Driving mechanisms and global turnover rates for litter pools

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Current activities (where we left off after the Biosphere 2 workshop):
Carlos: Coding models (such as the ones below in this document) in R to accept multiple independent variables. Working on producing consistent results between SoilR and Stan.
Will: Posted two .csv files with global temperature and precip estimates.
Carol: Organized the LIDET dataset into a usable format.
Kiona: Used OpenBUGS to run our simplest model successfully. Working with Jarrett and Carlos to implement multi-model averaging with OpenBUGS, SoilR, and Stan.
Natasja: Ran our simplest model in R using a max-likelihood boostrapping procedure and compared results to Kiona's OpenBUGS analysis and found good agreement.
David: Offered help on posting data/code on GitHub, scripting models, assembling climate data, and getting supercomputer time if we need it.

Proposed work plan:
Data assembly: The LIDET data are available, but ideally we could have access to all the data in the Tuomi et al. 2009 paper. **Carol**, would you be able to gather as much additional litter decomposition data (along with associated climate and litter chemistry data) as possible? For the eventual mapping, we have climate data. **Will**, could you also assemble and post the litter chemistry data? I think our plan was to extract Lignin:N from CLM outputs.
Model construction: Multiple people have coded up models in multiple platforms. I think this diversity is good. **Kiona**, **Natasja**, **Jarrett**, and **Carlos**, would you continue these efforts in R and Stan? I suggest starting with a small number of models (the ones listed below) and getting this prototype set working and consistent across all the platforms.
Multi-model analysis: **Kiona** mentioned several multi-model approaches. Could **Kiona**, **Jarrett**, and **Carlos** work on the multi-model weighting schemes once we have the consistent prototype models running individually?
Map construction: This area will rely heavily on **Will**. He will feed in the driver data to the parameterized models that we come up with. Initially I think we should use the parameters from each of the prototype models individually. Later we can use parameters from the weighted "supermodel".

Prototype approach: For the short term, I suggest that we get a consistent set of models working based on the LIDET data. I suggest models 1-4 below as the prototypes. We can then use the parameters from this prototype set of models to generate a prototype set of k-value maps. At that point, we can assess our progress, scale up, and implement the multi-model approaches.

Tentative Timeline:

	Dec-Jan	Feb	Mar	Apr	May	Jun	Jul
Litter decomp data assembly							
Driving dataset assembly							
Prototype model construction							
All model construction							
Prototype model averaging							
All model averaging							
Prototype maps							
Full set of maps							
Manuscript drafting							

Abstract

Introduction
Controls on litter decomposition
Key flux into soils and the atmosphere
Need to understand drivers at global scale
-Alternate models should be considered
No global-scale synthesis of litter turnover rate exists
Need global benchmarks for ESMs
Global maps with uncertainties are needed for ESM testing
Bayesian approaches/model averaging are needed to scale up observations and quantify uncertainty
Hypothesize that contribution of temperature model to explaining global observations is small
Precipitation model increases explanatory power
Precip/PET model should explain observations the best and most simple model
Adding temperature to the above model should result in a marginal increase in model power

Methods

Results

Discussion

Global map of litter turnover times using one-pool or multi-pool models

Based on LIDET and other large-scale datasets
Interpolate using CDI, but need to choose CDI function. Current functions are in dispute; need to choose some.
ki = k0*f(M, T, Chemistry, interactions)
Build up from simple to more complex
Use Bayesian inversion to extract parameters
Iterate through all possible models
Model averaging
Vary model weights by biome? Bin by temperature?
Model fit index for each site

Start with one model; add complexity; compare fits; evaluate if different models apply to different sites. If not, then conduct Bayesian assimilation on single model. If so, then pursue model fit index and combination of multiple model.

LIDET data with site met data
Four alternative models that include combinations of litter quality, precip, and temperature drivers
Fit models to dataset
In Bayesian framework, weight the different models at each observational site
Test for varying importance of drivers across sites
Extract parameters from model fitting and use them to generate a global map based on climate reanalysis data and CLM litter quality data. Do this for roots and leaves.
-Predictions of turnover generated for each model, then the maps get averaged

Models:

$$\frac{dC}{dt} = A * C * f(L, P, T)$$

$$A = \begin{bmatrix} k_1 & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{1n} & \cdots & k_n \end{bmatrix}$$

$$f(T) = e^{-\frac{E_a}{R}(\frac{1}{T}-\frac{1}{T_{ref}})}$$

$$f(P) = \frac{1}{1 + a * e^{b*P}}$$

$$f(P,T) = \left(1 - e^{-\alpha|T-273|}; T < 273 \middle| 1 - e^{-\beta P(T-273)}; T \geq 273\right)$$

$$f(L) = e^{-g*L_N}$$

Model 1:

$$\frac{dC}{dt} = A * C * f(L) * f(T)$$

Model 2:

$$\frac{dC}{dt} = A * C * f(L) * f(P)$$

Model 3:

$$\frac{dC}{dt} = A * C * f(L) * f(P, T)$$

Model 4:

$$\frac{dC}{dt} = A * C * f(L) * (P) * f(T)$$