

Preliminary results from SPIRALE balloon-borne *in situ* stratospheric measurements during 2009 polar summer



Valéry Catoire, Nathalie Huret, Gwenaël Berthet, Gisèle Krysztofiak, Rémi Thiéblemont, Claude Robert
 LPC2E-OSUC, UMR 6115 CNRS-Université d'Orléans,
 3A Avenue de la Recherche Scientifique, 45071 Orléans Cedex 2, France



The SPIRALE (French acronym for infrared absorption spectroscopy by tunable laser diodes) balloon-borne instrument has been launched twice within 17 days in the polar region (Kiruna, Sweden, 67.9°N – 21.1°E) during summer, at the beginning and at the end of august 2009. *In situ* measurements of the trace gases O₃, CH₄, CO, OCS, N₂O, HNO₃, NO₂ and HCl have been performed between 10 and 34 km height, with very high vertical resolution (~5 m). The stratospheric profiles of these species present specific structures associated with tropical intrusion in the low levels. Both flight results are compared with each other in order to evaluate the impact of the turn-around occurring during this season on the chemical composition of the stratosphere.

The SPIRALE instrument: Infrared absorption spectroscopy of tunable laser diodes

- ✓ *In situ* measurements of several tracers and chemically active species.
- ✓ Laser absorption takes place in an open air Herriott cell with 6 diodes as light sources in the domain 1250 - 3000 cm⁻¹.
- ✓ Very long absorption path (434 m here) between 2 mirrors due to a deployable mast 3.5 m.



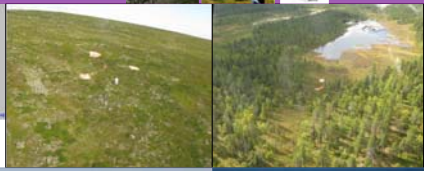
- ✓ Fast measurements (every 1.1 s) permit a vertical resolution of 5 m.
- ✓ Detection limits of few 10 pptv with uncertainties of 3% - 30% depending on the abundance of the species.

SPIRALE 1st flight: 07 Aug 2009: DAYTIME

Measurements from 01:45 to 06:00 UT (3h45-8h local)



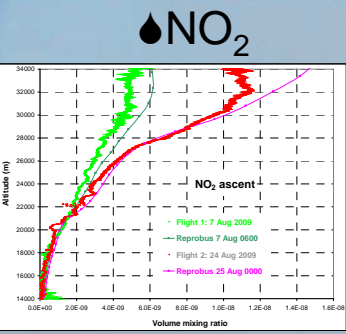
Trajectory and Profile



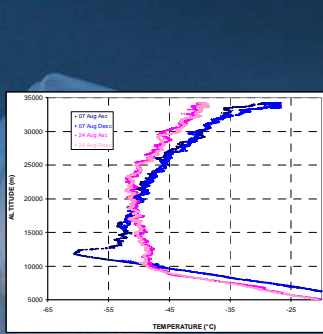
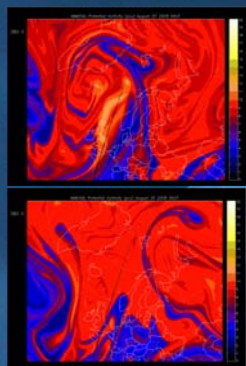
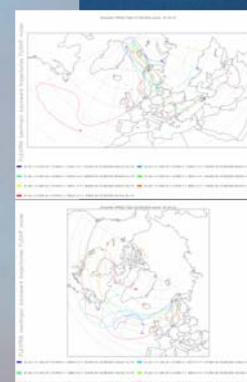
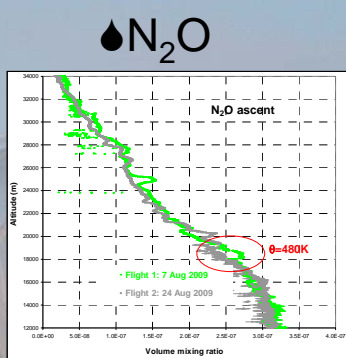
Trajectory and Profile

SPIRALE 2nd flight: 24 Aug 2009: NIGHTTIME

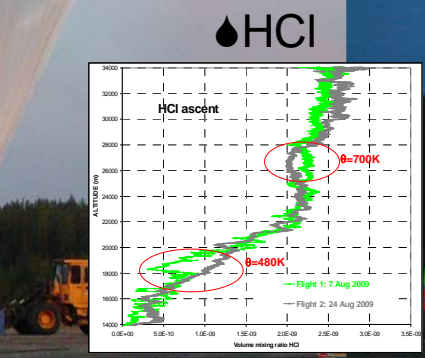
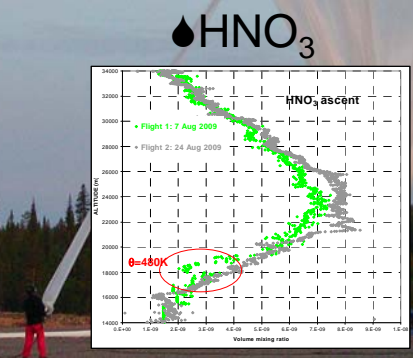
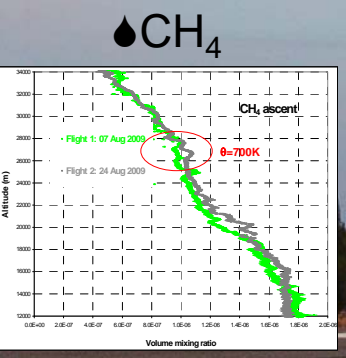
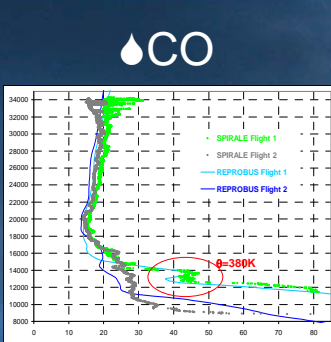
Measurements from 20:49 to 01:38 UT (22h29 – 3h38 local)



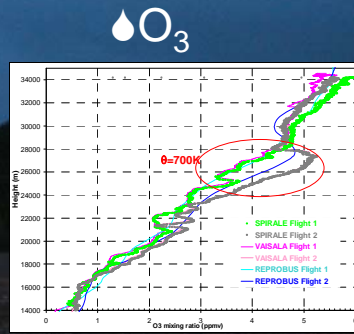
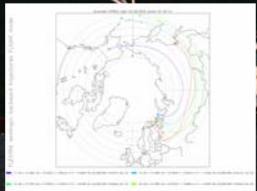
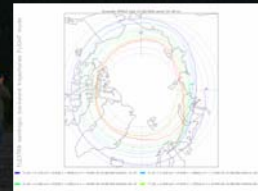
- Diurnal effect on NO₂ correctly reproduced by Reprobus 3D-CTM (Lefèvre et al., 1994)
- As expected, diminution of the concentration in the stratosphere: N₂O principal natural source of NO_x in the stratosphere → Anti-correlation between N₂O and NO₂.
- At 18-20 km (θ=480K), higher N₂O mixing ratio for Flight 1 than for Flight 2, anti-correlated to HNO₃ and HCl lower mixing ratios, corresponding to northern latitudes backward trajectories (Flextra model: Stohl et al., 1995).



- At 12-14 km (θ=380K), great difference in CO and O₃ mixing ratios between Flight 1 and Flight 2
- tropical intrusion shown on PV maps below (Mimosa model: Hauchecorne et al., 2002)



- O₃ confirmed by Vaisala probe.
- Notable increase of O₃ at 26-28 km (θ=700K) for Flight 2 / Flight 1, correlated to CH₄ and anti-correlated to HCl, corresponding to more southern backward trajectories (Flextra model: Stohl et al., 1995).



SPIRALE BALLOON DATA: a tool for dynamics studies, a reference for satellite data, a basis for global and small scales modelling processus studies → better understanding of the summer polar stratosphere

REFERENCES:
 Hauchecorne et al., Quantification of the Transport of Chemical Constituents from the Polar Vortex to Middle Latitudes in the Lower Stratosphere using the High-Resolution Advection Model MIMOSA and Effective Diffusivity, J. Geophys. Res., 107, 8289–8302, 2002.
 Lefèvre et al., Chemistry of the 1991-1992 stratospheric winter: Three-dimensional model simulations, J. Geophys. Res., 99, 9183-9195, 1994.
 Stohl et al., Interpolation errors in wind fields as a function of spatial and temporal and their impact on different types of kinetic trajectories, J. Appl. Meteor., 34, 2149-2165, 1995.

ACKNOWLEDGEMENTS: The authors thank the LPC2E technical team: L. POMATHIOD, B. GAUBICHER, B. COUTÉ, T. VINCENT, F. SAVOIE, M.-A. DROUIN for successful operations, and A. Hauchecorne and F. Lefèvre for making available the Mimosa and Reprobus models. The authors also thank the CNES balloon launching team for successful operations and the Swedish Space Corporation at Esrange. The ETHER database (Pôle thématique du CNES-INSU-CNRS) and the "CNES sous-direction Ballon" are partners of the project. The Strapolété project was funded by the French "Agence Nationale de la Recherche (ANR-BLAN08-1_31627)", the "Centre National d'Etudes Spatiales (CNES)", and the "Institut Polaire Paul-Emile Victor" (IPEV).

