ANALYSIS OF ERROR SOURCES IN MULTI-GNSS GEODETIC PRECISE POSITIONING

Contribution of the Galileo system

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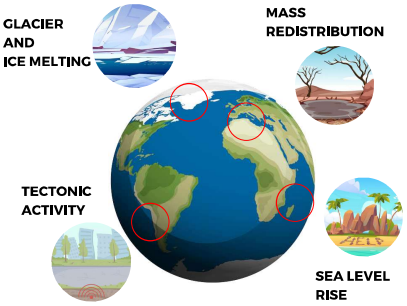
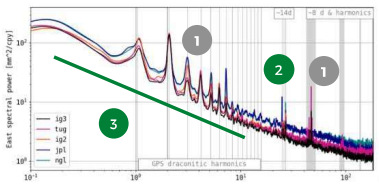
MOTIVATION & RESEARCH AIMS

Geophysics, seismology, atmospheric science, hydrology, and natural hazard research have all benefited from GPS geodesy to track changes on the Earth's surface. **The need to find millimeter-to-submillimeter level ground displacement signals is growing.**



However, **systematic errors** are present in the time series of GPS-derived positions.



Cumulated spectra of the East coordinates
Presentation P. Rebischung - Tour de l'IGS #1 : REPRO3

1. Signals at low frequencies associated with **GNSS characteristic periods**

2. **Fortnightly signals due to the propagation of sub-diurnal errors (Penna et al., 2007, Stewart et al., 2005)**

   Explanatory mechanisms
   - orbit mismodeling
   - **aliasing of station-specific position biases influenced by satellite geometry**

   Possible causes
   - **ocean tides loading**
   - multi-path
   - antenna bias
   - EOP models

3. **Background power-law noise, inversely proportional to the (frequency)^κ**

   Geodetic implications
   - realistic parameter (velocities, ...) uncertainties (Mao et al, 1999; Santamaria et al, 2011).

   Possible causes
   - surface loading?
   - **orbit-induced long-term errors**

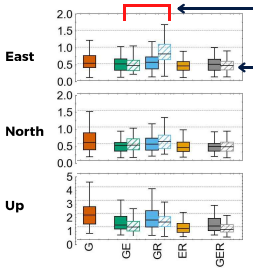
How can a multi-GNSS approach with GALILEO identify and understand the systematic errors in GNSS precise positioning?

VALIDATION AND ASSESSMENT OF OCEAN TIDE LOADING (OTL) ERRORS

A NOVEL ESTIMATION STRATEGY TO REDUCE FORMAL UNCERTAINTIES AND SEPARATE OTL ERRORS FROM OTHERS.

	KINEMATIC ESTIMATION	STATIC ESTIMATION
	A posteriori estimation by spectral analysis of the sub-daily positions	Simultaneous estimation of OTL empirical params and positions
	Simple (software, data processing)	Decorrelated errors by stacked NEQ Reduced uncertainty
	Sensitive to position and estimation noise (receiver clock, propagation, orbit)	Software changes At least 1 year of data

TOWARD A MULTI-GNSS ESTIMATION: HOW TO HANDLE GPS-SPECIFIC ERRORS OF K1/K2 TIDES



Residual OTL amplitude for K1 (mm)

- Only Galileo can observe the East components
- Down-weighting of GPS for K1/K2 tides

Optimal weighting per tide, per constellation

K1 and K2 frequencies sensitive to GPS specific errors because of the orbital and constellation repeat period.

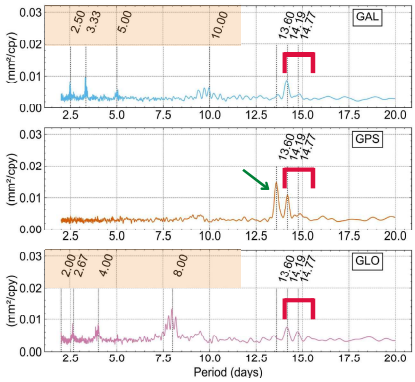
DIFFERENT CONSTELLATION-SPECIFIC SIGNALS APPEAR UP TO THE 14-DAY BAND CORRECTED BY THE EMPIRICAL OTL PARAMETERS.

13.60 days: specific to GPS

14.19 days: common to GPS, Galileo & GLONASS

Galileo/GLONASS orbital errors

+ OTL errors contribute to spectral band > 50 days for GPS



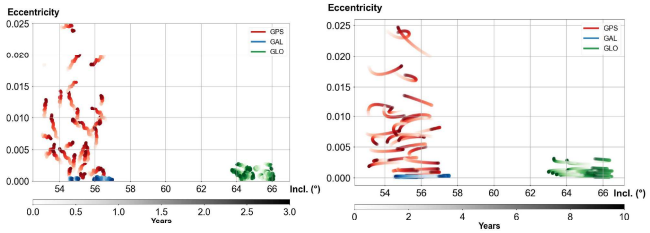
Stacked spectra of the differences of UP coordinates with nominal and adjusted OTL model

Possible mitigation of aliased signals
- Reduction of 14-day signals due to OTL mismodeling
- To some extent reduction at the GPS draconitic harmonics.

INVESTIGATING INTERANNUAL ORBITAL INSTABILITY TO UNDERSTAND POWERLAW NOISE

GPS SATELLITE ORBITS ARE MORE SUSCEPTIBLE TO INTERANNUAL INSTABILITY THAN GALILEO OR GLONASS SATELLITE DYNAMICS DUE TO COMPLEX DYNAMICAL RESONANCES.

WITH REAL DATA | **WITH SIMULATED DATA**

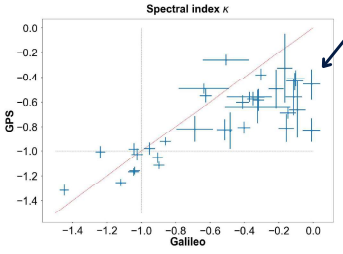


Plan (inclination, eccentricity)

CAUSES OF ORBITAL RESONANCES

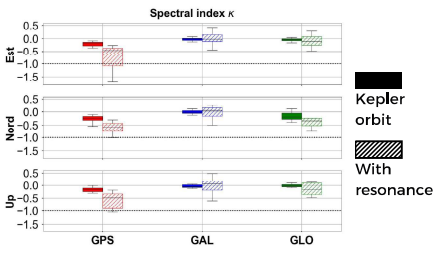
Third-body perturbation	→	Luni-solar resonance
Geopotential term (J32, J44)	→	Deep 2:1 resonance
Constellation design	→	Different sensibility

POWER-LAW PROCESSES SEEM SPECIFIC TO GPS-DERIVED POSITIONS WHILE USING OTHER CONSTELLATIONS, POSITIONS ARE BETTER CHARACTERIZED BY WHITE NOISE.



GAL-derived positions have a whiter noise than GPS-derived positions.

WITH REAL DATA



WITH SIMULATED DATA

CONCLUSIONS & PERSPECTIVES

- **Benefits of multi-GNSS approach:** Galileo, BeiDou
- **And many other sources of errors to investigate:** non-tidal loading, multipath, antenna, orbital modeling