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Impact of upper-level fine-scale structures in the deepening of a Mediterranean "hurricane"

C. Claud (1), J.-P. Chaboureau (2), S. Argence (3), D. Lambert (2), E. Richard (2), N. Gauthier (1), B. Funatsu (1), P. Arbogast (4), K. Maynard (4), and A. Hauchecorne (5)

(1) Laboratoire de Meteorologie Dynamique, CNRS/IPSL, Palaiseau, France, (2) Laboratoire d'Aerologie, Universite de Laboratoire d'Aerologie, Universite de Toulouse / CNRS, Toulouse, France, (3) Numtech, Aubiere, France, (4) Meteo-France, Toulouse, France, (5) Laboratoire Atmospheres, Milieux et Observations Spatiales, Verrieres le Buisson, France

Subsynoptic scale vortices that have been likened to tropical cyclones or polar lows (Medicanes) are occasionally observed over the Mediterranean Sea. They are usually associated with strong winds and heavy precipitation and thus can have highly destructive effects in densely-populated regions. Only a precise forecasting of such systems could mitigate these effects. In this study, the role of an approaching upper-level Potential Vorticity (PV) maximum close to the vicinity of a Medicane which appeared early in the morning of 26 September 2006 over the Ionian Sea and moved north-eastwards affecting Apulia, is evaluated using the anelastic non-hydrostatic model Méso-NH initialized with forecasts from ARPEGE, the French operational forecasting system.
To this end, in a first step, high resolution PV fields have been determined using a semi-Lagrangian advection model, MIMOSA (Modelisation Isentrope du transport Meso-echelle de l'Ozone Stratospherique par Advection). MIMOSA PV fields at and around 320 K for 25 September 2006 at 1800 UTC clearly show a stratospheric intrusion under the form of a filament crossing UK, western Europe and the Tyrrhenian Sea. MIMOSA fields show a number of details that do not appear in ECMWF analysed PV fields, and in particular an area of high PV values just west of Italy over the Tyrrhenian Sea. While the overall structure of the filament is well described by ARPEGE analysis, the high PV values in the Tyrrhenian Sea close to the coast of Italy are missing. In order to take into account these differences, ARPEGE upper-level fields have been corrected after a PV inversion guided by MIMOSA fields. Modifications of PV in ARPEGE lead to a deepest system and improved rain fields (both in location and intensity), when evaluated against ground-based observations.
In a second step, Meso-NH simulations coupled with corrected and non-corrected ARPEGE forecasts have been performed. The impact of the corrections on the intensity, the trajectory and the associated precipitation has been evaluated using in situ and satellite observations, in the latter case through a model to satellite approach. When the PV corrections are applied, the track of the simulated Medicane is closer to the observed one. The deepening of the low is also better reproduced, even if it is over-estimated (982 hPa instead of 986 hPa), as well as the precipitation. This study confirms the role of fine-scale upper level structures for short range forecasting of sub-synoptic vortices over the Mediterranean Sea. It also suggests that ensemble prediction models should include perturbations related to upper-level coherent structures.