Workshop NWP Portugal

Lightning Probability Forecast in Mainland Portugal

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Motivation

• A study based on 13 years of lightning data is presented using Cloud-to-Ground (CG) flash density maps on a 0.2°x0.2° resolution grid (**Fig.1**), as well as intra annual distributions (**Fig.2**). Thunderstorm events in mainland Portugal result primarily from frontal systems approaching in the winter/spring seasons and convective instability in the summer/autumn seasons, especially due to diurnal surface heating, particularly observed during the months of May to September.

•In this study CG geographical incidence and temporal distribution in mainland Portugal is characterized. Also, satellite imagery and CG locations were used to identify convective cells originating flash discharges.

•The Portuguese Meteorological Institute (IPMA) has been exploiting a Lightning Detection Network (LDN) since June 2002, with 4 sensors in mainland Portugal operating in integration with 5 more Spanish sensors since January 2003, in cooperation with the Agencia Estatal de Meteorologia (AEMET, Spain). In January 2017 a network upgrade was performed, replacing the VAISALA IMPACT sensors by LS7002 series (**Fig.3**) and also the LP2000 was replaced by a TLP (Total Lightning Processor).

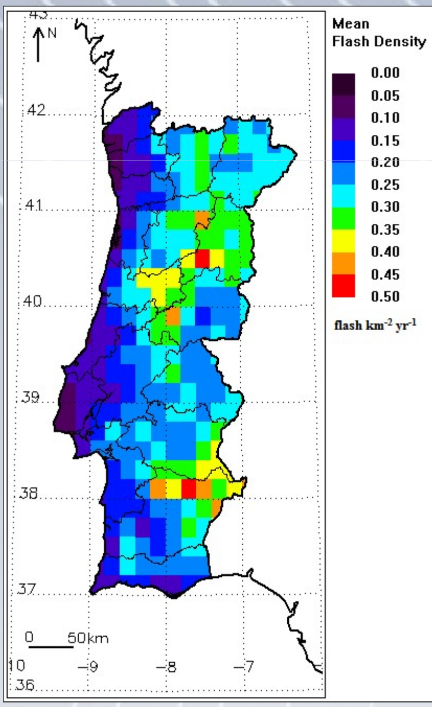
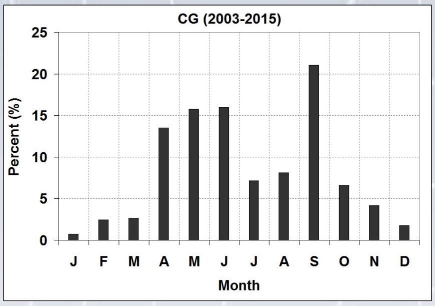


Figure 1. Mean flash density (flash km^{-2} yr^{-1}) distribution over a regular grid (0.2°x0.2°) for the period of 2003 to 2015 (13 years) in a plot X,Y (longitude, latitude).

Figure 3. LS7002 sensor.

Figure 2. Monthly distribution of CG occurrences (2003 to 2015) in mainland Portugal.



Method / Approach

• The forecast probability of lightning at IPMA is based on a logistic regression model using 4 stability indexes as predictors, which are computed using ECMWF numerical model. Essentially, stability indexes are any of several quantities that attempt to evaluate the potential for convective storm activity and that may be readily evaluated from operational sounding data, using among others temperature and dew point at different pressure levels.

• The predictors used in this study are the following static stability indexes: the Jefferson Index (JI), Modified Total Totals (TTm), Lifted Index (LI) and Showalter Index (ShI).

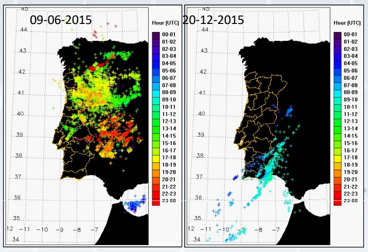
Static Stability Indexes

$$JI = 1.6^* \Theta_{w\,850} - T_{500} - 0.5^*(T_{700} - T_{d\,700}) - 8.0$$

$$TT_m = (T_{2m}+T_{925}+T_{850}) + ((T_{d\,2m}+T_{d\,925}+T_{d\,850})/3) - 2^*T_{500}$$

$$LI = (T_{env\,500}) - (T_{part\,500}) \quad » \; [1000, 925, 850 \text{ hPa}]$$

$$ShI = (T_{env\,500}) - (T_{part\,500}) \quad » \; [850\text{-}500 \text{ hPa}]$$



Test Cases & Simulation Results

• For the preliminary test cases two examples were selected, associated with different weather patterns: summer convection (09-06-2015) and winter cold front (20-12-2015) types. Another test case, pos-frontal system (02-02-2017) is presented in satellite imagery (**Fig.4**) and lightning occurrences were plotted (**Fig.5**), with additional information of CG polarity.

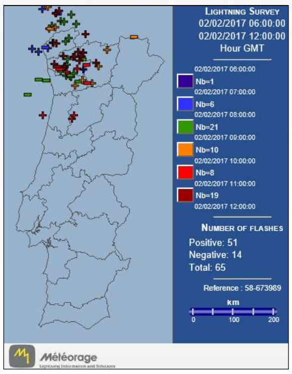
• For the simulation results a model was used based on 4 static stability indexes as predictors (**Fig.6**), computed with ECMWF numerical model fields (horizontal resolution of 16 km up to 6 days).

Satellite Imagery

Figure 4. Satellite product (RGB-HRV, 02-02-2017 at 09 UTC) from MSG - EUMETSAT.

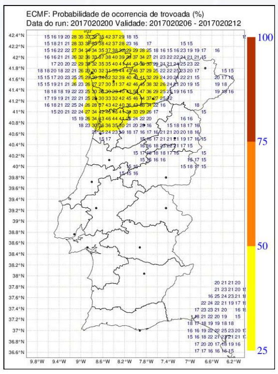
Lightning Data

Figure 5. Hourly CG occurrences for the day 02-02-2017 [06-12 UTC].



Simulation Results

Figure 6. Probability of CG occurrences for the day 02-02-2017 [06-12 UTC].



Conclusion

• Lightning observation and forecast in Portugal is important in areas such as those of energy and telecommunications network management, as well as weather hazard prevention and monitoring for civil protection services. Upgrade and improvements in the Portuguese LDN is essential, but also the quality of the forecasting model presented in this study will help to improve lightning predictability. The forecasting model is still under evaluation but preliminary results show that it provides useful guidelines in assessing both yearly incidence and the areas most affected by thunderstorm and lightning events. Climatology studies are also important and can bring further insight into the spatial and temporal distribution of lightning events, as well as on their possible correlation with weather patterns and orography.