A NUMERICAL STUDY OF THE EFFECT OF SUMMER ATMOSPHERIC BLOCKING ON THE METHANE CONCENTRATION IN WESTERN SIBERIA

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Keywords

Methane, wildfires, atmospheric blocking

Abstarct

The results of numerical modeling and measurements of methane concentration for the period of summer atmospheric blocking for the territory of Western Siberia are presented in work.

Background

Methane is an important greenhouse gas, and its atmospheric concentration has nearly tripled since pre-industrial times. The growth rate of atmospheric methane is determined by the balance between surface emissions and photochemical destruction by the hydroxyl radical. The relationship between methane concentration and atmospheric circulation must be taken into account. However, this relationship is not well understood. This work is aimed to study the effect of the July 2007 blocking event on methane concentration in Western Siberia. Atmospheric blockings are the most important phenomena of the circulation of the mid-latitudes. In 2007, the atmospheric circulation was characterized by almost continuous blocking in Western Siberia from July 2 to July 18. A slight weakening of the blocking was observed on July 7-8. Between July 15 and 18, in the northern regions of Western Siberia, wildfires were recorded.

Aim

Estimation of the effect of atmospheric blocking on methane concentration in the period of July 2007 according to the JR-Station data using the WRF v3.8.1

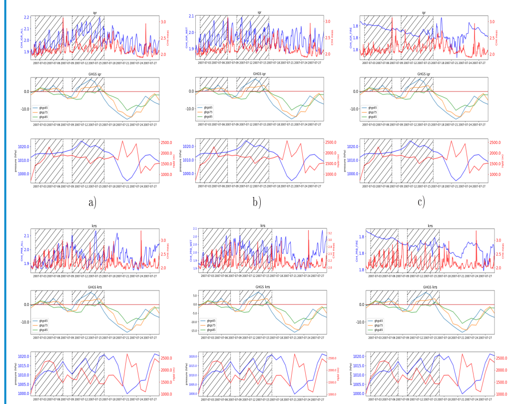
Data and model description

Two stations of the JR-Station project was used - Igrim and Karasevoe (data are available at: http://db.cger.nies.go.jp). To study the effect of different emission on methane concentration in Western Siberia under atmospheric blocking conditions, numerical modelling was performed using the WRF-Chem v.3.8.1 model.

Table 1. Parameters used in the model WRF-Chem.

Domain	45-67° N and 55°22'-105° E up to level 50 gPa, cells 100x105x21,Lambert projection, dx = 27 km, dy = 27 km
Period calculate	01.07.2007 to 29.07.2007
Meteorology data	FNL (NCEP) [Grace Peng, 2014]
Chemical mechanism	RACM, [Stockwell W., 1997, Ahmadov R. 2012]
Initial and boundary conditions	Mozart4 [UCAR]
Emission:	
Anthropogenic	HTAP-2 [Janssens-Maenhout G.,2015], EDGAR V.4.3.2 [Crippa M.,2018]
Biogenic	MEGAN2.1 [Guenther A.,2006]
Fire	FINN v1.5 [Wiedinmyer C. 2011]
Wetland	MACC v1an [Bergamaschi P.,2013]
Microphysics	Morrison double-moment [Morrison H., 2009]
Longwave rad.	RRTM [Mlawer E.J. 1997]
Shortwave rad.	Dudhia [Dudhia J. 1989]
Surface layer	Rev. MM5 [Jiménez P.A. 2012]
Soil model	Noah [Tewari, M., 2004]
ABL	Yonsei Univ. [Hong S.-Y.,2006]
Cloud Parameterization	Grell 3D [Grell 1993, 2002]

The comparison of measure data and simulation results



a) b) c)

d) Total emission; e) Wetland emission; f) Wildfire emission

Figure 1. The methane concentration (ppm) for Igrim (igr) (a,b,c) and Karasevoe (krs) (d,e,f). In each figure: (upper panel), model concentration (blue), measured (red). Middle panel: blocking criterion for latitudes 65, 75 and 85 N. Lower panel: pressure (blue) and day height of the boundary layer (red). Hatching shows blocking periods. Emissions used: total - a,d; wetland - b,e; biomass burning - c,f.

Concentration growth rates

We can be drawn from the presented data wetland emissions make the main contribution to the dynamics of methane concentration. If they excluded, then the remaining emissions are not enough to keep in a constant concentration of methane for a month. However, the wetland emission was set by a constant; the model was showing an increase in concentration during blocking, which may indicate methane accumulation. In fig.1c shown graphs the concentration measured on Igrim station and obtained from the simulation using only methane emissions from biomass burning. The model concentration is generally lower than the observed concentrations. Until 16 July the modelling results didn't show concentration methane variation within a day. From July 16, the model data coincide with the measured data. In the nighttime, the concentrations increased for the measured and model data. Qualitatively, the simulation and measurement results are the same. The growth rate of concentration for Igrim station in the period between noon and midnight (Vgrad) was 4-8 ppb/hour for model calculations and 30-50 ppb/hour for observed data. Average Vgrad of methane given in Table 2.

Table 2. Average Vgrad methane (ppb/hour) for station Igrim .

Period (July 2007)	Measured	Wildfire emission	Wetland emission	Total emission
10-15	9.86 ± 14.91	0.05 ± 0.34	8.23 ± 2.85	8.29 ± 1.82
16-19	34.39 ± 8.27	1.63 ± 1.45	10.45 ± 1.69	11.8 ± 6.98

The emissions from wetlands exhibit the constant existence of the diurnal variation with Vgrad 20-25 ppb/hour (fig.1b). Considering that during the period of blocking, the contribution of other emissions is insignificant, it follows that the growth rate deficit is 6-17 ppb/hour. Based on this assessment, it can be assumed that either those used in calculating methane emissions from biomass burning are underestimated, or we do not take into account the increase in emissions from wetlands during the blocking period.

Conclusion

The WRF-Chem model reproduces the changes in methane concentration during periods of summer blocking in Western Siberia with the used set of emissions. During the blocking period, an increase of concentration CH_4 may be associated with the accumulation from wetland emissions and methane emissions from biomass burning in a blocking area. However, for model data, the growth rate of concentrations between noon and midnight is lower than for measure data. It is may be due to underestimated emissions of methane from fires from July 16-19, or emissions from wetlands during the blocking period.

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