

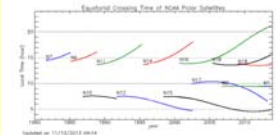
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In climate and Earth energy budget studies, understanding the presence and distribution of clouds is an essential first step. AVHRR measurements comprise the longest record of imager data from a common instrument for remote sensing of cloud and radiation properties. The NASA LaRC AVHRR cloud mask is a global cloud detection algorithm used as part of the Climate Data Record (CDR) project initiated by NOAA's National Climatic Data Center (NCDC). The objective of CDR program is to provide climate information derived from weather satellite data for more than 30 years.

Recent improvements in the LaRC AVHRR cloud mask include detecting more daytime small cumulus and thin Cirrus in tropical oceans, especially over Sun Glint regions, better discrimination between polar clouds and snow ice surfaces including nighttime over Antarctica where $3.7\text{ }\mu\text{m}$ signals are noisy, and enhancement of nighttime ocean thin Cirrus and low clouds detection.

Monthly averaged global and zonal cloud fractions from improved NOAA 18 AVHRR cloud mask compare well with CERES-MODIS Edition 4 (CM Ed4), MODIS team, and CALIPSO cloud mask. Spatially and temporally matched cloud detection statistics between NOAA 18 AVHRR and CALIPSO cloud mask will also be presented.

- **AVHRR observations:**
 - Core channels: 0.63, 0.86, 3.74, 10.8 and 12.0 μm
 - "Classes" of AVHRR data, creates challenges for cloud detection algorithm:
 - **AVHRR new era:** NOAA-15, NOAA-16 (05/2003-present), NOAA-18, NOAA-19 : Core channels but also have NOAA-17, NOAA-9, NOAA-11, NOAA-14: More channels but 3.74 μm has different calibration and poor data quality
 - **AVHRR old days:** NOAA-16 (09/2000 - 04/2003), NOAA-17, MetOp-A, MetOp-B: 1.61/3.74 μm data missing
 - **AVHRR no12:** TIROS-N, NOAA-6, NOAA-8, and NOAA-10: Only 4 channels, no 12.0 μm channel
- Orbit drift throughout instrument lifetime



- NASA MERRA surface skin temperature and atmospheric profiles: to predict TOA 3.7, 11, and 12 μm clear sky temperatures
- Dynamically generated 0.63 μm clear sky overhead albedo maps
- Daily snow and ice maps from the National Snow and Ice Data Center (NSIDC)
- 10° surface emissivity, Water percentage, IGBP ecosystem, and elevation maps

MODIS collection 5 cloud mask

- 5-km cloud layer products
- 333-m Vertical Feature Mask (VFM). 80-km clouds excluded

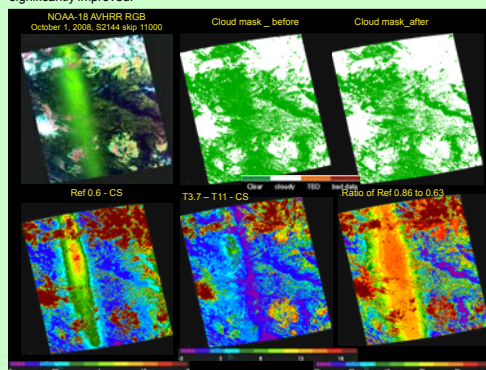
See ATBD for detailed description of AVHRR cloud mask algorithm

Cloud Mask:	Clear Category:
Clear	Strong Clear
Cloudy	Weak Clear
Bad data	Smoke
	Fire
Cloud Category:	
Strong Clouds	Snow
Weak Clouds	Clear glint
Glint Clouds	Shadow
VISST* no retrieval	Aerosol

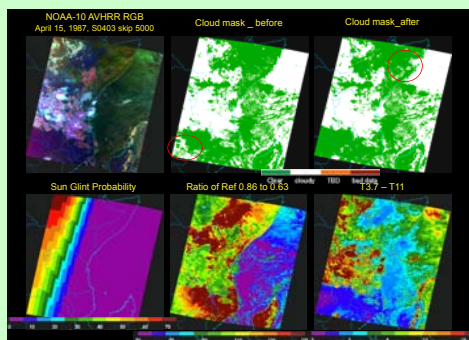
VISST – a cloud property retrieval algorithm

After the initial development of the four classes of AVHRR cloud masks, many daytime and nighttime AVHRR RGB images and cloud mask results from different NOAA satellites were examined. Improvements have been made. Pixel level examples for each of the classes are presented below:

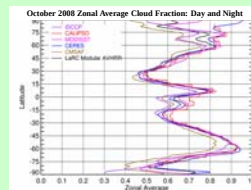
Detecting low clouds in Sun Glint ocean has always been a challenge. In this NOAA-18 case over Pacific Ocean, small and low clouds were initially under-detected, especially in strong Sun Glint region. Fine tuned visible (0.63) and BTd (T3.7-T11) tests, combined with ratio of reflectance 0.86 to 0.63 test. The cloud mask has been significantly improved.



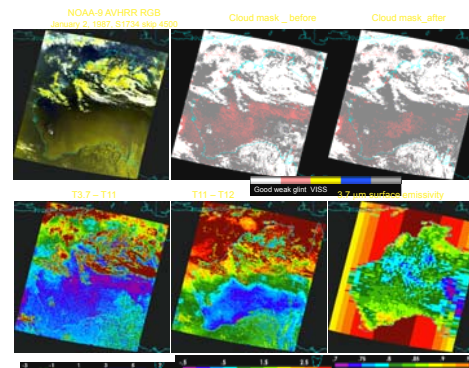
In this NOAA-10 case over East coast of Africa, there were false clouds at the bottom left corner of the image due to Sun glint over land, also some low clouds over African Horn were missed. The land cloud detection tests were adjusted based on Sun Glint probability and the BTd of T3.7 – T11 and ratio of 0.86 and 0.63 tests were added to pick up missed low clouds.



Comparison among CM Ed4, CALIPSO, LaRC AVHRR, ISCCP, MODIS-ST and CMSAF are shown below:



- LaRC AVHRR quite close to CERES MODIS and CALIPSO
- 5-10% uncertainty amongst algorithms common in non-polar regions
- Polar uncertainty much greater



CALIPSO-BASED CLOUD DETECTION VALIDATION: OCTOBER 2008			
Land Surface Type	Average	CERES MODIS	
Geographic Regions, and Time of Day	Fraction of Correct Cloud and Cloudy Pixels	Fraction Correct	(12 Day Average)
DATASET: G-2A - K2			
Land, 40°S - 40°N, No Surface Cover	0.856	0.086	
Land, Polar, No Surface Cover	0.754	0.707	
Ocean, 40°S - 40°N, No Surface Cover	0.877	0.094	
Ocean, Polar, No Surface Cover	0.854	0.062	
Land & Ocean, Global, No Surface Cover	0.854	0.064	
MIST G2A - K2			
Land, 40°S - 40°N, No Surface Cover	0.865	0.073	
Land, Polar, No Surface Cover	0.927	0.878	
Ocean, 40°S - 40°N, No Surface Cover	0.888	0.065	
Ocean, Polar, No Surface Cover	0.857	0.813	
Land & Ocean, Global, No Surface	0.729	0.789	