

Space for Smarter Government Programme



Altimeter-based Sea Level estimates along the UK coast

Project Sea Level SpaceWatch

*Paolo Cipollini, Helen Snaith
National Oceanography Centre*



**National
Oceanography Centre**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Web: <http://www.spaceforsmartergovernment.uk/>

Email: ssgp@sa.catapult.org.uk

Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



CATAPULT
Satellite Applications

Rationale



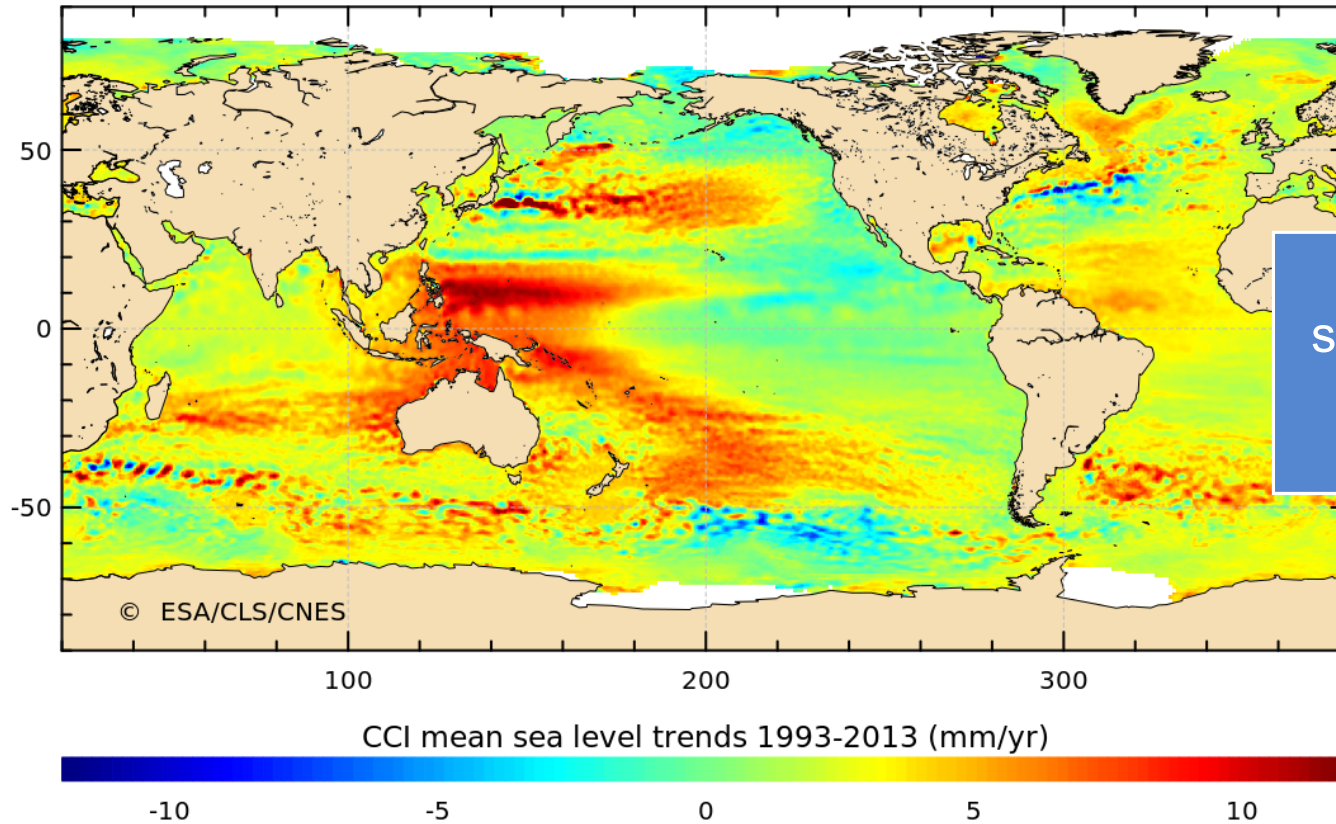
- Sea Level information has great value for coastal planning/ research
- Traditionally provided by tide gauges at the coast – but:
 - TGs heavily influenced by local dynamics
 - TGs measurements include vertical land movement
 - TGs are not everywhere!
- Altimetry can provide complementary sea level information

Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Can we provide similar information in the coastal zone?!

Led by the UK Space Agency
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Aims of the demonstration service

- Provide sea level information around the UK, using data from space-borne altimeters
 - reprocessed with coastal altimetry techniques to maximise the quantity and quality of the retrieval
- Provide that information alongside with tide gauges
 - to facilitate comparison
- → in support of the agencies advising Government on sea level and coastal flooding

Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

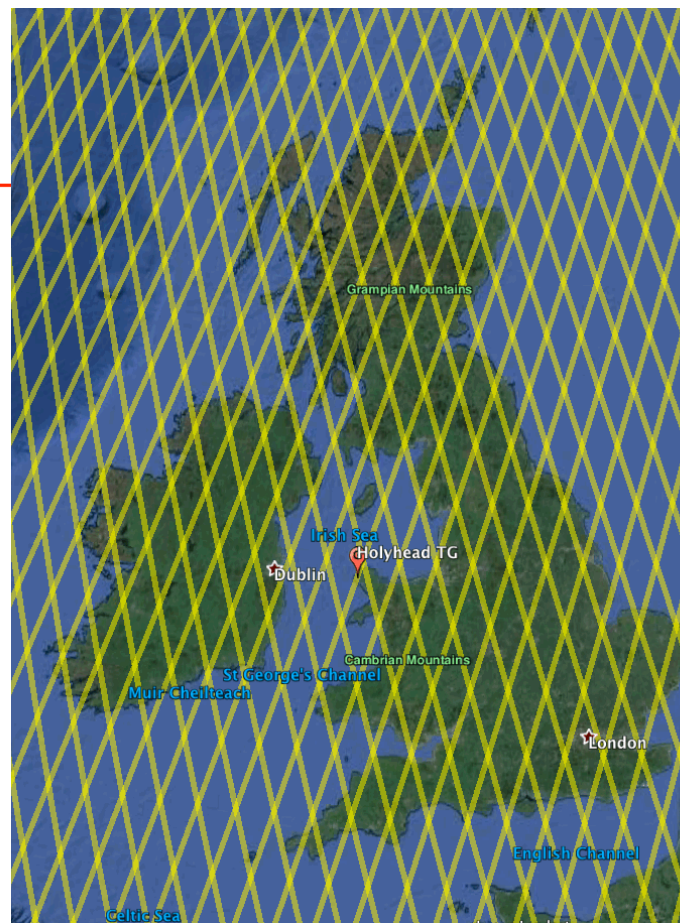
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



CATAPULT
Satellite Applications

Satellite enabled solution

- we demonstrate the feasibility using data from the radar altimeter on board ESA Envisat
 - 35-day repeat orbit in Oct 2002 – Oct 2010
 - then moved to 30-day orbit, until end of mission in April 2012
 - same orbits now resumed by CNES/ISRO AltiKa mission, from March 2013



Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



CATAPULT
Satellite Applications

Altimeter processing for Sea Level SpaceWatch



- retrack Envisat using specialized coastal retracker (ALES)
- compute two sea level quantities:
 - **TWLE** - Total Water Level Envelope i.e. the actual level including tides and atmospheric forcing – useful as a reference and because it displays extreme events (surges)
 - **SSHA** - Sea Surface Height Anomaly, i.e. anomaly w.r.t. the mean sea surface, with tides/atmospheric effects removed → this is the one from which we derive Sea Level Rates
- co-locate measurements on nominal ground tracks, and build time series
- compute a few statistics (next page)

Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



CATAPULT
Satellite Applications



Quantities computed from altimetry

- matrices (rows correspond to time/cycle, columns correspond to position) with
 - **rolling annual mean** in SSHA
 - **rolling one-year trend** in SSHA
- vectors (function of position) with
 - overall **trend** over whole time series
 - **amplitude of the annual signal** over whole time series
 - **phase of the annual signal** (in days) over whole time series
- all the above output in netCDF, with addition of TWLE and SSHA

Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



CATAPULT
Satellite Applications



Led by the UK Space Agency

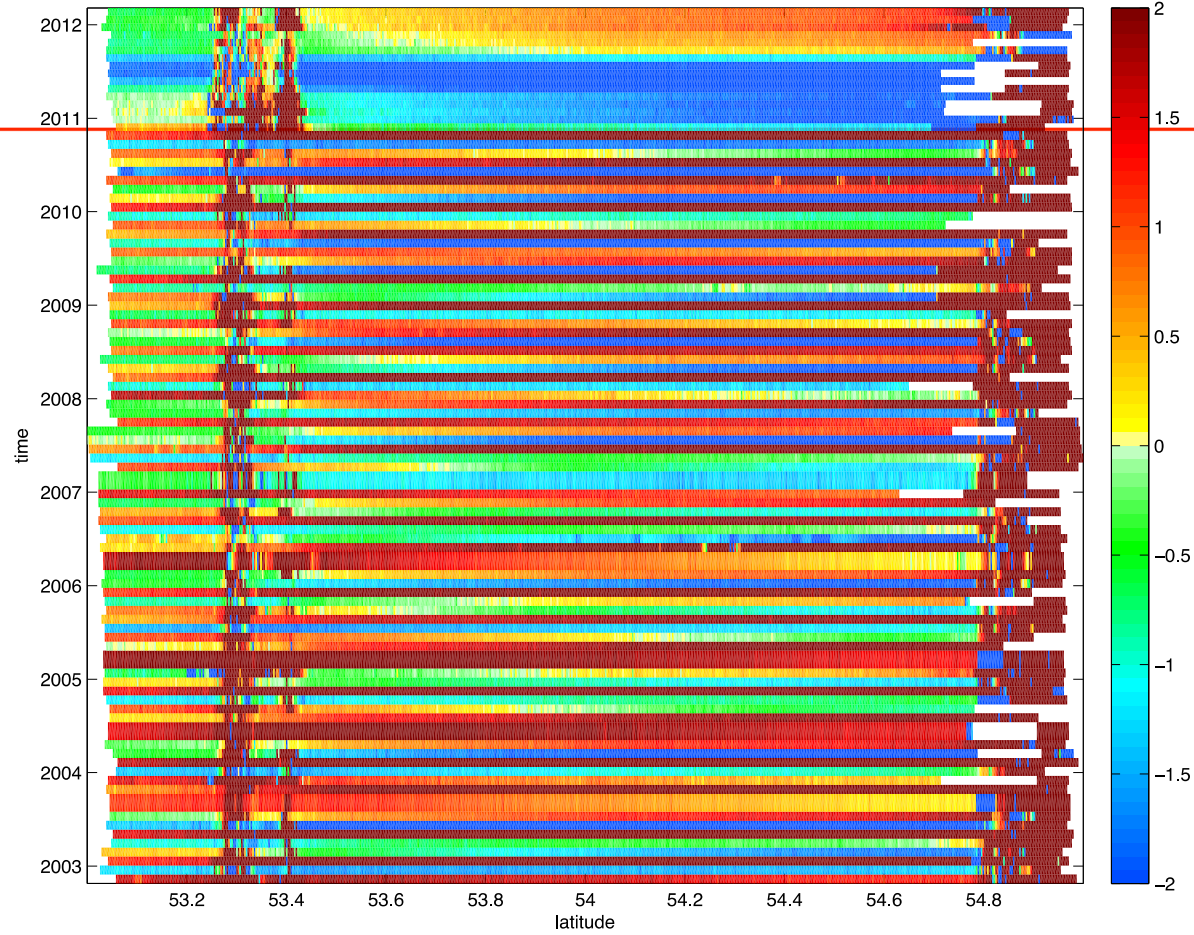
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Total Water Level Envelope (m)



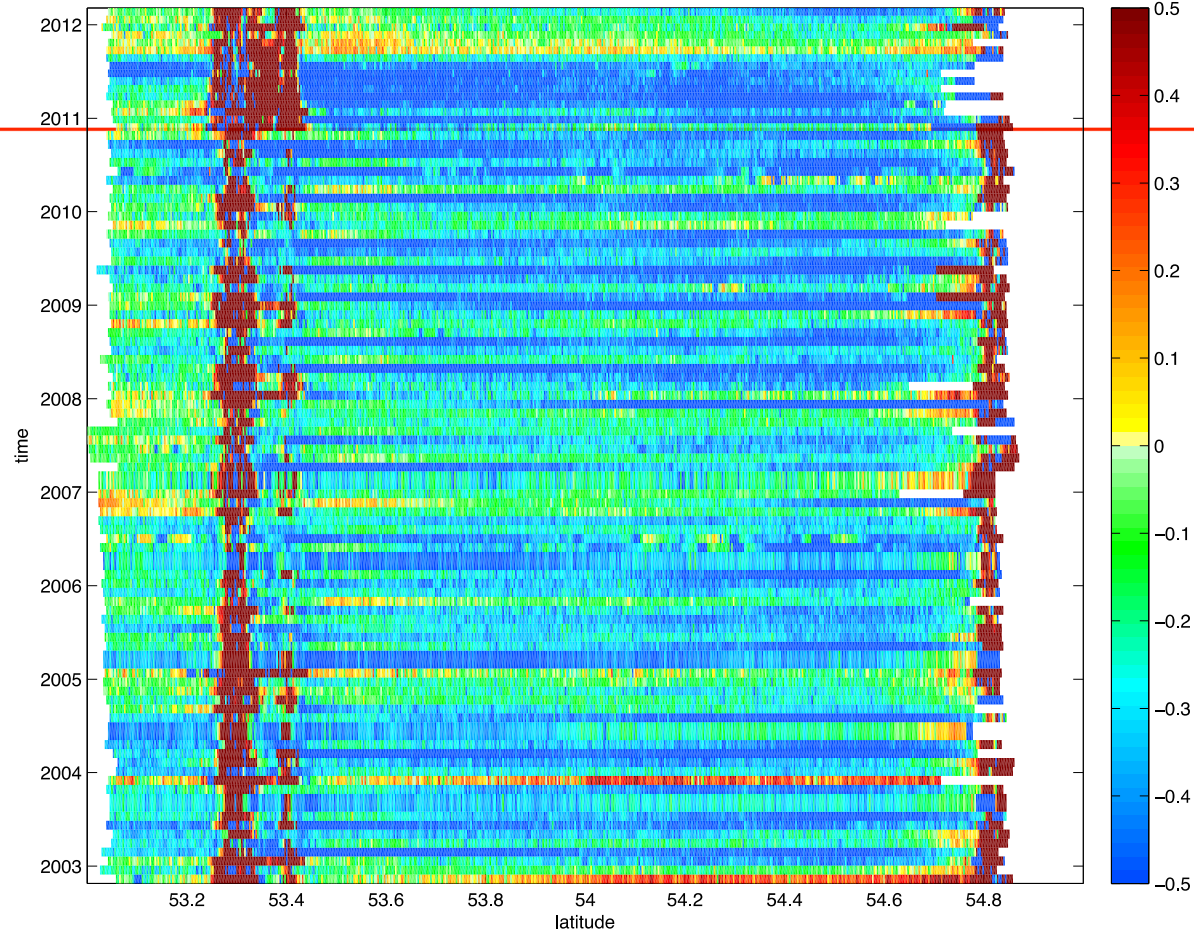
Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



Sea Surface Height Anomaly (m)



Led by the UK Space Agency

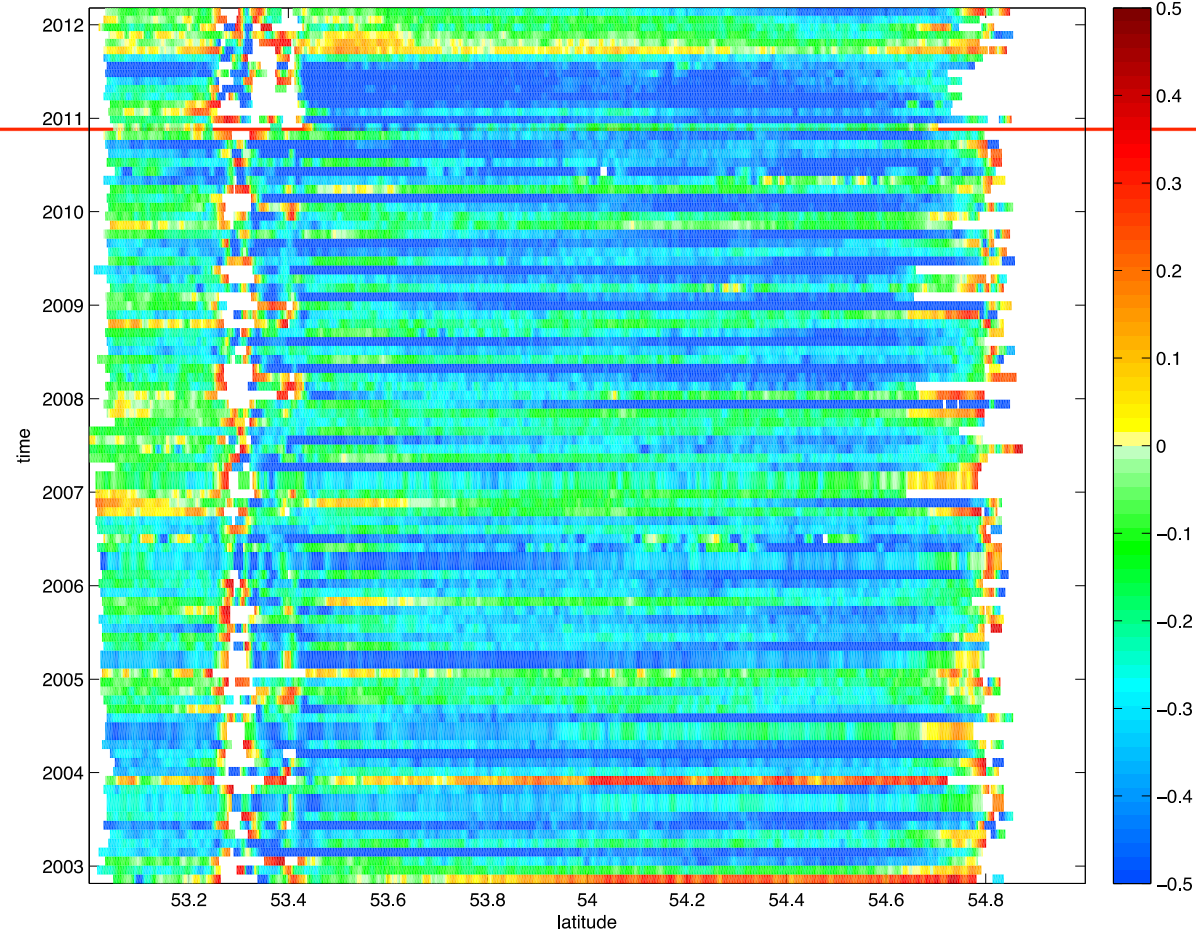
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Sea Surface Height Anomaly – Screened and Filtered (m)

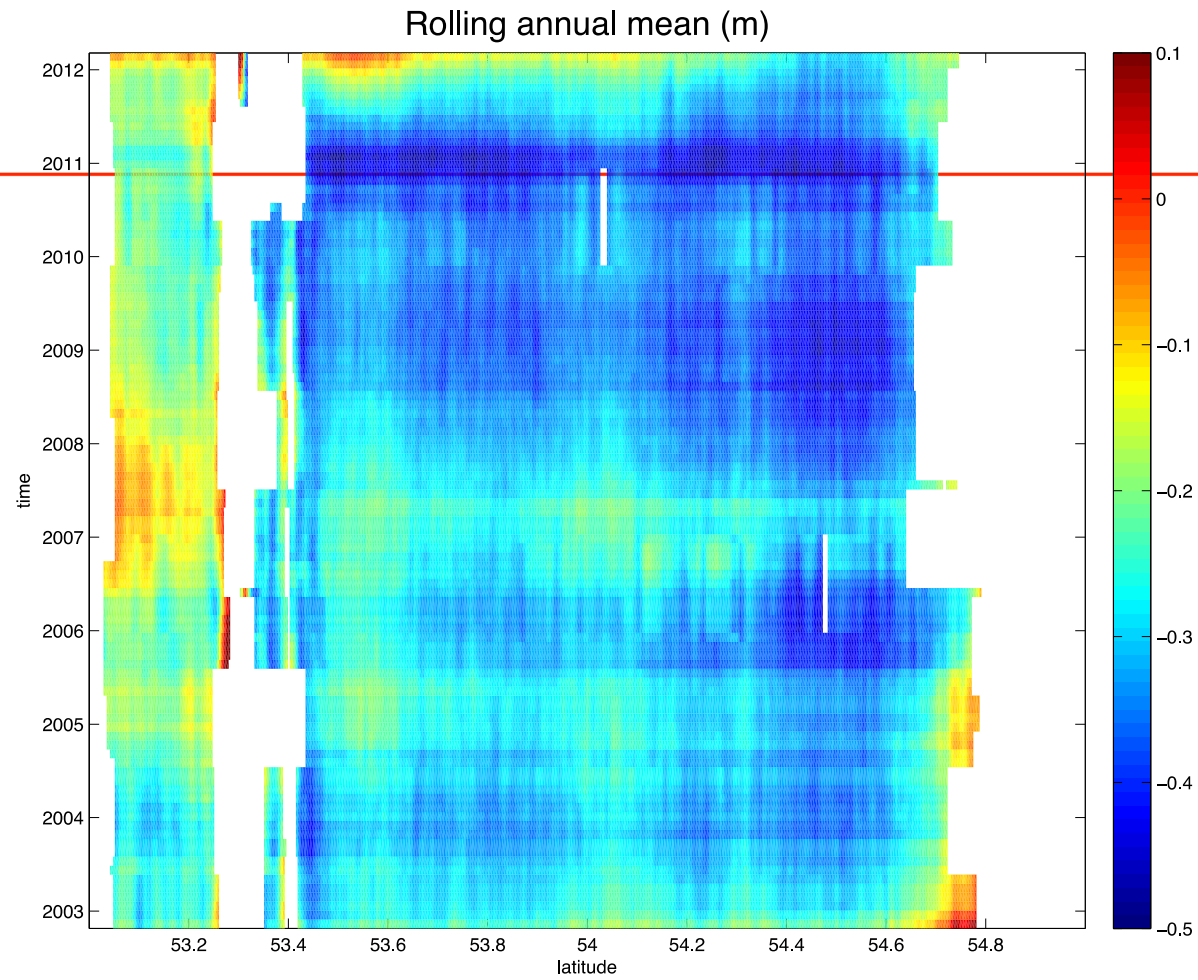


Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



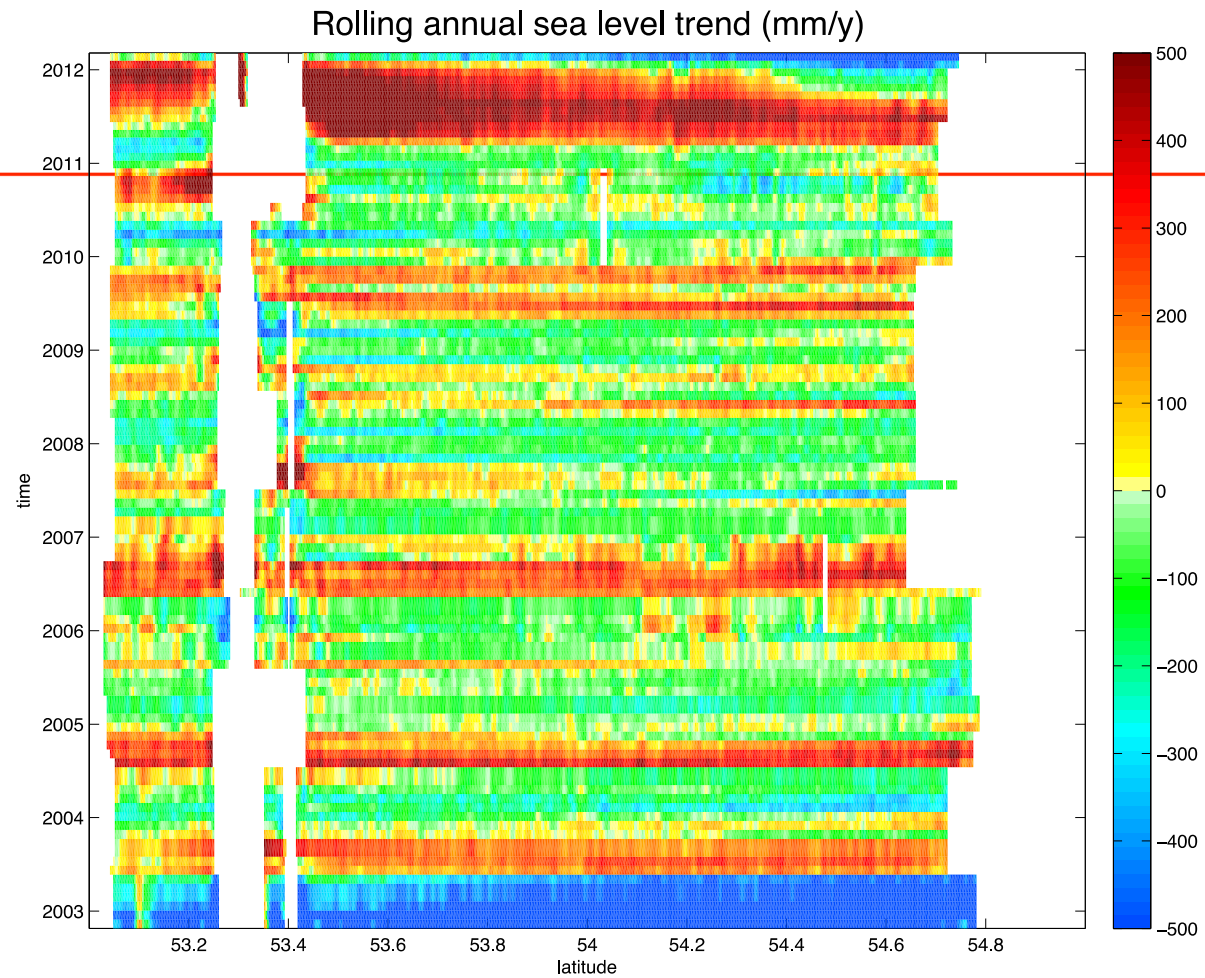


Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



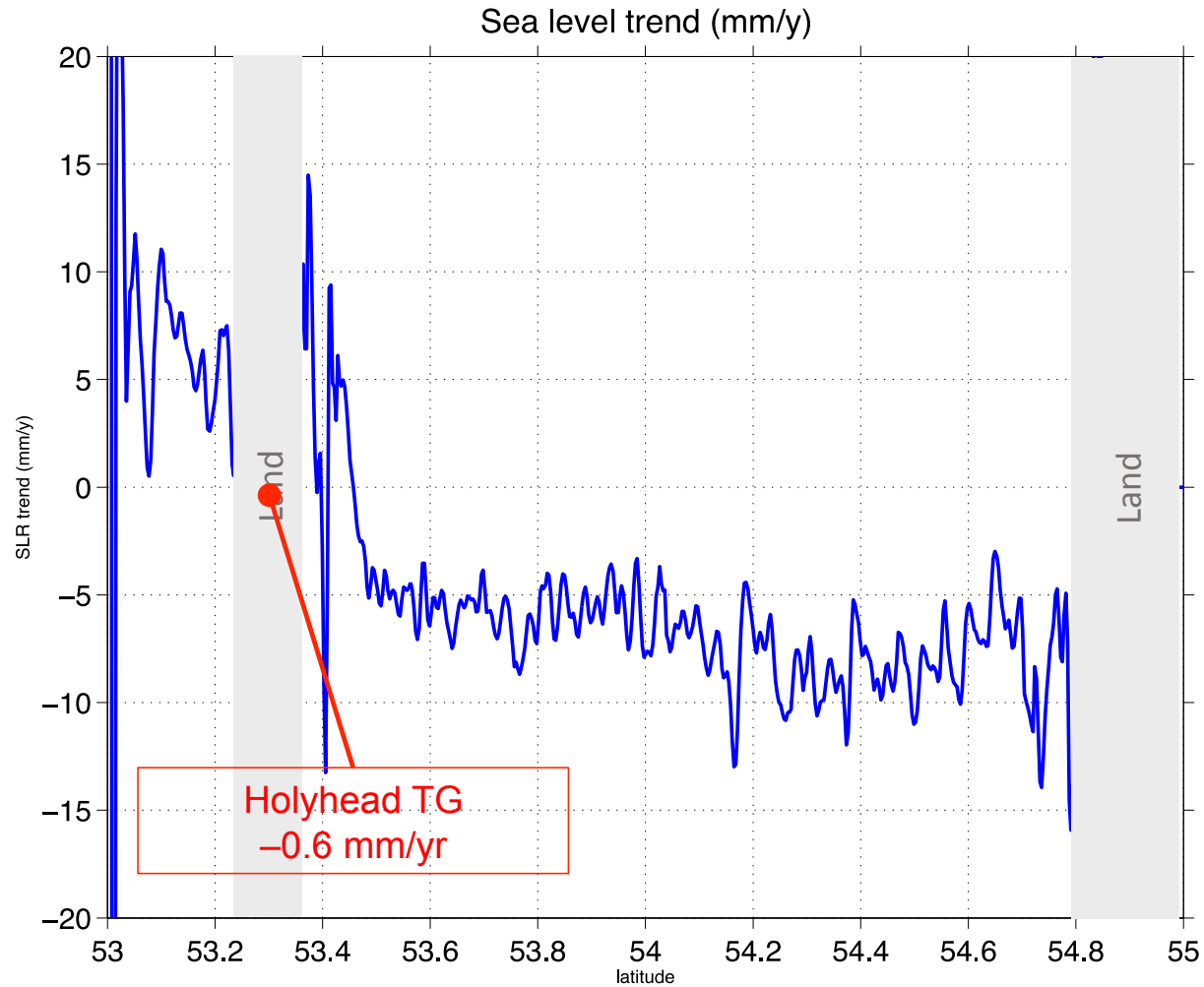


Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



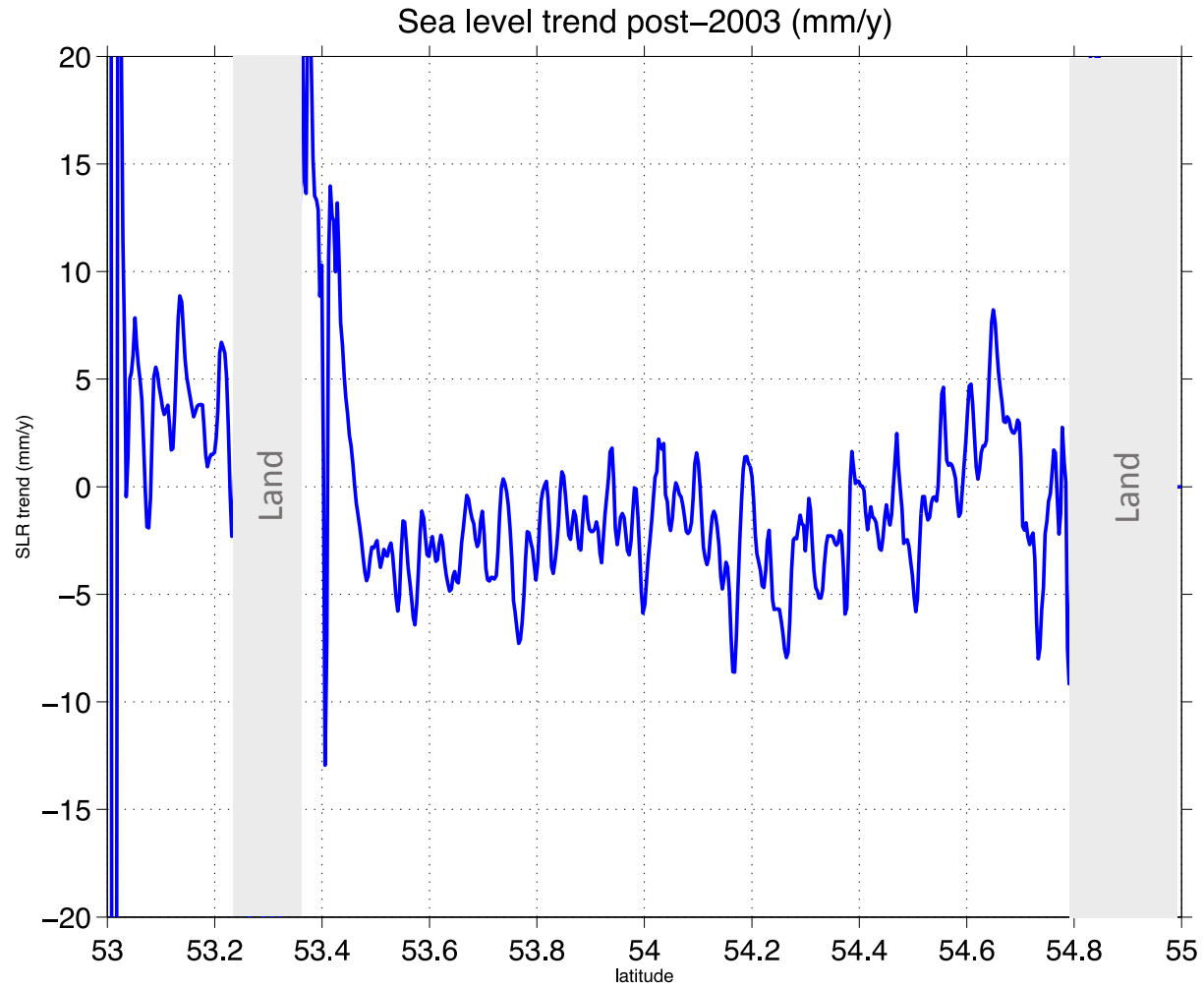


Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

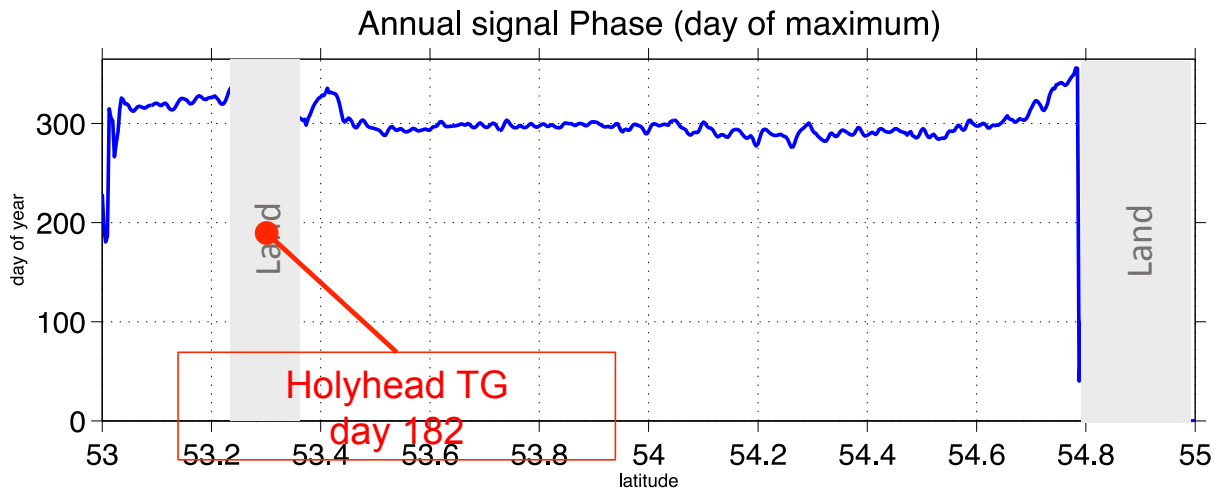
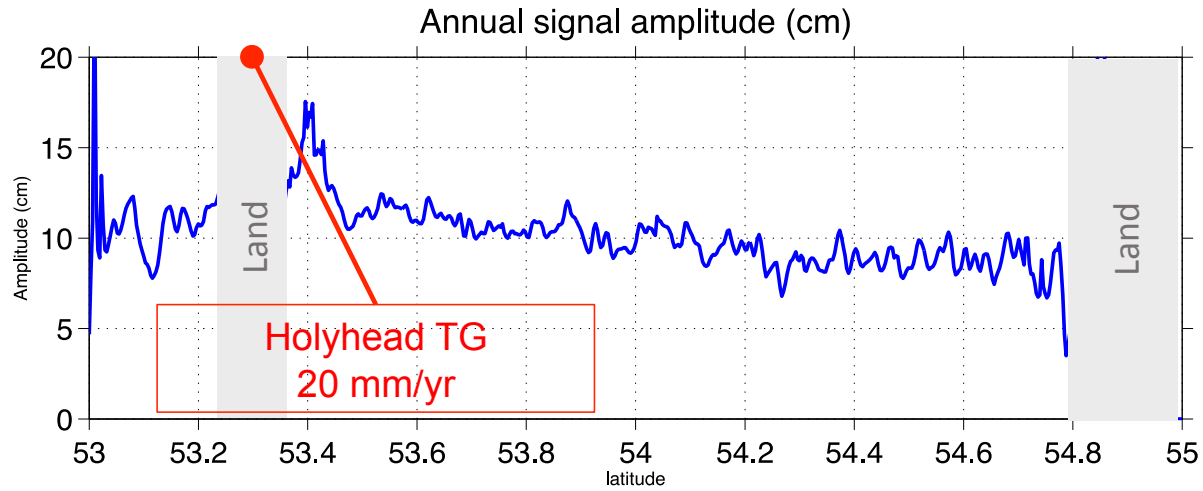




Led by the UK Space Agency
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



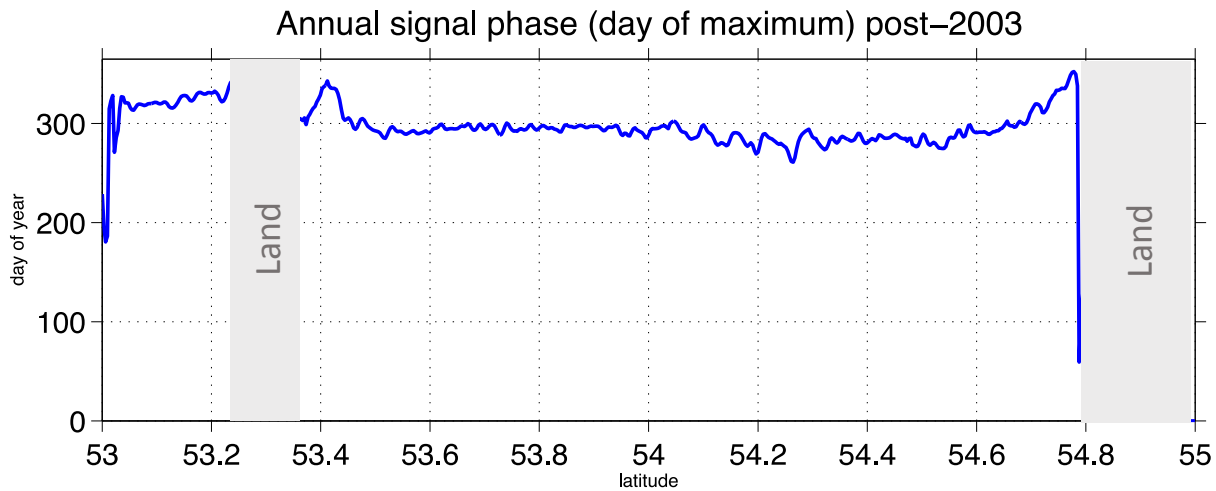
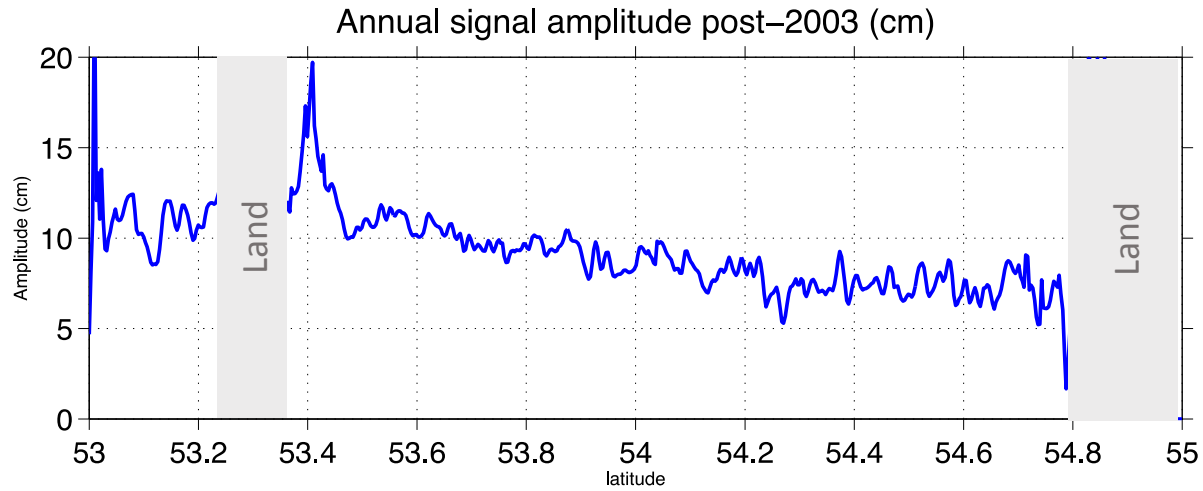


Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Led by the UK Space Agency

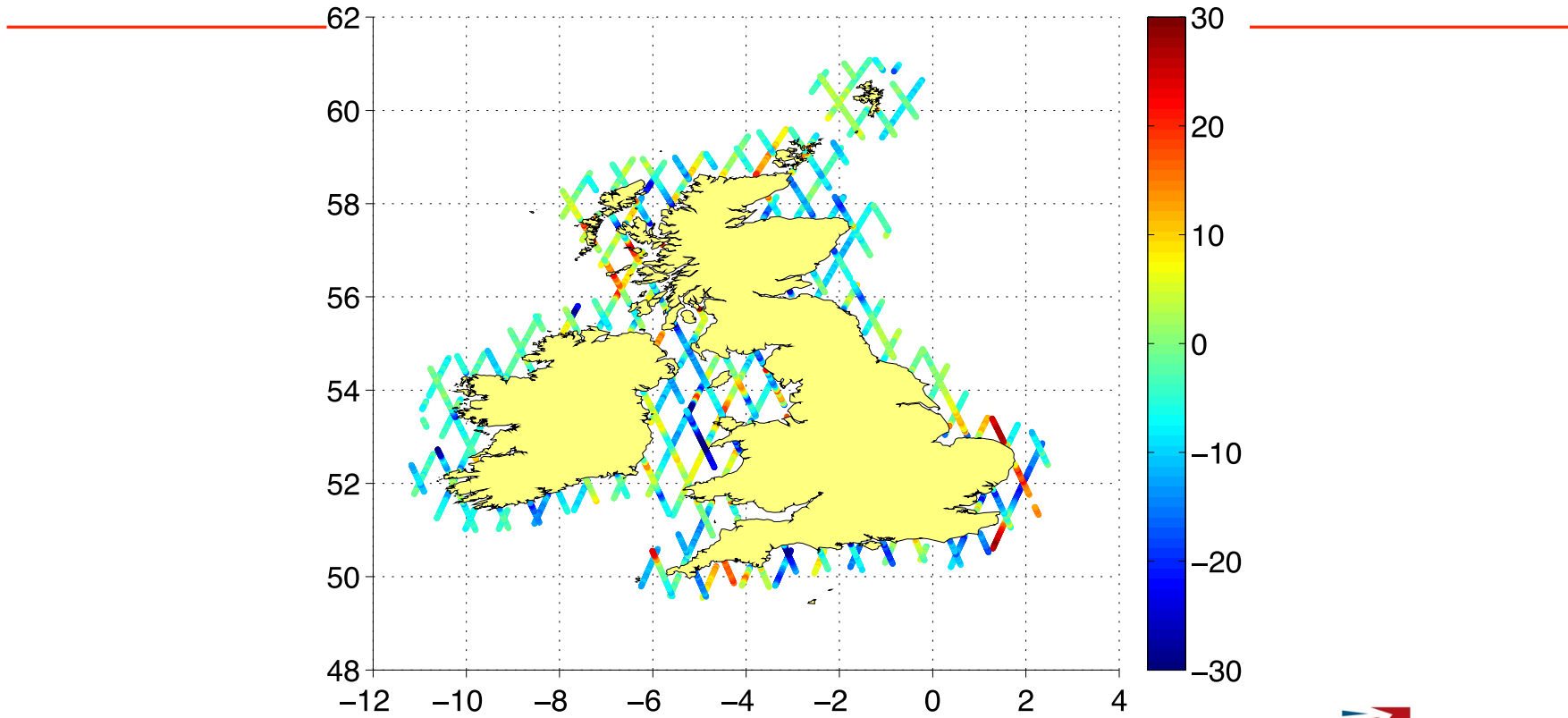
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Sea Level Trend (mm/yr) from Envisat 2002–2010



Led by the UK Space Agency

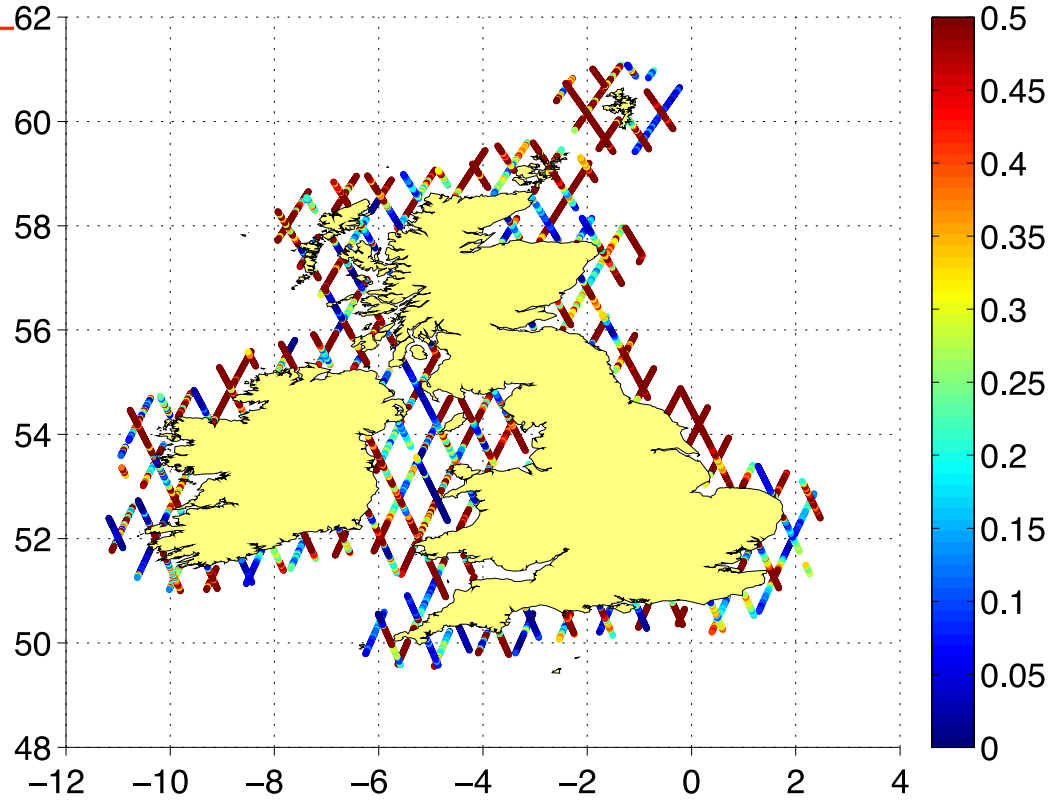
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





p-value of Sea Level Trend estimate from Envisat 2002–2010



Led by the UK Space Agency

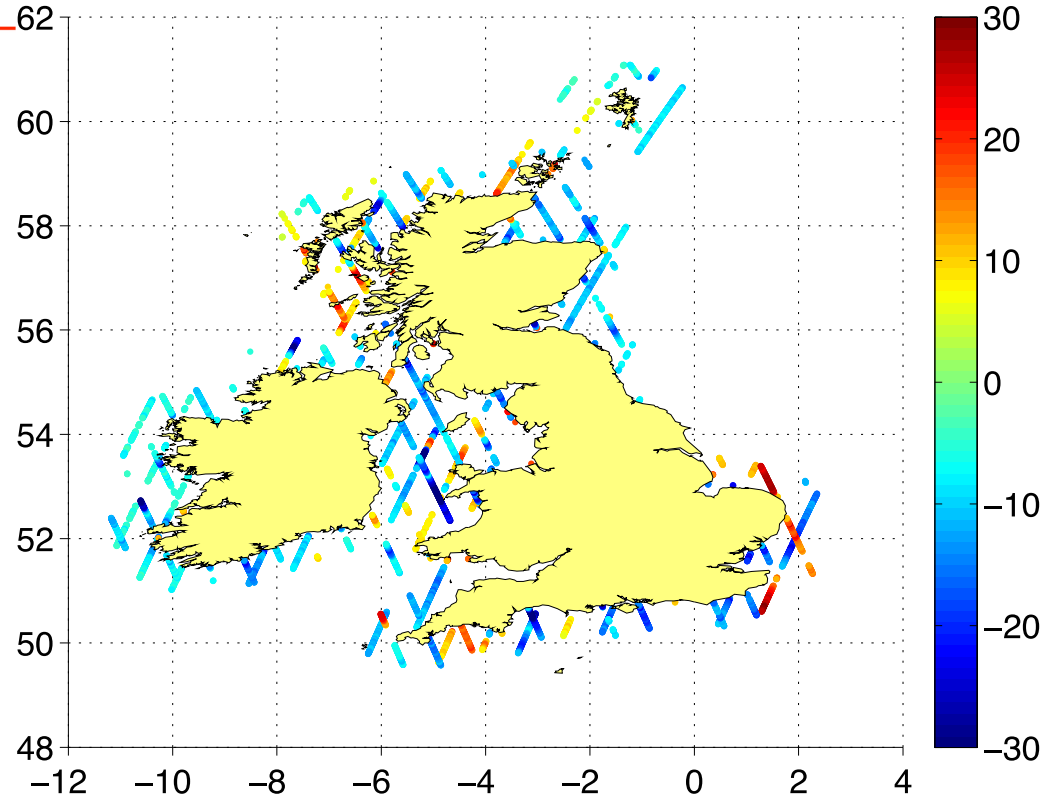
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Sea Level Trend (mm/yr) from Envisat 2002–2010 – significant



Led by the UK Space Agency

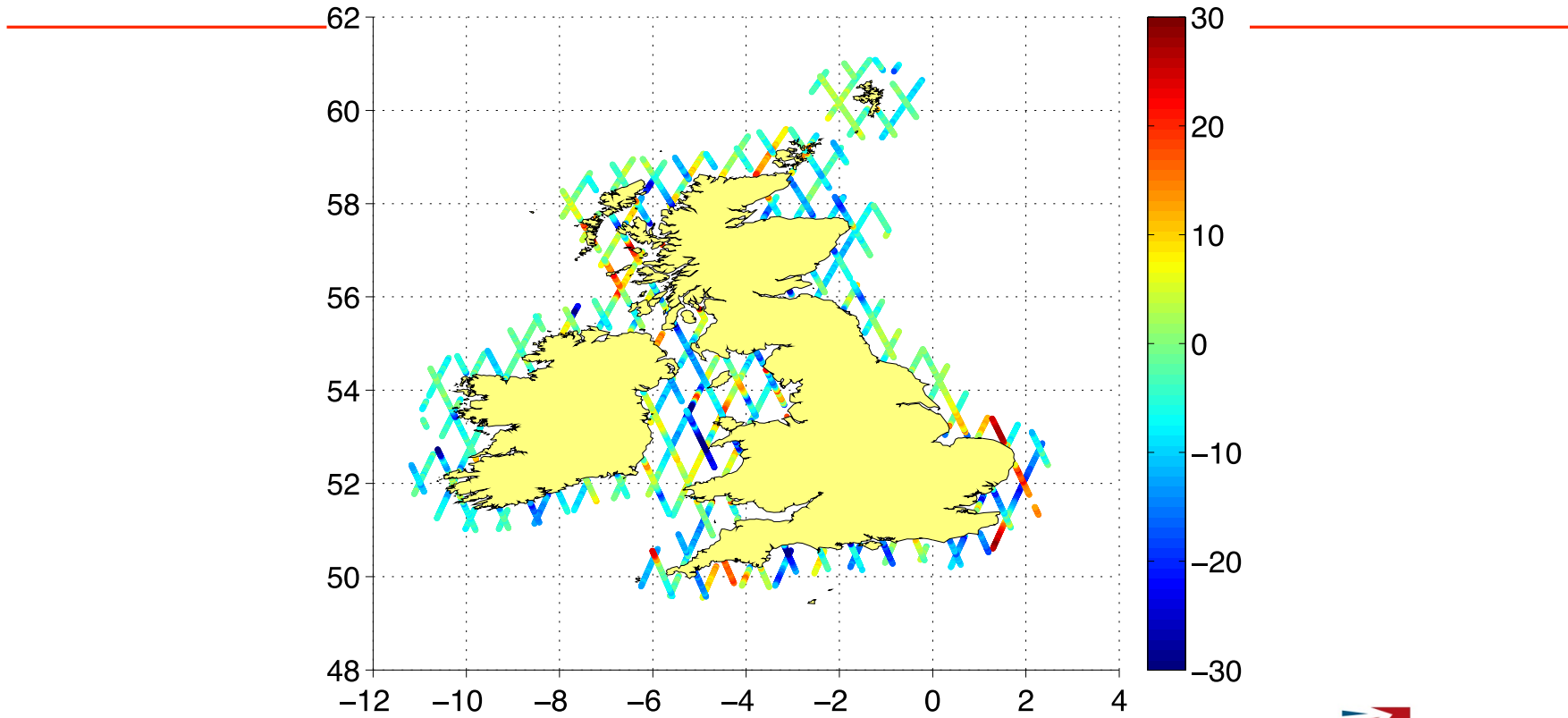
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Sea Level Trend (mm/yr) from Envisat 2002–2010



Led by the UK Space Agency

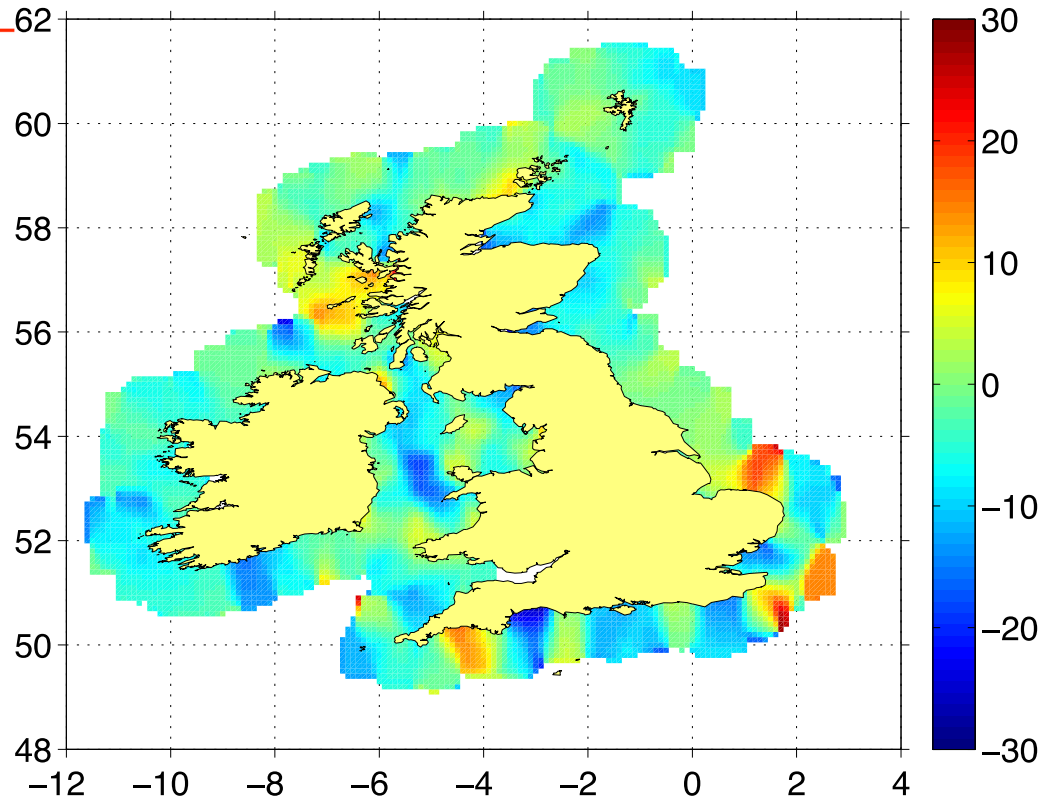
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Sea Level Trend (mm/yr) from Envisat 2002–2010



Led by the UK Space Agency

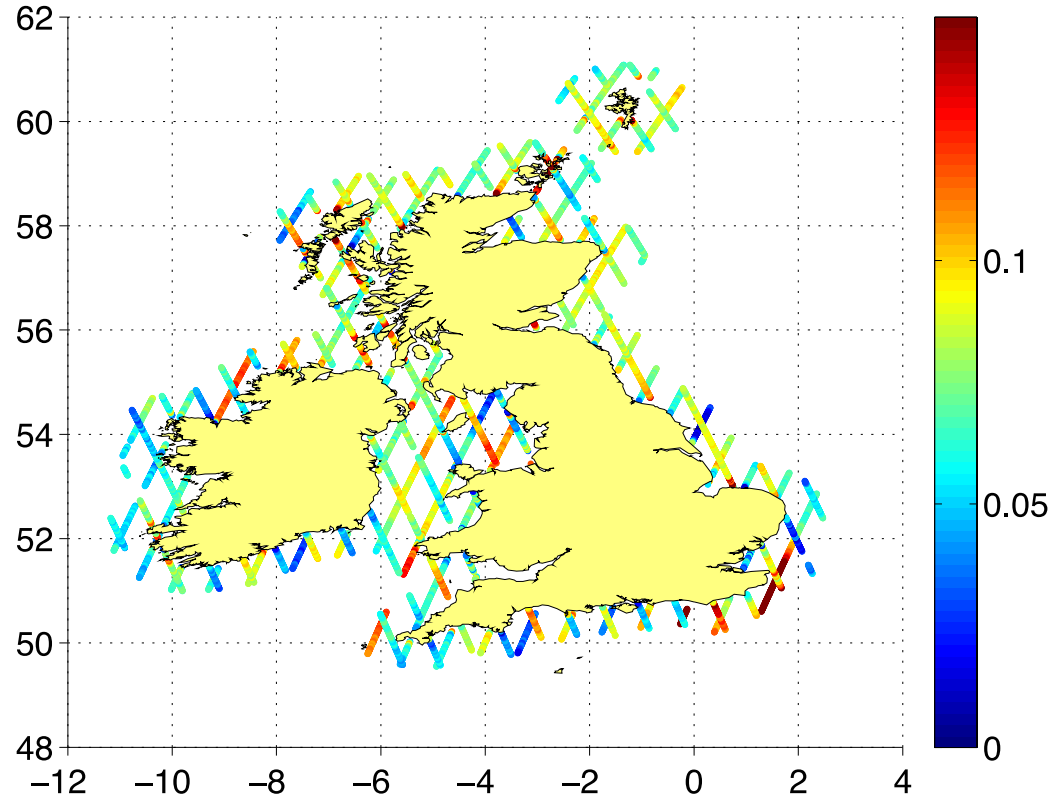
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Amplitude of Sea Level annual cycle (m) from Envisat 2002–2010



Led by the UK Space Agency

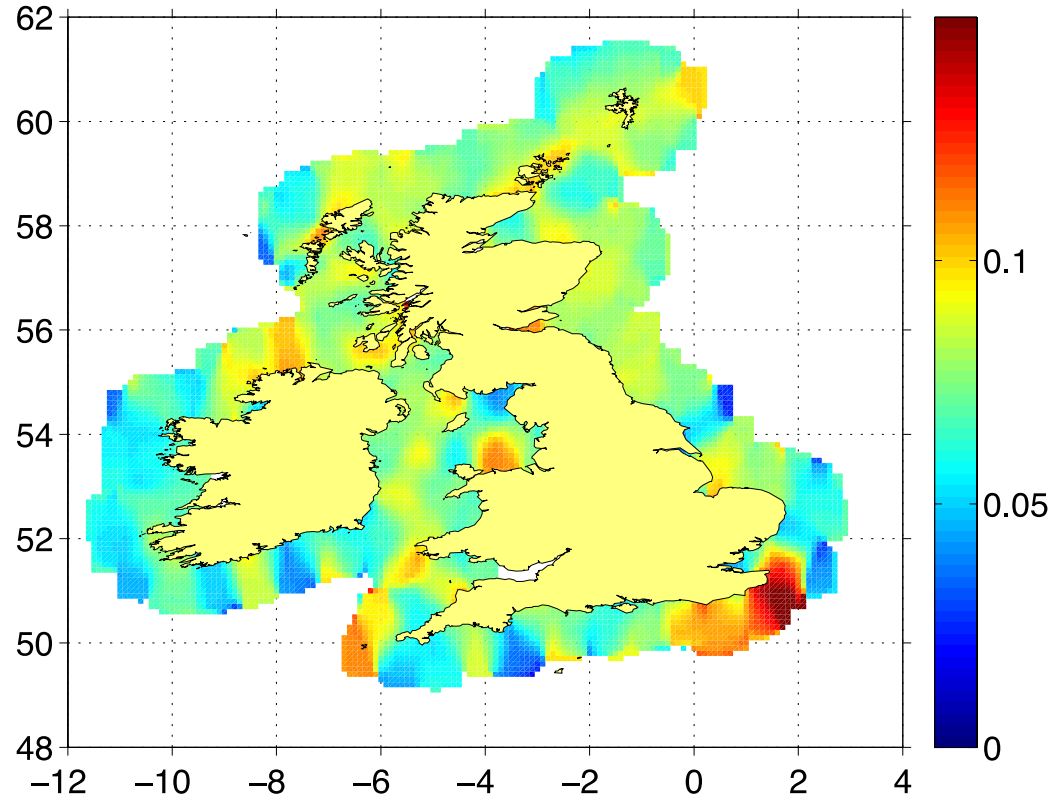
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Amplitude of Sea Level annual cycle (m) from Envisat 2002–2010



Led by the UK Space Agency

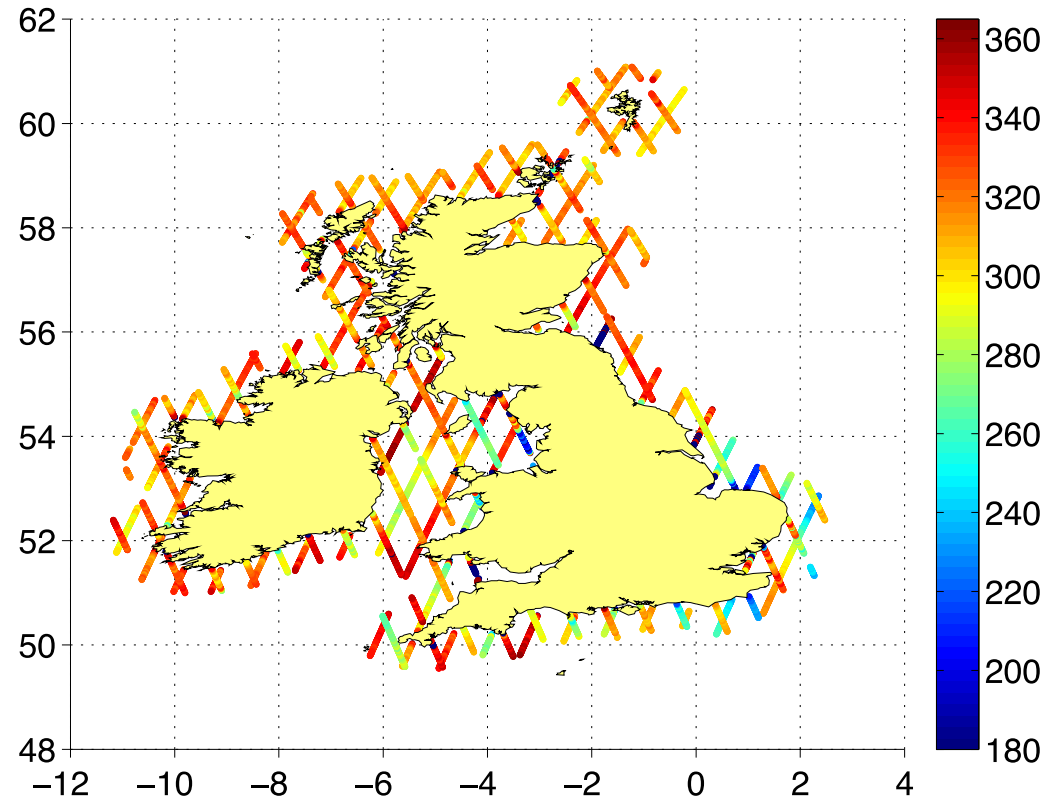
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Phase of Sea Level annual cycle (day-of-year) from Envisat 2002–2010



Led by the UK Space Agency

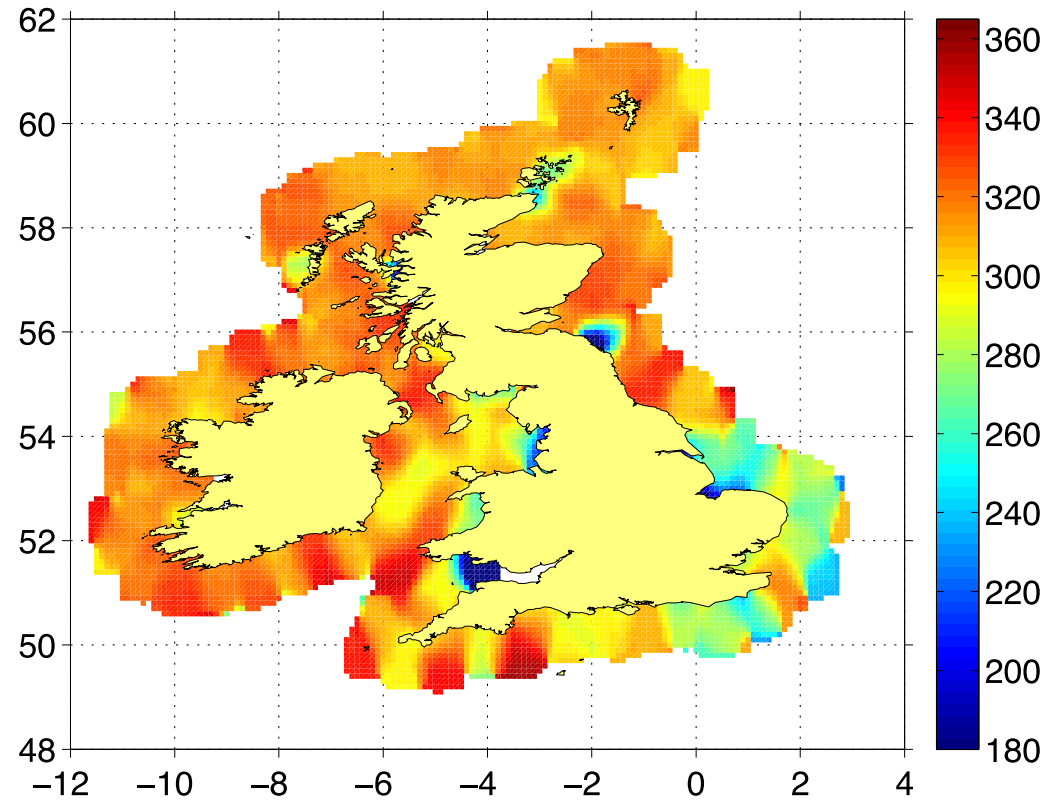
Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Phase of Sea Level annual cycle (day-of-year) from Envisat 2002–2010



Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA





Conclusions

- Altimetry has the potential to provide Sea Level information (trends, variability, seasonal signals) in the coastal region...
- ... with a fine spatial sampling that nicely complements the virtually continuous temporal sampling by Tide Gauges
- ... and linking open ocean → shelf seas → coastal zone in a way that cannot be achieved with other observational techniques at present.

Led by the UK Space Agency

Delivered in collaboration with the Satellite Applications Catapult

Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA



CATAPULT
Satellite Applications