GFDL Sea Level Experiments

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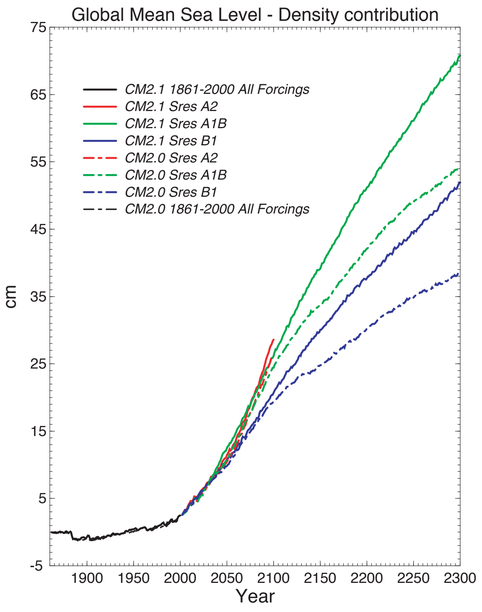
GFDL has recently developed two new AOGCMs. These two models are very different from the earlier GFDL models. An important new feature is the use of an explicit free surface scheme in the ocean component of the model. This allows true water fluxes when water moves across the atmosphere-ocean interface. In the past, a virtual salt flux scheme needed to be used which could distort the impact of these fluxes.

In addition to a long 1860 control integration, the new AOGCMs have been used to study climate changes over the past 140 years and into the future. The future integrations used the SRES B1, A1B and A2 scenarios. Present day and year 2100 stabilization integrations were also performed.

Steric Rise



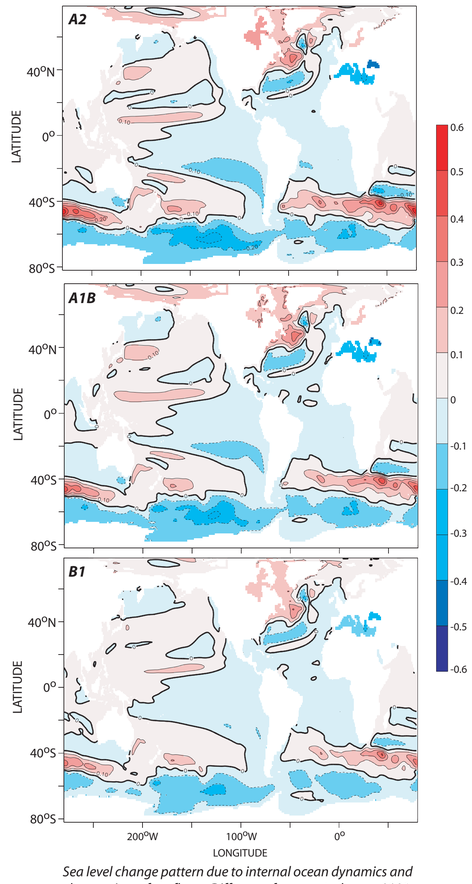
Globally averaged sea level rise due to changes in density only. Solid lines are results from CM2.1; dashed from CM2.0. After 2100, the forcing is held constant at the 2100 concentrations in all runs.

Analysis of the integrations indicates that volcanic eruptions can have remarkably long lasting impacts on sea level rise, as long as 1 century. For example, the large Krakatau eruption in 1883 impacts sea level rise well into the 20th century in the model integrations (Delworth et al. 2005).

As noted by earlier authors, sea level changes have very long response time scales to changes in radiative forcing. Evidence for this statement is indicated by the fact that sea level continues to rise long after the radiative forcing is held constant in the various stabilization integrations.

There are large differences in the amount of sea level rise between the two AOGCMs. This difference is due to large differences in the CONTROL simulations of these models in the Southern Ocean (Russell et al. 2006). In one, the Southern Hemisphere jet and associated surface wind stress maximum is located much too far north, as is the case in most other AR4 models. The poorly located winds, leads to a poor Southern Ocean simulation with too little mixing when compared to observations. In the second model, the winds and Southern Ocean simulation are much more realistic. The more realistic mixing in this model allows the ocean to take up much more heat when the radiative forcing increases due to the increasing greenhouse gases. The increased heat uptake results in a much larger sea level rise.

Patterns of Sea Level Rise



Sea level change pattern due to internal ocean dynamics and changes in surface fluxes. Difference from control, years 2081 to 2100 average. Units are meters. Blue shading represents decreases in sea level (negative values).

The pattern of sea surface height changes due to internal ocean dynamics resulting from changes in the surface fluxes indicate that the pattern of change is very similar among the various forcing scenarios. Only the magnitude of the change varies from scenario to scenario.

One change that is evident is the increase in sea surface height between 40°S and 60°S. This is due to the southward shift in the ACC associated with the southward shift of the atmospheric wind stress maximum as the climate warms. Another common pattern is seen in the North Atlantic and is associated with the weakening of the thermohaline circulation. The pattern of change in the Pacific is not understood and is being investigated.

Summary:

- ***Sea Level has very long response time scales.***
- ***Volcanoes can impact sea level for several decades.***
- ***The Southern Ocean simulation in CONTROL impacts the transient climate response.***
- ***The patterns of sea level rise seem not very dependent on emission scenario.***

References:

Delworth, T. L., V. Ramaswamy, and G. L. Stenchikov, 2005:
The impact of aerosols on simulated ocean temperature and heat content in the 20th century. *(GRL, 32, L24709, doi:10.1029/2005GL024457.)*

Russell J. L., K. W. Dixon, A. Gnanadesikan, R. J. Stouffer and J.R. Toggweiler, 2006:
The Southern Hemisphere Westerlies in a Warming World: Propping Open the Door to the Deep Ocean, *(J Clim., in press.)*