Momentum Transfer Events in LRI Data:
# Detection and Analysis

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Momentum Transfer Events in GRACE-FO

- MTEs: Events that show changes in range rate in LRI and similar disturbance in ACC.

- They are sporadic and sudden changes in momentum (around 3 seconds long).

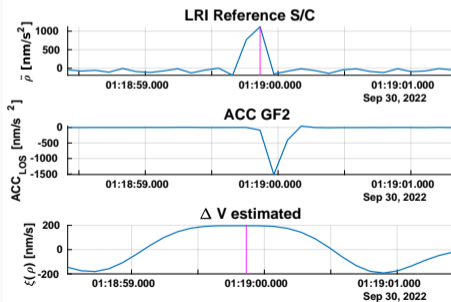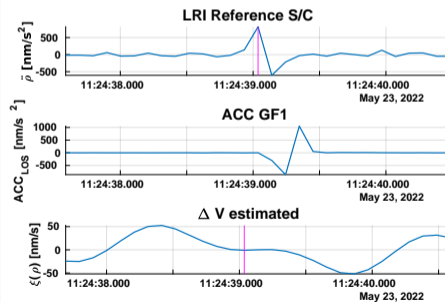- Possible causes: impacts by meteoroids or debris.
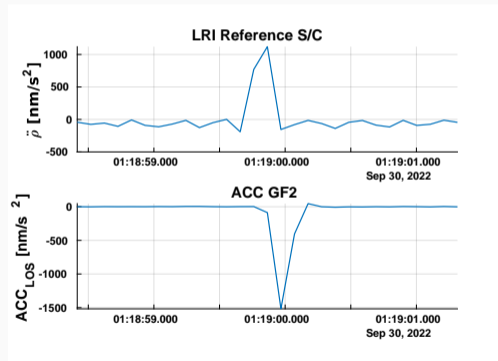
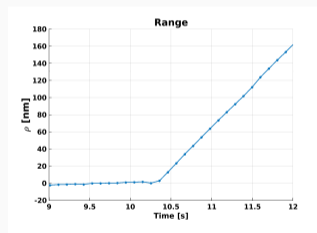# Types of MTEs detected

- Changes in range rate = Δv

High Δv

Low Δv

Detection: Δv estimation filter, $\xi(\rho)$

- The LRI range data, ρ, is passed through a Δv estimation filter, $\xi(\rho)$.
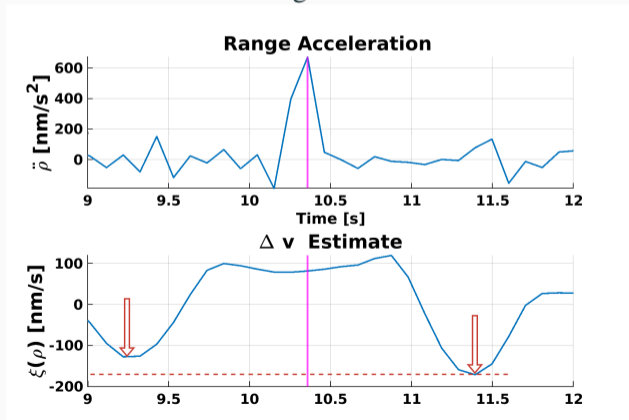
Detection: Δv estimation filter, $\xi(\rho)$

- The LRI range data, ρ, is passed through a Δv estimation filter, $\xi(\rho)$.

- Samples before and after the event used for a least squares fit.

- The change in the range rate, Δv is thus estimated.
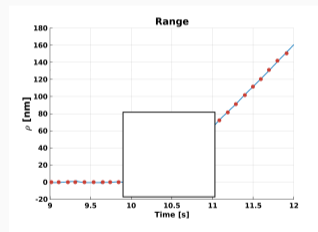
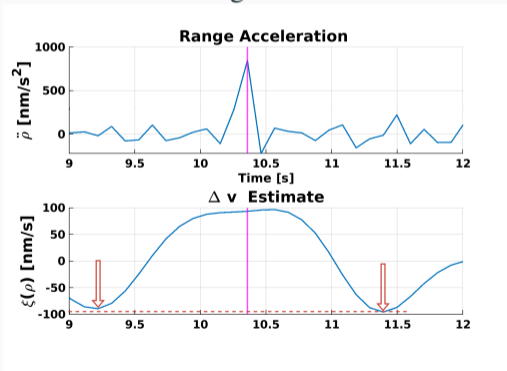# Detection: Moving Mean

Moving mean = 1

Detection: Moving Mean

- A moving average is applied to range, ρ before passing it through the filter.
- This is to reduce the filter artefacts in the final Δv time series.
- Moving averaged data should not spill into the actual event.

Moving mean = 5

Detection: Threshold

- Events above a selected Δv threshold are collected and called MTE candidates.

- The range accelerations for these candidates are cross correlated with ACC_{LOS}.

- The events where correlation is high are deemed the final MTEs detected.
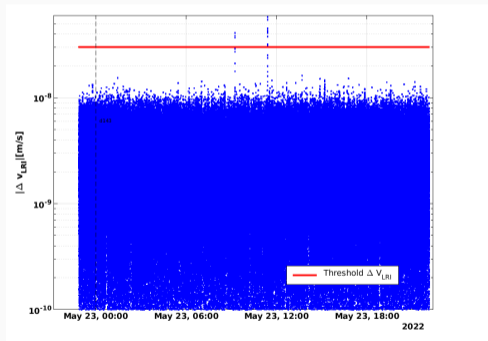
Preliminary Results

- The following parameter set was chosen:
    - Filter length = 3s
    - Number of points for the least squares fit = 9
    - Moving mean parameter = 5
    - Δv threshold: 45 nm/s
- MTE candidates over 5 years of LRI range data: 1664
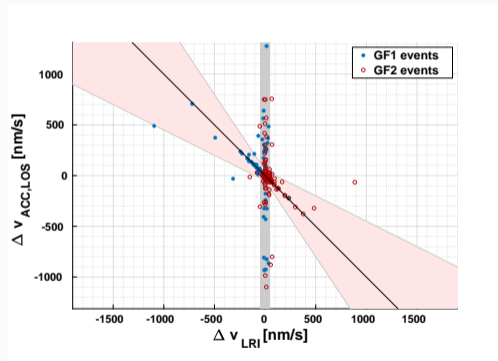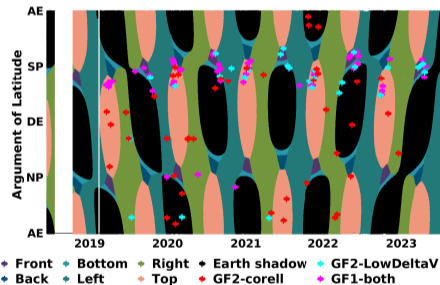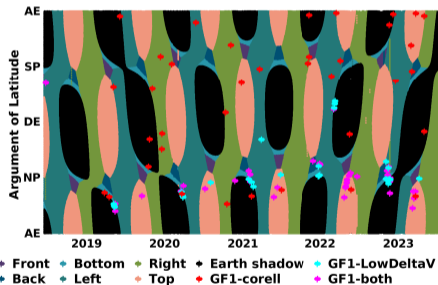- MTEs detected: GF1 - 104 , GF2 - 139

Preliminary Results

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  - Filter length = 3s
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- MTEs detected: GF1 - 104 , GF2 - 139

Preliminary Results: Surfaces of S/C illuminated by the sun

# Detection: Optimisation parameters

- Simulating different amplitudes of Δv in the LRI data, to check the detection output for the following parameters:
    - **Filter length:** 2 s, 3 s or 4 s
    - **Number of fit points selected for the least squares fit:** 5, 9, 15.
    - **Number of sample points for the moving mean:** 1, 3, 5, 7, 10
   - **Δv threshold:** 10 nm/s to 60 nm/s

Number of False Events

- Simulate the filter response for LRI instrument noise.

- Determine the number of detected events per year for each threshold value and moving mean parameter - Falsely detected events.

- Repeated for the 9 combinations of filter length and number of points for fit.
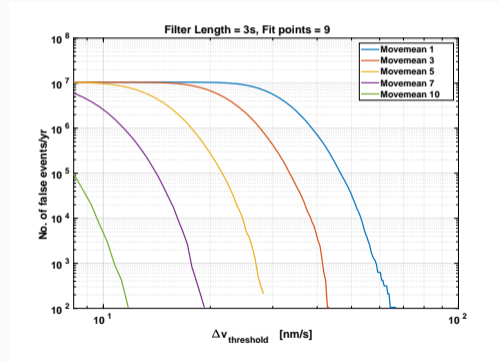
Number of True events

- With ESA MASTER v8.0.3, the number of events expected to appear for a GRACE-FO like orbit is calculated.

- For each parameter (moving mean parameter, filter length , fit points, threshold), number of events expected to be detected is calculated.

Movemean 5, Filter length = 3s, Fit points = 9
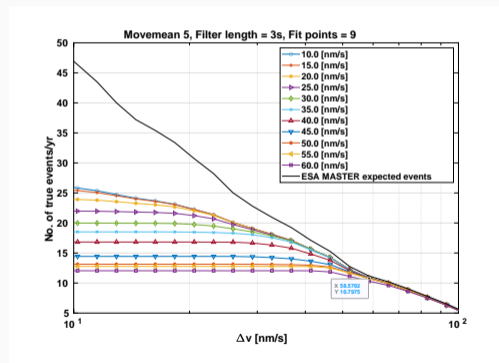
Error in Δ𝑣 estimation

- Accuracy of the estimation of the Δ𝑣 for filter length and number of points for fit combination and for each moving mean parameter.

- For chosen parameters at Δ𝑣 = 60 nm/s, the error is 24.4%
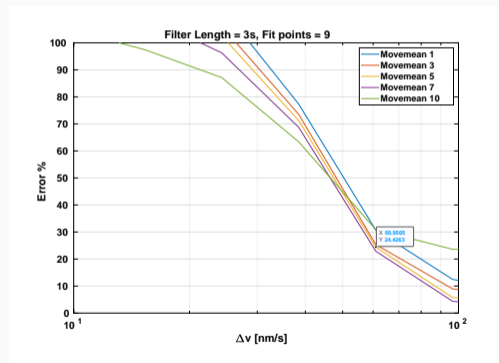
Better Detection Parameters

- Compared to the preliminary results, the following parameters have **higher number of true events per year** and the **lower number of false events** for Δv = 60 nm/s :
  - Filter length = 3s
  - Number of points for the least squares fit = 5
  - Moving mean parameter = 7
  - Δv threshold: 30 nm/s
  - **Error = 23.5%**

Summary

- MTEs are events that appear as sporadic and short changes in range rate while also showing a similar signature in the accelerometers either S/C.
- The algorithm for detection used least squares fit formulated into a filter to estimate the Δv time series using the LRI range data, ρ.
- Simulations were performed over four optimization parameters to get the highest true detected events per year and the lowest falsely detected events per year.
- In addition, the error of Δv estimated for different combinations of the parameters was calculated.
- Analysing these values, a better combination of detection parameters compared to the ones used in the preliminary results, are deduced. Subsequently, they will be used to estimate Δv over the 5 year LRI range data.