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Inter-annual precipitation changes as quadratic signals in the GRACE time-variable gravity

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The Gravity Recovery and Climate Experiment (GRACE) satellite mission has been producing scientific results on mass variations on inter-annual timescales, e.g. melting of ice sheet in Greenland and mountain glaciers in Alaska, Eastern Africa drought, water level increase in Caspian Sea, etc. In these discussions only linear trends and the seasonal components have been analyzed in the monthly GRACE time series, whereas little attention has been paid so far to the existence of the quadratic changes which signify the temporal accelerations. With over 6 years of GRACE data and revisiting the time-variable gravity field of various regions, we find that such acceleration/deceleration terms are quite often significantly different from zero. They include East Africa, near Obi River, Caspian Sea, Black Sea, Central Asia, and southern South America, whereof discussions of linear trends without specifying the epochs are inadequate. Here we investigate geophysical implication of these quadratic terms; in particular gravity changes in land areas reflect, to a large extent, soil moisture variations. Soil moisture is the time integration of water fluxes, i.e. precipitation, evapotranspiration and runoff. Here we consider that the linear trend in precipitation is responsible for the quadratic change in gravity, and examine trends of observed precipitation in various regions from CMAP (Climate Prediction Center Merged Analysis of Precipitation). Thus, in order to compare linear trend in CMAP and acceleration in GRACE, we calculate month-to-month difference of equivalent water depth at GRACE grid points, and modeled them with seasonal variations and linear trends. We found good agreement between their geographical distributions although amplitudes are smaller in GRACE, meaning the quadratic gravity changes in the GRACE data do reflect inter-annual changes of precipitation fairly faithfully.