CIVIL AND ENVIRONMENTAL ENGINEERING

OGS/CNR/DIATI - Development of a low-resolution version of the EC-Earth global climate

Funded By	C.N.R. - CONSIGLIO NAZIONALE DELLE RICERCHE [P.iva/CF:02118311006] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale [P.iva/CF:00055590328] Dipartimento DIATI
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Context of the research activity	The goal of the research is to participate in the development of a very low resolution and computationally efficient version of the state-of-the-art EC-Earth global climate model, aiming at the tuning and validation of the model climate by performing ensembles of control experiments, and to apply it to the study of tipping point transitions in the climate system.
	The current generation of state-of-the-art (e.g. CMIP6) global numerical climate models (GCM) has seen a tremendous investment in terms of development in recent years. Such models are characterised by increasing spatial resolution (which currently lies between 25 and 100km) and by the capability to represent a large number of processes and components of the climate system, leading to the current definition of comprehensive "Earth-system models". These models typically require huge computing resources (typically thousands of core-hours per model year), allowing running them only at high-performance computing (HPC) centers, using hundreds of computing cores. This limits their use at an academic level but also limits the length of model integrations and/or the size of the ensembles, making it almost impossible to use these models for long-term analysis of the climate, as for example for paleoclimatic studies. At the other end of the modelling spectrum, we find so-called models of intermediate complexity (EMIC), commonly based on GCM dynamical cores of a previous generation, with only a limited and very simple representation of few components of the climate system (often only atmosphere and ocean) and with extremely coarse spatial resolution (often of the order of 600km). These models present the advantage though of needing only limited computing resources, allowing to run thousands of model years and large ensembles on smaller workstations. The goal of this project is to develop a very low-resolution version of the state-of-the-art global Earth-system model EC-Earth, creating a model which can compete with EMICs in terms of computational needs but at the same

Objectives	time characterised by advanced, state-of -the-art representation of model components and an in-depth representation of physics. EC-Earth is a model which participated in the CMIP5 and CMIP6 model comparison projects and its latest next-generation version (EC-Earth4) is currently under development by a large European consortium in which Politecnico di Torino is participating. Starting from this version, the project aims at developing a configuration with a low resolution both in the atmosphere (between 200 and 600km – to be defined) and in the ocean (about 2°), allowing it to run at a limited cost (typically between 16 and 48 cores and less than 100 core-hours per model year) on computers easily available at University/department level. This part of the work will initially involve defining/creating or retrieving appropriate boundary conditions (such as topography, land-sea masks etc.) and initial conditions, testing the model by performing control experiments on department workstations and perform model parameter tuning. Later the focus will be on analyzing model results and comparing them with observations/reanalyses datasets to verify the representation of a realistic mean climate and of significant climate processes and performing sensitivity experiments to identify parameter sensitivity in the model. The availability of a low-resolution version of EC-Earth4 will allow in the future to use EC-Earth4 also for University teaching/training and, thanks to the possibility of running large ensembles with long integration times, extends significantly the applicability of the model to a wide range of scientific topics, from paleoclimate studies, exoplanetary climate studies of habitability and using large ensembles to study climate tipping points and extremes. In particular, in a second part of the PhD project the developed model will be applied, by running large ensembles, to study “tipping point” transitions in the climate system (in particular the weakening of the Atlantic Meridional Overturning Circulation) with the goal of identifying possible early “warning signals”. This project will be performed in the framework of the HPC-TRES (“High Performance Computing Training and Research for Earth Sciences”) Joint Research Unit, dedicated to advancing capacity building and advanced formation in the fields of Earth-System modelling and of numerical methods in an HPC setting and it is in particular being co-funded by HPC-TRES (through OGS - Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), by the Institute of Atmospheric Sciences and Climate of the Italian National Research Council (CNR-ISAC) and by DIATI - Politecnico di Torino. The research will be performed in close collaboration and with co-tutoring by CNR-ISAC (Torino unit) and will expose the candidate also to the wider HPC-TRES community (with participation in the annual HPC-TRES workshop) and to the pan-european EC-Earth development community.

Skills and competencies for the development of the activity	Possible experience/training/studies on climate dynamics, climate change or fluid dynamics; experience in the analysis and post-processing of meteorological or climate data (e.g. NetCDF); possible experience with development of meteorological or climate models and associated diagnostic software. Possible knowledge of relevant programming languages (e.g. python, Fortran, R) and HPC environments and tools (Linux, bash scripting, CDO, Git). Master degree (Laurea Magistrale) in relevant fields (engineering, physics or mathematics).