COSMO models (8) comparison over Italian alert areas: long trends and last year review

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The methods

Precipitation- high resolution network → problems with the data: dataset not stable in time, data not always reliable..

• Common area → Italy
• Method → 24h/6h averaged cumulated precipitation or maximum values (both observed and forecasted) over 90 meteo-hydrological basins
\[ \overline{FOR} = \frac{1}{N} \sum_{i=1}^{N} \left( \text{for}_i \right) \]

\[ \text{Mean value } 24h/12h/6h/\text{cumulated precipitation forecasted} \]

\[ \text{Number of grid points inside alert area} \]

\[ \text{i-th grid point precipitation value} \]

\[ \overline{OBS} = \frac{1}{K} \sum_{i=1}^{K} \left( \text{obs}_i \right) \]

\[ \text{Mean value } 24h/12h/6h/\text{cumulated precipitation observed} \]

\[ \text{Number of station points inside alert area} \]

\[ \text{i-th station precipitation value} \]

\[ FOR_{\text{MAX}} = \max \left( \text{for}_i \right) \]

\[ OBS_{\text{MAX}} = \max \left( \text{obs}_i \right) \]
LONG TREND PRECIPITATION with high resolution stations

- 0.2 thres → yes/no prec discriminant
- Seasonal cycle of error: summer over, winter under
- ECMWF systematic overestimation
- During last years the spread has been reduced a little
LONG TREND PRECIPITATION with high resolution stations

- Underestimation: 7, EU, ECMWF, GR
- Cycle error for I7 and ME

The second day has got cycle error more pronounced
- The summer is the more difficult season
LONG TREND PRECIPITATION with high resolution stations

POD run 00 th= 0.2 mm/24h time=0024

POD run 00 th= 0.2 mm/24h time=2448

- Cycle error
- Summer is difficult

LOW THRESHOLDS
LONG TREND PRECIPITATION with high resolution stations

- Cycle error with big spread
- DJF14 warm, moist and rainy/snowy → strong dependency from pluviometric regime
- Low POD in summer and winter
LONG TREND PRECIPITATION with high resolution stations

FAR run 00 th= 0.2 mm/24h time=0024

• Cycle error
• Summer is difficult

FAR run 00 th= 0.2 mm/24h time=2448
LONG TREND PRECIPITATION with high resolution stations

FAR run 00 th= 20 mm/24h time=0024

FAR run 00 th= 20 mm/24h time=2448

HIGH THRESHOLDS

•The results confirm POD
LOW THRESHOLDS

• Very slightly improvement in time

ETS run 00 th = 0.2 mm/24h time=0024

ETS run 00 th = 0.2 mm/24h time=2448
LONG TREND PRECIPITATION with high resolution stations

ETS run 00 th = 20 mm/24h time=0024

- Very slightly improvement/quite stable in time but more pronounced spread during last years

ETS run 00 th = 20 mm/24h time=2448

HIGH THRESHOLDS
201406-201505: Average over area > 0.2 mm/24h

- Good/light underestimation
201406-201505: Average over area > 2 mm/24h

- Good/light underestimation
201406-201505: Average over area > 10 mm/24h

- Spread
- Good for I7, GR, ME
- Light underestimation for 7, EU
201406-201505: Average over area > 20 mm/24h

- Spread
- Good for I7, GR, ME, I2, IT
- Light underestimation for 7, EU, ECM
201406-201505: Average over area > 30 mm/24h

- Spread
- General skill decreasing
- Good for I7, GR, ME, I2, IT
- Light underestimation for 7, EU
201406-201505: Average over area > 50 mm/24h

- Spread
- Good for I7, GR, ME, I2
- Light underestimation for 7, EU, IT
201406-201505: Maximum over area > 0.2 mm/24h

- Grouped dots
- Light overestimation
201406-201505: Maximum over area > 2 mm/24h

- Grouped dots
- General overestimation
201406-201505: Maximum over area > 10 mm/24h

- spread dots
- general overestimation
201406-201505: Maximum over area > 20 mm/24h

- spread dots
- 3 groups
201406-201505: Maximum over area > 30 mm/24h

- spread dots
- 3 groups
201406-201505: Maximum over area > 50 mm/24h

- spread dots
- 3 groups
Average over area > 0.2 mm/24h
Average over area > 2 mm/24h
Average over area > 10 mm/24h
Average over area > 20 mm/24h
Average over area > 30 mm/24h
Average over area > 50 mm/24h
Maximum > 0.2 mm/24h
Maximum > 2 mm/24h
Maximum > 10 mm/24h
Maximum > 20 mm/24h
Maximum > 30 mm/24h
Maximum > 50 mm/24h
RELATIVE ERROR jja 2014

Cumulated seasonal precipitation (mm)

Rel Err = (for-obs)/obs %

Cosmo-7
Cosmo-GR
Cosmo-EU

Cosmo-ME
Cosmo-ITA
Cosmo-I7
Cosmo-I2

ECMWF
RELATIVE ERROR son 2014

Rel Err = (for-obs)/obs %

Cumulated seasonal precipitation (mm)

Cosmo-7
Cosmo-GR
Cosmo-EU
Cosmo-ME
Cosmo-ITA
Cosmo-I7
Cosmo-I2
ECMWF
Stephenson et al. Introduce the extreme dependency score (EDS) as a good alternative to standard scores for verification of rare events.

<table>
<thead>
<tr>
<th></th>
<th>Event observed yes</th>
<th>Event observed no</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast yes</td>
<td>A</td>
<td>b</td>
<td>a + b</td>
</tr>
<tr>
<td>Forecast no</td>
<td>c</td>
<td>d</td>
<td>c + d</td>
</tr>
<tr>
<td>Total</td>
<td>a + c</td>
<td>b + d</td>
<td>n = a + b + c + d</td>
</tr>
</tbody>
</table>

Extreme dependency score → investigate the performance of an NWP model for rare events.
<table>
<thead>
<tr>
<th>Measure</th>
<th>Formula</th>
<th>Scale</th>
<th>Best Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency bias index</strong></td>
<td>$FBI = \frac{a + b}{a + c}$</td>
<td>$[0, \infty]$</td>
<td>best 1</td>
<td>The frequency bias index indicates whether the forecasting system under or over-forecasts the number of events.</td>
</tr>
<tr>
<td><strong>Hit rate (POD)</strong></td>
<td>$H = \frac{a}{a + c}$</td>
<td>$[0, 1]$</td>
<td>best 1</td>
<td>The hit rate represents the probability that the event is forecast when it occurs.</td>
</tr>
<tr>
<td><strong>False alarm rate (POFD)</strong></td>
<td>$F = \frac{b}{b + d}$</td>
<td>$[0, 1]$</td>
<td>best 0</td>
<td>The false alarm rate represents the probability of forecasting the event when it did not occur.</td>
</tr>
<tr>
<td>% not events obs. Not correctly forecasted. fraction of the observed &quot;no&quot; events were incorrectly forecast as &quot;yes&quot;.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>True skill score</strong></td>
<td>$TSS = H - F$</td>
<td>$[-1, 1]$</td>
<td>best 1</td>
<td>The true skill score gives information on how the forecasting system distinguishes between occurrences and not occurrences.</td>
</tr>
<tr>
<td><strong>Base rate</strong></td>
<td>$BR = \frac{a + c}{n}$</td>
<td>$[0, 1]$</td>
<td></td>
<td>The base rate represents the probability that the event occurs. By definition, 1-BR plotted versus increasing thresholds represents the probability that precipitation amount does not exceed a certain threshold.</td>
</tr>
<tr>
<td><strong>Extreme dependency score</strong></td>
<td>$EDS = 2\left[\ln\left(\frac{a+c}{n}\right)/\ln\left(\frac{a}{n}\right)\right] - 1$</td>
<td>$[-1, 1]$</td>
<td>best 1</td>
<td>What is the association between forecast and observed rare events? Converges to $2\eta - 1$ as event frequency approaches 0, where $\eta$ is a parameter describing how fast the hit rate converges to zero for rarer events. EDS is independent of bias, so should be presented together with the frequency bias.</td>
</tr>
</tbody>
</table>
• To get clear information about how the forecasting system detects the extreme events, it would be fair if the EDS is compared for events having the same base rate. One has to investigate if better value of the EDS are related to an improvement in the quality of the forecasting system or if they are due to the event variability over the years.

• The equation defining the EDS uses the left hand side of a contingency table and the total number of cases (sample size). This results in an increased freedom for false alarms and correct negatives, which can freely vary with the only restriction that their sum has to be constant. Therefore, it is paramount to use the EDS in combination with other scores that include the right hand side of the contingency table, as the F and/or the FBI to show that improvements are not due to an increase of false alarms. (Ghelli&Primo,2009)
The Extreme Dependency Score (EDS) has been introduced as an alternative measure to verify the performance of numerical weather prediction models for rare events, taking advantage of the non-vanishing property of the score when the event probability tends to zero. This score varies from 1 (best value) to −1 (worst value).

The EDS is written as a function of BR:

$$EDS = \frac{\ln(BR) - \ln(HR)}{\ln(BR) + \ln(HR)}$$

Equation presents the EDS as a function of the base rate and the hit rate. When HR = 1, the EDS = 1 and when BR = 1, the EDS = −1. On the other hand, when the base rate is equal to one, the event happens all the time and so the EDS is not an appropriate score since it is focused on verification of extreme events (low probability of occurrence). Therefore, if different data samples need to be compared, it is imperative to have similar base rate.
• Thus, even if there are no misses and the EDS value is maximum, the forecasting system might have a high number of false alarms. Therefore, an EDS = 1 does not imply a skilful system. If values of the EDS for different periods need to be compared, then the base rate must be constant in time to avoid changes in the EDS to be just a reflection of changes in the BR.

• If the base rate is constant, an increase of the EDS implies a better probability of detection (hit rate), i.e. a more skilful system. If only the hit rate is constant, then an increase of the EDS is only due to a higher event probability. If neither the base rate nor the hit rate is constant, then the improvement of the EDS could be due to any of the previous reasons.
The extreme dependency score: a non-vanishing measure for forecasts of rare events (Stephenson et al.)

EDS takes the value of 1 for perfect forecasts and 0 for random forecasts, and is greater than zero for forecasts that have hit rates that converge slower than those of random forecasts.

EDS has demonstrated here that there is dependency between the forecasts and the observations for more rare events, which is masked by the traditional skill scores that converge to zero as the base rate vanishes. EDS does not explicitly depend on the bias in the system for vanishing base rate and so is less prone to improvement by hedging the forecasts. EDS has the disadvantage that it is based only on the numbers of hits and misses, and so ignores information about false alarms and correct rejections. Therefore, EDS is non-informative about forecast bias, and a forecasting system with a good EDS could be very biased. Therefore, one should present EDS together with the frequency bias as a function of threshold in order to provide a complete summary of forecast performance.