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Fourteen-years (1989-2002) of cloud-to-ground (CG) lightning data show a significant enhancement of lightning associated with Lake Charles and Baton Rouge, Louisiana. A peak density value of 7 flashes km⁻² yr⁻¹ exists on the western side of the Lake Charles urban area. The Lake Charles CG lightning enhancement is greatest during the summer season (June, July, and August), and for each season the greatest enhancement occurred during the late morning/afternoon (0900-1800 LT period). The percentage of CG flashes lowering positive charge to ground shows a relative minimum over Lake Charles and Baton Rouge (4-8%). The values of median peak negative current show a sharp difference between land and the Gulf of Mexico; inland values are near 24 kA, while over the Gulf waters immediately offshore the values are over 30 kA. A clear relationship between the CG lightning enhancements and the locations of sources of PM10 across Southern Louisiana suggests that pollution plays a key role in lightning enhancement. Urban effects can be neglected due to the small population of Lake Charles and the fact that most of the lightning enhancement is upwind (west) of the urban area. The Lake Charles anomaly is not associated with the sea breeze enhancement as it is 50 km inland from a nearly straight coastline. The observations of higher negative peak currents immediately off the Louisiana coastline and the existence of a relative minimum of negative peak current from the mouth of the Mississippi River southeastward into the Gulf gives support to the hypothesis that the surface conductivity influences the calculated negative current distribution. Land, fresh, and salt water have differing effects on the attenuation of a lightning discharge's electromagnetic signal as it travels over the particular surface. The signal is attenuated less over salt water (higher conductivity), making the negative peak current appear higher. Or alternatively, the peak current may be intrinsically higher over salt water, again because of the higher conductivity.

AE41B MCC: 3000 Thursday 1020h

Electrical Effects of Thunderstorms on the Middle and Upper Atmosphere I (joint with A, SA, SM)

Presiding: D D Sentman, Geophysical Institute, University of Alaska, Fairbanks; V P Pasko, Pennsylvania State University

AE41B-01 1025h INVITED

New Space Shuttle Observations of Transient Luminous Events During the MEIDEX

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The Mediterranean Israeli Dust Experiment (MEIDEX) was conducted on-board the space shuttle Columbia during its last mission in January 2003. Nocturnal observations with a multispectral CCD video camera were targeted above thunderstorms near the Earth's limb, with the aim of recording Transient Luminous Events (TLEs) in the mesosphere. Most of our nighttime observations were conducted in the SE-Pacific (Australia and Papua-New Guinea), equatorial Africa, the southern Indian Ocean and South America. Relevant inputs and information on the active storms during a specific orbit were uplinked to the crew daily. The necessary shuttle attitude maneuvers were deduced based on the use of (almost) real-time IR satellite images and VLF lightning location data that were available on the Internet. In order to enhance the probability of success of each observation, the astronauts were instructed to visually observe lightning activity (easily discernable from the shuttle) and to direct the gimbaled camera toward these regions. A total of more than 8 hours of video obtained during the MEIDEX was saved, and it includes a considerable amount of new sprite data. Most events were captured at ranges 1600-1900 km from the shuttle, using the red filter (665nm). The results suggest the occurrence rate of sprites and elves over oceanic and continental storms may be higher than earlier estimates. Strong enhancements of the brightness of the airglow layer above lightning flashes were observed, with lateral dimensions on the order of 400-500 km. It is assumed that these may be Elves observed edge-on, though it may also be a new type of airglow enhancement. The calculated brightness of these events is in the range 2.2-8.8 MR. This phenomena seems to be widespread and is probably a manifestation of the interaction between lightning EMP and QE fields and the lower nocturnal ionosphere. A unique observation from space of the Congo basin in Africa caught a chain of events where in the span of less than 2 minutes two meteors penetrated above a thunderstorm, that immediately afterwards generated several Sprites and Elves in the same atmospheric volume. This seems to confirm earlier observations and theoretical work on the role of meteors in mesospheric TLE generation. International, multiple-station ground-based ELF-VLF data obtained during the mission is used for geo-location of the parent flashes of the optically visible TELs.

AE41B-02 1045h

Geo-location of Sprites Observed from the Space Shuttle Columbia during STS-107 using ELF methods

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During the Mediterranean Israeli Dust Experiment (MEIDEX) on board the Columbia space shuttle, sprites, elves and other TLEs were observed by the astronauts using a multispectral CCD video camera. Simultaneously on the ground a number of groups collected extremely low frequency (ELF) electromagnetic data to try to identify, locate, and quantify parameters related to the parent lightning that triggered the TLEs. Using 5 ELF stations (Israel, Hungary, Japan, Antarctica and California) we were able to triangulate on numerous common events. In addition, we have developed a new method of determining the geo-location of the transient ELF sources using both horizontal-magnetic and vertical-electric field data at a single station (Israel). This method involves fitting the observed magnetic and electric field spectra to theoretical spectra with known source-receiver distances. Furthermore, we have found that it is possible to dramatically improve the bearing accuracy of the ELF transient signals by using the ratio of the Poynting vector components. We have initially focused on the TLEs observed over central Africa during the night of 22 January, 2003. The majority of transients on this night are related to positive CG flashes within these thunderstorms, though some events had no clear parent-lightning signatures in the ELF domain.

AE41B-03 1100h

Ongoing Studies of the Characteristics of Storms and Lightning Discharges Which Do and Do Not Produce Sprites

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Within a year after the first intentional ground and aircraft monitoring of sprites (1993), it had become apparent that this class of mesospheric transient luminous event was almost uniquely associated with positive polarity cloud-to-ground lightning strokes (+CGs). Yet not all +CGs, even those with high peak currents, produce sprites. Moreover, sprite parent +CGs (SP+CGs) tend to occur only in certain types of convective storm systems. On the U.S. High Plains, the SP+CGs are most common in the stratiform precipitation regions of mature mesoscale convective systems (MCSs) larger than 10-20x10**4 km**2. The summer 2000 Severe Thunderstorm Electrification and Precipitation Study (STEPS) produced the most complete database of coordinated low-light television (LLTV), 3-D lightning mapping array (LMA) and remote ELF transient data available to date. A major question is whether large charge moment changes are both a necessary and a sufficient condition for sprites? This presentation presents the results of a reanalysis of the STEPS database which, aided by ELF charge moment change estimates,

AE41A-07 0935h INVITED

Objective classification of radar profile types, and their relationship to lightning occurrence

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A cluster analysis technique is used to identify 16 "archetypal" vertical radar profile types from a large, globally representative sample of profiles from the TRMM Precipitation Radar. These include nine convective types (7 of these deep convective) and seven stratiform types (5 of these clearly glaciated). Radar profile classification provides an alternative to conventional deep convective storm metrics, such as 30 dBZ echo height, maximum reflectivity or VIL. As expected, the global frequency of occurrence of deep convective profile types matches satellite-observed total lightning production, on scales down to very local features. Each location's "mix" of profile types provides an objective description of the local convective spectrum, and in turn, is a first step in objectively classifying convective regimes. These classifiers are tested as inputs to a neural network which attempts to predict lightning occurrence based on radar-only storm observations, and performance is compared with networks using traditional radar metrics as inputs.

URL: <http://homepage.mac.com/wxguyinal/Cluster/Cluster.htm>

has revealed substantially more events than in the original catalog. Particular attention is paid to charge motion changes in three major classes of storms, (1) MCSs with many SP+CGs in the stratiform region, (2) supercells with only sporadic sprite events during restricted portions of their life cycle, and (3) MCSs and supercell storms which, in spite of many +CGs, produce no transient luminous events. In addition, the characteristics of continuing currents in High Plains lightning discharges monitored using high speed video cameras (1000 fps) is compared with ELF/ULF measurements (Courtesy: Martin Fullekrug). Additional observations of sprites and elves were obtained during summer 2003, in conjunction with an upgraded Duke University ELF transient monitoring system. Some initial results will be presented.

AE41B-04 1115h INVITED

Fine structures, velocity and the ELF signature of gigantic jets*

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Gigantic jet is a type of transient luminous events that optically connect thundercloud-top and the ionosphere [Su et al., Nature 423, p974-976, 2003]. The dynamical evolution of gigantic jets can be divided into three stages: the leading jet, the fully developed stage, and the trailing jet. At the fully developed stage, the upper portion of the gigantic jets is very similar to classical sprites, and the lower portion remembers blue jets. In this talk, a few interesting properties and the spatial-temporal evolution of the fine structures of gigantic jets will be discussed. The ELF and the lightning signatures of the gigantic will also be compared, and a possible generating mechanism will be presented. * This work was partially supported by 92-NSPO(B)-ISUAL-FA09-01 and NSC 92-2111-M-006-002

AE41B-05 1135h

Dynamics of Streamer-to-Leader Transition in Transient Luminous Events Between Thunderstorm Tops and the Lower Ionosphere

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Sprites commonly exhibit vertically oriented branched structures filling large volumes of atmosphere in the altitude range 40-90 km above thunderstorms [e.g., Gerken and Inan, JASTP, 65, 567, 2003]. These structures likely represent scaled by atmospheric pressure versions of weakly ionized thin channels of ionization, called streamers, which are commonly observed during initial stage of discharge development in short (several cm) gaps in relatively cold (i.e., 300 K) air at ground pressure [Raizer, Gas Discharge Physics, 1991, p. 334]. The appearance of sprites is very different from the lightning phenomenon occurring at near ground pressures, which deposits large amounts of energy in relatively small volumes leading to total single ionization of atoms [Raizer, 1992, p. 373]. Recent observations of transient luminous events (TLEs) emanating from thundercloud tops, exhibiting some lightning like features near the cloud tops, and then propagating upward through the altitude range typically occupied by sprites [Wescott et al., JGR, 106, 21549, 2001; Pasko et al., Nature, 416, 152, 2002; Su et al., Nature, 423, 974, 2003] represent an opportunity to study a transition from lightning-like structures at thundercloud altitudes to large scale filamentary sprite-like structures at the lower ionospheric altitudes. It is likely that this type of TLEs originates from a streamer zone of conventional lightning leaders and represents a "final jump stage" of the leader process, when the streamer zone of a leader makes contact with the opposite electrode (i.e., ionosphere) [Pasko and George, JGR, 107, doi:10.1029/2002JA009473, 2002]. The understanding of streamer-to-leader transition and scaling of this transition as a function of atmospheric pressure therefore represents a first necessary step toward understanding of complex dynamics of optical features observed in these events. In this talk we will present results of modeling studies, which allow investigation of effective time scales of the initial stage of

air heating in streamer channels up to 5000 K at which the thermal ionization becomes important. The model is zero-dimensional and accounts for time dynamics of air heating and ionization at a fixed point inside of the streamer channel. The model is derived from previous studies conducted for similar purposes at ground pressure [Lowke, J. Phys. D: Appl. Phys., 25, 202, 1992; Naidis, J. Phys. D: Appl. Phys., 32, 2649, 1999; Vidal et al., IEEE Trans. Plasma Sci., 30, 1339, 2002]. In the first part of the talk for calibration purposes we will present comparisons of our model and available laboratory data on time scales of air heating in streamer channels at ground and near ground pressures [Larsson, J. Phys. D: Appl. Phys., 31, 1998] following approach described in [Naidis, 1999]. In the second part we will present results corresponding to a range of air pressures, electric fields and electron densities representative of conditions in streamer channels at TLE altitudes. The obtained transition times indicate that the re-brightening events observed by Pasko et al. [2002] and trailing jet events observed by Su et al. [2003], which terminate at altitudes around 50-60 km, likely correspond to the final section of an upward leader, which was not able to complete the next step due to a dramatic increase in air heating time scales above 50 km.

AE41B-06 1150h

The Sprite2003 Campaign

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During the northern hemisphere summer of 2003, from July 18 to September 18, a sprite observation campaign was conducted with measurements from Southern Europe, coordinated with measurements from the magnetically conjugate region in South Africa. The goal of the campaign was to investigate the electromagnetic signatures of sprite emissions, their effect on the ionosphere above, and possible effects of the relativistic acceleration process manifested in the magnetically conjugate hemisphere. Measurements in Europe included optical video imaging from a remotely controlled, semi-automatic, camera system located at the Observatoire Midi Pyrenee in the Pyrene mountains in Southern France, and ELF-HF electromagnetic observations from several locations. The observations in South Africa included kHz time-resolution measurements of optical emissions taken by an array of 6 photometers and VLF electromagnetic emissions. The presentation will give an overview of the campaign, the meteorological conditions, and present some first results.

URL: <http://www.dsri.dk/~neubert/sprite2003>

AE41B-07 1205h

A Semi-Automatic, Remote-Controlled Video Observation System for Transient Luminous Events

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In support for global ELF/VLF observations, HF measurements in France, and conjugate photometry/VLF observations in South Africa, we developed and operated a semi-automatic, remotely controlled video system for the observation of middle-atmospheric transient luminous events (TLEs). Installed at the Pic du Midi Observatory in Southern France, the system was operational during the period from July 18 to September 15, 2003. The video system, based two low-light, non-intensified CCD video cameras, was mounted on top of a motorized pan/tilt unit. The cameras and the pan/tilt unit were controlled over serial links from a local computer, and the video outputs were distributed to a pair of PCI frame grabbers in the computer. This setup allowed remote users to log in and operate the system over the internet. Event detection software provided means of recording and time-stamping single TLE video fields and thus eliminated the need for continuous human monitoring of TLE activity. The computer recorded and analyzed two parallel video streams at the full 50 Hz field rate, while uploading status images, TLE images, and system logs to a remote web server. The system detected more than 130 TLEs - mostly sprites - distributed over 9 active evenings. We have thus demonstrated the feasibility of remote agents for TLE observations, which are likely to find use in future ground-based TLE observation campaigns, or to be installed at remote sites in support for space-borne or other global TLE observation efforts.

URL: <http://www.dsri.dk/~neubert/sprite2003>

AE42A MCC: Level 2 Thursday 1330h

Electrical Effects of Thunderstorms on the Middle and Upper Atmosphere II Posters (joint with A, SA, SM)

Presiding: D D Sentman, Geophysical Institute, University of Alaska, Fairbanks; **V P Pasko**, Pennsylvania State University

AE42A-0784 1330h POSTER

The Spectroscopy and Energetics of Red Sprites

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During the past decade, the study of red sprites has evolved from the observation of general physical properties and application of relatively simple models to detailed research into the fundamental nature of the morphology, chemistry, and energetics of this highly dynamic phenomenon. Spectroscopy is one area that has provided significant information on the energetics and chemistry of sprites. This includes observations from video spectrographs and narrow band imaging and photometry. This talk will review spectroscopic and photometric observations and present recent results on ionization and electron energetics observed in sprites.