IMPORTANCE OF COLD POOLS AND ASSOCIATED OUTFLOWS TO THE EVOLUTION OF A CONVECTIVE OUTBREAK IN NORTHEASTERN SPAIN

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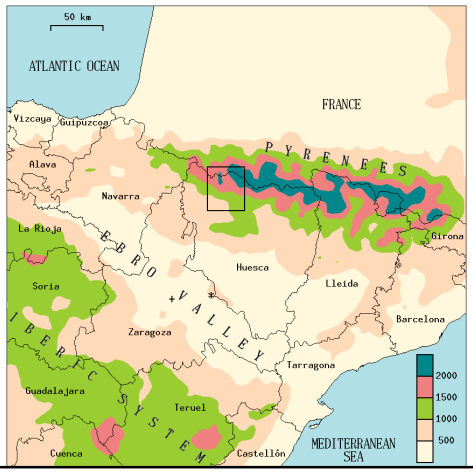
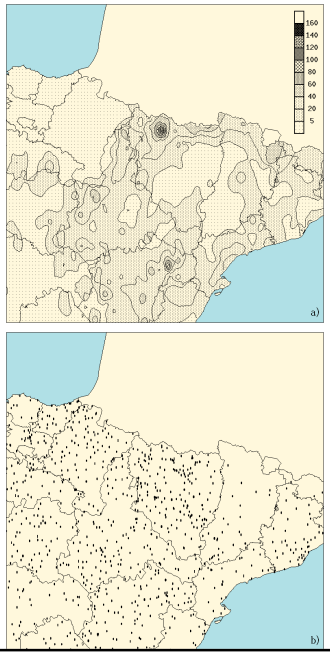


RAINFALL 24 h

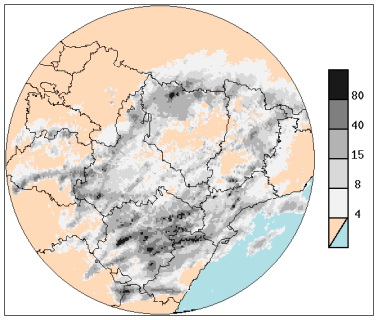
RAINGAUGES NETWORK



07 UTC
7 August 1996

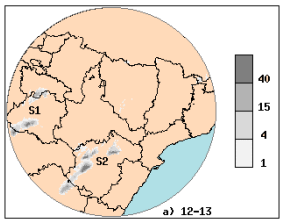
07 UTC
8 August 1996

RADAR-ESTIMATED



Significant rainfall along the Pyrenees and Iberic System
Connecting corridor across the low lands of Ebro valley
Flash-floods in **Biescas** (>250 mm; 225 mm 15-18 UTC)

RADAR-ESTIMATED HOURLY RAINFALL

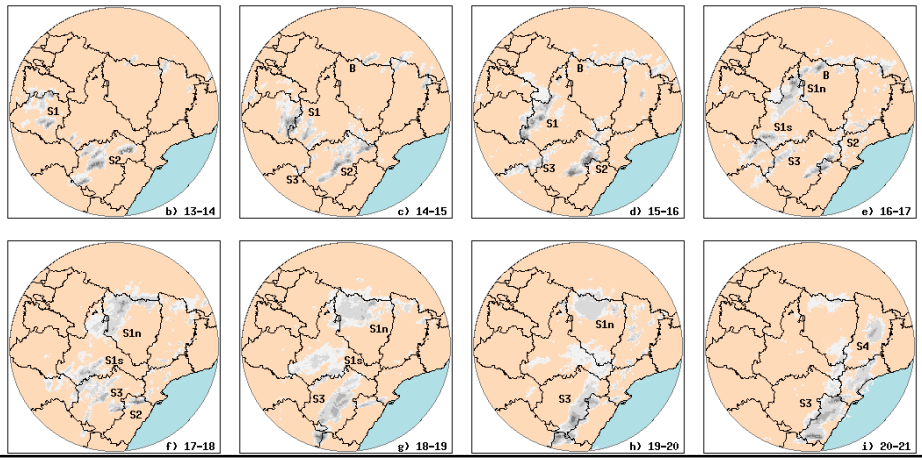


The episode began at 12 UTC over the mountains: **Diurnal heating**

Differential movement of the main MCSs **S1** and **S2** after 15 UTC

Merger of **S1n** with the Biescas convective storm **B** at 17 UTC

Complex evolution: Role of **convectively-induced features ???**



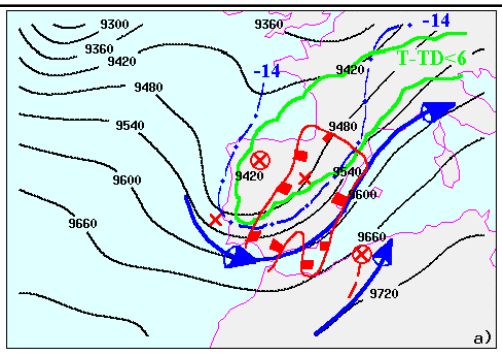
SYNOPTIC ENVIRONMENT

MID-UPPER LEVELS

Advance of a trough and cold front

Upward Q-G forcing in eastern Iberian peninsula

ULJS off the Mediterranean coast

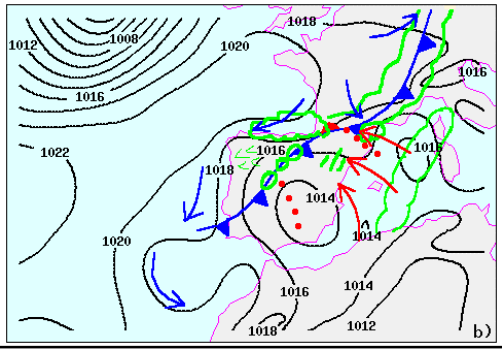


12 UTC

LOW LEVELS

Low in southeastern Spain / Warm-moist advection

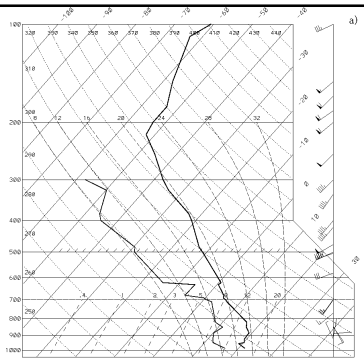
Cold front blocked against the Pyrenees



PRECONVECTIVE SOUNDING AT ZARAGOZA

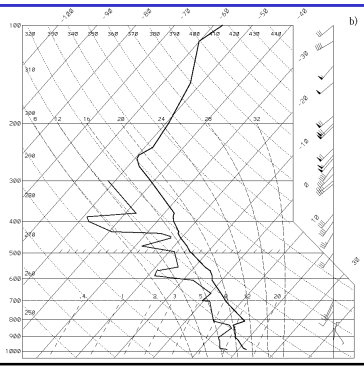
00 UTC

CAPE	31 J / kg
CIN	383 J / kg
TT	51
K	35
LI	+1
PW	33 mm



12 UTC

CAPE	945 J / kg
CIN	165 J / kg
TT	55
K	35
LI	-2
PW	37 mm



SURFACE MESOSCALE COMPOSITES

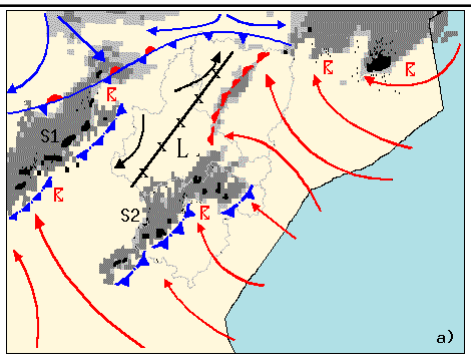
12 UTC

Upslope wind systems

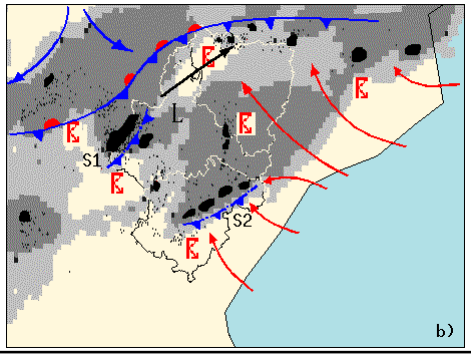
SW-NE oriented deformation zone

Mesolow in the Ebro valley of thermal origin

Outflow boundaries from S1 and S2



15 UTC



MESOSCALE NUMERICAL SIMULATIONS

*** PSU-NCAR mesoscale model (non-hydrostatic version MM5)**

*** Simulations:**

- 3 domains: 82x82x31 (36 and 12 km) / 112x112x31 (4 km)
- Interaction: two-way
- I.C and B.C: NCEP global analysis + Surface and Upper air obs.
- Period: 24 h, from 00 UTC 7 August 1996

*** Physical parameterizations:**

- PBL: Based on Blackadar (1979) scheme (Zhang and Anthes 1982)
- Ground temperature: Force-restore slab model (Blackadar 1979)
- Radiation fluxes: Considering cloud cover (Benjamin 1983)
- Resolved-scale microphysics:
  - 36 km - Cloud water, rainwater, cloud ice and snow (Zhang 1989)
  - 12/4 km - Mixed-phase model (+ graupel) (Lin et al. 1983)
- Parameterized convection:
  - 36 km: Kain-Fritsch (1990)
  - 12 km: Grell et al. (1991)
  - 4 km: None

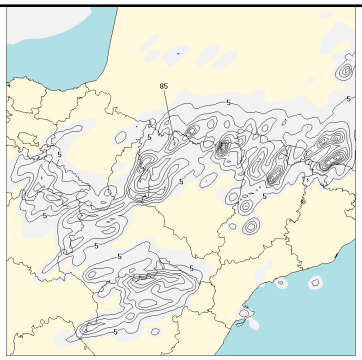
FORECAST

Spatial pattern well captured

Deficiencies along the Mediterranean coast

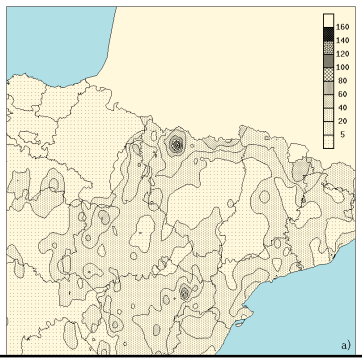
Precipitation maxima generally more intense

Precipitation center at Biescas: 85 mm



TOTAL PRECIPITATION

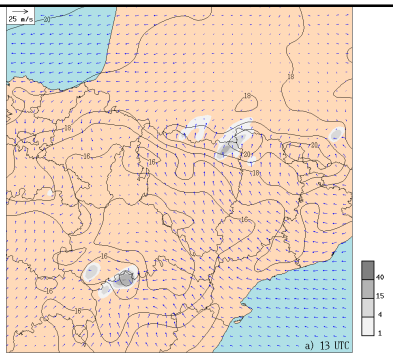
OBSERVED

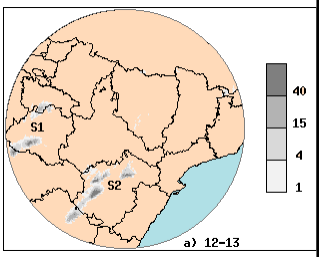


12 - 13 UTC

Orographic triggering

S1, **S2**, **cells** along Pyrenees





TEMPORAL EVOLUTION

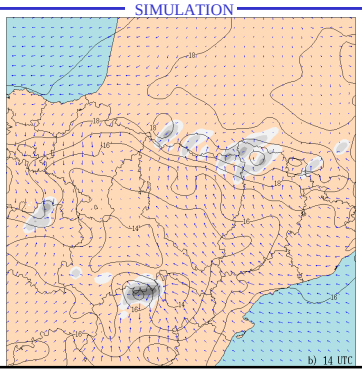
SIMULATION — RADAR

13 - 14 UTC

General **upslope** wind flows

Mesolow in the Ebro valley

Blocking high pressure areas

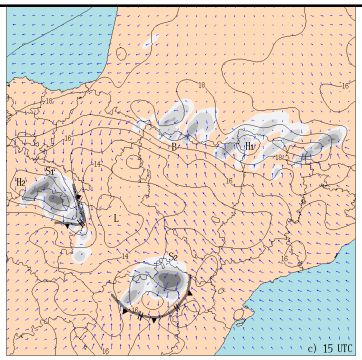


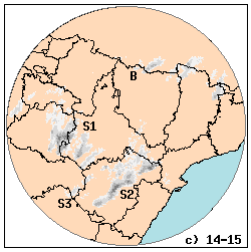
14 - 15 UTC

Deepening of the mesolow

Deformation zone

Storm at Biescas **B**





TEMPORAL EVOLUTION

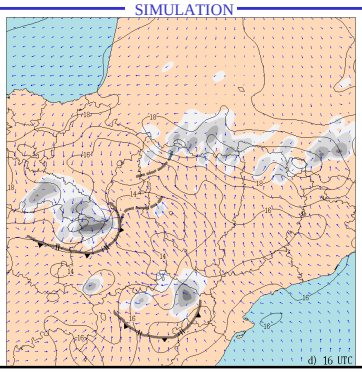
SIMULATION — RADAR

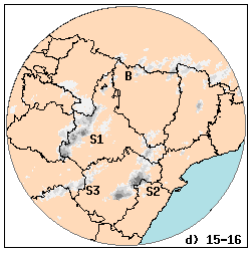
15 - 16 UTC

S1 and **S2** moving **E**-wards

Convective **outflows**

Strong LL **convergence**

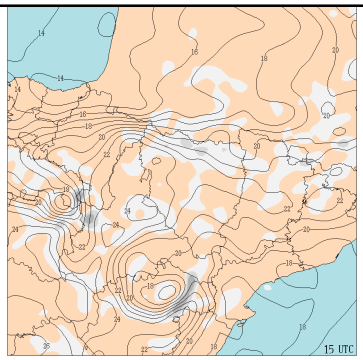




FORECAST

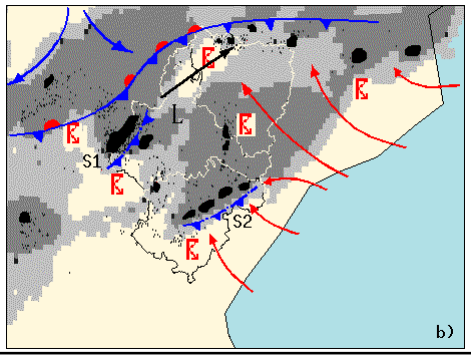
Spreading cold pools

Intense upward motion along the leading edges



COLD POOLS AND OUFLOW BOUNDARIES

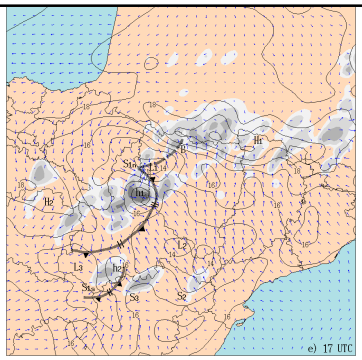
OBSERVED POSITION

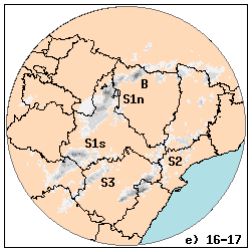


16 - 17 UTC

S1 moving **NE**-wards (**S1n**)

Convective **disruption** of the flow



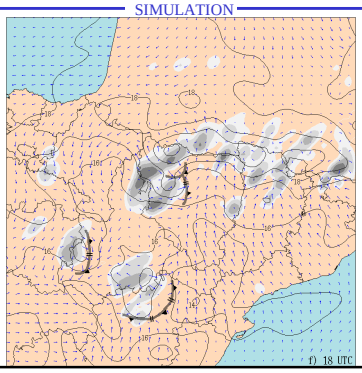


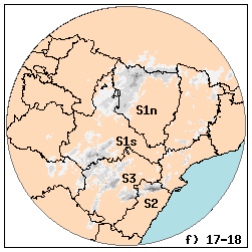
TEMPORAL EVOLUTION

SIMULATION — RADAR

17 - 18 UTC

Connection between **S1n - B**

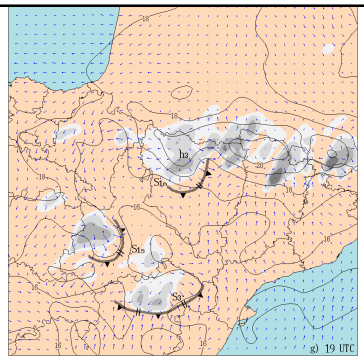


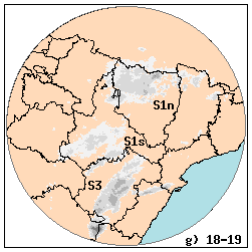


18 - 19 UTC

Extension of the merger

Low-level divergence (**h3**)





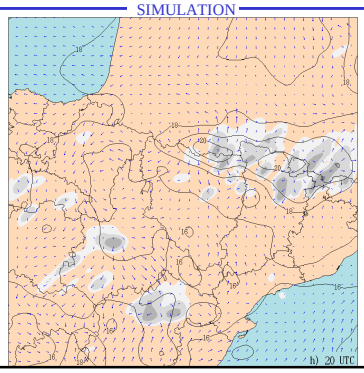
TEMPORAL EVOLUTION

SIMULATION — RADAR

19 - 20 UTC

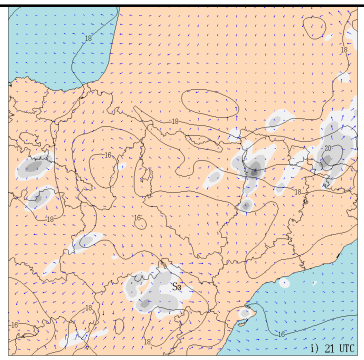
Weakening of the mesolow

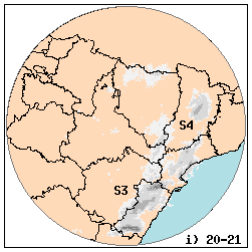
Weak, disorganized LL flow



20 - 21 UTC

Dissipation convective systems

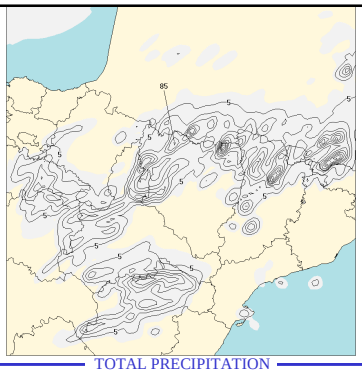




TEMPORAL EVOLUTION

SIMULATION — RADAR

FULL SIMULATION

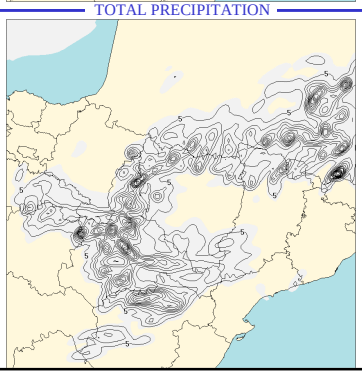


TOTAL PRECIPITATION

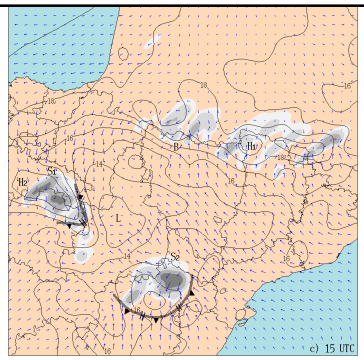
IMPORTANCE COLD POOLS & OUTFLOWS

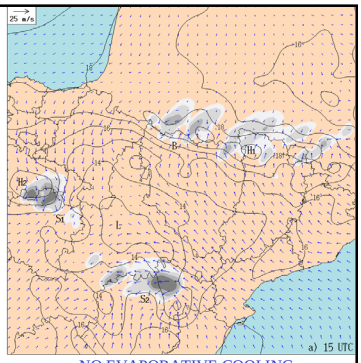
NO EVAPORATIVE COOLING

Similar spatial structure, **but ...**
Excessive rainfall over Zaragoza
Incorrect timing and **lack of propagation**



14 - 15 UTC



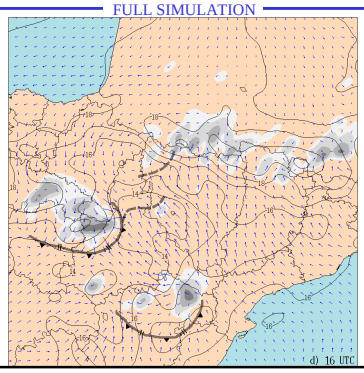


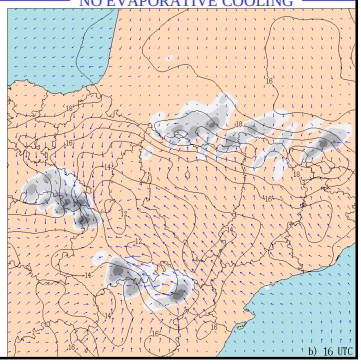
IMPORTANCE COLD POOLS & OUTFLOWS

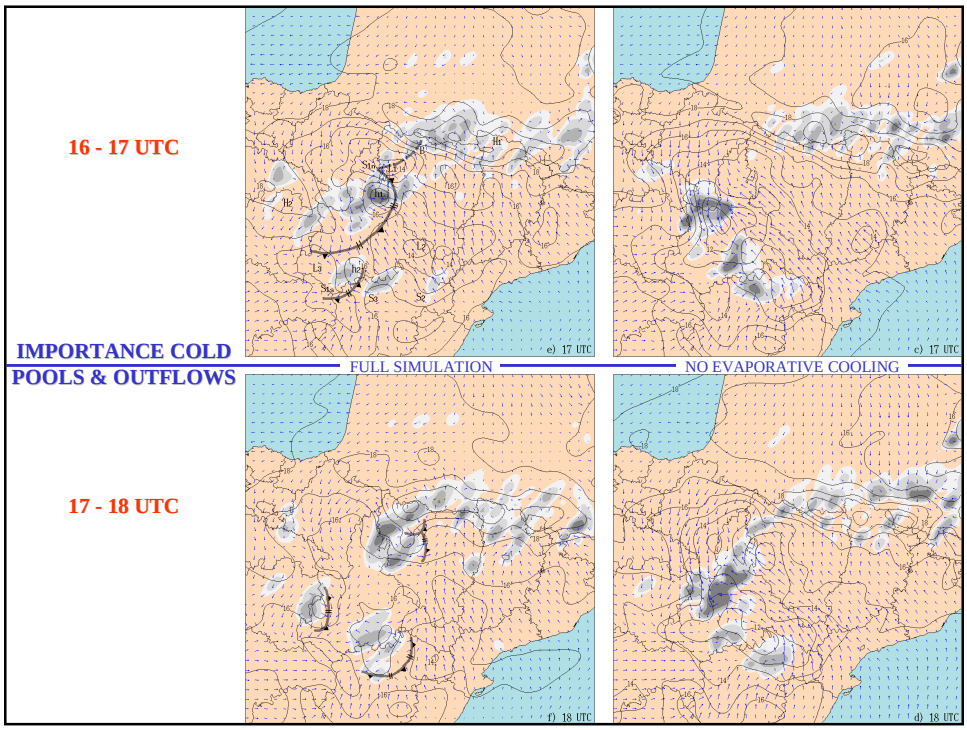
FULL SIMULATION

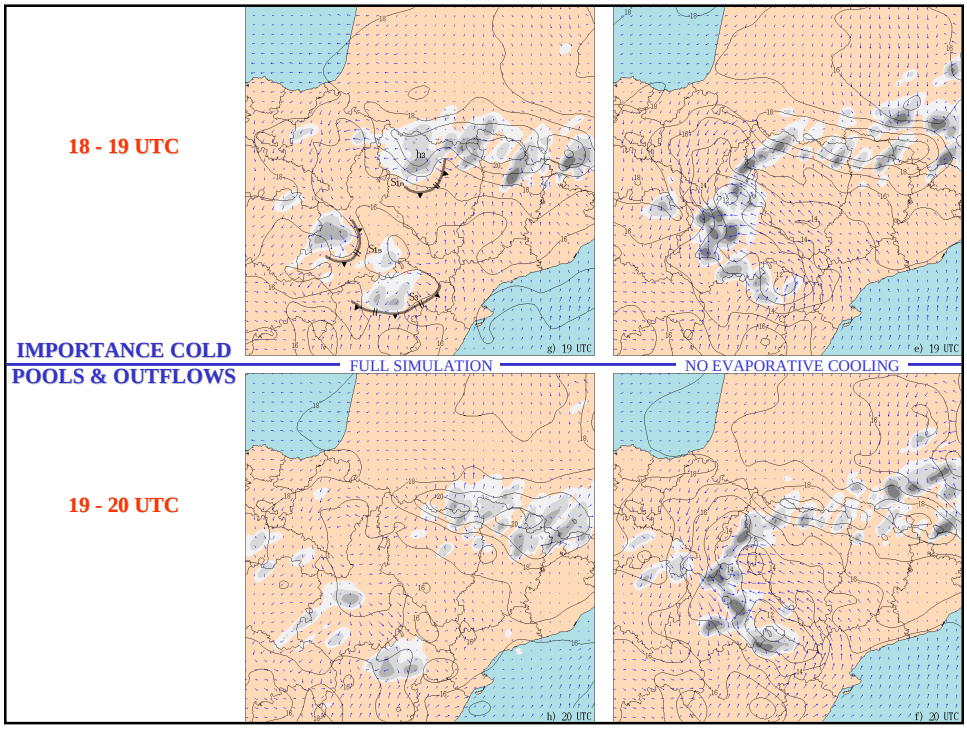
NO EVAPORATIVE COOLING

15 - 16 UTC

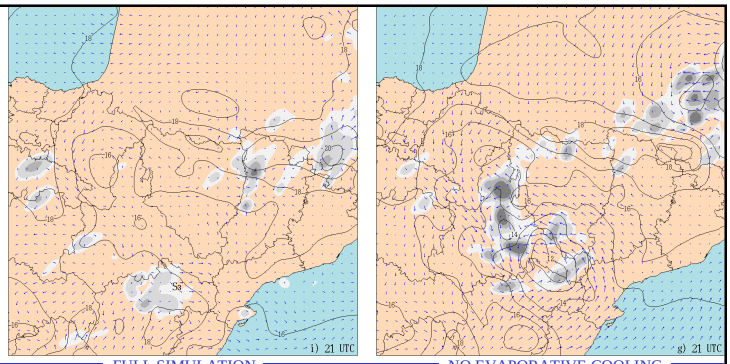





16 - 17 UTC
IMPORTANCE COLD POOLS & OUTFLOWS
FULL SIMULATION
NO EVAPORATIVE COOLING
17 - 18 UTC
e) 17 UTC
c) 17 UTC
f) 18 UTC
d) 18 UTC


18 - 19 UTC
IMPORTANCE COLD POOLS & OUTFLOWS
FULL SIMULATION
NO EVAPORATIVE COOLING
19 - 20 UTC
g) 19 UTC
e) 19 UTC
h) 20 UTC
f) 20 UTC

20 - 21 UTC



FULL SIMULATION

NO EVAPORATIVE COOLING

IMPORTANCE COLD POOLS & OUTFLOWS

CONCLUSIONS

*** Moderately fine horizontal grid resolution (4 km) + conventional initialization provides valuable information of the convective event and the simulated timing is remarkable**

*** The strong orographic influences typical of the region and the leading role of diurnally-forced circulations (mesolow in the Ebro valley and upslope winds) well-handled by the mesoscale model, as well as the development of convective cold pools (resolved-scale)**

*** The cold pools naturally acted to stabilize the environment, and the accompanying outflows helped to propagate the convection quite in the same way as indicated by the observations, avoiding unrealistic, excessive precipitation in the areas dominated by the mesolow**

*** Realistic parameterizations of convective downdrafts necessary in the operational context**

ACKNOWLEDGEMENTS

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