# Breakout Session 1: Forward modeling of tectonic and hydrological signals

- We should go beyond assuming hydrological signal as simple sinusoidal seasonal cycles and tectonic (or GIA) signals as linear secular trends.

- The typical approach is to work with residuals (tectonics = observations – hydrology, or hydrology = observations –tectonics) sometimes without fully understanding the modeling (of hydrology or tectonics).
  - understanding the impact of hydrologic loading on stress or strain rate fields.
  - simultaneous inversion of tectonics & hydrology using (simple) physical models.
  - Other analysis techniques (PCA, etc.) to isolate spatially coherent signals.

# Suitability of hydrological observations

- Access to borehole/well water level measurements.
  - Need of knowledge of water pumping history and detailed stratigraphy.
- In addition to soil moisture/snow models, modeling of man-induced loading contributions (reservoirs, pumping, irrigation, etc.).
- Taking advantage of other kind of measurements:
  - Plate Boundary Observatory (PBO) pore pressure sensor as a proxy for groundwater level.
  - River, lake, reservoir gauge measurements (water level gauges, altimetry, etc.).

# Suitability of hydrological observations

- Other geodetic observations (“borehole geodesy”):
  - Extensiometers, strainmeters, tiltmeters used for monitoring water pumping.
  - Taking advantage of “new” directional/horizontal drilling linked to gas/oil extraction (intensive use of water); possibility of monitoring & collaboration.
- Taking advantage of industry collaboration.
- Legal framework for capturing water well data.
- Possibility to install GPS receivers on deep casing wells to isolate “surface” groundwater related subsidence/uplift (ex. New Orleans).

# Estimation of hydrological loading

- Separation of global and local hydrology:
  - Large scale effects can be modeled using global hydrology models (GLDAS, etc.).
  - Remaining contribution is due to local hydrology (strongest part for ground gravity measurements); can be modeled using simple models using only precipitation (from ground rain gauges or satellite derived estimates), or using borehole water level measurements.
- Longer records are needed to separate tectonics from hydrology which contains long term variations linked to climate variability (El Nino, global climate changes, etc.)

# Estimation of tectonics

- Geodetic observations (GPS, gravity, etc.) should be compared/validated with cumulative slip rates determined from geological observations.
- Considering different rheology models, not just elasticity & Maxwell visco-elasticity (transient deformation, Burger rheology, etc.).
- Providing separate products for long-term geologic deformation/ motion vs short-term present day tectonic motion.
- Needs of accurate models for seismic cycle.
- Developing and using regional scale hydrology models to relate basin/catchment scales and regional tectonic deformation (particularly important for the vertical component).