THE LAND-SAF SURFACE ALBEDO AND DOWNWELLING SHORTWAVE RADIATION FLUX PRODUCTS

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ABSTRACT

In this contribution we give a short overview of the status of the surface albedo and down-welling short-wave radiation flux products which are developed by Météo-France in the framework of the Satellite Application Facility on Land Surface Analysis (Land-SAF). Both products are based on the 0.6µm, 0.8µm, and 1.6µm channels of the Meteosat/SEVIRI instrument and are calculated and distributed in near real time. The methodology is briefly described, product examples are shown, and first validation results are discussed.

1. INTRODUCTION

The Satellite Application Facility on Land Surface Analysis is coordinated by the Portuguese Meteorological Institute based in Lisbon. Its objective is to provide value added products for the meteorological, climatological, and environmental science communities. The project entered the Initial Operational Phase at the beginning of the year 2005. Since then Meteosat Second Generation data are routinely processed by the Land-SAF operational system on a near real time basis. In the current project phase the products to be delivered comprise the land surface albedo, land surface temperature, short-wave and long-wave down-welling fluxes, snow cover, leaf area index and the fraction of vegetation cover.

2. DOWN-WELLING SURFACE SHORT-WAVE RADIATION FLUX

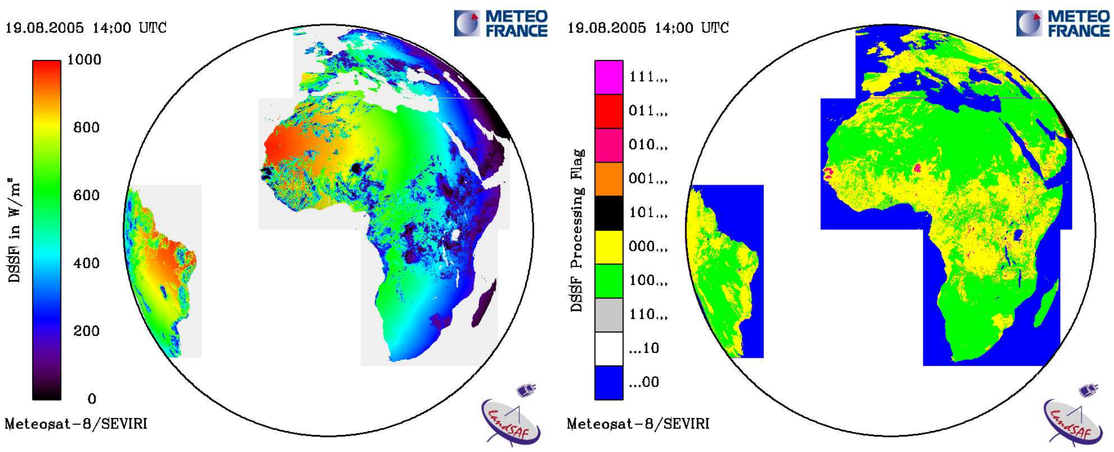
The down-welling surface short-wave radiation flux (DSSF) refers to the radiative energy in the wavelength interval [0.3µm, 4.0µm] reaching the Earth's surface per time and surface unit. It essentially depends on the solar zenith angle, on cloud coverage, and to a lesser extent on atmospheric absorption and surface albedo.

Methodology

The method for the retrieval of DSSF that is implemented in the Land-SAF system largely follows previous developments achieved at Météo-France in the framework of the SAF on Ocean & Sea-Ice (Brisson et al., 1999; Ocean & Sea Ice SAF, 2002). Separate algorithms are applied for clear sky and cloudy sky situations based on the information provided by the Nowcasting-SAF cloud mask product. In the presence of clouds the down-welling radiation reaching the ground is considerably reduced. The brighter the clouds appear on the satellite images, the more radiation is reflected by them and the less radiation reaches the surface. In this case the top-of-atmosphere albedo is first calculated from the observed directional reflectance values by applying a broadband conversion and an angular dependence model. It then serves as the most important input information for a simple physical parameterisation of the radiation transfer in the cloud-atmosphere-surface system. In the clear sky case the DSSF estimate is directly determined with a parameterisation for the effective transmittance of the atmosphere as a function of the concentration of atmospheric constituents. Dynamic information on the water vapour content comes from the ECMWF numerical weather prediction model and climatologic values are used for ozone concentration and aerosol properties.

Results

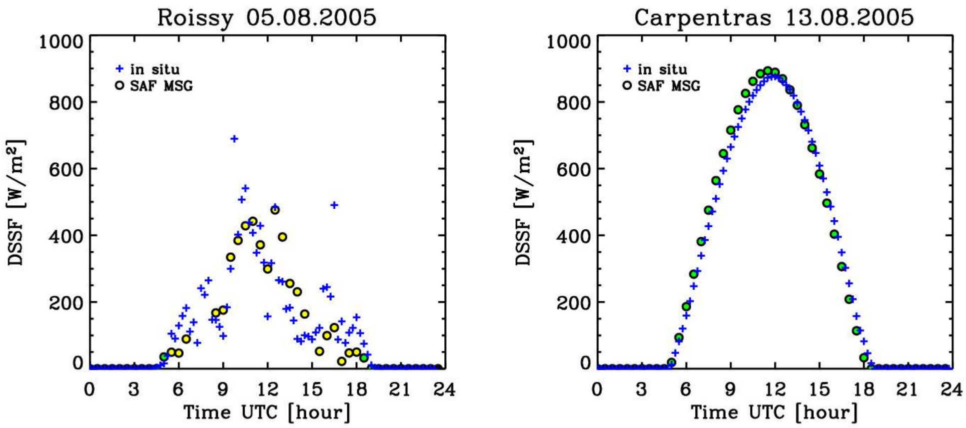
The DSSF product is currently generated every 30 minutes at the full spatial resolution of the SEVIRI instrument based on every second slot of Meteosat images. It is delivered to the users with a timeliness of less than three hours. The Land-SAF system separately processes four continental windows comprising Europe, Northern Africa, Southern Africa, and South America. Figure 1 shows a re-composed example of the DSSF product for the full Meteosat disk. Along with the physical DSSF estimate the product files contain a processing flag providing additional information about the execution of the algorithm.



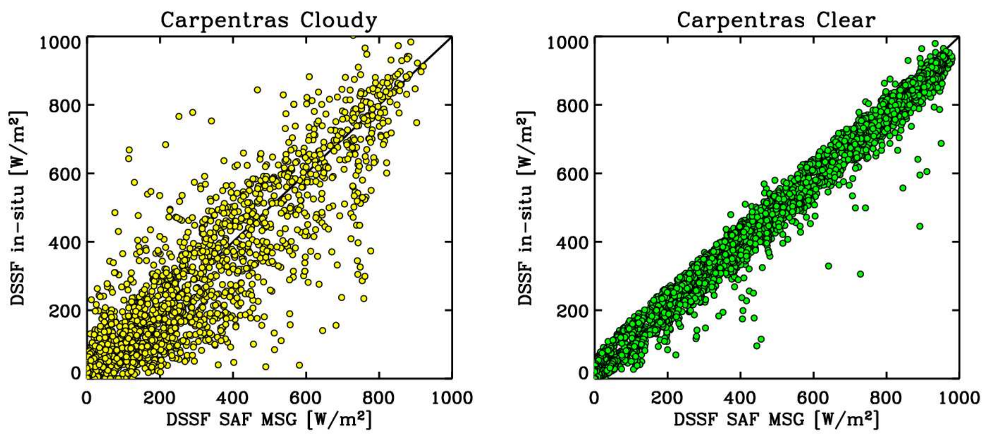
1. The DSSF product generated for the 19th of August 2005 at 14:00 UTC and the corresponding processing flag (green: clear-sky, yellow: cloudy sky, other colours indicate special cases not described here).

Validation

Up to now validation studies have only been performed with ground data from the radiometric stations of Roissy and Carpentras which are located in the North and South of France, respectively, with different climatic conditions. Examples for the comparison of the corresponding daily time series are shown in Figure 2. The in-situ measurements were averaged over time intervals of 15 minutes.

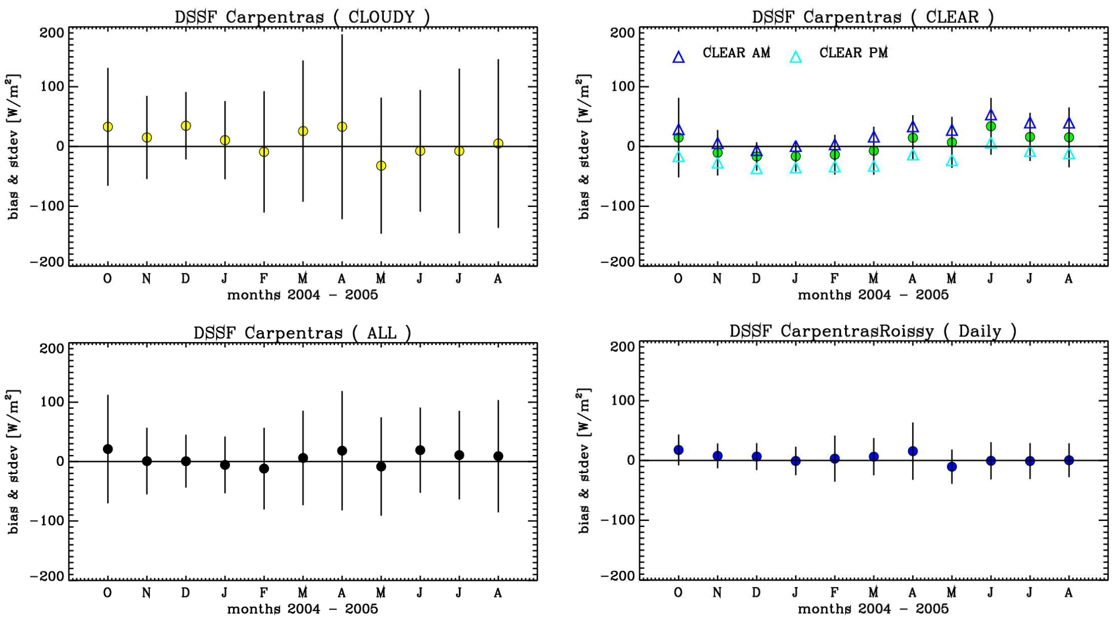


2. Examples for the validation of the DSSF product with in-situ measurements at the radiometric stations of Roissy and Carpentras (France). The yellow and green dots, respectively, indicate whether the cloudy or clear sky methods were applied.



3. Scatter plots between in-situ measurements at Carpentras and the Land-SAF DSSF product for the corresponding pixel.

Figure 3 shows scatter plots between the satellite estimates and the in-situ measurements at Carpentras. The figure includes data points from the complete available period from October 2004 to August 2005. As expected, the dispersion is much larger for cloudy sky since the potentially very complex structure of the cloud layer is more difficult to describe with a simple model than the clear atmosphere. Quantitative validation results are given in Figure 4. The dots indicate the bias between the satellite estimates and the in-situ measurements. The (one-sided) length of the error bar corresponds to the standard deviation of the difference between the two values. Results are given separately for the clear and cloudy cases as well as for all data points together irrespective of the conditions. The figure also includes the statistics for a daily averaged DSSF product which naturally exhibits a much smaller standard deviation. (The daily averaged product has been calculated for validation purposes only and is not generated operationally for the time being.)



4. Quantitative validation results obtained with measurements from the radiometric station of Carpentras.

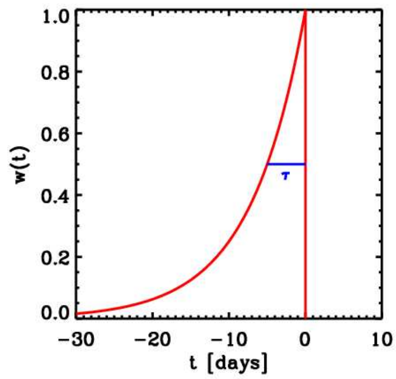
3. LAND SURFACE ALBEDO

Since the reflectance properties of the surface vary on much larger time scales than the image repeat cycle, the albedo product is based on a composition of the information from a large number of Meteosat images in order to reduce the sensitivity to undetected clouds or atmospheric variability, which represent the most important practical problems when determining surface albedo from satellite observations.

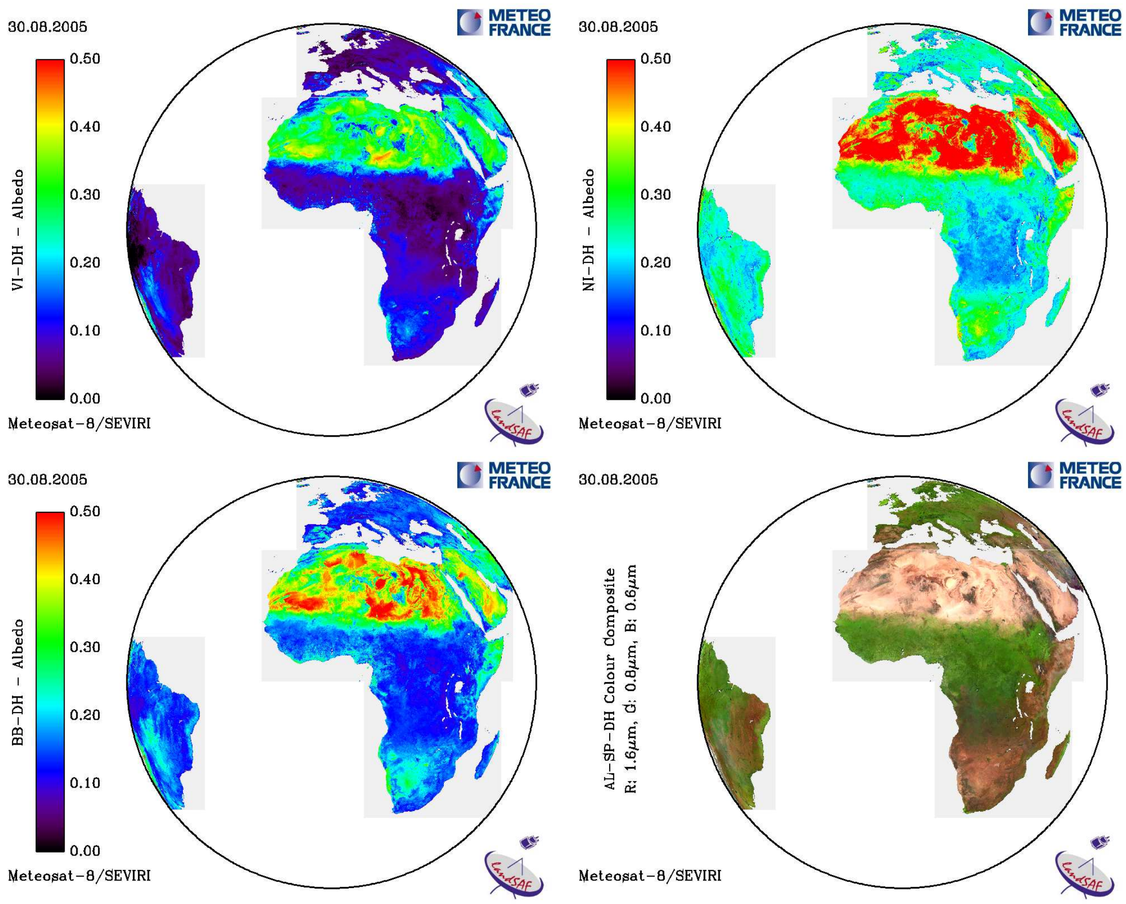
Methodology

In a first step the simplified radiative transfer code SMAC (Rahman and Dedieu, 1994) is applied for cloud-free pixels of every Meteosat image at 15 minutes interval in order to correct the observed reflectances for atmospheric effects. Afterwards, a linear BRDF model (Roujean et al., 1992) describing the angular dependence is fitted to a daily time series of the resulting top-of-canopy reflectance factor values. Albedo estimates are then determined by suitably integrating the BRDF model functions with the retrieved parameter values and by applying a linear narrow- to broadband conversion formula. Directional-hemispherical and bi-hemispherical albedo estimates are derived.

In order to achieve a temporal composition of the observations over a longer time period, the model estimate from the previous algorithm execution is used as a priori information in the inversion process. By adapting its relative weight, an effective temporal scale can be chosen (see Figure 5). The iterative temporal composition approach assures a homogeneous gap-free product while still keeping the flexibility to adapt to rapid reflectance changes which can be provoked by snow fall.



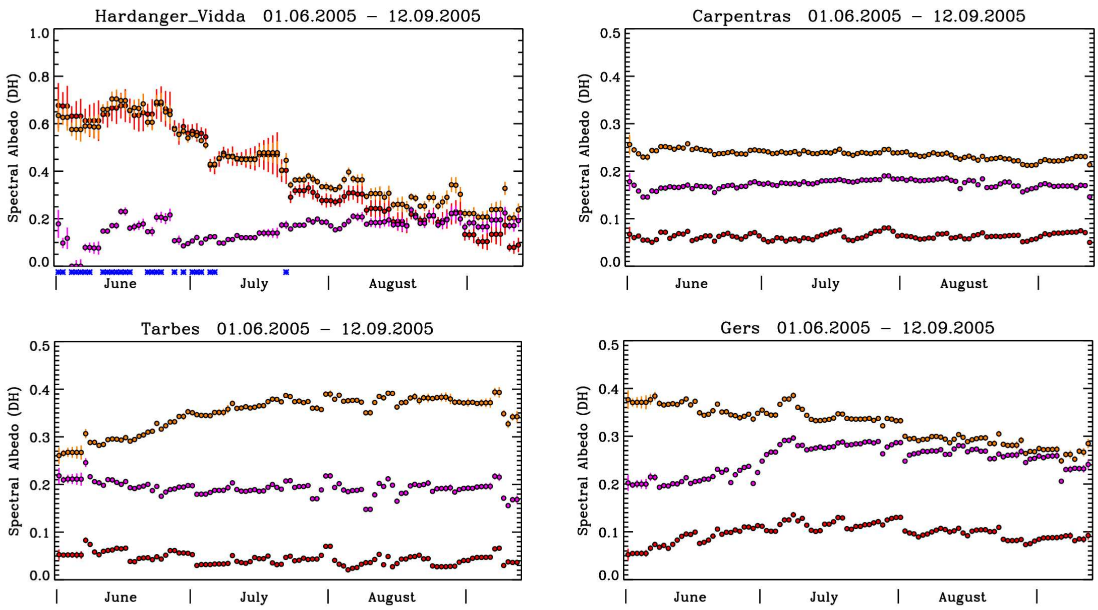
5. Effective temporal weight function for the reflectance observations resulting from the iterative composition scheme implemented in the albedo algorithm.



6. The directional-hemispherical broadband albedo estimates delivered for the 30th of August 2005 and a colour composite of the corresponding spectral albedo estimates.

Results

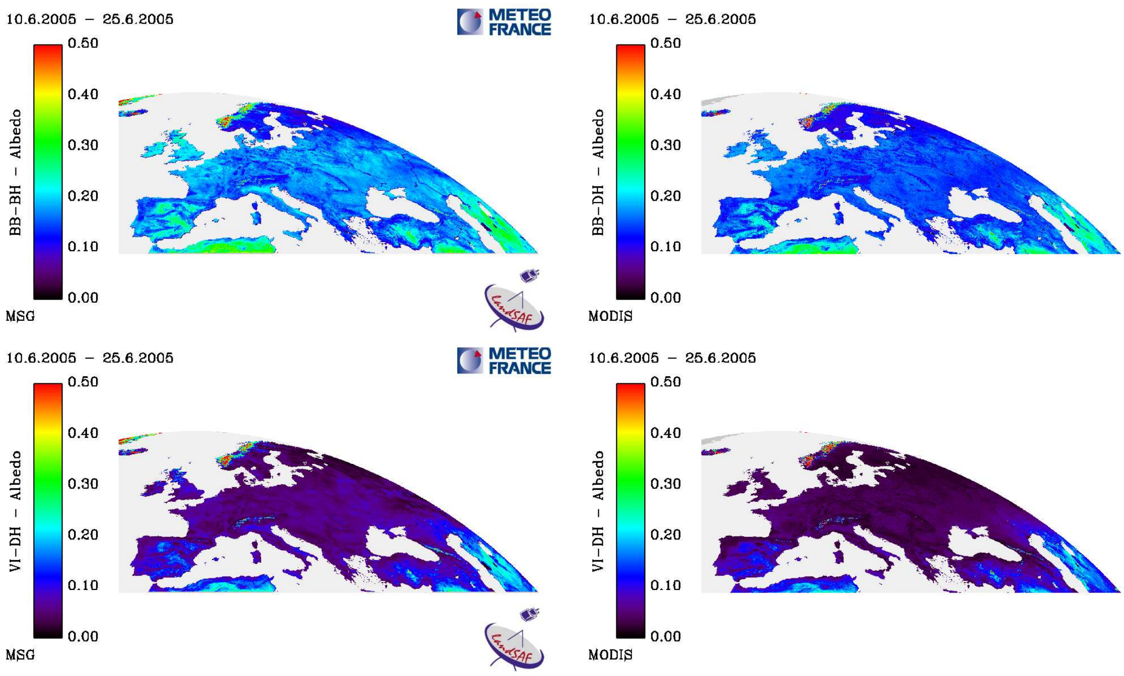
The albedo products are calculated and delivered on a daily basis in near real time. The product files include the different spectral and broadband albedo variants, their respective error estimates, and a processing flag. An example of re-composed full disk images is shown in Figure 6. The time series of Figure 7 for various test pixels located in the South of France (Carpentras, Tarbes, Gers) and Norway (Hardanger Vidda) show a rather different temporal evolution of the spectral albedo over the depicted period. The variations on small time scales are due to residual problems in cloud elimination and atmospheric correction which need to be addressed in more detail.



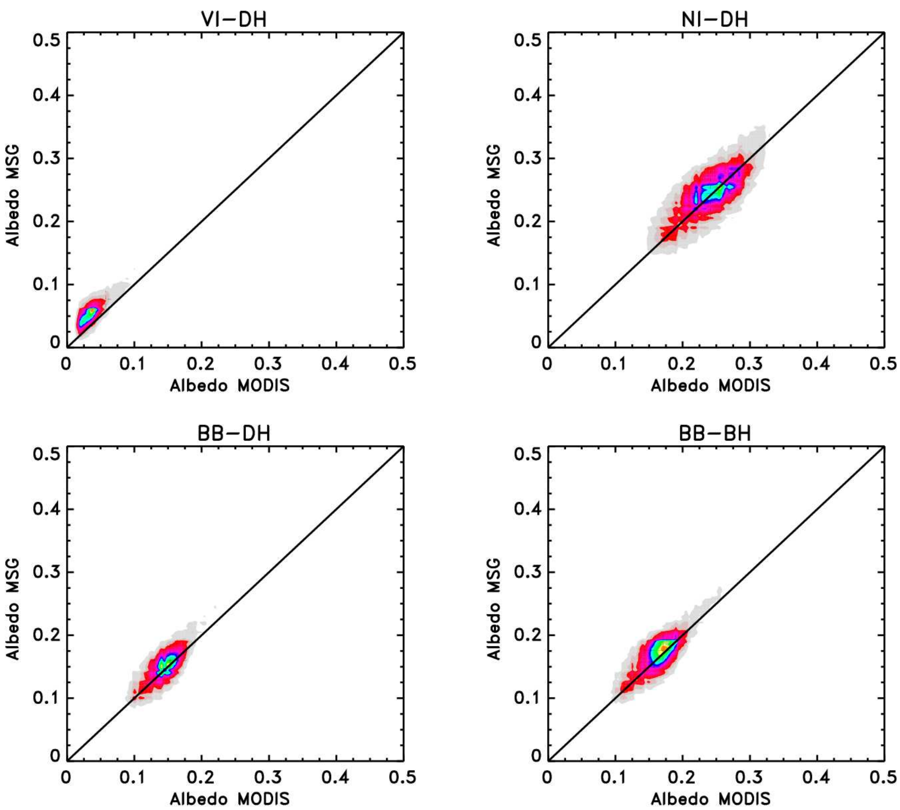
7. Spectral albedo time series for some example sites. Red: 0.6µm, Orange: 0.8µm, Magenta: 1.6µm.

Validation

Since suitable ground measurements at homogeneous test sites have not yet been available, the validation of the albedo product is presently based on an inter-comparison with the corresponding MODIS satellite albedo product. Figure 8 includes maps of the Land-SAF albedo product as well as of the corresponding MODIS product re-projected to the SEVIRI instrument resolution. The validation results are quantified in Figure 9 in the form of graphs of the joint probability density distribution of the two albedo estimates.



8. Comparison of Land-SAF (left) and re-projected MODIS albedo maps (right) for the total (top) and visible (bottom) broadband wavelength ranges.



9. Quantitative comparison of the Land-SAF/MSG and MODIS products. VI: visible broadband, NI: near infrared broadband, BB: total short-wave broadband; DH: directional-hemispherical, BH: bi-hemispherical.

4. CONCLUSION

At the present time (October 2005) the surface albedo and DSSF products are regularly generated and distributed in near real time by the Land-SAF operational system. The DSSF product (as well as its long-wave counterpart and the land surface temperature) are already accessible to external users via the project website (http://landsaf.meteo.pt) and the albedo product is expected to be released in the near future. More detailed information about the algorithms and data formats is given in the Product User Manuals available on the website.

In addition to methodological improvements of the algorithms, the main development activities during the Initial Operational Phase will concentrate on the exploitation of the data from the AVHRR instrument onboard the METOP satellites of the upcoming European Polar System. Possibly merged products benefiting from the synergy of the geostationary and polar observation systems will be developed. The system is planned to be fully operational in the year 2007.

5. REFERENCES

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