Nordic Temperature Problem - plan and status
Draft/LR

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1 The problem and status of work

In a working meeting in Helsinki the 31st of January 2005, the Nordic Temperature Problems were defined as follows:

Northern winter problem

In the model, too warm predicted near-surface temperatures in a stable arctic boundary layer. Differences between observation and forecast of the order of ten degrees are common. In reality, clear sky, no significant SW radiation, shallow surface layer with strong surface temperature inversion over snow covered surface. Relative humidity may be large but not close to saturation. Observed latent and sensible heat fluxes are small, in the model generally somewhat larger. Extra clouds/fog seem to form in HIRLAM.

Northern spring problem

Too cold daytime near-surface temperatures, supressed diurnal cycle. Differences between observation and forecast of the order of ten degrees are common. Clear sky cases, magnitude of measured SW radiation and heat fluxes increase towards summer. At least some snow on ground but typically not on trees, ice cover on lakes. In the model heat fluxes are often large, compensate each other and the ratio of sensible (smaller)/latent (larger) heat is often incorrect. Excessive cloudiness and humidity are frequently produced by the model.

In the January meeting, a plan for further studies was outlined. After the meeting, several people have continued working with the different aspects of the problem. Significant amount of e-mail exchange, a short meeting during the All Staff Meeting 2005, some local seminars and one report published in the Hirlam Newsletter 47 (Tijm, 2005) have emerged during February-March 2005. Material related to the problem was made available at the web site hirlam.fmi.fi/NorTemPro. In the following, directions of the ongoing work are discussed. The plans are related mainly to the winter problem, because here it is realistic to expect finding solutions relatively soon, based on the work already done and ongoing.

2 New surface-snow scheme

A new version of HIRLAM surface scheme, with improved handling of snow surface, has been developed by (Gollvik, 2005). It has been tested in one-dimensional HIRLAM by (Tijm, 2005), the results showing encouraging improvements both in winter and in spring. A plan for preparation and running extensive three-dimensional model comparison was agreed during ASM05. A version based on HIRLAM v. 6.3.5 is suggested for comparisons.

Before starting the 3D experiments,

◦ Prepare a list of the new variables used in the scheme. *Stefan*, **status: done**.

◦ Decide which T_{2m} (forest) variable to use in data assimilation and verification. Test all candidates against Sodankylä mast and SYNOP data. **status: unknown**

◦ Include the data assimilation step. *Ernesto*, **status: ongoing**.

◦ Check the v. 6.3.5 code for remaining critical bugs. *Stefan, Ernesto*, **status: ongoing**.

As soon as the code is considered ready, the three-dimensional tests will be started at ECMWF computers by *Timo*, supported by Laura and Kalle. Sodankylä data set first for winter, then for spring will be used in comparisons. Periods after Nov 2004 will be used, because for them data from RCR 6.3 and RCR 6.4 already exist. **status: waiting**.

Things to develop further:

◦ A more physical soil freezing to be implemented *Ernesto?*

◦ Cleaning up SURTEND_SNOW, so that routine CALCTEND is used *Ernesto, Stefan?*

◦ Add a new variable for snow on ice *Stefan*

The aim is to have the snow scheme tested and implemented into HIRLAM reference in early autumn 2005. For this, three-dimensional tests at ECMWF should be started not later than in May. In addition, seasonal tests are planned at SMHI.

3 Condensation-related problems

It has been shown by (Tijm, 2005) and suspected in several e-mails between Sander, Karl-Ivar and Bent that too effective condensation or ineffective removal of cloud (fog) condensate could be partly responsible for the winter and spring problems, via interaction with short- and long-wave radiation. The two condensation schemes available in the reference HIRLAM, STRACO and KFRK, behave differently especially in spring cases.

To do:

◦ Check in Sodankylä cloud and radiation observations if a systematic correlation exists between too high low cloud amount/cloud condensate content and too warm near-surface temperatures in HIRLAM. *Zhenya, Timo, Laura*, **status: to be started**

◦ Study the possible reasons of the problem in the formulation of the parametrizations and compare STRACO and KFRK behaviour. *Bent* in contact with *Karl-Ivar, Paulius?*, **status: starting**.

◦ Think about the (future) role of moist turbulence parametrizations. *Sander*, **status: waiting for advances in moist CBR work**.

Related:

◦ Study the sources and sinks of atmospheric moisture: where is the extra/missing condensate originating from? A water budget-type study needed?

◦ Formation of fog/low status in spring conditions near coast-line and over sea/ice. Behaviour of condensation parametrizations and moist turbulence in these situations.

4 Stable arctic boundary layer

Based on theoretical studies, LES results and some observations reported e.g. by (Zilitinkevich and Esau, 2005), earlier by (Perov et al, 2001) it is evident that new approaches into the parametrization of long-lived stable arctic boundary layer (LSABL) are needed and may lead to at least partial improvements in handling the coldest near-surface temperatures. Systematic comparison of model and Sodankylä observations in the problematic for HIRLAM LSABL situations, from the point of view of surface/boundary layer, is a natural first step in this direction.

To do:

◦ Use Sodankylä mast heat flux and temperature observations + sounding data to identify periods of LSABL and see if they coincide witht the poor T_{2m} predictions in HIRLAM. Related

questions:

◦ What is the observed height of planetary boundary layer?

◦ Do capping inversions exist, what would be their role in nature/model?

◦ What is the role of vertical resolution of the model in situations of very shallow boundary layer?

At the same time, develop further the parametrizations and test them in the framework of one-dimensional HIRLAM.

Related:

◦ Roughness in forest, possible dependent on static stability. Relation to wind and wind profiles.

Persons: Sergei, Veniamin, Timo, Zhenya, **status: ongoing with moderate speed from the theoretical side; depending on Sodankylä data set.**.

5 Radiation problems

An underestimation of downwelling longwave arctic clear sky fluxes, common in NWP radiation parametrizations, was discusssed already by (Savijarvi, 2001). Improvements were suggested by (Räisänen et al., 2000) and partly implemented into HIRLAM as described by (Rontu and Järvenoja, 2003; Rontu and Senkova, 2003). Comparisons in Cabauw/DeBilt were done by Sander, Ulrika and Hannu - unexplained underestimation revealed by ECMWF and HIRLAM radiation code, so problems in sounding or radiation measurements there are possible. It has also been suspected that formulation of (ice-)cloud long-wave emissivity needs improvement, because at present HIRLAM may overestimate SLWDN in cloudy cases, that contributes to the too warm winter temperatures.

To do:

◦ Compare systematically the measured and predicted radiation fluxes in Sodankylä (Cabauw). In Sodankylä, measurements of SLWDN have been obtained in addition to the present SSWDN, SSWUP and SLWUP.

◦ Run one-dimensional comparisons of the HIRLAM scheme with ECMWF-RRTM.

Persons: Ulrika, Nastya in contact with Petri, Hannu and Klaus. **Status: ongoing**, Ulrika's and Hannu's results reported in e-mails.

6 Preparation of Sodankyla data set for comparisons

A Nordic Temperature Problem data set should be extracted from the regularly collected meteorological mast profile, flux, sounding, SYNOP data in Sodankylä. The data should be processed, described and needed tools provided for the use of interested researchers.

Persons: Zheniya, Markku, Laura, Priit in contact with Cisco and Eric, **status: ongoing**, Eric's results reported by e-mail.

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