

Wind, waves and currents from space: past, present, future

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National Oceanography Centre (NOC)

&

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Satellite Oceanographic Consultants Ltd (SatOC)



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NERC SCIENCE OF THE
ENVIRONMENT

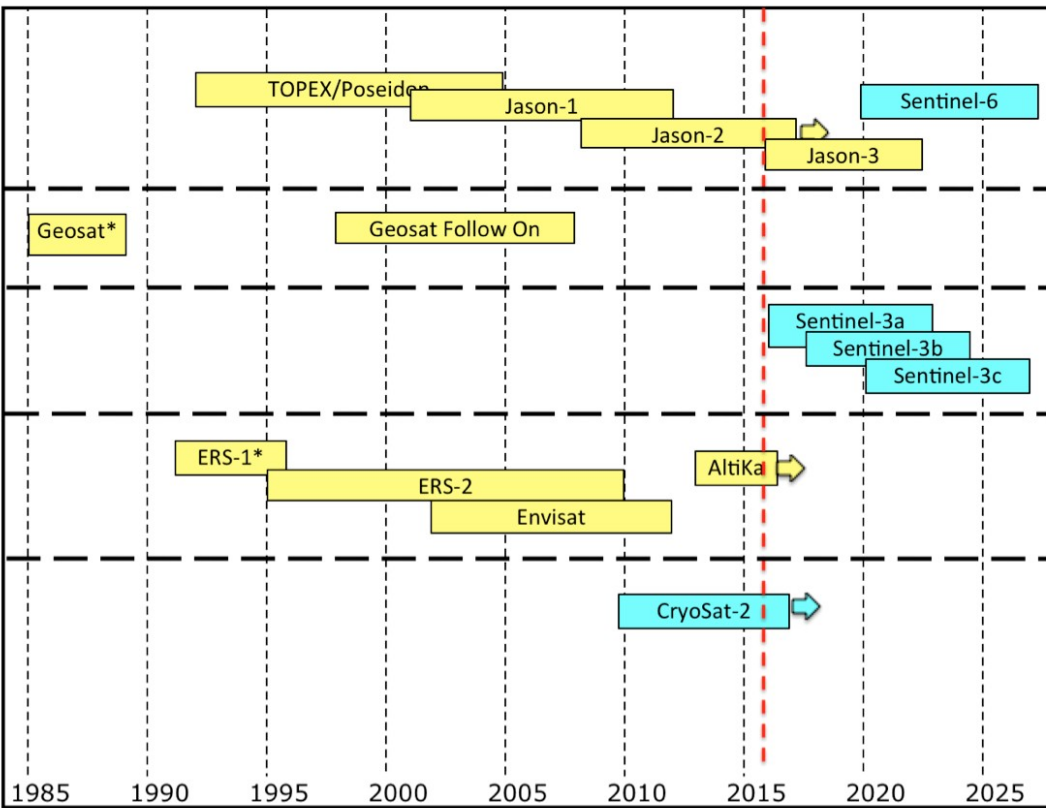
Content

- Wind, waves and currents from space
- Satellite altimetry
 - Climatologies, storm surges, coastal wave field
- High-resolution imaging of current vectors
 - Squinted Synthetic Aperture Radar Interferometry
 - Demonstration & validation in Liverpool Bay
- Update on GNSS-Reflectometry for winds
- Summary & take-home message

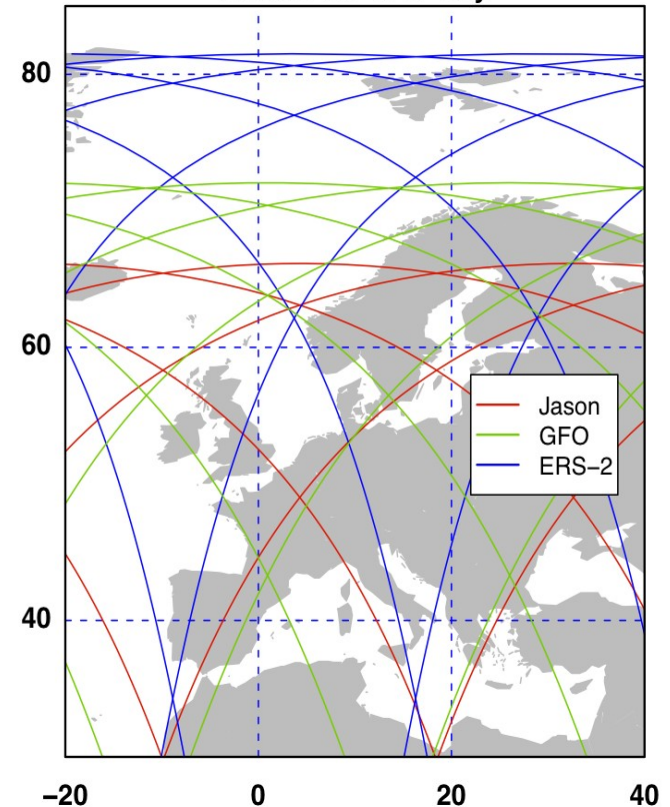


Satellite Altimetry

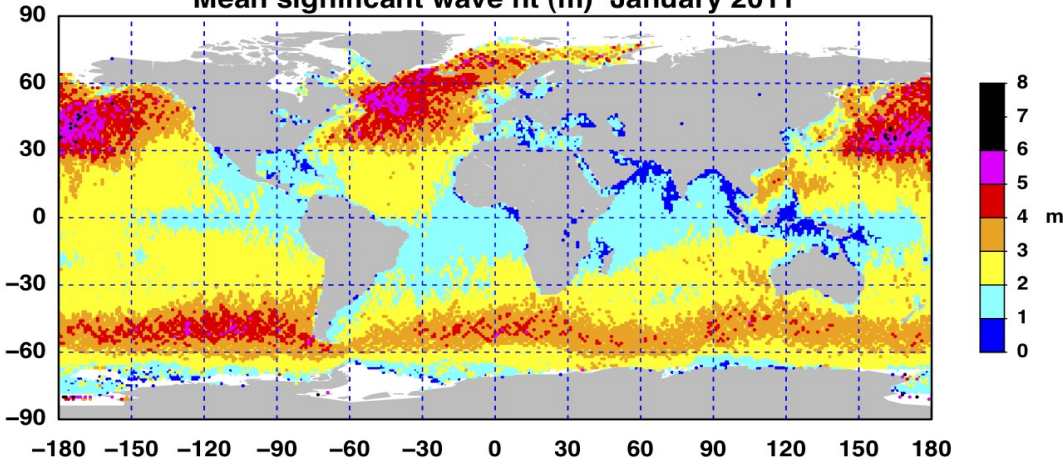
- 20+ years of global data
- Sea surface height, significant wave height, wind speed
 - Geostrophic currents, wave period, wind stress, rain rate,...



Tracks on one day

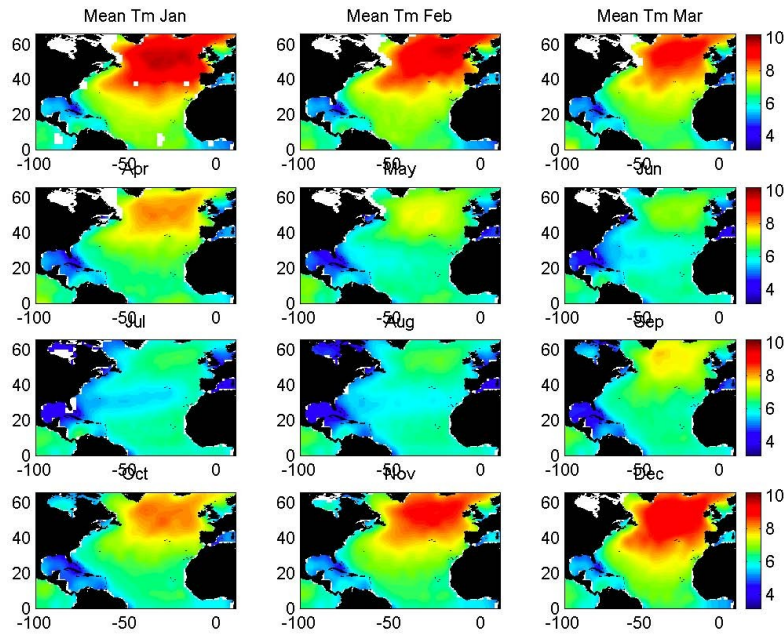


Mean significant wave ht (m) January 2011

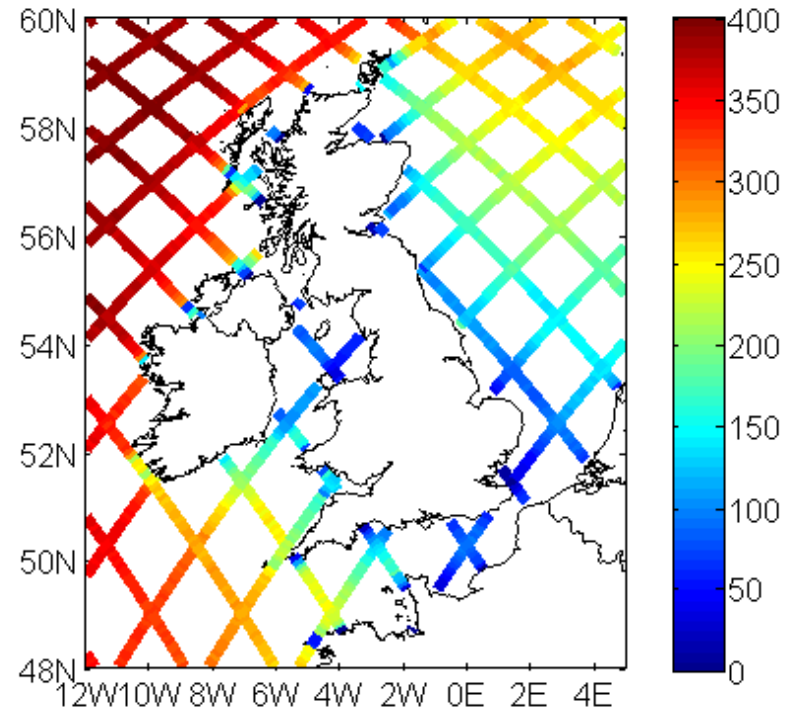


Courtesy: David Cotton, SatOC Ltd

Climatological mean wave period (1993-2003 Topex)

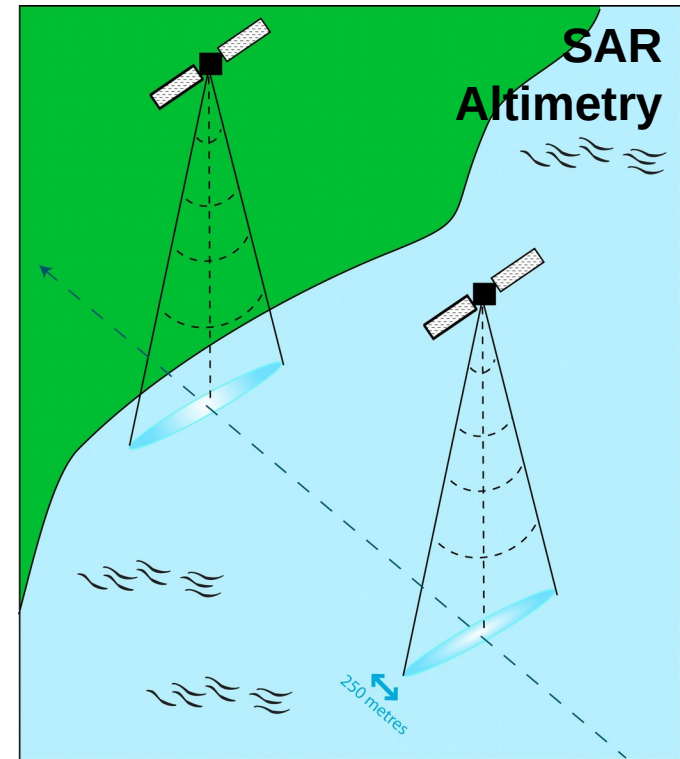
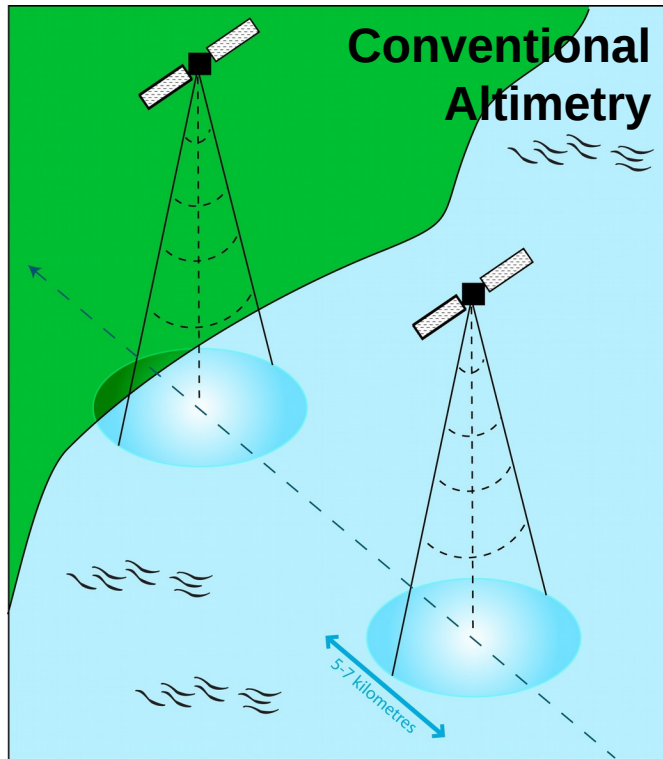


Mean Power from Jason-1 for given wave energy converter device



- Long-term satellite altimeter data records
- Climatologies, estimation of extremes, variability and trends
 - E.g. renewable energy resource assessment

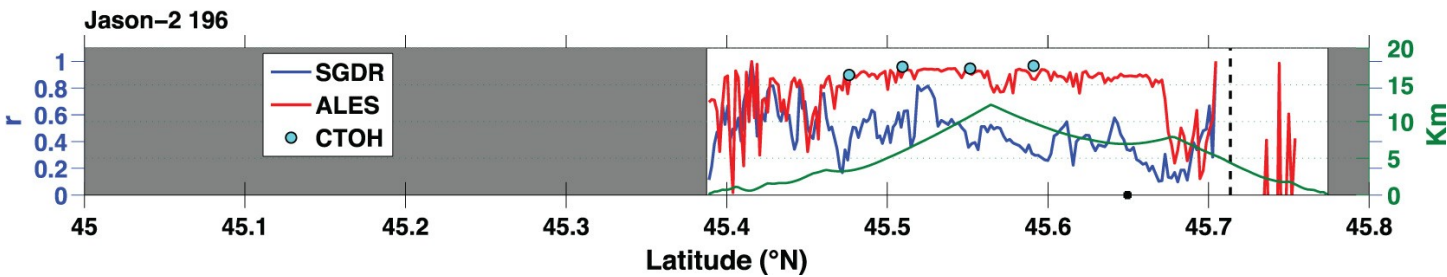
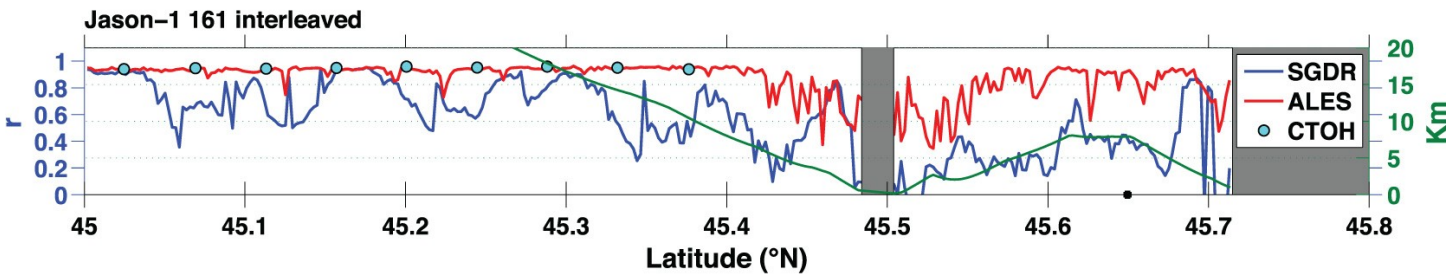
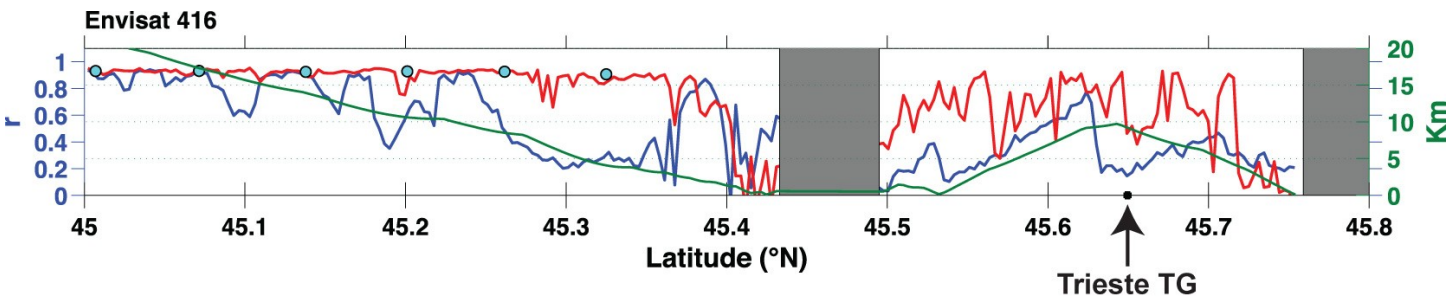
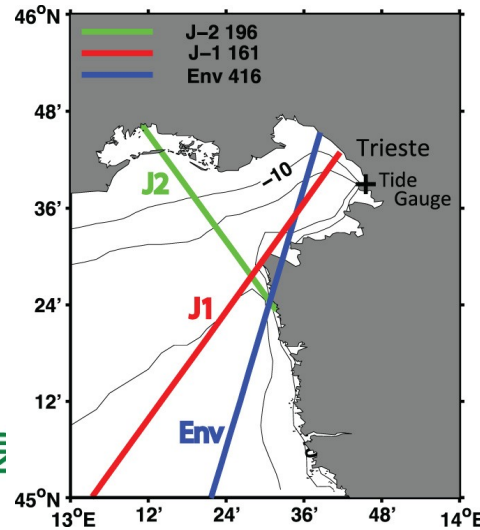
Towards finer resolution and better performance near land



- Coastal Altimetry
- Advanced reprocessing at NOC to recover more and better data in the coastal zone

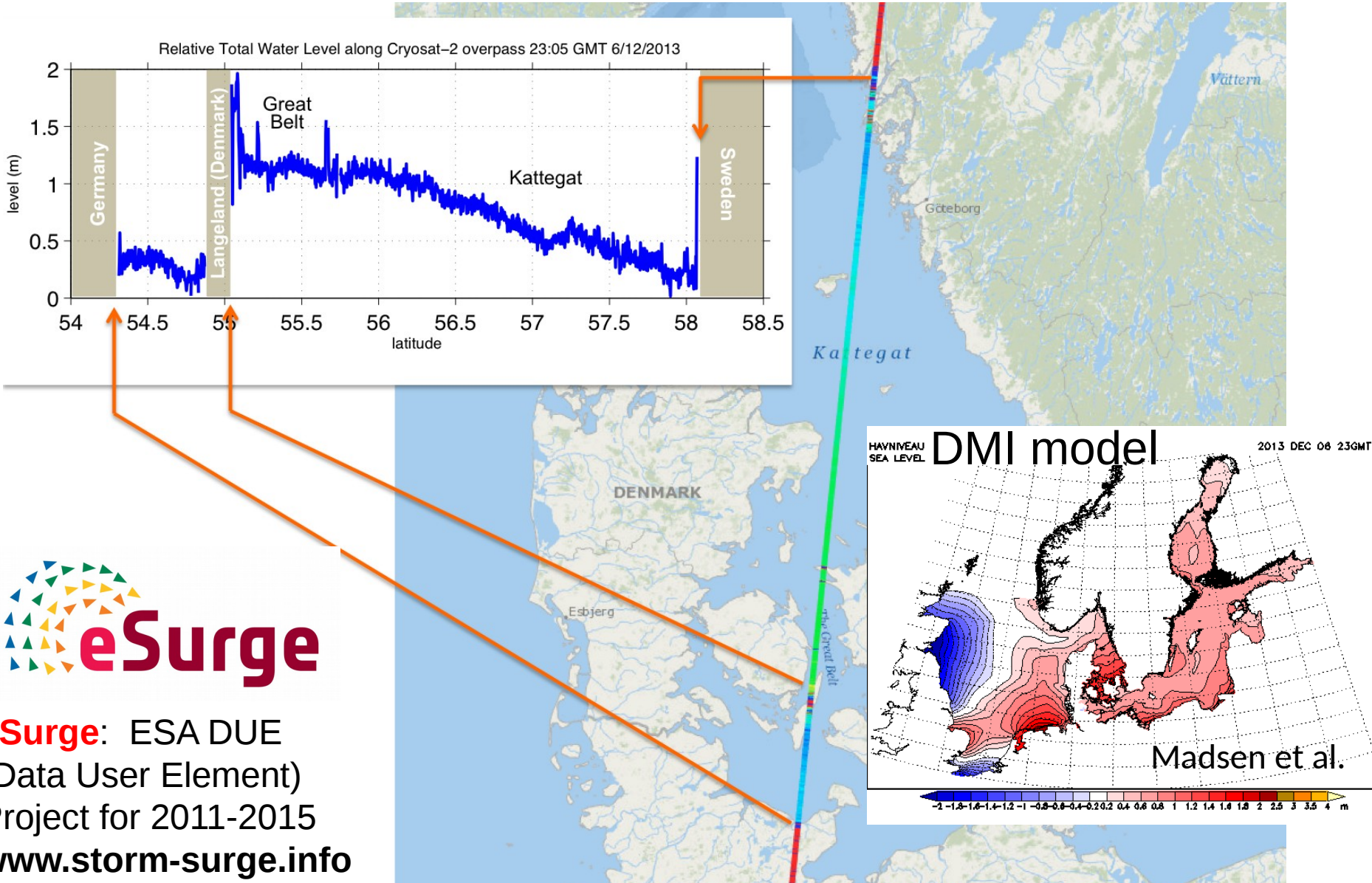
- SAR altimetry
- New technology leading to better precision, finer resolution and better performance near land

Improved coastal altimetry in the North Adriatic



Passaro, Cipollini et al., RSE, 2014

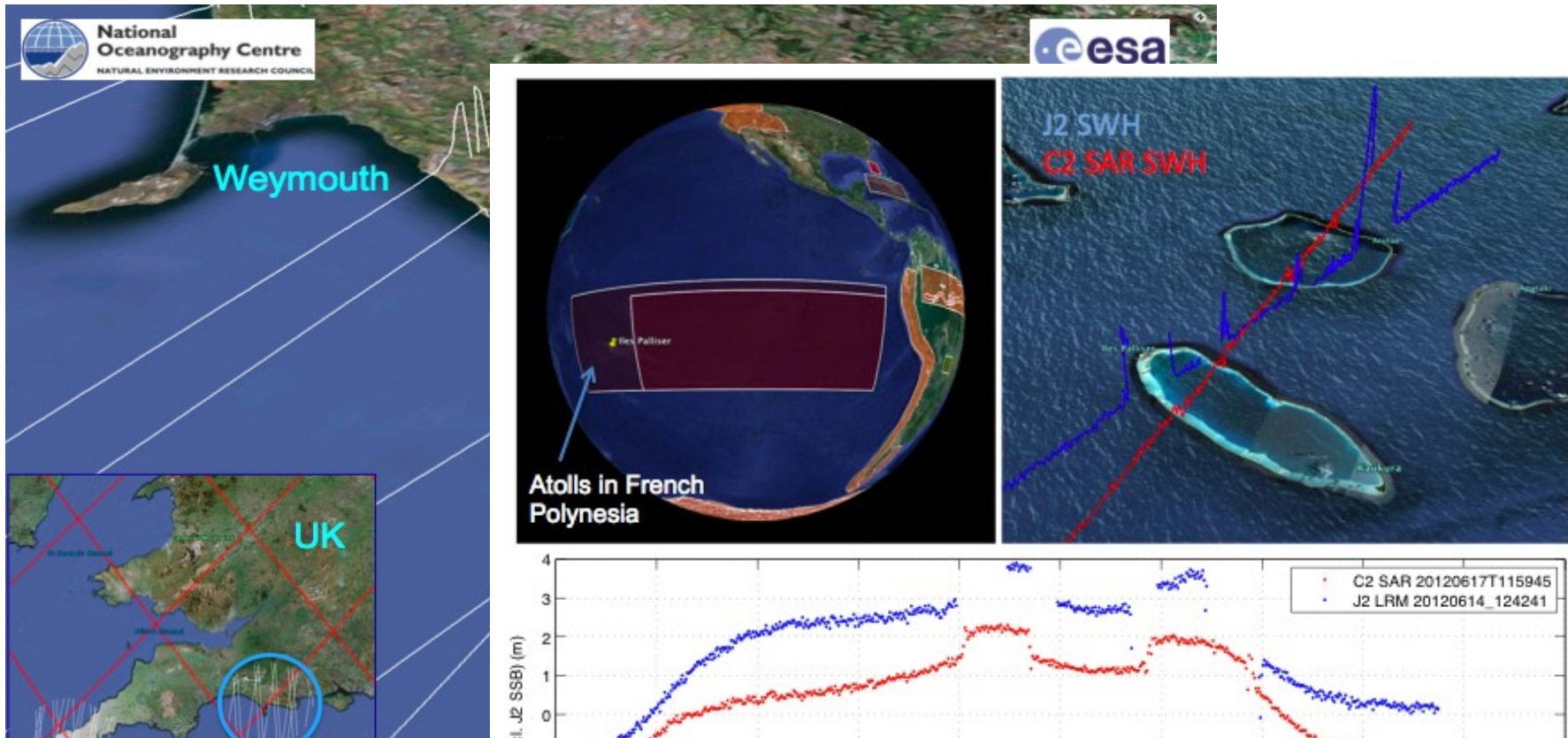
Cryosat-2 observations of Storm Xaver



eSurge: ESA DUE
(Data User Element)
Project for 2011-2015
www.storm-surge.info

Cryosat overpass Friday 6 Dec 2013 23:05 – Data on eSurge server by Saturday 12:00

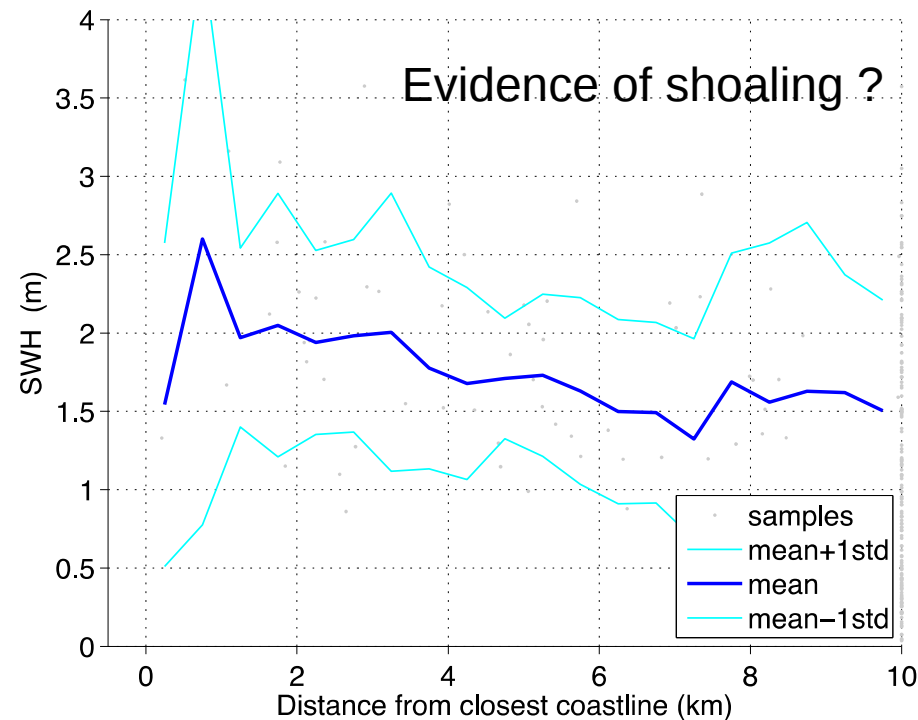
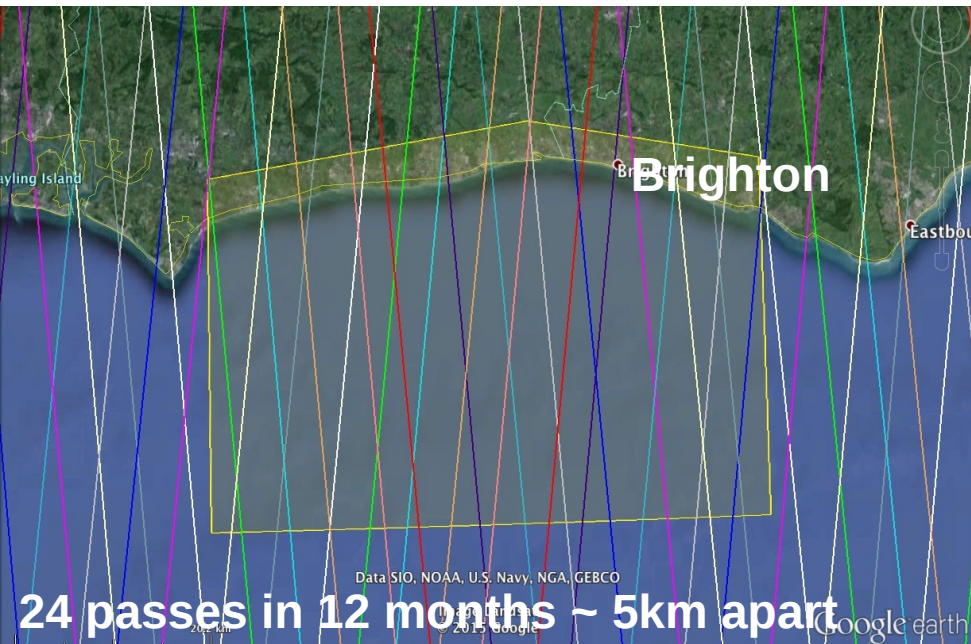
Finer resolution and better performance with Cryosat-2 SAR mode altimetry



- Demonstrated in-orbit with Cryosat-2
- Now available on Sentinel-3A/B/C/D series
- To be used on Sentinel-6/Jason-CS series

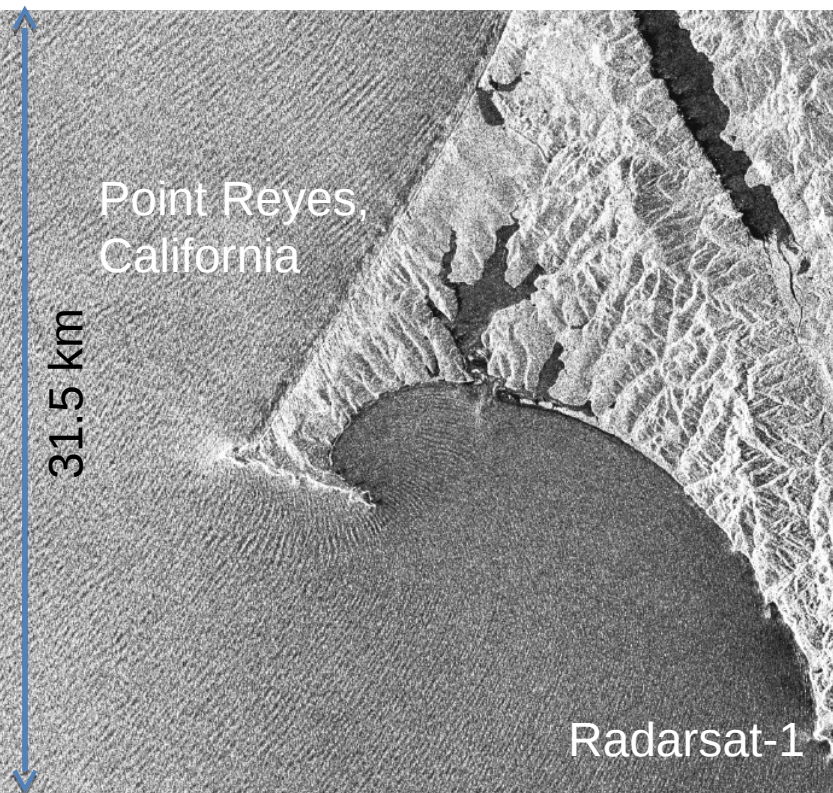
Characterising the coastal wave field

- Measuring along tracks gives access to information about spatial evolution of coastal wave field
 - On average around the UK, SWH starts to decrease $\sim 2\text{km}$ from land
 - In specific areas, more detailed information available ...
 - E.g. Brighton

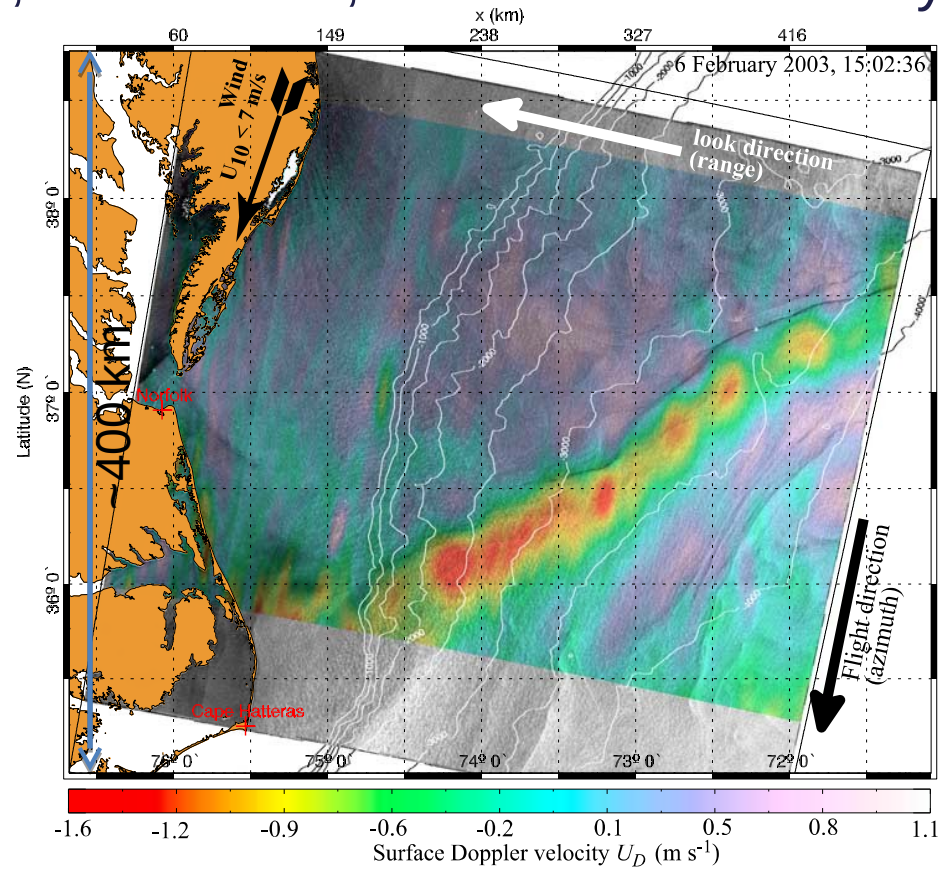


Synthetic Aperture Radar

- Side-looking microwave radar
- High-resolution images
 - Directional swell spectrum
 - High-resolution wind speed, swell SWH, surface radial velocity

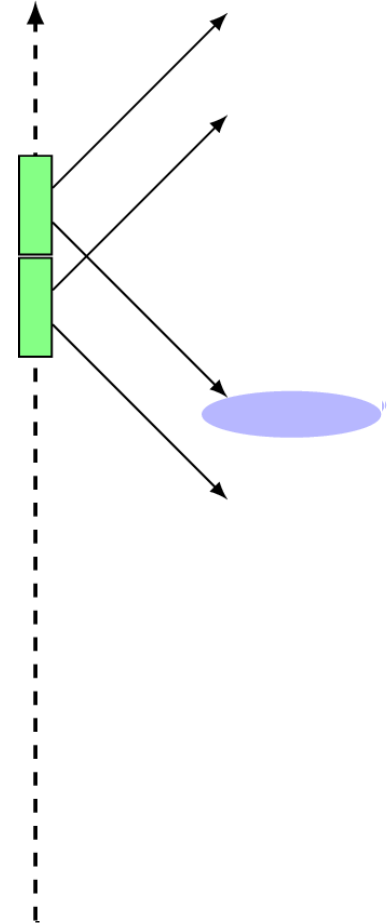
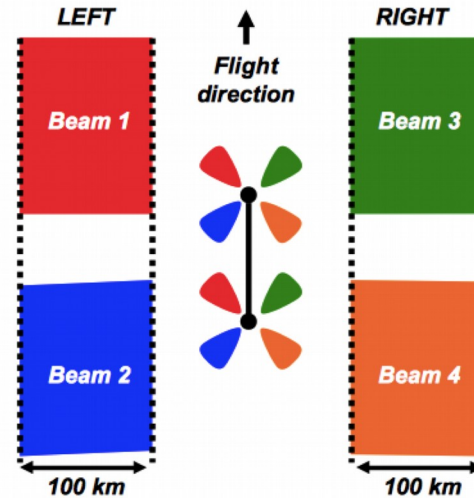
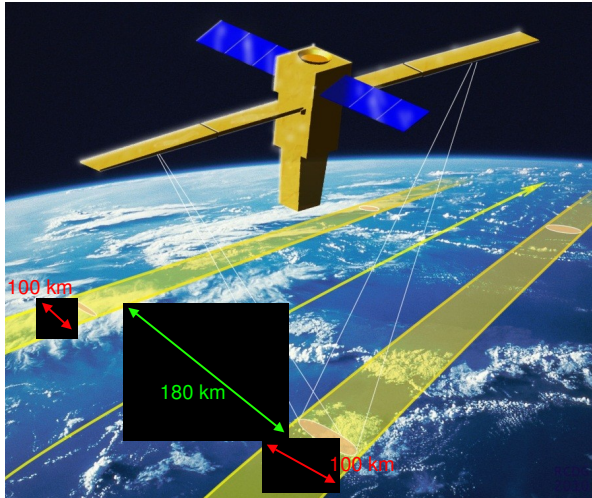


From Vachon et al., 2004



From Chapron et al., 2005

A new concept for high-resolution imaging of ocean surface current vectors



- Squinted Along-Track Interferometric SAR

- Single-pass along-track interferometry between two successive SAR images provides direct estimates of ocean surface motion in line-of-sight direction
- Each scene viewed from two directions to get 2D vector

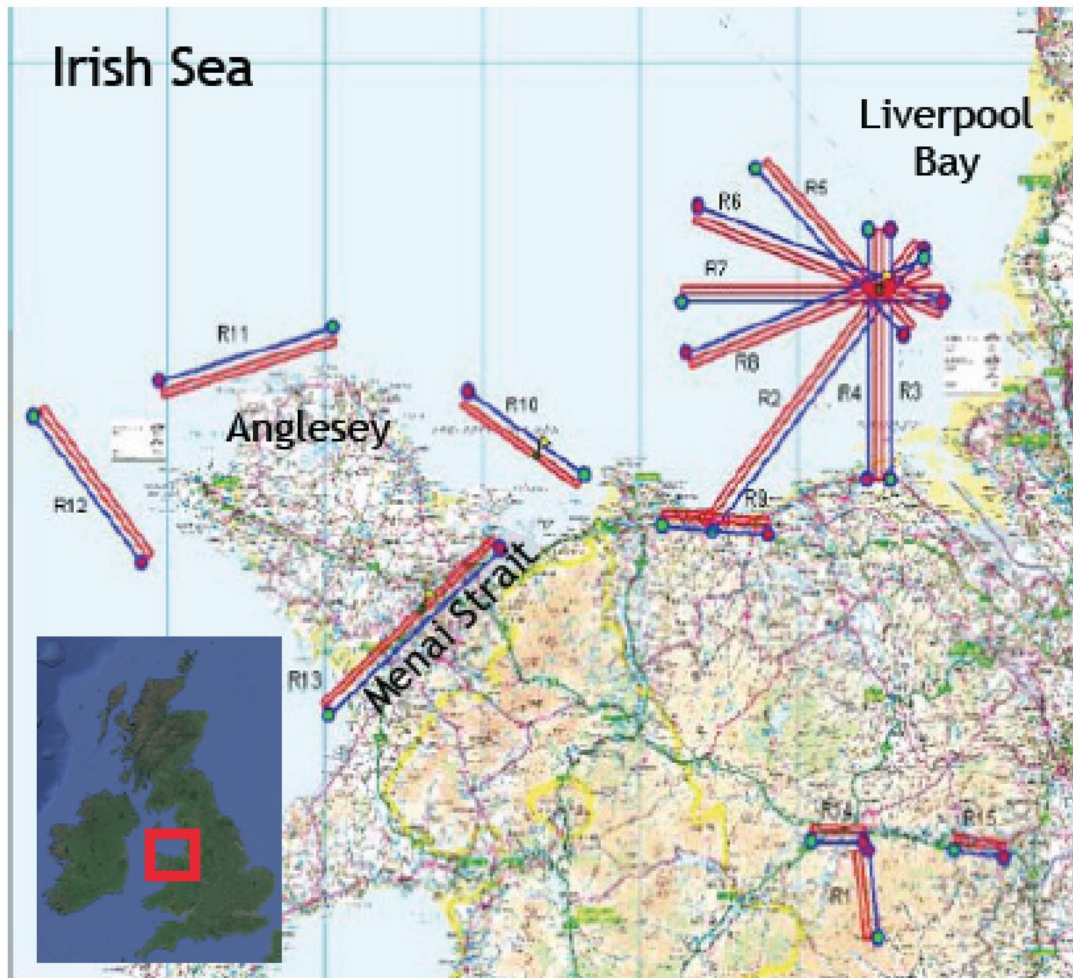
1km resolution

Coincident wind vector and directional swell spectra

In prep for submission as future ESA mission

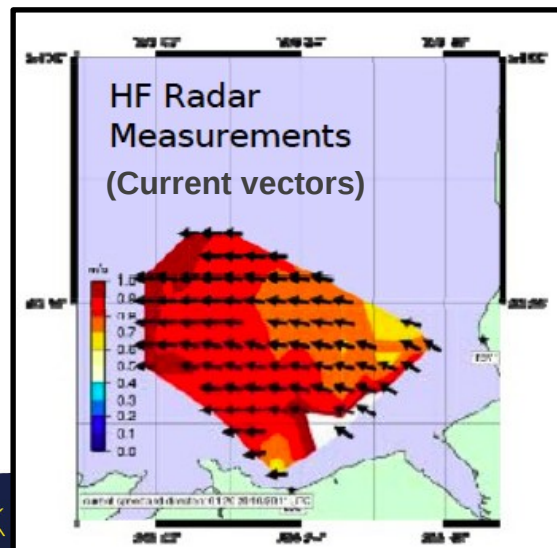


Airborne demonstration

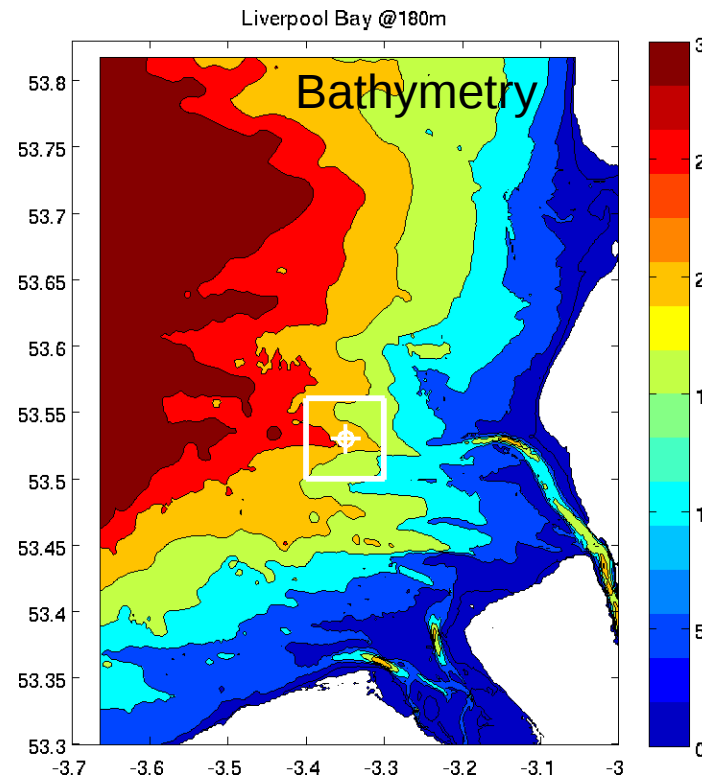
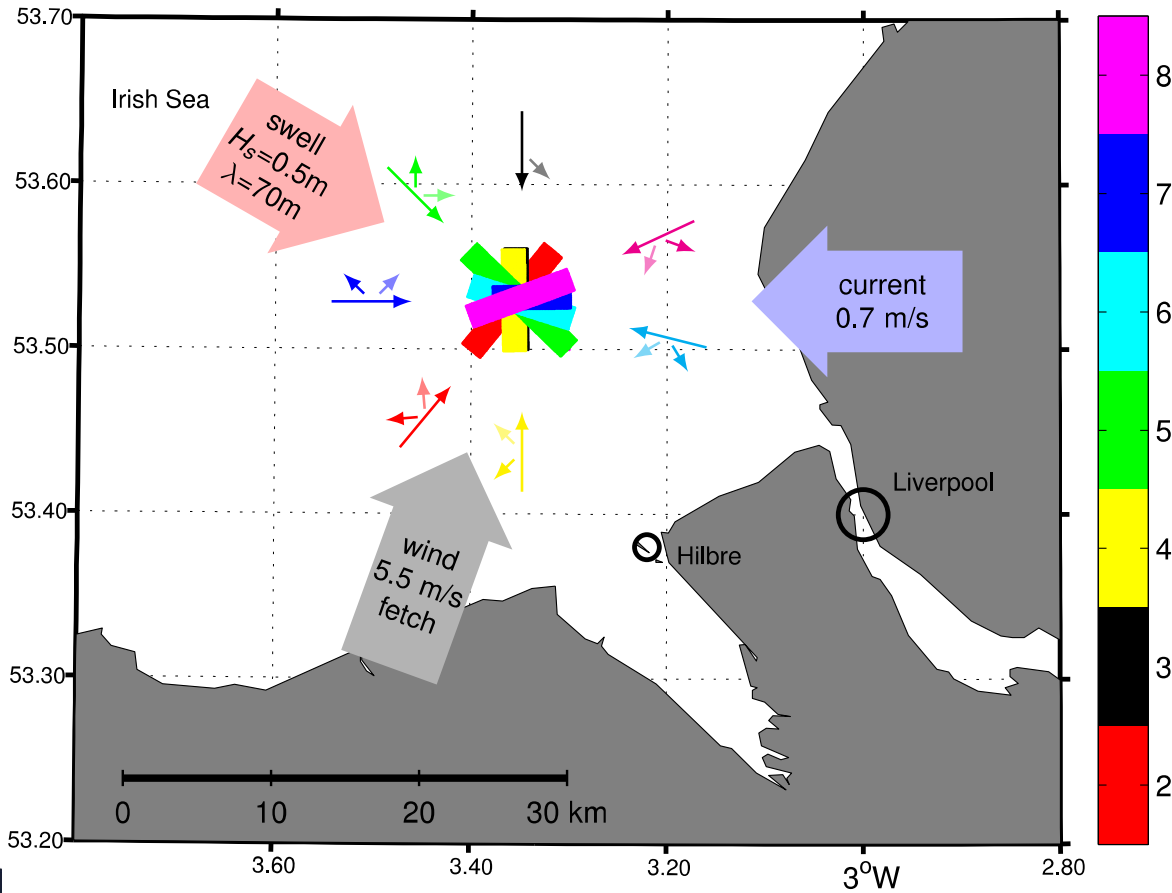


- October 26th, 2011
- Javelin Configuration

Validation against ADCP and HF radar in Liverpool Bay



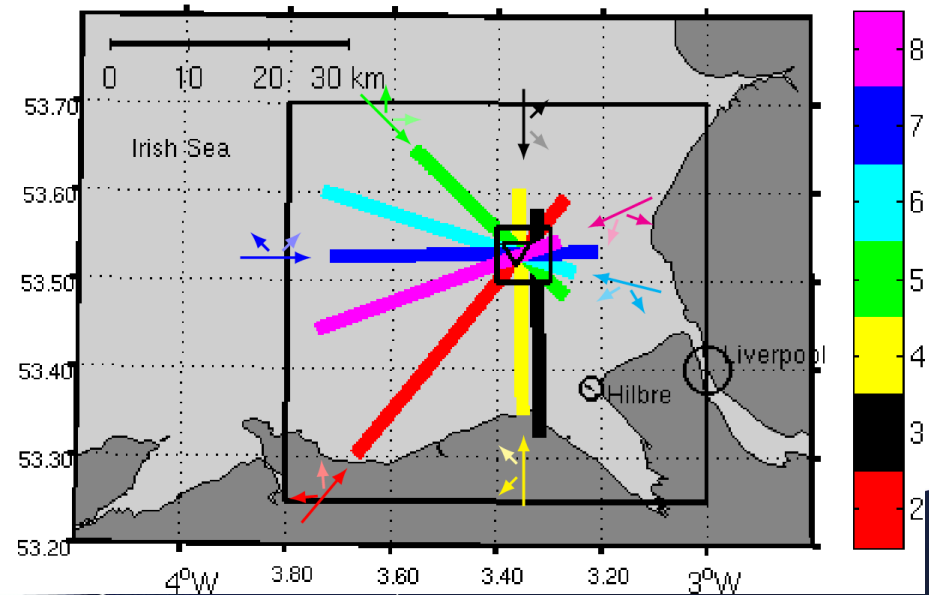
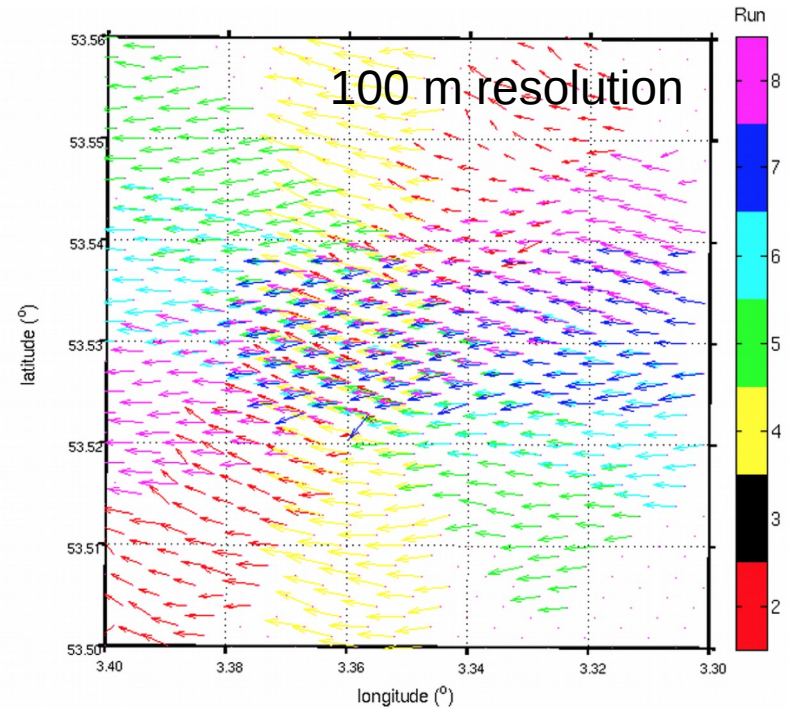
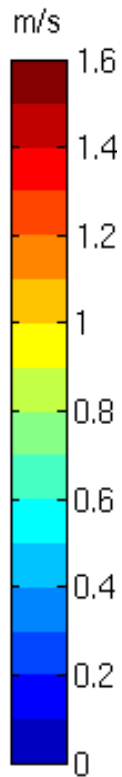
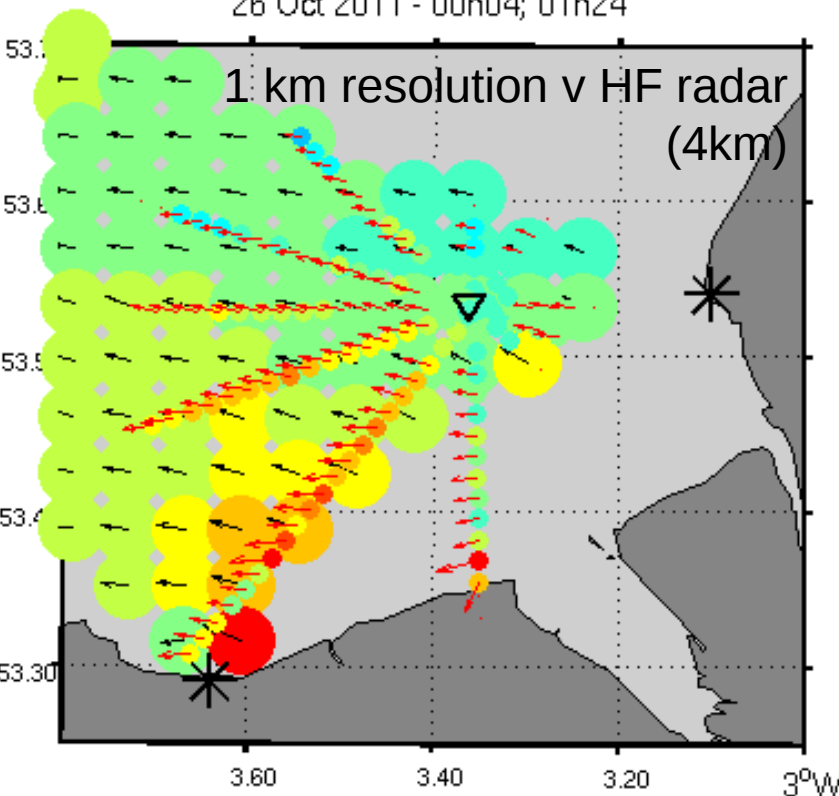
Geophysical conditions during the flight



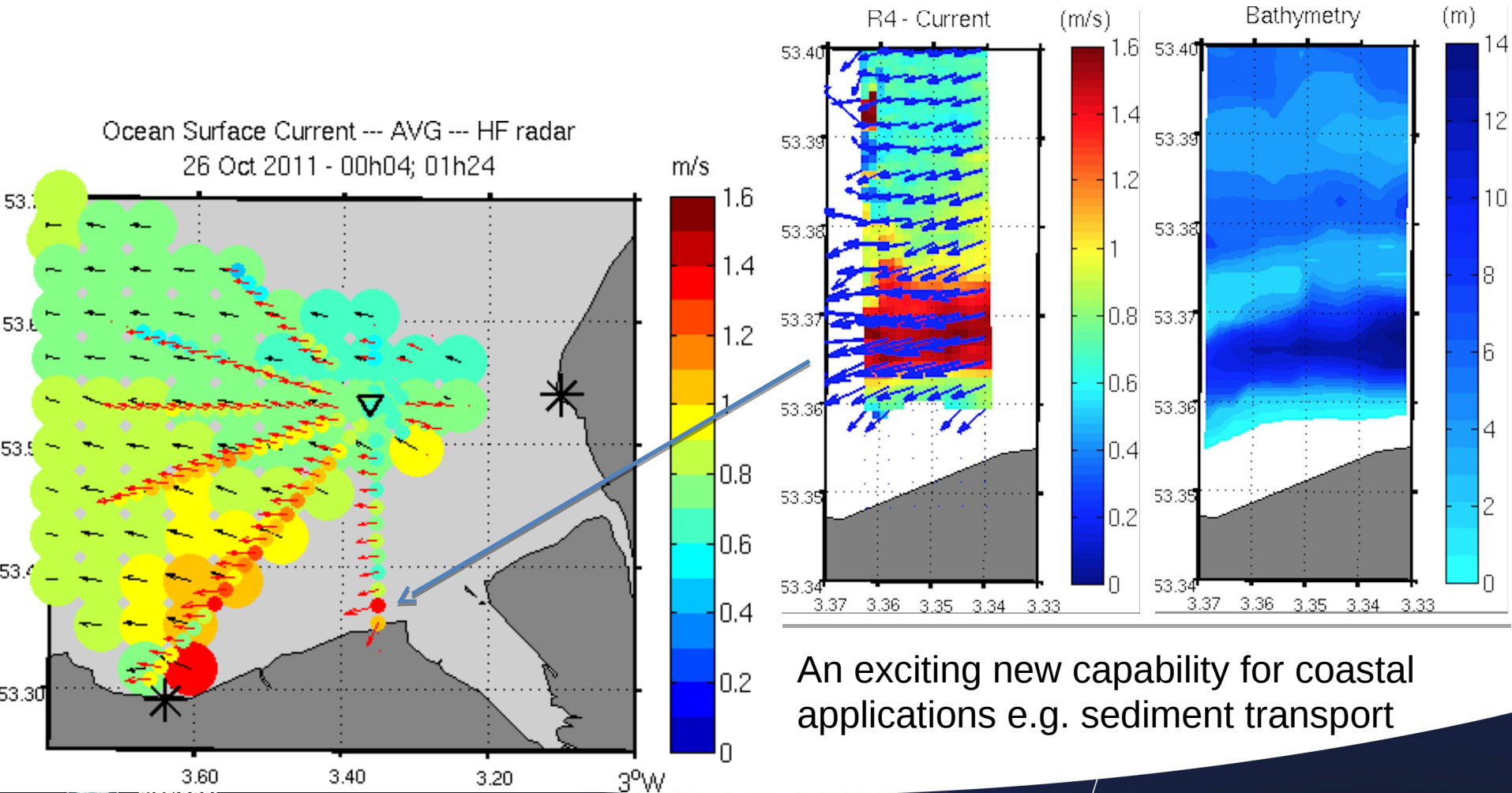
- Westward tidal current
- Light wind from SSW (fetch limited)
- Low energy NW swell
- Shallow water

Demonstrating high-resolution surface current vectors mapping

Ocean Surface Current --- AVG --- HF radar
26 Oct 2011 - 00h04; 01h24



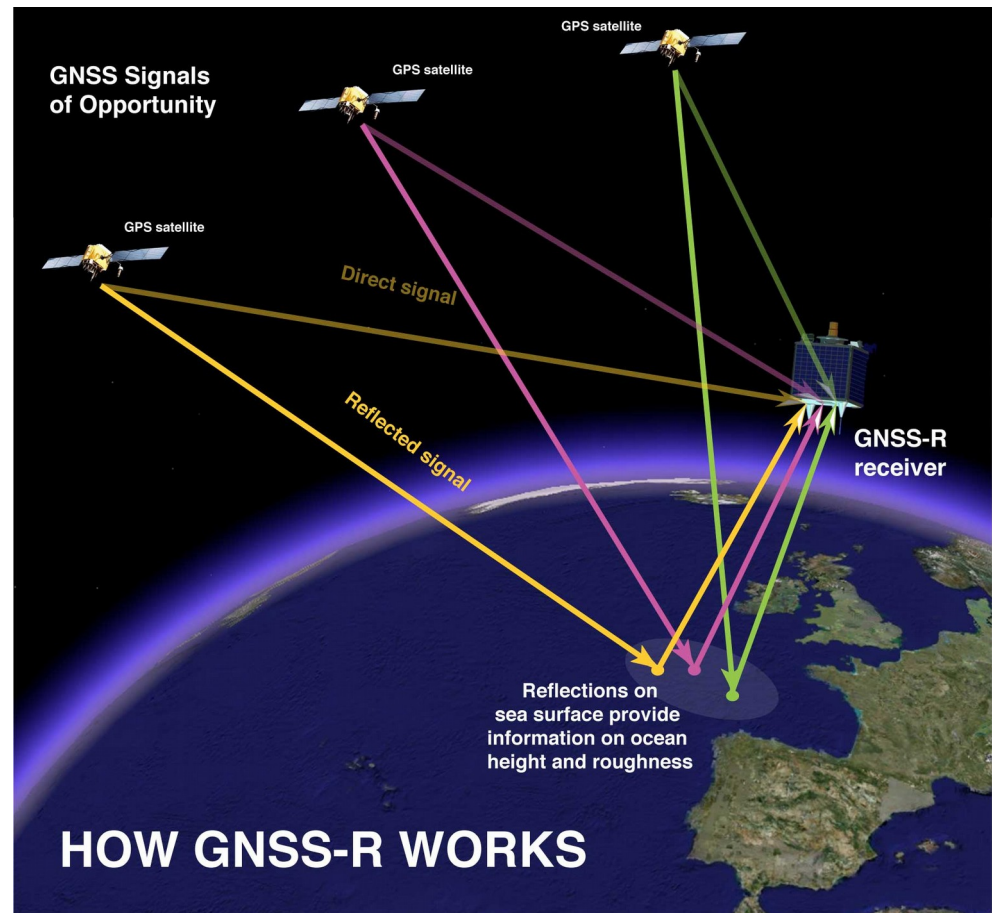
Detecting narrow coastal current jets linked to bathymetry



An exciting new capability for coastal applications e.g. sediment transport

GNSS-Reflectometry for winds

- GNSS-R uses signals of opportunity from Global Navigation Satellite Systems
 - e.g GPS, Galileo...
- Global, ubiquitous signals
- Small low-cost receivers
 - Suitable for small satellites or satellites of opportunity to build constellations of GNSS-R receivers
 - Huge improvement in space-time sampling

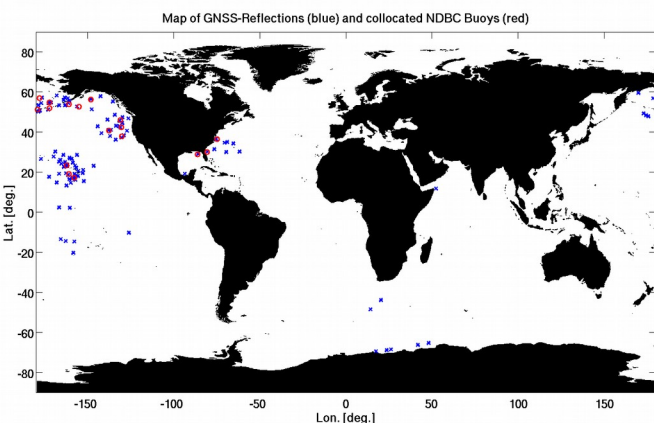
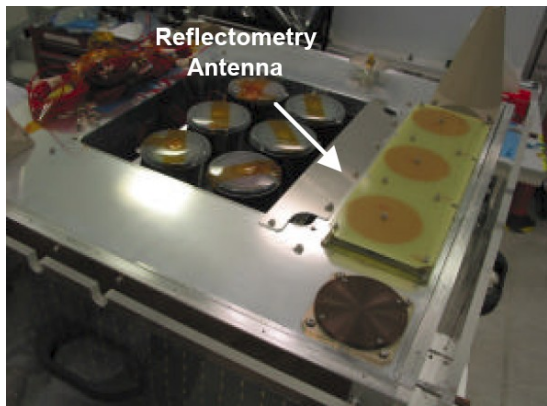


- More frequent wind data = relevant to many scientific and operational applications
- Weakly affected by precipitation = better winds in heavy rain ?
 - e.g. hurricanes

A long journey...

2003

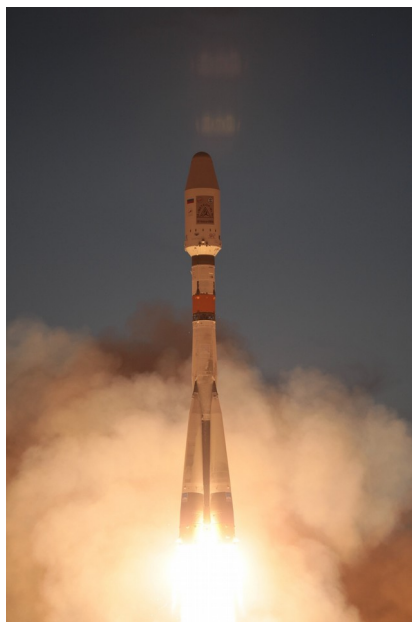
Proof-of-concept on UK-DMC with Surrey Satellite Technology Ltd



Collected ~ 50 data points over ocean

8 July 2014

UK TechDemoSat-1 with SGR-ReSI GPS-R payload



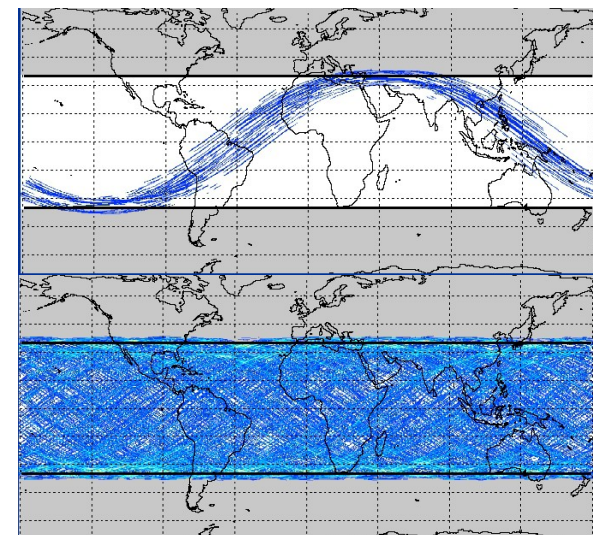
In partnership with:



Oct Dec 2016

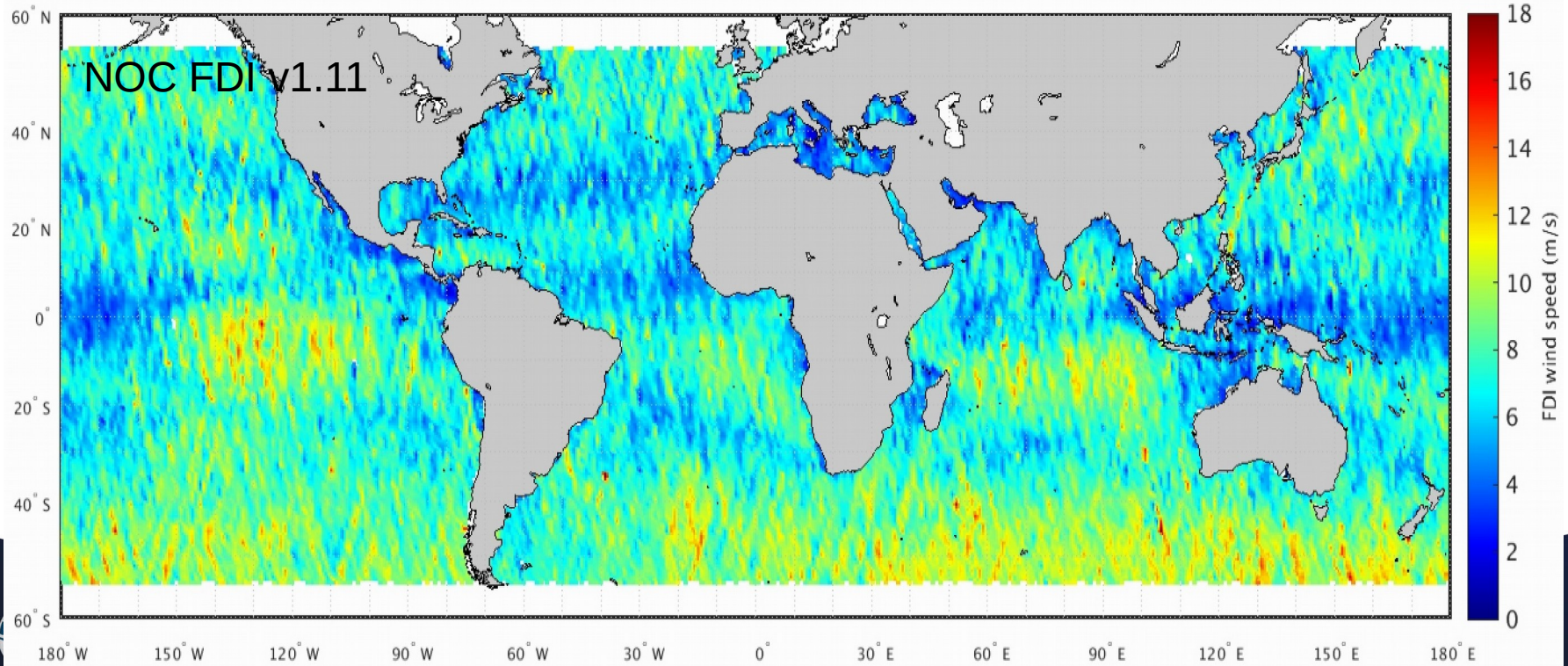
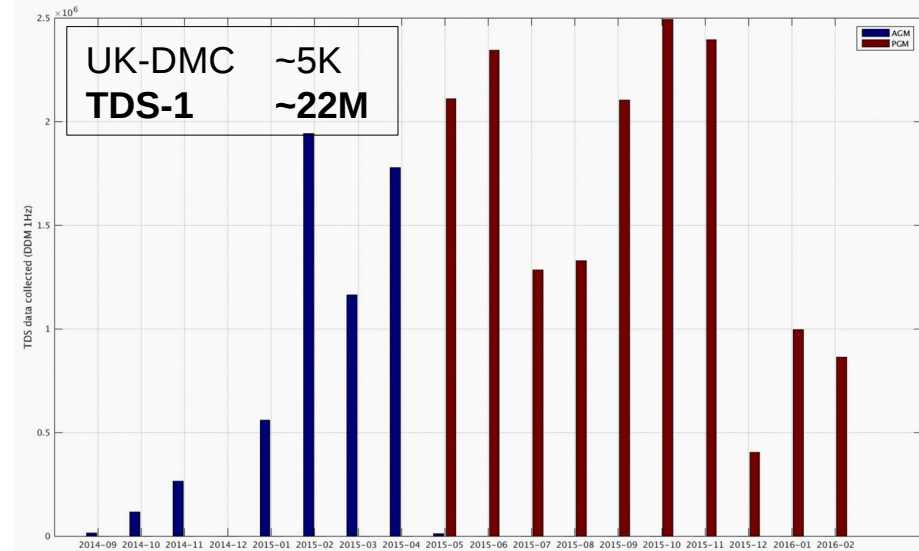
NASA Cyclone Global Navigation Satellite System (CYGNSS) mission

Constellation of 8 SGR-ReSI



Aims for mean revisit time ~ **4 hours**

First global GNSS-R winds with TechDemoSat-1



Summary & take home message

- Multitude of observations of wind, waves and currents with satellites
 - for over 20 years + new emerging capability
- Opportunities from existing satellite data archive
 - E.g. Climatologies, extremes, variability, trends
- Opportunities from improved capability
 - Coastal altimetry for sea level, waves and winds
 - Application to storm surge forecasting
 - Wind-wave-current-bathymetry interactions
 - Validation of high-resolution wave and circulation models
 - Frequent temporal sampling of winds relevant to offshore applications and weather/hurricane forecasting

Thank you

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