AE32A MCC: Level 1 Wednesday 1330h

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

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

AE32A-0156 1330h POSTER

Trace Gas Transport and Lightning NO_x Production during a CRYSTAL-FACE Thunderstorm Simulated using a 3-D Cloud-Scale Chemical Transport Model

L. Ott[1] (leo@atmos.umd.edu); K. Pickering[1] (pickerin@atmos.umd.edu); G. Stenchikov[2] (gera@envsci.rutgers.edu); R.-F. Lin[3] (lin@agnes.gsfc.nasa.gov); B. Ridley[4] (ridley@ucar.edu); J. Lopez[5] (jlopez@mail.arc.nasa.gov); M. Loewenstein[5] (Max.Loewenstein-1@nasa.gov); E. Richard[6] (richard@al.noaa.gov)

[1]Department of Meteorology, University of Maryland, College Park, MD 20742, United States

[2]Department of Environmental Sciences, Rutgers University, 14 College Farm Road, New Brunswick, NJ 08901-8551, United States

[3]Goddard Earth Sciences and Technology Center/University of Maryland Baltimore County, Code 912 NASA Goddard Space Flight Center Greenbelt Road, Greenbelt, MD 20771-0001, United States

[4]Atmospheric Chemistry Division, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-3000, United States

[5]NASA Ames Reseach Center, Mail Stop 245-5, Moffett Field, CA 94035-1000, United States

[6]NOAA Aeronomy Lab, 325 Broadway, Boulder, CO 80305-3328, United States

As part of the Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Florida Area Cirrus Experiment (CRYSTAL-FACE), a number of thunderstorms were observed by aircraft and radar in July, 2002. Measurements of CO, O_3, and NO were conducted onboard the NASA WB-57 within the anvils of the Florida storms. Observations of cloud-to-ground lightning were available from the National Lightning Detection Network for the project's duration. Selected CRYSTAL-FACE storms were simulated using the PSU/NCAR mesoscale model (MM5) and the resulting meteorological fields were used to drive an offline cloud scale chemical transport model (CSCTM) developed at the University of Maryland. The transport of CO, NO_x, and O_3 was simulated, as was the production of NO_x by lightning. Transport in the model was tested through comparisons of the probability distributions of simulated CO and O_3 with those constructed from the anvil observations. An estimate of NO_x production per lightning flash is obtained by comparing in situ chemical observations with model results.

AE32A-0157 1330h POSTER

In Situ Observations of Lightning-Produced Nitric Oxide in Thunderstorm Cores

John H Helsdon[1] (605-394-1987; john.helsdon@sdsmt.edu)

Andrew G Detwiler[1] (andrew.detwiler@sdsmt.edu)

Donald R MacGorman[2] (dmacgorm@gcn.ou.edu)

Brad Baker[1] (brad.baker@sdsmt.edu)

Tom A Warner[1] (tom.warner@sdsmt.edu)

[1]Institute of Atmospheric Sciences, SD School of Mines and Technology 501 E. St. Joseph St., Rapid City, SD 57701-3995

[2]CIMMS/Univ. of Oklahoma, 100 E. Boyd Rm 1110, Norman, OK 73019

The SD School of Mines & Technology armored T-28 aircraft was deployed to Norman, OK, from 14 May - 10 June 2003 in order to obtain measurements of lightning-produced nitric oxide (NO) mixing ratios in the cores of active thunderstorms (17 - 21 kft altitude range) in conjunction with lightning channel locations determined by the newly-installed NSSL lightning mapping array (LMA). To sample the NO, a TEI 42C-TL NO/NOx analyzer was used, operating in the NO-only mode. The inlet tube for the sampling system was situated above and behind the pilot's canopy along the aircraft axis. Six research and two calibration/test flights were conducted. Electric fields rarely exceeded 50 kV/m in the regions sampled with hydrometeors comprised of aggregates, graupel, and small hail. The TEI instrument often indicated broad regions of elevated NO that may have accumulated from many lightning discharges over a period of time, which were then distributed by convective circulations. A number of instances of narrow NO spikes were observed that we attribute to recent lightning discharges that passed through the sampled region. Peak values were typically from a few to 10s of ppbv. In one instance lightning attached to the T-28's propeller. The NO reading rose to 180 ppbv in one second, then decayed. Depending on the actual time during which NO generated during this discharge entered the inlet (probably less than one second), and subject to a more refined calibration of the raw instrument reading, we estimate that the peak mixing ratio to have been in the range of 0.5-1 ppmv. With the LMA-derived lightning locations anticipated to be available shortly, we will present a more refined analysis of the overall NO mixing ratio structure within these thunderstorm cores as well as analyses of the NO spikes, focusing on the lightning strike to the aircraft.

AE32A-0158 1330h POSTER

NOx Production in Laser -Induced Plasma as a Function of Dissipated Energy

Mahbubur Rahman[1] (+46-18-4715805; Mahbubur.Rahman@hvi.uu.se)

Vernon Cooray[1] (+46-18-4715809; Vernon.Cooray@hvi.uu.se)

[1]Division for Electricity and Lightning Research, The Department of Engineering Sciences, The Ångström Laboratory, Uppsala University, Box 534, Uppsala SE-751 21, Sweden

Lightning has been identified as a potentially important natural source of nitrogen oxides (NOx =NO+NO2) and thus several laboratory experiments have been conducted to measure the NOx production as a function of energy dissipated in sparks and laser plasma discharges. Chameides et al. [1977] measured NOx production in air subjected to a centimetre long spark by chemiluminescenc and derived a yield of (6 1) 1016 molecule J-1. The sparks were generated by a 35 kV electrostatic generator, yielding an energy of 36 mJ per spark. Levine et al. [1981] measured NOx production in air using chemiluminescent technique from several centimetre long sparks having a discharge energy of 12 kJ, which is more than a five order of magnitude energy increase compared to the energy produced in Chemeides experiment and derived a yield of (5 2) 1016 molecule J-1. Hill et al. [1988] investigated also the production of NO in atmospheric coronas using a specially designed plasma reactor operated at a pressure of 0.1 MPa and a temperature of 300 K and found a yield of NO to be (1.4 0.7) 1016 molecule J-1. Wang et al. [1998] employed sparks with lightning like peak currents of up to 30kA, a spark of 4 cm long at atmospheric pressure and found that the production was about (15-40 1016) molecule J-1. Navarro-González et al. [2001] simulated lightning in the laboratory by a laser-induced plasma generated by a pulsed Nd.YAG laser at 1064 nm and found a yield of NO to be 1.5 0.5 1017 molecule J-1. Rehbein et al. [2001] measured NOx from a 0.5-2.0 cm long sparks in the energy range of 0.5-2.5 J by chemiluminescenc and derived a yield of (2.97 0.2) 1016 molecule J-1. An experiment on the production of NOx from a DC corona discharge maintained by applying a high voltage to the central wire of a coaxial metal cylinder, has also been conducted by Rehbein et al. For the estimated energy dissipated in the discharge of about 0.4 mJ it has been found that the NOx yield was slightly higher for the positive corona and the NOx production was in general two orders of magnitude smaller than that of spark discharges (3-5) 1014 molecule J-1. Here an experimental study on the production of NOx as a function of dissipated energy in laser-produced plasma in air is presented. A plasma was produced by focusing a (60-180)mJ, 5-ns, 532-nm pulse from a Q-switched Nd:YAG laser. The results show that the produced NOx molecules per joule in the case of laser plasma at 532 nm is comparable to the case of electrical discharges. The results also show that the NO and NOx production rates are linearly correlated to the dissipated plasma energy, within the studied energy range. From the results one can observe that the laser plasma with energy in the range of 13-99 mJ generates 6.7 1016 NOx molecules per joule and 4.6 1016 NO molecules per joule.

Reference Chameides W L, et. al.J Atmos Sci 1977;34:143-9. Hill R. D., et. al. Ind. Eng. Chem. Res. 1988;27, 1264-9. Levine J S, et. al. Geophys Res Lett 1981;8:357-60. Navarro-González R. et. al. Geophys. Res. Lett. 2001;28(20):3867-70 Rehbein N.et. al. J. Electrostatics 2001;51-52:333-9 Wang Y et. al. J Geophys Res 1998;103(D15):19149-59.

AE32A-0159 1330h POSTER

The Appalachian Lightning Jump

Gary R Huffines[1] (970-351-1071; gary.huffines@unco.edu)

Richard E Orville[2] (979-845-9244)

[1]University of Northern Colorado, Department of Earth Sciences Ross Hall Campus Box 100 University of Northern Colorado, Greeley, CO 80634, United States

[2]Texas A&M University, CIAMS Texas A&M University, College Station, TX 77843-3150, United States

Cloud-to-ground (CG) lightning flash densities have been consistently lower over the Appalachian Mountains than in surrounding regions, as recorded by the National Lightning Detection Network (NLDN). The decreased lightning activity might be expected as the mountain range can reduce the amount of low level convergence in storms moving through that area. One feature that has not been documented is when CG lightning activity stops completely when a storm system reaches the Appalachians from the west and northwest and begins again as the storm moves beyond the mountains to the east. The occurrences of this lightning jump over the Appalachian Mountains are presented along with some characteristics of the storms exhibiting this behavior.

AE32A-0160 1330h POSTER

Combined Climatology of Lightning and Radar Data for Central Europe

Ullrich Finke[1] (49-511-762-4453; finke@muk.uni-hannover.de)

Thomas Hauf[1]

Oliver Kreyer[1]

Michael Theusner[1]

[1]Institute of Meteorology and Climatology, University of Hannover, Herrenhaeuser Str. 2, Hannover 30419, Germany

Central Europe is a region with highly variable thunderstorm activity. The annual number of thunderstorm days in this area varies between 13 days in the northern parts and 26 days in the alpine region with a high interannual variability. Around the half of all storms are related to frontal systems. The northern parts have a considerable number of winter thunderstorms. Basing on lightning location data for the years 1992-2003 a climatology of lightning and storm occurrence is presented. The geographical distribution is analyzed, particularly with respect to orography and the regions where the storm development starts. The statistical distribution of lightning is compared against the convective precipitation amount as derived from operational radar data and ground observations. The correlation to the various stability indices is critically analyzed. Since 2003 the data from a newly installed SAFIR system for an area of 200km x 200km in Northern Germany are available. SAFIR data contain both cloud-to-ground and intracloud lightning. A comparing statistical analysis of these data is given with emphasis to the temporal evolution of both types of lightning.

AE32A-0161 1330h POSTER

Combined TOA/MDF Lightning Location Using Three Globally Distant Sites

Troy G Wood[1] (650-723-3789; twood@stanford.edu)

Umran S Inan[1] (650-723-4554; inan@nova.stanford.edu)

[1]Stanford University, 350 Serra Mall St David Packard Bldg Rm 351, Stanford, CA 94305, United States

Lightning discharges generate electromagnetic pulses, known as sferics, that propagate through the waveguide formed by the earth and the ionosphere. The energy in the VLF band of the sferic can propagate over great distances (∼10,000 km) with low loss (3 dB/Mm) and can therefore be detected far from the source lightning location. Using sferic measurements from VLF receivers located at three globally separated sites (Palmer Station, Antarctica; Upland, Indiana; Sde Boker, Israel) the locations of individual lightning discharges are triangulated. Both time of arrival (TOA) and magnetic direction finding (MDF) data are used in the location algorithm. The very large distances between receiver sites and a high global sferic rate (∼100 per second) create space-time complications in the correlation of data between sites causing ambiguities in the pairing of sferics detected at one site to their corresponding sferics detected at the other two sites. These complications sometimes result in the detection of "ghost" lightning discharges which occurs when physically inconsistent (not originating from the

same lightning discharge) yet statistically consistent (acceptable arrival times and azimuths) sferics are used in the location algorithm. Both "ghost" event reduction and location accuracy for three verses two station location are discussed. Selected results are shown from August 2002.

AE32A-0162 1330h POSTER

Lightning Climatology: Median Peak Current Increase Along the U.S. Coast

Brandon L Ely[1] (979-845-7655; bely@tamu.edu)

Richard E Orville[1] (979-845-9244; rorville@tamu.edu)

[1]Texas A&M University, Department of Atmospheric Sciences, College Station, TX 77843-3150, United States

Climatological studies of cloud-to-ground (CG) lightning have discovered interesting features across the United States. One such feature that has been noted in previous research is a sharp increase in the median negative peak currents along the U.S. coasts. The values over the ocean are consistently higher than over land with a rapid increase of approximately 4kA at the coastline. The median positive peak currents also show an increase offshore. However, there is no distinct change at the coastline. One explanation for this observation is the higher conductivity of the salt water decreases the attenuation of the electromagnetic signal of the CG flashes over the water. This would lead to a flash that would appear stronger to the NLDN sensors. However, there is a problem with this hypothesis. If the attenuation explanation is correct, the same sharp transition at the coastline should be seen in the positive peak current. A possible explanation for the absence of the sharp coastline increase in the positive peak currents is due to intracloud flashes, which are detected as weak positive CG flashes and contaminate the dataset. To minimize contamination all positive flashes below 10kA are omitted. However, this cutoff can also remove weak positive CG flashes and leave strong intracloud flashes in the dataset. Analyses of the peak currents for selected locations along the U.S. coasts are performed to determine the validity of this hypothesis.

AE32A-0163 1330h POSTER

Cloud-to-Ground Lightning and Surface Rainfall During Warm-Season Thunderstorms in Florida

Bruce Gungle[1] (520-670-6671 Ext 233; bgungle@usgs.gov)

E Philip Krider (520-621-6836; krider@atmo.arizona.edu)

[1]Inst of Atmospheric Physics, University of Arizona, Tucson, AZ 85721-0081

Relationships between cloud-to-ground (CG) lightning and surface rainfall have been studied in 9 isolated, warm-season thunderstorms near the Florida seacoast. Counts of CG lightning flashes and the associated rain volumes were measured as a function of time in storm-centered reference frames that followed each storm over a network of rain gauges. Values of the storm-integrated rain volume per CG flash range from 6.6 x 10**3 to 6.4 x 10**4 cubic meters per CG flash, with a mean and standard deviation of 2.4 x 10**4 $\pm$ 2.1 x 10**4. Lag correlation analyses (using 5 minute bins) between the CG lightning and rainfall rates show that the peak rainfall followed the lightning (positive lag) by 0 to 20 minutes in 7 storms, and 2 storms showed no significant lag. A plot of the optimum precipitation lag (in the 7 storms that had a positive lag) vs. the total number of CG flashes shows a linear trend (R2 = 0.78), a result that suggests storms with more CG flashes have longer lags, but our statistics are limited. A plot of the lagged rain volume vs. the concurrent CG flashes in all storms shows a linear correlation (R2 = 0.81) with a slope that corresponds to 1.6 x 10**4 cubic meters per CG flash. We conclude that warm-season thunderstorms in Florida produce a relatively constant precipitation volume per CG flash, and that CG lightning can be used as a proxy for the location and intensity of convective rainfall in that weather regime.

AE32A-0164 1330h POSTER

Rainfall, Convective Intensity, and Lightning Characteristics of Tropical Mesoscale Convective Systems according to TRMM

Stephen W Nesbitt[1] (970-491-6944; snesbitt@atmos.colostate.edu)

Robert Cifelli[1] (970-491-8516; rob@atmos.colostate.edu)

Steven A Rutledge[1] (970-491-8283; rutledge@atmos.colostate.edu)

Daniel J Cecil[2] (256-961-7549; Daniel.Cecil@msfc.nasa.gov)

Edward J Zipser[3] (801-581-6137; ezipser@met.utah.edu)

[1]Colorado State University, Department of Atmospheric Science, Fort Collins, CO 80523

[2]University of Alabama - Huntsville, 320 Sparkman Dr., Huntsville, AL 35805

[3]University of Utah, 135 S 1460 E Rm 819, Salt Lake City, UT 84112-0110

The multi-year database of observations of radar, passive microwave, and lightning flash rates from the TRMM satellite has allowed examination of the properties of Tropical rainfall systems. This study seeks to use the University of Utah multi-year TRMM database to investigate the properties of rainfall systems having horizontal dimensions of rainfall on the mesoscale. Quantification of these systems properties is important for many climate implications because of their significant contribution to rainfall, heating budgets, rainfall estimation and hydrology, and the global electric circuit. The goals of this study are three-fold, including: (1) examining the sensitivity in regional rainfall contribution as a function of the definition of a mesoscale convective system (MCS), whether it be defined by radar or passive microwave sensors, rainfall or convective intensity thresholds, and/or by length or areal scales, (2) quantify the bulk regional and seasonal rainfall contribution, convective intensity, convective-stratiform partitioning, and lightning characteristics of MCSs based on radar or ice scattering definitions, (3) examine the internal vertical and horizontal structures (including rainfall rates) of MCSs on a regional basis by examining their radar reflectivity profiles, ice scattering intensities, and lightning flash rates as a function of horizontal and vertical morphology in both convective and stratiform regions. This will be performed by using the standard TRMM convective-stratiform separation as well as an automated pattern recognition algorithm to identify characteristic reflectivity structures (e.g. linear convective pattern vs. an embedded convection pattern).

AE32A-0165 1330h POSTER

Overview of the Year-One Field Program Phase of the Thunderstorm Electrification and Lightning Experiment (TELEX) 2003

Dave Rust[1] (405 3660404; dave.rust@noaa.gov); Don MacGorman[1]; Terry Schuur[2]; Jerry Straka[3]; Bill Rison[4]; Tim Hamlin[4]; Paul Krehbiel[4]; Eric Bruning[2]

[1]NOAA/National Severe Storms Laboratory, 1313 Halley Cir, Norman, OK 73069, United States

[2]University of Oklahoma/Cooperative Institute for Mesoscale Meteorological Studies, 1313 Halley Cir, Norman, OK 73069

[3]University of Oklahoma/School of Meteorology, Sarkey Energy Center, Norman, OK 73029, United States

[4]New Mexico Institute of Mining and Technology, 801 LeRoy Place, Socorro, NM 87801, United States

Recent research has raised several issues that have significant implications for understanding storm electrification and lightning. The scientific purpose of TELEX is to test and revise hypotheses concerning the inter-relationships among the wind field, microphysical characteristics, electrical structure, and lightning of isolated severe storms and of large storm systems (called mesoscale convective systems, MCSs). We conducted the first-year's field program of TELEX in central Oklahoma, 11 May-6 June. This was the initial spring field deployment for several new observing systems operating in central Oklahoma: a 10-cm wavelength polarimetric Doppler radar, a lightning mapping array (LMA), and a new mobile lab for storm intercept and coordination of mobile ballooning of electric field meters and data acquisition. Also, the electric field meter was substantially upgraded (both mechanically and electronically) to provide higher resolution data, including more accurate determination of instrument orientation using a three-axis flux gate magnetometer arrangement and a two-axis accelerometer. The improvements allow more accurate determination of the electric field vector, and thus inferred charge structure, in context of the three-dimensional structures of storm parameters and lightning. Presented in this paper are examples from among the seven storm-intercept missions during which fourteen balloon soundings were obtained with instrumented balloons carrying a radiosonde and electric field meter. Owing to a scarcity of isolated deep convection in the target area during the program, the flights are mostly from nighttime multicellular storms and MCSs. Electric fields ranging above 100 kV/m were measured.

AE32A-0166 1330h POSTER

Which Tropical Continental 'Chimney' Dominates the Global Electrical Circuit, and Why?

Earle R. Williams[1] (781-981-3744; earlew@ll.mit.edu)

Gabriella Satori[2] (satori@ggki.hu)

[1]Massachusetts Institute of Technology, Parsons Laboratory MIT 48-211, Cambridge, MA 02139, United States

[2]Hungarian Academy of Sciences, Geodetic and Geophysical Research Institute, Sopron H-9400, Hungary

Global measures of lightning activity, including classical thunder day observations, optical measurements with the Optical Transient Detector and Lightning Imaging Sensor in space and Schumann Resonance observations are all consistent in showing a predominance of Africa among the three tropical "chimneys". Given the common assumption that thunderstorms are the "batteries" of the global circuit and the Wilson conduction current measurements over thunderstorms (Blakeslee et al, 1989), one expects Africa to dominate the DC global circuit. Yet the classical Carnegie Curve' and numerous diurnal records of ionospheric potential (Markson) clearly show South America as the dominant chimney. This paradox has resolution in an often overlooked aspect of C.T.R. Wilson (1920) giving special attention to "shower clouds" as contributors to the DC global circuit in addition to thunderstorms. Observations from the NASA TRMM (Tropical Rainfall Measuring Mission) satellite support a greater number of shower clouds in South American than Africa. Further climatological thermodynamic comparisons for surface stations in the Amazon and Congo River basins are examined to understand chimney ranking in lightning and in conduction current. Evidence will be presented that the hotter and dryer characteristics of the most continental chimney (Africa) can account for its factor of two predominance in lightning activity.

AE32A-0167 1330h POSTER

On the Dynamics of the North-South Seasonal Migration of Global Lightning

Gabriella Satori[1] (satori@ggki.hu)

Earle R Williams[2] (earlew@ll.mit.edu)

Dennis J Boccippio[3] (Dennis.Boccippio@nasa.gov)

[1]Geodetic and Geophysical Research Institute, HAS, Csatkai u. 6-8., Sopron H-9400, Hungary

[2]Massachusetts Institute of Technology, Parsons Laboratory, MIT 48-336B, Cambridge, MA 02445, United States

[3]NASA/MSFC, SD-60, Huntsville, AL 35812, United States

The daily Schumann resonance (SR) frequency patterns are mainly determined by the lightning source-observer configuration consequently their variations are indicative for the changes of global lightning position. Four basic types of daily frequency patterns have been distinguished corresponding to the four seasons observed for each SR mode at Nagycenk, Hungary. The number of days with daily frequency patterns characteristic for a season were very different. Similar daily frequency patterns have been observed during 160-165 consecutive days from the beginning of November to the first part of April in any year of SR observations at Nagycenk. The same time sequences (four seasons with different lengths) can be recognized in the global lightning distribution observed by OTD (Optical Transient Detector) (Christian et al., 2003) as it was shown in the seasonal distributions of the daily frequency patterns of Shumann resonances. The land/ocean ratio is smaller in the Southern Hemisphere than in the Northern Hemisphere. It seems that oceanic thermodynamical properties (large thermal inertia) are manifested in the dynamics (speed) of the north-south lightning migration identified by the long lasting (160-165 days) southern position of global lightning in the Southern Hemisphere summer and by the time lag of the northward lightning migration in spring. The spring-fall asymmetry of the migration speed is attributed to the different thermodynamical properties of land and ocean.