Comparison of SEVIRI and POLDER Cloud Products with new space Lidar observation

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1. Data set and period

Three Ways to Observe Cloud Properties

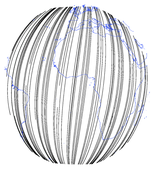
SEVIRI radiometer : 2 visible, 2 near-infrared and 8 thermal-infrared spectral bands.
Cloud types and cloud pressures provided by the SAF-NWC at pixel scale (Derrien and Legleau, 2005) .

POLDER (POLarisation and Directionality of the Earth's Reflectances) on board the ADEOS2 platform: multi-spectral (8 solar spectral bands), multi-polarization, multi-directional (up to 14 different viewing angles) capabilities.
Cloud amount, cloud phase, cloud pressure, etc ..... at 20km scale (Parol et al., 2004).

GLAS (Geoscience Laser Altimeter System) on board the ICESAT (Cloud and Land Elevation Satellite) platform
532nm and 1064nm altimetry channels.
Cloud layer and aerosol vertical profiles, cloud optical Thickness at 7km scale (Spinhirne et al., 2005).

Cloud property compared in this study :
cloud pressure and cloud types

The GLAS data set



14 days in October 2003
86 orbits projected on the SEVIRI grid
GLAS overpass time :
7:30 and 19:30 local time
For each 7km-pixel along the track, using GLA11 product version 26:
•number of detected cloud layers,
•top and base altitudes of the cloud layer, optical thickness for thin layer (not used here)
•observation of surface echo : yes/no

Classification of GLAS cloudy column in cloud type: 3 criteria
•altitude: level of the top of the highest layer (vertical column divided in 10 levels of pressure)
•opaque or thin: use of the ground signal flag
•single or multi-layer:
single layer : one or several cloud layers at the same level
multi-layer: two cloud layers or more at different levels

The SEVIRI data set

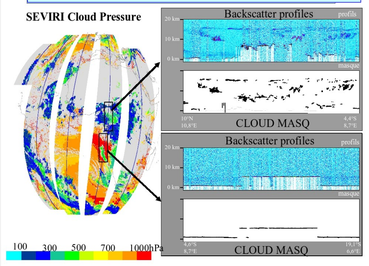
The SEVIRI SAFNWC cloud type and cloud pressure products (version 1.2) are obtained every 15' allowing for a difference in observing time between SEVIRI and GLAS data and SEVIRI and POLDER data smaller than 7.5'. Cloud types are: clear, partial, very low, low, middle, thick high, very thick high, very thin cirrus, thin cirrus, cirrus, cirrus over dense clouds

The POLDER data set

Cloud pressure measurements from POLDER2 (Parol et al. 2004) available for the same period but at a different overpass time (1030 local time) are projected on the SEVIRI grid.Two cloud pressures are derived from POLDER measurements. The first one, the Rayleigh pressure, is derived from spectral polarization measurements. The second one, the oxygen pressure, is derived from the absorption measurements in the oxygen A-band (Vanbauce et al, 1998). Due to increase of path length by scattering the oxygen pressure is expected to represent an intermediate level between cloud top and base. SEVIRI cloud top pressure is derived from CO_2 slicing and/or thermal infrared and water vapor channels.

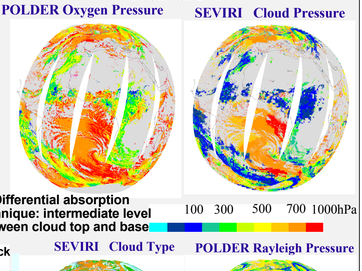
10 October 2003

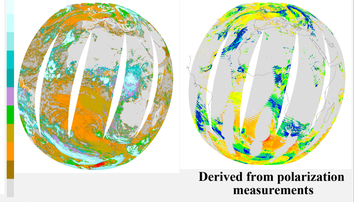
An example of coincident GLAS and SEVIRI data



Coincident POLDER2 and SEVIRI data

10 October 2003





2. GLAS and SEVIRI main cloud type classification comparison:

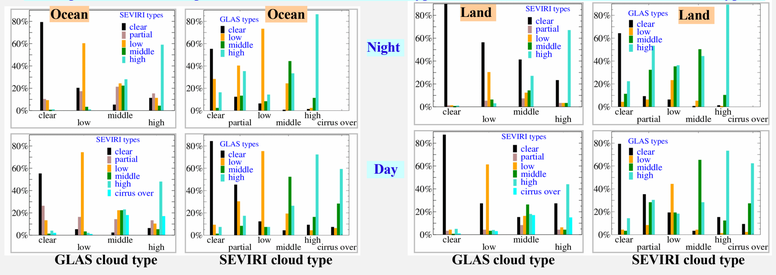
for ocean, land, night and day cases

GLAS cloud types are gathered in 4 main types according to the level of the highest cloud layer.
The 11 SEVIRI cloud classes are gathered in 6 cloud types. The cirrus over class is available only for daytime cases.
GLAS and SEVIRI low cloud frequencies are close. At night, the SEVIRI high cloud frequency is 12% smaller than the GLAS high cloud frequency. The middle clouds are less frequent in the SEVIRI data set than in the GLAS one. 60% of the GLAS high clouds are also classified high cloud by SEVIRI. On the opposite, the SEVIRI high clouds are classified as high clouds by GLAS in more than 70% of the cases.

		Clear	Partial	Low	Middle	High	Cirrus over
Night	ocean	18%/26%	15%	37%/30%	9%/5%	36%/24%	
	land	34%/52%	3%	3%/5%	13%/4%	49%/37%	
Day	ocean	31%/21%		35%/34%	11%/5%	23%/16%	7%
	land	51%/56%	18%/4%	7%/10%	12%/5%	20%/19%	7%

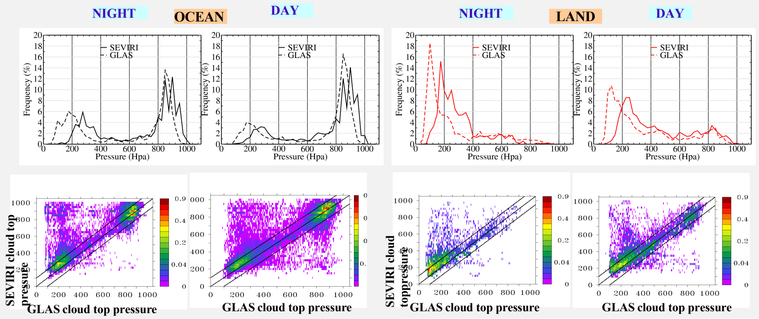
SEVIRI and GLAS cloud class frequency over ocean, land, for night and day

Comparison at SEVIRI pixel scale: GLAS/SEVIRI cloud type distribution for each SEVIRI/GLAS cloud type



3. GLAS and SEVIRI cloud pressure mono and bidimensional distributions

for ocean, land, night and day cases



The GLAS and SEVIRI distribution shapes are similar over land as well as over ocean: a large peak at high pressure level a smaller peak at low pressure level over ocean, a large peak at low pressure level over land. This peak is smaller in the daytime distributions than in the nighttime distributions It is linked to convection cycle over land

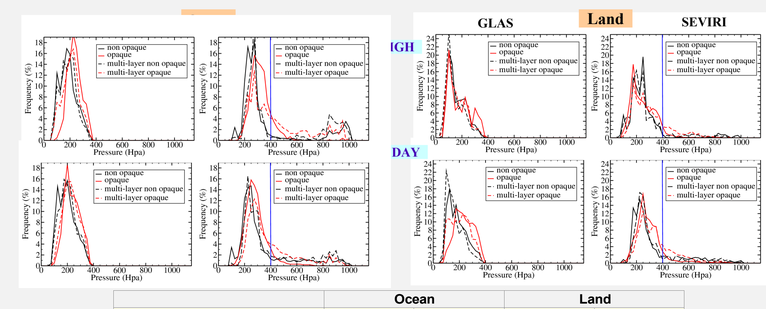
Higher pressure levels are observed in the SEVIRI distribution. The bi-dimensional histograms show that at night the SEVIRI pressure is rarely smaller than the GLAS pressure. The average difference between SEVIRI and GLAS pressure is smaller for the day time data.

	Ocean		Land	
	Night	Day	Night	Day
	102/210hPa	41/155hPa	89/153hPa	50/159hPa

Mean and RMS of (SEVIRI-GLAS) cloud top pressure differences

4. GLAS and SEVIRI Cloud top distributions as a function of GLAS high cloud type

for ocean, land, night and day cases and GLAS cloud top below 400hPa



	Ocean		Land	
	Night	Day	Night	Day
All GLAS high clouds	186/292hPa	121/210hPa	108/159hPa	101/176hPa
High opaque mono layer clouds	78/108hPa	47/88hPa	61/81hPa	45/104hPa

Mean and RMS of (SEVIRI-GLAS) cloud top pressure differences

The shapes of the SEVIRI and GLAS distributions change in the same way as the GLAS cloud type changes. The largest discrepancy between GLAS and SEVIRI is found at night over ocean, for the non opaque and/or multi-layered cases. The SEVIRI and GLAS cloud pressure differences are smaller over land than over ocean. Over ocean, these differences are smaller for daytime data.

5. SEVIRI Cloud top distributions as a function of GLAS low cloud top pressure

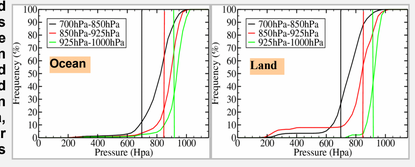
over ocean and land for the opaque single layer GLAS classes

	Ocean		Land	
	Night	Day	Night	Day
all low clouds	21/78hPa	-6/106hPa	-43/120hPa	-47/147hPa
op. s. layer low cld.	12/68hPa	-8/106hPa	-49/112hPa	-59/155hPa

Mean and RMS of (SEVIRI-GLAS) cloud top pressure differences for all GLAS low clouds and for opaque single layer low cloud

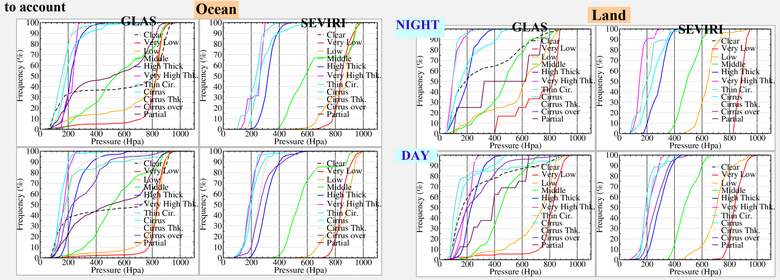
Over the ocean the average difference between SEVIRI and GLAS cloud top pressure is small. The sign change in the bias from night to day data must be investigated. Over land, the SEVIRI pressure levels compared to the GLAS ones are higher in the atmosphere. The curves of the SEVIRI cumulated cloud pressure distributions for the 3 classes of GLAS low level and opaque single layer cloud type with cloud pressure between 700hPa and 850hPa, 850hPa and 925hPa, 925hPa and 1000hPa, are in the expected order on the pressure frequency plots. Over ocean, the percentage of SEVIRI pressure lower than 600hPa is smal, this is not the case over land.

Cumulated SEVIRI cloud pressure distribution for the 3 low level and opaque single layer GLAS classes



6. Cloud top cumulated distributions as a function of SEVIRI cloud type

for ocean, land, night and day cases – only pixels with a 3x3 pixel neighbouring in the same class are taken in to account



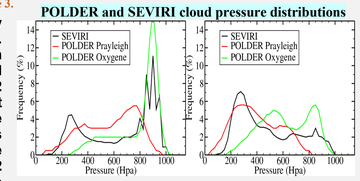
On the plots of the GLAS cloud pressure cumulated distributions for each SEVIRI class, the mid-level cloud curve does not show a well marked pressure level. This points out the well known difficulty to detect correctly this type of cloud with passive infrared, CO2 or water vapor measurements. In section 2, the plots of the distribution for each SEVIRI cloud type of the main GLAS cloud types show that the SEVIRI mid-level cloud class corresponds to a mixing of the 3 GLAS main cloud types. The very low cloud class for SEVIRI corresponds to GLAS low cloud in more than 90% of the case, excepted over daytime land. As also shown on the plots of section 2 over ocean, the clear or partially covered SEVIRI cases that are detected as cloudy by GLAS belong to high level or low level cloud classes for GLAS. Over land, the fraction of low pressure level clouds for GLAS is larger for clear or partially covered SEVIRI cases.

As well as for daytime than night-time and over land or ocean and for the 6 SEVIRI high level classes, 80% of the GLAS cloud pressure is below 400hPa, excepted over ocean for the difficult case of cirrus above another cloud layer. The distribution curve obtain for the SEVIRI thin cirrus is less satisfactory for the day data set than those at night. Over ocean and at night, the SEVIRI high clouds correspond to GLAS cloud pressure smaller than 300hPa in more than 90% of the cases. Among all SEVIRI high cloud class it is the very high and thick cloud class for which the GLAS and SEVIRI cloud top pressure distribution are the closest.

7. POLDER2 and SEVIRI cloud pressure distribution comparison

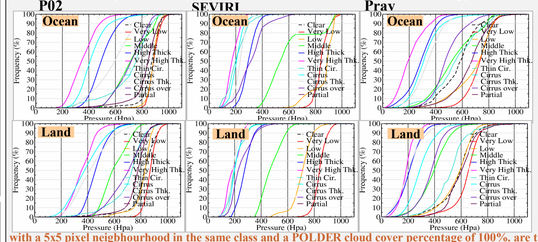
The POLDER pressures are available only for cases with an optical thickness above 3.

The shape of the SEVIRI cloud pressure distribution is very close from those used for the GLAS-SEVIRI comparison (cf. section 3). The large peak in the high pressure over ocean associated with the large low cloud frequency is well represented in the Oxygen pressure (P02) distribution. The 2 sub peaks observed in the SEVIRI distributions are not present in the GLAS distribution nor in the PO2 distributions. These secondary peaks could be due to the method used to process the data in case of temperature profile inversion in the SAFNWC algorithm. As expected (cf section 1), the PO2 pressure distribution do not reach the very low pressure associated to the highest cloud top. Over land the SEVIRI distribution peak in the low pressure values is shifted toward larger pressure values. The Rayleigh pressure (Pray) distribution shape shows three striking features: very low pressure, a shifted peak in the high pressure values toward lower pressure and no cloud above 850hPa over land .



The plots of the cloud top cumulated distributions as a function of SEVIRI cloud type show that over ocean, the cases with very small values of Pray belong to the SEVIRI very thick and high cloud class. Surprisingly, over land, those cases belong to the three types of high thick cloud. The organization from the low pressure to the high pressure of the Po2 and Pray cumulated distribution curves for the thick very high, thick high, middle and low cloud corresponds to that is expected.In spite of the optical thickness threshold (3 in the POLDER scheme) the Po2 and Pray curves for the thin cirrus class are mainly in the pressure part of the plots above 400hPa. The cirrus over class curve in the Pray plots is close from the middle level cloud curve. In the Po2 plots, that curve is closer from low cloud curves.

Cloud top cumulated distributions as a function of SEVIRI cloud type



with a 5x5 pixel neighbourhood in the same class and a POLDER cloud cover percentage of 100%. are taken into account

8. Conclusions and Perspectives

For 86 orbits in October 2003, coincident GLAS and SEVIRI cloud top pressure and cloud type have been compared. As well as over ocean than land and for day and night cases, the shapes of the GLAS and SEVIRI cloud top pressure distributions are similar. On the average, the cloud pressure are larger for SEVIRI than for GLAS.

30% to 40% of GLAS high clouds, in particular the non opaque or multi-layered cases, are classified clear, partially covered, low or middle in the SEVIRI classification. GLAS middle level clouds are distributed in all the cloud layer in the SEVIRI classification. For all the SEVIRI high and cirrus cloud classes, in more than 80%, a high cloud layer is detected in the GLAS data set. It is for the low cloud over ocean that the best agreement is found between SEVIRI and GLAS classifications.

For the same period, POLDER Rayleigh and Oxygen cloud pressure distribution have been compared to the SEVIRI ones. The global shape of the Pray and PO2 are distinct from each other and also differ from the SEVIRI ones. The PO2 cloud distribution is in agreement with that expected. The PO2 indicates some intermediate level between cloud top and cloud base. The same analysis of the cloud top pressure distributions as a function of the SEVIRI cloud type as the one applied to the GLAS SEVIRI comparison has been undertaken. It was found that the PO2 and the Pray cumulated distributions in particular for the thin cloud class show a distinct behavior from those of SEVIRI.

This work will be continued on a larger ensemble of cloud observations from SEVIRI, CALIOP(CALIPSO) and PARASOL over several months.