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## Relative outside Humidity - Analysis of Variance

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**Equipments and locations.** Three Vantage Pro2 weather stations were placed and monitors the environmental data (44 observables) at every minute at three different locations and one more is to be settled. The location of the observation points are given in Table 1.

**Table 1: Observation points in Transylvania**

| Place | Weather station | GPS | Elevation | Distance from ground |
|---|---|---|---|---|
| Reghin | st1 | N 46° 46' 12.41" E 24° 41' 27.99" | 390m | 1.5m |
| USAMV-CN | st2 | N 46° 45' 34.00" E 23° 34' 20.53" | 381m | 1.5m |
| UT-CN | st3 | N 46° 47' 45.40" E 23° 37 34.33" | 326m | 20m |

"Vantage Pro2" Integrated Sensor Suites which includes solar, temperature, humidity, wind and rain sensors and the data are recorded into a MySQL database at every minute by using a home-made client-server uploading software - first time reported in (Bălan & others, 2008) for monitoring of direct and total solar radiation system.

**Introduction.** Relative outside humidity is an important parameter which may affect recovering of the solar energy in a ratio to be estimated.
During year periods, humidity varies in wide ranges. By using the data recorded in 2009, 2010 and 2011 on USAMV-CN observation point (the values on the first day of the months, at beginning of the hours), following surface levels were obtained for relative outside humidity:

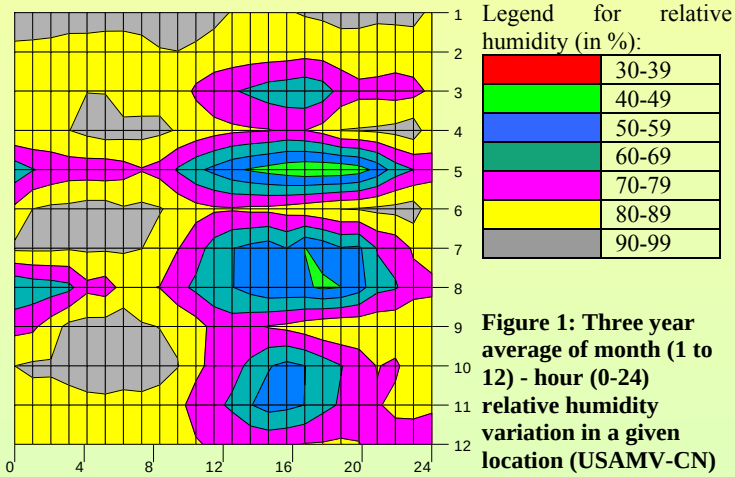


**Figure 1: Three year average of month (1 to 12) - hour (0-24) relative humidity variation in a given location (USAMV-CN)**

The variability of relative humidity during year and during day has a major impact on vegetation growing (Jamiyansharav & others, 2011) as well as on the recover of the solar energy using different modern techniques for adsorbtion and storage of the thermal energy (Dicaire & Tezel, 2011).
The research was aimed to obtain a mathematical model able to estimate and predict the evolution of the humidity in a given location by using relative humidity measurements without involving of other observables.

**Material.** By using the hour to hour data from one monitored location (st2 in Table 1) - a place in court yard of the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, analysis of the relative outside humidity were conducted. Due to several power fails breaking the communication between the weather station and its acquisition system only about 67% of the data were available and were included into the analysis (5872 records out of 8760).

**Method.** The analysis was conducted using StatSoft Statistica (v.8.0). The ARIMA models were found to be statistically significant in agreement with the observations and were further investigated in order to obtain the best agreement. The Statistica software provides various results graphs, forecasts, and tools for assessing the quality fit to the data using ARIMA models. ARIMA(p, d, q)(pS, dS, qS) are a model to fit a continuous variable (the relative humidity in our case):
p: Number of nonseasonal autoregressive parameters;
q: Number of nonseasonal moving average parameters;
pS: Number of seasonal autoregressive parameters;
qS: Number of seasonal moving average parameters;

**Results.** Auto-Regressive Integrated Moving Average analysis revealed that a (2,0,1)(1,0,1) model with one intervention (abrupt & permanent, at case number 96) were able to explain over 98.5% of the total variance (see following table).

**Table 2: The parameters of the best found ARIMA model**

| Transformations: none; Model:(2,0,1)(1,0,1); Seasonal lag: 24; MS Residual= 10.619 | | | | | | |
|---|---|---|---|---|---|---|
| | **Param** | **Asympt. - SE** | **Asympt. - t( 8755)** | **p** | **Lower 95% CI** | **Upper 95% CI** |
| **p(1)** | 1.381508 | 0.040282 | 34.2958 | 0.000000 | 1.302545 | 1.460470 |
| **p(2)** | -0.403192 | 0.039490 | -10.2100 | 0.000000 | -0.480602 | -0.325783 |
| **q(1)** | 0.233182 | 0.042911 | 5.4341 | 0.000000 | 0.149068 | 0.317297 |
| **Ps(1)** | 0.995731 | 0.001438 | 692.5417 | 0.000000 | 0.992913 | 0.998550 |
| **Qs(1)** | 0.910355 | 0.007088 | 128.4290 | 0.000000 | 0.896460 | 0.924250 |

The obtained model is statistically significant and may be used to do forecast. The unexplained variances according to the ARIMA model are given in the next figure:

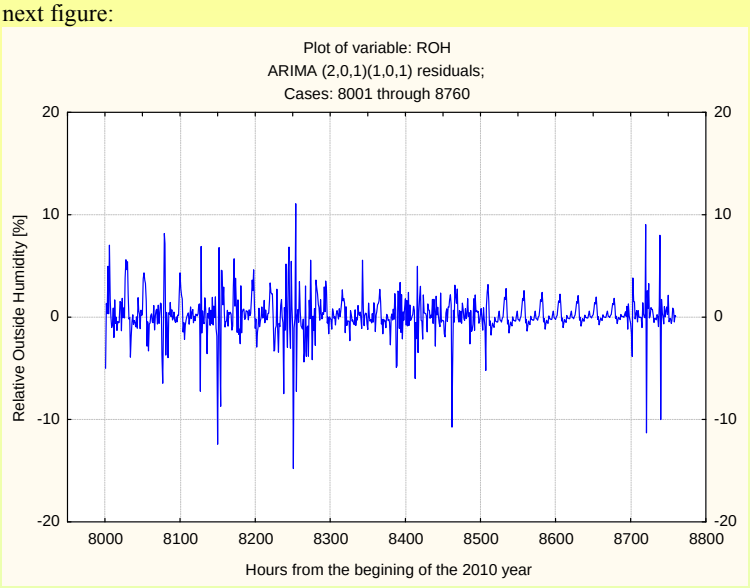


**Figure2: ARIMA model unexplained variance**

Partial autocorrelation analysis (next figure) revealed that the periodicity of the outside relative humidity is more likely near to 23h than 24h.

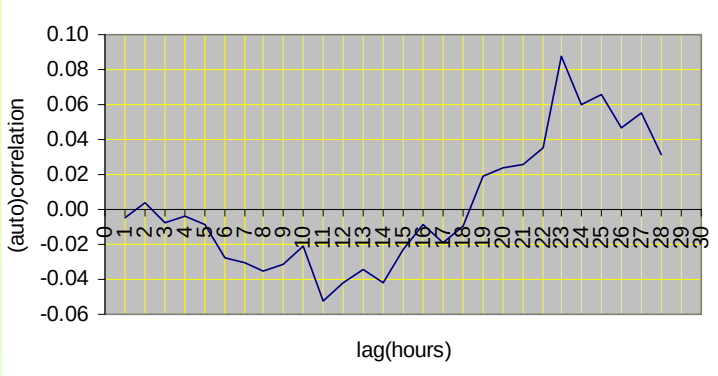


**Figure 3: Periodogram of relative humidity**

Further analysis by including more data points (from 10 to 10 minutes as example) is able to provide a more accurate value of the period.

**Discussion.** Reporting our results with other similar results we can say that we are in a good agreement with the results of (Shiri & others, 2010). Thus, (Shiri & others, 2010) reported a (1,0,1)(1,1,1) ARIMA model when the data from 25 years were averaged monthly and were converted to a stationary series by differencing order 1.

## References

(Bălan & others, 2008): M.C. Bălan, M. Damian, L. Jäntschi, 2008. Preliminary Results on Design and Implementation of a Solar Radiation Monitoring System, Sensors 8(2):963-978.
(Dicaire & Tezel, 2011): D. Dicaire, F.H. Tezel, 2011. Regeneration and efficiency characterization of hybrid adsorbent for thermal energy storage of excess and solar heat. Renewable Energy 36(3):986-992.
(Jamiyansharav & others, 2011): K. Jamiyansharava, D. Ojima, R.A. Pielke, W. Parton, J. Morgan, A. Beltrán-Przekurat, D. LeCain, D. Smith, 2011. Seasonal and interannual variability in surface energy partitioning and vegetation cover with grazing at shortgrass steppe. Journal of Arid Environments 75(4):360-370.
(Shiri & others, 2010): G. Shiri, B. Salahi, R. Samadzadeh, M. Shiri, 2010. The investigation and forecasting of relative humidity variation of pars Abad-E-Moghan, North-West of Iran by ARIMA model. Research Journal of Applied Sciences 5(6):459-465.