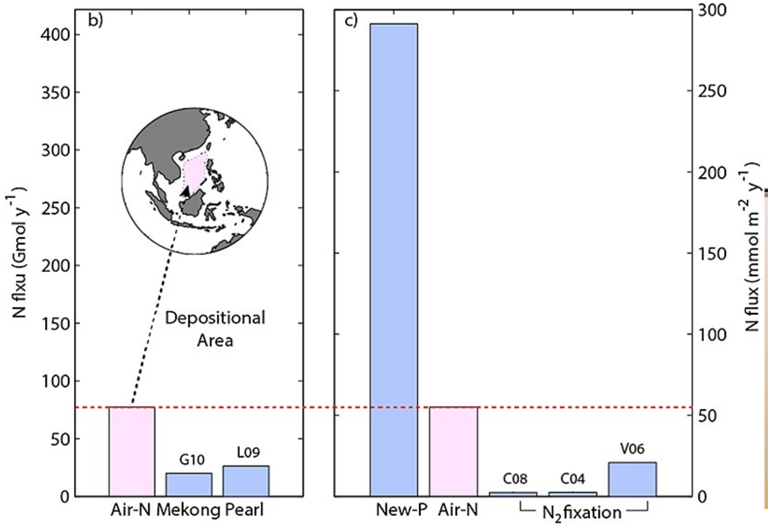
Estimating the global satellite-derived surface NH3 concentration

Zhenqi Luo 2020.11

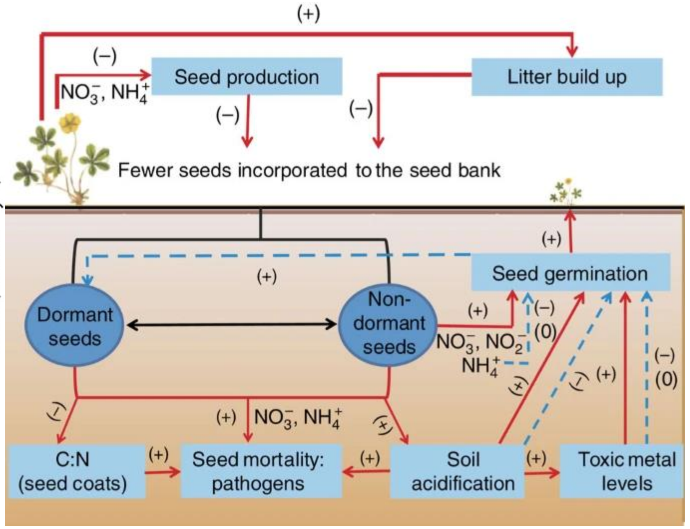
Estimation of surface NH3 concentration

- Important in modelling the dry deposition of NH3
  - Soil acidification
  - Aquatic ecosystem eutrophication
  - Drinking water contamination
  - Form ammonium salt——particulate matters (PM)
    - Air quality
    - Human health
- National monitoring programs: 2014
  - NNDMN (2014~): China
  - AMoN-China (2015~)
  - AMoN-US: US
  - EMEP: Europe
- Satellite instruments
  - IASI: 2008-2016
    - daytime (09:30)
    - processed into 0.25°×0.25° (arithmetic averaging method)
  - AIRS
  - CrIS
  - TES
- Chemistry transport models (CTMs)——GEOS-Chem (vertical profile and monthly averages): 2014
  - Daily average and 9-10am average
  - 2°×2.5°×47level
  - Meteorological filed data: GEOS-FP
  - Emissions: EDGAR
    - East Asia: MIX
    - Europe: EMEP
    - US: NEI
    - Canada: CAC
    - Biomass burning: FINNv1 (agricultural fires, wildfire and pre-scribed burning)



Atmospheric N deposition to the **South China Sea**

(Kim et al., 2014)



soil seed bank depletion by **N** pollution

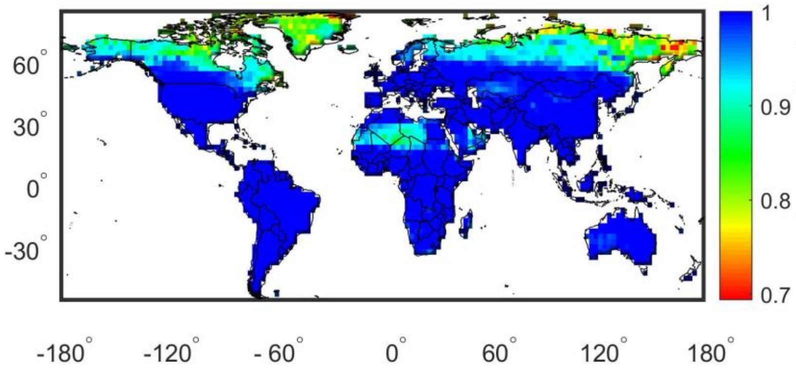
(Basto et al., 2015)

Estimation of surface NH3 concentration

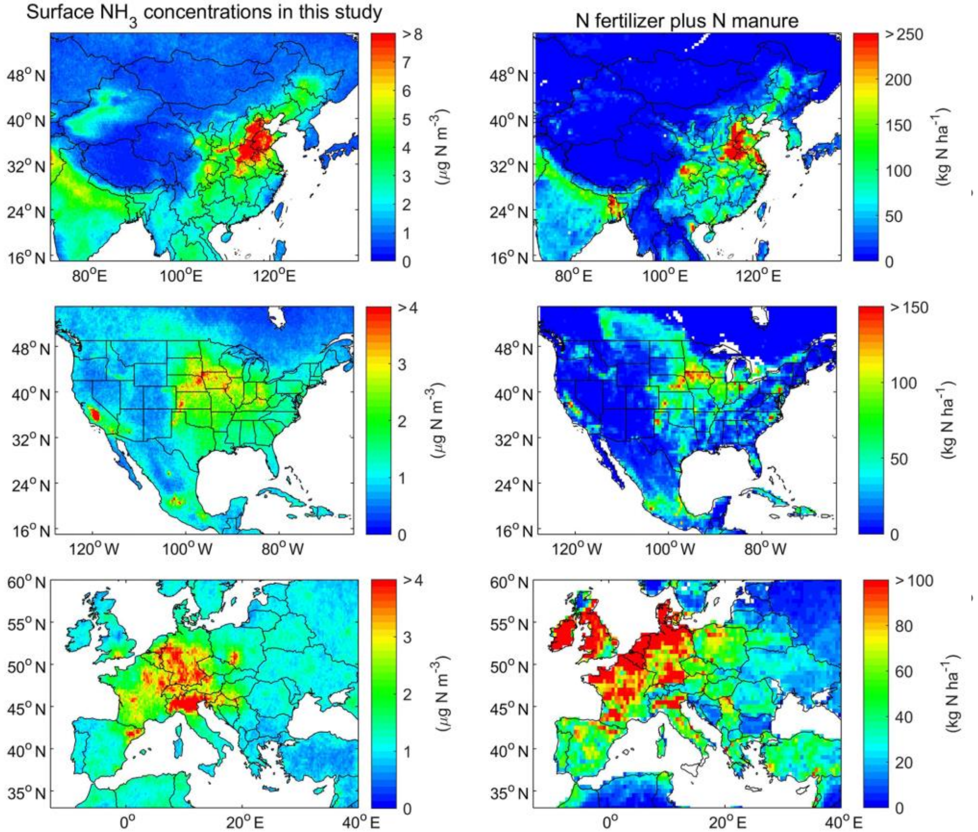
- Step1: fit NH3 profile at each grid box——Gaussian function
  - $\rho = \sum_{i=1}^{n} \rho_{max,i} e^{-(\frac{z-z_{0,i}}{\sigma_i})^2}$
    - ρ: NH3 concentrations at the layer height z
    - $\rho_{max,i}$: the maximum NH3 concentrations at the height $z_{0,i}$
    - σ_i: an indicator for the spread or thickness of the NH3 concentrations
- Step2: Extrapolate NH3 concentrations at any height——$G_{GEOS-Chem}$
- Step3: Aggregated the IASI NH3 columns $\Omega IASI$(0.25°×0.25°) to the GEOS-Chem grid size $\overline{\Omega IASI}$ (2°× 2.5°)——averaging method
  - $\overline{\mathrm{G}_{IASI_{9-10}}} = \frac{G_{GEOS-Chem}}{\Omega_{GEOS-Chem}} \times \overline{\Omega_{IASI_{9-10}}}$
    - $\overline{\mathrm{G}_{IASI_{9-10}}}$: the satellite-derived surface NH3 concentrations at a GEOS-Chem grid size at 9-10am
    - $\frac{G_{GEOS-Chem}}{\Omega_{GEOS-Chem}}$: surface NH3 concentrations to NH3 columns calculated from GEOS-Chem
- Step4: Downscale——satellite-derived scaling factor
  - $\mathrm{G}_{IASI_{9-10}} = \overline{\mathrm{G}_{IASI_{9-10}}} \times \frac{\Omega IASI}{\overline{\Omega IASI}}$
    - $\mathrm{G}_{IASI_{9-10}}$: the satellite-derived surface NH3 concentrations at a satellite IASI grid size (0.25°×0.25°) at 9-10am
    - $\frac{\Omega IASI}{\overline{\Omega IASI}}$: scaling factor
- Step5: Convert the instantaneous to daily average
  - $G_{IASI}^{*} = \frac{G_{GEOS-Chem}^{1-24}}{G_{GEOS-Chem}^{9-10}} \times \mathrm{G}_{IASI_{9-10}}$
    - G_{IASI}^{*}: daily average surface NH3 concentrations
    - $\frac{G_{GEOS-Chem}^{1-24}}{G_{GEOS-Chem}^{9-10}}$: the GEOS-Chem surface NH3 concentrations at the daily average to the average of 9-10 am.

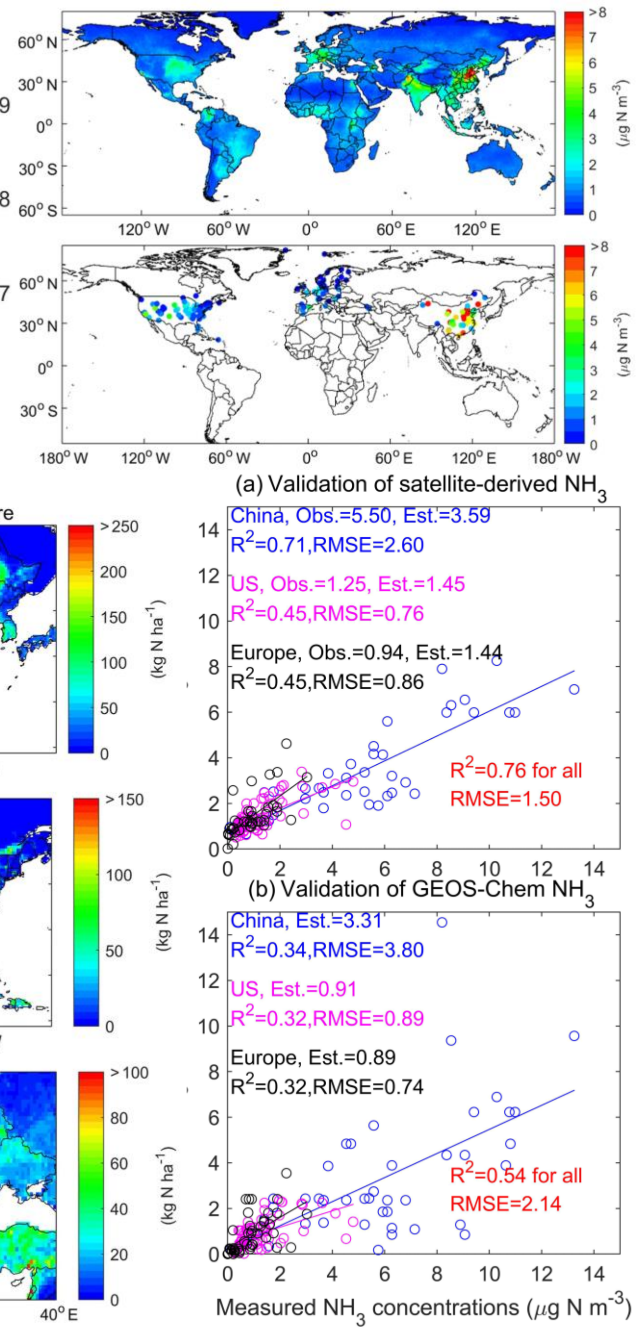
Results——satellite-derived surface NH3

- NH3 vertical profiles from GEOS-Chem
  - 60°N and 55°S can be well modelled
- Validation
  - capture the general spatial pattern fairly well
  - IASI-derived surface NH3 concentrations had better consistency than GEOS-Chem
    - China
    - the US
    - Europe
- Spatial distributions
  - China——croplands (R^2=0.65)
    - eastern China
    - Sichuan Basin
    - northwestern Xinjiang
  - US——croplands, livestock (SJV) (R^2=0.30)
    - Central US
    - Eastern US
    - Western coastal
  - Europe——croplands (R^2=0.17)
    - Western



(Liu et al., 2019)

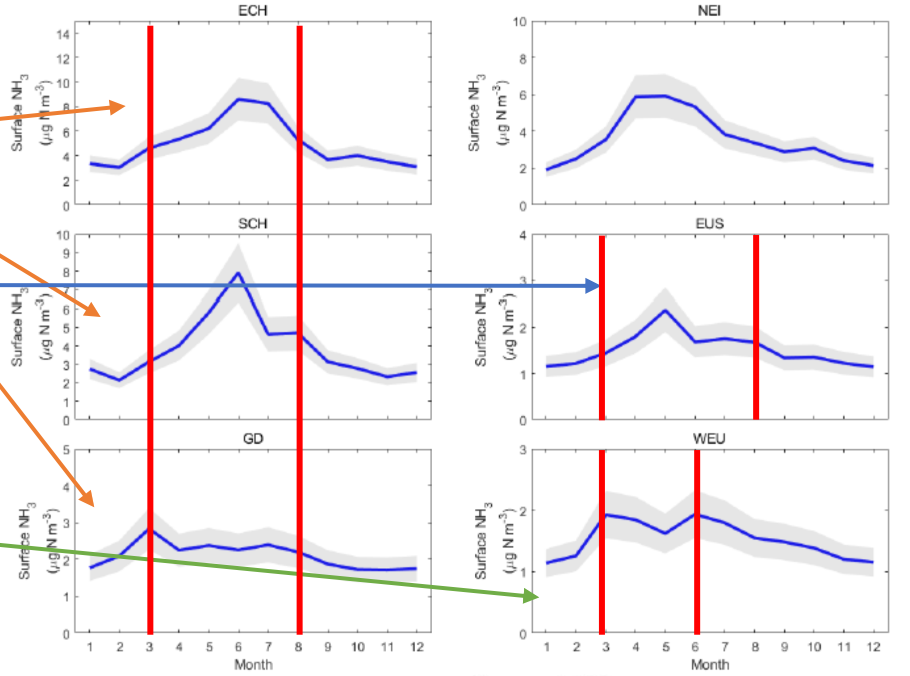


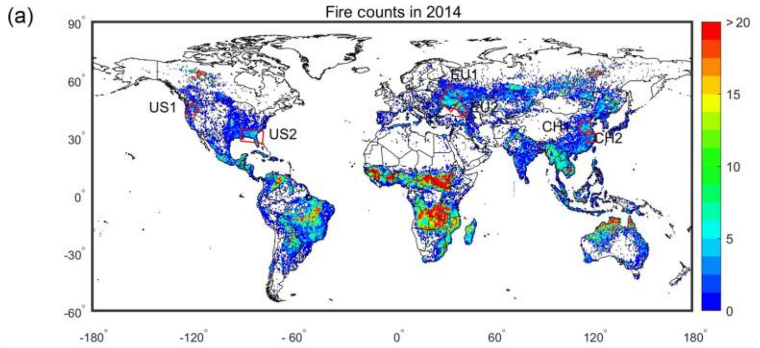


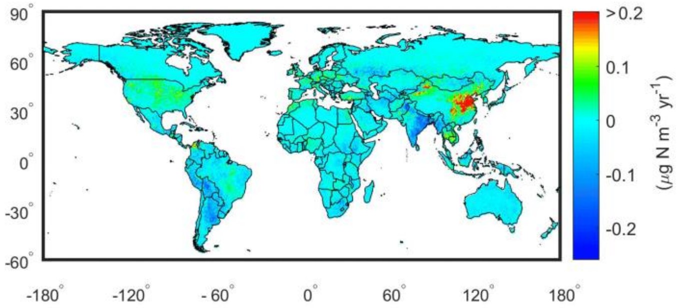
Results——satellite-derived surface NH3

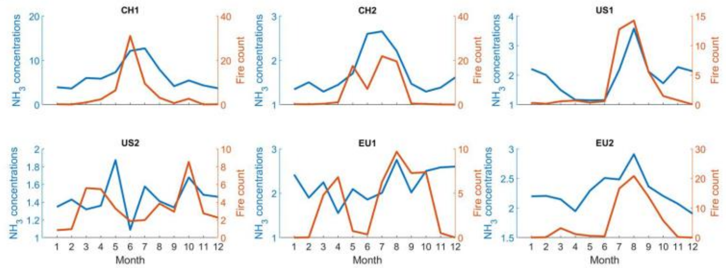
(Liu et al., 2019)

- Seasonal variations
  - China (ECH/SCH/GD)——Spring and summer (3-8)
    - N fertilizer/manure application
    - temperature in warm months
  - Eastern US (EUS)——3-8, maximum in 5
    - higher temperature
    - emissions in vast croplands
  - Western Europe——3-6
    - higher temperature
    - frequent N fertilization
- the relationship with biomass burning
  - CH1: crop straw burning
  - CH2: the wetter climate and more frequent precipitation events
  - US1: the forest fires or anthropogenic biomass burning
  - US2: potential mineral N fertilization and anthropogenic biomass burning or forest fires
  - EU1: the biomass burning and the agricultural fertilizations
  - EU2: the biomass burning
- Trends









Questions?