History of the International Satellite Cloud Climatology Project

William B. Rossow

Distinguished Professor Emeritus, City College of New York, NY, USA

The International Satellite Cloud Climatology Project (ISCCP) was established 40 years ago as the first project of the World Climate Research Programme (WCRP) to provide a globally uniform cloud climatology for climate research. WCRP Report 6/2022 (*http://doi.org/10.13021/gewex.isccp*) recounts the history of this project from the early planning, through development and two revisions of the data collection and processing approach, to its current operational phase, emphasizing the evolution of the project concept and how that evolution shaped the characteristics of the data products.

The earliest concept for the use of the data products was to quantify cloud effects on the top-of-atmosphere (TOA) radiation budget and check the fidelity of climate model representations of these effects. A more specific articulation of the tasks required and better definition of the needed cloud properties led to the extension of this concept to encompass cloud effects on both TOA and surface radiation, which also motivated the establishment of the Surface Radiation Budget (SRB) and Baseline Surface Radiation Network (BSRN) projects. In the 1980s and 1990s, BSRN, together with ongoing and planned NASA radiation budget satellite missions (Nimbus-6/7 and the Earth Radiation Budget Experiment, ERBE), would provide more direct evaluations of the fluxes calculated using the ISCCP cloud products. The first version of the data products, ISCCP-C, covered July 1983 through June 1991. Significant achievements by the time of the completion of the first version of the data products in the early 1990s were: (1) establishment of the first absolute radiance calibrations for the global constellation of weather satellite imaging instruments, (2) development and thorough testing of a cloud detection procedure based on a quantitative evaluation of available methods, (3) demonstration that usefully accurate determinations of cloud radiative effects on the TOA and surface fluxes could be obtained by employing radiative models for retrieval and flux calculation using the same cloud microphysics and ancillary data (ISCCP-FC and SRB), and (4) provision of almost a decade of globally uniform depictions of diurnal, synoptic, and seasonal cloud variations. However, in the 1980s, detailed knowledge of ice clouds was lacking, so this first version of the cloud products treated all clouds as liquid. Better information about ice clouds was developed in the late 1980s and early 1990s from an international set of field experiments (led by the U.S., Japan, and Europe) and early satellite retrievals of ice cloud properties, which led to a second version of the products in the mid-1990s that included a separate treatment of ice and liquid clouds.

The organization of GEWEX in 1989–1990 expanded the concept of the role of clouds in climate to include radiation and precipitation. This broader concept motivated the reporting in the second version of the ISCCP products, beginning in the mid-1990s, of both radiative and bulk mass cloud properties as well as the release of the higher resolution (pixel-level with 32 km, 3 hr sampling) products for cloud process studies. The processing of the second version of the data products, ISCCP-D, extended from the mid-1990s into the early 2010s: ISCCP-D finally covered July 1983 through December 2009. Using the second version of the products led to a better understanding of cloud type distributions and their vertical structures, which allowed the estimation of cloud effects on radiative flux profiles (ISCCP-FD). The release of the radiative flux products (SRB and ISCCP-FD) represented achievement of one of the primary goals of ISCCP: separating the TOA radiation budget into its surface and atmospheric components to evaluate cloud-radiative feedbacks on atmospheric and oceanic circulations. In addition, analyzing patterns in mesoscale cloud property distributions (cloud regimes or Weather States) helped advance understanding of the related variations of clouds, radiation, and precipitation in different meteorological conditions. All of these studies supported development of more comprehensive evaluations of cloud process feedbacks on the energy and water cycle with early emphasis on diagnosing these feedbacks on weather-scale to seasonal and slower climate variations [e.g., Madden-Julian Oscillation (MJO), African Easterly Wave (AEW), and El Niño events). Study results by the 2000s suggested that cloud-radiation-dynamics feedback is positive for storm systems (including large scale events like MJO and AEW), reinforcing latent heating feedback from precipitation, and negative in fair weather conditions, and that the combination of weather-scale effects enhances the equator-to-pole heat transport by the atmosphere and decreases the transport by the ocean.

The advent of more advanced satellite cloud measurements in the late 1990s and 2000s, notably Moderate-resolution Imaging Spectroradiometer and Polarization and Directionality of Reflectance (MODIS and POLDER), Advanced Infra-Red Sounder and Infrared Atmospheric Sounding Interferometer (AIRS and IASI), Special Sensor Microwave Imager and Advanced Microwave Radiometer (SSMI and AMSR), and CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), supported a second revision of the ISCCP products by refining the radiance calibrations and revising the assumed properties of clouds in the retrieval models. In particular, the cloud particle size, phase, and vertical layer structure were revised in both the retrieval and flux calculation models. Increased computer capabilities also allowed switching the processing from the 32-km-sampled to the 8-km-sampled imaging data and creating a pixel-level product that is globally-merged at 0.1° every 3 hr for better tracking of cloud systems. These changes enhanced the usefulness of the ISCCP products for cloud process studies in com-

Founders and facilitators of ISCCP at the 30th anniversary symposium. Clockwise from lower left: Robert A. Schiffer [founder, International Project Manager, National Atmospheric and Space Administration (NASA)/USA], Thomas Vonder Haar [founder, Chairman of Working Group for Radiative Fluxes (WGRF) oversight, representative of the International Radiation Commission (IRC), Colorado State University (CSU)/USA], William B. Rossow [head of the ISCCP Global Processing Center (GPC), 2nd Chairman GEWEX Radiation Panel (GRP) oversight, later Project Manager, NASA/City College of New York (CCNY)/USA], Christian Kummerow (3rd Chairman GRP oversight, CSU/USA), Ehrhard Raschke [founder, representative of IRC, member of WGRF, U. Koln/U. Hamburg/Max Planck Institute (MPI)/Germany]. Not pictured: Garth Paltridge [founder, Commonwealth Scientific and Industrial Research Organization (CSIRO)/Australia], Pierre Morel (founder, Director WCRP Joint Planning Staff, France), Roy Jenne [founder, National Center for Atmospheric Research (NCAR)/USA], Graeme Stephens [1st Chairman GRP oversight, CSU/Jet Propulsion Laboratory/USA].

bination with the newer satellite measurements. In the 2010s, there was also a growing emphasis on extending the length of record for climate studies to provide long-term background context for field experiments and advanced satellite measurements, which usually have limited space-time sampling or coverage. This purpose led to the decision to transition the project to a fully-operational organization to maintain and extend the record. Today, the ISCCP record covers 1983 through 2018, but will soon be extended. Similar action is needed for other global data products to build up a more comprehensive global observing system.

The evolution of the ISCCP concept under GEWEX in the 2000s encompassed the complete role of clouds in the weather and climate variations of the energy and water cycle. The global pixel-level product allows tracking of meteorological systems to directly estimate the bulk cloud process time derivatives for comparison with weather and climate models. Thus far, the ISCCP datasets have been used to quantify (1) the cloud effects on radiative fluxes at 3 hr, 100 km intervals covering the globe for multiple decades, separated by cloud types and weather states and including estimates of vertical profiles in the atmosphere; (2) the cloud properties associated with different kinds of weather systems; (3) the cloud properties associated with differing precipitation rates; and (4) Lagrangian cloud system dynamics for tropical convection, tropical cirrus, subtropical marine stratus, and extratropical cyclones. Ongoing studies using ISCCP products will include the diagnosis of cloud processes on the exchanges of radiative and latent energy and the evolution of cloud properties over the lifecycle of tropical and extratropical storms and during slower atmospheric variations. Together with products from other GEWEX projects [SRB/BSRN, Global Precipitation Climatology Project (GPCP)/Global Precipitation Climatology Center (GPCC), GEWEX Water Vapor Project (GVAP), GEWEX Aerosol Climatology Project (GACP), SEAFLUX, LandFlux] combined into the GEWEX Integrated Product, direct and systematic quantitative estimates could now be made of cloud feedbacks on weather systems and on atmospheric and oceanic variations on scales from intra-seasonal to multi-decadal.

In 2022, a new opportunity exists because all operational weather satellite imagers have (at least) 10 common spectral channels. These extra channels would allow pixel-level retrieval of more cloud microphysical information (particle size and phase), the key to connecting cloud variations with precipitation, and of better information about overlapping cirrus, both of which would improve both the cloud property retrievals and the radiative flux determinations. The increased imaging frequency now common to these satellites would allow a reduction of the time sampling interval to at least 30 min, still with global coverage (with multiple polar orbiters), and allow for better study of the connection of smaller-scale turbulence and cloud properties and better identification of the conditions at precipitation onset. Moreover, the range and coverage of other operational satellite measurements of surface and atmospheric properties, particularly the microwave water vapor sounders (providing below-cloud humidity), are now more extensive and frequent (6 hr sampling intervals). While continuing the current ISCCP to extend the length of a homogenous time record (now 35 years in length), a new project in parallel could be established to collect and process the more extensive observations based on the same operational agency arrangements for ISCCP (in fact, the current project could be just a subset of the expanded project). Available computer power makes such a project feasible with global spatial-temporal sampling intervals of at least 3 km and 30 min, especially with highly modular processing code like that used by ISCCP. New analysis procedures, such as neural-network-based schemes, have been demonstrated that can perform the necessary multichannel retrievals rapidly and with good accuracy. Such a project, called ISCCP-NG, has been proposed.