**GEOG-G440/540 Terrestrial Ecosystem Modeling**

**In-Class Exercise 4: Data Assimilation**

In this exercise you will be comparing results from simple two pool C cycle model data assimilation (DA) (or model optimization) experiments from three different test cases:

1. Test 1: optimization with Rtot and Ctot (results shown in powerpoint presentation in class and saved as test1.pdf)
2. Test 2: Only *Rhtot* observations included in optimization/DA experiment (test2.pdf)
3. Test 3: Only *Ctot* observations included in optimization (test3.pdf)
4. Test 4: Only Rpas, Ract, Cpas, Cact (i.e. *Rhlitter, Rhsoil, Clitter, Csoil*) included in the optimization and NOT total Rh or C) (test4.pdf)

The results of each experiment are given in the associated pdf. You will also see the reduction in parameter errors for each parameter. Note that even when the true value of the parameters is not found, the error on each parameter is often reduced by the optimization. If we did not know the true value of the parameters, this “parameter error reduction” could lead us to think we have accurately found the correct parameter value, when in fact this is not the case.

The same model parameters are optimized in each case:

* Q10
* Wf\_m
* Wf\_x0
* Tau\_litter
* Tau\_soil
* Me\_litter
* Me\_soil
* C\_litter\_t0
* C\_soil\_t0

Please refer back to the Introduction to the simple two pool C model notes or Exercise 1: Building the Model for information on these parameters.

Note that this is a synthetic experiment; therefore, the “true” value of the parameters is known (and is set to the default values we have been using in the past three exercises). If the DA experiment is working well, the true values of the parameters should be found by the DA algorithm.

**Questions:**

Please answer the questions below using the results given for each test in the respective pdfs.

1. Compare the results from test 1 and test 2.
   1. Which variable(s) are *not* well constrained by the optimization in test 2 compared to test 1 (i.e. the posterior simulations not close to the observations)? Why do you think this is?
   2. For which parameters have the true values been found in *both* test 1 and test 2? Using what you have learned in class, hypothesize as to why that might be (despite the fact that different observations were used in both cases)
   3. For which parameters is the posterior parameter value (final black cross) very different in test 1 and test 2? Again, why do you think that is?
2. Now we will compare the results from test 1 and test 3.
   1. *Before you look at the results from test 3:* what do you expect to find when you look at the results from test 3 in terms of which variables will be well estimated by the optimization (posterior model closely matches observations) and which for which parameters will the optimization have found the true value?
   2. Now look at the results from test 3. Were your expectations correct? If not, why do you think that is?
3. Finally, we will compare the results from test 1 (in which only the total Rh and C pool content are used in the optimization) and test 4 (in which the Rh and C pool contents from each of the litter and soil pools – but not the total – are used in the optimization).
   1. *Again, before you look at the results from test 4:* do you expect that the posterior model-data RMSE for each of the variables (i.e. Rh for litter, soil and total and C pool for litter, soil and total) will be much lower than the prior for all the variables? Explain your reasoning.
   2. Do you expect that the posterior RMSE for all variables will be lower, higher, or about the same in test 4 than for test 1? Explain your reasoning.
   3. Do you expect that any of the parameters will be better estimated by the test 4 experiment than in test 1? Why (or why not)?
   4. Now take a look at the results from test 4. Using what we explained in class, explain why the results might have been different from your expectations.
4. Which of the four tests would you use if you wanted to get the best estimate of all variables? Why?
5. Based on what we learned in class, what other type of DA experiment tests would you do to see if you improve the model predictions?