Impacts of ocean acidification and dust depositions on trace metal cycling and bioavailability

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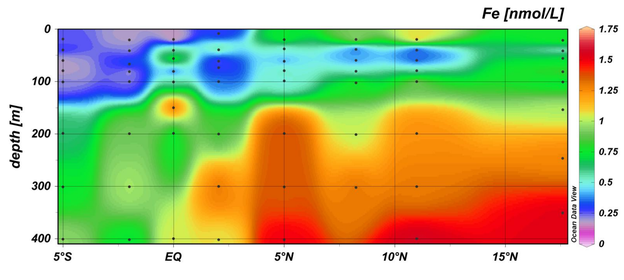
Summary

We are synthesizing previous trace metal work in SOPRAN, where a main focus has been on the role of desert dust for biogeochemical cycles in waters off Cape Verde (Fe and Mn in Fig. 1). The future experimental/analytical work will elucidate the interrelations of atmospheric dust deposition, organic matter in seawater, and trace metal cycling on metal bioavailability in context of ocean acidification (OA, Fig. 2). A key is the actual trace metal and macronutrient solubility from dust in natural seawater (shown for several trace metals in Figs. 3-6). Further we will perform controlled laboratory dust solubility experiments using dust collected in atmospheric samplers at CVOO and natural seawater from the Cape Verde region. Second, we will participate in the Gran Canary mesocosm experiment to investigate possible phytoplankton-trace metal interactions in response to atmospheric perturbation (dust & CO_2, Fig.2).



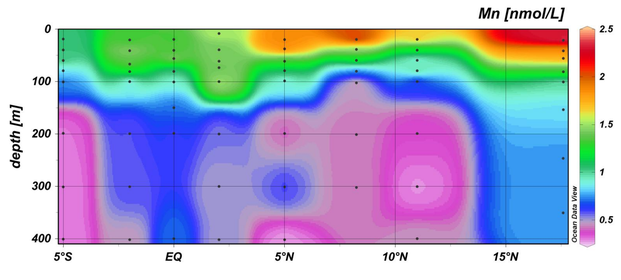


Fig. 1: Two dimensional plots of dissolved iron (Fe) and manganese (Mn) in the sunlit Eastern Tropical Atlantic Ocean (CVOO & 23 W) (Wuttig *et al.*, in prep.) with clear dust influences.

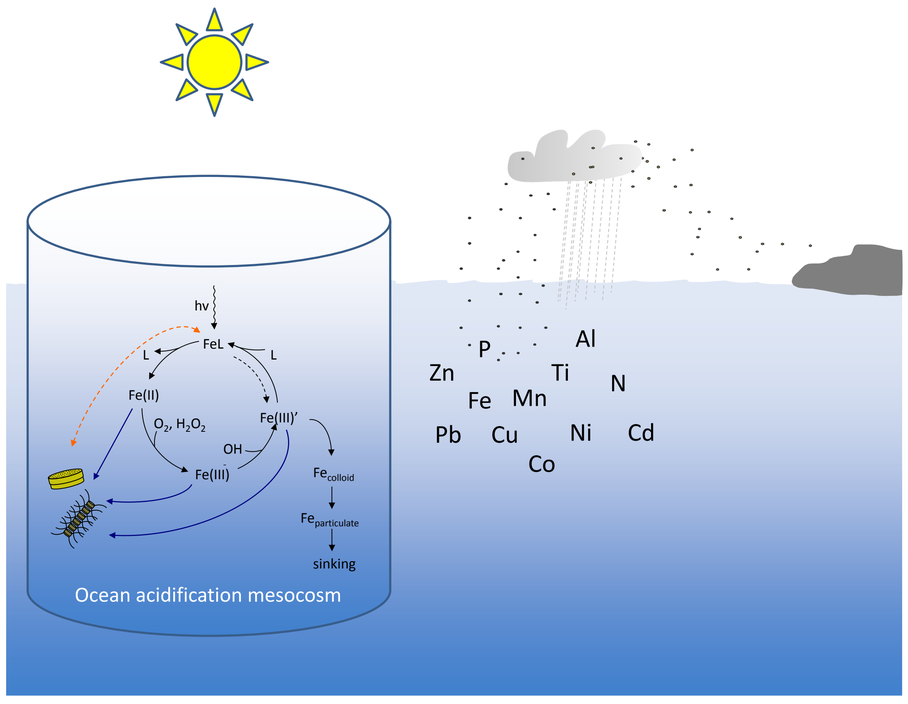


Fig. 2: Schematic of atmospheric dust deposition and cycling of redox sensitive metals (here Fe) in an ocean acidification mesocosm experiment

Phase I

Dust (Fe) effects on
N – fixation and primary production

Phase II

- Photochemical processes
- Organic complexation (CDOM)
- Fe solubility
- Ti and Al as dust tracers

Phase III

- Synthesis of phases I & II
- OA effects on metal solubility and cycling

Product

- Holistic understanding of TM input and cycling in the Anthropocene
- Model parameterization

The DUNE-2 project

- A **DU**st experiment in a low **N**utrient, low chlorophyll **E**cosystem (Mediterranean)
- Mimicking two consecutive wet depositions of 10g/m^2 of artifical dust in the dust seeded mesocosms (D1, D2 and D3)
- Control mesocosm (C1, C2 and C3)
- Trace metal clean mesocosms

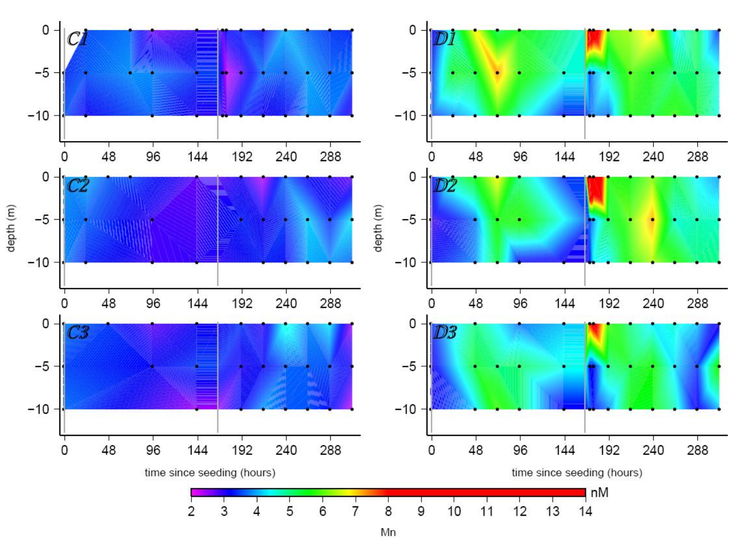


Fig. 3: Evolution of Mn in the 6 mesocosms (left: control mesocosms: C1, C2 and C3 and right: dust seeded mesocosms: D1, D2 and D3). The graphs are plotted as the time since the 1st seeding (h) vs. the depth (m) in the mesocosms. The grey bars highlight the two dust additions (t0 and t166) (Wuttig *et al.*, 2012).

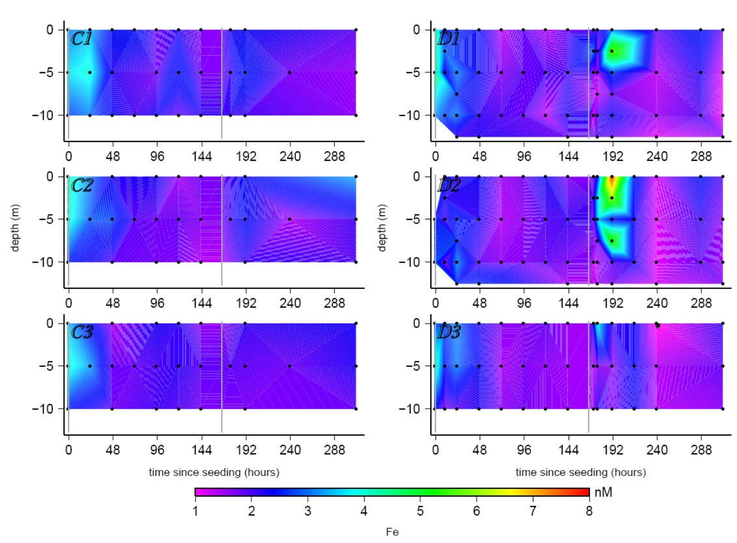


Fig. 4: Evolution of Fe in the 6 mesocosms (left: control mesocosms: C1, C2 and C3 and right: dust seeded mesocosms: D1, D2 and D3). The graphs are plotted as the time since the 1st seeding (h) vs. the depth (m) in the mesocosms. The grey bars highlight the two dust additions (t0 and t166) (Wuttig *et al.*, 2012).

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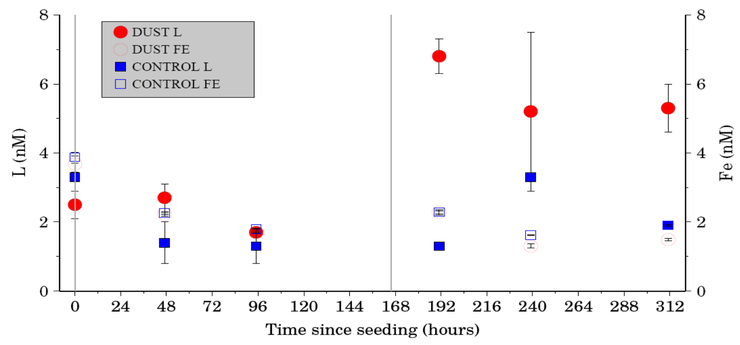

Fig. 5: Evolution of the arithmetical means of the Fe binding ligand and the Fe concentration in the dust seeded and the control mesocosmsat 5m depth with time since the seeding (h).

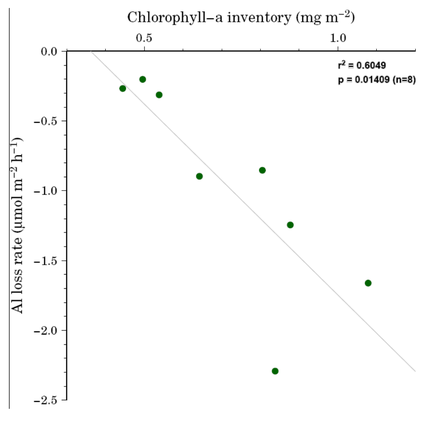

Fig. 6: Correlation of the Al loss rate versus the chlorophyll-*a* inventory which was calculated after Giovagnetti *et al.* (2012).

Conclusions

- Distinct behavior of Mn (Fig. 3), Fe (Fig. 4) and Al after the two consecutive dust depositions.
- 3 days after each dust addition, Al decreased due to scavenging onto biogenic sinking particles. Al loss rate was related to chlorophyll-*a* inventory (Fig. 6, calculated after Giovagnetti *et al.*, 2012).
- Fe (Fig. 4) 1st: decrease due to scavenging onto sinking dust particles. 2nd: dissolution from dust particles due to the excess of Fe binding ligands (Fig. 5) with a fractional solublitiy of 0.12%.
- Fractional solubilities from dust particles in seawater were ~1% for Al and ~40% for Mn (Fig. 3) which are both inorganically controlled.
- Mn: equivalent loss rates .
- Al: after 1st additon 1 order of magnitude higher loss rate than after 2nd.

References:

Giovagnetti, V., Brunet, C., Conversano, F., Tramontano, F., Obernosterer, I., Ridame, C., and Guieu, C.: Assessing the role of dust deposition on phytoplankton ecophysiology and succession in a low-nutrient low-chlorophyll ecosystem: a mesocosm experiment in the Mediterranean Sea, Biogeosciences Discuss., 9, 19199-19243, 10.5194/bgd-9-19199-2012, 2012.

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SOPRAN
Surface Ocean Processes in the Anthropocene

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