Building dependence into sea-level projections: ice-sheet interactions

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Sources of sea-level rise uncertainty are numerous, however the continental ice sheets constitute both a potentially large contribution to future sea-level and physical mechanisms that are difficult to model (e.g. ice melt ponding, submarine melting, basal lubrication, ocean melting/interaction, ice cliff failure and ice sheet fracturing). In addition to this uncertainty, one must also consider possible interconnectivity between the ice sheets (East Antarctica, West Antarctica and Greenland): whether changes in an ice sheet drive changes in another and visa-versa. Clearly external drivers impact all ice sheets (e.g. temperature and precipitation) but not in the same way and underlying causal relations between ice sheets will either reflect these or other mechanisms. We analyse satellite derived mass-balance estimates, whose signal combines SMB and rapid dynamics, using a statistical methodology called vector-auto regression. We find that a twice integrated auto-regressive model, which is composed of two linear relationships (Greenland, West Antarctica and an external linear trend, and West and East Antarctica) is successful in estimating the mass-balance observations. This result points to present-day ice sheet mass evolution, and its first derivative being a non-stationary process. We show that these relationships can be easily implemented into probabilistic sea-level projections with clear differences from projections following the assumption of independent sea-level components.