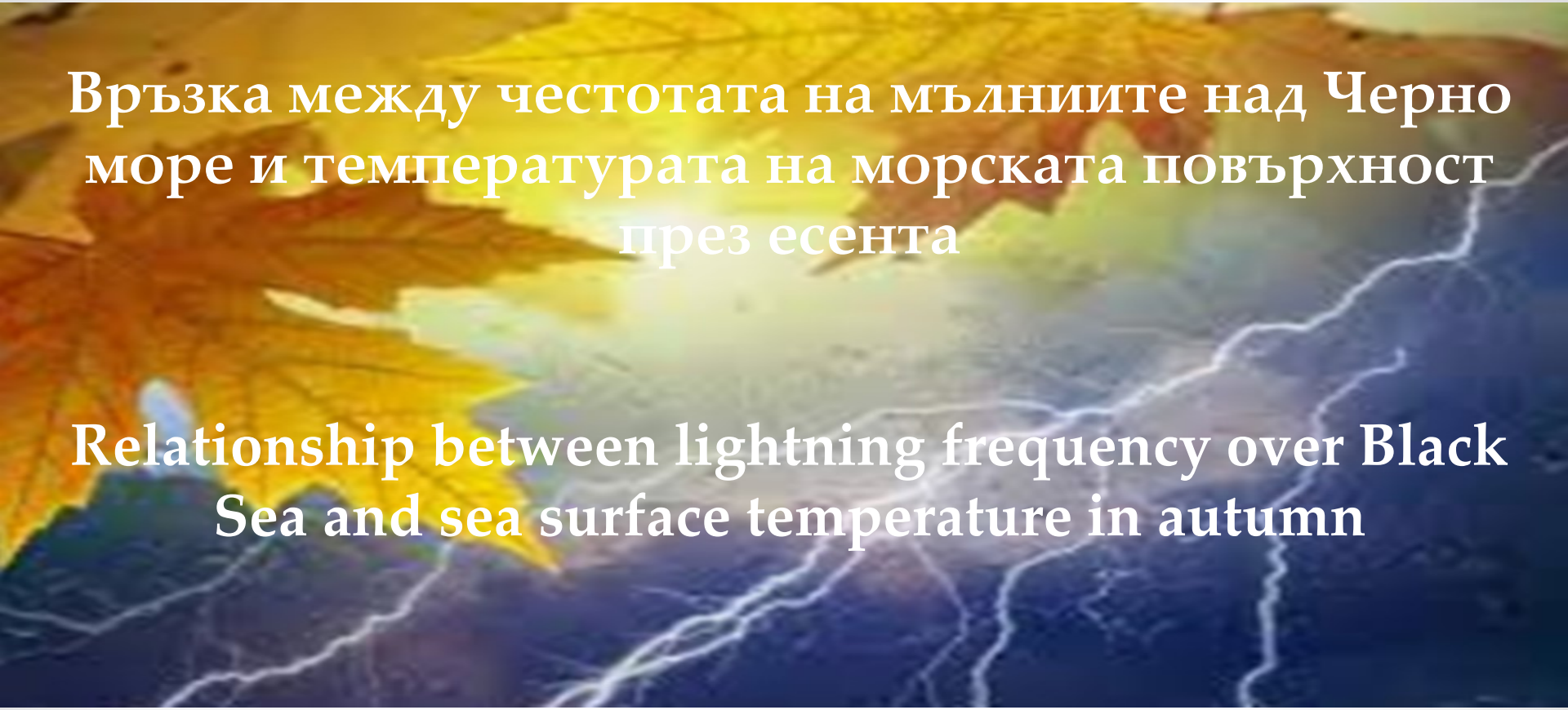
4-ти научен семинар
"Физика и химия на Земята, атмосферата и океана "



Връзка между честотата на мълниите над Черно море и температурата на морската повърхност през есента

Relationship between lightning frequency over Black Sea and sea surface temperature in autumn

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AIM: To investigate if there is a relationship between lightning activity and sea-surface temperature (SST) of the Black sea in **AUTUMN.**

Why only in AUTUMN?

The ANSWER is in: Analysis of seasonal variations of lightning over two different surface areas: continental (Bulgaria) and maritime (Black Sea).

DATA

The **lightning** data during **winter, spring, summer and autumn** for **10 years** (**March 2005-February 2015**) are analyzed.

Lightning data are provided by the **ZEUS** lightning detection network operated by the National Observatory of Athens. The number of recorded flashes and the flash density at different time intervals (annual, seasonal, monthly and 3-hours) in grid boxes of **0.25x0.25 degrees** over land and sea are determined. Each grid box is characterized as continental or maritime depending on the underlying surface of the area it represents.

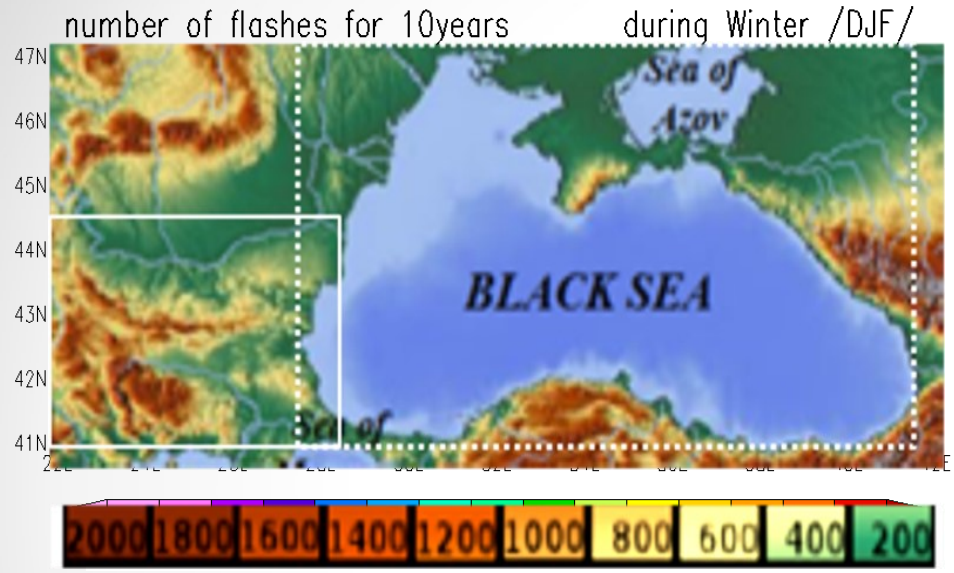
Continental domain
[22,5°:28,5°]E and [41,25°:44,25°]N

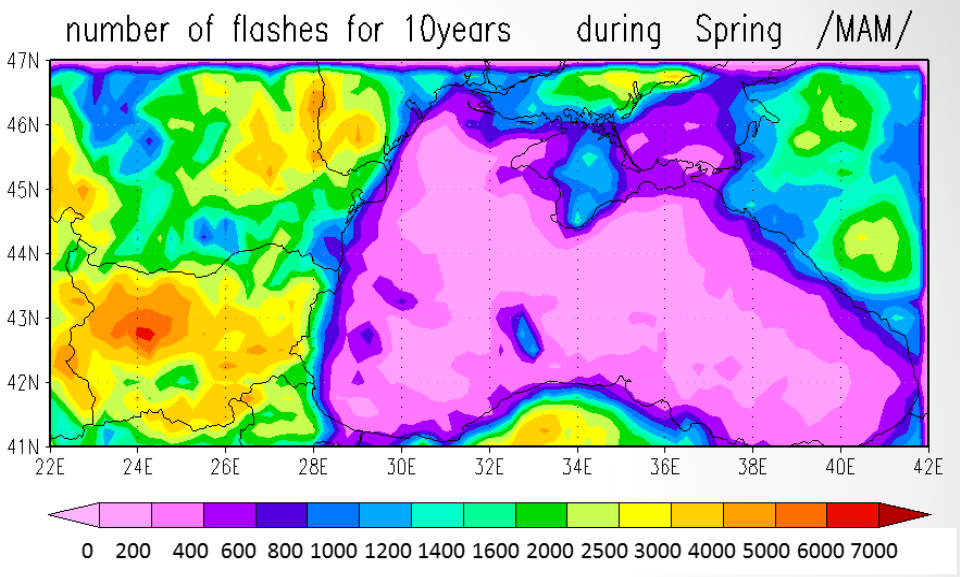
Bulgaria

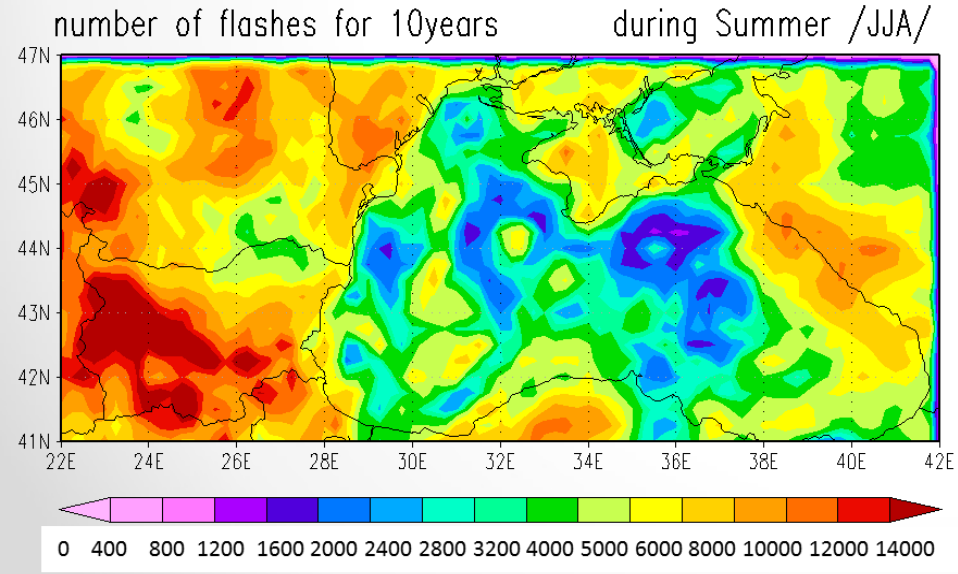
Maritime domain
[27°:42°]E and [41°:47°]N

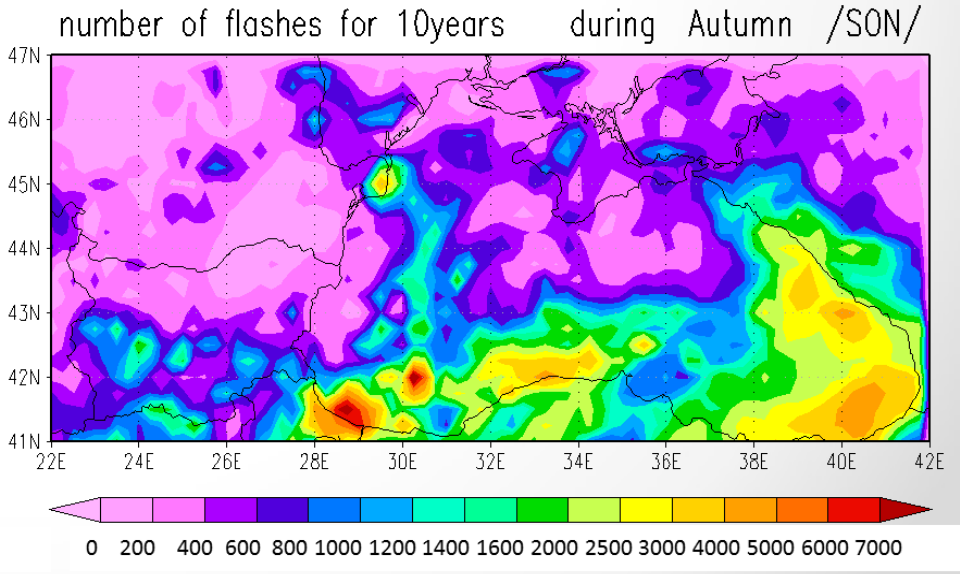
Black sea

Seasonal-spatial distribution of the number of flashes for 10 years (March 2005-February 2015) /the scales are different for each season /

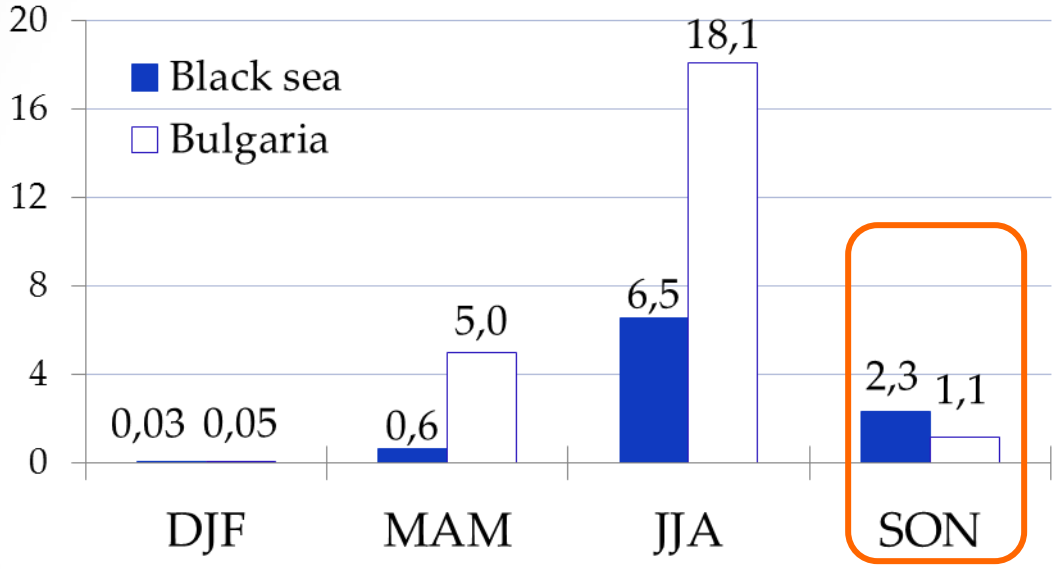








Flash density [flashes/km^2] during winter (DJF), spring (MAM) ,summer (JJA) and autumn(SON)



Lightning activity in winter, spring and summer is in accordance with the annual global distribution - the flash density over land surface (Bulgaria) is higher than over the maritime area (Black Sea). However in the autumn the flash density is higher over the Black Sea than over the land surface (Bulgaria).

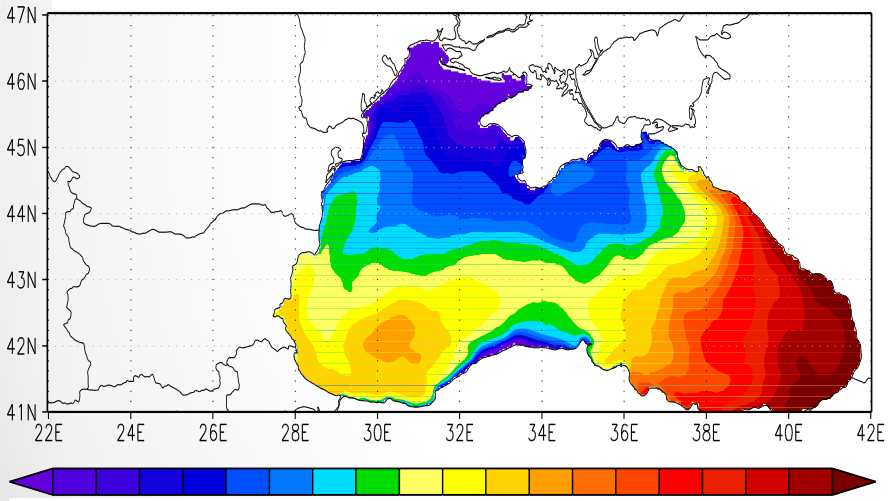
These results lead to the next question and the following task in the present work:

? What are the reasons for the higher flash density over sea compared to over land during the autumn season?

! One possible reason could be that the sea surface temperature (SST) in autumn is higher than the land surface temperature.

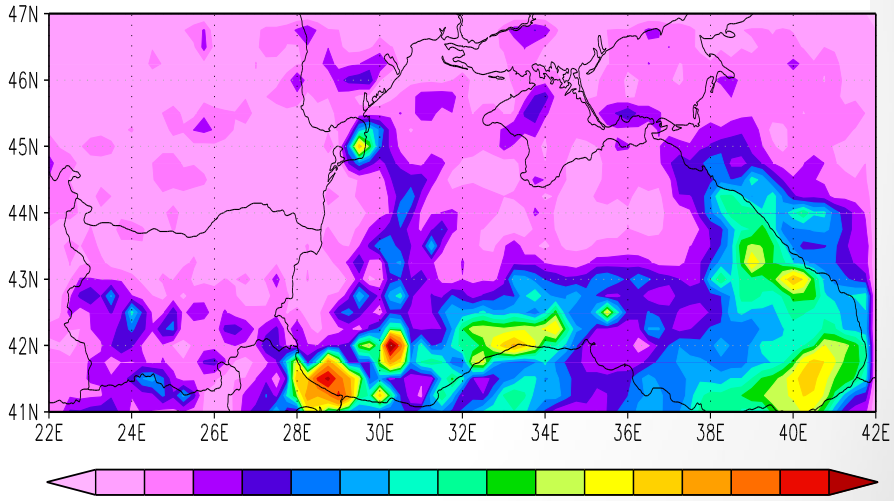
First step: To investigate if there is a relationship between lightning activity and sea-surface temperature (SST) of the Black sea in autumn.

Mean Sea Surface Temperature
September (2005-2014)



21.2 21.4 21.6 21.8 22 22.2 22.4 22.6 22.8 23 23.2 23.4 23.6 23.8 24 24.2 24.4 24.6 24.8 [C°]

Number of flashes
September (2005-2014)



0 300 600 900 1200 1500 1800 2100 2400 2700 3000 3500 4000 5000 6000 7000

The warm waters of the southern part of the Black Sea are associated with a higher number of lightning, compared to the relatively colder waters of the northern part of the basin, which are associated with a much lower number of lightning.

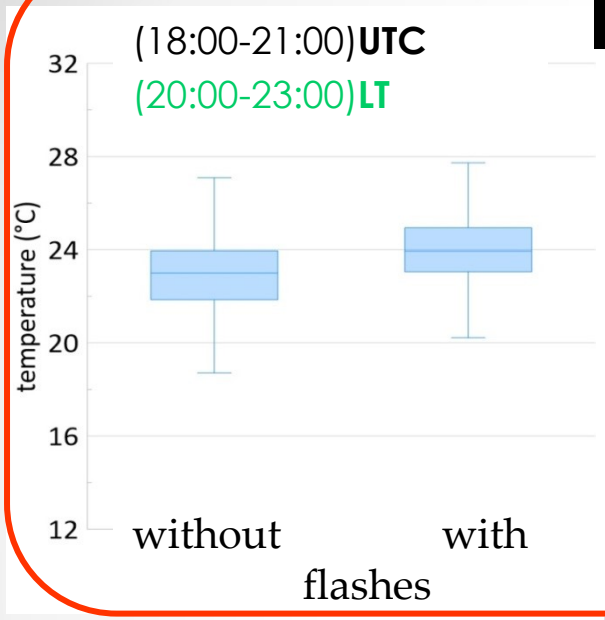
AIM: To study if there is a relationship between lightning activity and sea-surface temperature (SST) of the Black sea during autumn.

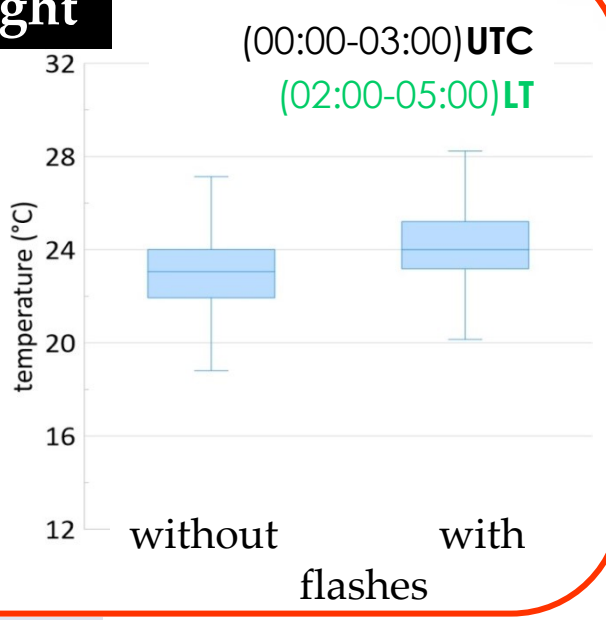
DATA:

- Data of sea surface temperature **(SST)** is retrieved from the **ERA5 reanalysis** of the European Centre for Medium-Range Weather Forecasts, downloaded for the hours 0000UTC, 0600UTC, 1200UTC, 1800UTC for each day of September (2005-2014). The SST is compared with lightning number for each time interval ((00:00-03:00)UTC, (06:00-09:00)UTC, (12:00-15:00)UTC, (18:00-21:00)UTC) of the September days and at grid boxes of 0.25°×0.25°.
- Data is grouped into two samples – **cases with flashes** and **cases without flashes**. Cases with flashes are formed by each box (0.25°x0.25°) of the grid, where at least one flash had been registered in the studied 3-hour intervals. **Local time**: LT= EET = UTC+2hours.

Box and whisker plot of the sea-surface temperature (**SST**) distribution for the cases **without** and **with** flashes for all four investigated time-intervals from September 2009.

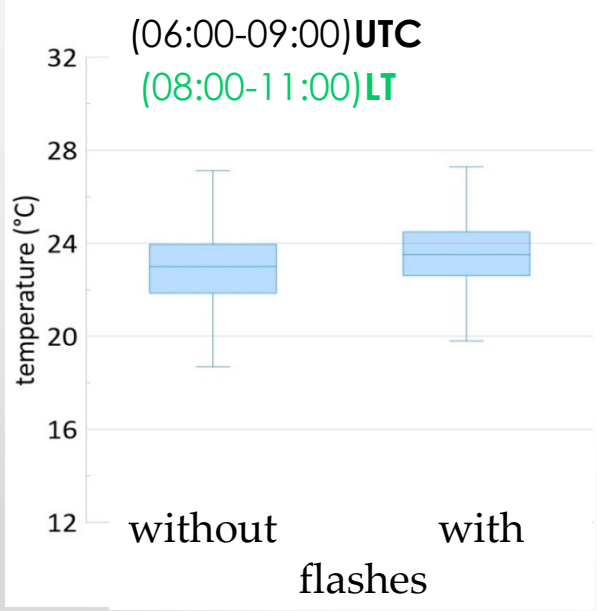
night

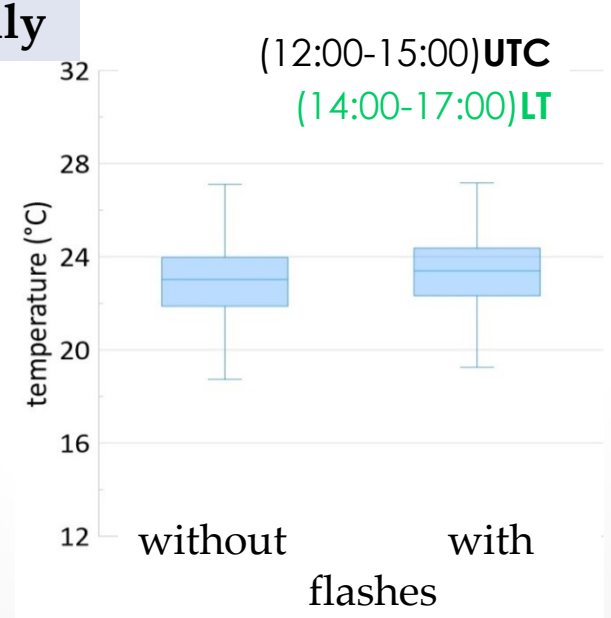




The mean and median of SST are **higher** in the cases with flashes compared to the corresponding values in the cases without flashes. The differences are more pronounced in the night intervals: (20:00-23:00)LT and (02:00-05:00)LT.

daily



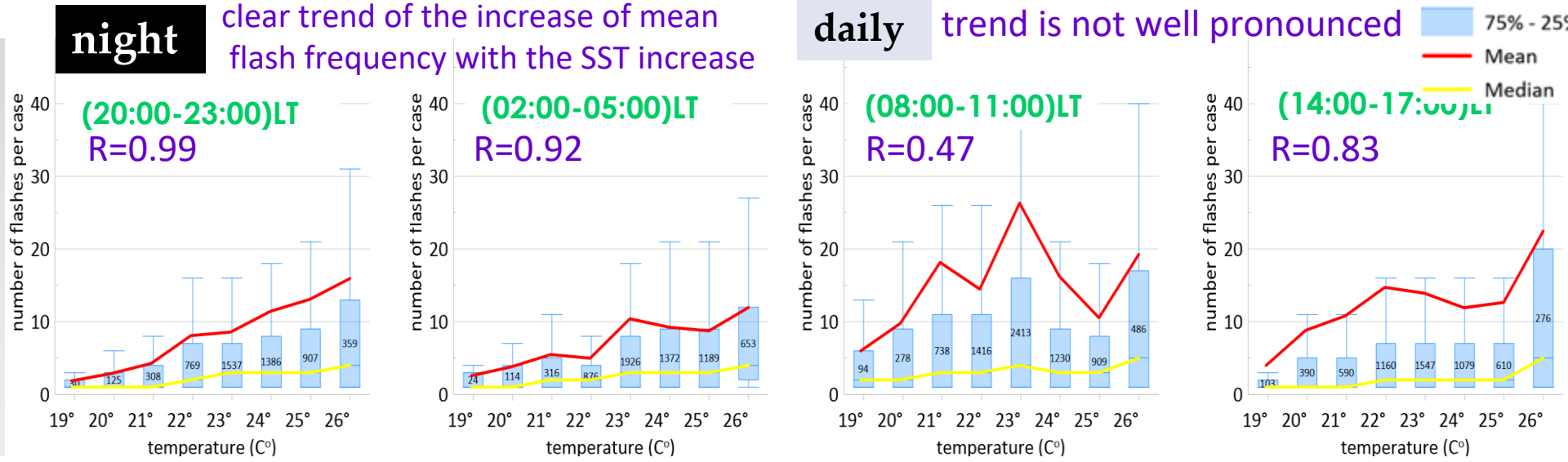


median–blue line;
box:25% and 75% ;
upper whisker:
P(75%) + 1,5*IQR;
bottom whisker:
P(25%) – 1,5*IQR;
interquartile range:
IQR = P(75%) – P(25%)

Box and whisker plot of the **flash frequency** (number of lightning per case) as a function of **SST**

night clear trend of the increase of mean flash frequency with the SST increase

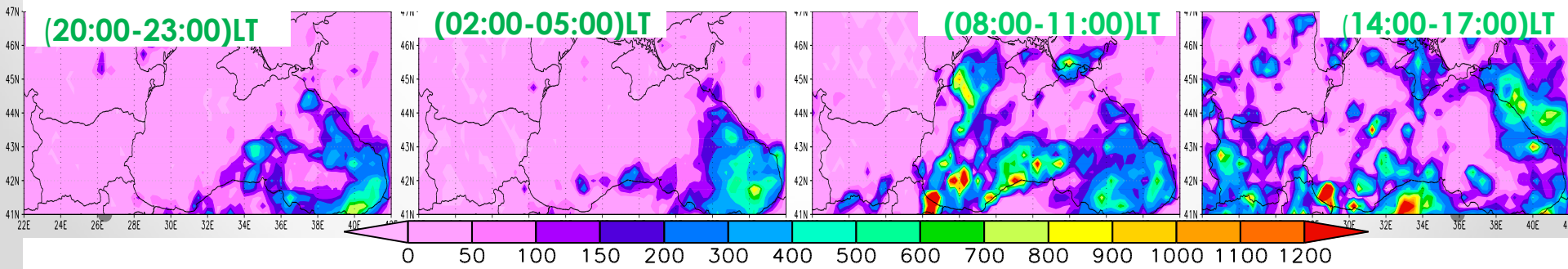
daily trend is not well pronounced



-The influence of the SST on the formation of thunderclouds is different depending on the diurnal time interval.

- The night the higher SST values probably play a more significant role in thunderstorm clouds formation at particular orographic conditions. The largest number of flashes is detected over the southeastern part of Black sea, located between mountains. The combination between warm sea surface and mountain sea breeze (slope winds and sea breeze) during night intervals create favorable conditions for cloud formation. These conditions are associated with a bigger temperature gradient between the warmer air, located just above the "warm" sea surface, and the colder air, cooling faster due to the closeness of the mountains, above it.

Hours-spatial distribution of the number of lightning/September/2005-2014/



CONCLUSION:

- In winter, spring and summer the flash density is higher over land (Bulgaria) than over the Black sea, while in autumn - vice versa.
- The mean and median of SST over the Black Sea in autumn are higher for the cases when lightning occurred than when it is absent. This difference is more pronounced during the night intervals.
- For the investigated night intervals when the sea-surface temperature increases, the mean values of the flash frequency also increases, while for the daytime hours such tendency is not clearly evident.
- The results indirectly show that the influence of SST on the formation of thunderclouds is more significant during the night than during the day.

Благодаря за вниманието!

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