Swarm-IPIR Description of the Visualization and Use-Cases
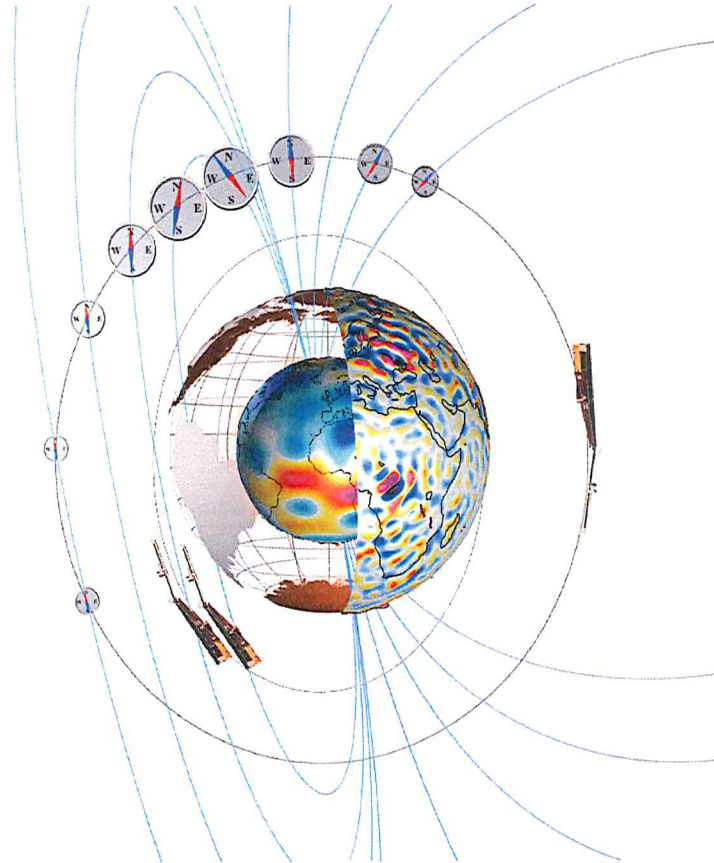

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1   Introduction

1.1   Scope and applicability

This document comprises the Swarm Level 2 (L2) Swarm- IPIR products Description of the Visualization and Use-Cases (DVUC) document for the Swarm Data, Innovation and Science Cluster (Swarm DISC) consortium in response to the requirements of [AD-1]. Swarm-IPIR includes the following products [AD-4][AD-3]:

- EFIx_PL_1B – 2Hz data from the Electrical Field Instrument (EFI).
- TECxTMS_2F – TEC data derived from onboard GPS.
- AOBxFAC_2F – Auroral Oval Boundaries (AOB) using the Field-Aligned Current (FAC) method.
- IBIxTMS_2F – IBI: Ionospheric Bubble Index.
- Polar Cap Products (PCP).

The Swarm-IPIR Product Definition document [AD-4] is available in the SVN folder: https://smart-svn.space-center.dk/svn/smart/SwarmDISC/DISC_Projects/ITT1_4_ionospheric_irregularities/Deliverables/.

Current or updated versions of this document are available in the SVN folder: https://smart-svn.space-center.dk/svn/smart/SwarmDISC/DISC_Projects/ITT1_4_ionospheric_irregularities/Deliverables/.

2   Applicable and Reference Documentation

2.1   Applicable Documents

The following documents are applicable to the definitions within this document.

[AD-1]   SW-SW-DTU-GS-114, rev 1 Statement of Work for Swarm DISC ITT 1.4 "Ionospheric irregularities and fluctuations based on Swarm data".

[AD-2]   IPIR-Swarm-IPIR-12017 – Ionospheric Plasma IRregularities characterised by the Swarm satellites.

[AD-3]   https://earth.esa.int/web/guest/missions/esa-eo-missions/swarm/data-handbook

[AD-4]   SW-TN-UiO-GS-001, Swarm-IPIR Product Definition.

[AD-5]   SW-TN-UiO-GS-003, Swarm-IPIR Description of the Processing Algorithm.

2.2   Reference Documents

The following documents contain supporting and background information to be taken into account during the activities specified within this document.

[RD-1]   Virtual research platform (VirES), https://vires.services.

2.3 Abbreviations

Acronym *or abbreviation*	Description
DISC	The Data, Innovation and Science Cluster
GFZ	The Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, DE
IPIR	Ionospheric Plasma IRregularities and fluctuations based on Swarm data
LEO	Low Earth Orbit
L1b	Level 1b (satellite data)
L2	Level 2 (satellite data)
SVN	SVN Repository with server located at DTU. Presently, the following URLs apply: https://smart-svn.spacecenter.dk/svn/smart/SwarmDISC/DISC_Projects/ITT1_4_ionospheric_irregularities/Deliverables/
Swarm	Constellation of 3 ESA satellites, https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm
TBD	To Be Defined
UiO	The University of Oslo, Oslo, Norway

3   Visualisation Approach

The Swarm-IPIR products [AD-2], [AD-4] will open several new and interesting possibilities for studies related to ionospheric plasma irregularities and space weather. The resulting products will be represented in CDF files (section 3.2) and will be made compatible with the VirES platform (section 3.1).

3.1   VirES platform

VirES for Swarm is a highly interactive data manipulation and retrieval interface for the ESA Swarm constellation mission products. It includes tools for studying various geomagnetic models by comparing them to the Swarm satellite measurements at given space weather and ionospheric conditions. Swarm data are available for anyone to use via the virtual research platform VirES via the website [RD-1].

3.2   Content of the input variables and files

The detailed description of the processing algorithms and product specifications for the Swam-IPIR products are given in [AD-4],[AD-5]. The Swarm-IPIR includes the following products that require visualisation:

- Derived parameters from the electron density Ne (visualisation examples in section 3.3.1):
    - Background density (background Ne)
    - Foreground density (foreground Ne)
    - Rate of change of density (ROD),
    - Rate of change of density index in 10 seconds (RODI10s),
    - Rate of change of density index in 20 seconds (RODI20s),
    - Filtered Ne fluctuations in 10 seconds (delta_Ne10s),
    - Filtered Ne fluctuations in 20 seconds (delta_Ne20s),
    - Filtered Ne fluctuations in 40 seconds (delta_Ne40s),
    - Ne gradient in 100 km scale (Grad_Ne@100km),
    - Ne gradient in 50 km scale (Grad_Ne@50km),
    - Ne gradient in 20 km scale (Grad_Ne@20km),
    - Ne gradient near the edge of a polar cap patch (Grad_Ne@PCP_edge),
    - PCP_flag,
    - Grad_Ne@PCP_edge.
- Derived parameters from the GPS data and other flags (visualisation examples in section 3.3.2):
    - Median of VTEC from all available GPS satellites (mVTEC),
    - Rate of change of TEC (mROT),
    - Rate of change of TEC index in 10 s (mROTI10s).
    - Rate of change of TEC index in 20 s (mROTI20s).
    - num_GPS_satellites
    - Ionosphere_region_flag
    - IPIR_index

3.3 Expected output plot examples within VirES platform

The user-friendly visualisations for IPIR products are proposed based on the VirES platform are proposed in the following.

3.3.1 Visualisations of parameters from the electron density

In this section, we present the user-friendly visualisations for IPIR products derived from the electron density. Figure 3.3.1 presents the suggested visualization of IPIR products derived from the electron density data based on the VirES platform. Since the IPIR data are all scalar, it is possible to present the data as color in a map as shown in the globe in the left panel or plot the parameters in stack plot on the right panels in Figure 3.3.1.

There are 14 variables derived from the density. Thus, to analyse them together in VirES, it is suggested to use all graphical elements available by the client of VirES.
- 3D maps and standard line plots are useful for global overview of the parameters and filtering.
- 2D plots of these parameters, which we understand here as plots of parameters with respect to latitude in a selected coordinate system (geographic, magnetic), as well as plots of parameters with respect of time, will be of much benefit, as they allow the user for a global overview as a function of time.
- Stack plots will be of highest use, where the user can put different datasets above each other, allowing for a detailed analysis of different variables with respect to time. Here we foresee that the IPIR parameters can be plotted as a function of time (i.e., along the orbit), and the timespan could be selected by the user (as in Figure 3.3.1 the stack plot shows data for a part of the orbit). Selection of the time, could be done together with filtering time in the lowest panel of the VirES interface.
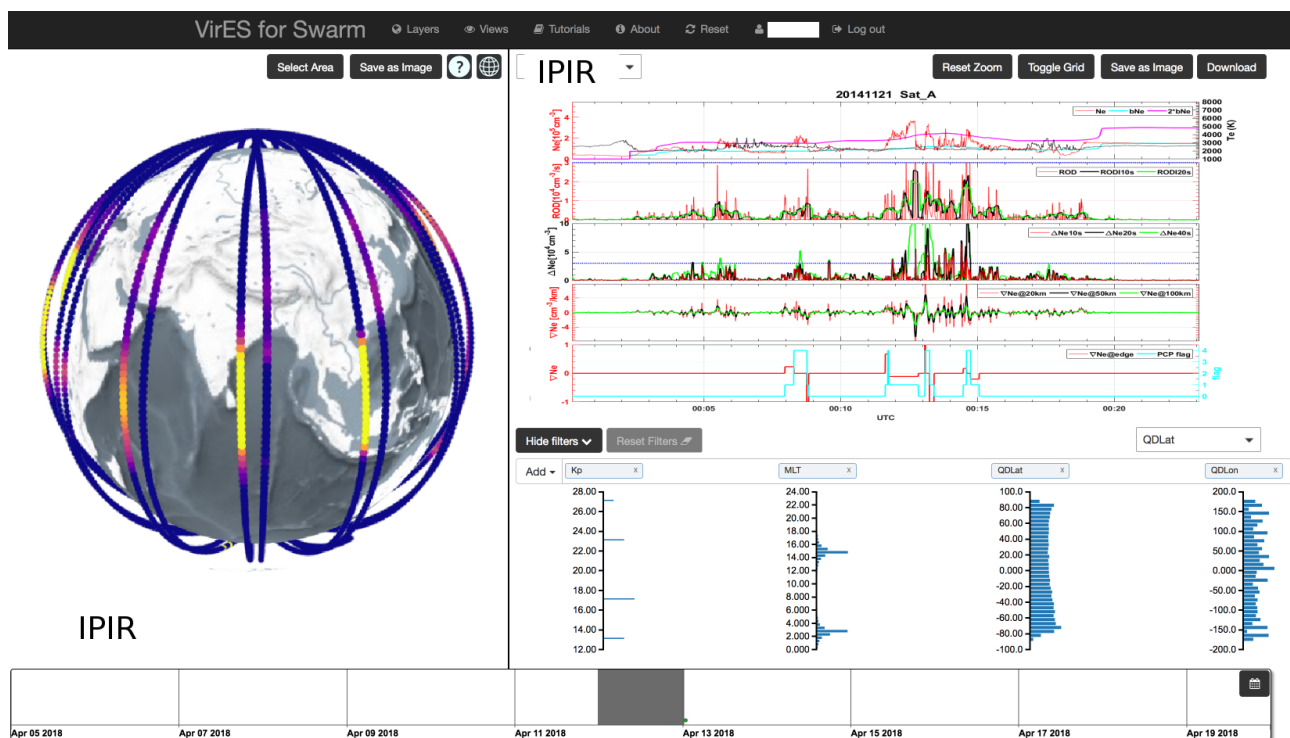

Figure 3.3.1 Proposed representation based on the VirES platform of the IPIR products derived from the electron density data during a selected time period.

3.3.2   Derived parameters from the GPS data and other flags

Figure 3.3.2 presents the suggested visualization of the derived parameters from the GPS data and other flags based on the VirES platform. Again, as in the case for the electron density data, the parameters derived from the GPS data and other flags, can be presented in a similar manner. It would be advisable to allow the user to plot different derived parameters from density and GPS in a stack plot.
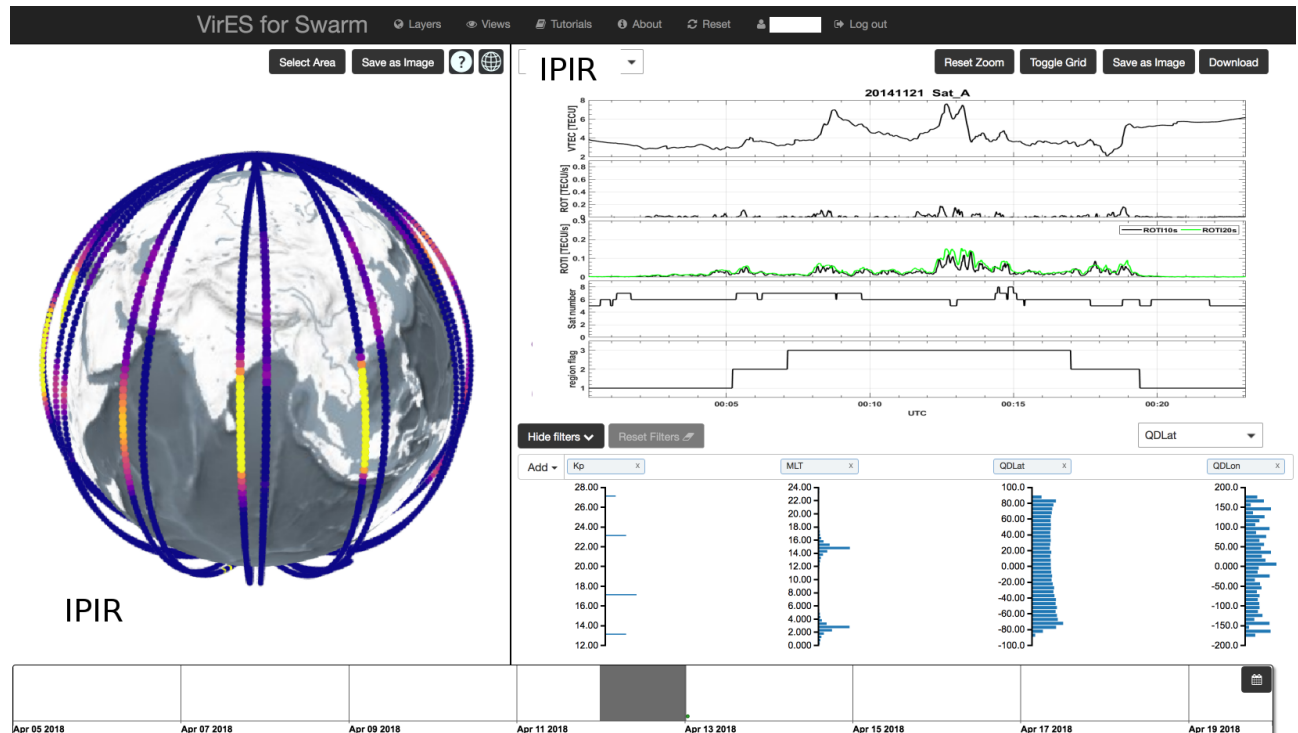

Figure 3.3.2 Proposed presentation based on the VirES platform of the IPIR products derived from GPS data for the selected time period.

3.3.3   Plotting several parameters in one plot (parameter vs. time)

Different parameters can be plotted with different colours in a single panel. It is however advisable that the user can select which parameters to plot (one, two, or more of them).

Examples of sets of parameters that can be beneficial to look at in a single plot are given below:

   a)   Background Ne, foreground Ne, Ne
   b)   Grad_Ne@100km, Grad_Ne@50km, Grad_Ne@20km
   c)   RODI10s and RODI20s
   d)   ROD, mROT
   e)   delta_Ne10s, delta_Ne20s, and delta_Ne40s
   f)   mROTI20s, mROTI10s, mROTI

An example of such a plot is given in Figure 3.3.3. In the upper panel the plasma density is plotted together with the background and twice of that, as well as with the electron temperature. In the lower panel different RODI parameters are shown in a single plot.

Such an approach to visualisation would reduce the number of 2D panels needed for the analysis.
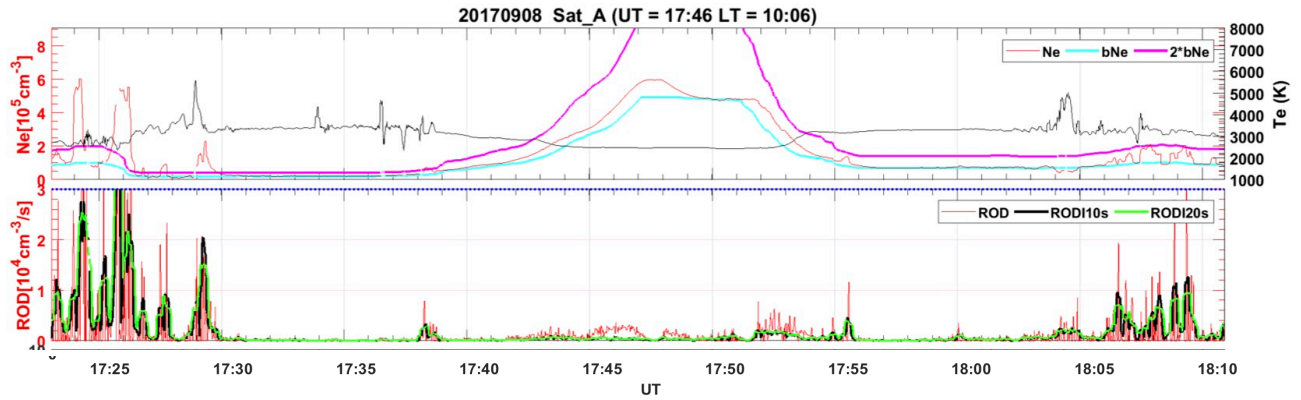
Figure 3.3.3 An example of overplotting different parameters in a specific 2D plot.