CONSORTIUM FOR SMALL SCALE MODELING
COSMO

An outlook on the developments in the field of Validation and Diagnostics in COSMO

Flora Gofa, WG5 Coordinator

During the last several years, the main efforts of the WG5 activities has been to develop verification tools to be used by the whole COSMO Consortium, to standardize the verification procedures, to homogenize the results, and to provide new kinds of information about the model performance. This has led to the development of NWP Test Suite that, as a permanent activity, allows for the evaluation of new COSMO-model versions. The continuous developments, concerning very high resolution deterministic forecasts and the convection- permitting ensemble forecasts, considerably influence the verification activities and bring challenges that WG5 need to face. It has become evident that the various users of model products need a wide variety of dedicated and specific information. For this reason, different strategies have to be identified. Verification activities should be able to differentiate their outcomes and to diversify methodologies and approaches in order to meet the requirements of different user communities (as, e.g., model developers, forecasters, and external clients). Finally, all verification activities should be adapted to the new modelling systems based on ICON-LAM that gradually replace the COSMO-model based systems.

The main activities of the Working Group 5 currently cover the following areas:

- Common verification framework for operational models, monitoring of model performance, and identification of systematic errors;
- Evaluation of spatial verification techniques applicability;
- Evaluation of convection-permitting EPS performance;
- Utilization of non-conventional observational datasets for operational and scientific purposes;
- High impact weather and user-oriented verification products.

The work of WG5 will continue along the same lines although with renewed content for each activity based on scientific developments and arising needs. In what follows, the colours highlighting the section titles indicate the time frame of the respective actions (short- to mid-term actions, mid- to long-term actions):

Common Verification framework.

Operational verification used to be carried out routinely by COSMO members using VERSUS software within a point-wise verification framework. Since 2019, MEC-Rfdbk has been gradually adopted by the participating NMSs (this work is the major focus of PP CARMA). It is expected that by the end of 2021 MEC-Rfdbk will be the common tool for all Consortium members. The most striking advantages of the new verification system are (i) the shortfall of data pre-processing (all data in one place, observation and forecast correctly assigned to each other, quality control done by data assimilation, small files) through the use of the Model Equivalent Calculator (MEC), (ii) the fast and simple calculation of standard verification scores with the R-based Rfdbk library, and (iii) the interactive browsability and online production of results on COSMO web with the R Shiny library. MEC-Rfdbk is also suitable for EPS verification. In the near future, results from development at DWD concerning the EPS-verification capabilities of MEC-Rfdbk and its conditional verification capabilities can also be utilized by the Consortium members. This step seems feasible (even although it is not currently included into the applications defined through PP CARMA).

Exploitation of spatial verification techniques.

Numerous advanced methods have been proposed in order to assess the (added) value of very high resolution forecasts, most notably spatial verification methods. Availability of radar data, data from merged radar-surface station observations, and satellite data contributed to the growth of popularity of these methods. The plethora of spatial verification methods has led to the need to analyse how these methods relate to one another, how each method works, what information could be gleaned from each method, and whether a given method actually conveys any useful information . The PP INSPECT (completed in December 2018) provided a means to summarize the experience of applying spatial verification methods to COSMO forecast systems at very high resolution. The project provided criteria for deciding which methods are best suited to particular applications and made a wide range of spatial verification methods available (in terms of software and configurations) so that they became commonly used within the COSMO community. This effort will be continued through the PP AWARE and will be extended (in terms of methodologies and parameters to be verified) beyond the application to the precipitation forecasts only. Furthermore, through such research efforts verification practices will be able to contribute to the development of products for the seamless prediction of phenomena related to nowcasting applications and high impact weather forecast evaluation.

Utilization of non-conventional observational datasets.

Most of the spatial methods for high resolution verification depend on gridded observations whose spatial resolution should be commensurate to (high resolution) the NWP products. Moreover, observations often do not permit characterization of the phenomenon of interest, and therefore do not provide a good reference for objective verification. Visibility/fog, atmospheric stability indices, convective weather/thunderstorms, and freezing rain are illustrative examples of phenomena (forecasted by the NWP model directly or through post-processing) for which appropriate observational data sources need to be thoroughly considered (no matter how the above phenomena are forecasted). Such data can stem from direct measurements of the quantities to be verified (e.g., a lightning diagnostic from a model is compared with direct measurements of lightning strikes). However, some quantities produced by an NWP model are not directly measurable/observable. In that case, we need to derive or infer estimates from other measurements of interest. The available options incorporate remote sensing datasets, datasets derived from telecommunication systems including cell phones, data collected from citizens, reports on weather impacts, and claim/damage reports from insurance companies. The focus of WG5 activities in this regard will be to identify the sources and recognize the value of less conventional observations and to properly align them with the NWP parameters in order to be able to include them into verification practices.

Evaluation of convection permitting EPS performance.

Further development of verification capabilities within the COSMO Consortium must continue to take into account advances in probabilistic and ensemble forecasting. "Convection-permitting" ensembles, which focus on short timescales (0-24h), are subject to large error growth related to highly non-linear convection processes. Convection-permitting ensemble prediction systems pose complex challenges in terms of verification that must focus on the relative gain of using such systems with respect to improved representation of convection-related parameters. In this research field, close collaboration with WG7 (which is ongoing, inter alia, through PP AWARE) needs to be continued as the adaptation of spatial verification methods on probabilistic forecasts is the most perplexing subject of research in the international community nowadays.

Severe and High Impact Weather.

A rapidly increasing demand to provide accurate forecasts of extreme weather events leads to the need to objectively evaluate forecasts of extreme weather. Forecast methods and verification are important aspects of any high impact weather (HIW) consideration. While traditional verification methods have limited usefulness in this context, many of the newer diagnostic approaches may provide useful information to aid understanding of errors in model processes for such weather regimes. Severe events are rare. Standard skill scores are often not useful as most of them depend on base rate which tends to zero for rare events. PP AWARE addresses various HIW issues, such as the representation of HIW in the observations and the importance of observation uncertainty, the systematic and stochastic errors of HIW forecasts and the forecast sensitivity to model resolution, and the representation of HIW in post-processed products. Efforts currently undertaken within the framework of PP AWARE will be continued in the following years. The endorsement of WMO HiWeather international initiative will provide a continuous stamina in this field of work.

Crucial Point: *The experience gained over the past several years indicates skilled but limited resources in the COSMO community regarding operational verification activities and implementation of new approaches and methodologies. Nevertheless, in order to realize the planned actions, it is necessary to have additional human resources dedicated to verification activities in the immediate future.*