The importance of atmospheric acidity for nutrient deposition on global scale

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INTEREST OF THE STUDY

Atmospheric deposition can be an important source of nutrients and trace elements for land and ocean ecosystems. Atmospheric acidity is an important driver of the solubility of nutrients and trace elements present in atmospheric aerosols.

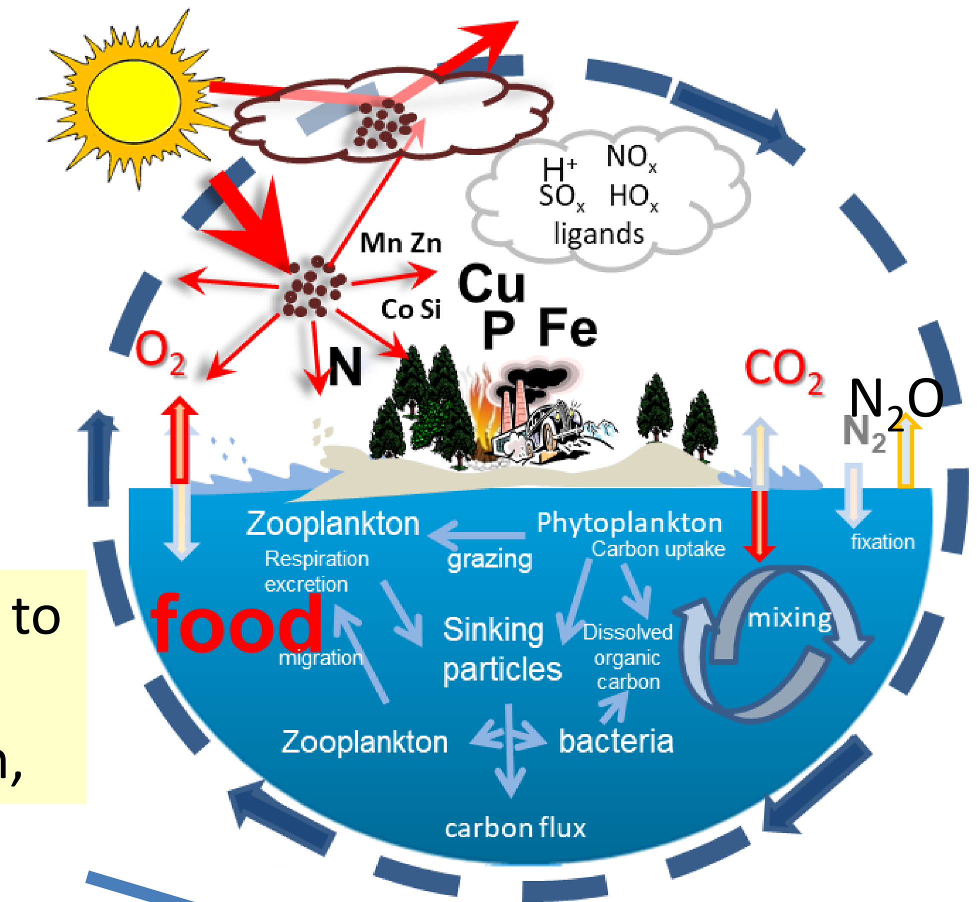
HIGHTLIGHTS

TM4_ECPL simulations with anthropogenic and biomass burning emissions of the years 1850, 2010 and 2100 show that near surface aerosol pH is very acidic and over the tropical oceans no significant changes happened since 1850 emissions, while over the north hemisphere oceans aerosols were more less acidic in 1850 and are expected to become again in the future.

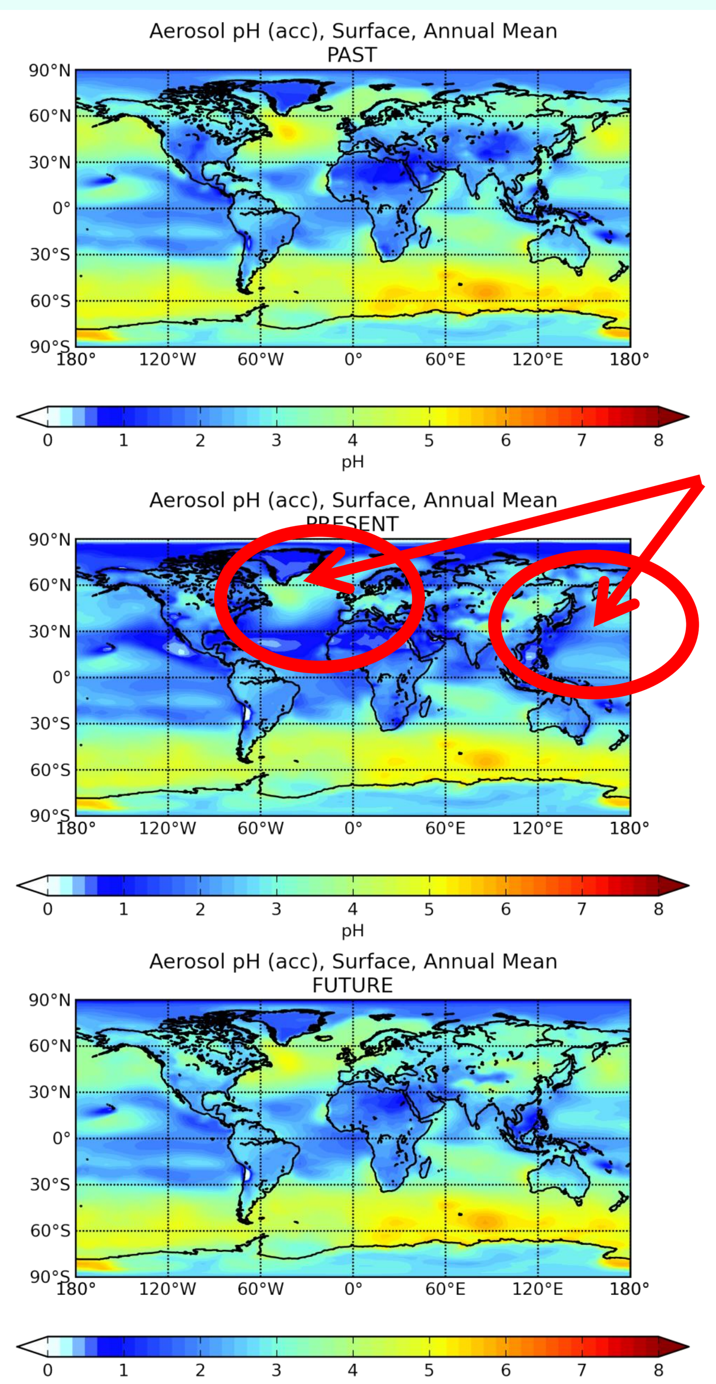
These changes are affecting the HNO_3/NO_3^- partitioning into the aerosol phase and the solubilisation fluxes of nutrients like Fe and P and their overall deposition to the ocean.

TM4-ECPL model is able to reproduce observed aerosol pH distribution,

The relative abundance of nutrients in atmospheric deposition has changed since 1850 and is projected to changes in 2100 due to changes in primary emissions &the solubilization fluxes.

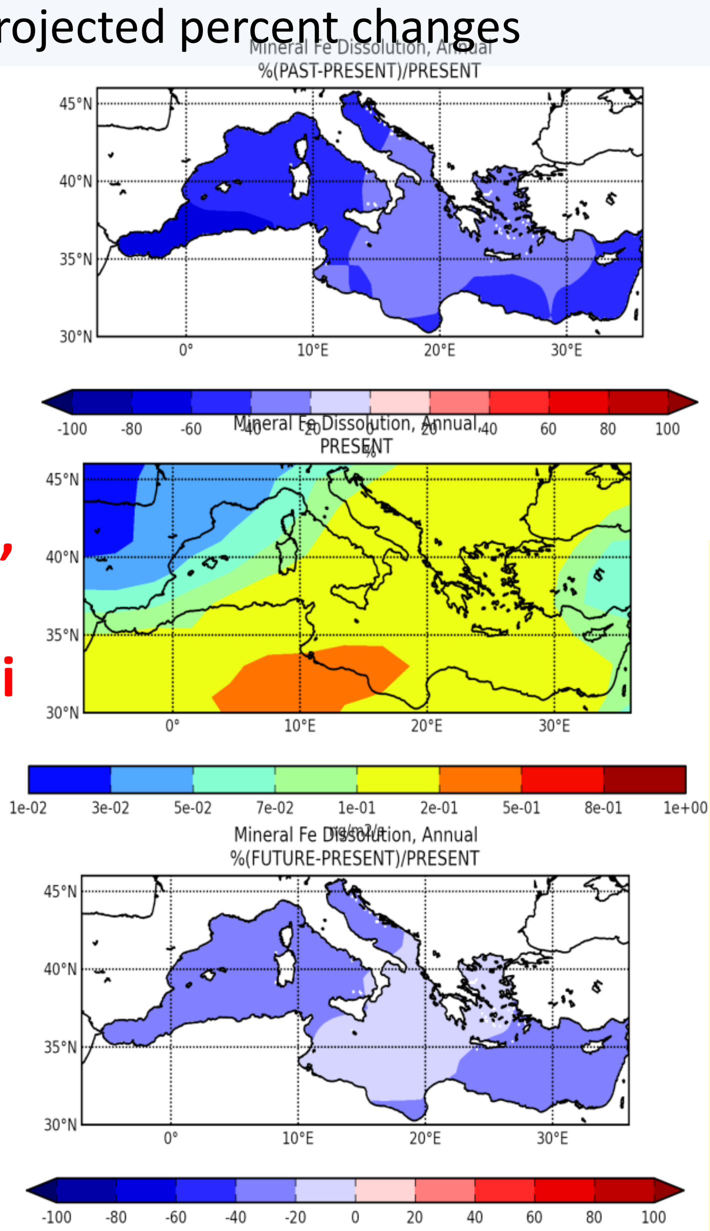


Changes in submicron surface aerosol pH



more acidic
Less NO_3^- in aerosol,
faster deposition

Solubilisation flux of Fe over the Mediterranean (past changes, present day solubilisation flux and projected percent changes

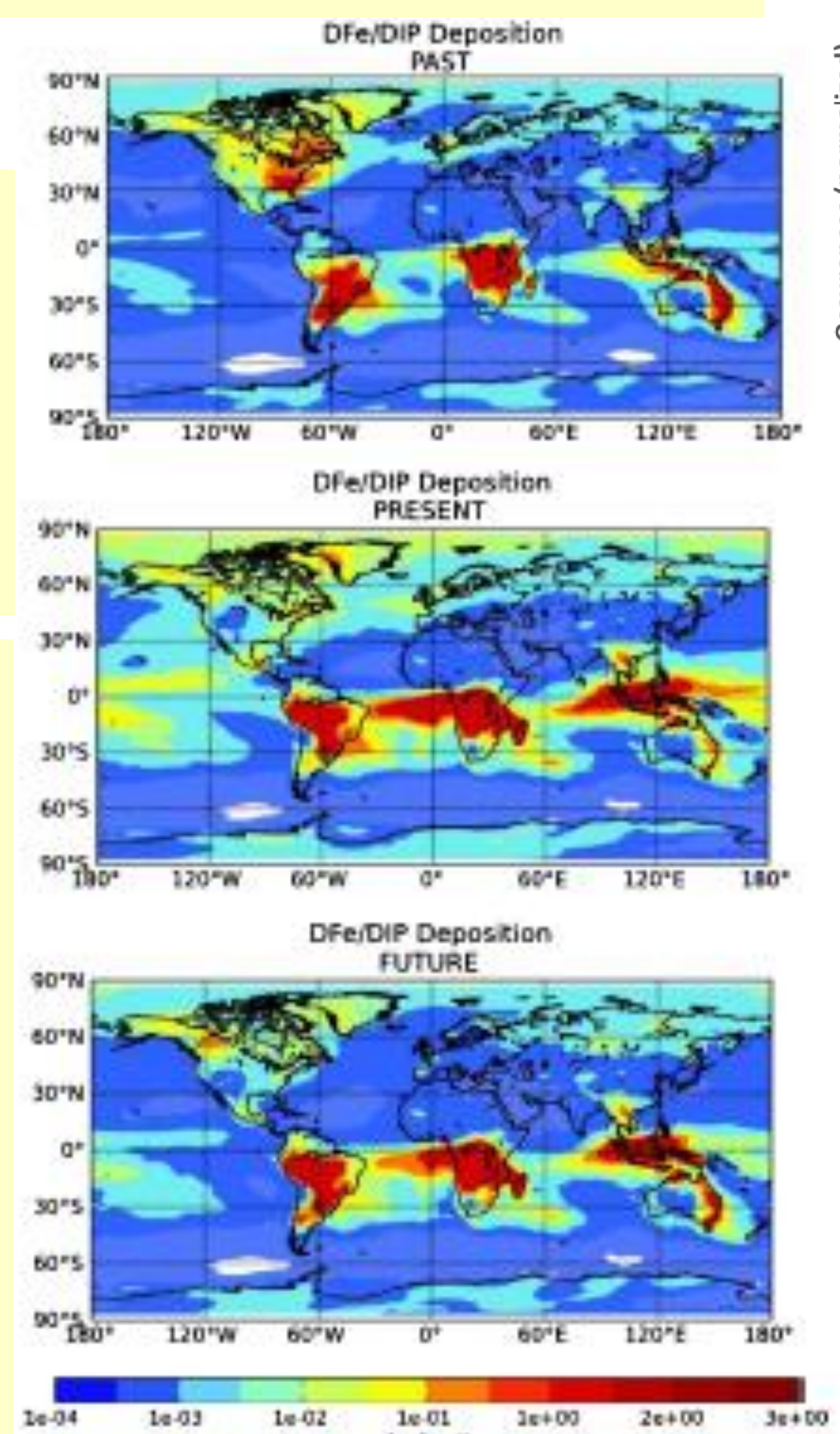


Kanakidou et al Deep Sea II, 2020

Fe and P show a different dependence on atmospheric acidity—Fe requires a more acidic environment to solubilize than P.

Ratios of deposition fluxes of DFe/DIP (soluble Fe to soluble inorganic P from all sources) (past = emission year 1850, present = emission year 2008, future = emission year 2100).

Figure from Kanakidou et al ERL, 2018



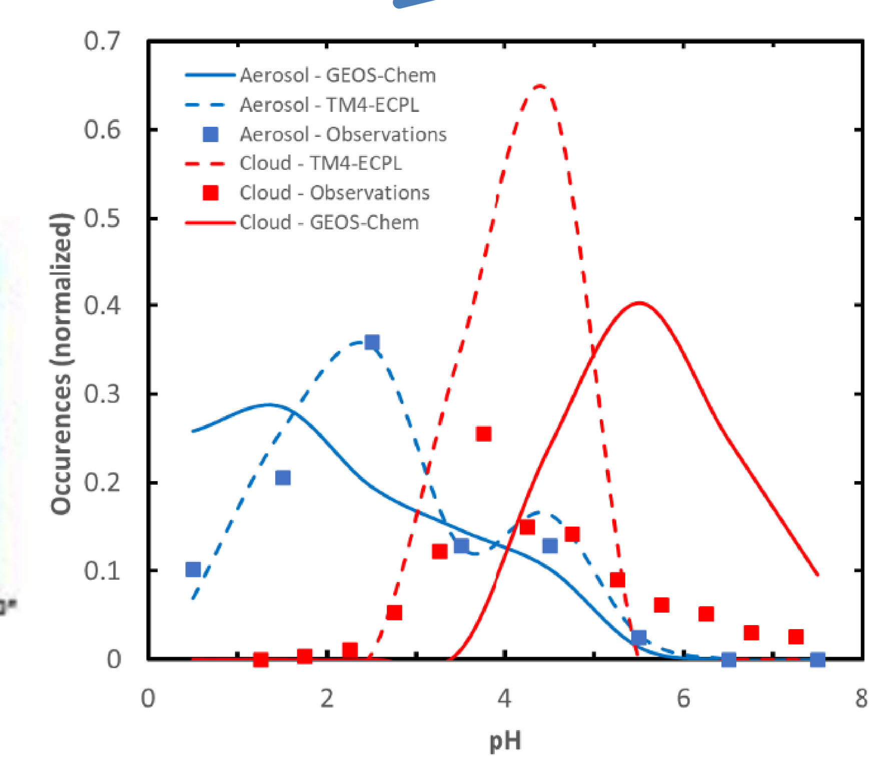


Figure from Pye et al., ACP 2020

AIM OF THE STUDY

This study aims to evaluate human-driven past and future changes in the aerosol acidity and the resulting changes in the nitrogen, phosphorus and iron atmospheric deposition and solubility..

TM4-ECPL global model

Described in Kanakidou et al., Deep Sea Res II, 202010.1016/j.dsr2.2019.06.014

Oxidants/gases/aerosols/multiphase chemistry

(Myriokefalitakis et al., ACP, 2011)

- **Nitrogen and Organic P deposition** *(Kanakidou et al GBC 2012, JAS 2016)*
- **Fe & dust atmospheric cycle** *(Myriokefalitakis et al Biogeoscience 2015,2016)*
- AEROCOM OA & CCN intercomparison *(Tsigaridis et al., ACP, 2014; Fanourgakis et al. ACP, 2019)*
- **Meteorology ERA-Interim**
- **Interannual emissions -** ACCMIP anthropogenic emissions MEGAN MACC biogenic, ACCMIP anthropogenic, ACCMIP fire emissions, Online sea salt and marine POA *(Daskalakis et al., ACP, 2015, 2016)* and dust

able 1. Summary of source estimates for total N (NO_x/NO_3^-, NH_3/NH_4^+, organic N), P(inorganic and organic P) and Fe (in Tg N yr^{-1}, g P yr^{-1} and Tg Fe yr^{-1}, respectively). A range is provided, where available, with a suggested estimate in parenthesis. For details see in the xt and the table footnotes.

Range of various sources of nutrients

ources	Nitrogen[a]	Phosphorus	Iron
esert dust	0.1–4.2 (0.3)	0.23[c]–3.8[b] (1.1)	35–115 (35)[b]
oil and lightning	6–23[d] (14)		
cean (gases and sea spray)	8.9–34.7 (14.4)	0.005–2.71 (0.01)[g]	
ioaerosols	0.6–18.6 (9.0)	0.002–2.13 (0.156)	0.001–0.05 (0.001)
olcanoes	0.4–1.3 (0.9)[h]	0.006–0.218 (0.01)[h]	0.008–0.305[i]
iomass burning	15.6–44.06 (19.4)	0.071–2.5[e,f] (0.1)	1.07–5.3[e] (1.2)
errestrial anthropogenic	60.3–77.3 (62.5)		0.66–0.77
iipping	5.3		0.015–0.016
otal	105.2–198.2 (126)	0.5–9.5 (1.38)	36.8–121.4[e] (42.1[b])

Kanakidou et al., Environ. Res. Letters, 2018, 13 063004

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