

# Serving the TerraSAR-X Mission For Over Eight Years: Current Status and Recent Extensions of the TerraSAR-X Ground Segment

Birgit Schättler, Egbert Schwarz, Falk Mrowka, Thomas Fritz  
and Ground Segment Team

German Aerospace Center (DLR)

*Advanced SAR Workshop 2015, St. Hubert, Canada, 22-Oct-2015*



Knowledge for Tomorrow

# Outline

- Mission Context
- Production Statistics
- Acquisition Mode Portfolio
- Ground Station Network
- Implications of TanDEM-X Science Phase
- Near-Real Time Capabilities



# Mission Context

## TerraSAR-X Mission

- classical SAR imaging
- individual SAR image based on end user orders
- short-term tasking and immediate product delivery

## TanDEM-X Mission

- interferometric SAR acquisitions
- consistent high-resolution global DEM world-wide
- long-term acquisition and DEM production planning

TanDEM-X acquisition = TSX and TDX acquisition

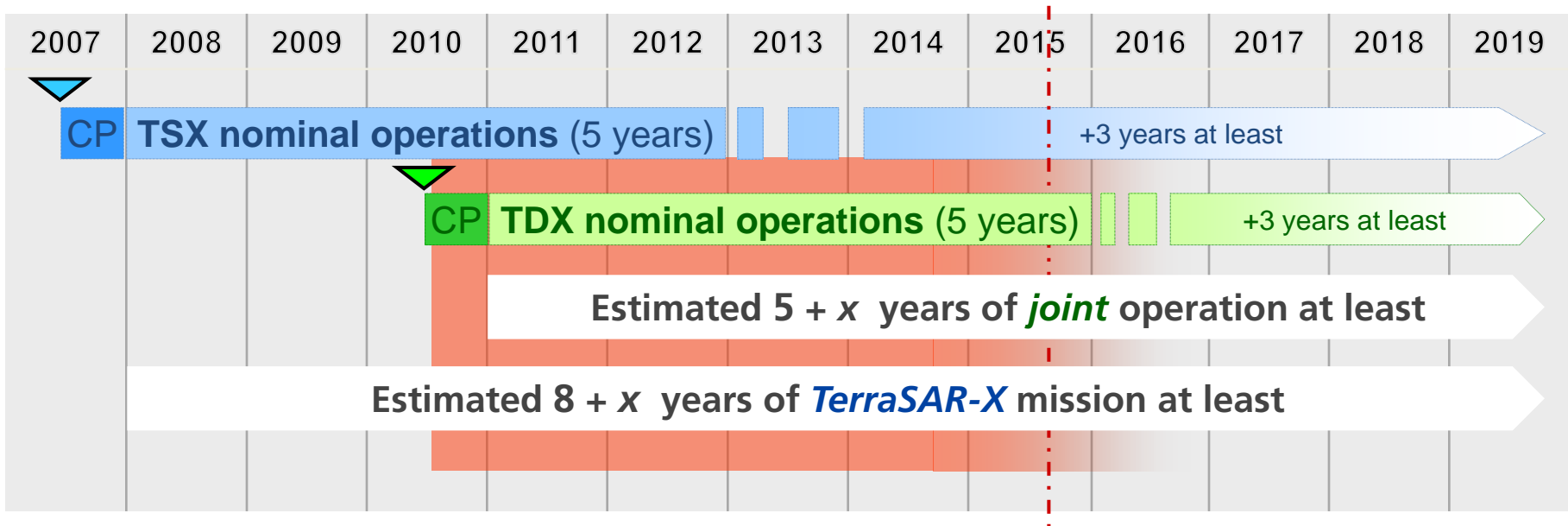
TerraSAR-X acquisition = TSX or TDX acquisition

Joint space segment: TSX and TDX satellites

Common TerraSAR-X / TanDEM-X ground segment



# TerraSAR-X and TanDEM-X: On-Going Missions

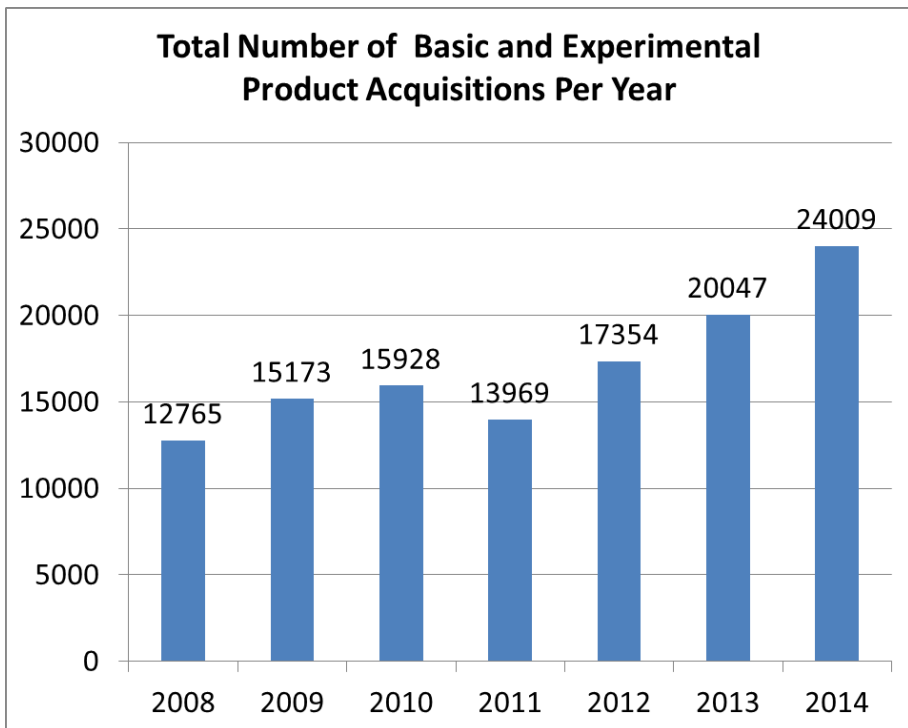


- Battery degradation: ~ 25 % for TSX, ~ 17 % for TDX
- Hydrazine left: ~ 43% for TSX, ~ 63 % for TDX
- Cold gas (flight formation fine control): **less than 1 year left**
  - formation flying based on hydrazine already done during TDX CP
  - alternative concepts under evaluation

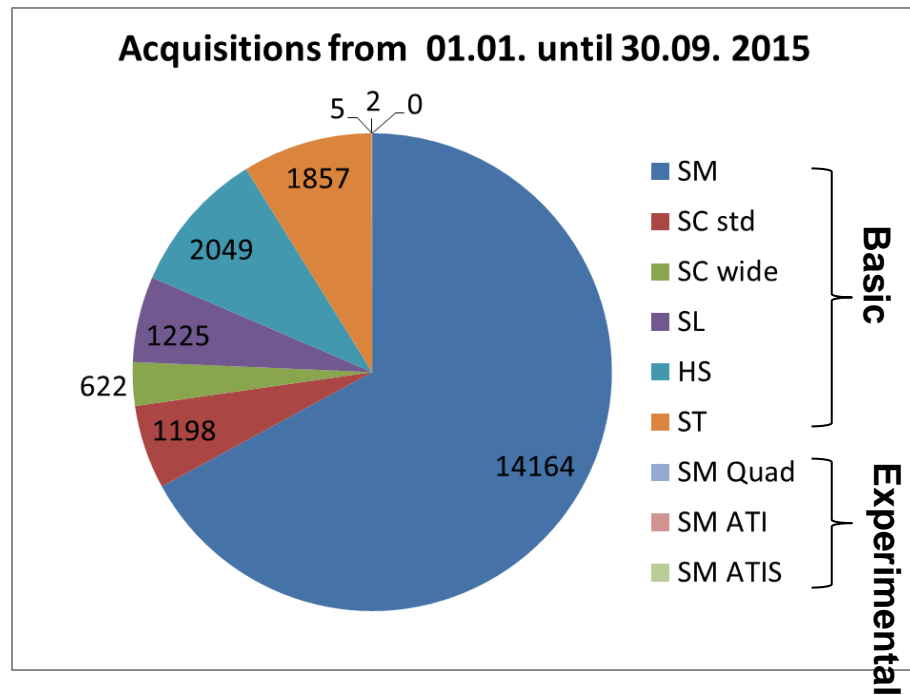
courtesy: S. Buckreuss, TerraSAR-X Mission Manager



# Growing Number of TerraSAR-X Acquisitions



> 26000 expected in 2015



# Current TerraSAR-X Acquisition Mode Portfolio for Basic Products

mode	coverage az x rg [km <sup>2</sup> ]	resolution class [m]
Wide ScanSAR (SC wide)	200 x (194–266)	40
ScanSAR (SC)	150 x 100	18
Stripmap (SM)	50 x 30	3
Spotlight (SL)	10 x 10	1.7 – 3.5
High Resolution Spotlight (HS)	5 x 10	1.4 – 3.5
High Resolution Spotlight 300 MHz (HS-300)	5 x (5 – 10)	1.1 – 1.8
Staring Spotlight (ST)	(2.5 – 2.8) x ~ 6	0.24 az , 1.0 rg (complex)

*TerraSAR-X Basic Product Specification TX-GS-DD-3302 Issue 1.9*

Wide ScanSAR and Staring Spotlight operationally introduced in 2013





*Staring Spotlight over Fennimore, Wisconsin, USA (2013)*

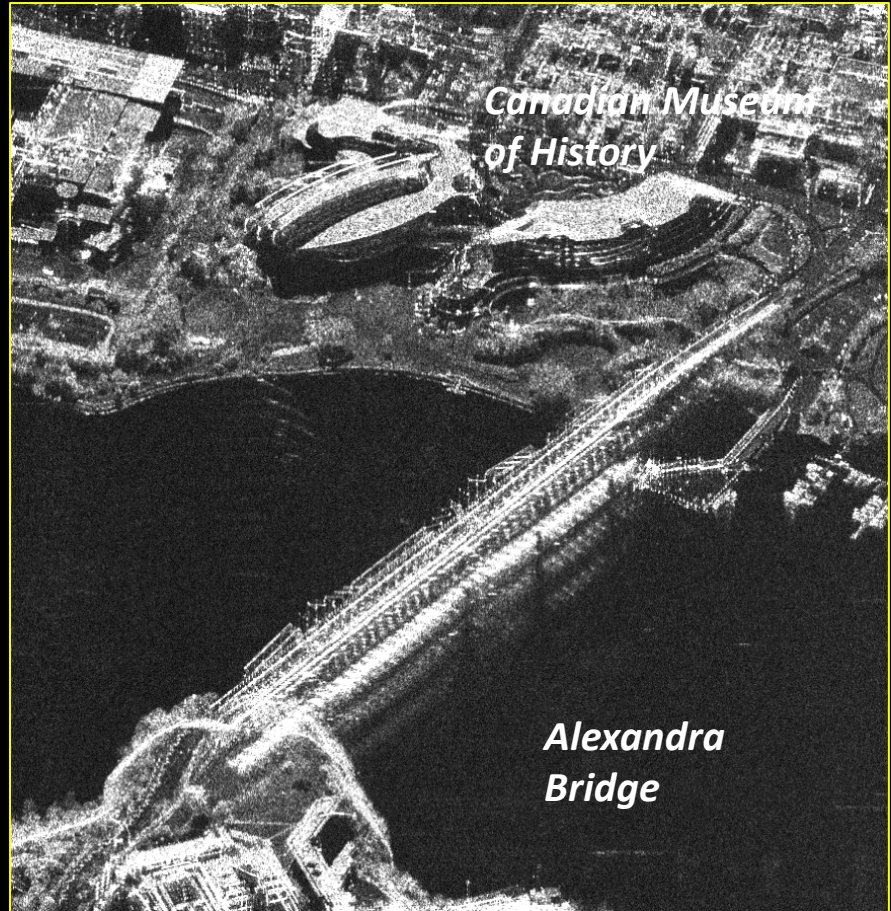


*Staring Spotlight over Fennimore, Wisconsin, USA (2013)*



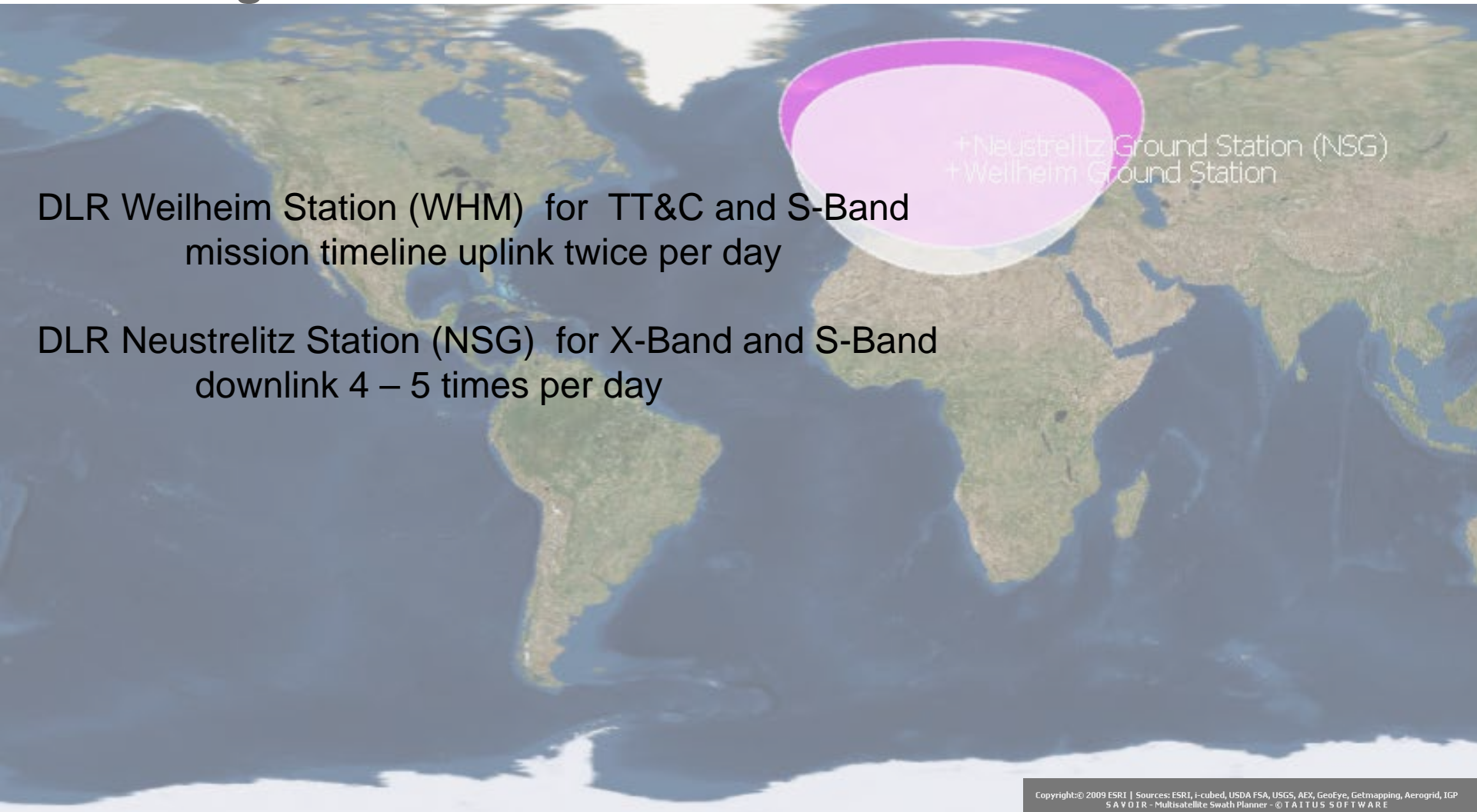
*Staring Spotlight over Ottawa, Canada, 2015-10-06*





*Staring Spotlight over Ottawa, Canada, 2015-10-06*

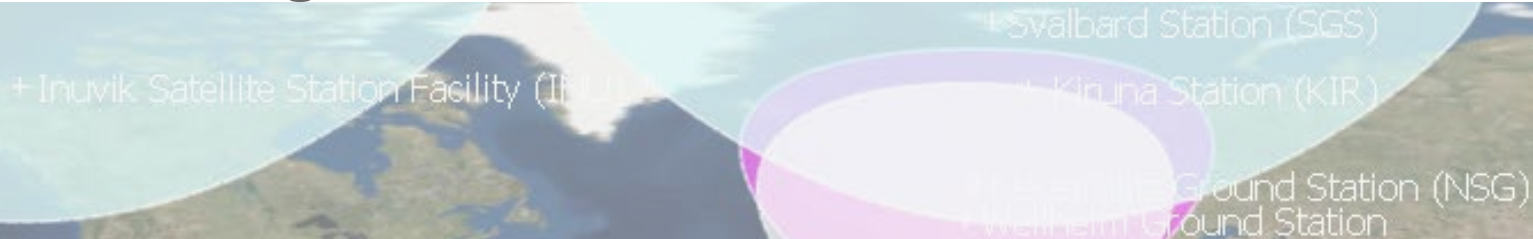
# Ground Stations Used By TerraSAR-X Ground Segment - Configuration at Mission Start



DLR Weilheim Station (WHM) for TT&C and S-Band  
mission timeline uplink twice per day

DLR Neustrelitz Station (NSG) for X-Band and S-Band  
downlink 4 – 5 times per day

# Ground Segment TerraSAR-X Ground Stations - Current Configuration



**DLR Weilheim Station (WHM)** for TT&C and S-Band  
mission timeline uplink twice per day

**DLR Neustrelitz Station (NSG)** for X-Band, TT&C and S-Band  
downlink 4 – 5 times per day

**KSAT Svalbard Station (SGS)** for X-Band and S-Band  
nominal: 2 contacts around noon, additional contacts e.g. for NRT

**DLR Inuvik Station (INU)** for TT&C, S-Band and X-Band

**DLR Antarctica Station (OHG)** for TT&C, S-Band and X-Band

nominal: TanDEM-X, but also TerraSAR-X background , TerraSAR-X NRT

**SSC Kiruna Station (KIR)** for X-Band

nominal: TanDEM-X, but also filling with TerraSAR-X

# TanDEM-X Science Phase - Formation Flight Configurations and DRA Operation

09'14 – 03'15

pursuit monostatic flight configuration

**76 km (10 sec) along-track separation** between TSX and TDX

03'15 – 09'15

bistatic flight configuration with varying large cross-track baselines

**up to 3.6 km horizontal separation** between TSX and TDX

since 10'15

close bistatic flight configuration with small along-track baselines

since 12'14

operation of **experimental dual-receive antenna (DRA) configuration**

quad pol and along-track interferometry acquisitions



# TanDEM-X Science Phase - TerraSAR-X Mission Impacts

09'14 – 03'15

pursuit monostatic flight configuration

**76 km (10 sec) along-track separation** between TSX and TDX

=>

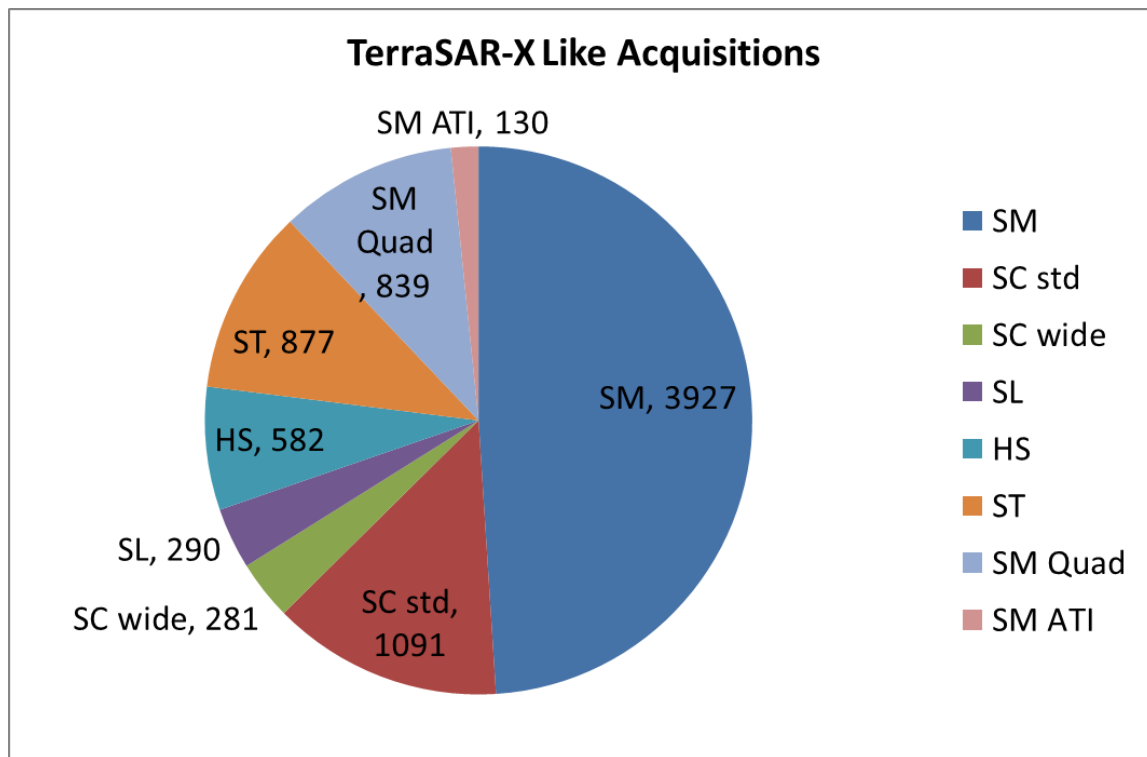
TanDEM-X acquisition = TSX acquisition + TDX acquisition  
= 2 TerraSAR-X like acquisitions

***TerraSAR-X Like Products*** available for users



# TerraSAR-X Like Data Takes Available in EOWEB for External User Product Ordering

	2014	2015	Total
<b>SM</b>	1900	2027	3927
<b>SC std</b>	885	206	1091
<b>SC wide</b>	231	50	281
<b>SL</b>	100	190	290
<b>HS</b>	270	312	582
<b>ST</b>	407	470	877
<b>SM Quad</b>	272	567	839
<b>SM ATI</b>	77	53	130
<b>Total</b>	<b>4142</b>	<b>3875</b>	<b>8017</b>



# TerraSAR-X Like Products in EOWEB

**Shop Cart** | **Order Monitoring**

**Catalogue** | **Future Products / Acquisitions** | **User Set**

**Collections :**

Deselect all    Expand/collapse   2 Collections selected

- TanDEM-X Pursuit TSX-1 Like Experimental**
  - TSX-1-Like.SAR.L1b-Stripmap-ATI
  - TSX-1-Like.SAR.L1b-Stripmap-Quadpol
- TanDEM-X Pursuit TSX-1 Like**
  - TSX-1-Like.SAR.L1b-Staring-Spotlight
  - TSX-1-Like.SAR.L1b-ScanSAR
  - TSX-1-Like.SAR.L1b-Stripmap
  - TSX-1-Like.SAR.L1b-High-Resolution-Spotlight
  - TSX-1-Like.SAR.L1b-Spotlight

**Query Mode:** Standard

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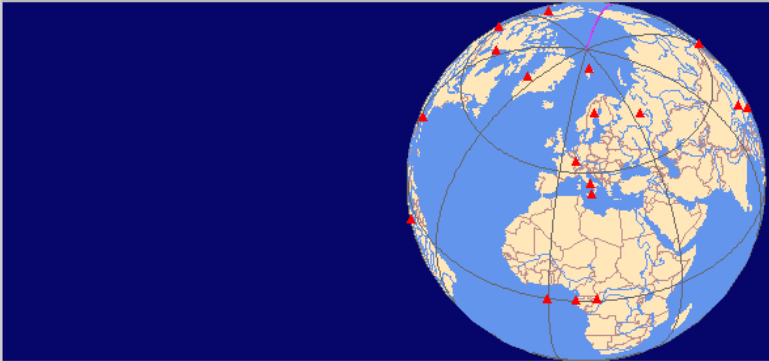
**Date:** Choose a Date | **Area:** Rectangle

From: 2015-01-01 00:00:00 | To: 2015-01-01 23:59:59

Center Lat/Lon: 0.000 | 0.000

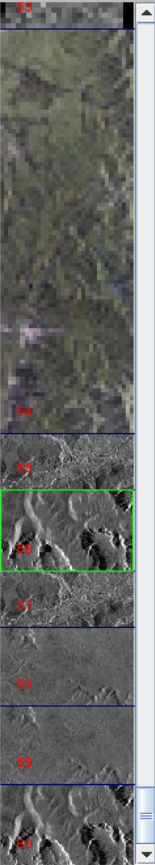
Extension Lat/Lon: 180.000 | 360.000

Step by range



1 record selected

	Id	Avail.	Abstract	Mission/...	Start Date	Sensor Mode	Polarization...	Polarization ...	Relative...	Beam	
←	60	●	TSX-1-Like.SAR.L1b-Staring-Spotlight	TSX-1	2015-01-01T01:26:19.6...	StaringSpotlight	Single	HH	106	spot_062	SAI
←	56	●	TSX-1-Like.SAR.L1b-Staring-Spotlight	TDX-1	2015-01-01T01:26:29.4...	StaringSpotlight	Single	HH	106	spot_062	SAI
←	41	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T03:07:12.5...	Stripmap	Single	HH	107	tanDEM_a1_0...	SAI
←	27	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T03:07:22.3...	Stripmap	Single	HH	107	tanDEM_a1_0...	SAI
←	29	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T03:59:19.7...	Stripmap	Single	HH	107	tanDEM_a1_0...	SAI
←	31	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T03:59:29.8...	Stripmap	Single	HH	107	tanDEM_a1_0...	SAI
←	33	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T04:04:39.0...	Stripmap	Single	HH	107	strip_014	SAI
←	35	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T04:04:48.9...	Stripmap	Single	HH	107	strip_014	SAI
←	28	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T04:56:45.8...	Stripmap	Single	HH	108	strip_019	SAI
←	22	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T04:56:55.7...	Stripmap	Single	HH	108	strip_019	SAI
←	14	●	TSX-1-Like.SAR.L1b-High-Resolution-Sp...	TSX-1	2015-01-01T05:03:03.2...	HighResSpotlight	Single	HH	108	spot_081	SAI
←	13	●	TSX-1-Like.SAR.L1b-High-Resolution-Sp...	TDX-1	2015-01-01T05:03:13.4...	HighResSpotlight	Single	HH	108	spot_081	SAI
←	51	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T05:03:46.3...	Stripmap	Single	HH	108	strip_013	SAI
←	30	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T05:03:56.4...	Stripmap	Single	HH	108	strip_013	SAI
←	6	●	TSX-1-Like.SAR.L1b-Stripmap-Quadpol	TSX-1	2015-01-01T05:13:33.4...	Stripmap	Quad	HH/HV/VH/VV	108	stripFar_006	SAI
←	1	●	TSX-1-Like.SAR.L1b-Stripmap-Quadpol	TDX-1	2015-01-01T05:13:43.6...	Stripmap	Quad	HH/HV/VH/VV	108	stripFar_006	SAI
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←	32	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T09:03:05.7...	Stripmap	Single	HH	110	strip_007	SAI
←	34	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T09:03:15.4...	Stripmap	Single	HH	110	strip_007	SAI



**Dedicated EOWEB product collections**

**Data take pairs taken 10 sec apart**

[Start Search](#)



# TerraSAR-X Like Products in EOWEB

**Collections :**  
 Deselect all    Expand/collapse   2 Collections selected

- TanDEM-X Pursuit TSX-1 Like Experimental
  - TSX-1-Like.SAR.L1b-Stripmap-ATI
  - TSX-1-Like.SAR.L1b-Stripmap-Quad...

**1 record selected**

	Id	Avail.	Abstract	Mission/...	Start Date	Sensor Mode	Pol:
* 60	●	TSX-1-Like.SAR.L1b-Staring-Spotlight	TSX-1	2015-01-01T01:28:19,6...	StaringSpotlight	Sing	
* 58	●	TSX-1-Like.SAR.L1b-Staring-Spotlight	TDX-1	2015-01-01T01:28:29,4...	StaringSpotlight	Sing	
* 41	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T03:07:12,5...	Stripmap	Sing	
* 27	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T03:07:22,3...	Stripmap	Sing	
* 22	●	TSX-1-Like.SAR.L1b-Stripmap	TSX-1	2015-01-01T04:56:46,8...	Stripmap	Single	HH
* 28	●	TSX-1-Like.SAR.L1b-Stripmap	TDX-1	2015-01-01T04:56:55,7...	Stripmap	Single	HH

TerraSAR-X Science [sss.terrasar-x.dlr.de](http://sss.terrasar-x.dlr.de)

Tandem-X Science <https://tandemx-science.dlr.de/>





# TanDEM-X Science Phase - TerraSAR-X Mission Impacts

03'15 – 09'15

bistatic flight configuration with varying large cross-track baselines  
**up to 3.6 km horizontal separation** between TSX and TDX

=>

***Preferred Satellite Concept*** in mission planning timeline generation

if baseline exceeds given margin and resources allow:  
perform TerraSAR-X data take on TSX satellite (reference orbit)



# TanDEM-X Science Phase - TerraSAR-X Mission Impacts

since 12'14

operation of **dual-receive antenna (DRA) configuration**  
quad pol and along-track interferometry acquisitions  
no downlink possible during DRA data taking

=>

## ***Ground Station Pool Concept***

*mission planning timeline generation and on-ground SAR production*

- use of additional X-band contacts
- online raw data transfer from stations SGS and KIR to NSG
- grouping of stations into one receiving station pool
- mission planning uses next free downlink slot a for given data take



# TerraSAR-X NRT System Capabilities

- Morning and evening timeline upload for a 12 h desirable / 12 h critical timeline with order deadline a few hours before  
=> for data take at end of timeline: allow about 17 hours for tasking
- Product latency after downlink: about 10 – 20 minutes
- No orbit information available in X-band downlink  
=> usage of predicted orbit information only
- NRT ground station pool  
=> online raw data transfer to Neustrelitz
- Mission planning uses next possible pool contact for NRT downlink and schedules it as soon as possible within the chosen contact



# TerraSAR-X NRT Processing at Inuvik and Antarctica O'Higgins Stations

- NRT processing systems installed both at Inuvik and O'Higgins
  - => NRT processing at stations possible in future
  - => but due to limited network performance:
    - only NRT delivery of L1B quicklook products
- Once sufficient network performance from INU available (Mackenzie Valley Fibre Link)
  - => Include INU into NRT ground station pool



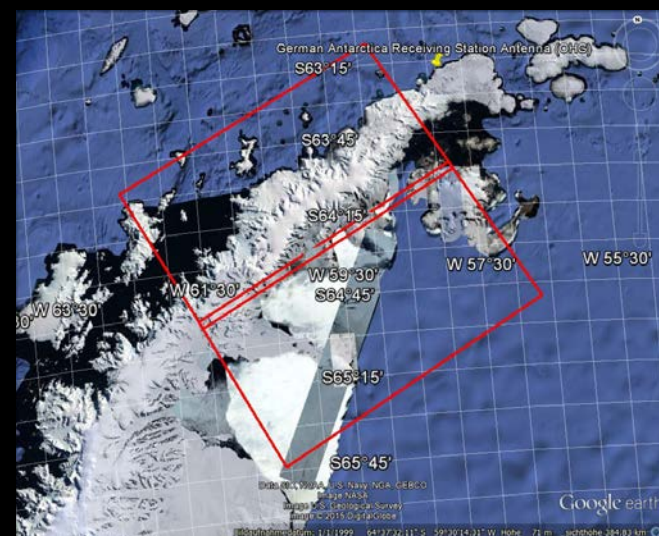


## First NRT Test Processings at German Antarctic Receiving Station (OHG)

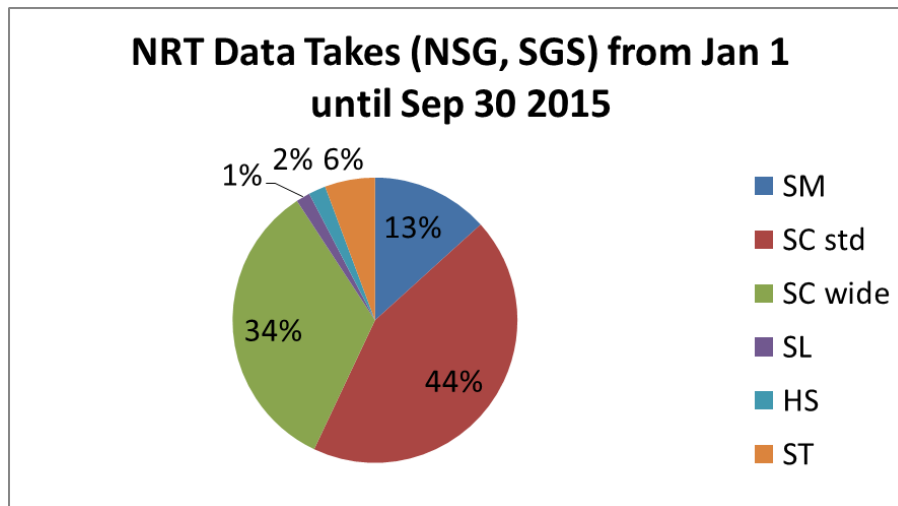
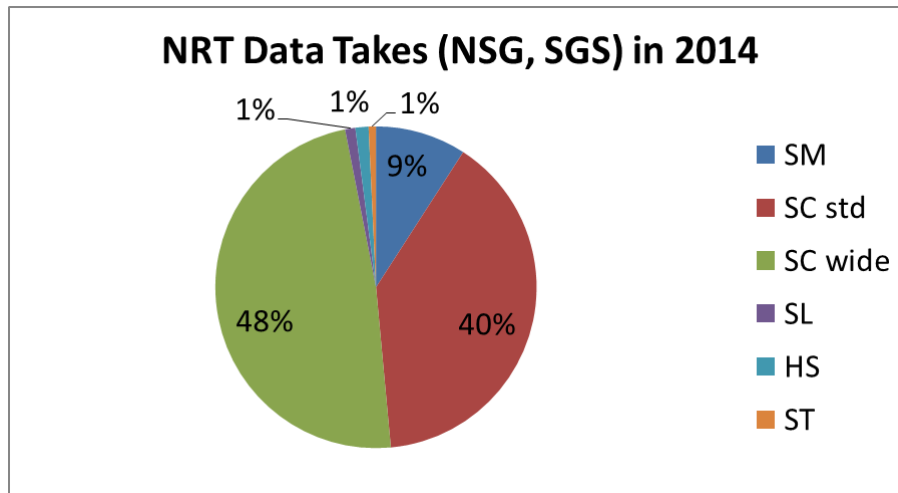
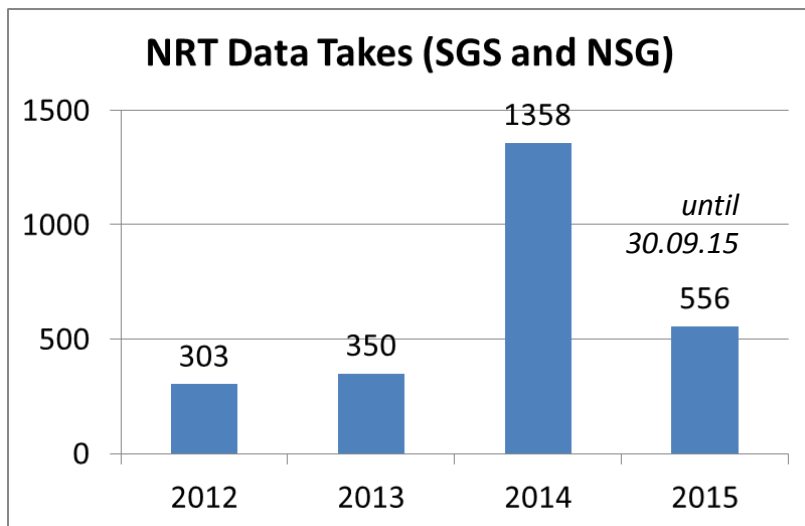
Wide SC HH MGD RE  
over Antarctic Peninsula

Acquisition 2015-10-12T23:41:09  
Downlink 2015-10-12T23:41:57  
Processing ~ 35 minutes

Scene 1: 2015-10-12T23:41:10  
Scene 2: 2015-10-12T23:41:25



# Growing Demand in NRT Data Takes ?



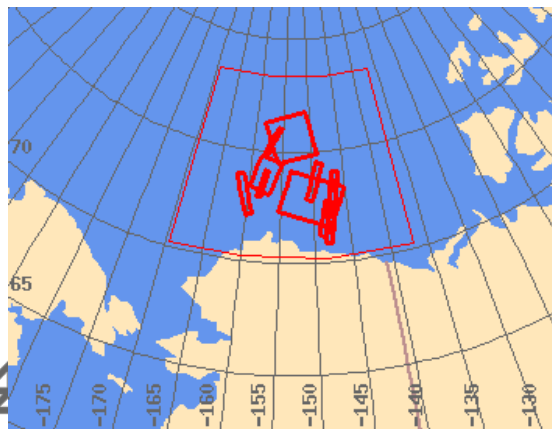
# TerraSAR-X NRT Support in October for ONR Arctic Sea State Campaign 2015

Research Vessel Sikuliaq in Beaufort Sea  
*Sea State and Boundary Layer Physics of the Emerging Arctic Ocean*

[http://www.apl.washington.edu/project/project.php?id=arctic\\_sea\\_state](http://www.apl.washington.edu/project/project.php?id=arctic_sea_state)

TerraSAR-X support comprises

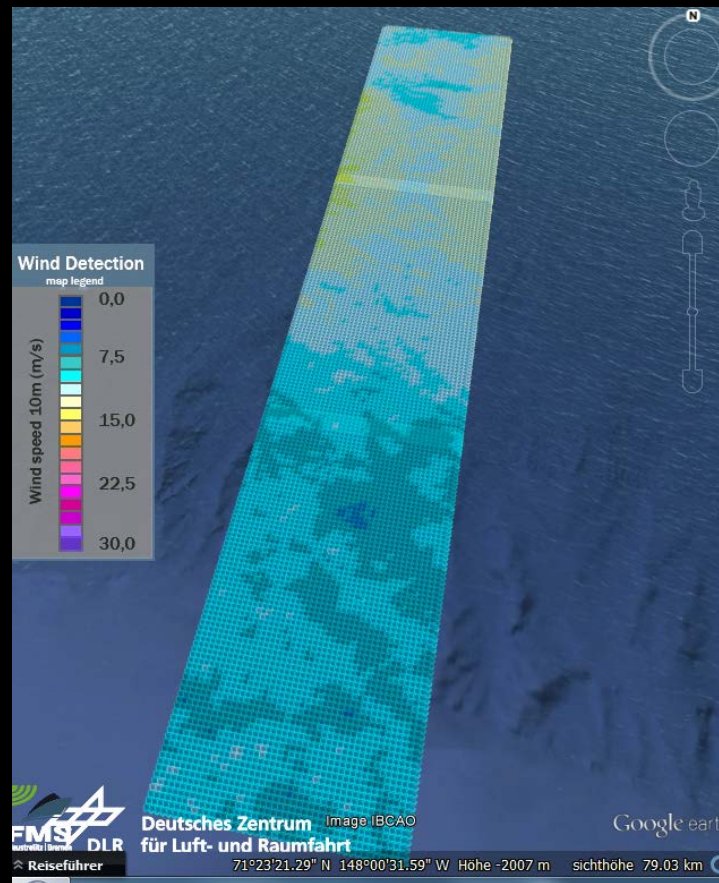
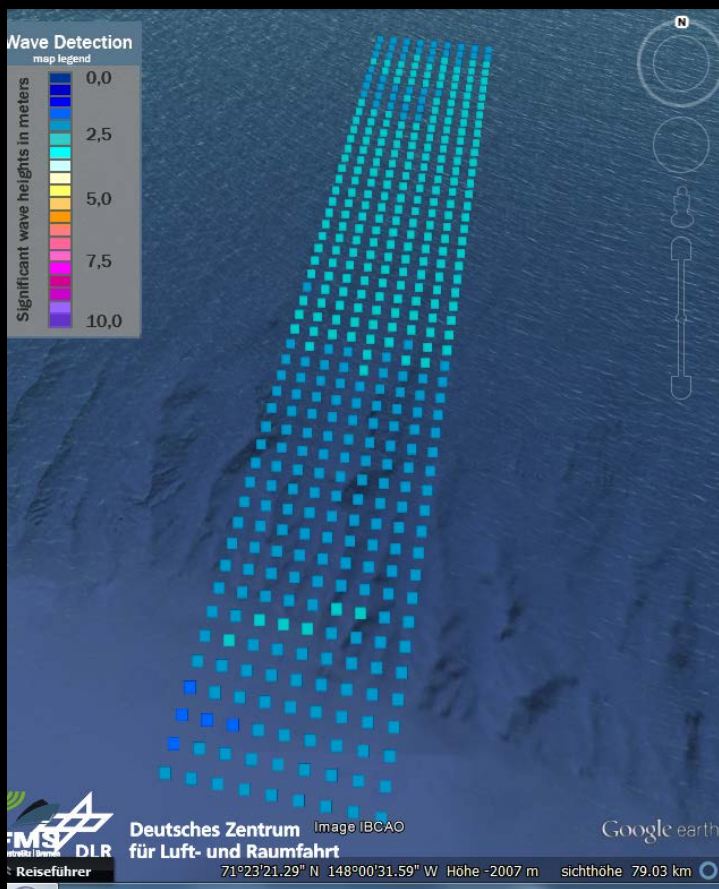
- additional SGS contacts used for D/L
- NRT L1b product delivery
- quicklook deliveries
- new: wind and wave charts



*9 acquisitions (SM, SC, SC wide)  
between Oct 07 and Oct 18 and more to come*



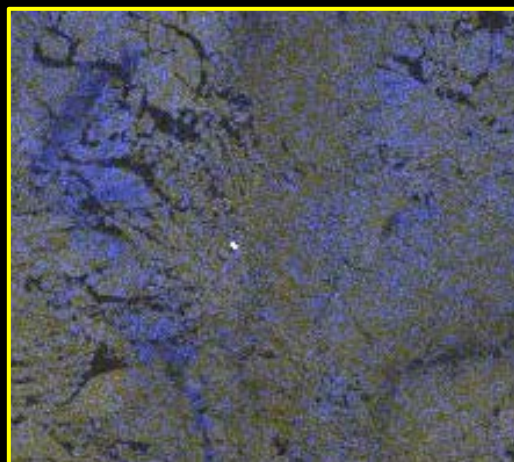
# New NRT Feature under Test: Wind and Wave Charts



Scenes: *TSX1\_SAR\_MGD\_SE\_\_SM\_S\_SRA\_20151013T161558*

Core Processors by Maritime Security Lab Bremen (Team Susanne Lehner)  
XWAVE-2 (Pleskachevsky et al., 2015) XMOD-2 (Jacobsen et al, 2013)





### Latest Update from the Field

**15 October 2015**

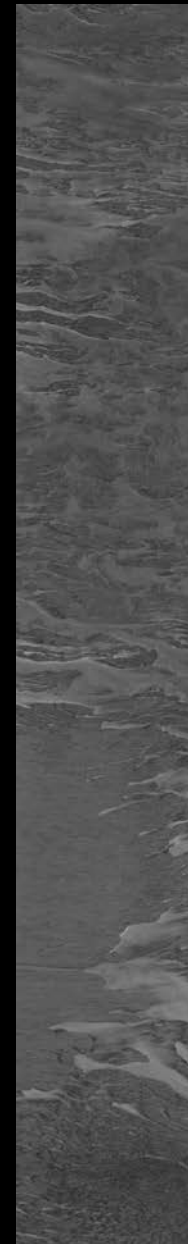
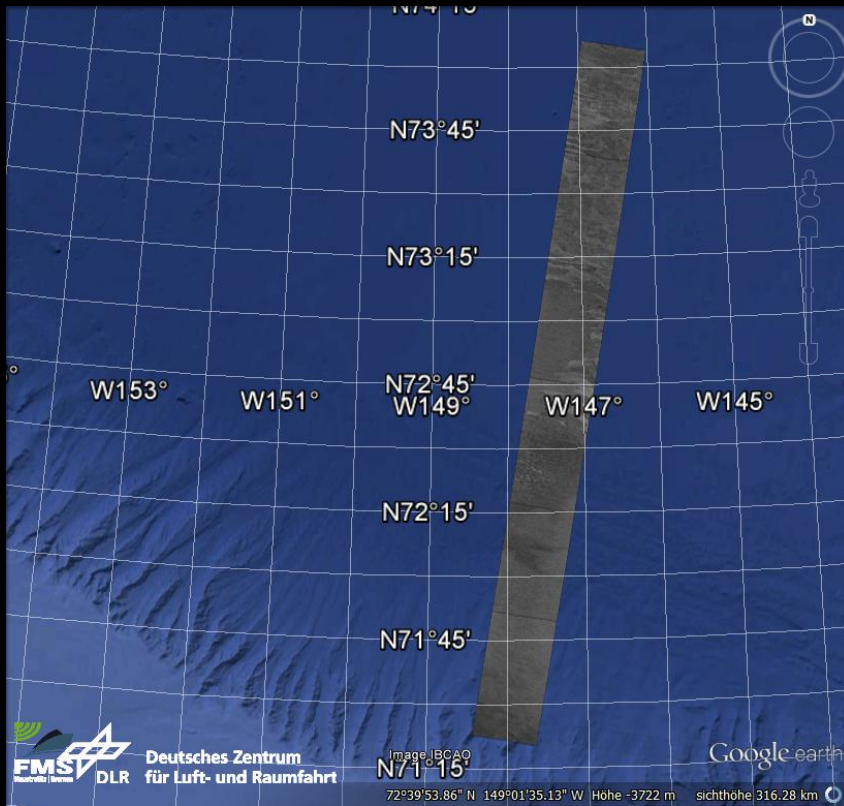
We have been transiting through the ice pack and surveying the effects of the waves. Pancake ice is everywhere, but new ice is already filling in between the pancakes. Refreezing is occurring rapidly. Much of this has to do with the radiation balance, which is changing as the days get shorter and shorter. Today is cold and clear, and the sun did not emerge until 10:15 ADT. That sun won't be up for long, and tomorrow it will be even less.

As we measure the ice "in situ," our colleagues are measuring it remotely. Today we have an aircraft survey above us by a team from the Naval Research Lab. We also have satellite observations several times per day. These measurements give us spatial context for what we are observing from the ship.



**SM dual HH/VV  
2015-10-15T17:16**

[http://www.apl.washington.edu/project/project.php?id=arctic\\_sea\\_state](http://www.apl.washington.edu/project/project.php?id=arctic_sea_state)



SM single VV (7 Scenes)

2015-10-13 16:15:29 – 16:16:21

Downlink 17:32 (NSG)

Delivery 18:19

=> 7 Scenes in 45 Minutes

# Summary

TerraSAR-X mission on-going.

Recent and current TerraSAR-X ground segment upgrades

- to better serve the TerraSAR-X user community
  - new modes Wide SC and Staring Spotlight
  - NRT extensions, specifically in maritime products domain
  - Extension of downlink capacity
- to deal with TanDEM-X mission imposed constraints

We are looking forward for – hopefully – many more years of operations to come.

*TerraSAR-X is partly funded by the German Federal Ministry for Economic Affairs and Energy (50 EE 1328) and realized in a public-private partnership between DLR and AIRBUS Defence & Space*

