FMI's Tiksi greenhouse gas concentration and flux measurement system data formats

There are three main measurement systems running on a single industrial PC under Linux/KDE operating system. The programs are written in python programming language, and they are run directly from the source code, i.e. program source is visible/editable at the station. These systems are:

1. $CH_4/CO_2/H_2O$ micrometeorological flux measurement system
2. Supporting meteorological observations for the flux system
3. CH_4/CO_2 concentration measurement system

All the systems produce ASCII (text) data files, and in addition rotating text log files for identifying/solving possible system problems. Data is stored as one minute means for the systems 2 and 3, and at 10 Hz (10 readings/second) for the flux system. The flux system data files are large, and preliminary results are calculated in the station computer every 30 minutes. These data/result files are sent/fetched via internet preferably automatically once or twice a day for plotting to check out whether the systems are working properly. In addition of transfering above mentioned files (preferably via rsync, FTP is also useable), a possibility to get a remote connection to the computer (telnet/ssh and/or vnc) would be important in case of system malfunctions. The measurement systems (computers) at the station should also have a common time server, to which all the system should syncronise their time-of-day clocks.

1. Data from the flux measurement system

A raw data files contain 30 minutes (one measuring period) of data at 10 Hz, and they are named as *dddhhmm*.RAW, where *ddd* is data period's start day-of-year (001-365/366), *hh* hour and *mm* minute. The files are space separated text files with each data line containing:

Parameter	Short name	Sensor/Source	Format
Data read hhmmss.t (in UTC)	time	Computer clock	%08.2f
wind speed in u direction	u [cm s-1]	Metek anemometer	%d
wind speed in v direction	v [cm s-1]	Metek anemometer	%d
wind speed in w direction	w [cm s-1]	Metek anemometer	%d
sonic temperature	Ts [C]	Metek anemometer	%d
CO2 concentration	CO2 [ppm]	LGR	%.2f
H2O concentration	H2O [mmol mol-1]	LGR	%.2f
CH4 concentration	CH4 [ppm]	LGR	%.4f

The format for each parameter is expressed with format characters used e.g. in C and python.

The amount of uncompressed ASCII data is ca. 800 kB/file, or 38 MB/day (24 hours). This data is automatically compressed (zipped) every day to a daily file named as Tiksi_flux_raw_*dddyyyy*.zip , where *yyyy* is the year. The size of this file is ca. 11 MB. In addition the program writes a second file in csv (comma separated values in ASCII, i.e. text) format consisting 30-min averages of additional data

read from LGR:

Parameter	Short name	Sensor/Source	Format
Period end date and time time in UTC	endDT [UTC]	Computer clock	yyyy-mm-dd hh:mm
Average LGR cell pressure	p [torr]	LGR	%.2f
Minimum LGR cell pressure	min(p) [torr]	LGR	%.2f
Maximum LGR cell pressure	max(p) [torr]	LGR	%.2f
Average LGR cell temperature	T [C]	LGR	%.2f
Minimum LGR cell temperature	min(T) [C]	LGR	%.2f
Maximum LGR cell temperature	max(T) [C]	LGR	%.2f
Average LGR mirror time	mt [us]	LGR	%.2f
Minimum LGR mirror time	min(mt) [us]	LGR	%.2f
Maximum LGR mirror time	max(mt) [us]	LGR	%.2f

File name is in format Tiksi_flux_LGR_*yyyymmdd*.csv, where *yyyy* is the year, *mm* month and *dd* day. The first line in every file is a header line consisting of comma separated short names enclosed in double quotation marks:

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"endDT [UTC]","p [torr]","min(p) [torr]","max(p) [torr]","T [C]","min(T) [C]","max(T) [C]","mt [us]","min(mt) [us]","max(mt) [us]"
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Data starts from line 2. The amount of uncompressed ASCII data is ca. 4 kB/day.

After each measuring period (30 minutes) preliminary results are calculated and appended to a file named as Tiksi_flux_res_*yyyymmdd*.csv:

Parameter	Short name	Format
Period end date and time time in UTC	endDT [UTC]	yyyy-mm-dd hh:mm
Average wind direction	wdir [deg]	%d
Average wind speed	wspeed [m s-1]	%.3f
Friction velocity	fvel [m s-1]	%.3f
Average wind u component velocity	u [m s-1]	%.3f
Average wind v component velocity	v [m s-1]	%.3f
Average wind w component velocity	w [m s-1]	%.3f
Average sonic temperature	Ts [C]	%.2f
Average CO2 concentration	CO2 [ppm]	%.2f
Average H2O concentration	H2O [mmol mol-1]	%.2f
Average CH4 concentration	CH4 [ppm]	%.4f
CO2 mass mixing ratio, dry air	s [ug(CO2) g-1(dry air)]	%.3f
H2O mass mixing ratio, dry air	q [mg(H2O) g-1(dry air)]	%.3f
CO2 mass mixing ratio, moist air	S [ug(CO2) g-1(moist air)]	%.3f
H2O mass mixing ratio, moist air	Q [mg(H2O) g-1(moist air)]	%.3f
Average wind component u variance	<u'u'> [m2 s-2]	%.3e
Average wind component v variance	<v'v'> [m2 s-2]	%.3e
Average wind component w variance	<w'w'> [m2 s-2]	%.3e
Average sonic temperature variance	<T'T'> [K2]	%.3e
Average CO2 concentration variance	<CO2'CO2'> [ppm2]	%.3e
Average H2O concentration variance	<H2O'H2O'> [umol2 mol-2]	%.3e

Parameter	Short name	Format
Average CH4 concentration variance	<CH4'CH4'> [ppm2]	%.3e
Avarege s variance	<s's'> [ug2 g-2]	%.3e
Avarege q variance	<q'q'> [mg2 g-2]	%.3e
Avarege S variance	<S'S'> [ug2 g-2]	%.3e
Avarege Q variance	<Q'Q'> [mg2 g-2]	%.3e
Wind w and sonic T covariance	w'T' [K m s-1]	%.3e
Wind w and CO2 concentration covariance	w'CO2' [ppm m s-1]	%.3e
Wind w and H2O concentration covariance	w'H2O' [ppm m s-1]	%.3e
Wind w and CH4 concentration covariance	w'CH4' [ppm m s-1]	%.3e
Wind w and s covariance	w's' [ug g-1 m s-1]	%.3e
Wind w and q covariance	w'q' [mg g-1 m s-1]	%.3e
Wind w and S covariance	w'S' [ug g-1 m s-1]	%.3e
Wind w and Q covariance	w'Q' [mg g-1 m s-1]	%.3e
Number of data records (lines)	nLines	%d
Number of filtered data records	nFiltered	%d
Lag for u component	lag(u)	%d
Lag for v component	lag(v)	%d
Lag for w component	lag(w)	%d
Lag for T component	lag(T)	%d
Lag for CO2	lag(CO2)	%d
Lag for H2O	lag(H2O)	%d
Lag for CH4	lag(CH4)	%d
Lag for s (always 0)	lag(s)	0
Lag for q (always 0)	lag(q)	0
Lag for S (always 0)	lag(S)	0
Lag for Q (always 0)	lag(Q)	0
Average temperature of air	<Ta>-To [C]	%.3f
Density of air	<density>/1000 [kg m-3]	%.3f
CO2 mass flux density	Fs/1000 [mg m-2 s-1]	%.3e
CO2 mole flux density	Fs/Mc [umol m-2 s-1]	%.3e
Density correction of CO2 flux	dFs/1000 [mg m-2 s-1]	%.3e
H2O mass flux density	Fq/1000 [g m-2 s-1]	%.3e
H2O mole flux density	Fq/Mw [mmol m-2 s-1]	%.3e
Evaporation flux	3600*Fq/1e6 [mm h-1]	%.3e
Density correction of H2O flux	dFq/1000 [g m-2 s-1]	%.3e
Latent heat flux	FL [W m-2]	%.3e
Webb corrected CO2 flux	FSW [mg m-2 s-1]	%.3e
Webb corrected H2O flux	FQW [mg m-2 s-1]	%.3e
Vapour pressure deficit	VPD/100 [hPa]	%.3e
Relative humidity	100*RH [%]	%.3e
Buoyancy flux	B [K m s-1]	%.3e
Sensible heat flux	FH [W m-2]	%.3e
Momentum flux	FM [N m-2]	%.3e
Inverse Obukhov lenght	L-1 [m-1]	%.3e
Friction velocity 2	fvel2 [m s-1]	%.3f

Parameter	Short name	Format
Minimum CO2 concentration	min(CO2) [ppm]	%.2f
Maximum CO2 concentration	max(CO2) [ppm]	%.2f
CO2 average(last 30s) - average(first 30s)	CO2 avg(last 30s)-avg(first 30s) [ppm]	%.2f
Rotation angle 1	phi	%.3e
Rotation angle 2	psi	%.3e

The first line in every file is a header line consisting of comma separated short names enclosed in double quotation marks. Data starts from line 2. The amount of uncompressed ASCII data is ca. 45 kB/ day.

2. Data from the meteorological measurement system

The system writes daily csv files which contain one minute mean data. The files are named as Tiksi_flux_meteorology_*yyyymmdd*.csv:

Parameter	Short name	Sensor/Source	Format
Date and time in UTC, start minute	startDT [UTC]	Computer clock	yyyy-mm-dd hh:mm:ss
Air temperature	T [C]	Pt100	%.1f
Soil temperature 1	T1_soil [C]	Pt100	%.1f
Soil temperature 2	T2_soil [C]	Pt100	%.1f
Shelter (system box) temperature	T_shelter [C]	Pt100	%.1f
Relative air humidity	RH [%]	Vaisala Humicap HMD45D	%.0f
Air pressure	p [hPa]	Vaisala PMT16ASWD	%.1f
Net radiation	NetRad [W m-2]	Kipp&Zonen NR-LITE	%.1f
Photosynthetically active radiation	PAR [umol s-1 m-2]	Kipp&Zonen PAR-LITE	%.0f
Photosynthetically active radiation reflected from ground	PAR_refl [umol s-1 m-2]	Kipp&Zonen PAR-LITE	%.0f

The first line in every file is a header line containing comma separated short names enclosed in double quotation marks. Data starts from line 2. The amount of uncompressed ASCII data is ca. 100 kB/day.

3. Data from the concentration measurement system

The system write daily csv files which contain one minute mean data. The files are named as Tiksi_conc_*yyyymmdd*.csv, and they are in csv format:

Parameter	Short name	Sensor/Source	Format
Date and time in UTC, start minute	startDT [UTC]	Computer clock	yyyy-mm-dd hh:mm:ss
Valve positions	vpos	Relay module	%d
CH4 concentration	CH4 [ppm]	LGR DLT-100	%.4f
CH4 concentration standard deviation	stdev(CH4) [ppm]	Calculated by the program	%.4f
CO2 concentration	CO2 [ppm]	LGR DLT-100	%.2f
CO2 concentration standard deviation	stdev(CO2) [ppm]	Calculated by the program	%.2f
LGR cell pressure	p_LGR [torr]	LGR DLT-100	%.1f
LGR cell temperature	T_LGR [C]	LGR DLT-100	%.1f
LGR mirror time	mt_LGR [us]	LGR DLT-100	%.2f
Precooler temperature	T_ECpre [C]	M&C EC30 air dryer	%.1f
Cooler stage 1 temperature	T_EC1 [C]	M&C EC30 air dryer	%.1f
Cooler stage 2 temperature	T_EC2 [C]	M&C EC30 air dryer	%.1f
Inlet line pressure	p_inlet [hPa]	Pressure transmitter	%.1f
Pressure before LGR	p_in [hPa]	Pressure transmitter	%.1f
Pressure after LGR	p_out [hPa]	Pressure transmitter	%.1f
Inlet line sample temperature	T_inlet [C]	T/RH sensor module	%.1f
Inlet line sample relative humidity	RH_inlet [%]	T/RH sensor module	%.1f
Inlet line sample dew point temp.	dwpt_inlet [C]	Calculated (computer)	%.1f
Vent air temperature	T_vent [C]	T/RH sensor module	%.1f
Vent air relative humidity	RH_vent [%]	T/RH sensor module	%.1f
Vent air dew point temperature	dwpt_vent [C]	Calculated (computer)	%.1f
Vent air flow	flow_vent [l min-1]	flow sensor	%.2f
Sample air flow	flow_sample [l min-1]	flow sensor	%.2f
Sample air dew point temperature	dwpt_sample [C]	Vaisala DMT242	%.2f
Room/system temperature	T_room [C]	LM-35	%.1f

The first line in every file is a header line containing comma separated short names enclosed in double quotation marks. Data starts from line 2. The amount of uncompressed ASCII data is ca. 200 kB/day.