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Orographic forcing and Doppler wind, the key for nowcasting heavy precipitation in the Alps

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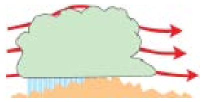
MOTIVATION

The prediction of the location, the onset and the let-up time of heavy orographic precipitation embedded in frontal passages is a difficult task, especially in an operational weather centre where high precision forecasts are needed and fast decisions have to be taken. In the nowcasting time frame the radar measurements constitute the main source of information, because they are available every few minutes with high spatial resolution. However, simple extrapolation of radar precipitation maps for nowcasting heavy rain in a mountainous region is not successful, because the mountains strongly influence the motion of air masses and thus the development of precipitation.

OROGRAPHIC FORCING



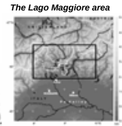
It is observed that heavy orographic precipitation systems are often persistent over several hours and exhibit distinct persistent spatial patterns which are related to the orography.

... FROM MAP

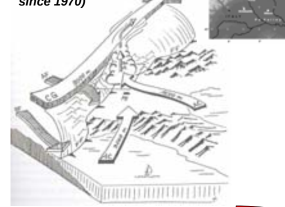
Studies from the Mesoscale Alpine Programme show that the temporal and spatial distribution of the heavy rain is strongly related to both thermodynamical conditions and mesoscale wind field. They have been conducted over the Lago Maggiore target area, located in the Central European Alps (Houze at al, 2001; Georgis et al, 2003; Asencio et al, 2003, Medina & Houze, 2003; Rotunno & Ferretti, 2003).

The importance of the wind direction and intensity in determining the precipitation patterns is confirmed also by the local weather forecasters.

The Lago Maggiore area



Typical winds over Southern Central Alps during heavy precipitation events (Kappenberger, forecaster since 1970)

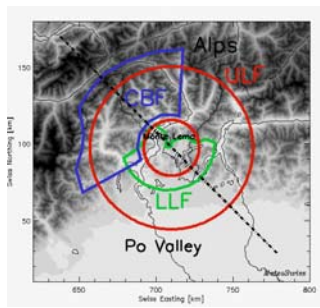


THE CONCEPT

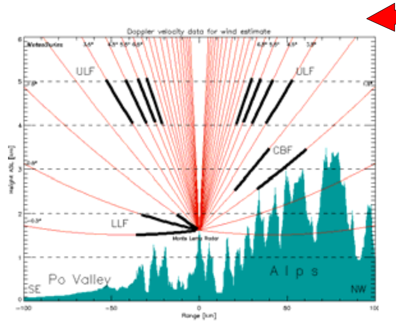
The strength and direction of the mesoscale wind field can be used as short term indicators for NOWCASTING the location, the intensity and the timing of heavy orographic precipitation.

Flow	Height	Location
LLF : Low-Level flow	1.5-2 Km	upstream over the plain
CBF : Cross-Barrier flow	2.5-3.5 Km	just South of the Alpine crest
ULF : Upper-Level flow	4-5 Km	circle around the radar

NOVEL HEURISTIC APPROACH



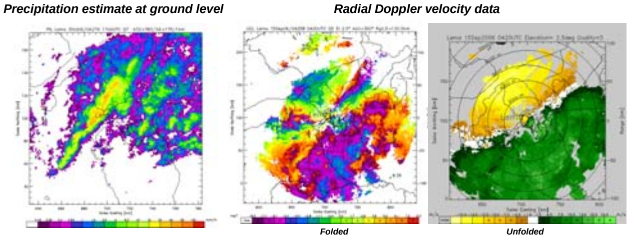
Location of the 3 areas in which the flows are estimated.



Vertical section of the Monte Lema radar scan strategy (red lines) along the dashed line of the left figure, with the regions selected for the estimate of the flows (black thick lines).

DATA

Precipitation estimate at ground level — *Radial Doppler velocity data*



1x1 km spatial resolution
5 min. temporal resolution

1 Km x 1° spatial resolution
5 min. temporal resolution

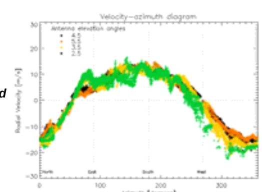
Four-Dimensional Doppler Dealiasing scheme by James and Houze Jr (2001)

40 years of experience in radar operation in the Alps at MeteoSwiss (***Joss & Waldvogel***,1990; ***Germann*** *et al.*,2006)

METHODOLOGY

In order to estimate the intensity and the direction of the flow, sine fit is done by multiple regression using normal equations and Singular Value Decomposition,

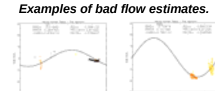
Right: example of velocity-azimuth diagram for the estimate of the ULF. The colours correspond to data coming from different antenna elevation angles. The flow is from S-SE with an intensity of ~12 m/s.



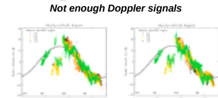
Positive velocities = towards the radar
Negative velocities = away from the radar

A number of quality controls is performed before and after the fitting, in order to detect the low quality flow estimates and to reject the data which lead to wrong flow estimates (mainly convective cases).

Examples of bad flow estimates.



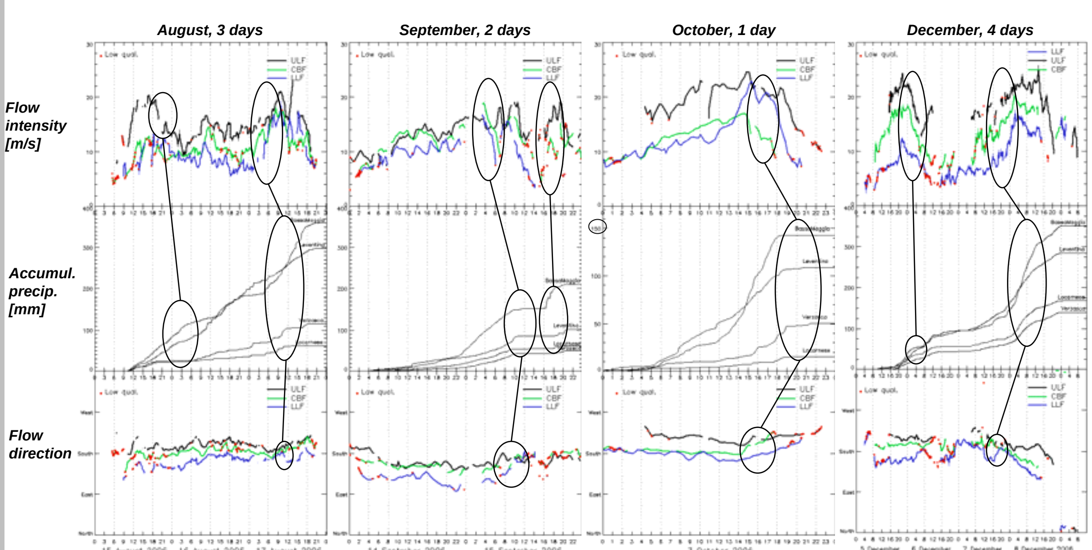
Not enough Doppler signals



Dealiasing failed

PRELIMINARY RESULTS

In the figure below, the flows intensity and direction relative to 4 heavy orographic precipitation events observed in the Lago Maggiore region in 2006 are compared to the accumulated precipitation averaged over different Alpine catchments, as it is estimated by the radar. In the black circular boxes the most significant features are highlighted.



CONCLUSIONS

- Heavy orographic precipitation seems to be related to the intensity and direction of the flows at different heights.
- In particular, changes in the mean rain rate over different geographical areas seem to be anticipated or characterized by changes in the intensity and direction of LLF, CBF and ULF.
- Doppler radar seems to be a valid help for nowcasting heavy orographic precipitation in the Alpine area.

FUTURE WORK

- To extend the analysis to all 2003-2007 heavy precipitation events.
- To investigate the role of airmass stability.
- Analysis of the vertical distribution of reflectivity and Doppler velocity through vertical sections parallel to the LLF.

FINAL GOAL

- To give to the forecasters information which can be operationally used for nowcasting heavy precipitation in the Alps.
- Better understanding of orographic precipitation mechanisms.

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