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AVHRR operational cloud masks intercomparison

CLAVR-x

The Clouds from AVHRR Extended (CLAVR-x) series of algorithms are designed to serve two roles in the NOAA/NESDIS AVHRR processing. First it serves as the first guess cloud mask for other NESDIS applications. Secondly, it provides a full suite of global cloud properties from the AVHRR.

The main characteristics of CLAVR-x are
- The cloud mask reports a 4-level decision - clear, probably clear, probably cloudy and cloudy
- Spatial uniformity tests are used to reduce cloud contamination in clear and cloudy pixels.
- 6 cloud types are produced (fog, water, super-cooled water, opaque ice, cirrus and multi-layer cirrus)
- NWP, SST weekly analyses and a Fast RTM model (PFAST) are used in cloud detection and cloud property estimation.
- 1d var approaches are used for all cloud retrievals
- Cloud temperature and emissivity estimated from a split-window approach.
- Other products include optical depth and particle size.
- Products are available regionally at 1 km and globally at 4 km (pixel) or 55 km (gridded).

Description available on http://cimss.ssec.wisc.edu/clavr

MAIA

The MAIA cloudmask is developed at Météo-France. It is operational at CMS for processing NOAA polar AVHRR data. MAIA V2 is incorporated in EUMETSAT Numerical Weather Prediction SAF AAPP package. MAIA V3 will be used for the operational production of SST at a global scale in the Ocean & Sea Ice SAF and is planned in AAPP6 early 2007 for NOAA and MetOp processing after a MetOp global validation stage. For NOAA, MAIA V3 has been validated to interactive classified targets.
Four products are available:
- Cloud Mask with a confidence flag
- Cloud Type (10 classes)
- Cloud top temperature of opaque clouds
- SST

The main characteristics of MAIA are:
- Grouped thresholding approach
- Dynamic thresholds derived from RTM (through look-up tables)
- Use of ancillary data: SSTand albedo climatologies, Landuse and topography maps, NWP forecast parameters.
- Many different spectral features (single channels and ratios and differences) + texture

Products are available at 1km resolution in the AAPP output format.

Description on http://www.meteorologie.eu.org/ici

PPS

The Polar Platform System (PPS) software package is developed at SMHI in the frame of the EUMETSAT Nowcasting SAF to process data of polar (NOAA/MetOp) platforms in Europe. Four products are available:
- Cloud Mask
- Cloud Type
- Cloud top temperature and height
- Precipitating clouds

The main characteristics of the PPS Cloud Mask and Cloud Type are very similar to those of MAIA.
The version 1.0 of PPS to produce all these four products using locally received HRPT data was released to Eumetsat member (and cooperating) states in june 2004.
PPS is currently run in operational mode at six European Met Services including the Ocean & Sea Ice SAF High Latitude center and the Climate SAF for cloud parameters at high latitudes.
Recently its scope has been widened to the global scale.
It has been validated over Europe by comparing results to interactive classified targets, and using a large database of European Synop reports.

The PPS is coded in Python, C and Fortran (interfacing to AAPP, RTTOV and Grib). The output format is HDF5.

Description on http://www.smhi.se/saf

CLAVR-x – MAIA – PPS intercomparison over European passes

Motivation

Operational satellite cloud classification from AVHRR at Eumetsat has traditionally been limited to 1km locally received HRPT data and from various processing centers around the member states. In contrast, NOAA has focused on global processing of 4 km GAC AVHRR data.

Eumetsat will soon launch MetOp, which will provide the first global 1km data from AVHRR. MetOp also represents a new level of cooperation between NOAA and Eumetsat in terms of data sharing.

The goal of this work is to intercompare the AVHRR cloud algorithms run operationally by NOAA and Eumetsat and to begin a collaboration to jointly improve our ability to estimate cloud properties from the AVHRR.

Data

The intercomparison activity has just started and the present results have been done on 7 scenes:

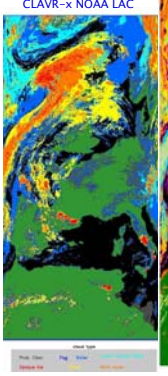
- 6 full daytime NOAA18 HRPT summer scenes acquired simultaneously at Meteo-France/CMS and SMHI and the corresponding NOAA LAC data for 6 different days in July 2006.
- 1 full NOAA17 HRPT winter case from SMHI station and the corresponding NOAA LAC data.

The classification convention is the same for MAIA and PPS but is slightly different in CLAVR-x. To conduct the intercomparison, we made the following assumptions:
- Cloud mask. Clear:
  clear , probably clear (CLAVR-x)
  cloud free sea, land , snow or sea ice covered (MAIA & PPS)
- Low clouds:
  Clouds with pressures greater than 680 hPa (CLAVR-x)
  Very-low, Low opaque clouds ($T_{cloudtop} > T_{700hPa}$), fractional (MAIA & PPS)
- Mid clouds:
  Clouds with pressures between 440 and 680 hPa (CLAVR-x)
  Mid, high opaque clouds ($(T_{500hPa}+T_{tropo}/2) < T_{cloudtop} < T_{700hPa}$), (MAIA & PPS)
- High clouds
  Clouds with pressures less than 440 hPa (CLAVR-x)
  Very high opaque, very thin, thin, thick cirrus, cirrus above others, fractional (MAIA, PPS)

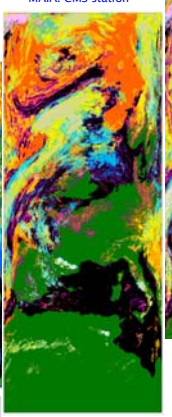
Ex: NOAA18 – 2006-07-01 12:52 UTC

RGB 124

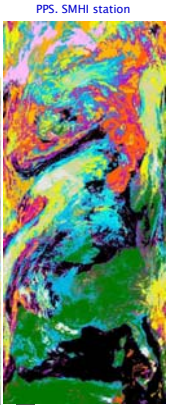
CLAVR-x NOAA LAC

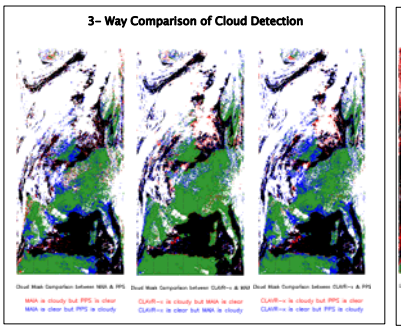


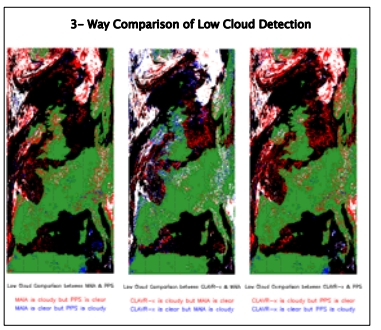
MAIA. CMS station

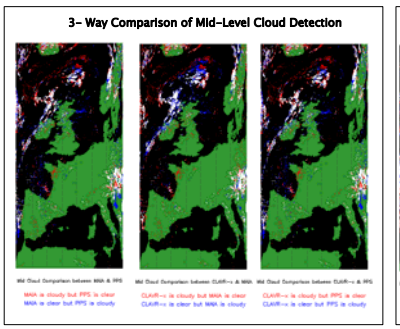


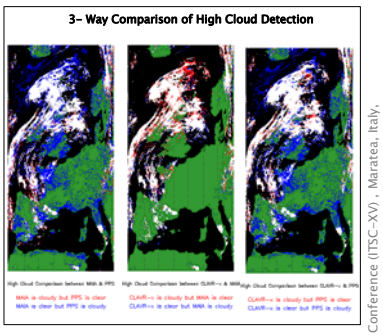
PPS. SMHI station











Statistical agreement over the 7 orbits

Sea. fraction of data = 0.51

Comparisons	M & C	P & C	P & M
cloud mask agreement =	0.922	0.918	0.941
high cloud agreement =	0.929	0.858	0.892
mid cloud agreement =	0.919	0.910	0.932
low cloud agreement =	0.924	0.896	0.929

Land. fraction of data = 0.49

Comparisons	M & C	P & C	P & M
cloud mask agreement =	0.890	0.833	0.836
high cloud agreement =	0.934	0.773	0.779
mid cloud agreement =	0.931	0.928	0.921
low cloud agreement =	0.895	0.920	0.900

Conclusion

- Over water, all three cloud masks agree over 90% of the time
- Over land, all three cloud masks agree over 80% of the time though the agreement between CLAVR-x and MAIA approaches 90%.
- For layered cloud detection the best agreement (93%) is found for high clouds over land between CLAVR-x and MAIA. Here the agreement with PPS falls below 80%.
- Except for high clouds over land, the levels of agreement are quite uniform with all values being around 90%.

The 2006 Internatioanl TOVS Study Conference (ITSC-XV) , Maratea, Italy, October 4-10, 2006

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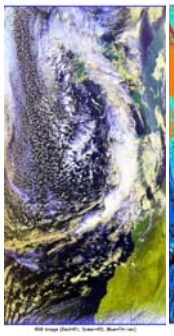
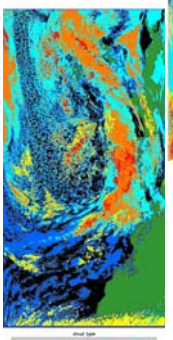
CLAVR-x – MAIA – PPS intercomparison

Ex: NOAA17 – 2006-01-15 11:30 UTC

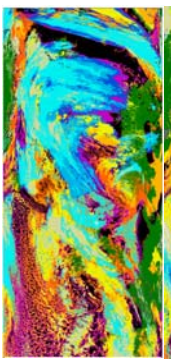
RGB 124



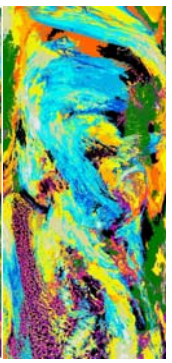
CLAVR-x NOAA LAC



MAIA. CMS station

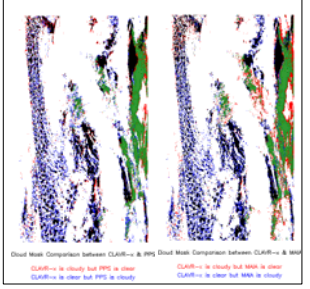


PPS. SMHI station

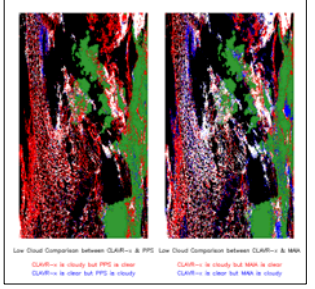


Unprocessed
Cloudfree land
Cloudfree sea
Snow covere
Sea ice
Very low clouds
Low clouds
Medium level clouds
High clouds
Very high clouds
Very thin cirrus
Thin cirrus
Thick cirrus
Cirrus above low/medium
Fractional clouds
Unclassified

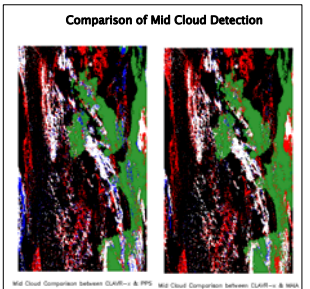
Comparison of Cloud Detection



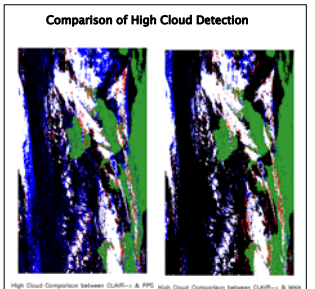
Comparison of Low Cloud Detection



Comparison of Mid Cloud Detection



Comparison of High Cloud Detection



MAIA - PPS comparison and convergence over interactive marine targets

Motivation

As part of the OSI SAF Global Metop/AVHRR SST development a special WP was set up to compare the MAIA and the PPS cloudmasks. Work done before CLAVR-x/MAIA/PPS intercomparison.The aim was to:

- validate and improve when necessay the MAIA cloudmask over sea prior to the implementation in the OSISAF chain.
- secure a general high quality and coherency between the two different schemes.

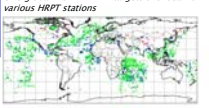
Data

Oceanic datasets with AVHRR training and validation targets interactively collected by experienced nephanalysist and guided by other ground based remote sensing data (cloud radar/lidar):

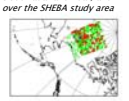
- Training and validation data
  - CMS Global
  - SMHI European
  - SMHI Arctic
- Validation data
  - CMS European
  - CMS Modis
- For visual inspection
  - 6 full HRPT scenes from La Reunion
  - 6 full HRPT scenes from Kangerlussuaq

Cloudy
Clear
Sea-Ice

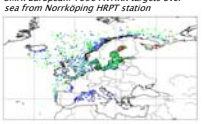
CMS global: 2677 AVHRR targets over sea from various HRPT stations



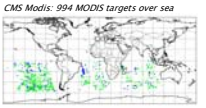
SMHI Arctic: 1798 NOAA LAC AVHRR targets over sea, near Barrow Alaska (ARM site with cloud radar and lidar) and over the SHEBA study area



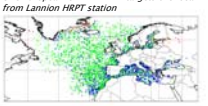
SMHI European: 1656 AVHRR targets over sea from Norrköping HRPT station



CMS Modis: 994 MODIS targets over sea



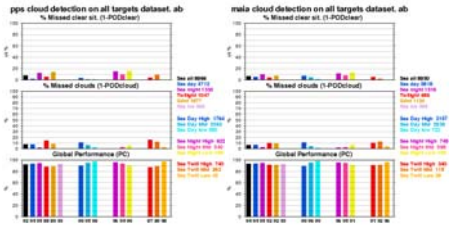
CMS European: 3427 AVHRR targets over sea from Lannion HRPT station

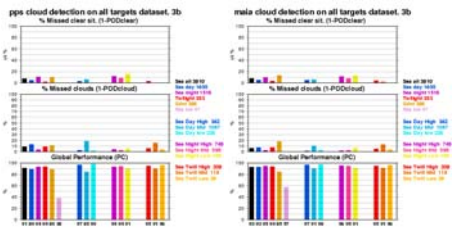


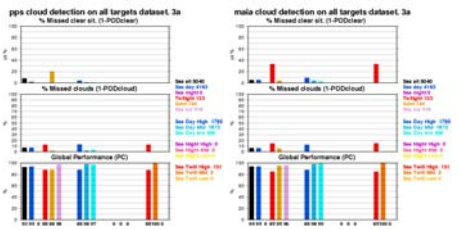
Sun zenith - all targets:

NWP surface temperature - all targets:

Results after updating both MAIA and PPS over sea







Statistical scores

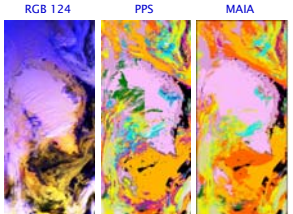
- Hit rate: $PC=(n_a+n_d)/(n_a+n_b+n_c+n_d)$
- Rate of missed cloudy situations: $(1\text{-}POD_{Cloud})=(n_b/(n_a+n_b)$
- Rate of missed clear situations: $(1\text{-}POD_{Clear})=n_c/(n_c+n_d)$

	Cloud detected	Clear detected
Cloud observed	n_a	n_b
Clear observed	n_c	n_d

- MAIA and PPS cloudmasks proved very similar over sea
- Most of the problems identified at the start of this project have been solved for both masks:
  - About 92-94% of clear+cloudy situations are correctly classified
  - Only about 5% of clouds and 5% of clear situations are missed
- MAIA cloud detection slightly more severe compared to PPS
  An additional test exists in MAIA with a relaxed threshold on the local texture -> "marine" cloud mask to allow O&SI to monitor sea surface thermal fronts
- This study pointed to some remaining cloud detection problems over sea:
  - Ice-detection using 3b for both schemes. (But more interactive targets needed.)
  - Semi-transparent cirrus cloud detection over sea ice difficult for both schemes
- The problems related to cloud detction in the polar night not sufficiently challenged with this dataset

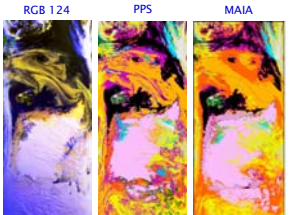
Detailed report on : http://www.osi-saf.org

RGB 124 PPS MAIA



Kangerlussuaq: NOAA 17 2005-05-15 15:00 UTC

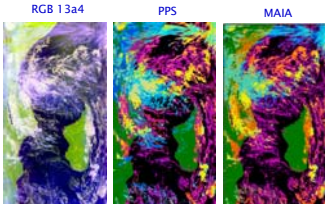
RGB 124 PPS MAIA



Kangerlussuaq: NOAA 16 2005-05-15 15:18 UTC

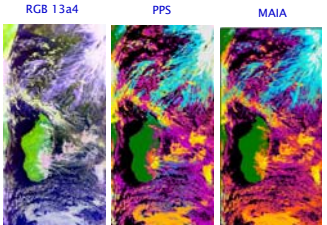
Unprocessed
Cloudfree land
Cloudfree sea
Snow covere
Sea ice
Very low clouds
Low clouds
Medium level clouds
High clouds
Very high clouds
Very thin cirrus
Thin cirrus
Thick cirrus
Cirrus above low/medium
Fractional clouds
Unclassified

RGB 13a4 PPS MAIA



La Réunion: NOAA 17 2005-06-27 07:16 UTC

RGB 13a4 PPS MAIA



La Réunion: NOAA 17 2005-07-07 06:46 UTC

The 2006 International TOVS Study Conference (ITSC-XV) , Maratea, Italy. October 4-10, 2006