ADVANCES IN ATMOSPHERIC SCIENCES, 2025

• Meeting Summary •

The International Radiation Symposium 2024※

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ABSTRACT

The International Radiation Commission held its quadrennial International Radiation Symposium (IRS) in Hangzhou, China, from 17–21 June 2024. A lively meeting of 276 scientists from 18 countries occurred at the Zhejiang Sanli New Century Grand Hotel. There were ten oral and two poster sessions covering a wide range of topics, from radiative transfer theory and modeling to particle radiative properties, solar UV radiation, and ground-based measurements. This summary is not an exhaustive overview but rather a broad sample of the many talks delivered at IRS.

Key words: atmospheric radiation, atmospheric remote sensing, field observations

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1. Overview

The International Radiation Commission (IRC), one of eleven commissions within the International Association of Meteorology and Atmospheric Sciences (IAMAS), held its quadrennial International Radiation Symposium (IRS) in Hangzhou, China, from 17–21 June 2024. The symposium, hosted by Zhejiang University in Hangzhou, returned to its original schedule after the global COVID-19 pandemic delayed the 2020 symposium by two years. A lively meeting of 276 scientists from 18 countries occurred at the Zhejiang Sanli New Century Grand Hotel (Fig. 1). The 2024 symposium in Hangzhou marks the second time the symposium was held in China. Welcome remarks with an emphasis on IRC history were delivered by the president of the IRC, Peter PILEWSKIE. This was followed by a welcome message from Mu MU on behalf of the Chinese National Committee for IAMAS and an introduction to Hangzhou and its historical significance by Zhenhong DU, dean of the Earth Sciences School at Zhejiang University. Local Organizing chair Lei BI concluded by highlighting the symbolism of the IRS logo and an overview of the meeting format. There were ten oral and two poster sessions covering a wide range of topics, from radiative transfer theory and modeling to particle radiative properties, solar UV radiation, and ground-based measurements. All ten sessions are highlighted below, with summaries of several talks from each. This summary is not an exhaustive overview but rather a broad sample of the many talks delivered at IRS.

The IRC presented awards at the banquet dinner hosted at the Hangzhou Cuisine Museum. After an extensive number of local dishes and performances by local musicians and dancers, the recipients of the Young Scientist Award, Dr. Jake GRISTEY, and the Gold Medal Award, Prof. Ping YANG, were announced. Three recipients of Poster Awards, sponsored by the IAMAS associated journal, *Advances in Atmospheric Sciences* were also recognized: Stavros VIGKOS, Institute for Environmental Research and Sustainable Development, National Observatory of Athens; Jaume Ruiz de MORALES, Universitat de Girona; and Mayuki SANO, Tohoku University.

At the end of the week, the local organizers at Zhejiang University coordinated an afternoon of visits to various landmarks around Hangzhou, which provided scientists with an excellent opportunity to connect and discuss topics that arose during the week's activities.

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2. Topical Union Session (Key note Sessions)

The first keynote talk of the symposium was delivered by Daren LYU, who provided an overview of the upcoming Chinese mission Climate and Atmospheric Composition Exploring Satellites (CACES). The CACES mission will use two Low Earth Orbit (LEO) satellites. Together, they will perform LEO to LEO microwave occultation measurements, where one satellite transmits microwave pulses through the limb of the atmosphere, and the other acts as a receiver. Additionally, these satellites will make nadir-facing infrared-laser occultation measurements. LYU showed simulations of this two-satellite constellation in counter orbit capable of making 3-D measurements of greenhouse gas concentrations. The combination of these two techniques will improve our understanding over the traditional 1-D column density measurements.

To conclude the opening session, retired NASA scientist Warren WISCOMBE talked about his personal journey working in the atmospheric radiation field. After obtaining a bachelor's degree in physics from the Massachusetts Institute of Technology, WISCOMBE, motivated by the environmental movement, shifted his focus away from the popular physics topics of the day, such as black holes and quarks, to more tangible topics while completing his doctorate at the California Institute of Technology. He discussed the path that led to his most significant scientific contributions, starting with his work at the small California company Systems, Science and Software. In 1971, WISCOMBE was granted funding to develop a comprehensive spectral atmospheric radiation model named ATRAD. Many projects spun out from this development. His first AGU abstract was accepted in 1972, covering a detailed calculation of Arctic radiation. He published his first paper on solar radiation calculations for Arctic summer under stratus cloud conditions. In 1979, he published the MIEV0 code, an algorithm to solve Mie scattering calculations, which is still widely used today. WISCOMBE ended his talk by urging students to get out into the field to make measurements and learn how to write good scientific computer programs.

The recipient of the IRC Young Scientist Award in 2004, Toshihiko TAKEMURA, presented a keynote address on the effects of aerosols on climate change. Black carbon is a positive radiative forcing agent. Therefore, its removal from the atmosphere has been proposed as a climate change mitigation strategy. However, TAKEMURA showed that the decrease in surface air temperatures due to reduced black carbon concentrations is smaller than expected. The atmosphere has been shown to adjust rapidly in response to the reduction of black carbon because of its short lifetime within the atmosphere. Sulfate aerosols are another short-lived climate forcing agent, but have a negative radiative forcing and, therefore, cool the atmosphere by scattering incident shortwave radiation. Removing sulfate aerosols has a more significant impact on surface air temperatures than black carbon. Additional sensitivity experiments using a general circulation model and a global cloud-resolving model have been leveraged to quantify climate change by comparing different amounts of anthropogenic aerosol emissions from regions associated with short-lived climate forcing agents. The results from this work will be used to assess impacts on human health, crop yields, flooding, and drought. Ultimately, this analysis will help develop mitigation strategies for short-lived climate forcing agents.

Remote sensing measurements from the Geostationary Environment Monitoring Spectrometer (GEMS) satellite were presented by Jhoon KIM. This scanning UV-visible spectrometer, sampling radiation from 300 to 500 nm, is used to retrieve the atmospheric composition over Asia. Unlike satellites in low-Earth orbit, GEMS can measure the diurnal variation of atmo-

Fig. 1. IRS 2024 group photo, taken at the Zhejiang Sanli New Century Grand Hotel.

spheric pollutants such as ozone, nitrogen dioxide, sulfur dioxide, and formaldehyde. KIM showed that data fusion techniques can be used to combine measurements from multiple satellite platforms to retrieve aerosol optical depth. These retrievals were shown to agree with ground-based measurements. Machine learning methods were applied to correct stray light issues with the L1 irradiance product. Measurements from GEMS enable unprecedented spatial and temporal resolution of atmospheric constituents from geostationary orbit.

There is a need for radiative transfer parameterizations that approach the 3-D Monte Carlo solution but on faster timescales. Bernhard MAYER addressed this topic by starting with background on clouds and how they interact with radiation. The heating rates of 3-D cloud geometries used in radiative transfer were compared with the 1-D plane parallel cloud model. MAYER showed that the heating rates for cubic and spherical cloud geometries are three and two times higher, respectively, than the plane parallel geometry. One example of a fast, dynamic parameterization of 3-D radiative effects that better estimates realistic cloud heating rates is the 10-stream radiative transfer model. Numerical weather predictions and large eddy simulations typically assume each column in the model is independent. Without horizontal energy transfer, errors arise on spatial scales of less than 1 km. The 10-stream radiative transfer model, which accounts for this horizontal energy transfer, is a fast parameterization that closely approximates 3-D heating rates in a fraction of the time a 3-D Monte Carlo model requires.

Maria HAKUBA spoke about the trends and variability in Earth's Energy Imbalance (EEI) and ocean heat uptake. EEI is defined as the difference between incoming solar radiation and outgoing reflected solar and emitted terrestrial radiation. The global energy imbalance is measured to be about 1 W m^{-2}. While seemingly small, HAKUBA pointed out that when multiplied by the surface area of the Earth, this imbalance exceeds humanity's total energy usage. The ocean absorbs roughly 90% of the excess energy. Thus, ocean profiling is critical to accurately measuring EEI. The Global Energy and Water Exchanges project quantifies ocean heat uptake by comparing and combining satellite and in-situ observations. HAKUBA pointed out that seamless continuity of observing systems and long-term climate data products are critical for improving our understanding of how the climate is changing.

An essential step in validating General Circulation Models (GCM) is accurately reproducing past climates, which builds confidence in the predictions of future climate states. Ayako ABE-OUCHI discussed the simulation of Ice Age climates in GCMs, which are characterized by vast portions of the Earth being covered in ice sheets. The increase in Earth's albedo greatly impacts the global climate. However, obtaining Ice Age climate conditions within a GCM has proven difficult. ABE-OUCHI showed that deep-sea modeling and ice core studies suggest a tight link between climate and the Atlantic Meridional Overturning Circulation (AMOC). This presentation showed AMOC to be shallower during the Last Glacial Maximum than it is today.

The 2024 International Radiation Commission's Young Scientist Award went to Jake GRISTEY (Fig. 2). This award is granted to someone who has made recent noteworthy contributions to radiation science and is regarded as having great potential as a future leader in the field. GRISTEY's keynote address covered 3-D, diurnal, and spectral shortwave radiation. Surface solar irradiance for a scene with shallow cumulus clouds was shown to have a bimodal distribution, which can be explained by 3-D shortwave radiation effects. The difference between surface solar irradiance calculated from 3-D and 1-D radiation simulations decreases as the averaged spatial scale increases, asymptotically approaching a non-zero value. Another study

Fig. 2. The 2024 IRC Young Scientist Award winner, Dr. Jake GRISTEY, with former PhD advisor Dr. Christine CHIU (right) and IRC president Peter PILEWSKIE (left).

investigating diurnal shortwave radiation concluded that a constellation of 36 satellites could retrieve hourly, global top-of-atmosphere outgoing shortwave radiation with high accuracy. Lastly, GRISTEY highlighted the capabilities of hyperspectral observations of reflected solar radiation, such as the ability to discern surface types or various cloud regimes using cluster analysis of thousands of spectra.

Ping YANG was the recipient of the 2024 International Radiation Commission's Gold Medal Award (Fig. 3), conferred to a senior scientist who has made lasting contributions to radiation science. YANG gave an overview of his scientific career, discussing his research efforts and the mentors who shaped his path during his keynote address. After completing his undergraduate studies in China, YANG moved to the United States and completed his Ph.D. with Kuo-Nan LIOU, the recipient of the IRC Gold Medal in 2012. Following his graduate studies, YANG briefly worked at NASA before accepting a position at Texas A&M University in 2001, where he met another important mentor, George KATTAWAR. Over the decades, he has applied his deep knowledge of radiative transfer to solve many disparate problems, such as light scattering of ice crystals and non-spherical aerosol particles, invisibility cloaks for irregular particles, halos on Mars, and less invasive methods for detecting sickle cell disease. YANG ended his talk by emphasizing the importance of teaching the fundamentals of light scattering and radiative transfer.

3. Radiative Transfer Theory and Modeling

Various approaches for radiative transfer were demonstrated within this session, from statistical-based techniques like correlated-k to newer machine learning-based methods. Some utilized satellite observations to train and test artificial neural networks, while others used modeled data. A few presentations focused on developing fast and accurate radiative transfer parameterizations for models and satellite retrievals. To reduce computation time, one presenter discussed simplifying the multiple scattering term within the radiative transfer equation. Another solved for spectrally resolved radiances using principal component analysis trained on simulations and measurements.

Invited speaker, Christine CHIU, presented a machine learning approach for emulating 3-D shortwave radiative transfer for shallow cumulus cloud fields. The training and testing datasets were generated using Large Eddy Simulations with 100-meter horizontal and 30-meter vertical resolution. CHIU showed that there is heating enhancement at cloud edges due to forward scattering. These fast simulators can predict surface radiation and heating rates with a –0.4% bias and a 2% root mean squared error in surface downwelling flux.

The second invited speaker for this session, Zhanqing LI, discussed the radiative impact of aerosols on planetary boundary layer thermodynamics and convective clouds.

This analysis showed that aerosol-cloud interactions remain the largest uncertainty in climate forcing and that neglecting cloud-coupling results in underestimating aerosol-cloud interactions within models.

Radiative transfer is one of the fundamental physical processes of the Earth-atmosphere system. Longwave scattering, an often overlooked component of climate models, is essential for accurate estimations of climate change. Kun Wu investigated three longwave radiative transfer processes in his talk: the spectral region where longwave and shortwave overlap, scattering by clouds, and specification of ocean emissivity. This analysis showed that longwave scattering by clouds reduces the outgoing

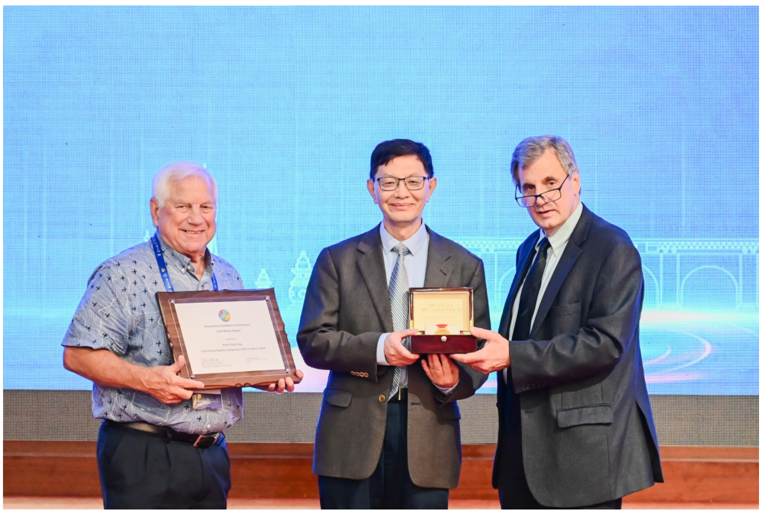

Fig. 3. The 2024 IRC Gold Medal winner, Dr. Ping YANG, with Dr. Bill SMITH, the 2022 IRC Gold Medal recipient (left), and IRC president Peter PILEWSKIE (right).

radiation to space, resulting in a warming effect in the troposphere. This effect is especially prevalent in the tropics and low latitudes, leading to a larger temperature gradient towards the polar regions and thus strengthening Hadley circulation.

4. Particle Radiative Properties

There has been increased attention on the radiative properties of particulates within Earth's atmosphere due to wildfires, desertification of land, and anthropogenic emissions. This session featured many talks on how different particles affect atmospheric and solar radiation, as well as how remote sensing can be used to detect these particles. During the first day of talks, researchers spoke about the refractive index and optical modeling of black carbon and its impact on atmospheric radiation, modeling the optical properties of inhomogeneous mineral dust, and increased light absorption due to soot aerosols from wildfires. Researchers on the second day discussed the computation of the invariant imbedding T-matrix and light scattering of ice crystals.

Zhibo ZHANG was invited to discuss how surface coatings around dust aerosols affect short and longwave radiative effects. Dust is often coated with pollutants, which changes the hygroscopicity of the particle. Using a core-shell model, ZHANG found that coated dust has a smaller cooling effect than non-coated dust in the shortwave region of the spectrum, whereas the longwave region had a stronger warming effect.

Invited speaker Hajime OKAMOTO discussed the retrieval of cloud properties and vertical air motion from measurements taken by the recently launched Earth Clouds, Aerosols, and Radiation Explorer (EarthCARE) satellite. EarthCARE is a joint mission between Europe and Japan and carries four instruments: a 94 GHz cloud profiling radar, a 355 nm backscattering lidar, a multispectral imager, and a broadband radiometer. A synergistic ground-based observation system in Konganei, Tokyo, will evaluate the level 2 products derived from EarthCARE's observations.

5. General Remote Sensing

Throughout the week, many talks in this session used data from legacy instruments to perform analyses on decades of measurements. Other speakers highlighted exciting new science from recently launched satellites and promising techniques for future missions. Multispectral and hyperspectral observations in the visible to near-infrared can be leveraged to retrieve properties of the ocean, clouds, aerosols, and phytoplankton. Airborne and spaceborne lidar was touted for its many applications, such as detecting turbulence and retrieving aerosol and cloud optical properties. Many satellites carry multiple instruments on the same platform to leverage individual sensor characteristics in a synergistic retrieval. This session showcased remote sensing techniques utilizing broadband radiometers, multispectral imagers, polarimeters, lidars, radars, and microwave sounders.

Invited speaker Meng GAO presented an overview of NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) satellite and its geophysical retrievals. PACE can discern several types of phytoplankton using contiguous spectral sampling across the visible, while multiangle sampling can determine aerosol properties. An upcoming validation campaign will investigate the accuracy of the retrieved products from PACE's measurements.

Jerome RIEDI described the upcoming Multiangle, Multispectral, Multi-polarization Imager (3MI), a space-based instrument due to launch next year. The sensor consists of two wide field-of-view cameras with a rotating filter wheel capable of polarimetric measurements at nine wavelengths and non-polarimetric measurements at three wavelengths. Successive images taken over short temporal intervals will provide 10–14 different look-angles of the same scene. The data from the 3MI instrument can be used to monitor aerosol properties and determine the vertical structure of clouds.

A detailed comparison of measured reflectances between MODIS and VIIRS was given by Xiaoxing XIONG. MODIS and VIIRS share similar calibration mechanisms, as they were developed and built by the same vendor. Both instruments use lunar brightness observations for calibration, which are stable over time if viewed at the same lunar phase. Lunar observations taken by MODIS on board the Terra and Aqua satellites differ by 1–2% per channel. While the various VIIRS instruments generally agree, XIONG showed that the instrument onboard the Suomi-NPP satellite consistently measures higher radiances than VIIRS on the NOAA-20 and NOAA-21 satellites.

6. Ground-Based Measurements and Field Observations

Space-based observations often trade spatial resolution for global coverage. Ground and field-based observations offer in-situ and localized remote sensing measurements with high temporal resolution, facilitating detailed process studies at the regional scale. Many of the talks within this session focused on aerosol properties. Aerosol radiative forcing remains one of the largest uncertainties within the Earth's climate system, and the mechanisms of cloud-aerosol interactions are poorly understood. Direct in-situ measurements and remote sensing systems are needed to constrain the radiative properties of these ubiquitous atmospheric particles.

Surface temperatures in the Arctic have increased more rapidly than in any other region. This amplification necessitates in-situ measurements to constrain weather and climate models. Manfred WENDISCH discussed radiation measurements from the High Altitude and Long Range research aircraft - Project on Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms (HALO-(AC)^3) field campaign. HALO-(AC)^3 has made the first quasi-Lagrangian observations in the Arctic region. This technique calculates air mass trajectories to determine strategic flight paths for IN-SITU sampling. The HALO-(AC)^3 field campaign payload included a microwave radiometer, a polarization camera, and spectral and broadband solar and thermal-infrared sensors.

Another talk focusing on the Arctic region discussed measurements of cloud thermodynamic phase from shipborne measurements during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) field campaign. Climate models often underestimate the frequency of ice phase clouds within the Arctic region. Minghui DIAO demonstrated the importance of correctly identifying cloud phase and showed that it is essential for accurately determining the cloud radiative effect. The results from this talk showed that clouds in current models have less water content than the in-situ measurements from MOSAiC suggest.

Two talks focused on the intercloud transition zone, where clouds dissipate into the background atmosphere. Francesco SCARLATTI showed the Marshak spectrally invariant transition zone can be detected with a ground-based hyperspectral camera. Jaume Ruiz de MORALES characterized this region with backscatter measurements from a ceilometer, finding that most clouds have transition zones where backscattering decreases smoothly as a function of distance rather than sharply decreasing.

7. Radiation Budget and Forcing

Monitoring the flow of incoming and outgoing radiation is critical to understanding the energy imbalance of the Earth-atmosphere system. The satellites that carry CERES instruments are all slated for decommissioning within the next few years. Plans are underway for new missions (Libera the Earth Climate Observatory, or ECO) and sensors (Black Array of Broadband Absolute Radiometers – Earth Radiation Imager, or BABAR-ERI) to provide continuity with the existing multi-decadal data record. Another focus of this session was the study of cloud, aerosol, and dust radiative forcing, that is critical for predicting future climate scenarios, informing policy and mitigation strategies, and understanding various feedback mechanisms.

Jake GRISTEY showed how Libera plans to implement and evaluate the radiance-to-irradiance conversion for its split-shortwave channel. This talk described Libera's role in providing continuity to the NASA Clouds and the Earth's Radiant Energy System (CERES) observations and its ability to provide new and enhanced capabilities for future ERB missions. Libera's additional split-shortwave channel, a first for ERB missions, will improve our understanding of shortwave energy disposition within the Earth-atmosphere system. Libera will also fly a wide-field-of-view camera, which will be utilized for simple scene identification and Angular Distribution Model (ADM) generation. Gristey discussed how ADMs are used to retrieve irradiance and presented methods for which Libera's split-shortwave ADMs will be evaluated.

A new space-based mission for monitoring the Earth's Energy Imbalance (EEI), ECO, was presented by Steven DEWITTE. Dewitte emphasized why the monitoring of EEI is needed for a predictive understanding of climate change and described how ECO will achieve high levels of accuracy via a differential measurement method. This method utilizes two Earth-viewing and two solar-viewing instruments.

BABAR-ERI is an innovative first step towards a low-cost and low-mass strategy for imaging broadband radiation at high spatial resolution and low uncertainty. Odele CODDINGTON described how BABAR-ERI will image high-accuracy shortwave and total broadband radiances at a 1 km resolution. BABAR-ERI will implement electrical substitution radiometers, providing key advantages over traditional bolometers. BABAR-ERI has SI traceability to the Watt, absolute calibration for each pixel, and improved stability, linearity, and dynamic range. This capability will enable process-level understanding and improve future ERB missions.

Invited speaker Minghuai WANG discussed the importance of low marine cloud response to anthropogenic emissions and their impacts on climate change. These cloud formations are crucial for global climate studies as they have a wide geographic spread and tend to cool the Earth due to their high reflectivity. A convolutional neural network was developed to predict cloud radiative effects, the results of which have revealed that changes in number concentration have dominated the trend over the past two decades. Wang showed that the Community Earth System Model version 2 agrees with the convolutional neural network predictions.

The connection between the Pacific Decadal Oscillation (PDO) and shortwave radiation variability at the surface and top of atmosphere was discussed by Boriana CHTIRKOVA. This analysis utilized unforced simulations to generate statistics between the PDO and surface downwelling shortwave radiation. The PDO was found to account for roughly one-third of shortwave radiation variability in the Northern Hemisphere over decadal timescales. CHTIRKOVA explained that the PDO is the first principal component of sea surface temperature anomalies and revealed that the CHIP6 model shows an interesting spatial pattern of these anomalies, which don't show up as strongly in the CERES data record.

8. Weather, Climate and Environment Applications

Aerosol particles can modify the formation of clouds and precipitation, alter local heating rates through either scattering or absorption, and affect human health. Many talks centered their attention on highly absorbing anthropogenic black and brown carbon aerosol that results from high-temperature combustion and biomass burning. The light absorbing properties of black carbon have long been studied, but those of brown carbon are less understood. Non-anthropogenic aerosols also need further study. Sea salt aerosols near coastal regions impact precipitation but are poorly represented in forecasting models. Another common topic within this session was the forecasting and study of solar variability at the surface, that is critical for the management of solar power on regional and global scales.

Guangxing LIN discussed modeling the absorption of brown carbon aerosols in China. Brown carbon is a sunlight-absorbing component of organic aerosols and is a strong absorber at UV wavelengths. LIN discussed the ability of GCMs to capture the seasonal variation of absorption due to brown carbon over China. The results of this analysis showed that models underestimate brown carbon absorption in northern Chinese cities during winter when compared to measurements.

The use of satellite measurements to retrieve sea ice emissivity and emission temperature over the Arctic from microwave measurements was presented by invited speaker Byung-Ju SOHN. SOHN showed how we can leverage radiation at multiple wavelengths in the microwave region that penetrate to different depths within the sea ice. He also showed how an Artificial Neural Network approach can be utilized to bypass some of the traditional retrieval steps in estimating sea ice emissivity.

Another invited speaker, Xianglei HUANG, presented a climate analysis utilizing two decades of infrared hyperspectral observations, and how these can inform future climate states. This talk explained why it is difficult to identify a clear-sky footprint from an infrared sounding alone, but demonstrated how colocated MODIS imagery can help identify clear-sky scenes with higher confidence.

The improvement of cloud forecasts by assimilating all-sky microwave and infrared radiances using the Joint Effort for Data assimilation Integration with the Model Prediction Across Scales – Atmosphere (JEDI-MPAS) system was featured in this session. Invited speaker Zhiquan LIU explained that JEDI-MPAS is now mature enough to assimilate radiances in all-weather situations and is ready for the community to adopt for research purposes.

9. Solar UV Radiation

Surface UV radiation and its impact on human health was highlighted in this session. Data from the Third International Solar UV Radiometer Calibration Campaign (UVCIII) and Atmospheric parameters affecting SPectral solar IRradiance and solar Energy (ASPIRE) campaign were used to validate short-term forecasting of surface solar UV. Forecasting models are driven by a need to predict periods of high surface UV irradiance in order to disseminate warnings quickly so that citizens can take necessary precautions.

Kyriakoula PAPACHRISTOPOULOU gave an invited talk on nowcasting and short-term forecasting of surface-level solar UV flux. The UV-Index Operating System relies on radiative transfer models, Earth-observing satellite measurements, and retrievals to estimate the UV flux at high spatial and temporal resolution. The main atmospheric inputs include cloud and aerosol properties as well as ozone concentration. Any uncertainties in these components propagate into the UV forecast. Surprisingly, the UV flux forecast was not significantly improved when utilizing accurate inputs of aerosol optical depth or total column ozone amount.

The Geostationary Operational Environmental Satellite (GOES)-R series carry an instrument measuring solar spectral irradiance known as EUVS, the Extreme Ultraviolet Sensor. Martin SNOW gave an overview of the EUVS measurements and data products. These include observations of the Magnesium II core-to-wing ratio at a cadence of 3 seconds, a new capability for the GOES satellite series. Snow explained how the Magnesium II index can be used as a proxy for chromospheric activity.

10. China's Satellite Remote Sensing Program

A special session highlighted China's growing fleet of satellites measuring various components of the Earth system. Several talks reviewed the second-generation meteorological satellite FengYun-3G, the first Chinese satellite to measure the 3-D structure of precipitation at low to mid-latitudes. The polar orbiting FengYun-3F carries an instrument that monitors the outgoing shortwave, longwave, and total reflected and emitted radiation. Another instrument onboard FengYun-3F is the Ozone Monitoring Suite (OMS), a hyperspectral spectrometer sampling radiation from the visible region of the spectrum, which is used to estimate ozone, nitrogen, and oxygen concentrations. Instruments onboard the FengYun-4 series of satellites are the world's first geostationary hyperspectral infrared sounders. Measurements from this fleet are being used to track carbon monoxide and ammonia over Eastern Asia.

Another key payload, the dual frequency precipitation measurement radar (PMR), has proven capable of measuring 3-D precipitation structure and has observed several extreme weather events. Peng ZHANG gave an invited talk discussing the on-orbit performance of PMR and FengYun-3G since its launch in April 2023. Invited speaker Rui LI compared FengYun-3G with its predecessors, the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Measurement Core Observatory (GPMCO).

Lin CHEN provided an overview of the instruments onboard FengYun-3G and their associated data products. Measurements from the MEdium Resolution Spectral Imager are utilized to estimate many different Earth system properties, including cloud phase, snow cover, and sea surface temperature. Microwave Radiation Imager observations are used to estimate cloud liquid water amount, total precipitable water, as well as temperature and moisture profiles. Measurements from the Global Navigation Satellite System Occultation Sounder can estimate profiles of electron density and sea surface wind speed. Lastly, CHEN explained how the PMR instrument can be used to retrieve estimates of precipitation phase and rate, as well as latent heat.

Multiple talks discussed the development of retrieval algorithms that use observations from the FengYun-4 fleet. Chao LIU outlined a cloud optical and microphysical retrieval using measurements from the Advanced Geosynchronous Radiation Imager (AGRI). Liu described a machine learning algorithm trained to detect cloud phase and produce a cloud mask. A second talk given by Disong FU explained how machine learning techniques can enhance the accuracy of cloud detection when using AGRI measurements. FU presented a new retrieval of aerosol optical depth using a deep learning model.

11. Radiation Science in the Tibetan Plateau Regions

The Tibetan Plateau has experienced noticeable warming and a rapid increase in surface temperatures compared to the global average over the past forty years. Climate models lack the spatial resolution to predict the observed warming due to the complex topology of the region. Researchers in this session used reanalysis data to analyze the possible mechanisms for the observed warming. While this was the main topic of discussion, other talks covered how cloud top temperature and optical thickness can be used to identify convective clouds over the region and how stratospheric ozone loss enhances summer precipitation.

Haibin ZHANG provided an overview of warming amplification over the Tibetan Plateau and the different processes that drive it. ZHANG explained that the Tibetan Plateau is warming due to a decrease in surface albedo, leading to increased atmospheric water vapor and a subsequent amplification in the region's downward longwave radiation. Albedo feedback was shown to have the largest impact on warming, followed by moist atmospheric heat transport and lapse-rate feedback.

The amplification of Tibetan surface warming in an abrupt 4xCO_2 experiment was presented by Yuwei WANG. The primary purpose of this analysis was to explain how CO_2 forcing is driving the Tibetan Plateau's rising surface temperatures. Moisture and albedo feedback provide a majority of the variance within predictions of temperature change, with albedo feedback being primarily associated with the retreat of glaciers. The results of this analysis show a 7.3 K warming in the Tibetan Plateau region over a 150-year time period.

Yaxin XIANG presented the characteristics and sources of organic aerosols at Yangbajing, a city in the Tibetan Plateau. XIANG highlighted how the Tibetan Plateau has low amounts of local aerosol emissions but is subjected to high amounts of aerosol transport from India and China.

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