THE ENERGY AND ENTROPY BUDGETS OF UK PEATLANDS – ARE SOME NEAR EQULIBRIUM?

Fred Worrall,
Department of Earth Sciences,
Durham University

Durham University

Earth Sciences

Co-authors and acknowledgements

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  - Ross Morrison
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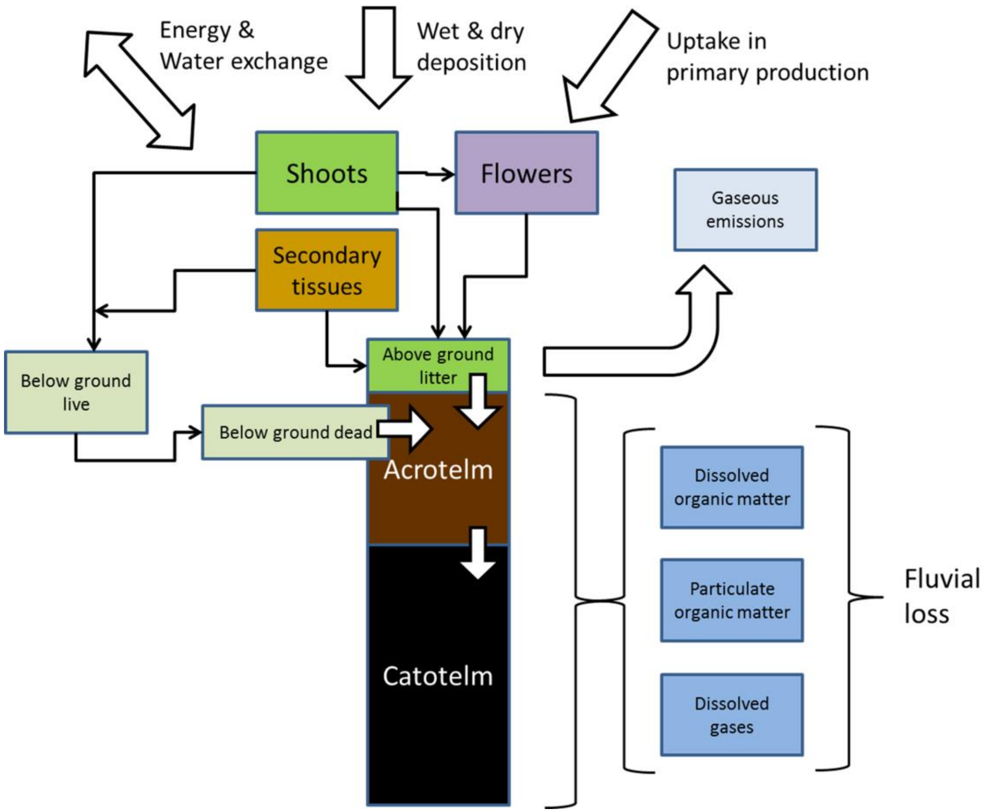
Plenty of budgets?

- Carbon
- Nitrogen
- Greenhouse gases
- Oxygen
- Phosphorus
- Energy
- Molecular
- But
  - Budgets are scalar
  - How do we predict change?

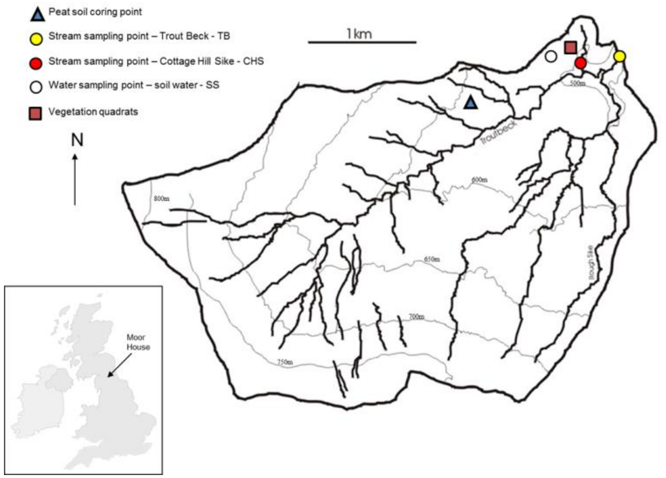


Entropy budget

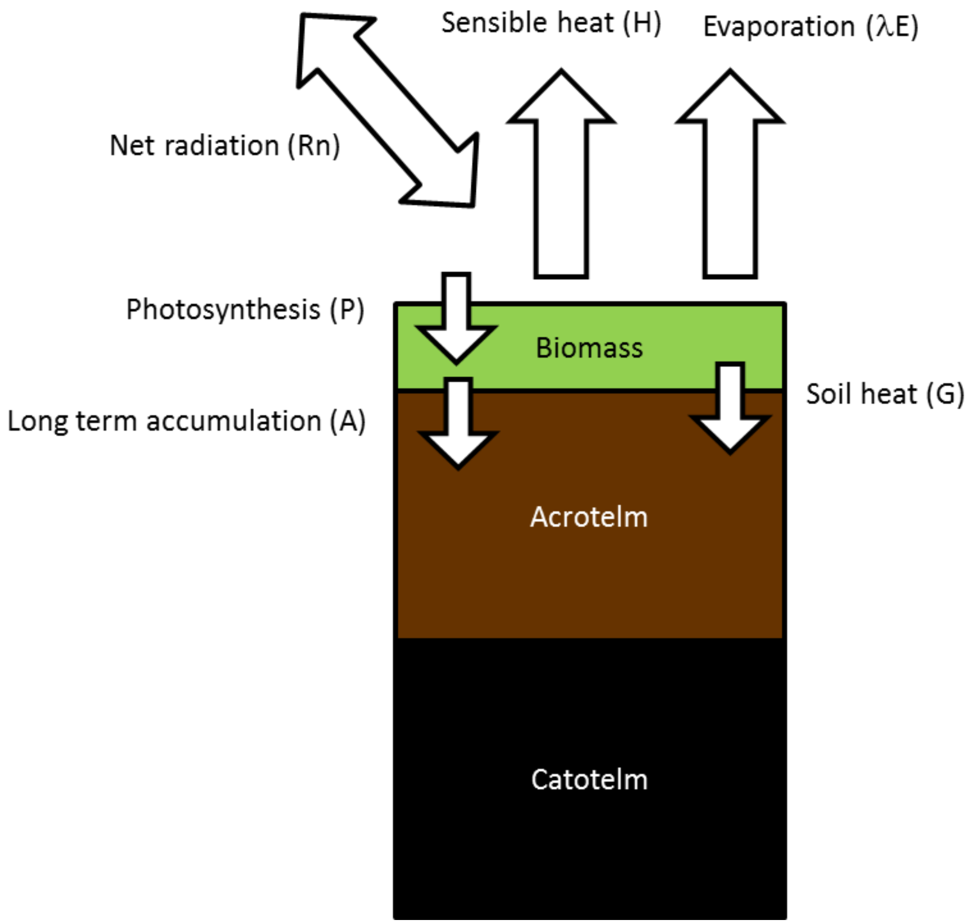
- 2^{nd} law of thermodynamics applies

$$\frac{dS}{dt} = \sigma \to 0$$

  - Entropy is a vector with both magnitude and a direction
- System is not at equilibrium
  - System will exist to maximise entropy production (MEP)
- Study site
  - Moor House NNR
  - Upland blanket bog
  - 20 years of hydrometeorological data



Energy budget



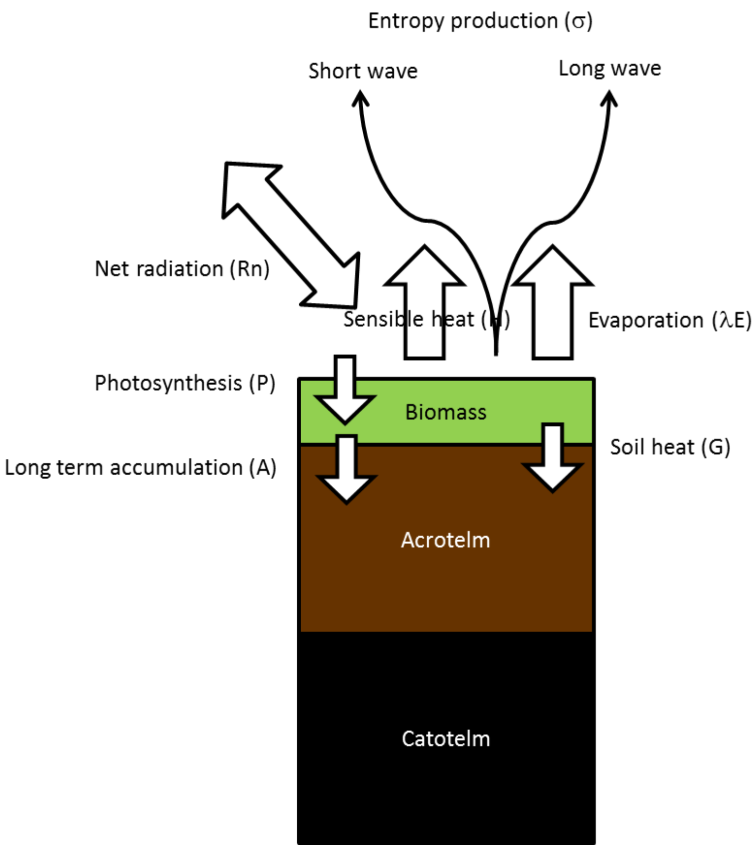
- The hydrological energy budget

$$R_n = H + G + \lambda E + P + e$$

Where: R_n = net radiation; H = sensible heat flux; λE = evaporation; G = soil heat flux; P= primary production; and e = residual term

- Evaporation by modified Penman-Grindley method
- Soil heat flux from soil temperature profile
- Net radiation comes from ECN monitoring
- Calorimetry to measure P
- Balanced with H

Entropy budget



- Each energy flux has an entropy flux, eg. entropy flux due to sensible heat flux

$$J_H = -\frac{H}{T_{sfc}}$$

Where: H = sensible heat flux; T_{sfc} = soil surface temp (K).

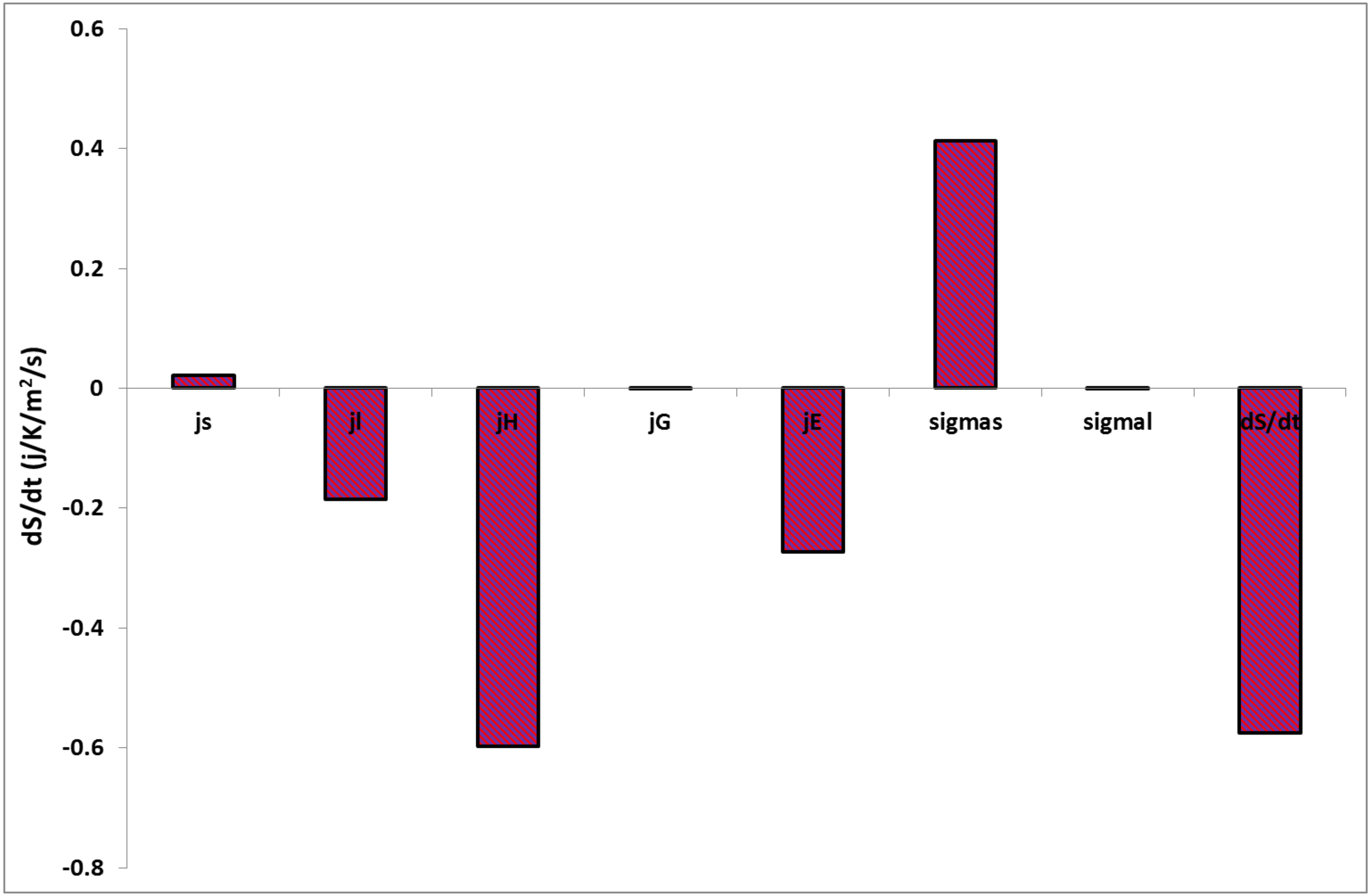
- Entropy production is associated with long and short wave radiation, eg. incoming long wave radiation

$$\sigma_l = Q_{lin}\left(\frac{1}{T_{sfc}} - \frac{1}{T_{atm}}\right)$$

Where = Q_{lin} = incoming radiation energy flux; and T_{atm} = atmospheric temperature.

- This could be calculated for Moor House

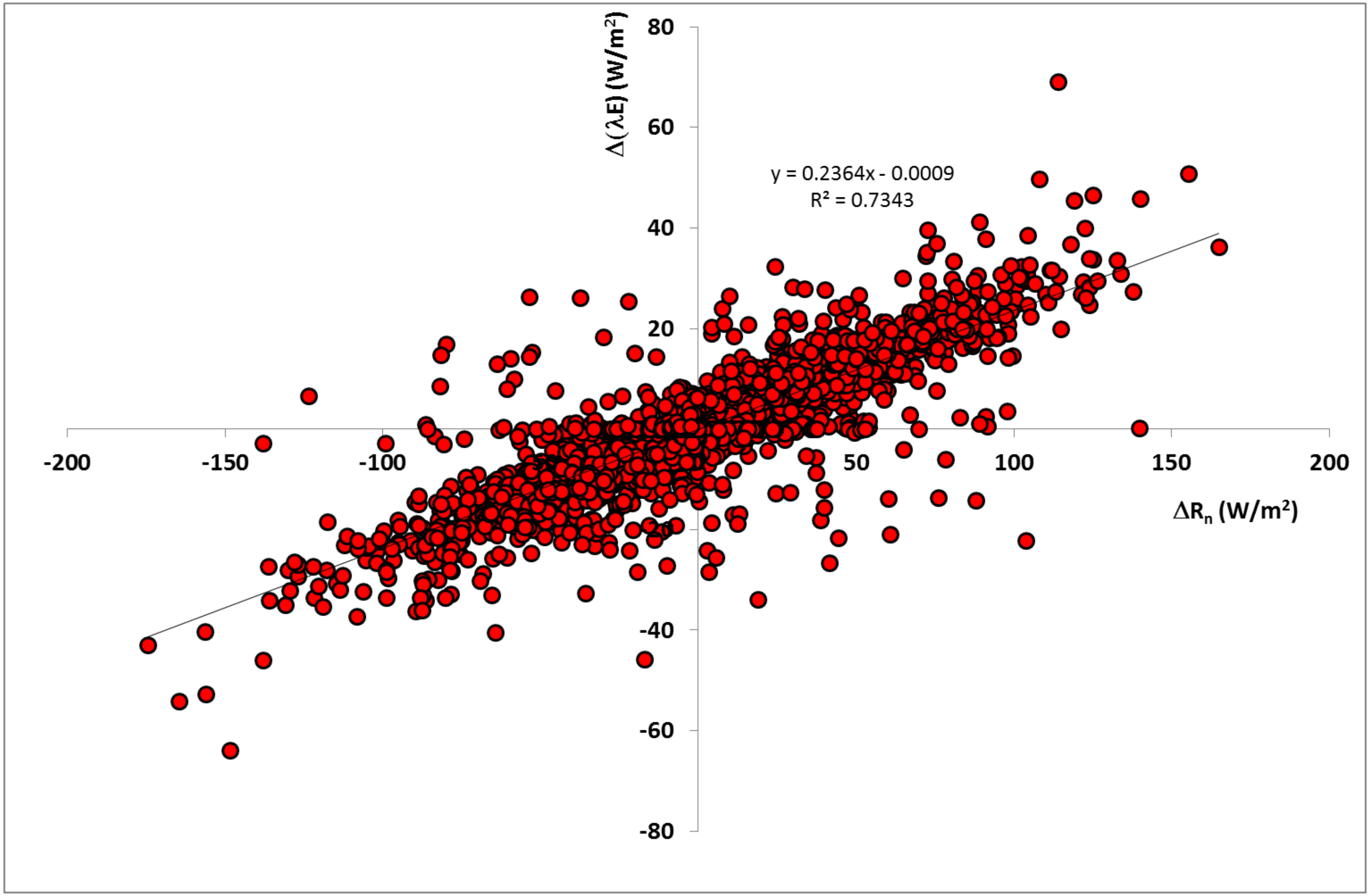
Entropy budget



So what?

- We can estimate a long term entropy budget
  - Median $dS/dt = -0.57\ J/K/m^2/s$
- No means of interpreting the result
- Two alternatives:
  - Measure dS/dt for more sites
  - Measure the response to change
    - If a site is far from equilibrium it will maximise its entropy change for an incoming change in energy

Change in λE with change in Rn

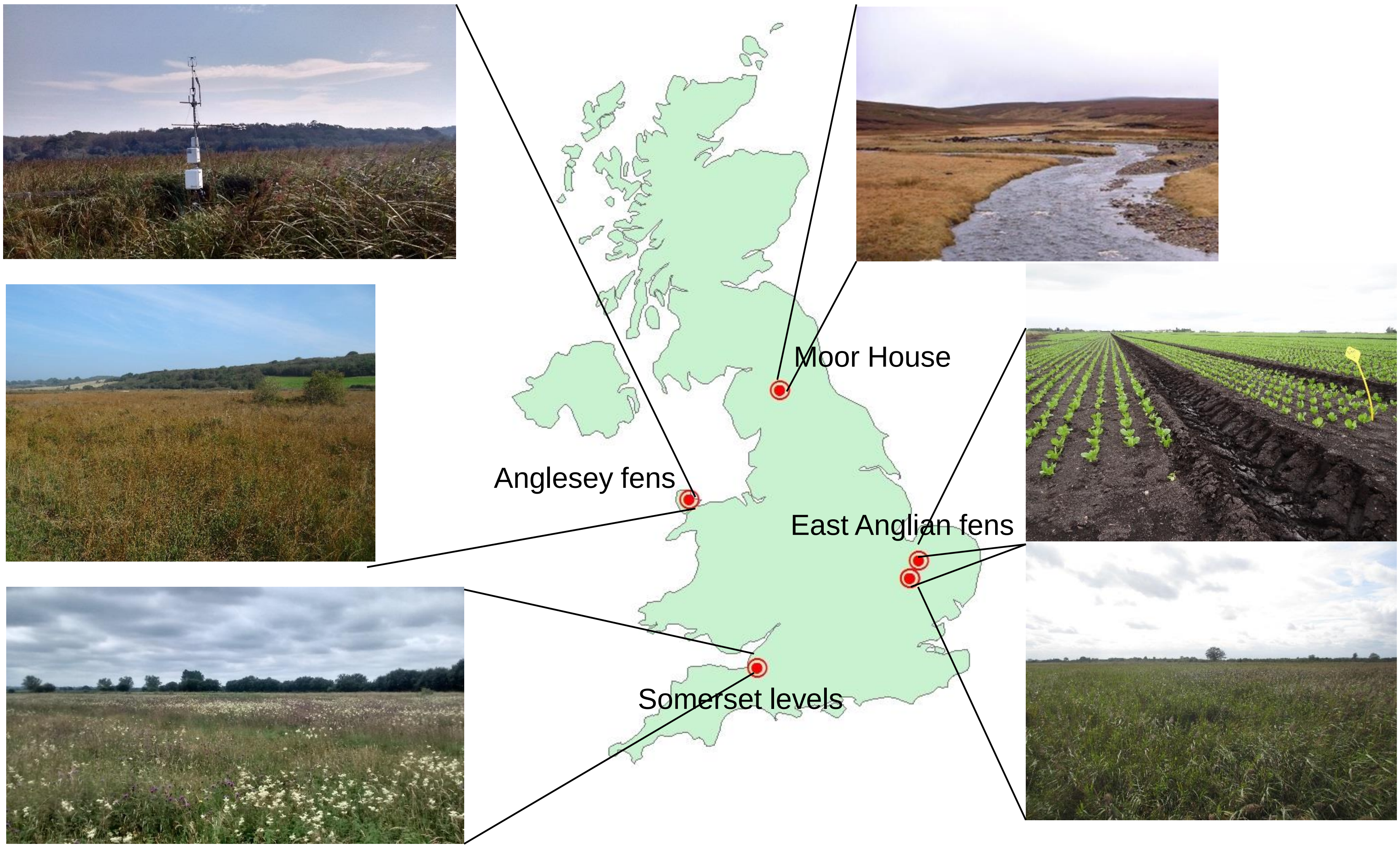


Extra sites …

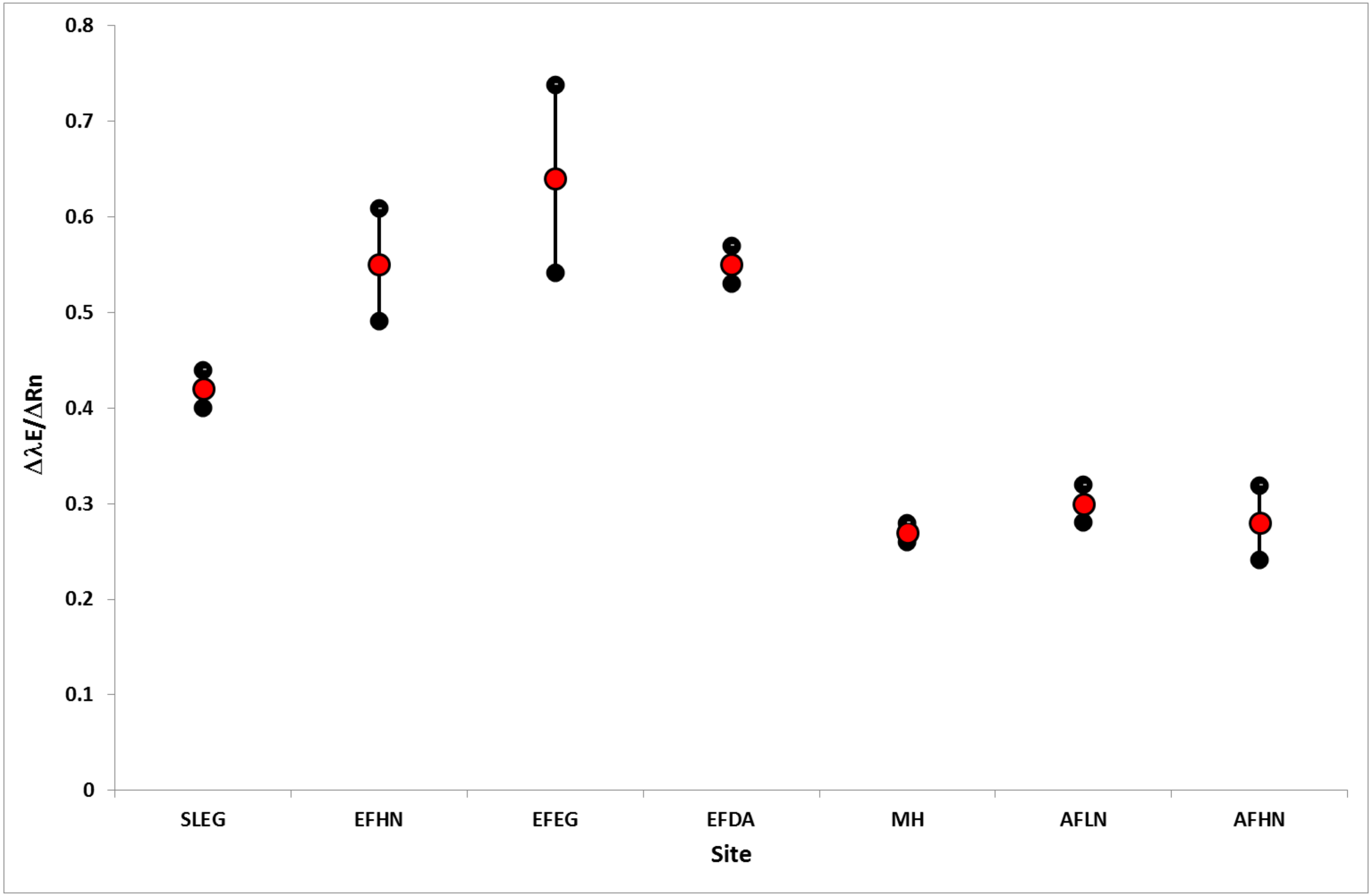
Region	Site	Site type	Code
North Pennines	Moor House	Upland blanket bog	MH
East Anglia	Wicken Fen	Low nutrient semi-natural	EFLN
	Bakers fen	Extensive grassland	EFEG
	Rosedene Fm	Arable on deep peat	EFDA
Somerset Levels	Tadham Moor	Extensive grassland	SLEG
Anglesey Fen	Cors Erddreiniog	Low nutrient semi-natural	AFLN
	Cors Erddreiniog	High nutrient semi-natural	AFHN

- We can measure response to change wherever there is a daily energy budget
  - More detailed required for full entropy budget
- Seven peatland sites with sufficient data

Study sites

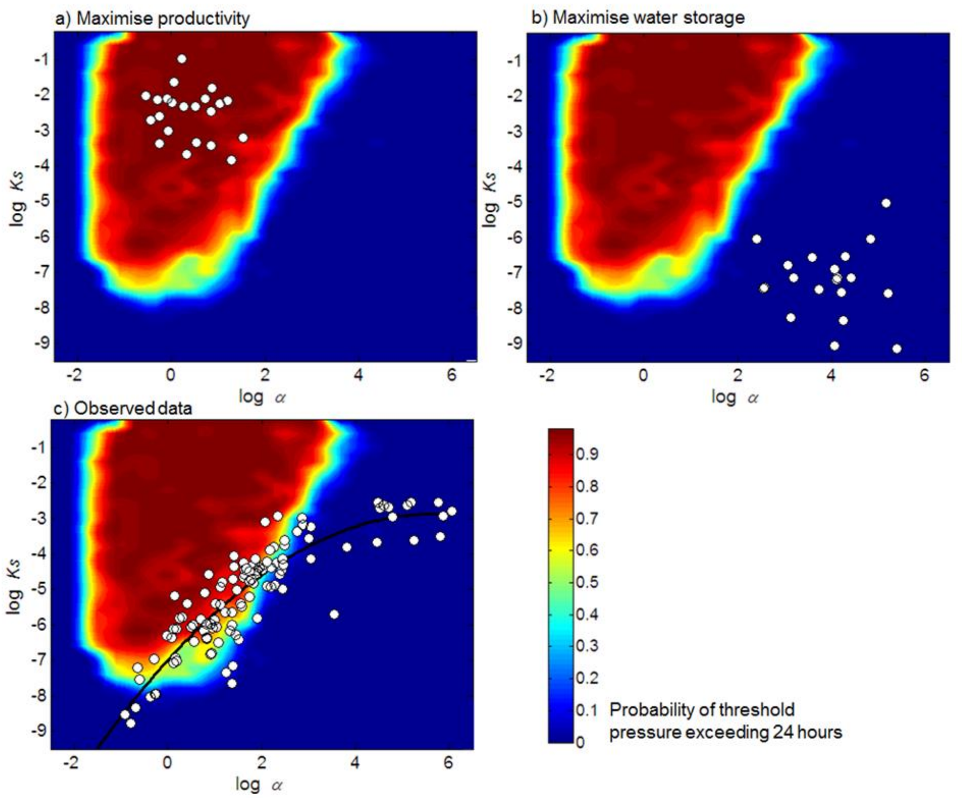

Moor House
Anglesey fens
East Anglian fens
Somerset levels

Change in λE for change in Rn

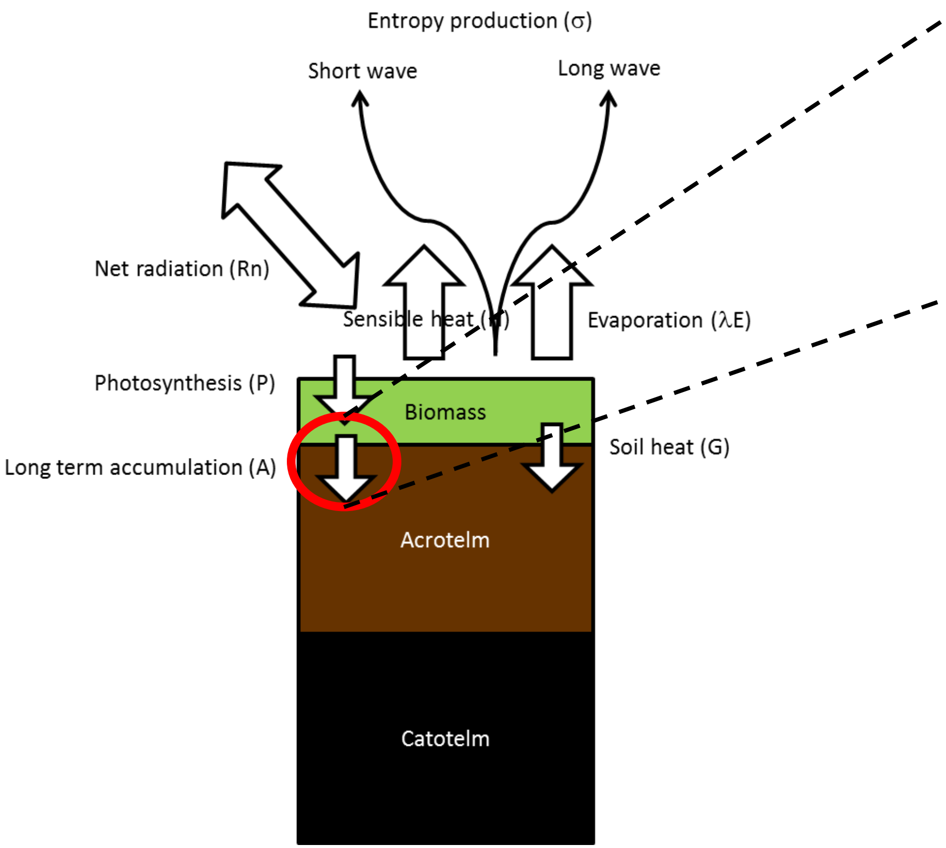


So what?

- Kettridge et al. (2015)
  - Predicted two types of hydrologically stable behaviour
  - Maximise productivity or maximise water storage
- So far
  - We have two, significantly different states
  - One state limits water loss compared to the other
  - One state appears nearer to equilibrium than thought
- Next step
  - Calculate entropy budget for all sites



So what?



- What about this bit?
  - Accumulating carbon is accumulating energy and creating order
- Implication
  - Peatlands must shift more entropy than other systems because they accumulate energy
  - The more water you evaporate the more you can accumulate
  - A thermodynamic explanation for why peatlands must be wet.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