

## Seasonal Spatial Patterns of Greenland Ice Mass Change recovered by GRACE Gravity Data

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Numerous studies have examined on Greenland Ice Sheet (GrIS) mass balance and concluded that GrIS is the largest contributor to the contemporary global mean sea level rise. The GrIS mass loss is mainly associated with increase meltwater runoff and ice discharge. Recently, abrupt changes of ice flow were reported in large glaciers due possibly to the lubrication of injected meltwater to the interface between glacier and bedrock. This indicates that seasonally modulated ice flow by surface run-off and subglacial hydro-system is an important component to explain recent ice loss of GrIS. However, it is not yet clear whether the dynamic response to basal water is a common phenomenon throughout GrIS. To investigate seasonal variation of ice dynamics over GrIS, we examined GRACE monthly solutions after removing aliasing error with EOF decomposition. We found a large amount of summer ice mass loss at marginal GrIS, especially West, Southeast and South coast regions. During the subsequent falls, the spatial pattern of ice mass changes is similar but its sign tends to be opposite to that in summer. In addition, in 2012, after extreme summer melting, winter accumulation of ice mass was not observed over GrIS. This implies that enhanced winter ice flow would be occurred, and it would be a significant contributor to recent GrIS ice mass loss.