UNITED NATIONS GLOBAL GEODETIC CENTRE OF EXCELLENCE

Joining Land and Sea | 2-5 December 2024

Height is hard

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Height is hard … but important

- Which way does water flow?
- What is at risk during a flood?
- How do we build a sewerage system in the city?
- How to develop an efficient irrigation system for agriculture?
- How to ensure the correct inclination of railways and roads?
- How to know the under keel clearance of a ship?
- How to monitor the sea level change?
- What is the height of the top of the mountain?

https://www.welt.de/vermischtes/weltgeschehen/gallery9348988/Das-Jahrzehnt-der-Wetterkatastrophen.html

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TOGETHER.

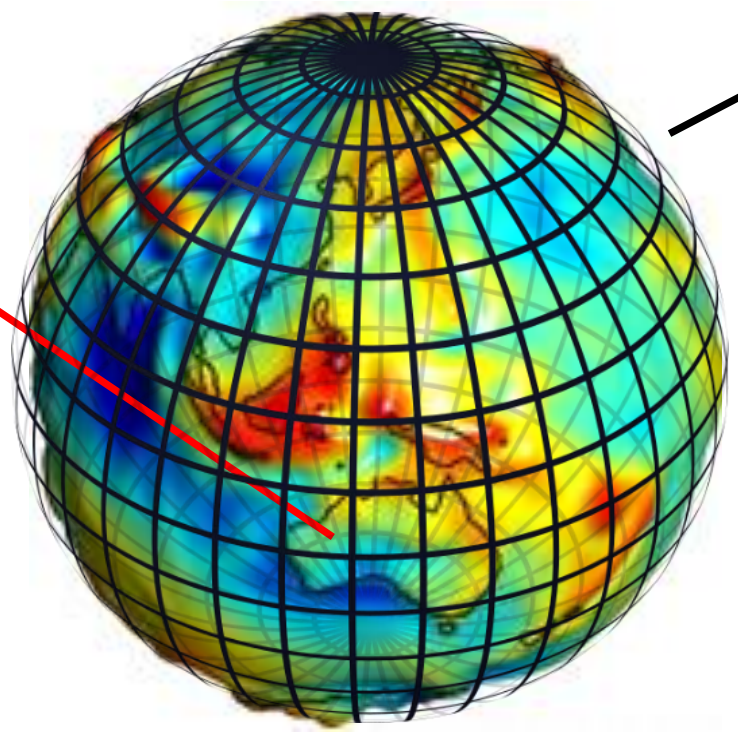
Introduction to height

- Traditionally, people want to know the height of something with respect to sea level.
  - These are known as “physical heights”
- Satellite positioning systems (GNSS and remote sensing) determine heights relative to the ellipsoid.
  - These are known as “geometric heights”
- It is important to understand how these systems are different and how data from these systems can be used together.

Physical vs Geometric heights

Equal Gravitational Potential

- Complex
- Physically meaningful
- Precise
- Need a model to use with GNSS
- Water **always** flow downhill



Geometric

- Simple
- Not physically meaningful
- Precise
- Used by GNSS
- Water doesn't always flow downhill

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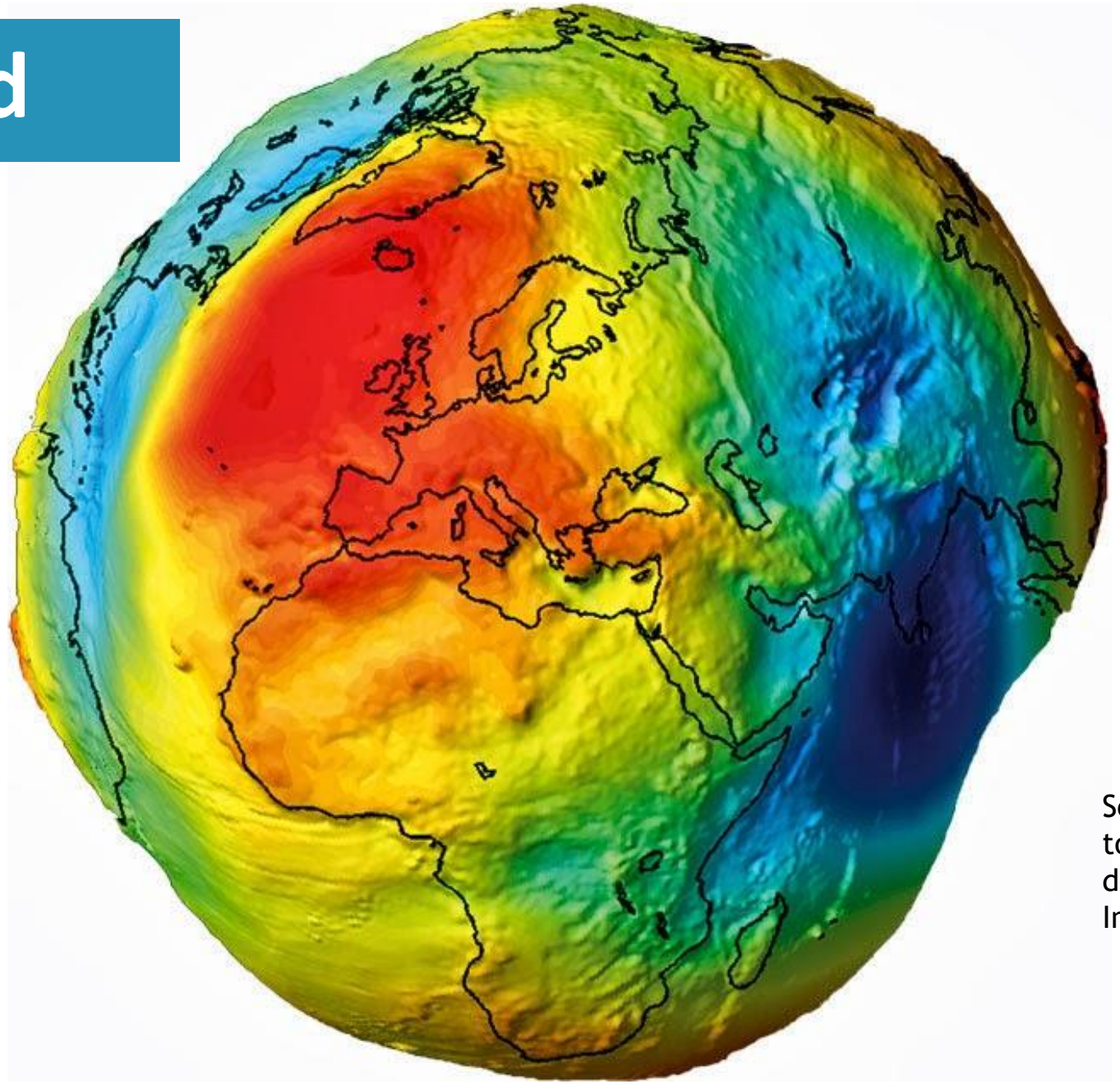
The Geoid



Scale exaggerated to make the difference visible. In reality ±150 m.

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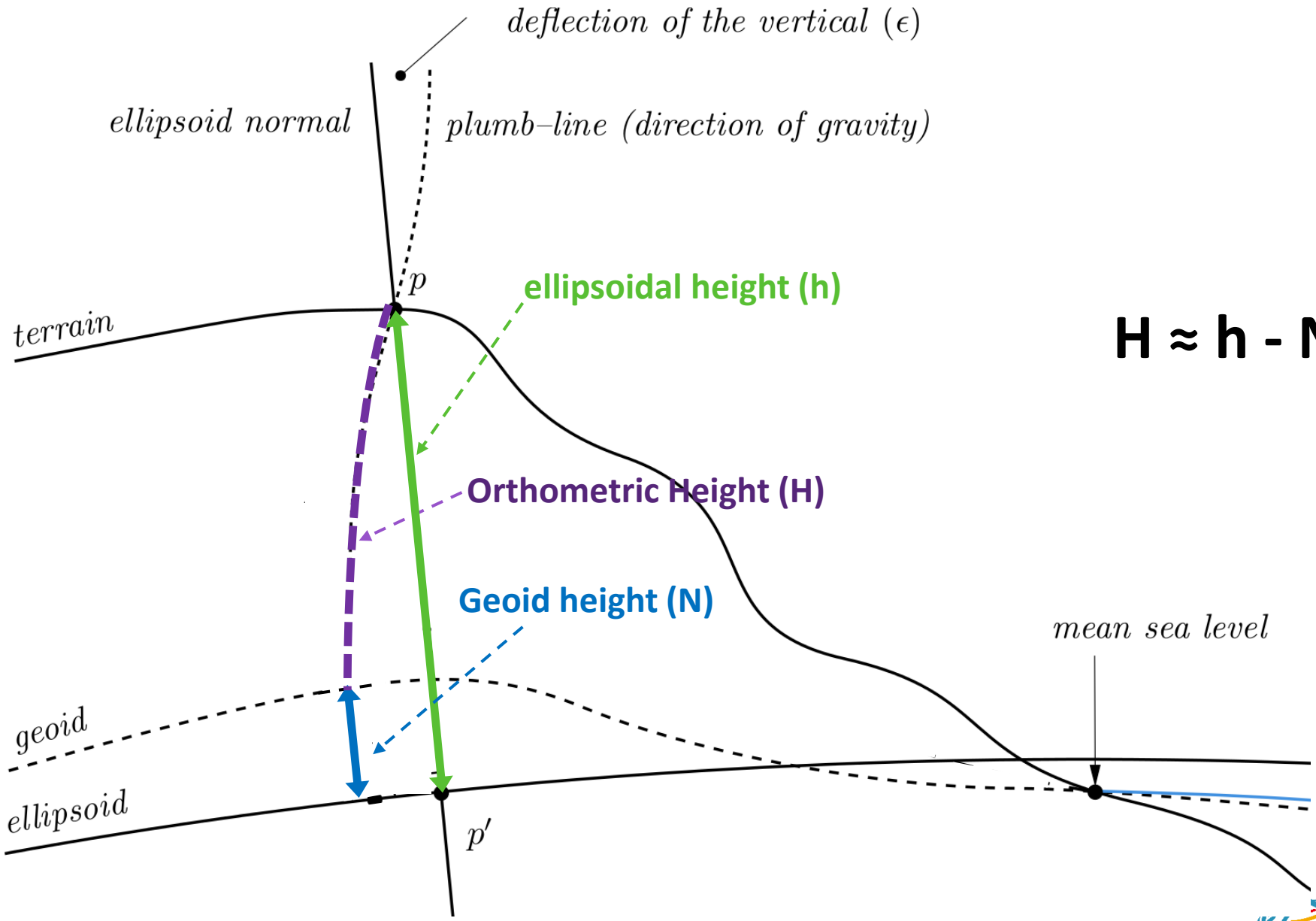

$$H \approx h - N$$

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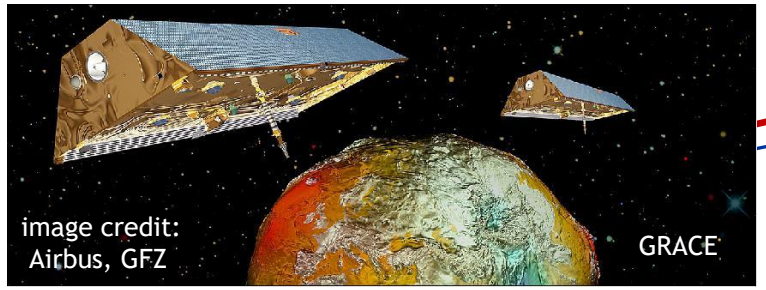
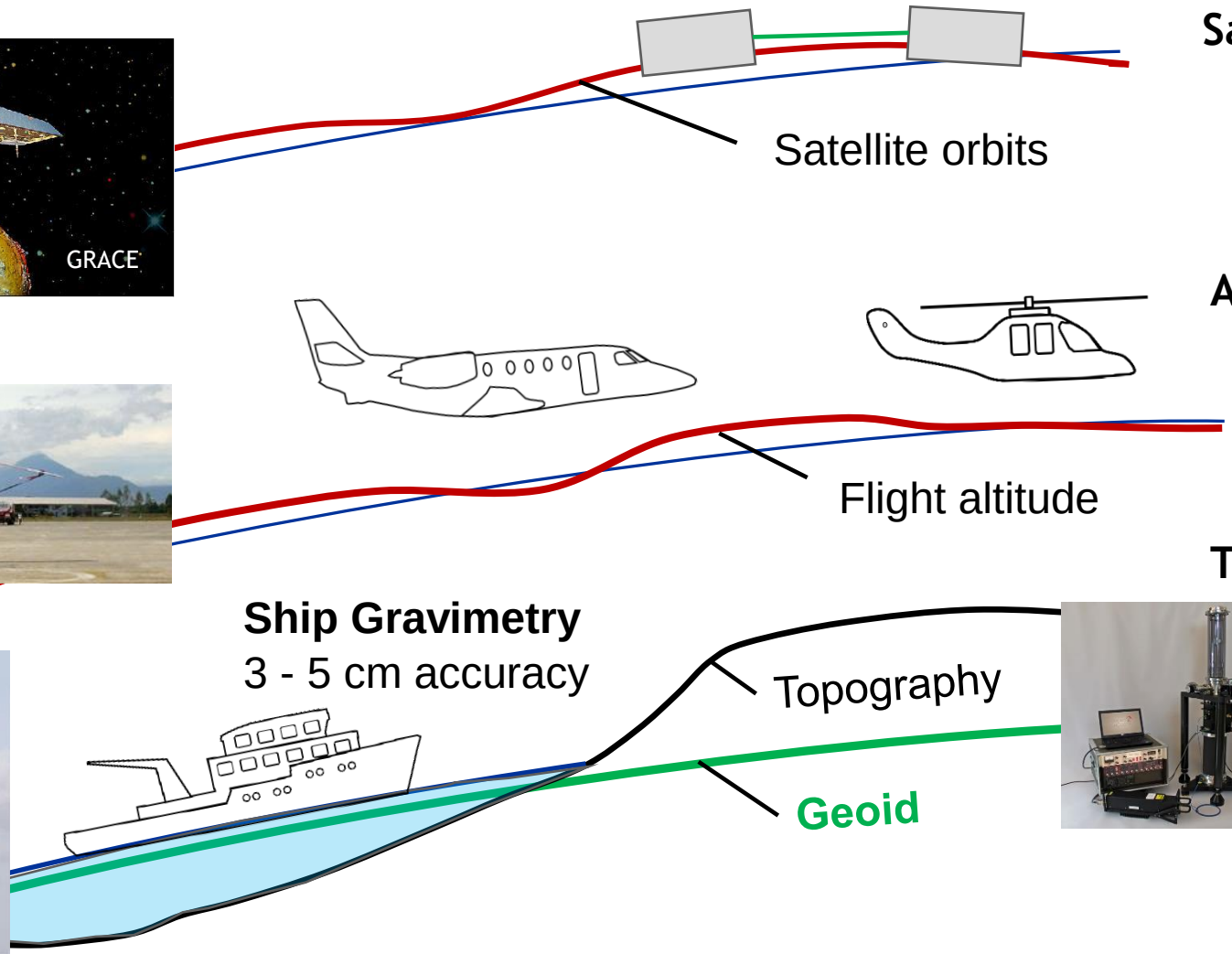
Gravity measurements





Satellite Gravimetry
20 cm accuracy

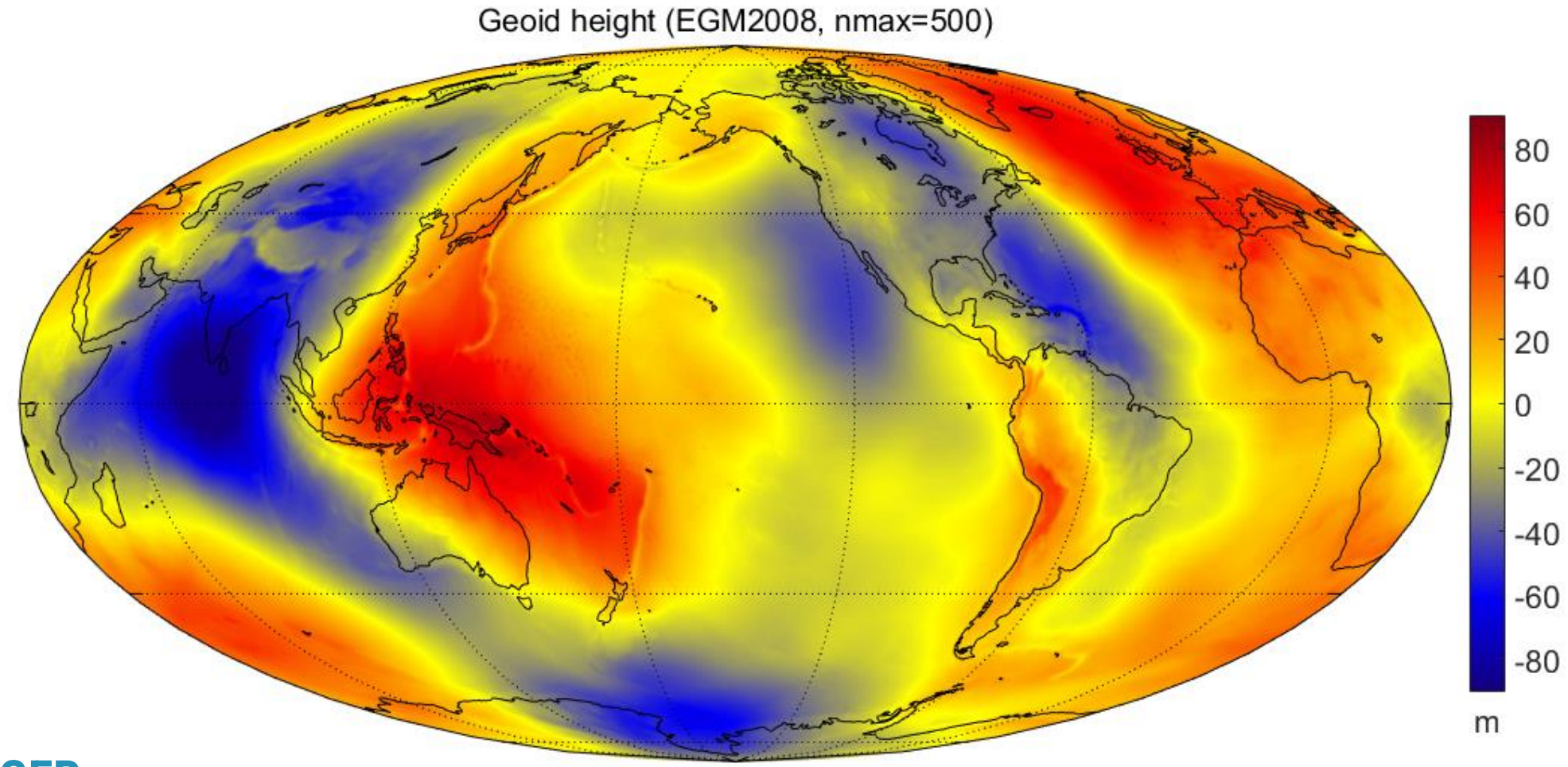
Airborne Gravimetry
3 - 5 cm accuracy

Ship Gravimetry
3 - 5 cm accuracy

Terrestrial Gravimetry

1 cm accuracy

Global geoid model (EGM2008)



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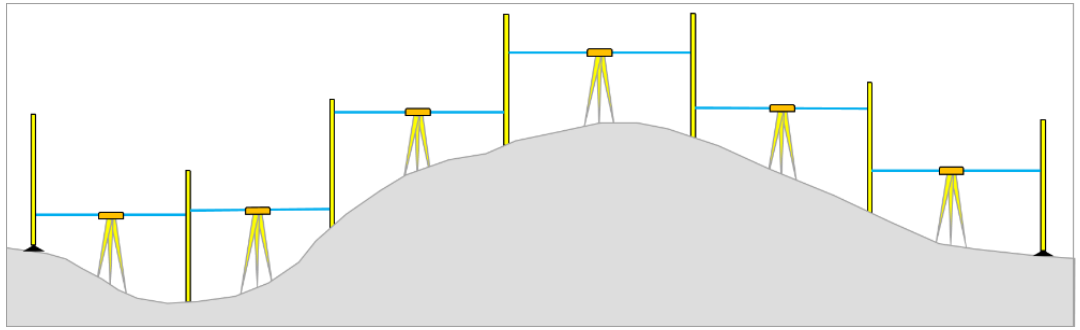
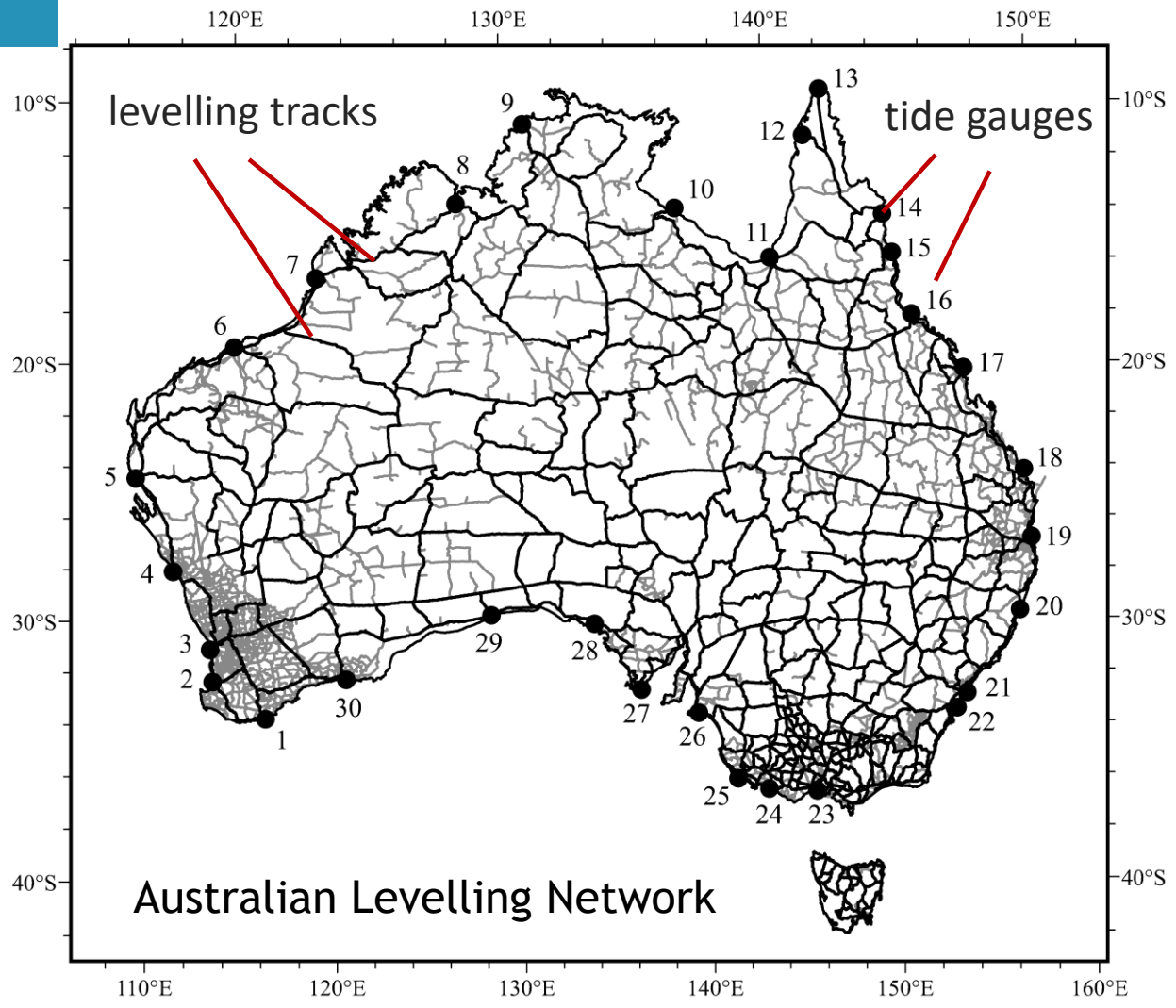
Country height datums

- Models like the Earth Geopotential Model 2008 are a combination of space, air, ship and terrestrial gravity and can form the basis of a country height datum.
- The amount of data from different regions in EGM2008 is not the same.
- In some cases, countries have added to EGM2008 models with extra gravity data to improve the accuracy of the model.

Country height datums



- Australian Levelling Network
- Over 200,000 km of levelling to transfer heights
- Connected to 32 tide gauges for observation of Mean Sea Level (MSL)



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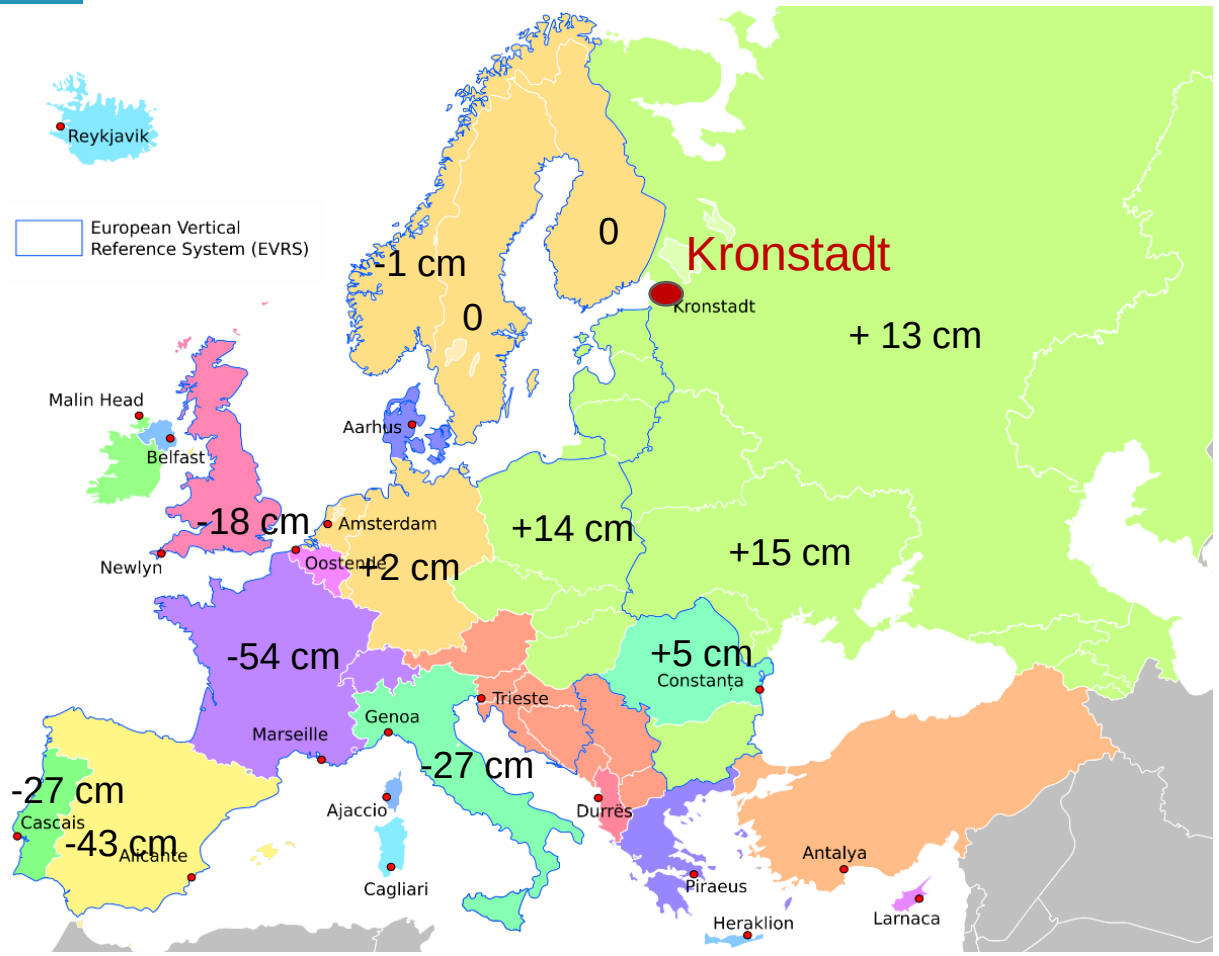
Country height datums

- Every country created its own using different tide gauges as a zero reference.
- Bright green coloured in the east of Europe use as a reference the tide gauge of Kronstadt.
- Tide gauges in Amsterdam were a reference for Nederland and Germany,
- Marseille for France or
- Alicante for Spain.

- So can a **mountain peak that is placed exactly on country's border** have two different heights and both will be right.



https://de.wikipedia.org/wiki/Europ%C3%A4isches_H%C3%B6henreferenzsystem

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Joining Land and Sea using geodesy

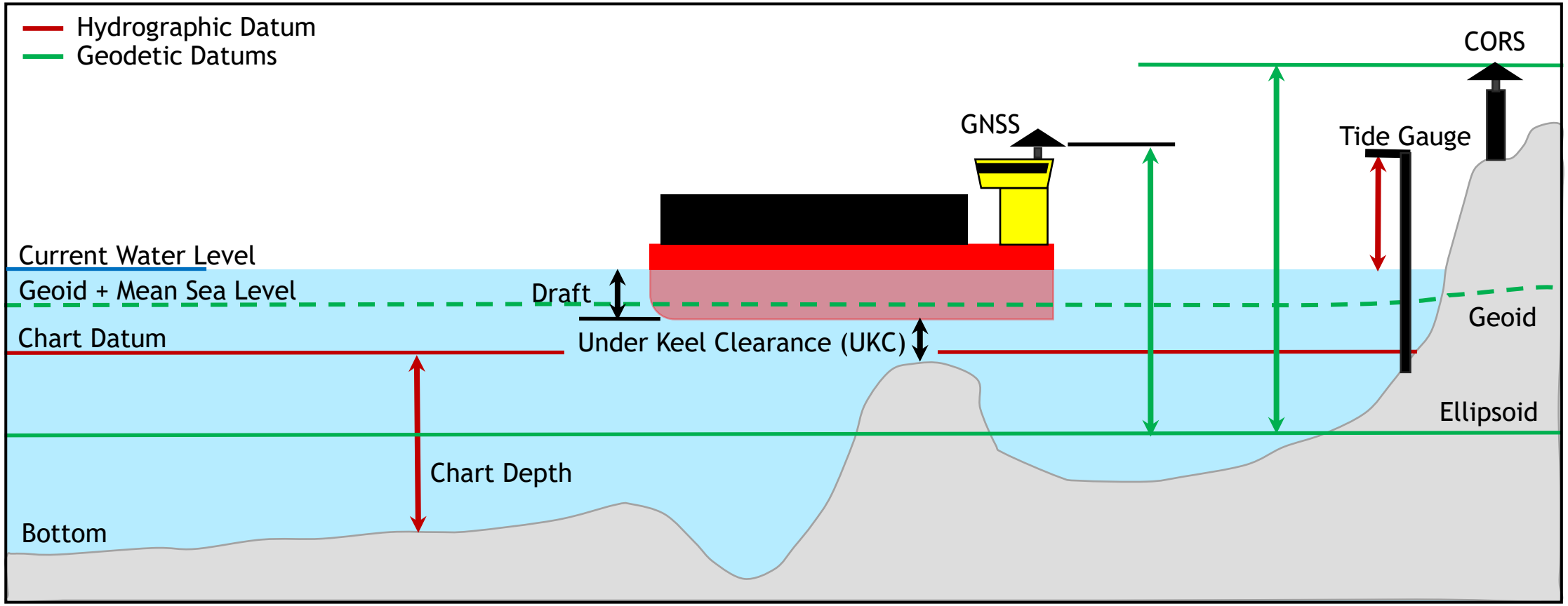
Solution – use the geoid as the primary height reference surface and link all other surfaces (ellipsoid, MSL, HAT, LAT, MDT …) to the geoid.

- POSITIVES
  - Physical height reference surface – water always flows downhill
  - Exists onshore and offshore

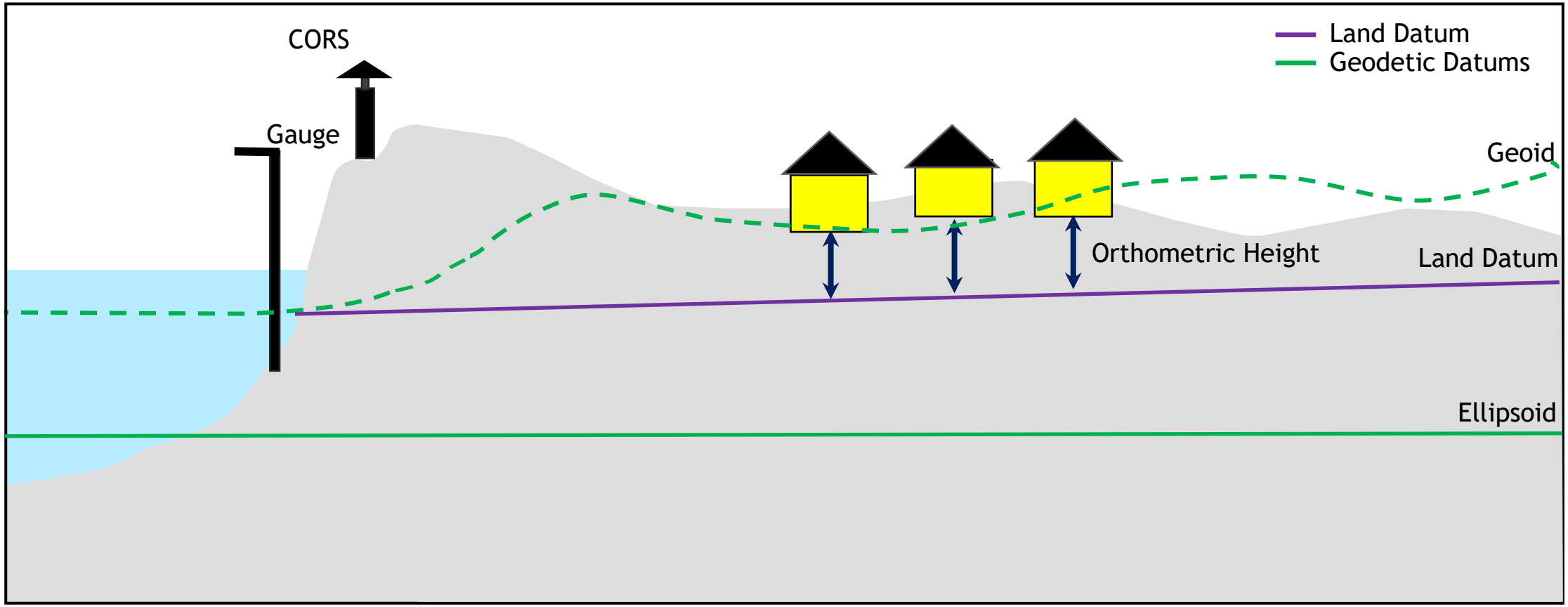
  (No other surfaces meet these two criteria)

- CHALLENGES
  - Global geoid model has absolute accurate of ~20 cm (relative accuracy is better than this)
  - Local / Regional geoid models require airborne and terrestrial gravity data which can be expensive
  - Development of hydroid models to convert between MSL, LAT etc. and the geoid are challenging (but necessary for every primary reference surface)

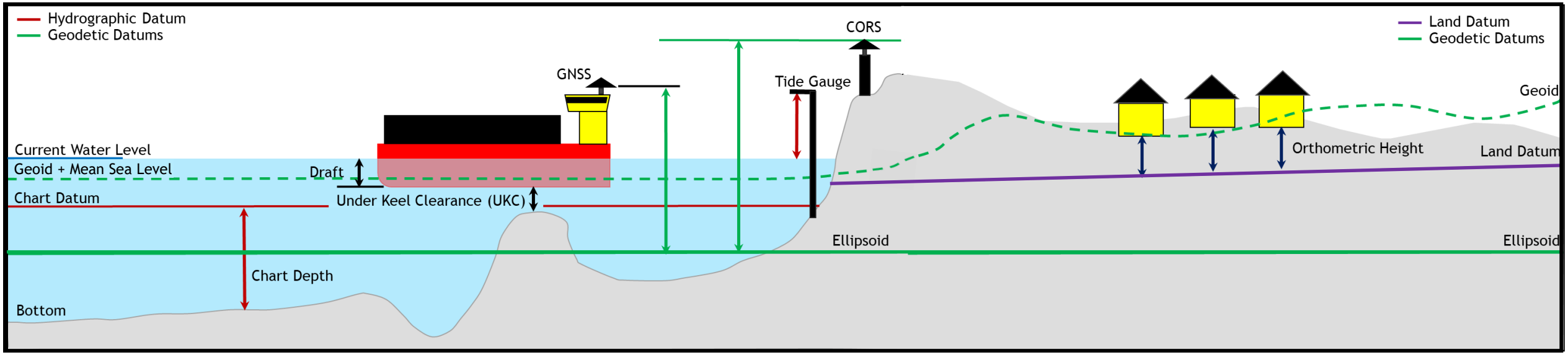
The Sea


Hydrographic Datum
Geodetic Datums
CORS
GNSS
Tide Gauge
Current Water Level
Geoid + Mean Sea Level
Draft
Chart Datum
Under Keel Clearance (UKC)
Geoid
Ellipsoid
Chart Depth
Bottom

The Land


CORS
Gauge
Land Datum
Geodetic Datums
Geoid
Orthometric Height
Land Datum
Ellipsoid

Joining Land and Sea using geodesy



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