Title: Scientific Machine Learning for World Dynamics Modeling **Topic:** Machine Learning and Software Engineering

City and country: Nice, France

Team or project in the lab: COATI, INRIA d'Université Côte d'Azur Name and mail of the advisor: Emanuele Natale, <u>emanuele.natale@inria.fr</u> Name and mail of the head of the department: David Coudert, <u>david.coudert@inria.fr</u>

General presentation of the topic

Integrated assessment models aim to link together the main features of society and economy with the biosphere in order to provide a unified framework to qualitatively forecast the evolution of the socioeconomic system. Several such models, such as the World3 model by Meadows et al. and the DICE model by Nordhaus, have largely influenced the scientific debate. Modern software engineering and machine learning techniques have the potential to revolutionize this field, allowing the development of models that are far more reliable than those considered so far. In particular, data-driven approaches to dynamical systems have already shown promising results in some scientific applications; this internship project aims at adapting these new techniques and contributing to the state of the art of integrated assessment modeling.

Objective of the internship

The goal of the internship is to contribute to WorldDynamics.jl, an open source Julia programming library which aims at allowing scientists to easily use and adapt different integrated assessment models, by leveraging the modern scientific-computing language Julia. In the first part of the internship, the student will contribute to the library by implementing an integrated assessment model which is not yet included in it. In doing so, the student will follow best software engineering practices, collaborating with the other team members through the git versioning system, and writing high-quality Julia code. In the second part of the internship, the student will familiarize themself with modern scientific machine learning techniques, e.g. SINDy (Sparse identification of nonlinear dynamics), and work together with the other team members in adapting the techniques to improve the accuracy of current integrated assessment models.

Bibliographic references:

- Online book with Scientific Machine Learning fundamentals in Julia: <u>https://book.sciml.ai/</u>
- Integrated Assessment Modeling library that is being developed by the research group offering the internship: <u>https://github.com/worlddynamics/WorldDynamics.jl</u>

Expected ability of the student: The ideal candidate should have a strong desire to quickly become familiar (if he/she isn't already) with basic software engineering practices and tools, such as writing clean, readable, and well-organized code, using the git versioning system and the GitHub platform to collaborate on a programming project. A solid background in discrete probability and linear algebra, and familiarity with fundamental statistics and machine learning concepts such as linear regression and neural networks, are recommended but not required.