SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2020
Project Title:	NUMERICAL SIMULATION OF MOUNTAIN WAVES AND ICING CONDITIONS IN THE IBERIAN PENINSULA
Computer Project Account:	……SPESVALE……
Principal Investigator(s):	FRANCISCO VALERO
Affiliation:	FACULTAD DE FÍSICA. UNIVERSIDAD COMPLUTENTE DE MADRID
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……
	……
Start date of the project:	01/01/2020
Expected end date:	31/12/2020

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			300000	1600
Data storage capacity	(Gbytes)			10000	320

Summary of project objectives (10 lines max)

During this year both Harmonie and WRF have been implemented in ECMWF in order to simulate some mountain wave and icing episodes and compare differences between both kind of simulations, proposing finally the optimum model to diagnose and forecast these events.
According with the purposes of this special project, the main objectives can summarized as follow:

- High-resolution simulations of 20 mountain wave episodes in the Iberian Peninsula have been obtained with the WRF model using different physical schemes.
- The high-resolution simulations will be analysed from both deterministic and probabilistic point of view, taking the requirement of ensemble into account.
- Analysis of those synoptic environments and mesoscale factors related to mountain waves and icing conditions in the Iberian Peninsula.

Summary of problems encountered (10 lines max)

The team has implemented the Harmonie and the WRF models. Some episodes have been simulated with Harmonie and WRF but we have some errors. In particular, we have some problems in the Harmonie suite due to the use of ecFlow in ECMWF's virtual servers. WRF model is also unreliable to produce regular simulations. Now the Harmonie problems has been fixed by HIRLAM community and the WRF ones are under investigation.
Currently we have simulated 20 mountain wave episodes with WRF and the key variables in the formation of mountain waves and icing conditions are been analysed. Next, we will run more than 70 mountain wave episodes (from a total of 300) with WRF and our purpose is doing the same with Harmonie.

Summary of plans for the continuation of the project (10 lines max)

- The episodes of mountain waves and icing conditions, mentioned in the original request, will be simulated with both Harmonie and WRF.
- The simulated variables, key in the development of mountain waves and icing conditions, will be analysed and the similitude and differences between the outputs obtained from Harmonie and WRF will be studied.
- We proposed some *warnings* for area near to airports for presence of mountain waves and icing conditions since events of mountain waves with possible icing episodes are very dangerous for aircrafts.

List of publications/reports from the project with complete references

Bolgiani, P., Fernández-González, S., Valero, F., Merino, A., García-Ortega, E., Sánchez, J., Martín, M. (2018). Numerical Simulation of a Heavy Precipitation Event in the Vicinity of Madrid-Barajas International Airport: Sensitivity to Initial Conditions, Domain Resolution, and Microphysics Parameterizations. Atmosphere, 9(9), 329.

L.Quitián-Hernández, S.Fernández-González, J.J.González-Alemán, F.Valero, M.L.Martín (2018): Analysis of sensitivity to different parameterization schemes for a subtropical cyclone. Atmospheric Research, 204, 21-36.

S. Fernández-González, M. Sastre, F. Valero, A. Merino, E. García-Ortega, J. L. Sánchez, J. Lorenzana, M. L. Martín (2019): Characterization of Spread in a Mesoscale Ensemble Prediction System: Multiphysics versus Initial Conditions. Meteorologische Zeitschrift, 28 (1), 59 – 67. DOI: 10.1127/metz/2018/0918

A. Manzano, M. A. Clemente, A. Morata, M. Y. Luna, S. Beguería, S. M. Vicente-Serrano, M. L. Martín (2019): Analysis of the atmospheric circulation pattern effects over SPEI drought index in Spain. Atmospheric Research, 230.https://doi.org/10.1016/j.atmosres.2019.104630

A. Merino, E. García-Ortega, S. Fernández-González, J. Díaz-Fernández, L. Quitián-Hernández, M.L. Martín, L. López, J.L. Marcos, F. Valero, J.L. Sánchez (2019): Aircraft icing: in-cloud measurements and sensitivity to physical parameterizations. Geophysical Research Letters. https://doi.org/10.1029/2019GL084424.

Díaz-Fernández, J. (2019): Modelización de ondas de montaña en las proximidades del aeropuerto Adolfo Suarez Madrid-Barajas. Seminario Final de la Red Temática Winter Precipitation and Strong Winds: Observational Studies (WiPSWis) (CGL2016-81828-REDT/AEI). Oral Presentation: Madrid, 8 marzo 2019.

Díaz-Fernández, J., Quitián Hernández, L., Santos-Muñoz, D., Fernández-González, S., Valero, F., Merino, A., García-Ortega, E., Sánchez, J. L., Sastre, M. and Martín, M. L. (2019). Poster: Mountain wave episodes using the high-resolution HARMONIE-AROME model in Spain. Congress of American Geophysical Union (AGU). General Assembly Conference. Poster. San Francisco, 7-11 December 2019.

Lara Quitián Hernández, Daniel Santos-Muñoz, Juan Jesús González Alemán, Javier Diaz-Fernandez, Sergio Fernández-González, Pedro Bolgiani, Mariano Sastre, Francisco Valero, Maria Luisa Martin (2019): Analysis Of Several Subtropical Cyclones By Means Of The High-Resolution HARMONIE-AROME Model. Congress of American Geophysical Union (AGU). General Assembly Conference. Poster. San Francisco, 7-11 December 2019.

Bolgiani, P., Fernández-González, S., Valero, F., Merino, A., García-Ortega, E., Sánchez, J. L., Martín, M. L. (2020). Simulation of Atmospheric Microbursts Using a Numerical Mesoscale Model at High Spatiotemporal Resolution. Journal of Geophysical Research: Atmospheres, 125(4), 1–23.

Quitián-Hernández, L., J. J. González-Alemán, D. Santos-Muñoz, S. Fernández-González, F. Valero, M. L. Martín (2020): "A subtropical cyclone formation via warm seclusion development: The importance of surface fluxes". *Journal of Geophysical Research: Atmosphere* (accepted). https://doi.org/10.1029/2019JD031526.

Díaz-Fernández, J., Quitián Hernández, L., Santos-Muñoz, D., García-Gago, A., Bolgiani, P., Fernández-González, S., Valero, F., Merino, A., García-Ortega, E., Sánchez, J. L., Sastre, M. and Martín, M. L. (2020). Mountain waves analysis in the vicinity of the Madrid-Barajas airport using the WRF model. Under review.

Bolgiani, P., Santos-Muñoz, D., Fernández-González, S., Sastre, M., Valero, F., Martín, M. L. (2020). Microburst Detection with the WRF Model: Effective Resolution and Forecasting Indices. Under review.

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

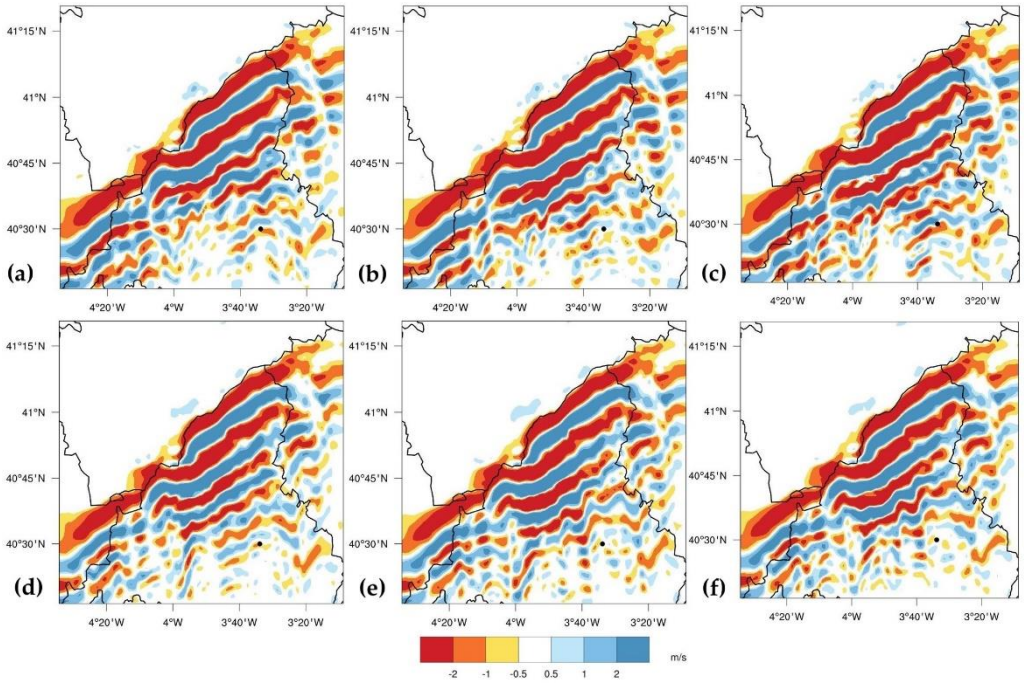
The team involved in this special project is the same research team of the special project SPESMART. In both projects one of the purposes is to implement both WRF and Harmonie in order to simulated different events. In the SPESVALE, both models will simulate selected episodes of mountain waves with possibility of icing conditions.

The Harmonie model has been implemented in order to simulate mountain wave episodes and icing conditions (detailed in the original request). However, some problems were found in the suite when the model is running at 1 x 1 km. Moreover, we had some problems in compiling WRF model that were finally fixed.

Throughout the last year, both Harmonie and WRF models were properly compiled and some episodes of mountain waves and icing conditions were simulated. In particular, we are focused on the Guadarrama Mountain area because it is near the Barajas International airport. In this area, we have identified several mountain wave episodes with MSG images that affect the aircrafts landing.

During this year, 20 mountain wave episodes and icing conditions in the vicinity of Bajaras International Airport were simulated with the WRF model. These episodes were identified and selected with MSG images. Next, such episodes will be simulated with Harmonie although some of them are being simulated with the Harmonie model.

On Figure 1 the episode on 26 January 2018 is shown. This episode was simulated using WRF and vertical motions, LWC and IWC crossections and LWC distributions are analysed. Six parameterizations are used. The domain is located in the inner of Iberian Peninsula; in particular, near the Guadarrama Mountains near the Barajas International Airport of Madrid.



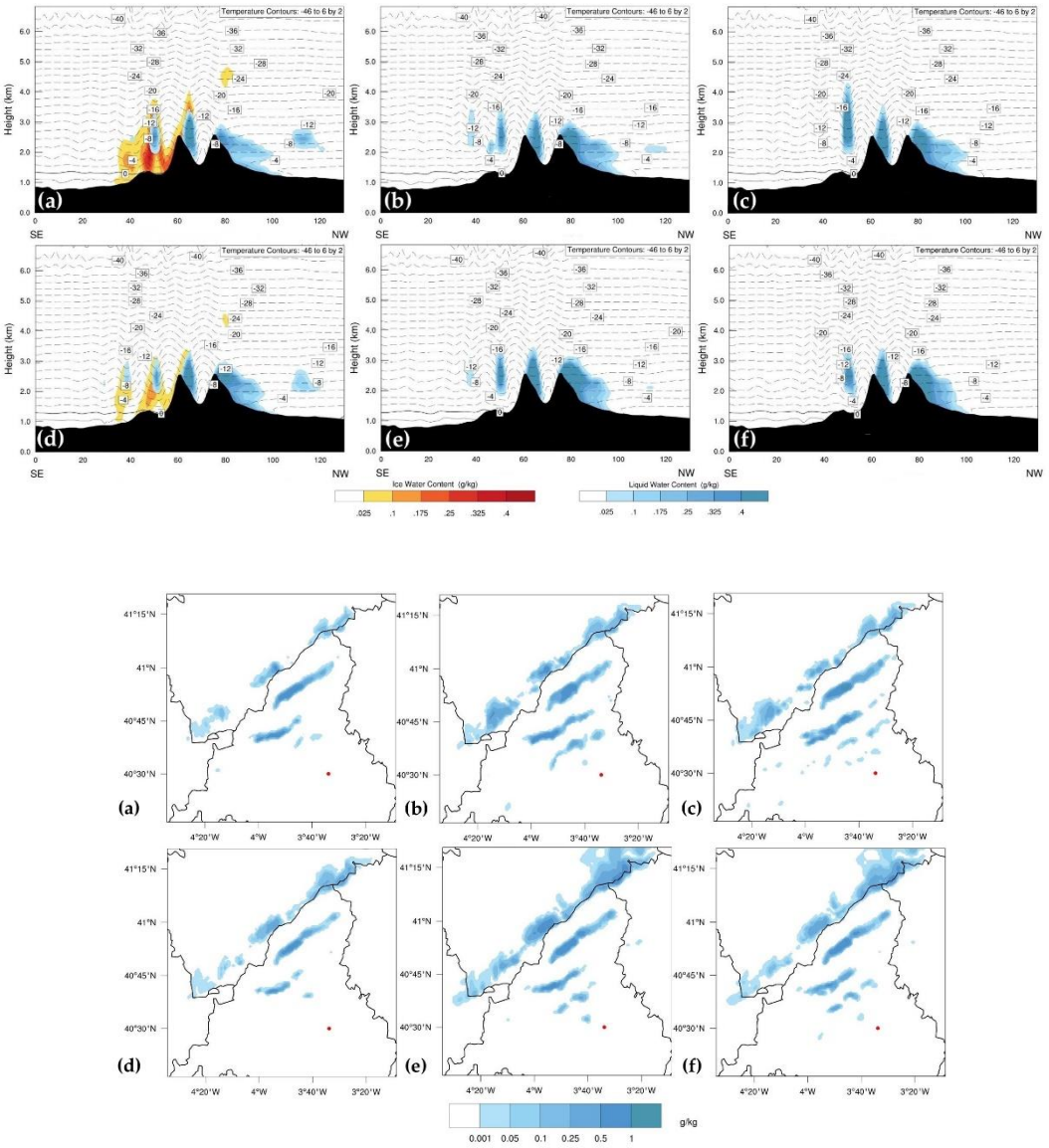
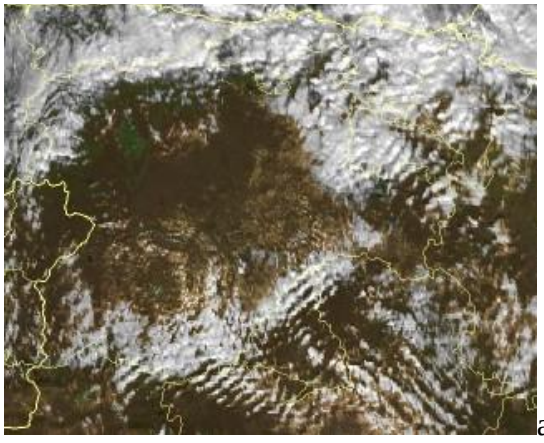
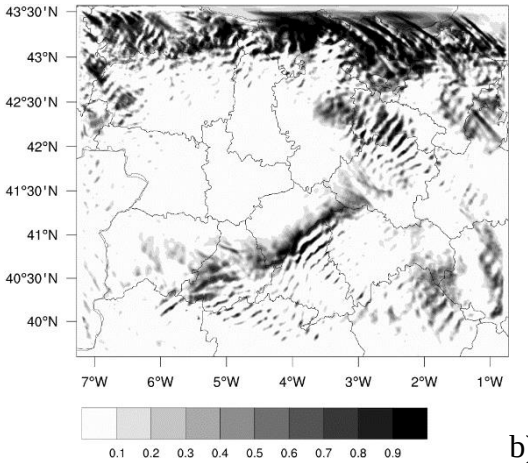


Figure 1: WRF simulations of vertical motion, LWC and IWC crossections and LWC distributions on 26 January 2018.

For example, the episode of mountain wave on 26 November 2018 was simulated using the Harmonie model. The HRVIS MSG image, pseudoimage satellite visible channel MSG and total cloud cover are depicted in Figure 2.



a)



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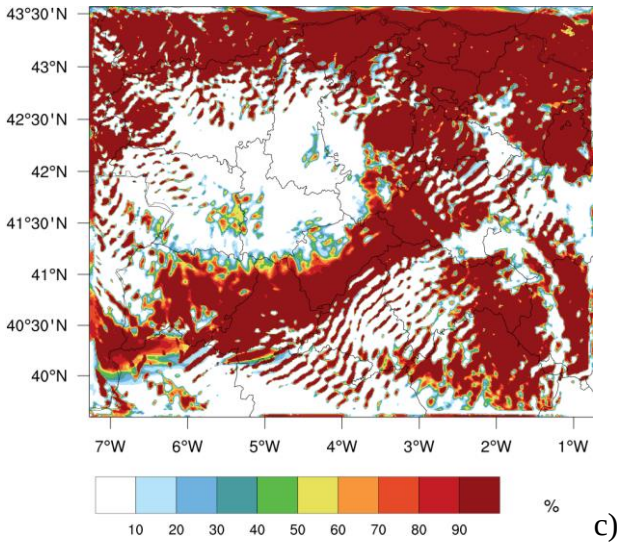

Figure 2: HRVIS MSG image (a), pseudoimage satellite visible channel MSG and total cloud cover simulated by Harmonie on 26 November 2018.

Oh the other hand, almost 300 mountain wave episodes have been identified via MSG images from 2000 to 2020. From those, over 70 have been selected as the most suitable episodes to be simulated with both Harmonie and WRF. The next step will be to simulated these 70 episodes and once such episodes are simulated with both models, Harmonie and WRF, differences and similitudes between key simulated variables in windward and leeward of the mountain near the Barajas Airport will be analyzed focusing on provide some mountain waves and icing conditions warning procedure to pilots.