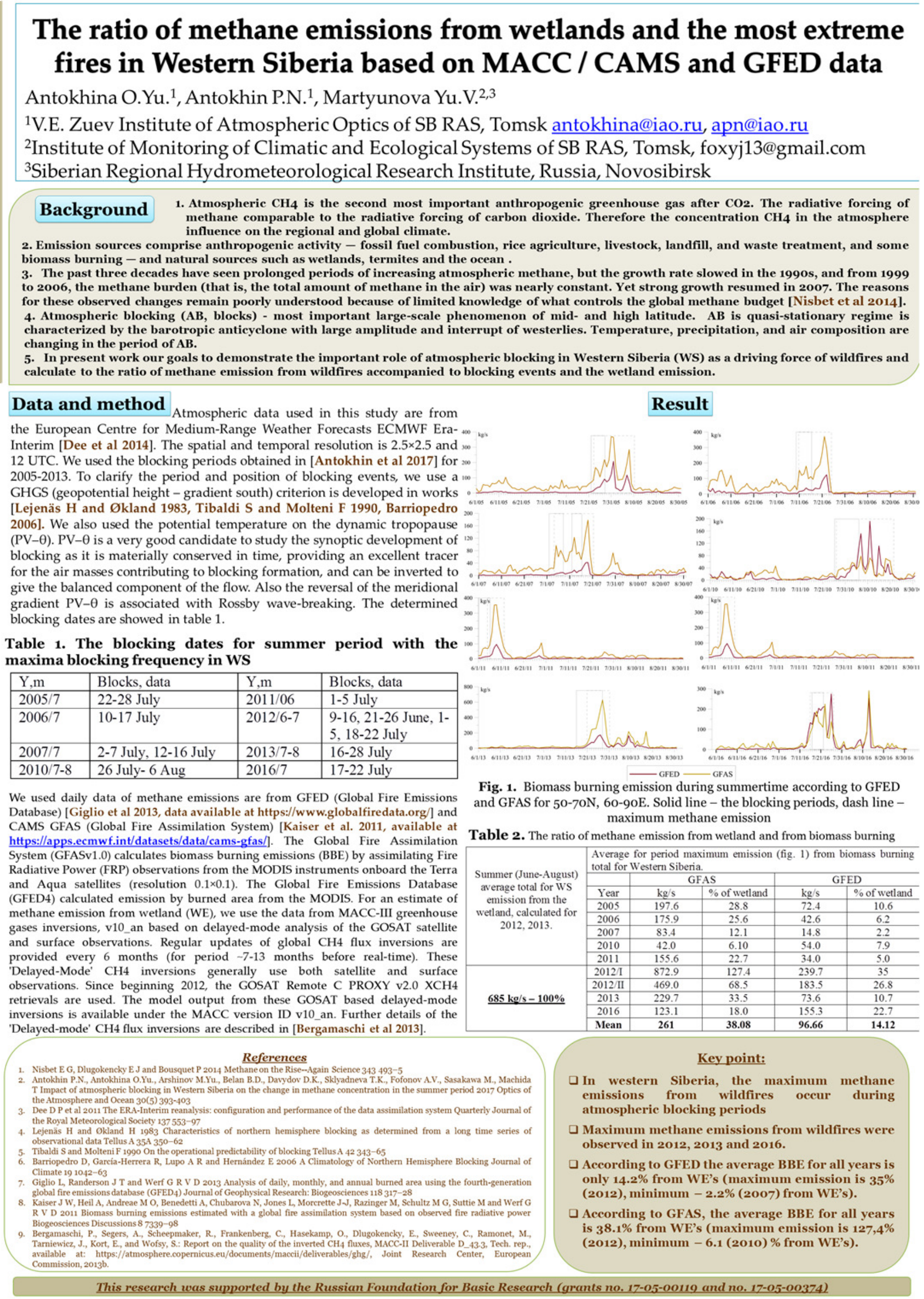
The ratio of methane emissions from wetlands and the most extreme fires in Western Siberia based on MACC / CAMS and GFED data

Antokhina O.Yu.[1], Antokhin P.N.[1], Martyunova Yu.V.[2,3]

[1]V.E. Zuev Institute of Atmospheric Optics of SB RAS, Tomsk antokhina@iao.ru, apn@iao.ru
[2]Institute of Monitoring of Climatic and Ecological Systems of SB RAS, Tomsk, foxyj13@gmail.com [3]Siberian Regional Hydrometeorological Research Institute, Russia, Novosibirsk



The ratio of methane emissions from wetlands and the most extreme fires in Western Siberia based on MACC / CAMS and GFED data

Antokhina O.Yu.[1], Antokhin P.N.[1], Martyunova Yu.V.[2,3]
[1]V.E. Zuev Institute of Atmospheric Optics of SB RAS, Tomsk antokhina@iao.ru, apn@iao.ru
[2]Institute of Monitoring of Climatic and Ecological Systems of SB RAS, Tomsk, foxyj13@gmail.com
[3]Siberian Regional Hydrometeorological Research Institute, Russia, Novosibirsk

Background

1. Atmospheric CH4 is the second most important anthropogenic greenhouse gas after CO2. The radiative forcing of methane comparable to the radiative forcing of carbon dioxide. Therefore the concentration CH4 in the atmosphere influence on the regional and global climate.
2. Emission sources comprise anthropogenic activity — fossil fuel combustion, rice agriculture, livestock, landfill, and waste treatment, and some biomass burning — and natural sources such as wetlands, termites and the ocean .
3. The past three decades have seen prolonged periods of increasing atmospheric methane, but the growth rate slowed in the 1990s, and from 1999 to 2006, the methane burden (that is, the total amount of methane in the air) was nearly constant. Yet strong growth resumed in 2007. The reasons for these observed changes remain poorly understood because of limited knowledge of what controls the global methane budget [Nisbet et al 2014].
4. Atmospheric blocking (AB, blocks) - most important large-scale phenomenon of mid- and high latitude. AB is quasi-stationary regime is characterized by the barotropic anticyclone with large amplitude and interrupt of westerlies. Temperature, precipitation, and air composition are changing in the period of AB.
5. In present work our goals to demonstrate the important role of atmospheric blocking in Western Siberia (WS) as a driving force of wildfires and calculate to the ratio of methane emission from wildfires accompanied to blocking events and the wetland emission.

Data and method

Atmospheric data used in this study are from the European Centre for Medium-Range Weather Forecasts ECMWF Era-Interim [Dee et al 2014]. The spatial and temporal resolution is 2.5×2.5 and 12 UTC. We used the blocking periods obtained in [Antokhin et al 2017] for 2005-2013. To clarify the period and position of blocking events, we use a GHGS (geopotential height – gradient south) criterion is developed in works [Lejenäs H and Økland 1983, Tibaldi S and Molteni F 1990, Barriopedro 2006]. We also used the potential temperature on the dynamic tropopause (PV–θ). PV–θ is a very good candidate to study the synoptic development of blocking as it is materially conserved in time, providing an excellent tracer for the air masses contributing to blocking formation, and can be inverted to give the balanced component of the flow. Also the reversal of the meridional gradient PV–θ is associated with Rossby wave-breaking. The determined blocking dates are showed in table 1.

Table 1. The blocking dates for summer period with the maxima blocking frequency in WS

Y,m	Blocks, data	Y,m	Blocks, data
2005/7	22-28 July	2011/06	1-5 July
2006/7	10-17 July	2012/6-7	9-16, 21-26 June, 1-5, 18-22 July
2007/7	2-7 July, 12-16 July	2013/7-8	16-28 July
2010/7-8	26 July- 6 Aug	2016/7	17-22 July

We used daily data of methane emissions are from GFED (Global Fire Emissions Database) [Giglio et al 2013, data available at https://www.globalfiredata.org/] and CAMS GFAS (Global Fire Assimilation System) [Kaiser et al. 2011, available at https://apps.ecmwf.int/datasets/data/cams-gfas/]. The Global Fire Assimilation System (GFASv1.0) calculates biomass burning emissions (BBE) by assimilating Fire Radiative Power (FRP) observations from the MODIS instruments onboard the Terra and Aqua satellites (resolution 0.1×0.1). The Global Fire Emissions Database (GFED4) calculated emission by burned area from the MODIS. For an estimate of methane emission from wetland (WE), we use the data from MACC-III greenhouse gases inversions, v10_an based on delayed-mode analysis of the GOSAT satellite and surface observations. Regular updates of global CH4 flux inversions are provided every 6 months (for period ~7-13 months before real-time). These 'Delayed-Mode' CH4 inversions generally use both satellite and surface observations. Since beginning 2012, the GOSAT Remote C PROXY v2.0 XCH4 retrievals are used. The model output from these GOSAT based delayed-mode inversions is available under the MACC version ID v10_an. Further details of the 'Delayed-mode' CH4 flux inversions are described in [Bergamaschi et al 2013].

Result

Fig. 1. Biomass burning emission during summertime according to GFED and GFAS for 50-70N, 60-90E. Solid line – the blocking periods, dash line – maximum methane emission

Table 2. The ratio of methane emission from wetland and from biomass burning

Summer (June-August) average total for WS emission from the wetland, calculated for 2012, 2013.	Average for period maximum emission (fig. 1) from biomass burning total for Western Siberia.				
		GFAS		GFED	
	Year	kg/s	% of wetland	kg/s	% of wetland
	2005	197.6	28.8	72.4	10.6
	2006	175.9	25.6	42.6	6.2
	2007	83.4	12.1	14.8	2.2
	2010	42.0	6.10	54.0	7.9
	2011	155.6	22.7	34.0	5.0
685 kg/s – 100%	2012/I	872.9	127.4	239.7	35
	2012/II	469.0	68.5	183.5	26.8
	2013	229.7	33.5	73.6	10.7
	2016	123.1	18.0	155.3	22.7
	Mean	**261**	**38.08**	**96.66**	**14.12**

References

1. Nisbet E G, Dlugokencky E J and Bousquet P 2014 Methane on the Rise--Again Science 343 493–5
2. Antokhin P.N., Antokhina O.Yu., Arshinov M.Yu., Belan B.D., Davydov D.K., Sklyadneva T.K., Fofonov A.V., Sasakawa M., Machida T Impact of atmospheric blocking in Western Siberia on the change in methane concentration in the summer period 2017 Optics of the Atmosphere and Ocean 30(5) 393-403
3. Dee D P et al 2011 The ERA-Interim reanalysis: configuration and performance of the data assimilation system Quarterly Journal of the Royal Meteorological Society 137 553–97
4. Lejenäs H and Økland H 1983 Characteristics of northern hemisphere blocking as determined from a long time series of observational data Tellus A 35A 350–62
5. Tibaldi S and Molteni F 1990 On the operational predictability of blocking Tellus A 42 343–65
6. Barriopedro D, García-Herrera R, Lupo A R and Hernández E 2006 A Climatology of Northern Hemisphere Blocking Journal of Climate 19 1042–63
7. Giglio L, Randerson J T and Werf G R V D 2013 Analysis of daily, monthly, and annual burned area using the fourth-generation global fire emissions database (GFED4) Journal of Geophysical Research: Biogeosciences 118 317–28
8. Kaiser J W, Heil A, Andreae M O, Benedetti A, Chubarova N, Jones L, Morcrette J-J, Razinger M, Schultz M G, Suttie M and Werf G R V D 2011 Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power Biogeosciences Discussions 8 7339–98
9. Bergamaschi, P., Segers, A., Scheepmaker, R., Frankenberg, C., Hasekamp, O., Dlugokencky, E., Sweeney, C., Ramonet, M., Tarniewicz, J., Kort, E., and Wofsy, S.: Report on the quality of the inverted CH4 fluxes, MACC-II Deliverable D_43.3, Tech. rep., available at: https://atmosphere.copernicus.eu/documents/maccii/deliverables/ghg/, Joint Research Center, European Commission, 2013b.

Key point:

- In western Siberia, the maximum methane emissions from wildfires occur during atmospheric blocking periods
- Maximum methane emissions from wildfires were observed in 2012, 2013 and 2016.
- According to GFED the average BBE for all years is only 14.2% from WE's (maximum emission is 35% (2012), minimum – 2.2% (2007) from WE's).
- According to GFAS, the average BBE for all years is 38.1% from WE's (maximum emission is 127,4% (2012), minimum – 6.1 (2010) % from WE's).

This research was supported by the Russian Foundation for Basic Research (grants no. 17-05-00119 and no. 17-05-00374)