LandscapeDNDC used to model nitrous oxide emissions from soils under an oak forest in southern England

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1 INTRODUCTION

The IPCC obliges signatory countries to reduce greenhouse gas emissions by 20% by 2050. It is expected that this will require the use of Tier 3 tools for inventory reporting in the UK and this work initiates the assessment of one such tool, as part of a PhD project.

AIMS:

- Understand and help to develop the LandscapeDNDC model for use with 2 contrasting forests in the UK, starting with the Straits Enclosure oak forest at Alice Holt in Hampshire, in SE England;
- Validate modelled N_2O, NO_x and CO_2 values with measured data;
- Quantify N_2O, NO_x and CO_2 emissions from the selected forests;
- Identify factors affecting the variations in these emissions.

NO_x soil emission data measurements will start in mid April 2013.

2 STRAITS ENCLOSURE

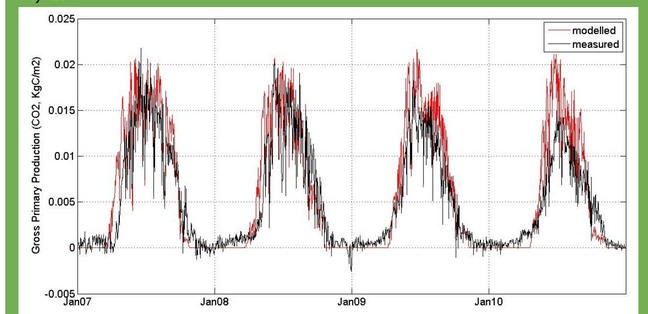
The Straits Enclosure is a small oak forest, 90 ha in size, planted in 1935 and situated in Hampshire, about 75km SW of central London. The canopy consists mainly of *Quercus robur* and *Quercus petraea* and is managed by Forest Research, the research agency of the Forestry Commission. There is a significant undergrowth of hazel, hawthorn, brambles and grasses in the western half of the forest. The eastern half was thinned in 2007.

The forest and its soils have been measured and monitored since 1949. In 1994 a Level II site was established within the forest for monitoring within the Environmental Change Network and in 2006 it became the first of three official research forests in the UK to facilitate integrated, cross-disciplinary study. A FLUXNET tall tower was established in 1999 in the centre of Straits to measure CO_2 fluxes using the eddy co-variance principles.

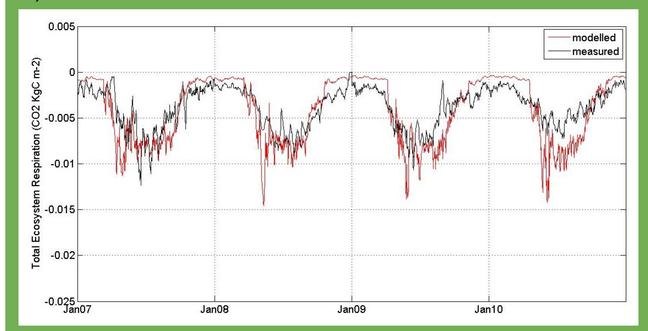
Latitude		51° 10′ N
Longitude		0° 50′ W
Altitude		80m AMSL
Slope		0
Mean annual temperature (1960-1990)		9.5°C
Mean annual rainfall (1960-1990)		780mm
Total N deposition	1996 1997	9.1 kg ha-1 7.4 kg ha-1
Soil		Pelo-stagnogley with a depth of 80cm to C horizon of Cretaceous clay
Soil organic carbon	at 5cm at 30cm	2.7% 1.6%

4 RESULTS

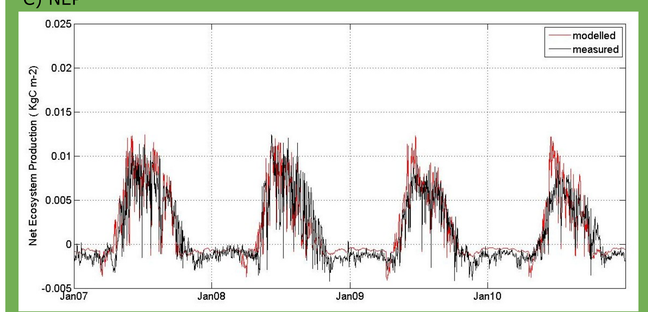
A) GPP



B) TER



C) NEP



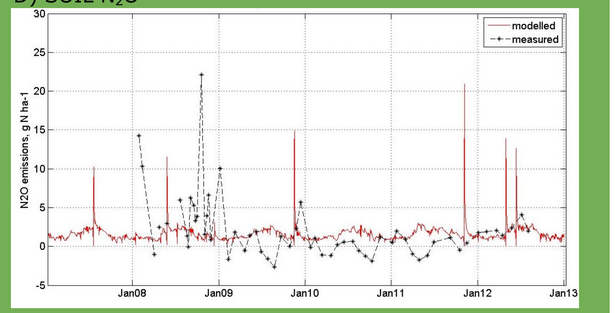
The model was run from 1995 –2012 using local daily meteorological data as input. Results shown are daily figures for years 2007—2010 when measurements of soil emissions and eddy-covariance data are available and years 1999-2008 for soil moisture.

A-C) Above-canopy eddy covariance measurements (Wilkinson et al, 2012) are of Net Ecosystem Exchange (NEE = -NEP). Total Ecosystem Respiration (TER) is derived from measured night-time CO_2 levels and day time temperatures. Gross Primary Production (GPP) is then calculated from adding TER and NEP. In 2009 and 2010, reduced GPP and NEP are thought to be due to an infestation of defoliating moth larvae (Wilkinson et al., 2012).

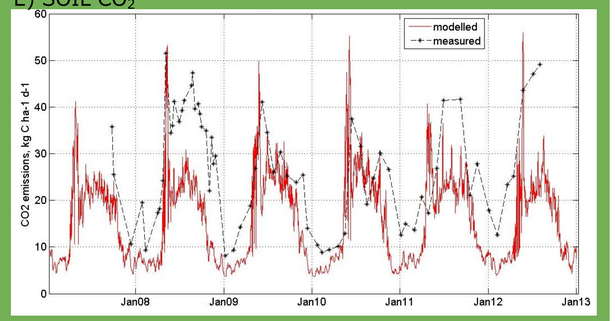
D-E) Soil chamber measurements of N_2O and CO_2 were made at 6 sites within the forest at intervals throughout the day for 41 days between 2008 and 2010, about every 2 weeks. Figures shown are daily averages for the 6 sites (preliminary data)

F-G) Soil temperature and soil moisture have been averaged from recordings made every 30 min. at 10cm. The water table is at 100cm for much of the year.

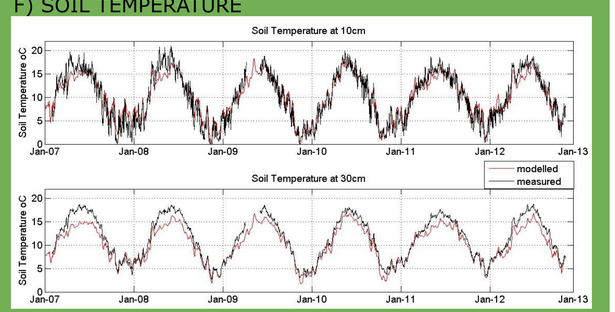
D) SOIL N_2O



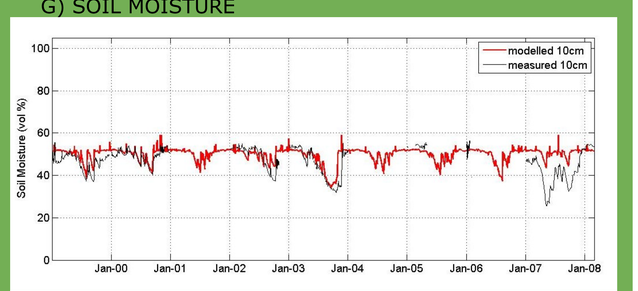
E) SOIL CO_2



F) SOIL TEMPERATURE



G) SOIL MOISTURE

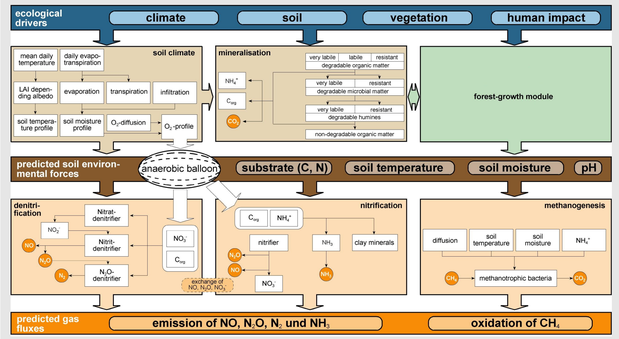


3 LandscapeDNDC MODEL

LandscapeDNDC (Haas et al 2012) is a recently developed process-oriented model, based on the biogeochemical model, DNDC (Li et al, 2000), in order to simulate biosphere-atmosphere-hydrosphere exchanges at a site and regional scale. It can model forest, agricultural and grassland ecosystems and allows modelling of regional land use change over time.

It is tested here at the site scale for an oak forest in SE England. Results shown are compared with measured data for above canopy carbon dioxide fluxes, soil chamber CO_2 and N_2O emissions, soil temperature and soil moisture values.

A schematic diagram of the site level DNDC model is given below,



5 CONCLUSIONS

After calibrating tree growth parameters LandscapeDNDC simulations show a reasonable match for the seasonal variations in:

- CO_2 from both eddy co-variance and soil chamber measurements
- N_2O from soil chamber measurements
- Soil temperature and soil water content

The scale of N_2O soil emissions is less well modelled and N_2O uptake is not currently possible in the model.

Further work is required to establish whether improvements can be made in the modelling. Soil chamber measurements for NO_x, N_2O, CO_2 will be made together for a full year commencing mid April 2013.

REFERENCES

HAAS, E., KLATT, S., FRÖHLICH, A., KRAFT, P., WERNER, C., KIESE, R., GROTE, R., BREUER, L. and BUTTERBACH-BAHL, K., 2012. LandscapeDNDC: a process model for simulation of biosphere –atmosphere–hydrosphere exchange processes at site and regional scale. *Landscape Ecology*, ***28***, 4.

LI, C., ABER, J., STANGE, F., PAPEN, H. and BUTTERBACH-BAHL, K., 2000. A process-oriented model of N2O and NO emissions from forest soils: 1. Model development. *JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES*, **105**(D4), pp. 4369-438 .

WILKINSON, M., EATON, E., BROADMEADOW, M. and MORISON, J., 2012. Inter-annual variation of carbon uptake by a plantation oak woodland in south-eastern England. *Biogeosciences Discuss*, **9**, pp. 9667-9710

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