PREDICTABILITY OF PROTOTYPE FLASH FLOOD EVENTS IN THE WESTERN MEDITERRANEAN UNDER UNCERTAINTIES OF THE PRECURSOR UPPER-LEVEL DISTURBANCE

R. Romero, A. Martín, V. Homar, S. Alonso and C. Ramis

Meteorology Group, Departament de Física, Universitat de les Illes Balears
Palma de Mallorca, Spain

7th Plinius Conference on Mediterranean Storms (Rethymnon, Crete, Greece), 5-7 October 2005

Hydroptimet

✍Included in the European Program of Transnational Cooperation Interreg IIIB-Medocc (Western Mediterranean Region)

✍Final goal: To improve the hydro-meteorological tools used in the Western Mediterranean Region for the surveillance and prediction of flash flood events

http://hydroptimet.medocc.org

✍Case studies:

- Catalogne, 9-10 June 2000
- Cévennes, 8-9 September 2002
- Piémont-I, 24-25 November 2002
- Piémont-II, 25-26 November 2002

METHODOLOGY

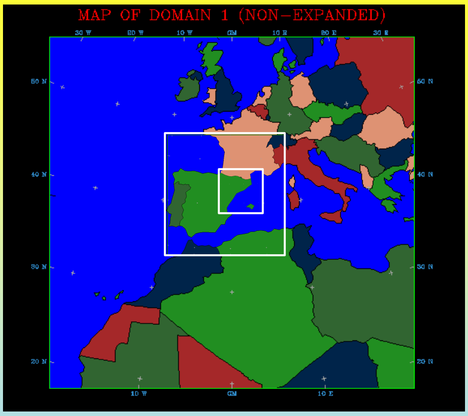
- Ensemble of mesoscale numerical simulations of each event with the MM5 non-hydrostatic model, after perturbing in a systematic way the upper-level disturbance (sensitivity analysis)

- These perturbations are introduced to the initial conditions by applying a potential vorticity (PV) inversion procedure to the positive PV anomaly associated with the upper-level trough (physically consistent balance)

- Guidance from the MM5-adjoint model, which consistently showed the highest sensitivities of the dynamical control of heavy rainfall to the flow configuration about the upper-level disturbance on the day before (precursor agent)

	TYPE OF PERTURBATION OF THE UPPER-LEVEL TROUGH				
EVENT	*Unchanged*	*Weakened 25%*	*Intensified 25%*	*Moved Westward 200-300 Km*	*Moved Eastward 200-300 Km*
Catalogne	Control	PV -25	PV +25	PV 216W	PV 216E
Cévennes	Control	PV -25	PV +25	PV 270W	PV 270E
Piémont-I	Control	PV -25	PV +25	PV 216W	PV 216E
Piémont-II	Control	PV -25	PV +25	PV 216W	PV 216E

CATALOGNE 9-10 JUNE 2000

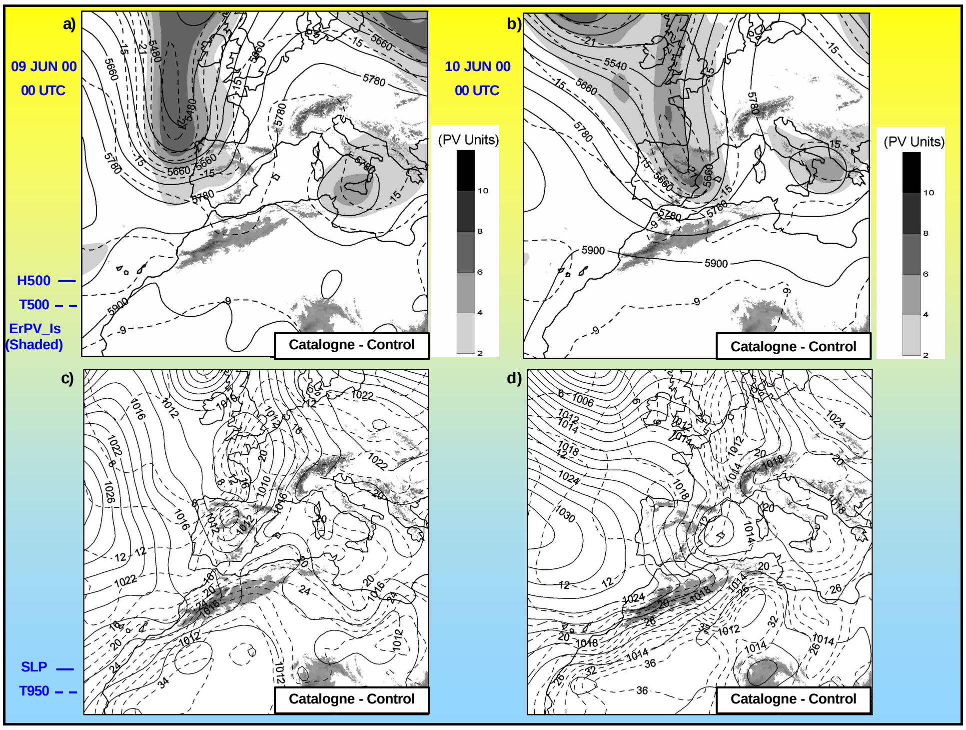


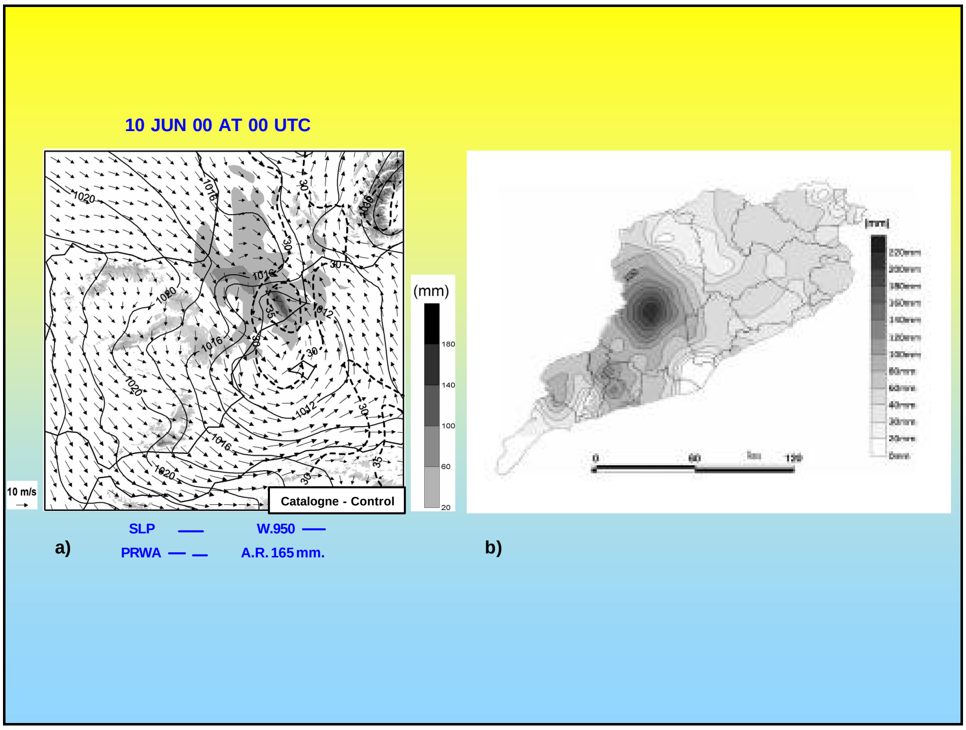
- Graupel and ice number concentration (Reisner et al., 1998).
- Betts-Miller (Betts and Miller, 1986; 1993) was used to calculate moist convection effects on the coarse domain and Kain-Fritsch scheme (Kain and Fritsch, 1990) on the second domain (for the inner domain no convective scheme was used).
- The sea level surface temperature remains constant during the set of simulations.

MM5-v3 MODEL

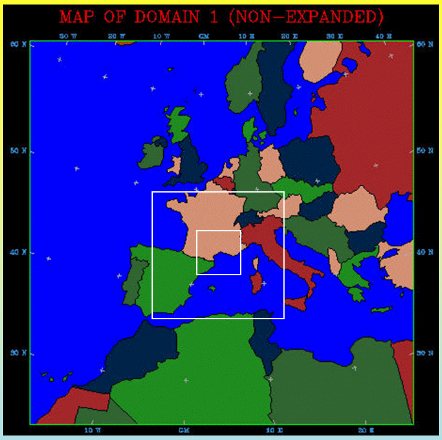
CHARACTERISTICS OF THE SIMULATIONS

- Three domains: 54, 18 and 6 km with two-way interaction.
- Lambert Conformal map projection.
- 82x82x24 grid points.
- Global analysis on standard pressure surfaces from NCEP (available at 00 and 12 UTC with 2.5º horizontal resolution) have been used to set initial and boundary conditions of coarse domain.
- Time steps for model integration are 18s (fine domain), 54s (middle domain) and 162s (coarse domain).
- 36 hours simulation (from 09/06/00 at 0000 UTC to 10/06/00 at 1200 UTC).
- The analysis were improved using surface and upper-air observations.


a)
09 JUN 00
00 UTC
b)
10 JUN 00
00 UTC
(PV Units)
(PV Units)
H500
T500
ErPV_Is
(Shaded)
Catalogne - Control
Catalogne - Control
c)
d)
SLP
T950
Catalogne - Control
Catalogne - Control


10 JUN 00 AT 00 UTC
(mm)
10 m/s
Catalogne - Control
SLP
PRWA
W.950
A.R. 165 mm.
a)
b)

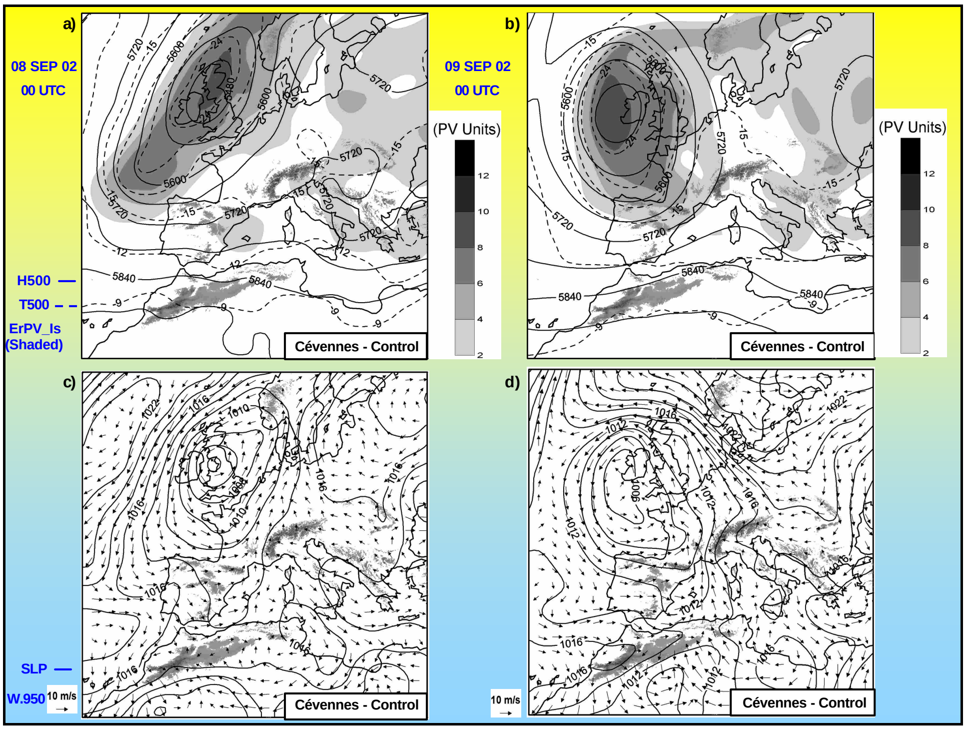
CÉVENNES 8-10 SEPTEMBER 2002



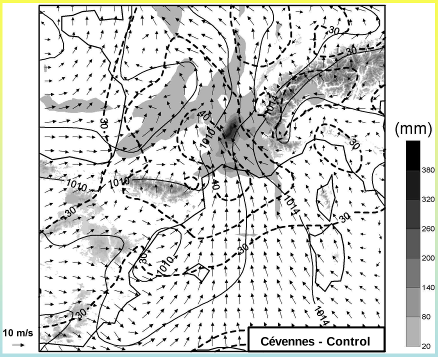
MM5-v3 MODEL

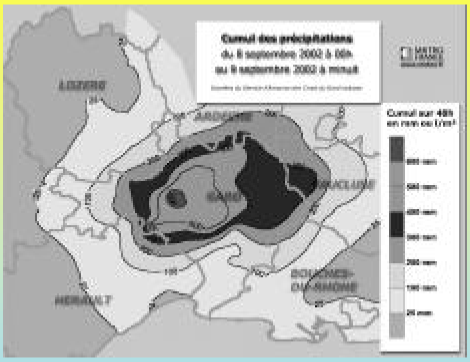
CHARACTERISTICS OF THE SIMULATIONS

- Three domains: 54, 18 and 6 km with two-way interaction.
- Lambert Conformal map projection.
- 82x82x24 grid points.
- Global analysis on standard pressure surfaces from NCEP (available at 00 and 12 UTC with 2.5º horizontal resolution) have been used to set initial and boundary conditions of coarse domain.
- Time steps for model integration are 18s (fine domain), 54s (middle domain) and 162s (coarse domain).
- 55 hours simulation (from 08/09/02 at 0000 UTC to 10/09/02 at 0600 UTC).
- The analysis were improved using surface and upper-air observations.
- Graupel and ice number concentration (Reisner et al., 1998).
- Kain-Fritsch scheme (Kain and Fritsch, 1990) was used to calculate moist convection effects on the coarse and second domains (for the inner domain no convective scheme was used).
- The sea level surface temperature remains constant during the set of simulations.



09 SEP 02 AT 00 UTC

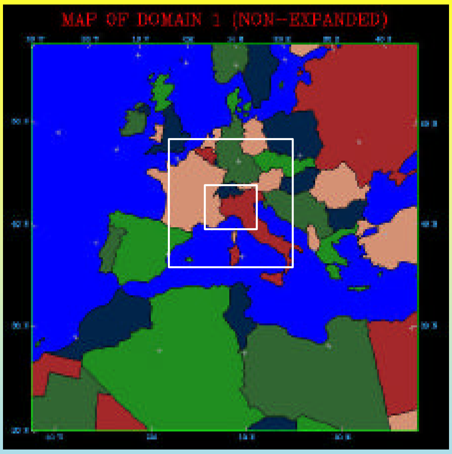




a) SLP — W.950 —
PRWA — — A.R. 367 mm.

b)

PIÉMONT 24-26 SEPTEMBER 2002



✍Graupel and ice number concentration (Reisner et al., 1998).

✍Betts-Miller (Betts and Miller, 1986; 1993) was used to calculate moist convection effects on the coarse domain and Kain-Fritsch scheme (Kain and Fritsch, 1990) on the second domain (for the inner domain no convective scheme was used).

✍The sea level surface temperature remains constant during the set of simulations.

MM5-v3 MODEL

CHARACTERISTICS OF THE SIMULATIONS

✍Three domains: 54, 18 and 6 km with two-way interaction.

✍Lambert Conformal map projection.

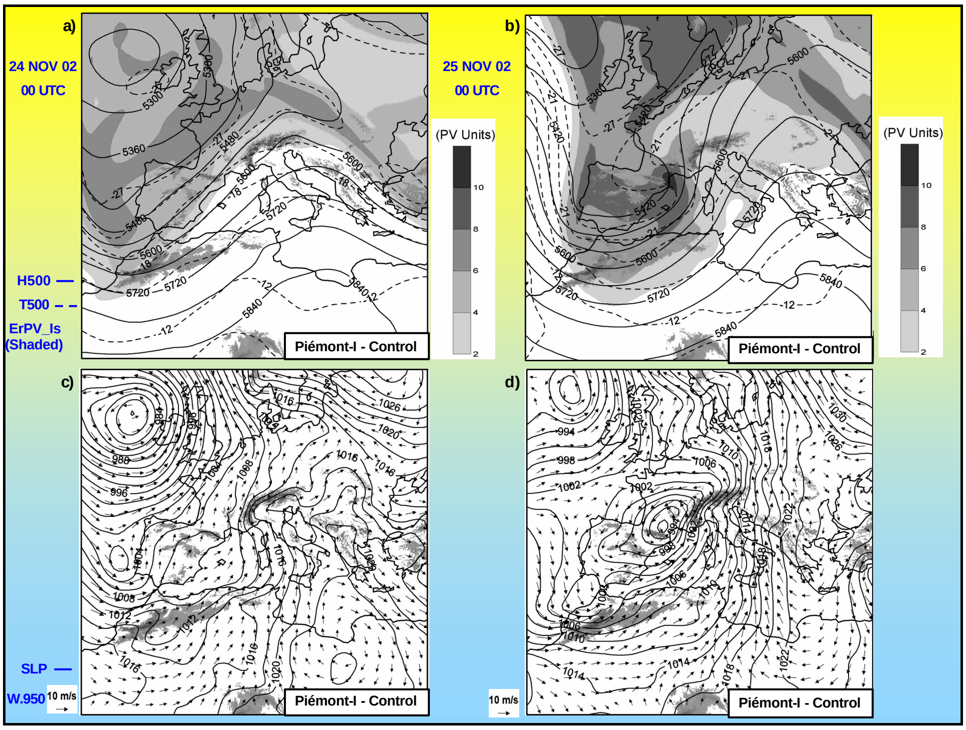
✍82x82x24 grid points.

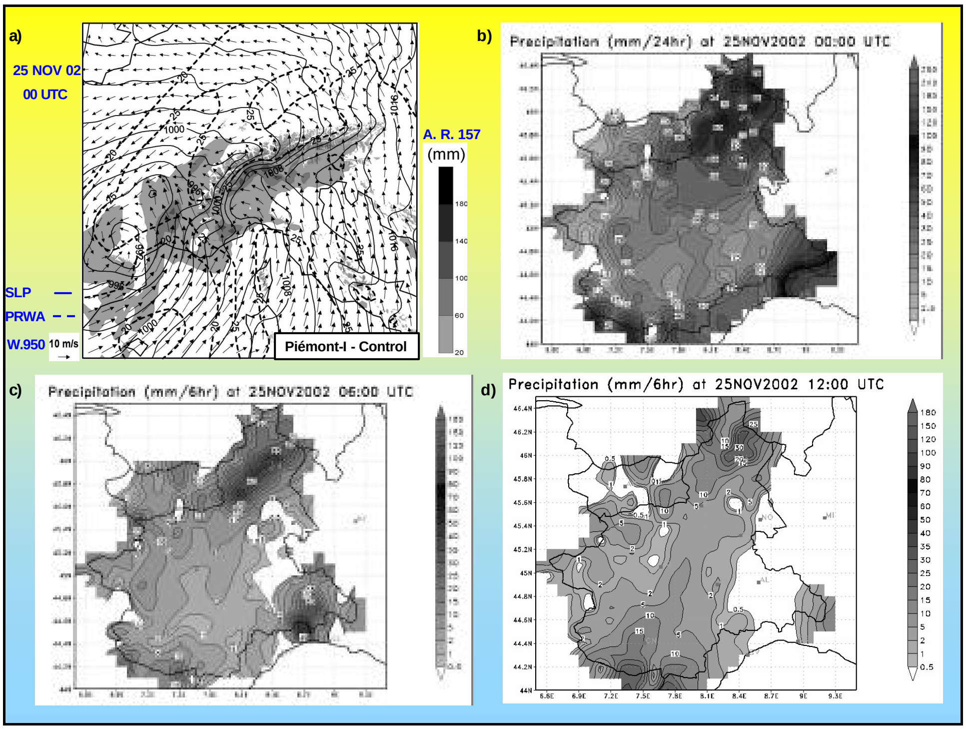
✍Global analysis on standard pressure surfaces from ECMWF (available at 00, 06, 12 and 18 UTC with 0.3º horizontal resolution) have been used to set initial and boundary conditions of coarse domain.

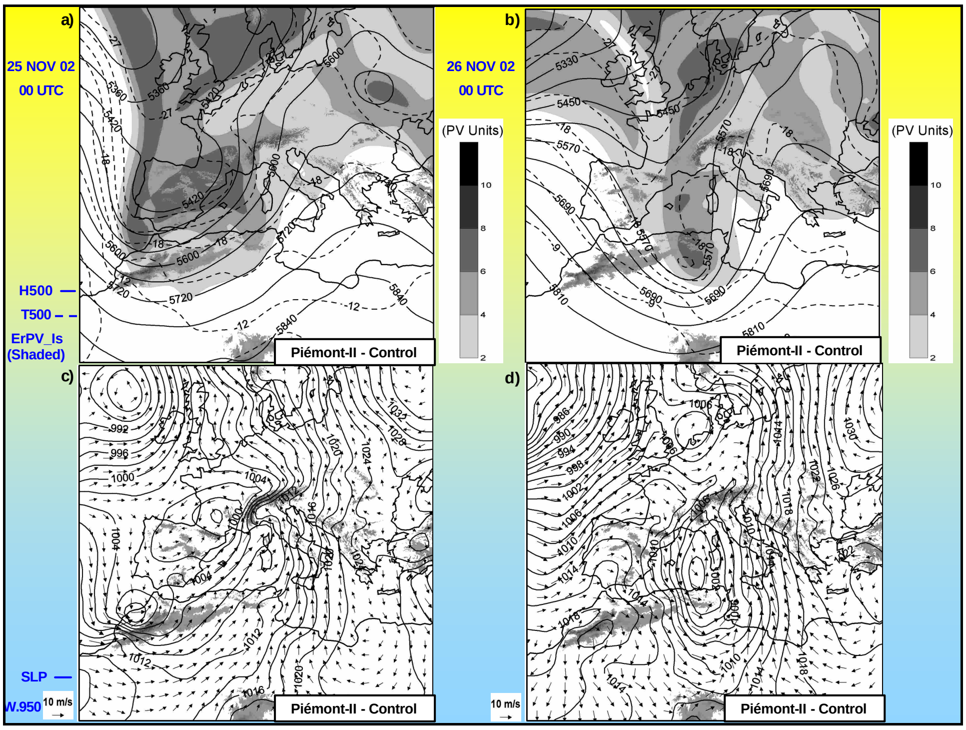
✍Time steps for model integration are 18s (fine domain), 54s (middle domain) and 162s (coarse domain).

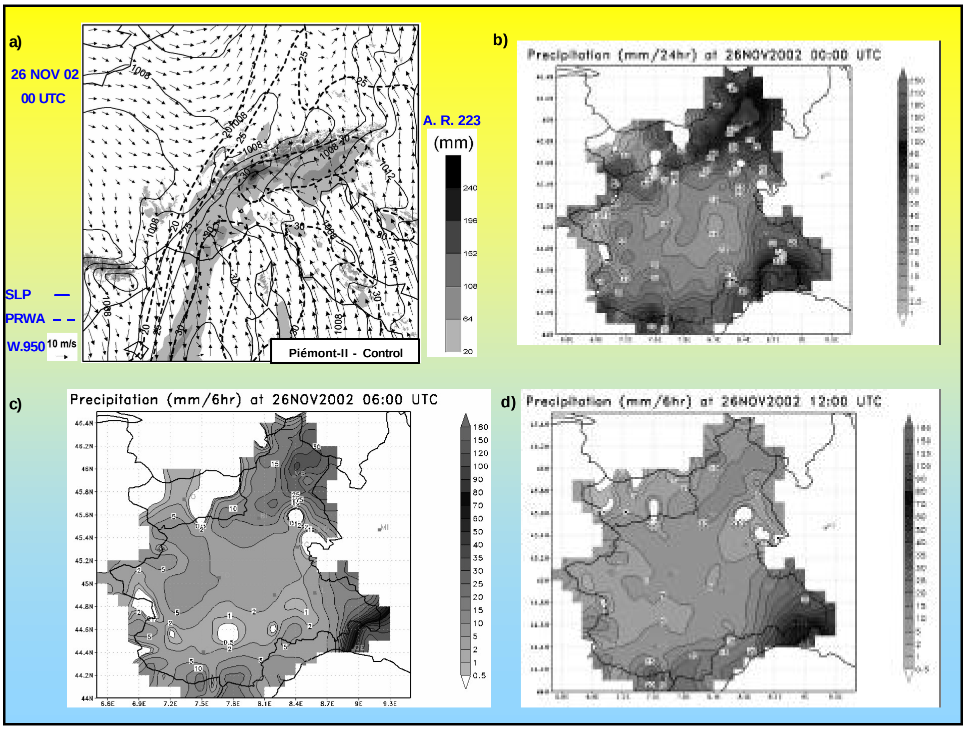
✍36 hours simulation (from 24/11/02 at 0000 UTC to 25/11/02 at 1200 UTC for Piémont-I, and from 25/11/02 at 0000 UTC to 26/11/02 at 1200 UTC for Piémont-II) .

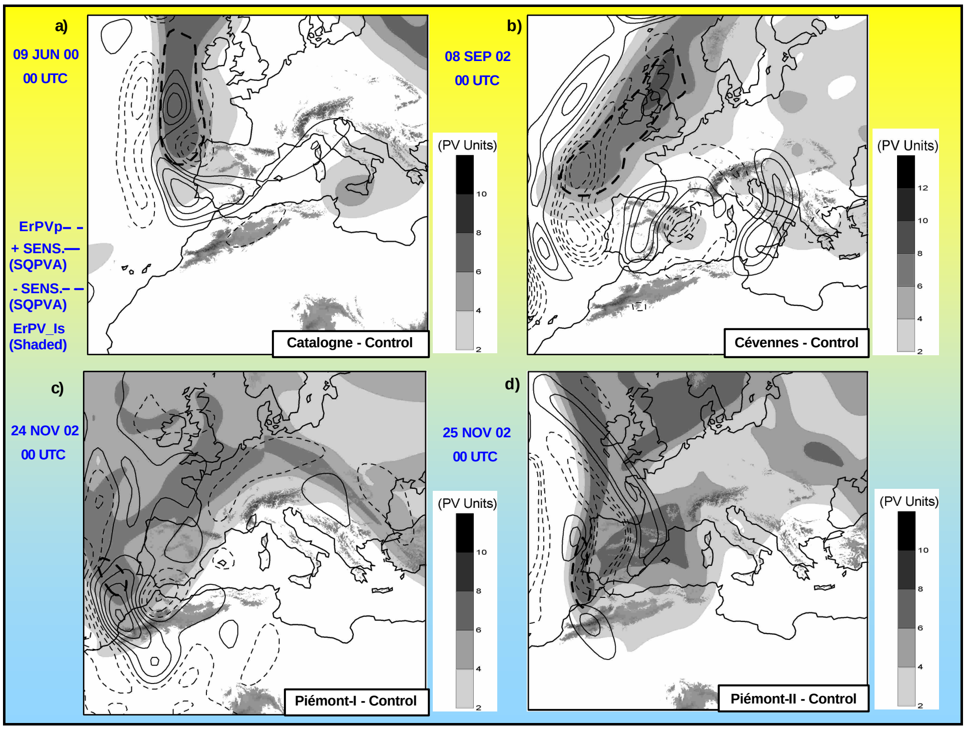
✍The analysis were improved using surface and upper-air observations.

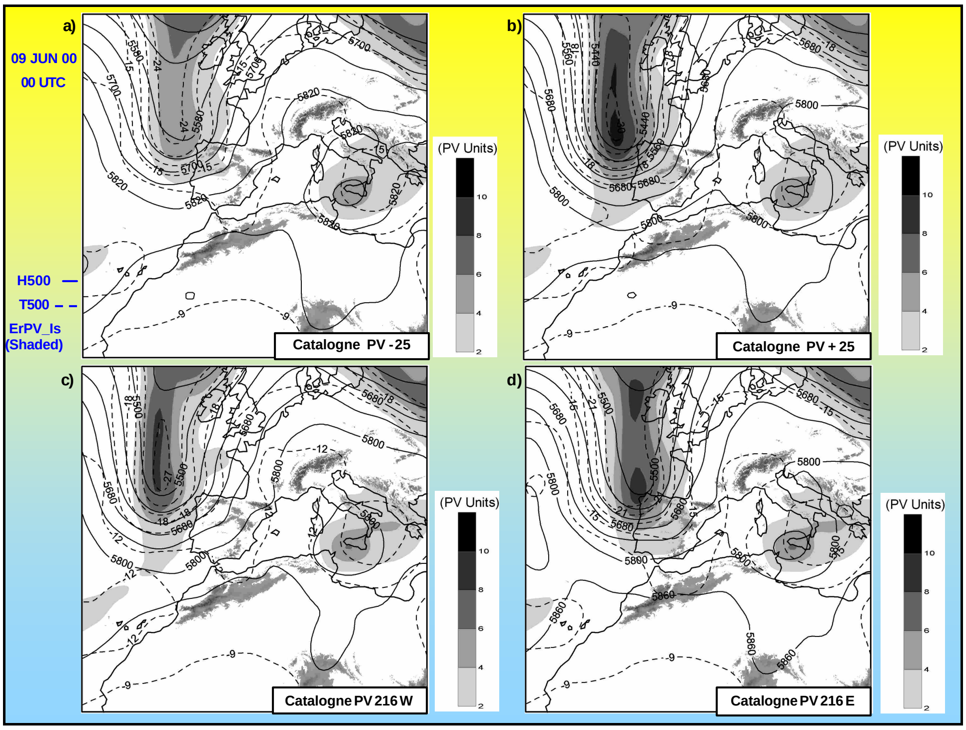

a)
24 NOV 02
00 UTC
b)
25 NOV 02
00 UTC
(PV Units)
H500
T500
ErPV_Is
(Shaded)
c)
d)
SLP
W.950
10 m/s
Piémont-I - Control

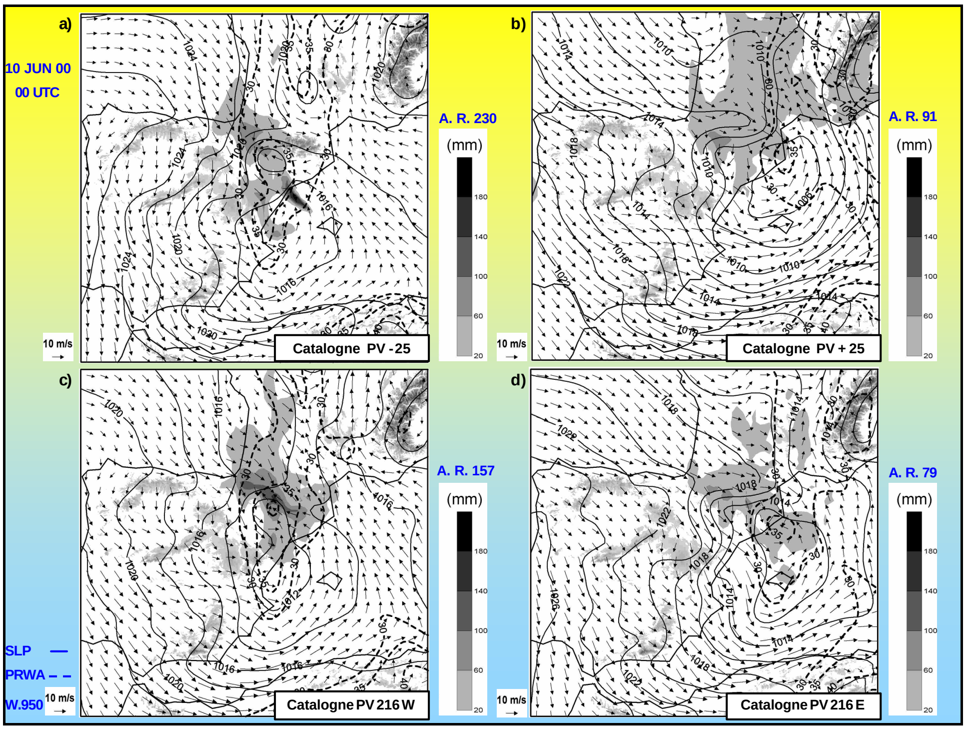

a)
25 NOV 02
00 UTC
A. R. 157
(mm)
SLP
PRWA
W.950
10 m/s
Piémont-I - Control
b)
Precipitation (mm/24hr) at 25NOV2002 00:00 UTC
c)
Precipitation (mm/6hr) at 25NOV2002 06:00 UTC
d)
Precipitation (mm/6hr) at 25NOV2002 12:00 UTC

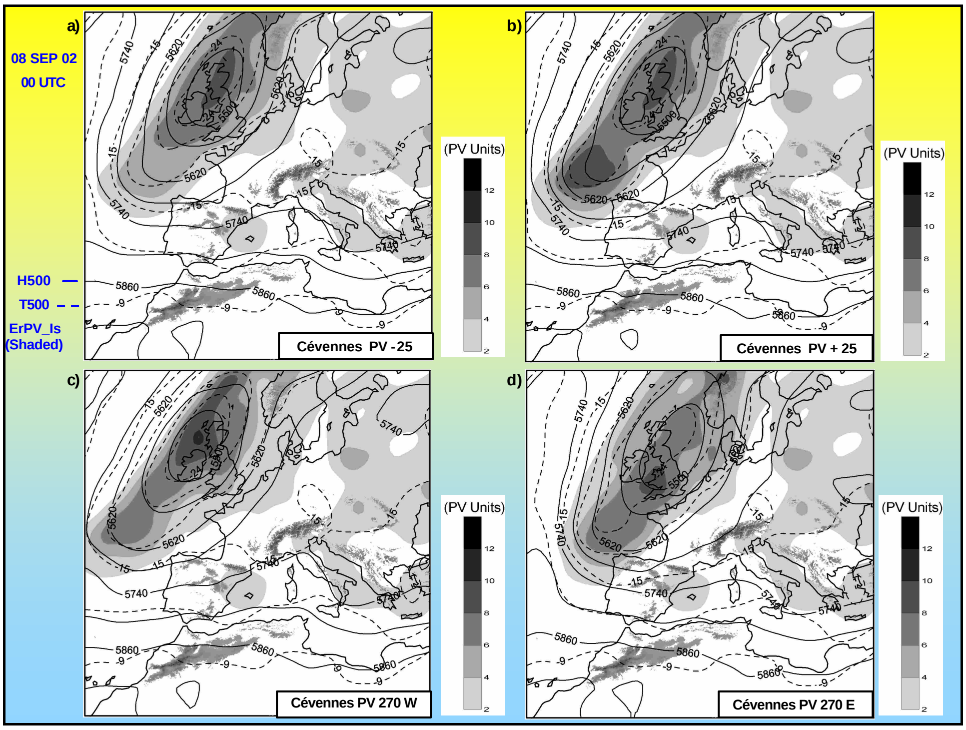

a)
25 NOV 02
00 UTC
b)
26 NOV 02
00 UTC
(PV Units)
H500
T500
ErPV_ls
(Shaded)
Piémont-II - Control
c)
d)
SLP
W.950
10 m/s

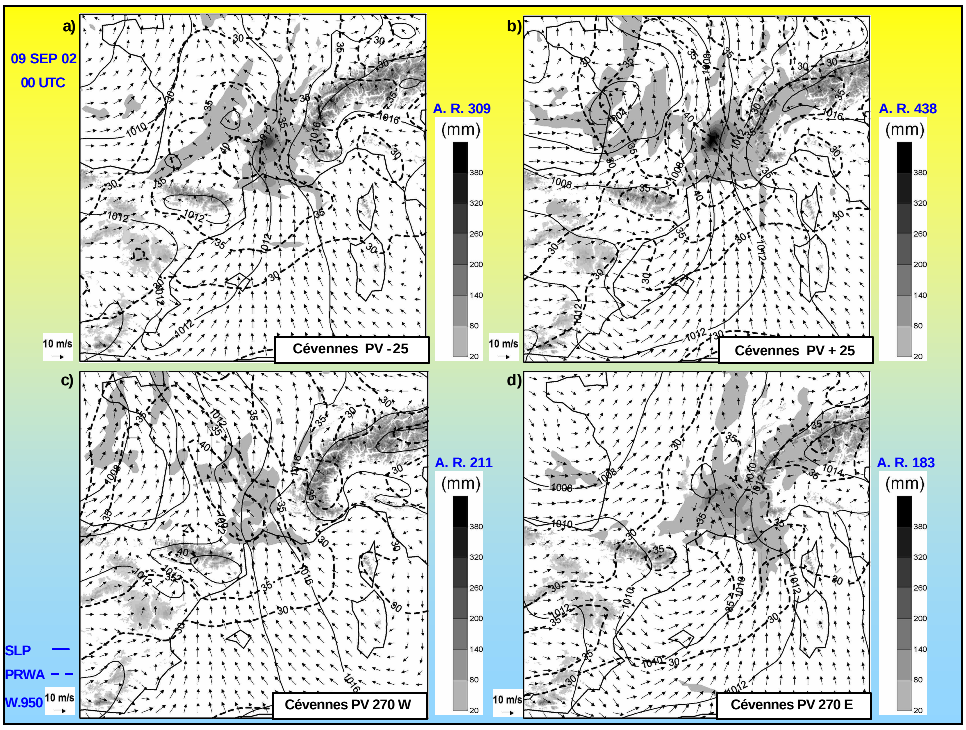

a)
26 NOV 02
00 UTC
A. R. 223
(mm)
SLP
PRWA
W.950
10 m/s
Piémont-II - Control
b)
Precipitation (mm/24hr) at 26NOV2002 00:00 UTC
c)
Precipitation (mm/6hr) at 26NOV2002 06:00 UTC
d)
Precipitation (mm/6hr) at 26NOV2002 12:00 UTC

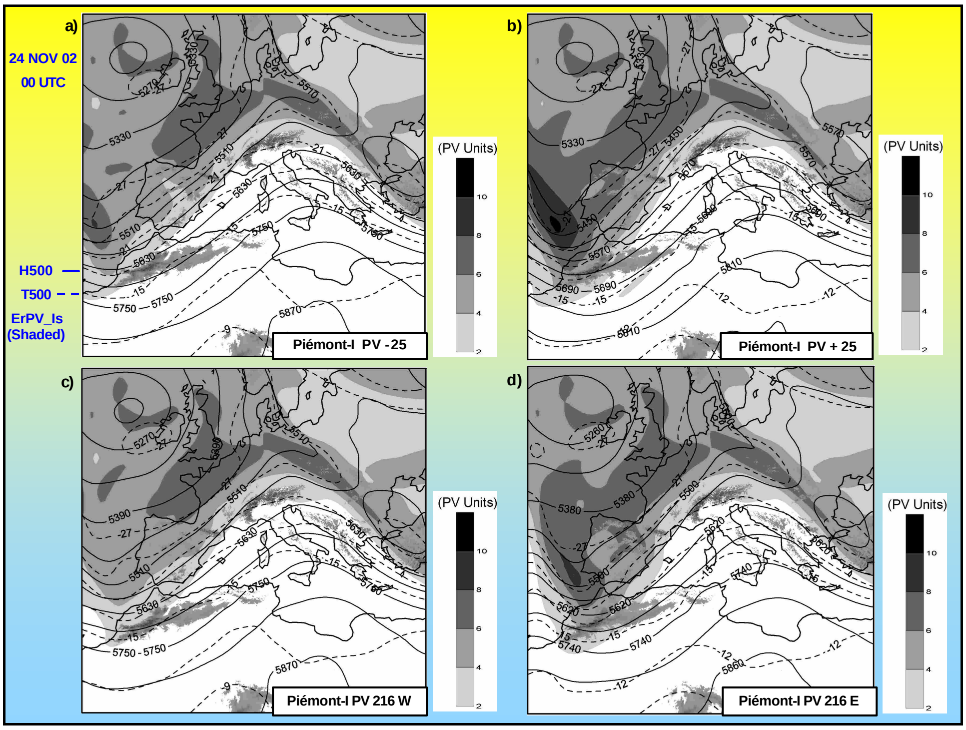

a)
09 JUN 00
00 UTC
ErPVp– –
+ SENS.—
(SQPVA)
- SENS.– –
(SQPVA)
ErPV_ls
(Shaded)
Catalogne - Control
b)
08 SEP 02
00 UTC
Cévennes - Control
c)
24 NOV 02
00 UTC
Piémont-I - Control
d)
25 NOV 02
00 UTC
Piémont-II - Control
(PV Units)

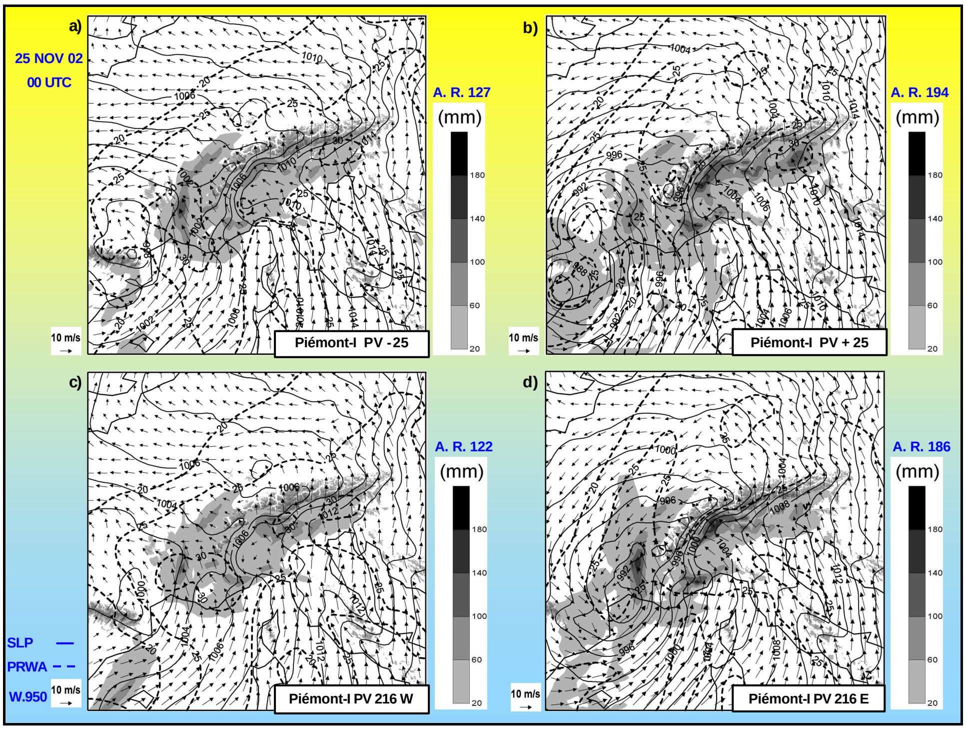

a)
09 JUN 00
00 UTC
H500 —
T500 – –
ErPV_ls
(Shaded)
Catalogne PV -25
b)
Catalogne PV +25
c)
Catalogne PV 216 W
d)
Catalogne PV 216 E
(PV Units)

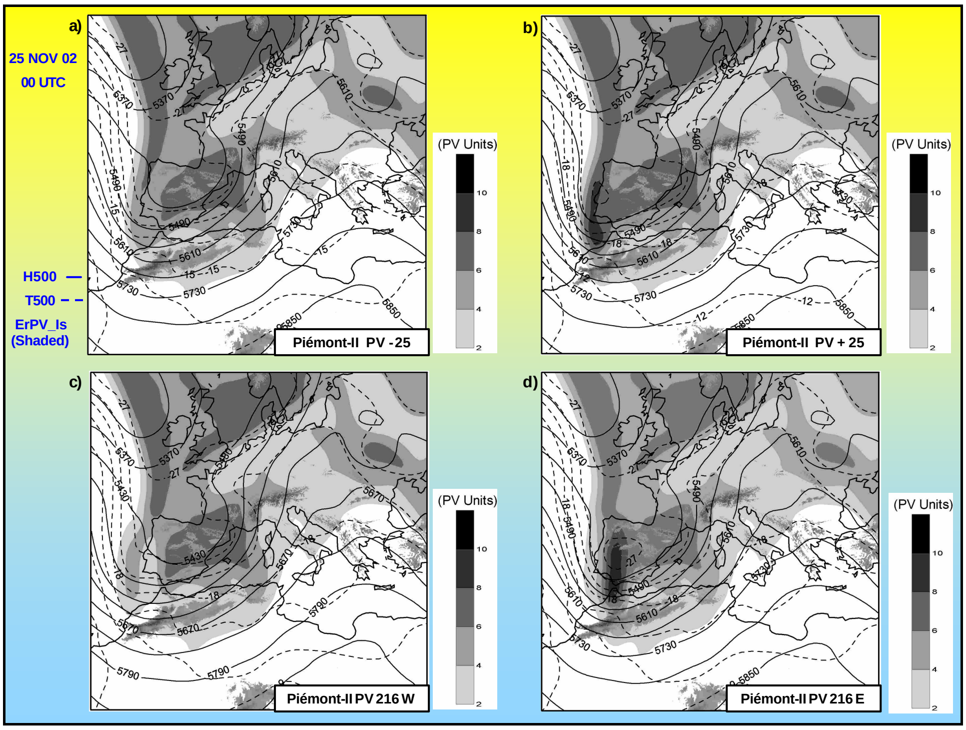

a)
b)
c)
d)
10 JUN 00
00 UTC
A. R. 230
A. R. 91
A. R. 157
A. R. 79
(mm)
Catalogne PV -25
Catalogne PV + 25
Catalogne PV 216 W
Catalogne PV 216 E
10 m/s
SLP
PRWA
W.950

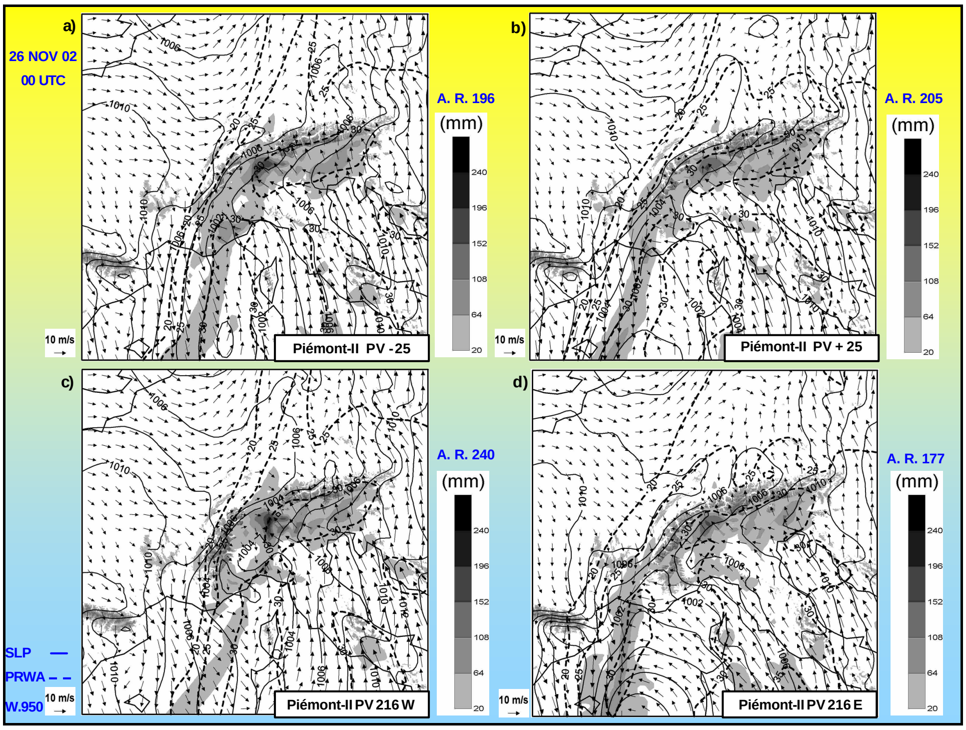

a)
b)
c)
d)
08 SEP 02
00 UTC
H500
T500
ErPV_ls
(Shaded)
(PV Units)
Cévennes PV -25
Cévennes PV + 25
Cévennes PV 270 W
Cévennes PV 270 E


a)
09 SEP 02
00 UTC
A. R. 309
(mm)
Cévennes PV -25
b)
A. R. 438
(mm)
Cévennes PV + 25
c)
A. R. 211
(mm)
Cévennes PV 270 W
d)
A. R. 183
(mm)
Cévennes PV 270 E
SLP
PRWA
W.950
10 m/s


a)
24 NOV 02
00 UTC
(PV Units)
Piémont-I PV -25
b)
(PV Units)
Piémont-I PV + 25
c)
(PV Units)
Piémont-I PV 216 W
d)
(PV Units)
Piémont-I PV 216 E
H500
T500
ErPV_ls
(Shaded)


a)
b)
c)
d)
25 NOV 02
00 UTC
A. R. 127
A. R. 194
A. R. 122
A. R. 186
(mm)
Piémont-I PV -25
Piémont-I PV + 25
Piémont-I PV 216 W
Piémont-I PV 216 E
SLP
PRWA
W.950
10 m/s


a)
b)
c)
d)
25 NOV 02
00 UTC
H500
T500
ErPV_Is
(Shaded)
(PV Units)
Piémont-II PV -25
Piémont-II PV + 25
Piémont-II PV 216 W
Piémont-II PV 216 E



SUMMARIZING …

The results (from only four cases !!!) generally show that:

✍The events dominated by mesoscale low-level disturbances (Catalogne and Piémont-II) are very sensitive to the initial uncertainties, such that the heavy rainfall location and magnitude are, in some of the experiments, strongly changed in response to the "forecast errors" of the cyclone's characteristics (genesis area, shape, intensity, translational speed, …)

✍In contrast, the other situations (Cévennes and Piémont-I) dominated by a large-scale disturbance that regulates a moist LLJ, show higher predictability. Both the action of the Alps range, in enhancing the LLJ, and the role of the local topography in providing upward motion to the low-level warm, moist maritime air-mass, improves the predictability of this kind of episodes.

✍The predictability in this study has been associated to the model capability of providing good guidance of the flash flood situations in each case and a reasonably correct localization of the affected areas, under arbitrary perturbations of the IC. The same methodology could be used to design an EPS forecasting tool, provided the real climatology of upper-level PV error is considered.

✍However, hydrological considerations are omitted in the present study being aware of current limitations of mesoscale prediction systems for providing a good quantitative rainfall forecast at hydrographical basin scale.

Thank you very much for your attention !!!