

Improving polar stratospheric composition for CAMS with a prognostic NAT PSC tracer

Simon Chabrilat¹, Samuel Remy², Swen Metzger³, Quentin Errera¹, Daniele Minganti¹, Catherine Wespes¹, Vincent Huijnen⁴ and Johannes Flemming⁵

¹ Royal Belgian Institute for Space Aeronomy, BIRA-IASB, 1180 Brussels, Belgium

²HYGEOS, Lille, France

³ ResearchConcepts Io GmbH, Freiburg, Germany

⁴ KNMI, De Bilt, the Netherlands

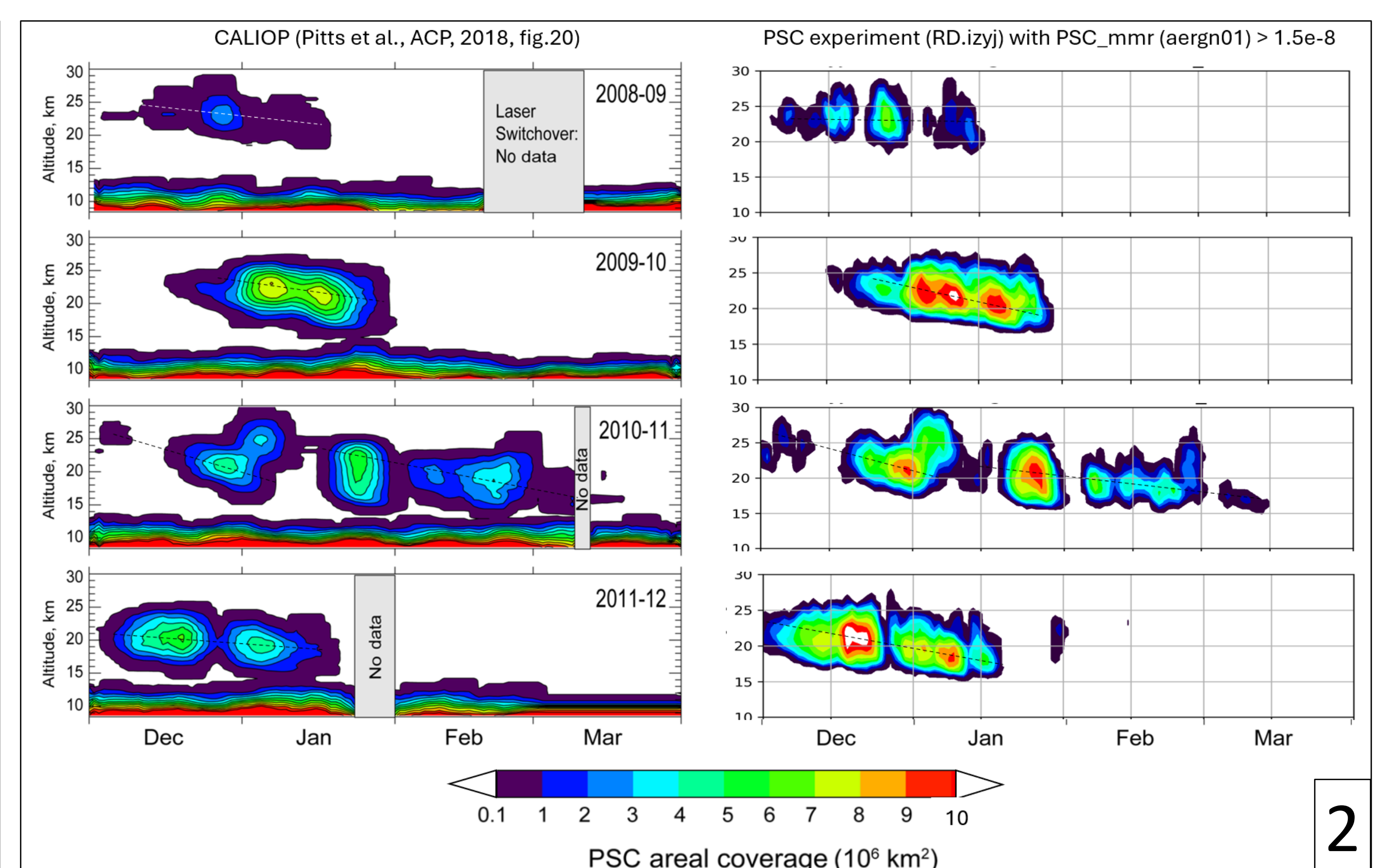
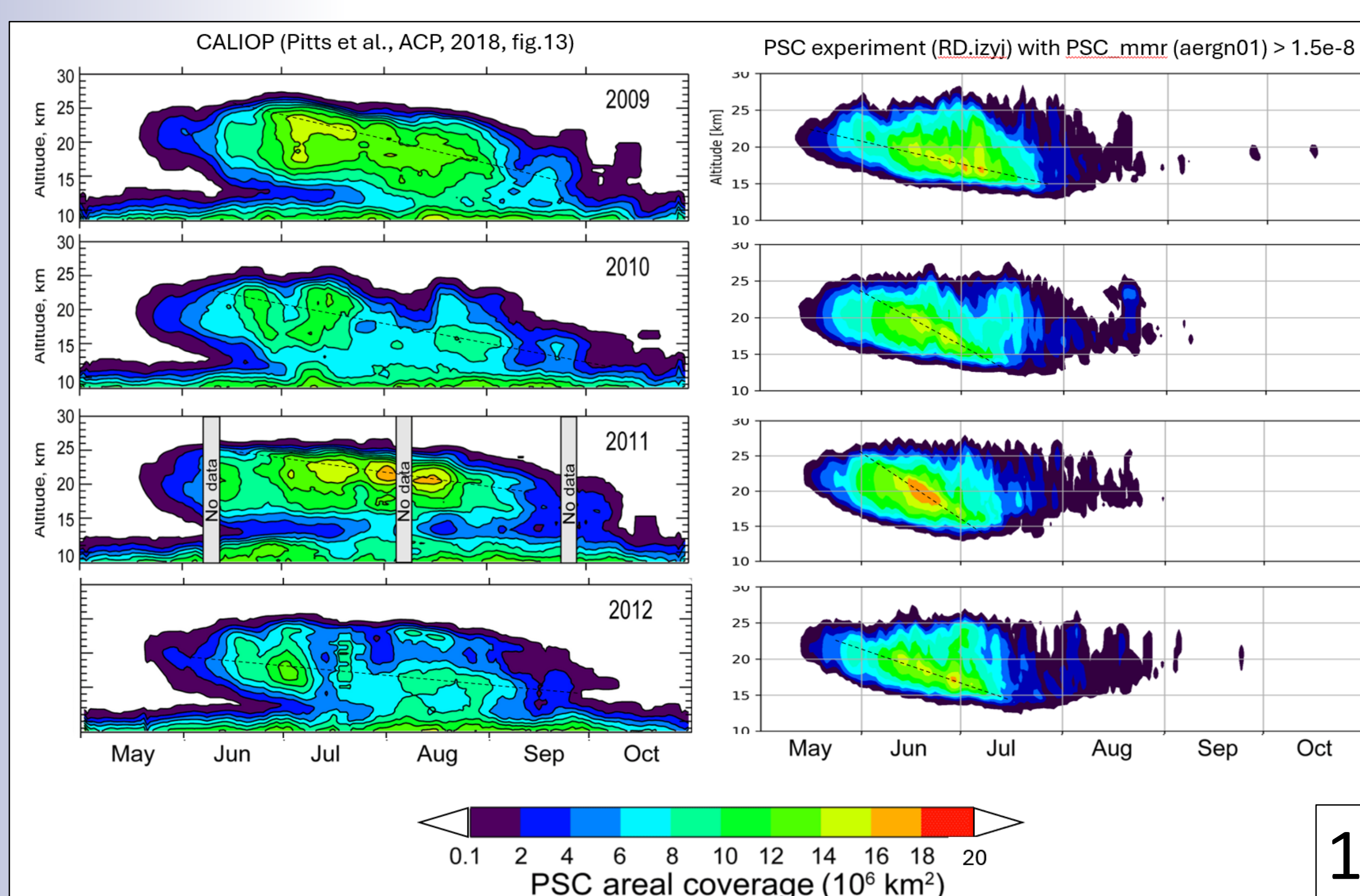
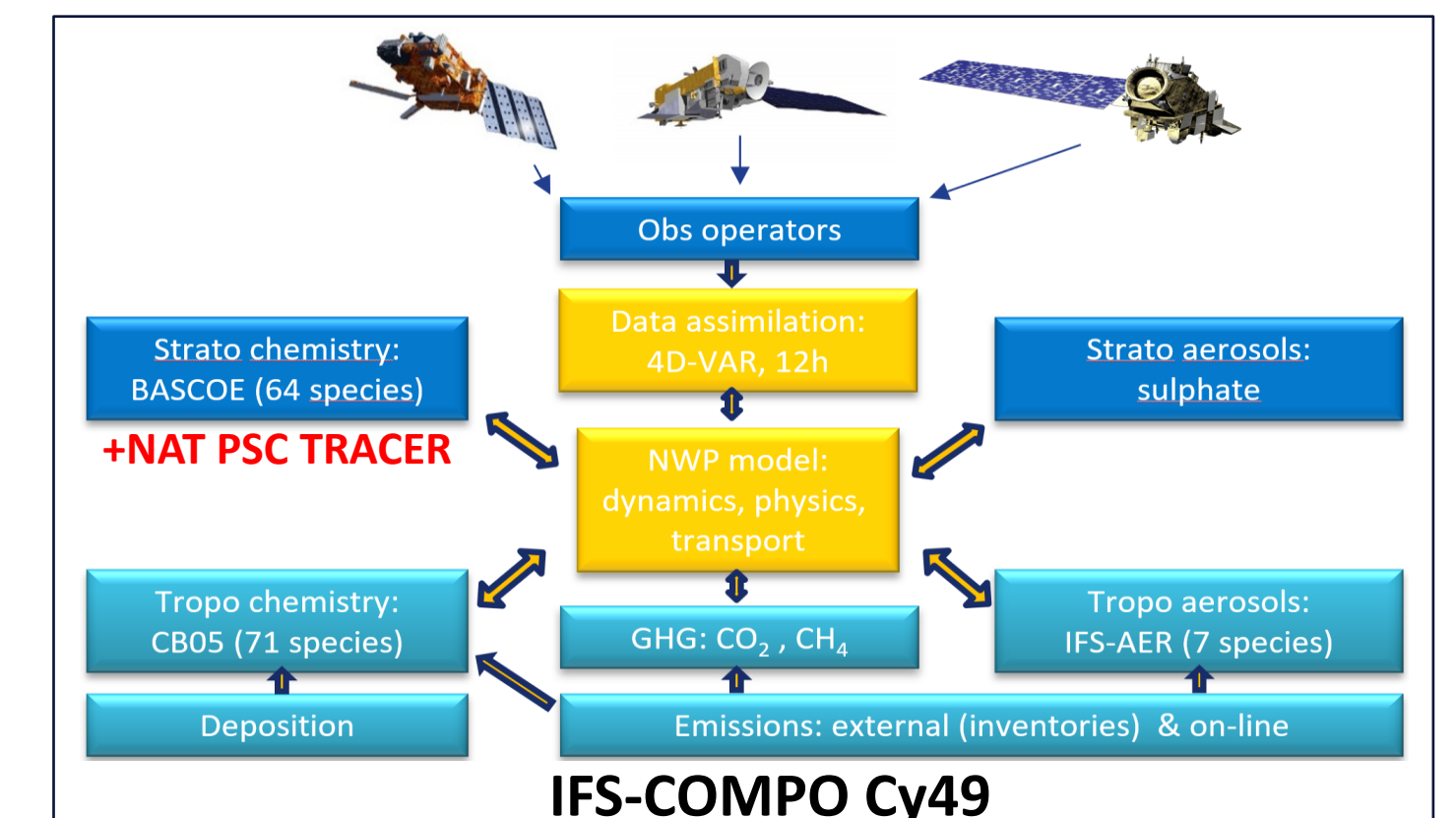
⁵ ECMWF, Shinfield Park, Reading, UK

Contact: simon.chabrilat@aeronomie.be

Polar stratospheric clouds (PSCs) play a central role in chemical ozone depletion by enabling heterogeneous chlorine activation and by modulating the stratospheric reactive nitrogen budget through denoxification and denitrification. Current operational chemistry models often rely on diagnostic or simplified PSC treatments that limit the realism of denitrification timing, vertical redistribution of nitric acid (HNO_3), and associated chemical feedbacks.

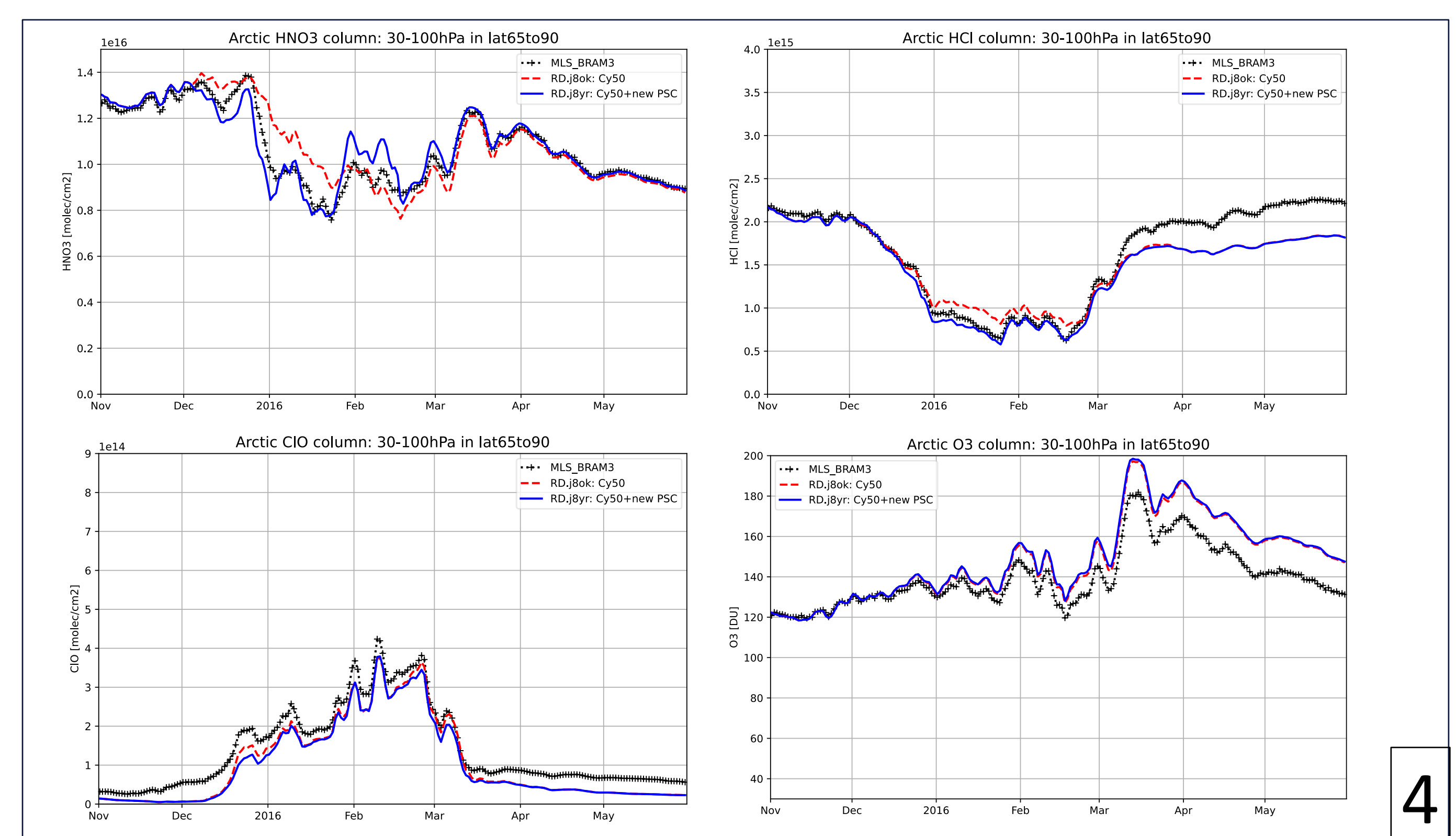
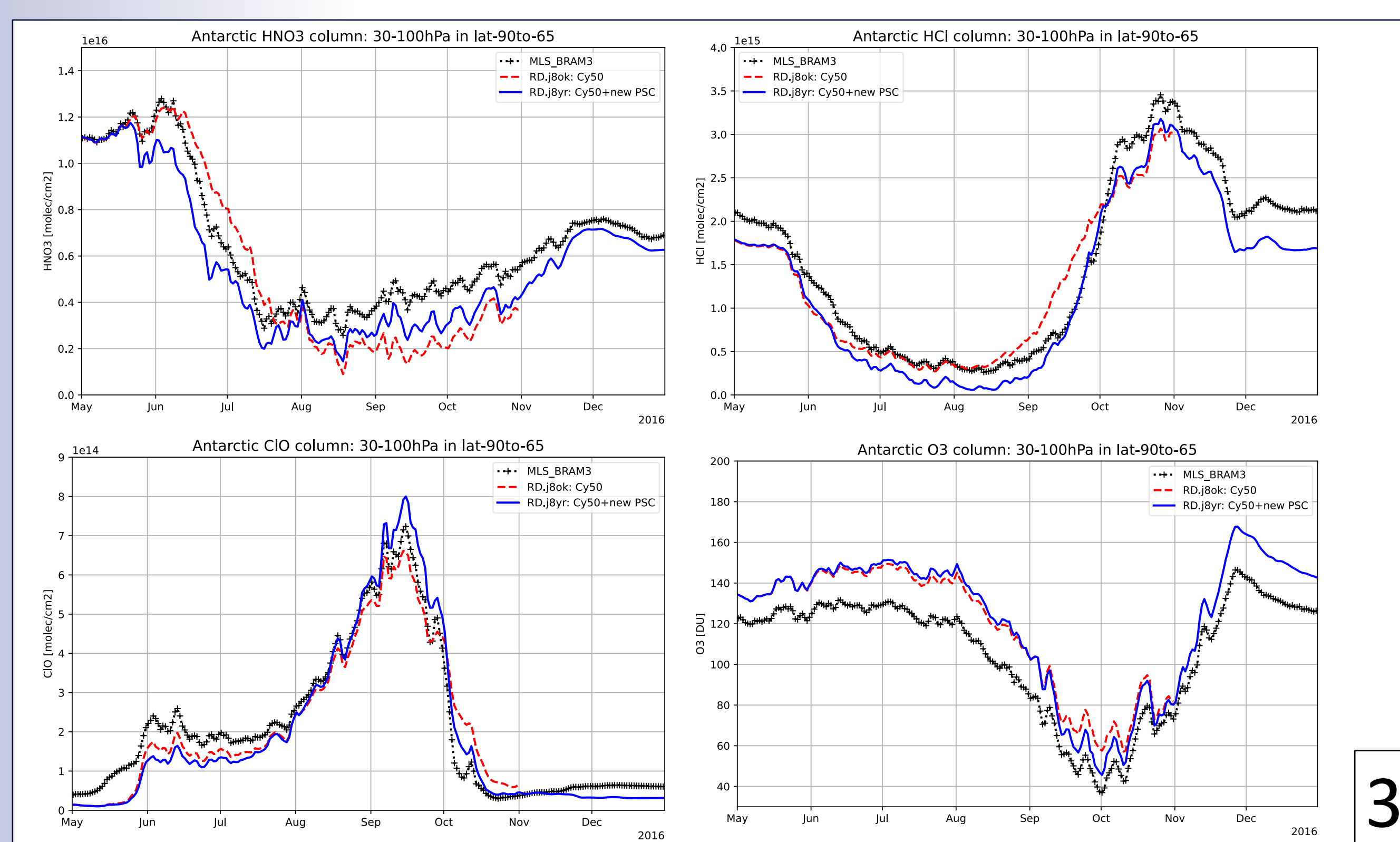
The ECMWF Integrated Forecasting System with Composition (IFS-COMPO) delivers analyses and forecasts of atmospheric composition for the Copernicus Atmosphere Monitoring Service (CAMS). This includes stratospheric composition through the chemistry module BASCOE and a simple one single tracer for sulfate aerosols (Chabrilat et al., 2025).

We have added a prognostic PSC tracer to explicitly represent Nitric Acid Trihydrate (NAT) formation, sedimentation, and evaporation. This enables a conservative treatment of denitrification through explicit removal of HNO_3 by sedimenting PSCs.



PSC areal coverage as a function of altitude over the Antarctic (frame 1: 90°S-50°S) and over the Arctic (frame 2: 50°N-90°N). Left columns: CALIOP observations (Pitts et al., 2018); right columns: IFS-COMPO simulations using the new NAT PSC tracer.

After tuning parameters for supersaturation, particle size, and evaporation rate, we run multiyear composition forecasts using the ERA-5 reanalysis for winds and temperature. Modelled PSC occurrence, seasonal coverage, and vertical descent are evaluated against CALIOP lidar observations for both hemispheres. The prognostic PSC tracer captures the observed spatial extent and interannual variability of PSCs (frame 1), even over the Arctic where the interannual variability is large (frame 2). The simulated rate of sedimentation is faster than in the observations, indicating the need to further tune the particle size.



Seasonal evolution of the partial columns of HNO_3 , HCl , ClO and ozone in the lower stratosphere (30-100 hPa), averaged over the Antarctic (frame 3: 90°S-65°S) and over the Arctic (frame 4: 65°N-90°N).

Black: reanalysis of MLS observations (BRAM3 – Errera et al., 2019);

blue: reference simulation with irreversible loss of HNO_3 whenever NAT PSC can condense; red: simulation using the new PSC NAT tracer.

The prognostic PSC formulation substantially improves the simulation of wintertime denitrification and the temporal evolution of HNO_3 , chlorine reservoirs, and chlorine activation in the lower stratosphere above the Antarctic (frame 3) and the Arctic (frame 4).

This work establishes a robust framework for future coupling between PSC microphysics, aerosol thermodynamics, and stratospheric chemistry, and represents a key step toward a physically consistent treatment of gas-particle partitioning and denitrification in global composition forecasting systems.

References

- brillat et al. (2025): <https://doi.org/10.5194/gmd-18-8973-2025>
Errera et al. (2019): <https://doi.org/10.5194/acp-19-13647-2019>
Pitts et al. (2018): <https://doi.org/10.5194/acp-18-10881-2018>