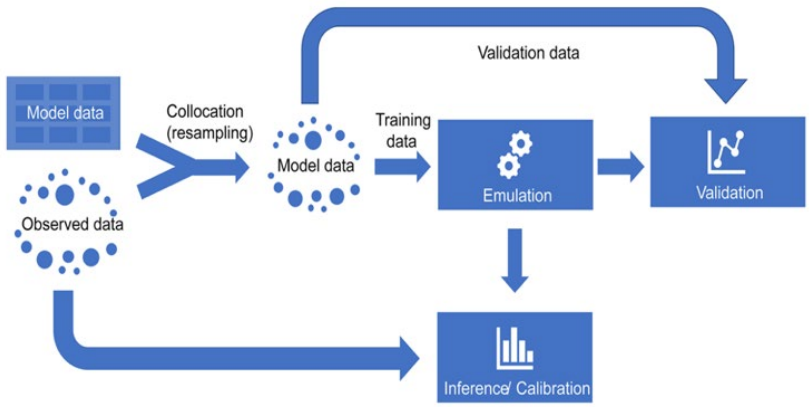
Improving climate model simulations with satellite observations

Anthropogenic aerosols cause a forcing of climate change that is potentially comparable in magnitude but opposite in sign to greenhouse gases. In contrast to the climate effect of greenhouse gases, which is understood relatively well, the negative forcing (cooling effect) caused by aerosols represents the largest reported uncertainty in the most recent assessment of the Intergovernmental Panel on Climate Change (IPCC). This uncertainty severely hampers future predictions of climate change. Strong aerosol cooling in the past and present would imply that future global warming may proceed at, or even, above the upper extreme of the range projected by the IPCC. A better representation of aerosol emissions, properties, and processes in climate models is essential for improving climate predictions. Improved satellite measurements of aerosol and cloud properties have recently become available (and more improvements are expected in the near future) but it is not straightforward how to use this information to improve representation of aerosols and aerosol-cloud interactions in climate models.

In this project, a method to constrain climate model simulations with satellite measurements will be developed based on a Perturbed Parameter Ensemble (PPE). A PPE is a set of simulations created using a single climate model with perturbations made to uncertain physical parameters or inputs to the model. In this way, we will produce a large set of "model variants", which represent model runs for different combination of parameters (related to aerosol emissions, properties, processes), and then select the plausible model variants given the available satellite observations. It is unfeasible to create model simulations for all different parameter combinations (up to a million) and therefore we will use Gaussian process emulators to extend a limited number of 'real' model runs to a densely sampled representation of the full parameter space. For the application of Gaussian process emulators to climate model simulations an open source Python tool is available. An overview of the procedure is shown in the figure below. Once the PPE is created, it will be used in combination aerosol properties measured by the POLDER satellite to constrain the climate model simulations. If time permits, it is possible to extend the project to also consider cloud observations to constrain aerosol cloud interactions.

The research will be carried out at SRON-Netherlands Institute for Space Research that is located at the Leiden University campus (from September 2021 onwards). The project will be very important for the SPEXone satellite instrument that has been developed under lead of SRON and will fly on the NASA Phytoplankton, Aerosol, Cloud & ocean Ecosystem (PACE) mission, to be launched in January 2024.



(Adopted from Watson-Parris, D., et al , https://doi.org/10.5194/gmd-14-7659-2021, 2021)