

**Royal Netherlands Navy**  
Hydrographic Service


Unifying vertical reference surfaces in the North Sea  
An overview of developments

**TU Delft** Delft University of Technology

**Deltares**  
Enabling Delta Life

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**Introduction**

Vertical references:

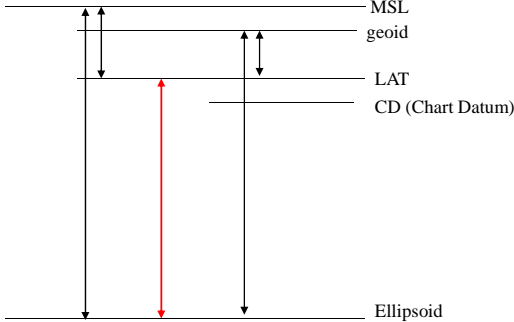
<u>Marine</u>	<u>Terrestrial</u>
MSL	Geoid
LAT (IHO TR!)	Ellipsoid
Chart Datum	National system

Complications of these differences:  
 Coastal management tasks require merging;  
 GNSS heights cannot be used;  
 Reference level of hydrodynamic models problematic.

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### Theory



The diagram illustrates the vertical relationship between different datums. From top to bottom, the levels are: MSL (Mean Sea Level), geoid, LAT (Lowest Astronomical Tide), CD (Chart Datum), and Ellipsoid. Vertical double-headed arrows indicate the distances between MSL and geoid, geoid and LAT, LAT and CD, and CD and Ellipsoid. A red vertical arrow also indicates the distance from the Ellipsoid to the LAT level.

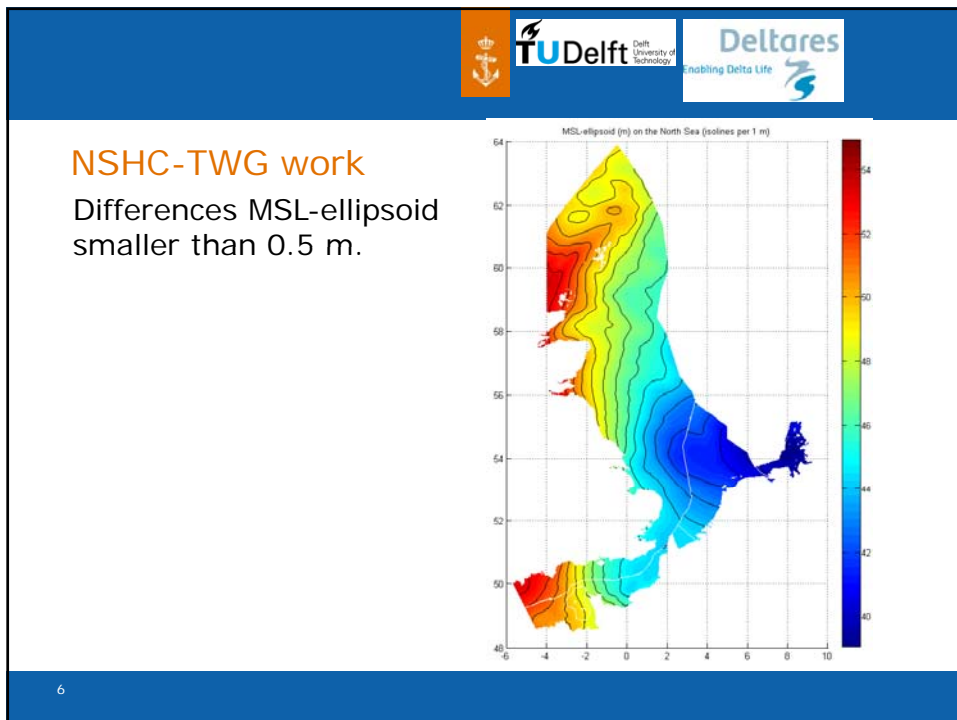
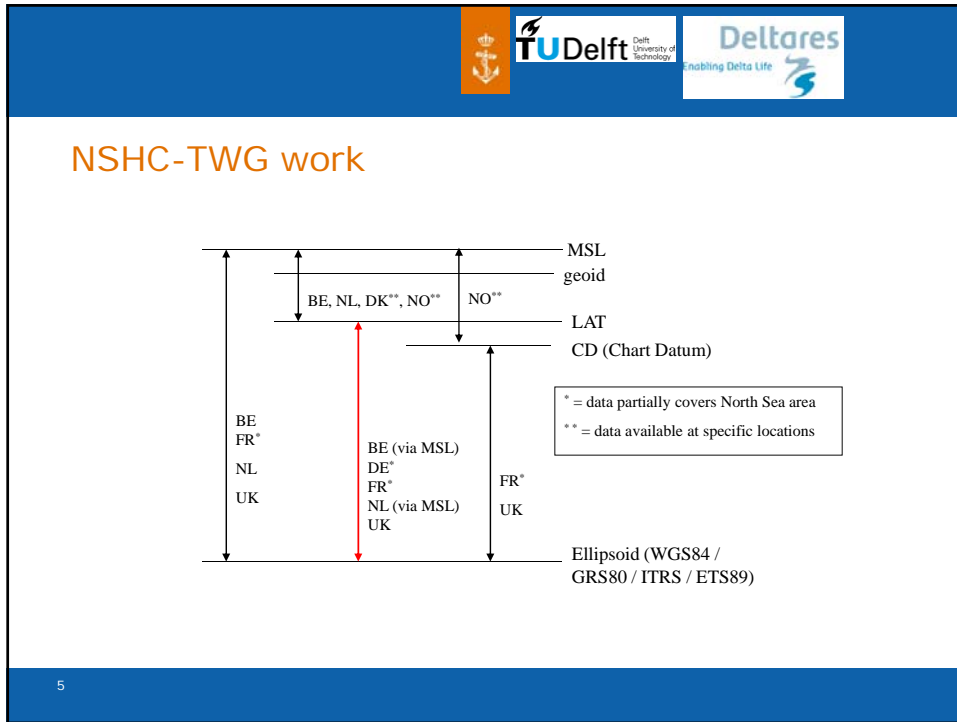
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### Theory

<p><u>Geoid</u></p> <p>Equipotential surface = reference surface of hydrodynamic model</p> <p>Defined terrestrially</p>	<p><u>MSL</u></p> <p>Is not defined on land</p> <p>Can be observed at tide gauges</p> <p>Can be observed outside the littoral zone by radar altimetry</p>
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NSHC-TWG work  
Differences MSL-ellipsoid smaller than 0.5 m.

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**NSHC-TWG work**  
Differences LAT-ellipsoid smaller than 0.5 m.

LAT-Ellipsoid on the North Sea (m) (isolines per 1 m)

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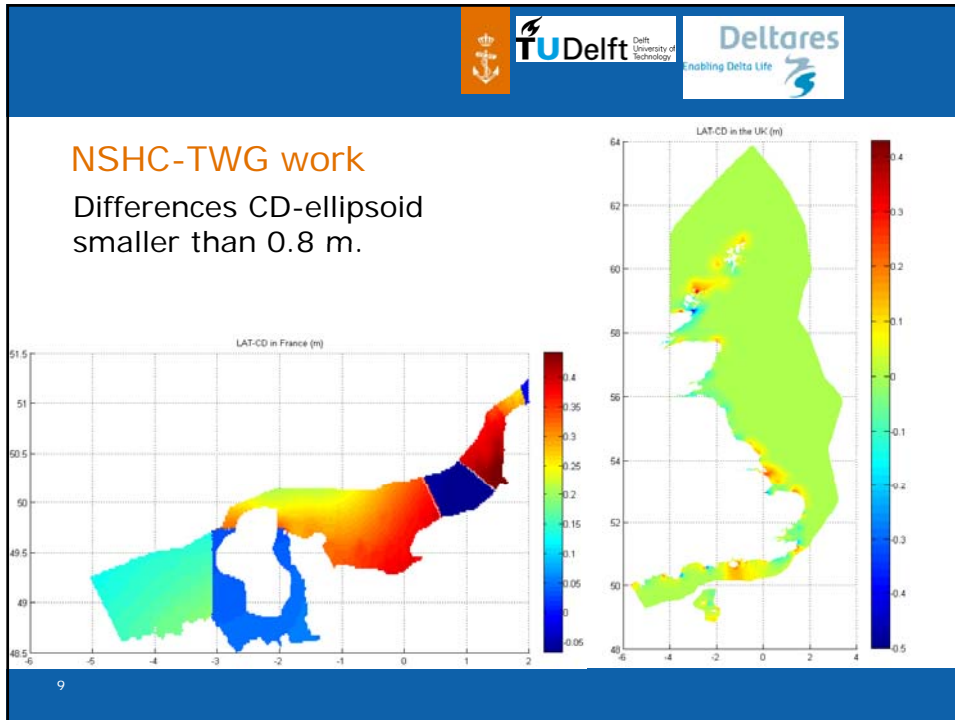
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**NSHC-TWG work**  
Differences CD-ellipsoid smaller than 0.8 m.

Chart Datum - ellipsoid (m) on the North Sea (isolines per 1 m)

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Bringing Land And Sea Together

**BLAST**  
Bringing Land and Sea Together

BLAST WP3:  
developing the marine and coastal reference base  
TUDelft/Deltares, University College London, Danish TU

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## TUDelft/Deltares contribution

Connect the geoid with the other reference surfaces  
Using:

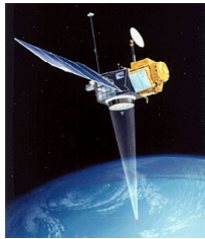
- (Retracked) radar altimetry
- Gravimetric data from various sources
- Hydrodynamic model DCSM
- Iterative model calibration

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## Radar altimetry

- + High-spatial resolution
- + Homogenous coverage
- Gaps along the coast
- Observes instantaneous sea surface
- Requires hydrodynamic model to reduce heights to equipotential surface.



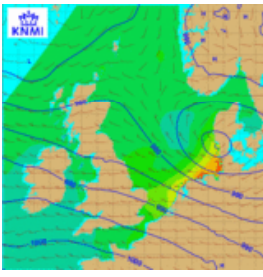
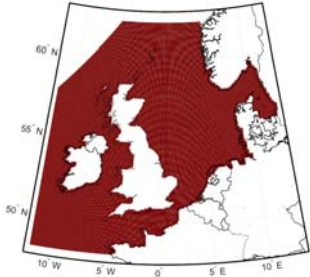

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### DCSM

Used operationally to forecast water levels and storm surges in the North Sea.  
Calculates the sea level and the depth-averaged current (2D version) on the Northwest European Continental Shelf.



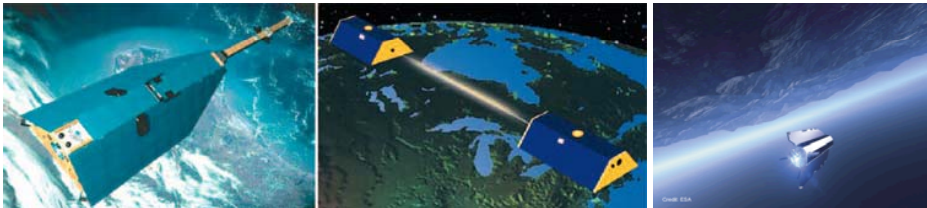
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### Gravimetry

Satellite gravimetry: low spatial resolution  
Airborne/marine/terrestrial gravimetry: inhomogeneous coverage



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## Conclusion

NSHC-TWG surfaces neither consistent nor fully covering North Sea.

BLAST provides opportunities to create common reference surfaces.

This has the potential to create consistent depth model of North Sea,  
and it enables marine and terrestrial data merging.