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Height Change Detection in Antarctica Using ICESat Data Based on Kriging/Kalman Filtering Technique

h. huang

Wuhan University, School of Geodesy and Geomatics, China (hlhuang@sgg.whu.edu.cn)

Studies of the response of ice sheets to climate change require data sets with high accuracy and uniform ice sheet coverage. Measurements from the Geoscience Laser Altimeter System(GLAS) aboard NASA's ICESat satellite are used to estimate changes in the ice sheet surface heights and the secular change in Antarctic ice mass. Usually, the most common technique used in analyzing satellite altimetry data to study height change in the ice sheets is the dh/dt technique based on the cross-over geometry. However, this approach only uses less ten percent of the available data. So in this paper, Kriging is introduced as an alternative method, which will enable us to use all of the data and the data statistics to estimate height changes and other surface characteristics. Results of height change rate dh/dt in Antarctica for the years 2003-2005 produced using Kriging and cross-over analysis are compared. In the Amery Ice Shelf and in the West Antarctic coastal area and near latitude$-81^\circ N$, the difference in dh/dt between the two methods is statistically significant. Specifically, Kriging gives higher positive dh/dt at the Amery Ice Shelf, and does not show the pervasive negative dh/dt in the Pine Island/Thwaites Glaciers area. In addition, Kriging results also show a systematic positive difference of approximately $0.03 \pm 0.02 m/yr$ over the smoothest part in Antarctica. Both methods detect the large positive dh/dt at approximately [lon,lat] of $\left[\begin{array}{cc} -120^\circ E & -82^\circ N \end{array} \right]$,with Kriging showing higher positive dh/dt. Further more, ICESat derived heights collected between Feb.03–Nov.04 using a Kriging/Kalman filtering approach to investigate height changes in Antarctica are analyzed. The model's parameters are height change to an a priori static digital height model, seasonal signal expressed as an amplitude B and phaseθ, and height change rate dh/dt for each block. From the Kalman filter results, dh/dt has a mean of -0.06 m/yr in the flat interior of Antarctica. Spatially correlated pointing errors in the current data releases give uncertainties in the range 0.06 m/yr, making height change detection unreliable at this time. Our test shows that when using all available data with pointing knowledge equivalent to that of Laser 2a, height change detection with an accuracy level 0.02 m/yr can be achieved over flat terrains in Antarctica.

Keywords: height change, Antarctica, ice sheet, ICESat, cross-over ,Kriging, kalman filtering