CIVIL AND ENVIRONMENTAL ENGINEERING

DIATI/OGS/ASI - From interannual variability to Climate Change: exploiting Spectral Observations to improve Climate Model projections

Funded By	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale [P.iva/CF:00055590328] A.S.I. - AGENZIA SPAZIALE ITALIANA [P.iva/CF:03638121008] Dipartimento DIATI

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Context of the research activity	This research uses spectrally-resolved observations (IASI, upcoming FORUM mission) to constrain climate feedbacks and improve global climate models, which currently have uncertainties in physical parameterizations, affecting radiative balance and climate sensitivity. The PhD work will link radiative responses to interannual variability (e.g., ENSO) and long-term climate change, using observations to better represent clouds and enhance climate projection reliability.

Objectives	Global climate models have evolved into increasingly sophisticated tools that incorporate numerous physical processes and Earth system components. Advances in model resolution and complexity have led to improvements in the quality and reliability of the simulated climate. However, a major source of uncertainty lies in parameterizations - particularly those governing convection, cloud microphysics, and aerosol processes - which directly influence the radiative balance of the system. These uncertainties limit the models' ability to accurately represent crucial climate feedbacks and their sensitivity to climate forcing changes. Proper model development and tuning are therefore essential to reduce systematic biases, constrain feedback processes and improve the reliability of future climate projections. Observations play a fundamental role in constraining climate feedbacks and informing model development through multiple pathways. The tuning process requires careful identification of appropriate observational fields and metrics that can effectively constrain model behavior and reduce uncertainties. Beyond traditional approaches focused on bulk radiative balance, spectrally-resolved observations enable the investigation of the climate response across different wavelength regions - particularly in the far-infrared, a previously underexplored spectral window. This region contains distinct signatures of various climate forcings and feedbacks and is highly sensitive to upper-tropospheric water vapor and cirrus clouds. Satellite-based measurements, such as the Infrared Atmospheric Sounding Interferometer

	(IASI) and the upcoming FORUM mission, provide unique insight into how spectral radiances respond to changing greenhouse gas concentrations and warming surface temperatures. This observational constraint is crucial for assessing Earth's radiation budget accurately and developing more robust climate models that can better represent the complex interplay of climate system components. During the PhD, the candidate will work at the interface between climate model development and observations, identifying potential pathways to better assess climate feedbacks and improve the reliability of climate model projections. The candidate will explore the connection between the radiative response to natural interannual variability - such as that linked to ENSO - and the response to forced climate change. Understanding this link will allow exploiting the information contained in observations to better constrain physical processes, most importantly those connected to cloud processes. This project is being cofunded and will be performed in collaboration with the project MC-FORUM (Meteo and Climate exploitation of FORUM), an ASI-funded project to evaluate the impact of measurements by the future FORUM mission in the climate field. The research will expose the candidate also to the wider to frequent scientific exchange with the partners of the MC-FORUM ASI project.

Skills and competencies for the development of the activity	Master degree (Laurea Magistrale) in relevant fields (engineering, physics or mathematics). 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) and using or writing associated diagnostic software. Possible knowledge of relevant programming languages (e.g. python or julia) and experience in the usage of HPC environments and tools (Linux, bash scripting, cdo, git).