Interannual Variability and Trends of CH₄, CO and OH using the Computationally-Efficient CH₄-CO-OH (ECCOH) Module

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Introduction

Methane (CH₄) is the second most important anthropogenic greenhouse gas (GHG). Its 100-year global warming potential (GWP) is 25 times larger than that for carbon dioxide. The 100-year integrated GWP of CH₄ is sensitive to changes in hydroxyl (OH) levels. Oxidation of CH₄ and carbon monoxide (CO) by OH is the main loss process, thus affecting the oxidizing capacity of the atmosphere and contributing to the global ozone background.

Limitations of using archived, monthly OH fields for studies of methane’s and CO’s evolution are that the feedbacks of the CH₄-CO-OH system on methane, CO and OH are not captured.

In this study, we employ the computationally efficient CH₄-CO-OH (ECCOH) module (Elshorbany et al., 2015) to investigate the nonlinear feedbacks of the CH₄-CO-OH system on the interannual variability and trends of the CH₄-CO-OH system.

Modelling Approach

The ECCOH module (Elshorbany et al., 2015) is implemented within the NASA GEOS-Chem Climate Model (Rennie et al., 2008, Pawson et al., 2008, Ott et al., 2010, and Mofid et al. (2012)).

Model Scenarios:

- **Base**: Simulation period: 1988-2007
- **AllVary**: Simulated near-surface methane levels by different scenarios. Vertical line represents the simulated annual mean of CH₄.
- **ECCOH**: The simulated interannual variation of methane’s global growth rate agrees reasonably well with that estimated from GMD data.
- **AllVary**: The non-linear effects of the CH₄-CO-OH system on the temporal evolution of global mass-weighted methane are smaller, but significant, as compared to the effects of variations of methane emissions.

Results and Discussion

- **Large Scale Interannual Variations in Methane, CO, and OH**

The magnitudes of the year-to-year deviations (relative to the mean (1988-2006)):
- **CH₄**: Small differences between the two scenarios since the Base scenario includes the important source of variation associated with anthropogenic methane emissions and methane’s background is large. The nonlinear effects of the CH₄-CO-OH system on the temporal evolution of global mass-weighted methane are smaller, but significant, as compared to the effects of variations of methane emissions (see Fig. 2).
- **CO**: 10% greater in the AllVary scenario.
- **OH**: Decrease by 2.5% to 5% in the AllVary scenario.
- **Much larger variations on regional scales are masked in the global average**

- **Significant interannual variations in methane, CO, and OH**

**Spatial and Temporal Distributions of the Loss Rates of Methane and CO**

- **CO loss rate from the AllVary scenario is relatively higher over biomass burning regions but lower over Asia**

- **CO loss rate from the AllVary scenario shows much higher variability that reaches up to 20% compared to ~5% in the Base scenario.**

**Interannual variability in the AllVary scenario is relatively higher**

**References**