Representativity of a mesonet temperature observations with respect to model fields

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Observations from mesoscale networks are affected by the whole range of dynamic scales, including very small and fast scales that cannot be adequately resolved even by high-resolution, convection-resolving models. Representativity error should then accounted for when comparing model fields with observations. An important component of representativity error arises from the difference between model and real orography.
In this work, model analysis fields are estimated at station locations by simple interpolations, and the statistical properties of estimate-observation differences are studied, depending on season and hour. The topic of forecast error is deliberately not addressed. Local orographic features are used to classify observing sites in *Plain*, *Valley* and *Mountain* stations (PVM classification). By characterizing the sample distribution of estimate-observation differences at each station location, it is possible to estimate the systematic error (mainly, but not only due to orography difference) and to classify the network stations for their representativity with respect to each of the models: ECMWF, COSMO-I7, COSMO-I2. **A representativity study is in general necessary before addressing a forecast verification based on any kind of observations**.

Observations

Quality controlled (Lussana et al., 2010) temperature observations from the mesonet of ARPA Lombardia (Northern Italy):
***** at 00 UTC : mean(23-01 UTC)
***** at 12 UTC : mean(11-13 UTC)

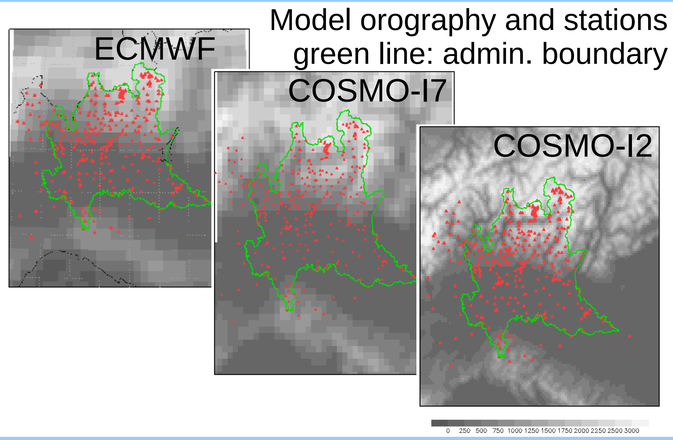
The bi-hourly mean filters out small spatial scales, partly reducing representativity error.

Model Analysis fields

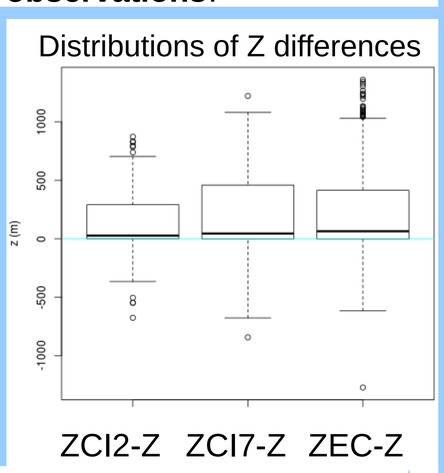
***** NWP model considered (operational configuration):
1. **EC**: ECMWF-*IFS* (available at 0.125° resolution both for latitude and longitude, corresponding to 14 Km and 9 Km in the S-N and E-W directions, respectively);
2. **CI7**: COSMO-I7 (resolution 7 Km);
3. **CI2**: COSMO-I2 (resolution 2.8 Km).

***** Dataset: 2m Temperature, 1 year (June 2010→May 2011);

***** **EC**, **CI7**: 00 UTC, 12 UTC **analysis**; **CI2**: **+03h forecast**

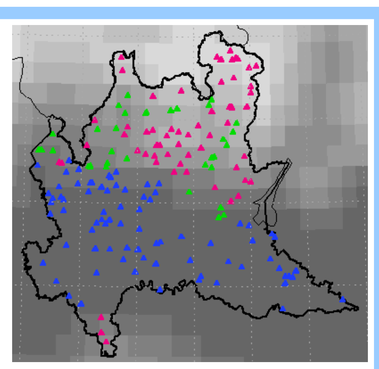


Model orography and stations
green line: admin. boundary



PVM (Plain, Valley and Mountain) classification

Stations are classified according to spatial variability of the surrounding orography. Variability is evaluated in a 7 km box by means of an high-resolution (250 m) digital elevation model:
Plain → low elevation, very low variability: 80 stations
Valley → high variability: 35 stations
Mountain → high elevation, low variability: 59 stations
Total station number providing data in the considered period: 154 (in an area of about 170 Km x 170 Km)



Model elevation at station locations

Bilinear interpolation is used to estimate model elevation at station locations: ZEC, ZCI7, ZCI2. The three distributions of ZEC, ZCI7, ZCI2 (not shown) have larger dispersion (IQR) than the distribution of station elevations: real orography (in particular valley floors where many stations are located) is generally exceeded by the smoother model orography, except for ridges.
***** Elevation differences may be large, reaching several hundreds of meters
***** (ZEC – Z) has more outliers than (ZCI7-Z), although with a smaller IQR.
***** IQR(ZCI2-Z) is smaller than IQR(ZEC-Z) and IQR(ZCI7-Z)

Comparison between Model estimates (Tbil) and Observed (Tobs) temperature values

The purpose is to evaluate station representativity with respect to each model.
Tbil is obtained through a bilinear interpolation, then not considering elevation.
A systematic difference between Tbil and Tobs can be estimated and corrected. A large variability of the Tbil-Tobs difference is problematic: indicates a substantial lack of correlation between the two series.
The choice of using a relatively simple interpolation enables explaining the two series different behaviour as a station representativity error related to unresolved meteorological scales in each model.
For each model, with reference to the Tbil-Tobs difference distribution:
* The systematic difference is evaluated by the median;
* The variability is evaluated using the IQR (Interquartile Range=q(0.75)-q(0.25));
Station representativity vary in time and space.
The PVM station classification separates different geographical conditions.
Seasonal dependence have been evaluated by considering winter and summer separately.
Diurnal cycle influence has been taken into account by separately considering 00 UTC and 12 UTC analysis within each season.
The boxplots show the ECMWF Tbil-Tobs distributions, separately for each PVM class and in seasonal/diurnal time aggregation. Median and IQR of Tbil-Tobs difference distribution for the three models are shown in the Table on the right, with the same PVM/seasonal/diurnal aggregation.

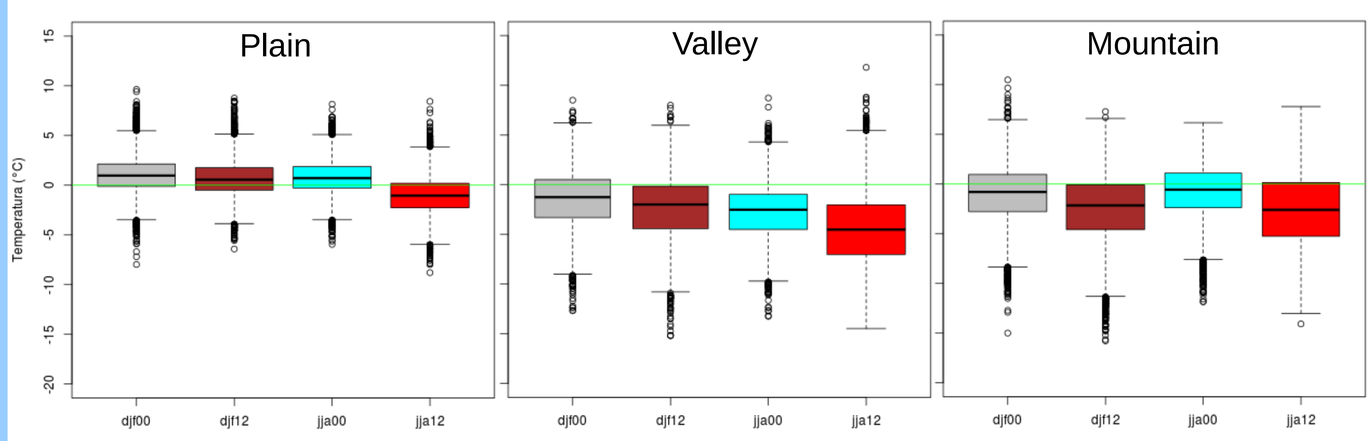


Table: (Tbil-Tobs) distribution median and IQR
Spatial aggregation: PVM classification
Temporal aggregation: 1 year; seasonal/diurnal

DJF: Winter→ December 2010, January-February 2011; **JJA**: Summer→ June-July-August 2010

period	*mod*	*P median*	*P IQR*	*V median*	*V IQR*	*M median*	*M IQR*
6/2010-5/2011	CI2	**0.01**	2.67	**-2.09**	**3.73**	-2.75	**4.29**
6/2010-5/2011	CI7	0.16	2.71	-3.39	4.50	-3.58	5.00
6/2010-5/2011	EC	0.27	**2.33**	-2.71	4.36	**-1.43**	**4.35**
DJF 00	CI2	**0.57**	2.45	**-0.93**	**3.90**	-1.60	**3.37**
DJF 00	CI7	0.80	2.50	-2.29	4.73	-2.84	4.12
DJF 00	EC	0.97	**2.25**	-1.25	**3.82**	**-0.79**	3.73
DJF 12	CI2	**-0.13**	2.61	-2.24	**4.12**	-4.14	4.63
DJF 12	CI7	-0.24	**2.29**	-3.01	4.83	-4.99	6.00
DJF 12	EC	0.56	**2.26**	**-1.99**	4.27	**-2.15**	**4.51**
JJA 00	CI2	**0.02**	2.66	**-1.63**	**2.91**	-1.58	**3.10**
JJA 00	CI7	0.62	2.69	-3.23	3.79	-2.26	3.95
JJA 00	EC	0.71	**2.15**	-2.51	3.52	**-0.56**	3.48
JJA 12	CI2	**-0.80**	2.74	**-3.21**	**3.27**	-3.86	**4.55**
JJA 12	CI7	-0.91	2.92	-4.28	4.17	-4.27	5.45
JJA 12	EC	-1.05	**2.45**	-4.51	4.99	**-2.59**	5.40

Units °C.
Green : smallest |median| and IQR within each spatio-temporal aggregation (two values in case of small difference)

Station Representativity Classification:

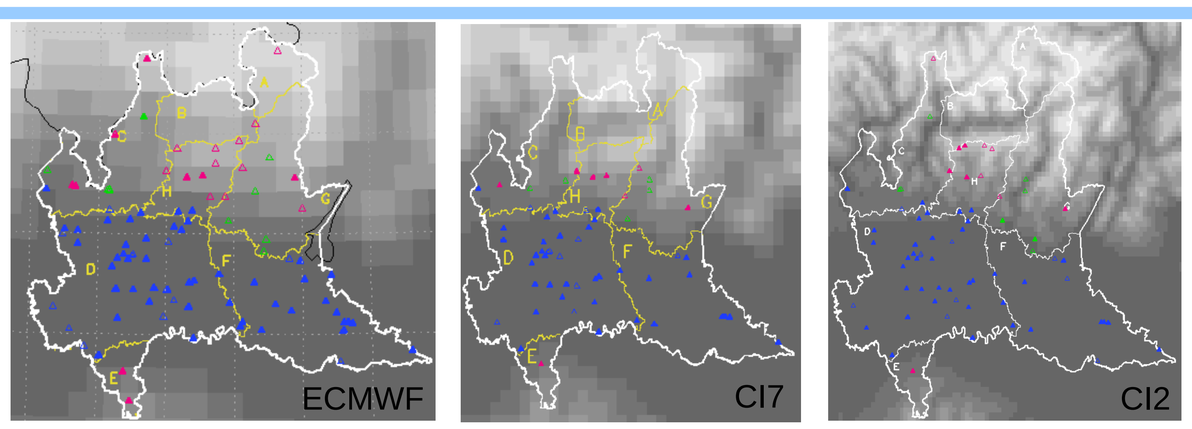
This classification is based on the Tbil-Tobs variability evaluated considering the whole period (6/2010 – 5/2011). The variability is estimated using the IQR:

Non-Representative Station (DEL) ← IQR > 2.5°C

Representative Station (SEL) ← IQR ≤ 2.5°C
***** | median | ≤ 1 °C immediate comparison between Tobs and Tbil;
***** | median | > 1 °C comparison possible **after bias correction** (Tbil-median);

	ECMWF			COSMO-I7			COSMO-I2		
DEL			83			114			106
SEL	58	33	**91**	40	18	**58**	47	21	**68**
	| median | ≤ 1	| median | > 1	Total	| median | ≤ 1	| median | > 1	Total	| median | ≤ 1	| median | > 1	Total

Representative (SEL) and non-representative (DEL) stations for each model.



The figures above show the representative stations for each model using the 1-year complete dataset (yellow boundaries mark civil protection alert areas).
In a practical application, each station should be considered representative or not for a particular model depending on season and hour.

Conclusions

***** Large differences between station elevation and model orography (up to 1000 m)
***** Analysis fields variability and observed temperature variability are in agreement.
***** Analysis estimates at station locations are affected by systematic error, mainly, but not only due to the differences between station elevation and model orography.
***** Tbil, Tobs and (Tbil-Tobs) distributions characteristics depends on PVM classification, season (winter/summer), hour (00/12).
***** Bias estimate : median(Tbil-Tobs); **representativity : small IQR(Tbil-Tobs)**
***** Plain stations. In general, Tbil and Tobs are in agreement; Tbil-Tobs presents low values both for median and IQR.
***** Mountain and Valley Stations. Occurrence of significant systematic errors between Tbil and Tobs is frequent and the variability of their difference is large.
***** Each station has been classified depending on its representativity respect to each model. The classification is based on Tbil-Tobs median and IQR.
***** Representativity and bias correction for each station can and should be evaluated depending on season and hour

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