REQUEST FOR A SPECIAL PROJECT 2024–2026

MEMBER STATE: SPAIN

Principal Investigator[1]: MARIA A. JIMÉNEZ

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Project Title: PHYSICAL MECHANISM AT A BASIN SCALE IN COMPLEX TERRAIN REGIONS: PERSISTENT FOG AND SEA-BREEZE FRONT PROPAGATION

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.	**SP** ESTURB	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2024	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for project year:		**2024**	**2025**	**2026**
High Performance Computing Facility	[SBU]	5,000,000	5,000,000	5,000,000
Accumulated data storage (total archive volume)[2]	[GB]	250	500	500

EWC resources required for project year:		**2024**	**2025**	**2026**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

Continue overleaf.

[1] The Principal Investigator will act as contact person for this Special 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.

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Extended abstract

All Special 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 Special 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 Special 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 related to the organization of the flow at lower levels in complex terrain regions are made by our group through the **combined use of experimental data** (very often from campaigns that we organize or where we participate with our own instrumentation) **and numerical modelling** (mesoscale and 1D simulations). The principal source of computing time for the very high-resolution simulations has been so far the **SPESTURB** project at ECMWF. We have been using the resources of the ECMWF since 2002 with full satisfaction and with the support of the Spanish Meteorological Agency (AEMET), that has provided extra resources if needed and available.

Mesoscale simulations are done with the **MesoNH model**, and usually with 2 or 3 nested domains: the outer one with horizontal resolutions of the order of a kilometre and the inner ones of a few hundreds of meters. These runs are computationally expensive since the vertical resolution is very high (3m close to the surface) to properly capture the observed features of the lower atmospheric boundary layer. Besides, horizontal domains are often large to cover the whole basin/island in order to include the winds at the basin/island scale. Typically, the simulated period is about 48-60 hours to have the complete diurnal cycle of the processes studied beyond the spinup of the run.

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.

Simulations of the previous special projects are made at the north side of the Pyrenees based on observations of the **BLLAST** experimental field campaign. Results have shown that at night-time with clear skies at the foothills of the Pyrenees downslope winds interact with downvalley winds, whose duration and intensity depend on the meso/synoptical winds (Jiménez et al, 2014). Besides, the physical mechanisms that take place in the formation of the exit valley jet are analysed (Jiménez et al, 2019). Simulations performed at the south side of the Pyrenees were based on observations of the Cerdanya Cold Pool Experiment during autumn 2015 and winter 2017 (**CCP´15** and **CCP´17**, Conangla et al, 2017). From the runs it is possible to characterize the cold pool formation at the center of the basin and its dependency (depth, horizontal extension and temporal scales) on the surface heterogeneities (in some runs, snow was also taken into account).

In the last special project, 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**, https://www.hymex.org/?page=liaise). This campaign is a combined effort of MeteoFrance, the UK Met-office and different research centres and universities from Spain. The measurement area is a large irrigated area in a semi-arid environment surrounded by rainfed sloping terrain, with well-defined thermal or topographical forcings. Several measurement techniques were used to measure the surface-atmosphere forcings, including instrumented aircraft, radiosondes and tethered-balloon soundings, a network of surface energy budget stations in the irrigated and rainfed areas, and diverse in-situ remote-sensing equipments (WindRASS, Raman Lidar, UHF radar...). Besides, measurements at the bottom parts of the basin are still made to better characterize the effect of the surface heterogeneities in the organization of the flow at lower levels, the cold pool features and the fog events. It is important to mention that an intercomparison of models (MesoNH, UM, WRF) leaded by the IP of this special project is made to evaluate how models reproduce the physical mechanisms that take place at this site.

Numerical studies related to the organization of the flow at lower levels in the **island of Mallorca** have been continuously made (Cuxart et al, 2014; Jiménez et al, 2016) and during the last special project the attention was focused on the sea-breeze conditions. Simulations have shown how the initiation/decaying and the propagation of the sea breeze front inland depends on the topographical features of the basin but also on the larger-scale circulations. The simulation strategy has been changed and runs over the island are made taking 3 domains with horizontal resolutions at 5km (covering the Balearic Islands), 1km (over the Mallorca island) and 250m (centered over one of the studied basin). These runs are computationally more expensive but resolutions of 250m (or even less) are needed to properly characterize the propagation of the sea breeze front. We are still analysing these results in the framework of the current special project.

The **aim of the proposed special project** is a continuation of the current one since the studied regions are the eastern Ebro river subbasin and the island of Mallorca. With the proposed new special project, a combined inspection of the simulations based on the observations of campaigns that we have organized/participated will be used to increase the current knowledge of the surface-atmosphere interface in complex terrain regions.

Regarding the **eastern Ebro river subbasin**, a combined inspection of in situ observations and simulations will be made to better understand the physical mechanisms that take place during fog events, that are very frequent in the region and particularly they can remain for several days (Cuxart et al, 2012). Also, the attention will be focused on the colder pooling within the basin and on the propagation of the sea-breeze front (*Marinada*, Jiménez et al., 2023), as a continuation of the current special project. Simulated cases will be based on the observations that started after the LIAISE campaign and that they are still taken at the site.

Simulations over the **island of Mallorca** will be made to further understand the interactions between the sea and land breezes with the locally-generated winds of lower scale and with the winds at a larger scale (interactions between the sea and land breezes generated at the three main basins). The simulated cases will be based on observations during the AGROWIND experimental field campaign (2021-2024). It consists in 4 measurements sites (temperature and humidity at 2 levels close to the surface and wind at about 3m) at the foothills of the Tramuntana mountain range that, together with the AEMET surface network of automatic weather stations, are used to evaluate the interaction of the sea/land breeze to other winds of smaller scale such as upslope/downslope winds but also to upvalley/downvalley circulations.

It is important to recall that all the mesoscale runs will be validated against surface observations (from AEMET and Servei Meteorològic de Catalunya networks) and through the observations taken during the campaigns (captive balloon, surface energy budget station, windRass, 50 m-tower densely instrumented, among others). Besides, modelled land-surface temperatures will be compared to those derived from satellite sensors (Meteosat, MODIS, Landsat, ASTER).