B15A-1409: The Arctic Carbon Monitoring and Prediction System, a data assimilation system to reduce uncertainty of the permafrost-carbon climate feedback.

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Background

Accelerated warming of the Arctic poses a constant threat to vegetation, hydrology, and permafrost. Permafrost contains a significant amount of frozen carbon that could release into atmosphere due to continuous ground warming. Many challenges are associated with predicting permafrost warming and its impact on the Arctic ecosystem and on global climate. Here we take an integrated approach by combining existing in-situ and remotely sensed datasets with the mechanistic model and develop a model-data-assimilation system to better predict anticipated carbon fluxes from thawing permafrost.

Ecosystem Modeling

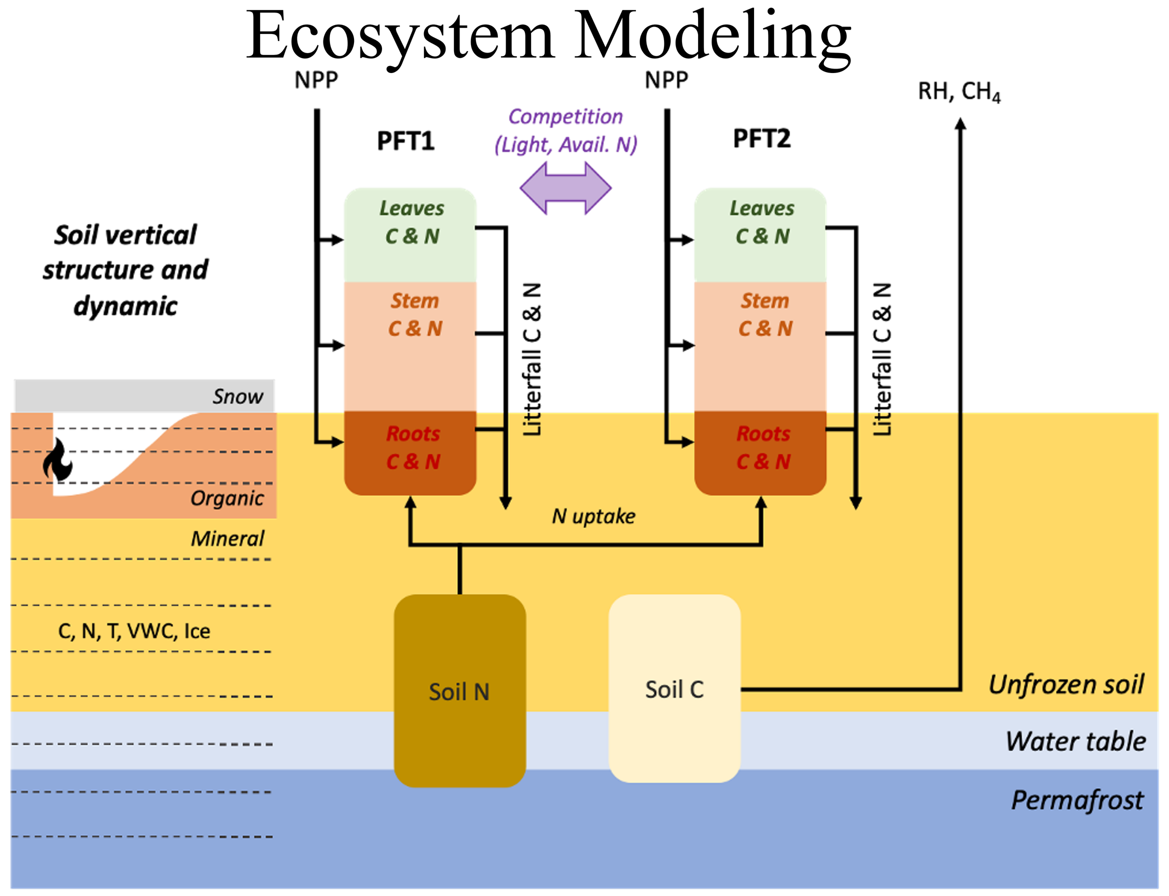


Figure 1. A schematical representation of the DVM-DOS-TEM model features.

What is DVM-DOS-TEM?

The DVM-DOS-TEM is a process-based biosphere model that couples a dynamic vegetation model, a dynamic organic soil model and a terrestrial ecosystem model. The model has been specifically developed and parameterized to represent biophysical and biogeochemical processes at play in the main land cover types of boreal forest, arctic tundra and wetland ecosystems.

The DVM-DOS-TEM input data.

The model is driven by forcing of climate, wildfire and atmospheric CO_2 time series, land cover distribution, soil texture and physiography. Wildfire disturbances are affecting carbon and nitrogen dynamics by burning the vegetation and the organic layer at a ratio related to fire severity. By burning the organic layer, wildfire is also affecting soil thermal and hydrological regimes.

Available Data

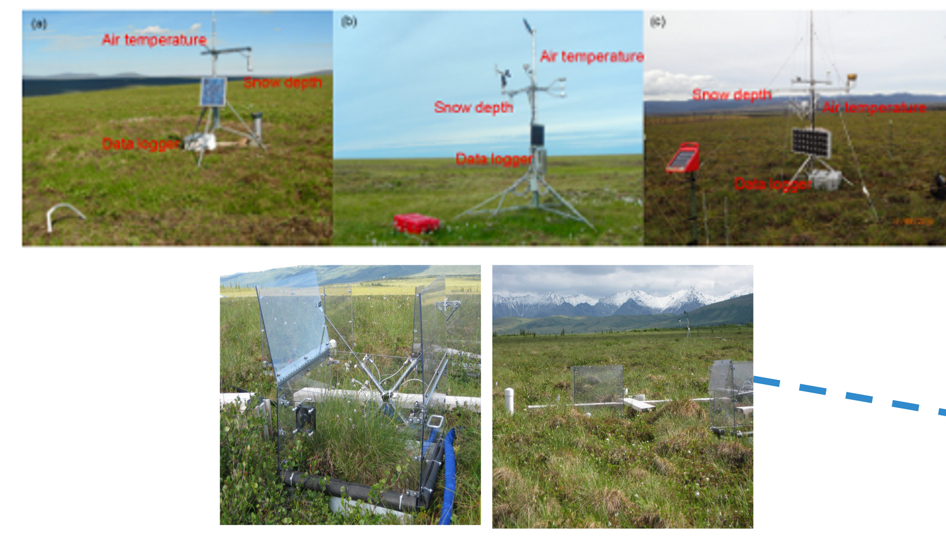


Figure 2. Photos of permafrost monitoring stations and in-situ soil carbon flux monitoring stations.

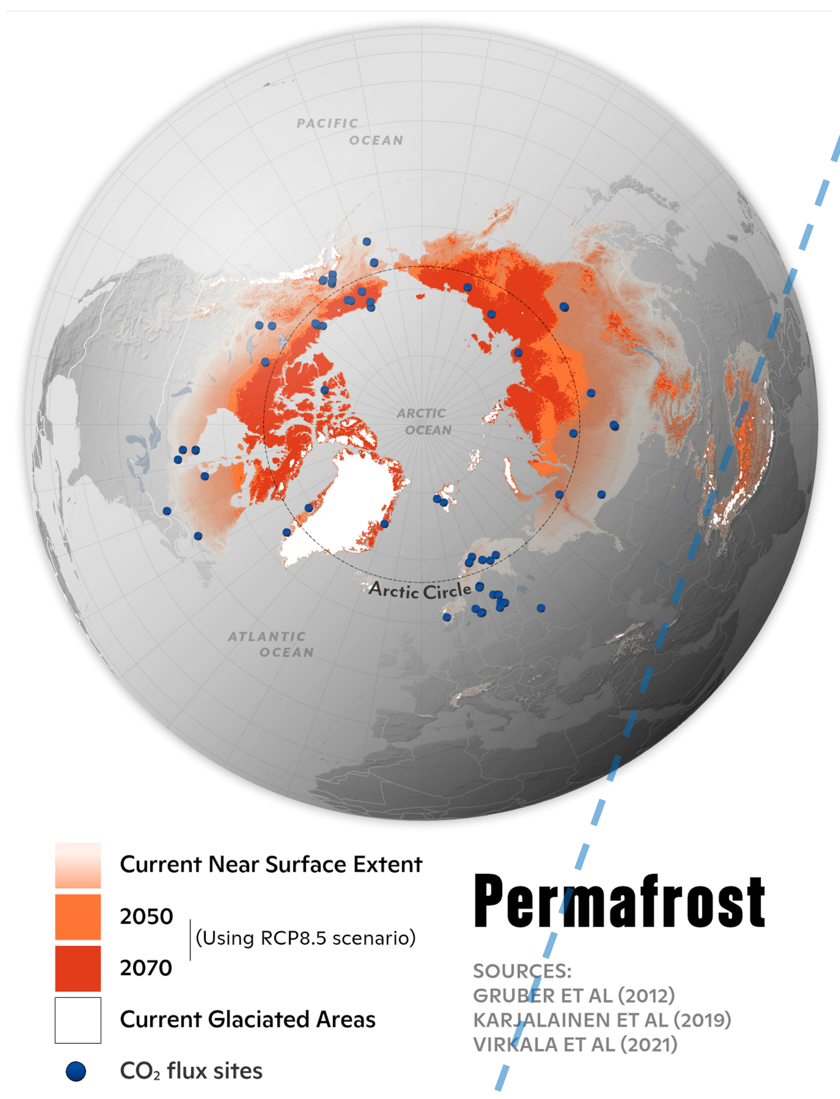


Figure 3. Flux Tower Station Network and projected permafrost conditions.

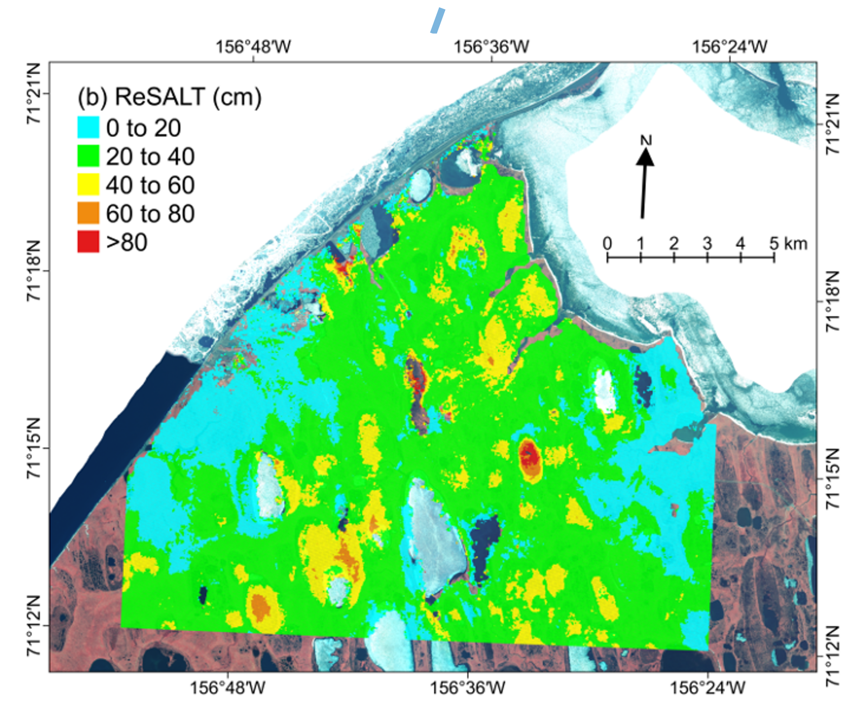
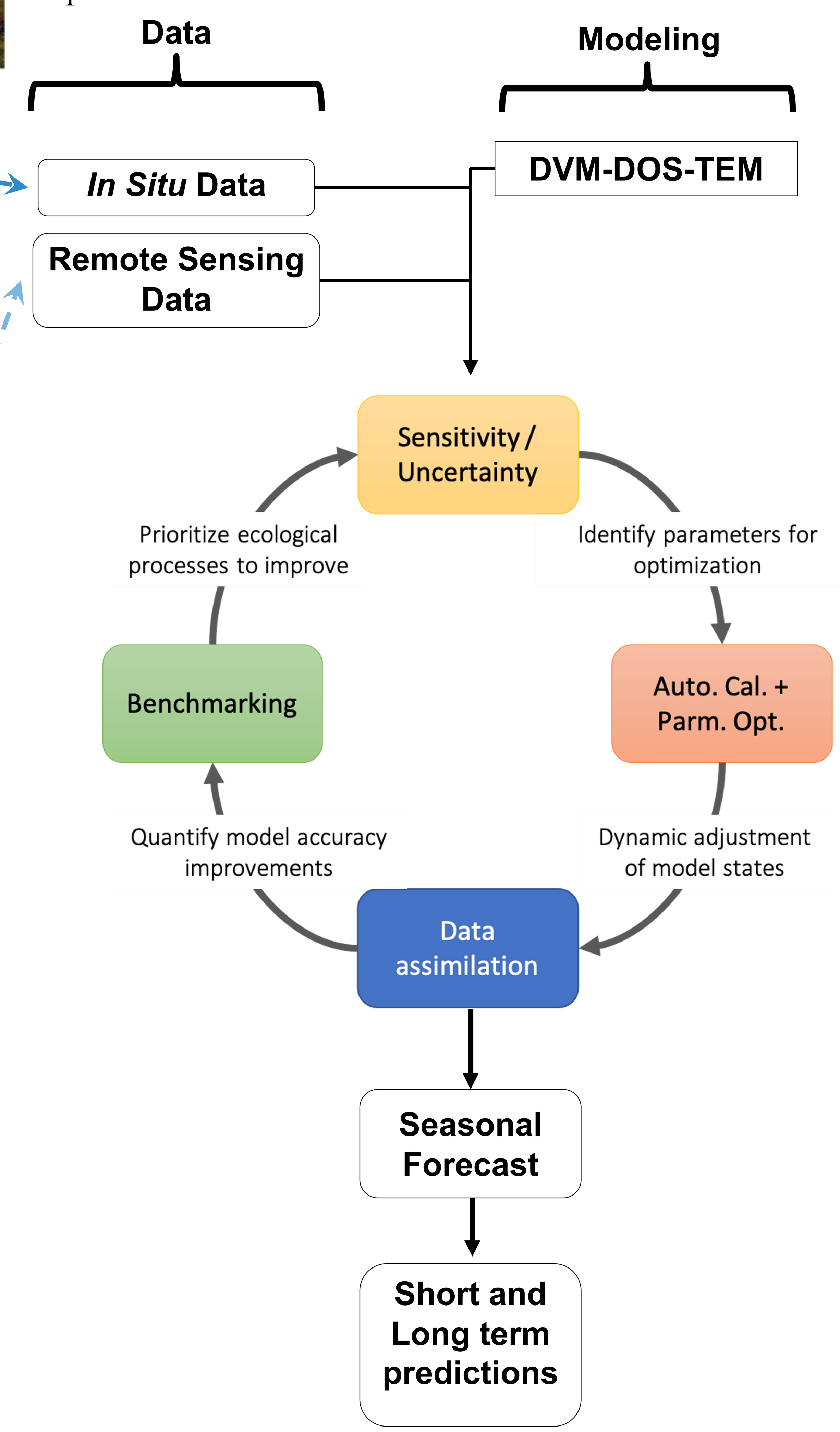


Figure 4. An example of the remotely sensed data that can be used in the Prediction System. The active layer thickness estimated from from Interferometric Synthetic Aperture Radar (Schaefer et al., 2015).

Schaefer, K.; Liu, L.; Parsekian, A.; Jafarov, E.; Chen, A.; Zhang, T.; Gusmeroli, A.; Panda, S.; Zebker, H.A.; Schaefer, T. Remotely Sensed Active Layer Thickness (ReSALT) at Barrow, Alaska Using Interferometric Synthetic Aperture Radar. *Remote Sens.* 2015, 7, 3735-3759. https://doi.org/10.3390/rs70403735

Elements of a Prediction System

The system would consist of data and a model combined using data assimilation to produce a permafrost short- and long-term predictions.

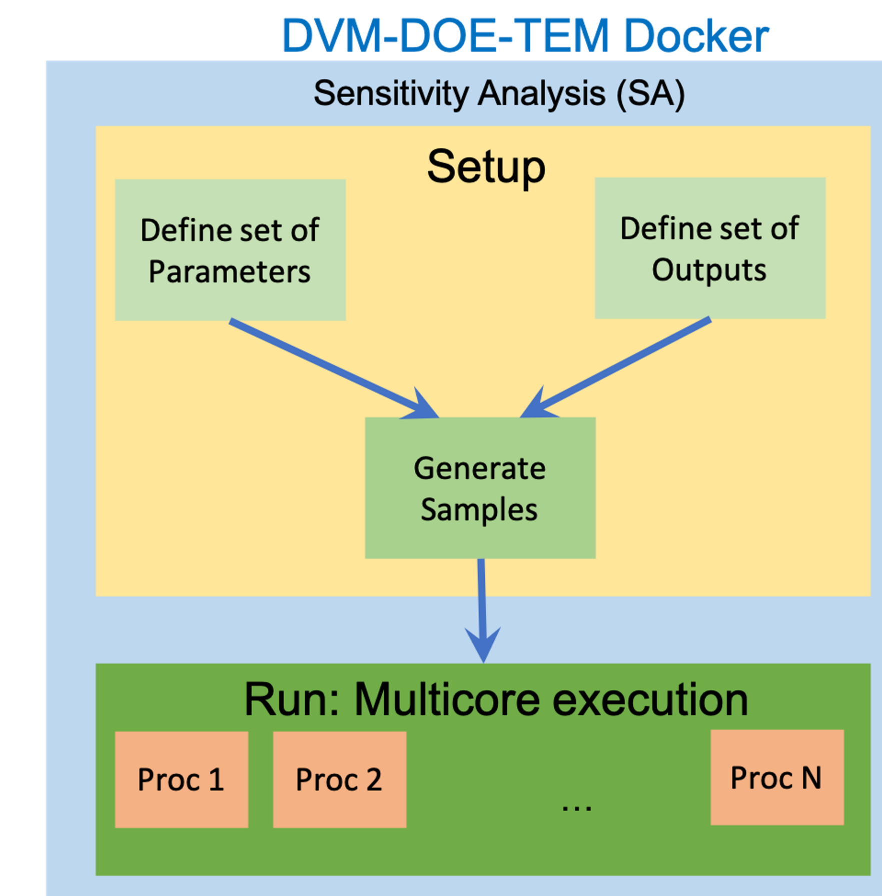


Current progress

The system will include four major components:

1) Sensitivity Analysis (testing)
2) Uncertainty Quantification (developing)
3) Model-data calibration
4) Data Assimilation

Sensitivity Analysis



https://github.com/ua-snap/dvm-dos-tem

Figure 5. A schematic representation of the newly developed sensitivity analysis tool for the DVM-DOS-TEM model.

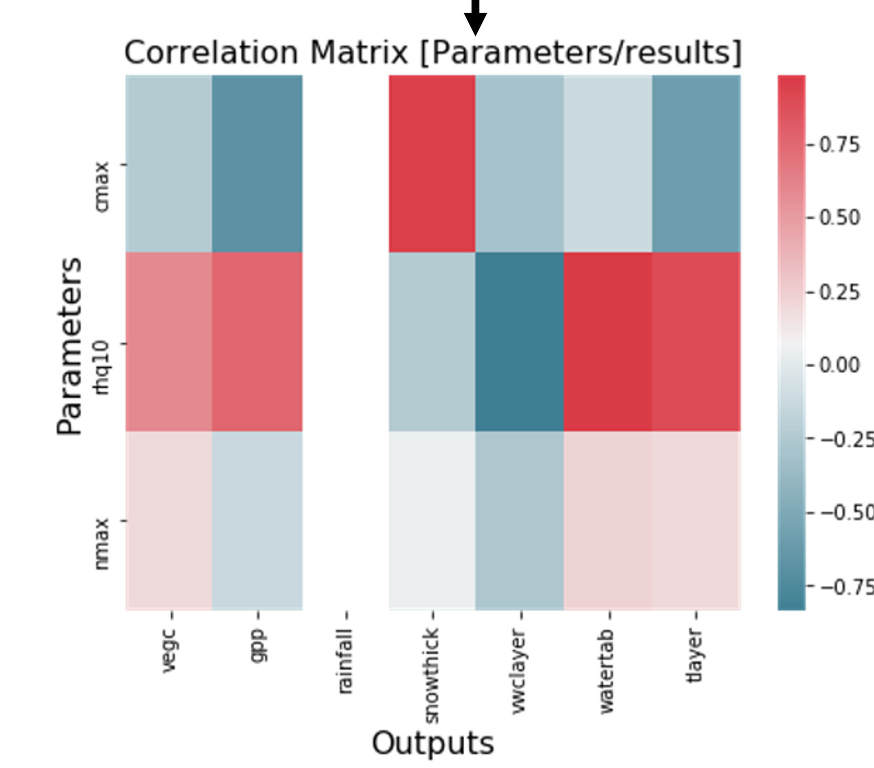


Figure 6. An example of the parameter-output correlation matrix produced as a result of the sensitivity analysis run

Functional benchmarking will be used to identify processes that would gain the most from data assimilation. Benchmarking will also help quantifying the gain of model performance in response to data assimilation.

Sensitivity / Uncertainty analysis will be use to identify the model parameters that will become the targets of the data assimilation.

Automated calibration and parameter optimization will help reducing model uncertainty by producing new parameterization that reflect better ecosystem spatial heterogeneity.

Data assimilation and model adjustment module using ensemble Kalman filter will be developed to sequentially adjust the model states.