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Construction of a Matched Global Cloud and Radiance Product from LEO/GEO and EPIC Observations to Estimate Daytime Earth Radiation Budget from DSCOVR

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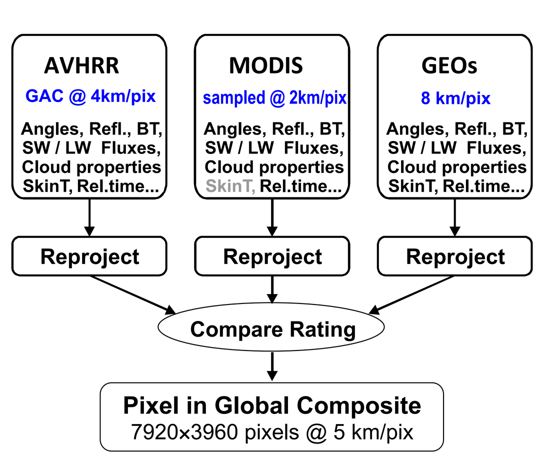
Introduction

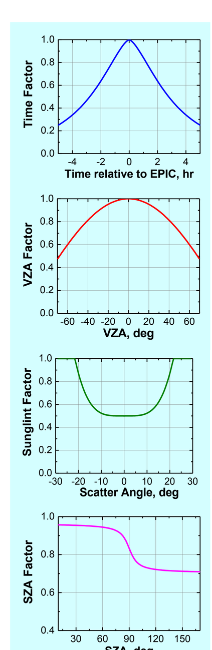
With the launch of the Deep Space Climate Observatory (DSCOVR), new estimates of the daytime Earth radiation budget can be computed from a combination of measurements from the two Earth-observing sensors onboard the spacecraft, the Earth Polychromatic Imaging Camera (EPIC) and the National Institute of Standards and Technology Advanced Radiometer (NISTAR). Although these instruments can provide accurate top-of-atmosphere (TOA) radiance measurements, they lack sufficient resolution to provide details on small-scale surface and cloud properties. Previous studies (e.g. Loeb et al. 2000) have shown that these properties have a strong influence on the anisotropy of the radiation at the TOA, and ignoring such effects can result in large TOA-flux errors. To overcome these effects, high-resolution scene identification is needed for accurate Earth radiation budget estimation.

Global GEO/LEO Composites

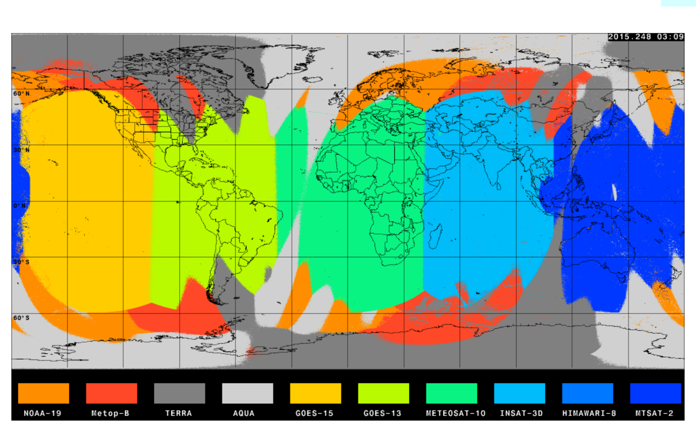
Selected radiance and cloud property data measured and derived from several low earth orbit (LEO, including NASA *Terra* and *Aqua* MODIS, NOAA AVHRR) and geosynchronous (GEO, including GOES (east and west), METEOSAT, INSAT-3D, MTSAT-2, and HIMAWARI-8) satellite imagers were collected at the time of each EPIC image to create 5-km resolution global composites of data necessary to compute angular distribution models (ADM) for reflected shortwave (SW) and longwave (LW) radiation.



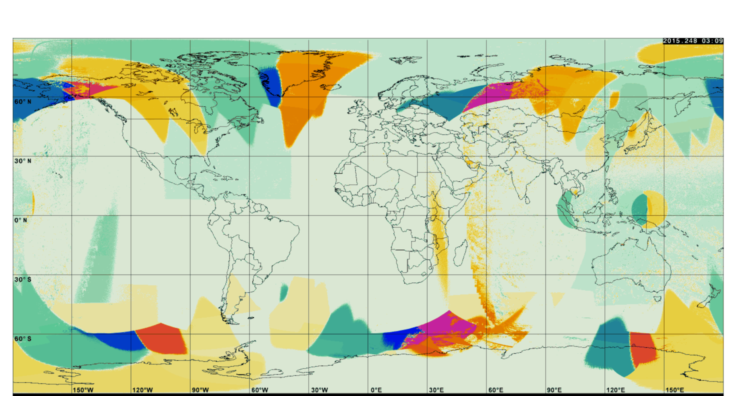
$$\text{Rating} = \begin{bmatrix} 164\,(\textbf{AVHRR}) \\ 188\,(\textbf{MODIS}) \\ 210\,(\textbf{GEOs}) \end{bmatrix} \times \text{Time Factor} \times \text{VZA Factor} \times \text{Sunglint Factor} \times \text{SZA Factor}$$



Selection of satellite data for each 5-km pixel based on numerical rating system computed from five parameters: satellite type, relative time of observation, viewing zenith angle, solar zenith angle, and probability of sun glint.



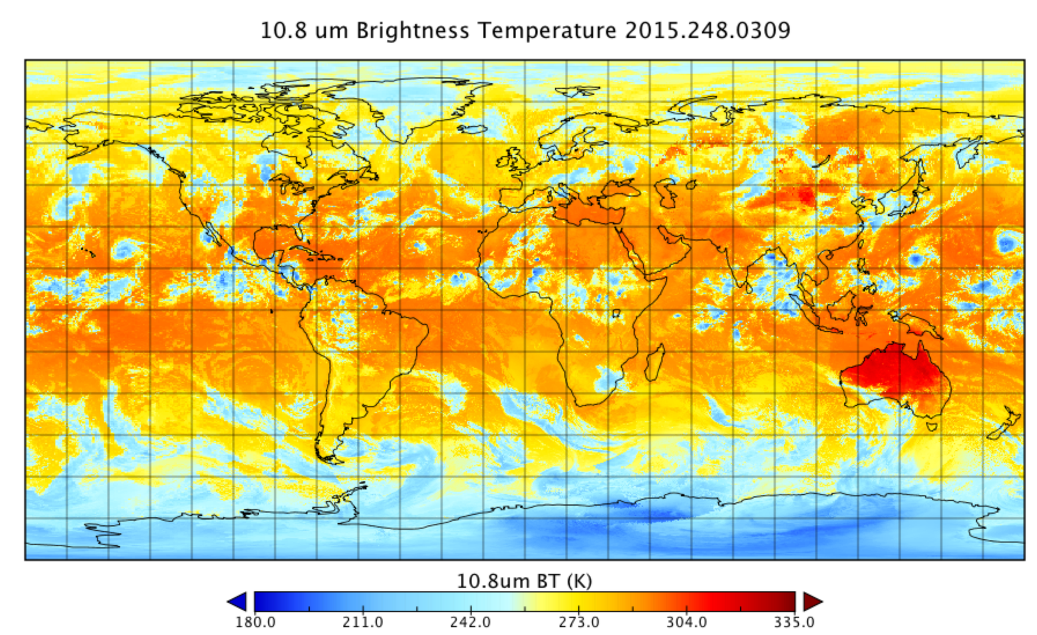
Example of selected satellite data for global composite at 0309 UT on 5 Sep 2015.

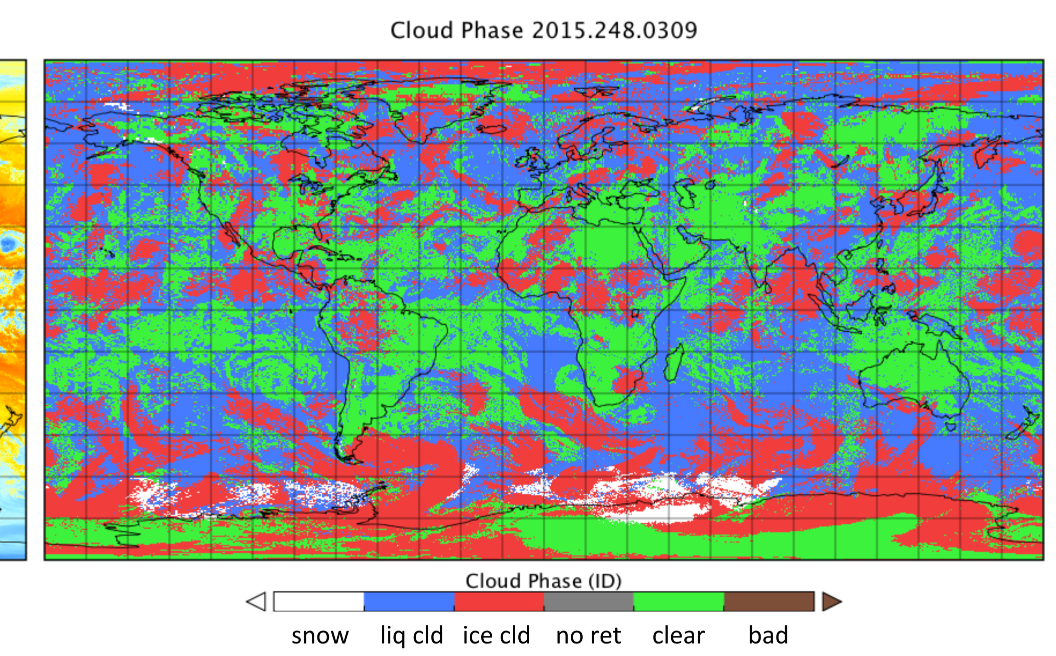


Over 72 percent of satellite scan times in the composite are within 1 h of EPIC reference time

92 percent of scan times are within 2 h of reference time

The global satellite data composites provide an independent source of radiance measurements, cloud properties, and scene identification information necessary to construct ADMs that are used to determine the daytime Earth radiation budget.





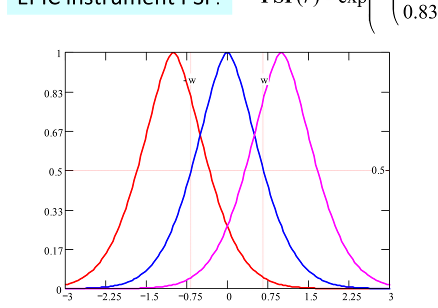
EPIC-view Composites

Cloud and radiance data from the LEO/GEO retrievals within the EPIC fields of view (FOV) are convolved to the EPIC point spread function (PSF) in an analogous manner to the Clouds and the Earth's Radiant Energy System (CERES) Single Scanner Footprint TOA/Surface Fluxes and Clouds (SSF) product, but with a modified procedure to optimize spatial matching between EPIC measurements and the high-resolution composite cloud properties.

Producing EPIC Composites

To optimize PSF calculations, global composite data are re-projected to EPIC-perspective coordinates, and converted to proper physical units, if necessary (e.g. brightness temperature to radiance), to retain accuracy in the PSF averaging. To minimize under-sampling of the global composite data and to improve overall accuracy, the resolution of the EPIC-perspective coordinates is doubled, and nearest-neighbor sampling is used to re-project the composite data to the EPIC-perspective coordinates.

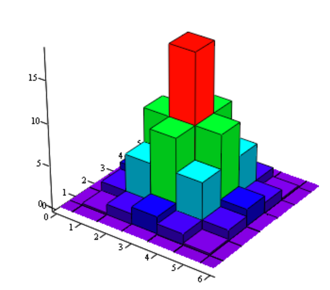
EPIC instrument PSF: $\mathbf{PSF}(r) = \exp\left(-\left(\frac{r}{0.839}\right)^{1.63}\right)$

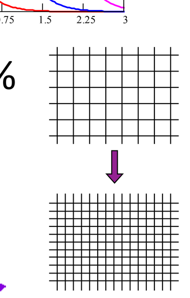


PSF weights, %

0	0	0.01	0.02	0.01	0	0
0	0.05	0.42	0.89	0.42	0.05	0
0.01	0.42	4.55	11.01	4.55	0.42	0.01
0.02	0.89	11.01	30.38	11.01	0.89	0.02
0.01	0.42	4.55	11.01	4.55	0.42	0.01
0	0.05	0.42	0.89	0.42	0.05	0
0	0	0.01	0.02	0.01	0	0

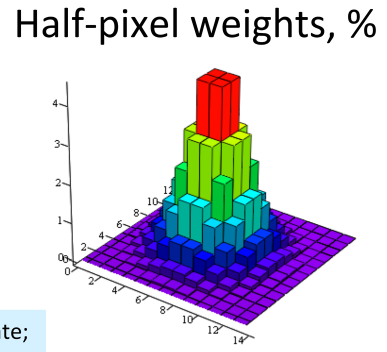
PSF weights, %



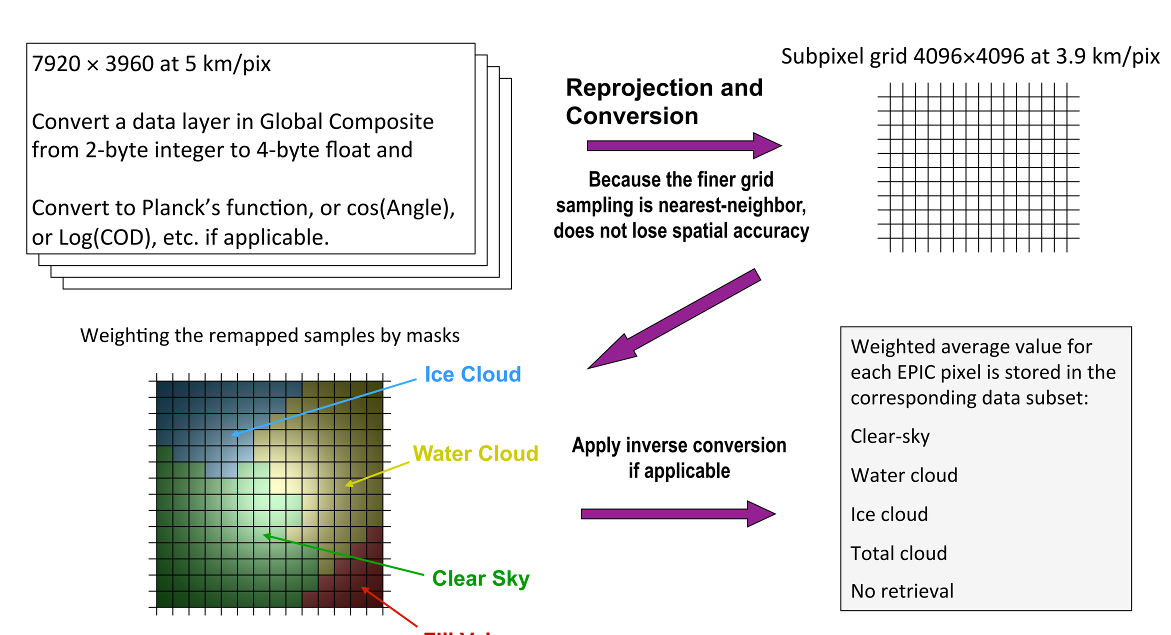


Convert the original EPIC Lat/Lon grid 2048×2048 (at nadir 7.8 km/pix) to Subpixel Lat/Lon 4096×4096 (at nadir 3.9 km/pix)

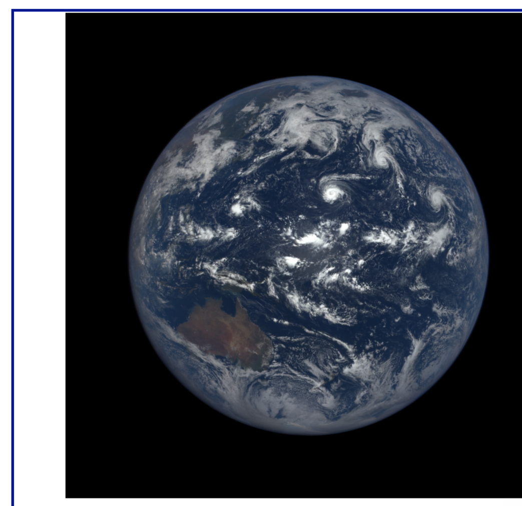
Half-pixel weights, %



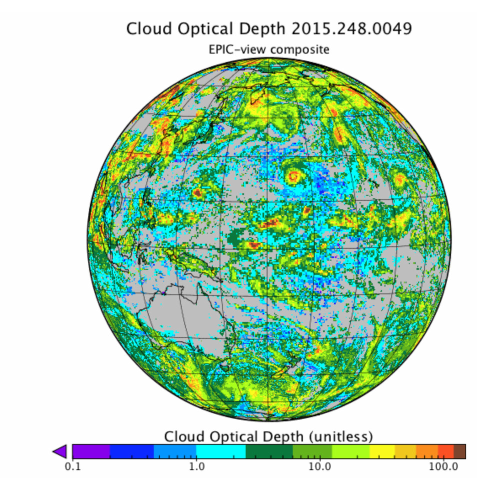
1. Half-pixel weights are more accurate;
2. Subpixel grid preserves spatial resolution of the global composite.



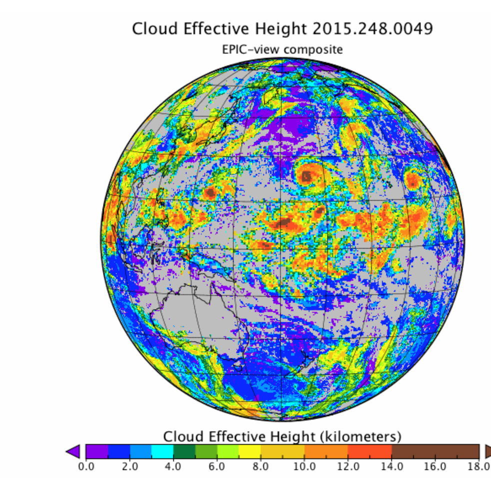
The PSF-weighted average value of each radiance and cloud property parameter is computed for each cloudiness type within every EPIC footprint based on the cloud mask parameter (cloud phase) from the global composite. The weighted values for each parameter are then stored (after any appropriate inverse conversion) within the five available data subsets, as well as surface type fractions within each EPIC footprint.



EPIC RGB Image
5 September 2015 0049 UT



EPIC composite - COD



EPIC composite – Cld. eff. Height

Satellite Radiances and Cloud Properties

The following table summaries the satellite radiance, cloud property, and scene identification data available in the global and EPIC composite data files. Both types of composite data files are stored in standard netCDF-4/HDF-5 format.

	Parameter	AVHRR	MODIS	GEOs	Global Composite	EPIC composite: general	Clear sky	Ice Cloud	Water Cloud	Total Cloud	No retrieval
1	Latitude	Lat	Lat	Lat	1D	2D					
2	Longitude	Lon	Lon	Lon	1D	2D					
3	Solar Zenith Angle	✓	✓	gridded	✓	✓					
4	View Zenith Angle	✓	✓	gridded	✓	✓					
5	Relative Azimuth Angle	✓	✓	gridded	✓	✓					
6	Reflectance in 0.63um	0.63 um	0.63 um	0.65 um	✓		✓	✓	✓	✓	✓
7	Reflectance in 0.86um	0.83 um	0.83 um	—	✓		✓	✓	✓	✓	✓
8	BT in 3.75um	3.75 um	3.75 um	3.9 um	✓		✓	✓	✓	✓	✓
9	BT in 6.75um	—	6.70 um	6.8 um	✓		✓	✓	✓	✓	✓
10	BT in 10.8um	10.8 um	10.8 um	10.8 um	✓		✓	✓	✓	✓	✓
11	BT in 12.0um	12.0 um	11.9 um	12.0*	✓		✓	✓	✓	✓	✓
12	SW Broadband Albedo	✓	✓	✓	✓		✓	✓	✓	✓	✓
13	LW Broadband Flux	✓	✓	✓	✓		✓	✓	✓	✓	✓
14	Cloud Phase	✓	✓	✓	✓		FOV fraction	FOV fraction	FOV fraction	FOV fraction	FOV fraction
15	Cloud Optical Depth	✓	✓	✓	✓			✓	✓	✓	
				·	·	Log(COD)		✓	✓	✓	
16	Cloud Effective Particle Radius	✓	✓	✓	✓			✓	✓	✓	
17	Cloud Effective Height	✓	✓	✓	✓			✓	✓	✓	
18	Cloud Top Height	✓	✓	✓	✓			✓	✓	✓	
19	Cloud Effective Temperature	✓	✓	✓	✓			✓	✓	✓	
20	Cloud Effective Pressure	✓	—	✓	✓			✓	✓	✓	
21	Skin Temperature (retrieved)	✓	—	✓	✓		✓				
22	Snow Map		from IGBP		✓	✓					
23	Surface Type		from IGBP		✓	Surface Types		(4 predominant types per EPIC pixel)			
					·	Surface Type Fraction		(percent coverage)			
24	Time relative to EPIC		± 3.5 hours maximum		✓	✓					
25	Satellite ID				✓	✓					
						Precipitable Water		(from MOA)			
						Skin Temperature		(from MOA)			
						Vertical Temp. Change		SkinTemp − MOA Temp @ 300mB above surface			
						Surface Wind Speed (east-west)			(from MOA)		
						Surface Wind Speed (north-south)			(from MOA)		

* GOES-12,-13, -14, -15 have 13.5 μm band instead of 12.0 μm

The composite data files provide well-characterized and consistent regional and global cloud and surface property datasets covering all time and space scales to match with EPIC. The composites are useful for many applications including

- inter-calibration of non-UV EPIC channels
- provide high-resolution independent scene ID for each EPIC pixel
- convolve with EPIC radiances and CERES ADMs to compute flux from NISTAR radiances
- serve as comparison source for EPIC cloud retrievals
- provide cloud mask for other retrievals based on EPIC radiances

Testing of the composite data is expected to be completed soon, and full-scale production and documentation of the composite dataset will begin shortly. Sample days of global and EPIC-view composites are available for viewing at

http://ceres-iprod.larc.nasa.gov/CERESVis

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References

Loeb, N. G., F. Parol, J.-C. Buriez, and C. Vanbauce, 2000: Top-of- atmosphere albedo estimation from angular distribution models using scene identification from satellite cloud property retrievals. *J. Climate,* **13,** 1269–1285.

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