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FinROSE chemistry transport model

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Model

The FinROSE chemical transport model (Damski et al., 2007) is a global model of the stratosphere and mesosphere. The model produces the distribution of around 35 species. The chemistry describes around 110 gas phase reactions and 37 photodissociation processes. The model includes heterogeneous processing and PSC sedimentation and tropospheric abundances are given as boundary conditions. The model was run with a horizontal resolution of 3 by 6 degrees at 35 hybrid levels, from the surface up to 0.1 hPa (ca. 65 km) (Thölix et al., 2010).

The stratospheric ozone and water vapour distribution was simulated using the FinROSE chemistry-transport model driven by reanalysis data from the European Centre for Medium-Range Weather Forecasts (ECMWF). In this work the ERA-Interim (1989-2011) winds and temperatures were used.

Marambio ozone timeseries

Severe ozone loss has been observed in the Southern Hemisphere polar vortex since the mid 1980s. The decrease in emissions of ozone depleting substances has led to expect that the stratospheric ozone would slowly recover over the next decades.

Ozone soundings have been made in Marambio, which is situated on the Antarctic Peninsula, since 1988, i.e. soon after the discovery of the Antarctic 'ozone hole'. The ozone sounding record at Marambio (64S, 57W) now covers more than two decades of nearly continuous ozone profile data.

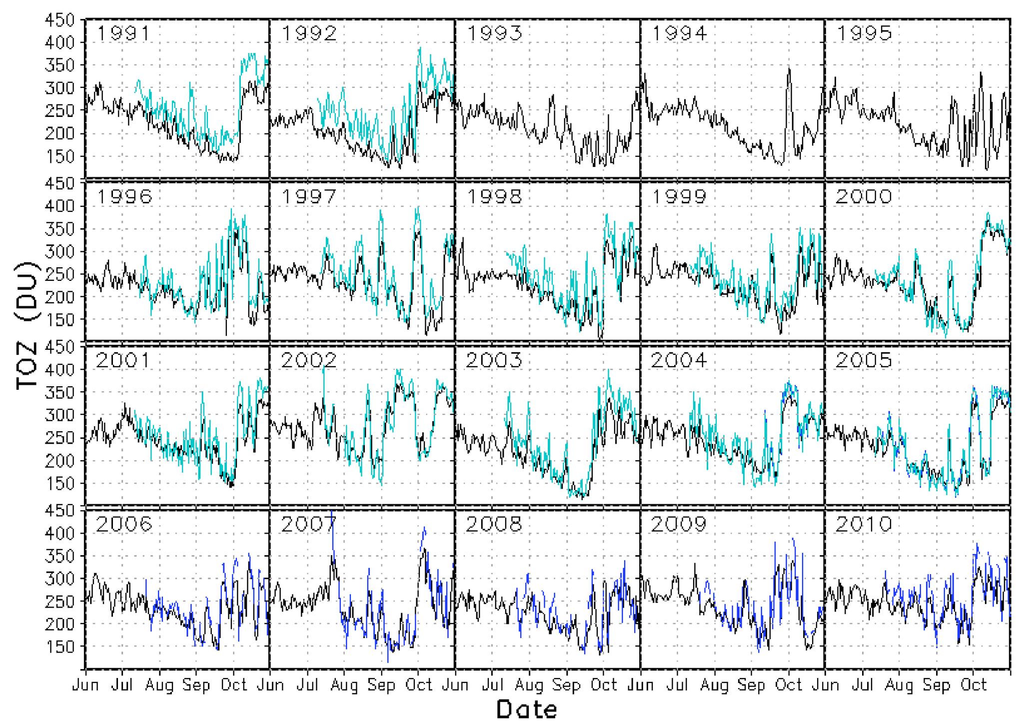

Figure 1. Total column ozone above Marambio 1991-2010, June to October. The black line shows FinROSE model data TOMS data is shown in cyan and OMI in blue. The total ozone shows a large variability due to the the location of Marambio close to the vortex edge.

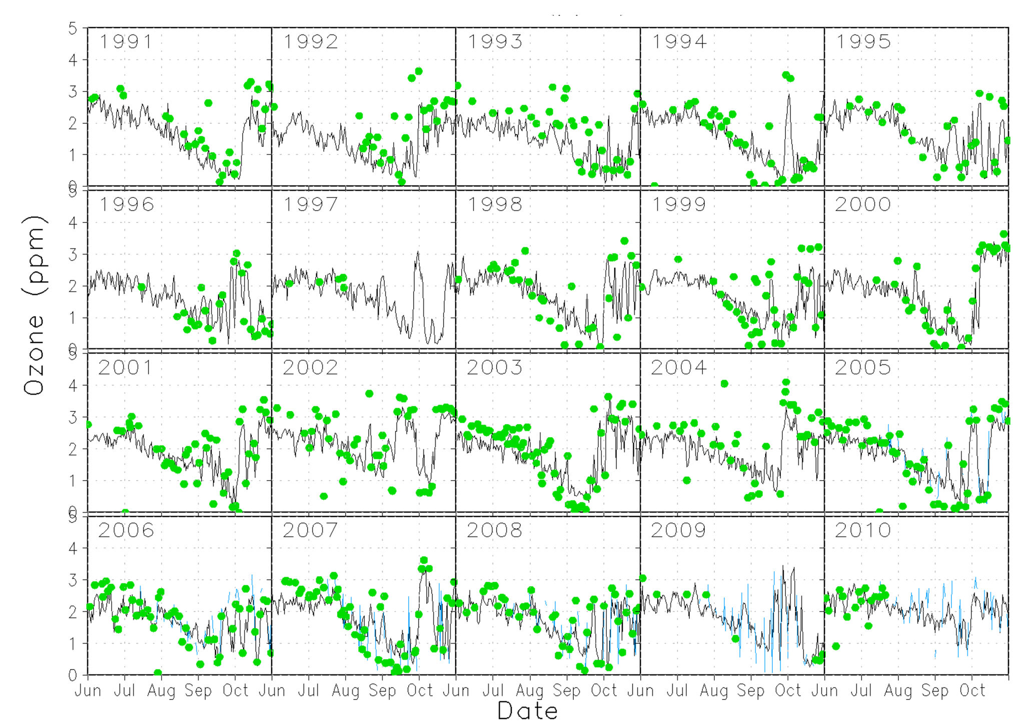

Figure 2. Ozone partial pressure at 54 hPa above Marambio, 1991-2010. The black line shows FinROSE model data. The green dots represents sounding data. The cyan line shows MLS overpass data.

Arctic water vapour 2010

Accurate soundings of stratospheric water vapour have been made above Sodankylä (67.7N, 26.6E) since early 2000s. Two major water vapour measurement campaigns have been organized in Sodankylä, i.e. the LAPBIAT Upper Troposphere Lower Stratosphere Water Vapour Validation Project (LAUTLOS-WAVVAP) in 2004 and the LAPBIAT atmospheric sounding campaign in 2010.

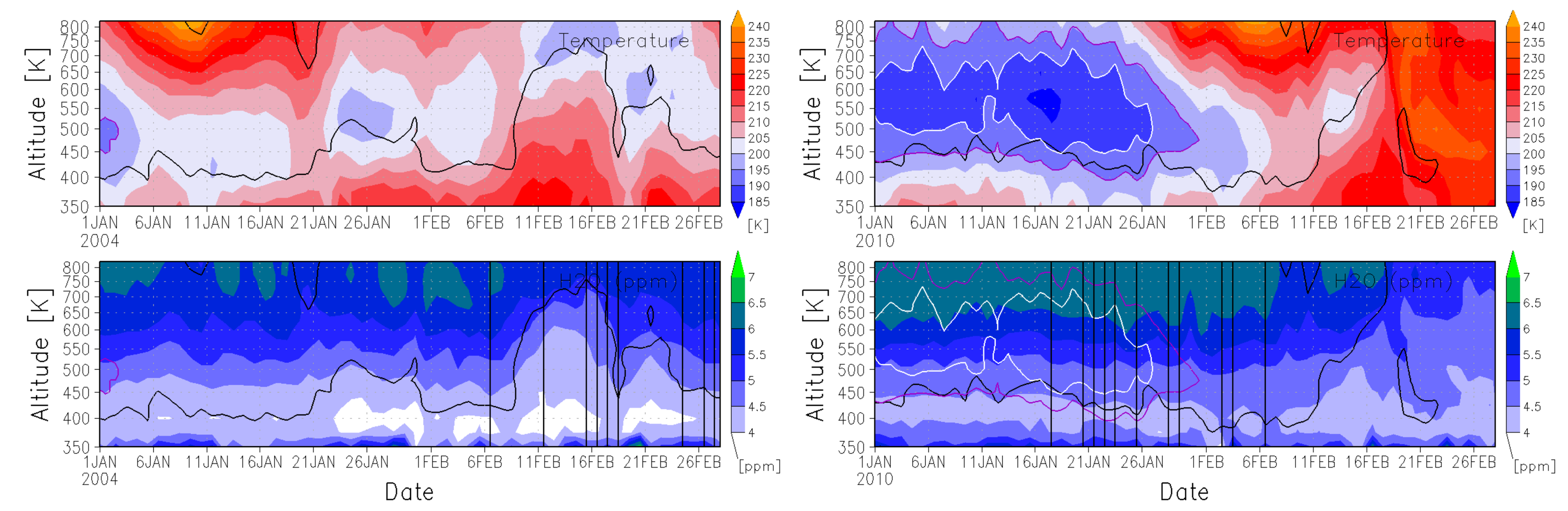

Figure 3. The vertical distribution of temperature (upper panels) and water vapour (lower panels) above Sodankylä during two major sounding campaigns. The left panels show the conditions during January and February 2004 and the right panels for early 2010. The contours show approximate PSC threshold temperatures 190 K (white), 195 K (purple) and polar vortex edge (black). Vertical lines indicate the dates of water vapour soundings.

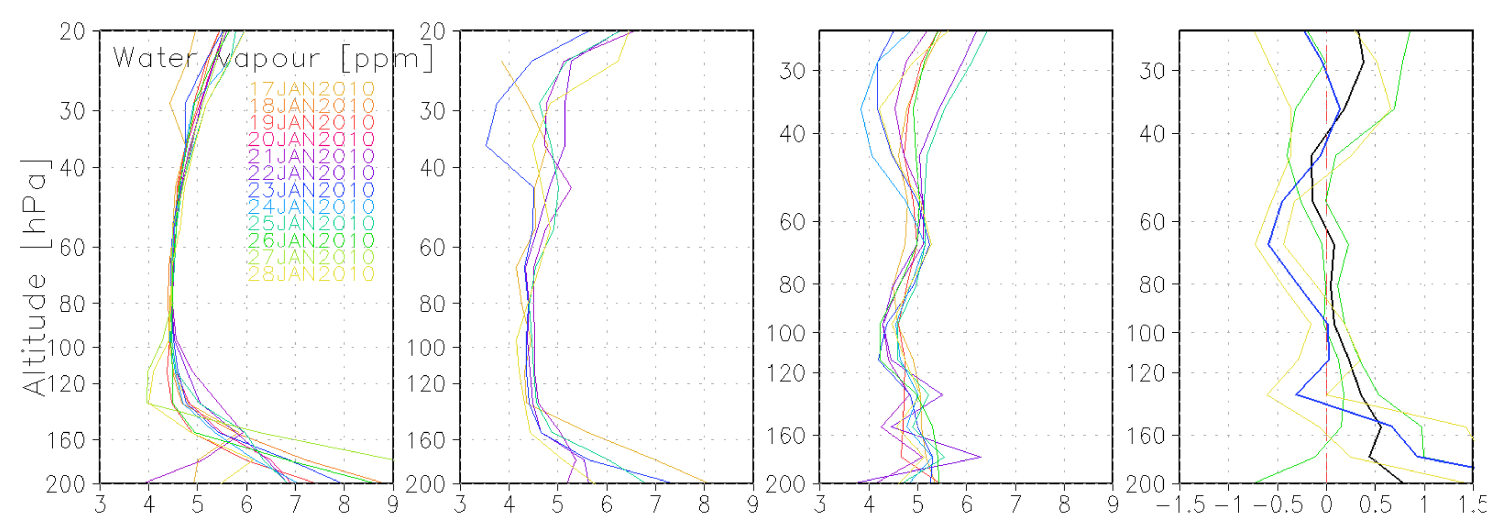

Figure 4. Comparison between Sodankylä water vapour sounding profiles and model data, during the 2010 campaign. Water vapour (ppm) from FinROSE, soundingsand MLS. Right panel shows the difference and deviation, model-sounding (black) and model-MLS (blue).

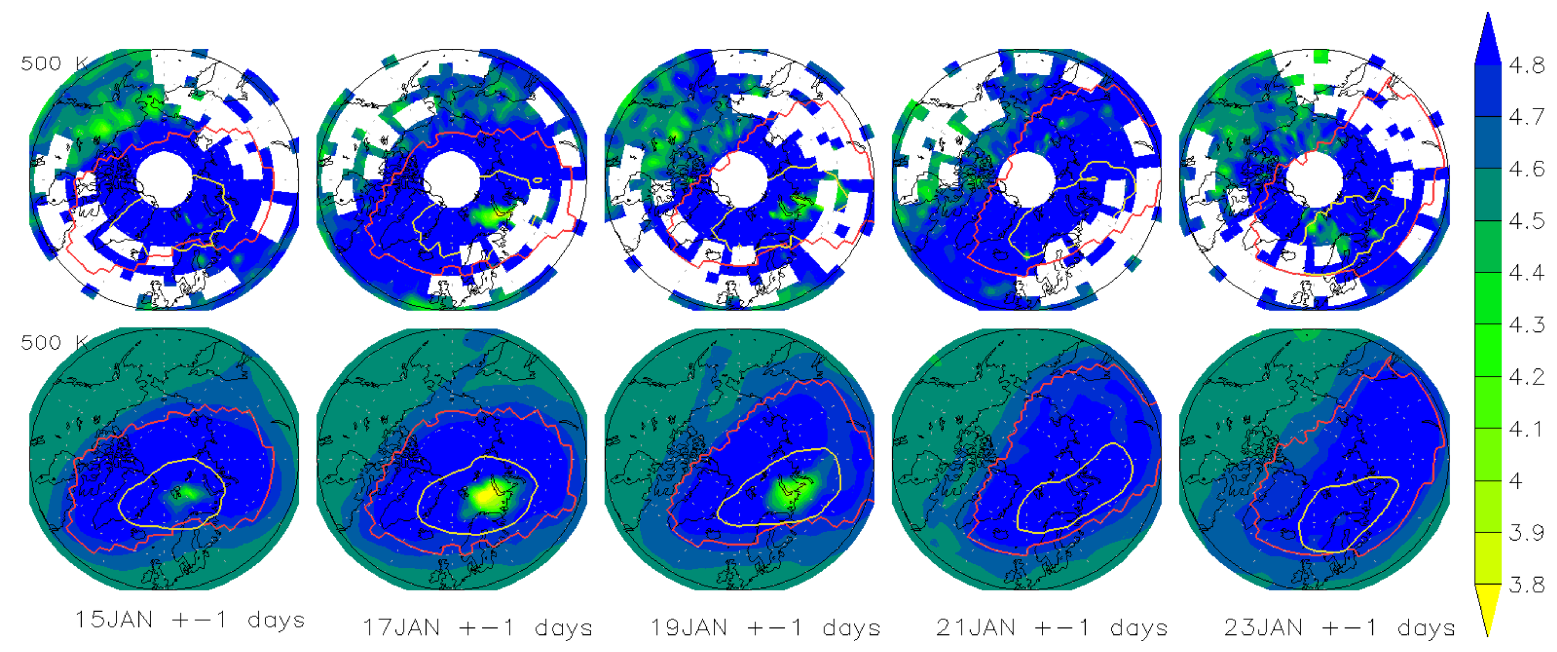

Figure 5. The distribution of water vapour (ppm) at the 500 K potential temperature level during part of the 2010 campaign. The vortex edge is indicated by a red contour (largest PV gradient). The approximate area of ice PSC occurrence is shown by the 190 K isotherm (yellow contour). MLS data is shown in the upper row and FinROSE data in the lower row. The figures show data averaged over three days, 15th to 23rd of January 2010. Large scale dehydration is seen in the coldest part of the vortex.

Arctic ozone loss in the spring 2011

The severity of the Arctic ozone loss varies significantly from year to year depending on the meteorological conditions in the stratosphere. Chlorine and bromine species are converted to their active forms at low temperatures when polar stratosphere clouds are formed. In the spring of 2011 the conditions in the Arctic polar vortex were exceptionally favourable for ozone depletion. The conditions persisted until the beginning of April, which led to unprecedented Arctic ozone depletion. The total ozone column decreased down to ca. 250 DU over significant areas, i.e. a column ozone loss of 40%. At the end of March the severely ozone depleted polar vortex moved over Scandinavia.

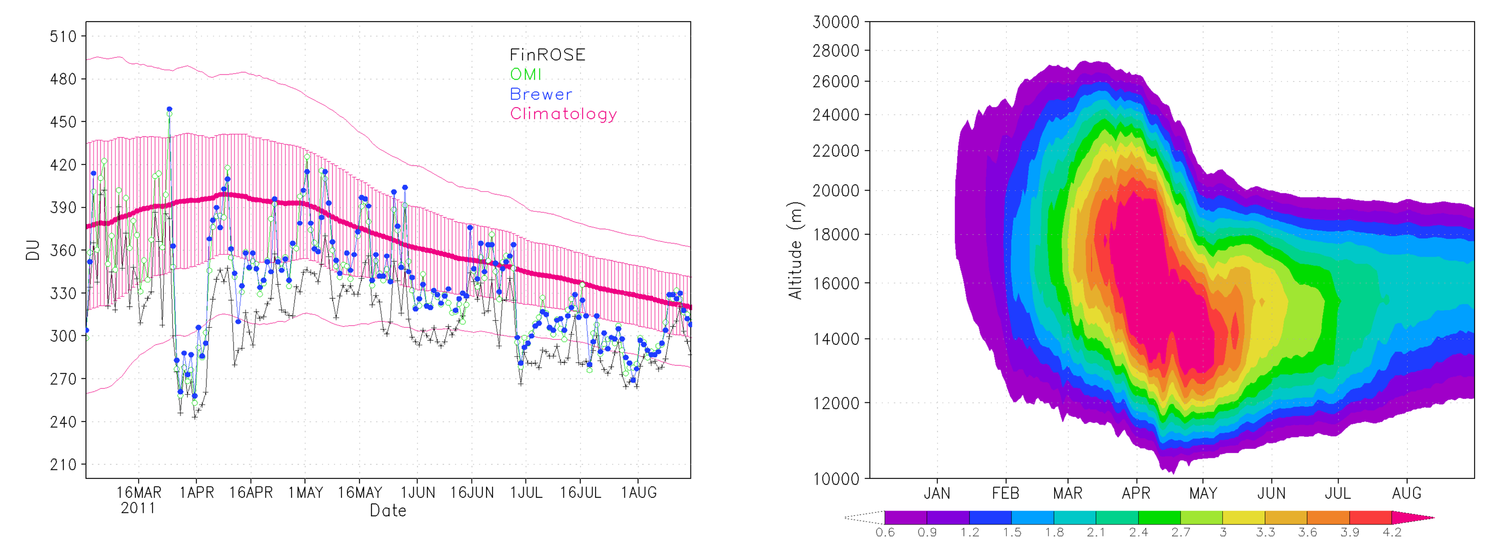

Figure 6. Left panel: Total ozone at Jokioinen (60.8N, 23.5E) in spring 2011. Black curve shows FinROSE, green OMI satellite measurements and blue Brewer ground based measurements. The red thick curve shows climatology calculated from Brewer observations. The shaded area shows one standard deviation, thin red curves two standard deviations. Right panel: Ozone depletion (mPa) due to heterogeneous chemistry at latitudes 60-90N.

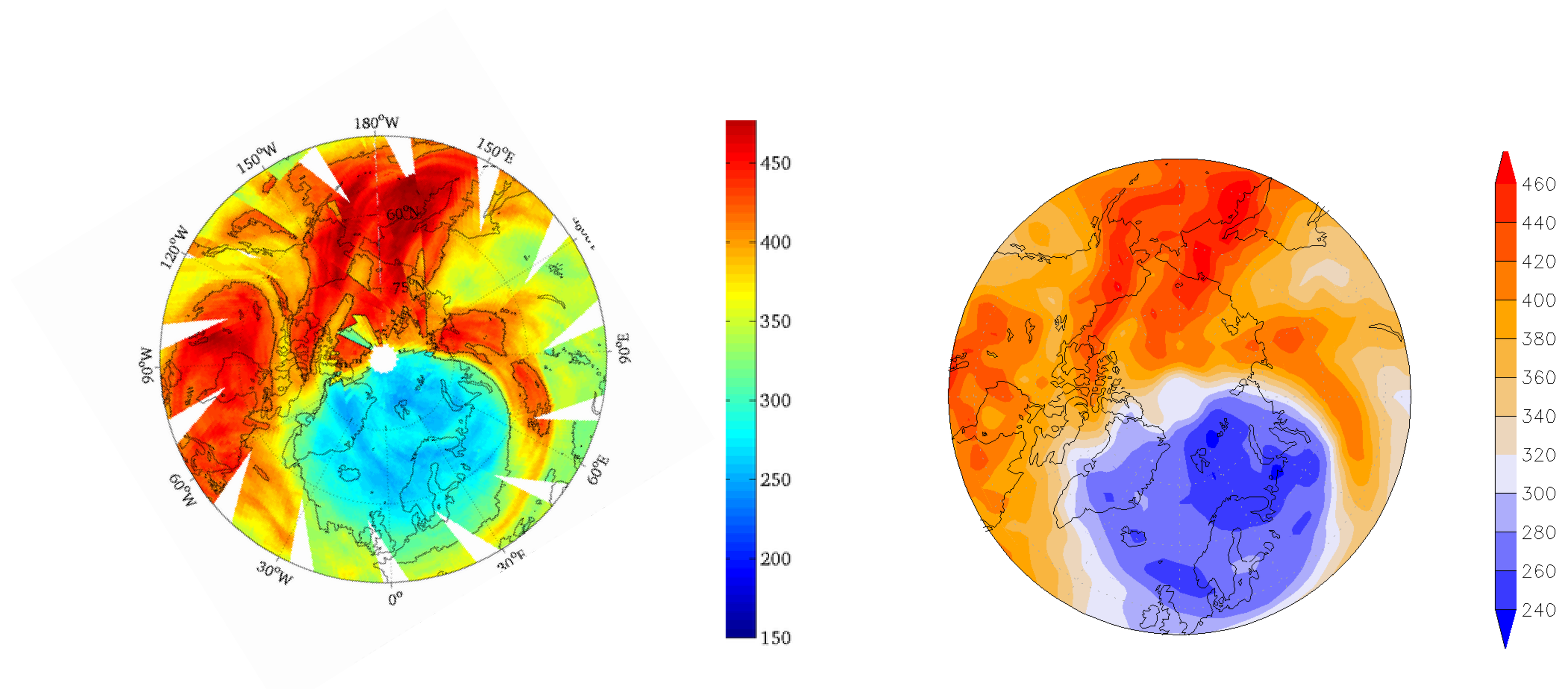

Figure 7. Total ozone at 28 March 2011. OMI on the left panel andFinROSE on the right panel.

Acknowledgements

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References

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- Thölix, L., Backman, L., Ojanen, S.-M., 2010: The effects of driver data on the performance of the FinROSE chemistry transport model, IJRS, 31, 24, 6401–6408.

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