REQUEST FOR AN EMI R&D PROJECT 2027–2029

Country/Organisation: SPAIN

Principal Investigator[1]: MARIA A. JIMENEZ

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Other researchers: ALEX SERRA NIETO

Project Title: STUDY OF THE PHYSICAL MECHANISMS UNDER SEA BREEZE CONDITIONS IN COMPLEX TERRAIN REGIONS

To make changes to an existing project please submit an amended version of the original form

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPESTURB**	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2027	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for project year:		**2027**	**2028**	**2029**
High Performance Computing Facility	[SBU]	5,000,000	5,000,000	5,000,000
Graphics Processing Unit Cluster-A	[GBU]			
Graphics Processing Unit Cluster-B	[GBU]			
Accumulated data storage (total archive volume)[2]	[GB]	500	500	500

[1] The Principal Investigator will act as contact person for this EMI R&D Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.
[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

EWC resources required for project year:		**2027**	**2028**	**2029**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

Continue overleaf.

Principal Investigator: Maria A. Jiménez

Project Title: Study of the physical mechanisms under sea breeze conditions in complex terrain regions

Extended abstract

All EMI R&D Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

Following submission by the relevant Member State the EMI R&D Project requests will be published on the ECMWF website and evaluated by ECMWF and its Scientific Advisory Committee. The requests are evaluated based on their scientific and technical quality, and the justification of the resources requested. Previous EMI R&D Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests exceeding 5,000,000 SBU should be more detailed (3-5 pages).

Studies on the **organization of low-level flow in complex terrain regions** are conducted by our group through a combined approach that integrates **experimental observations**—often obtained from field campaigns that we either organize ourselves or participate in with our own instrumentation—and **numerical modelling**, including mesoscale and one-dimensional simulations. The primary source of computational resources for very high-resolution simulations has been the SPESTURB special project at ECMWF. We have been using ECMWF facilities since 2002, with additional support from the Spanish Meteorological Agency (AEMET), which has provided extra resources whenever required and available.

Mesoscale simulations are performed using the **MesoNH model**, typically with two or three nested domains. The outer domain usually has a horizontal resolution on the order of one kilometre, while the inner domains reach resolutions of a few hundred meters. Moreover, the horizontal extent of the domains is often large enough to encompass the entire basin or island, ensuring that flows at this spatial scale are adequately captured. These **simulations are computationally demanding** due to the very high vertical resolution—about 3 m near the surface—required to accurately represent observed features of the lower atmospheric boundary layer. Simulation periods generally span 48–60 hours, allowing for the representation of a complete diurnal cycle of the processes under study, beyond the model spin-up phase.

In the first special projects, we mostly concentrated on flows in the stable boundary layer over land, introducing progressively complex terrain and morning and evening transitions for a better understanding of the physical mechanisms observed in experimental field campaigns. In the more recent special projects, the effect of surface heterogeneities is explored to better understand observations in the surface layer, the bottom boundary condition for the atmospheric component of numerical weather models.

Special projects in the past has allowed us to increase the knowledge of the nocturnal flows at the foothills of the Pyrenees during the Boundary-Layer Late Afternoon and Sunset Turbulence (**BLLAST**, summer 2011) experimental field campaign (Jiménez et al 2014 and 2019) or during the Cerdanya Cold Pool Experiment during autumn 2015 and winter 2017 (**CCP'15** and **CCP'17**: Conangla et al, 2017). Simulations have been used to study the interactions between downslope and down-valley winds, influenced by mesoscale and synoptic conditions, the formation of an exit valley jet and the cold air pooling in the bottom parts of the basins.

During the last special projects, the attention was focused in the **eastern Ebro subbasin** where an experimental field campaign was made in July 2021 (Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment, **LIAISE**, Boone et al, 2025). This campaign is a combined effort of MeteoFrance, the UK Met-office and different research centres and universities from Spain. The study area is a large irrigated region in a semi-arid environment, surrounded by rainfed slopes with strong thermal and topographic influences. Multiple measurement techniques were used, including aircraft, soundings, surface stations, and remote sensing instruments. A **mesoscale model intercomparison** (MesoNH, UM, WRF; Jiménez et al, 2025) leaded by the IP of this special project was made to assess how well these models reproduce the physical mechanisms present when the sea breeze generated at the coast (commonly known as *Marinada*; Jiménez et al, 2023) reaches the site.

Numerical studies related to the organization of the flow at lower levels under **sea breeze conditions in the island of Mallorca** have been continuously made (Cuxart et al, 2014; Jiménez et al, 2016). Simulations have shown that the initiation/decaying and the propagation of the sea breeze front inland depend not only on the topographical features of the basin but also on the larger-scale circulations. In the latest special project, simulations were used to accurately characterise the convergence zone in the centre of the island, which was generated by the interaction of sea breeze fronts in the three main basins (Serra et al, 2026).

In the framework of the research project ***Improving the understanding and prediction of sea BReezes and their effects on the meteorologIcal conditions of complex Semi-Arid regions (BRISA)*** funded by the Spanish Ministry of Science, two experimental field campaigns will be organized during summer 2026 and 2027 in Cadiz (south of the Iberian Peninsula) and Mallorca, respectively. We plan to organize measurements in the vertical (soundings, tethered balloons and WindRass, among others) and in the horizontal (surface weather stations and surface energy balance stations along the coast and inland), that will be complemented by satellite-derived surface temperature fields from MODIS, Meteosat, ASTER or Landsat. Observations will cover the warm months of the year (from March to October) but some of the equipment will remain for three years. Intensive Observational Periods (IOPs) are expected during 15 days in July 2026 and 2027 with measurements over land and sea.

The **aim of the proposed special project** is to perform simulations of the IOPs that will be reported during the BRISA campaigns in Cadiz and Mallorca. A combined inspection of the simulations and the observations of the campaigns that we have organized/participated will be used to increase the current knowledge of the surface-atmosphere interface under sea breeze conditions in complex terrain regions. Particularly, simulations will be crucial to understand how the surface heterogeneities (related to the topography but also to the soil cover) modify the sea breeze front propagation. Besides, we will evaluate the importance of the synoptical winds in the sea breeze initiation and its mature phase and its dependence of the convergence zone features (location and intensity).

Regarding the **eastern Ebro river subbasin**, a 2nd mesoscale intercomparison is under construction and co-leaded by the IP of the current special project (the case will be launched by the end of 2026). The simulated event is based on observations of a *Marinada* during the LIAISE experimental field campaign. Results from Lunel et al (2024) and Jiménez et al (2025) emphasise the importance of accurately representing surface features (it is an irrigated region attached to rainfed slopes) in order to realistically reproduce the characteristics of the sea breeze when it reaches the site. Consequently, irrigation will be activated in the simulations to further explore its impact on the organisation of the flow at lower levels.

To conclude, mesoscale simulations performed in the framework of this special project will be crucial to further understand the physical mechanisms that take place under sea breeze conditions in complex terrain regions. Following this, we will explore if they are also statistically represented in coarser resolution databases (such as CERRA and CORDEX) as it is made in Serra et al (2026) for the sea breeze in the Palma basin.