ICON Data Product 2.1: Line-of-sight Wind Profile

This document describes the data product for ICON MIGHTI Line-of-sight Winds (DP 2.1), which is in NetCDF4 format.

This data product contains an altitude profile of the line-of-sight winds for a single image taken by MIGHTI. There is one file for each sensor (A or B), for each color (red or green) and for each image (usually every 30 or 60 seconds). The profile spans from ~90 km (for green) or ~150 km (for red) to ~300 km, though altitudes with low signal levels are masked out. This data product is generated from the Level 1 MIGHTI product, which is a calibrated interferogram. The spacecraft velocity is removed from the interferogram phase, then an onion-peeling inversion is performed to remove the effect of the line-of-sight integration. After the inversion, each row (i.e., altitude) is analyzed to extract the phase, and thus the line-of-sight wind. Level 2.1 files from MIGHTI-A and MIGHTI-B are combined during the Level 2.2 processing (not discussed here). See Harding et al. [2017, doi:10.1007/s11214-017-0359-3] for more details of the inversion algorithm. One update to this paper is relevant: Zero wind removal is now performed prior to the creation of the Level 1 file, instead of during the L2.1 processing.

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.

Dimensions

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 likely have a varying size.

Dimension Name	Nominal Size
`Start_Mid_Stop`	3
`ICON_L2_MIGHTI_A_Green_Altitude`	82
`Epoch`	1
`Vector`	3

Variables

Variables in this file are listed below. First, the most important variables (the "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_L2_MIGHTI_A_Green_Line_Of_Sight_Wind	Line-of-sight horizontal wind profile. A positive wind is towards MIGHTI. The wind is the primary data product in this file. This variable contains the projection of the horizontal wind (at the tangent point) onto the line of sight. An entire altitude profile is observed simultaneously. An onion-peeling inversion is used on the raw observations to remove the effects of the integration along the line of sight. The line-of-sight wind is defined such that a positive value indicates motion towards the spacecraft. This direction is given by the Line_Of_Sight_Azimuth variable. It is assumed that the vertical wind is zero, but even large vertical winds (~100 m/s) do not significantly affect this data product, since the line of sight is nearly horizontal everywhere. It should be noted that while this measurement is ascribed to a particular latitude, longitude and altitude, it is actually an average over many hundreds of kilometers horizontally, and 2.5-30 kilometers vertically (depending on the binning). See Harding et al. [2017, doi:10.1007/s11214-017-0359-3] for a more complete discussion of the inversion algorithm.	m/s	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Line_Of_Sight_Wind_Error	Line-of-sight horizontal wind error profile The statistical (1-sigma) error in the line-of-sight wind. This is usually dominated by shot noise, but also includes the effects of dark and read noise, as well as calibrations errors (e.g., the zero wind calibration), and spacecraft pointing error (which affects the uncertainty in removing the spacecraft velocity from the observed velocity). Other systematic errors or biases may exist (e.g., the effect of gradients along the line of sight) which are not included in this variable.	m/s	ICON_L2_MIGHTI_A_Green_Altitude

Variable Name	Description	Units	Dimensions
ICON_L2_MIGHTI_A_Green_Wind_Quality	A quantification of the quality, from 0 (Bad) to 1 (Good) NOT YET IMPLEMENTED While the intent is that the variable Line_Of_Sight_Wind_Error accurately characterizes the statistical error in the wind data, it is possible that systematic errors are present, or that the statistical error estimation is not accurate. If it is suspected that this is the case, the quality will be less than 1.0. If the data are definitely unusable, the the quality will be 0.0 and the sample will be masked. Users should exercise caution when the quality is less than 1.0.	arb	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Fringe_Amplitude	Fringe amplitude profile An approximate volume emission rate (VER) profile in arbitrary units. Technically this a profile of the amplitude of the fringes, which has a dependence on thermospheric temperature and background emission. Thus, it does not truly represent volume emission rate. However, it is a useful proxy. The units are arbitrary, but an attempt has been made to cross-calibrate MIGHTI-A with MIGHTI-B. In contrast with the wind inversion, which is nonlinear due to the phase extraction step, the amplitude inversion is purely linear. The Level 1 interferogram is analyzed to obtain a single brightness value per observing angle, and this is inverted with the distance matrix to obtain a value of the amplitude per altitude.	arb	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Fringe_Amplitude_Error	Fringe amplitude error profile The statistical (1-sigma) error in the fringe amplitude. As with the wind, systematic errors are not included, but can arise from sources such as horizontal gradients and inaccurate calibration.	arb	ICON_L2_MIGHTI_A_Green_Altitude

support_data

Variable Name	Description	Units	Dimensions
Epoch	Sample time, midpoint of exposure. Number of msec since Jan 1, 1970. This variable contains the time corresponding to the wind profile reported in this file. It is evaluated at the midpoint of the exposure time. It is in UTC and has units of milliseconds since Jan 1, 1970. A human-readable version of the time can be found in the global attributes Date_Start and Date_Stop.	ms	

Variable Name	Description	Units	Dimensions
ICON_L2_MIGHTI_A_Green_Time	Sample time at start, mid, stop of exposure. Number of msec since Jan 1, 1970. This variable is the same as Epoch, except it includes the start time and stop time. This variable has length 3: [start_time, mid_time, stop_time].	ms	Start_Mid_Stop
ICON_L2_MIGHTI_A_Green_Altitude	WGS84 altitude of each wind sample The altitudes of each point in the wind profile, evaluated using the WGS84 ellipsoid. If the variable Integration_Order=0 (which is the default value), then these altitudes are one half sample above the tangent altitudes of each pixel's line of sight (consistent with the assumption implicit in the inversion that the wind and emission rate are constant within the layer between tangent altitudes). If Integration_Order=1, this variable contains the tangent altitudes.	m	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Latitude	WGS84 latitude of each wind sample The latitudes of each point in the wind profile, evaluated using the WGS84 ellipsoid. The latitude only varies by several degrees from the bottom of the profile to the top. It should be noted that while a single latitude value (the tangent latitude) is given for each point, the observation is inherently a horizontal average over many hundreds of kilometers.	deg	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Longitude	WGS84 longitude of each wind sample The longitudes (0-360) of each point in the wind profile, evaluated using the WGS84 ellipsoid. The longitude only varies by several degrees from the bottom of the profile to the top. It should be noted that while a single longitude value (the tangent longitude) is given for each point, the observation is inherently a horizontal average over many hundreds of kilometers.	deg	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Line_Of_Sight_Azimuth	Azimuth angle of the line of sight at the tangent point. Deg East of North. Consider the vector pointing from the spacecraft to the tangent point (i.e., the line of sight). At the tangent point, this vector is parallel to the ground. This variable contains the azimuth angle of this vector, evaluated at the tangent point. It 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.	deg	ICON_L2_MIGHTI_A_Green_Altitude

metadata

Variable Name	Description	Units	Dimensions
ICON_L2_MIGHTI_A_Green_Chi2	Chi^2 of the line fit to unwrapped phase used to determine wind To convert a complex interferogram to a wind value, a line is fit to the unwrapped phase vs optical path difference. The chi^2 value of that fit (here defined as the square of the residual, averaged over optical path difference) can be used as a quality-of-fit metric. It is used to find and mask values which have a unusably low SNR.	rad^2	ICON_L2_MIGHTI_A_Green_Altitude
ICON_L2_MIGHTI_A_Green_Spacecraft_Velocity_Vector	ICON's velocity vector in Earth-centered, Earth-fixed coordinates A length-3 vector [vx,vy,vz] of ICON's velocity in Earth-centered Earth-fixed (ECEF) coordinates at the midpoint time of the observation. The effect of spacecraft velocity has already been removed from the LINE_OF_SIGHT_WIND variable.	m/s	Vector
ICON_L2_MIGHTI_A_Green_Spacecraft_Latitude	The WGS84 latitude of ICON The latitude of ICON at the midpoint time of the observation, using the WGS84 ellipsoid.	deg	
ICON_L2_MIGHTI_A_Green_Spacecraft_Longitude	The WGS84 longitude of ICON The longitude (0-360) of ICON at the midpoint time of the observation, using the WGS84 ellipsoid.	deg	
ICON_L2_MIGHTI_A_Green_Spacecraft_Altitude	The WGS84 altitude of ICON The altitude of ICON at the midpoint time of the observation, using the WGS84 ellipsoid.	m	
ICON_L2_MIGHTI_A_Green_Resolution_Along_Track	The horizontal resolution in the spacecraft velocity direction NOT YET IMPLEMENTED	m	
ICON_L2_MIGHTI_A_Green_Resolution_Cross_Track	The horizontal resolution perpendicular to the spacecraft velocity direction NOT YET IMPLEMENTED	m	
ICON_L2_MIGHTI_A_Green_Resolution_Altitude	The vertical resolution NOT YET IMPLEMENTED	m	
ICON_L2_MIGHTI_A_Green_Line_Of_Sight_Vector	The look direction of each MIGHTI line of sight, as a vector in ECEF The vector from the spacecraft to the tangent point (i.e., along MIGHTI's line of sight), as a unit vector in Earth-centered Earth-fixed (ECEF) coordinates. A vector is provided for each tangent point. If this vector is transformed to an azimuth and zenith angle at the tangent point, the zenith angle will be 90 deg, and the azimuth angle will be the same as the Line_Of_Sight_Azimuth variable.		ICON_L2_MIGHTI_A_Green_Altitude, Vector

Variable Name	Description	Units	Dimensions
ICON_L2_MIGHTI_A_Green_Bin_Size	How many raw samples were binned vertically for each reported sample To improve statistics, adjacent rows of the interferogram can be averaged together before the inversion. This improves precision at the cost of vertical resolution. If no binning is performed, this value will be 1, corresponding to ~2.5 km resolution. A value of 2 corresponds to ~5 km resolution, etc.		
ICON_L2_MIGHTI_A_Green_Integration_Order	Order used to discretize the integral for inversion: 0=Riemann, 1=Trapezoidal In formulating the inversion, an assumption must be made regarding the choice of basis functions, which can be thought of as an assumption regarding the behavior of the wind and amplitude within each altitude layer. The most basic assumption is that these quantities are constant within each altitude layer, which corresponds to Integration_Order=0. However, if it is assumed that the variation within each layer is linear, Integration_Order=1. This sacrifices precision to improve vertical resolution.		
ICON_L2_MIGHTI_A_Green_Top_Layer_Model	How the top altitudinal layer is handled in the inversion: "exp" or "thin" In formulating the inversion, an assumption must be made about the shape of the emission rate profile above the top measured altitude, since this shape is not measured. It can be assumed to go to zero (Top_Layer_Model="thin") or assumed to fall off exponentially with a scale height of 26 km, a value extracted from running a variety of airglow models (Top_Layer_Model="exp"). Usually this choice will not affect the inversion significantly. In cases where it does, the quality variable will be decreased.		

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