SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2018
Project Title:	Evaluation of coastal climate trends in the Mediterranean area by means of high-resolution and multi-model downscaling of ERA5 reanalysis
Computer Project Account:	SPITBRAN
Principal Investigator(s):	Carlo Brandini Valerio Capecchi Francesco Pasi Stefano Taddei
Affiliation:	LaMMA Consortium - Environmental Modelling and Monitoring Laboratory for Sustainable Development
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	01/01/2018
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)	/	/	3 000 000	92233 (June 2018)
Data storage capacity	(Gbytes)	/	/	1000	2628 (ECFS, June 2018)

Summary of project objectives

(10 lines max)

The aim of the project is to build a new climatic database of wind/wave regimes over the last 30-35 years (ie a hindcast), at high resolution along the coasts of the Mediterranean Sea. This will be achieved by using a cascade of state-of-the-art atmospheric and wave numerical models, forced by the best (in terms of model cycle, output temporal frequency and horizontal resolution) reanalysis data currently available (ERA5). This new climatic database can provide many important inputs for the Integrated Coastal Zone Management (ICZM), with a particular focus on the North-Western Mediterranean. This work will be partially connected with ongoing initiatives, such as the MAREGOT (www.lamma.rete.toscana.it/en/maregot) project, funded by the EU in the framework of the Italian-France Cross-border program, to which the LaMMA Consortium is involved as a partner. This project is aimed at identifying the best strategic actions for mitigating the impact of climate change along the coasts.

The availability of the ERA5 reanalysis dataset at a higher resolution with respect to past datasets, is believed to give much greater reliability to specific products for coastal areas. These final downscaled products can provide both a much more accurate assessment of the wave climate along the Mediterranean coastlines, and possibly validate climate projection models to be able to draw more robust statistically sound conclusions.

Summary of problems encountered (if any)

(20 lines max)

During the first year of the SPITBRAN Special Project, foreseen activities were:

1. extracting the ERA5 data (years 2008-2017) from the MARS archive to be used as initial and boundary conditions for the BOLAM+MOLOCH+WW3 numerical chain
2. installing the BOLAM+MOLOCH+WW3 models on cca
3. running the BOLAM+MOLOCH+WW3 numerical chain for the first 10 years (2008-2017)

Regarding point nr 3. above, we encountered some problems in initialising the BOLAM model with ERA5 data (on model levels) as initial and boundary conditions.

A first problem was encountered because the BOLAM model needs input data in grib2 format and thus a conversion is needed to convert ERA5 surface data from grib1 format to grib2. In particular, some problems were encountered when converting variables sea-ice cover and snow depth, which are mandatory for the BOLAM initialisation. Therefore, a pre-processing has been implemented to convert grib1 surface data using the grib_filter command with a specific rule regarding the localDefinitionNumber and parameterNumber.

A second problem was encountered in initialising the MOLOCH model with BOLAM simulation. Using the latest beta version of the MOLOCH model (released in June 2018), the procedure stops, producing anomalous sea-level pressure values. This error has been forwarded to the BOLAM/MOLCH developers for assistance.

Finally the data storage capacity requested in the SPITBRAN proposal was under-estimated to store the ERA5 for initialising the BOLAM model (actual disk space is about 2.6 TB). However, these data are going to be removed from the ECFS once the mesoscale simulations are performed.

Summary of results of the current year (from July of previous year to June of current year)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

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Regarding point nr 1. above, the activity was carried out by using a simple Bash script. To retrieve ERA5 data more efficiently, as suggested by the ECMWF User Support Section and as stated in the documentation
https://software.ecmwf.int/wiki/display/UDOC/Guidelines+to+write+efficient+MARS+requests, the script was modified to extract from the MARS archive one month per request.
A sample request is reported below:

```
retrieve,
  class=ea,
  dataset=era5,
  date=2014-08-01/to/2014-08-31,
  expver=1,
  levelist=1/to/137,
  levtype=ml,
  param=129/130/131/132/133/152,
  stream=oper,
  time=00:00:00/03:00:00/06:00:
  type=an,
  target="ERA5_ml_[dataDate]",
  grid=0.25/0.25,
  area=70.0/-50.0/20.0/60.0
```

Regarding point nr 2. above, the BOLAM and MOLOCH models (and pre/post processing utilities) were compiled on cca using the Intel Fortran compiler (version 17.0.3). The compilation relies on the NetCDF library (version 4.4.1) and the ecCodes tools (version 2.7.3). As far as we know this is the first time these two models are compiled on ECMWF supercomputer and with the ecCodes in place of the deprecated grib_api tools. The WW3 model will be compiled in a second moment before the end of the year.
Regarding point nr 3. above, the BOLAM and MOLOCH domains have been defined (see Figures 1 and 2 below). The number of grid points is 690X410 for the BOLAM grid and 498X626 for the MOLOCH grid. The number of vertical levels is 50 for both domains.

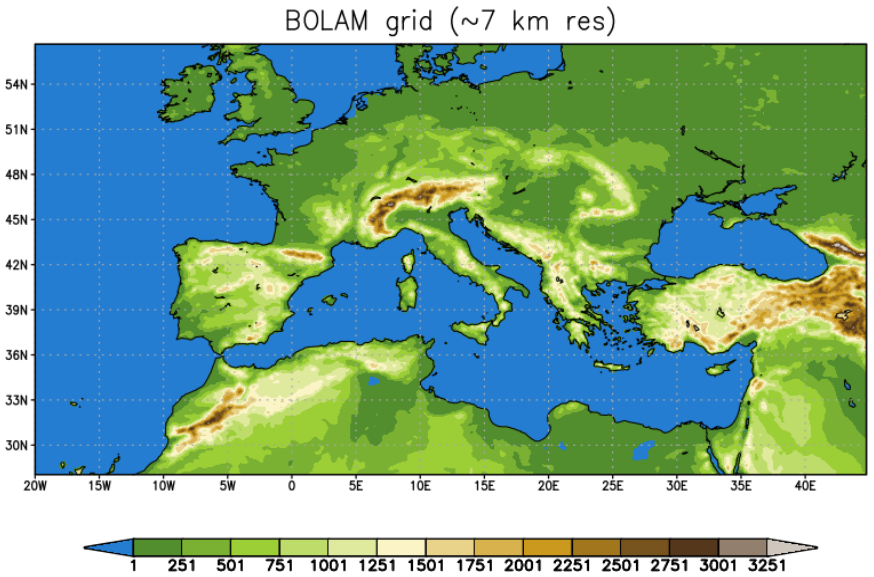

Figure 1: extent of the BOLAM domain

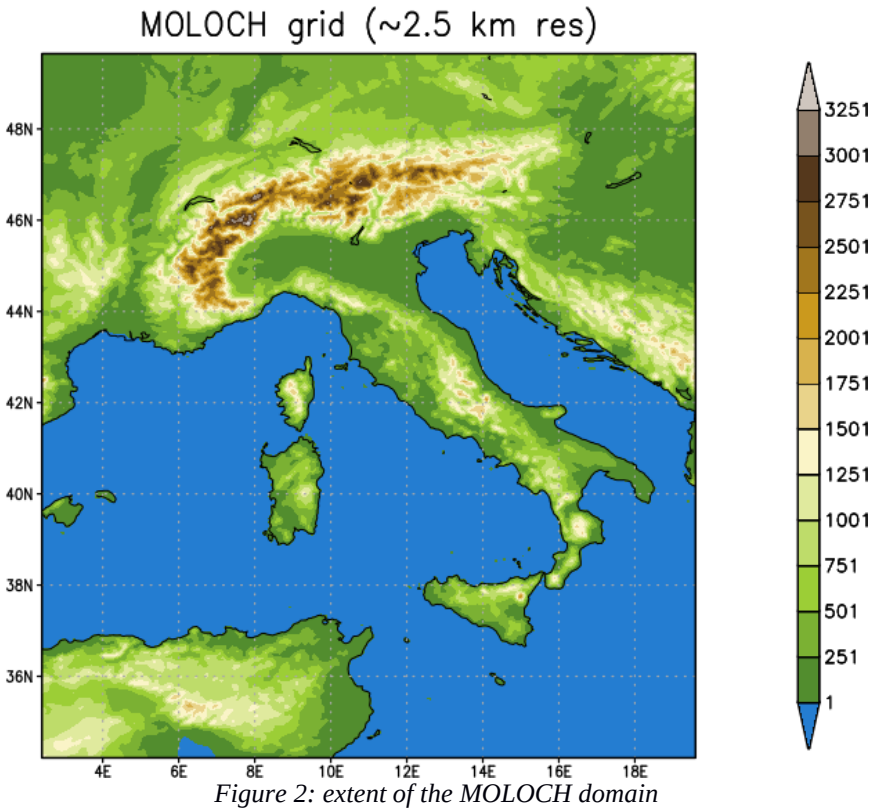

Figure 2: extent of the MOLOCH domain

Some numerical tests were performed aimed at (i) evaluating the SBU's cost of each BOLAM and MOLOCH simulation (no grid nesting), (ii) evaluating the CPU time requested to accomplish a 24-hour simulation with mesoscale models, (iii) optimizing the ratio number-of-processors/queue-time (i.e. PBS directives) and (iv) investigating the best strategy to perform a long-range climate simulation with mesoscale models. About 90 KSBU were consumed for these tasks.
In particular, a test numerical experiment has been performed using the ERA5 to feed a MOLOCH simulation directly (i.e. without the intermediate BOLAM grid). The analysed case is the Livorno flooding occurred on 9/10 September 2017 (see https://software.ecmwf.int/wiki/display/FCST/201709+-+Rainfall+-+Italy). Below in Figure 3, we show the observed precipitations (top) and the ERA5 and MOLOCH Quantitative Precipitation Forecasts (bottom left and bottom right respectively).

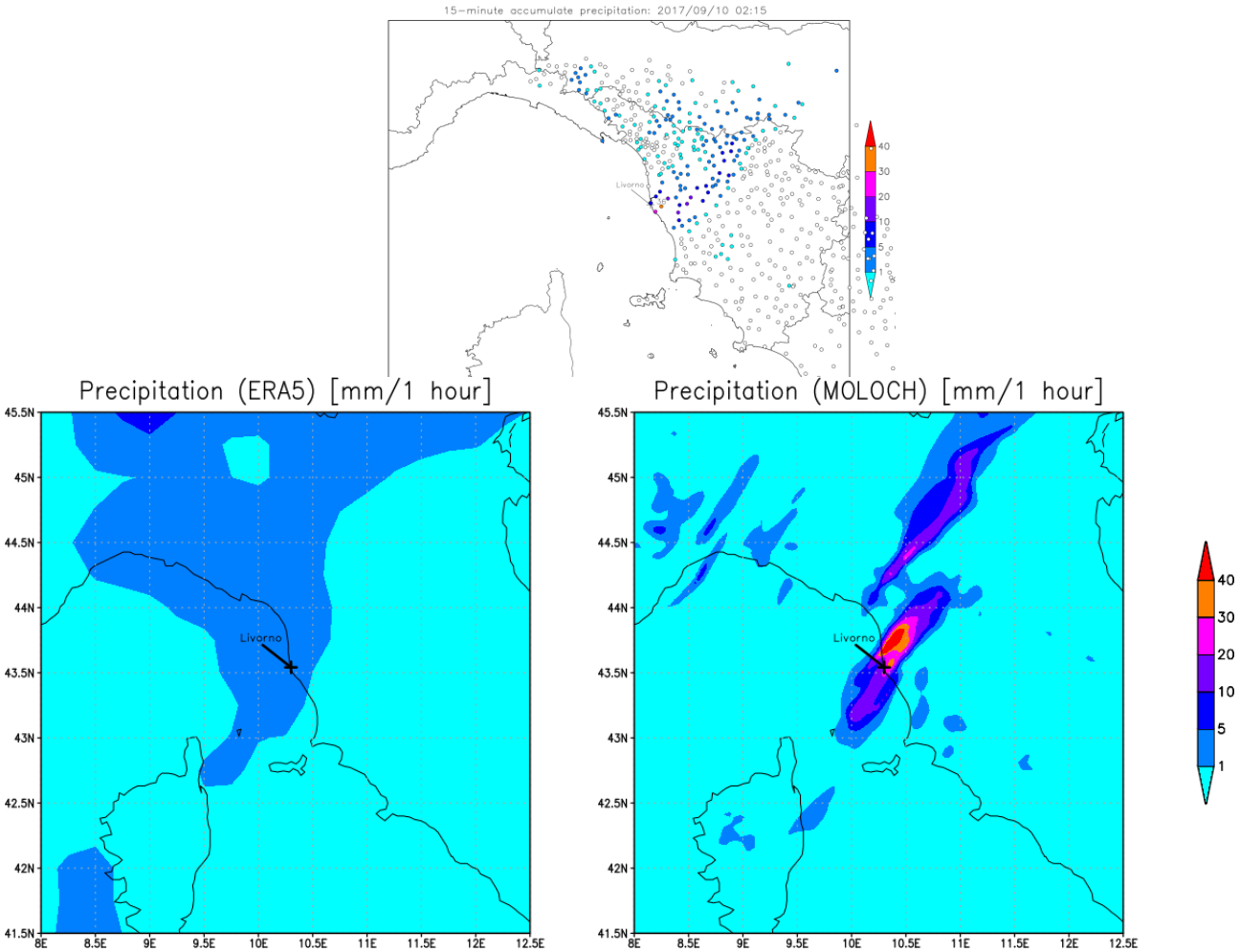

Figure 3, Livorno flooding case, 9-10 September 2017: (top) 15-minute cumulated precipitation as registered by local rain-gauges at 2:15 UTC and (bottom left) 1-hour cumulated precipitation at 3:00 UTC as simulated in the ERA5 data and (bottom right) 1-hour cumulated precipitation at 3:00 UTC as simulated by the MOLOCH model fed with ERA5 data.

List of publications/reports from the project with complete references

none

Summary of plans for the continuation of the project

(10 lines max)

By the end of the current year (2018) all the simulations foreseen for the first 10 years (2008-2017) of the BOLAM+MOLOCH numerical chain are going to be produced since the technical issues regarding the initialisation of the MOLOCH model within a BOLAM grid are expected to be fixed shortly.

Considering the test numerical experiments performed so far, a 24-hour period simulation takes about 5/6 minutes with the BOLAM model and about 14/15 minutes with the MOLOCH model using EC_total_tasks=96 in the PBS directives. Thus to realize one year of reanalyses, the BOLAM+MOLOCH numerical chain takes about 120 hours on cca with the mentioned settings and the 2008-2017 time series should be completed in less than two months. In addition, we have to consider the time consumed for pre/post processing (estimated in about 10% of the integration time). After this step in the remaining time and with the SBU not consumed, the WW3 simulations will be started using the MOLOCH wind at 10-metre variable as input data.

In case of further errors/problems occur for the atmospheric numerical chain, two options will be considered:

1. using the latest stable version of the MOLOCH model (released in 2017) for the BOLAM to MOLOCH nesting
2. using the beta version of the MOLOCH model (released in June 2018) to perform a ERA5 to MOLOCH nesting (as done for the study case shown above). This option is estimated to be more expensive in terms of SBU computed, because of a larger MOLOCH domain to avoid or reduce boundary effects. In this case, a request for additional resources in the current year would be needed.