AMMONIA EMISSIONS IN BIOMASS BURNING REGIONS: ESTIMATION FROM SATELLITE-DERIVED MEASUREMENTS AND COMPARISON WITH BOTTOM-UP INVENTORIES

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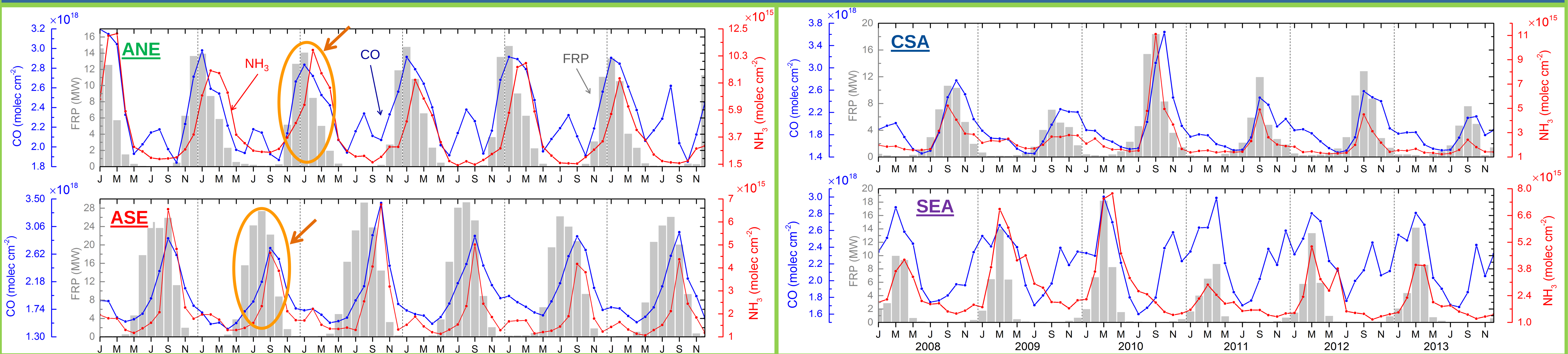
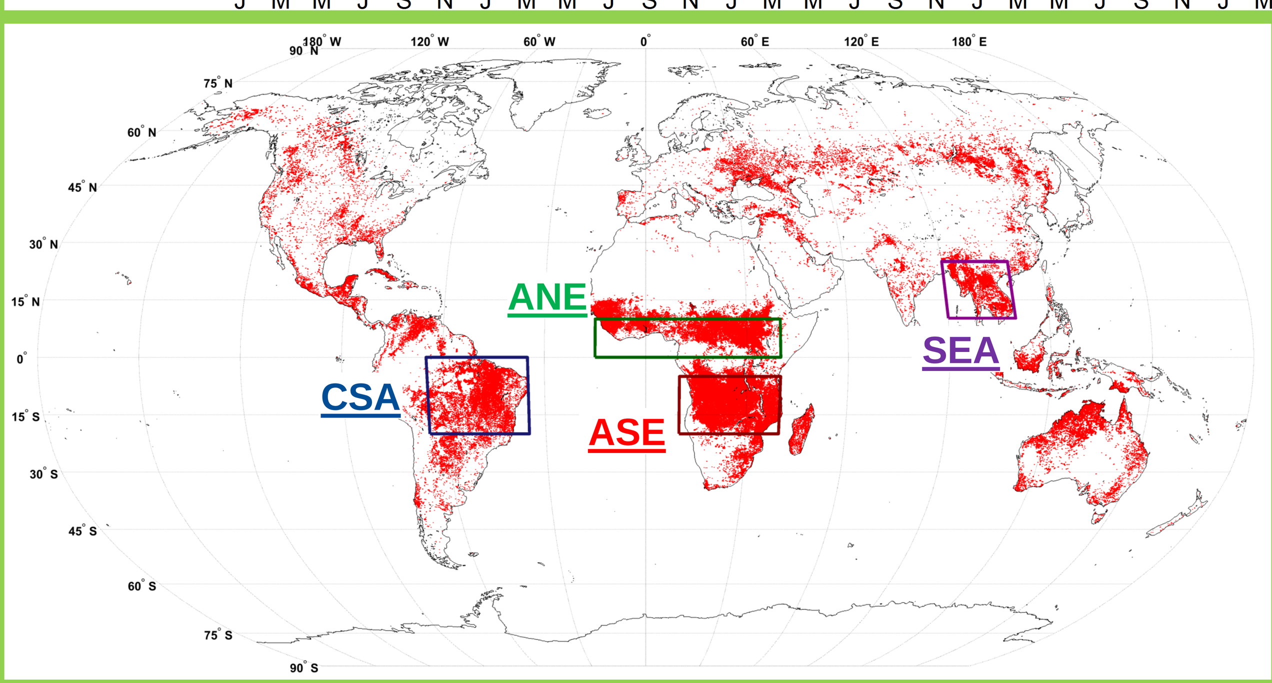
Vegetation fires emit important amounts of trace gases in the atmosphere. They contribute to about 13% of NH_3 global emissions and could even rival with anthropogenic emissions for CO. These emissions have important impacts on the environment (e.g. eutrophication and acidification of the ecosystem, loss of plant diversity), climate and human health (e.g. respiratory diseases) [1, 2]. Despite the numerous studies achieved in the past decades, mainly from "bottom-up" approaches, uncertainties in biomass burning emissions remain large and difficult to quantify, especially for the reactive nitrogen compounds [3]. We analyze, for four regions known for their important fire activity [4], extensive time series (2008-2013) of mean NH_3 and CO total columns (molec.cm^{-2}) retrieved from IASI measurements for their correspondence with the fire radiative power (FRP, from MODIS Terra and Aqua).



Time series of the monthly means of MODIS Terra and Aqua derived FRP (MW) (gray bars), and NH_3 (red lines) and CO (blue lines) IASI total columns (molec.cm^{-2}) for the ANE (top), ASE (second), CSA (third) and SEA (bottom) regions.



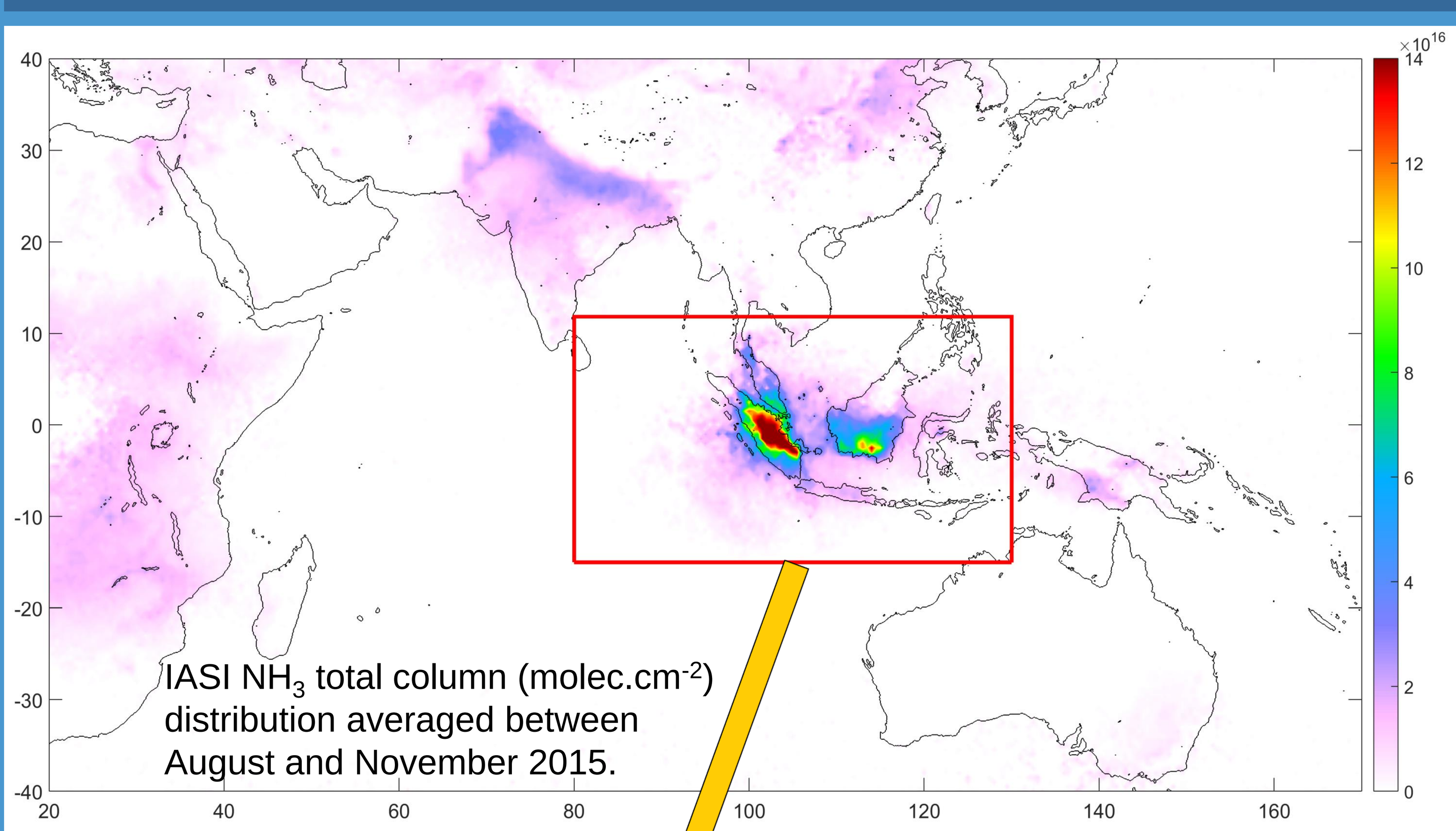
Active fires detected by the MODIS Terra and Aqua sensors during the year 2015 with the four studied regions (ANE, ASE, CSA and SEA) highlighted.

Principal results

- **General good correspondence between the maxima of FRP (MW), NH_3 and CO (molec.cm^{-2}) monthly means, presumably indicating that most emissions for these regions are linked to pyrogenic sources.**
- Systematic 1-2 month lag in NH_3 maxima compared with the FRP for the two regions of Africa (ANE and ASE):
  - ASE: Same 1-2 month lag between CO and the FRP maxima. Likely related to the combustion of more woody material towards the end of the dry season, emitting more incompletely oxidized products than grassland (van der Werf et al., 2006 [3]).
  - ANE: No lag observed between CO and the FRP maxima. Observed NH_3 mean columns might be the combined effect of vegetation fires and emissions from soil [5].
- Best agreement between NH_3 and FRP found for the CSA region with interannual variability of the FRP well reflected on the concentration of NH_3.

Case Study: The exceptional 2015 Indonesia's wildfires

Indonesia experienced in autumn 2015 the most severe forest fires in almost two decades. In the region, fires are generally human-induced for land clearing purpose and therefore recurrent. In 2015, the fires were amplified by the strongest El Niño Southern Oscillation (ENSO) since 1997, which caused severe droughts throughout the western Pacifica area [6]. Tropical forests and peatlands burned out of control for about two months (between September and October), mostly on Sumatra and the Indonesian portion of Borneo, resulting in the lost of more than 2.6 million hectares of forests and the release of 1.75 billion tons of CO_2 into the atmosphere (estimates from the Global Fire Emissions Database). During several days, the Indonesian emissions of CO_2 even exceeded these of China or the USA and the transport of large fire plumes over the region was responsible for the exposure of 40 million people to hazardous level of air pollution [6]. We give a first estimation of the daily NH_3 emission fluxes (Tg day^{-1}) for this fire event using a simple box model and we compare them to the emission fluxes from the seven previous years.



IASI NH_3 total column (molec.cm^{-2}) distribution averaged between August and November 2015.

Conversion of the estimated total masses (Tg) (bottom left panel) over the studied region (red rectangle) into daily emission fluxes (Tg NH_3 day^{-1}) (second panel) using a simplified box model:

$$E_{i+1}(NH_3) = \frac{TM_{NH_3,i+1} - TM_{NH_3,i}e^{-t/\tau_{eff}}}{\tau_{eff}\left(1 - e^{-t/\tau_{eff}}\right)}$$

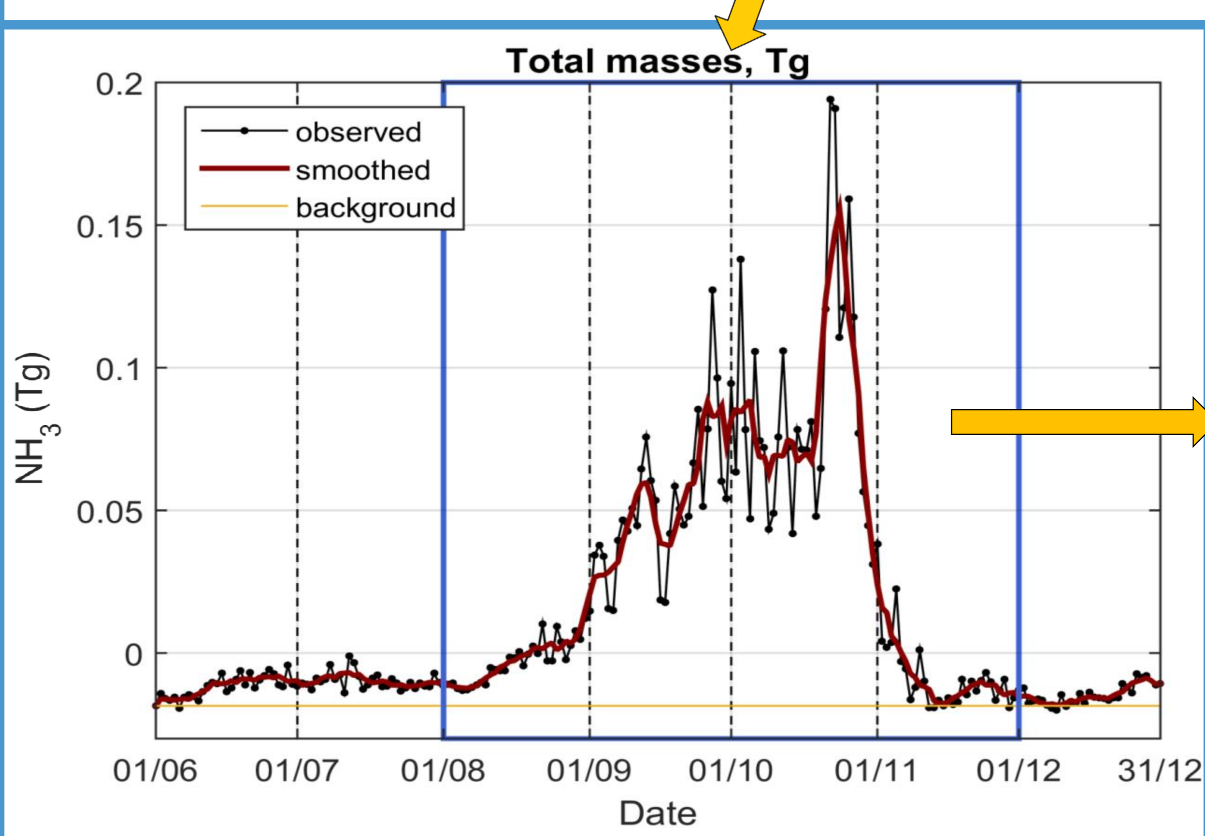
Effective lifetime

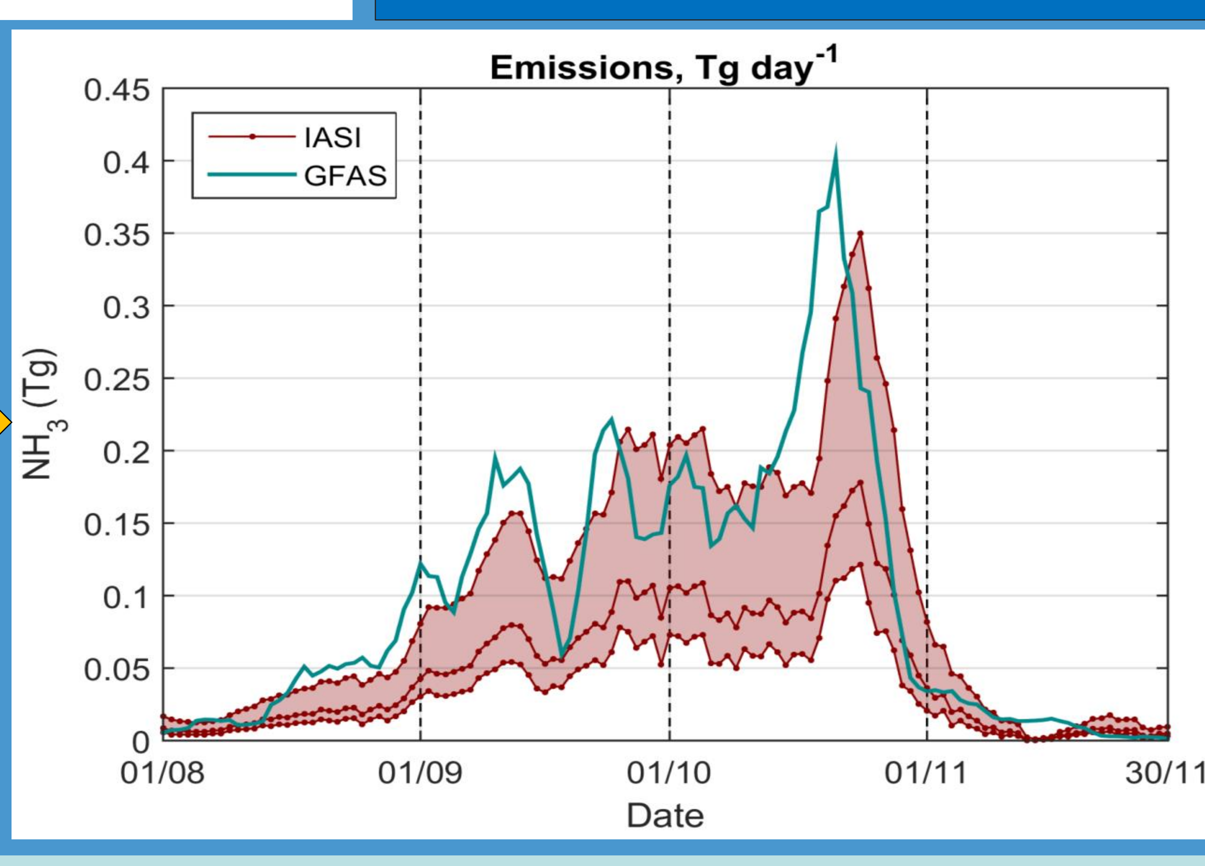
Total mass (Tg) for day i

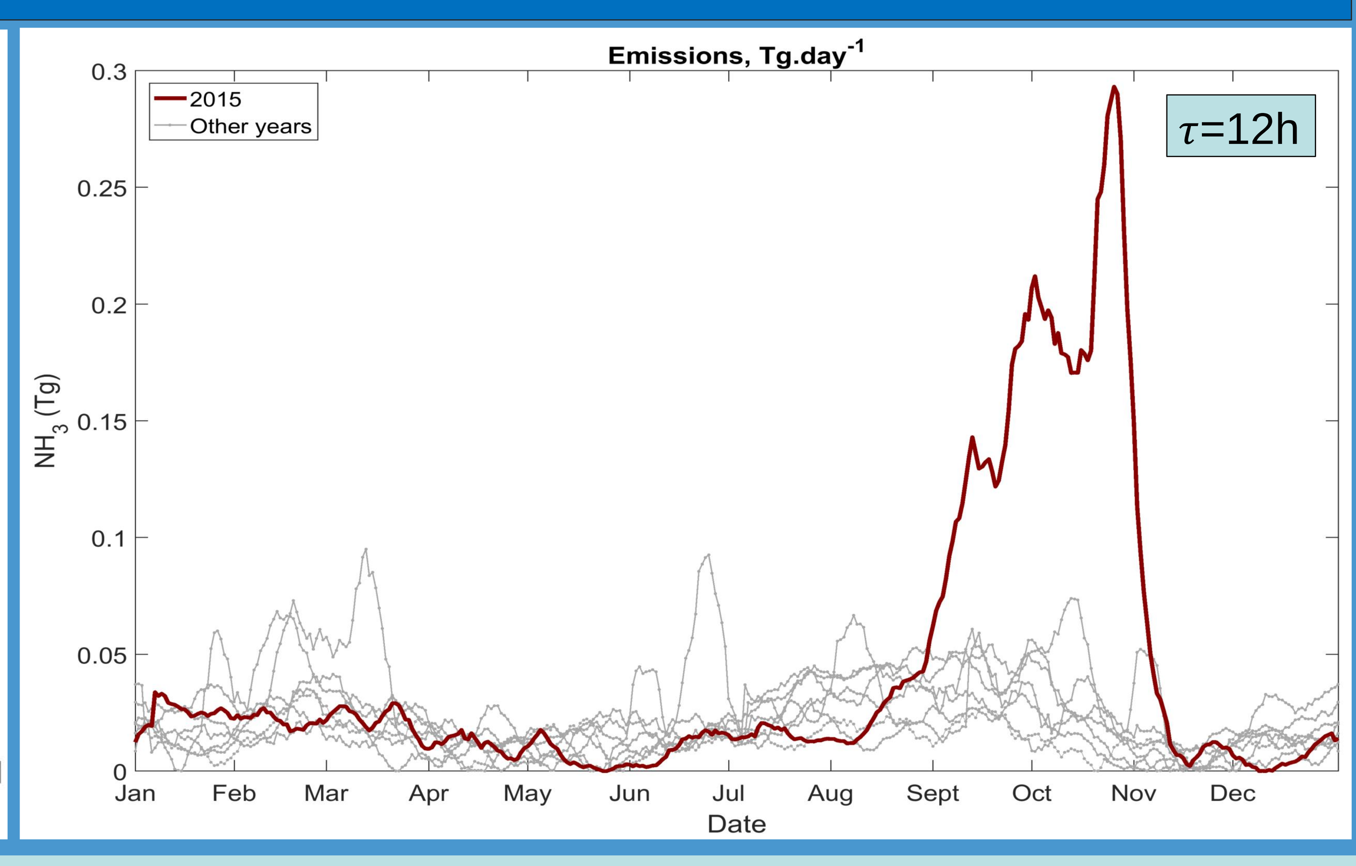
Time between two observations (here 1 day)

Consideration of three different effective lifetimes for NH_3 (12, 24 and 36h) results in a set of possible values of emission fluxes within the range given by the three lifetimes (red shaded area).

- **Good correspondence found between the IASI-derived emission fluxes and the emission fluxes given by the GFASv1.2 bottom-up fire inventory (green line, right panel), especially when considering the lower lifetime for NH_3 (12h).**
- **Maximum of emissions for the year 2015 (bottom right panel) about 3-6 times higher than for the seven previous years.**







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