



Efforts to Monitor Geoid Change in Mexico

Towards a Significant Improvement
for National and Regional
Geoid Solution

Contents

- Current geoid solution: GGM06
- Gravimetric network,
current state and perspective.
- Heights and its Variations
 - Re-construction
of the geodetic vertical control network.
 - Magnitude of vertical movements detected.

Contents

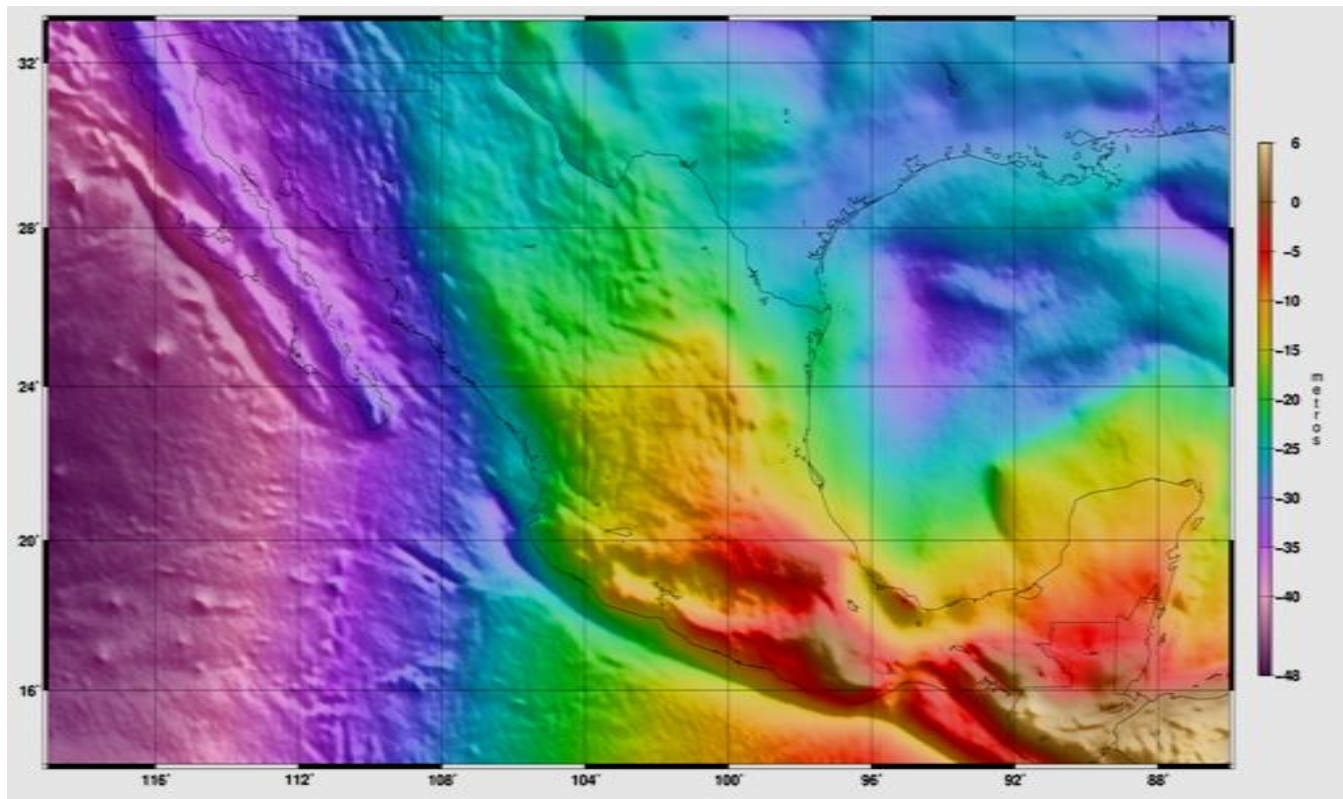
- **Current geoid solution: GGM06**
- Gravimetric network, current state and perspective.
- Heights and its Variations
 - Re-construction of the geodetic vertical control network.
 - Magnitude of vertical movements detected.

Geoid Solution

- Geoid solutions with free access have been released since August 2004.
- Kind of solution from INEGI:
 - Constraints: pure gravimetric
 - Geoid fixed in time
 - Approach: Stokes-Helmert technique (UNB)

Geoid Solution

- Currently recommended: GGM06
software available at: www.inegi.org.mx

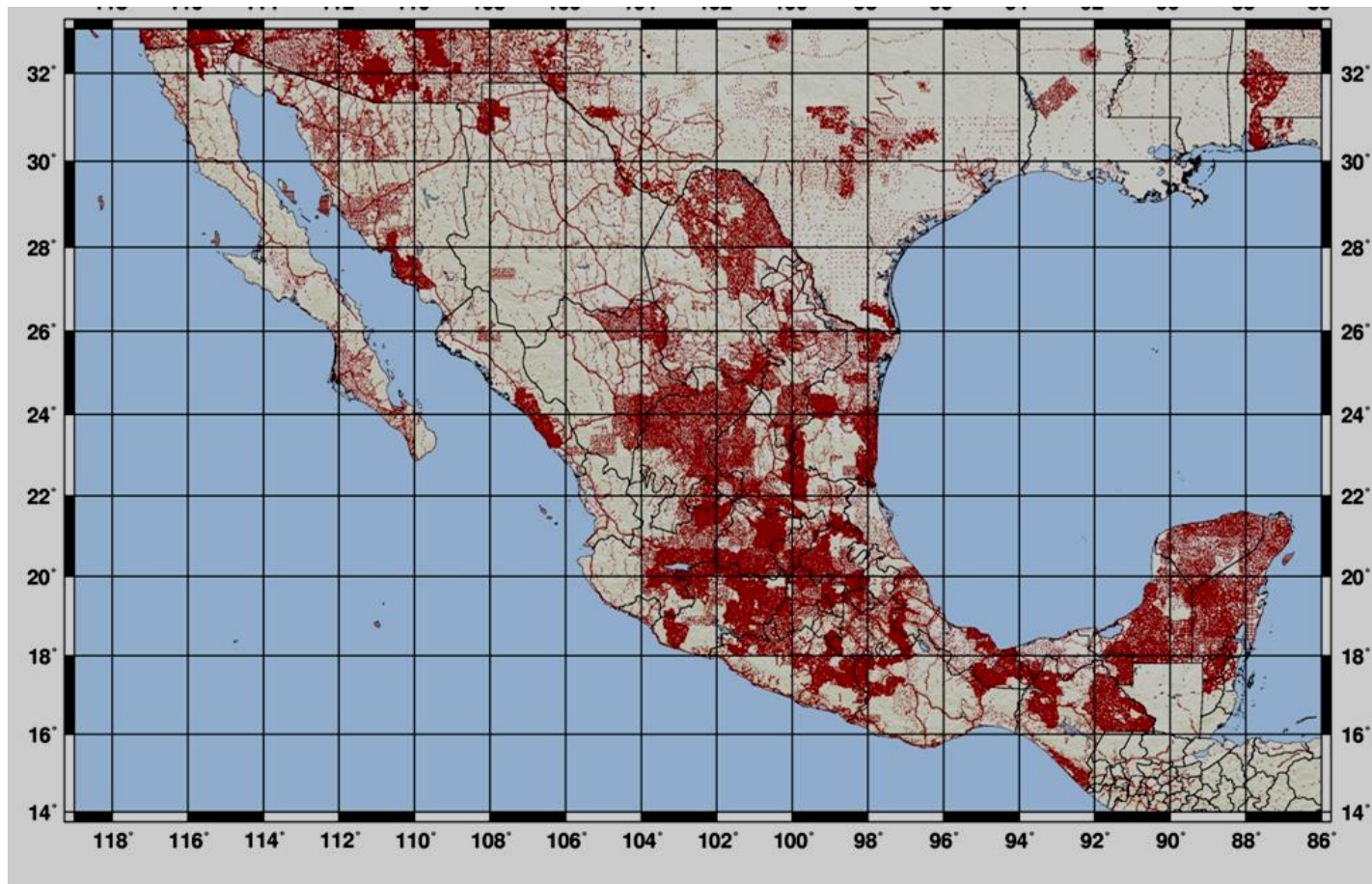


Geoid Solution

- Last geoid solution (GGM06) used three terrain gravity sources:
 - INEGI
 - DMA (1993)
 - PEMEX (1987)
 - Sea anomalies: derived from altimetry T/P

Geoid Solution

- Input coverage for GGM06



Geoid Solution

Weaknesses detected

- Extended data voids and lack of offshore data buffer prevent an exact determination of geoidal heights.
- Regional disagreement among gravity sources can be high (10 and 20 mGal).
- Geoid accuracy has been regionally affected in dm level by some biases in gravity anomaly.
- Offshore accuracy has not been determined.

Geoid Solution

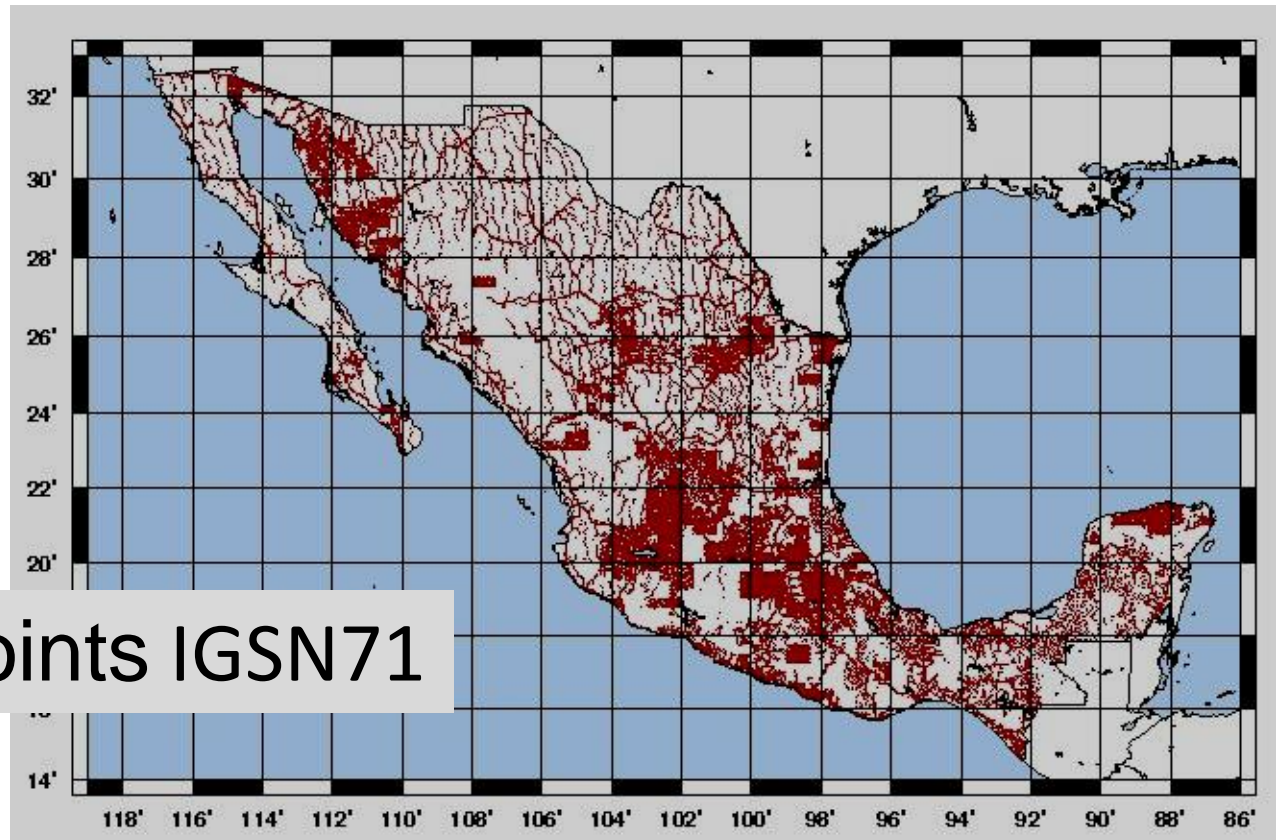
- Perspective:
 - Strategy for improving accuracy
 - Analysis of input gravity
 - Removal of biases medium/long wavelength
 - Insertion of recent GRACE-derived g anomalies
 - Implementation of most recent software version (SHGeo, UNB)
 - For next solution:
 - Sought < 10 cm absolute accuracy point by point
 - Assessment by improved GNSS/BM

Contents

- Current geoid solution: GGM06
- **Gravimetric network,
current state and perspective.**
- Heights and its Variations
 - Re-construction
of the geodetic vertical control network.
 - Magnitude of vertical movements detected.

Gravimetric Network

- Gravity surveys continue to densify homogeneously throughout the country.



62,065 points IGSN71

Gravimetric Network

- Current densification criteria:
 - 1 point per 2.5'x2.5' cell
 - all benchmarks observed

ongoing

Gravimetric Network

- Weaknesses detected
 - Offshore-buffer gravity values missing!
 - Regional and general accuracy is unknown!
 - Absolute g reference missing!
 - Calibration line for gravimeters missing!

Gravimetric Network

- Solutions for near future
 - Diagnosis of INEGI's base network:
 - study robustness of the current base network,
 - design of reinforcement links,
 - evaluate a simultaneous adjustment.
 - Obtain new absolute g observations for:
 - assessment of network consistency,
 - detecting regional biases,
 - establishment of one calibration line,
 - regular monitoring of time variations.
 - Possible redefinition of g values for the whole net
(if significant distortions were detected).

Gravimetric Network

- Not implemented yet:
 - Airborne gravimetry
 - Shipborne gravimetry
 - Absolute g

Contents

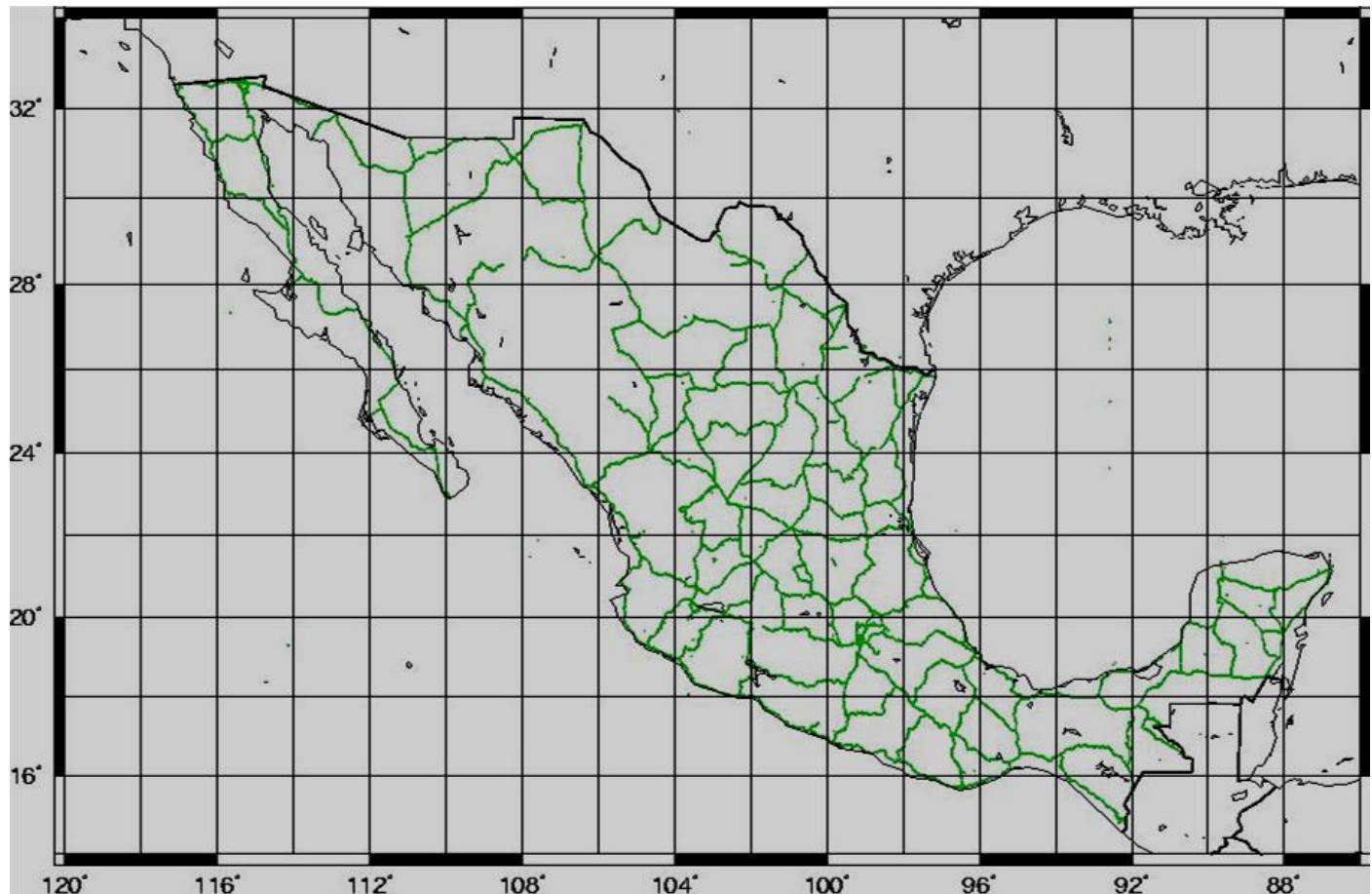
- Current geoid solution: GGM06
- Gravimetric network,
current state and perspective.
- **Heights and its Variations**
 - **Re-construction
of the geodetic vertical control network.**
 - Magnitude of vertical movements detected.

Vertical Control Network

- Datum adopted: NAVD88
- First order network is built in stages:
 - Older network:
 - surveys 1949 – 2002
 - analog devices
 - Recent observations (re-construction)
 - surveys 2002 – to date.
 - electronic devices

Vertical Control Network

Accumulated levelling 1949 – 2002



Vertical Control Network

Recent levelling, 2002 to date



30,000 km
25,000 benchmarks

Vertical Control Network

Benchmarks re-observed:



Re-levelling helps
monitoring vertical deformations.

Vertical Control Network

Weaknesses detected:

- No rigorous modelling of some systematic errors has been applied to the network (field data is insufficient for this),
- Most of older benchmarks are destroyed.
- Reference NAVD88 heights are uncertain due to time variations.

Vertical Control Network

EXPECTATIONS:

- To complete the construction of a recent network within next few years,
- To organize re-observed level differences,
- To estimate time-variations in level differences along the country.

Contents

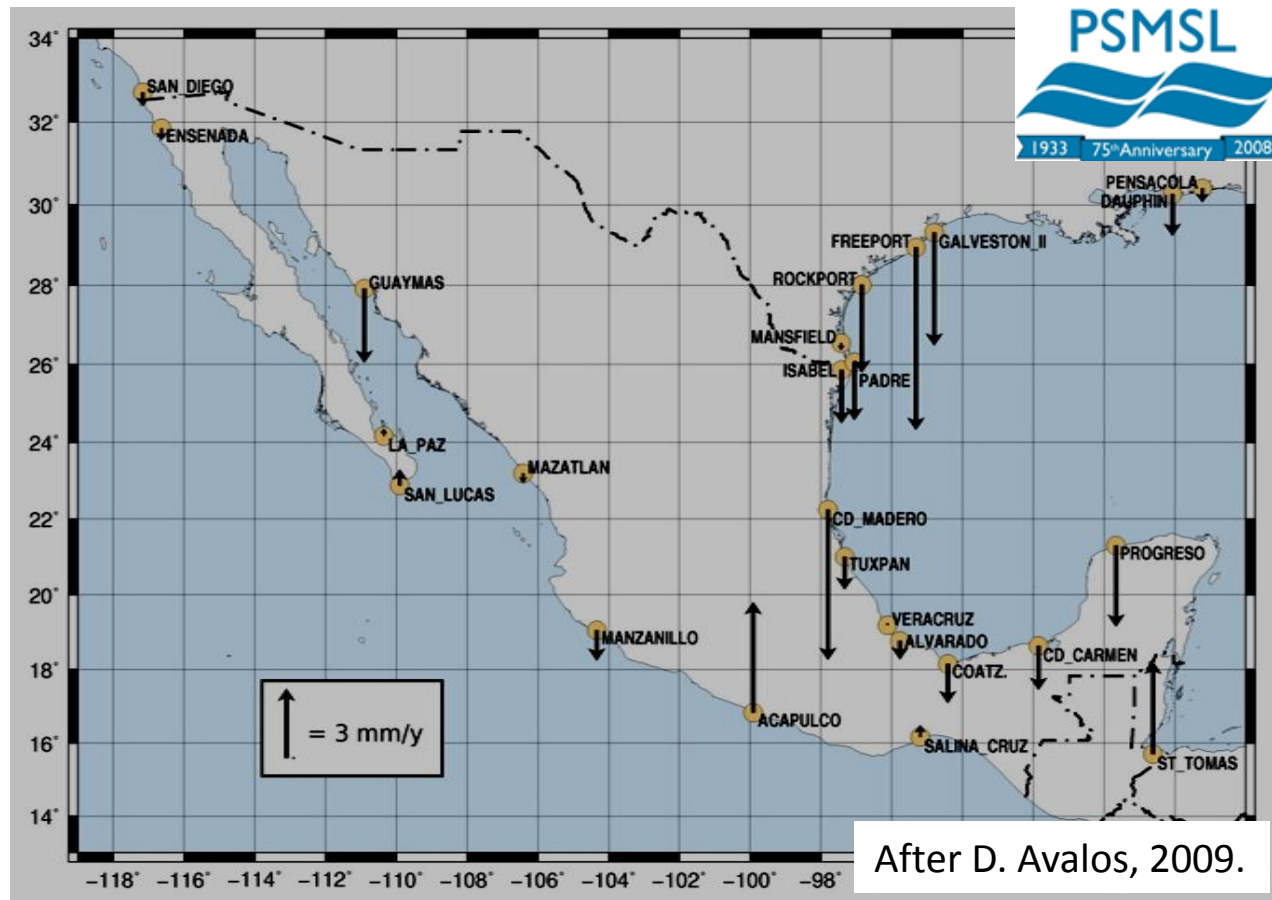
- Current geoid solution: GGM06
- Gravimetric network, current state and perspective.
- **Heights and its Variations**
 - Re-construction of the geodetic vertical control network.
 - **Magnitude of vertical movements detected.**

Recent Vertical Movements

- Mexico is mostly built on deformation areas.
- Current vertical displacements are studied.
- Existing estimates come from:
 - MSL tracking,
 - GPS time-series,
 - Re-levelling.

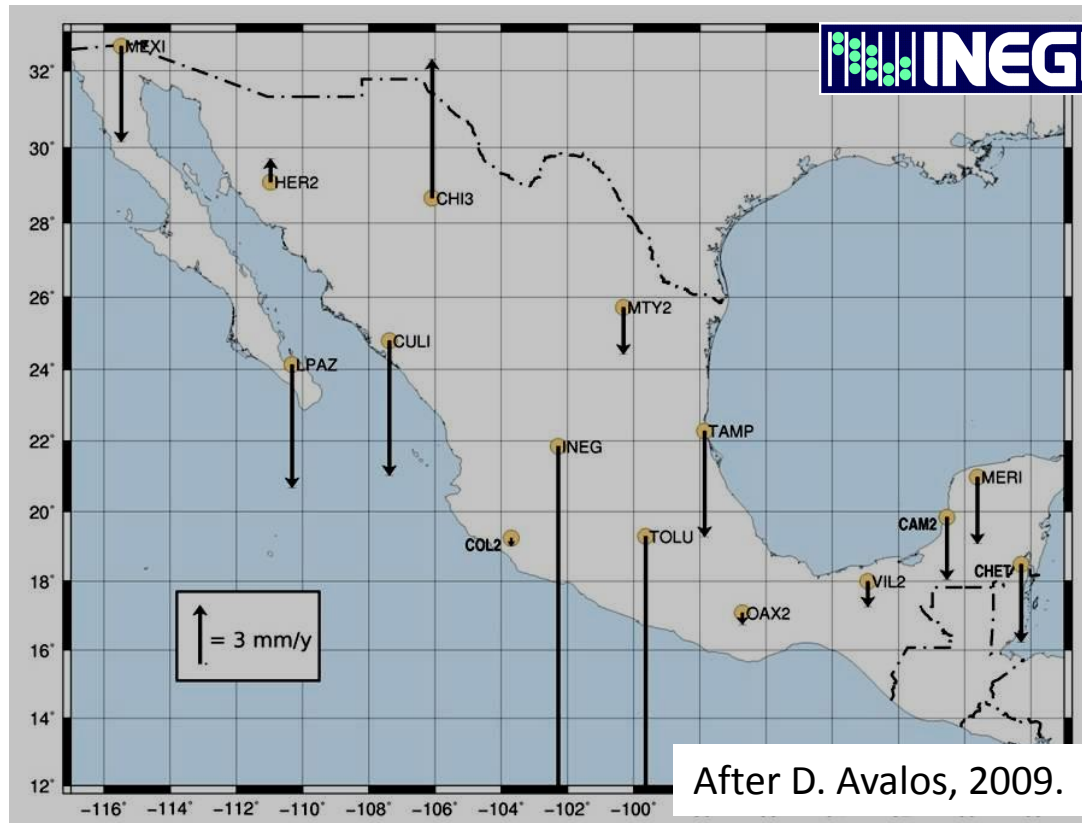
Recent Vertical Movements

- Point velocity from MSL records:



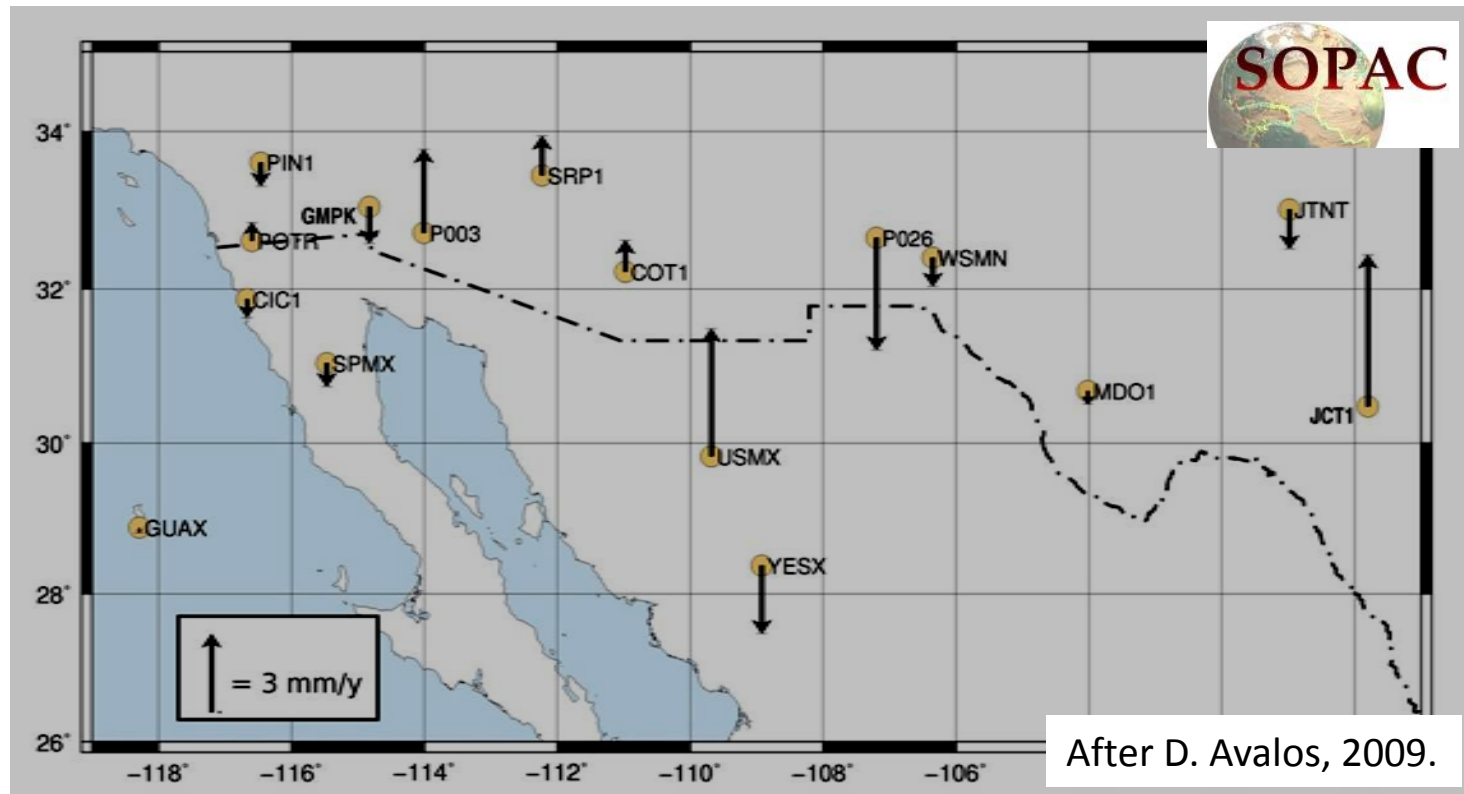
Recent Vertical Movements

- Point velocity from GPS time-series:
Network: INEGI-RGNA



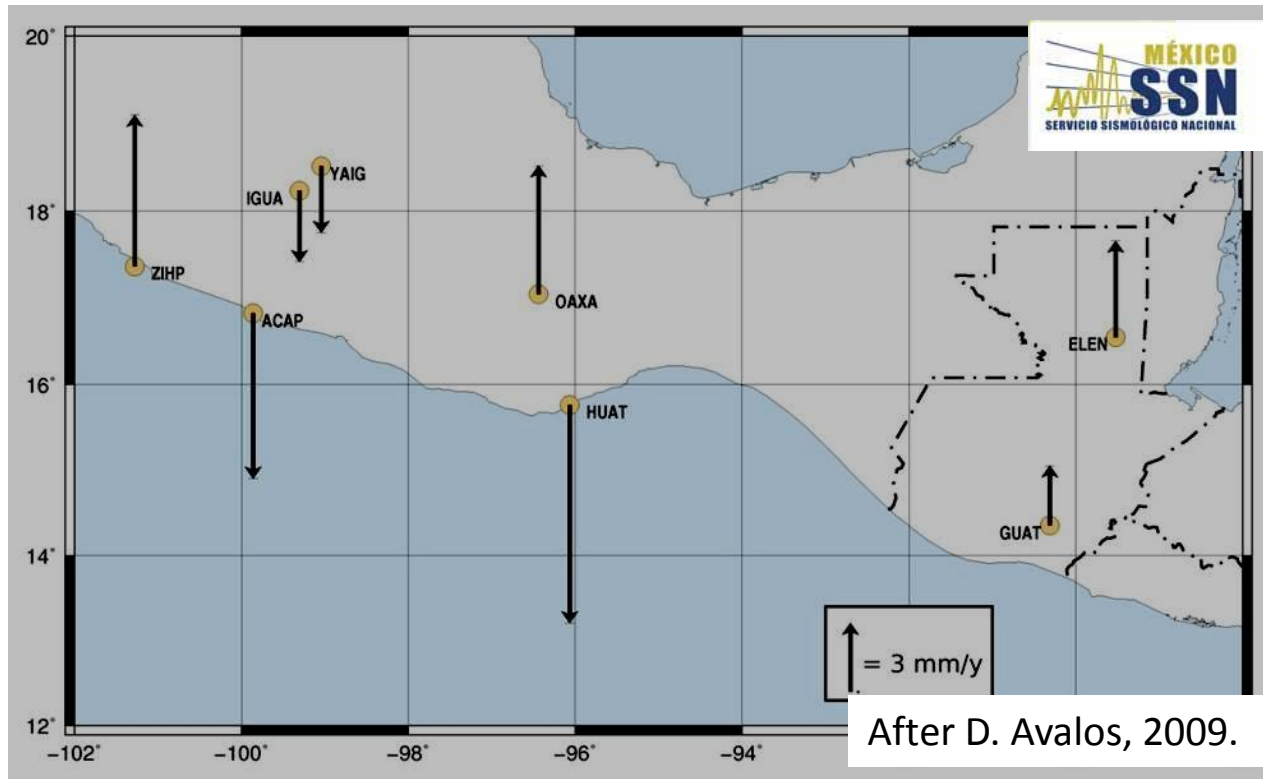
Recent Vertical Movements

- Point velocity from GPS time-series:
Network: SOPAC



Recent Vertical Movements

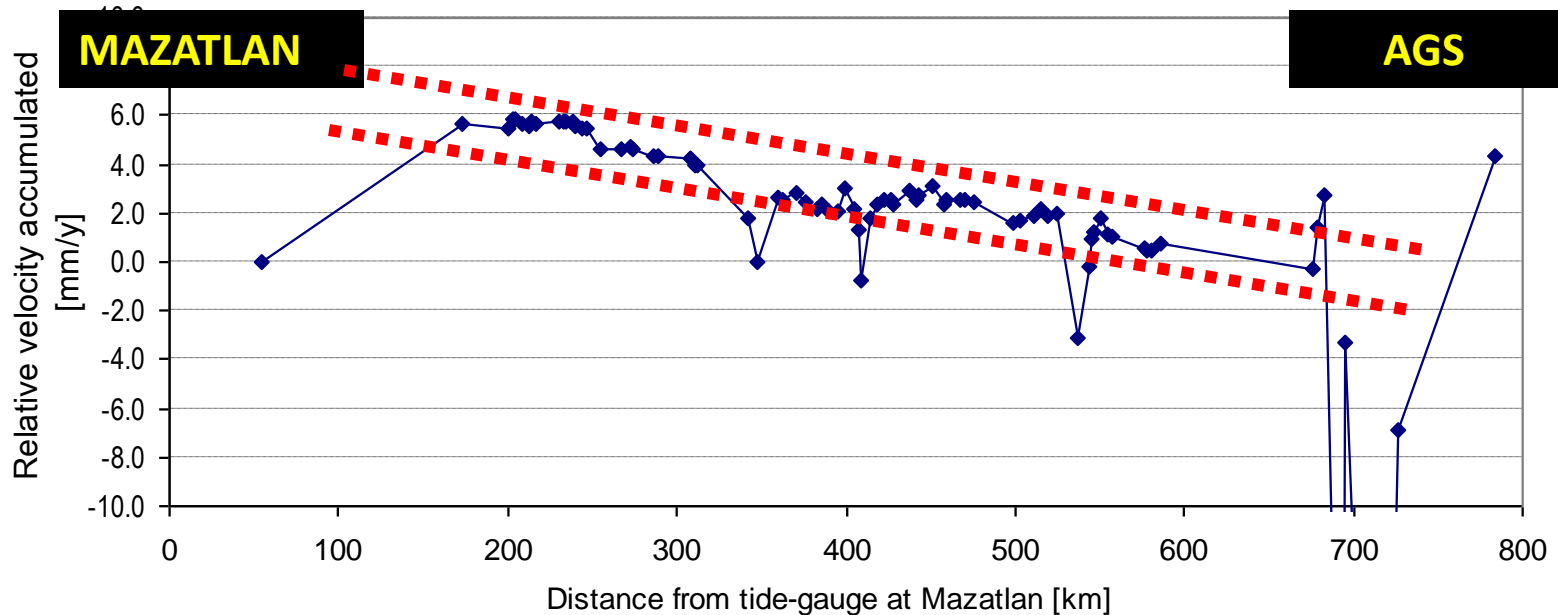
- Point velocity from GPS time-series:
Network: UNAM-SSN



Recent Vertical Movements

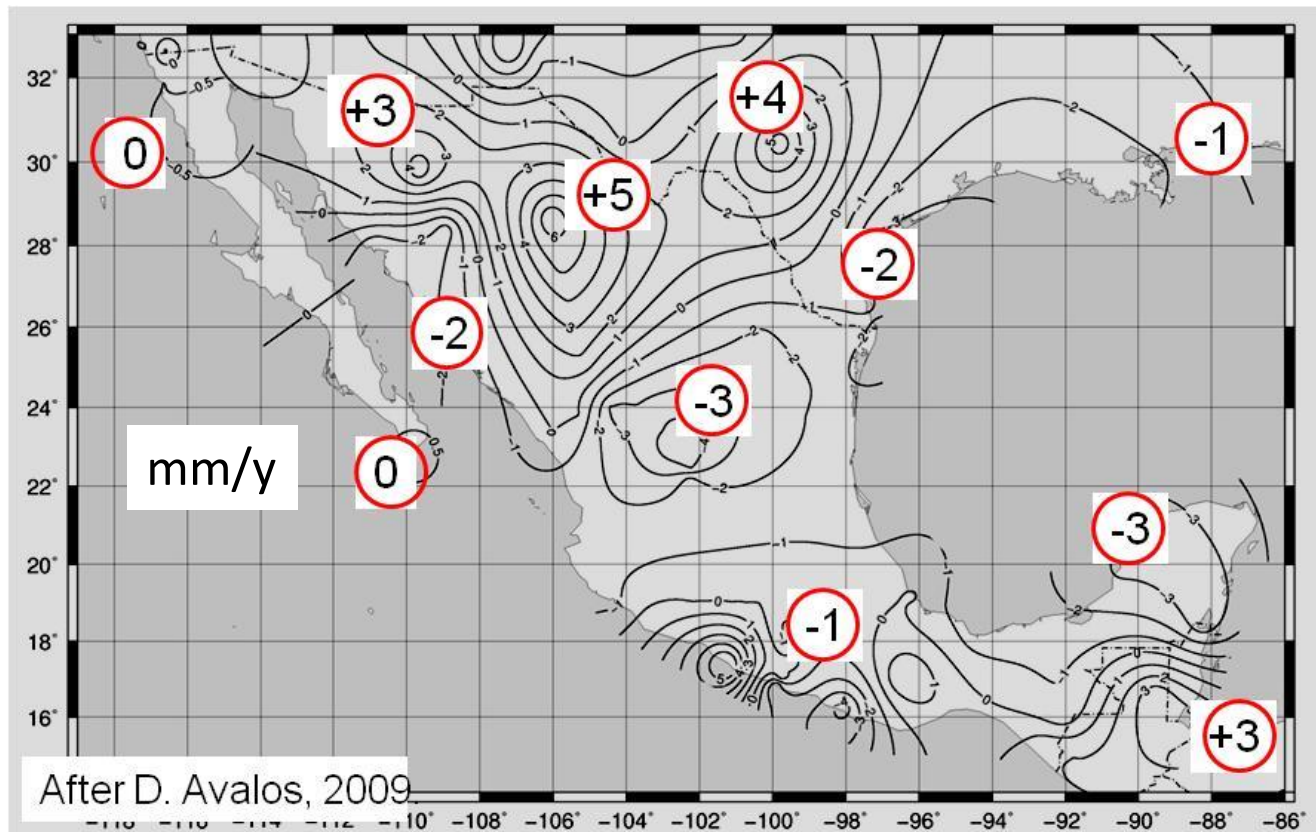
– Relative velocity from re-levelling

Detection of General Trends per Profile
And unstable monitoring Sites



Recent Vertical Movements

- Vertical Crustal Movements, Preliminary map:
 - (excluding variations of local extent)



Recent Vertical Movements

IMPLICATIONS:

- Current displacements are significant and should be accounted for in height determination,
- Geoidal heights from GNSS/leveling could be significantly improved considering local vertical motions to achieve epoch consistency,
- Actual VCM (medium wavelength features) seems to have potential to change the geoid at 1cm level only after accumulating 20 years of motion.

Recent Vertical Movements

IMPLICATIONS:

- Point velocities can be highly deceiving for detecting VCM in Mexico,
- Re-leveling is potentially best (mitigation of systematic errors needs attention).

Remarks

- Ongoing studies aim to improve the input for geoid computation.
- An effort in monitoring time-variations for geodetic quantities is giving preliminary results.
- Rates of Geoid change might be obtained in the future as an implication of changes in heights and gravity field.