Equation discovery for climate impact: symbolic regression to emulate climate impact indicators for unseen scenarios

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Abstract Climate change risks are often assessed using climate impact indicators (CIIs) determined for various socio-economic scenarios. Ideally, for every scenario an impact model, e.g. an ecological model or a hydrological model, processes outputs of a climate model to produce CIIs. However sometimes, even if outputs of a climate model are available for all scenarios, computation costs of the impact model can limit the number of scenarios with available CIIs.

To fill this gap, we propose to infer CIIs for unseen scenarios, i.e. scenarios not processed by the impact model, with an interpretable equation. This equation is discovered using symbolic regression on a scenario processed by the impact model. Specifically, we discover an equation that predicts CIIs based on climate impact drivers (CIDs), where CIDs are variables of the climate model averaged monthly and spatially.

In our application, the impact model is a biogeochemical model of the Mediterranean Sea driven by the same regional climate model for two scenarios: RCP4.5 and RCP8.5. Our CII is the annual mean Net Primary Production (NPP) summed over an offshore area in the Gulf of Lion (located in the North-western Mediterranean basin), where NPP is the total rate of organic carbon production by photosynthesis of marine phytoplankton minus their respiration.

Preliminary results show that the discovered equation reproduces well the trend and the interannual variability of NPP for the testing scenario RCP4.5, unseen during the training. Indeed, the scenario RCP8.5 is preferred for training as it spans a wider range of climatological contexts. If our preliminary results are confirmed, we could extend our approach to a large ensemble of climate models, in order to characterize the uncertainty of CIIs.