



Universidade de Brasília

Departamento de Engenharia Civil e Ambiental

# Identification and Analysis of Storm Tracks Associated with Extreme Flood Events in Southeast and South Brazil

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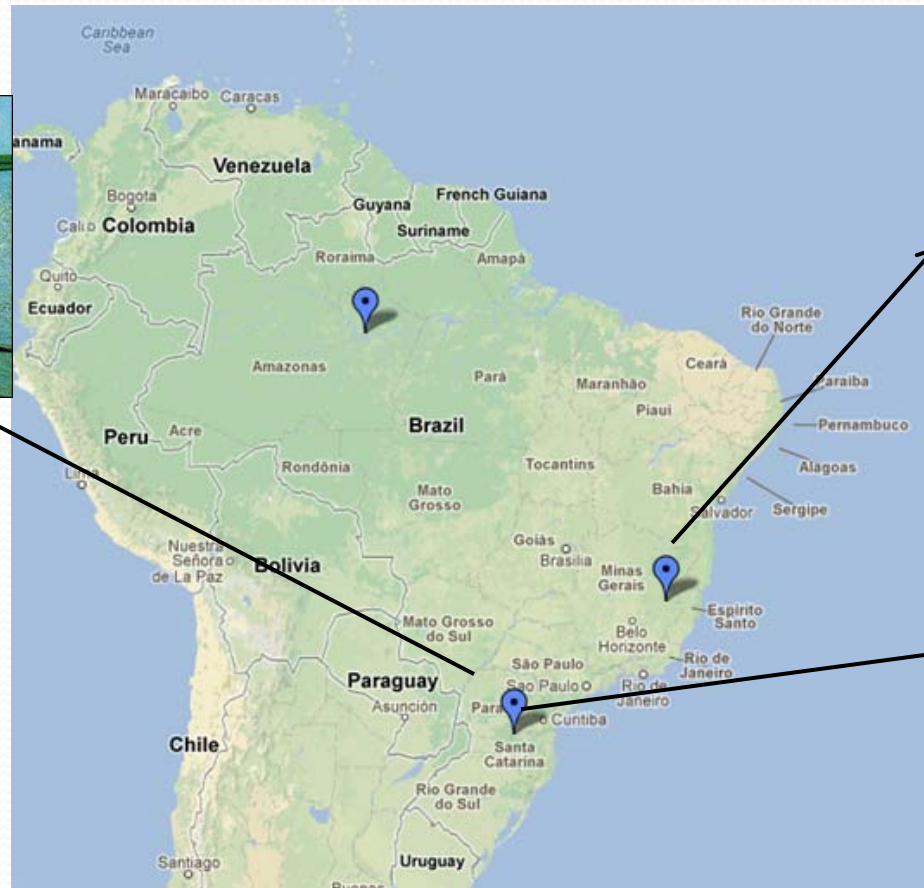
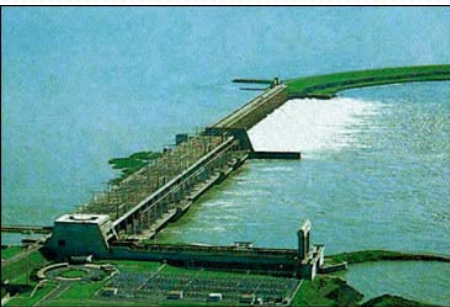
# Key Points

- Randomness of the flood event and iid (independent and identically distributed data) assumption in traditional flood frequency analysis (FFA);
- But for a certain region, particularly large basins, can we think about a physical theory to explain the extreme floods conditioned on the evolution of the associated climate system? A causal chain?
- If yes → Formal consideration in the models of the physical mechanisms responsible for the generation of extreme floods → recognize the natural climate variability in many temporal scales (interannual, decadal, etc), and fluctuations in response to anthropogenic changes in the atmosphere, soil use and vegetation cover;
- Main goal of this work: advance the traditional studies of FFA by using the ideas from the flood hydroclimatology field → (extreme) floods as the result of the interaction between regional and global patterns of atmospheric and ocean circulation;
- Long term goal: develop a model for non-stationary prediction and simulation of floods conditioned on the climate state.

# Methodology

Step 1: Identification of extreme flood events (10-20 biggest ones) in flood-prone regions of Brazil:

**Jupia reservoir**  
**Parana Basin**  
**( $A = 476800 \text{ km}^2$ )**



**Rio Doce Basin**  
**( $A = 40500 \text{ km}^2$ )**



**Cities of Porto União**  
**and União da Vitória**  
**Iguaçu basin ( $A = 24200 \text{ km}^2$ )**

**La Plata Basin**

# Methodology

Step 2: *Storm* tracks associated with the biggest flood events:

- NCEP/NCAR and 20<sup>th</sup> century V2 reanalysis data
- 850, 800, 700 and 600 mb levels
- Days 0 to -9
- 6 hours data

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**WRIT Trajectory Tool**

**Help**  
Instructions  
Datasets and variables  
Caveats

**Other WRIT Tools**  
WRIT Monthly Timeseries Tool  
WRIT Monthly Mapping Tool  
Background Information

### Web-based Trajectory Tool

Plot a trajectory: **Please try out this page and let us know what you think.** We plan to improve the plotting capabilities as well as add more functionality such as multiple initial levels or locations. The code used to calculate the trajectories is kindly supplied by the University of Melbourne and details are on their [Parcel Trajectory Software Home Page](#).

**Trajectory Options:**

**Dataset?**

**Enter start date to end date (YYYY MM DD HH to YYYY MM DD HH) e.g. 1989 2 1 18.**

For backwards, end date should be higher than start. You are currently limited to 60 time steps or about 15 days. HH should be 00,06,12, or 18

YYYY  MM  DD  HH

To

YYYY  MM  DD  HH

1000mb  
925mb  
850mb  
800mb

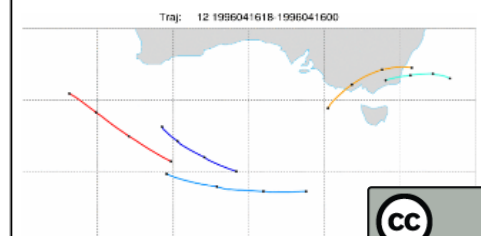


The  
University of  
Melbourne



**Parcel  
Trajectory  
Software  
Home Page**

**3D 3-day trajectories**



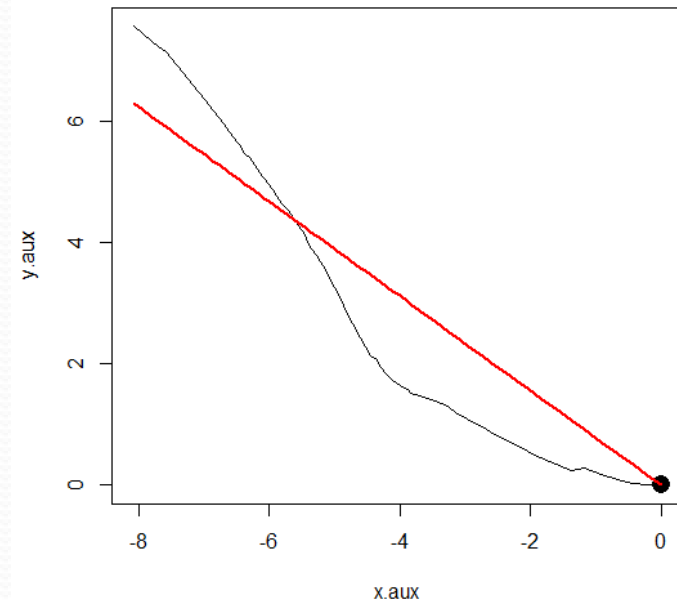


# Methodology

Step 3: Can we think about a way to cluster the flood events based on the synoptic atmospheric circulation patterns?

One possibility: K-means clustering of trajectories based on their attributes:

1. Average velocity
2. Geographical location of moisture source (day -5)
3. Average trajectory slope entering the basin (from day -3):



# Methodology

Step 4: Climatology (flood season) of moisture integrated fluxes and divergence field (E-P) from Reanalysis data (NCEP/NCAR and 20<sup>th</sup> century V2);

Step 5: Flood statistics associated with each trajectory cluster;

Step 6: For the cluster of the biggest flood events (if any):

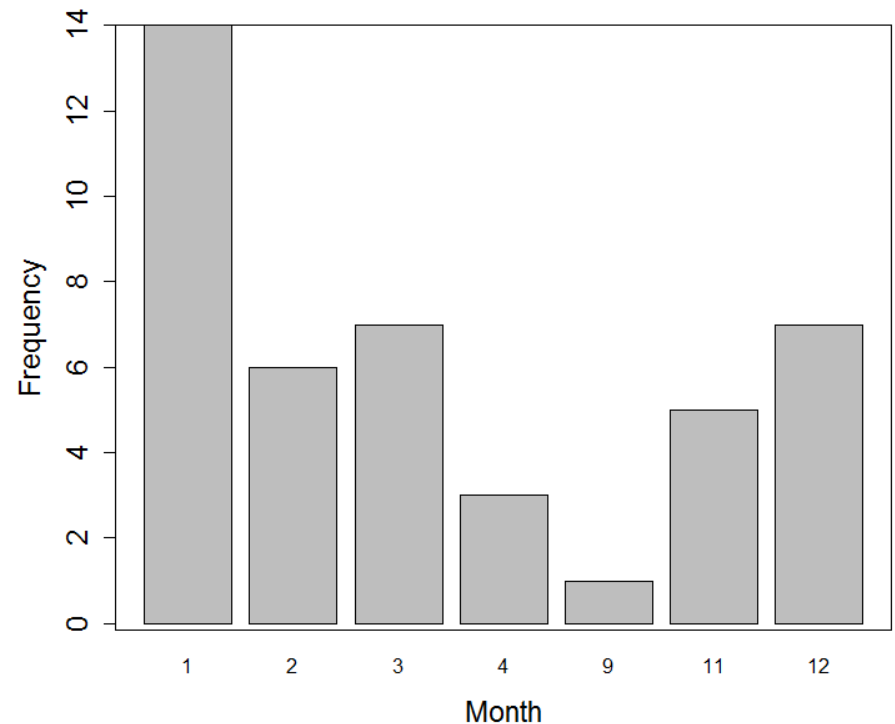
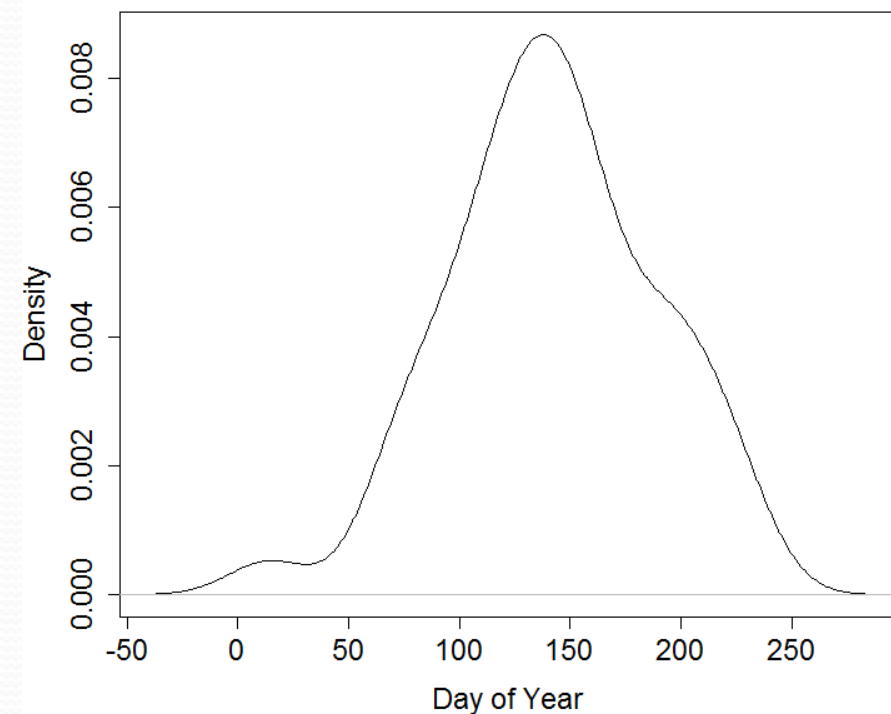
- Integrated moisture flux (from Reanalysis data) for days -1 to -5 of the event;

- Composite analysis of synoptic fields: SST, SLP, GH, temperature, OLR, soil moisture, etc;

Step 7: See if any significant pattern emerges.

# Results – Rio Doce basin

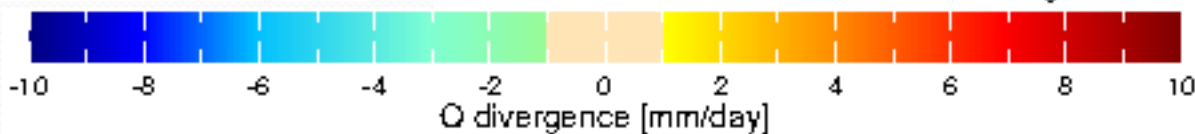
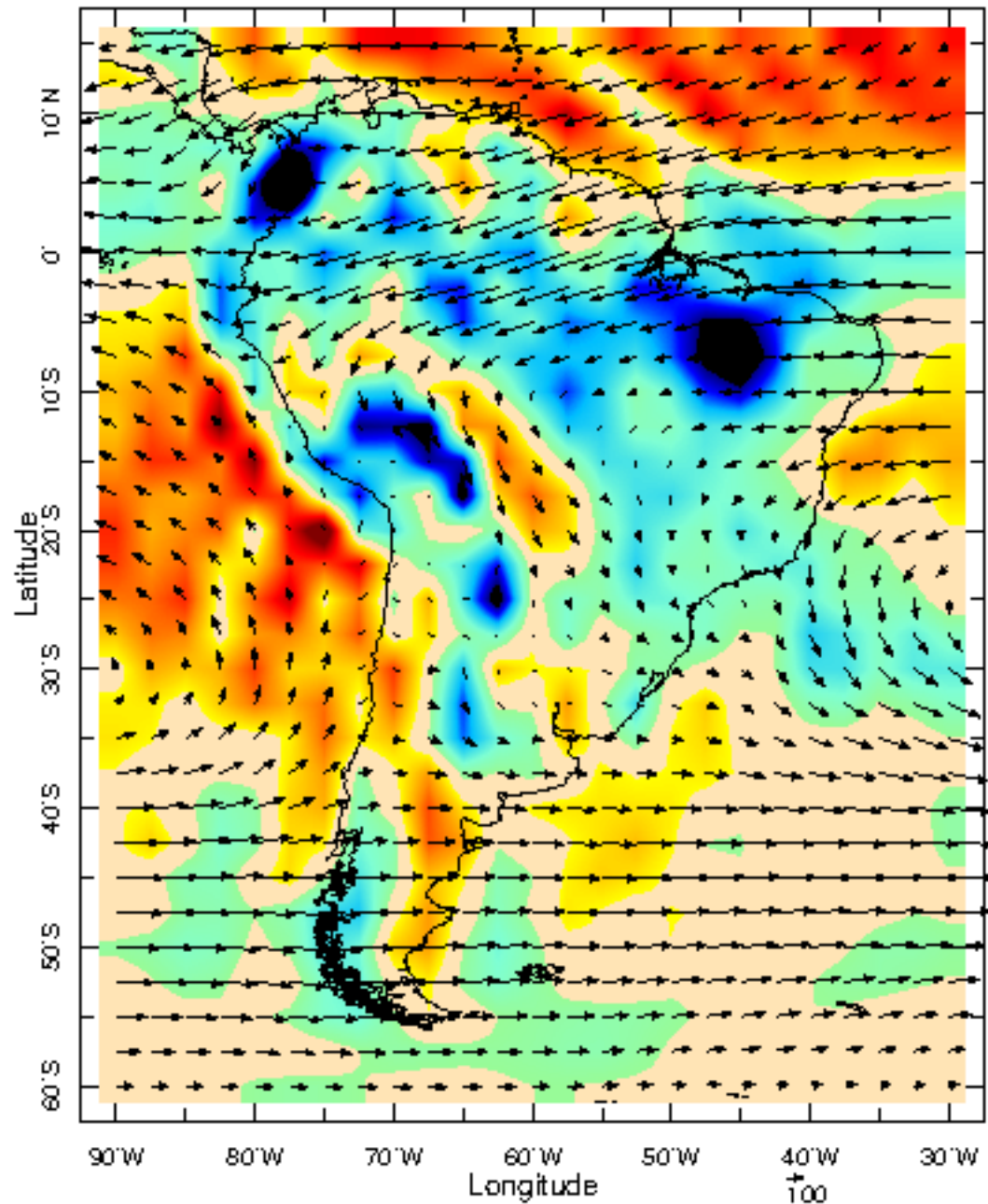
Timing of flood peak based on daily flow data from Jan/1965 to Dec/2005 (data from ANA)



# Results

## Rio Doce basin

Moisture integrated flux and divergence for the Dec-Mar period from NCEP-NCAR Reanalysis



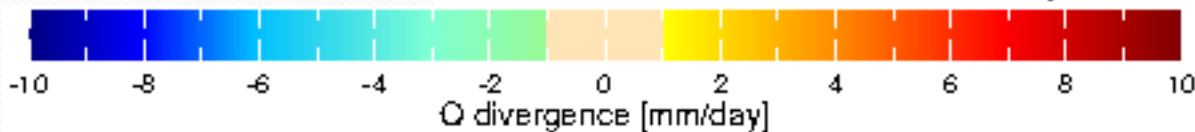
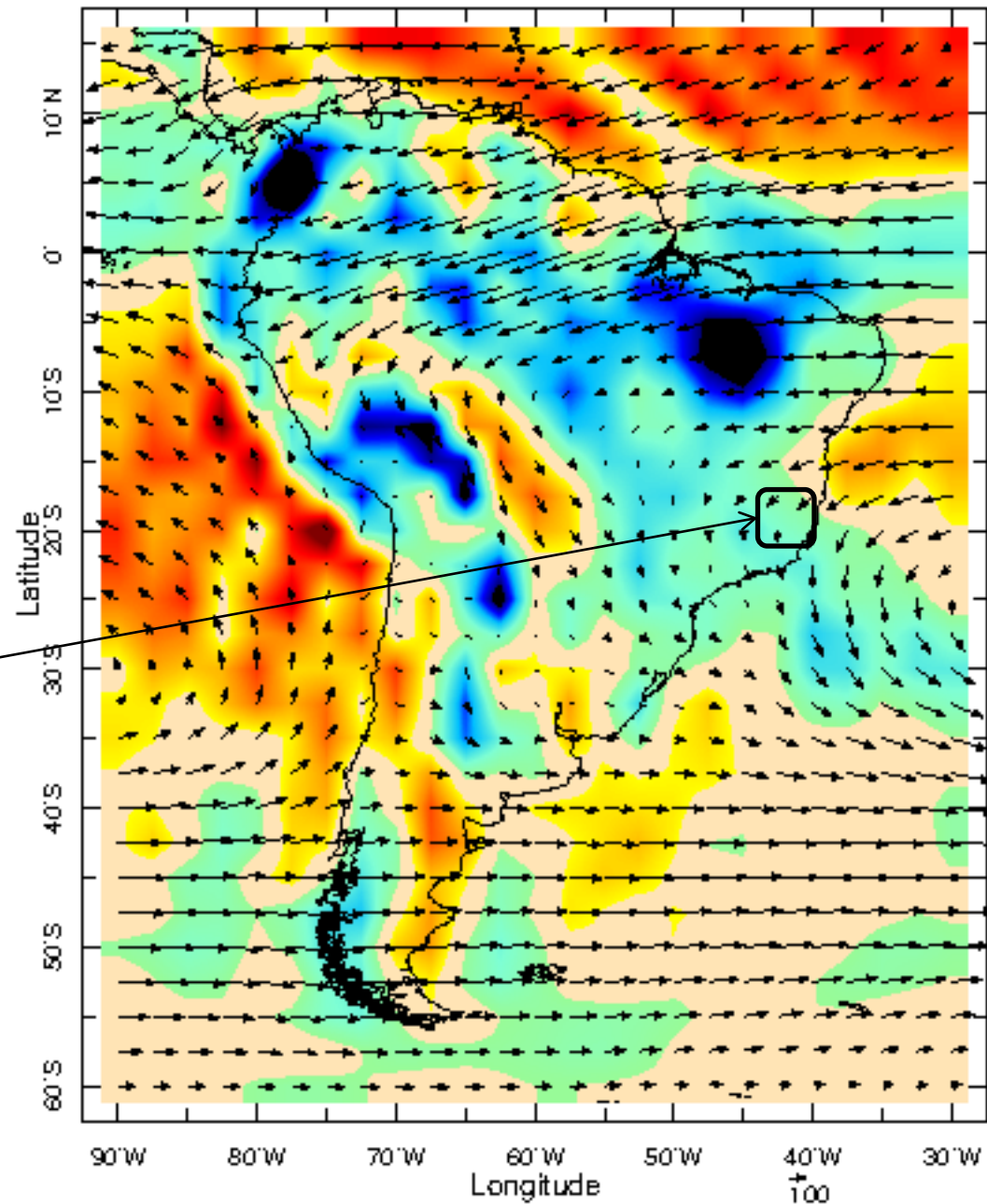


# Results

## Rio Doce basin

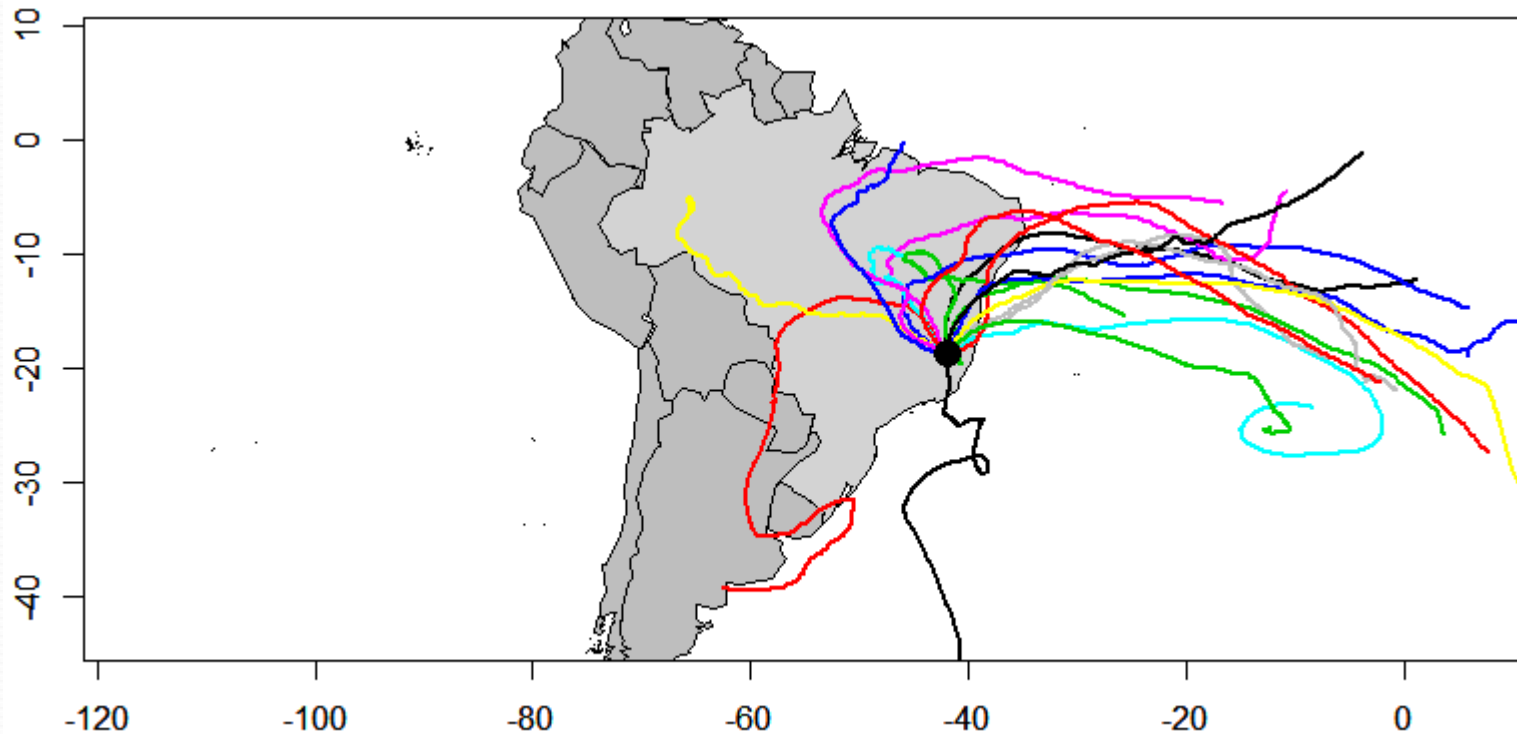
Moisture integrated flux and divergence for the Dec-Mar period from NCEP-NCAR Reanalysis

On average, moisture fluxes come from South Atlantic



# Results – Rio Doce basin

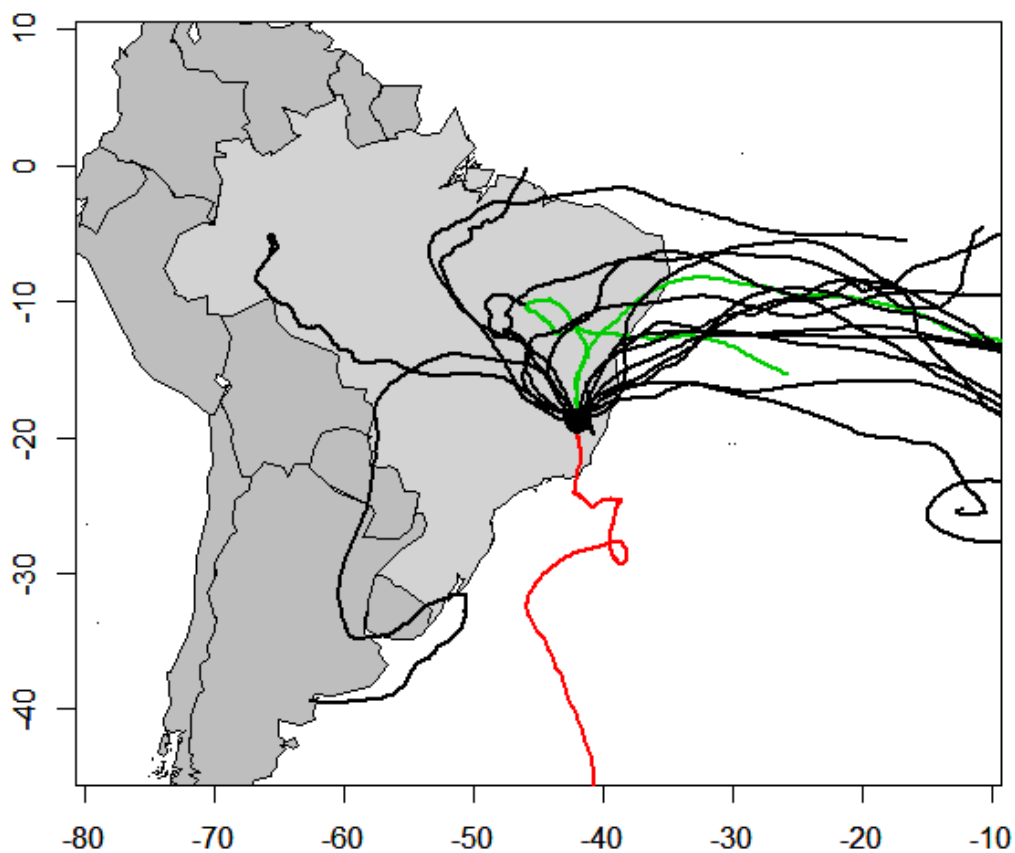
Tracks associate with the 20 biggest flood events  
850 mb level



# Results – Rio Doce basin

Clustering of trajectories

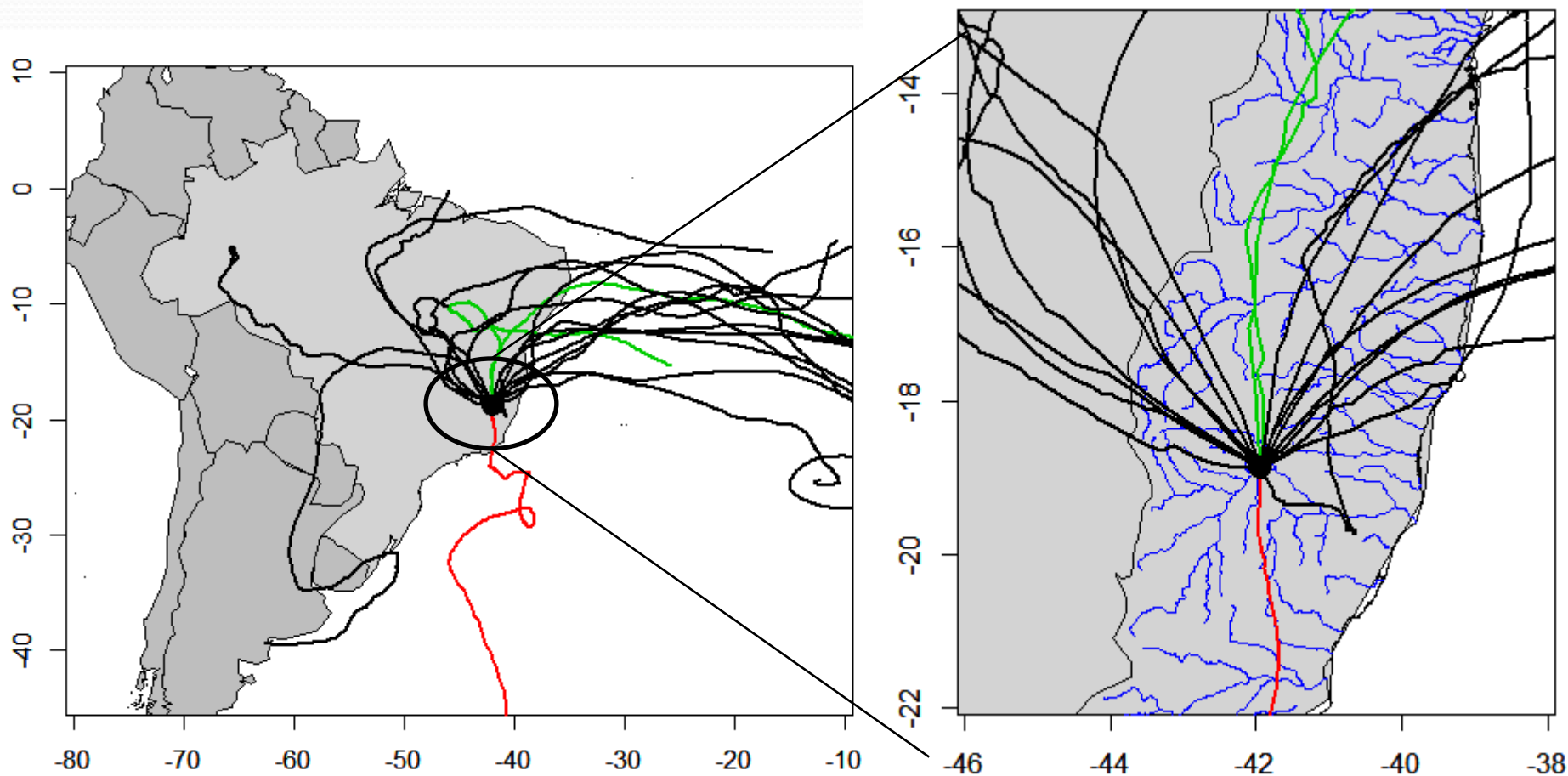
850 mb level



# Results – Rio Doce basin

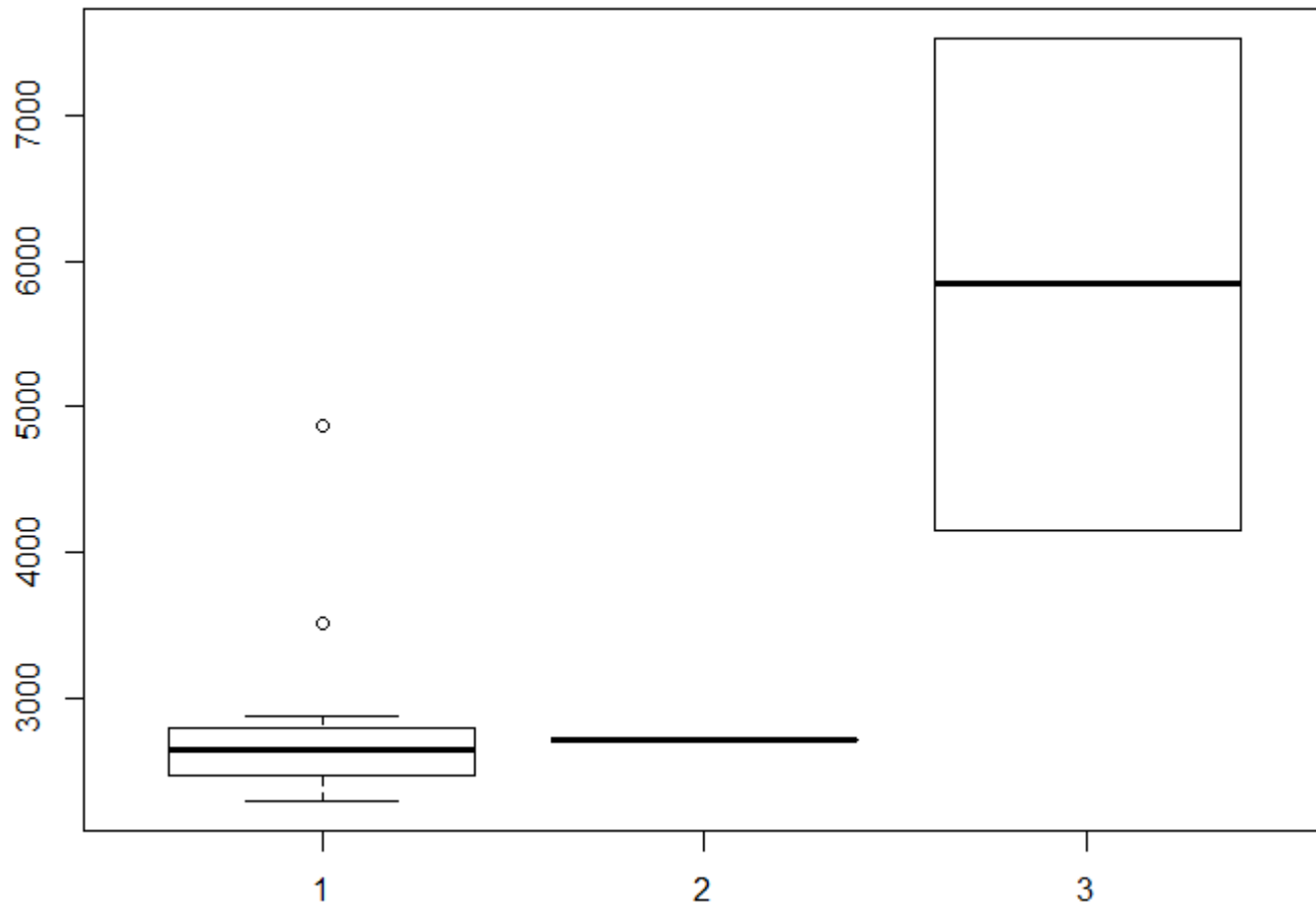
Clustering of trajectories

850 mb level



# Results – Rio Doce basin

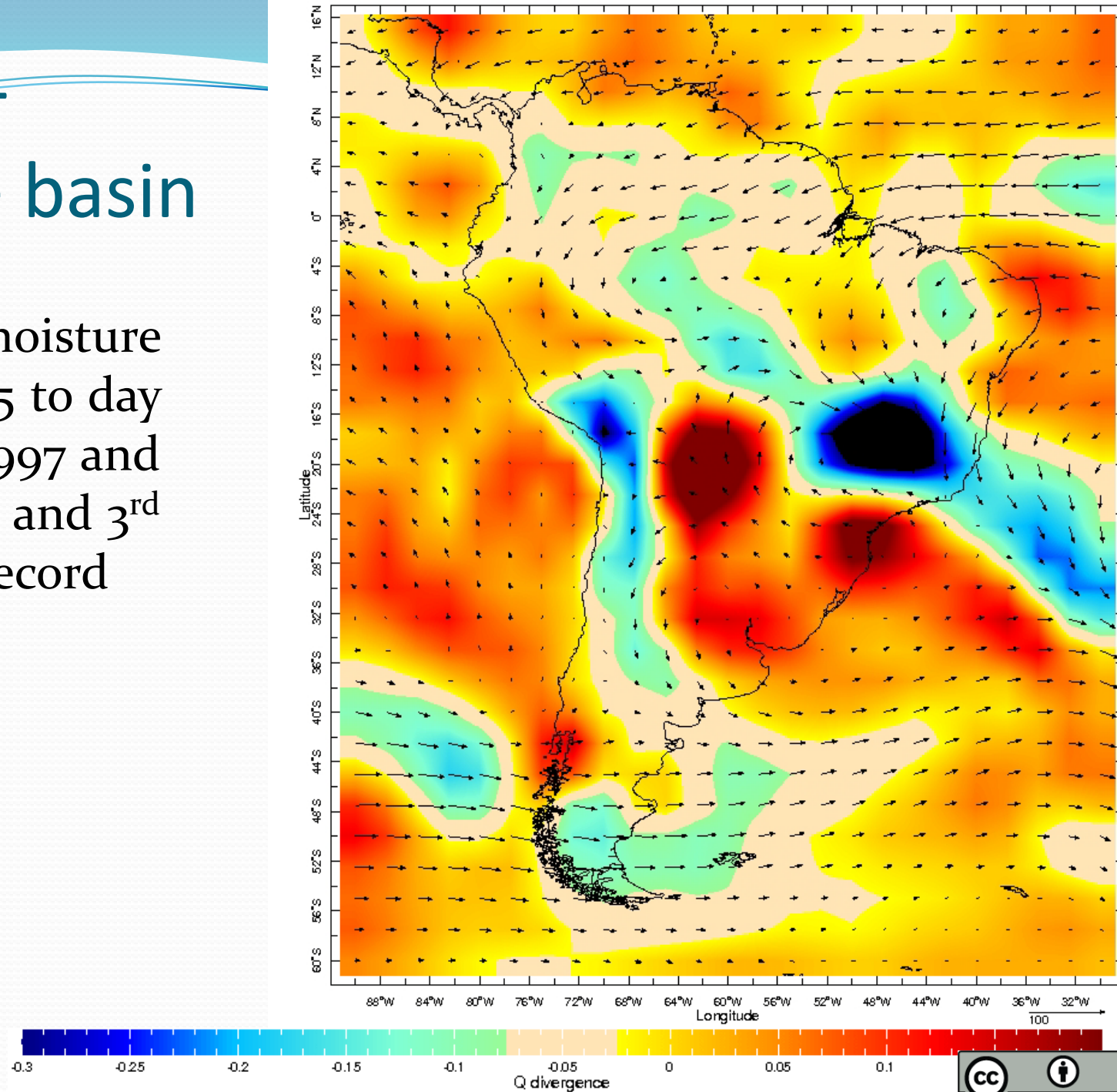
## Clustering of flows and volume





# Results – Rio Doce basin

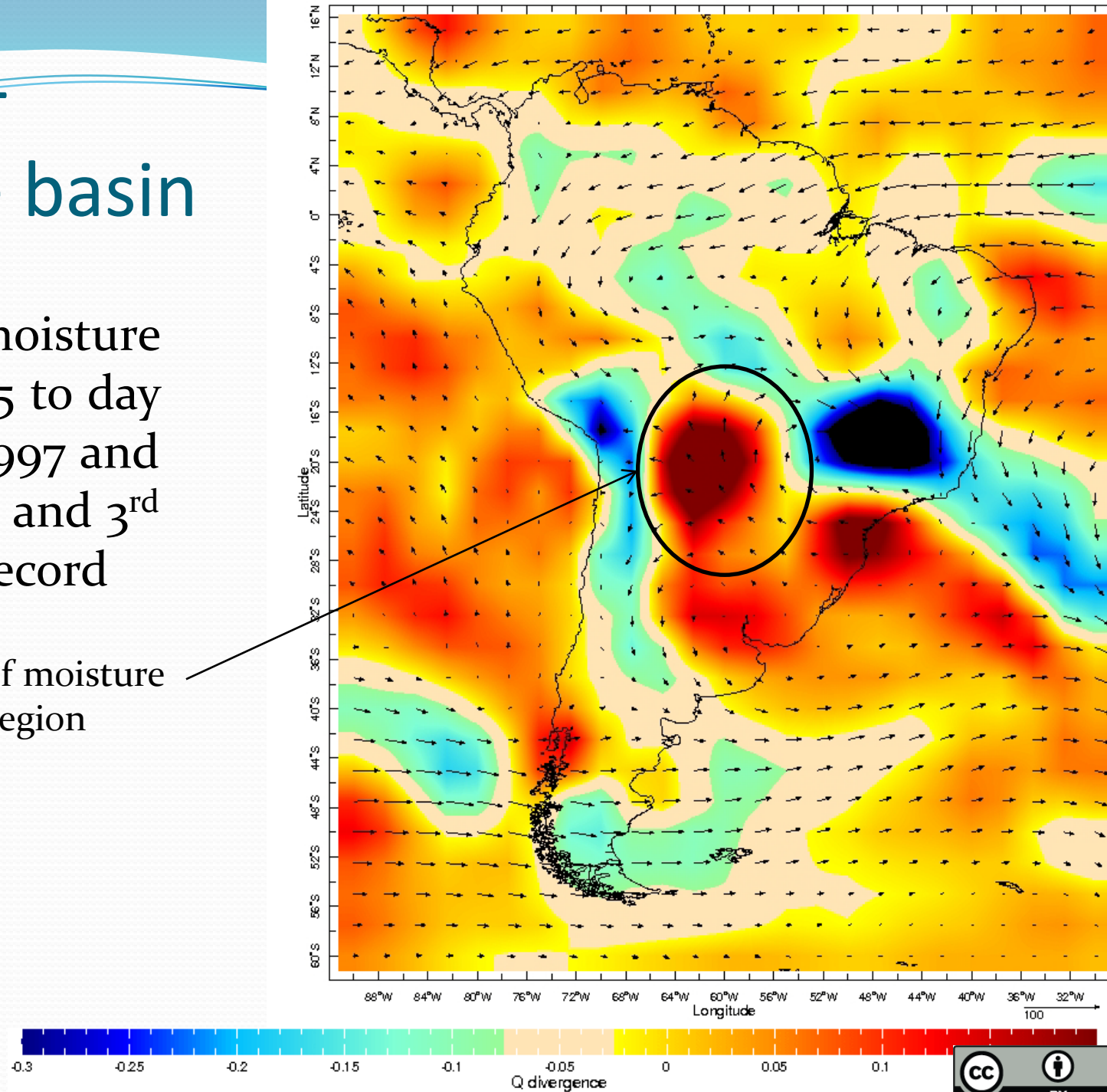
Integrated moisture  
flux for day -5 to day  
-1 of 05 Jan 1997 and  
2 Feb 1979: 1<sup>st</sup> and 3<sup>rd</sup>  
in the flood record



# Results – Rio Doce basin

Integrated moisture  
flux for day -5 to day  
-1 of 05 Jan 1997 and  
2 Feb 1979: 1<sup>st</sup> and 3<sup>rd</sup>  
in the flood record

Strong divergence of moisture  
from the Pantanal region  
(wetland)

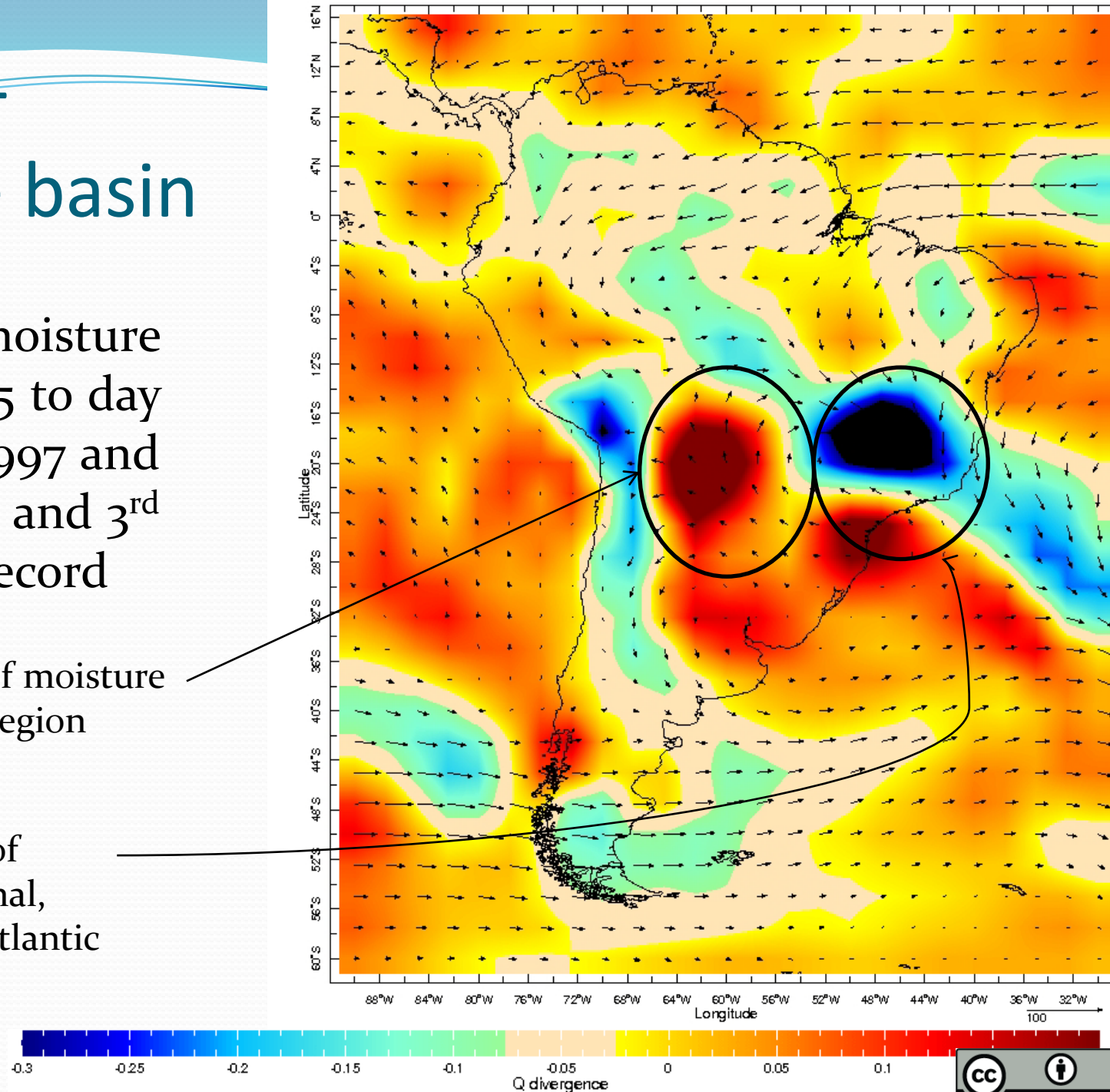


# Results – Rio Doce basin

Integrated moisture  
flux for day -5 to day  
-1 of 05 Jan 1997 and  
2 Feb 1979: 1<sup>st</sup> and 3<sup>rd</sup>  
in the flood record

Strong divergence of moisture  
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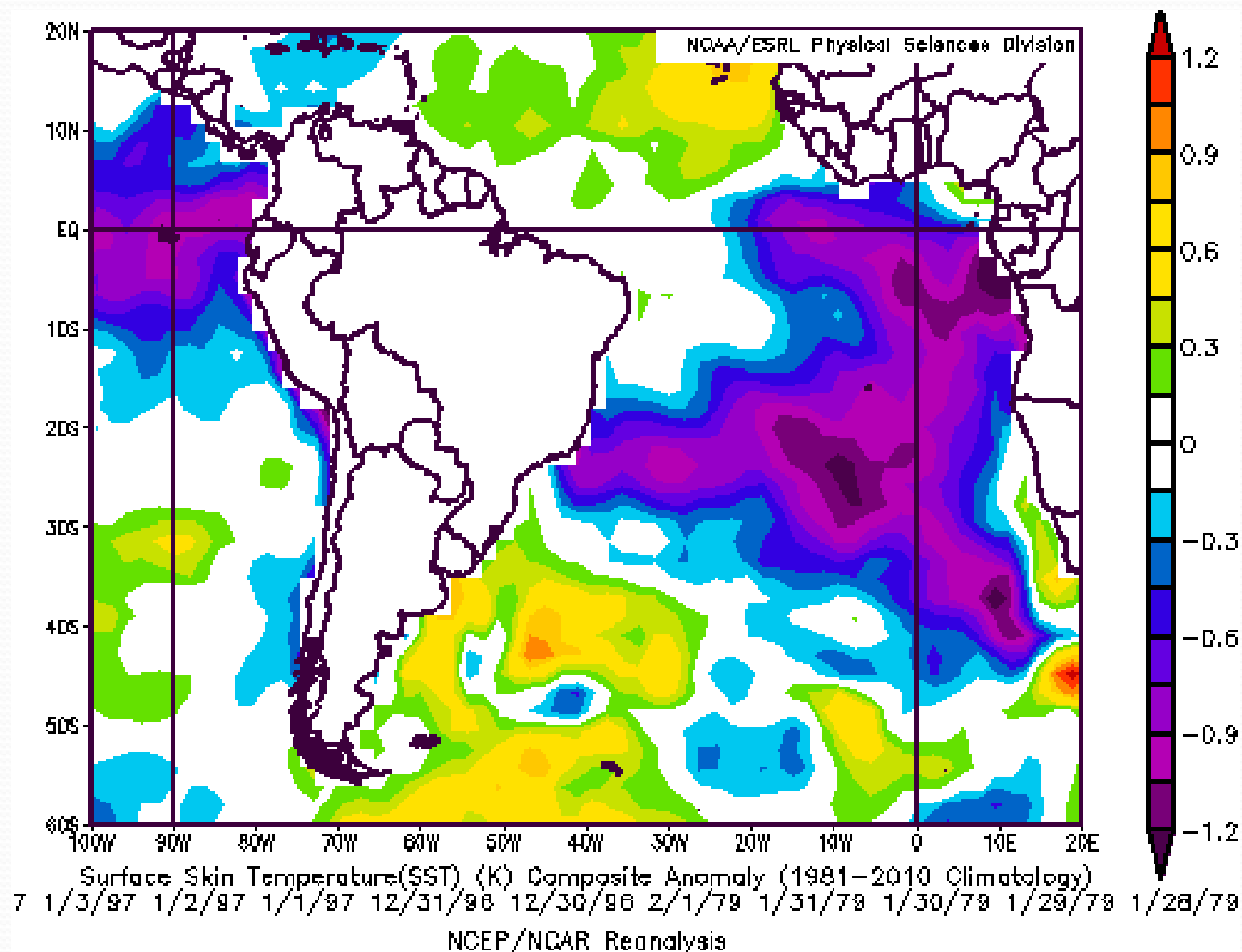
Strong convergence of  
moisture from Pantanal,  
Amazon and South Atlantic





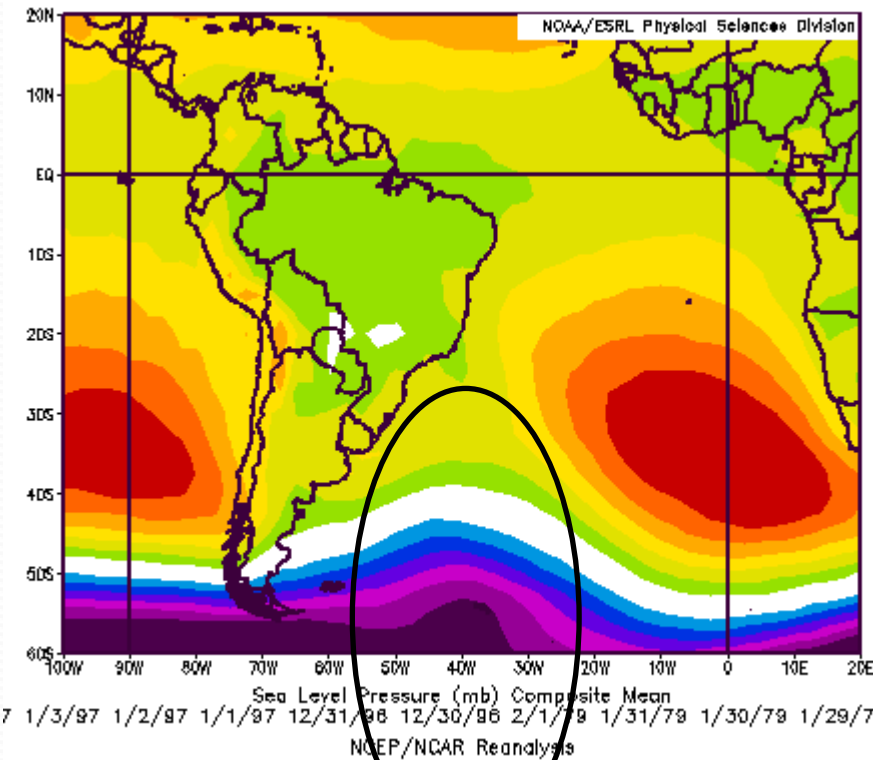
# Results – Rio Doce basin

## Composite Analysis: SST

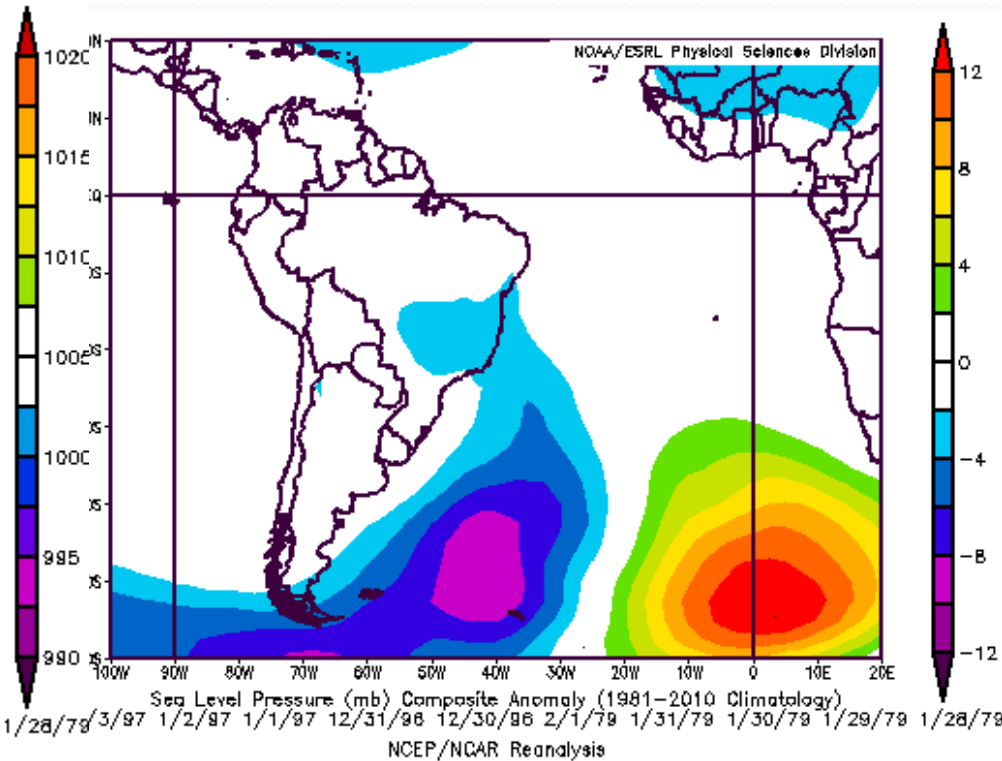


# Results – Rio Doce basin

## Composite Analysis: SLP field (mean and anomaly)



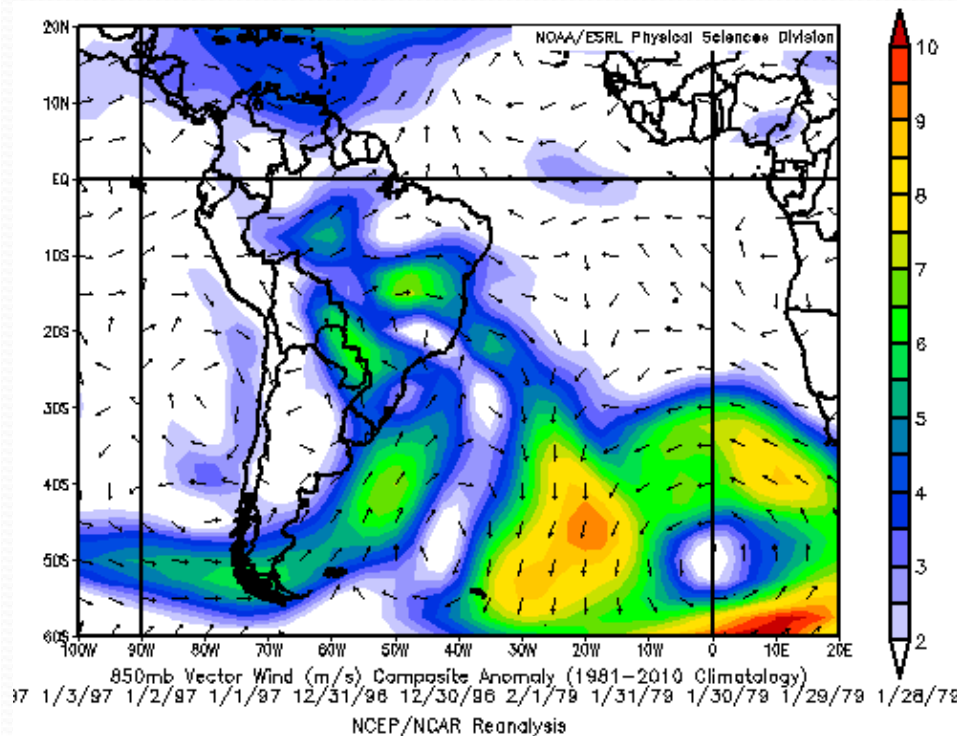
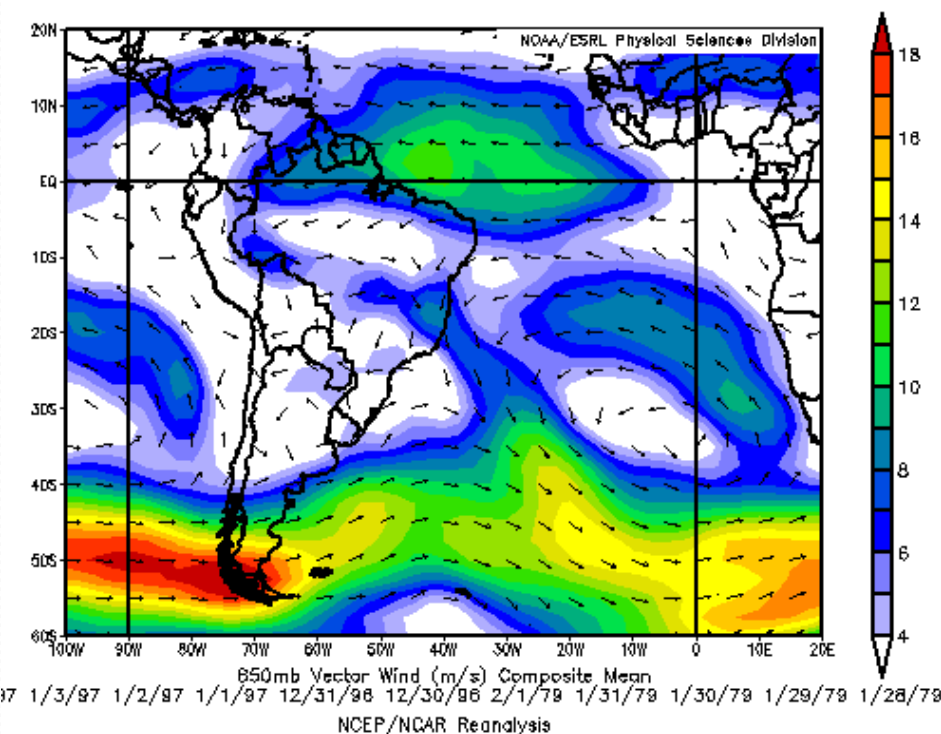
trough





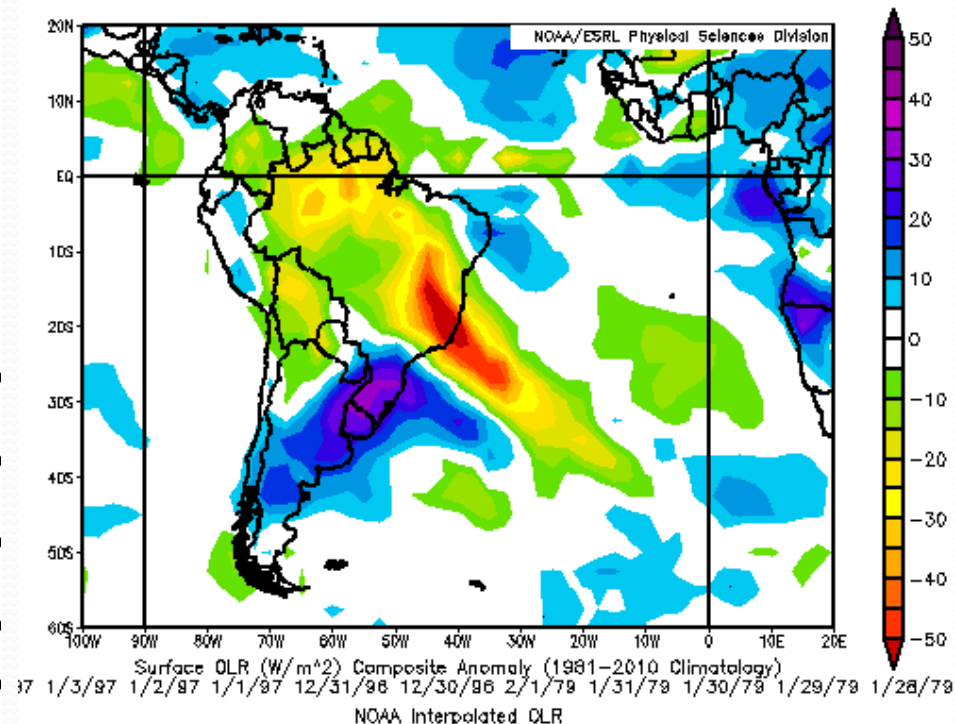
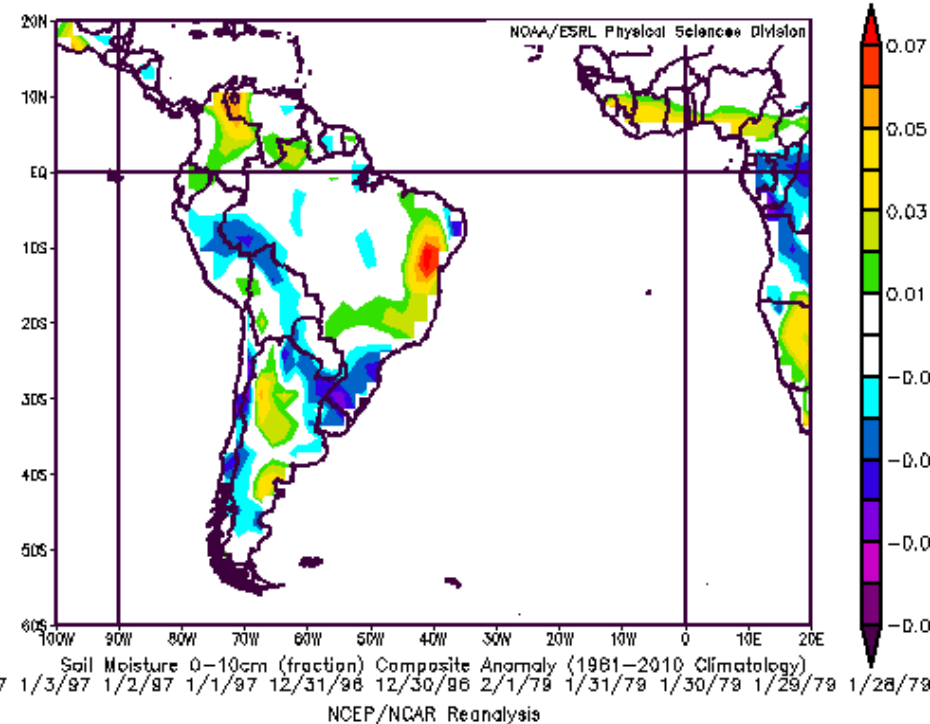
# Results – Rio Doce basin

## Composite Analysis: Low level wind vector



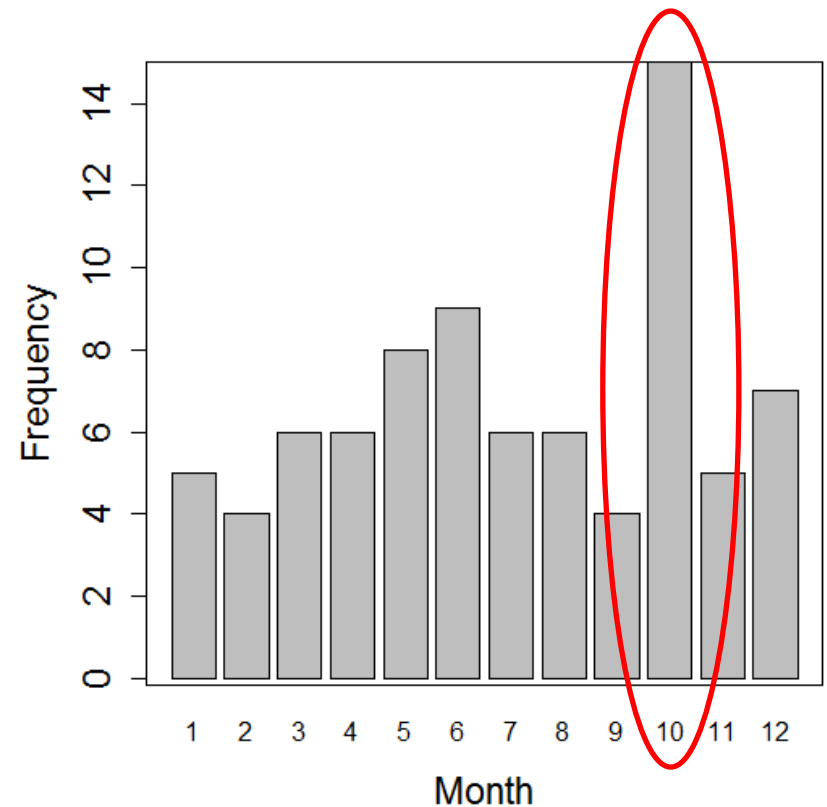
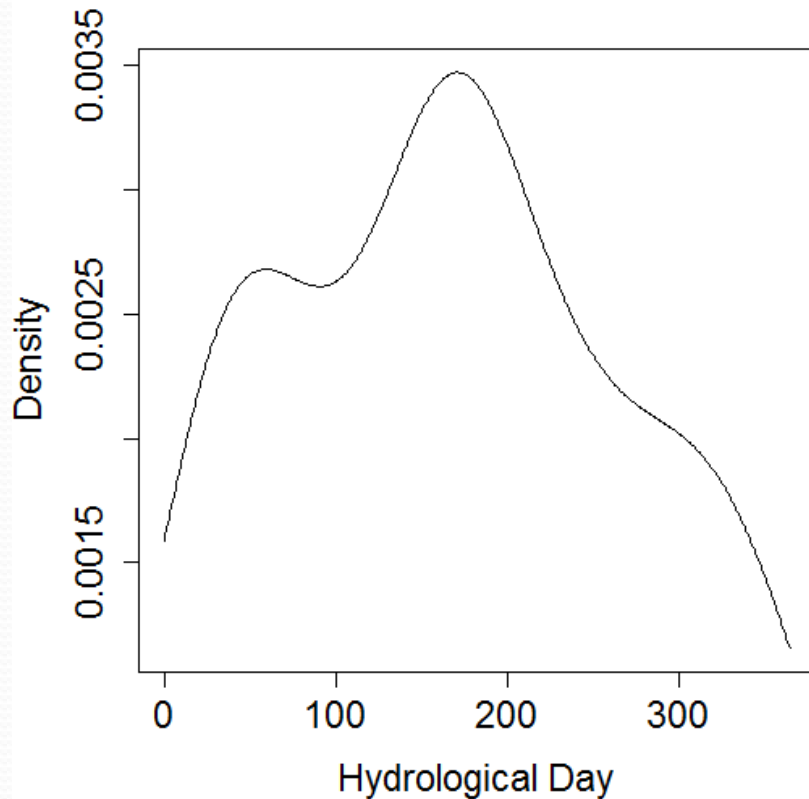
# Results – Rio Doce basin

## Composite Analysis: Soil Moisture and OLR



# Results – Porto Uniao City (Parana basin)

Timing of flood peak based on daily flow data from Jan/1930 to Dec/2011 (data from ANA)

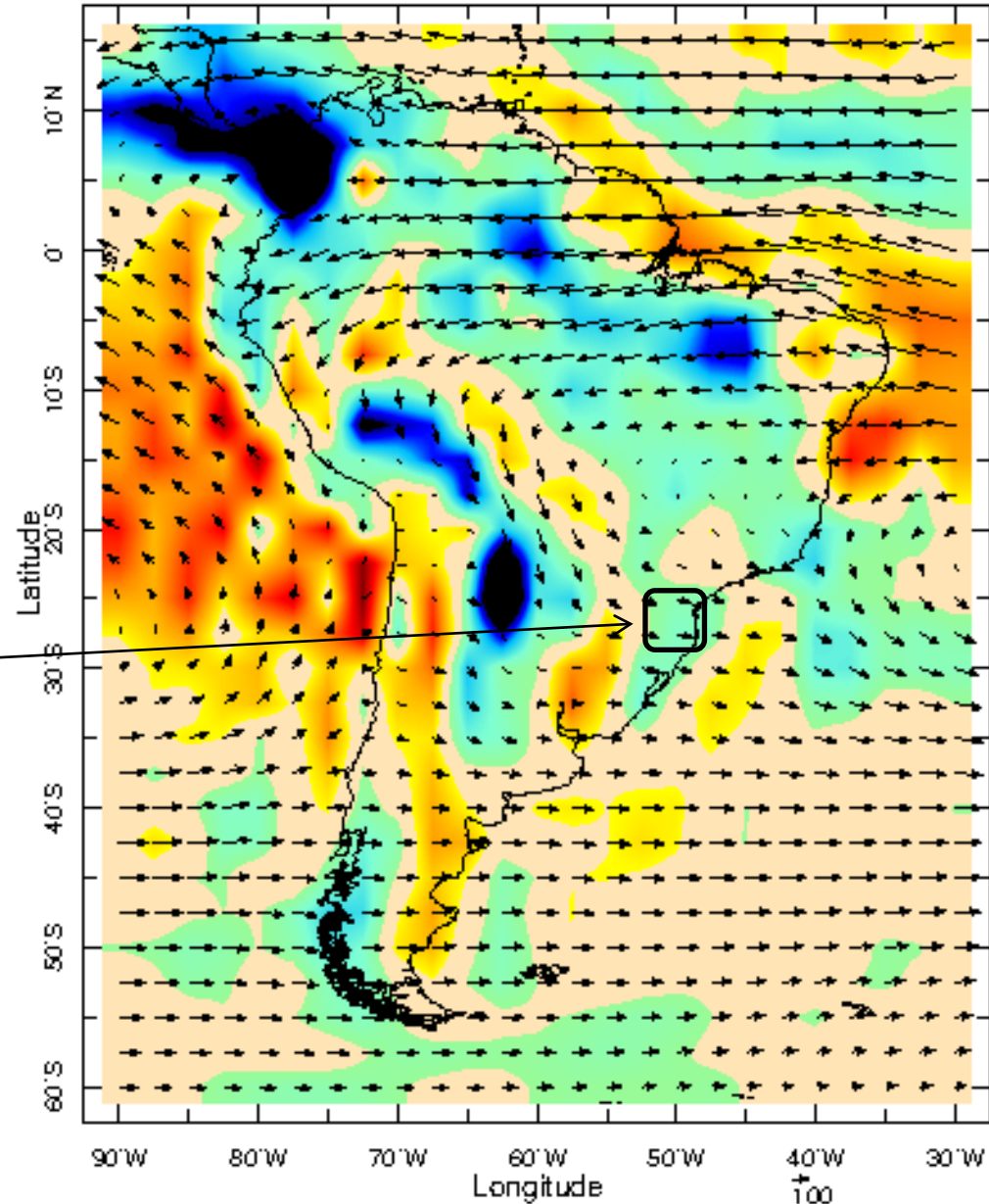


# Results

## Porto Uniao

Average moisture  
integrated flux and  
divergence for October  
from NCEP-NCAR  
Reanalysis (1949-2011)

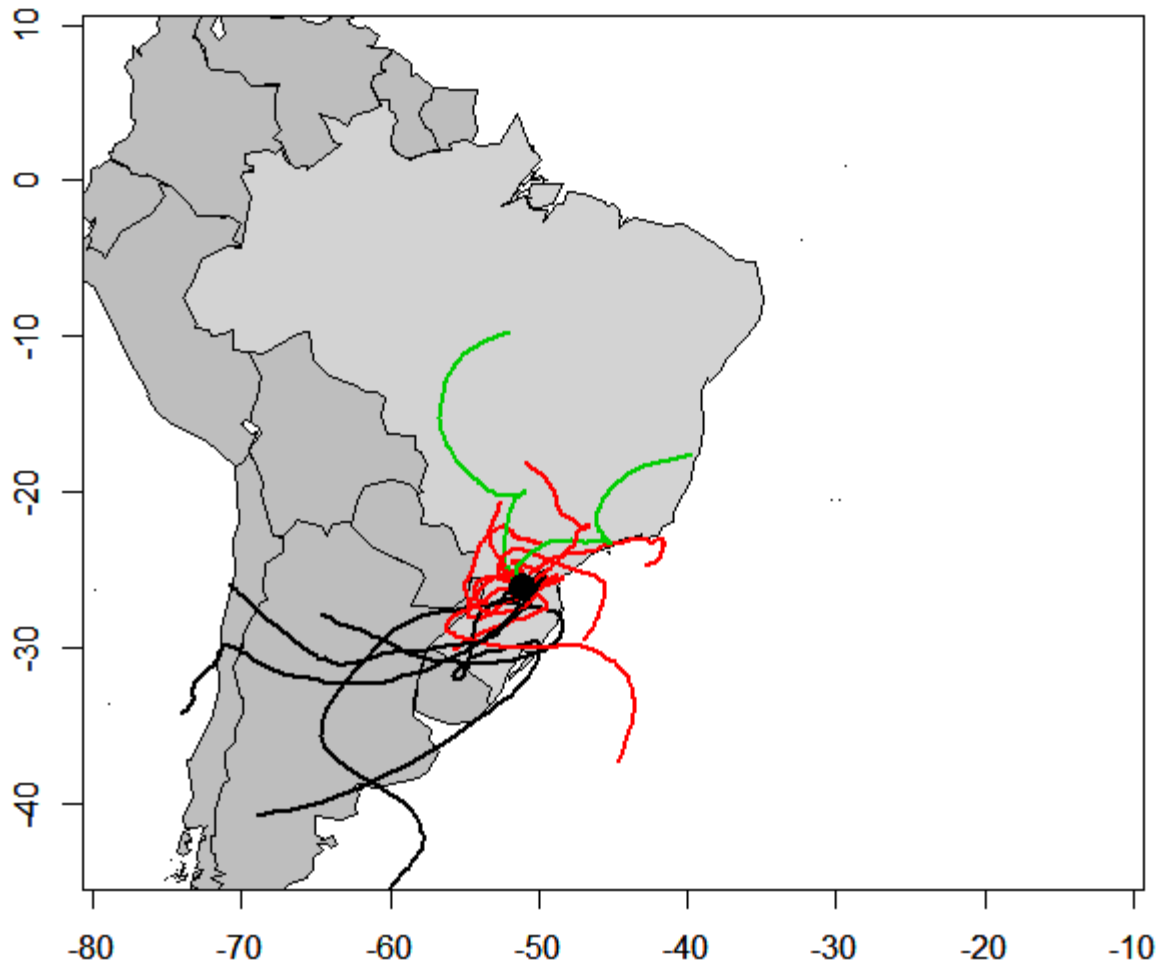
On average,  
convergence of  
moisture fluxes  
from the SALLJ and  
westerlies



# Results – Porto Uniao

Clustering of trajectories and floods

850 mb level

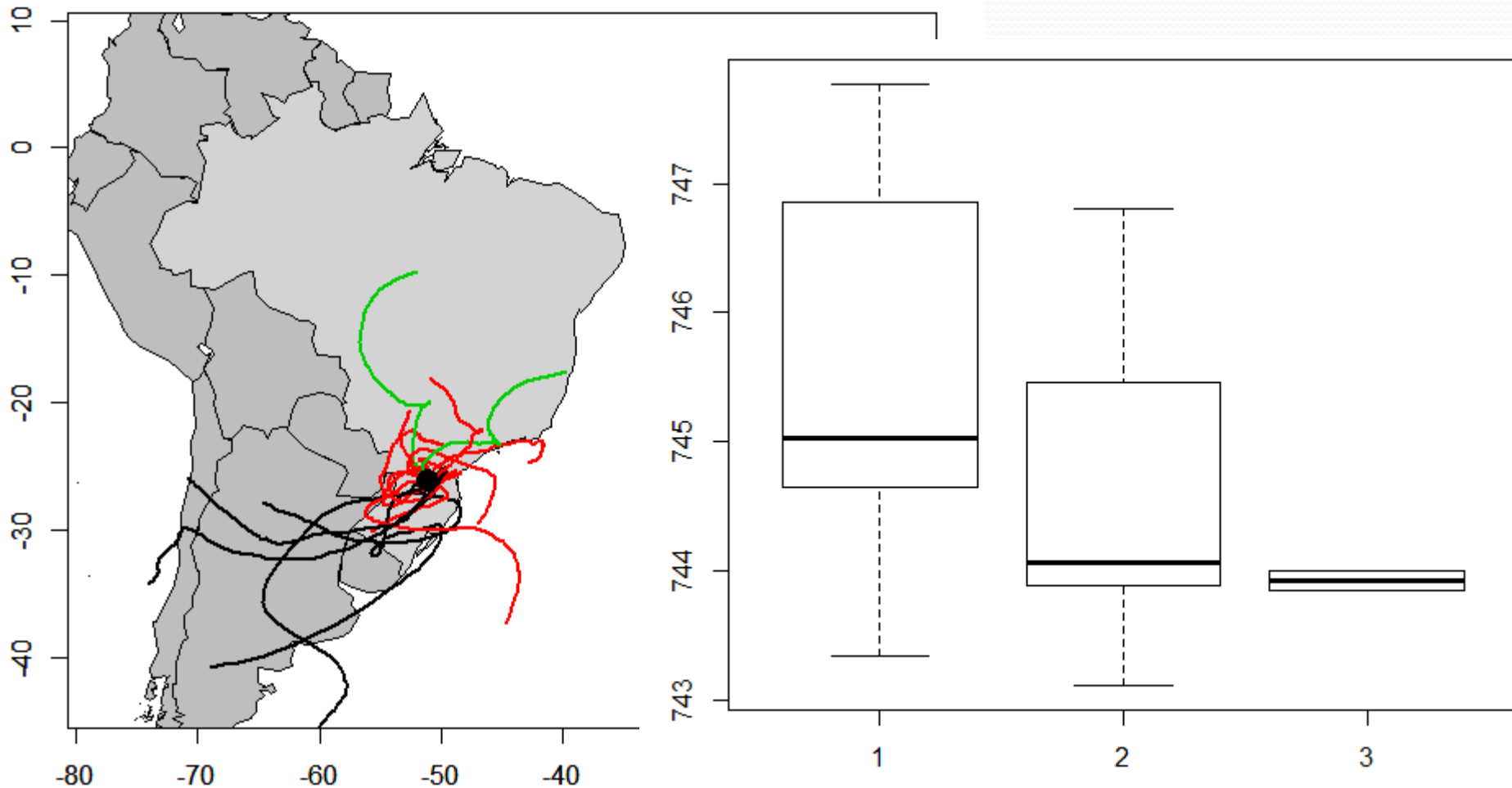




# Results – Porto Uniao

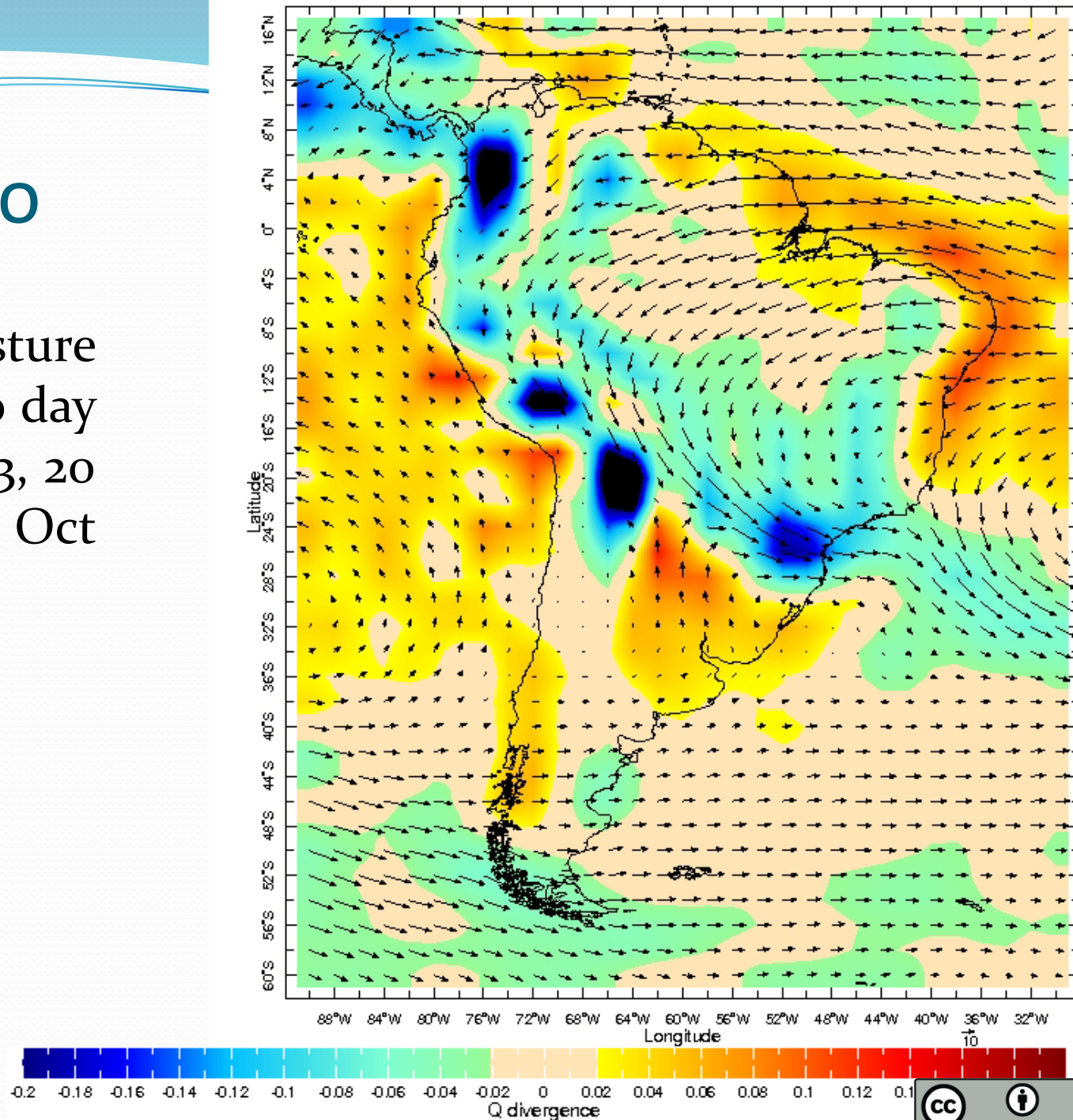
Clustering of trajectories and floods

850 mb level



# Results – Porto Uniao

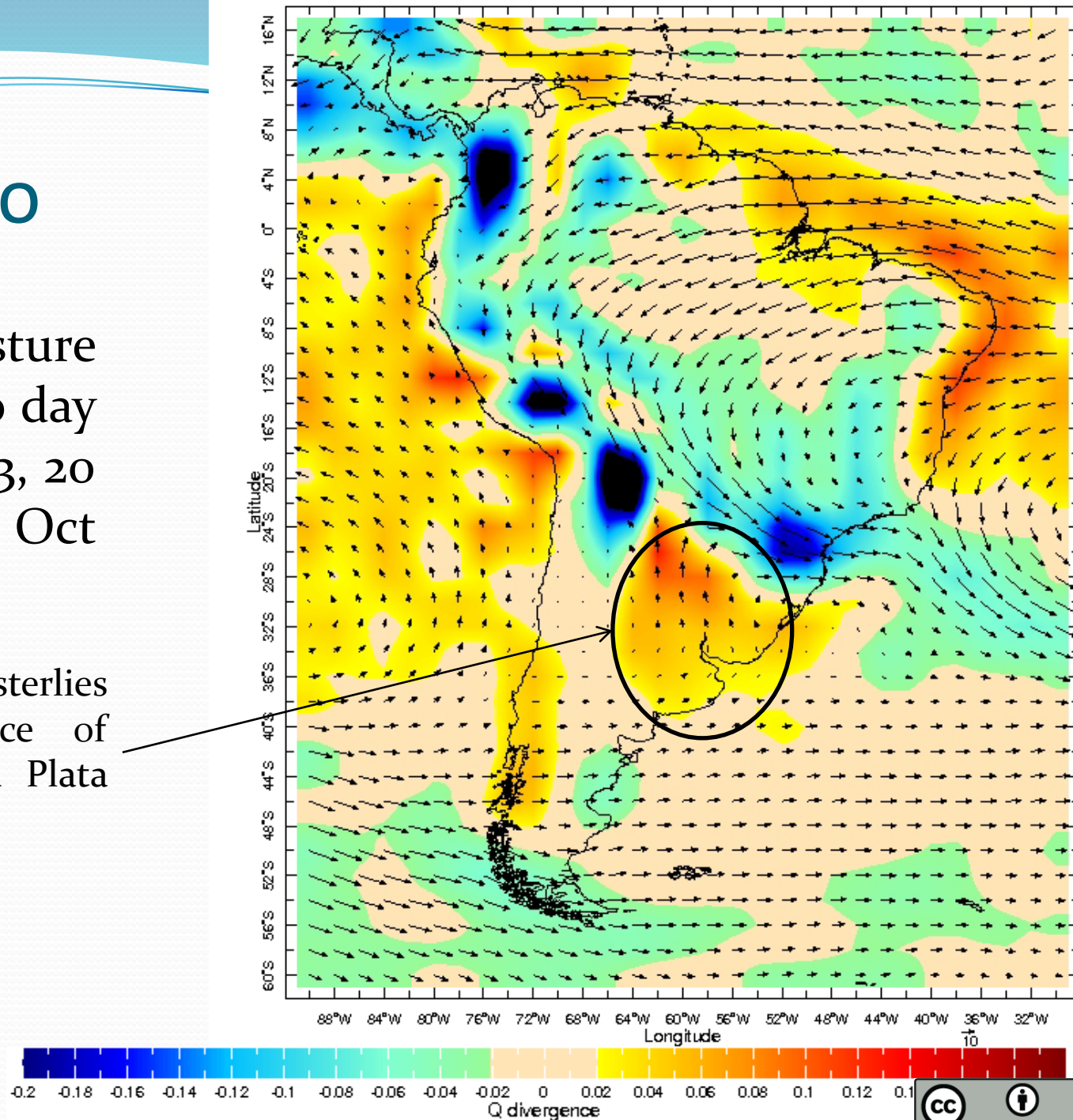
Integrated moisture  
flux for day -5 to day  
-1 of 06 Oct 1993, 20  
Oct 1950 and 31 Oct  
2008



# Results – Porto Uniao

Integrated moisture  
flux for day -5 to day  
-1 of 06 Oct 1993, 20  
Oct 1950 and 31 Oct  
2008

Disturbance in the westerlies  
and strong divergence of  
moisture from the La Plata  
basin



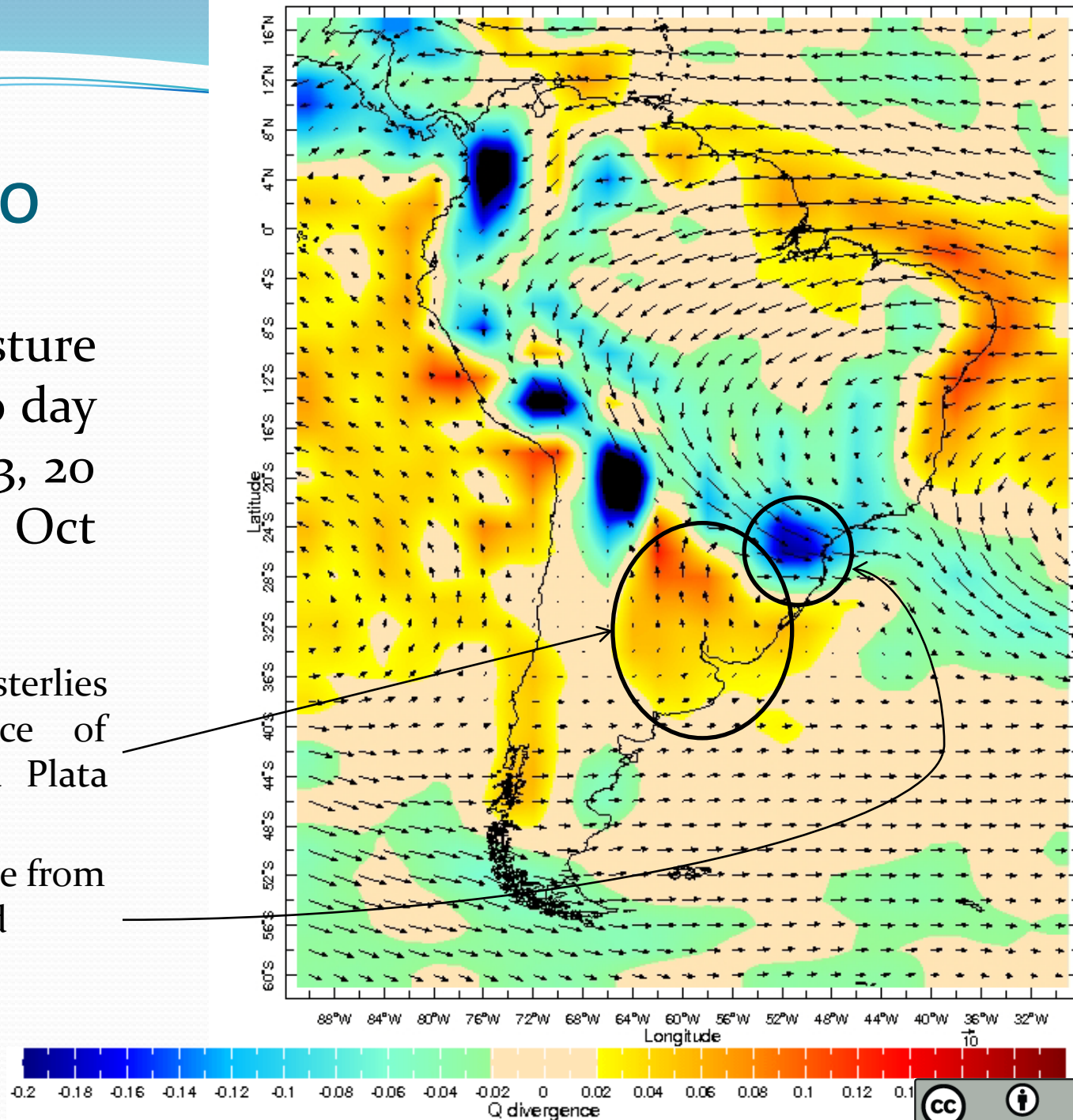


# Results – Porto Uniao

Integrated moisture  
flux for day -5 to day  
-1 of 06 Oct 1993, 20  
Oct 1950 and 31 Oct  
2008

Disturbance in the westerlies  
and strong divergence of  
moisture from the La Plata  
basin

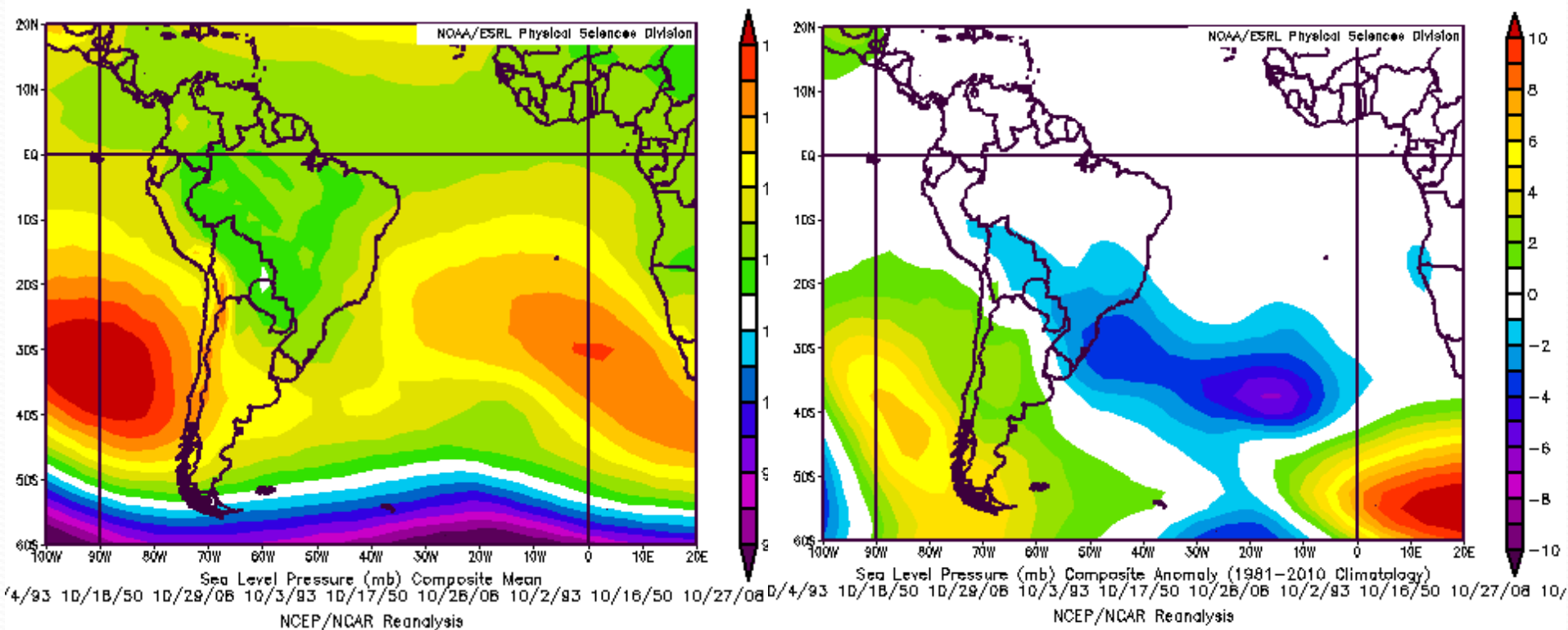
Convergence of moisture from  
disturbed westerlies and  
SALLJ



# Results – Porto Uniao

Composite Analysis: SLP field (mean and anomaly)

→ No significant anomalies in the SST field





# Final Remarks and Acknowledgments

- Preliminary results suggest that some large floods are associated with common atmospheric circulation patterns;
- In both regions a disturbance in the westerlies was associated with the flood events in the tropics;
- A strong cold anomaly in the South Atlantic SST could have induced the atmospheric pattern in the Rio Doce basin;
- Several questions remain and will be theme of future work:
  - How many times such climate states (or nearby) were visited in the past? Do they always produce such floods? If not, what are the other necessary conditions (e.g. soil moisture)? What can we expect with climate changes?
  - Can we use numerical models to simulate such states and establish the causal chain up to certain point useful for flood predictions?
- The first author acknowledges the financial support from the School of Technology (UnB) and EGU to attend this conference.