T4.1-P17 Quality Assessment of Meteorological Data from CTBTO/IMS Radionuclide Stations

Petra Seibert[1], Cosima Jank[2], Anne Philipp[2]

[1]Institute of Meteorology, University of Natural Resources and Life Sciences, Vienna, Austria

[2]Department of Meteorology and Geophysics, University of Vienna, Austria

petra.seibert@univie.ac.at, http://homepage.univie.ac.at/petra.seibert/

CTBT: SCIENCE AND TECHNOLOGY 2017 CONFERENCE

ABSTRACT

All radionuclide stations are equipped with meteorological sensors and transmit their data to the IDC. These data help to interpret radionuclide measurements, especially with respect to local influences. Data from selected stations are transmitted real time to the World Meteorological Organization (WMO). Meteorological measurements not being the primary mission of the IMS, their quality is not seen as a priority. However, data can only be used if they are available and reliable. Therefore, data from DEP33 Schauinsland, a mountain station used in the first ATM Challenge, and JPP38 Takasaki, which is important for monitoring the DPRK test site, were investigated in detail. For the data quality at Schauinsland, several problems were found, most severe ones were with relative humidity which are of no useful value at this station. Data at Takasaki were found to be of better quality but still not satisfactory. Furthermore, available data from the network were screened. They show in general problematic quality, especially as concerns relative humidity and precipitation. Also, station height data are missing for a majority of stations. In order to achieve satisfactory quality, there is a need for regular inspections and maintenance of the equipment as foreseen in the Ops Manual. Automatic quality checks within the SOH procedures would be helpful.

Excerpts from official documents related to meteorological data at RN stations

OPERATIONAL MANUAL FOR RADIONUCLIDE MONITORING AND THE INTERNATIONAL EXCHANGE OF RADIONUCLIDE DATA (DRAFT, CTBT/WGB/TL-11,17/18/Rev.5):

3.3.4. Equipment Providing Meteorological Data

81. Specifications require that stations provide data recorded every 10 minutes on local meteorological conditions (Appendix I and Reference [4]). Required parameters are wind speed and direction, temperature, humidity and atmospheric pressure; precipitation is an optional parameter.

82. Those data can be provided either from equipment installed as part of the station or from a nearby (within about 10 km) national meteorological facility if its data can be considered representative also for the station. In the latter case, additional information on the facility and arrangements is provided in the station specific documentation, including data type, responsible personnel, transmission methods and frequencies, reliability and the method for incorporation of meteorological data into the station data.

83. Meteorological instrumentation is required to meet World Meteorological Organization standards and is installed according to those standards as closely as possible. Details of the equipment, relevant capabilities and possible site specific influences on the meteorological measurements are recorded in the station documentation (as described in Appendix III).

4.2. Operation of Meteorological Equipment

174. Meteorological equipment operates in an automatic mode. Station operational procedures include regular inslatexsympection of data by Technical Secretariat personnel and service visits to verify the functionality of the instrumentation.

CHAPTER 5: MAINTENANCE AND REPAIRS

5.1.4. Priority of Maintenance

242. A repair prioritizing scheme is used to ensure that all stations maintain or return to operational status as soon as possible after experiencing maintenance problems: urgent (priority 1), enhanced (priority 2) and other (priority 3).

246. Other repairs (priority 3) are required when the station experiences any failure that does not require enhanced or urgent repair, i.e. when a radionuclide station experiences a failure in a non-critical component of the systems or infrastructure, including sensors or equipment that are providing optional state of health information or supplementary data, such as local meteorological data. Resolution of the problem and restoration of operational conditions are to be made within one month of the failure. In this case, the period required to restore the operational condition of the components would not be considered as part of the station downtime.

FROM APPENDIX III:

Meteorological data	Unit	Averaging time	Reporting interval
Atmospheric pressure	hPa	10 min	10 min
Wind speed	m/s	10 min	10 min
Wind direction	° from N, clockwise	10 min	10 min
Temperature	°C	10 min	10 min
Relative humidity	%	10 min	10 min

Methods and data

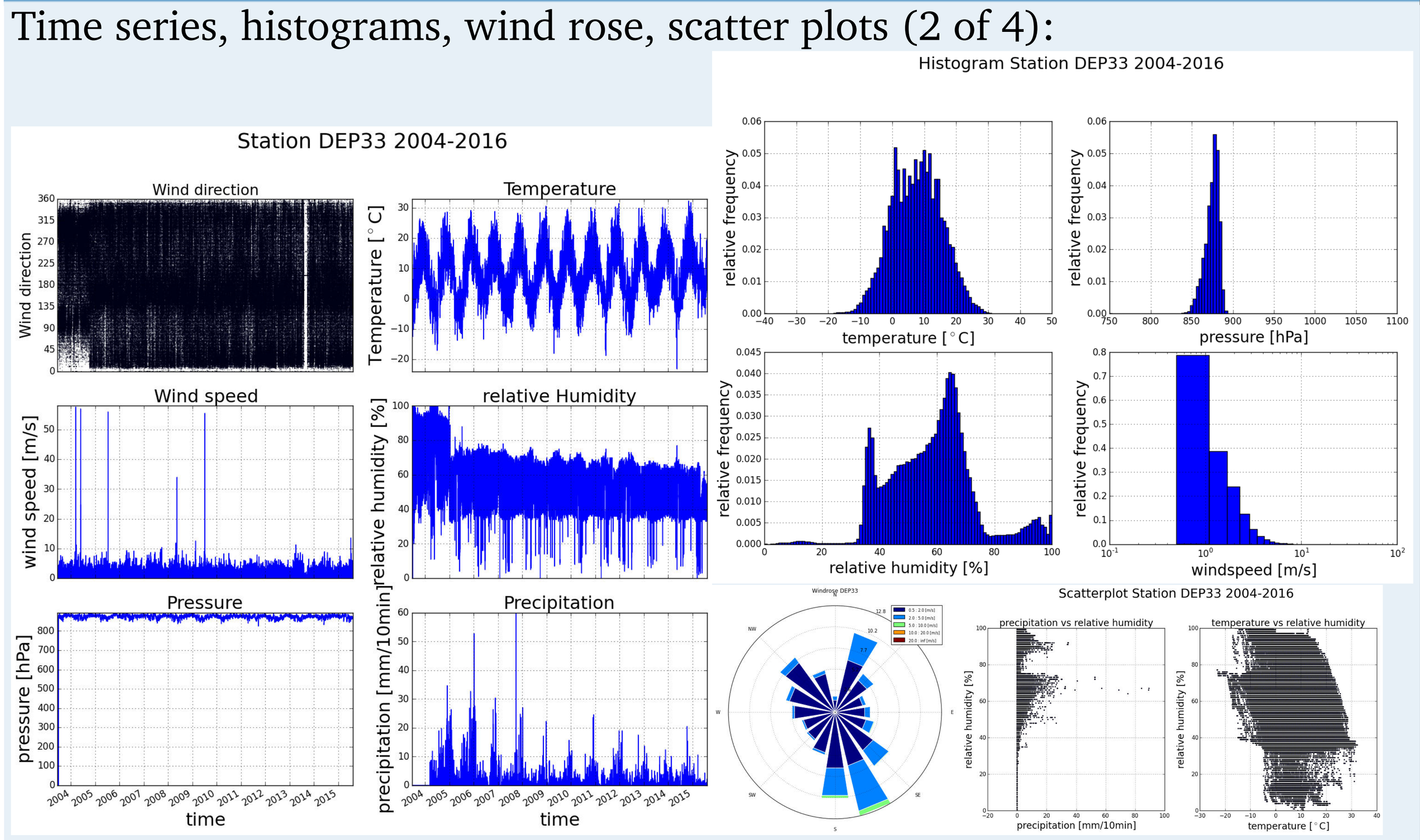
- In the context of an internship and then through a vDEC contract, all meteorological data collected at RN stations until April 2016 were studied (for statistical purposes, only until end of 2015)
  - detailed study of DEP33 Schauinsland, Germany
  - detailed study of JPP38 Takasaki, Japan
  - automated evaluation of all stations
- Data were inspected visually and with simple statistical methods using
  - time series
  - frequency distributions (histograms)
  - scatter plots of two parameters
  - checking of exceedance of general climatological threshold values
- Tools used are `python` with `matplotlib` for plotting and LaTeX for tabulating numerical results.

Findings not specific to stations

- Missing values are usually coded by a large negative value such as -9999, but these missing value codes are neither standardised nor documented. They may also be, for example, -99 or even something like -99.9000015258789
- Some stations have messages with unreasonable time stamps, e.g. dates such as 1904-01-01 1970-01-01 1970-01-03 1984-01-17 1998-01-01 or dates jumping back and forth.
- For many of the stations, the station height was missing in the metadata list delivered: only 23 out of 74 stations had an elevation value, and no station had a specific barometer elevation value (as required by WMO).

Results at Schauinsland

Time series, histograms, wind rose, scatter plots (2 of 4):



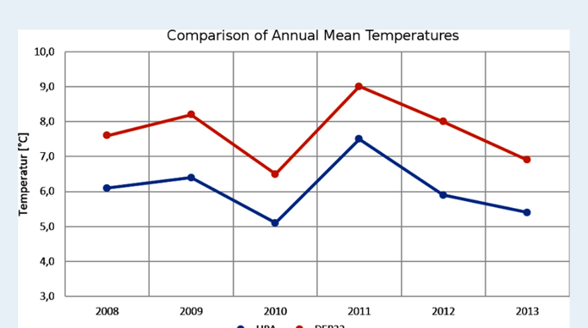
What can be learnt from the time series:

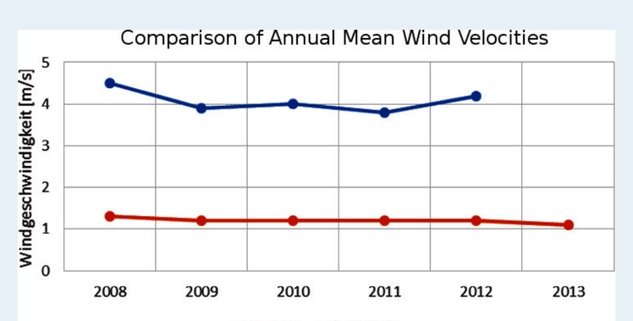
- Wind direction has a significant gap in 2014, and a different distribution before end of 2005
- Wind speed has several highly suspicious outliers
- Pressure has a single outlier at the beginning
- Relative humidity lacks low values (esp. at low temperatures), and after 2006 also high values. Data appear to be useless.

What the histograms show:

- Temperature: between –5°C and 15°C, the distribution is not smooth – certain values are overrepresented
- Relative humidity: problems are visible here as well

Comparison with nearby station of WMO Global Atmospherich Watch / UBA

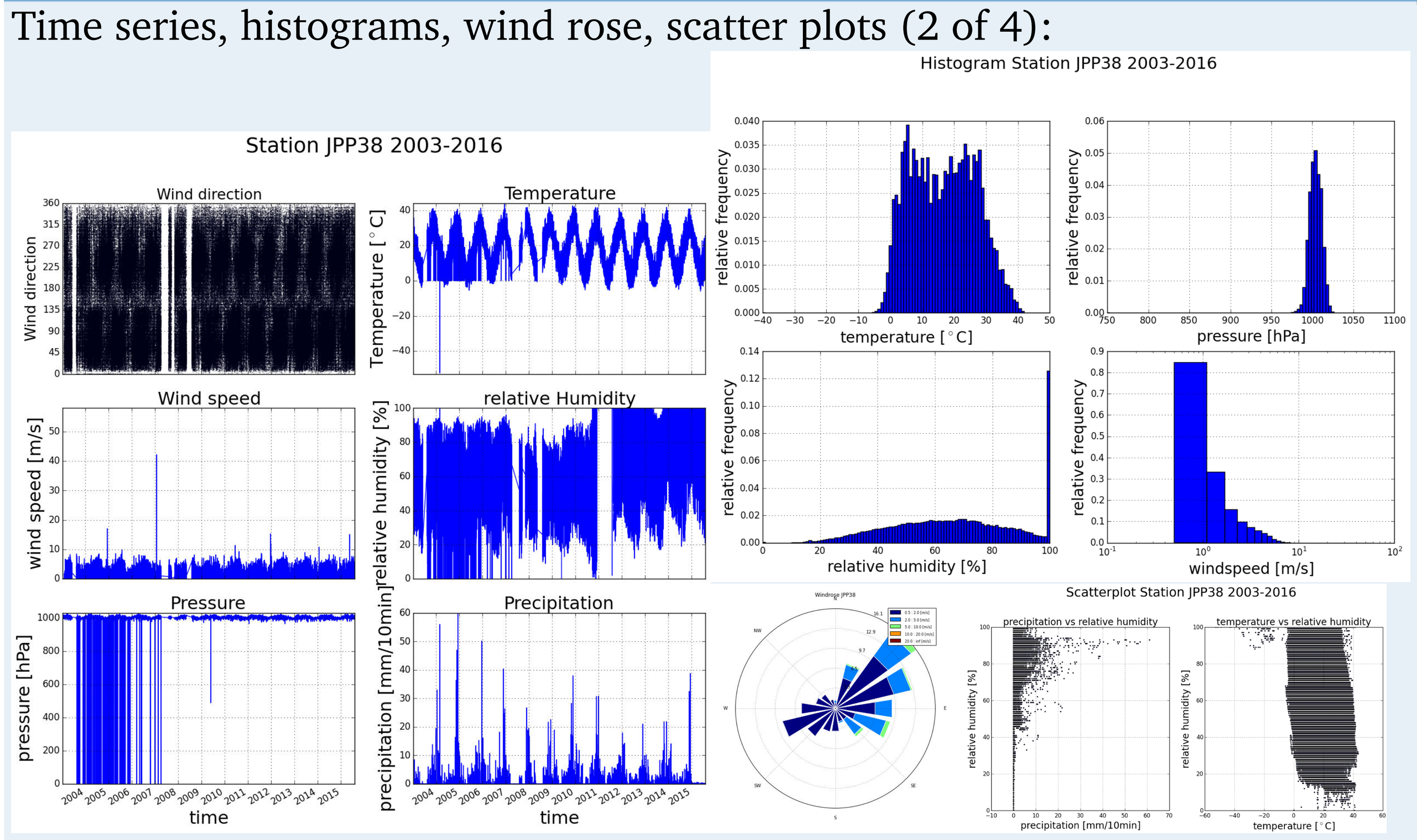




- The IMS stations appears to be systematically too warm by 1.5 K
- The IMS station has much lower wind speeds – could be an effect of being more surrounded by forest, or instrument problem, or combination of both

Results at Takasaki

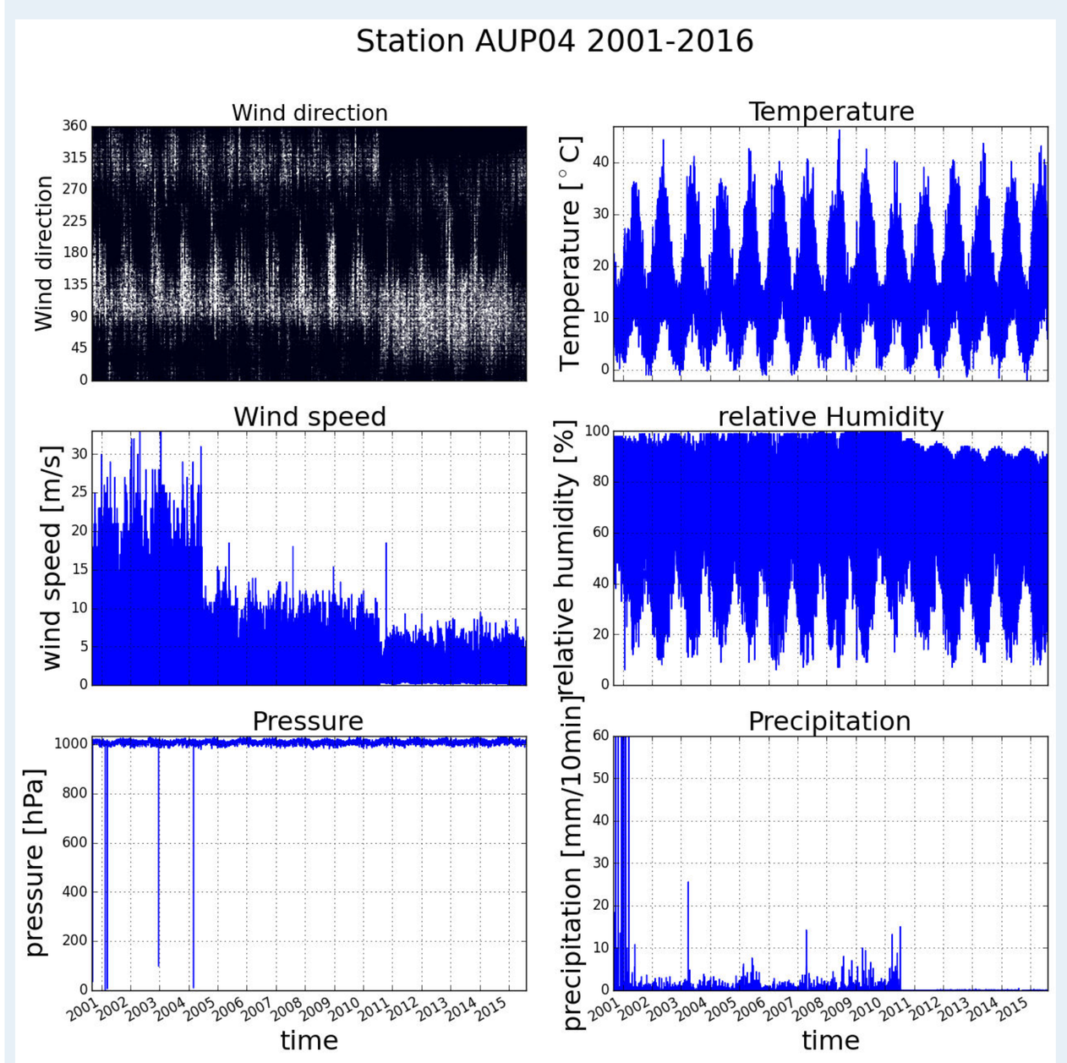
Time series, histograms, wind rose, scatter plots (2 of 4):

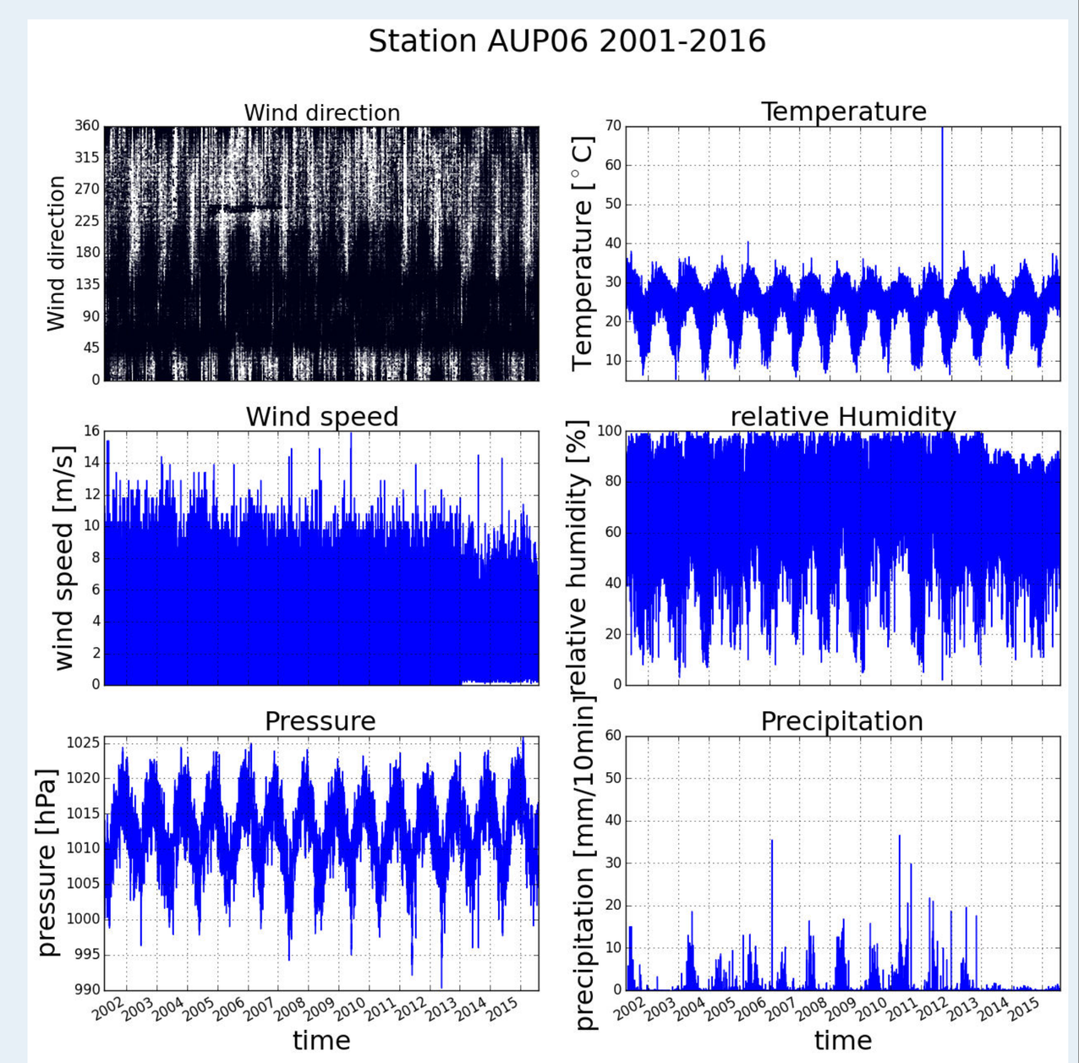


Results:

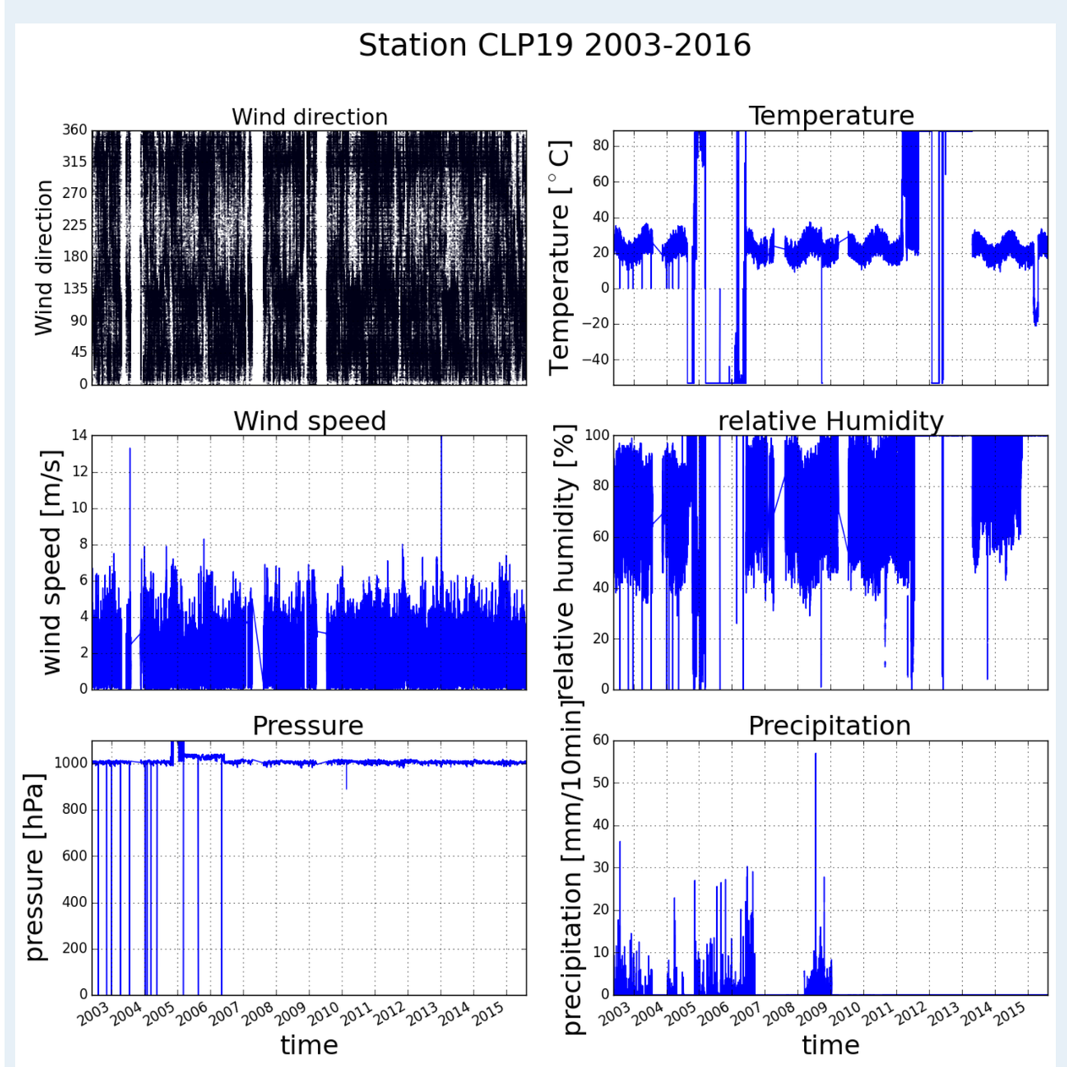
- Several longer data gaps
- Suspicious peaks of wind speed
- Many failures of the pressure sensor, until early 2008 and in 2010
- Temperature appears to be clipped at 0°C in many cases until ca. 2010
- Relative humidity does not reach values close to 100% before 2011, low values also often mistaken.
- Highest precipitation rates have strong variability from year to year, not clear whether this is realistic.
- Temperature:again, the distribution is not smooth for the central part
- Relative humidity: problems are visible here as well

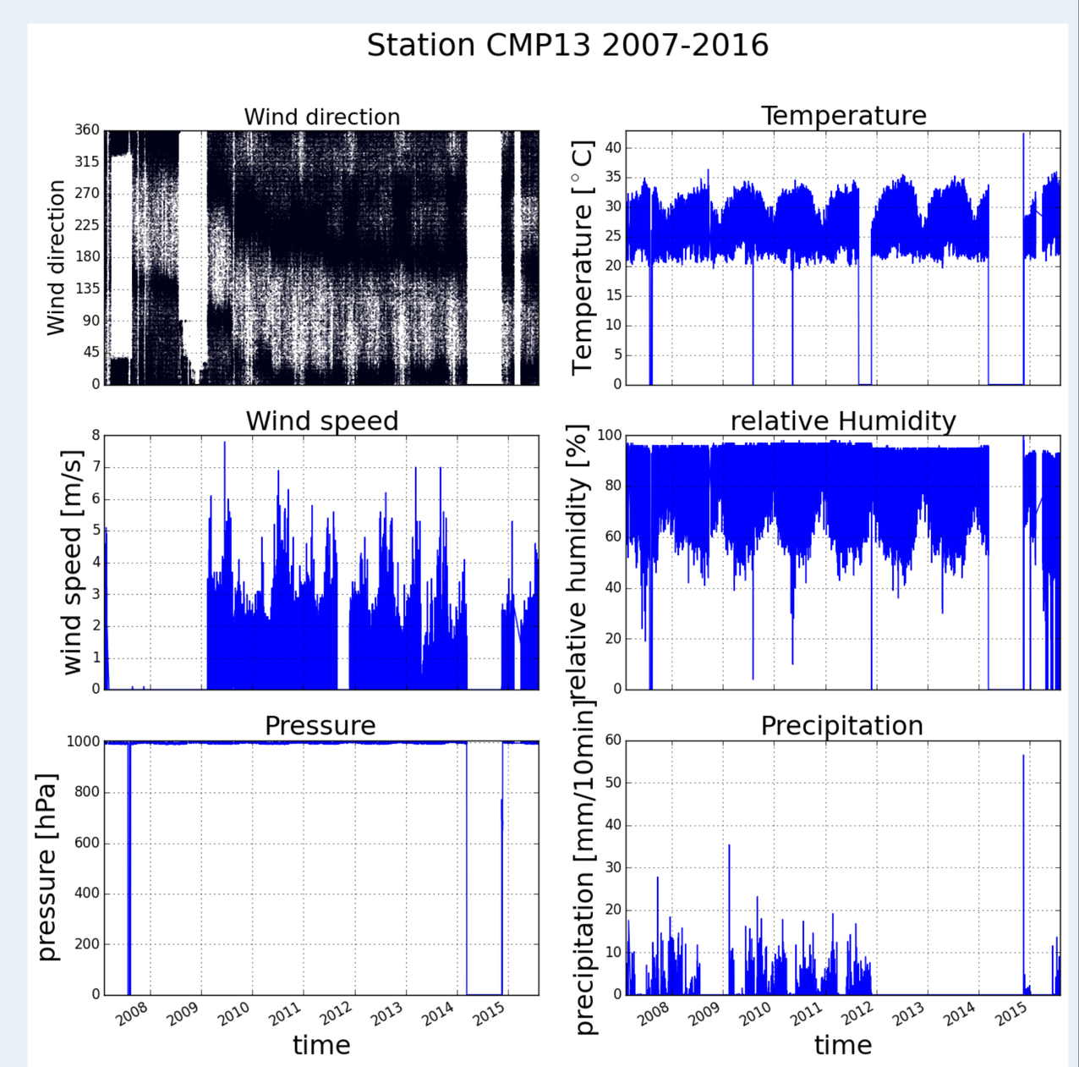
Some arbitrary examples of stations illustrating the quality problem





AUP04 (Melbourne): Some problems. AUP 06 (Townsville, QLD): almost ok.





CLP19 (Easter Island): reasonable periods mixed with problems, esp. for precipitation.

CMP13 (Edea, Cameroon): data gaps, drift in wind direction!, some bad relative humidity data.

Global results

This table provides an overview of extreme and mean values. The stations are in no particular order.

Many stations / parameters exhibit anomalous extreme values. Mean values are also sometimes affected by them.

Station	temperature [C]			wind speed [m/s]			pressure [hPa]			relative humidity [%]			precipitation [mm/h]		
	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max
CAP15	-53.8	-25.2	50.0	0.0	4.9	50.0	973.2	1012.4	1050.0	3	81.3	100	0.0	0.0	298.8
FJP26	-53.3	25.1	35.7	0.0	2.6	26.6	963.8	1008.3	1040.7	8	79.6	100	0.0	0.2	471.6
GBP66	-53.5	-6.5	50.0	0.0	2.5	44.9	894.5	1009.7	1048.8	3	87.8	100	0.0	0.3	585.0
FRP28	-40.0	27.0	36.2	0.0	1.5	49.8	862.5	1016.3	1035.1	7	75.8	100	0.0	0.2	536.4
USP79	-53.2	20.6	45.2	0.0	0.6	13.0	841.7	964.7	972.8	5	90.5	100	0.0	0.0	0.0
PAP50	0.0	26.9	36.5	0.0	2.6	10.4	993.3	1000.4	1006.9	3	71.7	100	0.0	0.4	600.0
FRP31	-40.0	25.6	50.0	0.0	3.4	24.7	857.7	1007.5	1045.0	3	81.1	100	0.0	0.3	577.2
PHP52	-7.0	16.9	43.3	0.0	1.0	39.0	919.6	939.3	947.9	3	79.9	100	0.0	0.3	598.8
USP73	-52.9	-10.1	50.0	0.0	4.3	49.8	917.5	983.8	1050.0	3	75.2	100	0.0	0.4	592.8
FRP29	-40.0	24.8	36.1	0.0	5.9	50.0	820.6	1007.9	1050.0	4	75.9	99	0.0	0.6	600.0
KWP40	-52.8	27.9	50.0	0.0	3.1	31.9	830.2	1005.7	1024.7	3	61.1	100	0.0	0.0	41.4
DEP33	-23.2	7.7	32.3	0.0	1.2	49.2	824.5	874.4	893.3	3	57.9	100	0.0	0.9	536.4
ARP03	-17.1	9.0	48.7	0.0	1.4	37.0	890.5	919.1	954.0	4	61.6	95	0.0	0.7	525.6
USP70	-52.6	19.9	50.0	0.0	1.9	50.0	977.6	1008.1	1026.4	3	50.3	100	0.0	0.0	0.0
JPP38	-52.4	16.8	43.5	0.0	1.2	50.0	964.9	1003.4	1029.1	3	66.1	100	0.0	1.1	366.6
USP74	-53.2	14.4	48.7	0.0	4.5	50.0	887.7	943.5	973.9	3	56.1	100	0.0	0.0	0.0
AUP08	0.0	26.9	31.7	0.0	6.2	30.0	991.2	1011.1	1019.5	3	76.5	100	0.0	0.2	289.2
USP72	-56.7	22.9	47.3	0.0	4.7	49.3	914.5	1014.8	1046.9	3	69.5	100	0.0	35.0	225.0
GBP68	-49.4	12.8	50.0	0.0	5.2	49.0	972.5	1013.1	1038.1	3	74.8	100	0.0	2.3	598.8
ISP34	-42.1	5.9	50.0	0.5	4.8	49.6	932.7	993.9	1032.0	3	73.0	100	0.0	3.2	6.0
MNP45	-40.0	-0.4	48.7	0.0	5.7	50.0	820.0	844.7	900.1	3	59.3	100	0.0	0.4	552.0
CAP16	-50.0	-3.1	31.2	0.0	2.8	12.4	820.4	985.1	1023.6	6	65.4	100	0.0	0.0	55.2
CLP18	-52.9	8.7	50.0	0.0	4.2	34.2	940.7	999.4	1044.1	3	70.2	100	0.0	0.0	4.2
AUP09	2.0	27.1	37.9	0.0	4.1	36.0	989.0	1006.4	1016.5	4	68.5	100	0.0	0.2	282.0
USP75	-23.3	13.4	50.0	0.0	0.7	50.0	868.1	1002.6	1050.0	3	72.4	100	0.0	0.0	0.0
NOP49	-49.3	-7.3	20.2	0.0	5.4	50.0	897.0	951.9	994.7	11	83.8	100	0.0	0.3	6.0
PGP51	20.4	28.0	36.1	0.0	0.9	14.0	1000.5	1008.2	1015.2	44	80.0	97	0.0	0.2	237.6
CLP19	-53.3	11.4	50.0	0.0	2.0	14.0	890.5	1008.1	1049.9	3	83.6	100	0.0	0.2	342.0
BRP11	-53.3	23.3	49.9	0.0	3.3	45.6	934.2	1014.8	1037.9	3	85.6	100	0.0	0.4	292.8
RUP58	-33.2	5.0	35.8	0.0	2.7	28.0	963.4	997.3	1045.9	9	65.1	94	0.0	0.3	582.0
USP78	-53.1	-0.7	49.4	0.0	3.7	19.6	910.8	1017.0	1033.8	3	88.2	100	0.0	0.0	0.0

Station	temperature [C]			wind speed [m/s]			pressure [hPa]			relative humidity [%]			precipitation [mm/h]		
MYP42	-60.0	18.8	49.9	0.0	1.9	22.8	820.1	844.0	1049.5	3	82.3	100	0.0	0.1	384.0
RUP60	-47.0	2.2	30.9	0.0	4.2	37.3	946.9	999.7	1033.0	17	71.5	100	0.0	0.0	16.2
RUP61	-31.6	5.9	39.0	0.0	1.8	11.9	821.0	999.7	1038.2	11	76.1	99	0.0	0.1	90.0
RUP56	-32.8	2.3	33.2	0.0	1.5	20.8	951.7	978.1	1005.8	15	68.4	96s	0.0	146.6	598.8
CAP14	-9.9	10.4	33.7	0.0	2.0	13.7	820.0	994.1	1040.8	14	73.6	94	0.0	0.1	84.0
AUP06	5.1	24.4	40.5	0.0	4.2	15.9	990.3	1012.8	1025.9	3	69.7	100	0.0	0.1	219.6
NZP46	-53.4	11.8	26.9	0.0	6.7	24.3	963.1	1011.6	1043.0	40	87.7	100	0.0	0.1	127.2
CKP23	-38.1	24.4	37.4	0.0	4.2	26.8	977.8	1012.7	1050.0	35	81.0	100	0.0	0.2	139.2
NZP47	-53.4	15.4	31.4	0.0	4.5	20.5	886.5	1006.7	1028.3	22	82.0	100	0.0	0.1	97.2
AUP10	-10.4	18.2	43.9	0.0	4.0	22.1	989.7	1014.4	1036.2	4	62.1	100	0.0	0.1	419.4
AUP04	-2.0	14.9	46.3	0.0	3.7	33.0	977.5	1009.7	1033.2	6	68.6	100	0.0	0.1	218.4
FRP27	-40.0	24.7	49.8	0.0	1.9	50.0	820.0	975.2	1021.3	3	58.3	99	0.0	109.8	594.0
ARP01	-60.0	20.4	50.0	0.0	1.5	27.4	882.3	1013.1	1048.8	3	58.3	100	0.0	0.1	232.2
RUP54	-41.1	3.2	36.5	0.0	1.9	36.0	956.7	1000.2	1043.4	15	74.3	100	0.0	113.1	600.0
CMP13	0.0	22.3	42.5	0.0	0.5	7.8	989.5	997.8	1005.2	3	86.0	100	0.0	0.1	339.6
RUP59	-49.0	2.3	35.9	0.0	1.4	13.1	960.8	990.3	1037.2	8	71.1	97	0.0	0.0	114.0
KIP39	-35.0	26.7	44.7	0.0	3.0	11.1	1001.8	1009.8	1017.8	3	79.9	100	0.0	0.1	318.0
USP77	-53.5	24.3	50.0	0.0	3.9	16.2	822.0	1010.7	1022.4	3	73.6	100	0.0	0.0	0.0
USP80	-53.2	26.8	37.1	0.0	4.3	50.0	898.8	989.5	998.6	3	79.1	100	0.0	0.0	0.0
AUP05	-33.0	-11.3	8.0	0.0	11.8	44.2	949.0	985.4	1015.0	6	56.0	100	nan	nan	nan
USP76	-45.2	-1.5	34.7	0.0	1.3	11.2	940.6	980.9	1022.7	11	73.5	100	0.0	0.0	0.0
TZP64	0.0	26.3	34.5	0.0	1.6	6.5	991.1	1002.3	1012.1	9	74.6	95	0.0	0.1	308.4
GBP67	0.0	18.1	29.3	0.0	3.6	13.8	960.5	967.8	977.2	3	85.9	100	0.0	0.0	558.0
USP71	-53.3	-0.6	50.0	0.0	3.7	50.0	940.6	997.5	1049.8	3	79.5	100	0.0	0.0	0.0
FRP30	-40.0	6.0	22.6	0.0	8.2	38.4	877.4	999.4	1033.3	4	77.1	100	0.0	0.1	224.4
CAP17	-17.7	6.2	31.8	0.0	6.7	43.5	942.1	999.2	1035.4	3	80.6	100	0.0	1.6	499.2
JPP37	-53.3	19.2	48.5	0.0	1.5	50.0	867.6	1001.7	1017.1	3	90.1	100	0.0	0.5	404.4
MRP43	0.0	25.5	46.9	0.0	4.5	17.5	1002.6	1012.0	1024.4	3	49.7	100	0.0	0.0	451.2
SEP63	-21.5	8.2	32.4	0.0	2.5	14.6	956.0	1007.5	1046.0	11	73.8	100	0.0	0.0	153.6
PTP53	-10.9	18.6	50.0	0.0	5.4	49.2	973.0	1015.4	1034.5	3	74.0	95	0.0	0.3	51.0
MXP44	0.2	19.0	49.9	0.0	6.5	28.8	996.7	1013.1	1025.3	3	67.8	95	0.0	0.0	87.6
AUP07	-8.4	4.9	11.3	0.0	10.4	32.4	949.9	998.7	1031.4	22	85.1	100	0.0	0.1	16.8

Conclusions

- There are significant problems with meteorological data in most of the stations.
- The problems are not resolved fast enough.
- Wrong data in the IDC data base are neither removed nor flagged.
- The general handling of the data is not consistent (missing value codes).
- With the current quality of the data, forwarding them to WMO for distribution in the GTS and use in weather prediction models is not recommendable!

Why care about the quality of meteorological data?

- The IMS manual stipulates meteorological measurements and their specifications.
- They are useful to interpret radionuclide measurements, for example with respect to local sources.
- They can serve for comparison with modelled meteorological conditions, in order to judge how well the transport to this station was simulated in ATM.
- The CTBTO/PrepCom has agreed with the World Meteorological Organisation to deliver its meteorological measurements for the benefit of the meteorological community, and in the end also the quality of the models on which ATM relies.

Recommendations

- If the provisions of the IMS Manual (including those quoted above, but not limited to them) would be implemented, most of the problems would probably not appear or be resolved within reasonable time.
- Proper processing of the data has to be ensured which would make sure that data ingested by the IDC data base are standardised and conforming to definitions, especially with respect to missing value codes.
- Probably, the meteorological equipment at all stations should be inspected and replaced or repaired where necessary. A step-by-step plan should be set up for this purpose (priority to stations which have measured unusual radionuclide concentrations or where there is no standard WMO station in a wide surrounding).
- Simple check for plausibility should be implemented as soon as possible, and alerts of station personell to be triggered in case of bad data (include meteorology in State-of-Health?)
- Make sure that metadata such as elevation or characterisation of the environment are available to IDC users including vDEC contract partners.
- Train staff tasked with site survey and site construction in WMO Guidelines for siting of meteorological stations.

This work is carried out under the vDEC contract *Quality Assessment of Meteorological Data Collected at IMS RN Stations*. We are grateful for the support by our (former) CTBTO colleagues, especially Monika Krysta, Martin Kalinowski, and Jolanta Kusmierczyk-Michulec. All views expressed are under the sole responsibility of the authors and not of the CTBTO/PTS.