Thesis Outline DRAFT

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1 Introduction

- Why is understanding the carbon balance of forests important?

- Terrestrial ecosystems and oceans responsible for removing around half of all human emitted carbon-dioxide from the atmosphere and therefore greatly reduce the effect of anthropogenic induced climate change. Terrestrial ecosystem carbon uptake is the least understood process in the global carbon cycle. It is vital that we improve understanding in order to better constrain predictions of future carbon budgets (IPCC report).

- Thesis aims and outline.

2 Literature Review and Background

- Variational data assimilation, in particular 4D-Var. Possibly also touch on MCMC techniques. Automatic differentiation for TLM and minimisation routines in Python.

- DALEC2 and the processes it models.

- Information Content (IC) measures.

- Desroziers and how to represent B and R.

- NEE measurements, error and footprint model.

3 Methods

- Outline of Leaf Area Index (LAI) measurement campaign and other work at Forest Research.

4 4D-Var and information content in carbon balance observations with DALEC2

- Implementation of DALEC2 in a 4D-Var scheme for parameter and state estimation.

- Introduce explicit expressions for information content for observations relating to DALEC2 at a single time.

- Results from IC experiments.

- Begin by considering IC in the context of a set of twin experiments using DALEC2.

- Measures: Shannon information content, degrees of freedom for signal, influence matrix and adjoint Sensitivity.

- Apply results to actual data acquired from Alice Holt.

- Results: temporal information content in observations. What set of observations is best?

- Investigate effect of data drop out, miss-specification of errors (twin experiments), quantity and time of sampling.

- Future work: Use SiPNET model to repeat IC experiments.

5 Improving the representation of background and observational error covariance matrices in carbon balance models

- Following on from chapter one (IC in Carbon pool obs. $>$ IC in NEE obs., no. of Carbon pool obs. $<<$ no. of NEE obs.). Spread info in NEE obs. by moving away from a diagonal representation of the observation error covariance matrix, R.

- Hopefully use a method such as Deroziers to improve our estimates of both B and R. Does this improve our results from the data assimilation experiments? Could use twin experiments here.

- Apply this to 4D-Var and MCMC techniques to compare effect on both.

- Future work: If method effective apply to JULES 4D-En-Var with empire.

6 Effect of disturbance on the Alice Holt research forest

- Split NEE data into multiple data sets using flux tower footprint model, then parameterise DALEC2 for each data set. Compare the differences between the parameterisations with particular focus on the thinned/unthinned halves of the forest.

- Compare the model parameters for LAI to observations taken in a planned field work campaign. From the field work is there a distinct difference between thinned/unthinned sides of the forest.

- Any changes to model (variable time step, phenology)? Could implementing a better phenology model in DALEC2 improve our LAI estimates and maybe capture litter fall more accurately? (More thought need here)

- Inclusion of understory hazel in DALEC2, does this improve our estimates? Comparison with Eric's SPA which includes understory.

7 Conclusion

- Summary and future work.