SRNWP Expert Team on Surface Processes (model and data assimilation)

Draft of a workplan for 2008-2009

Revised version (05 September 2008)

Introduction :

The Expert Team on Surface Processes will focus on research activities related to the description of the lower boundary of atmospheric NWP models in order to provide realistic exchanges of heat, momentum, and matter (water vapour, chemical species,…) between the Earth's surface and the atmospheric boundary layer.

The actual diversity of Earth's surface types means that this group will have to consider : continental surfaces including vegetation, bare soil, snow, glaciers, urban areas, fresh water (lakes, lake-ice, snow on lakes) and oceanic surfaces (open water, sea-ice, snow on sea-ice).

A number of constraints are associated with SRNWP applications : the temporal time scale is only few days and the spatial scales of interest are gradually becoming smaller (going from the meso-β-scale of about 10 km to the meso-γ-scale around 2 km). This has a number of consequences on research priorities given in the various consortia. The short temporal time scales mean that, for components of the environmental system evolving with much slower time scales, the description should focus more on their analysis (or initialisation) than on their actual modelling (prediction). This is true for the ocean, the sea-ice, the glaciers, and the vegetation. Even though it is believed that in some situations the diurnal cycle of surface temperature from the ocean and the sea-ice can influence the boundary layer evolution and the genesis of important meteorological phenomena, the modelling of slow components of the Earth's system should be limited to vertical exchanges for SRNWP applications. The increase in horizontal spatial resolutions implies that some surface types that were neglected with coarser resolutions are becoming more important and will require a specific description. This is particularly true for towns and lakes that were ignored in NWP models until recently. It also means that some aspects of the « mosaic » approach used to describe sub-grid scale variability could be less a priority in future

As a consequence, research activities of this ET can be divided in three main areas:
- description of surface physiography using high resolution datasets (static components of the system)
- data assimilation and surface analyses (slow evolving components of the system)
- surface modelling and parameterizations (fast evolving components of the system < 1 day)

As mentioned above, the increasing diversity of Earth's components to be included in high resolution SRNWP models makes coordinated efforts between consortia compulsory. Indeed, none of them can address all the issues related to their modelling and analysis. This evidence has already lead to a number of significant joint initiatives between consortia. Such collaborations should be continued and enhanced in the coming years. The role of this ET will be to foster and stimulate areas of new collaborations.

Scientific context :

Collaborations take naturally place between consortia when common numerical tools, scientific methodologies and datasets are defined and used. Another motivation is when complementary

areas of expertise are identified. For example, this is the case for ALADIN and LACE consortia that are using the same NWP model ALADIN. During the past 15 years collaborations between HIRLAM and ALADIN consortia have been very fruitful on surface processes by making use of the same land surface scheme ISBA (Noilhan and Planton, 1989; Noilhan and Mahfouf, 1996) and of a similar soil analysis technique (Bouttier et al., 1993). Such collaborations are intensifying with the HARMONIE project where the ALADIN dynamics with the HIRLAM and AROME physics will be used by HIRLAM consortium for meso-γ-scale forecasting. In particular for surface processes, HIRLAM consortium has chosen to adopt the externalised surface module SURFEX with ALADIN surface analysis systems (for both soil and near-surface variables). The new soil assimilation scheme under development within SURFEX is based on the Simplified Extended Kalman Filter proposed by Hess (2001) in COSMO consortium. Collaborations between COSMO consortium and other consortia have recently started with the inclusion of the simple two-layer lake model FLake developed by Mironov (2006; Mironov et al., 2008) at DWD. Collaborations between MetOffice and the other consortia have not been very strong in the past. However, the coupling methodology for the externalisation of the ISBA land surface scheme (SURFEX module) has been taken from the MetOffice proposal (Best et al. 2004).

The areas of expertise in each consortium regarding surface processes are summarized below :
- ALADIN/LACE : soil/vegetation modelling, urban area modelling, soil analysis
- HIRLAM : snow modelling and analysis, SST and sea-ice analysis
- COSMO : lake modelling, soil analysis, soil/vegetation modelling, sea-ice modelling, snow modelling
- MetOffice : soil/vegetation modelling, SST and sea-ice analysis

Another important aspect to be recognized for SRNWP activities on surface processes (and therefore that will have to reflect in the current workplan) is the interest in taking advantage of EUMETSAT Satellite Application Facilities (SAF) products. There should be an increasing usage of satellite data in the near future for a better characterization of the Earth's surface in almost real time, either through improved specifications or through data assimilation. A number of products are mature enough to be considered for SRNWP applications. Therefore the use of EUMETSAT SAF products (LandSAF, OSI-SAF, H-SAF) by the various consortia is strongly encouraged as a mean for increasing collaborations on surface processes. Other products such as the European precipitation radar mosaic (OPERA) should also be considered (when available) by this ET.

Description of identified collaborations :

Modelling aspects

Important collaborations are being established between the various consortia around the use of a common lake modelling system. The FLake model developed within COSMO (Mironov, 2006) has been adopted by the other consortia. In particular, FLake has been included within the externalized module SURFEX to be used by HIRLAM, ALADIN and LACE consortia. A first validation study of FLake within SURFEX is currently done over the Alquevar lake (Portugal) in parallel to similar efforts in Hungary over the Balaton lake (ALADIN-LACE consortium). In a second step, the influence of lake modelling on AROME short-range forecasts will be evaluated. Conclusions from these studies and similar ones undertaken by the other consortia should be shared during a workshop on « Parameterization of lakes in numerical weather prediction and climate modelling » that will take place in September 2008 in Zelenogorsk, Russia, at the initiative of the Russian State Hydrometeorological University (St. Petersburg), the Finnish Meteorological Institute and DWD. Given the strong mutual modelling interest around FLake, each consortium is strongly encouraged to participate to this workshop in order to share experiences and to define future SRNWP

collaborations and interactions on common issues (e.g. validation studies, data bases, initialisation of lake temperature, off-line applications and nowcasting). Contacts will be taken with ECMWF since they also plan to use FLake.

There is a significant evolution of surface schemes towards externalized modules (SURFEX, JULES) including land data assimilation systems. This modularity could be helpful for future collaborations.

Among HIRLAM, ALADIN and LACE consortia, the most important collaboration for the next two years (2008-2009) will be to finalize the coupling of the externalized SURFEX module to various NWP models (AROME, ALADIN, HARMONIE). The various aspects of this task are summarized in a scientific and technical document (Bouyssel et al., 2007) that was completed by establishing working groups with specific goals after the first ALADIN/HIRLAM SURFEX Workshop organized in December 2006 (Toulouse, France). A number of visits are planned in 2008 in order to complete this activity. An important requirement from HIRLAM consortium, in order to use SURFEX as a surface modelling system, is the inclusion of some specific features that are not available in the current externalized module. This was the case for FLake. Another action has been identified for the inclusion of a double surface energy balance in order to better describe energy and water exchanges between a snow layer and a forest canopy. A one-week visit is planned at Météo-France (end 2008) to define the scientific content of such modifications. The HIRLAM consortium will then add this new feature within SURFEX. Another feature to be developed by HIRLAM in collaboration with ALADIN is the inclusion of a snow layer above sea-ice and lake-ice. Results from the intercomparison project SnowMIP-2 will be used to evaluate more precisely the strengths and weaknesses of individual snow schemes used in SRNWP models for describing snow/forest interactions.

Special attention will be paid in several consortia (COSMO, HIRLAM, ALADIN, LACE) on diagnostic of variables at screen-level. A new prognostic module (named CANOPY) has been recently introduced in SURFEX (Masson and Seity, 2008) that needs to be thoroughly evaluated since it is used for model verifications and for atmospheric and soil analyses as an observation operator. For data assimilation purposes, the Jacobians of the screen-level vertical interpolation module are needed and require specific evaluations in particular for the new prognostic module CANOPY. A common framework for such comparisons would be useful.

Data assimilation aspects

The development of an externalized land surface assimilation scheme within SURFEX has started within ALADIN and LACE consortia. This new system is based on a Simplified Extended Kalman Filter (SEKF) and will assimilate both screen-level observations, satellite derived soil moisture and vegetation properties. It will also be able to accomodate improved forcings in terms of downward radiative fluxes (e.g. LandSAF products) and surface precipitation (e.g. radar derived products). The HIRLAM consortium will participate intensively in its evaluation for NWP applications (INM) and also for continental carbon monitoring within the GEOLAND-2 programme (KNMI). The current soil analysis scheme based on « optimal interpolation » and developed for the global model ARPEGE (Giard and Bazile, 2000) is under evaluation by several ALADIN–LACE partners. Developments have also started to make this analysis available within SURFEX. This will be useful for high resolution modelling systems (HARMONIE, AROME) that do not have yet their own soil analyses. Another important aspect of the ALADIN/HIRLAM collaboration has been the definition of common tools for land surface data assimilation. To reach this goal, an intercomparison exercise of two-dimensional spatial interpolation schemes (CANARI for ALADIN-LACE and SPAN for HIRLAM) has been initiated for screen-level temperature and relative humidity analyses and sea-surface temperature and sea-ice extent analyses. Similarly to the joint effort around SURFEX, the

underlying idea is to have one common 2D spatial interpolation tool such that specificities missing in one system could be imported from the other. Along these lines, the HIRLAM consortium will help the ALADIN-LACE consortium to produce a snow analysis within CANARI (mostly based on a spatial interpolation of snow depth SYNOP data but that could also include some satellite information on snow cover spatial extent). This activity will start by the end of 2008. Collaborations are envisaged with the COSMO consortium on the interest of a MSG based now mask that has been developed by the MeteoSwiss service. The MetOffice consortium is intending to develop a snow cover assimilation scheme from which guidance could be provided to the ALADIN/ LACE consortium. Contacts with ECMWF will be taken since they use similar surface analysis tools and their developments regarding the use of satellite data (soil moisture, leaf area index) are ahead of ours.

Physiographic data bases

The most relevant aspect regarding this activity is the use of high resolution soil and vegetation maps. The ECOCLIMAP data base (1 km for vegetation covers and 10 km for soil types) is used for AROME and HARMONIE, but not yet for ALADIN (in particular the soil type resolution is still at one degree). A federative initiative among the consortia would be to increase the usage of EUMETSAT SAF products. This will be the case for high resolution SST and sea-ice extent analyses : currently such data are used by the HIRLAM consortium but not yet by ALADIN and LACE (mostly because these analyses were only done at global scale and interpolated over limited area domains). The ALADIN-LACE consortia agreed to develop regional analyses based on OSI-SAF products with the help of HIRLAM expertise. The albedo LandSAF product can now be available in real-time to NWP centres and should be evaluated for SRNWP applications. A collaboration has just started where a simple albedo analysis scheme based on a Kalman filter and developed at Météo-France will be evaluated for ALADIN-LACE applications. Finally there is a need to increase databases on lake and town surface properties, and to have higher resolution (1 km) soil texture databases. With regard to lake properties, particular attention should be paid to the development of a lake-depth dataset An inventory of the physiographic databases that are used in each consortium will be done in order to assess differences and similarities.

Summary :

The past fruitful collaborations between HIRLAM and ALADIN-LACE consortia in the area of surface processes modelling and data assimilation have recently intensified with the HARMONIE project. A number of common numerical tools have been defined in order to benefit from the complementary expertise of each consortium. These collaborations were defined during a ALADIN/ HIRLAM SURFEX workshop held in December 2006 (Toulouse), and updated during the HIRLAM/ARPEGE/ALADIN/AROME surface assimilation workshop in November 2007 (Budapest). A number of collaborative initiatives will continue during the next two years (2008-2009).

Collaborations with the other consortia (COSMO, UK Met Office) are starting with the use of a common simple lake model FLake. The workshop on lake modelling that will take place in September 2008 in Zelenogorsk will be an opportunity to enhance common activities among the five consortia regarding the following items :

–validation studies using dedicated observational data sets

–specification of physiographic lake properties (data base constitution)

–data assimilation (initialization) of lake temperature

The increased usage of EUMETSAT SAF data sets is strongly recommended among all SRNWP partners in order to share experience regarding the quality of such products and methodologies to include them in numerical models (e.g. simple analysis schemes). The availability of national

products (e.g. The French RADOME network, the soil moisture network SMOSMANIA) and high quality observations from other well equipped observational sites (e.g. Meteorological Observatories such as Lindenberg, Payerne, Cabauw) could also be a mean to define validation studies over common domains

Finally, **it seems appropriate to organize a SRNWP workshop on surface processes in 2009**.in order to establish closer collaborations between the ALADIN/LACE/HIRLAM consortia and the COSMO/MetOffice consortia, that are presently recognized in the present document as being rather weak and that maybe difficult to set-up outside a dedicated meeting. It is suggested to have a one-day meeting after the 2nd workshop on remote sensing and modeling of surface properties (12 June 2009 in Toulouse).

Some consistency issues between the surface and the atmosphere (e.g. orographic parameters) that were raised during the 2006 SURFEX Workshop should be examined by interacting with the ET on physical parameterizations.

Key reference publications

Land surface schemes

Met Office

Essery, R.H.L., M.J. Best, R.A. Betts, P.M. Cox, and C.M. Taylor, 2003: Explicit representation of subgrid heterogeneity in a GCM land-surface scheme. Journal of Hydrometeorology, 4, 530-543.

COSMO

Heise, E., B. Ritter, and R. Schordin, 2006: Operational implementation of the multilayer soil model. COSMO Technical Report No 9, 19 pp.

HIRLAM

P. Samuelson, S. Gollvik, and A. Ullerstig, 2006: The land-surface scheme of the Rossby Centre regional atmospheric climate model (RCA3). SMHI Technical Report No 122, 25 pp.

ALADIN-LACE

Noilhan, J., and S. Planton, 1989: A simple parameterization of land surface processes for meteorological models. Monthly Weather Review, 117, 536-549

Noilhan J., and J.-F., Mahfouf, 1996: The ISBA land surface parameterisation scheme. Global and Planetary Change, 13, 145-159

Masson, V., and Y. Seity, 2008: Including atmospheric layers in vegetation and urban offline surface schemes. Journal of Applied Meteorology and Climatology (under revision)

Lake model

Mironov, D.V., 2006: Parameterization of lakes in numerical weather prediction. Part I: Description of a lake model. German Weather Service, Offenbach am Main, Germany, 41 pp.

Mironov, D., A. Terzhevik, F. Beyrich, S. Golosov, E. Heise, G. Kirillin, E. Kournzeneva, B. Ritter, and N. Schneider, 2008: Parameterization of lakes in numerical weather prediction: description of a lake model and single-column tests (to be submitted to Geophysica)

Surface analysis schemes

Met Office

Smith, R.N.B., E.M. Blyth, J.W. Finch, S. Goodchild, R.L. Hall, and S. Madry, 2004: Soil state and surface hydrology diagnosis based on MOSES in the Met Office Nimrod nowcasting system. Met Office Forecasting Research Technical Report No 428, 35 pp.

COSMO

Hess, R., 2001: Assimilation of screen-level observations by variational soil moisture analysis. Meteorology and Atmospheric Physics, 77, 145-154

HIRLAM

Rodriguez, E. B. Navascues, J.J. Ayuso, and S. Järvenoja, 2003: Analysis of surface variables and parameterisation of surface processes in HIRLAM. Part I: Approach and verification by parallel runs. HIRLAM Technical Report No 59, Norrköping, Sweden, 52 pp.

ALADIN-LACE

Bouttier, F., J.-F. Mahfouf, and J. Noilhan, 1993: Sequential assimilation of soil moisture from atmospheric low-level parameters. Part I: Sensitivity and calibration studies. Journal of Applied Meteorology, 32, 1335-1351

Giard, D., and E. Bazile, 2000: Implementation of a new assimilation scheme for soil and surface variables in a global NWP model. Monthly Weather Review, 128, 997-1015

Coupling aspects

Best, M.J., A.C.M. Beljaars, J. Polcher and P. Viterbo, 2004: A proposed structure for coupling tiled surfaces with the planetary boundary layer. Journal of Hydrometeorology, 5, 1271-1278

Bouyssel, F., S. Gollvik, G. Hello, L. Kraljevic, P. Le Moigne, E. Martin, V. Masson, S. Tijm and P. Termonia, 2007: Scientific and technical issues for a joint collaboration between HIRLAM and ALADIN on surface parameterizations, Internal report, 11pp.

Physiographic data bases

ALADIN-LACE

Masson, V., J.-L. Champeaux, F. Chauvin, C. Mériguet, and R. Lacaze, 2003: A global database of land surface parameters at 1-km resolution in meteorological and climate models. Journal of Climate, 9, 1261-1282.

Relevant web sites

FLake : http://lakemodel.net
Land SAF : http://landsaf.meteo.pt
OSI SAF : http://osi-saf.org

Summary of planned actions

Modelling aspects

Implementation and validation of FLake within ALADIN, COSMO, HIRLAM, LACE and MetOffice (use of common datasets for validation studies)
Evaluations and validations of the externalized surface module SURFEX within ALADIN, HIRLAM, and LACE.
New SURFEX developments within ALADIN and HIRLAM (snow-forest canopy interactions, desertic dust transport module)
Diagnostics on 2m parameter diagnostic formulations (e.g. CANOPY, QSNE-based stability functions) within ALADIN, LACE, HIRLAM and COSMO (use of common validation datasets)
Continuous monitoring and validation of simulated soil parameters against high quality observations from selected measurement sites within ALADIN and COSMO.

Data assimilation aspects

Implementation of the analysis system CANARI for screen-level parameters, SST, sea-ice within ALADIN, HIRLAM and LACE following an intercomparison study.
Implementation of the OI soil analysis system within ALADIN, HIRLAM and LACE
Evaluation of satellite derived albedo from LandSAF within ALADIN and LACE
Development of a snow analysis scheme within CANARI for ALADIN, HIRLAM and LACE using experience from COSMO and MetOffice
Development and validation of an EKF soil analysis scheme using SURFEX within ALADIN, HIRLAM, and LACE

Specific developments in each consortium

Modelling

Development of a multi-layer snow scheme (MetOffice)
Implementation and tuning of snow and forest schemes (HIRLAM)
Development of a snow on ice parameterisation in HIRLAM (to be further included in SURFEX)
Development of MSO/SSO parameterisation and near surface winds in connection with surface roughness and surface exchanges (HIRLAM)
Revised external parameters and modifications to plant transpiration in the surface scheme (COSMO)
Implementation of the Van Genuchten soil hydraulics (MetOffice)
Development of a flexible tile structure including elevation bands (MetOffice)
Coordination and technical developments of the new community land surface model JULES (Joint UK Land Environment Simulator) based on MOSES (MetOffice)

Data assimilation

Revision to the soil moisture analysis scheme (COSMO)
Implementation of a soil temperature nudging scheme (MetOffice)
Evaluation of JULES driven by the NLDAS forcing (MetOffice)

Recommended exchanges of information on:

- The documentation of the surface modelling and analysis systems in each consortium
- Experience regarding more advanced aspects on surface processes in each consortium

- Physiographic databases for soil, vegetation, urban areas, lakes, anthropogenic sources Description of orography and orographic effects
- Validation sites (observational datasets in terms of soil moisture, surface fluxes)