Two case studies of heavy precipitation and strong winds in a subtropical environment. Validation of HARMONIE model

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Objective

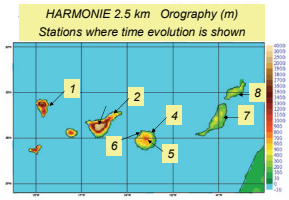
Canary Islands, located at latitude 30 degrees off Africa coast, usually have a very stable weather dominated by a trade wind regime and its interaction with the orography but sometimes suffers severe weather produced by extratropical lows moving South, tropical systems moving North or hybrid systems. On the western Isles the interaction with a very step orography generate complex weather phenomena as strong winds and heavy precipitation.

In 2010 winter several cases of adverse weather occurred in the Isles. During the period 31st January-2nd February an hybrid tropical-extratropical system produced generalized heavy precipitation over the western islands. During the second period, 16th-18th February a large extratropical low produces significant precipitation and very strong winds reaching hurricane force at several locations.

In this study we try to asses the performance of the Numerical Weather Prediction (NWP) models available at AEMET and specially the performance of HARMONIE which is run at convection permitting resolution.

Model setup

- Non Hydrostatic HARMONIE system in AROME configuration
- Version 36h1
- EDMF vertical diffusion and shallow convection. Explicit deep convection.
- Horizontal: 2.5 km resolution with 600x600 points
- Vertical: 60 vertical levels
- Initialized directly from ECMWF 16km analysis
- Boundaries from ECMWF forecasts.



An hybrid system producing heavy precipitation over the Canary Islands

- An extratropical cyclone moves to the Subtropics and transforms into an hybrid system (a mixture of tropical cyclone and baroclinic system). During a period of 3 days, 31st January-2 February 2010, gives significant amounts of precipitation which many locations catching amounts above 200 mm. The distribution over the Islands is irregular.

31 January 2010

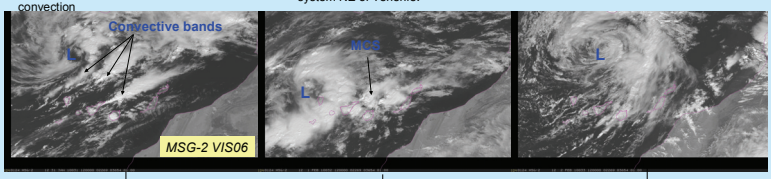
- Several convective lines moving W-E and crossing the Islands. Over the eastern Islands precipitation is generally low but locally moderate due to some fine scale convection

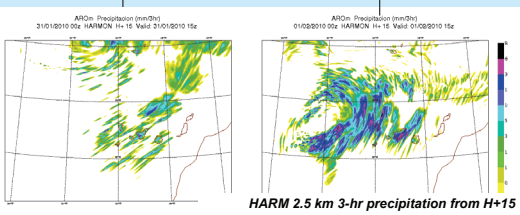
1 February 2010

- Convection more organized. Bigger convective bands. Largest precipitation amounts. A Mesoscale Convective system NE of Tenerife.

2 February 2010

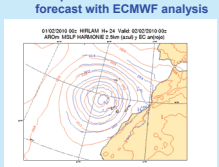
- Mature system moving NE. Less precipitation



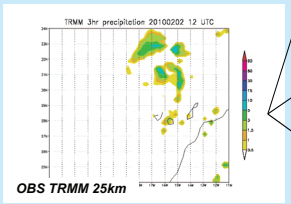


Radar images are not available for this period. We compare with MSG-2 and TRMM images. HARM reproduce large and mesoscale patterns but not the fine scale nor the exact timing.

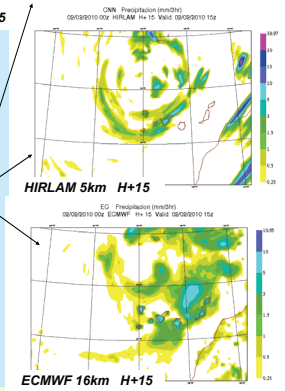
Comparison of HARM H+24 forecast with ECMWF analysis

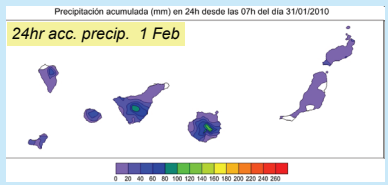


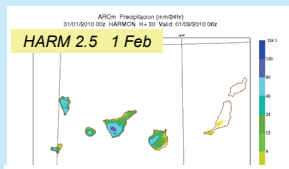
The synoptic scale inherited from the host model is well represented.

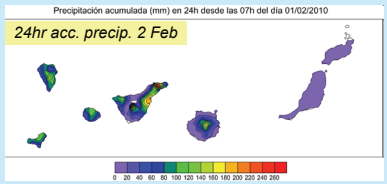


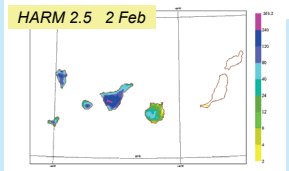
Comparison of precipitation from different models and TRMM estimates (accumulation in 3 hr). In HIRLAM 5 km the system is a bit delayed.



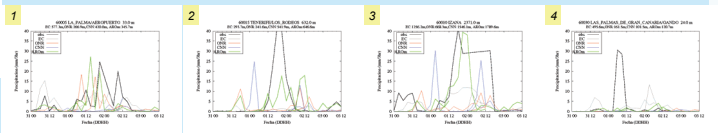




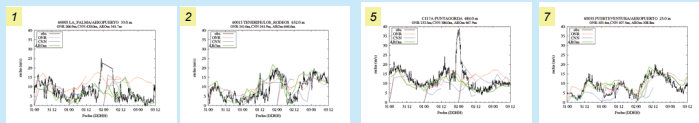




The model is able to reproduce distribution of precipitation associated with mesoscale systems, in general it produces amounts only a little below the obs. and reproduces the orographic enhancement but the model is not able to simulate maxima related to fine scale convection as the peak NE of Tenerife or the moderate precipitation of Eastern islands



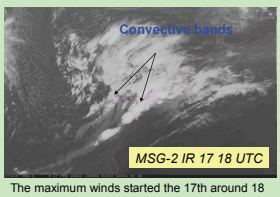
Evolution of precip. accumulated in 3 hr during the period for the station numbered in the upper figure. Comparison of **OBS**, ECMWF, HIRLAM 16, HIRLAM 5 and HARM 2.5. The errors are large in timing and estimation of the maxima. HARM 2.5 gives somewhat better results but it's also not able to reproduce the local scale.



Evolution of 10m wind during the period for the station numbered in the upper figure. Comparison of **OBS**., HIRLAM 16, HIRLAM 5 and HARM 2.5 forecast (H+36). Models reproduce well the general evolution although can't reproduce some of the peaks. Model 10m wind underestimate significantly (not shown) the wind at Izaña (3400m). In general HARM clearly improves HIRLAM.

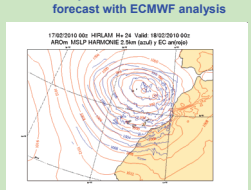
A large extratropical low producing very strong winds over the Canary Islands

- A large extratropical low with explosive cyclogenesis moved Southward producing organized heavy precipitation and very strong winds.
- During a period of three days several cloud bands crossed the Canary Islands. When the low approached the Islands it produced very strong winds.

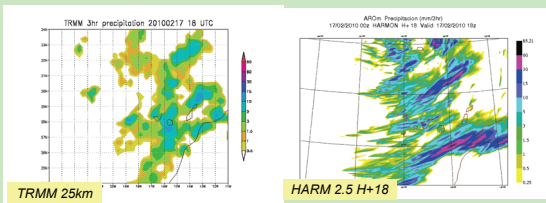


The maximum winds started the 17th around 18 UTC when the center of the low was close to the Islands and several cloud bands with strong low level jets associated with them swept the Islands. The 18th, convection in the cold core is not organized and the wind rolled W but is still very strong.

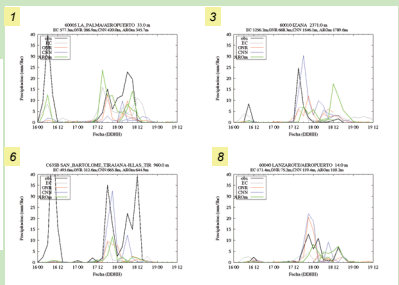
Comparison of HARM H+24 forecast with ECMWF analysis



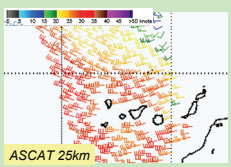
The system seems to be too large for the model domain. Forecast differ from the analysis in the gradient and the secondary low.

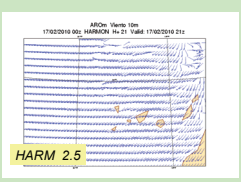


Accumulated precipitation for the 17th, 15-18 UTC. Precipitation systems are larger in this case so explicit treatment of the clouds works better . HARM 2.5 represents the band patterns (see also satellite image) although no the spatial and temporal details.

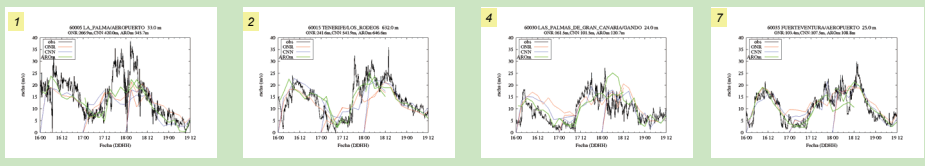


Evolution of the 3h acc. precip. The amounts are smaller in this period and in general are better represented by the models. The timing is much better but in some locations the substemation is large.

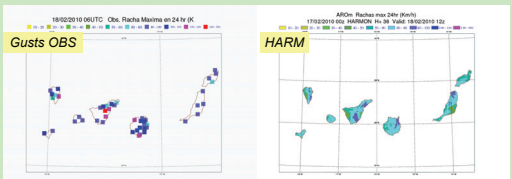




ASCAT 10m wind 17, 22:45 and HARM H+21 valid 21:00. De comparison is not straight forward due to the different resolutions. The model reproduces the synoptic scale and the intensity. There are some small scale circulations associated with the convection that are probably too strong.



Evolution of 10m wind gust during the period of three days. Comparison of **OBS**., HIRLAM 16, HIRLAM 5 and HARM 2.5 forecast (H+36). Models reproduce well the gust evolution with HARM giving the smaller errors.



Maximum gusts in 24 hr from the 17th, 06:00. The distribution of the maximum gusts is related to the orography and is qualitatively well reproduced by the model although its intensity is underestimated.

Conclusions

- We analyze two cases of heavy precipitation and strong winds in a subtropical environment (Canary Islands). One of the cases is an hybrid tropical-extratropical system and the other one a large extratropical low with explosive cyclogenesis.
- We have analyzed the performance of the AEMET operational models: ECMWF (16 km), HIRLAM (16 and 5 km) and the experimental model HARMONIE (2.5 km). We have run HARMONIE v36h1 in AROME configuration for two 3 day periods of heavy precipitation and strong winds. HARMONIE 2.5 km resolution is directly coupled to ECMWF model (16 km).
- The general evolution, the large scale and the mesoscale are well represented by the model but not the fine scale. The model is not able to predict the maximum values of 250 and 200 mm/day associated with small scale convective systems. The model captures the enhancement of precipitation by the orography but misses other local effects.
- The evolution of the wind is very well represented by the models but not the peeks, probably associated with the convective bands, which are clearly underestimated.
- The overall conclusion is that HARMONIE is able to add value to ECMWF and HIRLAM model .
- Results suggest how this high resolution model simulations can be used: Mesoscale features are realistic and the model is able to suggest the occurrence of heavy precipitation and very strong winds with some uncertainty in the location and timing of the events. It seems that still is room for forecasters to improve this very high resolution model output.

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