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Estimation of transboundary SO_2 fluxes in Siberia and Russian Far East using EANET and OMI observations

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Air pollution caused by emissions from industrial and other anthropogenic sources is a long-standing issue for the East Asian region, and will likely remain so in the near future. Being moderately to long-lived, some pollutants survive long-range atmospheric transport and thus are capable of affecting air quality in regions remote to the emission sources. One of problems one may address to quantify this important potential is studying transboundary fluxes of species of interest. Recently the approaches to such problems became more deterministic due to increasingly available data products providing large spatiotemporal coverage, *e.g.* 3D models and satellite observations.

In this study, we quantify the transboundary fluxes of sulphur dioxide (SO_2) over the Asian segment of Russian border (shared with Mongolia and China) in 2015. Using the meteorological fields from the ERA INTERIM (EI) re-analysis [1], we calculate the amounts of air transported every 6h in different vertical domains across the border. We reckon that about $5.5 \cdot 10^{18}$ moles of air was transported (net) outwards Russia in the EI-simulated dynamic planetary boundary layer (PBL). We further use the SO_2 retrievals products available from the Ozone Monitoring Instrument (OMI, [2]) and the EI data to reconstruct the concomitant mixing ratios of SO_2 in the PBL. The convolution of these terms allows to quantify the net transport of SO_2 within the PBL, which amounts to not less than (180-190)$\cdot 10^3$ tons transported inwards Russia in 2015. We find that this result is robust (within $\pm 5 \cdot 10^3$ tons) when less certain data (*e.g.* at radiative cloud fraction > 0.2) from OMI PBL SO_2 product are included. Similar robustness is seen when the SO_2 transport is calculated for the periods when only concomitant satellite data is available (around noon, corresponds to about 17% of total net air transport) and when nearest in time SO_2 columns are used for the remaining periods (*e.g.*, night time, about 91% of total net air transport, respectively). This implies that the available satellite data covers well the periods of non-equilibrium air transport with elevated SO_2 burdens, which to a certain extent is intrinsic to the PBL diurnal dynamics. The largest SO_2 PBL import flux into Russia of about $80 \cdot 10^3$ tons/month is diagnosed in April and is nearly equally shared between the border segments with Chinese North and Russian Far East. The general circulation pattern renders import of SO_2 into Russia prevailing throughout April-June and September-October, whilst smaller export fluxes of up to $20 \cdot 10^3$ tons/month are reckoned for February and November, respectively. Owing to the more scarcely available OMI data (corresponding to $<5\%$ of total net air transport), SO_2 transport in January and December is poorly quantifiable.

At last, we verify the reconstructed PBL mixing ratios from OMI and EI data against the SO_2 observations available at selected background monitoring stations of the Acid Deposition Monitoring Network in East Asia (EANET, http://www.eanet.asia/). Taking into account the substantial uncertainties (noise levels) inherited from the OMI-derived data, we ascertain that realistic distributions (*viz.* medians and interquartile ranges) were used for the calculations in this study. Overall, we conclude that similar analysis may be employed for other species of interest (*e.g.* ozone or ammonia), and the first attempt was already done [3]. Conjoint use of the EI, OMI and EANET data allows analysing transboundary fluxes of SO_2 for the period extending beyond past decade.

0.1 References

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