A31A MCC: 3022 Wednesday 0800h

Remote Sensing of Atmospheric Constituents I

Presiding: **J C Gille,** University of Colorado and NCAR**; W W McMillan,** University of Maryland, Baltimore County

A31A-01 0800h

Imaging Ozone Distributions Across Space-Time Using Satellite Data And Physical Information

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Atmospheric studies often require the generation of high resolution maps of ozone distribution across space and time. The high natural variability of ozone concentrations and the different levels of accuracy of the algorithms used to generate data from remote sensing instruments introduce major sources of uncertainty in ozone modelling and mapping. These elements of atmospheric ozone distribution cannot be confronted satisfactorily by means of conventional interpolation and statistical data analysis. We suggest that the techniques of Modern Spatiotemporal Geostatistics (MSG) can be used efficiently to integrate salient (although of varying uncertainty) knowledge bases about atmospheric ozone in order to generate and update realistic pictures of ozone distribution across space-time. MSG techniques rely on a powerful scientific methodology that does not make the restrictive assumptions of previous techniques. A numerical study is discussed involving data sets generated by measuring instruments on board the Nimbus 7 satellite. In addition to exact (hard) ozone data, the MSG techniques process uncertain measurements and secondary (soft) information in terms of total ozone-tropopause pressure empirical relationships. The proposed total ozone analysis can take into consideration major sources of error in the TOMS/SBUV TOR (related to data sampling etc.) and produce high spatial resolution maps that are more accurate and informative than those obtained by conventional interpolation techniques.

A31A-02 0815h

BrO nadir Column Retrieval from SCIAMACHY

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First measurements from the space-borne instrument SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) have been analyzed for BrO absorption using the Differential Optical Absorption Spectroscopy (DOAS) method. As a result of polarization residual structures in channel 2 of the SCIAMACHY instrument, a UV-shifted spectral range was utilized in the BrO column retrieval from nadir SCIAMACHY lv-0 data in contrast to the traditional' wavelength window employed for the GOME (Global Ozone Monitoring Experiment) BrO retrieval. In this study, direct comparisons of the BrO total column have been made to columns retrieved from the GOME instrument and values observed to agree qualitatively. The results are also discussed in view of indications for a tropospheric background of BrO.

A31A-03 0830h

Retrieval of Oxygen A-Band Spectra from Airborne Measurements

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A strategy to measure the column averaged CO_2 dry air volume mixing ratio, X_{CO_2}, from space was introduced by Kuang *et al* (2002), which employs high resolution spectra of reflected sunlight taken simultaneously in near-infrared CO_2 (1.58 μm and 2.06 μm) and O_2 (0.76 μm) bands. The retrieval algorithm involves a line-by-line, multi-stream, multiple scattering model for producing synthetic radiance spectra in scattering and absorbing atmospheres; a wavelength-dependent instrument line shape function; and an inverse method based on optimal estimation theory (Rodgers, 2000). To test the retrieval scheme, we used high-precision, high-resolution O_2 A-band spectra (759-771 nm) of sunlight reflected from the sea surface (O'Brien *et al.*, 1996). These spectra were obtained with a grating spectrograph directed toward sunglint on the sea surface from a research airplane. Using the retrieval algorithm, we were able to retrieve a sample spectrum to within an rms error of 1.5%. This spectrum required wavelength scaling to match the calculated spectrum. The continuum level, tilt and a zero level offset were fitted. The objective is to retrieve surface pressures with precisions between 0.1-0.3% from this data set. This is the next logical step in demonstrating the feasibility of retrieving X_{CO_2} from space with precision near 0.3%.

A31A-04 0845h

Improvement of the Retrieval of Surface Parameters from MOPITT Measurements and their Impact to the Retrievals of Tropospheric Carbon Monoxide Profiles

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Carbon monoxide (CO) is an important tropospheric trace species and can serve as a useful tracer of atmospheric transport. The Measurements of Pollution In The Troposphere (MOPITT) instrument uses the 4.7 micron CO band to measure the spatial and temporal variation of the CO profile and total column amount in the troposphere from space. Launched in 1999 on board the NASA Terra satellite, the MOPITT instrument was designed to perform with about 3-4 km vertical resolution and 22 km horizontal resolution. MOPITT is an eight-channel gas correlation radiometer; each channel generates an average (A) signal and a difference (D) signal. The thermal channel A-signals are sensitive primarily to emission from the surface, which depends on both the surface skin temperature (Ts) and emissivity (E). The D-signals are sensitive to both thermal emission/reflection and solar reflection (daytime) from the surface and target gas absorption and emission for different vertical levels. Because 4.7 micron CO bands are relatively optical thin through the atmosphere, the surface emission always provides the primary signals to the 4.7 micron thermal channels for both A- and D-signals. In the operational MOPITT CO retrieval algorithm (V3), surface skin temperature and emissivity are retrieved simultaneously with the CO profile. To obtain accurate MOPITT CO results, it is also important to retrieve surface skin temperature and surface emissivity accurately, and understand the effects of any errors in retrieved surface skin temperature and surface emissivity on retrieved CO. In this study, simulated retrieval experiments will be conducted to show the impacts of errors in retrieved surface skin temperature and surface emissivity on retrieved CO. Because MOPITT A-signals are sensitive to both surface emissivity and surface skin temperature, it requires an accurate specification of the surface skin temperature to determine surface emissivity. Therefore, the collocated MODIS surface skin temperatures (MOD11) within the MOPITT FOV are used as inputs for MOPITT 7A-signal, which is least contaminated by atmospheric absorption of CO, to compute the surface emissivity through an iterative retrieval algorithm. The monthly 1 degree-gridded averaged MOPITT 4.7 micron surface emissivity map is then used as a priori surface emissivity to constrain the surface skin temperatures obtained from the MOPITT simultaneous inversion algorithm. The validation of this monthly 1 degree-gridded averaged 4.7 micron surface emissivity map is presented and its impacts to the retrievals of surface skin temperature and tropospheric CO profiles from MOPITT measurements are also discussed.

A31A-05 0900h

Geostationary Satellite Observations of Particulate Pollution: Spatial and Temporal Features of the June 24-28, 2003 Eastern US Air Pollution Episode

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NOAA/NESDIS has been retrieving near real-time total column aerosol optical depths in the visible channel from a Geostationary Operational Environmental Satellite (GOES) for the past three years (http://orbit-net.nesdis.noaa.gov/crad3/gasp/RealTime.html). Aerosol retrievals from a geostationary satellite allows monitoring of particulate pollution over the United States at high spatial (4 km) and temporal (30 minutes) resolution. GOES aerosol retrievals have been shown to be accurate at 30 percent and might be useful in monitoring and forecasting air pollution episodes. The usefulness of GOES aerosol optical depth retrievals in tracking and forecasting regional particulate pollution will be demonstrated by using the June 24-28, 2003 air pollution episode as an example. This episode, like other regional-scale episodes, offers an opportunity to analyze the GOES aerosol optical depths on a regional scale. It resulted in deteriorated air quality across the eastern United States; the polluted air hovered over the region stretching from Georgia to New York with aerosol optical depths ten times higher than the background values. We will present the analysis of spatial and temporal features of this multi-day smog episode and discuss the role of geostationary satellite observed aerosol optical depths in the NOAA-EPA air quality forecast program.

A31A-06 0915h

Satellite Estimation of the Anthropogenic Component of Sahelian and Saharan Dust

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Saharan dust impacts the Earth radiation balance. It was suggested that anywhere between 20-50% of the dust is anthropogenic, generated from human activity in the Sahel. Recent study By Prospero et al noticed that most of the sources should be north of Latitude of 15 deg. where population density is small. Here we use Aqua and Terra data to study the dust sources and their possible anthropogenic origin. Dust packages emitted from the Bodele depression and other sources in the southern part of the Sahara, are transported in the winter by a Northern East winds over the Sahel to the ocean. We are tracking these packages with MODIS from their sources to the ocean, showing that most of the dust reaching the Ocean from the Sahelian shore is

generated in the Sahara, suggesting that the anthropogenic influence in the area is negligible. Saharan dust was suggested to be the main source of nutrients to the Amazon forest. Here we are also showing that these South Saharan sources around the Bodele depression are very active in the winter and rather passive in the summer, suggesting that the type of dust reaching Brazil, and its mineral content from these sources may be different from the dust that arrives to North America and Europe emitted in the summer from different sources.

A31A-07 0930h

Quantitative Constraints on Aerosol Optical Properties Over Dark Water from MISR Multi-angle Imaging

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Prior to the NASA Earth Observing System (EOS) satellite launchs, a broad picture of global aerosol distributions was already emerging, from the combination of earlier in situ and satellite measurements with transport modeling. One goal of the instruments aboard the EOS satellites is to quantitatively improve our knowledge of the aerosol radiative impacts and transport budgets developed from the pre-launch picture, by better constraining aerosol amounts and types, globally. To address this goal, details of low-light-level instrument calibration, as well as assumed aerosol properties and other attributes of the satellite aerosol retrieval algorithms, must be understood, within a few percent accuracy. We identified 14 occasions when the Multi-angle Imaging SpectroRadiometer (MISR) instrument aboard the EOS Terra satellite took high-quality data over islands hosting operational AERONET sun photometers, under relatively cloud-free conditions, at times when aerosol optical thickness (AOT), AOT variability, wind speed, and ocean surface reflectance were low. We simulated top-of-atmosphere equivalent reflectances in all 36 MISR channels using AERONET-derived AOT and particle properties, and compared with MISR radiance products. The details of these comparisons raise interesting questions that bear upon the quality of satellite instrument calibration, the nature of data sets required to validate satellite aerosol retrieval algorithms, and about the combinations of measurements needed routinely to achieve quantitative improvements in the aerosol picture over global oceans. This work is performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

URL: http://www-misr.jpl.nasa.gov

A31A-08 0945h

Comparison of MISR and MODIS Aerosol Optical Depth.

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The Multi-angle Imaging SpectroRadiometer (MISR), aboard NASA's Terra Spacecraft is making measurements of the Top-of-Atmosphere radiance in four spectral bands, centered at 446, 558, 672 and 866 nm, at nine view angles (70.5, 60.0, 45.6, and 26.1 degree, forward and aftward of nadir and nadir). The MODerate resolution Imaging Spectroradiometer (MODIS), also aboard the Terra platform, is making observations of the upwelling earth radiance in a wide spectral range (36 channels). Aerosol optical depths over land and ocean are derived from the measurements of the two instruments. A study was performed to compare MISR and MODIS aerosol optical depths with those derived from simultaneous measurements made by sunphotometers at several AERONET sites. Sources of disagreements between the two instruments are explored in this study. The results are presented in this paper.

A31B MCC: 3018 Wednesday 0800h

Chemistry and Dynamics of the Upper Troposphere and Lower Stratosphere I *(joint with SA, AE)*

Presiding: **D J Cziczo,** NOAA Aeronomy Laboratory**; O Cooper,** NOAA Aeronomy Lab and CIRES

A31B-01 0800h INVITED

Chemistry of Cosmogenic Radioisotopes in the Stratosphere

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Bombardment of Earth's atmosphere by Gev cosmic ray protons produces two neutrons/cm^2/second, which react with ^{14}N nuclei to form ^{14}C. The initial stratospheric reaction of the bare ^{14}C atom with O_2 forms ^{14}CO, which is subsequently oxidized to $^{14}CO_2$ by HO. The $^{14}CO_2$ is then the basis for age-dating studies of inorganic carbon, and of organic carbon after incorporation by photosynthesis. Proton spallation of light nuclei (chiefly ^{14}N, ^{16}O) produces various isotopic fragments, many of them radioactive, containing 8 or fewer protons and 10 or fewer neutrons. For geophysical studies, the most important of the radioisotopes so produced are ^{3}H, ^{7}Be, and ^{10}Be. Proton spallation of ^{40}Ar produces many isotopes with atomic weight less than 40, including ^{34}Cl, ^{36}Cl, ^{38}Cl, ^{39}Cl, ^{35}S, ^{38}S, ^{22}Na, ^{24}Na, ^{32}Si, ^{32}P, and ^{33}P, all of which have been detected in the atmosphere. The "million year" isotopes (^{10}Be, ^{36}Cl) are useful for geological dating. The short-lived isotopes were collected both from rainwater captured at ground level, and on filter paper at 18 kilometers altitude carried by an RB-57 aircraft (**1970**, J. A. Young, C. W. Thomas, N. A. Wogman and R. W. Perkins, *JGR*, 75, 2385). The radioisotopes were measured with multidimensional gamma ray spectroscopy, which was able to detect ^{24}Na and ^{38}Cl without prior chemical separation. Count rates as low as 0.1 count/minute were monitored, even in the presence of 10^7 counts/minute of fallout fission products from nuclear testing in the atmosphere. This fallout background is now greatly reduced because of the four decades old ban on nuclear testing in the atmosphere. The stratospheric collection of ^{24}Na (15 hour half-life) was interpreted as scavenging of the radiosodium by particulate matter, and retention on filter paper with an efficiency of 100 percent within the statistical accuracy in comparison with its production in argon tanks carried on the aircraft. The efficiency of collection of radiochlorine atoms was only about 1/3, which was suggested as incomplete transfer to particles in the much shorter time available before radioactive decay. The chemistry of chlorine atoms such as ^{38}Cl (37 minute half-life) and ^{39}Cl (55 minutes) is probably still homogeneous gas phase in nature. Only small fractions might have reached H^{38}Cl or H^{39}Cl in the time available since nuclear creation of these atoms. Because cosmic ray intensity does not vary diurnally, the atmospheric chemistry of atomic radiochlorine atoms could be investigated under the very different free radical conditions found during night-time.

A31B-02 0815h

Large-Scale Equatorward Transport of Ozone in the Subtropical Lower Stratosphere

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Anomalous vertical profiles of ozone were observed in the sub-tropical lower stratosphere (near South Florida) in July 2002 during the NASA sponsored Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Florida Area Cirrus Experiment (CRYSTAL-FACE) measurement campaign. It is shown that there is an enhancement of ozone (initially > 150 %) above the tropopause extending up to 410 K potential temperature. This ozone increase is the result of recent transport of mid and high latitude lower stratospheric air into the sub-tropics. This meridional transport was a consequence of a geostrophic flow pattern established by a quasi-stationary anticyclone centered over the South-central US that persisted for much of July 2002. We show the spatial and temporal extent of meridional isentropic transport into the sub-tropics by examining the ozone vertical profiles in combination with the O3:NOy correlations as well as isentropic back trajectory calculations. The anomalous ozone profiles are also reproduced in a global chemical transport model.

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A31B-03 0830h

Radiative Forcing Associated with Changes in Upper Tropospheric Ozone Resulting from Deep Convection

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Deep convection transports large quantities of ozone precursors from the boundary layer to the upper troposphere. Once in the upper troposphere, ozone is produced efficiently and can be transported large distances. The 3-D University of Maryland Chemical Transport Model (UMD-CTM), driven by meteorological data from the NASA GEOS-3 Data Assimilation System, was run for the month of June 1985, encompassing a portion of the Kansas/Oklahoma PRESTORM experiment. In addition, the UMD-CTM was run for several 3 to 4 day periods during the same month but without convective transport. Upper tropospheric ozone downwind of major Central U.S. convective episodes was enhanced by as much as 20 ppbv in the model run with convection over the run without convection. Plumes of convectively enhanced ozone were noted exiting the east coast of the U.S. The radiation code from the GEOS-3 GCM was used to compute longwave and shortwave radiative fluxes at all model levels over a domain that included the U.S. and Western Atlantic. The radiative forcing associated with this increased upper tropospheric ozone was computed by subtracting the fluxes calculated using the ozone field from the CTM run without convection from the one run with convection. The results illustrate the importance of parameterizing convective transport properly in regional and global models.

A31B-04 0845h

Heat Balance in the Tropical Tropopause Layer

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Using a cloud resolving model, we show that the heat balance in the tropical tropopause layer (TTL) is between convective cooling and the combined heating effect of radiation and large scale heating/cooling. As expected, large scale dynamical cooling in the TTL such as due to the Brewer-Dobson circulation lifts and cools the TTL. The opposite effect is observed when dynamical heating is applied. In all cases, however, significant convective cooling exists in the TTL. Our results are in contrast to a recent suggestion by Thuburn and Craig (2002) based on a 1D radiative-convective model that the TTL (their substratosphere) is a stratospheric feature decoupled from convection.