

# SUBMERGED DUNES AND BREAKWATER EMBAYMENTS MAPPED USING WAVE INVERSIONS OF SHORE-MOUNTED MARINE X-BAND RADAR DATA

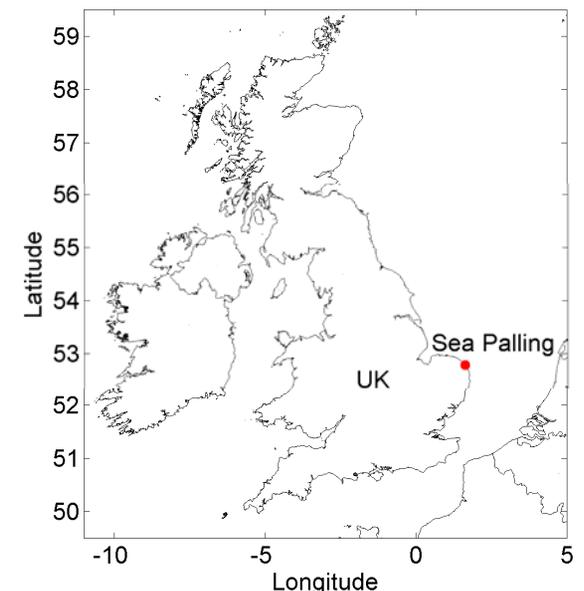


Paul S. Bell

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- **LEACOAST2 Project, Sea Palling**
- **About Radar & Wave inversions**
- **Outputs – Wave patterns, bathymetry, currents, feature inversion**

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# Flooding of Sea Palling, 1953 Storm Surge

**Sea Palling.**-The sea broke through a 100-yard gap in the dunes, washing away houses and causing the deaths of seven people, including three children. Some of the inhabitants in the bungalows were still refusing to leave their homes.



## NORFOLK GALE DISASTER

100 MISSING AND DEAD

Seas' Wild Rush into Towns and Villages

AT LEAST 100 PEOPLE ARE REPORTED MISSING OR DEAD IN FLOODS ALONG THE NORFOLK COAST, WHICH STARTED WITH DANGEROUS NIGHT GALES AND HIGH SEAS. MANY HAVE BEEN BURIED UNDER DEBRIS AND THE WINDY FLOODS WIPED OFF BUNGALOWS IN THIS PART OF THE COUNTRY. 85 LADIES KNOWN TO WOMEN HAS BEEN REGISTERED ALONG THE COAST BETWEEN KING'S LYNN AND NORWICH.



The worst flood victims are:-  
**BUNTONS.**—It was reported definitely this morning that 40 people, including most Americans, might have been drowned. Twelve before have been mentioned, including three of those mentioned and a child. Most of the bungalows between Hunstanton and Sea Palling, principally owned by American tourists, were swept away. They were washed to the sea's edge and the bodies were cut off. It was also stated definitely today that 20 might have been killed at Sea Palling.  
**KING'S LYNN.**—Floods before have been reported between 1948 and 1951, people have been drowned from South Lynn leaving boats, when the boats are starting in second half of night. Part of the sea wall completely missing has been reported.  
**SEA PALLING.**—The sea broke through a 100 yard gap in the dunes, washing away houses and causing the deaths of seven people, including three children. Some of the inhabitants in the bungalows were still refusing to leave their homes.  
**SEA PALLING.**—The sea broke in late last night, which was washing on houses. There is extensive damage to the sea wall and the Hunstanton and Colchester dunes. The police states that seven houses are missing.  
**BUNTONS.**—Five people, including three women and a child, are missing, and the body of a woman has been recovered. Some bungalows have been washed from the roof of a house by the sea and a house completely was destroyed.

Flying Over the Battered Coast:  
Spray at 1000 Feet



THE FRANKS  
SIRIUS  
COLLECTION

Sea Palling, the Sea Wall c1955 Ref: S470045

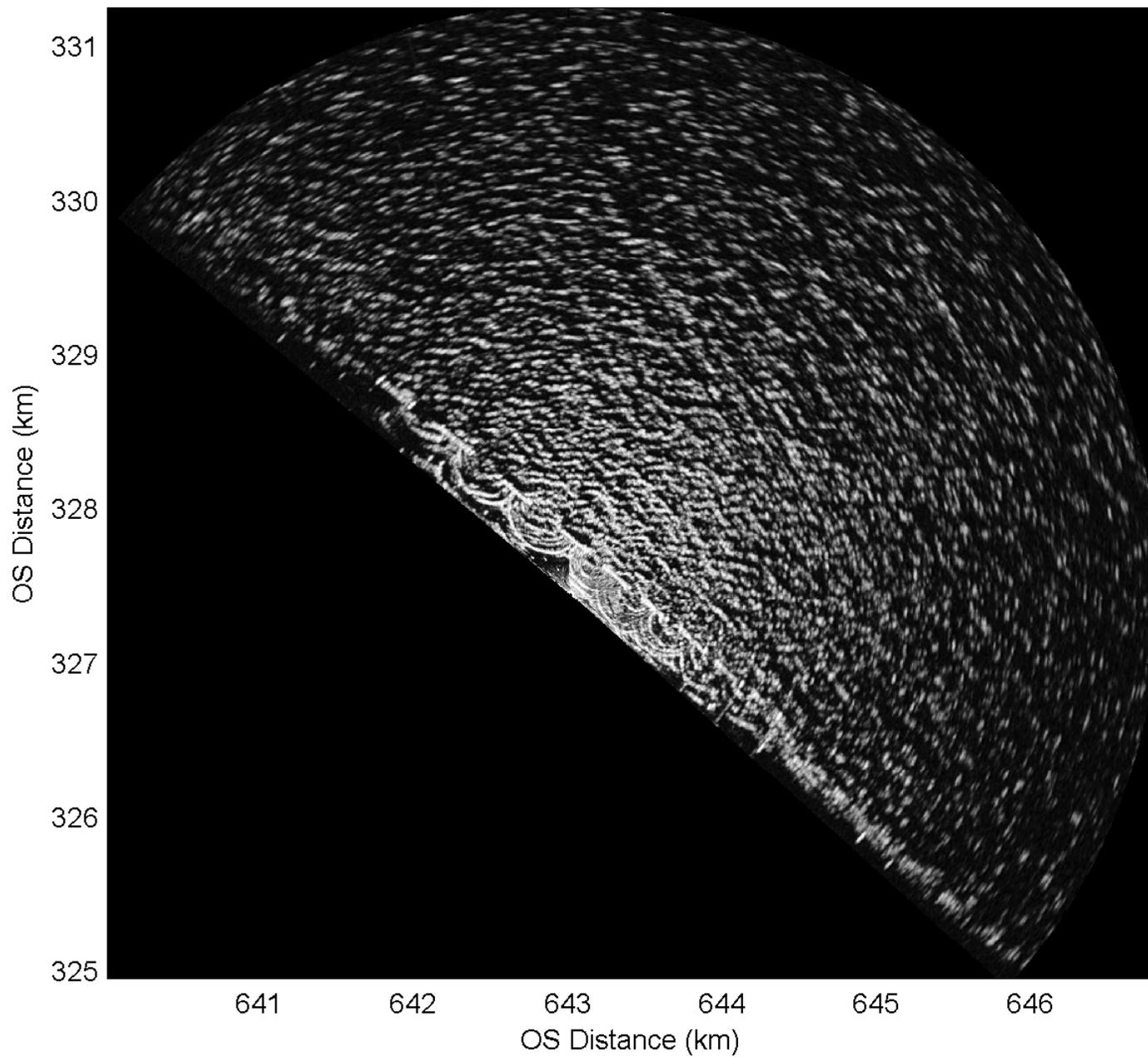
# Sea Palling, East Anglia, UK



## **X-Band Radar**

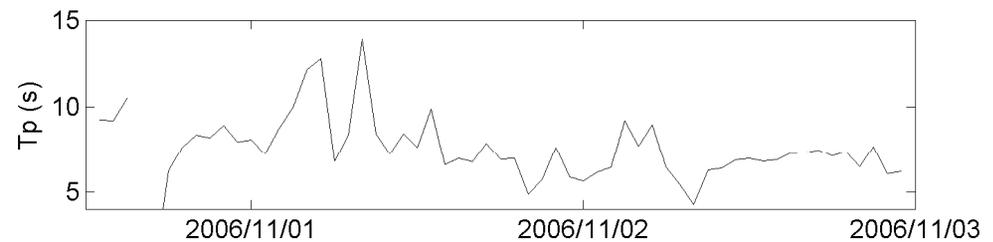
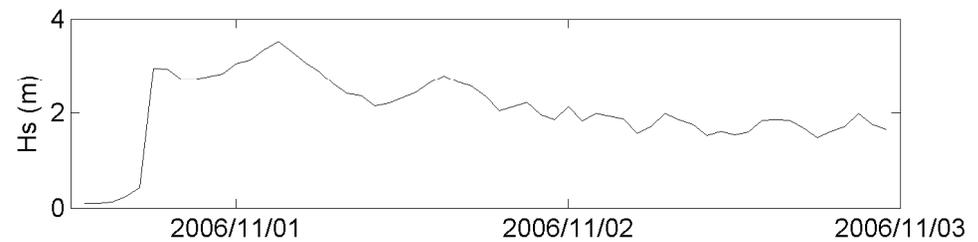
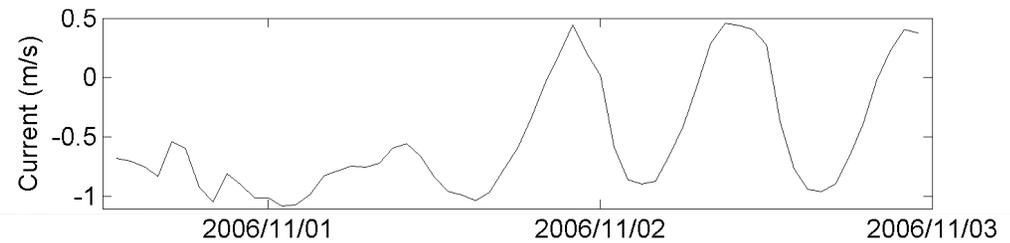
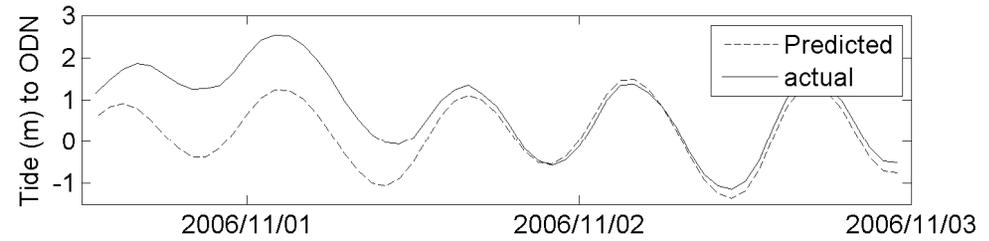
- 9.8GHz (3cm) standard marine radar
- 2.4m Antenna rotating once every 2.8 seconds
- Short pulses (60ns)
- Record 256 images at 20MHz (~12minutes)
- Digitise using PC based system (in house design)
- Wave inversion using approximation to non-linear wave theory (Hedges, 1976), modified to include currents.

Radar Snapshot, Sea Palling, 01-Nov-2006 10:00:19

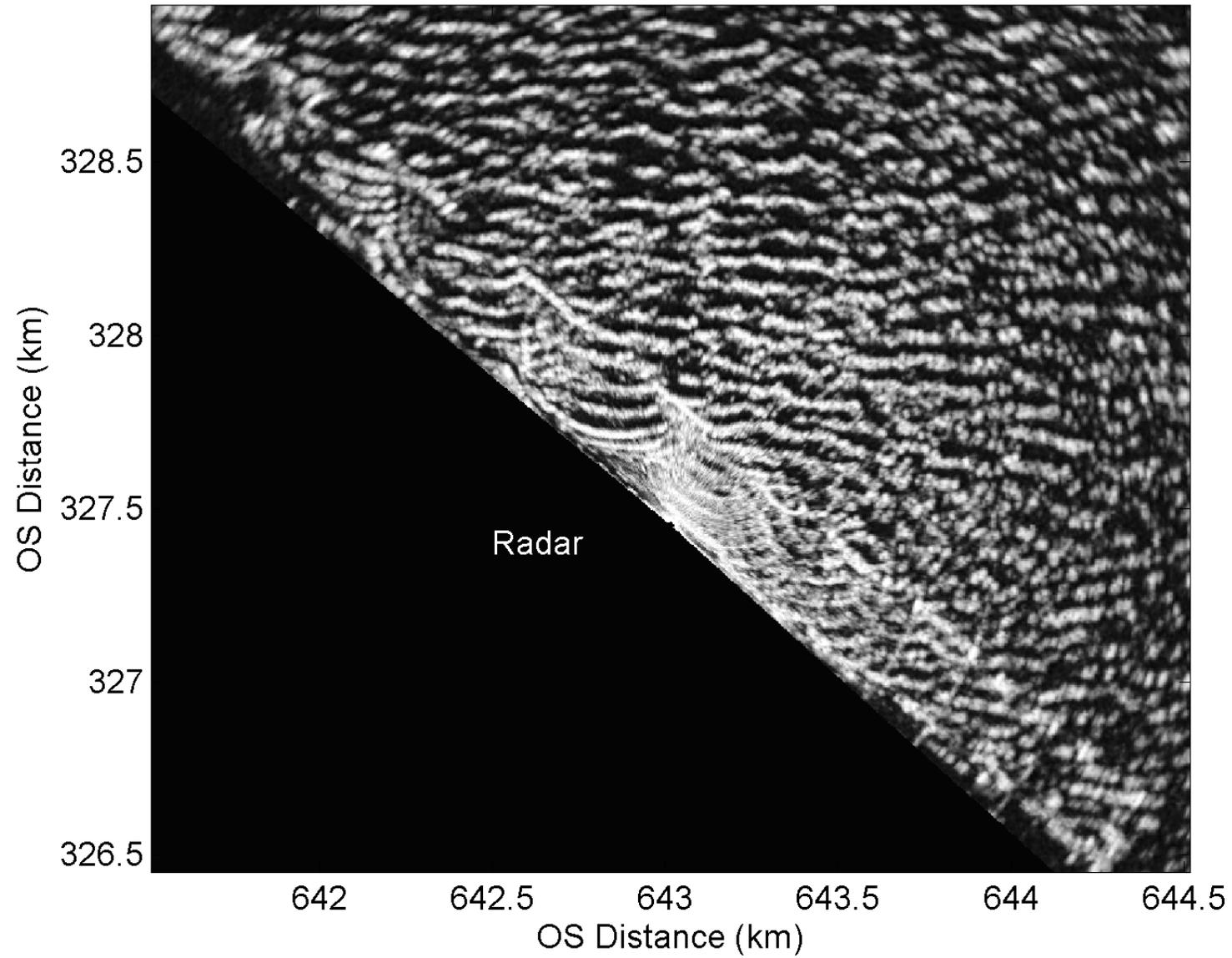


# Storm & Surge October 31<sup>st</sup> 2006

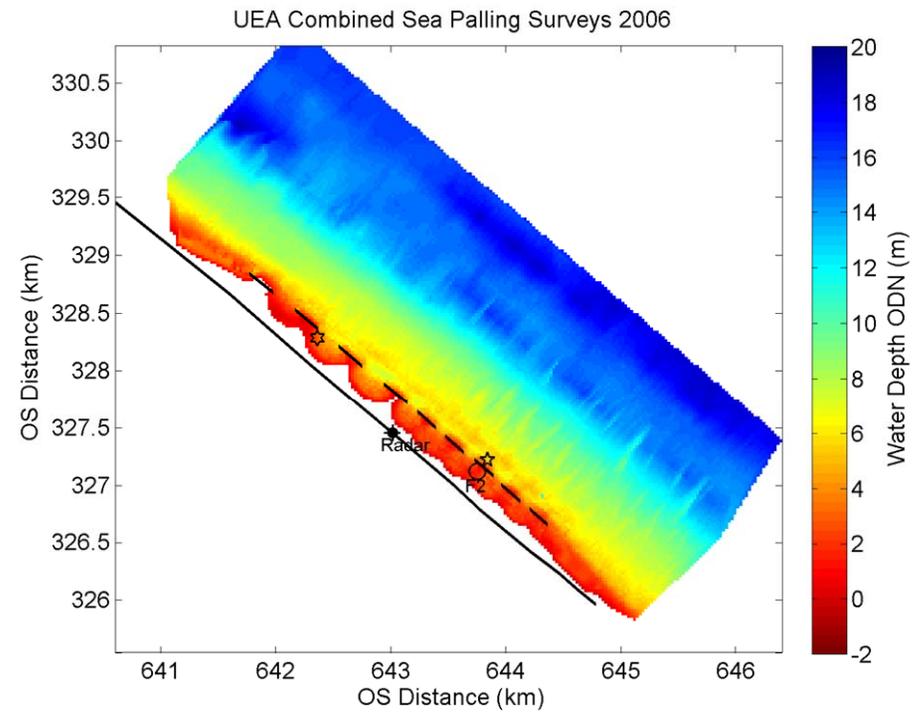
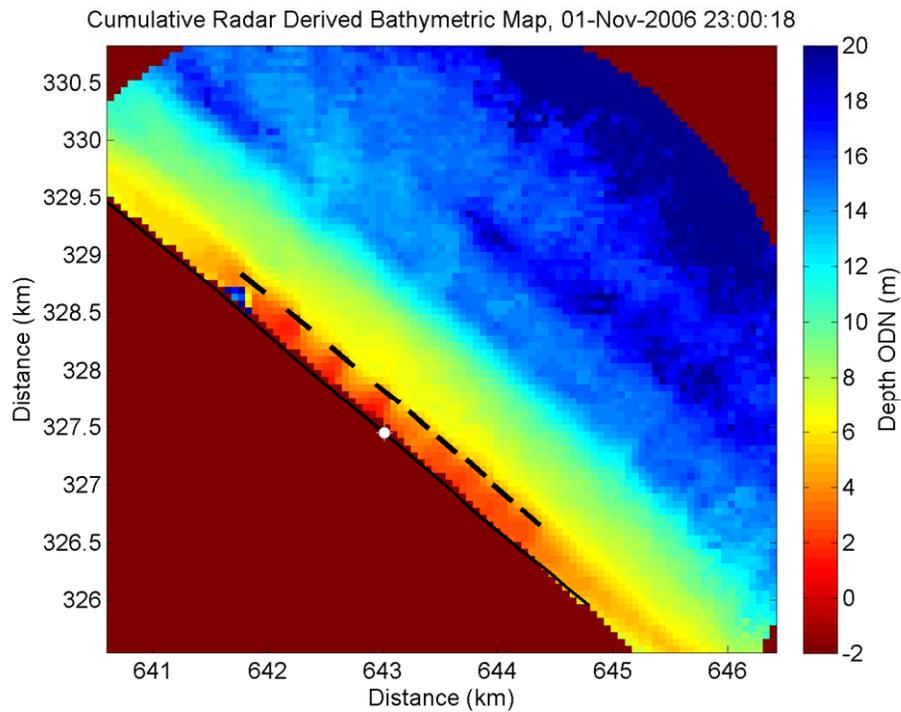
## ADCP Data



# Radar Snapshot

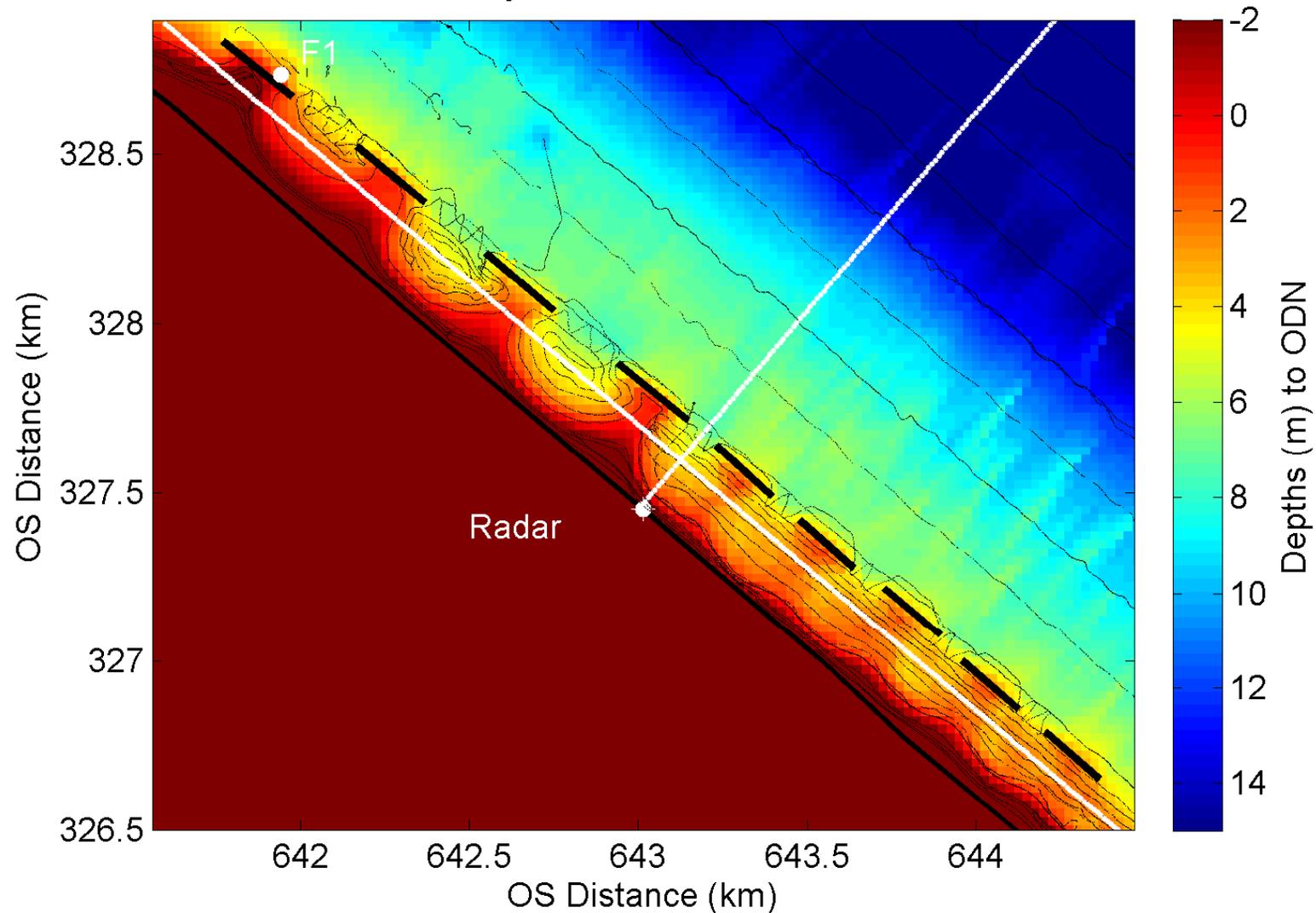


# Wide Area Bathymetry inversion & UEA Survey

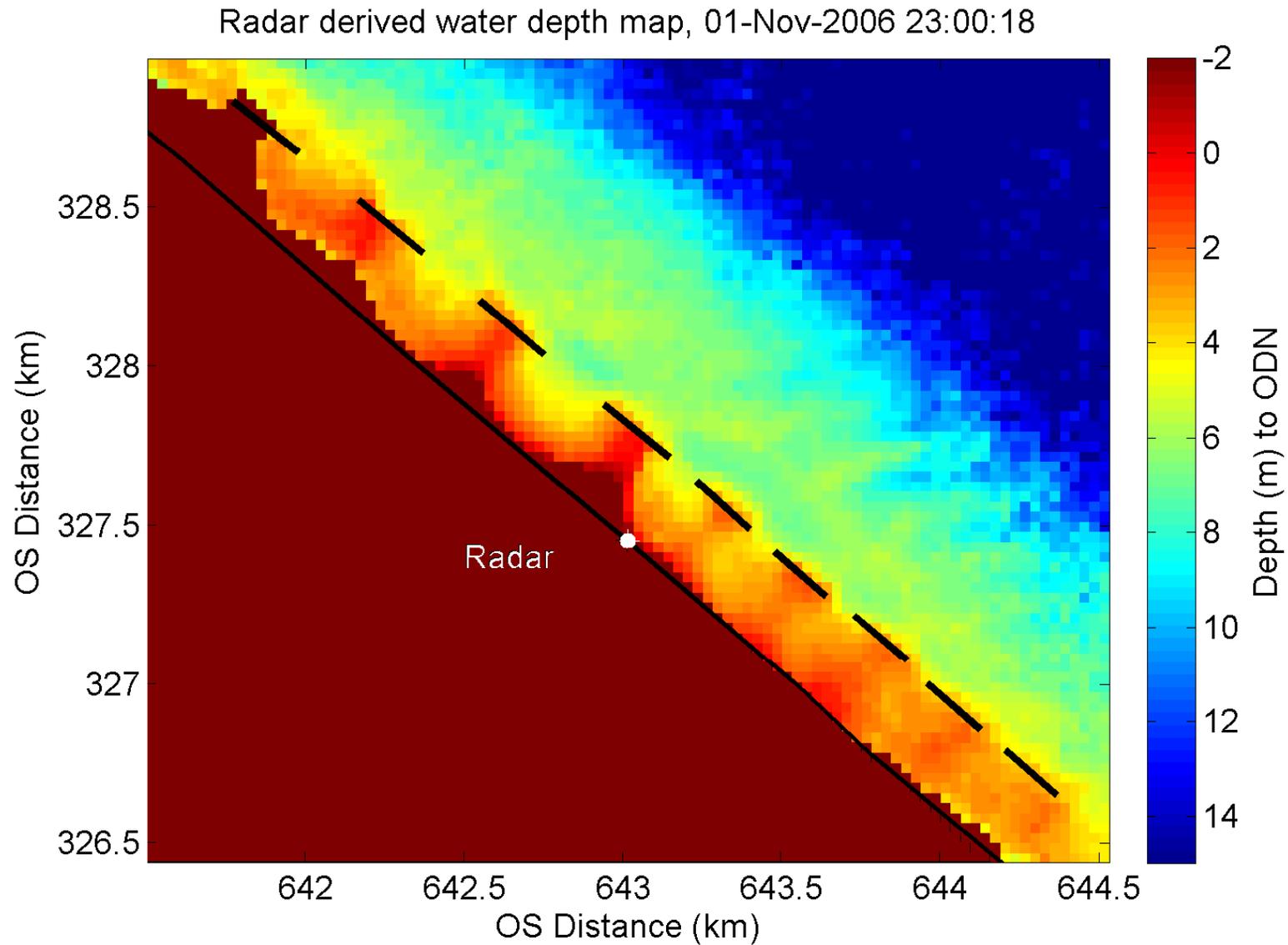


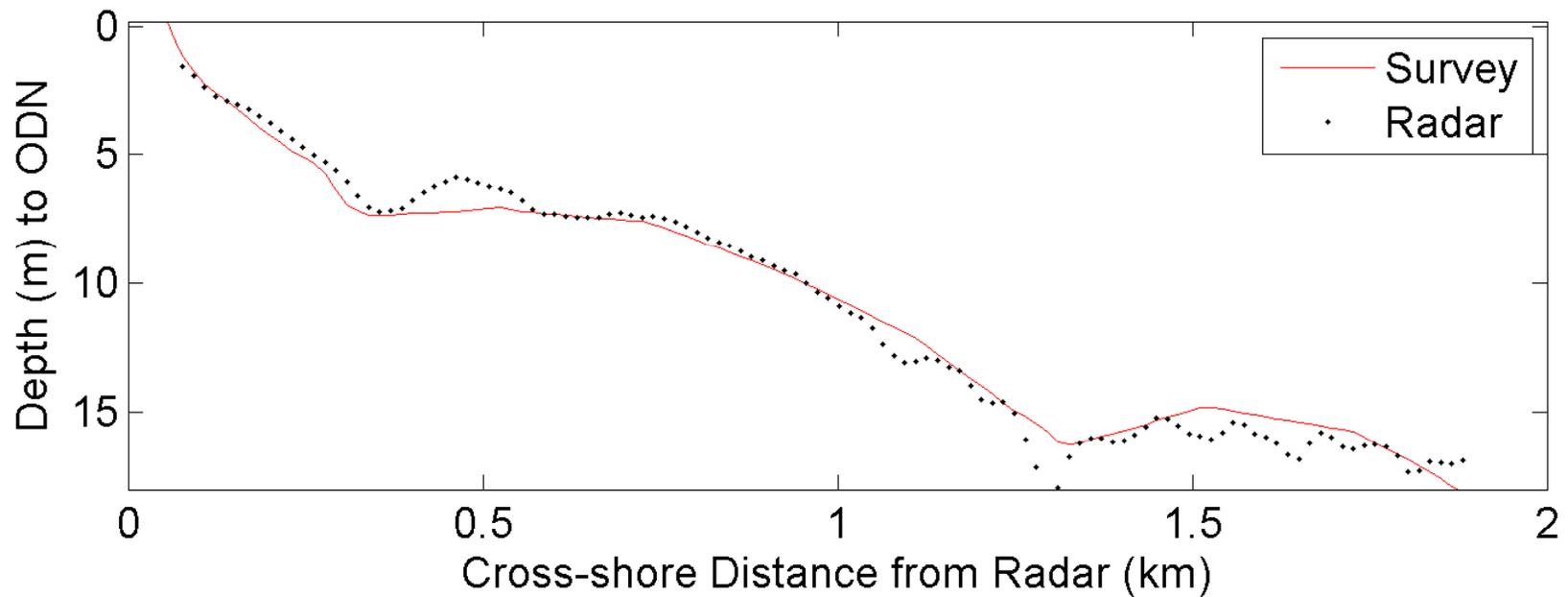
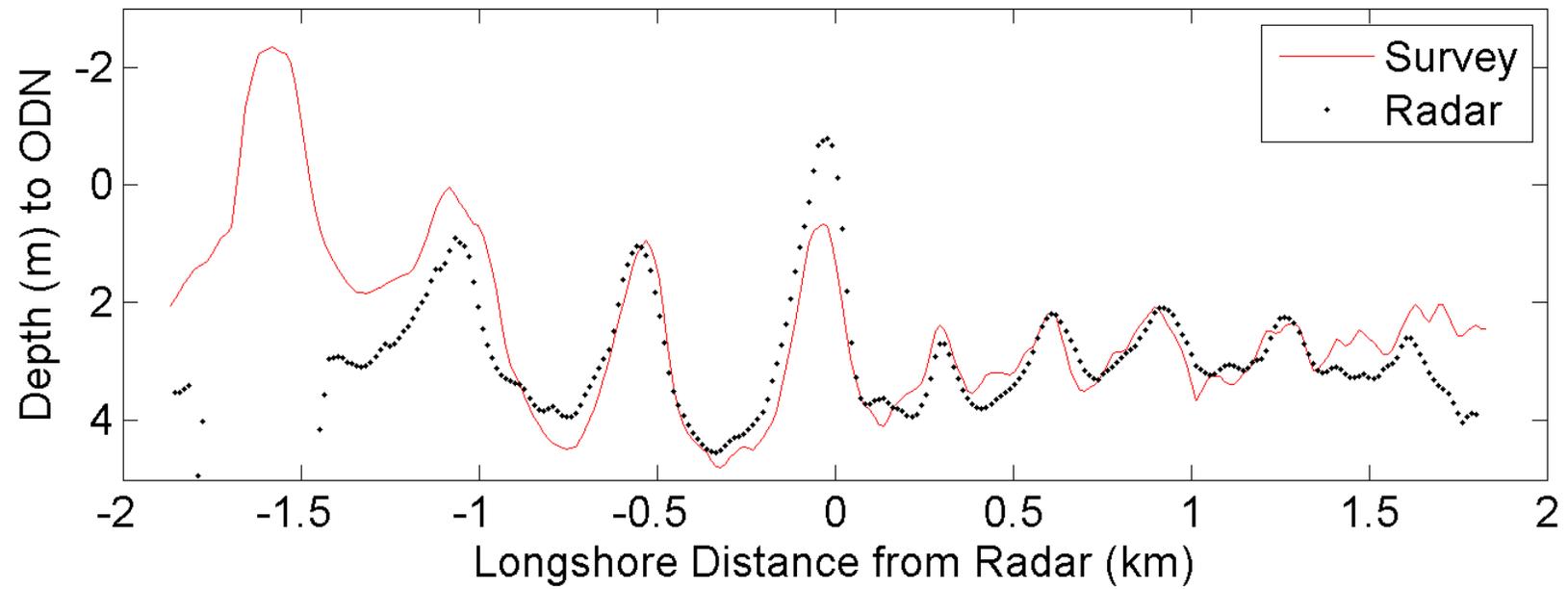
# Conventional survey (Gridded), Carried out by University of East Anglia, UK

Survey data : November 2006

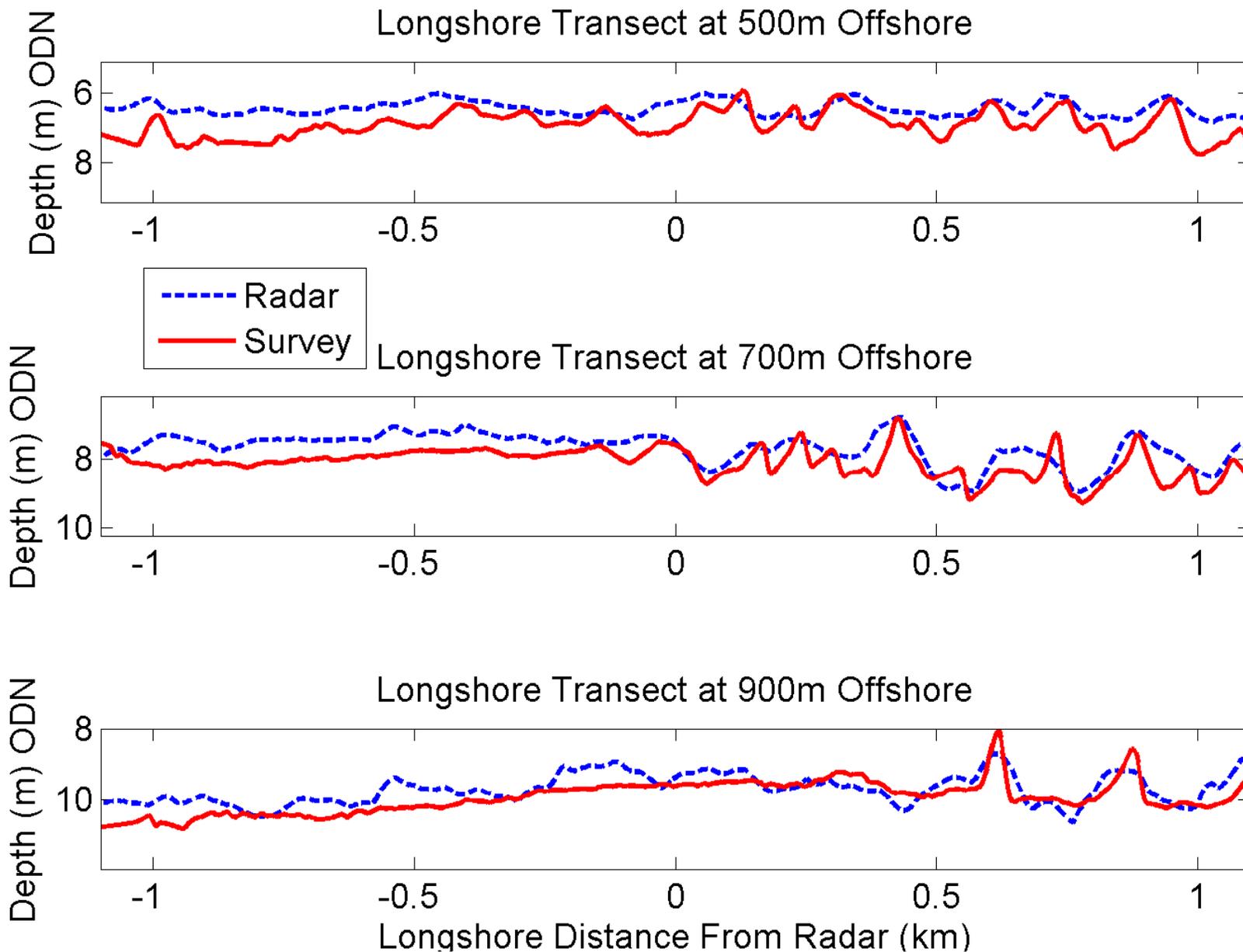


# Radar Derived Bathymetry

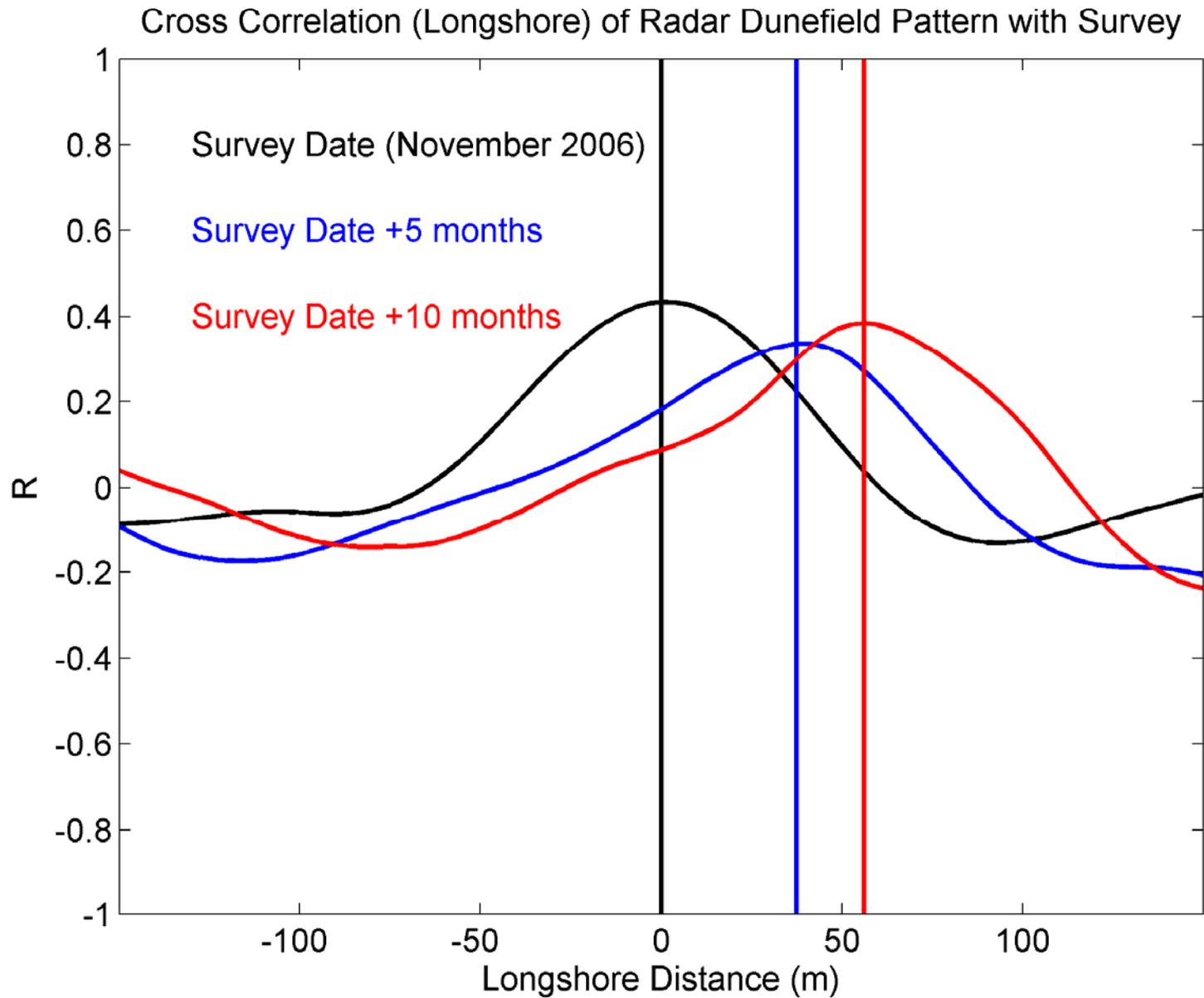




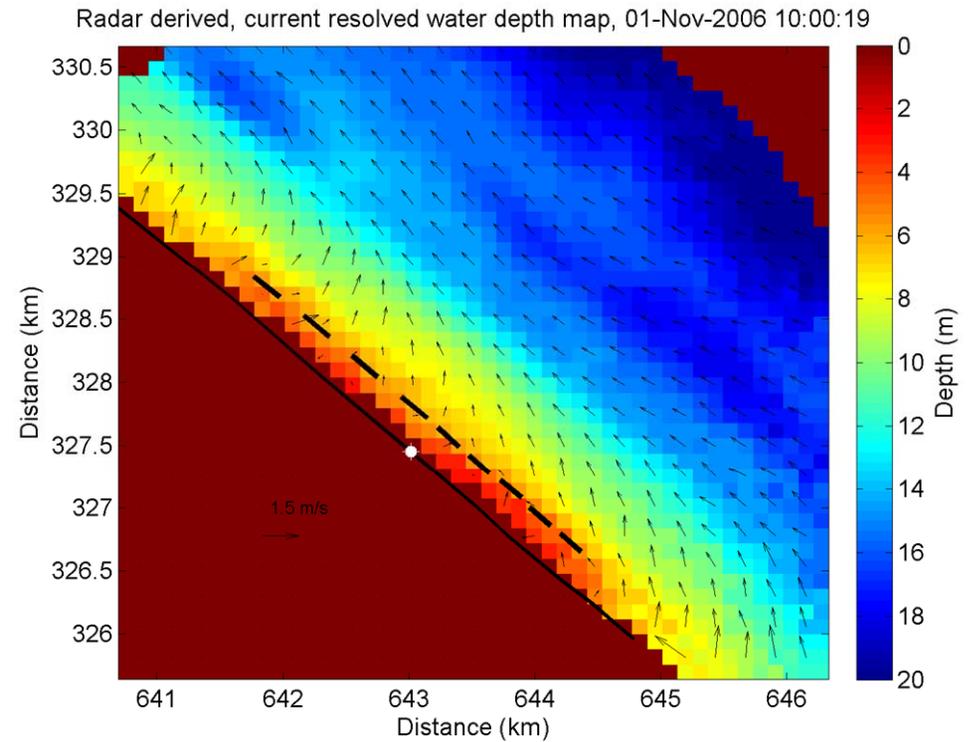
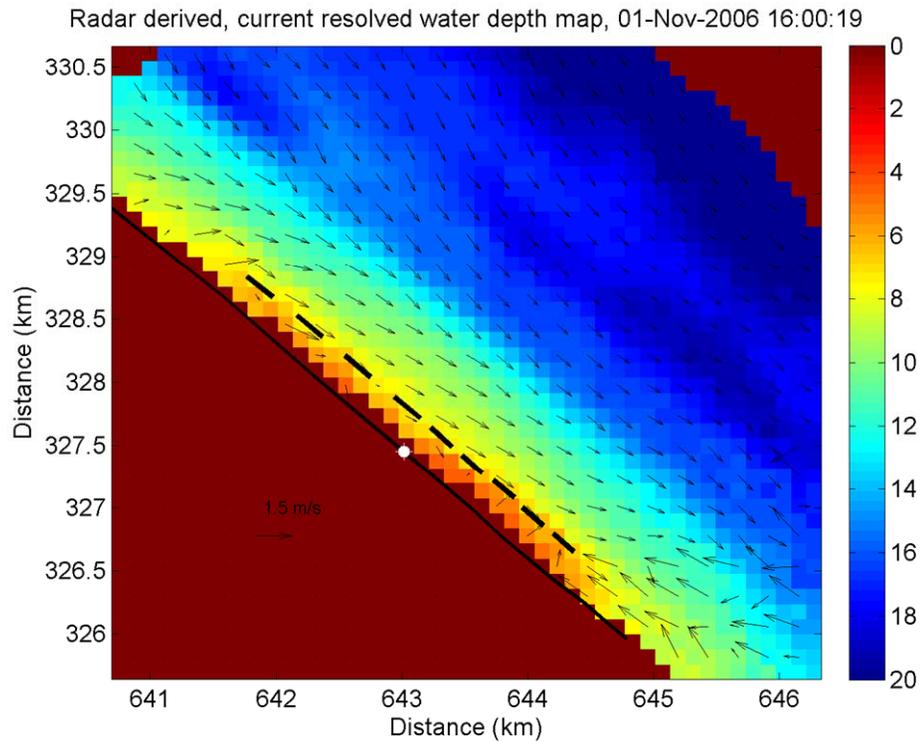
# Longshore Transects through Dunefield



# Tracking of dune migration



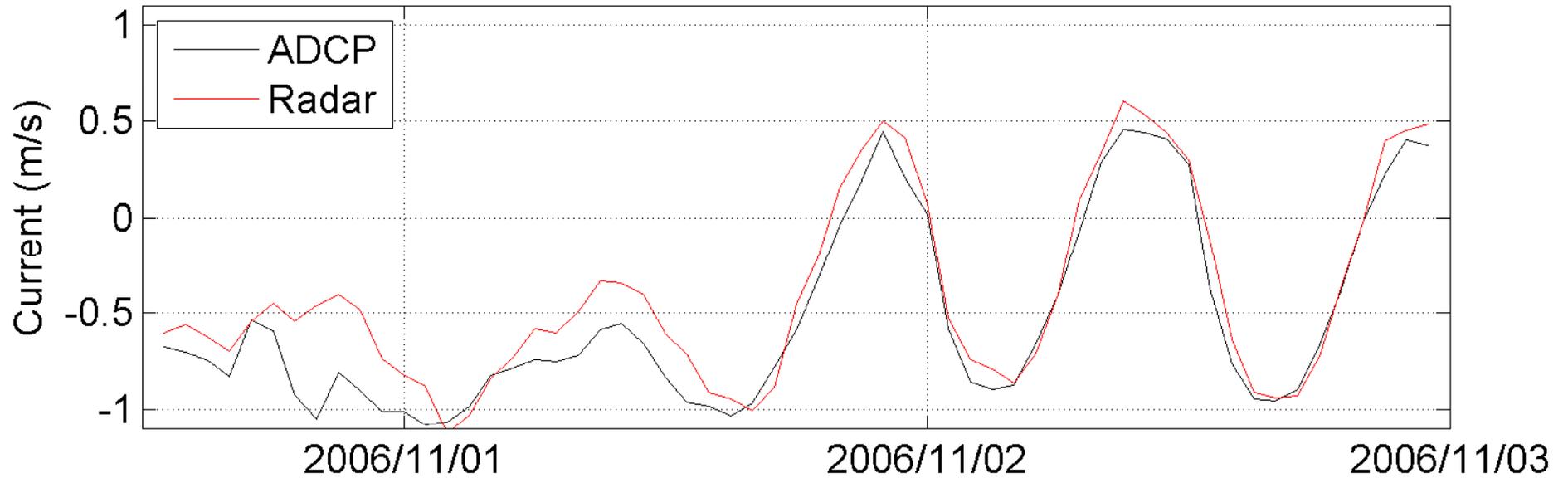
# Bathymetry & Currents



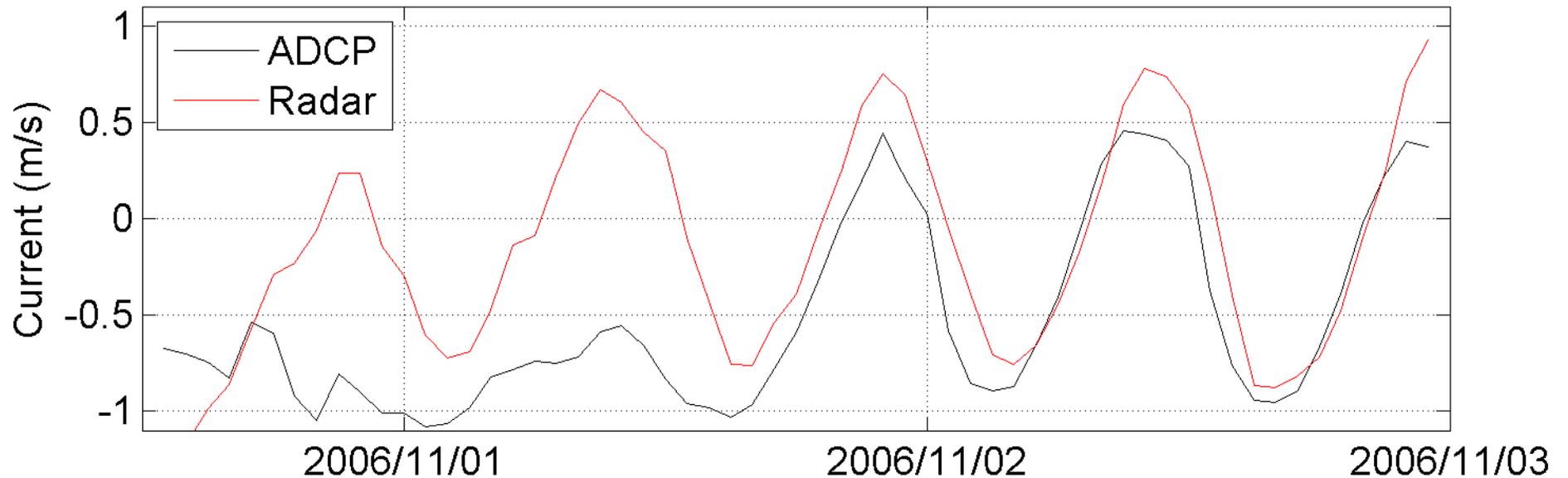
**Flood**

**Ebb**

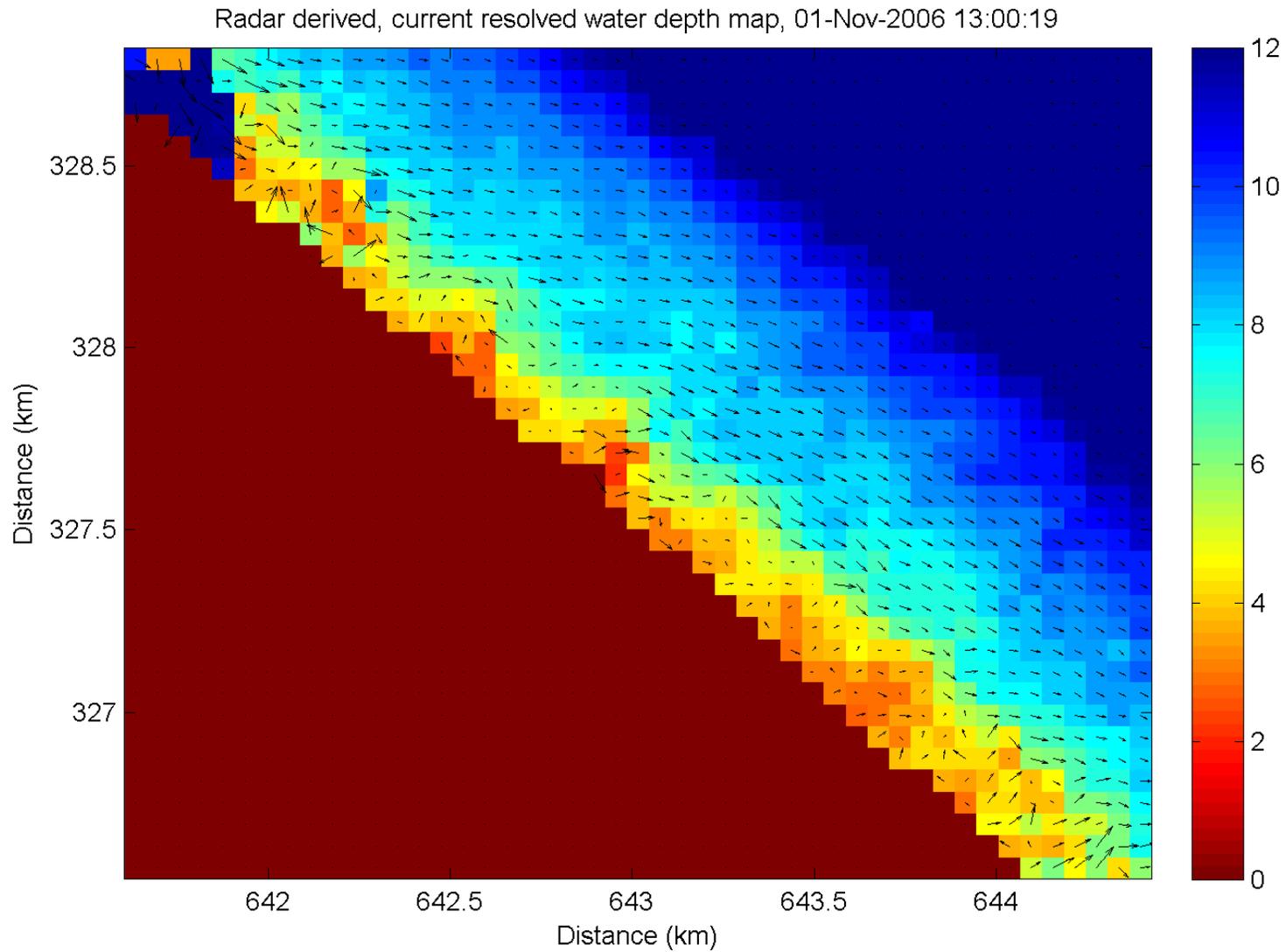
Comparison of radar derived current & ADCP at inshore ADCP location



Comparison of radar derived current @ 1km offshore & inshore ADCP



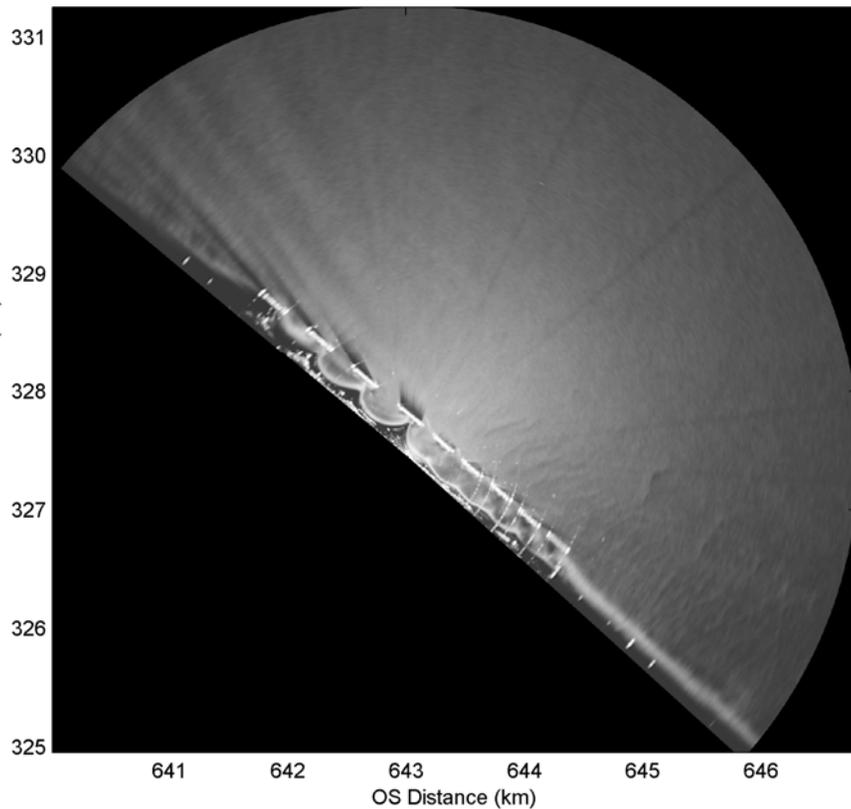
# Slack water offshore, flood inshore



# A Work in Progress – Surface Feature Inversion

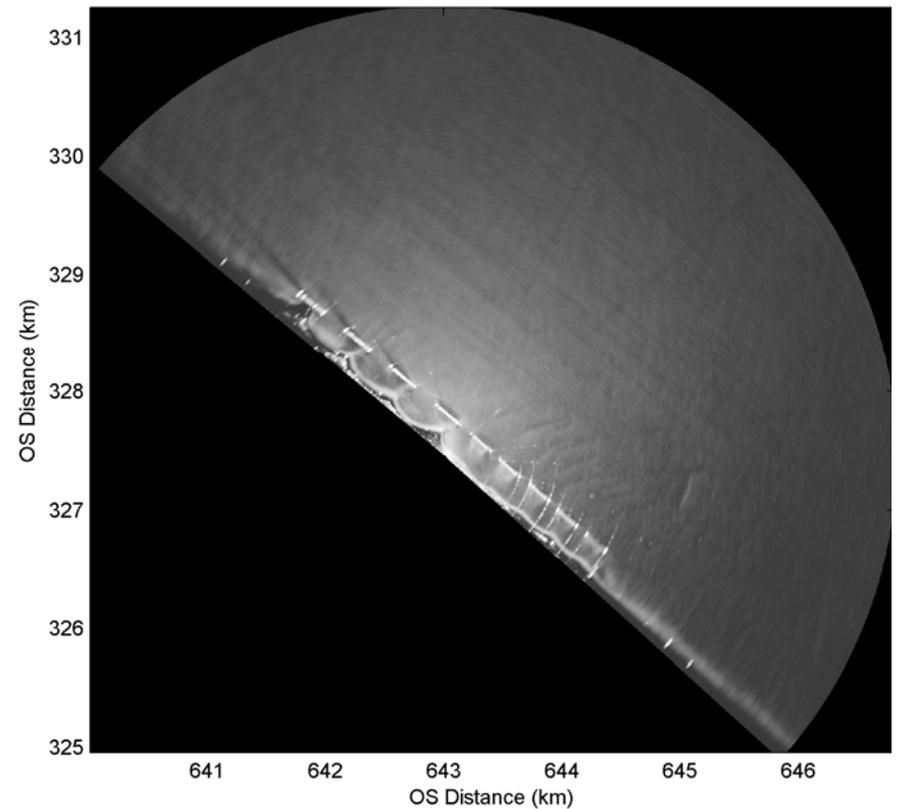
## Subtidal dune features visible in radar timelapse images of surface roughness

Radar Timelapse, Sea Palling, 01-Nov-2006 22:00:19



Ebb

Radar Timelapse, Sea Palling, 02-Nov-2006 04:00:21



Flood

## A Theory of the Imaging Mechanism of Underwater Bottom Topography by Real and Synthetic Aperture Radar

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Hamburg, Federal Republic of Germany*

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*Institut für Meereskunde, Universität Hamburg, Federal Republic of Germany*

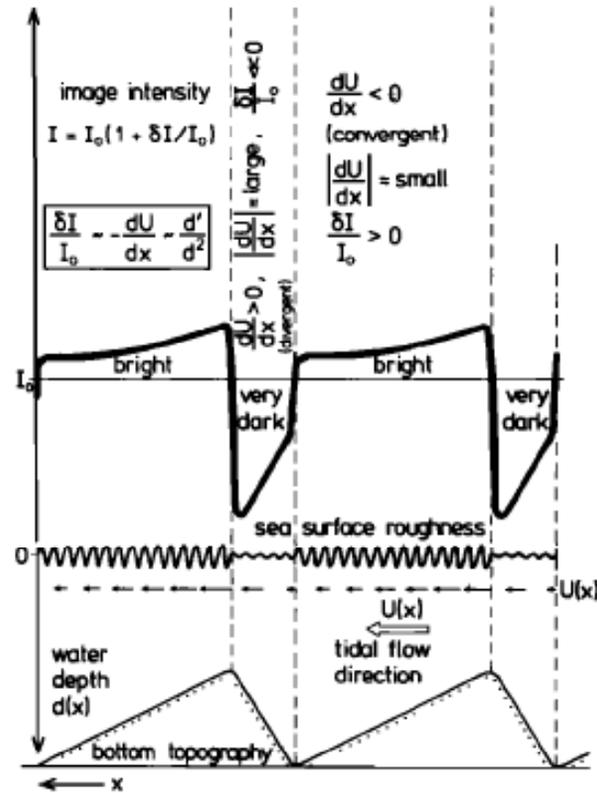


Fig. 4a. Schematic plot of the relationship between an asymmetric sand wave profile and associated variations in tidal current velocity, short-scale surface roughness, and radar image intensity. The steep slopes of the sand waves face the flow direction and are associated with strongly reduced image intensity (dark streaks).

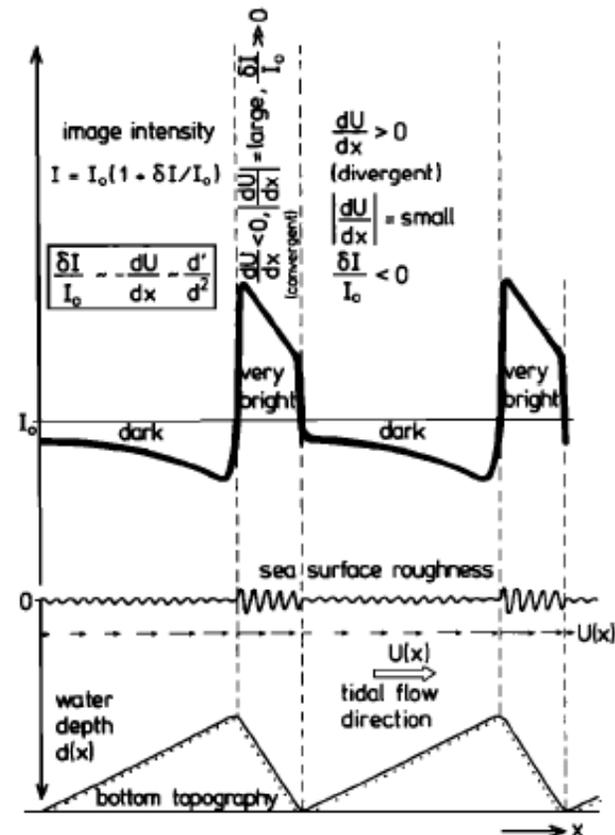
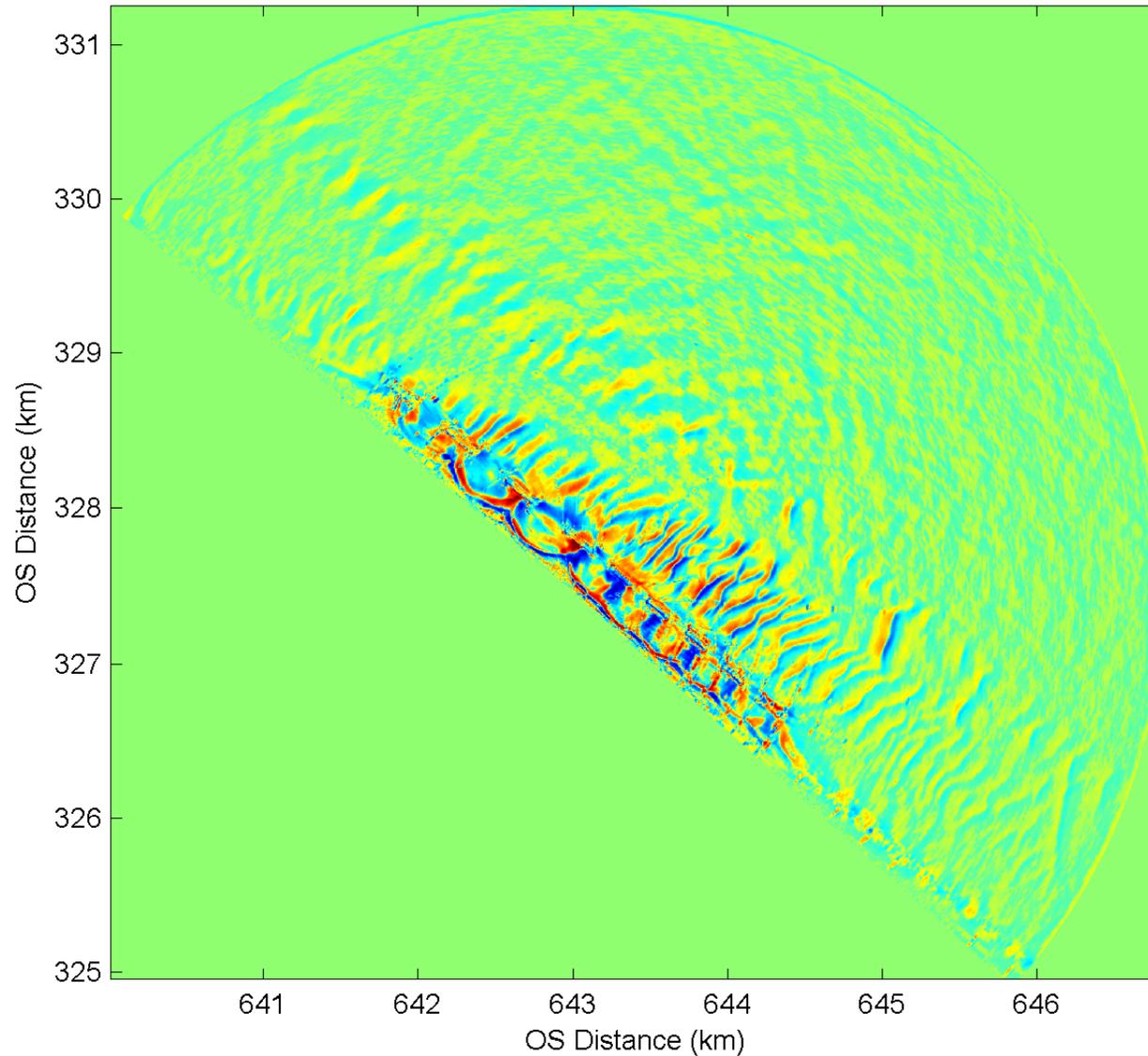


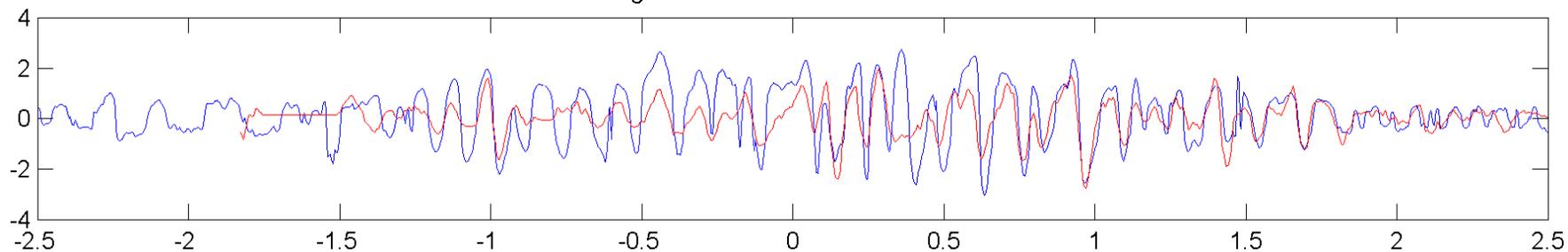
Fig. 4b. Same as Figure 4a but with flow direction reversed. Now the steep slopes lie on the downstream side and are associated with strongly increased image intensity (bright streaks). The result is a reversal of the image intensity modulation pattern, which makes the images of Figures 3a and 3b look like negatives of each other.

# Colour is related to slope of sea bed

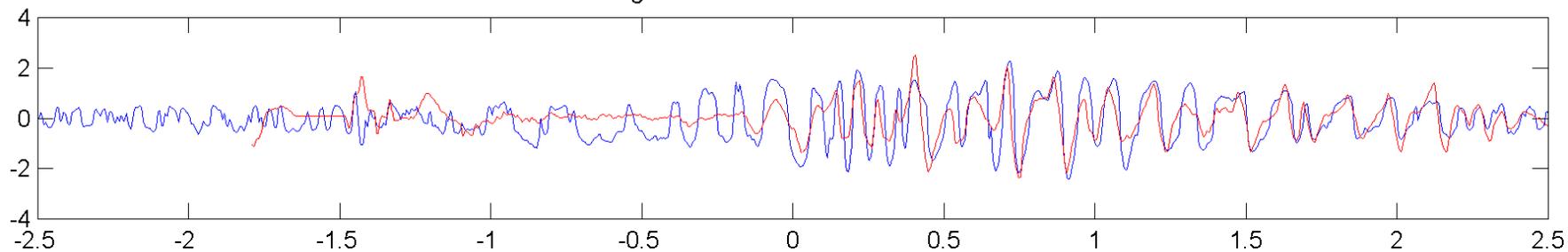
Inferred subtidal dune field based on current-modulated sea surface radar signatures, Spring-Neap Cycle ending 20061104



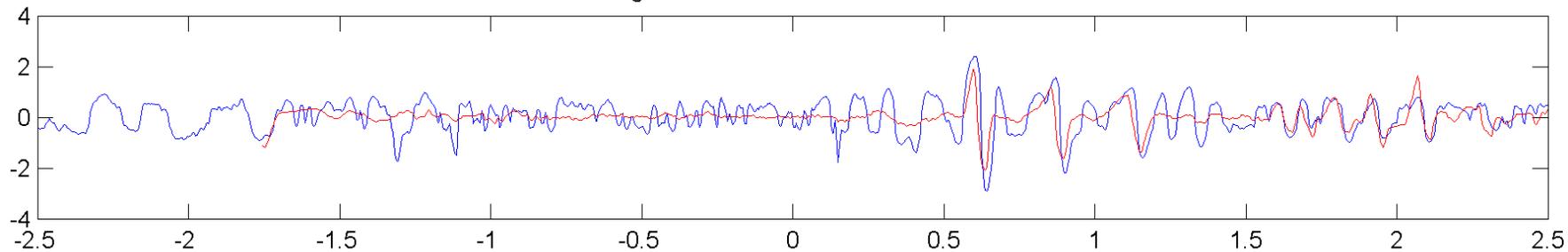
Longshore Transect at 500m Offshore



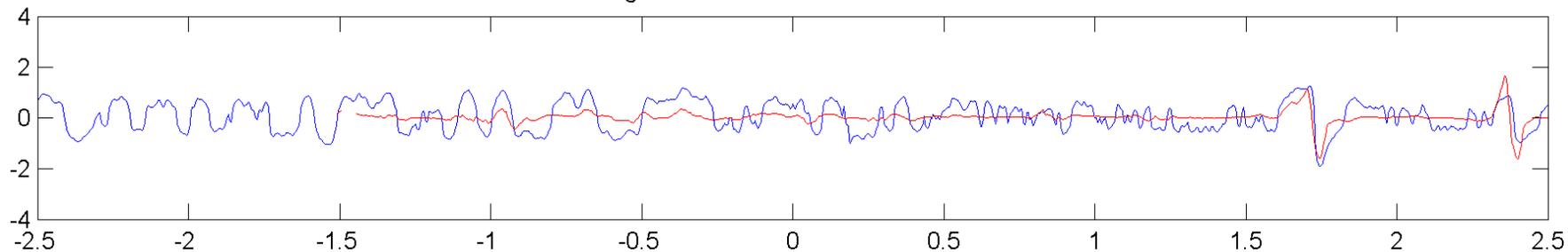
Longshore Transect at 700m Offshore



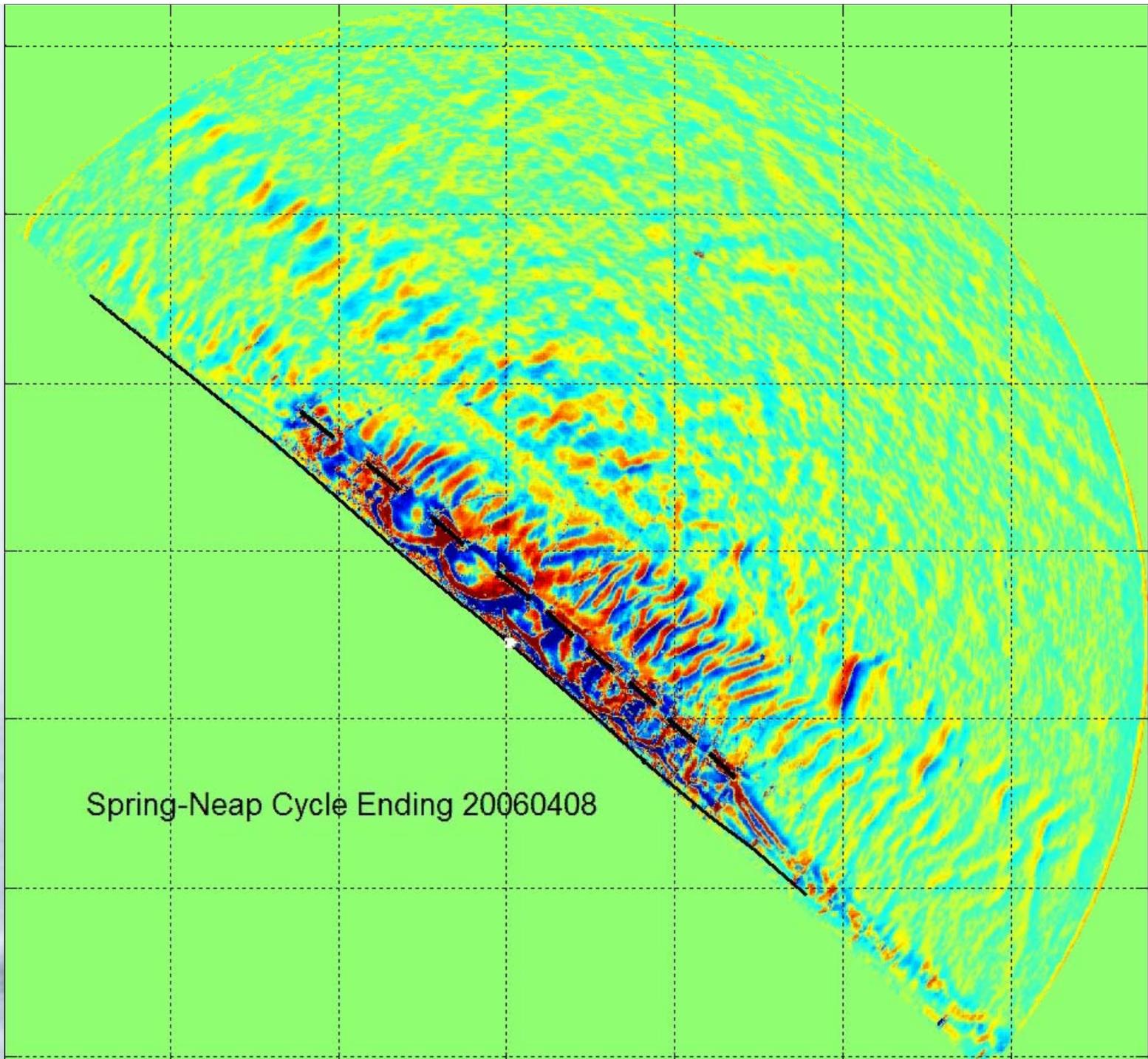
Longshore Transect at 900m Offshore



Longshore Transect at 1100m Offshore



Longshore Distance From Radar (km)



Spring-Neap Cycle Ending 20060408

# Summary

- Wave inversion used to derived bathymetry & currents
- Generally use up to 4km range, can do 8km under optimal conditions (storm)
- Bathymetry generally within 1m of survey
- Currents being validated where possible
- Subtidal dune migration tracked using two independent radar derived products –  
Bathymetry & Surface Feature Inversions

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