



DLR - 10-14 June 2013

Monitoring Polar Ice Sheets using TanDEM-X

Preliminary results

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Overview

- The MEaSUREs-2 NASA project
- Project Objectives
- TerraSAR-X/TanDEM-X contribution
- Preliminary Result
- Perspectives and Conclusion



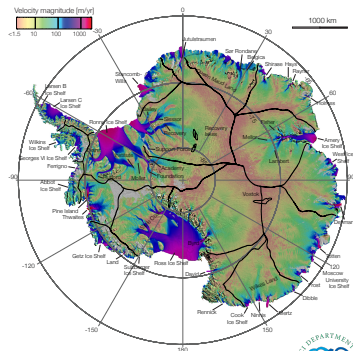

 NASA MEaSUREs-2 Project

Ice Velocity Mapping of the Great Ice Sheets: Antarctica

We aim to improve our knowledge of the ice dynamics of the great ice sheets to better understand their current and future impact on sea level change.

Background : This project builds upon the successful predecessor delivered to the community through NSIDC:

- MEaSUREs-1 InSAR-Based Antarctica Ice Velocity Map (NSIDC-0484)
- MEaSUREs-1 Antarctic Grounding Line from Differential Satellite Radar Interferometry (NSIDC-0498)
- MEaSUREs-1 InSAR-Based Ice Velocity Maps of Central Antarctica: 1997 and 2009 (NSIDC-0525)



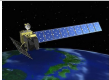

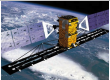




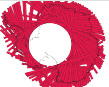




Project Objectives

The primary objective is to establish a long-term ESDR of ice velocity in Antarctica

- Increase the available temporal range - reprocessing 1996 ERS-1/2 tandem data; 1997 RADARSAT-1 AMM-1 and 2000 MAMM.
- Extend the ESDR forward by producing a second reference year - TerraSAR-X, TanDEM-X, RADARSAT-2, ALOS PALSAR-2, Sentinel-1
- produce time series of ice velocity over selected regions.
- Provide updated information on grounding line position using DInSAR to detect decadal time-scale grounding line migration.
- Provide MODIS image mosaics of Antarctica for year 2014.
- Provide high-resolution SAR image mosaics (by-products of the velocity mapping for 1996-2016), to update ice-front positions and detect decadal changes.



Data Processed

	ALOS PALSAR	ENVISAT ASAR	RADARSAT-1/2	ERS-1/2	TSX/TDX	Sentinel-1a/b
Sensor/Agency						
Band	L	C	C	C	X	C
Repeat (day)	46	35	24	3/1	11	12/6
Coverage (year)	2006-10	2007-09	1997, 2000, 2009-present	1992,1996	2011-2012	?
Data Processed						
Comment	Best coverage in coastal areas	Best coverage of the interior	Only coverage of central Antarctica	So far used for time series	Used for time series	-

Acquisitions for the International Polar Year 2007-09 were coordinated by the Space Task Group (STG). At present, the Polar Space Task Group is building on the IPY success and is coordinating present and future SAR acquisitions in polar regions.



Monitoring Polar Ice Sheets using TanDEM-X: Antarctica & Greenland

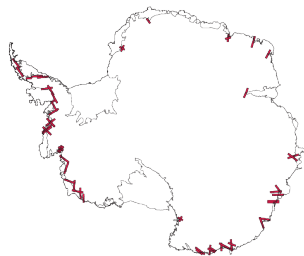
2 proposals submitted:XTI_GLAC_NR0343, XTI_GLAC_NR0508

Objective: Scientific evaluation of TanDEM-X for glacier mass balance studies. Specific objectives are:

- to validate our existing ice velocity product using TanDEM-X
- to improve elevation information available for the test sites
- to establish a unique reference data set
- to update ice velocity and grounding line measurements
- to analyze any changes (volume and velocity) in glaciers observed.

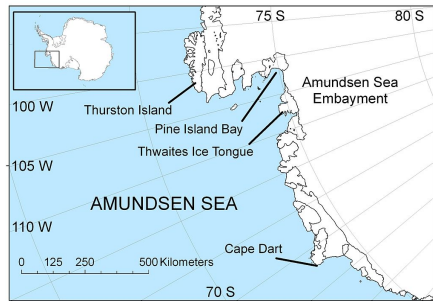
Data Takes and Imaging Mode:

- Test sites were carefully chosen to achieve an Antarctica/Greenland wide impact with fewer sites.
- Three consecutive acquisitions per year per site over 3 years (+ continuation thereafter if possible).
- Image mode: Bistatic; HH-HH; TerraSAR-X beams
- Antarctica: 55 sites (Temporal preference: Jun-Aug)
- Greenland: 28 sites (Temporal preference: Dec-Feb)

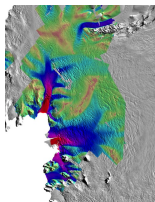


Annual time series of ice velocity - Amundsen Sea

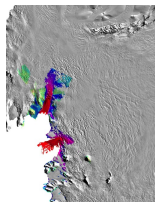
Amundsen Sea Embayment is known to be one the most active sector in Antarctica. The flow of these glaciers has increased in recent years, if they were to melt completely global sea levels would rise by about 0.9-1.9 m.



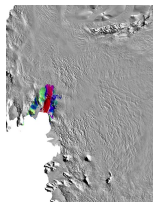
Annual time series of ice velocity - Amundsen Sea



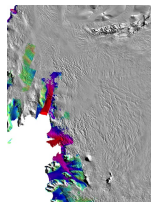
1996 ERS



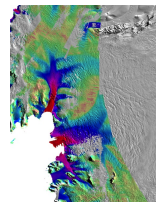
2000 R1



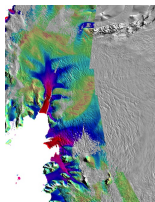
2002 R1



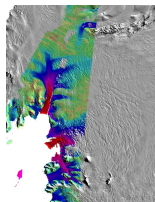
2006 ALOS



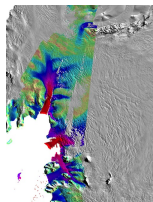
2007 ALOS



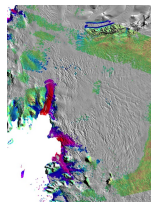
2008 ALOS



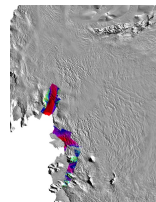
2009 ALOS



2010 ALOS

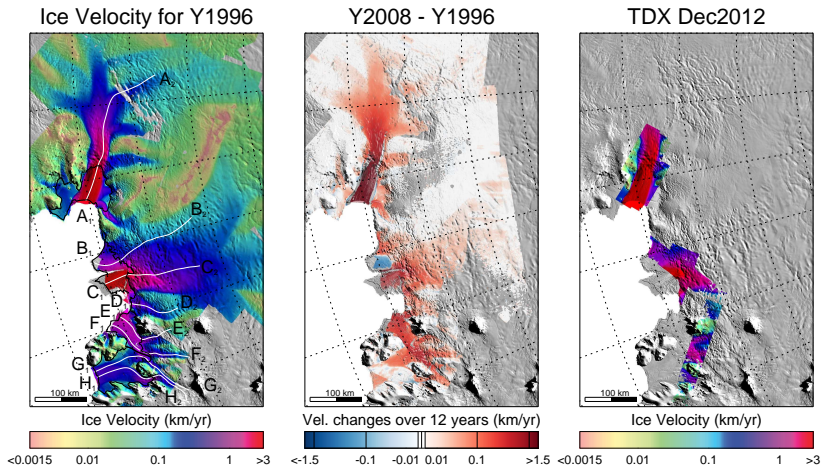


2011 R2

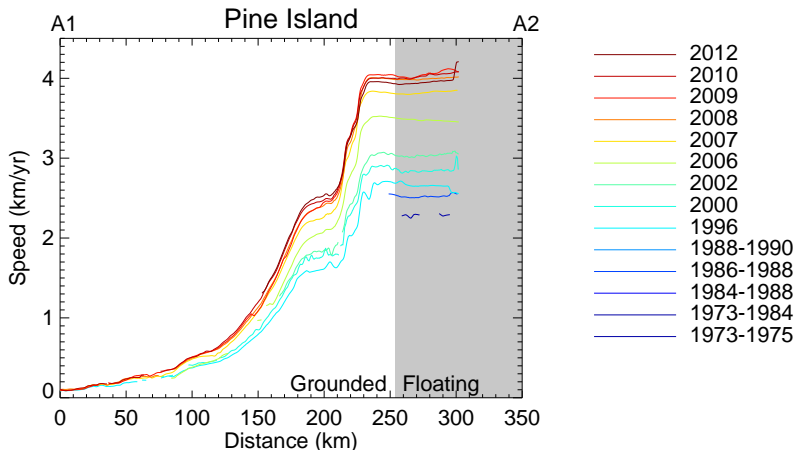


2012 TDX

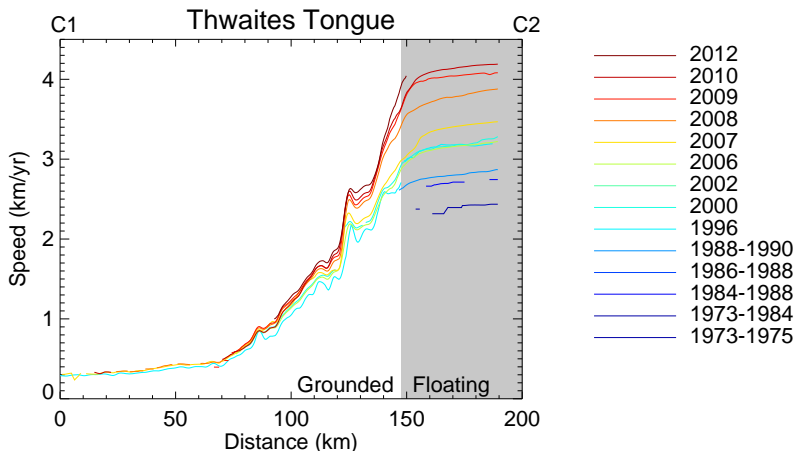
Amundsen Sea Sector



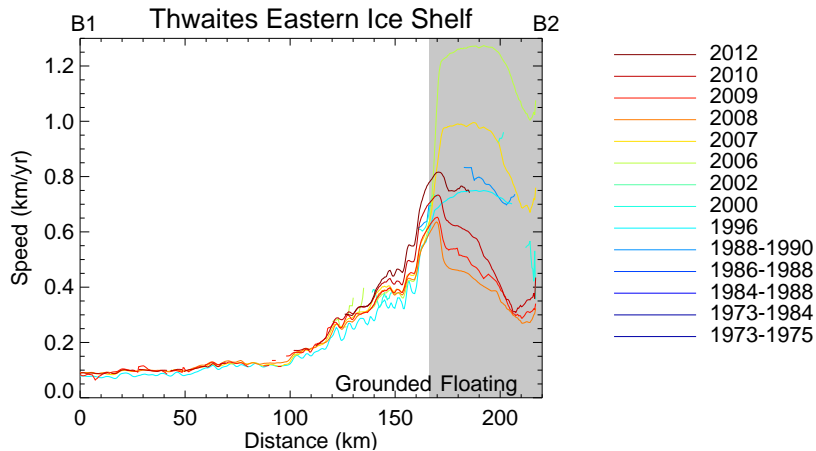
Ice velocity change on Pine Island Glacier



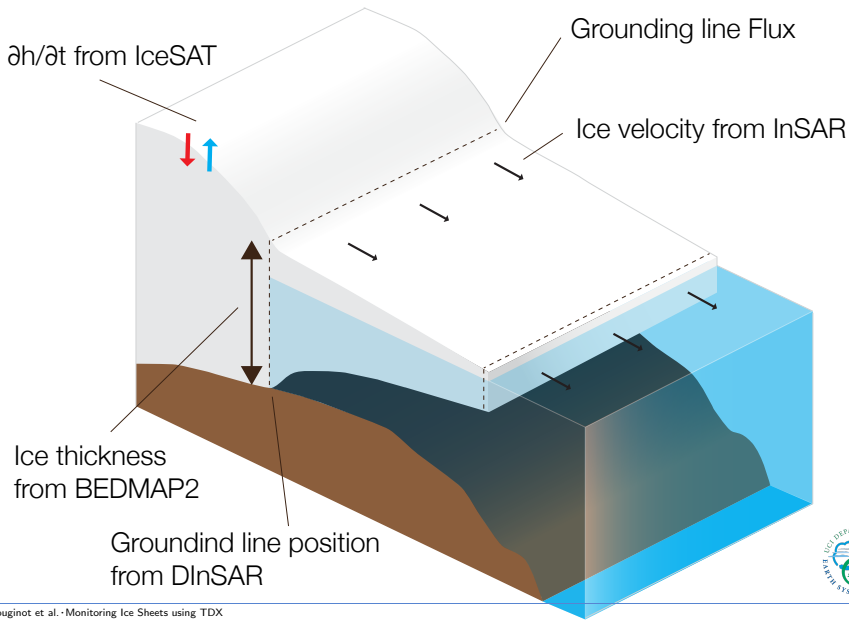
Ice velocity change on Thwaites Tongue



Ice velocity change on Thwaites Eastern Ice Shelf



Ice Flux measurement



Ice Flux into Amundsen Sea Embayment

Table : Mass flux in Gt/yr of glaciers that flow into Amundsen Sea, West Antarctica from 1973 to 2012.

Year	Pine Island	Thwaites	Haynes	Crosson	Dotson	Total
1973-1975	77±6	-	-	-	-	} 195±25 ¹
1973-1984	-	74±7	-	12±2	-	
1986-1988	85±7	-	-	-	-	} 216±27 ¹
1984-1988	-	85±7	-	14±3	-	
1988-1990	-	93±9	-	-	-	
1996	89±6	98±7	12±1	19±3	20±4	237±21
2000	99±6	101±10	14±1	21±7	21±6	256±30
2002	103±7	-	-	-	-	
2006	120±9	105±8	13±1	25±3	26±4	289±25
2007	129±8	109±8	14±1	25±3	27±4	305±24
2008	135±9	117±9	14±1	28±3	28±4	321±26
2009	139±8	118±9	14±1	28±3	29±4	328±26
2010	137±7	119±9	14±1	29±4	29±4	329±25
2011	136±10	119±9	15±1	-	30±4	329±28 ²
2012	135±11	121±10	15±2	29±4	31±4	332±31

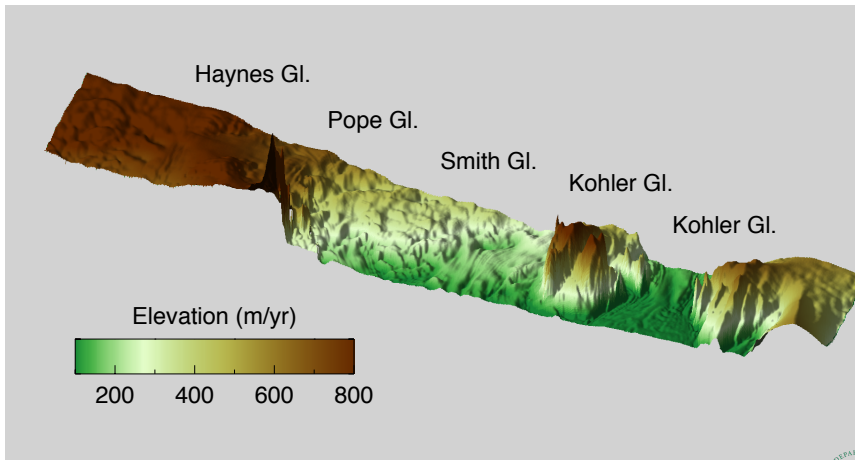
¹ Haynes and Dotson fluxes are from 1996, corresponding errors are doubled.

² Crosson flux is from 2010.



DEM using TDX - Pope, Smith and Kohler Glacier

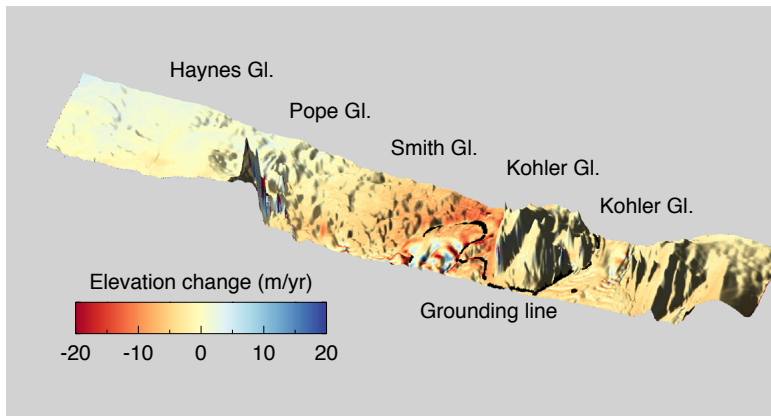
DEM generated with TanDEM-X data acquired in 2011.



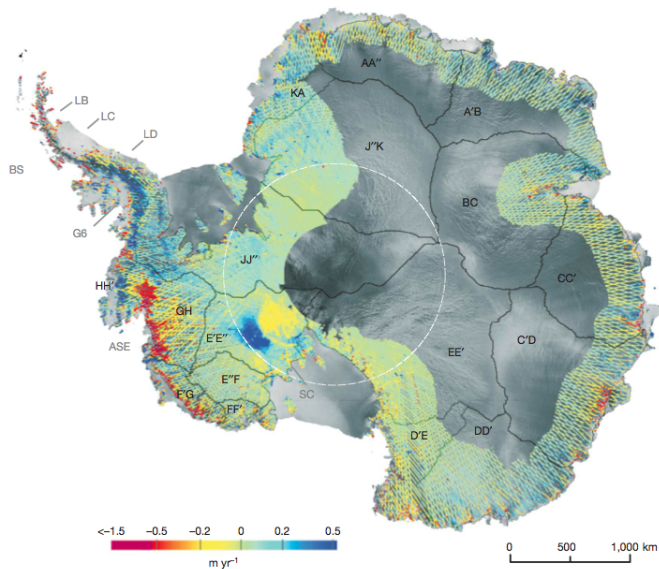
Thinning rate - Pope, Smith and Kohler Glacier

Pritchard et al. 2009 reported strong ice thinning on Smith Glacier with about 9 m/yr using ICESat data. Flament and Rémi 2012 reported similar values using Envisat with about -7.4 m/yr.

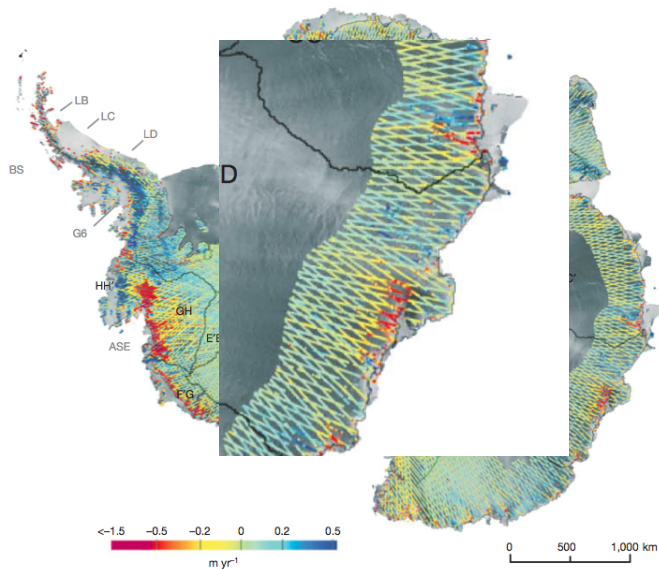
Difference between 2 DEMs generated with TanDEM-X data acquired in July 2011 and 2012 :



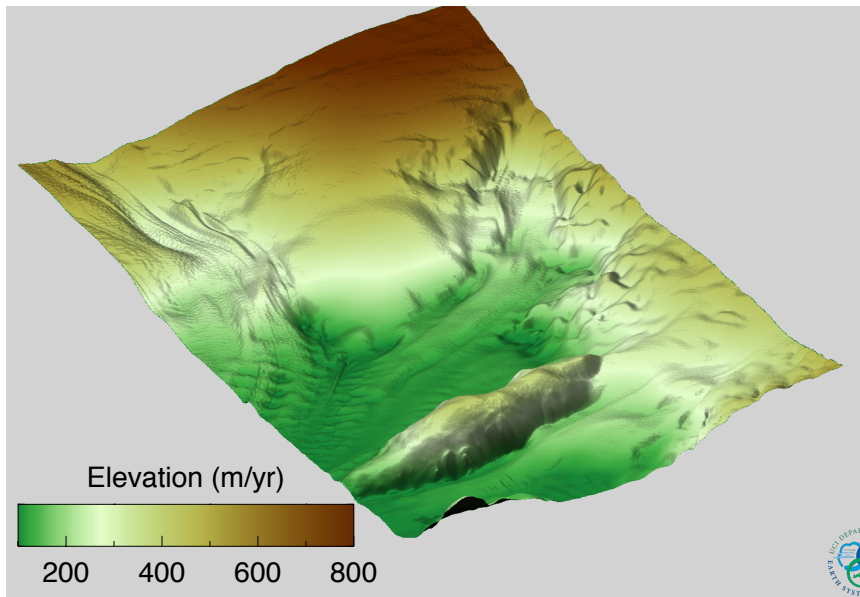
ICESat elevation change in Antarctica



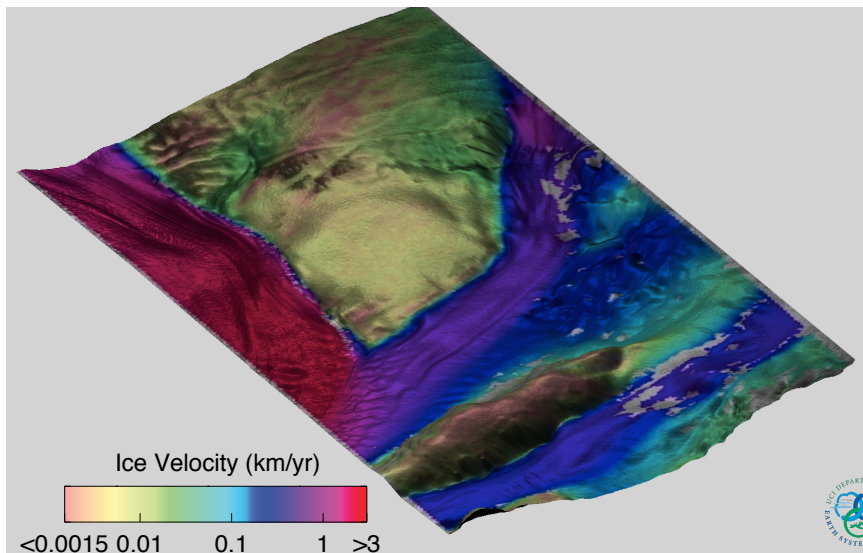
ICESat elevation change in Antarctica



Denman, East Antarctica



DEM+velocity using TDX over Denman, East Antarctica



Conclusion

- Building on our previous global ice velocity mapping project, we will continue to generate new products including the most recent TSX/TDX data.
- TanDEM-X is the ideal tool to measure ice flux by getting ice elevation and ice velocity simultaneously. Improve ice flux estimation is crucial to measure the impact of the Ice Sheets on the sea level rise.
- We developed an acquisition scenario that allows us to survey changes around Antarctica (and Greenland). By focussing on key areas around coastal Antarctica our data plan ensures a continental impact with a limited number of acquisitions



