Impact of the Sarychev eruption during the 2009 StraPolÉTé campaign

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In the framework of the International Polar Year, the StraPoLÉTé (French acronym for "Stratosphère Polaire en ÉTé") project has been started on January 2009. This project is associated with a successful balloon borne campaign which took place close to Kiruna (Sweden) from 02 August 2009 to 12 September 2009 with eight balloon flights. During this campaign the main characteristics of the summertime arctic stratosphere have been captured. The data set obtained using UV-visible and infrared instruments, remote sensing and in-situ spectrometers provide detailed information on vertical distributions of more than fifteen chemical tracers and reactive species from the upper troposphere to the middle stratosphere. A number of in-situ optical aerosol counters (STAC instrument), and a photopolarimeter (MicroRadibal instrument) have provided information on the nature and size distribution of the stratospheric aerosols. These aerosol measurements with high precision and high vertical resolution are relevant to qualify the dynamical processes occurring in this region during summertime.

The balloon observations have highlighted high amounts of aerosols in the lower stratosphere. These observations have been explained by a passing volcano plume. Indeed, in June 2009 the Sarychev volcano located in the Kuril Islands to the northeast of Japan erupted explosively, injected ash and an estimated 1.2 Tg of sulfur dioxide into the upper troposphere and lower stratosphere. This eruption is one of the 10 largest stratospheric injections in the last 50 years. The data set have been completed by satellite instruments (CALIOP, IASI) offering large spatial coverage of the region of interest and by the NDACC lidar instrument deployed in OHP (Observatoire de Haute-Provence, France). Data analysis was made using the HadGEM2 chemistry-climate model to highlight major mechanisms that controlled the distribution of aerosols. The AEROWAVE (AEROsol WAter Vapor and Electricity) campaign conducted in spring 2010 over Kiruna was used to quantify the aerosol concentrations after the eruption in "recovered background conditions".

IASI SO_2

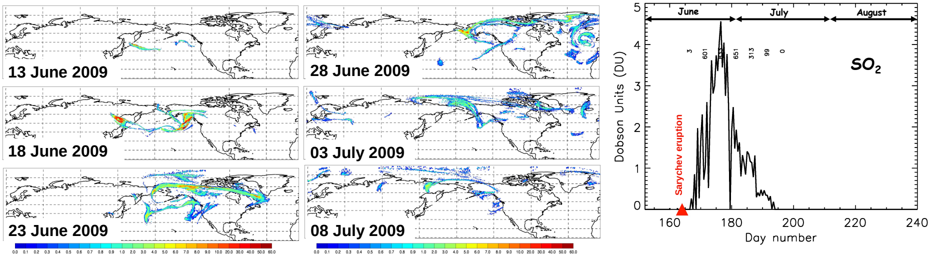

Figure 1: evolution of the SO_2 plume (left) and AOD over Kiruna (right) after the Sarychev eruption observed by the IASI instrument onboard the METOP-A satellite. Numbers on the right figure: number of averaged observations.

CALIOP aerosol

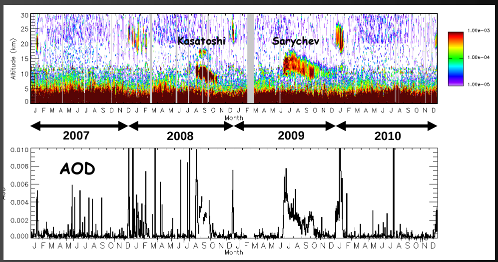

Figure 2: daily mean aerosol extinction coefficient (top) and AOD between 8-20 km (bottom) measured by the CALIOP lidar onboard the CALIPSO satellite over Europe (40-80°N, 15W-45E) during the 2007-2010 period.

HadGEM2 climate model

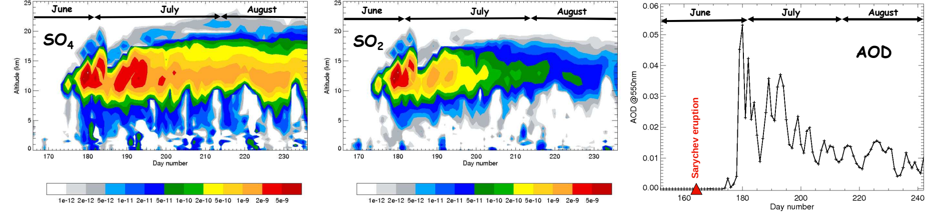

Figure 3: SO_4 (left), SO_2 (middle) and AOD (right) daily evolution over Kiruna during August, 2009 modelling by the HadGEM2 climate model (J. Haywood, 2009).

OHP lidar aerosol

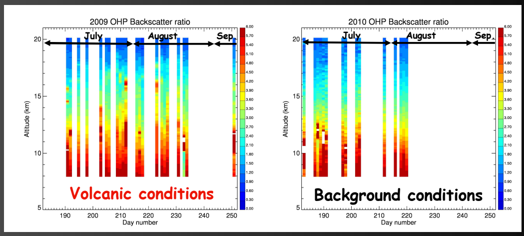

Figure 4: aerosol backscatter ratio observed with the OHP lidar (Observatoire de Haute Provence, France) during the July-August period for 2009 (left: volcanic condition) and 2010 (right: background conditions).

Aerosol concentrations

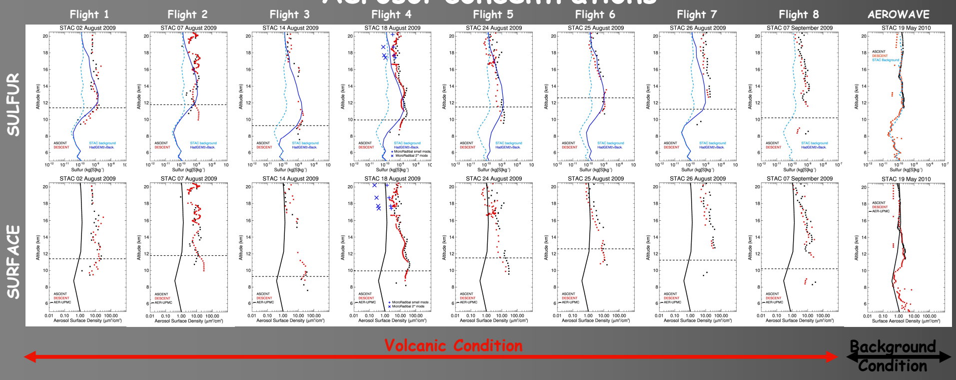

Figure 5: aerosol sulfur (top) and surface area density (bottom) for the StraPolÉTé balloon flights (volcanic conditions, August-September 2009) and during the AEROWAVE campaign (background conditions, 19 May 2010) for the ascent (black squares) and descent (red squares). STAC and MicroRadibal balloon observations are compared on 18 August 2009. The HadGEM2 sulfur model outputs (top blue lines) added to the background profile (top light blue dashed lines) have been compared to the observations during the August, 2009. The typical background aerosol profile from the SPARC ASAP scenario (50 ppt SO_2 in the lower stratosphere + 512 ppt OCS at the surface), simulated by the AER-UPMC model is added to the surface area density profiles (bottom black lines). Black dotted lines: altitudes of the tropopause.

Temperature

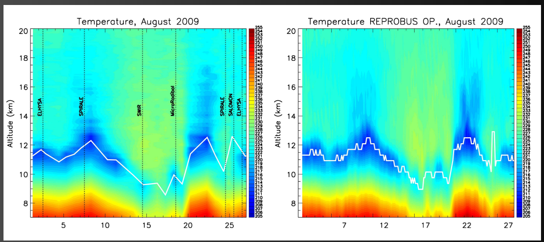

Figure 6: temperature measured by ozone-sondes launched during the STRAPOLETE campaign (left) and simulated by the Climate-Transport Model REPROBUS driven by the operational ECMWF winds. White line: altitudes of the tropopause.

Figure 7: launch on 24 August 2009 (Kiruna, Sweden).

Figure 8: Sarychev eruption from the ISS on 12 June 2009 (NASA).

Conclusion: The StraPolÉTé and AEROWAVE campaigns have provided opportunities to study the variability of the Junge layer in the lower stratosphere. This layer is created by the transport of sulfur precursors like OCS and SO_2 emitted from oceans, volcanoes and polluted regions. The good agreement between the HadGEM2 climate model and the observations gives evidence that moderate stratospheric eruptions control the variability of the Junge Layer. Moderate eruptions like the Sarychev eruption have the potential to increase the background aerosol loading by a factor 5 to 10.

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