OASIS-YOPP

Observations of the Arctic Stratosphere In Support of YOPP

http://www.thuleatmos-it.it/

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Areas of contribution

User-aspects and verification

Polar atmospheric processes

Modelling and forecasting

Observations

Summary

Polar stratospheric processes impact tropospheric circulation, climate, and weather patterns. One of the most important processes occurring in the stratosphere is the springtime final breakdown of the stratospheric polar vortices (Stratospheric Final Warming, SFW). In the Arctic, SFWs may follow two different patterns: they can start at around 10 hPa and then proceed upward and downward, or start in the lower mesosphere and progress downward with time. These two paths lead to different tropospheric pressure and temperature patterns in the following month. Both the timing and the vertical profile of Arctic SFWs can therefore be employed as predictive tools and verification parameters. This project aims at contributing to two of the main PPP research goals: 1) Implement additional observations in the polar regions and 2) Establish and apply verification methods for modeling efforts in polar regions. We will provide daily ground-based and in situ measurements of lower and middle atmospheric chemical and physical parameters during the period of occurrence of SFWs in the Arctic, February 1st to March 31st, 2018 (during SOP). Measurements of stratospheric vertical profiles of N₂O, H₂O, CO, O₃, temperature and pressure, and daily launches of radio soundings will be carried out from Thule (76.5°N, 68.8°W), Greenland, in a region where conventional observations supporting YOPP appear to be very scarce. These data sets will provide highly resolved measurements, from the lower stratosphere to the
mesosphere, of a SFW in the Arctic and will be used to verify CCMs prediction of the timing and the vertical profile of SFWs.

Description

This research project aims at contributing to the Polar Prediction Project (PPP) and more specifically to YOPP activities. It will contribute to two of the main research goals: 1) Implement additional observations in the polar regions to support the understanding of polar processes and modeling, which would require also the optimization of the necessary ground-based instruments, and 2) Establish and apply verification methods for modeling efforts appropriate for polar regions.

In the Arctic, in most cases, SFWs start at around 10 hPa and then proceed upward and downward, to the upper and lower stratosphere, during the following weeks. Alternatively, as it occurs in the Antarctic, Arctic SFWs can start in the lower mesosphere and progress downward in time. These two paths of vortex breakup arise from different magnitudes of planetary wave activity, leading to different tropospheric pressure and temperature patterns in the following month. Both the timing and the vertical profile of Arctic SFWs can therefore be employed as predictive tools and verification parameters.

We plan on providing daily ground-based and in situ measurements of lower and middle atmospheric chemical and physical parameters during the period of occurrence of Stratospheric Final Warmings (SFWs) in the Arctic, from February 1st to March 31st, 2018 (during the Special Observing Period, SOP). Measurements will be carried out from the observatory located at Thule, Greenland (76.5°N, 68.8°W), in a region where conventional observations supporting YOPP appear to be very scarce, and where the proposing groups have been carrying out atmospheric measurements since the early 1990’s. The observatory, supervised by the Danish Meteorological Institute (DMI), is part of the international Network for Detection of Atmospheric Composition Change (NDACC, http://www.ndsc.ncep.noaa.gov).

In particular, this research effort can contribute with stratospheric vertical profiles of N2O, H2O, CO, and O3, observed by means of two ground-based millimeter-wave spectrometers; temperature and pressure stratospheric vertical profiles carried out by means of a lidar system during the first part of the campaign, at dusk; and daily launches of radio soundings which will provide vertical profiles from the ground to 25-30 km altitude of pressure, temperature, humidity and wind. The observed chemical species act as tracers at various levels of the polar stratosphere, depending on their sources and sinks. N2O profiles are useful in the lower stratosphere, up to about 20-25 km, H2O profiles are well suited for the middle atmosphere, up to 40-45 km, and CO can act as a tracer from 40 to 65 km. Measurements of CO and N2O will have a 3-hour time resolution and will be acquired alternatively one after the other, so that each species will be observed every 6 hours. Water vapor spectral measurements are instead obtained continuously but will also have a time resolution of about 6 hours. Lidar temperature profiles will be carried out only during hours of darkness or at dusk and will have a time resolution (integration time of measurements) of about 3 hours, depending on daylight. Radio soundings will be launched daily throughout the campaign.

Additional useful measurements of column contents of various chemical species will be provided through the collaboration with NCAR, whose personnel operates from Thule a ground-based FTIR spectrometer (also within NDACC) which observes species such as HF, N2O and HCl capable of discriminating vortex from extra vortex air. DMI will also contribute to the project with measurements of total ozone and NO2, by means of a UV-visible SAOZ spectrometer, and ozone soundings data during winter.

The use of stratospheric vertical profiles of chemical species and lidar temperature (the latter will be available as long as a few hours of dusk occur), as well as radio sounding data which are otherwise absent in a radius of more than 500 km around Thule, will allow us to characterize the evolution of the polar vortex and follow the different stages of the Arctic SFW. This will provide the PPP modelling community a chance to identify best
practices and key diagnostics to evaluate models in the polar regions during the developing phases of an event that is critical to the meteorological patterns in the troposphere. Although most studies make use of global reanalyses of meteorological parameters (temperature, pressure, wind) to evaluate models (and the proponents will also make use of reanalyses in this project to get an overview on the vortex evolution over the entire Arctic region) it is critical to verify model forecasts with actual measurements, as reanalyses are influenced by the model itself during data assimilation. This is particularly true in the polar regions where measurements are sparse. Furthermore, the data set that will be acquired in this project, in particular CO and O3 profiles, reaches altitudes that are not available to reanalyses data, therefore further extending the altitude at which the chemical and physical processes parameterized in CCMs can be evaluated and tuned.

In order to gain an overview on the evolution of the polar vortex, the proponents will also make use of the Aura/Microwave Limb Sounder (MLS) datasets for N2O, H2O, and CO concentration profiles, as well as temperature profiles. The MLS dataset has proven to be a unique tool for studying the chemistry and dynamics of the polar regions, but it is worth stressing that the MLS was launched in 2004 on a 5-year mission and no follow up satellite mission for the observation of polar middle atmospheric chemical species has been planned by NASA or by ESA. This will inevitably result in a gap of satellite-based winter measurements over the polar regions after MLS, which can only be filled by means of a network of ground-based and in situ observations, for which the overlapping with present MLS observations is crucial to maintain a long-term record.

Timeline

2016-07-01 - 2018-07-25

Regional emphasis

Northern hemisphere: Yes
Southern hemisphere: No

Key project deliverables

- Radio sounding profiles of pressure, temperature, humidity and wind delivered in near-real time;
- Measurements of stratospheric vertical profiles of N2O, H2O, CO, O3, temperature and pressure to be delivered approximately 3 months after completion of the planned measurements campaign;
- Integrated analyses on the atmospheric measurements of tracers, temperature, and winds obtained during the campaign, delivered 10 months from the end of the campaign;
- Comparisons of ground-based and in situ measurements obtained during the SFW with CCMs forecasts, completed 24 months from the end of the campaign;
- Comparison of retrieved middle atmospheric chemical composition with satellite observations, completed 24 months from the end of the campaign.
Data management

http://www.thuleatmos-it.it/

Is data provided to WMO Global Telecommunication System

No