The BALTEX regional reanalysis project

Interrim report for special project spfihlbg "Better exploitation of existing observing systems in BRIDGE"

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1. Overview

The BALTEX regional reanalysis project is a joint undertaking of the Finnish (FMI) and Swedish (SMHI) national meteorological services, organized as an ECMWF special project (Fortelius et al, 2002). Its objective is to carry out high resolution data assimilation around the Baltic drainage basin (Fig. 1) over one year during the BALTEX main experiment BRIDGE (Sept. 1999–Oct. 2000), and thereby to promote the use of assimilation products in regional climate system research. A specific objective is to produce gridded fields of all components needed to close the energy and water cycles, with a spatial resolution of 22 km and a temporal resolution of six hours. The assessment of these products using available independent measurements constitutes a significant part of the project. Details about the project status and data archive are given on the project home page, which is linked to the BALTEX web site http://w3.gkss.de/baltex/.

2. Assimilation system

The assimilation system used is a specially designed version of the HIRLAM numerical weather prediction system maintained by the international HIRLAM project, consisting of the national meteorological services of Denmark, Finland, France, Iceland, Ireland, The Netherlands, Norway, Spain, and Sweden.In the BALTEX configuration, the atmospheric forecast model is a hydrostatic two time level, semi-Lagrangian, semi-implicit limited area grid point model (Källen 1996). Prognostic variables are surface pressure, horizontal wind, temperature, specific humidity, specific cloud condensate and the kinetic energy of small scale turbulence (TKE). The model is run with a horizontal resolution of approximately 22 km, and has 31 levels in the vertical.

Parameterized processes include radiation (Savijärvi 1990), grid scale condensation and precipitation (Rasch and Kristjansson 1998), deep and shallow convection (Kain and Fritsch 1998) and vertical mixing by small scale turbulence according to Cuxart et al. (2000). The convection and turbulence are intimately connected through the TKE, that is used for triggering shallow convection and for defining the mixing length of the turbulent diffusion. The surface fluxes of momentum, sensible heat and latent heat are treated in the framework of a Monin-Obukhov surface layer with stability-dependent drag coefficients.

At the surface each grid box contains of a certain fraction on land, sea or ice. Fluxes

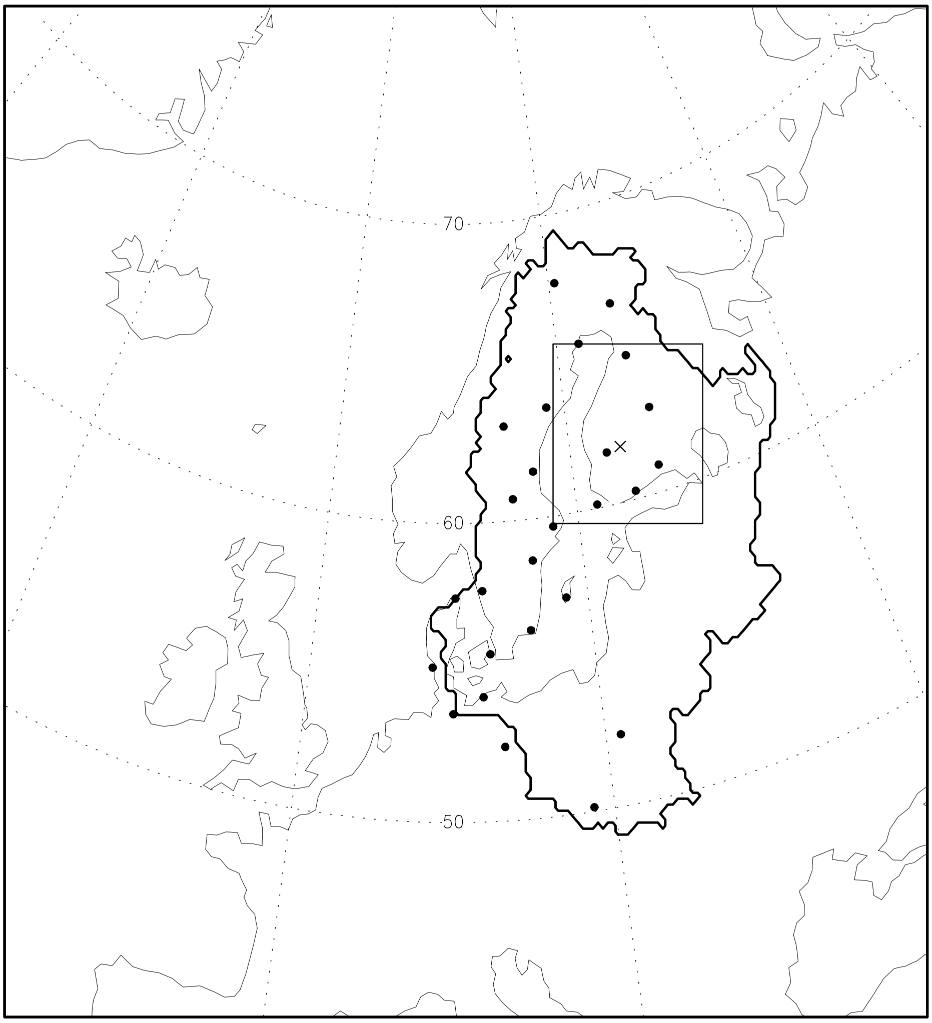

Figure 1: The BALTEX reanalysis area. The heavy closed contour indicates the drainage basin of the Baltic Sea. Black circles indicate weather radars. The significance of the rectangle over Finland is explained in Section 4.

are computed individually for each surface type, and averaged over the grid box. The energy and water budgets of the soil and vegetation are treated as in the second version Rossby Centre climate model (Bringfelt et al. 2001): The land points are divided in forest and open land. The evapotranspiration includes transpiration from the vegetation, evaporation of water intercepted on the canopy, and evaporation from bare soil. Parameterization of soil moisture and runoff is based on soil moisture variability functions traditional in hydrological models.

The analysis of atmospheric variables is based on a variational formulation (3DVAR). It minimizes a cost function measuring the distance between the model state and a background field and the model state and the observations respectively (Gustafsson et al. 2001, Lindskog et al. 2001). The analyzed atmospheric state is filtered with respect to gravity waves using a diabatic digital filter to get a balanced initial field for the prognostic model.

The observations used are extracted from the archives of the ECMWF. They consist of surface data from reporting weather stations, ships and drifting buoys, and upper air data from radio soundings and reporting aircraft. During BRIDGE SMHI and FMI have increased the number of globally-disseminated surface observations (SYNOP-reports).

The analysis of surface variables includes assimilation of snow and sea surface temperature (SST) observations. The SST and ice evolution in the Baltic Sea is described with a coupled ice-ocean model (Gustafsson et al. 1998). The model SST is adjusted through a nudging process with observations from the marine service SMHI twice a week. The numerous inland lakes in Scandinavia are described with slab and one-dimensional lake model (Ljungemyr 1996). The lake model as well as the Baltic Sea model are forced with atmospheric data from the forecast model, and are coupled back through the updated temperature and ice fields.

The assimilation cycle is 6 h and at every cycle a 30 h forecast is run. At the lateral boundaries the atmospheric model is forced by operational analyses from the archives of ECMWF, updated every three hours.

3. Data archive

The BALTEX BRIDGE data assimilation archive describes the physical evolution of the climate system as analyzed and predicted by HIRLAM. Snapshots of atmospheric motion, temperature, specific humidity, specific cloud condensate, turbulent kinetic energy, diagnostic cloud cover, and surface pressure are available every six hours on the grid of the forecast model. The sea surface is described by the sea surface temperature, ice cover, and roughness, while the snow pack, soil temperature and soil water content are available over land. In addition physiographical data on orography, distribution of land and sea etc. are available, as are diagnostic variables like temperature and moisture at screen level, wind at 10 m above ground, and cloud cover.

The snapshots are augmented with the cumulative effects of parameterized physical processes. These include two-dimensional fields of radiative fluxes at the top of the atmosphere and at the surface, surface fluxes of sensible heat, latent heat, and momentum, as well as precipitation, evaporation, and local runoff. In addition, three-dimensional distributions of the flux of precipitating water, the local cumulative tendencies of temperature, humidity, and cloud condensate due to turbulence alone and to all parameterized processes together, and the temperature tendency by radiation, are stored on a sub set of the model grid, covering the catchment basin of the Baltic Sea. Other processes of interest, such as the net condensation of water vapour or the convective fluxes of sensible and latent heat can be studied by forming linear combinations of the stored fields. Like the snapshots, the cumulative fields have a temporal resolution of six hours, but a selection of two-dimensional fields is available every hour.

4. Preliminary results

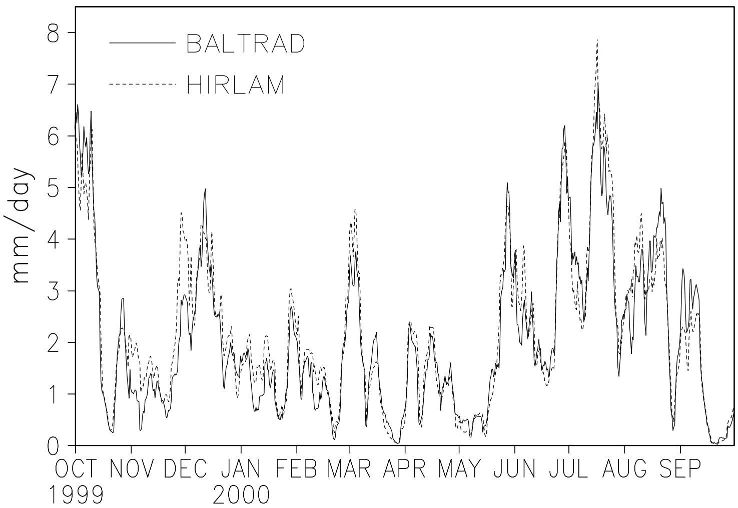

Figure 2: Areal precipitation amounts for the rectangular region covering southern Finland. The dashed lines show 5-day running averages as given by the reassimilation model, while the solid lines are base on 12-hourly gridded precipitation totals from the BALTEX Radar Data Centre.

The assimilation for the 1st BRIDGE year (Oct. 1999-Sept 2002) was completed in the spring of year 2002, and analysis of the results is still going on. Fig. 2 demonstrates the ability of our assimilation system to predict areal rainfall amounts. The graphs shown represent five-day running averages of the areal precipitation over the rectangular area covering southern Finland in Fig. 1. Solid lines are based on precipitation retrievals from the BALTEX Radar Data Centre (Michelson et al., 2000), while dashed lines are given by the assimiation system. The latter are based on hours 6-12 from four cycles for each day. We find the good correspondence between the two totally independent estimates encouraging.

5. References

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