Verifying NWP-model chains by using model independent analyses

Manfred Dorninger and Theresa Gorgas
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1. Motivation

Draw-up an “ideal“ verification scheme for an inter-comparison of model chains

Criteria/Tasks/Challenges:

• verify the whole model chains including their global model
• use same initialisation time and forecast periods for all models
• run over unified verification area
• use novel (spatial) verification methods
• verify multiple meteorological parameters (not only precip.)
• use NWP model independent analyses as reference
2. Data
2.1. Observation data (JDC-data) and VERA analysis

JDC-data: WWRP D-PHASE (FDP, Rotach, et al., 2009, BAMS) and WWRP COPS (RDP, Wulfmeyer, et al., 2008, BAMS), data available: (http://cera-www.dkrz.de/WDCC/ui/Index.jsp)

- 32 data providers
- GTS-Stations: 1232
- NGTS-Stations: > 13000
- Mean station distance: GTS: ~ 36km
  GTS+Non-GTS: ~ 12km

Frames:
- D-PHASE (black, large)
- COPS (black, small)
- this study (green)

Red: Non-GTS stations
Blue: GTS stations
2.1. Observation data (JDC-data) and VERA analysis

*The analysis scheme VERA*

(Vienna Enhanced Resolution Analysis)

- Data quality control scheme
- Thin-Plate-Spline algorithm
- Downscaling via the „Fingerprint“ method

Not dependent on first guess fields – „model independent“

<table>
<thead>
<tr>
<th>Wind</th>
<th>Potential Temperature</th>
<th>Precipitation: Accumulated to 1h, 3h, 6h, 12h, 24h</th>
<th>Post processing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSL - pressure</td>
<td>Equivalent – Pot. Temperature</td>
<td></td>
<td>- Mixing Ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Moisture Flux</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Divergence</td>
</tr>
</tbody>
</table>

2.2. NWP-model chains

- Selection from D-PHASE model ensemble

• selected models should reflect the variety of model types in terms of dynamics, parametrisation, hydrostatic vs. non-hydrostatic and convection-permitting models
• same initialisation time → do not use the coupled model runs, model starts from the same observations.
• same forecast period
• overlapping of the model domains maximized → same topography and same weather situation are described by the models
### 2.2. NWP-model chains

- Selection from D-PHASE model ensemble

<table>
<thead>
<tr>
<th>Model</th>
<th>Model abbreviation</th>
<th>Mesh Size</th>
<th>Init. UTC</th>
<th>Forec. Range [h]</th>
<th>Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chain 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECMWF-</td>
<td>ECM</td>
<td>25km</td>
<td>00, 12</td>
<td>240</td>
<td>ECMWF</td>
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<tr>
<td>ECMWF-BC</td>
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<td>25km</td>
<td>00, 06, 12, 18</td>
<td>90</td>
<td>ECMWF</td>
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<tr>
<td>COSMO-7</td>
<td>CO7</td>
<td>7km</td>
<td>00, 12</td>
<td>72</td>
<td>Meteo Swiss</td>
</tr>
<tr>
<td>COSMO-2</td>
<td>CO2</td>
<td>2.2km</td>
<td>00, 03, 06, 09, 12, 15, 18, 21</td>
<td>24</td>
<td>Meteo Swiss</td>
</tr>
<tr>
<td><strong>Chain 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARPEGE</td>
<td>ARP</td>
<td>0.25/0.5 deg (lat/lon)</td>
<td>00</td>
<td>72</td>
<td>Météo-France</td>
</tr>
<tr>
<td>ALADIN-FR</td>
<td>ALA</td>
<td>9.5km</td>
<td>00</td>
<td>30</td>
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<tr>
<td>AROME</td>
<td>ARO</td>
<td>2.5km</td>
<td>00</td>
<td>30</td>
<td>Météo-France</td>
</tr>
<tr>
<td><strong>Chain 3</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>CMC-GEM</td>
<td>CMG</td>
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<td>00</td>
<td>24(144)</td>
<td>Environment Canada</td>
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<td>CMC-GEM-L</td>
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<td>00</td>
<td>24</td>
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<tr>
<td>CMC-GEM-H</td>
<td>CMH</td>
<td>2.5km</td>
<td>06</td>
<td>18</td>
<td>Environment Canada</td>
</tr>
</tbody>
</table>
2.2. NWP-model data

All model data are interpolated on the VERA 8 km grid:

ARO: 600 x 704 km; 6764 GP
All other models: 1056 x 704 km; 11837 GP
3. Verification strategy and methods

Evaluation period:
- Overall evaluation (D-PHASE period; Jun-Nov 2007)
- Case studies

Evaluation domain:
- whole domain
- elongated sub-domain (analyse frontal propagation)

Parameters:
- precipitation
- but also $\Theta_e$, wind, frontal speed and location

Verification scores:
- traditional verification metrics (e.g., bias-corrected RMSE)
- novel verification metrics (e.g., SAL, ISS, wavelet coherence)
4. Results
4.1 Overall evaluation

BC_RMSE: no added value of HRES models visible $\rightarrow$ double penalty problem

Intensity-scale skill score (ISS, Casati et al., 2004)
1: perfect forecast
0: no skill added to reference forecast
4. Results

4.2 Case studies

Convective case: 7 Aug. 2007
Morning hours: MCS
Afternoon: shower cells over large area

Frontal case: 18 Sept. 2007
Fast moving front from west to east
impinging the Alps
4. Results
4.2 Case studies

SAL: Structure – Amplitude – Location (Wernli et al., 2008)
perfect forecast: $S=A=L=0$
4. Results
4.2 Case studies

- **Convective case**
  - CO7: 07.08. - 08.08.
  - ALA: 07.08. - 08.08.
  - CML: 07.08. - 08.08.

- **Frontal case**

Precipitation amount is...

- I: $S > 0$, $A > 0$
  - too large and/or too flat
  - underestimated

- II: $S > 0$, $A < 0$
  - too small and/or too peaked
  - overestimated

- III: $S < 0$, $A < 0$
  - too small and/or too peaked
  - underestimated

- IV: $S < 0$, $A > 0$
  - too large and/or too flat
  - overestimated
4. Results

4.2 Case studies

Frontal case:

meridional mean of W-E gradient of $\Theta_e$. 
4. Results
4.2 Case studies

Hovmöller diagram
Propagation speed: inverse slope $\Delta x/\Delta t$
Horizontal line $\rightarrow$ prop. Speed = infinite
Vertical line $\rightarrow$ stationary "system"

0.1 K/km
4. Results
4.2 Case studies

Estimated propagations speeds:
VERA: 15 m/s
ECM: 17 m/s
CO7: 15 m/s
CO2: 12 m/s – 18 m/s
5. Summary and Outlook

• Criteria established for a fair model chain inter-comparison
• use of NWP model independent analyses as reference based on JDC-data set
• selection of verification scores used to address the question: Can HRES models add skill to their coarse driving models?
• other meteorological parameters than precipitation are verified
• results indicate a different picture for each model chain

→ Invitation to participate in ICP2:
   side meeting at 18h30 in G10

http://www.ral.ucar.edu/projects/icp/index.html
References:


