**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!

**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 research activities within HyMeX:**

- model investigations and data analyses of previous HIW in the Mediterranean
- preparation of the externally funded HALO demonstration mission NEPTUN 2011
- data gained during NEPTUN will be utilised to study the predictability of Mediterranean cyclones with new modelling techniques,
- development of adaptive observing and forecasting strategies for the Mediterranean.

**Synoptical Settings**

Four typical synoptic scenarios causing „High Impact Weather“ in the Mediterranean basin:

1. High amplitude trough approaching Med Sea from the west
2. Remnant lower tropospheric circulation activated by upper level trough
3. Streamer reaching Med Sea without cyclogenesis
4. Lee-cyclogenesis generated south of the Alps

**Selection and analysis of historical cases of HIW**

Selection of historical cases using the SOM technique

**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 HIW (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.
Investigation of Dynamic and Thermodynamic Processes of Mediterranean Cyclones Leading to High Impact Weather (HIW)

Ulrich Corsmeier, Norbert Kalthoff, Claus-Jürgen Lenz, Christoph Kottmeier
Institute for Meteorology and Climate Research, IMK

Sensitivity studies with COSMO on predictability and orographic effects

- prognostic variables: wind vector, pressure, temperature, specific humidity, cloud water & cloud ice content
- time-independent, hydrostatic, restituting, horizontally homogeneous basic state
- rotated horizontal coordinates, terrain-following coordinates in vertical direction
- grid structure: Arakawa-C/Lorenz grid
- time integration: 3 time-level, time-splitting Leapfrog scheme
- parameterizations:
  - radiation: 2-stream method (Ritter & Geleyn, 1992)
  - large scale precipitation: bulk formulation (Kessler type)
  - subgrid scale turbulence: prognostic TKE, closure Mellor-Yamada level 2.5
  - soil model: multi-layer model, opt. force-restore method

COSMO: Non-hydrostatic, compressible, numerical limited-area model (http://www.cosmo-model.org)

- initialization data and boundary data interpolated from GME results
- simulation start: 11 Sept. 2008, 00 UTC
- duration: 144 h, 50 member ensemble forecast of 560 gpm on 500 hPa

Future plans
- Implementation of a 2-way-nesting scheme
- Implementation of PV-inversion

KOSMO version 4.6 model setup
- initialization data and boundary data interpolated from GME results
- simulation start: 11 Sept. 2008, 00 UTC
- simulation time: 78 h, time step: 30 s
- domain: 451 x 361 grid points, 40 vertical levels, grid spacing: 0.09° (~10 km)
- prognostic calculation of rain water content, snow content
- parameterization of convection: Tiedtke scheme
- multi-layer soil model: 7 layers

Influence of orography on precipitation

The influence of steep orography on surface pressure in the western Mediterranean on 11 September, 2008, 00 UTC

Real orography
- Eroded orography (<600 m)

- In case of eroded orography no lee cyclogenesis has taken place south of the Alps. Instead a deep low has been developed after 36 hours over central Europe, mainly north of the Alps. After 72 h the eroded orography run shows less pressure perturbation in the Mediterranean area, whereas as in the reference run a lee-cyclogenesis still exists.

HALO demonstration mission NEPTUN 2011 and HyMeX mission 2012

The Brig flood
- 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 (LI DAR) 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
- 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 vapor DIAL and wind LI DAR, similar to the state of the art installation on board the DLR research aircraft FALCON. An example for high resolution water vapor 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 lee cyclogenesis takes place over the Mediterranean Sea.