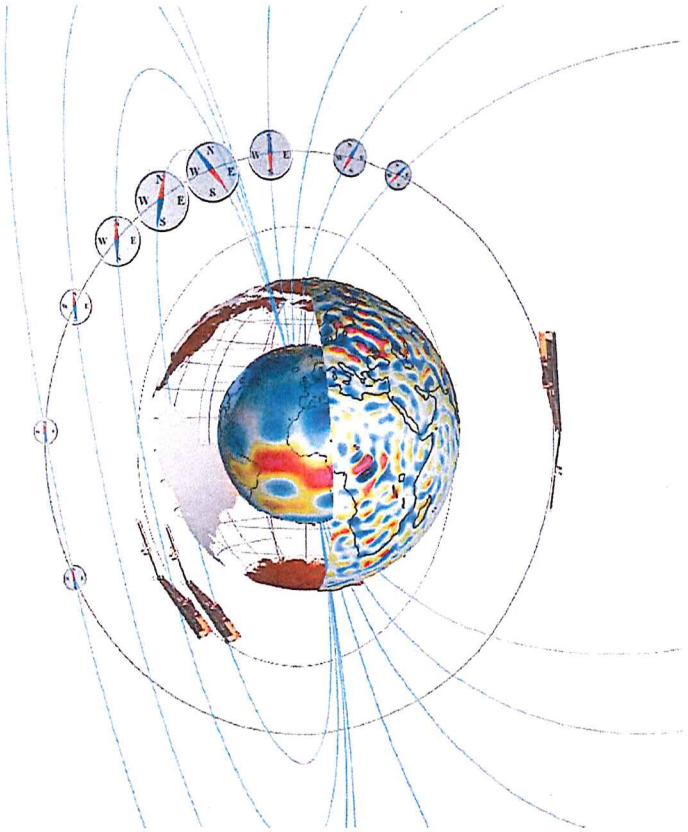
Swarm IPIR
Product Definition Document



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Record of Changes

Reason	Description	Rev	Date
Initial vers.	Released	1 dA	05 May 2018
Corrections of entries	Released	2 dA	04 July 2018
Final version	Minor corrections of the entries, correction of the IPIR index, units of gradients. Issue 1A released.	1A	01 Sept. 2018
Final version	Table for CDF entries updated.	1B	02 Nov. 2018

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1 Introduction

1.1 Scope and applicability

This document is the Swarm Level 2 (L2) IPIR - Ionospheric Plasma IRregularities characterised by the Swarm satellites - Product Definition Document (PDD) for the Swarm Data, Innovation and Science Cluster (Swarm DISC) consortium in response to the requirements of [AD-1]. PDD is to be published on the Swarm Data Handbook [AD-1]. Current or updated version of this document is available in the SVN folder: https://smart-svn.spacecenter.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-1-2017 – Ionospheric Plasma IRregularities characterised by the Swarm satellites.

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

2.2 Abbreviations

Acronym ***or abbreviation***	***Description***
CDF	Common Data Format
DISC	The Data, Innovation and Science Cluster
ESA	European Space Agency
GFZ	The Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, DE
IPIR	Ionospheric Plasma IRregularities characterised by the Swarm satellites
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_iono-spheric_irregularities/Deliverables/
Swarm	Constellation of 3 ESA satellites, https://earth.esa.int/web/guest/missions/esa-opera-tional-eo-missions/swarm
TBD	To Be Defined
UiO	The University of Oslo, Oslo, Norway

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3 Product identifier

The product identifier is: **L2 Cat-1: IPDxIRR_2F**

L2, Cat-1 : IPIR is the level 2 fast track product, that is processed by UiO through the DISC consortium.

IPD : stands for Ionospheric Plasma Density

x : The product is derived separately for each of the three satellites, and x identifies the satellite used (A, B, C).

IRR : stands for IRregularities in the plasma density

2F : signifies that this is a fast track product. The validation is performed by means of an internal quality check in the algorithms of the product, and the quality of the product is provided by a quality flag. It is released without a validation report.

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4 Product definition

Product identifier	**IPDxIRR_2F**
Definition	Time series of characteristics of the plasma density and plasma irregularities along the orbit from single satellite measurements. Time series of local plasma conditions, including background density and total electron content. Data related to geomagnetic regions in the ionosphere. Indication of severity of plasma irregularities for ground-based users provided.
Input data	EFI_LP_1B, TECxTMS_2F, **AOBxFAC_2F**, IBIxTMS_2F, PCP – Polar Cap Products
Input time span	3 days
Spatial representation	Data provided along entire orbits at positions of SwA, SwB, and SwC.
Time representation	1 second time series (the electron density data are downsampled to 1 second resolution; the timestamp of the electron density and TEC data are rounded to the nearest integer UTC seconds)
Units	See data format table
Resolution	Temporal data resolution of 1 second, density variations estimated at 0.5 second resolution.
Uncertainty	N/A
Quality indicator	Quality flags are handed through from Level 1b and Level 2 processing which is used as input data.
Data volume	ca.10 MB per day, per satellite
Data format	CDF
Output data	CDF file with time series

Variable name	Data Type	**Description**	**Unit**
Timestamp	CDF_epoch	CDF epoch of the measurement	-
Latitude	CDF_DOUBLE	Position in ITRF – Latitude	deg
Longitude	CDF_DOUBLE	Position in ITRF – Longitude	deg
Radius	CDF_DOUBLE	Position in ITRF – Radius	m
Ne	CDF_DOUBLE	Plasma density; directly copied from the Langmuir probe files	cm^-3
background Ne	CDF_DOUBLE	Background density; calculated from Ne using a percentile filter	cm^-3
foreground Ne	CDF_DOUBLE	Foreground density; calculated from Ne using a percentile filter	cm^-3
Te	CDF_DOUBLE	Electron temperature; directly copied from the Langmuir probe files	K
PCP_flag	CDF_UINT4	The polar cap patch flag	-

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Grad_Ne@100km	CDF_DOUBLE	The electron density gradient in a running window calculated via linear regression over 27 data points for the 2 Hz electron density data	cm^-3/m
Grad_Ne@50km	CDF_DOUBLE	The electron density gradient in a running window calculated via linear regression over 13 data points for the 2 Hz electron density data	cm^-3/m
Grad_Ne@20km	CDF_DOUBLE	The electron density gradient in a running window calculated via linear regression over 5 data points for the 2 Hz electron density data	cm^-3/m
Grad_Ne@PCP_edge	CDF_DOUBLE	The linear electron density gradient calculated over the edges of a patch; non-zero only at the edges of polar cap patches.	cm^-3/m
ROD	CDF_DOUBLE	Rate Of change of Density	cm^-3/s
RODI10s	CDF_DOUBLE	Rate Of change of Density Index (RODI) is the standard deviation of ROD over 10 seconds	cm^-3/s
RODI20s	CDF_DOUBLE	Rate Of Density Index (RODI) is the standard deviation of ROD over 20 seconds	cm^-3/s
delta_Ne10s	CDF_DOUBLE	Derived by subtracting Ne by its median filtered value in 10 seconds; indicates the electron density fluctuations smaller than 75 km	cm^-3
delta_Ne20s	CDF_DOUBLE	Derived by subtracting Ne by its median filtered value in 20 seconds; indicates the electron density fluctuations smaller than 150 km	cm^-3
delta_Ne40s	CDF_DOUBLE	Derived by subtracting Ne by its median filtered value in 40 seconds; indicates the electron density fluctuations smaller than 300 km.	cm^-3
num_GPS_satellites	CDF_UINT4	total number of tracked GPS satellites above 20 degrees	-
mVTEC	CDF_DOUBLE	Median of VTEC from all available GPS satellites above 30 degrees.	TECU
mROT	CDF_DOUBLE	median of Rate Of TEC (ROT) from all available GPS satellites above 30 degrees.	TECU/s
mROTI10s	CDF_DOUBLE	Median of Rate Of TEC Index (ROTI) from all available GPS satellites above 30 degrees. The ROTI of each satellite is the standard deviation of ROT over 10 seconds.	TECU/s
mROTI20s	CDF_DOUBLE	Median of Rate Of TEC Index (ROTI) from all available GPS satellites above 30 degrees. The ROTI of each	TECU/s

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			satellite is the standard deviation of ROT over 20 seconds.	
	IBI_flag	CDF_UINT4	Plasma Bubble Index, copied from the level-2 Ionospheric Bubble Index product, **IBIxTMS_2F**.	-
	Ionopshere_region_flag	CDF_UINT4	0: equator, 1: mid-latitudes; 2: auroral oval; 3: polar cap	-
	IPIR_index	CDF_UINT4	0-3 low, 4-5 medium, and > 6 high level of fluctuations in the ionospheric plasma density	-
	Ne_quality_flag	CDF_UINT4	Quality flag for the Ne data and the derived data from Ne, e.g., background density, foreground density etc. It is a mixture of the LP and TII QFlags. It is calculated as LP_QFLAG*1000 + TII_QFLAG.'	-
	TEC_STD	CDF_DOUBLE	Standard deviation of VTEC from GPS satellites.	TECU
Output time span	1 day			
Latency	10 min			
Update rate	1 per day			
Notes	The meanings of the PCP_flag are as follows: 0 if the plasma density measurement occurred outside a polar cap patch. 1 if the plasma density measurement occurred at one of the edges of a polar cap patch (no plasma velocity measurements are available). 2 if the plasma density measurement occurred at the leading edge of a polar cap patch. 3 if the plasma density measurement occurred at the trailing edge of a polar cap patch. 4 if the plasma density measurement occurred inside a polar cap patch proper. When no ion drift data is available, the leading and trailing edges cannot be distinguished. In this case the polar cap patch flag is set to 4 throughout the patch proper and to 1 throughout both edges.			

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