Mediterranean Storms
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APPLICATION OF A NUDGING PROCEDURE FOR RAINFALL ASSIMILATION TO THE 2001 ALGERIAN FLOOD

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ABSTRACT

A nudging procedure for assimilating precipitation data into a limited area model (BOLAM) has been applied to the Algerian flood event, occurred in November 2001. The assimilation scheme modifies the model specific humidity profiles according to the difference between predicted and observed rainfall. The forcing is a function of the precipitation type, stratiform or convective. Idealized experiments have been performed implementing a lagged forecast procedure, in order to evaluate the scheme's performance. Results of a realistic experiment, using satellite retrieved data, are presented.

1 INTRODUCTION

The severe weather episode that affected the southern Mediterranean area between 9 and 11 November 2001 was characterized by heavy rainfall over Algeria and wind storm especially over the Balearic Islands. A high level cold trough, extending from northeast to southwest over the western Mediterranean sea, developed on 9 November, associated with a pronounced tropopause fold. On the following day, favoured by the baroclinic unstable environment, an intense cyclone rapidly evolved moving northward towards the Balearic Islands where, on 11 November, caused a severe wind storm. The operational BOLAM forecast from 00 UTC, 11 November showed, consistently with the ECMWF analyses, a cyclone evolution resembling an "hurricane-like" event which probably never took place, although a very deep low actually developed.

Genovés and Jansà (2002) showed that latent heat release linked with surface heat fluxes played a crucial role in the evolution of the low. A nudging procedure that modifies the humidity profiles should have an appreciable impact on the cylogenesis. Hence, this case study represents a suitable opportunity for testing and evaluating the nudging procedure not only in terms of improvement in precipitation forecasts, but also in terms of impact on short-range forecasting of an intense Mediterranean cyclone.

An accurate description of the assimilation procedure can be found in *Davolio & Buzzi* (2002); briefly, after comparing the observed and forecasted precipitation, the scheme modifies the model specific humidity profile, q(k), according to the following equation:

$$\frac{\partial q(k)}{\partial t} = -\nu_{S,C}(k)\tau^{-1}\left\{q(k) - \varepsilon_{S,C}q^{*}(k)\right\} \qquad (1)$$

where q*(k) is the model saturation humidity profile, τ is a relaxation time, $\varepsilon_{s,c}$ is an over/under saturation coefficient and $\nu_{s,c}(k)$ is a vertical modulation profile, whose value may vary in the interval [0-1]. $\varepsilon_{s,c}$ and $\nu_{s,c}(k)$ depend on the precipitation type, convective or stratiform.

2 IDEALIZED EXPERIMENT: SET UP AND RESULTS

A lagged forecast scheme has been implemented, performing three simulations as follows. The first simulation (C) consisted of a 36-h run, initialized 10 November, 12 UTC. The second (F) was initialized 12 hours before, at 00 UTC of the same day and lasted 48 hours. While C represents the reference state and provides the precipitation target data, F is considered the "real" forecast to be improved (compared to C). Finally, a third 48-h simulation (N) was performed, starting from the same initial condition as F, but applying the nudging procedure for 12 hours, from 10 November, 12 UTC. 2-hourly rainfall data obtained from C are used for the assimilation, with the aim of forcing the forecast towards C.

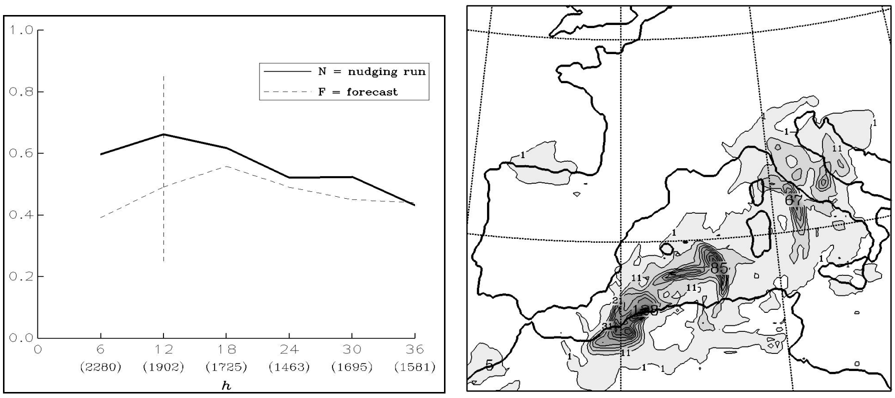

Figure 1. Evolution of the equitable threat score (left panel) computed for 6-h accumulated precipitation for F and N (see text), starting 10 Nov. 2001 at 12 UTC. Numbers in brackets indicate numbers of observation exceeding the threshold value of 2 mm/6h. The vertical dashed line indicates the end of the assimilation period. 12-h accumulated precipitation (right panel) at 11 Nov. 2001, 00UTC for the control run C. Shading and contour interval is 10 mm.

The 12-h accumulated precipitation field at 11 November 00 UTC (that is at the end of the assimilation phase) is considerably improved by the nudging, as comes out by comparing F and N with C. The forecast error is reduced by assimilating rainfall data, and the improvement extends well after the end of the nudging period, as shown by the equitable threat score in Figure 1.

The simulations show also the deep cyclogenesis that took place between 10 and 11 November (see for example the control forecast C in Figure 2). While C produces a very deep low (985 hPa) resembling a "hurricane-like" cyclone, surrounded by an area of more leveled pressure, in F the cyclone appears as a weaker large scale pressure system, without an intense core. As expected, the nudging procedure has an appreciable impact on the cyclogenesis. Indeed, as shown in Figure 2, the evolution of the low centre is improved during and after the rainfall assimilation in terms of both intensity and timing. Also its trajectory is positively modified.

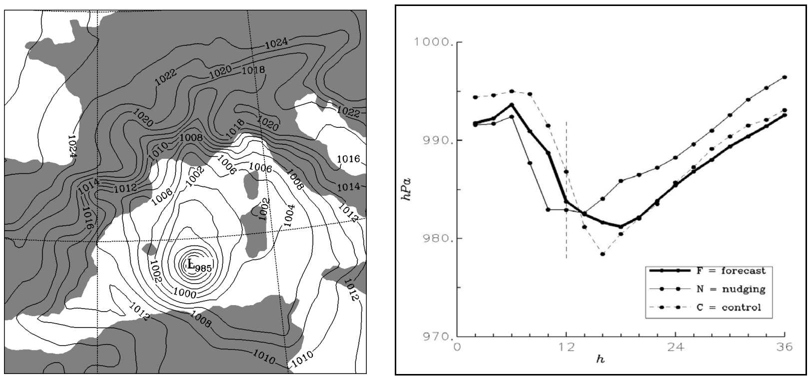

Figure 2. Mean sea level pressure field (left panel) at 11 Nov. 2001, 12 UTC after 24-h simulation (C, control run). Contour interval 2 hPa. Central MSLP value (hPa) evolution (right panel) for the three runs, C (dashed line), F (thin line) and N (thick line), computed at 2-h intervals from 10 Nov 2001, 12 UTC to 12 Nov 2001, 00 UTC. The vertical dashed line indicates the end of the assimilation period

3 ASSIMILATION OF SATELLITE RAINFALL DATA

The nudging scheme has been further applied to the Algerian flood event in a more realistic framework, attempting to assimilate satellite precipitation estimates (Rapid Precipitation Update method, *Turk et al.*, 2000). Since the scheme does not account for the statistical weight of the background field (model) and observations, and because of the apparent low quality of the data over land (the heavy rainfall over Algeria is missing), the assimilation has been performed only over the sea.

Two 72-h forecasts have been carried out, both starting from 9 November 2001, 00 UTC. The first represents the reference forecast (RF). The second one (NF) is forced by the nudging scheme for 12 hours, from 10 November, 00 UTC that is after 24-h of free forecast, using 2-hourly accumulated satellite rainfall data.

Comparing the 12-h accumulated precipitation fields (Figure 3) as estimated from satellite and forecasted by the model (RF), discrepancy over Algeria as well as differences over the Mediterranean sea are evident. The assimilation (Figure 3) seems to reduce most of the forecast error over the sea in terms of intensity and location. The rainy area between Sardinia and the Italian coast, missing in RF, has been generated by the nudging, even if it appears weaker than the observation (30 instead of 40 mm/12h). Moreover south of Sardinia the narrow rain band shown in RF is considerably reduced in NF, according to the satellite data. Also around the Balearic Islands the rainfall field has been improved. As for the previous idealized experiments, the rainfall assimilation affects the model dynamics, modifying the Mediterranean cyclone development.

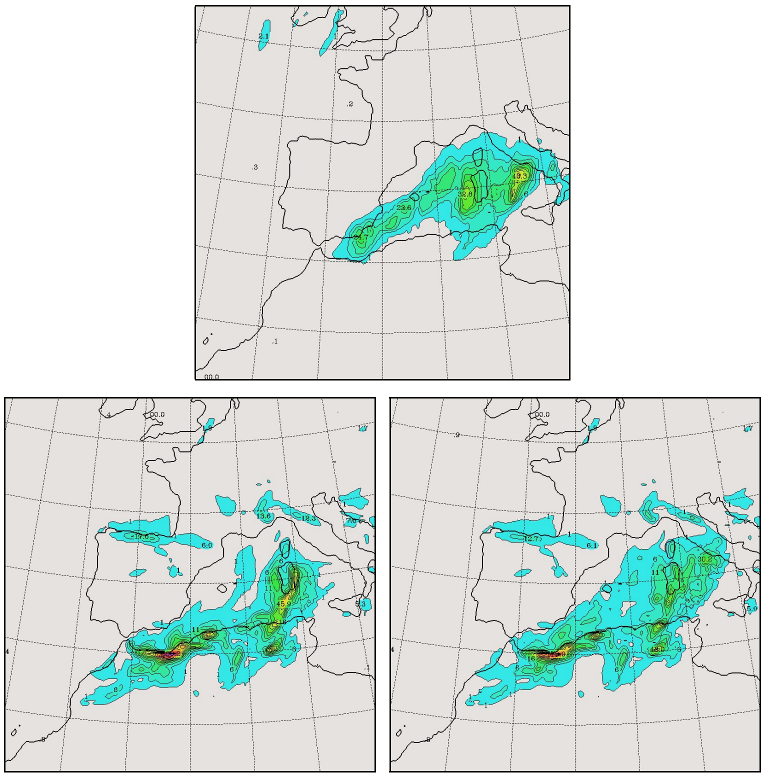

Figure 3. 12-h accumulated precipitation at 12 UTC, 10 Nov 2001 as estimated from satellite (top panel), for the reference forecast RF (bottom left) and for the nudging forecast (bottom right). Contour interval is 5 mm. Note that assimilation was made only over the sea.

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