The High Precipitating Event over Southern Var, on January 18th and 19th, 2014

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Introduction

Very rainy conditions affected the south of France over the weekend of the 18th and 19th January 2014. This long-lasting disturbed episode was driven by a slow progressing deep low at upper level (Figs 1a and 1b). The Var Département was particularly hit. The 48 hour accumulated rainfall varied between 70 to 120 mm (Fig. 2) in most places. However values probably approached 150 to maybe 250 mm over a relatively narrow band from Entrecasteaux to the sea via La Londe des Maures. From this total, 40 to 70 mm fell on Saturday 18th January, while the remaining 100 to 200 mm fell on Sunday, the 19th (Fig. 3). These quantities fell in a very short time, no more than 6 to 9 hours. This very intense rainfall was the result from a stationary mesoscale convective system. Such an event is relatively rare during winter. A preceding case of this kind could have been in Herault Departement at Puisserguier on 28th January 1996 (Rivrain, 1997). The La Londe des Maures case produced 2 human fatalities and important property losses, and also involved flooding in the Gapeau River catchment area. Impact was enhanced by already significant preceding precipitation.

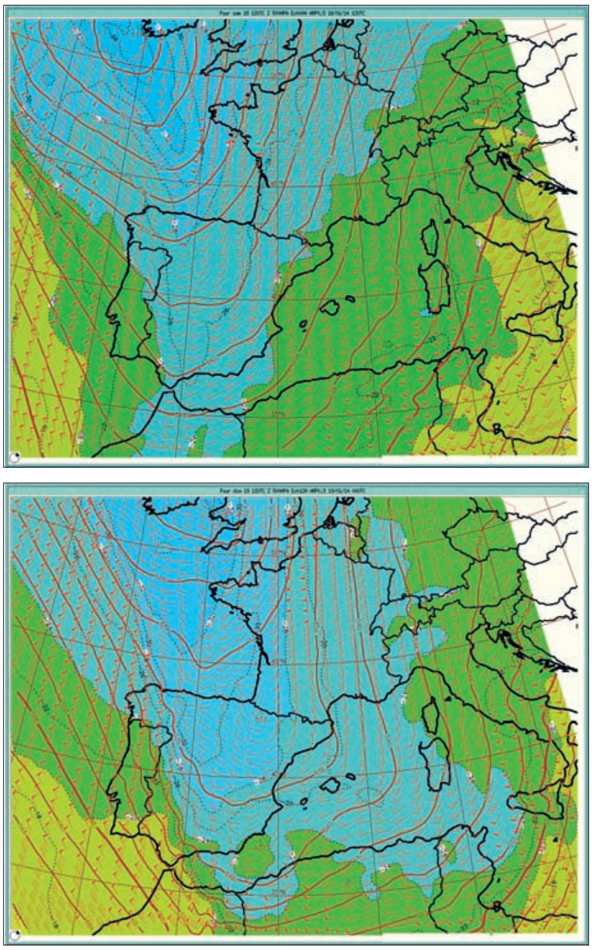


Figure 1: Geopotential height (brown line, gpm), winds (barbs) and temperature (shaded with dashed line every 2°C) at 500 hPa from the ARPEGE model, at (a) 12 UTC 18 January 2014, and (b) 12 UTC 19 January 2014 (superimposed is a box locating the area of the most important rainfall amount).

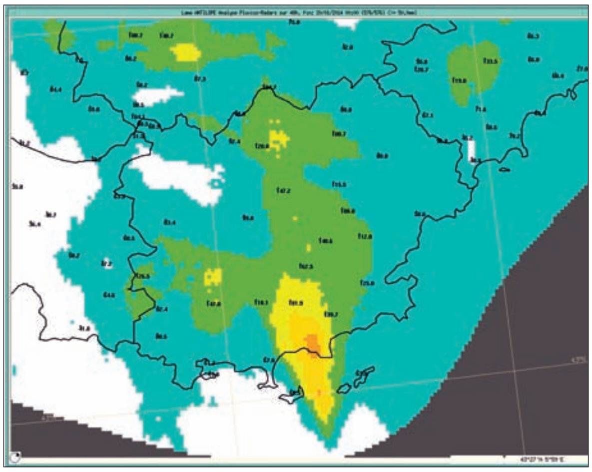
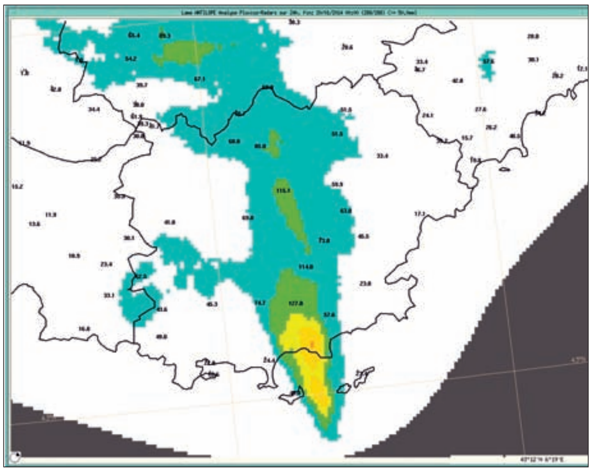


Figure 2: 48 hour accumulated precipitation from 00 UTC, 18 January till 00 UTC, 20 January 2014, provided by the ANTILOPE analysis. The ANTILOPE product is based on both RADAR data and measurements from the raingauge network.

Caption :			
Green	*: → 50 mm*	*Dark green :*	*→ 100 mm*
Yellow	*: → 150 mm*	*Orange*	*: → 200 mm*
Dark Orange :	*→ 300 mm*		

In the following sections, the meteorological ingredients will be exposed, from a synoptic point of view to a very fine scale one. Moreover, forecasting model behaviour will be analyzed briefly, illustrating the benefits from fine scale and non-hydrostatic simulations.

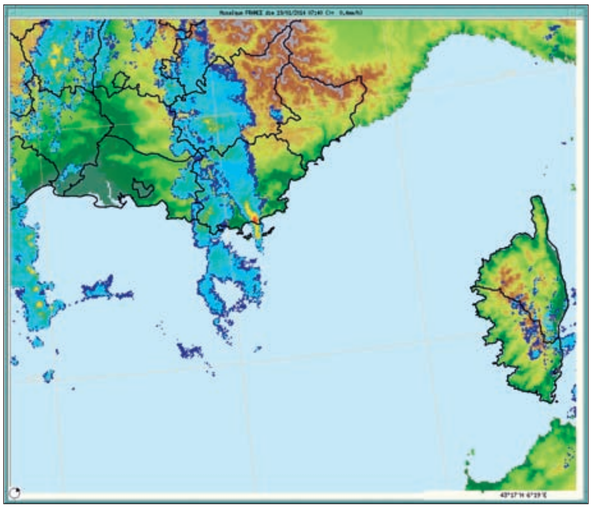


▲ *Figure 3: 24 hour accumulated precipitation from 00 UTC, 19 January till 00 UTC, 20 January 2014, provided by the ANTILOPE analysis.*

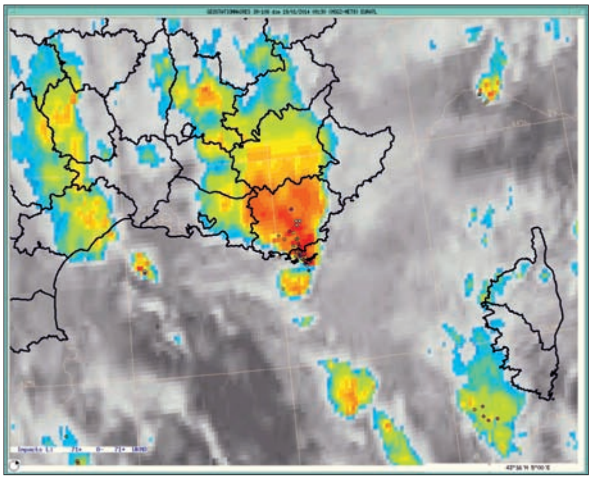
The stationary event

A stationary convective system developed over southern Var late in the night of January 18th to 19th, then persisted there until early afternoon of 19th. For 6 to 9 hours it was anchored offshore close to Porquerolles and Port Cros islands. From the radar network, it appeared as a north-south elongated narrow band (Fig. 4). The convective system regularly regenerated from its southern end. On the other hand, infrared satellite observations revealed a very classical V shape pattern, a frequently observed stationary storm attribute (Fig. 5).

As revealed by the ANTILOPE analysis (produced by mixing rain gauge and radar data), rainfall was particularly intense, exceeding 50 mm per hour around the epicentre, probably bringing the accumulation close to, and maybe over, 200 mm in 6 to 9 hours (Fig. 6). This epicentre of 200 mm has to be considered as a crude though likely estimate, as : 1/ the nearest Collobrières radar was out of order ; 2/ no raingauge provided a precipitation estimate in the strongest accumulation neighborhood ; 3/ some hail was reported (implying a significant lowering of the 300 mm RADAR estimate).



▲ *Figure 4: composite radar reflectivities from the French radar ARAMIS network, at 0740 UTC, 19 January 2014.*



▲ *Figure 5: infrared MSG image, at 0930 UTC, 19 January 2014. 15 minute cloud-ground lightning accumulation is superimposed.*

Meteorological ingredients

a. From a synoptic point of view

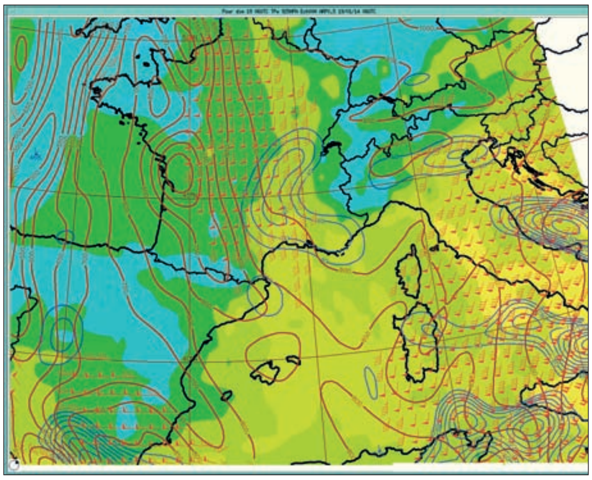
At upper level, a large scale trough associated with a strong meridional extension slowly approached from the west. The convective system onset did not clearly involve upper potential vorticity advection : the height of the 1.5 PVU level didn't change significantly. However the convective genesis area was located around the left exit of the southerly upper jet (Fig. 7).

On the other hand, at low level, southerly inflow dominated over the western Mediterranean Sea, bringing wet and warm air toward the French coast. Convergence also appeared off the Var Département between the southerly flow west of Corsica and the easterly coming from the gulf of Genoa (Fig. 8). This mesoscale feature will be discussed in following sections.

b. From a mesoscale point of view

At low level, one can notice a relatively narrow tongue of high 950 hPa wet-bulb potential temperature approaching the Var Département (Fig. 9). This warm and moist advection appeared rather focused, exacerbated by convergence between southerly and easterly flow. The warm tongue was associated with a very unstable environment, as illustrated by forecast verti-

Figure 7: 925 hPa wet-bulb potential temperature (shaded), wind (barbs, above 40 kt) at the 1.5 PVU, height of the 1.5 PVU (brown continuous line, intervals of 50 dam), vertical velocity (blue continuous line, from and below -40x10-2 Pa/s), from the ARPEGE model at 06 UTC 19 January 2014.



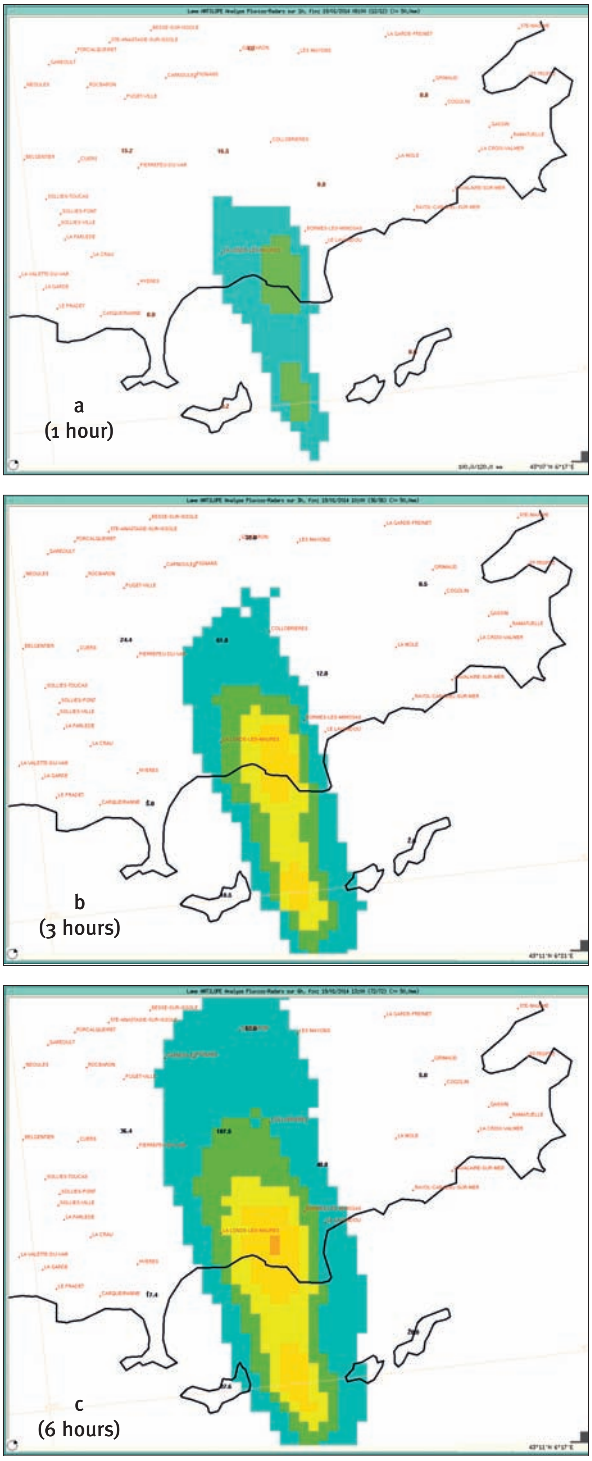


Figure 6: accumulated precipitation provided by the ANTILOPE analysis : (a) 1 hour, (b) 3 hours, (c) 6 hours. Measurements from the raingauge network are superimposed.

Caption :			
Green	› 50 mm	Dark green	› 100 mm
Yellow	› 150 mm	Orange	› 200 mm
Dark Orange	› 300 mm		

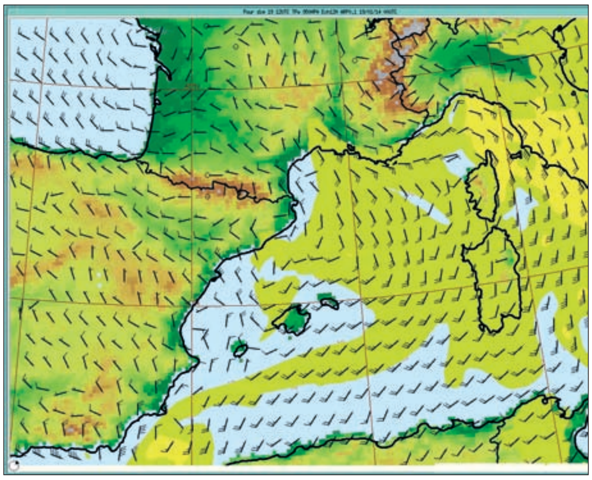


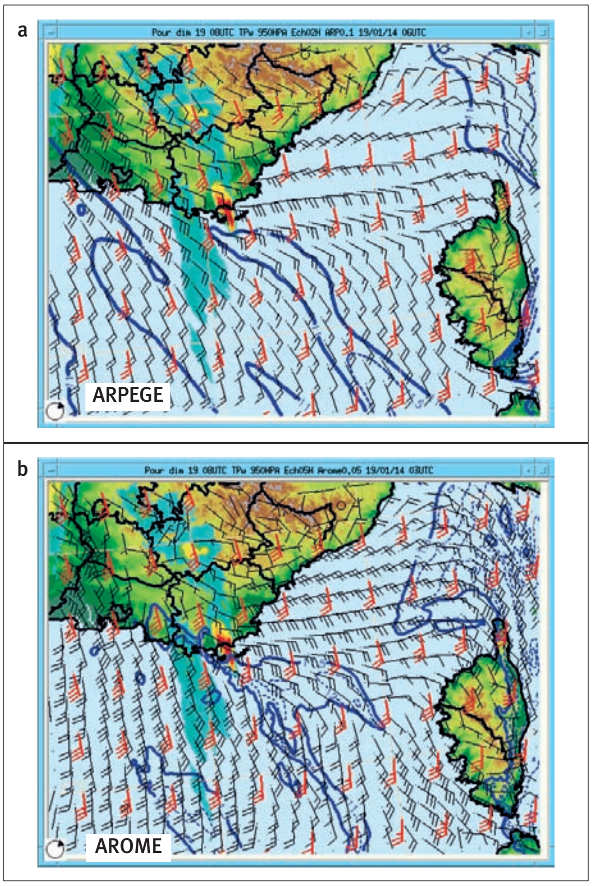
Figure 8: 950 hPa wind (barbs) and 950 hPa wet-bulb potential temperature (shaded above 10°C) from the ARPEGE model at 12 UTC 19 January 2014.

cal profiles around the triggering time of the convective system, or else by high CAPE areas (in excess of 500 J/kg) off the Var Département (Fig. 10).

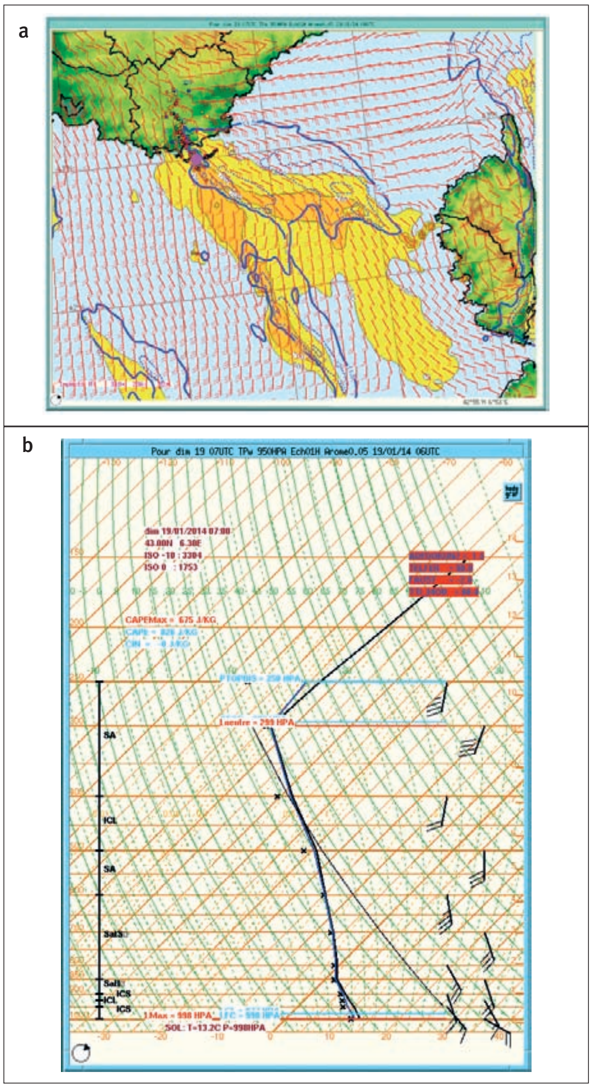
This focused and convergent pattern lasted throughout the life cycle of the convective system (6 to 9 hours, not shown), permitting its maintenance over the same location.

The convergence in the feeding flow was probably the main triggering mechanism of the stationary storm. However, we will mention below other processes also contributing to its development.

One can note that the AROME fine scale model (grid spacing of 2.5 km) compared to the ARPEGE model (mesh close to 10 km) developed a more pronounced convergence, closer to the French coasts, and associated with warmer wet-bulb potential temperatures (12°C instead of 11°C, Fig. 9). Thus, in terms of low level ingredients for the development of the system, the AROME model was clearly more suggestive.



▲ *Figure 9: 950 hPa wet-bulb potential temperature (blue continuous and dashed line, from and above 11.5°C) and wind at 950 hPa (black barbs, kt) at 08 UTC 19 January, from (a) ARPEGE and (b) AROME. Wind at 600 hPa (red barbs, kt) from ARPEGE and 1 hour rainfall accumulations from ANTILOPE analysis are superimposed.*



▲ *Figure 10: AROME forecast for 07 UTC 19 January. (a) wet-bulb potential temperature (blue continuous and dashed line, from and above 11.5°C) and wind at 950 hPa (black barbs, kt), CAPE (based on the most unstable parcel, shaded from 500 J/kg). 1 hour cloud-ground lightning total is superimposed. (b) Vertical profile between Porquerolles and Port Cros islands (pink disc).*

Mesoscale analysis based on mesonet observations is a way of characterizing the true environment into which the MCS was embedded. At first, this analysis confirms that forcing for the convective system was linked to a convergence zone (Fig. 11a and Fig. 12a). At 6 UTC, convergence emerged clearly between the aforementioned easterly and southerly winds. Afterwards (10 UTC), the wind turned northwest at Hyères (encircled, Fig. 12b). The convergence remained, however, revealing something more. Indeed the 2 m temperature field changed also significantly. A cooling of 3 to 5 degrees occurred below the storm (Fig. 12b compared to Fig. 11b).

Thus a “cold pool” (also called a “meso high” by Maddox et al, 1979 and 1980) rapidly built, acting as a virtual relief to the maintenance of the stationary system. Such a convective retroaction is regularly observed in southern France (Ducrocq et al, 2008).

One can suggest a final factor : the orography, in particular the “Maures” range, which could also contribute to the forcing of the convective event.

Benefits from fine scale and non-hydrostatic simulations

Treatment of this case by the non-hydrostatic high resolution (mesh of 2.5 km) AROME model is very satisfying. Benefits are here substantial compared to the the hydrostatic ARPEGE model. Of course, this behaviour is far from being systematic.

At first, as explained above, the meteorological ingredients simulated by AROME are more pronounced : in particular the warm advection and the low level convergence facing the Var Departement are both stronger. In the case of the convergence, this may be due to a better management of the Corsica wake effect due to a finer spatial definition.

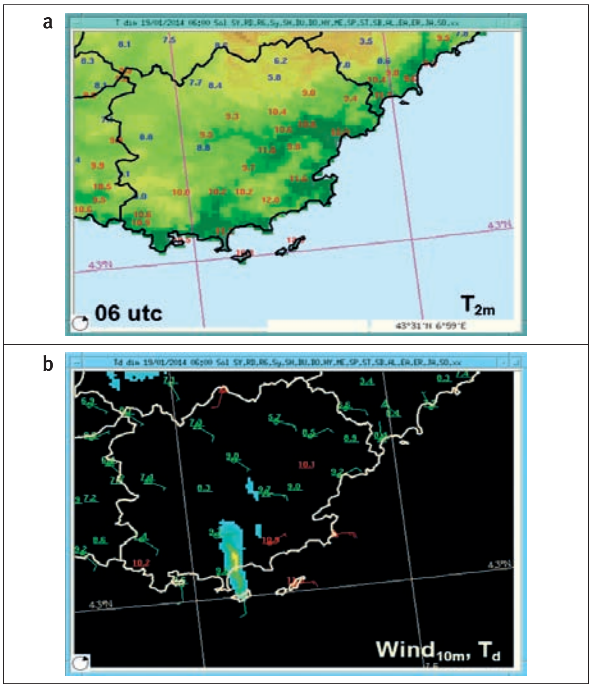


Figure 11: Observations at 06 UTC 19 January 2014,
(a) 2 m AGL temperature (in blue as ‹ +9°C),
(b) 10 m AGL wind, 2 m AGL dew point temperature (in red, as › +10°C) and 1 hour accumulate rainfall from the ANTILOPE analysis.

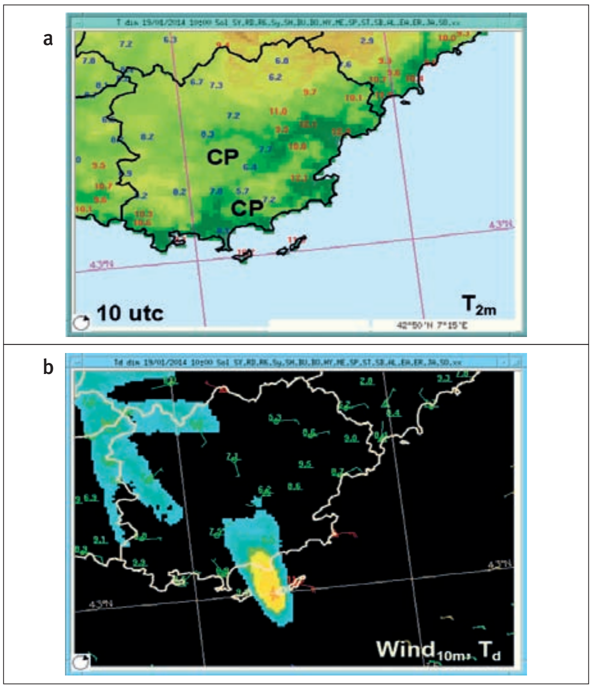


Figure 12: Observations at 10 UTC 19 January 2014
(a) 2 m AGL temperature (in blue as ⇠ +9, "CP" means Cold Pool,
(b) 10 m AGL wind, 2 m AGL dew point temperature (in red, as ⇢ +10°C) and 1 hour rainfall amount from the ANTILOPE analysis. Hyères observation is encircled.

Moreover, owing to these sharper and probably more accurate ingredients, AROME showed more realism in terms of rainfall prediction compared to the ARPEGE model. In particular, one can note its axis of 24 hours rainfall above 50 mm accumulation from the Var to the western Alpes de Haute Provence Départements, showing some similarities with observations (Figs 13 et 14). Indeed, AROME was able to produce with some accuracy (in location and timing) the convective system (Fig 15).

However, prediction was far from perfect. The simulated precipitating system was too far north with close to the epicenter rainfall amounts close to the epicentre at least 100 mm lower than reality.

Summary and concluding remarks

An intense rainy episode affected southern France during the weekend of January 18th to 19th 2014. The epicentre of the event was located over the Var Département, around the La Londe des Maures region. Indeed a stationary convective system developed there on Sunday January 19th, and brought about 200 mm in 6 to 9 hours. Damages were significant. Two casualities were counted.

The mesoscale convective system owed its genesis to various processes. But the most important ones were probably situated at low level and at fine scale. At first, one notices a focused warm and moist advection (wet-bulb potential temperature close to 12°C) facing the Var Département associated with a strong and stationary convergence environment (between southerly and easterly flows). This specific feature persisted throughout the event.

On the other hand, in its mature phase the storm generated a cold pool below itself, developing a thermal deficit of 3 to 5°C in comparison to the environment.

The cold pool was probably anchored by the surrounding relief. It contributed to the maintenance of the convective system by locally intensifying convergence and lifting.

This scenario implying a cold pool is well known in southern France (Ducrocq et al, 2008 ; Bresson, 2011). In this respect, the recent episode looks like other high precipitating events affecting Var, such as the June 2010 Draguignan case (450 mm at the epicenter). The two events also have in common a convergence environment off the Var Département between easterly and southerly winds (Bresson, 2011). Nonetheless, in June 2010, warm and moist advection was stronger (wet-bulb potential temperature at 18 to 19°C versus 12°C in January 2014) with a more northern location (the easterly flow was strongly implicated in the advection).

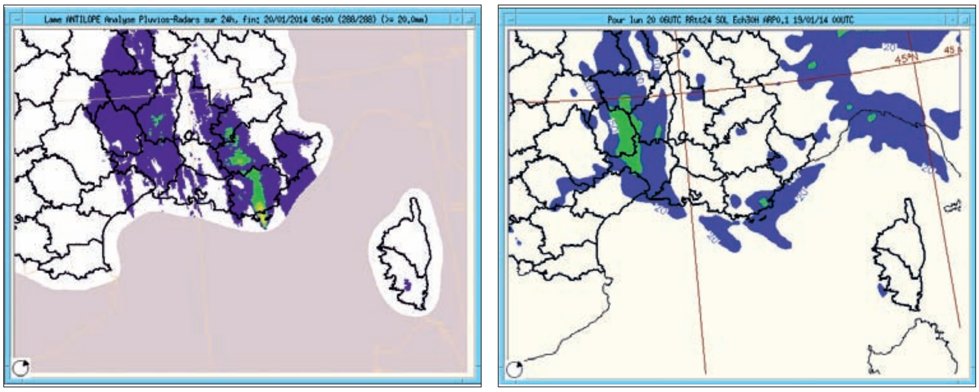


Figure 13 : 24 hour rainfall accumulation (from 06 UTC 19.01 to 06 UTC 20.01) from (a) the ANTILOPE analysis, (b) from the ARPEGE model (00 UTC run).

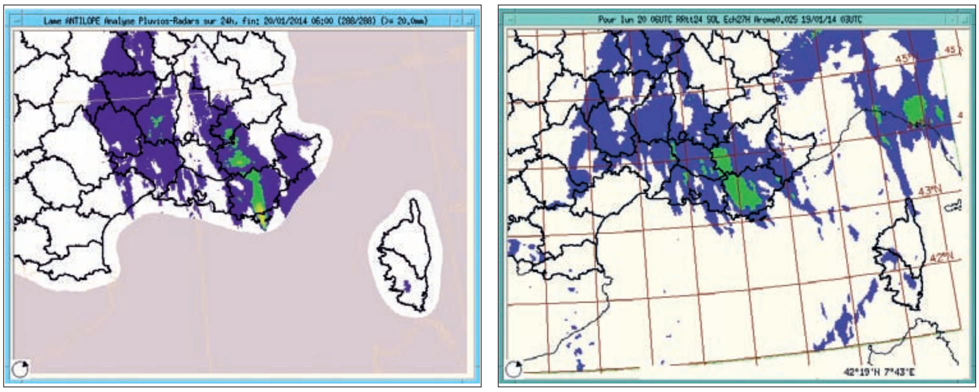


Figure 14 : 24 hours rainfall accumulation (from 06 UTC 19.01 to 06 UTC 20.01) from (a) the ANTILOPE analysis, (b) from the AROME model (03 UTC run).

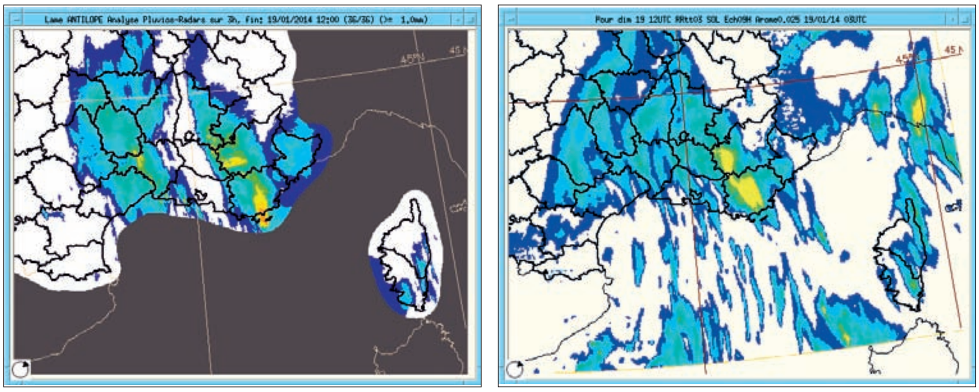


Figure 15 : 3 hours rainfall accumulation (from 09 UTC 19.01 to 12 UTC 19.01) from (a) the ANTILOPE analysis, (b) from the AROME model (03 UTC run).

The benefits of fine scale and non-hydrostatic simulations are significant here. By generating sharp and probably accurate convective ingredients off the Var Département, AROME was able to simulate a fairly realistic convection system in terms of its pattern, chronology and location. In the present case, AROME outmatched the ARPEGE model, suggesting a more realistic rainfall accumulation. Of course such a behaviour is not systematic. This aspect is all the more remarkable given that AROME's assimilation process was deprived of Collobrières radar data. This underlines the crucial impact of spatial definition and physics.

References:

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