Specifications of surface fields conversions for ALADIN/SURFEX (ISBA) scheme

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1. Introduction

This document deals with specifications for surface fields conversions for ALADIN/SURFEX (ISBA) scheme as an initiative on SRNWP Interoperability programme. The proposals and specifications in this document follow recommendations for surface fields conversions given by SRNWP ET on surface processes (J.-F. Mahfouf, 2009).

Recently, a nice progress in conversion from IFS (HTessel) with thorough validation have been done by J. P. Ferreira during his stay in M-F (J. P. Ferreira, 2009). As a complement to his work, proposals and specifications for surface fields conventions from models of other consortia were the main aims of this report. Since COSMO was the only consortium that provided a relevant documentation at the time of preparation of this report, it concerns mostly with the conversions from COSMO (TERRA) model but also tries to foresee some aspects of general difficulties that may be encountered during the implementation of the conversion software.

2. General notes on surface fields conversion

It is recognized that conversion of surface fields between different models can be very complex and arbitrary due to strong dependency of surface variables on the physics of a particular model. This emphasizes importance of identifying appropriate variables for conversion. The aim is to exchange only variables with minimal dependence on the model's specificities. However, this may not be always straightforward and it can be case dependent. If applicable, one should perform a normalization of variables for instance to account for soil textural differences between source and target model. In a better case, this "inter-operable" conversion variables can be provided directly by the source model or they can be computed from other ancillary data.

Nevertheless, it is important to note that surface schemes are usually reflecting the biases of atmospheric models which can make the application of converted fields even more problematic.

Computation of conversion variables

Number of interpolations from source to target grid should be reduced to a minimum. Thus it is advised that conversion variables, if not provided directly, should be computed on the source grid using additional ancillary data (e. g. soil texture parameters). Thus computed fields can be then interpolated to target grid and finally converted back to the prognostic variables used in the target model.

Horizontal interpolation

Horizontal interpolation needs to consider land sea-mask that must be available on both source and target grids in order to interpolate points of the same nature. For the points where the type differs the nearest point of the same nature from the source grid has to be used. This standard procedure is already used in Surfex *prep* as well as in 927 configuration. Distinction between the grid point types could be possibly extended also to different grid point tiles where each tile represents a fractions of a grid point surface (e. g. urban, nature, lake...). However this would bring additional complexity not to mention an arbitrariness if the classification of the surface tiles would differ between the source and target model. Thus it is proposed to use only a grid-point dominant surface type for horizontal interpolations. Nevertheless, the interpolation method can be revised in the future if a need for higher sophistication will arise.

Vertical interpolation

Since the vertical discretization is usually different between source and target soil schemes a vertical interpolation is necessary. One possibility is to use fine intermediate grid. Although this method can be considered as a precise one, it proved to be inappropriate for the practical applications in ISBA due to the fact that the first layer in ISBA is significantly smaller (only 0.01m) compared to the underlying layer which is about one to two orders thicker.

Since the number of vertical layers in the current soil models is relatively small a cruder methods can be applied. The ISBA scheme is based on force restore method so no explicit model layers are assigned for soil temperature. Thus arbitrary model level (or weighted average of several layers) from the source model have to be specified to represent the ISBA soil temperature. This method is currently used for soil temperature conversion from IFS (HTessel) and it is also proposed to use the same strategy for COSMO model.

However, it must be noted that this method has a disadvantage when considering that any change of vertical discretization in the source model would have to be reflected back in the conversion code as well. From this point of view the former method using fine intermediate grid is more general. Nevertheless, assuming that the vertical resolution of soil models do not change so frequently the later solution is still acceptable.

Conversion to prognostic variables

After the horizontal and vertical interpolations the interpolated quantities have to be converted back to the actual prognostic variables needed by the soil scheme of the target model.

Vertical adjustment

Since the source orography (interpolated on the target grid) can differ from the native target's one, an adjustment has to be applied on some variables that can be affected by the hight difference. This is mostly important for the surface and soil temperatures, snow water content and partition between liquid and solid water in the soil.

3. Description of COSMO (TERRA) soil scheme

This section briefly describes basic characteristics of COSMO (TERRA) soil scheme as found in the documentation at the time of preparation of this report (see G. Doms et al., 2007 and E. Heise, 2006).

- multi-layer scheme composed of 8 layers, first 7 layers are active while the last one represent lower boundary condition with climatological constant values
- thermal transfer based on numerical solution of the heat conduction equation (HCE method)
- the same layers are used for hydrological part (only first 6 layers are hydrologically active).
- eight soil types are distinguished: ice, rock, sand, sandy loam, loam, loamy clay, clay and peat

layer 1	0.0 – 0.01 m
layer 2	0.01 – 0.03 m
layer 3	0.03 – 0.09 m
layer 4	0.09 – 0.27 m
layer 5	0.27 – 0.81 m
layer 6	0.81 – 2.43 m
layer 7	2.43 – 7.29 m
layer 8	7.29 – 21.87 m

Table 1: TERRA soil layers

4. Conversion of COSMO (TERRA) surface fields

Here is a list of variables (with descending priority) and proposals for conversion into ISBA equivalent quantities.

Deep soil liquid and ice water content

For short range weather forecast initialization of root zone soil moisture is of the biggest importance. The reason is that the root soil moisture is directly linked with the processes at the surface via evapotranspiration. It's important to note that one must be careful when considering the usual units of kg/m^2 as in this case an actual depth of layers is accounted for and it is necessary to normalize the moisture content with the layer depths. However, this normalization may not be sufficient as the soil types may differ considerably between TERRA and ISBA so additional normalization is necessary. Thus it is advised to use soil wetness index (*SWI*) that is more directly linked with the evapotranspiration processes. This approach is approved as for the meteorological applications we are usually more interested in good representation of evaporation fluxes then in the absolute soil moisture content itself.

The *SWI* is computed using soil water content thresholds which are depending on the soil texture. The standard formulation of *SWI* in ISBA is

$$SWI_{ISBA} = \frac{w_p - w_{wilt}}{w_{fc} - w_{wilt}} veg + \frac{w_p}{w_{fc}} (1 - veg)$$

where w_p is the soil water content, w_{fc} value at field capacity, w_{wilt} value at wilting point and *veg* vegetation fraction.

To account for differences in *Rsmin* and *LAI* between TERRA and ISBA schemes one can apply additional *Rsmin/LAI* scaling of *SWI* in order to prevent big differences in evaporation (see J. P. Ferreira, 2009).

$$SWI_{ISBA} = LAI_{scal} \frac{w_p - w_{wilt}}{w_{fc} - w_{wilt}} veg + \frac{w_p}{w_{fc}} (1 - veg)$$

$$LAI_{scal} = \frac{(R_{smin} / LAI)_{TERRA}}{(R_{smin} / LAI)_{ISBA}}$$

where *Rsmi* is minimal stomatal resistance and *LAI* is leaf area index.

Given the soil water content thresholds w_{fc} and w_{wilt} (and alternatively also *Rsmi* and *LAI*) a deep soil moisture w_p can be computed putting equivalence between SWI_{TEERA} and SWI_{ISBA}.

The *SWI* (or equivalently ancillary variables for its computation) can be provided either individually for liquid and for ice water or together as a total moisture content. The latter solution is preferred as anyhow one will have to repartition liquid and ice contents according to the soil temperature changes after applying vertical adjustment to new orography. Since the partition between liquid and ice water can be diagnosed inside ISBA it doesn't make much sense to interpolate *SWI* (or soil water thresholds) separately for the two phases.

available ancillary data for *SWI*:

Currently, COSMO can provide soil water content thresholds w_{fc} and w_{wilt} necessary for computation of *SWI* and also *Rsmin* and *LAI*. The possibility to have *SWI* directly in COSMO output is still negotiated.

conversion

The proposal is to use weighted average of the TERRA *SWI* for layers 2 - 6 to represent ISBA deep soil *SWI*.

Snow water content and snow albedo

Both snow water content (in kg/m^2) and snow albedo can be interpolated directly from TERRA scheme. Alternatively, they could be initialized from 923 climatology fields.

Deep soil temperature

A deep soil temperature is not of the greatest importance as it only has a small impact on short-range weather forecast so it's fairly justified to apply a simpler method for the conversion based on association of ISBA deep soil temperature with the temperature of the most representative TERRA soil layer (or weighted average of several layers).

Another alternative approach would be to use longer time average (e. g. 5 day average) of TERRA soil temperature in order to obtain a more representative estimate, however, this would lead to an unavoidable increase of necessary data volume for conversion so this solution is not recommended.

It is suggested to use temperature of layer 5 in TERRA scheme or alternatively a weighted average of layer 4 and 5 to obtain a representative value for the 50cm depth temperature in ISBA.

Superficial liquid and ice water content

Given the vertical discretization of TERRA scheme, it is suggested to use *SWI* (for the total water content liquid+ice) of the first TERRA layer to compute ISBA total moisture content.

After the application of vertical adjustment the partition between superficial liquid and ice water contents can be diagnosed adopting the algorithm already present in configuration 901 (see cprep1.F90).

Surface temperatures

The ISBA surface temperature can be interpolated directly from TERRA surface temperature.

vertical adjustment

Adjustment of surface and deep soil temperatures will be necessary to account for the change of orography height. For this purpose standard soil temperature gradient -0.7°C/100m is usually used (see G. Doms et al., 2007).

Interception water content

As the interception reservoir can be considered as a very fast evolving prognostic variable the initialization to zero should be satisfactory.

5. Internal notes

- At the present state, interpolations of fields are done in 927 configuration. Interpolated fields are then passed to *prepsurex* to prepare SURFEX initial files. There is also possibility to use directly *prep* tool for interpolations but this option is not currently used due to bad optimization of *prep* code for vectorized computations.
- It is proposed to include *SWI* in the list of surface prognostic variables provided by ALADIN for SRNWP Interoperability programme. This action could be considered as an exemplar initiative towards interoperability and inspiration for other consortia. As for the technical aspects, there is currently possibility of writing *SWI* in the output only in the SURFEX. Configuration 927 does not provide this option and would have to be extended.
- The feasibility of GRIB2 format for exchange of surface variables has been examined. It was recognized that given the variety of surface variables the current GRIB2 standard table for surface fields will not be sufficient for description of all the variables. Thus local table specific for ALADIN/SURFEX (ISBA) fields will have to be created for interoperability purposes.

References

J.-F. Mahfouf, 2009: Answers from the SRNWP ET on surface processes to the SRNWP Interoperability programme regarding surface issues

J. P. Ferreira, 2009: Improving the surface initialization of Aladin (ISBA) from IFS (HTessel) analysis

G. Doms, J. Forstner, E. Heise, H.-J. Herzog, M. Raschendorfer, T. Reinhardt, B. Ritter, R. Schrodin, J.-P. Schulz, G. Vogel, 2007: A Description of the Non-hydrostatic Regional Model LM, Part II: Physical Parametrization
See http://www.cosmo-model.org/content/model/documentation/core/cosmoPhysParamtr.pdf

E. Heise, B. Ritter, R. Schrodin, 2006: Operational implementation of the multilayer soil model
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P. Le Moigne, Soil ice initialization in SURFEX (presentation)

Appendix

Comparison of ALADIN (ISBA) and COSMO (TERRA) physiographic fields

Description	ALADIN (ISBA)		COSMO		Remark
	Name	Unit	Name	Unit	
surface geopotential	SPECSURFGEOPOTEN	J/kg	FIS	J/kg	
land-sea mask	SURFIND.TERREMER	1	-	-	not listed in COSMO table
standard deviation of sub-grid scale orography	SURFET.GEOPOTENT	J/kg	SSO_STD	m	
anisotropy of sub-scale orography	SURFVAR.GEOP.ANI	1	SSO_GAMMA	1	
angle between the direction of sub-scale orography and x-axis	SURFVAR.GEOP.DIR	rad	SSO_THETA	1	
mean slope of sub-grid scale orography	-	-	SSO_SIGNA	1	
bare land roughness length	SURFZ0REL.FOIS.G	J/kg			
dynamical roughness length times g	SURFZ0.FOIS.G	J/kg	Z0	m	
thermal roughness length times g	SURFGZ0.THERM	J/kg			
momentum roughness length times g	SURFZ0VEG.FOIS.G	J/kg			
land fraction (lakes?)	SURFPROP.TERRE	1			
fraction of urbanization	SURFPROP.URBANIS	1			
lake fraction	-	-	FR_LAKE	1	
fraction of ground covered by plants	-	-	PLCOV_MX	1	COSMO – vegetation period
evergreen forest	-	-	FOR_E	1	

fraction					
deciduous forest fraction	-	-	FOR_D	1	
dominant vegetation index	SURFIND.VEG.DOMI	1			
soil texture type	-	-	SOILTYP	1	1-ice, 2-rock, 3-sand, 4-sandy loam, 5-loam, 6-loamy clay, 7-clay, 8-peat
surface emissivity	SURFEMISSIVITE	1	EMIS_RAD	1	
maximum depth of soil column	SURFEPAI.SOL.MAX	m	-	-	
soil depth	SURFEPAIS.SOL	m	-	-	
plant root depth	-	-	ROOTDP	m	
lake depth	-	-	DEPTH_LK	m	
proportion of clay	SURFPROP.ARGILE	1	-	-	
proportion of sand	SURFPROP.SABLE	1	-	-	
maximum vegetation fraction	SURFPROP.VEG.MAX	1	-	-	
vegetation fraction	SURFPROP.VEGETAT	1	-	-	
albedo	SURFALBEDO	1			not listed in COSMO table
bare land albedo	SURFALBEDO.COMPL	1	-	-	
sea/ice albedo	SURFALBEDO.SOLNU	1	-	-	
vegetation albedo	SURFALBEDO.VEG	1	-	-	
climate surface temperature	SURFTEMPERATURE	K			
climate deep soil temperature	PROFTEMPERATURE	K			
2m temperature (climatological mean)	-	-	T_2M_CL	K	
climate surface moisture	SURFPROP.RMAX.EA	kg/m^2			
climate deep soil moisture	PROFPROP.RMAX.EA	kg/m^2			
snow water equivalent (clim or hist?)	SURFRESERV.NEIGE	kg/m^2			
leaf area index	SURFIND.FOLIAIRE	m^2/m^2	LAI_MX	m^2/m^2	ALADIN (ISBA) – monthly COSMO – vegetation period
minimal plant stomatal resistance	SURFRESI.STO.MIN	s/m	RS_MIN	s/m	