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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17/04/2015

European Geosciences Union
General Assembly 2015
Vienna | Austria | 12 – 17 April 2015
EGU.eu

Key Points

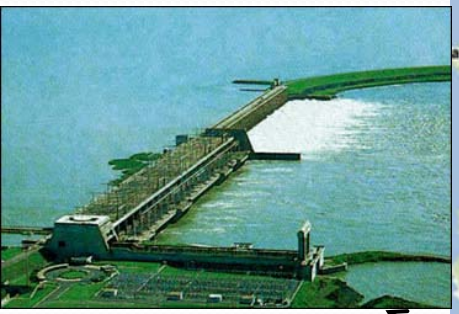
- Randomness of the flood event and iid (independent and identically distributed data) assumption in traditional flood frequency analysis (FFA);
- But for a certain region, particularly large basins, can we think about a physical theory to explain the extreme floods conditioned on the evolution of the 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.

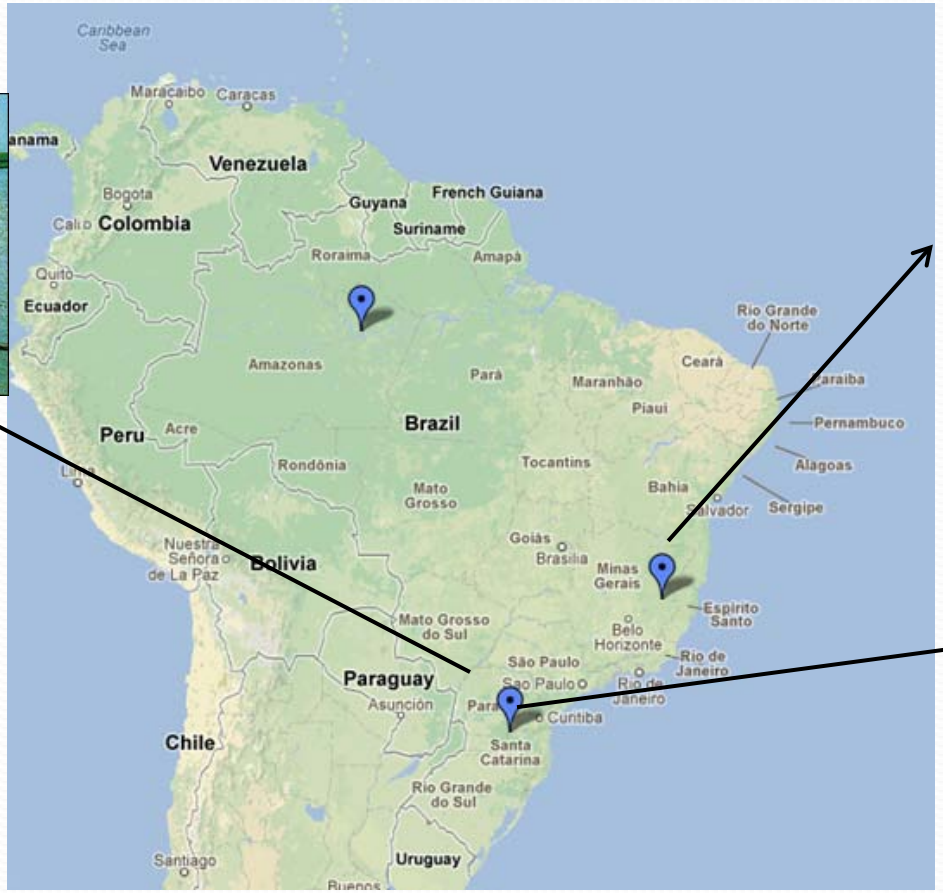
Methodology

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

Rio Doce Basin
(A = 40500 km²)

Jupia reservoir
Parana Basin
(A = 476800 km²)





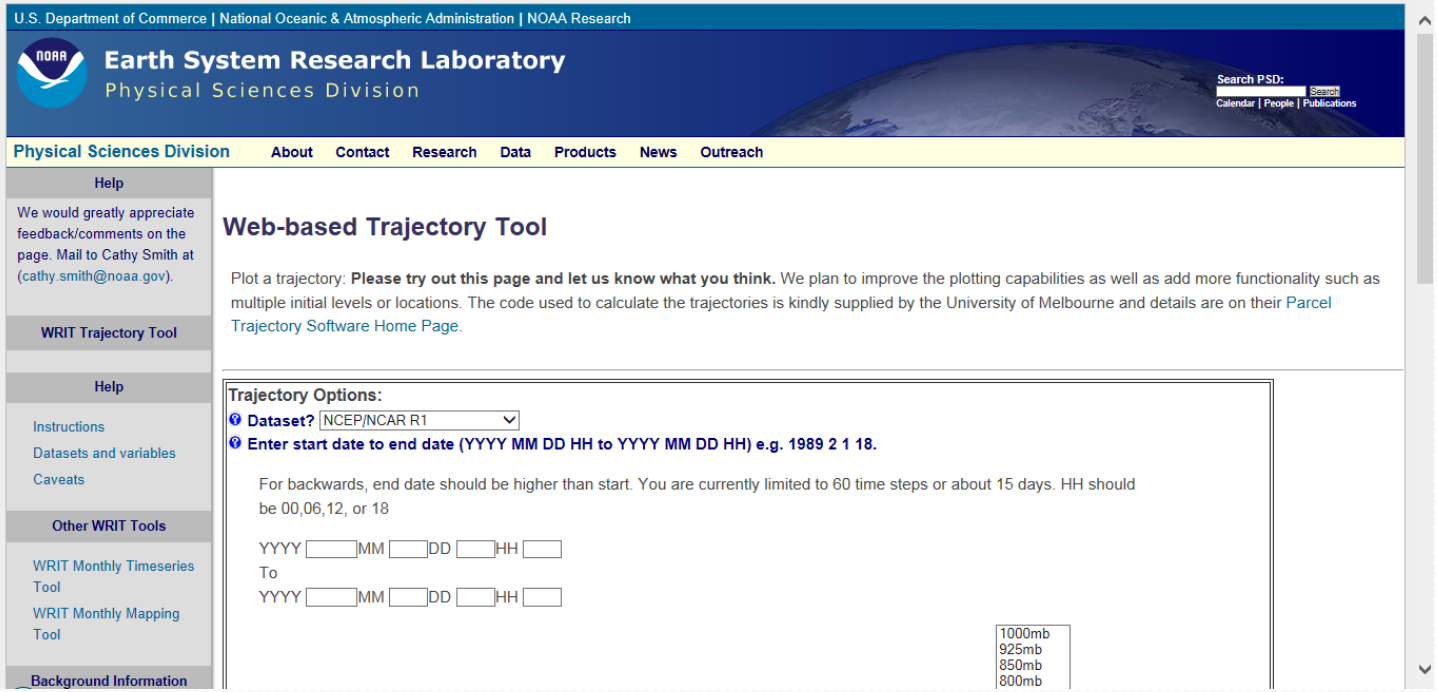
Cities of Porto União and União da Vitória
Iguaçu basin (A = 24200 km²)

La Plata Basin

Methodology

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

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

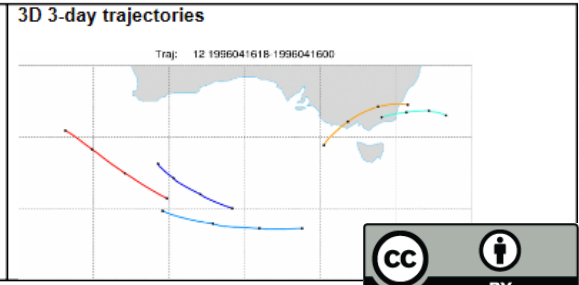


The University of Melbourne

earthsciences

Parcel Trajectory Software

Home Page

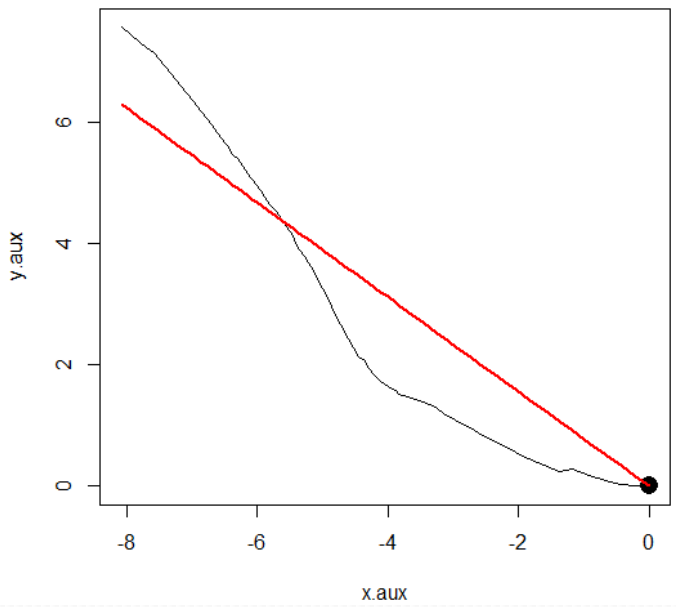


Methodology

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 20th century V2);

Step 5: Flood statistics associated with each trajectory cluster;

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

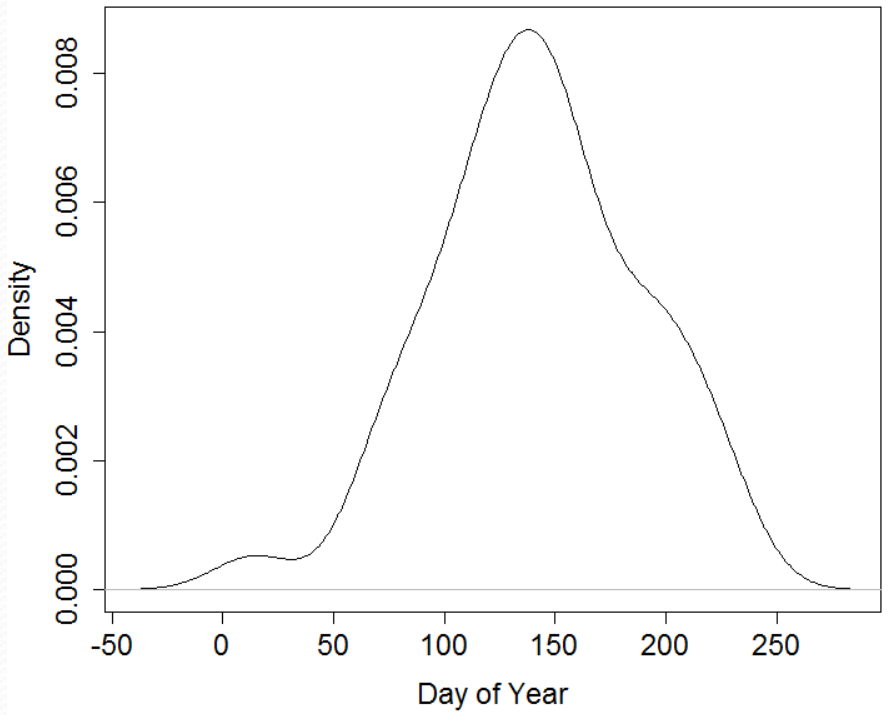
→ Integrated moisture flux (from Reanalysis data) for days -1 to -5 of the event;

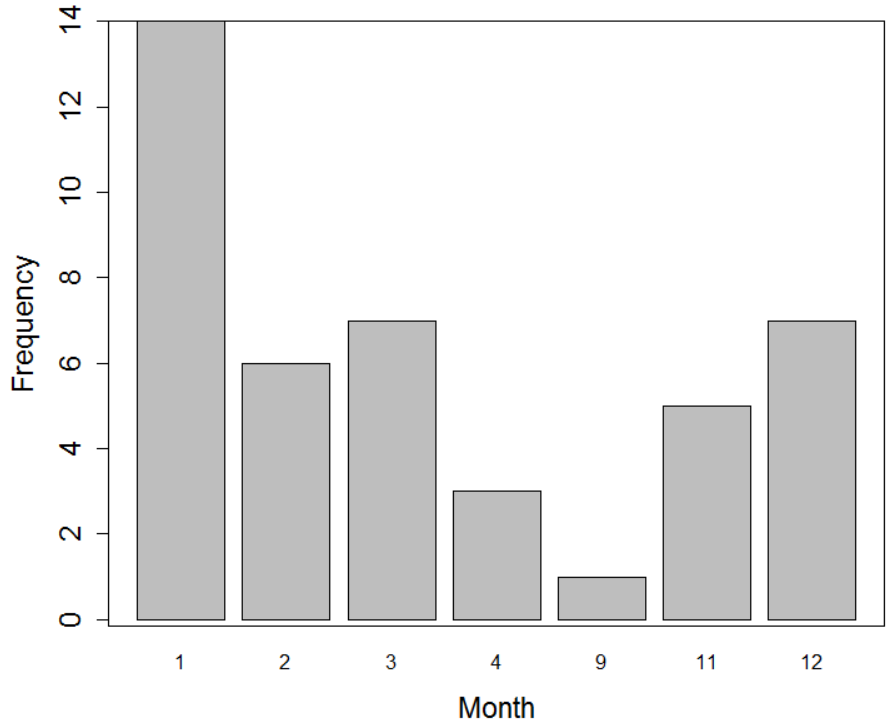
→ Composite analysis of synoptic fields: SST, SLP, GH, temperature, OLR, soil moisture, etc;

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)

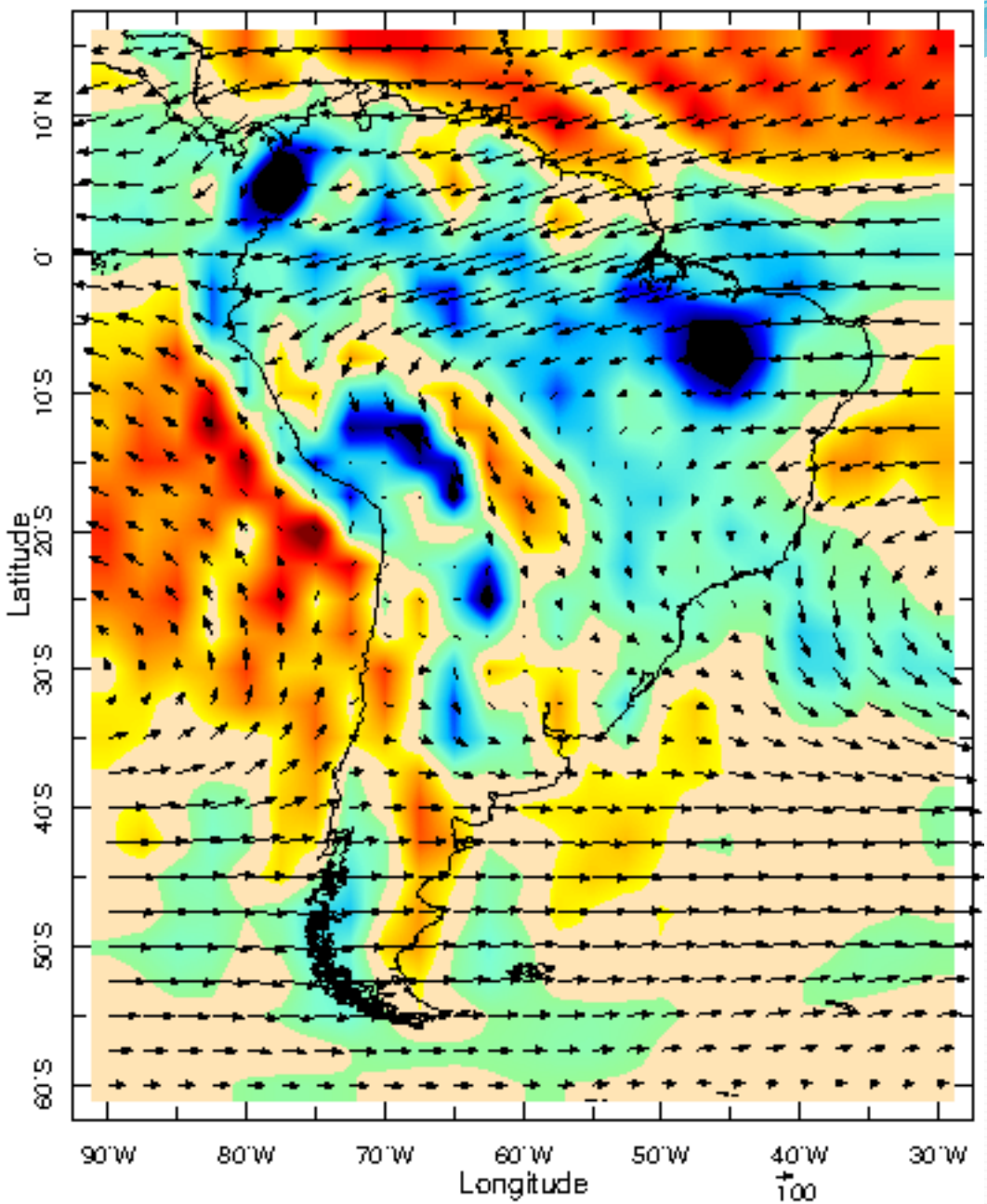




Results

Rio Doce basin

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

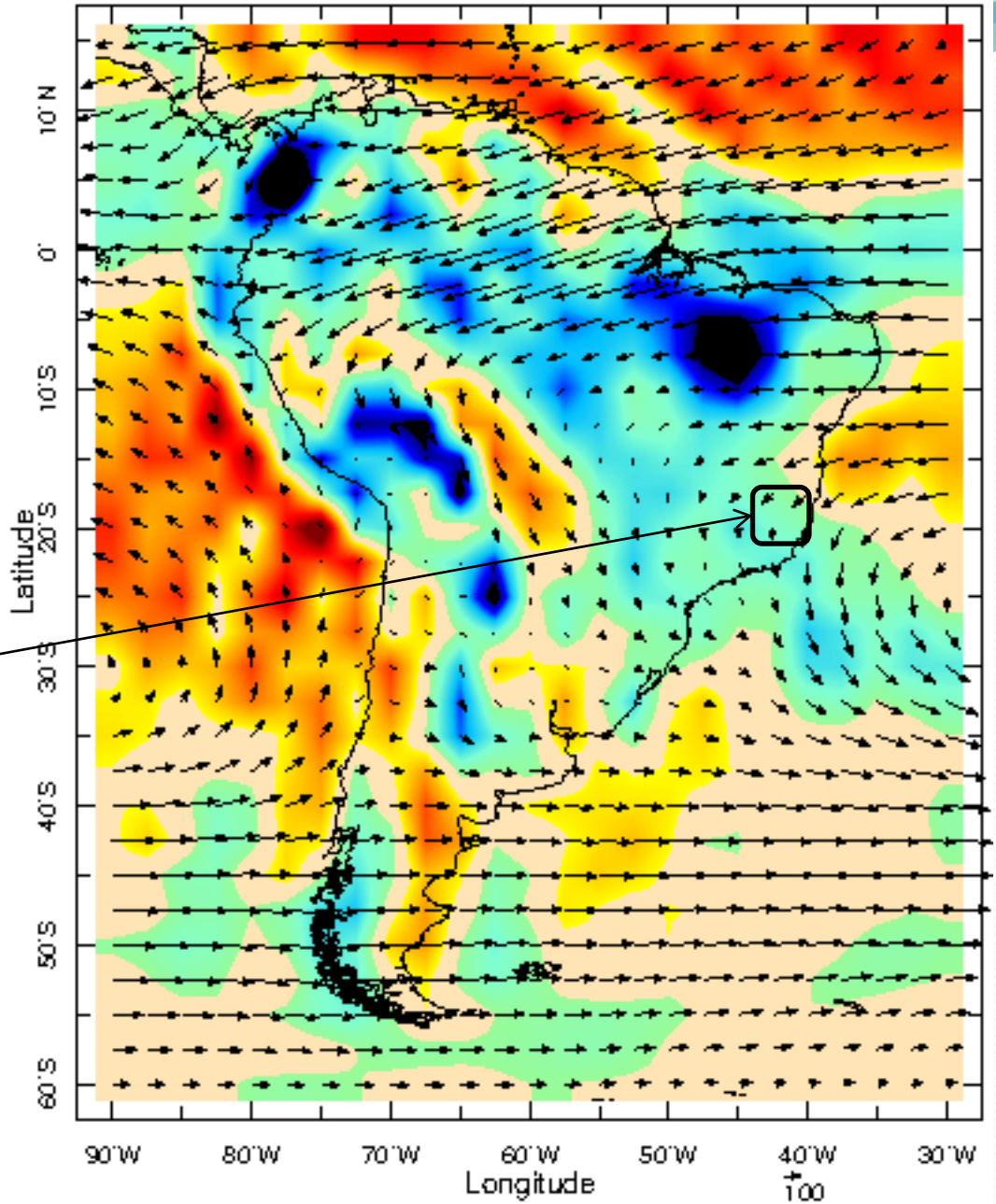


Results

Rio Doce basin

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

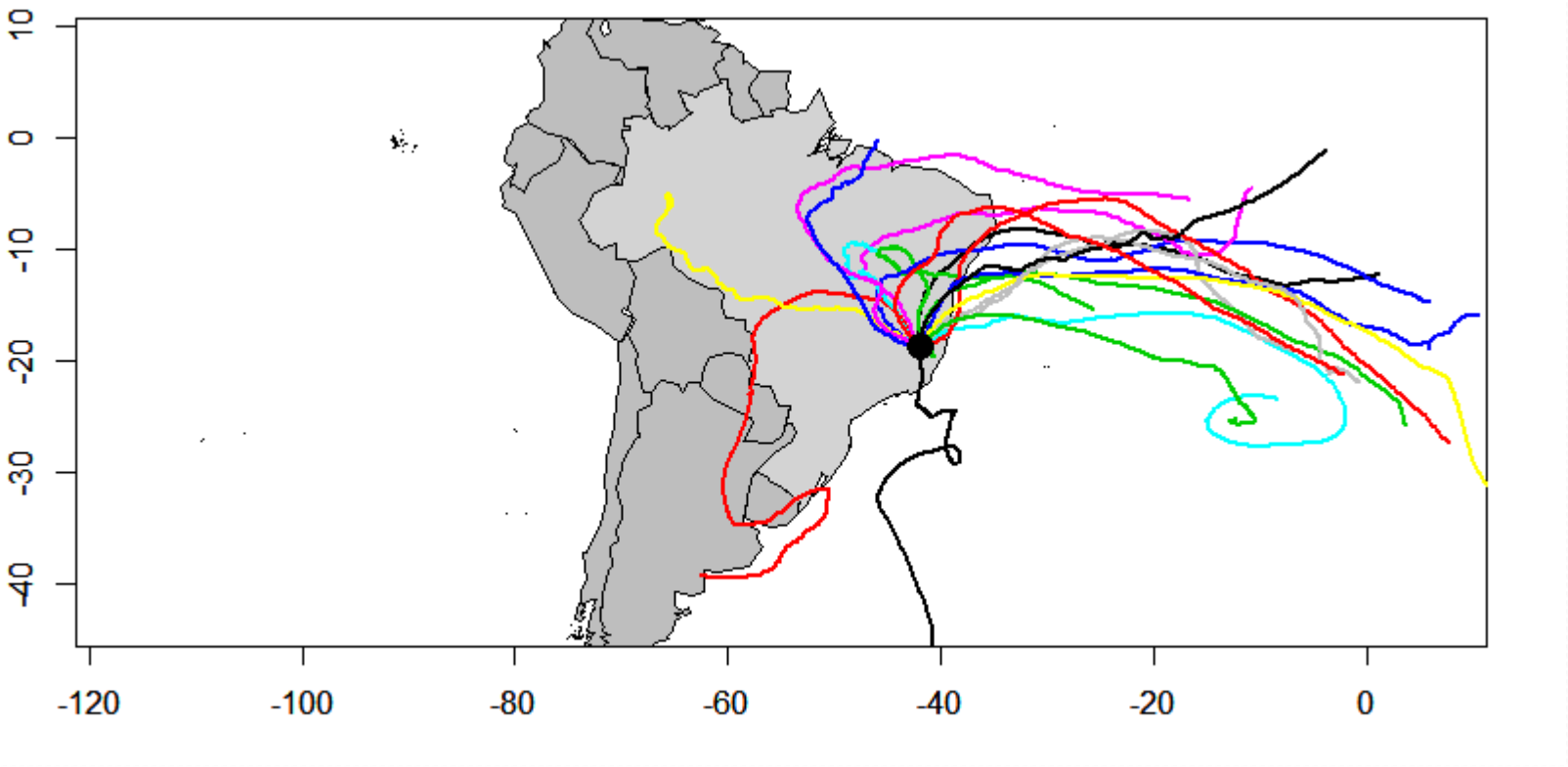
On average, moisture fluxes come from South Atlantic



Results – Rio Doce basin

Tracks associate with the 20 biggest flood events

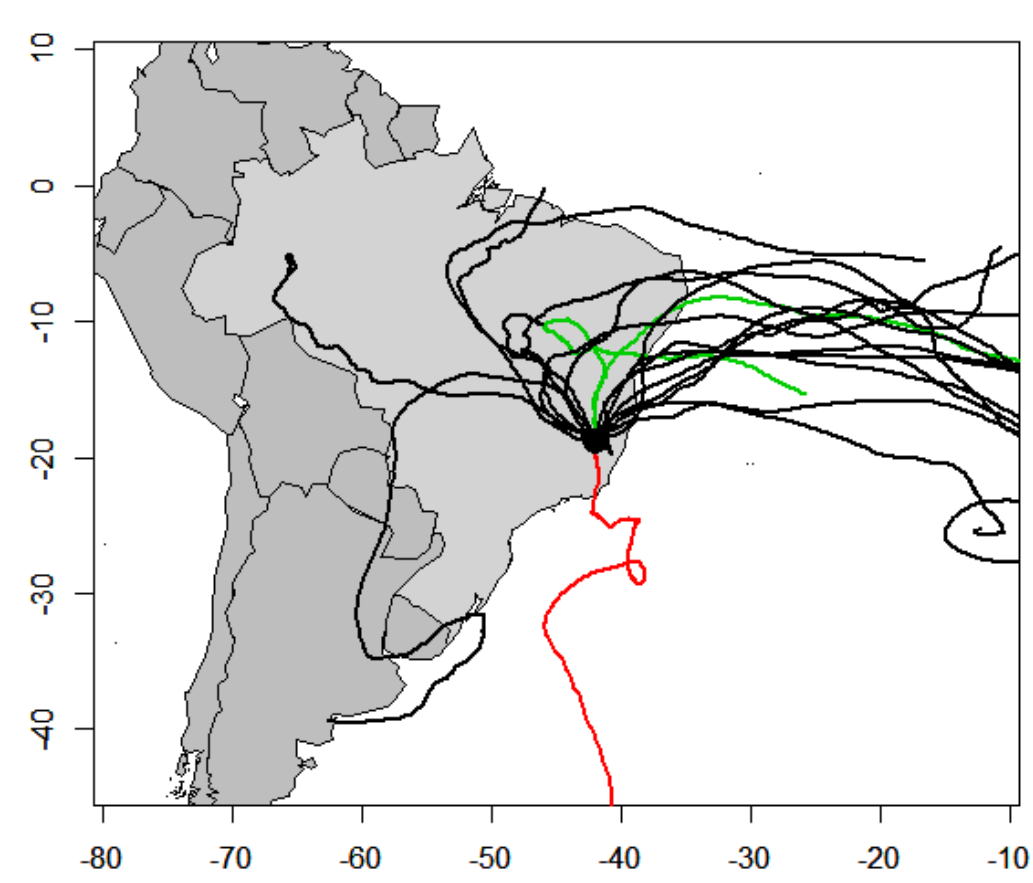
850 mb level



Results – Rio Doce basin

Clustering of trajectories

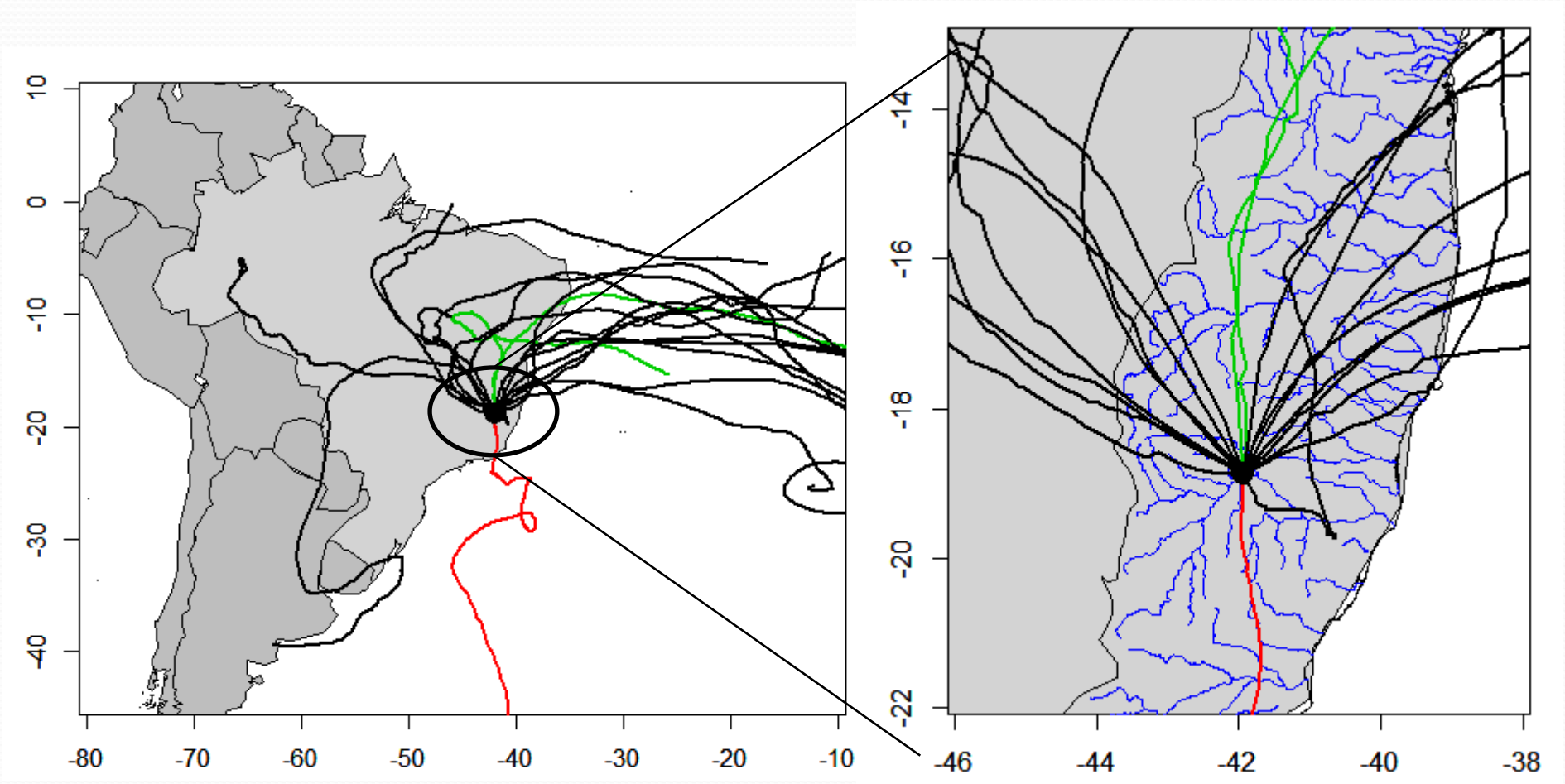
850 mb level



Results – Rio Doce basin

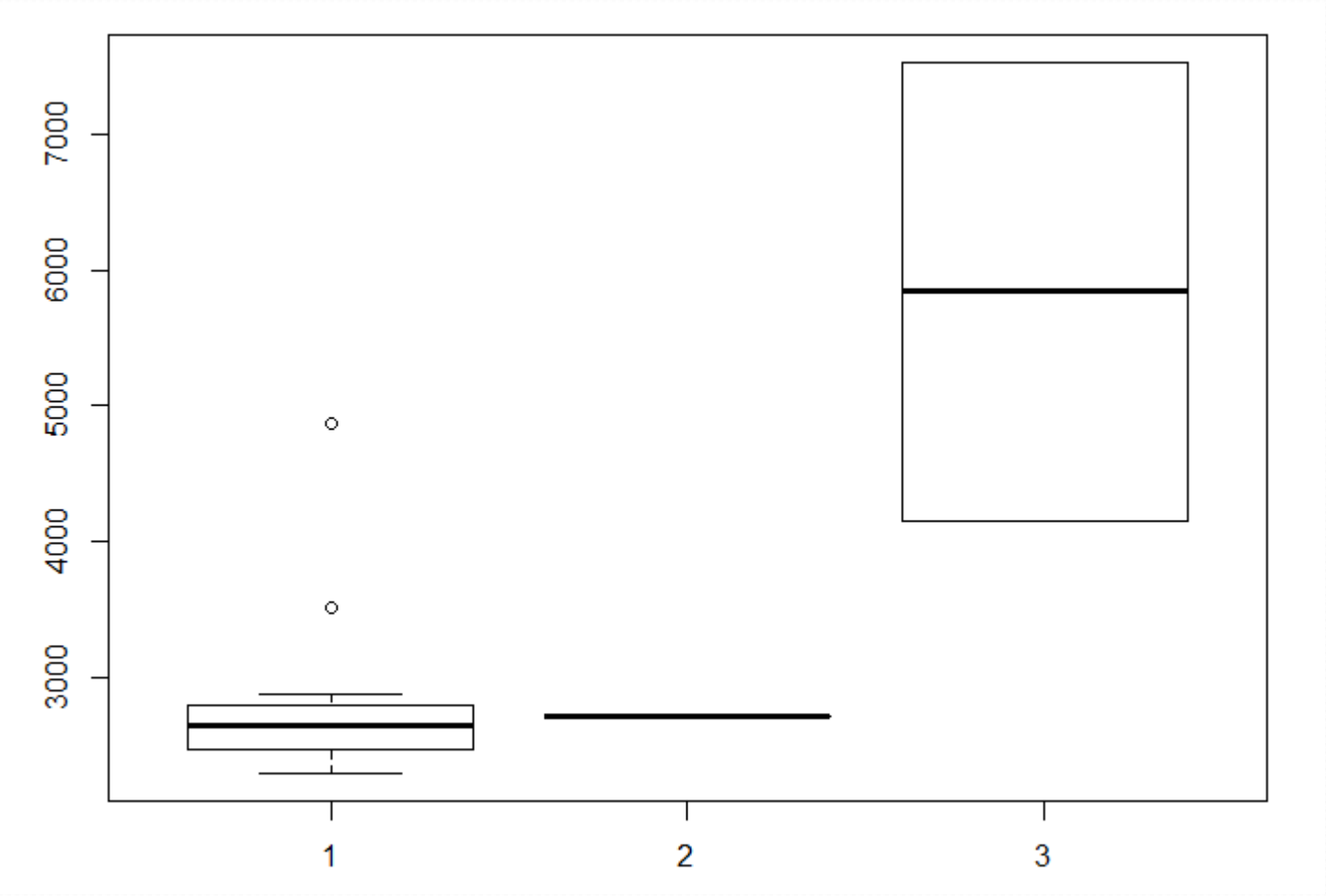
Clustering of trajectories

850 mb level



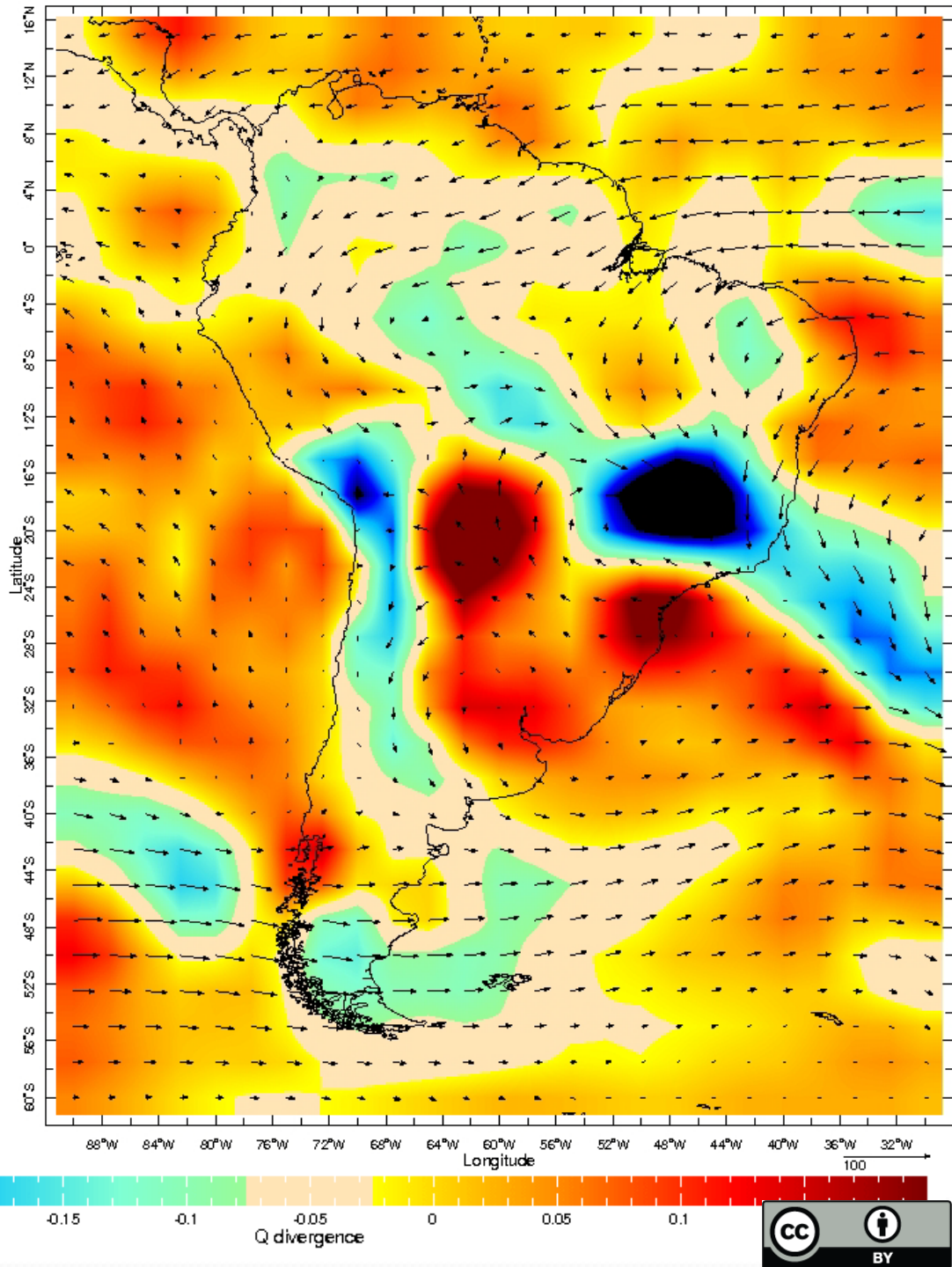
Results – Rio Doce basin

Clustering of flows and volume



Results – Rio Doce basin

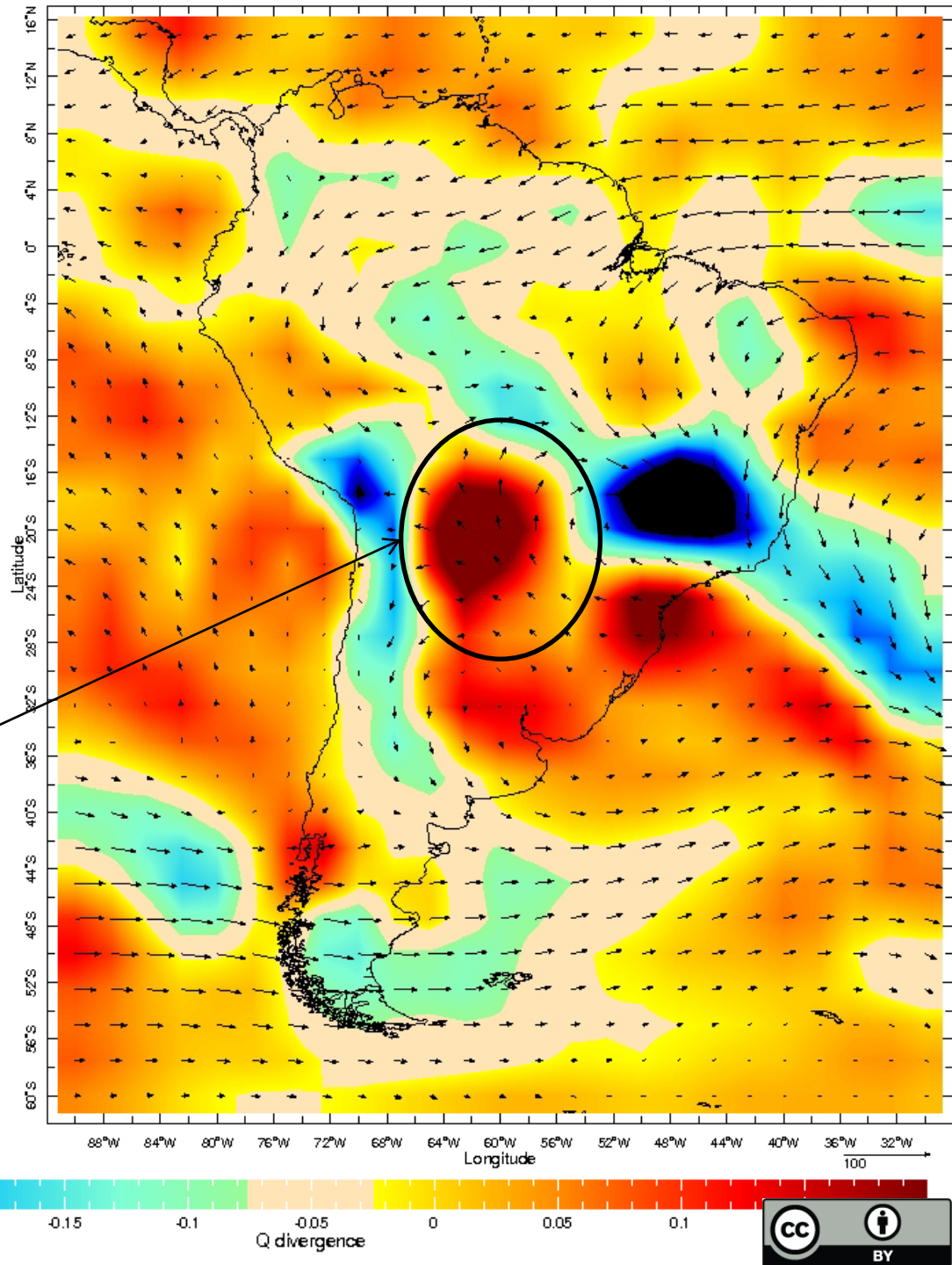
Integrated moisture flux for day -5 to day -1 of 05 Jan 1997 and 2 Feb 1979: 1st and 3rd in the flood record



Results – Rio Doce basin

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

Strong divergence of moisture from the Pantanal region (wetland)

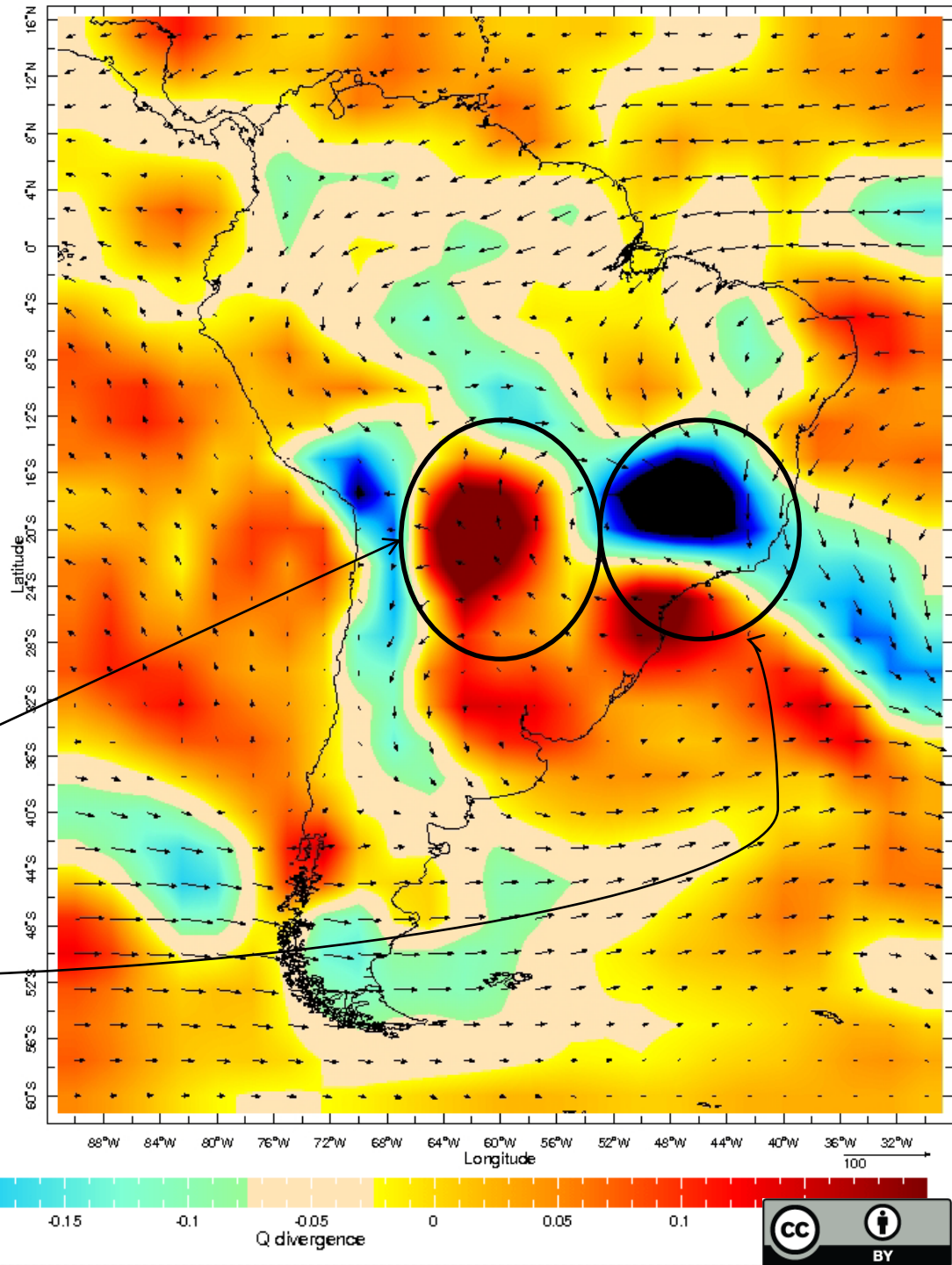


Results – Rio Doce basin

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

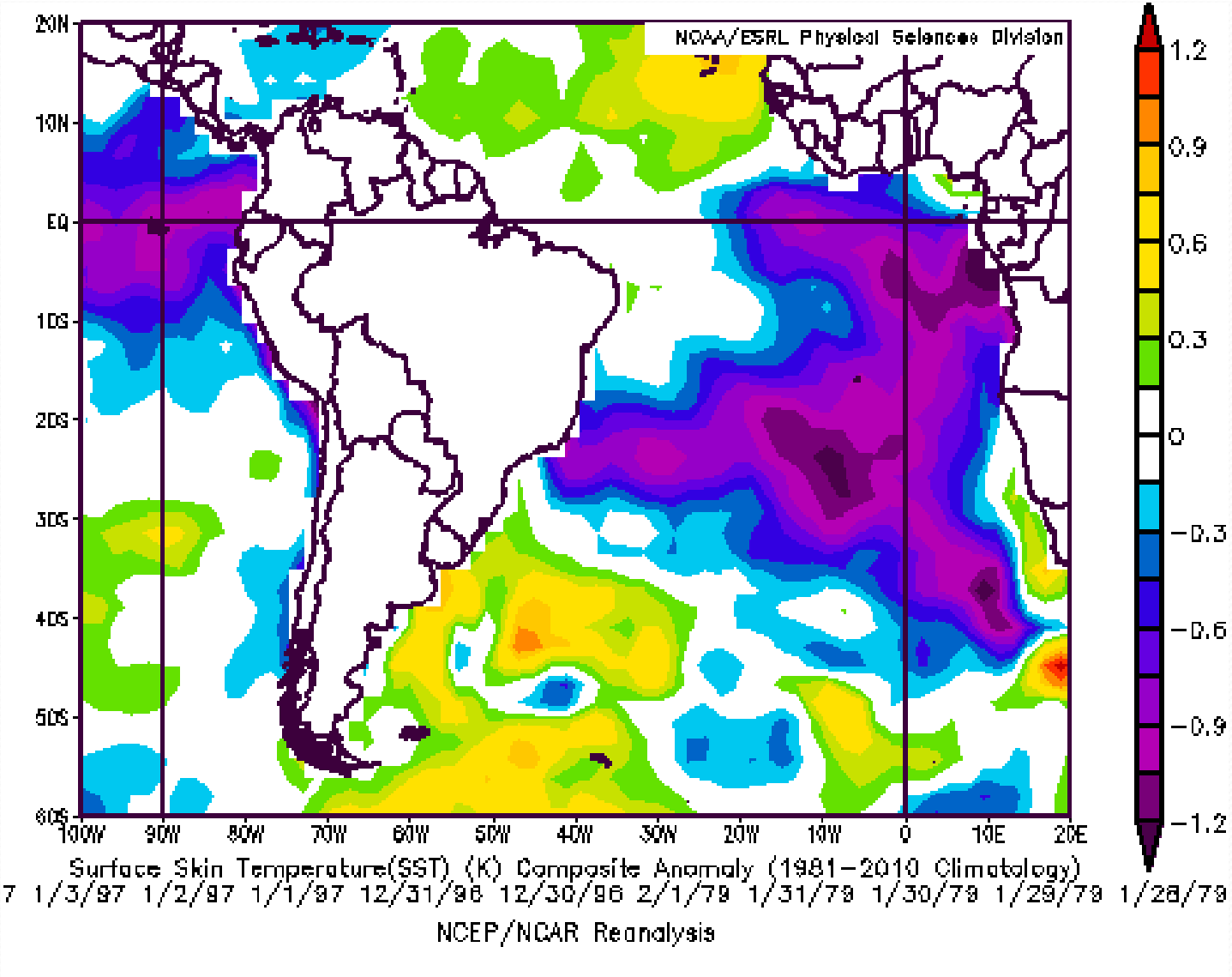
Strong divergence of moisture from the Pantanal region (wetland)

Strong convergence of moisture from Pantanal, Amazon and South Atlantic



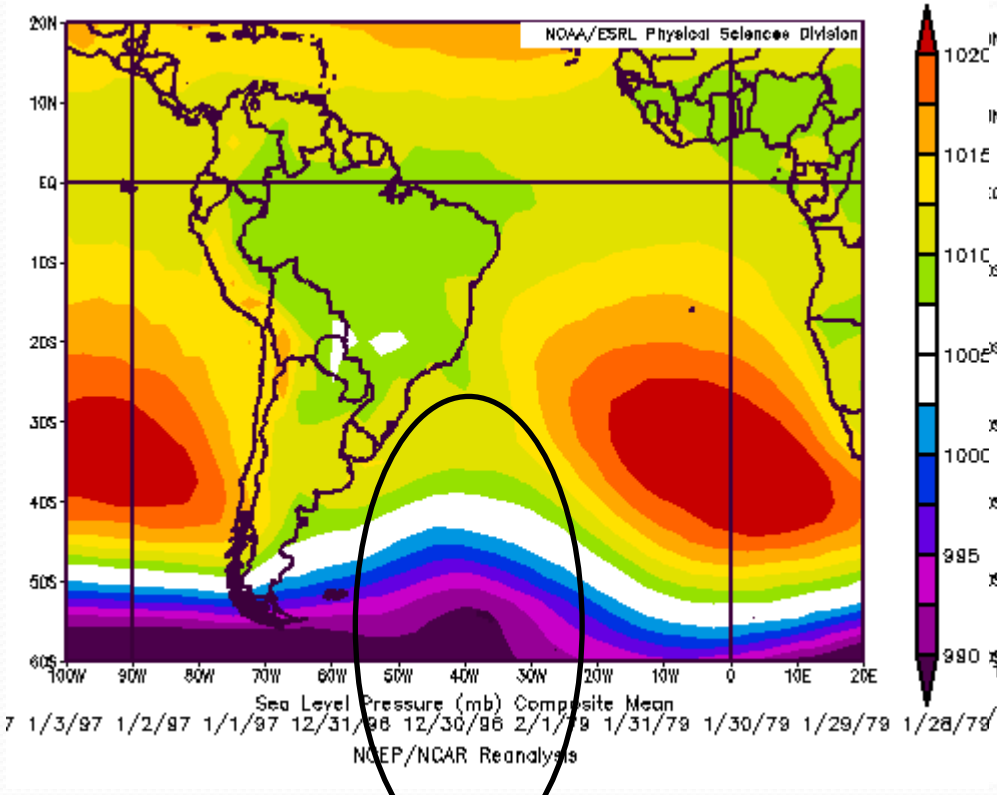
Results – Rio Doce basin

Composite Analysis: SST



Results – Rio Doce basin

Composite Analysis: SLP field (mean and anomaly)



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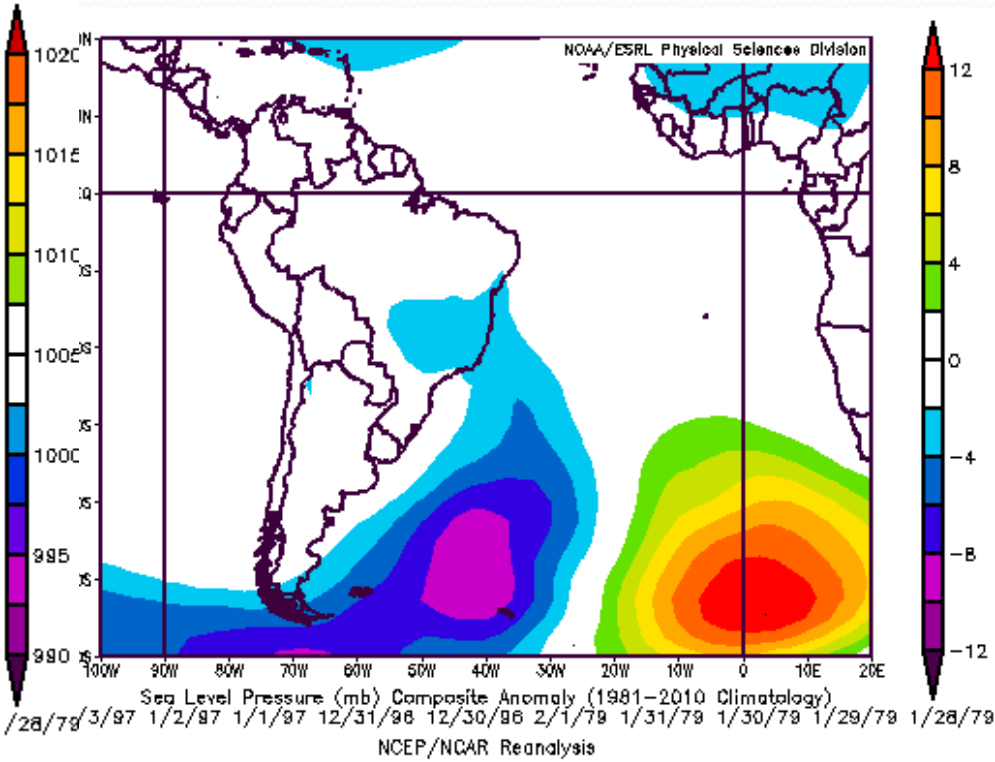
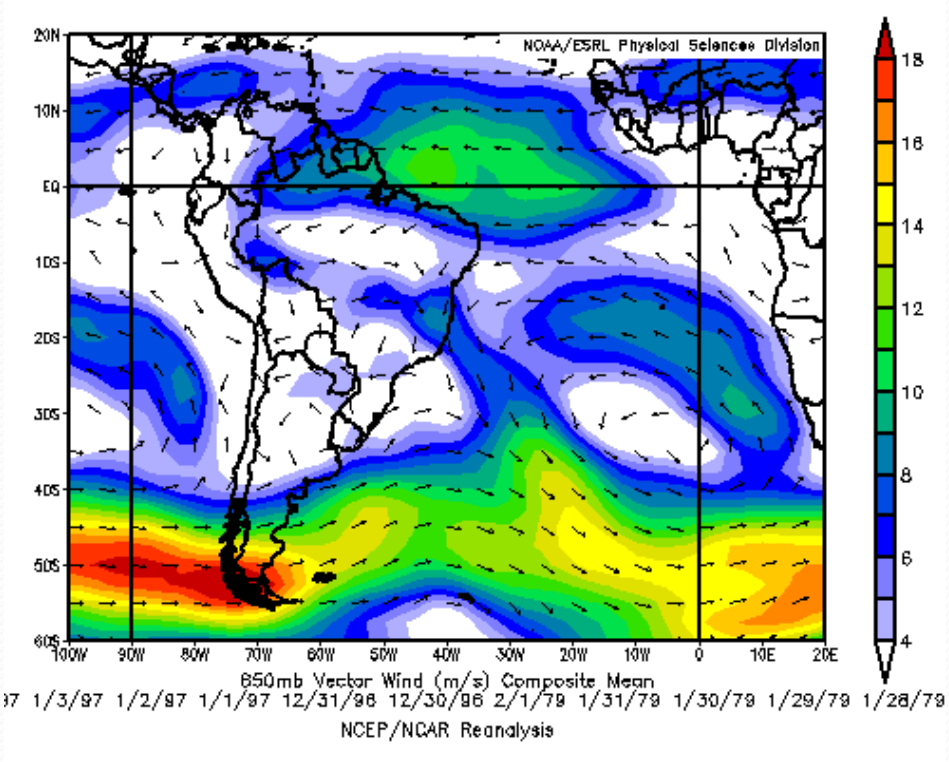
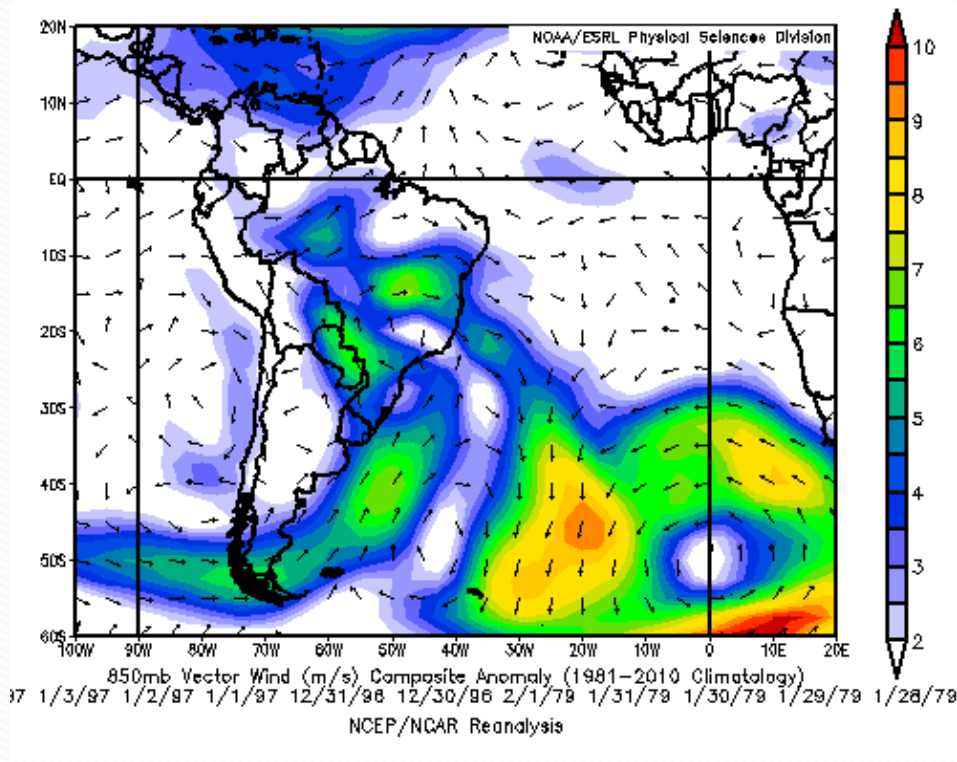


Results – Rio Doce basin

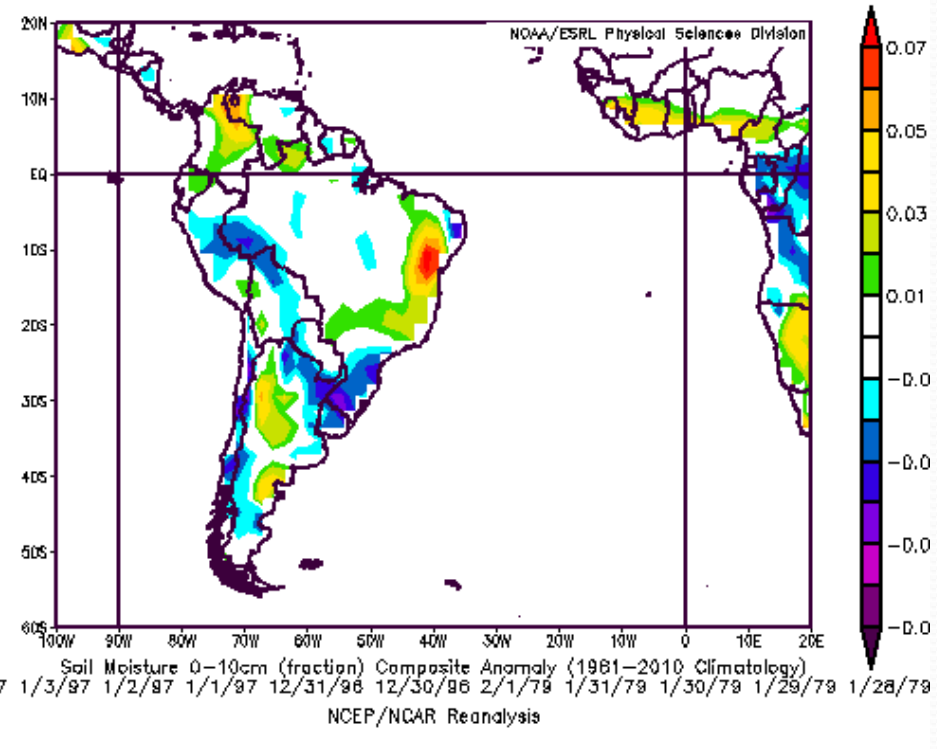
Composite Analysis: Low level wind vector

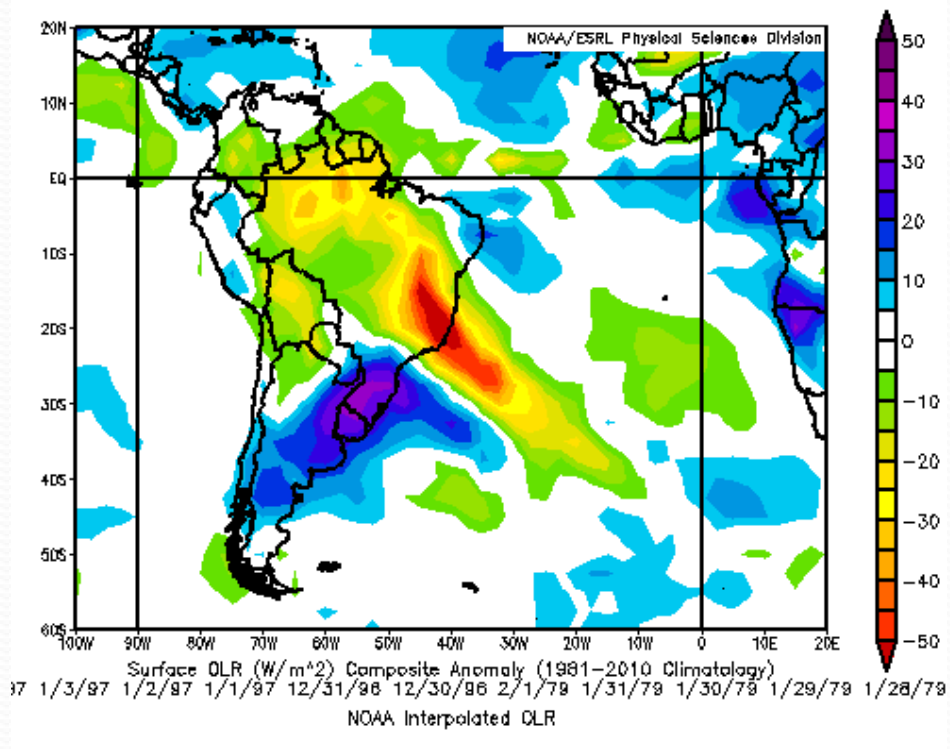




Results – Rio Doce basin

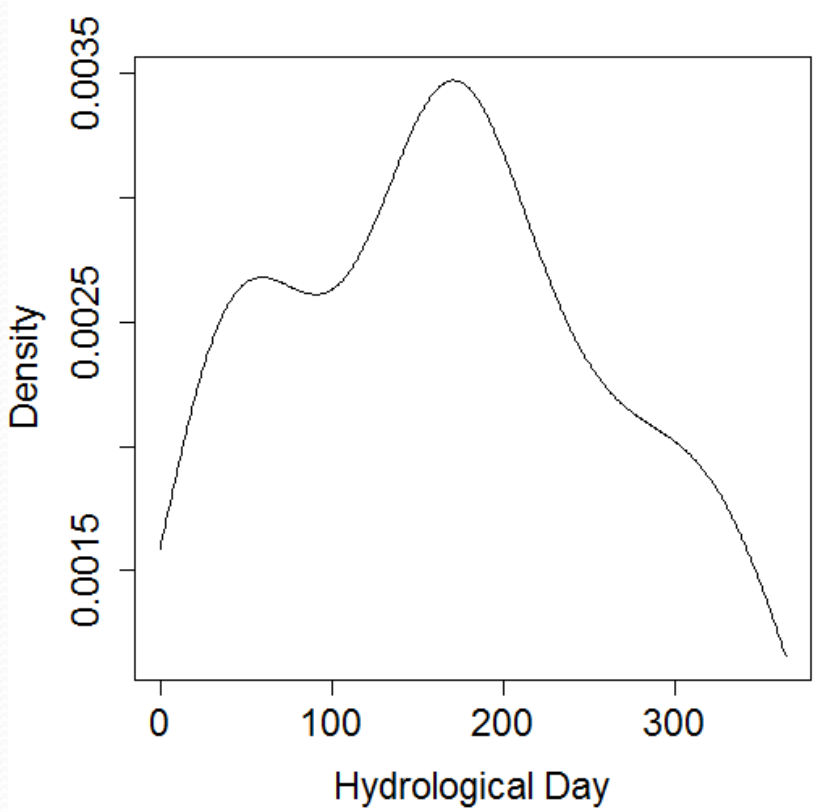
Composite Analysis: Soil Moisture and OLR

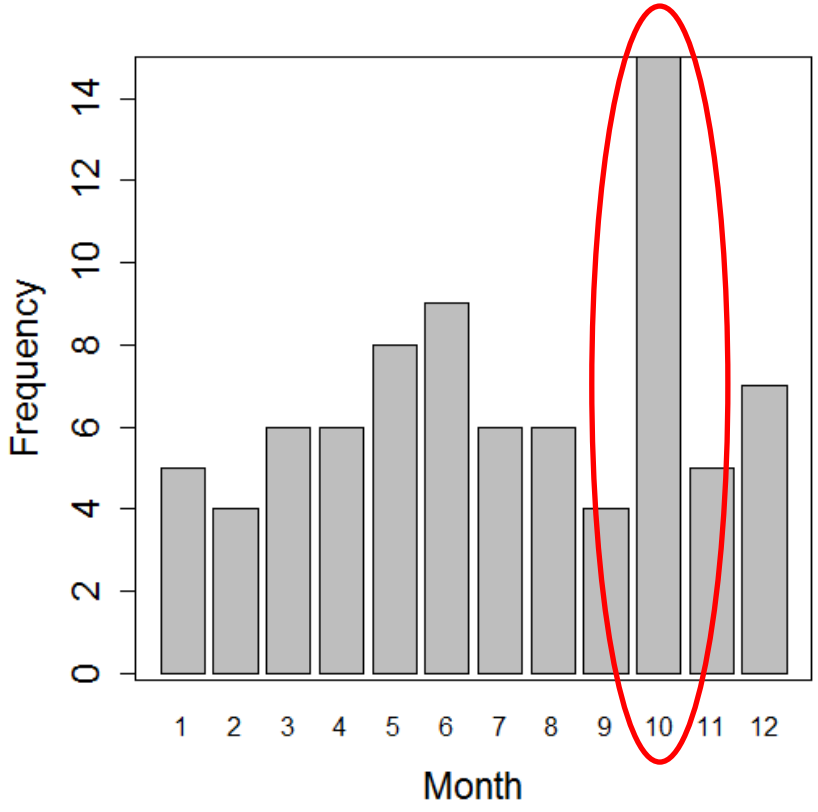




Results – Porto Uniao City (Parana basin)

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



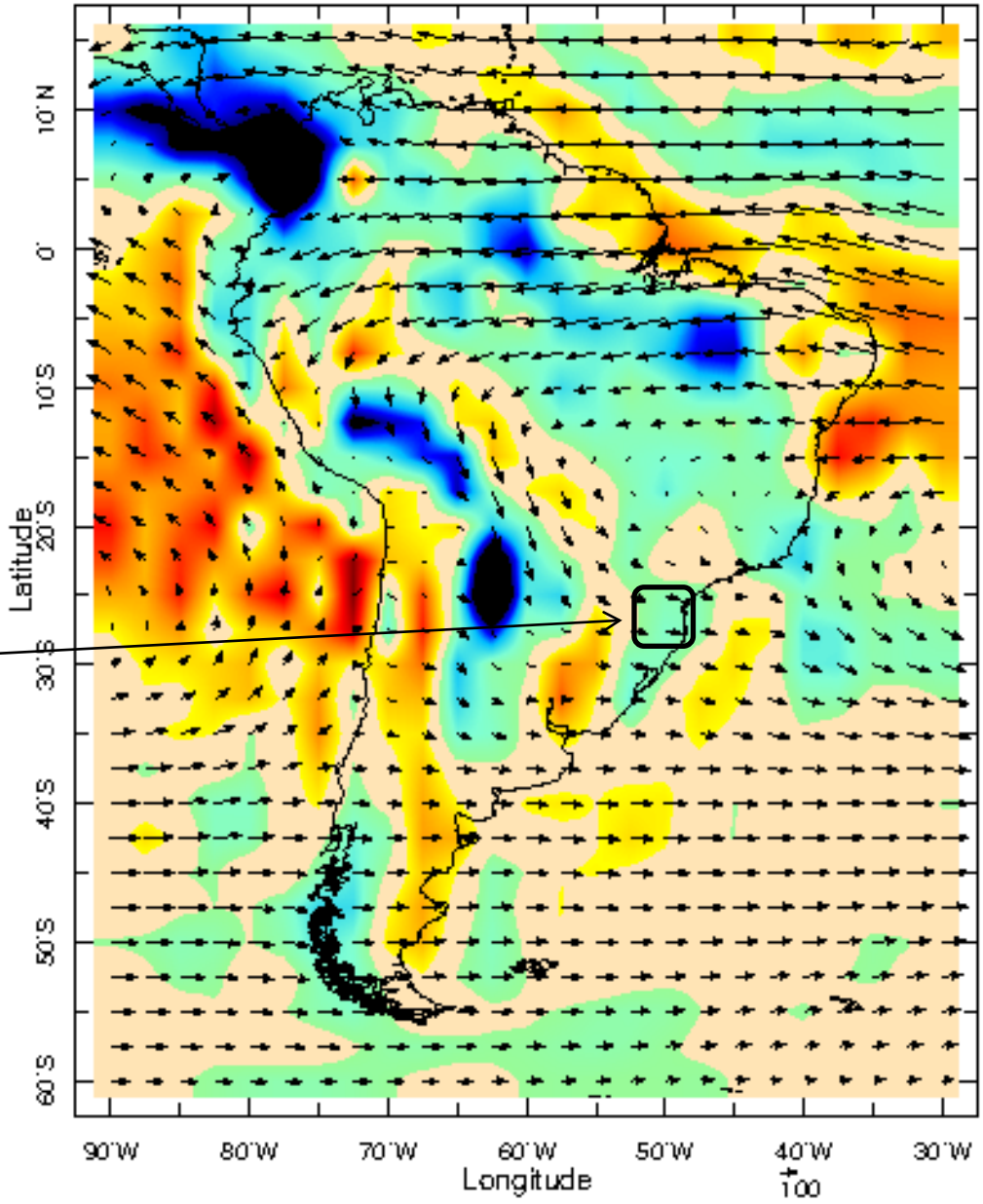


Results

Porto Uniao

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

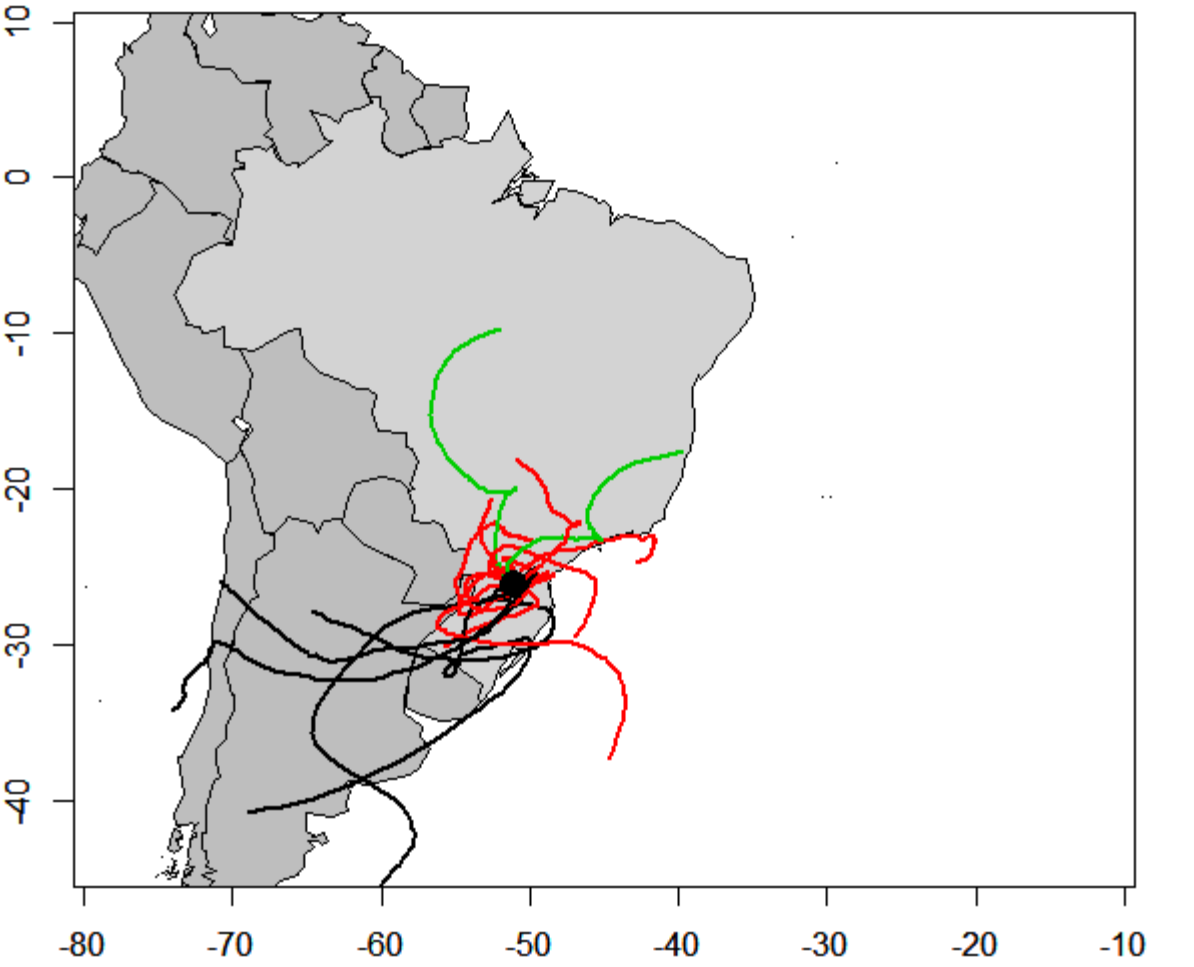
On average, convergence of moisture fluxes from the SALLJ and westerlies



Results – Porto Uniao

Clustering of trajectories and floods

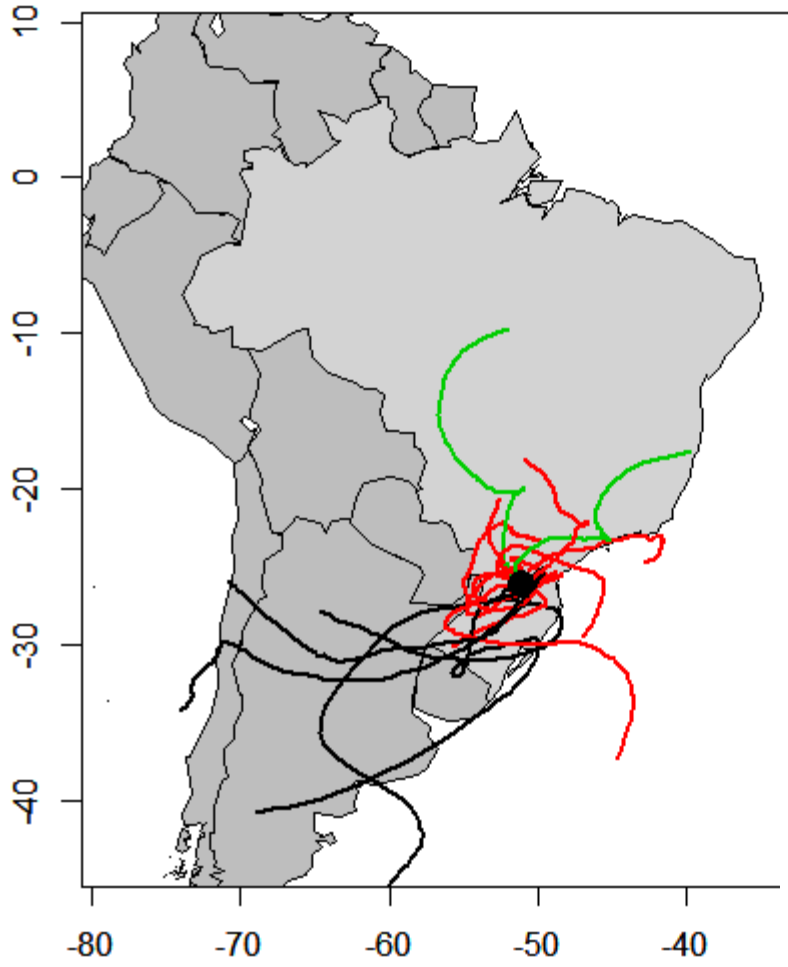
850 mb level

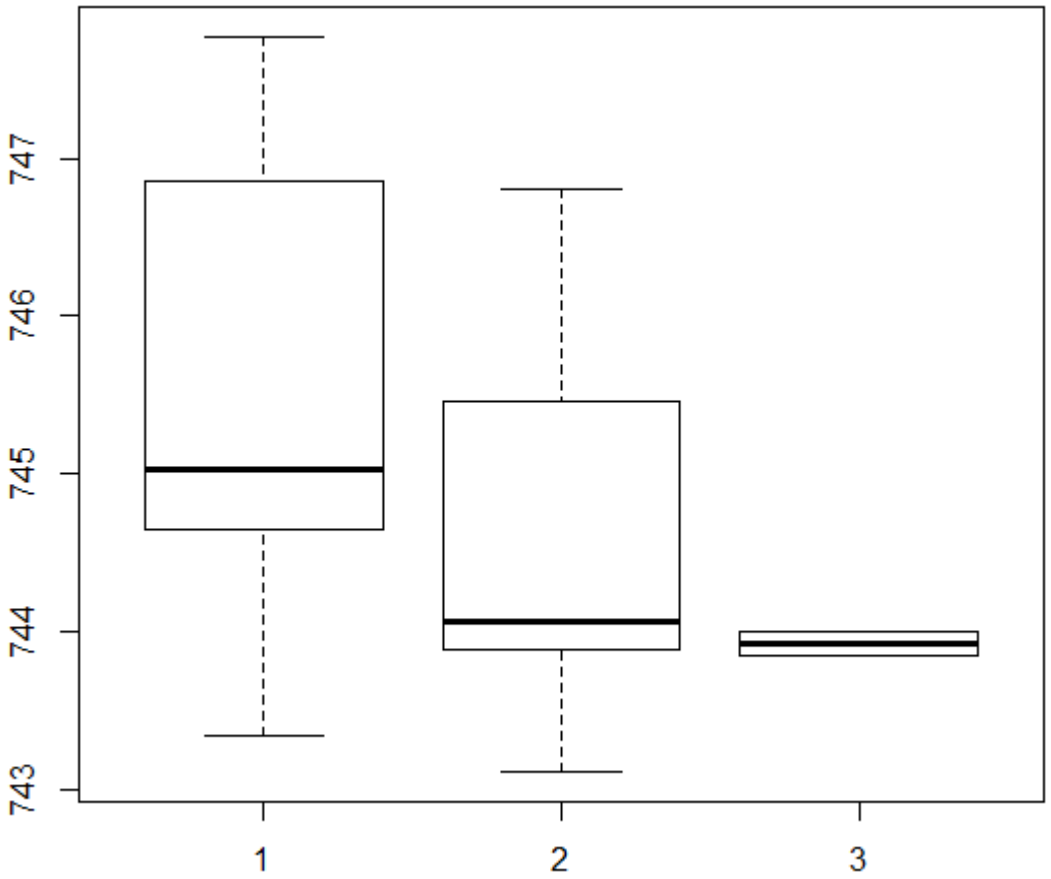


Results – Porto Uniao

Clustering of trajectories and floods

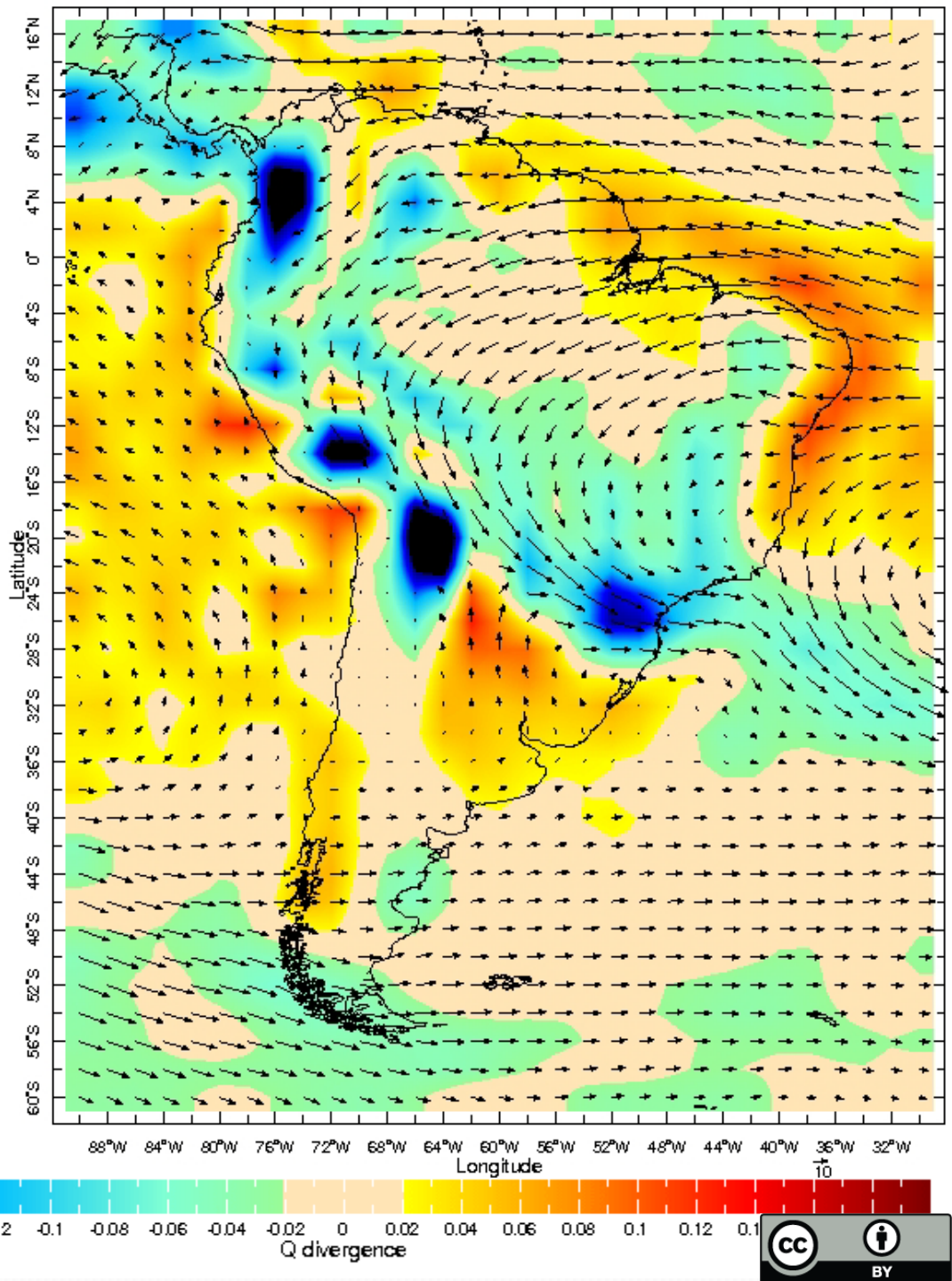
850 mb level





Results – Porto Uniao

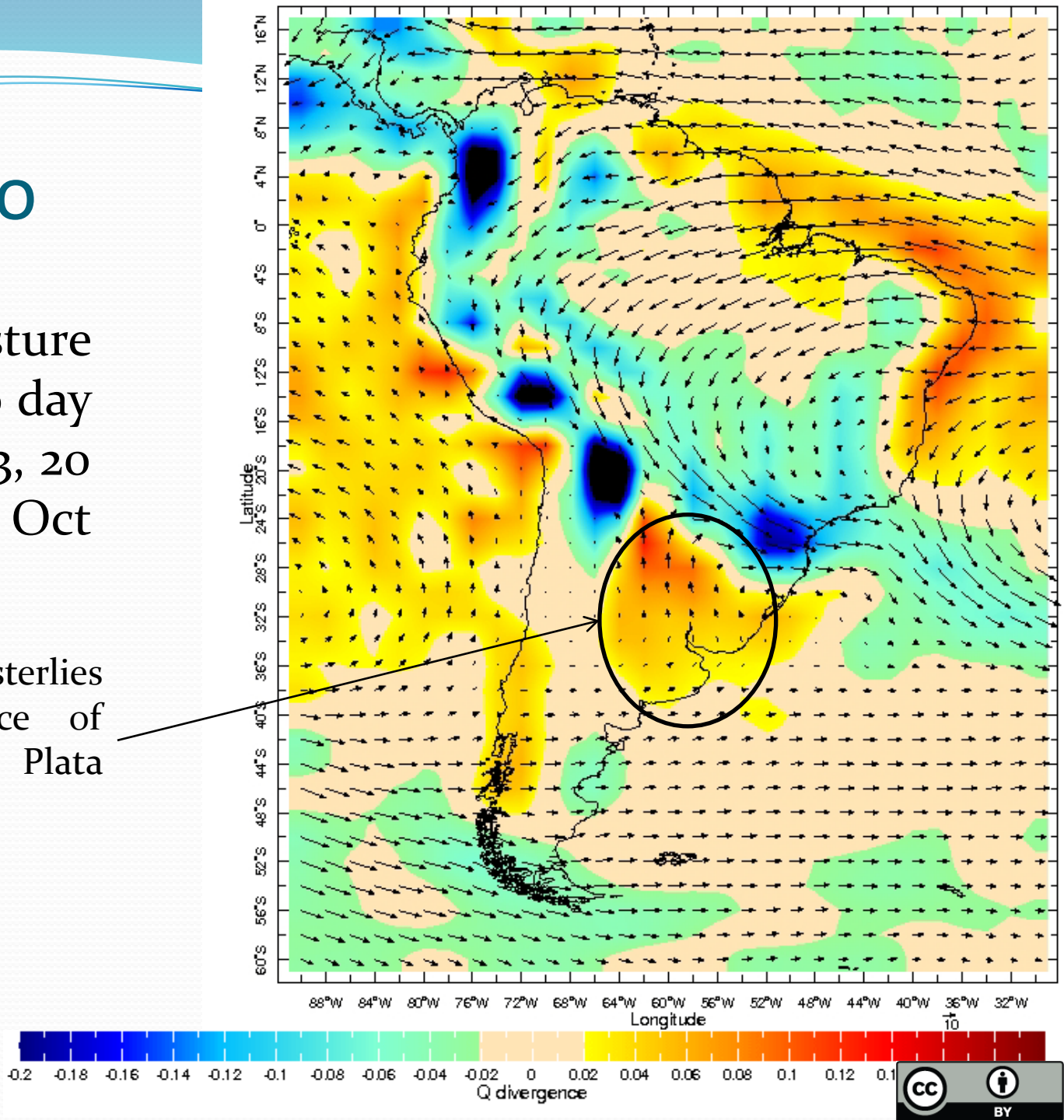
Integrated moisture flux for day -5 to day -1 of 06 Oct 1993, 20 Oct 1950 and 31 Oct 2008



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

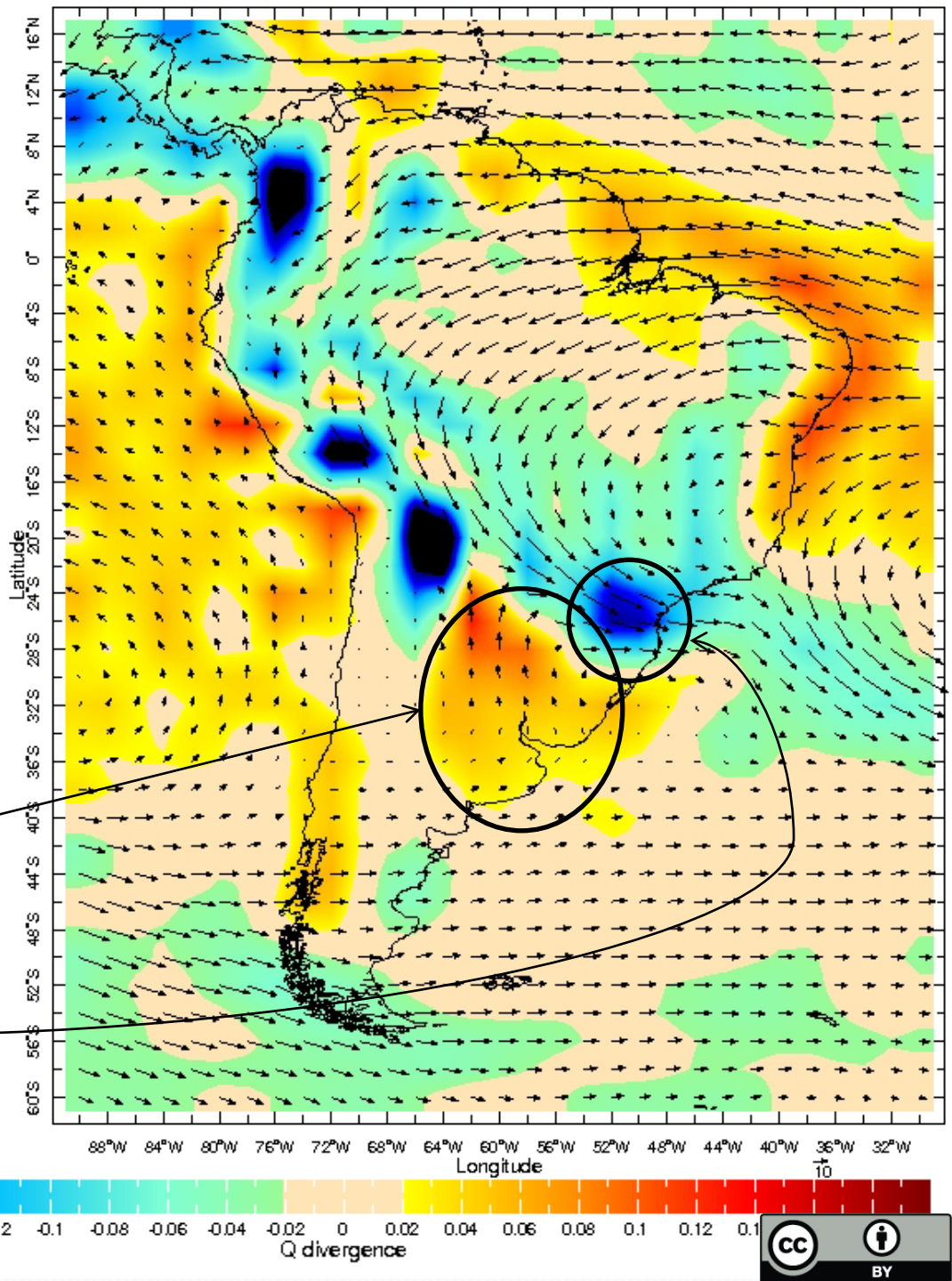


Results – Porto Uniao

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

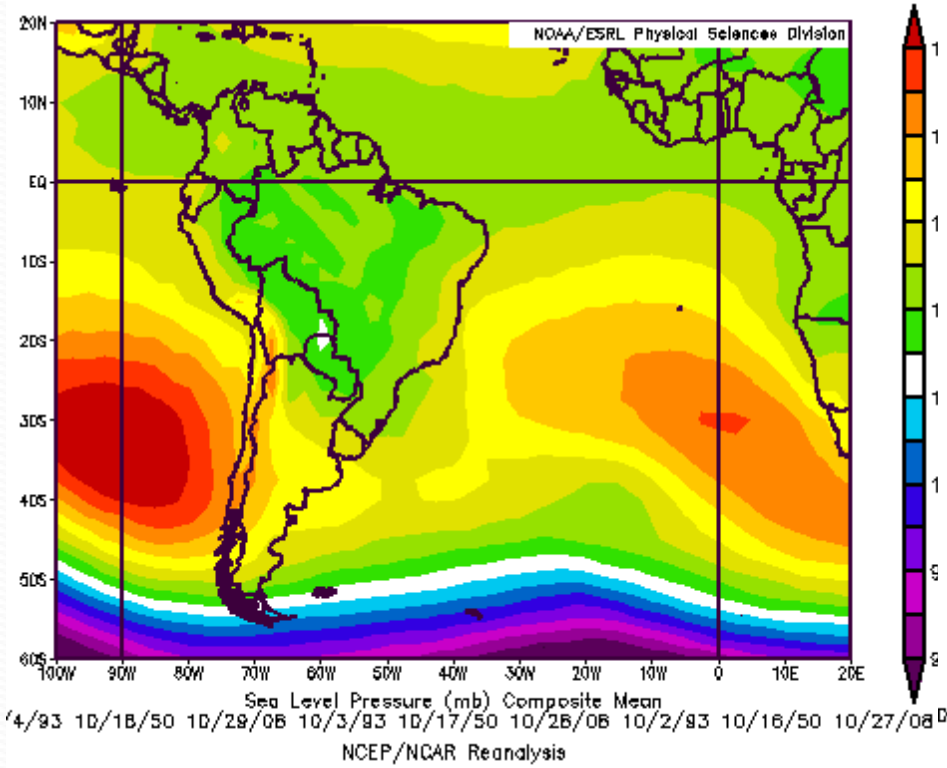
Convergence of moisture from disturbed westerlies and SALLJ

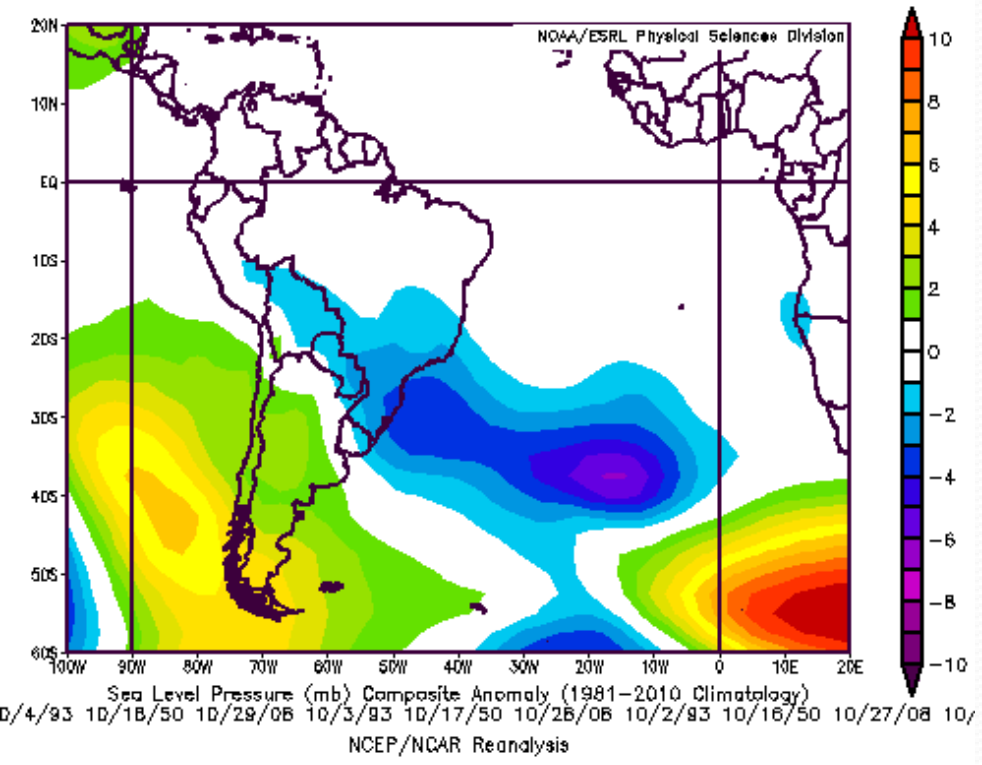


Results – Porto Uniao

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.