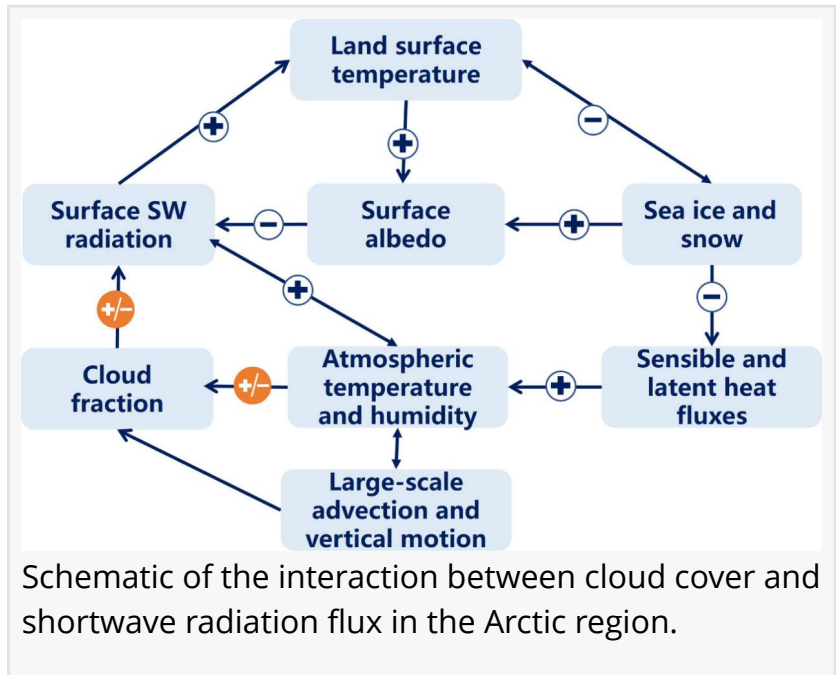


Cloud data gaps obscure Arctic solar energy estimates

GA, UNITED STATES, September 21, 2026 /EINPresswire.com/ -- A review maps uncertainties preventing accurate estimates of the Arctic surface energy budget. Synthesizing satellite, ground-based, and modeling evidence, it shows how disagreements in [cloud fraction](#) alter surface shortwave radiation calculations. The analysis identifies principal causes and proposes coordinated observations, multisensor fusion, and artificial intelligence for more reliable climate assessment.



The Arctic is warming two to three times faster than the global average, while shrinking sea ice and snow are changing surface reflectivity and solar-energy absorption. Clouds can cool the surface by reflecting sunlight or warm it by trapping longwave radiation, making cloud an important control on Arctic amplification. Yet detecting clouds is unusually difficult over bright snow and ice, at high solar zenith angles, and during polar night. Sparse ocean observations, uneven ground stations, inconsistent definitions and retrieval methods complicate comparisons among products. Because of these challenges, deeper research is needed into Arctic cloud fraction and its effects on surface shortwave radiation.

Researchers from the Aerospace Information Research Institute, Henan Academy of Sciences; Wuhan University; and Shandong University of Science and Technology published (DOI: 10.34133/remotesensing.1053) the comprehensive review on June 18, 2026, in Journal of Remote Sensing. The article examines how uncertainty in cloud fraction (CF) affects estimates of surface shortwave radiation (SW) across the Arctic. By comparing observational platforms, retrieval approaches, and validation strategies, it helps clarify a key source of uncertainty in estimates of the Arctic surface radiation budget and provides a scientific basis for improving regional and global climate assessments.

The review finds that Arctic clouds are mainly low-level ice-phase and mixed-phase clouds. Daytime CF generally peaks in September, reaches a minimum in April, and is approximately 12.3% higher over ocean than land. Most available datasets indicate increasing cloudiness, especially during sunlit months and over sea-ice regions, but disagree on trend magnitude, seasonality, and vertical structure. These inconsistencies produce estimated Arctic surface SW differences of roughly 20 to 70 W m⁻². The review's central contribution is an Arctic-wide unified diagnosis across major data products linking these errors to inconsistent definitions, sampling scales, calibration, retrieval algorithms, surface brightness, polar-night conditions, and limited ground-based reference measurements. If these regional and seasonal differences are scaled to the global surface using simple area weighting, they correspond to about 0.7–2.3 times the roughly 2 W m⁻² increase in surface downward thermal radiation over one decade reported in IPCC AR6. This increase is associated with rising greenhouse gas concentrations, including CO₂. Although this calculation provides only an order-of-magnitude spatial comparison, it highlights the potential significance of Arctic CF uncertainty for global radiation-budget and climate assessments.

More than 80% of Arctic clouds occur below 6 km; ice-phase clouds dominate about 55% of the year, and mixed-phase clouds account for 28% of annual cover. Comparisons among 16 satellite-derived cloud datasets show CF discrepancies exceeding 20% in April but remaining below 10% in August. Passive sensors may miss thin clouds or confuse clouds with snow and ice. Active instruments such as the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) improve vertical detection, but cannot sample north of 82°N and have narrow swaths. Sensor, algorithm, calibration, and orbital differences can generate CF errors from a few percentage points to more than 15%. References also disagree: at Barrow, radiation-based estimates aligned more closely with sky-camera observations than a radar–lidar product, although seasonal errors remained. These biases propagate into radiation products; some reanalysis comparisons show monthly Arctic SW deviations above 90 W m⁻², while summer low-cloud errors approach 160 W m⁻².

The authors emphasize that no single observing platform can fully characterize Arctic cloud–radiation interactions alone. They advocate integrating complementary satellite and ground-based observations under consistent definitions, scales, and validation conditions. Such coordination could reduce the risk of platform-induced changes being misinterpreted as climate signals and support more reliable assessments of cloud impacts on Arctic surface radiation and climate change.

This work is a review article, not a new experimental study. The team synthesized published evidence from ground stations, climate models, reanalyses, passive satellite sensors, and active radar and lidar missions. It compared CF characteristics, long-term trends, detection uncertainties, and their propagation into SW estimates. The synthesis included analyses of 16 cloud datasets and products from the Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Very High Resolution Radiometer (AVHRR), CALIPSO, CloudSat, and Clouds and the Earth's Radiant Energy System (CERES) datasets.

Future progress requires denser Arctic observation networks, particularly over oceans and sea-ice margins, alongside coordinated satellite constellations and standardized evaluation protocols. Multisensor fusion and geospatial artificial intelligence (GeoAI) could integrate visible, infrared, microwave, radar, lidar, and environmental data while quantifying uncertainty. Arctic-specific radiative kernels may trace how cloud errors affect energy-budget calculations. Better products would strengthen climate-model evaluation, improve projections of polar amplification and sea-ice change, support environmental monitoring, and provide a firmer basis for understanding global climate and energy dynamics.

DOI

10.34133/remotesensing.1053

Original Source URL

<https://spj.science.org/doi/10.34133/remotesensing.1053>

Funding information

This work was supported by the National Natural Science Foundation of China Grants (No. 42501437 and No. 42571425), the Joint Fund of Henan Province Science and Technology R&D Program (Project No. 245200810087), the Henan Natural Science Grants (No. 252300420853), the High-level Talent Research Start-up Project Funding of Henan Academy of Sciences (Project No. 241825014), the Hubei Natural Science Grants (No. 2025AFD419), and the Key Laboratory of Polar Environment Monitoring and Public Governance (Wuhan University), Ministry of Education (No. 202402).

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