# Comparison between AWS and routine measurements of meteorological elements at Mandalgobi site of AMPEX-Project area

D.OYUNBAATAR[1], Ts.GANBOLD[2], KAIHOTSU Ichirow[3], TSUTOMU Yamanaka[4]

1 Hydrology section, Institute of Meteorology and Hydrology, Khudaldaany str-5, Ulaanbaatar-46, Mongolia
2 Climate section, Institute of Meteorology and Hydrology, Khudaldaany str-5, Ulaanbaatar-46, Mongolia
3 Department of Natural Environmental Sciences, Hiroshima University, 739-0025, Japan
4 Terrestrial Environmental Research Center, University of Tsukuba, Japan

*Key words: Results comparison, Routine and AWS measurements, AMPEX project, Mandalgobi station,*

## Introduction

Collection of adequate and high quality data is primary and very important aspect of many hydrological and climate studies and for such proposes every country or study area establishes own observation network with necessary instrumentation.

Modern development of techniques and technology in the field of hydrology and meteorology, allows to use of automatic instruments with high frequency and accuracy and on the other hand fast changing hydro.meteorological phenomena and application requirements of results of study, requires use of automatic station for observation of different natural phenomena. Another important points of application of automatic weather stations are fast, easy ways of data transmission and exchange, data processing and linkage to other applications etc.

Therefore, equipping of hydro.meteorological network by automatic stations became important issue for any counties and most of developed countries already have established own automatic station network.

In case of Mongolian hydrometeorological, still uses old conventional, manual instrumentation and only in a few sites established some automatic weather stations within certain projects, which designed to solve certain problems for short time period.

It is still necessary to develop more accurate and practical technique to measure many elements of climate in order to improve the quality of data, consequently improve results of research studies.

Under the framework of ADEOS II Mongolian Plateau Experiment for ground truth (AMPEX) an automatic weather station was installed at Mandalgobi site, beside just beside to Mongolian standard meteorological station. Proposes of the project are to provide ground truth data for calibrating and validating algorisms of satellite sensors and to study variability of hydrometeorological components in space and time in the study area.

Aim of this paper is to conduct preliminary comparison of results of AWS measurement with Routine observation of Mandalgobi station and consequently to reveal certain differences of simultaneous measurements, caused by instrumentation differences, observation technology, man-factor etc. For comparison have selected 7 elements (wind speed and direction, air humidity, pressure, air and soil surface temperature and precipitation) for period of one year, 2001.

Comparison is made on different time base with computation of maximum and minimum values, difference magnitudes, and some statistical parameters.

## Background study

The study area in terms of geography is considered moderately hilly, as semi-arid grassland with mean elevation of 1100-1350 m a.s.l.

Climate of the area is typical harsh continental with strong diurnal and seasonal variations. Annual precipitation is 164.9 mm which is about 30 per cent less than county's average. Daily maximum rainfall is 70.7-84.3 mm. 80-90 percent of annual precipitation falls during the warm periods of a year. Long term observation shows that rainfall event occurs only 27-33 times per a year. Due to relatively less relief differences climate of the study area quite uniform. Annual mean air temperature is 1.7°C and maximum and minimum air temperature reach 36-38°C and – 34-36°C, respectively. Annuals mean wind speed varies from 3.1 to 6.1 m/s and maximum wind speeds at Mandalgobi station reach 34.0 m/s (B.Jambaajamts, Kh.Sarantuya.1986).

The Mandalgobi meteo.station has been established in 1944.

Similar analysis on comparison of routine and AWS measurements have conducted in 1998 at

Arvakheer site (Erdenetsetseg.D., D.Oyunbaatar., H.Ohno et al, 1999) within the project of Japan International Research Center for the Agricultural Sciences (JIRCAS) and GEWEX Asian Monsoon Experiment (GAME).

Within the AMPEX project also measures soil moisture by TDR at several depth at all AWS sites and results and analysis of soil moisture measurements have been presented in several papers (T.Yamanaka, I.Kaihotsu, D.Oyunbaatar., Times Space Soil Moisture variation over a Mongolian Grassland., Western Pacific Geophysics Meeting, July, 2002, Wellington, NewZealand and T.Yamanaka, I.Kaihotsu, D.Oyunbaatar., Temperature effect on soil water content by TDR and its correction using in situ data., 2002 ).

## Study area and instrumentation

The Mandalgobi site is located in south-west corner of the area with size of 120 x 160 km (Figure 1) and coordinates of the site is N : 45°44'29.3" E : 106°15'52.7" with altitude of 1393 m.

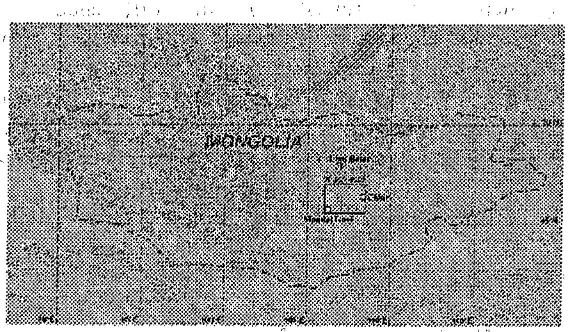



Figure 1. AMPEX project site

Table 1. Instrumentation comparison of stations

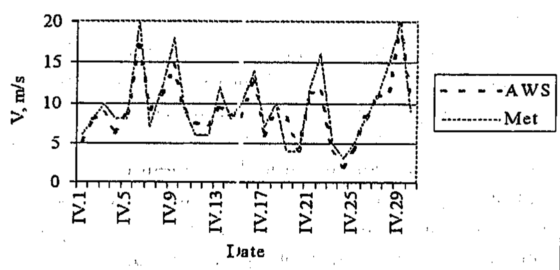
| Meteo. elements | Meteo.station | | AWS-AMPEX | |
|---|---|---|---|---|
| | Sensor type | Install. height, | Sensor type | Install. height |
| Wind speed | Wind vane | 10 m | Propeller anemometer | 3.2 m |
| Air humidity | Hygrometer | 2 m | Ventilated capacitance sensor | 1,6 m |
| Air temperature | Mercury thermometer | 2 m | Ventilated platinum resistance thermometer | 1.6 m |
| Pressure | Mercury barometer | | Barometer | 1.1 m |
| Soil surface temperature | Thermometer | at soil surface | Infrared radiation thermometer | at soil surface |
| Precipitation | Tretyakov type | 2 m | Tipping bucket | 1,5 m |
| Wind direction | Wund vane | 10 m | Wind vane | 3.2 m |

## Results of comparison

Comparison for wind speed, air humidity, air temperature, pressure and soil surface temperature was conducted at standard time of observation, at 8:00, 14:00, 20:00 and 2:00 clock and these selected time may consider as morning, day, evening and night time. Concerning seasons, January, April, July and October months were selected as winter spring, summer and autumn seasons. Comparison analysis for wind speed and precipitation is on daily mean base.

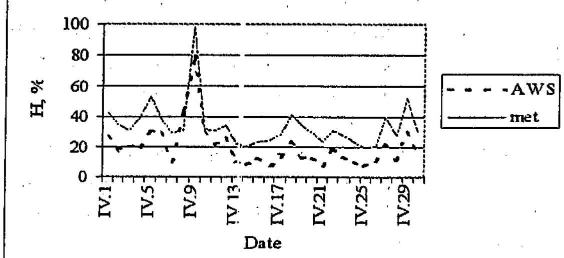
*Wind speed:* Analysis shows that routine measurement higher than AWS results on average by 0.3-0.4 m/s and in some cases maximum difference reach until 4.6 m/s (Figure 2.). Certainly such differences related to installation height and type of sensors of the stations. In case of Mandalgobi standard station, the wind speed sensor installed at 10 m and the wind sensor is simple sheet type with scale of 1.0 m/s. As for AWS, the wind sensor located at 3.2 m.

Figure 2. Wind speed for April at 14:00 at MGS




*Air humidity:* In all cases, the routine measurements always exceed AWS values (Figure 3.) and differences are varying from 9.4 (nighttime) to 15.5 % (daytime).

Figure 3. Air humidity for April at 14:00 at MGS




*Air temperature:* Measurement results are quite close for all selected times (Figure 4). However, in the morning time, at 8:00 clock in wintertime, routine measurements are slightly higher or warmer than AWS, but in July AWS results higher than routine measurements. Temperature differences in both cases are about 0.5 degree. In the afternoon, at 14:00, also AWS results exceed routine measurements by 0.7 degree on average. In October, at nighttime (2:00 clock), routine measurements again slightly higher than AWS. The comparison shows, that there is some differences distinguished by seasons and also day or night periods of a day. Results of routine and AWS measurement at Arvaikheer site show that difference was around 1$^0$ to 1.5$^0$ and because of the difference of the location, of measurement height and of sensor (D.Erdenetsesteg et al,1998).

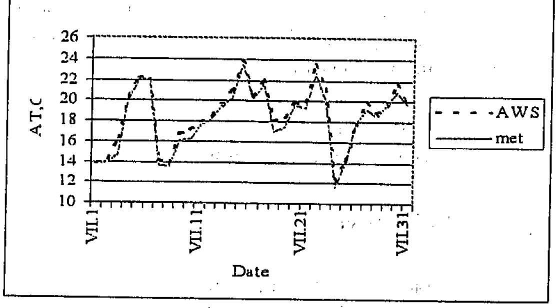


Figure 4. Air temperature for July at 8:00 at MGS

*Air pressure:* In warm periods (July) observe clear difference between two stations. Routine measurements slightly higher than AWS results by 0.7 hPa on average and there are no significant differences by standard time of observation (Figure 5.).

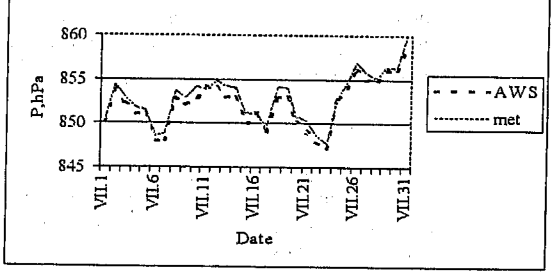


Figure 5. Pressure for July at 14:00 at MGS

*Soil surface temperature:* Due to complicated, different factors, such as instrumentation, environment (air and surface interaction), soil surface temperature differs by season and time.

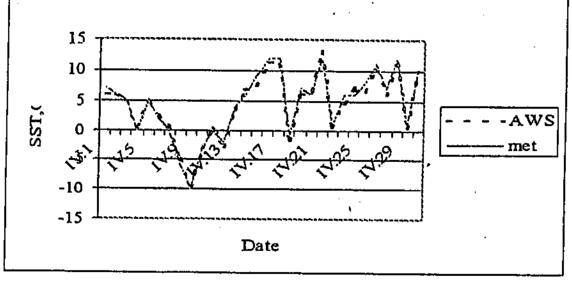


Figure 6. Soil surface temperature for April at 20:00 at MGS

In the morning, in cold periods when temperature is below zero, routine measurements are much lower than AWS (on average by -1,5°C cooler) and for warm periods results are nearly same. In the afternoon (at 14:00 clock), in January month, AWS results are cooler than routine measurements by – 2.2°C and in April and October, when temperature is plus, routine results are higher than AWS data by 5.0°C (Figure 6).

In evening period, in most of seasons, results of the two stations are relatively close to each other, only for winter tine, routine measurements cooler than AWS results. During the nighttime, in January and April, routine measurements are cooler than AWS by –1.0°C, in July results are close and in October, routine measurements are warmer (higher) than AWS results by 1,5°C.

*Precipitation:* Annual sum of precipitation measured at AWS and meteo.station was 137,8 and 146.3 mm, respectively. In general tipping bucket rain gauge tends to fail in measuring precipitation amount particularly for large storm events. The precipitation amount obtained by the AWS's tipping bucket may be somewhat underestimated (Ts.Yamanaka, I.Kaihotsu et al., 2002). Maximum daily total is 27 mm recorded on July by AWS's rain gauge but at same day routine measurement show 32.6 mm rain which indicate above mentioned lack of tipping bucket type rain gauge. Also, AWS's rain gauge could not measure solid precipitation as snow for January, February and December where precipitation sum for the mentioned periods was 5.0 mm at standard meteo.station.

In generally, routine measurement exceeds AWS values (Figure 7).

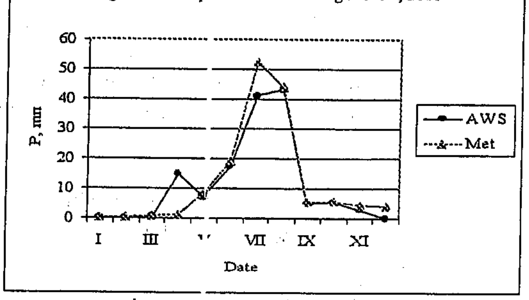


Figure 7. Precipitation at Mandalgobi site, 2001

*Maximum and minimum values analysis:* To catch maximum and minimum values (daily, monthly etc) is important issue for any hydrometeorological observation. As mentioned early, frequency of routine measurement is every 3 hours as standard time observation and in case of AWS, measurement interval is 10-30 minutes. Therefore, which AWS measurement more accurately could catch extreme values. For example, according to AWS measurement, maximum and minimum temperature for 2001 were, 35.3°C (VII.15, 15:30) and –34.7 (I.9, 9:00), respectively (Yamanaka.T, Kaihotsu.I., et al, 2002). But, in case routine measurement, maximum and minimum air temperature were 34.2°C (VII.15, 14:00) and −33.2°C (I.8, 8:00), respectively and difference between extreme values measured by two station is 1.3 degree.

The largest 30-min values of 20.64 m/s of wind speed was recorded at 11:30 on April 6 (Yamanaka.T, Kaihotsu.I., et al, 2002), but routine measurements recorded maximum value of wind speed as 20 m/s , which show limitation and low accuracy of sensor of standard station.

For other elements, maximum and minimum values were compared by standard time of period and is presented in Table 2. Comparison shows that if extreme values select from 8 standard time observation, then not so big difference between two station and only for cases of humidity and soil surface temperature have observed certain differences.

*Daily base analysis:* When values are averaged on daily base then results of two stations are close, except air humidity, where routine measurements exceed AWS values (Figure 8). Routine data averaged as mean of 8 measurement and AWS daily mean is average of whole year measurement.

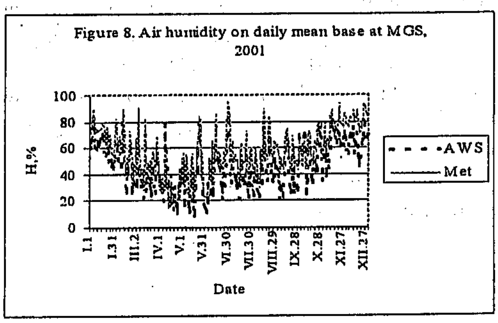



Figure 8. Air humidity on daily mean base at MGS, 2001

*Statistical analysis:* Standard deviations of measurements were calculated and compared by seasons (Table 3).

*Monthly and annual mean comparison.*

## Summary

- There is clear differences due to instrumentation type and installation height
- Certainly exist differences caused by operating environment such harsh and dry climate, day or night time, by season etc
- However, on daily or monthly averaged results of the two stations are quite similar in terms of magnitude and temporal pattern within permissible accuracy of Mongolian standard measurement
- The study needed to continue in more detail to develop certain correction factor between two measurements

### References

Yamanaka,T., I.Kaihotsu., D.Oyunbaatar., Ts.Ganbold., M.Ikeda., T.Takasao., Report on Automatic Weather Station Monitoring Results, Sept,2000-Aug, 2001, Mandalgobi, 2002

Erdenetsetseg D., Oyunbaatar D., Hiroyuki Onho., Yousay Hayashi., Atsushi Maruyama., Some measurement results of meteorological elements at Arvaikheer site, Papers in Meteorology and Hydrology, IMH, Ulaanbaatar, No.21/2, pp.37-45, 1999

Climate of Dundgobi province, Editors: B.Jambaajamts, Kh.Sarantuya, Hydrometeorological Department, Mandalgobi,1986

Table 2. Maximum and minimum values comparison

| | | Wind speed | | Humidity | | Air temperature | | Pressure | | Soil surface temperature | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AWS | Met | AWS | Met | AWS | Met | AWS | Met | AWS | Met |
| | Max | 19,92 | 20,00 | 96,70 | 99,00 | 34,50 | 34,20 | 876,00 | 876,10 | 58,75 | 59,00 |
| | Min | 0,00 | 0,00 | 4,25 | 1,30 | -32,68 | -33,20 | 840,00 | 840,00 | -35,30 | -37,00 |
| | Mean | 5,12 | 5,84 | 49,77 | 60,37 | 2,08 | 2,04 | 857,84 | 857,88 | 3,15 | 3,52 |

Table 3. Standard deviations

| | Wind speed | | Humidity | | Air temperature | | Pressure | | Soil surface tenperature | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AWS | Met | AWS | Met | AWS | Met | AWS | Met | AWS | Met |
| Max | 4,05 | 4,59 | 24,87 | 24,07 | 8,55 | 8,51 | 7,50 | 7,39 | 11,85 | 11,36 |
| Min | 1,84 | 2,43 | 0,87 | 5,85 | 0,75 | 2,50 | 0,71 | 2,29 | 0,10 | 2,26 |
| Mean | 2,67 | 3,36 | 15,47 | 14,43 | 4,85 | 4,96 | 4,57 | 4,60 | 5,50 | 5,92 |