Dragon Sea Ice Remote Sensing – Preparations of Future Activities

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CIRFA
CENTRE FOR INTEGRATED REMOTE SENSING AND FORECASTING FOR ARCTIC OPERATIONS

EOS
Earth Observing Systems

Sea Ice Deformation

Inhomogeneous drift of sea ice

Sea ice deformation/stress

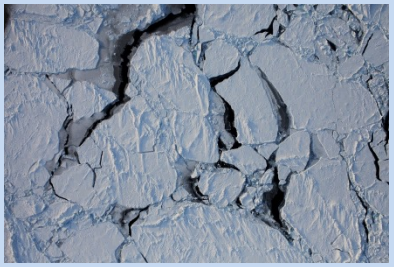
Causes:

Opening / closing of leads

Formation of shear- or pressure- ridges

Results in:

Change of sea ice concentration



Change of sea ice thickness

Affects:

Navigation of the marine traffic in polar regions

Interaction between atmosphere, ice, and ocean

Viewgraph prepared by Jakob Griebel, AWI

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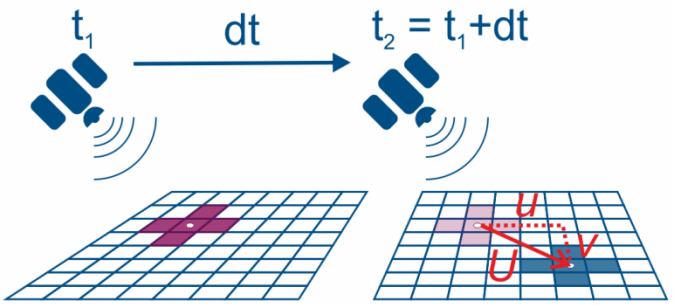
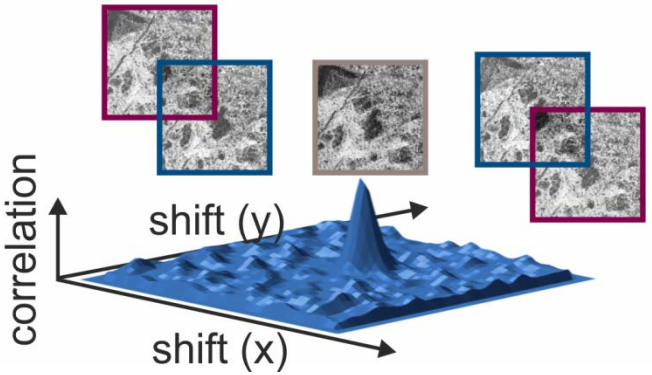
Detection of Drift- & Deformation

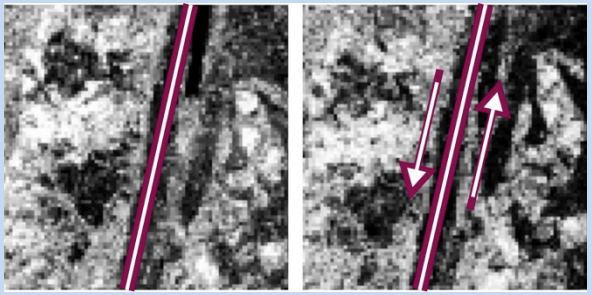
Sea ice pattern matching algorithms → retrieval of the sea ice drift field



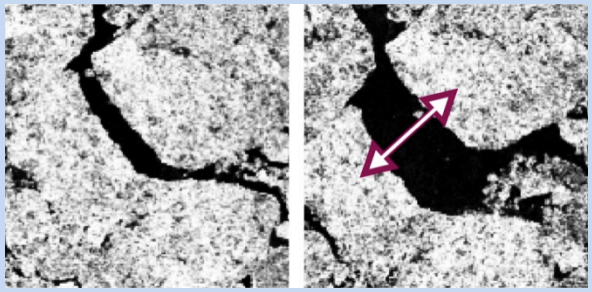


Sea ice deformation causes temporal variations of recognizable patterns

Example: Shear



Example: Divergence

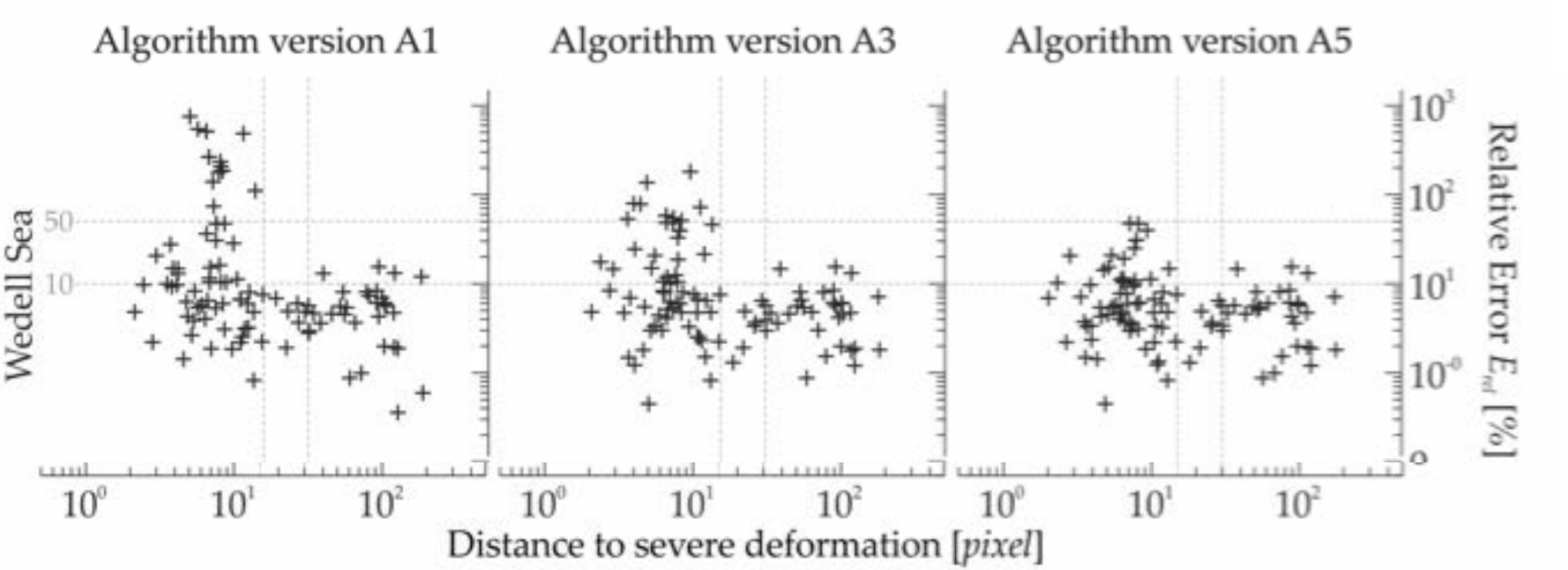


Drift-detection algorithm have to take sea ice deformation into account

Viewgraph prepared by Jakob Griebel, AWI

Detection of Drift- & Deformation

Improvement of algorithm through explicitly considering deformation patterns

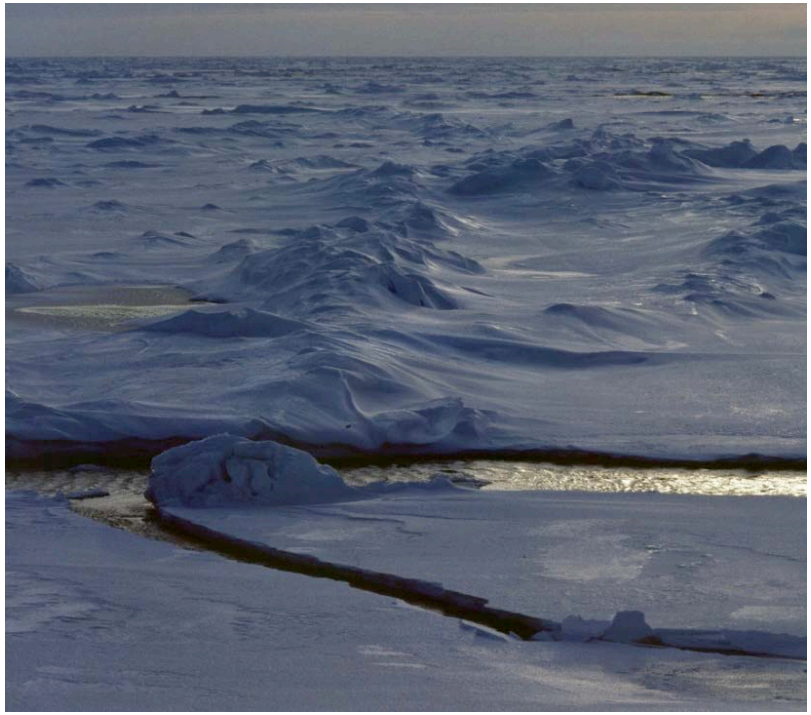


A1 – pattern matching, A3 = A1+median filter and reliability assessment,
A5 = A1+reliability assessment + segmentation of windows around deformation zones

Griebel, J., Dierking, W., A method to improve high-resolution sea ice drift retrievals in the presence of deformation zones, Remote Sensing 2017 (under review, minor revisions)

Retrieval of Sea Ice Topography

Characteristics of Ice Ridges (1)



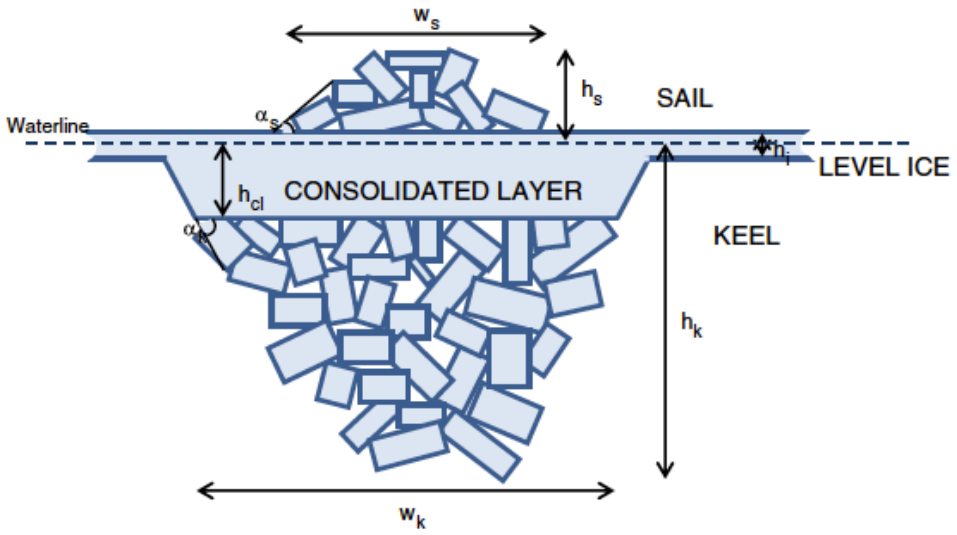
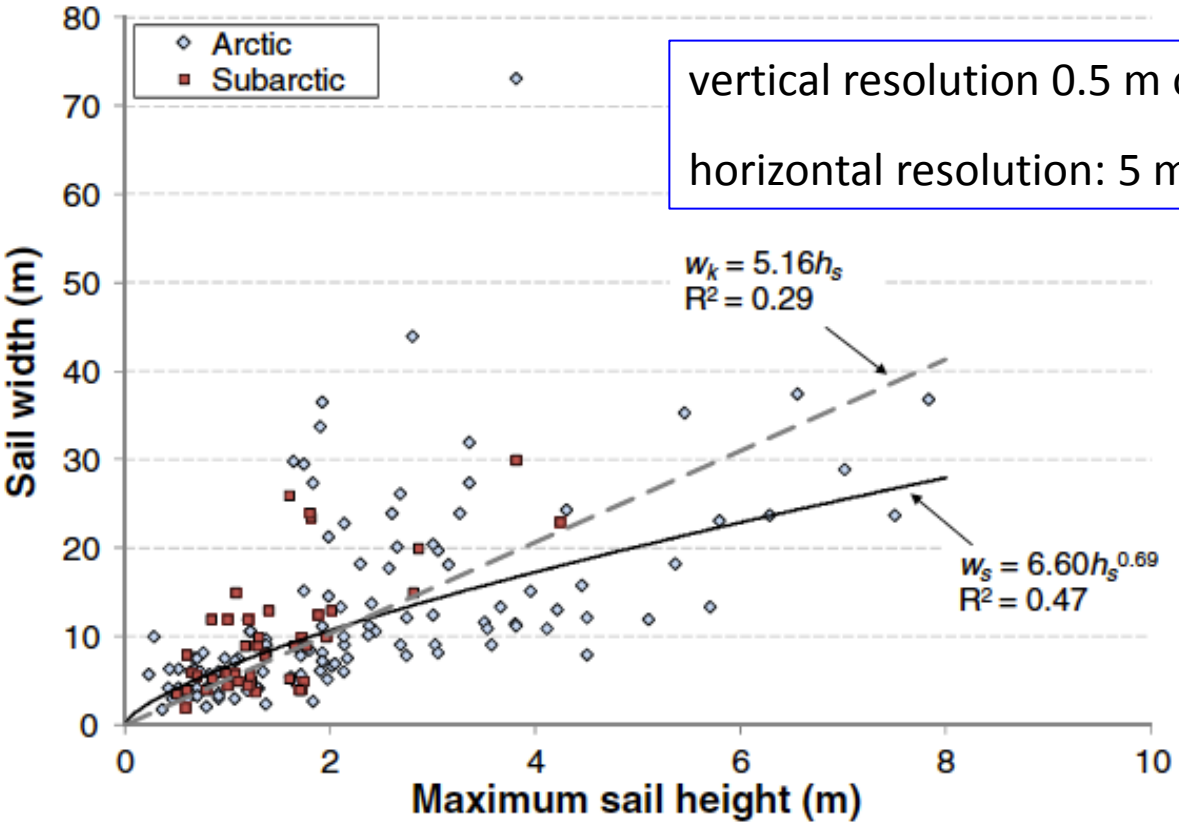


Fig. 1. Typical model of a first-year ice ridge.

Retrieval of Sea Ice Topography

Characteristics of Ice Ridges (2)



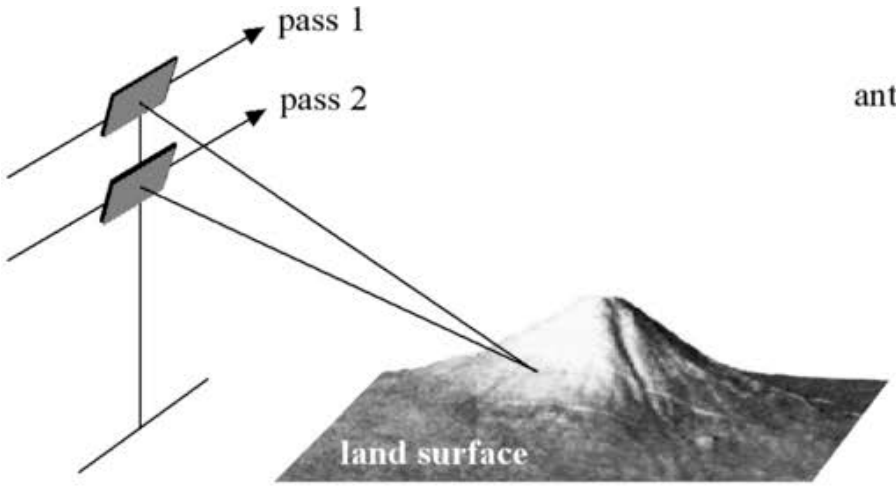
vertical resolution 0.5 m or better

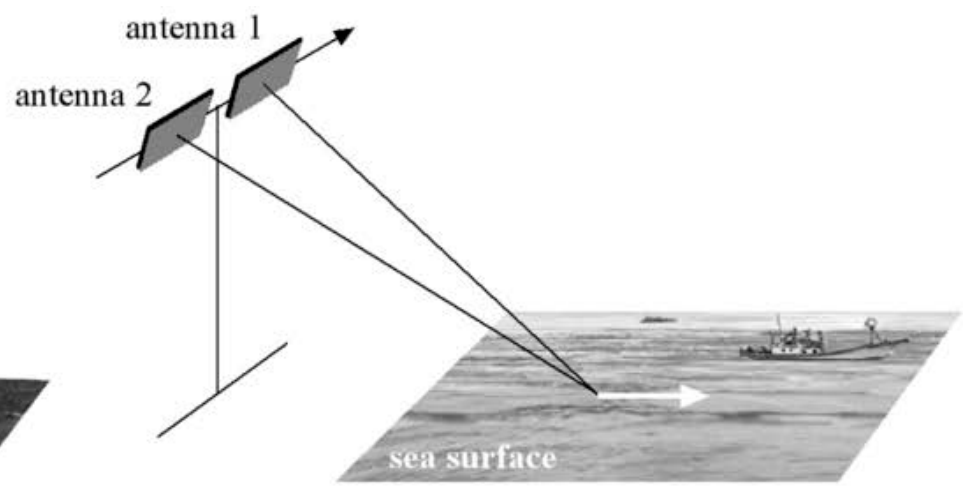
horizontal resolution: 5 m or better

Strub-Klein & Sudom, Cold Regions Science and Technology 82, 2012

Retrieval of Sea Ice Topography

Using Interferometric SAR?





Across-track and along-track interferometry

- sensitive to topography
- not sensitive to motion

- sensitive to movements
- not sensitive to topography

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Retrieval of Sea Ice Topography

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InSAR: numbers for different mission scenarios?

Band	L		C		X		K_u		K_a	
λ [m]	0.24		0.055		0.031		0.022		0.0084	
H [km]	745 km		700		500		780		740	
θ [deg]	25	40	25	40	25	40	25	40	25	40
Δy [m]	4.2	2.7	4.6	5.0	2.8	1.9	3.5	2.3	8.9	5.8
B_{cn} [km]	52	112	10.2	13.1	6.7	13.9	6.0	12.7	0.85	1.8
B_n [km]	19.8	43.1	3.9	5.0	2.6	5.3	2.3	4.9	0.32	0.69
h_a [m]	4.2	3.5	4.6	6.4	2.8	2.4	3.5	3.0	8.9	7.5
σ_h [m]	0.60	0.50	0.66	0.92	0.40	0.35	0.50	0.42	1.3	1.1

Table 1: Ambiguity heights h_a and relative height errors σ_h (rounded values) for optimal baselines B_n, determined for different satellite configurations (λ – radar wavelength, H – orbit height, θ – radar incidence angle, Δy – ground range resolution). It is assumed that p=1, N_L = 1, and $\gamma_N \approx 1$ in equations 2, 4, and 8.

Dierking et al., The Cryosphere Discussions, 2017

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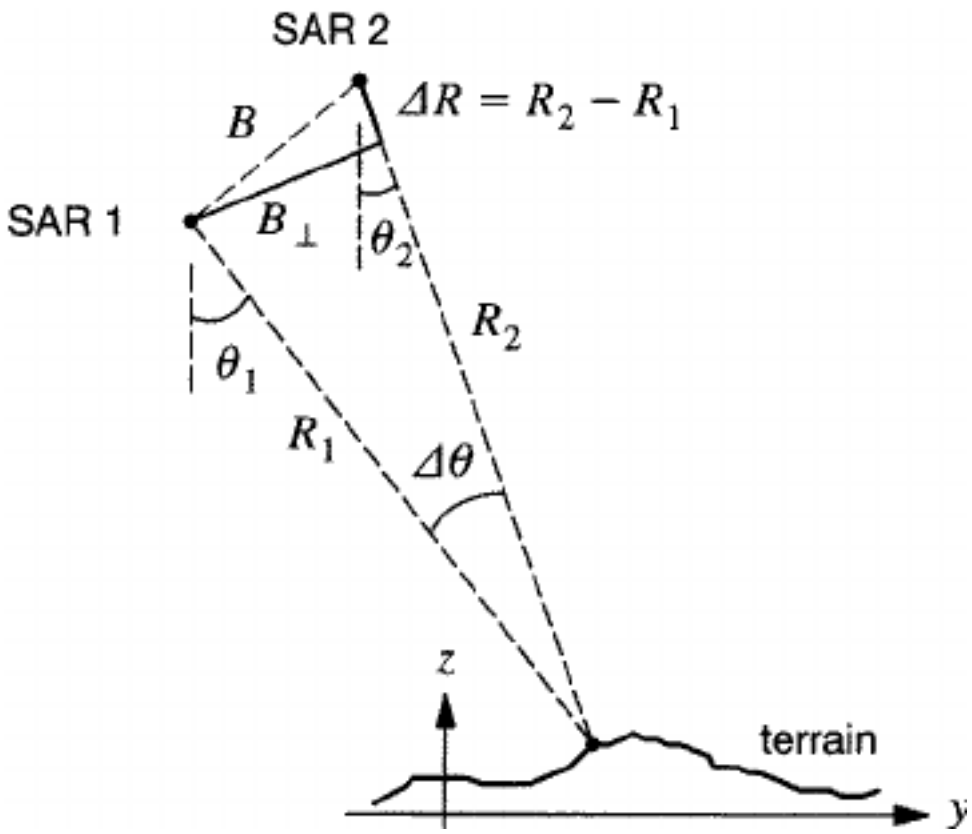
Interferometroc Baseline And Height Sensitivity



Favourable conditions for retrieval of surface elevation:

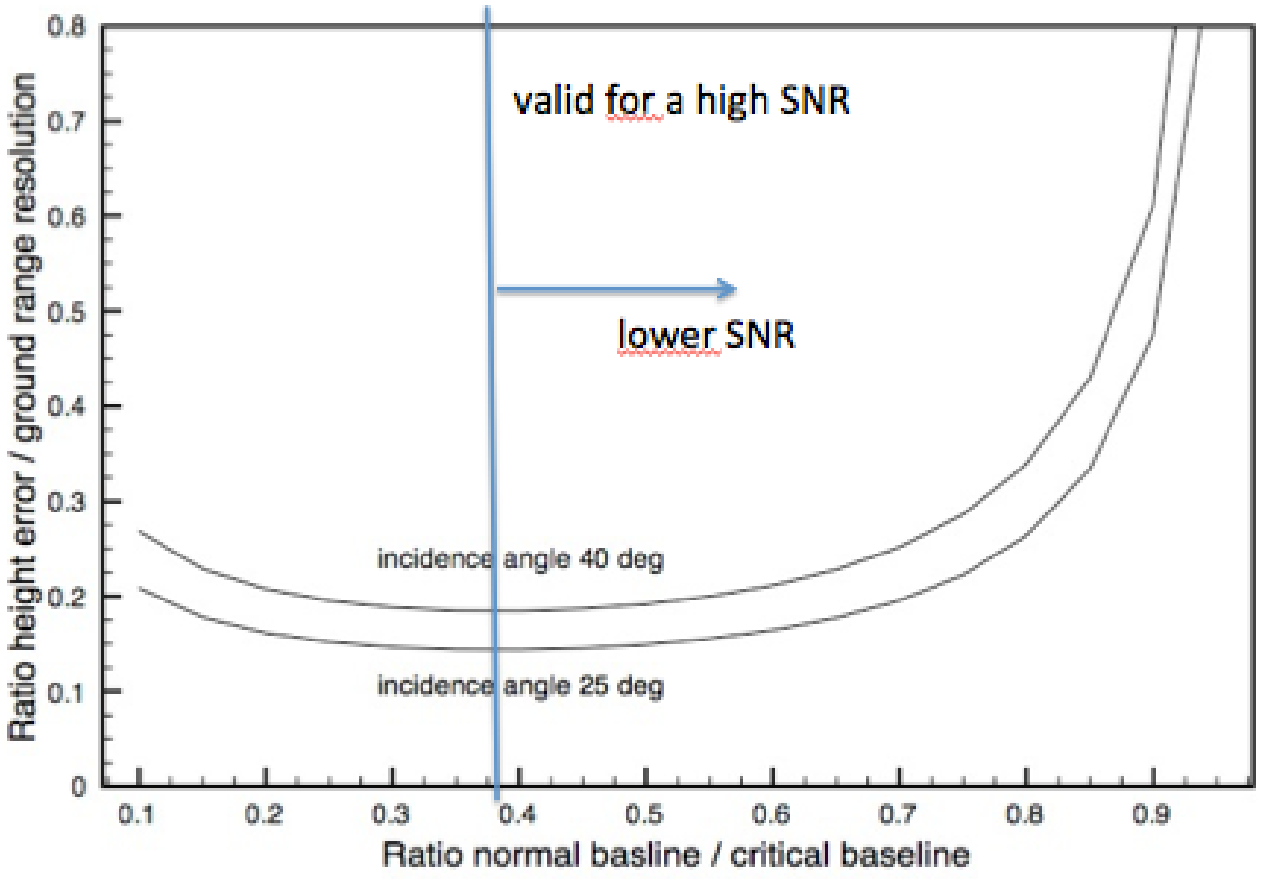
- long baseline B_n
- short radar wavelength
- low orbit
- steep incidence angle

BUT: critical baseline

=> loss of coherence!

Retrieval of Sea Ice Topography

Optimal Baseline (1)



Dierking et al., The Cryosphere Discussions, 2017

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Optimal Baseline (2)

Band	L		C		X		K_u		K_a	
λ [m]	0.24		0.055		0.031		0.022		0.0084	
H [km]	745 km		700		500		780		740	
θ [deg]	25	40	25	40	25	40	25	40	25	40
Δy [m]	4.2	2.7	4.6	5.0	2.8	1.9	3.5	2.3	8.9	5.8
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Optimal Baseline (2)

Band									K_a	
λ [m]									0.0084	
H [km]									740	
θ [deg]									5	40
Δy [m]									9	5.8
B_{cn} [km]	52	112	10.2	13.1	6.7	13.9	6.0	12.7	0.85	1.8
B_n [km]	19.8	43.1	3.9	5.0	2.6	5.3	2.3	4.9	0.32	0.69
h_a [m]	4.2	3.5	4.6	6.4	2.8	2.4	3.5	3.0	8.9	7.5
σ_h [m]	0.60	0.50	0.66	0.92	0.40	0.35	0.50	0.42	1.3	1.1

Single satellite platform possible?

Perhaps Ka-band(?) Otherwise: no way!

Satellite tandem required!

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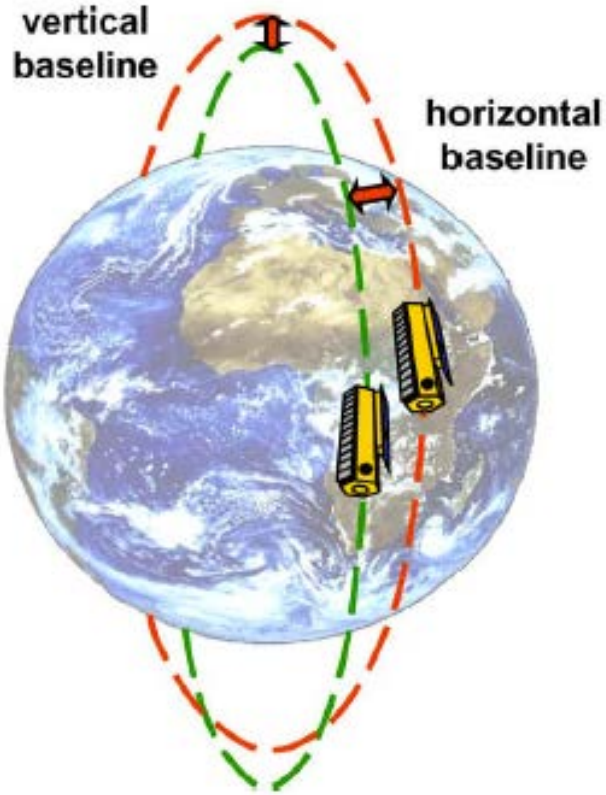
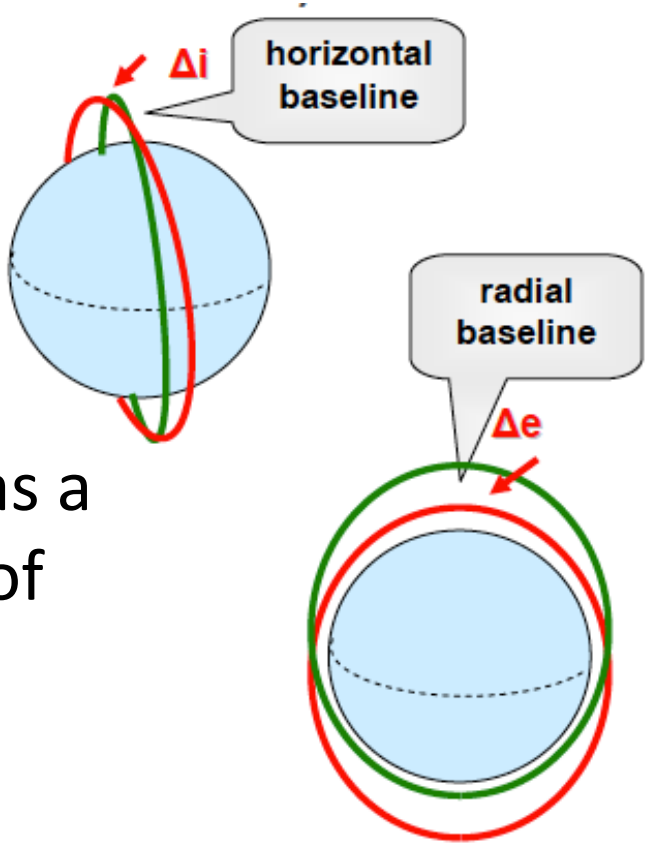
Retrieval of Sea Ice Topography

Realization of Large Normal Baselines in Space (1)





Baseline changes as a function of latitude!

Krieger et al., Trans. Geoscience and Remote Sensing, Vo. 45, No. 11, 2007
Krieger et al., presentation Fringe 2009

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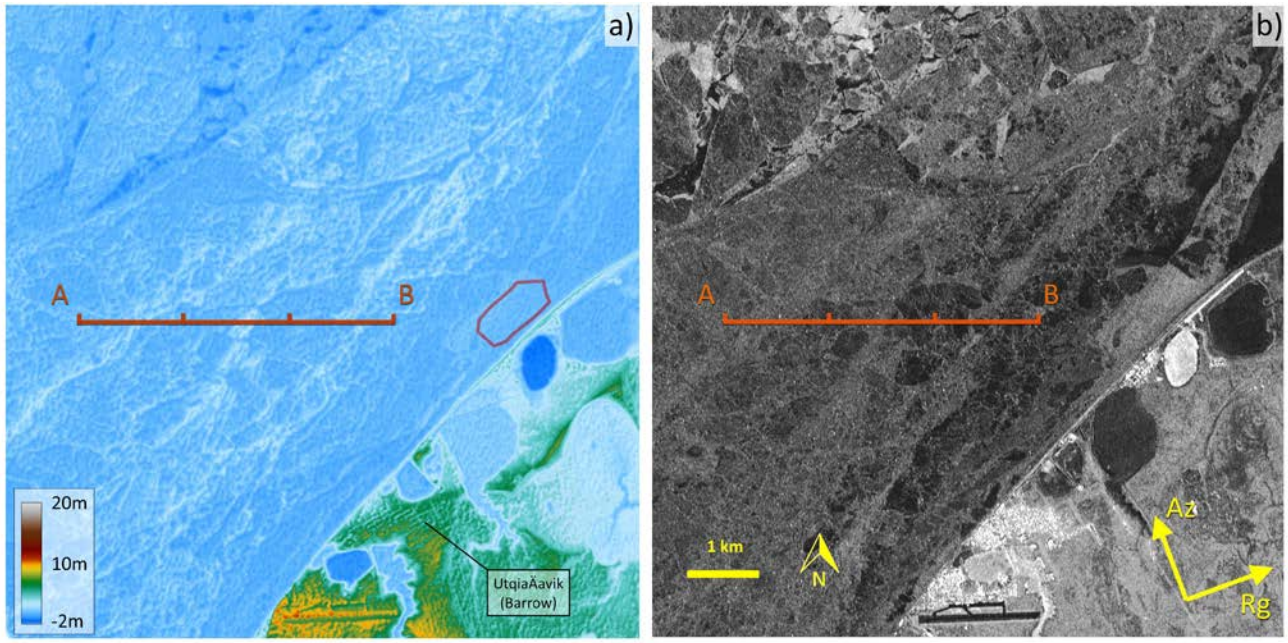
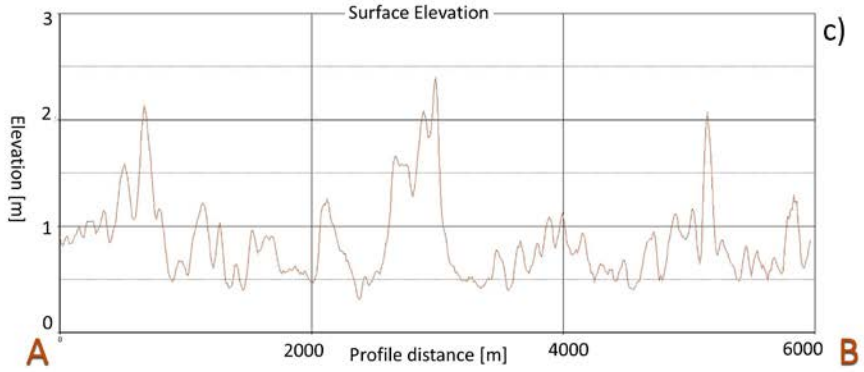
Tandem-X Science Phase: Landfast Ice Surface Topography





Dierking et al., The Cryosphere, 2017

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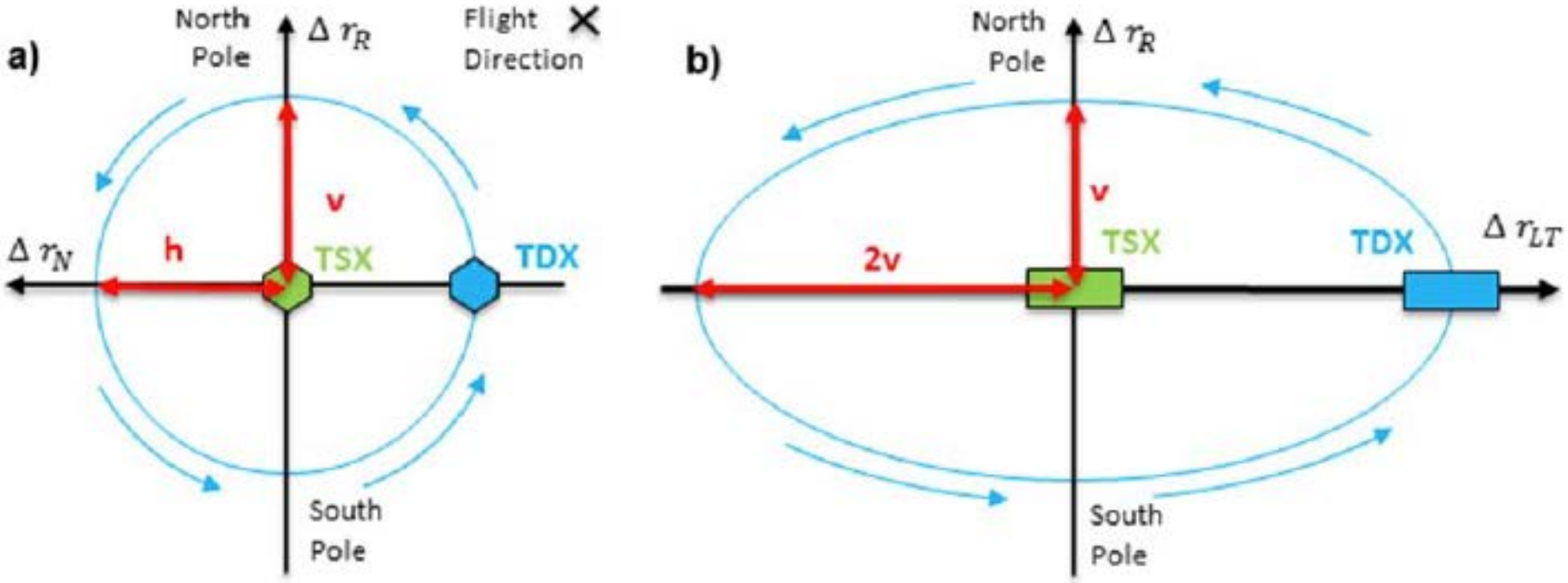
Realization of Larger Normal Baselines in Space (2)



Tandem-X bistatic mode:
along-track baseline variation between ±2 x vertical baseline
Example: VB 300m, ATB 0 at poles, ±600m at equator

Maurer et al., SpaceObs Conference, Korea 2016

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Influence of Along-Track Baseline

$$\Delta\phi = \Delta\phi_{topo}(B_{ac}) + \Delta\phi_{mov}(B_{al}) + \Delta\phi_{noise} + 2\pi n$$

Critical ATB causing phase shifts => 0.5m height change

Band	L		C		X		K_u		K_a	
v [km/s]	7.0		6.7		7.0		7.0		6.7	
u_{LOS} [m/s]	0.05	0.6	0.05	0.6	0.05	0.6	0.05	0.6	0.05	0.6
B_{al} [m]	3360	280	737	61	434	36	308	26	112	9.4
B_{al} [s]	0.480	0.04	0.11	0.009	0.062	0.005	0.044	0.004	0.017	0.0014

Movement or topography?

Dierking et al., The Cryosphere Discussions, 2017

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