Height systems

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Outline

- Why bother about height systems?
- Relevant terms
- Coordinate systems
- Reference surfaces
- Geopotential number
- Height systems

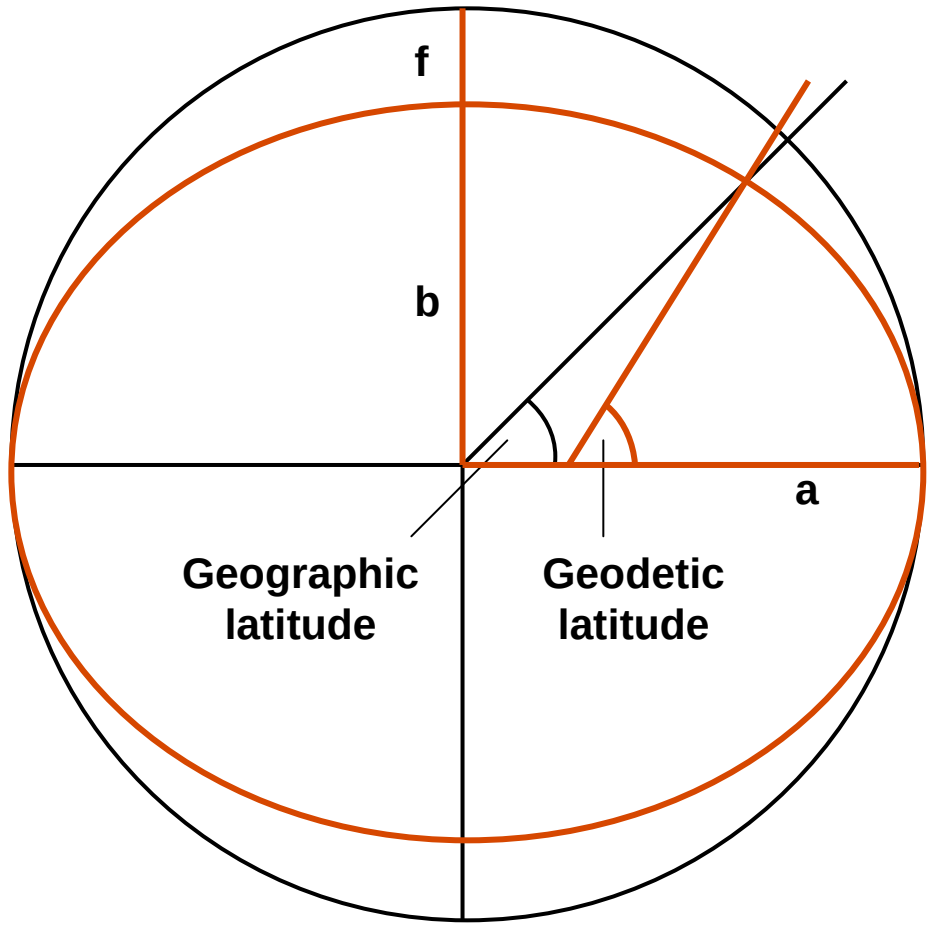
Why bother about height systems?

- give a meaning to a value defined for height
- combination of measurements from different sources
  - GPS measurements vs. leveling measurements
- three-dimensional calculations
  - SAR interferometry

Relevant terms

- spheriod
  - any surface resembling a sphere
  - an ellipsoid of revolution
- ellipsoid
  - defined by axes, flattening and eccentricity
- flattening and eccentricity
  - characterize the deviation from a sphere

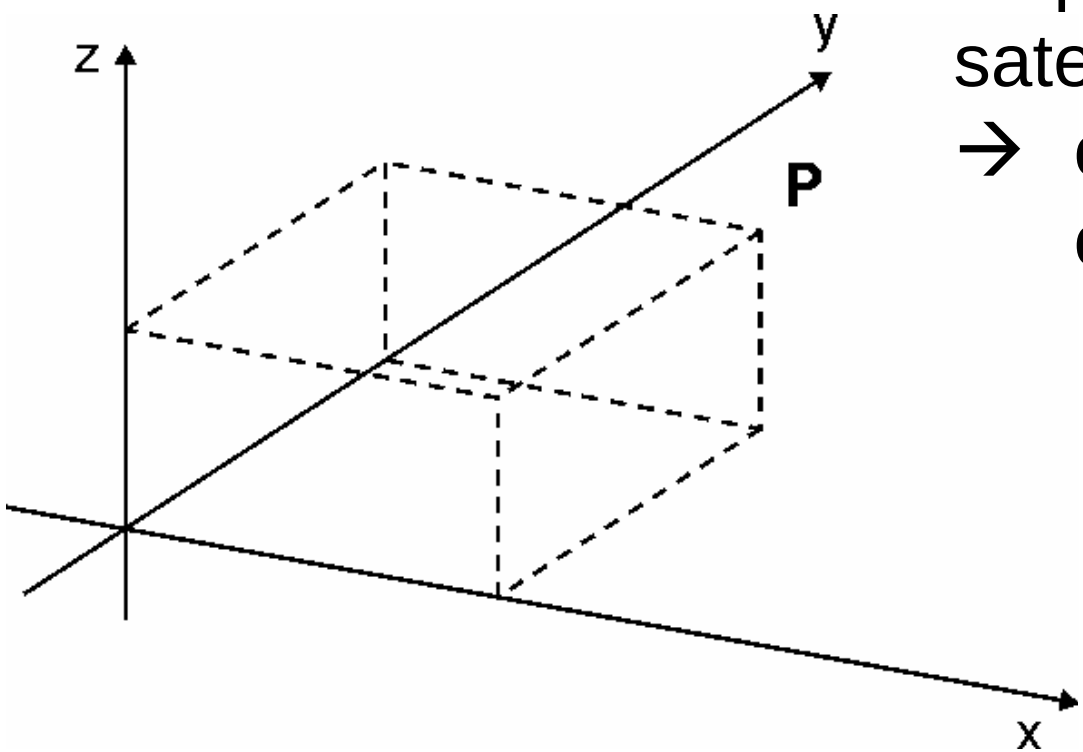
Geographical and geodetic coordinates



Geographical and geodetic coordinates

- geographical coordinates
  - implying spherical Earth model
- geodetic coordinates
  - implying ellipsoidal Earth model

Cartesian coordinates

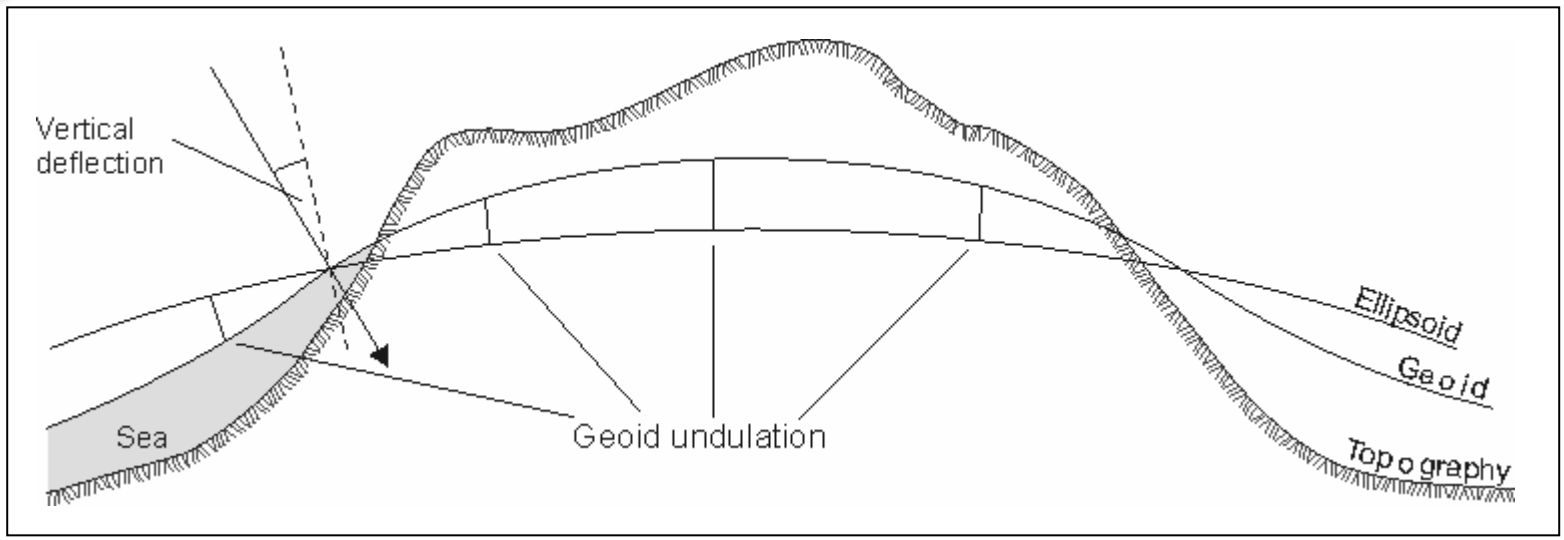


- geodetic coordinates inappropriate for satellite imagery
  → cartesian coordinates

Approximation vs. Reality

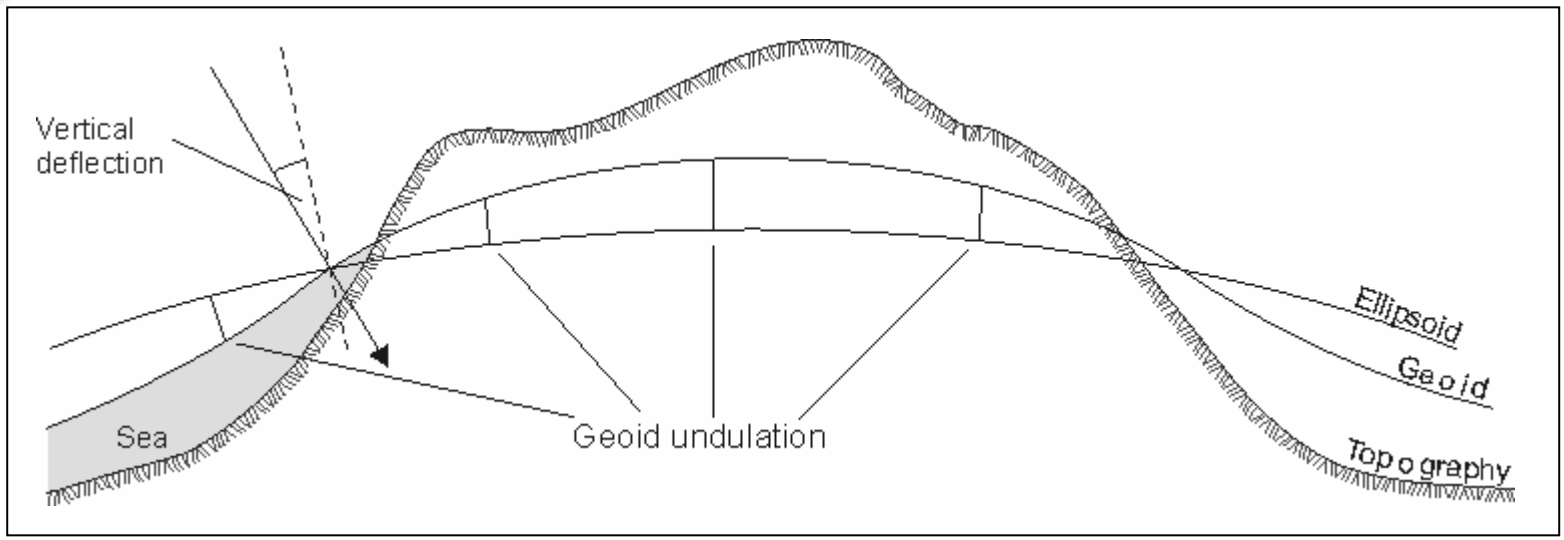
- ellipsoid is a good approximation to the shape of the Earth but not an exact representation
- Earth surface is everywhere perpendicular to the direction of gravity
  → *equipotential surface*
- true shape of the Earth is known as *geoid*

Reference surfaces



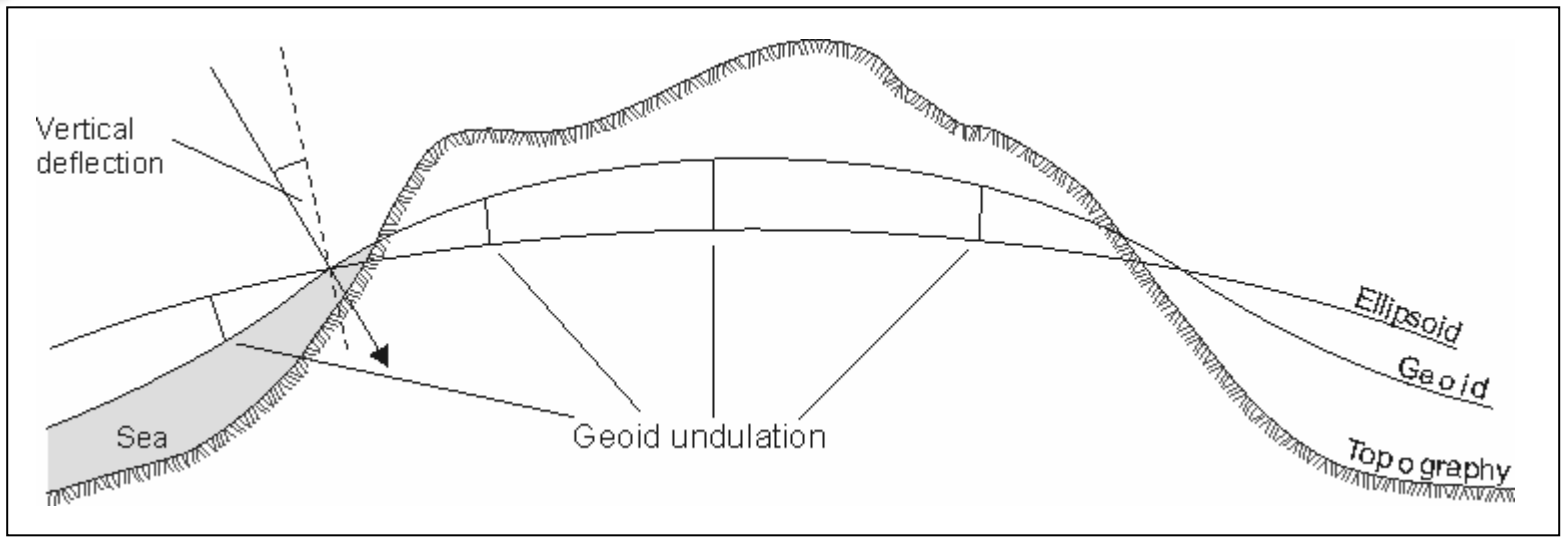
- three reference surfaces
  - topography
  - geoid
  - ellipsoid

Reference surfaces



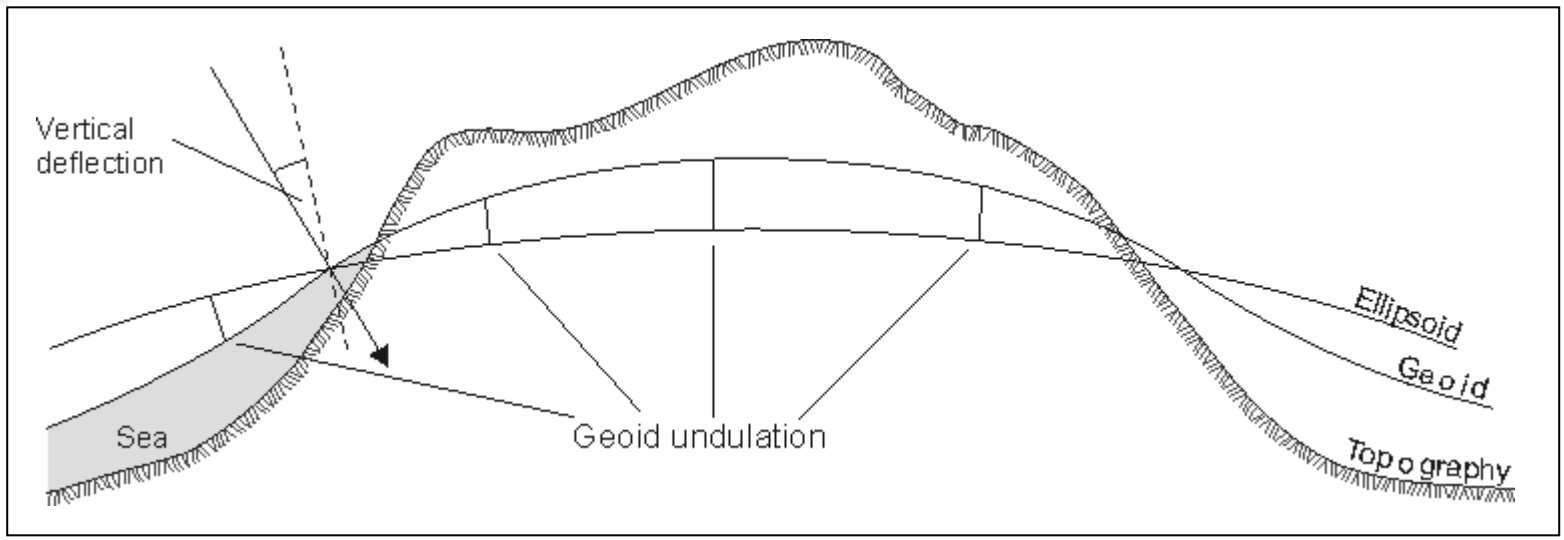
- *topography* represents the physical surface of the Earth

Reference surfaces



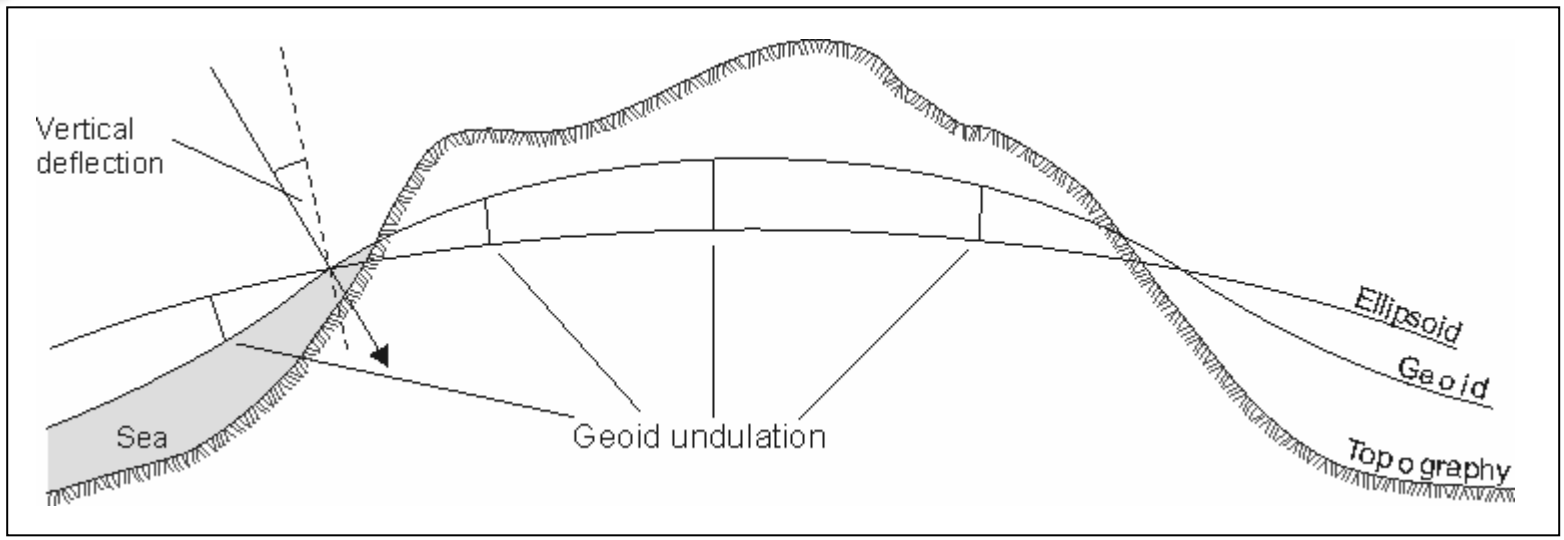
- *geoid* defined as level surface of gravity field with best fit to mean sea level
  - maximum difference between geoid and mean sea level about 1 m

Reference surfaces



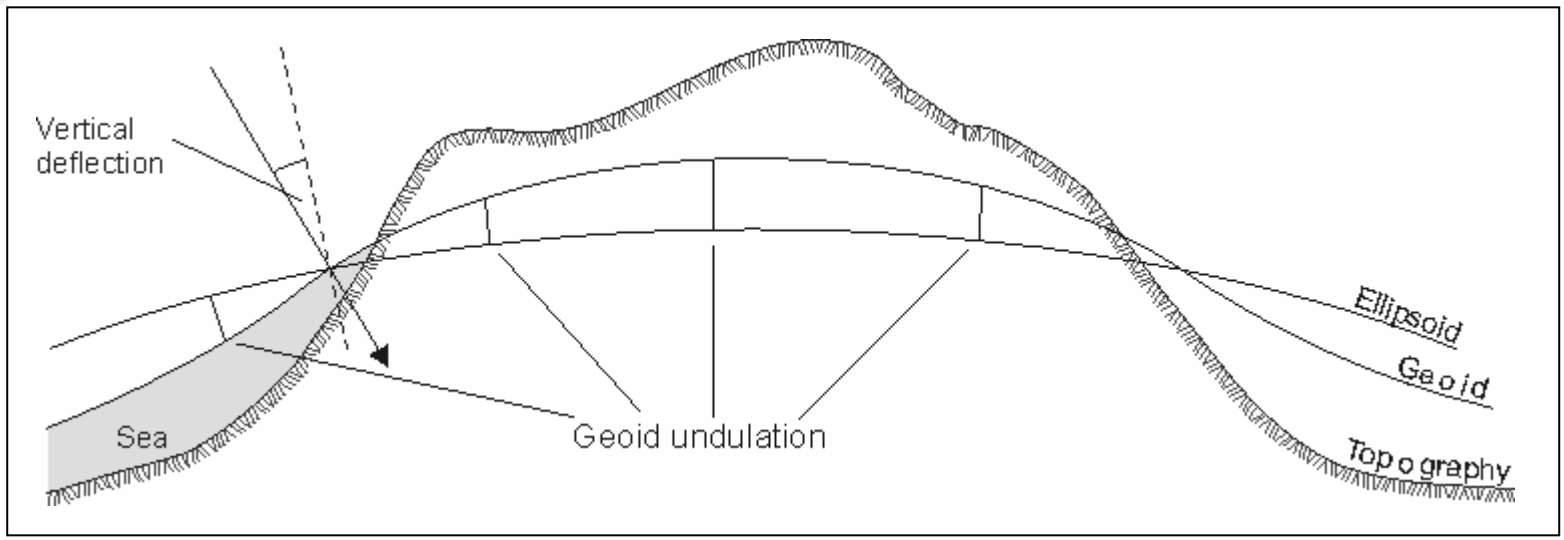
- *ellipsoid* defines mathematical surface approximating the physical reality while simplifying the geometry

Reference surfaces



- *geoid undulation*: vertical separation between geoid and reference ellipsoid
  - differences between ± 100 m
  - global root mean square of around 30 m

Reference surfaces



- *vertical deflection*: angle between the ellipsoid normal and the plumb line
  - usually resolved in a north-south component ξ and an east-west component η
  - angles usually amount to a few arc seconds

Global earth model

- geoid defined by a set of coefficients of a spherical harmonic expansion
  → global earth model
- several models available
  - OSU91
  - Earth Geopotential Model 1996 (EGM96)

Geopotential number

- different height systems can be related to each other by the geopotential number C

$$C = W_0 - W = \int_{geoid}^{point} g \, dn$$

  - W and W_0: the potentials of gravity of a point and the geoid
  - g: gravity value
  - dn: leveling increment

Geopotential number

- different heights calculated by dividing the geopotential number by a gravity value

Heights

- dynamic height
  - constant normal gravity γ_0 for an arbitrary standard latitude (usually 45 degrees)
  - no geometrical meaning
- orthometric height
  - natural “height above sea level”
  - measured along the current plumb line from the foot point on the geoid and the point on the surface
  - gravity value: mean gravity

Heights

- normal height
  - vertical distance from terrain surface to the ellipsoid reduced by the height anomaly
  - measured along the ellipsoidal normal
  - gravity value: mean normal gravity

Solution

- ellipsoid is convenient reference frame
  - mathematical figure
  - provides good approximation to the geoid
- geoid better height reference system
  - reference to mean sea level allows to use tide gauges as height reference points
  - physical significance: ensures horizontal representation of water surfaces such lakes and seas

Questions

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