Height Unification

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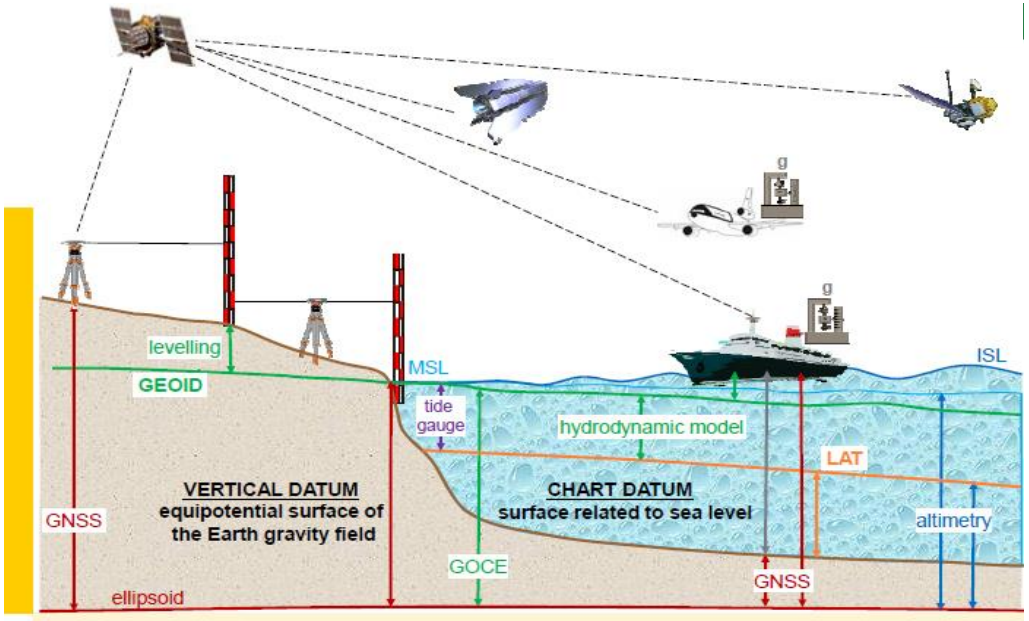
Necessity and Objectives (1)

- **Height is the most important component for the global monitoring of the Earth**
  - Sea level change
  - Change of the sea surface topography
  - Post glacial uplift
  - Ice melting etc.
- **There is no vertical reference surface which is suitable for all applications and users**

  -> Need relationship among reference surfaces



Necessity and Objectives (2)

Background and Necessity

- **Currently, more than one hundred Local Vertical Datum exist = *Discrepancies***
  - Discrepancies can reach up to +/- 2m in a global frame
  - Source of discrepancies : error propagation of spirit leveling with the distance, applying different gravity reduction methods, etc.
  - They do not allow the data exchange in international projects, because they are only compatible with themselves
  - They do not support the reliable realization of h=H+N in world-wide scale

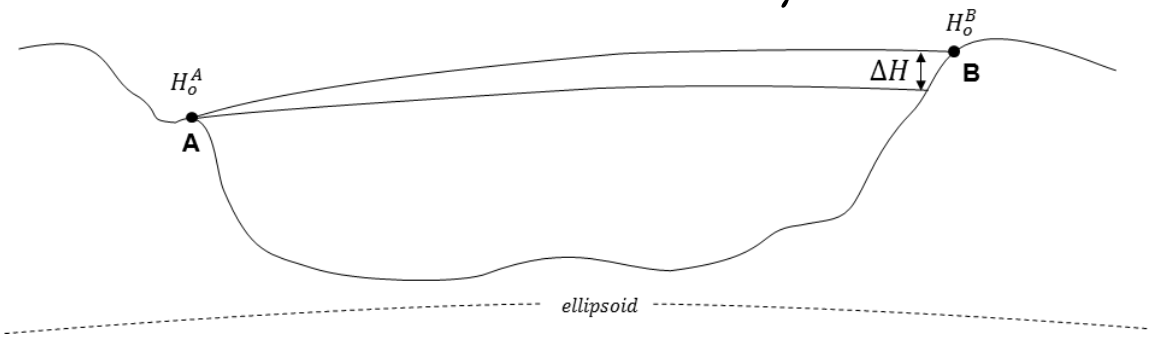
Objectives

- **Supports geometrical (h) and physical heights (H), as well as their combination (h=H+N) with a cm precision**
- Globally allows the unification of the existing physical height systems
- Provides high-accuracy and long-term stability of the vertical/radial components with cm accuracy

Methodology (1)

- **Case1 : classical approach**
  - Data : spirit leveling data, global gravitational model or local gravity data
  - Methodology : adjust leveling network and determine local equipotential surface

$$W_P = W_0 - c_P \Leftrightarrow H_n = \frac{c_P}{\overline{\gamma}}$$



  - Limit : apply only on continents
  - Example : EVRF2007
    - 27 European countries
    - 7,939 nodal points and 10,347 measurements were used
    - Geopotential numbers and normal heights were calculated
    - 13 points were used for fitting : to the level of EVRF 2000

$$\sum_{i=1}^{13} (c_{EVRF\,2000} - c_{EVRF\,2007}) = 0$$

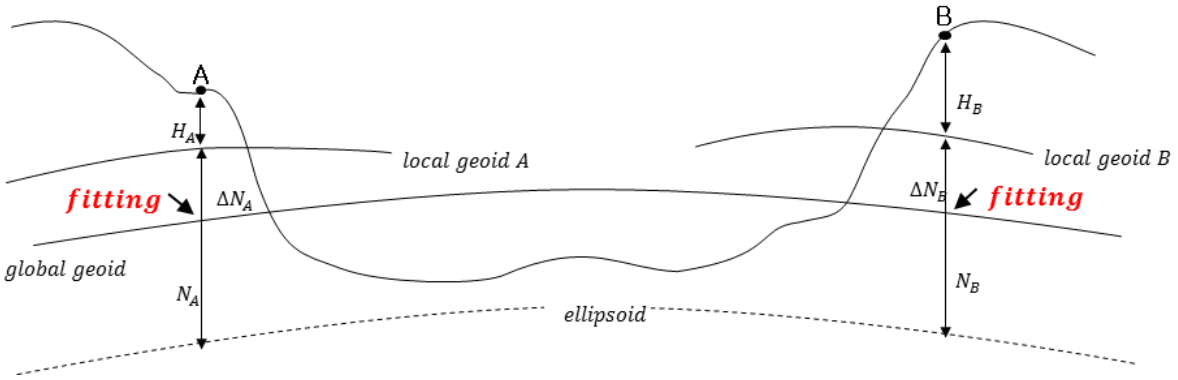
Methodology (2)

- **Case2 : general approach (Jekeli, 2012)**
  - Data : GNSS, spirit leveling data and global gravitational model
  - Methodology : calculate the local geoid based on GNSS and leveling data
    determine local offset with respect to global geoid

$$h_{WGS84} = H^{(global)} + \left(N_{bets}^{(global)} + \Delta N_{ellipsoid} \right) = H^{(LVD)} + N_{WGS84}^{(local)}$$

$$\Updownarrow$$

$$N_{WGS84}^{(local)} - N_{best}^{(global)} = H^{(global)} - H^{(LVD)} + \Delta N_{ellipsoid}$$



- *general case for realization and unification (cost and time effective)*

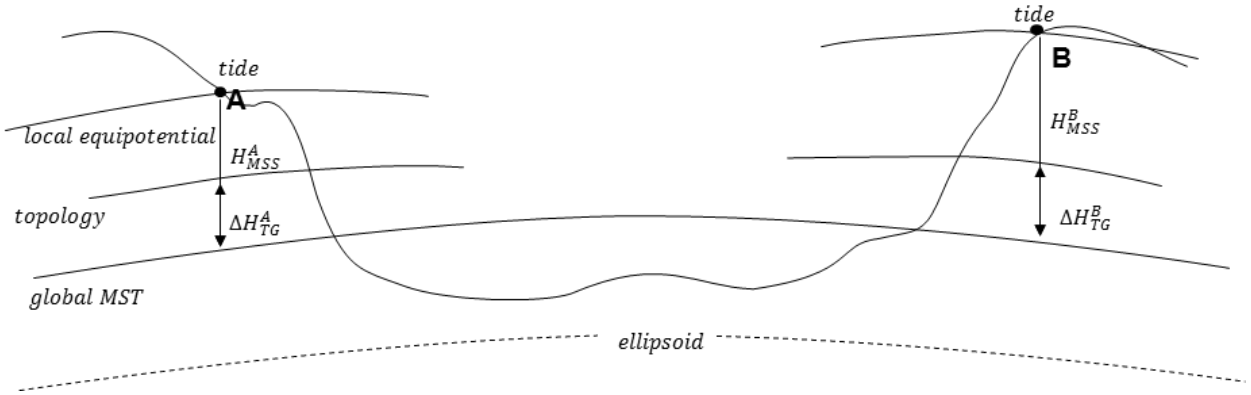
Methodology (3)

- **Case3 : oceanographic approach (Ihde, 2015)**
  - Data : mean sea surface topography, tide gauge observations
  - Methodology : calculate the local mean sea level based on tide gauge
    determine local offset with respect to mean sea surface topography

$$H_{0,VRF} = \left(h_{MSS}^{TG} - N^{TG}\right) - H_{MSS}^{TG} + \Delta H_{TG}$$

$$\Updownarrow$$

$$\left(h_{MSS}^{TG} - N^{TG}\right) = H_{MST}^{Mod}$$

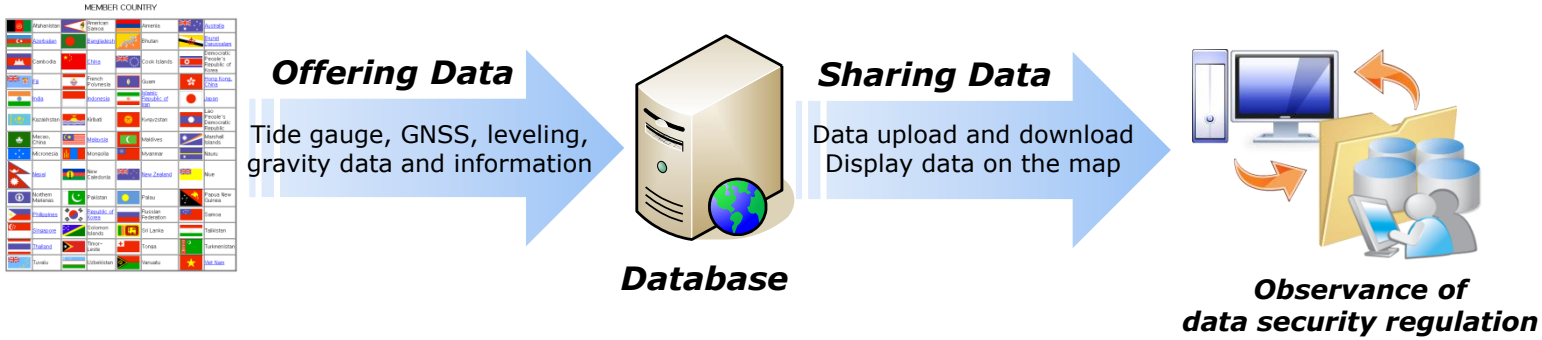


  - Limit : apply only tide gauge observations available

Challenge (1)

Data

- **Data collection**
  - Target data : tide gauge, GNSS, spirit leveling, gravity data
  - Survey information : history, observer information, number of data, distribution, quality, etc.
- **Data Standardization and Database Construction**
  - Data format : naming, significant digit etc. (e.g. latitude and longitude : float, 6 digit)
  - Database construction depends on country or type of data
- **Data Sharing and Service**
  - Database searching and up/download of data
  - Setup the security regulation of data



Challenge (2)

Technical Exchange and/or Transfer

- **Determination of Methodology**
  - Methodology : classical, general, oceanographic approach
  - Develop algorithm and software
  - Apply the algorithm for local vertical datum and analyze
- **Establish a training course**
  - Concept of the potential and height
  - Surveying methods
  - Construction of a geoid
  - Unification of the vertical datum, etc.

THANK YOU!