5 Minute ISFS Data for SCP

These data contain surface meteorology measurements of the Integrated Surface Flux System (ISFS) during the Shallow Cold Pool Study (SCP) at the Pawnee Grasslands, Colorado, during September, October and November of 2012.

For general information about the operations of the ISFS during SCP see https://www.eol.ucar.edu/field_projects/scp.

The ISFS five minute dataset contains first moments and some second moments of variables measured by the NCAR ISFS stations during SCP.

The data are stored in NetCDF files. Information on the NetCDF file format and software is available at http://www.unidata.ucar.edu/software/netcdf/. Information specfic to ISFS NetCDF files is available at https://www.eol.ucar.edu/content/isfs-netcdf-files.

Datasets

Three datasets are available:

- geo_tilt_cor: http://data.eol.ucar.edu/codiac/dss/id=385.003 All wind vectors have been rotated to geographic coordinates (+U is wind to the east, +V is wind to the north), and 3D wind vectrors are corrected for tilt of the anemometer relative to a plane of mean flow (see #SonicTiltCorrection). Values for T, RH and P are derived at sonic anemometer locations where they were not measured, as described below. See #DataEdits and #Derived Variables.
- geo_no_tilt_cor: http://data.eol.ucar.edu/codiac/dss/id=385.004 All winds are rotated to geographic coordinates, but 3D wind vectors have not been corrected for anemometer tilt. Values for T, RH and P were derived at sonic anemometer locations where they were not measured, as described below. See #DataEdits and #Derived Variables.
- instrument: http://data.eol.ucar.edu/codiac/dss/id=385.005 Winds from 3D sonic anemometers are in instrument, not geographic coordinates, with no correction for tilt. The data edits and derivations listed under #DataEdits and #Derived Variables have not been applied to this dataset.

NetCDF File Names

Each NetCDF file contains one day of data, from 00:00 to 24:00 UTC. The file names are of the following forms, depending on the dataset, where YYYYMMDD is the UTC date of year, month and day:

- isfs_qc_gtc_YYYYMMDD.nc , QC'd, geographic, tilt-corrected sonic winds
- isfs_qc_gntc_YYYYMMDD.nc, QC'd, geographic, non-tilt-corrected sonic winds
- isfs_nqc_inst_YYYYMMDD.nc, not QC'd, sonic winds in instrument coordinates

Measurements

The measurment sites (or stations) were given names A1-A19, C and M. All "A" stations had a CSAT3 3D sonic anemometer and two NCAR aspirated hygrothermometers. As shown in the tables on the SCP project page, some "A" stations had an additional Handar 2-D sonic anemometer and/or a barometer. Station C was a 3 meter tower with 2 CSAT3 sonics, 4 hygrothermeters, a barometer and a 2D sonic. Station M, the main tower was a 20 meter tower with 13 levels of measurements. Components of incoming and reflected surface radiation were sampled near the M tower. Soil temperature, moisture, heat flux and thermal properties were measured at two sites. A CSI EC150 3-D sonic with IR gas analyzer was added later in the project on Nov 12 at station A8.

Time Representation

The **base_time** variable contains one value, the time of the start of the file, as a number of POSIX (non-leap) seconds since 1970 Jan 1, 00:00 UTC.

Values for each time-varying measurement will be found in the NetCDF files, as a variable with a **time** dimension. There are 288 5 minute periods per day, so the time dimension is 288.

The **time** variable contains the time to be associated with each sample, in units of seconds since **base_time**, or 00:00 UTC of the day. Each time value is the middle of the averaging period, and will have values of 150 (00:02:30 UTC), 450 (00:07:30), etc, up to 86250 (23:57:30 UTC).

Stations

A variable measured at more than one station, such as winds from the 3-D sonic at 1 meter, will have a **station** dimension of 21. Station indices 1-19 are for the A stations, 20 is the C tower and 21 is M, the main tower. Variables that were measured at one or two sites generally do not have a **station** dimension. Instead the **short_name** will have a suffix indicating the station, such as ".C".

Dimensions

The NetCDF dimensions in each file are:

Dimension name	size	description
time	288	number of 5 minute periods in a day
station	21	index for each of the 21 ISFS stations
layout	2	index to indicate one of two station layouts.

Short Name Attributes

Each measured variable will have a **short_name** NetCDF attribute. The field before the first period in the **short_name** is a generic variable name, such as **T** for temperature, **Rsw** for short wave radiation, or **u** for the U component of the wind. For second moments, such as variances and co-variances, the first field of the **short_name** will contain single quote marks after a variable to indicate it is an average of a deviation. For example, a leading short name of **w'tc'**, is short for: `mean( (w-mean(w)) * (tc-mean(tc)) )`, **w** is the vertical wind component, and **tc** is the temperaure from the speed of sound.

Higher Moments

For each of the 3-D sonic anemometers, the following second moments in **u**,**v**,**w** and **tc** are provided for the computation of eddy-correlation fluxes. Scalar values such as water vapor density and carbon dioxide were also measured at some 3-D anemometer locations. **kh2o** is a water vapor measurement from a Campbell krypton hygrometer at 5 and 10 meters on the "M" tower. **h2o** and **co2** are water vapor and carbon-dioxide measurements from LICOR 7500 gas analyzers at 1 and 2 meters on the "M" tower, and from the EC150 at station "A8".

Second Moments

	u	v	w	tc	kh2o	h2o	co2
u	u'u'	u'v'	u'w'	u'tc'	u'kh2o'	u'h2o'	u'co2'
v		v'v'	v'w'	v'tc'	v'kh2o'	v'h2o'	v'co2'
w			w'w'	w'tc'	w'kh2o'	w'h2o'	w'co2'
scalar variances				tc'tc'	kh2o'kh2o'	h2o'h2o'	co2'co2'

Heights

The height in meters above ground of the measurement, if appropriate, will be indicated in a second field after a period in the **short_name**, for example **RH.0.5m**, or **u'tc'.20m**.

Variable Names

The actual NetCDF variable names will have underscores, '_', in place of periods and single quotes. Therefore a variable with a **short_name** attribute of **w'co2'.3m.A8** will have a NetCDF variable name of **w_co2__3m_A8**.

Units and Long Names

Each variable will have NetCDF attributes containing the units of the measurement, and a long name giving more information on the measurement.

Counts Attributes

Variables from sensors used in eddy-covariance flux measurements will have a **counts** attribute indicating the number of samples that were included in each statistic.

Missing Data

The missing data value is 1x10^37. A missing value indicates either that nothing was measured at the location indicated in the variable name and station index, or the sensor was not reporting at the given time, or it was detemined that the data value did not meet QC criteria during post-project analysis.

Non-Time Series Variables

The files also contain non-time series values for station latitude, longitude and altitude. The latitude and longitude were determined with a handheld GPS during the project. The altitudes were determined by survey with a theodolite during the project. The online field logbook has further information on these values.

Station Moves and Layouts

Stations 15 and 17 were moved on October 4th. The latitude, longitude and altitude variables therefore have a "layout" dimension of 2, to provide for the two locations of station 15 and 7. The sonic at station 15 was also raised from 1 to 2 meters above ground as part of the move, and the sonic at 17 lowered from 1 to 0.5 meters.

Wind Coordinates

The U and V components of the wind vectors from the 2D and 3D anemometershave been rotated to geographic coordinates, such that a positive U is the component of the wind blowing to the east, and a positive V is the component of the wind blowing to the north.

Sonic Tilt Correction

The 3D sonic anemometers were installed as level as was possible, but not perfectly "bubble" level.

The **geo_tilt_cor** dataset contains 3D wind vectors and second moments which have been rotated to a coordinate system where the mean **W** component is zero, as described in /content/sonic-tilt-corrections.

Calibration Corrections

These corrections have been applied to all three datasets

- P from barometers: corrected for offsets seen in comparison with transfer standard.
- Pyrgeometers: post-project calibration factors applied.

Data Edits

The following corrections have been applied to the **geo_tilt_cor**and **geo_no_tilt_cor** datasets, but not to the **instrument** dataset. Removing a data value means it was overwritten with the missing data value.

- co2, h2o from LI/COR 7500 on M tower: data removed during times of sensor maintenance as well as some instancess where excess moisture affected sensor operation.
- kh2o from krypton hygrometers on M tower: data removed during times of sensor maintenance, and low sensor voltages due to liquid water in the absorption path.
- co2,h2o from the Campbell Scientific EC150 IRGA gas analyzer at A8: data removed during times of sensor maintenance as well as some instances where excess moisture affected sensor operation.
- T,RH from NCAR hygrothermometers: data removed during times of sensor maintenance/cleaning as well as some instances prompted by erratic **Ifan** (aspiration fan current) values specific to each sensor
- Gsoil: re-applied Philip correction to heat flux plate based on heat conductivity as measured by the TP01
- Tsoil: corrected for data sampling problems of Tsoil at grass site between Oct 6 and Oct 12.
- Gsoil: re-applied Philip correction to heat flux plate based on heat conductivity as measured by the TP01
- u'h2o', v'h2o', w'h2o': Values computed from a CSAT3 with krypton hygrometer have been corrected for the absoption by oxygen, and the spatial decorrelation. Values from a CSAT3 and a Licor 7500 or CSI IRGA have been corrected for the spatial decorrelation.

Derived Variables

Barometric pressure was not measured at 1 meter AGL at sites 1,2,4,5,6,7,11,13,15,16,17,18 or 19. In the **geo_tilt_cor** and **geo_no_tilt_cor** data sets, those values have been derived using the formula:

$$P_2 = P_1 * e (-g * (z_2 - z_1) / (Rair * T)$$

where P_1 and z_1 are the pressure and elevation of the reference barometer, Rair = 287 ($m^2/s^2/K$), g=9.7984 m/s^2, T is the air temperature, and z_2 is the elevation of the desired pressure.

Derived pressure values

Derived Variable	Sites	Reference	Refererence Site	Temperature References
P.1m	1,2,4,5,6,7	P.1m	3	T.0.5m, T.2m
P.1m	11	P.1m	12	T.0.5m, T.2m
P.1m	13	P.1m	14	T.0.5m, T.2m
P.1m	15	P.1m	10	T.0.5m, T.2m
P.1m	16,17	P.1m	21 (M)	T.0.5m, T.1.5m
P.1m	18,19	P.1m	20 (C)	T.1.5m.C, T.2.5m.C
P.2m.A15	15	P.1m	15	T.0.5m,T.2m
P.0.5m.A17	17	P.1m	17	T.0.5m,T.2m
P.2m.C	20	P.3m.C	20	T.1.5m.C, T.2.5m.C
P.0.5m.M	21	P.1m	21	T.0.5m.M
P.2m.M	21	P.1m	21	T.1.5m
P.3m.M	21	P.5m.M	21	T.3m.M, T.4m.M
P.4m.M	21	P.5m.M	21	T.3m.M,T.4m.M
P.10m.M	21	P.5m.M	21	T.6m.M,T.8m.M
P.4m.M	21	P.5m.M	21	T.3m.M,T.4m.M

Low rate temperature and relative humidity measurements were not made at all the locations of the 3-D sonic anemometers. In order to compute air densidy, and flux corrections, these variables have been derived by a linear interpolation over height of the two nearest measurements. Note the wide interpolation and extrapolation of T and RH at 10 and 20 meters on the M tower.

Derived T,RH Variable	Sites	Reference1	Reference2
1m	1-19	0.5m	2m
1m	21	0.5m	1.5m
2m	20	1.5m.C	2.5m.C
2m	21	1.5m.M	1.5m.M
5m.M	21	4m.M	6m.M
10m.M	21	8m.M	15m.M
20m.M	21	8m.M	15m.M
3m.A8	8	0.5m	2m

- **Long-wave radiation (Rlw):computed from the radiation measured by the thermopile (Rpile) and the case temperature (Tcase)**
- **Surface heat flux (Gsfc): heat flux at the surface was computed from value measured by the heat flux flux plate at 5 centimeters, and the heat storage above it, as computed from the soil temperatures and heat capacity.**

Summary Table of Variables

Description	short_names	height AGL (meter)	stations	Sensor
3D winds, temperature, diagnostic, 2nd moments	(u,v,w,tc,ldiag).1m, (u'u', u'v',...).1m	1	1-21	CSAT3
	(u,v,w.tc,ldiag).0.5m.A17	0.5	17	
	(u,v,w.tc,ldiag).0.5m.M	0.5	21 (M)	
	(u,v,w.tc,ldiag).2m.A15	2	15	
	(u,v,w.tc,ldiag).2m.C	2	20 (C)	
	(u,v,w.tc,ldiag).2m.M	2	21 (M)	
	(u,v,w.tc,ldiag).3m.M	3	8	
	(u,v,w.tc,ldiag).3m.M	3	21 (M)	
	(u,v,w.tc,ldiag).4m.M	4	21 (M)	
	(u,v,w.tc,ldiag).5m.M	5	21 (M)	
	(u,v,w.tc,ldiag).10m.M	10	21 (M)	
	u,v,w.tc,ldiag).20m.M	20	21 (M)	
Fast water vapor, 2nd moments	h2o.1m.M, (h2o'h2o'.1m.M, u'h2o'.1m.M, ...)	1	21 (M)	Licor 7500
	h2o.2m.M, (h2o'h2o'.2m.M ,u'h2o'.2m.M, ...)	2	21 (M)	
	h2o.3m.A8, (h2o'h2o'.3m.A8, u'h2o'.3m.A8, ...)	3	8	CSI IRGA
	h2o.5m.M, (h2o'h2o'.5m.M, u'h2o'.5m.M, ...)	5	21 (M)	CSI Krypton
	h2o.10m.M, (h2o'h2o'.10m.M, u'h2o'.10m.M, ...)	10	21 (M)	
Fast CO_2, 2nd moments	co2.1m.M, (co2'co2'.1m.M, u'co2'.1m.M, ...)	1	21 (M)	Licor 7500
	co2.2m.M, (co2'co2'.2m.M, u'co2'.2m.M, ...)	2	21 (M)	
	co2.3m.A8, (co2'co2'.3m.A8, u'co2'.3m.A8, ...)	3	8	CSI IRGA
Licor 7500 diagnostic	lidiag.1m lidiag.2m	1,2	21 (M)	Licor 7500
CSI IRGA diagnostic	irgadiag.2m.A8	2	8	CSI IRGA
Krypton voltags	k2oV.*m.M	5,10	21 (M)	CRI Krypton detector voltage
2D Winds	(U,V).0.5m	0.5	1,2,3,5,6,20	Handar
	(U,V).*m	6,8,15	21	
Air temperature	T.0.5m, T.2m	0.5, 2	1-19	NCAR Hygrothermometer
	T.1m.C, T.1.5m.C, T.2.5m.C	1, 1.5, 2.5	20 (C)	
	T.1.5m.M, T.2.5m.M, ...	1.5,2.5,3,4,6,8,15	21 (M)	
Relative humidity	RH.0.5m, RH.2m	0.5, 2	1-21	
Aspiration Fan Current	Ifan	1-21		
Barometric pressure	P.1m	1	1-21	Vaisala PTB and ParoScientific 6000
	P.*m.M	0.5,2,3,4,10,20	21 (M)	
	P.2m.C	2	15, 20 (C)	
4 component Radiation	Rsw.in, Rlw.in, Rsw.out, Rlw.out		near 11	Kipp and Zonen
Surface Wetness	Wetness		near 11	Decagon LWS
Surface Heat Flux	Gsfc		grass (g) and cactii (c) sites near 11	derived
Soil Temperature	Tsoil.0.6cm,Tsoil.1.9cm, Tsoil.3.1cm, Tsoil.4.4cm	0.6, 1.9, 3.1 and 4.4 cm depths	c and g	EOL NCAR

Description	short_names	height AGL (meter)	stations	Sensor
Soil Heat Flux	Gsoil.5cm	5cm depth	c and g	REBS HRF-3
Soil Moisture	Qsoil		c and g	Decagon ECH20 EC-5
Soil Heat Capacity	Lambdasoil		c and g	Hukesflux TP01

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