Estimation of possible impact of black carbon emissions from 2019 large Siberian forest wildfires on the Arctic region

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Climate and environmental effects

Black carbon is considered as both short lived climate force and environmental pollutant:

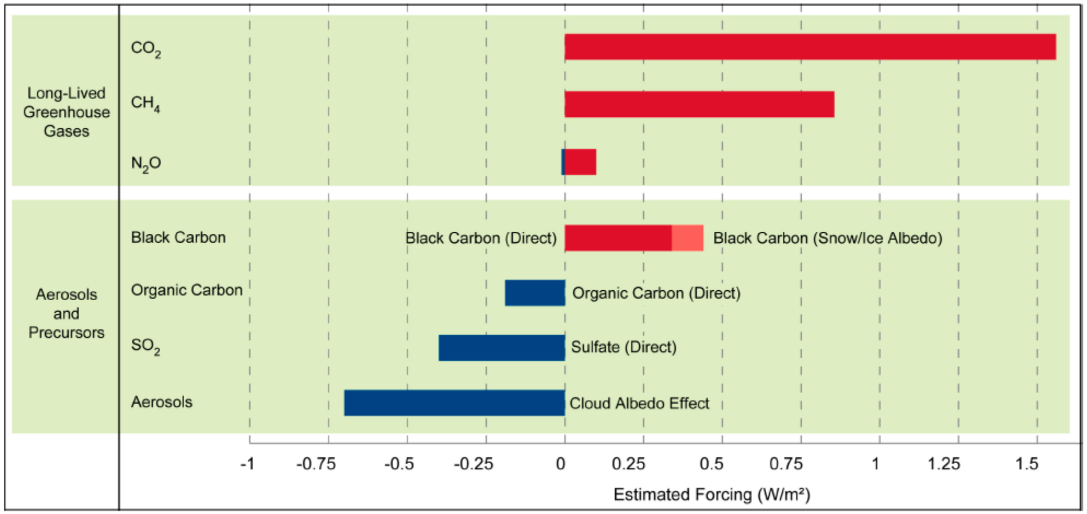
1) direct absorption of solar radiation,
2) cloud pollution, which leads to both absorption of solar radiation and warming of clouds
3) indirect effect - albedo reduction (from about 98% to 90-97%). Thus the absorption increases from 2 to 3-10% (1.5 - 5 times) - The most important effect for Arctic region.

The total effect of black carbon particles on the radiation balance as a result of direct absorption of solar radiation, interaction with clouds and their heating, as well as changes in snow and ice albedo is estimated from 0.64 W m-2 (IPCC, 2013) to 1.1 (0.17-2.1) W m-2 (Bond et al., 2013).

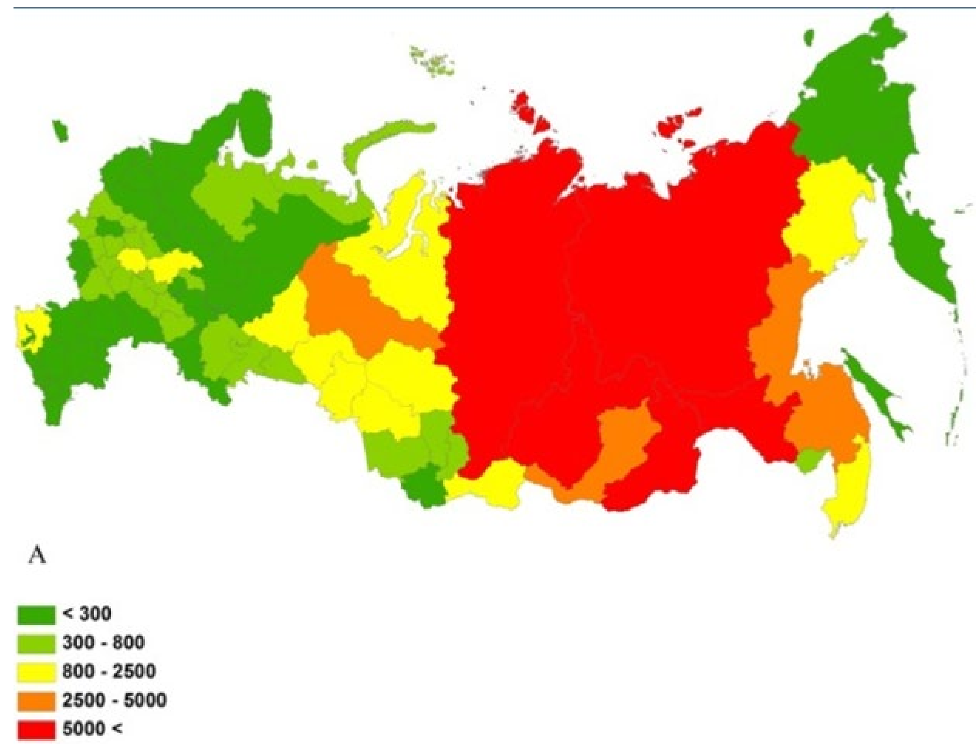
Short-lived climate forces, in contrast with global forces, such as GHGs, has mostly regional effects and therefore are important for most vulnerable regions, such as Arctic region.

The estimation of black carbon emissions is subject to great uncertainty, also due to the fact that there is no clear definition of black carbon

Black carbon characteristics



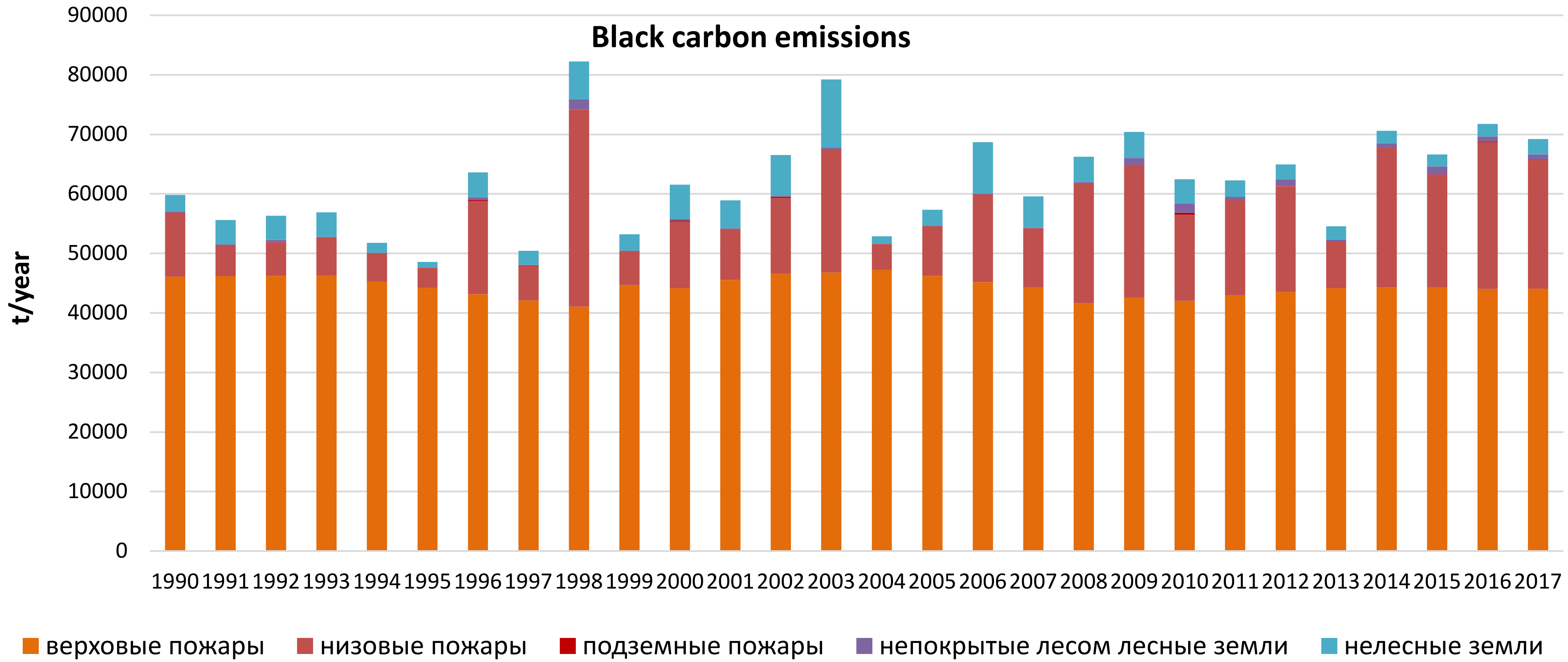
Characteristics	Black carbon
Atmospheric life-time	From few days to few weeks
Absorption	Absorption of solar radiation across the spectrum
Radiation forcing	+0.34-1 Wt m^{-2} - direct effect + 0.05 Wt m^{-2} - indirect albedo effect +/-? – clouds effect
Input to global warming	Considered as 3rd important force after CO_2 и CH_4, but with high uncertanities



Average BC emissions (t/year) from forest fires in Russia in 2007 – 2012 гг.
A – total average annual emissions; B – crowning fires
(IGCE data)

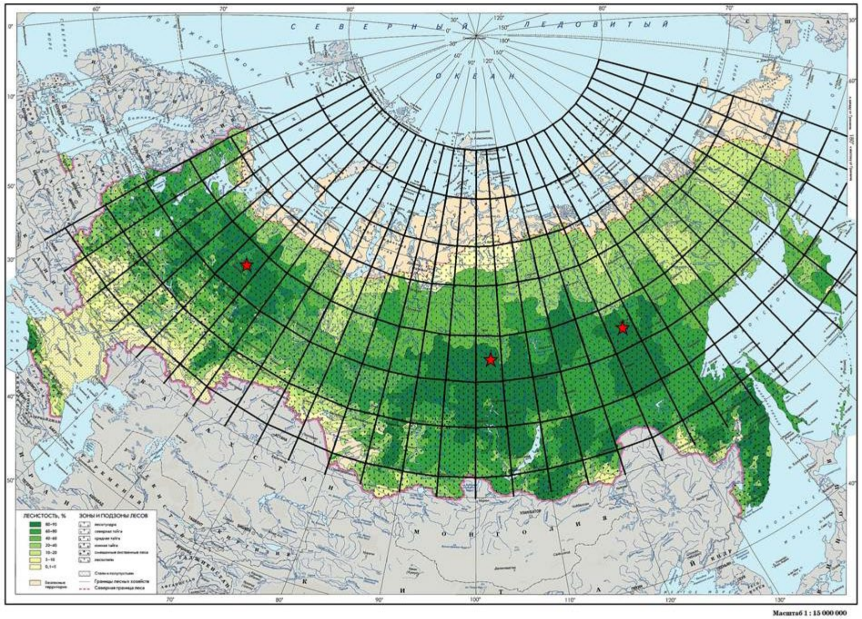
The aim of this work was to estimate the probability of transportation of black carbon originated from simulated forest fires in Russian boreal taiga to Arctic region and its deposition to ice surface and contribution to shortwave radiative forcing.

The experiments were made for three regions in the boreal taiga (Komi, Krasnoyarsk and Yakutia) with the greatest probability of extreme forest fires according to the statistical data from 2000 to 2015.

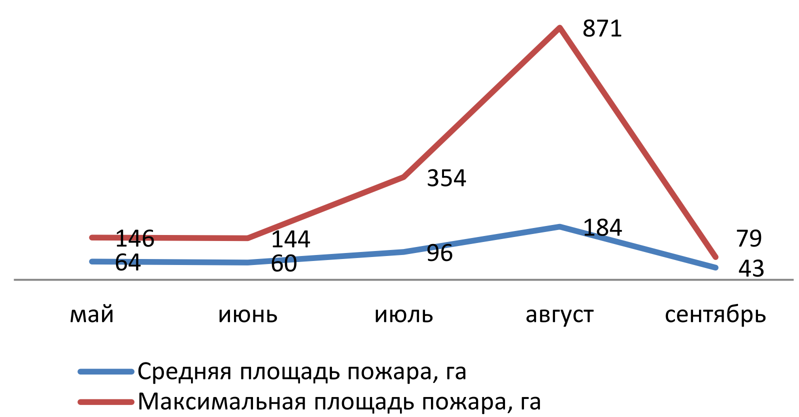


Total BC emissions in 2019 is 118 t

Simulating fires

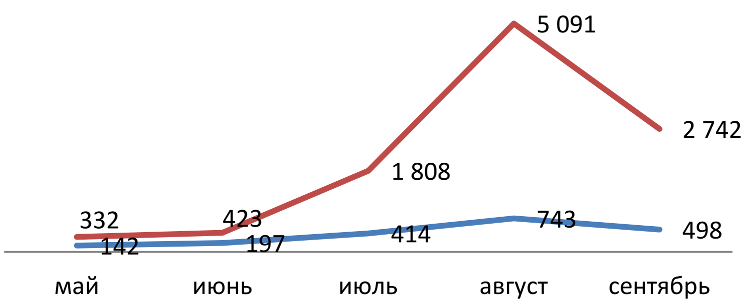


Komi

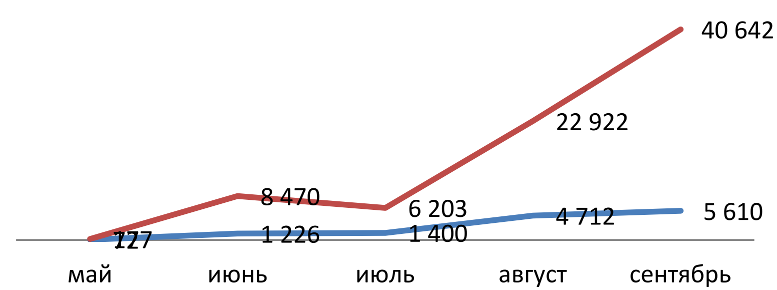


	Komi	Krasnoyarsk region	Yakutia
	Average number of fires		
май	1	122	21
июнь	2	91	23
июль	4	47	41
август	25	46	75
сентябрь	1	18	29

Krasnoyarsk region

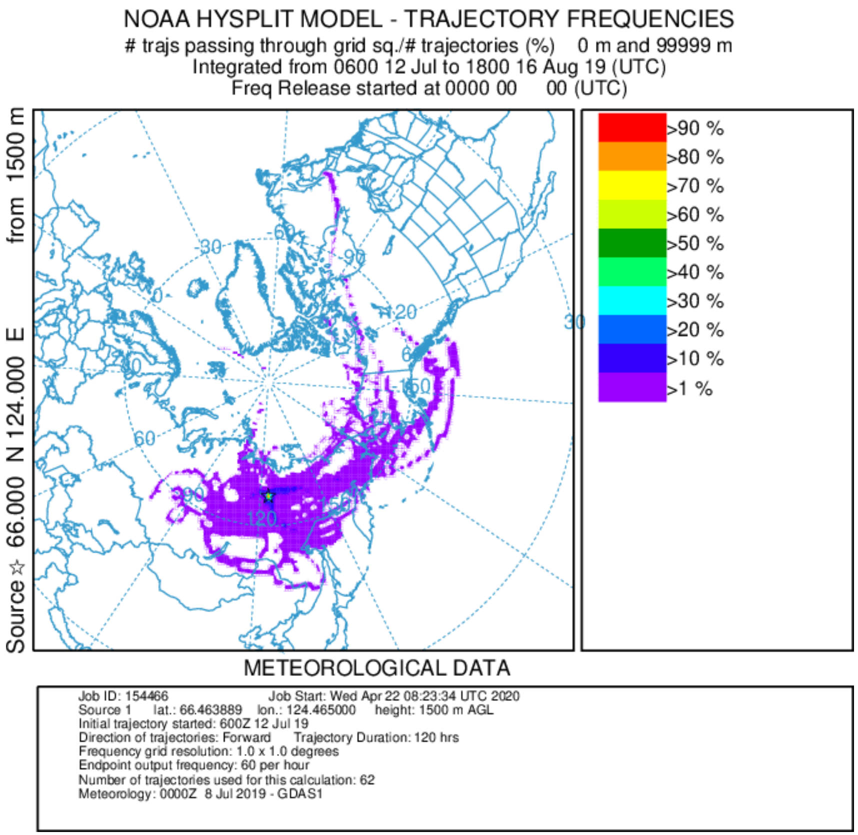


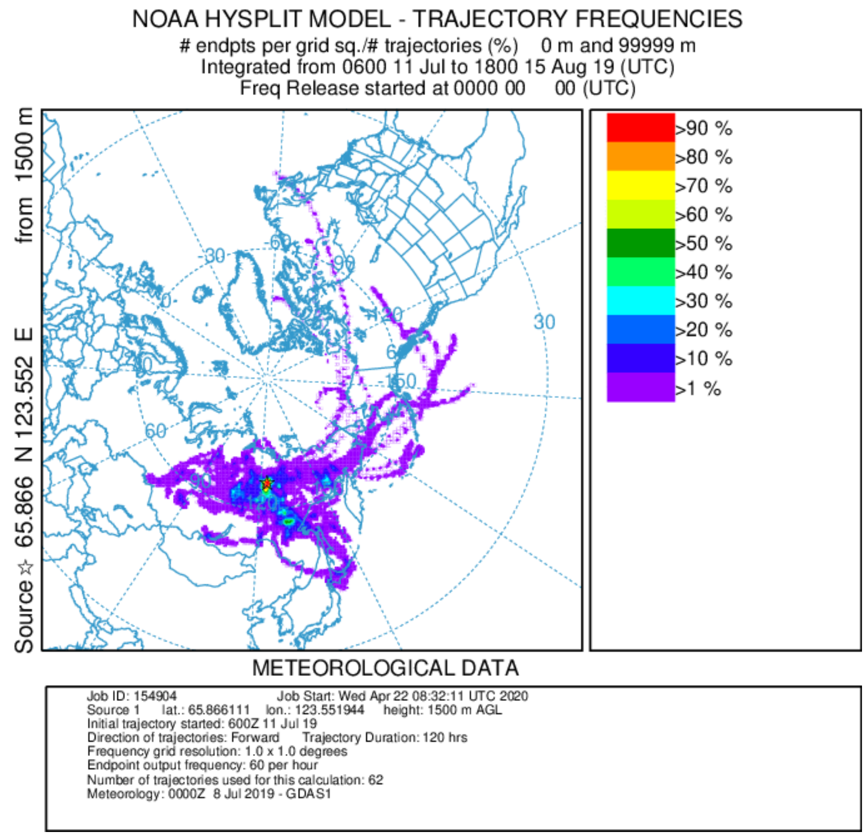
Yakutia



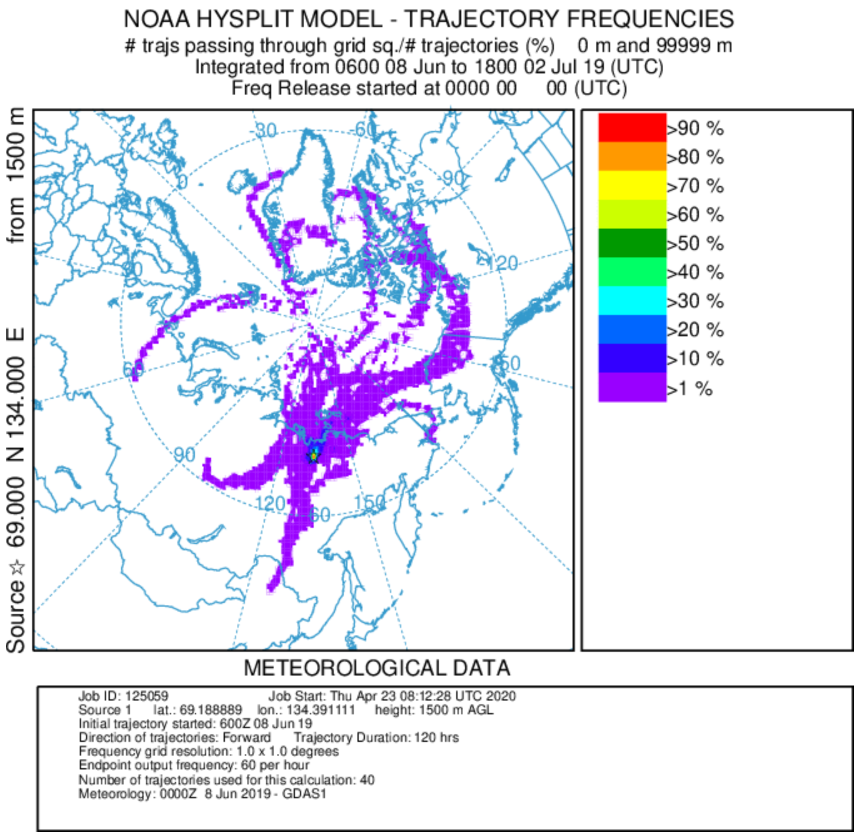
№	Latitude	Longitude	First day	Number of days	BC emission intensity t/day	Total emission, t
1	61.0850	99.1311	2.07.2019	40	59.5	2381.0141
2	66.4639	124.4650	12.07.2019	37	48.4	1791.4745
3	60.8450	99.8169	12.07.2019	30	46.5	1394.7932
4	65.8661	123.5519	11.07.2019	38	42.3	1605.9788
5	64.0169	105.0000	3.07.2019	2	35.5	70.9721
6	64.5269	113.5069	10.07.2019	40	34.9	1397.8627
7	61.6231	98.2850	2.07.2019	40	32.0	1281.0335
8	61.9069	119.3111	17.07.2019	14	27.4	383.2537
9	65.6139	100.6300	3.07.2019	2	25.9	51.8510
10	67.3450	137.2281	25.06.2019	6	24.8	148.8781
11	63.8289	131.1881	22.07.2019	18	23.6	424.4766
12	69.1889	134.3911	8.06.2019	20	23.0	459.2524
13	62.6589	121.2331	15.07.2019	16	22.1	353.5388
14	67.1589	152.4361	13.06.2019	19	21.9	416.0517
15	63.3431	106.0831	3.07.2019	2	21.7	43.4831
16	68.2761	136.7939	28.06.2019	1	21.4	21.4199

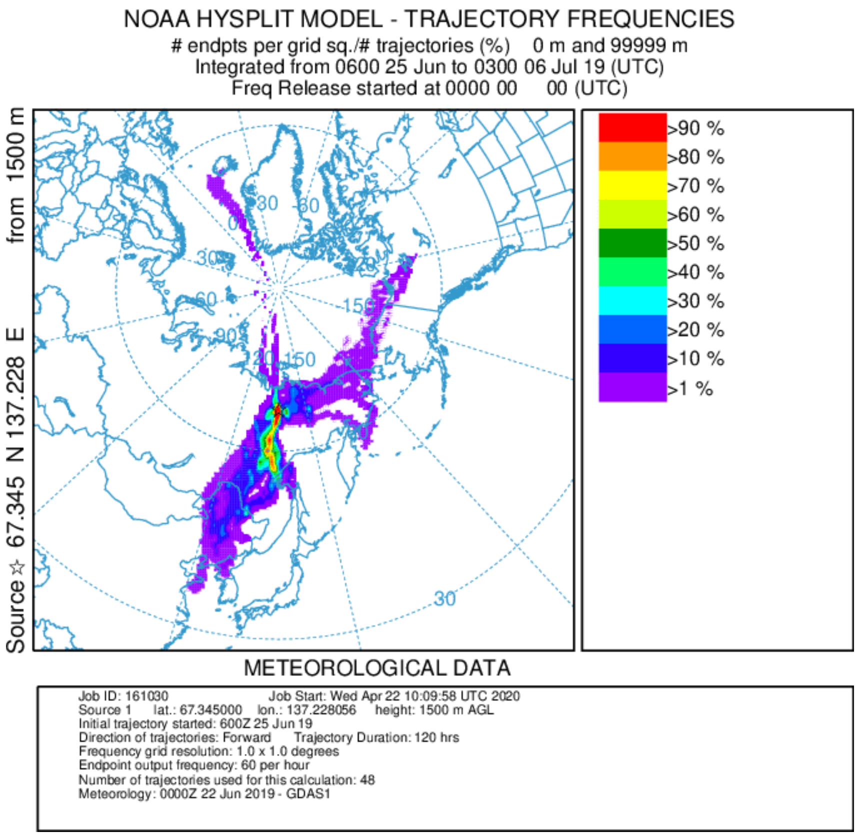
Most typical situation



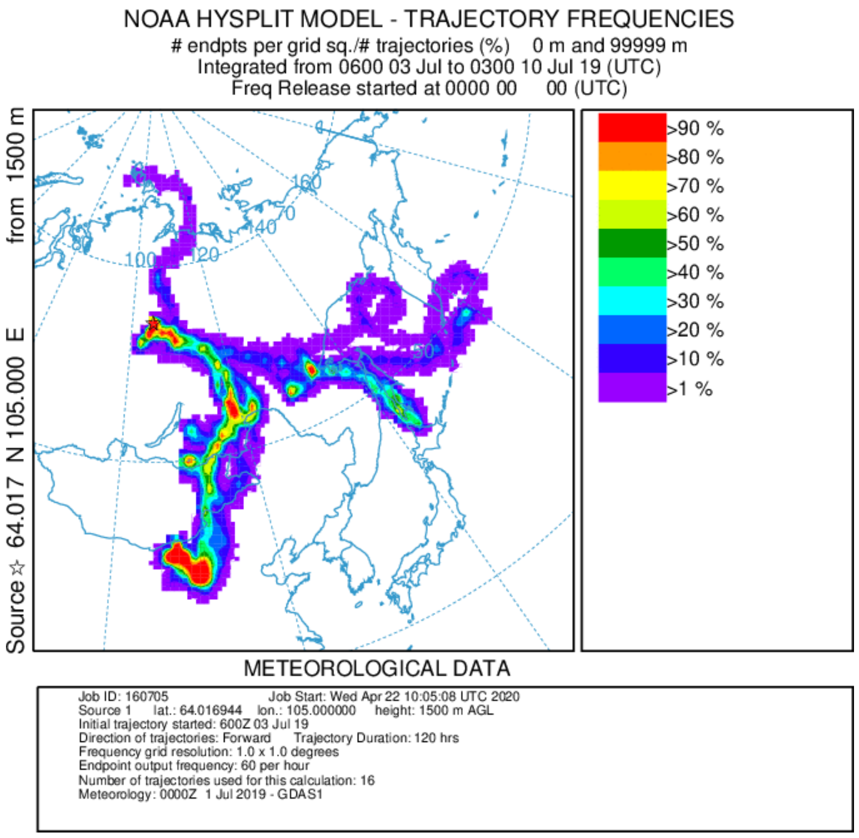


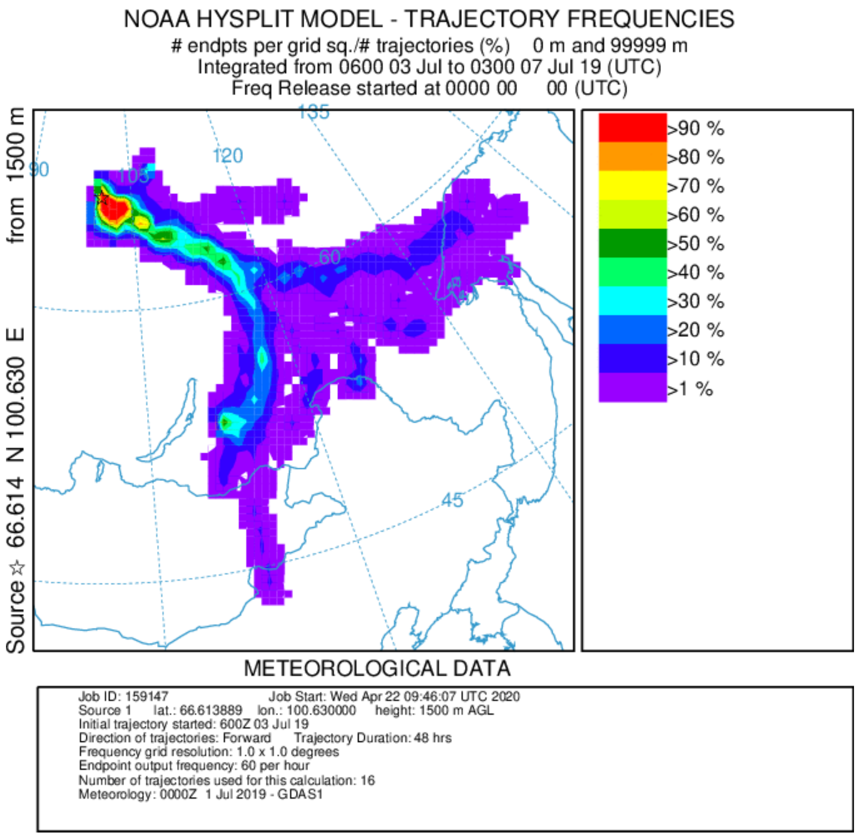
situation for drift into the Arctic





Short intensife fires





The BC climatic effect from different forest fires scenarios on the Arctic was estimated by the aerosol block of climate model developed by Institute of Numerical Mathematics

Global climate model INMCM5

Spatial resolution:

Atmosphere 2 × 1,5 degree, vertical resolution 21 level,

Ocean 1 x 0.5 degree, vertical resolution 40 levels.

Aerosol block consist of 10 components:

fine and coarse sea salt, fine and coarse continental dust, sulphur dioxide, sulphate aerosol, hydrophobic and hydrophilic black carbon, hydrophobic and hydrophilic organic carbon

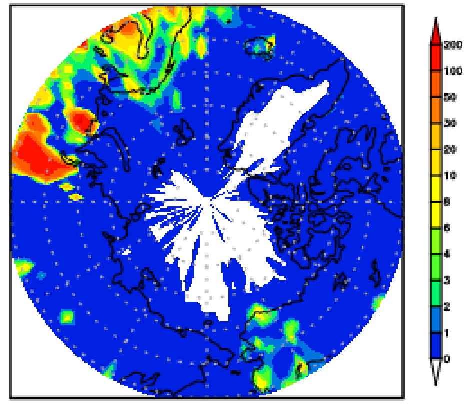
Accounting processes:

transport, diffusion, dry and wet deposition, dry and wet absorption by the surface.

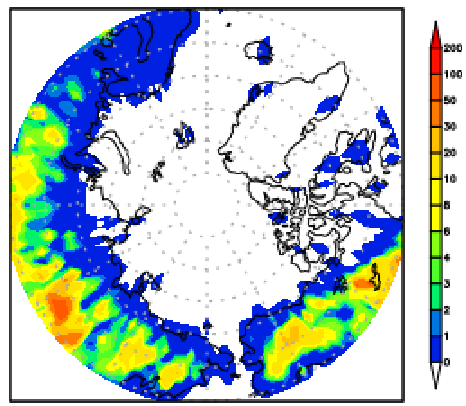
INMCM5 model parameters important for BC simulation

	share, %	dencity, kg/m^3	Dry particle radius, мкм	Wet absorption velocity, m/s	Dry absorption velocity, m/s
Hydrophilic BC	20	1000.0	0.02	0.0002	0.0002
Hydrophobic BC	80	1000.0	0.06	0.002	0.0002

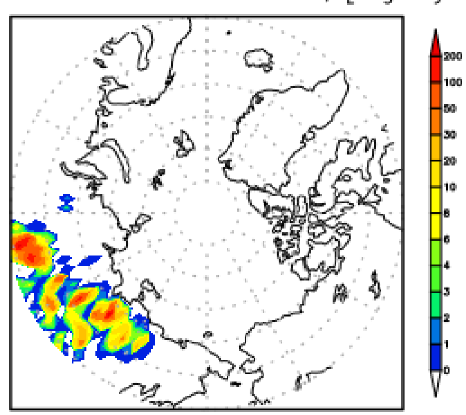
CMIP6 ANTHRO BC emission, 1jan1985–31dec2014, [mgm⁻²yr⁻¹]



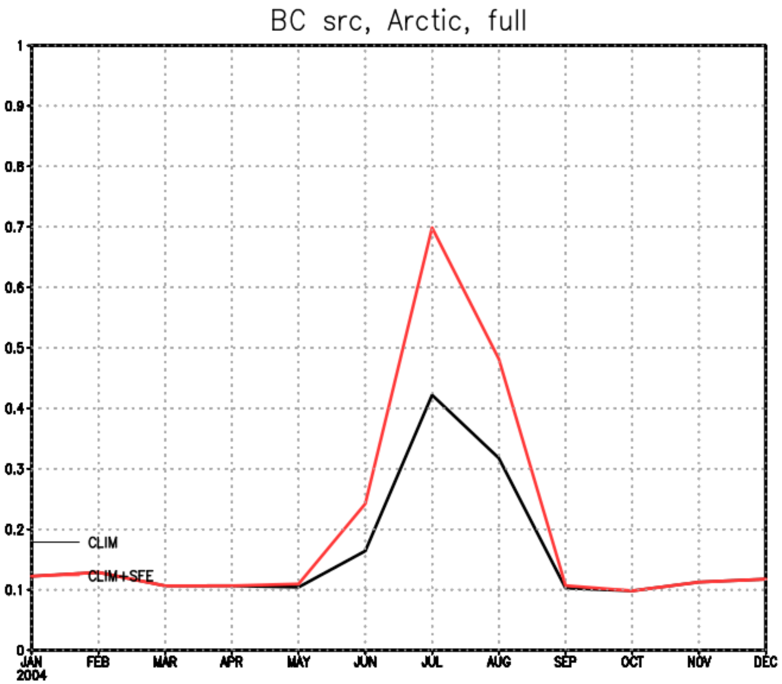
CMIP6 BB BC emission, 1jan1985–31dec2014, [mgm⁻²yr⁻¹]

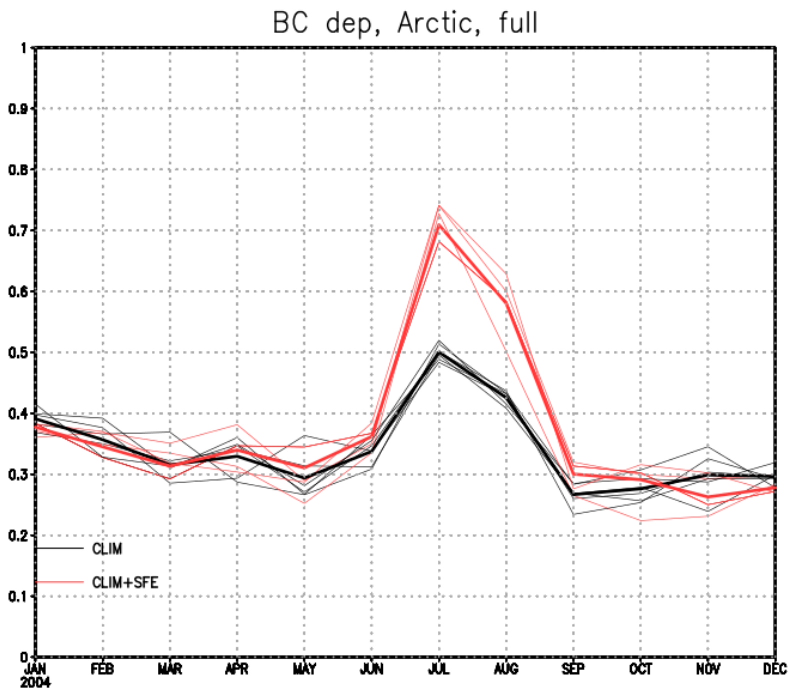


ICGE SibFires2019 BC emission, [mgm⁻²yr⁻¹]



Seasonal change of BC emissions and deposition

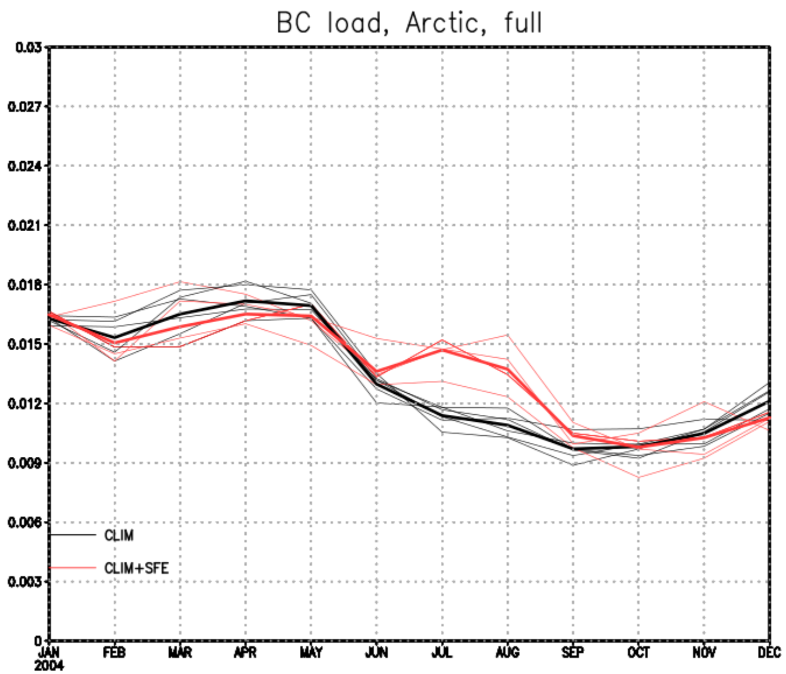


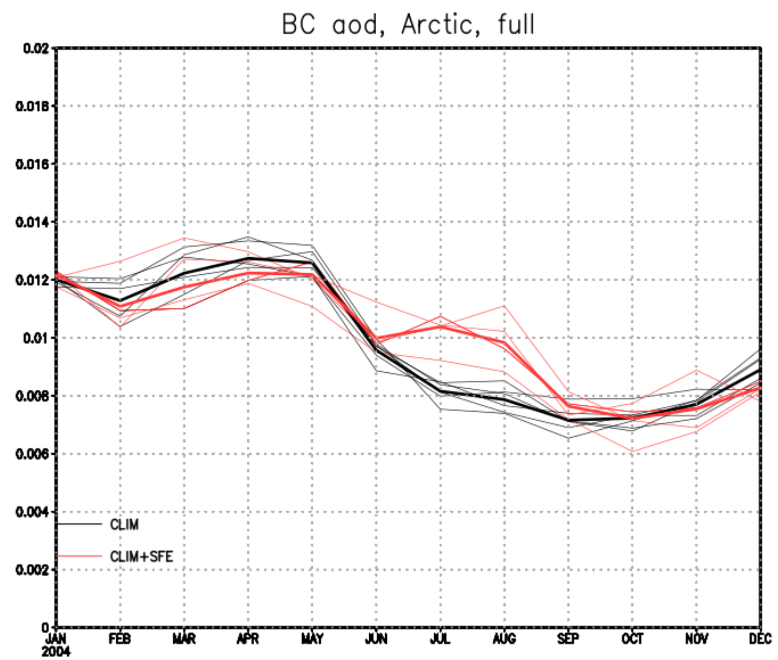


Black line - BC emissions used for climate modelling

Red line - BC emissions used for climate modelling + BC from fires 2019

Seasonal change of BC concentration in air and optical depth





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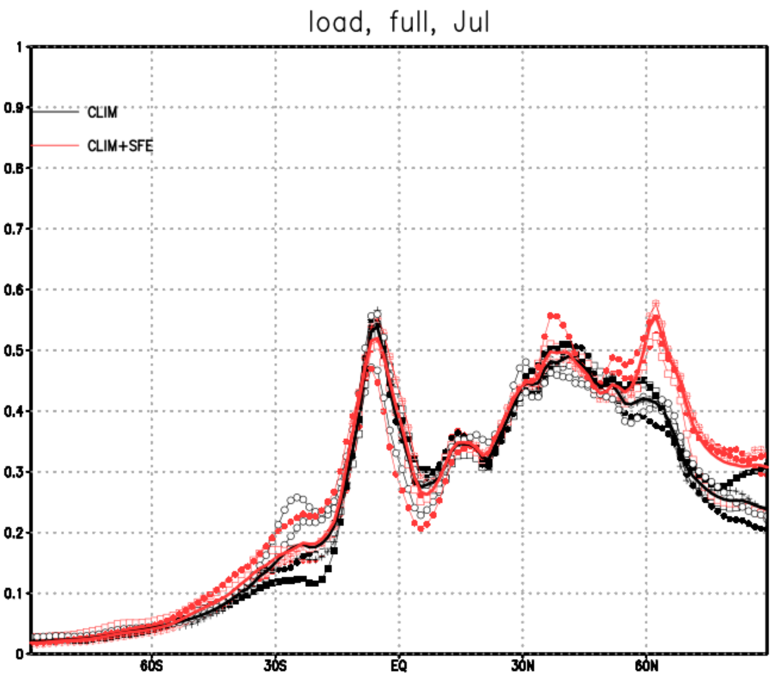
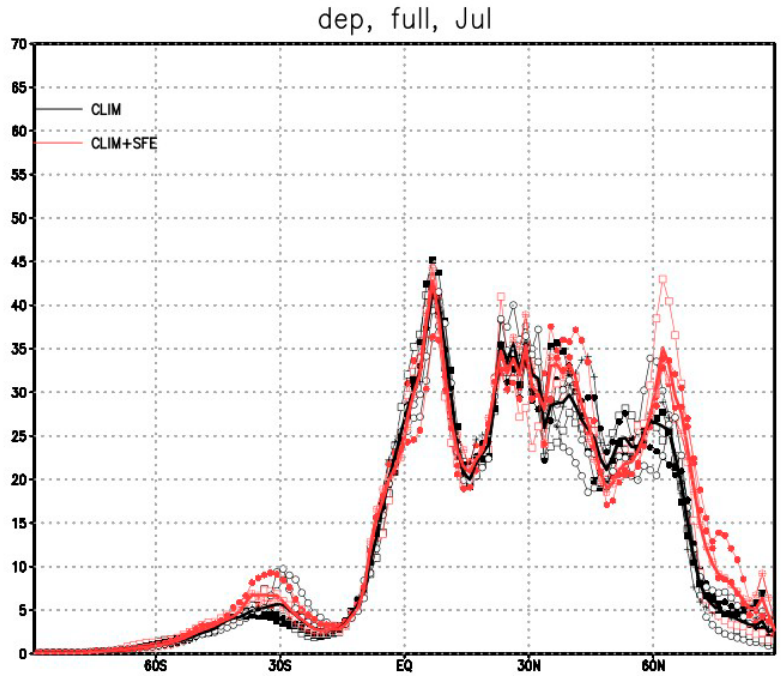
BC concentration and deposition in July





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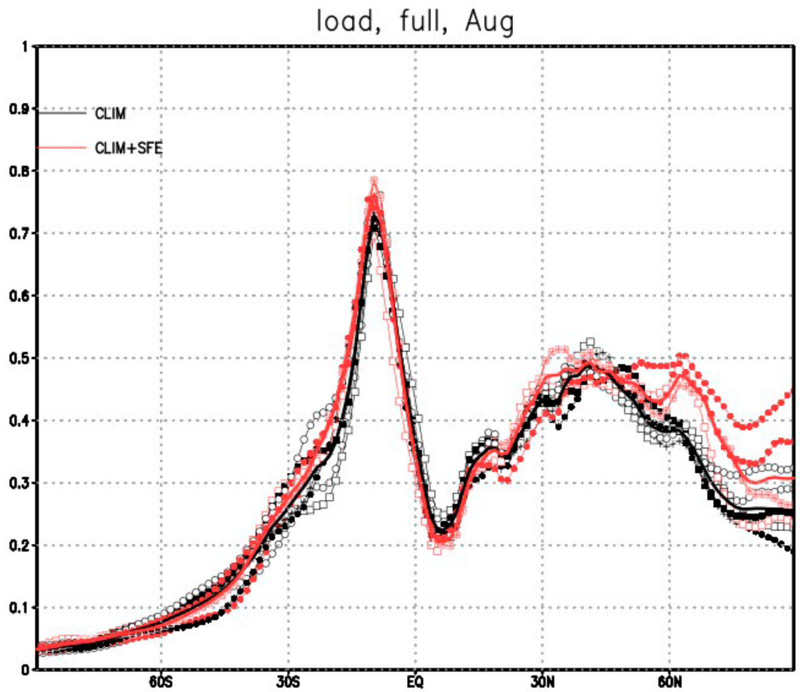

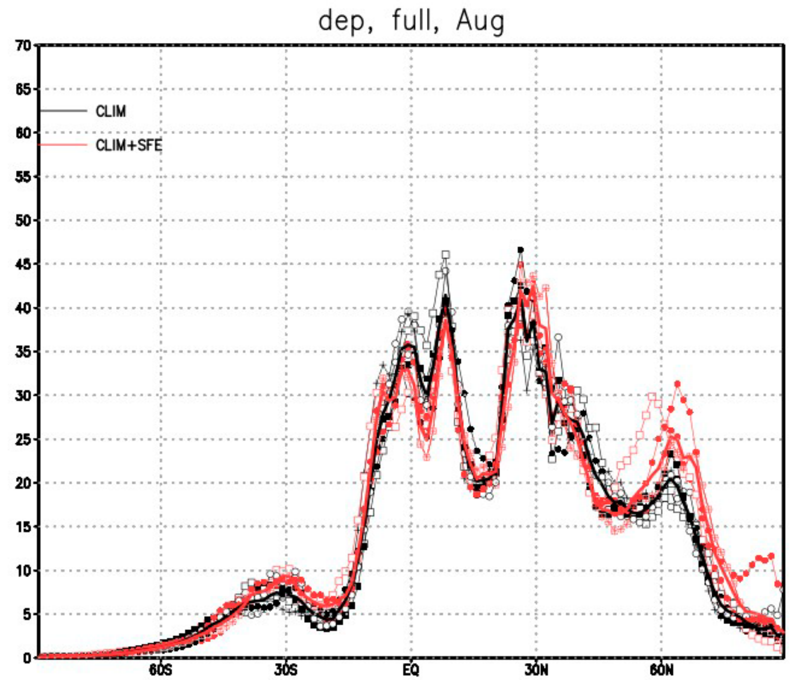

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Thank you for your attention

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