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Antarctic ice mass balance from satellite geodesy: understanding the signal beyond linear trends

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Satellite geodetic methods have revolutionized our knowledge on present-day mass changes of the Antarctic ice sheet. These methods include Synthetic Aperture Radar (SAR) for flow velocities, satellite altimetry (ENVISAT, ICESat, CryoSat-2) for surface height changes and, finally since 2002, GRACE (Gravity Recovery and Climate Experiment) for mass changes. While SAR applications provide "snapshots" of ice flow variations, ENVISAT radar altimetry and GRACE satellite gravimetry observe variations in geometry and mass, respectively, in about a monthly resolution, or even higher. Most analyses have concentrated on linear trends. In this context, interannual variations, notably due to fluctuations of the surface mass balance (SMB), appear as noise which complicates the interpretation of trends and their comparison over different time spans. Atmospheric modeling of SMB has been employed to evaluate this interannual "noise" in the trend analysis. Meanwhile, the space geodetic techniques are mature enough to monitor the non-linear interannual variations.

In this presentation we compare interannual signals from GRACE satellite gravimetry, ENVISAT radar altimetry (RA) and atmospheric modeling. We use ENVISAT RA results from the Along-Track Repeat Satellite RA approach and precipitation-minus-evaporation estimates from ECMWF as an approximation for SMB. As the main result, the three approaches provide consistent pictures of SMB-related nonlinear interannual variations. This consistency gives confidence in either approach and confirms, in particular, that the nonlinear variations in the geodetic time series mainly reflect actual signals of the ice sheet. By the ECMWF atmospheric modeling data, geodetically observed interannual SMB variations in West Antarctica and along the Antarctic Peninsula can be related to global atmospheric conditions of the El Niño Southern Oscillation (ENSO). A synthesis of the three approaches promises to add value to either datasets, to aid their interpretation and to stimulate further improvements of the individual approaches, and thus to refine our abilities to monitor and understand ongoing changes in the cryosphere.