AE41A MCC: 3020 Thursday 0800h

Lightning, Meteorology, and Climate II *(joint with A, H)*

Presiding: **E Williams,** Massachusetts Institute of Technology**; W A Petersen,** University of Alabama in Huntsville

AE41A-01 0800h INVITED

Improving Convective Precipitation Forecasting Through Assimilation of Regional Lightning Measurements in a Mesoscale Model

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A technique developed for assimilating regional lightning measurements to a mesoscale meteorological model is presented. The aim is to improve the short-term forecasting of convective rain rates by dynamically initializing the model's vertical air moisture distribution on the basis of real-time lightning information. Utilizing location, timing and flash rate data, retrieved from a long-range network of sferics receivers in Europe, a mesoscale meteorological model is informed as to when and where a deep moist convection is occurring. The model's convective parameterization scheme decides whether the air moisture that feeds the storm has to be enhanced. Moisture amounts, related to the observed flash rates, are added to the layers associated with a model estimated convective cloud and coincidental observation of lightning occurrence. Lower moisture amounts are added to model layers that are not within a convective cloud in order to trigger convection in the next time-steps. Our philosophy is to determine the most appropriate corrections to simulate more realistic moisture profiles for the model's convective parameterization scheme. The relationship between flash rate and the vertical distribution of air moisture is investigated for a number of experimental moisture adjustment profiles. The study is facilitated based on three flood inducing storm cases associated with deep convection in a warm-season environment over the Mediterranean region. We show that assimilating lightning data can improve the model's description of the mesoscale environment resulting in an improved forecast of convective precipitation at lead times ranging from one to twelve hours. The approach is general enough to apply to any mesoscale model, but with an expected varying degree of success.

AE41A-02 0820h

Lightning Behaviour in the Northwest Territories, Canada

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Thunderstorms play an important role in the cycling of water and energy over the boreal ecosystem of the Northwest Territories (NWT) of Canada during the warm season. Associated lightning activity can also initiate forest fires. Global distributions of lightning derived from satellite observations indicate that this region experiences a relatively large amount of lightning, given its high latitude location. However, no previous work has been directly applied to the NWT. A variety of data sets have been used to study lightning activity, cloud and convective processes in the water cycle and their impacts on the forests of the NWT for the 1994-1999 fire seasons. These include the archived strike data from the lightning detection network operating in the NWT, fire data from the Canadian Forest Service's national Large Fire Database, surface and upper-air station data, and historical gridded data from the Environment Canada and the National Centers for Environmental Prediction (NCEP) digital archives. Lightning activity over the NWT is linked with its geographic alignment, large scale flows, and diurnal heating cycle. The convective storm season and resultant lightning activity is characterized as short but intense with a strong peak in cloud-to-ground lightning during June and July. The maximum area of lightning activity varies in space and in time and is influenced by local moisture sources (such as wetland areas and small lakes) and by topography. The diurnal distribution of strikes indicates that most of the lightning is linked with daytime-heating initiated thunderstorms. There was a relatively low amount of lightning activity during the 1994-95 seasons but an unusually high fraction of positive lightning strikes during 1995. The positive ground strikes may have been influenced by the presence of smoke from fires. Lightning-initiated fire occurrence peaks during July, while much of the burned area occurs in June. Events with an especially large number of lightning strikes (more than 2000) are characterized by the eastward progression from the Gulf of Alaska toward the Mackenzie Basin of an anomalously strong 500-hPa trough, and the associated breakdown of a strong 500-hPa ridge over the NWT.

AE41A-03 0835h

The Meteorological Setting of Narrow Bipolar Events

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Narrow Bipolar Events (NBEs) are an impulsive form of electrical breakdown in storms which emits strong VHF radiation. It is well known that these events can be readily detected by VHF receivers in orbit and thus may provide a highly practical means to globally monitor storm activity. However, relatively little is known about how NBEs relate to the convective phase of storms and of how good a predictor they are of severe weather events such as large hail, damaging winds, and tornadoes. On June 10, 2002, numerous energetic NBEs were detected over Kansas by the Los Alamos National Laboratory Edot array, which is primarily located in Florida. These NBEs were also detected by a VHF receiver on-board the SVN 54 GPS satellite. The NBEs were associated with severe thunderstorms which produced softball size hail exceeding 11 centimeters in diameter and a weak F0 tornado. In another case study, several F2 tornadic Florida storms were analyzed for March, 2001. Unlike the Kansas storms, the NBEs of the Florida tornadic storms were spread out over a much wider area and exhibited considerable variability in both frequency of occurrence and predominant polarity of vertical charge transfer. To further explore the significance of the NBE rate variability, we will analyze NEXRAD radar volume scans in conjunction with Edot 3-dimensional locations to better understand how NBEs correlate with the thunderstorm life-cycle.

AE41A-04 0850h

Intraseasonal Forcing of Lightning and Convective Activity in the Southern Amazon as a Function of Cross Equatorial Flow

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Recently, Wang and Fu (2002) developed a monsoon-index (V-index; VI), based on changes in cross-equatorial 925 hPa meridional wind flow in the northwest Amazon. This index appears to be a robust metric of seasonal and intraseasonal changes in precipitation regime (e.g., wet vs. dry) across the Amazon and other parts of South America. While the VI identifies continental-scale variability of the monsoon, it yields no information on structural changes in the convective regime. For example, how does the overall three-dimensional structure of convection change as a function of VI-regime? Similarly, how are transitions in VI-regime manifested in lightning trends? In an effort to answer these questions we have examined four wet seasons (Dec.-Mar., 1998-2001) of TRMM satellite Lightning Imaging Sensor (LIS) and Precipitation Radar (PR) data in addition to two wet seasons (2000-2001) of ground-based Brazilian Lightning Detection Network (BLDN) data over South America. Composited LIS data indicate that the most statistically significant wide-spread response to VI-regime changes occurs over the south-central Amazon (SCAMZ), with other noticeable variations observed over portions of the subtropical Altiplano and Parana River basin. Most notably, over the SCAMZ both LIS and BLDN lightning data suggest for the southerly (northerly) VI-regime: 1) a pronounced widespread increase (decrease) in lightning activity; 2) a marked increase (decrease) in the amplitude of the diurnal cycle of lightning; (3) in association with (1) and (2), a factor of two relative increase (decrease) in the probability of any radar reflectivity pixel exceeding 30 dBZ above the freezing level; (4) an associated 20% increase (decrease) in pixel-mean ice water contents between the 7 and 11 km levels; and (5) an increase (decrease) in the relative frequency of occurrence of large rain rates. Interestingly, while our results suggest the presence of more vertically developed convection, lightning, attendant ice processes, and a larger relative fraction of high rain rates over the SCAMZ during the southerly-VI, the results of Wang and Fu (2002) suggest that greater mean daily rainfall totals occur over the SCAMZ during the northerly phase of the VI. One explanation for the apparently opposite trends in behavior between convective vertical structure/lightning and rainfall between VI-regimes, appears to reside in comparisons of the relative area coverage and/or frequency of precipitation in both regimes. For example, TRMM PR data indicate that the number of significantly raining pixels (reflectivity >20 dBZ) per orbit below the 4 km level is 33% larger in the northerly VI-regime than that of the southerly. Hence VI-regime transitions over the SCAMZ do affect changes in lightning frequency and vertical distributions of convective intensity, but these trends may behave in an opposite sense to raining-pixel area coverage and daily mean rainfall. Wang, H., and R. Fu, 2002: Cross-Equatorial flow and seasonal cycle of precipitation over South America. *J. Climate*, **15**, 1591-1608.

AE41A-05 0905h

African Lightning-Climate Variability

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Africa is one of the hot spots of global lightning activity, being the continent that produces the largest amount of lightning, based on satellite measurements. These thunderstorms over the tropical African continent are also a large contributor to the flux or moisture, heat and momentum between the tropics and the mid-latitudes. Understanding the variability of thunderstorm activity in the tropics may help us understand the Earth's complicated climate system. Although there are no continuous lightning data available from Africa, it is possible to monitor the regional lightning activity over Africa using remote sensing of extremely low frequency (ELF) radio waves in the Schumann resonance band (5-25 Hz). Schumann resonance (SR) data from the Negev Desert, Israel, were used to track the lightning activity over Africa, and then compared with the National Oceanic and Atmospheric Administration (NOAA) National Center for Environmental Prediction (NCEP) reanalysis product of various climatically important parameters over Africa (specific humidity, relative humidity, temperature, precipitable water, etc.) We have found that on a daily basis the tropical African climate parameters are highly correlated with the SR African lightning observations. We have also investigated the connection between the African lightning activity and the Hadley circulation over Africa, which show strong positive correlations.

URL: http://luna.tau.ac.il/~colin

AE41A-06 0920h

Southern Louisiana: Compelling Evidence for Pollution Enhancing Cloud-to-Ground Lightning

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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 or 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