Analysis of the dynamics of extreme rainfall events in summer in southern Uruguay

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UdelaR, Montevideo

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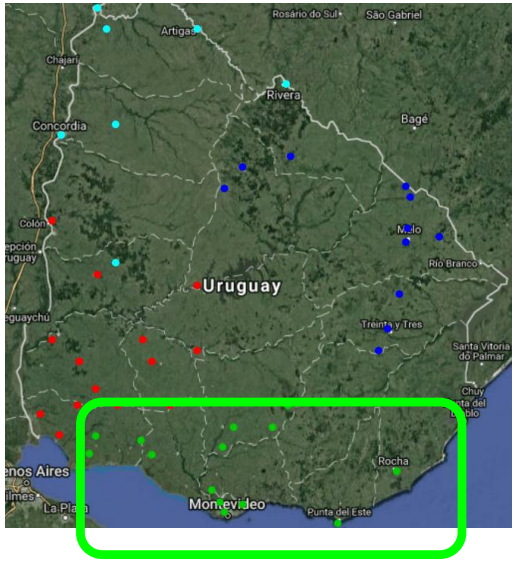
When I say Uruguay

When I say Uruguay

When I say southern

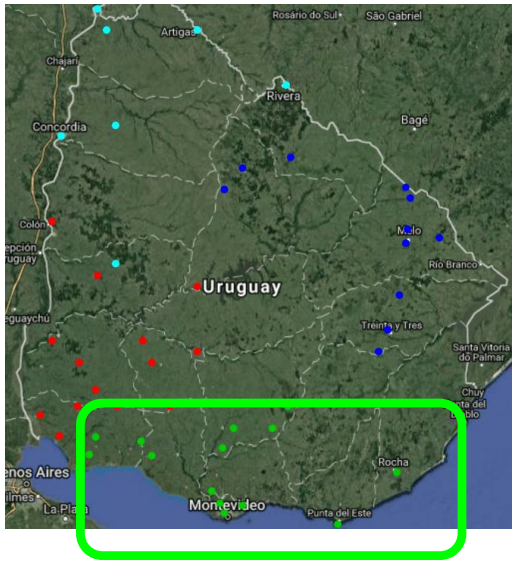
When I say Uruguay

When I say southern



When I say Uruguay

When I say southern



When I say extreme: days in which the accumulated exceeds 90 percentile

Objective of this investigation

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- Understand the main characteristics and atmospheric patterns that influence the extreme events of rainfall in summer in southern Uruguay

Motivation

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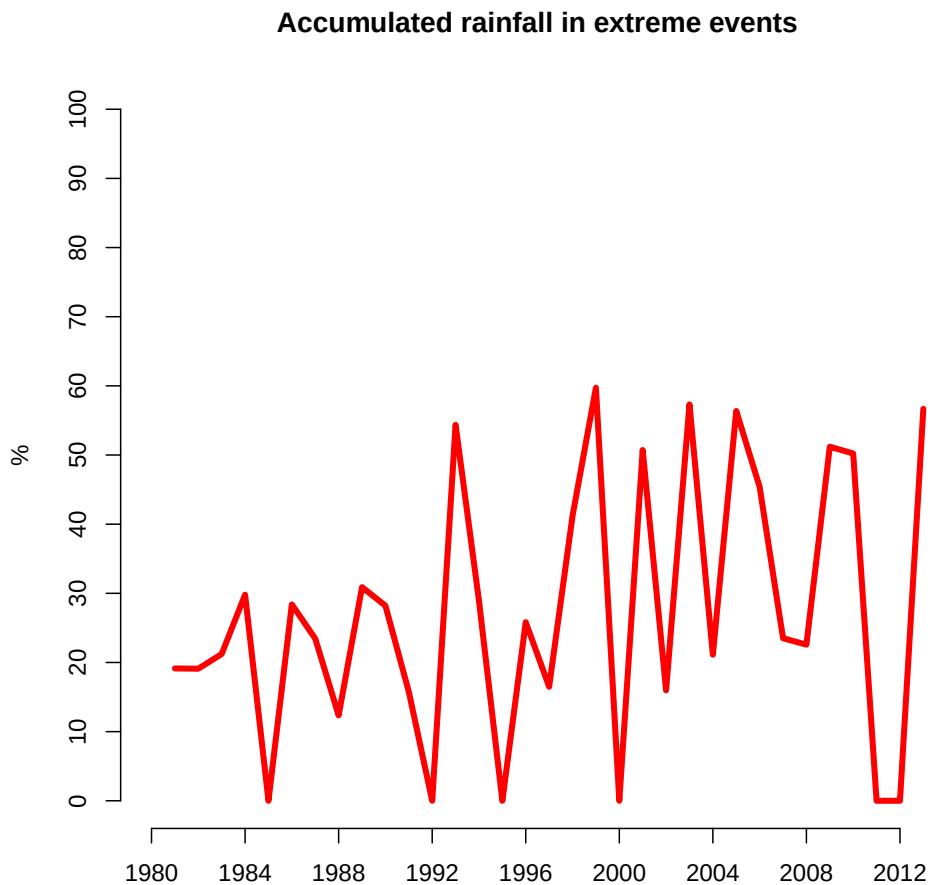

Data

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- Daily data, period 1980-2013

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- Observational accumulated rainfall in 15 pluviometers

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- NCEP reanalysis 2 - 2.5°x2.5°: geopotential height, wind, temperature, latent heat

Methodology

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- Composite analysis to study the dynamics (90% significance)

EOF- empirical orthogonal function

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- The EOF was calculated considering 2m temperature

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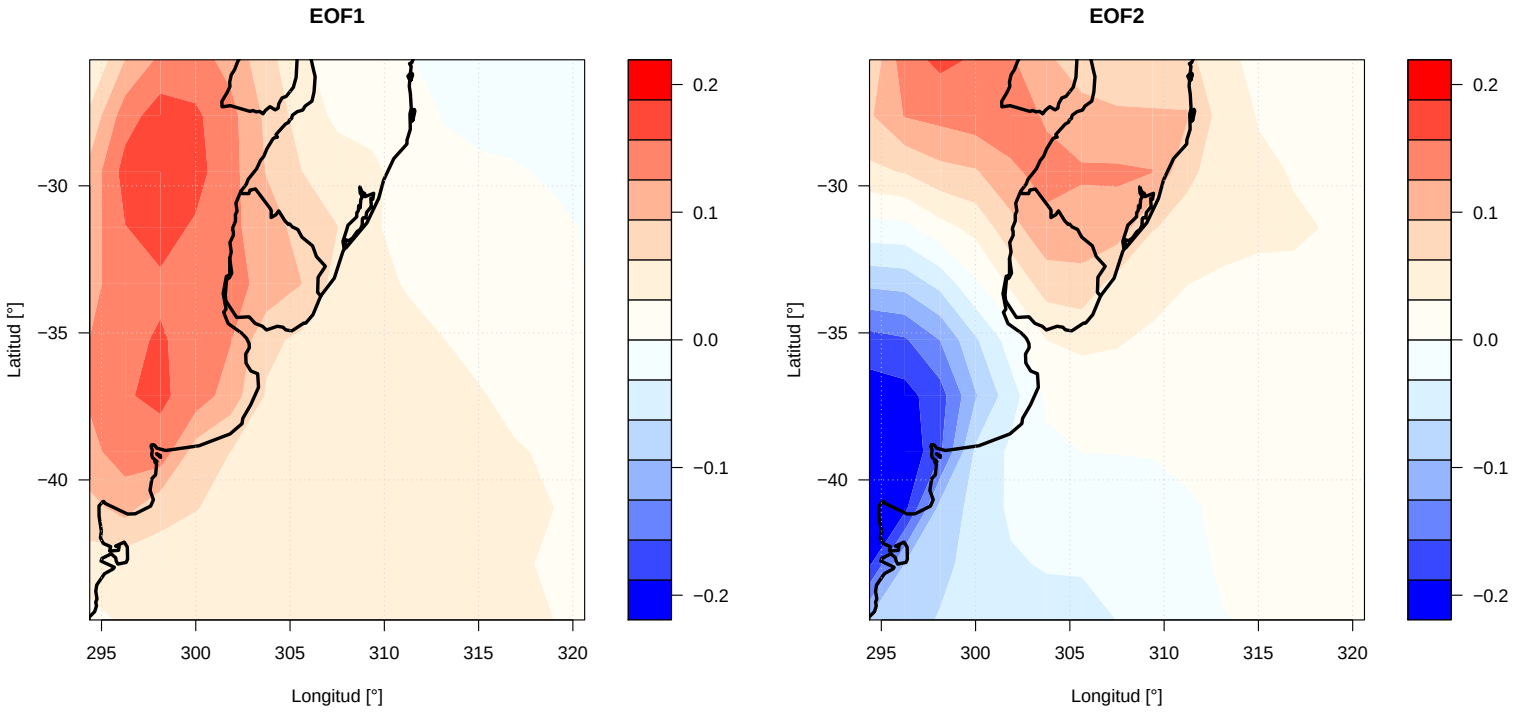
- They repesent 48% and 17% of variability



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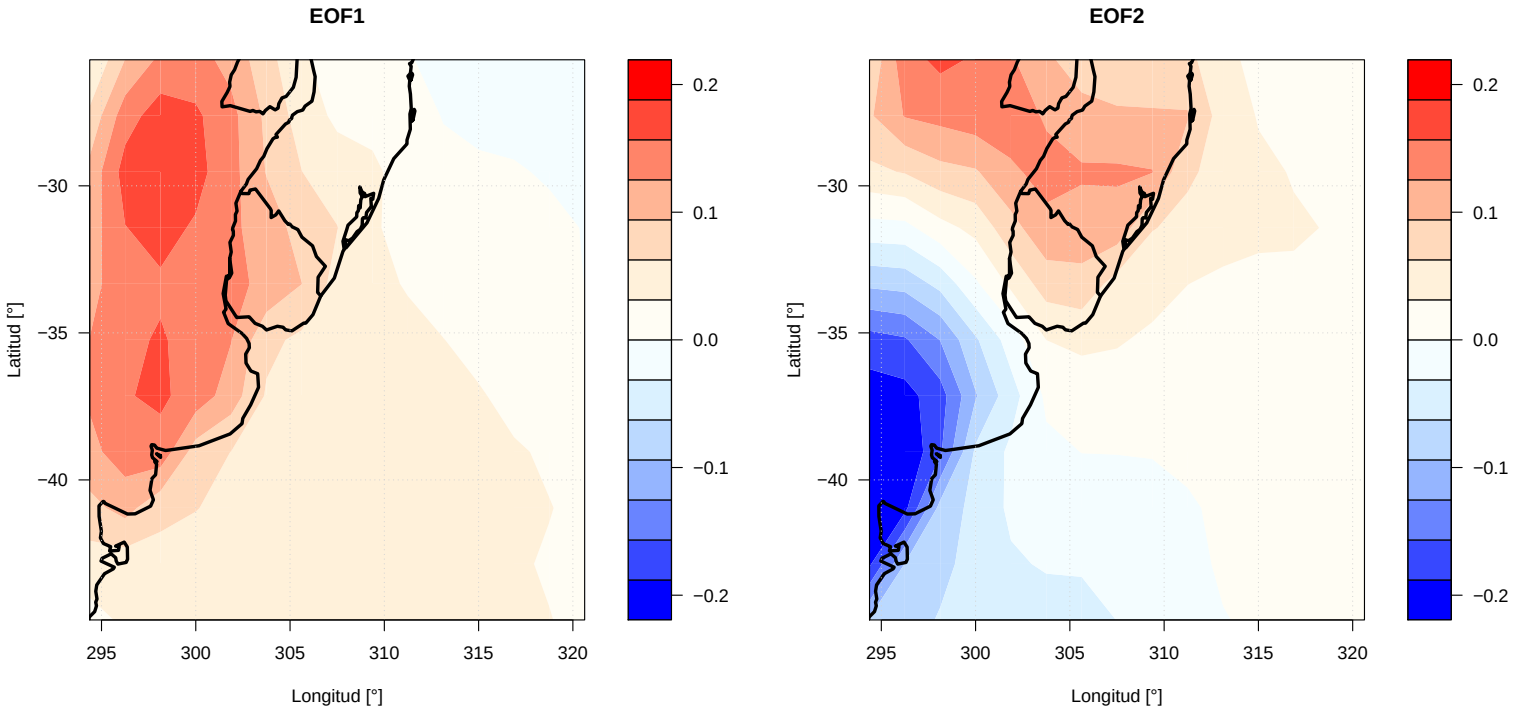

- EOF 1: temperature anomaly that leads to atmospheric (in)stability

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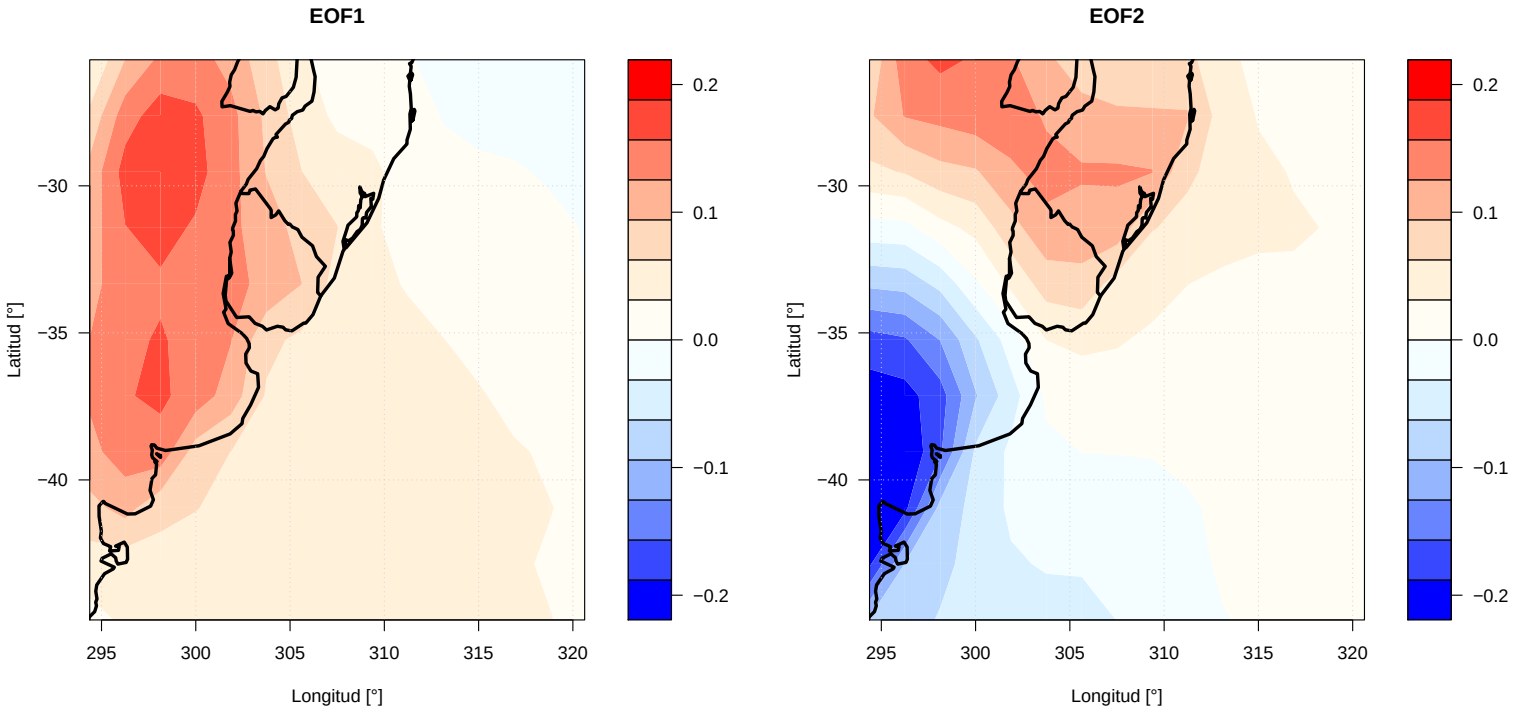

- EOF 1: temperature anomaly that leads to atmospheric (in)stability
- EOF 2: temperature gradient associated with frontal activity

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- We separated into different groups, considering each's extreme day value in First and Second Principal component(CP)

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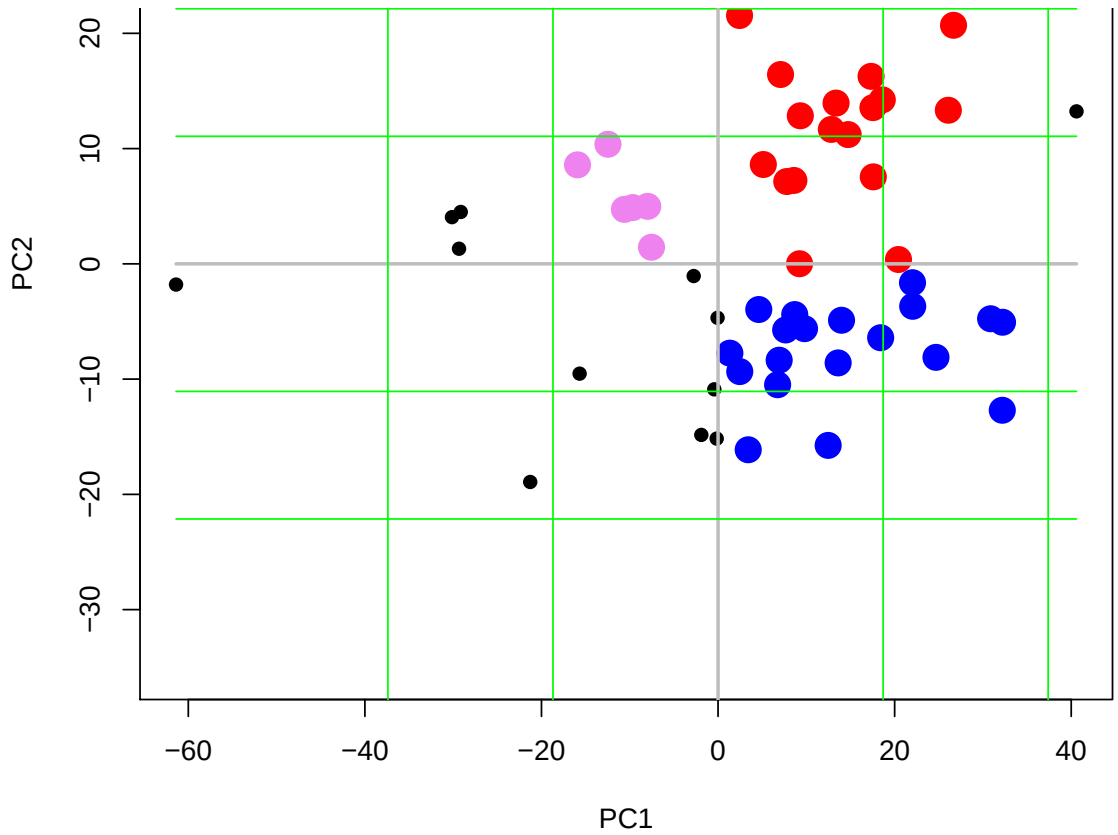

Red group (PC1 +, PC2 +)

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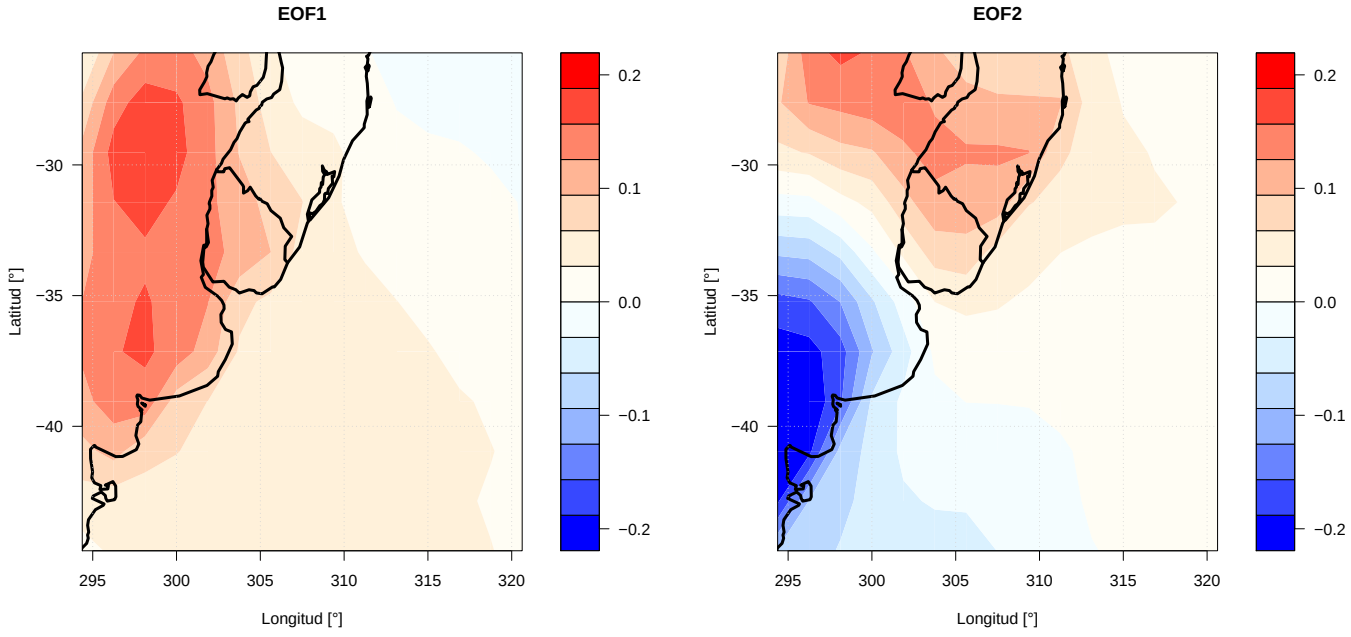

Atmospheric instability + Frontal activity

Red group (PC1 +, PC2 +)

2 metre temperature anomaly

Red group (PC1 +, PC2 +)

2 metre temperature anomaly

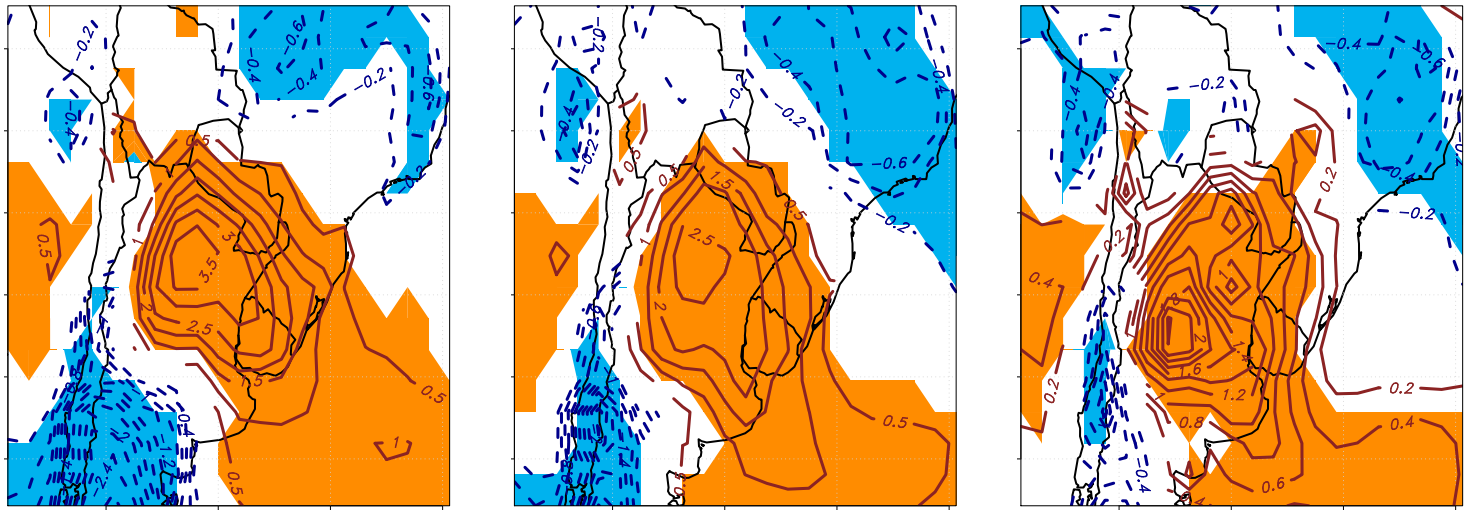

Figure 1: Day 0, Day -1, Day -2

- Stationary positive temperature anomaly generating atmospheric instability

Red group (PC1 +, PC2 +)

1000 hPa geopotential anomaly

Red group (PC1 +, PC2 +)

1000 hPa geopotential anomaly

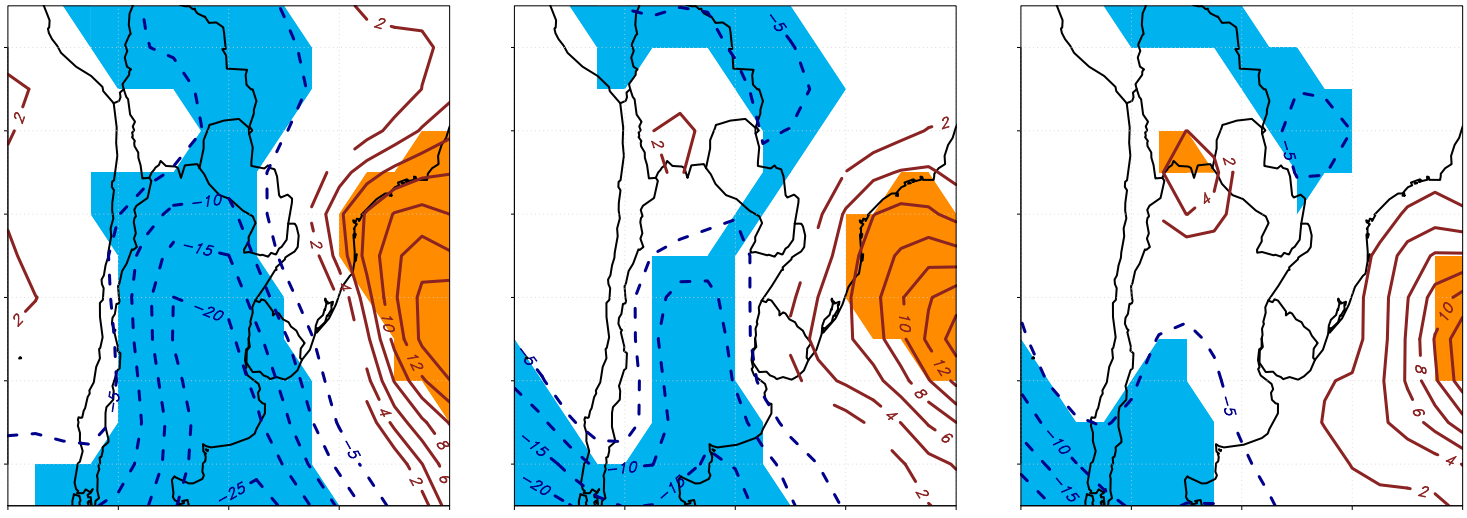

Figure 2: Day 0, Day -1, Day -2

- Surface low pressure approaching, and reaches Uruguay the day 0

Red group (PC1 +, PC2 +)

Frontal Index anomaly

Red group (PC1 +, PC2 +)

Frontal Index anomaly

Solman & Orlanski, 2010 :

$$|\nabla T_{850}| \, x \, |\nabla \xi_{850}| \tag{1}$$

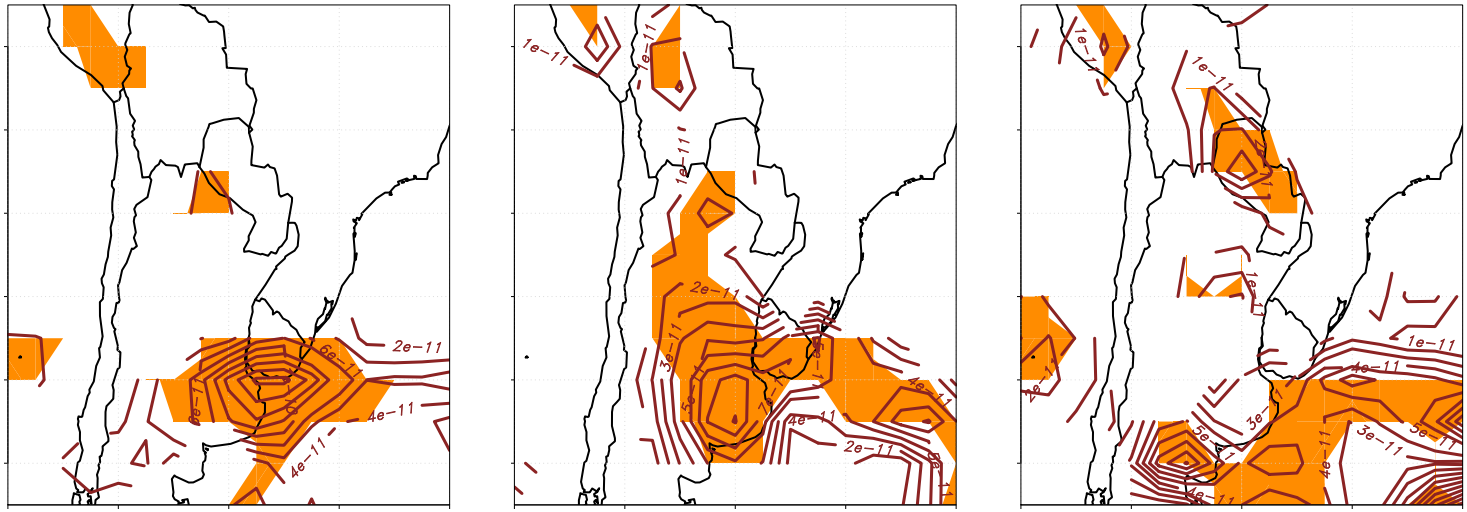

Figure 3: Day 0, Day -1, Day -2

- Cold front approaching from the south

Red group (PC1 +, PC2 +)

Latent heat anomaly, OLR anomaly

Red group (PC1 +, PC2 +)

Latent heat anomaly, OLR anomaly

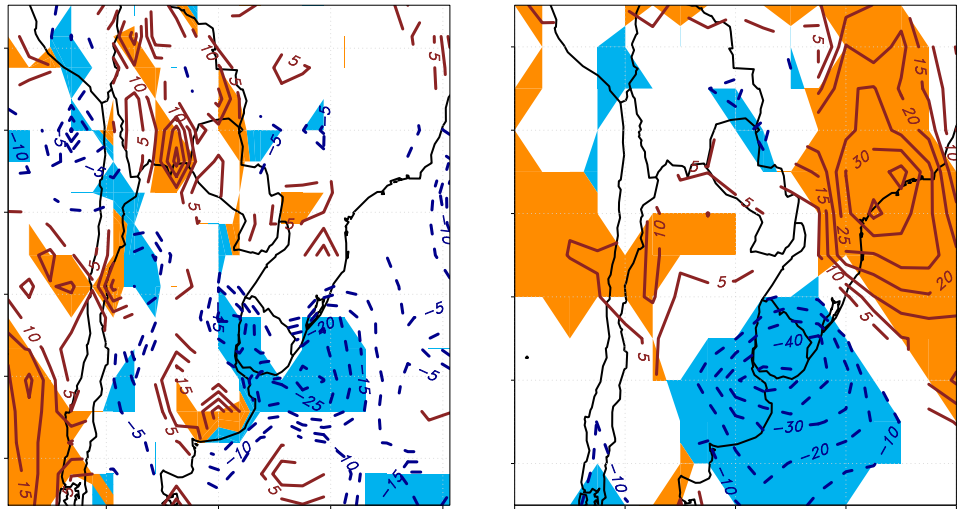

Figure 4: Day 0, Day 0

- Negative latent flux anomaly, indicating evaporation
- Negative OLR, indicating rainfall in all the country

Red group (PC1 +, PC2 +)

Why does it rain?

Red group (PC1 +, PC2 +)

Why does it rain?

- Atmospheric instability due to positive temperature anomaly

Red group (PC1 +, PC2 +)

Why does it rain?

- Atmospheric instability due to positive temperature anomaly
- Surface low pressure generating upward movement and condensation

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- Atmospheric instability due to positive temperature anomaly
- Surface low pressure generating upward movement and condensation
- Even more humidity due to evaporation

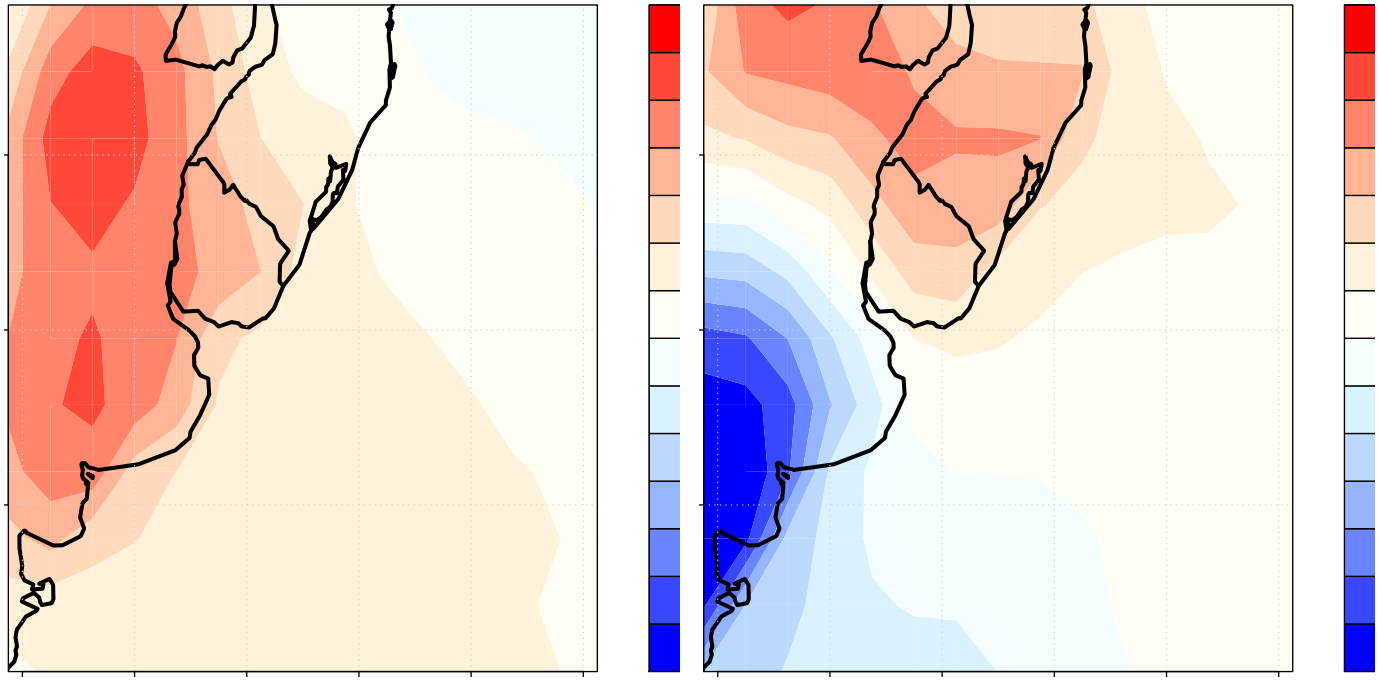
Red group (PC1 +, PC2 +)

Why does it rain?

- Atmospheric instability due to positive temperature anomaly
- Surface low pressure generating upward movement and condensation
- Even more humidity due to evaporation
- Frontal activity triggers the extreme rainfall event

Blue group (PC1 +, PC2 -)

Blue group (PC1 +, PC2 -)



Atmospheric instability

Blue group (PC1 +, PC2 -)

200 hPa geopotential height anomaly

Blue group (PC1 +, PC2 -)

200 hPa geopotential height anomaly

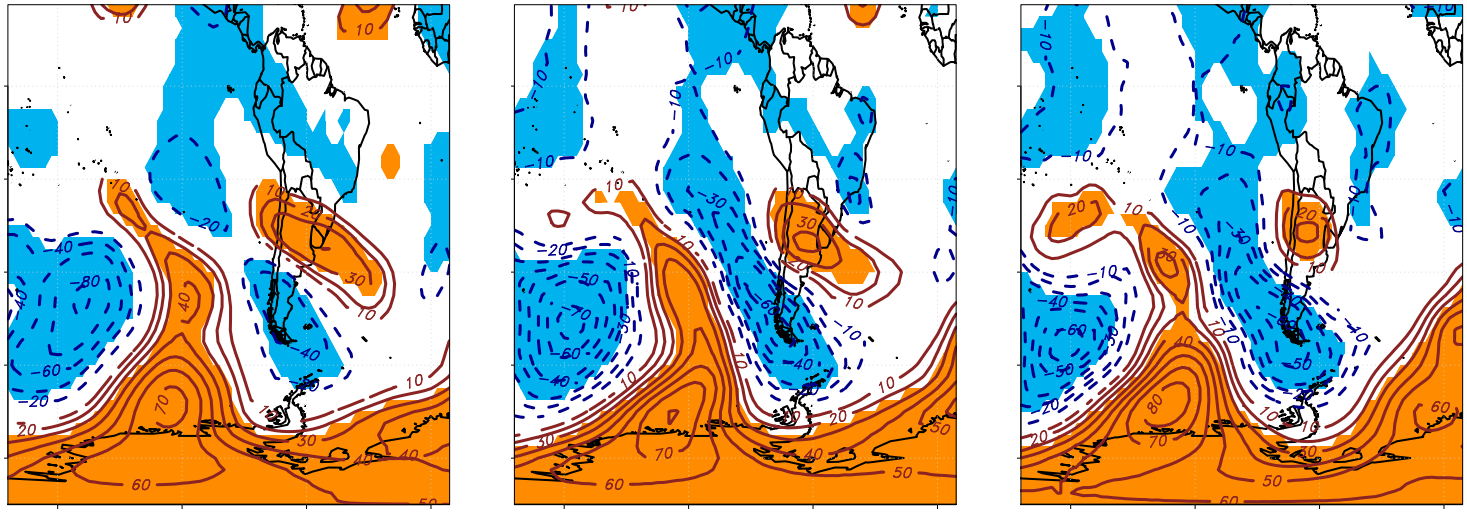


Figure 5: Day 0, Day -1, Day -2

- Stationary wave

Blue group (PC1 +, PC2 -)

1000 hPa geopotential height anomaly

Blue group (PC1 +, PC2 -)

1000 hPa geopotential height anomaly

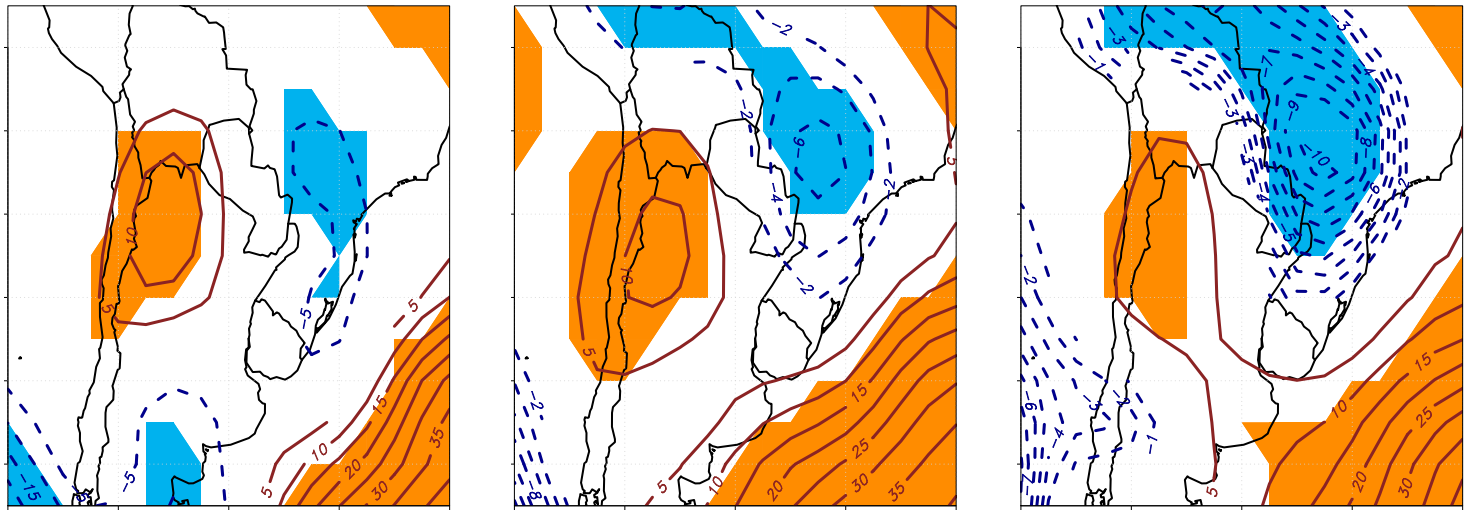


Figure 6: Day 0, Day -1, Day -2

- Blocking situation, caused by the stationary wave generating clear skies and preventing cold fronts from reaching the area

Blue group (PC1 +, PC2 -)

2 metre temperature anomaly

Blue group (PC1 +, PC2 -)

2 metre temperature anomaly

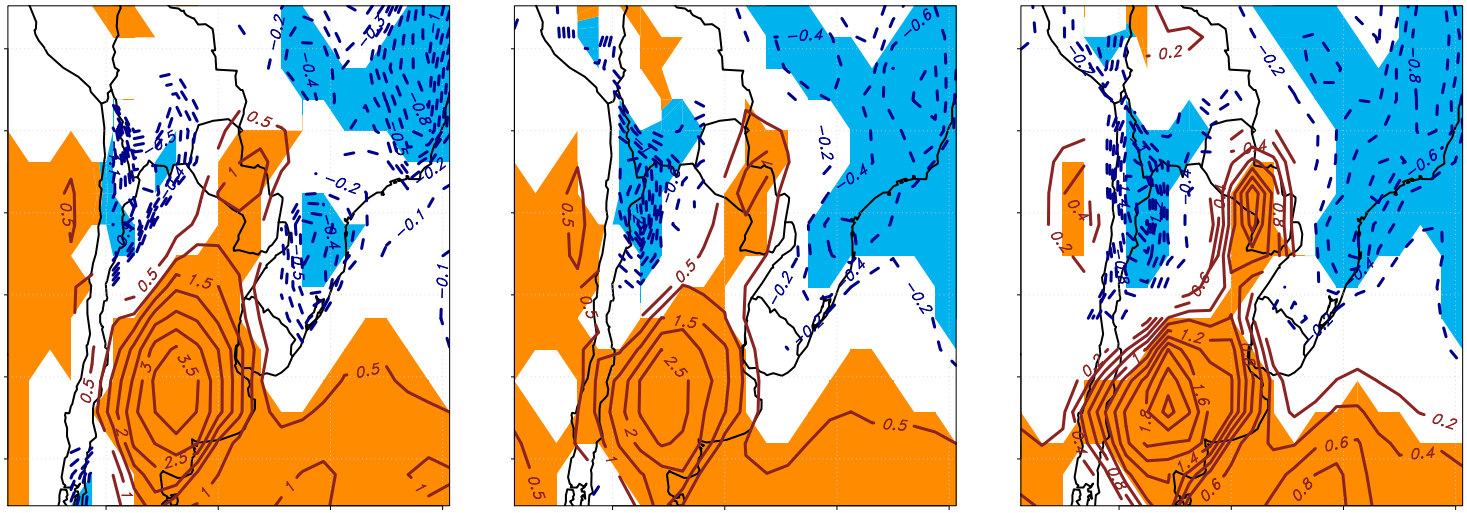


Figure 7: Day 0, Day -1, Day -2

- Positive temperature anomaly intensifying in the west of Uruguay

Blue group (PC1 +, PC2 -)

Heat flux anomaly

Blue group (PC1 +, PC2 -)

Heat flux anomaly

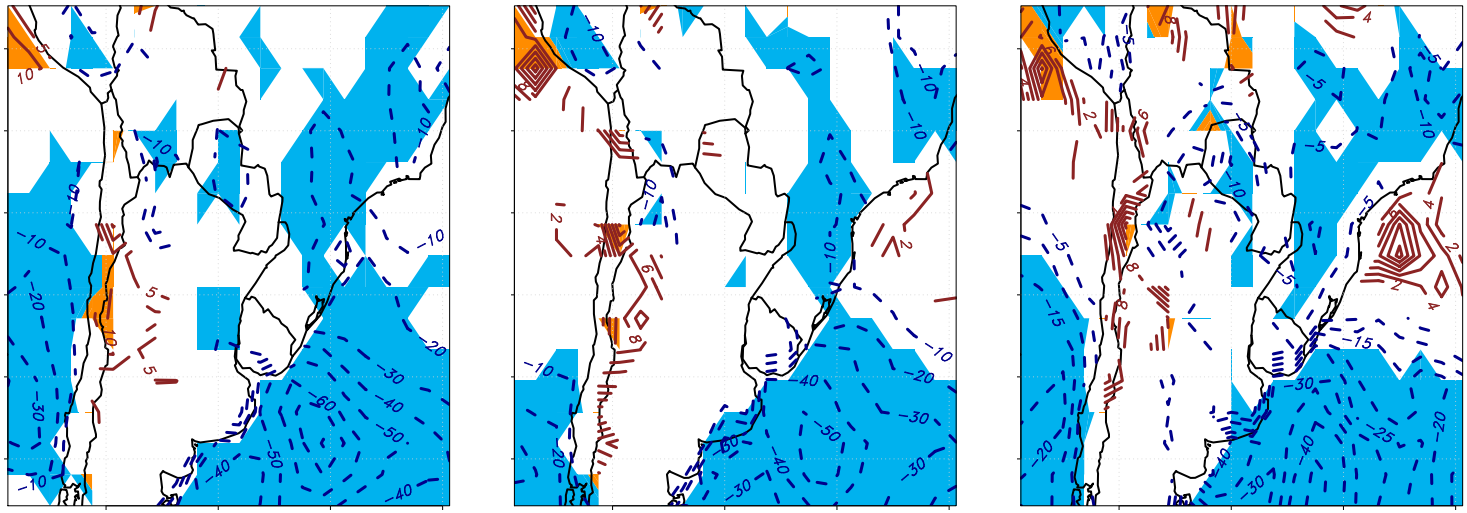


Figure 8: Day 0, Day -1, Day -2

- Heat transfer to the atmosphere, due to the clear sky, destabilizing the boundary layer

Blue group (PC1 +, PC2 -)

OLR anomaly

Blue group (PC1 +, PC2 -)

OLR anomaly

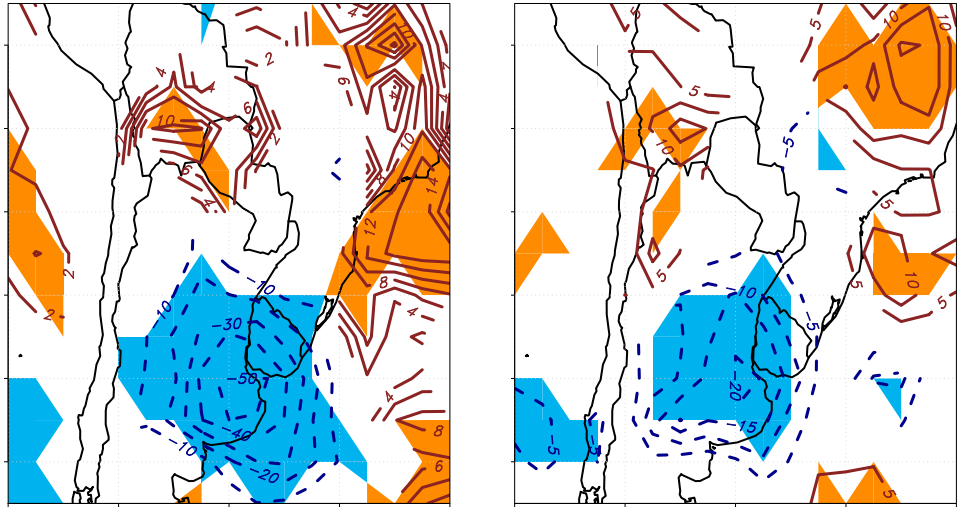


Figure 9: Day 0, Day -1

- Negative OLR anomaly in the west that approaches and instensifies

Blue group (PC1 +, PC2 -)

Why does it rain?

Blue group (PC1 +, PC2 -)

Why does it rain?

- Stationary wave associated with blocking episode

Blue group (PC1 +, PC2 -)

Why does it rain?

- Stationary wave associated with blocking episode
- High surface pressure favouring positive temperature anomalies and boundary layer destabilization

Blue group (PC1 +, PC2 -)

Why does it rain?

- Stationary wave associated with blocking episode
- High surface pressure favouring positive temperature anomalies and boundary layer destabilization
- Positive temperature anomalies in the west of Uruguay, generating atmospheric instability

Blue group (PC1 +, PC2 -)

Why does it rain?

- Stationary wave associated with blocking episode
- High surface pressure favouring positive temperature anomalies and boundary layer destabilization
- Positive temperature anomalies in the west of Uruguay, generating atmospheric instability
- Deep convective activity in the west of Uruguay that reaches the area

Violet group (PC1 -, PC2 +)

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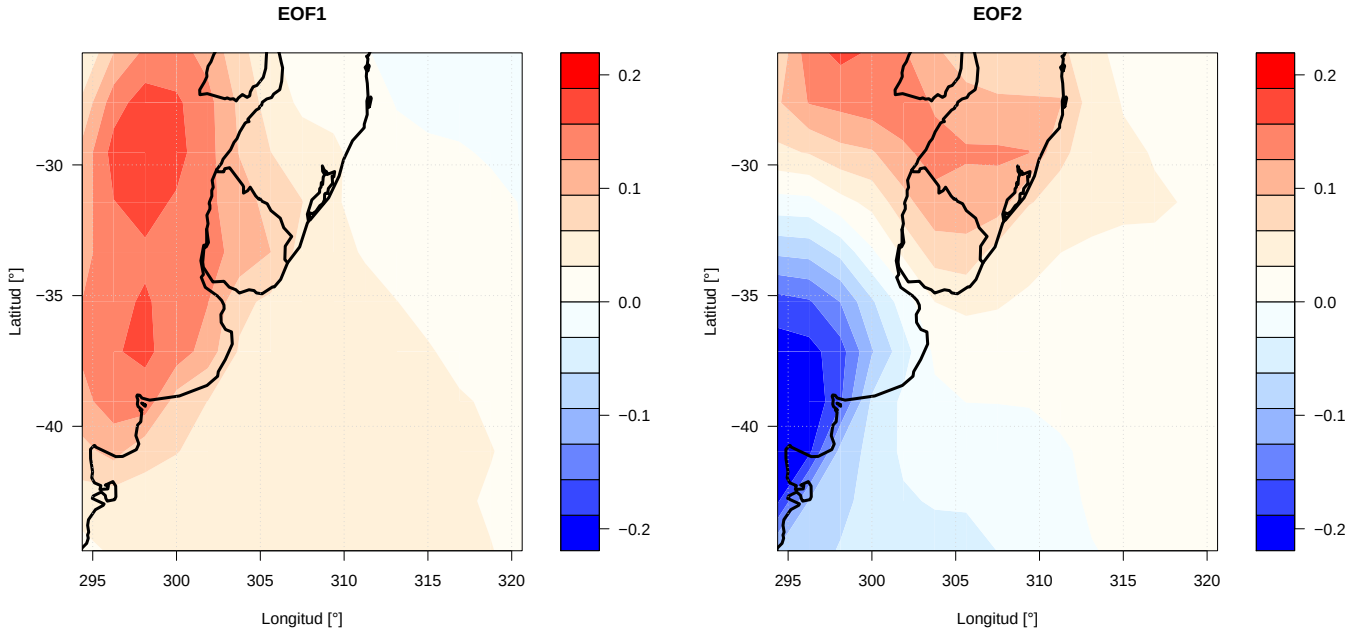

Frontal activity

Violet group (PC1 -, PC2 +)

200 hPa geopotential divergence

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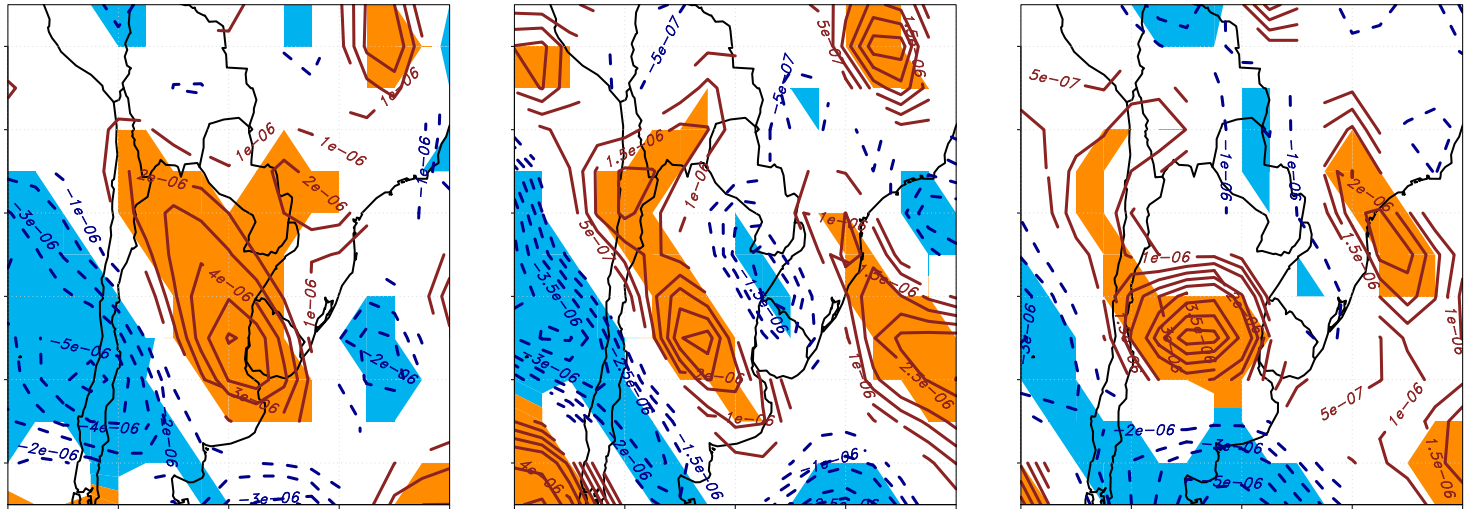

Figure 10: Day 0, Day -1, Day -2

- Positive divergence favouring upward movements

Violet group (PC1 -, PC2 +)

1000 hPa geopotential height anomaly

Violet group (PC1 -, PC2 +)

1000 hPa geopotential height anomaly

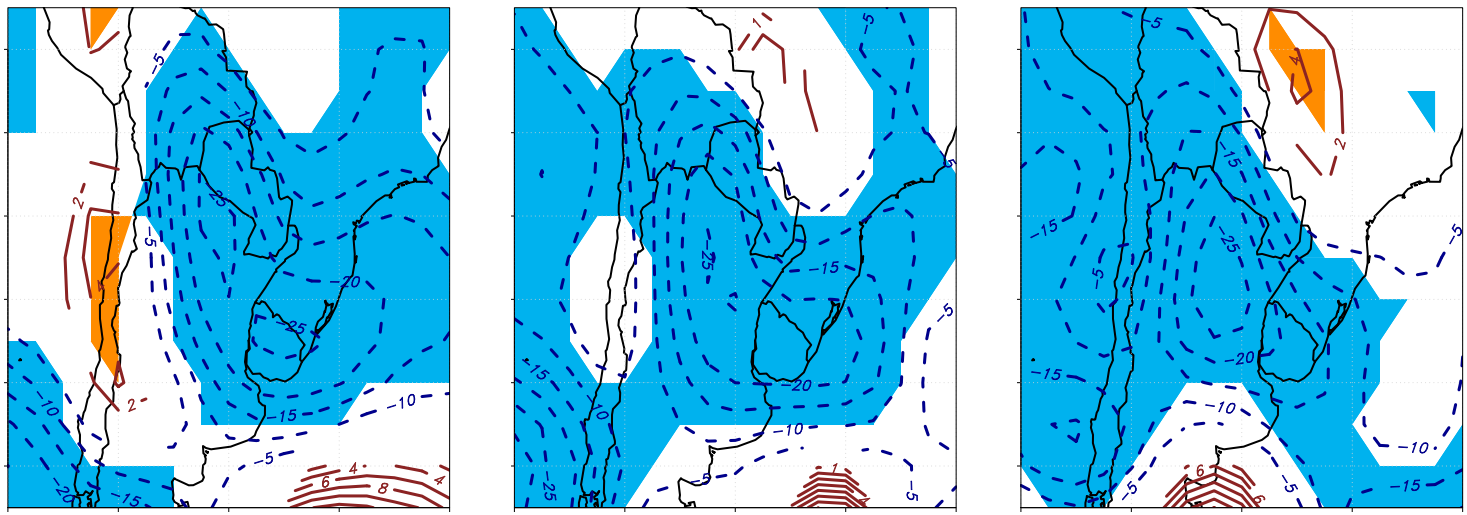

Figure 11: Day 0, Day -1, Day -2

- Low pressure favouring upward movement

Violet group (PC1 -, PC2 +)

850 hPa divergence

Violet group (PC1 -, PC2 +)

850 hPa divergence

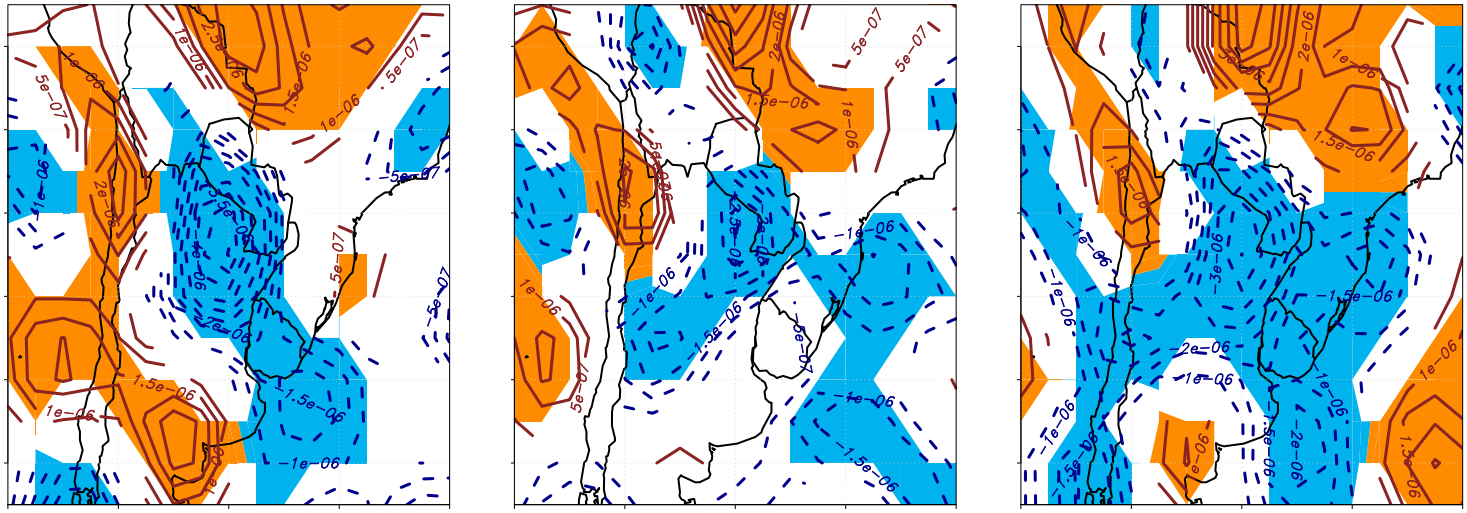

Figure 12: Day 0, Day -1, Day -2

- Negative divergence, indicating humidity advection

Violet group (PC1 -, PC2 +)

OLR anomaly

Violet group (PC1 -, PC2 +)

OLR anomaly

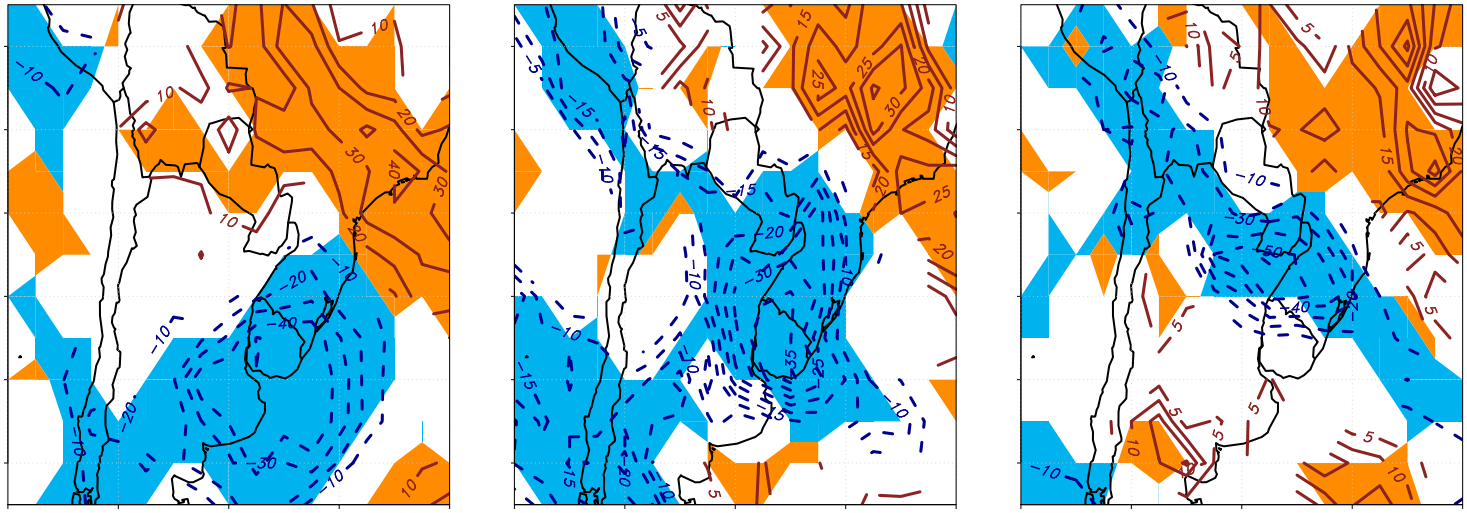

Figure 13: Day 0, Day -1, Day -2

- Negative OLR anomaly, indicating rainfall

Violet group (PC1 -, PC2 +)

Why does it rain?

Violet group (PC1 -, PC2 +)

Why does it rain?

- 200 hPa divergence favouring upward movements

Violet group (PC1 -, PC2 +)

Why does it rain?

- 200 hPa divergence favouring upward movements
- Low surface pressure favouring upward movements

Violet group (PC1 -, PC2 +)

Why does it rain?

- 200 hPa divergence favouring upward movements
- Low surface pressure favouring upward movements
- Humidity advection

Conclusions

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- Red extremes are characterized by a combination of atmospheric instability, evaporation and frontal activity in Uruguay
- Blue extremes are characterized by a instable boundary layer in Uruguay and deep convective activity approaching from the west
- Violet extremes are characterized by a combination of low surface pressure and humidity advection

Final conclusion

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Questions? Suggestions?