The formation of the gases and aerosol composition in the background and urban location of Western Siberia: a case study for the record-breaking hot April 2020

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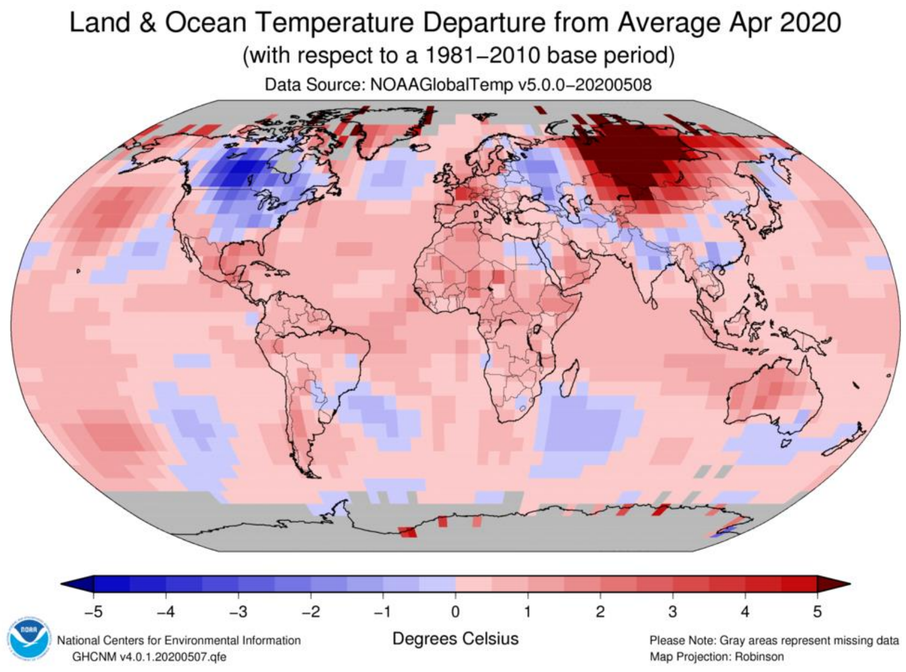
Background

There are many feedbacks associated with the chemical composition of the atmosphere and climate system. One of the exciting aspects of this matter is the study of the influence of extreme episodes associated with atmospheric circulation and changes in surface temperature. April 2020 was the second abnormally hot (the first in 2016) for our planet. The most pronounced temperature anomalies were characteristic of Western Siberia, where the average monthly temperature exceeded the norm by an average of 5°C, and in the northern regions of Western Siberia by 10-12°C. According to the Russian weather services departments for Western Siberia, in 2020 was the first hottest April [https://ria.ru/20200420/1570277368.html].

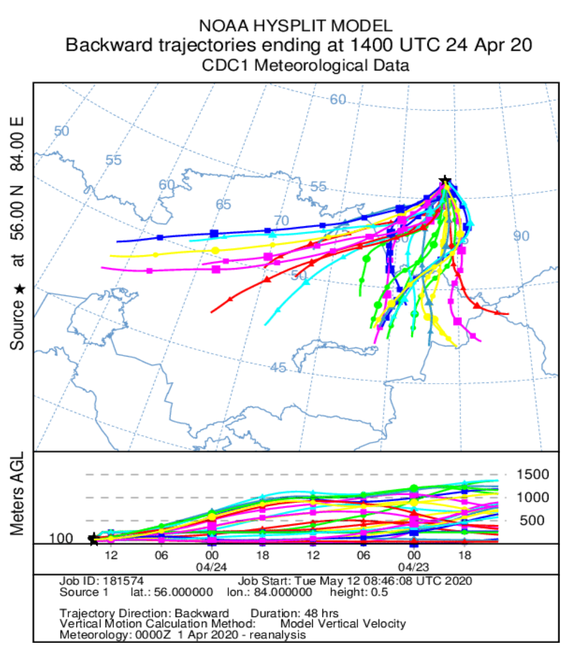


We present the observed changes in the gas and aerosol composition during an abnormally warm April; analyze the circulation patterns associated with the transfer of air masses, as well as the formation of atmospheric blocking conditions.

Data and method

The gases and aerosols concentration for April 2020 have been derived from the Tropospheric ozone research station (TOR-station) [Davydov et al 2019] and Fonovaya station (FON-station) [Arshinov et al 2018]. TOR and FON stations are located in suburban (Tomsk, 56°28'41"N., 85°03'15" E) and background areas (Kireyewsk, 56°21'50"N., 84°05'28" E) respectively. We used daily chemical composition and temperature data.

Meteorological data used in this study are from the NCEP/NCAR Reanalysis 1 [Kalney et al 1997]. The advantage of the NCEP/NCAR Reanalysis is its data uploading with a three-day lag to the current date. The spatial and temporal resolution is 2.5×2.5 and 12 UTC. In this work, to clarify the period and position of blocking events, we use a GHGS (geopotential height – gradient south) criterion that is present in works [Barriopedro et al 2006, Antokhina et al. 2017]. We use GHGS with the fixed blocking latitude (φ_{fix}) and flexible blocking latitude (φ_{flex}) according to [Antokhina et al. 2017]. For clarifying the origins of air masses advected to Western Siberia, we also used the potential temperature on the dynamic tropopause (PV–θ) [http://weather.utah.edu/]. Also, for analysis of the general direction of air masses, we utilized the HYSPLIT model [https://www.ready.noaa.gov/HYSPLIT.php]. We used the daily data of hotspots (forest fire position) from Worldview [https://worldview.earthdata.nasa.gov/



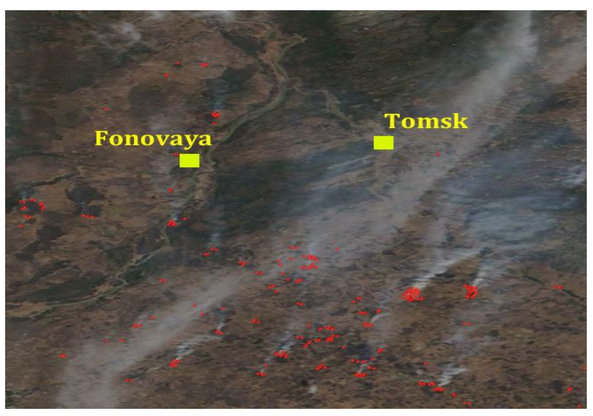


Figure. 2. Backward trajectories of air particles for April 24 2020 (left), forest fire hotspots at April 23 2020 in south part of Western Siberia (around monitoring station) (right)

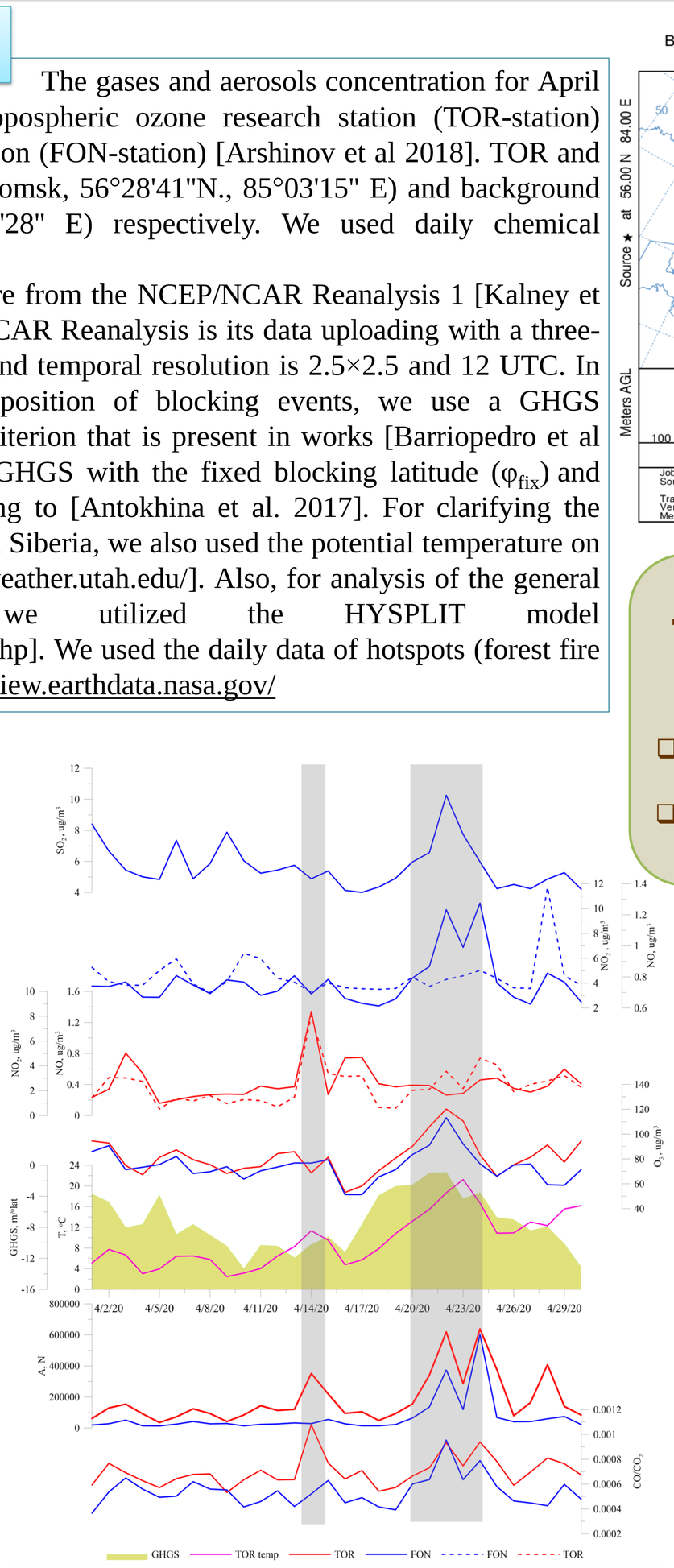
Result

Figure. 1. GHGS indexes of blocking, surface temperature (T) for TOR station, gases (CO - carbon oxide, CO_2 carbon dioxide, O_3 - ozone, SO_2 -Sulphur dioxide, NOx - nitrogen oxides) and aerosol (A) (for TOR 0,25mkm, for FON 0,30 mkm) concentration in April 2020. Data for FON station:10m level, daily.

According to fig. 1, two episodes of an increase in the concentration of gases and aerosol for the stations can be distinguished (indicated by gray bars in the figure 1).

Event 1st: April 13-15, with a maximum of April 14 – **mesoscale** atmospheric conditions, local transfer

Event 2nd: April 17-24 with a maximum of April 23 – **high amplitude atmospheric ridge (GHGS≈0),** transfer from Kazakhstan



Key point our work:

The formation of the gases and aerosol composition in Western Siberia during anomaly hot April 2020 were under two main factors:

- **The role of transfer from the industrial centers of northern Kazakhstan (especially for ozone).**
- **The role of smoke plumes from early forest fire in Western Siberia.**

References

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