A NUMERICAL STUDY OF THE WINDSTORM KLAUS: ROLE OF THE SEA SURFACE TEMPERATURE AND DOMAIN SIZE

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I. INTRODUCTION

The windstorm denominated 'Klaus' occurred between the 23rd and 24th January 2009. When it landed over the coast of France it wrecked havoc in France and Spain. Klaus belongs to those kinds of storms classified as meteorological bombs (Sanders and Gyakum, 1980). Analysing the pressure maps and satellites images it is possible to see that it was "similar" to the cyclone "Lothar" that has been the subject of several works (e.g. Wernli et al 2002). It's challenging to forecast correctly the genesis and evolution of this kind of cyclones (Sienkiewicz et al. 2004).

In general, latent heat release that is due to condensation may have a strong impact on the evolution of cyclones as shown by observational and modelling studies (Davis and Emanuel 1991, Fantini 1991). In meteorological bombs the latent heat release seems to be crucial to promote low-level vorticity (Kuo and Low Nam, 1990).

Most of the meteorological bombs in the Atlantic Basin form just north of Gulf Stream (Sanders and Gyakum 1980; Robber, 1984). The impact of the sea surface temperature on storm evolution is usually evaluated for tropical cyclones, whereas how it affects the extra-tropical cyclones has been object only of a few case studies (e.g. Giordani and Caniaux 2001). The importance of SST is critical in understanding how possible scenarios of global warming may modify the evolution and the strength of extra-tropical storms. In this study we analyzed how the sea surface temperature impacted in the numerical simulations on the evolution of the cyclone "Klaus". We analyzed contextually how the domain size is a very important for forecasting correctly the deepening of the cyclone.

II. PRESENTATION OF RESEARCH

A study of sensitivity of development of the cyclone to the sea surface temperature is presented here. The study was conducted by using the model BOLAM developed at ISAC-CNR (Buzzi and Foschini, 2000).

The study investigates the role of the SST in the evolution of the cyclone, we show also the importance of choosing the model domain in order to forecast correctly the evolution of the cyclone.

We performed the control simulation SST0 and 9 runs in which the SST was increased from 1 K (SST1) to 9 K (SST9). The model runs were performed with a horizontal resolution of 30 km. As we are not interested in studying the sensitivity of the forecast to the grid resolution, it is sufficient to simulate sufficiently well the genesis and the evolution of the cyclone. The numerical simulations started at 0000 UTC of 23 Jan 2009.

However, before analyzing the sensitivity to SST we tried a couple of domains in order to check the sensitivity of the domain size. A "good" prediction of this cyclone was obtained only when the initial perturbation was contained in the domain. With a too small domain even with a higher resolution (15 km) with respect to the simulations analyzed in this paper (all at 30 km horizontal resolution) but not including the initial perturbation, the simulated cyclone do not reach the intensity obtained with the simulation with a coarser grid step (984 hPa vs 974 hPa).)

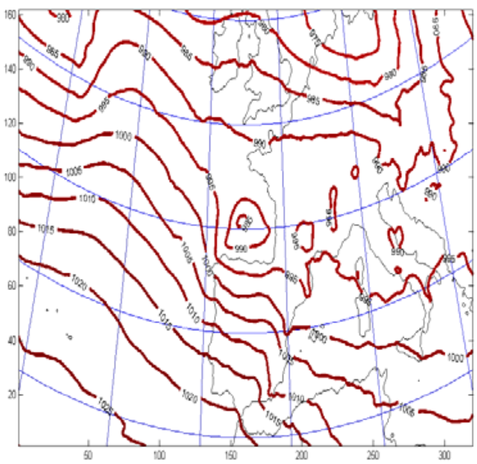

FIG. 1: MSLP at 00 00 24 Jan 2009, model resolution 0.13º was selected to simulate numerically the evolution of Klaus. Minimum Pressure 984 hPa.

III. RESULTS AND CONCLUSIONS

The results of the sensitivity of "Klaus" to SST can be resumed in Figs. 2, 3 that show the evolution of the MSLP minima and 10 m wind speed maxima for the 10 numerical simulations when the cyclone reaches its maxim intensity, i.e. at 00 00 UTC of 24th Jan 2009 (These value were obtained considering subdomain of 31x31 grid points encompassing the cyclone). The positions of MSLP minima and 10 m wind speed maxima of the sensitivity experiments were not much different from the control simulation (not shown). It worth noting as there is not a unique trend of the minimum MSLP and maximum wind speed. When the temperature is larger than 5º the trend slope increases suggesting a non-linear effect due to increasing of the water vapour and more production of rainfall (Fig. 4).

Increasing the SST implies providing furthermore a source of latent heat that seems to be fundamental in the evolution of this kind of cyclones (Tartaglione et al., 2009). The sea surface is the main source of water vapour whose condensation provides the energy to invigorate the strength of the cyclone. Tartaglione et al. (2009) showed that the cyclone is generated by “dry” baroclinic instability, but without latent heat contribution it was not able to transform itself in an exceptional windstorm.

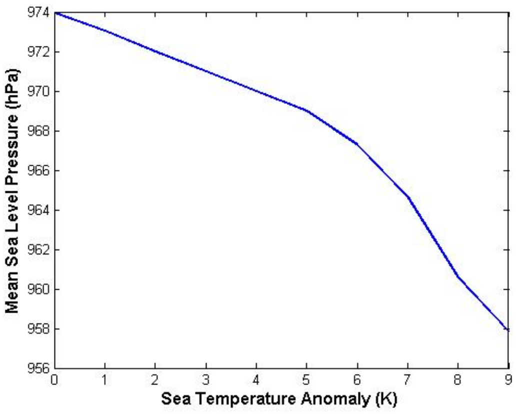

FIG. 2: ‘Klaus’ MSLP minimum as a function of the SST anomaly with respect to the control simulation (SST0).

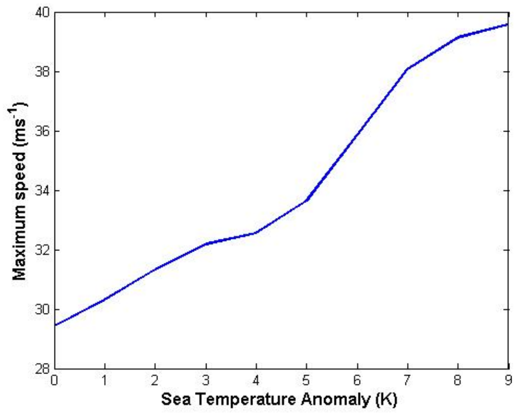

FIG. 3: As Fig 2 but for the maximum wind speed.

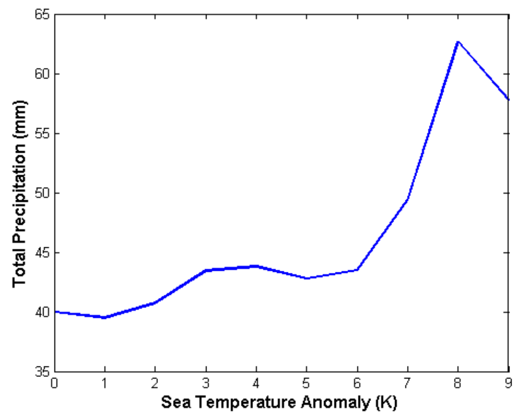

FIG. 4: As Fig. 2 but for the total precipitation (mm in 6 h)

We showed here the high sensitivity of meteorological bomb like ‘Klaus’ to SST. Although it represents only a case study, it seems that the SST plays a significant impact on the evolution of this kind cyclone, a result to be considered when we take in account global warming scenarios. We performed simulations of this cyclone increasing and decreasing the atmospheric temperature but keeping the same sea temperature of the control experiment and we found that the evolution of the cyclone is not as sensitive as the one obtained changing the sea temperatures.

IV. AKNOWLEDGMENTS

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