1ª CONFERENZA NAZIONALE SULLE PREVISIONI METEOROLOGICHE E CLIMATICHE

Istituto Superiore per la Protezione e la Ricerca Ambientale

ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

La verifica delle previsioni numeriche dei modelli meteorologici del SIMM di ISPRA: focus sulla attività in ambito MesoVICT

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La gestione e l'operatività di un modello numerico, ovvero di un sistema previsionale, richiedono una attenta e routinaria **attività di forecast verification**. La verifica è utile e necessaria per fornire una valutazione sulle prestazioni del modello (o del sistema) in esame attraverso il confronto tra previsto e osservato ed è fondamentale per guidare correttamente i modellisti nelle attività di sviluppo e miglioramento del modello stesso. Queste finalità hanno guidato negli anni **le attività di forecast verification e model intercomparison** che hanno interessato le previsioni fornite dalle diverse componenti modellistiche del **SIMM – Sistema Idro-Meteo-Mare di ISPRA.**

Queste attività sono state spesso condotte in ambito europeo e internazionale anche sulla base di campagne osservative su aree come l'arco alpino (e.g., **progetto INTERREG FOREALPS**) e il Mediterraneo (e.g., **iniziative WMO "MAP D-PHASE" e "HyMeX"**).

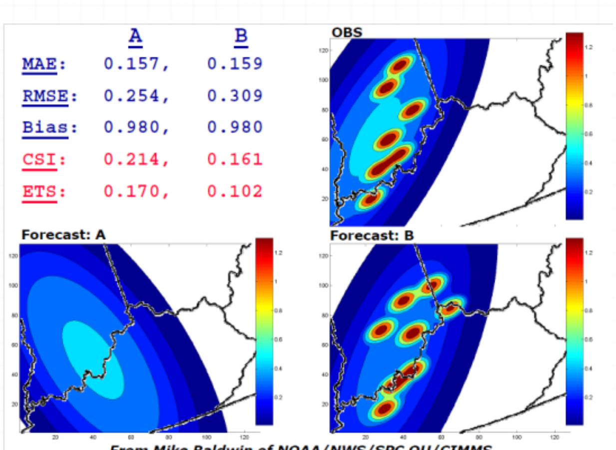
In particolare, le attività di verifica hanno riguardato le previsioni fornite dai **modelli meteorologici alla base del SIMM** (Casaioli et al., 2014; Speranza et. al., 2007), i.e., il modello **idrostatico BOLAM**, sul bacino del Mediterraneo e gran part dell'Europa, e il modello **non idrostatico MOLOCH**, sull'Italia, **sviluppati dal CNR-ISAC** (Mariani et al., 2015).

Gli studi hanno, inoltre, evidenziato come ciascuna metodologia di verifica sia in grado di fornire informazioni solo su alcuni aspetti della qualità della previsione. **Metodologie classiche** di verifica possono poi essere **sensibili alle differenze di scale rappresentate nei campi verificati e alla presenza di errori spaziali**, in particolare considerando previsioni ad alta risoluzione spaziale e/o aree territoriali con topografia complessa.

Quest'ultimo aspetto è stato, in particolare, considerato nell'ambito dell'**iniziativa WMO "MesoVICT – Mesoscale Verification Intercomparison over Complex Terrain**" (Mariani et al., 2018): uso ed eventuali limitazioni del metodo *feature-oriented* "**Contiguous rain area (CRA) analysis"** (Ebert e Mcbride, 2000, Grams et. al, 2006, Mariani et al., 2008) per la verifica della precipitazione in termini di posizione, area, intensità, forma, orientazione, ecc.

Feature-based methods

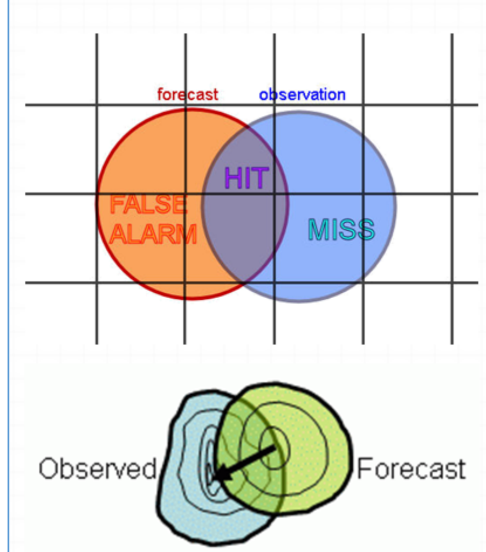
- ❑ Feature-based methods provide thorough information on forecast quality.
- ❑ Weather forecasters and model developers appreciate the ability of these methods to:
  - ✓ computationally mimic the human judgement; and
  - ✓ quantify and qualify the sources of forecast error.



From Mike Baldwin of NOAA/NWS/SPC OU/CIMMS

- ❖ Decompose fields into sets of *features* that can be objectively identified and described by *attributes*
- ❖ Use image processing and data mining techniques to *locate* and *classify* events
- ❖ Produce scores based upon the *similarity/dissimilarity* between features in observations & forecasts

Contiguous rain area analysis



Double penalty effect: the event is correctly simulated, but it is misplaced with respect to the original position.

The forecast is **penalized twice**:

- ❖ once for missing the event in the correct position; and
- ❖ once for producing a false alarm where the event is not observed.

The contiguous rain area analysis (**CRA**; Ebert and McBride 2000) is an feature-oriented technique based on a **pattern-matching** of two contiguous areas delimited by a chosen isohyet.

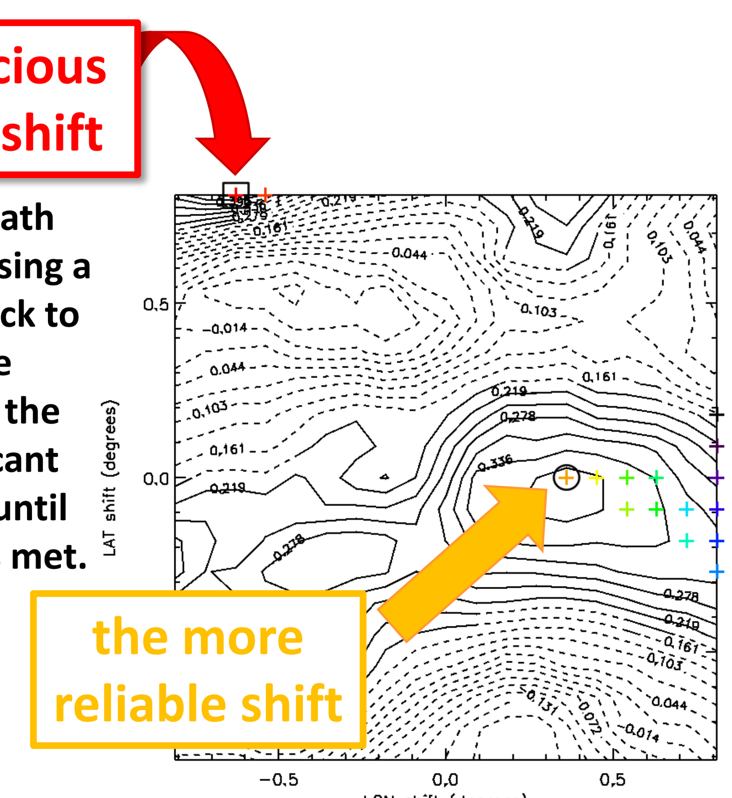
Methodology applied for MesoVICT

CRA analysis (Ebert and McBride, 2000; Grams et al., 2006) using "traditional" pattern matching criteria (max CORR; min MSE) and imposing some additional checks/constraints

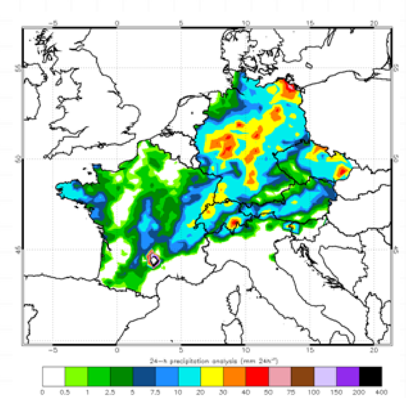
- Max **shifting value** (search distance): 15, 20, 30 grid points in both LON & LAT
- Check on **No. of effective grid points** (**N_{eff}**), i.e., the smaller N_{eff} is, the greater the min CORR is to have a statistical significant shift → considering only **statistical significant shifts**
- Check on % of precipitation out of the verification domain (**domain jumping**)
- Check on ratio between "max forecast after best shift" and "max forecast before the best shift"
- A (final) **eyeball comparison** by using the **2-D CRA analysis shift plot** to compare the "best pattern match" against the "intermediate matches" found during the CRA application (aka **CRA matching path**), obtained through minim. MSE or maxim. CORR, to **determine whether** the best pattern match found **is a correct, reasonable match or is an isolated result obtained by chance** that does not represent a realistic assessment of the forecast displacement error.

2-D CRA analysis shift plot (da Mariani e Casaioli 2018)

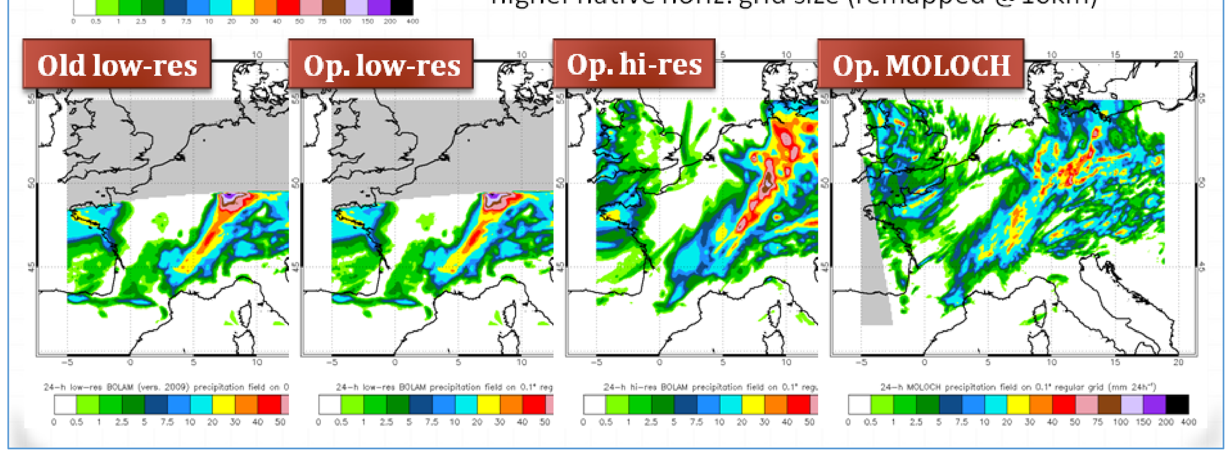
The CRA matching path (crosses) is reported using a colour scale, from black to red, indicating the progressive order of the intermediate significant best matches found until the final best match is met.

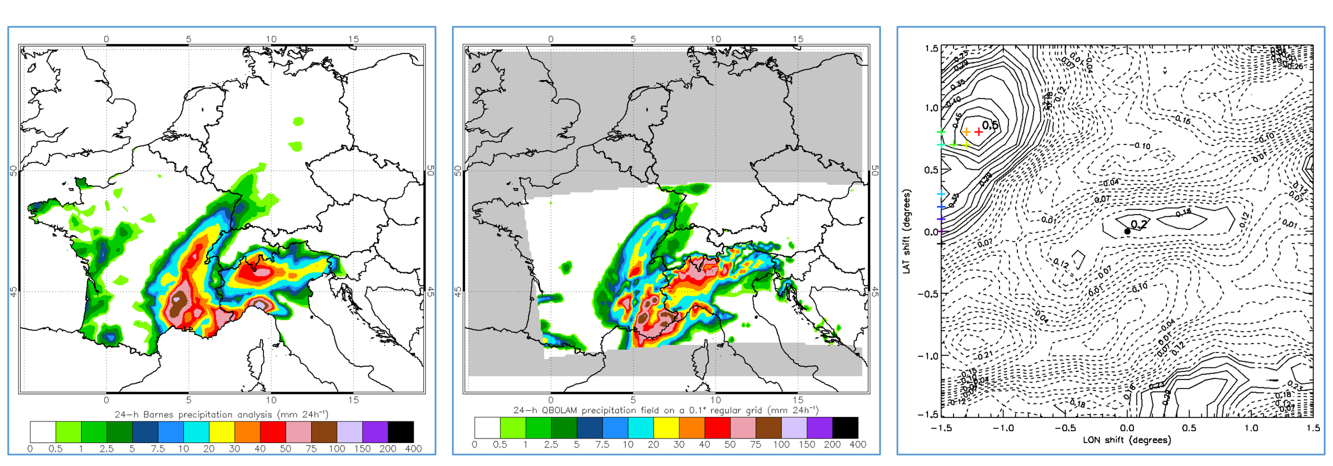


20–22 June 2007 (core case/mandatory)

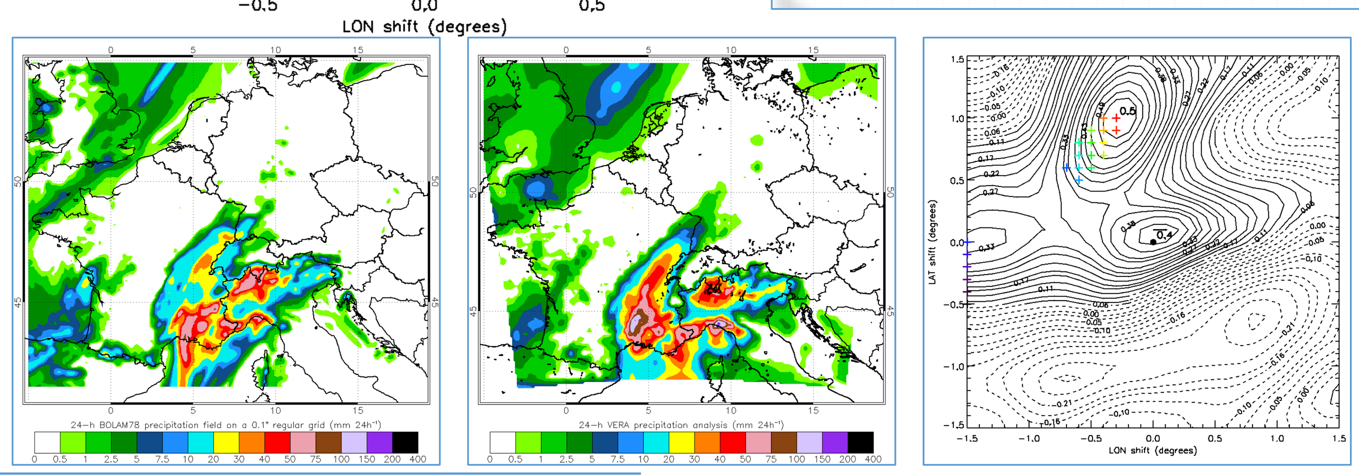


- ✓ Convective events, started in the evening of 20 JUN
- ✓ 24-h heavy precipitation mainly recorded on **21 JUN** in Southern Swiss, Germany, Slovenia and Hungary
- ✓ 3 configs. of BOLAM with similar horiz. grid size (10km & 7.8km / remapped @10km) but different domains (***obs. rain band not completely forecast***) and/or parameterizations (incl. convection)
- ✓ 1 config. of convection-permitting MOLOCH with a higher native horiz. grid size (remapped @10km)





Es. confronto su dominio limitato: Barnes analysis vs. BOLAM a 0.1° del 2007 (MAP D-PHASE). CRA relativa a soglia di 10.0 mm 24 h^{-1} con max. CORR.



Es. confronto senza dominio limitato: VERA analysis vs. BOLAM a 0.07°. CRA relativa a soglia di 10.0 mm 24 h^{-1} con max. CORR.

Conclusions

- ✓ The CRA analysis has the **advantage of easily provide information on forecast error**, but an automatic, **unsupervised use** of this feature-based approach, even if possible, **might produce misleading results**.
- ✓ Some care has to be taken when evaluating the best pattern matches achieved with the CRA analysis to distinguish reliable results from the suspicious, unphysical ones.
- ✓ **Quality checks to assess the statistically significance of the results** as a function of the number of verification grid points could be effective (but not always sufficient) to detect non-realistic pattern matches and, in some cases, to correct them.
- ✓ It is **highly suggested using a tool like the 2-D CRA shift analysis plot**. This plot, together with the CRA matching path, turns out to be useful to correctly evaluate the diagnosed spatial forecast errors. This is **particularly true when evaluating deterministic forecasts over complex terrain at convection-permitting resolution**.
- ✓ The CRA analysis is **sensitive to the model resolution** and it is found to be strongly dependent on the event and its physical characteristics.
- ✓ **For the spatial verification of the higher resolution QPFs, it could be also useful to apply an iterative approach**: the CRA analysis could be first applied over a coarse grid to get close to the right best pattern match – identifying this way a first guess of the best match; then a comparison over a finer resolution grid could be performed to refine the match.
- ✓ Results confirms that CRA tends to provide **more robust and reliable results when using the CORR maximization as pattern matching criterion**.
- ✓ **Min MSE should be avoid** or used in conjunction with either max CORR or other additional constraints or check (e.g., % of grid points out of the verif. domain), to discriminate the CRA results.
- ✓ **Results can be influenced by the difference in resolution** (spatial scales resolved) between observation and forecast fields, even if comparison is performed on a coarser verification grid, especially when considering higher entity threshold and/or convective events.
- ✓ **Verification at short accumulation time could be problematic** since either entities are defined over a reduced number of grid points or results are associated to erroneously matches.
- ✓ **The CRA could be sensitive to lack of information in the observed entity** (e.g., over MED) **and/or in the forecast entity** (e.g., when the rainfall band under investigation is partially observed outside the model domain), since it could be conditioned by the "domain jumping" issue.

Questo studio è stato condotto nell'ambito dell'iniziativa internazionale MesoVICT.

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