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Multi-temporal satellite analysis of Wilkins Ice Shelf, Antarctic Peninsula, and consequences for its stability

Melanie Rankl (1), Johannes Fürst (1), Veit Helm (2), Angelika Humbert (2), and Matthias Braun (1)

(1) FAU Erlangen-Nuremberg, Geography, Erlangen, Germany (melanie.rankl@fau.de), (2) Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Glaciology Section, Bremerhaven, Germany

Antarctic Peninsula (AP) ice shelves have been affected by ice front retreat and surface lowering over the past decades. 12 major ice shelves have disintegrated or significantly retreated and have been affected by volume loss. Longterm ice shelf thinning is twice as high at western AP ice shelves than at eastern AP ice shelves. Wilkins Ice Shelf (WIS), located at the western AP, has undergone considerable ice front retreat since the 1990s. It lost $\sim$ 5000 km^2 of its size since then. Surface lowering at WIS was found to be the largest at AP ice shelves between 1978 and 2008.

Here, we analyze time-series of satellite data in order to assess dynamic changes of WIS following the ice front retreat between 1994 and 2010. We present multi-temporal changes in surface velocities and deduced products, such as strain rate and stress regimes. Surface flow was derived from SAR intensity offset tracking applied to ALOS PALSAR image pairs. In addition, we show variations in ice thickness between 2003 and 2012 derived from TanDEM-X satellite acquisitions and altimetry datasets (CryoSAT-2, ICESat). The bistatic TanDEM-X acquisitions are very suitable for interferometric processing due to highly coherent image pairs.

The results showed surface velocity speed up during break-up of an ice bridge between two confining islands in 2006-2008, when an area of $\sim$ 1800 km^2 broke off. A sharp transition between compressive and extensive in-flow strain rates evolved at the narrowest part of the ice bridge, which contributed to the formation of a crack and hence, failure of the ice bridge in April 2009. First principal stresses were estimated to amount to $\sim$ 250 kPa in the vicinity of the crack formation.

The imaging TanDEM-X radar geometry allowed for a comprehensive ice thickness mapping of the ice shelf in 2012 and resolved many details due to the high spatial resolution. The ice thickness at WIS was found to be very heterogeneous. Thickness changes between 2003 and 2012 revealed increased thickness loss in recent years 2009-2012 at the western WIS as well as partially very thin ice there (<30 m in 2012). Decoupling of the ice shelf from the stabilizing Latady Island might be inevitable in the near future.

In summary, the comprehensive analysis of WIS based on remote sensing data and derived products revealed dynamic changes after ice front retreat. The future stability of WIS might be considered weak, given considerable ice thickness loss and partially very thin ice, ice flow acceleration and the identification of developing fractures during recent years.