V1.1 NOAA Level 2 CyGNSS Winds Basic User Guide

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1 Product Description and Content

NOAA has produced and made available to the public the latest version, v1.1, of NOAA Level 2 CyGNSS winds. This product provides time-tagged, precision geolocated along-track average wind speed of non-overlapping 25x25Km cells. The data is made available in NetCDF file format. Each file provides daily global coverage from all eight CyGNSS spacecraft. Corresponding latitude and longitude variables, including several Level 1 parameters are also included in these files. Table 1 reports the complete list of variables found in these files.

Table 1 List of variables found in NOAA Level 2 CyGNSS NetCDF files

Name	Description	Data type	Dimension
sample	Sample index	Long	grid(ysize)
spacecraft_num	CyGNSS spacecraft number	Byte	grid(ysize)
prn_code	GPS PRN code	Byte	grid(ysize)
sv_num	GPS space vehicle number	Long	grid(ysize)
antenna	Receive antenna	Byte	grid(ysize)
sample_time	Sample time	Double	grid(ysize)
lat	Latitude	Float	grid(ysize)
lon	Longitude	Float	grid(ysize)
sc_lat	Subsatellite point latitude	Float	grid(ysize)
sc_lon	Subsatellite point longitude	Float	grid(ysize)
incidence_angle	Incidence angle	Float	grid(ysize)
track_id	Track ID	Long	grid(ysize)
rx_gain	Rx antenna gain	Float	grid(ysize)
snr	Signal-to-noise ratio	Float	grid(ysize)
range_corr_gain	Range corrected gain	Float	grid(ysize)
sample_flags	Status flags for the sample	Long	grid(ysize)
num_ddms_utilized	Number of DDMs utilized	Byte	grid(ysize)
ddm_sample_index	Level 1 NetCDF sample indices	Long	grid(xsize,ysize)

ddm_channel	Level 1 DDM reflectometry channel	Long	grid(xsize,ysize)
nbrcs_mean	Normalized BRCS averaged in a 25x25km grid cell	Float	grid(ysize)
nbrcs_mean_corrected	Corrected normalized BRCS averaged in a 25x25km grid cell	Float	grid(ysize)
wind_speed	Retrieved wind speed	Float	grid(ysize)
azimuth_angle	Azimuth angle	Float	grid(ysize)
sc_roll	Spacecraft attitude roll angle	Float	grid(ysize)
sc_pitch	Spacecraft attitude pitch angle	Float	grid(ysize)
sc_yaw	Spacecraft attitude yaw angle	Float	grid(ysize)
sc_alt	Spacecraft altitude	Float	grid(ysize)

2 Quality Flag

A quality flag variable (named ‘sample_flags’ – see Table 1) is provided so as to help the end user filter out poor quality samples and/or select specific data subset (e.g. retrieve wind speed samples for a specific satellite orbital node). The ‘sample_flags’ variable unit is a bit field. In this current version (v1.1) of the data product, eight separate bits (starting at bit 0) are currently used.

Table 2 shows the list of bits with their respective description.

Table 2 'Sample_flags' bit description

Bit flag	value	description
0	0	data is considered of 'good quality'
	1	data is considered of 'poor quality'. This is the result of the logical OR of: bit 6 being 'set', bit 7 being 'set'.
1	0	descending node
	1	ascending node
2	0	data from GPS blocks IIR and IIRM
	1	data from GPS block IIF only
3	0	data from GPS blocks IIF and IIRM
	1	data from GPS block IIR only
4	0	data from GPS blocks IIR and IIF
	1	data from GPS block IIR-M only
5	0	the Level 1 "nst_att_status" flag (i.e. related to the nano star tracker) is zero
	1	the Level 1 "nst_att_status" flag is nonzero
6	0	wind speed quality OK WHILE the nano star tracker flag (i.e. nst_att_status) is set
	1	low confidence in the reported wind speed WHILE the nano star tracker flag is set.
7	0	free of unrealistic wind speed samples
	1	unrealistic wind speed samples detected

Equation (1) shows how to filter out the 'poor quality samples' (i.e. bit 0) using the modulo operator such that

$$MOD\left(\frac{\text{long(sample\_flags)}}{2^0}, 2\right) = 0. \quad (1)$$

Whenever Equation (1) is true, the wind speed samples are considered of good quality. Note the exponent in the denominator of the modulo operand: a '0' is used because bit 0 represents the poor overall quality flag bit. Similarly, if one is interested in plotting all available ascending data, then this exponent would be replaced with a '1' and Equation (1) would be set equal to 1.
As an illustration, Figure 2-1 shows an ascending and descending passes of NOAA CyGNSS winds on 2020 August 04, with poor quality samples filtered out using Equation (1).

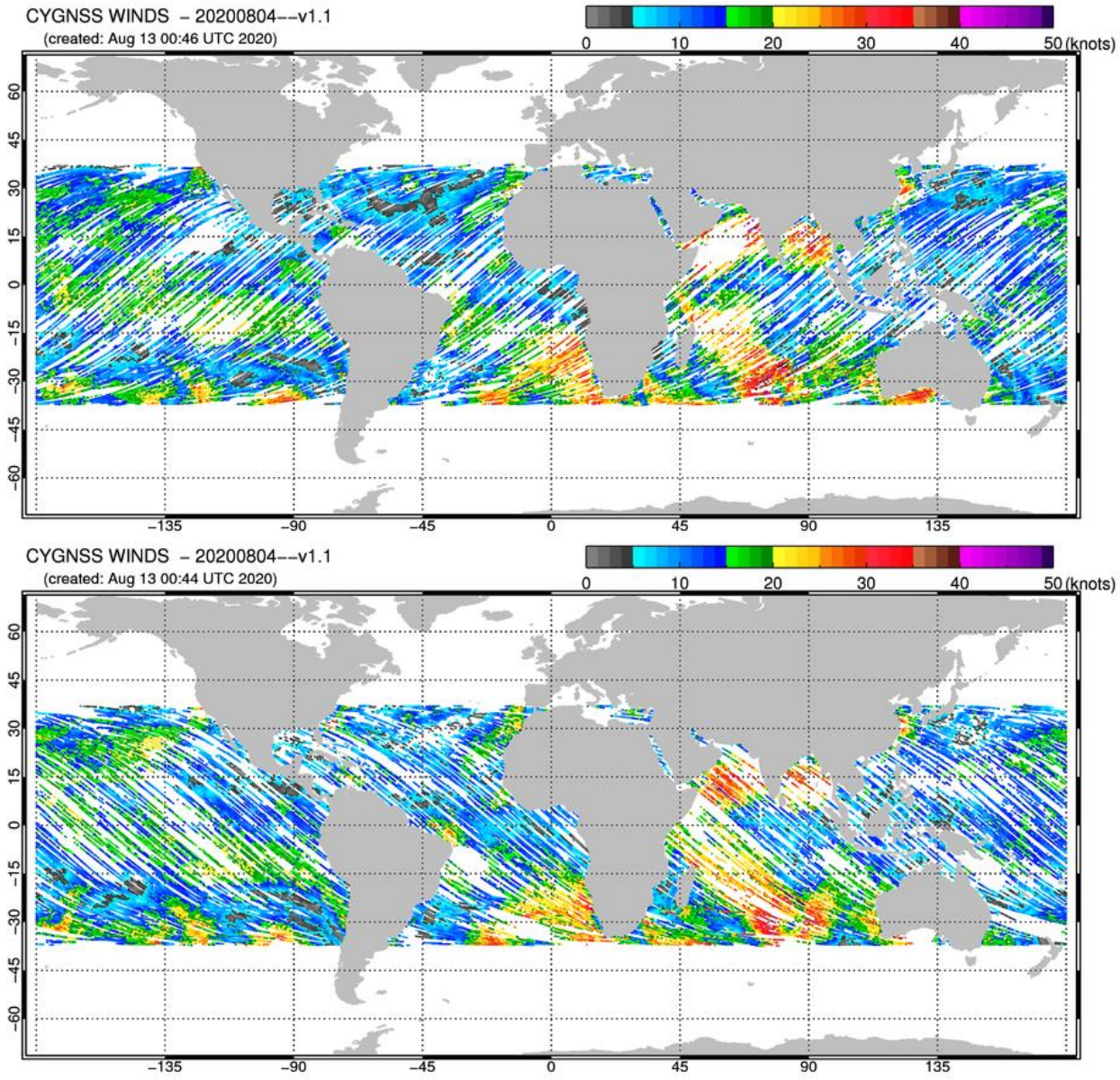

Figure 2-1 Ascending (top) and descending (bottom) passes from all eight CyGNSS spacecraft, showing global retrieved winds for a 24hr period on 2020 August 04.

3 Data file availability

Although the CyGNSS Level 1 data files have been made available to the public since March 18 2017, all eight instrument noise floors were noticeably high until mid to end of April 2017, as shown in Figures 10 and 11 from (Said, Jelenak, Chang, & Soisuvarn, An

assessment of CyGNSS normalized radar cross section calibration, 2019). As a result, the NOAA Level 2 CyGNSS winds are made available starting May 01 2017.
As previously mentioned, each NetCDF file contains global daily coverage from all eight CyGNSS spacecraft spanning a time period of up to 24 hours. In normal circumstances, there should be a NetCDF file available for each day of year. However in certain cases, files may be unavailable for an entire day (e.g. high solar beta angle period, where the spacecraft roll angle is higher than nominal). It is worth noting that if only one spacecraft has its data entirely flagged on a specific day, a NetCDF file will still be made available for that day since it will include valid data for the remaining seven spacecraft.
Finally, once the data is collected from all operating spacecraft for a given day, a NetCDF file is then created and pushed from the NOAA servers to the PO.DAAC.

4 List of references

The following references provide important background information regarding this product including the motivation behind its creation. We invite the users to read these documents. Questions are welcome and can be sent to the authors of this user guide. Note that an ATBD including a peer reviewed journal article will be published soon providing additional details regarding the v1.1 NOAA CyGNSS wind product.

CYGNSS. (2018). CYGNSS Level 1 Science Data Record Version 2.1. Ver. 2.1. PO.DAAC. doi:https://doi.org/10.5067/CYGNS-L1X21

Said, F., Jelenak, Z., Chang, P. S., & Park, J. (2020). *An introduction to v1.1 NOAA CyGNSS Wind Product and a look at v3.0 Level 1 data.* NOAA. College Park: OSWT. Retrieved from https://manati.star.nesdis.noaa.gov/research/fsaid/references/20200609_noaa_cygnss_wind_ver1.pdf

Said, F., Jelenak, Z., Chang, P. S., & Soisuvarn, S. (2019). An assessment of CyGNSS normalized radar cross section calibration. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 50-65.

Said, F., Jelenak, Z., Park, J., Chang, P. S., & Soisuvarn, S. (2019). *NOAA CyGNSS Wind Product - Ver 1.0.* College Park: OWST. Retrieved from https://manati.star.nesdis.noaa.gov/products/20191106_noaa_cygnss_wind_ver1.pdf

Said, F., Jelenak, Z., Park, J., Soisuvarn, S., & Chang, P. S. (2019). *First Look at NOAA CyGNSS winds in the Tropical Cyclone Environment.* NOAA. Benevento: IEEE GNSS+R 2019. Retrieved from http://www.gnssr2019.org/files/gnssr_mtg_noaa_20190521_final[2454].pdf

Said, F., Jelenak, Z., Park, J., Soisuvarn, S., & Chang, P. S. (2019). *Latest cal/val assessment of v2.1 L1/L2 data.* NOAA. College Park: OSWT. Retrieved from

https://manati.star.nesdis.noaa.gov/research/fsaid/for_qi/cygnss_science_team_mtg_noaa_20190114.pdf

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