Climate Change and Cryospheric Modeling

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Cryosphere consists of snow, river and lake ice, sea ice, ice shelves and ice sheets, glaciers and ice caps, frozen ground. It is 2nd largest component of the climate system (10% of land, 75% of fresh water) and linked to energy budget (reflection of solar radiation). It becomes a natural sensor of climate variability and important climate change variable. Warming in cryosphere is evident including snow decrease, lake and river Ice decrease (later formation and earlier melt), sea ice extent decrease, loss of glacier and ice caps, sea level rise, and permafrost loss. Especially about sea level rise, the IPCC projected 53.5~91.4 cm of sea level rise by 2100, but this projection did not include a significant contribution from the Antarctic Ice Sheet (IPCC AR5, 2013). Therefore, future IPCC estimates will almost certainly be revised upwards. Recently, a series of studies pointed out the collapse of the West Antarctic Ice Sheet (WAIS), especially the Thwaites Glacier Basin, is accelerating and may have already passed a tipping point based on new observations and simulations (e.g. Cole et al. 2014; Favier et al. 2014; Joughin et al. 2014; Rignot et al. 2014; Paolo et al. 2015; Feldmann and Levermann 2015; DeConto and Pollard 2016 ; Fogwill et al. 2017). Antarctica is the main driver of the risk of really high sea level rise, so we really need to understand what's happening there. New study with a comprehensive sea level rise emulator that accounts for Antarctic rapid discharge from hydrofracturing and ice cliff instability and includes the socioeconoimc indicators, projected a high of 1.8m sea level rise by 2100 (Mauels et al. 2017). Since then, there have been more systematic international collaborations focusing on the sea level rise caused by Greenland and Antarctic ice sheet melting using ice sheet models such as SeaRISE (Sea-level Response to

Ice Sheet Evolution), ice2sea (estimating the future contribution of continental ice to sea-level rise), COMBINE (Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection). Now it becomes one of grand challenges of WCRP (World Climate Research Program), and ISMIP6 (Ice Sheet Model Intercomparison Project 6) is endorsed to CMIP6 (Coupled Model Intercomparison Project Phase 6) for the next IPCC report. Moreover, IPCC will publish the SPOCC (Special Report on the Ocean and Cryosphere in a Changing Climate) in 2019. Recently, numerical modeling of the Antarctic ice sheet not only focus on the long-time diffusive response to surface mass balance changes (e.g. ISMIP6), but also processes occurring at the marine boundary of the ice sheet, which are progressively incorporated in newly developed state-of-the-art ice sheet models (e.g. MISMIP+, MISOMIP).