A CERES-Consistent Long-Term Cloud and Clear Sky Radiation Property Dataset Using AVHRR Observations

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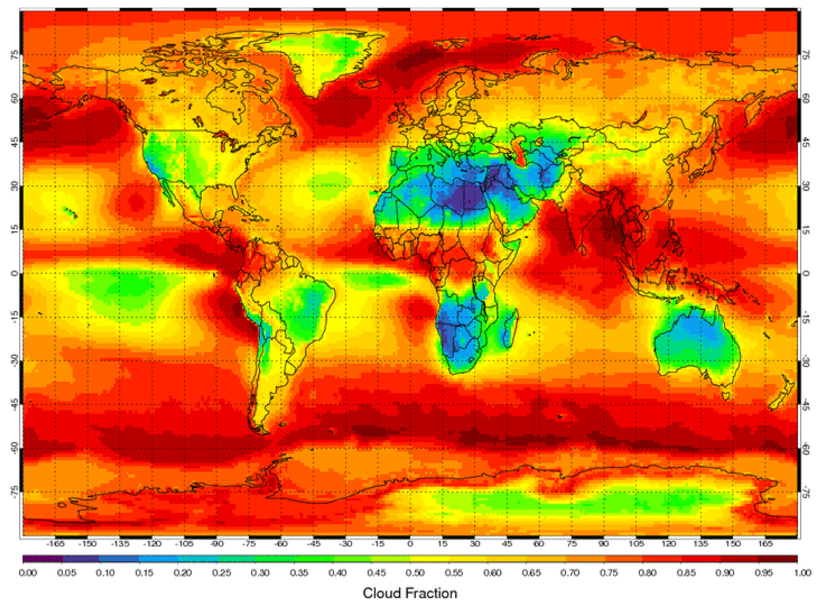
Example CDR Images

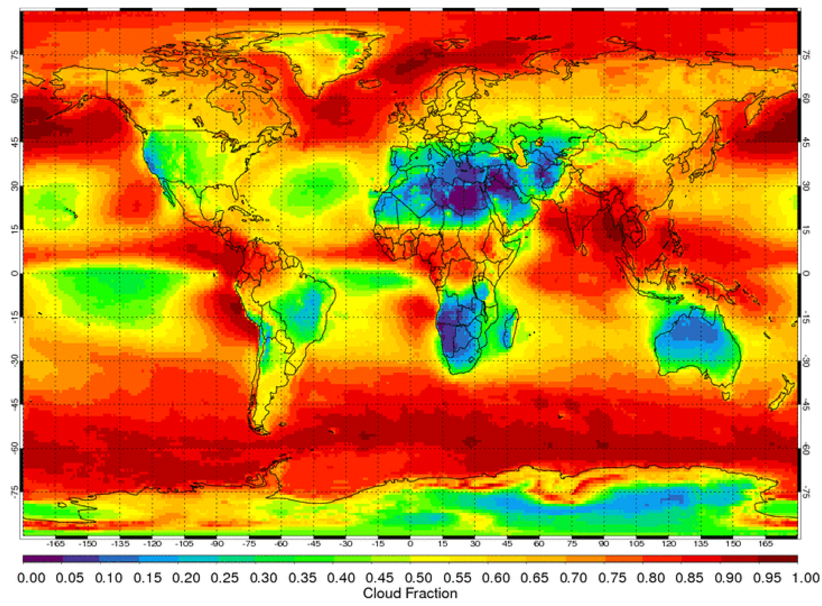
Nominal 5-Channel Imagers: June, July, August 1985-2014, NOAA-09 to -19, ~2 AM/PM Orbits

Gridded Summer Mean Total Cloud Fraction

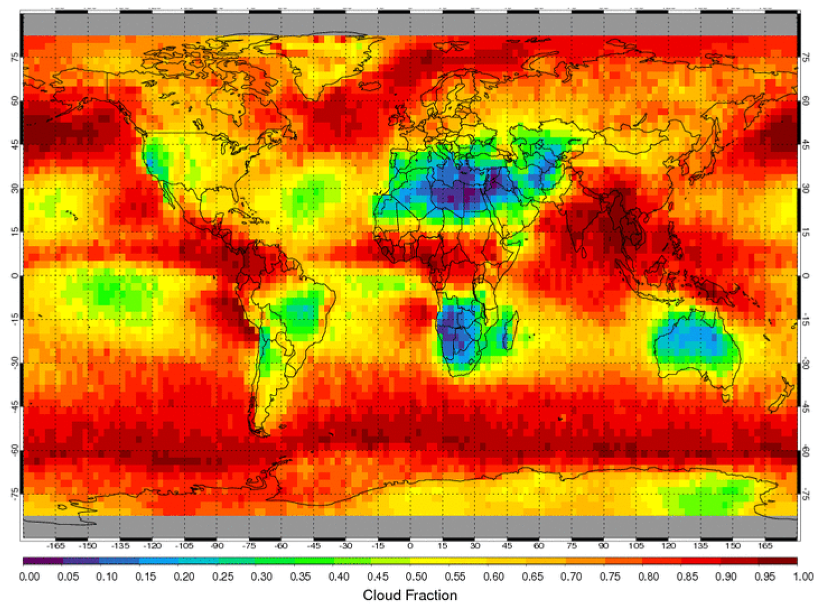
NASA LaRC AVHRR, 1985-2014



NASA LaRC CERES Edition 4 Aqua MODIS: 2002-2011

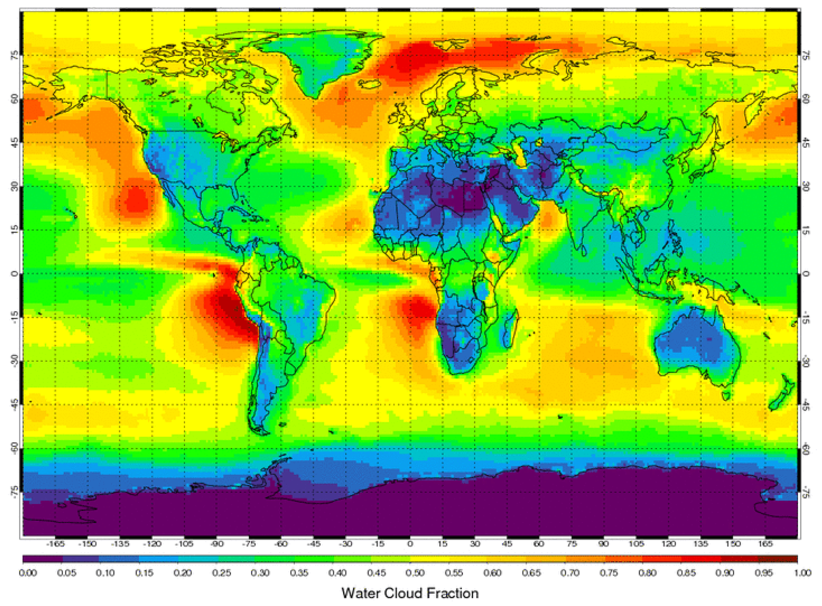


CALIPSO Day & Night Cloud Fraction: 2007-2014

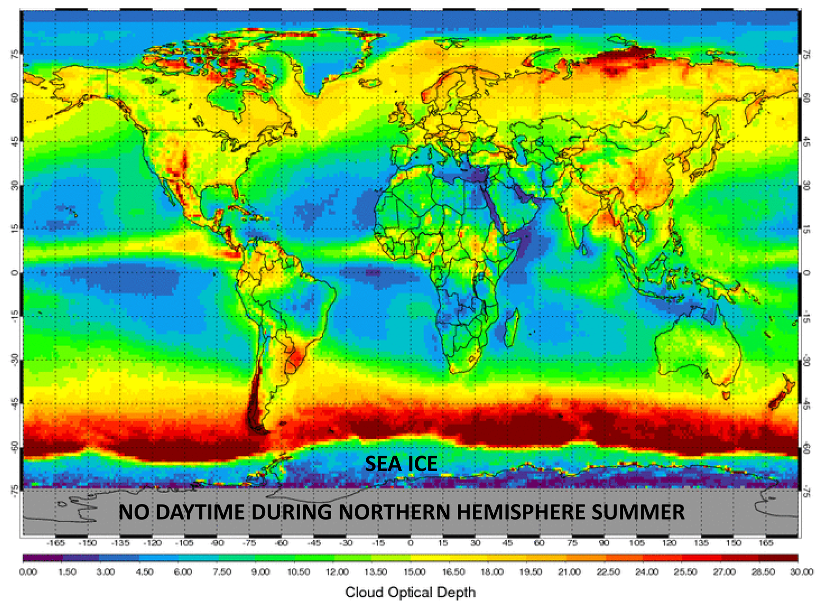


Other Selected Gridded Summer Mean SatCORPS AVHRR CDR Products, 1985-2014

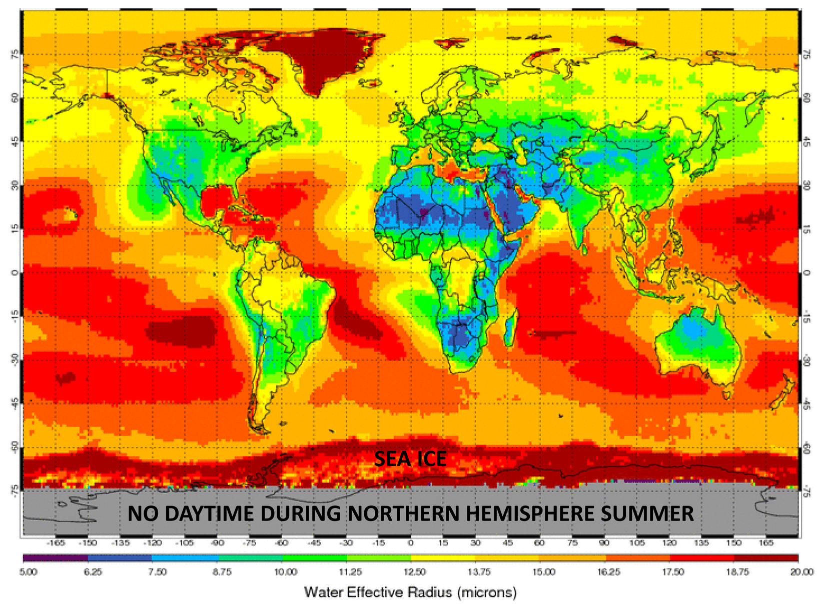
Day and Night Water Cloud Fraction



Day Liquid and Ice Cloud Optical Depth



Day Water Droplet Effective Radius



CDR Description

A TCDR of global 4-km resolution AVHRR Global Area Coverage (GAC) cloud and clear-sky radiation parameters is being produced using the NASA LaRC Satellite ClOud and Radiative Property retrieval System (SatCORPS), which is consistent with the MODIS cloud analyses within the NASA CERES program (Minnis et al. 2011). Calibrated solar reflectances from a companion FCDR are also included in the TCDR output. Auxiliary input includes MERRA surface maps, vertical profiles, and snow/ice maps. 700+ billion AVHRR GAC pixels have been processed thus far, covering afternoon orbits from NOAA-09 to -19 (1985-2014). These products are in original AVHRR swath projection in NetCDF-4 format. The CDR will eventually include NOAA-7 and -15, the 4-channel imager series (TIROS-N, NOAA-6, -8, and -10), and 6-channel imager series (NOAA-16, NOAA-17, MetOp-A and –B) over the next year.

Climate Data Record Products
Calibrated 0.63, 0.86, and 1.61-μm Reflectance
Cloud Mask
Cloud Thermodynamic Phase*
Cloud Optical Depth**
Cloud Liquid Water Droplet or Ice Crystal Effective Radius**
Cloud Effective Pressure, Temperature, and Height
* CDR Quality During Daytime Only
** CDR Quality During Daytime Over Snow/Ice Free Surfaces

Additional Products Included In CDR Output
Cloud Top Pressure, Temperature, and Height
Cloud Base Pressure and Height
Overshooting Convective Cloud Top Pixel Detection
Clear Sky Pixel Skin Temperature
AVHRR/ Aqua CERES-Derived Shortwave Broadband Albedo
AVHRR/ Aqua CERES-Derived Longwave Broadband Flux

CDR Product Validation Using CALIPSO

Cloud Detection

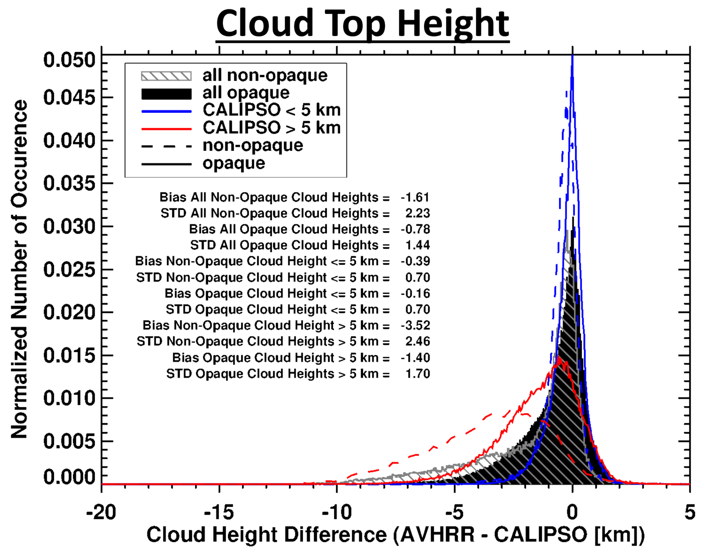
Land Surface Type, Geographic Region, and Time of Day of Comparison	Fraction of Correctly Identified AVHRR Clear and Cloudy Pixels	Number of Matches
DAYTIME (0° ≤ SZA < 82°)		
Land, 60 S – 60 N, No Snow/Ice Cover	0.865	264968
Land, Polar, No Snow/Ice Cover	0.897	28662
Ocean, 60 S – 60 N, No Snow/Ice Cover	0.913	740472
Ocean, Polar, No Snow/Ice Cover	0.953	67945
Land & Ocean, Global, Snow/Ice Covered	0.827	399539
NIGHT (SZA ≥ 82°)		
Land, 60 S – 60 N, No Snow/Ice Cover	0.876	280351
Land, Polar, No Snow/Ice Cover	0.880	23241
Ocean, 60 S – 60 N, No Snow/Ice Cover	0.927	763485
Ocean, Polar, No Snow/Ice Cover	0.961	97717
Land & Ocean, Global, Snow/Ice Covered	0.717	720595

AVHRR and CALIPSO matched within 15 min and 2.5 km of each other for the 2008 seasonal months. AVHRR pixel must be entirely filled with or void of CALIPSO-observed cloud to be considered in this analysis, omitting partially filled pixels. CALIPSO and AVHRR cloud phase must match for cloud top height comparison to ensure that the "same" clouds are being compared, given uncertainties associated with the 15-min match window

Cloud Phase

Land Surface Type, Geographic Region, and Time of Day of Comparison	Fraction Correct	False Alarm Rate For AVHRR Ice Phase Classification	False Alarm Rate For AVHRR Water Phase Classification	Number of Matches
DAYTIME (0° ≤ SZA < 82°)				
Land, 60 S – 60 N, No Snow/Ice Cover	0.893	0.013	0.219	56535
Land, Polar, No Snow/Ice Cover	0.877	0.026	0.175	6418
Ocean, 60 S – 60 N, No Snow/Ice Cover	0.926	0.017	0.100	322785
Ocean, Polar, No Snow/Ice Cover	0.908	0.055	0.099	23529
Land & Ocean, Global, Snow/Ice Covered	0.778	0.150	0.276	74066
NIGHT (SZA ≥ 82°)				
Land, 60 S – 60 N, No Snow/Ice Cover	0.899	0.030	0.265	66437
Land, Polar, No Snow/Ice Cover	0.820	0.110	0.265	5408
Ocean, 60 S – 60 N, No Snow/Ice Cover	0.919	0.089	0.077	331800
Ocean, Polar, No Snow/Ice Cover	0.832	0.289	0.053	29719
Land & Ocean, Global, Snow/Ice Covered	0.874	0.112	0.213	172102

Cloud Top Height

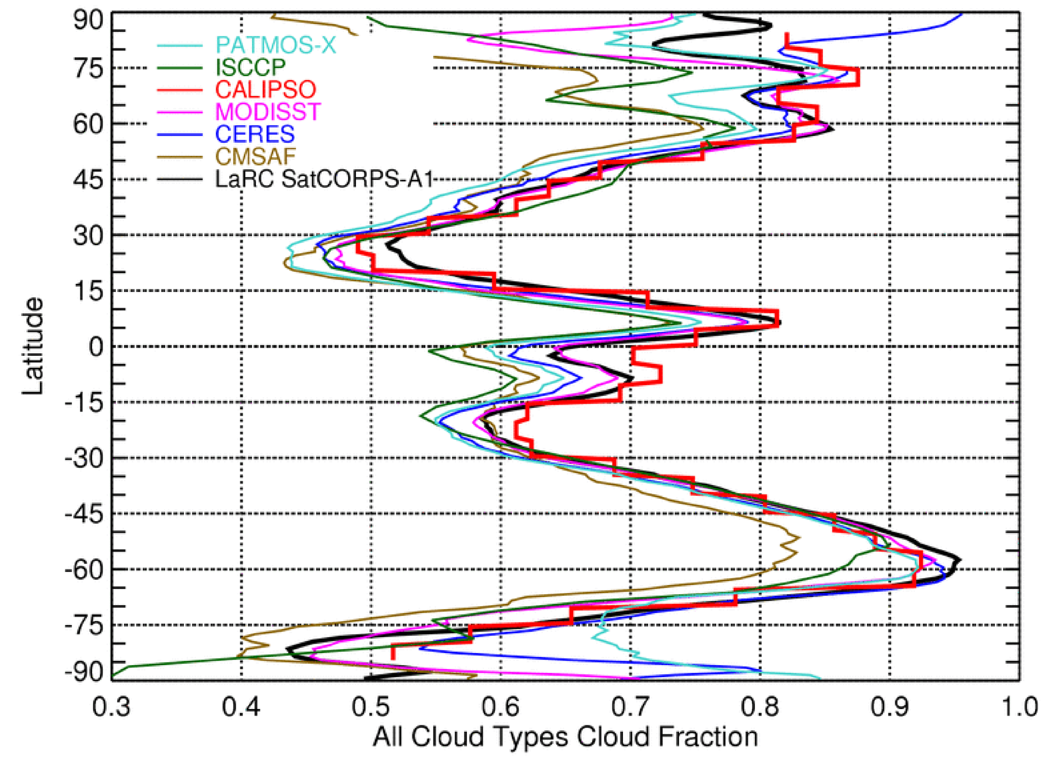


Current Uses and Applications Based on the CDR

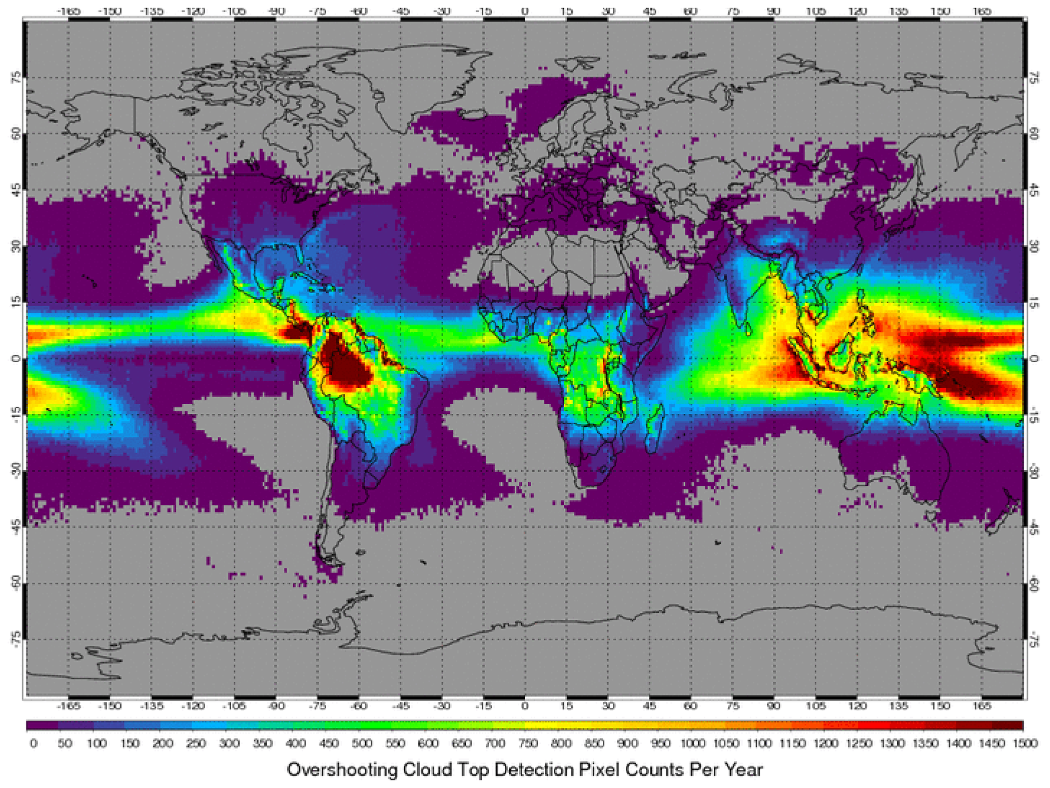
Delivery of the NASA LaRC AVHRR cloud & clear-sky radiation TCDR to NCEI began April 2015. The user community is not yet able to access the TCDR output from an NCEI ordering tool, so current uses and applications are limited to internal activities at LaRC.

- Analysis of daily mean cloud property trends across the AVHRR time series
- Comparison of retrieved monthly and zonal mean cloud properties with those from other global climatologies
- Scene identification for Earth radiation balance studies during ERBE-era (mid-1980's) NOAA-09 and NOAA-10 - Shrestha et al. (*J. Climate*, 2014)
- Development of LEO/GEO global cloud analyses for the NOAA Deep Space Climate Observatory (DSCOVR) Science Team to study daytime Earth radiation balance from the NISTAR radiometer and EPIC imager
- Analysis of regional and seasonal distribution of global tropopause-penetrating convective cloud tops

October 2008 Zonal Mean Day and Night Cloud Fraction Intercomparison



NASA LaRC AVHRR Gridded Overshooting Convective Cloud Top Pixel Detections Per Year, ~2 AM/PM Orbits, 1985-2014



Future Improvements of the CDR and Anticipated Applications

Possible Changes and Improvements

- Intercalibrate IR channels between AVHRRs throughout the 35+ year time series
- Improve low cloud height assignment, especially in the presence of temperature inversions
- Enhance automated overshooting cloud top detection using improved IR and possibly visible channel pattern recognition
- Improve TOA broadband SW and LW fluxes using satellite- and scene- specific SZA and VZA dependent narrowband-to-broadband (BB) radiance fits, employing the latest CERES Angular Distribution Models to convert to BB flux
- Test and possibly employ the NASA MERRA-2 reanalysis
- Enhance dynamic range and quality of cloud optical depths retrieved at night using a neural network approach
- Add multilayer cloud and aerosol optical depth retrievals
- Improve retrievals over snow/ice & cirrus retrievals during day
- Develop a suite of Level 3 products that could include daily, monthly, and zonal means at varying spatial resolution

Anticipated Applications

- Development of high resolution (≤ 0.25°) regional climatologies to examine processes such as:
  1) Urban heat island and trends in surface temperature within urban regions
  2) Impacts of anthropogenic aerosols produced within urban regions on cloud distribution and microphysics,
  3) Effect of land cover changes (i.e. deforestation, urbanization) on cloud characteristics,
  4) Analysis of trends and distribution of deep convective clouds over diurnal cycle and relation to UTLS water vapor & air chemistry
- Validation of climate model & reanalysis determined cloud properties and assimilation of TCDR products in reanalyses
- Identification of regions most favorable for solar energy production
- Development of global hazardous weather risk models by the reinsurance industry