

# Autumn - diurnal variation of lightning over Black Sea and Bulgaria

Savka Petrova\* and Rumjana Mitzeva

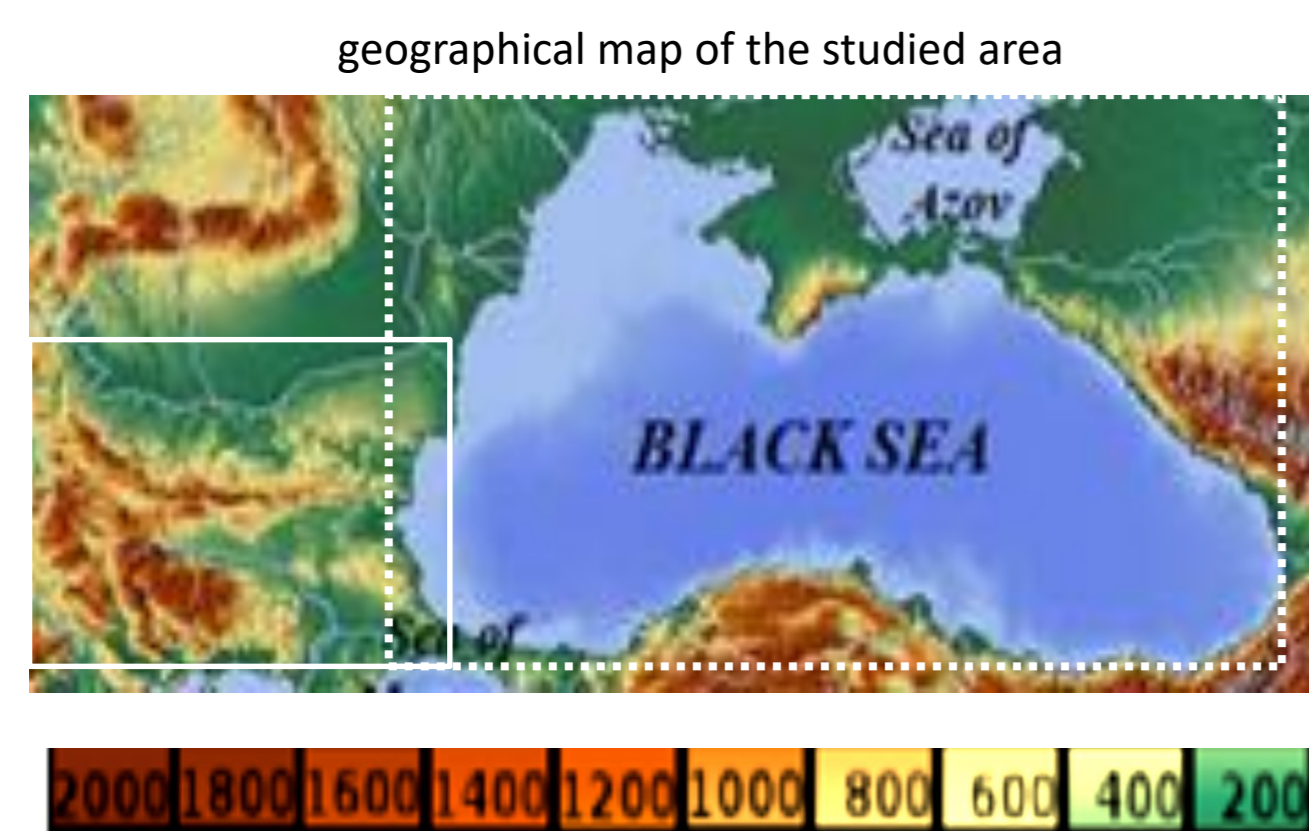
Faculty of Physics, University of Sofia, Sofia, Bulgaria

\*email: asavita@phys.uni-sofia.bg

**Introduction:** Studies of the global distribution of lightning show that the annual number of lightning over land is higher than over sea. However some researches reveal that lightning activity is different over various geographical locations and highly variable on timescales (annual, seasonal, monthly and daily). The lightning activity over land (Bulgaria) and over maritime area (Black sea) in autumn is analyzed.

**The present work is directed to reveal:**

- the difference in autumn diurnal variations of flash density over land (Bulgaria) and over maritime area (Black sea)
- locations and moments when maximum lightning over Bulgaria and over the Black sea during the autumn period.



## 2. DATA

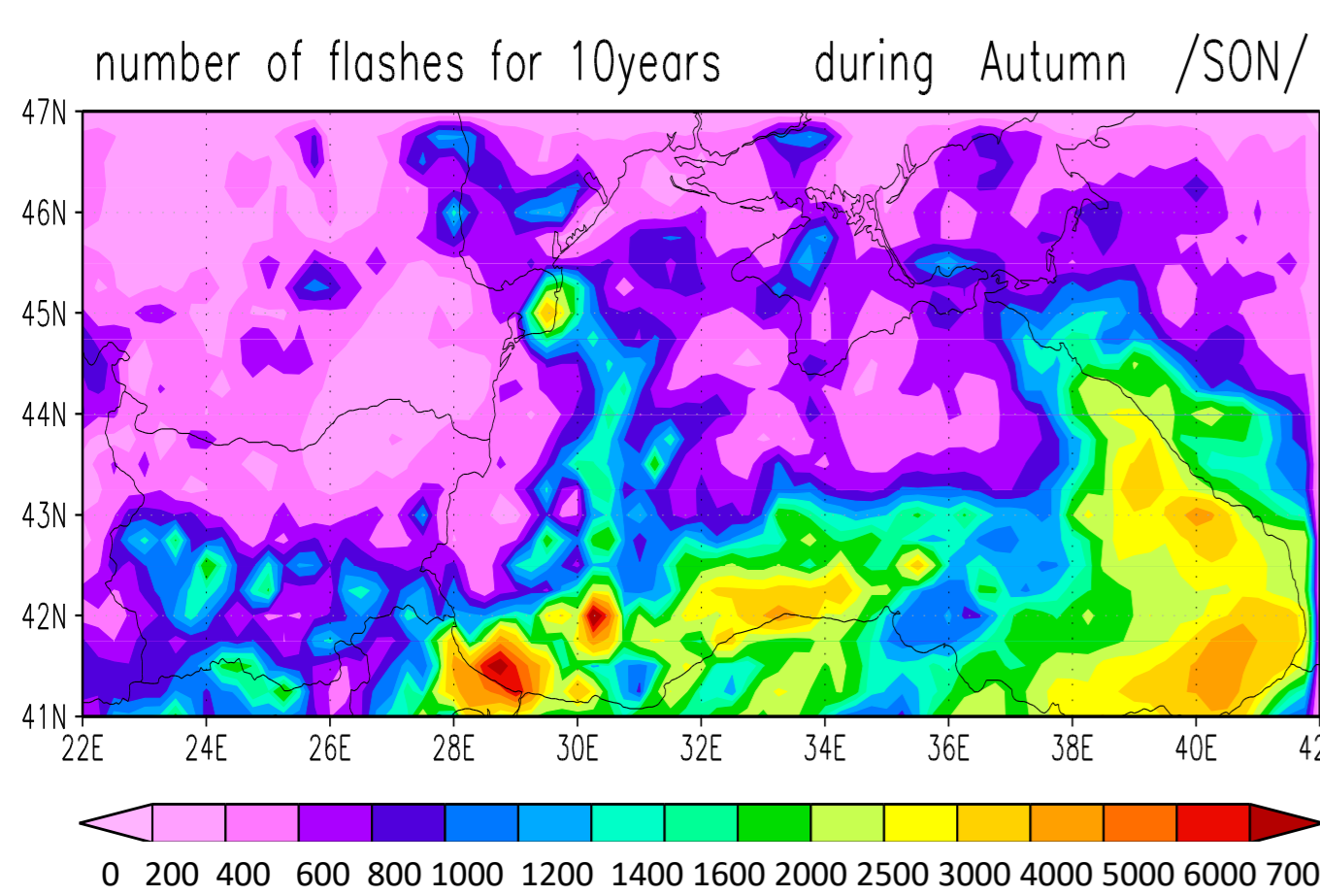
The lightning data during autumn period (September, October and November) for 10 years (2005-2014) are analyzed. Lightning data are provided from the ZEUS system operated by the National Observatory of Athens (NOA). ZEUS is a long-range lightning detection network. The lightning data are organized into 0.25x0.25 degree grid boxes and flash densities for each grid box are calculated. The number of recorded flashes and the flash density at 3-hour time intervals (corresponding to synoptic observations times: 0000 UTC, 0300 UTC, ..., 2100 UTC) are determined. Each grid box is characterized as continental or maritime depending on the underlying surface of the area it represents.

**Bulgaria** - the continental domain of the analysis is confined within 22,5° to 28,5°E and 41,25° to 44,25°N.

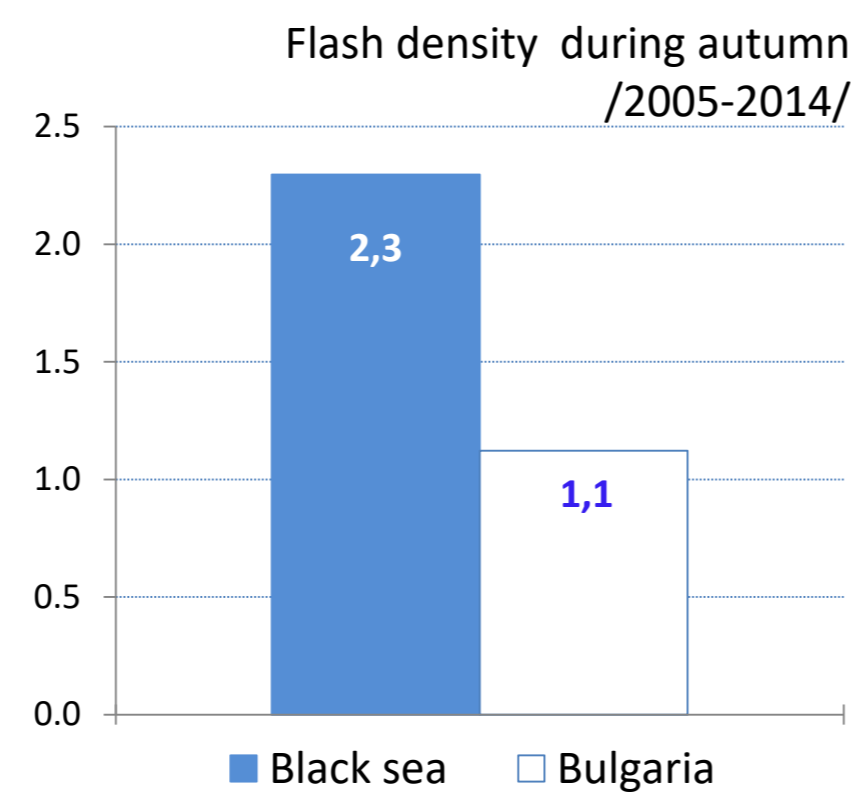
**Black sea** - the maritime domain of the analysis is confined within 27° to 42°E and 41° to 47°N.

The maritime area is approximately 3 times larger than continental area and for this reason in the present study the flash density (number of detected flashes during analyzed period divided by the corresponding surface area: [flashes/km<sup>2</sup>]) are used.

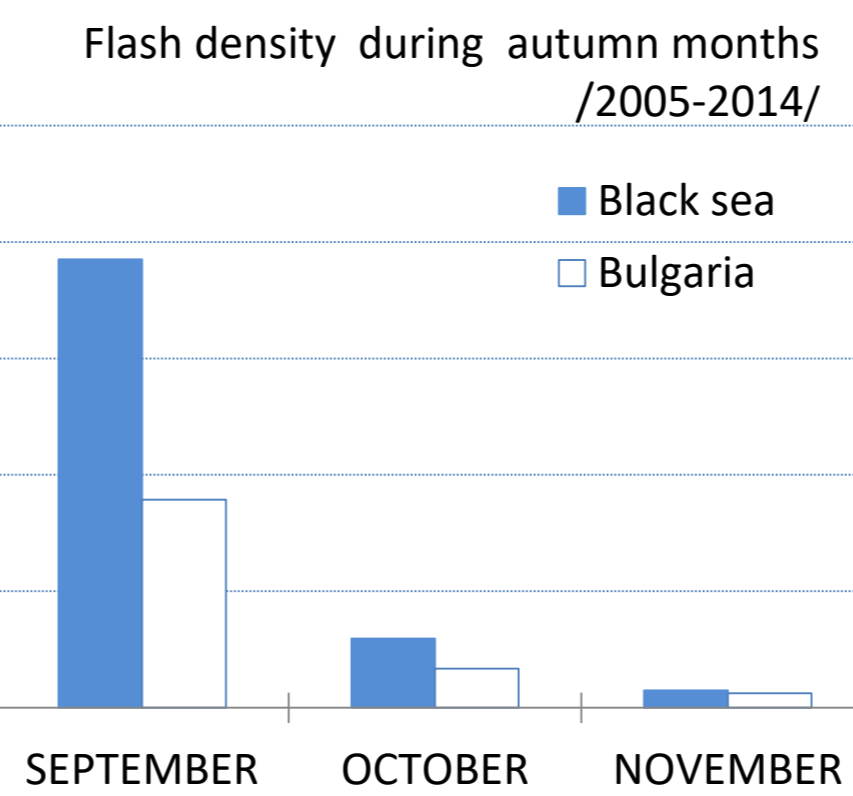
## 3. RESULTS



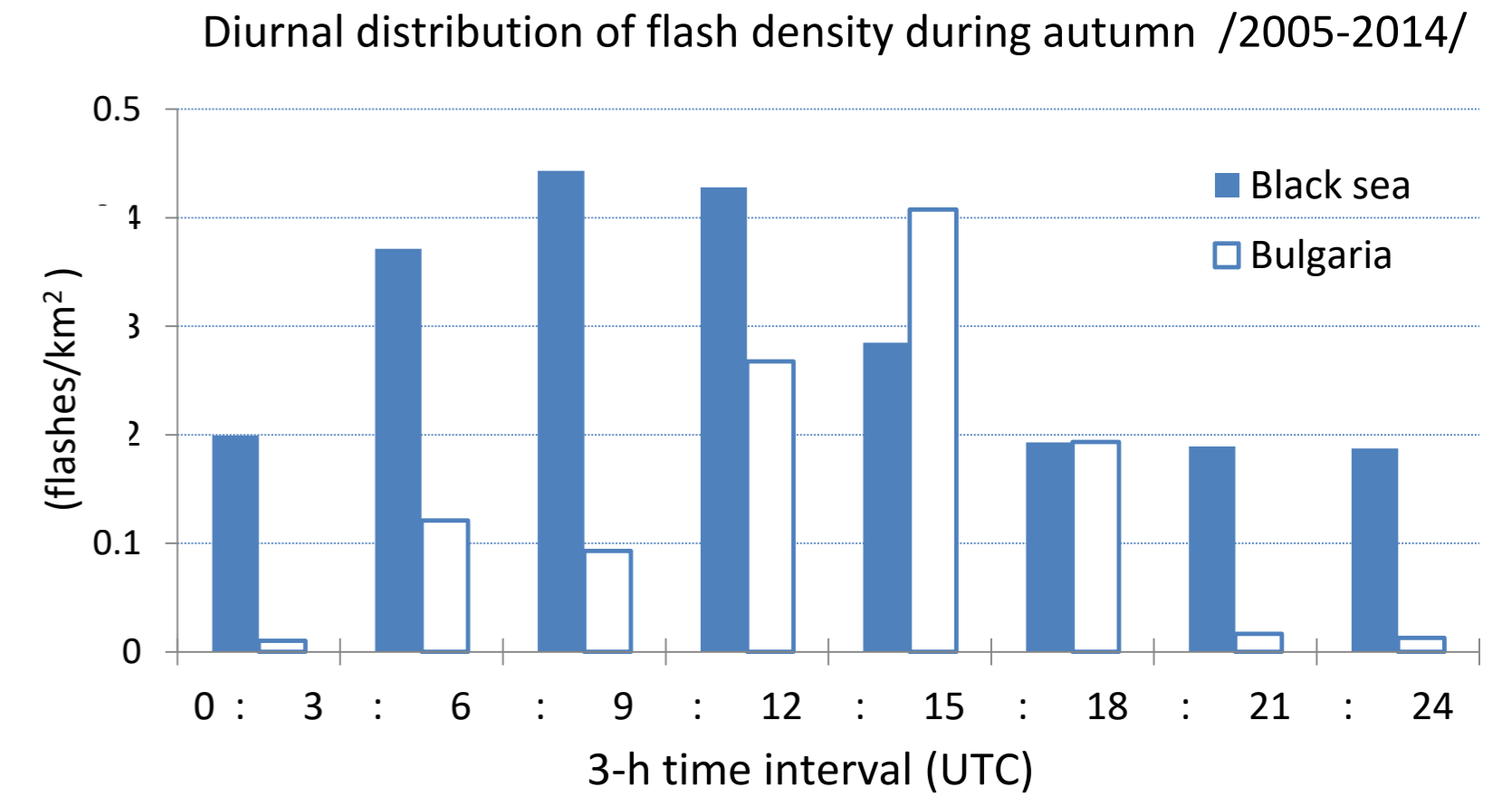
In autumn (2005-2014) much more number of lightning are observed in the southern part of the Black Sea, compared to the northern part of the basin. Over Bulgaria, the centers with the maximum number of lightning are over the mountains



Flash density in autumn (for 10 years) is about 2 times higher over the Black sea than over Bulgaria, while Petrova and Mitzeva (2019) reveal that during summer it is the opposite (flash density is about 3 times lower over the Black sea).

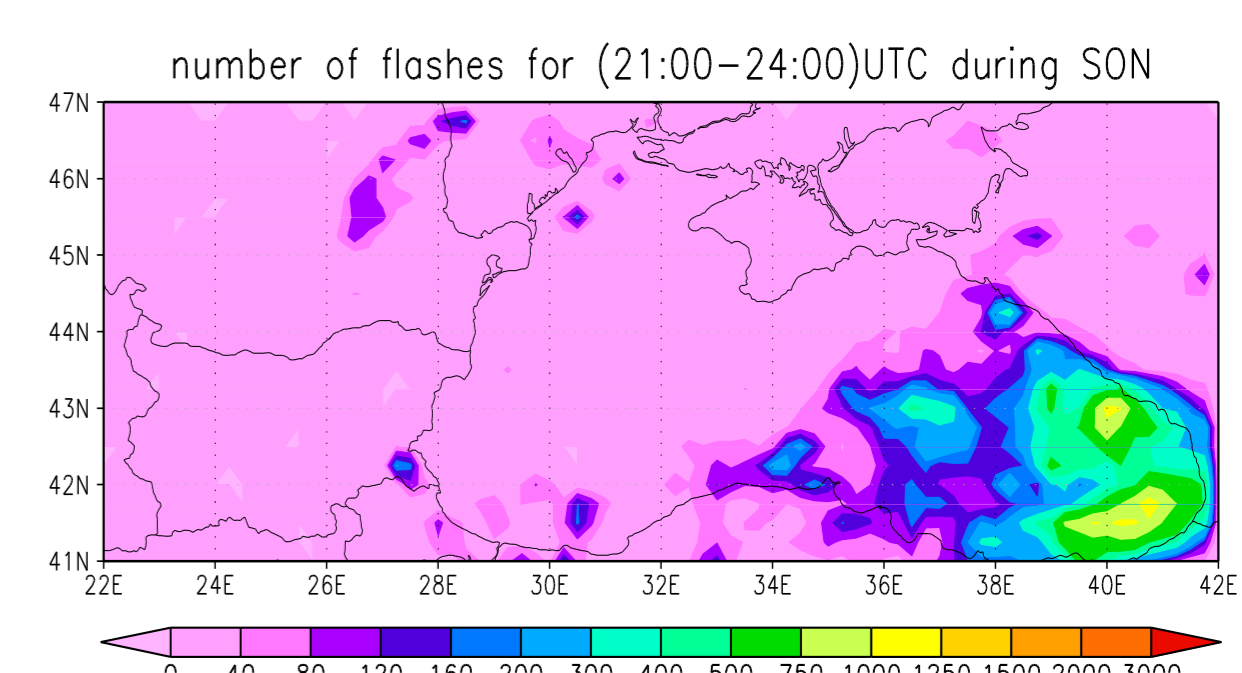
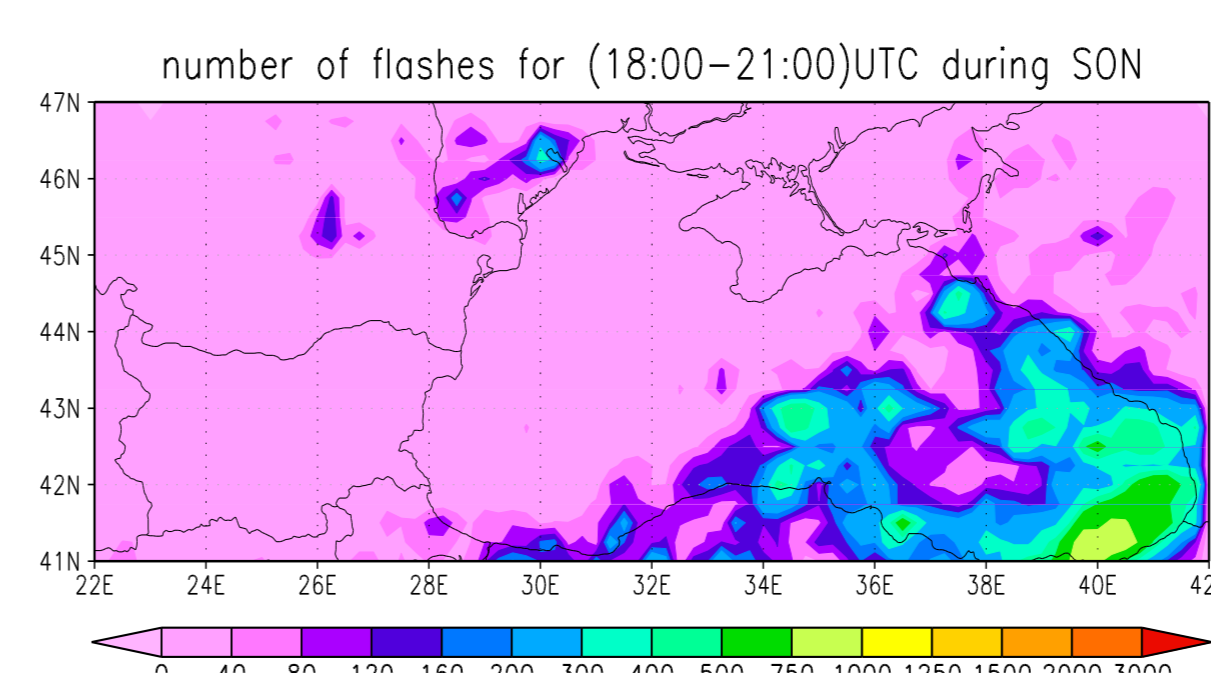
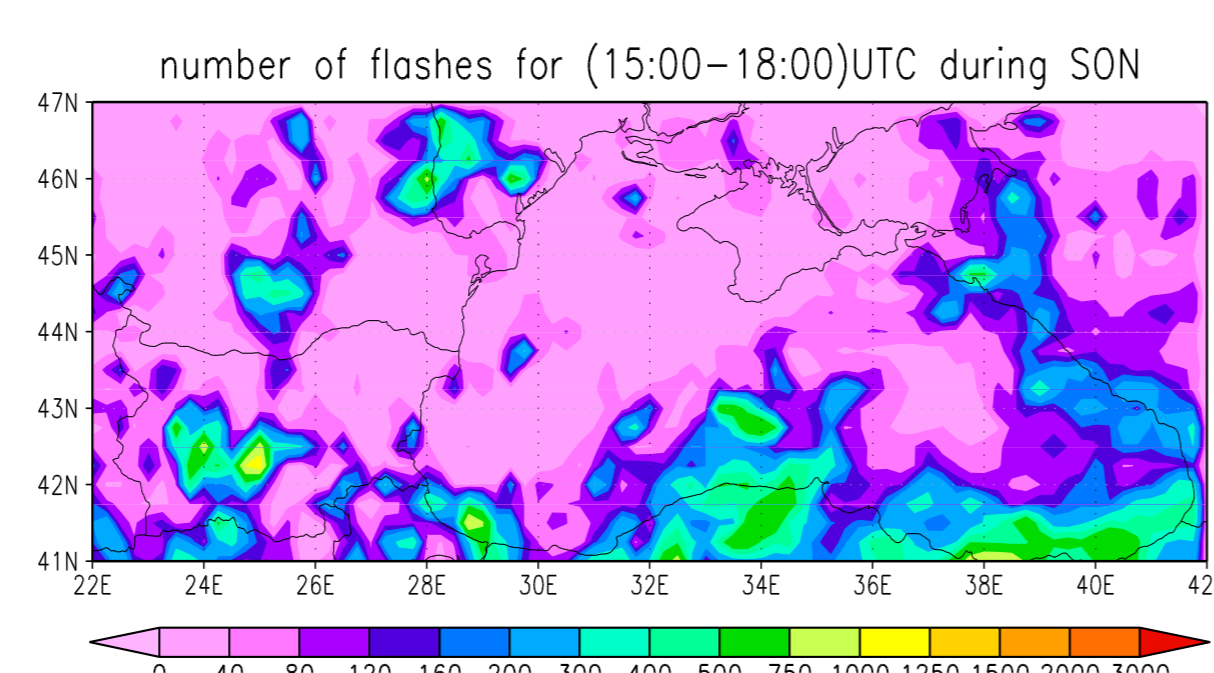
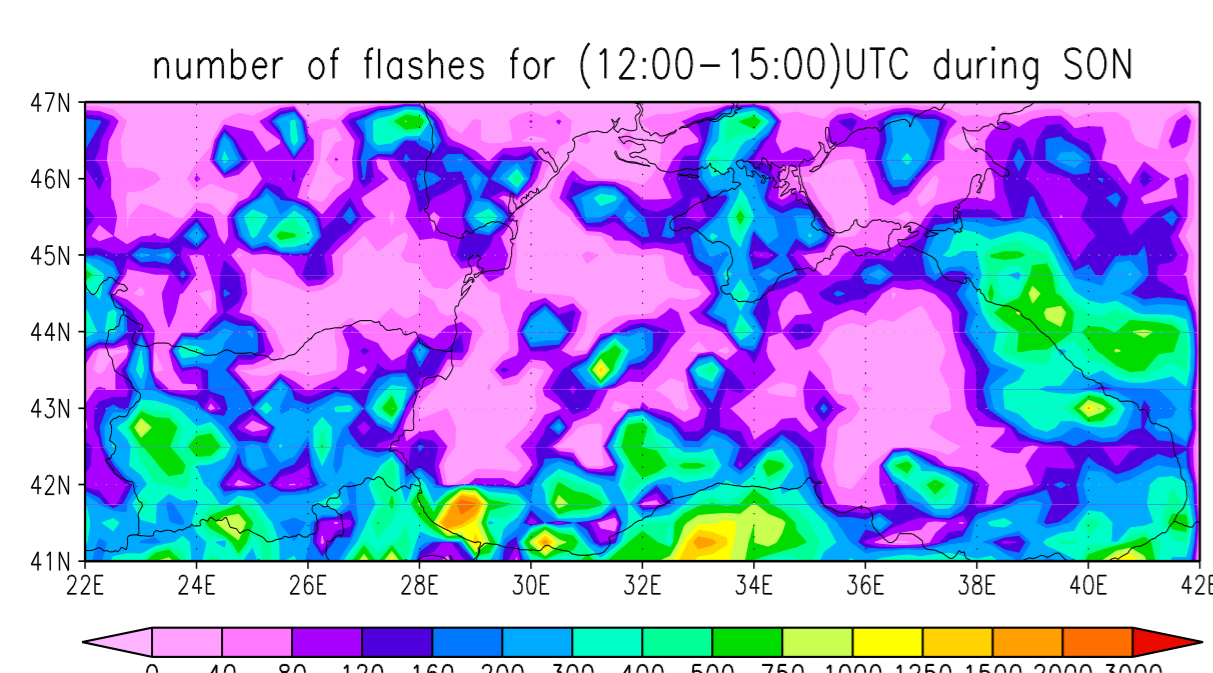
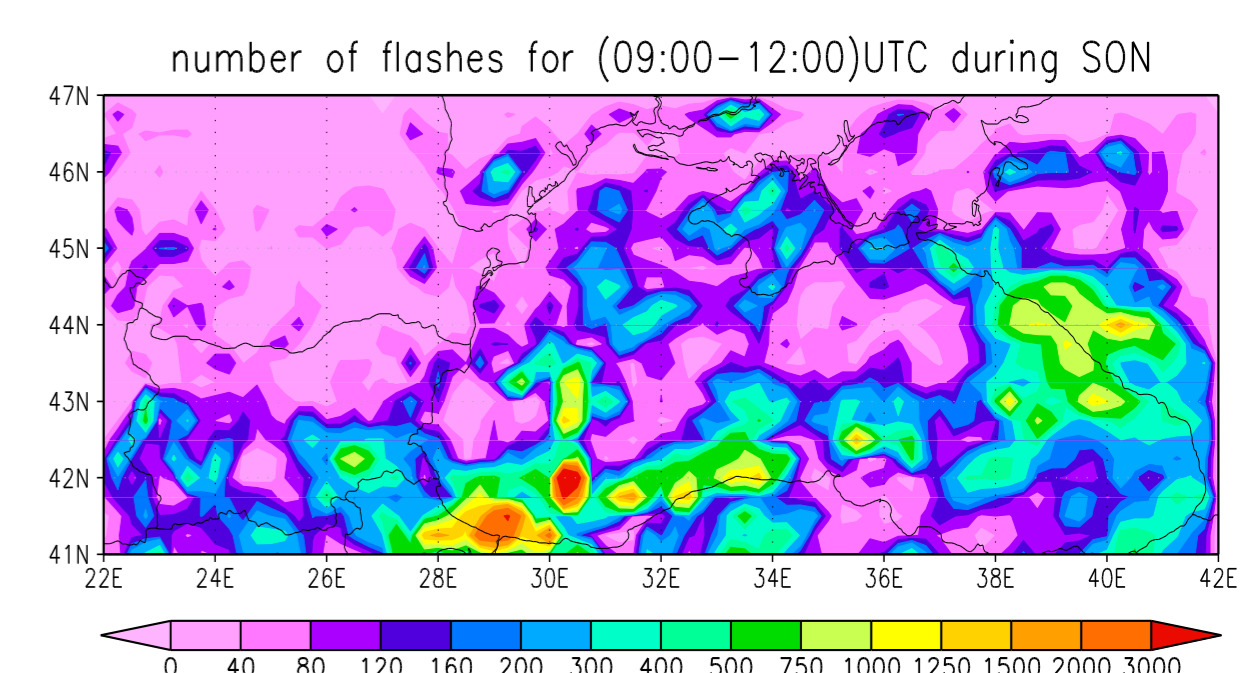
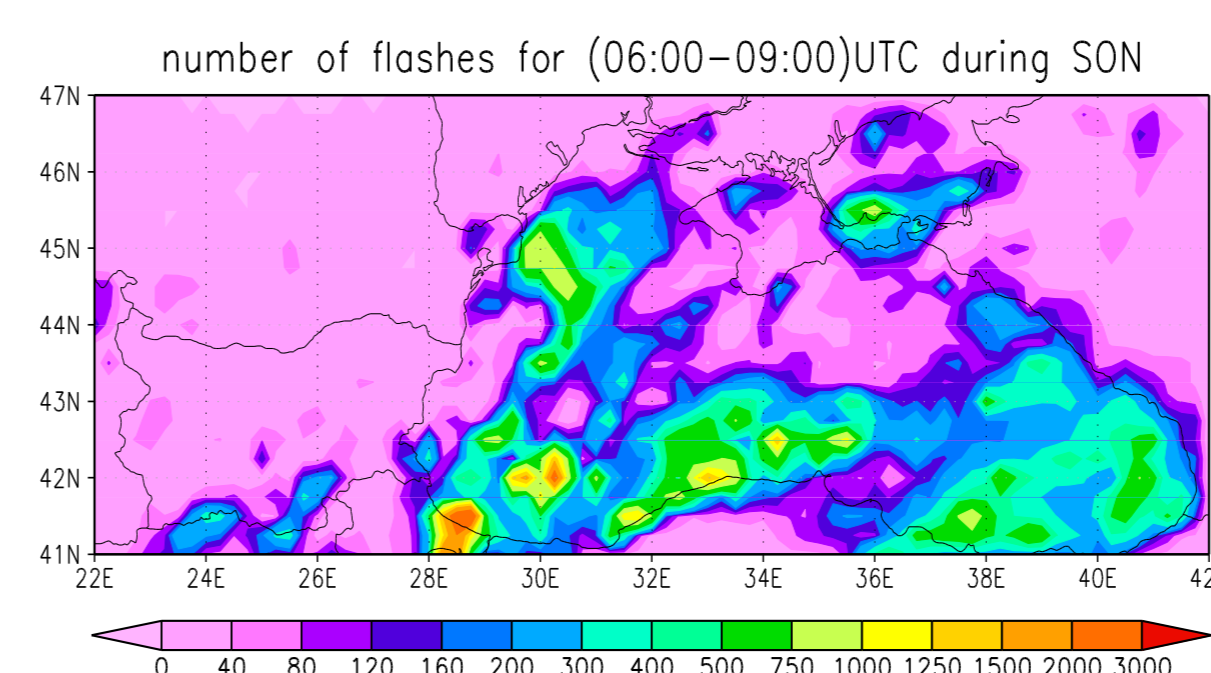
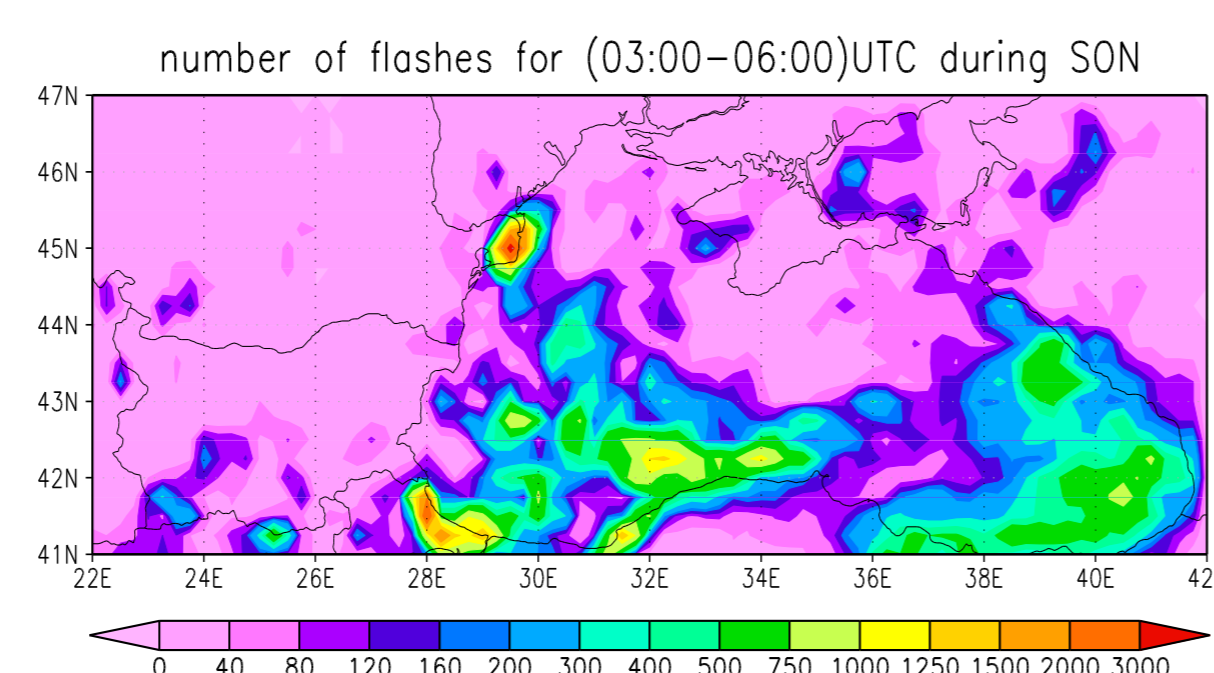
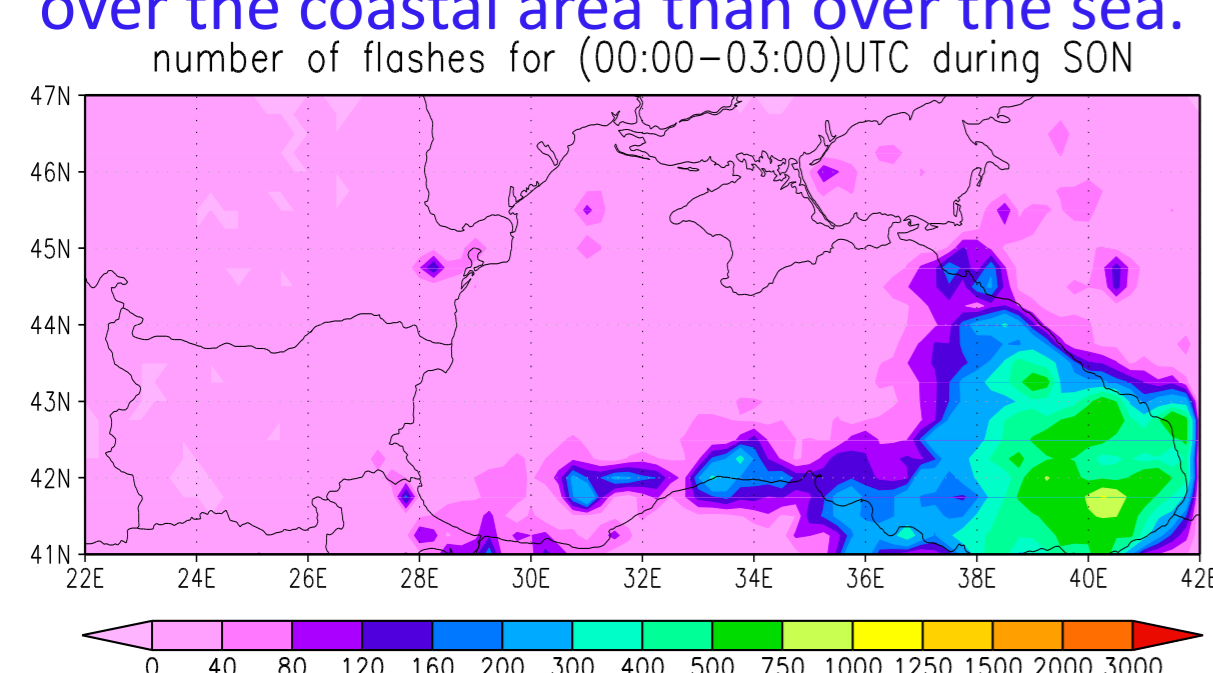


The comparison of the flash density in the autumn months shows that the maximum flash density occurs in September over the Black Sea. Also in September it is significantly higher (about 4 times) than in October and November.



**Autumn-diurnal distribution** of flash density (at 3-h time intervals) shows that lightning activity is higher over the Black Sea than over the land with the exception of afternoon hours. During the afternoon (12:00-15:00) UTC there is dominant presence of lightning over land (Bulgaria), while between (15:00-18:00) UTC the lightning activity is the same over land and over sea. The observed maximum flash density over the Black sea is in the morning interval (06:00-09:00)UTC, while over Bulgaria - in (12:00-15:00)UTC. Petrova and Mitzeva. (2019) also obtain that the maximum flash density over the Black Sea is in the morning and over Bulgaria is in the afternoon, but in the summer period.

The spatial distribution of flashes at 3-hour time intervals in boxes of 0.25°x0.25° for the 10 years during the autumn period is presented. The spatial distribution reveals that during the night (18:00-03:00)UTC lightning activity is observed mostly in the eastern part of the Black Sea, in the region surrounded by the land area with high mountains. In the morning and noon hours (03:00-12:00)UTC, different centers with a large number of lightning (>1000) are scattered over the Black sea. The higher flash density over Bulgaria than over the Black sea in the time interval (12:00-15:00)UTC is associated with lightning activity close to the location of mountains in Bulgaria. Spatial distribution also indicates that flashes detected in the time interval (15:00-18:00)UTC are found predominantly over the coastal area than over the sea.



## Summary:

- During the three autumn months (September, October, November) the flash density is higher over the Black Sea than over land (Bulgaria).
- In autumn the maximum flash density is in September over the Black sea.
- The maximum number of lightning over the Black sea is observed in the morning hours (06:00-09:00)UTC and over Bulgaria - in the afternoon (12:00-15:00)UTC.
- At the hours between 1800 UTC and 0300 UTC the maximum of the lightning activity is detected mostly in the eastern part of the Black Sea bounded by land area with high mountains.

## Reference:

Savka Petrova and Rumjana Mitzeva, 2019: Difference in diurnal variation of lightning over Bulgaria and Black sea. AIP Conference Proceedings 2075, 120010 (2019); <https://doi.org/10.1063/1.5091268>

## ACKNOWLEDGMENTS:

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