

# Hydro- & Cryosphere

**Irena Hajnsek and Science Team**

1st German/Japanese Science and Application Workshop  
for Next-Generation SAR

Sola City, Tokyo

June 27, 2013

Microwaves and Radarsystems

German Aerospace Center

Institute of Environmental Engineering

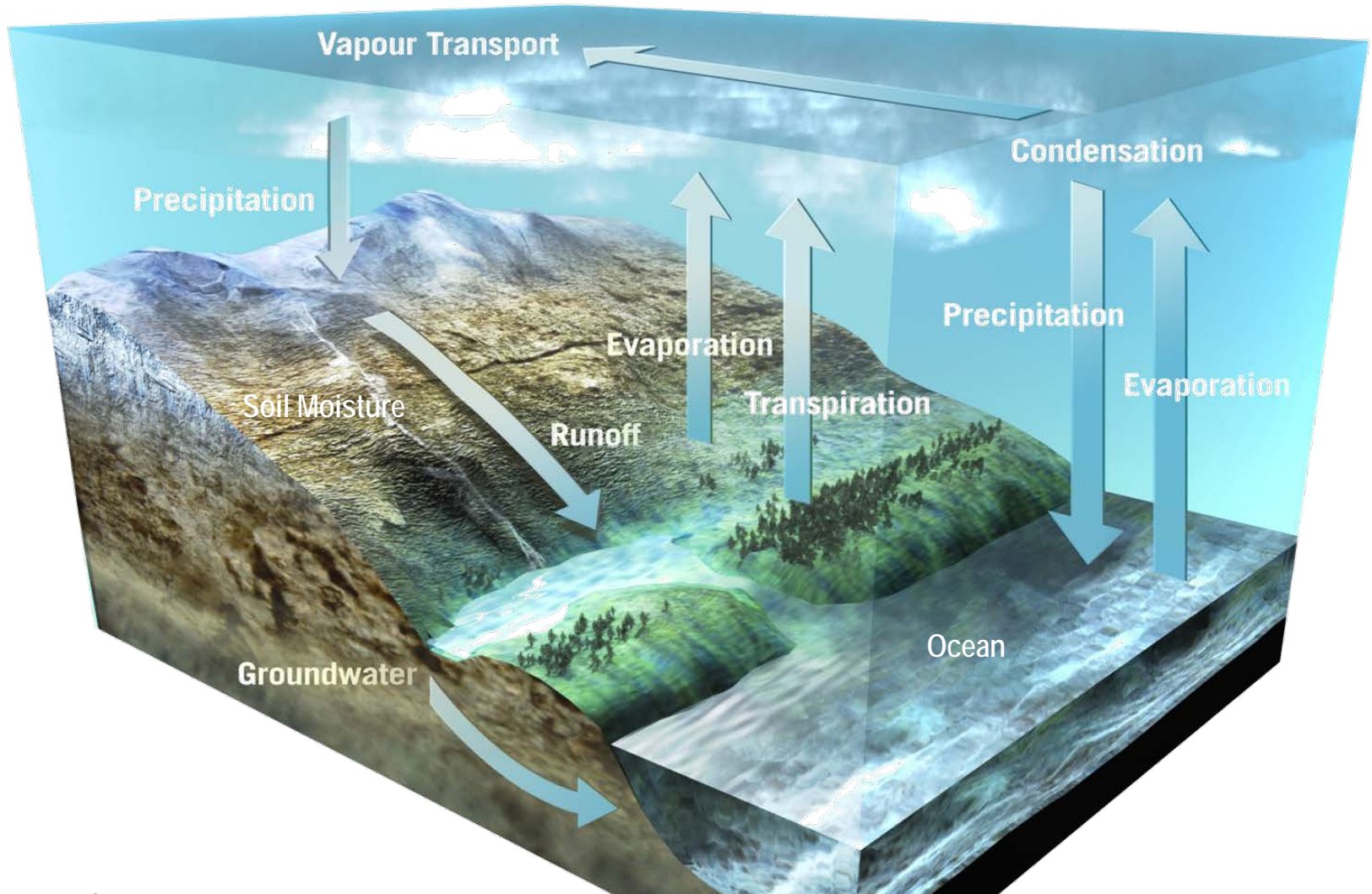
Swiss Federal Institute of Technology Zurich

Knowledge for Tomorrow



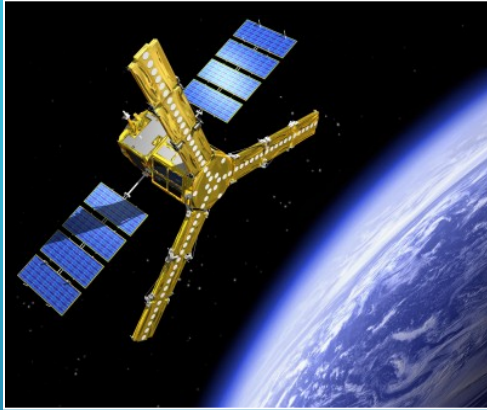
# Hydrosphere

Quantifying soil moisture dynamics and spatial distribution for hydrological prediction (local/global water cycle assessment)



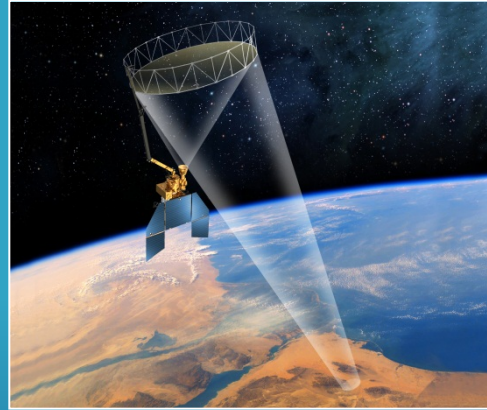
# Hydrosphere: Soil Moisture

SMOS



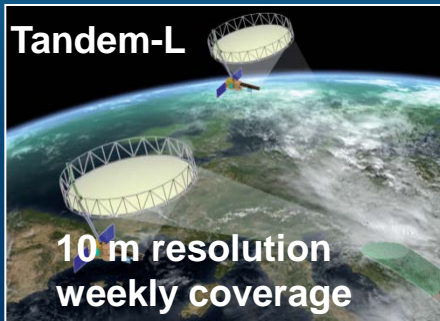
35 km resolution

SMAP



10-40 km resolution

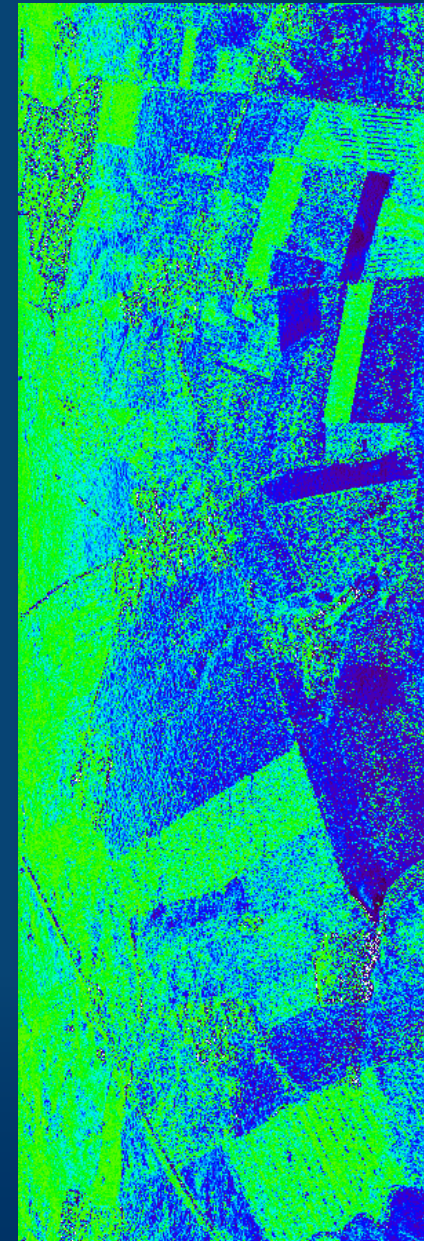
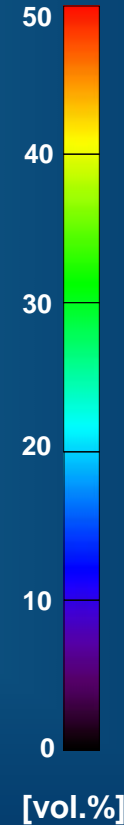
Tandem-L



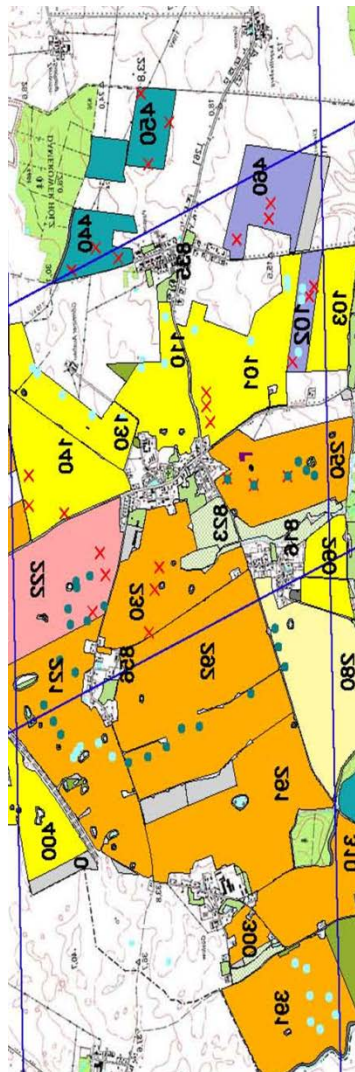
10 m resolution  
weekly coverage

Tandem-L provides unique & complementary information:

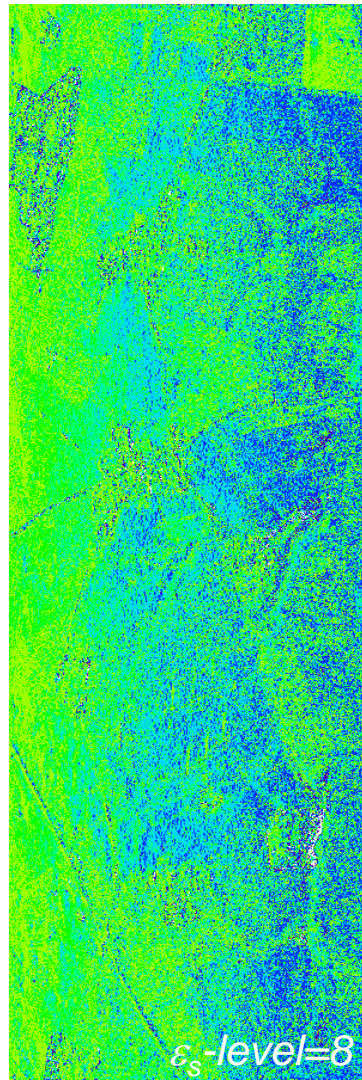
- *soil moisture*
- *water level changes*
- *river & ocean currents*
- *weekly coverage & high resolution*



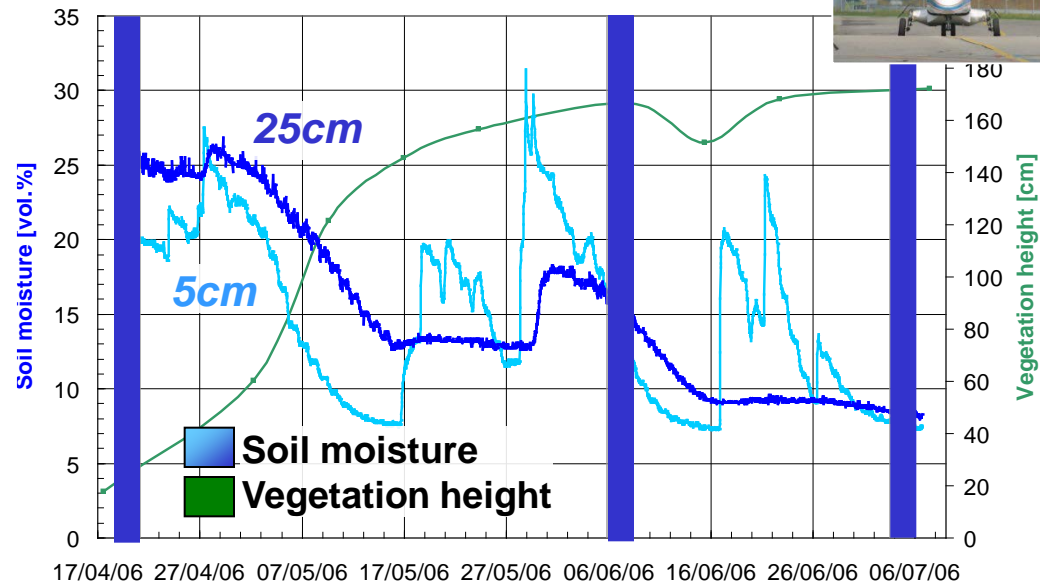
# Soil Moisture Inversion over 4 Months @ L-band



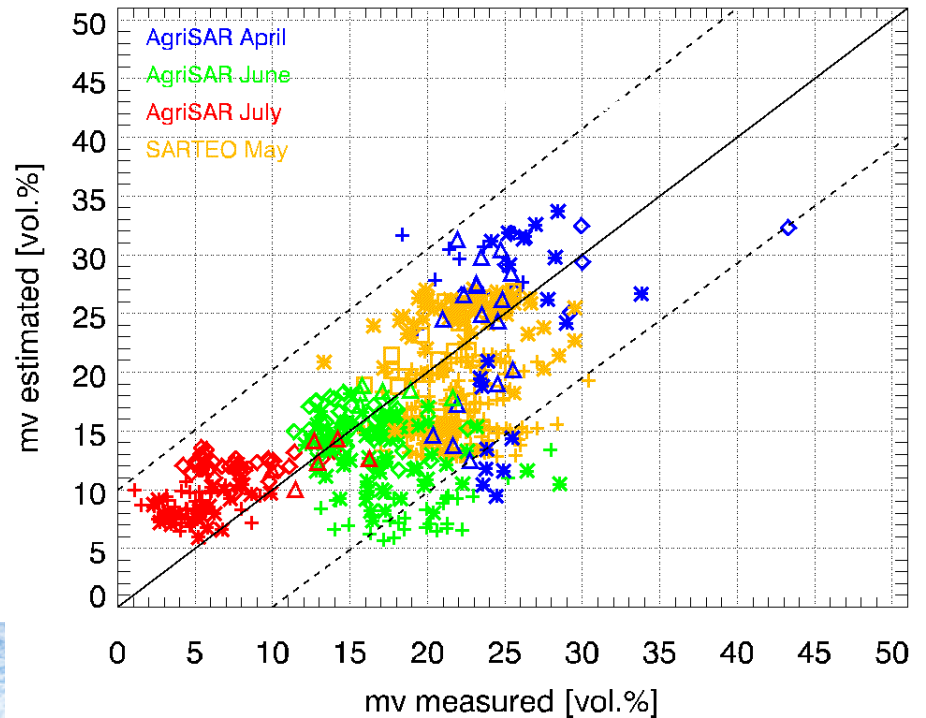
Land use



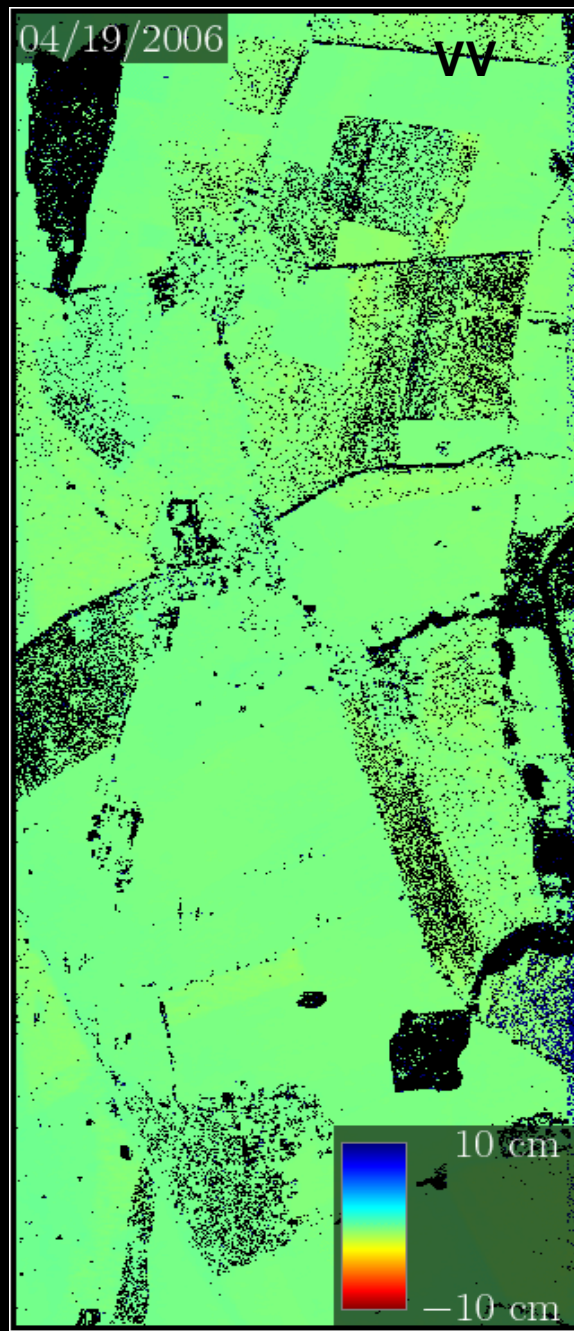
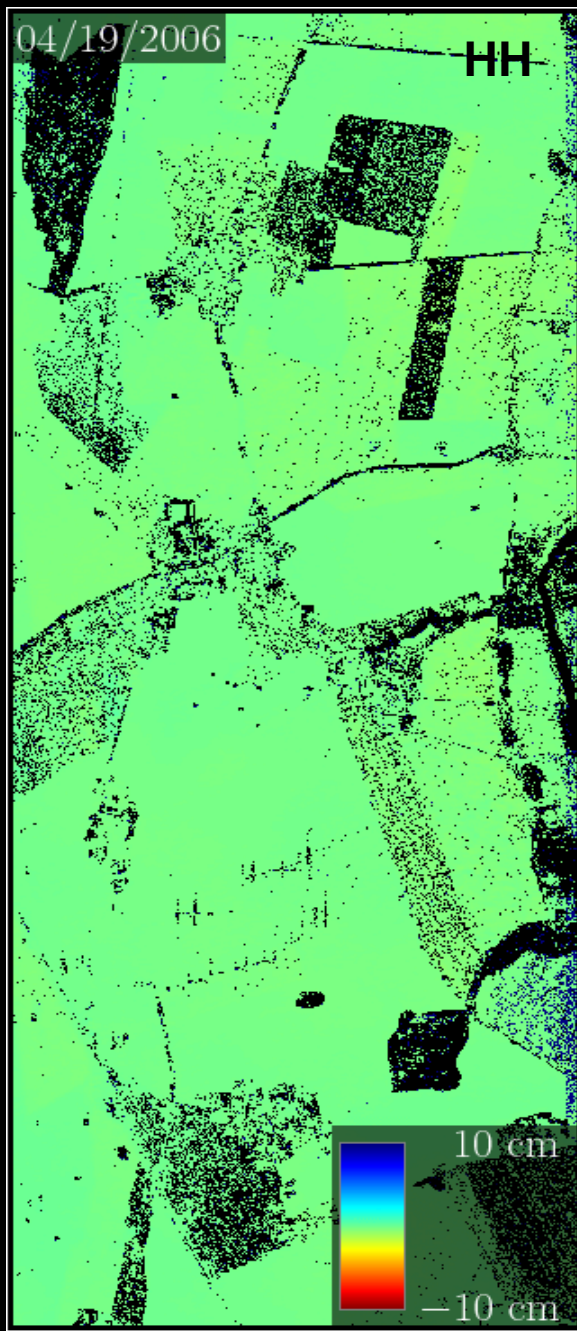
July, 5<sup>th</sup>



17/04/06 27/04/06 07/05/06 17/05/06 27/05/06 06/06/06 16/06/06 26/06/06 06/07/06



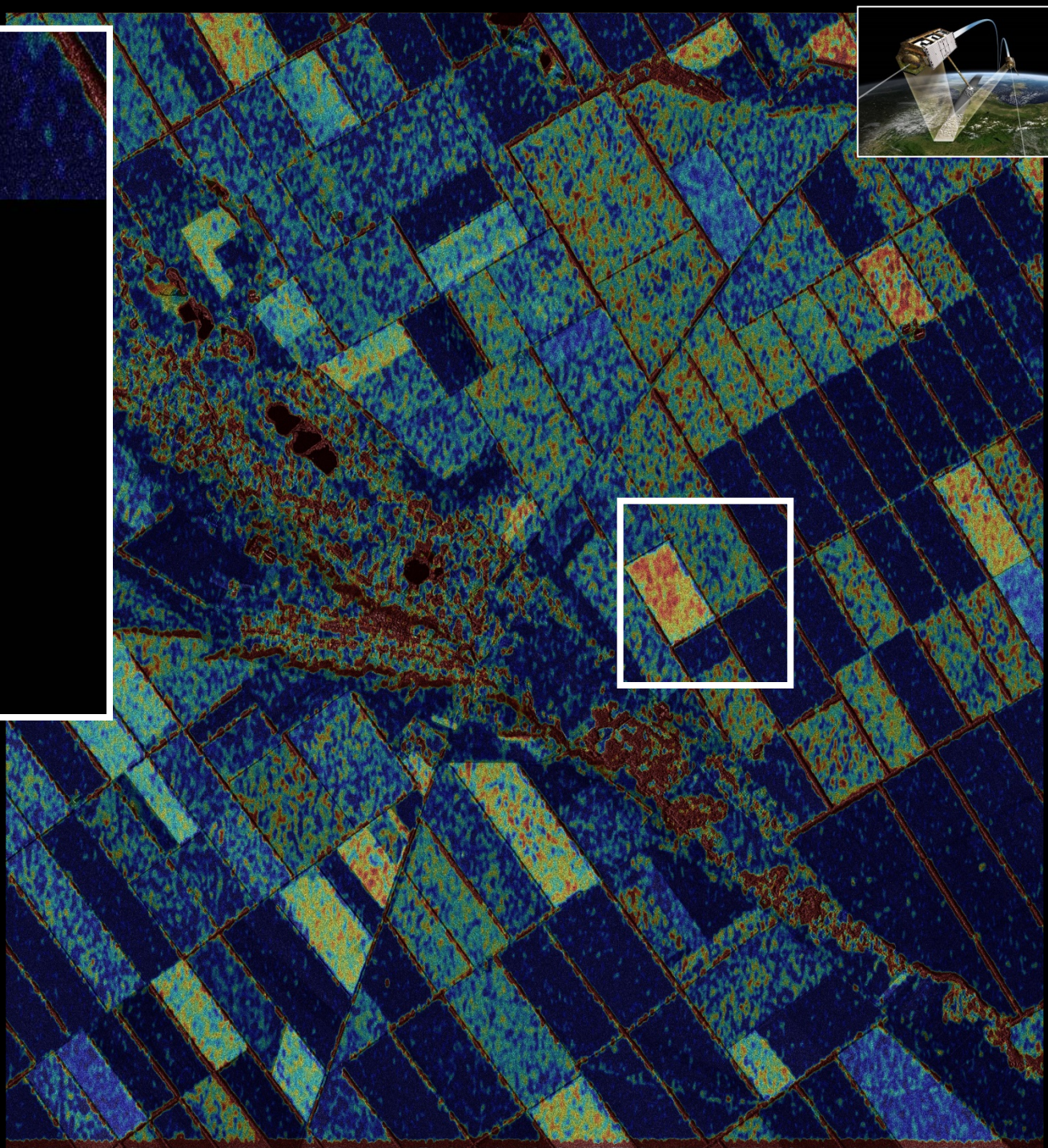
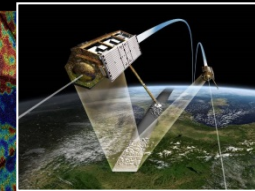
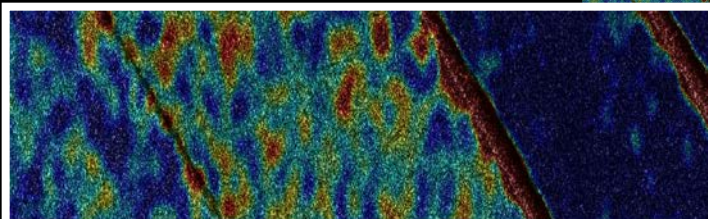
# Agricultural Field Dynamics @ L-band (D-InSAR)



# First Pol-InSAR Data Takes

Dual-Pol HH-VV Spotlight  
Test Site Location: Russia  
InSAR Mode: Monostatic  
Temporal Baseline: 3sec  
Spatial Baseline ( $\perp$ ): 275m

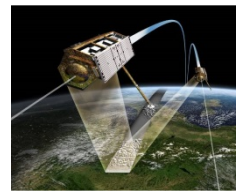




Max. phase difference



# Monitoring Phenology of Rice Fields

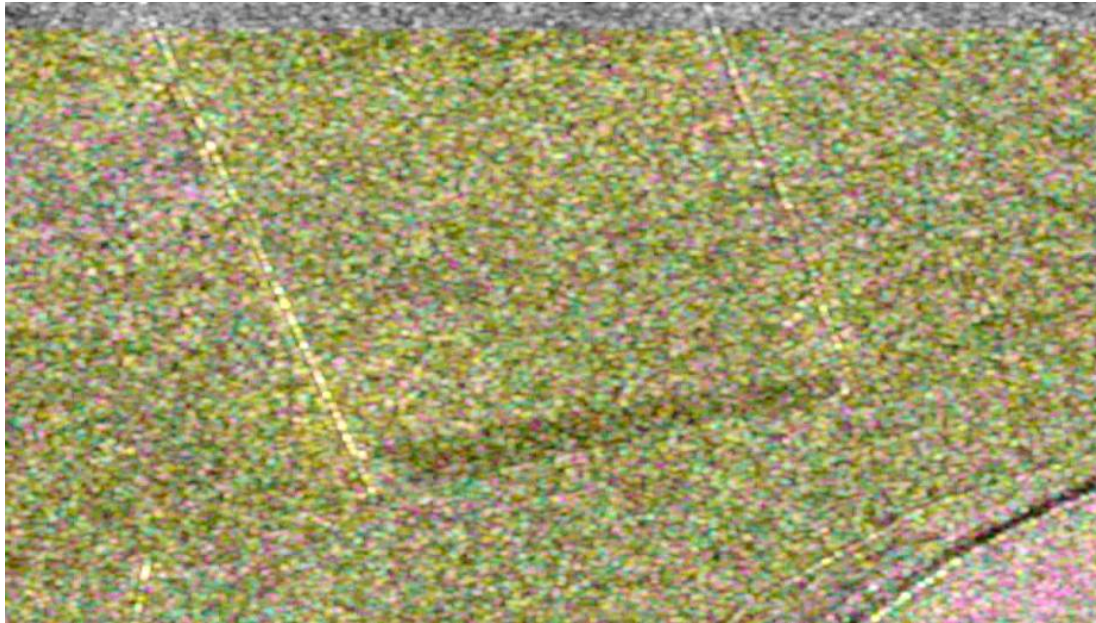


TerraSAR-X dual polarimetric:  
Rice imaging (blue)



TerraSAR-X Stripmap  
3x3 m spatial resolution

Rice crop field  
(May-August)

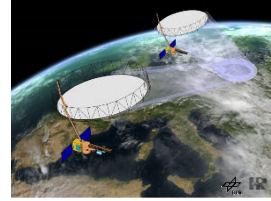


HH VV HH-VV



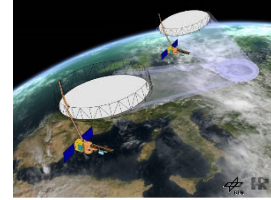


# User Requirements: Hydrosphere – Surface Water



<i>Attributes/ Application</i>	<i>Coverage</i>	<i>Accuracy</i>	<i>Resolution [m]</i>	<i>Observation Frequency</i>	<i>Tandem L contribution</i>	<i>Application</i>
<i>Surface water dynamics</i>						
<i>Surface soil moisture &amp; change</i>	<i>regional</i>	<i>5-10 %</i>	<i>50x50</i>	<i>daily-weekly</i>	<i>Pol-InSAR + D-InSAR (surface-vol seperation)</i>	<i>Hydrology, weather prediction, SVAT modelling</i>
<i>Surface roughness</i>	<i>regional</i>	<i>5-10 %</i>	<i>100x100</i>	<i>seasonal</i>	<i>InSAR coh. decorrelation</i>	<i>Erosion, contribution to desertification</i>
<i>Water level change</i>	<i>regional</i>	<i>10 cm</i>	<i>50x50</i>	<i>daily-weekly</i>	<i>Double differential- InSAR</i>	<i>River, Wetlands; Input for models</i>
<i>Surface Water velocity</i>	<i>regional</i>	<i>-</i>	<i>50x50</i>	<i>daily-weekly</i>	<i>Velocity vector (ATI)</i>	<i>Inverse reconstruction of discharge during floods</i>



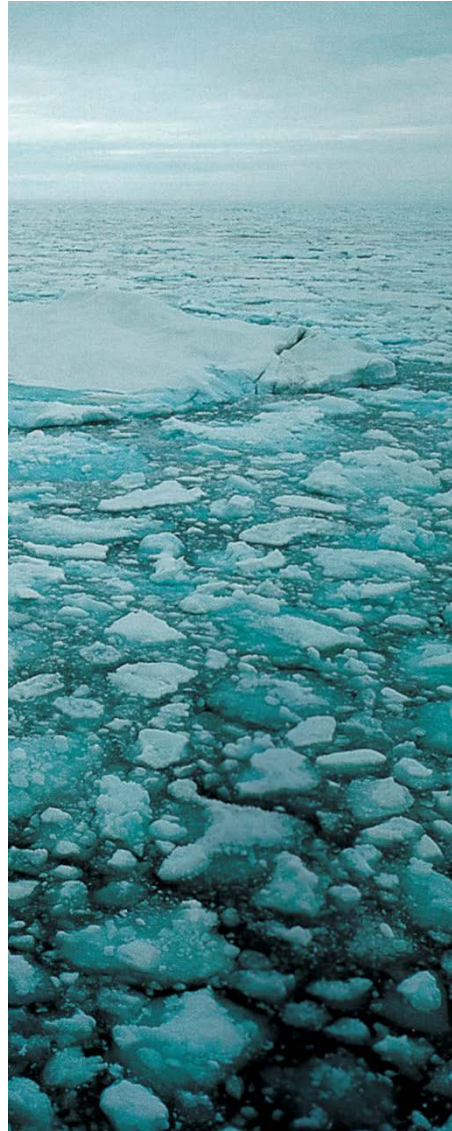


# User Requirements: Hydrosphere - Ocean

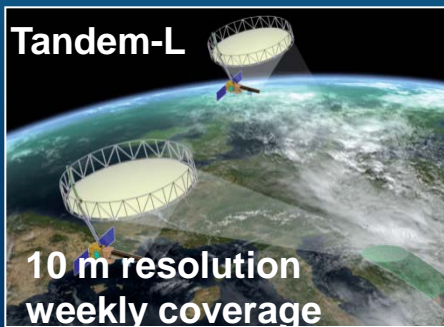
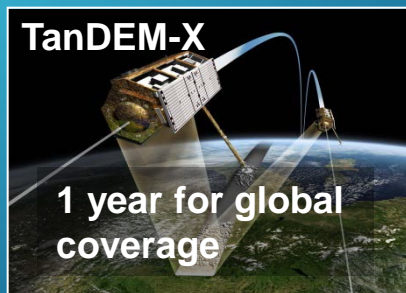
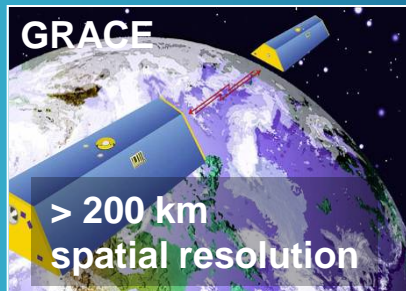
<i>Attributes/ Application</i>	<i>Coverage</i>	<i>Accuracy</i>	<i>Resolution [m]</i>	<i>Observation Frequency</i>	<i>Tandem L contribution</i>	<i>Application</i>
<i>Ocean dynamics</i>						
<i>Tidal flats height, water lines</i>	<i>regional (coastal)</i>	<i>0.5 m</i>	<i>20-50m</i>	<i>weekly</i>	<i>costal line detection (coherence)</i>	<i>Costal protection, change detection</i>
<i>Bathymetry under water</i>	<i>local (coastal)</i>	<i>0.5 m</i>	<i>20m-1km</i>	<i>During/After storms to monthly</i>	<i>wind- topography separation</i>	<i>Costal protection, change detection</i>
<i>Internal Waves position</i>	<i>regional</i>	<i>1 m/s</i>	<i>20-100 m</i>	<i>daily</i>	<i>velocity estimates &amp; detection</i>	<i>Ocean Mixing Influence climate change</i>
<i>Ocean currents</i>	<i>Regional</i>	<i>1m/s</i>	<i>20-1000 m</i>	<i>daily</i>	<i>velocity estimates &amp; detection</i>	<i>Dectection of current changes (e.g. Gulf stream)</i>



# Cryosphere

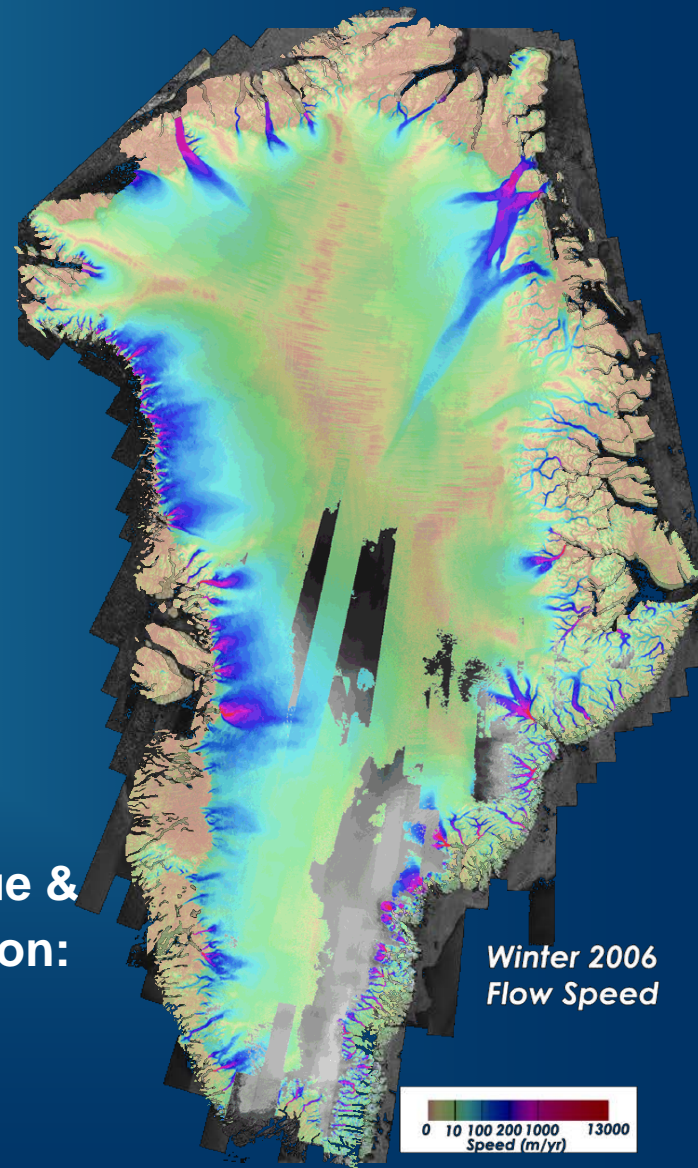


# Cryosphere: Ice Motion and Topography of Glaciers



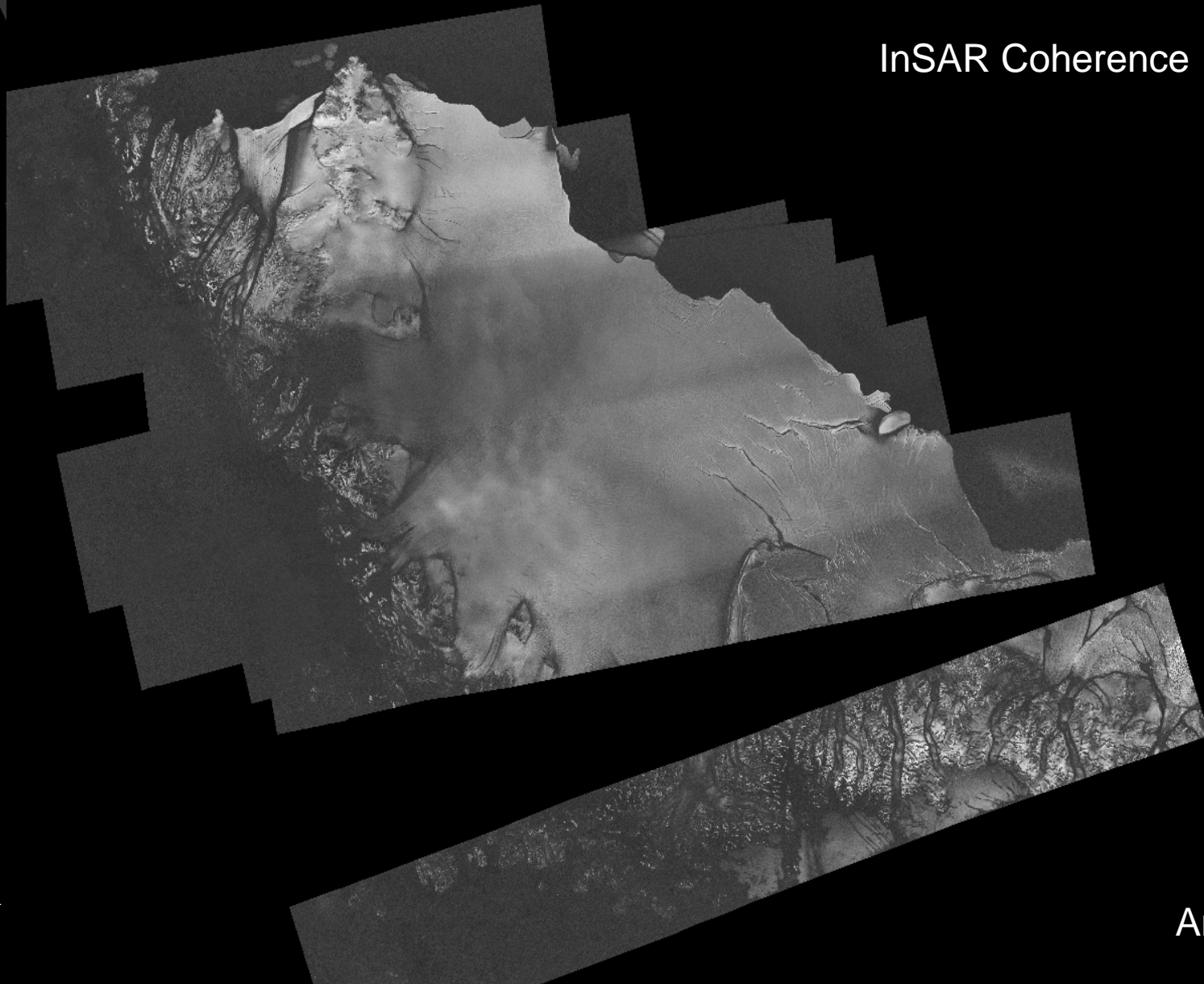
Tandem-L provides unique & complementary information:

- *3D Ice flow*
- *Ice Structure*
- *DEM*
- *weekly coverage, high resolution*



# Temporal Decorrelation

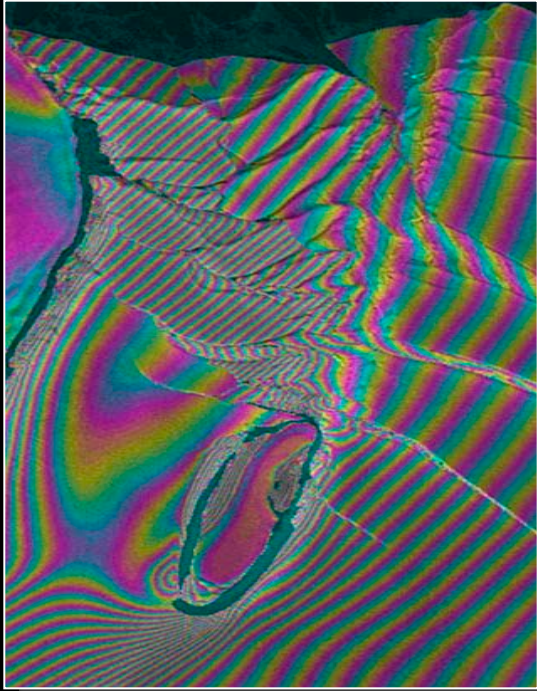
InSAR Coherence @ L-band 46 days  
ALOS-PaISAR



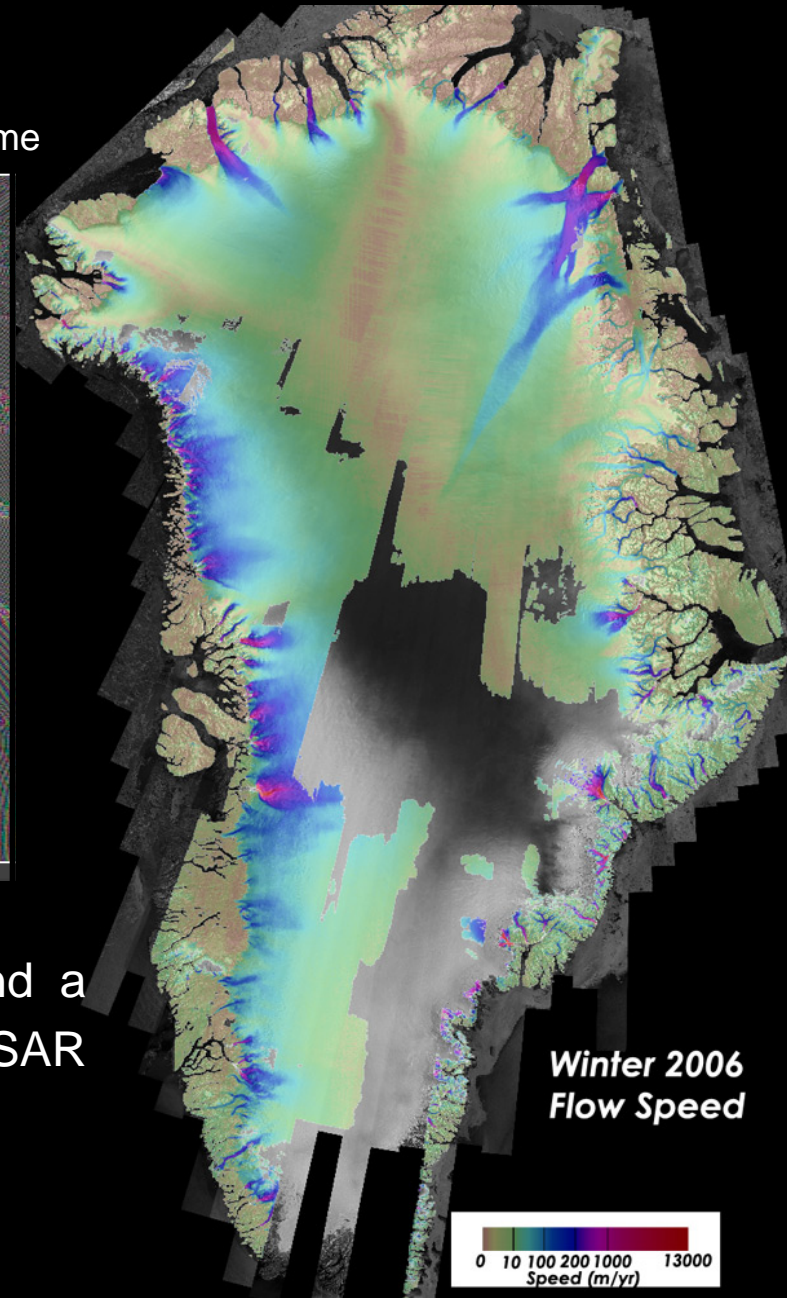
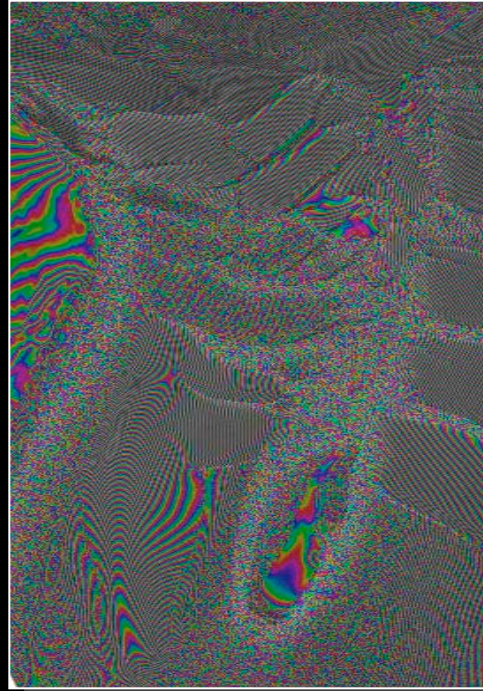
Antarctic Peninsula

# Ice Motion of Fast Moving Glaciers

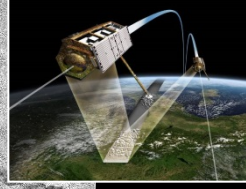
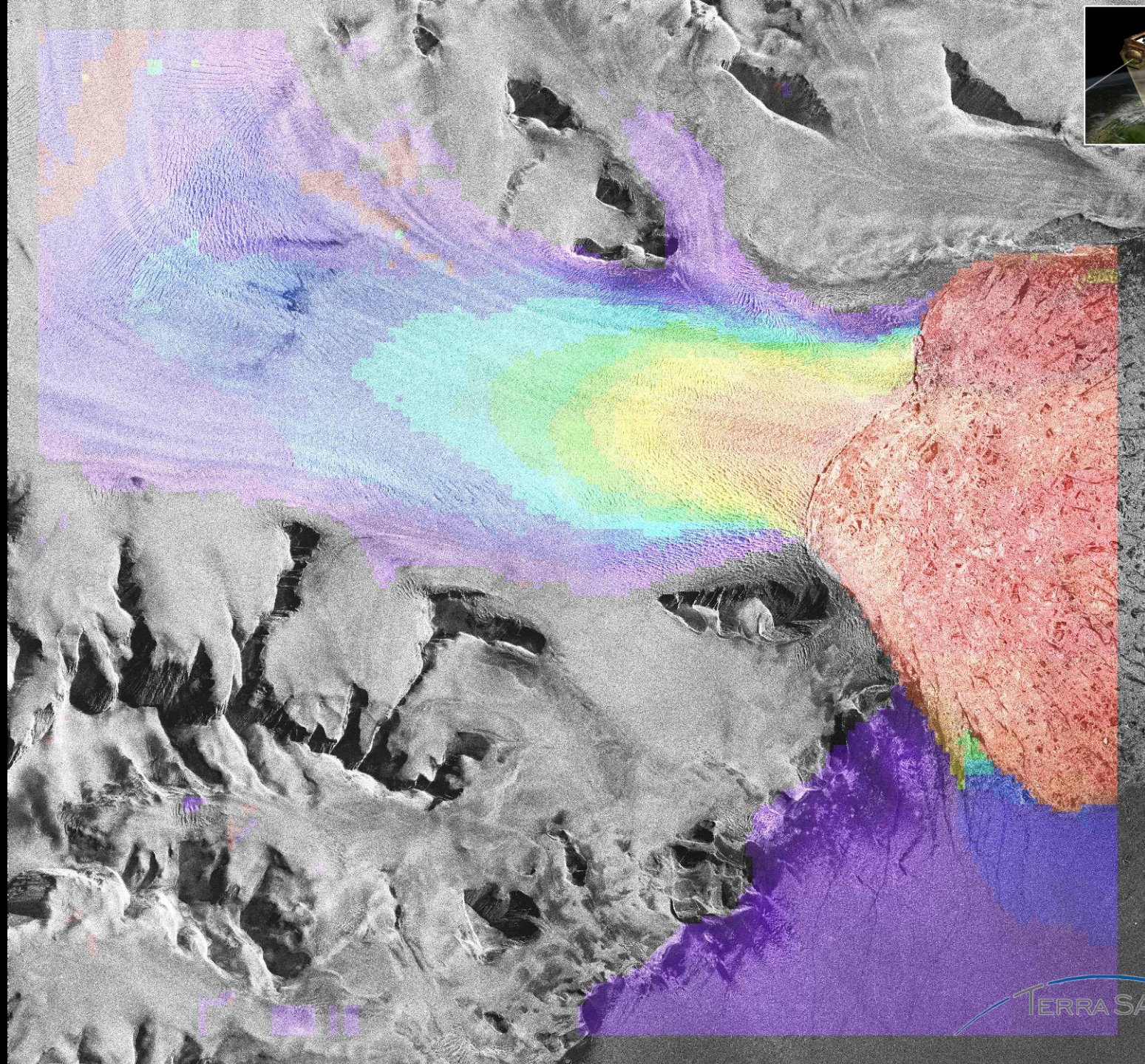
ERS Tandem 1-Day RP Time



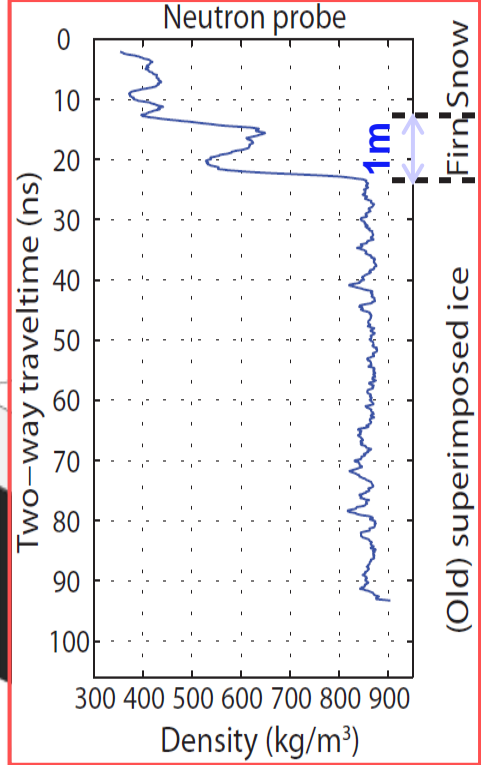
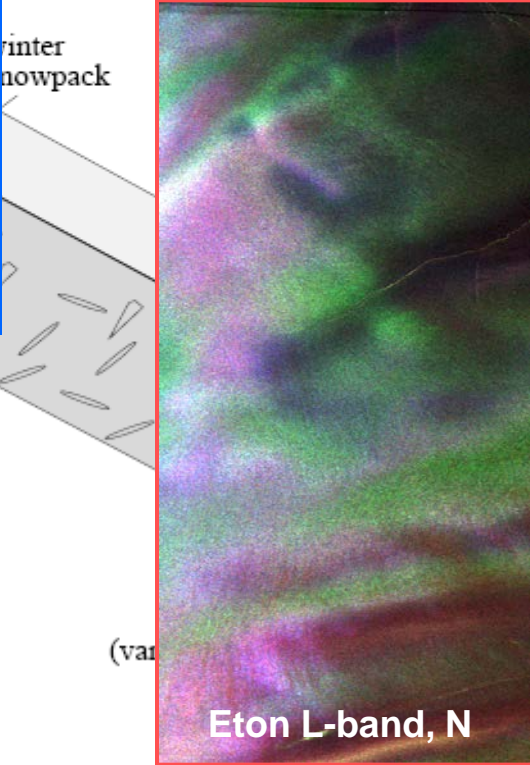
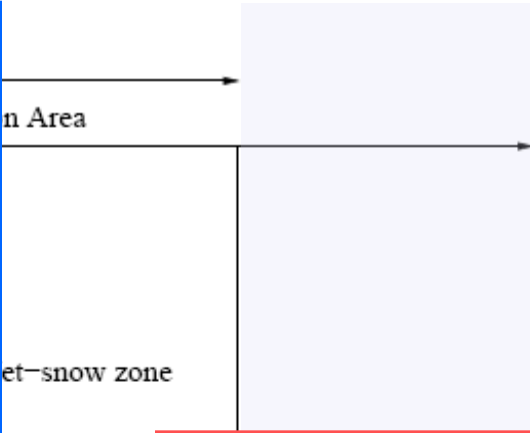
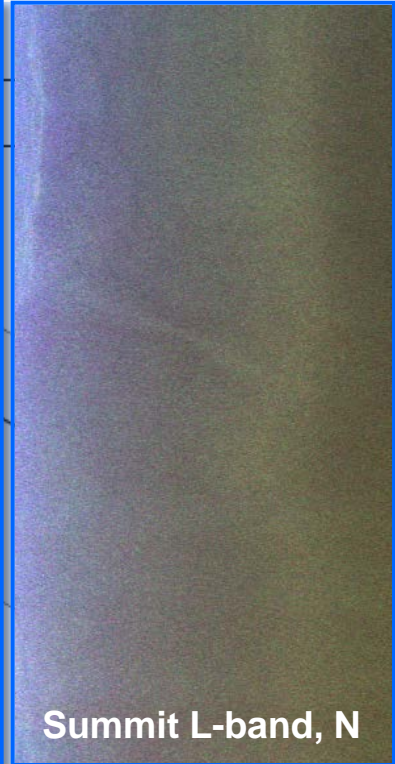
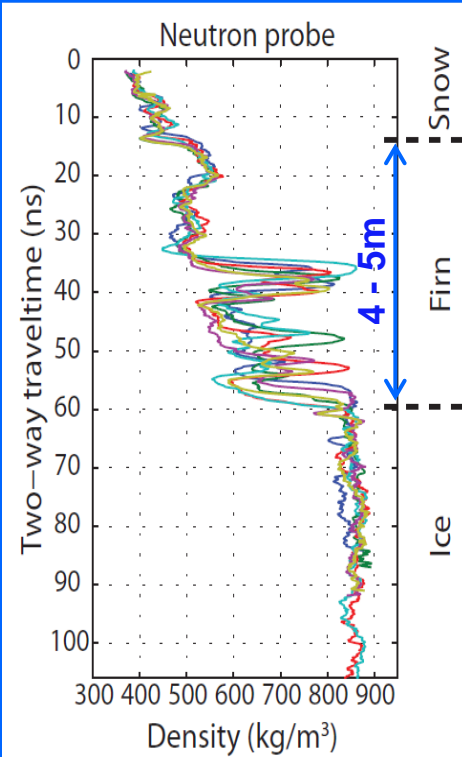
RADARSAT 24-Days RP Time



The combination of short repeat pass times and a systematic acquisition scenario and a low SAR frequency (L-band) is optimum for fast ice motion.



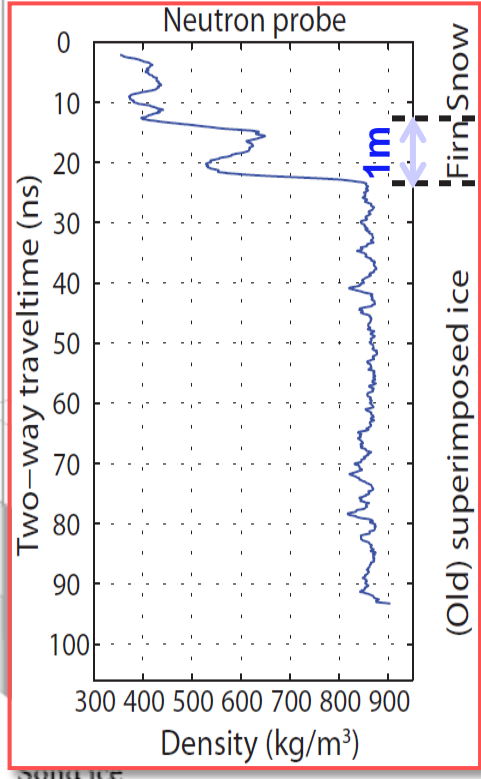
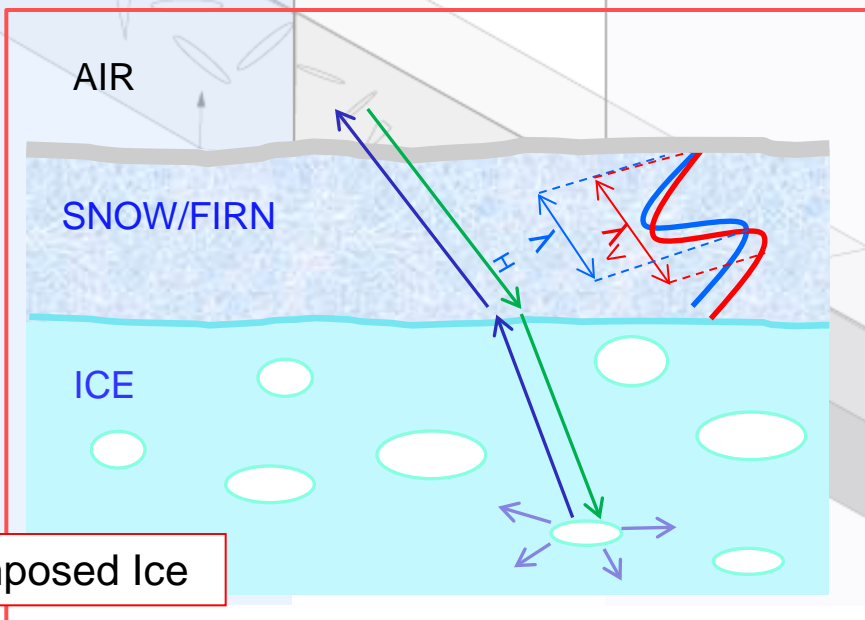
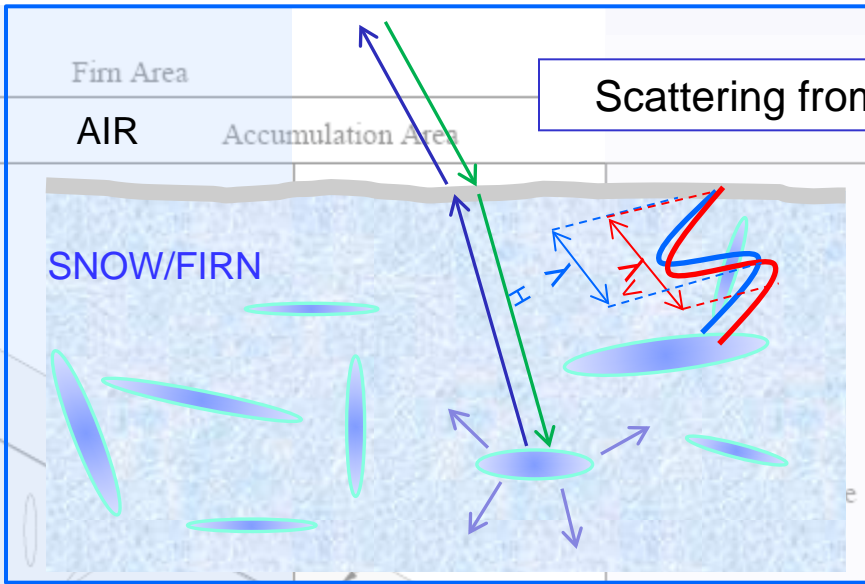
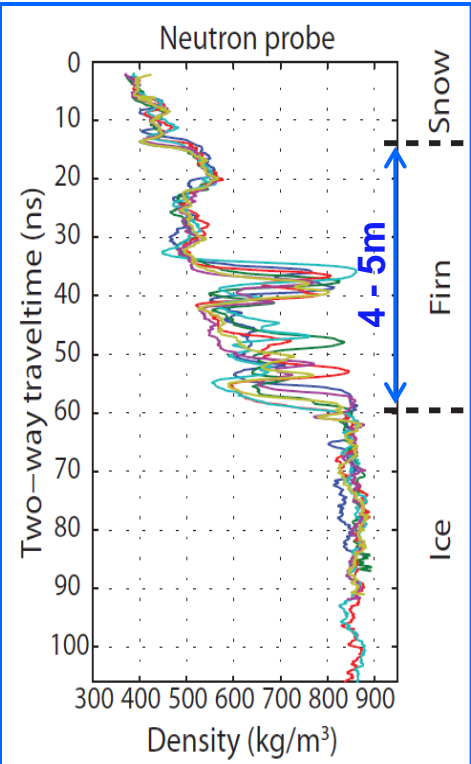
# Vertical Ice Structure @ L-band (2005/07)



T. Dunse et al., "Recent fluctuations in the extent of the firn area of Austfonna, Svalbard, inferred from GPR", Annals of Glaciology, vol .50, pp. 155-162, 2009



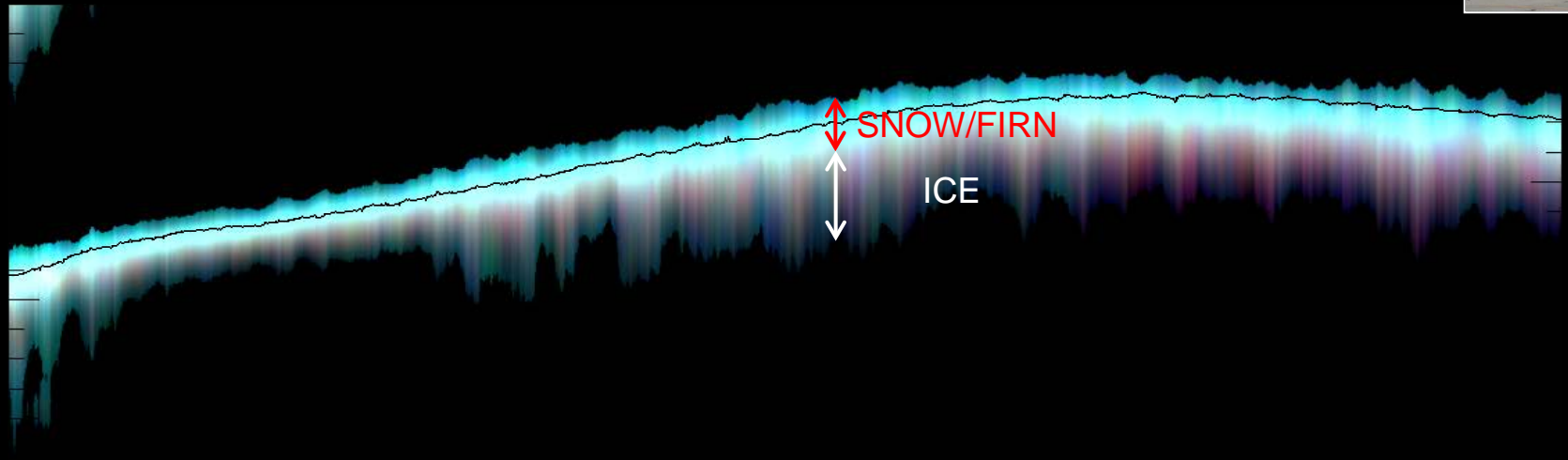
# Vertical Ice Structure @ L-band (2005/07)



Scattering from Superimposed Ice

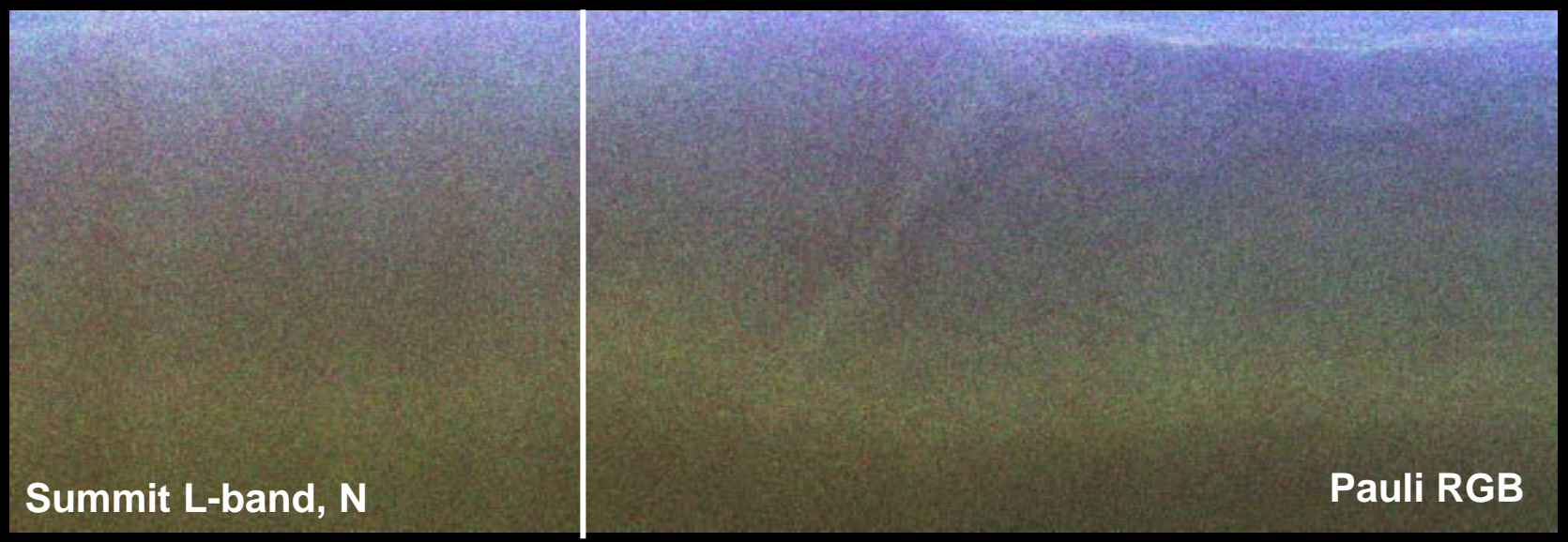
Scattering from Percolation Zone

# Vertical Ice Structure @ Svalbard (Austfonna)



E-SAR: 5 tracks - ~10m vertical resolution

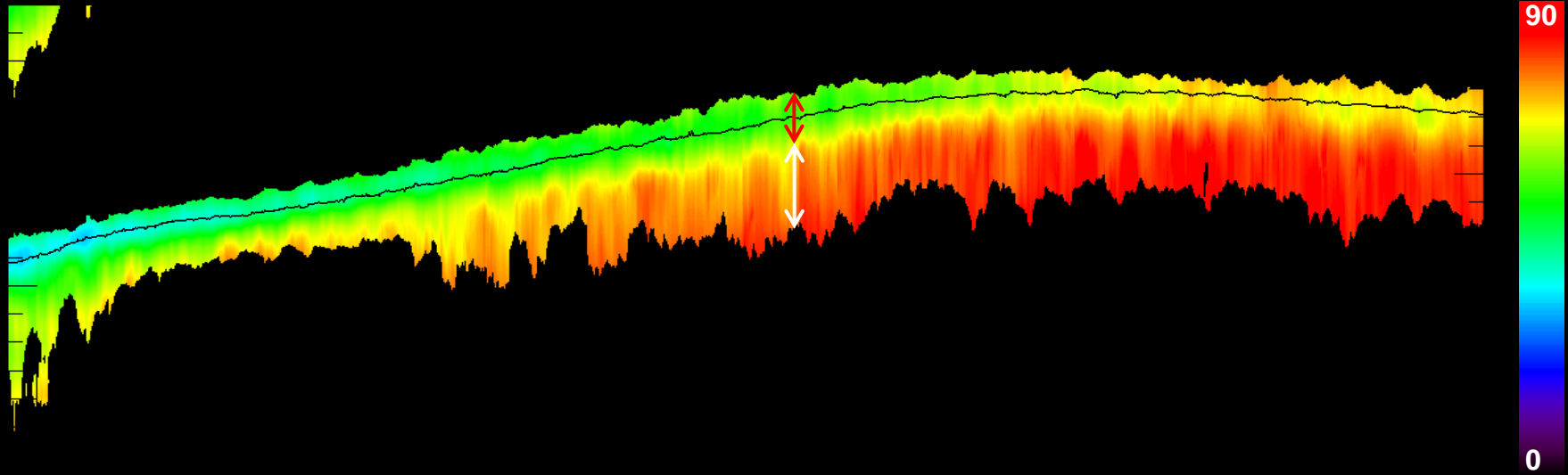
Pauli RGB



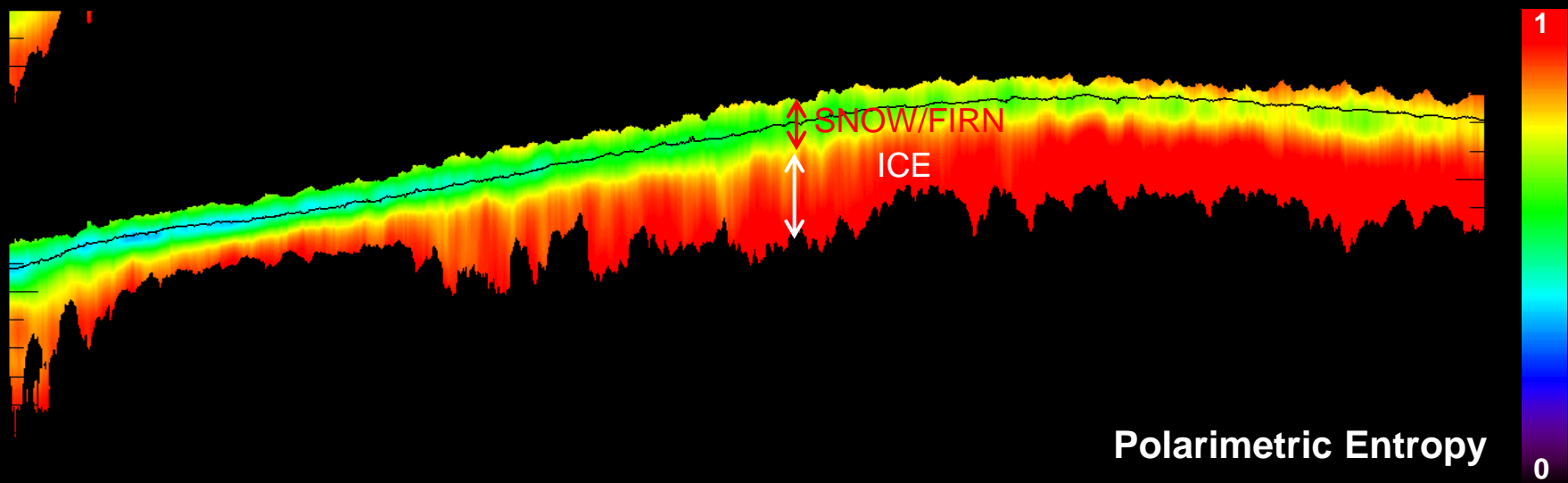
Summit L-band, N

Pauli RGB

# Vertical Ice Structure @ Svalbard (Austfonna)



Polarimetric Alpha

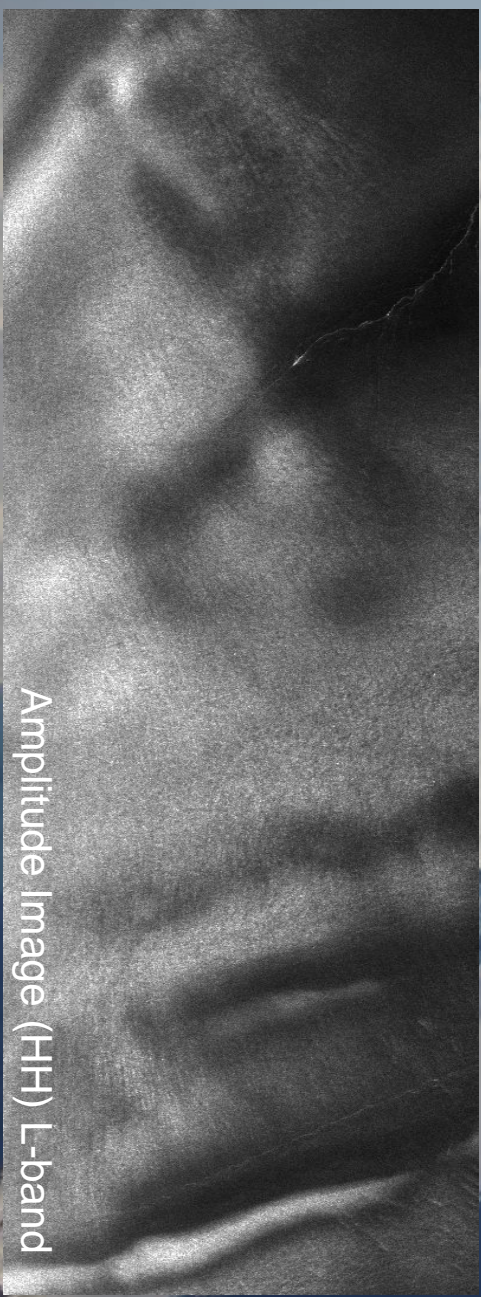


Polarimetric Entropy

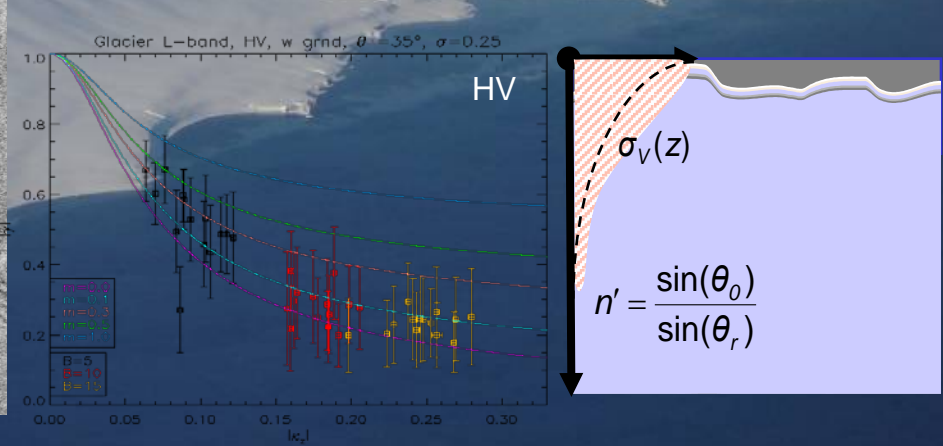
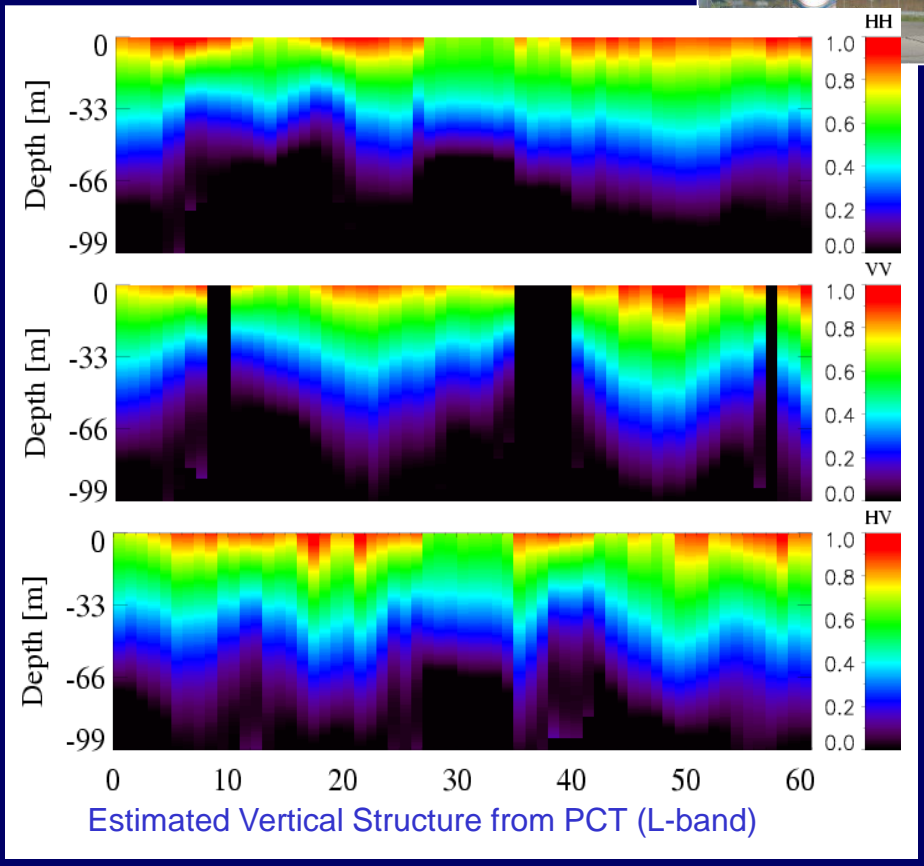
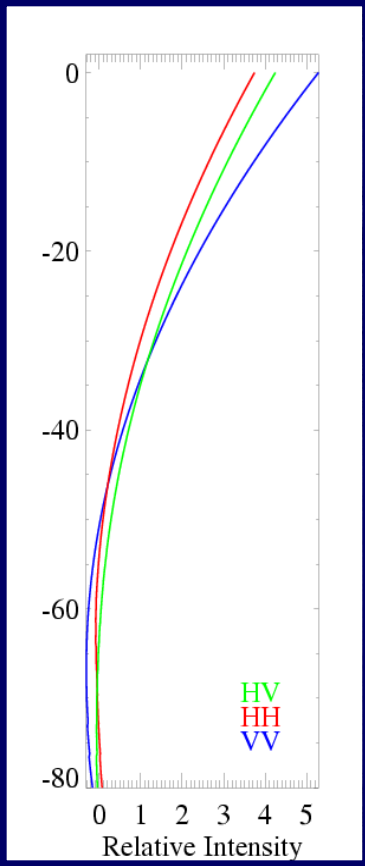
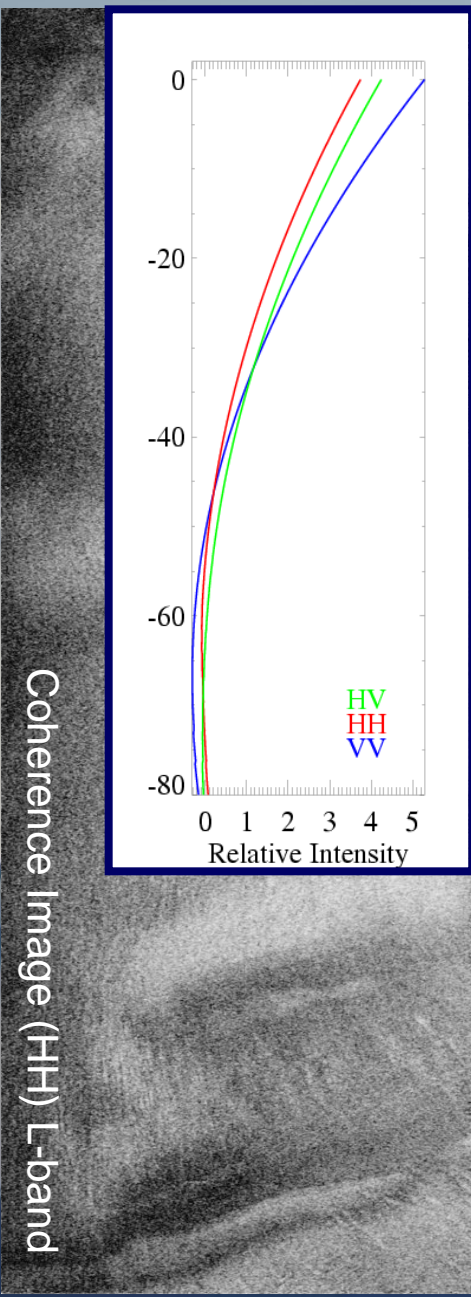


# Polarimetric Coherence Tomography (PCT)

Amplitude Image (HH) L-band

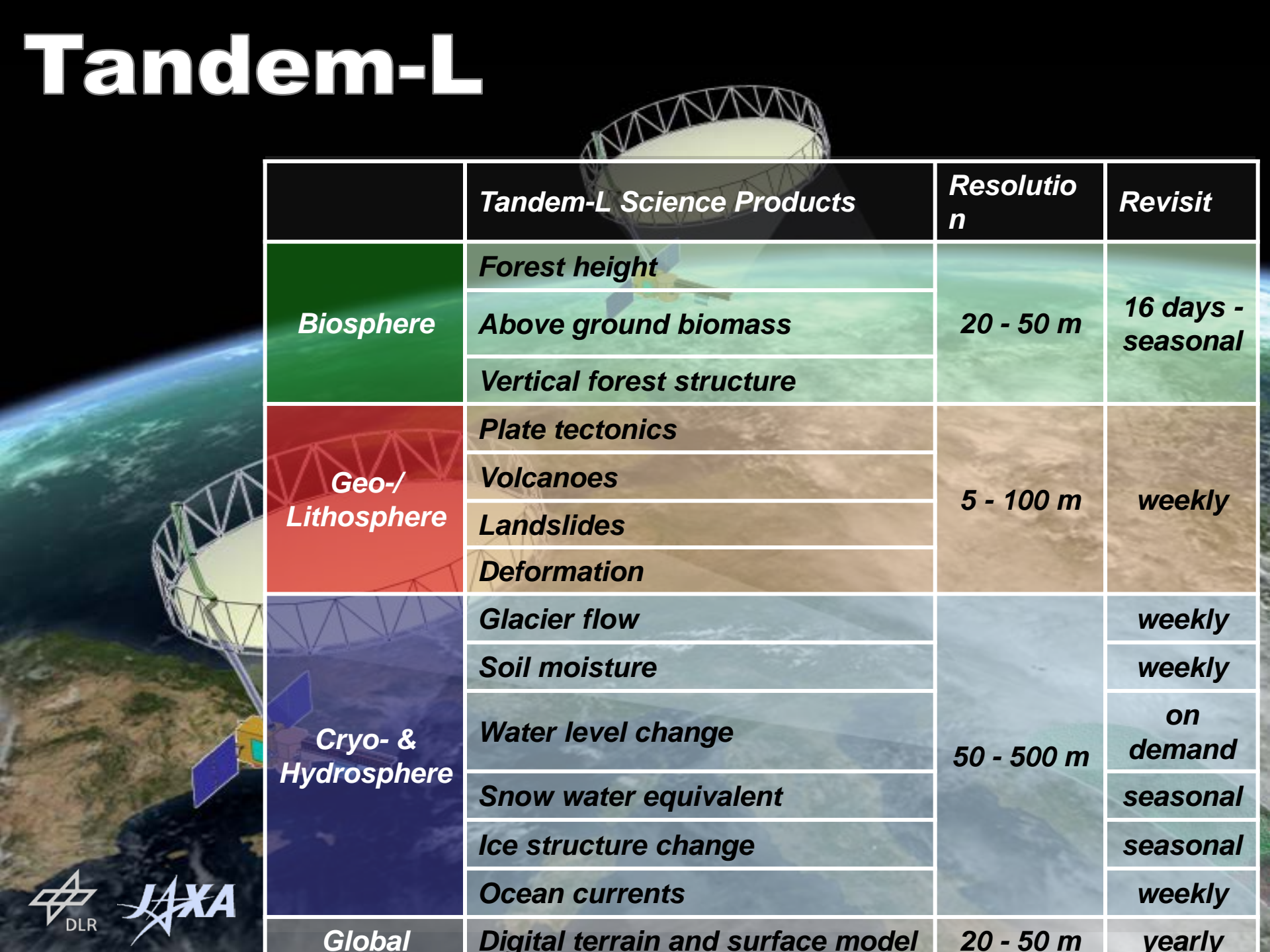


Coherence Image (HH) L-band



	Coverage	Accuracy	Resolution [m]	Observation Cycle	Application
<b>Ice sheets, Glaciers</b>					
<b>Topography</b>	<i>regional</i>	<i>Ice Sheets 5 cm Margins 0.5 m</i>	<i>25 m – 1 km</i>	<i>1 yr – 5 yr</i>	<i>Volume change; mass balance</i>
<b>Ice motion</b>	<i>regional</i>	<i>5 m – 50 m/yr</i>	<i>0.2 m - 1 km</i>	<i>3 mon - 1 yr</i>	<i>Dynamics</i>
<b>Ice export, Icebergs</b>	<i>local-regional</i>	<i>1 km<sup>2</sup></i>	<i>25 m – 100 m</i>	<i>1 mon</i>	<i>Mass balance of ice sheets and calving glaciers</i>
<b>Facies, Morphology</b>	<i>regional</i>	<i>-</i>	<i>50x50</i>	<i>1 mon – 3 mon</i>	<i>Accumulation, Mass balance</i>
<b>Sea Ice</b>					
<b>Ice concentration</b>	<i>regional</i>	<i>-</i>	<i>20-500</i>	<i>daily-weekly</i>	<i>Climate series, Sea ice thermodynamics</i>
<b>Ice thickness, Ice type</b>	<i>regional</i>	<i>-</i>	<i>20-500</i>	<i>daily-weekly</i>	<i>Sea ice thermodynamics, Ocean models</i>
<b>Ice motion</b>	<i>local-regional</i>	<i>1 km/d</i>	<i>100-5000</i>	<i>daily</i>	<i>Sea ice dynamics, Ocean circulation</i>
<b>Permafrost</b>					
<b>Topography</b>	<i>regional</i>	<i>cm</i>	<i>100m</i>	<i>monthly</i>	<i>Climate signal, Base information</i>
<b>Deformation, Landslides</b>	<i>local-regional</i>	<i>mm-cm</i>	<i>100-250m</i>	<i>weekly</i>	<i>Climate impact, natural danger</i>
<b>Structure of the active layer</b>	<i>regional</i>	<i>-</i>	<i>100-250</i>	<i>seasonal</i>	<i>Changes of the freezing cycles, Coupling with atmosphere</i>

# Tandem-L

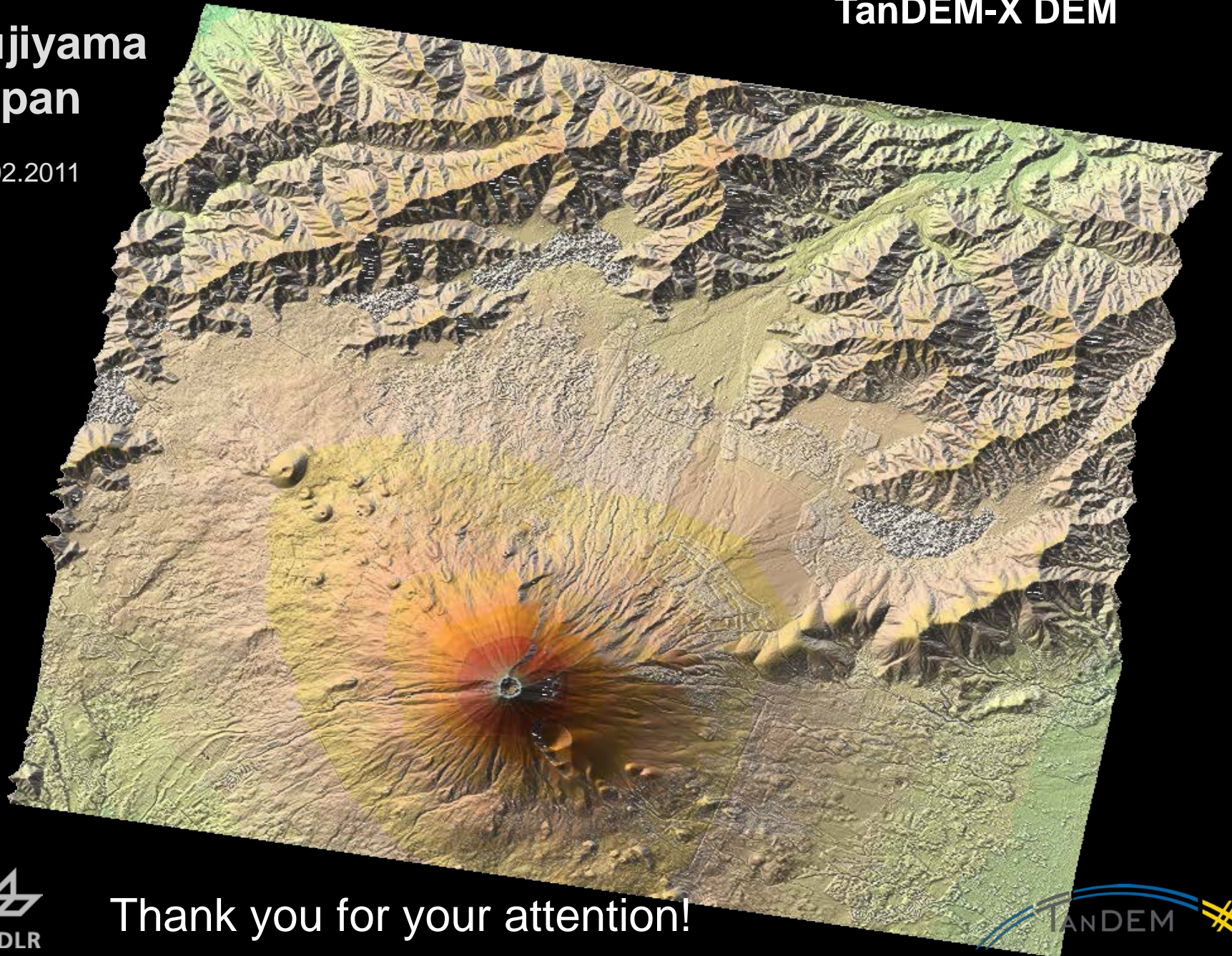


	<i>Tandem-L Science Products</i>	<i>Resolution</i>	<i>Revisit</i>
<b>Biosphere</b>	<i>Forest height</i>	<b>20 - 50 m</b>	<b>16 days - seasonal</b>
	<i>Above ground biomass</i>		
	<i>Vertical forest structure</i>		
<b>Geo-/ Lithosphere</b>	<i>Plate tectonics</i>	<b>5 - 100 m</b>	<b>weekly</b>
	<i>Volcanoes</i>		
	<i>Landslides</i>		
	<i>Deformation</i>		
<b>Cryo- &amp; Hydrosphere</b>	<i>Glacier flow</i>	<b>50 - 500 m</b>	<b>weekly</b>
	<i>Soil moisture</i>		<b>weekly</b>
	<i>Water level change</i>		<b>on demand</b>
	<i>Snow water equivalent</i>		<b>seasonal</b>
	<i>Ice structure change</i>		<b>seasonal</b>
	<i>Ocean currents</i>		<b>weekly</b>
<b>Global</b>	<i>Digital terrain and surface model</i>	<b>20 - 50 m</b>	<b>yearly</b>

# Fujiyama Japan

23.02.2011

TanDEM-X DEM



Thank you for your attention!

