

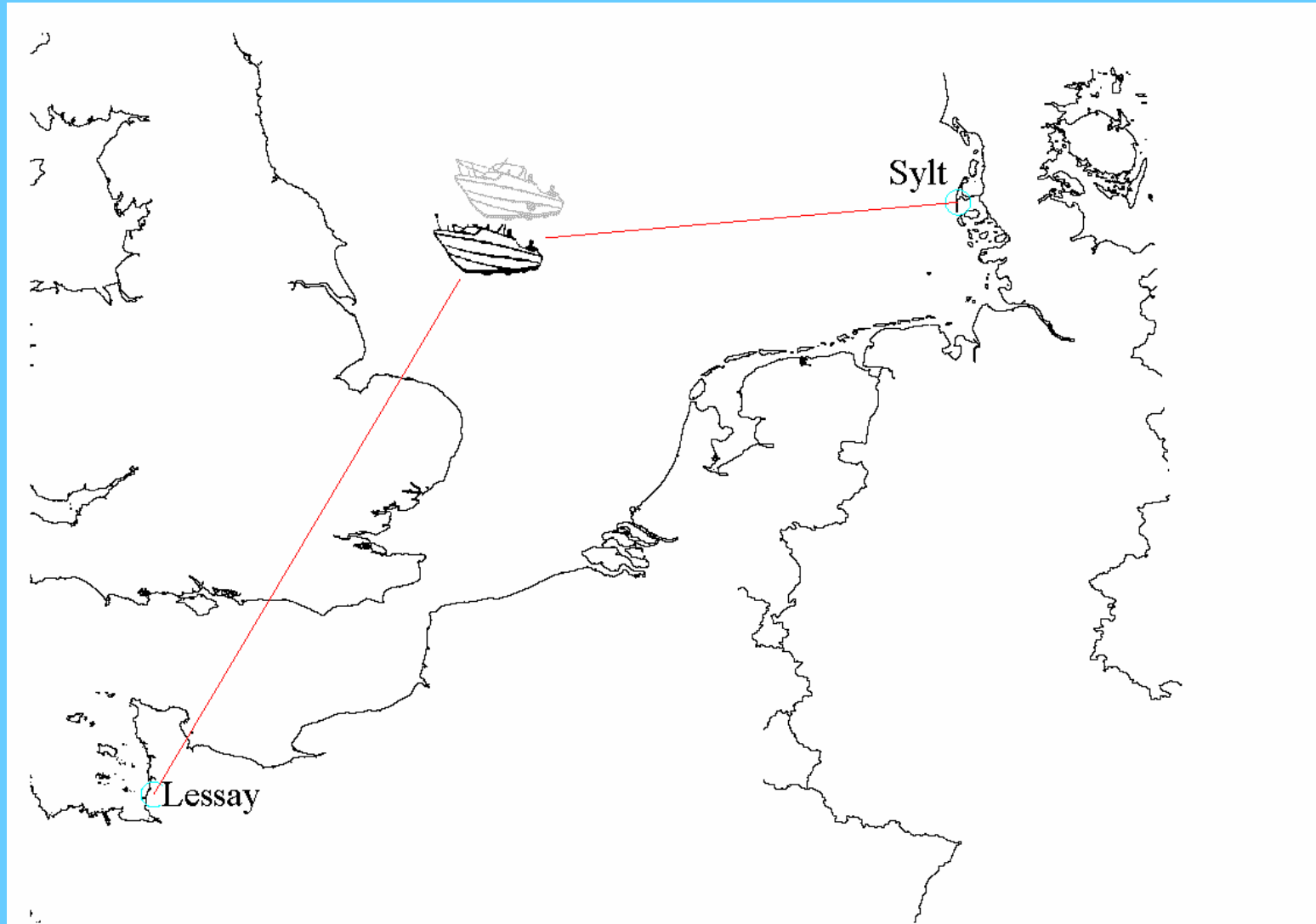
*33rd Annual Convention & Technical Symposium
International Loran Association*

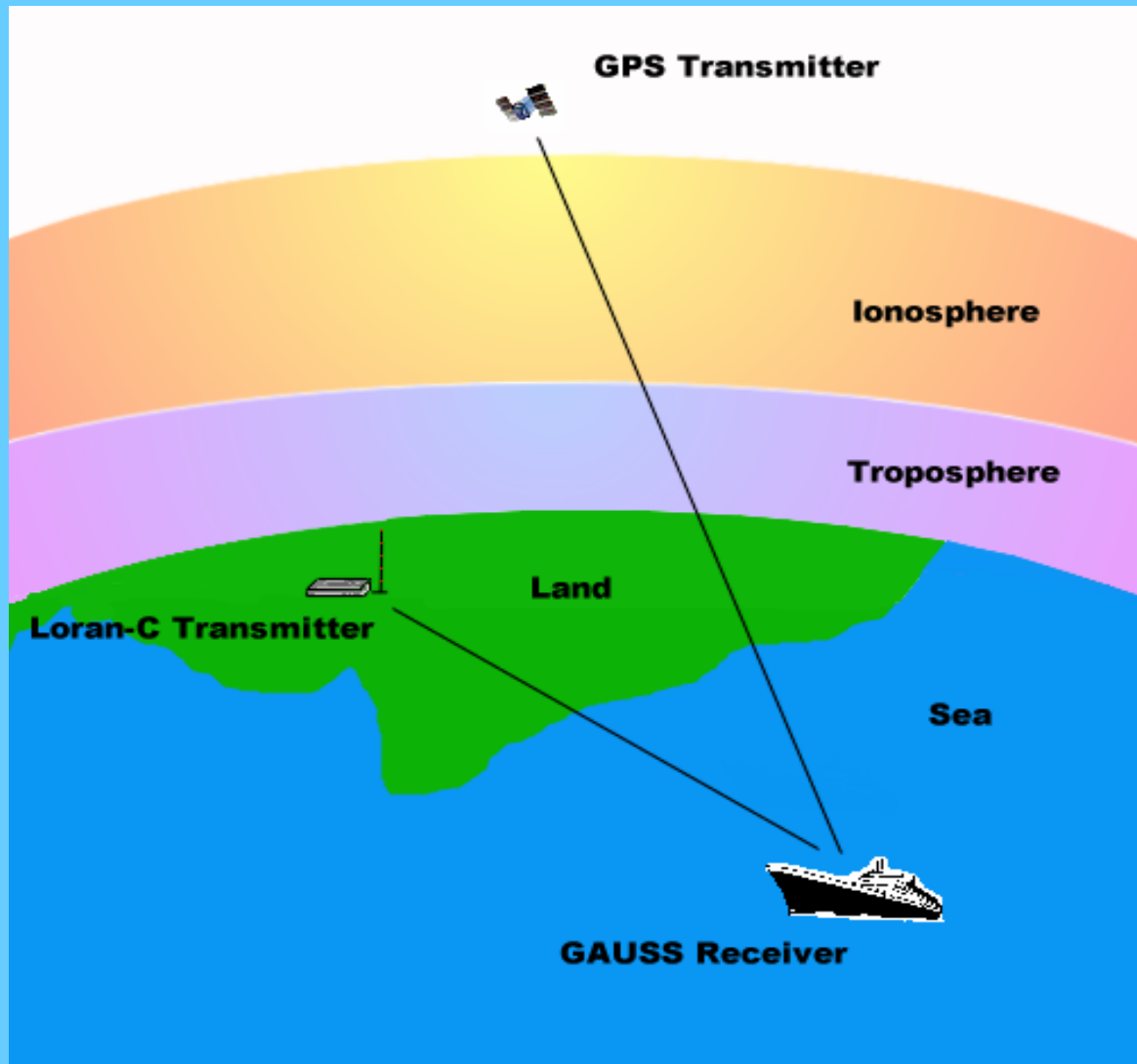
Extending the range of Loran-C ASF modelling

Dr Paul Williams
Professor David Last
University of Wales, UK



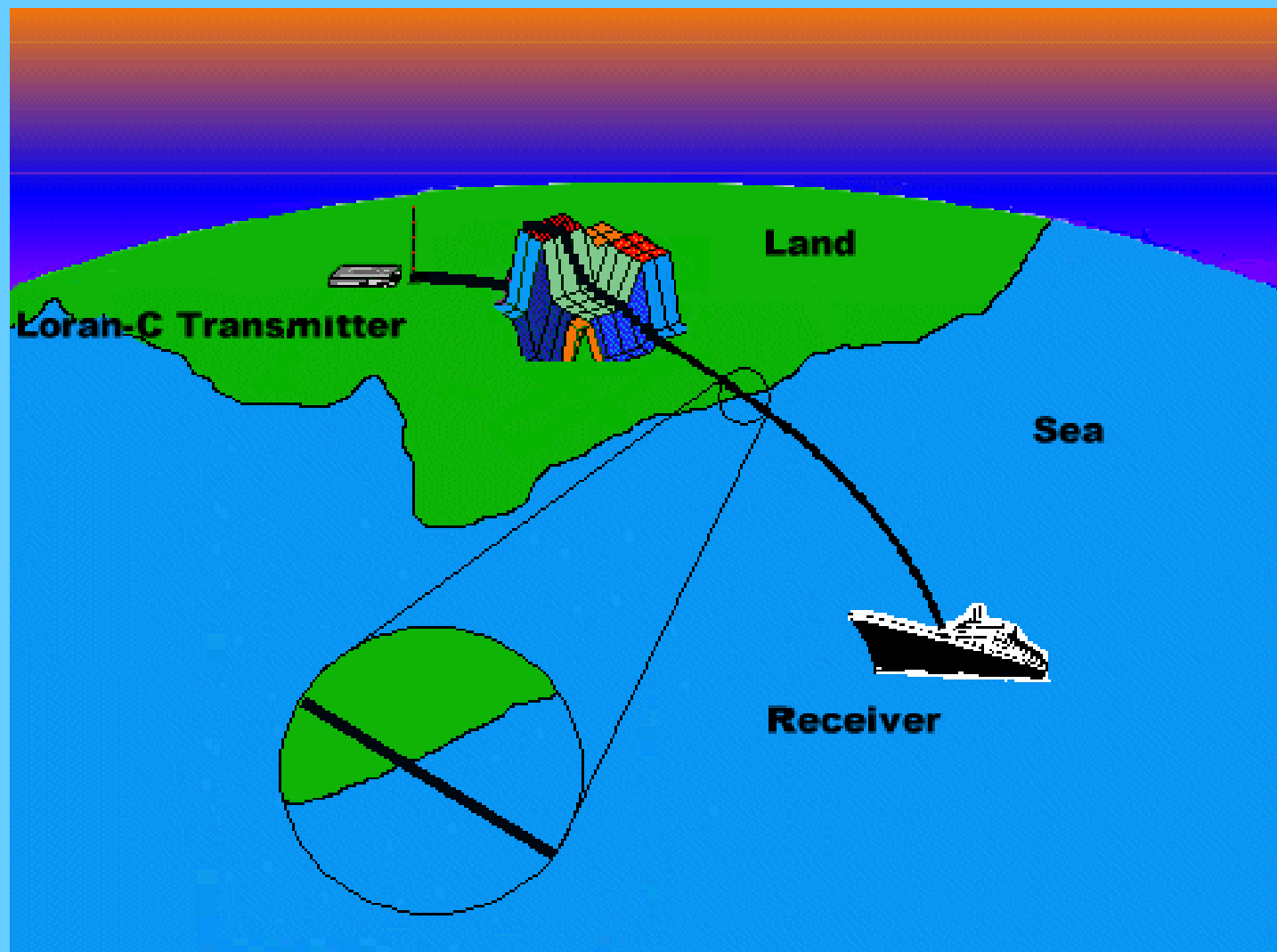
*October, 2004
Tokyo, Japan*

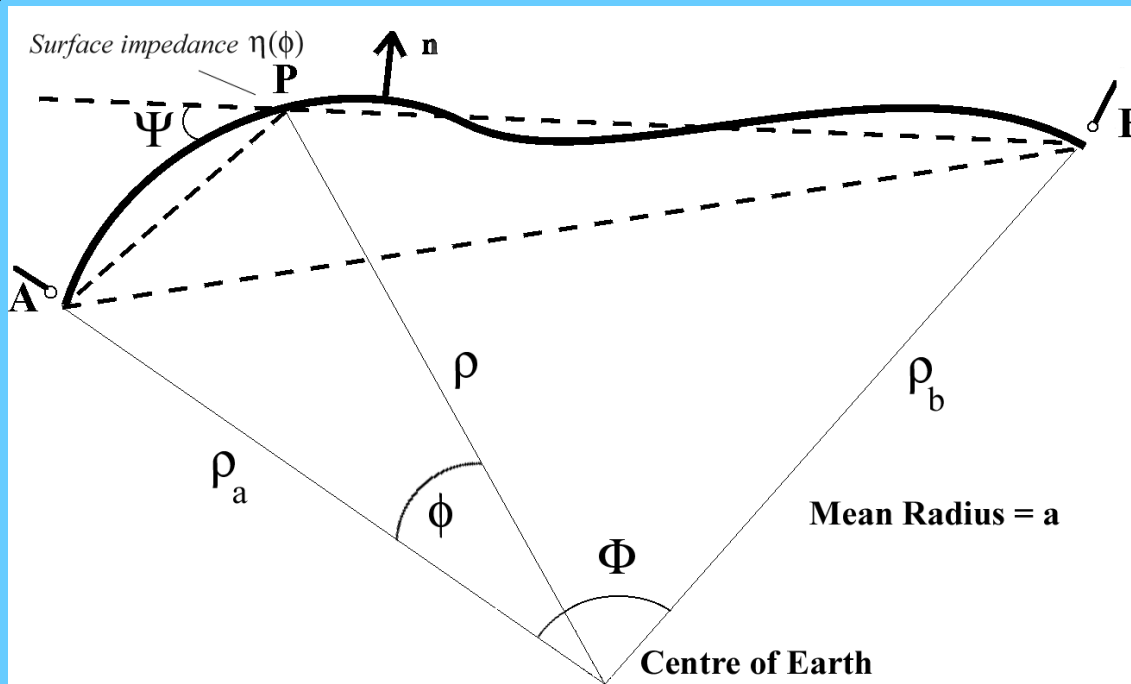




NELS ASF mapping - principles

- Calculate ASFs using most sophisticated computer models
- Measure values precisely at fewest data points
- Adjust modelled values to fit measured data
- Model gives detail, measurements remove biases
- Results validated by measurement programme





$$G = \frac{Z'_{AB}}{Z_{AB}}.$$

$$G(R) = 1 - \sqrt{\frac{j\beta_0}{2\pi}} \int_0^R \left(\psi + \frac{\eta}{\eta_0} \right) e^{-j\xi} \sqrt{\frac{R}{r(R-r)}} G(r) dr.$$

$$ASF(R) = G(R)_{Mixed-Path} - G(R)_{Salt-Water},$$

Start

Options

Locations

Cancel

☒ Generate radial list file
☒ Compute?
☒ Grid Radial data

Transmitter	Power kW	Nominal ECD
Williams	400.00	1.00
ShoalCove		
George		
PortHardy		
Caribou		
Nantucket		
CapeRace		

Enter New Location

Location Name

Input Data Boundaries

Destin

North

30.9

West

East

Advanced Options

Latitude Resolution : 0.01 deg

Longitude Resolution : 0.01 deg

Interval Distance : 630 m

Receiver Height : 0 m

OK

Cancel

Location Manager

Save

Add Location

Load

Remove

OK

Cancel

Name
Bismark
GrandJunct
PointPinos
Spokane
LittleRock
Destin

Monteath Options

Coastline Database File :-

C:\Balar\Coastline\usa.dat

Browse

Terrain Database Directory :-

C:\Balar\DTED

Browse

Conductivity Database Directory :-

C:\Balar\CND

Browse

Root Directory for Output Data :-

C:\Balar\OutputData

Browse

Maximum distance along radial: 2000 km

Frequency: 100 kHz

30.9

-85.9

29.8

-87.2

OK

Cancel

Advanced

Balor & Blodeuwedd

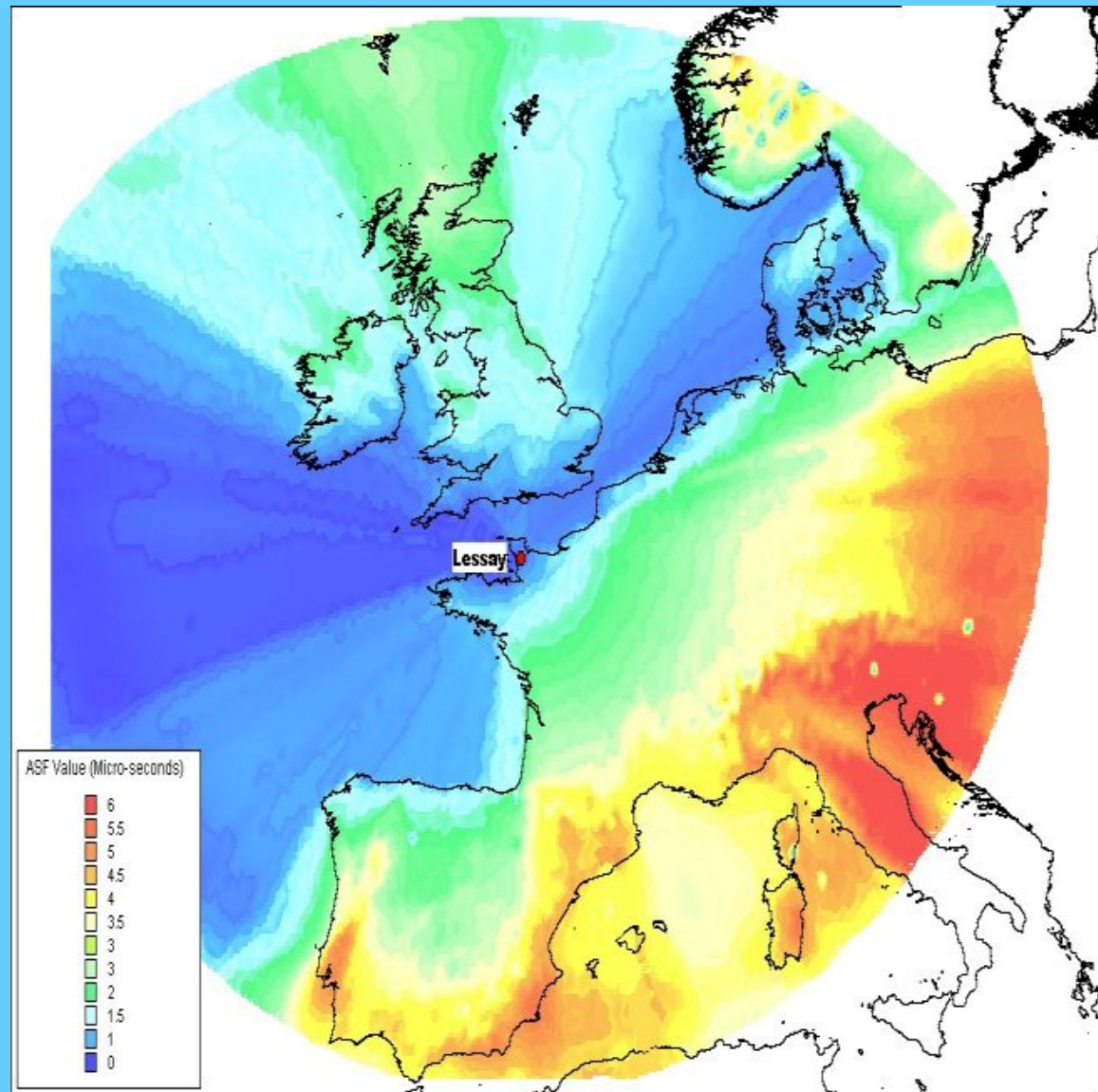
The Pantheons of British Mythology

*Balor of the
evil eye:
God of death
and destruction*

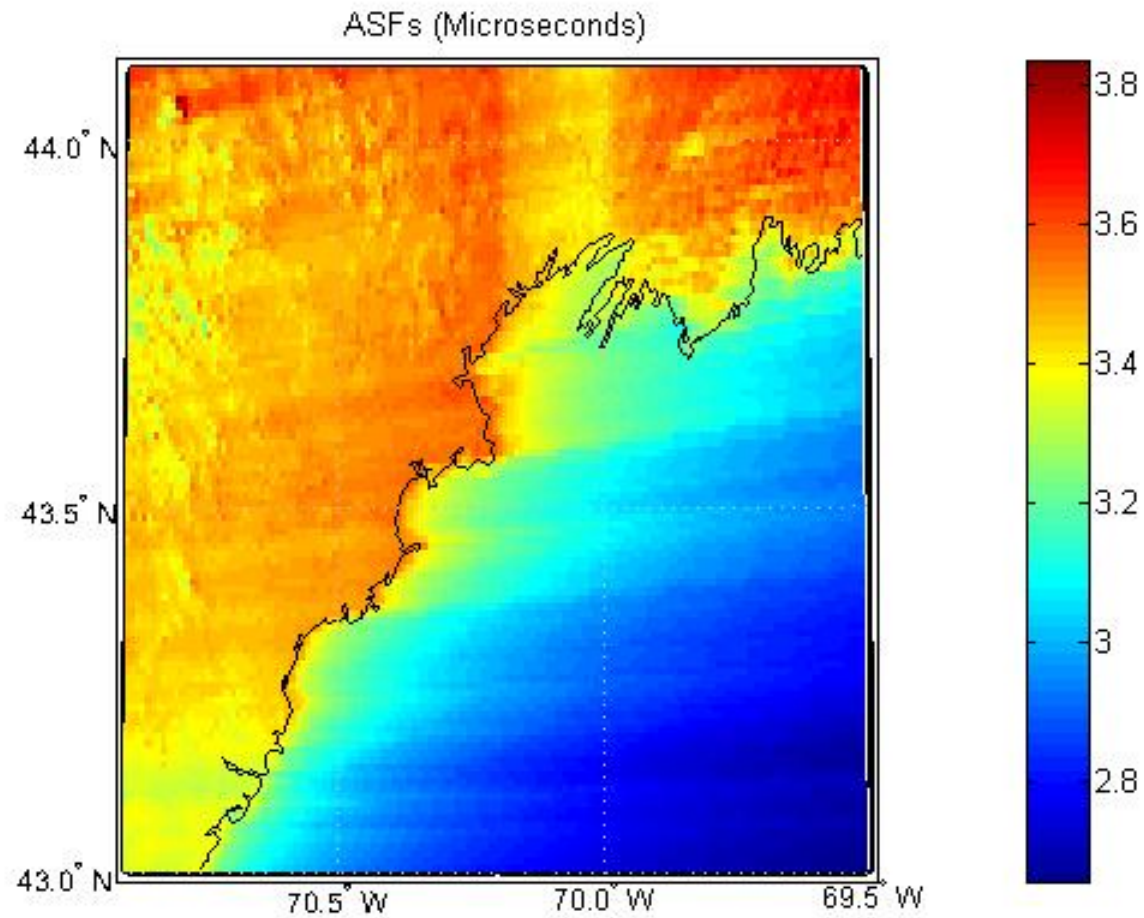


Pictures: Balorworld.com; gods-heros-myth.com; mysteriousbritain.co.uk

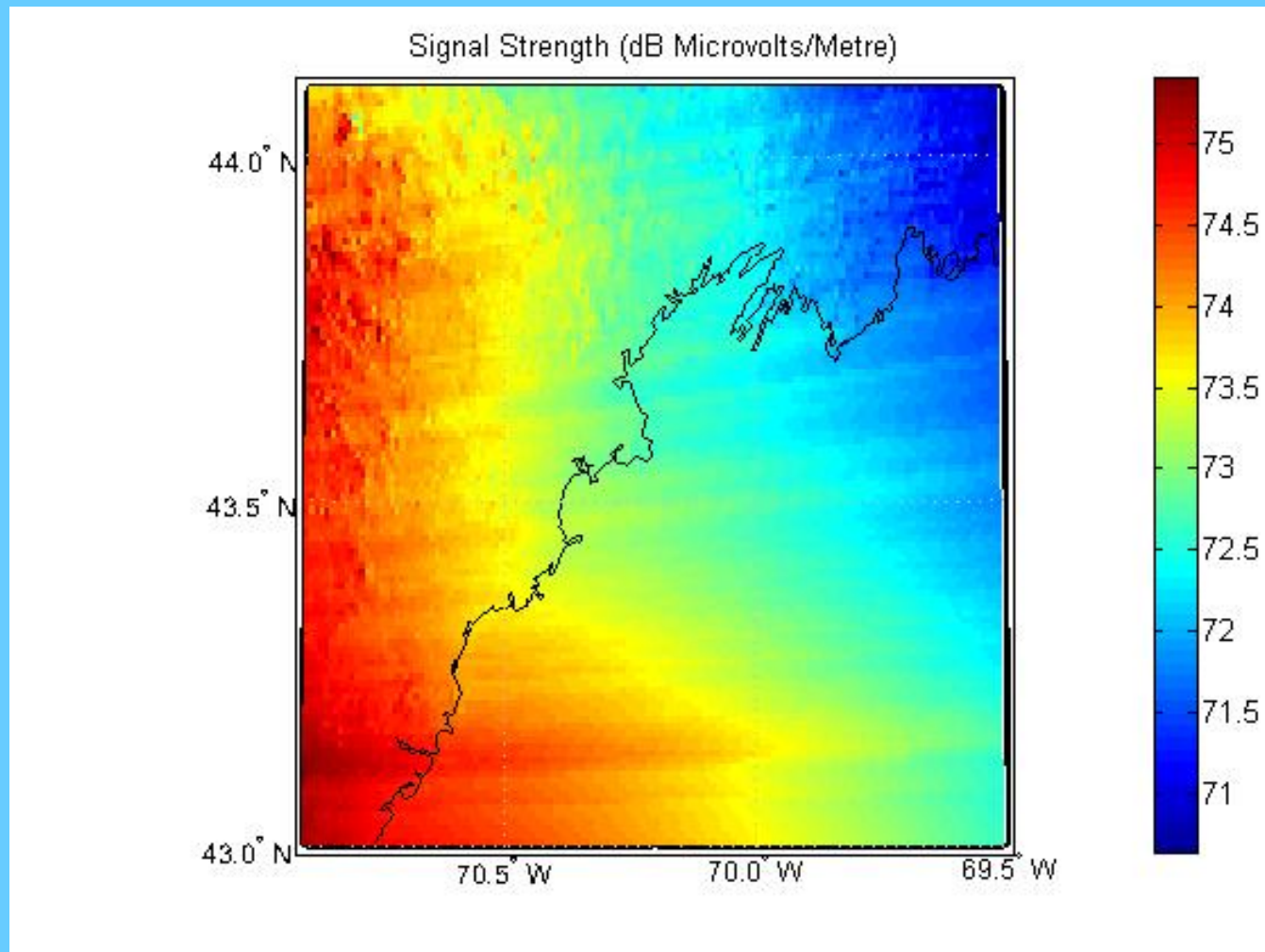
Lessay ASFs



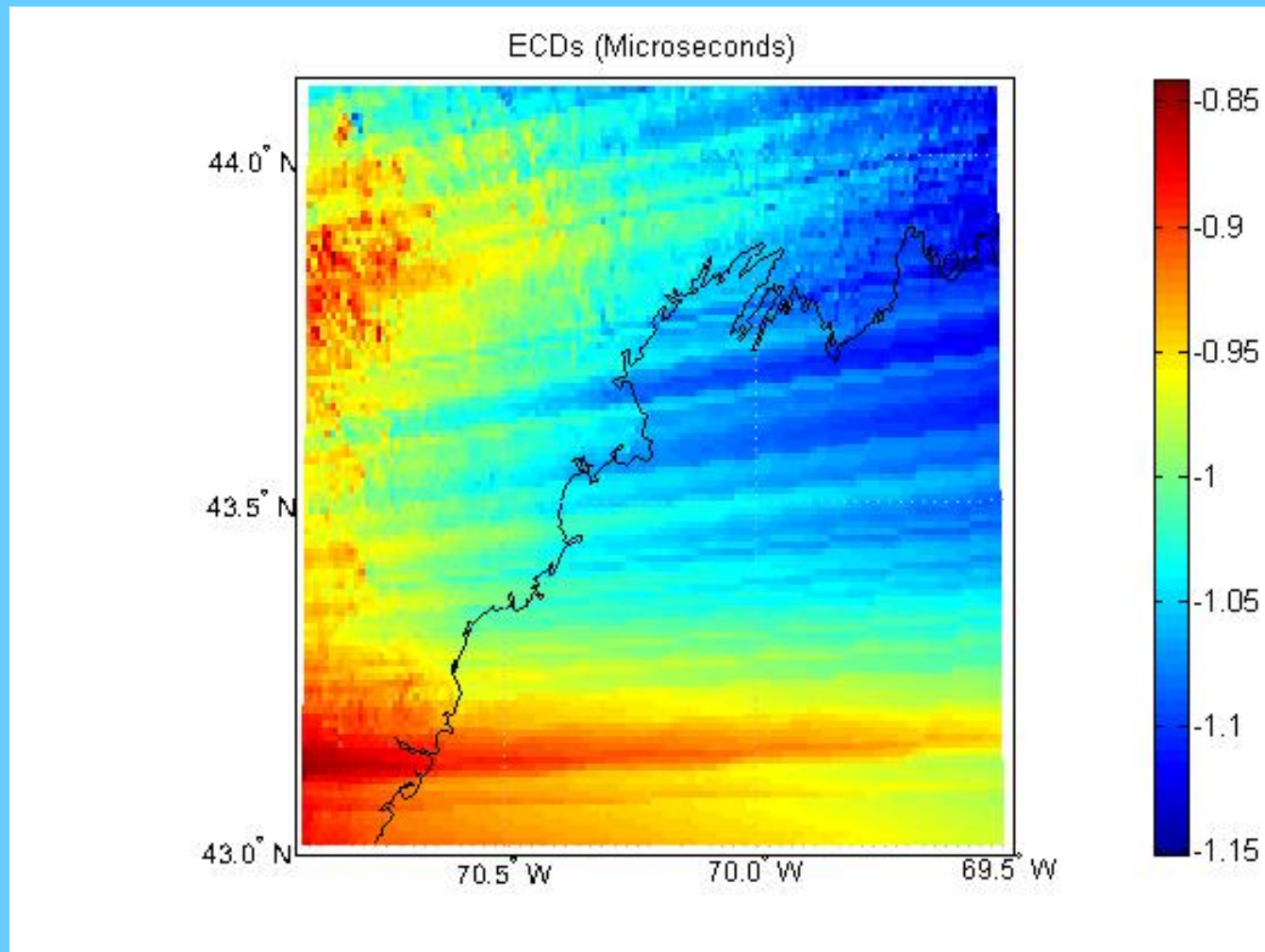
Seneca ASF values around Cape Elizabeth, Maine

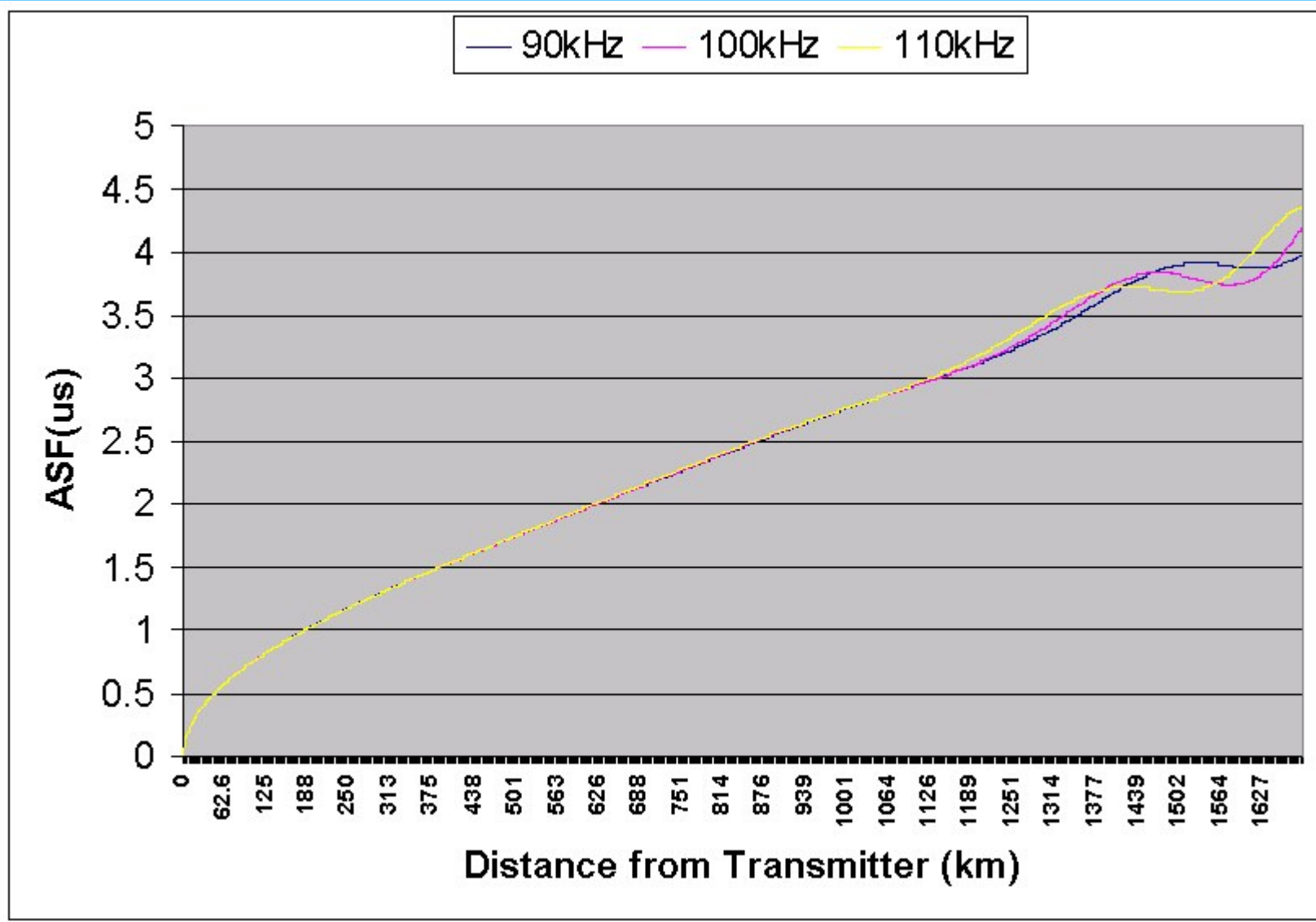


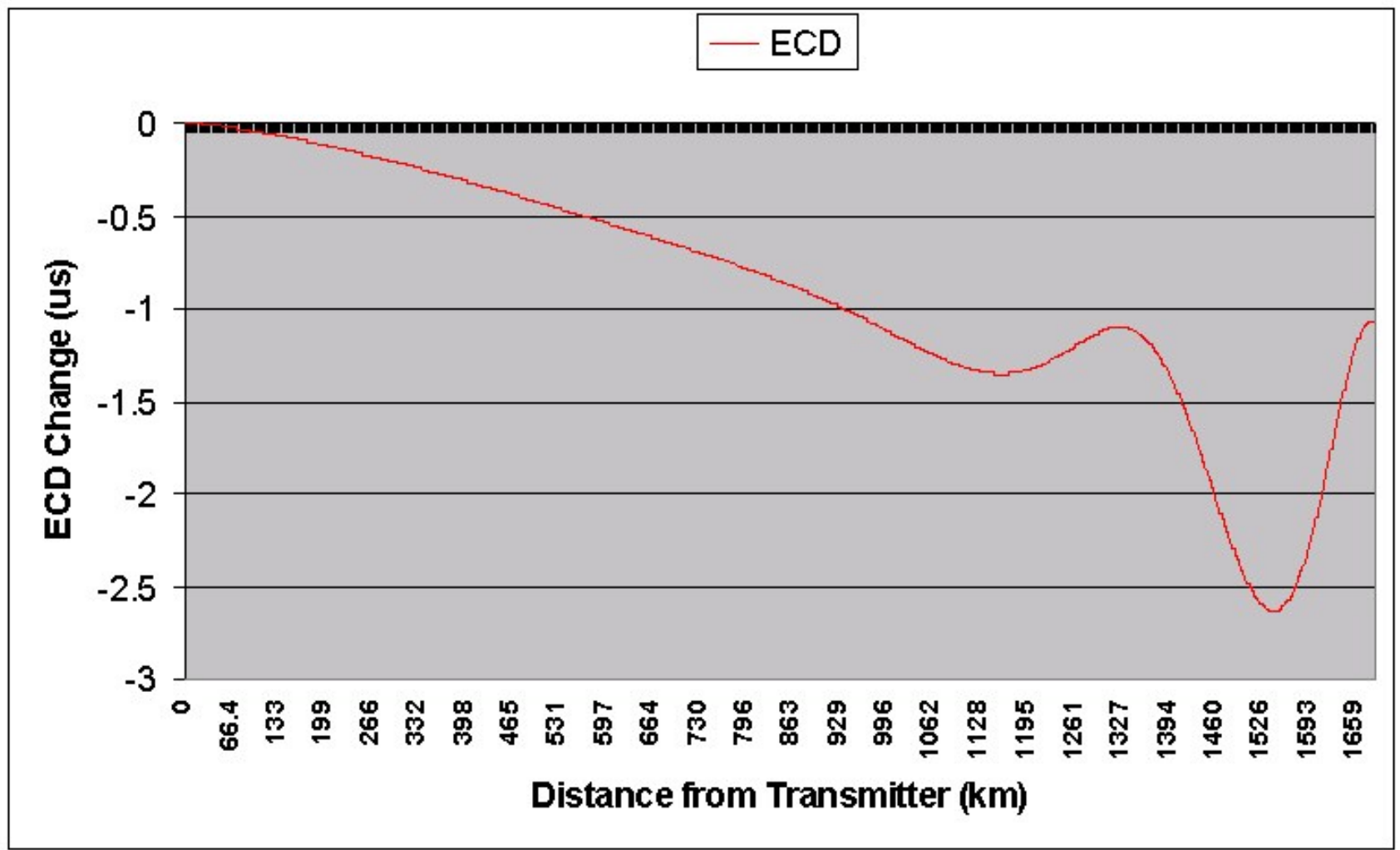
Seneca field strength values around Cape Elizabeth, Maine



Seneca ECD values around Cape Elizabeth, Maine

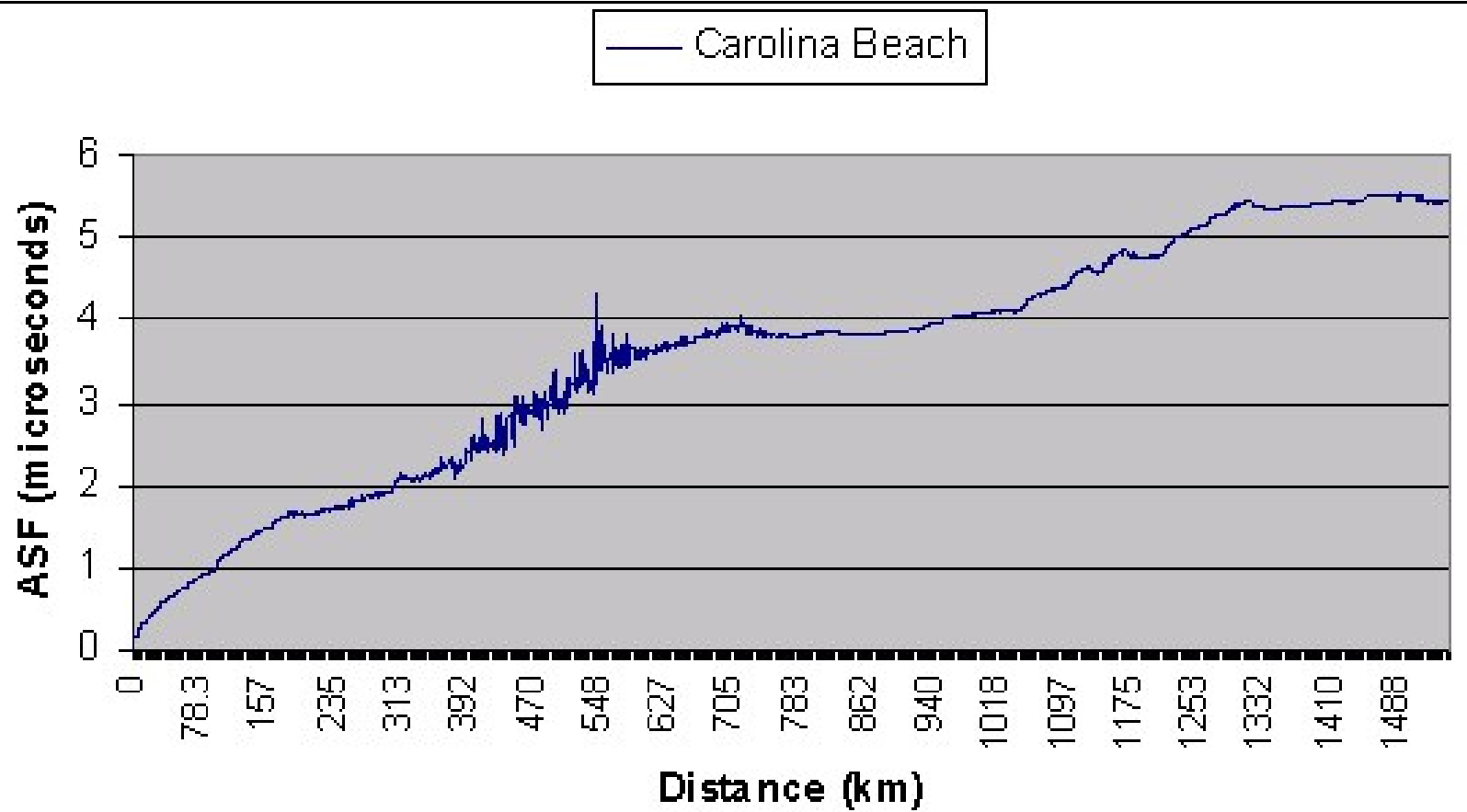




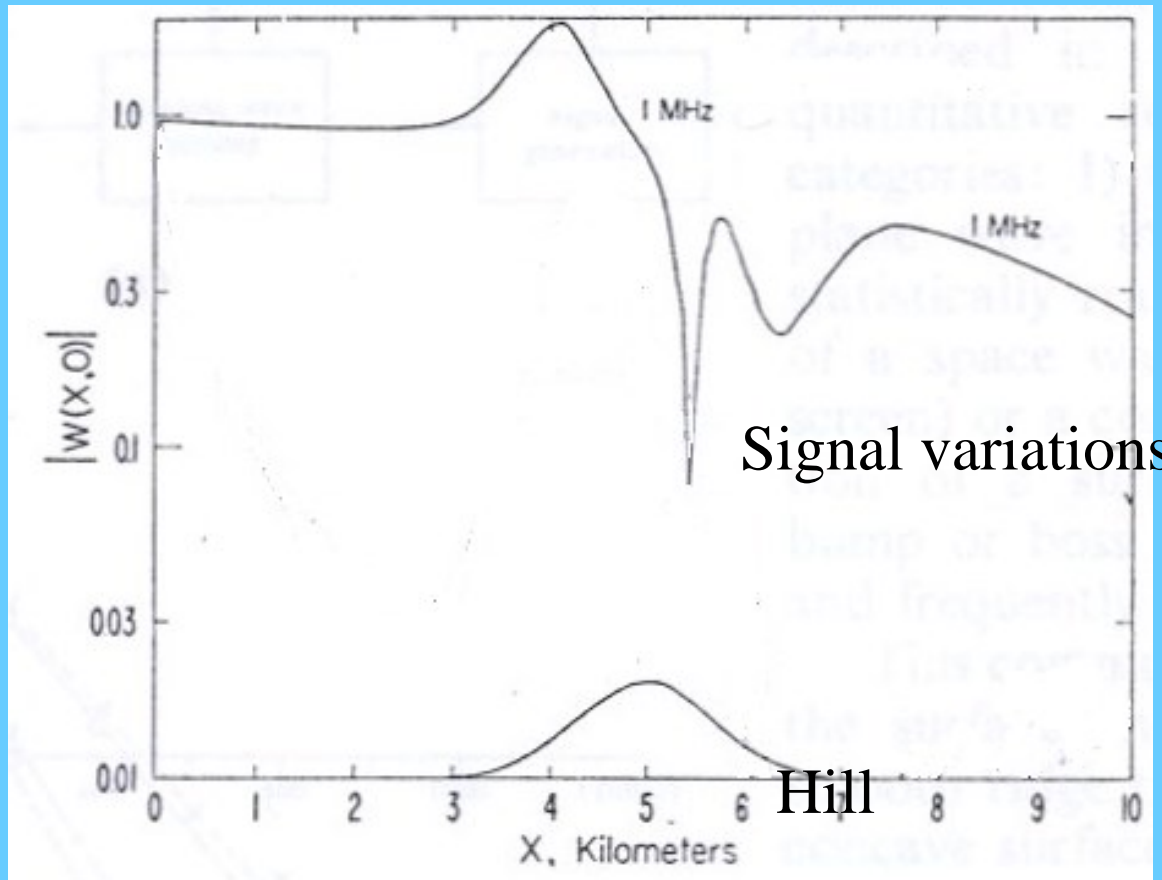


Ohio University flight trial route

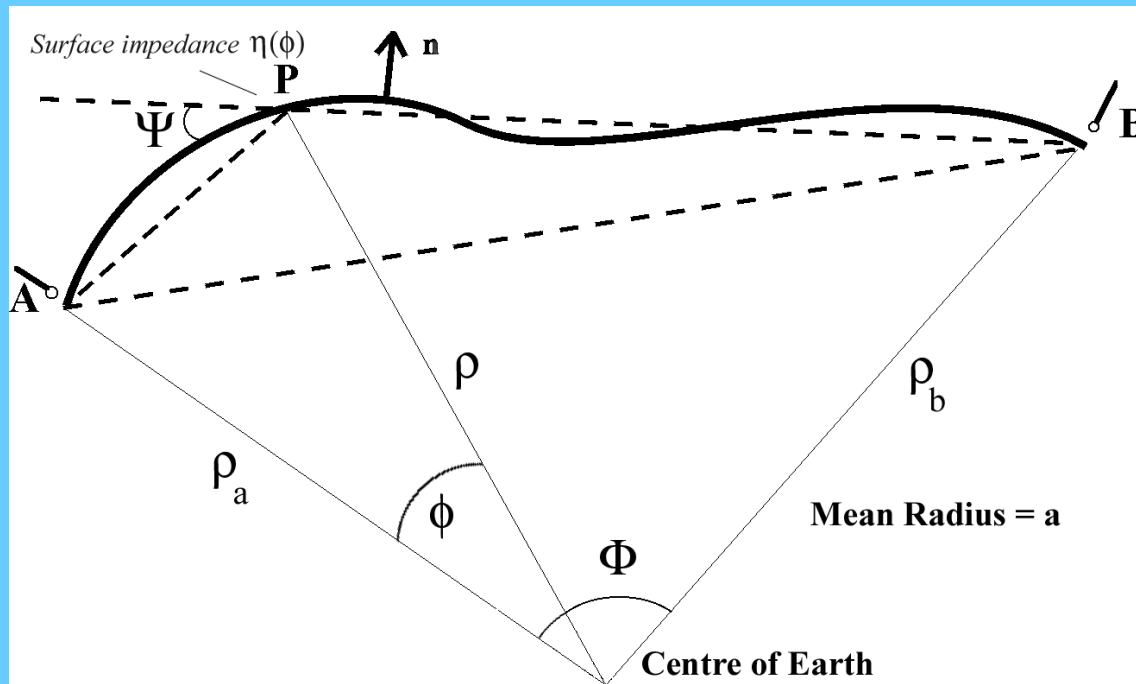




Could the wobble be in the model?



Signal variations in 1 MHz signal downstream of 1500m-high hill



$$G(R) = 1 - \sqrt{\frac{j\beta_0}{2\pi}} \int_0^R \left(\psi + \frac{\eta}{\eta_0} \right) e^{-j\xi} \sqrt{\frac{R}{r(R-r)}} G(r) dr.$$

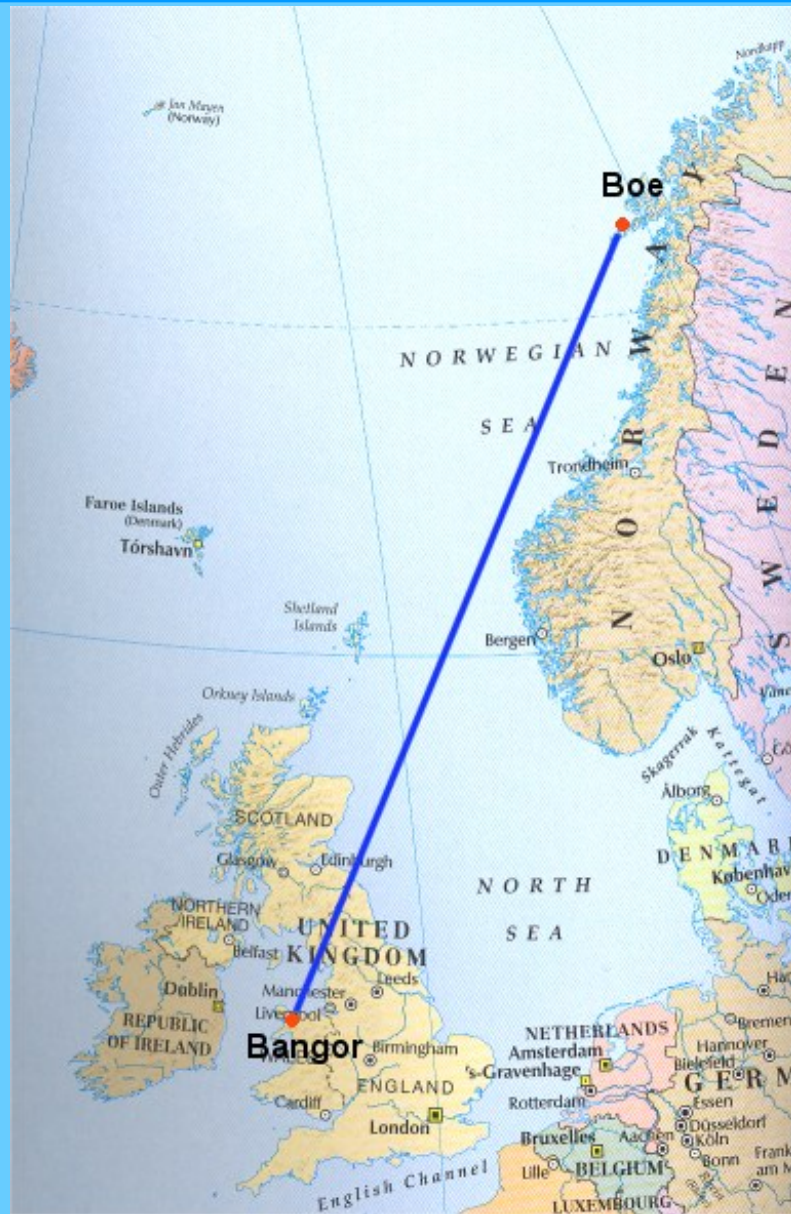
$$\xi = \beta_0 (|AP| + |PB| - |AB|)$$

From this:

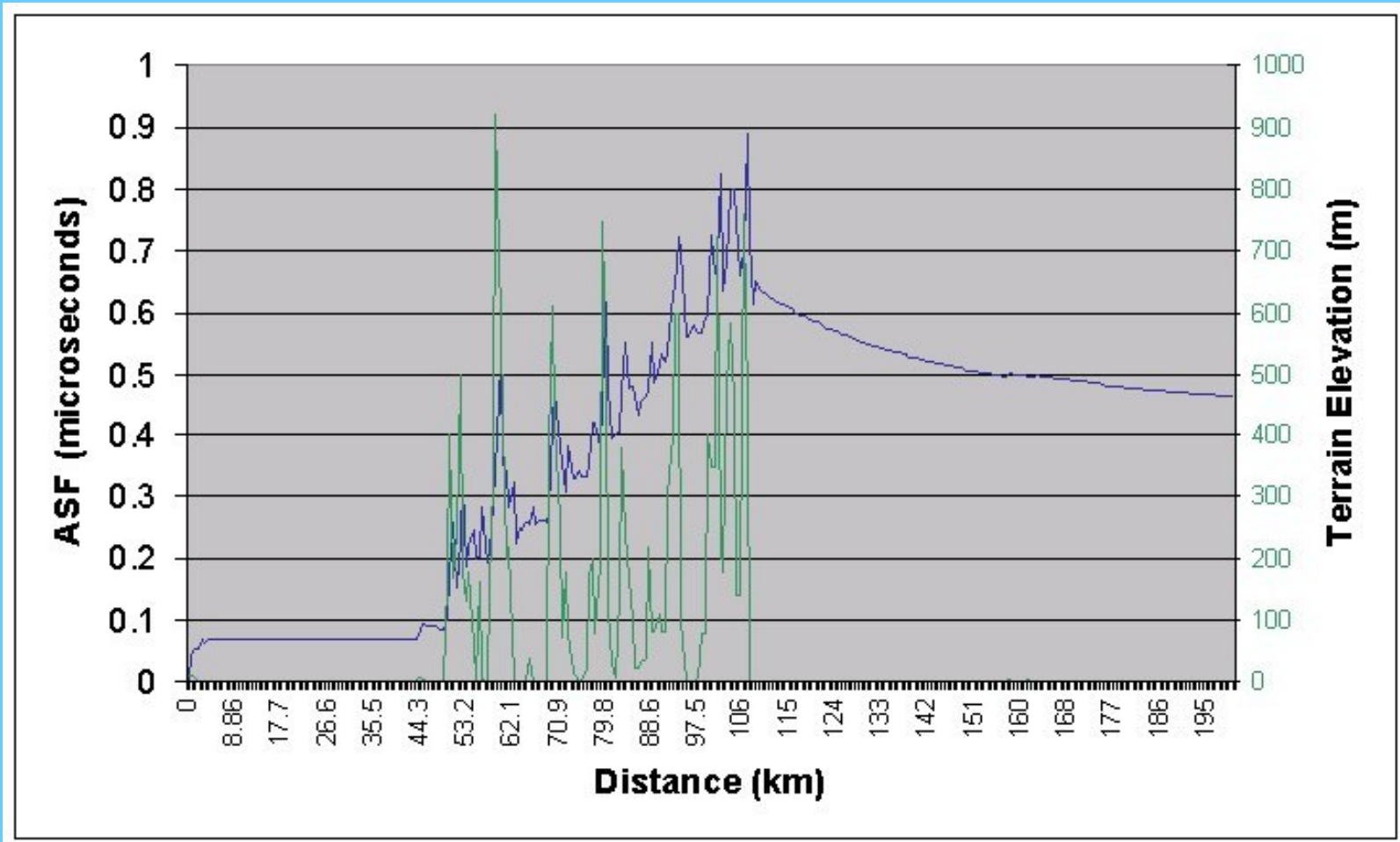
$$G(R) = 1 - \sqrt{\frac{j\beta_0}{2\pi}} \int_0^R \left(\psi + \frac{\eta}{\eta_0} \right) e^{-j\xi} \sqrt{\frac{R}{r(R-r)}} G(r) dr.$$

To this:

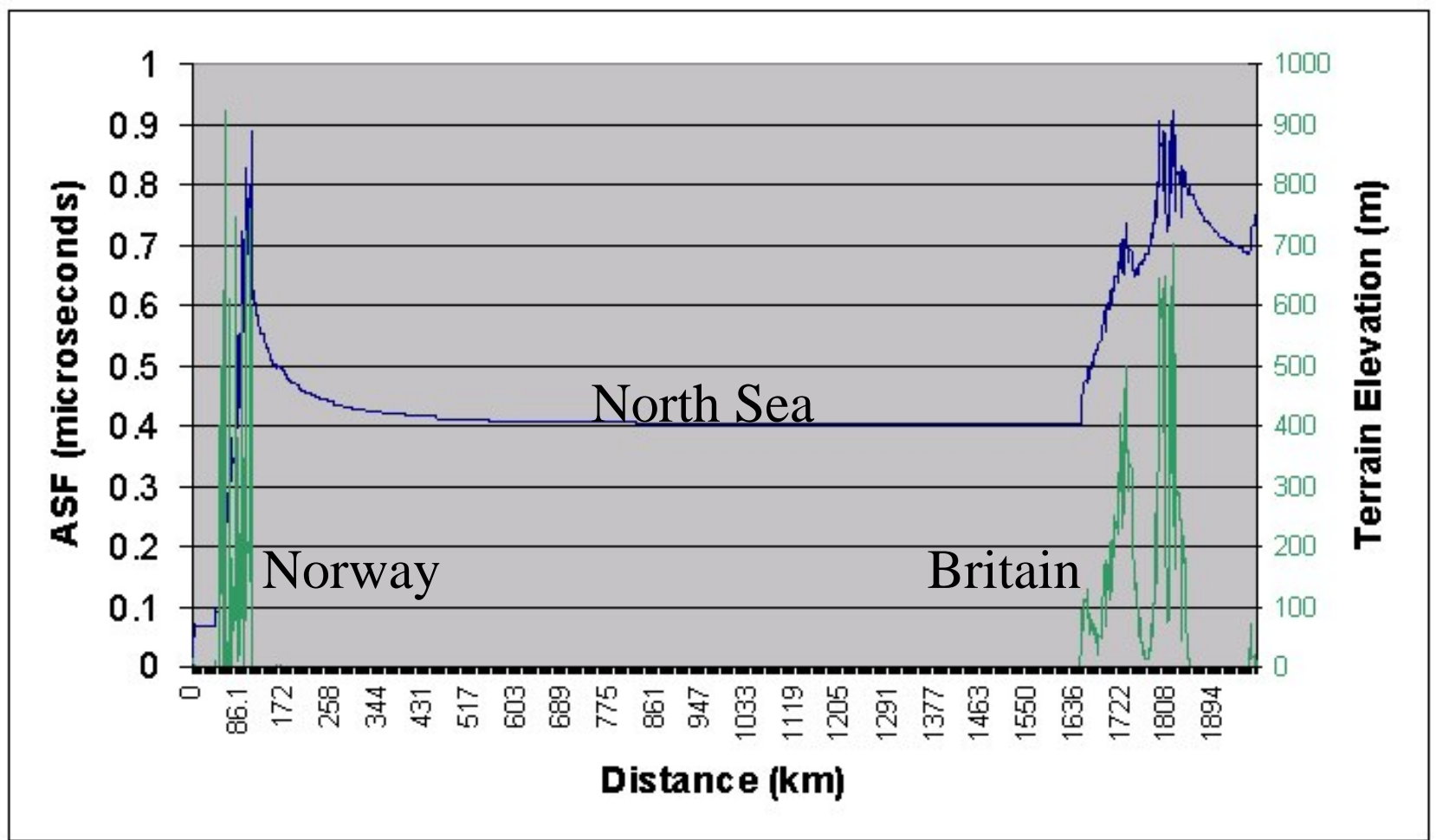
$$W(R) = W_{10}(R) - \frac{1}{2} \sqrt{\frac{j\beta_0}{2\pi}} \int_0^R (\Delta_s - \Delta_e) W(r) W_{20}(R-r) \sqrt{\frac{R}{r(R-r)}} dr$$

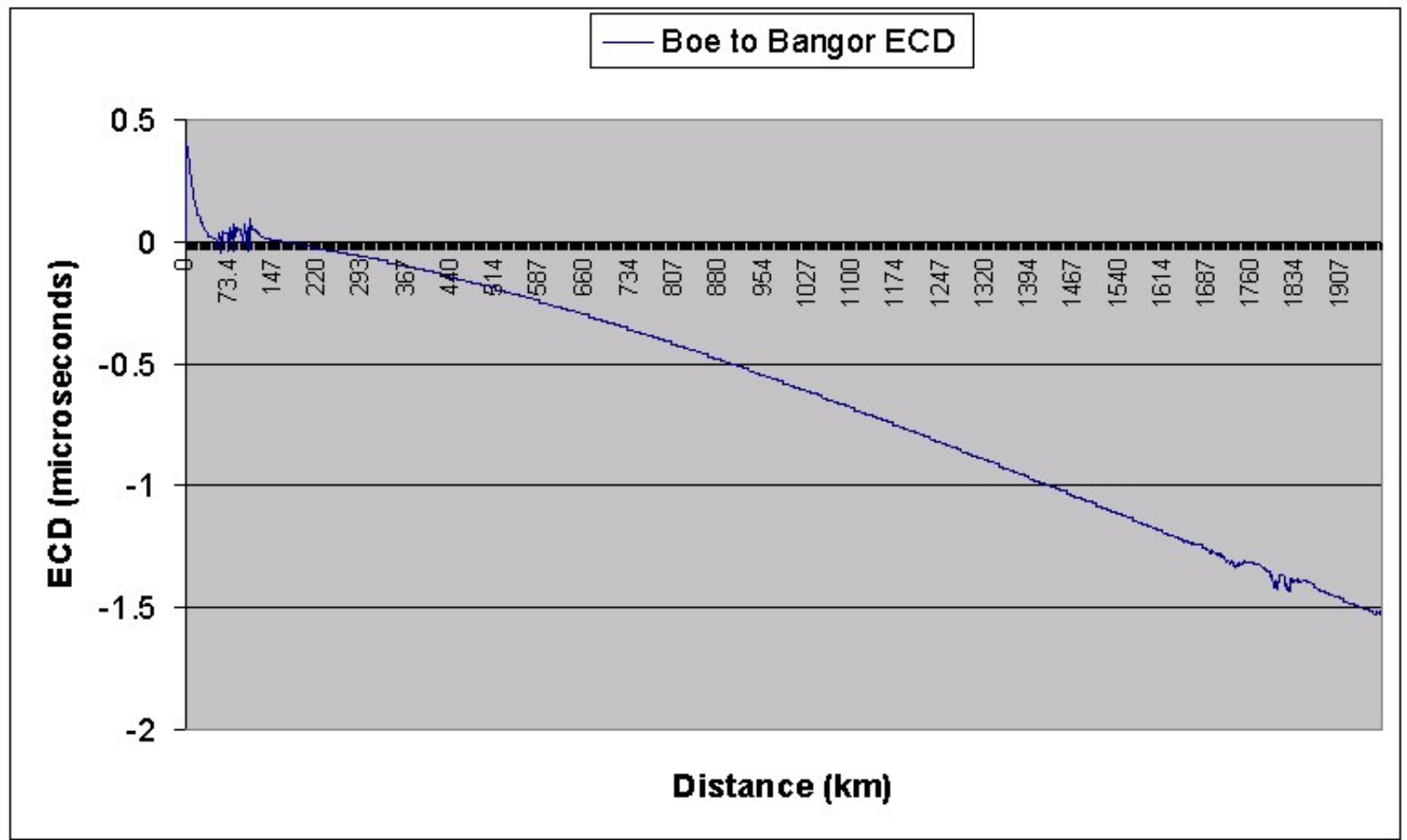


Bø to Bangor ASFs – Norwegian section



Bø to Bangor ASFs





Further Work

- Validation of new model
- ECD computation:
 - Method used?
- Optimisation of computations:
 - Arithmetic
 - Suitable integration interval
 - Vectorization of the algorithm
- Altitude of receiver:
 - Requires more complicated expressions

Summary of Status

- Discovered the origin of the 1000km wobble within the original simplified equation used by Monteath.
- Demonstrated an alternative solution to the problem of Loran-C propagation
- Incorporated the solution into the Balor software.