NATIONAL INSTITUTE FOR SPACE RESEARCH

Center for Weather Forecasting and Climate Studies

PARAMETERIZATION OF ELECTRIC DISCHARGES AND THE EFFECTS ON RAIN AND NOx PRODUCTION

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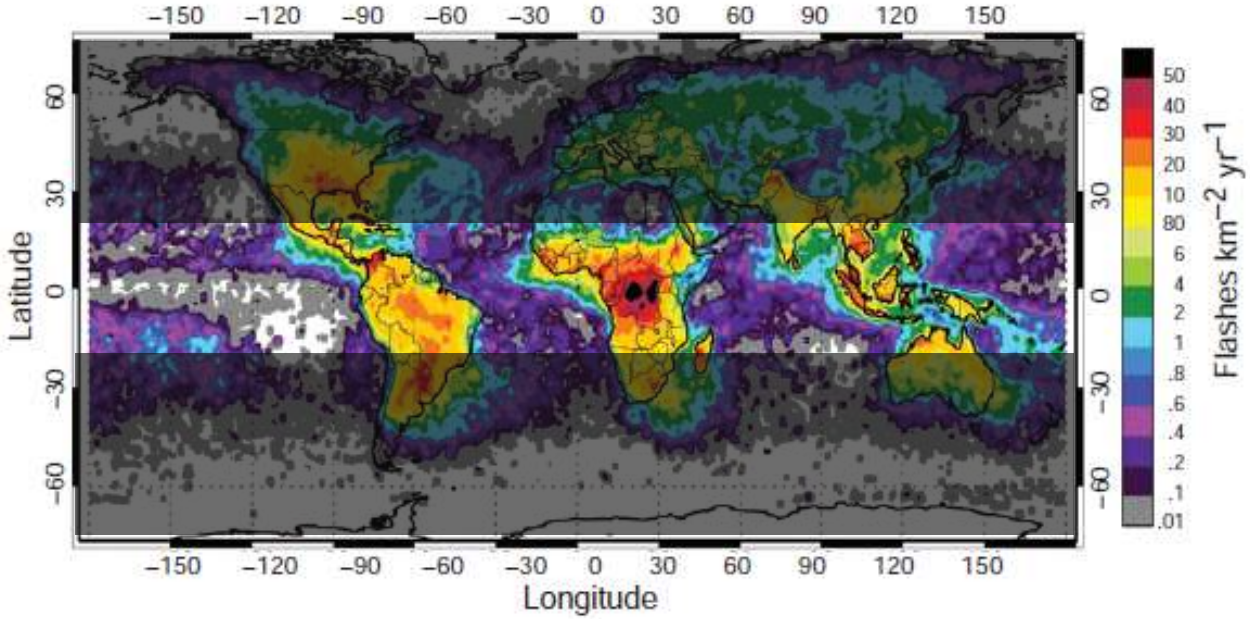
1.2 Electric Discharges in the Atmosphere

- Why should we estimate lightning in an atmospheric model?
  - Lightning activity is an **important issue in the tropical area** of the planet.
  - Agribusiness;
  - Forest Fires;
  - Building damages;
  - Electric Companies;
  - Climatological Studies;
  - Cloud microphysics Structure;
  - Chemical Reactions;
  - Affecting precipitation production; and
  - Largest source of NOx, an indirect GHG



Average annual distribution of the total lightning strikes observed by satellites. Source: Cristian et al. (2003, p. 5).

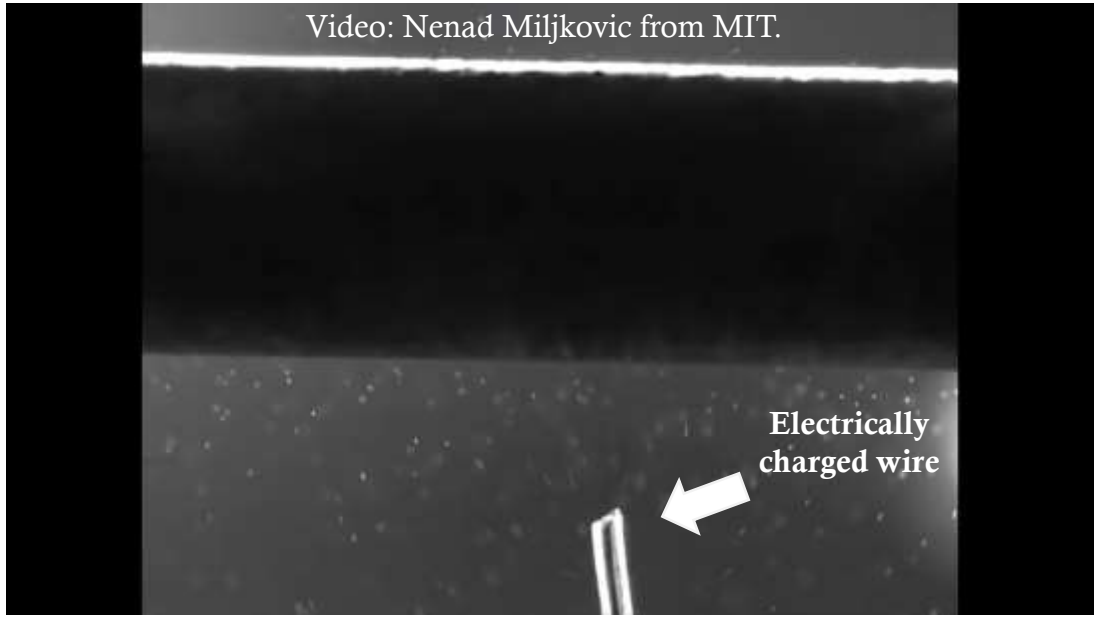
1.3 Eletric Discharge Effects on Rain Production

- The electric force inside the cloud is able to **change the trajectory of cloud droplets** (Plumlee and Semonin, 1965).

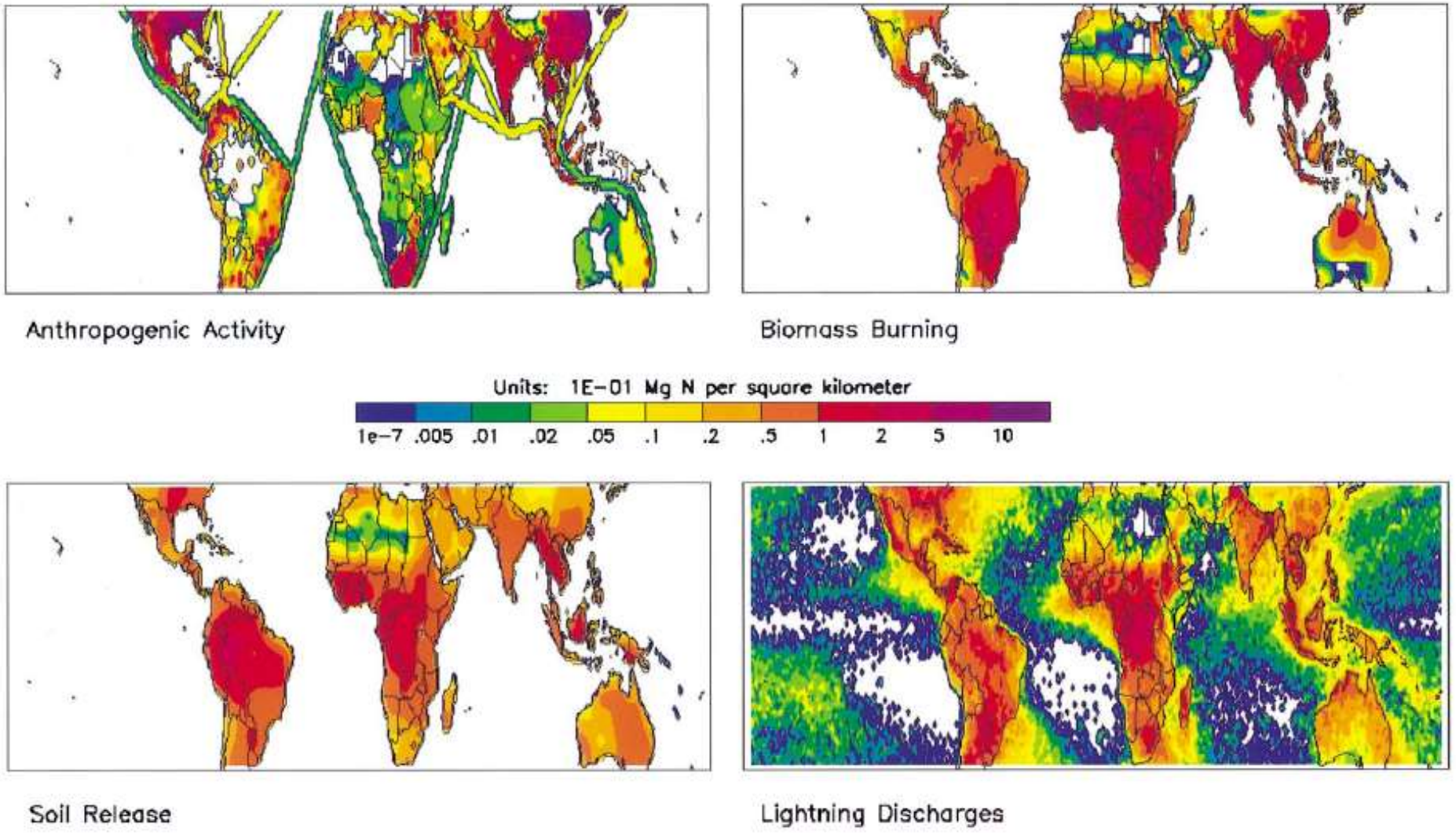
- **The electric force tends to accumulate the droplets** in regions of the cloud with strong electric field (Sartor, 1973, p.31).

- The result is an increase in the autoconversion of cloud droplets.
  - "***Autoconversion*** *is the process where cloud droplets collide and coalesce with each other and eventually form raindrops.*" (Stensrud, 2007: 281)

- Consequently, **the electrical activity is capable of increasing the production of raindrops**.



1.4 Eletric Discharge Effects on NO_x Production



Lightning is estimated to be the **largest natural source of NOx** (Galloway et al., 2004).

Annual nitrogen oxide production from the various sources in the tropics. Source: Bond et al. (2002, p. 1514).

Objective

- The **main objective** of this work is to **develop a lightning parameterization scheme** in the Eta regional model and to **include the effects of electrical activity** in the **production of rain** and in the chemistry of the atmosphere through the **production of Nitrogen Oxides**.

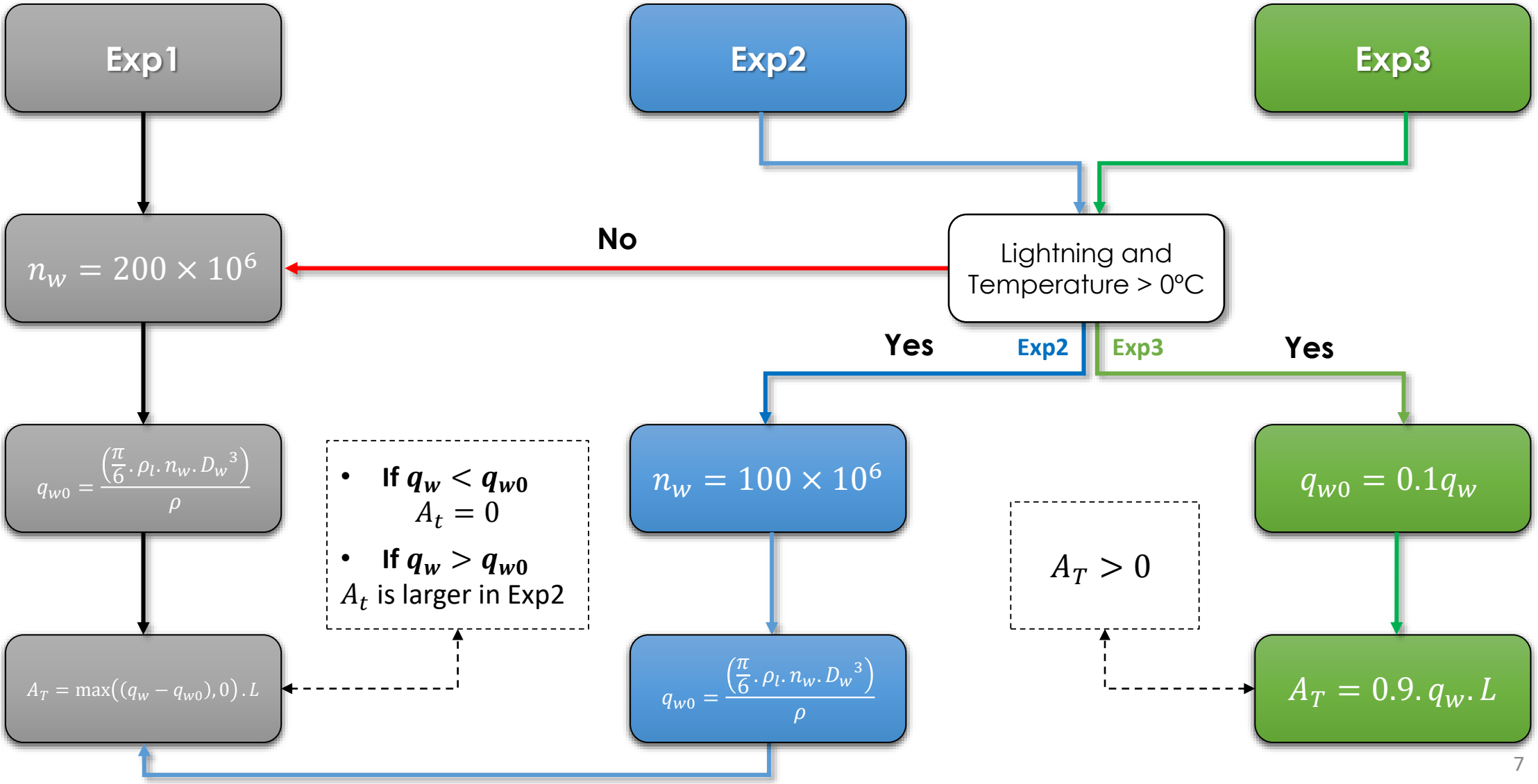
Motivation

- **Improve model precipitation estimate: hydrological cycle, water resources**
- **NOx : Indirect GHG**

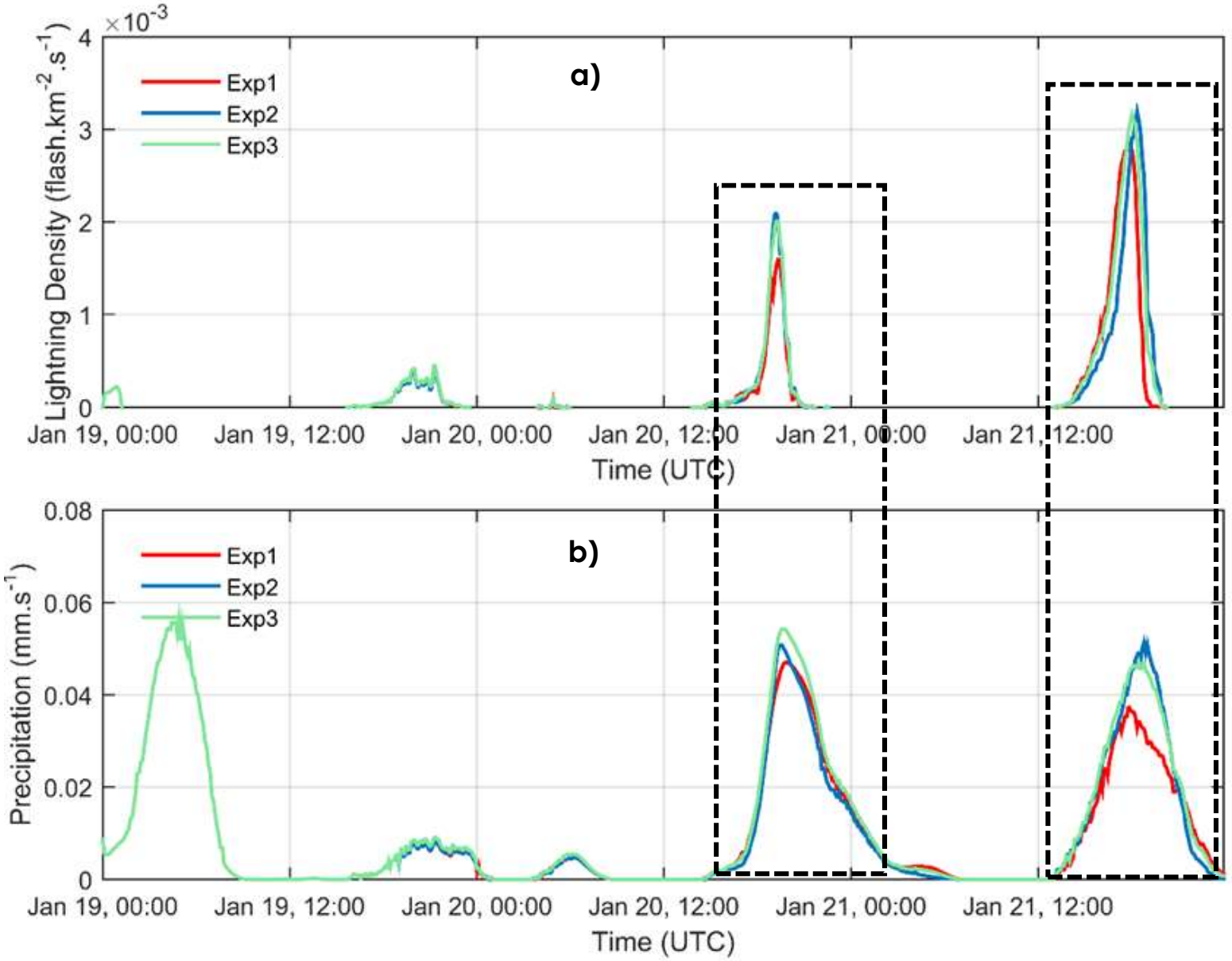
3. Results

3.1 Calibration
3.2 Lightning Simulation
3.3 Lightning Effects on Rain Production
    3.3.1 Lightning indirect Effects
3.4 Lightning Effects on NOx Production

2.1.3 Effects on Rain Production



3.3 Lightning Effects on Rain Production

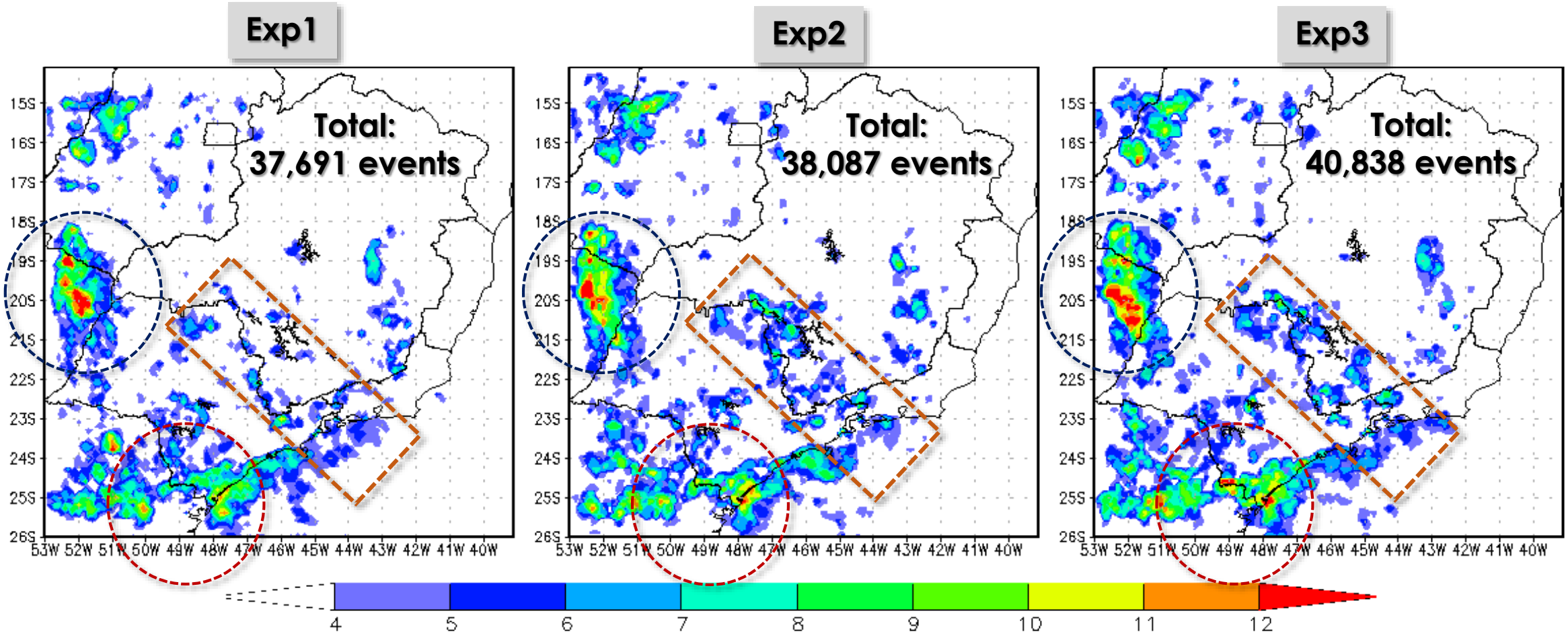


REMEMBER:

- **Exp1 – <u>No effets on autoconversion</u>**
- **Exp2 – <u>Effects on autoconversion</u>**
- **Exp3 – <u>Stronger effects on autoconversion</u>**

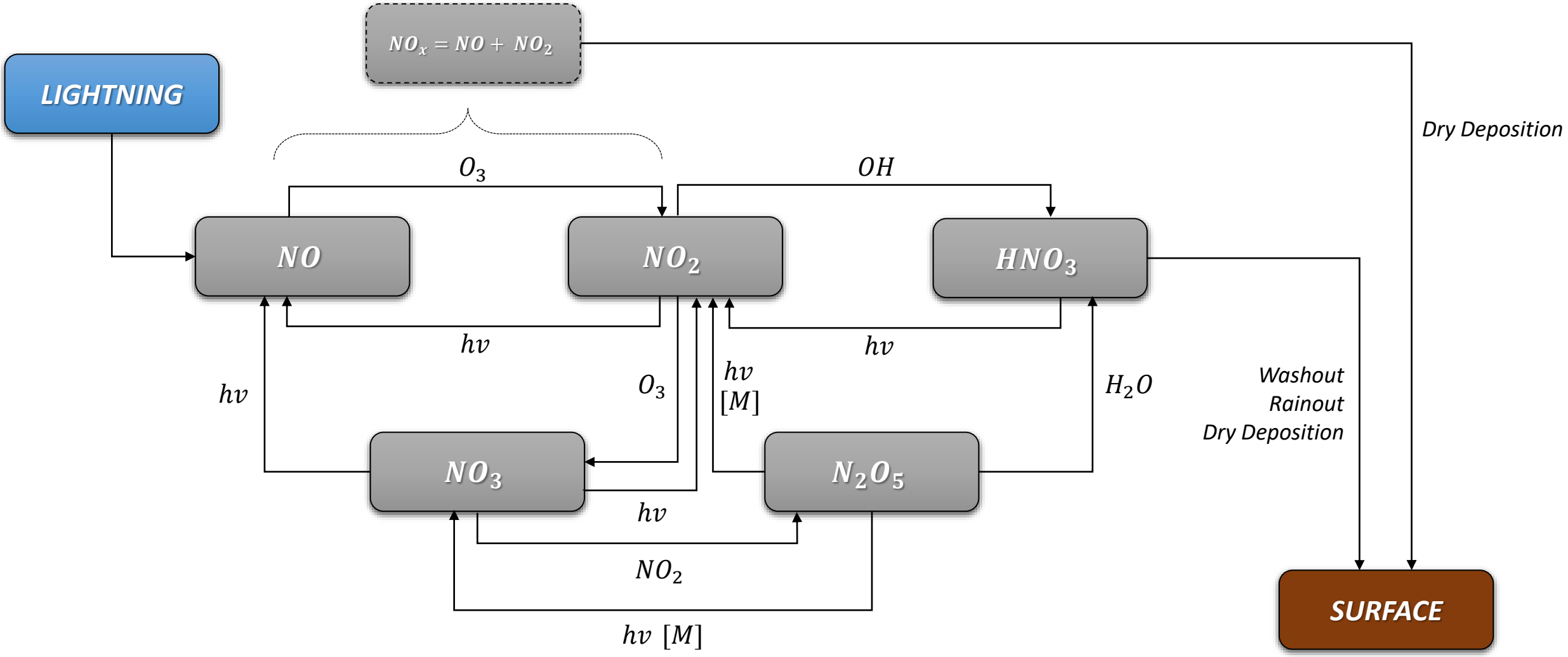
Time series simulation of a) lightning density and b) precipitation rate between 19/01/2017 0000 UTC and 22/01/2017 0000 UTC. The simulations refer to the averages over **the area limited by the coordinates 19S-19.5S and 47.5W-48.5W**.

3.3 Lightning Effects on Rain Production



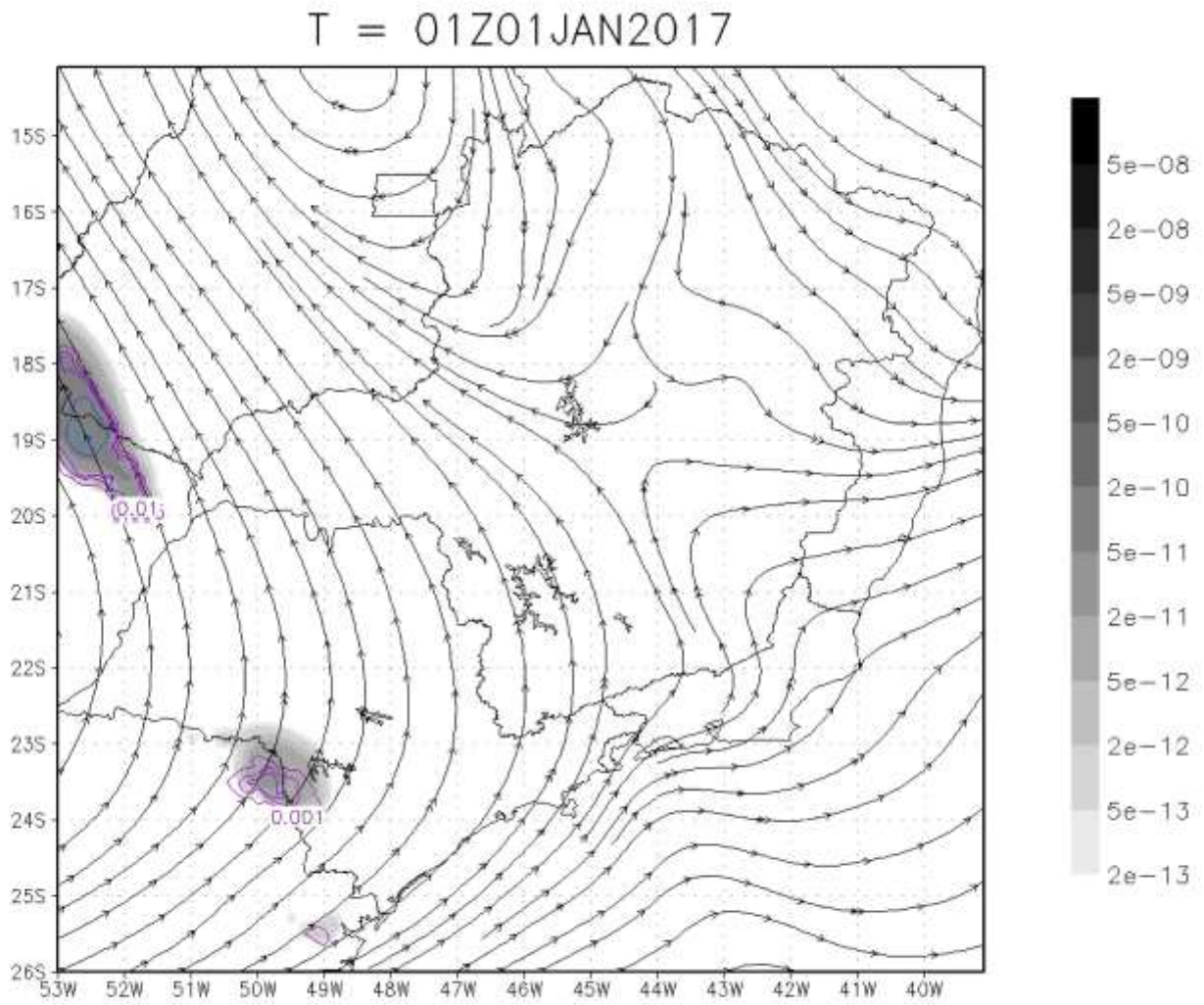
Total events of ***precipitation (mm/24h) above 30mm threshold that coincides with the occurrence of lightning activity*** ($flash.day^{-1}$) in the period from January to March 2017

2.1.4 Effects on NOx Production



$hv \rightarrow$ Photodissociation Process

3.4 Lightning Effects on NOx Production



Simulation of NOx production at 200 hPa during intense electrical activity. The mixing ratio of **NOx in shading** and the **lightning (flash/h.km²) in contour lines**. Eta model started on 01/01/2017 00 00UTC.

4. Conclusion and Final Comments

1. The **lightning scheme was able to reproduce the observations** of atmospheric electric discharges.
2. All the experiments showed **underestimation of lightning against observed** lightning data.
3. The lightning effect on cloud droplet autoconversion caused an **increase in the electrical activity**.
4. The lightning effect on cloud droplet autoconversion caused an **improvement in the performance of the lightning simulation in Exp2.**
5. **All experiments underestimated the precipitation** estimated by CMORPH satellite;
6. Precipitation underestimate was smaller in experiments with the effect of lightning on droplet autoconversion
7. It was found that **Exp2 and Exp3 presented more cases of precipitation above the 30 mm/day** threshold that were related to the occurrence of lightning during the analyzed period in comparison to Exp1.
8. It is suggested **to use the Exp2 configuration in Eta model** until further studies are carried out.

4. Conclusion and Final Comments

- The scheme was able to **reproduce the averages of the chemical species on the domain when compared to the CAMS** reanalysis data.
- Improvements are required for HNO3 sink.
- The concentrations of the species showed values close to the values described in the literature.
- The **horizontal and vertical transport of NOx proved to be efficient** and the mass of the species was conserved.
- The results are encouraging, but **new analyses and applications must be carried out** to improve the scheme.

5. Acknowledgment

- Coordination for the Improvement of Higher Education Personnel (**CAPES**);
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