Twangs: Model Parameters, Spatial Correlations and Possible Causes – a Summary

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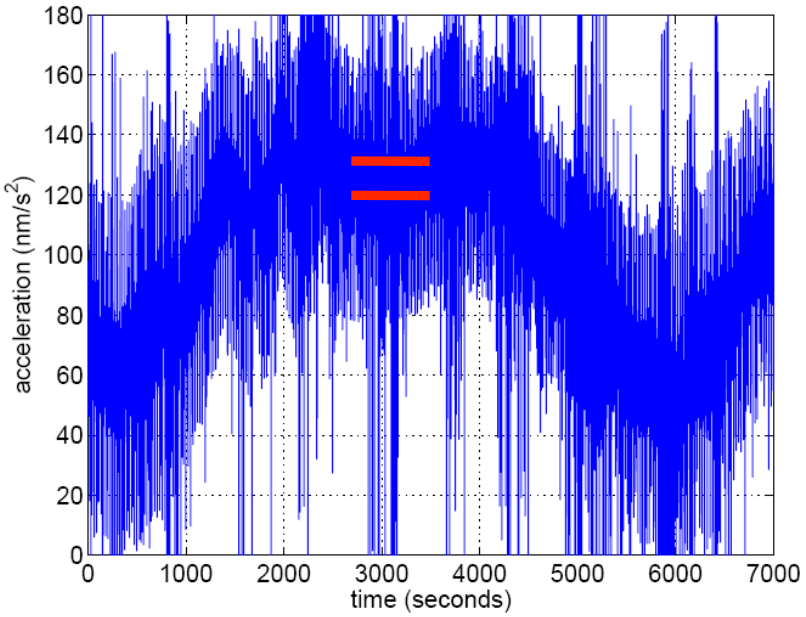
Motivation

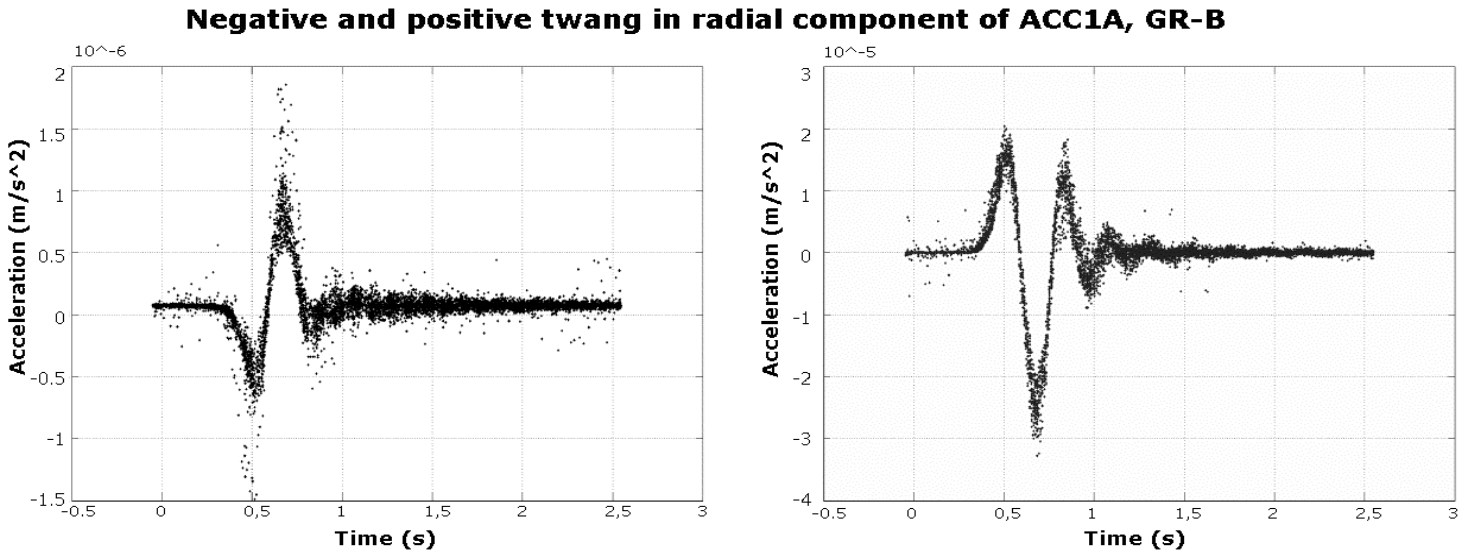
- Accelerometer data reveals more noise than expected
  - Analysis of 10 Hz 1A Accelerometer data (ACC1A)
  - Some sources of spikes could be identified:
    - Heater switching events
    - Magneto Torquer current changes



Level 1a data, along track axis, 10 Hz sampling, 3 Hz low-pass filter

Twangs

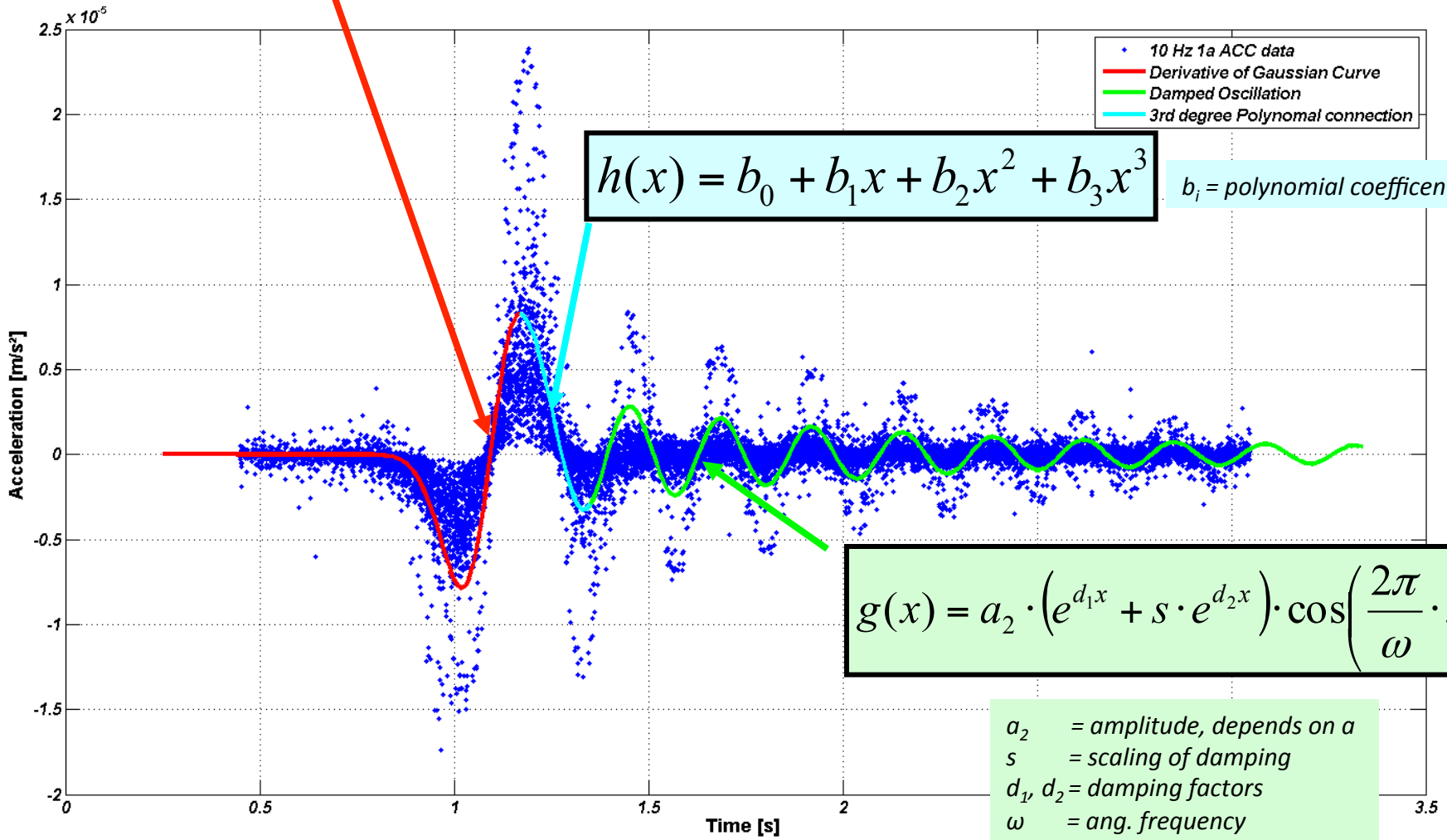
- The biggest spikes found (radial component)
  - Occur simultaneously in all axes of ACC
  - GRACE A data has significantly more twangs than GRACE B data
- Twangs may vary slightly in shape, period and amplitude, however we believe there is only two 'types' of twangs
  - Period/ duration of first two peaks is the same for all types across all axes, oscillation may occur for radial component
  - Makes is possible to superimpose accelerometer data via crosscorrelation with a model of a twang



Twangs

$$f(x) = \left(-\frac{a}{\sigma^3}(x-\mu)\cdot e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \right) \cdot \zeta(t)$$

a = amplitude
σ = width
μ = center (time)
$\zeta(t)$ = asymmetry factor



$$h(x) = b_0 + b_1 x + b_2 x^2 + b_3 x^3$$

b_i = polynomial coefficents

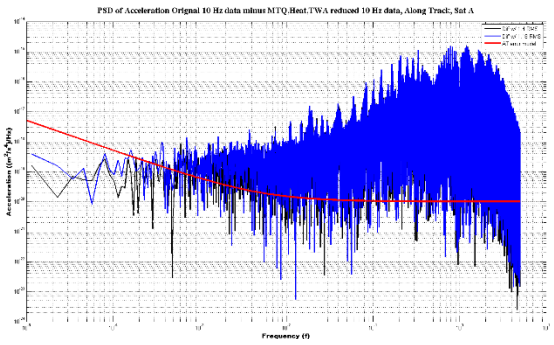
$$g(x) = a_2 \cdot \left(e^{d_1 x} + s \cdot e^{d_2 x} \right) \cdot \cos\left(\frac{2\pi}{\omega} \cdot x \right)$$

a_2 = amplitude, depends on a
s = scaling of damping
d_1, d_2 = damping factors
ω = ang. frequency

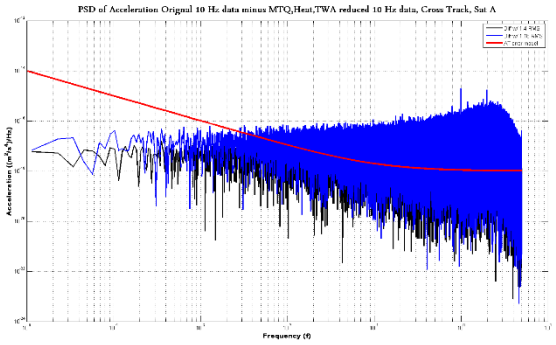
Reductions

- Torquer, Heater and Twang reduced ACC Data PSDs
  - According to ACC1A: impact possible

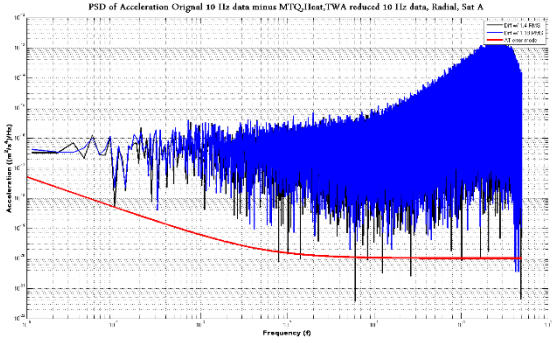
Along Track

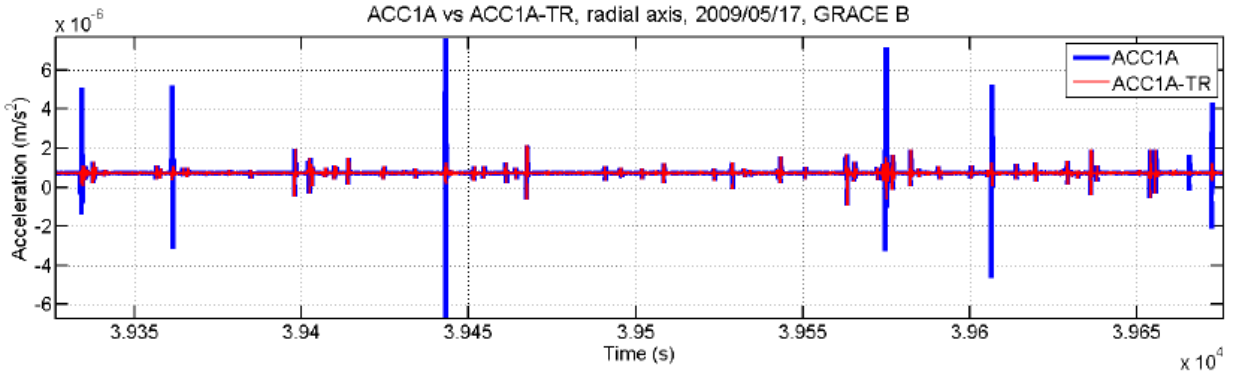


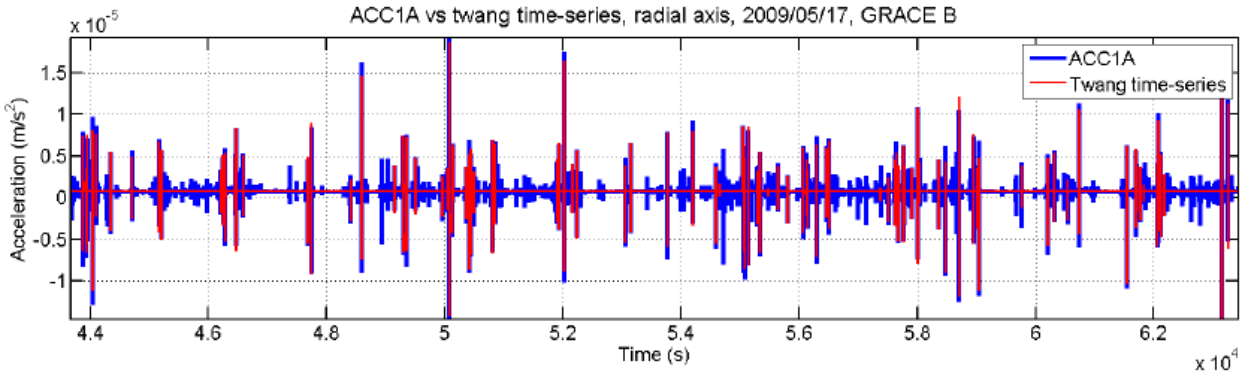
Cross Track



Radial



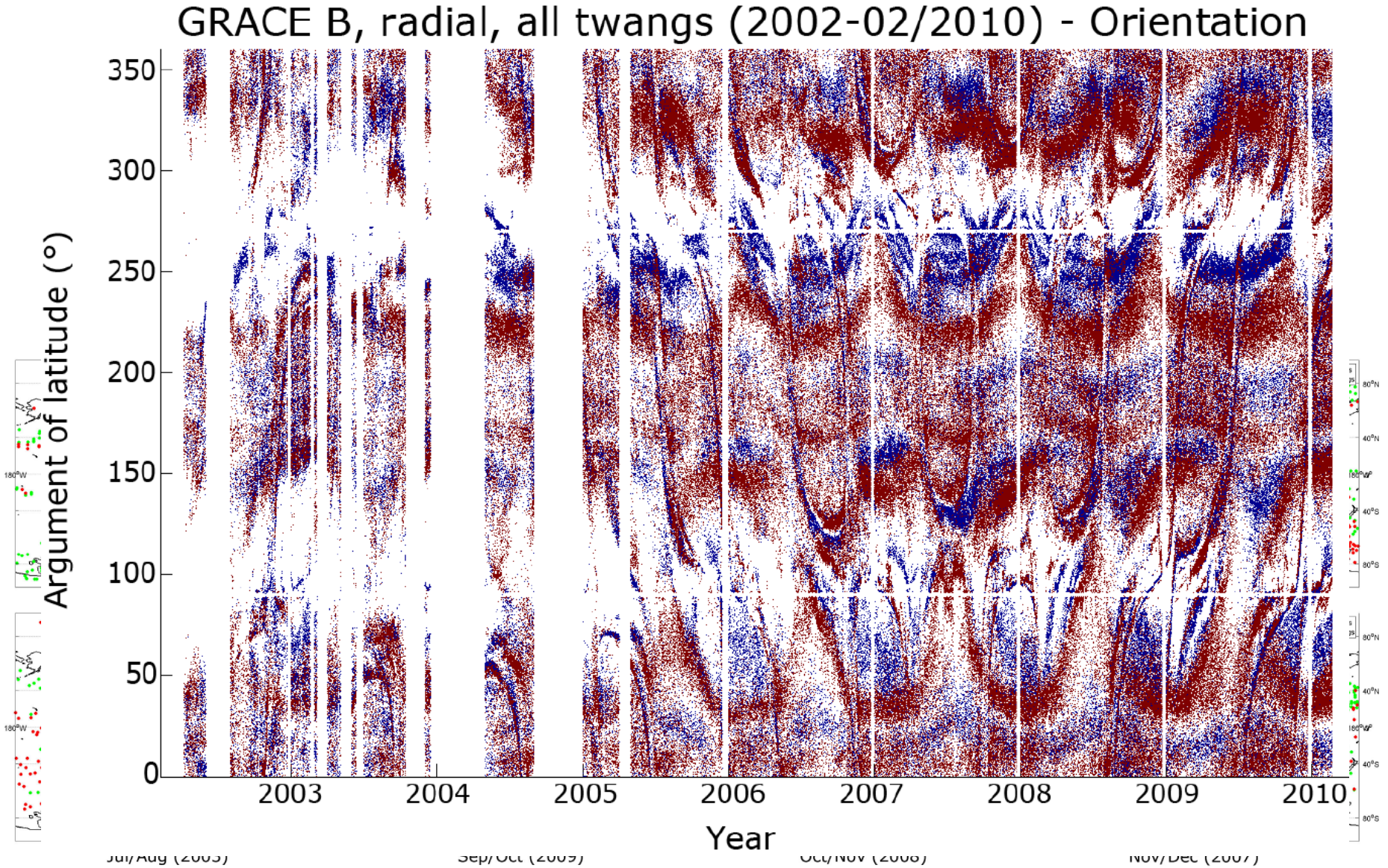




•Physical model of twang constructed which can be adjusted to any twang in ACC data with a 95% likelihood.

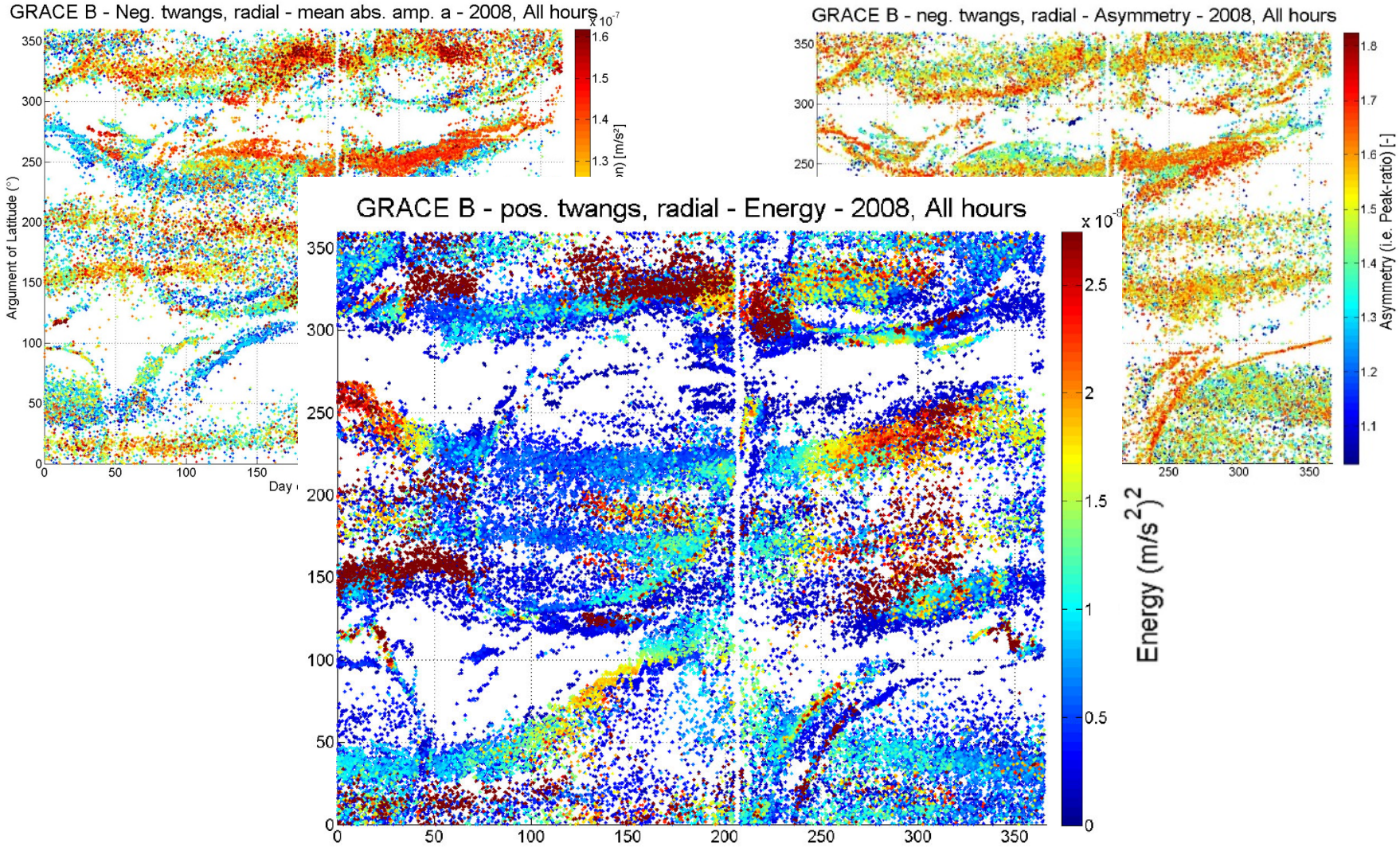
Geographical Distribution

- Strict geographical correlation



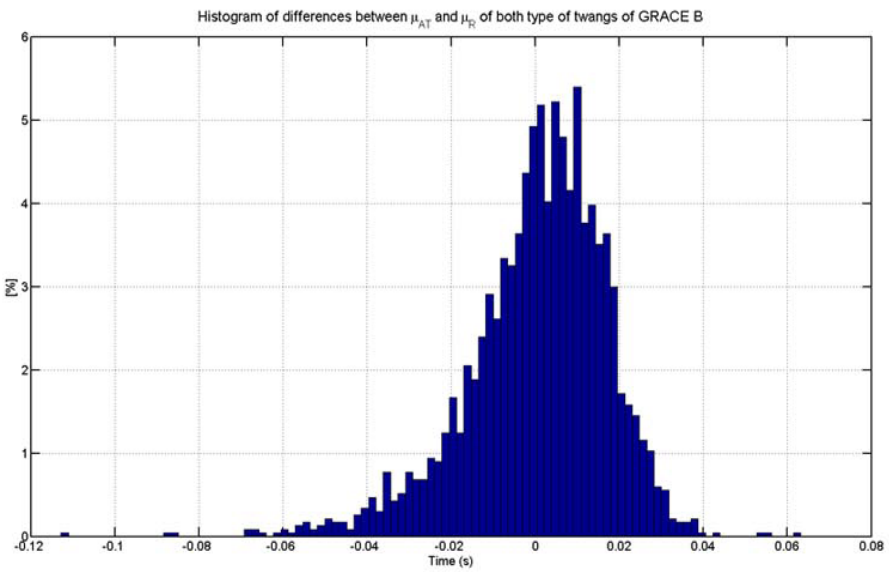
Geographical Distribution

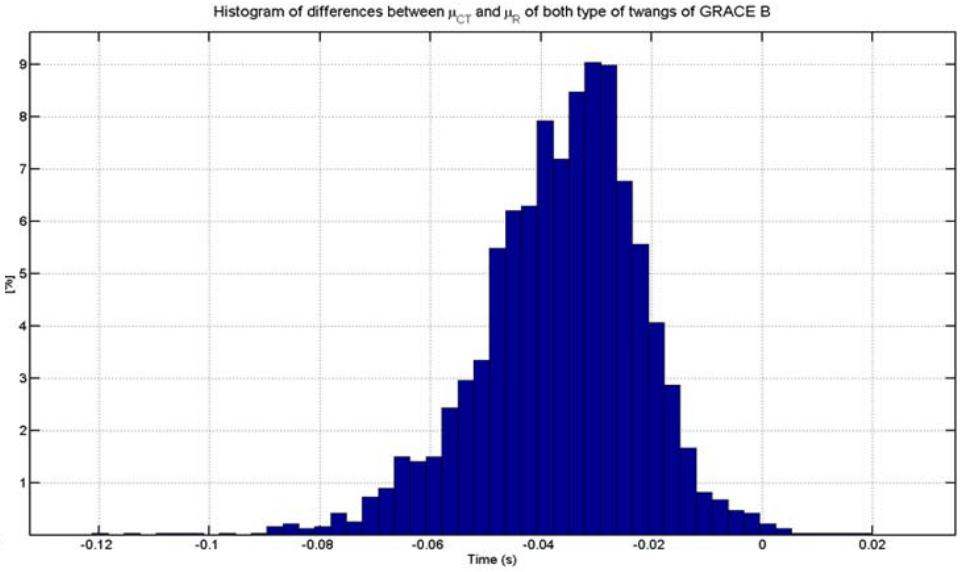
- Strict geographical correlation of Model parameters



Axes behavior

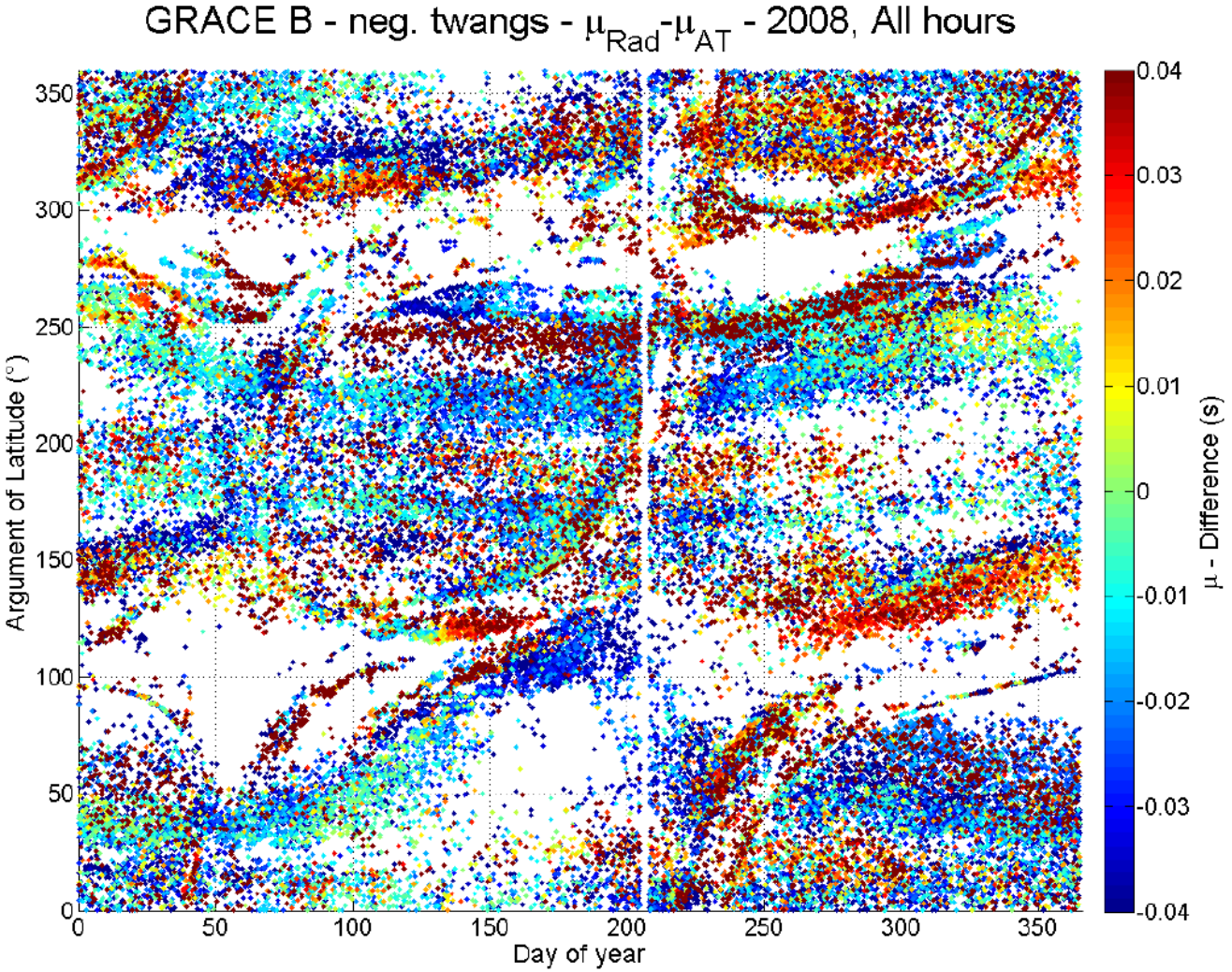
- Inconsistent time occurrence in the axes
  - Offsets = Difference of μ in model parameter
  - Appears to be evenly distributed and usually smaller than |0.06 s|





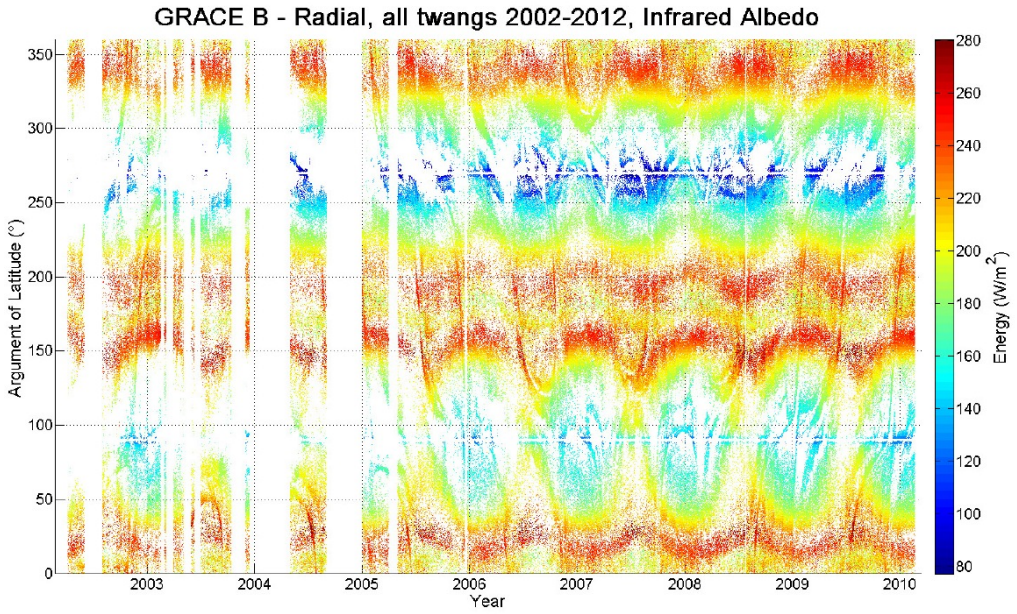
Axes behavior

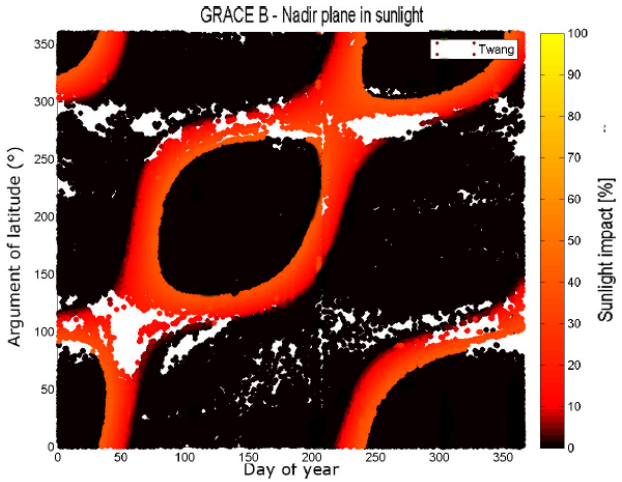
- Inconsistent time occurrence in the axes – Geographically correlated

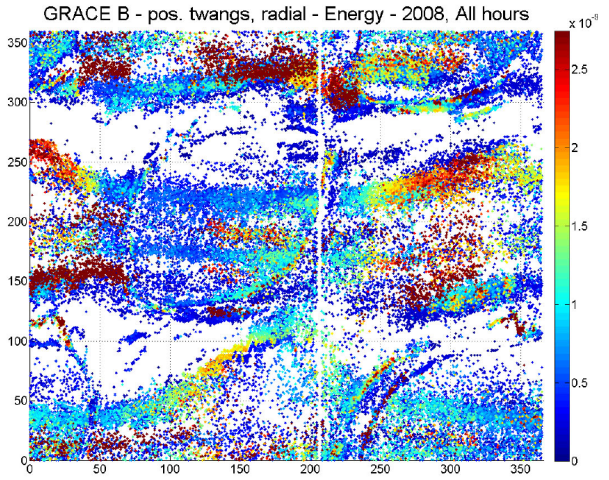


Correlations and Hypotheses

- Correlations to solar and terrestrial radiation
  - Especially visible when nadir surface is sunlit
  - Terrestrial IR-Emission clearly visible
  - Also some Albedo correlations could be found

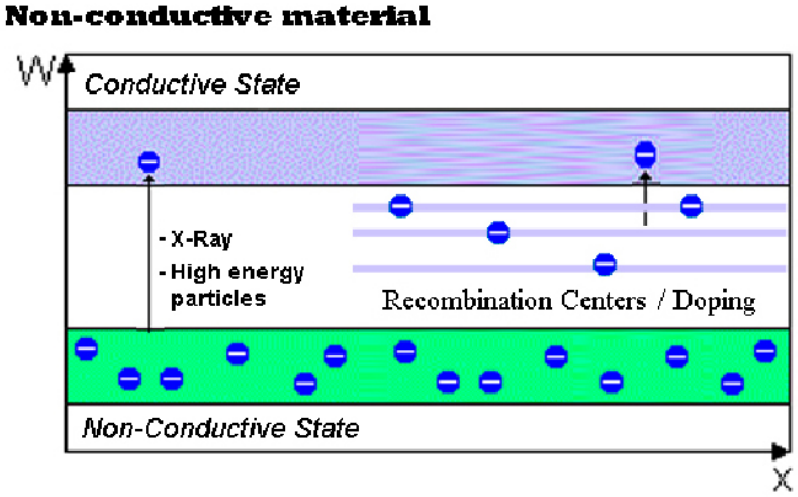






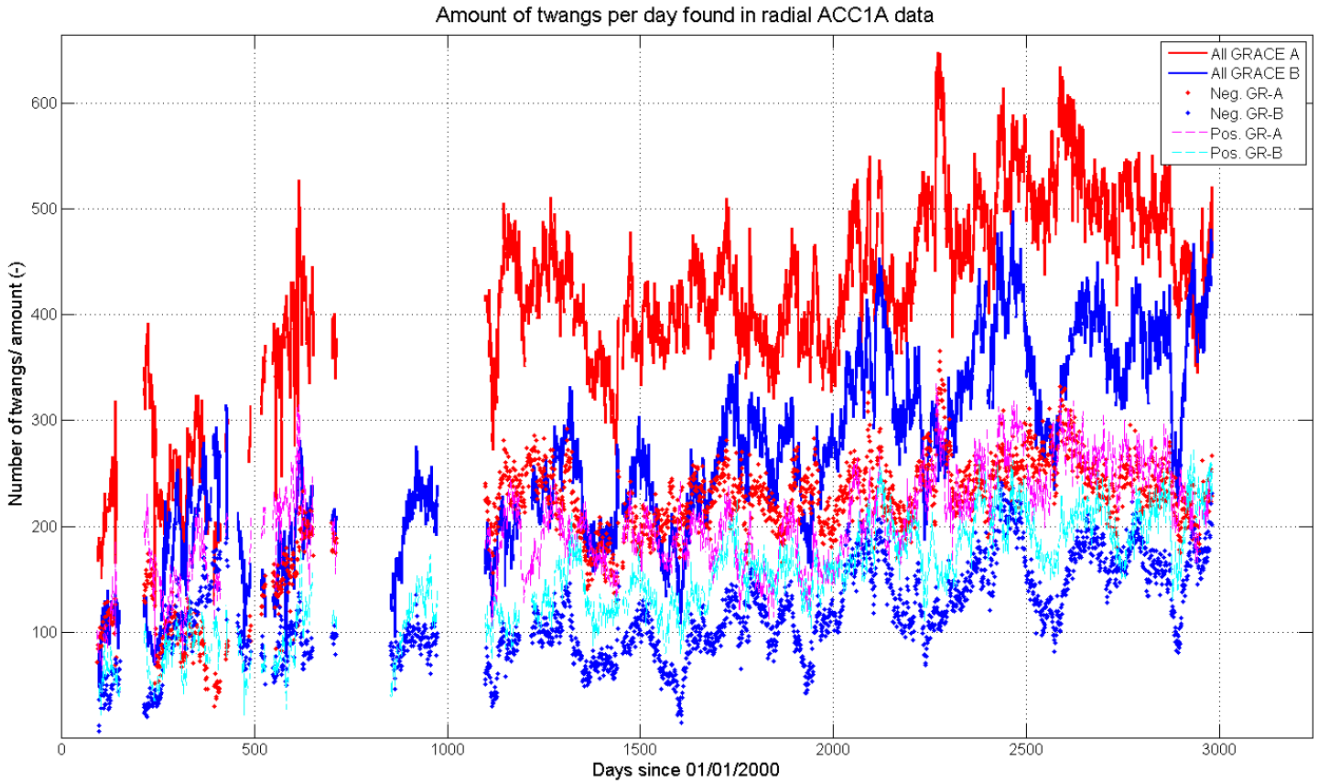
Correlations and Hypotheses

- Hypothesis:
  - Twangs are electrical discharging of a charged s/c surface
  - Discharge event couples into the accoleremeter
- Charges occur due to plasma, high energy electrons, solar radiation..
- High energy electrons in LEO only in polar regions, possibly harmful to insulating material
- Solar impact can decrease negative charge or lead to increased temporary conductivity of material
  - Less energetic twangs in nadir sunlit phase



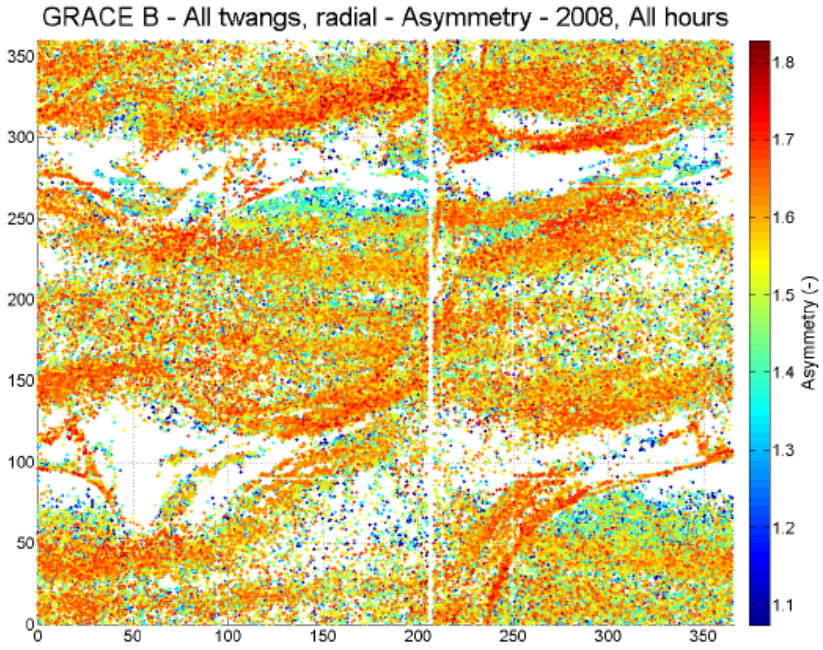
Correlations and Hypotheses

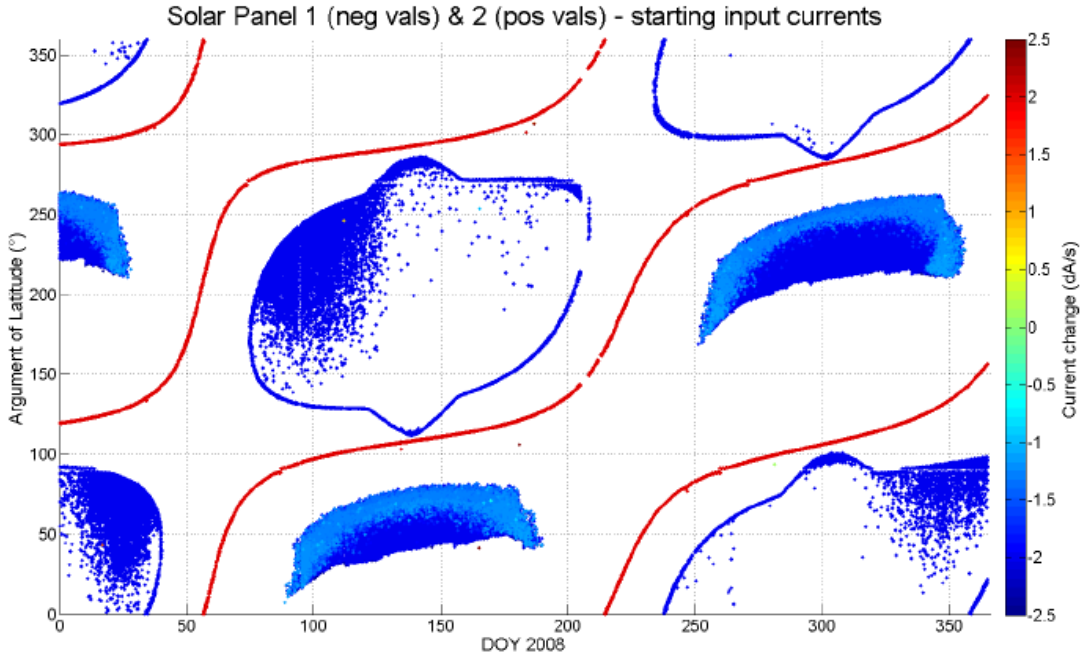
- Aging effect of material visible?
  - In the beginning roughly 100-200 twangs per type per day
  - Now > 500 twangs per day and slightly lower amplitude
    - More conductive material, less potential, more discharging events



Correlations and Hypotheses

- Not all can be explained with discharging:
  - Possible impact due to starting input current of solar arrays
  - Narrow bands are approximate input current start events





Conclusion & Outlook

- Twangs can be successfully modeled
  - PSD reveal a possible mapping into the gravity field
- Many geogprahically correlations found
- Twangs can be explained by means of discharging events
  - Or solar array input current
- Twangs could reveal an aging effect of the insulating material onboard of GRACE

- Level 1B data should be computed in order to estimate a possible impact onto the gravity field
- The hypothesis should be further tested
- Coupling into accelerometer not yet understood
- As satellite based gravity field missions get more precise:
  - Signals within ACC-data may be a key to obtain more accurate results