Space for Smarter Government Programme

Altimeter processing and data for Sea Level SpaceWatch Phase 2

Paolo Cipollini, Francisco Calafat
National Oceanography Centre

Web:
http://www.spaceforsmartergovernment.uk/
Email: ssgp@sa.catapult.org.uk

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

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

UK SPACE AGENCY

CATAPULT Satellite Applications

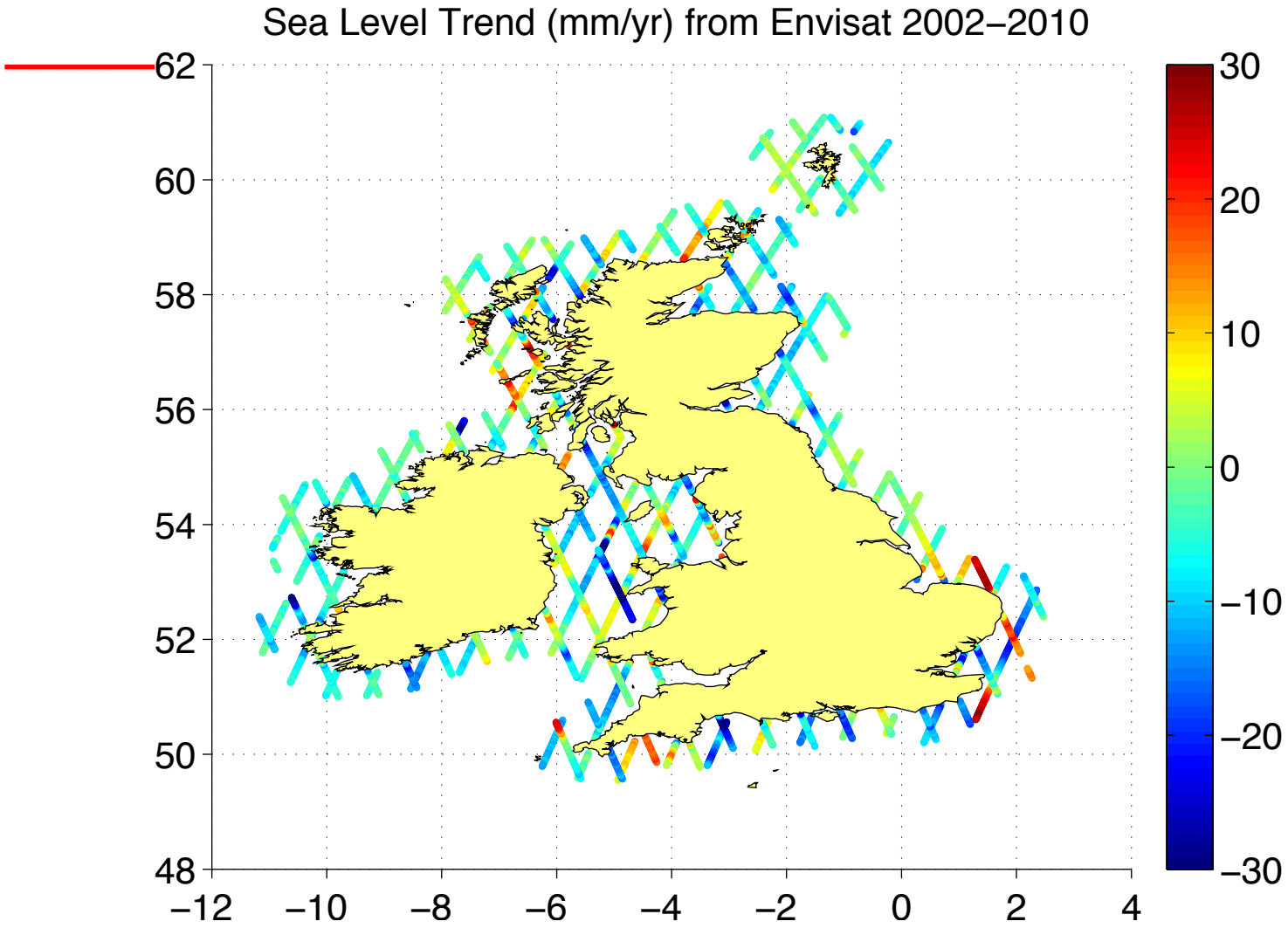
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

Outline

- Summary of extension and improvements wrt Phase 1
- The extended Jason-1/Jason-2 dataset 2002-2015
  - homogenisation of corrections
- Results:
  - trends and relative errors
  - amplitude and phase of the annual signals

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

PREVIOUS RESULTS – that's what we started from



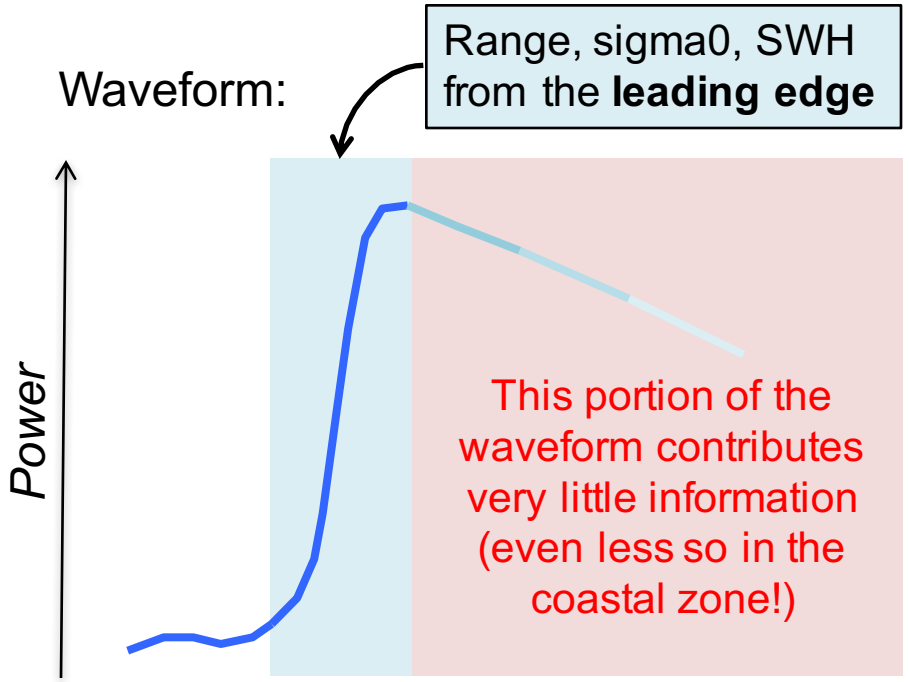
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

Altimeter processing for Sea Level SpaceWatch

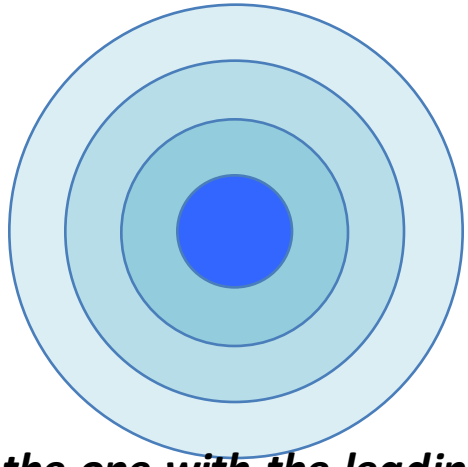
- Altimetry data in the coastal zone need specialized waveform processing (retracking). The solution adopted in SLSW is to use a specialized coastal retracker (ALES)
- compute two sea level quantities:
  - **TWLE** - Total Water Level Envelope i.e. the actual level including tides and atmospheric forcing – 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 (product)
- compute a few statistics (also a product)

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

The ALES approach

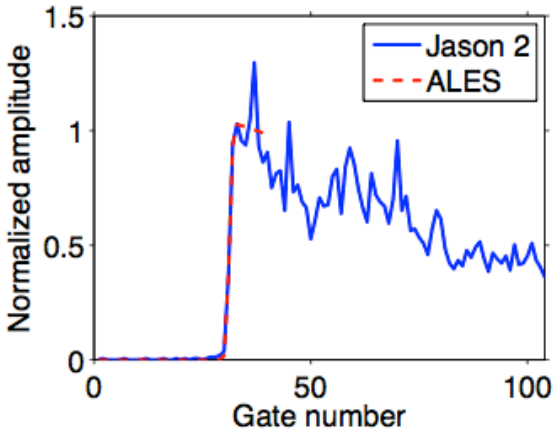


Illuminated surface:

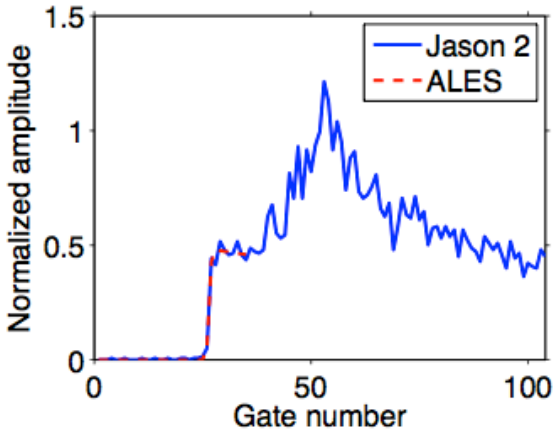


→ ***use only part of the waveform, the one with the leading edge***
Adaptive Leading-Edge Subwaveform (ALES) retracker

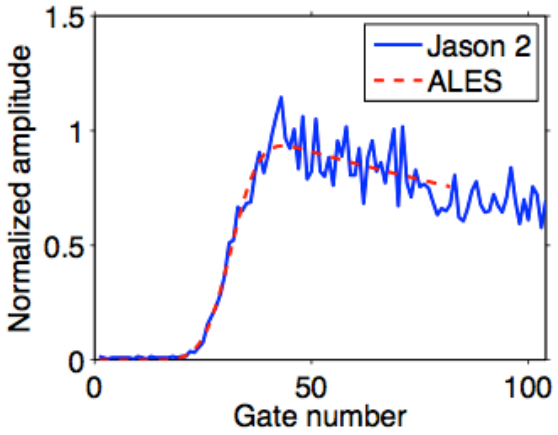
Examples of Jason-2 retracking by ALES



Open ocean
SWH = 0.75 m



Coastal ocean
SWH = 1.65 m



Open ocean
SWH = 9.5 m

- Validated for SSH for Envisat, J-1, J-2, AltiKa Passaro et al, 2014, 2015b)
- Validated for SWH for Envisat, J-1/2 (Passaro et al 2015a)
- J-1, J-2 and Envisat data available now for SeaLevel SpaceWatch, AltiKa in progress

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

Products in Phase 2

- Two pairs of missions 2002-2015 (14 full years)
  - Jason-1 + Jason-2 (10-day orbit)
    - processing completed
  - Envisat + AltiKa (35-day orbit)
    - AltiKa still work in progress
- Latest corrections, consistent across missions (see next slide)
- Time series of TWLE,SSHA, SSHA screened/filtered
- 14-yr trend & uncertainty (standard error)
  - computed with Newey-West algorithm that accounts for correlation of time series
  - validation: see Simon's talk
- Annual cycle phase and amplitude
  - Inter-annual variability can be characterized by the standard deviation and the maxima of annual sea level values or by a more sophisticated mode (see Francisco's talk)

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

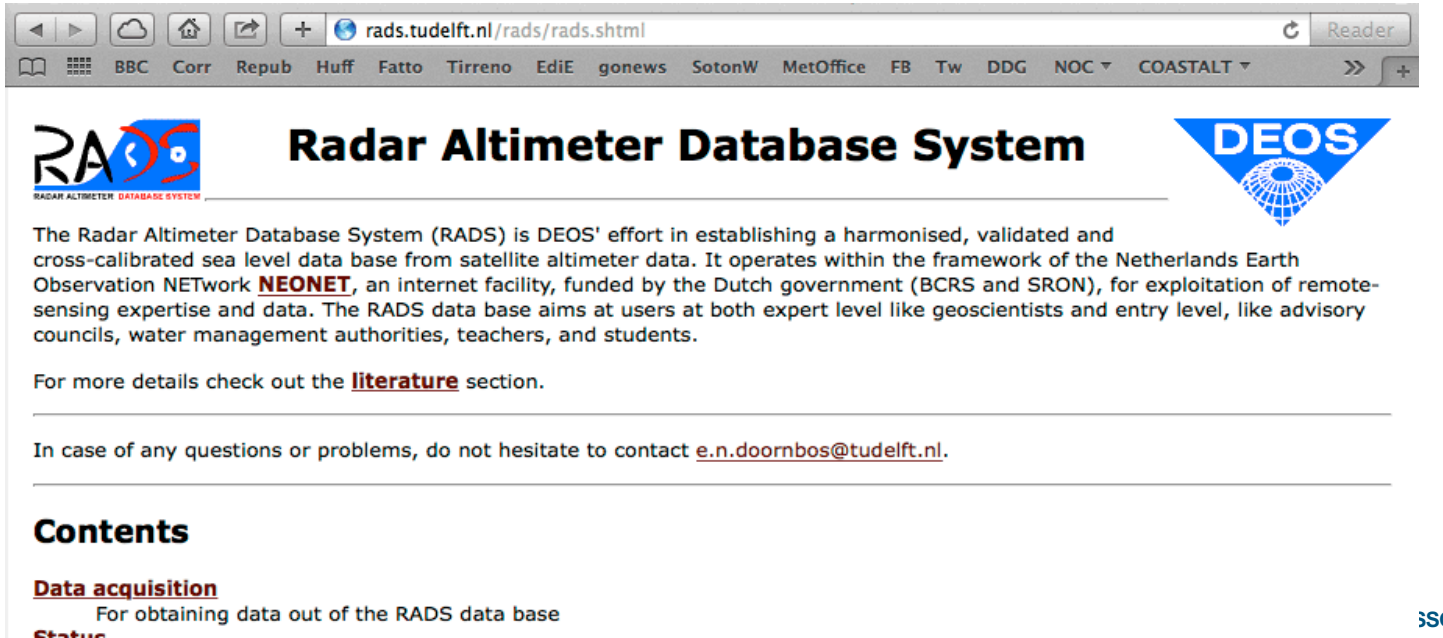
Updated corrections in SLSW - 1

- To derive SSH, altimetry data need to be corrected for instrumental, atmospheric and surface effects
  - To reach the required accuracy for SSH (~cm) and Sea Level rise rates (~mm/y) we need to apply **state-of-the-art corrections**
  - **a Mean Sea Surface** also needs to be subtracted
- Corrections need to be consistent across missions
  - correction provided with the original J-1 and J-2 data records are not the same! for instance J-1 has FES2004 and GOT4.8 tidal model, J-2 has FES2012 and GOT4.10

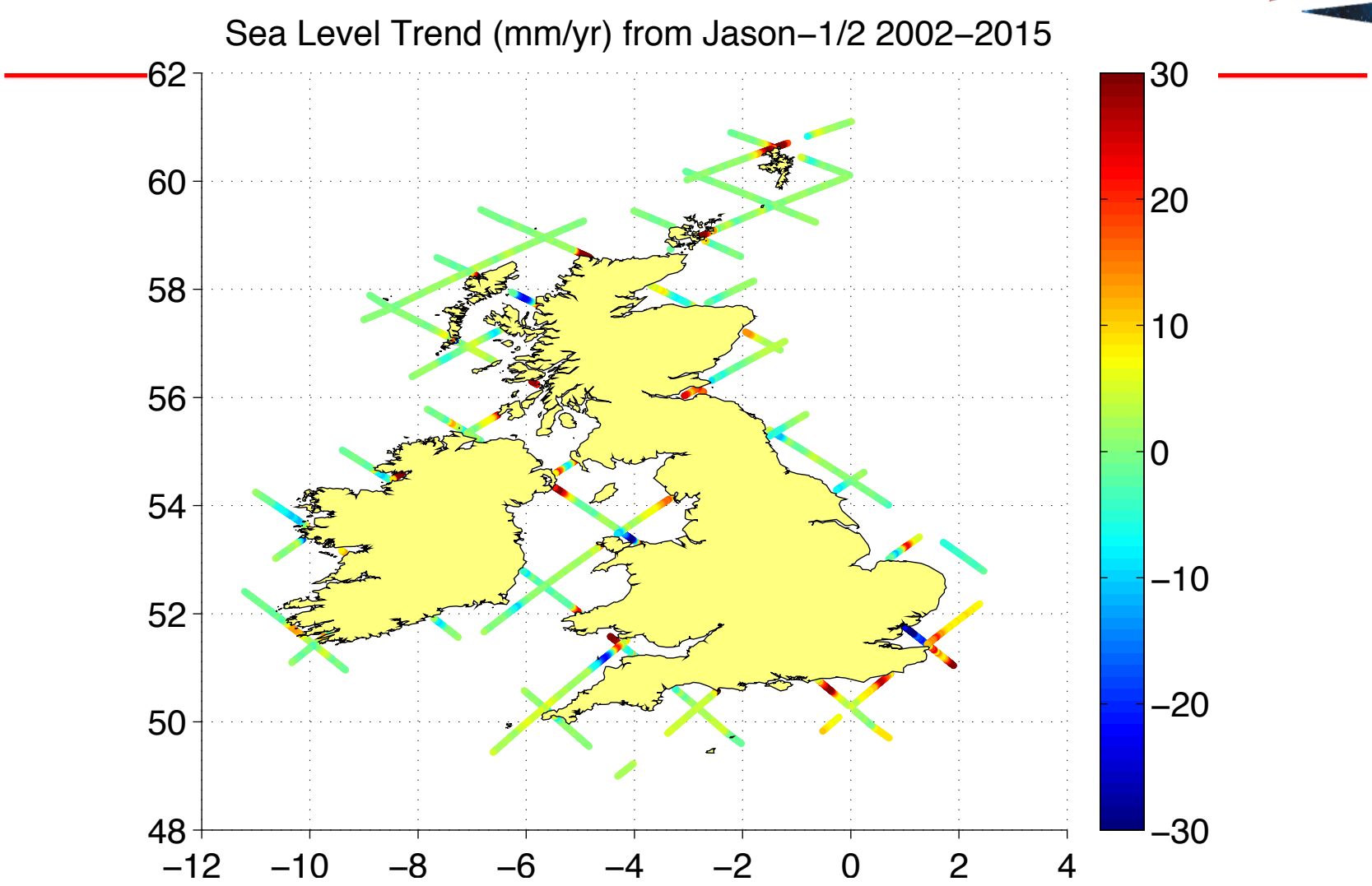
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

Updated corrections in SLSW - 2

- Solution: we get the latest corrections from the RADS archive, hosted by NOAA and TU Delft
  - No specific retracking in RADS, and only 1-Hz data (~7km), but the corrections are routinely updated and homogeneized across missions!



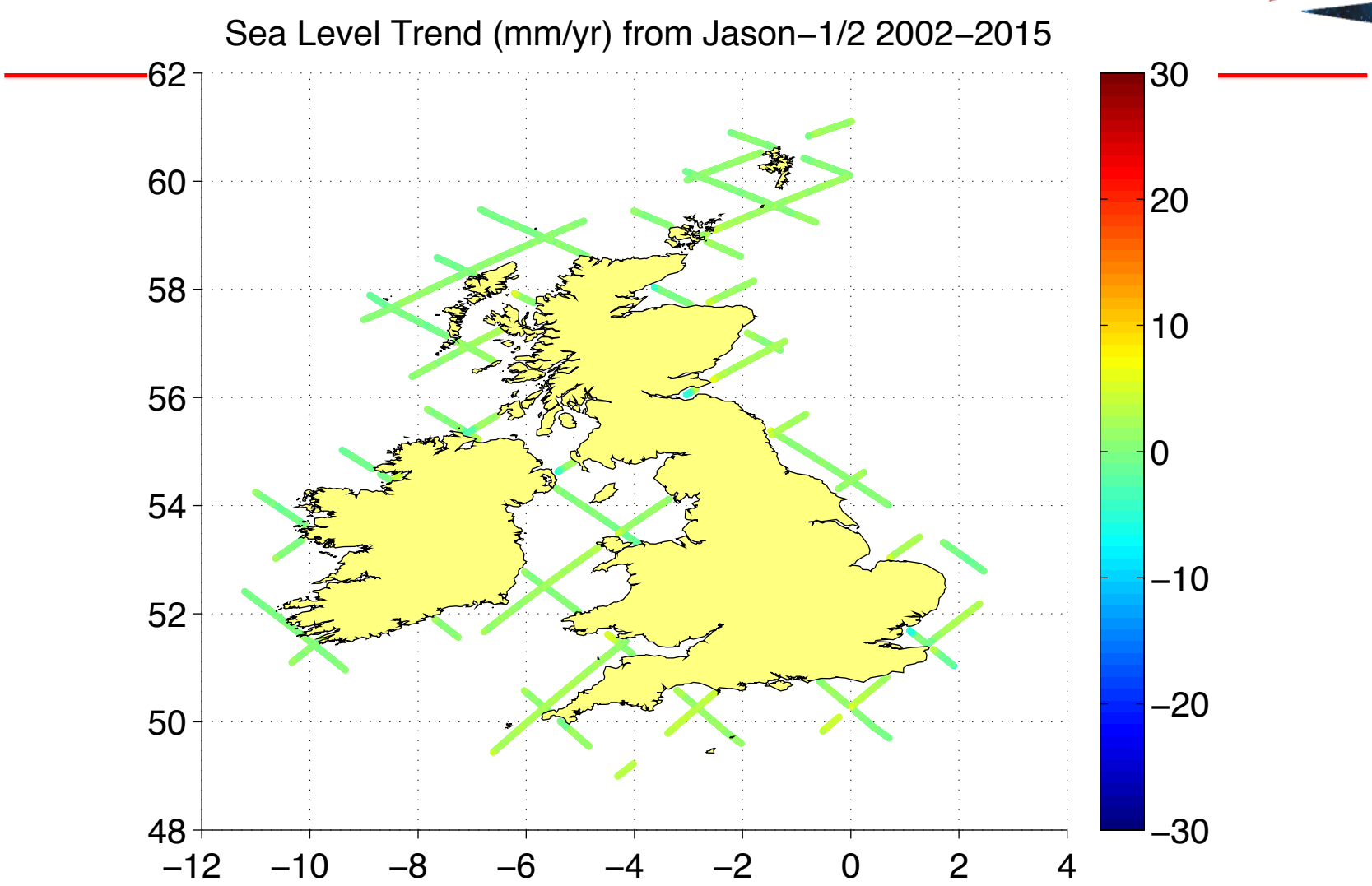
Jason-1/2
Original corrections



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

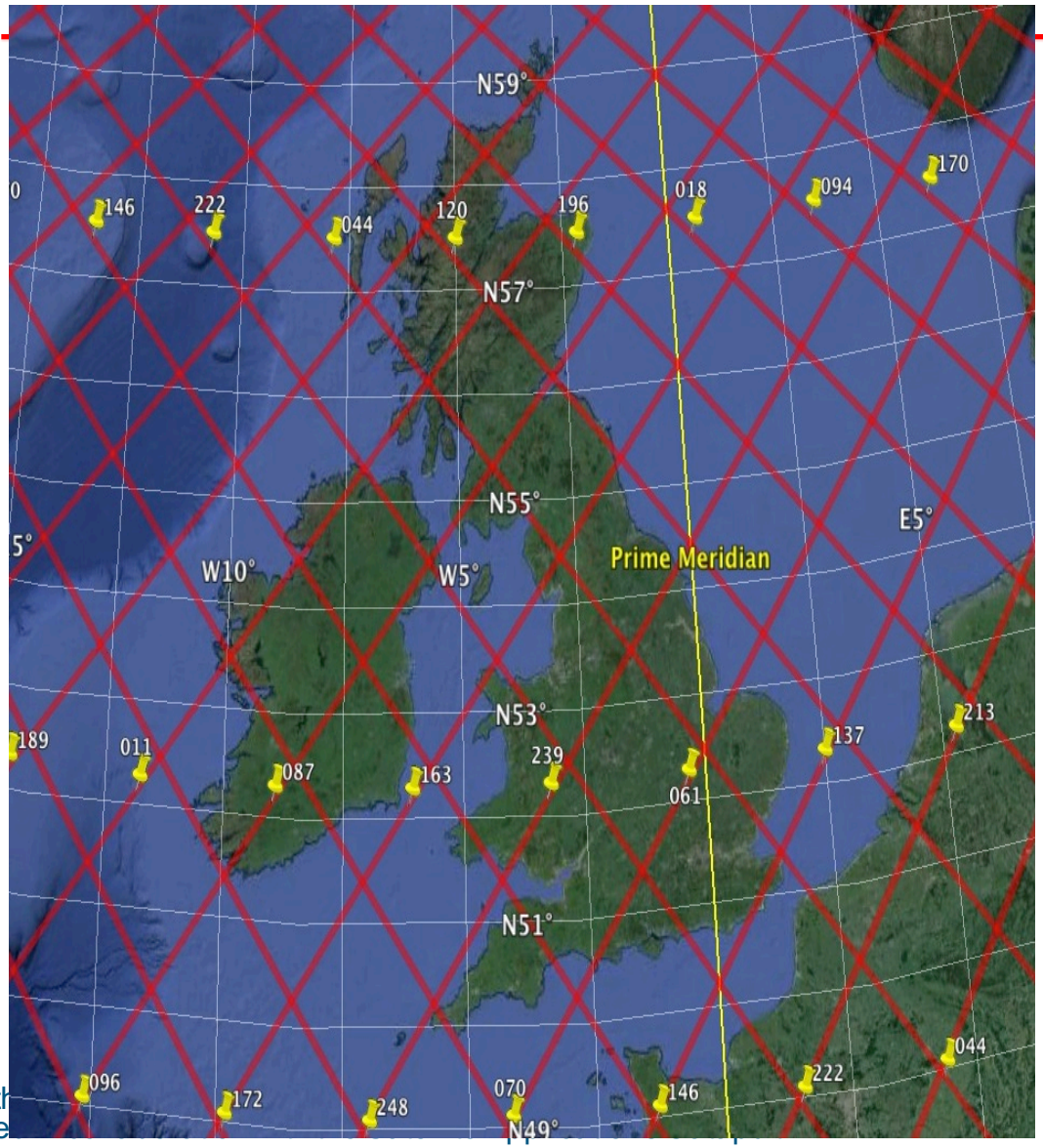
Jason-1/2
Updated corrections

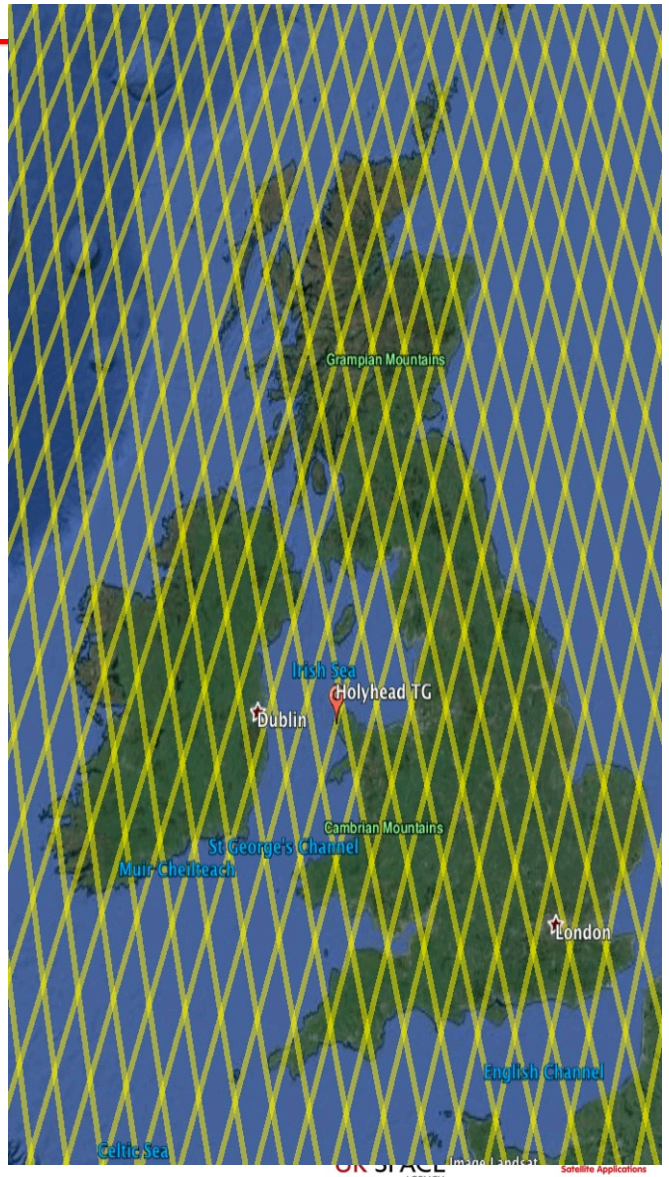


Led by the UK Space Agency
Delivered in collaboration with the Satellite Applications Catapult

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

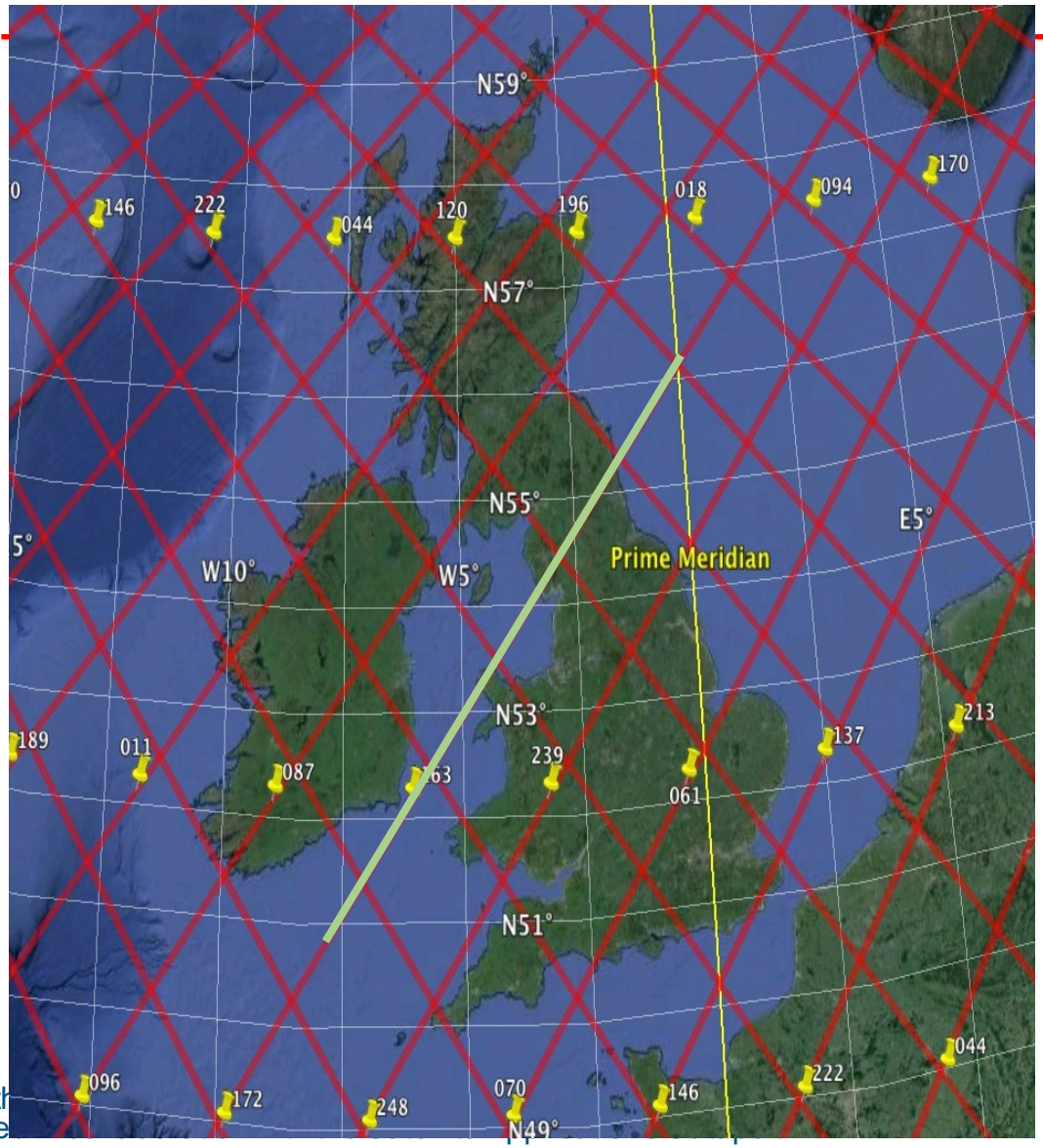
10-day and 35-day orbits

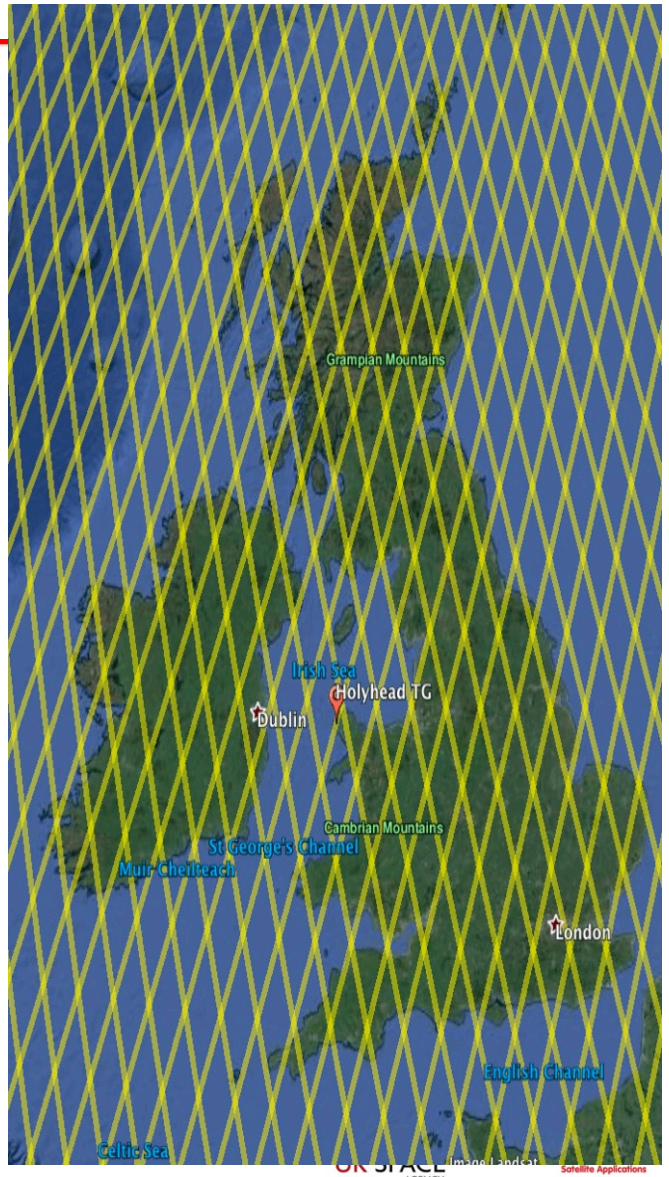




Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

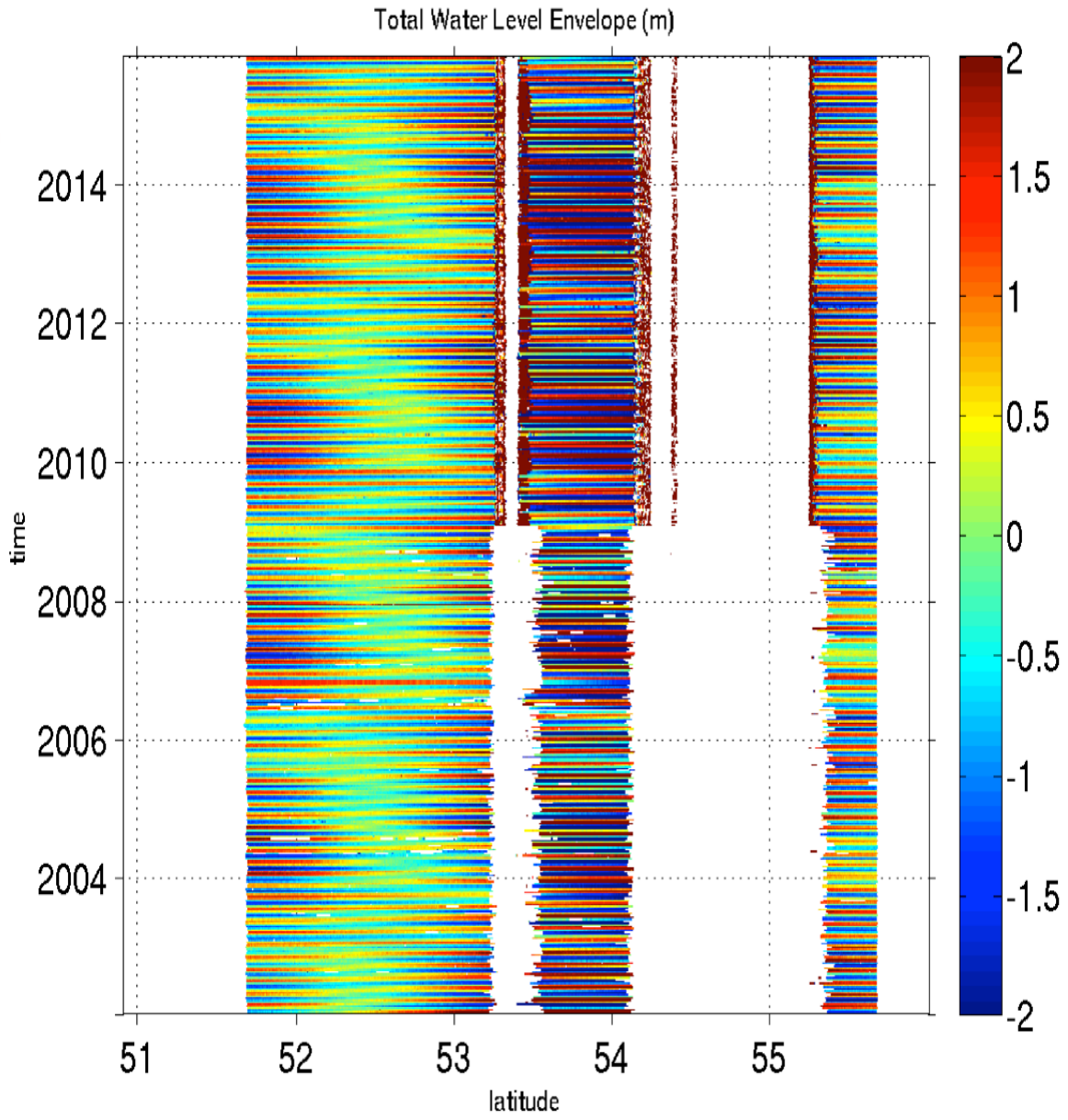
10-day and 35-day orbits





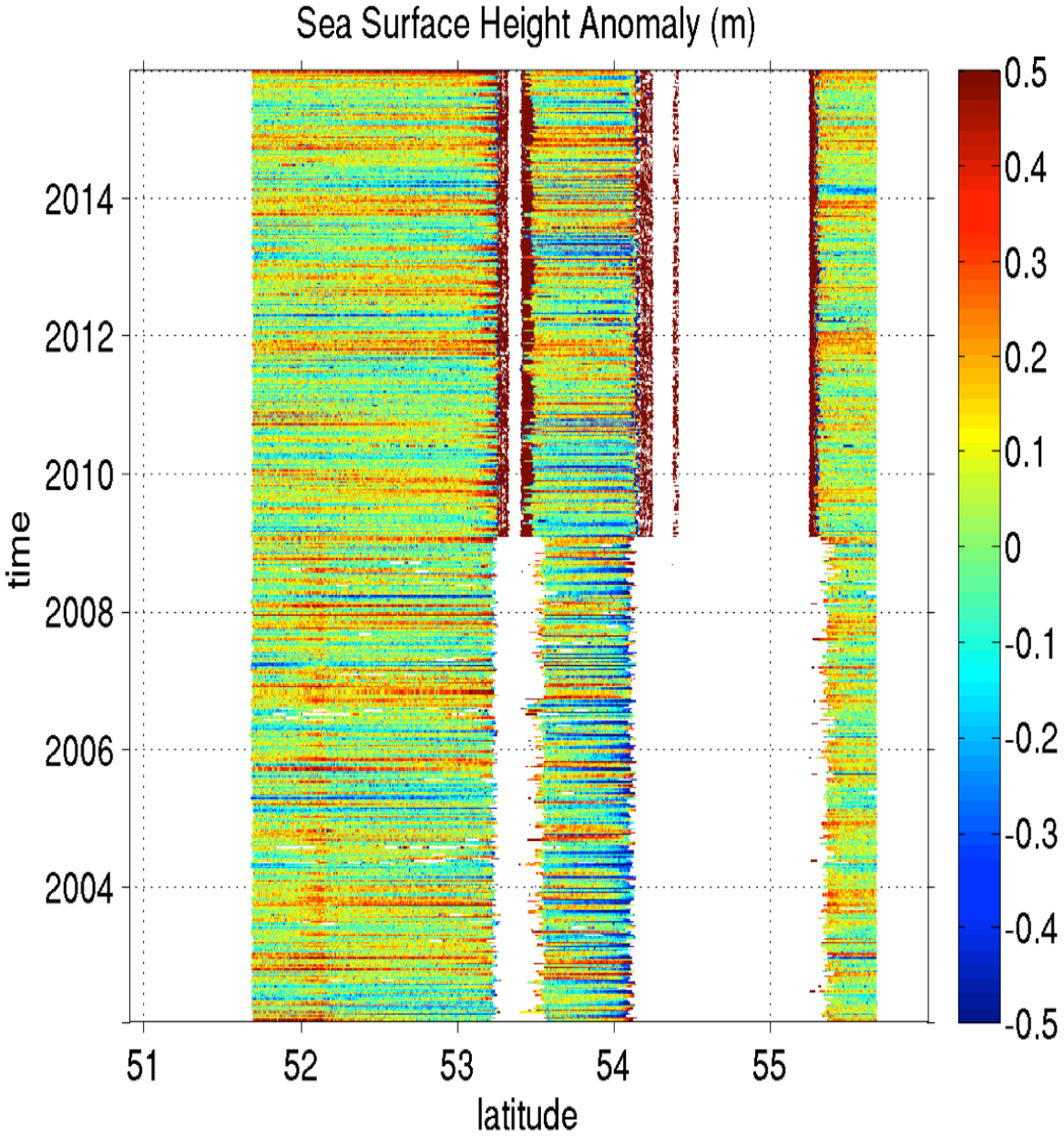
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

NEW DATA – Jason-1/2



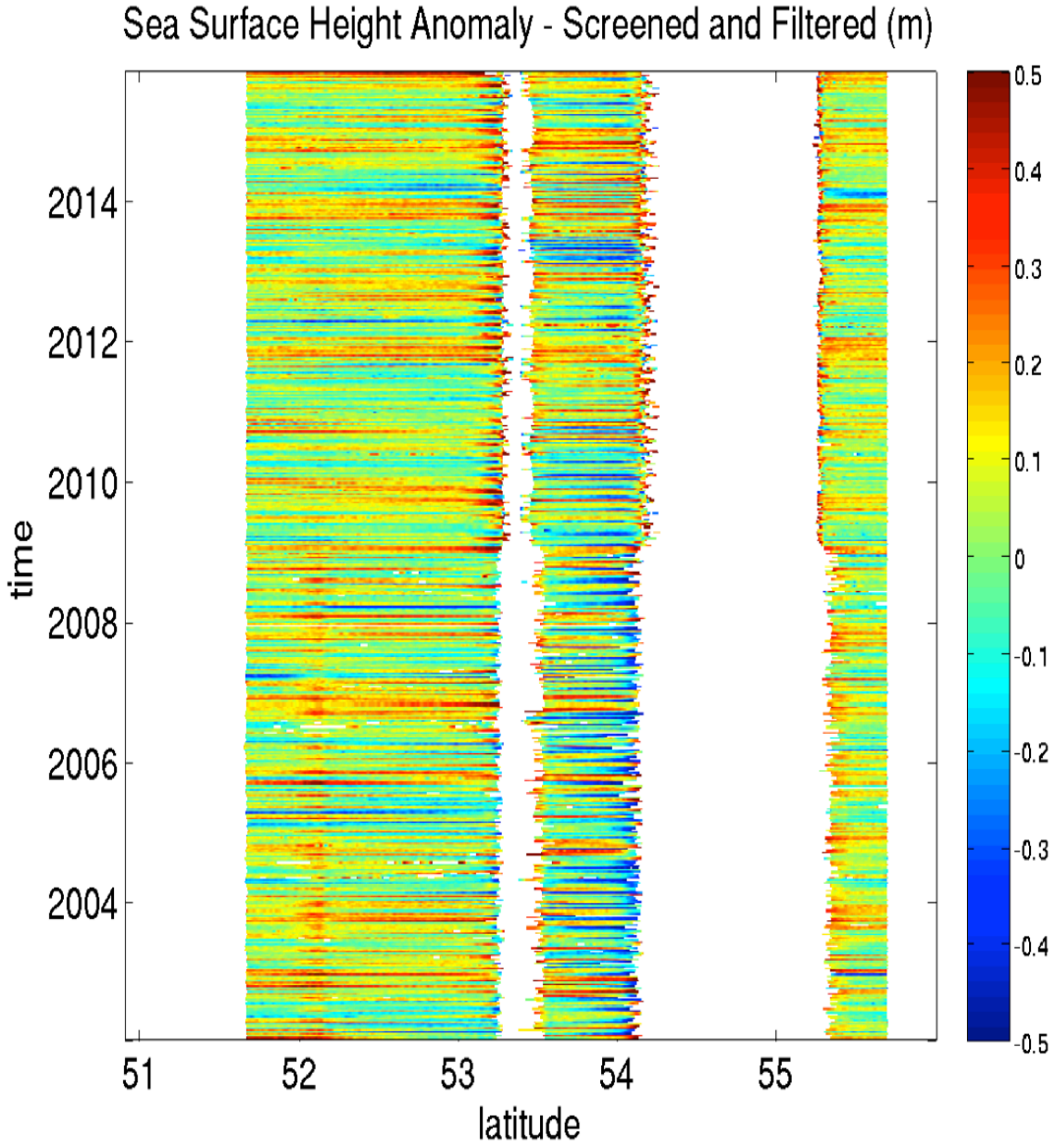
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

NEW DATA – Jason-1/2



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

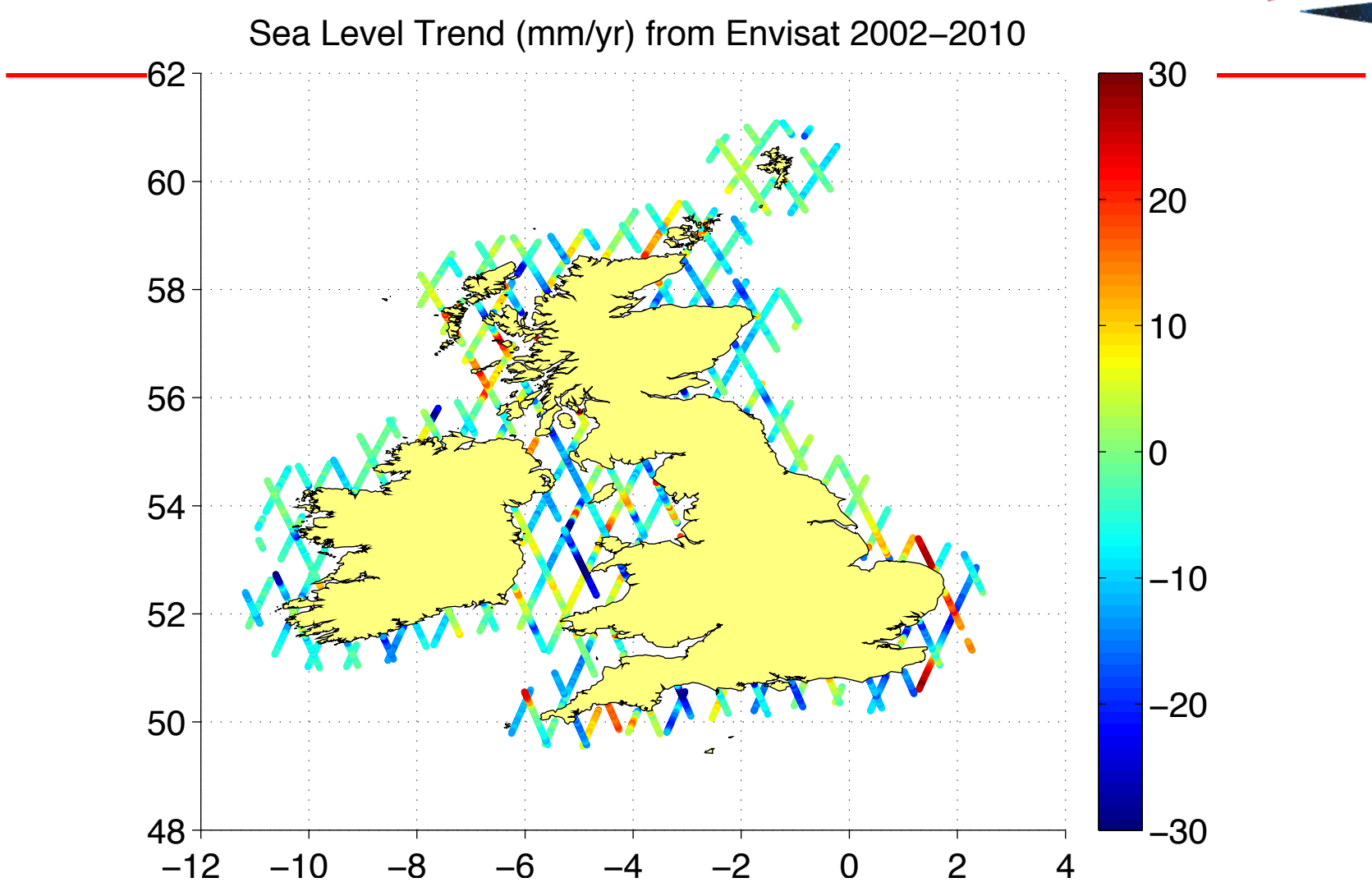
NEW DATA – Jason-1/2



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

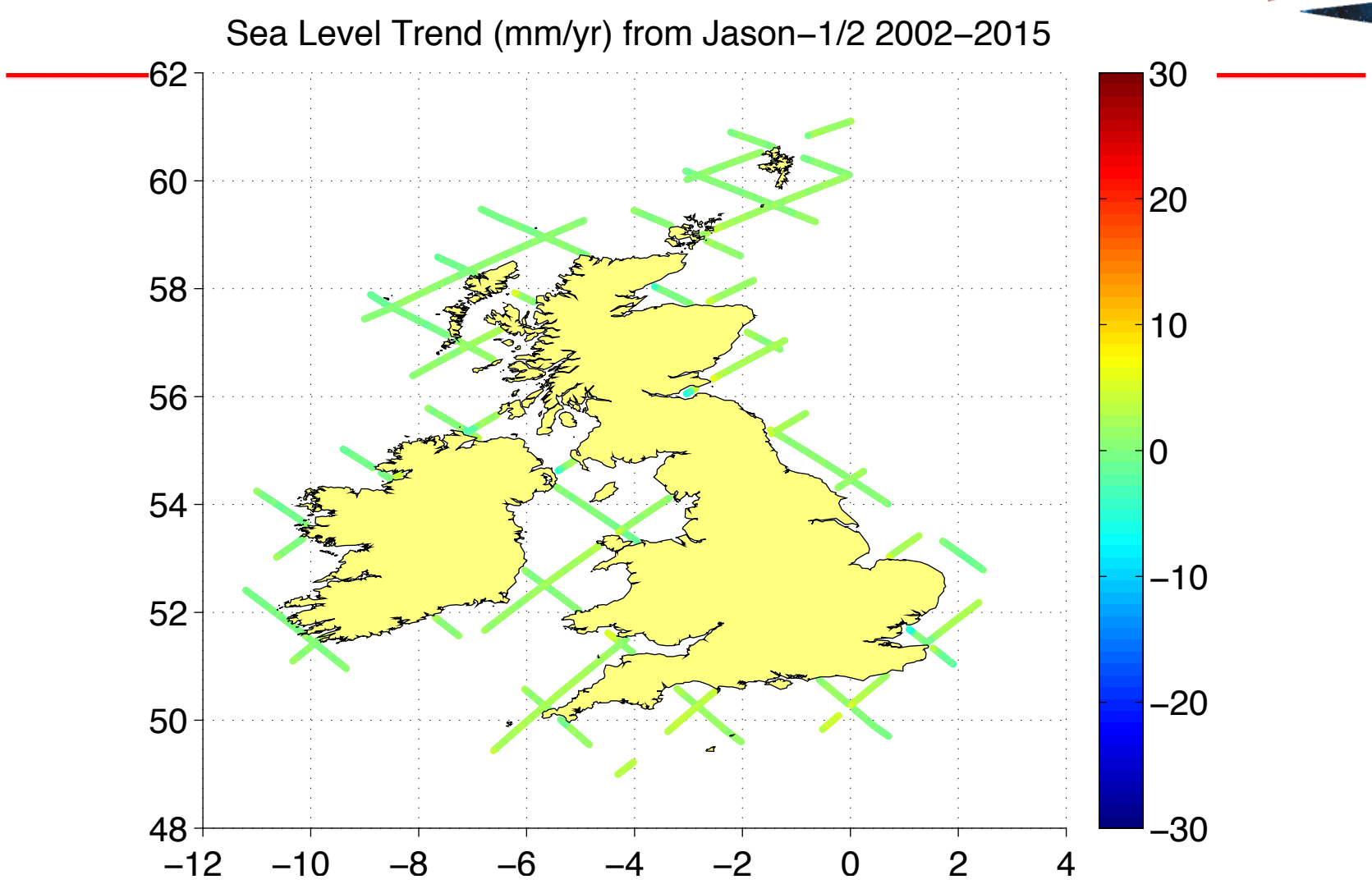
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

PREVIOUS RESULTS – Envisat



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

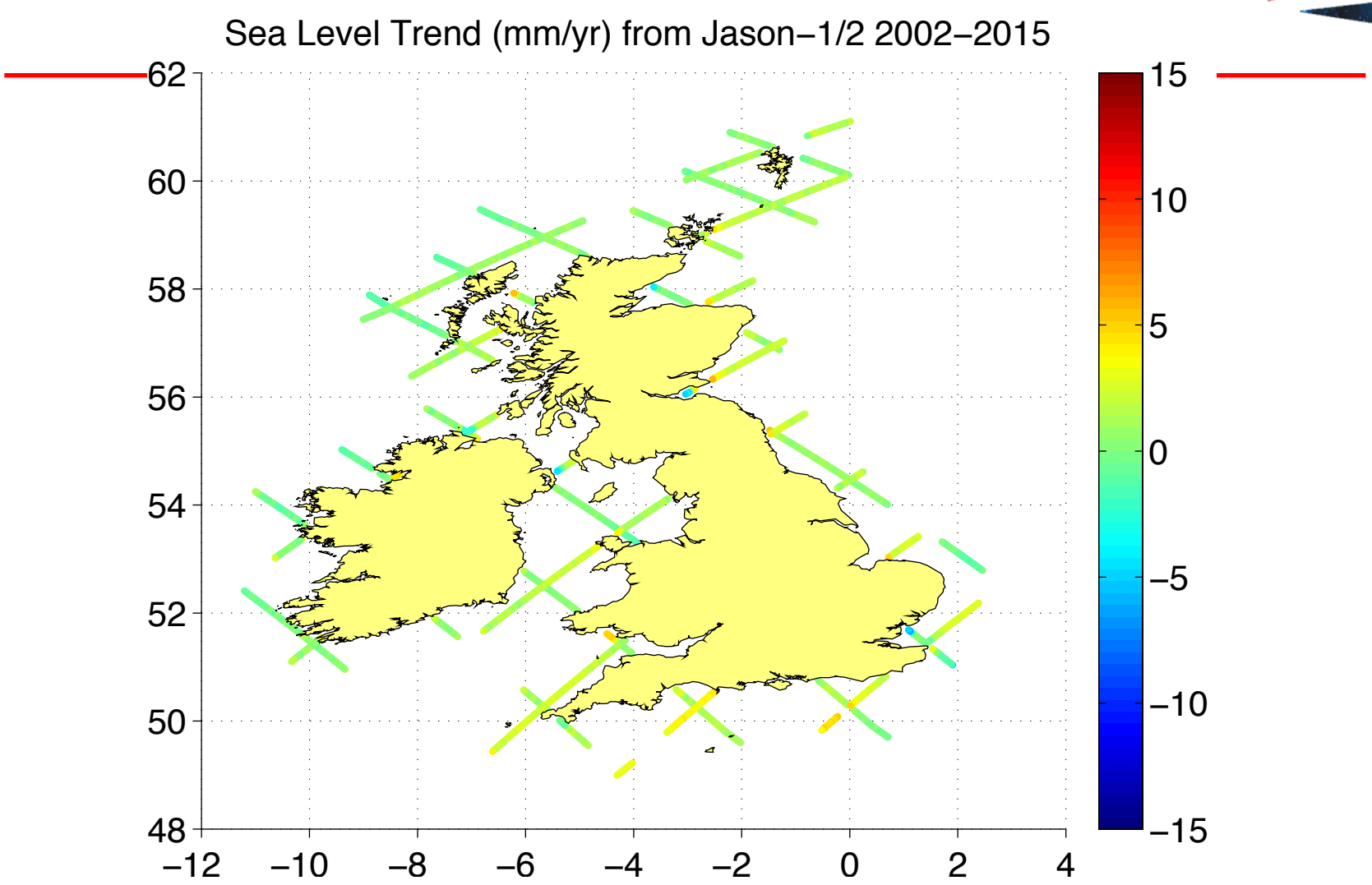
NEW RESULTS – Jason-1/2



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

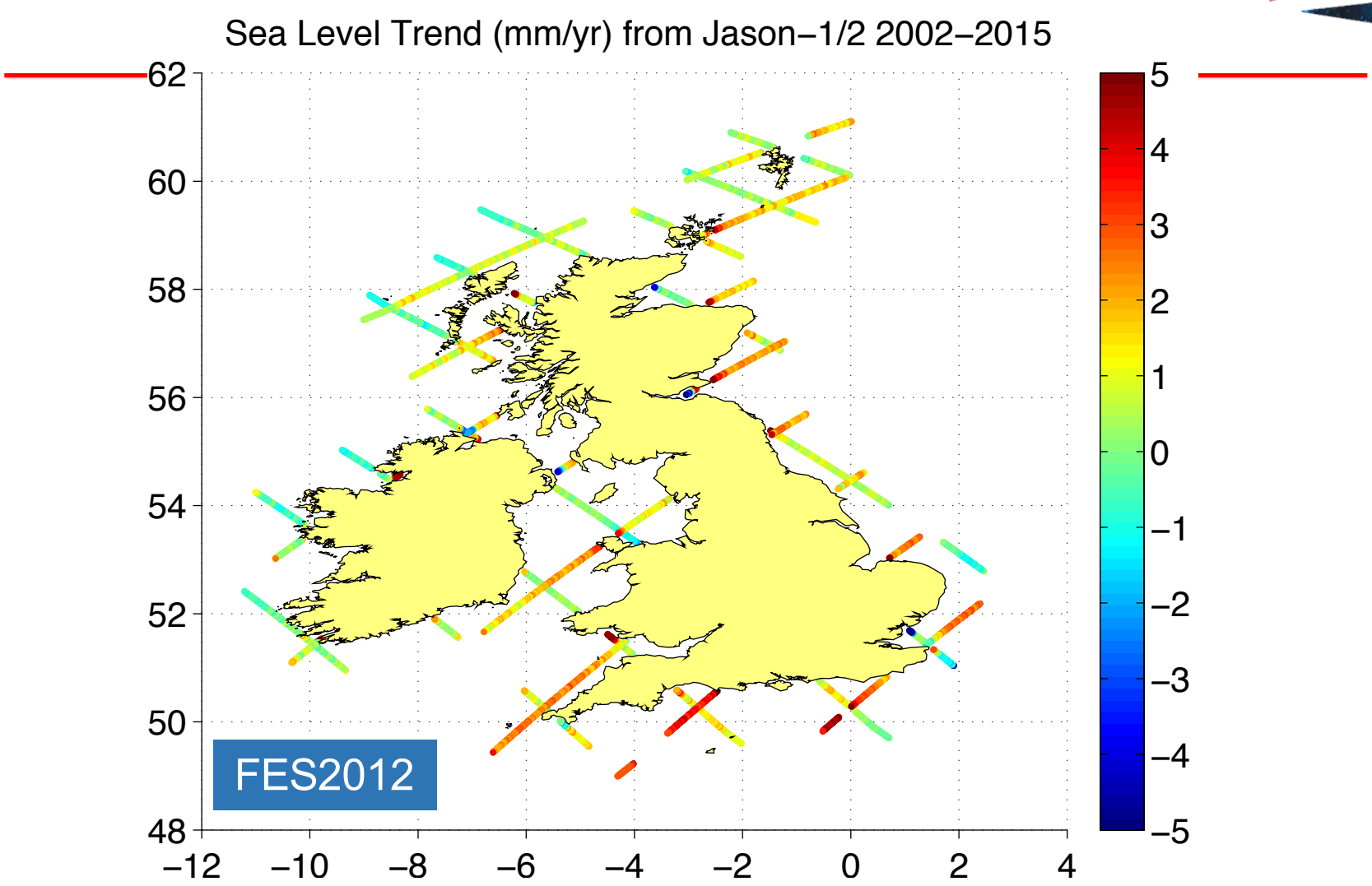
NEW RESULTS – Jason-1/2



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

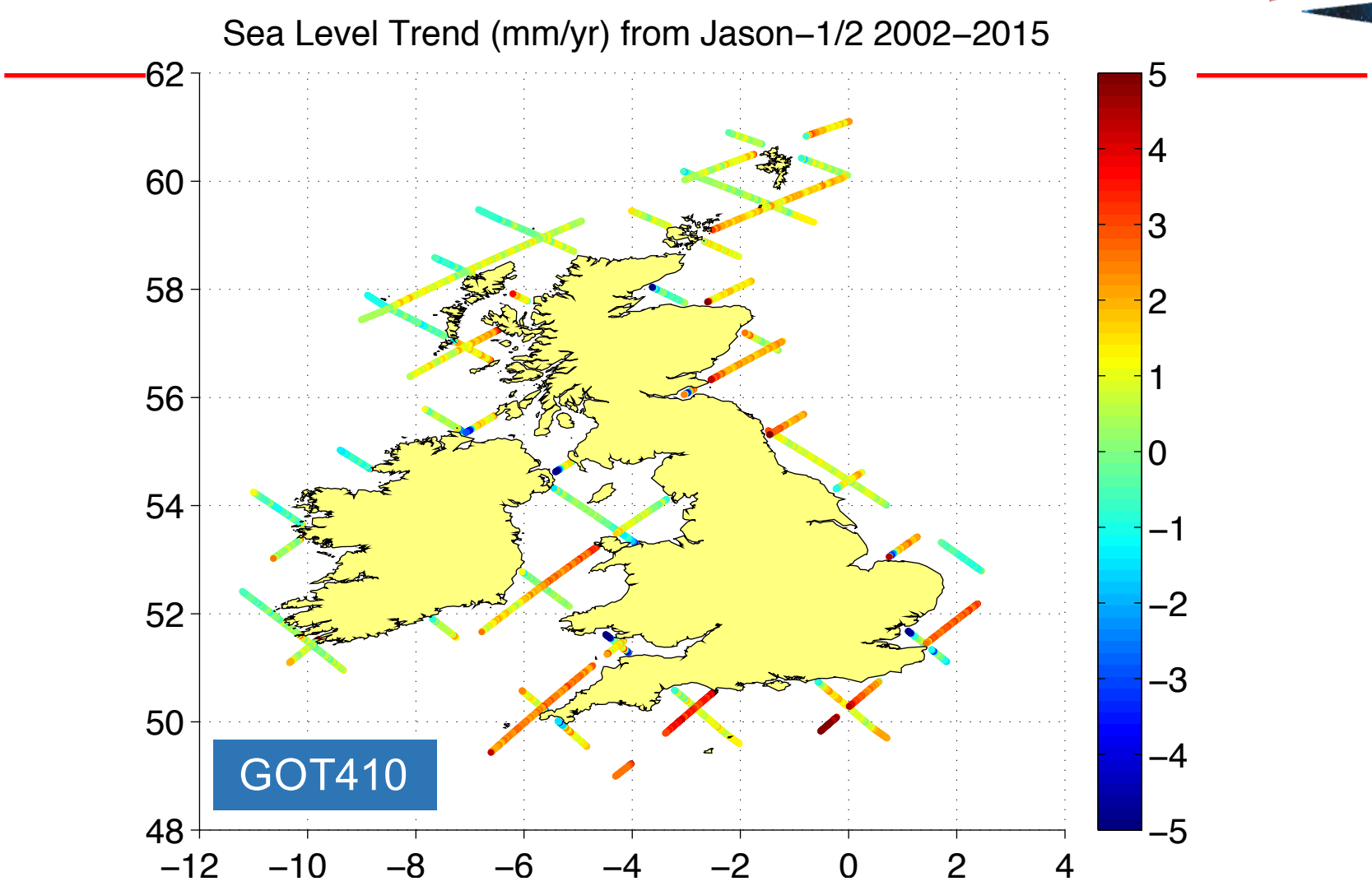
NEW RESULTS – Jason-1/2



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

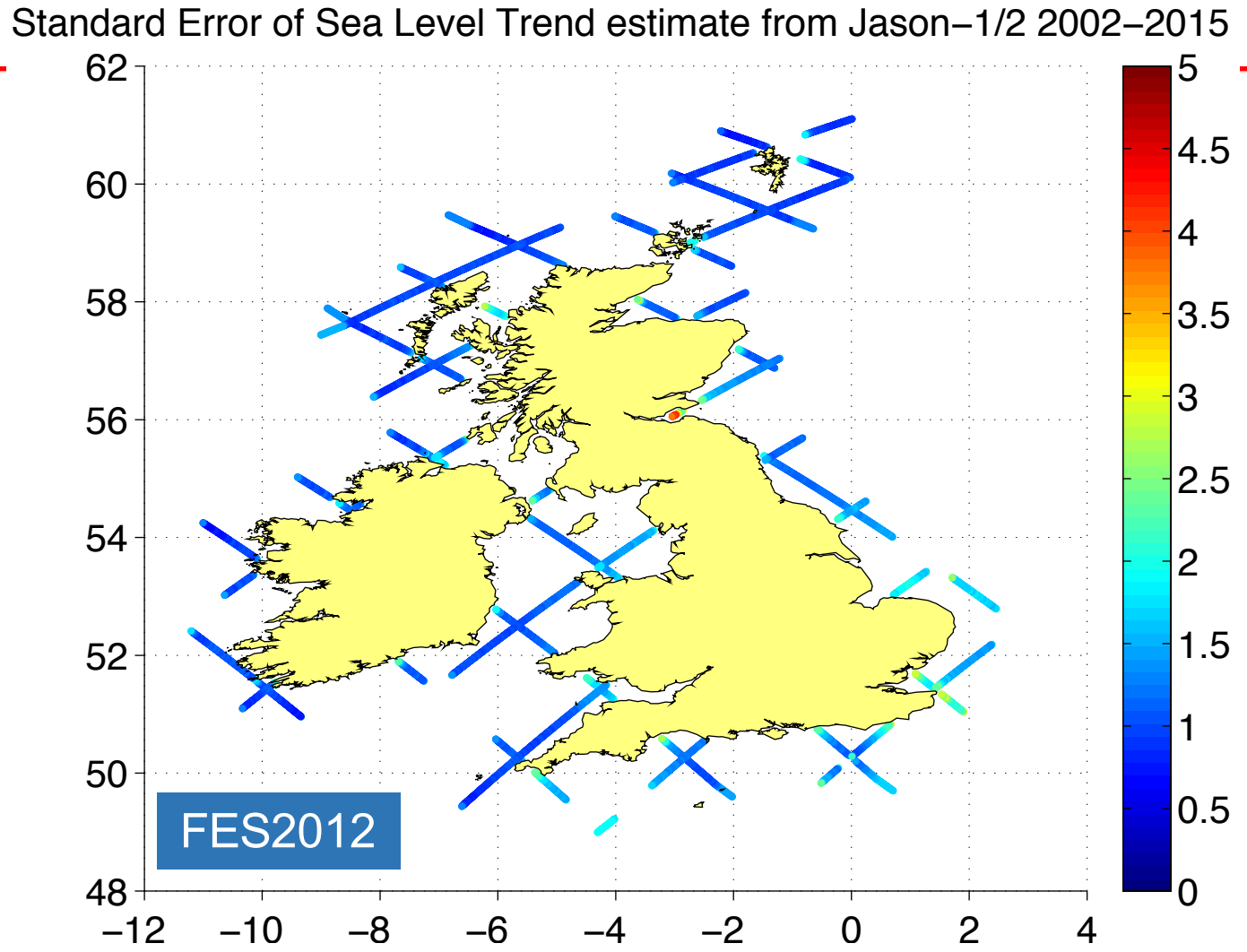
NEW RESULTS – Jason-1/2



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

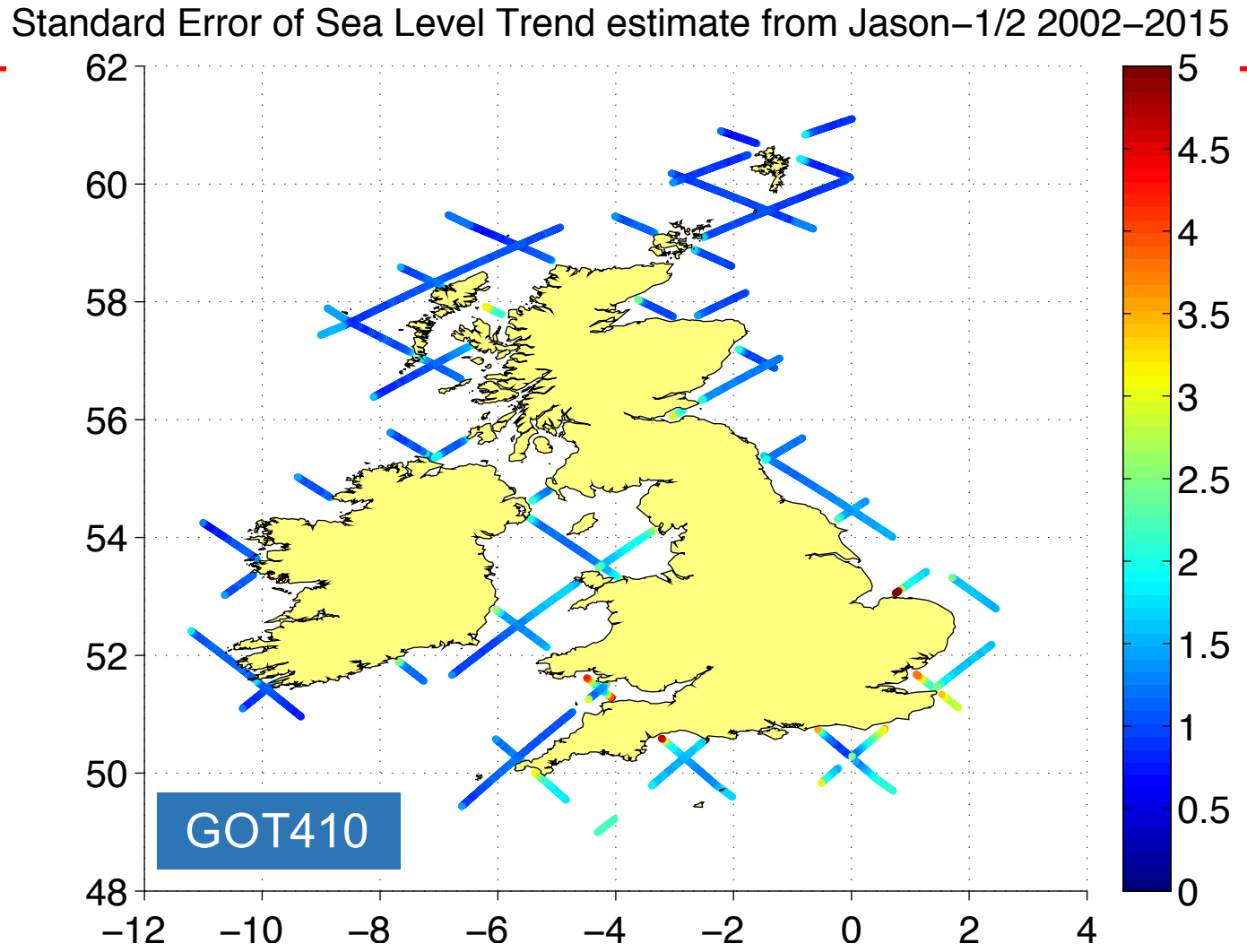
NEW RESULTS – Jason-1/2



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

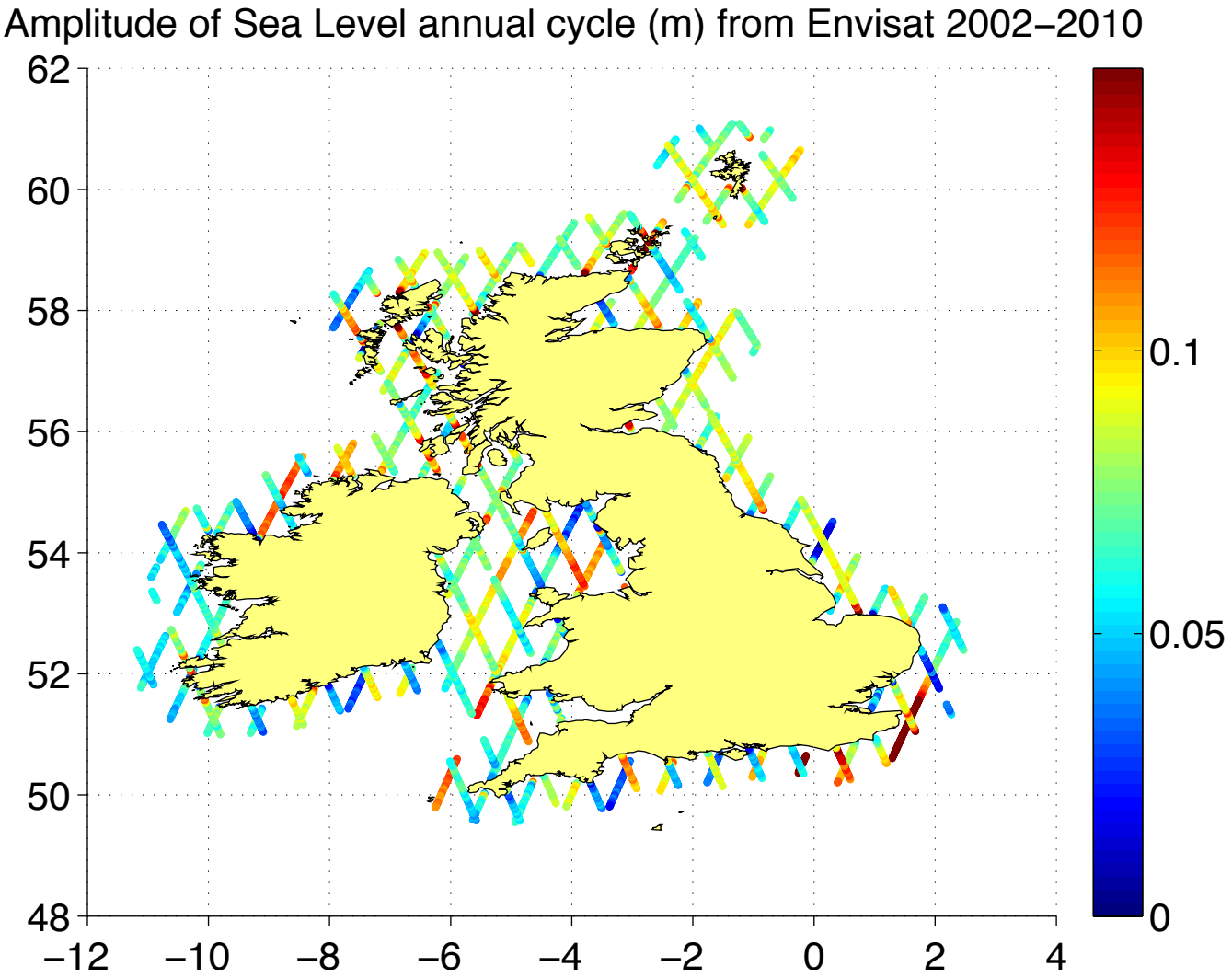
NEW RESULTS – Jason-1/2



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

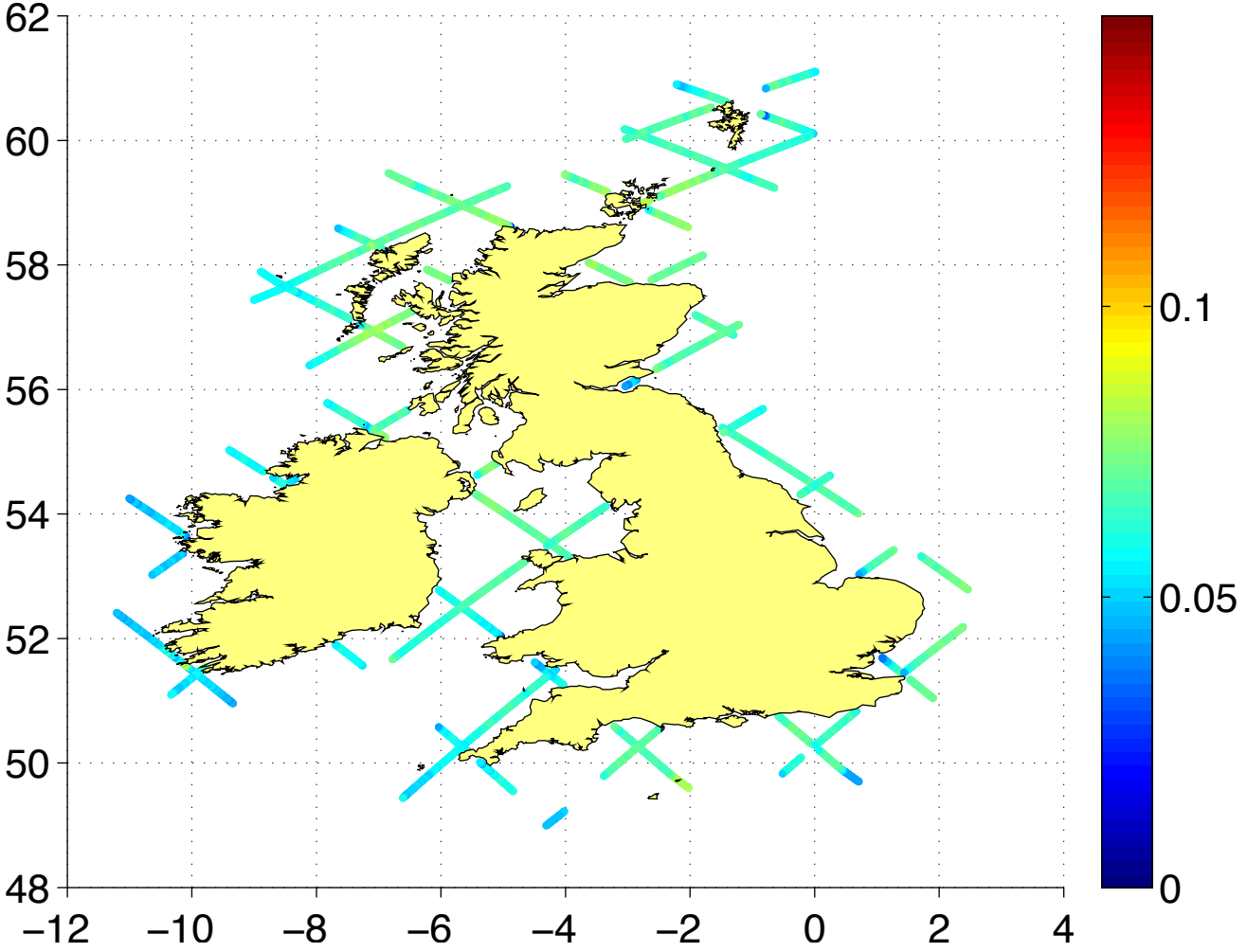
PREVIOUS RESULTS – Envisat



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

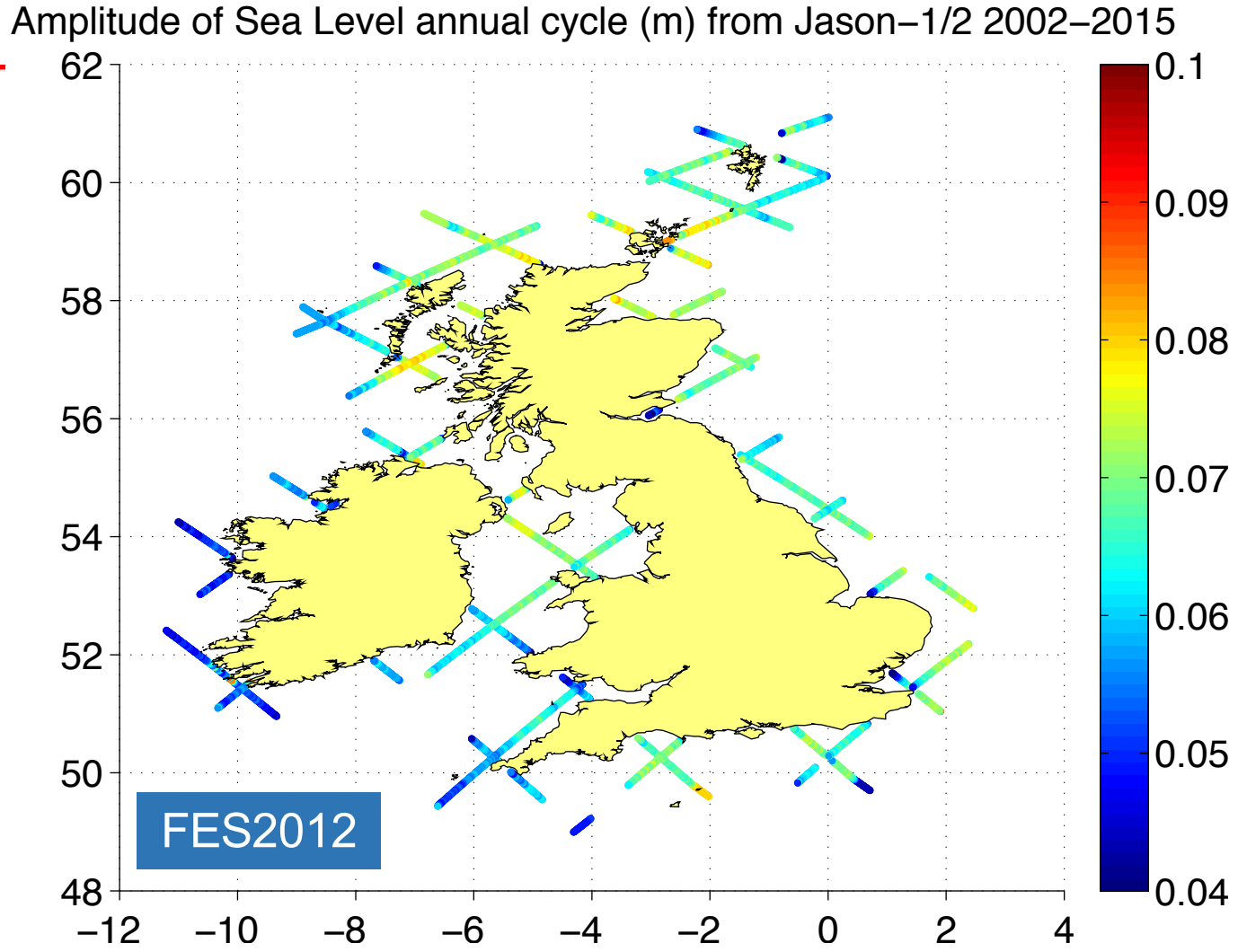
NEW RESULTS – Jason-1/2

Amplitude of Sea Level annual cycle (m) from Jason–1/2 2002–2015



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

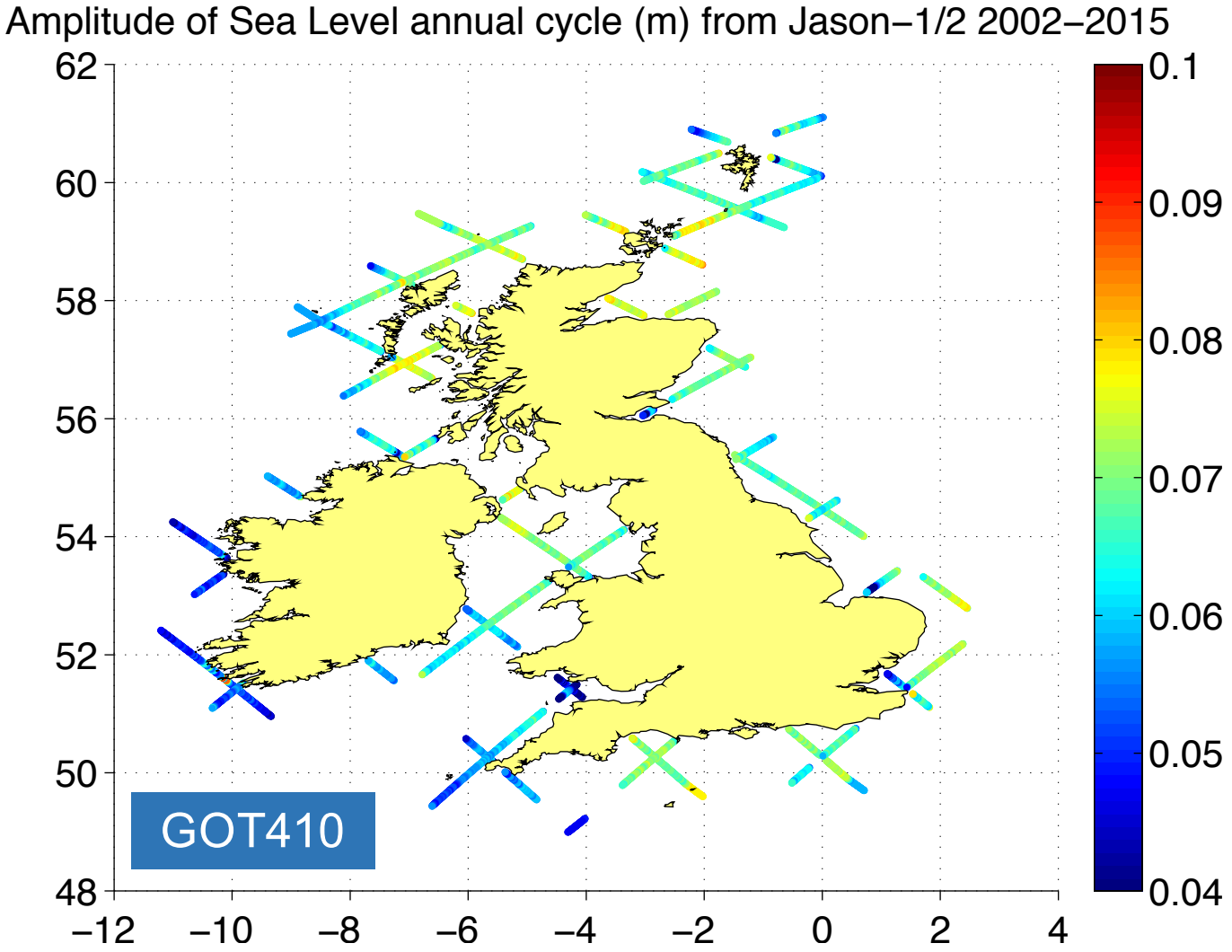
NEW RESULTS – Jason-1/2



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

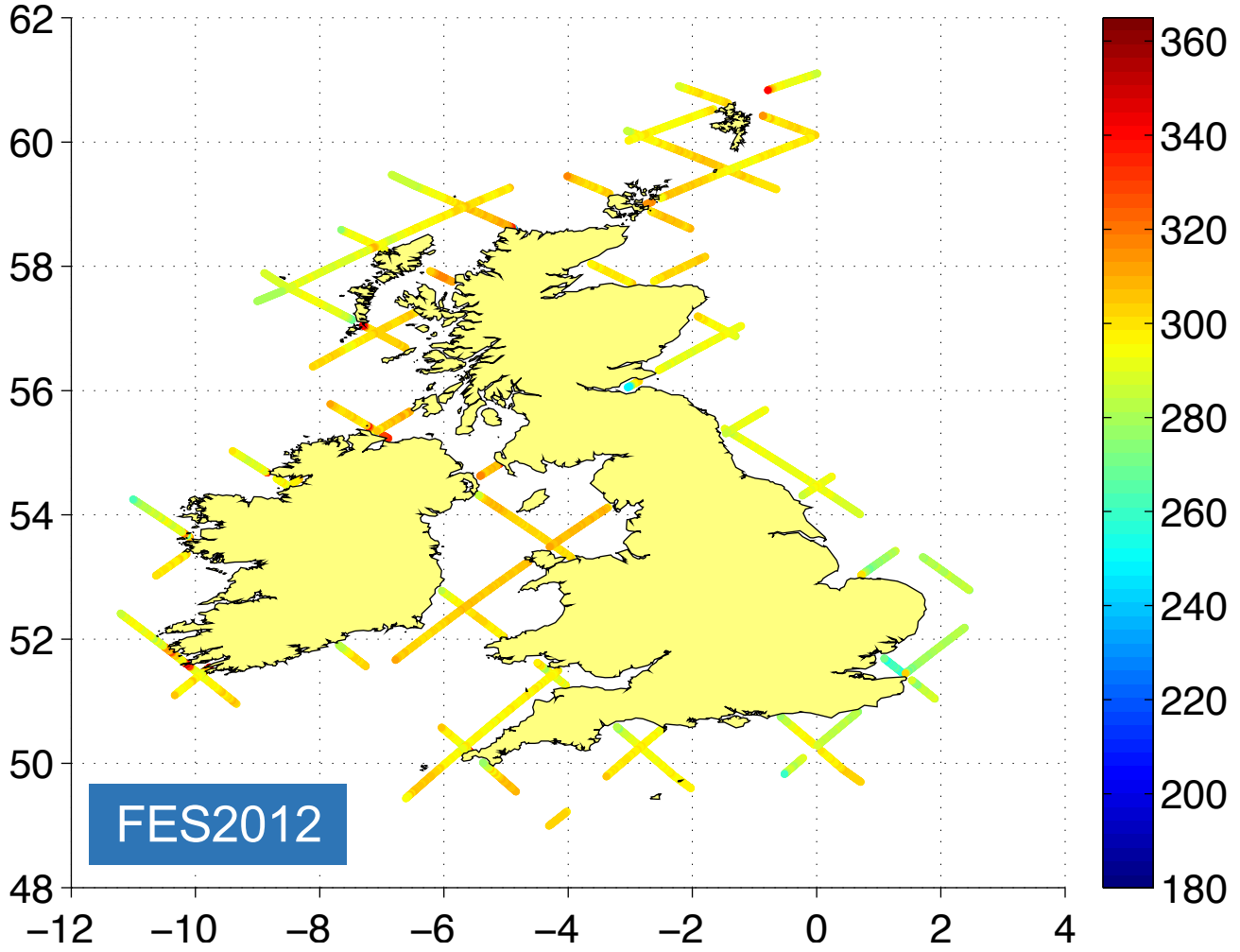
NEW RESULTS – Jason-1/2



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

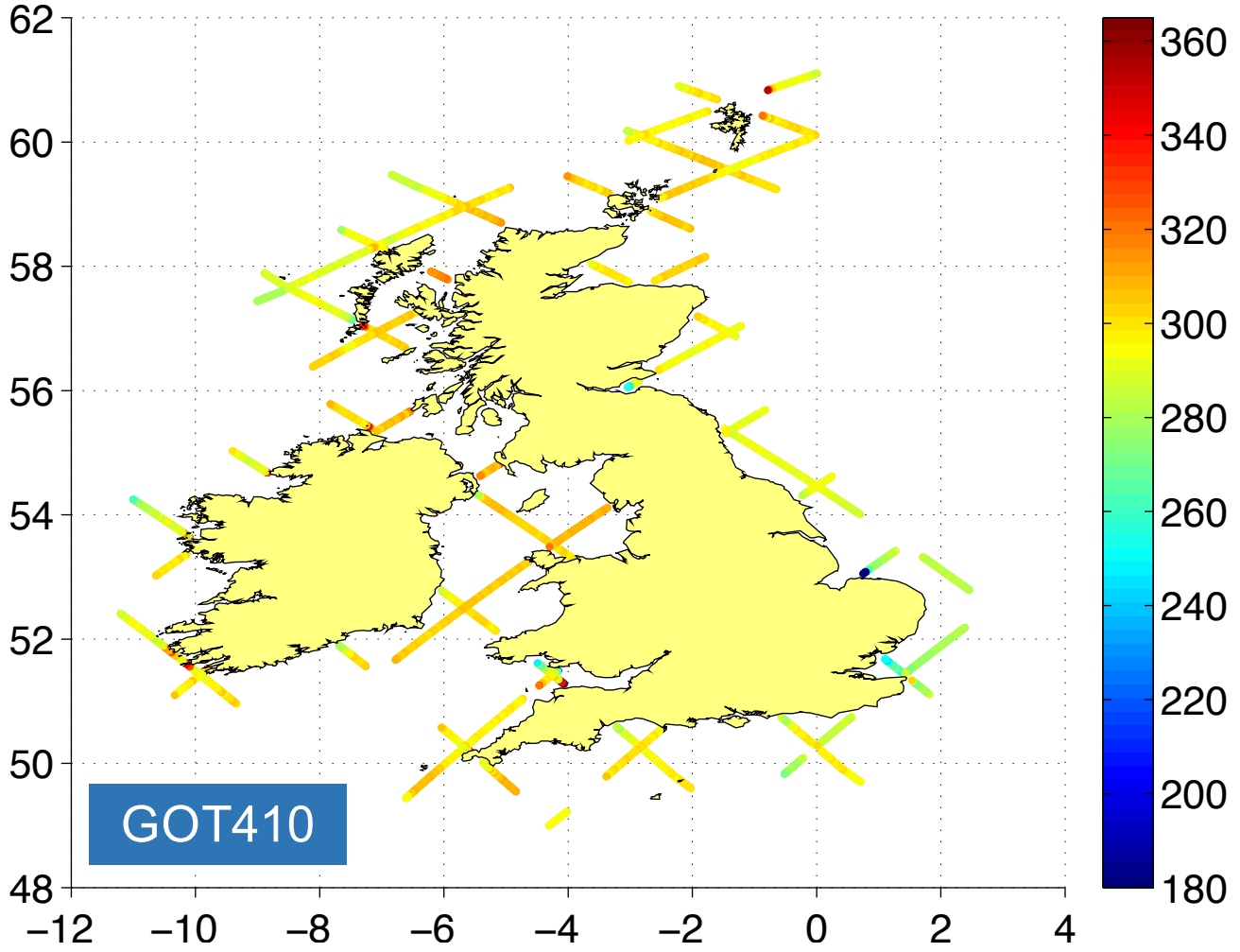
Disclaimer: NOC is responsible for the information contained in the presentation. Views expressed do not necessarily reflect those of the SSGP and UKSA

NEW RESULTS – Jason-1/2



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

NEW RESULTS – Jason-1/2



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

Conclusions

- Results from combined Jason-1/Jason-2 are improved (longer time series, 14 yr), 'less noisy'
  - AltiKa processing still being fine-tuned
  - Consistency of corrections crucial for reliable estimated
- Still a lot of regional variations, which fully support the Sea Level SpaceWatch concept
- **Jason-3** (launched Jan 16) fully compatible with the system
- **Sentinel-3** (launched Feb 16) very promising but on a different set of tracks

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