How do we Intend to Study the Effect of Land Heterogeneity on Superparameterizations?

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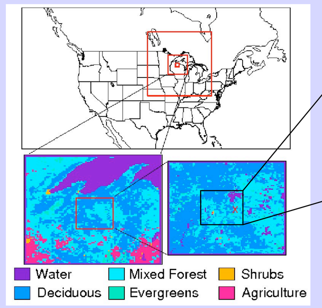
PREMISE: We have been working with D. Dazlich and M. Khairoutdinov to install our most recent version of the Simple Biosphere Model (SiB3) into the superparameterization framework, but this does not address any of the issues of heterogeneity. Simply put, how well does a limited sample (one or two axial 'strips') from a heterogeneous domain represent the variability within that domain? What kind of errors can we expect in the grid-scale exchange of energy, mass and momentum between the atmosphere and terrestrial biosphere from this limited sample?

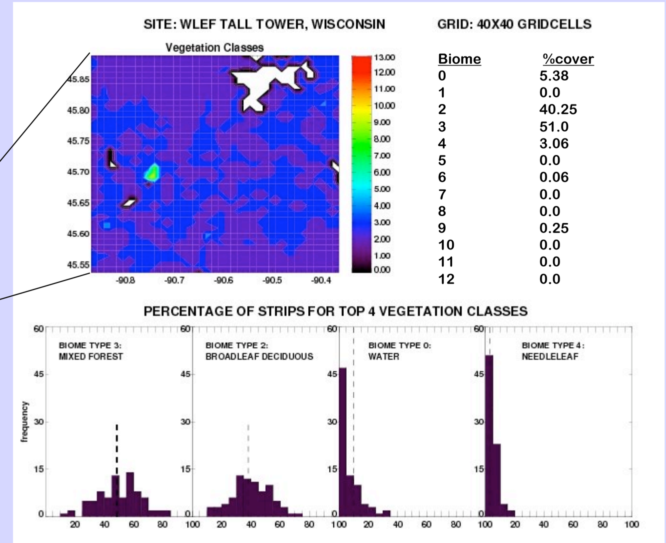
There are many questions to answer here, and this poster represents our first foray in to the topic. We've identified several 'starting points' in the investigation, and seek an exchange of ideas with other CMMAP meeting participants to assist in the formulation of our plan of attack. At the outset, we've identified several simple concepts that we believe are the logical place to start this research. They include:

• How well does an axial strip capture the variability in land cover inherent in a heterogeneous gridcell?
•Does variability in fluxes between the land and atmosphere follow directly from landcover?
•How well is the temporal evolution of the flux captured?
•What role does the scale of surface heterogeneity play? What native grid do we need to identify land variability on, and does this change with increasing or decreasing superparameterization gridcell size?

To start to analyze some of these questions, we have taken a 'pseudo-data' approach, where we can resolve the 'real' gridcell-level quantities, and compare their values to quantities upscaled from a limited sample of the grid. We are currently using two simulations of the CSU Regional Atmospheric Modeling System (RAMS) coupled to SiB3, run at 1 kilometer spatial resolution, as our pseudo-data experiments. One simulation is from the upper Midwest region of the United States, and the other simulates the region where the Tapajos River meets the Amazon in Brazil.

LAND COVER VARIABILITY





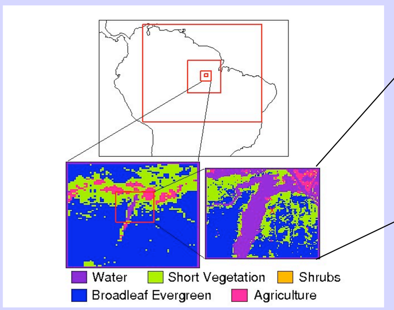
Biome Types		
0	-	Water
1	C3	Evergreen Deciduous
2	C3	Broadleaf Deciduous
3	C3	Mixed Forest
4	C3	Needleleaf
5	C3	Needleleaf Deciduous
6	C4	Broadleaf w/ Ground Cover
7	C4	Ground Cover/Maize Optical
8		Not Used
9	C3	Shrubs w/ Ground Cover
10	C3	Tundra
11	C4	Low-Latitude Desert
12	C3	Broadleaf Decid. Over Wheat

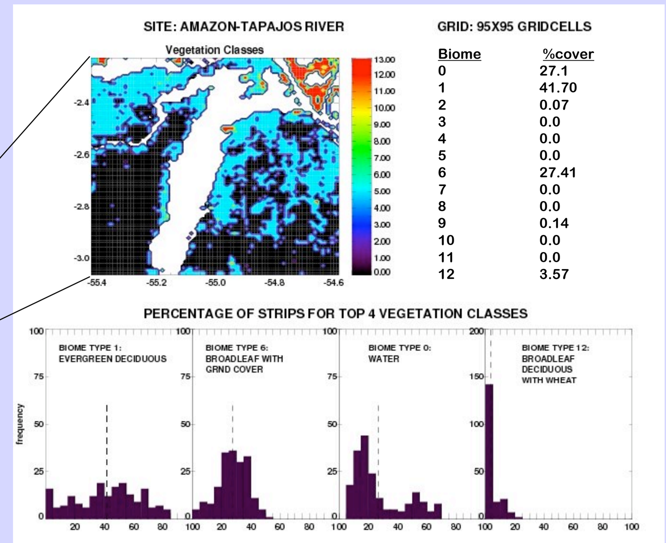
What can we say-obvious or otherwise-about the spatial distribution of land cover types in these two situations?

•The NA site has reasonably uniform heterogeneity; distributions of axial subsamples are generally grouped around the domain-mean percentage for a given landcover type

•SA site is more problematic; non-random features (Tapajos River) effect sample distributions

•Biome types with less than 10% coverage do not appear to have large impact





Further Questions:

•It seems pretty obvious that on a global basis, individual gridcells will vary between homogeneous (or uniform spatial heterogeneity) and spatially discrete variability

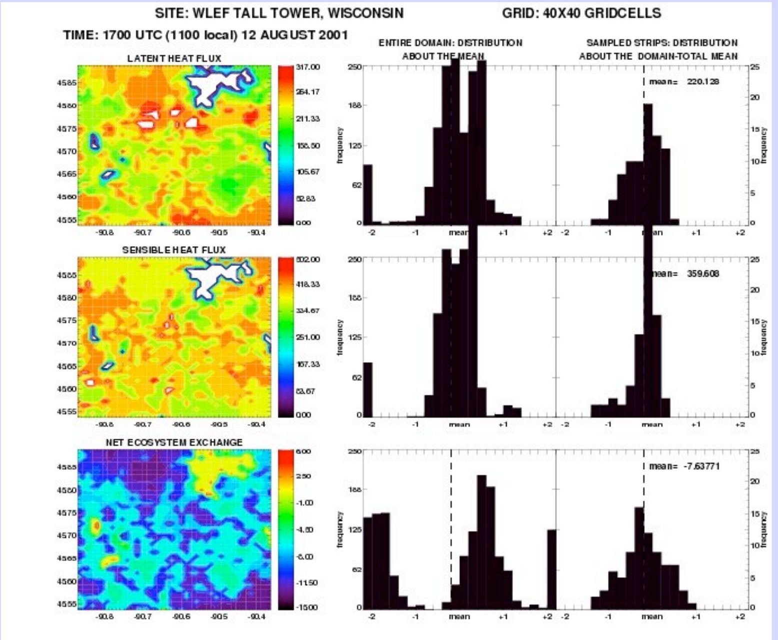
•Can we perform detailed analysis on a limited number of regions, and apply the results globally? Or do we need to perform a global analysis of this sort? If so, what should the resolution of the native grid be, and is it dependent on the resolution of the superparamaterization grid?

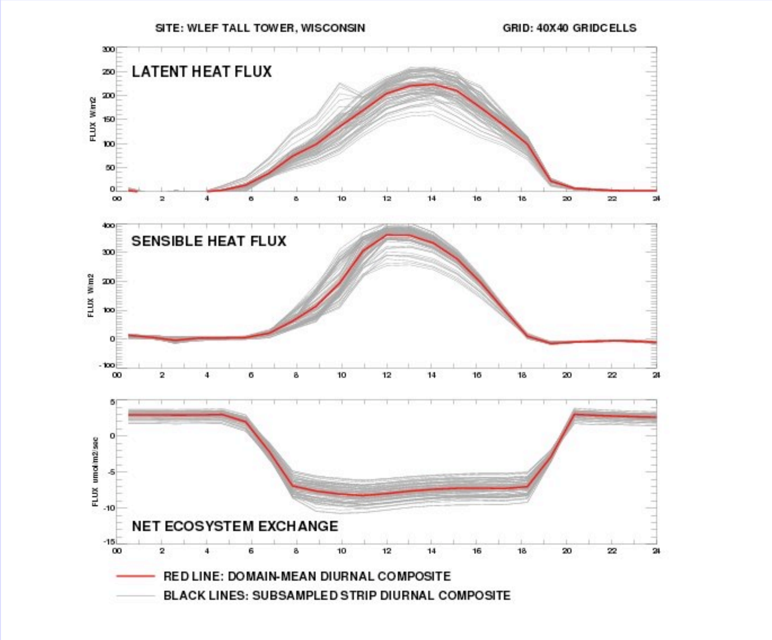
•Vegetation type is not the only variable in play here; quantities such as soil moisture, soil temperature, and snow presence/depth will effect the gridcell-level meteorology

•What about topography (elevation, slope and aspect)?

•Soil Type?

SPATIAL AND TEMPORAL FLUX VARIABILITY





Both NA and SA runs have 'real weather'-they are not idealized dry cases. August is the dry season in the central Amazon, but Wisconsin simulation has several fronts and both scattered and organized convection during the simulation. Soil moisture-and therefore soil moisture stress on photosynthesis-is spatially and temporally variable in both cases.

Some Observations:

•Both runs have spatially bimodal distributions of Net Ecosystem Exchange (NEE) of carbon. This is due to spatial organization of vegetation type and heterogeneity of soil moisture in NA simulation, and due mostly to land-water differences in the SA run

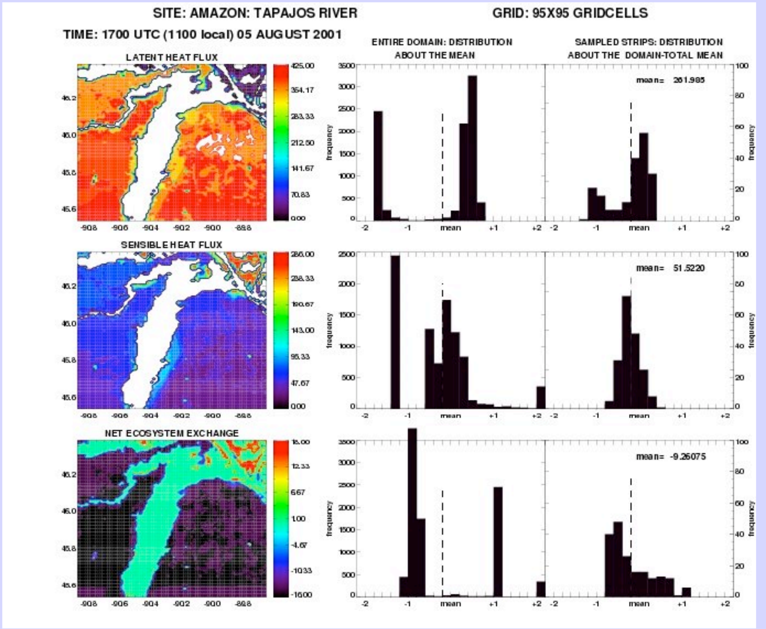
More Observations:

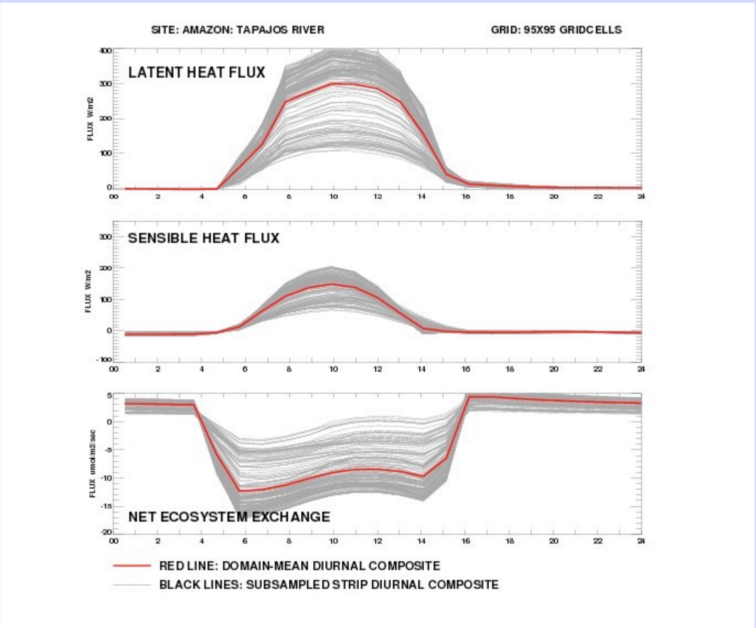
•Latent and sensible heat fluxes in the NA run are reasonably evenly distributed about the domain-total mean, both for all gridcells and for axial subsamples.

•SA latent and sensible sluxes are bimodal in a manner similar to NEE, due to land/water differences. Subsampled latent heat flux is bimodal, while subsampled sensible heat flux is small and nicely distributed about the domain mean.

•Diurnal cycle of all fluxes are well-behaved in NA run; local variability is smoothed out by domain average, and axial subsamples are distributed about the mean.

•SA flux diurnal cycles reflect large land-water differences. Water surface has low latent heat flux (in this simulation); Carbon flux of water surface is zero as well. In a more realistic simulation water surface will have a positive latent heat flux, and a small positive CO_2 flux.



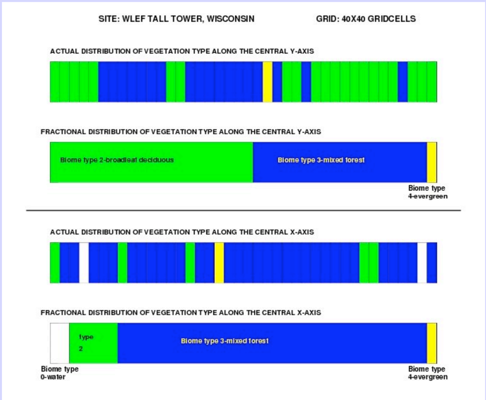


What's Next?

•Heterogeneous combinations of land cover, soil, and meteorological forcing (radiation, precipitation, wind, etc) produce large variability in fluxes. We're going to need to run simulations for both benign and active weather situations and subsample the results. Shown here are preliminary, well-behaved cases.

•The combination of heterogeneous surface flux and heterogeneous weather will determine domain-scale carbon flux; will the issues here be the same as for latent and sensible heat fluxes, or will the additional complexity increase the error?

SPATIAL SCALE OF LAND COVER VARIABILITY



•If we aggregate for relative contribution in a superparameterization, how do we treat spatial resolution?

•How do we treat multiple variables (vegetation type, soil type, soil conditions)?

•Can we use a statistical quantity such as a variagram to address this?

•Several investigators (i.e. Pielke, Avissar) have looked the effect of spatial heterogeneity on mesoscale meteorological processes. How will the simulation of this be modified in a superparameterization context?

WHAT'S NEXT?

•We need to develop an objective representation strategy for the land surface, based on global maps of biome type, soil type and topography. Consideration needs to be made for trace gas (CO_2, CH_4, etc) flux in addition to fluxes of latent and sensible heat, and momentum.

•Pseudodata experiments are an attractive and computationally reasonable technique to analyze these strategies. The next generation of pseudodata runs should include both total-domain and 2-dimensional runs to obtain a more complete picture of the interaction between surface processes and weather.

•What happens at coastlines? Will this be a difficult issue?

•We encourage suggestions from other CMMAP investigators on topics or investigative methods we may have overlooked.

•Several investigators (I.e. Pielke, Avissar, et al) have looked at spatial variability in a mesoscale modeling situation. This is not exactly analogous to a superparameterization, but their results may provide us some insight.

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