Testing HIRLAM surface and orography parametrizations

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Contribution to evaluation of surface-related parametrizations

• Build a new snow + orography framework for comparisons
• Try HARMONIE verification tools
• Detect problems and suggest improvements
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- Build a newsnow + orography framework for comparisons
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Schemes touched in the study

- “Newsnow” surface parametrizations
- Subgrid orography parametrizations
- QNSE stability functions
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Behaviour of the schemes in
• Mountains
• Sodankylä
• (Eastern Africa)
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Related material in Newsletter 53 (Kabelwa et al, Rontu)

“Newsnow” maybe influenced by developments of HIRLAM code
also outside the surface parametrizations
Schemes and definitions
Schemes and definitions

Newsnow

- Advanced treatment of soil and surface processes especially over snow/ice and in forest
- Based on ISBA, tiled and with heat diffusion in soil
- Samuelsson et al, 2006. The land-surface scheme of the Rossby Centre regional atmospheric climate model (RCA3).

SMHI, Meteorologi 122
Schemes and definitions

Newsnow

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- Samuelsson et al, 2006. The land-surface scheme of 
  the Rossby Centre regional atmospheric climate model (RCA3).
  SMHI, Meteorologi 122

MSO/SSO - Meso-scale and small-scale orography effects

- Wave and form drag due to hills and mountains
- (Enhanced) orographic roughness removed everywhere
- MSO based on Meteo France GWD parametrizations
- Rontu, 2006. A study on parametrization of
  orography-related momentum fluxes in a
  synoptic-scale NWP model. Tellus, 58A
Orographic effects on radiation

- Radiation on sloping surfaces
Orographic effects on radiation

- Radiation on sloping surfaces


QNSE - Quasi-normal scale elimination

- Advanced theory leading to new stability functions for ISBA and CBR

- (HIRLAM implementation is fragmentary)

Orographic effects on radiation

- Radiation on sloping surfaces

QNSE - Quasi-normal scale elimination

- Advanced theory leading to new stability functions for ISBA and CBR
- (HIRLAM implementation is fragmentary)

Alternative for turbulence

- Tuning of coefficients related to surface exchange
- Removal of surface turbulent stress turning
- De Bruijn and Tijm, 2008. Overall tuning of the turbulence scheme of HIRLAM with the focus on the stable boundary layer. Newsletter 53
# HIRLAM experiments

Table 1: HIRLAM experiment properties

<table>
<thead>
<tr>
<th></th>
<th>Northern domain</th>
<th>East Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIRLAM versions</td>
<td>“newsnow” before Easter</td>
<td></td>
</tr>
<tr>
<td>resolution</td>
<td>17km/60L</td>
<td>11km/60L</td>
</tr>
<tr>
<td>period</td>
<td>January 1-15, 2007</td>
<td>April 1-10, 2006</td>
</tr>
<tr>
<td>domain</td>
<td>North Atlantic-European</td>
<td>Tanzanian</td>
</tr>
<tr>
<td>initial analysis</td>
<td>3DVAR</td>
<td>interpolated ECMWF (climate mode)</td>
</tr>
<tr>
<td>parametrizations</td>
<td>STRACO for condensation</td>
<td>STRACO for condensation</td>
</tr>
<tr>
<td>boundaries</td>
<td>ECMWF analysis</td>
<td>ECMWF analysis</td>
</tr>
<tr>
<td>validation</td>
<td>HARMONIE tools + Sodankylä</td>
<td>HARMONIE tools</td>
</tr>
</tbody>
</table>

Table 2: Experiment names

<table>
<thead>
<tr>
<th>Experiment</th>
<th>MSO/SSO/Radoro</th>
<th>QNSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>72aos3</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>72aosv</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>72aosv0</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>72T11r</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>
January 2007 Sodankylä: HIRLAM reference a year ago

Temperature AWS 2m/Hirlam 2m

Temperature mast 31m/Hirlam 32m

Temperature gradient Ts-Tnlev mast/Hirlam

Screen level temperature  Exp 71b1SR Station Soda

T (31m) 71b1SR - Station Soda (32m)

Temperature gradient Exp 71b1SR sfc-nlev - Station Soda T(skin)-T(32m)
January 2007 Sodankylä: HIRLAM “newsnnow” a year ago

Temperature AWS 2m/Hirlam 2m

Temperature mast 31m/Hirlam 32m

Temperature gradient Ts-Tnlev mast/Hirlam
Temperature AWS 2m/Hirlam 2m

Temperature mast 31m/Hirlam 32m

Temperature gradient T2m-Tnlev mast/Hirlam
January 2007 Sodankylä: HIRLAM “newsnow” no oro no qnse

Temperature AWS 2m/Hirlam 2m

Temperature mast 31m/Hirlam 32m

Temperature gradient T2m-Tnlev mast/Hirlam
January 1-15, 2007 72aos3, ALL stations

10-metre wind speed, bias = 0.72
January 1-15, 2007 72aosv, ALL stations

10-metre wind speed, bias = 0.60

Scatterplot for 2248 stations
Wind speed
At {00,12} + 06 18
Period: 20070101-20070115

Obs = 120885

y mean = 4.8  y stdv = 3.3
x mean = 4.2  x stdv = 3.7
BIAS (y-x) = 0.60
RMS = 2.98
corr. coeff = 0.750
January 1-15, 2007 72aosv0, ALL stations

10-metre wind speed, bias = 0.33

Scatterplot for 2248 stations
Wind speed
At \{00,12\} + 06 18
Period: 20070101-20070115

Obs = 120891

y mean = 4.6  y stdev = 3.2
x mean = 4.2  x stdev = 3.7
BIAS (y-x) = 0.33
RMS = 2.48
corr. coef = 0.756
January 1-15, 2007 72aos3, European mountains

10-metre wind speed, bias = 0.12

Scatterplot for 346 stations
Wind speed
At {00,12} + 06 18
Period: 20070101-20070115

Obs = 18621

y mean = 4.3 y sdev = 2.9
x mean = 4.2 x sdev = 4.3
BIAS (y-x) = 0.12
RMS = 3.80
corr. coef = 0.507
January 1-15, 2007 72aosv, European mountains

10-metre wind speed, bias = 0.02

Scatterplot for 346 stations
Wind speed
At {00,12} + 06 18
Period: 20070101-20070115

Obs = 18617

y mean = 4.2  y stdev = 2.9
x mean = 4.2  x stdev = 4.3
BIAS (y-x) = 0.02
RMS = 3.79
corr. coeff = 0.510
January 1-15, 2007 72aosv0, European mountains

10-metre wind speed, bias = -0.83

Scatterplot for 346 stations
Wind speed
At {00,12} + 06 18
Period: 20070101-20070115

Obs = 18621

y mean = 3.3 y stdev = 2.3
x mean = 4.2 x stdev = 4.3
BIAS (y-x) = -0.83
RMS = 3.73
corr. coeff = 0.544
January 1-15, 2007 72aos3, European mountains

2-metre temperature, bias = 0.11

Obs = 19210

y mean = 1.3  y stdev = 5.2
x mean = 1.2  x stdev = 5.4
BIAS (y-x) = 0.11
RMS = 3.56
corr. coef = 0.776
January 1-15, 2007 72aosv, European mountains

2-metre temperature, bias = -0.67

Scatterplot for 354 stations
Temperature
At {00,12} + 06 18
Period: 20070101-20070115

Obs = 19100

y mean = 0.5  y stdev = 5.7
x mean = 1.2  x stdev = 5.4
BIAS (y-x) = -0.67
RMS = 3.92
corr. coef = 0.759
January 1-15, 2007 72aosv0, European mountains

2-metre temperature, bias = -0.83

Scatterplot for 354 stations
Temperature
At {00,12} + 06 18
Period: 20070101-20070115

Obs = 19210

y mean = 0.3  y stddev = 5.9
x mean = 1.2  x stddev = 5.4
BIAS (y-x) = -0.83
RMS = 4.23
corr. coef = 0.737
January 1-15, 2007 surface pressure (1)

72aosv0 v.s. 72aos3 \approx \text{ref newsnow} \text{ v.s. all modifications}

**Graph 1:** Statistics for 1689 stations
Period: 20070101-20070115
Surface pressure Hours: [00,12]
Solid RMS; Dashed BIAS; Dashed grey is number of cases

**Graph 2:** Statistics for 133 stations
Period: 20070101-20070115
Surface pressure Hours: [00,12]
Solid RMS; Dashed BIAS; Dashed grey is number of cases

MOU:
January 1-15, 2007 surface pressure (2)

$72\text{ao}_v \text{ v.s. } 72\text{ao}_3 \approx \text{oro + no qnse} \text{ v.s. } \text{oro + qnse}$
January 1-15, 2007 surface pressure (3)

72aosv0 v.s. 72aosv ≈ ref newsnow -v.s. oro no qnse
Summary of the forecast-observation bias
Summary of the forecast-observation bias

Quick conclusions

- oroparametrizations + QNSE are good for temperatures everywhere
- oroparametrizations + tuned turbulence are good for mountain winds
- tuned turbulence without oroparametrizations are good for winds over the whole domain and for pressure everywhere
- (not shown) no significant differences from 925 hPa upwards

Table 3:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Wind ALL</th>
<th>Mountain</th>
<th>Temperature ALL</th>
<th>Mountain</th>
<th>Pressure ALL</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>72aos3</td>
<td>0.72</td>
<td>0.12</td>
<td>-0.40</td>
<td>0.11</td>
<td>-0.36</td>
<td>-0.65</td>
</tr>
<tr>
<td>72aosv</td>
<td>0.60</td>
<td>0.02</td>
<td>-1.00</td>
<td>-0.67</td>
<td>-0.25</td>
<td>-0.40</td>
</tr>
<tr>
<td>72aosv0</td>
<td>0.33</td>
<td>-0.83</td>
<td>-1.05</td>
<td>-0.83</td>
<td>-0.22</td>
<td>-0.33</td>
</tr>
</tbody>
</table>
The problem of calm cases

Frequency distribution for 346 stations
Wind speed Period: 20070101-20070115
Number of cases 18621 Number of classes 25
At (00,12) + 06 18

Frequency distribution for 346 stations
Wind direction Period: 20070101-20070115
Number of cases 18788 Number of classes 25
At (00,12) + 06 18
The problem of representativeness

Wind velocity Exp 72aos_72ans 10m Station Strb

Wind velocity Exp 72aos_72ans 10m Station Schw
Newsnow in Tanzania

Temperature
At {00} + 06 18
Period: 20060401-20060409

Specific humidity
At {00} + 06 18
Period: 20060401-20060409
Newsnow in Tanzania
Concluding remarks
Concluding remarks

Did we learn something from this study?

- Schemes are better for some parameters and domains, worse for others
  - no clear winners
- There is a need to improve, tune, combine different aspects
  of all these schemes and their implementation
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Things to study and develop further

- Removal of the effective roughness - main influence out of mountains?
- Consistent implementation of QNSE functions
  (switchable on/off) and a sensitivity study
- Connections between the surface layer and the whole boundary layer
- Behaviour and parametrization of the breaking (orographic) buoyancy
  waves in the boundary layer
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  waves in the boundary layer

It is not easy to improve model by physical parametrizations

- Significant positive-only signals are not so common nowadays
- Validation and comparison methods need developments, too
- The amount of possible code combinations is increasing - supermarket?
- The best schemes and combinations are those with the least amount of coding errors?
- Methods of code development and implementation require attention
  in the HIRLAM-HARMONIE framework
Thanks to
Stefan Gollvik, SMHI (newsnow)
Jevgeni Atlaskin, RSHU (QNSE)
Hamza Kabelwa, RSHU and TMA (Tanzania)
Ulf Andrae, SMHI (verification tools)

Thank YOU for attention!