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FF: The water budget and precipitation efficiency of the Medicane occurring in December 2005

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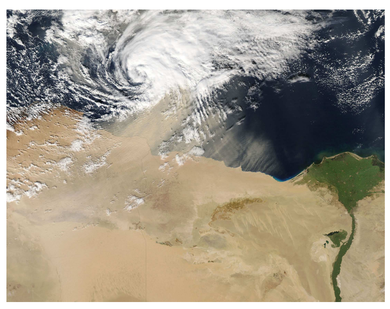
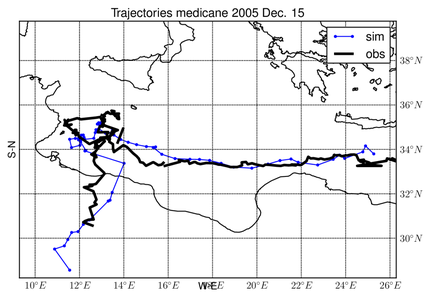
Abstract

The most intense cyclones in the Mediterranean are known to acquire characteristics of tropical hurricanes. These atmospheric systems are related to the most severe environmental hazards in the region, such as windstorms, floods.
In this study we present the results of a new technique focused on the water budget of cyclones which we applied to the Medicane case of December 2005, one of the clearest ever occurring in the Mediterranean. We decompose the atmospheric water budget in different terms, respect to the WRF model outputs from its microphysics and PBL schemes, as also, respect to the model simulated horizontal, vertical and diffusive moisture flux. Usually water budget analysis refers to the volume integration (mostly vertical column sums) of all the terms. However, in our case, there is only a temporal integration which is automatically done at each internal time-step of the model and at the same time at each grid point. Therefore, we achieve a higher detailed perspective of the moist dynamics in such events, providing three dimensional aspects of the water budget of cyclones. Finally, we calculate the precipitation efficiency of the Medicane evaluating thus the systems capacity in attributing extreme rainfall, respect to the water vapor drawn to its core.

Medicane December 2005

Medicane (Fita et al., 2007, @) from records (http://www.uib.cat/depart/dfs/meteorologia/METEOROLOGIA/MEDICANES/)





Satellite image of the medicane of December 2005. WRF trajectory and eye-based satellite retrieved one

WRF configuration

- 2 domain resolution: 10, 2 km, time-step: 60, 12 s, 50 lev.
- WRF physical set-up. mp: WSM5, ra_lw/sw: RRTMG, land: Noah, sfclay: MM5 similarity, pbl: YSU, cu: Kain-Fritch (only in first domain)
- Grid Nudging (only first domain), not in the pbl
- Initial/Boundary conditions: ERA-Interim
- Modifications in WRF code to obtain water budget terms from the internal time-steps of the model integration.
- Values accumulated and then de-accumulated from the outputs in order to obtain the output frequency changes

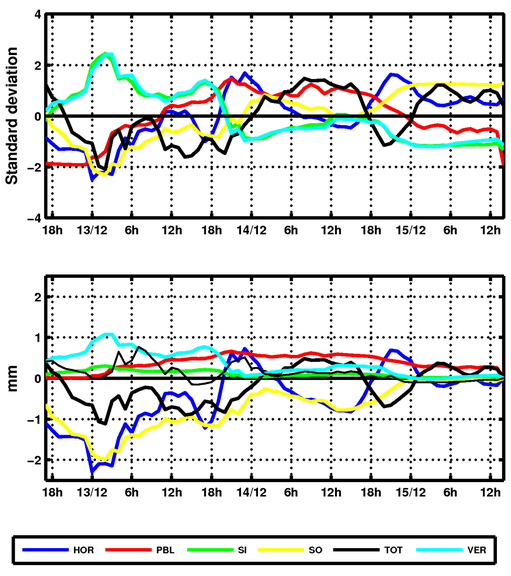
Water budget balance

Water budget taken from (Jiang et al., 2008, @; Huang et al., 2013, @) (mmh^{-1})

$$TEND = HOR + VER + CUM + PBL - SI + SO$$

$TEND = \partial_t q_v$	water tendency
$HOR = -\vec{\nabla}_h(q_v \vec{v}_h)$	horizontal convergence
$VER = -\partial_z(q_v w)$	vertical convergence
CUM	cumulus scheme term
PBL	pbl scheme term
$SI = Cond_c + Dep_s + Dep_g + Dep_i$	Sink
$SO = Evap_r + Evap_s + Evap_g + Mlt_s + Mlt_g$	Source

Results: Time-Series

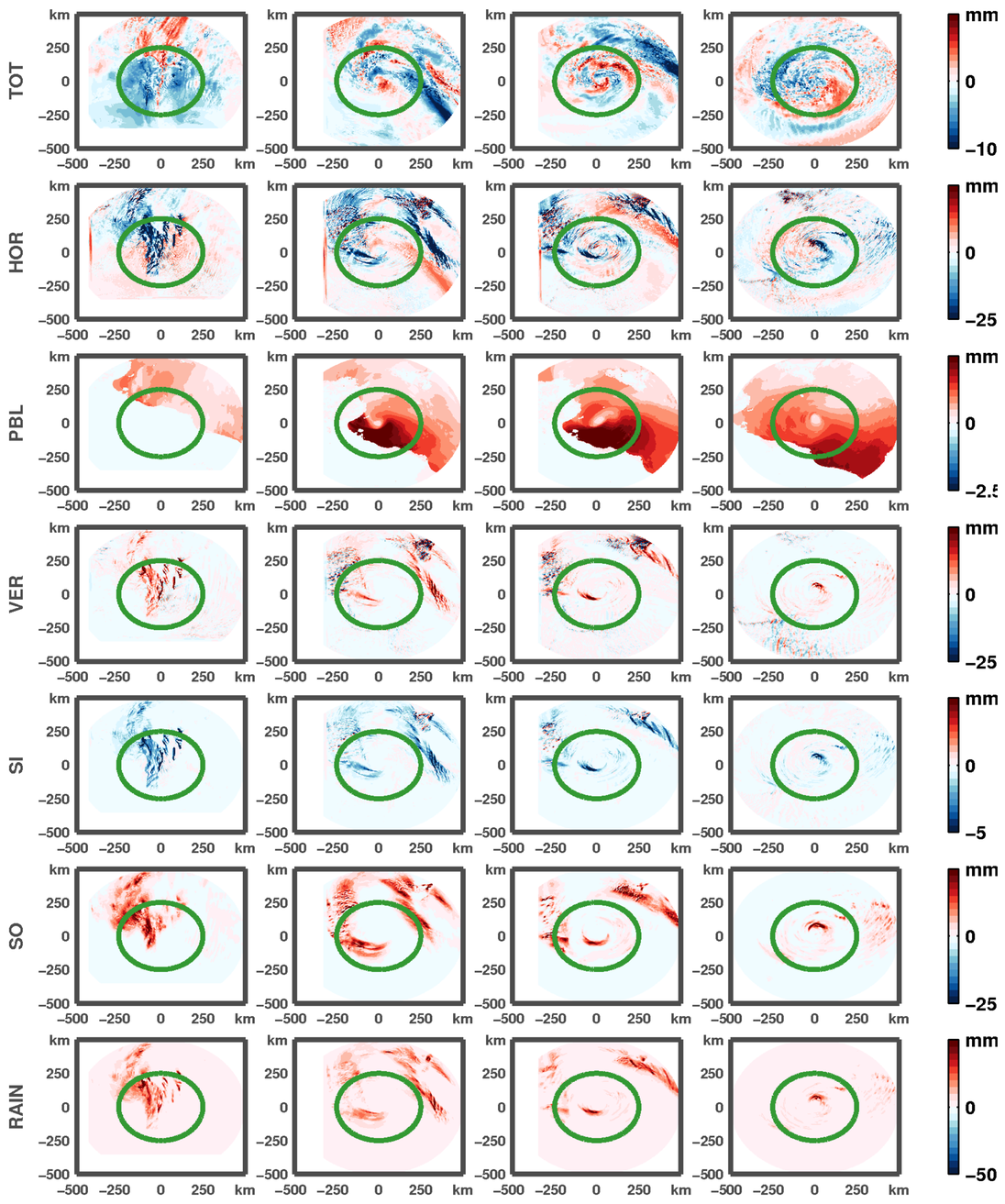


Tropical transition at 13^{20} ?
- 13^{02} heavy rain
- 13^{14} cold Front
- 13^{21} front drifted away
- 14^{03} medicane maximum

What next ?
- Does a baroclinic cyclone has a similar evolution?
- What about other water-involved process: Föhen effect, MCC, orographic-induced rain, ...

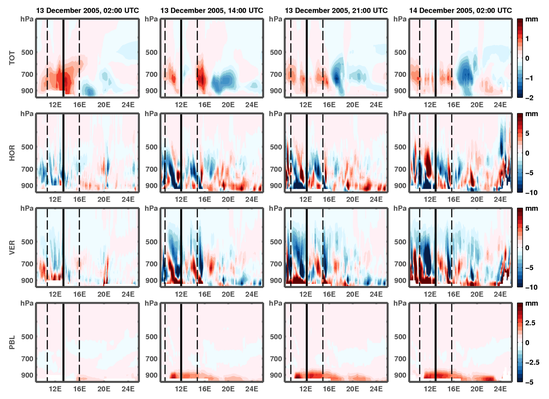
Time-series evolution of the different terms (also with precipitation in purple), of the vertical integrated and added within 200 km of radius following the center of the medicane. Bottom figure standardized with the respective standard deviation

Results: Total column integrate



Total column values of the different components of the water budget at different time-steps, 13^{02} (left column), 13^{14} (2nd column), 13^{21} (3d column), 14^{02} (right column)

Results: W-E cross sections



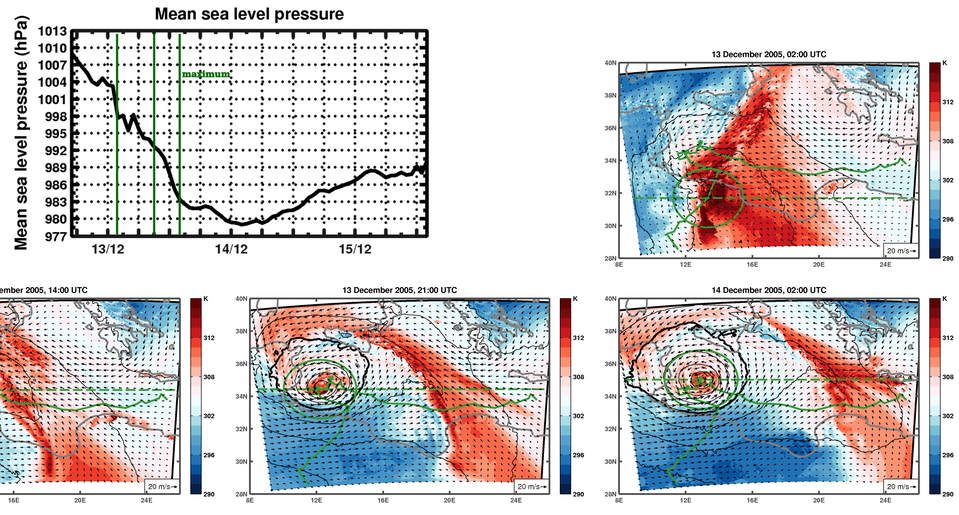
13^{02} Heavy rain: strong TOT water changes

13^{14}, 13^{21} Cold front (further E 200 km):
- Increase/Decrease TOT water
- Hor. conv.(700 hPa)/div (900 hPa)

14^{03} Medicane's maximum:
- Mark vertical conv./div. change (800 hPa) of HOR/VER (op. sign)
- Important role of the PBL (surface processes)

W-E Vertical cross sections of different terms of the water budget zoomed up to 300 hPa

Results: Medicane evolution



Mean sea level pressure evolution at the center of the medicane (top), snapshots (bottom) of surface temperature (shaded), mean sea level pressure (contours) and 10m wind speed at: 13^{02}, 13^{14}, 13^{21}, 14^{03}. Dashed W-E line shows location of cross sections, circle denotes the 200 km area from the center of the medicane

Bibliography

References

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