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Use of the MSA products as an adequate representation of the surface albedo in the ALADIN-Belgium NWP model

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d surface albedo represents the proportion of the incoming radiative flux ected by the surface. It is highly variable in space and time over terrestrial faces and plays a key role in surface-atmosphere interaction processes. particular, it is used in numerical weather forecast and climate models to ametrize surface boundary radiative conditions. Hence, the accurate owledge of surface albedo at the appropriate time and space scales is ential in estimating radiation balance components. Unfortunately, surface edo in numerical models is commonly prescribed from low-resolution sonal data sets. Such data sets are often based on limited ground-based edo observations and information on surface and vegetation types, even ugh such approaches do not accurately account for the actual structural cts of the underlying surface.

To account for the high spatial and temporal variability of the surface albedo, the ALADIN-Belgium NWP model has been initialized with the directional hemispherical reflectance generated by the Meteosat Surface Albedo (MSA) algorithm. The MSA product is generated every 10 days with a spatial resolution close to the 7 km mesh size of ALADIN-Belgium NWP model. A number of sensitivity forecast runs using the MSA products has shown a significant improvement of the simulated radiative fluxes with respect to simulations performed with a surface albedo derived from climatological values of soil and vegetation parameters. This finding suggests that the use of the high-resolution MSA products could also be valuable for improving model temperature forecasts.

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References

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Pinty et al., 2000 a. Surface albedo retrieval from Meteosat 1. Theory. J. Geophys. Res., 105 (D14), 18,099-18,112.

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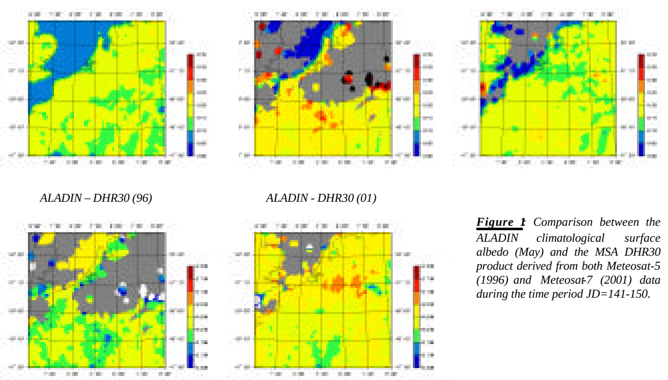


ALADIN (May) *DHR30 (96) JD:141-150* *DHR30 (01) JD:141-150*

ALADIN – DHR30 (96) *ALADIN - DHR30 (01)*

Figure 1: *Comparison between the ALADIN climatological surface albedo (May) and the MSA DHR30 product derived from both Meteosat-5 (1996) and Meteosat-7 (2001) data during the time period JD=141-150.*

bjectives

pact of MSA on simulated OSR and air surface temperature in the ALADIN Belgium NWP model

pact on OSR is estimated with respect to observed OSR from Meteosat-7 data

SA product description

e cornerstone of the surface albedo algorithm (Pinty et al., 2000a,b) relies on the exploitation of the temporal sampling of Meteosat as were an instantaneous angular sampling. The MSA algorithm accumulates VIS band half-hourly observations for each pixel during e day. The MSA product contains two data albedo products generated every compositing periods of 10 days with a spatial resolution ual to the one of Meteosat VIS band instrument. The first product (DHR30) represents the "spectral albedo" in the Meteosat sensor S band spectral interval [0.4 - 1.1 µm] assuming a Sun zenith angle of 30°. The Daily averaged Directional Hemispherical Reflectance HR) represents the daily averaged "spectral albedo" over the Sun zenith angles during the course of the best day weighted by the teosat sensor VIS band spectral response. The current experiment relies on the first quantity.

use the DHR30 data in the ALADIN Belgium model, the surface albedo values in the Meteosat visible band spectral region, αVIS, e been converted to broadband surface albedo, αBB,applying the following regression equation: $a_{BB}=0.959a_{VIS}+0.024$

e resulting surface albedo over the ALADIN Belgium domain, for the time period May 21 to 30 as derived from Meteosat-5 data (1996) d Meteosat-7 data (2001) referred here after as DHR30 (96) and DHR30 (01) respectively are shown in Fig. 1 and compared to the natological ALADIN surface albedo field.

ally, to perform our sensitivity forecast runs, the lacking surface albedo values in the MSA DHR30 fields due to pixels obscured by ud cover have been filled with the corresponding ALADIN climatological albedo value grid point

etrieval of reflected TOA solar radiation

served Outgoing Shortwave Radiation (OSR) are derived from Meteosat-7 data uired in the VIS band (0.4 – 1.1 µm). Our OSR estimation relies first on an iltering (NB-to-BB conversion) of the measurements in order to estimate the total rtwave radiance from the visible filtered measurements using a third order ression on the filtered measurements where the regression coefficients depend on solar zenith angle. $L_{sw}=D_0(q_s)+D_1(q_s)L_{VIS}+D_2(q_s)L^2_{VIS}+D_3(q_s)L^3_{VIS}$

a second step, an angular conversion is performed using of a set of 590 ADMs ived by Loeb et al. (2003) from measurements of the CERES instrument onboard of NASA's TRMM satellite.

rs associated to the OSR estimation are summarized on Table 1.

STEPS	SHORTWAVE
Narrow band measurement	5%
Spectral modeling	5.5%
Angular modeling	6%
TOTAL	16.5%

Table 1:*Summary of the error magnitudes associated to the TOA flux estimation from Meteosat-7 measurement*

Note that these magnitudes have to be understood as typical accuracies since they are function of the viewing geometry.

Uncertainty sources in the simulated OSR fluxes

Beside the model radiative code itself, atmospheric aerosols concentration, composition, and size distribution impact on the simulated solar fluxes values in addition to the surface albedo (see Fig.2). Moreover, the spectral behavior of vegetated and ground surface albedo in the solar spectrum account for an additional source of error in the OSR values as simulated by radiative code models which only consider a spectrally averaged surface reflectance value over the entire solar spectrum. Illustrations of the aerosols and surface spectral albedo impacts on the simulated reflected TOA solar fluxes are displayed in Table 2.

As the aerosols impacts deduced from Table 2 appear quite large, Fig. 3 presents typical aerosols optical depth values over the ALADIN Belgium domain. Note that a visibility of respectively 50 km, 23 km, and 5 km is equivalent to an aerosol optical depth of about 0.152, 0.235, and 0.78 at λ = 0.55 µm.

Diurnal variation of both the averaged ALADIN land surfaces DHR and the averaged sea surfaces DHR is displayed in Fig.4 for the selected time period.

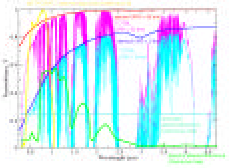


Figure2:. *The spectra of transmittance T of the direct solar beam at the sea level were calculated using MODTRAN4 with a Midlatitude Summer atmosphere, a spring-summer tropospheric aerosol model (VIS =50 km), an urban aerosol model (VIS=5 km), and the Sun at the zenith.*

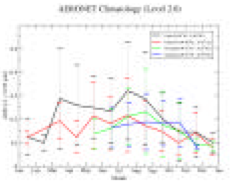


Figure 3: *Aerosol optical depth at 0.55 mm as recorded by Cimel Sun photometers at four AERONET sites located within the ALADIN Belgium domain*

VEGETATION (Deciduous Tree)	AEROSOL	MODEL		
	TROPOSPHERIC (VIS = 50 km)	RURAL (VIS = 23 km)	RURAL (VIS = 5 km)	URBAN (VIS = 5 km)
Uccle (JD = 145)	θs = 30.0 °	θv = 58.28 °	ϕ = 166.65 °	11:30 UTC
Spectral reflectance	248.21	249.54	263.08	171.01
Averaged	240.07	239.73	248.03	154.38
Uccle (JD = 145)	θs = 57.19°	θv = 58.28 °	ϕ = 102.33 °	16:00 UTC
Spectral reflectance	172.92	179.00	200.98	129.42
Averaged	166.13	171.32	191.78	120.47

Table 2: *Reflected TOA solar flux (Wm-2) calculated using MODTRAN4 with a Midlatitude Summer Atmosphere according to various aerosol models, solar zenithal angles, qs, and by considering both a spectral vegetation reflectance curve and a spectrally averaged reflectance value assuming a lambertian ground surface .*

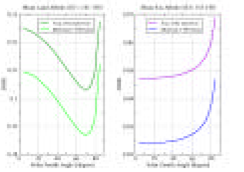
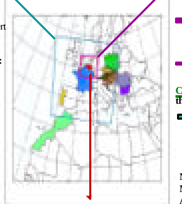


Figure 4: *Diurnal variation of (1) the land averaged and (2) sea averaged Directional Hemispherical Reflectances over the ALADIN Belgium domain.*

Model description



**DIN France Central Domain Size:
277x277 points of 9.5 km**

**ALADIN Belgium Full Domain Size
(including extension and coupling zones)
108x108 points of 7 km**

ber of level: 41
Projection: Lambert
ection Scheme:
ni-Lagrangian
e-Stepping Scheme:
o-time-level semi-
licit
el time step: 360 s
led with: ARPEGE

**SW corner: 47.47 N
0.11 E**
**NE corner: 53.47 N
9.60 E**

Runs at 48 hours ranges two times a day (0h00 and 12h00)

Coupling : Every 3 hours from the output of ALADIN-FRANCE

**Temperature
Wind Components
Specific Humidity
Geopotential**

**ALADIN Belgium Central Domain Size
97x97 points of 7 km**

Number of level: 41
Map Projection: Lambert
Advection Scheme: semi- Lagrangian
Time-Stepping Scheme: two-time level semi-implicit
Model Time Step: 360 s
Operational version: hydrostatic

Experimental setup

We have carried out 3 series of 10 runs at 48 hours ranges starting at midnight from May 21 to May 30, 2001. The first series was performed using the operational version of the ALADIN Belgium model (here after referred as ALADIN STD). In the second series of runs, we substituted the climatological ALADIN surface albedo field by the DHR30 (96) dataset (here after referred as DHR30 (96)). The last series of runs were conducted using the DHR30 (01) values (here after referred as DHR30 (01)).

Fig. 5 displays for each series of experiments a comparison between the simulated and retrieved clear sky OSR fluxes for 3 differents forecast horizon (namely at 9h00, 12h00, and 15h00). Note that to build our clear sky OSR fluxes data base only fluxes which were referenced simultaneously as free of cloud contamination in each of the 3 series of run for a given day and a forecast horizon but also in the retrieved OSR fluxes from Meteosat-7 data have been considered.

Fig.6 indicates that the use of the DHR30 dataset can modify the model temperature forecasts.

FORECAST HORIZON:

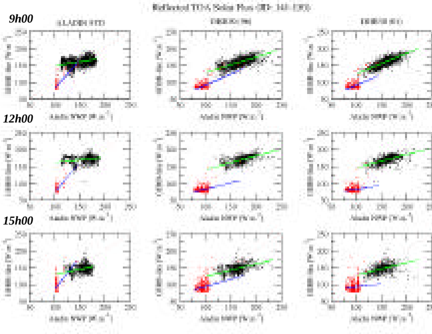
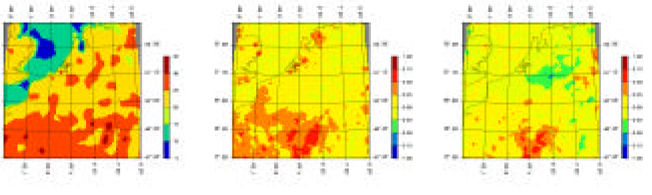


Figure 5: *Comparison between simulated and retrieved instantaneous clear sky TOA reflected solar flux for 3 differents forecast horizon. Black dots refer to clear sky comparison above land surfaces and red dots above sea surfaces.*



(a) ALADIN (b) ALADIN – DHR30 (96) (c) ALADIN – DHR30 (01)

Figure 6: *Air surface temperature anomalies at the forecast horizon of 12:00 hours relative to the operational version of the model given in panel (a) when using (b) the DHR30 (96) or (c) the DHR30 (01) dataset. Units are given in°C*

Conclusions and Perspective

Use of MSA DHR30 product as surrogate for the surface albedo in the ALADIN Belgium model allows to reduce the RMSE between simulated and observed OSR fluxes. As some vegetation characteristics change from year-to-year, better agreement with the retrieved OSR fluxes appears when using DHR30 data derived from Meteosat-7.

In addition, we have shown that the modification introduced in the surface albedo field impacts on the model temperature forecasts.

Finally, we plan to extend our comparison to additional time periods

			ALADIN SID .			DHR30 (96)			DHR30 (01)			OBS.
FORECAST HORIZON	SURFACE	Number	Mean	Correlation	r.m.s	Mean	Correlation	r.m.s	Mean	Correlation	r.m.s	Mean
9h00	LAND	2056	153.81	0.36	19.62	171.59	0.68	16.14	160.27	0.78	9.56	161.71
	SEA	455	105.34	0.78	18.01	98.15	0.61	13.70	97.59	0.46	14.20	89.69
12h00	LAND	774	159.73	0.24	22.45	173.66	0.60	14.96	162.90	0.55	16.48	170.64
	SEA	448	105.08	0.62	24.23	97.32	0.32	18.81	96.84	0.19	19.06	82.56
15h00	LAND	753	155.59	0.32	18.36	162.08	0.51	22.56	151.40	0.46	16.00	146.11
	SEA	482	104.51	0.39	18.56	98.42	0.24	16.60	98.10	0.10	17.38	92.74