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VARIATIONAL MULTISCALE BASED DISSIPATION MODELS FOR THE ESTIMATION OF ATMOSPHERIC SEEING

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In the observation of the universe by using ground based telescope facilities, the effect of atmospheric turbulence in the quality of the obtained data is of great importance. Especially when the diameter of the telescope is large, the optical distorsion due to turbulent effects can become significant enough to prevent the observation device to reach its maximum theoretical resolution. This is the reason why extensive efforts have been done in several directions:

- The development of adaptive optics mechanisms which allow to correct the phase distortion effects.
- The selection of observation sites which provide optimal atmospheric conditions.
- The design of telescope facilities which minimize the amount of turbulence of the aerodynamic flow around them. Minimizing the small eddy oscillations in the air flow around the telescope mirrors results in less optical distortion, which means that the corrections to be done by the adaptive mechanism are lesser, which in turn results in better obtained images.

It is clear that being able to evaluate the suitability of an observation site or a telescope facility design prior to the telescope construction is key for getting the best possible performance out of the telescope. Also, it is convenient to be able to quantify the characteristics of the adaptive optics mechanism to be installed in the telescope beforehand. Due to this, several efforts have been devoted recently to the quantification of atmospheric seeing parameters through numerical simulation.

In [4] we presented a strategy for the computation of seeing parameters, which, to our knowledge, is the first computational method capable of simulating seeing conditions at a local level, that is, by using a finite element computational fluid dynamics simulation with a resolution ranging from decimeters to few meters instead of using mesoscale simulation tools with a coarse resolution. The proposed model for the computation of the refraction index structure function C_n^2, the main parameter quantifying the quality of atmospheric seeing, is based on a Large Eddy Simulation of the incompressible flow and temperature fields, and has been successfully applied to the design phase of the *Advance Technology Solar Telescope* (ATST) and the *European Solar Telescope* (EST).

In this work we present a model for the numerical simulation of the C_n^2 function which is computed from a variational multiscale (VMS) based turbulence model. For finite element analysis, the basic idea of VMS is to split the unknowns into their finite-element part and a subgrid scale component, the subscale. The approximation adopted for the subscale defines the numerical model. The interesting feature about VMS is that it is capable of providing, at the same time, a numerical stabilization mechanism for the studied equations (in this case, the incompressible Navier-Stokes equations) and a turbulence model which takes into account the under-resolved scales. This has been studied in several works [3, 1, 2] with successful results. The advantage of using this kind of approach is that there is no interference between the numerical stabilization and the turbulence models because both issues are taken care of by the numerical subgrid scales. In this work we use the kinetic energy and thermal turbulent dissipations which arise from a variational multiscale based turbulence model in order to quantify the refraction index structure function.

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