Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AEM002-01 Room:201A Time:May 27 08:30-08:45

Observation, Modelling of Lightning Activity in Hurricanes

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Modern global lightning detection networks enable us to monitor and investigate the lightning activity in areas where there is little or no coverage by local lightning location systems, such as the remote regions or the oceans. Hence, we are now better able to track and understand the complex connection between hurricane development and electrical activity in these dangerous storms. In a recent study (Price et al., 2009) it was shown that in category 4-5 hurricanes (typhoons), there is a clear increase of lightning activity approximately one day before the maximum intensity (lowest pressure, strongest winds) of the storm. Additional analysis confirms this initial finding, possibly allowing us to use real-time lightning observations to forecast the time of hurricane intensification. We have also started modeling lightning activity in hurricanes using the WRF mesoscale meteorological model. Numerical simulations of the electrical activity in hurricanes, employing microphysical parameterization of the charging potential (using the Lightning Potential Index, LPI; Yair et al., 2010) show a reasonable agreement with the observations of lightning for the few case studies we have analyzed thus far. Both observations and modeling results will be presented.

Price, C., M. Asfur and Y. Yair, 2009: Maximum hurricane intensity preceded by increase in lightning frequency, Nature Geoscience, doi:10.1038/NGEO477, 2, 329-332.

Y. Yair, B. Lynn, C. Price, V. Kotroni, K. Lagouvardos, E. Morin, A. Mugnai, and M. d. C. Llasat (2010). Predicting the potential for lightning activity in Mediterranean storms based on the Weather Research and Forecasting (WRF) model dynamic and microphysical fields, J. Geophys. Res., 115, D04205, doi:10.1029/2008JD010868.

Keywords: Lightning, Hurricanes, Storm Intensity, Detection Networks, Modelling, WRF

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AEM002-02 Room:201A Time:May 27 08:45-09:00

Estimation of the global and Asian lightning activity based on the observation of ELF/VLF sferics

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In the recent decade, many researchers have been attracted to the investigation of global lightning activity. One of the reasons is the progresses in the observation of global lightning discharges. Measurements of electromagnetic waves radiated from CGs with ground-based systems have been developed drastically.

Electromagnetic wave radiated from could-to-ground (CG) lightning discharge is observed as transient waveform called as atmospherics or sferics. Sferics in the Very Low Frequency (VLF: 3-30 kHz) and Extremely Low Frequency (ELF: 3-3000 Hz) bands can be detected at a receiver which is several mega-meters from CGs due to the propagation with quite low attenuation. This long propagation enables us to monitor the global CGs activity only with single or few receivers. Using observed waveform in ELF or VLF range, information not only about the location but also about the electrical properties such as polarity, peak current and charge moment (Qdl) of individual lightning stroke can be derived.

In this study, we developed new algorithm to estimate location and charge moments for relatively small Qdl events ($|Qdl|>950$ C-km). This method is applied to the magnetic fields data observed in 1-100 Hz range obtained by global ELF observation network (GEON), Syowa station in Antarctica, Onagawa station in Japan, Esrange in Sweden, and Santa Cruz in U.S.A. Making use of the time-of-arrival method, the accuracy of geolocation and detection sensitivity is greatly modified. Thanks to this new algorithm, about a millions of CGs can be analyzed with one month (during January 2004). Global CGs distribution is derived with annual data (from October 2003 to July 2004) and about a million CGs whose Qdl are larger than 950 C-km are obtained. The results show the monthly and seasonal variation of global CGs distribution.

Furthermore, a new VLF observation network (Asian VLF observation network: AVON) is developed to monitor the activity of CGs in Southeast Asia. Observation sites of this system are located at Tainan in Taiwan, Saraburi in Thailand, and Pontianak in Indonesia. In this study, data observed at Tainan station and Pontianak station during three days (from October 13th, 2010 to October 15th, 2010) is used for the initial analysis. Using the waveforms obtained by this network, 1-3 sferics per seconds are geolocated. Median of geolocation error is estimated as 93 km comparing with WWLLN data using about 400 CGs located in the Maritime Continents. Furthermore, charge moment distribution for the CGs of $>$ 200 C-km in the Maritime Continents is derived with a combination of CG locations obtained by AVON and the transient waveform observed by GEON.

In this presentation, we introduce the speculation of new observation network to monitor the lightning activity in Southeast Asia and demonstrate the efficiency of combination of the measurement of ELF sferics and that of VLF ones.

Keywords: lightning, sferics, ELF, VLF

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AEM002-03 Room:201A Time:May 27 09:00-09:15

The characteristics of global lightning activities observed by ISUAL experiment

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Lightnings serve as an important charge transporter between cloud and ground, and emit sferics that propagate in the ground-ionosphere cavity. During the six-year observation of ISUAL/FORMOSAT-2, besides surveying upper atmospheric transient luminous events, more than 110,000 lightnings which exceeded the ISUAL trigger threshold were recorded. In this presentation, the distribution, the occurrence rate, distribution and seasonal variation of these lightnings at local time between 22:30 and 23:00 are reported and compared with those of the LIS experiment (Christian et al., 2003). The ocean-to-land ratio and geographic distributions suggests that the lighting recorded by ISUAL is averagely more energetic than the ones registered by LIS mission and intense lightning is more frequent over oceans. The anomaly of occurrence between warm and cold phases of ENSO will also be discussed in this presentation.

Keywords: Lightning, ENSO, ISUAL

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AEM002-04 Room:201A Time:May 27 09:15-09:30

Energetic radiation associated with thunderstorm activity

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Intense gamma rays likely associated with lightning and/or thunderstorm activities have been detected in recent years, at various altitudes ranging from the ground level to the ionosphere. However, neither the source of this radiation nor its nature has been clarified. We report gamma rays lasting for several minutes attributed to both winter and summer thunderstorms in Japan. Our findings in winter thunderstorm indicate that the gamma rays were emitted continuously from a downward hemispherical surface, the bottom of which was about 300 m above sea level, and this source of gamma rays moved from north to south above the observation site at a speed of about 7 m/s. The radiation source probably moved along with the charged region of the cloud at a height of around 1 km, because the estimated migration of the radiation source was consistent with the observed movement of atmospheric electric field variation between ground-based observation sites and with the wind speed and direction at about 1 km altitude. This movement implies that the intense electric field produced by the charged region in the thundercloud generated a radiation source beneath the charged region. On the other hand, gradual energetic radiations probably caused by a summer thunderstorm have been observed at the top of Mt. Fuji, Japan. The largest of such variation was gradual and lasted for about 20 minutes, and was found to be high-energy gamma rays having a continuous energy spectrum up to 10 MeV or more. Both the observations help explain probably the lightning initiation urged by the radiation.

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AEM002-05 Room:201A Time:May 27 09:30-09:45

ISUAL recorded halos brightness and their parent lightning emission

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Halo, another type of transient luminous event, is a bright disk at altitude 80-85 km above the thunderstorm. Unlikely the fact that almost exclusively +CG triggered sprites, most of halos were induced by -CG that occurred exclusively over the open water [Frey et al., 2007]. In this presentation, we analyzed total 185 ISUAL recorded pure halo events from July 2004 to Dec 2007. Using 1PN2-filter Imager, the average brightness of halos is ˜ 0.25 MR. We also derived the current moment using the 777.4 lighting emission of their parent lightning to [Adachi et al., 2009]. It is found that a relatively strong linear relationship between lightning peak current and lightning-induced halo emission. In total recognized 121 events by ELF radio emission at Nagycenk Observatory (NCK), Hungary, the polarities of their parent lightning for 23 halos are identified as +CG while 98 halos are for ?CG associated with NCK recorded ELF data. From NCK estimating CMC, we found a relatively weak correlation between NCK CMC and halo brightness. Furthermore, the extremely brightest halos over ocean were also found, and their lightning polarities were dominated by ?CG. The finding reflects the nature of intense peak current for oceanic lightning [Fullekrug et al., 2002]. It seems that lighting current may have more important effect on halos generation than charge moment.

Keywords: ISUAL, Halo

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AEM002-06 Room:201A Time:May 27 09:45-10:00

High-speed imagery of elves from airplane

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Elves are a kind of Transient Luminous Events (TLEs), which are optical events occurring in middle atmosphere and at lower ionospheric altitudes, and they are directly related to the electrical activity in underlying thunderstorm. Elves are occurring at an altitude of ˜90 km, can spread ˜300-600 km laterally and shape like a doughnut. In addition, the luminous duration at a certain point is ˜0.1 ms and the emission spread throughout within ˜2 ms with phase velocity which is faster than the velocity of light. The luminous duration of elves is extremely short.

The temporal and spatial emission variation of Elves have observed using multi -anode photometer arrayed in a vertical direction [Fukunishi et al., 1996], and using photometer arrayed in a broadband horizontal direction [Barrington-Leigh et al., 2001]. However, there was no two-dimensional image of Elves structural variation.

In full cooperation with NHK, we succeeded in capturing the first image using high-speed camera from jet airplane flown at an altitude of ˜13 km. The camera was installed on a window of airplane and trained on horizontally to the travelling direction. We used panchromatic camera, and frame rate is ˜8000 fps.

In November 28th, 2010, there were lightning swarm activities ˜400 km out at sea of Chiba prefecture from ˜18:00 and the data are images of elves which are that lightning induced. On the day, the airplane took off heading out to sea of Kanto at ˜20:30 and captured images from 21:48 to 22:45. We captured 21 TLEs for an hour and confirmed that at least 3 events of them are elves in initial analysis.

We investigate the relation between temporal and spatial variation of Elves structure and characteristics of parent lightning.