MONITORING OF METEO VISIBILITY

Radim Kopp
Doctoral Degree Programme, FEEC BUT
E-mail: xkoppr00@stud.feec.vutbr.cz

Supervised by: Zdeněk Kolka
E-mail: kolka@feec.vutbr.cz

ABSTRACT

Optical wireless connections are used for high speed data transmit over the atmosphere via optical beam. Quality of transmit depends on outside atmospheric conditions. Meteorological visibility is used for the description of the effect of outside environment on the optical beam. Meteorological visibility has to be monitored for several years to define some periodical process. I executed ranking of low meteorological visibility in France, Italy and Germany base on monitoring during the years 2002 and 2006.

1. INTRODUCTION

Optical wireless connections are used for high speed data transmitting for location where is impossible to use another technology. Reasons are character of terrain or expensive implementation. A big disadvantage of this technology is high sensitivity for outside atmospheric conditions. METAR is a format of data reported by meteorolgical stations. Meteorological visibility is part of them. This parameter is used for description of the effects of outside environment on transmitting optical beam. Unit is kilometer or meter. It is possible to conversion this parameter to attenuation in dB/km by using empirical formula. It can determine unavailability of data connection or change parameters of the transmitter and the receiver in next step.

2. PRINCIPE OF DETERMINING AVALIBILITY OF DATA CONECTION [1]

It is important to obtain METAR reporting for calculation of attenuation. METAR is reported by meteorological stations and airports services. Czech hydro-meteorological institute and Direction of air traffic reported METAR in Czech Republic. The University of Wyoming performs monitoring in the whole World. METAR format is on Fig.1. Value of visibility is 9999 here. This means visibility is ok and usually is 9999 the highest reported value. Monitoring range is from 15 to 60 minutes. It is important to obtain the value of visibility for several periodic sections for objective results. Continuance of these periodic sections is several months or year. Empirical formula is used for conversion visibilities to attenuation:

$$\alpha_{1,part} = \frac{17}{V_M\left(\frac{555}{\lambda}\right)^{q}}$$

$\boldsymbol{q}$ =1.6 for $V_M > 50$ km; 1.3 for 6 km < V_M < 50 km; 0.16 V_M + 0.34 for 1 km < V_M < 6 km ; V_M = – 0.5 for 0.5 km < V_M < 1 km; 0 for V_M < 0.5km.

$\alpha_{1,part}$ is attenuation caused by elements of water in atmosphere, V_M is meteorological visibility , λ is optical wave length and q is coefficient dependent on meteorological visibility as it is shown above.

Figure 1: Format of METAR.

Graphical process of visibility conversion to attenuation is shown on Fig.2 It is illustrational of the process of visibility at a German airport. Data was collected during four years with sampling frequency of 30 minutes.

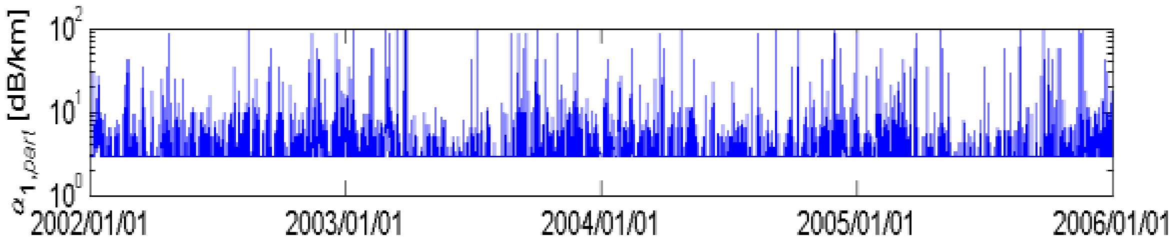


Figure 2: Example of process of attenuation during four years.

By using a cumulative distributive function (CDF) given by following equation:

$$F(x) = 1 - P(X \le x) = 1 - \sum_{x_i \le x} P(X \le x_i) = 1 - \sum_{x_i \le x} p(x_i)$$

it is possible to conversion the picture from Fig. 2 to following picture on Fig.3 It is possible to determine probability of occurrence of a certain attenuation with a specific value.

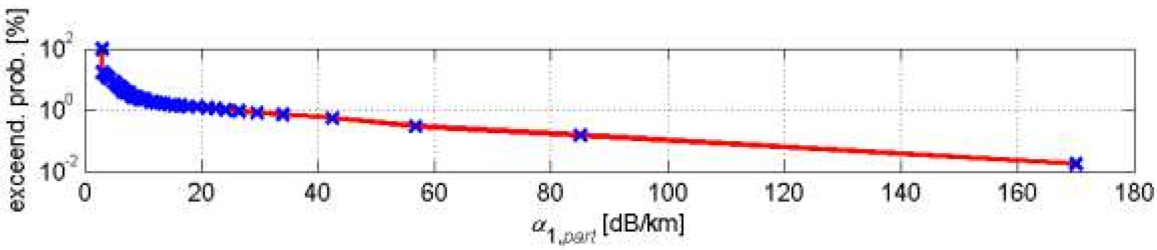
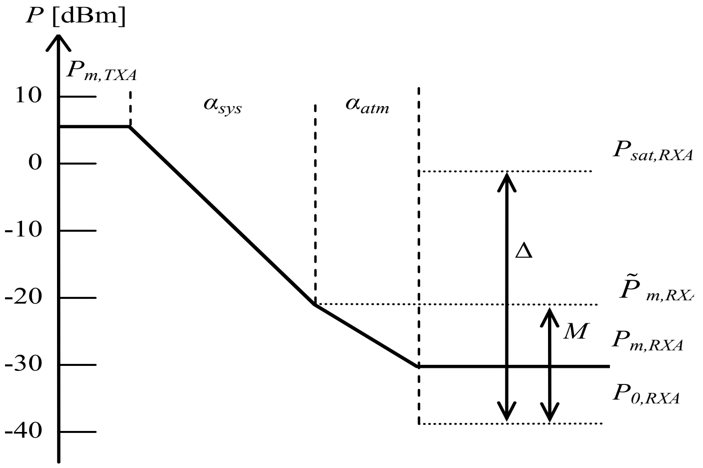


Figure 3: Empirical cumulative exceendence probability of attenuation coefficient $\alpha_{1,atm}$, λ = 850nm.

If we know the values when the real link is unavailable or it is a bad signal, then we can implement values from Fig.3 and compute the probability of these situations. Critical attenuation is dependent on the distance between the transmitter and the receiver and transmits power. Function of potency $\alpha_{1,atm}$ (include in α_{atm}) is shown on power diagram Fig. 4

it illustrates transmitting of optical beam between a transmitter and a receiver. These transmit can be described by following simplified equation:

$$P_{m,RXA} = P_{m,TXA} - \alpha_{sys} - \alpha_{atm}$$



$\boldsymbol{P_{m,RXA}}$...mean optical power on the receiving aperture

$P_{m,TXA}$...mean optical power on the transmitting aperture

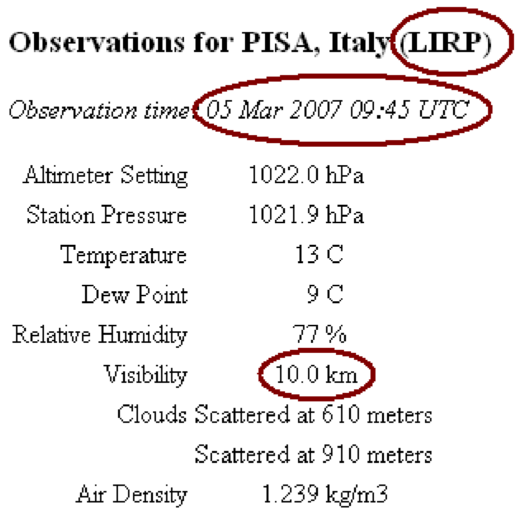
α_{sys}...system attenuation

α_{atm}...random atmospheric attenuation

Figure 4: Power level diagram between Tx and Rx systems

3. PROGRAM FOR MONITORING VISIBILITY IN EUROPE [2]

The values of visibility depend on the weather character which is specificity for a location of monitoring place. It is important to observe process in different climatic locations as in the mountains, on coasts, in the highlands etc. We need work with visibilities from whole the Europe because Czech Republic is midland country. These values are monitored by University of Wyoming. They are monitoring couple of different parameters. The best data format for me is shown on Fig.5. Important values were marked. Monitored locations are on Fig. 6.



Observations for PISA, Italy (LIRP)

Observation time: 05 Mar 2007 09:45 UTC

Altimeter Setting	1022.0 hPa
Station Pressure	1021.9 hPa
Temperature	13 C
Dew Point	9 C
Relative Humidity	77 %
Visibility	10.0 km
Clouds	Scattered at 610 meters
	Scattered at 910 meters
Air Density	1.239 kg/m3

Figure 5: Format of downloaded data.

Figure 6: Monitoring location in Europe.

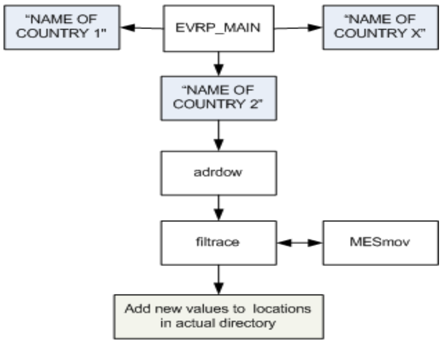


Figure 7: Developing diagram.

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2007 01 02 10 00 7.0
2007 01 02 11 00 10.0
2007 01 02 12 00 10.0
2007 01 02 13 00 10.0
2007 01 02 14 00 10.0
2007 01 02 15 00 6.0
2007 01 03 08 00 10.0
2007 01 03 09 00 10.0
2007 01 03 10 00 10.0
```

Figure 8: Example of format saving values.

Program is realized in Linux environment. Developing diagram is on Fig.7. For executing the main script EVRP_MAIN in periodical intervals is used Cron. This script makes testing of the connection of the main server from University of Wyoming. If the results are true action is given to adrdow script. This script exists for every country. Adrdow downloads html code and tests validity of dates. Validated data are processed by a script called "filtrace". This script does the main work in process html code. It takes out information about the name of the locality, date of creation and executes script MESmov. This script compares actual month in file with a lot a month in last saved dates. Data from last month are moved to archive with the name of month if the result was different and give process back to filtrace script. This script tested actuality of new data against last saved data. If the new data is different program saves them in following format: year, month, day, hour, minute, visibility in kilometers. Example is on Fig.8. These actions are made for all countries and localities listed in EVR_MAIN script.

Fig.7: Developing diagram Fig. 8: Example of format saving values

4. SUMMARY OF RESULTS FROM DIFERENT CLIMATIC LOCATIONS

For analyzing the typical process of visibility in different climatic environments was used data from France, Italy and Germany locations. These data are from University of Wyoming archive. These data was processed in Matlab program environment. I made analyzing decomposition of the data. It is important to use the data with homogeny decomposition for relevant interpret of the results. Example of processed data is on Fig. 9.

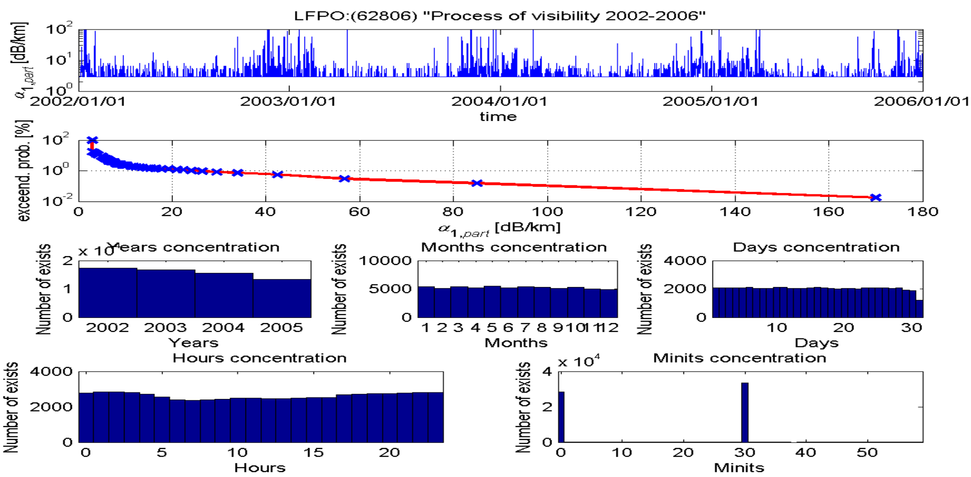

Figure 9: Example of processed data.

I made analysis of high values of attenuation $\alpha_{1,atm}$ > 40 dB/km. This value is a knee of measure values with the highest occurrence of $\alpha_{1,atm}$. If we know percent occurrence $\alpha_{1,atm}$ under this value we will make a decision how important these values are for dynamic setting transmitter and receiver. I made this analysis on samples in different climatic locations. Results are in the table shown below on Fig. 10.

Fig. 9: Example of processed data

FRANCE					
ID locatio	Name of location	α_{1part} > 40 dB/km [%]	Hours [h]	Type of locatio	Altitude [m]
LFTH	Hyeres / Le Palyvestr	0,0539	4,72	coast	3
LFPO	Paris / Le Bourge	0,7197	63,04	midland	66
LFCR	Rodez /Marcillac	1,3272	116,25	highland	643
ITALY					
ID locatio	Name of location	α_{1part} > 40 dB/km [%]	Hours [h]	Type of locatio	Altitude [m]
LIPQ	Ronchi	1,003	87,89	coast	12
LIPE	Bologna	2,26	197,97	midland	208
LIBQ	Monte Scuro	31,667	2774,1	mountain	1710
GERMANY					
ID locatio	Name of location	α_{1part} > 40 dB/km [%]	Hours [h]	Type of locatio	Altitude [m]
EDDH	Hamburg / Fuhlsbuttel	0,5329	46,67	coast	16
EDVK	Kasseln / Calden	0,4746	41,57	midland	277
ETSA	Landsberg	2,837	248,51	highland	623

Figure 10: Occurrence of high attenuation in different climatic locations.

5. COCLUSION

I preferred results with homogeny scatter of samples and the highest number of samples too. The time of observation was four years. Values from the same climatic locations are similar to another location. I gained the best results in Italy. There were values from the coast, midland and the mountains. There were very different percent results of high attenuation. The highest monitoring location in Germany and France are situated in altitude over 600 meters. We can see differences between midland and coast. High attenuation was over 0,001 % for all locations. Invert value is 99,999 %. This value indicates high availability of telecommunicate connection. This availability isn’t guaranteed for all locations. It is important to determine priority of individual optical data link and make a decision based on this priority for calibration of communication equipment

LITERATURA

[1] Solartec, s.r.o., Technická dokumentace k Fotovoltaickému systému FVS 2001 E 1,2kWp

[2] Solartec, s.r.o., Návod k obsluze a údržbě Fotovoltaického systému FVS 2001 E 1,2kWp

[3] Solartec, s.r.o., Uživatelská příručka Fotovoltaického systému FVS 2001 E 1,2kWp

[4] Solartec, s.r.o., Dokumentace stavební