with contributions from:
- Marta Marcos
- Alvaro Santamaria
-…

CeCile

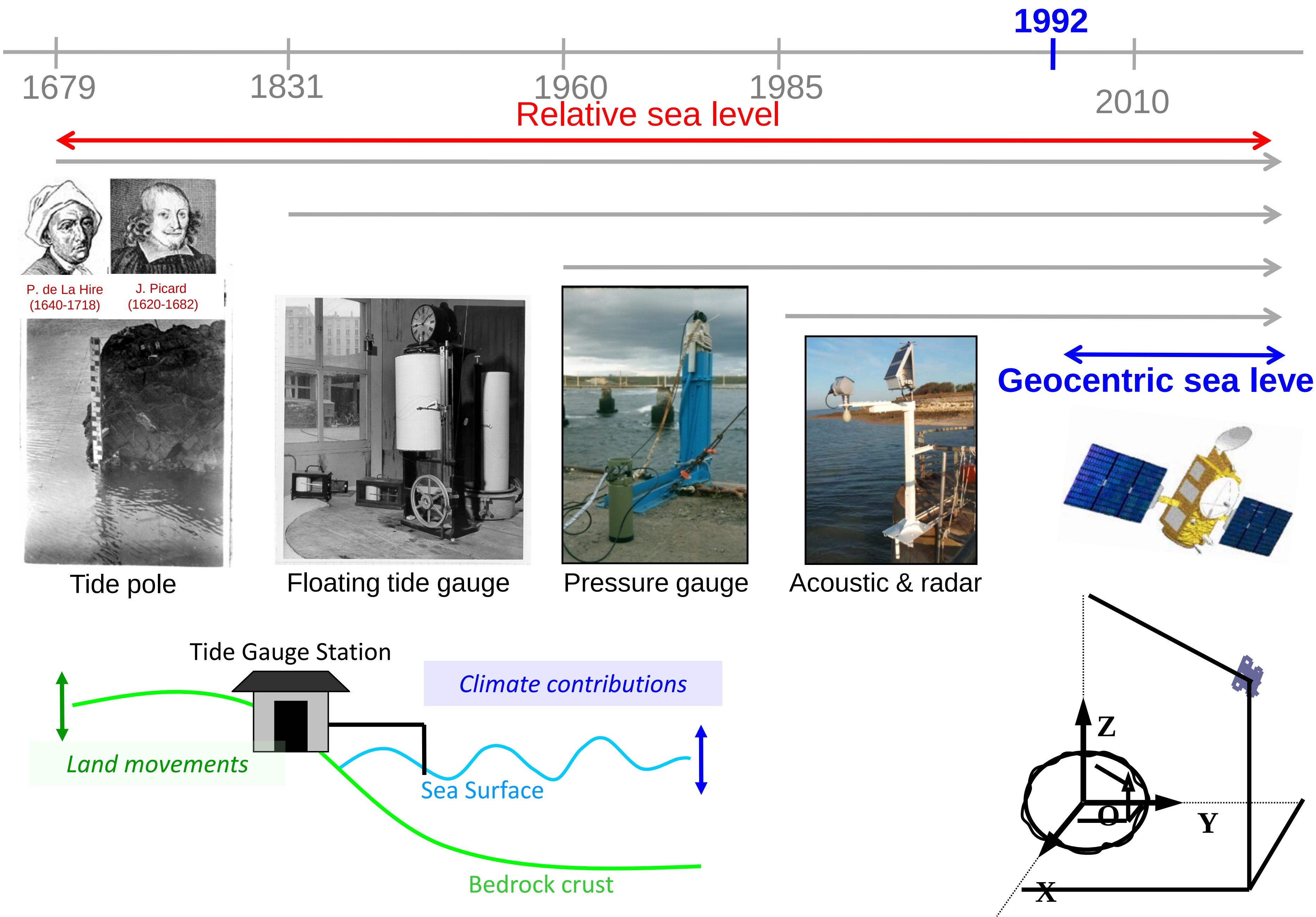
GNSS Observations & Sea Level

Guy Wöppelmann
gwoppelm@univ-lr.fr

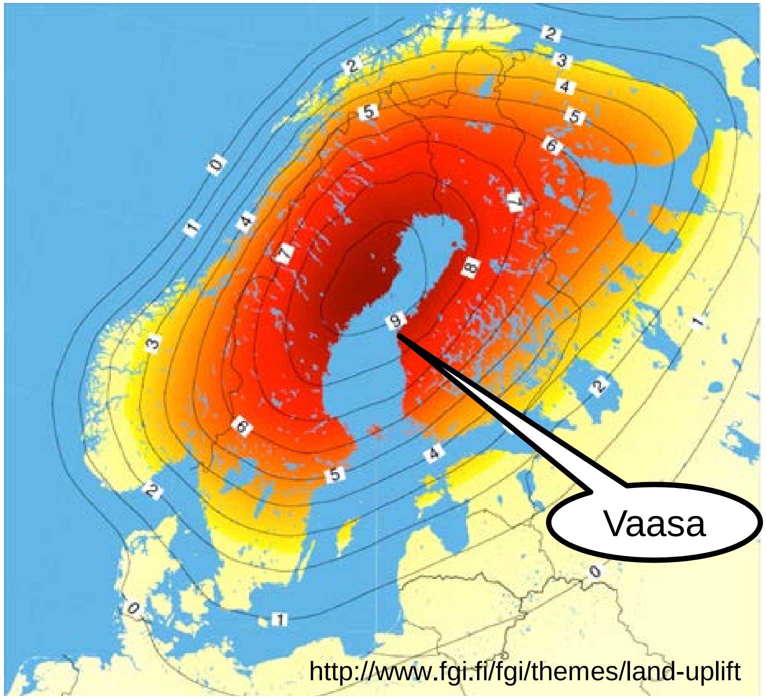
PSMSL 1933 2013

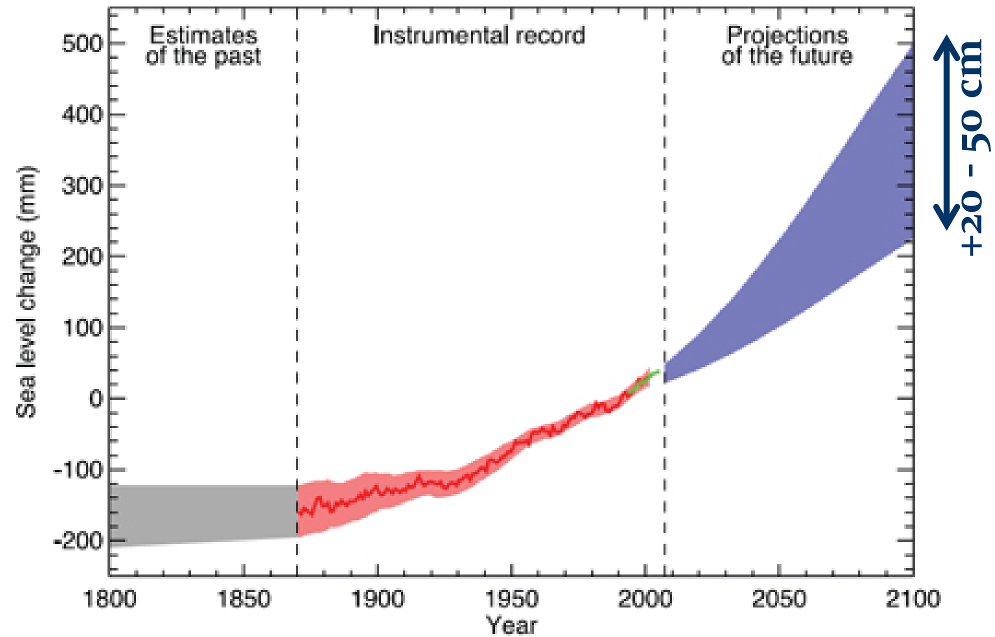
Liverpool, 27-28 Oct. 2013

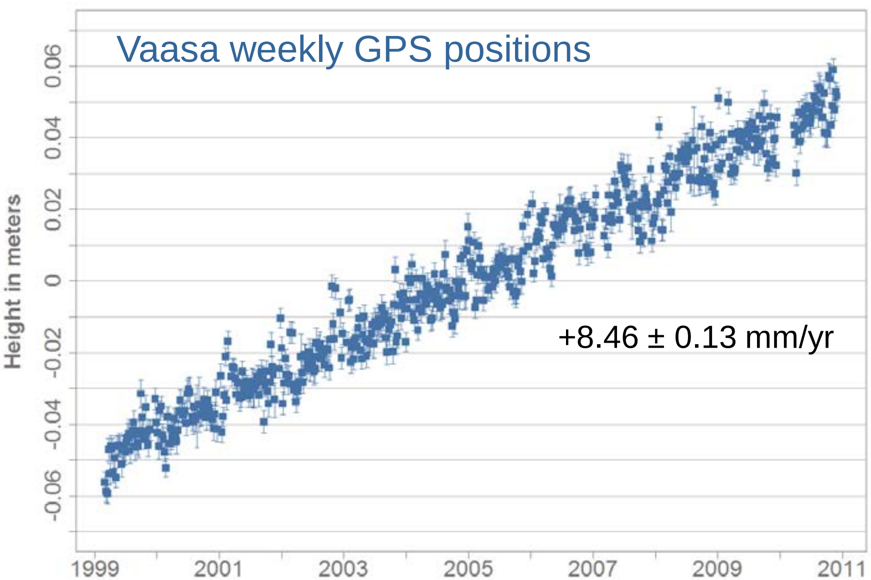
1. The Era of Recording Sea Level

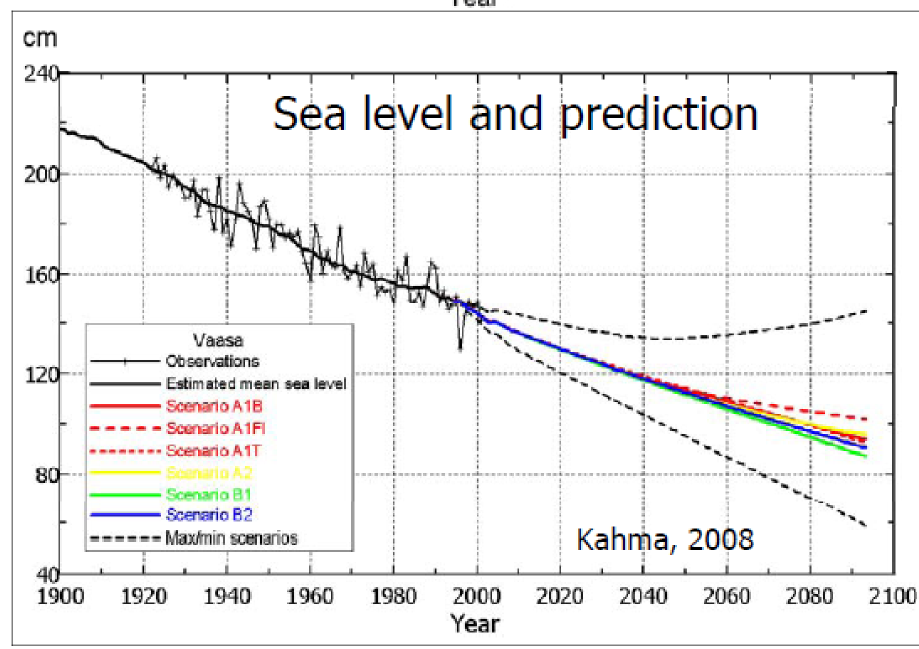


2. The importance of land movements at the coast

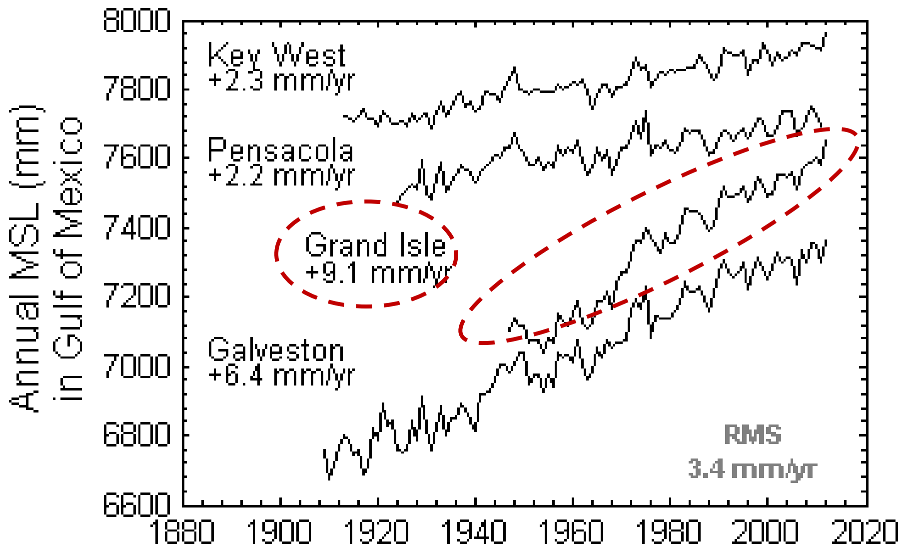


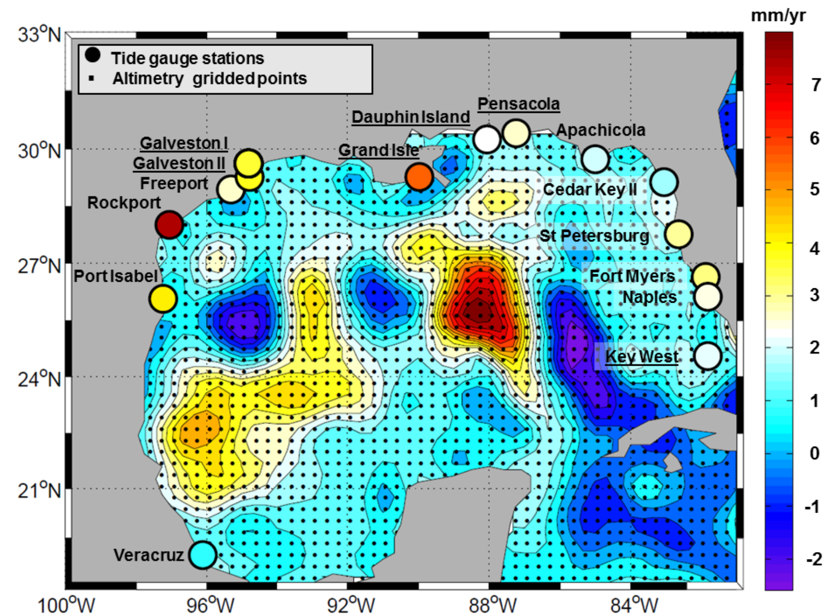




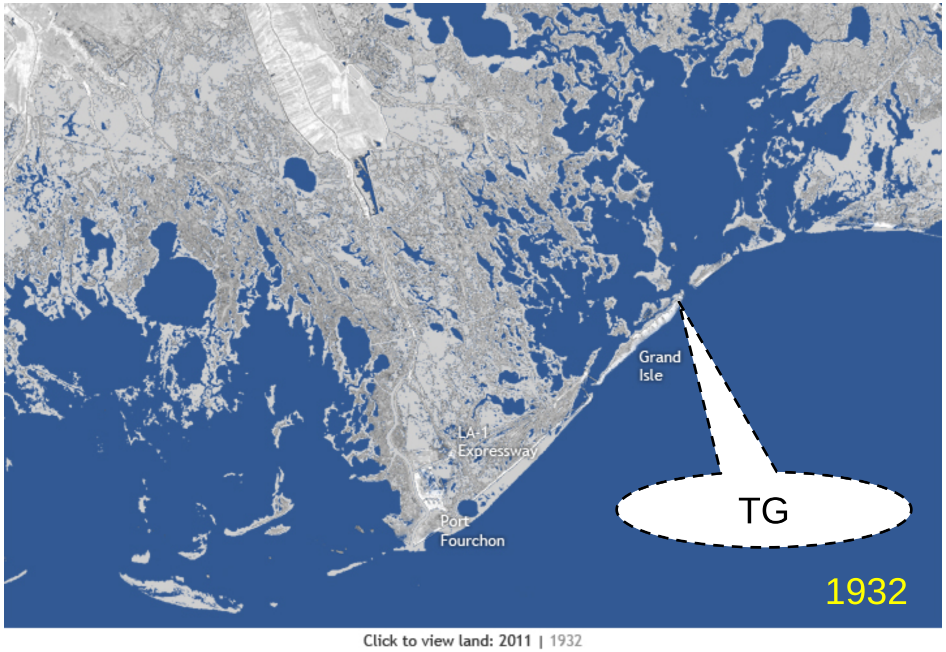


2. Gulf of Mexico & Grand Isle (Louisiana)

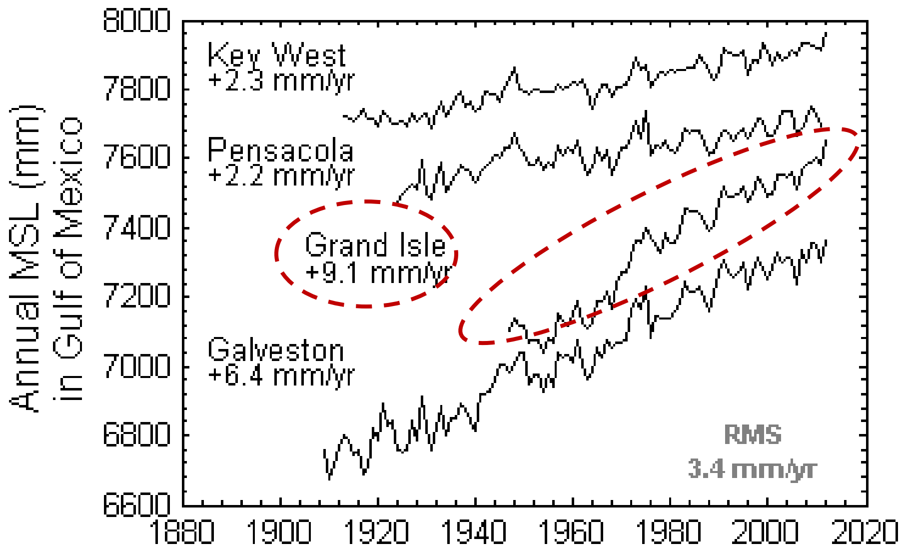


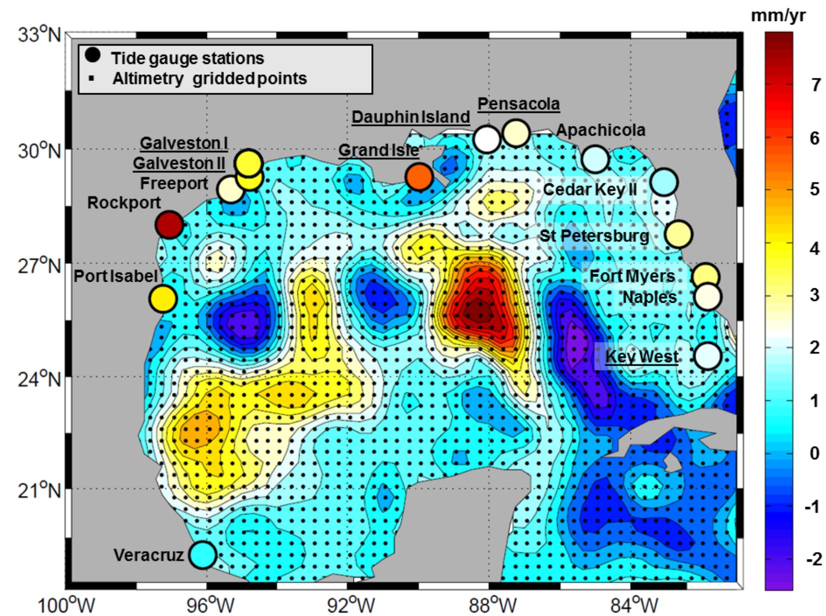


Maps by NOAA Climate.gov team (Stephen Gill)

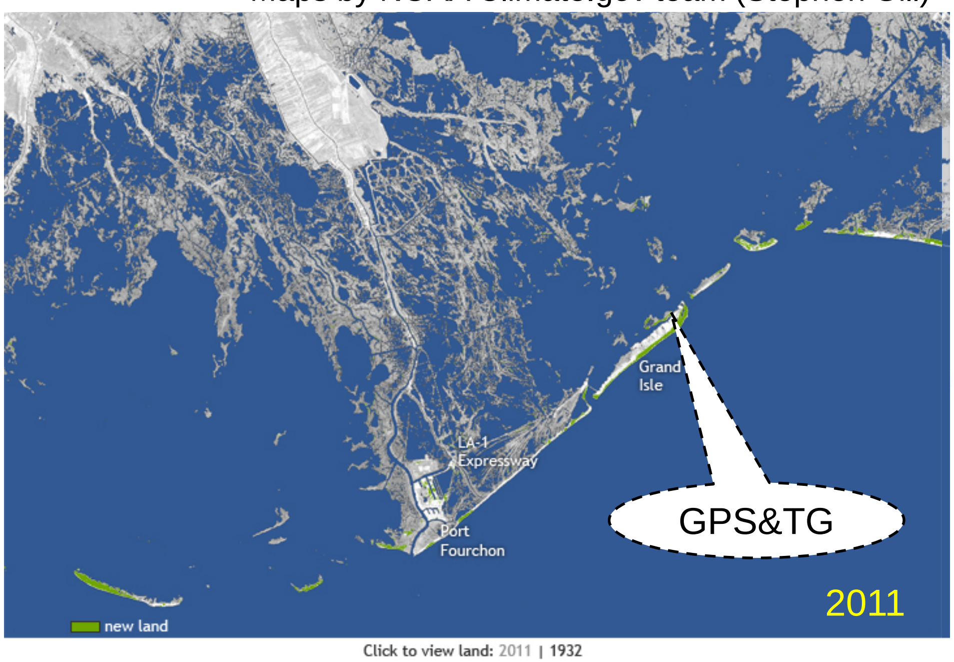


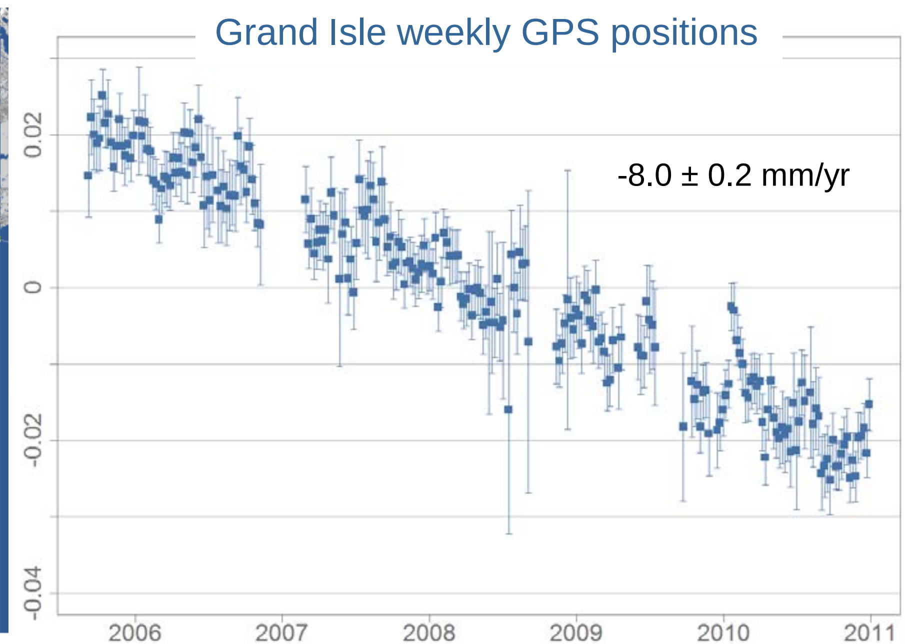
2. Gulf of Mexico & Grand Isle (Louisiana)





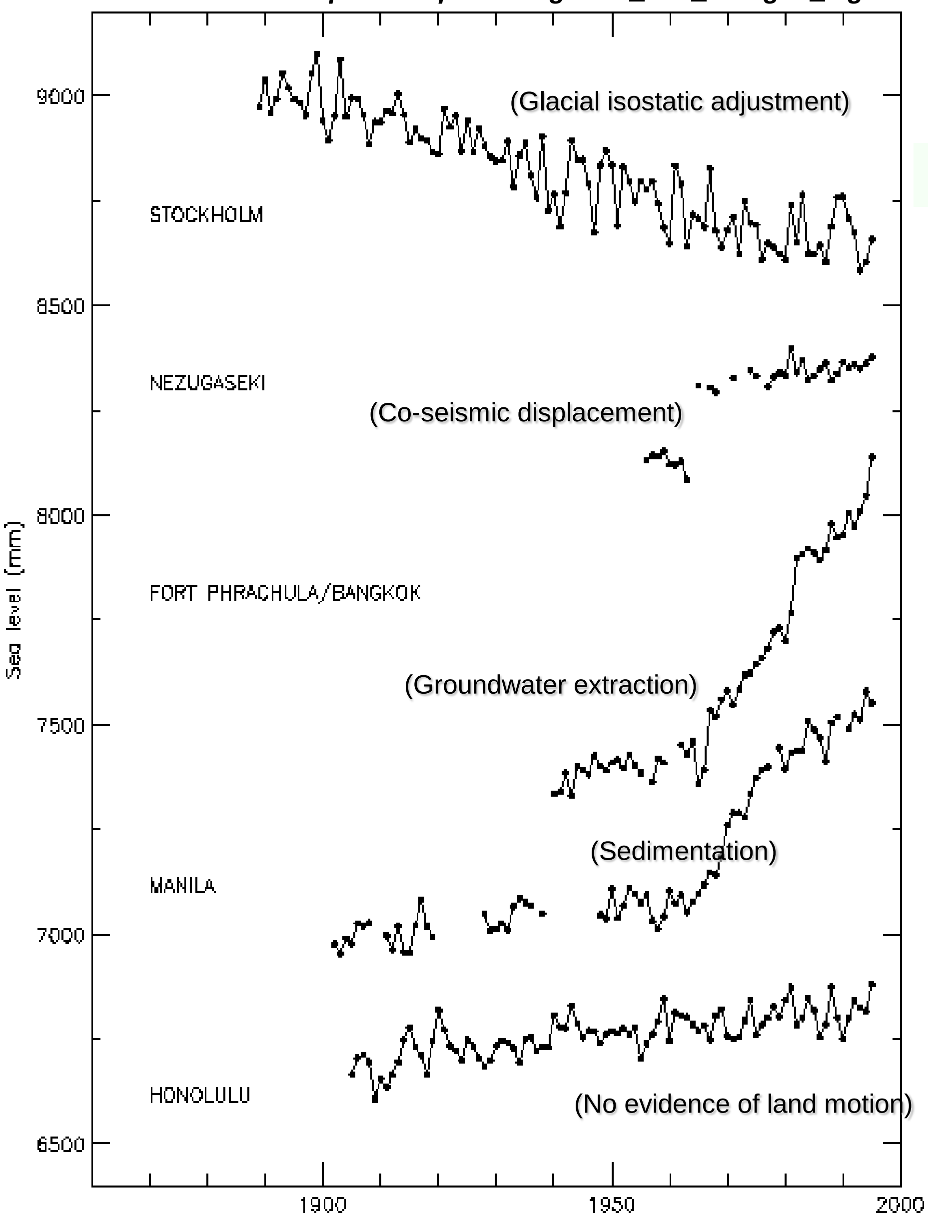
Maps by NOAA Climate.gov team (Stephen Gill)

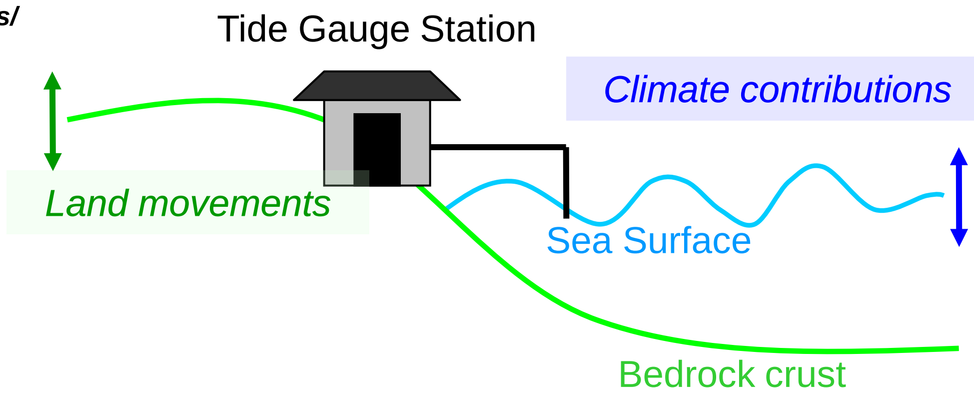




2. Wide range of VLM processes

Source PSMSL: http://www.psmsl.org/train_and_info/geo_signals/



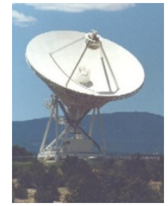


- **Determination**
  - → Modeling: Only GIA
    - Uncertainties (viscosity profiles, lithosphere thickness, ice retreat)
    - Other processes?
  - → Monitoring: Space Geodesy

- **Challenges**
  - → Rates of sea-level change: ~2 mm/yr
  - → Standard errors: one order of magnitude less to be useful in LTT sea level studies!

3. Measure (if one can): The GPS solution

Satellite Laser Ranging (SLR)



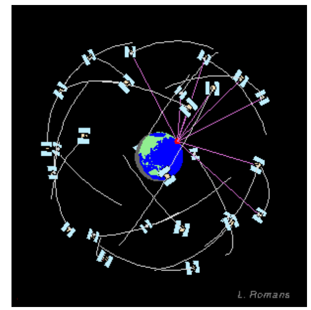
VLBI

DORIS

Absolute Gravimetry

- Review of Geodetic Techniques
  Carter *et al.* (1989; 1993)

- Campaign *versus* Continuous GPS
  Zerbini *et al.* (1996)
  Neilan et al. (1998) – JPL (IGS/PSMSL)



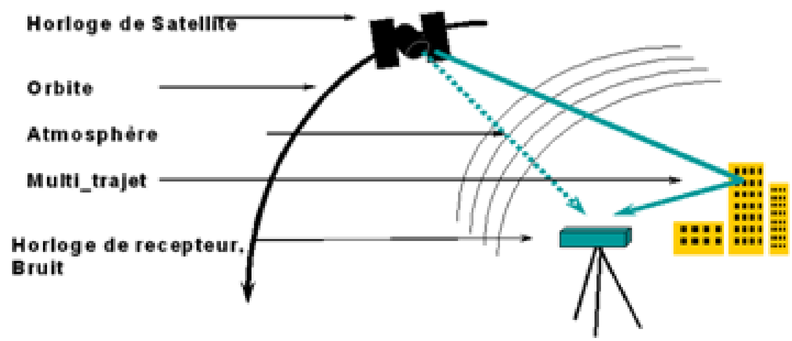
GPS constellation

Campaign mode

Continuous mode

- Regional *versus* Global GPS Processing
  Mazzotti *et al.* (2008)
  Legrand *et al.* (2010)

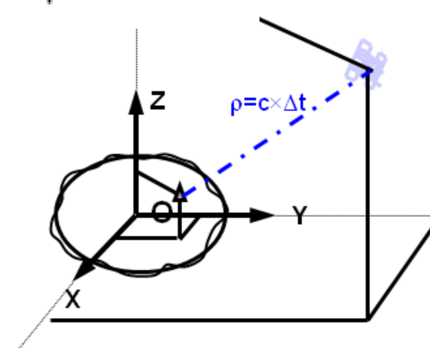
↳ International infrastructure (IGS)



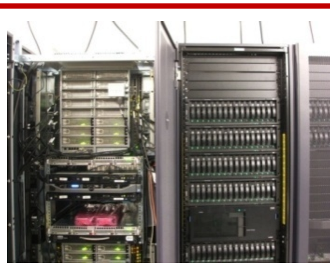
- IGS pilot project: TIGA (OS, DC, AC)
  Launched in 2001

- Cumulative GPS processing *versus*
  Homogenous GPS reprocessing

  Wöppelmann *et al.* (2007) in GPC



↳

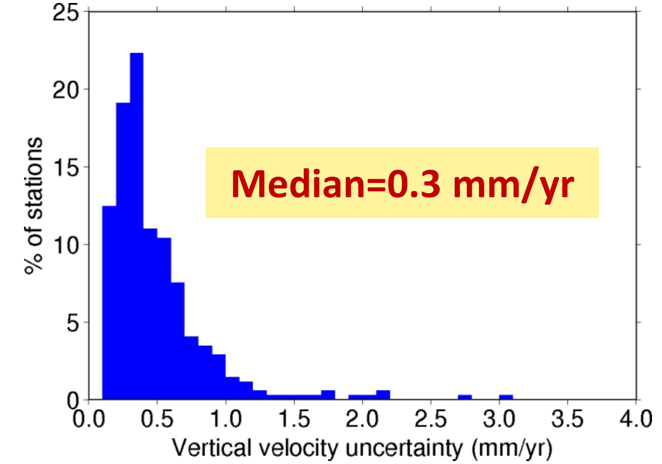


Dedicated Data Storage : **7 To**
"Lustre" Data File System

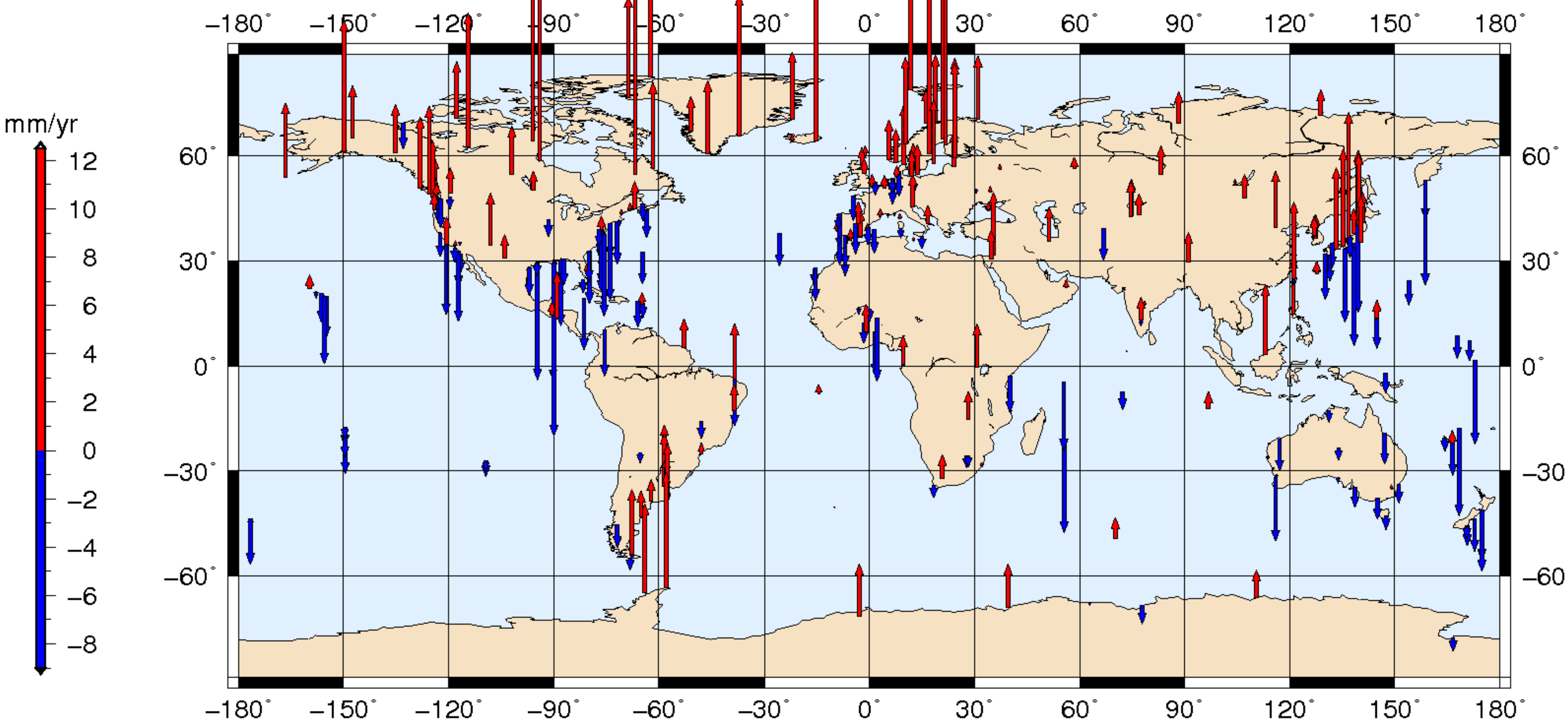
Altix ICE 8200 (SGI)
Cluster Linux (2008 → 2010)
128 processors → 392

3. GPS vertical velocities from the ULR consortium

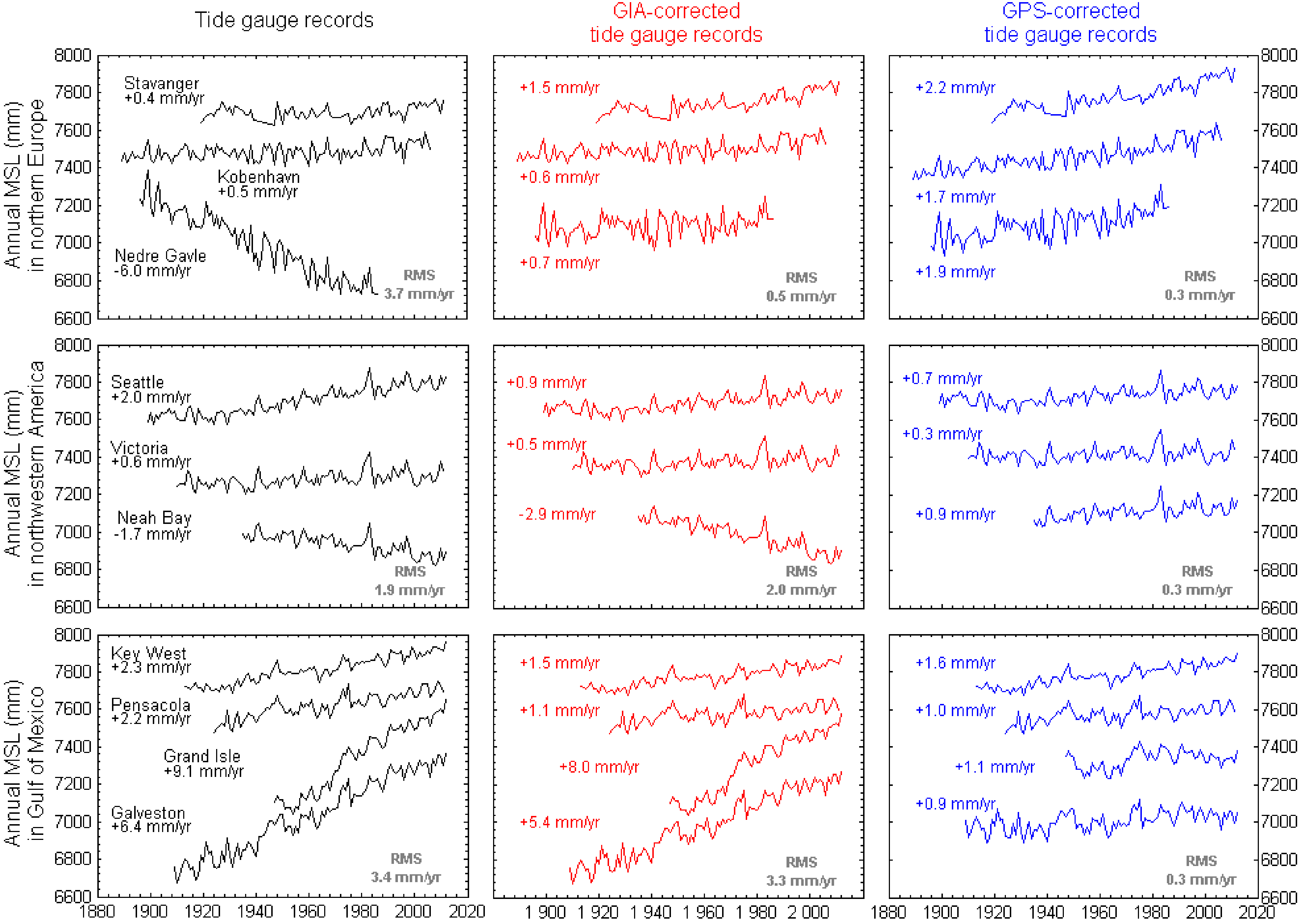
Santamaria-Gomez *et al.* (2012) available at www.sonel.org



- Calculation of uncertainties on velocities taking into account time-correlated noise
- **326 GPS velocities, from which 201 co-located at or near a tide gauge (<15km)**



3. GPS velocities at TG... How well do they work?



4. Studying Spatial Patterns of Sea Level Change

Douglas (2001)

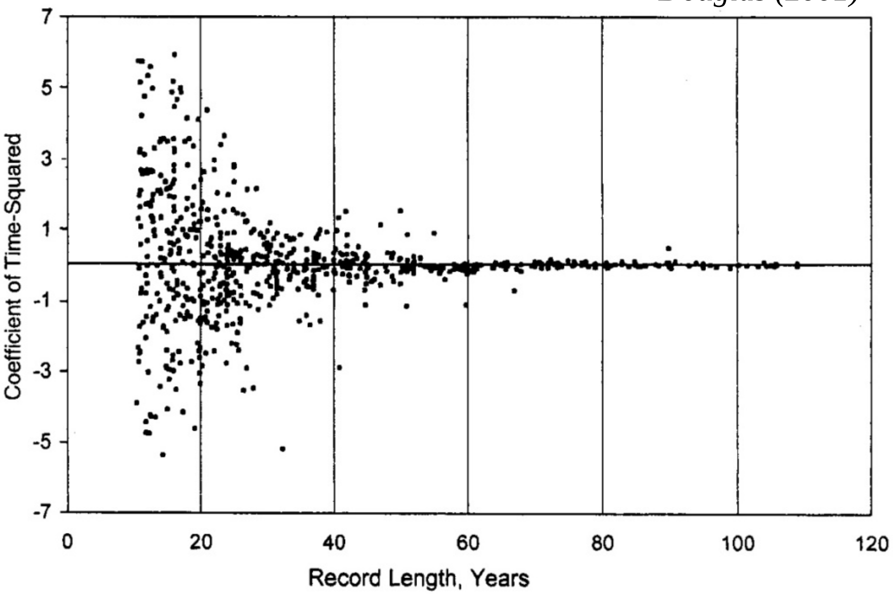


Figure 3.16 Acceleration component of relative sea levels.

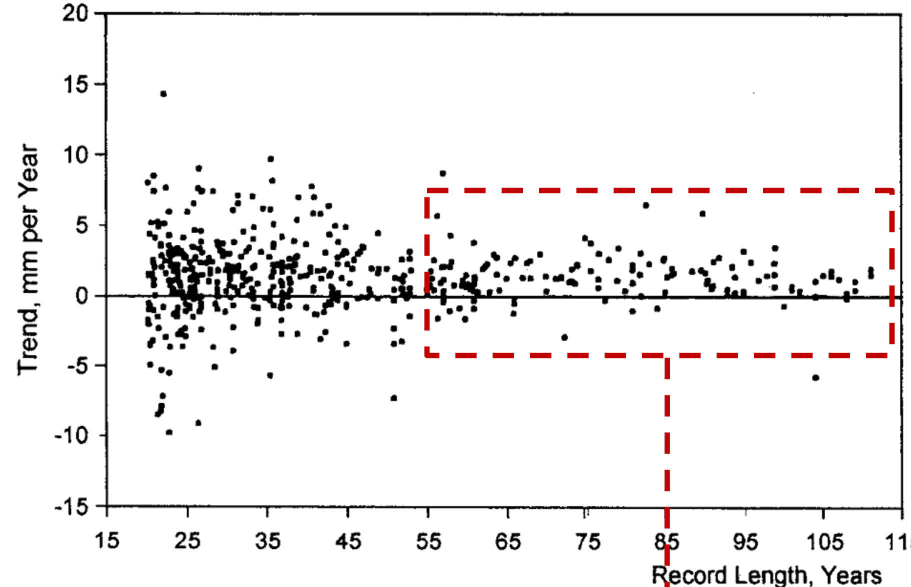
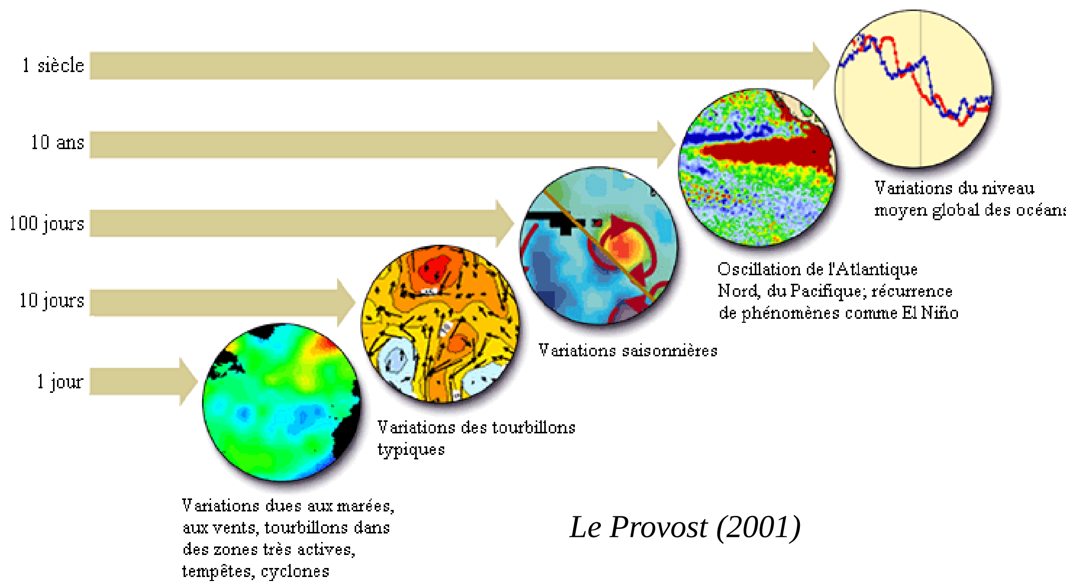


Figure 3.11 RLR-site sea level trends corrected for glacial isostatic adjustment.

Local VLM are the most likely source of spatial variability

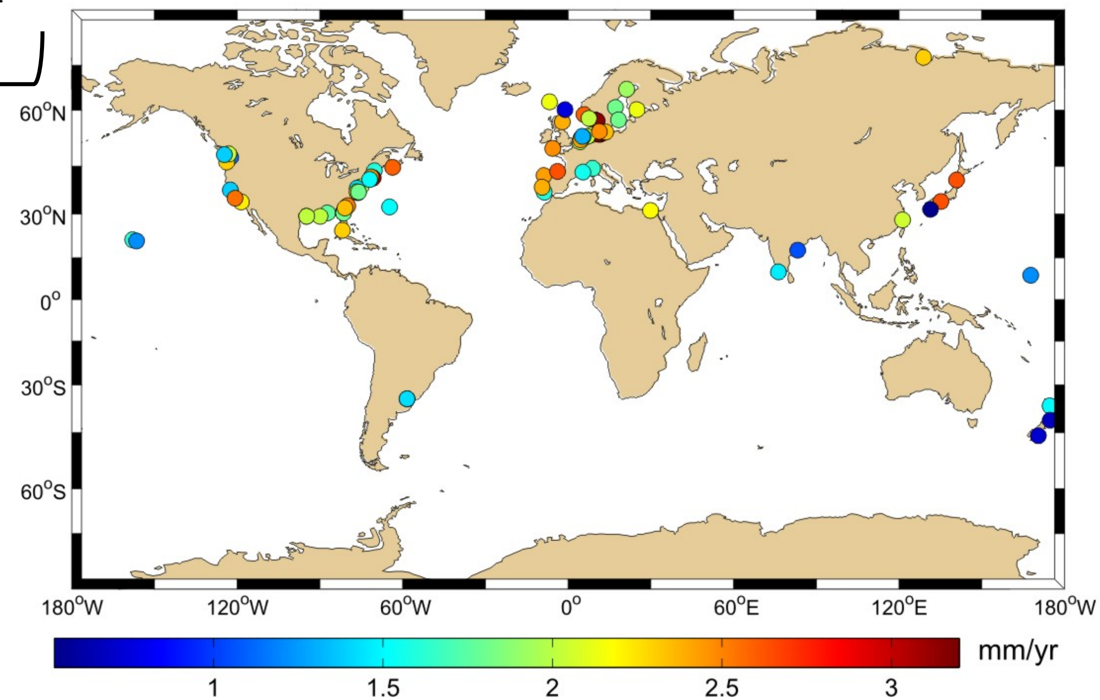


Le Provost (2001)

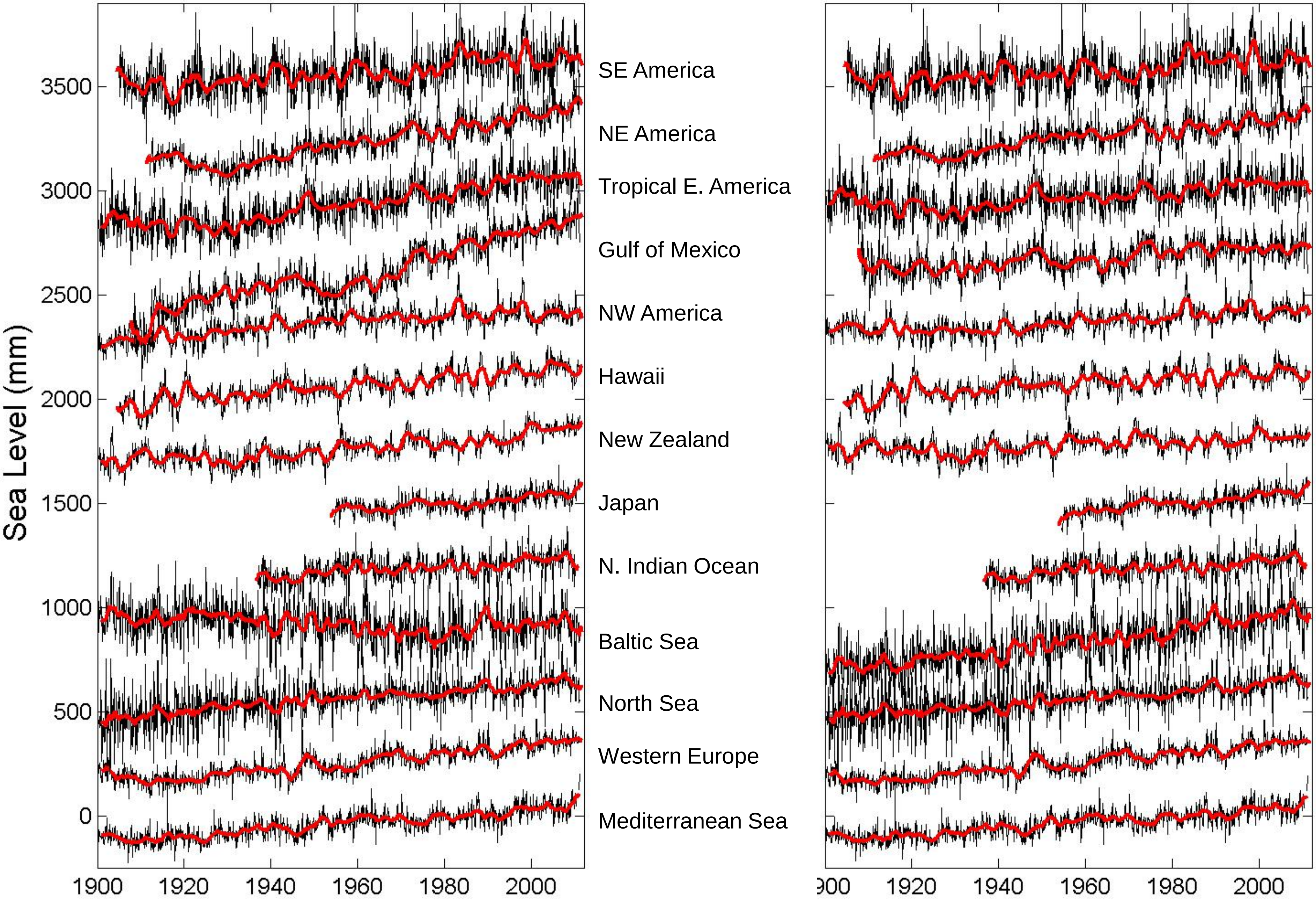
4. Studying Spatial Patterns of Sea Level Change

- Station selection criteria:
  - Tide gauge records > 50yr from 1900
    - 70% of valid data
  - Regional grouping based on correlation coefficients
  - Nearest robust GPS velocity estimate
    - Same land (Islands)
    - GIA gradient of TG-GPS stations < 0.4 mm/yr
    - Active tectonic areas : co-location or redundant GPS data

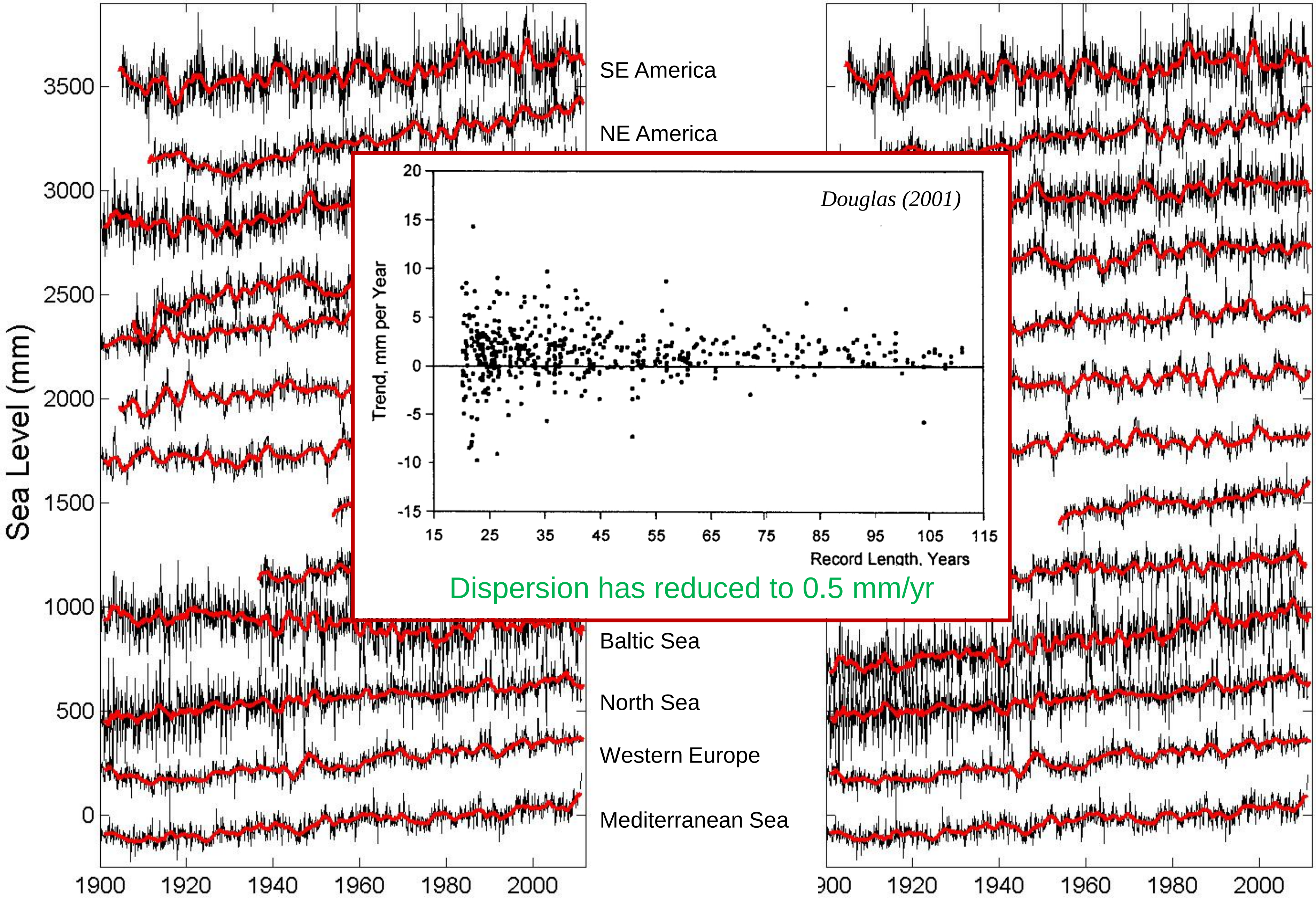
76 records
grouped into 17 regions



4. GPS velocities at TG... How well do they work?

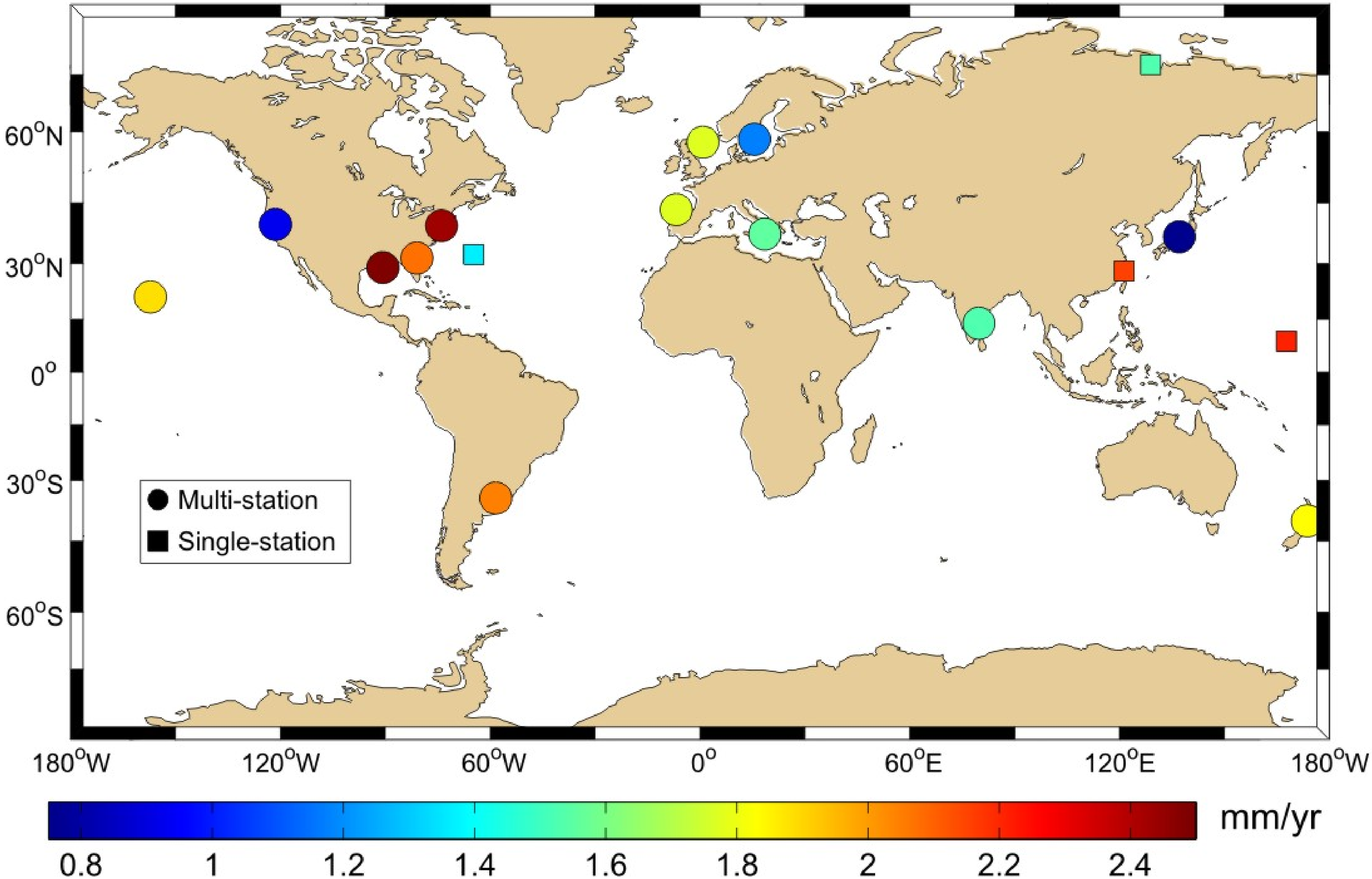


4. GPS velocities at TG... How well do they work?

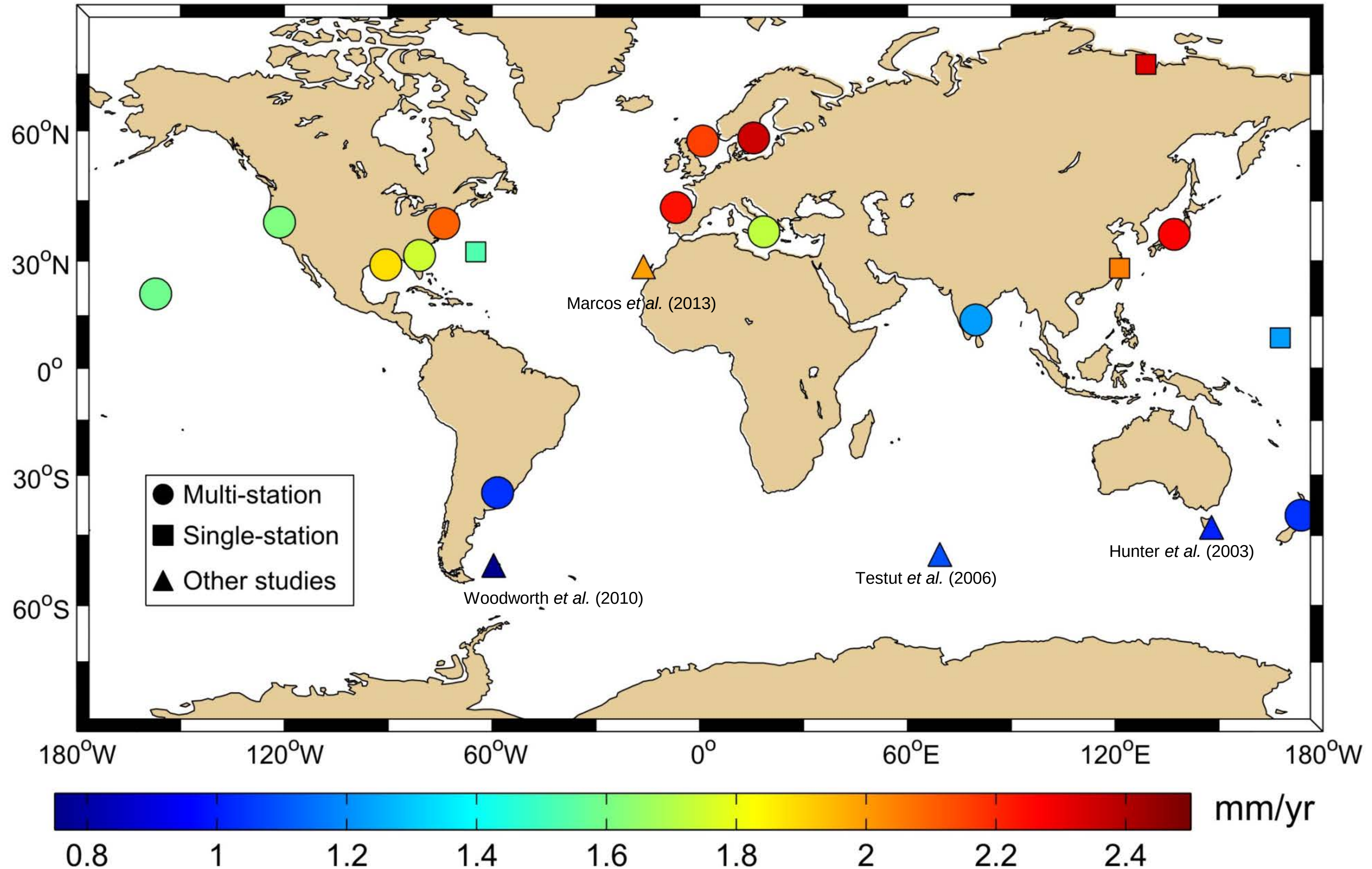


Dispersion has reduced to 0.5 mm/yr

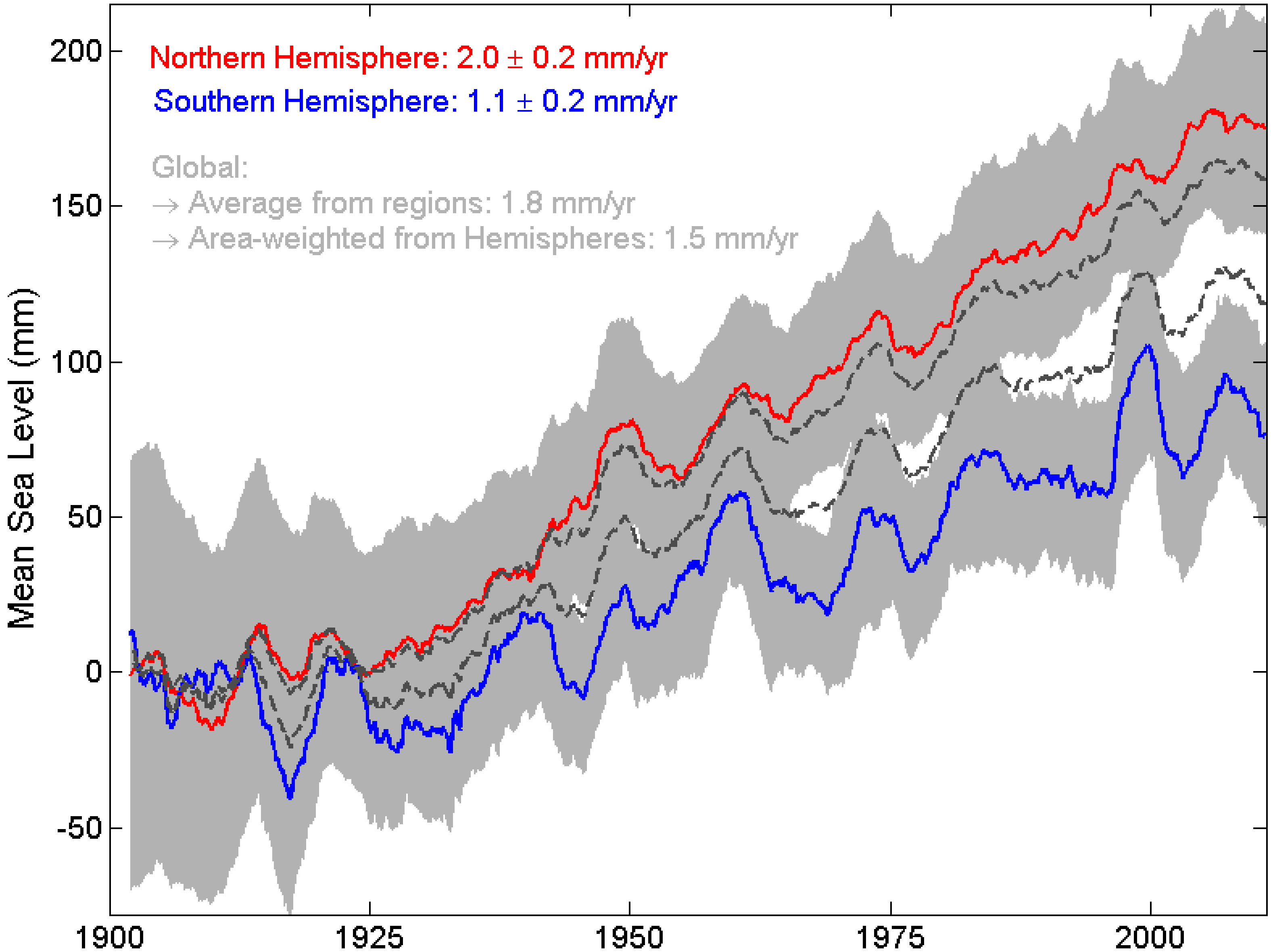
4. Spatial Patterns of Sea Level Change



4. Spatial Patterns of Sea Level Change



4. Hemispheric Sea Level Change



5. Concluding remarks

- Revisited study of global sea-level rise over the past 100 years
  - Updated datasets:
    - ↳ *Number of stations, time series completeness and length*
  - State-of-the-art methods and corrections
    - ↳ *e.g., Grouping with "Virtual station" technique*
      Vertical land motion (VLM) with best GPS velocities
- Evidence for a differential sea-level rise between hemispheres
  - Robust observational evidence
    - ↳ within the limitations of the datasets, **affecting any previous study**
- Major consequences in terms of sea level research
  - Reconcile past estimates: the crucial role of geographic sampling
  - Striving to close the budget of 20th global sea level rise is an elusive goal
  - Research avenue for explaining the cause of this pattern…
- VLM are an important source of spatial variability of sea level trends
  - Masking the detection of climate-related signals and fingerprints
    - ↳ GIA models are limited by essence to the GIA process
    - ↳ VLM corrections are essential, from other sources e.g. GPS
    - ↳ GLOSS (IOC/Unesco) requires GPS at TGs
      and making the data available