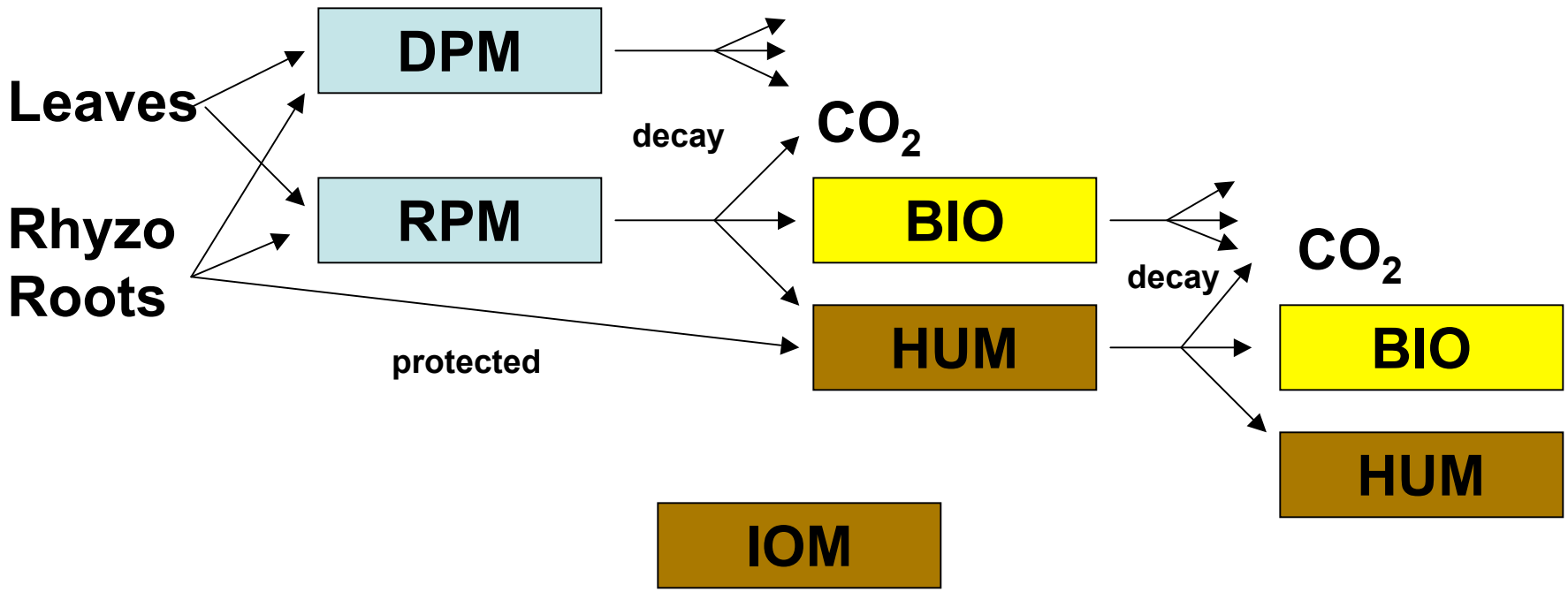
Ecosystem C Modeling

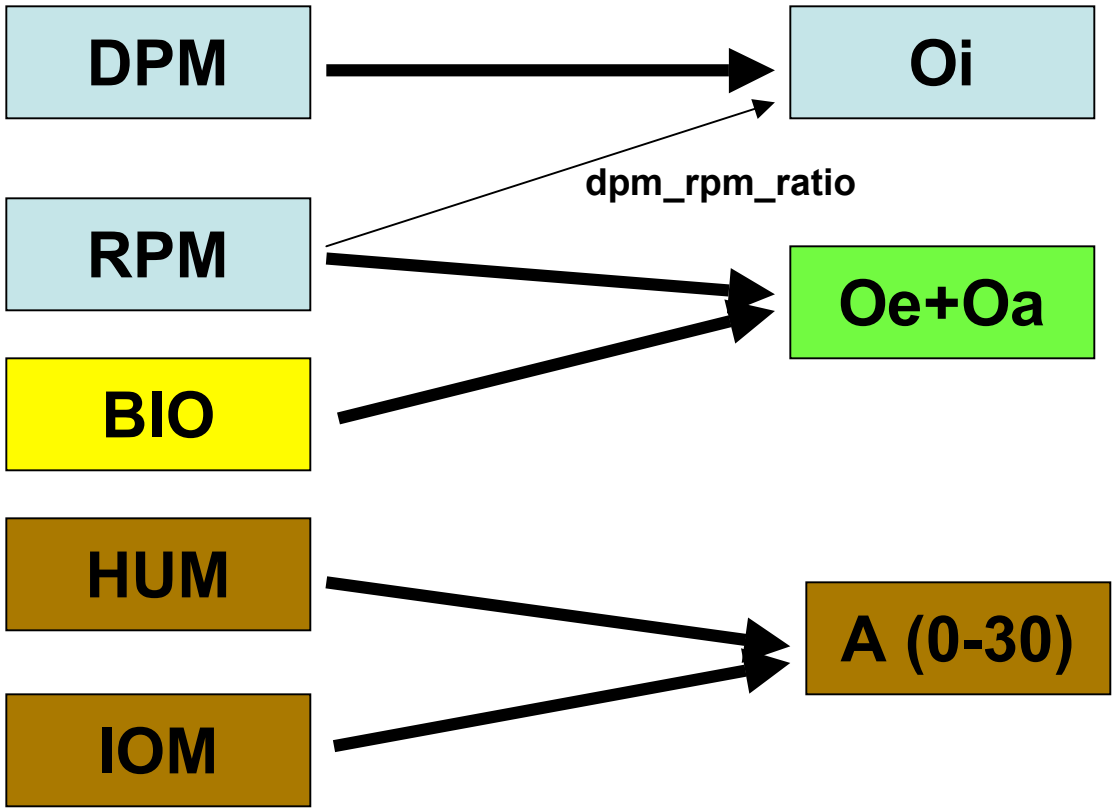
- Ultimate Objectives - Strategic
  - Apply findings and measurements to quantify ecosystem C dynamics
  - Generalize results for application to other ecosystems
- Proximate Objectives - Tactical
  - Organize data into logical constructs consistent with measurements and observations
  - Use model constructs to suggest additional measurements that confirm concepts and lead to better parameter estimates

Structure of the Rothamsted Carbon Model



RPM : Resistant Plant Material
DPM : Decomposable Plant Material
BIO : Microbial Biomass
HUM : Humified OM
IOM : Inert OM

Recategorization of Rothamsted Compartments



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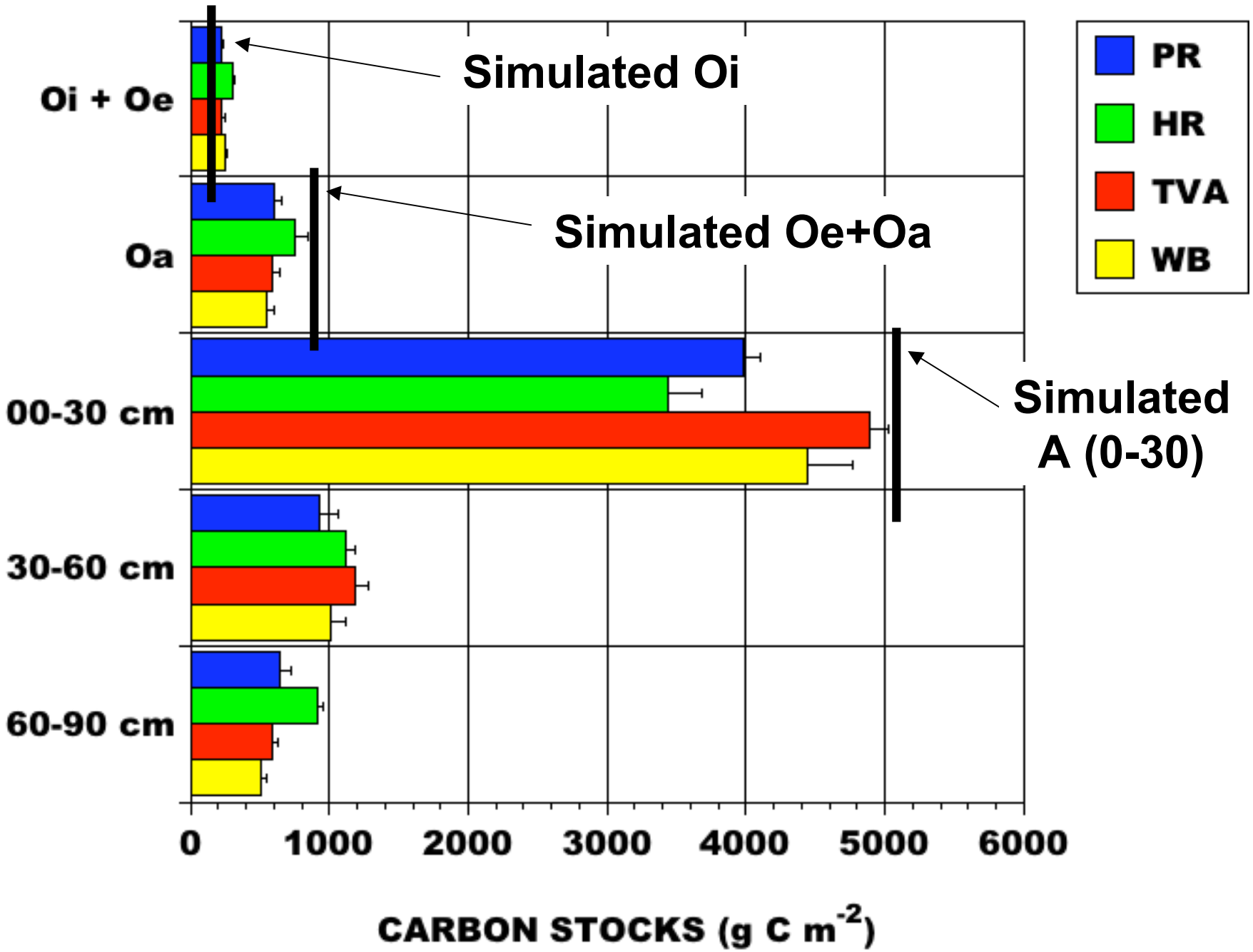
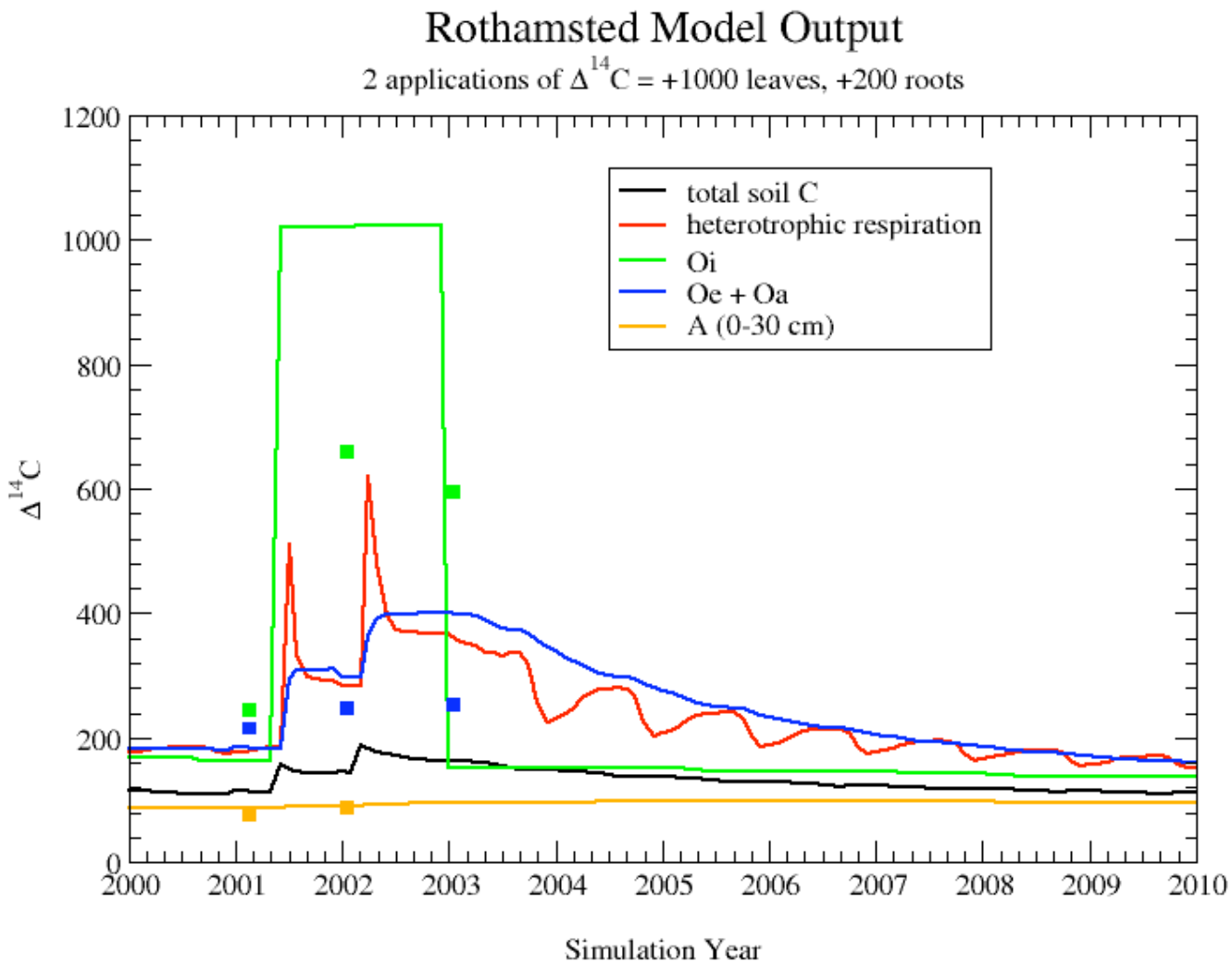
Assumptions

- Rhyzo + Root input = 2.2 t C ha^{-2} y^{-1}
- Leaf input = 2.2 t C ha^{-2} y^{-1}
- Rhyzodeposits not separated from root inputs
- Root to HUM fraction = 0.25
- Clay content = 23.4%
- Climate average used thorughout

Equilibrium Pools

Compartment	Model	WBW
DPM + associated RPM (Oi)	2.0	2.8
RPM + BIO (Oe + Oa)	9.8	9.4
HUM + IOM (A)	50.7	44.2


Simulated Oi
Simulated Oe+Oa
Simulated
A (0-30)
PR
HR
TVA
WB
Oi + Oe
Oa
00-30 cm
30-60 cm
60-90 cm
0
1000
2000
3000
4000
5000
6000
CARBON STOCKS (g C m-2)


Rothamsted Model Output
2 applications of Δ14C = +1000 leaves, +200 roots
total soil C
heterotrophic respiration
Oi
Oe + Oa
A (0-30 cm)
Δ14C
0
200
400
600
800
1000
1200
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Simulation Year

What is causing discrepancies?

- Importance of DOC underestimated
- Litter cohorts not aligned with model compartments
  - New material more rapidly decomposed
    - Interannual variation in decomposition significant?
    - Howdoes preferentially decomposed affect results?
  - Unclear separation of Oi and Oe/Oa, increased root inputs, decomposer translocation via immobilization of older material into O layers

More Detailed Litter Model Required

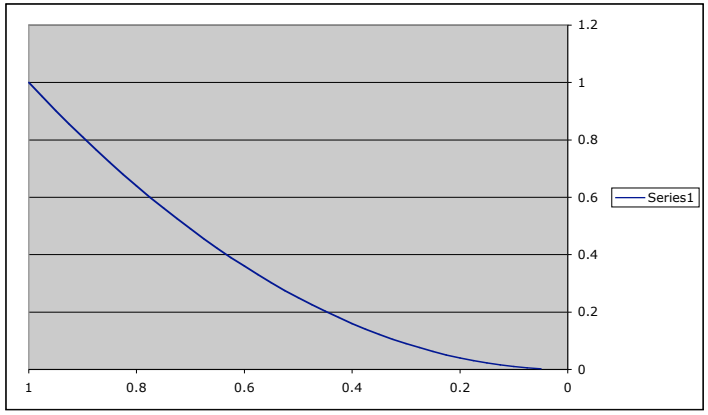
- Litter cohort models require mechanism to relate rate of decomposition to stage of decomposition (e.g. lignin:N)
- Theory exists (Q-model) but it is currently difficult to estimate parameters.
- Empirical (tactical) model required to explain field results. Generalization will require additional incorporation of empirical findings with theoretical constructs.

Quality Model

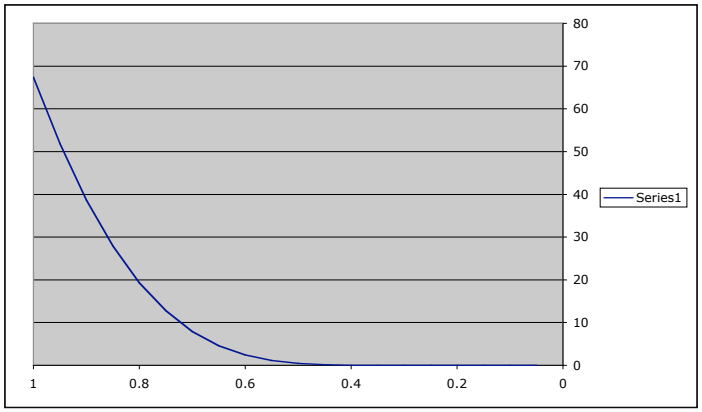
$$\frac{dq}{dt} = -f_c \eta_1(q) u(q,T)$$

- f_c = carbon concentration in decomposer biomass
- η = *measure of rate of quality change*
- *u = basic decomposition rate - function of q and environment*
- *A = activiation energy for liberation of carbon atom with quality q*
- *T = temperature*
- e_0 = *production to assimilation efficiency of decomposers*

$$\eta_1(q) = \eta_{12} q^2$$



$$u(q,T) = u_0 e^{-A/qT}$$



Change in quality with changes in amount

$$\frac{q(t)}{q_0} = \frac{A}{q_0} \cdot \frac{1}{\ln(e^{A/q_0 T} + \frac{A}{q_0 T} f_c u_0 \eta_{12} q_0 t)}$$

$$g(t) = \exp\left\{ -\frac{1-e_0}{e_0 \eta_{12} q_0} \left[\frac{q_0 T}{A} \ln\left(e^{A/q_0 T} + \frac{A}{q_0 T} f_C u_0 \eta_{12} q_0 t \right) - 1 \right] \right\}$$

Next Steps

- Quality model parameters are difficult to estimate make consistent with measurements
- Empirical models used to identify significance of specific hypotheses
  - Lead to improved parameter estimates or conceptual methods to achieve better estimates
  - Lead to conceptualizations that are more aligned to observations, improve abstract concepts
- Consider application of cohort/continuum concept to belowground data