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Verification of COSMO model forecasting of severe precipitation events in the South and Southeast regions of Brazil

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CLM-COSMO User Seminar, DWD, Offenbach, 06th to 10th of March, 2017

Abstract

The COSMO model has been used in Brazil at the National Meteorological Institute (INMET) and at the Parana State Meteorological Institute (SIMEPAR) for applications such as severe weather warnings and hydrological forecasting. An ongoing verification task of COSMO forecast simulation has been performed, through a joint ANELL research project PD-6491-0333-2013 between SIMEPAR and the Parana's electrical company COPEL-GeT and the results of this work are part of this project. The COSMO was initialized with the boundaries from GME and ICON, for years 2014 and 2015, respectively, both data sets provided by the Deutscher Wetterdienst, the Germany Meteorological Service. Additionally, a rainfall-runoff model was used for verifying river discharge into reservoirs of COPEL, located in the Iguazu River basin, in the state of Parana.

Background

- A large number of strong precipitation events was observed in the South of Brasil, during years 2014 and 2015 (Fig.1).

Fig. 1. Flood on 10th of June, 2014, at Uniao da Vitoria city, which is in the margins of Iguassu river.

- These events are quite often associated to death and economic disruptions and they challenge forecasters in the daily basis operation.
- The flood events in the South of Brazil were mainly due to abnormal El-Niño conditions, during these period, as depicted in Fig. 2.

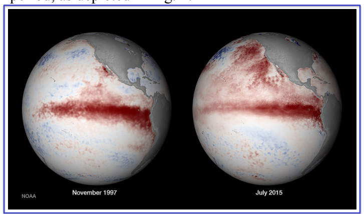


Fig. 2. NOAA's comparsion of the peak of El-Niño in 1997 (right) and in 2015 (left).

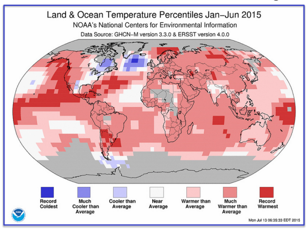


Fig. 3. Temperature anomaly for jan-jun 2015.

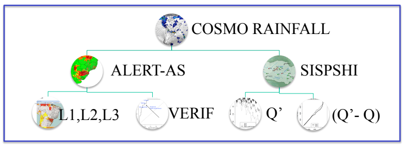
- On the other hand, nowadays hydrological forecasting systems depend very much on good automatic rainfall forecasting.

Motivation of the work

The INMET operates the ALERT-AS which is a severe weather warning system and Simepar developed and run the SISPSHI, a hydrological rainfall-runoff forecasting system, based on COSMO rainfall output. The goal of this work is to verify the performance of these systems during years 2014 and 2015, when the COSMO model used the boundaries from the GME and ICON global models, respectively.

System configuration: ALERT-AS

The COSMO was calibrated for the ALERT-AS by using a regression algorithm, which combines the atmospheric observations taken from occurred severe weather events and the model output. Three warning thresholds were calibrated for wind, 2m temperature, 2m relative humidity and 24 hours rainfall accumulation. This work is limited to the verification of the rainfall warning system. Thus three thresholds were obtained for 24-hr rainfall accumulation: (i) above 40mm (*first alert level, L1*); (ii) above 60mm (*second alert level, L2*) and (iii) above 80mm (*third alert level, L3*). An example of the ALERT-AS for Brazil is shown in Fig.4.



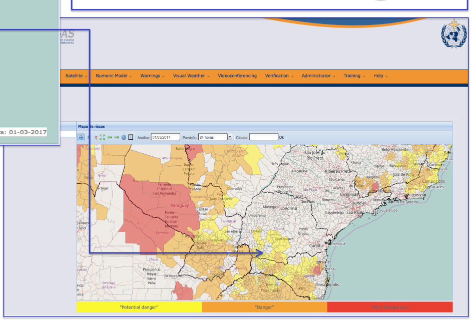


Fig. 4. The risk map of the ALERT-AS system and the 3 levels of warnings for servere events of rain, computed from COSMO forecasting. Right: as informed to users. Left (top): flow chart of the systems; left (bottom) a map with warning at municipality level.

System configurarion: SISPSHI

The Simepar hydrological system, SISPSHI, comprises a semi-distributed approach, with a Sacramento model as a core system and a local adaptation to take care of the water propagation through large basin channels. Thus the system is so-called **3R**, which extends for **R**ainfall, **R**unoff and **R**outing. It performs the water balance in the soil and in the basin channel, taken into account all the processes in Fig. 5.

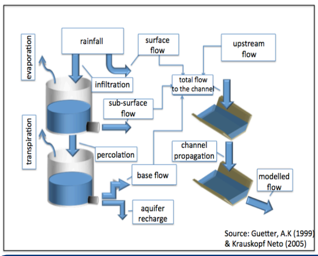


Fig. 5. Processes of the 3R-SISPSHI hydrological system which encompass the following tasks:
1. Rainfall data collection and QC;
2.Use of temporal series of rainfall and basin rainfall average;
3. Coupling to COSMO rainfall forecasting;
4. Compute the basin average forecast rainfall;
5. Perform the hydrological simultation and runoff river flow forecasting.

COSMO NWP Application

A large domain, covering Brasil and with 7km grid mesh, was used for providing a 5-day forecasting of total rainfall accumulation for the two previously mentioned applications, during years 2014 (with boundaries from GME) and 2015 (with boundaries from ICON):

- **For the ALERT-AS**, we verify the model warning output against the surface observation over each municipality within the verified region, which in our case it includes central and south parts of Brazil (as in Fig. 4). The verification was performed by computing bias, RMSE, Brier Scores and the Probability of Detection indexes. Besides, a contingency table was built upon the conditional probability of a given forecasted precipitation range agree to the observed value. The cells of the contigency table were used to computed the hit rate (HR) and the false alarm rate (FAR), for the three select warning thresholds (L1, L2 and L3), for 3 Brazilian geo regions and, for 2014 and 2015, respectively. These two indexes were then used for plotting a Relative Operating Curve (ROC), as way to access the performance of the ALERT-AS.
- **For the SISPSHI**, the runoff was forecasted for two cacthments in the Iguazu River, as depicted in Fig. 6: hydro-electric power stations close to União da Vitória and Foz do Areia cities. The SISPSHI output produced hourly runoff forecasting for the period of 120 hours, and the forecast was then verified against observed runoff, computed by using a reference model (based on the accumulated rainfall observations).
- The COSMO configuration was kept equal at both applications. However, during year 2014, the boundaries for the initialisation of the Limited Area Model corresponded to the GME global model and after January, 2015, they were from ICON global model, both provided by DWD.

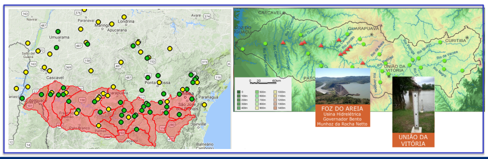


Fig. 6. Iguazu river basin and the observation locations (left) and the target hydro-electric power stations: União da Vitória and Foz do Areia (right).

Results

The plots in figures 7 and 8, summarize the results for the verification of the ALERT-AS severe weather warning system and for SISPSHI hydrological system, respectively.

- The ROCs in Fig 7 show the overall performance of the ALERT-AS for producing the 3 warnings thresholds for the three regions in Brazil, during 2014 and 2015, respectively.
- The Q-Q plots in Fig 8 (top) show a statistical comparison of distribution quantiles of observed (Q) and predicted runoff (Q'), for the two target Iguazu river reservoirs. The hourly bias plots (bottom) denote the quality of the runoff forecasting.

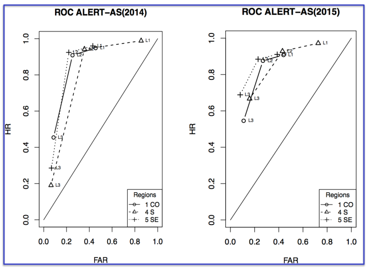


Fig. 7. ROC curves for the ALERT-AS system, for 3 selected threshold and for 3 regions of Brazil and for 2014 (left) and 2015 (right) periods.

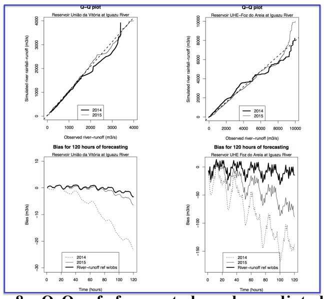


Fig. 8. Q-Q of forecasted and predicted distribuitions (top) of runoff and hourly bias (bottom) for the selected reservoirs, for 2014 and 2015.

Conclusions

Plots in Figures 7 and 8 show that the performance of the two analised system for years 2014 and 2015:

- Differs, being 2015 an improvement over 2014, though the forecasting during these years cannot be said entirely comparable, since the study was not done concomitantly;
- The hit rate for the ALERT-AS improved reasonably for 2015, specially for the large warning threshold and for Southeast region of Brazil.
- The results for the hydrological forecasting of runoff, by using the rainfall output from COSMO, show a large improvement on 2015, for both target hydro-electric power stations, as it can be noted by looking at the plot of Figure 8, showing the distribution and bias devitations from the reference forecasting, which was computed by using the observed rainfall.
- In spite of these differences, it is important to mention that 2014 had much more strong rainfall events than 2015.