Weather that Fuels Long-Lasting Lightning

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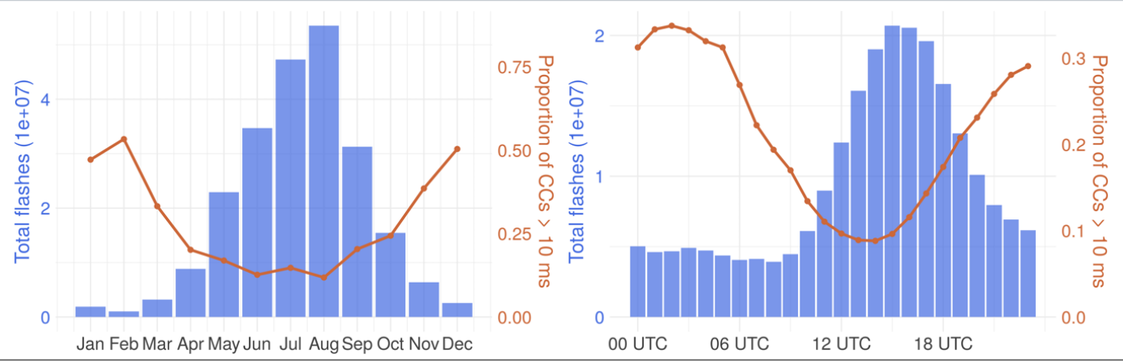
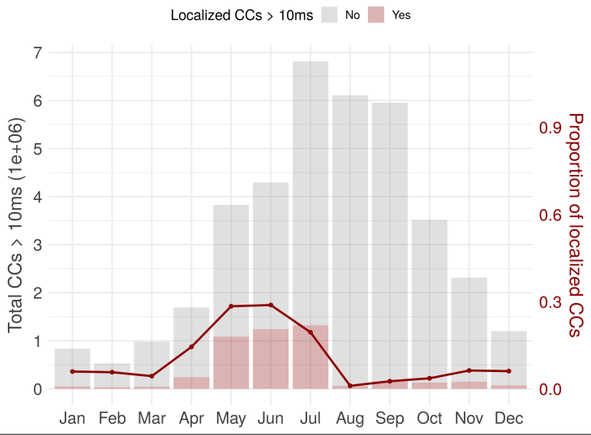
What are continuing currents (CCs)?

- Most lightning ends after a **few microseconds**.
- But continuing currents persist for up to **hundreds of milliseconds**.
- We found that they occur proportionally more often over the **ocean** and **coastal regions**, in **winter**, and at **night**.
- They often extend over **tens of kilometers**.



Why do they matter?



- They can transfer **larger amounts of charge** compared to normal lightning.
- They can cause serious **damage** to tall structures such as **wind turbines**.
- Risk is highest when current flows continuously over a **small area** ($\sim$5 km $\times$ 5 km) $\rightarrow$ localized **large charge transfer**.
- Localized continuing currents peak in **early summer**, coinciding with conditions that also favor **wildfires**.

How can we study them?

Meteorological Data

Source:	**ERA5** (35 variables).
Resolution:	0.25° $\times$ 0.25°, hourly.
Study area:	Europe.
Time period:	Aug 2024–Aug 2025.

Lightning Imager

Measurement:	Continuous optical sensing with a resolution of $\sim$1 ms.
Identification of continuing currents:	Sequences of **continuous optical signals** within a flash.

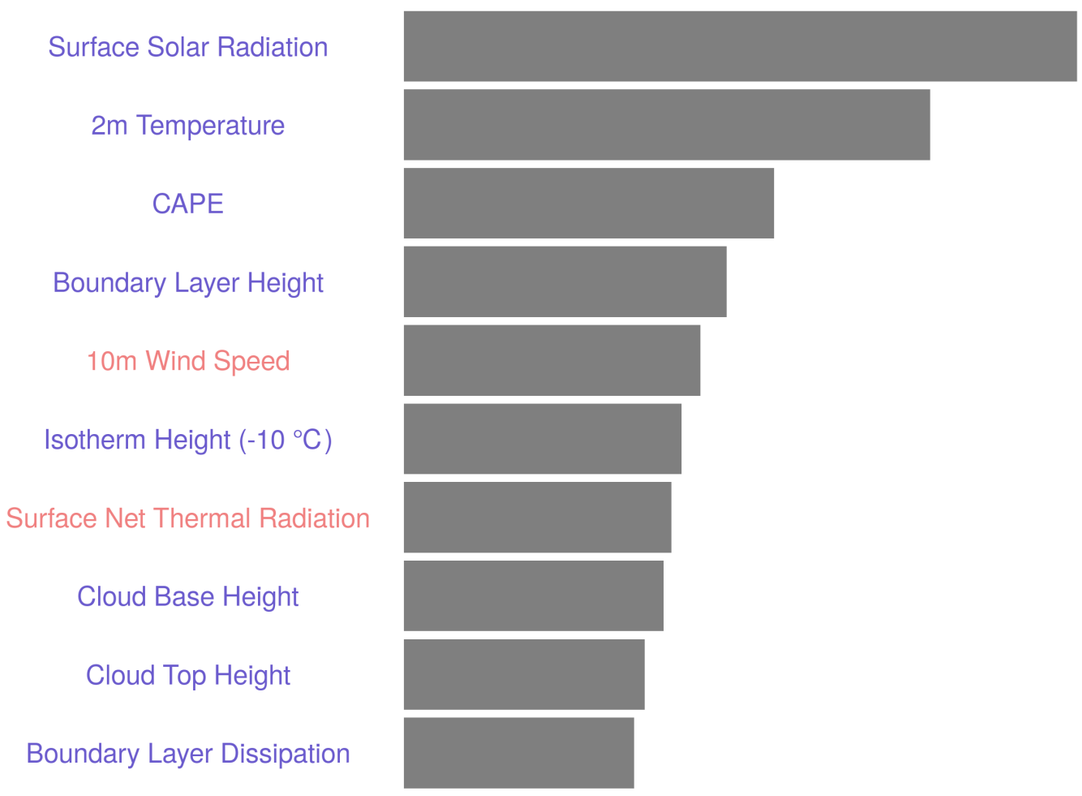
Machine Learning

Model:	**Random Forest**.
Response:	"Normal" vs. continuing currents (>10 ms).
Predictors:	ERA5 variables.
Output:	Ranked variable importance.

Which meteorological conditions favor continuing currents?

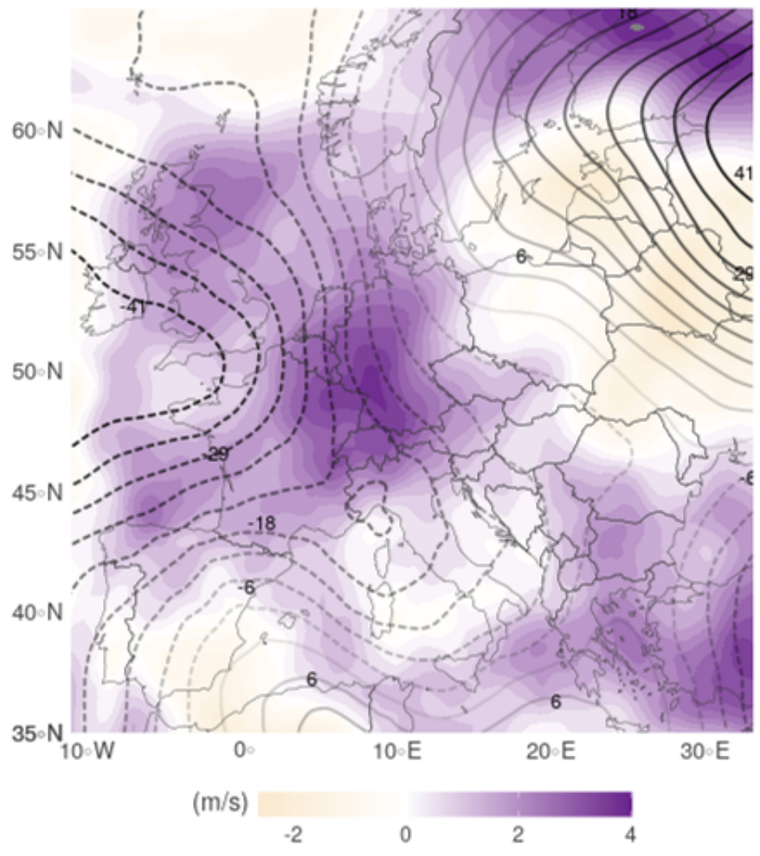
"Normal" lightning versus continuing currents

- Most of the conditions favorable for normal lightning have **lower values** except for **wind speed** and **net thermal radiation**.
- Variable importance distinguishing between continuing currents and normal currents:



Upper-level synoptic anomalies favoring continuing currents

- Enhanced **cyclonic circulation** over Atlantic and British Isles.
- **Stronger** upper-level **winds** over central Europe.
- **Anticyclonic circulation** over eastern Europe.



Difference between continuing current-dominated and normal-current dominated situations in geopotential height (m) and wind speed (m/s, shaded) at 300 hPa.

Summary of insights on continuing currents

- **Damage potential**: Higher for continuing currents due to large charge transfer.
- **Non-typical occurrence**: They are more frequent in seasons, daytimes, and regions when normal lightning activity is lower.
- **Distinct regimes**: They occur under distinct meteorological conditions, not randomly within normal-current environments.
- **Cooler, lower clouds:** They prefer lower temperatures, cloud-bases, and isotherm heights.
- **Stronger winds:** They prefer higher wind speeds near the surface and aloft.
- **Large-scale pattern:** They seem to prefer a cyclonic-anticyclonic dipole pattern across Europe.

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