Anomalous Methane Distributions in the Summer Stratosphere 2003 Using MIPAS Observations

Yvan J. Orsolini[2] (orsolini@nilu.no), **W.A. Lahoz**[1], **A. J. Geer**[1]

[1]*Data Assimilation Research Centre, DARC, University of Reading, UK,* [2]*Norwegian Institute for Air Research (NILU), Norway*

Introduction

The structure and evolution of the summer stratosphere in the Northern Hemisphere (NH) has been relatively little studied compared to stratospheric winter. While the average methane source gas distribution decay with height and latitude, anomalous stratospheric polar enhancements have been observed by MIPAS in the summer 2003 in the northern hemisphere. These give rise to methane meridional profiles increasing with latitude, seen as "W-shaped" patterns in along-track sections across the pole.

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Conclusions

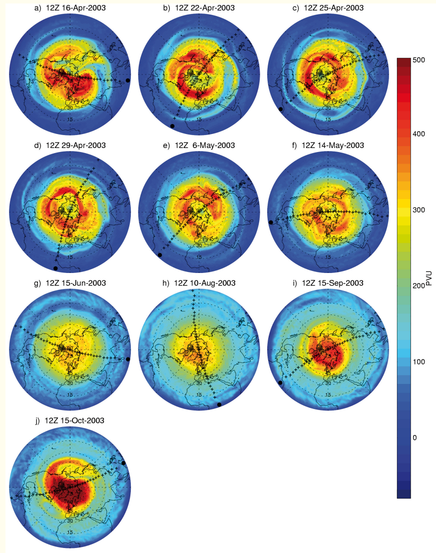
Anomalous polar distributions of methane in the spring and early summer 2003 arise from the transport of methane-rich air from mid to high latitudes following the break-down of the polar vortex. In particular, methane-rich air is found in long-lived "frozen-in" anticyclones, slowly circling the pole with a period of 2-3 weeks.

"W-shaped" meridional patterns have not been discussed before. The trace-gas signatures of summertime, frozen-in stratospheric anticyclones were first discovered in MLS observations by Manney et al. (2006), and are shown here for the first time in MIPAS data.

"Frozen-in" anticyclones

Using data from MLS from the spring and summer 2005, Manney et al. (2006) describe a frozen-in mid stratosphere anticyclone (FrIAC), which remains coherent while being slowly advected around the North Pole by the prevailing high latitude easterlies. Originating in the poleward transport of mid latitude air during the April final warming, the air masses confined in the anticyclone rotated around the Pole with a variable period of 2 or 3 weeks, before disappearing in August 2005. Frozen-in vortex remnants have been reported in models (*e.g. Orsolini 2001*) and observations (*Durry and Hauchecorne 2005*). FrIACs can be regarded as the opposite of vortex remnants, as the former are long-lived anticyclonic vortices originating from low latitudes, whereas the latter are long-lived cyclonic vortices originating from high latitudes.

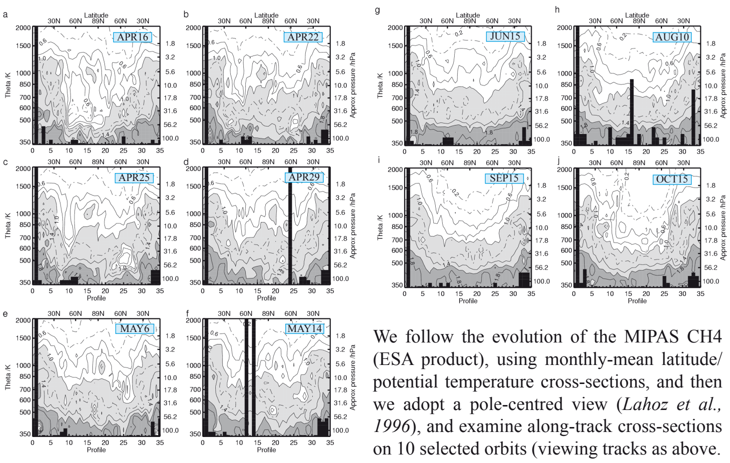
We see a FrIAC in 2003 developing out of the poleward transport of low-latitude air during the vortex breakdown in mid-April,

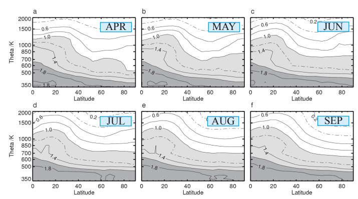


and then as a low PV small-scale anomaly circling the pole until mid-May. E.g.:

- potential vorticity at 850K (ECMWF operational analyses)
- corresponding MIPAS CH_4 along-track cross-sections

Methane distribution from MIPAS





We follow the evolution of the MIPAS CH4 (ESA product), using monthly-mean latitude/potential temperature cross-sections, and then we adopt a pole-centred view (*Lahoz et al., 1996*), and examine along-track cross-sections on 10 selected orbits (viewing tracks as above).

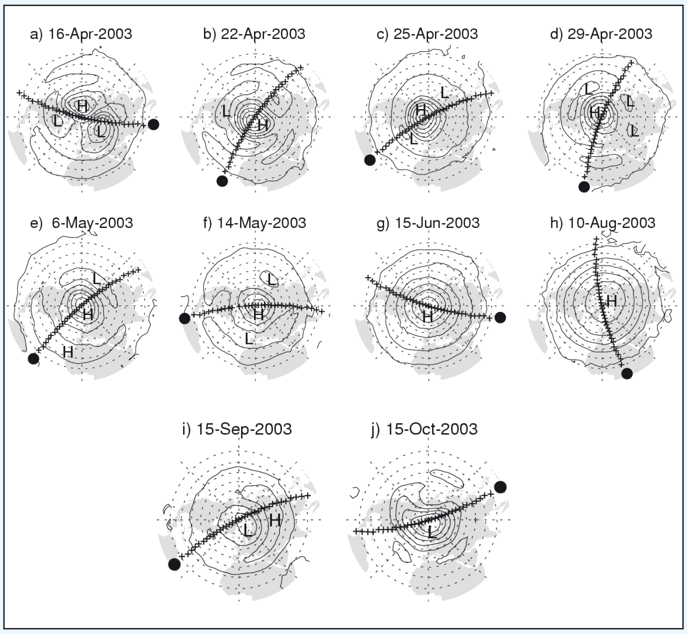
Features:

- W-shape pattern (i.e. raised CH4 levels at the pole), fading by August
- Elevated polar CH_4 can clearly be traced in along-track data until mid-June
- Polar vortex filamentation, lasting for 2-3 weeks

Spring-to-summer transition at high latitudes

The evolution of the NH circulation in the spring-to-summer transition in 2003 is followed using synoptic maps of 10-mb geopotential height (Met Office analyses). It reveals:

- Vortex weakening by mid April
- all signature of cyclonic circulations disappears by mid June
- the anticyclone grows, displaces the vortex off the Pole, and eventually becomes the summertime high and the dominant feature from early June to August



Reference

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