



Kartverket

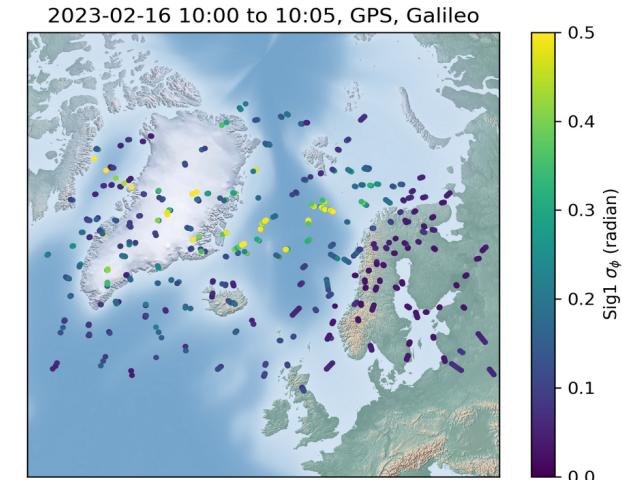
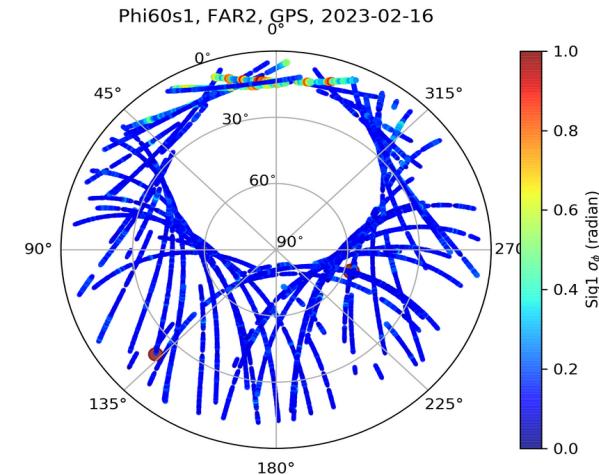
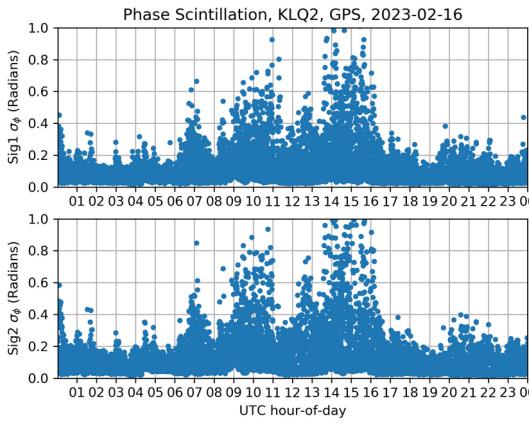


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BiScEF - A new format for archiving and sharing scintillation data

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Bi – Binary **Sc** – Scintillation **EF** – Exchange Format



BiScEF format

The format is intended to be used for archiving and exchange of scintillation data.

It is a flexible and extensible format. Although it defines many parameters and datasets, only a minimum set of information is mandatory.

It is based on NetCDF4 / HDF5 (A BiScEF file is both a valid NetCDF4 file and a valid HDF5 file)

Many metadata fields are defined. Some of these are mandatory. They are Attributes in the Root Group in the file.

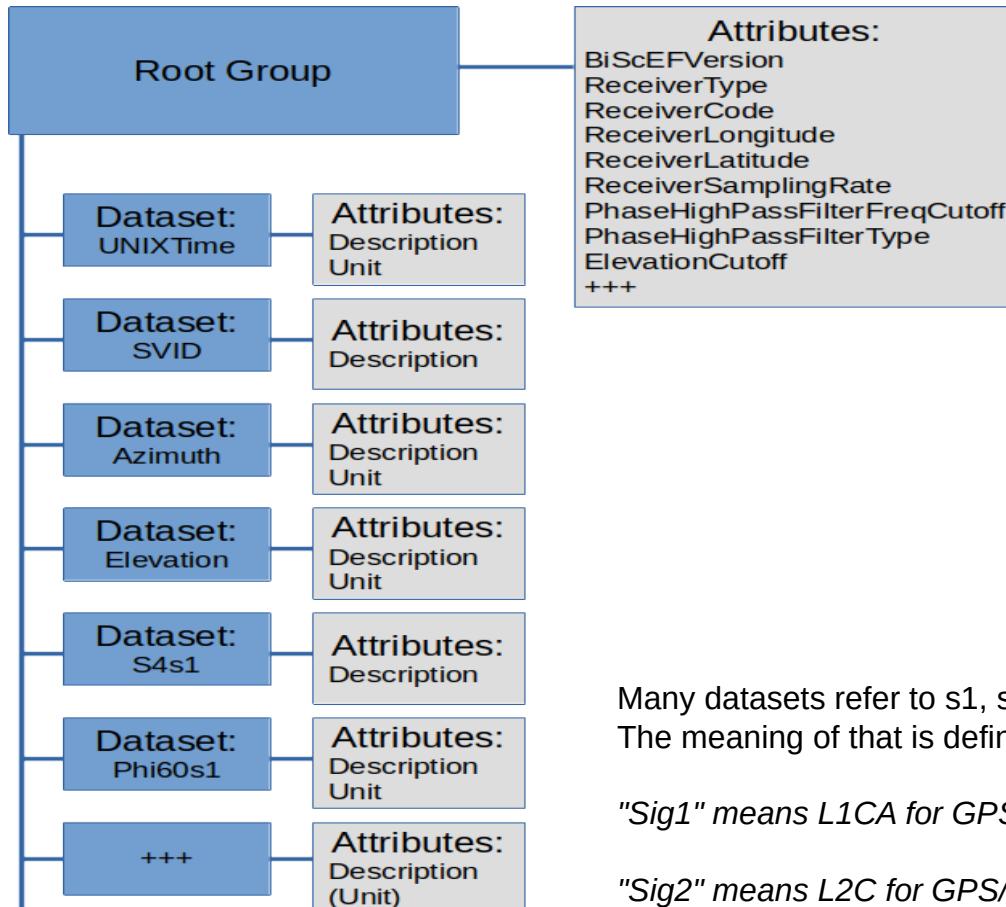
Data are organized as separate datasets containing 1D arrays in time.

All arrays are of the same length, such that all data at the same index are associated.

All datasets in the file share the same dimension "UNIXTime".

This has been chosen to provide all data on a common time axis which is not dependent on the GNSS constellation, and is supported by all computer systems.

BiScEF format



The Attributes list connected to the Root Group shows the mandatory attributes.

The Dataset boxes shows some common datasets. UNIXTime, SVID, Azimuth and Elevation are mandatory.

S4s1 (S4 for signal 1) and Phi60s1 (sigma phi for signal 1) are not mandatory, but expected to often be present.

There are many more datasets defined in the format description.

Many datasets refer to s1, s2, s3 («signal 1», «signal 2», «signal 3»). The meaning of that is defined in one of the metadata fields. We currently use this definition:

"Sig1" means L1CA for GPS/GLONASS/SBAS/QZSS, L1BC for Galileo, B1 for BeiDou.

"Sig2" means L2C for GPS/GLONASS/QZSS, E5a for Galileo, L5 for SBAS, B2 for BeiDou.

"Sig3" means L5 for GPS/QZSS or E5b for Galileo.

BiScEF format – On the web

The format description is available on the web, in a git repository:

<https://github.com/kartverket/BiScEF/>

The repo also contains:

- Data files for 3 scintillation events in 2023.
- Some example plots from those data
- Python scripts that can be used to generate plots from BiScEF format files.

The screenshot shows the GitHub repository page for 'BiScEF' owned by 'kartverket'. The main area displays a list of commits, showing updates to README.md, ExampleEvents, ExamplePlots, Python, and various format description files like BiScEF_FormatDescription_v1.0.odt and BiScEF_Structure.odg. The repository has 40 commits and was last updated on Sep 26. The 'About' section includes links to the Readme, MIT license, Activity, and Report repository. The 'Releases' section indicates no releases have been published. The 'Packages' section shows no packages have been published. The 'Contributors' section lists three contributors: saschu-space, stenseng Lars Stenseng, and knutstanley Knut.

BiScEF format – Example data

Example data files in the BiScEF format are provided in the git repository for three events in 2023. While these are not the most spectacular events they do contain measurements of scintillation activity. Feel free to use them for scientific studies, with appropriate acknowledgements.

Event #1

2023-01-13, 2023-01-14, 2023-01-15

Event #2

2023-02-14, 2023-02-15, 2023-02-16

Event #3

2023-03-02, 2023-03-03

The screenshot shows a GitHub repository page for 'kartverket / BiScEF'. The 'Code' tab is selected. On the left, there's a file tree under the 'ExampleEvents' folder, which contains sub-folders for different event periods: '20230113to20230115', '20230214to20230216', and '20230302to20230303'. Each folder contains several .nc files. On the right, there's a table showing the commit history for the 'ExampleEvents' folder. The commits are from a user named 'saschu-space' and are dated 15bad10, 2 months ago. The commits are:

| Name | Last commit message | Last commit date |
|--------------------|-------------------------|------------------|
| ... | | |
| 20230113to20230115 | Event data from Kulusuk | 2 months ago |
| 20230214to20230216 | Event data from Kulusuk | 2 months ago |
| 20230302to20230303 | More example files | 2 months ago |

BiScEF format – Plotting scripts

This format description is distributed with python scripts that can be used to generate a selection of plots from this kind of file. They are located in the folder «Python/Plotting/» in the repository.

There is one script to produce time series and skyplots from a single file, and one script to produce map plots based on data from multiple files.

The plots that are shown later in this presentation have been made using those scripts.

If run with the option "-h", they print instructions for usage:

```
$ python3 MakeDataPlots.py -h
usage: MakeDataPlots.py [-h] [-G] [-R] [-E] [-C] [-S] [--plot_ts_simple]
                       [--plot_ts_box] [--plot_sky] [--plot_heat_sigPhi]
                       [--elevationCutoff ELEVATIONCUTOFF]
                       filename

BiScEF data plotter

positional arguments:
  filename            Filename of input data file

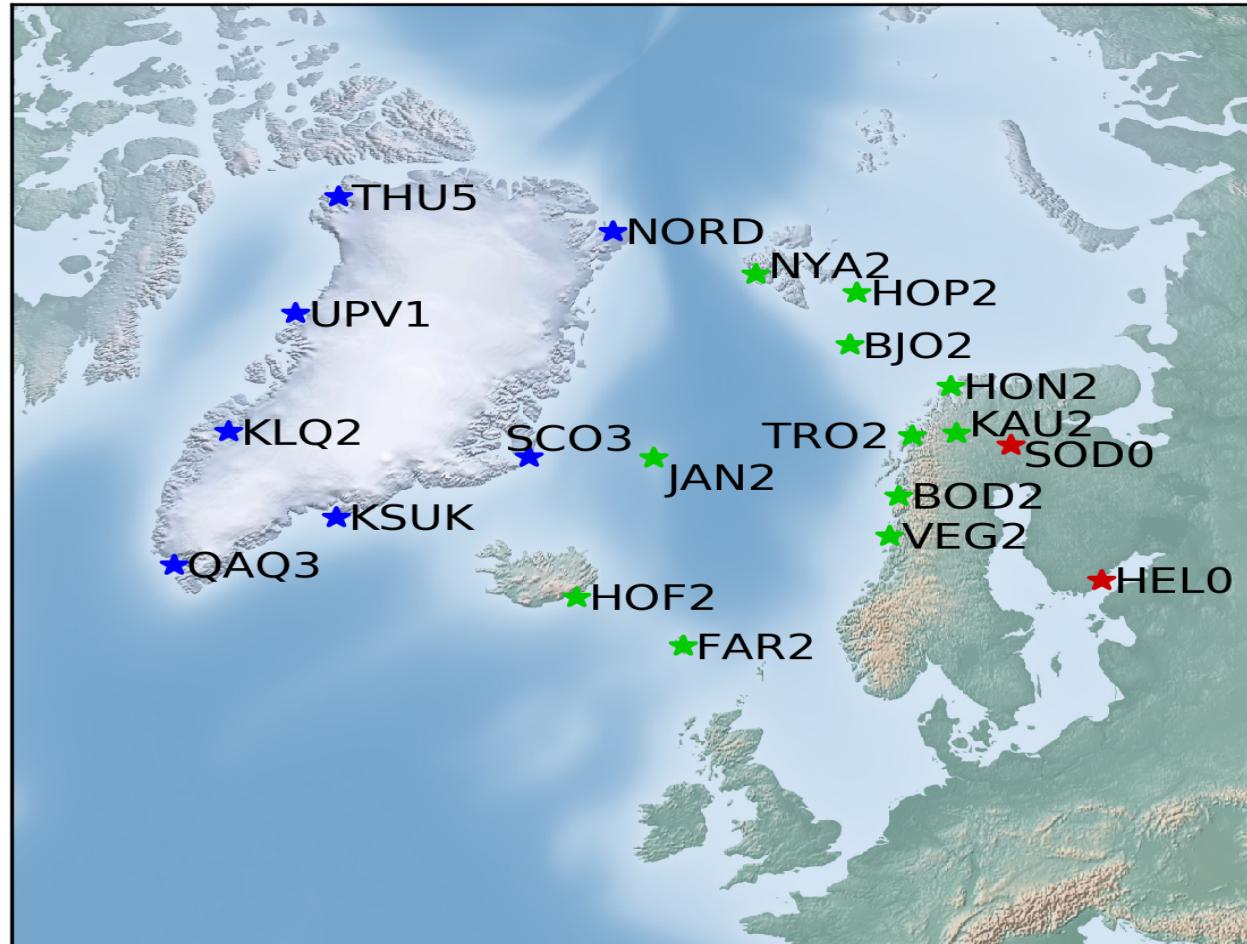
optional arguments:
  -h, --help          show this help message and exit
  -G, --GPS           Make plots for GPS (default: False)
  -R, --GLONASS        Make plots for GLONASS (default: False)
  -E, --Galileo        Make plots for Galileo (default: False)
  -C, --BeiDou         Make plots for BeiDou (default: False)
  -S, --SBAS           Make plots for SBAS (default: False)
  --plot_ts_simple    Plot simple time series (default: False)
  --plot_ts_box        Plot box-and-whiskers time series (default: False)
  --plot_sky           Plot skyplots (default: False)
  --plot_heat_sigPhi   Plot 2d histogram of sigma phi over time with mean
                       sigma phi (default: False)
  --elevationCutoff ELEVATIONCUTOFF
                       Set elevation angle cutoff (default: 5)

NB: This script assumes that the file contains data from one day (or less)
```

BiScEF data – DTU, NMA & FMI networks

DTU:

Data available from 2021. Some stations were not installed until 2022.



NMA:

Data available from 2012, but there are data gaps

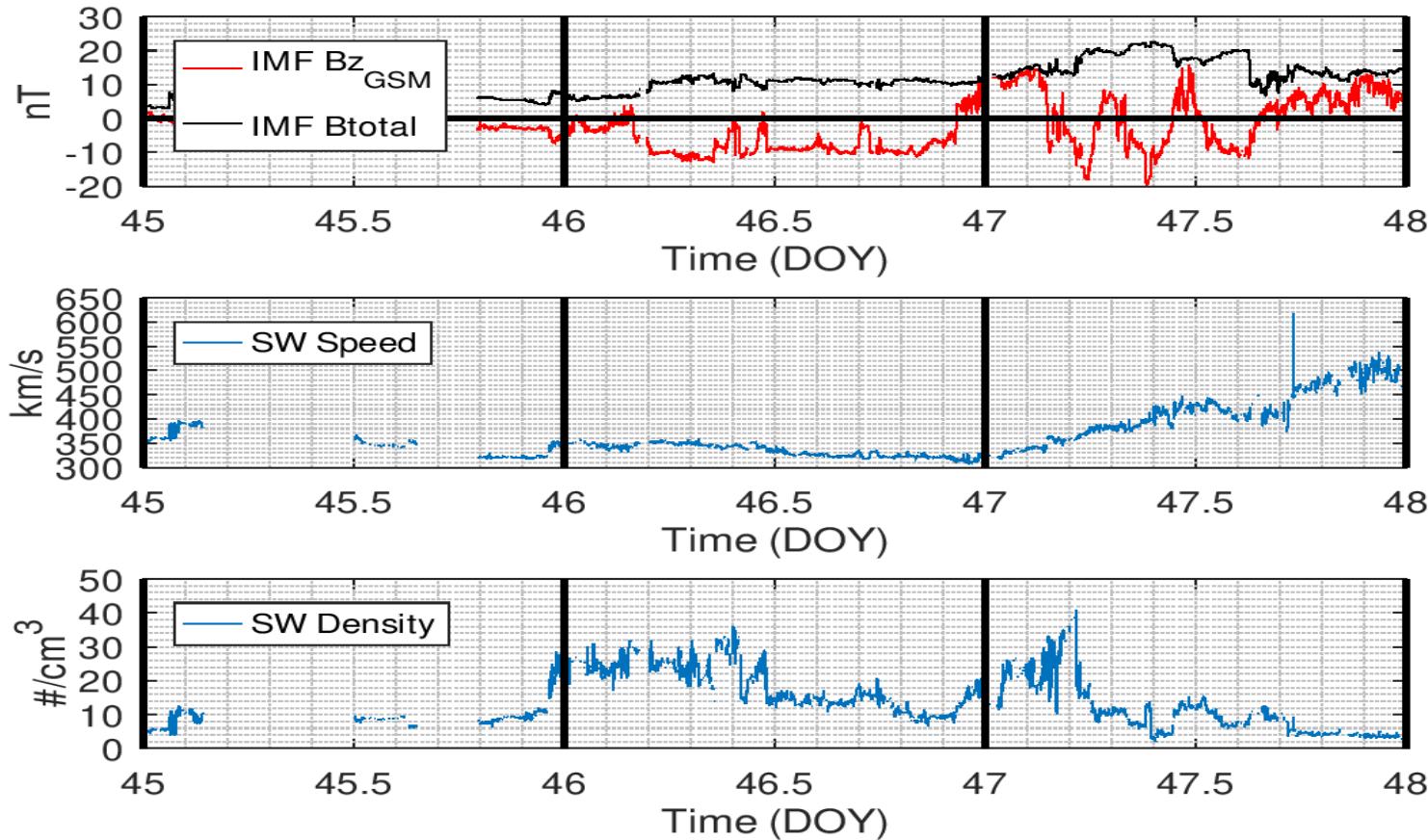
Mostly complete datasets for recent years (2020+)

FMI:

Data available from 2022.
The network has been expanded since the situation shown in the plot here.

Example event

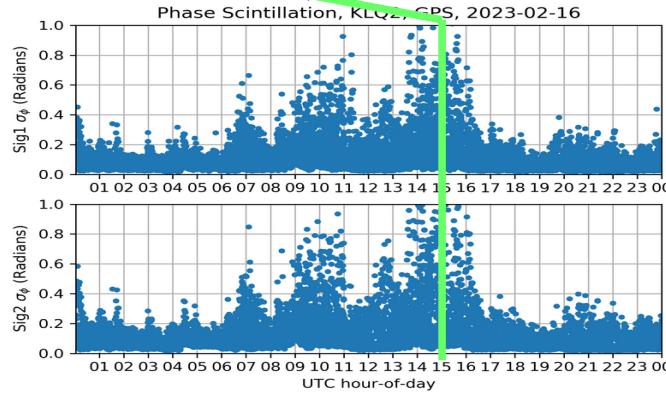
Solar wind data



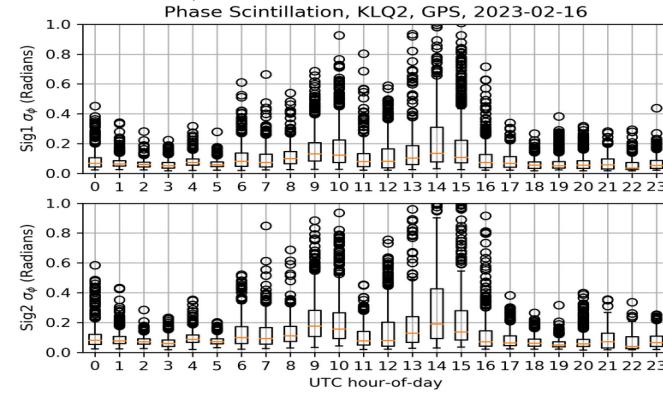
Example event

Examples of phase scintillation time series plots

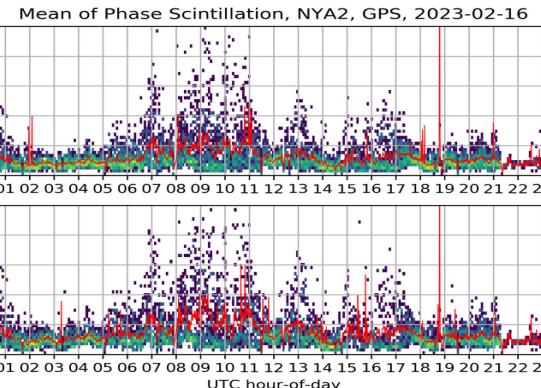
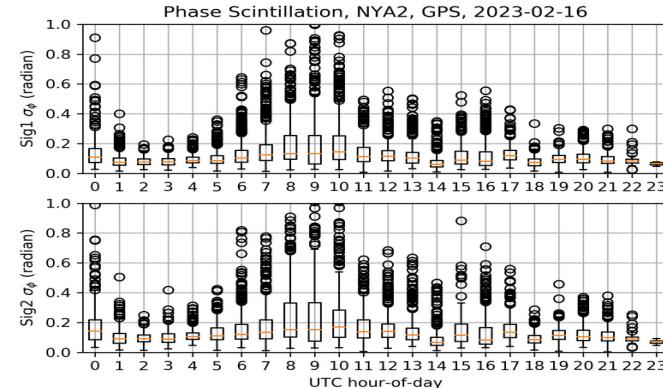
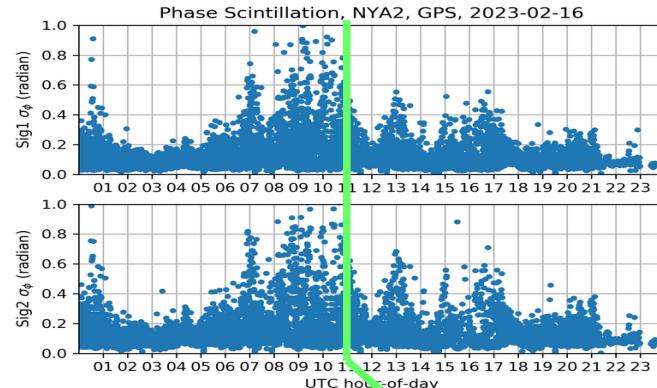
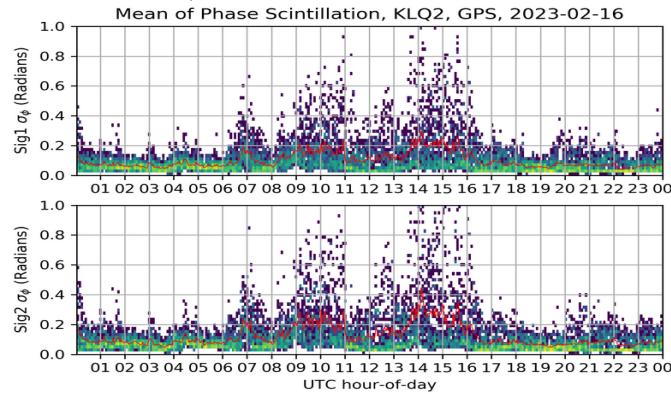
Local time mid-day
in Kangerlussuaq σ_ϕ points



σ_ϕ box-and-whiskers

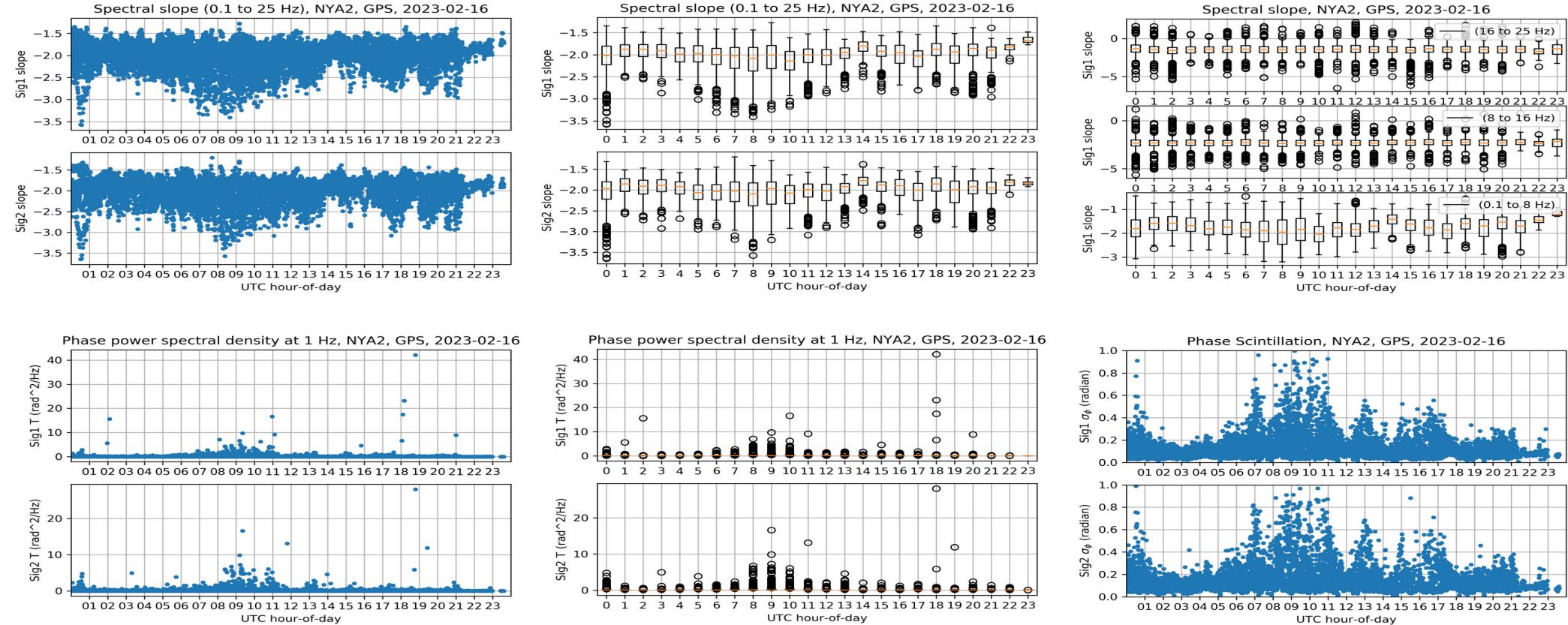


σ_ϕ heatmap & mean



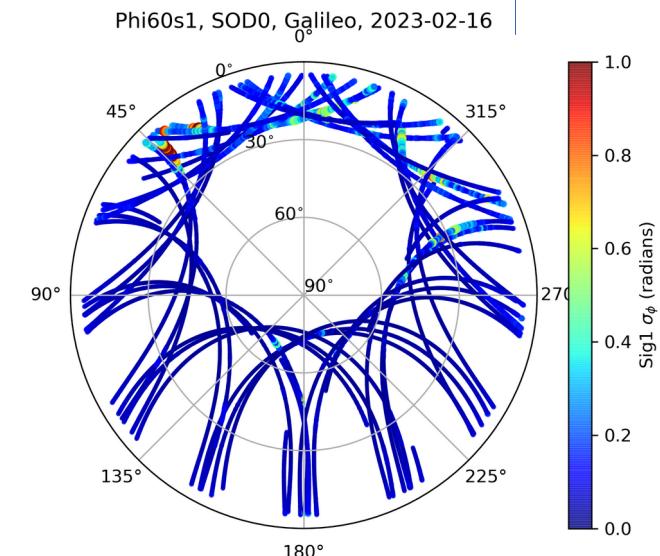
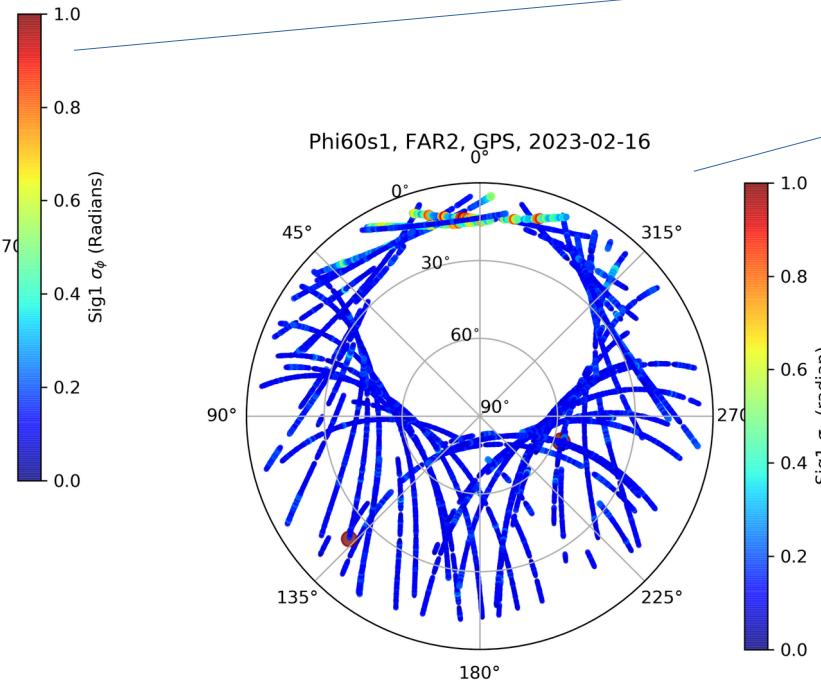
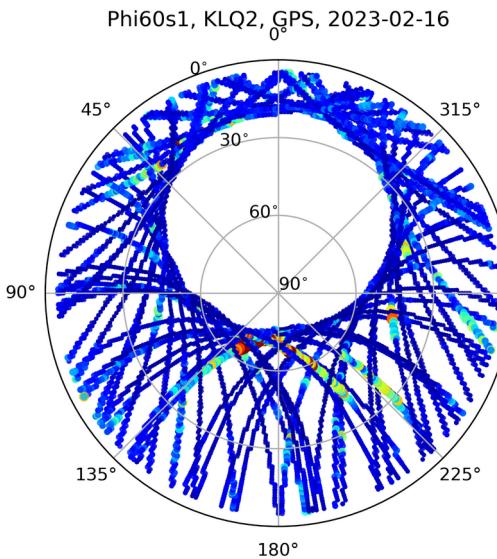
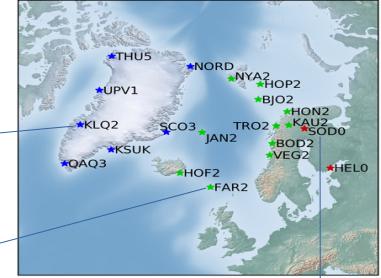
Example event

Examples of time series plots of spectral parameters



Example event

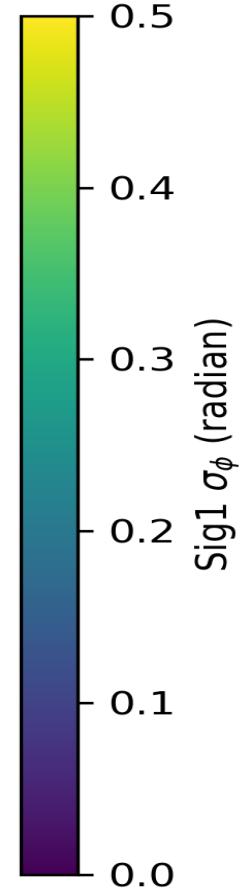
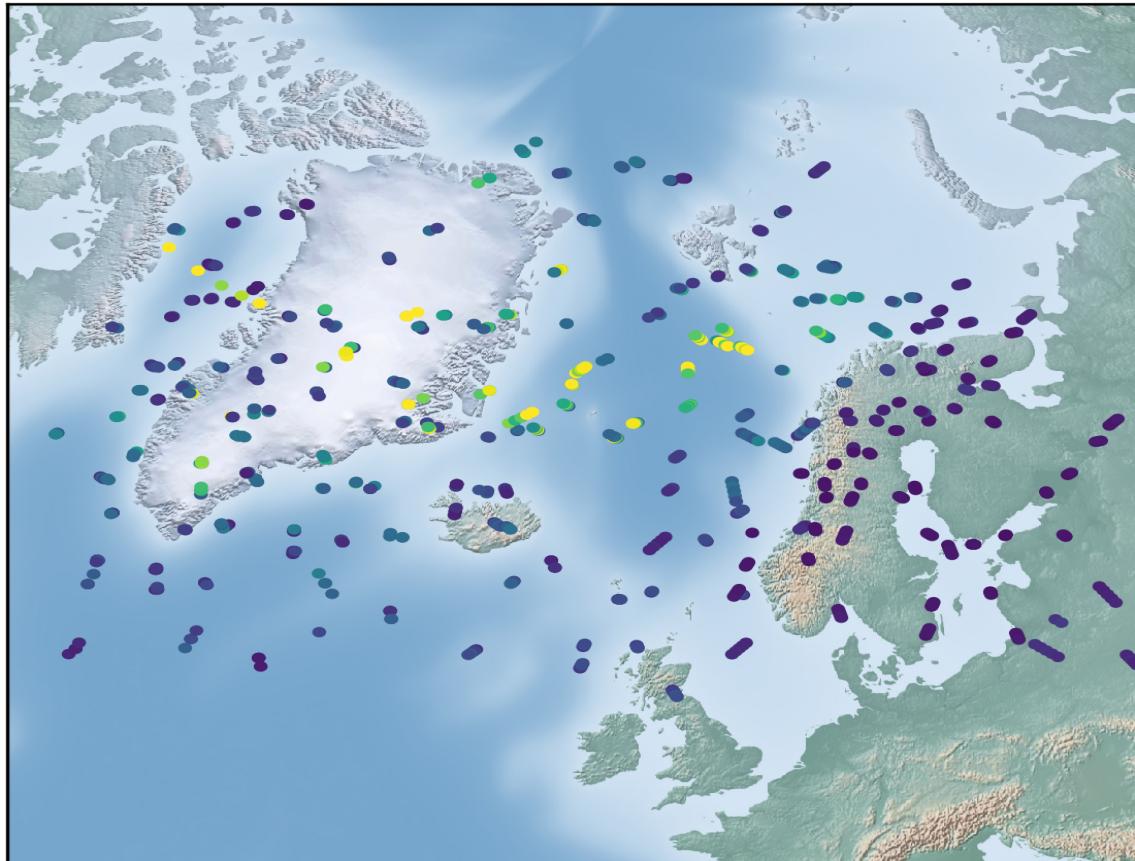
Examples of phase scintillation skyplots



Example event

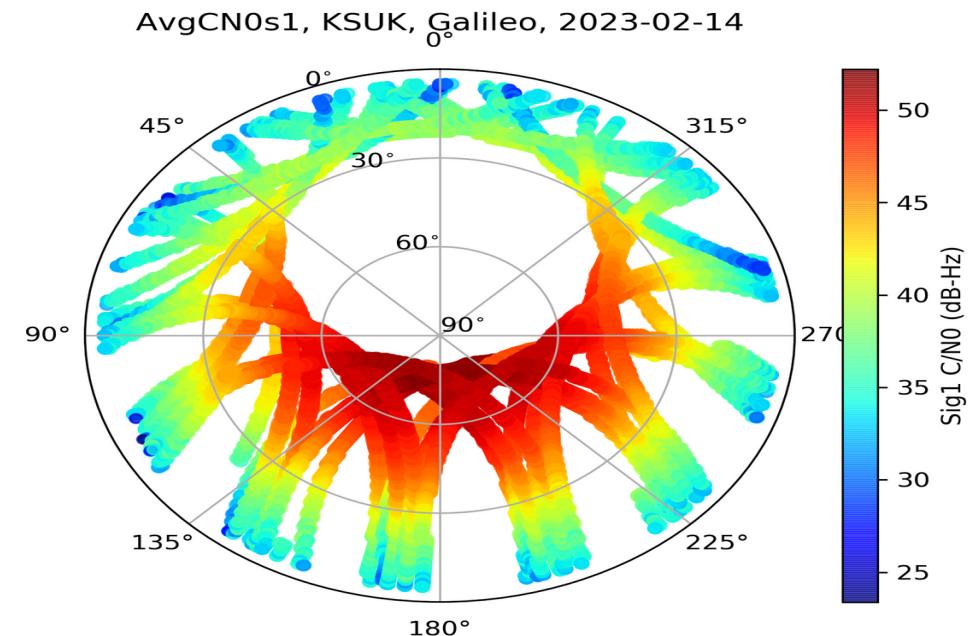
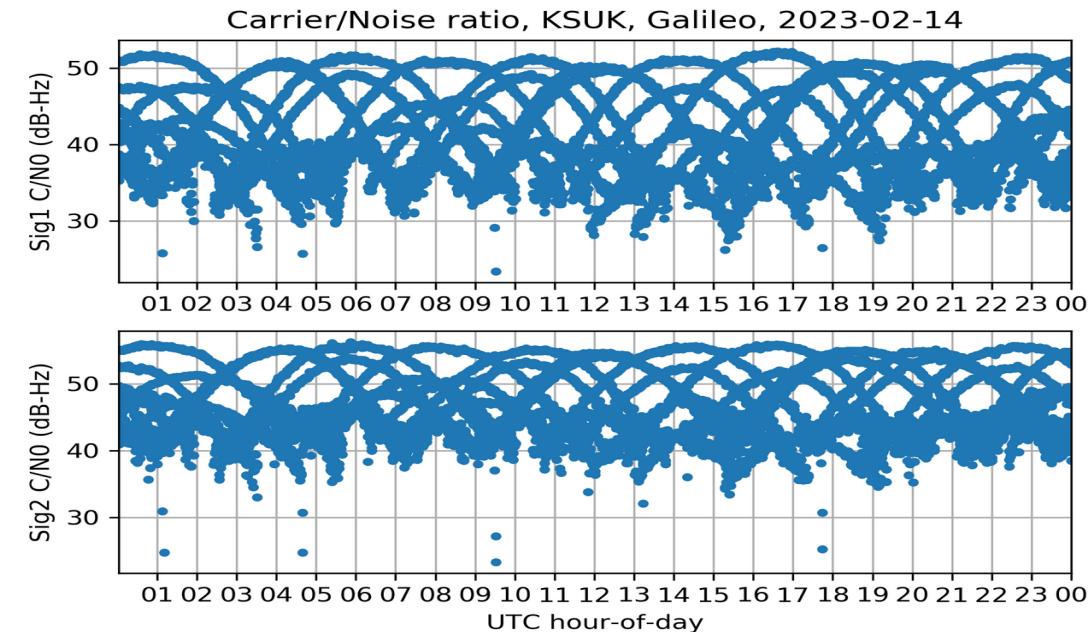
Example of phase scintillation map plots

2023-02-16 10:00 to 10:05, GPS, Galileo



Example event

Examples of time series plot and skyplot of C/N0



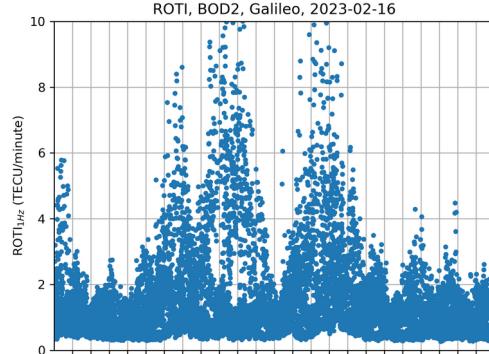
(no big surprises in the C/N0 data shown here, though)

Example event

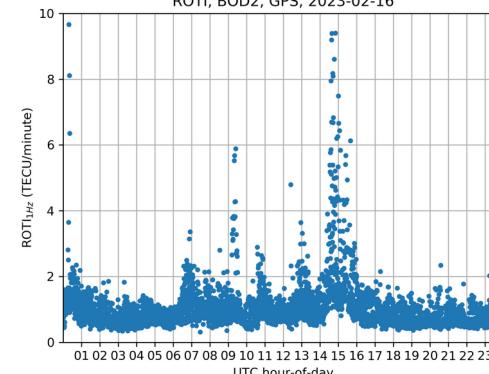
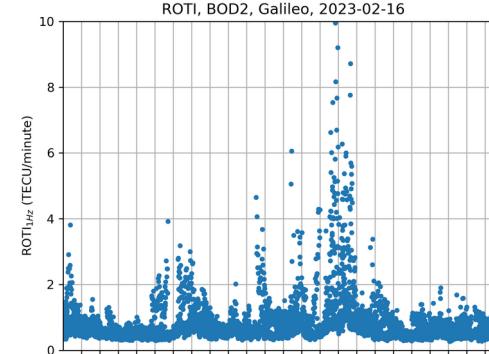
Examples of ROTI time series plots

In the NMA data files, phase data from the scintillation receivers has been decimated to a 1 Hz rate and ROTI has been calculated. Depending on your goals, you may want to use ROTI values directly, apply an elevation-dependent mapping factor or use an elevation cutoff.

Elevation
cutoff 5
degrees



Elevation
cutoff 30
degrees

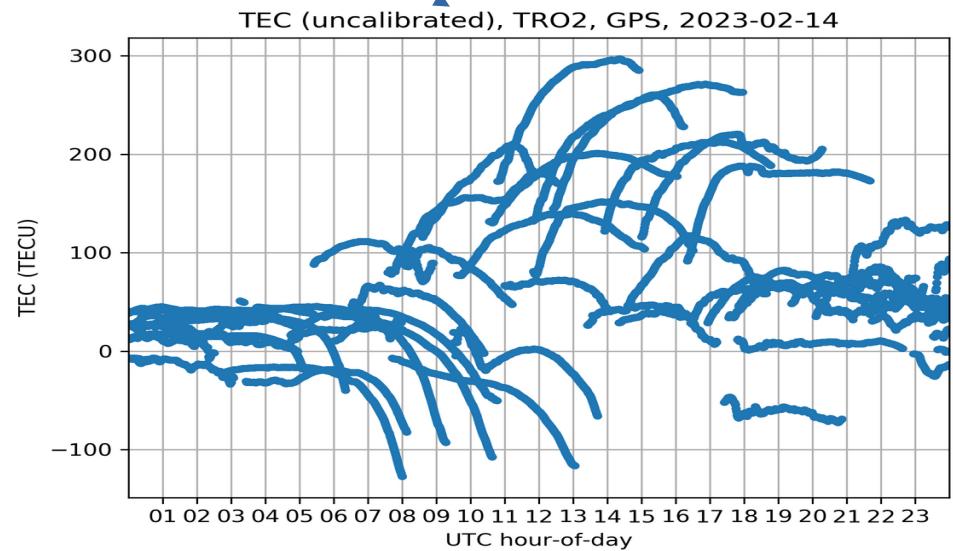
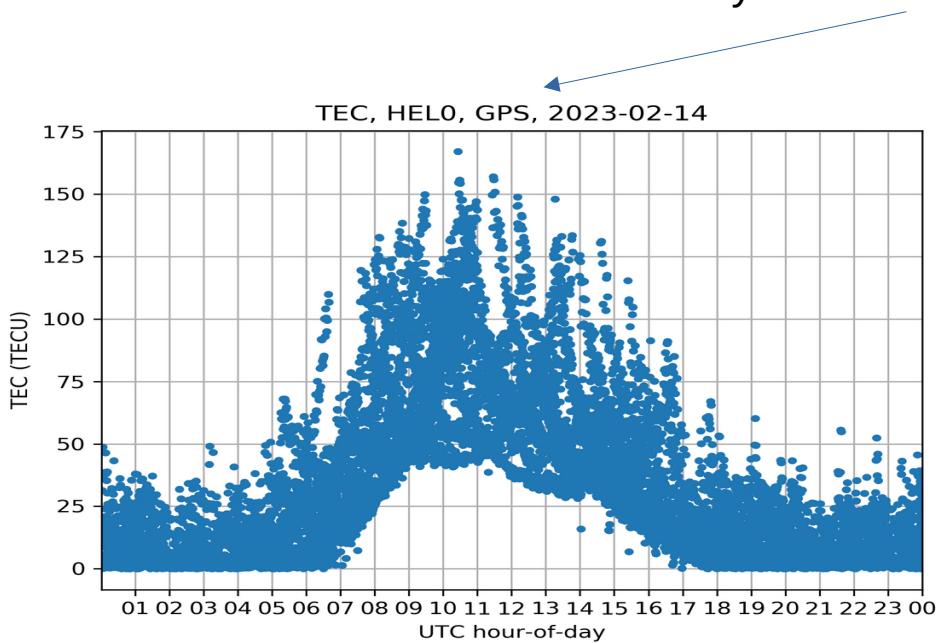


Example event

Examples of TEC time series plots

Slant TEC data are available in some data files.

They can be calibrated, or uncalibrated (i.e. Biases (DCBs) not applied)



Summary

The BiScEF format is based on NetCDF4 / HDF5, and is intended for archiving and sharing processed data from scintillation receivers.

The format description is available on the web, in a git repository:

<https://github.com/kartverket/BiScEF/>

It is made available under the very permissive MIT licence, permitting both non-commercial and commercial use.

Python scripts to make plots from the data files are available in the repository. They can be used as is, or as an example of how to read and handle the data.

Please make use of the format, give us feedback on the format, or request data from us.

Contacts:

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FMI: Petri Koskimaa <petri.koskimaa@fmi.fi>