The Effect of the Interannual Variability of the OH Sink on the Interannual Variability of the Atmospheric Methane Mixing Ratio and Carbon Stable Isotope Composition

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Introduction:

Although the hydroxyl radical (OH) accounts for the oxidation of approximately 90% of atmospheric methane (CH_4), the effect of interannual variability of its concentration distribution and strength on the interannual variability of atmospheric CH_4 mixing ratio and stable carbon isotope composition (δ13C-CH_4) has often been ignored.

Driver	Effect
Incoming UV-Radiation	OH Production
Atmospheric Composition	OH Production/ Lifetime/ Recycling
Temperature	Reaction Rate

Table 1: The atmospheric OH concentration varies due to changes in the incoming UV radiation, changes in the atmospheric composition and due to climate variability. Variability in carbon monoxide (CO) emissions from biomass burning induced by El Niño Southern Oscillation (ENSO) are particularly important.

Aim:

The objective was to simulate the effect of OH concentration fields calculated by two different atmospheric chemistry models: TM5 and ECHAM5/ MESSy (EMAC).

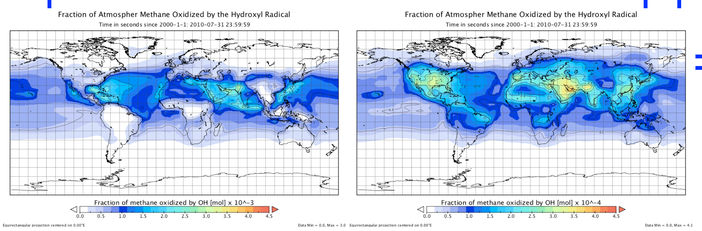

Figure 1: Mass fraction of atmospheric CH_4 oxidized by OH; *(right)* TM5 *(left)* EMAC. The mass fraction is obtained by multiplying the OH concentration [mol/cm^3] times the reaction rate.

Materials and Methods:

- The same set of CH_4 emissions and stratospheric reactants was used in all simulations.
- Two simulations were done per OH field
  - CH_4 sources vary interannually
  - CH_4 annually repeating sources

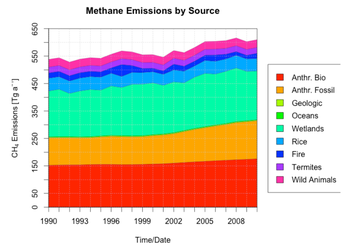

Table 2: CH_4 emissions were based on published bottom-up estimates including inventories, upscaled estimations and modeled fluxes. The isotopic signal of the sources and the fractionation factors of the sinks were based on literature values, however the isotopic signal of methane produced from the decomposition of plant material (e.g. wetlands and enteric fermentation) follow relationship with a map of C4 plant fraction based on Whitcar et al. (2008).

- Comparison with:
  - Mixing ratio and isotopic composition measurements at background stations
    - Robust indicators
      - Global/zonal means
      - Interhemispheric difference
  - Satellite Column mixing ratio measurements from SCIAMCHY and GOSAT
    - 2003 to 2005 SCIAMACHY
    - 2009 to 2010 GOSAT

Results:

- Mean CH_4 lifetime to OH was approximately 9.2 years for the TM5 OH and 8.2 years for EMAC OH fields.

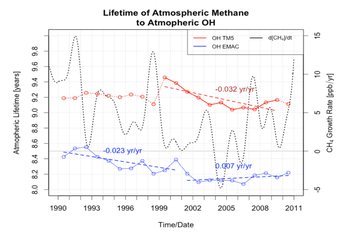

Figure 2: Methane lifetime to OH. (red) TM5 OH (blue) EMAC OH. Doted red line indicates a climatological OH field

Results (cont):

- Magnitude of CH_4 mixing ratio interannual variability caused by interannual variability in OH concentration: ±10 ppb

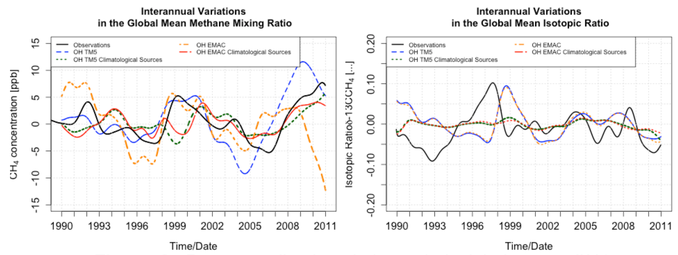

Figure 3: Deseasonalized and detrended global mean CH4 mixing ratio and δ13C isotopic composition

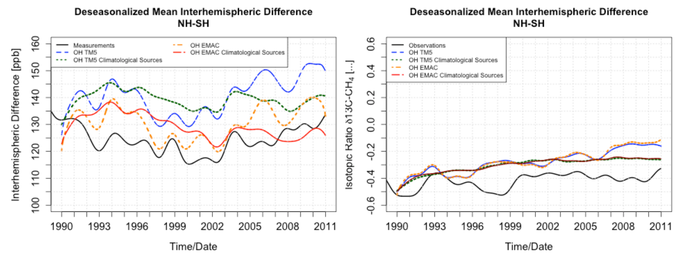

Figure 4: Deseasonalized interhemipheric difference of CH4 mixing ratio and δ13C isotopic composition. Based on zonal averages (30°N to 90°N) - (90°S to 30°S)

- The interannual variability of the mixing ratio interhemispheric difference is dominated by the sources because the OH sink is concentrated in the tropics, thus its interannual variability affects both hemispheres.

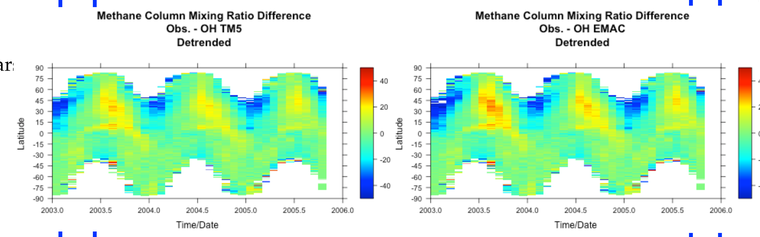

Figure 5: CH_4 column mixing ratio difference between simulations sampled at SCIAMACHY measurement points.

Results (cont.):

Conclusion:

- Effect of the internannual variability of the OH concentration is significant and comparable to the effect of all sources combined.
- We must considered the role of OH variability to improve our understanding of the recent trends in the global methane budget.

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Acknowledgments:

We thank the Prof. Dr. Jos Lelieveld and the Atmospheric Chemistry Department of the Max Planck Institute for Chemistry in Mainz for providing a set of OH fields, Anne Kubin and Prof. Langematz from the Institute of Meteorology at the Free University Berlin, Thomas Rockmann, Martin Krol and the Atmospheric Physisc and Chemistry Group at IMAU for their insight and discussions, Gordon Brailsford, Dr. Dave Lowe and Ross Martin for providing measurements from NIWA sites. We thank Miguel Mahecha and Jannis Buttlar for providing the R package for spectral decomposition based on siugular spectrum analysis. We thank Guiseppe Etiope for providing the geologic CH_4 source database.