Greenhouse gases and their isotopes in firn air and ice cores

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For a better understanding of natural feedbacks between global climate and greenhouse gas biogeochemical cycles, it is important to document what happened in the past. Ice cores and polar firn air provide a means to reconstruct polar temperature as well as atmospheric composition. Over the last two decades, I contributed with my international colleagues to decipher past greenhouse gas concentration changes, focusing notably on atmospheric methane [1-4]. Thanks to the success of European deep drilling operations in Greenland and in Antarctica (notably EPICA Dome C), and following the extraordinary adventure of Russian scientists at Vostok station, we have been able to reconstruct the evolution of CO_2, CH_4 and N_2O mixing ratio changes back to 800, 000 years before present.

Although these records show a general common pattern of glacial-interglacial variability, there are specificities to each greenhouse gas. Notably CH_4 and N_2O reveal a systematic millennial-scale variability, encountered during the last 8 glaciations.

In order to better understand the causes behind such variability at different time scales, I have investigated changes in the stable isotopic ratios of the three greenhouse gases. Using $\delta^{13}C$ of CO_2, we could show that the main mechanisms responsible for the ~40% increase of CO_2 during the last deglaciation involved the breakout of Southern Ocean stratification as well as a decreased biological productivity [5]. For CH_4 and N_2O, my main focus on their isotopic composition changes dealt with the anthropogenic increase, providing important constraints on the main sources involved [6-7].

More recently, I got interested in the carbon monoxide budget, which impacts atmospheric chemistry and the CH_4 lifetime through its control of OH hydroxyl radical in the troposphere. We have produced the first-ever record of CO and its $\delta^{13}C$ and $\delta^{18}O$ isotopic signature over the last millennium, pointing toward large changes in the biomass burning source strength, in relation with global climate [8].

I will give an overview of these different results and will discuss the perspective for ice core gas analyses in the future, notably taking into account recent advances in optical methods.

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Nutrient biogeochemistry in permeable sediments impacted by submarine groundwater discharge

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Submarine groundwater discharge is a major, yet poorly constrained conduit for the transport of nutrients at the land-ocean interface. The net flux of chemical species from groundwater to the coastal ocean is modulated by biogeochemical reactions in the permeable sediments of coastal aquifers. In order to provide insight on the biogeochemical transformations that occur at this boundary, the WHOI Coastal Groundwater Geochemistry group has performed detailed studies of groundwater nutrient cycling at Waquoit Bay (Massachusetts, USA). This system is an ideal natural laboratory due to natural and anthropogenic inputs of nutrients to the aquifer and a well-defined subsurface groundwater-seawater mixing zone that hosts wide-ranging redox driven reactions. This talk will focus on an overview of nitrogen and phosphorus cycling in the context of field, laboratory, and modeling studies.