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Remote sensing / satellite observations / data in support for socio-economical studies

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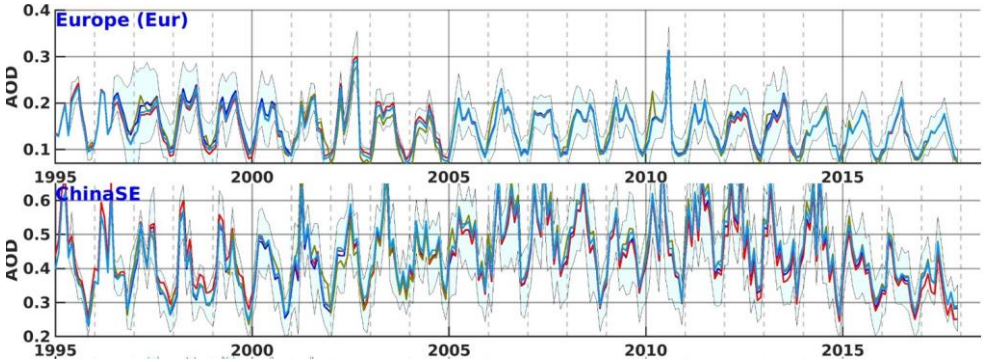
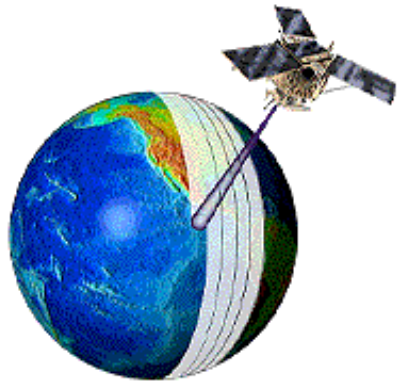
Satellites monitoring the environment

- Satellites provide global observations of multiple climate and environmental relevant parameters of the atmosphere, land and ocean.
- One of the major advantages is that satellites provide observations over areas where there are no ground observations or measurement network is sparse.
- Satellite measurements also facilitates the creation of long time series.



Sogacheva et al., ACP, 2020

Satellite instruments used for environmental monitoring



- Satellite instruments that monitor northern / Arctic areas are on a polar orbit.
  - at high latitudes coverage is better than at mid- or low latitudes.
- Satellite measurements are indirect: instruments measure radiation, that is con relevant environmental parameters.
- Most of atmospheric measurements are based on reflected solar radiation.
  - no observations during winter, clouds and snow can also limit observations
  - For snow and land ice monitoring also longer wavelengths are used that don't have similar limitations.

The lack of arctic observations is acknowledged in the remote sensing community

Plans for new missions

The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and the European Space Agency (ESA) are considering the prospects for observations from satellites in a highly elliptical orbit (HEO). This is a new opportunity that could bring weather imaging capabilities to the Arctic and high latitudes of similar quality to what is currently available in the tropics and mid-latitudes from geostationary satellites.

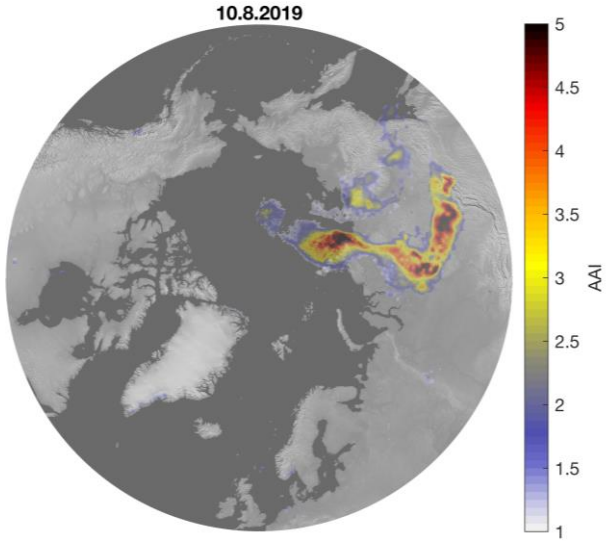
https://www.ecmwf.int/en/newsletter/150/news/new-opportunities-heo-satellites

Satellites monitoring the environment: FMI Activities

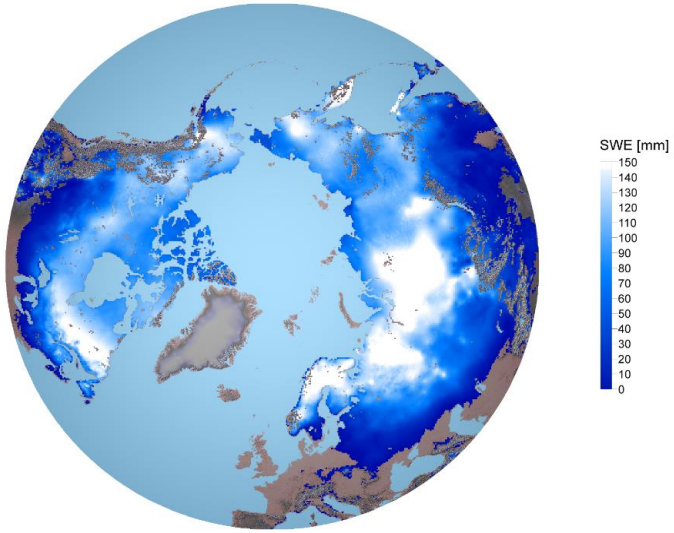
Atmospheric monitoring
- Air quality, aerosols, and atmospheric composition
- Emissions from forest fires and anthropogenic sources
- Greenhouse gases

Land monitoring
- Snow cover; extent, snow mass
- Freezing / thawing
- Land use changes, burnt area

Marine monitoring
- Sea ice extent and thickness

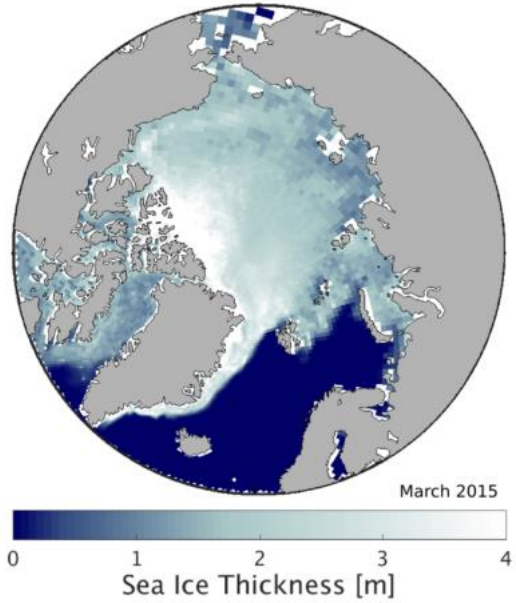


Absorbing Aerosol Index (smoke from fires)



Mean snow mass in March

Pulliainen et al., Nature 2020



http://esa-data-cci.org/

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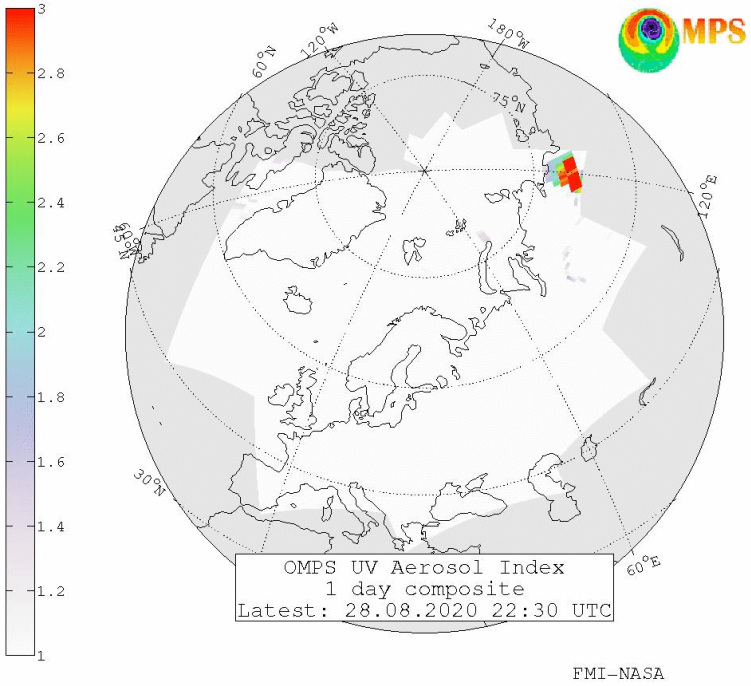
The SAMPO service

sampo.fmi.fi

Satellite Measurements from Polar Orbit

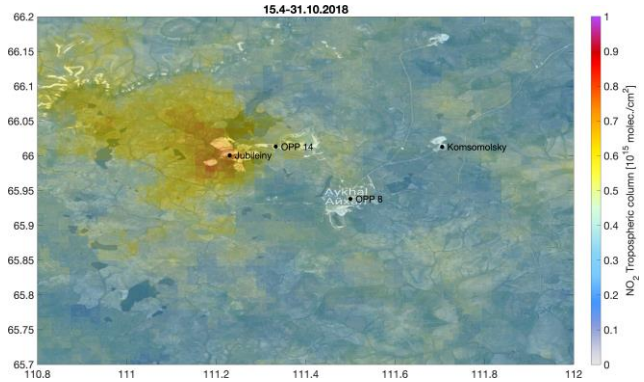
- Web-based service that provides direct readout data of the Northern Hemisphere from OMI and OMPS instruments.
  - Receiving stations are located at Sodankylä, Finland (OMI, OMPS), and Fairbanks, Alaska, US (OMPS).
- Observations on total ozone, absorbing aerosols (smoke, dust), clouds, SO_2 and UV-radiation are published about 15 min. after the satellite overpass.
- SAMPO allows e.g. near real time monitoring of smoke transport in the Arctic / Northern hemisphere

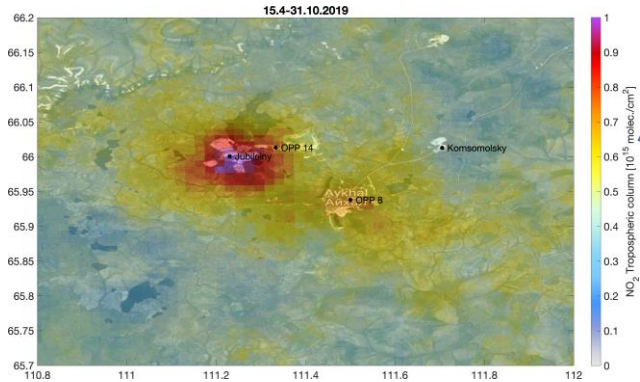


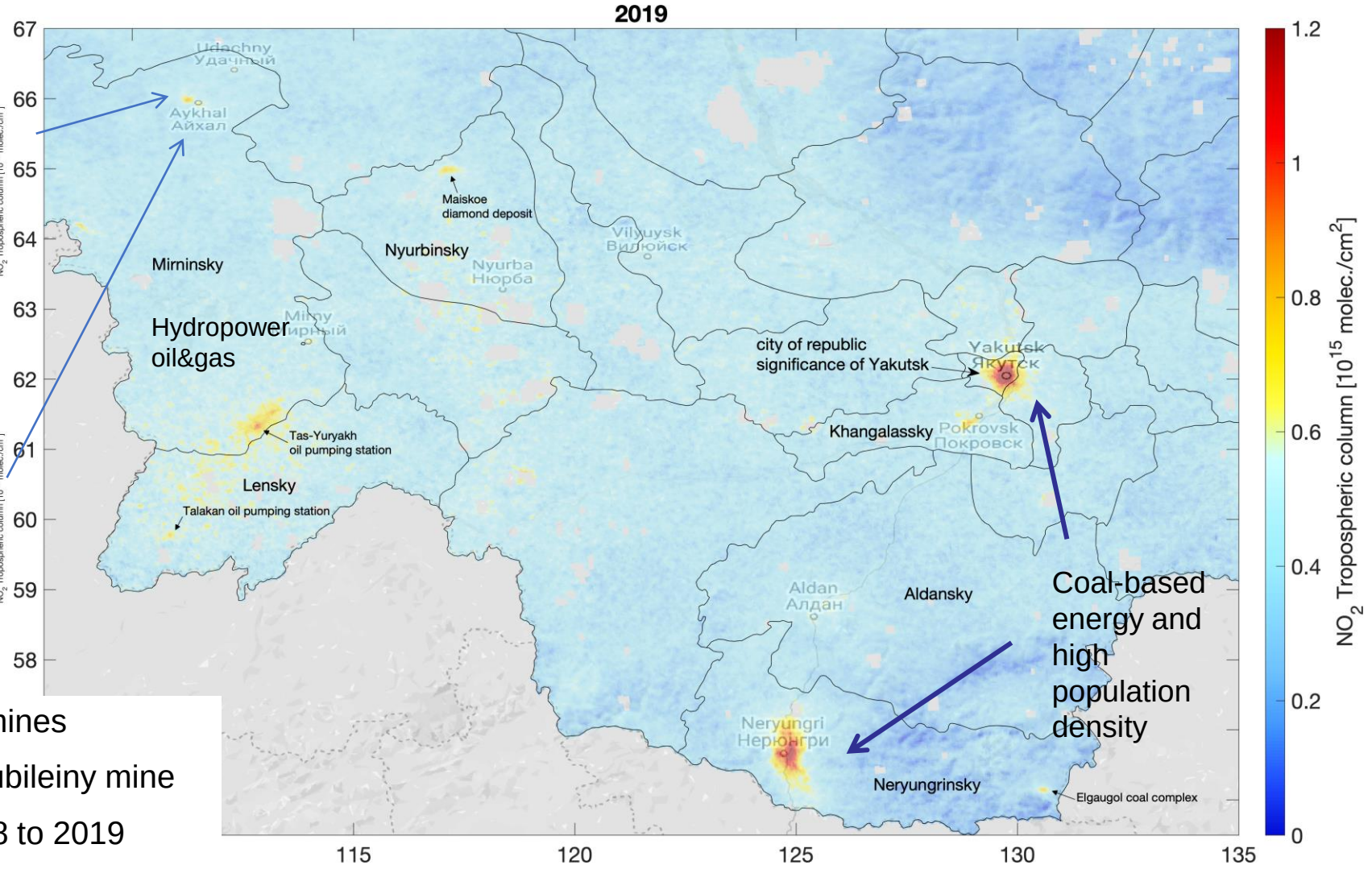
Contact: A.-M. Sundström, FMI

Satellite-based NO2 monitoring from energy and extractive sectors in Sakha Republic, Russia

I. Ialongo, H. Virta, FMI – D. Gritsenko, Aleksanteri Institute
N. Stepanova, Arctic Scientific Center of Sakha Academy of Sciences, Yakutsk Russia







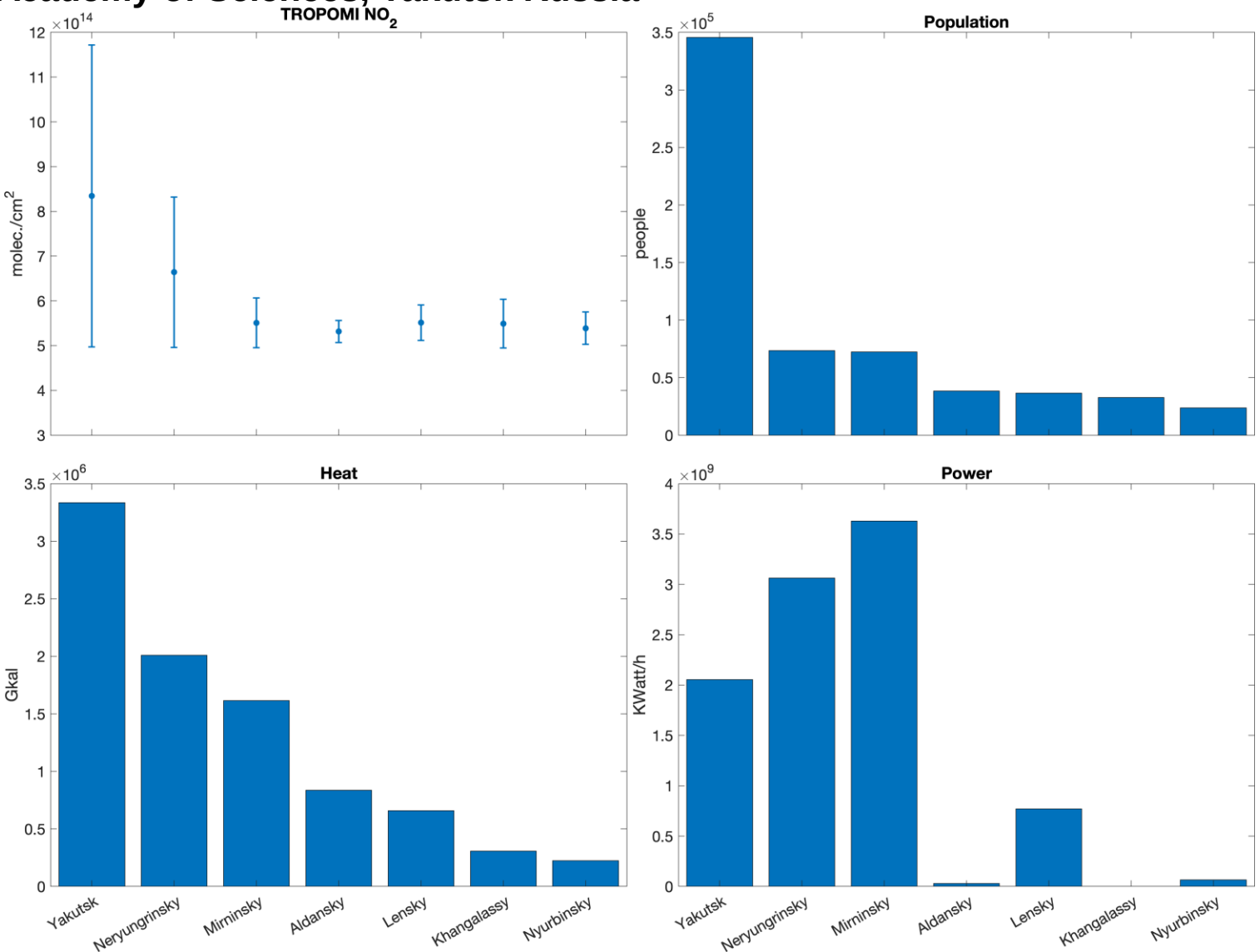
- Case study: Aykhal diamond mines
- NO2 enhancement over the Jubileiny mine
- About 30% increase from 2018 to 2019

Satellite-based NO2 monitoring from energy and extractive sectors in Sakha Republic, Russia

I. Ialongo, H. Virta, FMI – D. Gritsenko, Aleksanteri Institute
N. Stepanova, Arctic Scientific Center of Sakha Academy of Sciences, Yakutsk Russia

- The average district-level TROPOMI NO2 concentration values increase together with population and heat production

- Power generation in the Mirnysky district do not correspond to particularly high NO2 levels, probably because the energy system in the district is largely based on hydropower, oil and gas extraction.



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MethEO – Methane emissions in the Northern Hemisphere by applying both data from Earth Observing (EO) satellites and global atmospheric methane inversion model estimates

https://eo4society.esa.int/projects/metheo/

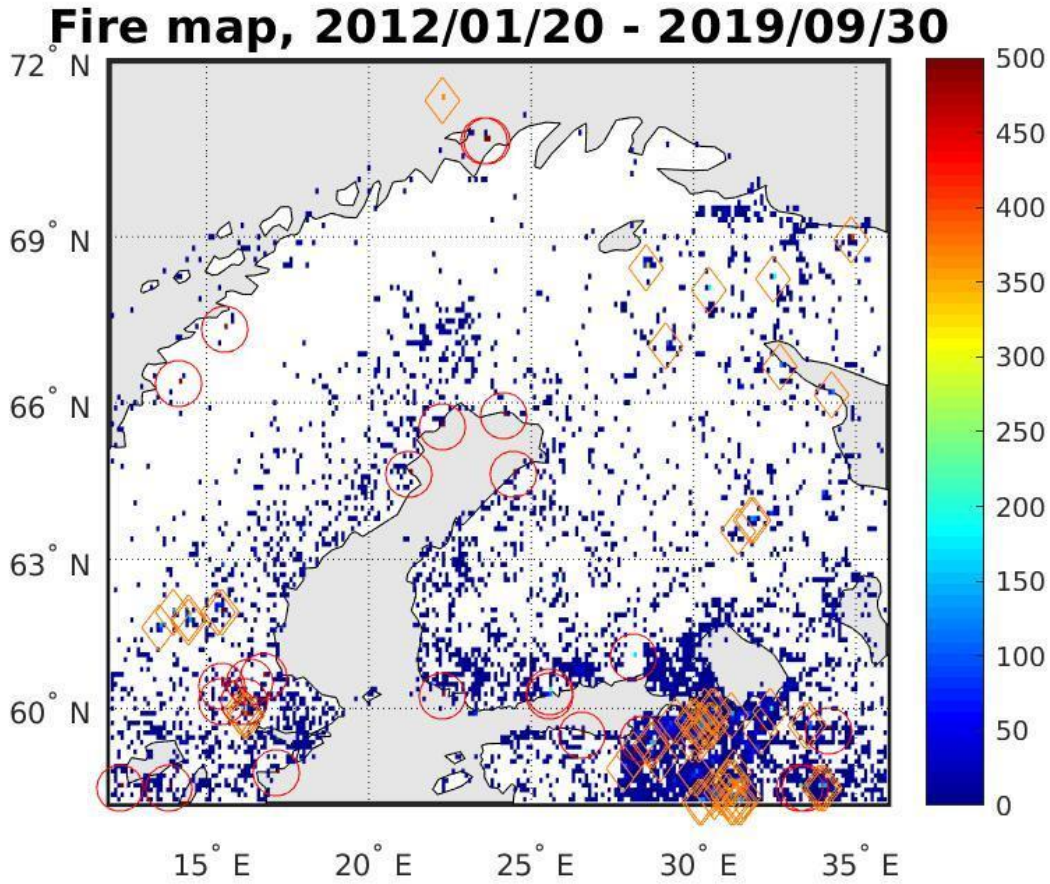
- In this project
  - Northern Hemisphere methane (CH4) sources and their connection to the soil freezing and thawing at high latitudes will be investigated .
  - methods for monitoring of CH4 (methane) emissions in the Northern Hemisphere by applying both data from Earth Observing (EO) satellites and global atmospheric methane inversion model estimates will be innovatively combined .

Forest fires in Fennoscandia under changing climate and forest cover

https://en.ilmatieteenlaitos.fi/iba-forest-fires

This IBA-ForestFires project

- **synthetizes the current knowledge of the occurrence, monitoring, modeling and extinction of forest fires in Fennoscandia and surrounding regions.**
- **project investigates how forest fires can promote black carbon emissions over Arctic.**
- **The results will help Arctic societies to prepare for the negative impacts of climate change and support the development of efficient mitigation strategies.**



Timo H. Virtanen, FMI

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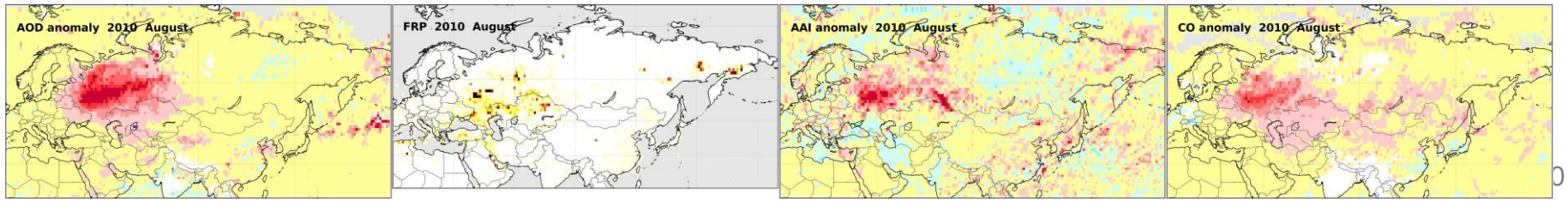
Satellite data for studying contribution of fires, PEEX

https://www.atm.helsinki.fi/peex/index.php/projects

- **AOD –** MODIS, Terra
- **AAI –** multi-satellite product
- **CO –** MOPPIT, Terra
- **FC –** MODIS
- **FRP -** MODIS
- **NO2** – OMI, TROPOMI
- **HCHO** – OMI, TROPOMI
- **SO2** – OMI, TROPOMI

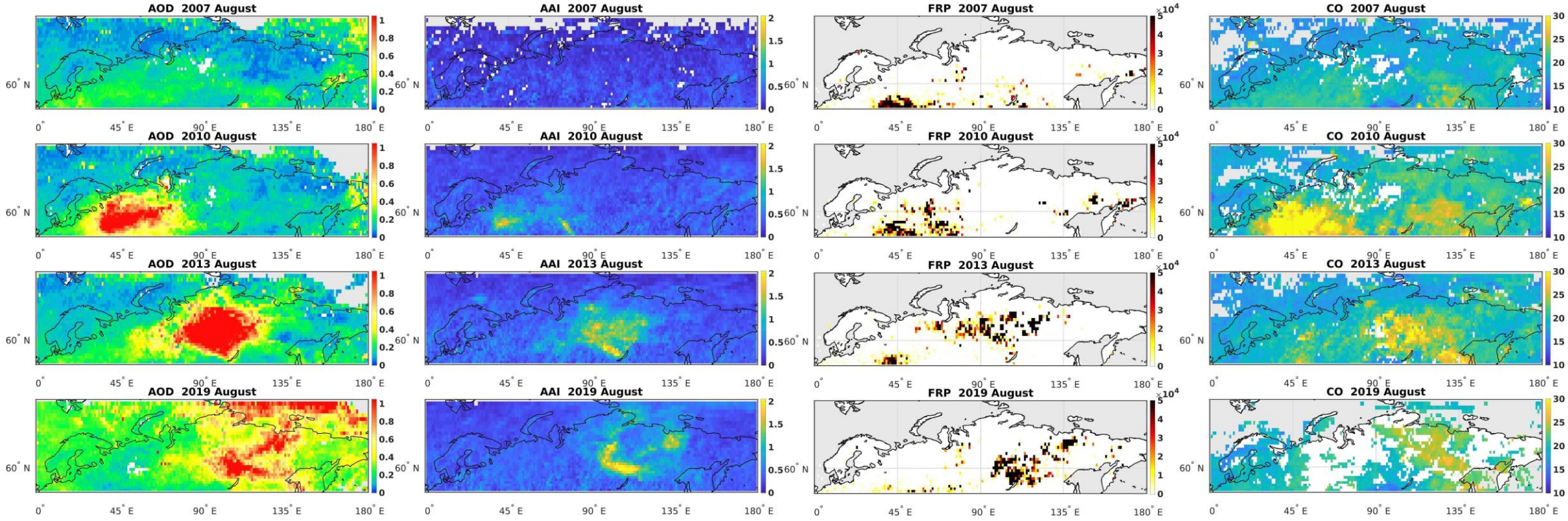
To support satellite-based studies, data from ERA5 model are utilized

- **Temperature**
- **Precipitation**
- **Evaporation**



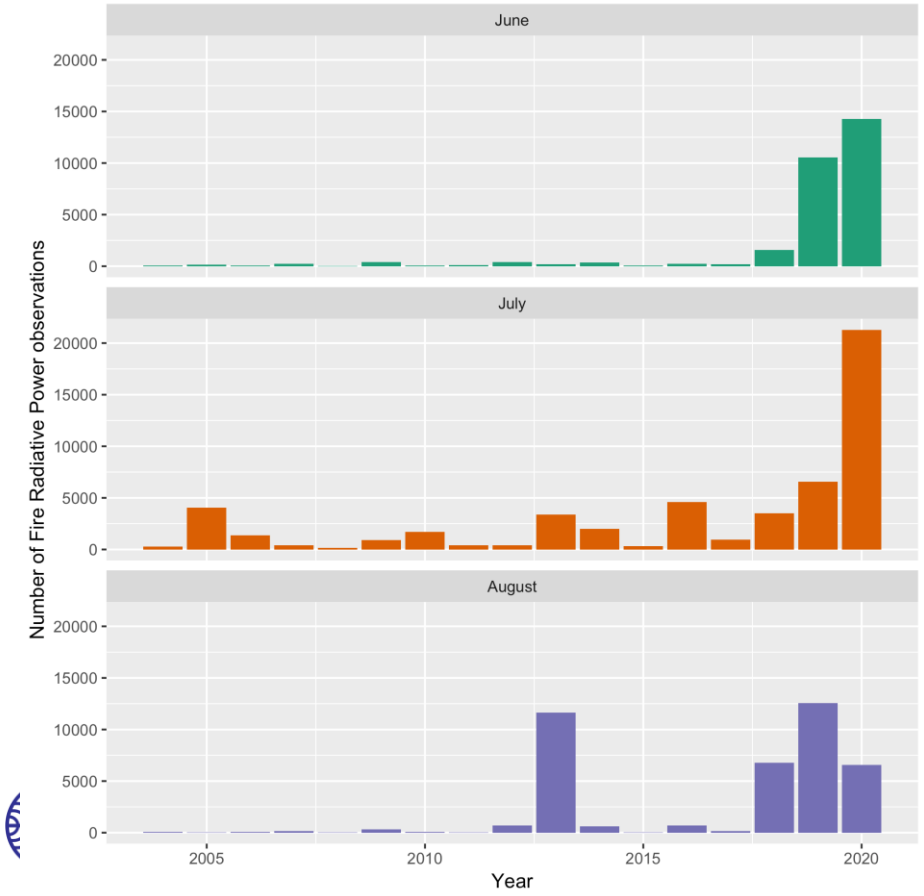
L. Sogacheva , A.-M. Sundström, FMI team

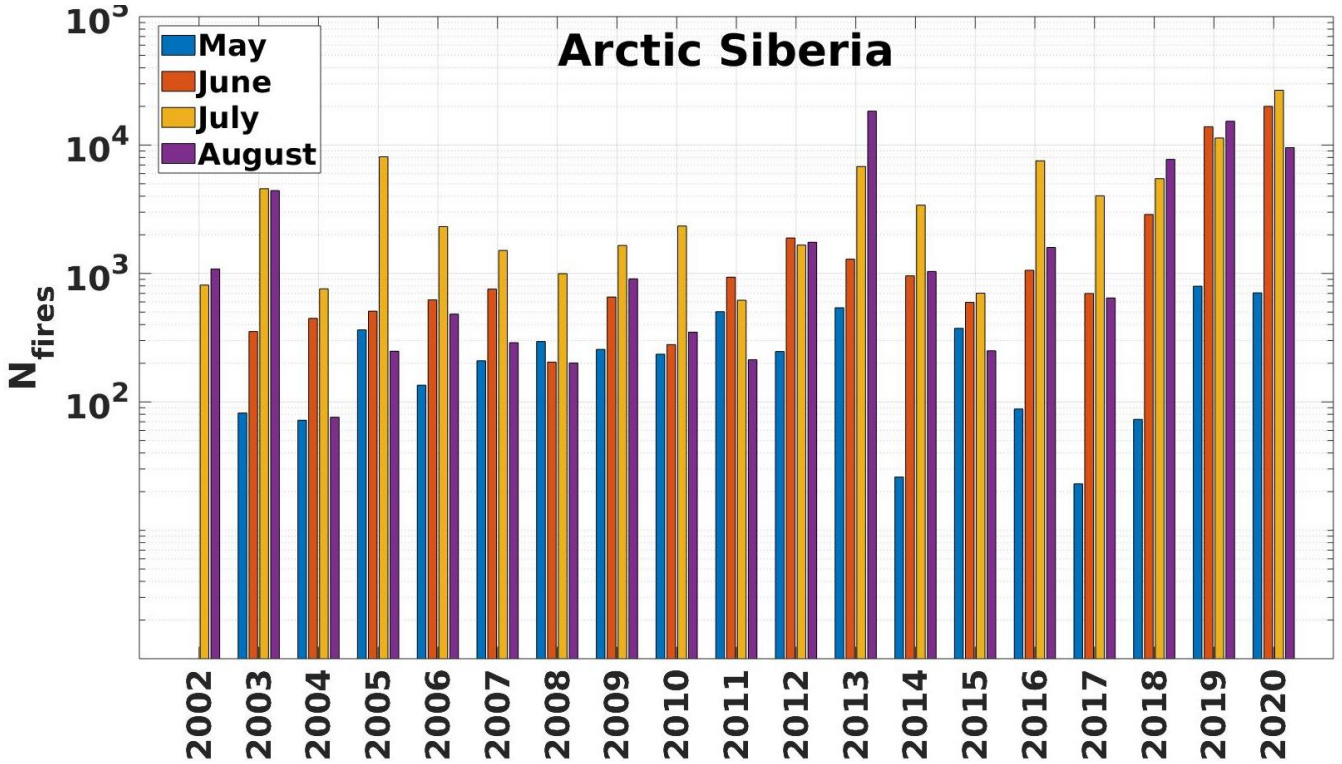
Satellite data for studying contribution of fires, Arctic area (1)



Satellite data for studying contribution of fires, Arctic area (2)

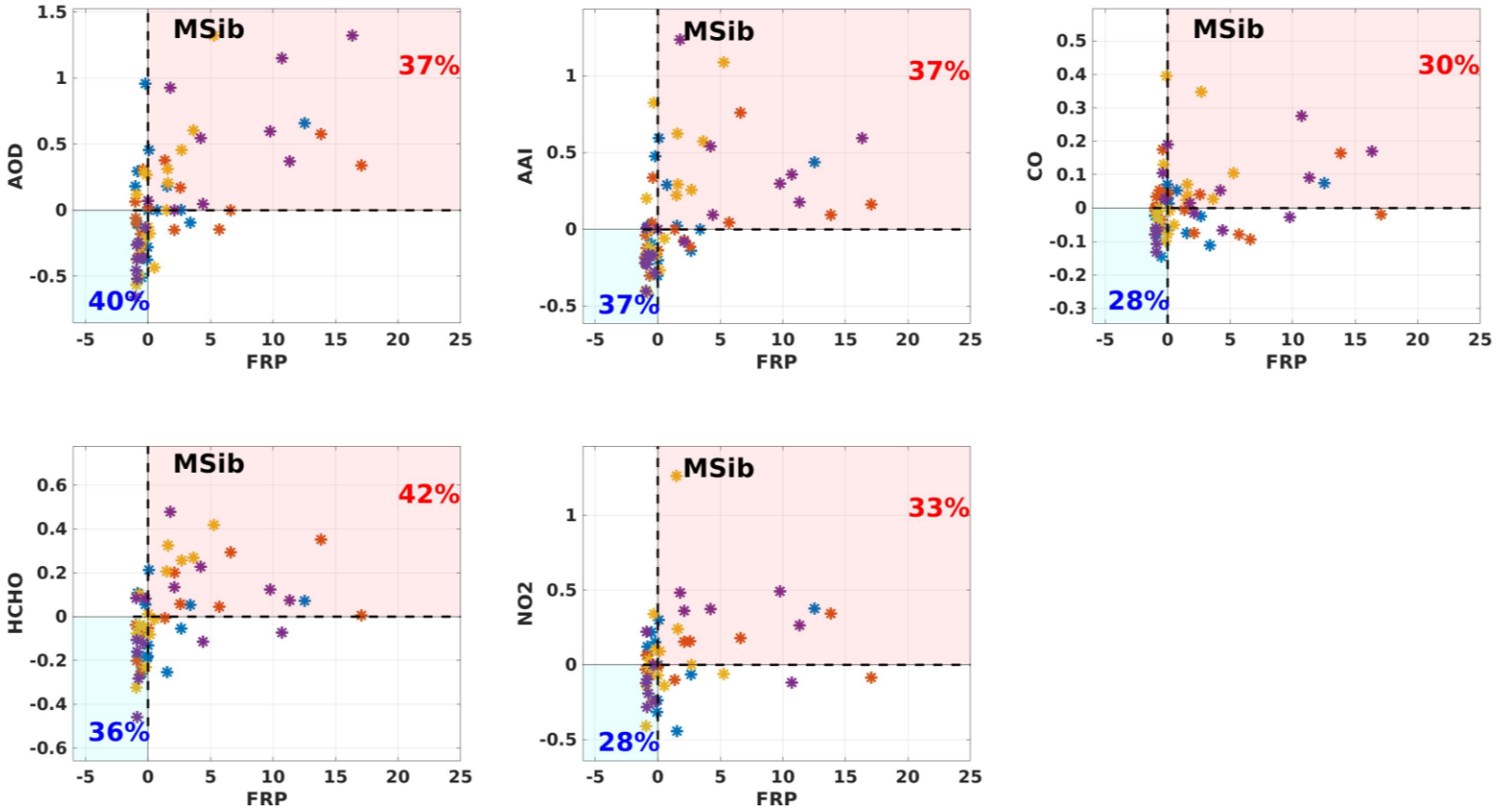
- FRP and N of fires, time series





Satellite data for studying contribution of fires, Arctic area (2)

- FRP and AOD/AAI/CO/HCHO/NO2 anomalies



Conclusions

- Special attention has to be put to the environmental changes happening in Arctic due to the temperature rise
- Satellites provide lots of data which allow following those changes
- We should think how to better utilize data available, in combination with ground-based and modelled data