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The role of SSTs in the development of explosive cyclogenesis: The storm of 21-22 January 2004 in the Eastern Mediterranean

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During the last two decades much attention has been given to the extra-tropical cyclonic systems that develop at an unusually rapid rate. The first synoptic and climatological study of such explosively developing storm has been documented by Sanders and Gyakum (1980). They defined an extra-tropical cyclone as “bomb” when its central sea-level pressure deepens by at least 1hPa per hour for 24 hours at a latitude of 60 0N. Strong sea surface temperature (SST) gradients accompanied with high surface fluxes of heat (latent and sensible) appear to characterize the favorable environment for the marine bomb development. Various modeling studies seem to suggest different roles of the SST and heat flux in forcing the extra-tropical atmosphere. Although models are sensitive to the lower boundary conditions, it is not clear if the forcing from different types of SST can significantly impact a given simulation of a rapid developing cyclonic system.

To this end, comparative numerical simulations of an explosive cyclogenesis event in marine environment were performed based on a non-hydrostatic limited area model. Reanalysis and satellite-measured SSTs were both used as model lower boundary conditions. The aim of this study is to investigate the sensitivity of storm characteristics to the different SST sources. The case of 21-22 January 2004 was chosen for analysis due to its intensity and impact in the coastal areas of Southern Greece. According to the MEDEX database (MEDiteranean EXperiment) this event was among the three deepest cyclones found in the entire Mediterranean during last decades. Model simulations on high spatiotemporal resolution resolved mesoscale features triggered by the different nature of SSTs. Although the atmospheric response was significant in terms of rain bands and surface fluxes, the phase and the structure of the system were not affected by the different boundary conditions forcing. In more details, the shifted rain bands, as they were simulated with reanalysis and satellite-measured SST forcing, are related with the different representation of the transition speed of the storm. These precipitation patterns are mainly attributed to the stronger surface fluxes of heat that impose a deeper destabilization of the boundary layer. Stronger surface fluxes, with differences exceeding 150 Wm-2, were predicted when the generally warmer reanalysis SSTs were used.