Model Simulations of Atmospheric Methane and Their Evaluation Using AGAGE/NOAA Surface and IAGOS-CARIBIC Airborne Observations, 1997-2014

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The global budget and trend of atmospheric methane (CH_4) have been simulated with the ECHAM/MESSy Atmospheric Chemistry (EMAC) model (T106 , 90 hybrid pressure levels, ~ 500 m vertical in the Upper Troposphere Lower Stratosphere (UTLS), 2 min time steps, troposphere nudged towards ECMWF data) for the period 1997 through 2014, distinguishing eleven CH_4 source categories. Simulated CH_4 has been compared to observations from selected AGAGE and NOAA surface stations and 327 intercontinental Civil Aircraft for Regular Investigation of the atmosphere Based on an Instrument Container (CARIBIC) flights. The surface data give long-term consistent time series, whereas the aircraft data cover different parts of the globe for different periods and effects specific for the UTLS have to be dealt with. Source segregated station simulation results have been rearranged to optimally fit in sum the station records, especially with respect to the inter-hemispheric CH_4-gradient (ΔNS). The resulting redistribution represents an emission scenario which is suitable to explain the considered observations.

Tagged simulations with the eleven initial source categories were carried out to analyze the composition of the observed global CH_4 burden and derive steady state CH_4 lifetimes from the different sources. In this model configuration, without any CH_4–H_2O feedback, the atmospheric CH_4 abundance is linearly dependent on the source strength and thus allows an a posteriori rescaling of individual emissions with proportional effects on the corresponding inventories. Aiming for an observation consistent ΔNS, Amazon wetland emissions had to be enhanced by 30.57Tg/y with compensating reduction of Northern Hemisphere fossil fuel related emissions. The correspondingly rescaled tagged results were superimposed without affecting the global mass balance. By including two additional (tagged) sources, one representing natural emissions (South America) and one shale gas production related emissions (North America), their potential role in growing CH_4 concentrations since 2007 has been investigated.

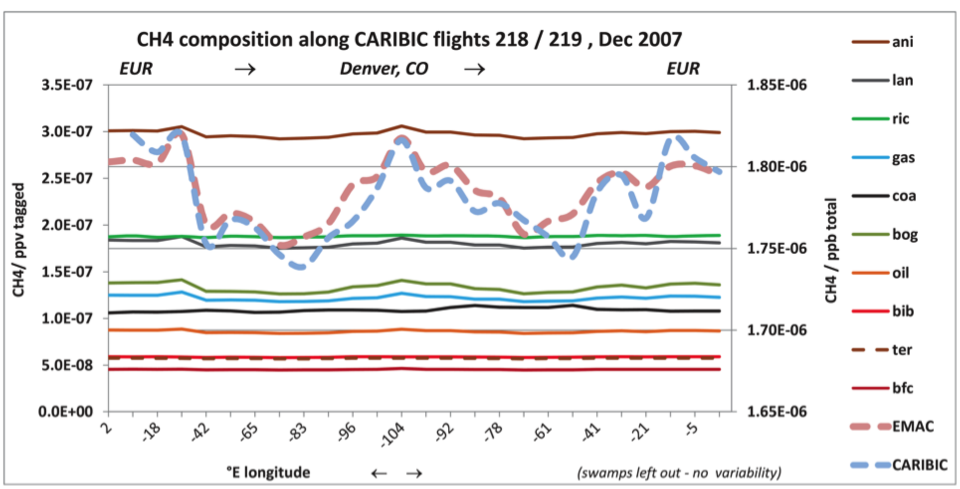

Figure 1. Example showing the different contributions (tagged, left) to the CH_4 burden (right) at cruise altitude of the CARIBIC observatory for 2 sequential flights, namely FRANKFURT-DENVER-FRANKFURT. The model values (red dashed) match the measurements (blue) which for a large part took place in the stratosphere (http://projects.knmi.nl/campaign_support/CARIBIC/171207/tsecPV07121712.gif). The discrepancy in symmetry is due to the time shift and slight differences in the actual flight corridor followed. Generally the model slightly dampens low values observed in tropopause folds due to limited resolution (about 500 m vertical).