

Recent Increase of Aerosol Fluorescence Contamination on the NDACC Long-Term Water Vapor Lidar Records and Proposed Correction Method

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Because of its radiative, thermodynamic and chemical properties, water vapor has long been known to be a key constituent of the atmosphere. To fully quantify, understand, and predict future water vapor-related impacts on atmospheric composition and climate, the Network for the Detection of Atmospheric Composition Change (NDACC) included in 2009 water vapor Raman lidar in its suite of long-term monitoring techniques. Since then, several high-capability water vapor Raman lidars have operated on a routine basis to provide long-term records of water vapor mixing ratio profiles up to the upper troposphere and lower stratosphere (UTLS).

In recent years, increased wildfire activity has been observed, causing widespread injection of smoke in the lower stratosphere by pyrocumulus (PyroCb) events. This increase in biogenic aerosol loading in the UTLS has impacted the measurement of water vapor by UV Raman lidar in the form of added fluorescence signal in the water vapor channel (407 nm). This impact was investigated and quantified using the long-term records of three high-performance Raman lidars contributing to NDACC, namely the TMWAL water vapor Raman lidar at the JPL- Table Mountain Facility (34  N), the RALMO lidar at the Meteoswiss station of Payerne, Switzerland (48  N), and the Li1200 lidar at the Ma  do Observatory of Reunion Island (20  S).

Comparisons with co-located radiosondes and aerosol backscatter profiles indicate that aerosol fluorescence in the UTLS can introduce very large and chronic wet biases of up to 75% above 15 km, thus impacting the ability of these systems to accurately estimate long-term water vapor trends in the UTLS.

A correction method based on the addition of an aerosol fluorescence channel at 410 nm was developed to mitigate the contamination, then tested on 22 TMWAL measurement nights in 2021. The proposed correction is able to effectively reduce the fluorescence-induced wet bias with an average difference with co-located radiosonde reduced to 5%, consistent with the difference observed during periods of negligible aerosol fluorescence interference. These results provide confidence that water vapor long-term trends can be reasonably well estimated in the upper troposphere, but they also call for further refinements, or the use of Raman lidar at 532 nm to confidently detect long-term trends in the lower stratosphere. These findings will have important implications on NDACC's water vapor measurements strategy in the years to come.