Long-term climate change and its potential impact on Florida

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IPCC-AR4 projection of rainfall in Florida

According to the externally forced model simulations (A1B scenario) for the twenty-first century used in the Intergovernmental Panel for Climate Change's Fourth Assessment Report (IPCC-AR4), the eastern North America (25^oN – 50^oN and 85^oW – 50^oW) will experience about 3.6^oC increase in the surface temperature, and 7% *increase* in rainfall by the end of the 21st century (2080 – 2099). On the other hand, the IPCC-AR4 projects that the Caribbean islands (10^oN – 25^oN and 85^oW – 60^oW) will experience about 14% *decrease* in rainfall by 2080-2099 with a larger decrease of 20% in early summer months of June to August. This sharp discontinuity of the projected rainfall change across 25^oN suggests that the 21st century climate projection for the state of Florida is quite complex and uncertain.

Figure 1 shows the composite maps of the projected changes in rainfall in the 21st century for (a) December, January and February (DJF), (b) March, April and May (MAM), (c) June, July and August (JJA), and (d) September, October and November (SON). Ten IPCC-AR4 models under A1B scenario are used to create these maps. As shown, the state of Florida is expected to have an overall much dried climate condition in the 21st century. However, this drying condition is highly dependent on geographic location and also on season. During winter season, the drying seems to be limited to the Florida Panhandle area. But, in spring, the entire region of Florida is projected to be much drier. In summer, the drying condition seems to be alleviated in the Northern Florida. However, the South Florida is expected to have a severe drying condition. During fall, all regions in Florida are subject to a weakly wet condition. On an average over Florida, the projected change in rainfall is about a 11% decrease in MAM, and a 8% decrease in JJA. During DJF, the projected change is about a 5% decrease, whereas in SON, it is about a 3% increase.

It appears that the projected impact of climate change on Florida is most severe in the South Florida in JJA, which is known as the mid-summer drought season [e.g., Mapes et al. 2005]. As clearly shown in Figure 1c, the projected drying in the South Florida in JJA is linked to the broad drying in the Caribbean region, which is a robust feature in all IPCC-AR4 models [e.g., Rauscher et al., 2008]. Therefore, it appears that the projected drying in South Florida in JJA can be best described as an extension and intensification of the Meso-American mid-summer drought in the 21st century as suggested in Rauscher et al. [2008]. Recent works by Lee et al. [2011] and Rauscher et al. [2011] provided a physical explanation for the projected summer drying of the Caribbean region. They argued that the so-called differential inter-ocean warming is main cause of the projected drying over the Caribbean in the 21st century. In specific, they used idealized climate model experiments to show that the preferential warming of the tropical Indo-Pacific in the 21st century induces a global average warming of the tropical atmosphere, and thus increases atmospheric static stability and decreases convection over the suppressed warming region of the tropical North Atlantic.

Impact of Atlantic Multidecadal Oscillation

The Atlantic Multidecadal Oscillation (AMO) is known as an important SST forcing that projects onto a distinctive global precipitation pattern. During a warm phase of the AMO, most of the United States, especially the Midwest, experiences a drying condition. But, the inflow to the lake Okeechobee, Florida is increased as much as 40% during a warm phase of the AMO mainly because the summer rainfall in South Florida is increased during a warm phase of the AMO [Enfield et al. 2001]. Therefore, due to the significant role of the AMO in the hydroclimate of Florida, it is important to include the AMO and its impact in the future projection of changes in rainfall for Florida.

It is important to realize that the IPCC-AR4 projection shown in Figure 1 does not account for the impact of internal variability such as the AMO because the internally generated multidecadal signals are canceled out after applying the composite mean of the IPCC-AR4 models. [e.g., Knight 2009]. Therefore, it is likely that the model projected changes in rainfall over Florida, induced by the anthropogenic greenhouse gas effect (Figure 1), are amplified or diminished by the AMO for the foreseeable future. For instance, it is widely believed that a warm AMO phase and the anthropogenic warming coexisted with comparable amplitude during the past decades. On the other hand if the AMO switches to a cool phase in future decades, then the effect of man-made warming will be amplified in such a way that the projected drying of South Florida in JJA shown in Figure 1c becomes much more severe.

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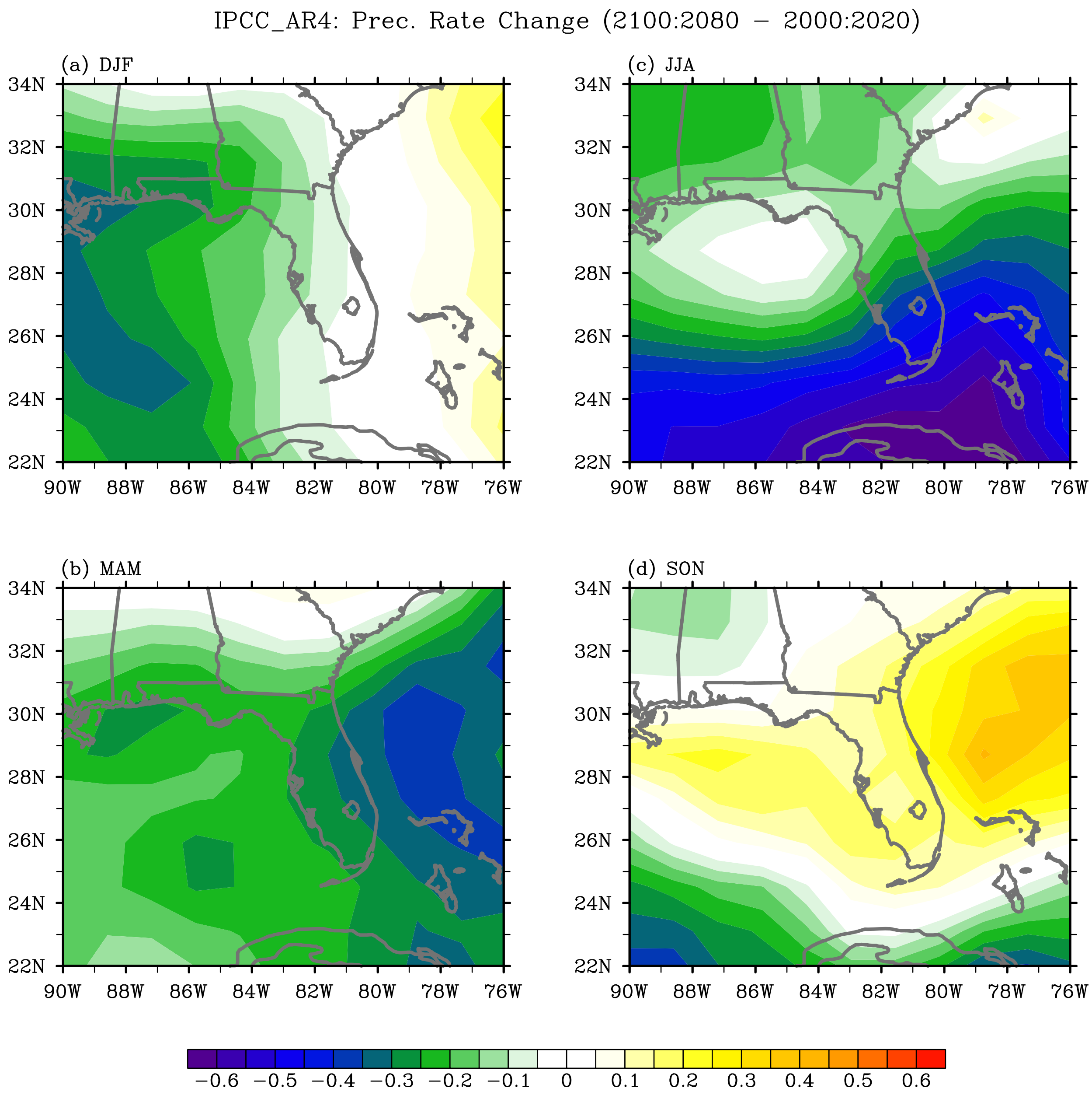

Figure 1. The composite maps of the projected changes in rainfall between periods 2080–2100 and 2000–2020 for (a) December, January and February (DJF), (b) March, April and May (MAM), (c) June, July and August (JJA), and (d) September, October and November (SON), computed from ten IPCC-AR4 model simulations under the A1B scenario. The unit is mm/day.