An application of SRNWP data pool radiation data with VERSUS software

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Abstract

In the verification field it is particularly important the exploitation of any kind of existing, controlled and homogenous set of surface and near surface observations. This becomes even more crucial in the Planetary Boundary Layer (PBL) where usually very limited dataset are available and observation concerning fluxes, radiation and soil characteristics are rarely available. In the EUMETNET framework of SRNWP programme an action has taken place with the aim to collect organize and control specialized observations in the PBL from selected stations all over Europe. In this study, the particular characteristics of these available observations are briefly described and their use in verification activities, through the verification system VERSUS, is presented. As a first application, an overview of the performance of the Italian and Greek implementations of COSMO model, as compared to the observed parameters, mainly surface fluxes and radiation, is discussed as well as specific case studies and applications of the conditional verification technique.

1 Introduction

Over the last years, limited area models as COSMO have increased their spatial horizontal and vertical resolution with the goal to achieve a better representation of the real topography and to resolve explicitly physical processes that otherwise would be of the sub-scale kind and would need a specific treatment (parameterization) of the corresponding equations. For this reason, usually, the increment of levels has mainly an impact on the planetary boundary layer (PBL) where turbulence, convection, fluxes of heat and moisture and radiation play all together, combined and separately, a major role. The improvement in the representation of PBL processes is of course, or can be, evident from the assessment of the general quality the forecast and from there the quality of forecasted fluxes or radiations balances can be inferred, having a look to the quality of 2mT forecast for example. At the same time the direct verification of such parameters is extremely important for modellers in the effort to focus the attention to the source of the physical process and not to one of the effect, which can be partially or even misleadingly representative.

Unfortunately this kind of information, organized as extensive dataset, are not usually available, while in the verification field it is particularly important the exploitation of any kind of existing, controlled and homogenous set of surface and near surface observations. Clearly, due the peculiarity of the processes, becomes even more crucial in the PBL, where usually observation concerning fluxes, radiation and soil characteristics are rarely available. Nevertheless in the EUMETNET framework of SRNWP programme, an action took place in the last years with the aim to collect, organize and control specialized observations in the PBL from selected stations all over Europe (Fig. 1). Data have been collected in a standard ASCII format since 2006, even if not complete, and made available to EUMTNET community for scientific purposes. These data have been used in this study to compare COSMO model to some of the available observations in the PBL, from some selected stations, and in particular: long and short wave radiation (upward and downward components) (LW and SW), latent and sensible heat flux (LHF and SHF).

The chosen stations are Cabauw, Lindenberg, Fauga-Muzac, Payerne, Debrecen and S.Pietro Capofiume, for the completeness of their datasets and because all of them are included in the model domain. Datasets have been made available on the COSMO Consortium website to the scientific community.

The main goal of this work, was to perform all the necessary adjustments in COSMO verification software (VERSUS), in order to be able to handle this kind of radiation data and to provide to the users some first examples of their application with the conditional verification feature for diagnostic studies.

2 Methodology of Comparison

For this application, the complete dataset 2011-2012 for both observations and forecasts has been used and compare with different methodologies. As forecasts parameters were given as an average from the reference time of the model run, a homogenising pre-processing phase with the observation was performed and hourly datasets created.

The comparison between model output and observations has been carried out mainly through long term time series and daily cycle. This choice has been adopted in order to be able to compare, from a more general point of view, the ability of the model to reproduce the parameters behaviour without paying attention to statistical score values.

The plots have been initially calculated over a stratification including all the set of stations described in the previous paragraph and afterwards some consideration focusing on the Italian station of S. Pietro Capofiume will be shown.

In this last part also some peculiar situations connected also to the usual weather parameters, like 2m temperature and total cloud cover, will be shown and discussed in the perspective of a conditional verification technique.

In the following Table 1 the association between the observations used and the model outputs is shown:

Table 1: Association of observations with model output parameters. Radiation observation balances have been calculated as they are not available from the datasets.All parameters in $W/m2$.

OBS Data	FCS Data
RSWD: incoming solar radiation	ASWDIR_S: Average direct downward SW rad Surface
RSWU: reflected solar radiation	ASWDIFD_S: Average diffuse downward SW rad Surface
(RSWD-U balance)	Averaged Balance of SW
RLWD: incoming thermal radiation	ALWD_S: Average downward LW radiation at the surface
RLWU: outgoing thermal radiation	ALWU_S: Average upward LW radiation at the surface
(RLWD-U balance)	Averaged Balance of LW
HS: sensible heat flux	ASHFL_S: averaged sensible heat flux
LE: latent heat flux	ALHFL_S: averaged latent heat flux

All the results shown in the present study, the calculations and the graphs have been produced using the VERSUS software. The initial ascii files of observations have been ingested and processed internally in order to produce the average values of LW and SW radiation and the appropriate association of forecast and observation parameters has been included in the respective configuration tables.

Figure 1: Geographical distribution of SRNWP data pool stations.

3 Results

It is useful, for the understanding of the basic physical processes in the PBL, to summarize, in Fig. 2, the annual radiation and heat balance of the Earth.

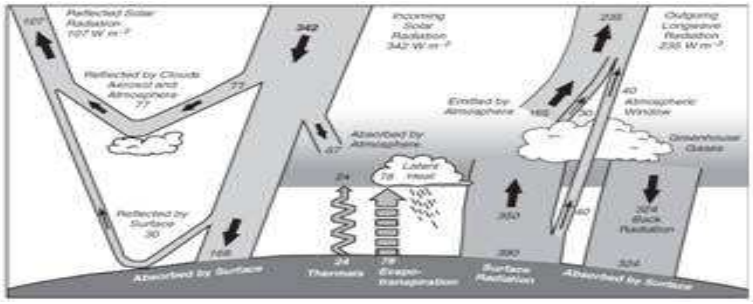

Figure 2: The mean annual radiation and heat balance of the Earth (Houghton et al 1996).

Fig.3 shows the daily cycles of long and short wave radiation and the LHF and SHF averaged on the period 2011-2012 for all the stations considered. The long period daily cycle is able to filter out seasonality and asses the general quality of the model. It is evident the general accordance between the model output and the observation, where the model overpredicts the LW upward radiation and the maxima of SHF (overestimated during the day and underestimated early morning and evening) and LHF (underestimated during the day) precede the observation.

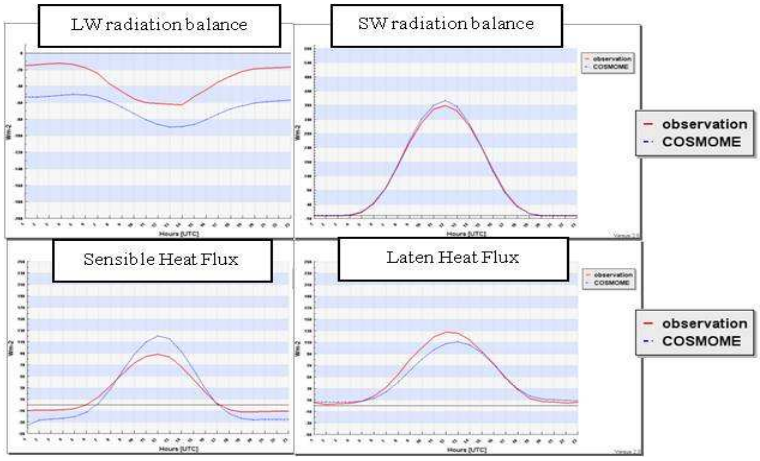

Figure 3: Daily Cycle LW and SW radiation – SHF and LHF for 2011-2012 – All SRNWP stations.

Focusing the attention on S. Pietro Capofiume station and comparing the previous parameters with daily cycles of 2mT (Fig.4) and total cloud cover (Fig.5), some other interesting considerations arise.

The typical COSMO model tendency to overestimate the 2mT during night and early morning is reflected also in the overestimation of negative (downward) flux of SH, taking in account that the SHF can be seen as proportional to $(T_{surf} \check{} T_{atm})$ if 2mT is considered representative of Tatm.

The light underestimation of 2mT during the day is less evident and the correspondent overestimation of positive flux (upward) could be due mainly to the surface heating produced by solar radiation (not present during the night). The connection between LW radiation and total cloud cover shown in figure 5 is even more interesting.

The overestimation of TCC in the daily cycle results clear also in the light underestimation of SW radiation during the central part of the day, while the higher amount of upward LW radiation compared with observation seems to be in contrast with this conclusion, as the presence of clouds, especially during the night, should result in a LW radiation balance closer to zero than the one showed below.

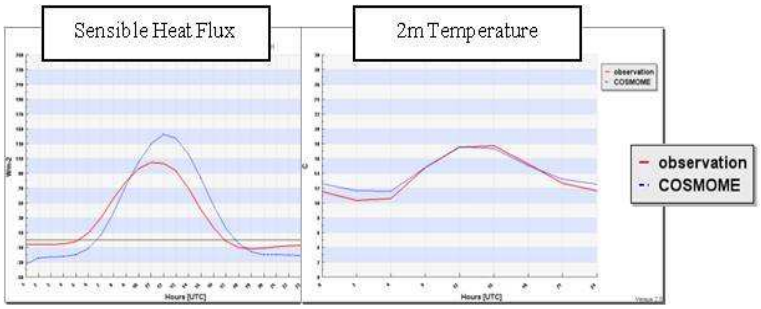

Figure 4: Daily Cycle of SHF and 2mT for 2011-2012 S. Pietro Capofiume.

Actually (see Fig. 6) also 2011-2012 winter scatter plots show an evident overestimation of the upward component of LW radiation balance, especially during the night (Step 24).

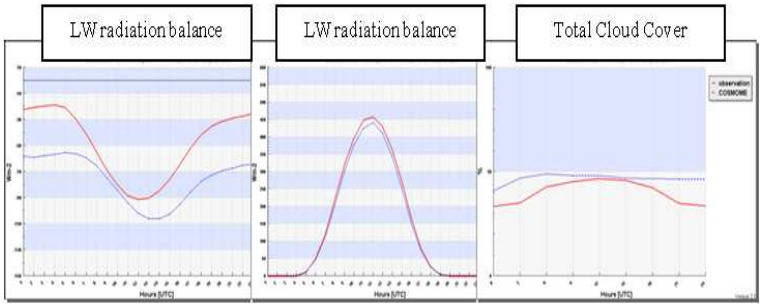

Figure 5: Daily Cycle of LW and SW radiation and TCC for 2011-2012 - S. Pietro Capofiume.

Under the reliable hypothesis of a several number of days with high amount of cloud cover and in connection with the daily cycles of TCC shown in Fig.5, the conclusion can be only that COSMO model predicts less thick clouds and/or less amount of low and medium clouds, able to maintain the LW radiation balance close to zero during the winter nights.

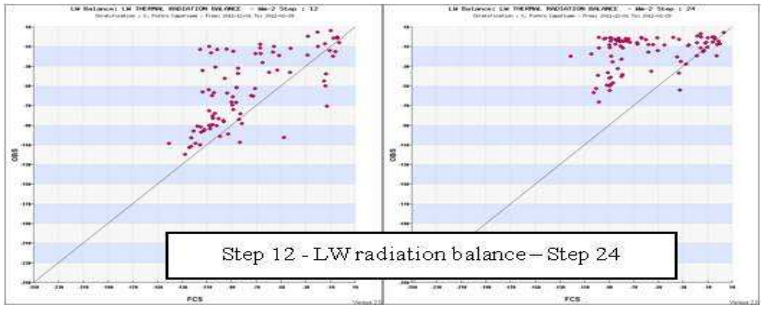

Figure 6: DJF scatter plots of LW radiation balance – Step 12 and 24 – S. Pietro Capofiume.

Another very interesting example, in the perspective of the application of conditional verification to these special observations in order to discover connection between physical processes and weather parameters behaviour, is shown in Fig.7.

Here in the time series of LW radiation balance it is shown and highlighted the period from 10.01.2011 to 20.01.2011. It is evident the mismatch between the observed LW radiation balance, that is almost zero, and the predicted one that has clear fluctuations of quite high magnitude. In this situation the examination of TCC time series and daily cycle is revealing of the problem.

The model predicted a complete wrong amount of cloud cover in those days, even up to 90-100% of error and the correspondent daily cycle shows the gap between forecast and observation. In this situation the whole predicted atmospheric column will be affected by the error and other parameters, not shown here, will present similar deficiency.

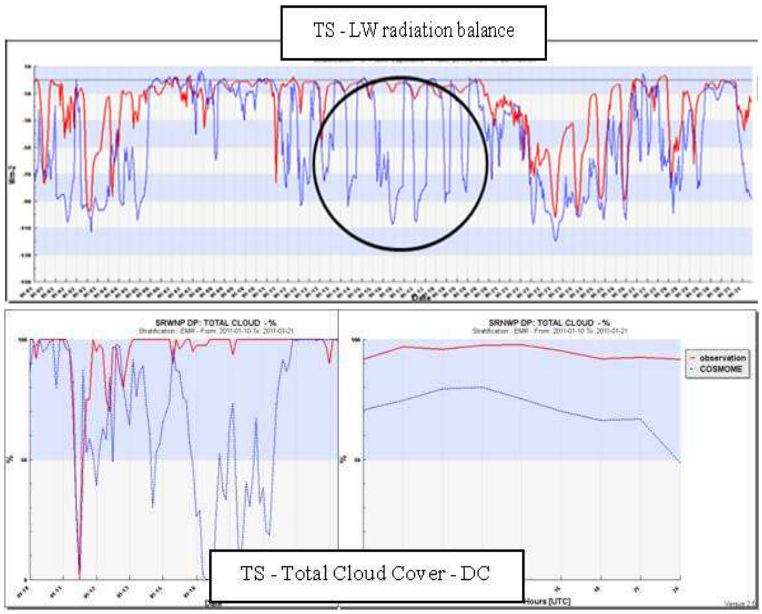

Figure 7: Time series of LW radiation and TCC, DC of TCC – 10-20 Jan 2011- S.Pietro Capofiume.

4 Conclusions

The exploitation of controlled and homogenous set of surface and near surface observations is fundamental in any verification process in the framework of NWP. This is even more crucial when the field of application of such activity is the PBL and the effort is to explore directly the sources of the physical processes. The availability of datasets like the one used here gives to the verificators and the modellers the possibility to check directly some specific model outputs and to cross-check them in connection with the usual weather parameters, also using the conditional verification techniques.

In this work it has been briefly shown how, radiation data can be utilized in VERSUS software together with other surface measured parameters in order to extract valuable information for COSMO model performance. As a first indication, COSMO generally predicts well LW and SW radiation balance and fluxes, with some exception, especially for LW radiation. It has been also explained how also the different aggregations of results can be revealing of the reason of model deficiencies, like the contemporary use of time series, daily cycle and scatter plots.

The overprediction of negative sensible heat flux has an impact also on the prediction of 2mT, mainly during the night and the early morning, while the shift of maximum in latent heat flux should be better investigated connected with dew point and specific humidity prediction. The model tends to steadily overpredict the upward LW radiation for both the complete station stratification and S. Pietro Capofiume, with almost the same behaviour. It has been shown how in two specific situations this can be due to different reason: the wrong representation of TCC in terms of percentage and/or in terms of cloud layer thickness.

Finally the use of conditional verification technique should be applied in order to find connection between specific significant thresholds, for which these fields become more significant, and the usual weather parameters.

References

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