QOS2016-326-1, 2016
Quadrennial Ozone Symposium of the International Ozone Commission

The effect of natural variability on atmospheric ozone measurements and their intercomparison

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Several initiatives are ongoing to improve the traceability of atmospheric composition measurements to agreed standards, to quantify and reduce the measurement uncertainties, and to quantify and improve the mutual consistency of atmospheric data across ground-based networks and between satellite missions (e.g., WMO O_3S-DQA, SI2N, ESA CCI and FRM projects, EU FP7 QA4ECV and EU H2020 GAIA-CLIM). With increasing data accuracy, natural variability has become a non-negligible source of error for single measurements, for their comparison, for their merging and for their assimilation in chemistry-transport models. Therefore a corresponding effort has been undertaken to quantify the specific uncertainties resulting from spatial inhomogeneities and temporal variability in the atmospheric field. Quantifying such uncertainties is for instance a key objective of the current EU H2020 project GAIA-CLIM.

In this contribution, we present a detailed quantification of the impact of natural inhomogeneities and variability on several corner-stone ozone observing systems and on the intercomparison of their data (both for validation and for merging purposes). This study is based on OSSEs (Observing System Simulation Experiments) of existing ozone observing systems carried out with the OSSSMOSE simulator, which includes explicit description of multi-dimensional effects impacting the remote sensing of atmospheric ozone (Verhoelst et al., AMT, 2015). Simulations are presented for total ozone column and ozone profile measurements acquired by GAW-contributing reference networks (Brewer, Dobson, NDACC DOAS, GAW/NDACC/SHADOZ ozonesondes) and by nadir-viewing UV-visible satellites (GOME, SCIAMACHY, GOME-2, Sentinel-5p TROPOMI). Illustrations show how natural inhomogeneities and variability introduces additional uncertainties: on the representativeness of single measurements, on comparisons between different (imperfectly) co-located measurements, and on higher-level products based on an averaging of unevenly distributed data.

As a generalization of these case-by-case results, we describe on the global scale how those additional uncertainties depend on measurement type, latitude, season, atmospheric phenomena etc., as this determines the fitness-for-purpose of the current ozone observing systems and provides valuable feedback for the design/optimization of ground networks and satellite missions.