On thunderstorm quantification (continuation)

Jan Parfiniewicz, Jerzy Konarski

Institute of Meteorology and Water Management 61 Podlesna str., PL-01- 673 Warsaw, Poland

1 Introduction

To estimate intensity and create a scale for Extreme Convective Phenomenon (ECP) we are analyzing lightning discharge density field obtained from PERUN lighting detection and location system. PERUN is a polish national weather service's lightning system that provides total lightning information (that is for both cloud (IC) and cloud-to-ground (CG) discharges) over territory of Poland [Parfiniewicz, 2013].

In 2012 a transformation from lightning density field to Virtual Fujita Scale [F] was defined. The transformation was based on correlation between severe weather events reports form SKYWARN POLSKA database and IC and CG data from PERUN SCM total lightning central processor. Two statistical F formulas as a function of lighting densities were invented.

2 Some Formulas and Case Study

The best formula for strong ECP events with number of lightning $[NoL] \geq 1$ under condition that there is at least one CG return stroke and number of cloud signals are more than 70 reads:

1

$$[F_a] = a \times (b \times ICs + c \times ICs)^{1/2} + d$$

where: $a = 0.047$, $b = 0.7$, $c = 0.3$, $d = 0.22$
and IC_s, IC_i are measured in $[NoL/\pi \times 15km^2 \cdot 10min.]$

For less severe events with $0 < [F] \leq 2.5$ another formula that includes CG data (Rs>0) is used:

2

$$[F_b] = a \times (b \times ICs + c \times Rs + d \times (ICs \times Rs)^{1/2})^{1/2}$$

where: $a = 0.088$, $b = 0.624$, $c = 0.112$, $d = 0.264$

Basing on F_a, F_b and taking into account above mentioned restrictions a resulting convective strength F0 is obtained.

In (1,2) IC_s is the first cloud signal registered by PERUN system as starting source emission point. IC_i is a burst of intermediate emission points picturing in two dimension the whole IC event. IC_e is the last emission point signal in given IC event.

The formulae (1,2) indicate that essential data discrimination categories are: IC intermediate data (IC_i), IC starting point data (IC_s) and CG return strokes (RS). Basing on formula studies we can say that IC data seems to play extremely important role in severe weather recognition and development.

The formulae were used to create a nowcast prediction module. It was tested in real time by weather forecasters. There were no heavy thunderstorm or tornado that were missed by transformation formulas (1,2). Overall estimated prediction in 1h forecasts of ECP remains on 90% level.

In 2012 PERUN system was upgraded to newest Vasiala TLP central processor (Vaisala) operating additionally with SCM which remained still operating. As a result two different total lightning datasets were produced by SCM and TLP central processors using the same SAFIR3000‘s sensor network. From that time 4 new TLS200 locations were added to the network, and 4 SAFIR3000 sensors were changed into TLS200.

We learned that using TLP total lightning data in formulas (1,2) gives different results than SCM data. Despite the fact that CG strokes for TLP and SCM were correlated quite well (about 85%) the most important cloud signals remained practically uncorrelated.

Maximum number of lightning in $[NoL/\pi \times 15km^2 \centerdot 10min.]$ **TLP vs. SCM**								
Is	IC_s	IC_i	IC_e	R_s	S_s	F_a	F_b	F_0
12750.00	6695.00	8513.00	6801.00	1416.00	0.00	3.98	5.99	5.00
1137.00	1314.00	3936.00	1204.00	612.00	295.00	2.16	2.51	2.40
Mean number of lightning in $[NoL/\pi \times 15km^2 \centerdot 10min.]$ **TLP vs. SCM**								
60.64	49.09	30.96	47.82	10.89	0.00	0.44	0.37	0.25
8.28	6.99	13.92	6.97	3.81	1.39	0.29	0.10	0.07
Standard deviation number of lightning in $[NoL/\pi \times 15km^2 \centerdot 10min.]$ **TLP vs. SCM**								
191.29	158.87	127.28	157.86	42.75	0.00	0.22	0.36	0.38
24.70	24.53	60.47	24.36	14.57	7.82	0.12	0.17	0.15
Correlation of individual category from Is to F_0 **TLP and SCM with** F_0**/SCM.**								
0.41	0.38	0.21	0.38	0.43	0.00	0.42	0.49	0.52
0.62	0.70	0.46	0.67	0.50	0.33	0.74	0.87	1.00
Correlation of individual category Is to F_0 **TLP vs.SCM**								
0.42	0.28	0.15	0.30	0.85	0.00	0.36	0.47	0.52

Statistics for comparison of SCM and TLP datasets in categories of IC and CG and formulas – (F_a, F_b, F_0) is expressed by maxima, average, standard deviation, and correlations of relevant lightning discharge discrimination categories with result scale factor F_0, and correlations SCM/TLP for each of IS, $IC_s, IC_i, IC_e, R_s, S_s, F_a, F_b, F_0$,

where:

- Is – Isolated emission points,
- IC_s – Intracloud start points,
- IC_i – cloud intermediate source locations,
- IC_e – cloud end points
- R_s – return strokes,
- S_s – subsequent strokes
- F_a – filter No 1. based on IC_s & IC_i, responsible for extreme tornado events,
- F_b – filter No 2. based mainly on R_s, when responsible for strong convective events with the prospect of weakening,
- F_0 – resulting convective strength.

Statistics were performed for period from 2014.07.29 to 2015.08.10, with total number 5485 studied 10 minutes episodes. Each episode is a density field for a domain over whole Poland (net 113 x 101 with 7 km grid). In total from which 231173 cases (grid points) were selected.

4 Resume

The most probable reason of low correlation of IC events between two systems is lack of sophisticated TLP data calibration (*Lightning Network Performance Evaluation Program-NPEP*) after the network upgrade. End of lightning season caused that the NPEP was not possible. Moreover four Safir 3000 sensors were changed into TLS200 sensors resulting in lowering density of Safir network.

We are planning to repeat the described comparison with recalculated TLP dataset when NPEP is performed at the beginning of 2016 lightning season. Transition from SCM to TLP data for formulae (1,2) is possible because of fact, that TLS200 and Safir3000 sensors are using basically the same signal filtering for IC.

References

[1] Vaisala, 2003+: SAFIR 3000–3, User Manual, DS Settings and Control Manual, Release 2.3, Helsinki, Finland, **July 2003**.

[2] http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/TLS200.aspx

[3] http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/tlp.aspx

[4] Parfiniewicz J., 2012: Concerning Thunderstorm Potential prediction. The European Meteorological Society Annual Meeting and 9^{th} European Conference on Applied Climatology, *d*, Poland,10-15 September 2012. Abstracts vol.9, EMS2012–81.

[5] $http://meetingorganizer.copernicus.org/EMS2012/EMS2012-81.pdf$

[6] $http://presentations.copernicus.org/EMS2012-81\_presentation.ppt$

[7] Parfiniewicz J.,2013, On thunderstorm quantification, COSMO Newsletter No. 13;
$http://www.cosmo-model.org/content/model/documentation/newsLetters/newsLetter13/cnl13\_07.pdf$

[8] Parfiniewicz J., 2013. Nowcasting strong convective events (SCE) – the Thunderstorm Thermometer, Meteorological Technology World Expo 2013, Brussels, Belgium, 15 -17 oct.$http://www.ukintpress-conferences.com/uploads/SPMTWX13/Breakout\_Session\_d2\_s2\_p5\_Jan\_Parfiniewicz.pdf$

[9] Parfiniewicz J., 2014: Steps to a storm forecasting and nowcasting strong convective events, Meteorological Technology International, **48**;
$http://viewer.zmags.com/publication/c4f984ab\#$/c4f984ab/50.

[10] Parfiniewicz J., 2014. Between forecasting and nowcasting strong convective events. COSMO newsletter no.14 http://www.cosmo-model.org/content/model/documentation/newsLetters/newsLetter14/default.htm

[11] Parfiniewicz J., Barański P., 2014. An Explosive Convection over Europe with 8-Minute Tornado Incident in Poland on July 20, 2007. Int. J. Environ. Eng. Nat. Resour. Volume 1, Number 6, 2014, Łazarewicz W., Parfiniewicz J., Walasek J., 2012-2016 http://awiacja.imgw.pl/index.php?product=burze **262-276**

[12] Łazarewicz W.,Parfiniewicz J.,Walasek J.,2012-2016,$http://awiacja.imgw.pl/index.php?product=burze$.