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Global variations in the vertical distribution of water during Mars Year 34 from multiple spacecraft observations

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Observations of the vertical distribution of water vapour provide a unique snapshot of the vertical transport processes that contribute to the global martian hydrological cycle. While previous datasets have largely been seasonally and spatially sparse, vertical profiles of water retrieved from the Nadir and Occultation for MArs Discovery (NOMAD) and Atmospheric Chemistry Suite (ACS) instruments on the ExoMars Trace Gas Orbiter (TGO) provide the most complete dataset so far. These data are now capable of providing robust constraints on the 4-D distribution of water, especially when also combined with retrievals of additional atmospheric properties (e.g. temperature profiles, dust column) that exert an influence on the evolving global water distribution.

A key limitation though is the fact that observations of water profiles are still relatively limited in coverage, in the global sense, and the vertical distribution of water at latitudes and times not regularly probed by NOMAD and ACS remains poorly understood.

To address this, we have created a global reference climatology of water vertical distribution for Mars Year (MY) 34 through a multi-spacecraft data assimilation combining several retrieval datasets with a Mars Global Circulation Model. Retrievals of dust column and temperature profiles from Mars Climate Sounder on the Mars Reconnaissance Orbiter and water vapour and temperature profiles from multiple instruments on the ExoMars TGO during the primary science phase covering the latter half of MY34 are combined through assimilation to create one unified physically consistent global dataset.

The vertical water vapour distribution is investigated globally. During the initial coverage of TGO observation that covers the dusty season in MY34, northern polar latitudes are largely absent of water vapour below 20 km with variations in abundance above this altitude throughout the dusty season linked to transport from mid-latitudes during a global dust storm, perihelion season and the intense MY34 C storm. The atmosphere is in a supersaturated state above 60 km for most of the time period investigated, with lower altitudes showing more diurnal variation in the saturation state of the atmosphere. A key benefit of the data assimilation technique is that constraints on dynamical transport imposed by the assimilated water vapour and temperature profiles leads to improvements in the simulated water ice distribution even though it is not altered directly by the assimilation process.

The climatology created, which will become publicly available for wider use by the martian scientific community, has also been independently validated against water vapour profiles from the SPICAM instrument.