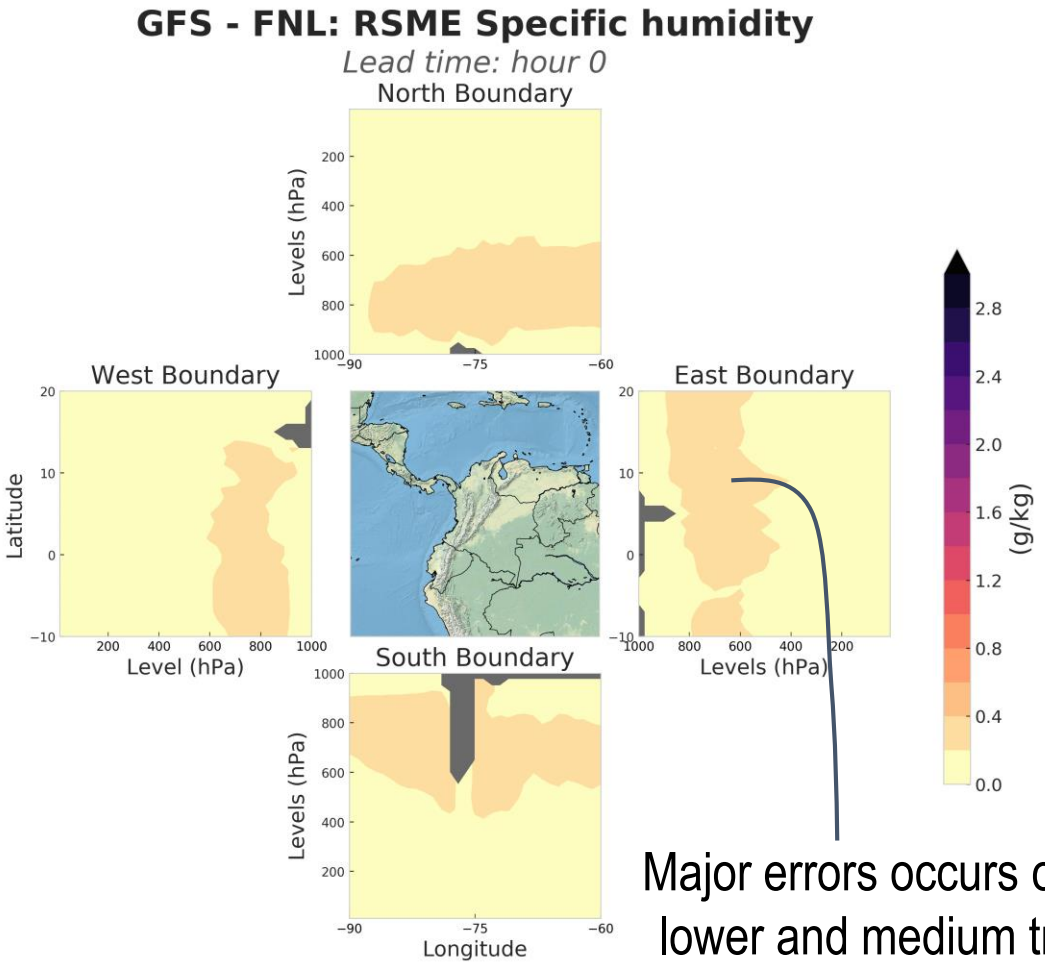
Specific Humidity



Major errors occurs over oceanic lower and medium troposphere

Spatial skill of GFS at the boundaries

Specific Humidity



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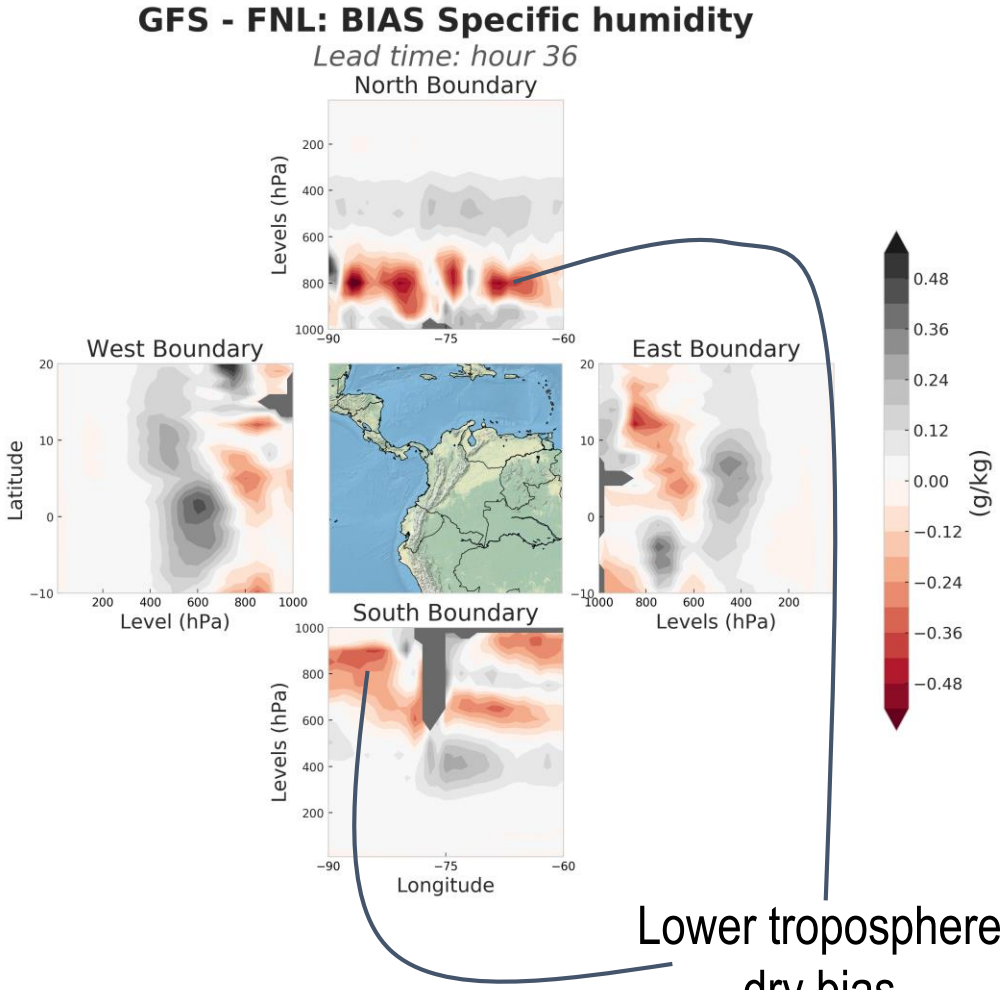
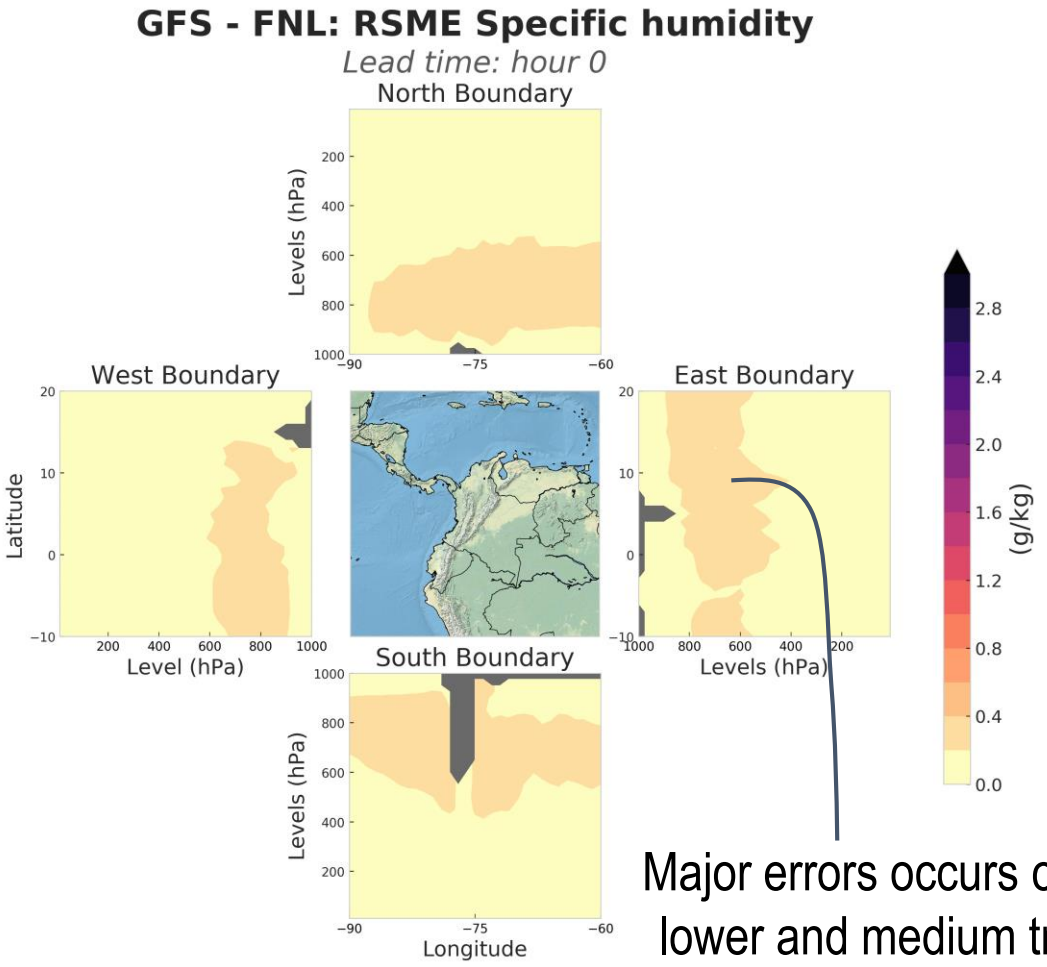
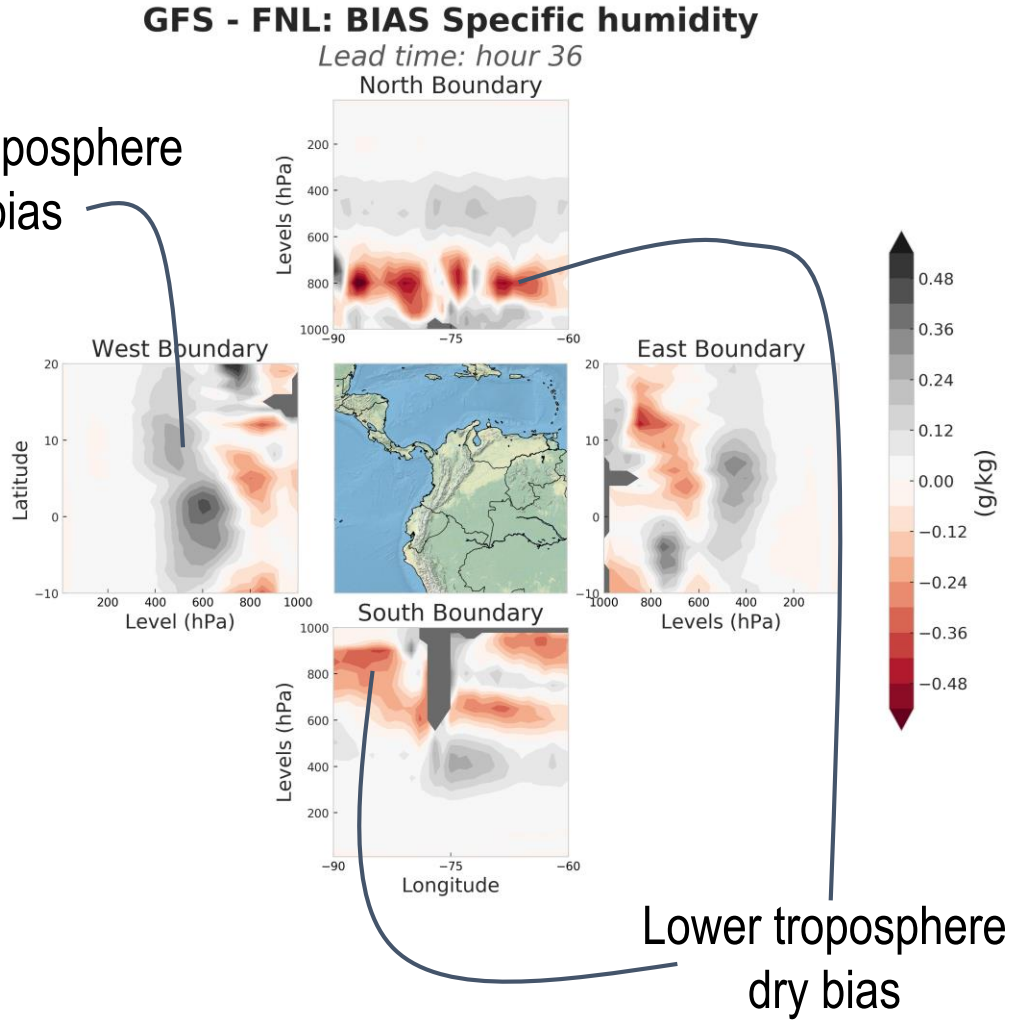


Lower troposphere dry bias

Specific Humidity



Major errors occurs over oceanic lower and medium troposphere

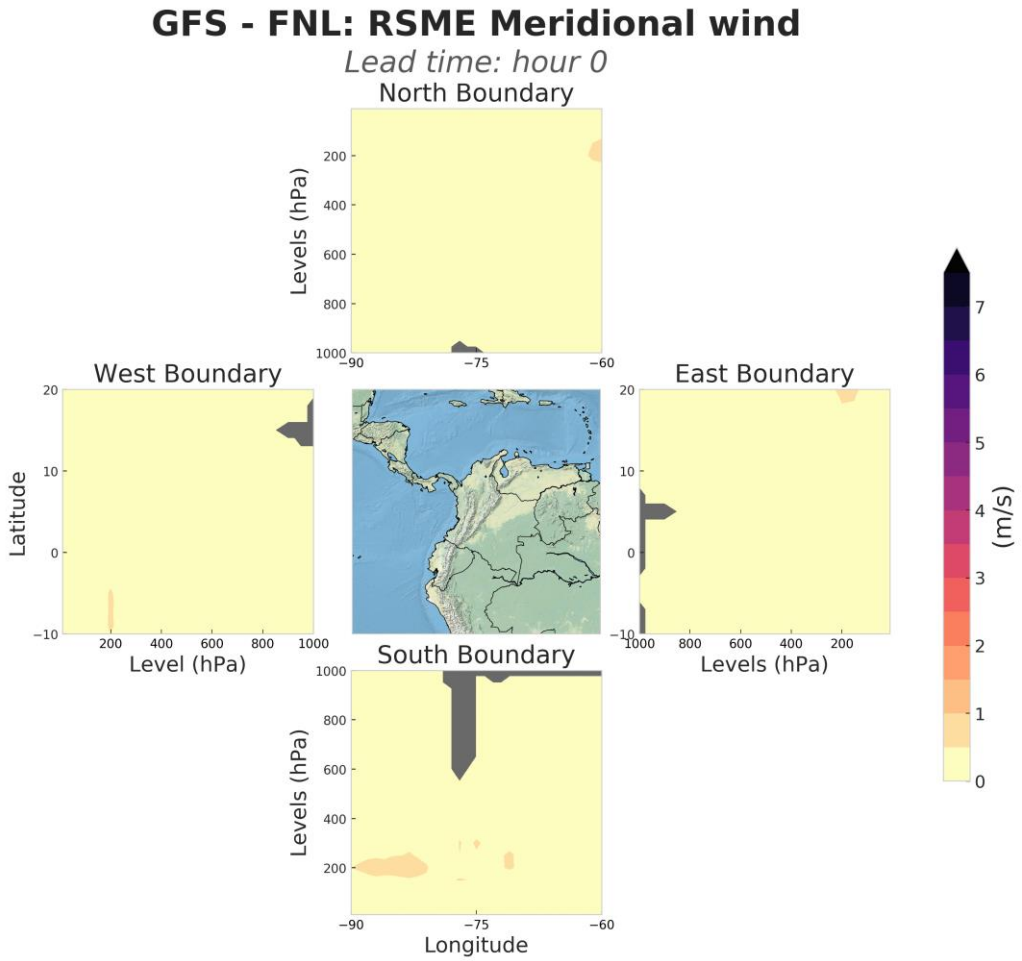


Medium troposphere wet bias

Lower troposphere dry bias

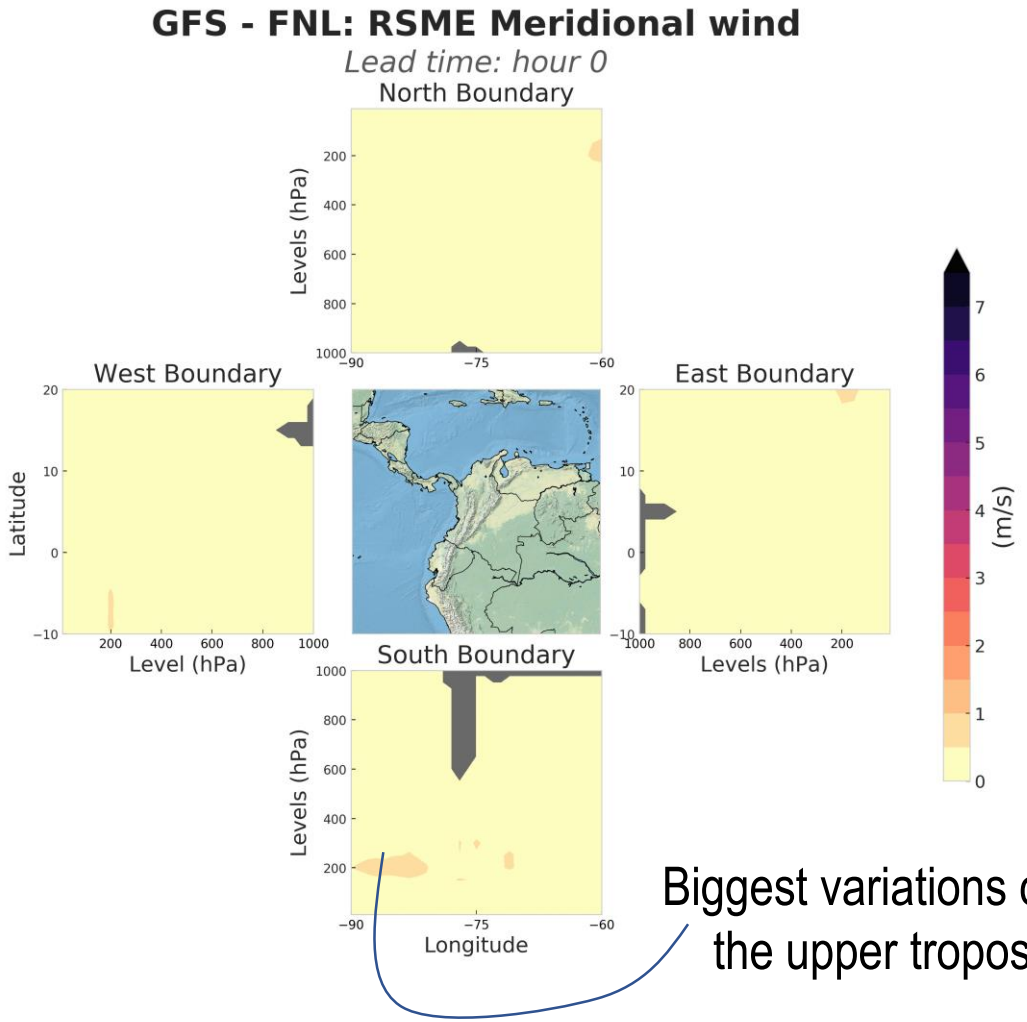
Spatial skill of GFS at the boundaries

Meridional winds



Spatial skill of GFS at the boundaries

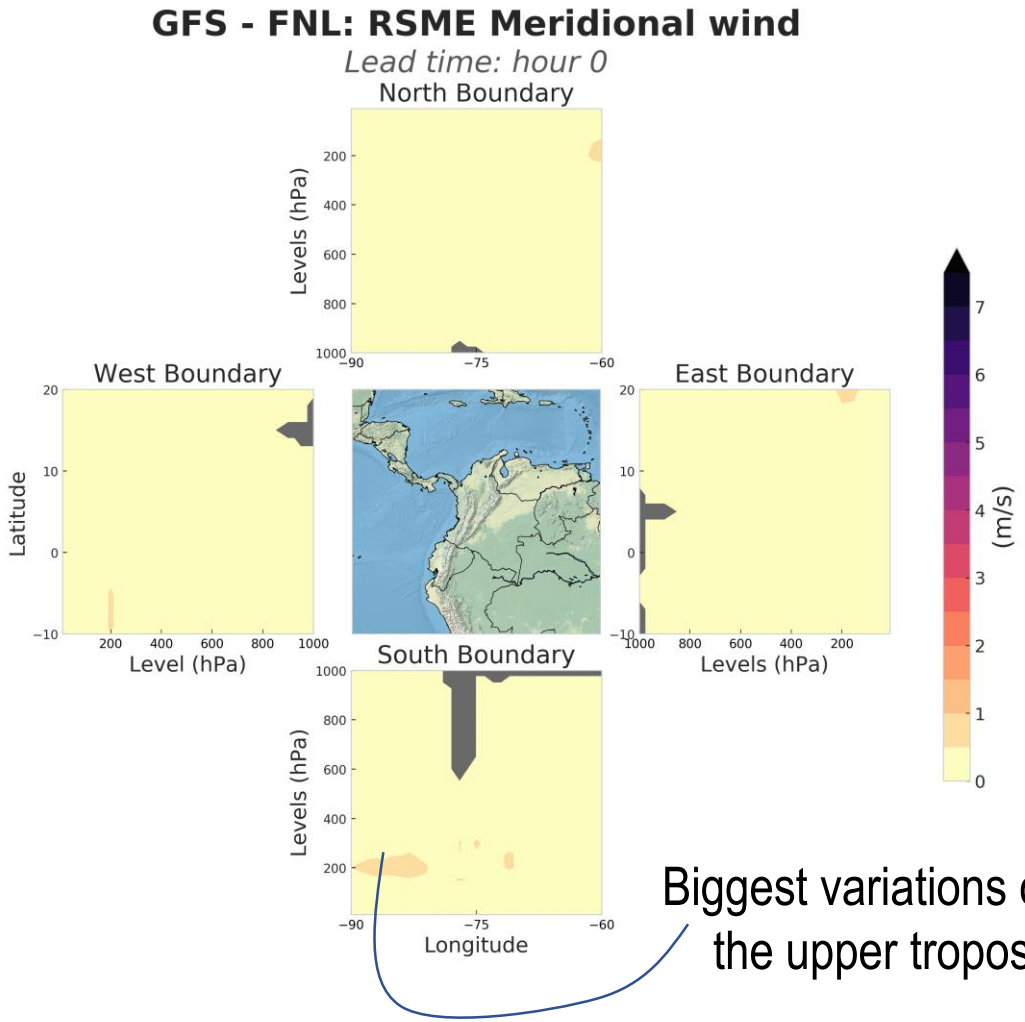
Meridional winds



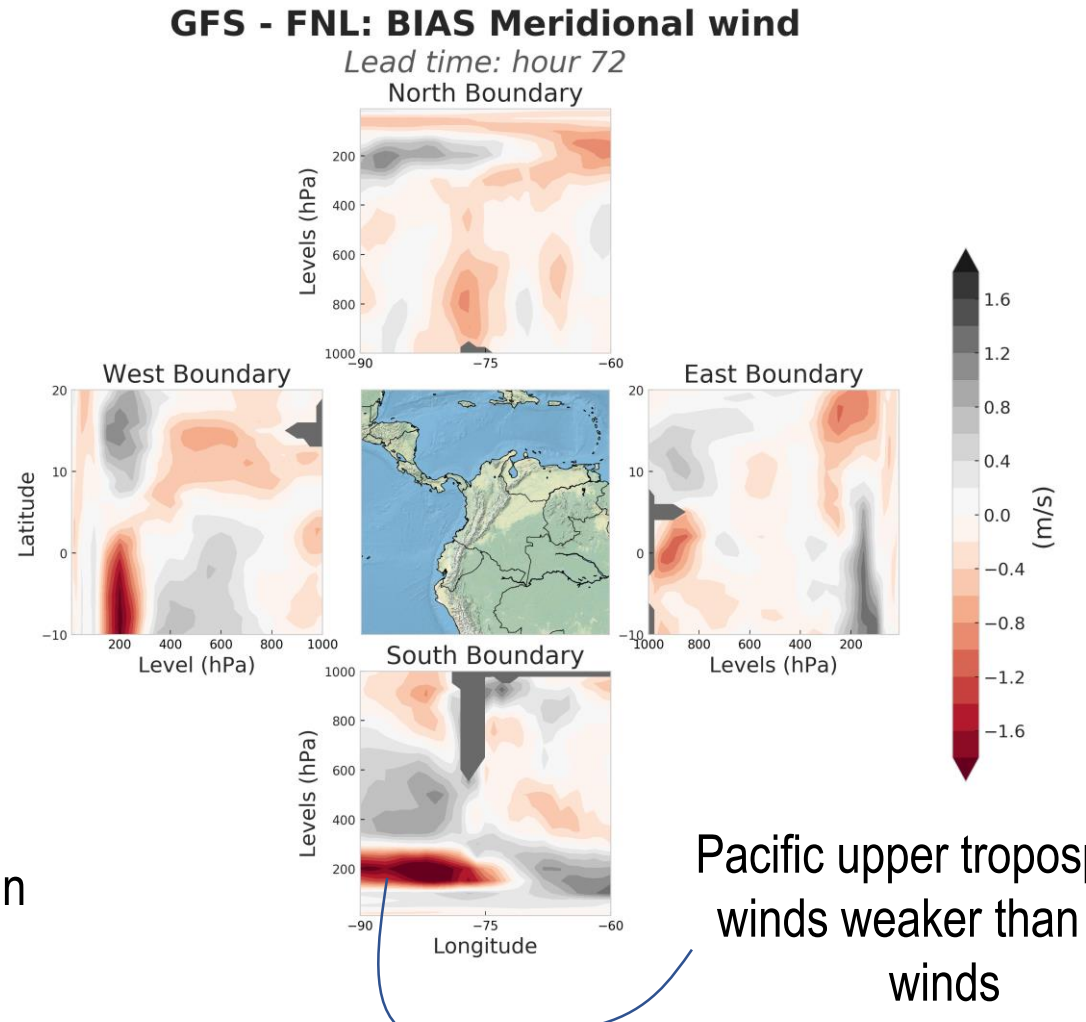
Biggest variations occurs in the upper troposphere

Spatial skill of GFS at the boundaries

Meridional winds



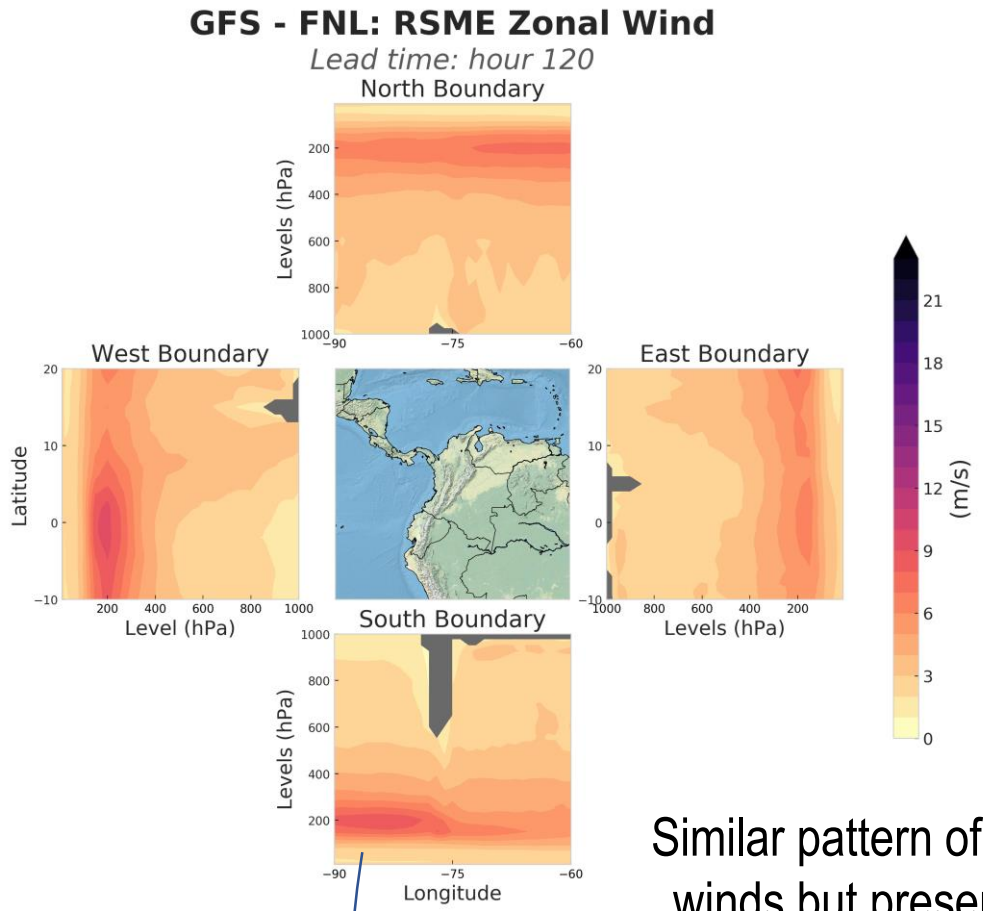
Biggest variations occurs in the upper troposphere



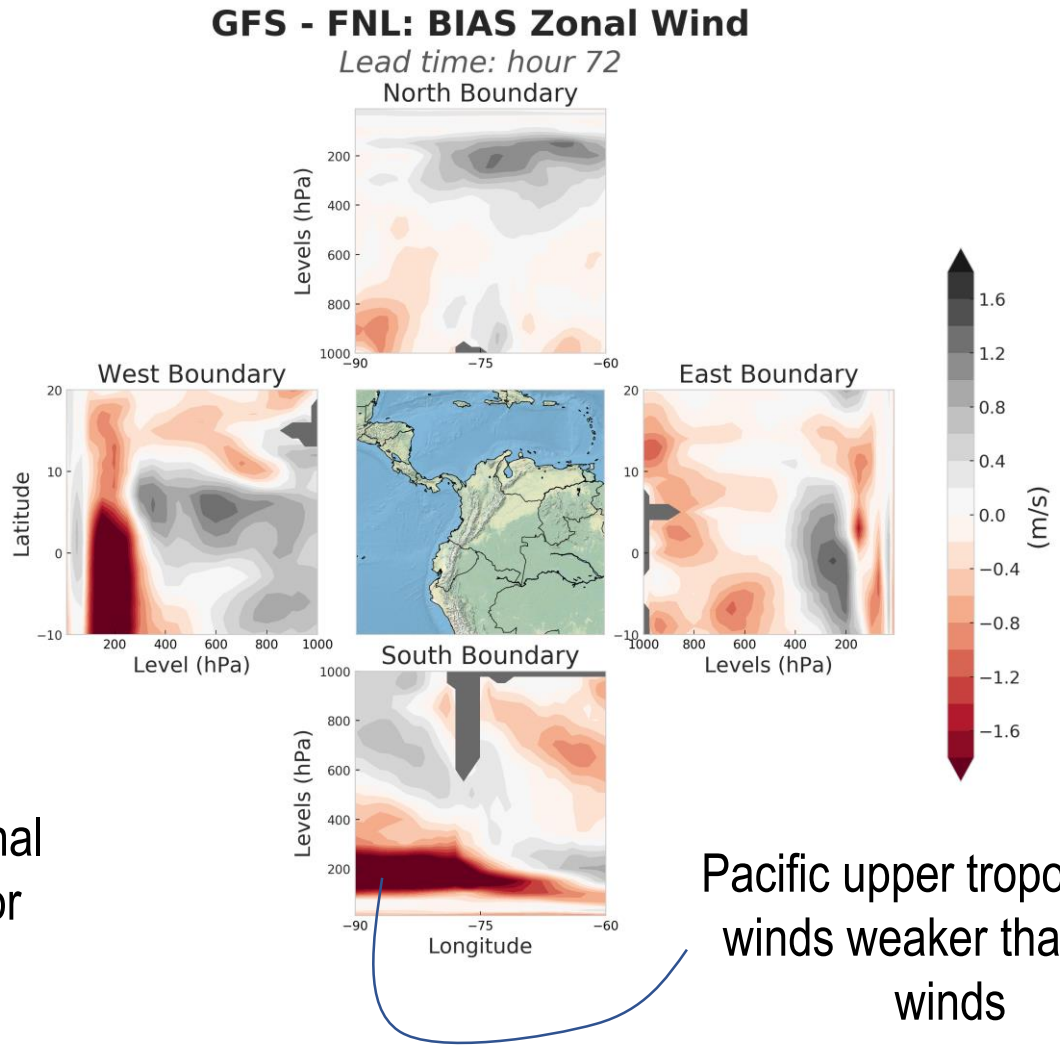
Pacific upper troposphere winds weaker than FNL winds

Spatial skill of GFS at the boundaries

Zonal winds



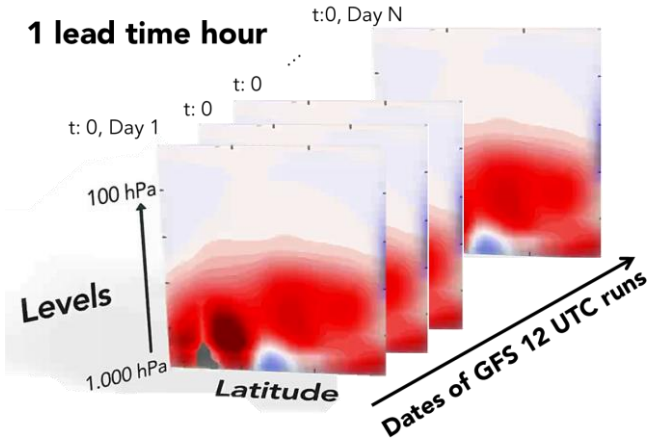
Similar pattern of meridional winds but present a major magnitudes of RSME.



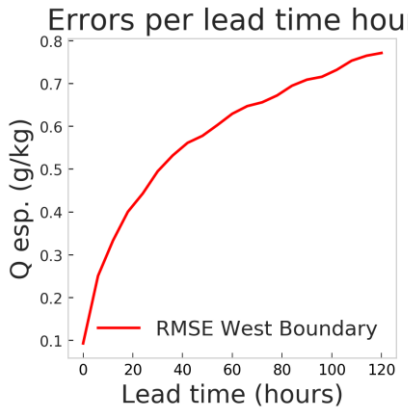
Pacific upper troposphere winds weaker than FNL winds

Methodology

Errors per lead time hour:
2015-2019 GFS data separated by lead hour and FNL data



Result: Error values per forecasted hour and boundary



2. Temporal skill of GFS forecast at the boundaries

Methodology

Errors per lead time hour:
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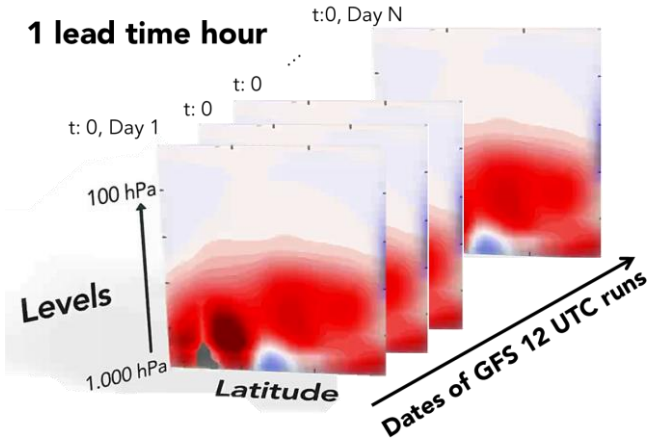
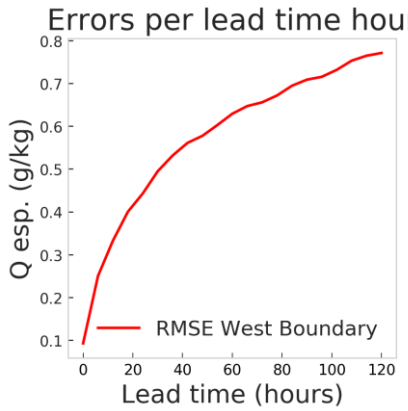
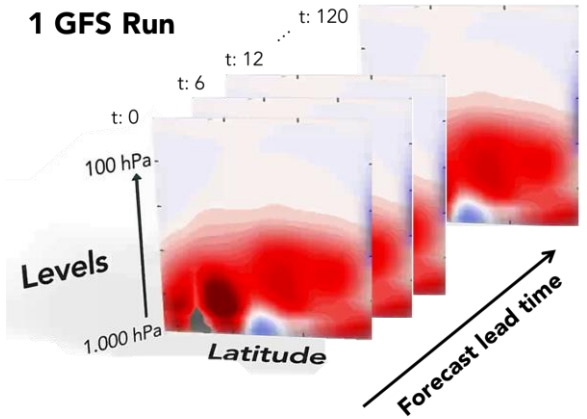


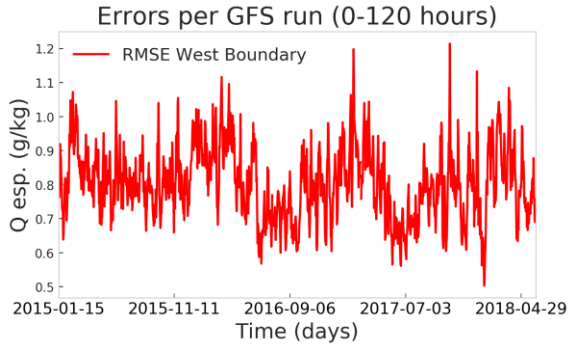
Result: Error values per forecasted hour and boundary



Errors per each GFS run:
2013-2019 GFS boundary data per run and FNL data

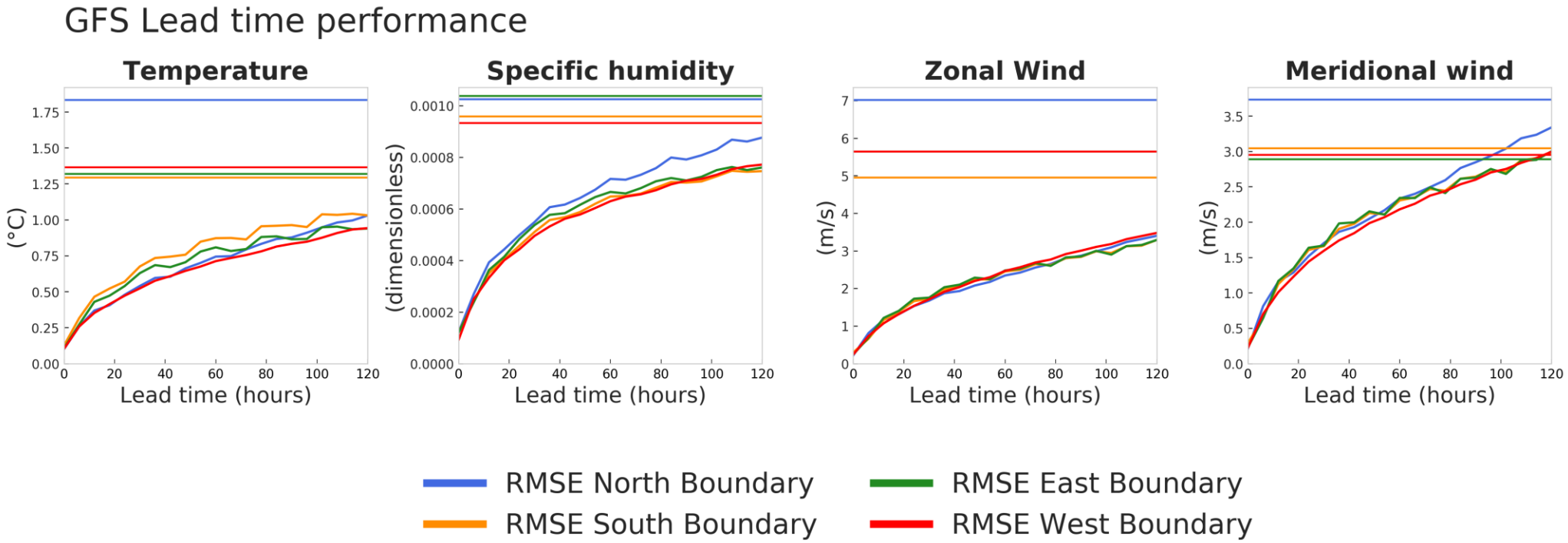


Result: Error values per daily GFS run and boundary



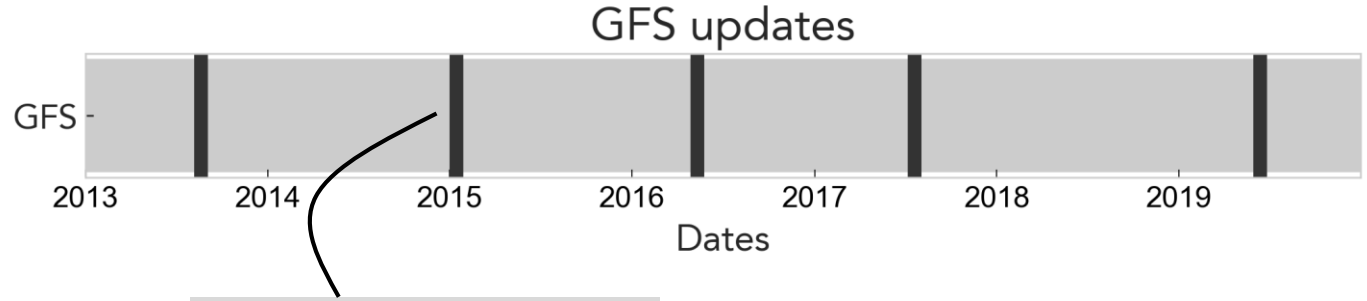
2. Temporal skill of GFS forecast at the boundaries

Lead time skill of GFS



Horizontal lines corresponds to the standar deviation of FNL data

Updates trough the time of GFS and its effects over the region



August 20, 2013 | **January 14, 2015** | May 11, 2016 | July 19, 2017 | June 12, 2019

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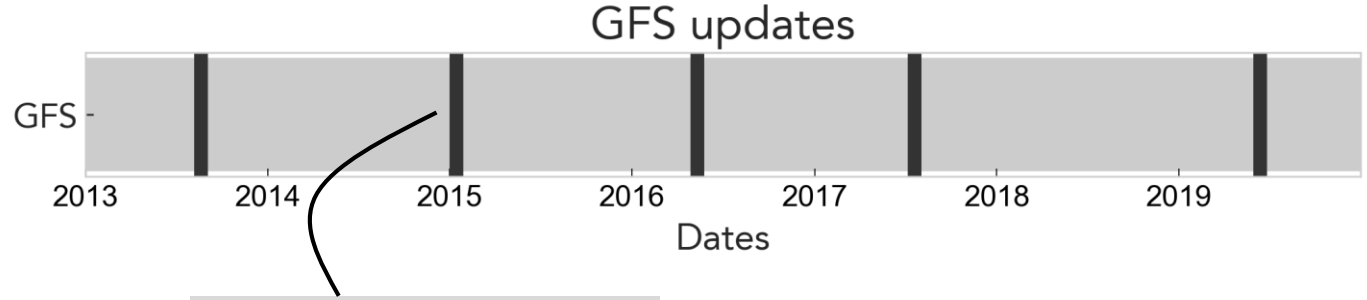

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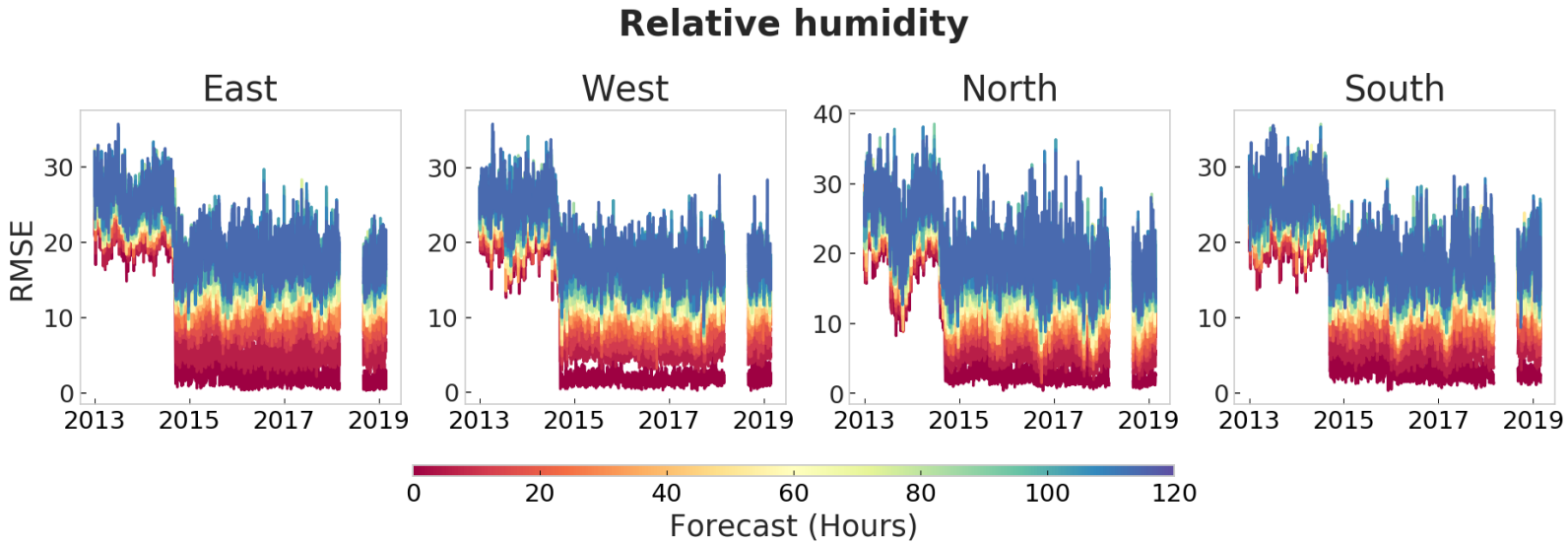

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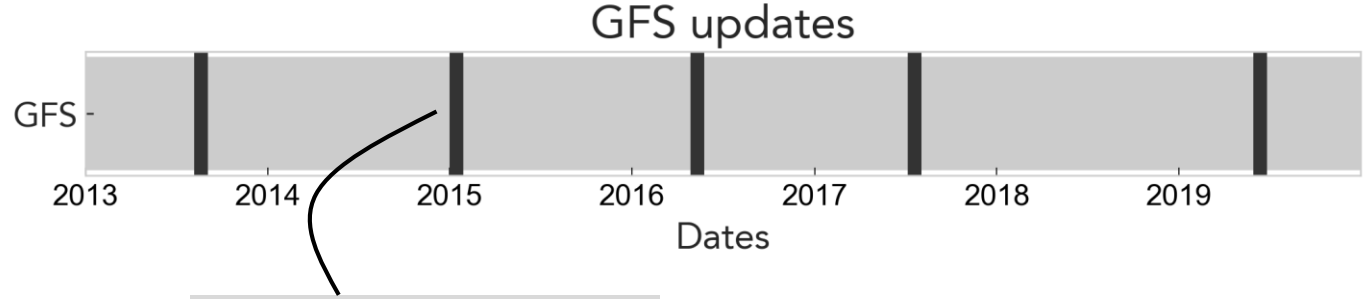

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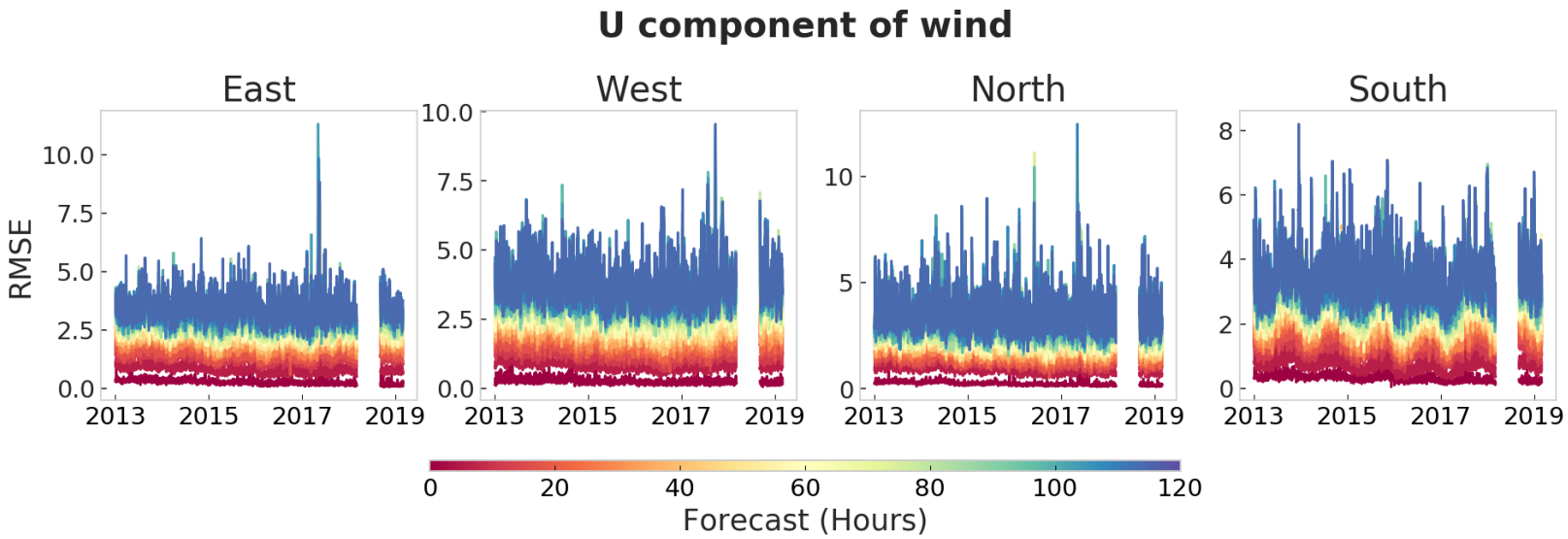

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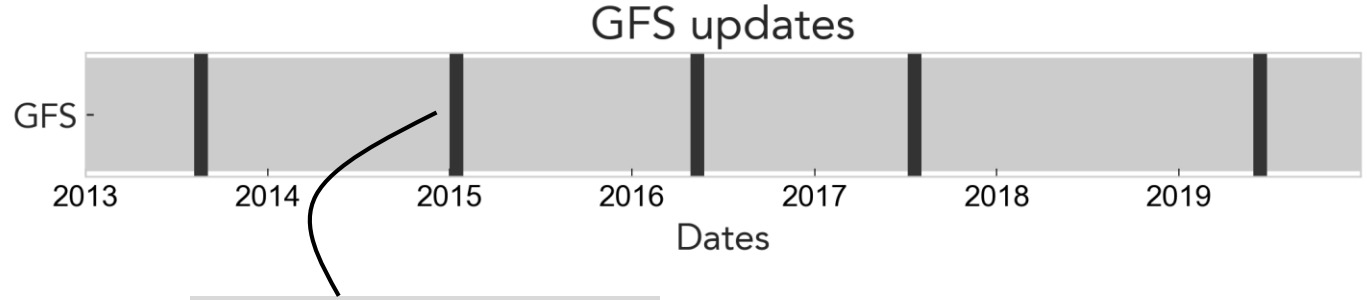

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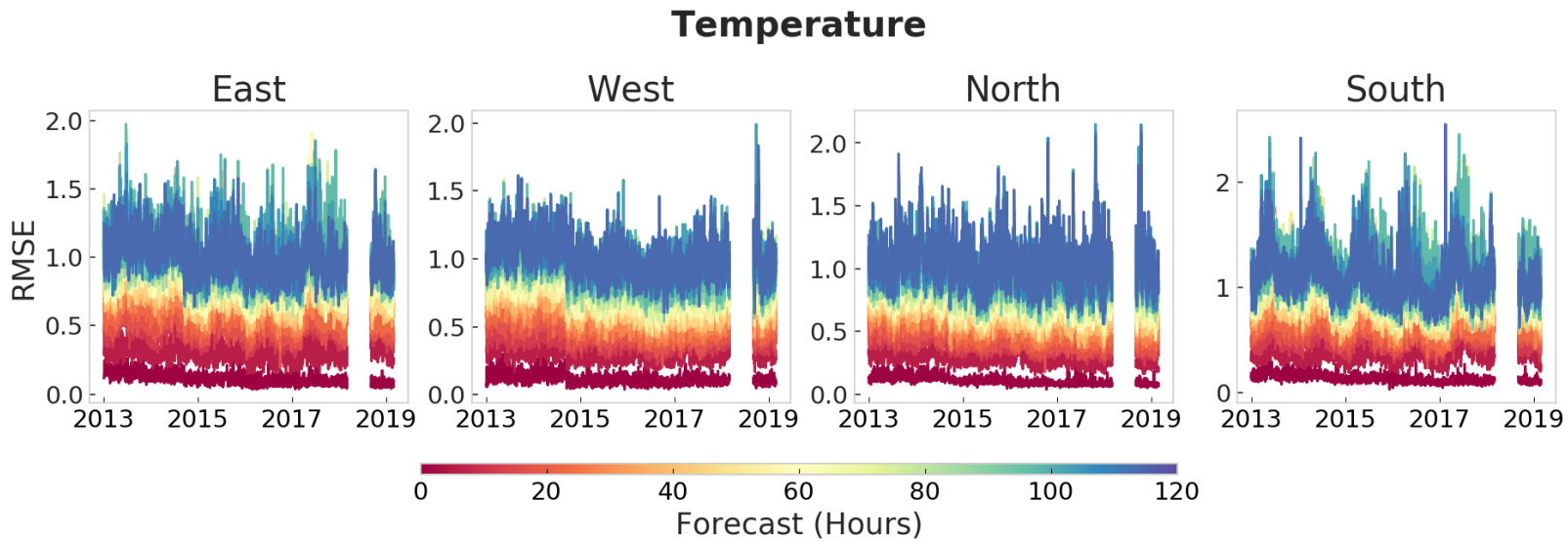
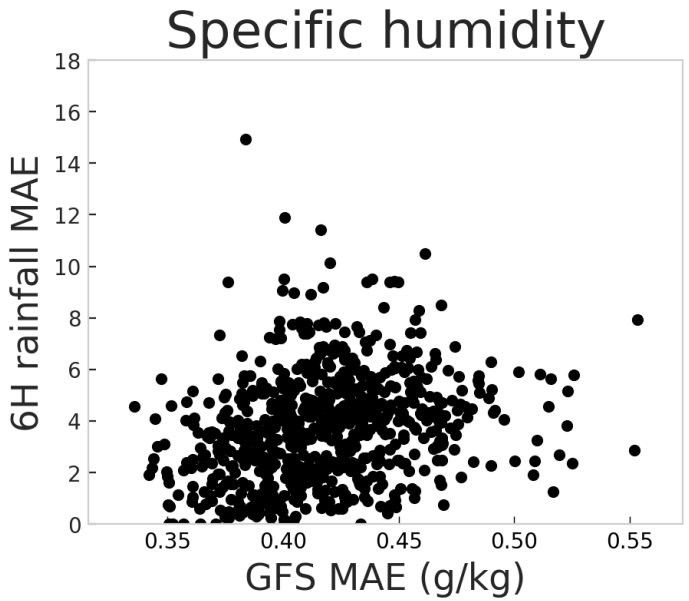


Methodology: Conditional analysis of errors per run

Local forecast error

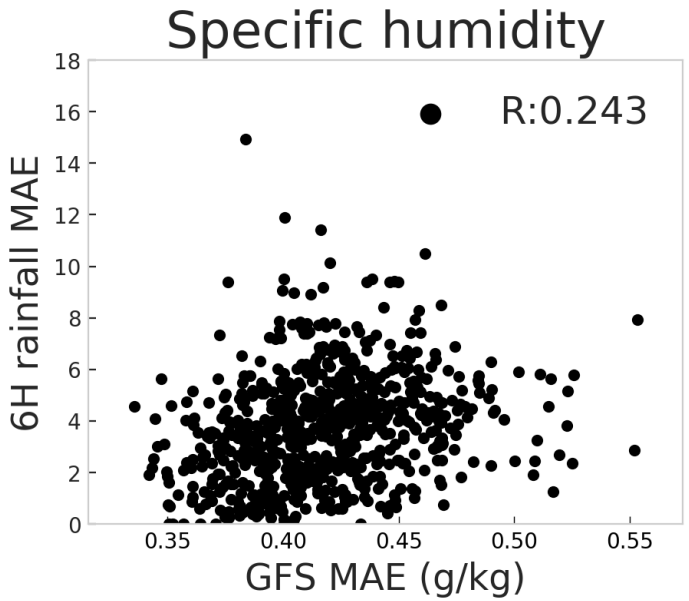


Boundary data GFS error

3. Conditional skill of WRF application per run regarding GFS errors

Methodology: Conditional analysis of errors per run

Local forecast error



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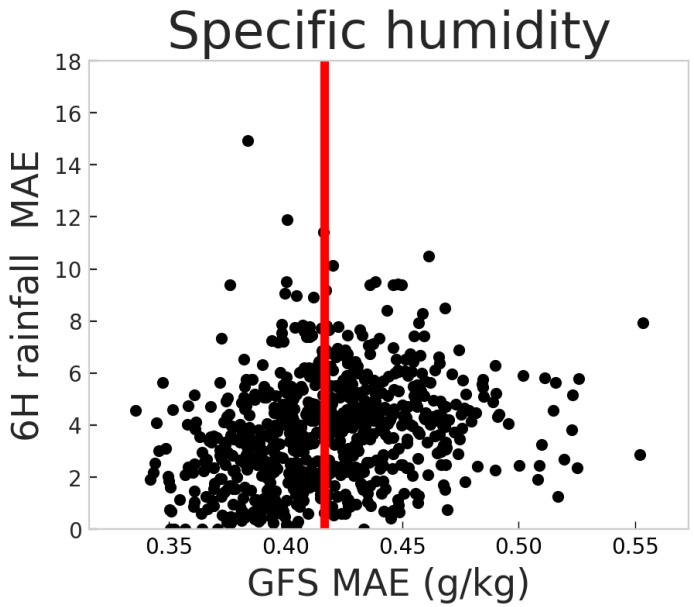

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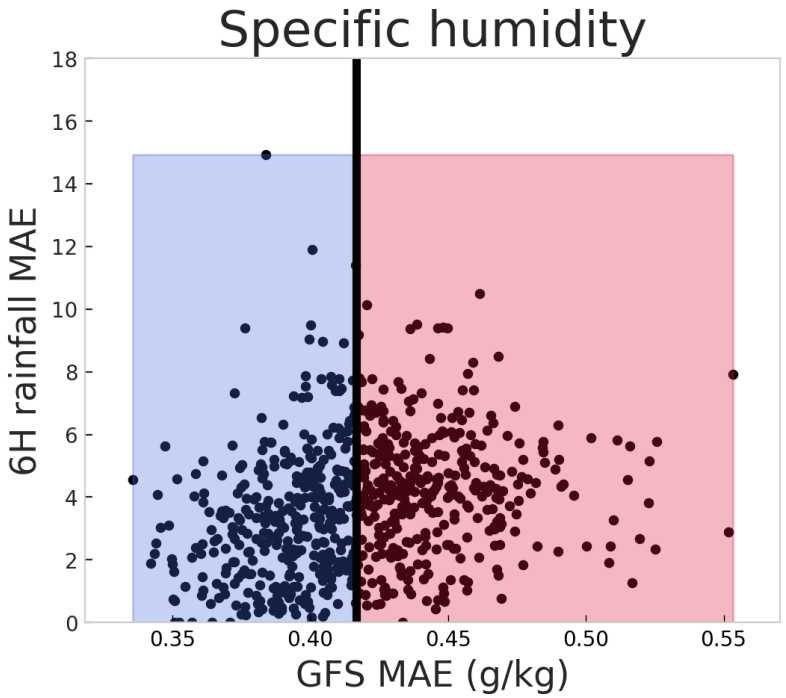

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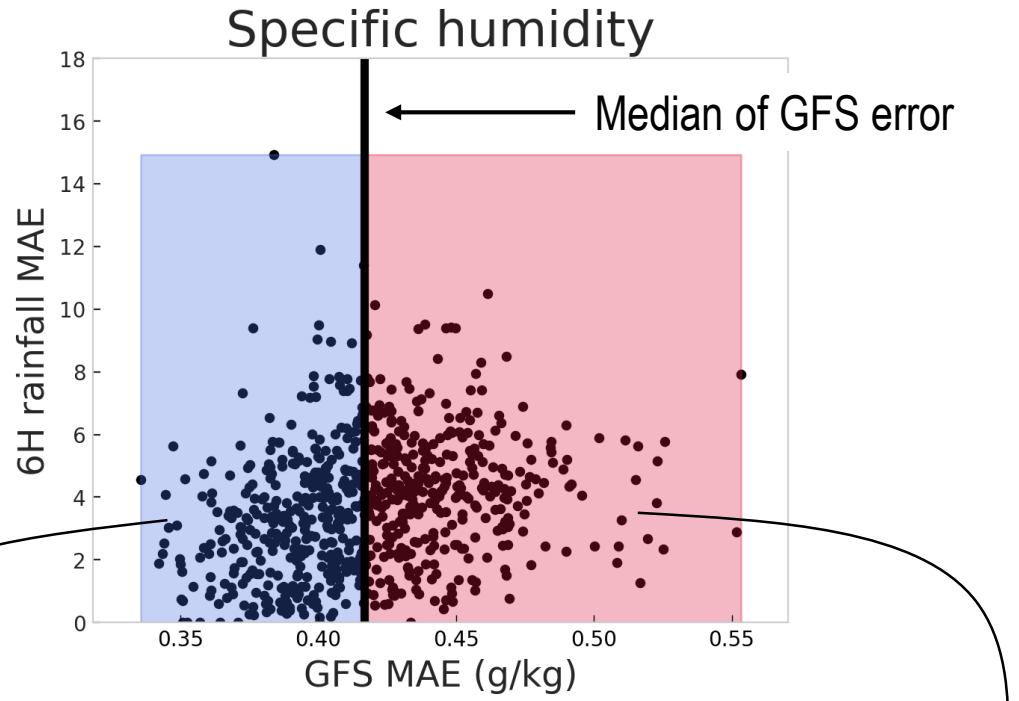


Local forecast error

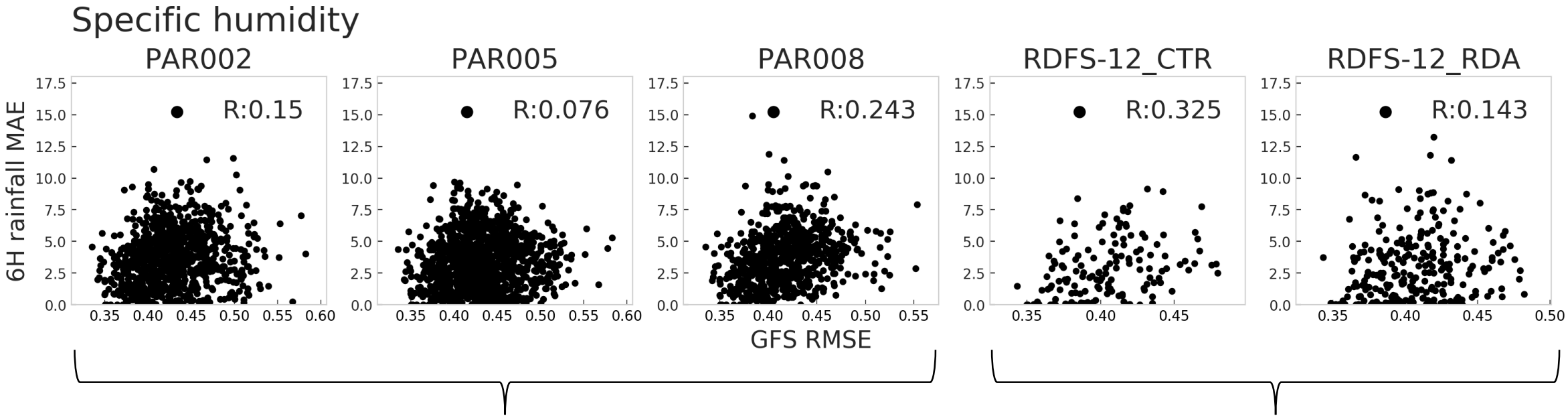
Boundary data GFS error

Bellow median: histograms when GFS has lower errors

Above median: histograms when GFS has higher errors

3. Conditional skill of WRF application per run regarding GFS errors

Conditional skill of WRF according to GFS errors



SYNAPSIS Configuration:

Medium-range forecast

Forecast lead time: 120 hours

Domain: Triple nested domain

Microphysics scheme: Lin (PAR002), Eta Ferrier (PAR005), Thompson (PAR008) Schemes.

RDFS Configuration:

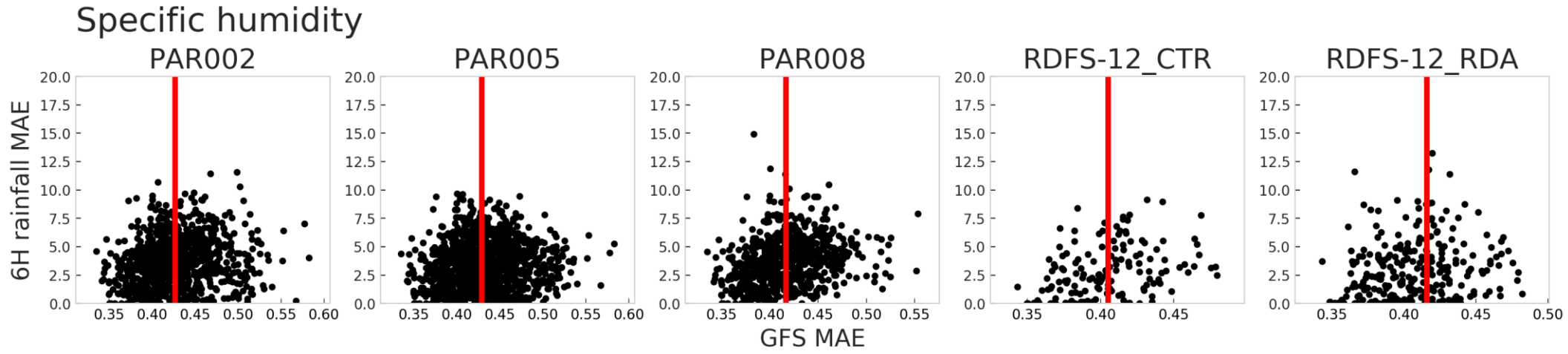
Short-range forecast

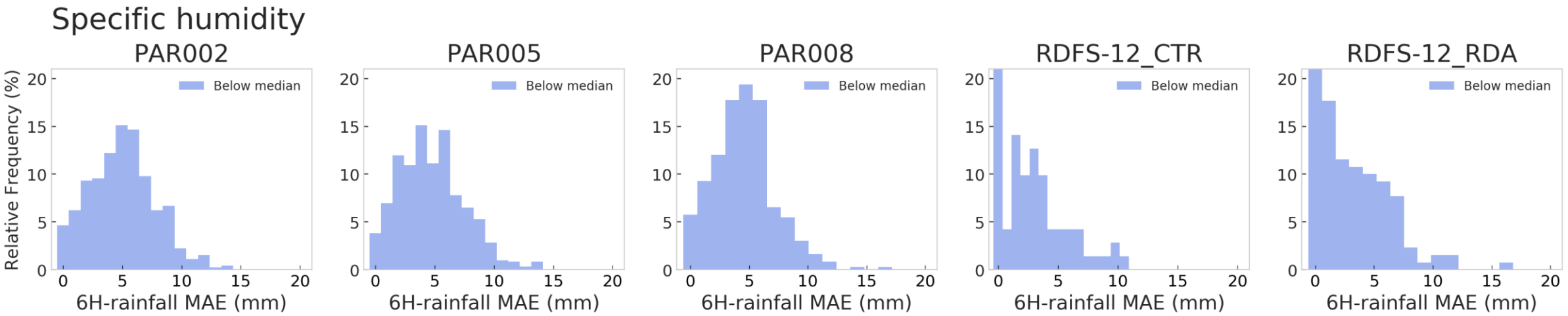
30 hours ,1 run with C-band radar data assimilation RDA version and CTR without data assimilation

Doble nested domain

Thompson Scheme

Conditional skill of WRF according to GFS errors





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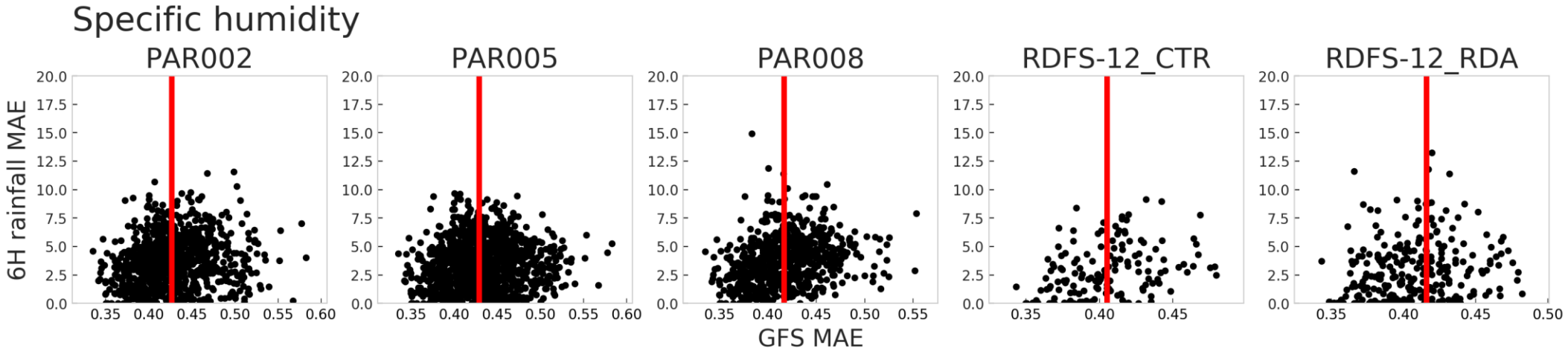

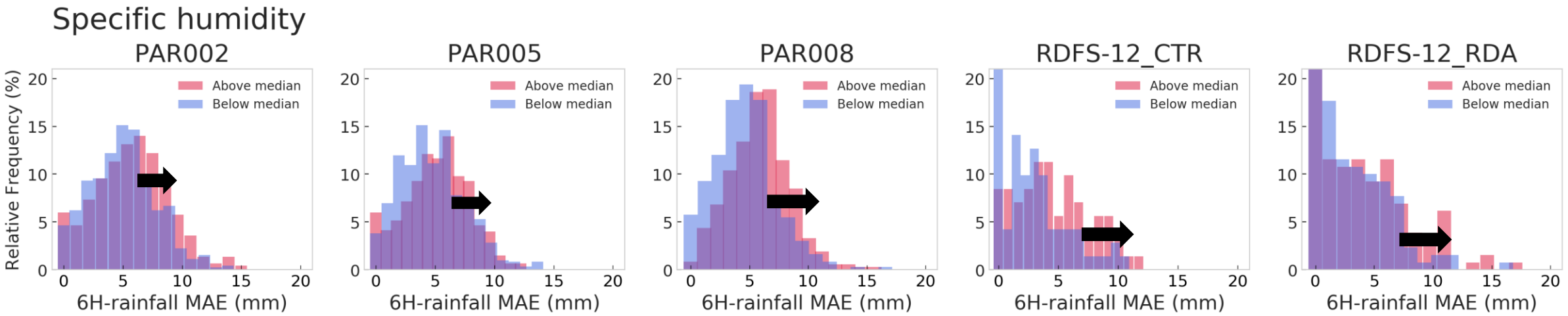

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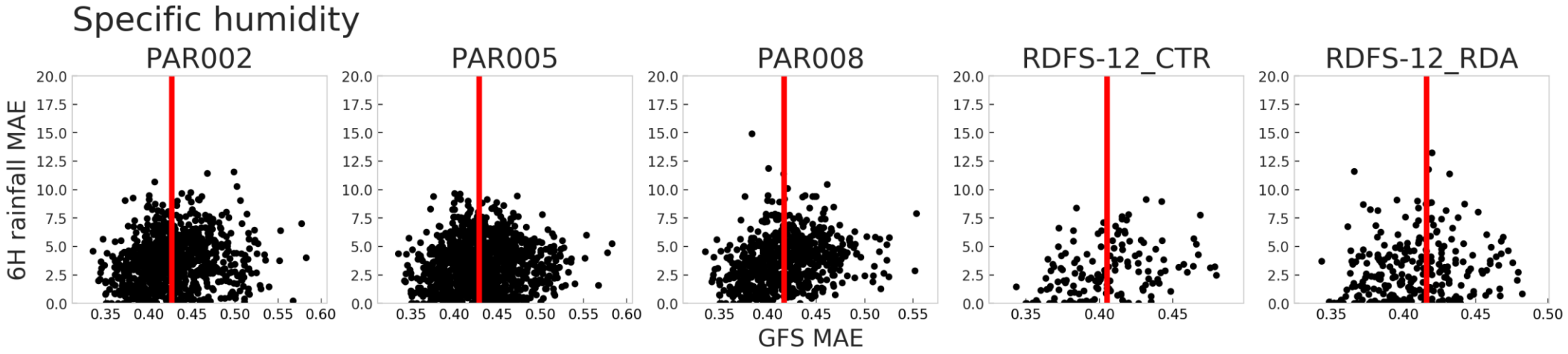

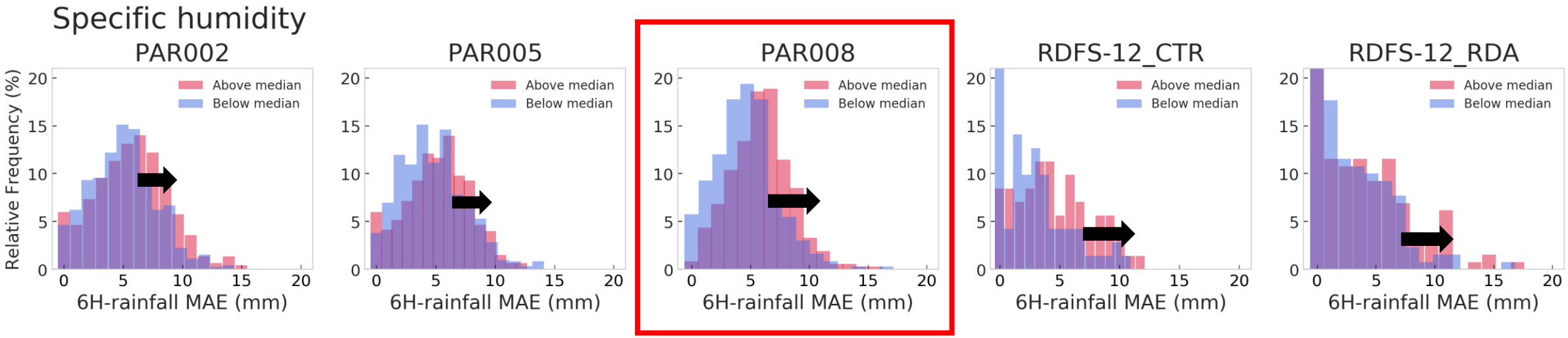

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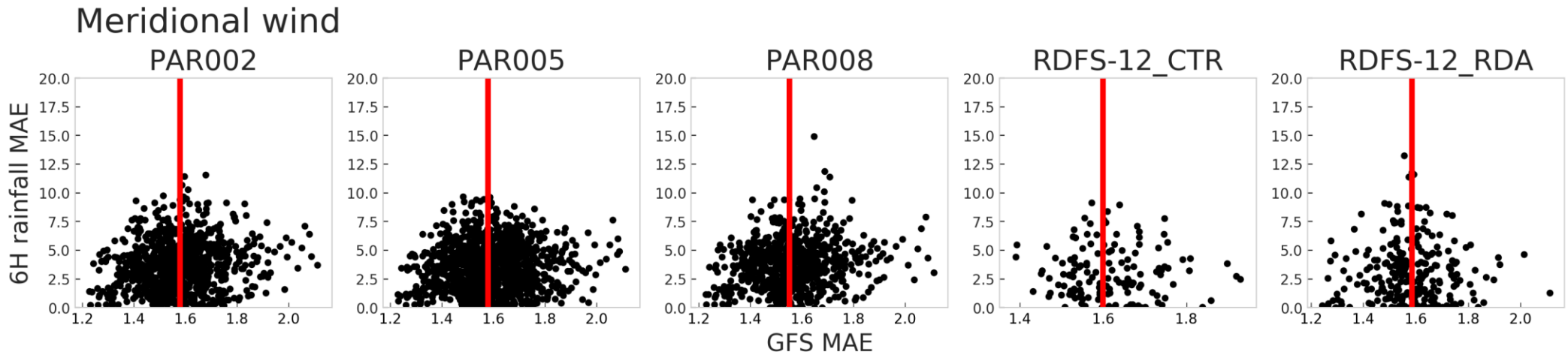

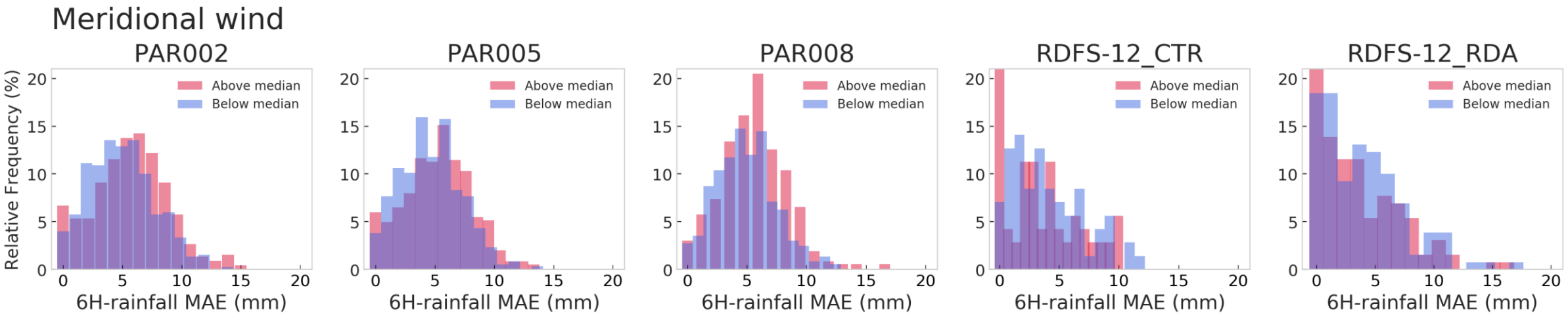

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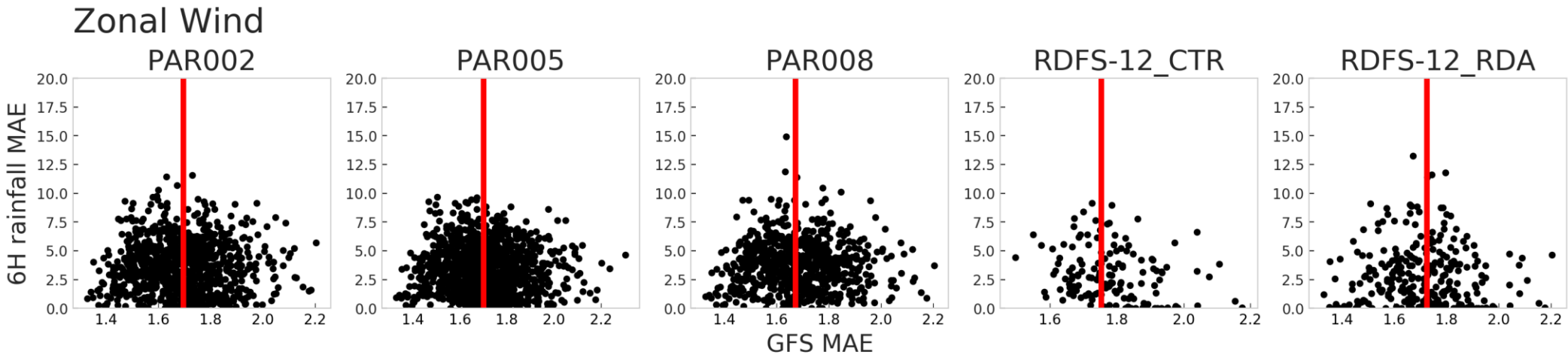

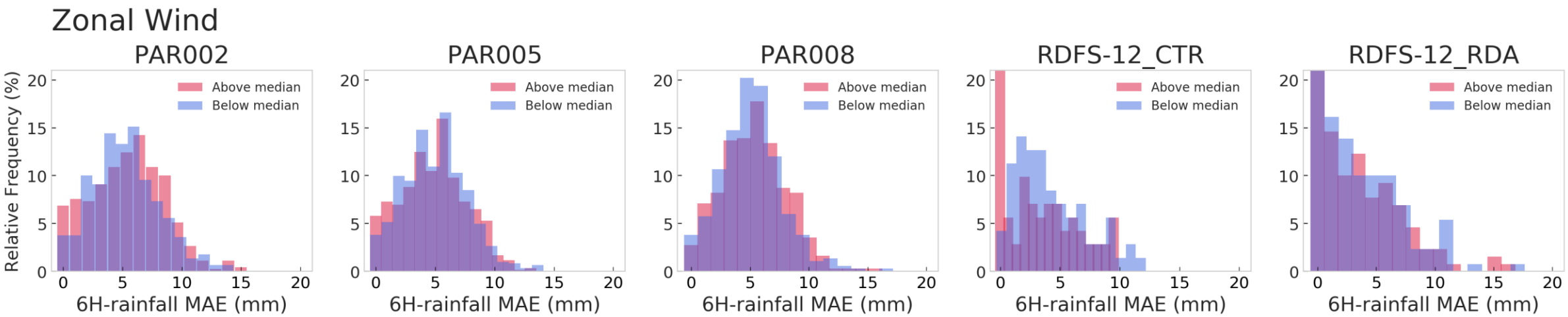

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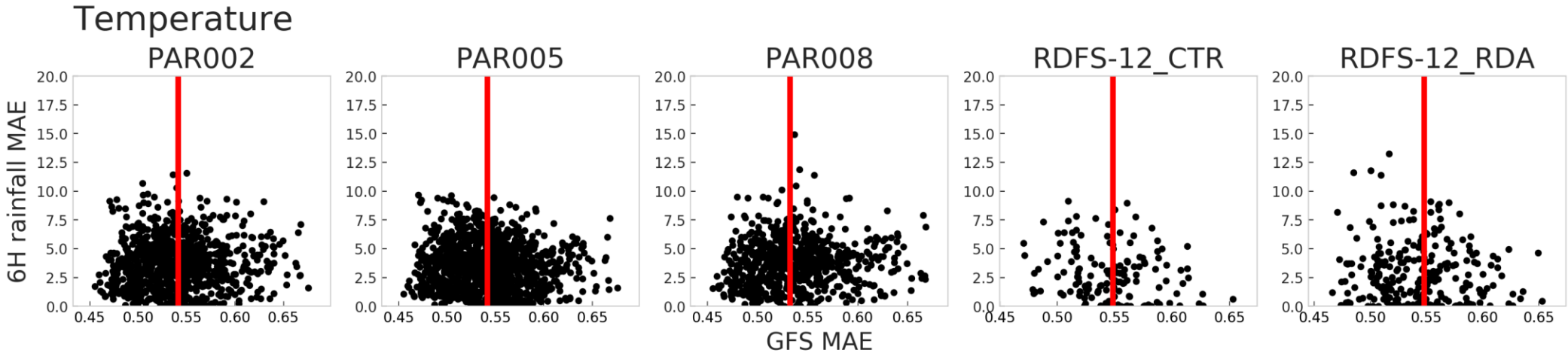

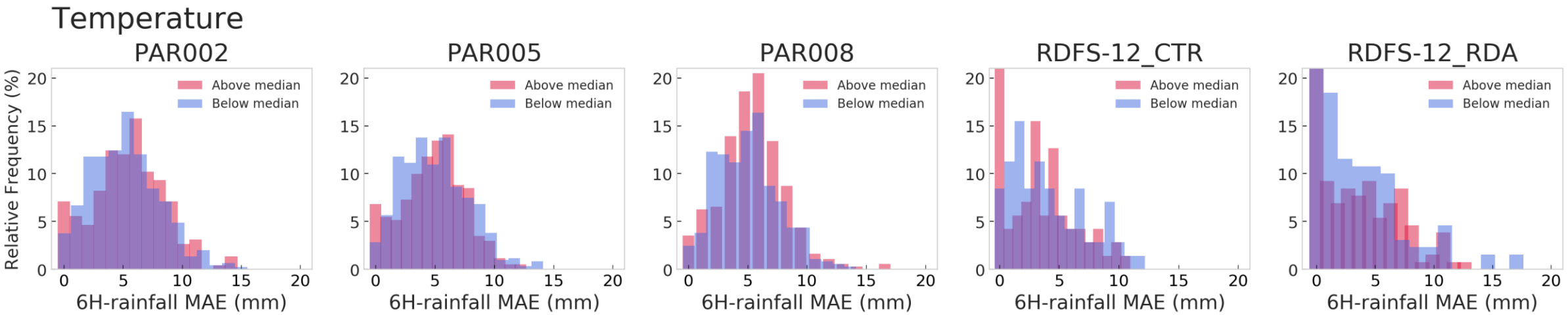

Take home messages!

GFS provides good boundary conditions to produce weather forecast in the Aburrá Valley (Colombia) using WRF model.

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The probability of obtaining lesser errors in 6-Hourly rainfall is higher when the humidity are well represented. Then is more important having input data with an accurate representation of the moisture transport.

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Future work:

Make an evaluation of local forecast by rainfall events using different global circulation models, like the operational forecast of ECMF.

UNIVERSIDAD NACIONAL DE COLOMBIA

SIATA

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Funding agencies

epm ISAGEN

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Alcaldía de Medellín