A sensitivity of the MAP IOP 15 lee cyclogenesis event to the estimated uncertainties in the upper-level dynamical factors

Kristian Horvath
Met. and Hydr. Service (DHMZ), Croatia
Email: horvath@cirus.dhz.hr

Maria-del-Mar Vich, **Romualdo Romero,** Branka Ivančan-Picek

From sensitivity to predictability

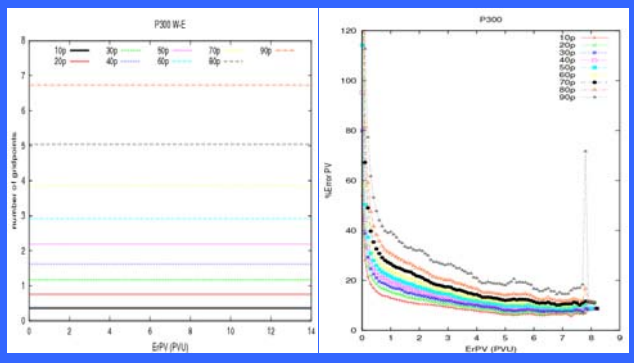
- Alpine lee cyclogenesis is sensitive to both macroscale and mesoscale features of the traversing upper-level trough
- The questions related with predictability to the upper-level dynamics:
  - How to estimate the initial-analysis uncertainty in the upper-level trough?
  - What is the influence of the upper-level initial-analysis uncertainty on the development of MAP IOP 15 Alpine lee cyclone and Bora in the Adriatic?

From sensitivity to predictability: Error statistics

- Error statistics based on Ertel's potential vorticity (ErPV), inferred from differences between ECMWF and NCEP analysis
- 21 case of the deepest Mediterranean cyclones (MEDEX, 1996-2006)
- Error statistics calculation:
  - Phase/displacement error (km) evaluated on the basis of finding maximal correlation between mesoscale "cores" of the upper-level ErPV
  - Amplitude/intensity error (f(ErPV), %) based on the ErPV fields with "subtracted" distance error

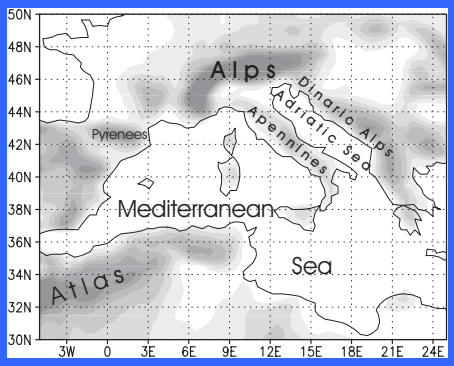
From sensitivity to predictability: Error statistics

- Example: error statistic at 300 hPa:
  - phase (displ.): 50th percentile ~ 50 km
  - amplitude (int.) for ErPV=4 PVU: 50th percentile ~ 12%
- Reasonable estimates (deep cyclones, some cases very old)!



MAP IOP 15: Introduction

- MAP IOP 15: deep and rapid Genoa cyclone 06-10 Nov 1999
- High-impact weather conditions:
  - Extreme Bora in the northern Adriatic (10-m V > 25 ms^{-1}, gusts > 40 ms^{-1})
  - Heavy rain in the northern Italy (> 60 mm / 12 h)

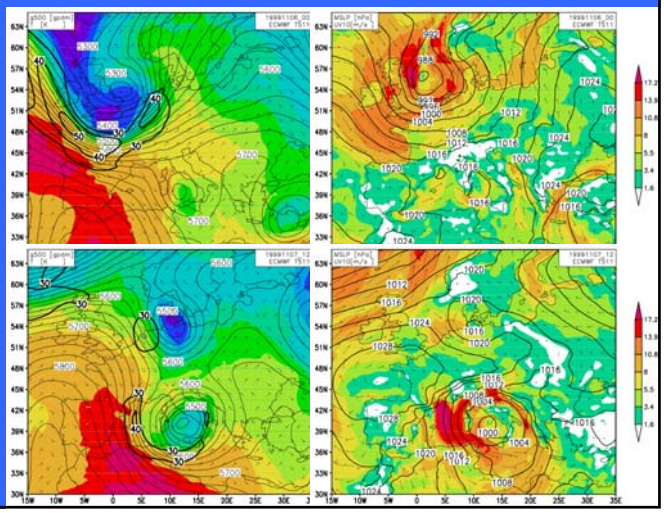


MAP IOP 15: Synoptic overview

- A typical case of deep Genoa lee cyclogenesis

- Upper row:
- upper-level trough over W. Europe
- Primary cyclone over UK

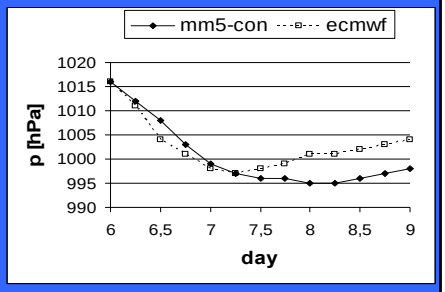
- Lower row:
- SE advection of the trough, cut-off
- secondary cyclone in the G. of Genoa



MAP IOP 15: The model

- PSU/NCAR mesoscale model (MM5)
- IC and LBC - ECMWF T511 MAP reanalysis
- 72-hr forecast range initialized on 00 UTC 06 Nov
- 3 two-way nested domains
  - 22.5/7.5/2.5 km, 35 levels
- parametrizations:
  - KF2 CPS, MRF PBL, R2

- Left: MSLP in cyclone centre (MM5 vs. ECMWF)
- Satisfactory simulation

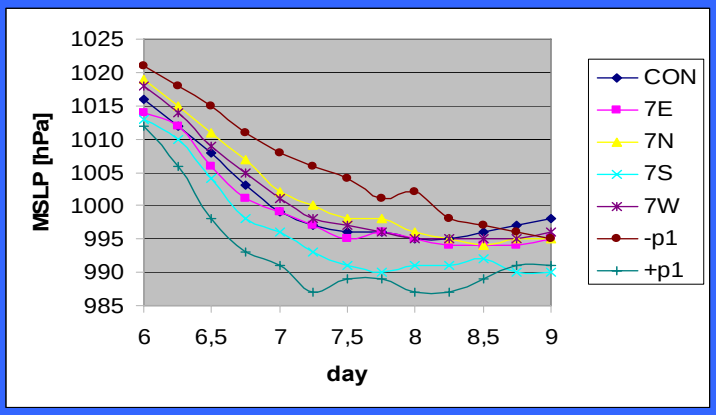


Sensitivity study: MAP IOP 15: Modification of the upper-level dynamics in the initial-analysis

- Options chosen:
  - Macroscale modifications (averaged over 500-100 hPa), using the 90th percentile of the ErPV error statistics:
  - Phase (Displacement) = 157.5 km
  - Amplitude (Intensity) = 23 %

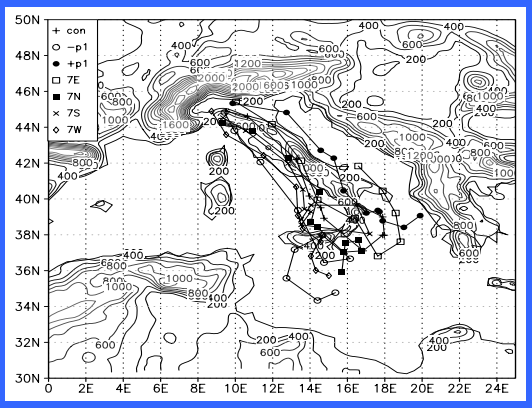
- Application of the piecewise potential vorticity inversion to the upper-level trough only (ErPV>1PVU)

Sensitivity study: MAP IOP 15: MSLP



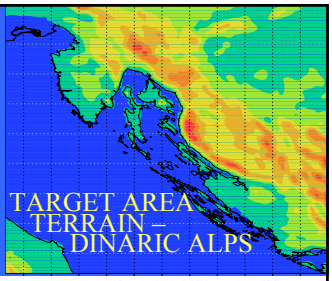
- The greatest spread of cyclone intensities (19 hPa) in most intensive deepening phase
- Reduced spread in the mature phase

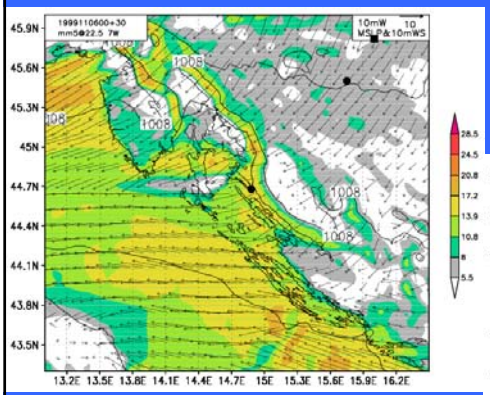
Sensitivity study: MAP IOP 15: Cyclone tracks

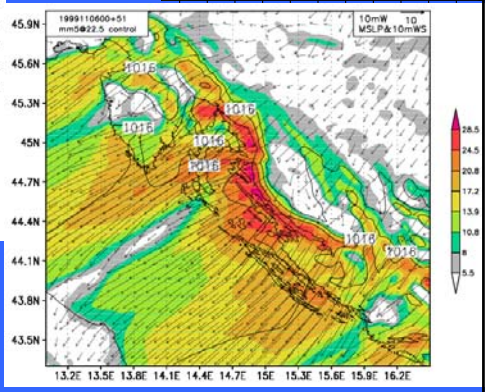


- 2 time intervals of the increase of cyclone centre positions:
  - 1. in the initial phase ~ 200 km
  - 2. in the mature phase ~750 km !

Sensitivity study: Bora





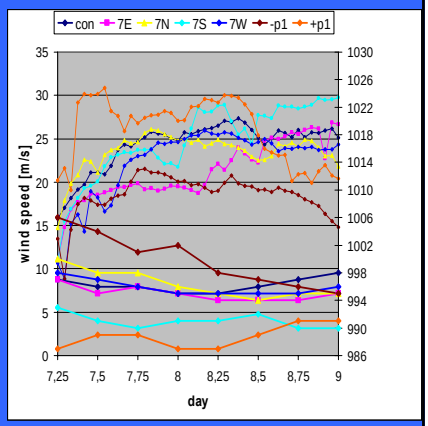


Bora spread from N-S as the cycl. moved along the Apennines

Reached ~25 m/s in the very lee of the Dinaric Alps

Sensitivity study: MAP IOP 15: cyclonic Bora

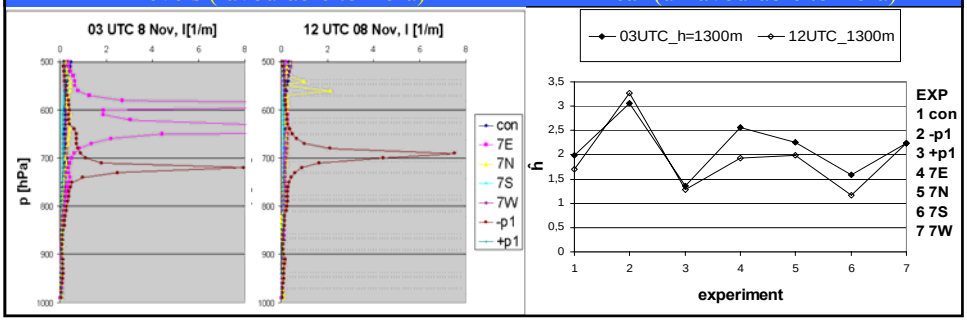
- Cyclonic Bora strength generally depends on the intensity and position of the cyclone, e.g. deepest cyclone – strongest Bora (orange curve)
- But, not always !
- e.g. in -p1 and 7W (EXP with PV moved to the west), cyclones at 09 Nov of similar intensities and positions, still–Bora 15m/s & 25m/s



- Q: What is the influence of upper-level dynamics to the flow impinging to Dinaric Alps (so-called "background flow")?

Sensitivity study: MAP IOP 15: Bora

- Characteristics of the background flow in the ensemble of simulations investigated through the analysis of:
- Scorer parameter (left plots)
  - In some simulations synoptic critical levels do exist → Trapping of energy in lower levels (favourable to Bora)
- Inverse Froude number (right)
  - Strong variations in flow regime, ranging from weakly non-linear (favourable) to strongly non-linear (unfavourable to Bora)



Conclusions

- ErPV error statistics provides a way to design realistic sensitivity/ predictability tests
- Strong sensitivity of the MAP IOP 15 Genoa cyclone to initial-analysis uncertainties in the upper-level dynamics (intensity 19 hPa, track 750 km)
- Bora is sensitive to both cyclone intensity&position and properties of background flow impinging to the Dinaric Alps (span of the integral Froude number over several flow regimes) resulting in the spread of Bora intensities of ± 30% of the wind speed in the control run
- Apparent low predictability of these interrelated systems
- Ensemble forecasting should add a value
- The method (for all sources of PV + adjoint) will be tested quasi-operationally (Balearic Islands, Spain)