A Quasi-Tropical Cyclone over the Western Mediterranean: Dynamical vs Boundary Factors

V. Homar, R. Romero, C. Ramis, S. Alonso

The Event. Description

Event description and social impacts:
- Very active episode on 11 and 12 September 1996:
  - 6 tornadoes at the Balearic Islands
  - Heavy precipitation in Valencia
  - A small and deep cyclone crossed Mallorca
- Extensive damages in harbours and the countryside

Objectives:
- Numerical sensitivity study of the small-scale cyclone, focusing on:
  - Upper levels dynamical features
  - Evaporation from the sea
  - Topography
The Event. Observations

- A sudden Surface Pressure decrease: 9 hPa in 2 h

![Cyclone center trajectory]

Observed Surface pressure in Palma

Synoptic Overview

- NCEP analysis 6h before the cyclone formation:

12 September at 00 UTC

- Geo-Tem 500 hPa
- Srf Pres-Tem 1000 hPa
Synoptic Overview

Upper levels

PV 300 hPa. 0600 UTC

PV 300 hPa. 1200 UTC

Numerical Experiments configuration

- The MM5 model was used to perform numerical simulations
- Kain-Fritsch convective parameterization is used
- Two domains are defined to obtain high resolution over the area of interest while retaining in the simulation the main synoptic features of the event

- Simulations start at 1200 UTC 11 September (18 h previous to the cyclone formation) and extend out to 36 h
- Corrected NCEP global analyses are used as initial and boundary conditions, available at 0000 and 1200 UTC
Control Run Validation

Cyclone center Trajectory, Surface pressure and precipitation:

Control Run Analysis

Surface pressure, rainfall and sea surface evaporation:
Control run. Analysis

Sensitivity analysis

Considered agents:
- Orography
- Latent Heat Release
- Evaporation from the sea (LHF)
- Upper levels cutoff intensity
PV inversion methodology

Sensitivity Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Description</th>
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<tbody>
<tr>
<td>NORO</td>
<td>No topography</td>
</tr>
<tr>
<td>NOLHR</td>
<td>No latent heat release from condensation</td>
</tr>
<tr>
<td>NOLHF</td>
<td>No latent heat flux. Evaporation.</td>
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<tr>
<td>NOPVP</td>
<td>Weakened upper levels PV perturbation</td>
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Sea surface pressure and accumulated precipitation 12 UTC
LHF and PV effect

Factors separation: LHF, PV perturbation and their synergism:

Effect of the synergism
**Air-Sea Interaction**

- Air-sea interaction instability (Emanuel, 1986 JAS)?

- Circulation attributed to the PV anomaly aloft is revealed as the triggering agent of the instability by enhancing values of evaporation from the warm sea surface.

- The principal effect of the upper levels PV anomaly was not a direct surface pressure decrease but the generation of surface flow which intensified the evaporation.

**Conclusions**

- **Synoptic settings:** cold cutoff over the Iberian Peninsula and a surface low over the Western Mediterranean.

- **Numerical experiments:** intense and deep convective activity

- **Sensitivity experiments show:**
  - the primary role of the latent heat release on the cyclogenesis, and the negligible role of the orography in this event.
  - the crucial effect of the upper levels cutoff and the enhanced evaporation from the sea.
  - the synergism of the circulation at low levels and the derived evaporation from the sea was the responsible of the small scale deep cyclogenesis.

- **Air-sea interaction instability** was able to sustain the observed cyclone intensity.