Analysis of several subtropical cyclones by means of the high resolution HARMONIE-AROME model

Lara Quitián-Hernández[1], María Luisa Martín[2], Daniel Santos-Muñoz[3], Juan Jesús González-Alemán[4], Sergio Fernández-González[3], Javier Díaz Fernández[1], Pedro Bolgiani[1], Mariano Sastre[1] and Francisco Valero Rodríguez[1]

[1]Dpt. of Astrophysics and Atmospheric Science. Faculty of Physics. Complutense University of Madrid, Ciudad Universitaria s/n. 28040 Madrid. Spain.
[2]Dpt. of Applied Mathematics. Faculty of Computer Engineering. University of Valladolid, Plza. de la Universidad, 1. 40005 Segovia. Spain.
[3]State Meteorological Agency (AEMET), Leonardo Prieto Castro, 8. 28040 Madrid. Spain.
[4]Enviromental Science Institute. University of Castilla-La Mancha, Avda. Carlos III s/n. 45071 Toledo. Spain.
L. Quitián-Hernández email: lquitian@ucm.es

Introduction and motivation

Subtropical Cyclones (STCs) are characterized by a hybrid structure sharing **tropical and extratropical features**[3]. The impacts of this kind of atmospheric systems are similar to the generated by tropical storms of even hurricanes, leading to widespread social damage and great economic losses. Carrying out accurate simulations becomes key for a forecast improvement of these extreme events.

In the current work, several STCs that occurred over the North Atlantic Ocean and experimented a transition into tropical storms (Delta, 2005) or even hurricanes (Vince, 2005 and Ophelia, 2017) are assessed by means of the **high-resolution HARMONIE-AROME model.**

The HARMONIE-AROME model

This model is developed and operated at **2.5 km resolution** through the collaboration of the **10 European National Meteorological Services** (NMS) that are part of the international research program **HIRLAM**, together with the **16 countries** that comprise the **ALADIN** consortium.

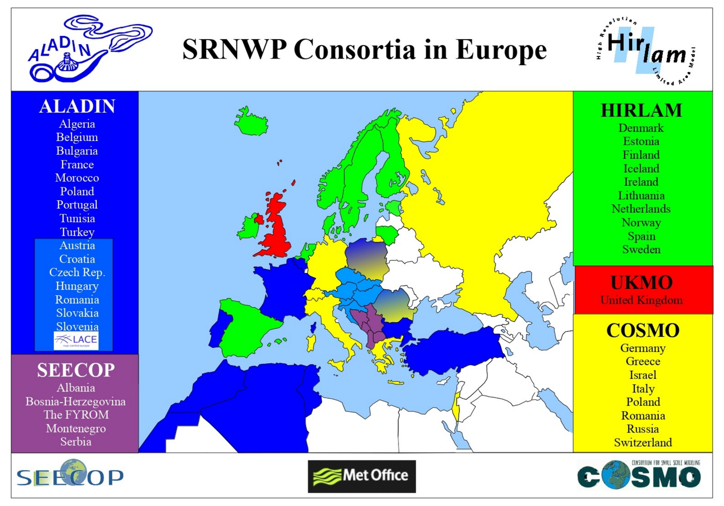

Figure 1. Short Range Numerical Weather Prediction (SRNWP) Network

The **HARMONIE-AROME model** has a **convection-permitting configuration** and uses a **non-hydrostatic spectral dynamical core** with a **semi-Lagrangian and semi-implicit discretization of the equations**. In this way, more realistic results are obtained, which allows providing an added value to the study of tropical transitions.

This model comprises a **data assimilation system** which substantially **improves the quality of the forecasts**, since it allows to evaluate the future state of the atmosphere starting from the best possible initial state.

Global Forecast System (GFS) vs Integrated Forecast System (IFS) vs HARMONIE-AROME model

Tabla 1: FV3-GFS vs ECMWF-IFS vs HARMONIE-AROME model configuration

		Dynamical Core	Assimilation Algorithm	Resolution	Initialization Freq.
GLOBAL	**FV3-GFS**	Non-Hydrostatic Spectral Finite Volume (FV)	Hybrid 4D Ensemble-Var 0.875/0.125 (3-hr window)	Horizontal: 13 km Vertical levels: 64 Time step: 225 s	6 hr (cycled)
GLOBAL	**ECMWF-IFS**	Hydrostatic Spectral Semi-Lagrangian (SL) and Semi-Implicit (SI)	4DVar (12-hr window)	Horizontal: 9/16 km Vertical levels: 137 Time step: 450 s	12 hr (cycled)
LAM	**HARMONIE-AROME**	**Convection-Permitting Non-Hydrostatic Spectral Semi-Lagrangian (SL) and Semi-Implicit (SI)**	**3DVAR (1-hr window)**	**Horizontal: 2.5 km Vertical levels: 65 (12m-10hPa) Time step: 75 s**	**3 hr (cycled)**

Results

Ophelia STC stage: 07 Oct, 2017 at 1200 UTC

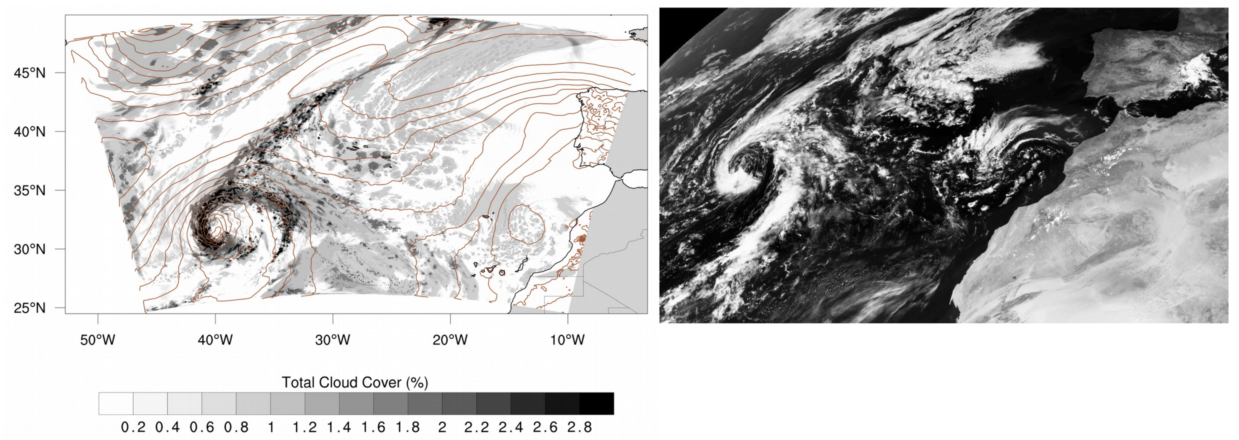

Figure 2. (a) HARMONIE-AROME model Total Cloud Cover (%). (b) Meteosat SEVIRI for VIS channel for hurricane Ophelia at its STC stage (1200UTC). (Source: Dundee Satellite Receiving Station).

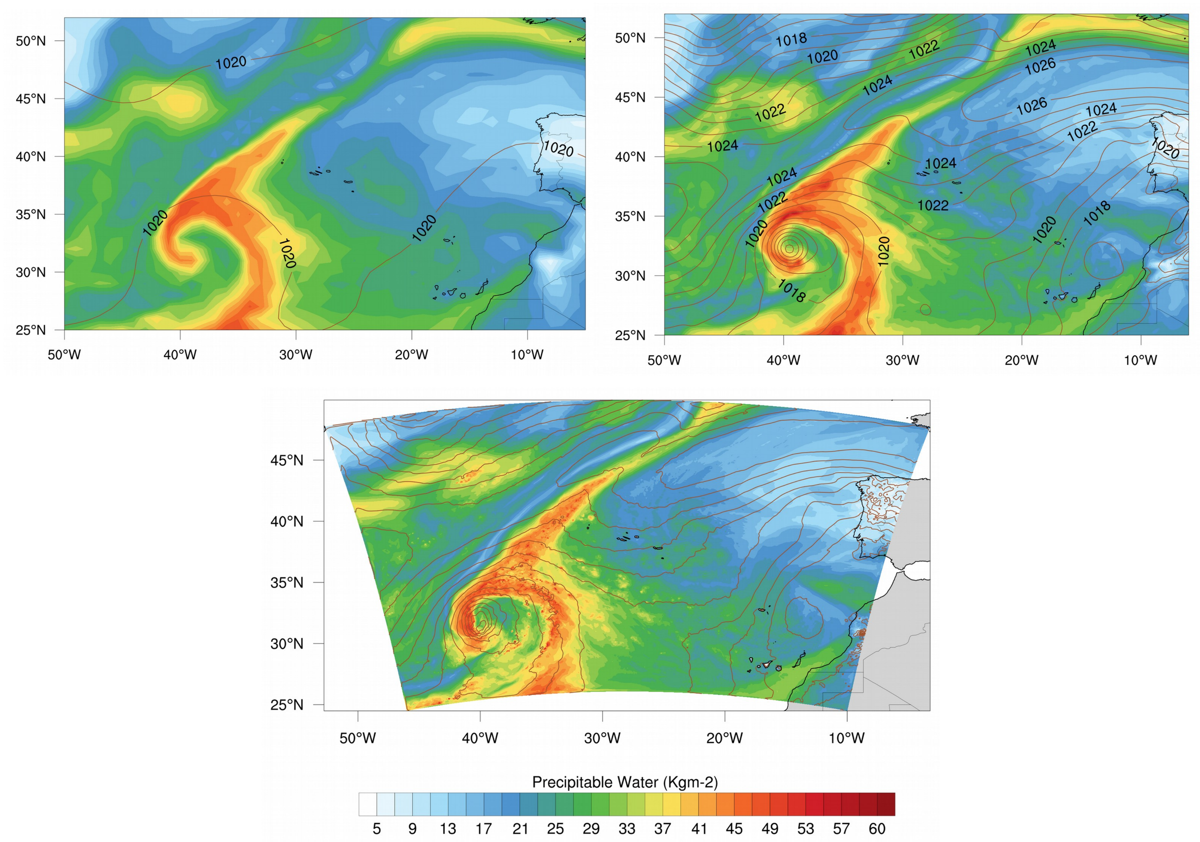

Figure 4. (a) GFS, (b) ECMWF-IFS and (c) HARMONIE-AROME model Precipitable Water (Kgm^{-2}) simulation for hurricane Ophelia at its STC stage (1200UTC).

Delta STC stage: 22 Nov, 2005 at 1800 UTC

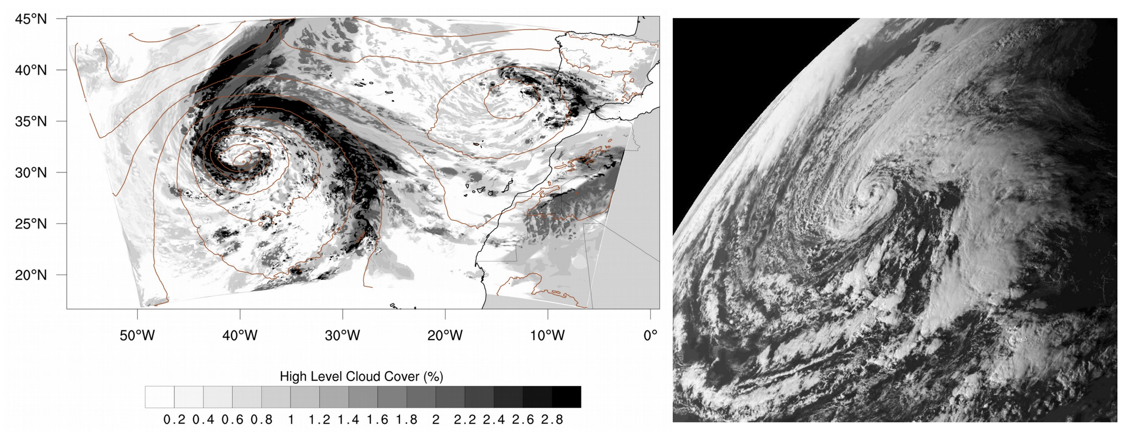

Figure 3. (a) HARMONIE-AROME model Total Cloud Cover (%). (b) Meteosat SEVIRI for VIS channel for hurricane Delta at its STC stage (1800UTC). (Source: Dundee Satellite Receiving Station).

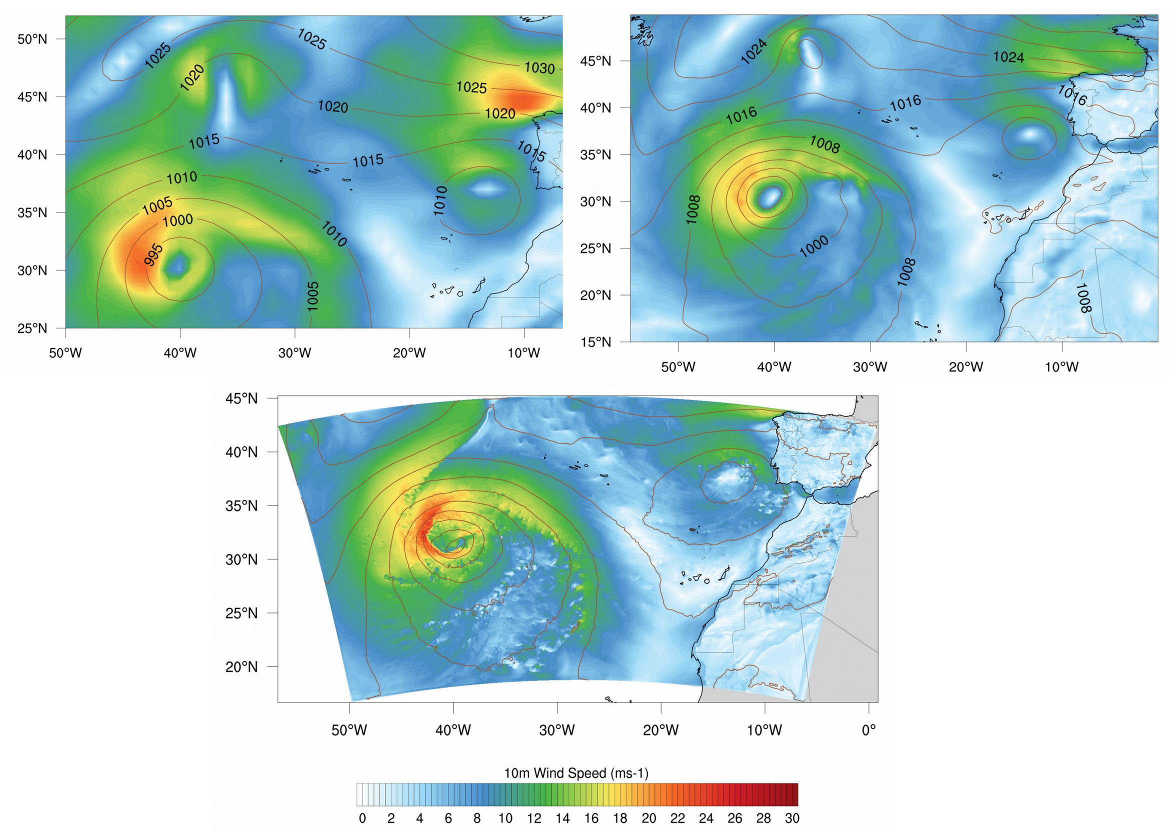

Figure 5. (a) GFS, (b) ECMWF-IFS and (c) HARMONIE-AROME model Wind Speed (ms^{-1}) simulation for hurricane Delta at its STC stage (1800UTC).

Conclusions

- HARMONIE-AROME is the high-resolution operational Limited Area Model (LAM) of the HIRLAM and ALADIN consortia.
- Is a semi-Implicit (SL), semi-Lagrangian (SL), non-hydrostatic model which explicitly resolve the convection (convection-permitting).
- It has a 2.5 km horizontal resolution with 65 hybrid vertical levels and a model time-step of 75 s.
- It is stressed the good results in the prediction of convection and extreme rainfall events (included electric shocks and hail), wind speed and 2m temperature.[1]

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Acknowledgments

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