Comparative analysis of data collected by installed automated meteorological stations and manual data in Central Asia.

Merkushkin Aleksandr

Uzhydromet

71 K. Makhsumov str., 100052 Tashkent, Uzbekistan

Tel: (998) 71-150-86-23

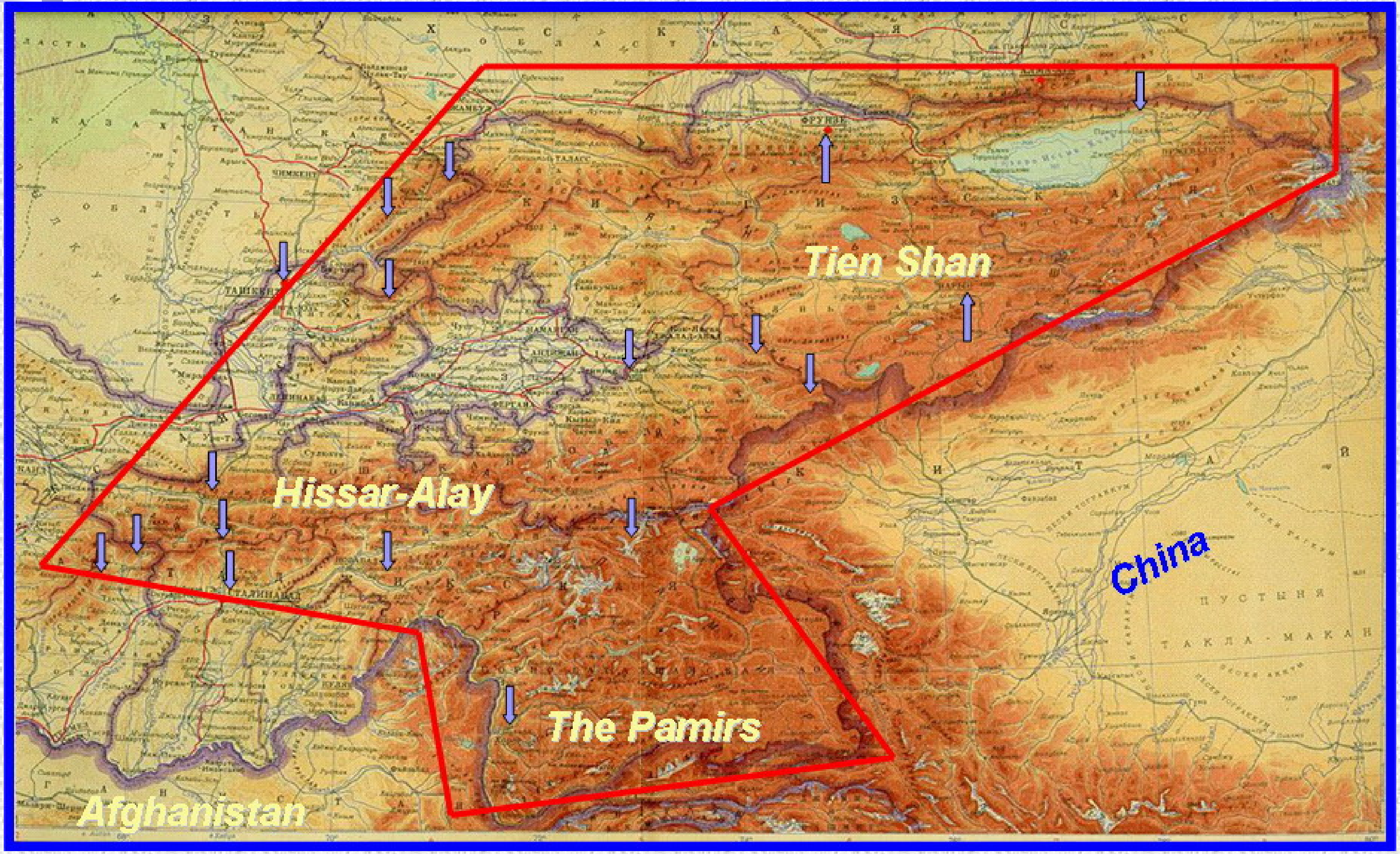
Fax: (998) 71-233-20-25

Email: asmerk@meteo.uz

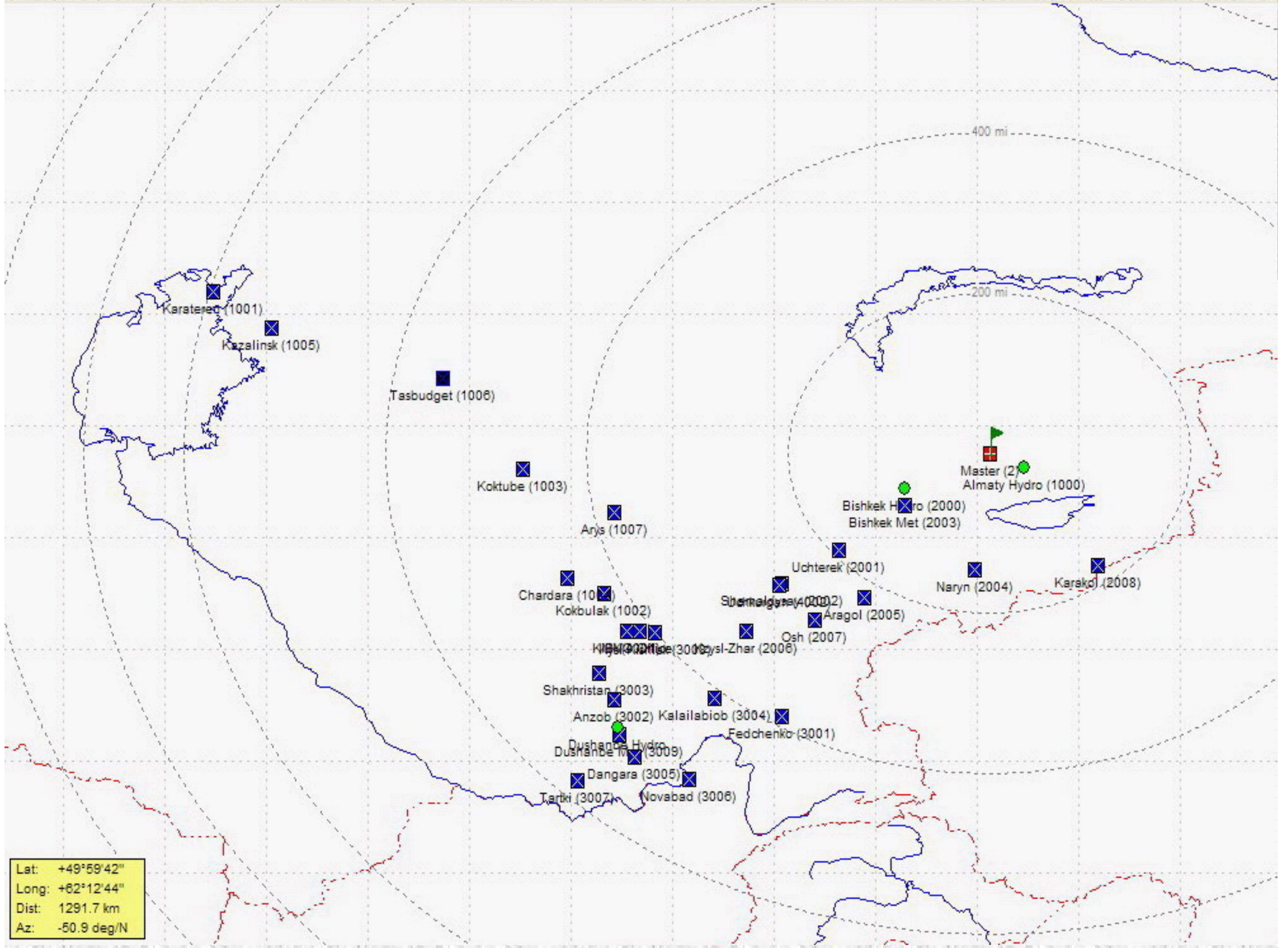
Abstract

Critical water management within the five central Asian republics (CAR) requires access to reliable climate and hydrological data. As part of the effort to strengthen trans-boundary water resources management within the region, the US Agency for International Development's (USAID) Natural Resources Management Program (NRMP) funded a pilot automated climate data collection network. Sixteen automated weather stations (AWS) were installed within Tajikistan, Kyrgyzstan, Kazakhstan, Uzbekistan and Turkmenistan during the period from February 2002 to September 2003. . Ease of use, low operational cost, suitability for remote unmanned operation, proven reliable collection of high quality data and capability to electronically store and transfer data are the primary reasons for utilizing automated climate monitoring instrumentation. Most of these stations use the USAID sponsored meteor burst radio communications to provide real time data telemetry and acquisition.

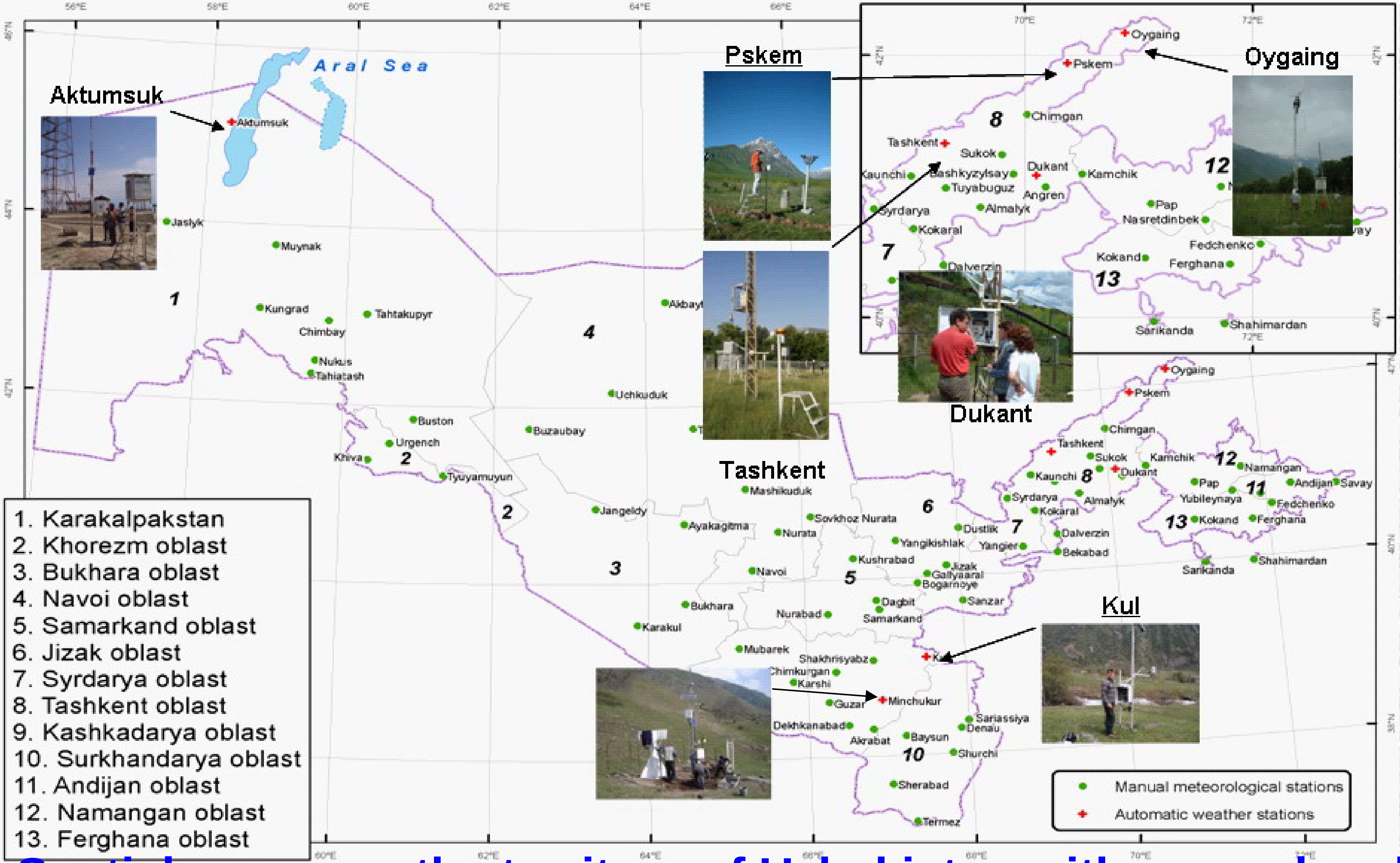
This automated data collection and telemetry system was the first of its kind deployed within the region. The national Hydromet service (NHS) within the CAR had little experience with this technology. Two key objectives of the program was to demonstrate the utility for remote automated deployment as well as allow for simultaneous operation with familiar manual monitoring. Eight of the stations were installed at operational climate stations that were staffed by NHS observers. This presentation provides the results of the comparative analysis from some of the simultaneous measurements.



Incomplete picture on spatial coverage the territory of Central Asia with automated weather stations

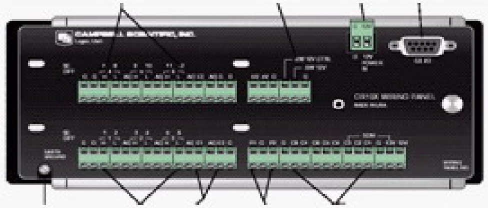


All automated weather stations (AWS) installed in Central Asia talk via Meteor Burst Communication System except AWS installed in Uzbekistan



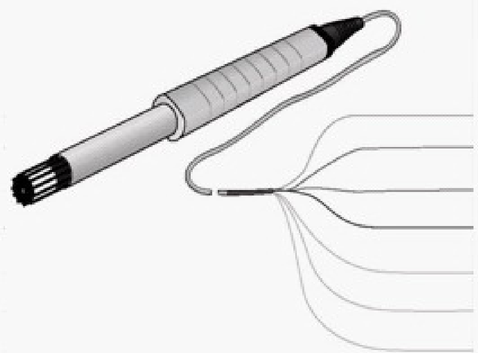
Spatial coverage the territory of Uzbekistan with manual and automated weather stations (only 7 of 78 meteorological stations are automated ones)

Sensors cabinet of installed AWS



Data logger and Control Module

Campbell Scientific CR10X-55..+85°C±0.1 of Full Scale Range @ (-25 to 50 °C)



Air TemperatureVaisala HMP45D

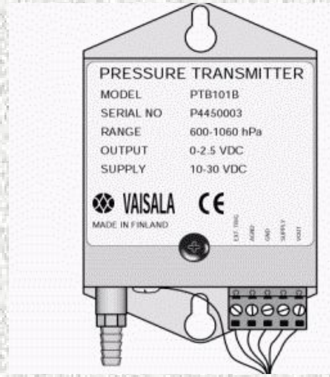
w/ Pt 100 IEC 751 enclosed in RM Young 41003 Multi-Plate Radiation Shield-40..+60°C±0.2 °C @ 20 °C ±0.5 °C maximum within range

Additional error is introduced due to heating of radiation shield and is dependent on wind speed and radiation intensity

Relative HumidityVaisala HMP45D

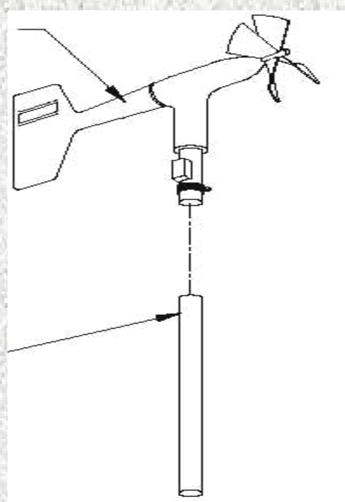
w/HUMICAP® 1800..100% ±1% against factory references±3% field calibrationMaximum error occurs between 90% and 100%

Sensors cabinet of installed AWS



Atmospheric PressureVaisala PTB100

Analog Barometer 600.. 1060 mb ±0.5 mb @ +20°C±6 mb maximum within -40.. +60 °C range. Measures absolute pressure and uses equation to calculate pressure at sea-level

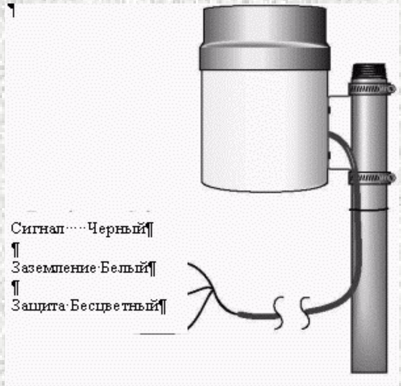


Wind Speed and Direction RM Young 05103

Wind Speed0..60 m/sGust survival 100 m/s±0.3 m/sWind Direction0..355° ±3°

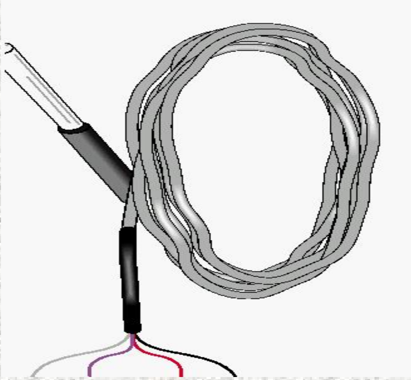
Sensors cabinet of installed AWS

Solar RadiationKipp & Zonen CM3 0..2000 W/m2±10% for daily sums.Second Class thermopile type pyranometer Standard ISO 9060.



Precipitation (Rainfall)Texas Electronics 525M Tipping Bucket Rain Gauge0.1 mm resolution1.0% < 25 mm/hr+0..-3% 25..50 mm/hr+0..-5% 50..75 mm/hrNot suitable for measurement of snow. Heated tipping bucket rain gauges are not recommended by WMO.

Sensors cabinet of installed AWS



Ground TemperatureCSI T-107/8 ThermistorT-107: -35°..+50°C ±0.4°C for range of –24°..48°C T-108: -5°..+95°C ±0.3°C for range of –3°..90°CSensitive to solar radiation heating when sensor exposed to sunlight

Snow Water Equivalent3 meter Hypalon® Snow Pillow w/ Druck 1230 Pressure Transducer.

7 m H_2O.

2 cm H_2O resolution

Extremely sensitive to placement. May be under representative because of snow bridging.

AWS installed performance rates

Station	Start of Record	End of Record	Performance	Parameters
Almaty	21-Sep-02	21-Dec-04	99.99%	3 hr Air temp, Rh, Air Pressure 24hr Max. and Min Air Temp, Precipitation
Bishkek	18-Jun-02	07-Dec-04	99.9%	3 hr Air temp, Rh, Air Pressure 24hr Max. and Min Air Temp, Precipitation
Tashkent	13-Sep-02	30-Nov-04	95.9%	3 hr Air temp, Rh, Air Pressure 24hr Max. and Min Air Temp, Precipitation
Naryn	15-Sep-02	03-Dec-04	94.1%	24hr Max. and Min Air Temp, Precipitation

AWS vs manual data comparison for daily and monthly calculations based on standard differences

3 hour Mean Temperature (degree C)

Station	AWS	Manual	Std. Diff.
Almaty	9.341	9.371	0.458
Bishkek	12.577	12.797	0.836
Tashkent	15.445	15.624	2.198

3 hour Mean Relative Humidity (percent)

Station	AWS	Manual	Std. Diff.
Almaty	63.851	65.064	4.387
Bishkek	62.387	61.928	4.377
Tashkent	56.300	55.546	8.357

3 hour Mean Atmospheric Pressure (mbar)

Station	AWS	Manual	Std. Diff.
Almaty	921.63	921.06	0.374
Bishkek	929.35	929.84	6.980
Tashkent	960.40	959.46	3.953

AWS vs manual data comparison for daily and monthly calculations based on standard differences

Mean Maximum Temperature (degree C)

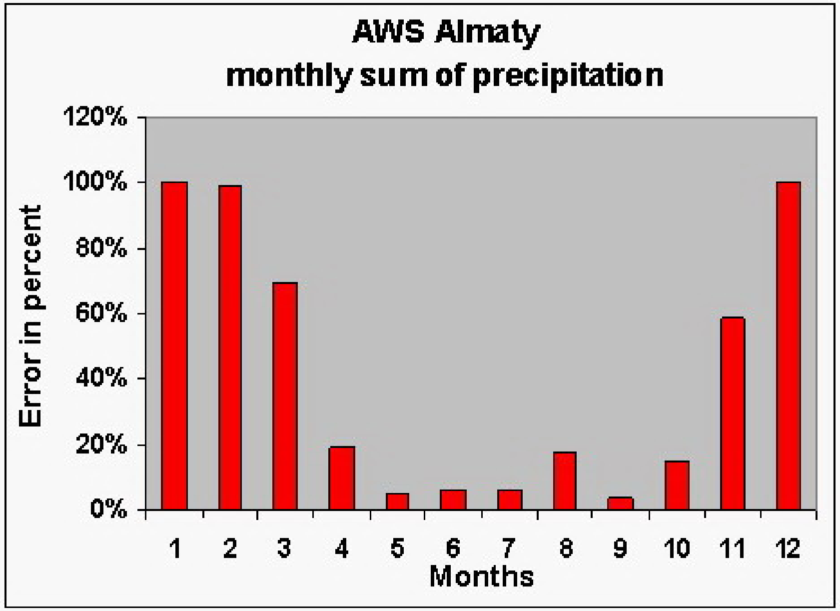
Station	AWS	Manual	Std. Diff.
Almaty	14.473	14.888	1.104
Bishkek	19.155	18.968	0.544
Naryn	9.706	9.783	0.861
Tashkent	22.405	22.453	1.142

Mean Minimum Temperature (degree C)

Station	AWS	Manual	Std. Diff.
Almaty	5.058	4.773	1.013
Bishkek	6.386	6.981	0.689
Naryn	-1.785	-1.534	0.534
Tashkent	9.513	9.780	1.016

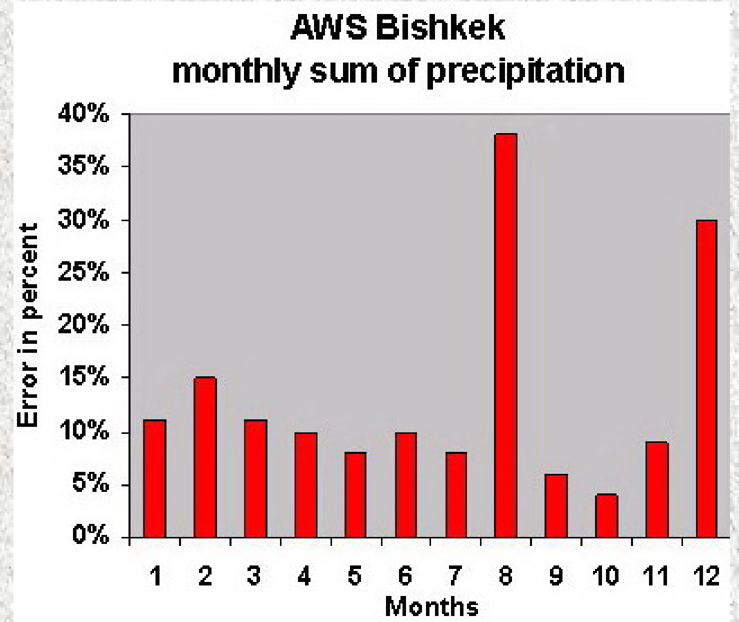
AWS vs manual data comparison for daily and monthly calculations based on standard differences

Month	Almaty		
	AWS	Manual	Error
1	0	77.6	100%
2	1.3	108.8	99%
3	50.1	161.1	69%
4	168.6	207.9	19%
5	239.1	251.8	5%
6	178.4	189.8	6%
7	171.6	182.2	6%
8	51.8	62.9	18%
9	9.5	9.9	4%
10	58.4	69	15%
11	64.4	158.2	59%
12	0.1	88.6	100%



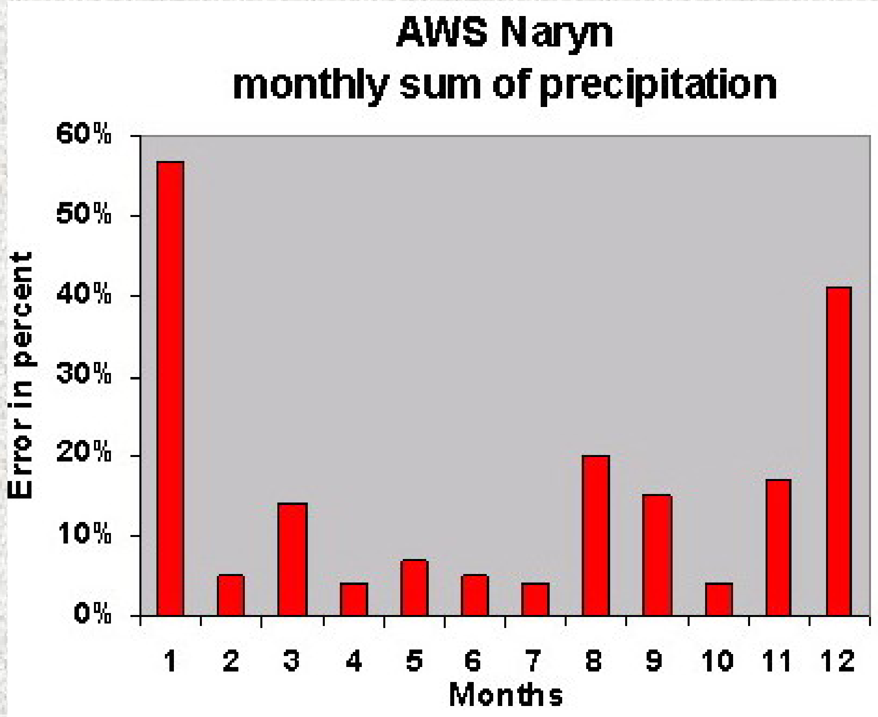
AWS vs manual data comparison for daily and monthly calculations based on standard differences

Month	Bishkek		
	AWS	Manual	Error
1	57.8	64.9	11%
2	83.5	97.7	15%
3	124.3	140.1	11%
4	135.5	149.8	10%
5	144.3	156	8%
6	97.5	108.1	10%
7	88.7	96	8%
8	23.6	38	38%
9	20	21.2	6%
10	119.2	124.4	4%
11	176.8	194.4	9%
12	68	97.4	30%



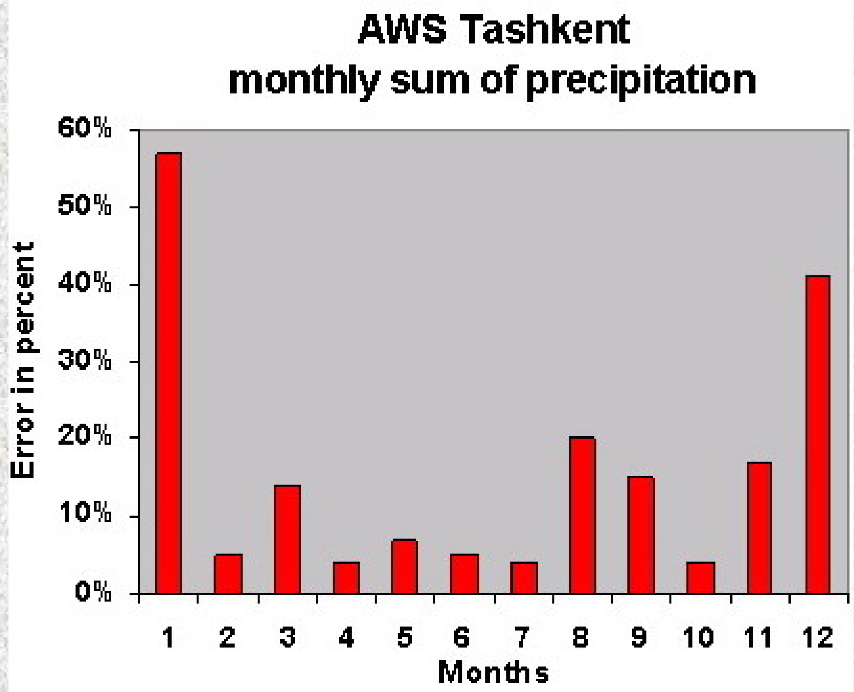
AWS vs manual data comparison for daily and monthly calculations based on standard differences

Month	Naryn		
	AWS	Manual	Error
1	9.6	22.2	57%
2	18.6	19.5	5%
3	67.9	78.6	14%
4	112.1	116.7	4%
5	87.3	93.8	7%
6	87.7	92	5%
7	80.1	83.7	4%
8	42.7	53.7	20%
9	3.8	3.3	15%
10	40.8	42.7	4%
11	78.8	94.6	17%
12	17.2	29.1	41%

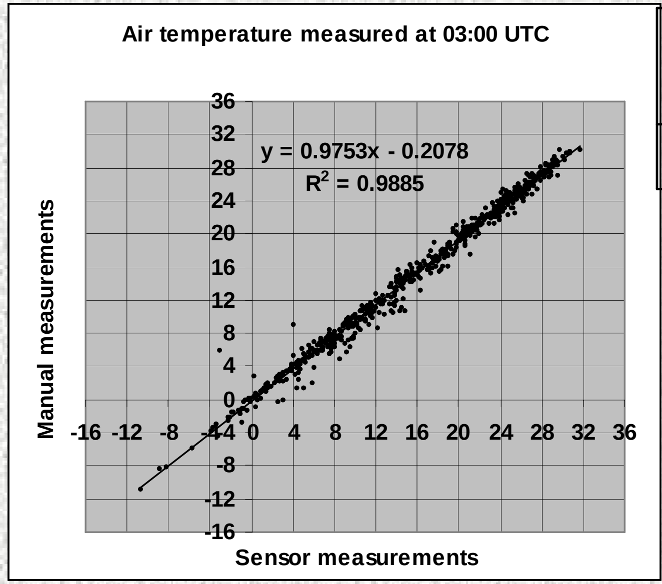


AWS vs manual data comparison for daily and monthly calculations based on standard differences

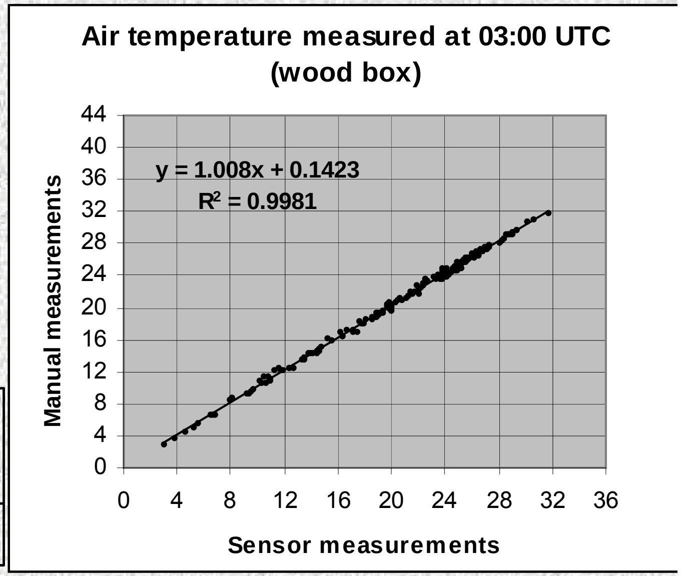
Month	Tashkent		
	AWS	Manual	Error
1	53.7	31.6	70%
2	109.8	120.4	9%
3	161.4	176.1	8%
4	106.9	127.6	16%
5	75	82.9	10%
6	22.8	25.9	12%
7	15.5	16	3%
8	5	6.1	18%
9	0.6	0.8	25%
10	19.5	24	19%
11	122.6	167.3	27%
12	129.7	157.7	18%



AWS vs manual data comparison for 3 hours and daily measurements based on T and F tests (air temperature)

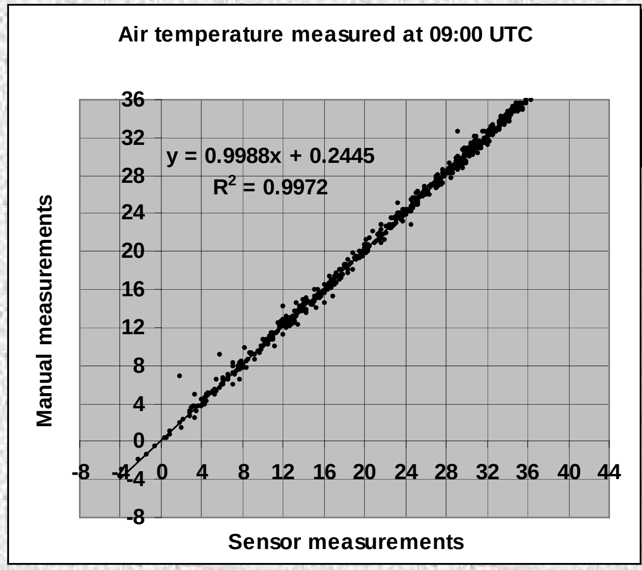


Mean manual	Mean sens.	Dif. mean	Dis man	Dis sen	Dis Ratio	T	F
15.19	15.79	-0.60	80.7	83.9	1.04	0.25	0.63

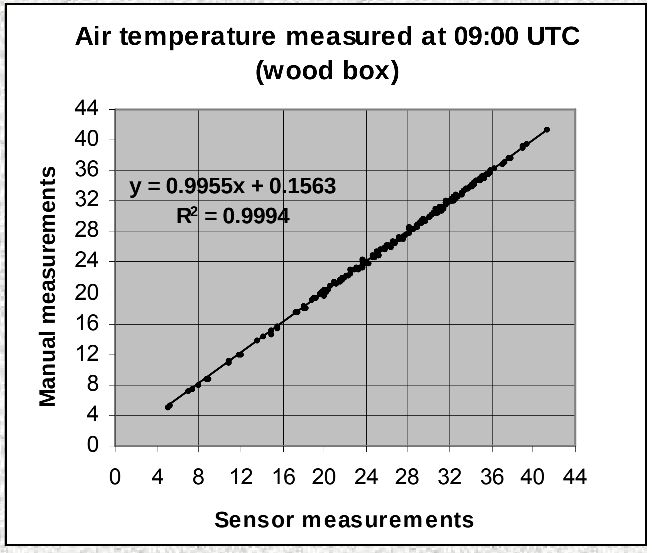


Mean manual	Mean sens.	Dif. Mean	Dis. man	Dis sen	Dis. Ratio	T	F
20.64	20.34	0.31	43.8	43.02	1.02	0.67	0.91

AWS vs. manual data comparison for 3 hours and daily measurements based on T and F tests (air temperature)

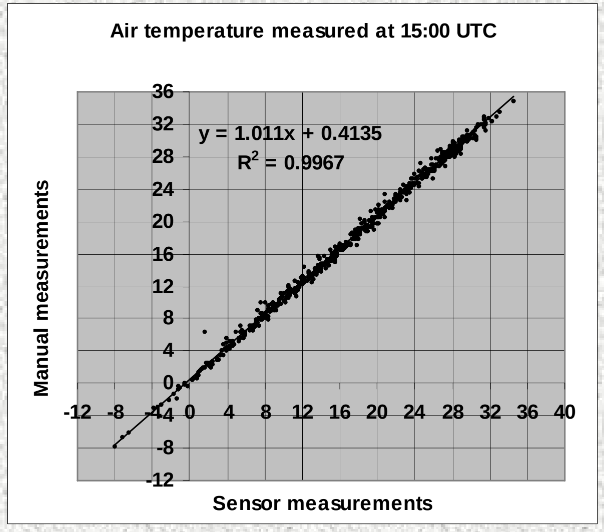


Mean manual	Mean sens.	Dif. mean	Dis. Man.	Dis. Sens.	Dis. Ratio	T	F
22.64	22.45	0.19	103.2	102.96	1.00	0.74	0.98



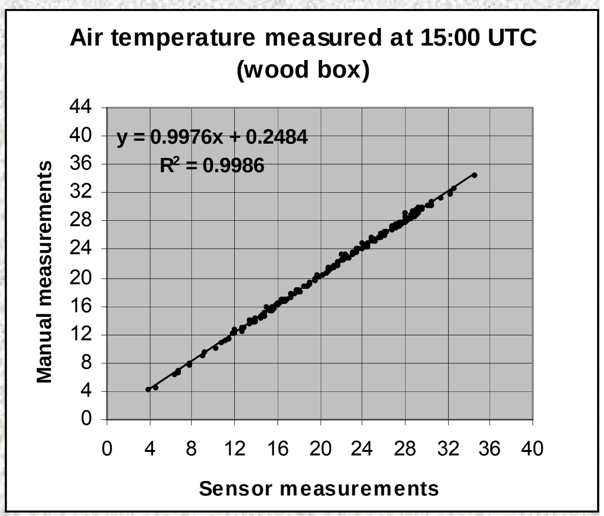
Mean manual	Mean sens.	Dif. mean	Dis. Man	Dis. sens	Dis. Ratio	T	F
27.33	27.30	0.03	52.91	53.4	1.01	0.96	0.95

AWS vs manual data comparison for 3 hours and daily measurements based on T and F tests (air temperature)

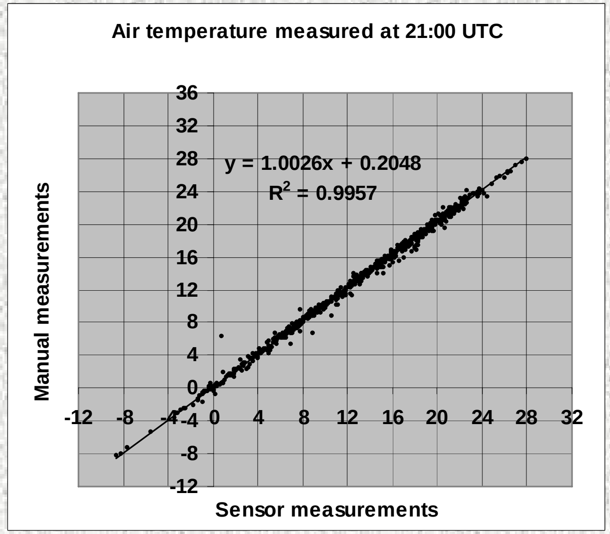


Mean manual	Mean sens	Dif. mean	Dis. Man	Dis. Sens.	Dis. Ratio	T	F
17.76	17.15	0.60	84.3	82.25	1.03	0.25	0.76

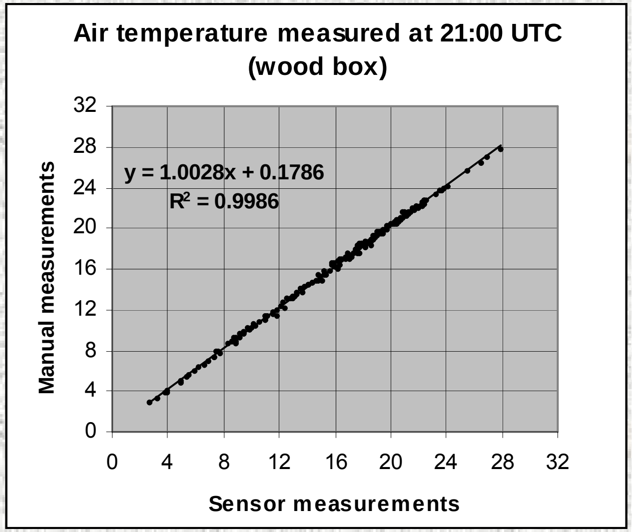
Mean manual	Mean sens	Dif. mean	Dis. Man	Dis. Sens.	Dis. Ratio	T	F
21.74	21.54	0.20	44.60	44.75	1.00	0.77	0.98



AWS vs. manual data comparison for 3 hours and daily measurements based on T and F tests (air temperature)

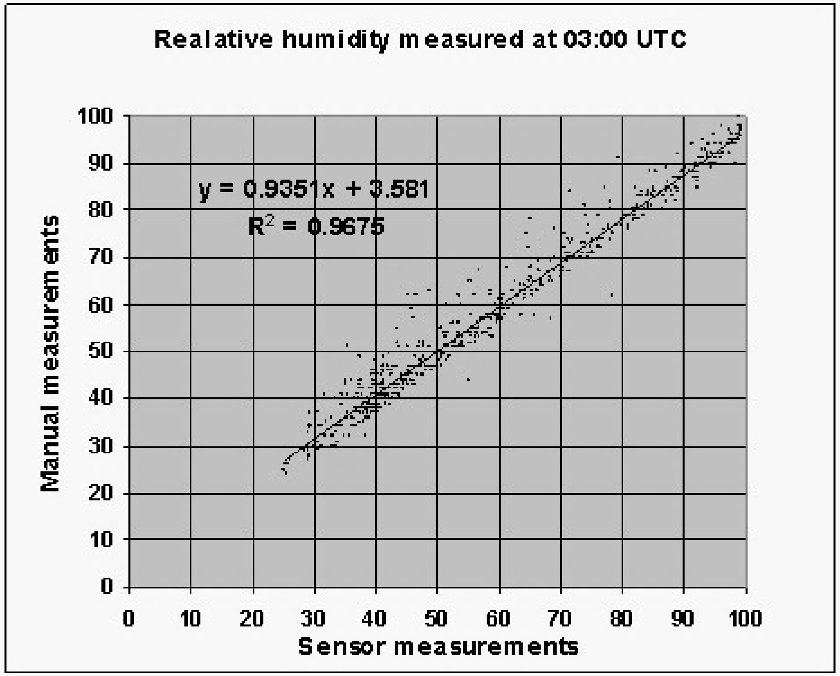


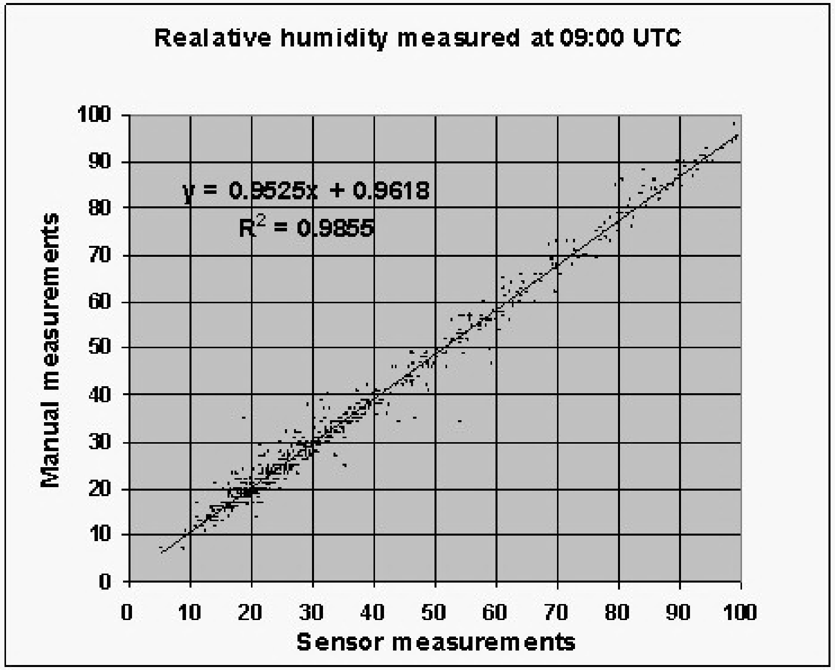
Mean manual	Mean sens	Dif. mean	Dis. Man	Dis. Sens.	Disp. Ratio	T	F
12.98	12.74	0.24	51.8	51.32	1.01	0.56	0.91



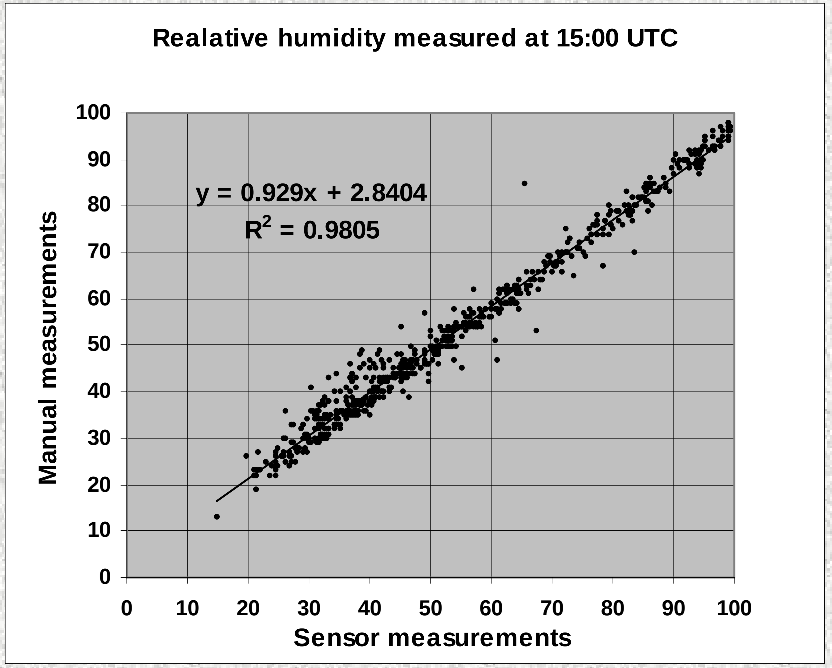
Mean manual	Mean sens	Dif. mean	Dis. Man	Dis. Sens.	Dis. Ratio	T	F
16.20	15.9	0.22	28.7	28.43	1.01	0.68	0.96

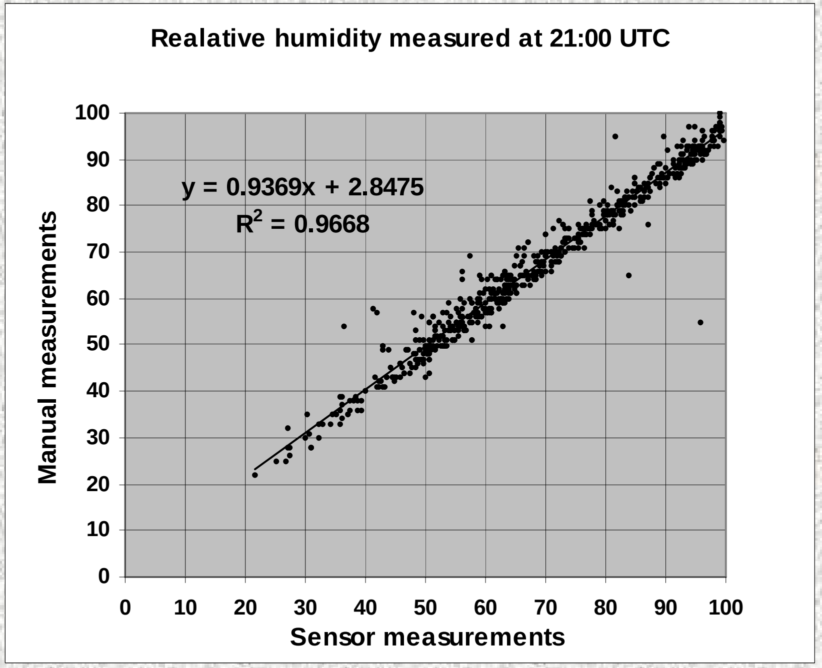
AWS vs. manual data comparison for 3 hours and daily measurements based on T and F tests (relative humidity)





AWS vs. manual data comparison for 3 hours and daily measurements based on T and F tests (relative humidity)

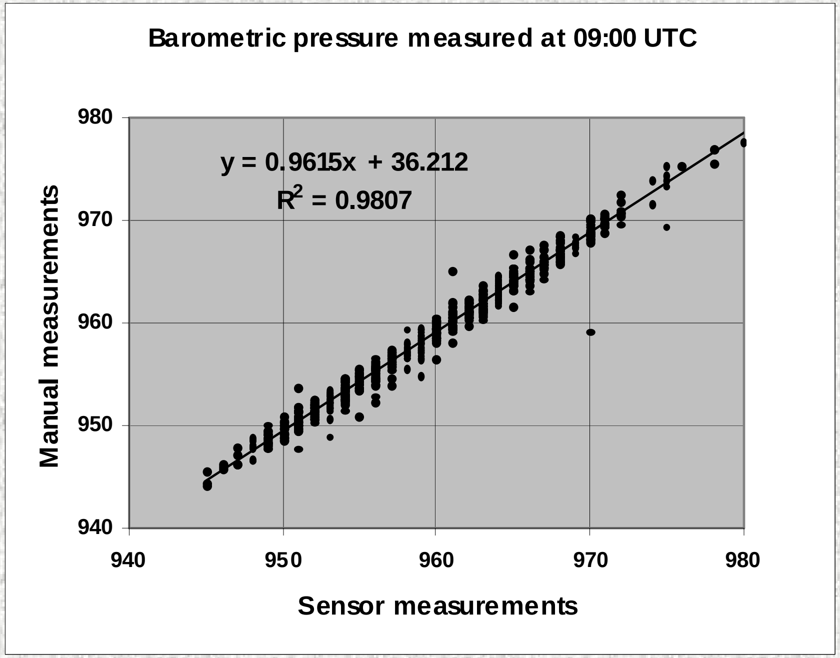


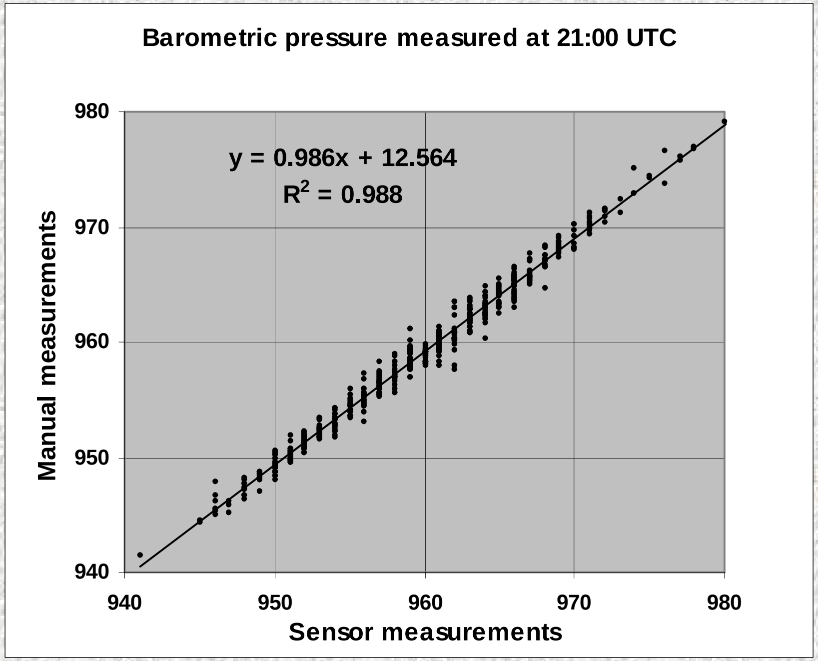


AWS vs manual data comparison for 3 hours and daily measurements based on T and F tests (relative humidity)

Time	Mean manual	Mean sens.	Dif. mean	Disp. Man	Disp. sensor	Disp. Ratio	T	F
3	58.95	59.21	-0.26	411.76	455.58	1.11	0.83	0.21
9	36.94	37.73	-0.79	454.28	493.26	1.09	0.52	0.31
15	53.91	54.98	-1.06	416.52	473.22	1.14	0.37	0.11
21	67.45	68.96	-1.51	307.37	338.55	1.10	0.14	0.23

AWS vs manual data comparison for 3 hours and daily measurements based on T and F tests (Barometric pressure)

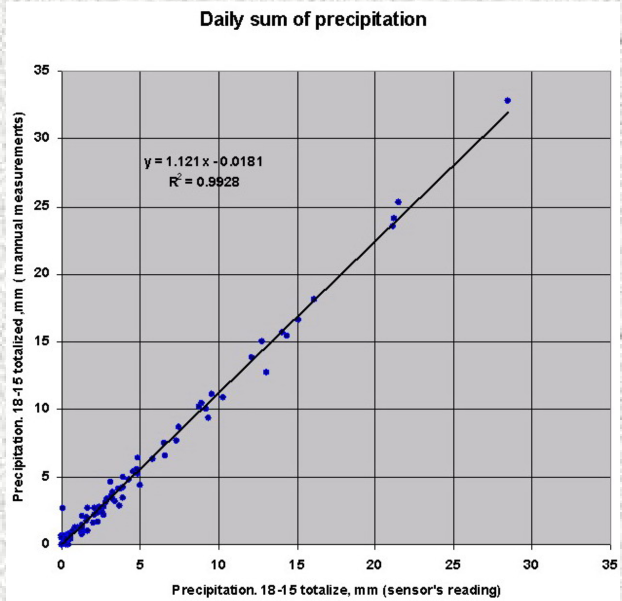




AWS vs manual data comparison for 3 hours and daily measurements based on T and F tests (Barometric pressure)

Time	Mean manual	Mean sens.	Dif. mean	Disp. Man	Disp. sensor	Disp. Ratio	T	F
3	958.86	959.59	-0.73	47.14	47.76	1.01	0.06	0.87
9	958.50	959.23	-0.73	46.01	48.64	1.06	0.06	0.49
15	958.52	959.35	-0.83	50.11	49.98	1.00	0.04	0.97
21	958.37	959.19	-0.82	49.06	49.86	1.02	0.04	0.84

AWS vs manual data comparison for 3 hours and daily measurements based on T and F tests (daily totalized liquid precipitation)



Differences			Ttest	Ftest
Min	Max	Averaged		
0.00	4.30	0.46	0.60	0.17

Conclusions

1. Only daily averaged measurements by sensors look like as confident in terms of statistically proven homogeneity in respect to manual data series
2. Data come from sensors with 3 hours resolution cannot be merged to the manual data series as being a replenishment of that data series without adequate data processing because the risk of heterogeneity
3. Variance sensor data-manual data can be minimized via mitigation the ambient influences