

Model functions at
scale of decisions
on land management

Not individual plants,
microsites in soil,
detailed root
architecture etc

Using the ECOSSE model to
simulate the impacts of
land use and climate change on
GHG emissions
from tropical peats

Model must
extrapolate beyond
current conditions

Mechanistic
description

Jo Smith, Jenny Farmer, Jodie Harthill

Type of Model

Detailed models
describing of individual
plants and microsites

Mechanistic models
that can extrapolate
beyond current
conditions, driven by
data available at the
selected scale

ECOSSE

Statistical models that
interpolate available
data

ECOSSE

Derived from two existing models...



ECOSSE

Smith et al, 2010

RothC is a pool model

Pool Models

Assumption: SOM in each pool is uniform (acts as a single molecule)



Assumption: Rate dependent on concentration of R_1 only

$$\frac{-d[R_1]}{dt} = k_1[R_1] \xrightarrow{\text{which integrates to...}} [R_1]_t = [R_1]_0 \exp(-k_1 t) \text{ (abc)}$$

dt: Rate of decomposition
 k_1 : Rate constant
 $[R_1]$: Concentration of R_1
 $[R_1]_t$: Concentration of R_1 at time t
 $[R_1]_0$: Concentration of R_1 at start
 $\exp(-k_1 t)$: Rate of exponential decay
 (abc): Environmental rate modifiers

Structure of RothC

Pool Models

RothC
(Jenkinson, 1977)

DPM

Decomposable plant material

DPM:RPM is set

by land use type

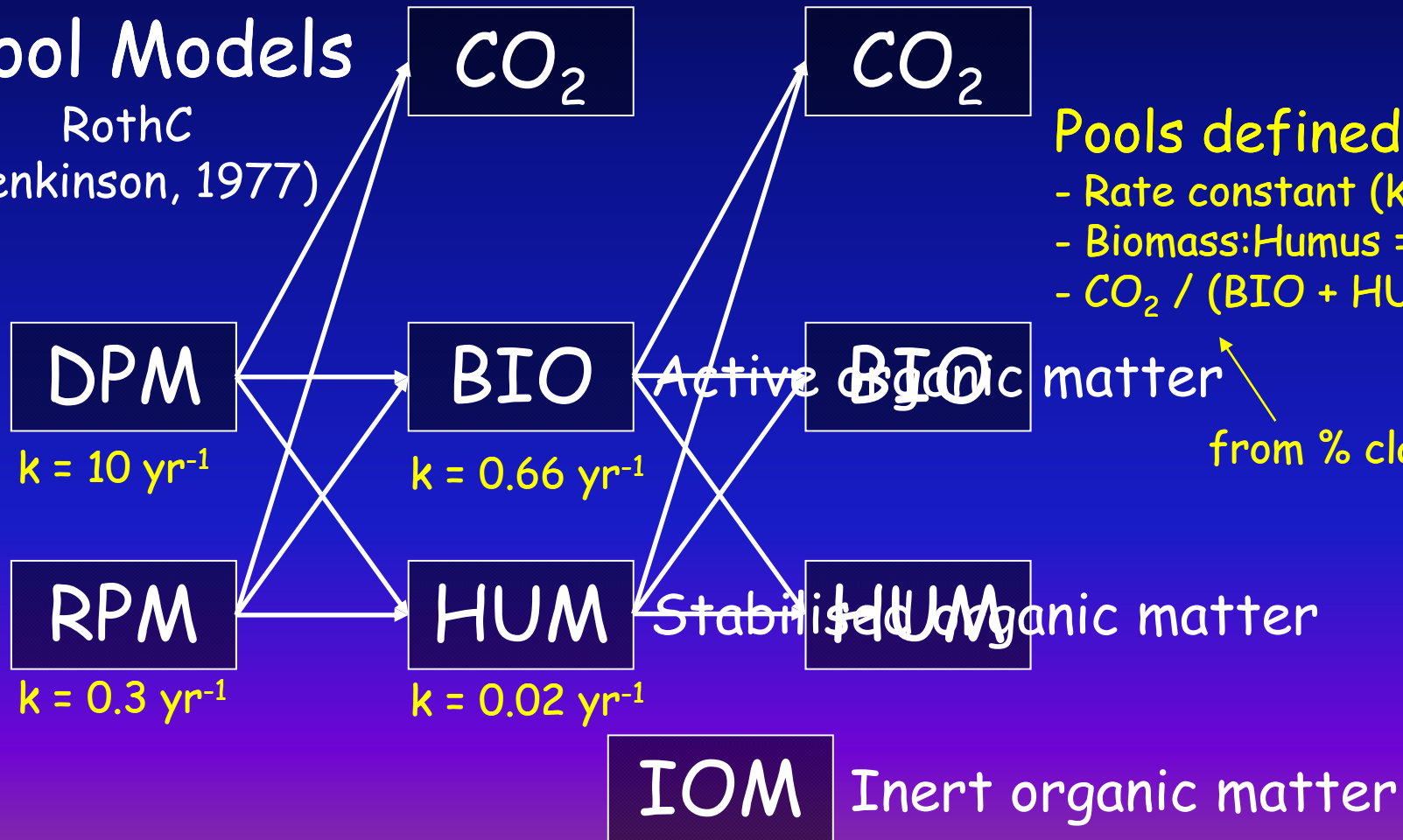
RPM

Resistant plant material

	<u>DPM:RPM</u>
Arable / Improved grassland	1.44
Unimproved grassland / Scrub	0.67
Deciduous / Tropical woodland	0.25

Structure of RothC

Pool Models
RothC
(Jenkinson, 1977)

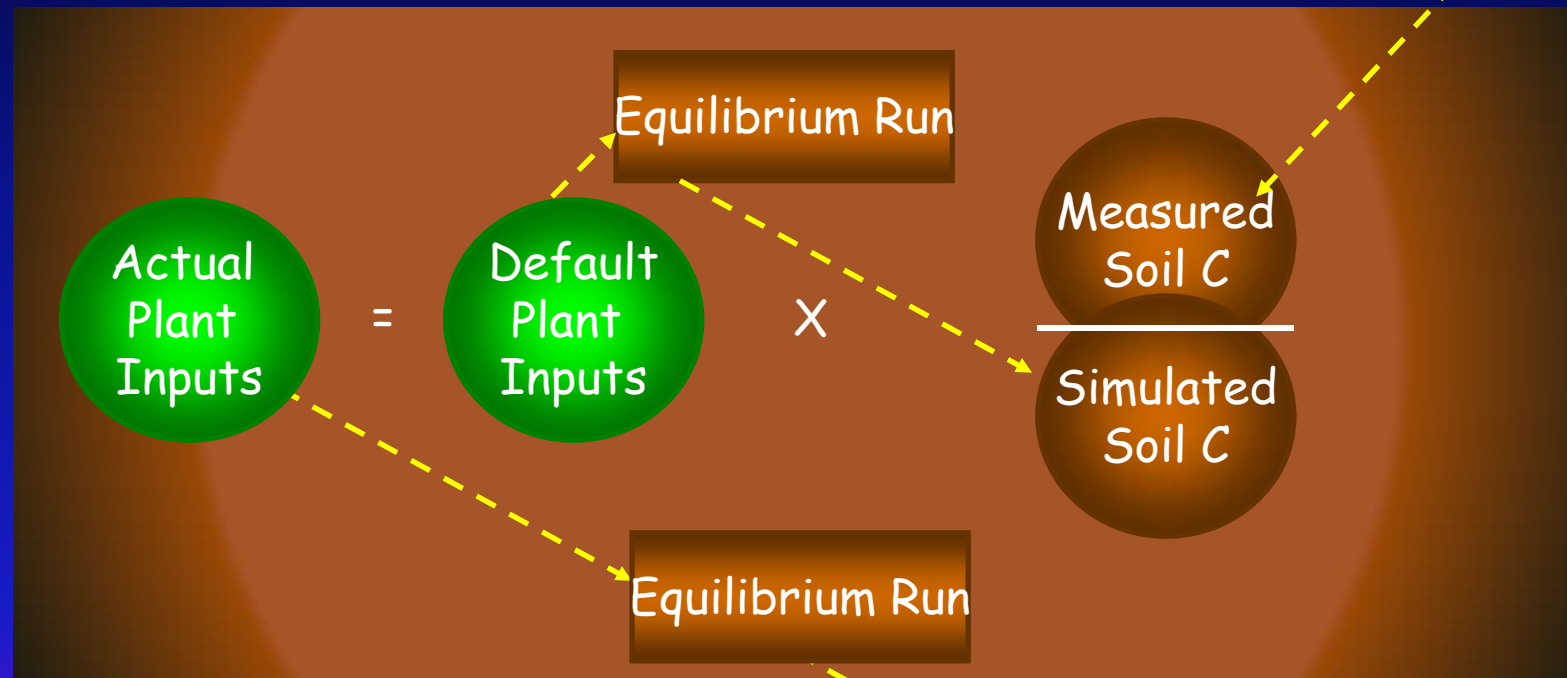


Pools defined by

- Rate constant (k)
- Biomass:Humus = 0.85
- $\text{CO}_2 / (\text{BIO} + \text{HUM})$

from % clay

How can RothC be used in global simulations?



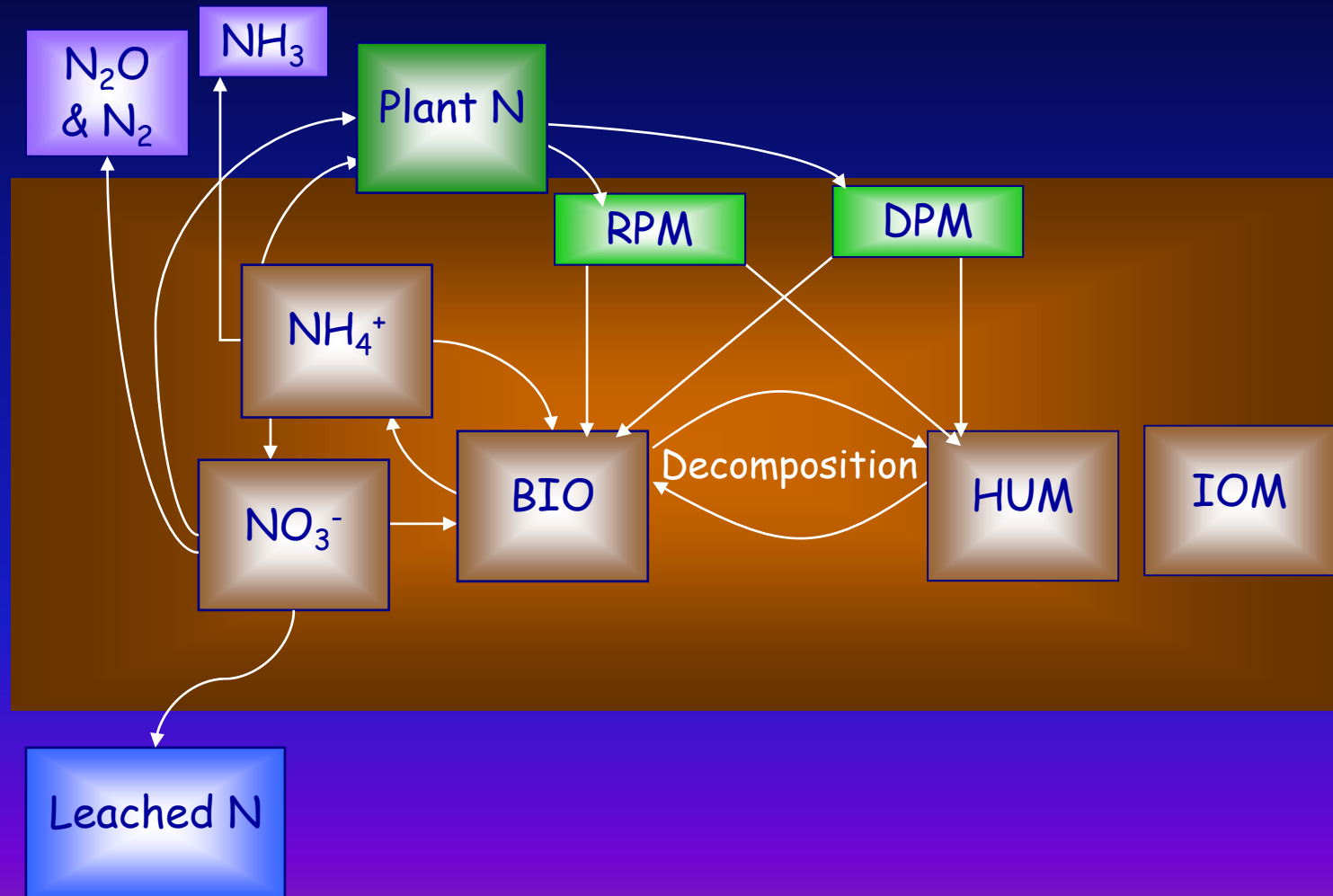
Initialisation -
the equilibrium
run

Using RothC to simulate GHG emissions from tropical peats

- Global / regional simulations of CO₂ losses from soils
 - Jenkinson et al 1991, Nature 351, 304 - 306
 - Smith et al 2000, Global Change Biology 6: 525-539
 - Smith et al 2005, Global Change Biology 11, 2141-2152
- Not suitable for anaerobic or highly organic soils
 - Lacks rate modifiers for
 - anaerobic conditions
 - soil pH
 - Cannot deal with soils that are not in steady state

SUNDIAL (SimUlation on Nitrogen Dynamics in Arable Land)

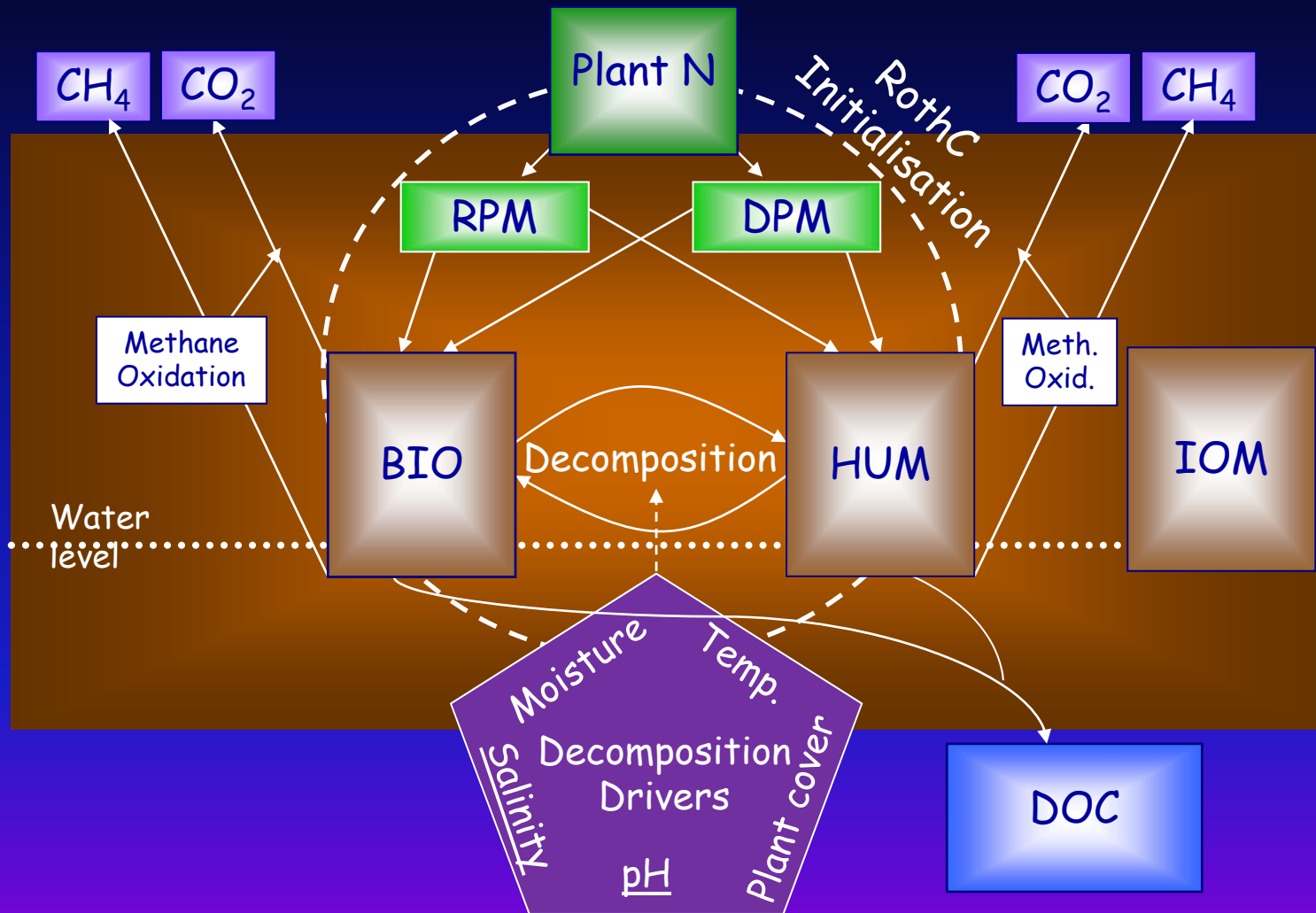
(Bradbury et al, 1993; Smith et al, 1996)



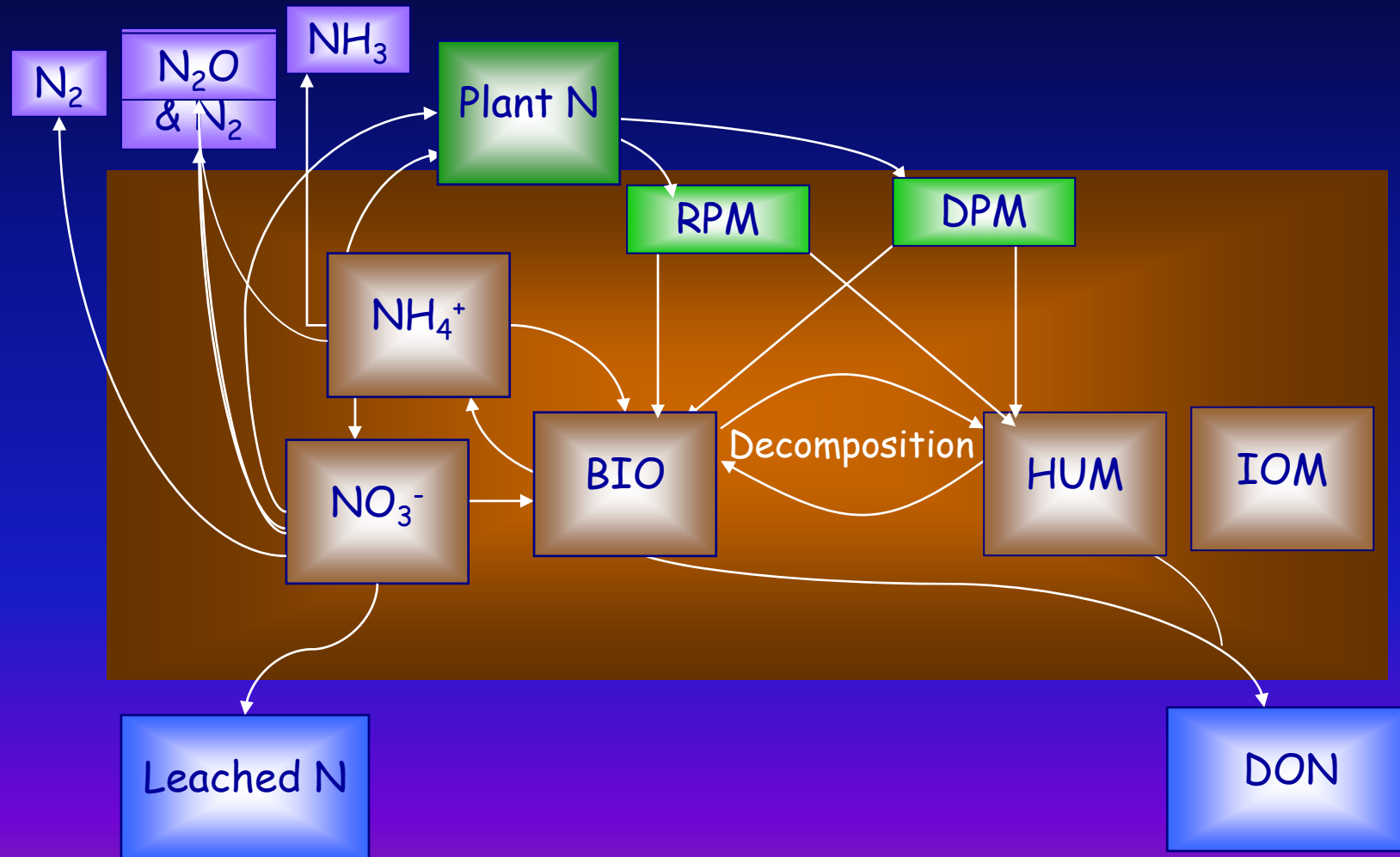
Using SUNDIAL to simulate GHG emissions from tropical peats

- Field-scale simulations of CO_2 and denitrification losses from arable soils
- No simulation of CH_4
- Not suitable for anaerobic or highly organic soils

Carbon Component of ECOSSE



Nitrogen Component of ECOSSE

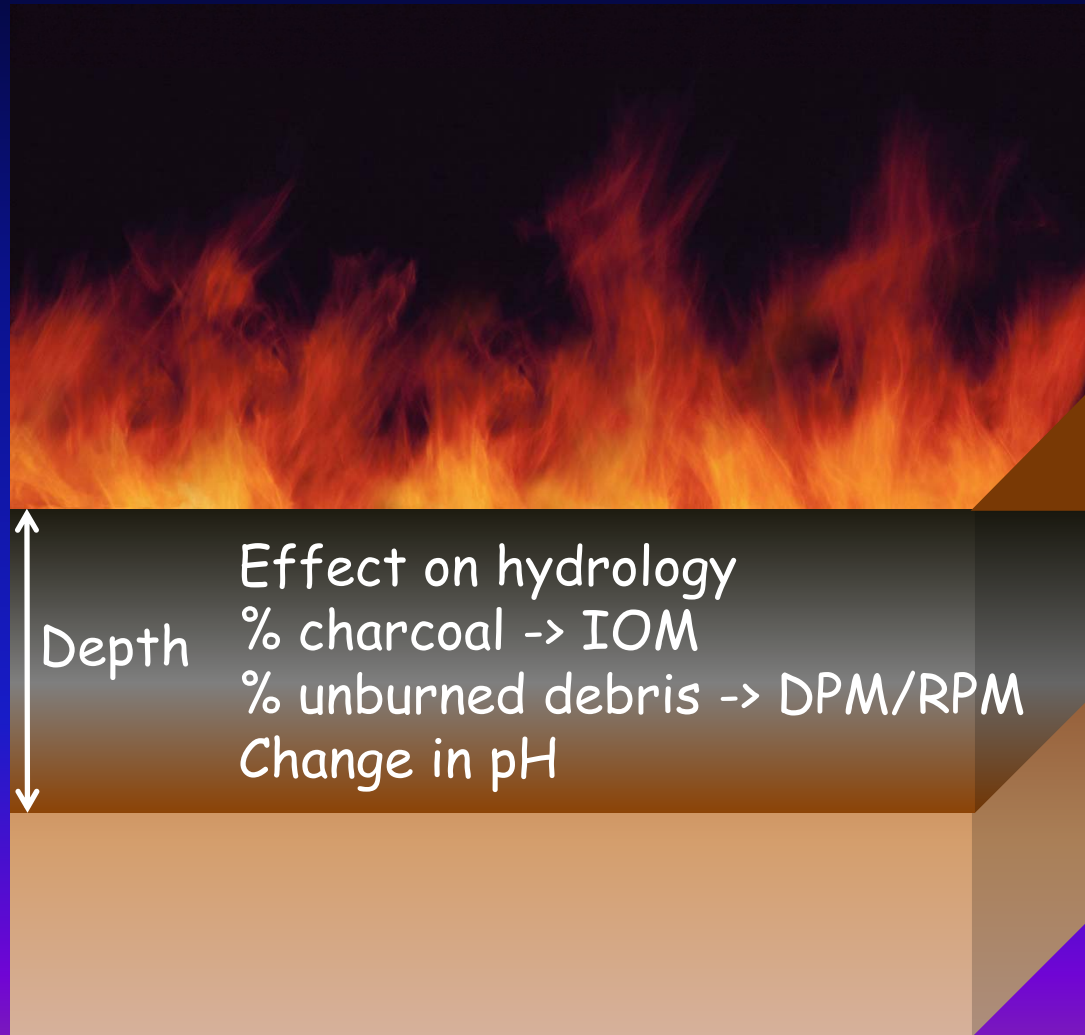


Using ECOSSE to simulate GHG emissions from tropical peats

- Field to global scale simulations of CO_2 , N_2O and CH_4 losses from soils
- Suitable for anaerobic and highly organic soils
- Tested in Scotland!
- Tropical soils - likely to require adaptation on
 - vegetation types
 - impacts of fire

Impacts of fire

Burnt layer
of soil



Jenny Farmer PhD work...

Supervised by Robin
Matthews, Jo Smith and
Pete Smith





Rate measurements

- Rates of CO_2 emissions from the two categories of sites:
 - Shallow peat
 - Logged forest, oil palm (1 yr, 5 yrs)



- Deep peat
 - Intact forest, logged forest, oil palm (3yrs, 5 yrs T&N)



Rate Measurements

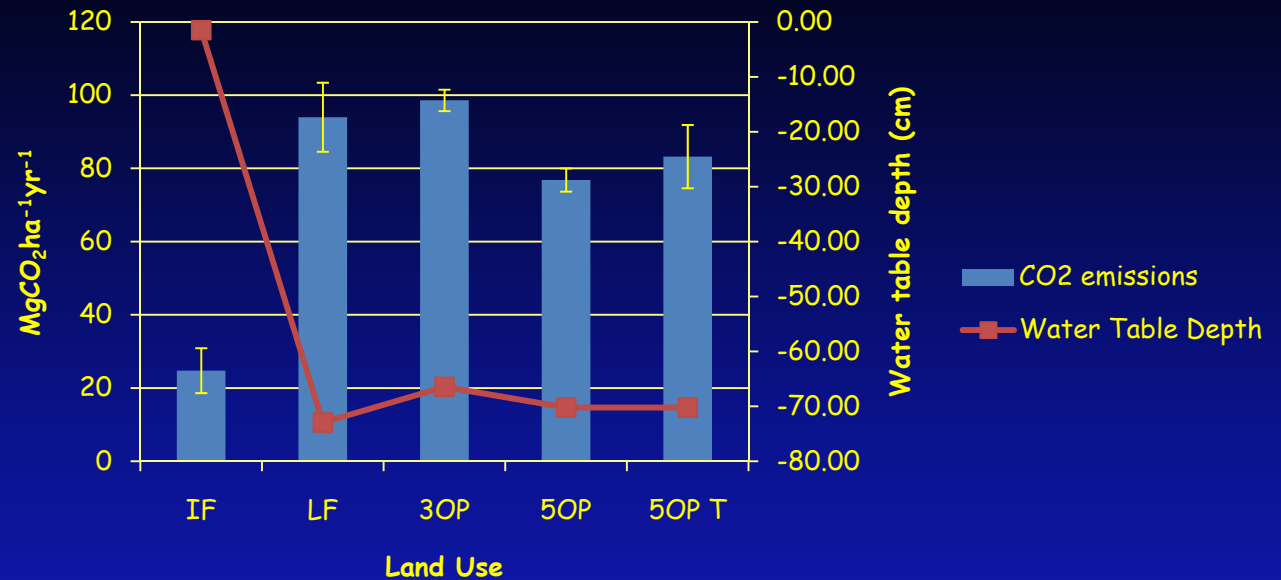
- 30 collars per land use
- Using a PP Systems EGM-4
 - Uses a gas analyser, the same as an IRGA but much more compact



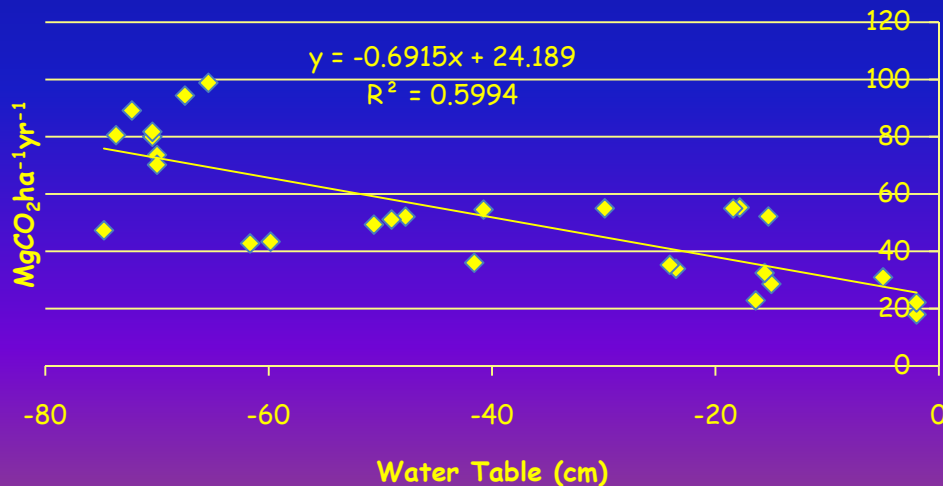


CO₂ Emissions Results

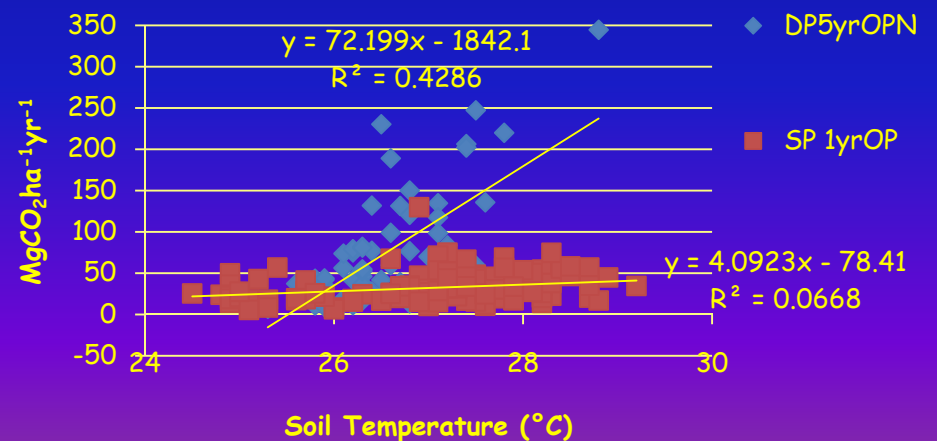
Deep Peat Sites CO₂ Emissions and WT



Average WT vs Average Emissions At All Sites

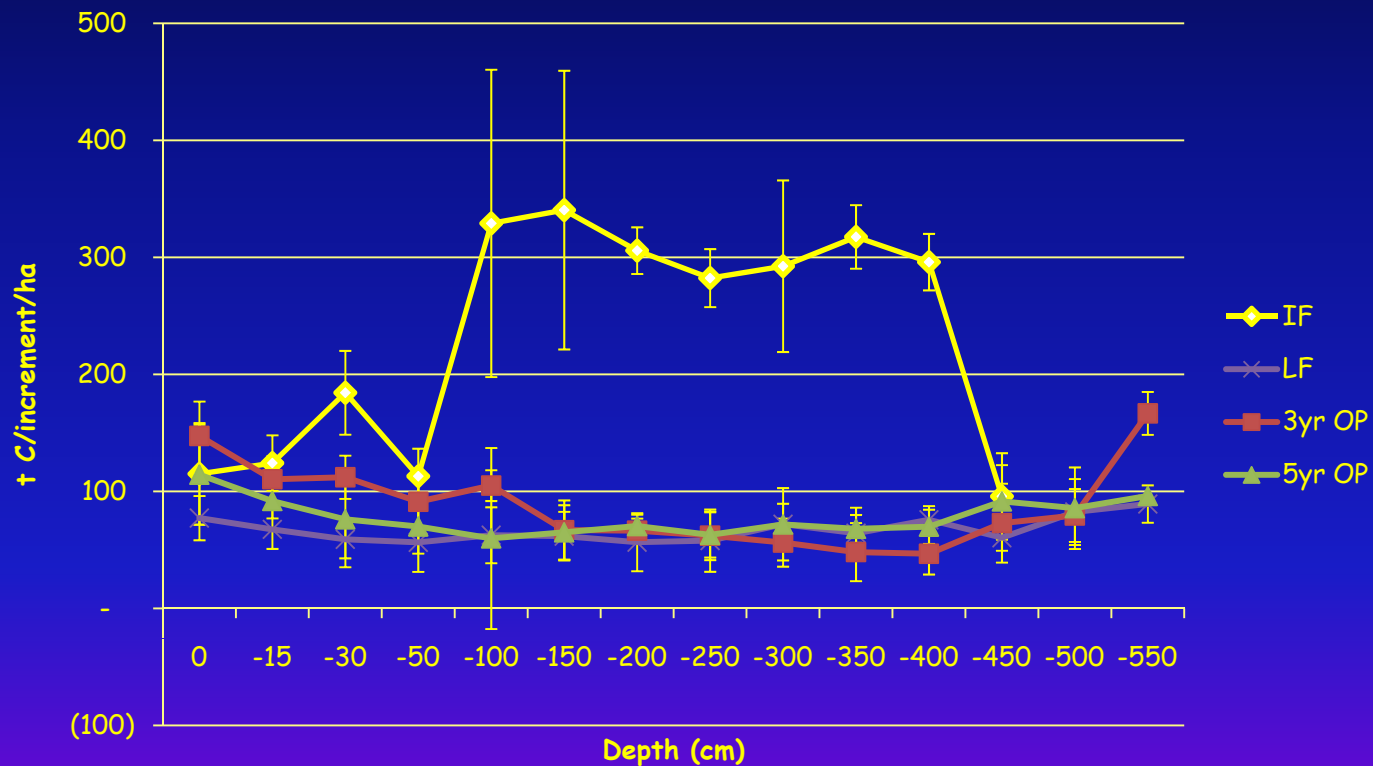


Soil Temperature And Emissions



Soil C Values

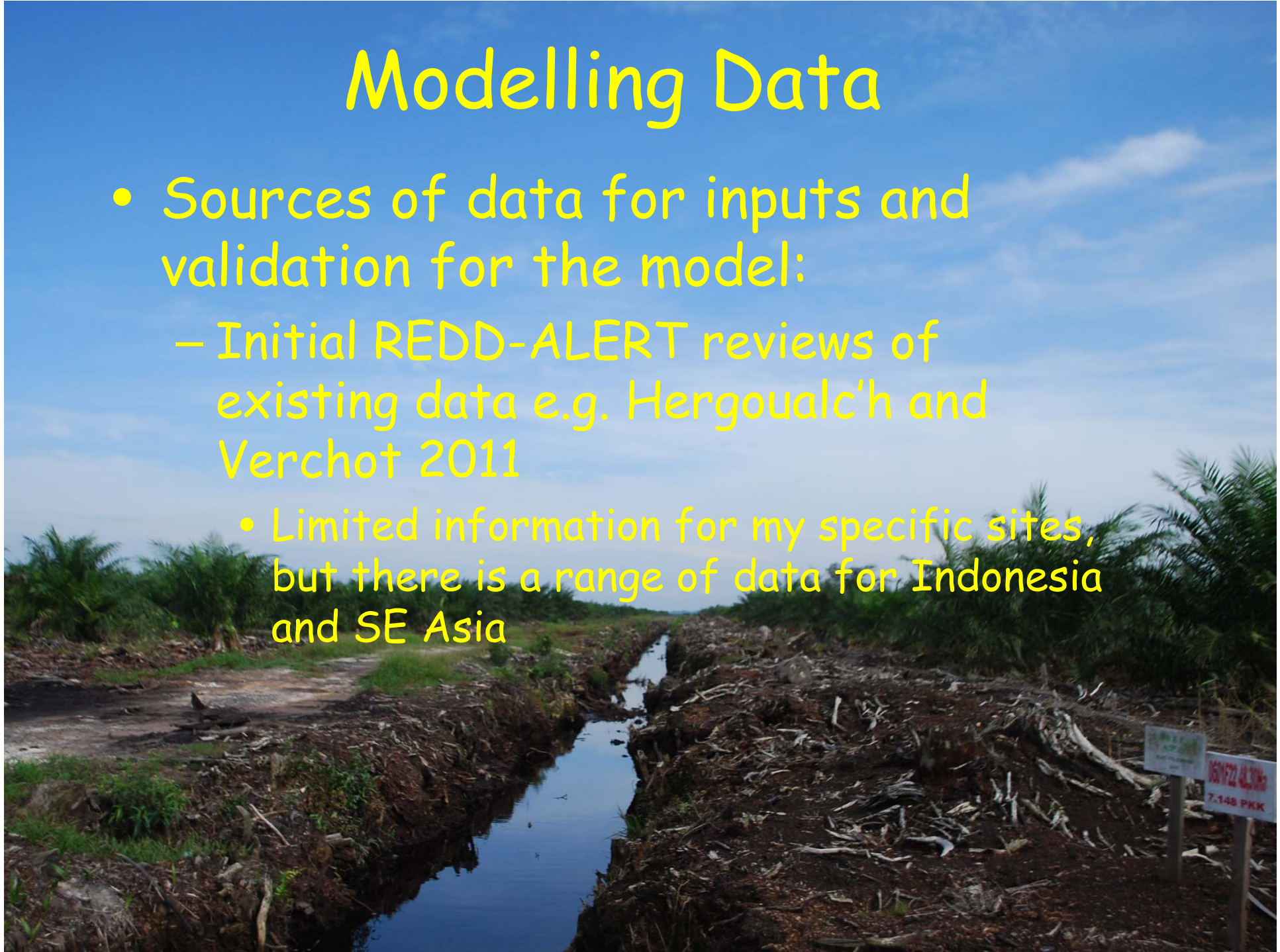
Average soil C in each deep peat land use



Marwanto and
Farmer
unpublished

Modelling Data

- Sources of data for inputs and validation for the model:
 - Initial REDD-ALERT reviews of existing data e.g. Hergoualc'h and Verchot 2011
 - Limited information for my specific sites, but there is a range of data for Indonesia and SE Asia



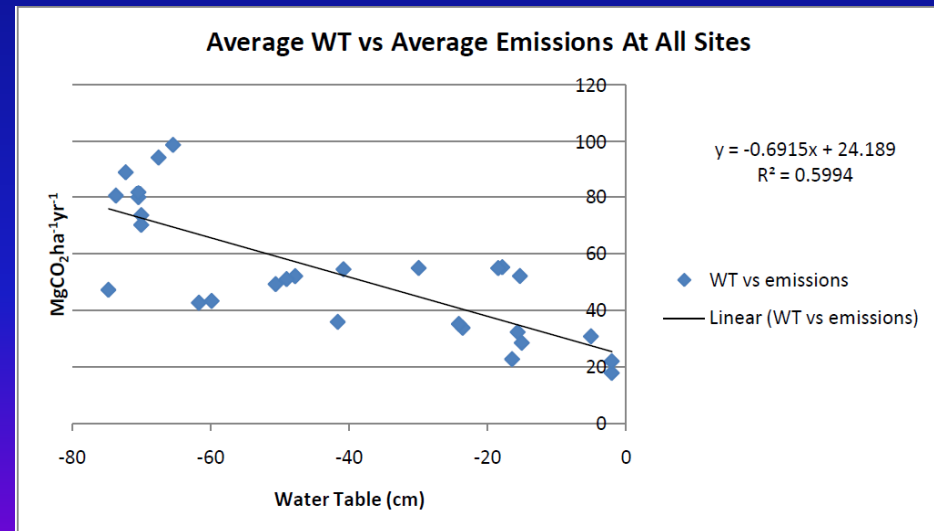
Sources of Modelling Data Cont.

- Fieldwork of other REDD-ALERT team members e.g. Setiari Marwanto of ISRI
 - Soil C, BD, soil profile
- My own research
 - CO₂, temp, pH, water table
 - Soil C, BD, soil profile
- New research as it comes in i.e. from new REDD-ALERT researchers
 - CH₄, N₂O
 - Can request additional work



Starting with Roth C

- Only CO_2 emissions, no field values for CH_4 and N_2O .
- Trends in field results (e.g. between temperature and CO_2 emissions and water table and CO_2 emissions) indicated the potential for Roth C application.

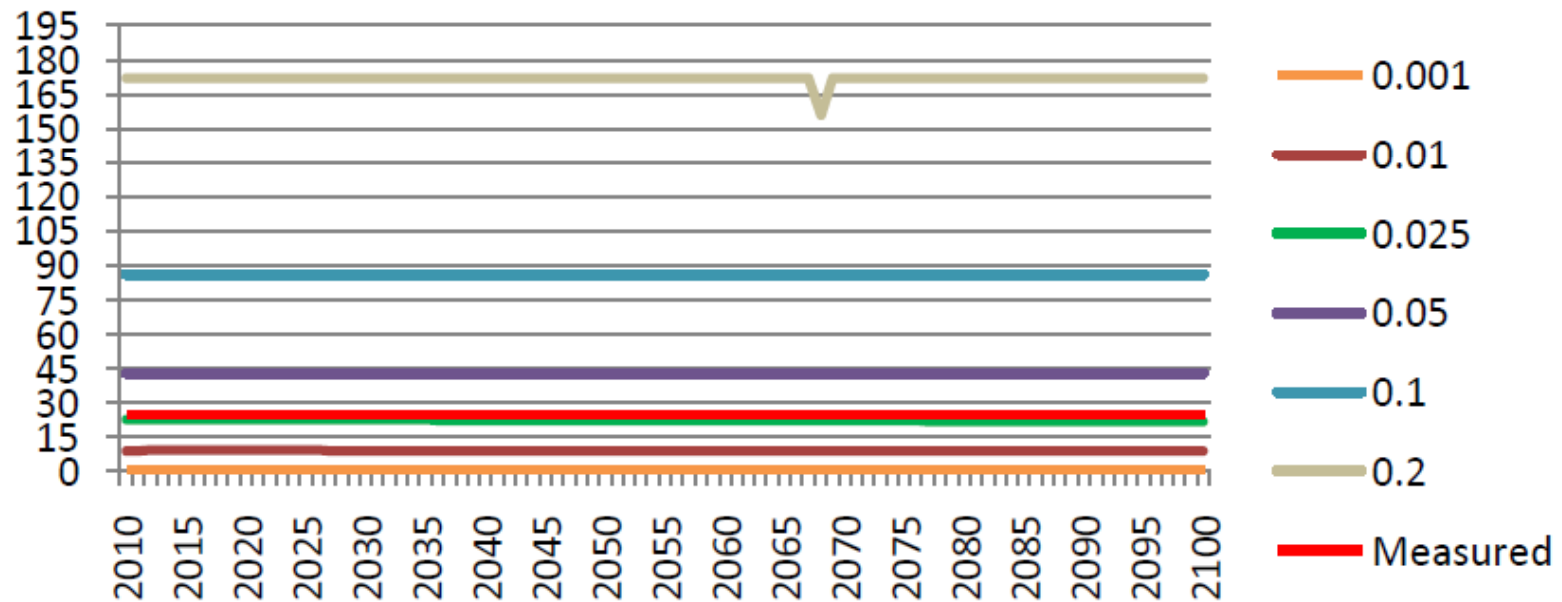


Adding Submerged Modifier

For steady state site (intact forest):

```
C
C
C ** Combining rate modifiers
C
C DO 160 M=1.12
C   RMSMD(M)=0.2
C   RATEM(M)=RTEMP(M)*RMSMD(M)*RMCROP(M)*RMPH*EXTRARM*RMSAL(M)
C 160 CONTINUE
C
```

Annual CO2 Emissions For Each Modifier Value



Future work

- Having initialised Roth C with our initial data set...
- Field sampling for further data on new and old sites:
 - CO_2 emissions,
 - wilting point and field capacity values,
 - partitioning of respiration,
 - evaluating the impact of burning on soil C and the IOM pool.
- All needed to run Roth C and later ECOSSE.



Using ECOSSE...

- Will start using ECOSSE once we have further field data (March/April 2012).
- Aim to initialise ECOSSE for these sites.
- Scaling up of site specific to national level.

```
C:\DOCUME-1\03jf9\LOCALS-1\Temp\Temporary Directory 2 for ecosse...
*****
E C O S S E
Estimator of C in Organic Soils: Sequestrn & Emissions

-----
ECOSSE VERSION 5
-----
Modular SUNDIAL-MAGEC
+ 5cm layers for all soil states
*****
Choose mode of model run
1 = Site specific
2 = Spatial simulation of cells
3 = Limited data site simulation
4 = Test run of USD
_
```

Carbon Calculator

- Based on the idea of the windfarm calculator
- Being developed to assess the impacts of oil palm plantations on peatlands
- Aims to be user friendly i.e. for plantation managers, policy makers.
- Using elements of Roth C to calculate emissions

The screenshot displays the user interface of the 'Scottish Government Carbon Calculator for Wind Farms on Peatlands - Version 2.0.0'. The interface is divided into several sections:

- Header:** Title 'Scottish Government Carbon Calculator for Wind Farms on Peatlands - Version 2.0.0' and date '07/06/2011'.
- Introduction:** A paragraph explaining the calculator's purpose: 'This spreadsheet calculates payback time for windfarm sited on peatlands using methods given in Nayak et al. 2008 (http://www.scotland.gov.uk/Topics/Information/2008/09/26/114572) and revised equations for GHG emissions (Nayak, D.R., Miller, D., Nolan, A., Smith, P. and Smith, J.U., 2010, Calculating carbon budgets of wind farms on Scottish peatland. Mires and Peat 4: Art. 9. Online: http://www.mires-and-peat.net/mag/4/mag_04_09.htm) Adapted to include detail of forestry management.'
- INSTRUCTIONS:** A section with a heading 'A' and sub-sections:
 - 'There are 6 worksheets giving instructions, data entry and outputs, ...'
 - 'Instructions' with a 'Click here' link.
 - 'Do I need to use this tool?' with a 'Click here' link.
 - 'Core input data' with a note 'Data needed in all calculations'.
 - 'Forestry input data' with a note 'Extra details sometimes needed for forestry calculations'.
 - 'Construction input data' with a note 'Extra details sometimes needed for construction calculations'.
 - 'Payback time and CO2 emissions'.
 - '...and 8 numbered worksheets showing calculations:'
 1. Windfarm CO₂ emission saving
 2. CO₂ loss due to turbine life
 3. CO₂ loss due to backup
 4. Loss of CO₂ Fixing Pot.
 5. Loss of soil CO₂
 - 5a. Volume of peat removed
 - 5b. CO₂ loss from removed peat
 - 5c. Volume of peat drained
 - 5d. CO₂ loss from drained peat
 - 5e. Emission rates
 6. CO₂ loss by DOC & POC loss
 - 7i. Forestry CO₂ loss - simple
 - 7ii. Forestry CO₂ loss - detailed
 - 7a. C sequest. in trees (3PG)

- Contributors:** A list of names: 'D. Nayak, J.U. Smith, P. Smith, P. Graves'.
- Logos:** Logos for 'UNIVERSITY OF ABERDEEN', 'The James Hutton Institute', 'Forestry Commission', 'THE UNIVERSITY OF EDINBURGH', and 'University of Glasgow'.
- Footer:** 'Note on official version number'.
- Navigation:** A tabbed interface at the bottom with tabs for 'Instructions', 'Do I need to use this tool?', 'Core input data', 'Forestry input data', 'Construction input data', and 'Payback Time'.

Jodie Hartill - PhD Project outline

- Changes in soil N_2O , N_2 and CH_4 fluxes from the conversion of tropical peat swamps in Jambi, Indonesia.
- Gain greater understanding of the mechanisms controlling the gaseous dynamics in deep peat systems
- Extensive and intensive fieldwork coupled with lab incubations where needed
- Use of pre existing models to simulate data
- Potential to adapt models if needed

Nitrogen Cycling, data analysis and links to modeling

N₂ and N₂O.

- Year round monthly gas sampling
- Intensive soil analysis periods (i.e. Daily over 7days)
- Water table monitoring
- Soil moisture/temperature
- Extractable mineral N and litter fall
- ¹⁵N tagging:
- Mineralization and nitrification potentials

Modeling

- Initially use HIP Model.
- Simple predictors of annual GHG fluxes will be identified
- Then ECOSSE.

Methane

CH₄

- Year round gas sampling
- Links between methanotrophs and water table fluctuations
- Links to N dynamics (AMO and MMO enzymes).

Modeling

- Data analyzed using ECOSSE model
- Potential to initialize the model and continue to use model.

Summary

- ECOSSE offers the opportunity to model GHG emissions from these tropical peatland systems.
- Still working on collecting all the (limited) required data.
- Some progress already with elements of ECOSSE (Roth C).