ICON Data Product 3.2: O+ Ionosphere

This document describes the data product for ICON L3.2 O+ ionosphere products, which is in NetCDF4 format.

This describes the Level 3.2 data product for ICON which is in NetCDF4 format. These files are named ICON_L3-2_YYYY-MM-DD_vXXrZZZ.NC, where YYYY-MM-DD is the year month day, XX shows the version number and ZZZ shows the revision number of this file. Each individual file contains one calendar day (24 hours) of data, merging data from the EUV and FUV Level 2 ionosphere products. The 12-second integration time is preserved in all samples. For FUV, the central 4 of 6 imaging stripes are used to match the EUV 12-deg horizontal field of regard. All data are filtered to remove flagged bad data (FUV Level 2.5 Data Quality = 0 in any of the 4 stripes, and EUV Level 2.6 Data Warning = 2). Consult the Level 2 data files for more information. Altitude profiles are generated on a 5-km resolution altitude grid. FUV data in all 4 stripes are binned and averaged using a weighted mean. EUV altitude profiles are interpolated onto the grid.

Each data source has been evaluated for precision to meet the original ICON science goals and requirements, but may require systematic offsets or scaling for accuracy in alternate applications, for details see:
Nighttime (FUV) O+ validation : https://doi.org/10.1007/s11214-023-00970-2
Daytime (EUV) O+ validation : https://doi.org/10.1007/s11214-022-00930-2

History

Version 01. Initial public release. A. W. Stephan 2025-01-13.

Dimensions

NetCDF files contain **variables** and the **dimensions** over which those variables are defined. First, the dimensions are defined, then all variables in the file are described.

The dimensions used by the variables in this file are given below, along with nominal sizes. Note that the size may vary from file to file. For example, the "Epoch" dimension, which describes the number of time samples contained in this file, will have a varying size.

Dimension Name	Nominal Size
`Epoch`	3088
`Altitude`	90

Variables

Variables in this file are listed below. First, "data" variables are described, followed by the "support_data" variables, and finally the "metadata" variables. The variables classified as "ignore_data" are not shown.

data

Variable Name	Description	Units	Dimensions
ICON_L32_Altitude	O+ Density Altitude Altitude corresponding to the retrieved quantities, in WGS84 in 5 km increments, centered, e.g. 150 km means 147.5 km <= Altitude < 152.5 km	km	Altitude
ICON_L32_HmF2	HmF2 Height of the peak electron density of the F2 layer from retrieval, in WGS.	km	Epoch
ICON_L32_HmF2_Error	HmF2 Error 1-sigma uncertainty in height of the F2 layer peak from retrieval, as determined from the reported statistical uncertainties and/or weighted averaging of the measurements	km	Epoch
ICON_L32_NmF2	NmF2 Electron density at the peak of the F2 layer from retrieval.	cm-3	Epoch
ICON_L32_NmF2_Error	NmF2 Error 1-sigma uncertainty in electron density at the peak of the F2 layer as determined from the reported statistical uncertainties and/or weighted averaging of the measurements	cm-3	Epoch
ICON_L32_Oplus	O+ Profile Number density of O+ as a function of altitude	cm-3	Epoch, Altitude
ICON_L32_Oplus_Error	O+ Profile Error 1-sigma uncertainty in the number density of O+ as a function of altitude as determined from the reported statistical uncertainties and/or weighted averaging of the measurements	cm-3	Epoch, Altitude

support_data

Variable Name	Description	Units	Dimensions
Epoch	Milliseconds since 1970-01-01 00:00:00 UTC Time corresponding to the center of each observation, in milliseconds since Jan 1 1970.	milliseconds	Epoch

Variable Name	Description	Units	Dimensions
ICON_L32_UTC_Time	Date and Time in UTC format UTC time corresponding to the measurement	string	Epoch
ICON_L32_Latitude	Geodetic Latitude Geodetic latitude at retrieval location, in WGS referenced to 300 km tangent point for daytime (EUV), and to HmF2 tangent point location for nighttime (FUV)	degrees	Epoch
ICON_L32_Longitude	Geodetic Longitude Geodetic longitude at retrieval location, in WGS referenced to 300 km tangent point for daytime (EUV), and to HmF2 tangent point location for nighttime (FUV)	degrees	Epoch
ICON_L32_Magnetic_Latitude	Magnetic Latitude Quasi-dipole magnetic latitude at retrieval location, referenced to 300 km tangent point for daytime (EUV), and to HmF2 tangent point location for nighttime (FUV) calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (https://github.com/aburrell/apexpy/).	degrees	Epoch
ICON_L32_Magnetic_Longitude	Magnetic Longitude Quasi-dipole magnetic longitude at retrieval location, referenced to 300 km tangent point for daytime (EUV), and to HmF2 tangent point location for nighttime (FUV) calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (https://github.com/aburrell/apexpy/).	degrees	Epoch
ICON_L32_Local_Solar_Time	Local Solar Time Local Solar Time at retrieval location	hours	Epoch
ICON_L32_Solar_Zenith_Angle	Solar Zenith Angle Solar Zenith Angle at retrieval location.	degrees	Epoch
ICON_L32_Data_Source	Data Source Data product contributing to each O+ measurement. Value: 2.5 is FUV nighttime ionosphere, 2.6 is EUV daytime ionosphere.	N/A	Epoch

Acknowledgement

This is a data product from the NASA Ionospheric Connection Explorer mission, an Explorer launched at 21:59:45 EDT on October 10, 2019, from Cape Canaveral AFB in the USA. Guidelines for the use of this product are described in the ICON Rules of the Road (http://icon.ssl.berkeley.edu/Data).

Responsibility for the mission science falls to the Principal Investigator, Dr. Thomas Immel at UC Berkeley:
Immel, T.J., England, S.L., Mende, S.B. et al. Space Sci Rev (2018) 214: 13. https://doi.org/10.1007/s11214-017-0449-2
Immel, T.J., England, S.L., Harding, B.J. et al. Space Sci Rev (2023) 219: 41. https://doi.org/10.1007/s11214-023-00975-x

Responsibility for the validation of the L1 data products falls to the instrument lead investigators/scientists.
EUV: Dr. Martin Sirk and Dr. Eric Korpela : https://doi.org/10.1007/s11214-023-00963-1, and https://doi.org/10.1007/s11214-017-0384-2
FUV: Dr. Harald Frey : https://doi.org/10.1007/s11214-023-00969-9, and https://doi.org/10.1007/s11214-017-0386-0
MIGHTI: Dr. Christoph Englert : https://doi.org/10.1007/s11214-023-00971-1, https://doi.org/10.1007/s11214-017-0358-4, and https://doi.org/10.1007/s11214-017-0374-4
IVM: Dr. Roderick Heelis : https://doi.org/10.1007/s11214-017-0383-3

Responsibility for the validation of the L2 data products falls to those scientists responsible for those products.

* Daytime O/N2 ratio : Dr. Robert Meier : https://doi.org/10.1007/s11214-018-0477-6
* Daytime (EUV) O+ profiles: Dr. Andrew Stephan : https://doi.org/10.1007/s11214-022-00933-z, and https://doi.org/10.1007/s11214-017-0385-1
* Nighttime (FUV) O+ profiles: Dr. Farzad Kamalabadi : https://doi.org/10.1007/s11214-018-0502-9
* Neutral Wind profiles: Dr. Brian Harding : https://doi.org/10.1007/s11214-017-0359-3, and https://doi.org/10.1029/2020JA028947
* Neutral Temperature profiles: Dr. Michael Stevens : https://doi.org/10.1007/s11214-022-00935-x, and https://doi.org/10.1007/s11214-017-0434-9
* Ion Velocity Measurements : Dr. Roderick Heelis : https://doi.org/10.1007/s11214-017-0383-3

Additional theoretical work in support of these products was supported by Dr. Robert Meier
Daytime O/N2 product : https://doi.org/10.1029/2020JA029059
Daytime (EUV) O+ profiles : https://doi.org/10.1029/2023JA031533

Additional validation work was performed by Dr. Jonathan Makela, Dr. Gilles Wautelet, and Dr. Yen-Jung (Joanne) Wu:
Neutral wind profiles : https://doi.org/10.1029/2020JA028726
Nighttime (FUV) O+ profiles : https://doi.org/10.1007/s11214-023-00970-2
Daytime (EUV) O+ profiles : https://doi.org/10.1007/s11214-022-00930-2
Ion Velocity Measurements : https://doi.org/10.1007/s11214-023-00993-9

Responsibility for Level 4 products falls to those scientists responsible for those products.

* Hough Modes : Dr. Chihoko Cullens : https://doi.org/10.1186/s40645-020-00330-6 and https://doi.org/10.1007/s11214-017-0401-5
* TIEGCM : Dr. Astrid Maute : https://doi.org/10.1007/s11214-017-0330-3
* SAMI3 : Dr. Joseph Huba : https://doi.org/10.1007/s11214-017-0415-z

Pre-production versions of all above papers are available on the ICON website.
http://icon.ssl.berkeley.edu/Publications

Overall validation of the products is overseen by the ICON Project Scientist, Dr. Scott England.

NASA oversight for all products is provided by the Mission Scientist, Dr. Jeffrey Klenzing (2018-2022) and Dr. Ruth Lieberman (2022-present).

Users of these data should contact and acknowledge the Principal Investigator Dr. Immel and the party directly responsible for the data product (noted above) and acknowledge NASA funding for the collection of the data used in the research with the following statement :

"ICON is supported by NASA's Explorers Program through contracts NNG12FA45C and NNG12FA42I".

These data are openly available as described in the ICON Data Management Plan available on the ICON website (http://icon.ssl.berkeley.edu/Data).

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