Mesoscale Verification Inter-Comparison over Complex Terrain (MesoVICT) project

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Background

Above Figure from Beth Ebert
Background
Background

Fig. 2 from G. et al. (2010, 10.1175/2010BAMS2819.1)
Filter Methods: Smoothing/Neighborhood

Fractions Skill Score (FSS)

\[
\text{FSS} = 1 - \frac{\sum_{s=1}^{n} (\hat{P}_s - P_s)^2}{\sum_{s=1}^{n} \hat{P}_s^2 + \sum_{s=1}^{n} p_s^2}
\]

Filter Methods: Scale Separation
Distance Measures

MED(A, B) is the average distance from points in the set B to points in the set A.

\[ MED(A, B) = \frac{\sum_x d(x, A \mid x \in B)}{N_B} \]

MED(B, A) is the average distance from points in the set A to points in the set B.

\[ MED(B, A) = \frac{\sum_x d(x, B \mid x \in A)}{N_A} \]

\( N_B \) is the number of points in the set B.
Distance Measures

Distance maps for A and B. Note dependence on location within the domain.
**Distance Measures**

**Baddeley’s Δ Metric**

\[ \Delta = |\omega(d(x, A)) - \omega(d(x, B))| \]

- \( p = 1 \) gives the arithmetic average of \( T \)
- \( p = 2 \) is the usual choice
- \( p = \infty \) gives the max of \( T \)
  (Hausdorff distance)

\( \Delta \) is the \( L_p \) norm of \( T \)

\( d(x, A) \) and \( d(x, B) \) are first transformed by a function \( \omega \). Usually,
\( \omega(x) = \max(x, \text{constant}) \), but all results here use \( \infty \) for the constant term.

\[ \Delta(B, A) = \Delta(B, A) = \left[ \sum_{x \in D} T^p \right]^{1/p} / |N| \]

\( |N| \) is the size of the domain, \( D \).
Image Warping

Forecast Image \((F(s))\)

Observed Image \((O(s))\)

Warped Image \((F(W(s)))\)

Graphic by Johan Lindström
Image Warping
Feature-based Methods

Results show (1) forecasts have some skill in capturing these events and (2) in which aspects the forecasts need improvement.

Ex: 90\textsuperscript{th} percentile of precipitation; storm placement/timing.
ICP Phase 1

WRF2 CAPS – STAGE II

WRF4 NCAR – STAGE II

WRF4 NCEP – STAGE II

Legend:
- Green: Observation
- Red: Forecast

Maps show data comparison and analysis for different stages.
Core
Deterministic precip
+ VERA analysis
+ JDC obs
6 cases, min 1

Tier 1
Deterministic wind
+ VERA analysis
+ JDC obs

Tier 2a
Ensemble precip
+ VERA ensemble
+ JDC obs

Tier 2b
Ensemble wind
+ VERA ensemble
+ JDC obs

Tier 3
Other variables ensemble
+ VERA ensemble
+ JDC obs

Sensitivity tests to method parameters
MesoVICT

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

Observations-Joint D-PHASE COPS (JDC) data-set

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

Frames: D-PHASE (large) & COPS (small) areas
Case 1 (core case): 20-22 June 2007 (COPS IOP case)
Strong convective developments north of the Alps followed by a cold front the next day. Cold air mass could not spill over the Alps.

Precipitation analysis for the 3h-period ending at 21 June 2007, 00 UTC.

Equivalent potential temperature analysis for 21 June 2007, 12 UTC.
Planned contributions of participants (selection)

ISPRA, Italy, Stefano Mariani et al.: CRA, BOLAM, MOLOCH reruns

ARPA-ER, Italy, Andrea Montani et al.: DIST, COSMO-LEPS reruns.

COSMO Priority project: INSPECT, A. Bundel, F. Gofa

CETEMPS, Italy, R. Ferretti et al.: WRF-CETEMPS reruns

UK MetOffice, UK, M. Mittermaier et al.: model re-runs, neighbourhood method, FSS

University of Bonn, Germany, M. Weniger et al.: probabilistic forecasts and observation uncertainty, image warping and wavelet analysis

NCAR, USA, E Gilleland et al.: testing and refining the software SpatialVx

Environment Canada, Canada, B. Casati: model re-runs, intensity-scale skill score, neighbourhood- and displacement technique

University of Ljubljana, G. Skok: FSS adapted for wind
New Geometric Cases

P1: Null Case

P3: Two lines each on west and south border

P2: Full Case

P4: One line along each border

P5: Exactly one grid cell with value 1 and all else are zero.

P6: Same as P5, but upper right corner instead of lower left.

P7: Same as P5 and P6, but in center of grid.

P8: 1-valued grid cells in each corner.

P9: Four 1-valued grid cells located on boundaries midway between corners

Pathological Cases
New Geometric Cases

Circle Cases
New Geometric Cases

Complex Terrain Cases
New Geometric Cases

Random Rain Cases

Also one case of “Holes” (inversion of one of the circle cases) and two circle cases with noise added to them.
New Geometric Cases

- Baddeley’s $\Delta$ = 28.84
- Hausdorff = 40.20
- Centroid distance = 40.00
- Zhu’s metric = 36.81

$dFSS = 32$

$dFSS = 34$

$dFSS = 32$

$dFSS = 34$
New Geometric Cases

\[
\begin{align*}
\text{MED(False Alarm)} &= 21.92 \\
\text{MED(Miss)} &= 21.92 \\
\text{Pratt’s Figure of Merit} &= 0.07
\end{align*}
\]
Baddeley’s $\Delta = 38.13$
$\mathcal{D} = 38.17$
Hausdorff = 43.43
Centroid distance = 0.00
Zhu’s metric = 50.5
$dFSS$ undefined
MED(False Alarm) = 21.72
MED(Miss) = 0.00
Pratt’s Figure of Merit = 0.12
New Geometric Cases

Baddeley’s $\Delta = 18.84$
$\mathcal{D} = 18.85$
Hausdorff = 28.43
Centroid distance = 0.00
Zhu’s metric = 38.36

MED(False Alarm) = 11.24
MED(Miss) = 11.24
Pratt’s Figure of Merit = 0.32
Summary

• Overview paper of project accepted to BAMS (available at Early online release: https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-17-0164.1).

• Special Collection of Papers for Monthly Weather Review.

• SpatialVx (R package for performing many of the spatial methods; still in beta form—use at your own risk!).

• All test cases and other information (including preliminary results) available at MesoVICT web site (https://ral.ucar.edu/projects/icp/).

• New geometric cases available soon (paper in progress).