# Impact of Dust Deposition on Fe speciation at the Tropical Eastern North Atlantic Time-Series Observatory site

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## TENATSO site

The Tropical Eastern North Atlantic Time-Series Observatory (TENATSO) north of the Cape Verde Islands (17°N, 24.5°W) is strongly influenced by Saharan dust events.

Processes shaping Fe speciation and bioavailability determine the impact of dust deposition on primary production and carbon cycle. To provide a better understanding of this complex, this work investigated 1) the role of dust particles in Fe speciation and removal and 2) the control of origin and fate of organic ligands on Dfe profile.
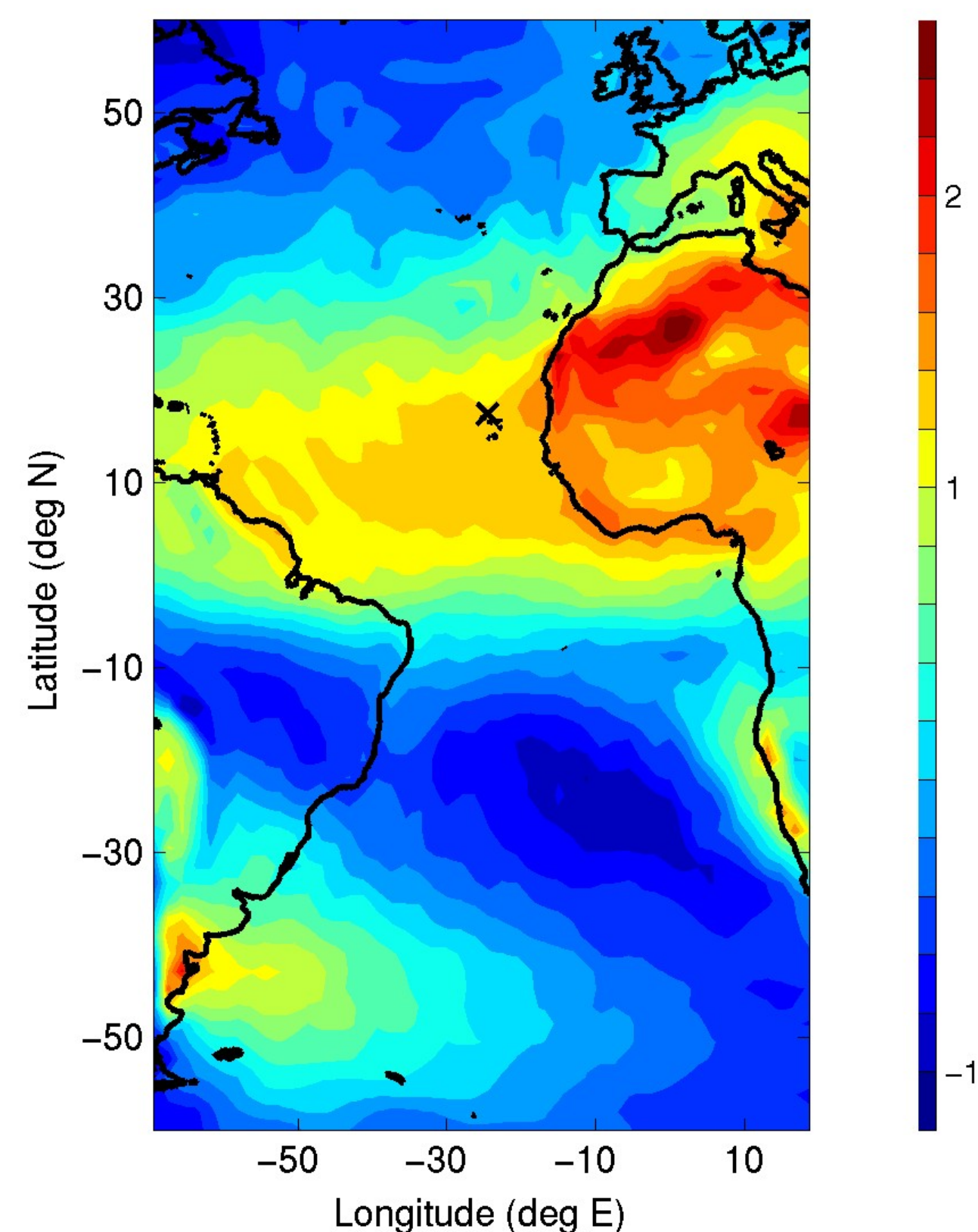


Logarithmic modeled dust deposition by Mahowald et al. 2003, in g m$^{-2}$ a$^{-1}$.

## Model of Iron Speciation

A one-dimensional model of the biogeochemistry and speciation of iron is coupled with the General Ocean Turbulence Model (GOTM) and a NPZD-type ecosystem model.
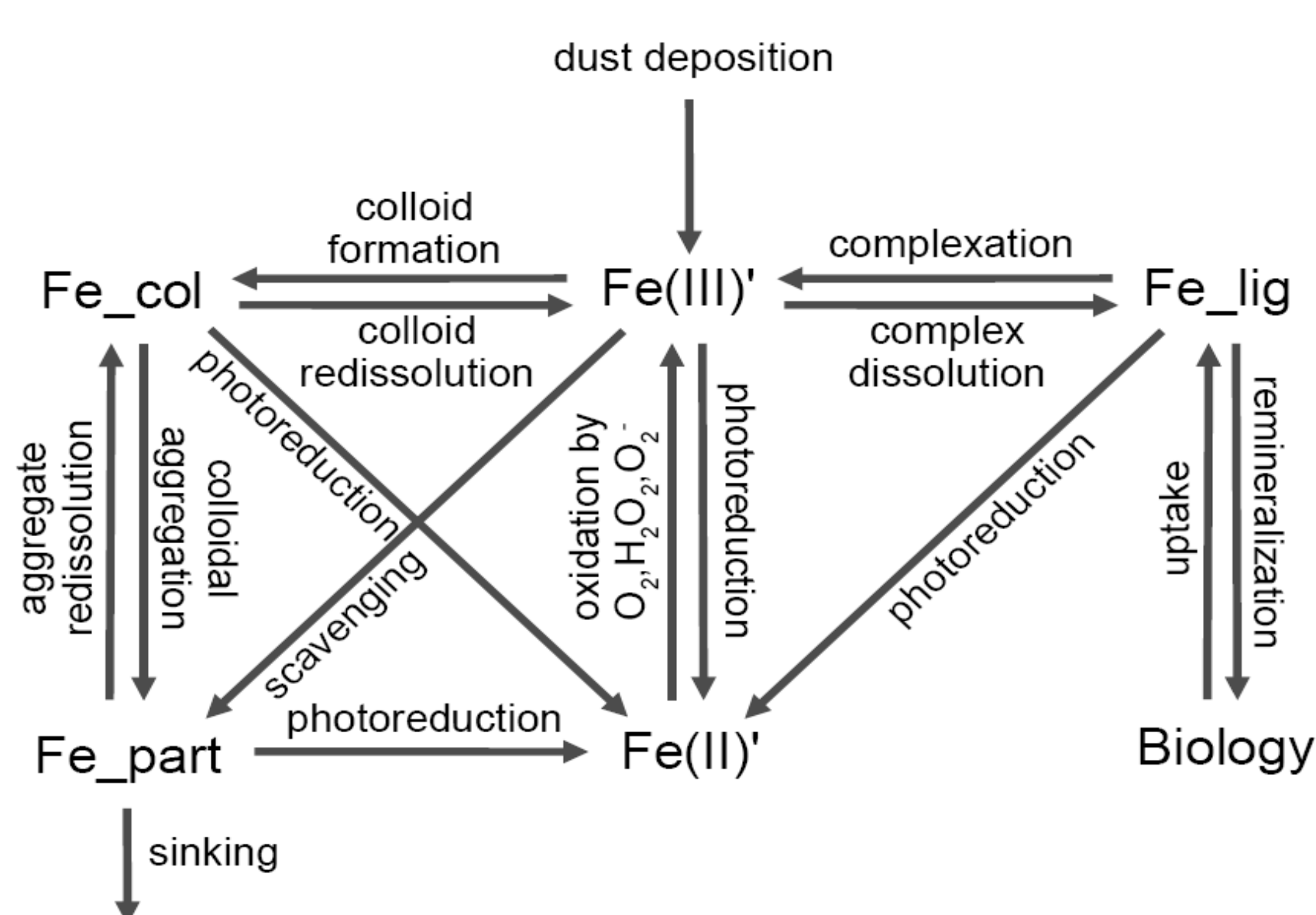


The iron pools represented in the model and the fluxes between them.

• As a precondition for Fe speciation, the model well reproduces mixed layer depth compared to climatological estimate.

• Modeled chl a concentration is in range of observations at TENATSO site.

• Primary production is ca. 650 mgC m$^{-2}$ d$^{-1}$ which is a little higher than satellite-based estimates.

## Role of dust particles in Fe speciation and removal

### 1. Vertical distribution of particles in different size classes

Because fine particles dominate Saharan dust, sinking particles are split into four classes by their composition and size: 1) small detritus, 2) fine dust particles, 3) large organic aggregates and organic fraction in mixed aggregates, and 4) inorganic fraction in mixed aggregates. The small particles sink at 5 m d$^{-1}$ and the aggregates at 50 m d$^{-1}$. Particle aggregation depends quadratically on the total concentration of small particles.

As a result of massive dust deposition and particle aggregation, the modeled vertical particle distribution shows a high abundance of small particles (red) in surface waters which decreases rapidly with depth and a low concentration of aggregates (green) which increases slightly with depth. Below 200m aggregates are in excess of small particles.
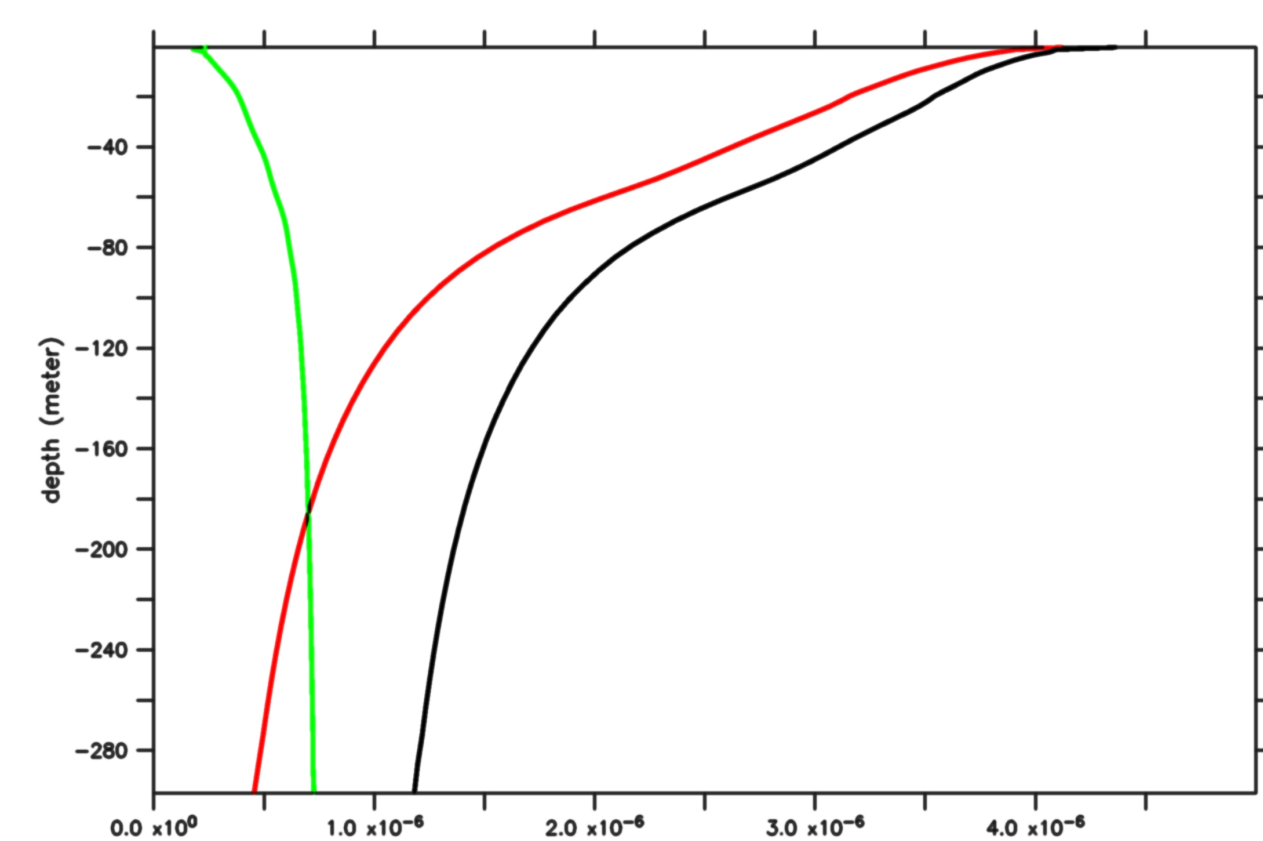




The averaged concentration of organic (dashed) and inorganic (solid) material in sinking particles indicates that scavenging of dissolved iron is dominated by absorption onto small inorganic particles near the surface and onto aggregates deeper in the water column.
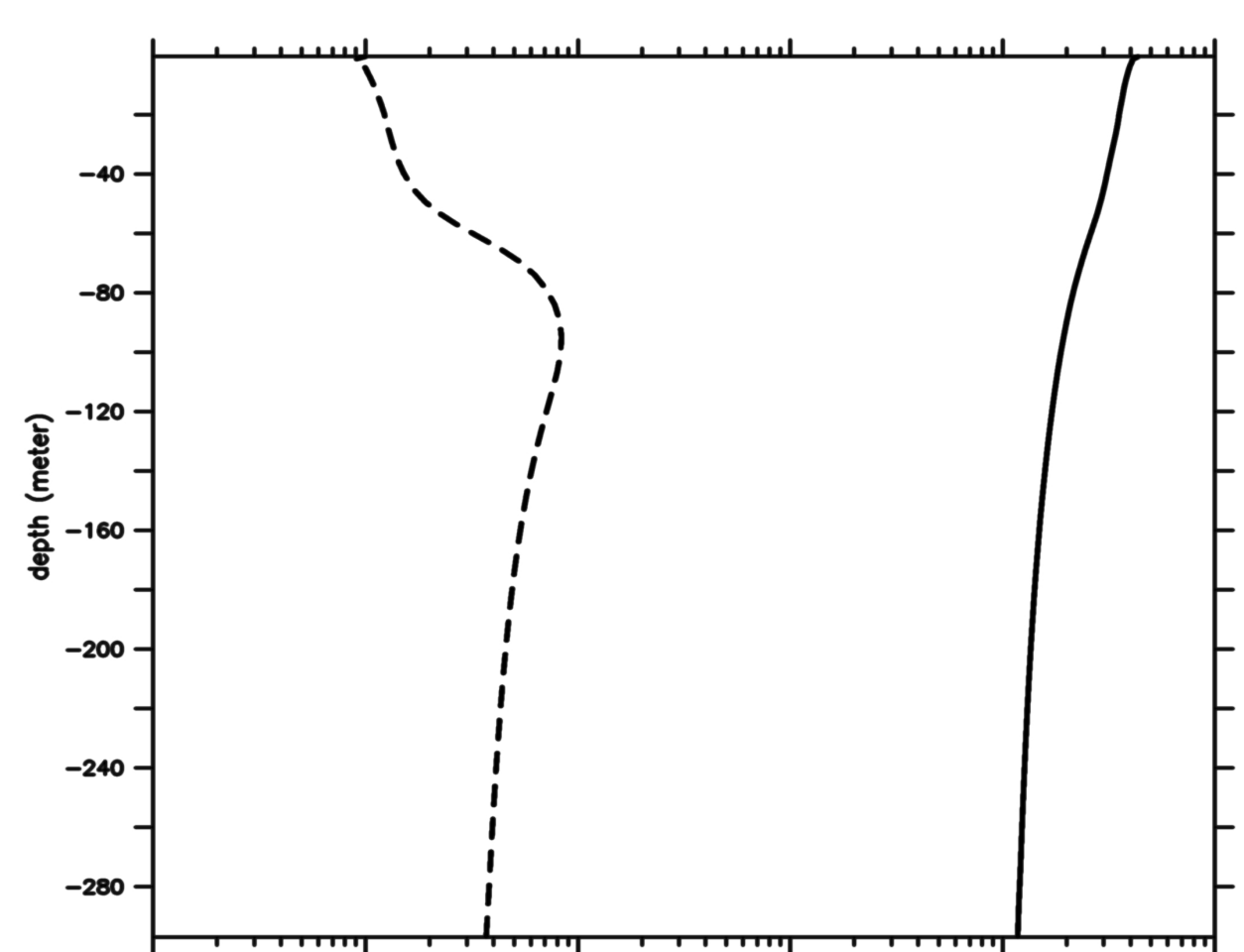
## 2. Role of particles in removing dissolved iron

Abundance and dynamics of particles control the vertical transport and residence time of iron by direct scavenging of Fe' and aggregation of colloidal iron (s. Fig.: right).

Fig. below: DFe concentration in sensitivity studies.
**Black**: without redissolution of colloidal and particulate iron;
**red**: only with redissolution of colloidal iron;
**green**: with redissolution of colloidal and particulate iron;
**Blue**: with reduced redissolution of colloidal iron.
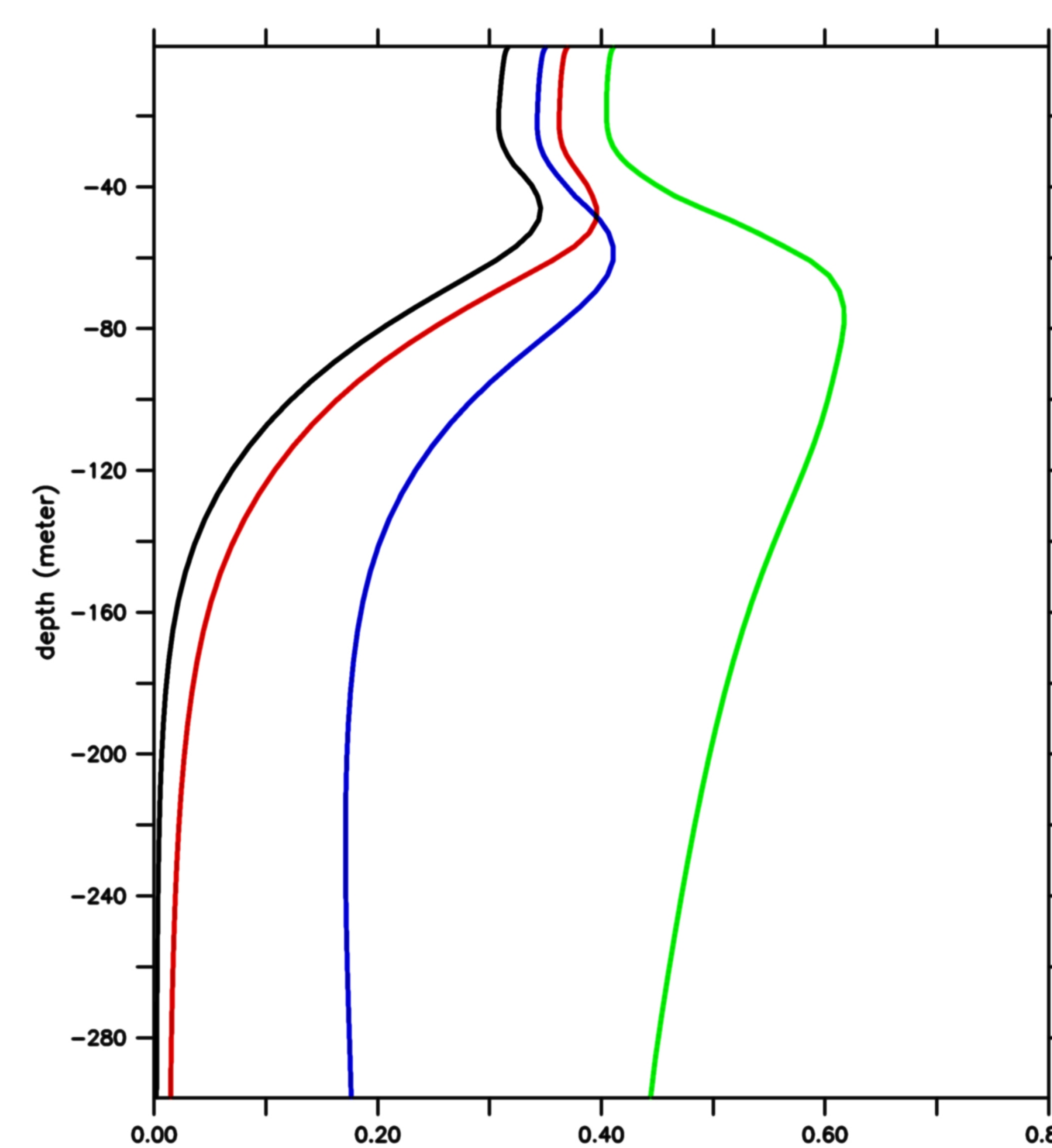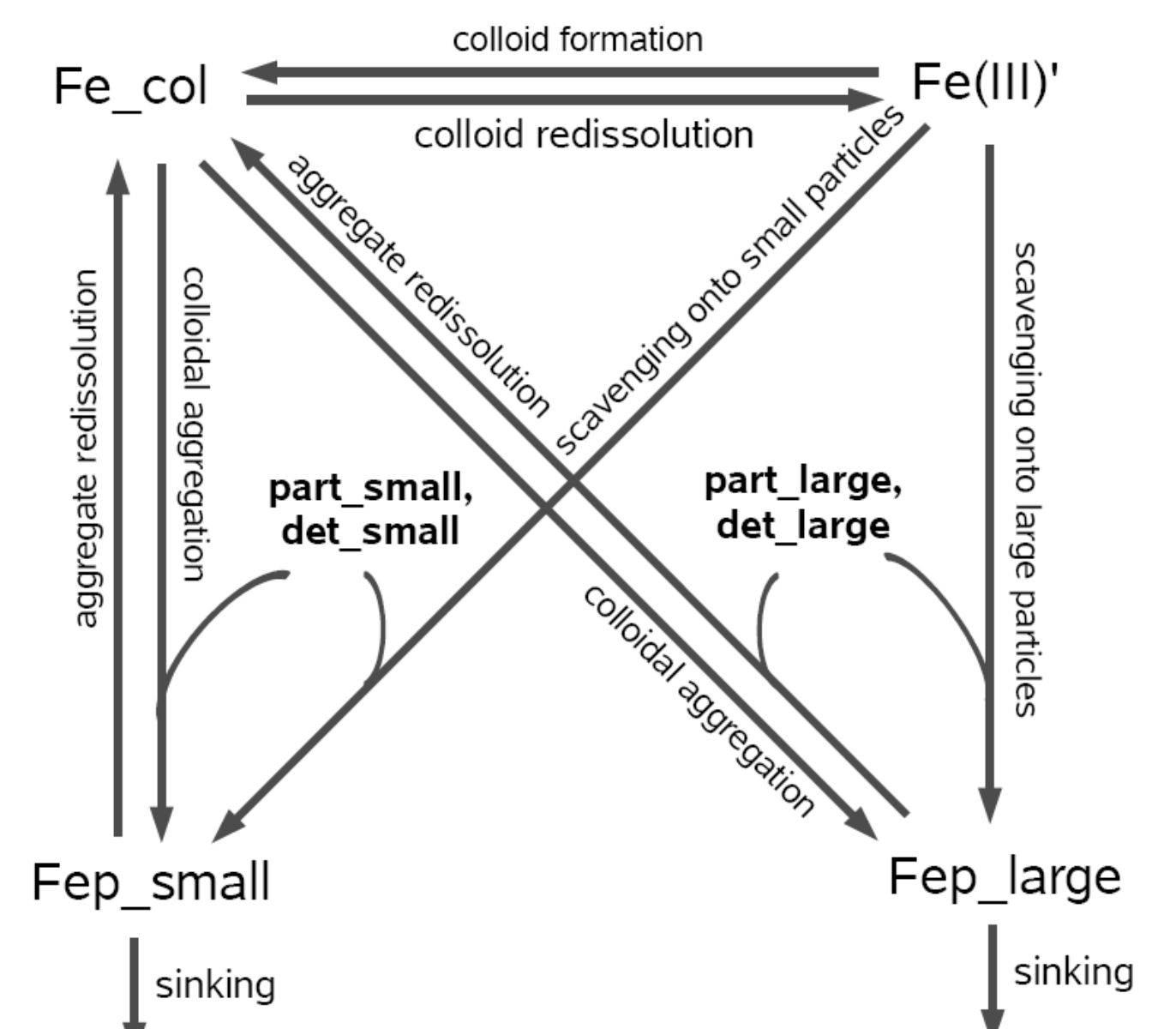




Sensitivity studies show that DFe concentration in deeper waters depends strongly on redissolution of colloidal and particulate iron. Without a way back from particulate to dissolved iron, we do not obtain a constant concentration of DFe in deeper waters as in measured profiles.
The modeled Fecol:Fesol ratio is controled by the redissolution rate of colloidal iron. By reducing the redissolution rate of colloidal iron, a Fecol:Fesol ratio of 1:25 is obtained, still much lower than the observed ratio.

## Modeling sources and sinks of organic Fe binding ligands

Organic ligands are distinguished into two classes by their conditional stability constants: the strong ligand (Lig_str) represents marine siderophores produced by phytoplankton under Fe-limitation; the weak one (Lig_we) represents porphyrin-like substances released by remineralization of detritus. Both are remineralized, taken up by phytoplankton and photochemically reactive.
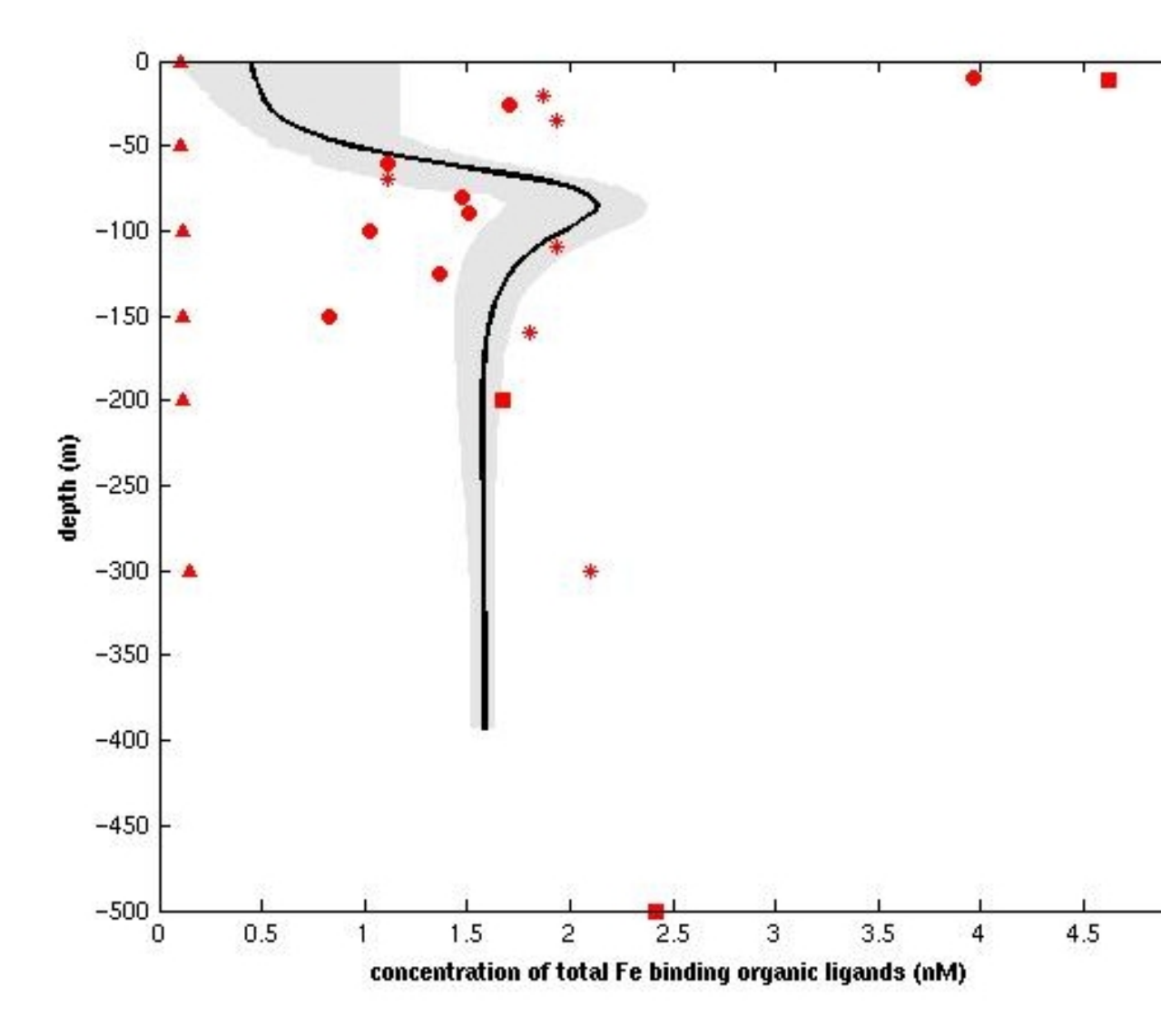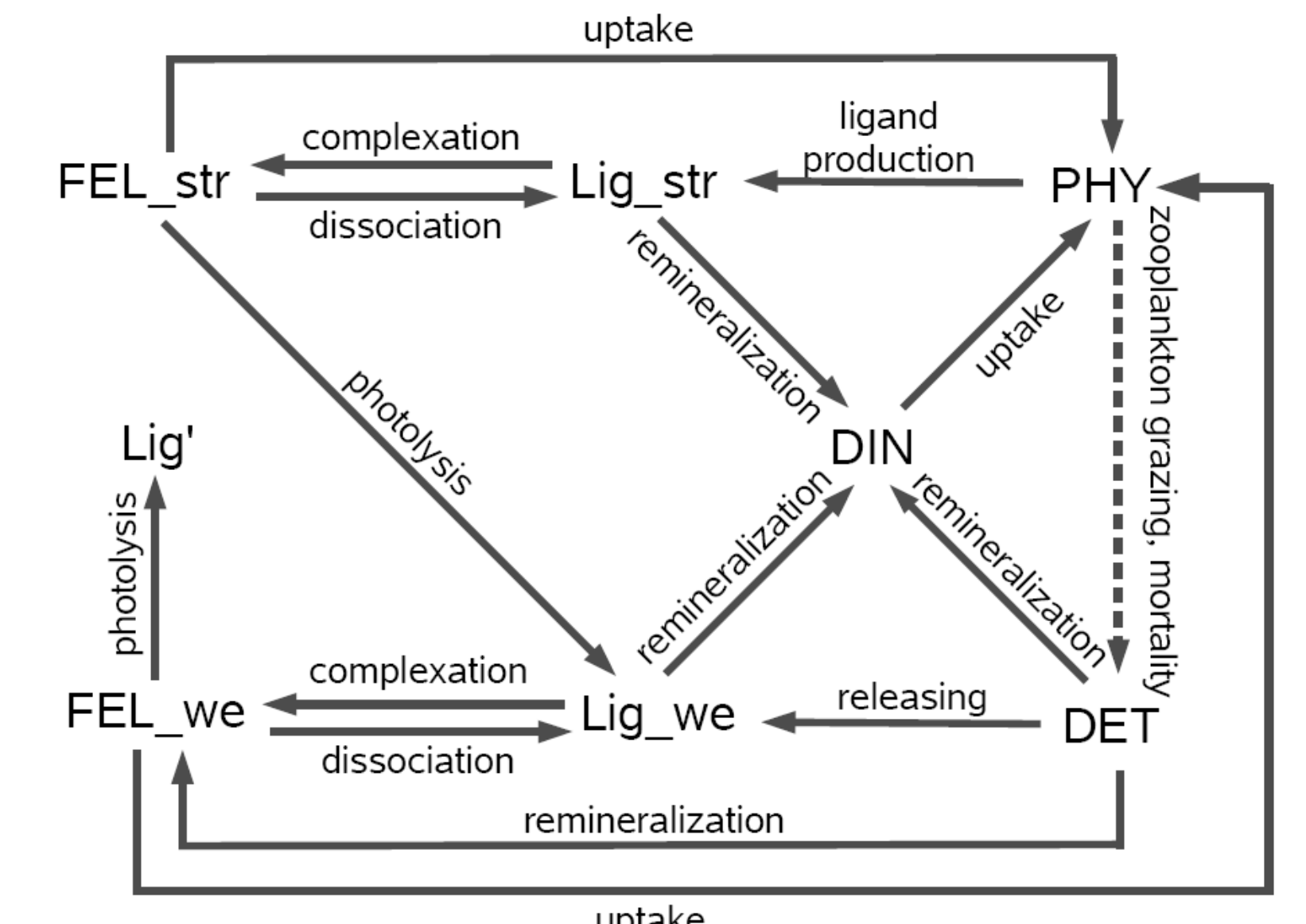




Modeled processes can well explain the abundance of strong ligands, but not the observed nutrient-like profile of weak ligands. The latter requires a restoring of total weak ligands towards a constant value, indicating that the decay time of Lig_we is too long for a 1d-model.
Grey area: variability of modeled ligand concentration;
Black curve: annual mean profile;
Red symbols: measured ligand concentrations.
Wu et al. 1999 (triangle) measured only the soluble ligands.

## Conclusions and outlook

A model of iron biogeochemistry developed for the BATS site has been extended for the TENATSO site with a more complex description of particle aggregation and sinking and the origin and fate of organic ligands.

Model results show that dust deposition brings, on the one hand, considerable input of dissolved iron into the surface waters and on the other hand, provides inorganic particles for Fe scavenging and for particle aggregation which accelerates the removal of dissolved iron.

Dfe concentration deeper in the water column depends strongly on redissolution of colloidal and particulate iron. Our assumptions, valid for inorganic colloids, lead to an underestimate of colloidal:soluble iron ratio.

Origin and fate of organic ligands affect Dfe profile significantly. In future work, colloidal organic ligands should be included and more informations on sources and decay of ligands are needed.

**References**
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