

# New Pandora Spectrometer instrument and opportunities for Atmospheric Cal/Val in Arctic areas

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# Sverdrup Station in Ny-Ålesund Svalbard, Norway

Located at 78N, 11E, the Sverdrup station in Ny-Ålesund, Svalbard is one of the northernmost research stations in the world.

The institute has a permanent staff of five on site and operates permanent research programs and supports visiting scientists with established or new research activities in Ny-Ålesund.

Scientific research, mapping and monitoring of climate, environmental pollutants, biodiversity and geological mapping are important fields of work in Ny-Ålesund.



# Sverdrup Station in Ny-Ålesund Svalbard, Norway

The Norwegian Polar Institute has had year-round operations in Ny-Ålesund since 1968, the building “*Sverdrup*”, a modern 700 m<sup>2</sup> building, was opened in 1999.

NILU is responsible for the data and the project management, while the daily maintenance will be handled through a service contract with the Polar Institute.

Ny-Ålesund is an unique site for observations of changes in the background level of atmospheric components and other Arctic data. Concentrations of the measured components are significantly lower than at other sites at the Northern hemisphere, due to the station’s remote location.



# Pandora at Svalbard, Norway

## ***Our team***

NILU: Are and Dorothea (engineers), Ann Mari (scientific responsible), Georg (project manager)  
Norwegian Polar Institute: (operational engineers)

## ***Funding***

Norwegian Space Centre

SIOS – Svalbard Integrated Arctic Earth Observing System





# Pandora at Svalbard, Norway

The instrument is a dual spectrometer, installed on the roof top of the Sverdrup building in August 2019.

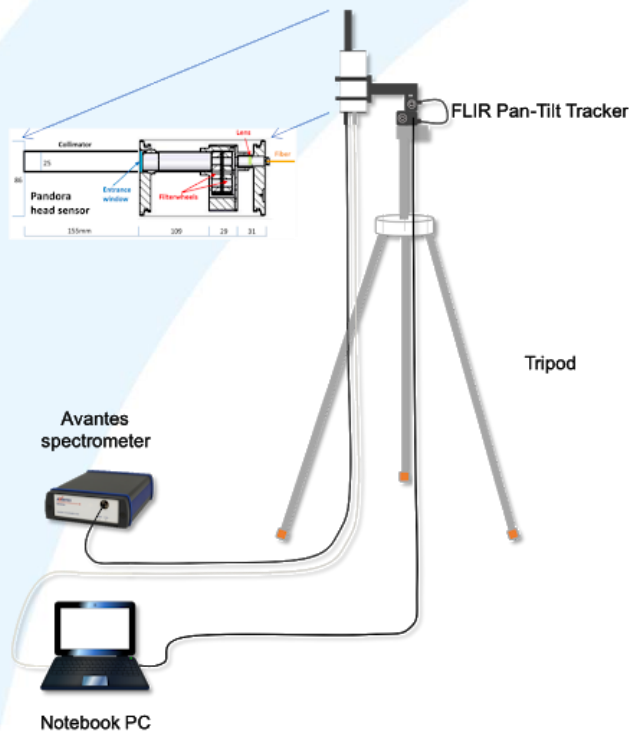
Spectroscopy is used to measure columnar amounts of trace gases in the atmosphere. These gases ( $O_3$ ,  $NO_2$ ,  $CH_2O$ ) absorb specific wavelengths of light from the sun/moon in the ultraviolet-visible spectrum.

The instrument can measure all year around, sun and moon synchronous. The polar night in Ny-Ålesund lasts from 24.October to 18.February.



# Pandora at Svalbard, Norway

Using the theoretical solar spectrum as a reference, Pandora determines trace gas amounts using differential optical absorption spectroscopy (DOAS). This principle attributes differences in spectra measured by Pandora to the presence of trace gases within the atmosphere (i.e. the difference between the theoretical solar spectrum and measured spectrum is caused by absorption of trace gas species).



# Satellite Validation Approach

## Main goals of Satellite Validation:

To provide products with **documented** and associated **traceable error bars**

Gain knowledge in **sensor characteristics** and **algorithms** in order to improve their quality and reliability.

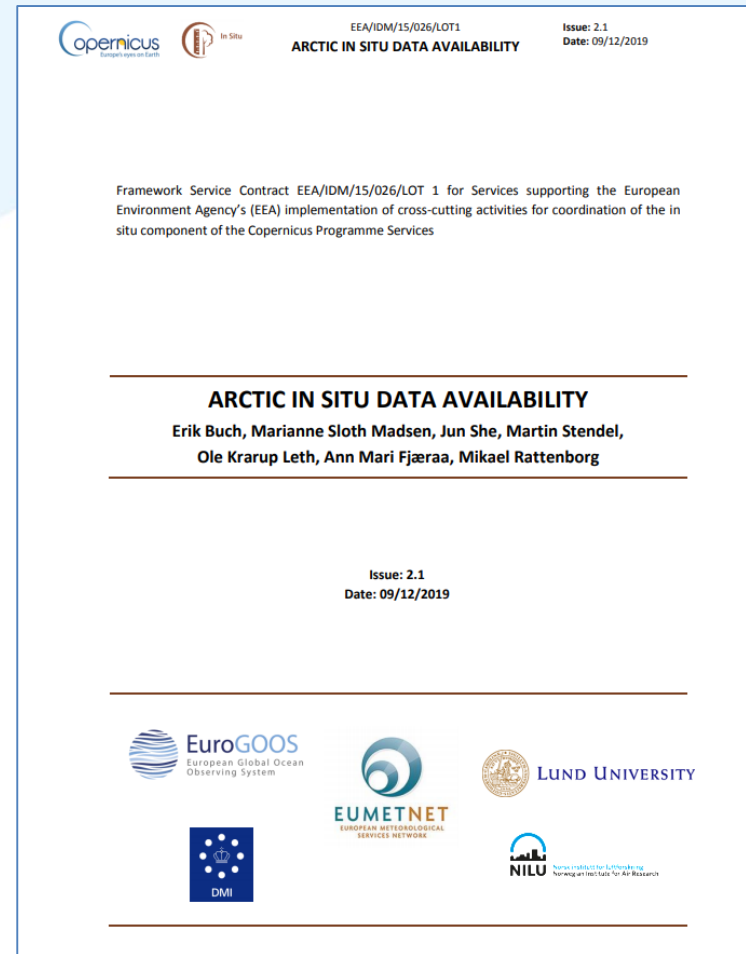
The **accuracy in the uncertainties** has a **long term impact** for most applications, e.g. in particular for climate.

Validation activities are a key component of a mission

Foundation for user credibility into data

Requires **continuous effort** during and after the mission life time

*FRM particular important, gives properly characterised reference, traceable to standards on which validation results can be anchored*



# Pandora as Reference Instrument for Measurements of Atmospheric Composition

In 2005 NASA initiated an effort at Goddard Space Flight Center (GSFC) to address **the gap in validation measurements** through the development of cost-effective, easy to deploy, **ground-based spectrometer called Pandora.**

NASA and ESA are collaborating to coordinate and **facilitate an expanding global network of standardized, calibrated Pandora instruments focused on air quality and atmospheric composition** and to ensure systematic processing and dissemination of the data to the greater global community in **support of in-situ and remotely sensed AQ monitoring.**

A major objective is to **support the validation and verification** of low-earth orbit and geostationary orbit based UV-visible sensors, **most notably Sentinel 5P, TEMPO, GEMS and Sentinel 4.**

The instruments provides **real-time, standardized, calibrated** and verified QA/QC data.

There are more than 120 Pandoras around the world.



# Pandora as Reference Instrument for Measurements of Atmospheric Composition

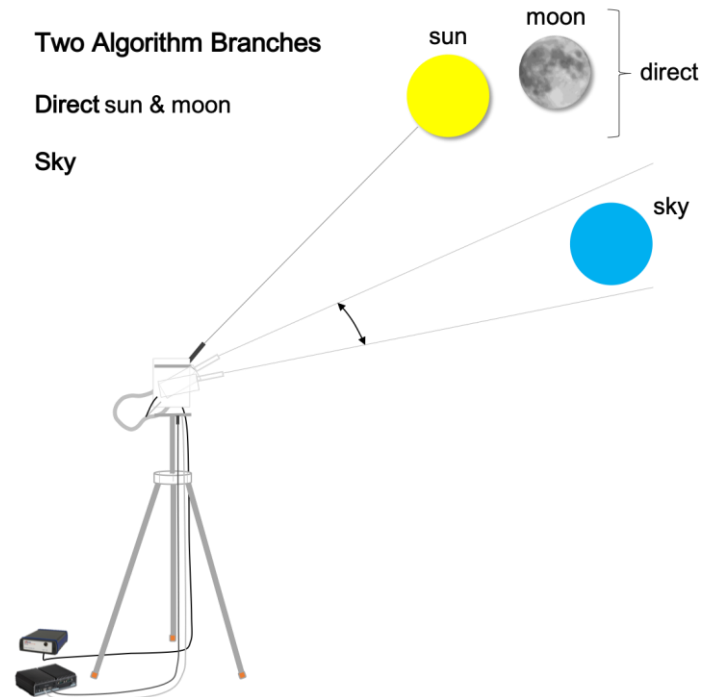
## What can the Pandora measure?

The Pandora spectrometer system is an instrument developed to measure vertical column densities of trace gases in the atmosphere using sun/lunar and sky radiation in the UV-visible part of the spectrum. Among currently experimental data products, such as  $\text{SO}_2$  and  $\text{CH}_2\text{O}$ , validated and near-real-time  $\text{O}_3$  and  $\text{NO}_2$  total vertical column density (VCD) data products are included.

## How does the Pandora take its measurements?

Pandora spectrometer instrument spectroscopy is used to measure columnar amounts of trace gases in the atmosphere. These gases ( $\text{O}_3$ ,  $\text{NO}_2$ ,  $\text{CH}_2\text{O}$ ) absorb specific wavelengths of light from the sun in the ultraviolet-visible spectrum.

Using the theoretical solar spectrum as a reference, Pandora determines trace gas amounts using differential optical absorption spectroscopy (DOAS).



# Pandora as Reference Instrument for Measurements of Atmospheric Composition

## Can anyone access the data from the Svalbard Pandora and other Pandora instruments?

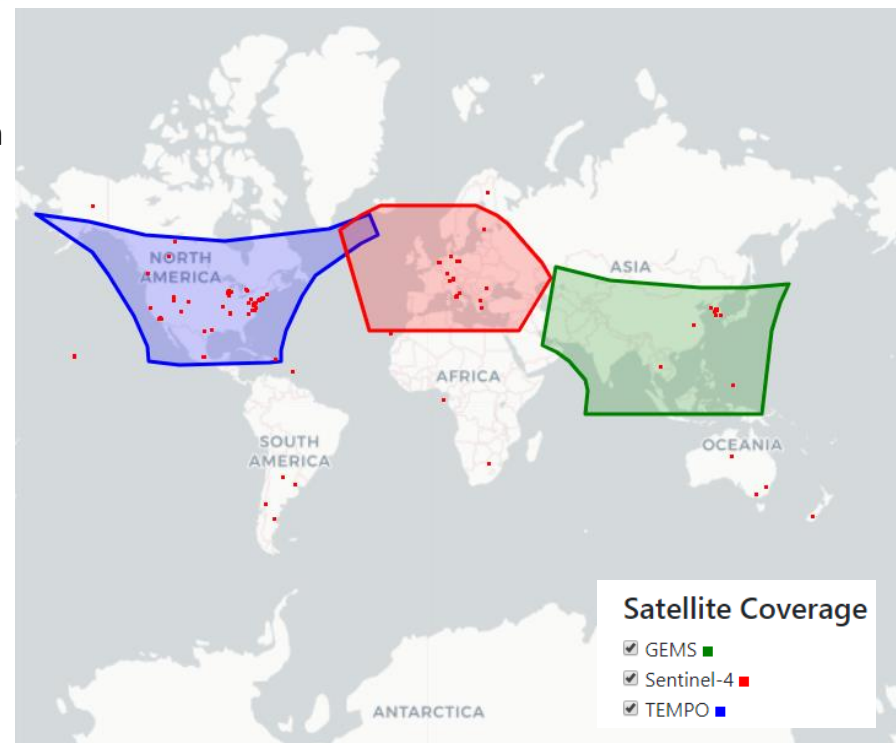
Yes, the data are free of charge and open\* accessible via the EVDC data portal at <https://evdc.esa.int> .

(\*Data users must accept the data policy)

## Why is the Svalbard Pandora so unique?

The Svalbard is unique in the meaning of being located in a very remote place, a location that is relatively “clean” and far away from polluted industrialized areas.

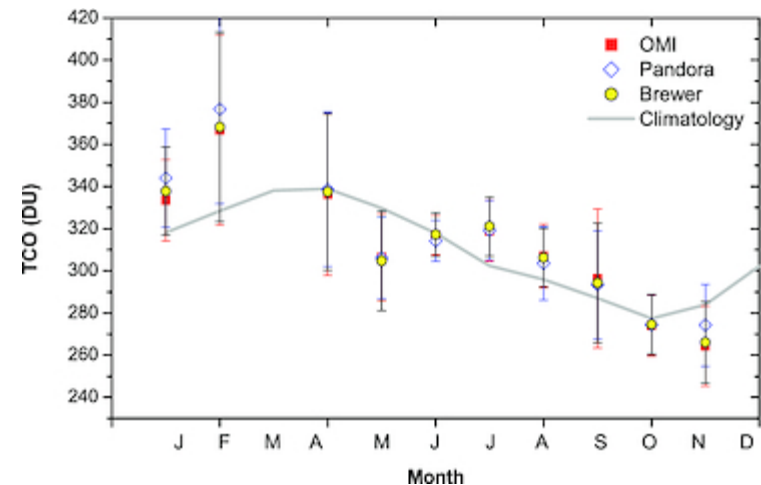
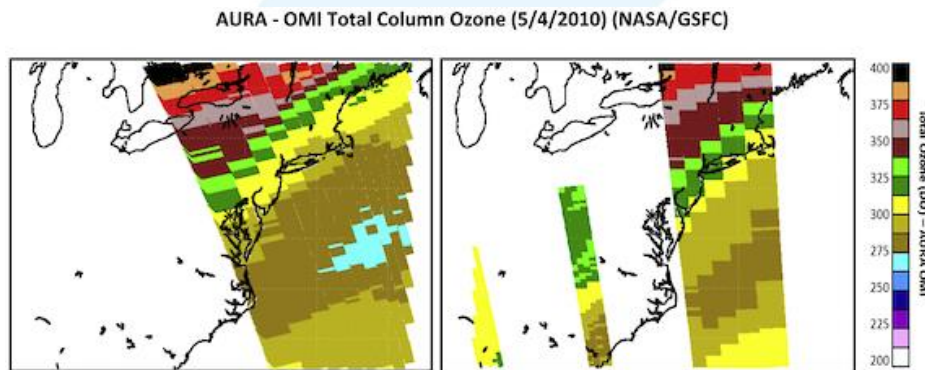
Clean areas = reference areas.



# Pandora as Reference Instrument for Measurements of Atmospheric Composition

## Which are the possible Cal/Val activities with focus on the Arctic?

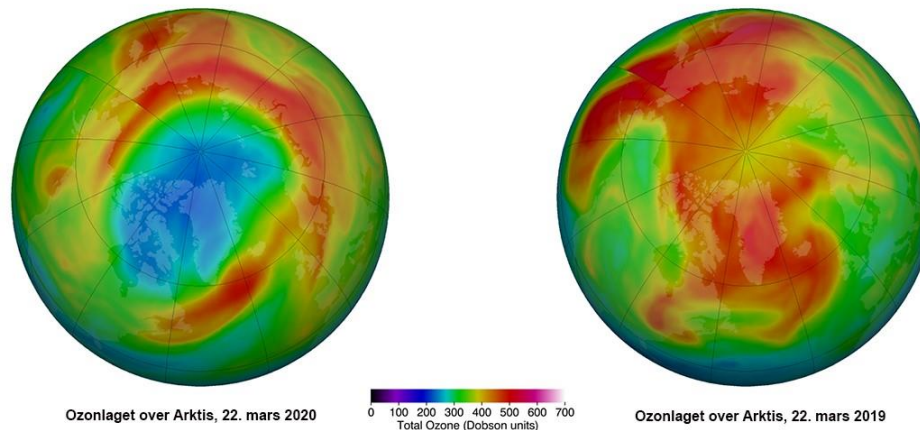
- trace gas measurements at high latitudes, e.g. by comparisons between Pandora and existing ozone network. (Brewer, S5P).
- study temporal dynamics in ozone and short-term changes in concentrations not possible to capture by sun synchronous satellite observations, alone.
- reveal variations that are not usually included in e.g. the UV index forecast?



# Pandora as Reference Instrument for Measurements of Atmospheric Composition

## Which are the possible Cal/Val activities with focus on the Arctic?

- The discovery of the Antarctic "ozone hole" in the mid 1980's initiated several ozone monitoring activities also at northern high latitudes.
- The discovery of the "new ozone hole" in Arctic areas in Winter 2019/2020 is opening for new possibilities



# Pandora as Reference Instrument for Measurements of Atmospheric Composition

## Which are the possible Cal/Val activities with focus on the Arctic?

- Validation of S5P measured  $C(NO_2)$  is essential for the scientific use of the satellite data for air quality, for atmospheric photolysis and chemistry, and for retrieval of other quantities (e.g., accurate atmospheric correction for satellite estimates of ocean reflectance and bio-optical properties).
- Formaldehyde as tracer – what is released from forest fires, combined with transport into Arctic Areas. So far only performed for areas outside the polar regions.
- Large differences in the predominant formaldehyde concentrations and transport issues in the dark and light periods can be examined.

