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Discussion session report: Nutrients supply to southern ocean surface

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Research questions and motivations

Southern Ocean (SO) is of paramount importance in the global carbon cycle due to the strong CO₂ sink and its active biological pump export. Trace metals (Fe, Co, Mn, Cu) and metalloid (e.g. silicon) supply are essential to this biological pump because other nutrients, including nitrogen and phosphorus, are mostly non-limiting in this ocean. Possible nutrient sources are deep or less deep sea (including hydrothermal supply), lateral advection from coastal margin and rivers, and atmospheric transport from continents, including volcanoes. This session is directly related to the new SOLAS topic number 3 "Atmospheric deposition and ocean biogeochemistry" but also on topic 1 "Greenhouse gases and the oceans" because of biogeochemistry feedback on carbon dioxide. Two pending questions would be a starter point of the discussion session:

- What is today the knowledge of this supply: atmosphere, deep sea, river and continental margin?
- What should we do to improve this knowledge?

Three main themes were addressed during the discussion and mostly on atmospheric dusts:

Relative importance of the different sources of trace metals in SO surface water

Dust deposition is known to be an important source of trace metals, as Fe, in southern ocean but to assess its impact, it is necessary to know its contribution relative to other sources like volcanic ash deposition, melting sea-ice or vertical mixing. Each source of limiting nutrients in SO requires specific study in order to determine the extent of their contribution and impacts. Melting sea-ice source is expected to be a more localized source relative to the atmospheric deposition of dust. We must address the geographic extended of the sea-ice melting effect on trace metal contents in SO. Because volcanic ash in SO are not evicted high in the atmosphere, they do not carry over very long distances. Volcanic ash are deposited on land rather than over oceans but could be remobilized later by wind, like mineral dust from soils, to be transported over long distances and deposited on Remote Ocean. The contribution by the deep water vertical mixing can be an important source of iron to the surface but these inputs are variable in space and time, and depend mainly on oceanic regimes. Physics of SO is not well enough known to fully assess the contribution of internal sources.

Mineral dust cycling in Southern Hemisphere

The atmospheric cycle of dust has been extensively studied over the past decades but almost exclusively in the North Hemisphere. There is still very little information on their life cycle in the Southern Hemisphere. Several issues need to be resolved to describe accurately this cycle include the following questions: Where are localized the dust hot spot in SH? What are the emission process? At what altitude mineral dust are

transported? What is the preferred way of deposit? What are the amounts deposited? Efforts should be made to progress on this point and some recommendation have been highlighted. As remote sensing by satellites is tricky in this region of the world because of the significant cloud coverage, we must develop in situ measurements to study dust atmospheric cycle. Major recommendations were the sampling of aerosols in altitudes coupled with LIDAR measurements in order to have information on dust transport and the development of automatic samplers to record time series deposition data.

Chemistry and bioavailability of dust in SH

Because of the difficulty of the dust sampling in the open SO, we have very little information on the dust chemistry and trace metals bioavailability. The amount deposited in SO are so low that it is currently very difficult to characterize accurately the chemistry of the deposit. One of the main recommendation is to characterize dust collected close to the emission area of the SH (Patagonia, Namibia and Australia). Comparison with dust from NH should provide some answers about their bioavailability. Furthermore, leaching lab experiment under specific conditions of SH (for example: higher pH than in NH) should be encouraged in order to assess more realistically trace metal solubility.