Study of greenhouse gases emitted by biomass burnings with a decade of infrared observation of CO_2, CH_4 and CO by IASI

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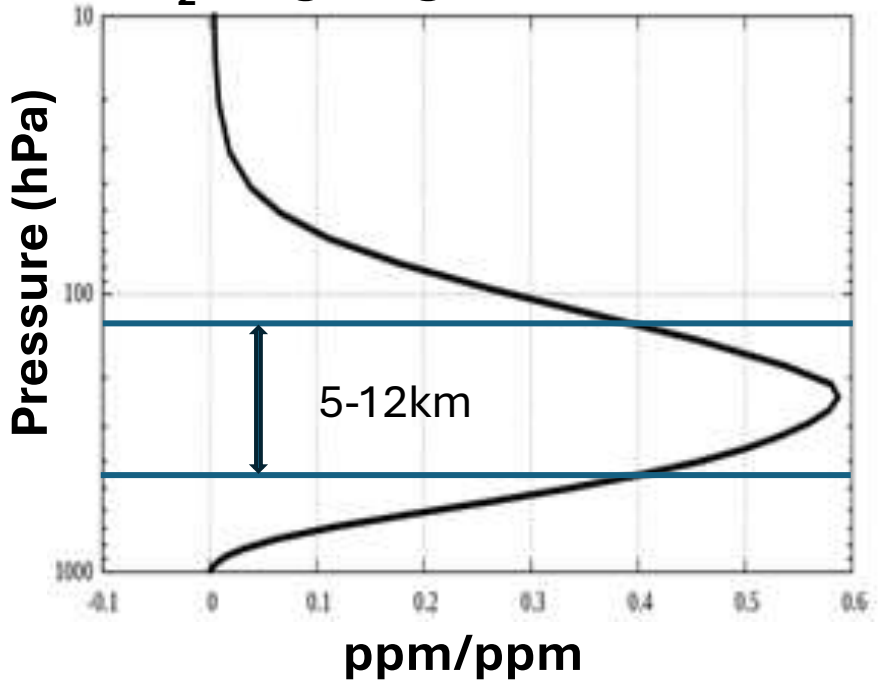
I came by train to IASI 2024

Atmospheric Concentrations : overview of IASI

Satellite observations by IASI:

- **Polar orbital satellite:** observations at 09:30 AM/PM LT.
- **Long time series** (2007-now with the 3 IASI instruments).
- **Retrieval of mid-tropospheric CO_2,CH_4 and CO** by neural network inversion (Crevoisier et al. (2013 and 2018)).
- **Partial column product** of CO_2 concentration between 500 hPa and 200 hPa (5-12km in tropics).

CO_2 weigthing function for IASI



Question:

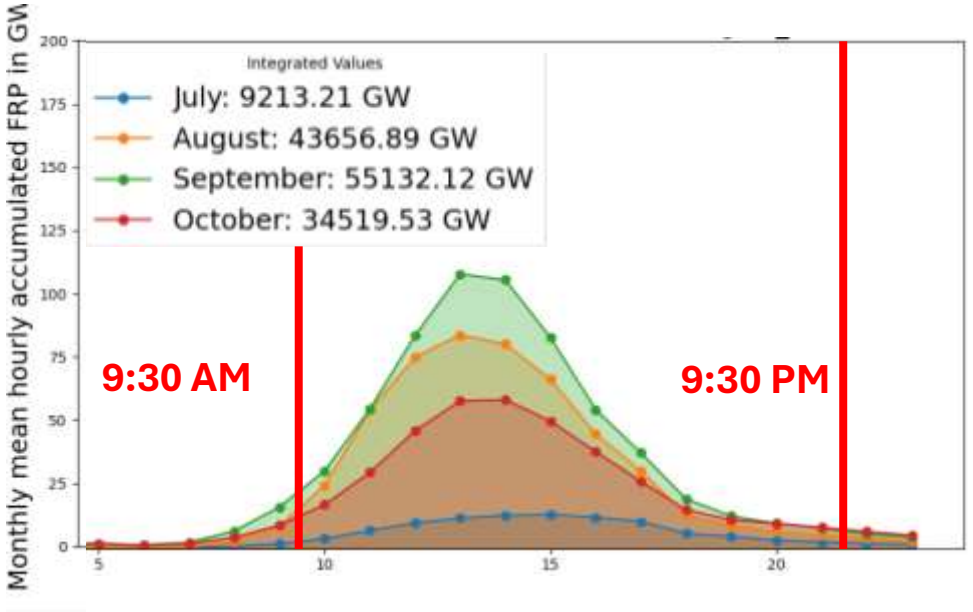
How can we analyse the contributions of biomass burnings emissions in the mid-tropospheric CO_2 concentrations?

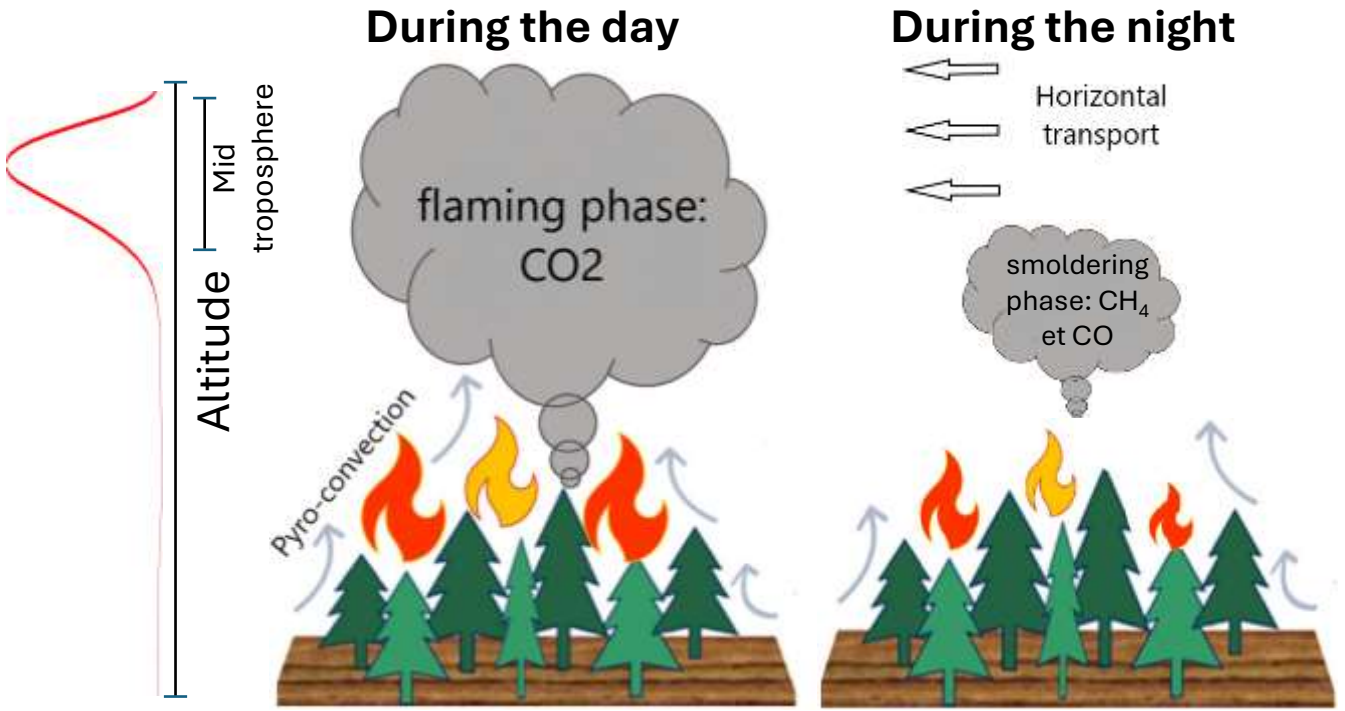
Analyzing biomass burning contributions: Daily Tropospheric Excess

Mid-toprospheric gas and its link with biomass burnings:

- **Daily Tropospheric Excess (DTE) method**:
  - For CO_2 with Chédin et al. (2005, 2008) and CO with Thonat et al. (2013, 2015)
  - Pyro-convection Rio et al. (2008, 2010)
  - Diurnal fire cycle

Diurnal fire cycle





My work: Add the impacts of transport and fire intensity on the variations of concentration.

Computing CO_2 anomalies

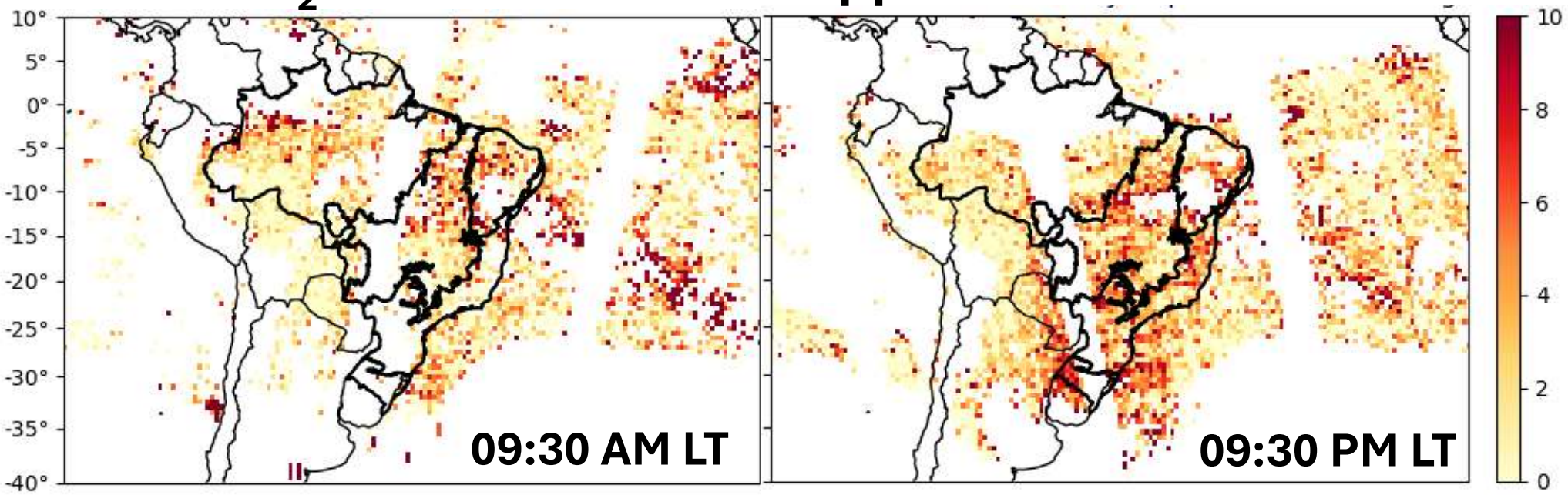
Challenges with anomalies of CO_2 :

- High background value but small variations
- Concentrations increase trend.
- Concentrations are latitudinal-dependent.

→

- Moving average of ±3 days
- Moving ±2° latitudinal band
- Calculate the background only on oceans

CO_2 mean anomalies in ppmv for 04/08/2020



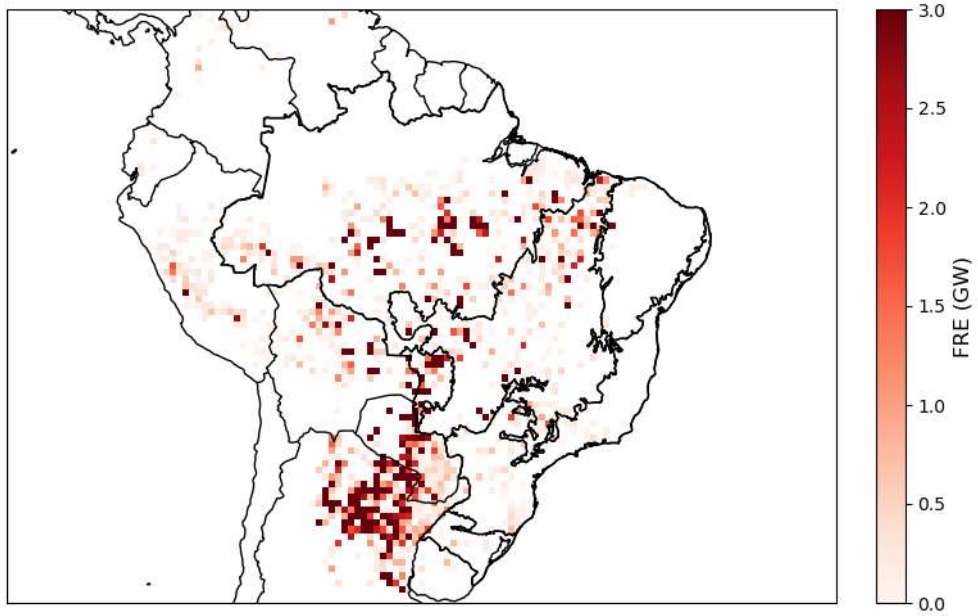
CO_2 mean anomalies and fire activity

A qualitative hypothesis of biomass burnings contribution:

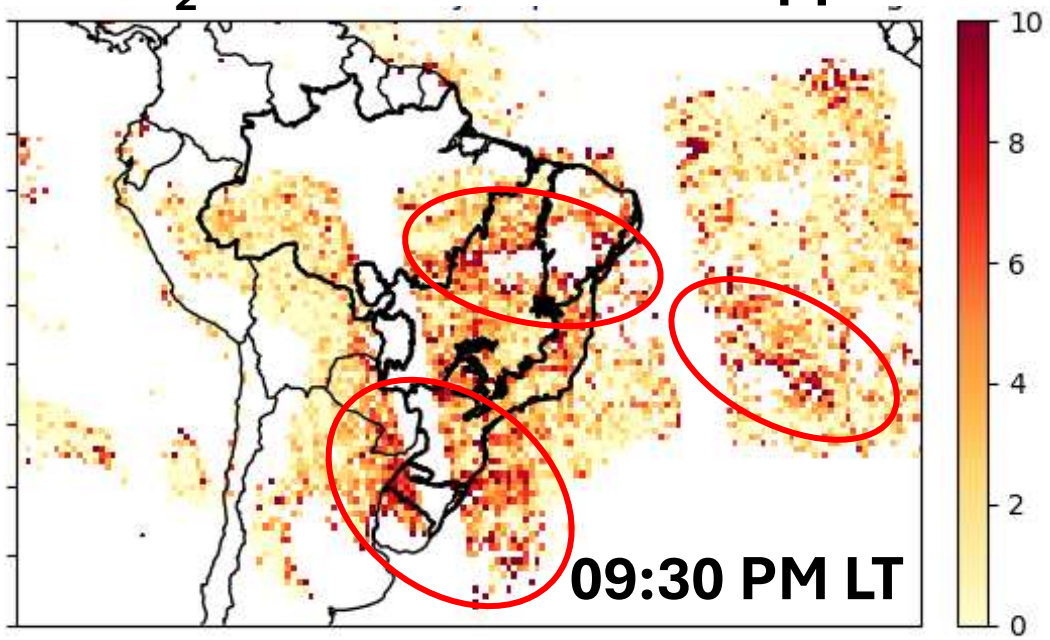
- Significative anomalies (>4 ppm):
  - To the east of Argentina.
  - Over the Cerrado region
  - Extensions toward the Atlantic.

Vertical transport by pyro-convection?
Horizontal transport ?

Fire Radiative Energy (FRE) in GW



CO_2 mean anomalies in ppmv

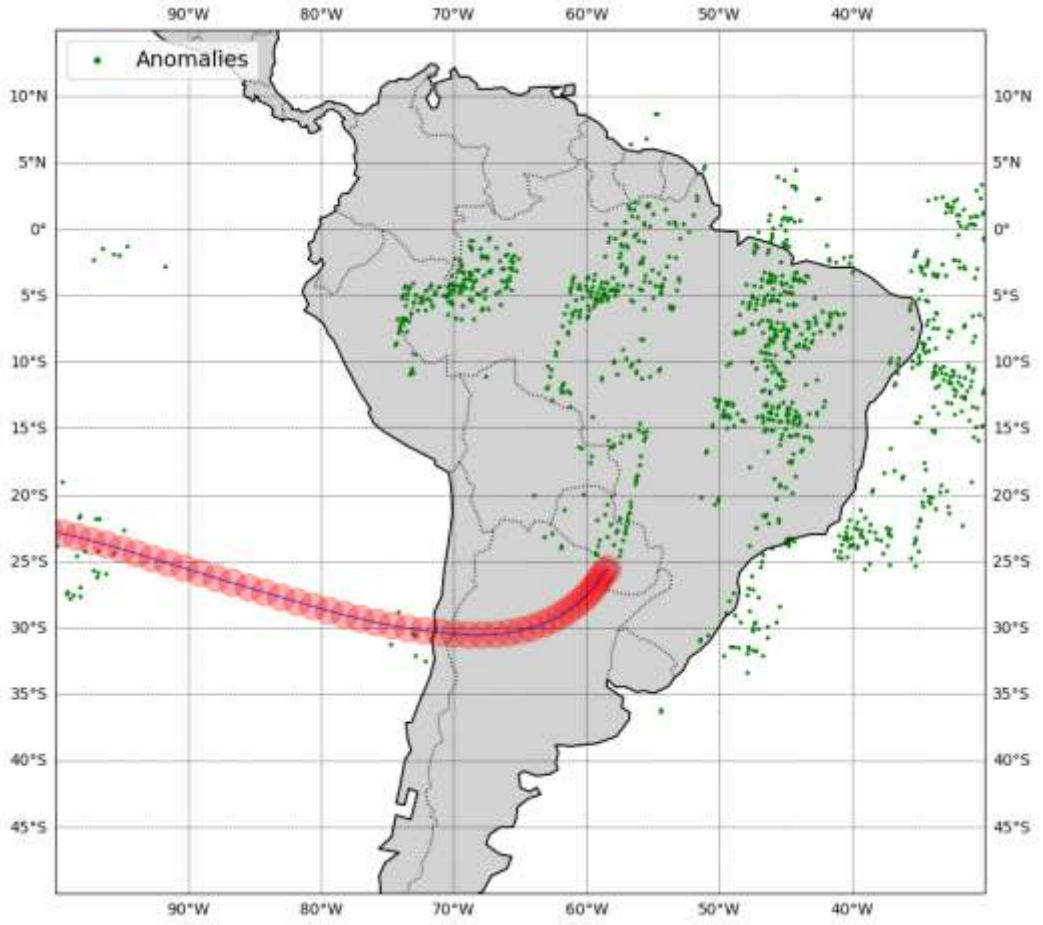


Methodology for linking anomalies to fires

A combination of CO_2 anomalies, transport and fires activity:

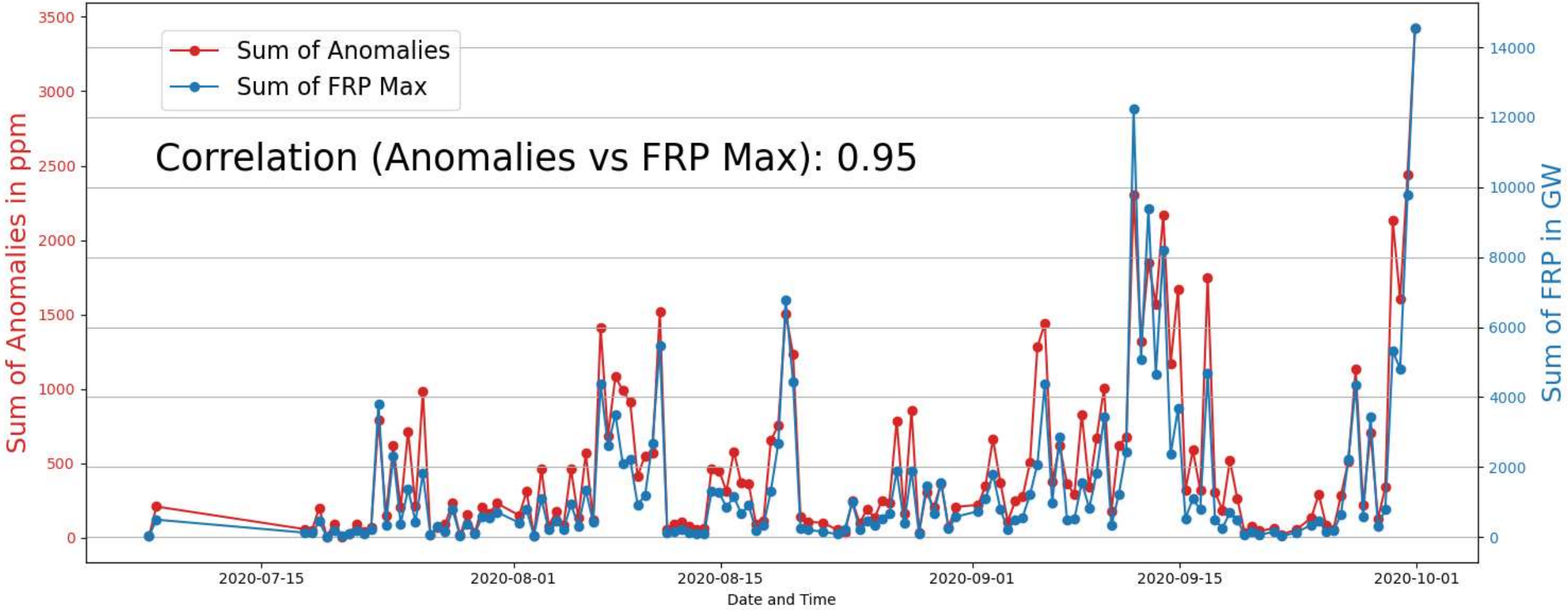
- **Selection of anomalies**: For each IASI observations (09:30 AM and 09:30 PM), anomalies > 4 ppm are identified.
- **Backward trajectories:** Generate backward trajectories from the identified anomalies.
- **Fire Radiative Power (FRP) collocation:** For each hourly time step, collocate backward trajectory points with the hourly sum of FRP within a 1° radius.
- **Detection of the FRP max for backward trajectories:** Selection of the maximal FRP contribution along the entire trajectory from all hourly collocations of each of backward trajectories.

→ **Focus on very big fires > 10 GW** (pyroconvection from 5 GW in Tory, K. J., et al 2021)



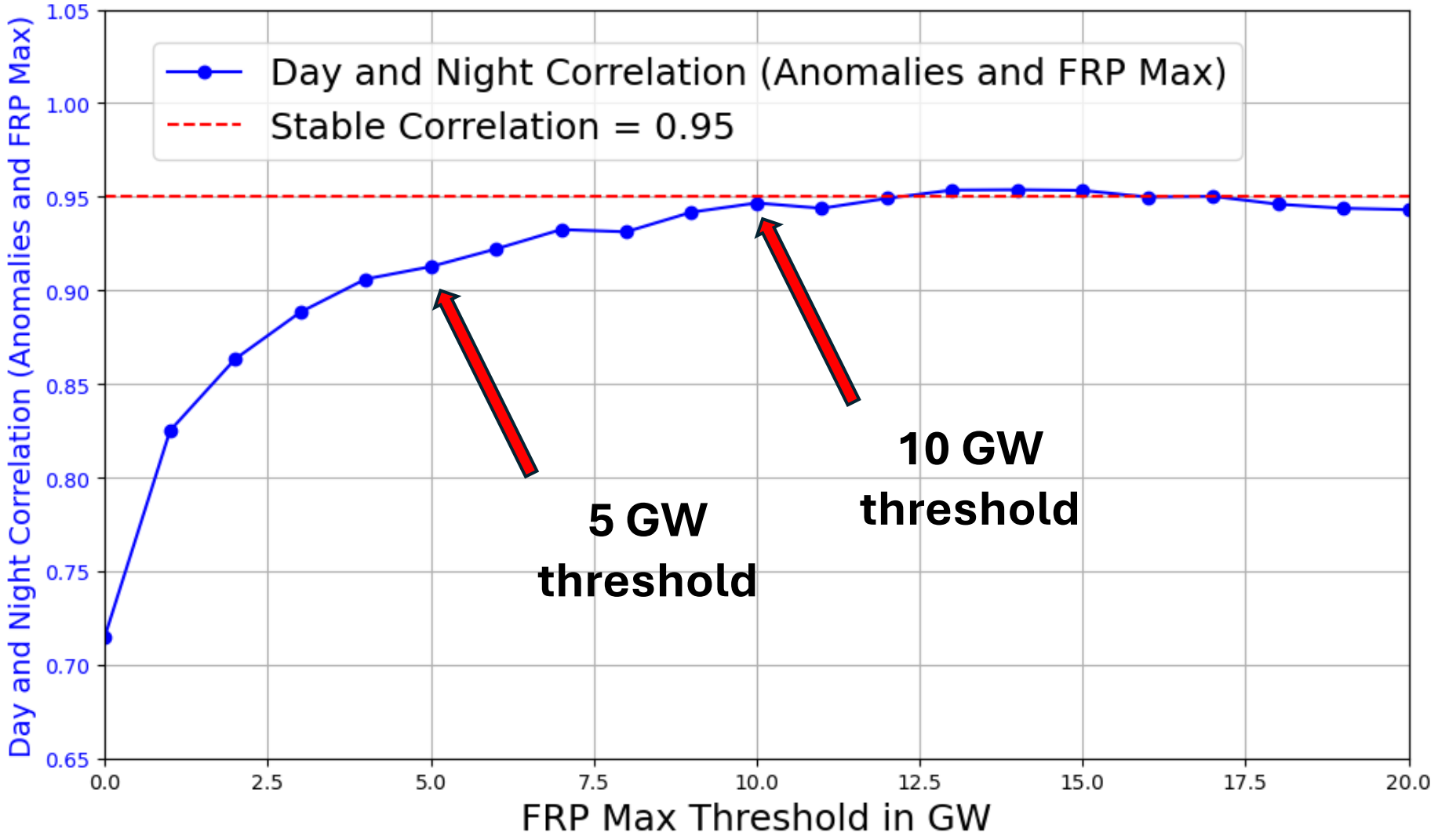
Seasonal analysis of anomalies and FRP max

Methodology on the total fire season in South America for 2020 with FRP > 10 GW and for 09:30 AM/PM observations:



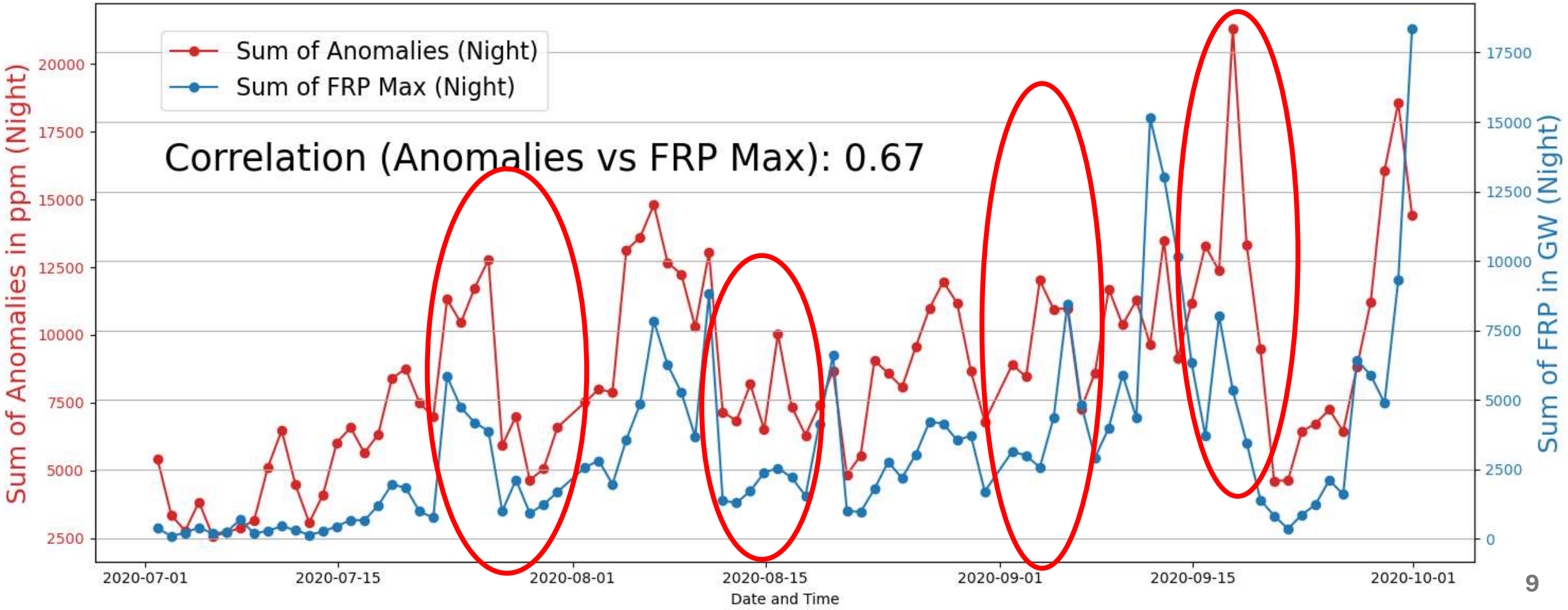
Refining with FRP threshold

Identification of local contribution by FRE threshold for pyro-convection:



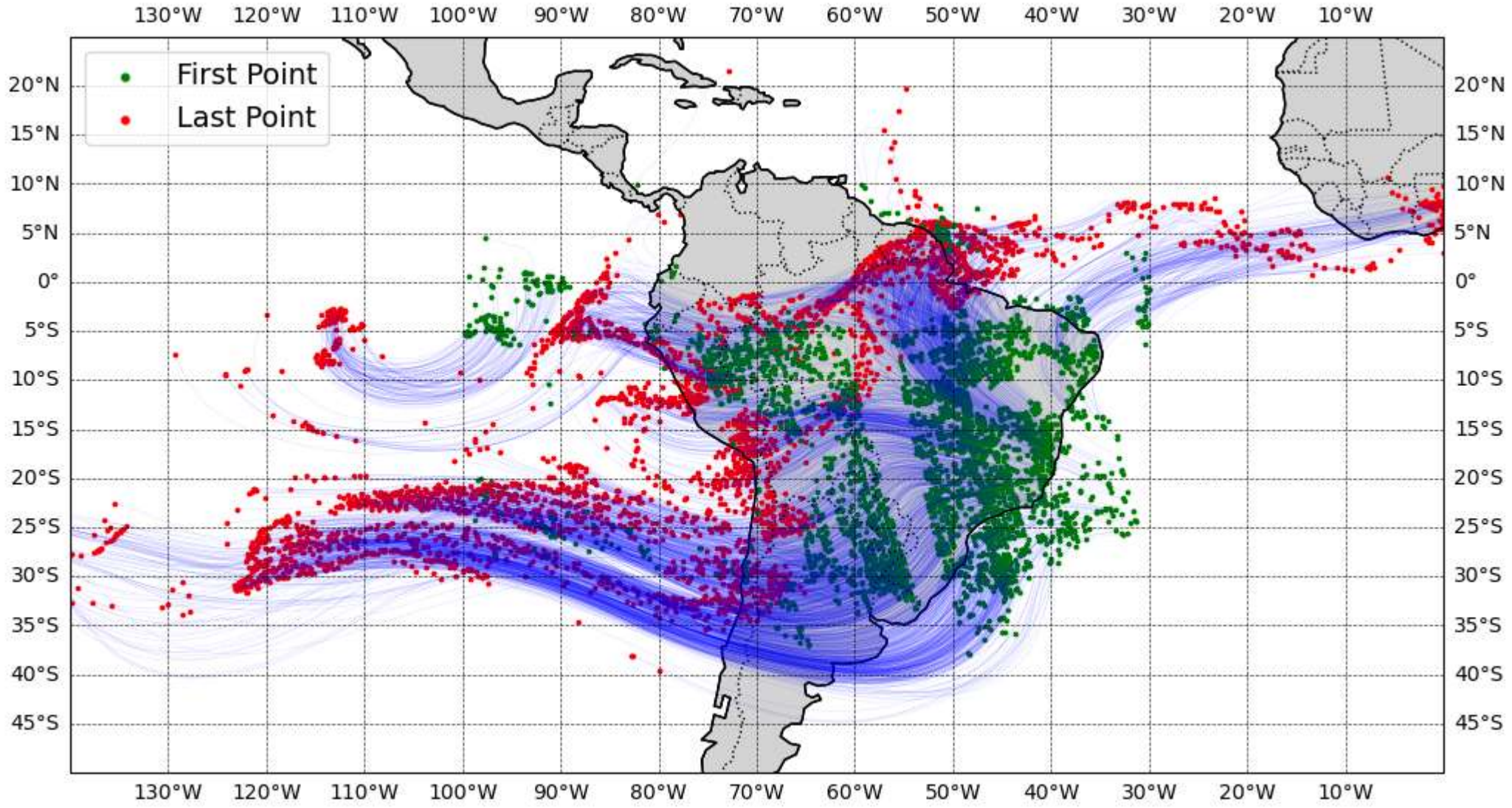
Seasonal Analysis of Anomalies and FRP

Methodology on the total fire season in South America for 2020 with no FRP threshold and for 09:30 PM observations:



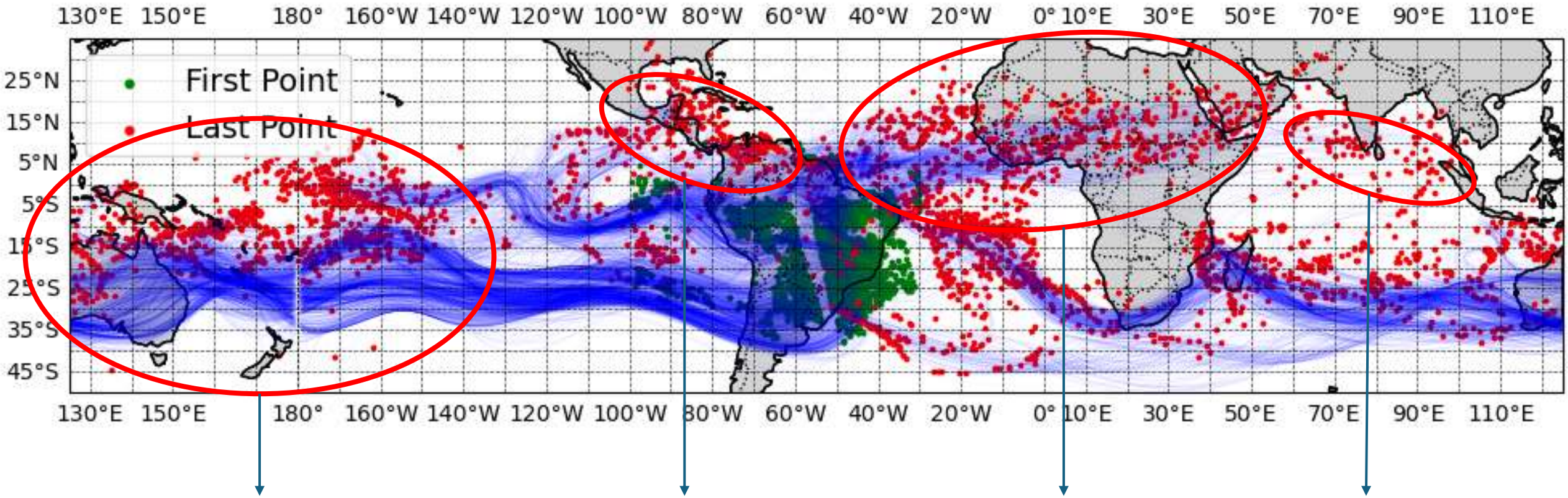
Identification of long-range contribution from fires

48 hours backward trajectories for anomalies in South America for 04/08/2020 evening:



Identification of long-range contribution from fires

10 days backward trajectories for anomalies in South America for 04/08/2020 evening:



Conclusions and perspectives

Conclusions:

Findings:

→ ***We linked variations of CO_2 in the mid-troposphere to detected fires intensity.***

- New approach that add transport and fire intensity analysis.
- Biomass burning emissions influence mid-tropospheric CO_2 concentrations through:
  - Local sources (strong correlation: 0.95 with 10 GW threshold) by pyro-convection.
  - From long distance transport (in particular tropical fire regions contributions).

→ Publication in process

Perspectives:

- ***Multi-species analysis***: CO_2 but also CH_4 and CO associated with fire intensity to better understand combustion effect.
- ***Tropical region analysis:*** etend to the other contributing tropical regions, based on geostationary fire detection.