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In this issue ...

Meeting/Workshop Summaries

Other Items of Interest

Regular Features

EDITOR'S CORNER

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I'm pleased to report that the Consolidated Appropriations Bill that consolidated funding normally allocated in 7 separate Appropriations Bills, including the Veterans Administration, Department of Housing and Urban Development, and Independent Agencies (including NASA) for FY2004 has been signed by the President on January 23, 2004. NASA and many departments of the government have been operating under 7 different continuing resolutions since the start of the fiscal year on October 1, 2003. The bill appropriates $15.38 B for NASA for FY 2004, which is $10 M more than the FY 2003 budget. The bill allocates $1.526 B for Earth science programs, not including earmarks, a decrease of $26 M to the budget request. The decrease is due primarily to an $11 M reduction to the Global Climate Change Research Initiative, primarily the Glory mission, and a recision of 0.59% applied against all projects.

The FY04 Earth science budget includes $86.9 M in specific earmarks, which includes $23 M for the EOSDIS Core System Synergy program to develop additional uses for EOS data, $8.5 M for an NPP data science system through ECS, and numerous other allocations to various Universities and Institutes to enhance the use of EOS data and its applications.

This funding allocation continues the development of NPP, Ocean Surface Topography Mission, Landsat Data Continuity, CloudSat, CALIPSO, Orbiting Carbon Observatory (OCO), Aquarius, and Glory. The FY05 budget submitted by the President for consideration by Congress defers GPM two years, and Ocean Vector Winds indefinitely, pending assessment of the impact of the loss of ADEOS II (Midori II) and the science utility of Coriolis (passive measurement approach). Future Earth Science System Pathfinder (ESSP) mission funding is deferred one year, but the Announcement of Opportunity (AO-4) release remains targeted for FY04, selection to include

Continued on page 2

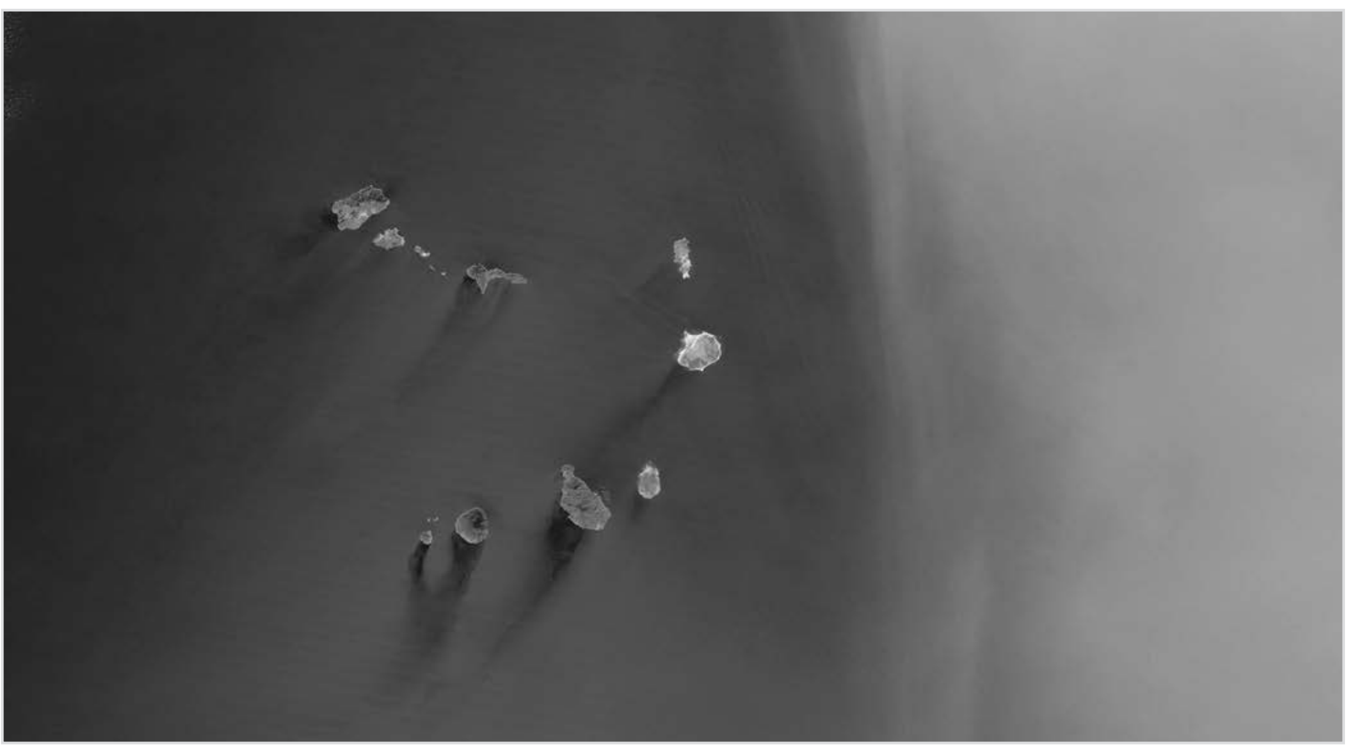
a risk reduction period. The Hydros ramp-up is tied to future ESSP funding.

The Aura satellite is now scheduled to launch between June 17 and 20. This mission is the last of the first series of EOS satellites, and is aimed at studying the Earth's ozone, air quality and climate. This mission is designed exclusively to conduct research on the composition, chemistry, and dynamics of the Earth's upper and lower atmosphere, employing multiple instruments on a single spacecraft. It will carry NASA instruments, MLS and TES, along with HIRDLS, a joint UK/US instrument, and OMI, an instrument provided by the Netherlands and Finland. Best wishes to the Aura Team for a successful launch.

Aquarius, OCO and Hydros were officially selected for the formulation phase as ESSP missions in January. The Jet Propulsion Laboratory will manage these new missions. Aquarius will measure global Sea Surface Salinity (SSS), OCO will generate and release precise global maps of carbon dioxide (CO_2) in the Earth's atmosphere, and Hydros will provide the first global view of the Earth's changing soil moisture and surface freeze/thaw conditions, enabling new scientific studies of global change and atmospheric predictability, and making new hydrologic applications possible.

The EOS Data Products Handbook, Volume 1, has been made a "living" document on the web. This recently revised document contains data product descriptions for Terra, TRMM, and the Data Assimilation System, and can be found at *eos.nasa.gov/eos_homepage/for_scientists/data_products/vol1.php*. Changes to the Handbook will be made periodically.

The Office of Earth Science at NASA Headquarters recently released the new Earth Science Enterprise Strategy document. It can be found at *earth.nasa.gov/science/index.html*. It's companion document, 'Understanding Earth System Change: NASA's Earth Science Enterprise Research Strategy for 2000-2010' is located at *earth.nasa.gov/visions/researchstrat*. You will also find links to the 'Earth Science Enterprise Applications Strategy,' 'Earth Science Enterprise Technology Strategy,' and 'Inspire the Next Generation of Earth Explorers: NASA Plan for Earth Science Education' at that same URL.



This striking image shows a clear view of the Cape Verde Islands in the eastern Atlantic as a massive wall of Saharan Desert dust is fast approaching from the east. In this scene, the Cape Verde Islands sit in the middle of a large area of sunglint, which refers to the bright patch of water around the islands where a lot of sunlight is being reflected directly up at the satellite. This scene was acquired on February 3, 2004, by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite. Image courtesy Jacques Descloitres, MODIS Land Rapid Response Team at NASA GSFC.

The Solar Radiation and Climate Experiment (SORCE) Science Team Holds its First Meeting Since Launch

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— Judith Lean, jlean@ssd5.nrl.navy.mil, Naval Research Laboratory
— Peter Pilewskie, peter.pilewskie-1@nasa.gov, NASA Ames Research Center
— Robert Cahalan, robert.f.cahalan@nasa.gov, NASA Goddard Space Flight Center

The SOlar Radiation and Climate Experiment (SORCE) team recently conducted its first science meeting since the January 2003 launch. The meeting, **Physical Processes Linking Solar Radiation and Solar Variability with Global Climate Change**, was held December 4-6, 2003, in Sonoma, California. Approximately 80 scientists gathered to focus on the understanding of the physical processes that connect the Sun's radiation and its variability to our terrestrial environment, including the processes involved with climate and ozone responses to solar radiative forcing, and the mechanisms that cause solar activity and irradiance variations.

The EOS SORCE mission is currently measuring the Sun's total and spectral irradiance with unprecedented accuracy and spectral coverage. In addition to securing a reliable database with which to characterize solar radiative forcing of climate and global change, the SORCE program seeks to foster new understanding of the origins of the solar variations and the physical pathways by which the Earth's atmosphere, oceans, and land respond, on multiple time scales. This undertaking involves numerous scientific disciplines—ranging from the theory of the solar dynamo that drives solar activity to the dynamical ocean-atmosphere systems that influence climate; from astrophysical aspects of solar-stellar synergy to the storage of galactic cosmic rays in tree rings and ice cores and their associations with paleoclimate records from ocean and ice cores during past millennia.

In addition to presenting the latest, exciting SORCE irradiance measurements, the intent of this first science team meeting since launch was to survey current understanding of the physical processes occurring on the Sun and in the terrestrial environment that potentially facilitate Sun-climate linkages. Subsequent science team meetings will address focused "subset" topics in greater depth. SORCE aims to provide a forum for multidisciplinary Sun-Earth studies, and this first meeting was an important part of establishing a dialog among researchers that we hope will continue and grow.

With over 60 abstracts submitted, attendees enthusiastically shared information, ideas, and opinions over the two-and-one-half days of oral and poster presentations. Many of the presentations are available on the SORCE website at *lasp.colorado.edu/sorce/Dec03 ScienceMeeting.html*. The scientific organizing committee, Judith Lean from the Naval Research Laboratory (NRL) and Peter Pilewskie from NASA Ames Research Center, arranged the meeting into six sessions:

1. Solar Radiation – Status of Current SORCE Measurements
2. Solar Radiation – Long-Term Records and Reconstructions
3. Long-Term Solar Variations
4. Climate Change Processes Involving Solar Radiation in the Troposphere
5. Global Change Processes Involving Solar Radiation in the Stratosphere
6. Future Directions in Sun-Climate Research

Three keynote overview presentations established the broad scientific context for the meeting and exemplified the extensive cross-disciplinary aspect of research in this topic. **Jack Eddy** (National Solar Observatory, Tucson, Arizona), widely regarded as the father of Sun-climate research, and chair of a recent NASA Sun-Climate Task Group, summarized "Current Status of Sun-climate Connections and Possible Processes." **V. Ramaswamy** (NOAA, Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey), lead author of the radiative forcing chapter of the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR), reported on the current status of "Solar Variations and Global Climate Change," placing the Sun's role in the broader context of other natural and anthropogenic climate forcings. **Jeffrey Hall** (Lowell Observatory, Flagstaff, Arizona), convener of a recent workshop on Solar-Stellar variability, summarized the findings of that meeting and "The Next Decade of Stellar Cycles Research."

Providing the meeting's most memorable quote, **Jack Eddy** eloquently reminded meeting attendees "*Were God to give us, at last, the cable, or patch-cord that links the Sun to the Climate System it would have on the solar end a banana plug, and on the other, where it hooks into the Earth—in ways we don't yet know—a Hydra-like tangle of multiple 24-pin parallel computer connectors. It is surely at this end of the problem where the greatest challenges lie.*" Eddy identified a number of such challenges including Earth's greater-than-expected apparent climate sensitivity to the solar cycle (**Figure 1**) and asked whether internal variability modes such as the El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO) might somehow be playing a role. On longer time scales, he identified the crucial need for improved knowledge of climatically-significant long-term solar irradiance variations.

Ramaswamy continued the theme of uncertainty in current knowledge of solar irradiance variations. Many long-term climate-response simulations, including those conducted for IPCC TAR, have utilized solar total irradiance time series with long-term trends notably larger than the solar cycle. Ramaswamy also pointed out that secular trends are poorly known even for contemporary solar total irradiance. General circulation model simulations show that although comparable solar and greenhouse gas forcings can at first appear to invoke nominally similar climate responses, closer scrutiny reveals differences. For example, the effects on precipitation and evaporation differ but the difference is the same. Ramaswamy pointed out that from a modeling perspective solar-induced climate change is modest, at most. Ozone might amplify the irradiance forcing, but there are large disagreements because of the uncertainty of ozone profiles.

Jeffrey Hall addressed long-term solar variability from a completely different perspective – the behavior of Sun-like stars. Evidence for stellar Maunder Minima inferred from a bimodal distribution of Sun-like stars a decade ago is now shaky. The apparent reduced irradiance in non-cycling Sun-like stars in Maunder-type periods was a basis for scenarios of long-term irradiance variations. A revised distribution of stellar activity from more than 7000 observations of solar-like stars does not reproduce the bimodal distribution (Hall & Lockwood 2004, *Science*, submitted) and implies notably less solar variability beyond that of the solar cycle. Hall echoed Ramaswamy's concern for the uncertainty in historical irradiance reconstructions. Currently the valid sample of solar twins consists of just one star. In the future, a broader set of activity proxies is needed and the sample must have expanded coverage of stellar brightnesses, including in a range of spectral regions, and of clusters, using automated observing stations.

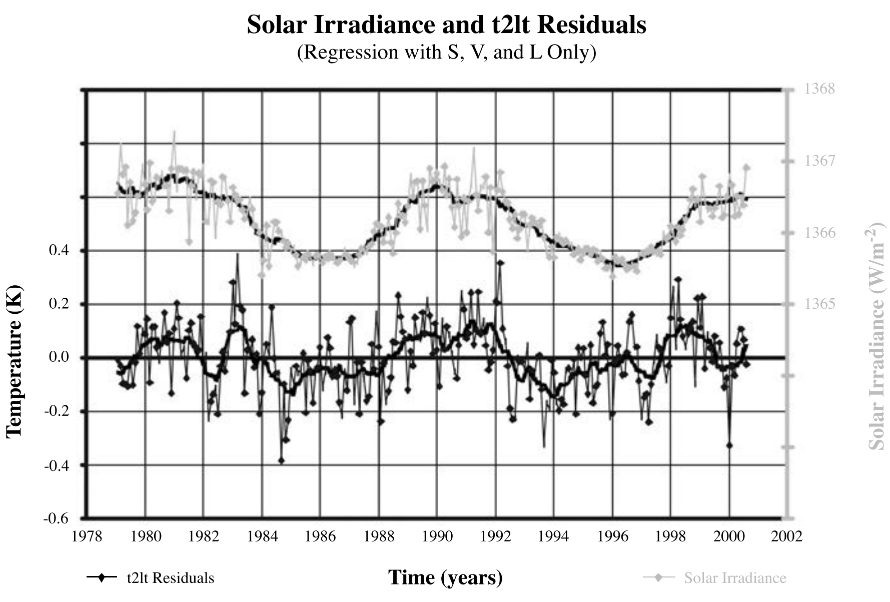
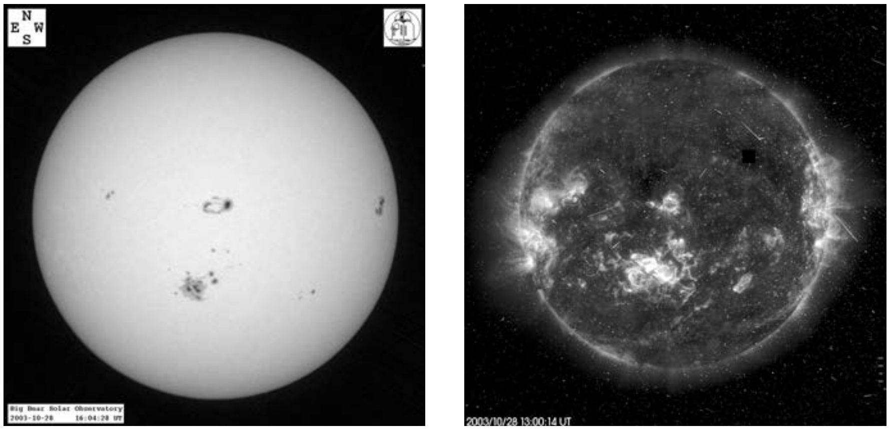


Figure 1: When the effects of ENSO, volcanoes, and a long-term trend are removed from the Microwave Sounding Unit global surface temperatures, the residual temperatures (lower curve) track the total solar irradiance (upper curve) (Douglass and Clader, *GRL*, 2002).

Session 1 – Solar Radiation – Status of Current SORCE Measurements
Chair: ***O.R. White***

Gary Rottman, SORCE Principal Investigator, began this session with an overview of the SORCE mission, including wonderful observations of the historically dramatic activity that occurred in October and November, months before the meeting. The history of SORCE goes back to the original EOS selection in 1989 of the Solar Stellar Irradiance Comparison Experiment (SOLSTICE) as one of the many instruments to fly on the two large EOS polar platforms. In response to a much later Announcement of Opportunity (AO) in 1997, the Total Solar Irradiance Monitor (TSIM) program was initiated, and finally in 1999 the EOS SOLSTICE and TSIM were combined to a single mission

Figure 2: Near the end of October, 2003, a very large active region near the center of the solar disk, recorded by the Big Bear Solar Observatory in white light (left image) produced historically high levels of X-rays and the solar corona, recorded at 17 nm by the EIT instrument on SOHO (right image).



called SORCE. The primary science objectives of SORCE are to make daily measurements of Total Solar Irradiance (TSI) and spectral irradiance over almost the entire spectral range from soft X-rays, through the visible and into the infrared. The SORCE program is managed as a Principal Investigator mode mission by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado, Boulder. LASP designed and developed the four scientific instruments, the Total Irradiance Monitor (TIM), the Spectral Irradiance Monitor (SIM), the Solar Stellar Irradiance Comparison Experiment (SOLSTICE), and the XUV Photometer System (XPS), and subcontracted the highly reliable and fully redundant spacecraft bus from Orbital Sciences Corp. The NASA Project Science Office is at Goddard Space Flight Center (GSFC) and continues to provide oversight to the mission.

SORCE was launched on January 25, 2003, aboard a Pegasus XL rocket into a low Earth orbit (LEO) with altitude near 600 km and inclination of 40°. The Mission Operations Center and Science Operations Center are both at LASP on the Boulder Campus, and commands and data are typically communicated with the satellite twice per day. All aspects of the mission exceed expectations with the spacecraft and instruments continuing to function flawlessly.

The SORCE instrument scientists provided overviews of instrument performance and some important early results from the first year of observations. **Greg Kopp** discussed the TIM designed to measure total solar irradiance with a new level of accuracy and precision thanks in large part to the many innovations of George Lawrence—most importantly, the new phase-sensitive detection scheme. **Jerry Harder** provided a first glimpse of the new spectral data being returned by SIM. These data are the first solar irradiance data in the visible and near infrared with sufficient precision to detect solar variability. There are intriguing new results that will constrain models of solar variations, especially in the near infrared, where it is not yet known whether faculae increase or decrease irradiance. The SOLSTICE on SORCE is a second generation and improved version of the instrument on the Upper Atmosphere Research Satellite (UARS). **Bill McClintock** showed the new SOLSTICE data that will validate and refine the data from UARS. The stellar comparison technique used by SOLSTICE is vastly improved on SORCE, especially at the longer wavelengths near 300 nm. Lastly, **Tom**

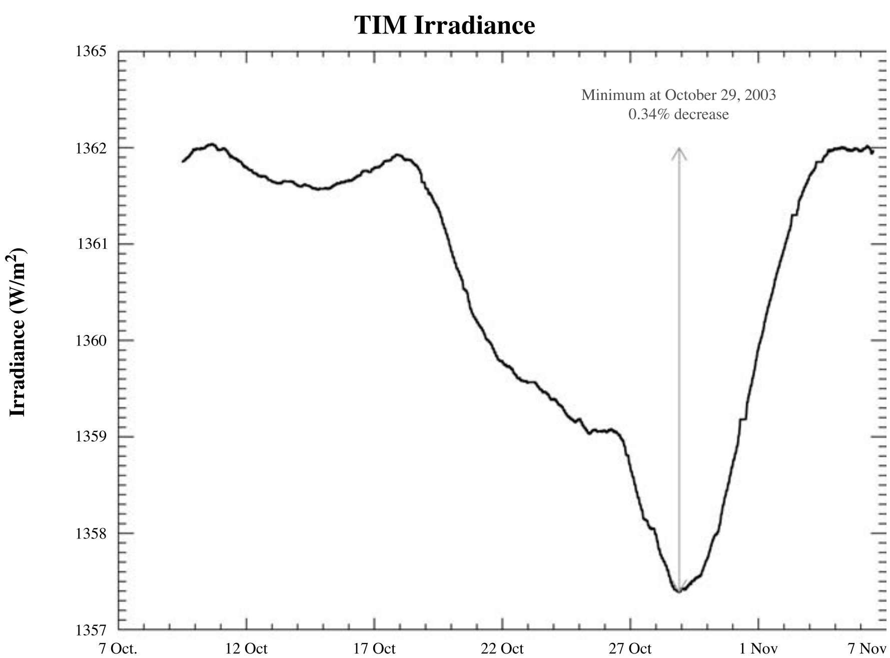


Figure 3: TIM measurements of TSI in October 2003. The extremely large sunspot groups gave rise to one of the largest dips in TSI ever recorded.

Woods talked about the soft X-rays and EUV observed by the XPS a sibling of a similar instrument operating on Woods' Solar Extreme ultraviolet Experiment (SEE) on the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft.

Just one month before this Science Team Meeting the Sun provided some exceptionally intense solar activity—the largest sunspots ever observed from space and some of the most intense solar flares (**Figure 2**).

The total solar irradiance variations during this particular time period are illustrated by the TSI observations shown in **Figure 3**. It was indeed fortuitous that the SORCE was fully operational at this time and that the instruments happened to be in ideal configurations to provide optimal flare observations. The results presented were very preliminary, but they were also very intriguing and are indicative of the wealth of new insight that will be forthcoming in our understanding of the Sun and of the Earth's response to its changing radiative power.

All science data are processed, analyzed, validated, and distributed through LASP's Mission and Science Operations Center in Boulder, Colorado. Processed data are being distrib-

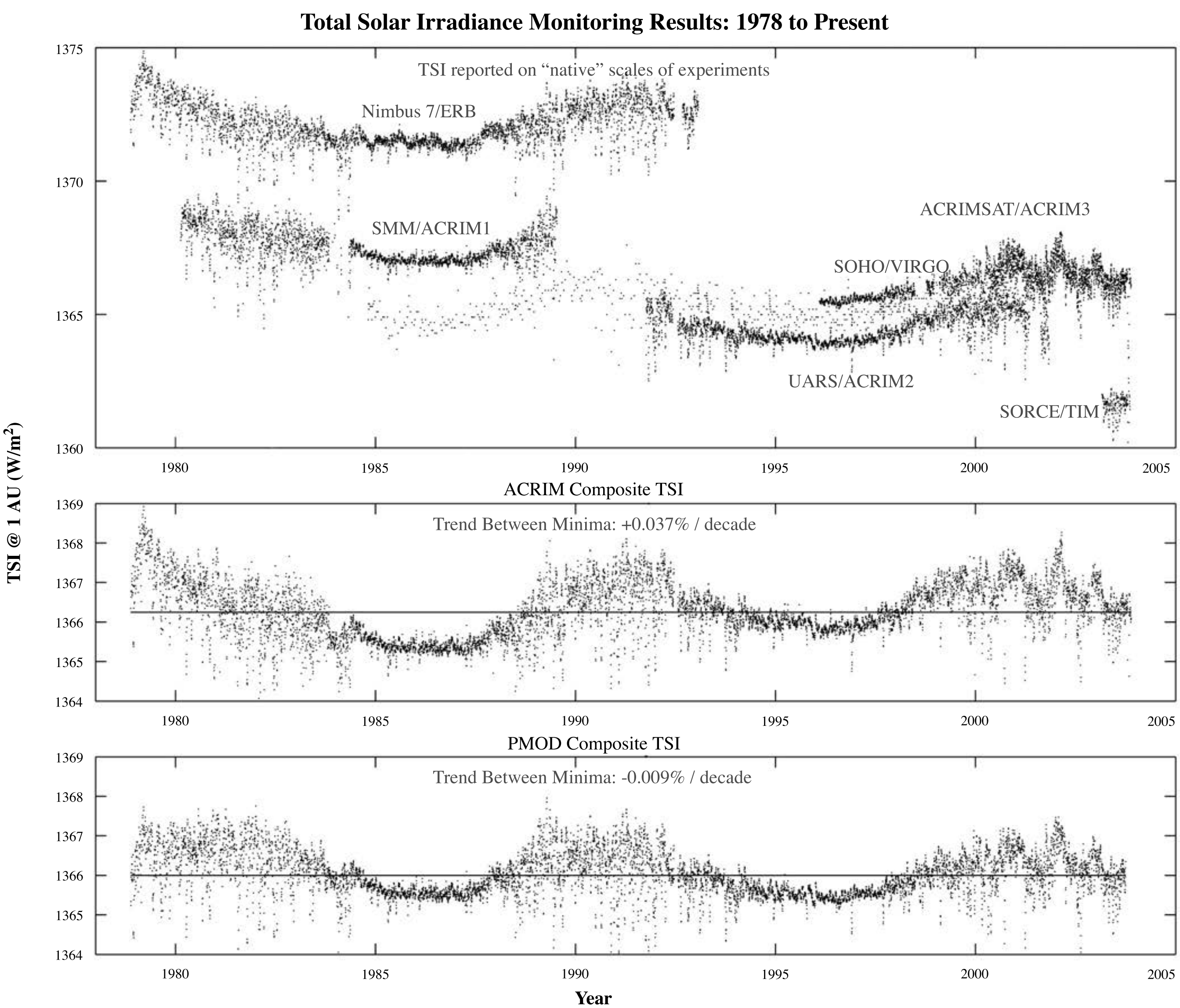


Figure 4: In the top panel are the total irradiance observations made by multiple spacecraft since 1978. From these observations are constructed two different composite records — the ACRIM composite, in the middle panel, has a significant irradiance increase between successive solar minima in 1986 and 1996, whereas the PMOD composite, in the lowest panel, does not.

uted to the science community through the GSFC DAAC (Distributed Active Archive Center). For additional information on obtaining SORCE data from the DAAC and reading the SORCE HDF data files, see *lasp.colorado.edu/sorce/data_access.html*.

Session 2 – Long-Term Records and Reconstructions
Chair: ***O.R. White***

Attendees at the SORCE meeting debated vigorously the evidence for secular change in the contemporary irradiance database, a controversial topic featured in a recent Earth Observatory feature—*earthobservatory.nasa.gov/Study/VariableSun/*.

The issue is whether—or not—total irradiance observations when combined in a composite record have a long-term upward trend, lacking in the Physicalisch-Meteorologisches Observatorium Davos (PMOD) composite in **Figure 4** but evident in the Active Cavity Radiometer irradiance Monitor (ACRIM) composite. Combining multiple satellite data sets presents problems of cross calibration and tracking of instrument sensitivities at different mission phases. The particular difficulty is bridging the 1989 – 1991 gap between ACRIM I and ACRIM II observations.

The composite total irradiance record in wide use, and the basis for historical reconstructions (lowest panel, Figure 4), is constructed by first making adjustments for drifts in the Hickey-Frieden (HF) radiometer on the Nimbus 7 spacecraft used during 1989-1992. The resultant composite is in good agreement with the long-term Earth Radiation Budget Satellite (ERBS)/Earth Radiation Budget Experiment (ERBE) record and also with independent predictions by proxy models. In contrast, the ACRIM composite total irradiance time series makes no adjustments to published data but assumes that ERBS/ERBE, rather than Nimbus 7/ERB, suffered instrumental drifts during 1989-1992. Between successive minima the PMOD composite has no significant trend whereas the ACRIM composite has a significant 0.04 % per decade trend.

Claus Fröhlich described in detail the complicated process of constructing a composite irradiance record in his talk "*Total Solar Irradiance Variability From 1978 to Present*." In particular, he identified the crucial importance of Nimbus 7 data in the gap between ACRIM I and ACRIM II observations. This gap occurred from 1989 to 1992, near the end of the Nimbus 7 mission, when significant drifts are thought to have occurred in the dataset. It is the significant irradiance increase of ~0.5 W/m^{-2} from 1989 to 1992 that is the source of the upward trend in the ACRIM composite (**Figure 5**). At most other times, the ACRIM and PMOD composite track quite closely. In a subsequent presentation "*The Construction of a Long-Term Total Solar Irradiance Record and Its Uncertainties*," **Steven Dewitte** described a different approach of scaling individual irradiance data sets to five point measurements made with higher-accuracy by radiometers on the Space Shuttle. This approach yields a composite record that has detectable differences between solar minima (but smaller than in the ACRIM composite) of the order of 0.2 W/m^{-2} per decade, but with large uncertainties (95% uncertainty: ± 0.35 W/m^{-2}). Of all the total irradiance data sets, only the ERBS, which extends from 1984 to the present, covers two solar minima. **Robert Lee** described the ERBS dataset "*1984 – 2003, Earth Radiation Budget Satellite (ERBS) / Earth Radiation Budget Experiment (ERBE) TSI Measurements.*" Due to very low solar exposure the ERBS radiometer is believed to have been remarkably stable during its mission. The ERBS dataset does not show evidence for a signifi-

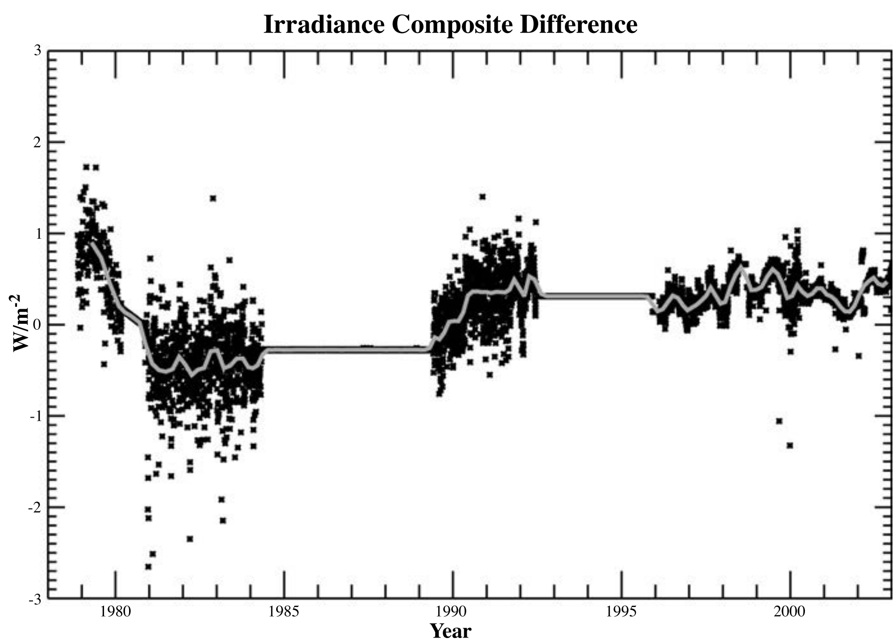


Figure 5: Differences between the PMOD and ACRIM composite total irradiance records occur primarily in 1989-1992. 0.05% per these 3 years (only), not per decade.

cant upward irradiance trend between solar cycle minima. Furthermore, the ERBS data are in good agreement with irradiance variability models of the sunspot and facular influences. The primary advocate of secular change in the contemporary irradiance record, **Richard Willson**, discussed the "*ACRIM Composite Total Solar Irradiance Time Series*." This time series combines ACRIM I and ACRIM II data sets using the Nimbus 7 observations to fill the gap between them, but without making any corrections for instrumental drifts. Rather, Wilson's thesis is that ERBS sensitivity declined while the Nimbus 7 sensitivity remained stable from 1989 to 1992. The session ended with Robert Lee's recognition that an external team, possibly composed of NIST calibration experts, may be needed to assess the radiometric evidence for real secular change versus instrumental drifts in the total irradiance data sets, especially those from Nimbus 7.

Session 3 – Long-Term Solar Variations
Chair: ***Hugh Hudson***

As V. Ramaswamy articulated in his Keynote address, knowledge of long-term solar irradiance variation is needed for reliable climate change attribution and detection. But the total irradiance database exists only for 25 years. So this knowledge must come indirectly, from proxies of solar activity such as cosmogenic isotopes (in tree rings and ice cores) and geomagnetic activity, and from improved understanding of the Sun itself—how its internal dynamo drives surface activity, and how irradiance responds. Session 3 addressed physical processes of solar variability.

Philip Goode described how statistically decomposing patterns in solar surface brightness can identify modes of variability that evolve with solar activity. Based on the correspondence between irradiance and the modes available at solar minimum, he suggested in his talk "*How Dim Can the Sun Be?*" that current solar minimum conditions may represent the lowest irradiance. **Mausumi Dikpati** provided an illuminating tutorial of recent developments in modeling "*The Solar Dynamo*" which add meridional circulations to the actions of turbulence (alpha effect) and differential rotation (omega effect). Together, these dynamical motions cycle magnetic flux in the solar convection zone (**Figure 6**), producing surface magnetic features that are sources of irradiance variability. Simulations of dynamo evolution are an important key for future scenario studies of plausible irradiance changes. Dikpati described comparisons of her dynamo model with solar observations in recent cycles. Since a sub-surface dynamo action drives the solar activity cycle, a reduction—or abeyance—of the dynamo are implicated during the anomalously inactive seventeenth century Maunder Minimum.

Yi-Ming Wang discussed "*The Sun's Large-Scale Magnetic Field and its Long-Term Variations*" including scenarios for magnetic field distributions consistent with the available sunspot data during the Maunder Minimum period. A portion of the total magnetic flux, the open flux, extends from the Sun into the heliosphere and envelops the Earth. It is the open, rather than total magnetic flux from the Sun that controls conditions in the heliosphere near the Earth and hence in the penetration of galactic cosmic rays that produce cosmogenic isotopes. But the very small modulation of open flux expected during the Maunder Minimum is inconsistent with the persistence of 11-year cycles in ^{10}Be throughout this period. Another important proxy of long-term solar activity is geomagnetic activity, recorded in ground-based magnetometers since the late 1880s. Like ^{10}Be the widely used *aa* index shows a steady increase from 1900 to 1950. And like the cosmogenic isotopes, geomagnetic activity reflects the magnetic conditions in the heliosphere whose variations perturb Earth's own magnetic field which registers in the ground-based instruments. In his talk "*Long-term Variations in IMF, Solar Wind and EUV Irradiance Inferred From Geomagnetic Activity*" **Leif Svalgaard** described the possibility of

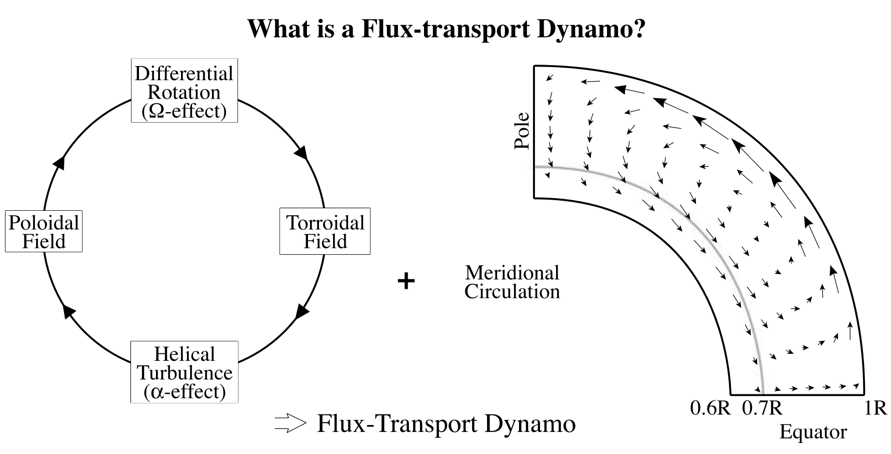
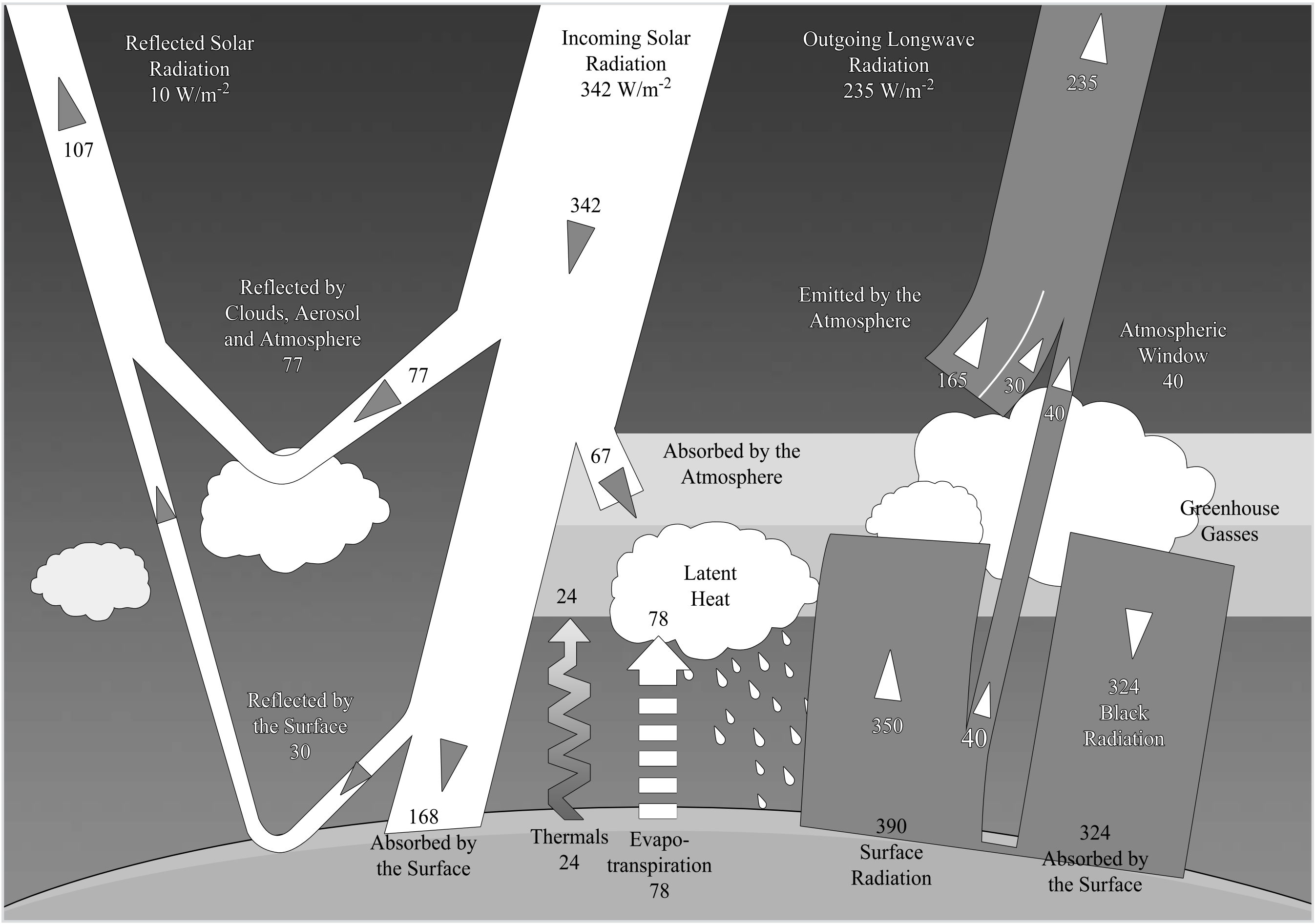


Figure 6: Schematic of the dynamical motions on the Sun that a flux-transport dynamo model simulates.

Figure 7: This radiation balance picture shows how incoming solar energy is distributed among parts of the Earth's atmosphere and surface. (Jeff Kiehl and Kevin Trenberth, NCAR)



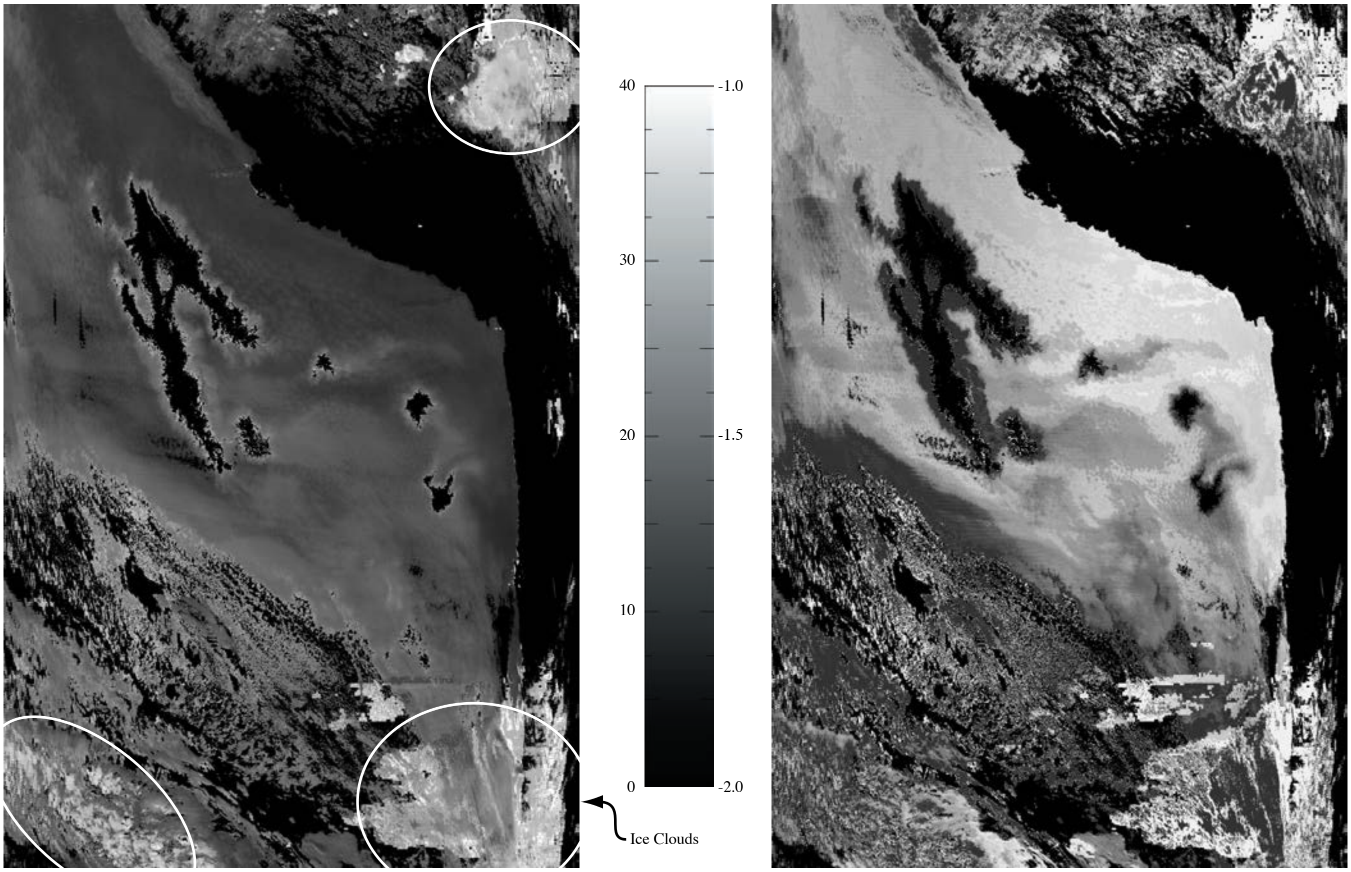
instrumental drifts in certain magnetometers that may account for the overall upward trend in geomagnetic indices in the beginning of the 20th century. This adds yet another controversy involving the determination of long-term trends in solar and terrestrial data sets. Following on Jeffrey Hall's keynote address, **Wes Lockwood** gave an "*Update on the apparent discrepancy between cycle timescale irradiance variability of the Sun and solar analog stars having similar magnetic activity levels*."

Session 4 –Climate Change Processes Involving Solar Radiation in the Troposphere
Chair: ***Peter Pilewskie***

Improving our understanding of the connection between solar radiation and climate processes in the troposphere is a critical element of the SORCE mission, considering that changes that occur in the troposphere are directly sensed by the surface biosphere. The balance between incoming solar radiation, measured by SORCE, and outgoing solar and infrared radiation (**Figure 7**) helps determine the most tangible of climate parameters, temperature. **Norm Loeb** provided insight into the Earth's contribution to the energy balance equation in his talk, "*Influence of Clouds and Aerosols on the Earth's Radiation Budget Using Clouds and the Earth's Radiant Energy System (CERES) Measurements*." He emphasized how the improved stability and accuracy of CERES measurements compared to previous radiation budget data sets were critical in quantifying climate sensitivity to cloud type.

Steve Platnick gave another view of Earth from space in "*An Overview of Solar Reflectance Remote Sensing Methods for Earth Science Applications*." Platnick explained how our knowledge of the spectral distribution of solar irradiance at the top of the atmosphere affects the accuracy of space-based retrievals of crucial parameters needed for climate monitoring. For example, the range of values in the literature for solar irradiance at 3.7 μm band (used for cloud particle size retrievals) was shown to

Figure 8: MODIS Terra granule, coastal Chile/Peru (18 July 2001, 1530 UTC).



3.7 μm retrieved r_e
(Thekaekara)

Δr_e
(KABGP - Thekaekara)

propagate into appreciable error in retrieved size when using MODIS data. This is illustrated in **Figure 8**, which shows retrieved cloud particle effective radius from the MODIS 3.7 μm band (left image) using exoatmospheric irradiance from Thekaekara *et al*. (1974). When another published value for the exoatmospheric irradiance in the 3.7 μm band was used (Kondratyev *et al*., 1965), the ensuing differences in retrieved effective radii (right image) were between 1-2 μm.

In the age of awareness of climate response to increasing greenhouse gas concentrations and anthropogenic aerosol particles, separating the contribution of solar variability from net climate variability is a critical element to solving the climate puzzle. This motivated **Caspar Ammann's** paper on "*Fingerprints of Solar Irradiance Changes During the Last Millennium: Impact of Different Background Trends on the Detection in Transient Climate Simulations*." The contribution of solar variability to net climate variability was estimated by extracting solar signals in multi-century Global Climate Model simulations with various ranges of solar forcing and comparing them with proxy climate reconstructions.

Solar influence on large-scale atmospheric dynamics was the central theme of several other papers in this session. In **Jerry Meehl's** talk, "*Coupled Ocean-Atmosphere Response to Solar Forcing in the Early 20th Century Compared to Greenhouse Gas Forcing in the Late 20th Century*," early twentieth century solar forcing was contrasted with late twentieth century greenhouse gas warming. The difference in climate response between the two periods was attributed to the relative spatial heterogeneity of solar forcing (compared with greenhouse gas forcing) leading to amplification of the temperature gradient-driven Hadley and Walker circulations. **Sultan Hameed** presented "*Atmospheric Centers of Action as Bridges Between Solar Activity Variations and Regional Climate Change*" in which he described the concept of centers of action in the atmospheric system. Sultan pointed out that one such center, the Aleutian Low, was likely responsible for the persistent rain at that time of the year in Sonoma.

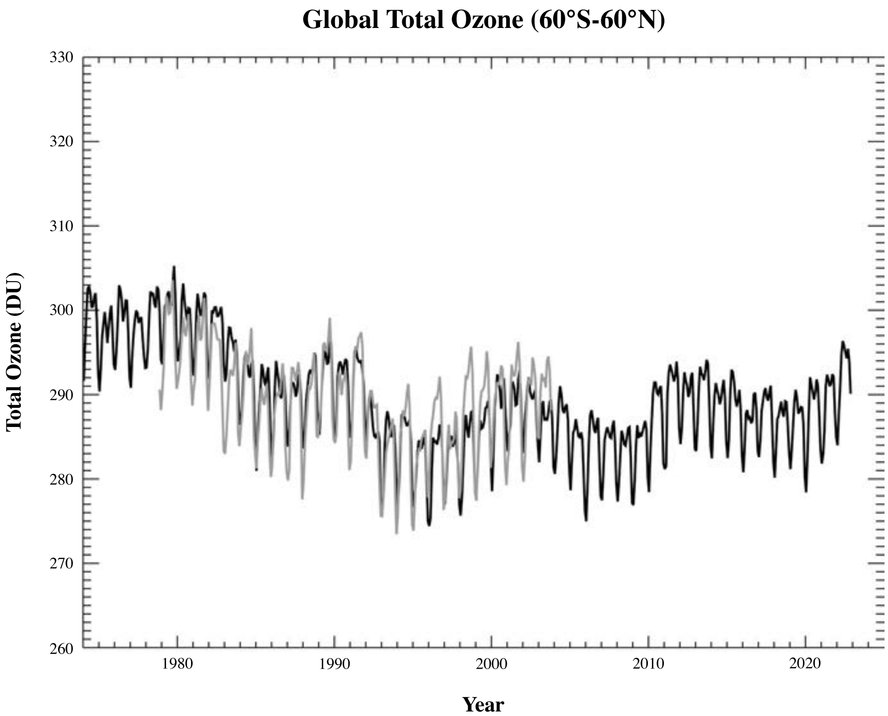


Figure 9: The trends in total ozone concentrations since 1960 and in the future, are estimated in the GSFC model to arise in part from the solar activity cycle, which produces 11-year variations superimposed on long-term trends arising from changes in chlorofluorocarbons and other atmospheric gasses.

He attributed correlations between solar activity and the intensity and geographic location of large-scale circulations to changes in regional climate and ocean dynamics.

In his paper, "*Evidence for Sun-Climate Connections on Multi-Centennial to Millennial Timescales*" **Gerard Bond** maintains that changes in northern hemispheric circulatory patterns due to solar variability caused southward shifts of drift ice. Bond used evidence from deep sea cores in the North Atlantic to suggest that recurring southward shifts of drift ice were influenced by variations in solar output through the entire Holocene. **Joan Feynman** presented "*Solar Influences on Surface Air Temperature During the Maunder Minimum*" where she explained that change in ultraviolet radiation was the mechanism responsible for variability in the troposphere, as determined by the Northern Annular Mode (NAM). Feynman showed a correlation between NAM index and solar activity over the past 50 years and used a solar UV irradiance extrapolation to derive the NAM index and to infer temperature anomalies during the Maunder Minimum.

The final talks in this session were devoted to solar influences on cloud cover and drought. **Bob Cess** presented "*Climate Change During 1985-1999: Cloud Interactions Determined From Satellite Measurements*" in which he showed evidence for a decadal variability in the top-of-atmosphere tropical radiative energy budget and suggested that the changes were related to an observed reduction in cloud cover. However, he concluded that the cause was by no means obvious and might be the result of natural periodic variability acting over decadal time scales. **Edward Cook's** paper on "*Solar Forcing and the Western US Bi-Decadal Drought Rhythm: An Analysis Back to AD 800*" presented evidence of a bi-decadal drought rhythm related to forcing by the Hale solar magnetic cycle (22 year period) and lunar tidal cycle (18.6 year period). A new reconstruction of the western US drought now extends back to 800 AD and this has provided an opportunity for a much longer evaluation of solar and lunar tidal forcing to be made than was previously possible.

Session 5—Global Change Processes Involving Solar Radiation in the Stratosphere
*Chair: **Marvin Geller***

The stratosphere plays an important role in global change for a number of reasons. It shields the biosphere from harmful solar UV radiation, which stratospheric ozone absorbs. At the upper boundary of the troposphere, stratospheric variations are implicated in climate change for example by altering the North Atlantic Oscillation. Changes in chlorofluorocarbon and greenhouse gas concentrations, volcanic aerosols and solar UV irradiance all influence ozone and temperature in the stratosphere, but in different ways, and with different strengths compared with their respective troposphere influences. Solar activity cycle modulation of the stratosphere is now well established.

Richard Stolarski tutored the meeting on current understanding of "*Ultraviolet Radiation and Stratospheric Ozone*." He discussed the extant long-term ozone record, and understanding of its variations, including during the solar cycle and projected in the future (**Figure 9**). **David Rind** described "*Mechanisms of Solar Influence on the Troposphere* *via the Stratosphere*" apparent in the Goddard Institute for Space Studies (GISS) Middle Atmosphere General Circulation Model, which includes responsive ozone chemistry. Stratospheric changes induced by solar and greenhouse gas influences are felt at lower tropospheric levels via dynamical motions that affect, for example, the phase of the NAO and intensity of the Hadley cell. But as Ramaswamy's keynote speech had noted, model representations of ozone can differ significantly. Empirical studies of ozone variability and solar variability are therefore crucial for illuminating actual processes.

After a brief Meteorology 101 introduction, **Robert Hudson** described an exciting new analysis approach for interpreting trends in the long-term ozone dataset. In his talk "*Deduction of Climate Variability From the Total Ozone Record, 1965-2000*" he showed how ozone concentrations are better understood when sorted not by latitude but by three separate meteorological regimes, defined by "fronts." Movements of the fronts appear to track solar activity, and imply changes in weather patterns. **Marvin Geller** took time out from chairing this session to discuss "*Solar-Induced Changes in Ozone.*" The contemporary record of ozone observations saw major volcanic eruptions whose effects on ozone are superimposed on solar cycle changes. Model-data comparisons can help separate the two processes. Both **Al Powell** and **Lon Hood** addressed processes in the lower stratosphere and troposphere induced by changes in solar UV radiation. Powell presented "*Ozone Heating Impacts on the Lower Atmosphere Hemispheric Wave Pattern as a Mechanism for Climate Change.*" From analysis of data near 200 mb, Powell showed how solar UV irradiance changes can alter ozone absorption and heating which affects the stability of the lower atmosphere and alters the energy distribution in atmospheric waves. From correlative and regression analyses of data from the National Centers for Environmental Prediction (NCEP), Hood showed a "*Thermal Response of the Tropopause Region to Short-Term Solar Ultraviolet Variations.*" The temperature in the tropical lower stratosphere and upper troposphere responds significantly to 27-day solar forcing with maximum amplitude near the 100 hPa level (**Figure 10**). **Alexander Ruzmaikin** described a simple model of solar UV variability influence on the planetary wave-zonal mean flow interaction. In this model, there are two major stable equilibrium states, possibly corresponding to two states of Northern Annual Mode, and one unstable state. External influences including solar variability, as well as internal process such as the Quasi-biennial Oscillation (QBO), influence the positions and occupation frequencies of the two states.

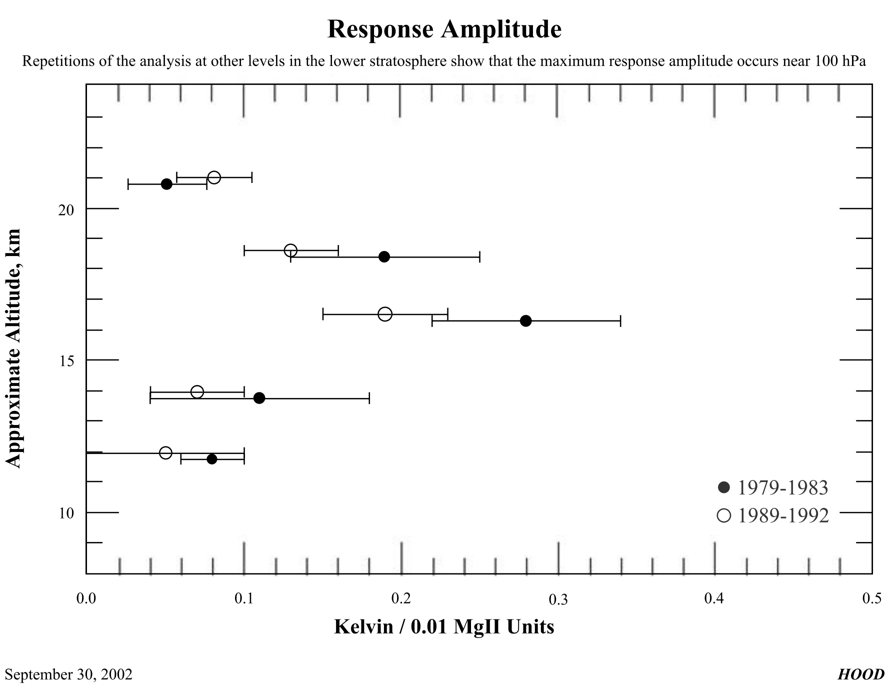


Figure 10: The response of the lower stratosphere to solar variations during the sun's 27-day rotation, derived from empirical associations

Session 6—Future Directions in Sun-Climate Research
Chair: **Gary Rottman**

At the conclusion of the meeting it was appropriate to look forward to future observations and research and to future meetings. There is considerable excitement about the data sets and programs now in place, providing unsurpassed temporal and spectral coverage of solar irradiance at a time of simultaneous and extensive Earth observations. Many of the observing programs and data sets explored during the conference will continue. The SORCE spacecraft and instruments are performing well, and the major limiting factor will likely be availability of resources from the various funding agencies. SORCE is expected to continue for another four years, and hopefully, many more beyond that. UARS still continues to make UV observations from two instruments, SOLSTICE and the Solar Ultraviolet Spectral Irradiance monitor (SUSIM). The Variability of Solar Irradiance and Gravity Oscillations (VIRGO) TSI devices, the Differential and Absolute Radiometer (DIARAD) and PMON, continue to take data and their host spacecraft, the Solar and Heliospheric Observatory (SOHO), also continues robust operations. ACRIMSAT is also expected to continue for several years. The biggest liability probably concerns the longest TSI data set from the ERBS instrument, and although the instrument continues to return data, funds for the data processing and analysis are threatened.

In the future we look forward to several missions. **Gerard Thuillier** described the PICARD Mission being developed by Centre National d'Etudes Spatiales (CNES) in France. This small spacecraft is scheduled to be launched in 2008 and will carry three instruments to measure total and spectral irradiance, to detect changes in solar diameter and the shape of the solar limb, and to observe solar oscillations in order to probe the solar interior. Gary Rottman had earlier reported on the fact that the TIM and SIM will be flown as part of the NPOESS program with launches after 2013. Inevitably there will be a gap between SORCE and the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) and NASA may partially fill this gap, but only with a TIM to provide TSI observations. Presently there are no plans for spectral irradiance observations between the time of SORCE and NPOESS, other that those on PICARD.

Marv Geller gave a brief overview of the Climate and Weather of the Sun-Earth System (CAWSES). This is a major 5-year international research program starting in January 1, 2004 and operating under the auspices of the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), which Geller chairs. CAWSES is divided into four Themes, the Solar Influence on Climate ; Space Weather: Science and Applications; Atmospheric Coupling Processes; and Climatology of the Sun-Earth System. More details on CAWSES can be found on the website: *www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html*. **Stan Solomon** described the Whole Atmosphere Community Climate Model (WACCM) presently being developed by NCAR. The model now extends from the surface to 140 km and will soon be extended through the thermosphere and ionosphere to 500 km. The WACCM may be improved significantly by the inclusion of the new SORCE spectral data, especially longward of 300 nm. **Tom Bogdan** gave a brief and provocative summary titled, "*The Best of Times, The Worst of Times*." This affectionate comment on the health and intellectual well-being of studies of solar variability and of global climate change, concluded the first SORCE Science Team meeting on a light note.

Plans for the second SORCE Science Team meeting are already underway. The topic of the meeting is expected to be decadal variability in the Sun and climate. Everyone is welcome! If you are interested, we look forward to seeing you there. Please mark your calendar for the last week in October and stay tuned to the SORCE website: *lasp.colorado.edu/sorce/meetings.html*.

Poster Sessions

"New Look for the Online Solar Databases at NGDC," by **Helen Coffey**, NOAA, National Physical Data Center, Boulder, Colorado.

"First Total Solar Irradiance Model based on PSPT Data," by **Angie Cookson**, California State University, San Fernando Observatory, Northridge.

"On the Influence of Solar Variability on Ion-Mediated Nucleation in the Atmosphere," by **Raffaella D'Auria**, University of California, Los Angeles.

"Modeling Solar Irradiance with the PSPT Solar Disk Observations and RISE Solar Spectrum Synthesis," by **Sean Davis**, LASP, University of Colorado, Boulder.

"Current and Future Solar Irradiance Measurements from SBUV/2 Instruments," by **Matt DeLand**, Science Systems and Applications, Inc., Lanham, Maryland.

"Comparisons of FUV Solar Irradiance Measurements by SORCE, TIMED-SEE, and UARS," by **Frank Eparvier**, LASP, University of Colorado, Boulder.

"Solar UV Center-to-Limb Variation of Active Regions," by **Linton Floyd**, Interferometrics Inc. and Naval Research Laboratory, Washington, DC.

"Physical Synthesis of the Solar Radiance, a Tool for Understanding Spectral Irradiance," by **Juan Fontenla**, LASP, University of Colorado, Boulder.

"Carbon I, Solar Activity and Secular Change?," by **Peter Fox**, High Altitude Observatory, NCAR, Boulder, Colorado.

"Dissimilarity in the Evolution of Solar EUV and Solar Radio Emission (2800 MHZ) During 1999-2002," by

Rajaram Kane, Instituto Nacional de Pesquisas Espacias, Sao Jose dos Campos, Brazil.

"Details of the SORCE/TIM On-Orbit Calibrations," by **Greg Kopp**, LASP, University of Colorado, Boulder.

"The Sun as Observed by SORCE SOLSTICE," by **William McClintock**, LASP, University of Colorado, Boulder.

"A Model of Solar Spectral Irradiance Between 200 and 400 nm," by **Jeff Morrill**, Naval Research Laboratory, Washington, DC.

"SORCE Science Data Processing and Availability," by **Chris Pankratz**, LASP, University of Colorado, Boulder.

"Total Solar Irradiance Measurements: Results and Future Requirements," by **Judit Pap**, University of Maryland, Baltimore County, Maryland.

"Historical Reconstruction of Solar Activity," by **Dora Preminger**, California State University, San Fernando Observatory, Northridge.

"Pre-Launch and On-Orbit Prism Transmission Calibrations for SIM on SORCE," by **Byron Smiley**, LASP, University of Colorado, Boulder.

"Measuring In-Flight Degradation of SORCE SOLSTICE," by **Marty Snow**, LASP, University of Colorado, Boulder.

"The Solar Spectral Irradiance From 200 to 2400 nm as Measured During the ATLAS and EURECA Missions," by **Gerard Thuillier**, Service d'Aeronomie du CNRS, France.

"Solar Feature Identification on PSPT Images," by **Stephen Walton**, California State University, San Fernando Observatory, Northridge.

"Phase Space Reconstruction and Predictability of Spectral Solar Irradiance From SOLSTICE," by **Guoyong Wen**, NASA/GSFC, Climate and Radiation Branch, Greenbelt, Maryland.

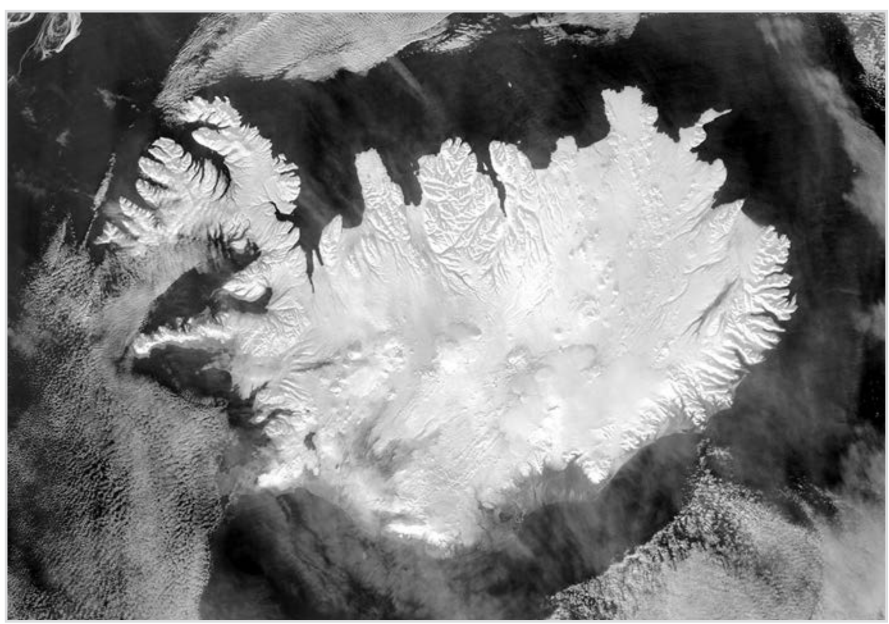
Acknowledgements

The authors are pleased to acknowledge the following individuals for their contributions to the SORCE mission and this Science Meeting.

- SORCE Team Members: Jerry Harder, Greg Kopp, George Lawrence, Bill McClintock, Tom Woods. All are at the LASP, University of Colorado.
- Session Chairs: O.R. White, National Center for Atmospheric Research, High Altitude Observatory, Boulder, Colorado; Hugh Hudson, University of California, Berkeley; Marvin Geller, Stony Brook University, New York.
- Bay Area Environmental Research Institute, Sonoma, California.
- Vanessa George who was the major organizing force and expedited every detail of the meeting. Her efforts assured our success.

For additional information on the SORCE Mission, see the SORCE website at *lasp.colorado.edu/sorce/* for the latest news and updates.

The 2004 SORCE Science Meeting is set for October 27-29 in New Hampshire. Additional information can be found at *lasp.colorado.edu/sorce/2004ScienceMeeting.html*



True to its name, Iceland is shown here covered in a white blanket of ice and snow. Low layers of clouds float over the Greenland Sea (left) and the Atlantic Ocean (bottom). Iceland's southern, low-lying coastlines are greyish, while the rest of the island remains pristine white. This image was acquired on January 28, 2004, by the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite. Image courtesy Jeff Schmaltz, MODIS Land Rapid Response Team at NASA GSFC.

CMORPH: A New High-resolution Global Precipitation Analysis System

— Robert J. Joyce, RS Information Systems, McLean, VA
— John E. Janowiak, Climate Prediction Center/NWS/NOAA
— Phillip A. Arkin, ESSIC/University of Maryland
— Pingping Xie, Climate Prediction Center/NWS/NOAA

A new high-resolution global precipitation analysis technique dubbed "CMORPH" (CPC MORPHed precipitation) has been developed at NOAA's Climate Prediction Center (CPC) for the real-time monitoring of global precipitation. CMORPH provides precipitation estimates on a 0.25° lat/lon grid from 60°N-60°S with a temporal resolution of 30 minutes. Analyses are available dating back to December 1, 2002, and are updated routinely. Plans have been made to extend these analyses back to early 1998.

The motivation for developing such an analysis system stems from the well-known fact that passive microwave (MW) observations yield more direct information about precipitation than is available from IR data. Yet, because platforms that house these instruments are relegated to polar orbits, the MW-derived estimates have poor spatial and temporal sampling characteristics. Conversely, while the IR data provide relatively poor estimates of precipitation, they provide extremely good spatial and temporal sampling. Given these facts, the natural course of action is to attempt to combine the data from these disparate sensors to take advantage of the strengths that each has to offer. To this end, a number of techniques have been developed in which the IR data are manipulated in a statistical fashion to mimic the behavior of microwave-derived precipitation estimates in which IR data are used to estimate rainfall in locations and instances where microwave data are not available.

CMORPH is a considerably different method that uses precipitation estimates that have been derived from low orbiter satellite microwave observations exclusively, and whose features are transported via spatial advection information that is obtained entirely from geostationary satellite IR data. Note that this technique is not a precipitation estimation algorithm but a means to combine estimates from existing algorithms. Therefore, this method is extremely flexible, permitting precipitation estimates from any satellite source to be incorporated. In effect, IR data are used as a means to transport the microwave-derived precipitation features during periods when microwave data are not available at a location. Advection vector matrices are produced by computing spatial lag correlations on successive images of geostationary satellite IR and are then used to propagate the microwave-derived precipitation estimates. This process governs only the movement of the precipitation features. At a given location, the shape and intensity of the precipitation features in the intervening hour periods between microwave scans are determined from a time-weighting interpolation between microwave-derived features that have been propagated forward in time from the previous microwave observation and those that have been propagated backward in time from the following microwave scan. We refer to this latter step as "morphing" of the features.

To date, the CMORPH technique uses precipitation estimates that have been derived from seven separate instruments: the Special Sensor Microwave Imager (SSM/I) instruments aboard the three Department of Defense meteorological satellites, the Advanced Microwave Sounding Unit (AMSU-B) aboard three NOAA polar orbiters, and the TRMM Microwave Imager (TMI) aboard the Tropical Rainfall Measuring Mission (TRMM) spacecraft. We soon hope to incorporate precipitation estimates from the Advanced Microwave Sounding Radiometer-EOS (AMSR-E) instrument aboard Aqua. The algorithms that produce the precipitation estimates used by CMORPH were developed by scientists at NOAA and NASA .

To demonstrate the time continuity of the half-hourly CMORPH estimates, we present in **Figure 1** a comparison among precipitation estimates from actual passive microwave information (top row), CMORPH estimates (middle row) and radar (bottom row) for a

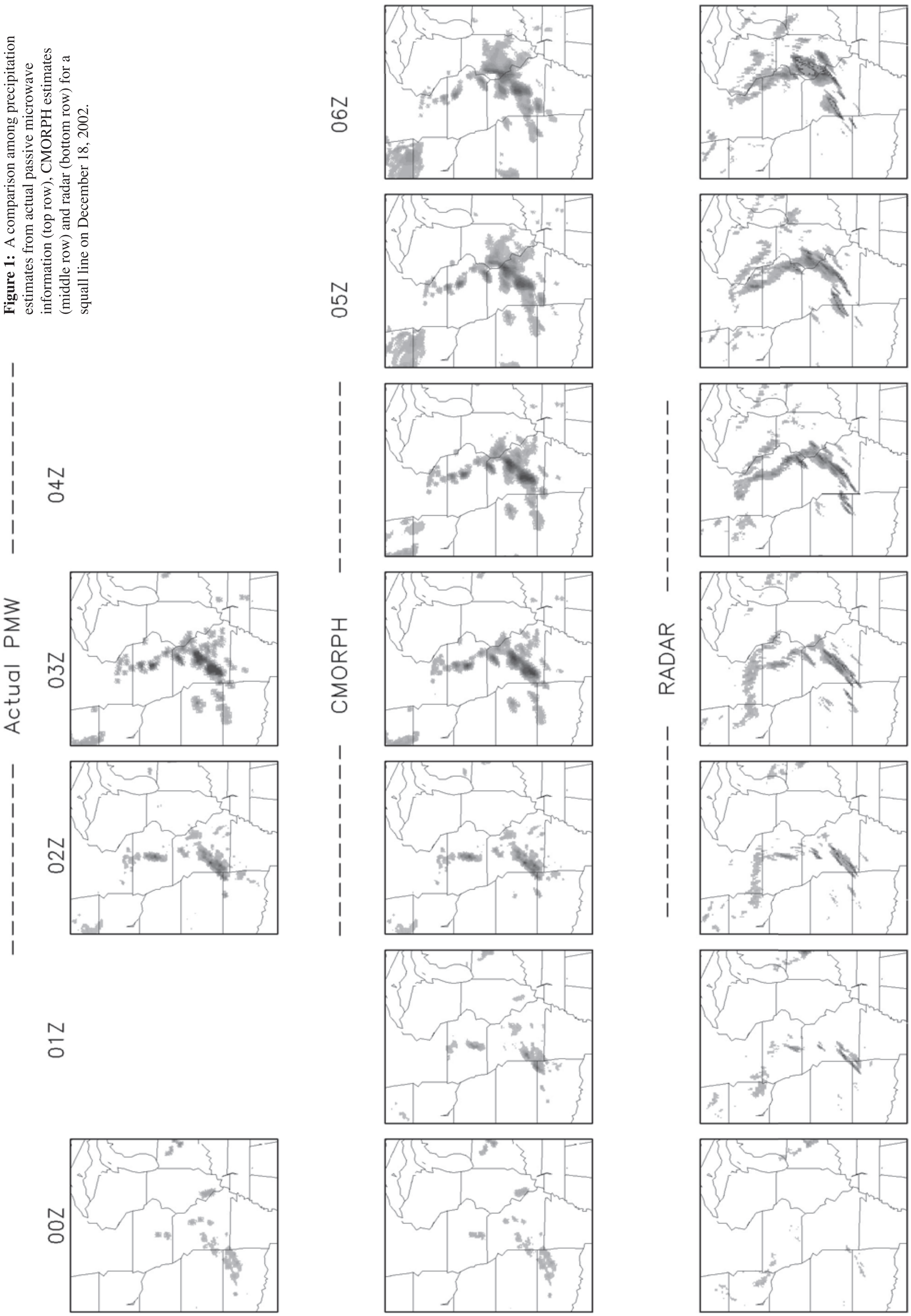


Figure 1: A comparison among precipitation estimates from actual passive microwave information (top row), CMORPH estimates (middle row) and radar (bottom row) for a squall line on December 18, 2002.

squall line on December 18, 2002. Note that the "blank" maps in the top row indicate that no passive microwave information was available at those times, which means that the CMORPH estimates that correspond to those times were generated by using the IR data to translate and to morph the precipitation features. The correspondence of the location of the precipitation features at these times of missing microwave data with the locations in the radar data suggest that CMORPH is a viable technique.

The results of a comparison of the CMORPH precipitation with high-resolution reference rain gauge analyses and radar estimates over the continental U.S. during April-December 2003 are shown in **Figure 2**. The figure indicates that CMORPH (black line) performs consistently better than an analysis in which microwave-derived estimates alone (gray line) are used, i.e., IR data are not used. It also indicates that the CMORPH estimates generally perform about as well as radar (light gray line). This good agreement with validation data suggests the potential for CMORPH to provide reasonably accurate precipitation measurements over areas of the globe where gauges and radars are sparse or non-existent, such as over oceans and over many meteorologically important land areas. Furthermore, the temporal and spatial scales of these estimates make them suitable for use in a variety of applications in the hydrologic, climate, and modeling communities. Initial studies indicate that the accuracy of the estimates produced by this method can be improved dramatically with more sampling from MW instruments and thus will benefit greatly from the Global Precipitation Measurement (GPM) mission, which is scheduled for launch in 2008.

More information about this methodology, the availability of the analyses, and daily comparisons with radar and rain gauges can be obtained from: *www.cpc.ncep.noaa.gov/products/janowiak/cmorph.html*

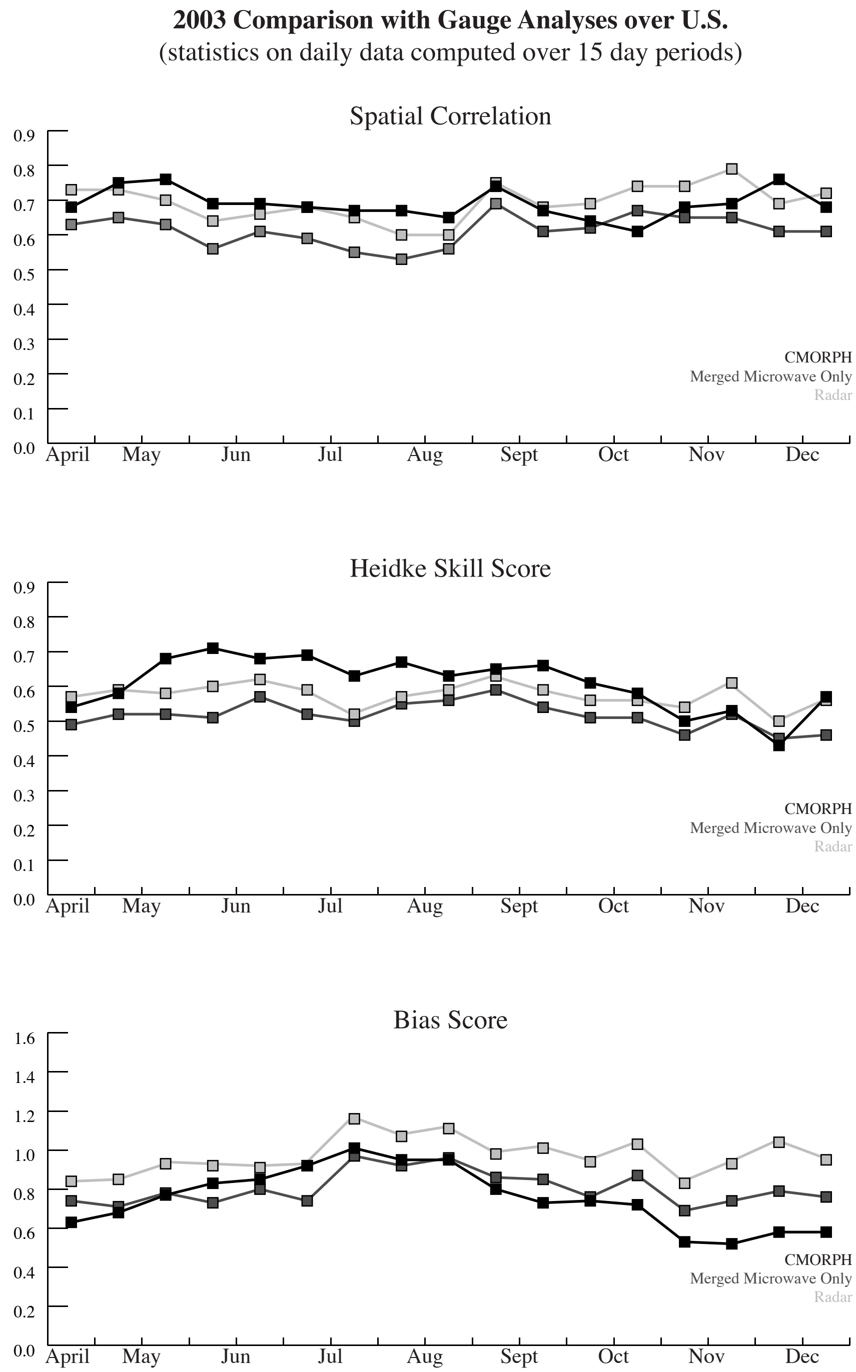


Figure 2: Statistics generated from a comparison of CMORPH (black line), NOAA/NWS Stage-II radar estimates (light gray line), and microwave-only estimates (gray line) using a high-resolution daily rain-gauge analysis over the continental U.S. as the benchmark. Statistics were computed on daily data for 15-day periods.

USGS Announces New Product Line

—John Dwyer, dwyer@usgs.gov, U.S. Geological Survey

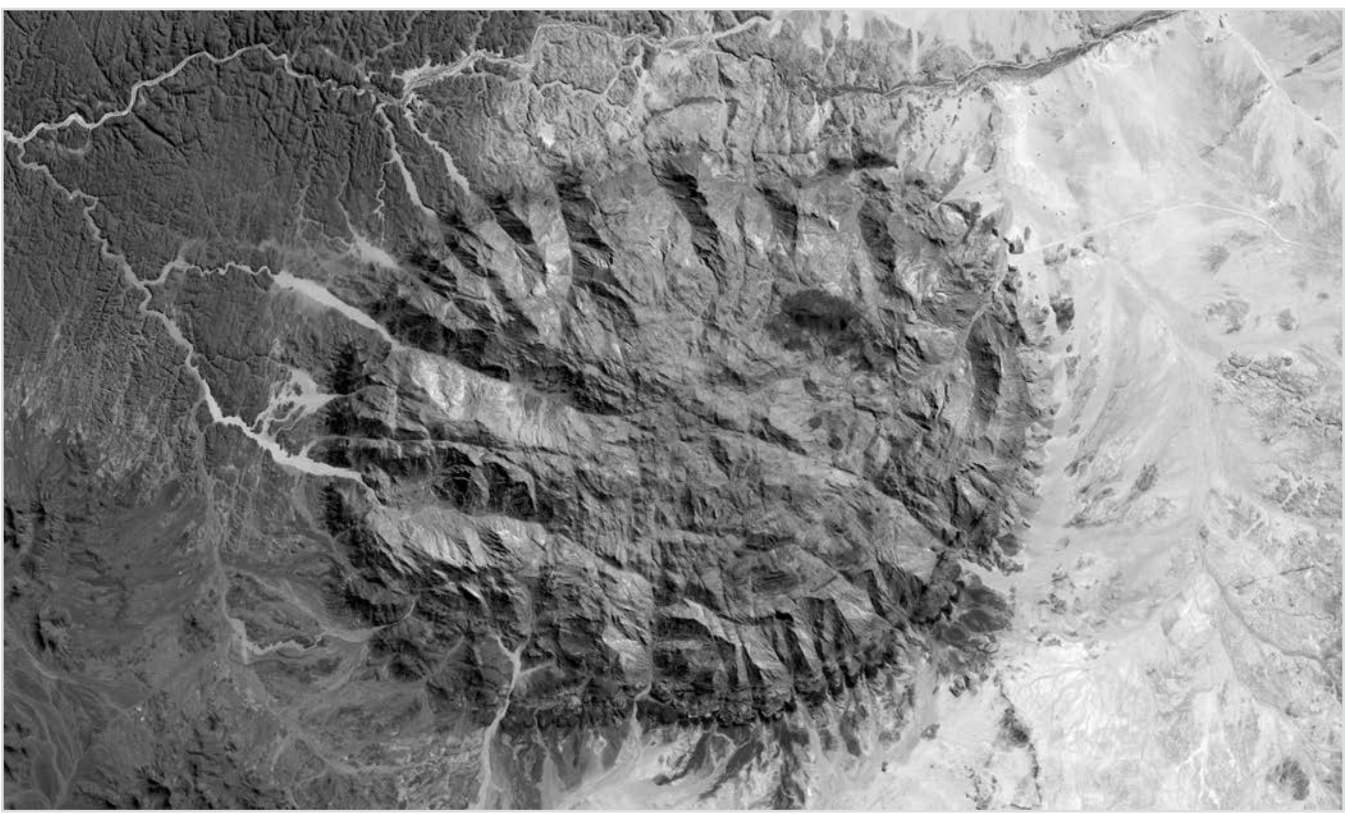
A technique to estimate radiometric values in Landsat 7 data gaps has been selected, and the resulting new products will be available to customers in June 2004.

The U.S. Geological Survey (USGS) Landsat 7 Project at the Earth Resource Observation System (EROS) Data Center in Sioux Falls, South Dakota has been taking steps to increase the utility of the Enhanced Thematic Mapper Plus (ETM+) data that includes non-functional scan-line corrector (SLC) artifacts. The SLC on the Landsat 7 ETM+ instrument failed May 31, 2003.

In the planned products, the gap pixels are replaced with data from a previously acquired SLC-on scene that is registered and histogram matched to the SLC-off image. The histogram matching technique is a localized linear transform performed in a moving window throughout the missing pixels.

Also, in March 2004 the current ETM+ SLC-off product will be available to the public with a user-selectable amount of interpolation to replace missing gap pixels. The USGS is continuing to research other methods of providing better gap pixel estimates/merged data products and will continue to provide information resulting from this work as it becomes available.

A sample product, with a comparison with the degraded data, further information and regular updates on the planned product release can be found at *landsat7.usgs.gov/slc_enhancements/*.



The locals call it Dâures—the burning mountain, but it may be better known as the Brandberg Massif. Its volcanism has long since stilled, but the granite core left behind apparently glows red in the light of the setting sun. The formation is a remnant of a long period of tumultuous volcanic and geologic activity on Earth during which the southern super-continent of Gondwana was splitting apart. This image was acquired by Landsat 7's Enhanced Thematic Mapper plus (ETM+) sensor. The image was provided by the USGS EROS Data Center Satellite Systems Branch as part of the Earth as Art II image series.

Kudos

The American Meteorological Society bestowed awards on the following ESE/EOS colleagues at its annual meeting held January 12-15 in Seattle.

Fellows

The honor of Fellow is given to an individual for recognition of outstanding contributions to the atmospheric or related oceanic or hydrologic sciences, or their applications, during a substantial period of years. Only two tenths of one percent of membership are approved as Fellows each year. In addition, winners of the AMS prestigious Rossby, Charney, Suomi, Sverdrup, Stommel, Brooks, and Abbe Awards are elected as Fellow. Following are ESE/EOS colleagues elected.

Robert F. Adler, NASA Goddard Space Flight Center

Robert M. Atlas, NASA Goddard Space Flight Center

Christopher S. Bretherton, Department of Atmospheric Sciences, University of Washington

Michael H. Freilich, Oregon State University

Richard B. Rood, NASA Goddard Space Flight Center

Carl-Gustaf Rossby Research Medal

This is the highest honor that the Society can bestow upon an atmospheric scientist. The award is presented annually for outstanding contributions to the understanding of the structure or behavior of the atmosphere. The medal is named in honor of Carl-Gustaf Rossby, widely known in the meteorological community for his contributions to the basic understanding of the dynamics and thermodynamics of the atmosphere. The following ESE/EOS colleague was elected:

Peter J. Webster, Earth & Atmospheric Sciences and Civil & Environmental Engineering, Georgia Institute of Technology "for enduring contributions to understanding the general circulation of the tropical atmosphere-ocean system, through insightful research and exemplary scientific leadership."

Verner E. Suomi Award

The Verner E. Suomi Award is given to individuals in recognition of highly significant technological achievement in the atmospheric or related oceanic and hydrologic sciences. The following ESE/EOS colleague was elected:

Michael H. Freilich, Oregon State University "for pioneering the development and scientific application of satellite scatterometry as an essential oceanographic tool."

Professor George H. Born, Department of Aerospace Engineering Sciences, University of Colorado, Boulder, and a member of the Jason-1 Science Team, has been elected a member of the National Academy of Engineering "for contributions to satellite orbit determination and for applications of satellites to geophysics and oceanography." *The Earth Observer* staff and the entire scientific community wishes to congratulate Professor Born on this outstanding accomplishment.

Coming CA Storms, Feb. 19; *KCAL & KABC TV* (Channels 9 & 2 in LA) interviewed **Bill Patzert** (NASA JPL) about coming storms and how they could give Southern California some relief from the 6 year drought.

Patzert Appointed to the Educational Board of the Metropolitan Water District (MWD) of Southern California, Feb. 17 2004; *MWD of Southern California* press release; **Bill Patzert** (NASA JPL) will help guide the development of "The Center for Water Education" and "The Western Center for Archaeology and Paleontology."

"Warm Florida" Earth & Sky Radio Series, Feb. 14; *Earth & Sky Radio*; **Bill Patzert** (NASA JPL) contributed to this radio series asking what exactly makes the Sunshine State so warm?

Two NASA Satellites Aid Weather Forecasts, Feb.9; *Palm Beach Post*; **Gary Jedlovec** (NASA MSFC) discusses how NASA satellites are providing greater detail that helps forecasters make better predictions

Ozone-Eater Molecule Caught in Action, Feb. 6; *Discovery.com*; **Paul Newman** (NASA GSFC) and **Ross Salawitch** (NASA JPL) discuss discovery of the CI-O-O-CI molecule, long believed to be responsible for killing ozone in the stratosphere

Drought Sneaks Up On Water Supply, Various dates, Feb. 2004; *Associated Press, CNN, Contra Costa Times, Cox Cable News, KABC TV and Radio* (790 am in LA), *KFWB* (980 am radio in LA), *Metro Networks, San Diego Union-Tribune, San Jose Mercury News, CA , Santa Barbara News-Press, Sarasota Herald-Tribune, FL, South Coast Beacon* (Santa Barbara, CA); **Bill Patzert** (NASA JPL) was interviewed about the California drought in various articles.

NASA Satellites Help Improve Ocean Condition Forecasts, Jan. 29; *Rednova, SpaceflightNow*, and others; **Yi Chao** (NASA JPL) discussed a prototype three-dimensional, three-day ocean condition forecast created with the assistance of NASA satellite data, computer models and on-site ocean measurements.

Pacific Dictates Droughts and Drenchings, Jan. 29; *British Columbia* (Canada) *Portal, Innovations Report* (Germany) *ScienceDaily* and more; The cooler and drier conditions in Southern California over the last few years appear to be a direct result of a long-term ocean pattern known as the Pacific Decadal Oscillation, according to research from **Steve LaDochy** (California State University-LA) and **Bill Patzert** (NASA JPL).

Giant Satellite Keeps Tabs on Volcanoes, Jan. 27; *Pittsburgh Post-Gazette*; **John LaBrecque** (Manager, NASA's program on solid Earth and natural hazards) talks about ASTER's role in studying volcanoes.

Using Hot Towers to Identify Intensifying Hurricanes, Jan. 12; *Associated Press, Discovery Canada, Environment News Service, Dallas Morning News, EC Planet* (Italian translation), and many more; TRMM data shows that a hurricane is twice as likely to intensify if a hot tower is seen in its eyewall, according to NASA's **Owen Kelley** and **John Stout** (both NASA GSFC). Research was inspired by **Joanne Simpson's** (NASA GSFC) hurricane studies that began in the 1950s.

Satellite Surface Wind Data Helps Improve 2-5 Day Weather Forecasts, Jan. 19; *Space Daily*; **Bob Atlas** (NASA GSFC) discusses how QuikSCAT data is providing meteorologists with more accurate data on surface winds over the global oceans.

NASA Supports Atmospheric Science Research at Hampton University, Jan. 19; *The Virginian-Pilot*; **William Grose** (NASA LaRC/National Institute of Aerospace), **Patrick McCormick** (Hampton University), and **James Russell** (Hampton University) speak about the research partnership between NASA LaRC and Hampton University.

From Neighborhoods to Globe, NASA Looks at Land, Jan. 14; *DadaAt* (Austria); **Innovations Report** (Germany); **Christa Peters-Lidard's** (NASA GSFC) research on NASA's Land Info concerning the effect that cities and other local land surfaces might have on regional and global land and atmospheric processes.

Forest Fires Fuel Climate Change Variations, Jan. 5; *ASCRIBE* newswire, *Environment News Service, UPI*; **Guido van der Werf** (NASA GSFC) and **James Randerson** (UC-Irvine) were quoted in various articles on how forest fires may play a more significant role in the build-up of greenhouse gases than was previously thought. Other researchers on the study included **G. James Collatz** and **Louis Giglio** (NASA GSFC), **Prasad S. Kasibhatla** and **Avelino F. Arellano Jr.** (Duke University), **Seth Olsen** (California Institute of Technology) and **Eric S. Kasischke** (Univ. Maryland, College Park)

NASA Scientists Studying 'Perfect Storm' Incidents, Dec. 21; *Newport News Daily Press*; **Bill Smith, Sr.**, (LaRC) and **John Murray** (NASA LaRC) discuss their work in a field experiment designed to improve weather forecasts.

Weathering the Forecast, Jan. 8; *Santa Barbara South Coast Beacon*; Sally Cappon interviewed **Bill Patzert** (NASA JPL) reports on why forecasters "can't seem to get it right."

NASA Satellites Improve Response to Global Agricultural Change, Jan. 20; *Brightsurf.com, Sciencedaily, Spaceref*; **Ed Sheffner** (NASA HQ) is featured in this story about how NASA's Earth satellite observing systems are helping the U.S. Department of Agriculture Foreign Agricultural Service improve the accuracy and timeliness of information they provide about important crops around the world.

International Summer School on Atmospheric and Oceanic Sciences
Observing Systems for Atmospheric Composition
September 20-24, 2004
L'Aquila Italy

Topics

- The need for observing systems of atmospheric composition
- The concept of a sensor web
- Sensor web components: Satellites, intensive field campaigns (chemistry, microphysics, and transparent process studies), ground-based monitoring networks
- Handling data from the Sensor Web

Lecturers Include

P. K. Bhartia, *NASA Goddard Space Flight Center, USA*
W. H. Brune, *Pennsylvania State University, USA*
K. L. Demerjian, *University at Albany, USA*
D. J. Jacob, *Harvard University, USA*
P. Newman, *NASA Goddard Space Flight Center, USA*
K. Reichard, *Pennsylvania State University, USA*
V. Rizi, *University of L'Aquila, Italy*
M. Schoeberl, *NASA Goddard Space Flight Center, USA*
A. Thompson, *NASA Goddard Space Flight Center, USA*
A. Wahner, *Institute for Atmospheric Chemistry, Julich, Germany*

Directors of the School

William H. Brune, *Director*
Mark Schoeberl *and* Andreas Wahner, *Co-Directors*

Local Organizer Committee

Guido Visconti, *guido.visconti@aquila.infn.it*
Piero di Carlo, *piero.dicarlo@aquila.infn.it*

Registration Fee

The registration fee is fixed at 600 euro (Students 400 euro) including: attendance to lectures, lecture notes, coffee breaks, social dinner and excursion. For those registering before May 30, 2004 the fee will be reduced to 450 euro (full) and 300 euro (students).

Contact

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Earth Science Enterprise Education Program Update

—Ming-Ying Wei, ming-ying.wei-1@nasa.gov, NASA Headquarters
—Diane Schweizer, diane.schweizer@nasa.gov, NASA Headquarters
—Theresa Schwerin, theresa_schwerin@strategies.org, Institute for Global Environmental Strategies

Paula Coble joined the NASA HQ Earth Science Education Team on Jan. 5, 2004, as Program Scientist. She joins Ming Ying Wei and Diane Schweizer, and will be taking the lead role in program management of the GLOBE Program and also will be working on cyberinfrastructure and information technology issues. She has been challenged to improve the flow of data and information from NASA observatories to the education community.

Coble has been heavily involved in science education since 1996, when she started Project Oceanography, a satellite-televised program for middle school science students that reaches over 2,000,000 students in 43 states and 17 foreign countries. Program schedules, archived videos, and written instructional materials for teachers can be found at: *www.marine.usf.edu/pjocean*. More recently, she served as the Director of the Florida Center for Ocean Science Education Excellence (COSEE), one of seven new regional centers funded by the National Science Foundation to enhance science education and promote the infusion of ocean science research knowledge into the public sector.

Draft NASA ESE Education Plan Available

Inspire the Next Generation of Earth Explorers: NASA's plan for Earth Science Education describes NASA's direction for Earth science education over the next five years. It describes Earth Science Enterprise (ESE) goals and objectives for education within the context of Agency goals, objectives, and outcomes for education and presents an approach for achieving them. The draft NASA ESE education plan is available online at *earth.nasa.gov/education/*.

NASA Earth Explorers Series — Tom Nolan's Excellent Adventure

The latest feature in NASA's Earth Explorers series spotlights NASA Jet Propulsion Laboratory (JPL) engineer Tom Nolan. Nolan is currently operations engineer for the Multi-angle Imaging Radiometer (MISR), an instrument onboard the Terra satellite, but his path to that position was anything but typical. See *www.nasa.gov/audience/foreducators* for this Earth Explorer's fascinating story.

Space Science Institute Education Workshop for Scientists, Engineers, and E/PO Managers, Boulder, Colorado, April 25-28 2004

This Space Science Institute (SSI) workshop offers participants a learning experience that supports the design and implementation of effective Education and Public Outreach (E/PO) programs. The workshop is targeted towards those who work in any sphere of space or Earth science, including scientists or engineers interested in K-14 E/PO, managers who are tasked with E/PO program design and with providing meaningful ways for scientists and engineers to contribute to E/PO efforts, and educators interested in gaining perspective about working with scientists and engineers in E/PO.

To celebrate the workshop's 10th anniversary, SSI will also be hosting a special symposium on Thursday, April 29. The symposium will feature SSI Workshop Alumni success stories and experiences in educational settings and will provide focused time for discussion about hot topics in space and Earth science education. It may be added onto the workshop experience or attended on its own. The workshop is sponsored by NSF, with support from the NASA Office of Space Science, Western Region Broker/Facilitator. For more information, visit *halvas.spacescience.org/registration/k12spring2004/1.asp*

DLESE Announces Annual Meeting, Madison, Wisconsin, July 11-13, 2004

The Digital Library for Earth System Education (DLESE) annual meeting will be held at the University of Wisconsin in Madison, WI from July 11-13, 2004. An optional skills workshop is scheduled for July 10th. The broad theme for the meeting is "DLESE: A Teaching and Learning Tool." Provide DLESE with your feedback on the subjects and focus areas that most interest you by filling out the preliminary call for interest found at: *www.dlese.org/annualmtg/2004/CallIntro.html*. These ideas and comments will greatly assist the planning committee as they prepare a meeting program that has the widest possible appeal and greatest impact. For more information visit *www.dlese.org/annualmtg/2004* or contact David Steer, Planning Committee Chair; Phone: 330-972-2099; Email: *steer@uakron.edu*

Educator Workshop — NASA Satellites Study Earth's Atmosphere: CALIPSO, CloudSat, and Aura working with the GLOBE Project — July 12-22, 2004, Fort Collins, Colorado

This event is currently scheduled for July 12-22, 2004 in Fort Collins Colorado. This workshop primarily targets middle school educators who will work with the CALIPSO, CloudSat, and Aura missions to involve students in reporting visual cloud observations and sun photometer data collection through the GLOBE project website. Accepted participants will receive both a stipend and travel expenses. Support will be provided to the participants to develop and present at regional workshops in their local school systems.

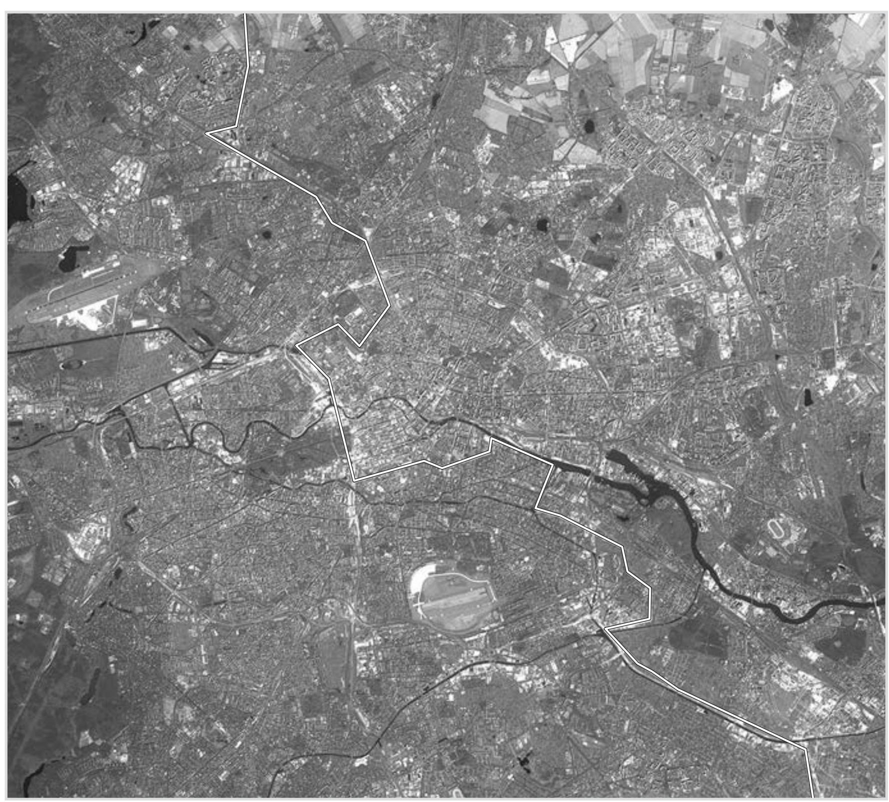
For an application and more information, click on "OUTREACH" at *www-calipso.larc.nasa.gov/* . Additional mission information can be found at: *cloudsat.atmos.colostate.edu* and *eos-aura.gsfc.nasa.gov*

NASAEarth Explorer Series — The GLOBE Program: Science In The Sunshine

The latest article in NASA's Earth Explorers series features a team of students that traveled to Croatia for an international GLOBE conference GLOBE is a worldwide network of K-12 students who, under the guidance of trained teachers, make a core set of environmental observations.

See: *www.nasa.gov/audience/foreducators/5-8/features/F_Globe_Program_Sunshine.html* to find out how a group of kids from the Edmund Burke School in Washington, D.C., helped NASA scientists assess the accuracy of satellite aerosol measurements.

Online versions of the monthly newsletters can be found at *earth.nasa.gov/education*



Inhabited since medieval times, the city of Berlin grew up out of settlements along the Spree River in a region of Europe long known as "the Mark of Brandenburg." From its first recorded settlements in 1237, Berlin has grown into the capital and biggest city of Germany. It has a population of about 3.5 million and extends over 889 square kilometers. The Spree River runs horizontally through the center part of the scene. To the left of center, on the south side of the Spree, is the city's Tiergarten, a large park in central Berlin. The park and gardens are an oasis of green amid the city's dense urban development, which appears gray in the image. At upper right, a patchwork of fields is visible.

Berlin was the capital of Prussia until 1945 and the capital of Germany between 1871 and 1945 and again since the reunification of Germany on October 3, 1990. Between 1949 and 1990, it was divided into East Berlin, the capital of the German Democratic Republic, and West Berlin. The city was divided by the Berlin Wall (white line on image) until November 9, 1989.

This ASTER image covers an area of 22.5 by 20.2 km, and was acquired August 22, 2002. Image courtesy NASA/GSFC/MITI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

NASA's Improved Web-Resource on the World's Changing Climate

—Rob Gutro, rgutro@pop900.gsfc.nasa.gov, Goddard Space Flight Center

Earth Observatory Feature Story: earthobservatory.nasa.gov/Newsroom/NasaNews/2004/2004030116590.html

Students, scientists, teachers, reporters and the scientifically curious can locate any kind of Earth science data much easier and quicker than ever before, using NASA's Global Change Master Directory (GCMD). The redesigned website, a directory of Earth science data and services was launched on March 1 to provide easier access to data and services.

Internet users can access the directory at *globalchange.nasa.gov* or *gcmd.nasa.gov*. The re-launched website is easier to navigate, with 9 tabs running atop the home page, including: Home, Data Sets; Data Services; Portals; Authoring; What's New; Community; Calendar; and Links.

The GCMD, updated daily, provides Earth science data sets and services relevant to global change research. The GCMD's 13 data set topics, found under the "Data Sets" tab, provide summaries of the data sets and specific information such as data over time and location, a citation for the creator of the database, and direct links to data and services.

Available dataset topics range from tiny airborne particles (aerosols) to the continental-sized ozone hole to global sea surface temperatures. The GCMD topics include: Agriculture, Atmosphere, Biosphere, Climate Indicators, Human Dimensions, Hydrosphere, Land Surface, Oceans, Paleoclimate, Snow and Ice, Solid Earth, Spectral/Engineering and Sun-Earth Interactions.

Users can search over 15,000 data sets and services and link to more than over 76,000 resources within the descriptions The individual data set descriptions were contributed by more than 1,300 data centers, government agencies, universities, research institutions, and private researchers around the world.

For scientists and others who want to add or modify GCMD datasets, they can do so under the "Authoring" tab by using the new "docBUILDER" web-based tools. Under the "Data Services" tab are available services from analysis and visualization tools to education and environmental advisories.

The "Portals" tab is the most important to specific groups of data users. "Perhaps the greatest contribution of the GCMD to the public has been the ability to create customized subsets of the directory that can be displayed, in turn, by special interest groups,"said Lola Olsen, Directory Project Manager at NASA's Goddard Space Flight Center in Greenbelt, Md. "These groups save major development and maintenance costs by re-using the directory capabilities." For example, member countries of the Joint Committee on Antarctic Data Management (JCADM) contribute directory entries using the GCMD tools and may then, in turn, host individual, customized subsets of the database through "portals" through which they can display their own contribution.

Reporters and others interested in upcoming recent climate change conferences can find up to 1,000 entries under the "Calendar" tab. Under the "What's New" tab, there are new Earth science and climate change research stories and the latest GCMD data set descriptions.

Students and teachers will also benefit from the "Learning Center" that can be found under the "Community" tab. Clicking on "FAQ: Frequently Asked Questions" at the bottom of the homepage, one can see answers to questions such as "Where can I find information about the ozone hole and ozone depletion?" Finally, the "Links" tab acts as a web-based search engine for easy access to over 2,500 Earth science web resources.

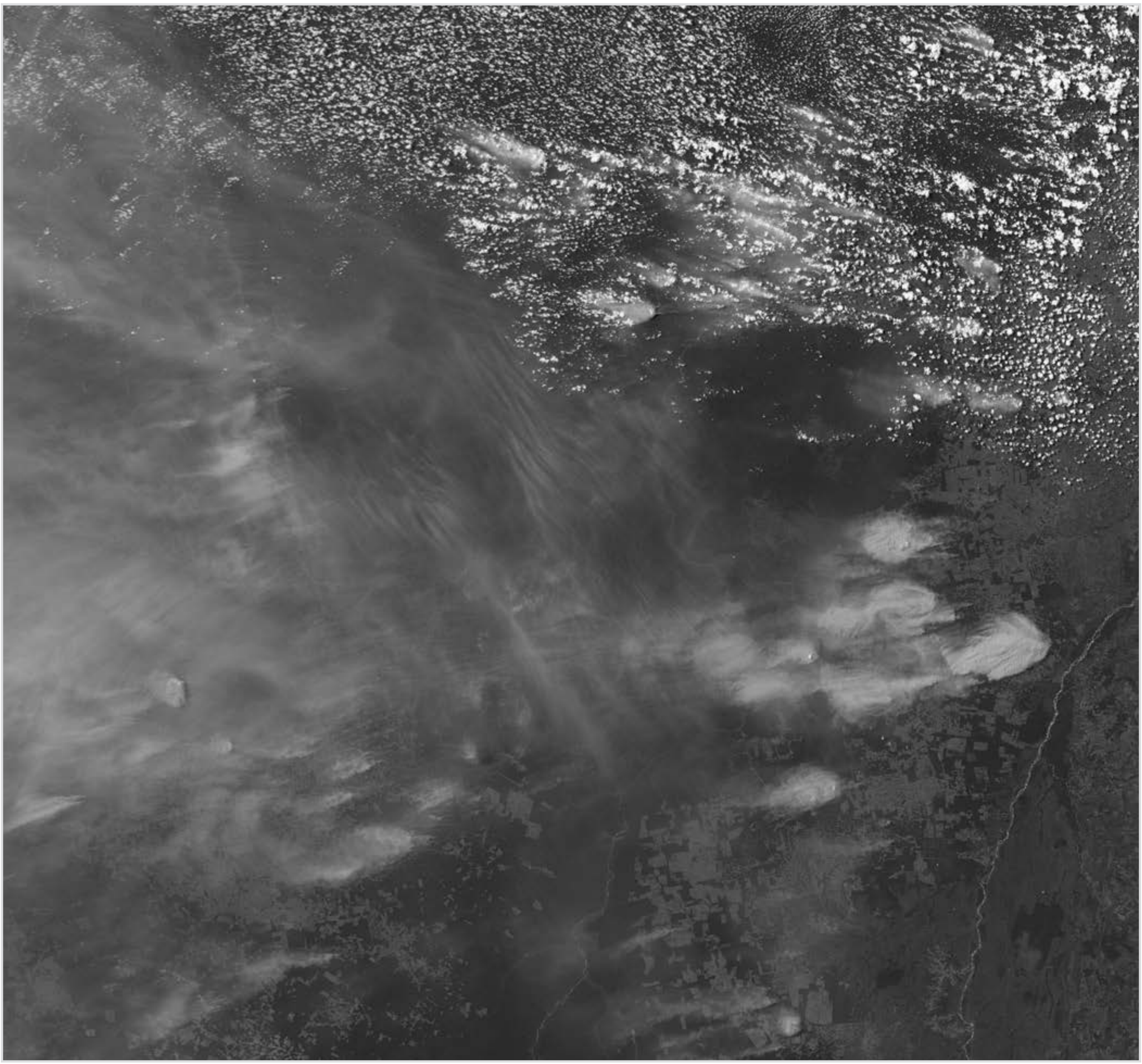
For those who use the directory often, there is also a search box icon that permits direct access to the directory through a simple download to a user's website. Users can also subscribe to an email notification on postings of new datasets for "Earth Science Topics" and "Geographic Locations" by clicking on "Subscribe" on the left tool bar.

The directory content is shared and available as part of NASA's contribution to the Committee on Earth Observation Satellites' (CEOS) International Directory Network (IDN). The content is also made available to the National Spatial Data Infrastructure's (NSDI) Federal Geographic Data Committee's (FDGC) Clearinghouse.

Questions can be directed to Lola Olsen, GCMD Project Manager, Code 902, NASA/Goddard Space Flight Center, Greenbelt, Md. 20771 Phone: 301-614-5361 E-mail: *olsen@gcmd.nasa.gov*.

To access the Global Change Master Directory, please visit on the Internet: *globalchange.nasa.gov* or *gcmd.nasa.gov*.

For more information, please visit on the Internet: *www.gsfc.nasa.gov/topstory/2004/0301gcmd.html*.



Mushrooms of smoke billow up from burning vegetation in the Amazon and spread across a wide region of Mato Grosso state in Brazil in this Moderate Resolution Imaging Spectroradiometer (MODIS) image captured by the Aqua satellite on August 11, 2002. To the north, puffs of cumulus clouds hang above the forest. According to a new study by NASA scientists, the absence of clouds where smoke is present isn't a coincidence; analysis of data captured by Aqua MODIS in August through October 2002 revealed that smoke from biomass burning inhibits cloud formation in the tropics. Image by Jesse Allen & Robert Simmon, based on data provided by the MODIS Science Team.

Warming Oceans Could Mean More Rainy Days in Paradise

—Mike Bettwy, mbettwy@pop900.gsfc.nasa.gov, Earth Science News Team, Goddard Space Flight Center

NASA Portal Feature Story: www.nasa.gov/vision/earth/environment/Tropical_Rain.html

Don't look for more sunny days while vacationing in paradise! A recent study of tropical oceans that used satellites including NASA's Tropical Rainfall Measuring Mission (TRMM), found that rain in the tropics will become more frequent as ocean temperatures rise.

A 'Wetter' Water Cycle

The Earth's pattern of evaporation and precipitation, known as the water cycle, will intensify due to warming temperatures, according to William Lau and Huey-Tzu Jenny Wu of NASA's Goddard Space Flight Center.

The rate that moisture in a cloud is converted into rainfall is known as precipitation efficiency. This study found that when sea surface temperatures warm, the precipitation efficiency for light rains dramatically increases. Compared to actual observations from the TRMM satellite, computer models used in weather prediction repeatedly underestimated this efficiency.

"We believe this is a scenario where in a warmer climate there will be more rain. And more warm rain will be associated with a more vigorous water cycle and extreme weather patterns," Lau said.

Warm vs. Cold Rain

Warm rain is created when water droplets form around airborne particles, such as dust, and produce clouds. As the droplets collide, they form raindrops, which grow large and heavy enough to fall out as warm rain. The researchers discovered that for every degree rise in sea surface temperature, a cloud produces as much as 10% more light-to-moderate rainfall.

Cold rains are associated with brief, heavy downpours. Here, strong vertical winds carry larger raindrops high into the atmosphere, where they freeze and continue to grow. This process is driven mostly by the speed of the winds and less on sea surface temperature. When water vapor condenses it releases heat, warming the lower atmosphere, as observed during warm rain. But, this warming also makes the air lighter and rise faster, creating strong vertical winds that produce more cold rain.

The study found warm rains account for about 30% of the total global rainfall and 72% of the total rain over tropical oceans, pointing to the major role of warm rains in the water cycle.

Additional research is needed to better understand the relationship between warming sea surface temperatures and increased warm-rain precipitation, and to determine how cold rain processes might be impacted.

NASA's Earth Science Enterprise is dedicated to understanding the Earth as an integrated system and applying Earth System Science to improve prediction of climate, weather and natural hazards using the unique vantage point of space. TRMM was launched in Nov. 1997 and is a joint mission with the National Space Development Agency of Japan (NASDA).

Clouds from Space

This image over Southern Brazil, taken from the space shuttle, shows a mixture of cold and warm clouds. Warm clouds are found near the bottom of the image. The tops of such clouds are generally found below 3.1 miles (5 km). Cold clouds with a more ragged, bumpy appearance, typically rise above 6.2 miles (10 km) and cover the top and left portions of the image. These clouds are capable of producing very heavy rain and thunderstorms. Credit: NASA ►

NOTE:

Once The Earth Observer is produced and sent to the printer, a PDF version is placed on-line at eos.gsfc.nasa.gov/earth_observer.php. *Approximately two weeks later, the printed copy is received from the printer, labeled and sent to everyone on our mailing list. If you would prefer the pdf version only, please email Steve Graham at steven.m.graham.2@gsfc.nasa.gov, and we will remove you from the mailing list. We will then send an email to you each time a pdf version is placed on the web site.*

EOS Science Calendar

August 17-19

MODIS Vegetation Workshop II, University of Montana, Contact: Steve running, (406) 243-6311, *swr@ntsg.umt.edu*

October 27-29

SORCE Science Team Meeting, Meredith, New Hampshire URL: *lasp.colorado.edu/sorce/2004ScienceMeeting.html*

Global Change Calendar

March 22-23

Seventeenth Annual Towson University GIS Conference, Towson University, Baltimore, MD. Contact: Jay Morgan, Email: jmorgan@towson.edu, URL: *cgis.towson.edu/tugis2004*

May 2-7

2004 Gordon Research Conference, Biogenic Hydrocarbons and the Atmosphere, Il Ciocco, Barga, Italy. URL: *www.grc.org*

May 23-28

American Society for Photogrammetry and Remote Sensing (ASPRS) Annual Conference, Denver, CO. URL: *www.asprs.org/denver2004*

June 16-24

8th Biennial HITRAN Conference, Cambridge, MA. URL:*cfa-www.hanuand.edu/HITRAN*

July 12-23

International Society for Photogrammetry and Remote Sensing (ISPRS), Istanbul, Turkey. URL: *www.isprs2004-istanbul.com*

July 18-25

35th COSPAR Scientific Assembly, Paris, France. URL: *www.copernicus.org/COSPAR/COSPAR.html*

August 1-6

Stratospheric Processes and their Role in Climate (SPARC) 3rd General Assembly, Victoria, British Columbia, Canada. URL: *sparc.seos.uvic.ca*

August 1-6

The Ecological Society of America 89th Annual Meeting, Portland, OR. URL: *www.esa.org/portland/*

August 16-26

The European Space Agency's (ESA) 2nd ENVISAT Summer School on Earth System Monitoring & Modeling, Frascati, Italy. URL: *envisat.esa.int/envschool/*

September 4-9

The 8th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC), Christchurch, New Zealand. URL: *www.igaconference2004.co.nz*

September 13-17

SPIE's Sensors, Systems, and Next Generation Satellites X (RSO3), Maspalomos, Gran Canaria, Spain. Contact Steven Neeck, steve.neeck@nasa.gov. URL: *spie.org/info/ers*

September 20-24

International Geoscience and Remote Sensing Symposium (IGARRS), Anchorage, Alaska. URL: *www.ewh.ieee.org/soc/grss/igarss.html*

October 13-16

Surface Ocean Lower Atmosphere Study (SOLAS) 2004 Open Science Conference, Halifax, Nova Scotia, Canaca. URL: *www.uea.ac.uk/eng/solas/ss04.html*

November 8-12

SPIE's Fourth International Asia-Pacific Environmental Remote Sensing Symposium, Honolulu, Hawaii. Abstracts due April 26, 2004. URL: *spie.org/conferences/calls/04/ae/*

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