Novel findings in the Reactive Halogens in the Marine Boundary Layer (RHaMBLe) project

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The Reactive Halogens in the Marine Atmosphere (RHaMBLe) project evolved into a large multi-experiment, multi-national, cross-disciplinary integrated programme aiming to quantify impacts of marine halogen emissions on atmospheric composition by the direct observation of a range of reactive halogen species (RHS) in the marine atmosphere.

RHaMBLe focussed on two identified atmospheric implications: i) participation of reactive halogen species in catalytic ozone destruction cycles including heterogeneous reaction in or on seasalt aerosol and ii) the formation of new aerosol particles in the coastal boundary layer and their potential to act as cloud condensation nuclei (CCN).

Open ocean measurements extended the long-term studies in the tropical Atlantic Ocean at the NERC Cape Verde Atmospheric Observatory with a simultaneous RRS Discovery transect through the biologically-active upwelling region west of Mauritania. These have provided a comprehensive characterisation of halogen compounds and their impacts in the marine atmosphere, providing substantial spatial and temporal coverage. The coastal field project at Roscoff provided direct observational linkage between new particle formation, RHS and ozone consumption.

Gustiness: The driver of glacial dustiness?

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Dust flux reconstructions indicate that dust emissions from most, if not all, major dust source areas decreased markedly during glacial terminations of the late Quaternary. In low- and mid-latitude records, dust fluxes fall by a factor of 2-4 from glacial to interglacial periods [1]. Long-term records from the equator to the poles demonstrate that glacial-interglacial dust flux variations maintain a consistent amplitude across glacial cycles (e.g., [2, 3]) and show coherence between high and low latitudes, particularly during terminations [3, 4].

The remarkable consistency of dust flux records reflecting widely-separated source regions suggests a global driver of dust flux variations. Most commonly, glacial-interglacial dust emission changes are taken to reflect increased aridity in source regions during glacial periods. Inhibition of vegetation by low atmospheric pCO_2, exposure of continental shelves, increased glaciogenic fine sediment supply and increased wind speeds have also been suggested as potential drivers of high glacial dust levels.

Here we use records from closed-basin lakes near several major dust source areas across the last termination to test the hypothesis that changes in aridity drive glacial-interglacial dust flux changes. As these lakes have no outlets, changes in their areas reflect changes in effective precipitation in their drainage basins. We find evidence to suggest that mid-latitude dust source regions may have been less arid in the last glacial period and still produced more dust.

We then proceed to evaluate remaining explanations for glacial-interglacial dust cycles, focusing on changes across the last termination. Our review of a wide range of data indicates that while other factors may be locally important, changes in gustiness – driven by changes in meridional temperature gradients and seasonality – is a plausible global driver of late Quaternary glacial-interglacial dust flux variations. If true, high-resolution dust records across terminations most closely track changes in transient wind events rather than changes in aridity or other factors.

[1] Kohfeld & Harrison (2001) *Earth-Sci. Rev.* **54** 81-114. [2] Lambert *et al*. (2008) *Nature* **452** 616-619. [3] Winckler *et al*. (2008) *Science* **320** 93-96. [4] Ruth *et al*. (2007) *Geophys. Res. Let.* **34** doi:10.1029/2002JD002376.