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Daily-resolved lightning climatology of the eastern Alpine region at the kilometer scale

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Lightning’s impact

Hazards:

- Injuries and fatalities.
- Damage equipment and structures (e.g. wind turbines and power lines).
- Start fires.
- Affect air-traffic management.
- Connection to other hazards, e.g. debris flows, mudslides, hail.

Aim

Lightning climatology . . .

. . . for the **eastern Alpine region**

. . . on the **kilometer scale**

. . . with **daily resolution**.

How to obtain lightning climatologies?

Lightning location systems (LLS) measure lightning discharges continuously in space and time with **detection efficiencies above 90%** and **location accuracy below 1 km**.

Smoothing of measurements:

- “count-cell” method with some spatio-temporal (weighted) averaging
- kernel density estimation around the location of lightning discharges
- generalized additive model (GAM) to identify functional dependencies of lightning and underlying characteristics

Data

Austrian Lightning Detection & Information System (ALDIS):

- cloud-to-ground (CG) discharges
- summer months April–September
- 11 years 2010–2020
- eastern Alps and surroundings with $^1/_4$ million km^2

This results in approx. 45.2 million spatio-temporal cells. One for each day of the year and each square-kilometer.

For each cell we count the number of years $\{0, 1, 2, \ldots, 11\}$ in which at least one CG discharge occurred.

Methods

For each cell this yields a **Bernoulli's urn** problem with replacement.

Imagine an urn for each cell, from which one can draw days either *with* or *without* lightning. The probability to draw a day with lightning will be denoted as π.

This probability π might vary conditioned on characteristics of the cell such as region, altitude, season, . . .

Methods

Generalized additive model:

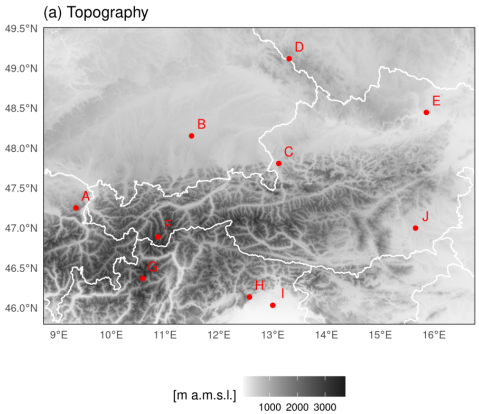
$$\begin{aligned}\text{logit}(\pi) = \beta_0 &+ f_1(\texttt{yday}) \\ &+ f_2(\texttt{log topo}, \texttt{yday}) \\ &+ f_3(\texttt{lon}, \texttt{lat}, \texttt{yday}) \\ &+ f_4(\texttt{log roughness})\end{aligned}$$

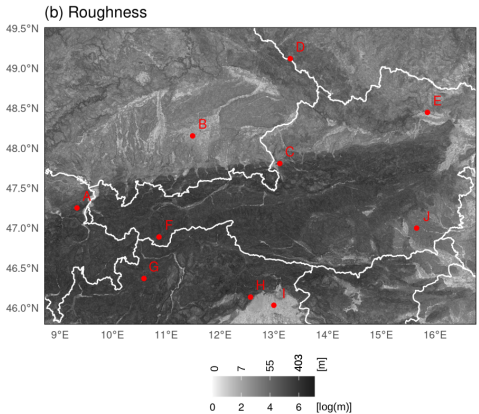
Expected number of thunderstorm days in k years:

$$\text{E}(\texttt{ts_days}) = k \cdot \pi$$

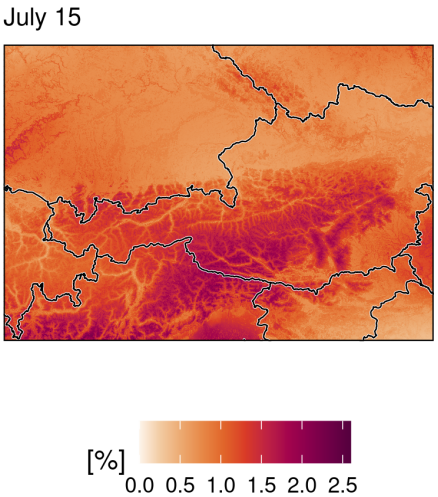
Data II

Digital elevation model TanDEM-X:



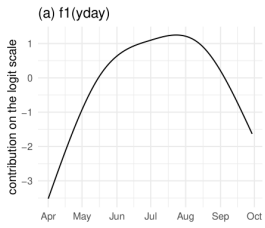


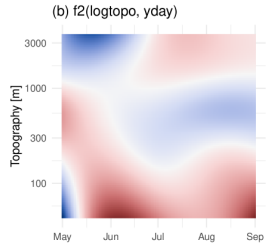
Results: Maps

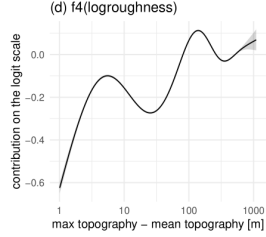


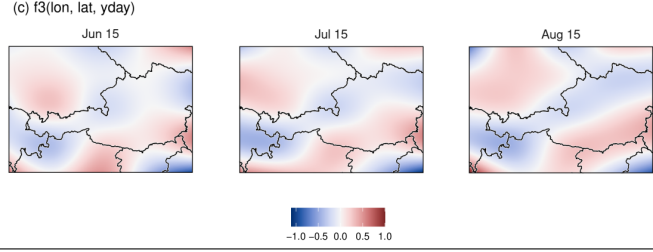
Results: Estimated functions

$$\text{logit}(\pi) = \beta_0 + f_1(\texttt{yday}) + f_2(\texttt{log topo}, \texttt{yday}) + f_3(\texttt{lon}, \texttt{lat}, \texttt{yday}) \; f_4(\texttt{log roughness})$$

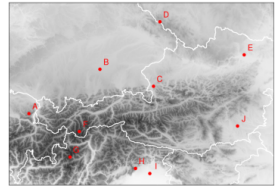


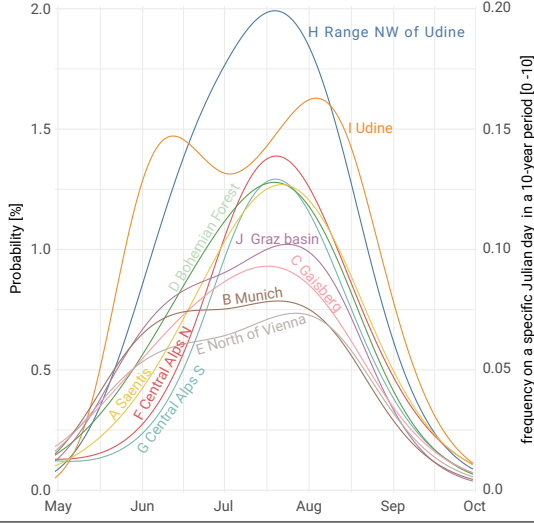




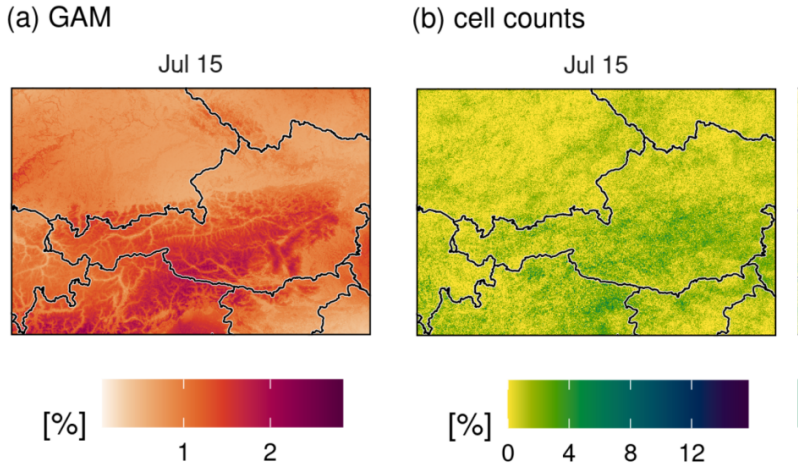


Results: Seasonal effects for locations





Discussion



Outlook

- **Flash density** climatology using a hurdle approach and a zero-truncated count data distribution.
- **Local characteristics** such as snow cover, tall structures, . . .
- **Continental scale** climatology covering Europe.



Simon, T. and G.J. Mayr. (2022) *Lightning climatology for the eastern Alpine region on the kilometer scale with daily resolution*, e & i Elektrotechnik und Informationstechnik, doi:10.1007/s00502-022-01032-1.

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