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

1495 UNIVERSITY OF ABERDEEN

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…

RothC is a pool model

Pool Models

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

$$R_1 \xrightarrow{\text{enzymes}} p_1R_1 + p_2R_2 + p_3R_3 + \ldots CO_2$$

Assumption: Rate dependent on concentration of R_1 only

$$\frac{-d[R_1]}{dt} = k_1[R_1]$$

which integrates to...

$$[R_1]_t = [R_1]_0 \exp(-k_1 t)abc)$$

- Rate of decomposition
- Reaction coefficient
- Concentration of R_1
- Concentration of R_1 at time t
- Concentration of R_1 at start
- Rate constant
- Environmental rate modifiers
- Time

Structure of RothC

Pool Models

RothC
(Jenkinson, 1977)

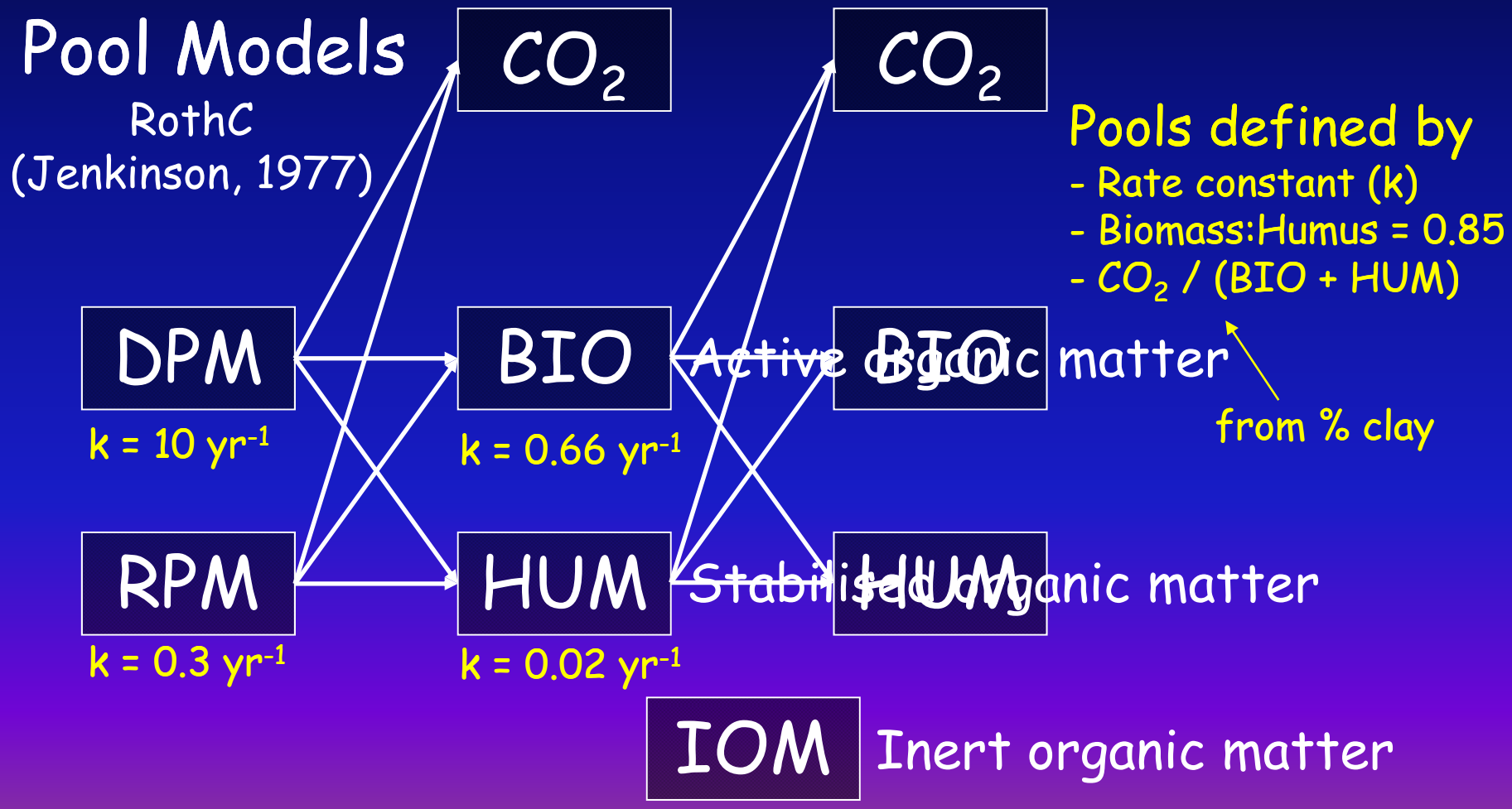
DPM Decomposable plant material

DPM:RPM is set
by land use type

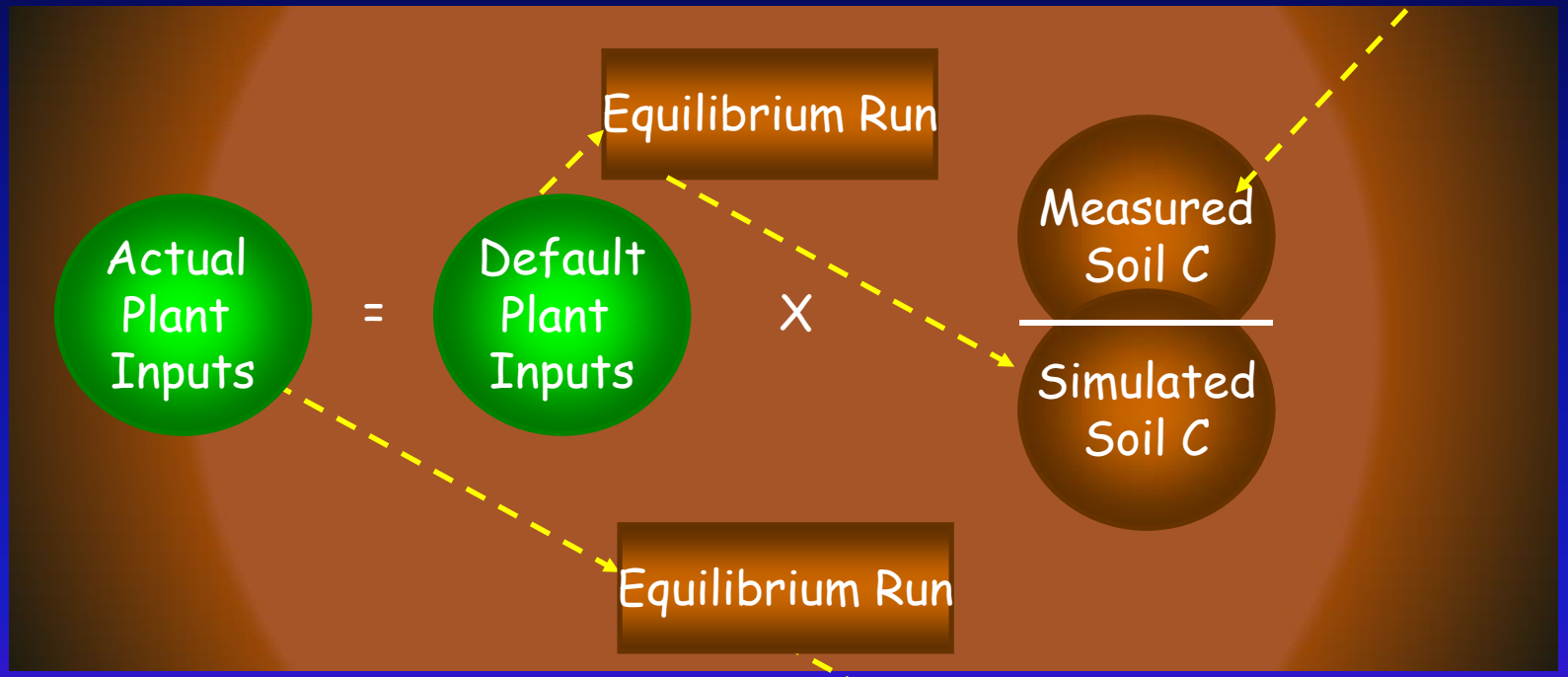
RPM Resistant plant material

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

Structure of RothC



How can RothC be used in global simulations?



Initialisation – the equilibrium run

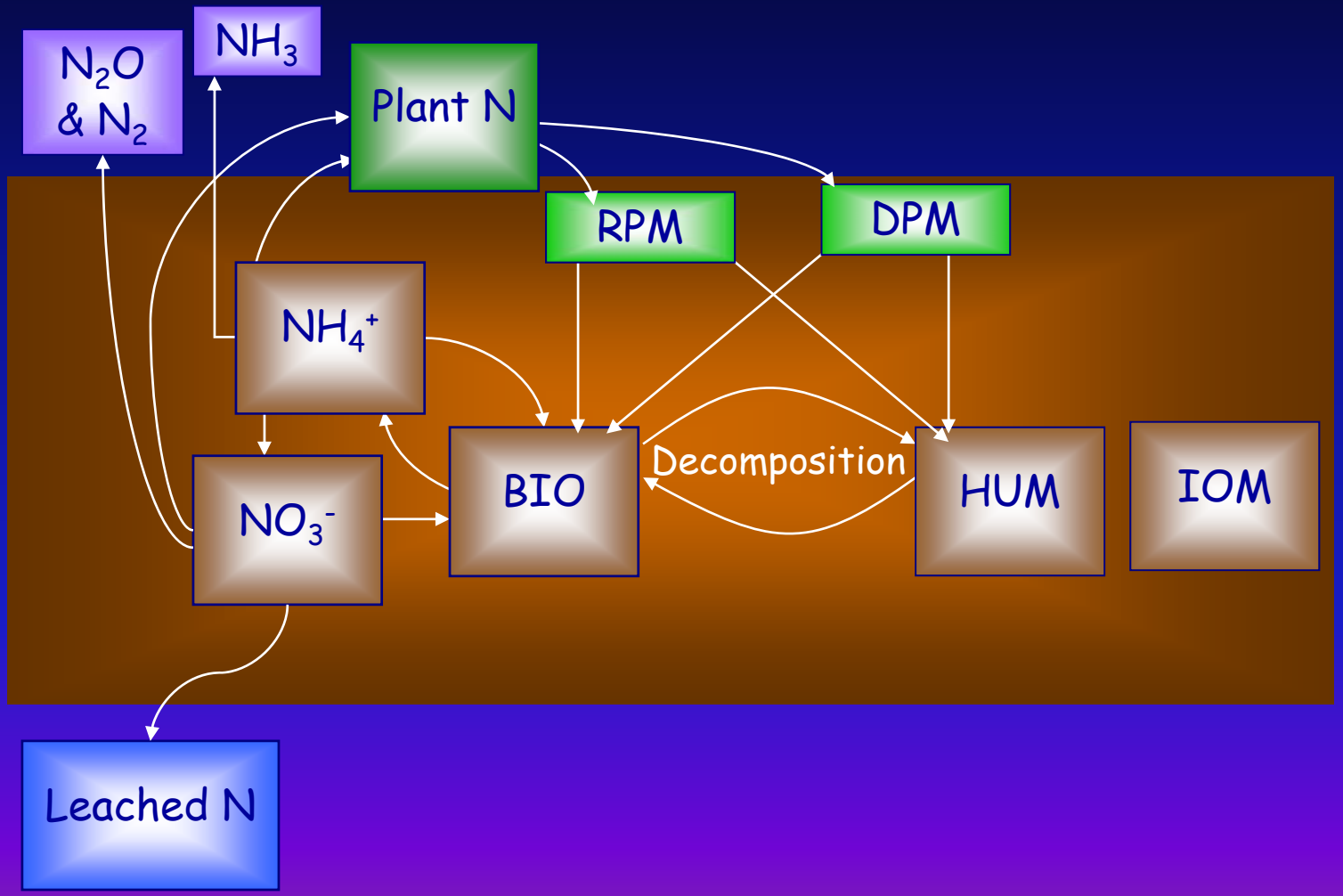
Using RothC to simulate GHG emissions from tropical peats

- Global / regional simulations of CO_2 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

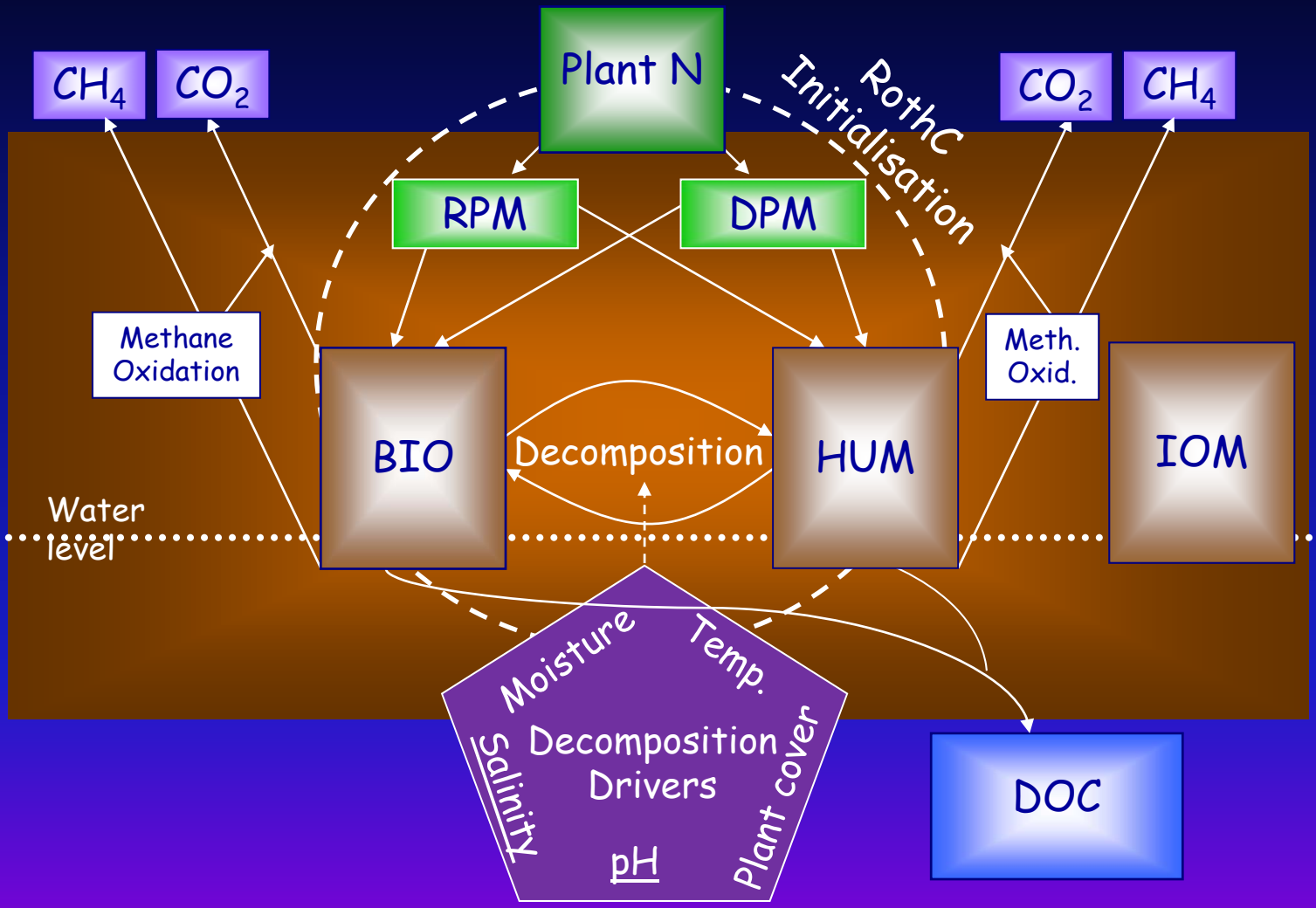
(Bradbury et al, 1993; Smith et al, 1996)



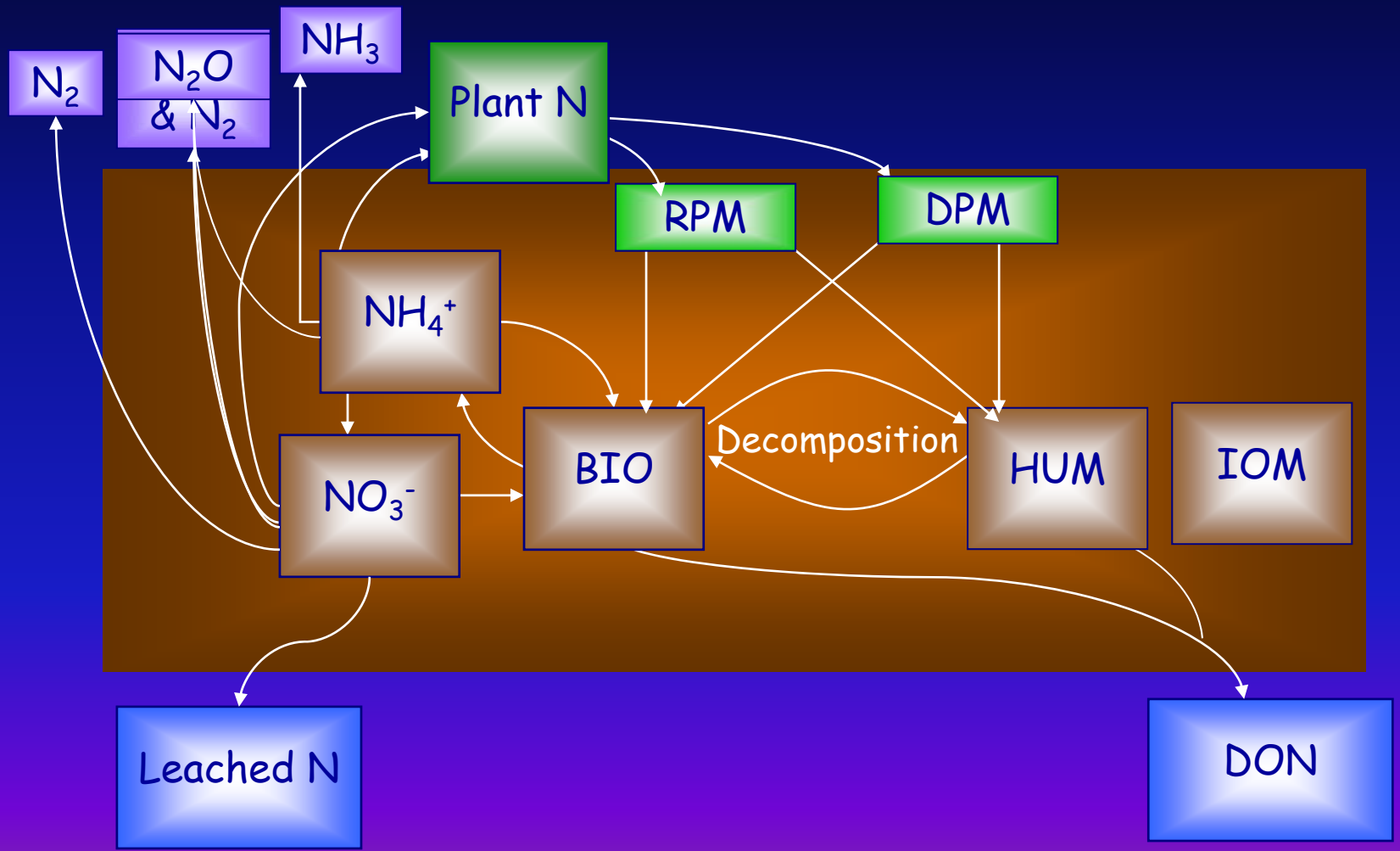
Using SUNDIAL to simulate GHG emissions from tropical peats

- 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

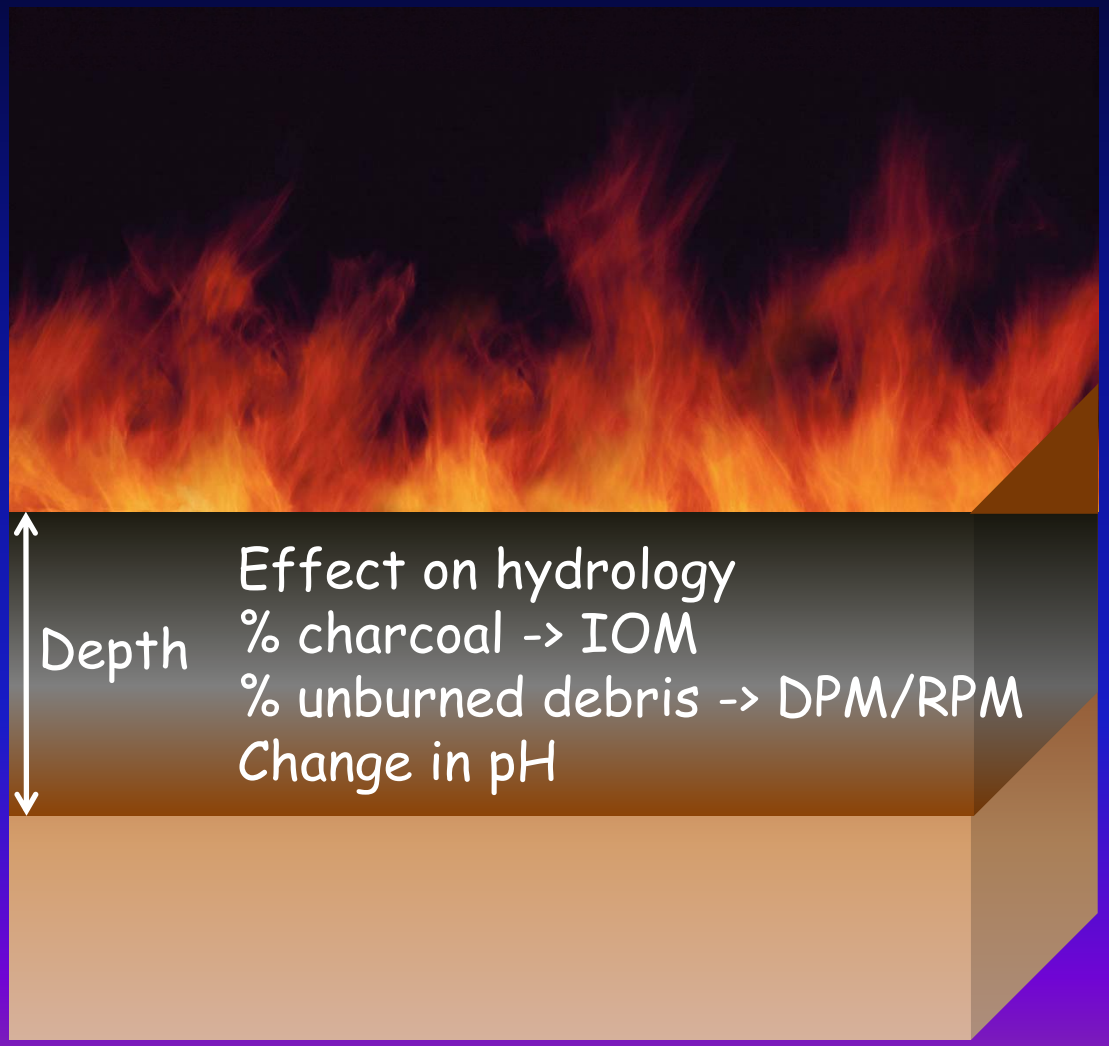


Using ECOSSE to simulate GHG emissions from tropical peats

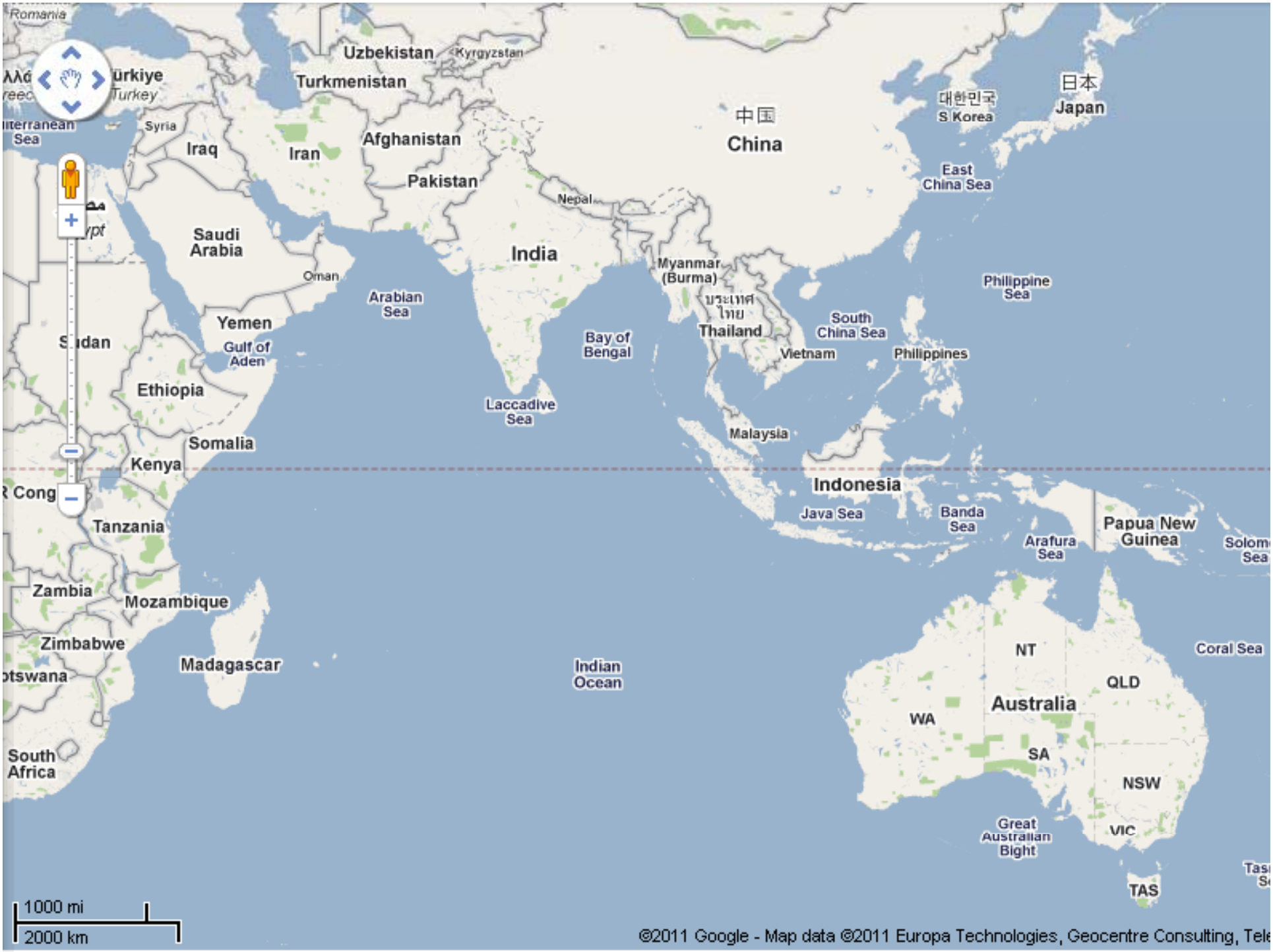
- Field to global scale simulations of CO_2, N_2O and CH_4 losses from soils
- Suitable for anaerobic and highly organic soils
- Tested in Scotland!
- Tropical soils - likely to require adaptation on
  - vegetation types
  - impacts of fire

Impacts of fire

Burnt layer of soil




Jenny Farmer PhD work...
Supervised by Robin Matthews, Jo Smith and Pete Smith
1 4 9 5
UNIVERSITY OF ABERDEEN
The James Hutton Institute


Romania
Uzbekistan
Kyrgyzstan
Turkmenistan
Türkiye
Turkey
Syria
Iraq
Iran
Afghanistan
Pakistan
China
대한민국
S Korea
日本
Japan
East China Sea
Nepal
Saudi Arabia
India
Oman
Arabian Sea
Myanmar (Burma)
ประเทศไทย
Thailand
South China Sea
Philippine Sea
Vietnam
Philippines
Bay of Bengal
Yemen
Gulf of Aden
Ethiopia
Laccadive Sea
Malaysia
Somalia
Kenya
Indonesia
Java Sea
Banda Sea
Arafura Sea
Papua New Guinea
Tanzania
Zambia
Mozambique
Zimbabwe
Madagascar
Indian Ocean
Coral Sea
NT
QLD
Australia
WA
SA
NSW
VIC
Great Australian Bight
TAS
South Africa
1000 mi
2000 km
©2011 Google - Map data ©2011 Europa Technologies, Geocentre Consulting, Tele

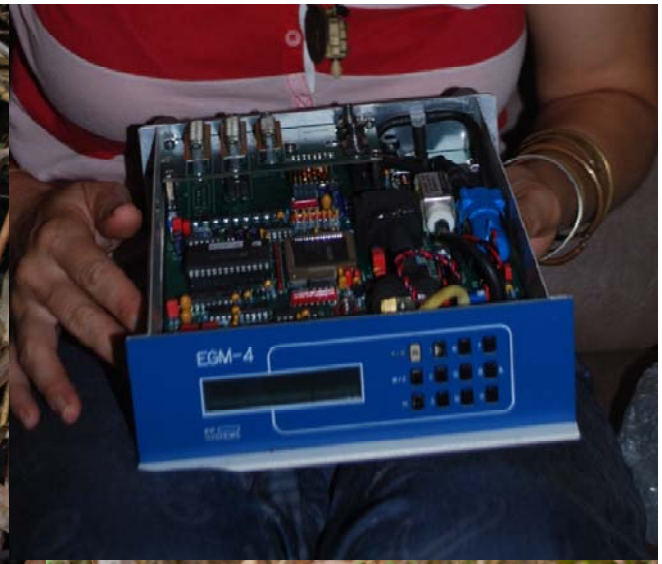
Rate measurements

- 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)

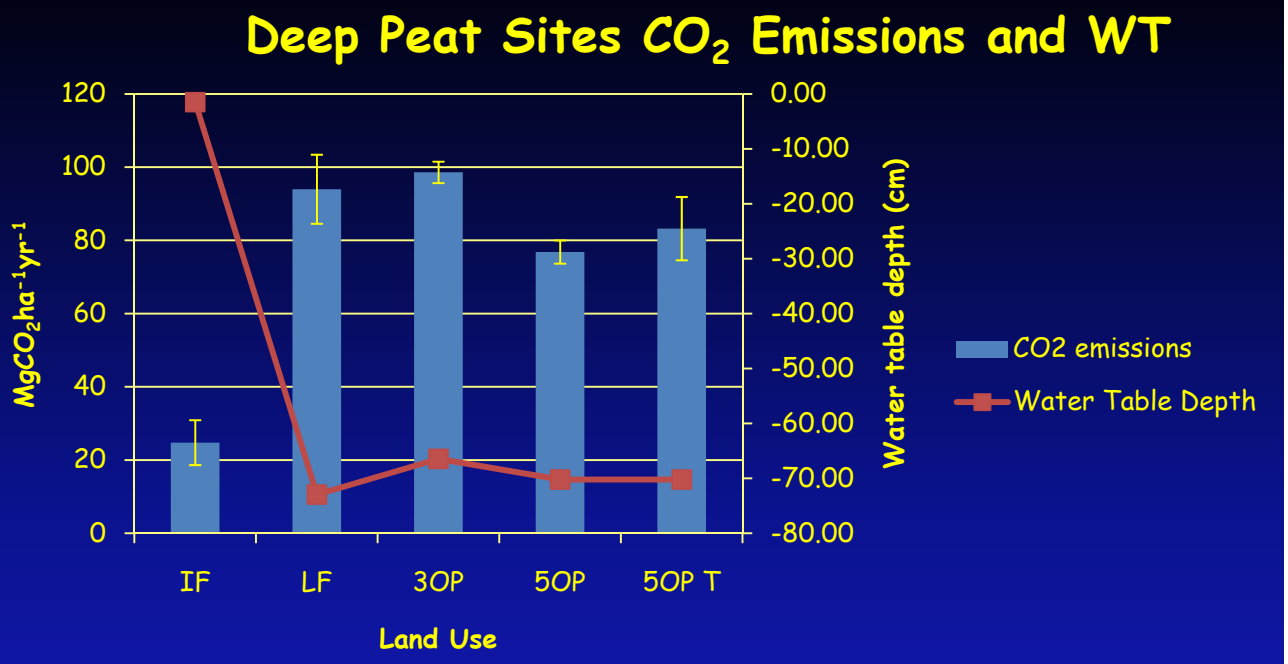
Rate Measurements

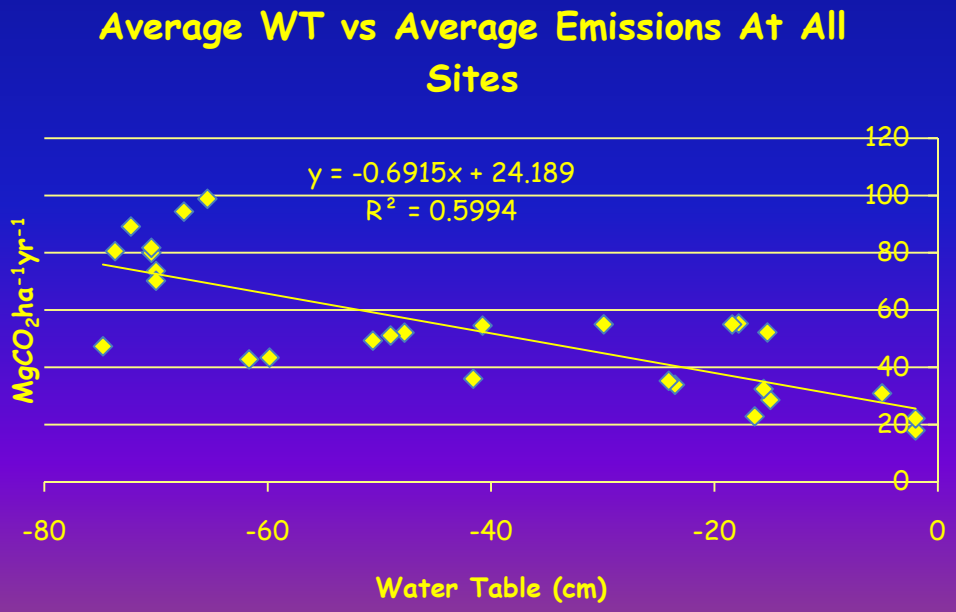
- 30 collars per land use
- Using a PP Systems EGM-4
  - Uses a gas analyser, the same as an IRGA but much more compact

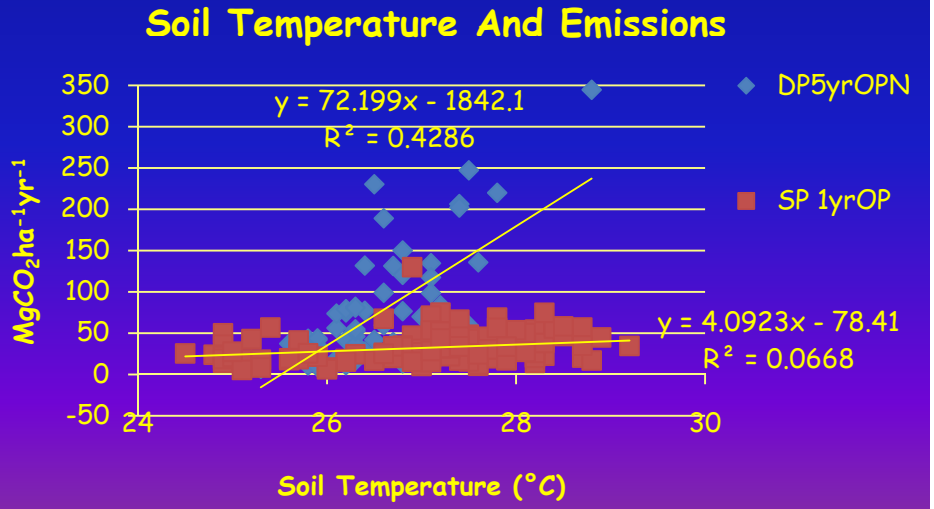

EGM-4


EGM-

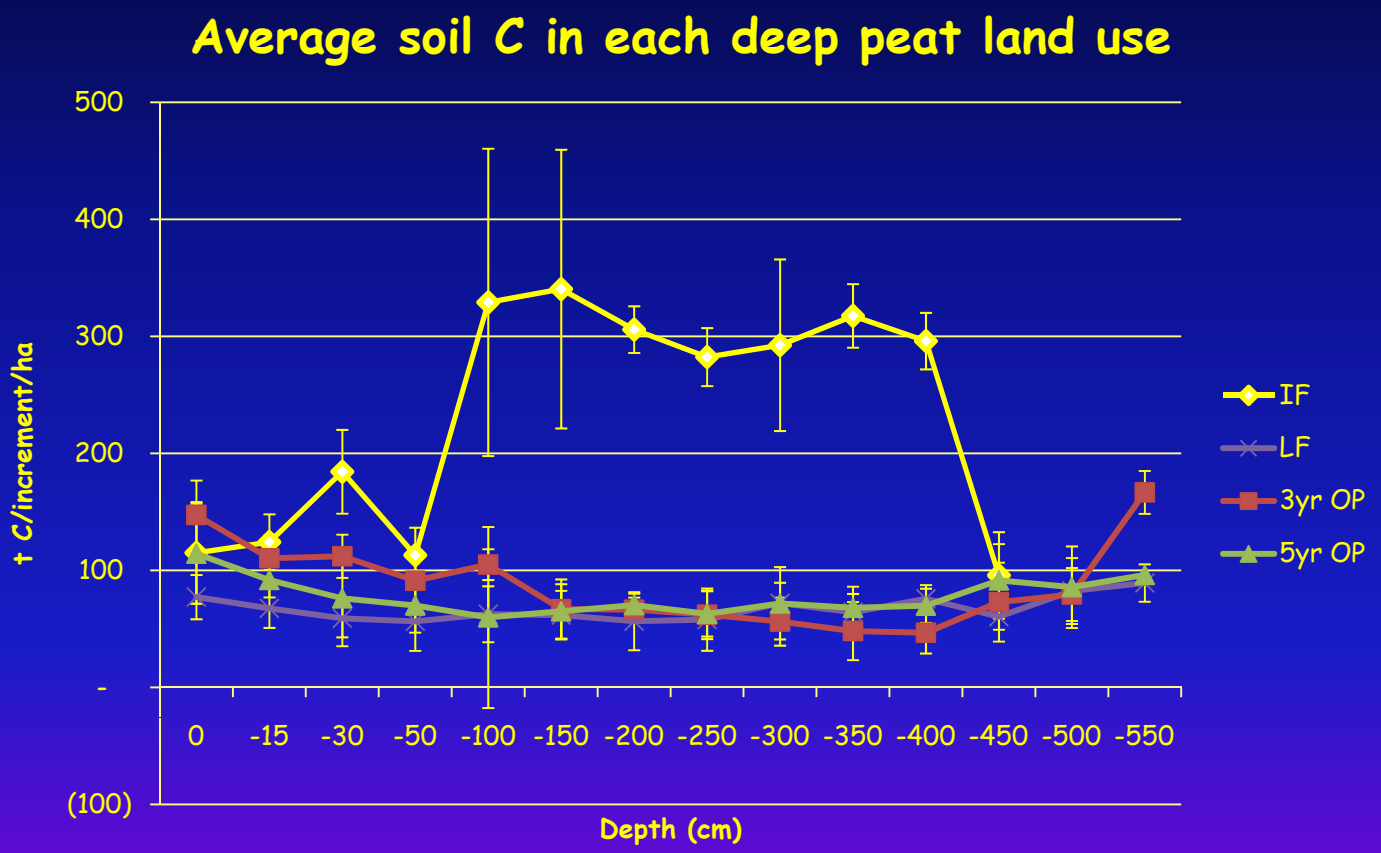
CO_2 Emissions Results







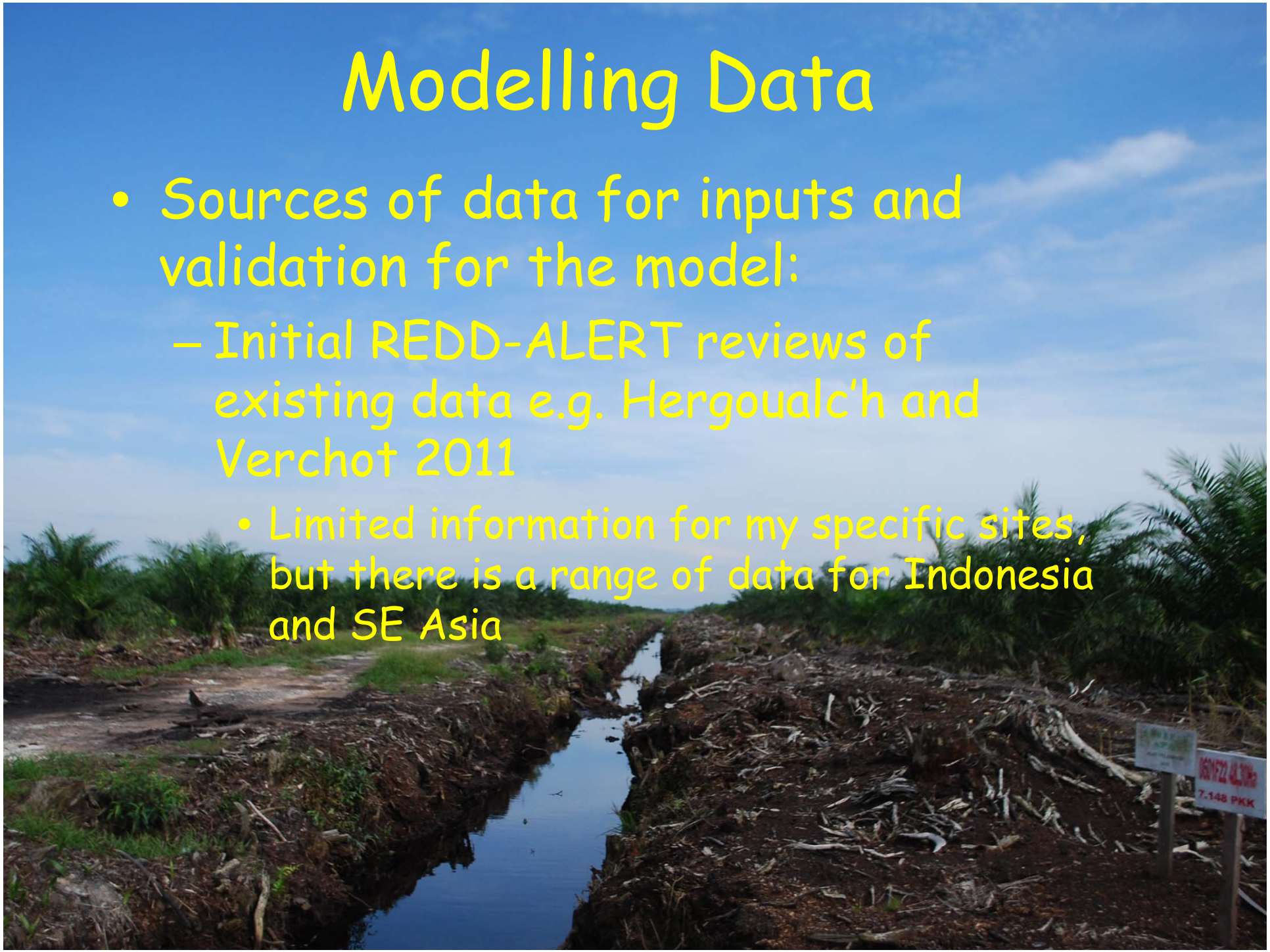
Soil C Values



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

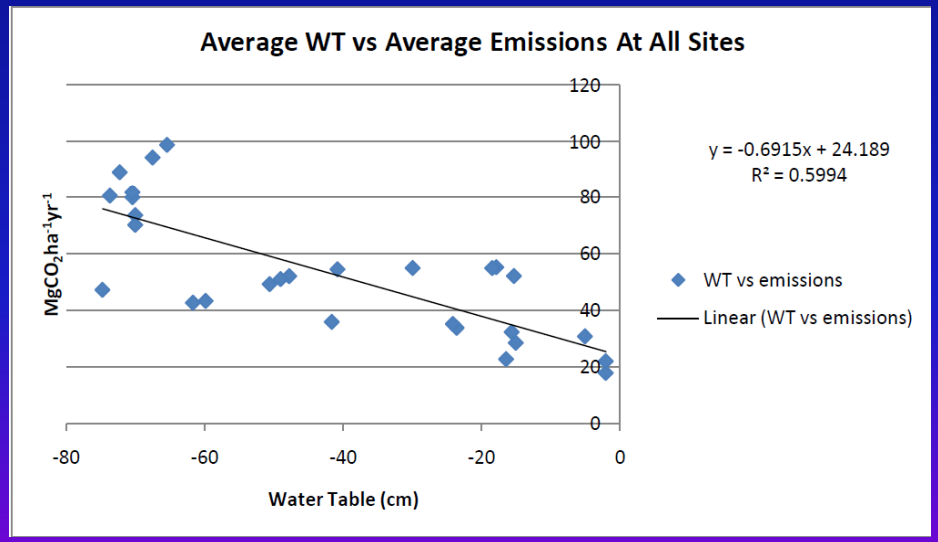


Sources of Modelling Data Cont.

- Fieldwork of other REDD-ALERT team members e.g. Setiari Marwanto of ISRI
  - Soil C, BD, soil profile
- My own research
  - CO_2, temp, pH, water table
  - Soil C, BD, soil profile
- New research as it comes in i.e. from new REDD-ALERT researchers
  - CH_4, N_2O
  - Can request additional work

Starting with Roth C

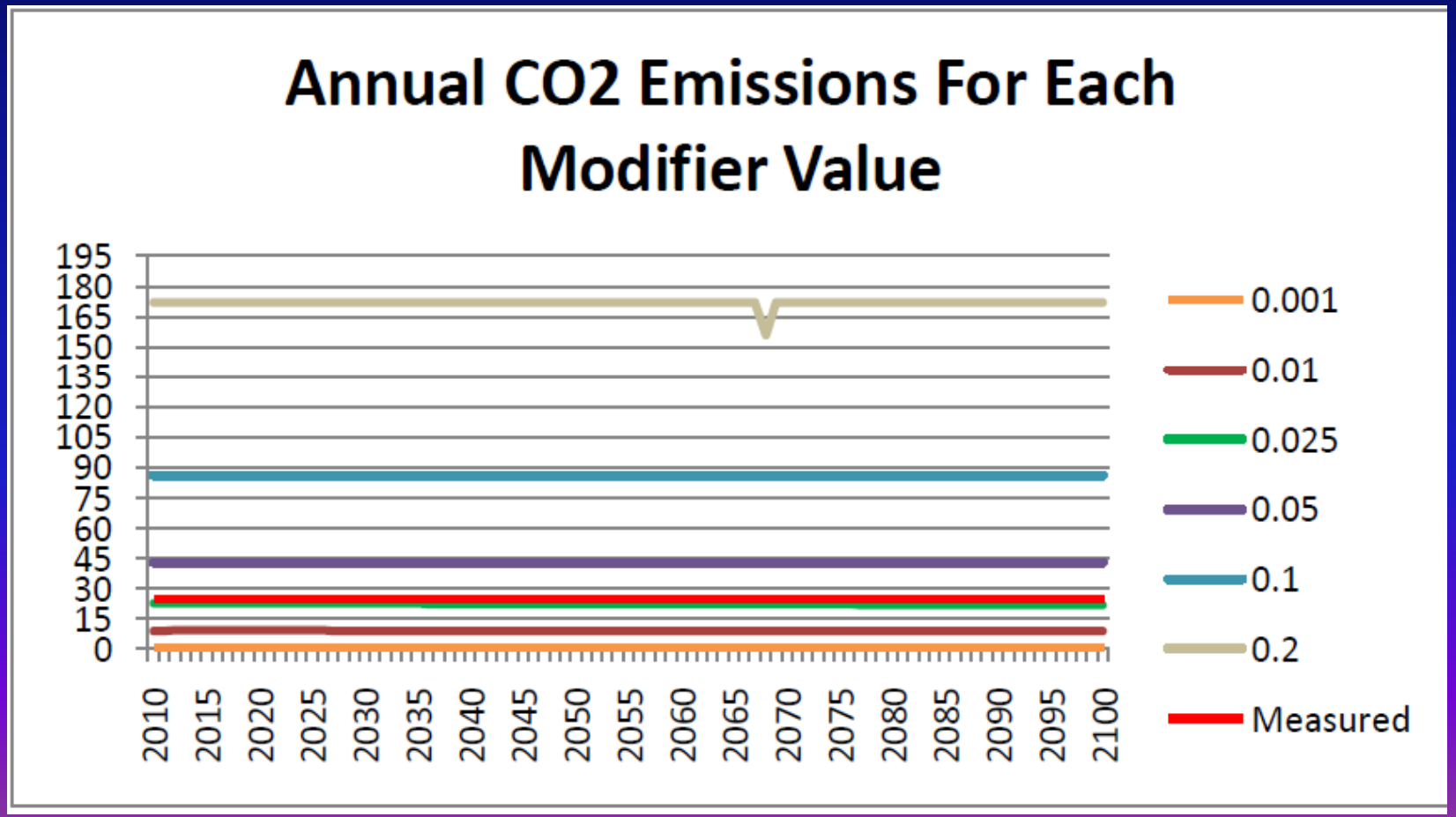
- Only CO_2 emissions, no field values for CH_4 and N_2O.
- Trends in field results (e.g. between temperature and CO_2 emissions and water table and CO_2 emissions) indicated the potential for Roth C application.



Adding Submerged Modifier

For steady state site (intact forest):

```
C
C ** Combining rate modifiers
C
      DO 160 M=1,12
            RMSMD(M)=0.2
            RATEM(M)=RMTEMP(M)*RMSMD(M)*RMCROP(M)*RMPH*EXTRARM*RMSAL(M)
  160 CONTINUE
C
```

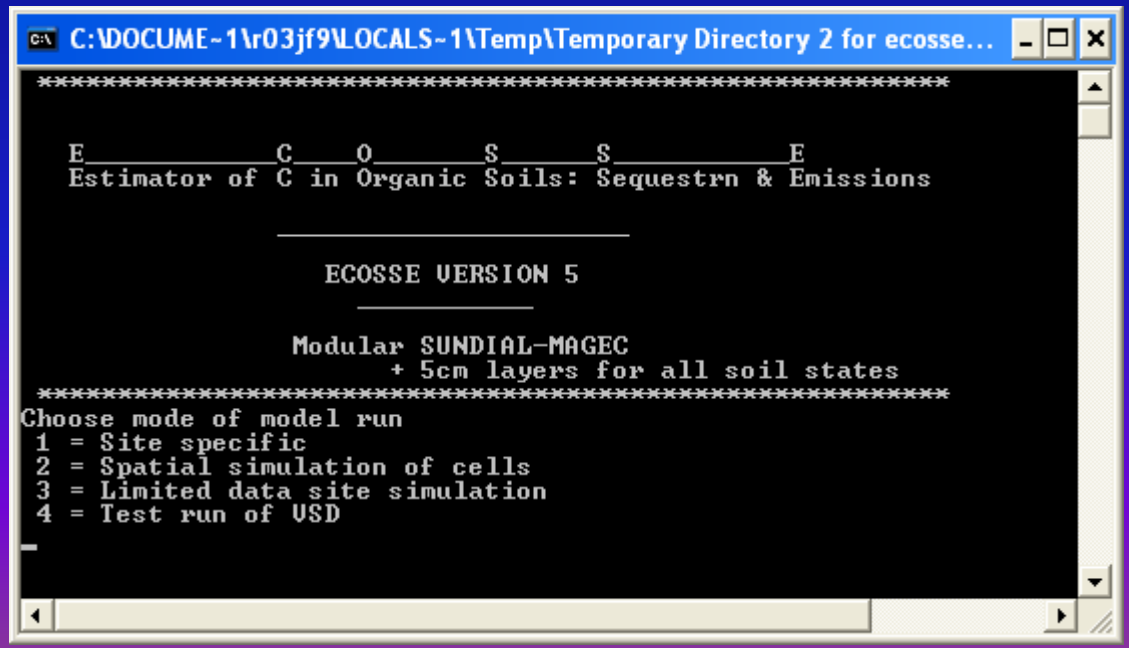


Future work

- 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.

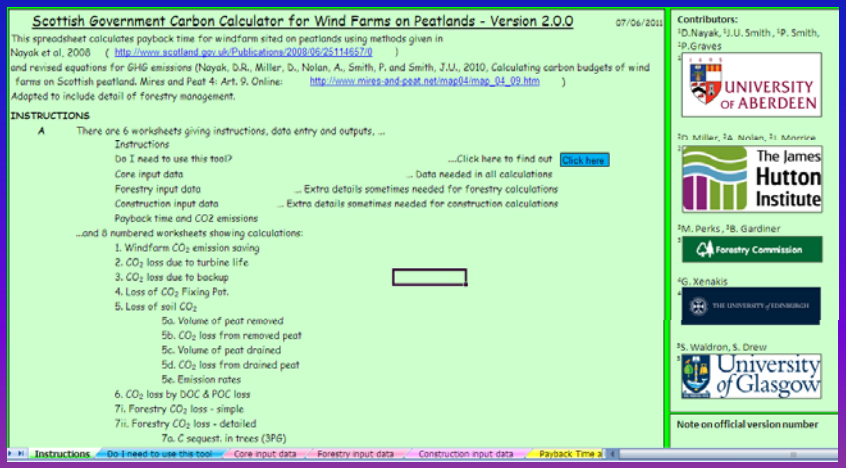
Using ECOSSE…

- 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.



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



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

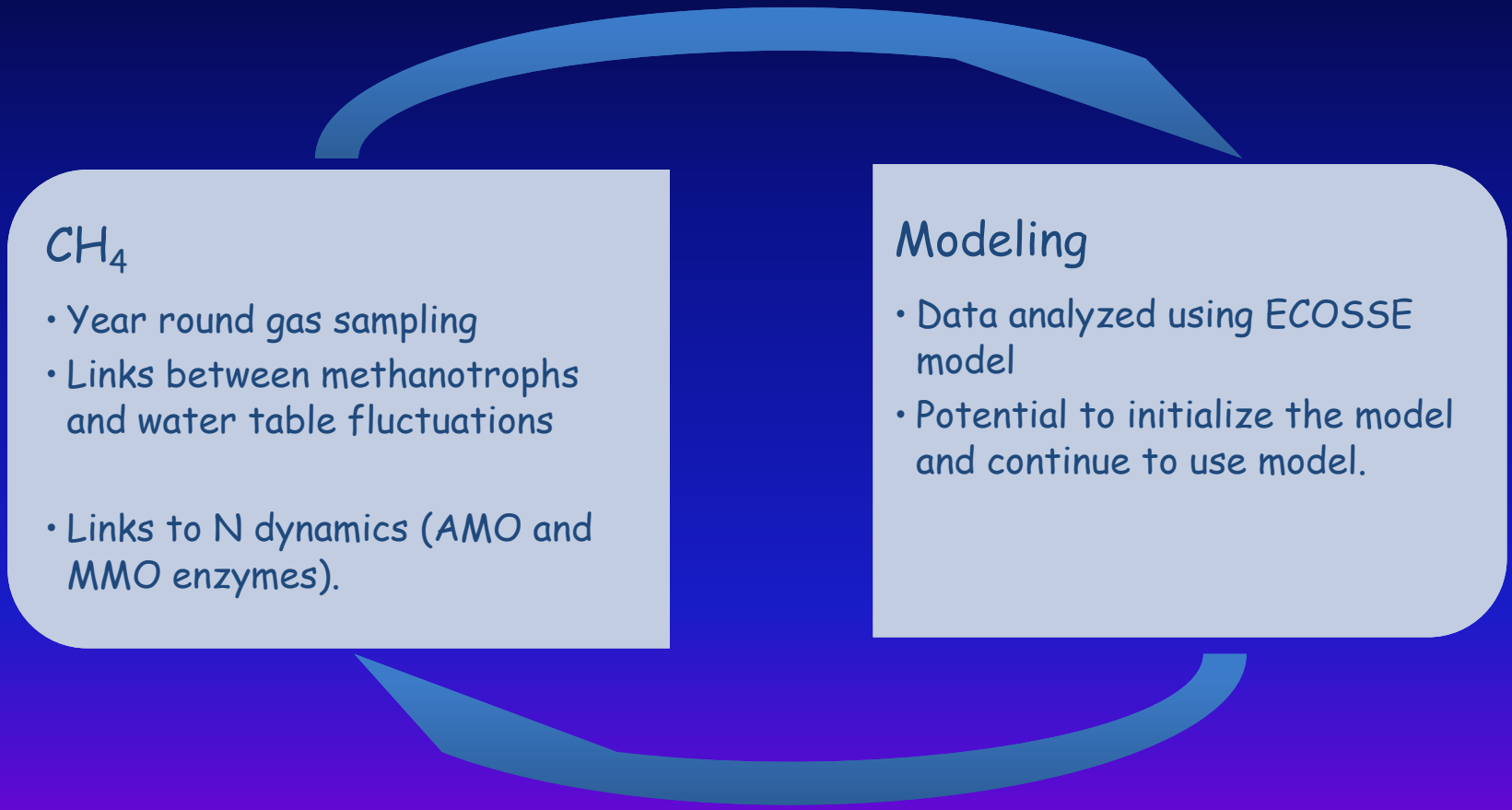
N_2 and N_2O.

- 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
- ^{15}N tagging:
- Mineralization and nitrification potentials

Modeling

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

Methane


CH_4
• 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).