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Global cloud cover: comparison of satellite, model, and volunteer data

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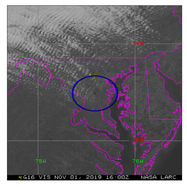
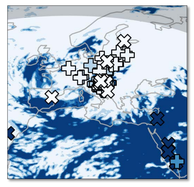
Introduction & Methods

Cloud cover is an important observational parameter that aggregates atmospheric conditions and processes. Here we compare satellite-derived cloud cover from Aqua, Terra, and GOES; modeled cloud cover from the NASA GEOS model; and volunteer-reported cloud cover from the international Global Learning & Observations to Benefit the Environment (GLOBE) Program. The comparison periods are winter (December 2017-January 2018) and summer (June-July 2018). Satellite-matched GLOBE data are provided by NASA Langley. We bin GLOBE data by the GEOS model 1x1-degree grid and analyze for spatiotemporal agreement among the three independent sources of cloud cover information.



GLOBE observation (blue circle) matched to GOES-16 retrieval



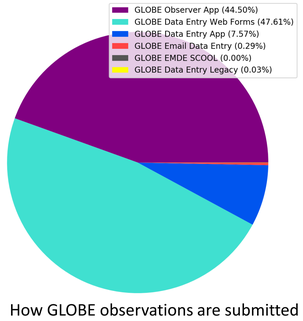
GEOS model cloud cover vs. GLOBE observations

GLOBE participants making a cloud observation

GLOBE data collection

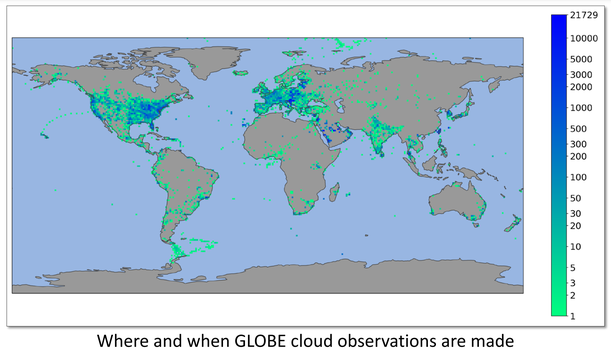
GLOBE participants are trained to collect cloud cover observations following a standardized protocol. Data can be submitted through online or mobile platforms. Most data (48%) are submitted by trained GLOBE students and teachers online. 45% of data is collected and submitted through the NASA GLOBE Observer app, which can be used by anyone in a GLOBE country and is free for iPhone and Android devices.

NASA GLOBE Observer app

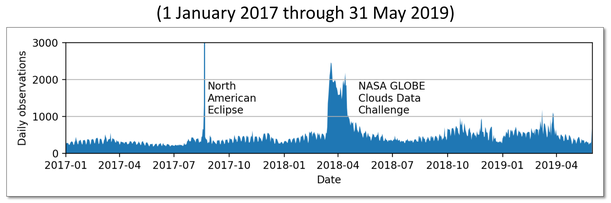


How GLOBE observations are submitted

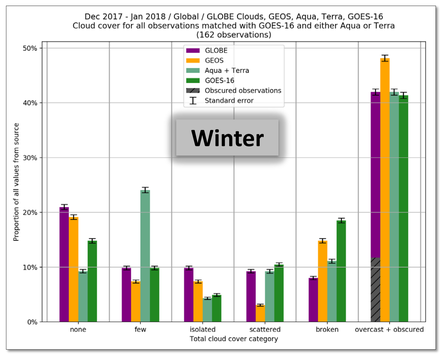
GLOBE cloud data

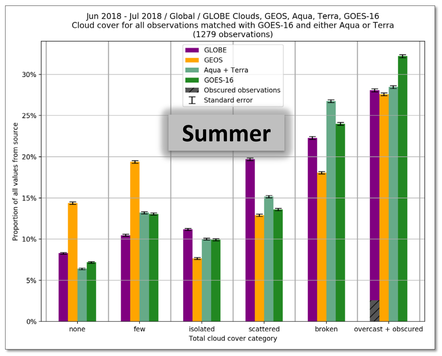


Where and when GLOBE cloud observations are made (1 January 2017 through 31 May 2019)



Satellite, model, and GLOBE cloud fraction





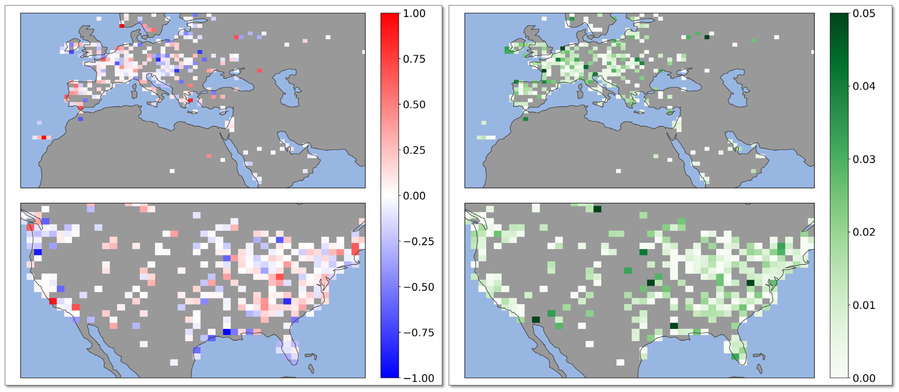
Comparison of satellite (Aqua, Terra, GOES-16), model (GEOS), and volunteer-reported (GLOBE) cloud cover observations made in GOES domain (180°W to 37°W over North America). The driving mechanisms explaining the seasonal differences in disagreement are still being explored. Summertime convection and wintertime mid-latitude cyclones may be important.

Call for observations: dust storms

See a dust storm? Submit your photos with the GLOBE Observer app.

GLOBE has issued an international call for dust storm observations. Anyone in a participating GLOBE country with a smartphone can contribute through the app. Atmospheric dust can pose serious vehicular and human health hazards. In situ ground data is sparse. GLOBE is filling data gaps that can help improve dust modeling, satellite retrievals, and early warning systems.

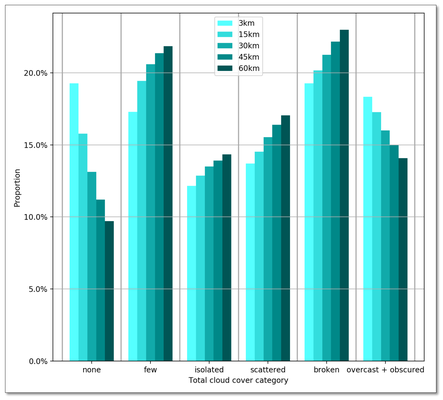
GLOBE – GEOS comparison



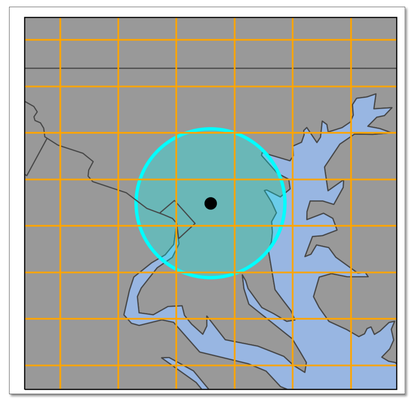
Comparison of GLOBE volunteer-reported cloud cover and GEOS model 1x1-degree output during summer. Left: absolute difference (GLOBE-GEOS). Right: Monte Carlo-derived confidence estimate of the difference.

Reconciling different spatial resolutions

Spatial averaging of satellite data is performed when a GLOBE observation is matched to a satellite. The radius of this averaging may have an impact on the comparison between GLOBE and satellites.



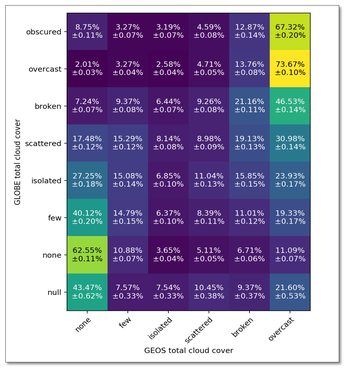
Proportion of hi-res GEOS modeled output within each cloud cover bin for averaging radii varied from 3km to 60km. As areal averaging increases, fewer model values fall into the ”none” and “overcast” cloud cover bins and more values fall into the intermediate bins.



GEOS 1x1-degree grid boxes (orange boxes) are compared with the 40-km radius of averaging for a satellite (cyan circle) centered on a single GLOBE observation taken at NASA Goddard Space Flight Center (black point).

Evidence of systematic bias in obscuration reporting

The GLOBE Cloud Protocol asks the observer to report not just cloud cover, but classify the type of cloud or obscuration in the sky. Obscuration categories include smoke, dust, haze, etc. Comparison with the GEOS and Aqua/Terra suggests approx. 70% of GLOBE observations reported as “obscured” are actually ”overcast”. Since discovering this, (1) informational resources have been posted on globe.gov and (2) we have started emailing volunteers misreporting overcast cloud cover as an obscuration (dust). Revision of the app design is additionally being explored.



Example of overcast skies. Low-lying stratus clouds blanketing Greenbelt, Maryland.

Example of obscured skies. Saharan dust sweeping over the Canary Islands.

Conclusions

Discrepancies between volunteer-reported GLOBE cloud cover observations and modeled GEOS cloud cover are found to be largely seasonally dependent. The comparison suggests localized convection primarily drives the disagreement.

GLOBE is found to have better agreement with Aqua- and Terra-derived cloud cover than GEOS model cloud cover is likely due to more similar resolution and average between the independent data products, and biases in the model cloud physics.

This analysis provides compelling evidence that GLOBE volunteers systematically misidentify overcast cloud conditions as “obscuration” (i.e., smoke or dust). GLOBE has issued a data call for dust storm observations. Methods to mitigate overcast vs. obscuration confusion are being explored, including follow-up emails and posting online educational material.

The coincident GLOBE and Aqua, Terra, GOES-15/16 cloud observations used in this analysis are publicly available. The full 2017-2018 dataset is at: observer.globe.gov/get-data/cloud-data