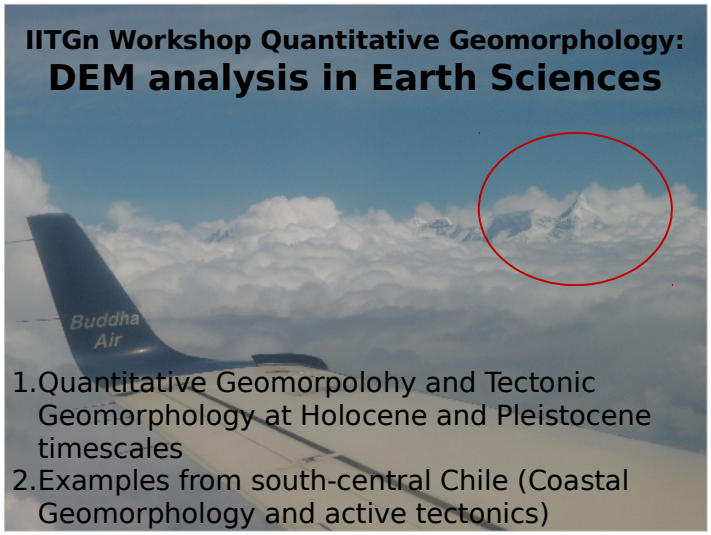
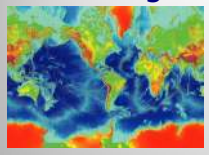
IITGn Workshop Quantitative Geomorphology:

DEM analysis in Earth Sciences

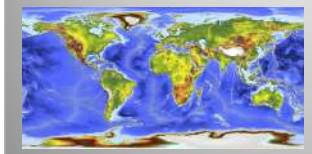


1. Quantitative Geomorpolohy and Tectonic Geomorphology at Holocene and Pleistocene timescales
2. Examples from south-central Chile (Coastal Geomorphology and active tectonics)

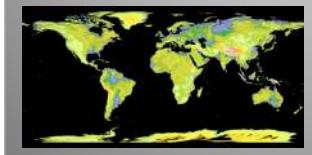
Digital Elevation Models



ETOPO5



Combination of various remote-sensing data (ESA)



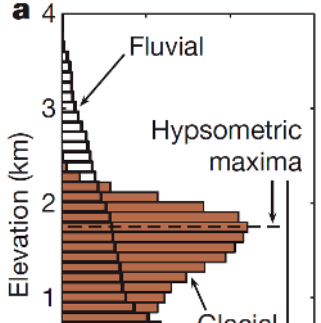
ASTER Global DEM (ASTER GDEM)

Hypsometric Curves

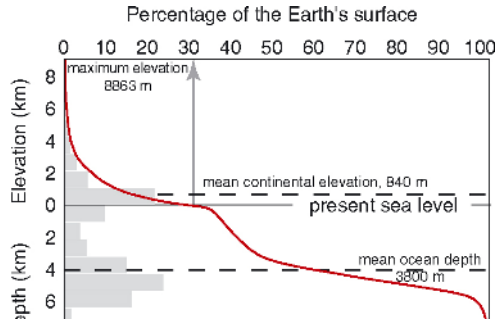
Hypsometry of a fluvial and glacial

fluvial landscape

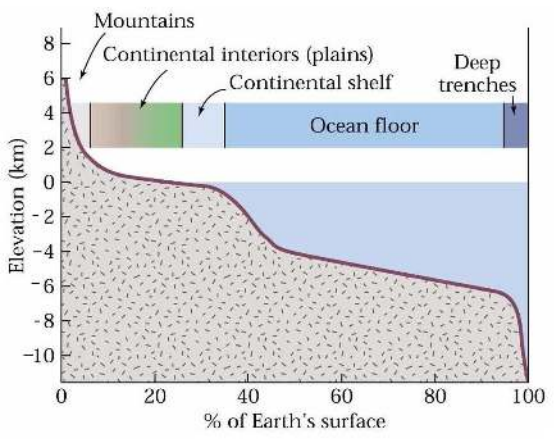
glacial landscape



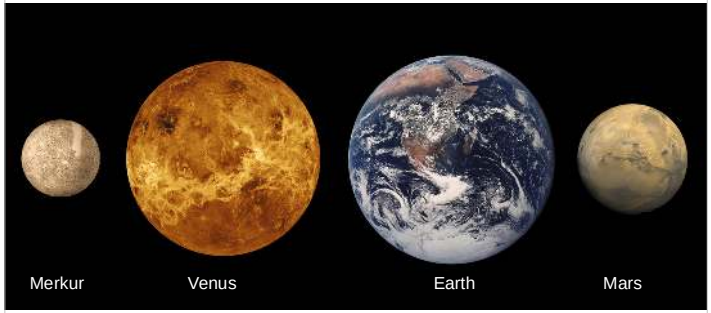
Hypsometric Curve of Earth



Hypsometric Curve of Earth

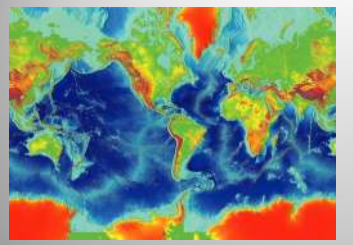


Earth-like planets



Sources: NASA

The mean depth of ocean basins



Use shallow-water wave equation to estimate ocean depth with travel times of large waves (i.e., tsunami). This technique was used before World War II to estimate ocean depths (before Sonars on submarines and other ships mapped the ocean depth).

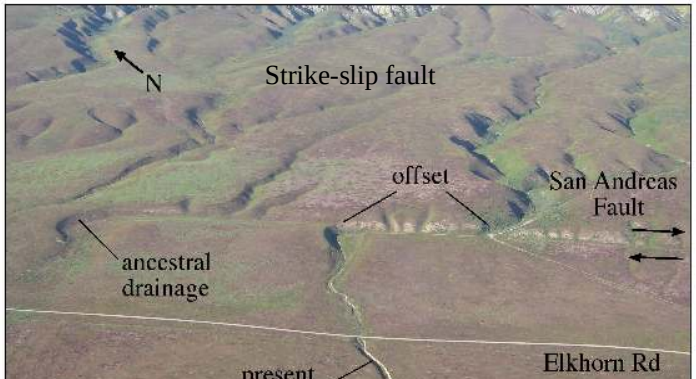
The mean depth of ocean basins

Tectonic Geomorphology

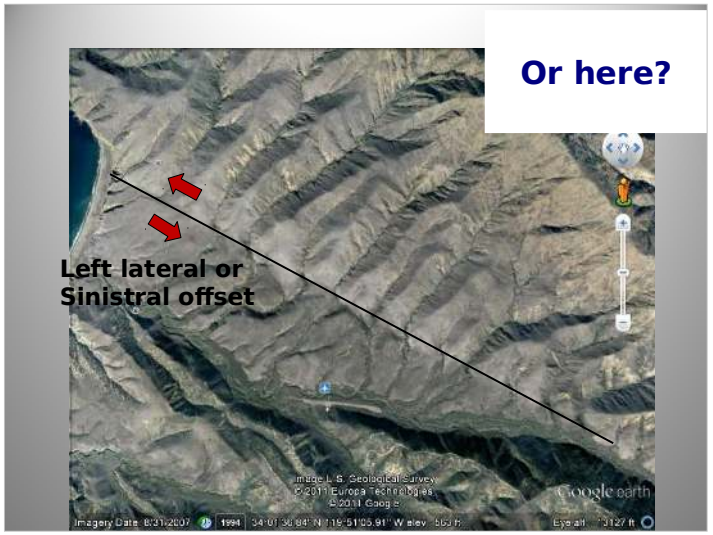
Basic principle:
Every feature of the landscape is there for a reason. We just have to be smart enough to figure out what the reason is.

What happened here?

Geomorphology, Anderson & Anderson, 2010

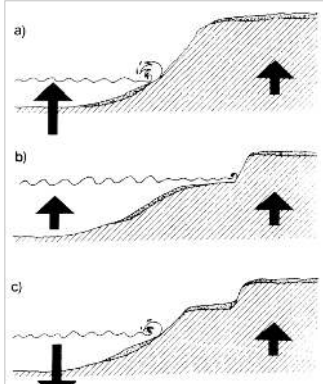


Or here?



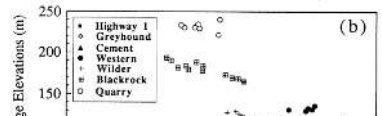
Definitions

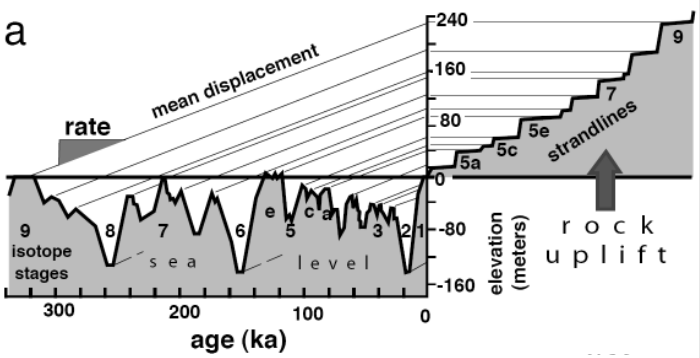
- Uplift rate (of surface or rock) is the vertical component of motion measured relative to a fixed datum (geoid) at the Earth's Surface (positive up)
- Erosion rate is positive down
- Surface uplift rate is the difference between rock uplift rate and erosion rate



Geomorphology and Tectonics

- Topographic profiles of uplifted marine terraces at Santa Cruz, CA, give two kinds of information:
- Total vertical uplift from height of wave-cut platforms initially at sea level
- Relative deformation along shore from shape of initial horizontal markers
- What additional type of data would be useful here?

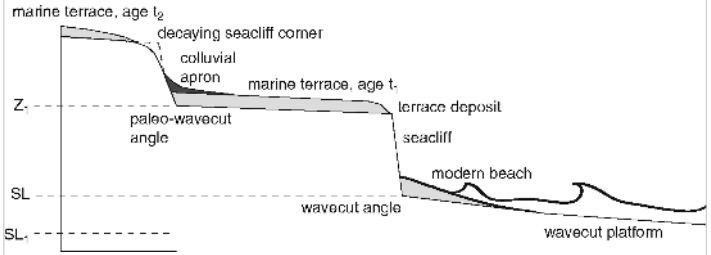




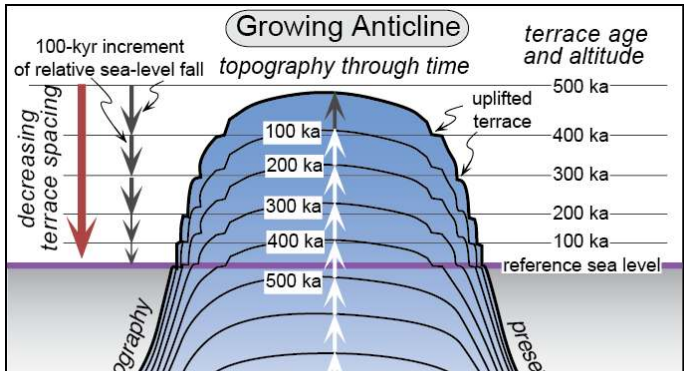
Graphical correlation of sea-level variations with coastal terrace record. Note that not all highstands older than 70 ky are represented in the terrace record.

Burbank and Anderson, Tectonic Geomorphology

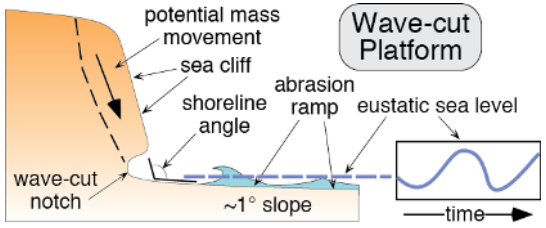
Anatomy of a modern rocky coastline

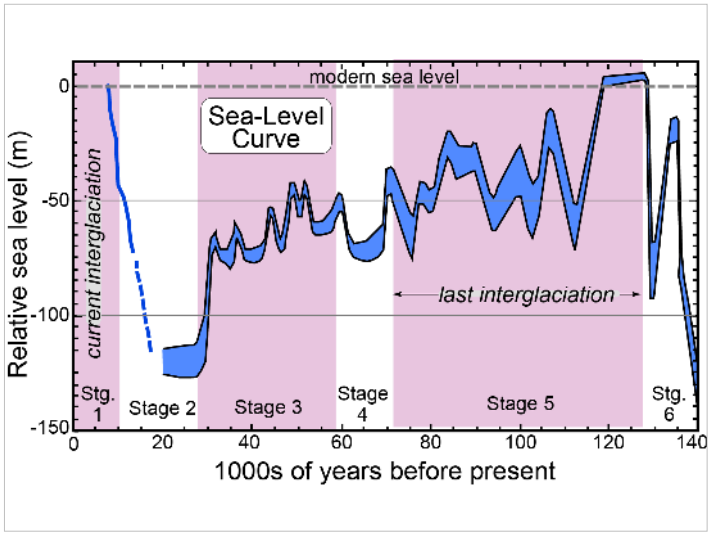


Geomorphology, Anderson & Anderson, 2010



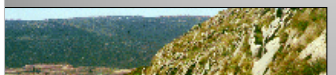
Anatomy of a modern rocky coastline





Measuring Geomorphic Rates

- We have several ways of measuring the rates of landscape evolution.
  - Dating of geomorphic surfaces: Much effort has been directed towards measuring the age of erosional surfaces (e.g., peneplains, terraces). using the exposure age of materials on that surface.
    - Thermoluminescence or electron spin resonance
    - ^{14}C dating of organic matter in the soil
    - Cosmogenic nuclides: ^{10}Be, ^{26}Al, ^{36}Cl
      - Example: clocking development of normal fault scarp in limestone:



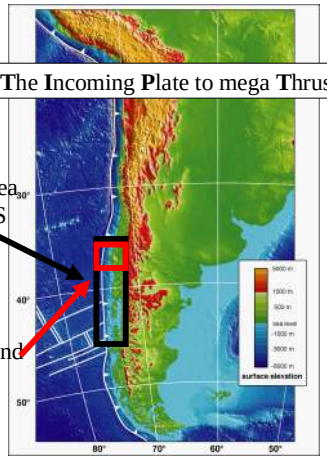
South America – tectonic setting and topography

TIPTEQ

from **T**he **I**ncoming **P**late to mega **T**hrust **E**arth**Q**uake Proc

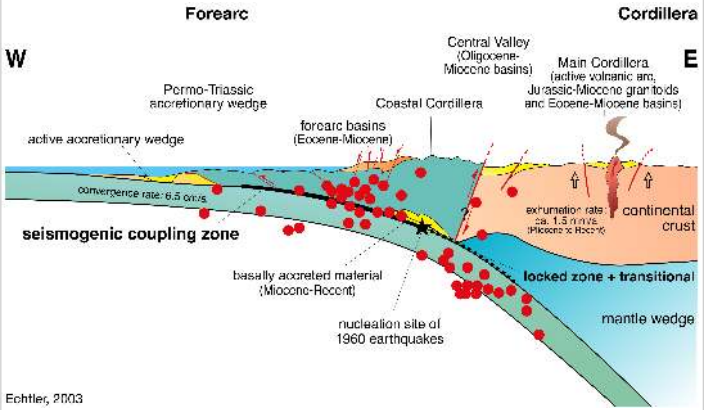
TIPTEQ working area from ~36° to ~46°S

Arauco Peninsula and Santa María Island

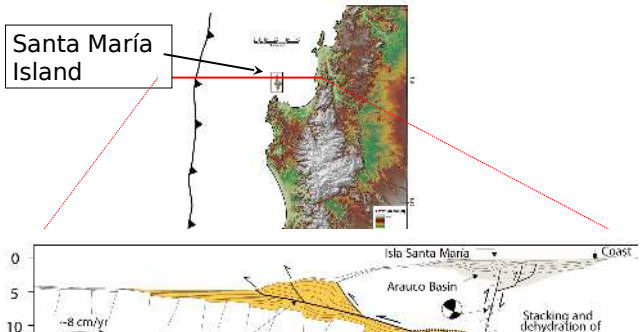


Modified after Strecker et al., 2003

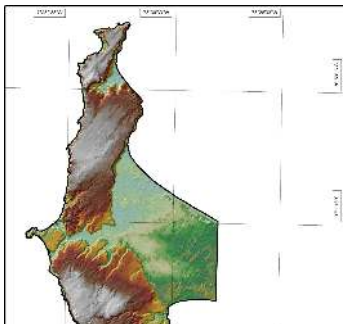
Interplate Interface and location of the seismogenic coupling zone in south-central Chile

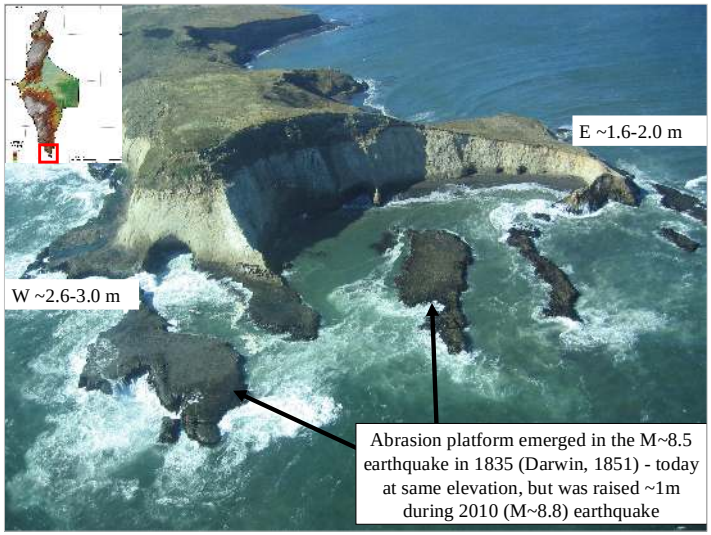


Main Structures of the Arauco Peninsula



Topography of Santa María Island





Beach berms on Santa María Island

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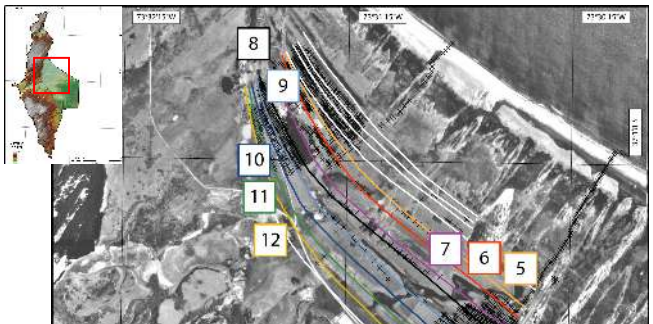
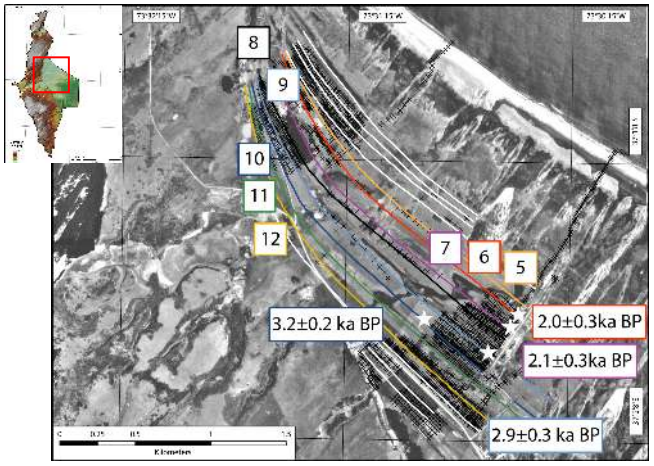


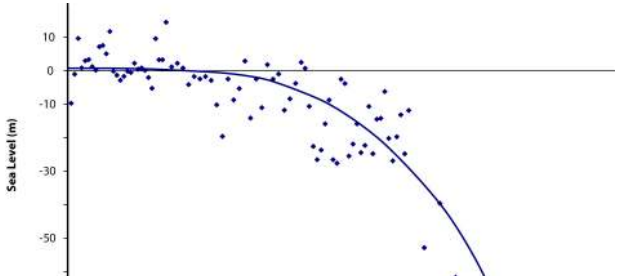
Beach berms on Santa María Island



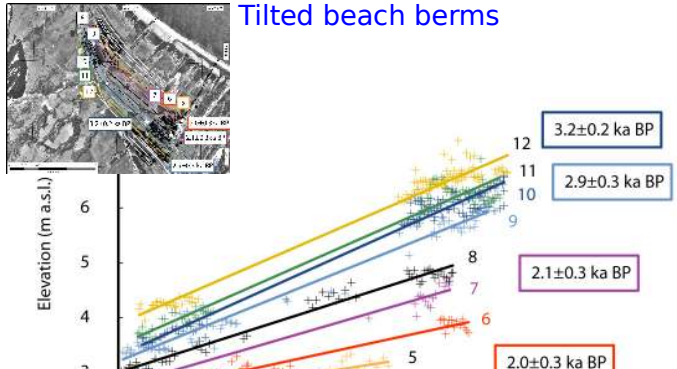
Bookhagen et al., 2006

Beach berms / strandlines on Santa María Island

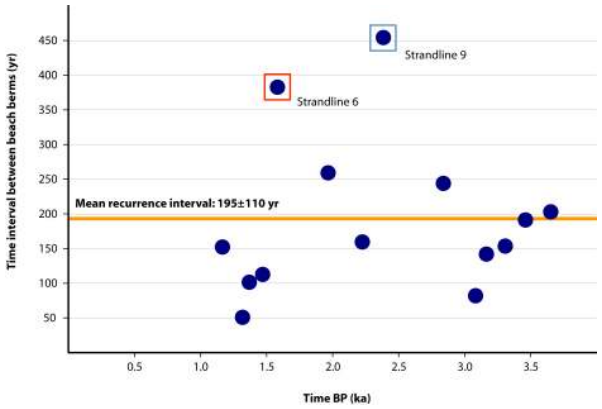
Holocene sea - level curve



Tilted beach berms



Recurrence intervals of beach berms



Bookhagen et al., 2006

Earthquake recurrence intervals

- Historic earthquake record: ~175 yrs
- Marine sediment cores suggest a Late Pleistocene – Holocene recurrence interval of ~200 yrs