ICON Data Product 1.1,1.2: MIGHTI Calibrated LOS Winds and Temperature Array

This document describes the data product for ICON MIGHTI-A Level 1.1, 1.2 Calibrated Science Image File, which is in NetCDF4 format.

This file contains MIGHTI fringe information for wind retrieval and uncalibrated IR intensities (in electrons/s) for temperature retrieval.

The MIGHTI image is separated into three regions corresponding to the atmospheric emission collected: the red side (630.0 nm), the green side (557.7 nm), and the IR mosaic (760 - 765 nm).

For the wind retrieval the fringes are analyzed for envelope (fringe amplitude) and phase delta as compared to the previously determined phase of a fringe representing zero motion of the atmosphere.

Various instrument and spacecraft parameters are provided by or derived from information in an ancillary file which includes housekeeping data (thermal sensors, pointing data, etc) from the entire day.

ECEF stands for Earth Centered Earth Fixed and ECI for Earth Centered Inertial.

Further information on the instrument and analysis processes can be found in https://doi.org/10.1364/FTS.2015.FM4A.1 by C. Englert, et. al., OSA 2015.

History

MIGHTI L1 Processing Code. Written by K. Marr, J. Harlander, C. Englert, L. Storm, and A. Thayer. Originally generated 1/1/17.

Initial release: Version 1.3.0. Provides: Red and green line of sight fringe phases (less zero wind phase), red and green amplitudes,
IR counts per second, red and green line of sight brightness profiles, tangent point geophysical data, and associated uncertainties.
Processing includes: Spike correction, flatfield correction, fringe visiblity correction, phase distortion correction, thermal effect correction,
and image transfer pickup correction.

2nd release: Version 2.0.0. Phase distortion and other calibration file updates.

3nd release: Version 3.0.0. Includes sensor lateral shift calculation (notch positions) and correction.
Update to zero wind determination. Phase correction based off signal intensity and time since launch. Spike correct v10. removeDC_v7.

4th release: Version 4.0.0. Added low signal correction to thermal drift files and then smoothed them over entire mission to reduce day to day variability.
Adjusted day/night offset in thermal drift in order to improve interpolation between them.
Changed dark limit to 2.5 days for better statistics. Tweaked the low signal correction.
Added a mask to the spike correct routine to supress pixels which had gone bad over the mission (v17).
Pre-calculated average dark for every day of mission.

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	1
ICON_L1_MIGHTI_A_IR_Array_Pixel_Index	429
ICON_L1_MIGHTI_A_IR_Array_Altitudes	20
ICON_L1_MIGHTI_A_Green_Array_OPD	380
ICON_L1_MIGHTI_A_Red_Array_OPD	342
ICON_L1_MIGHTI_A_Green_Array_Altitudes	82
ICON_L1_MIGHTI_A_Red_Array_Altitudes	60
ICON_L1_MIGHTI_A_Vector_LLA	3
ICON_L1_MIGHTI_A_Vector_XYZ	3
ICON_L1_MIGHTI_A_Vector_Roll	3
ICON_L1_MIGHTI_A_Time_Channel	3
ICON_L1_MIGHTI_A_IR_Channel	5
ICON_L0_MIGHTI_A_Image_ROI_Columns	92
ICON_L0_MIGHTI_A_Image_ROI_Rows	929

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_MIGHTI_A_IR_Array	CCD response per second to incident photons corresponding to the five IR filters CCD response per second to incident photons corresponding to the five IR filters by OPD and altitude. Raw CCD counts have been gain normalized and divided by integration time.	Rel. R (Electrons/s)	Epoch, ICON_L1_MIGHTI_A_IR_Array_Altitudes, ICON_L1_MIGHTI_A_IR_Array_Pixel_Index
ICON_L1_MIGHTI_A_IR_Array_Tangent_LatLonAlt	Tangent point latitudes, longitudes, and altitudes for IR altitudes - middle of FoV, all altitudes Tangent point latitudes, longitudes, and altitudes for IR side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	degrees, degrees, km	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Vector_LLA, ICON_L1_MIGHTI_A_IR_Array_Altitudes
ICON_L1_MIGHTI_A_IR_Array_Tangent_Local_Solar_Time	Tangent point local solar time for IR altitudes at middle of FoV Tangent point local solar times for IR array. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	hr	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_IR_Array_Altitudes
ICON_L1_MIGHTI_A_IR_Array_Tangent_Azimuth_Angle	Tangent point azimuth angle for IR altitudes at middle of FoV Azimuth angle (between line of sight and local north) at tangent points for IR array. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Line of sight is the vector pointing from the spacecraft to the tangent point. At the tangent point, this vector is parallel to the ground. This variable follows the typical geophysical convention of degrees East of North (North=0, East=90, South=180, West=270). It can vary by a few degrees from the top of the profile to the bottom, so one value is reported per altitude. MIGHTI-A and MIGHTI-B will have values approximately 90 degrees apart.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_IR_Array_Altitudes
ICON_L1_MIGHTI_A_IR_Array_Tangent_Solar_Zenith_Angle	Tangent point solar zenith angle for IR altitudes at middle of FoV Tangent point solar zenith angle for IR array. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_IR_Array_Altitudes

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_IR_Array_Tangent_Magnetic_Latitude	Tangent point magnetic latitude Tangent point magnetic latitude for IR array. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Quasi-dipole latitude and longitude are calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (doi.org/10.5281/zenodo.1214207). Quasi-dipole longitude is defined such that zero occurs where the geodetic longitude is near 285 deg east (depending on latitude).	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_IR_Array_Altitudes
ICON_L1_MIGHTI_A_IR_Array_Tangent_Magnetic_Longitude	Tangent point magnetic longitude Tangent point magnetic longitude for IR array. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Quasi-dipole latitude and longitude are calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (doi.org/10.5281/zenodo.1214207). Quasi-dipole longitude is defined such that zero occurs where the geodetic longitude is near 285 deg east (depending on latitude).	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_IR_Array_Altitudes
ICON_L1_MIGHTI_A_SC_Altitude	Spacecraft Altitude Spacecraft altitude at start, middle, and end of integration.	km	Epoch, ICON_L1_MIGHTI_A_Time_Channel
ICON_L1_MIGHTI_A_SC_Latitude	Spacecraft latitude Spacecraft latitude at start, middle, and end of integration.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel
ICON_L1_MIGHTI_A_SC_Longitude	Spacecraft longitude Spacecraft longitude at start, middle, and end of integration.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel
ICON_L1_MIGHTI_A_Total_Boresight_Sun_Angle	Total angle between the MIGHTI boresight and the sun Total (not component) angle between the MIGHTI boresight and the sun at start, middle, and end of integration.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel
ICON_L1_MIGHTI_A_Green_Phase	Phase difference between the green atmospheric line and the associated calibration line minus the corresponding Zero Wind delta - by optical path difference (OPD) and altitude Phase difference between the green atmospheric line and the associated calibration line minus the corresponding Zero Wind delta - by optical path difference (OPD) and altitude.	rad	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes, ICON_L1_MIGHTI_A_Green_Array_OPD
ICON_L1_MIGHTI_A_Green_Envelope	Envelopes of the green atmospheric fringes by optical path difference (OPD) and altitude Envelopes (fringe amplitudes) of the green atmospheric interferograms by optical path difference (OPD) and altitude.	Rel R	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes, ICON_L1_MIGHTI_A_Green_Array_OPD

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Green_Relative_Brightness	Relative brightness of green emission by altitude Relative brightness of green emission by altitude. Average of signal + DC for each altitude. SDL calibration used to convert counts to brightness.	Rayleighs	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Phase_Uncertainties	Uncertainties of the phases of the green atmospheric line by altitude Uncertainties of the phase deltas of the green atmospheric line by altitude. Calculated from total signal, modulated signal, and first principles based on assumption of shot noise dominance.	rad	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_VER_Correction_Phase	Uncertainties associated with the VER correction of the green atmospheric phases by altitude Value of the correction to green phases based on signal intensity by altitude. Calculated from parameters in the VER calibration file. Correction based off of parametrized data from the on-orbit cal lamp images on 7/21/2021.	radians	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_VER_Correction_Phase_Uncertainties	Uncertainties associated with the VER correction of the green atmospheric phases by altitude Uncertainties of the VER correction of the green atmospheric phases based on signal intensity by alitude. Equal to 20% of the correction. Correction based off of parametrized data from the on-orbit cal lamp images on 7/21/2021.	radians	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Envelope_Uncertainties	Uncertainties of the envelopes of the green atmospheric fringes by altitude Uncertainties of the envelopes of the green atmospheric fringes by altitude. Calculated from total signal, modulated signal, and first principles based on assumption of shot noise dominance.	Rel R	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Tangent_LatLonAlt	Tangent point latitudes, longitudes, and altitudes for green side - middle of FoV, all altitudes Tangent point latitudes, longitudes, and altitudes for green side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	degrees, degrees, km	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Vector_LLA, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Tangent_Local_Solar_Time	Tangent point local solar time for green side altitudes at middle of FoV Tangent point local solar times for green side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	hr	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Green_Array_Altitudes

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Green_Tangent_Magnetic_Latitude	Tangent point magnetic latitudes for green side altitudes at middle of FoV Tangent point magnetic latitudes for green side. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Quasi-dipole latitude and longitude are calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (doi.org/10.5281/zenodo.1214207). Quasi-dipole longitude is defined such that zero occurs where the geodetic longitude is near 285 deg east (depending on latitude).	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Tangent_Magnetic_Longitude	Tangent point magnetic longitudes for green side altitudes at middle of FoV Tangent point magnetic longitudes for green side. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Quasi-dipole latitude and longitude are calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (doi.org/10.5281/zenodo.1214207). Quasi-dipole longitude is defined such that zero occurs where the geodetic longitude is near 285 deg east (depending on latitude).	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Tangent_Solar_Zenith_Angle	Tangent point solar zenith angle for green side altitudes at middle of FoV Tangent point solar zenith angles for green side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Phase	Phase difference between the red atmospheric line and the associated calibration line minus the corresponding Zero Wind delta - by optical path difference (OPD) and altitude Phase difference between the red atmospheric line and the associated calibration line minus the corresponding Zero Wind delta - by optical path difference (OPD) and altitude.	rad	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes, ICON_L1_MIGHTI_A_Red_Array_OPD
ICON_L1_MIGHTI_A_Red_Envelope	Envelopes of the red atmospheric fringes by optical path differnce (OPD) and altitude Envelopes (fringe amplitudes) of the red atmospheric interferograms by optical path difference (OPD) and altitude.	Rel R	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes, ICON_L1_MIGHTI_A_Red_Array_OPD
ICON_L1_MIGHTI_A_Red_Relative_Brightness	Relative brightness of the red emission by altitude Relative brightness of the red emission by altitude. Average of signal + DC for each altitude. SDL calibration used to convert counts to brightness.	Rayleighs	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Red_Phase_Uncertainties	Uncertainties of the phase deltas of the red atmospheric line by altitude Uncertainties of the phase deltas of the red atmospheric line by altitude. Calculated from total signal, modulated signal, first principles based on assumption of shot noise dominance.	rad	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_VER_Correction_Phase	VER correction of the red atmospheric phases by altitude Value of the correction of the red phases based on signal intensity by altitude. Calculated from values in the VER calibration file. Correction based off of parametrized data from the on-orbit cal lamp images on 7/21/2021.	radians	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_VER_Correction_Phase_Uncertainties	Uncertainties associated with the VER correction of the red atmospheric phases by altitude Uncertainties of the correction to the red phase based on signal intensity by altitude. Equal to 20% of the correction. Correction based off of parametrized data from the on-orbit cal lamp images on 7/21/2021.	radians	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Envelope_Uncertainties	Uncertainties of the envelopes of the red atmospheric fringes by altitude Uncertainties of the envelopes of the red atmospheric fringes by altitude. Calculated from total signal, modulated signal, and first principles based on assumption of shot noise dominance.	Relative R	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Tangent_LatLonAlt	Tangent point latitudes, longitudes, and altitudes for red side - middle of FoV, all altitudes Tangent point latitudes, longitudes, and altitudes for red side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	degrees, degrees, km	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Vector_LLA, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Tangent_Local_Solar_Time	Tangent point local solar time for red side altitudes at middle of FoV Tangent point local solar times for red side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	hr	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Red_Array_Altitudes

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Red_Tangent_Magnetic_Latitude	Tangent point magnetic latitudes for red side altitudes at middle of FoV Tangent point magnetic latitudes for red side. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Quasi-dipole latitude and longitude are calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (doi.org/10.5281/zenodo.1214207). Quasi-dipole longitude is defined such that zero occurs where the geodetic longitude is near 285 deg east (depending on latitude).	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Tangent_Magnetic_Longitude	Tangent point magnetic longitudes for red side altitudes at middle of FoV Tangent point magnetic longitudes for red side. Taken at middle of FoV for all altitudes at start, middle, and end of integration. Quasi-dipole latitude and longitude are calculated using the fast implementation developed by Emmert et al. (2010, doi:10.1029/2010JA015326) and the Python wrapper apexpy (doi.org/10.5281/zenodo.1214207). Quasi-dipole longitude is defined such that zero occurs where the geodetic longitude is near 285 deg east (depending on latitude).	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Tangent_Solar_Zenith_Angle	Tangent point solar zenith angle for red side altitudes at middle of FoV Tangent point solar zenith angles for red side. Taken at middle of FoV for all altitudes at start, middle, and end of integration.	degrees	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Green_ECEF_Unit_Vectors	ECEF Unit Vectors per pixel representing the green lines of sight ECEF Unit Vectors per pixel representing the green lines of sight. Calculated from the boresight ECEF vector and pixel-to-view-angle ground calibrations, as documented in the MIGHTI alignment report. By OPD and altitude at start, middle and end of the integration.		Epoch, ICON_L1_MIGHTI_A_Vector_XYZ, ICON_L1_MIGHTI_A_Green_Array_Altitudes, ICON_L1_MIGHTI_A_Green_Array_OPD
ICON_L1_MIGHTI_A_Red_ECEF_Unit_Vectors	ECEF Unit Vectors per pixel representing the red lines of sight ECEF Unit Vectors per pixel representing the red lines of sight. Calculated from the boresight ECEF vector and pixel-to-view-angle ground calibrations, as documented in the alignment report. By OPD and altitude at start, middle and end of the integration.		Epoch, ICON_L1_MIGHTI_A_Vector_XYZ, ICON_L1_MIGHTI_A_Red_Array_Altitudes, ICON_L1_MIGHTI_A_Red_Array_OPD

Variable Name	Description	Units	Dimensions
ICON_L0_MIGHTI_A_Image_ROI_Pixels	Pixel values for the entire MIGHTI region of interest in spacecraft coordinate system ([ROWS]x[COLUMNS]). The entire unrotated imaged region from MIGHTI. Typically 92 x 929 pixels (altitude x optical path difference). During processing this image is rotated ninety degrees clockwise and then split into red, green, and IR regions.	Count	Epoch, ICON_L0_MIGHTI_A_Image_ROI_Rows, ICON_L0_MIGHTI_A_Image_ROI_Columns

support_data

Variable Name	Description	Units	Dimensions
Epoch	Milliseconds since 1970-01-01 00:00:00 UTC at middle of image integration Milliseconds since 1970-01-01 00:00:00 UTC at middle of image integration.	ms	Epoch
ICON_L1_MIGHTI_A_IR_Array_Pixel_Index	Pixel indices corresponding to the IR filter mosaic Pixel (OPD) indices corresponding to the IR filter mosaic (1st dimension).		Epoch, ICON_L1_MIGHTI_A_IR_Array_Pixel_Index
ICON_L1_MIGHTI_A_IR_Array_Altitudes	Tangent altitudes corresponding to the five IR filters Tangent altitudes corresponding to the rows of the IR filter mosaic (2nd dimension).	km	Epoch, ICON_L1_MIGHTI_A_IR_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Quality_Factor	Data quality Factor by altitude for 557nm Data quality Factor by altitude for green line. 0: unable to analyze data 0.5: data has one or more of the issues listed below 1.0: good data Reasons for 0.5 setting: Thermal Drift calibration file greater than 3 days old, uncertainty in green phases greater than 0.35.		Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Green_Array_OPD	Optical path differences corresponding to the L1 green side pixels (along fringe pattern) Optical path differences corresponding to the L1 green side pixels (along fringe pattern). The OPD increases from left to right in L1 rotated coordinates and is used to convert phase deltas to atmospheric winds as demonstrated in https://doi.org/10.1364/FTS.2015.FM4A.1 by C. Englert, et. al., OSA 2015. OPD range is roughly 4.9 - 5.9 cm depending on region of interest.	cm	Epoch, ICON_L1_MIGHTI_A_Green_Array_OPD

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Green_Array_Altitudes	Tangent altitudes corresponding to the green fringes - middle of integration, middle of FoV Tangent altitudes corresponding to the rows of the green fringes. Taken from middle of integration time at middle of FoV.	km	Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Quality_Factor	Data quality Factor by altitude for 630nm Data quality Factor by altitude for red line. 0.0: unable to analyze data 0.5: data has one or more of the issues listed below 1.0: good data Reasons for 0.5 setting: Thermal Drift calibration file greater than 3 days old, uncertainty in red phases greater than 0.35.		Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Red_Array_OPD	Optical path differences corresponding to the L1 red side pixels (along fringe pattern) Optical path differences corresponding to the L1 red side pixels (along fringe pattern). The OPD increases from left to right in L1 rotated coordinates and is used to convert phase deltas to atmospheric winds as demonstrated in https://doi.org/10.1364/FTS.2015.FM4A.1 by C. Englert, et. al., OSA 2015. OPD range is roughly 4.9 - 5.9 cm depending on region of interest.	cm	Epoch, ICON_L1_MIGHTI_A_Red_Array_OPD
ICON_L1_MIGHTI_A_Red_Array_Altitudes	Tangent altitudes corresponding to the red fringes - middle of integration, middle of FoV Tangent altitudes corresponding to the rows for the red fringes Taken from middle of integration time at middle of FoV.	km	Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_SC_Position_ECEF	Spacecraft Position Vector in ECEF Spacecraft Position Vector in ECEF as given in the MIGHTI ancillary file.	km	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Vector_XYZ
ICON_L1_MIGHTI_A_SC_Velocity_ECEF	ECEF Vector for spacecraft velocity ECEF Vector for spacecraft velocity as given in the MIGHTI ancillary file.	m/s	Epoch, ICON_L1_MIGHTI_A_Time_Channel, ICON_L1_MIGHTI_A_Vector_XYZ
ICON_L1_MIGHTI_A_Image_Times	Epochs corresponding to the Start, Middle, and Stop of the integration Epochs corresponding to the start, middle, and end of the integration.	ms	Epoch, ICON_L1_MIGHTI_A_Time_Channel
ICON_L1_MIGHTI_A_Roll_Angles	Roll angles of the field of view Roll angles of the field of view. Order: Boresight angle, CCD_Limb angle, CCD_Altitudes angle.	degrees, degrees, degrees	Epoch, ICON_L1_MIGHTI_A_Vector_Roll

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Quality_Flag_Low_Signal_To_Noise_Red	Quality Flag indicating low signal to noise in red signal Quality Flag indicating low signal to noise for red signal by altitude. Half up means the uncertainty is above 0.35rad. Full up means single-row analysis was impossible.		Epoch, ICON_L1_MIGHTI_A_Red_Array_Altitudes
ICON_L1_MIGHTI_A_Quality_Flag_Low_Signal_To_Noise_Green	Quality Flag indicating low signal to noise in green signal Quality Flag indicating low signal to noise for green signal by altitude. Half up means the uncertainty is above 0.35rad. Full up means single-row analysis was impossible.		Epoch, ICON_L1_MIGHTI_A_Green_Array_Altitudes
ICON_L1_MIGHTI_A_Quality_Flag_SAA	Quality Flag indicating that the spacecraft is within the South Atlantic Anomaly Quality Flag indicating that the spacecraft is within the South Atlantic Anomaly based on the spacecraft status register.		Epoch
ICON_L1_MIGHTI_A_Quality_Flag_Bad_Calibration	Quality Flag indicating an inappropriate calibration file has been used or was missing Quality Flag indicating a thermal drift file older than three days has been used.		Epoch
ICON_L1_MIGHTI_A_Quality_Flag_Sun_Moon_in_FoV	Quality Flag indicating that either the Sun or Moon is in or near the field of view. Quality Flag indicating either the Sun or Moon is in or near the field of view. Half up means the moon was within 5 degrees of the field of view for this image. Full up means the Sun is within 7 degrees of the field of view at some point during the day. For both cases the quality factors are set to zero for the whole image.		Epoch
ICON_L1_MIGHTI_A_SC_Attitude_Control_Register	Spacecraft Attitude Control Register Spacecraft Attitude Control Register. Bit 0: LVLH NORMAL Bit 1: LVLH Reverse Mode Bit 2: Earth Limb Pointing Bit 3: Inertial Pointing Bit 4: Stellar Pointing Bit 5: Attitude Slew Bit 6: Conjugate Maneuver Bit 7: Nadir Calibration Bit 8: Lunar Calibration Bit 9: Stellar Calibration		Epoch

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_SC_Pointing_Jitter	Spacecraft Pointing Jitter Spacecraft pointing jitter. On the basis of the ECEF quaternion ephemeris, a 60-second window is found. Over that window a linear fit is found. A residual between the actual values and linear fit is calculated. The standard deviation of that residual is reported as the jitter. The closest ehemeris time to the MIGHTI middle time is used in this variable.	degrees	Epoch
ICON_L0_MIGHTI_A_Time_UTC	ISO 9601 formatted UTC timestamp (at middle of image integration). ISO 9601 formatted UTC timestamp (at middle of image integration). Derived from original GPS values reported from spacecraft (Time_GPS_Seconds and Time_GPS_Subseconds). Time calculation is offset by 615ms (flush time) for the first image in the series and for all other images are adjusted by subtracting (integration time + 308 milliseconds) from the reported GPS time then adding the difference between the readout FRT and the header FRT. Time may be delayed by up to 10 ms due to FSW polling delay. Minimum allowed value for this variable is 1970-01-01 00:00:00 UTC and maximum allowed value is 2150-01-01 00:00:00 UTC. All character arrays are NULL terminated (size includes NULL).		Epoch
ICON_L0_MIGHTI_A_Time_GPS	Milliseconds since 1980-01-06 00:00:00 TAI (coincident with UTC) at middle of image integration. Milliseconds since 1980-01-06 00:00:00 TAI (coincident with UTC) at middle of image integration. Derived from original GPS values reported from spacecraft (Time_GPS_Seconds and Time_GPS_Subseconds). Time calculation is offset by 615ms (flush time) for the first image in the series and for all other images are adjusted by subtracting (integration time + 308 milliseconds) from the reported GPS time then adding the difference between the readout FRT and the header FRT. Time may be delayed by up to 10 ms due to FSW polling delay.	milliseconds	Epoch

Variable Name	Description	Units	Dimensions
ICON_L0_MIGHTI_A_Time_UTC_Start	Milliseconds since 1970-01-01 00:00:00 UTC at start of image integration. Milliseconds since 1970-01-01 00:00:00 UTC at start of image integration. Derived from original GPS values reported from spacecraft (Time_GPS_Seconds and Time_GPS_Subseconds). Time calculation is offset by 615ms (flush time) for the first image in the series and for all other images are adjusted by subtracting (integration time + 308 milliseconds) from the reported GPS time then adding the difference between the readout FRT and the header FRT. Time may be delayed by up to 10 ms due to FSW polling delay. Minimum allowed value for this variable is a long integer corresponding to 1970-01-01 00:00:00 UTC and maximum allowed value is a long integer corresponding to a time in year 2160 UTC.	milliseconds	Epoch
ICON_L0_MIGHTI_A_Time_UTC_Stop	Milliseconds since 1970-01-01 00:00:00 UTC at end of image integration. Milliseconds since 1970-01-01 00:00:00 UTC at end of image integration. Derived from original GPS values reported from spacecraft (Time_GPS_Seconds and Time_GPS_Subseconds). Time calculation is offset by 615ms (flush time) for the first image in the series and for all other images are adjusted by subtracting (integration time + 308 milliseconds) from the reported GPS time then adding the difference between the readout FRT and the header FRT. Time may be delayed by up to 10 ms due to FSW polling delay. Minimum allowed value for this variable is a long integer corresponding to 1970-01-01 00:00:00 UTC and maximum allowed value is a long integer corresponding to a time in year 2160 UTC.	milliseconds	Epoch
ICON_L0_MIGHTI_A_Time_GPS_Seconds	GPS seconds count when FSW received image packet header. GPS seconds count when FSW received image packet header. The FSW received the header of the first image in a series 615ms after start of image processing. Following headers are adjusted by subtracting (integration time + 308 milliseconds) from the reported GPS time then adding the difference between the readout FRT and the header FRT. Time may be delayed by up to 10 ms due to FSW polling delay.	Seconds	Epoch

Variable Name	Description	Units	Dimensions
ICON_L0_MIGHTI_A_Time_GPS_Subseconds	FSW 20MHz clock (50 nanosecond) offset from GPS seconds. FSW 20MHz clock (50 nanosecond) offset from GPS seconds. The FSW received the header of the first image in a series 615ms after start of image processing. Following headers are adjusted by subtracting (integration time + 308 milliseconds) from the reported GPS time then adding the difference between the readout FRT and the header FRT. The offset may be more than 1 second but never 2 or more seconds. Time may be delayed by up to 10 ms due to FSW polling delay.	50 Nanoseconds	Epoch
ICON_L0_MIGHTI_A_Time_Integration	Time to integrate MIGHTI-A region of interest (ROI) image.	milliseconds	Epoch
ICON_L0_MIGHTI_A_Time_Header_Free_Running_Timer	Free running timer reading for MIGHTI image header. The FRTs are millisecond free running timers used to calculate the time offset for this image's integration from the observatory GPS time tag. This is only used when it is not the first image in the integration sequence. When the prior image FRT is not known a timing error is generated as a calculation cannot be performed. The base GPS time is used as the start time.	milliseconds	Epoch
ICON_L0_MIGHTI_A_Time_Readout_Free_Running_Timer	Free running timer reading for MIGHTI image data readout start. The FRTs are millisecond free running timers used to calculate the time offset for this image's integration from the observatory GPS time tag. This is only used when it is not the first image in the integration sequence. When the prior image FRT is not known a timing error is generated as a calculation cannot be performed. The base GPS time is used as the start time.	milliseconds	Epoch
ICON_L0_MIGHTI_A_Time_Prior_Readout_Free_Running_Timer	Free running timer reading for MIGHTI prior image data readout start. The FRTs are millisecond free running timers used to calculate the time offset for this image's integration from the observatory GPS time tag. This is only used when it is not the first image in the integration sequence. When the prior image FRT is not known a timing error is generated as a calculation cannot be performed. The base GPS time is used as the start time.	milliseconds	Epoch
ICON_L0_MIGHTI_A_Time_Prior_Known	Flag indicating prior image's free running timer known. The FRTs are millisecond free running timers used to calculate the time offset for this image's integration from the observatory GPS time tag. This is only used when it is not the first image in the integration sequence. When the prior image FRT is not known a timing error is generated as a calculation cannot be performed. The base GPS time is used as the start time.	Flag	Epoch
ICON_L0_MIGHTI_A_MT_Device_ID	MIGHTI camera instrument ID (0=MIGHTI-A, 1=MIGHT-B).	Flag	

Variable Name	Description	Units	Dimensions
ICON_L0_MIGHTI_A_MT_Device_Current_Sense	MIGHTI camera current (power) monitor count.	Count	Epoch
ICON_L0_MIGHTI_A_Calibration_Lamp_1	MIGHTI interferometer 2 fine temperature sense count. MIGHTI krypton (557.03 nm) camera calibration lamp 1 setting (0=OFF, 1=ON).	Flag	Epoch
ICON_L0_MIGHTI_A_Calibration_Lamp_2	MIGHTI interferometer 2 fine temperature sense count. MIGHTI neon (630.48 nm) camera calibration lamp 1 setting (0=OFF, 1=ON).	Flag	Epoch
ICON_L0_MIGHTI_A_Calibration_Lamp_Current	MIGHTI camera calibration lamp combined current monitor sense count.	Count	Epoch
ICON_L0_MIGHTI_A_Calibration_Lamp_Temperature	MIGHTI camera calibration lamp combined temperature monitor sense count.	Count	Epoch
ICON_L0_MIGHTI_A_Interferometer_1_Temperature_Sense	MIGHTI interferometer 1 fine temperature sense count.	Count	Epoch
ICON_L0_MIGHTI_A_Interferometer_2_Temperature_Sense	MIGHTI interferometer 2 fine temperature sense count.	Count	Epoch
ICON_L0_MIGHTI_A_Optics_Bench_Temperature_Forward	MIGHTI optics bench forward temperature sense count.	Count	Epoch
ICON_L0_MIGHTI_A_Optics_Bench_Temperature_Rear	MIGHTI optics bench rear temperature sense count.	Count	Epoch
ICON_L0_MIGHTI_A_Optics_Temperature_Aft	MIGHTI optics aft temperature sense count.	Count	Epoch
ICON_L0_MIGHTI_A_TEC_Current_Input_Count	MIGHTI thermo-electric cooler combined (TEC-A + TEC-B) input current count.	Count	Epoch
ICON_L0_MIGHTI_A_TEC_Temperature_Cold_Count	MIGHTI thermo-electric cooler cold-side temperature sense count.	Count	Epoch

Variable Name	Description	Units	Dimensions
ICON_L0_MIGHTI_A_TEC_Temperature_Hot_Count	MIGHTI thermo-electric cooler hot-side temperature sense count.	Count	Epoch
ICON_L0_MIGHTI_A_MTA_Aperture1_Position	MIGHTI-A camera aperture 1 position sense flag. 0=OPEN, 1=CLOSED, 2=15% OPEN, 3=UNKNOWN	Flag	Epoch
ICON_L0_MIGHTI_A_MTA_Aperture2_Position	MIGHTI-A camera aperture 2 position sense flag. 0=OPEN, 1=CLOSED, 2=15% OPEN, 3=UNKNOWN	Flag	Epoch
ICON_L0_MIGHTI_A_MTA_Aperture1	MIGHTI-A camera aperture 1 switch setting (0=OPEN, 1=CLOSED).	Flag	Epoch
ICON_L0_MIGHTI_A_MTA_Aperture2	MIGHTI-A camera aperture 2 switch setting (0=OPEN, 1=CLOSED).	Flag	Epoch
ICON_L0_MIGHTI_A_MTB_Aperture1_Position	MIGHTI-B camera aperture 1 position sense flag. 0=OPEN, 1=CLOSED, 2=15% OPEN, 3=UNKNOWN	Flag	Epoch
ICON_L0_MIGHTI_A_MTB_Aperture2_Position	MIGHTI-B camera aperture 2 position sense flag. 0=OPEN, 1=CLOSED, 2=15% OPEN, 3=UNKNOWN	Flag	Epoch
ICON_L0_MIGHTI_A_MTB_Aperture1	MIGHTI-B camera aperture 1 switch setting (0=OPEN, 1=CLOSED).	Flag	Epoch
ICON_L0_MIGHTI_A_MTB_Aperture2	MIGHTI-B camera aperture 2 switch setting (0=OPEN, 1=CLOSED).	Flag	Epoch
ICON_L0_MIGHTI_A_Error_Compression	Error count during compression (per packet). Error count during compression (per packet). Should be zero (for no error) but if it is a non-zero number then the number indicates the number of packets that contained an overflow in the delta bit field during compression.	Count	Epoch
ICON_L0_MIGHTI_A_Error_Time	Error finding prior image readout FRT (0=GOOD, 1=ERROR). Error finding prior image readout FRT (0=GOOD, 1=ERROR). The prior image read out FRT was missing so proper time offset couldn't be calculated correctly. The time will indicate later then the actual time. This only occurs when not the first image of the series.	Flag	Epoch
ICON_L0_MIGHTI_A_CCD_CS_Register	CCD CS register value from image header at end of integration. CCD CS register value from image header at end of integration. See ICN-ICD-002 (MIGHTI) for more details on this parameter.	Flag	Epoch

Variable Name	Description	Units	Dimensions
ICON_L0_MIGHTI_A_Horizontal_Charge_Transfer_Efficiency_Count	Horizontal charge transfer efficiency register count indicating the horizontal overscan pixel configuration per MIGHTI ICD. Horizontal charge transfer efficiency register count indicating the horizontal overscan pixel configuration per MIGHTI ICD. See ICN-ICD-002 (MIGHTI) for more details on this parameter.	Count	Epoch
ICON_L0_MIGHTI_A_Image_BIN_Parameters	MIGHTI binning parameters (BINCOUNTS). Bitwise register (typical MIGHTI binning is 2x16 in CCD coordinates). Bits 0-7: Serial bin count (number of CCD columns per super-pixel). Bitwise register. Typical binning is 16 x 2 in unrotated coordinates. Bits 8-15: Parallel bin count (number of CCD rows per super-pixel). See ICN-ICD-002 (MIGHTI) for more details on this parameter.	Flag	Epoch
ICON_L0_MIGHTI_A_Image_First	First image in MIGHTI integration sequence (0=NOT FIRST, 1=FIRST).	Flag	Epoch
ICON_L0_MIGHTI_A_Image_ROI_Column_Count	MIGHTI region of interest (ROI) pixel column count.	Count	Epoch
ICON_L0_MIGHTI_A_Image_ROI_Column_Start	MIGHTI region of interest (ROI) pixel starting column.	Count	Epoch
ICON_L0_MIGHTI_A_Image_ROI_Row_Count	MIGHTI region of interest (ROI) pixel row count.	Count	Epoch
ICON_L0_MIGHTI_A_Image_ROI_Row_Start	MIGHTI region of interest (ROI) pixel starting row.	Count	Epoch

metadata

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Vector_LLA	Vector labels corresponding to the tangent latitude, longitude, and altitude Vector labels corresponding to the tangent latitude, longitude, and altitude.		ICON_L1_MIGHTI_A_Vector_LLA
ICON_L1_MIGHTI_A_Vector_XYZ	Vector labels corresponding to the ECEF lines of sight Vector labels corresponding to the ECEF lines of sight.		ICON_L1_MIGHTI_A_Vector_XYZ
ICON_L1_MIGHTI_A_Vector_Roll	Vector labels corresponding to the field of view roll angles Vector labels corresponding to the field of view roll angles.		ICON_L1_MIGHTI_A_Vector_Roll

Variable Name	Description	Units	Dimensions
ICON_L1_MIGHTI_A_Time_Channel	Vector labels corresponding to the time channels Vector labels corresponding to the time channels.		ICON_L1_MIGHTI_A_Time_Channel

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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