EAG Distinguished Lecture Tour 2013

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Lecture Abstracts

Lecture I: Oxygen isotope anomalies in the atmosphere

Isotope measurements belong to the most important tracers to study the Earth system. In atmospheric research, isotope effects are used to identify and quantify individual production and removal processes of atmospheric trace gases. For oxygen, with three stable isotopes, ^{16}O, ^{17}O and ^{18}O, measurements show that the variations between these three isotopes in the atmosphere are anomalous, also called "non-mass-dependent". The most important example for an anomalous oxygen isotope effect is the formation reaction of ozone (O_3).

At the same time, non-mass dependent oxygen isotope compositions have been detected in many other atmospheric molecules. In fact, there is almost no atmospheric species for which an anomaly has not been detected, or at least postulated. This is because O_3 is at the center of atmospheric oxidation reactions. Via chemical reactions the oxygen isotope anomaly is transferred from O_3 to other atmospheric compounds. Measuring the isotope anomaly therefore opens new opportunities to investigate chemical reaction mechanisms on the one hand, and mass fluxes between different species and reservoirs on the other hand. What started out as a peculiar isotope anomaly almost three decades ago has grown into a new research field that spans the full range from molecular physics studies to the reconstruction of climate parameters in the past.

Lecture IV: The isotopic composition of long-lived trace gases in the stratosphere

Long-lived trace gases like nitrous oxide (N_2O) or methane (CH_4) reach the stratosphere where they are removed via photochemical reactions. These reactions are associated with isotope effects that usually enrich the trace gases in heavy isotopes. As part of the global atmospheric circulation, air that has been processed in the stratosphere returns to the troposphere and therefore the stratospheric isotope enrichments can considerably affect the tropospheric isotope budgets of long-lived trace gases. We have investigated in detail the isotopic composition of several trace gases in the stratosphere, as well as the individual removal processes in laboratory experiments. Stratospheric samples were obtained during stratospheric balloon flights and on high altitude aircraft. The samples cover a large range in mixing ratios and show the largest heavy isotope enrichments observed in these compounds so far. In addition to the chemical removal, also dynamical processes affect the isotopic composition of trace gases in the stratosphere.