

On the Potential of Current Measurements by Spaceborne Along-Track InSAR

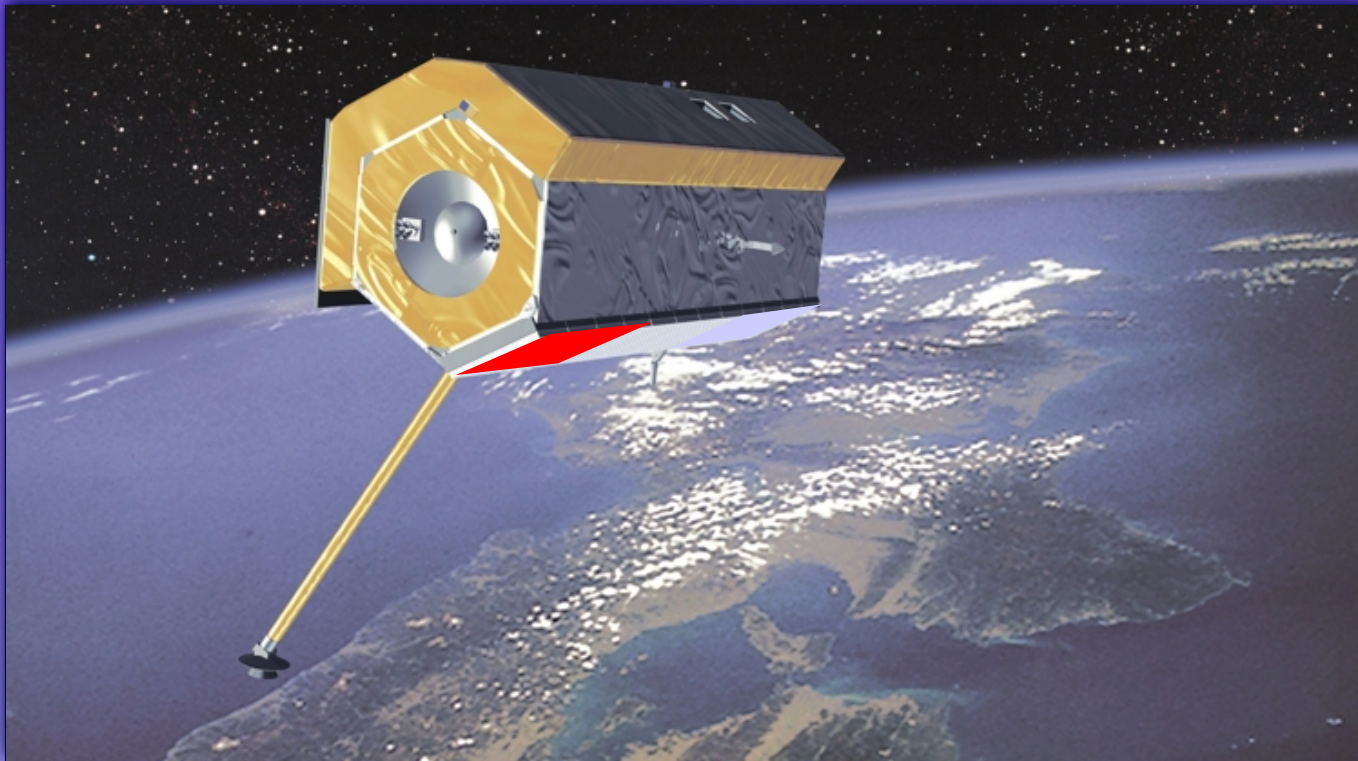
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Along-Track InSAR Raw Data Processing by
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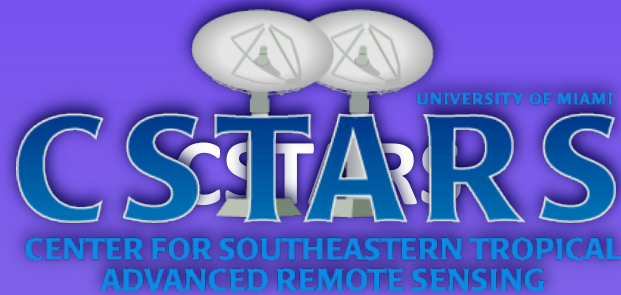


Along-Track Interferometric SAR (AT-InSAR)



Shuttle Radar Topography Mission (SRTM) (DLR / Infoterra, 2007) DLR / ASI, 2000)

- Two SAR antennas acquire images with short time lag
 - Phase difference \propto Doppler shift \propto line-of-sight velocity
- ➔ **Velocity measurements at SAR resolution**



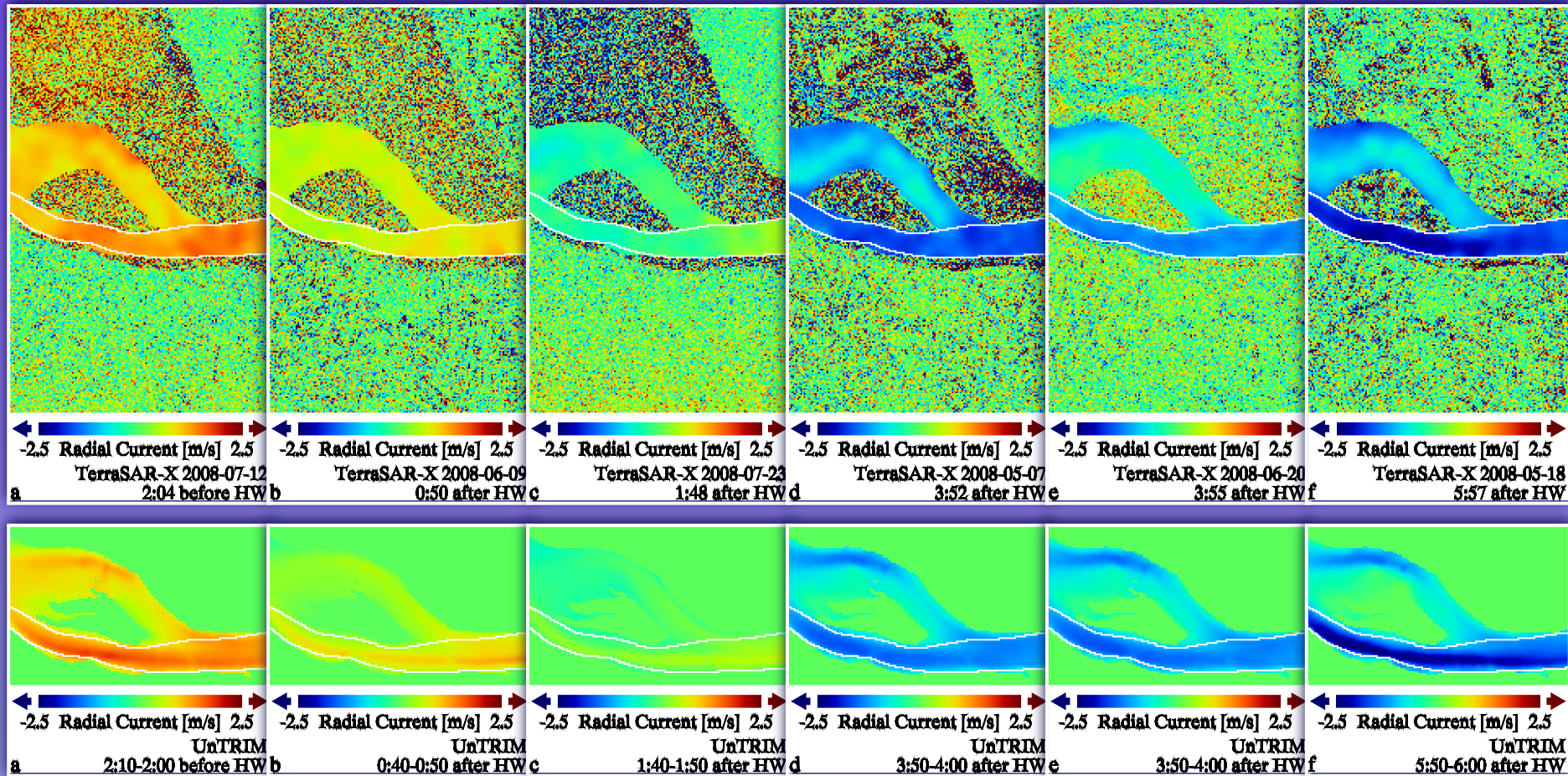
UNIVERSITY OF MIAMI
CSTARS
CENTER FOR SOUTHEASTERN TROPICAL
ADVANCED REMOTE SENSING



- State-of-the-art satellite receiving station operated by U Miami
- Direct access to most existing SAR satellites
- Beginning to acquire & process TerraSAR-X along-track InSAR images quasi-operationally in spring 2012

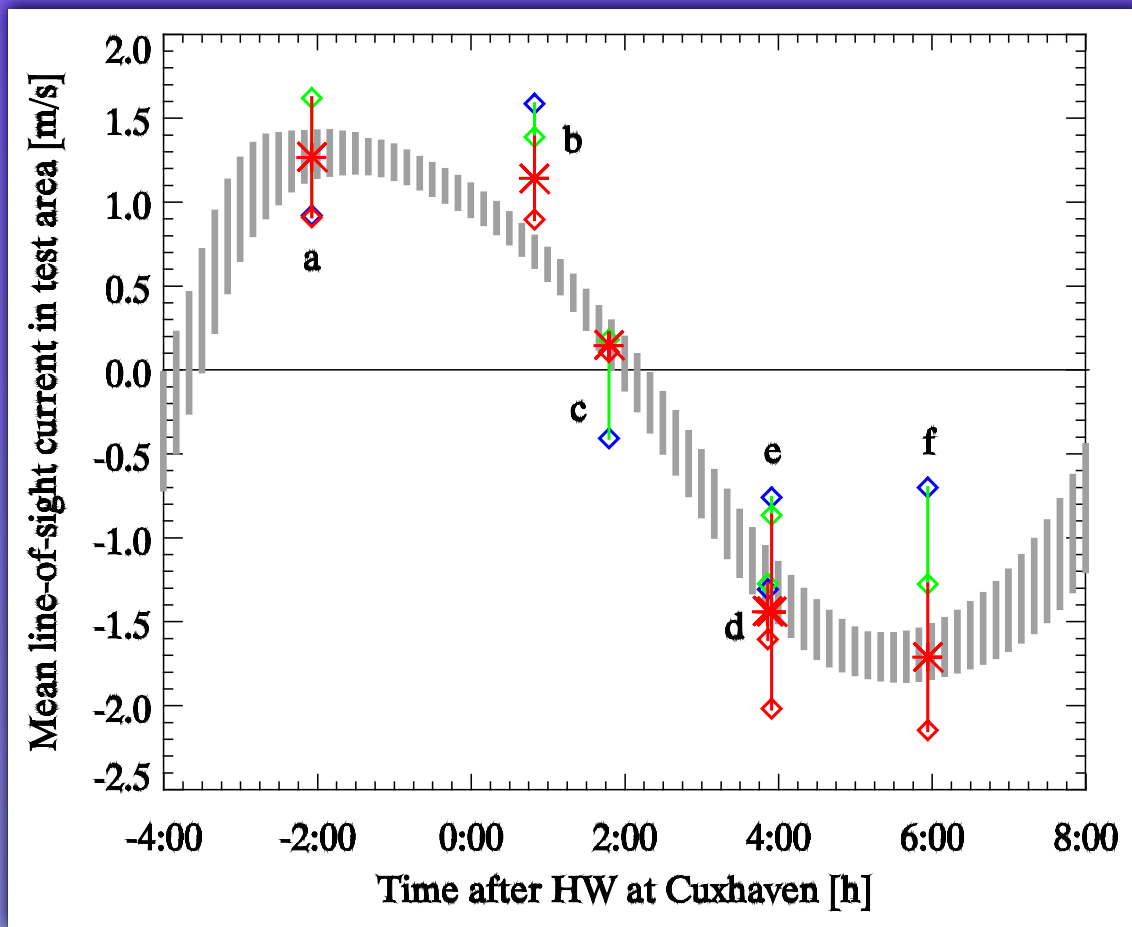
TerraSAR-X Example: Elbe River, Germany

Aperture Switching mode, test area size = 16 km × 25 km



- Six overpasses at different tidal phases
- Noise filtering & wave motion corrections applied
- Good agreement with numerical Elbe model

Quantitative Analysis of Elbe Results



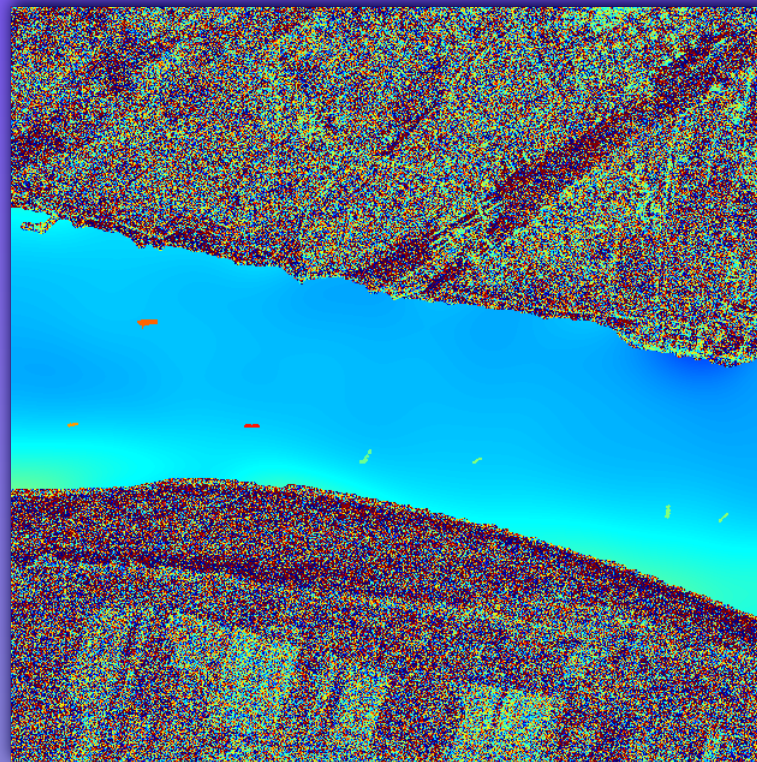
- | Range of tidal currents according to numerical model
- ◇ Doppler velocities from TerraSAR-X
- ◇ Large-scale trend removed
- ◇ 100% theoretical correction applied
- * 50% theoretical correction applied

Another TerraSAR-X / Elbe River Example

Dual Receive Antenna mode, test area size = 6.3 km × 6.3 km



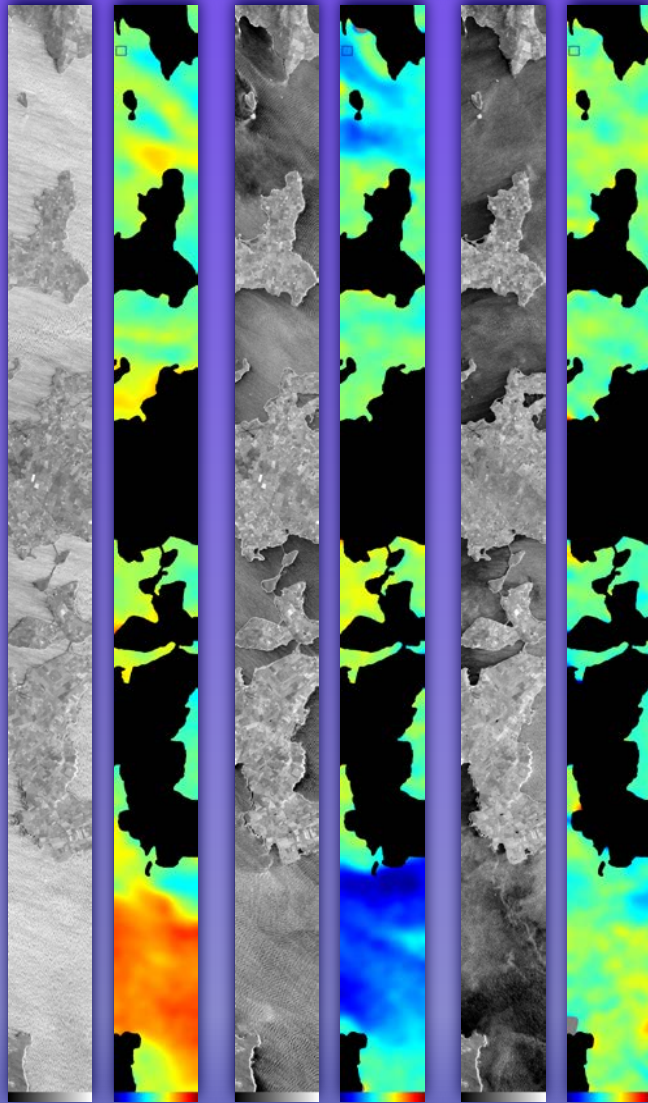
May 03, 2009



Current -2.5 m/s  +2.5 m/s
Ships -7.5 m/s  +7.5 m/s

- Test: High bandwidth, high PRF – original pixel size = 0.82 m × 1.17 m
- Eff. baseline ≈ 1.1 m (AS mode: typically 0.8 m)
- Better quality than AS mode, limited availability

Hydropower Test Site: Orkney Islands



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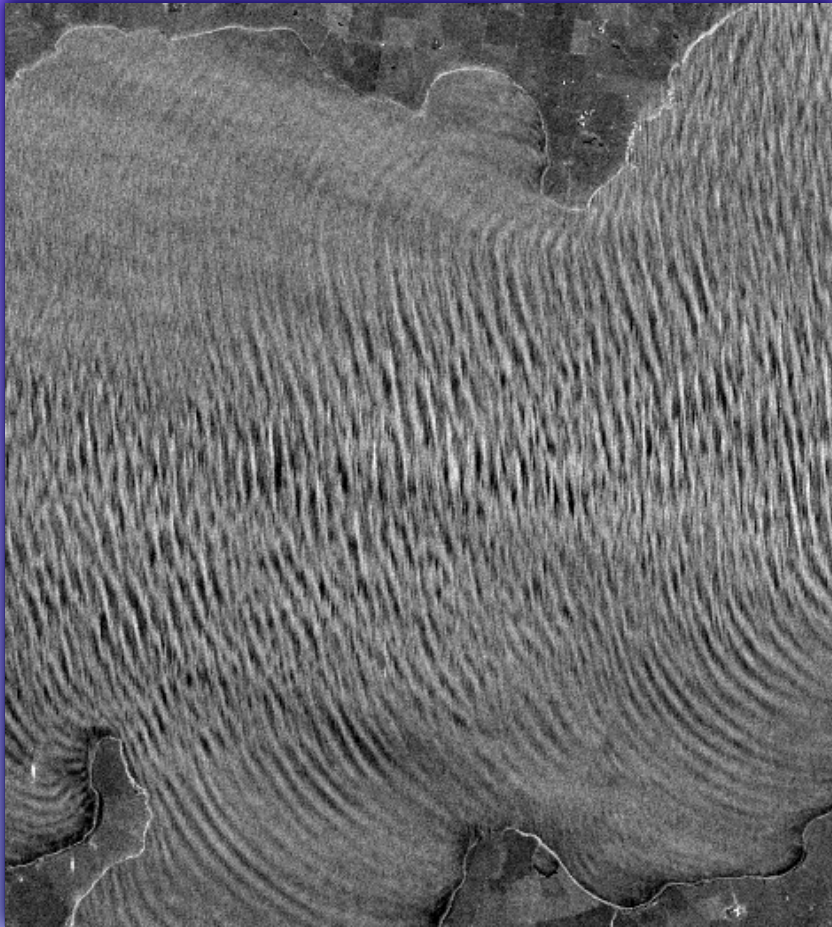
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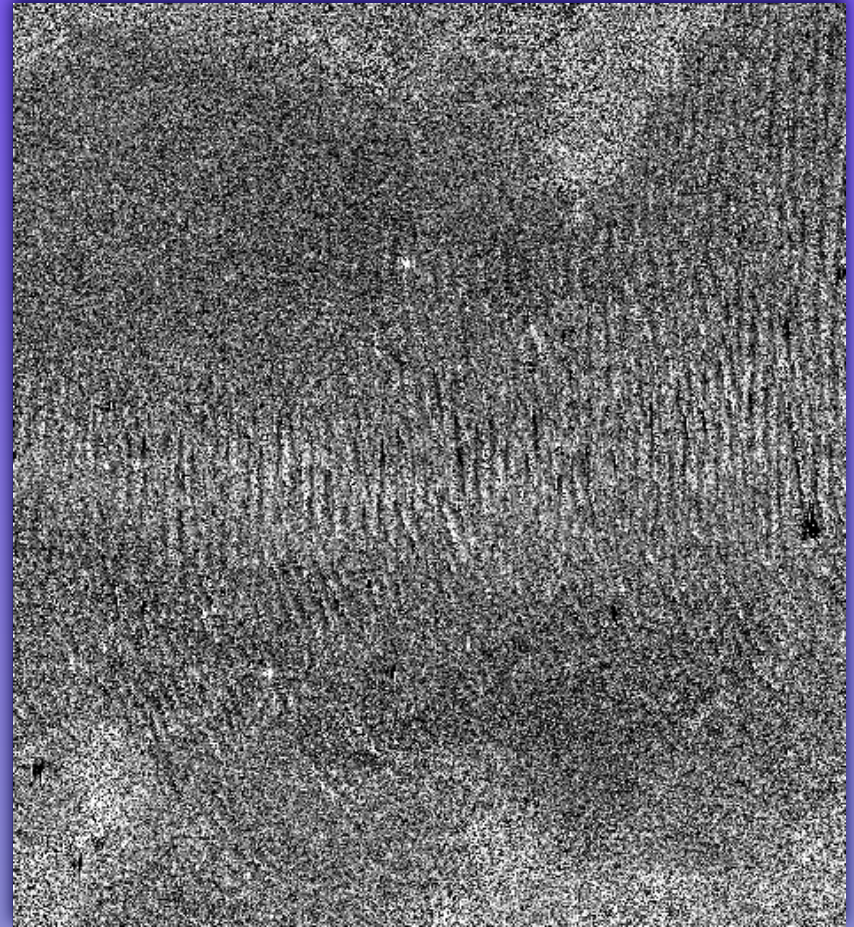
- Strong tidal currents, hydropower test area
- Acquired several long scenes in AS mode, high bandwidth
- Pixel size = $0.87 \text{ m} \times 2.13 \text{ m}$, coverage $\approx 4.6 \text{ km} \times 65.0 \text{ km}$
- Applied wave correction = $+1.04, -0.70, +0.66 \text{ m/s}$
- Mean residual current at coast = $+0.23, -0.04, -0.04 \text{ m/s}$
- Pretty good preliminary results; more detailed analysis to come

Orkney Detail

Averaged over about $10\text{ m} \times 10\text{ m}$ cells, $4.7\text{ km} \times 5.2\text{ km}$

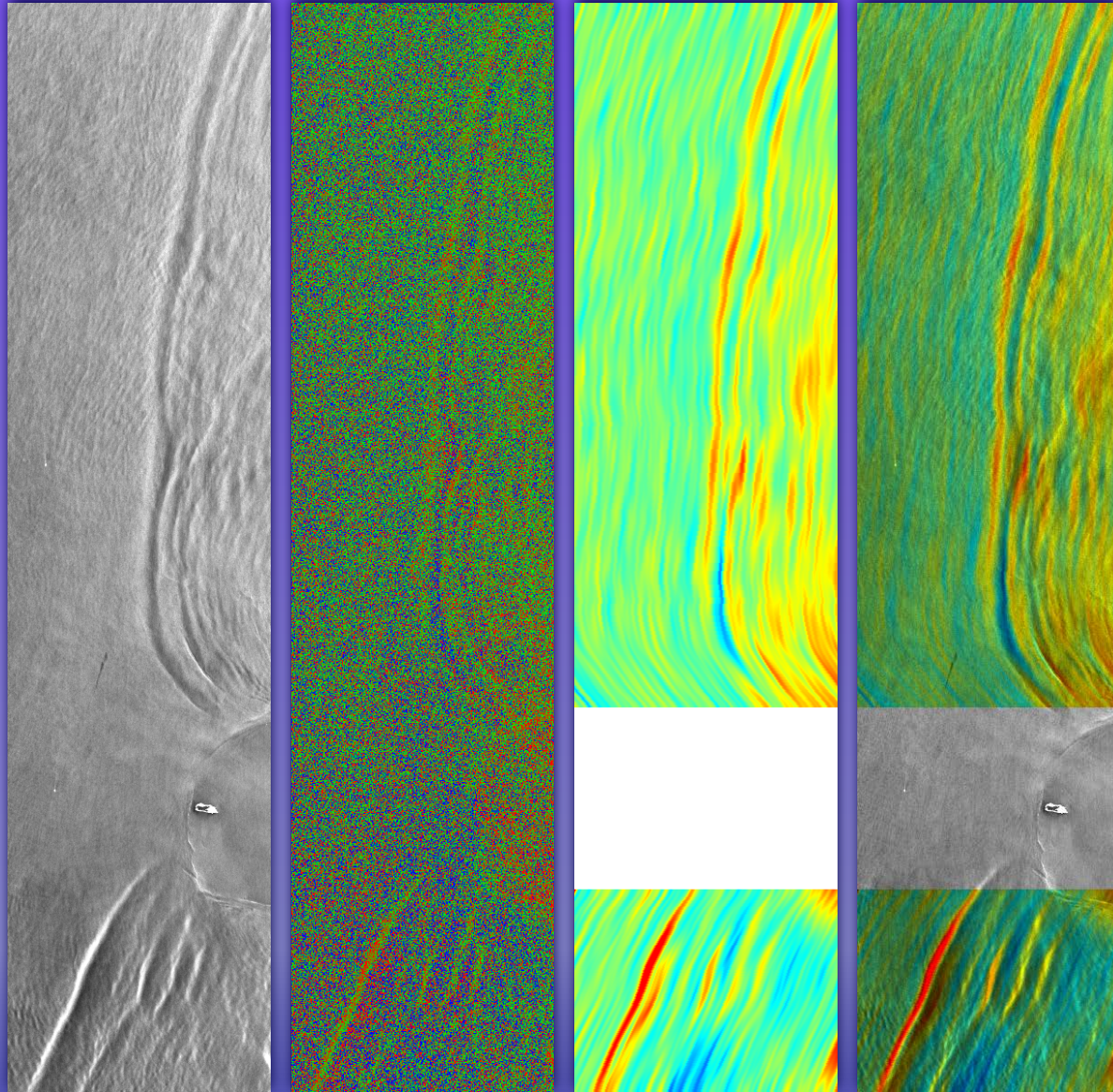


Intensity image



Phase image

Oceanography: Internal Waves at Dongsha

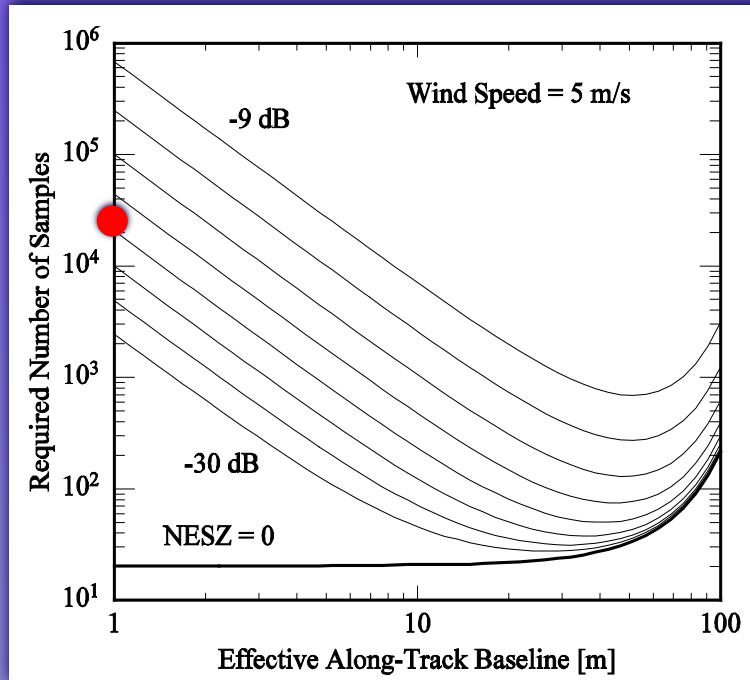


- DRA Mode campaign, April 22, 2010
- Scene coverage \approx 29 km \times 120 km
- Phase image filtered parallel to leading int. soliton signature
- Clear correlation of intensity & velocity
- Velocities consistent with expectations



Possible Performance Improvements

- Phase noise (and spatial resolution) can be reduced by averaging
- Short baseline: Poor phase sensitivity, instrument noise issues
- Long baseline: Poor coherence (decorrelation of signal)



- TerraSAR-X, 1515 pixels per 100 m × 100 m

Number of independent samples to be averaged for 0.1 m/s accuracy

→ Accuracy / resolution can be improved by factor 10 with more favorable instrument parameters

Summary

- Along-track interferometric SAR technique permits high-resolution surface current measurements from satellites
- Currently possible with TerraSAR-X, but suboptimal parameters
- Theoretical limits: 0.1 m/s accuracy at approx. 100 m resolution
- Promising applications
 - Current measurements in rivers
 - Coastal engineering (e.g. siting of hydropower turbines)
 - Oceanography (e.g. internal waves)

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