



Figure 5. Intensity distribution of CG flashes as a function of month and time (UTC) averaged over 2001-2011.

to lower CG activity and vice versa lower Z values are related to higher CG activity. In addition, we obtain with the grouping algorithm that on average a CC flash consists out of 7 CC signals, whereas for every CG stroke 5 CC signals are detected within a given CG flash.

#### C. Annual variation

Fig. 2 shows an annual variability in amount of CG detections. This behavior is found as well when looking at the total lightning data (not shown here). 2010 clearly is the year with the least lightning activity, followed in 2011 with the largest amount of lightning detections. Annual variations are found as well in other parts of the globe. Hence, one could wonder what causes a sudden increase/decrease between subsequent years. The onset of thunderstorms has been studied by many authors in the past and various elements are found to impact the development of convective systems. One such factor is the convective available potential energy (CAPE); an indicator of atmospheric instability. Large values of CAPE imply that sufficient updraft velocities are available for the development of a thunderstorm. This in its turn leads to the necessary charge separation and subsequent occurrence of lightning discharges. An increase in lightning activity with CAPE has been demonstrated for instance by [8] and [9]. CAPE in its turn is controlled by the wet bulb temperature. A relation between lightning activity and surface wet bulb temperature was quantified for the first time in [10]. Some further investigation is needed to clarify whether during 2010 average CAPE values were rather low compared to 2011 to account for the observed discrepancies.

#### D. Seasonal and daily variation

The CG lightning activity as a function of month and time (UTC) is plotted in Fig. 5, averaged over 2001-2011. It clearly shows a seasonal dependence with lightning dominating during the summer months. On average 95% of annual lightning registrations are recorded between May and September with a

lightning peak in June. Furthermore, above 70% of the activity takes place in the afternoon with a maximum between 15:00-16:00 UTC.

#### V. TRANSMISSION LINES

High-voltage transmission lines between 30kV and 380kV in Belgium are mainly operated by ELIA. These lines have lengths of up to a few tens of kilometers, making them vulnerable to direct lightning hits or flashover events. Outage reports were provided by ELIA for 2011. In addition to line number and voltage level, the time of electrical failure with a timing accuracy of about 1-2s and the cause of the disruption is provided for each outage. The latter one is either classified as coming from an unknown source or is meteorological related, i.e., caused by lightning. A total number of 204 outages were reported in 2011, of which 117 are lightning related.

We apply this to the CG detections of OP and TP. An outage report is correlated to a CG detection if the time difference between the time stamp of the outage and the CG detection is within 5s, and the distance between the position of the CG and a tower belonging to the line is within 5km. From this, we find that out of the 117 lightning related outages OP and TP find in 56 and 86 of the cases, respectively, a CG detection that meets the above criteria. Both OP and TP find two additional correlations between a CG detection and an outage report with unknown cause. The lower amount of matches found by OP can be explained by the lower location accuracy (LA) of the system compared to TP. From the ground-truth campaign in August 2011 [7] the location accuracy has been derived for OP and TP using those CG flashes in the camera's field of view whose strokes follow the same channel. As the lower part of the channel is unresolved, the derived LA values are upper limits. A LA of 6km and 1km is found for OP and TP, respectively, owing to the different methodology in locating LF sources.

#### VI. CONCLUSIONS

We have presented total lightning characteristics over Belgium. The data is based on the Belgian lightning detection network over an 11-year period spanning 2001 through 2011. The amount of detections varies over the years and no clear trend is noticeable. The spatial lightning distribution over Belgium is somewhat inhomogeneous. However, this inhomogeneity could be at least partly attributed to the positions of the various sensors favoring detections in the center of Belgium. The latter needs further investigation. A mean CG stroke and flash density is found ranging from 0.74-1.8/km<sup>2</sup>/yr and 0.48-0.99/km<sup>2</sup>/yr, respectively. The CC/CG flash ratio experiences a yearly variation with an average value of 1.94. Most of the lightning activity takes place during the summer months with a peak in the afternoon. In addition, CG detections of 2011 have been correlated to outage reports of high-voltage transmission lines as well. A lower amount of CG detections observed by OP overlap with an outage report