South East European Virtual Climate Change Center

ATMOSPHERIC DEPOSITION OF MINERALS IN DUST OVER THE OPEN OCEAN AND POSSIBLE CONSEQUENCES ON CLIMATE

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ABSTRACT

Dust minerals play important roles in initiating ocean primary productivity, cloud ice nucleation and atmospheric radiation. All three effects have impacts on climate and weather. Content of minerals in aerosols is determined by the mineral composition in arid soils. Numerical models for atmospheric transport of mineral dust might include simulation of mineral fractions as well if the geographic distribution of fractions is known. We describe recently developed global 1km gridded data of most frequent minerals in erodible soils (GMINER30). Mineral database is incorporated in DREAM-Iron model and is used in a case study simulation of atmospheric transport and deposition of iron embedded in dust aerosol.

IMPACT OF DUST AEROSOL ON OCEAN PRODUCTIVITY

Minerals carried by dust particles and deposited over remote ocean regions after long-term atmospheric transport can be important nutrient for the marine life. Iron, phosphorus and silicates embedded in dust are considered as major potential micronutrients for the ecosystems in remote oceans. Singh et al. (2008) showed that dust deposition over Arabian Sea several days later causes chlorophyll blooming. Cooling of the ocean surface is also noticed along with higher ocean wind speeds during dust events, which can lead to favorable conditions for blooming. Mahowald et al. (2010) show that iron input to the ocean not only increase ocean productivity but that this increase represents carbon-dioxide sink, which has a global worming offsetting effect. Depending on mineral composition of deposited dust particles, impact can be more or less intense. Iron in desert soils is almost non-soluble but cruse-based observations indicate that solubility increases during the aerosol transport. Factors such as mineralogy of sources, atmospheric (photo-) chemical processing and particle size features are among the most frequently proposed hypotheses (Baker and Croot 2008).

DATABASE OF SOIL MINERALOGY

Following Claqiun et al. (1999) we have developed a high-resolution global database of mineral composition in potentially erodible soils GMINER30 is on 30-seconds grid (~1km), the resolution appropriate to be used for dust emission process parameterization in fine-resolution atmospheric dust numerical models. Selected minerals (illite, kaolinite, smectite, feldspars, quartz, calcite, hematite and gypsum) are divided into clay and silt size populations with some of minerals contributing to the both groups. We supplement Claquin's mineral list with phosphorus and broaden their choice of soils with several additional FAO soil categories, covering relatively large area that is arid and bare, and thus potentially dust productive (Nickovic et al., 2010).
The database is available for download at: www.seevccc.rs/GMINER30
More details in submitted paper Nickovic et al., Technical Note: Minerals in dust productive soils – impacts and global distribution, Atmos. Chem. Phys. Discuss., 11, 26009-26034, doi:10.5194/acpd-11-26009-2011, 2011

REFERENCES

Baker and Croot (2008): Atmospheric and marine controls on aerosol iron solu- bility in seawater, Mar. Chem.doi:10.1016/j.marchem.2008.09.003
Buck et al. (2010a): The solubility and deposition of aerosol Fe and other trace elements in the North Atlantic Ocean: Observations from the A16N CLIVAR/CO2 repeat hydrography section. Mar. Chem., 120(1–4), doi: 10.1016/j.marchem.2008.08.003, 57–70.
Buck et al. (2010b): Particle size and aerosol iron solubility: A high-resolution analysis of Atlantic aerosols. Mar. Chem, 120(1–4), doi: 10.1016/j.marchem.2008.11.002, 14–24.
Claquin T., M. Schulz and Y. Balkanski (1999), Modelling the mineral of atmospheric dust sources, J. Geophys. Res., 104, 22, 243-256
Journet E., K. V. Desboeufs, S. Caquineau, and J.L. Colin (2008), Mineralogy as a critical factor of dust iron solubility, Geophys. Res. Lett., 35, L07805
Mahowald et al. (2010): Observed 20th century desert dust variability: impact on climate and biogeochemistry, Atmos. Chem. Phys., 10, 10875–10893, doi:10.5194/acp-10- 10875-2010
Nickovic S., A. Vukovic, M. Vujadinovic, G. Pejanovic, V. Djurdjevic and M. Dacic (2010), Mineral composition in arid soils: A global distribution, AGU Fall Meeting, abstract NH53A-1254
Singh et al. (2008), Enhancement of oceanic parameters associated with dust storms using satellite data, J. Geophys. Res., 113, C11008, doi:10.1029/2008JC004815

IMPLEMENTATION OF GMINER30 INTO DREAM-IRON

GMINER30 database is implemented into DREAM model in order to simulate atmospheric cycle of iron embedded into dust aerosol. First step in the implementation is to select minerals from GMINER30 that contain different amount of iron (Journet et al., 2008) and add their fractions within respective size population. Iron percentage is obtained by multiplying iron fraction with clay and silt content in each point, providing the model with an information on how much iron is available for uptake. Finally, as a common practice in atmospheric dust models, this matrix is multiplied with a dust sources mask that is in this cased based on choice of USGS land cover categories that characterize arid and bare soils.
Both soluble and total (consisting of soluble and non-soluble) iron concentrations are calculated in the model, along with standard dust aerosol concentration. There are 24 particle size bins in total, 8 of them for each category of aerosol (dust, total iron and soluble iron).

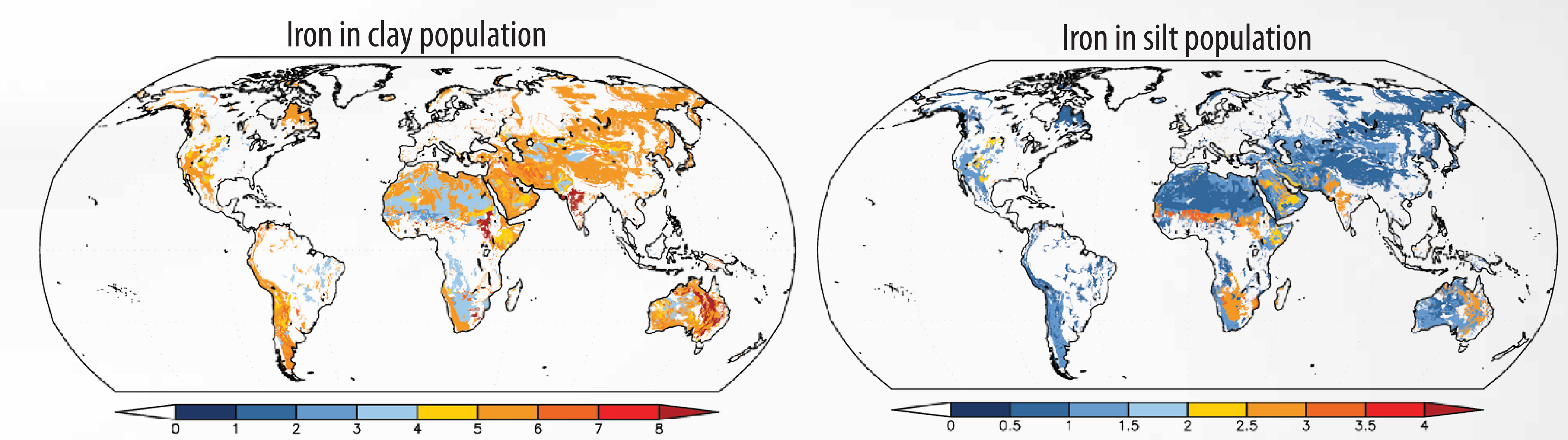

Figure 1. Iron fractions in potentially erodible soils

CASE STUDY

In the period June 20th – August 7th 2003, during the CLIVAR/CO2 Repeat Hydrography section A16N, traveling from Island to Brazil, aerosol samples were collected (Buck et al. 2010a, Buck et al.2010b). DREAM-Iron simulation is performed for July 2003 on 30km resolution and results are compared with observed data.

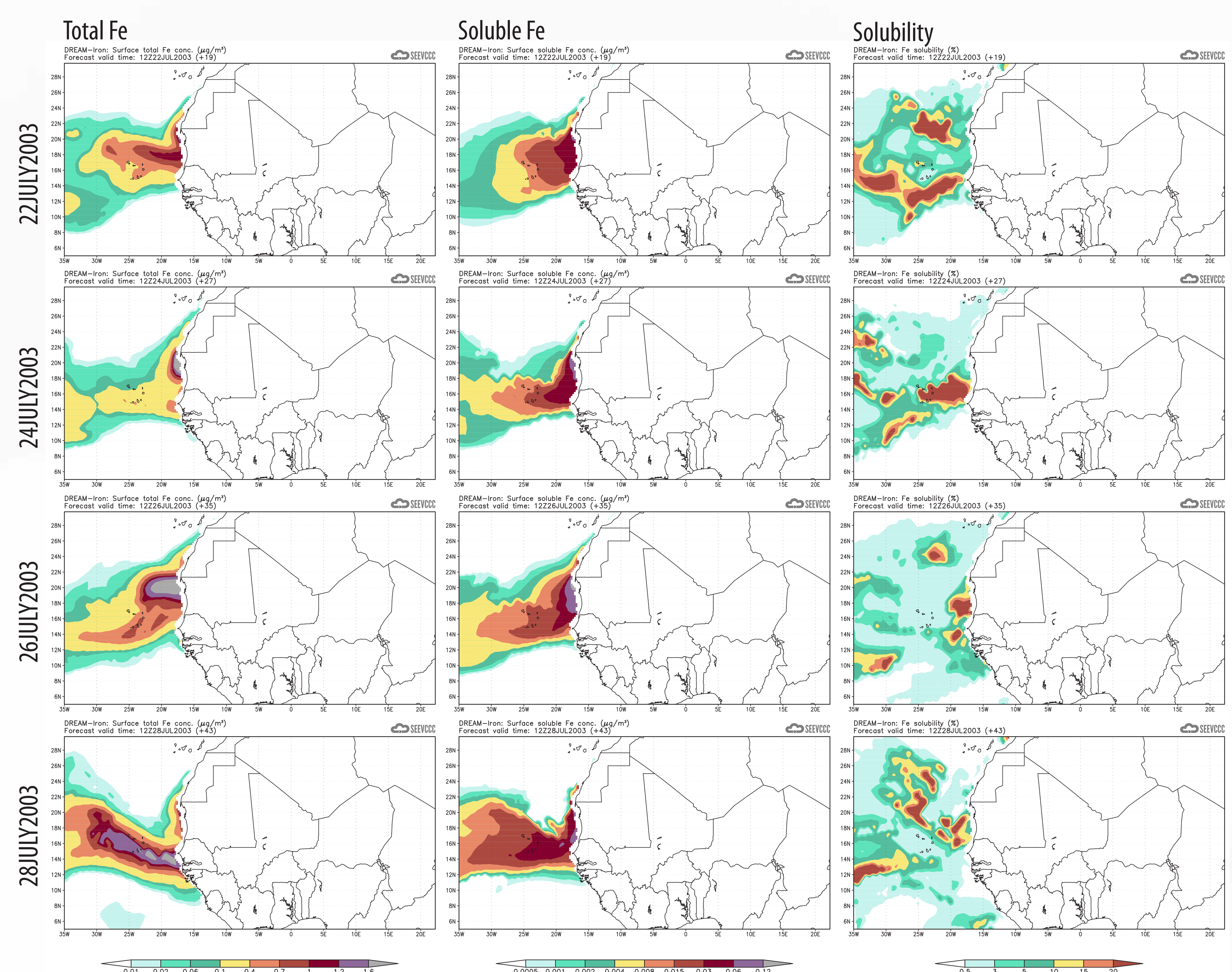

Figure 2. DREAM-Iron results for total Fe, soluble Fe and solubility

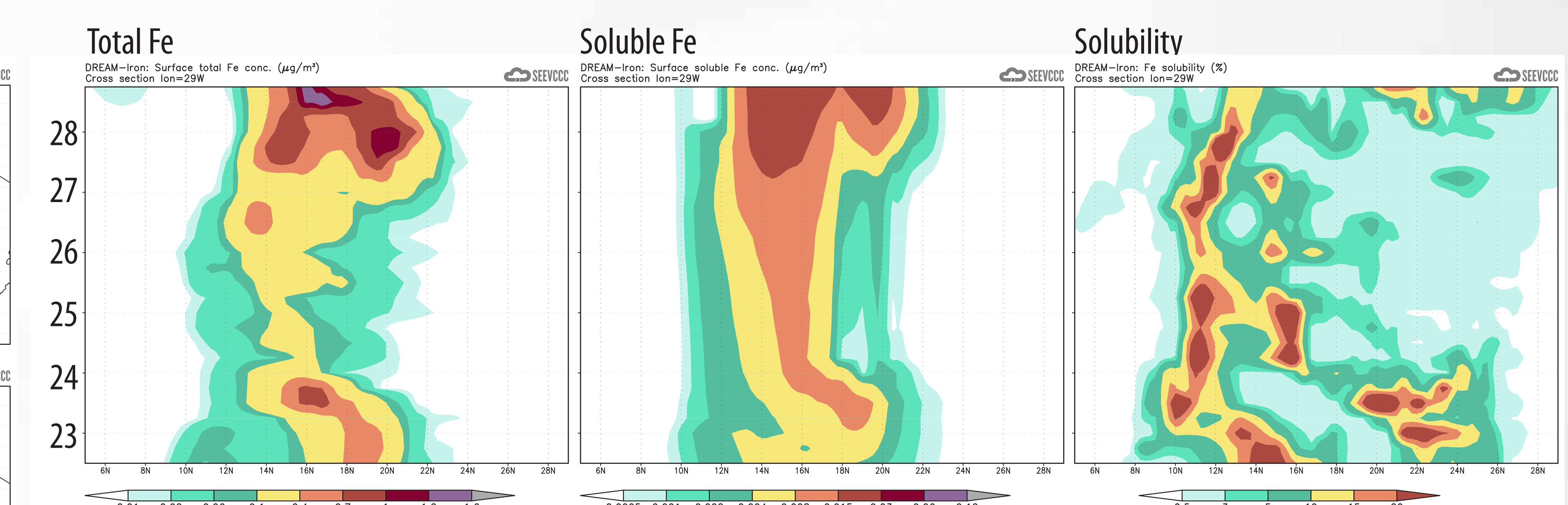

Figure 3. DREAM-Iron results for total Fe, soluble Fe and solubility, for 22-29 July 2003. Cross section longitude = 29W

Table 1. Observed data (Buck et al. 2010a, Buck et al. 2010b)

date	longitude	latitude	total Fe ($\mu g/m^3$)	soluble Fe ($\mu g/m^3$)	solubility (%)
22JULY2003	28.4W	21.1N	1.067	0.041	
23JULY2003	29.0W	19.5N	0.191	0.007	
24JULY2003	29.0W	18.0N	0.243	0.002	3.0
25JULY2003	29.0W	16.3N	1.865	0.052	
26JULY2003	29.0W	15.0N	4.168	0.101	5.1
27JULY2003	29.0W	13.4N	0.961	0.068	
28JULY2003	29.0W	11.7N	0.045	0.004	16.9
29JULY2003	28.5W	10.0N	0.098	0.007	

CONCLUSIONS

Development of the high-resolution mineral data base opens a new avenue for more appropriate studying of impacts of nutrients (Fe, P, Si) deposited with dust from the atmosphere. Our preliminary results demonstrate that the simulated total and soluble Fe concentrations are comparable with observations collected during the scientific cruise. Simulated soluble Fe fraction shows a high variability with respect to both temporal and spatial scales, opposing so a common view that the soluble Fe deposit is more homogeneous.