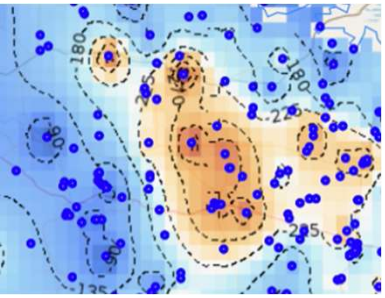
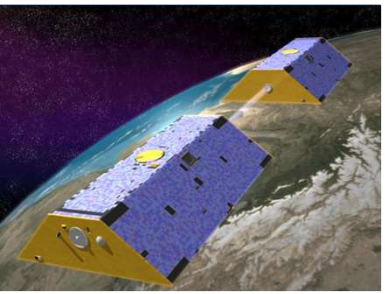
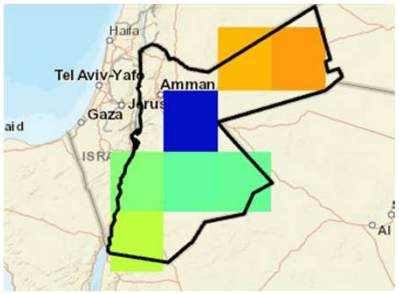
The GRACE Mission and Groundwater Storage Change Analysis

Use of the Gravity Recovery and Climate Experiment (GRACE) mission to monitor groundwater storage change: National workshop for Jordan and State of Palestine

Amman Jordan, February 25-26







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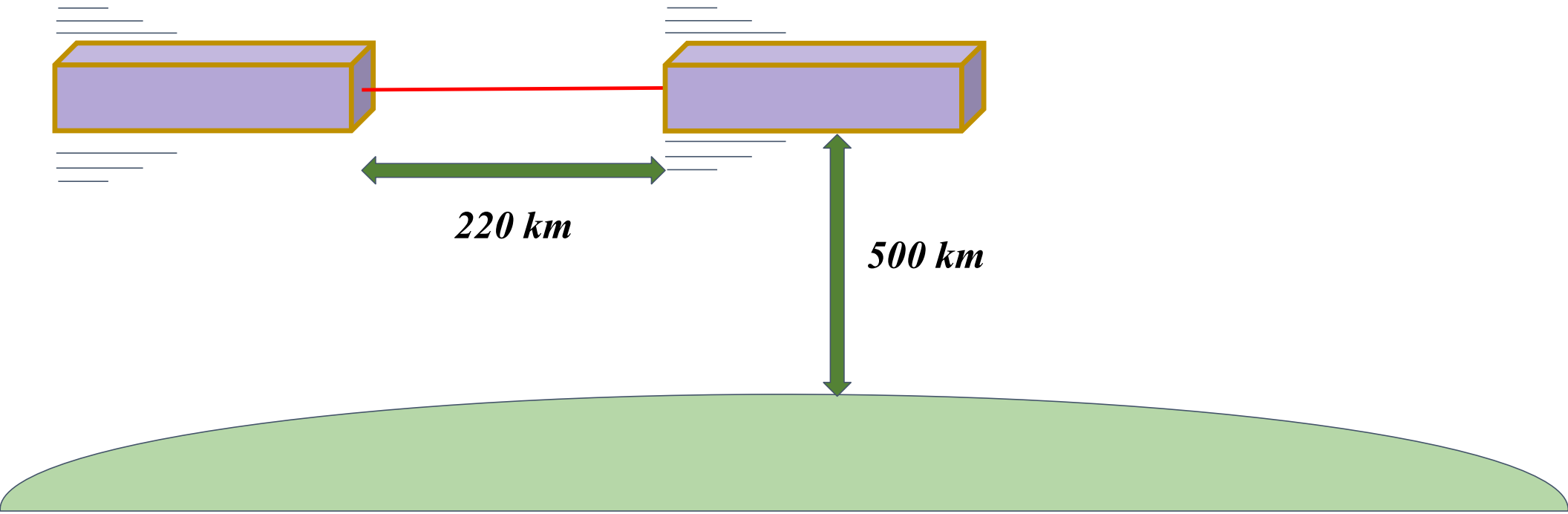
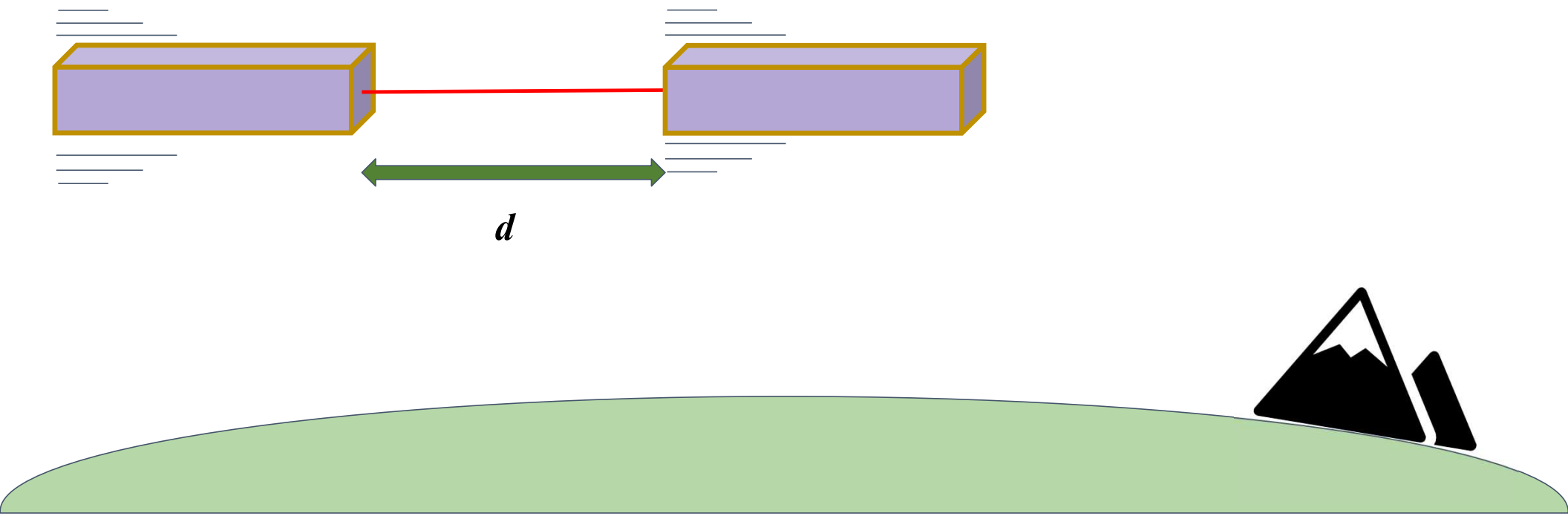
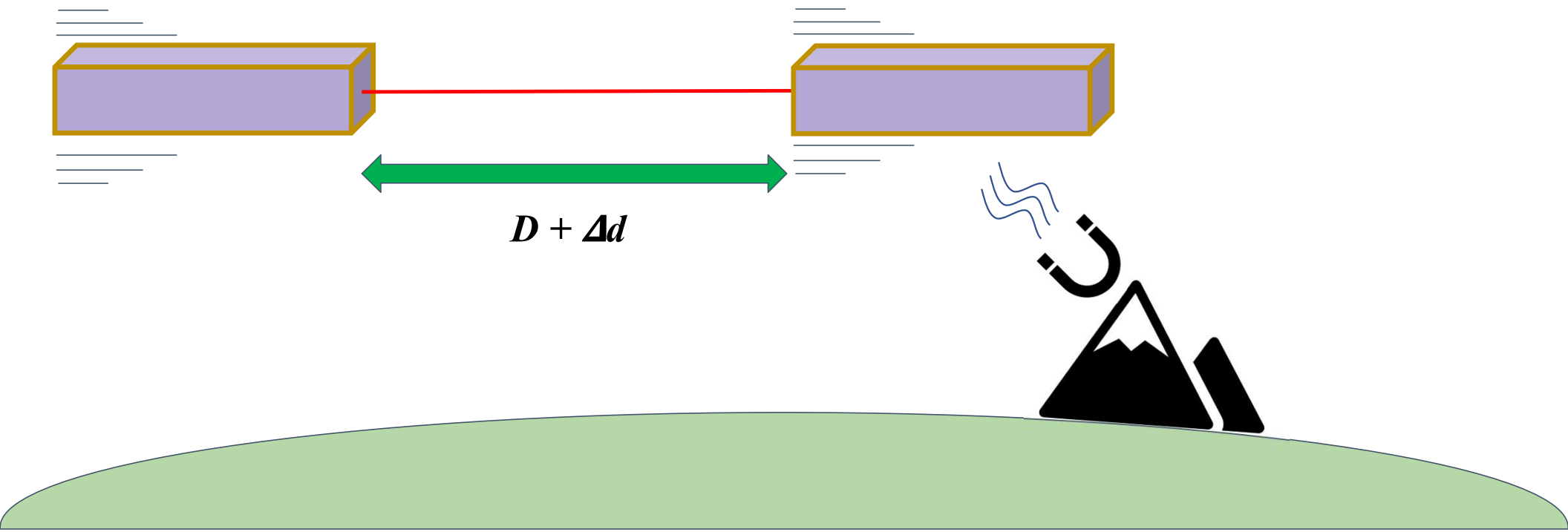
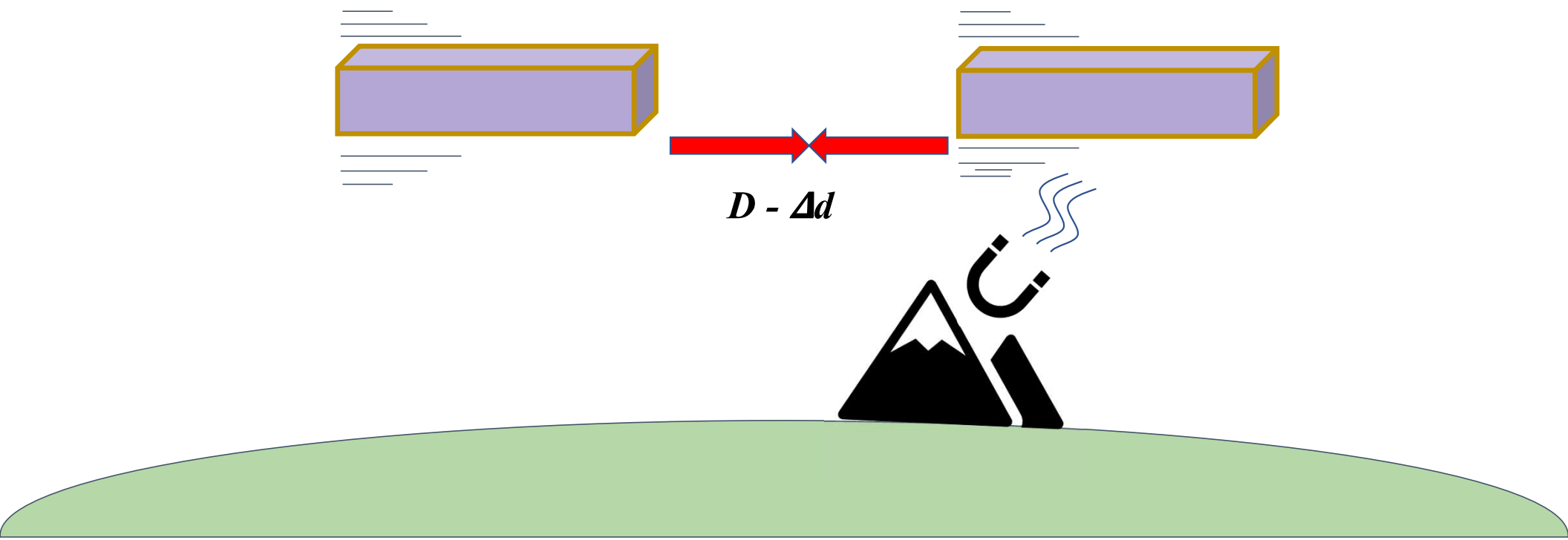
Gravity Recovery and Climate Experiment (GRACE)

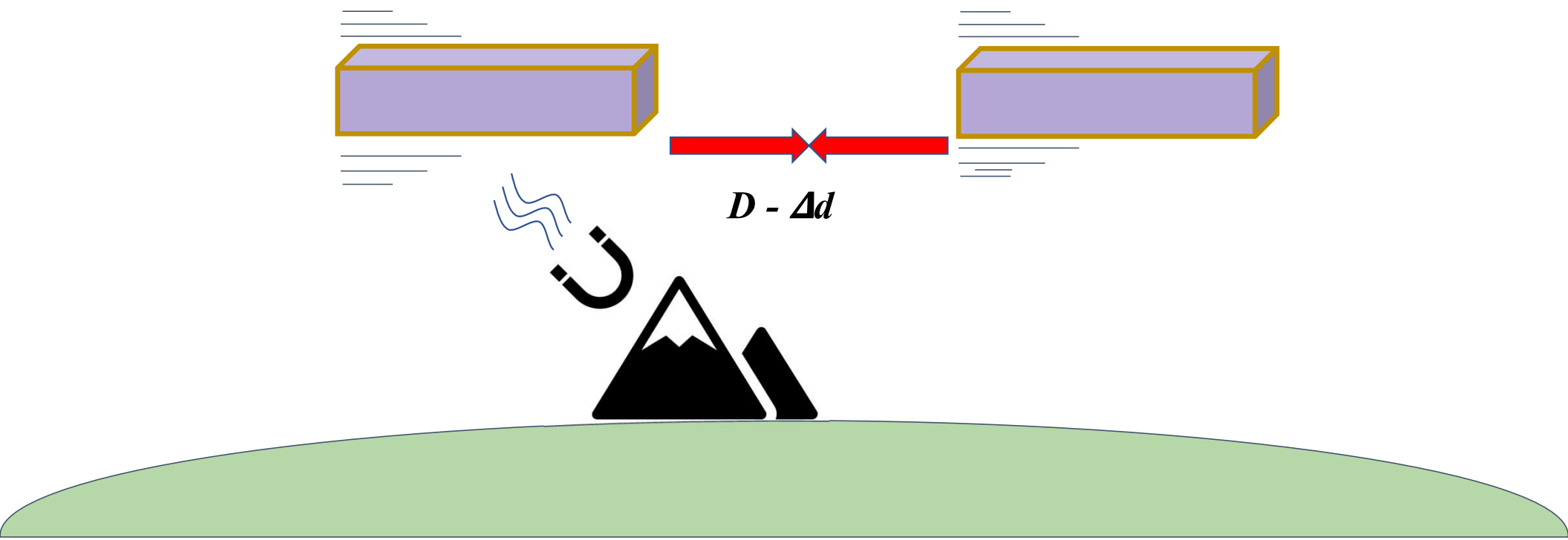
How it works

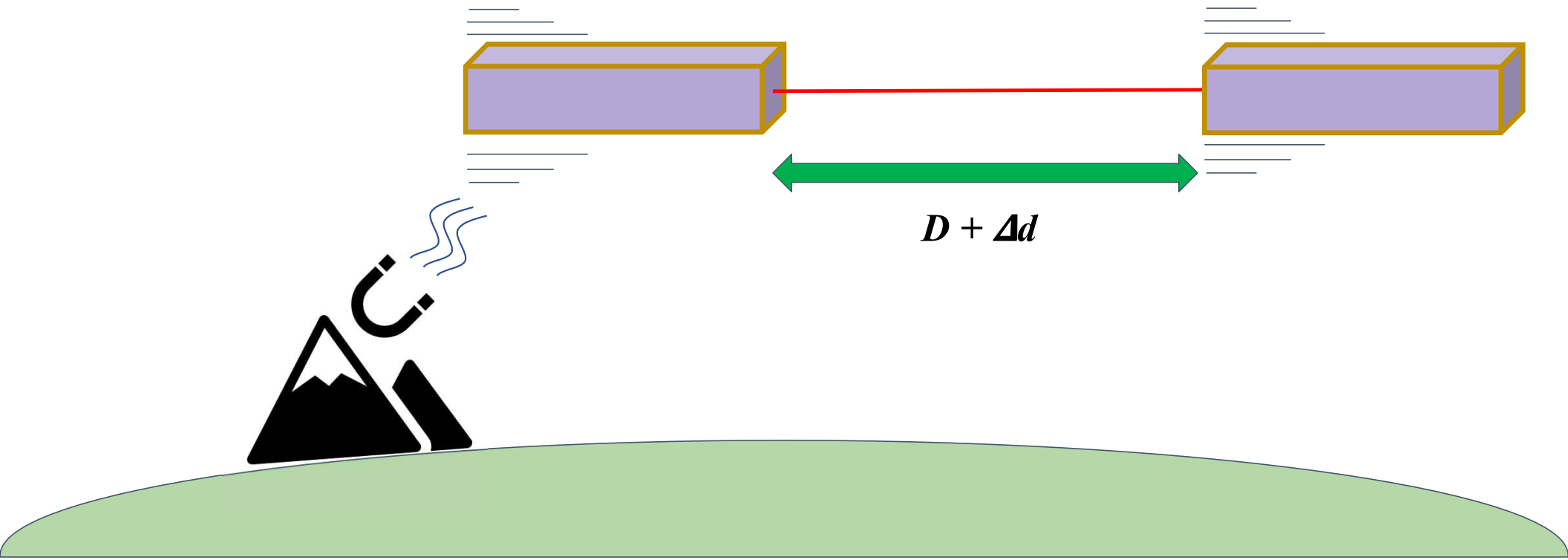



d

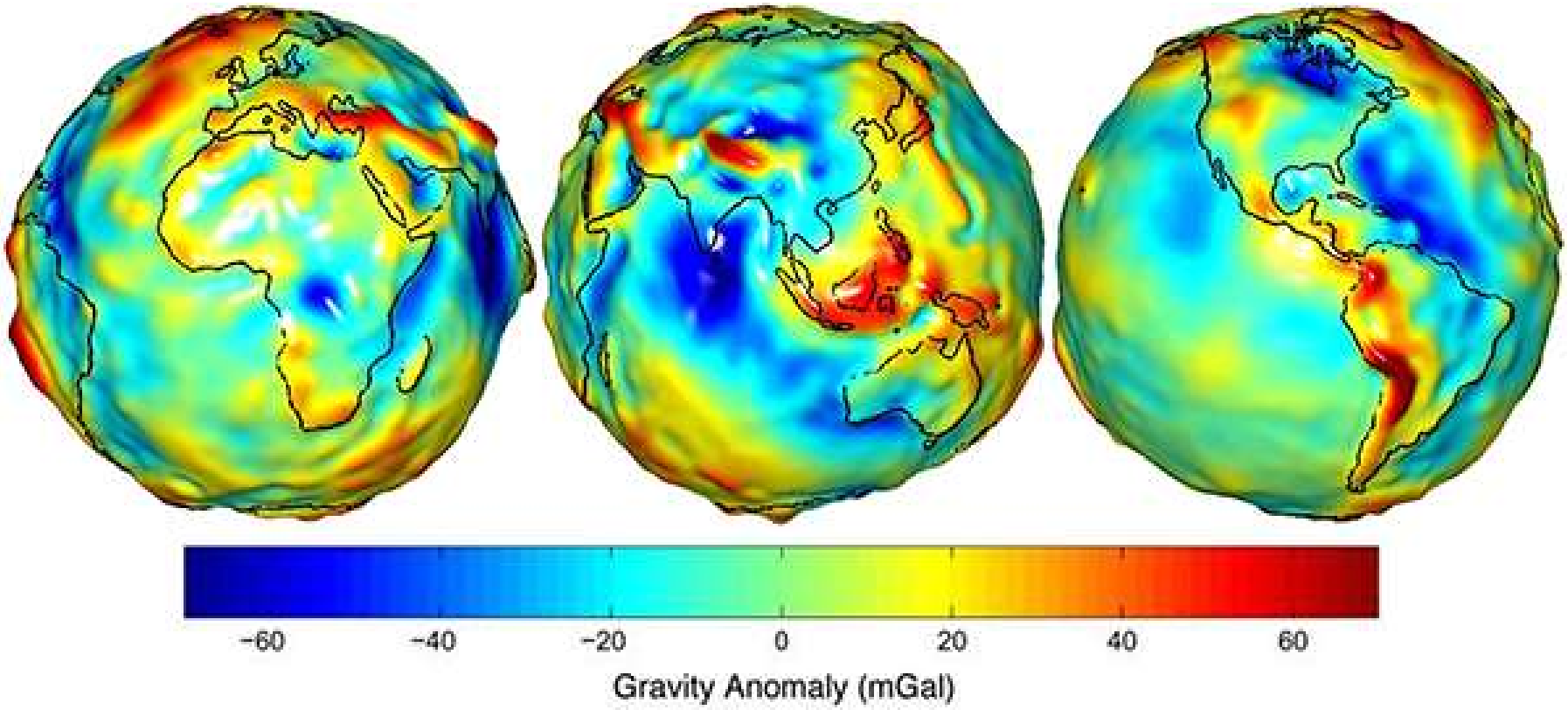

D + Δd


D - Δd

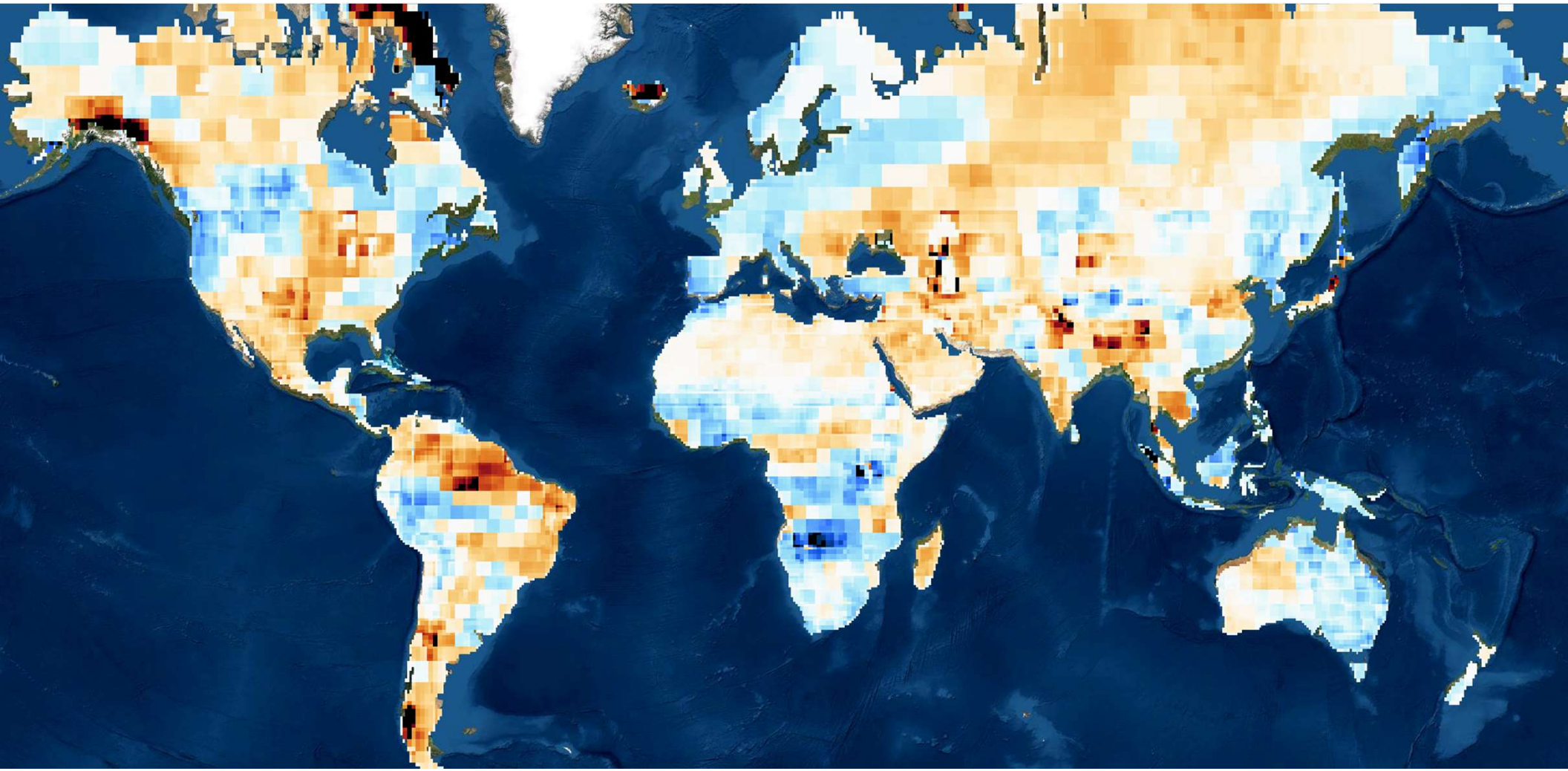

D - Δd

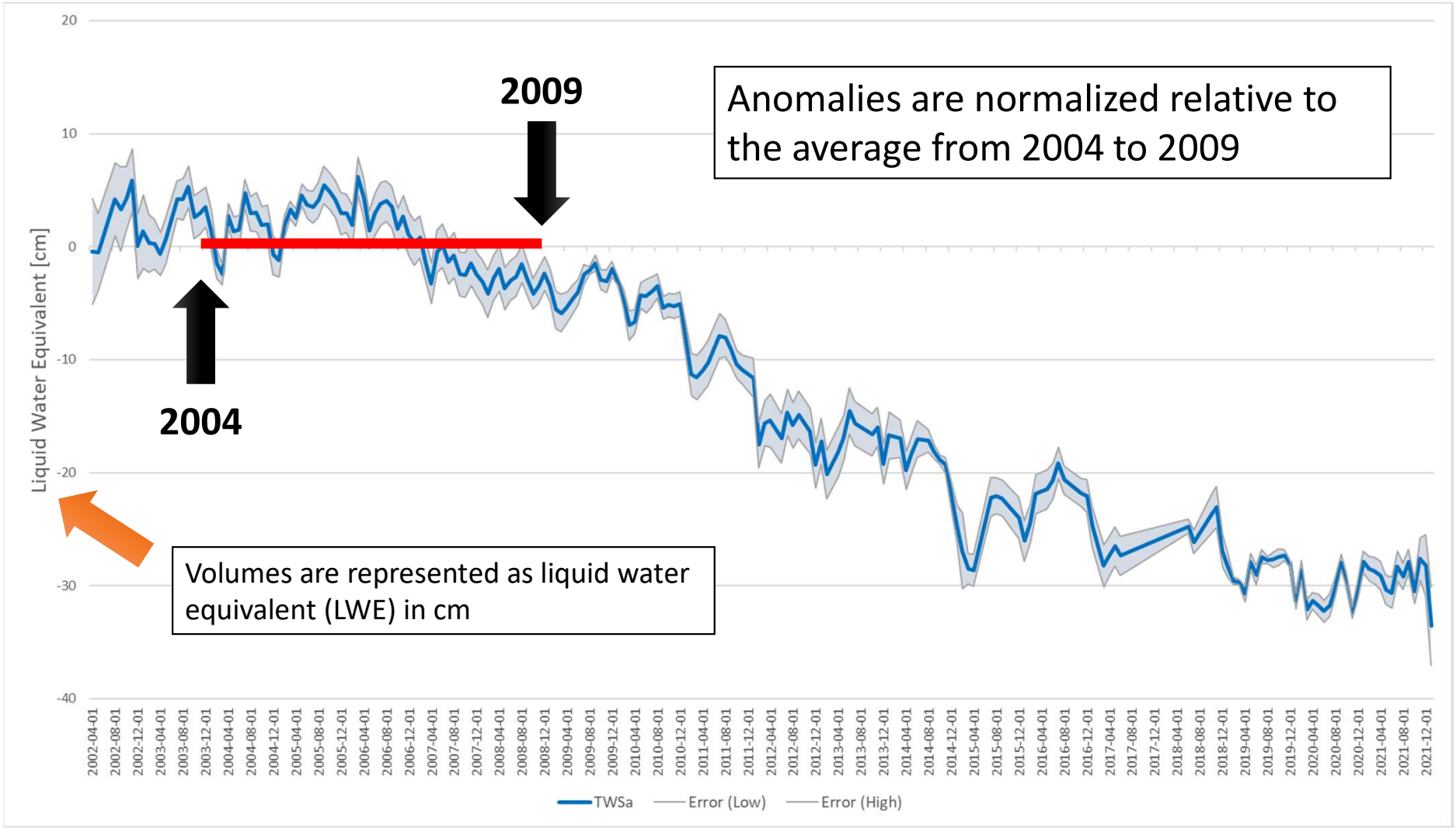

D + Δd

Gravity Anomaly



Total Water Storage Anomaly




2009
2004
Anomalies are normalized relative to the average from 2004 to 2009
Volumes are represented as liquid water equivalent (LWE) in cm
Liquid Water Equivalent [cm]
20
10
0
-10
-20
-30
-40
TWSa
Error (Low)
Error (High)

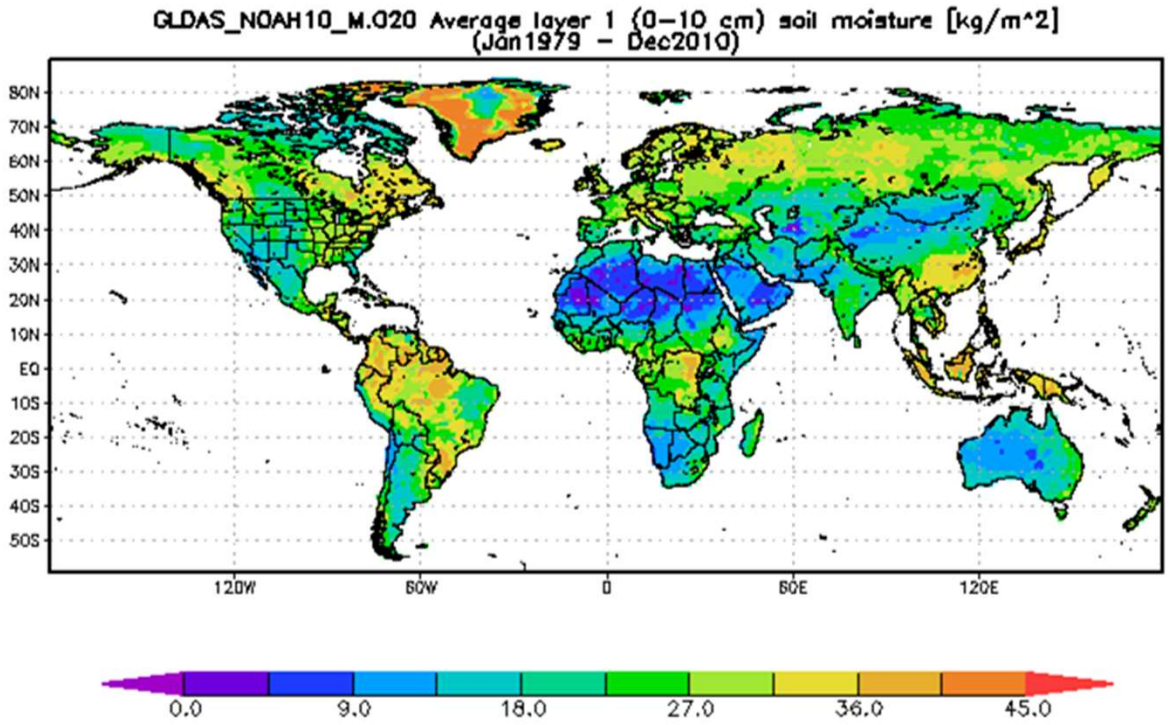
Global Land Data Assimilation System (GLDAS)

Land Surface Models

- **Noah**
- **VIC**
- **CLSM**

Terrestrial Water Components

- Plant canopy storage
- Snow water equivalent
- Surface water (small)
- Soil moisture



**Monthly mean calculated for each variable

$\sum$Tot_Storage - $\sum$Mean_Storage = Storage Anomaly

Methodology

$$GWa = TWSa - (SWEa + CANa + SMa)$$

GWa = Derived groundwater storage anomaly

TWSa = **GRACE** total water storage anomaly

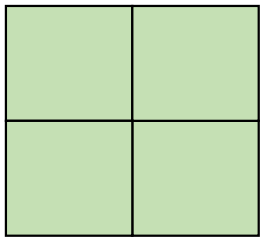
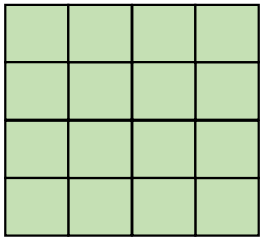
SWEa = **GLDAS** snow water equivalent anomaly

CANa = **GLDAS** canopy storage anomaly

SMa = **GLDAS** soil moisture anomaly

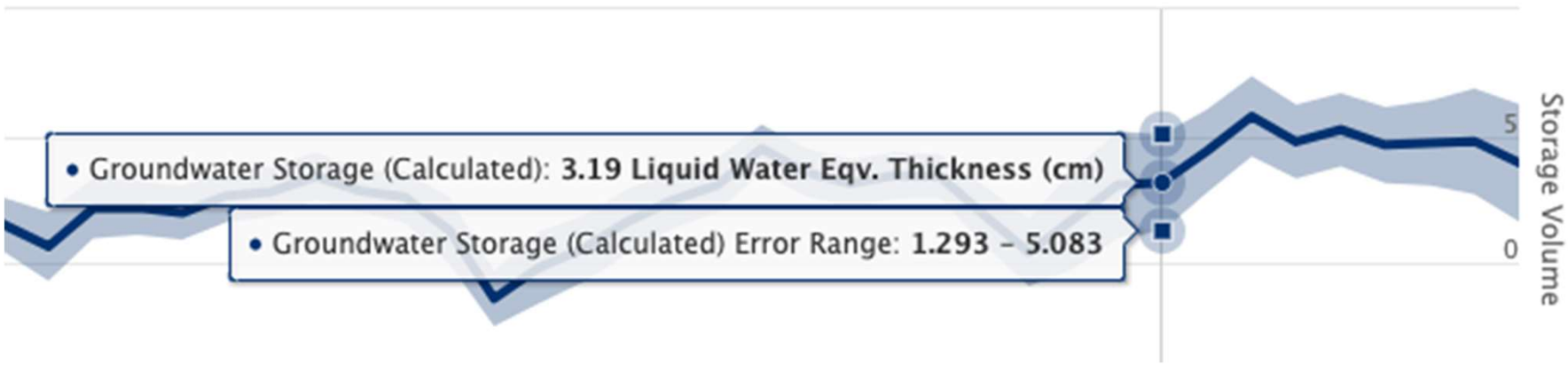
GLDAS Soil Moisture Component

Surface Model	Soil Moisture Storage Components
CLSM	SoilMoist_P_inst (Profile – includes Surface and Root Zone layers)
Noah	SoilMoi0_10cm_inst (0 – 10 cm) SoilMoi10_40cm_inst (10 – 40 cm) SoilMoi40_100cm_inst (40 – 100 cm) SoilMoi100_200cm_inst (100 – 200 cm)
VIC	SoilMoi0_30cm_inst (0 – 30 cm) SoilMoi_depth2_inst (depth varies spatially) SoilMoi_depth3_inst (depth varies spatially)

GRACE TWSa 0.5x0.5 degree 	**GLDAS VIC/CSLM** **SWEa, CANa, SMa** 1.0x1.0 degree 
GLDAS Noah **SWEa, CANa, SMa** 0.25x0.25 degree 	**Derived GWa** 1.0x1.0 degree 

For the GLDAS components, we use the mean of three embedded land surface models: Noah, VIC, CLSM. This allows us to compute uncertainty as follows:

$$\sigma GWa = \sqrt{(\sigma TWSa)^2 - (\sigma SWEa)^2 - (\sigma CANa)^2 - (\sigma SMa)^2}$$



Questions?