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THE UTILIZING OF RADIO TELEMERTY SYSTEM IN FOREST METEOROLOGY

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ABSTRACT

This paper describes an application of radio telemetry system in forest meteorology in southern part of Poland. The advanced remote sensing technology was an impulse for developing spatial studies of forest ecology and forest climatology. Coordinated of field measurement program with standardized collection methods and data formats are necessary to the meteorological forestry protection system functioning. Precision and long-term measurements of meteorological parameters at various temporal and spatial scales determine better understanding of forest ecosystem processes as well as documenting environmental changes.

1. INTRODUCTION

The rise of interest in forest meteorology and climatology in Europe has been caused by the return to principles of natural forming and optimal forest ecosystems. The role of ecological and biological research has mainly resulted from the change, essentially as for as reaction of environment to new dynamic directions its development is concerned. These researches have contributed to evolution of regional program of meteorological monitoring on areas influenced by interaction of industrial emission, degraded terrain, as well as seedling crop, forest nursery and gene bank ecosystems (Durło, 2004).

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Distinct incrementation of interest in meteorological and climatological conditions in Poland state forests has contributed to the revival of phytoclimatic research, mainly in expeditionary range; with utilization of modern methods, measuring systems and automatic equipment. The forest climatology abilities have increased as a result of progress in geoinformation technique such as stockpiling, processing and rendering data. Further evolution of forest meteorology and climatology research presents a base for forecasting activity in changes of habitable condition and stable forest ecosystems. The results of meteorological measurements on forest stations are an essential database for elaboration of meteorological forestry protection strategy (Durło et al., 2005).

2. GENERAL BACKGROUND

The current needs of complex meteorological protection of forestry demands a modern measurement and communication systems. Especial great claim concerns technical and information means, allowing on analysis of weather condition with large territory and time accuracy (Stafford et al., 1986; Mayer and Hubbard, 1992; RTAM, 1999; El Garouani et al., 2000; Bjarne Bro et al., 2003; Rożdżyński, 2004). However, it requires perfecting of observational system measuring continuous, ameliorating of method of data analysis and efficient system of data transmission also. The reorganization of national forest meteorological network (FMN) in Poland has been started from 1996. First step of this reorganization concerned complete exchange of meteorological devices and equipment, next, was coordination of field measurement program with standardized collection method, quality assurance procedures, and data archival formats.

The Polish Meteorological Forestry Protection System (SMOL) based on 15 regional telemetry networks. Besides, about 20 local networks are situated all over the country. The local telemetry networks provide data from terrain with natural calamity risk, strategic forest stand, likewise on terrain with native seedling crops and protect forest complex.

One of them are forests of Beskid Sadecki Mountains. This terrain is located in southern part of Poland, the south-west of Malopolska Province, between the big valleys of Poprad River and Kamienica River lying in the Radziejowa and Jaworzyna Krynicka ranges (φ = 49º21' N λ = 20º45' E, and φ = 49º27' N λ = 20º58' E). The area is situated in the VIII Carpathian Natural Forest Region, V Beskid Sadecki and Gorce Subregion (Trampler et al., 1990) (Figure 1).

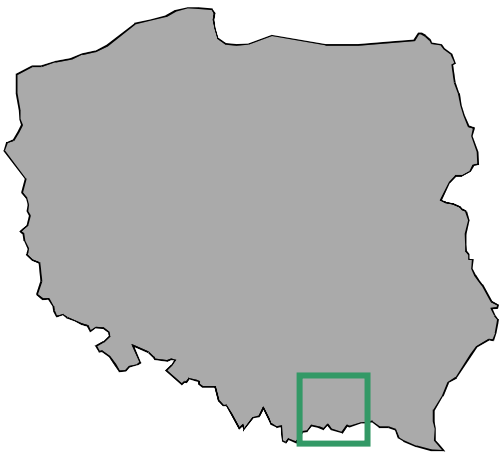

Figure 1. Study area, Beskid Sądecki Mts., Poland

Much of the Beskid Sadecki forests occupy rugged terrain, with steep mountains, deep valleys, narrow canyons and mountain ridges. Elevation ranged form 350.0 to 1114.0 m a.s.l.

2.1 SYSTEM FEATURE

The local radio telemetry network in Beskid Sądecki Mountains includes nine wireless DAVIS Vantage Pro meteorological stations. One station is located in upper part of Kamienica Valley, next one in Black Stream Valley, two stations are located in Poprad River Valley, next one on Kopciowa mountain ridge and last four stations are located in upper part of Jaworzyna Krynicka Massif and Pusta Wielka Massif. Generally, five stations are located in forest stand, the others in open area (Figure 2, Table 1).

In 2002 a radio telemetry system was installed and connected to the Forest Climatic Center in Krynica City. The Vantage Pro wireless weather station includes two components: the integrated sensor suite (ISS) which manages the external sensors array, and the Weather Envoy which can collect and store data from wireless sensors. The integrated sensor suite, and envoy communicate via an FCC certified, license-free frequency hopping transmitter and receiver. The frequency hopping spread spectrum technology provides greater communication strength over longer distance and troublesome mountain areas. Both the wireless ISS and all sensors are solar powered with battery backup. Due to big disparity of local topographical condition, the repeaters were indispensable. Each repeater have got a two antennas, one to receive data, ant another to retransmit it. The longest distance from radio to radio in this network is 30 km (Figure 3).

Efficient and without break-down work of meteorological network demands permanent control, particular in winter season. During the winter months repeaters operation can be disturbed by icing events and very low air temperature. Therefore, each datalogger and repeater on the Beskid Sadecki Forest Network is powered by combination of 30 Watt solar panel and 60Ah storage battery.

2.2 DATA COLLECTION

Meteorological data are commonly collected at 15 minutes intervals. The basic data collection includes air temperature, air and litter relative humidity, precipitation, solar radiation, wind speed and wind directions. These data are averaged or accumulated hourly, daily and monthly. All reports are stored in Forest Climatic Center local server in Krynica City. All documentation and metadata, regarding the meteorological measurement system, is stored and maintained by the FCC. Based on this meteorological data seven parameters are calculated and stored such as degree-days, pluvial-thermal index, potential evaporation index, water balance index, De Martonne's index, sprinkling irrigation index and biometeorological index (Feliksik and Durło, 2004). The end user has got a full access to these data every day. If special code of access owns, daily, weekly and monthly report can collect. The end user must be communicated with internet connections. The standard report is created by WeatherLink® for Vantage Pro™, Windows software, based on NOAA NCDC and GLOBE format. The report contains current conditions at a glance on the instant weather bulletin, graph data on a daily, weekly, or yearly basis and a view multiple weather variables to see their relationships at the same time.

2.3 IMPLEMENTATION

The fundamental purpose of stockpiling information about meteorological condition is composing short term prognoses and forecasting.

Base on air and litter humidity hourly data report is done in fire hazard. Each report is distributed to every forestry headquarters on monitoring terrain, forest guards and fire brigade every day. The wind speed and wind direction hourly database is basis for composing report about windblow and windfall hazard. Each report is sent to forest guards and road service units. Base on rainfall daily data report is prepared in flood hazard and fluvial erosion risk. The report is distributes to the same units and organizations as aforecited and to the department of the local administration. Base on hourly air minimum temperature data, report is done in frost hazard. The several-hours prognoses executed mainly in spring and autumn months and reports are distributed to forestry headquarters and forest nursery supervisors particularly.

Electronic mail and fax is main channel of information transmission. Weather Link software can export weather data into two GLOBE e-mail data entry formats: Davis Air Data Format (DAVAD), conforms to the atmosphere protocol for the Davis weather station and Davis Soil Data Format (DAVSD), conforms to the soil protocol for the Davis soil moisture and temperature station. In Forest Climatic Center in Krynica a DAVAD format is used most often.

The daily, monthly and yearly reports are exported as a text files to computer library (Table 2). The database is used in climatic models and cartographic elaboration. Exchange of data proceeds through Geographical Information System application. The forest meteorological database provides different thematic layers. Especially, geoinformation methods allow the detailed analysis of spatial patterns of various atmospheric parameters, providing an in depth look into the regularities and variability of weather over time and space (Daly et al., 1994).

The FCC database is sent to Department of Forest Protection and Forest Climatology Agricultural Univeristy in Cracow every month. Then, the climatic data is used in several climate models. Two kinds of models are executable in practice frequently. At first, prognostic models are composed with short-term scenarios; secondly, the regional climate models are used for simulation of long periods of time.

Using these elaborations, the foresters can identify the hazardous areas and decide to install and utilizing protection systems. Real time of meteorological data is a valuable resource for foresters to make critical decisions based upon extremely weather conditions.

On the basis of meteorological data from 2002-2005 a map of spatial disparity of spring frost risk potential was presented. The map is composed base on minimum air temperature (5 cm above ground level) data from nine DAVIS stations and 12 DAVIS temperature-humidity sensors. Localization of measuring sensors included all terrain forms and environmental types such as coniferous and mixed forest stands, meadows, plough lands, forest nests, greenwoods, brushwood, and forest nurseries.

The greatest contrasts in minimum temperature were clearly observed between the top of hills and valley bottoms situated in parallel direction. The highest probability of ground frost is in closed valleys and lower parts of gentle slopes. The lowest probability of ground frost is in upper parts of steep slopes (Figure 4, Table 3).

The highest probability of ground frost in forest stands was observed in middle age pine (larch-pine) forest located in lower parts of south gentle slope as well as riparian forest located in valley bottoms, forest nests and forest glades located in plateau and mountain ridges, greenwoods located in lower parts of gentle slopes irrespectively aspects and riverine bush.

3. CONCLUSIONS

Real time of meteorological data is a valuable resource for foresters to make important decisions based upon weather events. The operation proficiently meteorological network measuring is base of forestry protection system efficiency. Coordinated operation of local and regional telemetry network allows conducting of analysis at one's time and spatial scale. Standard data formats, quality assurance procedures, good method of documentation are absolutely necessary for effective operations of electronic data and their usefulness for a long time. The value of remote telemetry measuring system grows in context of more frequent appearing of extreme phenomena and climate changes forecast.

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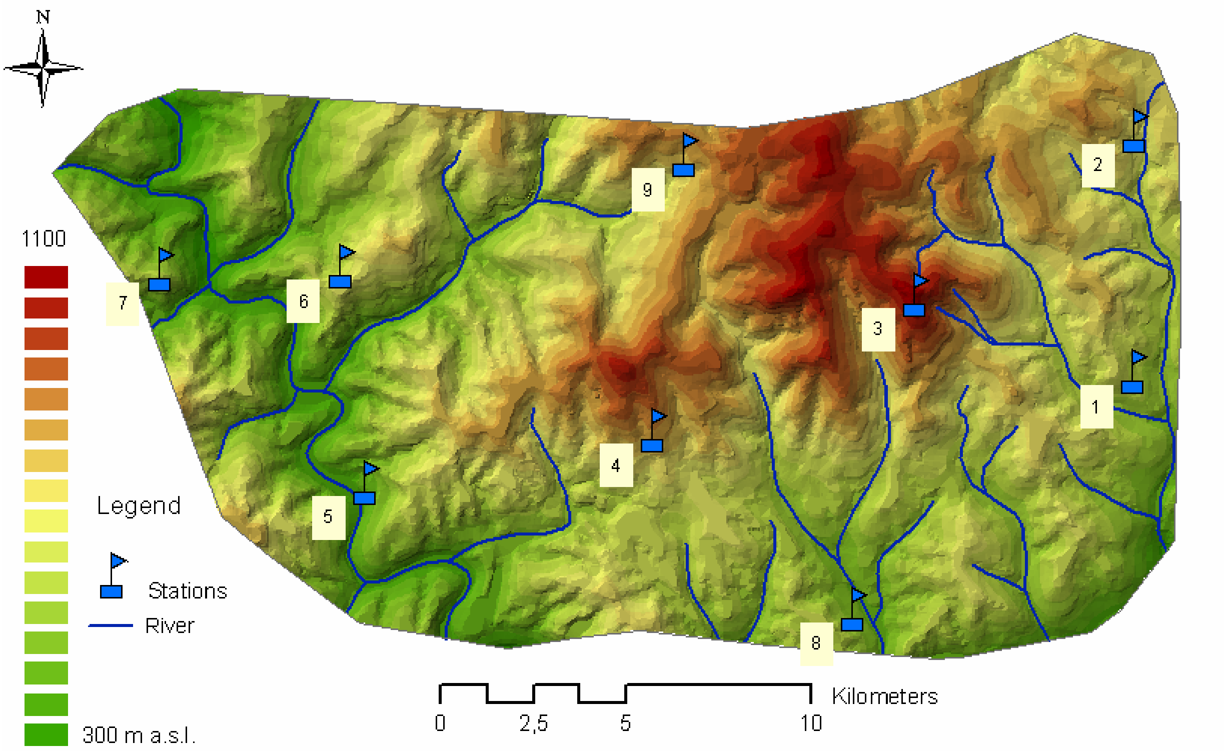

Figure 2. Map of Beskid Sądecki Mountains showing the local SMOL telemetry network

Code	Altitude m a.s.l.	Geographical coordinates	Topographic situation	Localization
01	580	49°22' N 20°58' E	Middle part of south-west gentle slope	Skirt of mixed forest
02	715	49°27' N 20°57' E	Mountain ridge	Big forest nest
03	1114	49°25' N 20°54' E	Summit	Ruderal grass
04	850	49°22' N 20°49' E	Upper part of north-east steep slope	Mixed forest stand
05	390	49°23' N 20°45' E	Open valley-bottom	Meadow, grass
06	635	49°27' N 20°47' E	Lower part of north-west gentle slope	Meadow, pasture land
07	960	49°26' N 20°40' E	Upper part of south steep slope	Coniferous forest stand
08	365	49°22' N 20°54' E	Open valley-bottom	Dry-ground forest
09	880	49°23' N 20°45' E	Upper part of south-west steep slope	Mixed forest stand

Table 1. Localization of remote weather stations, (Beskid Sądecki Mts.)

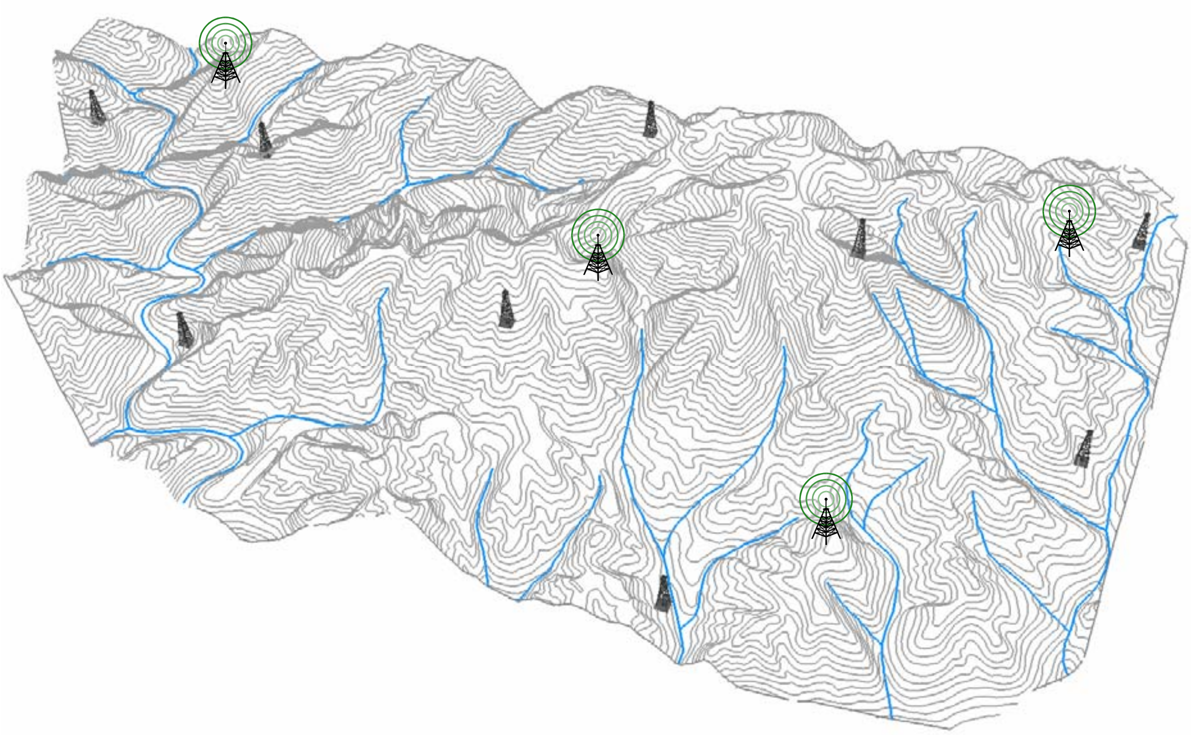

Figure 3. 3D map of Beskid Sądecki Mountains showing the base stations and repeaters positions

Day	Mean air temp	Max air temp	Min air temp	Min* air temp	Mean air hum	Mean litter hum	Rain	Avg wind speed	Avg wind direct	Sum solar rad
1	15,1	18,4	7,4	6,5	68	82	2,3	5,2	275	9.7
2	17,4	14,6	10,4	8,7	91	96	14,5	4,2	225	8.9
3	17,7	20,2	10,3	8,9	66	92	0,0	1,8	186	14.5
4	16,2	21,5	8,9	7,5	53	81	0,0	2,0	167	23.6
5	14,7	21,0	10,1	9,1	81	92	1,4	2,9	172	15.4
6	13,6	16,0	9,5	8,2	92	96	19,5	3,6	023	8.4
7	14,0	17,5	7,6	5,3	88	94	1,0	2,3	290	11.3
8	16,1	20,8	10,4	8,4	70	91	0,0	6,7	185	22.6
9	14,8	18,1	11,5	10,1	82	88	8,6	2,8	170	11.1
10	15,3	18,6	12,0	10,4	87	92	0,0	3,6	187	21.4
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30	28,1	23,2	17,6	15,9	78	64	0,0	4,2	123	26.5
31	23,3	18,8	18,0	16,6	65	59	0,0	3,8	168	22.7

Temp - ^{o}C; Hum - %; Rain - mm·m^{-2}; Wind speed - m·s^{-1}; Wind direction - ^{o};
Solar radiation - MJ·m^{-2}; * 5 cm a.g.l.

Table 2 Monthly Forest Climatic Center (FCC) report for July 2005, (Jaworzyna Forestry)

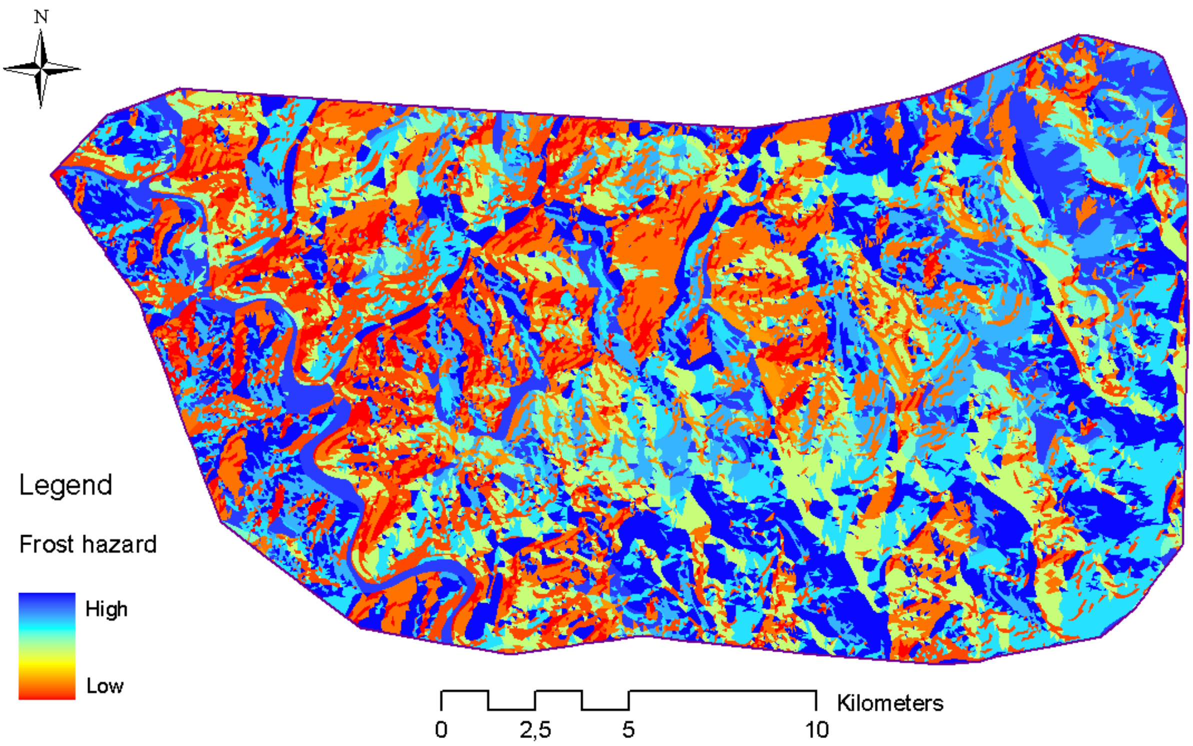

Figure 4. Map of the spring frost hazard in Beskid Sądecki Mts.

Landform	Deviation of air temperature °C			Probability
	Spring	Summer	Autumn	of ground frost %
Plateau, hilltop	0,0	0,0	0,0	45,0
Summie	5,2	3,2	4,1	15,0
Upper parts of north steep slopes	1,5	1,4	1,6	10,0
Upper parts of south steep slopes	3,5	3,1	3,8	10,0
Upper parts of west steep slopes	2,7	2,5	3,2	10,0
Upper parts of east steep slopes	3,1	2,7	2,9	10,0
Upper parts of north gentle slopes	1,5	1,0	1,2	15,0
Upper parts of south gentle slopes	2,1	1,8	2,0	20,0
Upper parts of west gentle slopes	1,5	1,3	1,5	20,0
Upper parts of east gentle slopes	1,7	1,5	1,5	20,0
Middle parts of north steep slopes	0,3	1,3	0,2	20,0
Middle parts of south steep slopes	3,1	2,6	3,0	25,0
Middle parts of west steep slopes	1,0	2,2	0,9	20,0
Middle parts of east steep slopes	0,6	2,5	0,5	15,0
Middle parts of north gentle slopes	0,3	0,2	0,3	55,0
Middle parts of south gentle slopes	0,5	0,6	0,5	60,0
Middle parts of west gentle slopes	0,8	0,5	0,6	50,0
Middle parts of east gentle slopes	0,5	0,3	0,5	50,0
Lower parts of north steep slopes	-1,0	-0,5	-0,8	15,0
Lower parts of south steep slopes	-3,2	-1,6	-2,9	20,0
Lower parts of west steep slopes	-1,8	-1,1	-1,6	20,0
Lower parts of east steep slopes	-1,7	-1,0	-1,5	15,0
Lower parts of north gentle slopes	-2,1	-0,8	-1,8	60,0
Lower parts of south gentle slopes	-5,3	-2,6	-4,1	75,0
Lower parts of west gentle slopes	-4,0	-2,1	-3,0	70,0
Lower parts of east gentle slopes	-3,0	-1,8	-2,7	70,0
Closed valley-bottom	-6,2	-4,3	-5,1	95,0
Open valley-bottom	-4,1	-3,0	-3,7	85,0

Table 3. The deviation of air minimum temperature in different landform in proportion to flat ground, (Beskid Sądecki Mts.)