

Global Shocks and Disruptions to Scotland's Surface Waters – Evaluating Ecosystem Dynamics Across Scottish peatlands.

Luisa Orci-Fernandez, Mathew Williams, Roxane Andersen, Luke Smallman.
The University of Edinburgh
Email: L.F.Orci-Fernandez@sms.ed.ac.uk
www.hydronationscholars.scot

Introduction

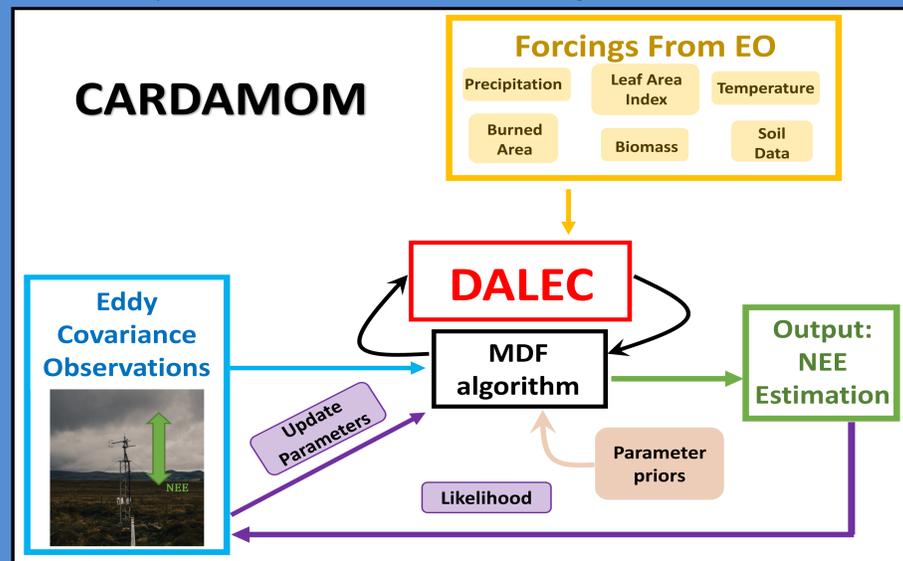
Climate change is affecting Scotland's weather patterns and hydrology. Scotland has ambitious net-zero goals, which include tree planting and peatland restoration targets. There is a challenge in balancing multiple objectives, including net-zero policies, Scotland's Biodiversity Strategy, agriculture, forestry, and the growth of the rural economy, all while understanding the hydrological impact of climate and land use changes. Current land use policies lack a clear assessment of hydrological risks associated with tree growth, food production, peatland restoration, and climate change.

We have few sites with detailed measurements of both the carbon and water cycles. Models exist which can bridge the gap between these sites, but require rigorous calibration and uncertainty quantification. Moreover, their reliability has yet to be fully quantified. In response to these challenges, our project will address the following questions:

- How well can a model calibrated using remote sensed data reproduce site-based estimate of C-exchange?
- Can this model calibrate C and water cycles interactions across Scottish peatlands?
- How will soil moisture and carbon dynamics change in response to various future climate and land use scenarios?
- How will these scenarios impact Scotland's surface water resources across mineral and organic soils while providing estimations of parameter uncertainty?

Methods

We used the CARDAMOM, to calibrate and validate the DALEC model using remote sensed Earth Observations (EO), then we compared model results for Net Ecosystem Exchange (NEE) to independent NEE measurements from Eddy Covariance towers across 3 Scottish peatlands, with different levels of degradation.



Results

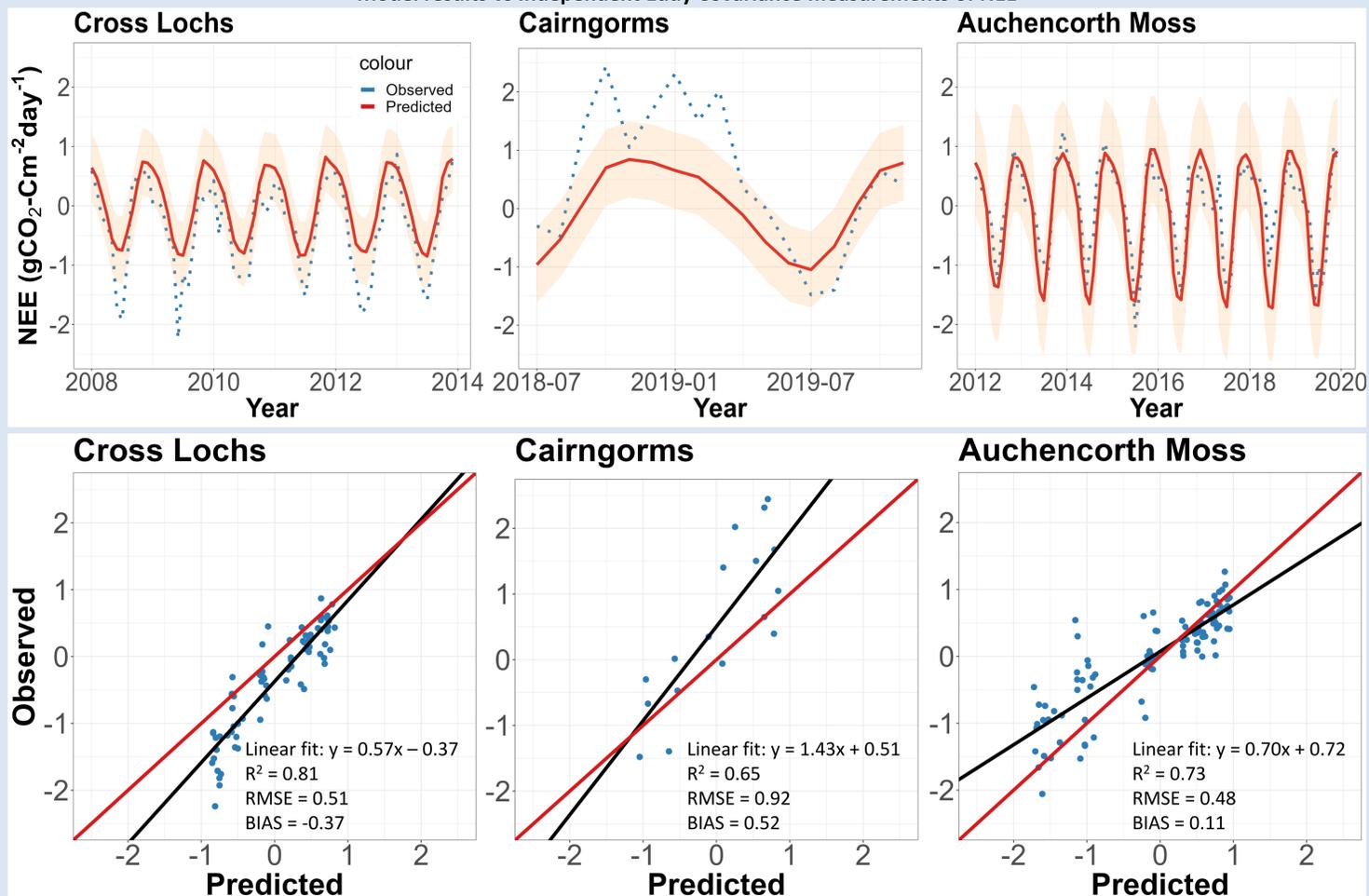
Our CARDAMOM estimates of NEE show a good fit with independent NEE measured at the Eddy Covariance sites:

- The model is able to capture seasonality of NEE. R^2 values indicate a strong correlation between Predicted and Observed NEE, additionally, RMSE and Bias are low.
- Comparison between model results and independent observations also show key areas of modelling improvement: At Cross Lochs CARDAMOM is underestimating peak carbon uptake and its missing peak emissions at Cairngorms.



Name and Location of Eddy Covariance Sites

Model results vs Independent Eddy Covariance measurements of NEE



Next Steps

1. Exploration of internal dynamics (compare measurements for other C-Cycle components such as Ecosystem Respiration, photosynthesis and Water balance components and dynamics with C-Cycle), to confirm the model is reproducing the sensitivity to changes in water table, degradation, and climate.
2. Explore the impacts of the different peatland degradation level.
3. Model evaluation and development to account for the presence of organic soils and soil moisture dynamics, and calibration and validation of the model at different scales.
4. Exploration and development of different future scenarios for land use and climate forecast.

References

- [1] Luke Smallman, T., & Williams, M. (2019). <https://doi.org/10.5194/gmd-12-2227-2019>.
 [2] Bloom, A. A., & Williams, M. (2015). <https://doi.org/10.5194/bg-12-1299-2015>.
 [3] Evans, C. D., et al. (2021). *Nature* **593**(7860): 548-552.
 [4] Morrison, R.; Cooper, H.M.; Artz, R.; Burden, A.; Callaghan, N.; Coyle, M.; Cumming, A.M.J.; Dixon, S.; Helfter, C.; Kaduk, J.; Levy, P.; McNamara, N.; Oakley, S.; Page, S.E.; Rayment, M.; Ridley, L.M.; Worrall, F.; Evans, C.D. (2021). <https://doi.org/10.5285/b8c9fd3d-f9ea-4fd8-9557-9022884f711d>

This work is being funded by the HydroNation Scholars Programme, hosted by the University of Edinburgh, under the supervision of Prof Mathew Williams (UoE), Prof Roxane Andersen (UHI), and Dr Luke Smallman (UoE). Eddy Covariance data is available through EIDC (<https://doi.org/10.1038/s41586-021-03523-1>).