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Impact of transport and modelling errors on the estimation of methane sources and sinks by inverse modelling

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Since the nineties, inverse modelling by assimilating atmospheric measurements into a chemical transport model (CTM) has been used to derive sources and sinks of atmospheric trace gases. More recently, the high global warming potential of methane (CH_4) and unexplained variations of its atmospheric mixing ratio caught the attention of several research groups. Indeed, the diversity and the variability of methane sources induce high uncertainty on the present and the future evolution of CH_4 budget.
With the increase of available measurement data to constrain inversions (satellite data, high frequency surface and tall tower observations, FTIR spectrometry,...), the main limiting factor is about to become the representation of atmospheric transport in CTMs. Indeed, errors in transport modelling directly converts into flux changes when assuming perfect transport in atmospheric inversions.
Hence, we propose an inter-model comparison in order to quantify the impact of transport and modelling errors on the CH_4 fluxes estimated into a variational inversion framework. Several inversion experiments are conducted using the same set-up (prior emissions, measurement and prior errors, OH field, initial conditions) of the variational system PYVAR, developed at LSCE (Laboratoire des Sciences du Climat et de l'Environnement, France). Nine different models (ACTM, IFS, IMPACT, IMPACT1x1, MOZART, PCTM, TM5, TM51x1 and TOMCAT) used in TRANSCOM-CH4 experiment (Patra el al, 2011) provide synthetic measurements data at up to 280 surface sites to constrain the inversions performed using the PYVAR system. Only the CTM (and the meteorological drivers which drive them) used to create the pseudo-observations vary among inversions. Consequently, the comparisons of the nine inverted methane fluxes obtained for 2005 give a good order of magnitude of the impact of transport and modelling errors on the estimated fluxes with current and future networks.
It is shown that transport and modelling errors lead to a discrepancy of 27 TgCH_4 per year at global scale, representing 5% of the total methane emissions for 2005. At continental scale, transport and modelling errors have bigger impacts in proportion to the area of the regions, ranging from 36 TgCH_4 in North America to 7 TgCH_4 in Boreal Eurasian, with a percentage range from 23% to 48%. Thus, contribution of transport and modelling errors to the mismatch between measurements and simulated methane concentrations is large considering the present questions on the methane budget.
Moreover, diagnostics of statistics errors included in our inversions have been computed. It shows that errors contained in measurement errors covariance matrix are under-estimated in current inversions, suggesting to include more properly transport and modelling errors in future inversions.