PANDOWAE-MED

The dynamics and predictability of Mediterranean cyclones leading to high impact weather

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THORPEX
A World Weather Research Programme

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Motivation

Sporadic, but not infrequent synoptic scale development leads to cyclogenesis over the western Mediterranean Sea causing subsequently storms, heavy precipitation and flash floods especially south of the Alps. These events, called “High Impact Weather” (HIW), are often accompanied with great damages and losses of lives. **But: Not the strongest cyclones are responsible for the heaviest HIW!**

Episode, Country	Date	Max. precipitation in 24 hours
Vaison-la-Romaine, F	22.-23. 09. 92	300 mm at selected sites
Brig, CH	23.-25. 09. 93	120 mm (23.09), 220 mm (24.09.)
Piedmont, I	04.-06. 11. 94	314 mm, 250 at several sites
Ticino, I	12.-13. 09. 95	186 mm in 12 h, 327 mm in 36 h
Friulia, I	19. 09. 95	180 mm
Friulia, I	05.-07. 10. 98	~ 250 mm in 48 h
Thyrrenian Sea	26.-27. 03. 99	

Severe HIW events in the Med Sea in the nineties

Brig, Switzerland, September 24th, 1993

Goals

Dynamics and predictability of Mediterranean cyclones will be investigated with particular emphasis on the relative contributions of upper-level forcing, moist processes and surface fluxes to the development of high impact weather.

Influence of convection of different scales on HIW generation:

- small-scale boundary layer turbulence
- development of cumulonimbus
- their organisation into mesoscale systems
- impact on the synoptic scale flow

Priority of the first 3 year phase :

- model investigations and data analyses of previous HIW in the Mediterranean
- preparation of the externally funded HALO demonstration mission NEPTUN 2010.

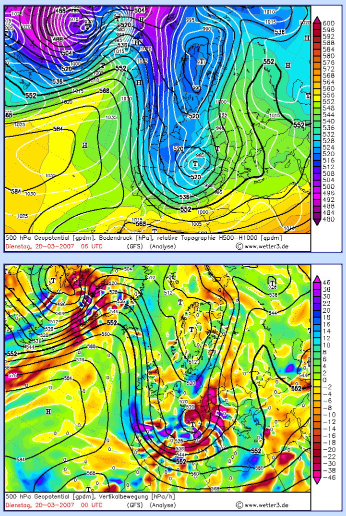
Priority of the second 3 year phase :

- data gained during NEPTUN will be utilised to study the predictability of Mediterranean cyclones with new modelling techniques from phase 1,
- develop adaptive observing and forecasting strategies for the Mediterranean.

Synoptical Settings

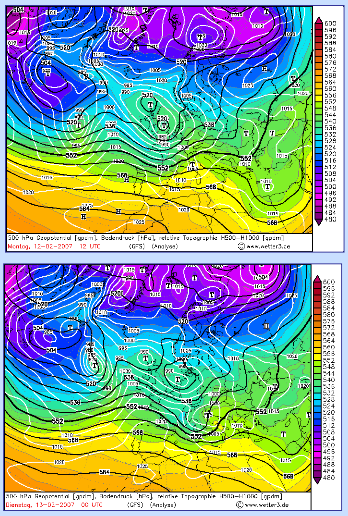
Four typical synoptic scenarios causing „High Impact Weather (HIW)“ in the Mediterranean basin

High amplitude trough approaching Med Sea from the west



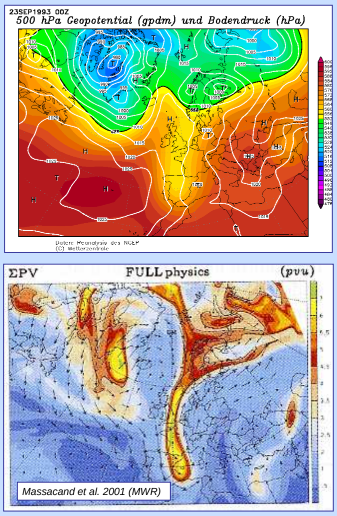
March 03, 2007

Remnant lower troposphperic circulation activated by upper level trough



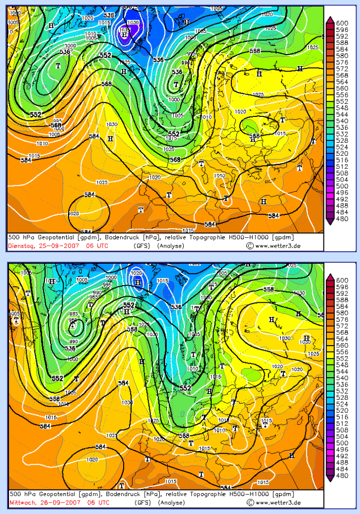
February 13, 2007

Streamer reaching Med Sea without cyclogenesis



September 23, 1993

Lee-cyclogenesis generated south of the Alps



September 25, 2007

8 steps to achieve the goals

1. Selection of historical cases leading to HIW over Med Sea; SOM-methode
2. Analysis of historical Med Sea HIW cyclogeneses; EOF-cluster analysis of TIGGE data
3. Implementation of 2-way-nesting scheme for COSMO-LM
4. Implementation of PV-inversion to modify initial conditions of COSMO-LM
5. COSMO LM sensitivity studies on Med Sea cyclogenesis: upper vs. lower level processes; large scale vs. convective scale forcing; influence of moisture, orography
6. Design of observing strategy for prototypic HIW situations during HALO-NEPTUN campaign
7. Contribute to HALO-NEPTUN forecasting strategy and aircraft operations
8. Investigation of HALO-NEPTUN HIW cases using tools developed in steps 2 to 4

Cooperation and exchange of intermediate results with PANDOWAE-ET

Links to PANDOWAE research areas

Primary research area: *Moist processes and diabatic Rossby waves*

- fundamental role of surface fluxes and moist convection in Med Sea cyclogenesis
- interaction between synoptic- and convective-scale processes

Contributions to research area: *Upper-level Rossby waves: triggering, propagation and wave-breaking*

- through investigation of the role of upper-tropospheric troughs in Med Sea cyclogenesis
- feedback of convective processes onto the synoptic-scale flow

Contributions to research area: *Ensembles and adaptivity*

- investigation of TIGGE data
- development of adaptive observing strategies for HALO-NEPTUN

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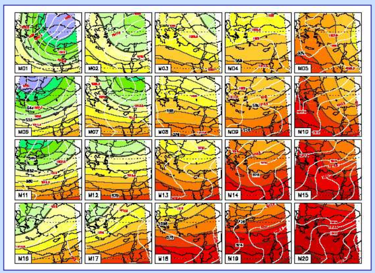
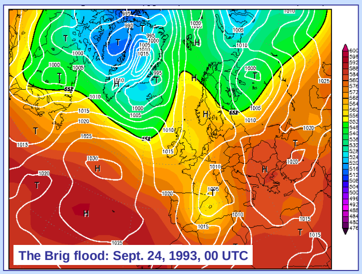
Step 1

Selection of historical cases using the SOM technique



Self-Organizing-Maps (SOM)



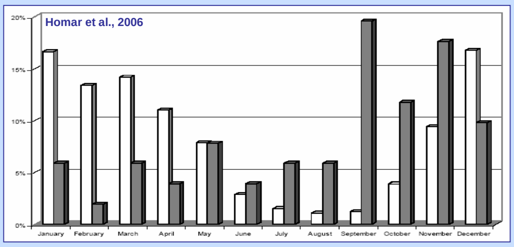
500 hPa and surface pressure

The **SOM technique** is an objective **pattern recognition method**. It sorts a certain amount of data vectors and allocates these vectors to a given number of representative sample vectors. This allows e.g. to distinguish between typical flow patterns in a selected area. The left figure shows a classification of the 500 hPa NCEP reanalyses between 1973 and 1999 for the eastern Mediterranean using 20 classes. **Flow pattern typical for HIW events (e.g. the Brig flood, right figure) can be extracted using SOM.**

Step2

Analysis of historical cases using EOF/cluster analysis

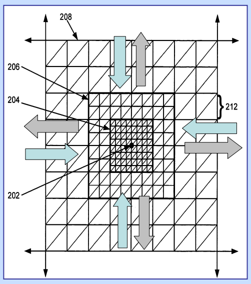
Monthly frequency of intense cyclones exceeding a given circulation threshold in the ERA-40 analysis 1957-2002 (white) and monthly distribution of episodes of high impact weather (grey) characterized by, storms, heavy rain and flash floods (Homar et al., 2006). **Note that intense cyclones do not correspond with HIW events in most cases.**



After applying an EOF analysis to TIGGE data, the principal components are used in a fuzzy cluster analysis to group the ensemble members relative to their contributions to the main modes of variability identified by EOF analysis. Representative members of the clusters will provide initial and boundary conditions for sensitivity studies with LM.

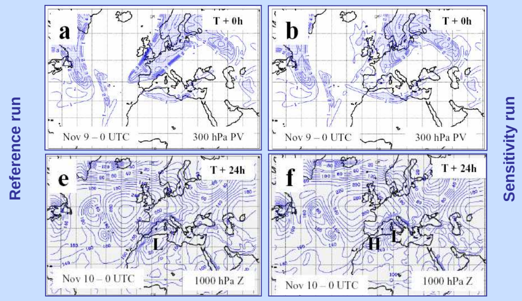
Step 3

Implementation of a 2-way-nesting scheme for COSMO-LM;



Step 4

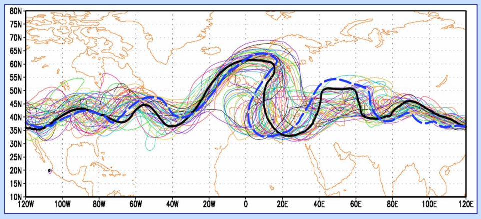
Implementation of PV-inversion to modify initial conditions of COSMO-LM



300 hPa PV for the reference and the modified initial state of simulation on Nov. 9, 2001, 0 UTC, and 24 h MSL pressure forecast (**Lambert et al., 2003**).

Step 5

Sensitivity studies with COSMO-LM

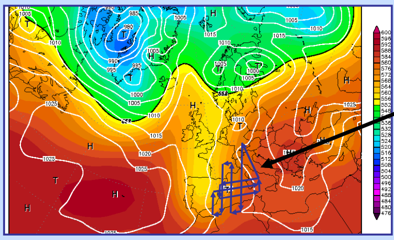


Six day (144 h) 50 member ensemble forecast of 560 gpdm on 500 hPa valid for Oct. 21, 2007, starting at Oct. 15, 2007. The thick black line represents the deterministic high resolution forecast for the same period. The dashed blue line shows the analysis of the 560 gpdm level for Oct. 21, 00 UT.

While there are regions with minor variations of the ensemble members over the Atlantic ocean and Asia, the ensemble solutions differ most significantly over the sensitive region of the Mediterranean Sea.

Step 6

The Brig flood



Sept. 23, 1993, 00 UTC: 500 hPa and surface pressure

Develop flight plans for HALO demo mission NEPTUN

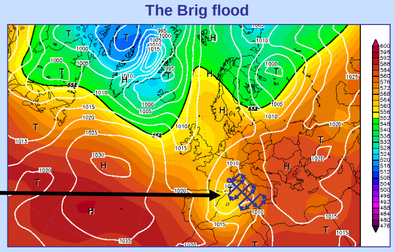
Prototypic HIW situations will be looked for, getting adequate measurements of the main processes controlling HIW development.

HALO aircraft will be operating at high altitudes and on long range flight patterns performing airborne remote sensing measurements of wind speed profiles (LIDAR) and turbulent fluxes of latent heat (DIAL).

Synchronously the low altitude research aircraft DO 128 will operate close to the Med Sea surface and in the entire boundary layer, doing in-situ measurements of sensible and latent heat fluxes.

Upstream targeted observations will be performed with HALO

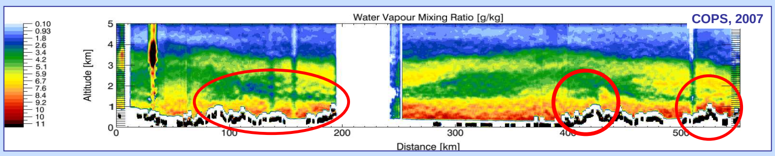
The Brig flood



Sept. 24, 1993, 00 UTC: 500 hPa and surface pressure

Step 7

Use of analysis and forecast tools for HIW events to support NEPTUN aircraft operations



During HALO demo mission NEPTUN in 2010 the new research aircraft will be equipped with water vapour DIAL and wind LIDAR, similar to the state of the art installation on board the DLR research aircraft FALCON. An example for high resolution water vapour measurements made during **COPS** in July 2007 above the Black Forest multiple PBL humidity features is shown (courtesy of DLR-IPA).

The DO 128 research aircraft is equipped to measure in-situ turbulent fluxes of momentum, sensible and latent heat with 1 m spatial resolution as shown in the figure (right) for a VERTIKATOR case over the Black Forest in 2002. During NEPTUN the DO 128 will detect the near sea surface fluxes while the he cyclogenesis takes place over the Mediterranean Sea.