kA and the transferred charge was 160 C with the duration time of 40 ms. The progressing feature of luminosity was observed by the 40X40 pin photo-diode array system at the distance of 630 m from the chimney. The average speed of upward luminosity was 6X106 m/sec. The upward-moving negatively charged leader from the chimney moved with the stepped motion like a negatively charged stepped leader moves downward from the thundercloud to the ground in the natural lightning. Positive currents up to 20 kA were confirmed without a downward return stroke when the upward-moving negatively charged leader propagated towards the thundercloud with the stepped-moving upward luminosity. The positive currents of 8 kA, 9 kA, and 20 kA were recorded with each upward elongation of tip of luminosity. The step length of luminosity was 45 m, 118 m and 311 m and the two-dimensional speed of each step was 1X107, 3X107 and 5X107 m/sec respectively. Interestingly, these currents are big compared to the usual estimated current of a downward-moving stepped leader in the natural lightning.

A21E-10 1120h

Observations of Energetic Radiation From Triggered Lightning

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During the summer of 2002, x-ray observations were made less than 30 m from rocket-triggered lightning at the International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida, using an instrument designed to measure energetic radiation during thunderstorms. The instrument consisted of a 5" NaI(Tl)/photomultiplier tube (PMT) scintillation detector, plus a control detector, identical in every way but with no scintillator. The data acquisition was triggered externally by the current measured at the 11 m tall launch tower, which usually corresponds to the occurrence of the return strokes. On 2002 July 20 and 25, 5 rockets were launched from the tower under thunderstorm conditions, resulting in a total of 5 triggered lightning flashes containing at least 24 return strokes terminated on the launch tower. During these lightning events, large amounts of energetic radiation (>>10 keV) in the form of x-rays and gamma-rays and/or energetic electrons were observed just prior to the majority (83%) of the recorded return strokes, depositing into the detector, on average, tens of MeV per stroke. The pulse shapes from the PMT preamplifiers were analyzed and found to be completely consistent with real x-rays and gamma-rays and not consistent with electrical noise in the system. Furthermore, no such signals were observed on the control detector. Also, based upon background measurements, the chance that the energetic radiation events were produced by accidental coincidences with naturally occurring background signals is completely ruled out. We conclude that these new observations provide strong evidence that electrons are accelerated to relativistic energies during triggered lightning discharges with a high occurrence rate and producing significant amounts of x-rays and gamma-rays. The timing of the energetic radiation, arriving 0-200 microseconds just prior to the return stroke, suggests that the mechanism that produces this radiation may be associated with the dart leader phase of the lightning. To date, the only viable models for such high-energy radiation involve the generation of runaway electrons in large electric fields. However, the field strengths and length scales involved in lightning processes provide a significant challenge to such models. These results have important implications for studying runaway electrons in air and the physics of lightning. Furthermore, triggered lightning makes detailed study of the phenomena practical, since in order to observe energetic radiation, the lightning must occur within a few hundred meters of the detectors due to the atmospheric attenuation.

A21E-11 1135h

Lightning Return-Stroke Current Waveforms Aloft, From Measured Field Change, Current, and Channel Geometry

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Direct current measurements are available near the attachment point from both natural cloud-to-ground lightning and rocket-triggered lightning, but little is known about the rise time and peak amplitude of return-stroke currents aloft. We present, as functions of height, current amplitudes, rise times, and effective propagation velocities that have been estimated with a novel remote-sensing technique [Willett and Le Vine, Proceedings, 10th International Conference on Atmospheric Electricity, Osaka, Japan, 10-14 June 1996] from data on 24 subsequent return strokes in six different lightning flashes that were triggering at the NASA Kennedy Space Center, FL, during 1987. The unique feature of this data set is the stereo pairs of still photographs, from which three-dimensional channel geometries were determined previously [Willett and Le Vine, AGU Fall Meeting, San Francisco, CA, December, 1995]. This has permitted us to calculate the fine structure of the electric-field-change (E) waveforms produced by these strokes, using the current waveforms measured at the channel base [Leteinturier and Hamelin, IEEE Trans. EMC, 33, 351-357, 1991] together with physically reasonable assumptions about the current distributions aloft. The computed waveforms have been compared with observed E waveforms from the same strokes [Willett et al., J. Geophys. Res., 94, 13,275-13,286, 1989], and our assumptions have been adjusted to maximize agreement.

In spite of the non-uniqueness of solutions derived by this technique, several conclusions seem inescapable: 1) The effective propagation speed of the current up the channel is usually significantly (but not unreasonably) faster than the two-dimensional velocity measured by a streak camera for 14 of these strokes. 2) Given the deduced propagation speed, the peak amplitude of the current waveform often must decrease dramatically with height to prevent the electric field from being over-predicted. 3) The rise time of the current wave front must always increase rapidly with height in order to keep the fine structure of the calculated field consistent with the observations.

A21E-12 1150h

Three-Dimensional Modeling of Maxwell Currents and Lightning in Electrified Storms

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While Maxwell current analysis is a relatively new addition to the modern era of storm electrical modeling, such current measurements have been made in past field projects both at the surface and above thunderstorms. These measurements have been used to infer the properties of the storm generator, but no comprehensive evaluation of Maxwell currents has been done, nor can it be done from an observational perspective. Modeling offers the opportunity to look at the character of the Maxwell current and its various components throughout the domain of a storm as well as their relationship to the storm generator. Likewise, the advent of lightning parameterization schemes for numerical electrification models provides the opportunity to examine the interrelationship between storm charging, charge structure, and lightning. Within this context and with the development of new instrumentation the opportunity arises to compare storm simulations of lightning evolution with observed lightning morphology. Several three-dimensional model simulations of electrified storms have been carried out over a range of storm intensity and complexity. This range encompasses weak to severe single-celled storms and a multicellular simulation. This talk will give an overview of results from these simulations related to the behavior of Maxwell currents and lightning as a function of storm evolution and character.

A21F MCC: 123 Tuesday 0830h

The Southern Oxidants Study Texas Air Quality Study (TexAQS 2000) II

Presiding: **P Daum,** Brookhaven National Laboratory**; J Meagher,** NOAA Aeronomy Laboratory

A21F-01 0835h INVITED

The Impact of TexAQS 2000 on Air Quality Planning in Houston

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Before the Texas 2000 Air Quality Study (TexAQS 2000) the State used the Urban Airshed Model to model nine different episodes in Houston with very poor results: only one episode met EPA model performance criteria. Questions existed regarding emissions uncertainties, meteorological modeling, and model chemistry. NOAA, DOE, and SOS led more than 35 organizations and 250 investigators who participated in TexAQS 2000. Major findings from TexAQS 2000 are: 1. There are two types of meteorological patterns that lead to ozone episodes in the Houston area: (i) stagnation associated with the sea breeze flow reversal causes a pool of industrial emissions and ozone to accumulate, then to move across the city as the wind flow picks up and (ii) plumes of ozone form when relatively persistent winds carry the emissions away from the city and industrial areas. 2. The chemistry that produces high ozone concentrations and rapid rises in ozone in the Houston area has been explained: multiple investigators in TexAQS 2000 have documented more rapid and more efficient formation of ozone in the plume from the Houston industrial area than any of them has observed in any previous field study. Houston's exceptionally rapid ozone formation arises from large amounts of anthropogenic VOCs in the atmosphere, often from the same plants that provide sufficient NOx. 3. This rapid and efficient ozone formation results most often from the presence of a specific subclass of hydrocarbons called light olefins, primarily ethylene and propylene. 4. Sometimes it is other specific hydrocarbons that cause the rapid formation of high concentrations of ozone, and sometimes it is just the total mass of a lot of relatively unreactive hydrocarbons. 5. The current emissions inventory for ethylene and propylene, as well as other VOCs, underestimates their routine emissions by a factor of roughly five to ten or perhaps even more. 6. It is not clear whether the emissions causing Houston's rapid ozone formation are the results of upsets or of routine operations or both. Each of the research groups in TexAQS 2000 has found that the data are consistent with routine emissions; however, their analyses do not exclude the possibility of multiple releases per day that would not be readily distinguishable from continuous emissions. 7. Further analysis of the data collected in 2000 and 2001 will be necessary to refine the estimates of the discrepancy between reported and actual VOC emissions and assign top-down VOC emissions inventory corrections for the current round of regulatory modeling. 8. Additional work will need to continue for the next few years with the cooperation of industry to develop an adequate bottom-up emissions inventory for VOCs. 9. The opportunity to compare regulatory modeling results to state-of-the-science aircraft measurements is a major advance in determining whether photochemical models are getting the right answers for the right reasons. Doing so is critical to development of effective and cost-effective control strategies.

Without TexAQS 2000 and subsequent findings, the one-hour ozone control strategies for Houston would not address the problem correctly. What's next? The challenges of the impending 8-hour ozone standard will demand even more precision in our technical work to develop efficient and cost-effective strategies to demonstrate attainment. There is a proposal to conduct another major field study in 2005 to build on our current understanding of the science for ozone, fine particulate matter, and regional haze in Texas.

A21F-02 0855h INVITED

AN OVERVIEW OF OBSERVATIONS MADE FROM THE G-1 AIRCRAFT DURING TexAQS 2000

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As part of the Texas Air Quality Study, the DOE G-1 aircraft conducted 18 research flights in and around the Houston metropolitan area between August 19 and September 12, 2000. Overall objectives were to characterize emissions and their relation to the production of O3 and particulate matter. Chemical parameters measured on the G-1 included the concentrations of O3, NO, NO2, NOy, CO, speciated VOCs, HCHO, SO2, H2O2, organic peroxides, and aerosol anions and cations. Particle size distributions were obtained over the range 5nm to 15 um. This presentation is an overview of the G-1 data set and secondary quantities such as the production rate of O3 which can be calculated using trace gas observations from the G-1. In order to put into perspective the extraordinarily high concentrations of reactive VOCs and concomitantly high O3 production rates observed in Houston, we will rely on similar aircraft measurements from Nashville, New York City, Phoenix, and Philadelphia.

A21F-03 0910h INVITED

An overview of results from the Electra aircraft during the Texas 2000 study

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Implementation of scientifically sound NOx and VOC emissions reduction strategies to reduce ozone formation in the Houston, TX metropolitan area will ultimately be based on the output from 3-D chemical-transport models. The extent to which these models can be expected to reproduce observed distributions of primary emissions, ozone, and other secondary photoproducts depends strongly on three separate factors: model transport and dispersion, model chemical mechanisms, and the emissions inventory used as model input.

Investigators at NCAR and NOAA have used the Electra airborne measurements as benchmarks against which two of these model input factors, the emissions inventory and the model chemical mechanisms, have been evaluated. An overview of the analysis methods will be presented and results examined in light of improving proposed emissions control strategies for the Houston area.

A21F-04 0925h

Ozone Distribution and Transport in the Houston Area: Insights Gained by Airborne Lidar

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The Texas 2000 Air Quality Study was conducted in August and September of 2000 to identify the chemical and meteorological processes that are responsible for the frequent exceedances of the ozone air quality standards in the Houston, TX area. To meet this objective a large array of instruments, both ground-based and airborne, was deployed, including the National Oceanic and Atmospheric Administration / Environmental Technology Laboratory airborne ozone and aerosol lidar. The airborne lidar's role was to characterize the horizontal and vertical distribution of ozone and aerosol in the Houston area. The nadir-looking lidar was flown onboard a DC-3 cargo airplane and measured along its flight path vertical profiles of ozone concentration and aerosol backscatter between the surface and approximately 2500 m above ground level. This presentation will focus on how the three-dimensional distribution of ozone in the Houston area observed with the airborne lidar was influenced by atmospheric flow patterns, in particular the land-sea breeze circulation. To determine the transport pathways of ozone plumes detected with the airborne lidar we relied on back trajectory calculations using data from the wind profiler network deployed during the Texas 2000 Air Quality Study. In addition, we will present measurements of boundary layer depth, derived from the lidar aerosol profiles, and assess how the spatial variability of mixing depth observed in the Houston area affected the ozone distribution and ozone peak values.

A21F-05 0940h INVITED

An Overview of Photochemical Gas-phase Measurements at the La Porte Municipal Airport During TexAQS-2000

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The TexAQS-2000 study was an effort to characterize the air chemistry of the Houston metropolitan area. With a mix of urban, power plant, and industrial source emissions and the influence of sunny, hot, and humid meteorological conditions, this region is subject to air pollution episodes during which O3 can exceed the NAAQS of 120 ppbv. Of the large number of ground monitoring sites that were set up for this study perhaps the one most heavily instrumented was at the La Porte Municipal Airport. This location was chosen because of the expectation that 1) the site would be occasionally downwind of the heavily-industrialized ship channel area which would provide the opportunity to characterize the emissions from that area, 2) the site would be subject to onshore flow from the nearby Galveston Bay area which would bring a wide range of air parcels - from relatively clean marine air to air containing a mix of fresh urban/industrial emissions from source regions to the south and east, and 3) the site would experience a wide spectrum of photochemically aged air masses. The La Porte Airport site was developed and instrumented with these expectations in mind. In addition to the standard complement of measurements of NOx, NOy, O3, CO, and SO2, instruments were deployed to measure OH, HO2, total OH loss, photolysis rates, a number of PAN-type species, alkyl nitrates, HNO3, C2-C10 organic compounds (including oxygenates), and selected Cl-containing compounds. In addition to these in situ measurements a number of remote-sensing instruments were deployed to measure O3, NO2, NO3, HONO, CH2O, SO2, and selected VOCs. This presentation will provide a summary description of the La Porte Airport site and an overview of the gas-phase measurements that were conducted there.

A21F-06 1015h INVITED

Observations from the Williams Tower measurement site during TexAQS 2000: an Overview

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The Williams Tower measurement site operated during TexAQS 2000 provided a unique sampling opportunity making it possible to study the meteorological and chemical day-night evolution of the planetary boundary layer. The skyscraper measurements were made from the 62nd floor of Williams Tower located in uptown Houston. Teams of scientists from six organizations set up 20 instruments for sampling 24 hours a day, seven days a week. Participant groups included Battelles Columbus Operations, Pacific Northwest National Laboratory, Brookhaven National Laboratory, Argonne National Laboratory, State University of New York at Old Westbury, Georgia Institute of Technology, University of California at Davis, and the Texas Natural Resources Conservation Commission. The measurement systems filled two rooms; one room was used primarily for gas-phase measurements of O3, NO/NOy, PAN, SO2, CO, CH2O, HNO3, HONO, H2O2, and organic peroxide. Temperature, pressure and moisture were also monitored. The measurements in the 2nd room focused on aerosol characterization some of which used new techniques. Aerosol size distribution was obtained using two scanning differential mobility analyzers. Aerosol bulk composition was obtained using time resolved filter sampling. Single particle size and composition was measured using a sampler that provides atomic composition using scanning electron microscopy with energy-dispersed X-ray analysis, and real-time single particle time of flight mass spectrometer.

This paper will present the overview of the tower observations made at the height of 830 feet above the ground in the context of results from aircraft and other surface site observations. The data provide a rather complete suite of gas and aerosol measurements which makes it possible to characterize the Houston air west of the major emission sources. The elevated measurement site also makes it possible to investigate the chemistry within and above the nocturnal boundary layer.

Results from box model calculations will be used to derive ozone production efficiency and correlate this quantity with air mass origin and emission sources. The connection between gas phase and particle size and chemistry will be explored.

A21F-07 1030h INVITED

Fine Particulate Matter Composition and Sources during the Texas Air Quality Study

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Extensive measurements of the composition and size distributions of fine particulate matter were made during the Texas Air Quality Study, conducted in Houston

during the summer of 2000. This presentation will summarize the major findings emerging from the analyses of ground-based aerosol measurements.

Some of the major findings include evidence for extensive secondary organic aerosol formation resulting from the reactions of biogenic hydrocarbons, evidence for large but sporadic contributions of aerosol mass from fires and evidence of heterogeneous reactions involving the formation of organonitrates.

In addition, aerosol composition during the TexAQS study period will be compared with the composition of aerosol collected over a 16 month sampling period. These analyses will show that aerosol composition measured during the TexAQS period was broadly representative of longer term trends.

URL: http://uts.cc.utexas.edu/~gcarch/HoustonSuperSite/

A21F-08 1045h

Meteorological Modeling of a Houston Ozone Episode

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The State of Texas requires accurate meteorological simulations of a Houston-Galveston ozone episode to drive their photochemical model for regulatory purposes. The episode of greatest interest occurred during TexAQS-2000, so there is an unusually large amount of data available for driving and validating the simulation.

The key meteorological process to simulate is the sea breeze. In the Houston area, this sea breeze takes two forms, both of which typically occur on a summertime day. The first form is the sea breeze front, which forms along the coast of the Gulf of Mexico and Galveston Bay if the midday winds are light or offshore and travels inland during the afternoon and early evening. The second form is an inertia-gravity wave response of unusually large amplitude and horizontal scale, due to Houstons proximity to 30 N. It manifests itself as a steady rotation of the wind, superimposed on the background flow, with an amplitude of 2-3 m/s.

The MM5 (v3.4) model characteristics were tailored to simulate this phenomenon. Over 20 vertical levels were located in the lowest 300 mb. The soil moisture availability was adjusted according to rainfall prior to and during the event so that the model simulated a reasonably accurate land-sea and urban-rural temperature contrast. A planetary boundary layer scheme was chosen to produce lower atmospheric structures similar to those observed in special soundings.

To further increase the agreement between the model and observed fields, data from five profilers and one Doppler lidar were assimilated into the simulation. Assimilation parameters were chosen to provide a large impact on the large-scale, slowly-varying winds while allowing the smaller-scale sea breeze front and other such phenomena to evolve according to the internal dynamics of the model. The assimilation was essential for compelling the model to capture a nighttime low-level jet that was present during part of the episode and which the unassimilated model runs were unable to reproduce.

Fine-tuning of the simulations has been done with guidance from the results from the photochemical model. The RMS temperature and wind speed errors have been reduced to less than 1.5 m/s on all key air quality days. The model appears to accurately simulate the wind reversals and recirculation of pollutants that are common during high-ozone events in Houston.

URL: http://www.met.tamu.edu/results

A21F-09 1100h

Comparisons of Air Quality Observations Collected During TEXAQS-2000 with Results of an Air Quality Forecast Model

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Air quality data collected by aircraft, at a highly instrumented surface site, and remotely by ozone lidar are used in this study to critically assess the NOAA Forecast System Labs air quality forecast model (MM5-CHEM). This model is a modified version of the Penn State/NCAR nonhydrostatic mesoscale model (MM5, version 3) that includes the on-line calculation of photochemical tendencies for 41 gas-phase species using the Regional Acid Deposition Model (RADM, version 2) photochemical mechanism. The model also incorporates one-way nesting into three sub domains, with the finest horizontal domain resolution of 1.67 km covering the Houston-Galveston region. Although forecasts from this model were available in real-time during the TEXAQS-2000 field study, the focus here is to test the response of model predicted ozone, and other oxidants, to perturbations in the emission inventory. In particular, when emissions of light-weight olefins emitted from several petrochemical complexes are adjusted to match emissions derived from downwind aircraft observations, the levels and distribution of ozone and other key oxidants are found to compare much more favorably with observed concentrations. The model thus becomes useful in estimating the contribution of these light-weight olefins to specific high-ozone episodes (e.g. August 30, 2000), as well as their contribution to ozone for the larger eastern Texas gulf region.

A21F-10 1115h

The Effect of Ethene and Propene Emissions on Ozone Production in Houston during the TexAQS 2000 Field Campaign.

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A coupled meteorological and chemical model, PEGASUS, was used to simulate ozone and ozone precursors in the vicinity of Houston between 28 August and 1 September during the 2000 TexAQS Field Campaign. A nested grid configuration was used with an outer grid encompassing the south-central U.S. with a grid spacing of 16 km and an inner grid encompassing the Houston metropolitan area with a 1.3 km grid spacing. Area, mobile, biogenic, and point source emission rates were based on a data set provided by the Texas Natural Resource Conservation Commission (TRNCC). The meteorological model employed data assimilation using observations from five radar wind profilers to limit forecast errors in the simulated wind fields around Houston. The simulated magnitude and distribution of ozone over downtown Houston was very similar to observations from the surface monitoring network. Observed and simulated ozone mixing ratios were as high as 140 ppb on 31 August. The model results were also in very good agreement with the spatial distribution of ozone, NOx, and NOy observed aloft by research aircraft. However, at surface stations and aircraft positions close to large point source emissions of VOCs, the simulated ozone mixing ratios were usually too low. For example, ozone mixing ratios at LaPorte were about 200 ppb on 30 and 31 August, but the predicted values at that location were between 110 and 120 ppb. Simulated VOCs, including propene and ethene, were also under-predicted. To examine whether an underestimation of the VOC point source emission rates may have contributed to the low ozone mixing ratios predicted by the model, two sensitivity simulations were performed in which the point source emission rates of ethene and propene were increased by a factor of 5 and 10. With the increased point source emission rates, ozone and VOC predictions were in better agreement with the surface and aircraft observations. Trajectories from the model indicated that the high ozone and VOC concentrations at LaPort on 30 August were from sources in the Houston ship channel; however, point source emissions close to Galveston were transported northward to LaPorte on 31 August. Because afternoon easterly flow associated with the bay-breeze was relatively weak between 28 August and 1 September, point source emissions did not significantly affect ozone concentrations in the downtown area.

A21F-11 1130h

Model-Measurement Comparisons of [OH], [HO2], and P(O3) in Houston

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An extensive set of chemical and physical measurements was made at the La Porte Airport in Houston during the 2000 Texas Air Quality Study. Observed hydroxyl and hydroperoxyl radical concentrations ([OH] and [HO2]) at La Porte are compared to those predicted by a steady state box model. The model is constrained by ambient measurements of ozone, reactive nitrogen compounds, carbon monoxide, volatile organic compounds, photolysis rate coefficients, and meteorological variables. The photochemical production rate of ozone (P(O3)) due to HO2 is derived from the observed [HO2] and nitric oxide concentration ([NO]) and compared to the model. Budgets of OH and HO2 are quantified using the model. Model-measurement comparisons of [OH], [HO2], [HO2]/[OH], and P(O3) are further evaluated by considering their dependence on variables such as [NO] and actinic flux. The results of this study are put into a broader context by including results from the 1999 Southern Oxidants Study in Nashville.

A21F-12 1145h

Particle Growth in Urban and Industrial Plumes in the Houston Metropolitan Area

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During the Texas 2000 Air Quality Study, airborne measurements of particle size distributions were made in the vicinity of Houston, Texas in the plumes from power plants, petrochemical facilities, and the Houston

urban center. Particle size distributions from 0.004-8.5 μm diameter were measured with 1 s time resolution. In all plumes from power plant and petrochemical industry sources, substantial enhancements in particle mass with increasing plume age were found in only those plumes rich in SO_2. Even in the plumes of refinery complexes with large emissions of NO_x, propene, ethene and aromatic VOCs, particle enhancements were not detected in the absence of SO_2. Nearby, modest sources of SO_2 produced detectable enhancements in particle number and volume. By assuming a particle composition, the fraction of plume S found in the particulate phase in various plumes was calculated and compared with results from a 2-D numerical model of plume photochemistry that incorporates the oxidation of SO_2 by OH. In the plumes of a large power plant near Houston, the increase in plume particulate S fraction with increasing plume oxidation estimated from the measurements was simulated within experimental uncertainty by the model. However, in a large plume originating from the petrochemical industries along the Houston ship channel, the model grossly underpredicted the observed particle growth. This underprediction is likely due to gas-to-particle conversion by organic species that are not incorporated in the model. Because particle growth was found only in the presence of SO_2, and because the measured concentrations of VOCs were insufficient to account for the observed particle growth using known gas-particle partitioning coefficients, further laboratory, numerical and field studies of particle growth in NO_x-VOC-SO_2 systems are recommended.

A22A MCC: Hall D Tuesday 1330h

Climate Processes in the Tropical and Subtropical Eastern Pacific II Posters

(joint with H, OS, GC)

Presiding: **D Baumgardner,** Universidad Nacional Autonoma de Mexico**; R Wood,** University of Washington

A22A-0050 1330h POSTER

Relationships Between Mean ABL Structure and Turbulent and Radiative Processes over the Cold Tongue during EPIC

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The range of atmospheric boundary layer (ABL) conditions over the cold tongue in the eastern equatorial Pacific has been examined using detailed flight-level observations collected by the NCAR C-130 research aircraft during the Eastern Pacific Investigation of Climate Processes (EPIC) field program in 2001. The ABL of the region is noteworthy because it mediates air-sea interactions. The coverage of ABL stratus clouds appears to be a primary factor related to the variability in ABL structure over the cold tongue. This coverage ranged from nearly continuous overcast on 19 September (RF08) to virtually clear on 2 October (RF14). The presence of clouds was generally accompanied by more vigorous ABL turbulence (as gauged in terms of the variance in vertical velocity), less ABL stratification (but better defined capping inversions), and much less vertical wind shear. The implication is that clear skies tend to be associated with a prominent southerly low-level jet but relatively weak surface winds; cloudy skies are associated with less of a low-level jet but stronger surface winds, given similar meridional sea level pressure gradients. Differences in the stratus cloud coverage may hence be significant to the atmospheric forcing of the ocean in the vicinity of the cold tongue. It is uncertain what determines this cloud coverage but it may be related to the humidity above the ABL. The relatively cloudy cases of RF08, RF11 and RF19 featured drier air aloft than the less cloudy cases of RF03, RF14 and RF18. It is possible that an important mechanism here was reduced downwelling longwave radiative fluxes at the top of the ABL in the former relative to the latter cases.

A22A-0051 1330h POSTER

Measurements of Near-Surface Sea Temperature From R/V Ron Brown During EPIC2001

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During EPIC2001, the R/V Ron Brown carried various sensors measuring continuous time series of sea temperature at several depths. Above the IMET hull sensor permanently installed near the bow at 5.6 m depth, a through-the-hull temperature sensor was mounted at 2.0 m depth. A precision thermistor was towed at a nominal depth of 5 cm from a side boom, and an advanced IR radiometer viewed the sea surface to obtain the skin temperature. In this paper we present comparisons between these instruments, reflecting the effects of rainfall, solar penetration, and wind mixing at various depths in the ocean surface layer. The cool skin model featured in the TOGA-COARE bulk flux algorithm is shown to agree well with direct measurement during nighttime, but consistently under-predicts the magnitude of the cool-skin effect during daylight hours. All sensors record the dramatic reduction in sea temperature from around 26 degrees to 18 degrees within a distance of less than 100nm through the northern edge of the equatorial cold tongue.

A22A-0052 1330h POSTER

Mixed Layer Modeling of Stratocumulus Diurnal Cycle in EPIC

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Radiosonde measurements taken aboard the NOAA vessel Ronald H. Brown during the EPIC 2001-Sc campaign show that the SE Pacific cloud-topped boundary layer in this region is generally well mixed. A mixed layer model initiated from these measurements is compared with ship-based observations of drizzle, cloud height, and entrainment, all of which show a pronounced diurnal cycle. Parameterizations for entrainment, radiation, surface fluxes, and drizzle are incorporated into the model. The model is forced by time-dependent vertical velocity and horizontal advective tendencies obtained from ECMWF analyses. With suitable parameterizations of entrainment and drizzle efficiencies, the model PBL height and diurnal cycle of cloud thickness agree well with observations. The entrainment efficiency supported by the EPIC observations is smaller than has been reported by earlier studies based on aircraft-based measurements. The drizzle efficiency, on the other hand, is larger. Throughout most of the diurnal cycle, the mixed layer model is self-consistent in that it does not predict an extensive layer of negative buoyancy fluxes below cloud base that would lead to boundary layer decoupling.

In addition to testing parameterizations, the model is used to explore the role of drizzle in maintaining cloud depth. In the EPIC region there tends to be extensive drizzle at cloud base, most of which evaporates before reaching the ocean surface. Under these conditions, drizzle acts to redistribute but not to remove water from the boundary layer, with its biggest effect on a mixed layer being reduction of turbulence. Hence it is hypothesized that drizzle may actually act to increase the mean cloud thickness by decreasing turbulent entrainment. Model results and analysis of observational data are presented to test this claim.

A22A-0053 1330h POSTER

Comparison Z-R Relationships in EPIC-2001

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An important objective of the EPIC-2001 field campaign is to improve understanding of the air-sea coupling processes that occur in the east Pacific warm pool region. To accomplish part of this objective, the NOAA R.V. Ronald H. Brown (RHB) operated a C-band radar during EPIC-2001 to provide high temporal resolution near-surface rainfall estimates that can be used as input to ocean mixed layer studies. The radar collected data for rainfall estimates out to a range of 150 km at continuous 10-minute intervals while the RHB was on-station at 10N, 95W (12 September 1 October 2001).

In this study, we examine the sensitivity of the radar rain mapping procedure to different reflectivity-rainfall (Z-R) relationships that were collected during EPIC-2001. Specifically, drop size distribution (DSD) data collected from a Joss Waldvogel (JW) disdrometer and 2D-P probe are compared in order to obtain the best Z-R relationship for the radar rain maps. Disdrometer data were collected on-board the R.V. New Horizon, located within about 100 km of the RHB. The 2D-P probe data were collected by the NCAR C130 research aircraft which flew a series of flight legs across the ITCZ region during the field experiment. For this study, all 2D-P data from flights within 1000 km of the RHB and heights below 1.5 km altitude were utilized. The drop diameter resolution of the 2D-P measurements is 0.2 6.2 mm. For the JW disdrometer, the upper size bin includes all drops exceeding 5.1 mm in diameter. The lower size threshold is sensitive to the amount of surrounding environmental noise. Preliminary estimates suggest that the low-end sensitivity of the JW deployed on the New Horizon is around 1 mm.

Analysis of the DSD data and resulting Z-R (Z=A*R**B) relationships from the two instruments showed that the JW disdrometer had a coefficient (A) approximately a factor of two larger than the 2D-P (416 vs 218) and an exponent (B) approximately 25% lower than the 2D-P (1.2 vs. 1.6). For rain rates exceeding about 5 mm/hr, these differences translate into a higher reflectivity for a given rain rate using the 2D-P data. The trends in the differences in Z-R s are consistent with physical processes (i.e., evaporation) occurring between the in-cloud (2D-P) and near surface measurements of the disdrometer. Moreover, the differences could also reflect biases in precipitation environments sampled by each instrument (e.g., larger drop spectra associated in regions of melting aggregates sampled by the 2D-P probe compared to smaller drop spectra sampled by the JW disdrometer associated with melting of rimed particles) as well as issues related to sampling geometry. However, sensitivity analyses conducted with the 2D-P data strongly suggest that the resulting Z-R relationships largely reflect differences in the low-end drop diameter sensitivity of two instruments. As the low end sensitivity threshold of the 2D-P is increased from 0.2 to 1.0 mm, the coefficient and exponent in the resulting Z-R change in such a fashion as to nearly match the corresponding JW coefficient and exponent values. These results have important implications for the radar rain maps since the application of the JW Z-R produces higher rain rates and accumulations in the more intense radar echo regions (> 34 dBZ) while the opposite occurs at lower reflectivities. Further, for a given echo pattern the 2D-P Z-R tends to produce larger rain areas compared to the JW Z-R.

A22A-0054 1330h POSTER

The Life Cycle and Composite Structure of Mesoscale Cellular Organization

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Little is known about the mesoscale structure in stratocumulus regions. For EPIC Sc, the NOAA ship Ronald H Brown was equipped with a suite of instruments to measure and observe the properties of the stratocumulus in this previously undersampled area. A synthesis of several types of radar, sounding, and meteorological data obtained aboard the ship and a nearby IMET buoy permits an integrated analysis of drizzling stratocumulus. Compositing is performed on radar and meteorological data in which representations of individual cells throughout their lifetimes are superimposed to obtain a information on drizzle cell evolution and mean