SAVANT 2018

NCAR/EOL ISFS High Rate Surface Meteorology and Flux Products Data Report

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In situ Sensing Facility

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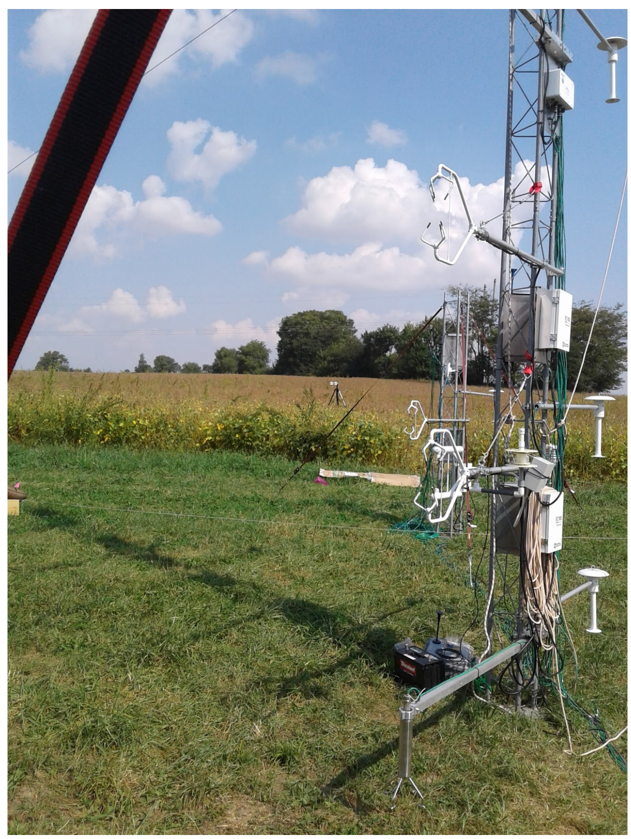

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Web References

SAVANT Homepage: https://www.eol.ucar.edu/field_projects/savant
SAVANT Field Catalog: http://catalog.eol.ucar.edu/savant/tools/missions
ISFS Operations during SAVANT: https://www.eol.ucar.edu/content/isfs-savant
ISFS Homepage: https://www.eol.ucar.edu/node/152

Related Documentation

ISFS netCDF File Conventions: ISFS netCDF File Conventions
ISFS Guides: https://www.eol.ucar.edu/content/isfs-guides
Companion Data Report: SAVANT High Rate IOP Data Report

Citations

If these data are used for research resulting in publications or presentations, please acknowledge EOL and NSF by including the following citations, as appropriate:

The ISFS Platform

NCAR - Earth Observing Laboratory. (1990). NCAR Integrated Surface Flux System (ISFS). UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.5065/D6ZC80XJ.

This Data Set

NCAR/EOL In-situ Sensing Facility. 2021. SAVANT: NCAR/EOL ISFS High Rate Surface Meteorology and Flux Products. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/BV8X-1090-180Z. Accessed 24 June 2021.

Overview

The Stable Atmospheric Variability and Transport (SAVANT) field project was held near Mahomet, Illinois and ran from 15 September 2018 to 15 November 2018. ISFS operated 4 main towers with a full suite of flux surface monitoring sensors, and additional 6 short flux towers plus 6 barometer sites. ISFS flux and surface measurements during this project can contribute to analyses of stable surface boundary layers, the effects of intermittent turbulence on drainage and converging flow, the effect of flow over shallow topographic conditions, to name a few.

Data Set Description

Data set Name:	NCAR/EOL ISFS High Rate Surface Meteorology and Flux Products
Time period:	15 September - 15 November, 2018
Location:	Mahomet, Illinois
Data format:	netCDF3; isfs_geo_hr_savant_YYYYmmDD_HH.nc
Data layout:	ISFS netCDF File Conventions
Data file frequency:	Each file contains 4 hours of data starting at hour 00 of the UTC day.
Data version:	v1.0
Data status:	final
Data access:	public

Time resolution:	-Varies from 50 ms for 20 Hz sensors to 1s for 1 Hz sensors. -Refer to **Table 3** for sampling rates. -Refer to ISFS netCDF File Conventions
Geographic coordinates:	Yes
Tilt corrected:	Yes

Site Description

There were 4 primary tower sites:

1. **init** - initiation tower
2. **rel** - release tower
3. **uconv** - upper convergence tower
4. **lconv** - lower convergence tower

Site	Lat	Lon	Notes
init	40.211544	88.410583	Where drainage flow was thought to initiate.
rel	40.211681	88.407139	Where artificial fog was released.
uconv	40.211039	88.405472	The upper location where there was convergent flow from a side gully.
lconv	40.210261	88.403683	The next lower convergence zone with a side gully.

Table 1. Lat/Lon of the 4 main tower sites. A Google Earth rendering is provided below.

All 4 locations had a multi-level flux profile tower, either 10m or 20m tall, placed in approximately the center of the gully.

rel, uconv, and lconv sites also had short auxiliary towers about 8m on either side of their main tower to check for horizontal homogeneity across the gully flow. Sonic anemometers and Hygrothermometer sensors were mounted on PAM towers at 1.5m. Data from these auxiliary towers have been merged with the main tower data set using the naming convention of 'a1' and 'a2' added to the variable name, e.g. u_a1_1_5m_lconv, u_a2_1_5m_lconv, RH_a1_1_5m_rel, RH_a2_1_5m_lconv, etc.

In addition, there were 6 sites (**p1 - p6**) with just a barometer, in the region surrounding the gully, to determine the pressure field. The lat/lon of these site towers are noted in **Table 2** below.

Site	Lat	Lon	Notes
p1	40.211087	-88.402702	Up a gully to the north, downstream of lower convergence.
p2	40.209293	-88.406606	Up the side gully to the south from lower convergence.
p3	40.213415	-88.407181	Up the side gully to the north from upper convergence.
p4	40.206626	-88.399242	Park at the park entrance on County Road 350E and walk about 1/3 mile along the paved bike path.
p5	40.213056	-88.394194	Just off County Road 350E.
p6	40.209490	-88.412331	On Crowley Road near the ISS SODAR trailer.

Table 2. Site coordinates based on data from Garmin GPS's at each site.

Instrument Description

The SAVANT high rate data set includes measurements from the following sensors:

Sensor	Manufacturer	Samples per second
2D sonic anemometer	Gill WindObserver	10
3D sonic anemometer	Campbell Scientific CSAT3*	20
H2O/CO2 Open-path InfraRed Gas Analyser (IRGA)	Campbell Scientific EC150	20
Hygrothermometer (aka TRH)	NCAR SHT85	1
Nanobarometer	Paroscientific 6000	13

Digital/Analog barometers	Vaisala PTB220/PTB210	1

*With the optional CSAT3A sonic anemometer head to couple with the IRGA EC150.
Table 3.

Variables measured by the instruments and included in the high rate data set are shown in **Table 4** below.

2D sonic anemometer	3D sonic anemometer	H2O/CO2 InfraRed Gas Analyzer (IRGA)	Hygrothermometer
U [m/s] V [m/s] Tc [°C] - sonic temperature	u [m/s] v [m/s] w [m/s] tc [°C] - sonic temperature Sonic diagnostics	co2 [mg/m3] h2o [g/m3] Tirga [°C] Pirga [mb] Gas analyzer diagnostics	T [°C] RH [%]

Table 4. List of variables by sensor. Note, the variable names follow ISFS netCDF naming conventions.

A mix of 4 different types of barometers were deployed, listed below in decreasing order of accuracy.

Sensor	Parameter	Notes
Nanobarometers	P [mb]	Installed at the rel and lconv sites at 1.5m and 20m.
Vaisala PTB220	P [mb]	Digital barometers at sites p1 - p6
Vaisala PTB110	Pirga, Tirga	Analog barometers internal to the H2O/CO2 gas analyzers at the rel and lconv sites at 1.5m, 6m, and 20m
Solid-state barometers	Pirga, Tirga	Internal to the H2O/CO2 gas analyzers at the init and uconv sites at 1.5m and 6m.

Table 5.

Note: Both the PTB110 and solid-state barometers are not really intended as primary pressure sensors, they are present so that the EC150 can compute air density for use in the calculation of gas density. Hence, our labeling of these data as "Pirga", rather than "P". Their inlet is a sintered metal frit on the bottom of the EC150's electronics box, surrounded by cables. Adjustments (e.g. bias correction, despiking) may be necessary to use these data.

Positions/Orientations

Table 6 below is a complete list of sensors associated with each of the 4 main sites. Height positions and sonic orientations were determined using a Leica Multistation (laser theodolite).

Site	Height (m)	Sensor	az (deg)	pitch (deg)	roll (deg)	lean	leanaz
init	0.2	Gill 2D sonic					
	0.2	TRH					
	1.5	CSAT3A + IRGA	36.3	0.02	NA	0.3	86.1
	1.5	TRH					
	3.0	CSAT3A	36.8	-0.69	0.86	1.2	126.2
	4.5	CSAT3	36.3	1.20	-1.19	1.2	-8.6
	4.5	TRH					
	6.0	CSAT3A + IRGA	36.1	-0.29	-0.86	0.7	-114.1
	10	CSAT3	36.3	0.51	-0.61	0.8	-46.7
	10	TRH					
rel	0.2	Gill 2D sonic					
	0.2	TRH					
	1.5	CSAT3A + IRGA	105.44	-1.09	1.34	2.0	-123.1
	1.5	CSAT3A (aux1)	106.94	0.14	-0.24	0.1	19.0
	1.5	CSAT3 (aux2)	103.49	-0.31	-1.75	0.9	110.8
	1.5	TRH					
	1.5	TRH (aux1)					
	1.5	TRH (aux2)					
	1.5	Nanobarometer					
	3.0	CSAT3A	105.73	-0.27	1.14	1.2	-103.7
	4.5	CSAT3	105.62	0.74	-0.46	0.8	13.5
	4.5	TRH					

	6.0	CSAT3A + IRGA	105.78	-0.31	0.56	1.4	-102.6
	8.5	CSAT3	106.01	0.81	-0.98	1.2	48.8
	8.5	TRH					
	10	CSAT3	106.03	0.99	-1.22	1.6	50.7
	15	CSAT3	105.31	0.28	-1.40	1.2	76.6
	15	TRH					
	20	CSAT3A + IRGA	105.27	-1.95	-0.18	2.1	158.1
	20	TRH					
	20	Nanobarometer					
uconv	0.2	Gill 2D sonic					
	0.2	TRH.0.2m					
	1.5	CSAT3A + IRGA	131.19	-0.23	-0.01	0.2	-157.4
	1.5	CSAT3A (aux1)	130.15	0.14	0.16	0.4	70.6
	1.5	CSAT3A (aux2)	131.80	-0.03	-0.48	0.2	-97.7
	1.5	TRH					
	1.5	TRH (aux1)					
	1.5	TRH (aux2)					
	3.0	CSAT3A	131.12	-0.48	0.86	1.1	-116.7
	4.5	CSAT3	130.56	0.22	0.17	0.9	-76.4
	4.5	TRH					
	6.0	CSAT3A + IRGA	130.62	0.03	0.92	1.7	-89.1
	10	CSAT3					
	10	TRH	131.29	0.86	-1.71	1.1	40.9
lconv	0.2	Gill 2D sonic					
	0.2	TRH					
	1.5	CSAT3A + IRGA	51.58	-0.22	0.04	0.5	113.6

	1.5	CSAT3A (aux1)	51.63	0.16	1.01	1.7	84.6
	1.5	CSAT3A (aux2)	49.54	-0.22	-1.14	0.4	120.2
	1.5	TRH					
	1.5	TRH (aux1)					
	1.5	TRH (aux2)					
	1.5	Nanobarometer					
	3.0	CSAT3A	52.31	-0.51	0.52	0.8	132.0
	4.5	CSAT3	52.78	0.65	-0.69	1.2	56.7
	4.5	TRH					
	6.0	CSAT3A + IRGA	52.57	-0.59	0.45	1.0	-127.6
	8.5	CSAT3	53.02	0.58	-0.87	1.2	61.5
	8.5	TRH					
	10	CSAT3	53.14	0.74	-0.15	0.7	-1.3
	15	CSAT3	52.87	0.96	-1.30	1.0	4.0
	15	TRH					
	20	CSAT3A + IRGA	52.31	-1.44	-0.17	3.8	-112.3
	20	TRH					
	20	Nanobarometer					
p1	1.5	Vaisala PTB220					
p2	1.5	Vaisala PTB220					
p3	1.5	Vaisala PTB220					
p4	1.5	Vaisala PTB220					
p5	1.5	Vaisala PTB220					
p6	1.5	Vaisala PTB220					

Table 6. List of sensors, heights, and sonic orientations by site.

Data Collection and Processing

All sensors were sampled independently with a Linux-based Data System Module or DSM. Data were stored directly onto USB sticks provided for every DSM. All DSMs were connected by a wireless network of Ubiquiti radios, so raw data could also be archived in real-time on a Linux laptop at the ISFS base trailer. Data were also transmitted from the base trailer to servers at EOL for local storage and added back-up. Data processing was performed by the in-house created data acquisition system called NIDAS.

NIDAS (NCAR In-situ Data Acquisition System) handles the data processing for all ISFS measurement systems. This is a linux based software produced by Gordon Maclean, formerly at NCAR/EOL. In a nutshell, NIDAS streams the raw data to multiple processes. These processes do a myriad of things, i.e. archiving, distribution, generating statistics, generating near-real time plots, writing netCDF files.

Each sensor is sampled independently in an asynchronous manner. A time tag of microsecond resolution is assigned to each sample at the moment it is received, based on a system clock, which is continually conditioned from a directly connected GPS with a pulse-per-second (PPS) signal - this allows us to compare and combine data from multiple towers. Minimal data interpretation is performed to differentiate individual messages from a sensor, assembling the data exactly as it was received into a sample, with the associated time-tag and an identifier of the sensor and data system. The concatenated stream of samples from all sensors is then passed on for archival and further processing.

NIDAS reads a series of configuration and calibration files that contain pertinent sensor metadata and, more importantly, any input variables that are to be applied to the data either during operations or in the post-processing. To generate the high rate data set, NIDAS reads the variables from the raw information, applies calibrations, resamples the timestamps, then writes the variables to netcdf.

Data Remarks

Time Tag Issue

High-rate data have been generated for the SAVANT during the 15 Sept - 15 Nov 2018 time period. High-rate samples are time stamped with the system time and there are instances when the system time on the DSM, and thus the data timestamp, does not track the GPS time (reference clock). Refer to **Table 7** below for a list of dates where sites were removed due significant differences between the system and GPS clock (greater than 5 s).

Date	Sites removed completely due to mismatched system/GPS timestamps
Sept 18	uconv - 1.5m, 3.0m, aux1*
Sept 19	uconv - 1.5m, 3.0m, aux1
Sept 20	uconv - 1.5m, 3.0m, aux1
Sept 21	uconv - 1.5m, 3.0m, aux1
Sept 22	uconv - 1.5m, 3.0m, aux1
Sept 23	p1, uconv - 1.5m, 3.0m, aux1
Sept 24	p1, uconv - 1.5m, 3.0m, aux1
Sept 25	p1, uconv - 1.5m, 3.0m, aux1
Sept 25	p1, uconv - 1.5m, 3.0m, aux1
Sept 26	p1
Sept 27	p1
Sept 28	p1
Sept 29	p1 (until 16:49:05)
Sept 30	uconv - 1.5m, 3.0m, aux1
Oct 15	init - 4.5m, 6m, 10m
Oct 16	init - 4.5m, 6m, 10m
Oct 17	init - 4.5m, 6m, 10m
Oct 18	init - 4.5m, 6m, 10m
Oct 19	init - 4.5m, 6m, 10m
Oct 20	p4, init - 4.5m, 6m, 10m
Oct 21	p4, init - 4.5m, 6m, 10m
Oct 22	p4, init - 4.5m, 6m, 10m

Oct 23	p4, init - 4.5m, 6m, 10m
Oct 24	p4, init - 4.5m, 6m, 10m
Oct 25	p4, init - 4.5m, 6m, 10m
Nov 4	uconv - 0.2m, aux1

*aux1 refers to ‘a1’ in the netCDF variable name.
Table 7. List of sites removed due to large deviations between the system and GPS timestamps, by date.

H_2O/CO_2 IRGA

CSAT3 EC-150 IRGA (infrared absorption gas analyzers) were used for H_2O and CO_2. Field staff noted very large CO_2 values at night early in the project, as respired air built up in the gully, that probably are real. These sensors did have some short-duration resets that may have been related to power availability. Also, frequent dew formation at night caused readings to be overly high. For the high-rate data files, we have implemented a filter removing data when the 5min average H_2O deviates by more than 2 g/kg from the mean of the TRH H_2O values. This conservative filter still has some values that clearly are not correct, especially as the dew forms.

Specific notes: <IRGA variable>_1_5m_lconv variable had a bad EC100 configuration (only CSAT) until 20 Sep.

2-D Sonic anemometer - Gill WindObserver

Gill WindObserver sensors were deployed upside-down ("flipped") to measure wind speed close to the surface (0.2m). Mounting upside down allowed water to enter the connector of the sensor at uconv, which caused us to lose some data. We also had to write new code to accommodate this orientation. Also, due to the inverted orientation of the Gills we were unable to accurately measure their azimuth with the Multistation, instead relying on averaging the azimuths of the above 3D sonics to estimate orientation.

<2D variable>_0_2m_init needed DSM power cycle 20 Oct
<2D variable>_0_2m_uconv needed to be replaced due to corrosion on 23 Oct

Where **<2D variable>** = U, V, Tc

3-D Sonic anemometer - CSAT3

CSAT3 sonic anemometers were used for turbulence measurements on all gully towers. Some reported a poor sonic signal. It was determined that a factory quality parameter was set too tight. Adjusting this parameter solved this issue. The missing data cannot be recovered.

Specific notes:

<csat variable> = u, v, w, tc, and diagnostics

<csat variable>_10m_uconv had bad data rate until reconfigured 20 Sep. The data before this point has been removed.

<csat variable>_6m_init dead on 21 Sep.

<csat variable>_1_5m_rel died 24 Sep., fixed 27 Sep. with parameter change

<csat variable>_15m_rel needed DSM reset on 8 Oct

<csat variable>_10m_rel needed new cable on 8 Oct

<csat variable>_a2_1_5m_lconv was down during the day of 20 Oct, but restarted itself

<csat variable>_3m_lconv was down, but fixed itself on 26 Oct

<csat variable>_a2_1_5m_lconv intermittent, replaced on 27 Oct

<csat variable>_1_5m_uconv2 intermittent, fixed itself 1 Nov (should be lconv??)

<csat variable>_a2_1_5m_lconv ec100 replaced on 2 Nov

Hygrothermometer (T, RH)

Each tower used NCAR temperature/relative humidity sensors for vertical profiles. This version had housings in which the fans were directly connected to the power line. This makes it difficult to know when a fan dies, which did happen several times during the project. In general, the measurements are quite stable. Double check the data and filter for those few lingering data spikes in the time series.

Specific notes:

<trh variable> = T, RH

<trh variable>_0_2m_rel had a loose SHT sensor that was fixed 19 Sep. The data have been removed before then.

<trh variable>_0_2m_init needed DSM reboot on 12 Oct. A small period of trh.1.5m.init data was removed after this.

<trh variable>_0_2m_rel fan failed around 4 Nov. and was swapped with trh.1.5m.aux2 on 7 Nov. These data have been removed. Aux2 data has not been removed, as the fan was revived after the switch.

<trh variable>_1.5m_init housing was replaced due to a bad fan on 10 Nov. However, we could not determine when the fan failed and could not justify removing any data prior to this point.

<trh variable>_4_5m_rel noisy fan replaced 29 Sep. No data issues were identified before this.

<trh variable>_4_5m_uconv housing replaced on 4 Nov, but the fan could have been bad since 1 Nov. We could only justify removing a period of data from 05-15 CST on 2 Nov. This temperature had been noted as running a bit high (warmest on the tower each day) since the beginning of the campaign, but this had not been consistent around the time of the fan's failure. 7 Nov: many fans seem to be running rough, but no spares were available.

<trh variable>_4.5m_init had a bad RH between 22-24 Nov. and has been removed.

<trh variable>_8_5m_rel dead until RS232/485 jumpering changed on 23 Sep.

<trh variable>_8_5m_rel was bad after 23 Nov. and has been removed.

<trh variable>_10m_init also had a loose SHT sensor that was fixed 20 Sep. The data have been removed before then.

<trh variable>_15m_lconv and trh.20m.lconv SHT sensors weren't installed until 20 Sep.

<trh variable>_15m_rel had several periods of bad RH until 6 Oct. Multiple periods have been removed.

<trh variable>_15m_rel noisy fan - replaced the housing 17 Oct.

<trh variable>_10m_uconv fan died sometime around 31 Oct. The housing was replaced on 3 Nov. and a couple of hours of data have been removed on 31 Oct. We could not justify removing any additional data during this period.

<trh variable>_20m_rel housing replaced on 3 Nov. No data issues were identified before this.

<trh variable>_20m_rel was replaced again on 11 Nov. due to a bad fan. Temps were very high after 6 Nov. so we have removed this period from the TRH data.

<trh variable>_20m_rel and **trh_15m_rel** both showed bad RH values between 25-27 Nov. and have been removed.

Barometers

The Paroscientific nanobarometers were connected to All-Weather quad-disk probes and appeared to work normally.

The PTB220 barometers were connected to single-disk pressure ports at each of the 6 outlying pressure sites. All pressure sensors worked as expected. The only issue was when the pressure tubing at site p6 was found disconnected and fixed on 11 Nov. We were unable to determine precisely when this occurred, however we suspect it happened around 05 CDT on 26 Oct. We have removed a few outliers in the data between this time and 12 CDT on 11 Nov., but are not confident enough to justify removing all of the data during this period. Thus these data should be used with caution.

P_1_5m_rel - spike in pressure observed 22 Sept near midnight.

General Comments

There was a lot of animal (mouse, rabbit, deer) activity during this experiment, which primarily impacted deployment of the PI's DTS fiber-optic temperature sensing system. ISFS cables that were not our green cable (ethernet and soil sensors) suffered some damage. We learned to encase these in hard plastic sleeves, but not before losing some data.

Power was the biggest issue for our system. ISFS used solar power at all sites, but field staff were kept busy reconfiguring these power systems to provide adequate power for each of the heavily-instrumented towers. After extensive testing both in the field and later in the lab, it appears that the charge controllers were not optimal for the batteries we were using. This combination of controller and battery had been used successfully by ISFS for over a decade, but may never have been pushed to this extreme of poor solar input (cloudy, in the fall), and large load. ISFS has since changed to a MPPT charge controller and LiPO batteries. As a result, several hours of night-time (primarily early-morning) data often were lost at individual towers. Fortunately, most of these outages did not overlap with project IOPs.

Notable Events

- 16 Sep: Operations started
- 25 Sep, 9PM: Gust front came through site
- 2 Oct: Sensor cleaning
- 11 Oct: Corn harvested
- 13 Oct: Sensor cleaning
- 19-20 Oct: Soybeans harvested
- 22 Oct: Sensor cleaning
- 15 Nov: Operations end

GCMD Science Keywords

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC CHEMISTRY > CARBON AND HYDROCARBON COMPOUNDS > ATMOSPHERIC CARBON DIOXIDE

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC PRESSURE > SURFACE PRESSURE

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC RADIATION > HEAT FLUX

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC TEMPERATURE > SURFACE TEMPERATURE > AIR TEMPERATURE

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WATER VAPOR > WATER VAPOR INDICATORS > HUMIDITY > HUMIDITY MIXING RATIO

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WATER VAPOR > WATER VAPOR INDICATORS > HUMIDITY > RELATIVE HUMIDITY

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WINDS > SURFACE WINDS > U/V WIND COMPONENTS

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WINDS > SURFACE WINDS > WIND DIRECTION

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WINDS > SURFACE WINDS > WIND SPEED

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WINDS > WIND DYNAMICS > TURBULENCE

EARTH SCIENCE > ATMOSPHERE > ATMOSPHERIC WINDS > WIND DYNAMICS > VERTICAL WIND VELOCITY/SPEED