1st Tidal and Water Level Working Group Meeting

DHN, Niteroi, Brazil 31/03/09 – 02/04/09

Vertical Offshore Reference Framework (VORF)

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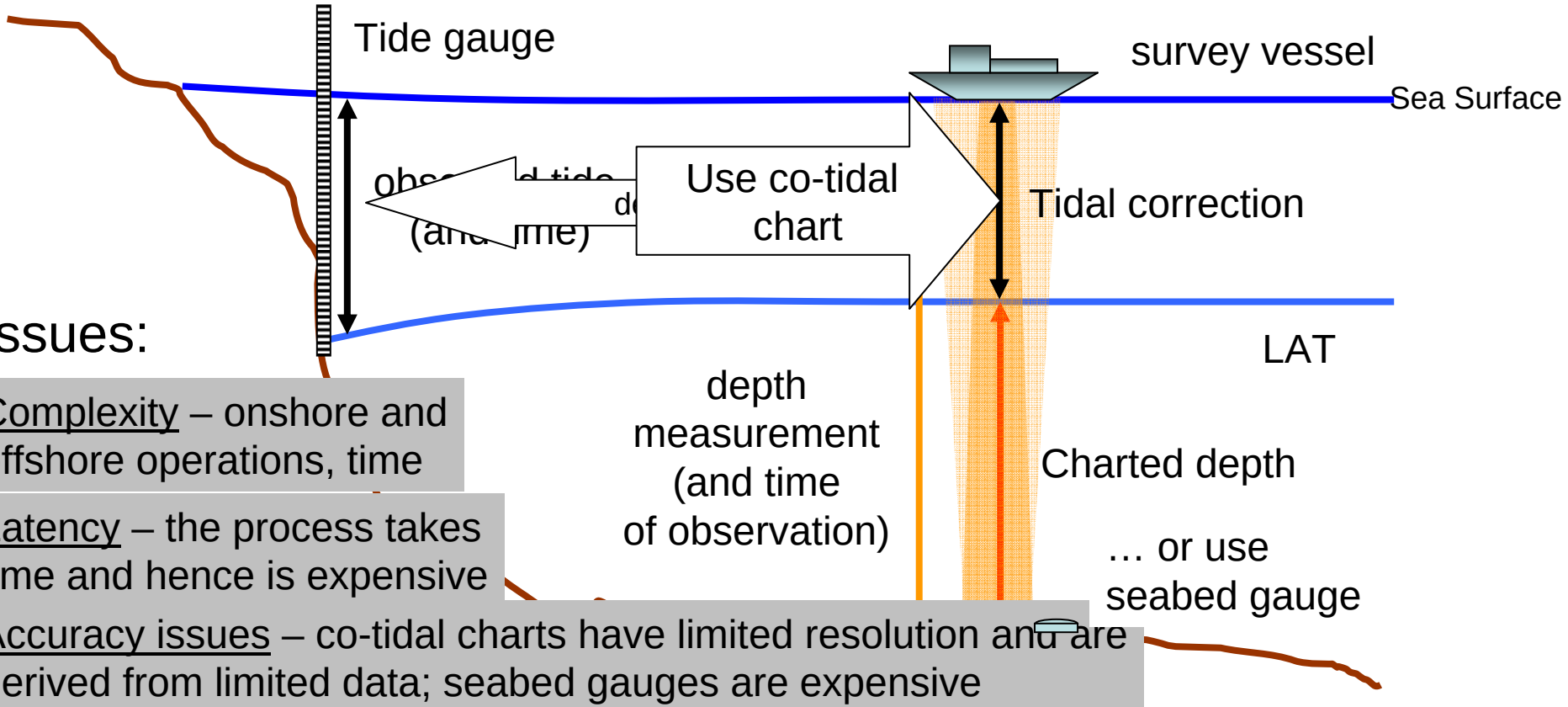
Presentation Structure

- What is VORF?
- Brief overview of the technical development
- Why is VORF needed?

What is VORF?

- VORF = Vertical Offshore Reference Frame
- A set of mathematical models of the major surfaces used in the current and future charting of UK home waters
- A suite of software utilities allowing the transformation of mapping and positioning data between the VORF surfaces

Current practice for bathymetric data processing



Issues:

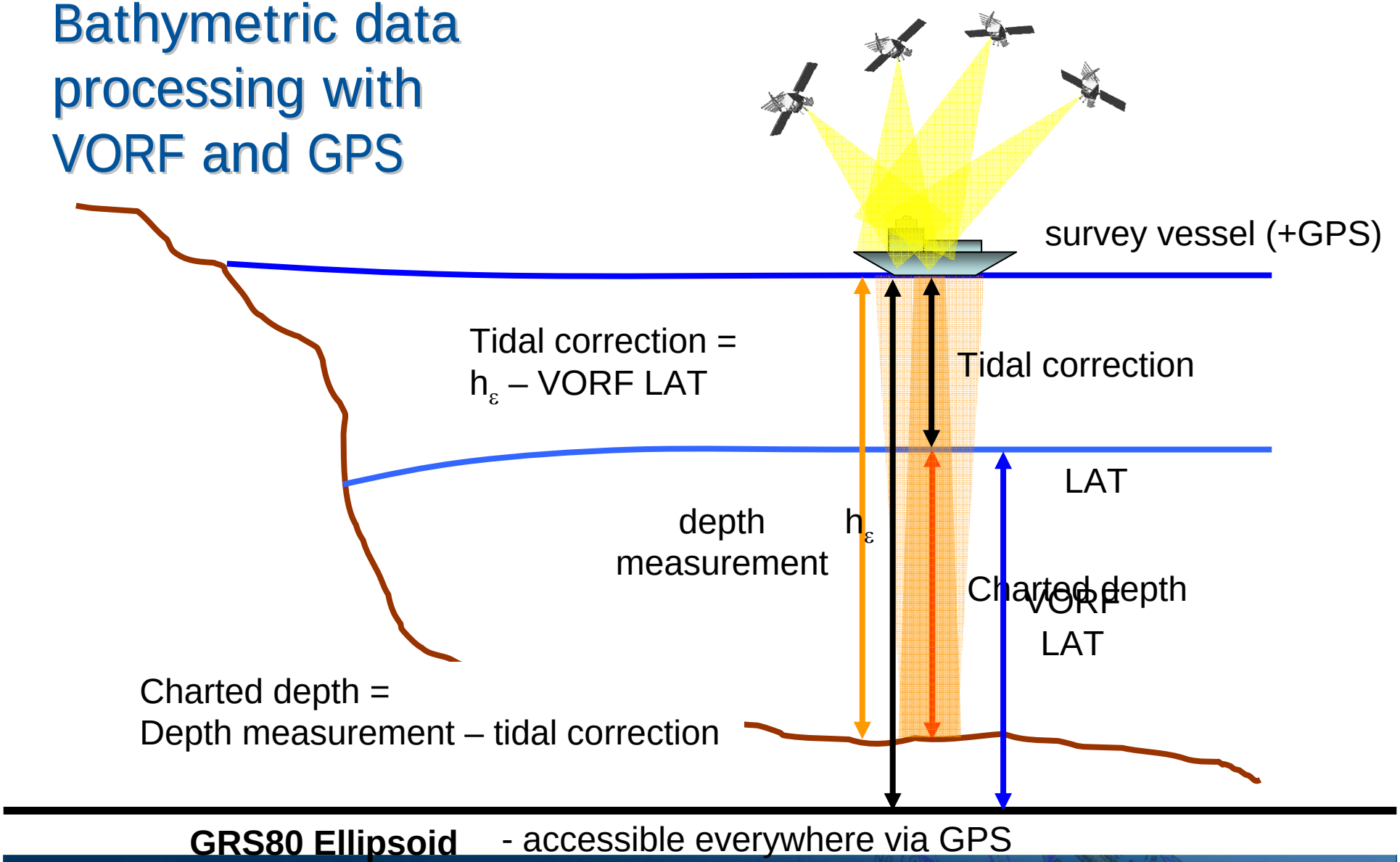
Complexity – onshore and offshore operations, time

Latency – the process takes time and hence is expensive

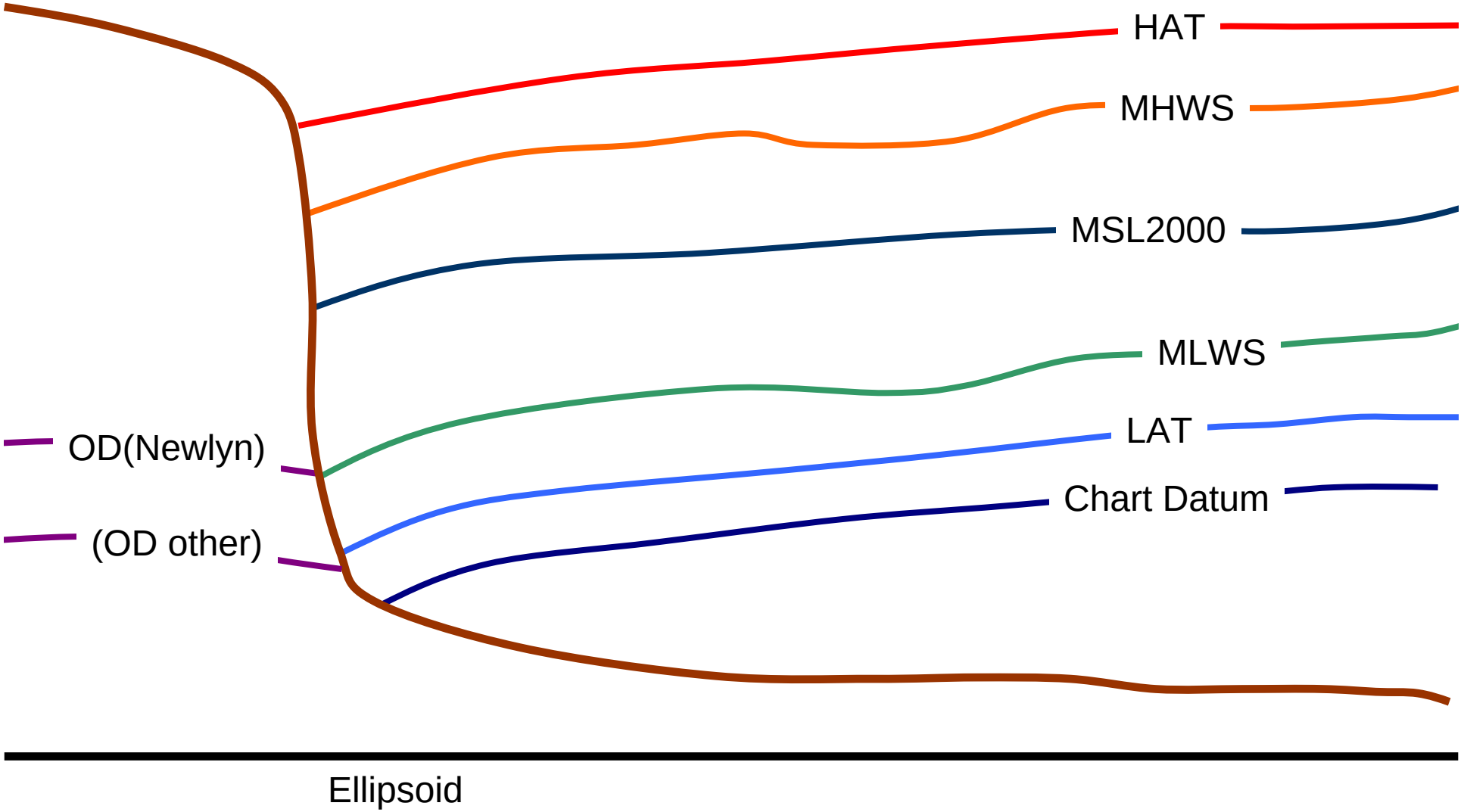
Accuracy issues – co-tidal charts have limited resolution and are derived from limited data; seabed gauges are expensive

Inconsistency – practices using Chart Datum are sometimes poorly defined and can lead to discrepancies

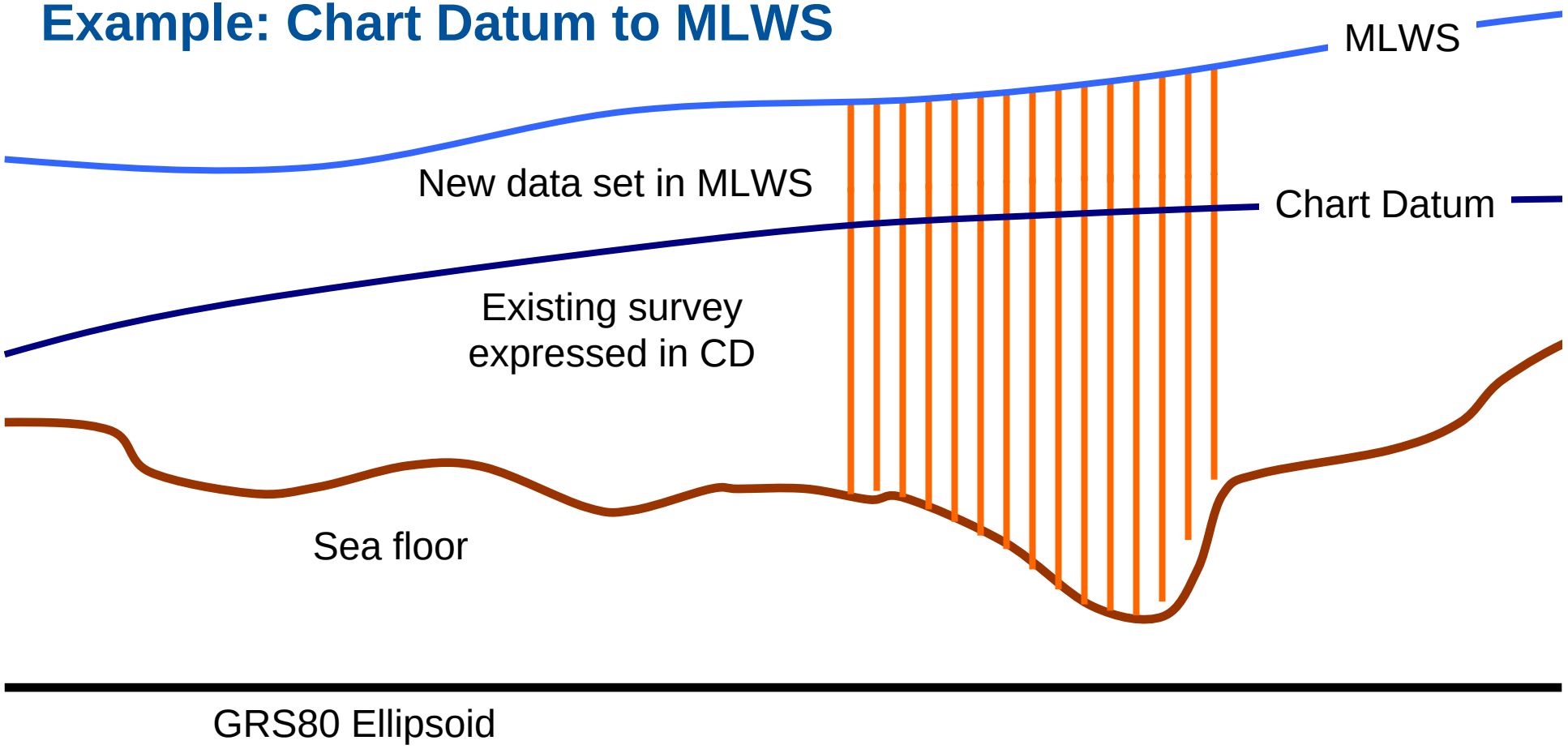
Bathymetric data processing with VORF and GPS



VORF surfaces:



Basic VORF functionality:
Transforming data between vertical datums
Example: Chart Datum to MLWS



Brief overview of the technical development of VORF

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Technologies applied in development of VORF

- Tide gauge data
- GPS data
- Satellite altimetry
- Gravity field models
- Tidal modelling

VORF Overall Approach

Find mean sea level

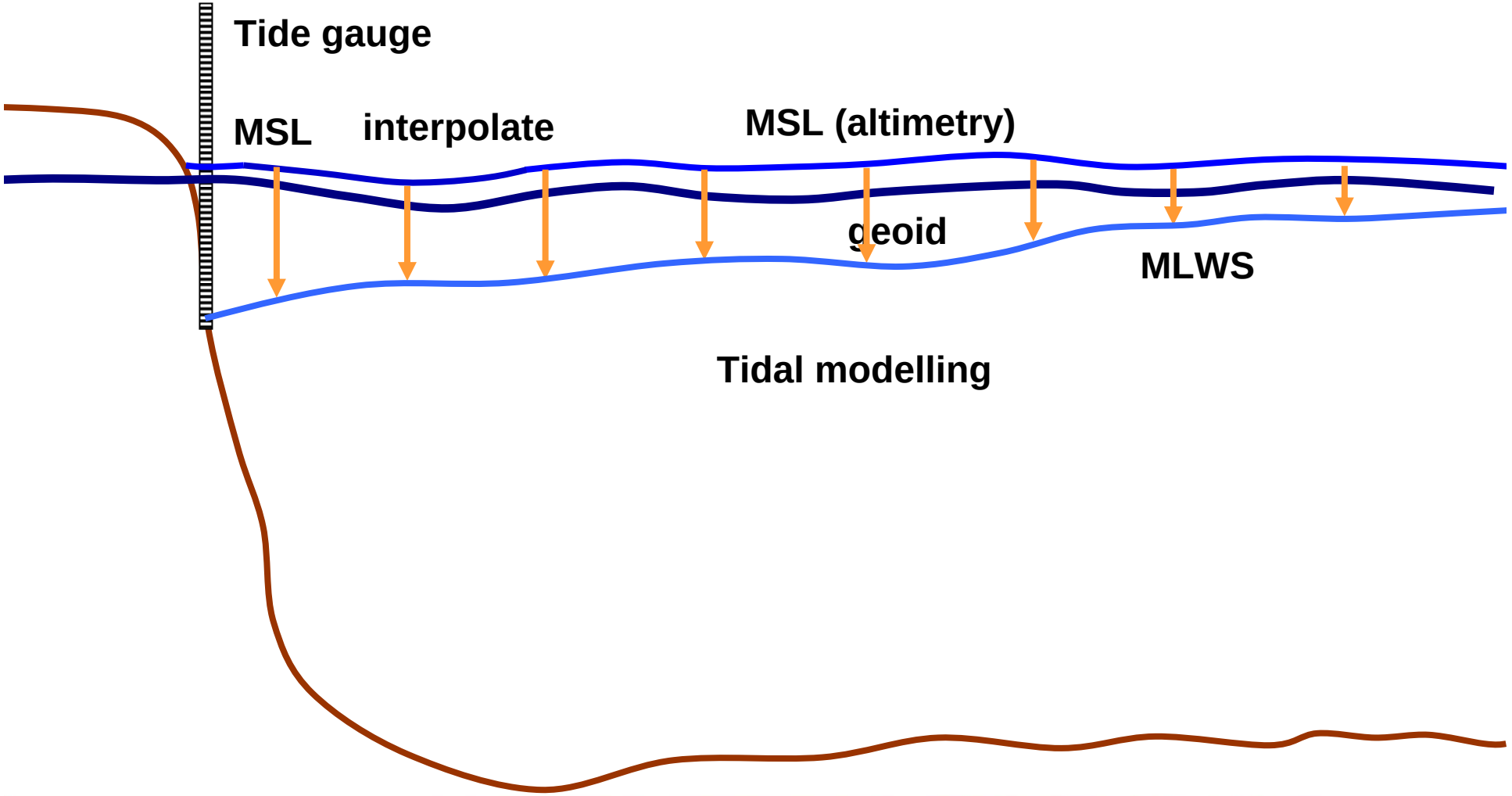
↓

Model lowest astronomical tide

↓

Combine surfaces

Overview of VORF computation method

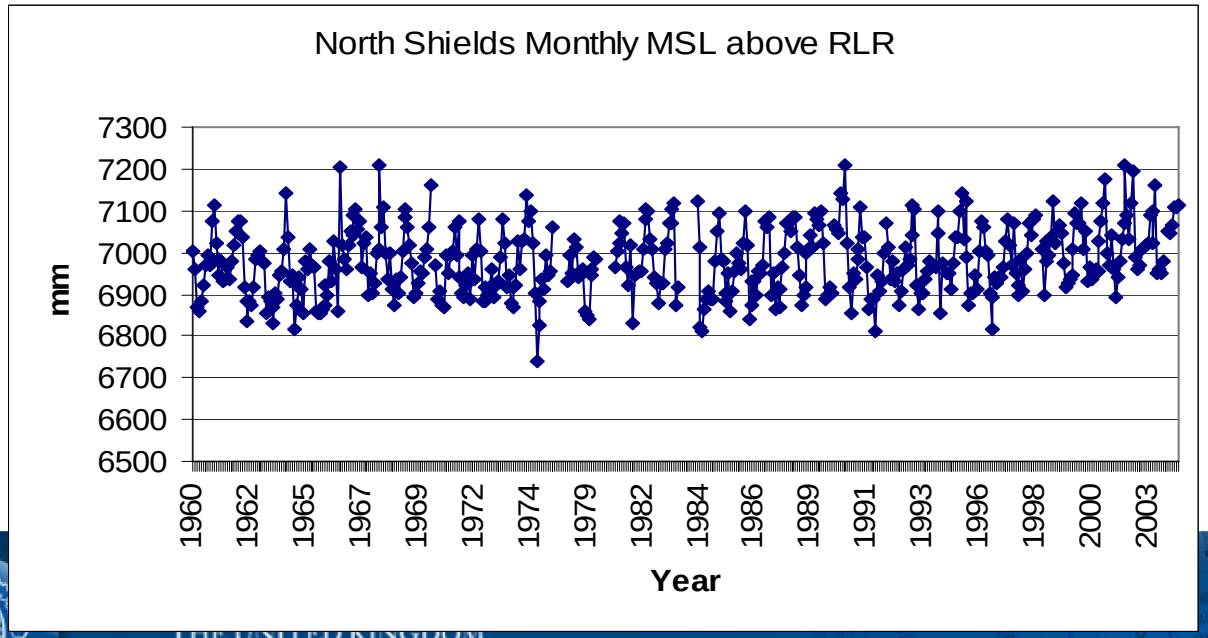


Monthly MSL Observations

Many tide gauge stations only have one month of observations.

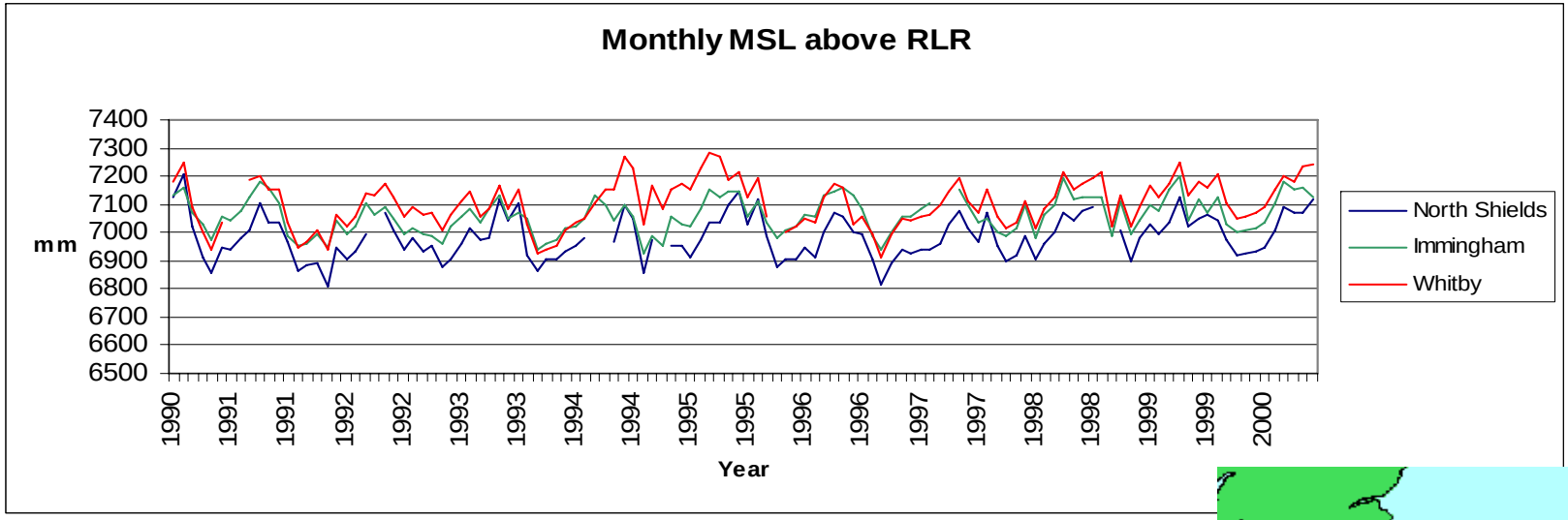
Variations due to winds, pressure, currents, etc.

Correct by cross comparison.



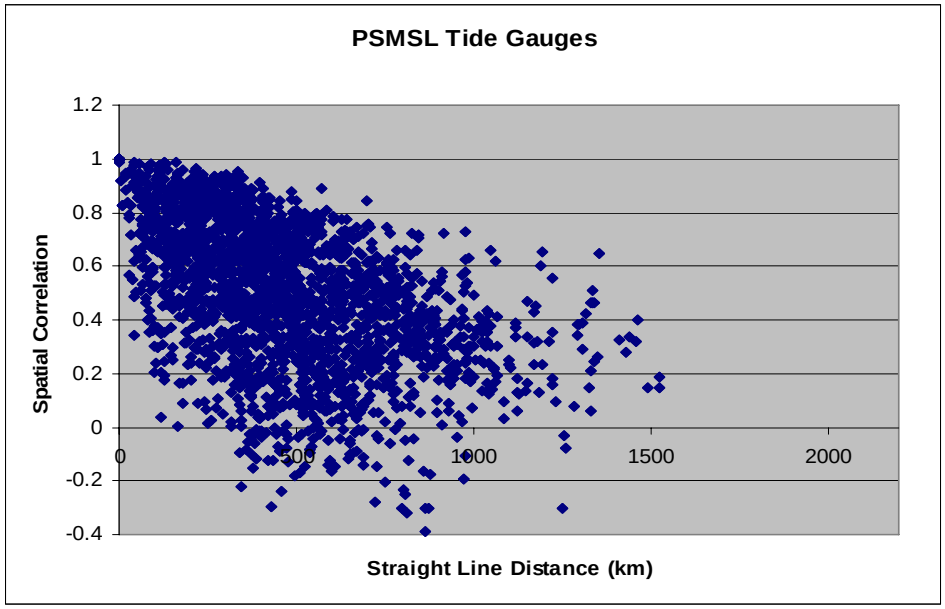
RLR = Revised Local Reference, which is sea level relative to the land.

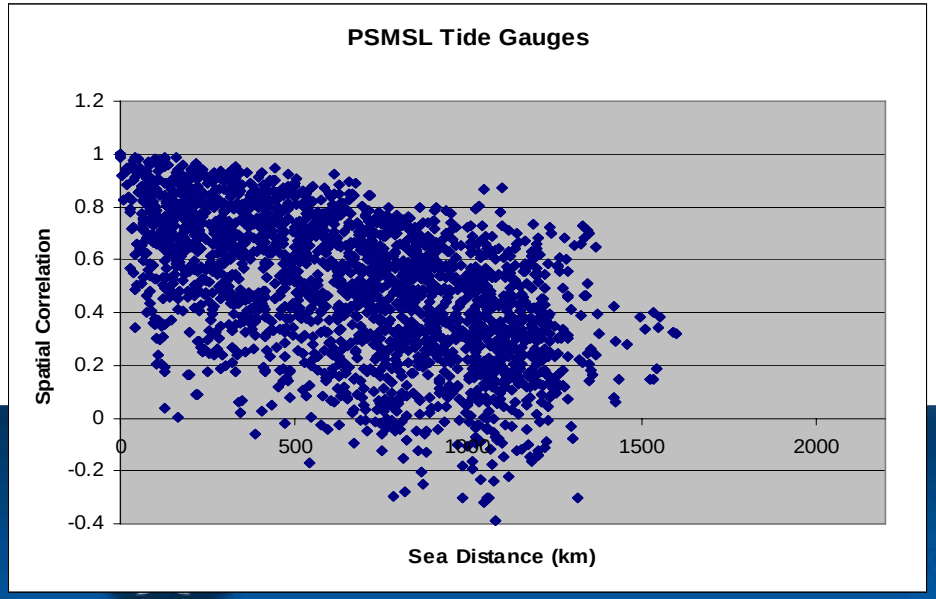
Spatial Correlation

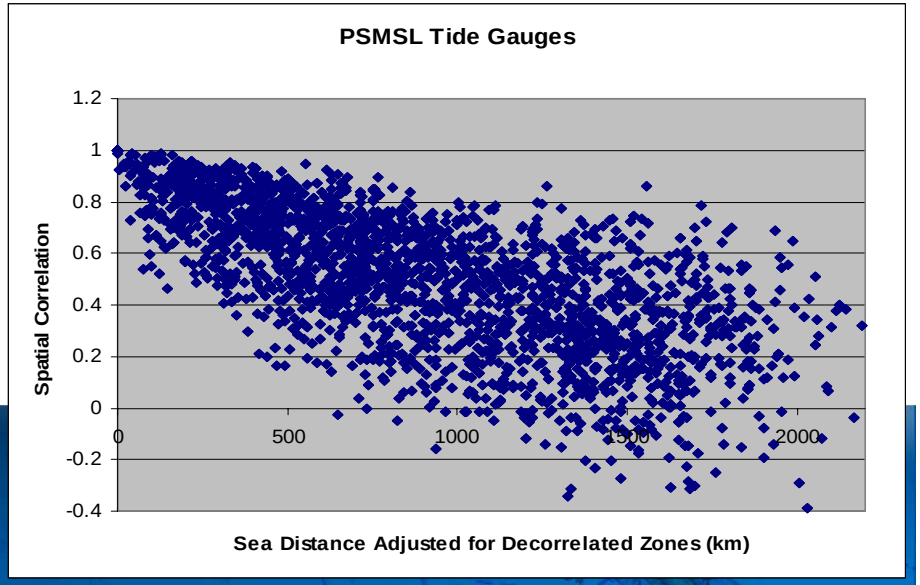


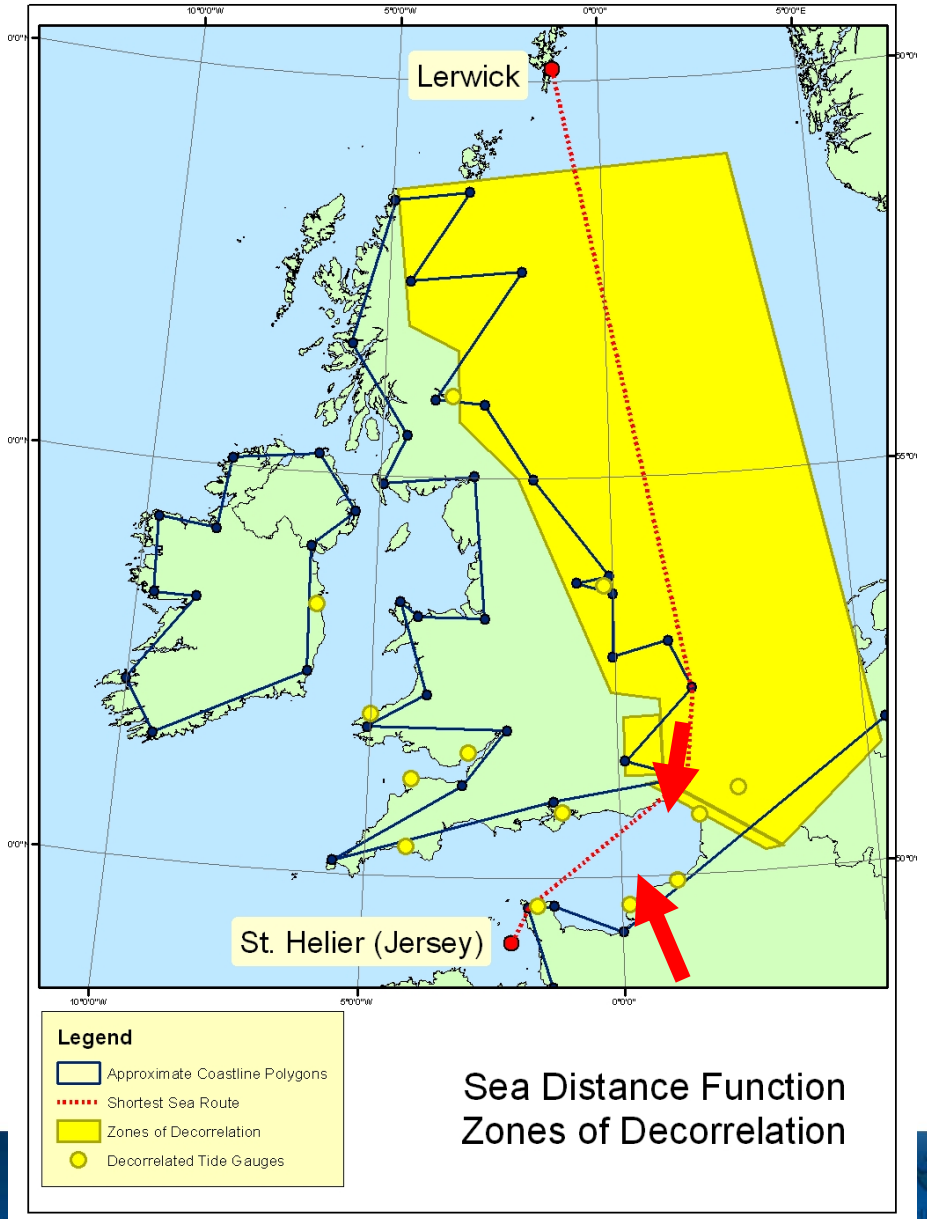
Correlations help to control the interpolation of MSL at stations where there are short series of data.

Spatial Correlation Scatter Plots



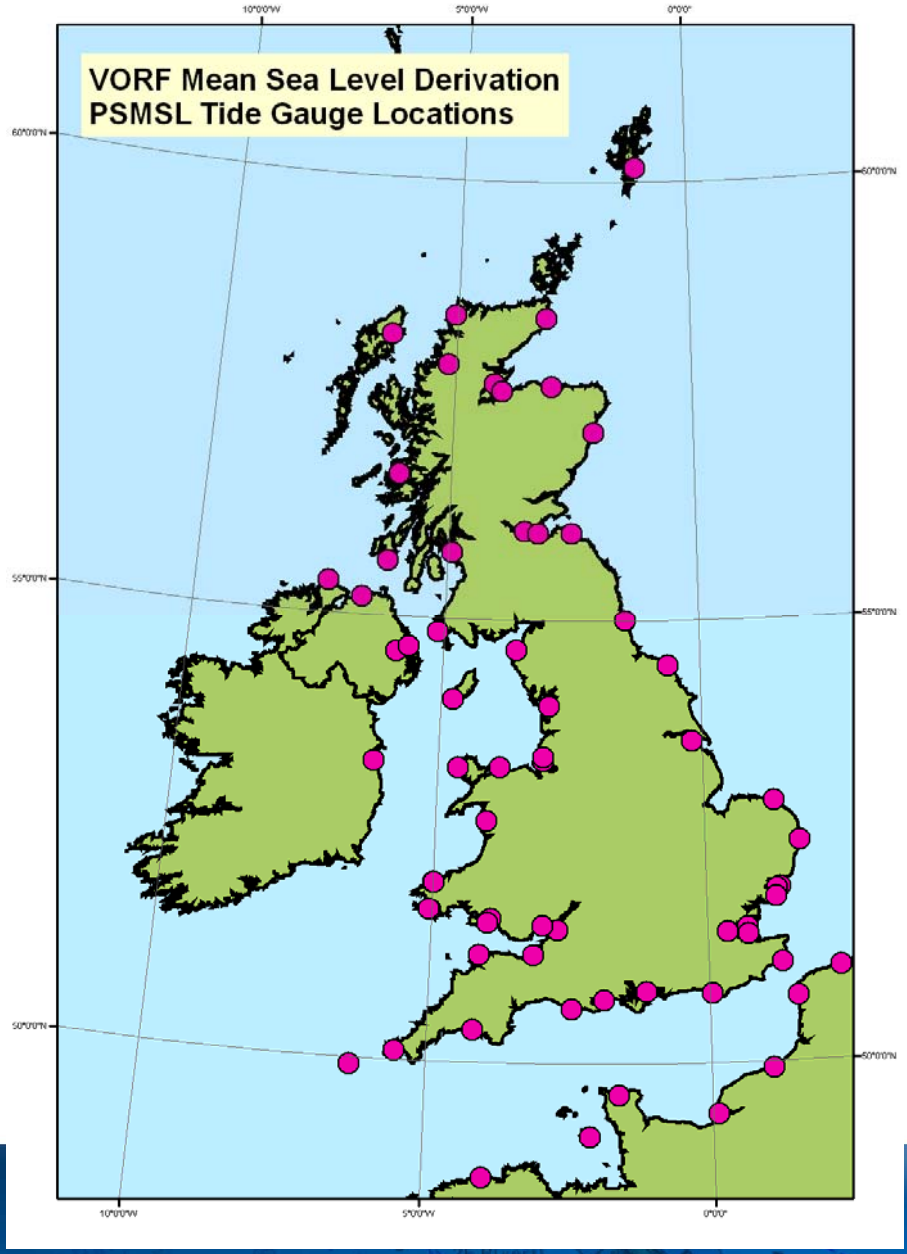





Lerwick
St. Helier (Jersey)
Legend
Approximate Coastline Polygons
Shortest Sea Route
Zones of Decorrelation
Decorrelated Tide Gauges
Sea Distance Function
Zones of Decorrelation

Data sources:
Tide Gauge data via the Permanent Service for Mean Sea Level (PSMSL)

- National Tidal and Sea Level Facility (NTSLF) stations
- High quality continuous observations
- BUT low spatial density



Data sources:
Tide Gauges Admiralty Tide Table (ATT)

- Around 700 Standard and Secondary Port locations
- Good spatial density
- BUT occasionally low precision due to short term data series

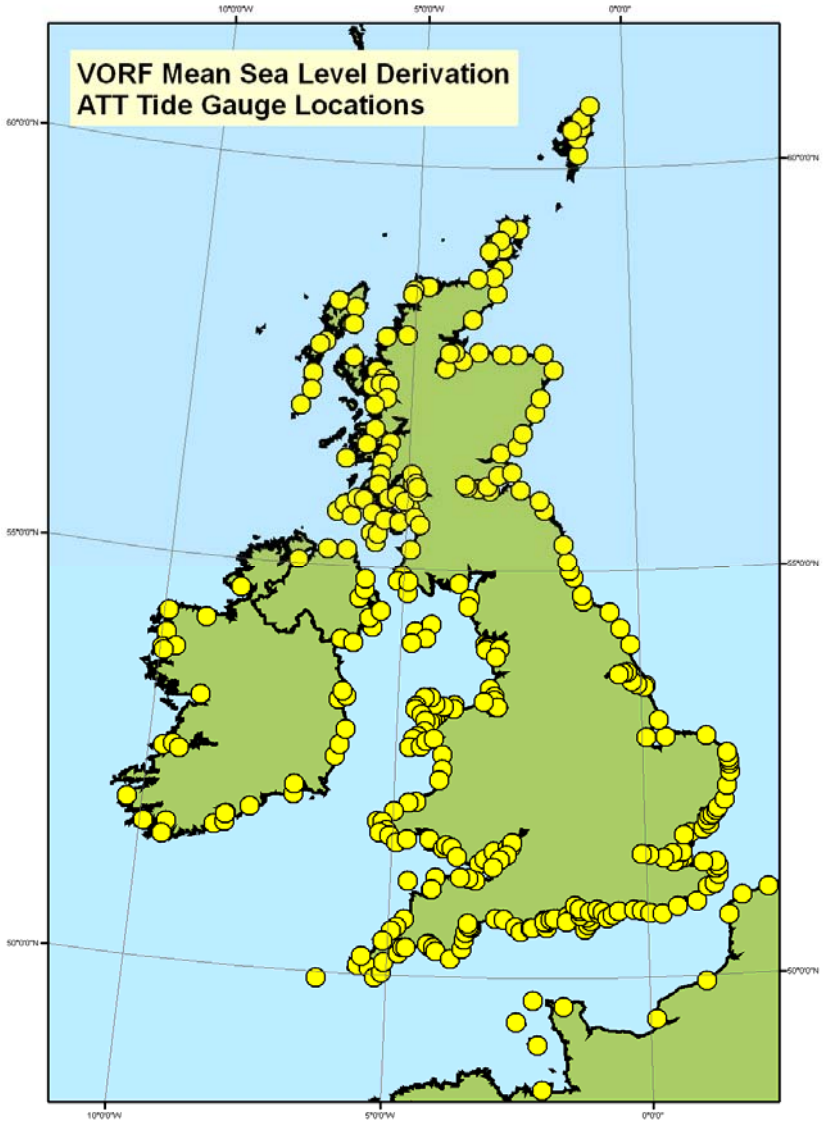
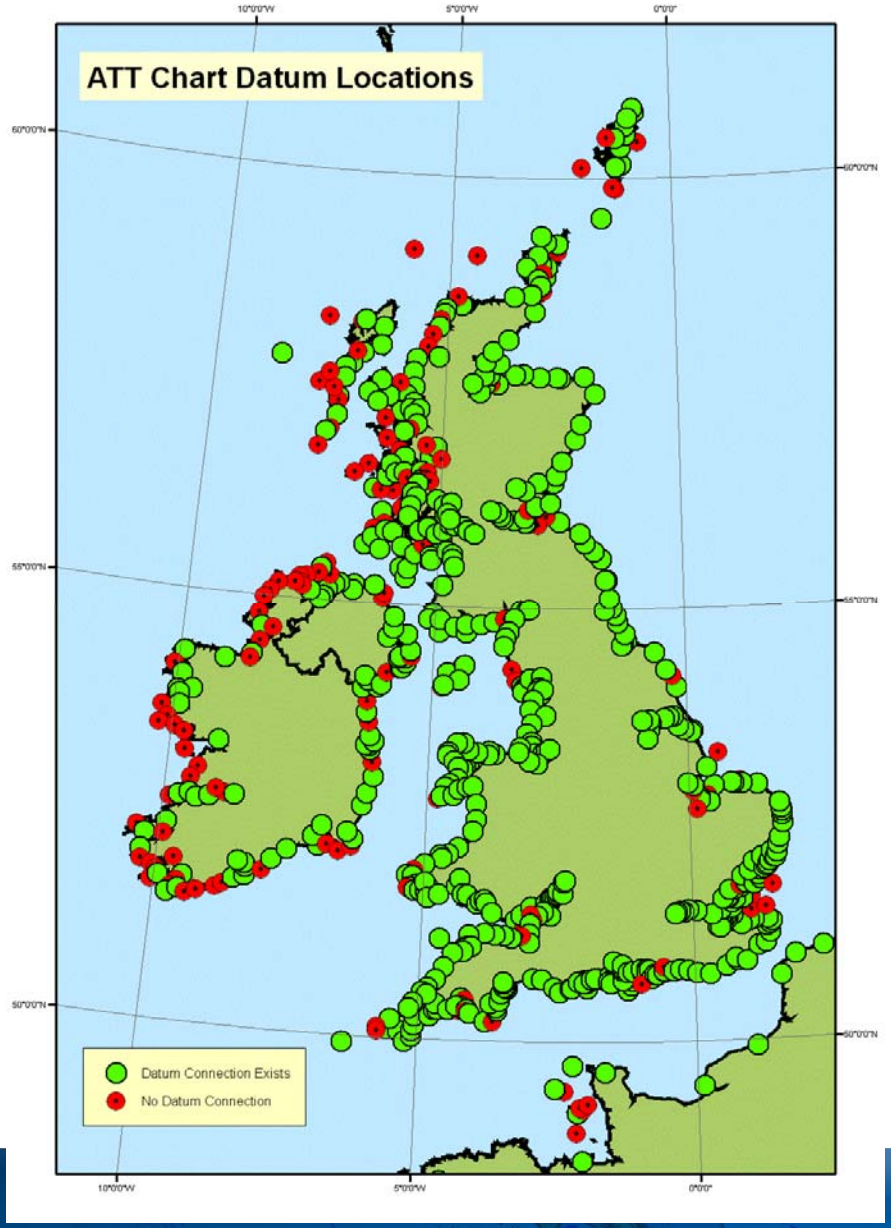
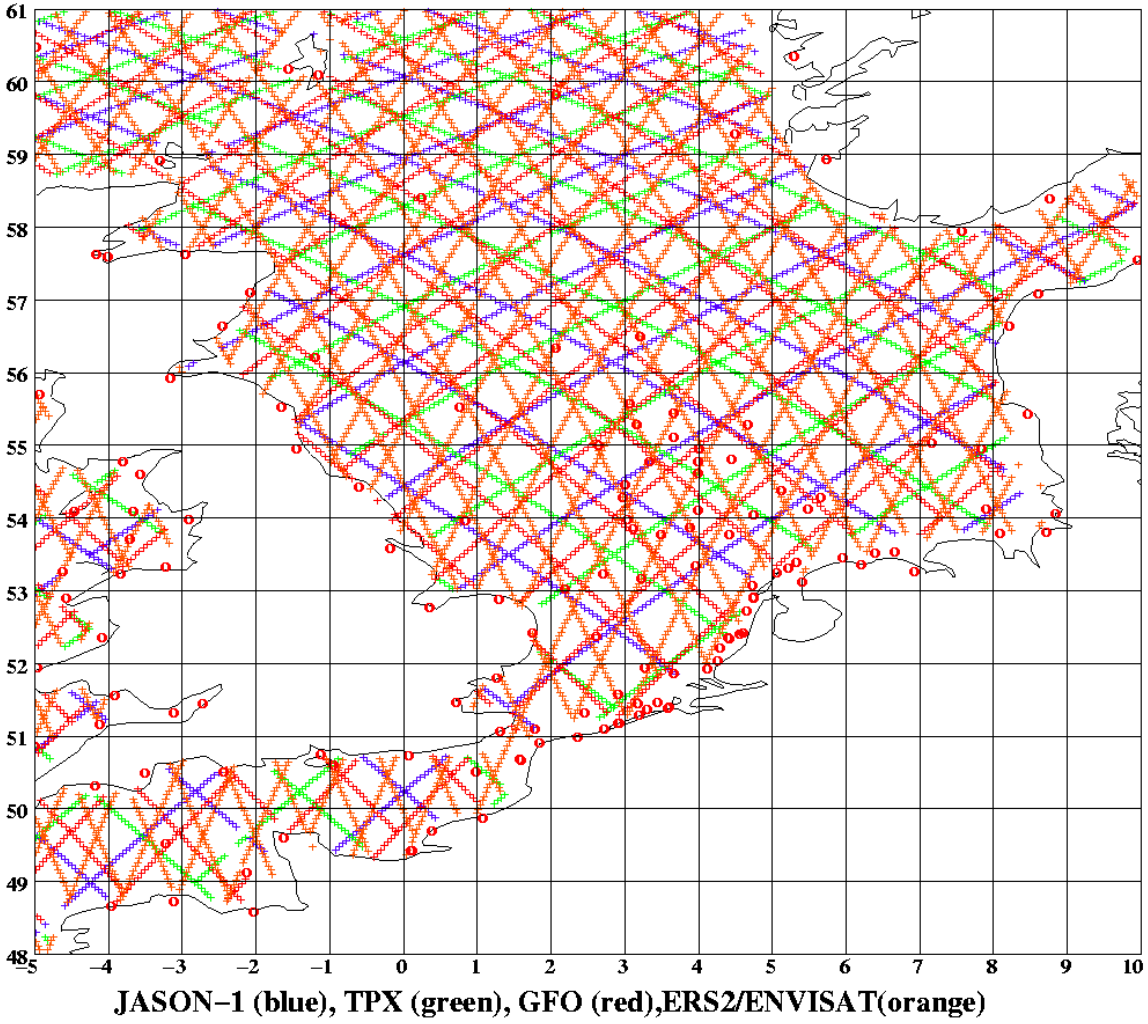


Chart Datum:

- VORF aims to unify all these separate datums into one, seamless surface
- Process involves verifying the link between CD and Ordnance Datum (the land-levelling height datum)



Technologies applied: Satellite Altimetry



JASON–1 (blue), TPX (green), GFO (red),ERS2/ENVISAT(orange)

ENVISAT

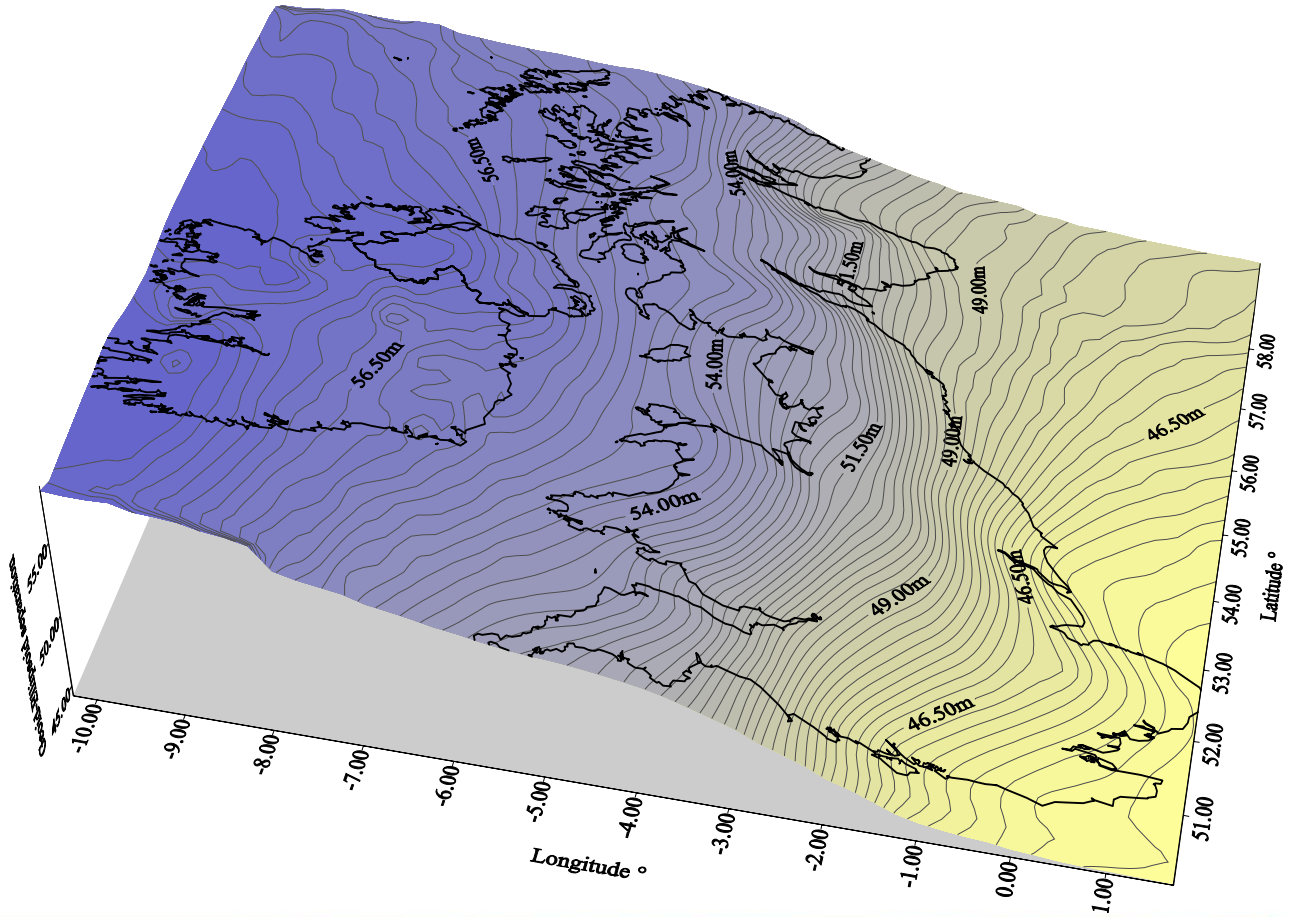
TOPEX

JASON

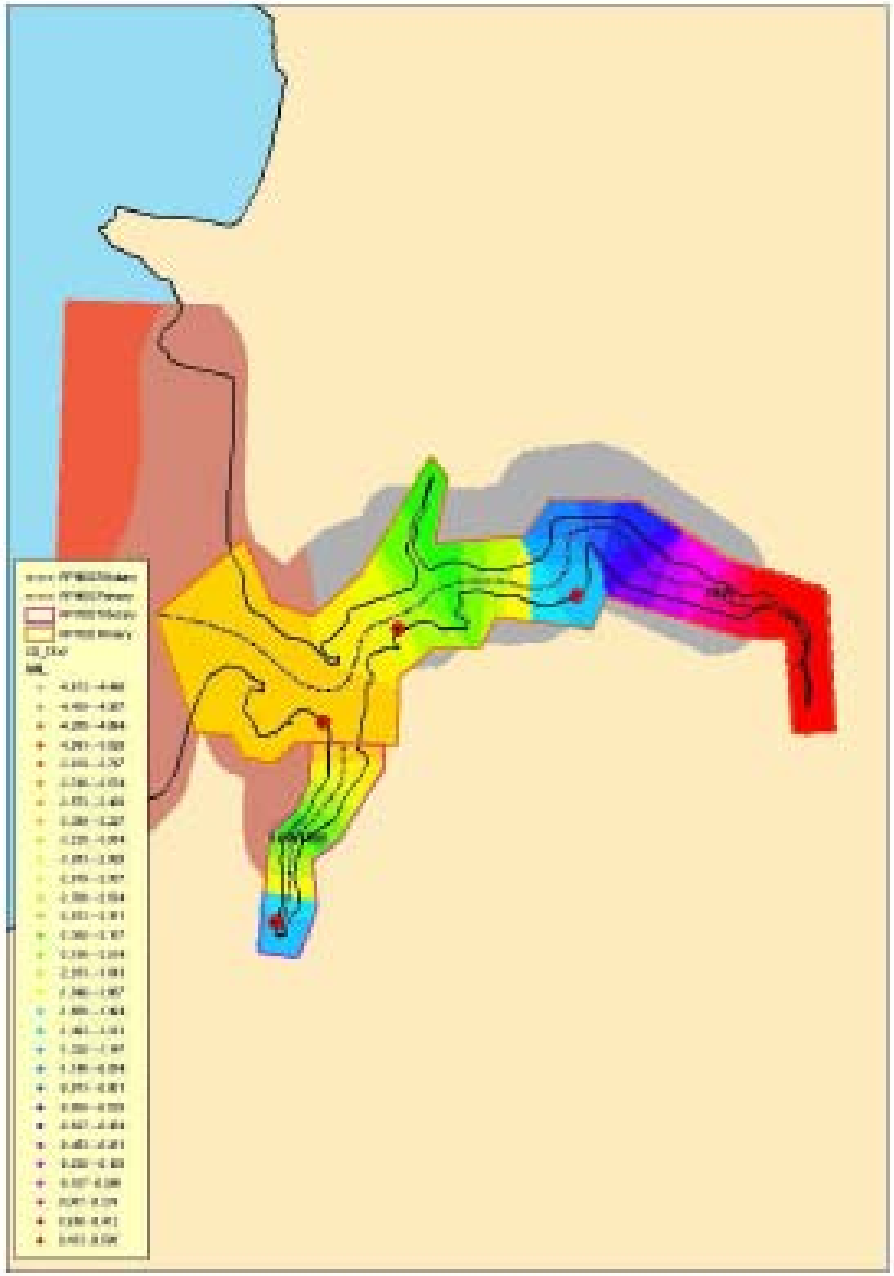
GFO

ERS1/2

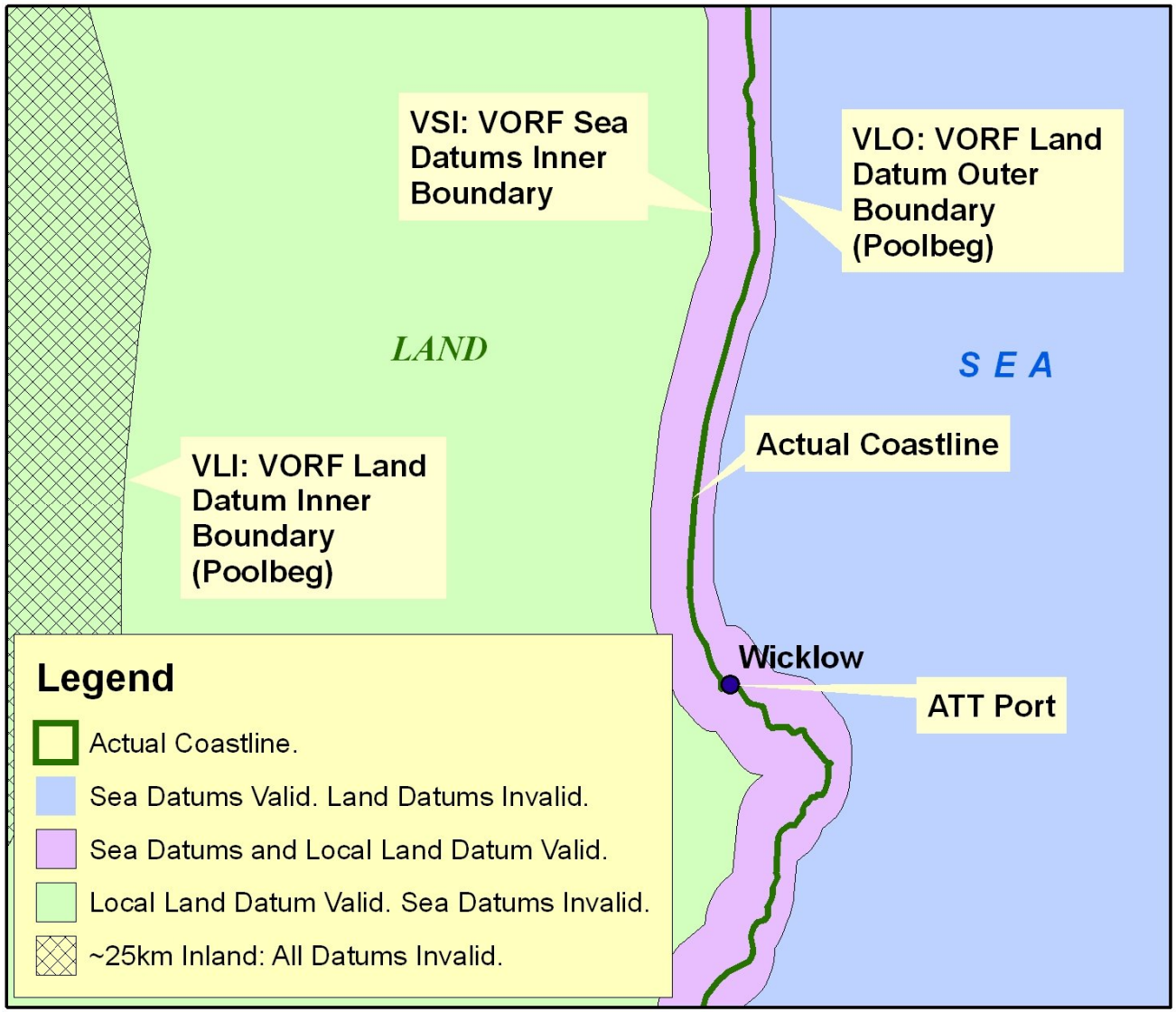
Technologies applied: OSGM05 – the latest UK gravity field model (OSGM09 available soon)



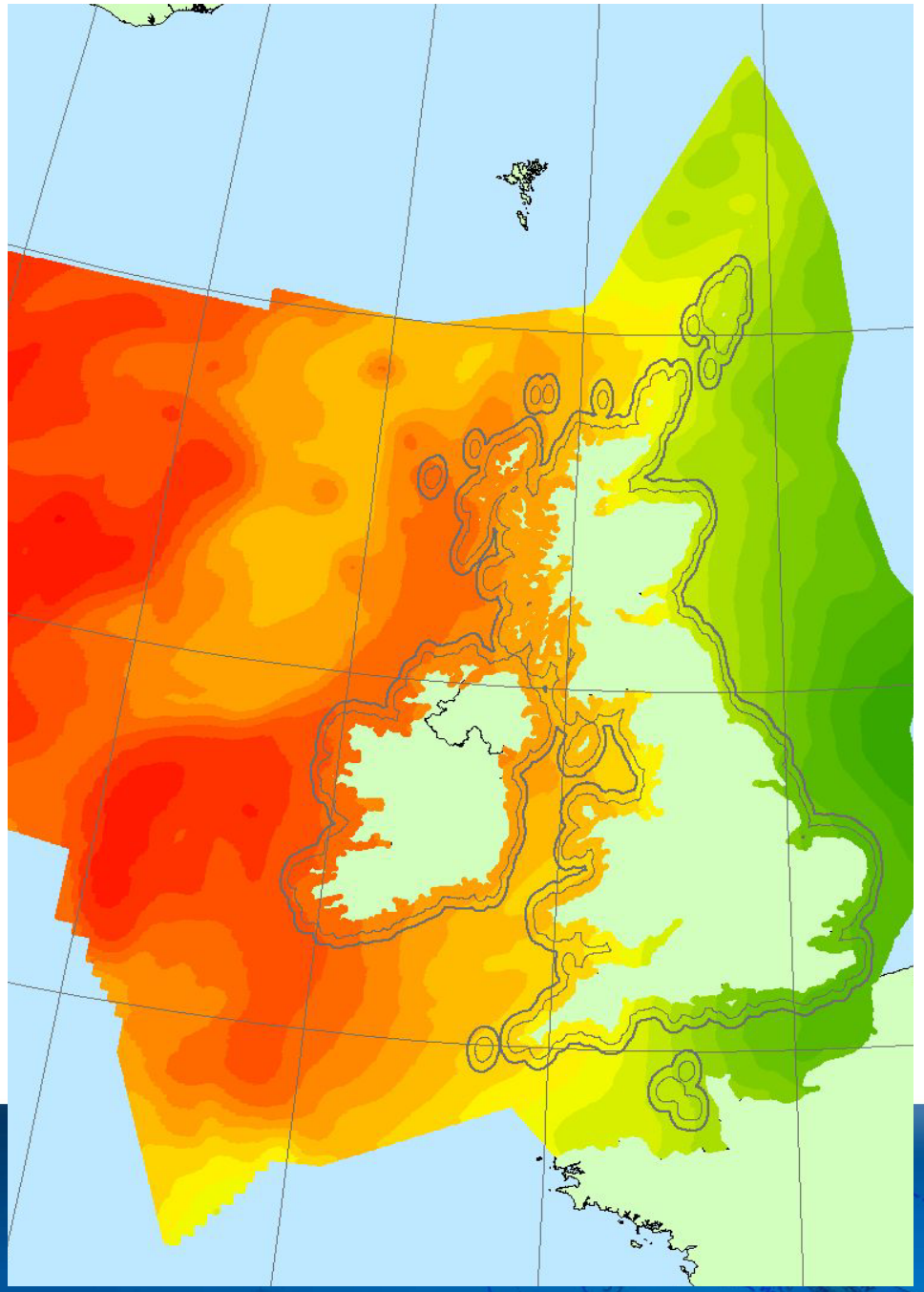
River Datums



Use of Areas of Applicability



Boundaries of VORF Model: UK Continental Shelf



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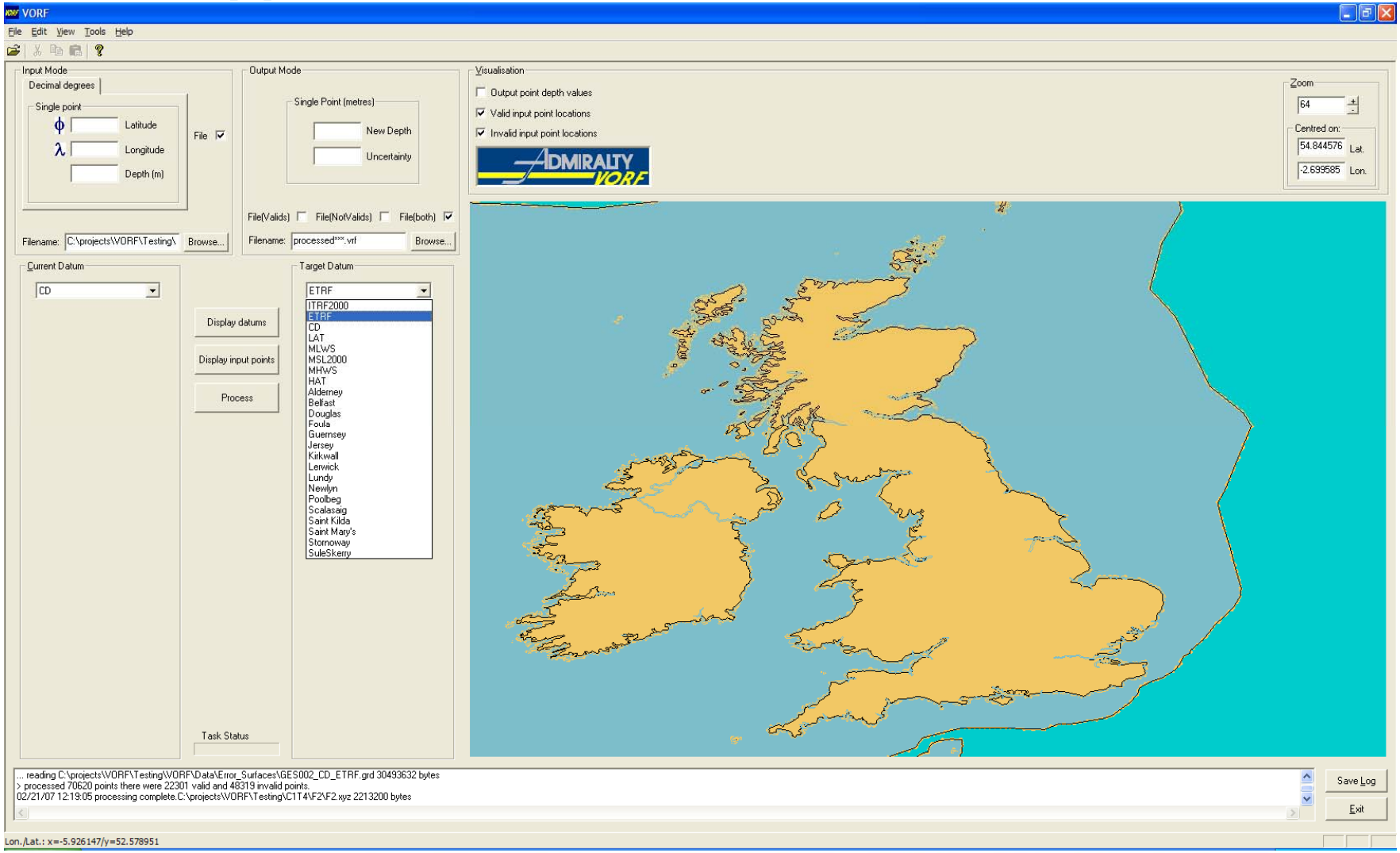
VORF software functionality

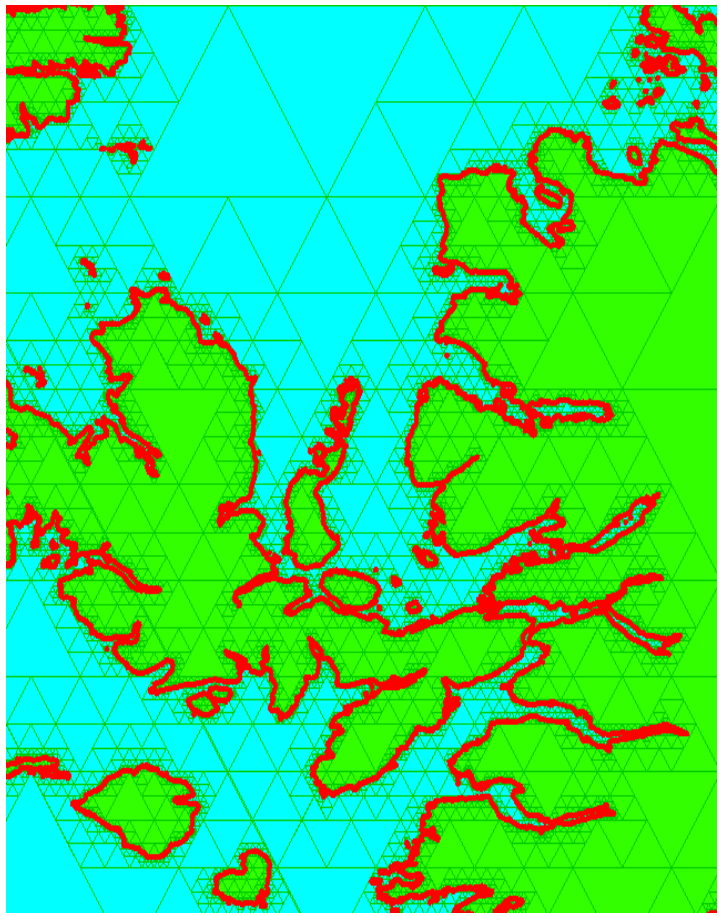
- Transformation between datums
- Estimated error in transformations
- Visualisation
- User error detection
- Point/file mode data import
- Deals with complexity of searching for special cases such as rivers and impounded datums.
- High speed data retrieval and processing.

VORF Application



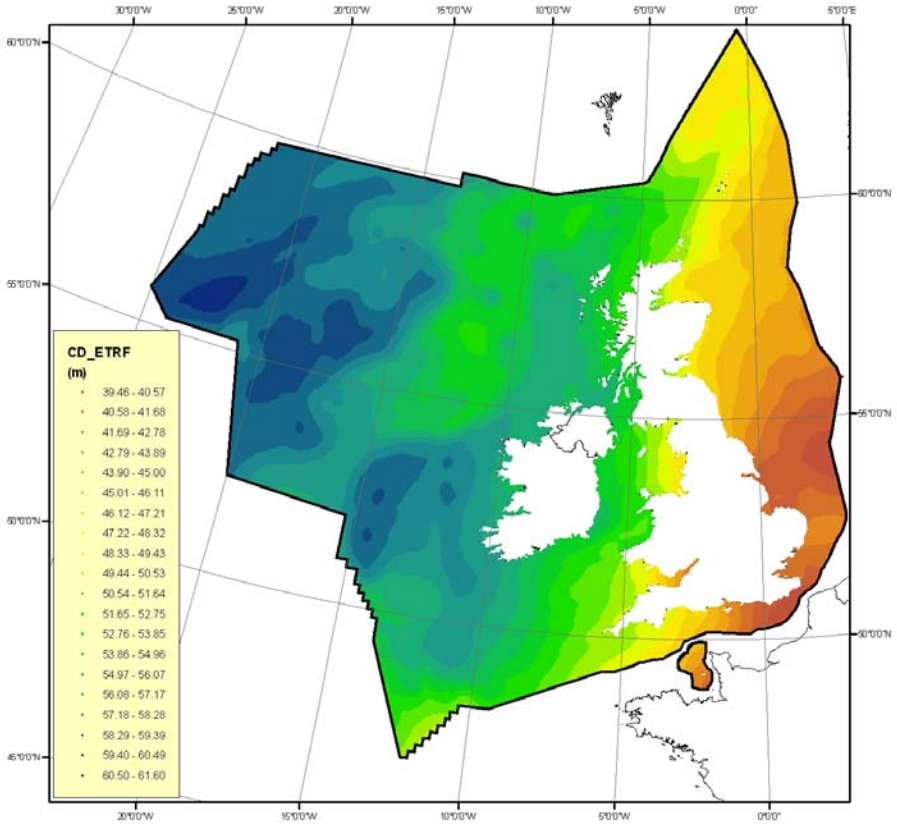
Ultra Rapid Point in Polygon (PiP) Benchmark Tests

- 400,000 line segment polygon set
- Conventional desktop PC (1 Gb RAM, 3 GHz processor)
- 8,000,000 queries carried out correctly in 16 seconds (including file reading)
- University College London (UCL) has developed new concepts in high performance PiP tests
- Technique based on quadtree subdivision of analysis space



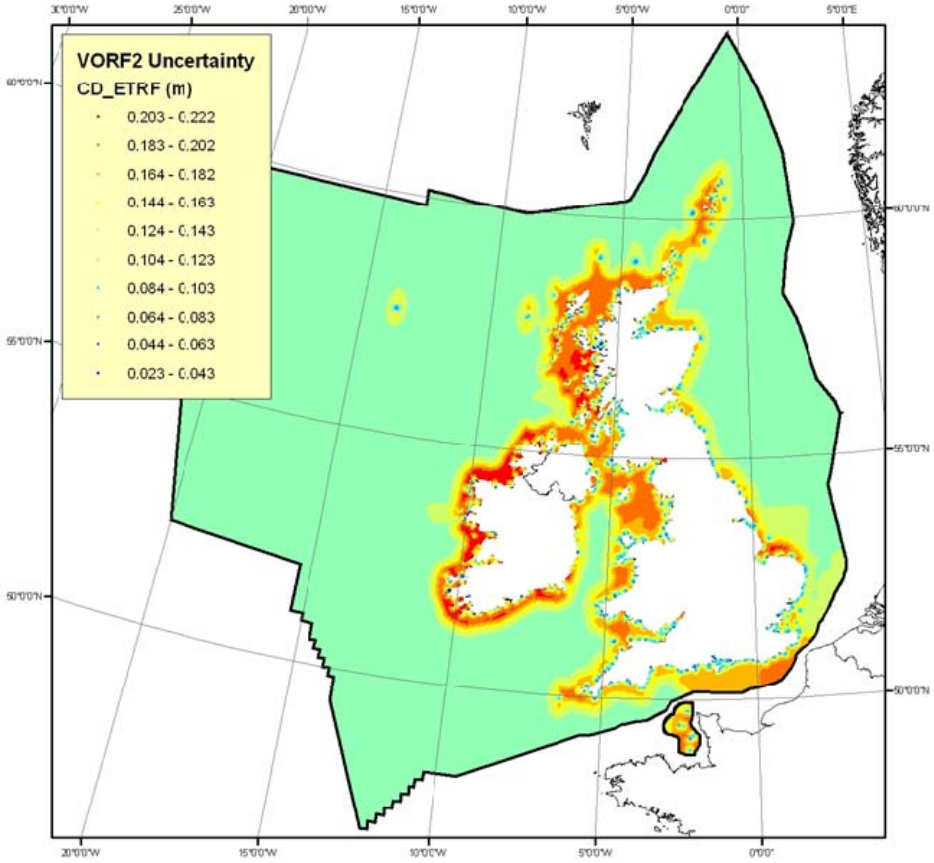
Current progress:

- V2.0 delivered to UKHO Jan 08.
- Now to do:
- Stakeholders to be revisited
- Needs full testing
- Needs to be developed into robust software
- Safety case



Accuracy achieved

- VORF was designed to be accurate to ±0.1m 1 sigma close to shore and ±0.15m 1 sigma offshore.
- Initial investigations show that it is slightly greater than this in some areas, but it will still be fit for purpose.
- VORF will be released with estimations of the uncertainties of the surfaces.



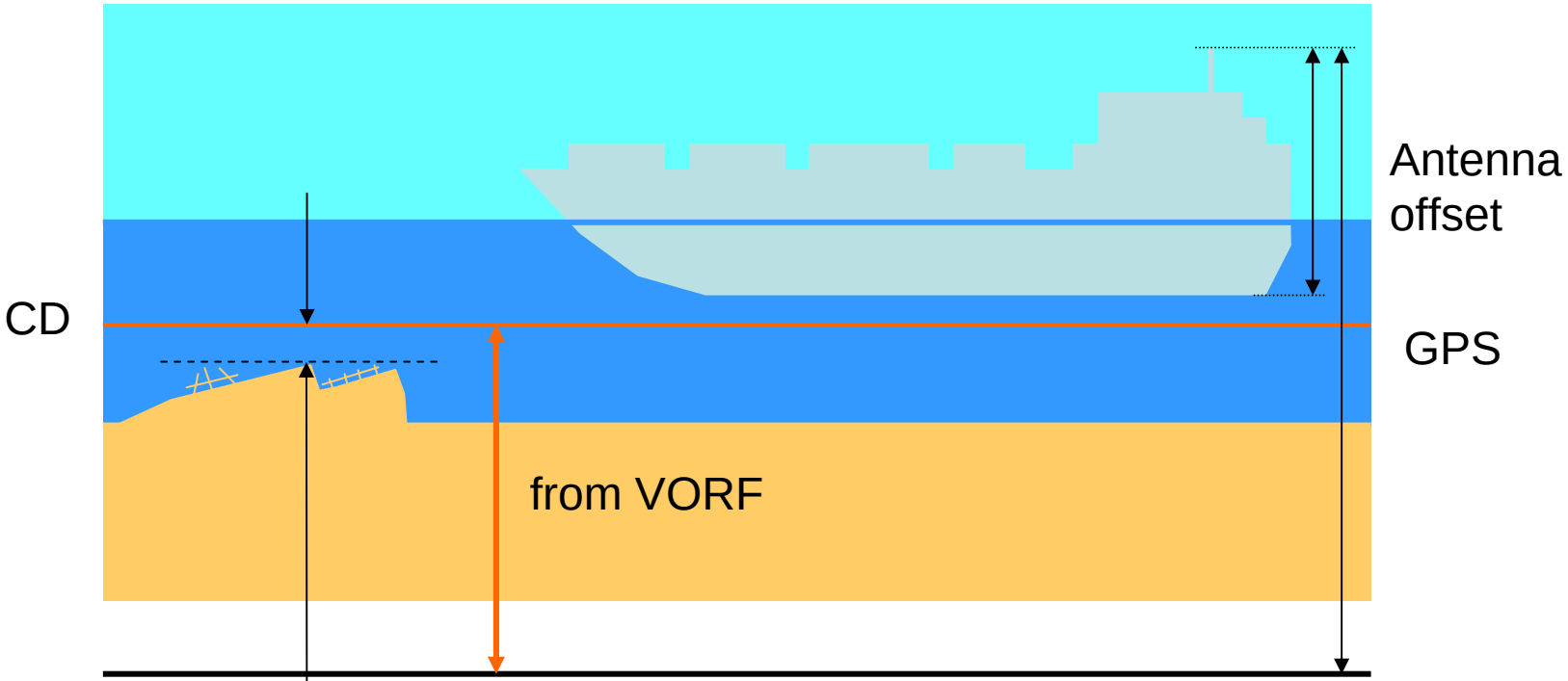
Why is VORF needed?

- Continuing developments in GPS
- LIDAR and multibeam technology
- Analogy with the Ordnance Survey heighting reference systems on land
- To deal with the increased use of GPS-based hydrographic surveys submitted to UKHO

How can VORF benefit the UKHO?

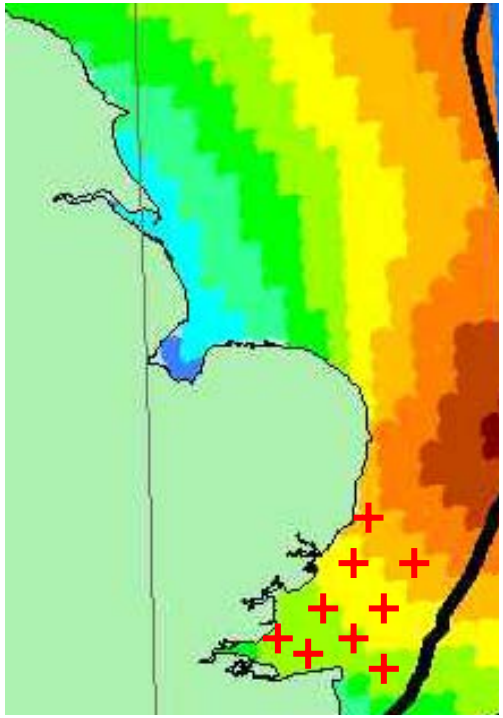
- Cost and efficiency of surveys
- Quality control
- Enabling new technologies
- Developing new products

Navigational users



Elimination of remote tide gauges

Specialist applications



Multibeam

VORF

→ **Improved digital bathymetry** → **Improved tidal models**

•Tidal predictions at “virtual tide stations” – accessible via satellite web link.

•Ship equipped with VORF and GPS is its own tide gauge – compare current reading to prediction, plot enhanced route/timing for approach to critical areas.

Summary of VORF advantages

- VORF derives continuous surfaces, with fixed reference to ETRF89.
- It provides a consistent interpolation between Chart Datums, and methodology for extrapolation offshore.
- It eliminates some of the reliance on remote or expensive tidal observations.
- It has the potential to be built in to real-time applications.
- It fully exploits current and future GPS technology, and is the basis for future accuracy enhancements.

Conclusions

- VORF is an enabling technology
- Surveying without tide gauges – cheaper, faster, more accurate
- New navigation and space management concepts
- Fully integrated data products
- SOLAS – improved navigation in critical areas
- VORF will help UKHO in its development of marine charting and navigation products