Two hats:
Experience with the roles as data provider in AC SAF and as heavy data user at FMI

Seppo Hassinen, FMI

Input from: Anu-Maija Sundström
Iolanda Ialongo, Henrik Virta

EUMETSAT
AC SAF
ATMOSPHERIC COMPOSITION MONITORING

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

User Workshop on Satellite Atmospheric Composition: raising awareness and expert consultation, 23-25 June

EUMETSAT
AC SAF
ATMOSPHERIC COMPOSITION MONITORING

Part of EUMETSAT ground segment

FMI
KNMI
DLR
LATMOS
RMI
s[&]t
DWD
ULB
DMI

Major Themes

Ozone chemistry (O3, BrO, OClO)

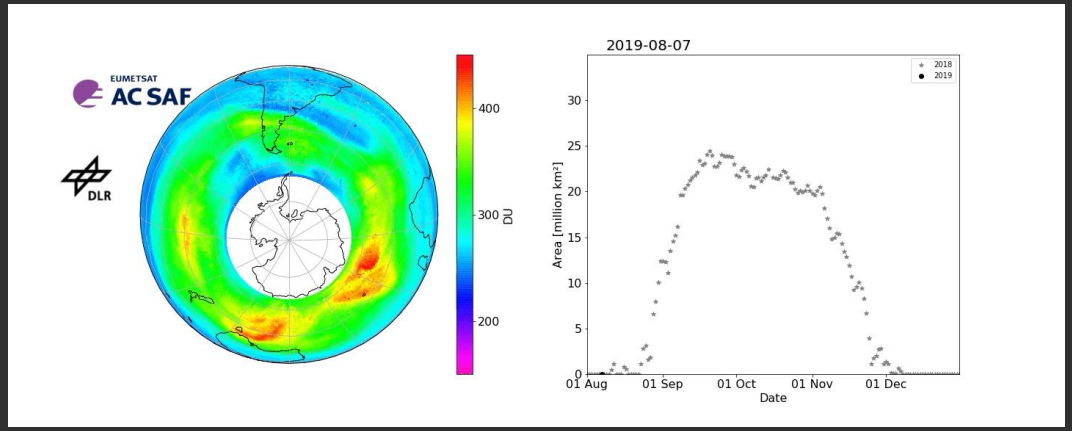
Air quality (NO2, HCHO, aerosols, CO)

Environmental security (Aerosols, NO2, UV)

Natural hazards (SO2, aerosols)

Policy monitoring (O3, NO2, SO2, CO…)

Health (UV, NO2…)



ac-saf.eumetsat.int / acsaf.org
helpdesk@acsaf.org
@Atmospheric_SAF

CDOP-4 planning ongoing (2022-2027)

GOME-2

Total ozone
Ozone profiles
Total NO2
Tropospheric NO2
Total SO2 (volc flag)
Total HCHO
Total BrO
Total H2O
AAI-PMD
LER
NRT and offline UV
AAH
SIF

Reprocessed DRs

IASI

Total CO
Partial CO
Total SO2
Total Ozone
Total HNO3
NH3
Ash
Dust

IASI-NG

CO
O3
HNO3
SO2
NH3
Ash
Dust
.....

IRS

NH3
CO
SO2
Ash
Dust

S4

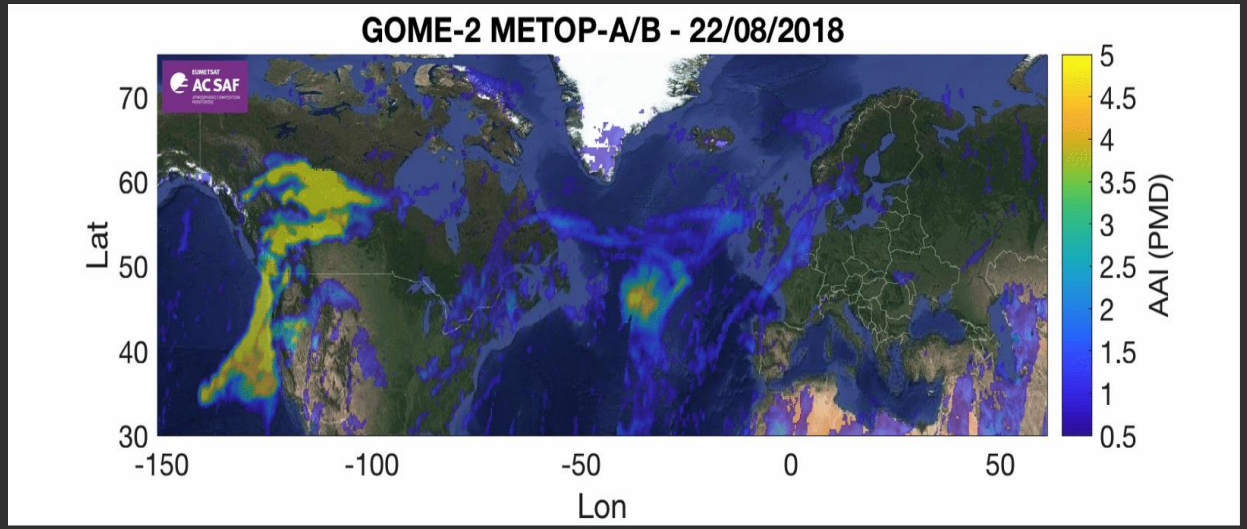
BrO
OClO
H2O
....

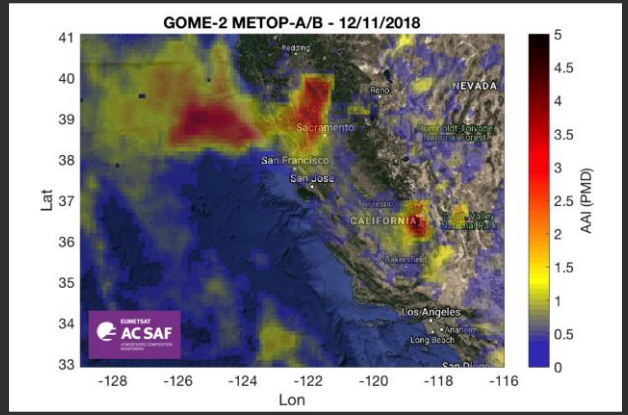
S5

BrO
OClO
H2O
....

The New York Times

Wildfire Becomes Deadliest in California History





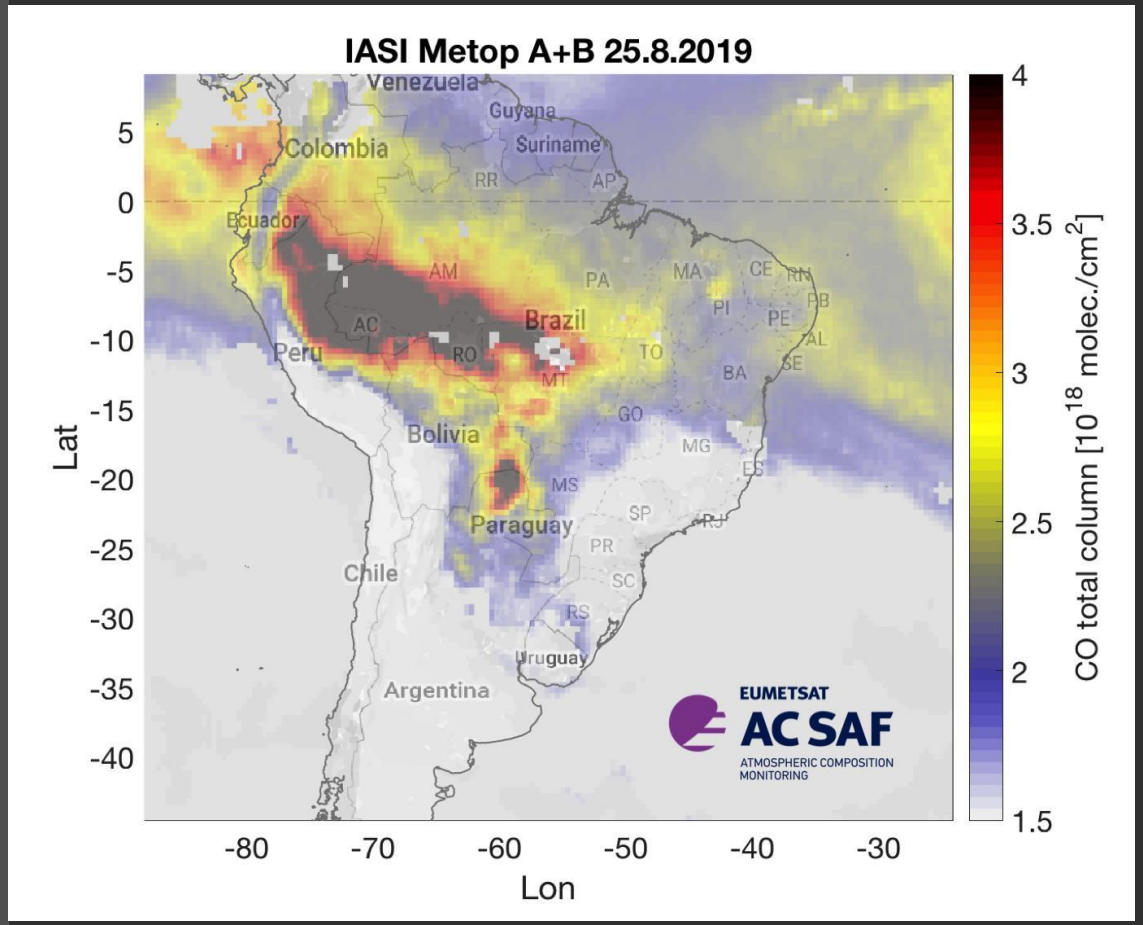
Wildfires in California in 2018

Ecohealthalliance.org

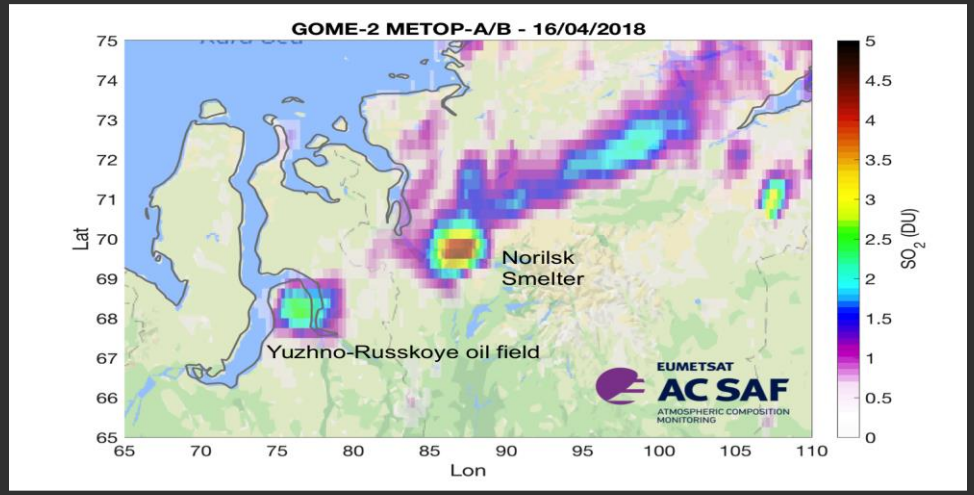
August 2019:

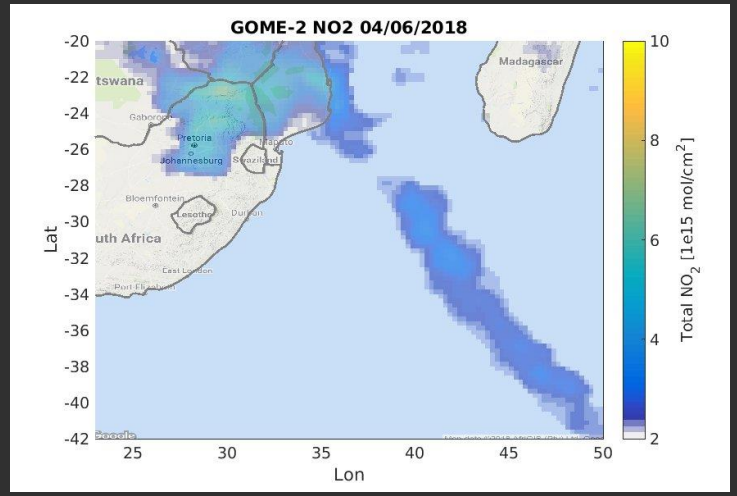
IASI observations show the extent of the carbonmonoxide plume due to Amazon fires.

Enhancements seen in NE are due to transported CO from fires in Africa



Anthropogenic sources

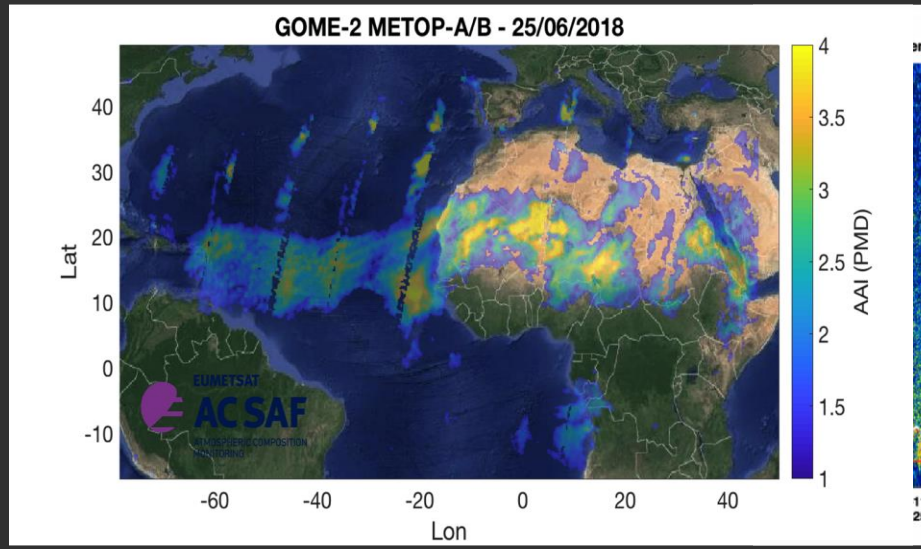


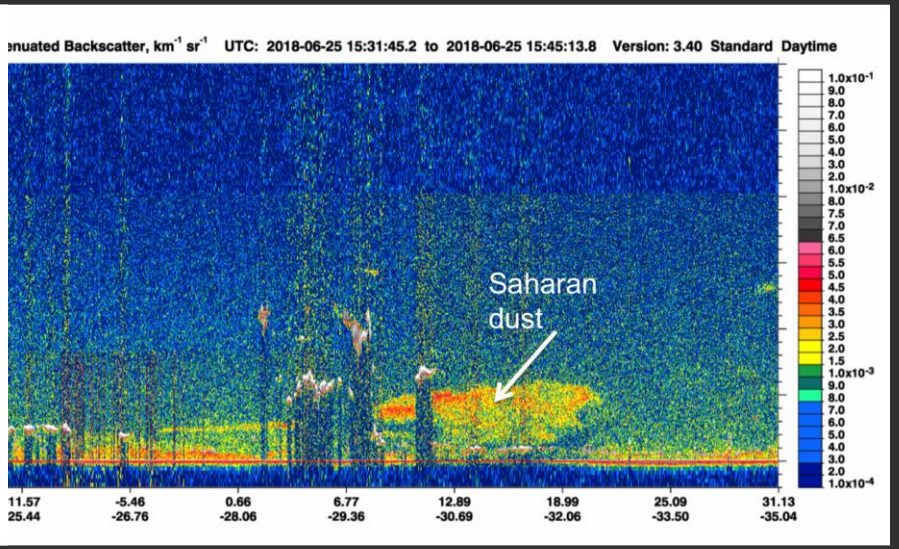


Industrial emissions, SO2 from Norilsk metal smelter on 16/04/2018

NO2 from Highweld in spreading over Botswana , Zimbabwe and Mosambik and southern Indian Ocean on 4th June. Main sources energy production and traffic

Long transport and biochemistry





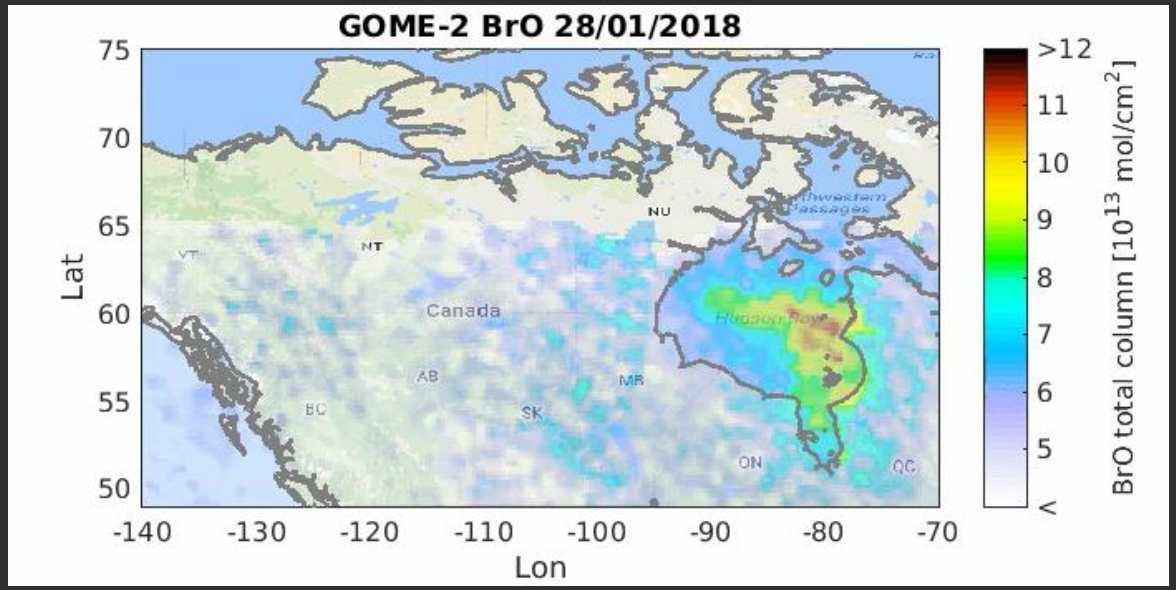
Saharan dust transported to Caribbean. And NASAs Calibso lidar showing dust layers on altitude of 3-6 km.

Effect to biological processes in Caribbean

Aviation services

Volcanic ash, Chile 2015

Volcanic SO2, Vanuatu 2018



BrO measured by GOME-2 between 28th Jan - 17th March 2018 with several strong episodes. The release of BrO in Polar areas requires special conditions related to e.g. sea ice, sea salt aerosols, low temperatures and sunlight.

Difficult to get the user requirements:

- Timeliness – easy
- Accuracy, precission – not so, depends on target applications etc
- Data formats – different opinions, but NetCDF is the way to go?

User commitments to use the data:

- Data providers need this kind of commitments – resource allocations
- Data users does not want to commit themself – fully understandable

L2 versus L3: Depends on user

Data provider opinions

USER trainings and workshops

Participants from various backgrounds: environmental offices, researchers, PhD-students from other fields than remote sensing, start up companies…

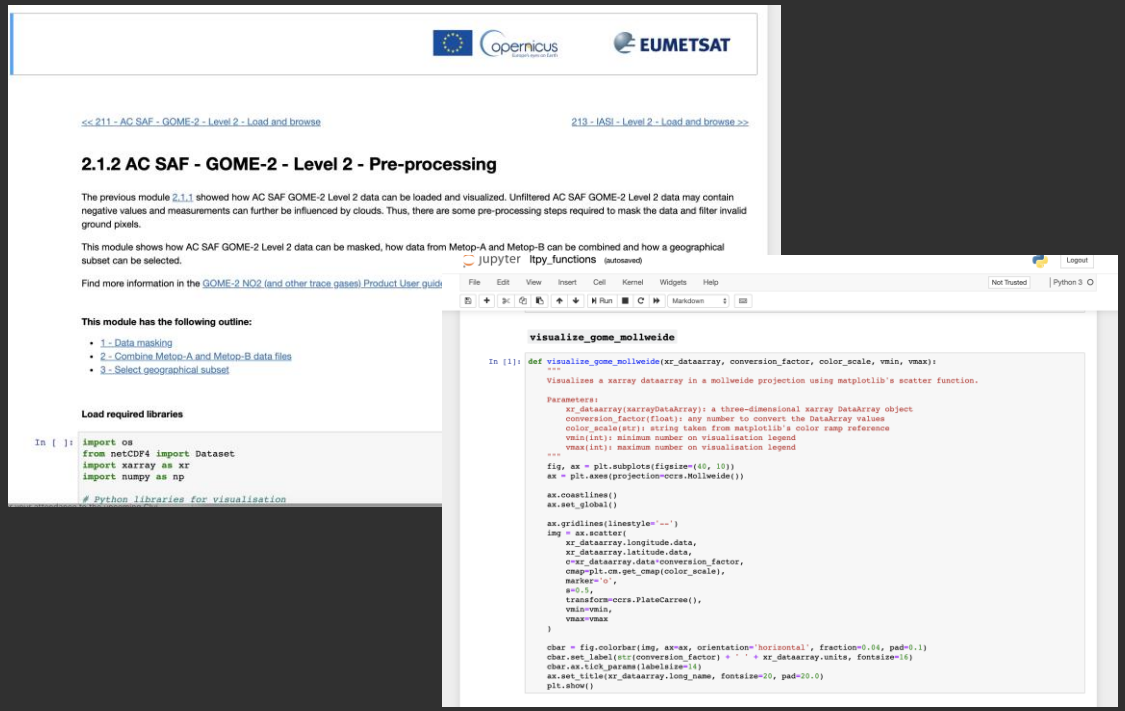
User requirements for data

First joint training course on atmospheric composition, Romania: EUMETSAT, CAMS, ESA, Babeş-Bolyai University

Wekeo / Jupyter Hub

Julia Wageman / MEEO

- Selected data downloaded to hub beforehand
- Jupyter notebook scripts available, executed in the hub with the data
- Easy to test
- Easy to get the first results



<< 211 - AC SAF - GOME-2 - Level 2 - Load and browse

213 - IASI - Level 2 - Load and browse >>

2.1.2 AC SAF - GOME-2 - Level 2 - Pre-processing

The previous module 2.1.1 showed how AC SAF GOME-2 Level 2 data can be loaded and visualized. Unfiltered AC SAF GOME-2 Level 2 data may contain negative values and measurements can further be influenced by clouds. Thus, there are some pre-processing steps required to mask the data and filter invalid ground pixels.

This module shows how AC SAF GOME-2 Level 2 data can be masked, how data from Metop-A and Metop-B can be combined and how a geographical subset can be selected.

Find more information in the GOME-2 NO2 (and other trace gases) Product User guid

This module has the following outline:

- 1 - Data masking
- 2 - Combine Metop-A and Metop-B data files
- 3 - Select geographical subset

Load required libraries

```
In [ ]: import os
        from netCDF4 import Dataset
        import xarray as xr
        import numpy as np

        # Python libraries for visualisation
```

jupyter ltpy_functions (autosaved)

File Edit View Insert Cell Kernel Widgets Help

Not Trusted | Python 3

visualize_gome_mollweide

```
In [1]: def visualize_gome_mollweide(xr_dataarray, conversion_factor, color_scale, vmin, vmax):
            """
            Visualizes a xarray dataarray in a mollweide projection using matplotlib's scatter function.

            Parameters:
                xr_dataarray(xarrayDataArray): a three-dimensional xarray DataArray object
                conversion_factor(float): any number to convert the DataArray values
                color_scale(str): string taken from matplotlib's color ramp reference
                vmin(int): minimum number on visualisation legend
                vmax(int): maximum number on visualisation legend
            """
            fig, ax = plt.subplots(figsize=(40, 10))
            ax = plt.axes(projection=ccrs.Mollweide())

            ax.coastlines()
            ax.set_global()

            ax.gridlines(linestyle='--')
            img = ax.scatter(
                xr_dataarray.longitude.data,
                xr_dataarray.latitude.data,
                c=xr_dataarray.data*conversion_factor,
                cmap=plt.cm.get_cmap(color_scale),
                marker='o',
                s=0.5,
                transform=ccrs.PlateCarree(),
                vmin=vmin,
                vmax=vmax
            )

            cbar = fig.colorbar(img, ax=ax, orientation='horizontal', fraction=0.04, pad=0.1)
            cbar.set_label(str(conversion_factor) + ' ' + xr_dataarray.units, fontsize=16)
            cbar.ax.tick_params(labelsize=14)
            ax.set_title(xr_dataarray.long_name, fontsize=20, pad=20.0)
            plt.show()
```

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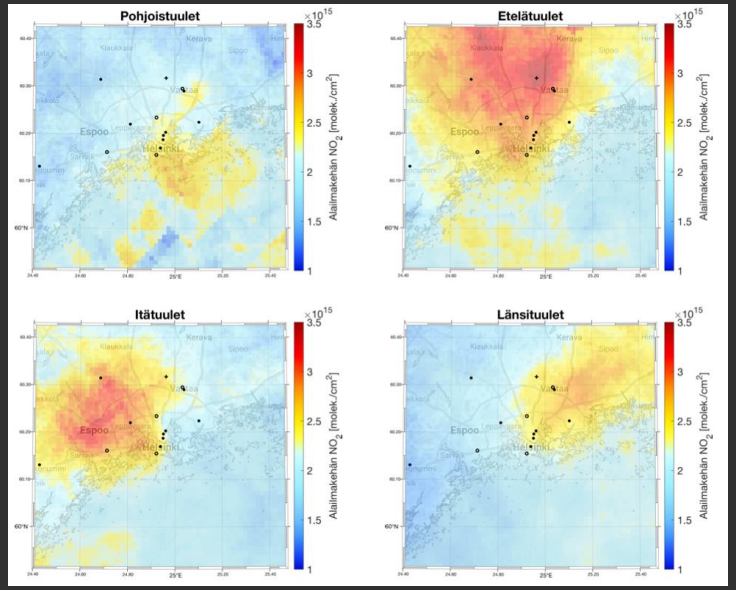
Heavy data user:

Weather services
Research:
- Marine
- Atmosphere
- Cryosphere
- Air quality
- Climate
- Space

Atmospheric composition point of view

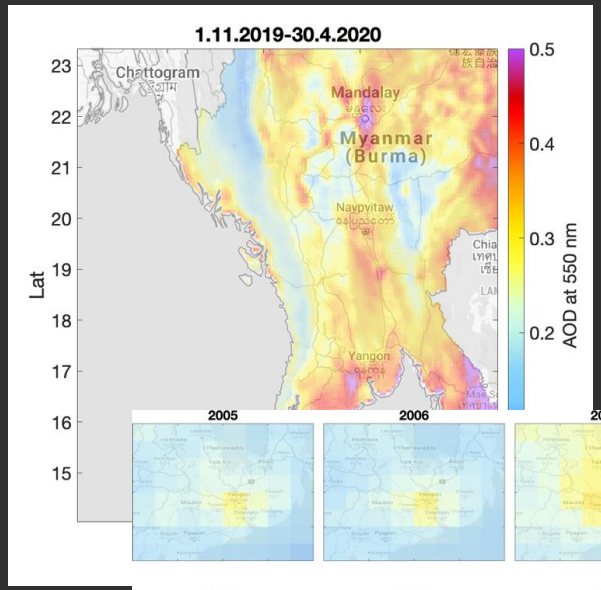
Reports for domestic authorities

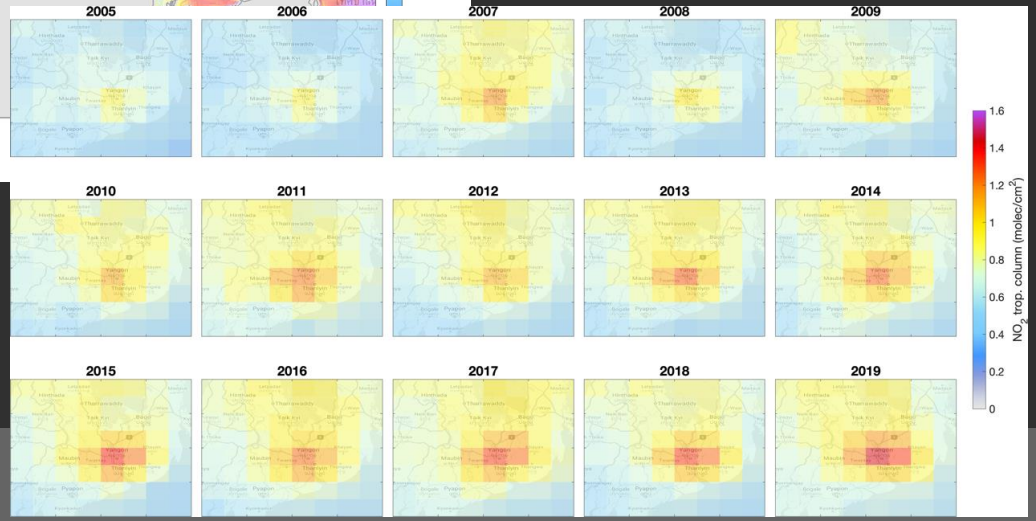


Ministry of Environment: Satellite observations to monitor AQ

NO2 over Helsinki, Finland: Effect of the wind direction

Reports for international organizations

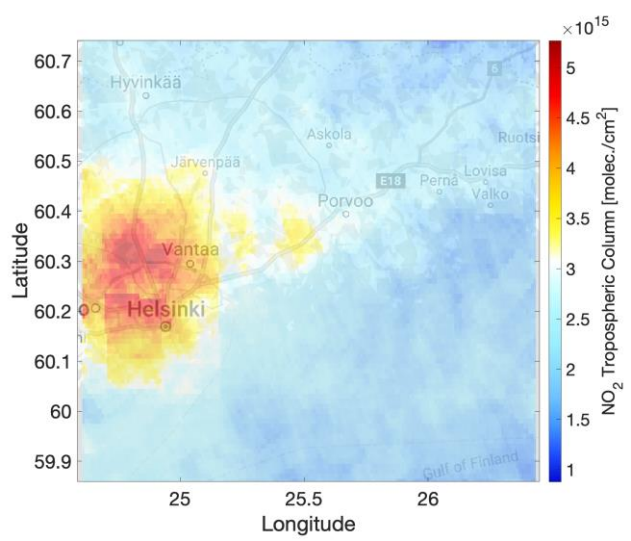




Reports on air quality, like for World Bank, SPARC….

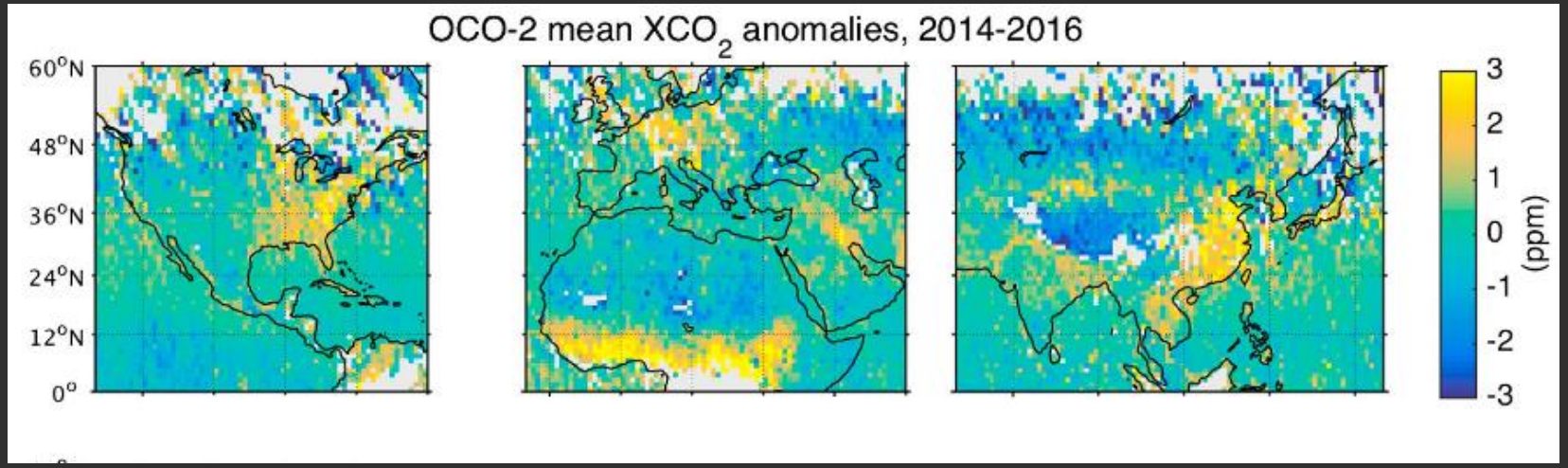
Reports for private sector

Private sector example: Satellite AQ data support sustainable development, Neste refinery near Helsinki



https://www.dropbox.com/s/1v44pgs6375x6q1/Neste%2520Sustainability%2520Report%25202018.pdf?dl=0

Science

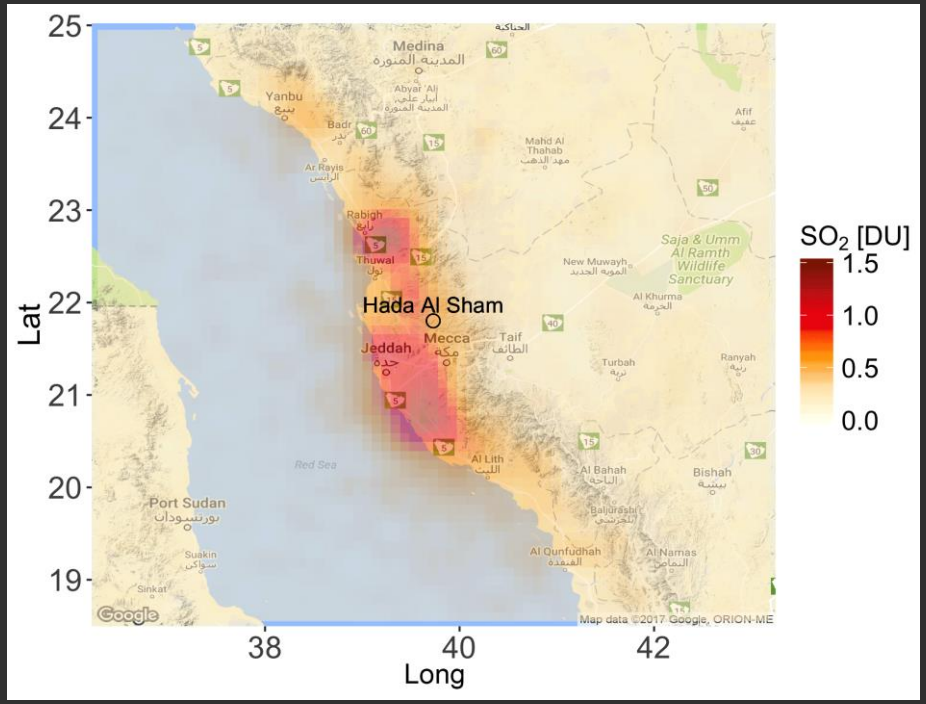


Anthropogenic CO2 emission areas from OCO-2

Hakkarainen, J., I. Ialongo, and J. Tamminen (2016), Direct space-based observations of anthropogenic CO2emission areas from OCO-2,Geo-phys. Res. Lett.,43, 11,400–11,406,doi:10.1002/2016GL070885.

Science

Average OMI boundary layer SO2 around Hada Al Sham, Saudi Arabia



Hakala, S., Alghamdi, M. A., Paasonen, P., Vakkari, V., Khoder, M. I., Neitola, K., Dada, L., Abdelmaksoud, A. S., Al-Jeelani, H., Shabbaj, I. I., Almehmadi, F. M., Sundström, A.-M., Lihavainen, H., Kerminen, V.-M., Kontkanen, J., Kulmala, M., Hussein, T., and Hyvärinen, A.-P.: New particle formation, growth and apparent shrinkage at a rural background site in western Saudi Arabia, Atmos. Chem. Phys., 19, 10537–10555, https://doi.org/10.5194/acp-19-10537-2019, 2019..

Data formats:

- Data stored in such a way that modern interfaces (like Panobly, pcolormesh) can read and map the files (= no 1D structures)
- Consistent file structure with date and time parameters
- Level 3 -> Daily global maps
- NetCDF instead of BUFR or native formats

Data size:

- File sizes should be manageable (full data versus selected parameters / spatial area)

Interfaces:

- Easy to download: Good APIs, WMS for quick looks, simple FTP services

Data user opinions