A41D MCC: Level 2 Thursday 0830h

Contributions to Middle Atmosphere Science by Solar Occultation Instrumentation I Posters *(joint with SA)*

Presiding: **L W Thomason,** NASA Langley Research Center**; R Bevilacqua,** Naval Research Laboratory**; G Taha,** University of Arizona

A41D-0708 0830h POSTER

Improved SAGE II Water Vapor Inversion

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Archived versions of SAGE II water vapor data exhibit some problems, including strong sensitivity to enhanced aerosol and seasonal variability unlike other stratospheric data sets as well as an apparent dry bias near the hygropause. A modification to the water vapor inversion technique has been developed which addresses these problems. Water vapor is measured with the SAGE II instrument using a single filter-based channel, nominally at 935 nm. It is hypothesized that the spectral response of the filter underwent a significant change in the first few years after launch, broadening and shifting to longer wavelengths. This is in accordance with evidence that the physically similar NO_2 channel, nominally at 448 nm, also underwent a change in wavelength after launch. The NO_2 retrieval was reworked and resulted in significant improvement in NO_2 in version 6.1. A similar change in the water vapor channel would affect the apparent strength of the water vapor feature as well as the contributions of other components such as molecular and aerosol scattering. It was found that a single constant filter adjustment is adequate to yield reasonable agreement with a water vapor climatology from HALOE for the period of 1986 through the present except immediately following the Pinatubo eruption when aerosol interference remains a problem. Better agreement is obtained by allowing slightly different aerosol clearing models for the post-El Chichon period and the post-Pinatubo period. Water vapor data in this newest version show marked improvement over earlier versions.

A41D-0709 0830h POSTER

Preliminary Evaluation of Version 6.2 SAGE II Water Vapor Data Set: Comparison With ATMOS/ATLAS-3 Measurements

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Acurate long-term profile measurements of stratospheric water vapor are needed to better understand possible changes that may have occurred over the past 20 years and its effect on the ozone distribution. The SAGE II satellite instrument has been obtaining water vapor measurements of the middle atmosphere since its launch in 1984. Previous versions of the SAGE II water vapor data reveal dry biases near the hygropause compared to other measurement system that can be as large as 40 % in mid latitudes. Comparisons with a new version of the SAGE II water vapor data set (Version 6.2) and other data sets show much better agreement over a broad range of latitudes and over different seasons. This paper will focus on comparisons between SAGE II and ATMOS/ATLAS-3 (Version 3), which flew on Space Shuttle in November 1994. Results will be shown from comparisons using individual pair coincidences and zonal averages.

A41D-0710 0830h POSTER

An Evaluation of the Geophysical Variability in Stratospheric Aerosol and Gas Experiment II Water Vapor Measurements

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The Stratospheric Aerosol and Gas Experiment (SAGE) II instrument has collected vertical profiles of stratospheric ozone, nitrogen dioxide, water vapor, and aerosol extinction at four wavelengths with high resolution since the program's inception in October, 1984. The latest version (v6.1) of SAGE II water vapor measurements in particular exhibit clear biases in comparisons with other instruments but were of sufficient quality to provide evidence of long-term stratospheric increases, in agreement with independent measurements. This bias has often been attributed to the inability to completely clear the effects of aerosols. The SAGE II processing team has made great strides in characterizing stratospheric water vapor. Recent advancements in the retrieval algorithm has significantly reduced this bias except in the proximity of heavy aerosol levels. These advancements include a single wavelength shift for 1986-present and the combination of 2 aerosol models. There exists a clear requirement for evaluating the water vapor's regular long-term behavior, and for extraction of information pertinent to broader studies of atmospheric radiation, dynamics, and chemistry. This data set becomes evermore valuable as time goes on due to its usefulness for global change studies. We present results characterizing the geophysical variability in the new v6.2 water vapor retrievals. Analysis techniques include performing singular value decomposition on the covariances between the water vapor and QBO time series to characterize the inter-annual variability in the data and empirical orthogonal function analysis to reproduce the tropical tape recorder. These results will be compared to HALOE v19 and SAGE II v6.1 derived patterns to objectively assess the algorithm improvements.

A41D-0711 0830h POSTER

POAM III Validation Summary

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The Polar Ozone and Aerosol Measurement (POAM) III instrument has been making solar occultation measurements at polar latitudes in both hemispheres since April 1998. To date this data set comprises more than 32,000 high-resolution (1 km) vertical profiles of O3, NO2 and H2O density, as well as aerosol extinction from 350 to 1018 nm. In this paper we summarize the status of the POAM III validation analysis for all retrieved species. Using spatially and temporally coincident measurements, the POAM III retrievals are compared with data from other satellites (HALOE, SAGE II, SAGE III), as well as both in-situ and remote sensing aircraft- and balloon-based instruments, including a large sampling of high-latitude ozonesondes. These measurements have been obtained both in routine operation, and as part of special campaigns (e.g., SOLVE I and II). The comparisons provide a statistical estimate of the POAM III retrieval accuracy and precision. Results of this validation analysis are compared for consistency with estimated retrieval errors obtained from a formal error analysis. POAM III data are of high quality and are publicly available for scientific investigations and for validation of new and soon-to-be-launched satellite instruments.

URL: http://wvms.nrl.navy.mil/POAM/poam.html

A41D-0712 0830h POSTER

HALOE Contributions to Solar Occultation Satellite Science Studies

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The Halogen Occultation Experiment (HALOE) instrument on board the Upper Atmospheric Research Satellite (UARS) has been operating without flaw since it was activated on October 11, 1991. The experiment uses the instrument methods of gas filter and broadband radiometry and the solar occultation technique to measure vertical profiles of O3, HCl, HF, CH4, H2O, NO, NO2, extinction due to aerosols, and temperature versus pressure. The HALOE mission has provided the longest remotely sensed, continuous, and near global record of HCl, HF, CH4, and NO measurements in existence. The data have been used to examine transport and chemistry throughout the stratosphere and in the lower mesosphere, validation of other remote sensors, and also to infer how the circulation strength in the middle atmosphere has changed during the UARS time period. We present an overview of the HALOE mission, some of the significant science highlights, comparison's with other instruments, and preliminary results of the next public release version which will extend the H2O profile well into the troposphere. Science highlights include the HALOE derived total Cl and F trends near the stratopause, the tropical tape-recorder signal in H2O, O3 trends, and ozone recovery.

A41D-0713 0830h POSTER

Long Term Calibration of the HALOE Instrument

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HALOE has been in operation for over 12 years providing quality data from the upper troposphere through the mesopause. Monitoring the stability of the experiment is important to ensure a consistent data set spanning such a long time period. Four calibration tests used to routinely ascertain instrument performance will be described here: gas cell concentration, gain, boresight, and field of view (FOV) mismatch. The concentrations of the species in the gas cells that are utilized in the gas correlation channels are determined by a novel approach using the retrieval results themselves. The gains between the gas cell and vacuum paths are determined by instrument scans of the solar disk and the onboard blackbody. The boresight accuracy of HALOE's telescope and the FOV mismatch function between the detectors for each gas correlation channel are determined from special solar scan data. Trends in this calibration data and their effect on final products will be presented along with techniques for determining new calibration values.

A41D-0714 0830h POSTER

New Studies On SAGE II And HALOE Comparisons

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Ozone is an important atmospheric constituent that shields the Earth's surface from harmful ultraviolet radiation, and also plays a critical role in radiation forcing, thus affecting climate change. Both the Stratospheric Aerosol and Gas Experiment II (SAGE II) and the Halogen Occultation Experiment (HALOE) employ the solar occultation technique to obtain unique information about ozone vertical profiles, primarily in the stratosphere. Examination of the interconsistency between data records is critical in building confidence in the measurements provided by these experiments. A comparison of the ozone data sets from SAGE II using its version 6.1 processing code and HALOE using its version 19 processing code is discussed for the period 1991 to 2000. The analysis of weighted mean and weighted root mean square differences in near coincident measurements by the two experiments shows an approximately 1% difference over the altitudes 18 to 50 km. We also examine the time dependence of the bias between measurements of the two instruments. Our results indicate statistically insignificant slopes, less then 0.3% year^{-1}, in the time series of differences between the two measurement systems over 20 to 50 km, with few exceptions. Thus no long-term calibration problems were revealed in SAGE II or HALOE. We also give an estimate of the long-term changes in SAGE II and HALOE ozone data sets by fitting weighted monthly zonal averages to a model including linear, annual, semi-annual, Quasi-Biennial Oscillation (QBO), Solar Cycle and autoregressive noise terms. We fit the above mentioned linear regression model using the weighted least squares approach. The comparison of the trends in ozone data from these instruments shows trend differences on the order of less then 0.3% year^{-1} in a majority of latitude bands at 25, 35, 45 and 55 km altitudes.

A41D-0715 0830h POSTER

Solar Occultation Data Available From the Atmospheric Sciences Data Center

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The Atmospheric Sciences Data Center (ASDC) at NASA Langley Research Center archives data from five solar occultation instruments. Since these data cover a time span of approximately 25 years, these data can be used to study long term trends such as the effects of volcanic eruptions and changes in ozone levels. These are the solar occultation data projects. The Stratospheric Aerosol and Gas Experiment (SAGE) I, II, and III projects cover the time span October 1978 through the present and provide vertical distributions of nitrogen dioxide, ozone, water vapor and aerosols. SAGE III which was launched on December 10, 2001 also obtains profile measurements of aerosol extinction at eight wavelengths, nitrogen trioxide, chlorine dioxide, clouds, temperature and pressure in the mesosphere, stratosphere, and upper troposphere with a vertical resolution of 0.5 - 1 km resolution. The Polar Ozone and Aerosol Measurement (POAM) II instrument measures the vertical distribution of atmospheric ozone, nitrogen dioxide, and aerosol extinction and covers the time span October 1993 through November 1996. The Stratospheric Aerosol Measurement (SAM) II project measures vertical distribution of stratospheric aerosols in the polar regions of both hemispheres and covers the time span October 1978 through December 1993. All of these solar occultation data along with documentation and read software are available from the NASA Langley ASDC at http://eosweb.larc.nasa.gov.

URL: http://eosweb.larc.nasa.gov

A41D-0716 0830h POSTER

The Stratospheric Aerosol and Gas Experiment (1979-1981): Reanalysis

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The Stratospheric Aerosol and Gas Experiment (SAGE) operated from February 1979 through November 1981 and made measurements of nearly-globally distributed profiles of ozone and aerosol extinction. This is an interesting period since it encompasses one of the lowest aerosol loading periods in the last 30 years and is prior to significant ozone loss due to CFCs. SAGE data for this period has significant scientific potential but has been compromised by deficiencies in the release version algorithm. The most noteworthy problems have been a latitudinally dependent altitude misregistration and difficulties in separating NO2 and aerosol effects in the shorter wavelength channels (380 and 450 nm). In this presentation, we discuss the changes to the algorithm that lead to a new release of the SAGE data and the resultant changes in data products. Primary changes include improved satellite ephemeris calculations, use of SAGE II transmission tools, and an improved aerosol model. We also use climatological NO2 profiles (from HALOE) and consequently solve for aerosol extinction at 380nm in addition to those retrieved in earlier versions (450 and 1000 nm).

A41D-0717 0830h POSTER

Evaluation of Reprocessed SAGE-I (V6.0) Ozone Data and Updates of Ozone Trends

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The SAGE-I (V5.9) ozone data have been found to have altitude registration errors of approximately 300 meter (Wang et al., 1996) due to ephemeris errors. Empirical corrections were applied to SAGE-I ozone data before they were used in many ozone trend studies (e.g. SPARC report 1998, WMO 2002). A recent study based on SAGE-I/II (1979 to July 2000) and HALOE (Oct. 1991 to April 2003) ozone measurements, indicates a slow down of upper stratospheric ozone loss since 1997 (Newchurch et al., 2003). It has, however, been argued that the uncertainty in empirically corrected SAGE-I ozone data and solar cycle effects may result in larger uncertainties on the ozone trends estimated by Newchurch et al. (2003). This paper will evaluate a new SAGE-I (V6.0) ozone data retrieval, which attempts to correct altitude registration errors. Correlative measurements from SBUV and ozonesondes will be used to validate the SAGE-I (V6.0) data and the altitude corrections will be compared against those in Wang et al (1996). The quality of the reprocessed SAGE-I ozone data below 20 km altitudes will also be evaluated. In addition updated ozone trends based on SAGE-I (V6.0) and SAGE-II (V6.2, including data after July 2000) will also be presented. Reference, 1. Newchurch M. J., Eun-Su Yang, D. M. Cunnold, Gregory C. Reinsel, J. M. Zawodny, James M. III Russell, Evidence for slowdown in stratospheric ozone loss: First stage of ozone recovery, J. Geophys. Res., 108, D16, 8617, 10.1029/2002JD003114 2. Wang H.J., D. M. Cunnold, and X. Bao, A critical analysis of SAGE ozone trends, J. Geophys. Res., 101, 12,495-12,514, 1996 3. Assessment of Trends in the Vertical Distribution of Ozone, SPARC report, 1998, WMO-Ozone Research and Montoring Project Report No 43. 4. Scientific Assessment of Ozone Depletion: 2002, WMO

A41D-0718 0830h POSTER

Rigorous Metric For Quantifying Ozone Recovery

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Newchurch et al. [2003] have shown that, based on SAGE and HALOE measurements, decreases in upper stratospheric ozone have slowed since 1997. This conclusion depends upon an accurate removal of long-term changes such as those due to the solar cycle and an accurate assessment of the residual uncertainties. This poster discusses error propagation in the cumulative sum approach and why it should reveal a change in the trend faster than typical analysis procedures. The attribution of the ozone changes based on coincident HALOE measurements of ozone, HCl, CH4, H2O, and temperature is also addressed in more detail.

A41D-0719 0830h POSTER

SAGE III Cloud Determination: Method and Examples

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The Stratospheric Aerosol and Gas Experiment (SAGE) III is the latest in a series of solar occultation satellite instruments designed for the measurement of aerosol and gases. SAGE III extinction data obtained at three wavelengths (525, 1020 and 1550 nm) is used to determine whether cloud is present along the optical path from the sun to the satellite instrument. The algorithm used differs from that previously used to detect cloud using the SAGE II instrument, where data was not available at 1550 nm. Due to the long optical path through the atmosphere, both instruments are extremely sensitive to low values of extinction. In the troposphere, cloud data is divided into two classes: non-opaque , which is mainly subvisual, and opaque. SAGE III is also able to detect the presence of polar stratospheric cloud. Unlike SAGE II where cloud presence was a research product, cloud presence is a standard data product for SAGE III. SAGE III cloud data from May, 2001 onwards, at altitudes between 6 and 30 km, is currently being made available for general use. The theoretical background to the SAGE III algorithm is described and contrasted with that used with data from the SAGE II instrument. Examples showing how the algorithm is applied to the data are presented for a cloud-free atmosphere, for non-opaque stratospheric and tropospheric clouds, and for opaque clouds. Under some circumstances the signature of thin cloud in the data set can be confused with that of dense aerosol, produced for example as a result of volcanic activity or by lofting of dust from the surface of the earth. This potential confusion necessitates a quality control procedure for the data; this procedure is explained, together with the changes that this operation produces on the output data format and timing. In the interest of the long-term continuity of the SAGE II/ SAGE III cloud data set some of the SAGE III data has been processed using both the current SAGE III algorithm and the older SAGE II algorithm. Preliminary results of this intercomparison are briefly described.

URL: http://www-sage3.larc.nasa.gov

A41D-0720 0830h POSTER

Long Term Monitoring of Post Pinatubo Aerosols

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Lidar observations at Hampton, Virginia (37.1N, 76.3W) show that the stratospheric aerosol loading, after recovering from the 1991 Mount Pinatubo eruption, has been very low for the past five years. Since Pinatubo, there have been no major eruptions to influence northern mid-latitude stratospheric aerosols. Thus, the aerosol level gradually decreased over the years since 1992, when the Pinatubo aerosol reached a peak level. Current lidar integrated backscatter values, measured at 694 nm wavelength, indicate the aerosol level to be slightly below "background" values measured in 1978 following a volcanically quiescent period. The current measurements suggest that the natural stratospheric aerosol background level may be lower than previously thought. This measurement activity is part of an on-going lidar monitoring program at

NASA Langley Research Center to study and characterize stratospheric aerosols. The results presented here, which include a long-term lidar record spanning 30 years, were obtained with a ground-based 48-inch lidar. We will present selected backscatter ratio profiles measured during periods of enhanced aerosol loading produced by the Pinatubo eruption and profiles measured during periods well after the Pinatubo aerosol was removed. In addition, lidar integrated backscatter measurements will be compared with optical depth measurements obtained by SAGE and SAGE II satellite-based instruments, which employ the solar occultation technique.

URL: http://www-sage2.larc.nasa.gov/

A41D-0721 0830h POSTER

Retrieval Analysis of Aerosol Properties Deduced From Extinctions at SAGE II, SAGE III, and HALOE Wavelengths

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SAGE II measures aerosol extinctions at four visible and near IR wavelengths. SAGE III measures aerosol extinctions at five additional wavelengths; the longest one is 1.55 micron. On the other hand, all HALOE aerosol channels are at IR wavelengths ranging from 2.45 to 5.26 micron. There are comparison opportunities when HALOE and SAGE II or SAGE III conduct measurements at close locations and times. The advantages of the following three methods of approach are discussed: (1) Converting HALOE aerosol extinctioni to extinctions at SAGE III wavelengths; (2) Converting either SAGE II or SAGE III aerosol extinctions to extinctions at HALOE wavelengths; (3) Deducing aerosol properties from SAGE II, SAGE III, and HALOE extinction measurements. It is found that in general, the conversion to extinction at 1.55 micron from HALOE measurements is more accurate than other approaches. It is also found that the retrieval uncertainty is highly dependent on the measurement uncertainty associated with each data set. The preliminary results of comparing HALOE with SAGE II or SAGE III are presented and the relatively larger discrepancies shown at higher altitudes are discussed.

A41D-0722 0830h POSTER

The Climatology of the High-Latitude Stratospheric Aerosol Measured by POAM From 1993 to 2003

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We present a climatology of the high-latitude stratospheric aerosol derived from the multi-wavelength extinction data of the POAM II and III instruments from 1993 to 2003. Stratospheric aerosols north of 54 N and south of 63 S were continually monitored by POAM II between September 1993 and November 1996. These data clearly show the decay of the volcanic aerosol from the Pinatubo eruption which was still evident when the spacecraft ceased operation at the end of 1996. POAM III was launched into a similar orbit in March 1998 and has monitored the seasonal variation in the aerosol layer since its recovery to background levels. Extinction data from these two instruments at six wavelengths from the ultraviolet to near-infrared are combined through principal component analysis to yield total aerosol surface area, volume and effective radius. The temporal and spatial evolution of these physical parameters, employed in chemistry and climate models, are presented and analyzed.

A41D-0723 0830h POSTER

Characterization of Aerosol and PSC Sensitivity of ACE Solar Occultation Measurements

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The ACE Fourier Transform Interferometer was launched on SCISAT on August 12, 2003 to make solar occultation measurements. This high spectral resolution (0.02 cm^{-1}) instrument has broad spectral coverage (750-4100 cm^{-1}). In the work presented here, we will discuss the potential of ACE measurements for characterizing stratospheric sulfate aerosol (SSA) and polar stratospheric clouds. Previously reported studies showed that the high spectral resolution solar occultation measurements of ATMOS, which have limited spectral coverage, can be used to characterize SSA composition under high and moderate loadings. It has also been shown that MkIV airplane-based measurements, with a spectral range similar to ACE, have use in characterizing aerosol size. The work presented here is a sensitivity study of ACE measurements to characterize aerosol size and composition under current aerosol loading conditions and higher aerosol loadings.

A41D-0724 0830h POSTER

A 25-year History of Aerosol Extinction Measurements by the Stratospheric Aerosol Gas Experiment Series

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The Stratospheric Aerosol and Gas Experiment (SAGE) series of instruments has now produced over 25 years of aerosol extinction measurements. These instruments consist of SAM II (1978-1993), SAGE (1979-1981), SAGE II (1984-present), and SAGE III (2002-present). This period encompasses several significant volcanic perturbations of the stratosphere including those by El Chichon in 1982 and Pinatubo in 1991. Since these events are relatively rare, the record between 1978 and the present is dominated by the lengthy relaxation back to non-volcanic levels. Within this period, at least two periods have been suggested to have reached a non-volcanic level throughout the stratosphere: 1979 and after 1999. In this presentation, we will compare mean and seasonal behavior of SAGE measurements those periods and discuss the problems associated with the use of SAGE data infer changes in stratospheric levels between them. Chief among these difficulties are the long-term stability of the instruments, the cross calibration of the instruments, and dynamic range of the instruments. All of these factors are crucial in establishing confidence limits on any derived difference in stratospheric aerosol levels between these periods.

A41D-0725 0830h POSTER

Comparing the Climatic Impact from Low Latitude versus High Latitude Volcanic Eruptions

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Explosive volcanic eruptions cause large amounts of SO_2 to be injected into the stratosphere. The SO_2 is converted to sulfate aerosols over time, which cause a significant radiative perturbation to the climate system. The resulting climate response should depend strongly on the latitude of the eruption. We examine these differences using observations and a new version (model E) of the Goddard Institute for Space Studies (GISS) general circulation model (GCM), comparing the temperature and circulation responses of the low latitude Mount Pinatubo (15°N) eruption on June 15, 1991, with those from the high latitude Katmai (58°N) eruption, which occurred on June 6, 1912. For the Pinatubo eruption, we constructed an aerosol data set utilizing SAGE II observations as well as other remote sensing instruments. Our new simulations with the GISS GCM, as well as previous simulations with the GFDL SKYHI and Max Planck ECHAM 4 GCMs, have shown that volcanic aerosol heating of the lower stratosphere from thermal IR and solar near-IR radiation causes changes in the circulation of the stratosphere by increasing the meridional temperature gradient, resulting in a stronger polar vortex. They also showed that reduced solar radiation in the troposphere caused cooler temperatures in the subtropics, which decreased the meridional temperature gradient. This caused a reduction in the amplitude of planetary waves and allowed further strengthening of the polar vortex. The resulting forced positive phase of the Arctic Oscillation caused changes in tropospheric circulation. For Katmai, aerosol data were derived primarily from pyrheliometric observations, and show that while the optical depth was similar in magnitude to the Mount Pinatubo eruption, it was confined to the Northern Hemisphere generally north of 30°N. Modeling of this eruption showed mainly mid- and high latitude cooling over continental areas for approximately 1 year following the eruption. This caused an increase in the meridional temperature gradient. Simulations also indicate a warmer and weaker stratospheric polar vortex in the first winter following the eruption.

A41E MCC: Level 2 Thursday 0830h

Remote Sensing of Atmospheric Constituents II Posters

Presiding: **V S Connors,** NASA Langley Research Center

A41E-0726 0830h POSTER

Using Structure Tensors for Atmospheric Parameter Estimation

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The structure tensor is a common tool for estimating motion in image sequences. The structure tensor can be extended to estimate other dynamical parameters such as diffusion constants or exponential decay rates. A general mathematical framework was developed for the direct estimation of the physical parameters that govern the underlying processes from image sequences. This estimation technique can be adapted to the specific physical problem under investigation, so it can be used in a variety of applications in trace gas, aerosol, and cloud remote sensing. The fundamental algorithm will be extended to the analysis of multi-channel (e.g. multi trace gas) image sequences and to provide solutions to the extended aperture problem. Based on this analysis, a method to compute atmospheric data parameter fields will be presented.

A41E-0727 0830h POSTER

New Laboratory Measurements of the Spectral Line Parameters of CO Applicable to Atmospheric Remote Sensing.

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New high-resolution (0.005 cm^{-1}), low-temperature (87-300 K), measurements of the spectral line parameters in the 1-0, 2-0, and 3-0 bands of CO are reported. The line parameters are the absolute intensities, collision-broadened half-widths, collision-induced line shifts,and the variation of these