REQUEST FOR A SPECIAL PROJECT 2021–2023

MEMBER STATE: SPAIN

Principal Investigator[1]: MARIA A. JIMENEZ & JOAN CUXART

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Project Title: THE ROLE OF BASIN TOPOGRAPHY AND SURFACE HETEROGENEITIES IN THE ORGANIZATION OF THE FLOW AT LOW LEVELS

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.)	2021	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2021-2023: (To make changes to an existing project please submit an amended version of the original form.)		**2021**	**2022**	**2023**
High Performance Computing Facility	(SBU)	900,000	900,000	900,000
Accumulated data storage (total archive volume)[2]	(GB)	250	250	250

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.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

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.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific Advisory Committee. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and 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 asking for 1,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more might receive a detailed review by members of the Scientific Advisory Committee.

The analysis of atmospheric motions in complex terrain, in our case from the mesoalpha (large basins) to the microscale (tens of meters), is 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. 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.

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, thee 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. 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 or kilometer and the inner ones of a few hundreds of meters. These runs are expensive computationally since the vertical resolution is very high (3m close to the surface) to properly capture the observed features of the lower atmospheric boundary layer.

The attention is focused in two regions at the north and south sides of the Pyrenees to cover different degrees of topography and soil cover complexities. Simulations at the north side of the Pyrenees have been based on observations of the BLLAST experimental field campaign. Results have shown that at nighttime 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. 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). 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. Simulations have been made without snow, with the valley totally covered by fresh snow, and also a case of partial snow cover. Results have shown that the atmospheric boundary layer features depend on the surface cover and the cold pool is more intense and deep under no-snow conditions. Besides, the presence of snow also modifies the organization of the flow at lower levels in the basin. This work is still in progress, during that last year of the current special project.

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. The aim of the proposed special project is twofold.

Firstly, the attention will be focused in the eastern Ebro subbasin where during an experimental field campaign will be conducted (Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment, LIAISE, https://www.hymex.org/?page=liaise) will be made between April and October 2021 (reported one year due to the COVID-19 situation). This campaign is a combined effort of MeteoFrance, the UK Met-office and different research centers and universities from Spain. The co-IP (Cuxart) of the current special project is a member of the core group of LIAISE and the UIB team will contribute to the deployment of instrumentation. 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 will be 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...). The mesoscale simulations of this region for some selected Intensive Operational Periods will allow a better understanding of the organization of the flow at low levels and the contribution of the surface heterogeneities (related to the topography but also to the differences in the soil moisture and soil cover). A special attention will be given to the thermal gradient in the bottom of the basin (due to the differences in the soil moisture) and from the bottom parts and the mountains that close the basin. Besides, we will explore the influence of the Sea-Breeze generated at the coast to the E and SE, that overpasses the coastal range only in the warm summer months. The interaction of the sea breeze with the within-basin flows will be a major scientific objective of the project. In this sense, an intercomparison of models (MesoNH, UM, WRF, MOLOCH) leaded by the co-IP (Jiménez) of this special project has just started with the aim to evaluate how models reproduce the physical mechanisms that take place at this site.

Secondly, we will continue exploring the organization of the wind at low levels in the island of Mallorca under Sea-and Land-Breeze conditions. The processes that take place during the initiation and the mature phases of the Sea-Breeze in Mallorca were studied from observations and mesoscale simulations in previous special projects. Now the aim is to characterize the interactions between the Sea-Breeze and the upslope winds generated at the slopes that close the three main basins. To proceed, an experimental field campaign will start in autumn 2020 for almost 3 years to measure the surface-atmosphere forcings in the three main basins to complement the observations from the Spanish Meteorological Agency (AEMET). The combined inspection of the observations and some selected simulations will allow us to study the propagation of the Sea-Breeze front inland, its interaction with the locally-generated winds and the influence of the surface heterogeneities (topography, shape of the basin, soil features, etc). The morning and evening transitions and the nocturnal counterpart, the land-breeze circulation, with the interaction with the inland surface thermal inversions will also be explored.

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).