Breakout Group I

Identification of specific weather phenomena which couple strongly to climate and for which a subgrid model is necessary

What is climate?

One of the main questions that came up is what exactly we mean by "climate" in this context. Some possible approaches to classification:

- Global vs. regional: some processes are important for the global climate, some processes only for particular regions.
- Time scales: there was some discussion about what timescale cutoff marks the boundary between "weather" and "climate" for the purposes of approaching this problem. Is everything beyond seasonal timescales climate? The conclusion seemed to be, as has been said by a couple of people already, that there isn't a sharp cutoff and we should be fairly flexible about the definitions here.
- Spatial scales: there is a clear link between the temporal and spatial scales of phenomena in many cases, particularly those involving wave propagation.
- Statistics: there was some discussion about whether we should be interested in more than just mean and variability in climate variables; this ties in to Prashant's comments about parameterisations as being representations of the relationship between first and second moments and higher moments of climate fields.
- Application-specific requirements: from the point of view of applications of climate model output (e.g. for predictions of drought for agricultural forecasting), there is a need for more than just mean climatology: in particular, precipitation extremes are very important.

Quantification of importance

We spent quite a bit of time discussing methodological approaches to the quantification of which weather phenomena have an impact on climate. Some ideas we came up with:

- One of the most promising ideas seems to be the use of nesting of higher resolution models (either regional climate models or cloud resolving models) withing coarser-scale GCMs. By examining the difference between simulated climate for nested models with one-way coupling and those with two-way coupling, we may be able to learn something about the feedbacks between different elements of the climate system. One question that arose here is what this really tells us about the climate impact of the weather phenomenon we are considering. It isn't completely clear that this simple approach will work.

- There are some more complex approaches to feedback analysis in models that may be applicable, for example Colman [2003].

- Another obvious simple approach is to compare climate model simulations with and without particular parameterisations, or to perform parameter sensitivity studies. This approach may be limited by the ability to perform sufficient model simulations to produce effective sensitivity results.

- Downscaling of high-resolution climate simulations may help to quantify the importance of processes that are resolved in the high resolution simulations that are not resolved in lower resolution simulations.

- There was some question about how we might think about different treatments of processes that are close to being resolved compared to processes that we have no chance of resolving.

- Following on from a question of Adam's earlier, it may be of use to go back to older models, or to develop a hierarchy of simplified models from existing GCMs. This would allow us to explore the use of more sophisticated analysis techniques, such as numerical continuation and bifurcation analysis, as exemplified by the work of Henk Dijkstra's group on circulation regimes in ocean models [Dijkstra and Weijer, 2003].

Processes

Here, "G" means that a process is important globally, "R" important in some regions, "?" means there is question about the importance of a particular process, and "-" means a process is, as far as we can tell, not important.

For each process, we show the importance for the global mean, variability and the extremes ("tails") of the climate distribution.

Mean	**Var.**	**Tails**	**Process**
G	G	G	Boundary layer state (for tropical convection; upscale processes)
G	G	G	Convection (moisture transport; momentum transport; mesoscale convective systems; convectively coupled waves; MJO)
G	G	R	Baroclinic eddies
?	-	G	Hurricanes/cyclones (ocean mixing; evaporation; transport of water to stratosphere)
R	G	R	Diurnal cycle (propagation of convection; boundary layer)
G	-	G	Surface fluxes (ocean–air)
G	G	G	Cloud microphysics
G	-	G	Gravity waves

References

R. Colman. A comparison of climate feedbacks in general circulation models. *Clim. Dyn.*, 20 (7-8):865–783, 2003.

H. A. Dijkstra and W. Weijer. Stability of the global ocean circulation: The connection of equilibria within a hierarchy of models. *J. Mar. Res.*, 61(6):725–743, Nov 2003.