Geophysical Research Abstracts
Vol. 19, EGU2017-7952, 2017
EGU General Assembly 2017
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Potential of multispectral synergism for observing tropospheric ozone by combining IR and UV measurements from incoming LEO (EPS-SG) and GEO (MTG) satellite sensors

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Satellite observations offer a great potential for monitoring air quality on daily and global basis. However, measurements from currently in orbit sensors do not allow to probe surface concentrations of gaseous pollutants such as tropospheric ozone (Liu et al., 2010). Using single-band approaches based on spaceborne measurements of either thermal infrared radiance (TIR, Eremenko et al., 2008) or ultraviolet reflectance (UV, Liu et al., 2010) only ozone down to the lower troposphere (3 km) may be observed. A recent multispectral method (referred to as IASI+GOME-2) combining the information of IASI and GOME-2 (both onboard MetOp satellites) spectra, respectively from the TIR and UV, has shown enhanced sensitivity for probing ozone at the lowermost troposphere (LMT, below 3 km of altitude) with maximum sensitivity down to 2.20 km a.s.l. over land, while sensitivity for IASI or GOME-2 only peaks at 3 to 4 km at lowest (Cuesta et al., 2013). Future spatial missions will be launched in the upcoming years on both low and geostationary orbits, such as EPS-SG (EUMETSAT Polar System Second Generation) and MTG (Meteosat Third Generation), carrying respectively IASI-NG (for IR) and UVNS (for UV), and IRS (for IR) and UVN (Sentinel 4, for UV). This new-generation sensors will enhance the capacity to observe ozone pollution and particularly by synergism of multispectral measurements.

In this work we develop a pseudo-observation simulator and evaluate the potential of future EPS-SG and MTG satellite observations, through IASI-NG+UVNS and IRS+UVN multispectral methods to observe near-surface O_3. The pseudo-real state of atmosphere (nature run) is provided by MOCAGE (MOdèle de Chimie Atmosphérique à Grande Échelle) chemical transport model. Simulations are calibrated by careful comparisons with real data, to ensure the best coherence between pseudo-reality and reality, as well as between the pseudo-observation simulator and existing satellite products. We perform full and accurate forward and inverse radiative transfer calculations for a period of 4 days (8-11 July 2010) over Europe.

For what concerns EPS-SG mission results, there is a remarkable agreement in the geographical distribution of LMT ozone partial columns, between IASI-NG+UVNS and the corresponding MOCAGE output. With respect to synthetic IASI+GOME-2 products, IASI-NG+UVNS shows a higher correlation between pseudo-observations and pseudo-reality, enhanced by about 11%. The bias on high ozone retrieval is reduced and the average accuracy increases by 22%. The sensitivity to LMT ozone is enhanced in average with 154% (from 0.29 to 0.75, over land) and 208% (from 0.21 to 0.66, over ocean) higher degrees of freedom. The mean height of maximum sensitivity for the LMT peaks at 1.43 km over land and 2.02 km over ocean, respectively 1.03 km and 1.30 km below that of IASI+GOME-2. IASI-NG+UVNS shows also good retrieval skill in the surface-2km altitude band with a mean DOF (degree of freedom) of 0.52 (land) and 0.42 (ocean), and an average altitude of maximum sensitivity of 1.29 km (land) and 1.96 km (ocean).

For what concerns the MTG mission, the strongest gain of IRS+UVN with respect to existing spaceborne sensors will consist in a hourly observation of LMT ozone over Europe, providing O_3 products with unprecedented temporal and vertical resolution.