Thesis Outline

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1 Introduction

- Why is understanding the carbon balance of forests important?
- Terrestrial ecosystems and oceans are 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.
- Representation of background and observation error and error correlations in data assimilation.
- Ecosystem models.
- DALEC2 and the processes it models.
- Information Content (IC) measures.
- Net Ecosystem Exchange (NEE) measurements, error and footprint model.

3 Methods

- Automatic differentiation for DALEC2 tangent linear model in Python (AlgoPy package).
- Outline of Leaf Area Index (LAI) measurement campaign (ceptometer, hemispherical photographs and litter traps) and other work at Forest Research.

4 4D-Var and improving the representation of background and observational error covariance matrices in carbon balance models

- Work from the attached paper draft.
- Implementation of DALEC2 in a 4D-Var scheme for parameter and state estimation.

- Investigation into effect of including parameter-state error correlations in the background error covariance matrix, B, and correlations between observation errors in time in the observation error covariance matrix, R.
- Results: Including parameter-state error correlations in B can significantly improve data assimilation forecast results. Including serial correlations between NEE observation errors in R also improves the assimilation forecast and we expect this to have a greater impact when assimilating more than one data stream.
- Future work/if time: Use Deroziers method to improve our estimates of both B and R. This will involve changing the Deroziers diagnostic so that it is applicable to a time window of observations in 4D-Var. Investigate the effect on our results from the data assimilation experiments. Using twin experiments with known error covariances to validate method.

5 Information content in carbon balance observations with DALEC2

- Introduce explicit expressions for information content for observations relating to DALEC2 at a single time.
- Measures: Shannon information content, degrees of freedom for signal, influence matrix and adjoint sensitivity.
- Consider IC in the context of a set of twin experiments using DALEC2.
- 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.
- Investigate information content in NEE and Total Respiration (RT) observations when observations are treated as half hourly, averaged twice daily or averaged daily by using a variable time step in DALEC2.

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?
- Implement a better phenology model in DALEC2 in order to improve our LAI estimates and possibly capture litter fall more accurately.
- Inclusion of understory hazel in DALEC2, does this improve our estimates? Comparison with Eric Casella's version of SPA, parameterised for Alice Holt, which includes understory.

7 Conclusion

- Summary and future work.