1. The Meteo-France externalized surface scheme and its integrated physiographical database Ecoclimap.

By: P. Le Moigne , V. Masson and J.-L. Champeaux

In the frame of AROME, a new project of Météo-France in terms of numerical weather prediction, joint efforts of CNRM (Centre National de Recherches Météorologiques) research departments, Laboratoire d'Aérologie and international Aladin community will contribute to the development of a new meso-scale weather prediction model for research activities, operational data assimilation and forecast (2008). In the development of AROME, the modelisation of surface processes has been externalised in order to have a full compatibility between the surface representation in research and operational models. One of the objectives of the externalisation is to better take into account the heterogeneity of the surface with specific physical parameterisations (town scheme, vegetation scheme, lake and open water schemes).

The initialisation of surface parameters is derived from the Ecoclimap physiographic database at 1 km of resolution (Masson et al., 2001). More than 200 ecosystems representing areas of homogeneous vegetation have been defined by combining existing land-cover and climate maps and additional information from AVHRR satellite data. Then, all surface parameters are derived from each of these ecosystems from look-up tables where the annual cycle of Leaf Area Index (LAI) is constrained by NDVI.

The exchanges of information data between the atmospheric and the surface model follow the specification of the Alma interface where only atmospheric variables, incoming radiation fluxes and surface fluxes (heat, latent, momentum) are exchanged. The initialisation of surface parameters and surface variables are done independently to the initialisation in the atmosphere.

The originality of the externalised surface relies on the representation of the surface in 243 covers. Each cover is defined by its fractions of nature, town, inland-water and sea. The associated physical parameterization are ISBA for vegetation, TEB (Town Energy Balance, Masson, 2001) for urban areas and Charnock's formulations with constant SST for lakes and seas (a 1D sea model is under development). The fraction of vegetation within a given cover may be splitted into several predefined patches. Surface fluxes are computed separately for each tile (each patch for vegetation) and then aggregated over the vegetation tile and finally averaged (according to the fraction of each tile) at the level of the interface between the surface and the atmosphere. The averaged fluxes for momentum, heat and moisture are the boundary conditions for the atmospheric turbulence scheme. In the same manner, the averaged emissivity, albedo and infrared temperature are the boundary conditions for the radiation scheme.

2. Overview of the main physical parameterization of the externalized surface scheme at CNRM. Hydrological applications.

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Parameterisations for surface processes have been improved in the past years, especially for the ISBA scheme used at Météo-France. First improvement concerns the use of 3 soil layers (following the Force-Restore approach) to represent more accurately the water contents. A fast drainage component was added in the root layer and in the deep layer as well as diffusion term between the two layers. An other option is to use a multi-layer scheme with an explicit diffusion of heat and mass in the soil (Boone et al., 1999). This last version also includes the soil ice.

Snow cover is an important component of surface processes because snow pack modifies significantly the surface properties like surface albedo, roughness and also thermal exchanges. Moreover, radiation fluxes as well as momentum, heat and latent fluxes are modified when there is snow at the interface between surface and atmosphere. Snow has also an important impact on hydrology because snow mantel retains most of the precipitation and prevent water to reach immediately the soil. Originally, a single layer snow scheme, with a single surface temperature for the snow and snow –free fraction of the grid was used in ISBA (Douville 95). A new parameterization (called ISBA-ES for Explicit Snow) of snow has been developed (Boone and Etchevers, 2000) with three prognostic variables for heat content, the snow water equivalent and the snow density. It takes into account internal physical process like snow compaction and liquid water retention and uses three vertical levels inside snow mantel.

Following work of Giard and Bazile, 2000, who introduce a 1 level parameterization of freezing in the soil, Boone, 2000 has proposed a 2 levels parameterization of soil freezing. This approach appears to be more accurate, especially in case of long cooling period.

Surface scheme contains a module, called ISBA A-gs (Calvet et al., 1998), which computes the effect of atmospheric CO_2 concentration on the stomatal aperture and photosynthesis. The computed net assimilation of plants is used to feed a simple growth sub-model and to predict the evolution of the Leaf Area Index and the Biomass. The used of Isba – A – gs option allows to simulate some adaptation of the vegetation to the climate forcing, which is particularly important for climate models.

Town Energy Balance scheme (Masson, 2000) has been designed to simulate heat storage, radiative and turbulent fluxes between the surface and the atmosphere over urban areas.

The current surface scheme is designed to be coupled with a distributed hydrological model: the SIM model (Habets et al. 2004). For that purpose, gravitational drainage (function of field capacity) at the bottom of the deep soil reservoir and surface runoff are daily accumulated and transferred to the hydrological model which simulates the water table and the surface hydrological transfer. The SIM model is now implemented over the main French river basin and is operational since the beginning of 2004 to compute real – time soil water content and riverflow at 900 rivergauges of the hydrological surface network.

Isba has been widely tested and calibrated using many in situ data (provided by large scale experiment but also by data taken at the plot scale on the long term) (see for instance Calvet et al. 1998 for the Isba – A – gs calibration studies). Moreover, CNRM participated to all the intercomparison exercices in the frame of Gewex/PILPS, like the Rhone – Aggregation intercomparison conducted very recently (Boone et al. 2004)

Recently, the surface model has been externalised from the atmospheric models, following the Alma concept.