

# ICON FUV Science Level 1 Data

This document describes the data product for ICON FUV Level 1 FUV-A Altitude Profile File, which is in NetCDF4 format.

The ICON Far UltraViolet (FUV) imager contributes to the ICON science objectives by providing remote sensing measurements of the daytime and nighttime atmosphere/ ionosphere. During sunlit atmospheric conditions, ICON FUV images the limb altitude profile in the shortwave (SW) band at 135.6 nm and the longwave (LW) band at 157 nm perpendicular to the satellite motion to retrieve the atmospheric O/N<sub>2</sub> ratio. In conditions of atmospheric darkness, ICON FUV measures the 135.6 nm recombination emission of O<sup>+</sup> ions used to compute the nighttime ionospheric altitude distribution.

The ICON Far Ultra-Violet (FUV) imager is a Czerny–Turner design Spectrographic Imager with two exit slits and corresponding back imager cameras that produce two independent images in separate wavelength bands on two detectors. For this science product, the 18x24 degree FOV is divided and co-added to produce 6 high sensitivity profiles with each nominally 12 second integration. These inform daytime and nighttime retrievals of the ionospheric composition and density (See Stephan et al and Kamalabadi et al, noted in the acknowledgements section of this file). Pointing and geolocation information are available in the FUV ancillary data also available at <https://icon.ssl.berkeley.edu>

More details about the mission, data products, responsibility, and data use can be found at the end of this document.

Each FUVB Level-1 file contains global attributes explaining the major properties of the file and variables. This is an example from one file.

0 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>).

1 ADID\_REF NASA Contract > NNG12F45C

2 CALIBRATION\_FILE See calibration files in general attribute fields FLATFIELD\_CORRECTION, BACKGROUND\_CORRECTION, RAYLEIGH\_CONVERSION

3 CONVENTIONS SPDF ISTEP/IACF Modified for NetCDF (v0.8)

4 DATA\_LEVEL L1

5 DATA\_TYPE APIDxE3 > ICON Application ID 0xE3: FUV Science Level 0.5 Data > FUV Science Level 1 Data

6 DATA\_REVISION 0

7 DATA\_VERSION 2.00000

8 DATA\_VERSION\_MAJOR 2

9 DATE\_END 2020-02-04T23:59:53 UTC

10 DATE\_START 2020-02-04T00:00:00 UTC

11 DATE\_STOP 2020-02-04T23:59:53 UTC

12 DESCRIPTION ICON FUV Level 1 FUV-B Altitude Profile File

13 DESCRIPTOR FUV-B > ICON FUV-B L1 Science Altitude Profile File

14 DISCIPLINE Space Physics > Ionospheric Science

15 FILE ICON\_L1\_FUV\_LWP\_20200204\_v02r000.NC

16 FILE\_DATE Fri Aug 14 08:31:44 2020

17 GENERATED\_BY ICON SDC > ICON FUV L1 Processor v1, Tori Fae ([tfae@paradigm.ssl.berkeley.edu](mailto:tfae@paradigm.ssl.berkeley.edu)) and Harald Frey ([hfrey@ssl.berkeley.edu](mailto:hfrey@ssl.berkeley.edu))

18 GENERATION\_DATE 20200814

19 HISTORY Version 2 Created by ICON FUV L1 processing with `icn_fuv_create_lwp_structure.pro` Fri Sep 18 12:06:56 2020

MODIFICATION HISTORY:

Written by: Harald Frey, Date: January 27, 2017

2019-12-11 major updates for calibration conversion

2020-01-22 made stripes consistent with LW, P6 looking forward, background, error

2020-03-20 new backgrounds, flatfields, quality parameter etc.

2020-04-06 allow negative values, bkg variable in Rayleighs etc.  
2020-05-28 new background, uncertainty, stars removed  
2020-08-17 no negative values sublimb, new attributes, turrets, mark insufficient HV  
2020-09-14 correctly deal with forced turret for sun protection  
20 HTTP\_LINK <http://icon.ssl.berkeley.edu>  
21 INSTRUMENT FUV-B  
22 INSTRUMENT\_TYPE Imagers (Space)  
23 LINK\_TEXT All ICON information and data can be found at the ICON web page [icon.ssl.berkeley.edu](http://icon.ssl.berkeley.edu)  
24 LINK\_TITLE ICON Website  
25 LOGICAL\_FILE\_ID ICON\_L1\_FUV\_LWP\_20200204\_v02r000  
26 LOGICAL\_SOURCE ICON\_L0P\_FUV-B\_Science-TD11\_2020-02-04  
27 LOGICAL\_SOURCE\_DESCRIPTION ICON FUV-B Level 1 Science Altitude Profile File  
28 MISSION\_GROUP Ionospheric Investigations  
29 MODS See history  
30 PARENTS Names of all L0 Files  
31 PI\_AFFILIATION UC Berkeley > SSL  
32 PI\_NAME T. J. Immel  
33 PROJECT NASA > ICON  
34 RULES\_OF\_USE Public Data for Scientific Use  
35 SOFTWARE\_VERSION ICON SDC > ICON FUV L1 Processor v1.0  
36 SOURCE\_NAME ICON > Ionospheric Connection Explorer  
37 SPACECRAFT\_ID NASA > ICON - 493  
38 TEXT ICON explores the boundary between Earth and space - the ionosphere - to understand the physical connection between our world and the immediate space environment around us. Visit '<http://icon.ssl.berkeley.edu>' for more details.  
39 TIME\_RESOLUTION 12000 milliseconds  
40 TITLE ICON FUV Level 1 FUV-B Altitude Profile File  
41 EPOCH0 1970-01-01/00:00:00  
42 FILE\_NAMING\_CONVENTION source\_datatype\_descriptor  
43 PROCESS\_LEVEL L1  
44 SAMPLE\_TIME 12  
45 SAMPLE\_UNIT Seconds  
46 SATELLITE\_ID ICON  
47 TEXT\_SUPPLEMENT Explanation of global attributes  
48 FLATFIELD\_CORRECTION Values of flatfield correction for each stripe  
49 BACKGROUND\_CORRECTION saa\_files\_2020-035  
50 RAYLEIGH\_CONVERSION Values for Rayleigh conversion

Use of this product for analysis depends on the combined use of the ancillary FUV data product which contains geopositioning data and instrument pointing details.

## History

Version 3 Created by ICON FUV L1 processing with `icn_fuv_create_swp_structure.pro` Tue Sep 22 08:20:36 2020

### MODIFICATION HISTORY:

Written by: Harald Frey, Date: December 08, 2016

2019-12-11 major updates for calibration conversion

2020-01-22 made stripes consistent with LW, P6 looking forward, background, error

2020-03-20 new backgrounds, flatfields, quality parameter etc.

2020-04-06 allow negative values, bkg variable in Rayleighs etc.

2020-05-28 new background, uncertainty, stars removed

2020-08-17 no negative values sublimb, new attributes, turrets, new calibration conversion 2300 V, mark insufficient HV

2020-09-14 correctly deal with forced turret for sun protection

# 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.

<b>Dimension Name</b>	<b>Nominal Size</b>
Epoch	6904
Rows	256
Columns	1
Stripes	6

# 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_L1_FUVA_SWP_Raw_M9	FUVA SW channel raw CCD counts profile for -9 to -6 degrees FOV  Vertical raw CCD counts profile for -9 to -6 degrees FOV	counts	Epoch, Rows
ICON_L1_FUVA_SWP_Raw_M6	FUVA SW channel raw CCD counts profile for -6 to -3 degrees FOV  Vertical raw CCD counts profile for -6 to -3 degrees FOV	counts	Epoch, Rows
ICON_L1_FUVA_SWP_Raw_M3	FUVA SW channel raw CCD counts profile for -3 to 0 degrees FOV  Vertical raw CCD counts profile for -3 to 0 degrees FOV	counts	Epoch, Rows
ICON_L1_FUVA_SWP_Raw_P0	FUVA SW channel raw CCD counts profile for 0 to +3 degrees FOV  Vertical raw CCD counts profile for 0 to +3 degrees FOV	counts	Epoch, Rows
ICON_L1_FUVA_SWP_Raw_P3	FUVA SW channel raw CCD counts profile for +3 to +6 degrees FOV  Vertical raw CCD counts profile for +3 to +6 degrees FOV	counts	Epoch, Rows
ICON_L1_FUVA_SWP_Raw_P6	FUVA SW channel raw CCD counts profile for +6 to +9 degrees FOV  Vertical raw CCD counts profile for +6 to +9 degrees FOV	counts	Epoch, Rows
ICON_L1_FUVA_SWP_PROFILE_M9	FUVA SW channel altitude column brightness for -9 to -6 degrees FOV  Vertical profile for -9 to -6 degrees FOV	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PROFILE_M6	FUVA SW channel altitude column brightness for -6 to -3 degrees FOV  Vertical profile for -6 to -3 degrees FOV	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PROFILE_M3	FUVA SW channel altitude column brightness for -3 to 0 degrees FOV  Vertical profile for -3 to 0 degrees FOV	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PROFILE_P0	FUVA SW channel altitude column brightness for 0 to +3 degrees FOV  Vertical profile for 0 to +3 degrees FOV	Rayleigh	Epoch, Rows

<b>Variable Name</b>	<b>Description</b>	<b>Units</b>	<b>Dimensions</b>
ICON_L1_FUVA_SWP_PR OF_P3	FUVA SW channel altitude column brightness for +3 to +6 degrees FOV  Vertical profile for +3 to +6 degrees FOV	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P6	FUVA SW channel altitude column brightness for +6 to +9 degrees FOV  Vertical profile for +6 to +9 degrees FOV	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M9_Error	FUVA SW channel altitude column brightness for -9 to -6 degrees FOV error  Vertical profile for -9 to -6 degrees FOV error using uncertainty_calculator_v2r0. Statistical 1-sigma error values associated with the brightness profiles. After estimating the instrument gain and the background signal statistics from the 24 hours of brightness profiles, 1-sigma errors are calculated for each altitude profile as a function of these quantities and the measured signal level.	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M6_Error	FUVA SW channel altitude column brightness for -6 to -3 degrees FOV error  Vertical profile for -6 to -3 degrees FOV error using uncertainty_calculator_v2r0. Statistical 1-sigma error values associated with the brightness profiles. After estimating the instrument gain and the background signal statistics from the 24 hours of brightness profiles, 1-sigma errors are calculated for each altitude profile as a function of these quantities and the measured signal level.	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M3_Error	FUVA SW channel altitude column brightness for -3 to 0 degrees FOV error  Vertical profile for -3 to 0 degrees FOV error using uncertainty_calculator_v2r0. Statistical 1-sigma error values associated with the brightness profiles. After estimating the instrument gain and the background signal statistics from the 24 hours of brightness profiles, 1-sigma errors are calculated for each altitude profile as a function of these quantities and the measured signal level.	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P0_Error	FUVA SW channel altitude column brightness for 0 to +3 degrees FOV error  Vertical profile for 0 to +3 degrees FOV error using uncertainty_calculator_v2r0. Statistical 1-sigma error values associated with the brightness profiles. After estimating the instrument gain and the background signal statistics from the 24 hours of brightness profiles, 1-sigma errors are calculated for each altitude profile as a function of these quantities and the measured signal level.	Rayleigh	Epoch, Rows

Variable Name	Description	Units	Dimensions
ICON_L1_FUVA_SWP_PR OF_P3_Error	FUVA SW channel altitude column brightness for +3 to +6 degrees FOV error  Vertical profile for +3 to +6 degrees FOV error using uncertainty_calculator_v2r0. Statistical 1-sigma error values associated with the brightness profiles. After estimating the instrument gain and the background signal statistics from the 24 hours of brightness profiles, 1-sigma errors are calculated for each altitude profile as a function of these quantities and the measured signal level.	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P6_Error	FUVA SW channel altitude column brightness for +6 to +9 degrees FOV error  Vertical profile for +6 to +9 degrees FOV error using uncertainty_calculator_v2r0. Statistical 1-sigma error values associated with the brightness profiles. After estimating the instrument gain and the background signal statistics from the 24 hours of brightness profiles, 1-sigma errors are calculated for each altitude profile as a function of these quantities and the measured signal level.	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M9_BKG	FUVA SW channel altitude column brightness for -9 to -6 degrees FOV background  Vertical profile for -9 to -6 degrees FOV bkg	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M6_BKG	FUVA SW channel altitude column brightness for -6 to -3 degrees FOV background  Vertical profile for -6 to -3 degrees FOV bkg	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M3_BKG	FUVA SW channel altitude column brightness for -3 to 0 degrees FOV background  Vertical profile for -3 to 0 degrees FOV bkg	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P0_BKG	FUVA SW channel altitude column brightness for 0 to +3 degrees FOV background  Vertical profile for 0 to +3 degrees FOV bkg	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P3_BKG	FUVA SW channel altitude column brightness for +3 to +6 degrees FOV background  Vertical profile for +3 to +6 degrees FOV bkg	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P6_BKG	FUVA SW channel altitude column brightness for +6 to +9 degrees FOV background  Vertical profile for +6 to +9 degrees FOV bkg	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M9_CLEAN	FUVA SW channel altitude column brightness for -9 to -6 degrees FOV without stars  Vertical profile for -9 to -6 degrees FOV without stars using artifact_removal_v1r3	Rayleigh	Epoch, Rows

Variable Name	Description	Units	Dimensions
ICON_L1_FUVA_SWP_PR OF_M6_CLEAN	FUVA SW channel altitude column brightness for -6 to -3 degrees FOV without stars  Vertical profile for -6 to -3 degrees FOV without stars using artifact_removal_v1r3	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_M3_CLEAN	FUVA SW channel altitude column brightness for -3 to 0 degrees FOV without stars  Vertical profile for -3 to 0 degrees FOV without stars using artifact_removal_v1r3	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P0_CLEAN	FUVA SW channel altitude column brightness for 0 to +3 degrees FOV without stars  Vertical profile for 0 to +3 degrees FOV without stars using artifact_removal_v1r3	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P3_CLEAN	FUVA SW channel altitude column brightness for +3 to +6 degrees FOV without stars  Vertical profile for +3 to +6 degrees FOV without stars using artifact_removal_v1r3	Rayleigh	Epoch, Rows
ICON_L1_FUVA_SWP_PR OF_P6_CLEAN	FUVA SW channel altitude column brightness for +6 to +9 degrees FOV without stars  Vertical profile for +6 to +9 degrees FOV without stars using artifact_removal_v1r3	Rayleigh	Epoch, Rows

## support\_data

Variable Name	Description	Units	Dimensions
Epoch	Epoch  Center time of the exposure, milliseconds after 1970-01-01/00:00:00 UT	milliseconds	Epoch
ICON_L1_FUVA_SWP_Start_Times	Start time  Start time of the exposure, UT		Epoch
ICON_L1_FUVA_SWP_Stop_Times	Stop time  Stop time of the exposure, UT		Epoch
ICON_L1_FUVA_SWP_Center_Times	Center time  Center time of the exposure, UT		Epoch
ICON_L1_FUVA_SWP_Integration_Time	Time  Integration time for integration in seconds	seconds	Epoch

Variable Name	Description	Units	Dimensions
ICON_L1_FUVA_SWP_Chain_ID	Number Chain ID for integration in seconds	number	Epoch
ICON_L1_FUVA_SWP_Quality_Flag	Quality indicator (also quickly shows times when images are available)  QUALITY_FLAG is an indicator of data quality = 0 = No errors or quality conditions, LVLH 1 = No errors or quality conditions, R-LVLH 2 = Lunar calibration 3 = Insufficient high voltage 4 = Nadir calibration 5 = Zero wind calibration 6 = Bad pointing 7 = S/C attitude slew 8 = Conjugate observation 9 = Stellar calibration 10 = Unreliable background subtracted 17 = unspecified error condition	number	Epoch
ICON_L1_FUV_Mode	Data collection mode  Data collection mode of FUV instrument 1 = Dayside science 2 = Nightside science 3 = Calibration 4 = Nadir 5 = Conjugate 6 = Stars 7 = Ram 8 = Off Target 9 = Engineering 13 = Unknown	number	Epoch
ICON_L1_FUVA_SWP_HV_PHOS	HV of SW channel phosphor  HV of phosphor screen	Volt	Epoch
ICON_L1_FUVA_SWP_HV_MCP	HV of SW channel MCP  HV of MCP	Volt	Epoch
ICON_L1_FUV_Turret	FUV turret angle  FUV turret angle in degrees with respect to nominal center position	degree	Epoch
ICON_L1_FUVA_CCD_TEMP	FUVA CCD temperature  FUVA CCD temperature	degree C	Epoch
ICON_L1_FUVA_Board_TEMP	FUVA board temperature  FUVA digital board temperature	degree C	Epoch
ICON_L1_FUVA_HV_TEMP	FUVA HVPS temperature  FUVA HVPS temperature	degree C	Epoch



Variable Name	Description	Units	Dimensions
ICON_L1_FUV_IMG_TEMP	FUV imager enclosure temperature FUV imager enclosure temperature	degree C	Epoch
ICON_L1_FUV_OPT_TEMP	FUV optics bench temperature FUV optics bench temperature	degree C	Epoch
ICON_L1_FUV_Turret_TEMP	FUV turret temperature FUV turret temperature	degree C	Epoch
ICON_L1_FUV_Scan_TEMP	FUV scan mirror temperature FUV scan mirror temperature	degree C	Epoch
ICON_L1_FUVA_SWP_GAIN_DAY	Average value of CCD output electrons per primary photo-electron in the image tube during day. It is calculated using the statistics of 24 hours of day profiles. Gain of each stripe is calculated independently. Gain for profiles	CCD electrons / photo-electron	Stripes
ICON_L1_FUVA_SWP_GAIN_NIGHT	Average value of CCD output electrons per primary photo-electron in the image tube during night. It is calculated using the statistics of 24 hours of night profiles. Gain of each stripe is calculated independently. Gain for profiles	CCD electrons / photo-electron	Stripes

## metadata

Variable Name	Description	Units	Dimensions
Rows	Row Number Vertical row numbers for profiles	number	Rows
ICON_L1_FUVA_Azimuth	Azimuth of FUVA channel with respect to spacecraft coordinates FUVA channel pointing azimuth	degree	Epoch
ICON_L1_FUVA_Elevation	Elevation of FUVA channel with respect to spacecraft coordinates FUVA channel pointing elevation	degree	Epoch
ICON_L1_FUVA_Roll	Roll of FUVA channel with respect to spacecraft coordinates FUVA channel pointing roll	degree	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>

Responsibility for the validation of the L1 data products falls to the instrument lead investigators/scientists.

\* EUV: Dr. Eric Korpela : <https://doi.org/10.1007/s11214-017-0384-2>

\* FUV: Dr. Harald Frey : <https://doi.org/10.1007/s11214-017-0386-0>

\* MIGHTI: Dr. Christoph Englert : <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 and N2 profiles: Dr. Andrew Stephan : <https://doi.org/10.1007/s11214-018-0477-6>

\* Daytime (EUV) O+ profiles: Dr. Andrew Stephan : <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. Jonathan Makela : <https://doi.org/10.1007/s11214-017-0359-3>

\* Neutral Temperature profiles: Dr. Christoph Englert : <https://doi.org/10.1007/s11214-017-0434-9>

\* Ion Velocity Measurements : Dr. Russell Stoneback : <https://doi.org/10.1007/s11214-017-0383-3>

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

\* Hough Modes : Dr. Chihoko Yamashita : <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.

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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Software version: ICON\_SDC > ICON\_FUV\_L1\_Processor v1.0