ČESKÝ HYDROMETEOROLOGICKÝ ÚSTAV

# Utilization of 15-yr characteristics of weather radar and lightning data for improvement of Czech Hydrometeorological Institute's convective storm nowcasting system

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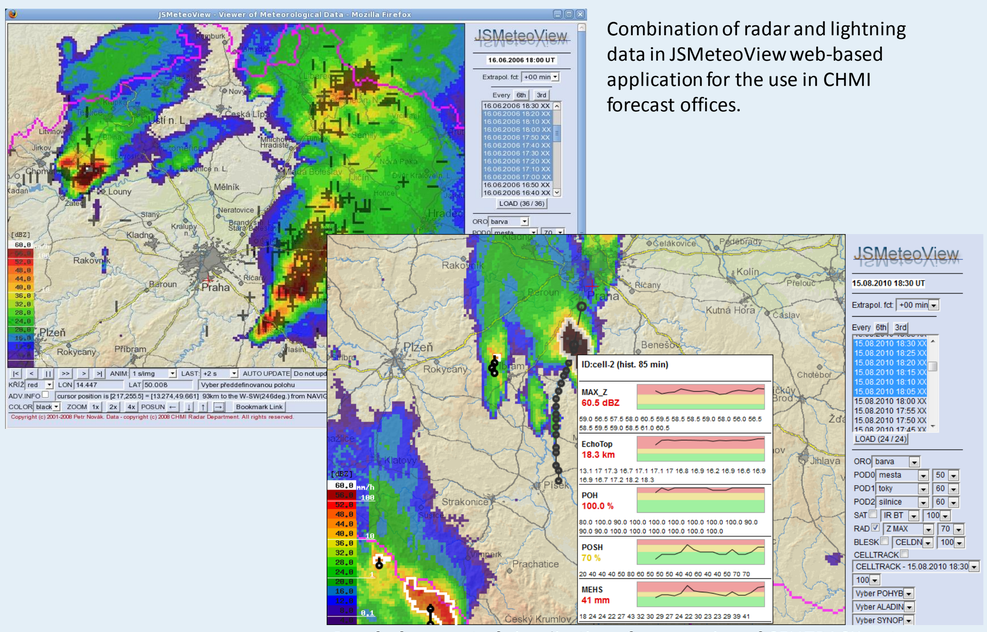
## I. CHMI weather radar and lightning detection datasets

- ✓ Since the 90's, the Czech Hydrometeorological Institute (CHMI) has been operating digital **Czech weather radar network** (CZRAD consisting of 2 C-band Doppler weather radars) and also has been utilizing lightning data from the **Central European Lightning Detection Network** (CELDN), part of EUCLID detection network (Schulz et al., 2016). Both datasets cover whole area of the Czech Republic and its neighborhood. Data archives are available in CHMI.
- ✓ The **15-Yr period from 2002 to 2016**, which has relatively even-quality data, was used to calculate long-term spatial and temporal characteristics of convective activity over the Czech Republic.

## II. Utilization of radar and lightning data in CHMI

- ✓ Radar and lightning data are used by CHMI nowcasting systems (Novák, 2007), (Kyznarová and Novák, 2009) and are operationally used in CHMI forecast offices, where they proved to be very useful for operational detection, monitoring and nowcasting of severe convective storms. Currently, new version of convective cell tracking system **CELLTRACK** (MAX Z ≥ 44 dBZ detection threshold used as approximation of convective storms) is under development in CHMI.
- ✓ Different characteristics derived from radar and lightning products will be tracked together with the identified cells and will be used as an indicator of severity of detected cells.
- ✓ Long-term characteristics of lightning and weather radar data are very useful during this development. They are used for improvement of convective storms climatology, better description and evaluation of products quality and for defining decision thresholds.

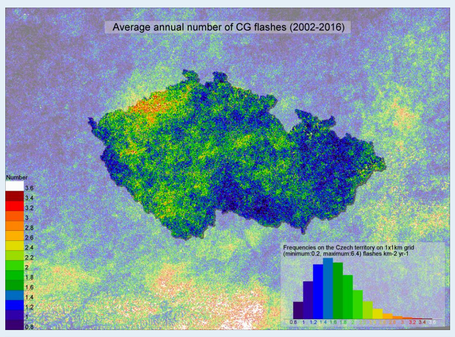


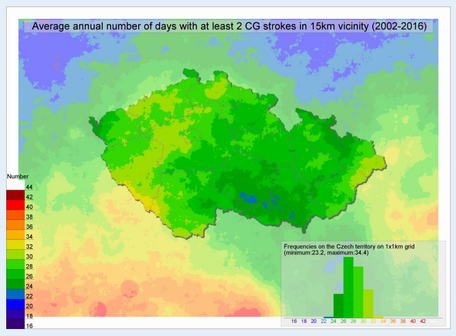

Combination of radar and lightning data in JSMeteoView web-based application for the use in CHMI forecast offices.

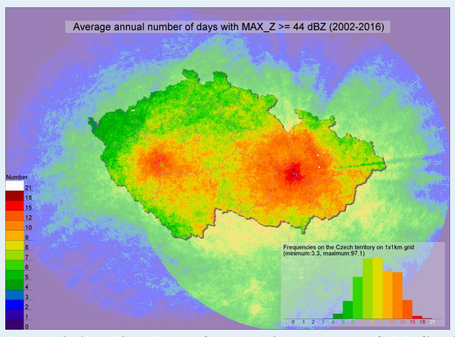
Proof-of-concept of visualization of new version of CELLTRACK system.

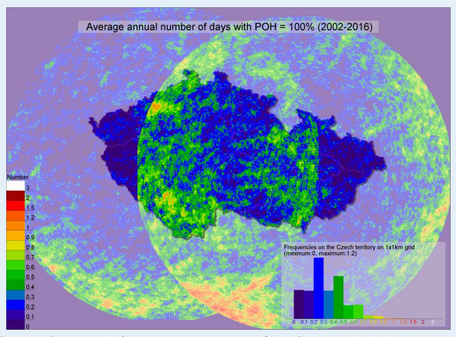
## III. Long-term characteristics

- ✓ Total of 6 449 532 lightning strokes were detected over the Czech Republic territory in 2002-2016 period. CG strokes comprise 61% and IC strokes 39% of all strokes. 3 909 118 CG strokes were combined into 1 909 368 CG flashes (average multiplicity 2.05). 83% of CG strokes were negative and 17% were positive.
- ✓ Many radar reflectivity products were recalculated for whole 15-Yr period - column maximum reflectivity **MAX Z**, constant altitude reflectivity **CAPPI**, **Echo Tops**, vertically integrated liquid **VIL**, **VIL density**, probability of hail **POH** (Waldvogel et al., 1979), probability of severe hail **POSH**, maximum expected hail size **MEHS** (Witt et al., 1998). Horiz. resolution of all products was 1x1km.
- ✓ Total of 27 506 198 gridpoints where MAX Z ≥ 44 dBZ (0.022% of all gridpoints) and 773 201 gridpoints where POH = 100% (0.001% of all gridpoints) detected over the Czech Republic in 2002-2016 period. Data availability of individual radars was over 95%.
- ✓ **Storms observations from Czech meteorological stations** were also used for comparison (261 468 hourly SYNOP records).

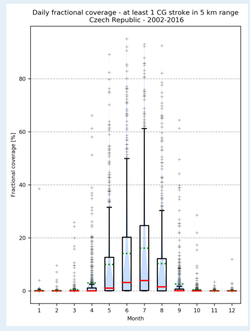


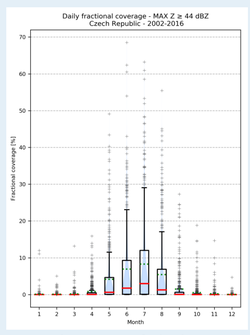



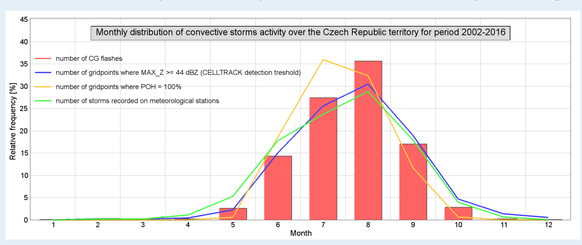

Spatial distribution of annual average of CG flashes, days with occurrence of at least 2 CG strokes in 15 km vicinity (15km vicinity best corresponds to the station observations), radar MAX_Z ≥ 44 dBZ and POH = 100%.



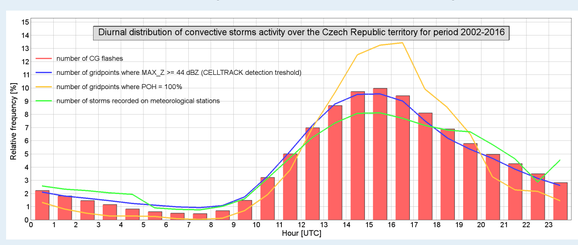




Distribution of daily fractional coverage of convective activity

- ✓ **Spatial distribution** of convective activity is **better described by lightning data**.
- ✓ **Spatial distribution of radar products is significantly influenced by scan strategy and its dependency on range** (increasing minimum visible height, beam broadening). Long-term accumulations or other derived characteristics are **very useful for identification of various quality issues**, description of products quality and its evolution over time (e.g. comparison of individual annual accumulations).
- ✓ **Daily fractional coverage of convective activity** over Czech Republic is well described by both lightning (CG strokes in 5km vicinity and range) and radar (MAX Z ≥ 44 dBZ ) products. Typical size of area impacted by convective activity during summer months is up to 10% of Czech Republic.



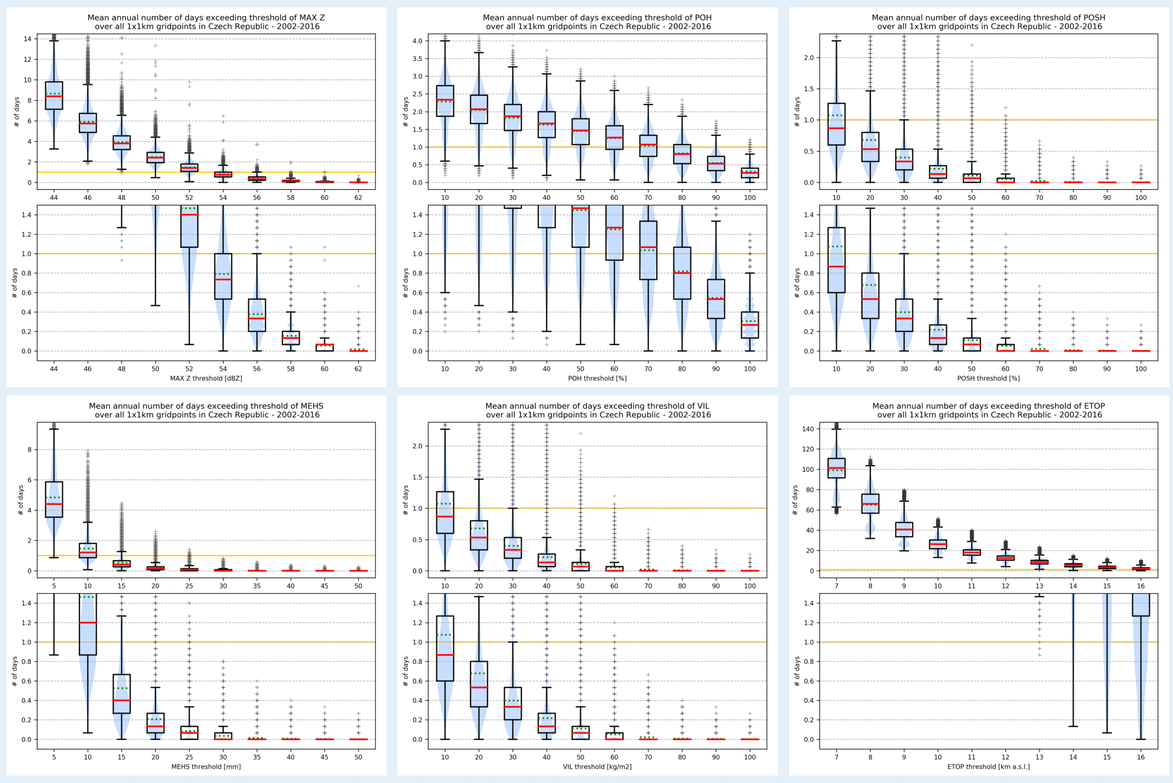

Monthly distribution of convective activity.




Hourly distribution of convective activity.

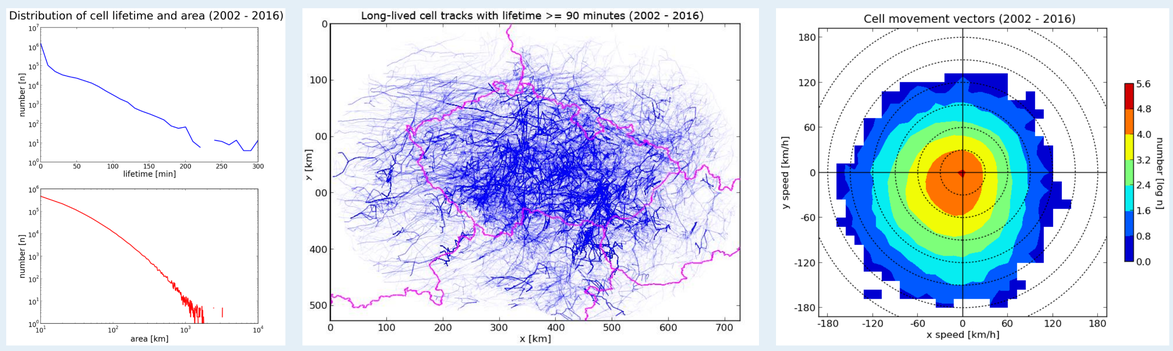
- ✓ Temporal distribution of convective activity is well described by both lightning and radar products. **Radar MAX Z ≥ 44 dBZ temporal distribution corresponds very well with CG flashes** distribution and also with distribution of **storms recorded on meteorological stations.**

- ✓ **Temporal distribution of hail probability is more sharp** (lower frequency in spring and autumn months and during night and morning hours) **and also slightly shifted** (highest frequency in July instead of August, daily maximum delayed after 16 UTC).




Mean annual number of days exceeding selected thresholds of different radar reflectivity products. Distributions of frequencies were calculated from all 1x1km gridpoints over Czech Republic. Median of distribution is shown by solid red line, mean by green dashed line. Yellow line denotes occurrence frequency 1 day per year.

- ✓ To support definition of criteria for storms severity ranking, frequencies of selected thresholds exceedance were calculated for various radar products.
- ✓ **MAX Z ≥ 44 dBZ** in given gridpoint over Czech Republic **occurs typically in 8-9 days per year. Frequency of 1 day per year was observed for MAX Z > 52 dBZ, POH > 70% or MEHS > 1 cm.** Values for other products and threshold can be extracted from boxplot graphs.




Analysis of cells identified by CELLTRACK algorithm. Distribution of lifetime and area of identified cells (left), tracks of long-lived cells – 90 minutes and longer (center), distribution of cell movement vectors.

- ✓ **CELLTRACK** algorithm was applied on whole 15-Yr dataset. Total of **1 850 340 cells was identified on MAX Z composites**.
- ✓ Frequency of identified cells and their tracks are **influenced by radar scan strategy and quality of MAX Z composites.**
- ✓ Distribution of cell movement vectors shows that **most cells move from South-West to North-East.**
- ✓ Distribution of cell lifetime shows that number of cells drops roughly exponentially with increasing lifetime. **Distribution of cell area corresponds roughly with lifetime distribution,** but the drop of cell area is even faster.

## IV. Conclusion

- ✓ Long-term characteristics of lightning data and weather radar products are very useful for better understanding of convective storms. They are used for improvement of CHMI nowcasting and warning systems (better convective storms climatology, improved description of radar and lightning products quality, definition of criteria for storms severity ranking and setting of thresholds for decision making process).

## V. References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