Intercomparison of intense cyclogenesis events over the Mediterranean basin based on baroclinic and diabatic influences

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A large number of high impact cyclones all over the Mediterranean basin have been reported on the data base of the MEDEX project (http://medex.inm.uib.es). A numerical study on the impacts and interactions of baroclinic and diabatic factors is carried out through a PV-based system of prognostic equations for 11 intense MEDEX cyclone episodes occurred in different zones of the basin (Western, Central and Eastern Mediterranean). The main aim of the study is to investigate the possible similarities and differences about the relative weight of the considered cyclogenetic factors on the cyclone evolutions as function of cyclone type and geographical area.

1 PV-based prognostic equations

A closed system of PV-based prognostic equations (Davis and Emanuel, 1991) is used to solve the geopotential height tendency equation. Geopotential height (ϕ) and stream function (ψ) are obtained from an initial PV distribution (q) via the **PV inversion technique**. The geopotential (ϕ^t), stream function (ψ^t) and PV (q^t) tendencies are given by the tendencies of the **Charney nonlinear balance equation** and the **Ertel's PV conservation equation** (Ertel's formulation), using the frictionless and diabatic form. From the **omega equation** it is obtained the vertical velocity (ω^*), and with the **continuity equation** the system is closed (giving the velocity potential χ). *Lateral homogeneous* and *Neumman top and bottom* boundary conditions are used for the tendencies.

2 Factor separation

Since the technique is based on PV Inversion the dynamical study will be based on the effects of PV anomalies (PVp). The effects of the anomalies will be isolated using the **Factor separation technique** (Stein and Albert, 1993). This technique allows to obtain the individual effects and the mutual interactions of a set of different factors (in this study contribuiting to the total geopotential height tendency). In this case the following effects are isolated:

- **E0**: Background flow
- **E1**: Upper level PVp (<700 hPa, RH<70 %)
- **E2**: Low level PVp (>700 hPa, RH<70 %)
- **E3**: Diabatic PVp (>500 hPa, RH>70%)
- **Eij**: Interaction Ei & Ej (+ E123)

3 Indications

The study is focused on the effects of each factor on the most relevant total geopotential height tendency signal (at 925 hPa) for the cyclone evolution at each time. An average of the effects of factor/interaction on the heigh tendency is calculated on the indicated space region at each time-step. Negatives values indicate deepening, moving or deforming the cyclone, whereas positive values would fill the low. The ECMWF 6 h-analysis have been used.

Figures show cyclone trajectory (black line), ϕ^t at 925 hPa (blue neg., red pos., every 10 gpm/6h), Sea level pressure (green) and average zone (pink) at mature cyclone time (top panel). Cyclone central pressure evolution (middle panel). Evolution of the Space-average tendency by each factor/interaction filtered with a three steps moving filter (black arrows show when the cyclone reached/left the Sea)

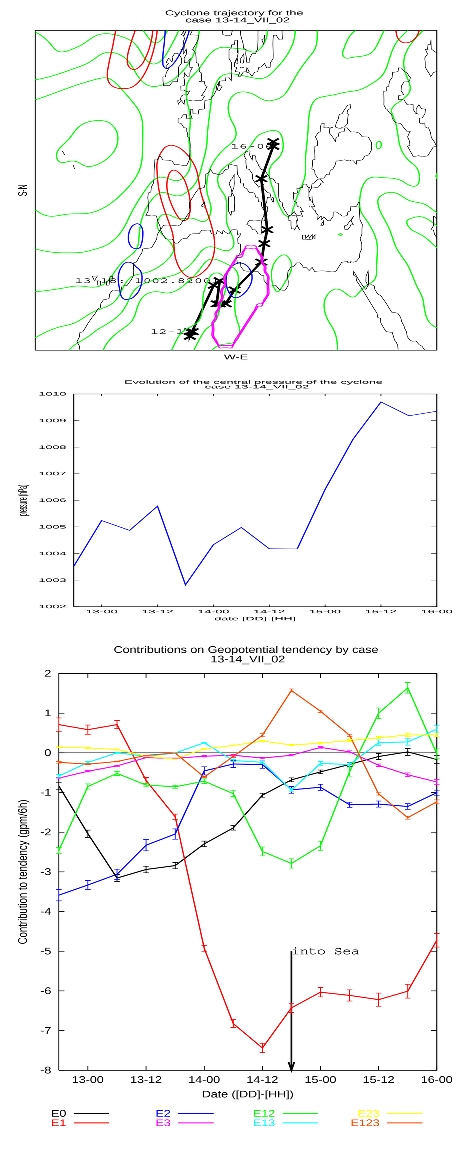

Figure 1: case 13-14_VII_02

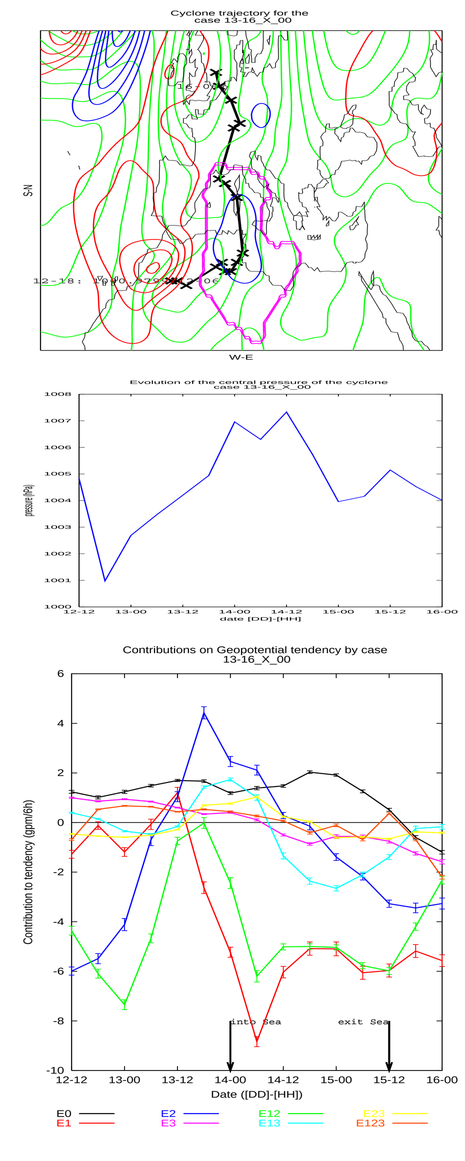

Figure 2: case 13-16_X_00

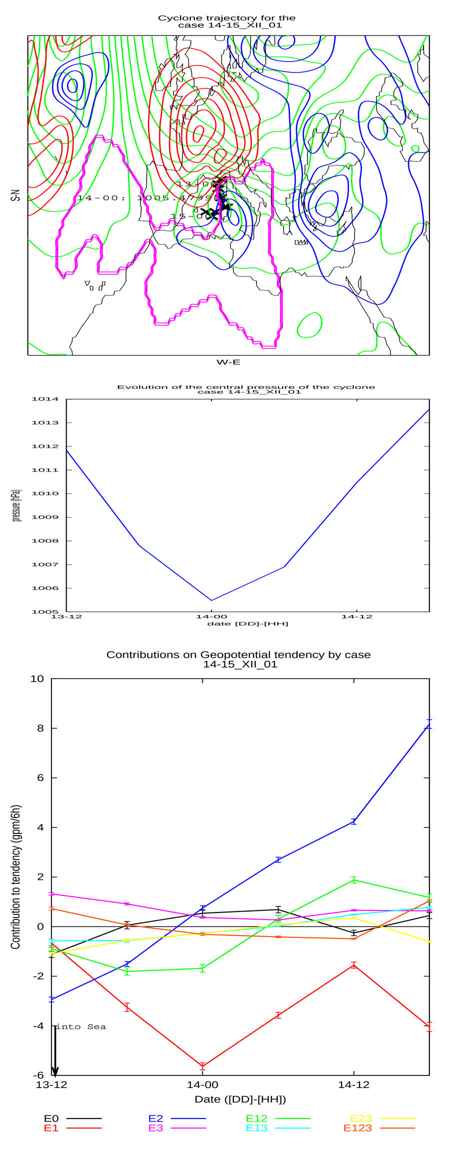

Figure 3: case 14-15_XII_01

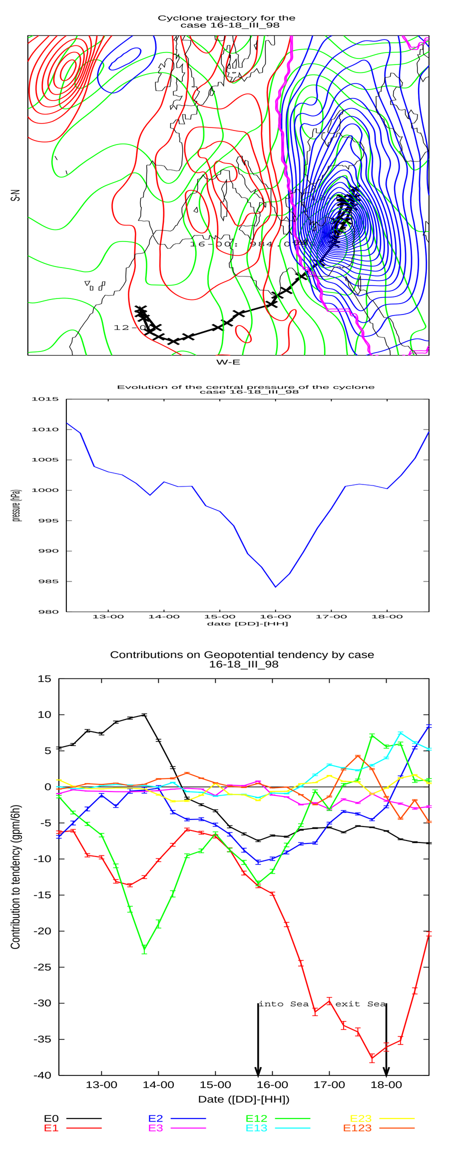

Figure 4: case 16-18_III_98

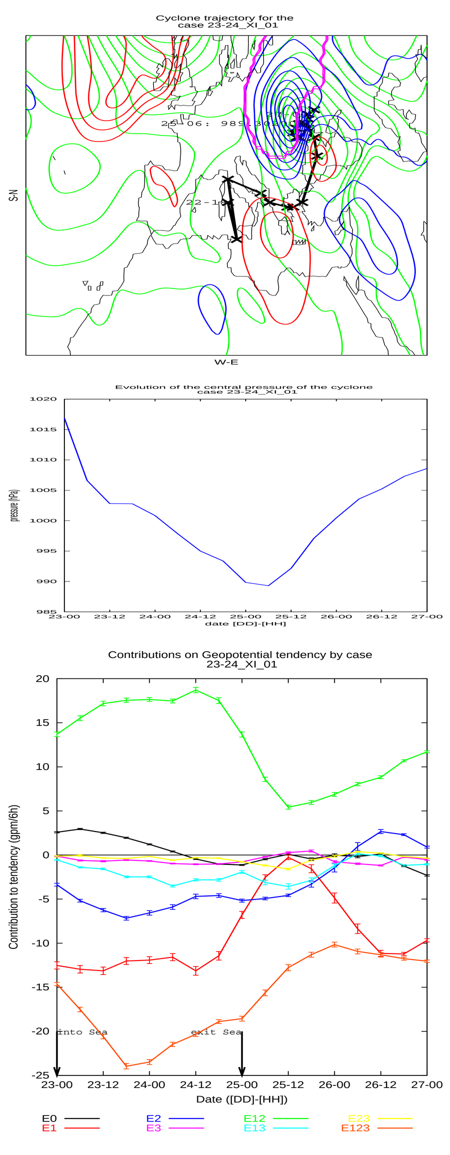

Figure 5: case 23-24_XI_01

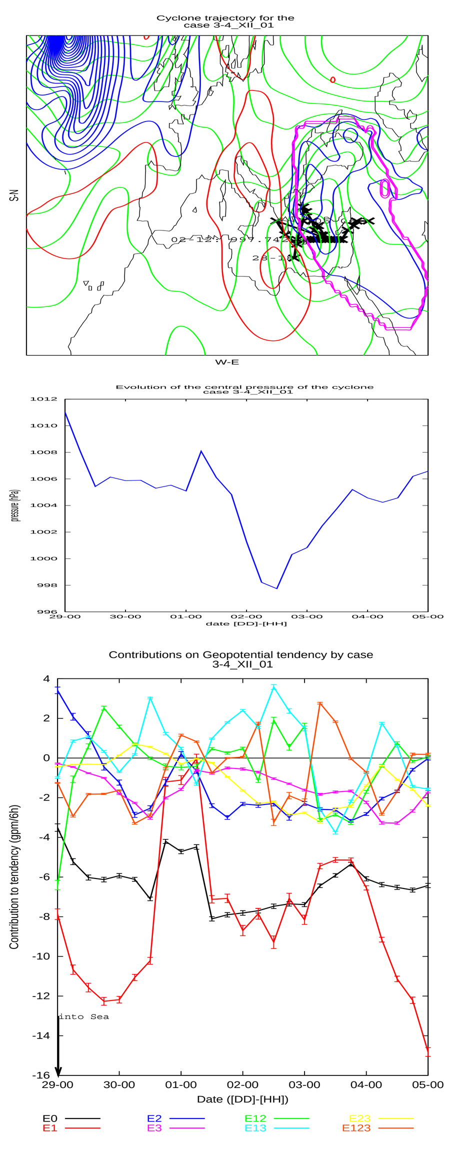

Figure 6: case 3-4_XII_01

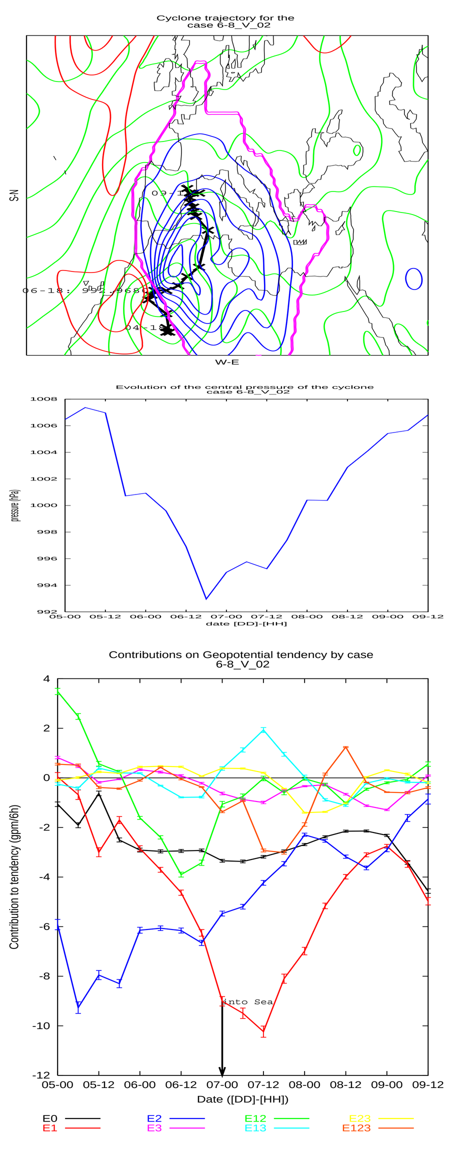

Figure 7: case 6-8_V_02

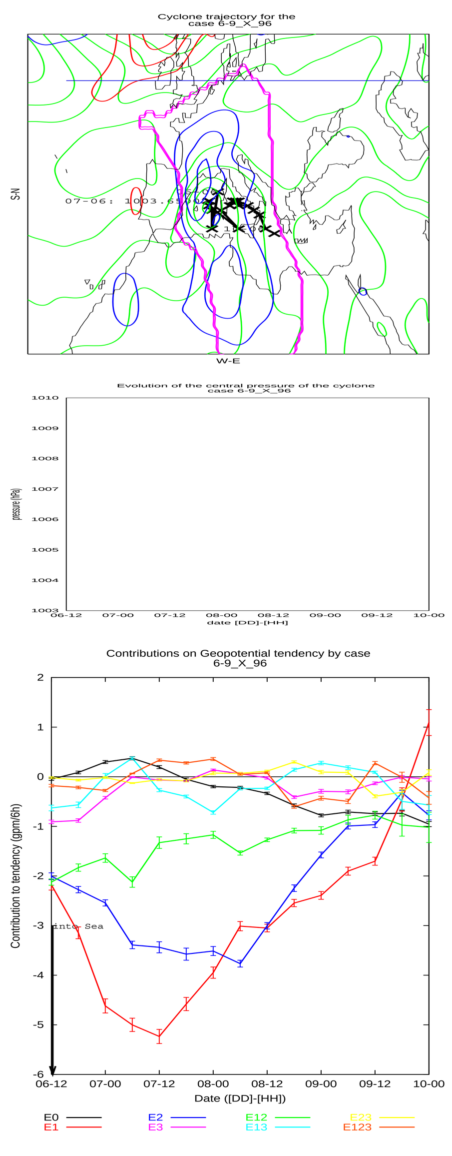

Figure 8: case 6-9_X_96

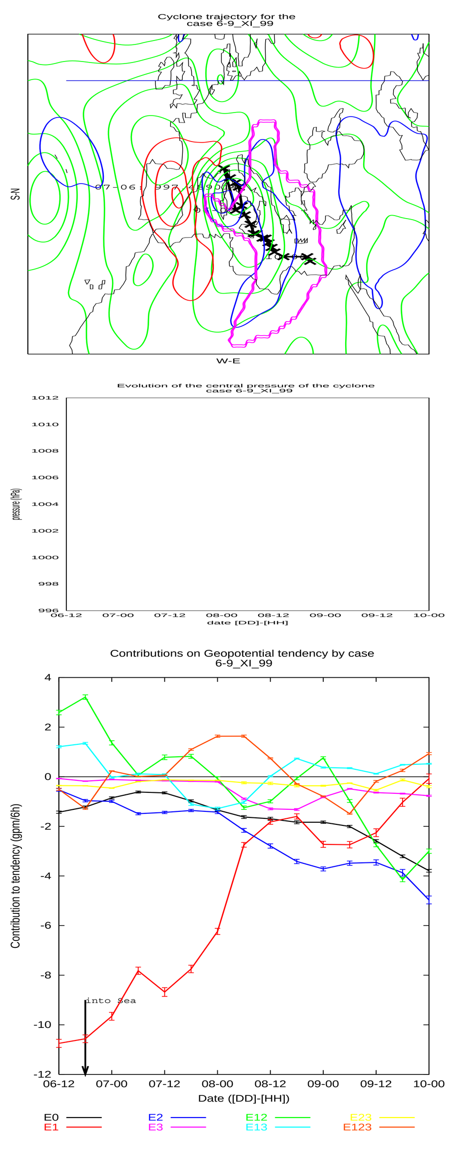

Figure 9: case 6-9_XI_99

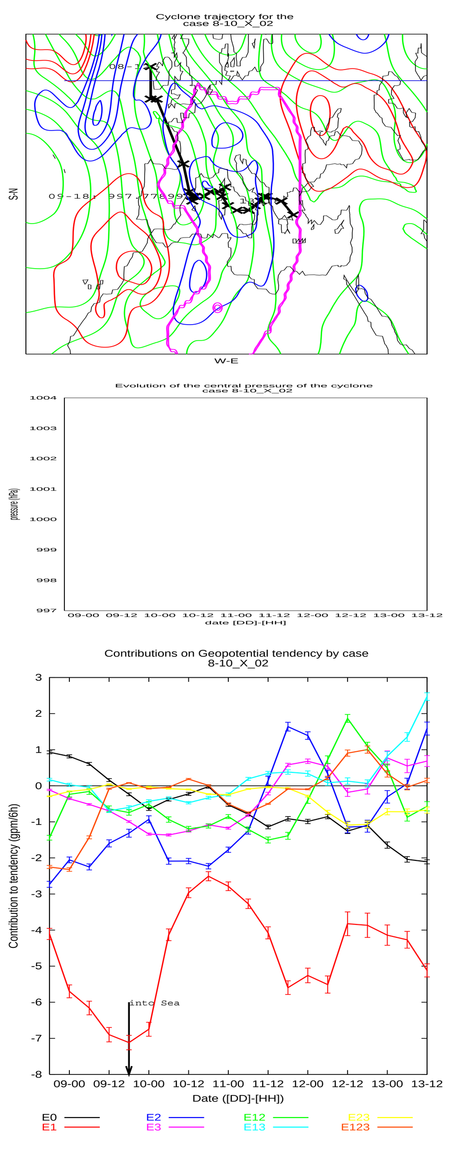

Figure 10: case 8-10_X_02

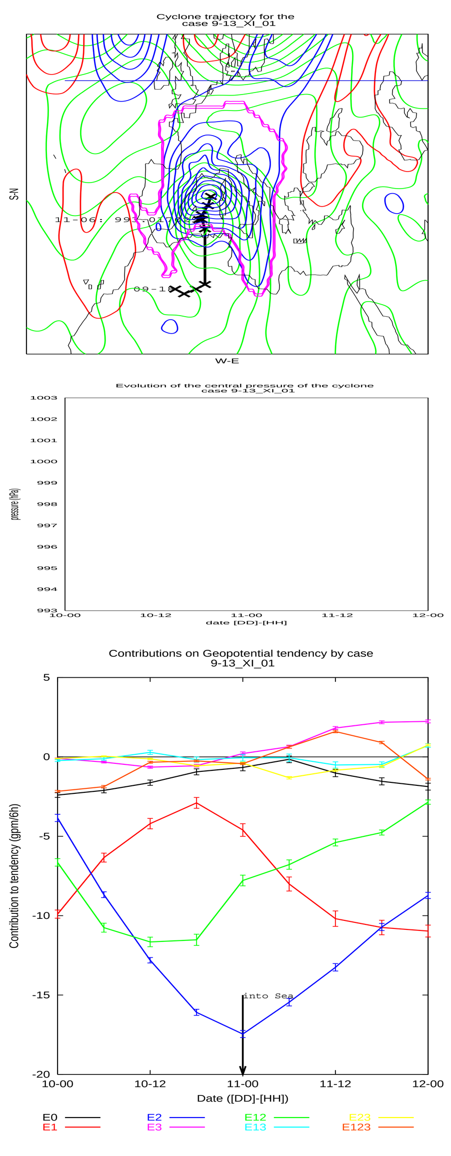

Figure 11: case 9-13_XI_01

4 Conclusions

- ∗ Generally case dependent on results
- ∗ Upper level PVp (E1) generally the most relevant
- ∗ Low level PVp (E2) & E12 main secondary roles
- ∗ Main flow (E0) significant role
- ∗ W & C Mediterranean mainly dominated by PV anomalies (E1, E2, E12)
- ∗ E Med. present different dependences (E12, E1, E123, E0)
- ∗ E3, E13 and E23 lowest contribution
- ∗ High deepening process when reaching the sea (leading to mature state)
- ∗ Factors are ofen cyclogenetic and cyclolitic during life cycle
- ∗ 'African' cyclones mainly dominated by Upper level E1 or E12
- ∗ 'Maritime' cyclones dominated mainly by E1 and lower by E0
- ∗ 'Alpine Lee' cyclones dominated initially strongly by E1

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Davis, C. A., and K. A. Emanuel, 1991: Potential vorticity diagnostics of cyclogenesis. *Mon. Weat. Rew.*, **119**, 1929–1953.

Stein, U., and P. Albert, 1993: Factor separation in numerical simulations. *J. Atmos. Scien.*, **50**, 2107–2115.