

REQUEST FOR A SPECIAL PROJECT 2012–2014

MEMBER STATE: Italy

Principal Investigator¹: Dr. Masciadri Elena

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Project Title: Optical turbulence modelling for astronomical applications: towards the Extremely Large Telescopes (ELTs).

If this is a continuation of an existing project, please state the computer project account assigned previously.	SP ITFOT	
Starting year: <small>(Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)</small>	2011	
Would you accept support for 1 year only, if necessary?	YES X <input type="checkbox"/>	NO <input type="checkbox"/>

Computer resources required for 2012-2014: <small>(The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2014.)</small>	2012	2013	2014
High Performance Computing Facility (units)	400000	400000	
Data storage capacity (total archive volume) (gigabytes)	150	150	

An electronic copy of this form **must be sent** via e-mail to: *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): 4 April 2011

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 an annual progress report of the project's activities, etc.

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Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

The Earth's atmosphere strongly limits the image resolution and sensitivity of all ground-based telescopes running in the near and mid-infrared ranges and having a pupil larger than 10 cm. Knowing that telescope resolution outside the atmosphere is proportional to the telescope pupil size, we conclude that the larger is the pupil size, the more important is the limitation introduced by the atmosphere on the telescope resolution. The plane wavefront coming from the observed scientific object is perturbed by the fluctuations of the refractive index of the atmosphere so that the light that is focused on the detector is spread on a large surface destroying the details of the image. The 8-10 m class telescopes and even more the new generation of extremely large telescopes (diameter $D \geq 30$ m) will be able to attain fundamental scientific goals such as the detection of extra-solar planets orbiting stars similar to our Sun provided we will be able to control and overcome the perturbations induced by the atmospheric turbulence that develops between us and the space. Techniques for the measurements and the correction of these perturbations exist and they are called 'adaptive optics techniques. These techniques depends however on the status of the turbulence and it is therefore extremely important to be able to know how the turbulence is distributed in the space and how fast is to optimize the use of the AO techniques. Even more important is the prediction of the status of the turbulence with some hours/days in advance to plan the typology of instrument to be located at the focus of the telescope (with different constraints with respect to the turbulence conditions) as well as the scientific program to be carried on. It happens frequently, indeed, that astronomical observations related to the most challenging scientific programs can be realized only with excellent turbulence conditions. Our ability in forecasting these particular conditions is therefore crucial to guarantee the success of the new class of telescopes and to maintain the competitiveness of the ground-based astronomy with respect to the space-based one. Knowing that the cost of a night of observation is typically of the order of several KDollars, it is straightforward to catch the challenge related to the optimization of the management of the telescope use.

The optical turbulence develops on spatial and temporal scales much smaller than the scales at which classical meteorological parameters such as temperature and wind speed evolve. Mesoscale models are required to perform prediction of this parameter. Studies on this subjects have been carried out by our group since more than a decade. The optical turbulence has been opportunely parameterized and successive progress have been achieved thanks to techniques of model calibration. We are currently involved in two major studies related to the employment of a numerical meso-scale model (Meso-Nh) for the forecast of the optical turbulence in astronomical applications:

- (1)** The first one aims to carry out a feasibility study for the European Southern Observatory (ESO) for the optical turbulence forecast at two main sites of ESO for ground-based facilities working in the near infrared and infrared: Cerro Paranal (site of the Very Large Telescope) and Cerro Armazones (the selected site for the European Extremely Large Telescope E-ELT). Both sites are located in the north part of Chile.
- (2)** The second project, supported by the Large Binocular Telescope (LBT) Consortium, aims to set-up an operational forecast system of the optical turbulence at Mt. Graham to support astronomical observations and management of instrumentations to be placed at the focus of the telescope.

In our researches we will focus our attention on these major critical points:

- Model calibration
- Parameterization of the optical turbulence (C_N^2)
- Spatial and temporal variability of the optical turbulence in different regions of the atmosphere.

The meso-scale model will be run in grid-nesting configuration and the model will be initialized and forced with products (forecasts) from the ECMWF. The most important constraints that gets important and critical for us the use of the c1a facility is the necessity to do several run to test different model calibration techniques that necessarily have to be done on a very rich sample of nights (the richer is the sample, the most representative is the calibration method). Besides, such a facility is fundamental for benchmark tests done on high horizontal and vertical resolution. At the status of art one of the most challenging objective is to improve the ability of the model in reconstructing the weakest and the strongest turbulence conditions in the free atmosphere.

We should need a disk space on C1a of 4.5 Gbyte. This is necessary to install the Meso-Nh model and the user libraries. We calculated a storing space equivalent to 150 Gbyte to store binary files related to ~ 100 simulations with the highest vertical resolution and one output each 6 hours. Each run with 64 proc. with medium and high vertical resolution requires, respectively, around 1500 SBUs and 4800 SBUs. We calculated a total of 400000 SBUs (equivalent to ~ 40-130 simulations depending on the vertical resolution).

Main bibliographic references:

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