UNIVERSITY OF Southampton

Processing TLEs to facilitate re-entry prediction of spent rocket bodies from GTO

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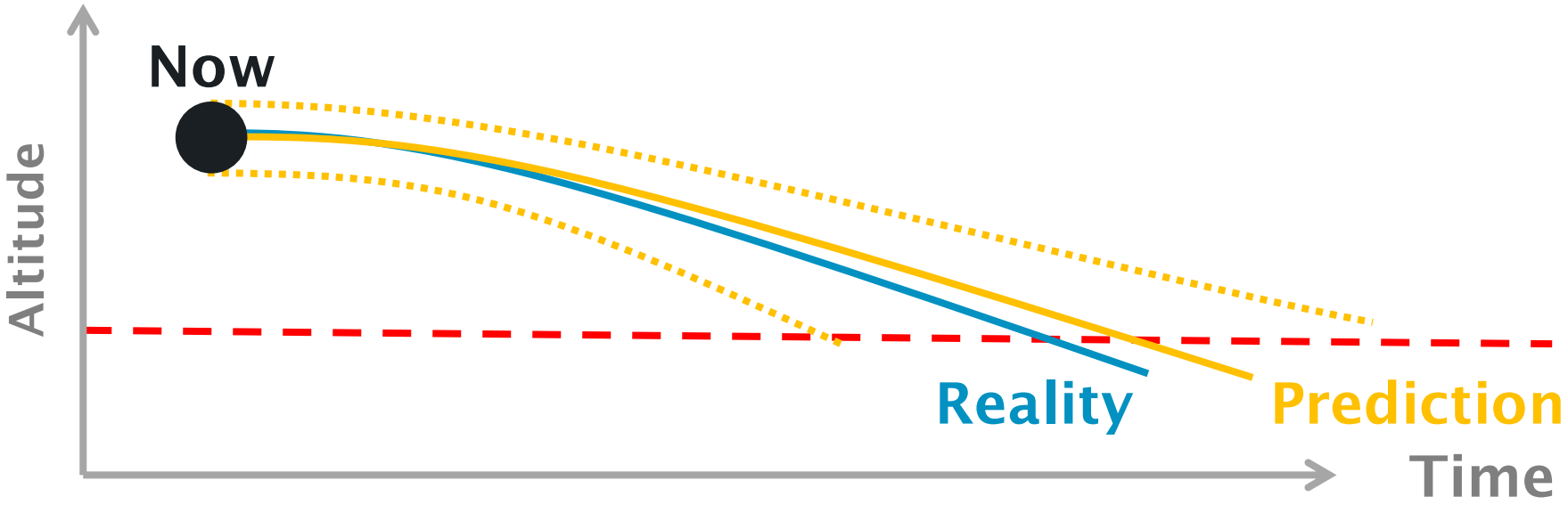
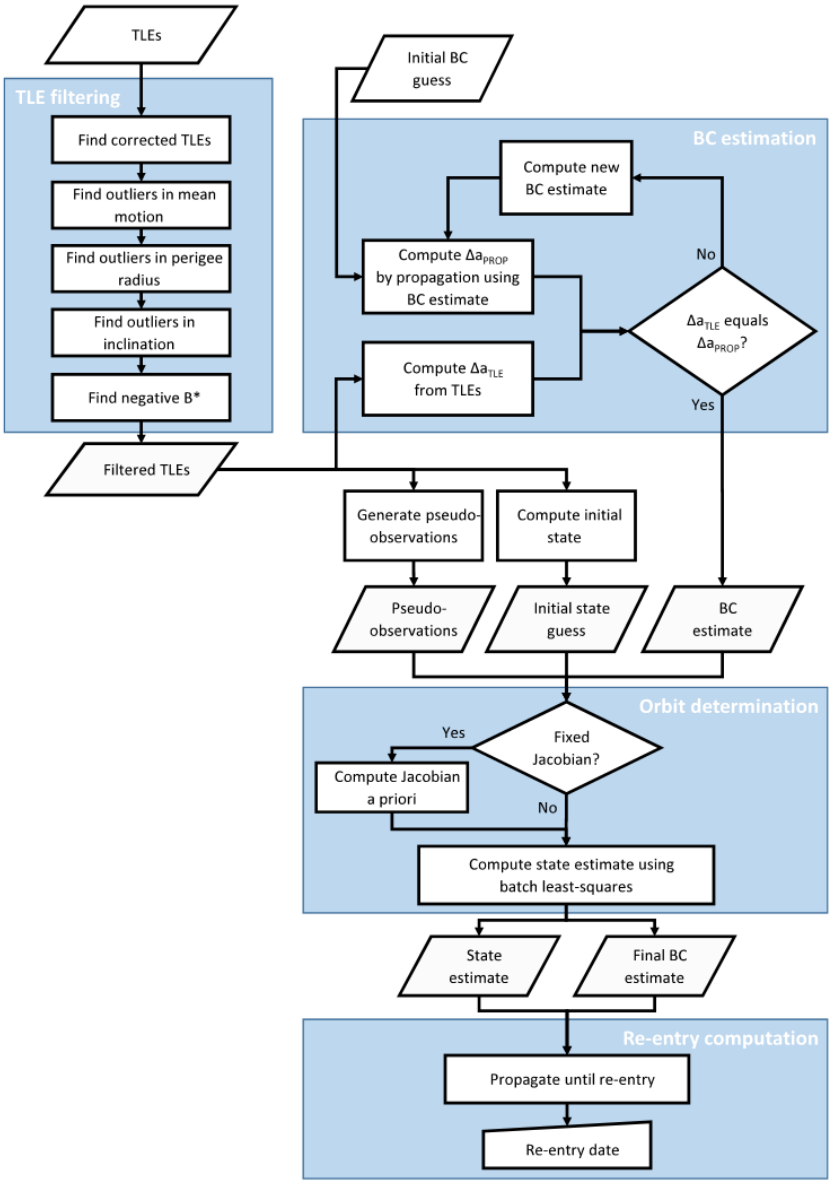
Re-entry prediction

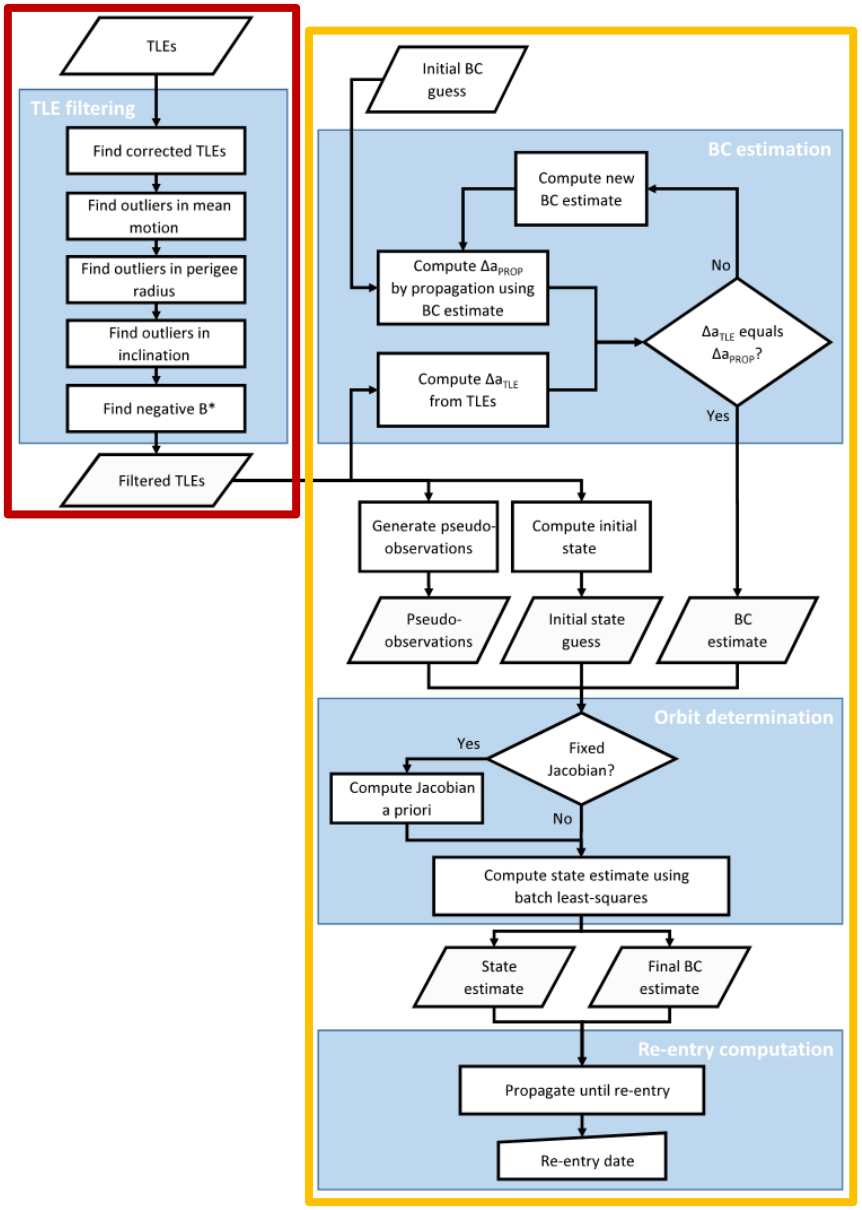


How to improve TLE-based predictions



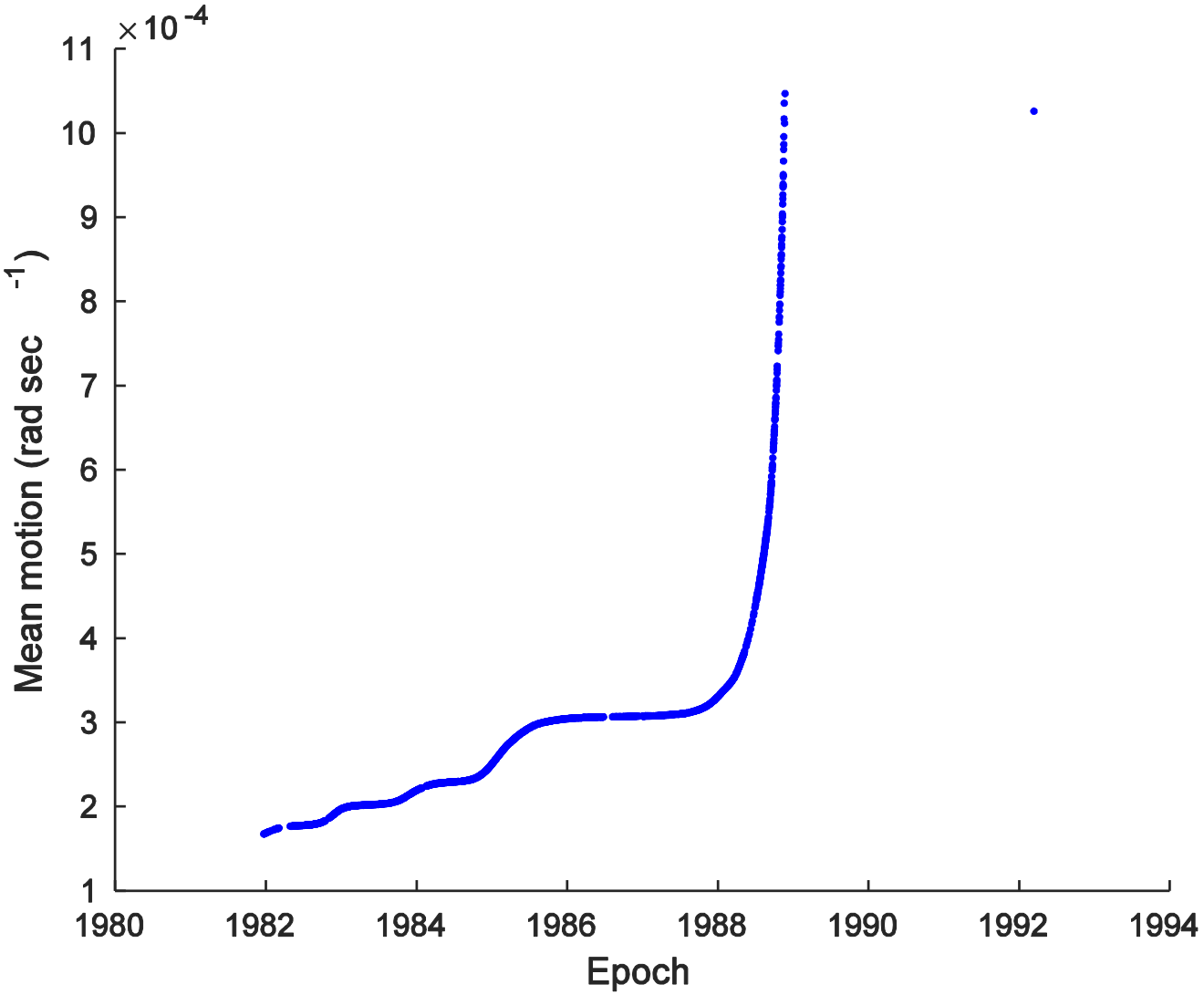
How to improve TLE-based predictions

Today

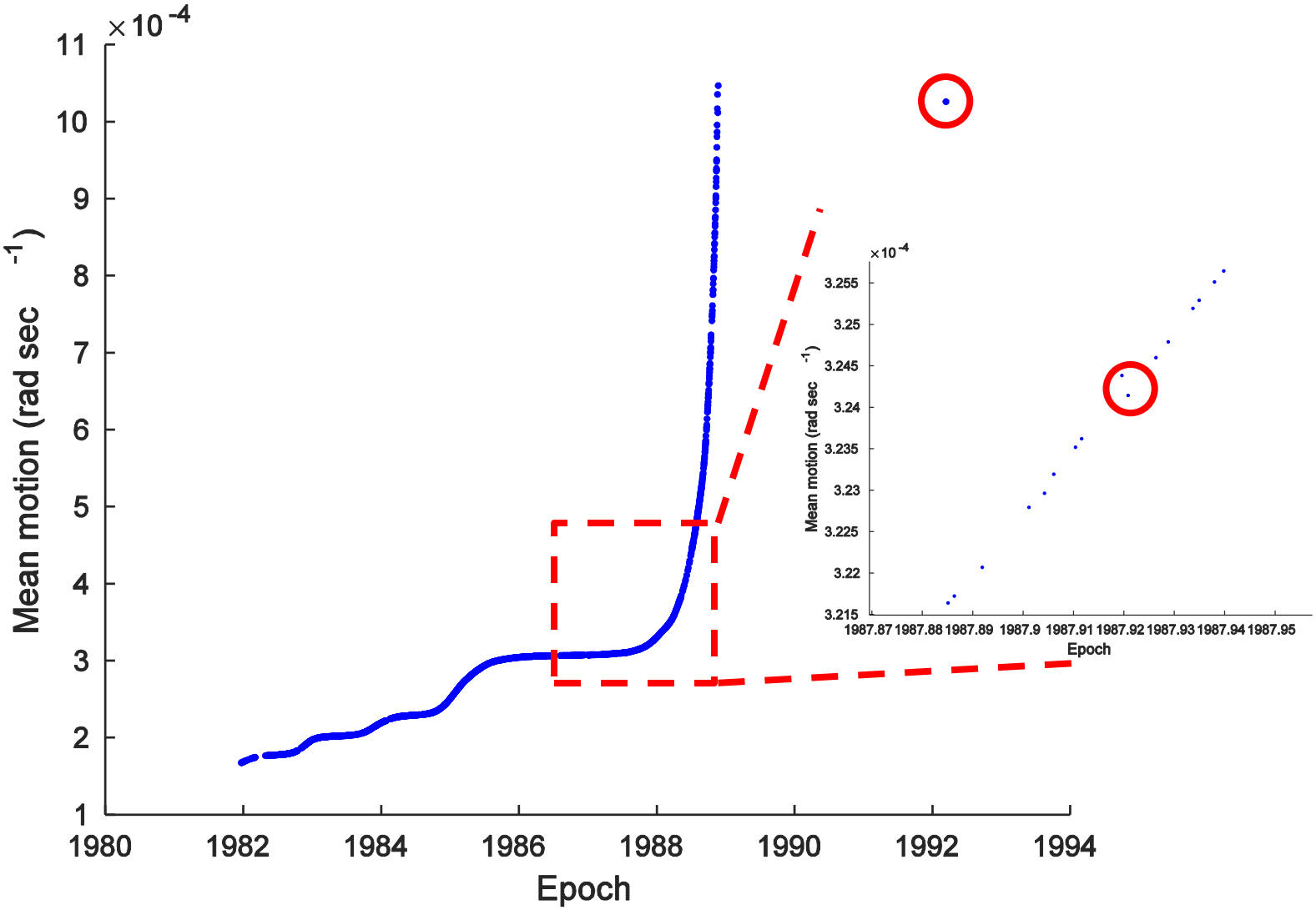


AAS 2016, Napa, CA

Problems with TLEs

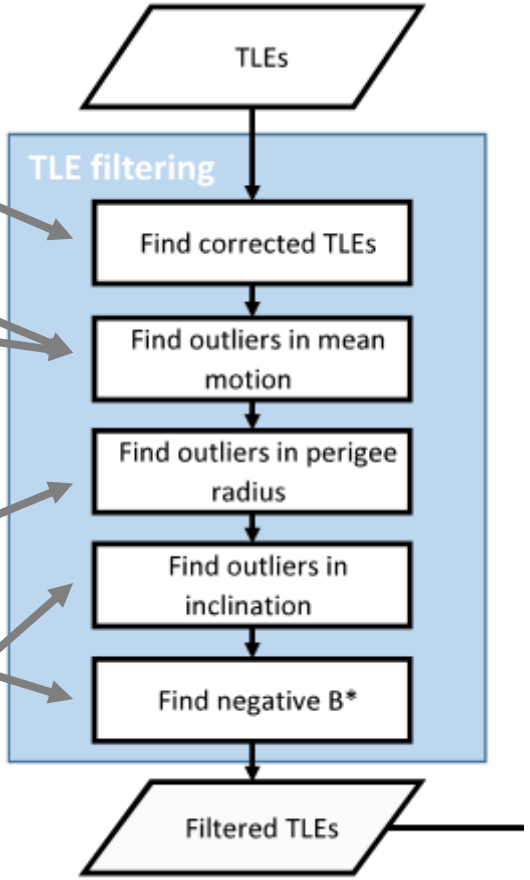


Problems with TLEs



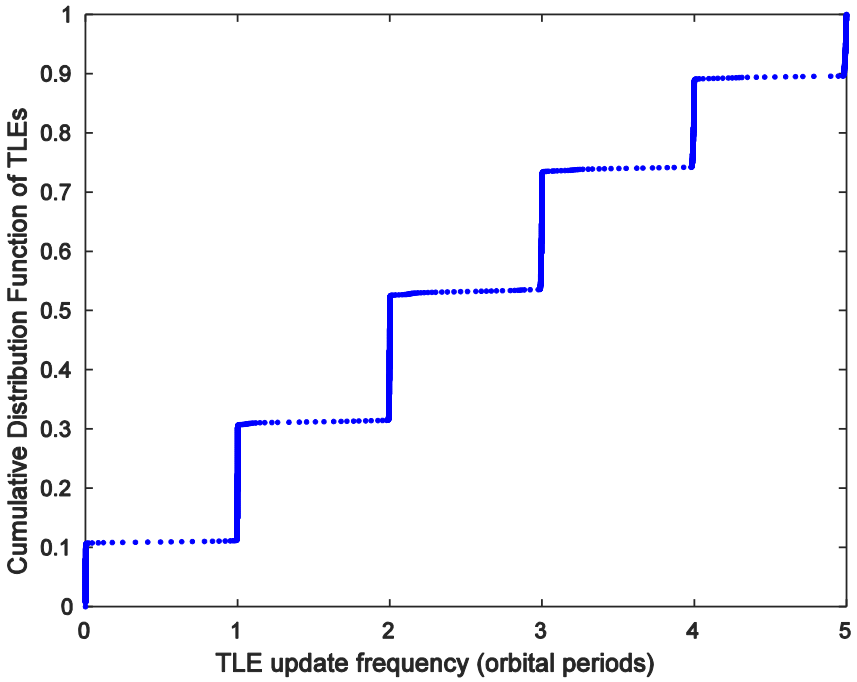
Addressing problems with TLEs

1. Corrected TLEs
2. Time gaps
3. Outliers in mean motion and events that physically change the object
4. Outliers in eccentricity and B^* – need to estimate the ballistic coefficient
5. Outliers in inclination – need orbit determination to converge

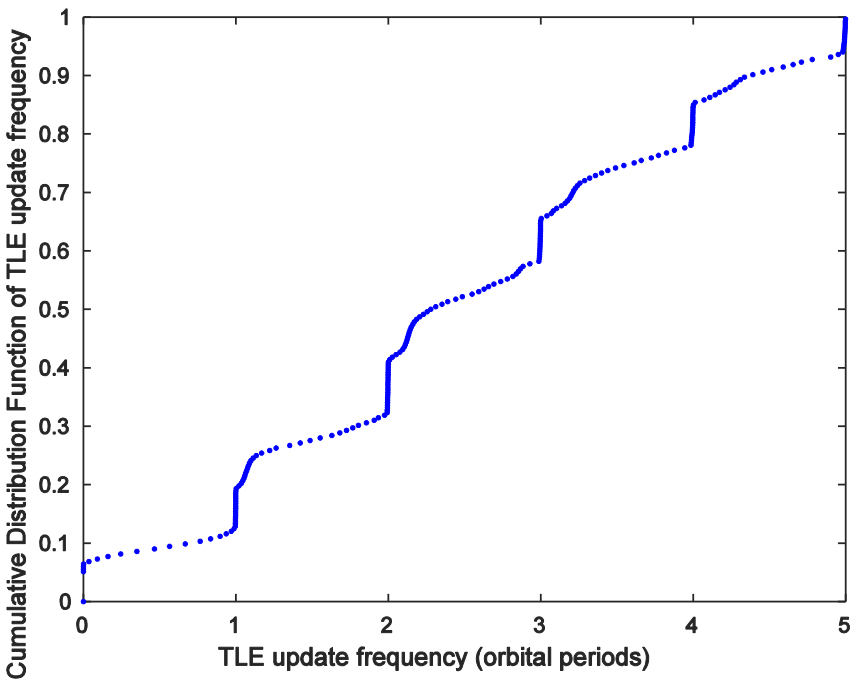


Corrections

Before 2011

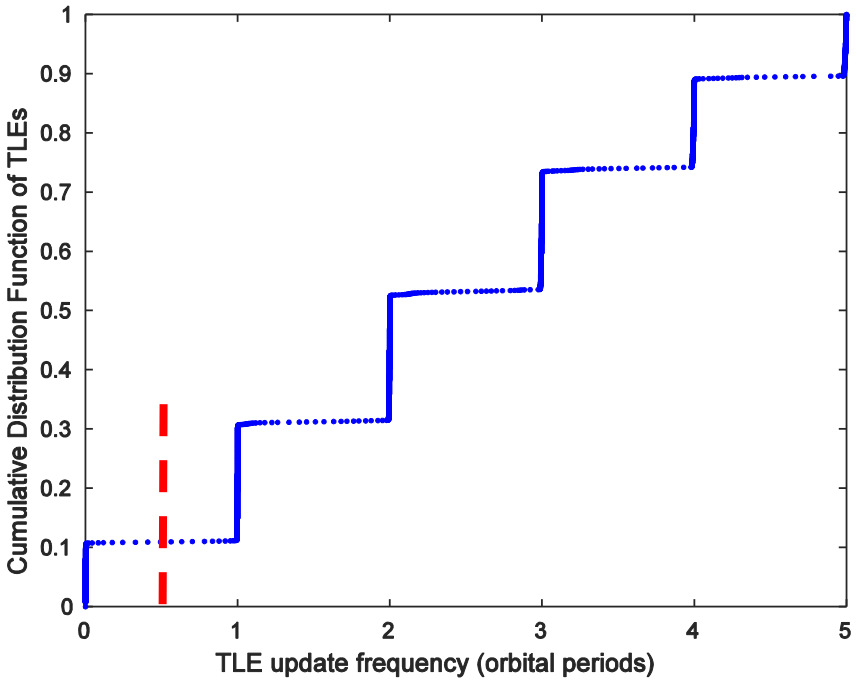


After 2011

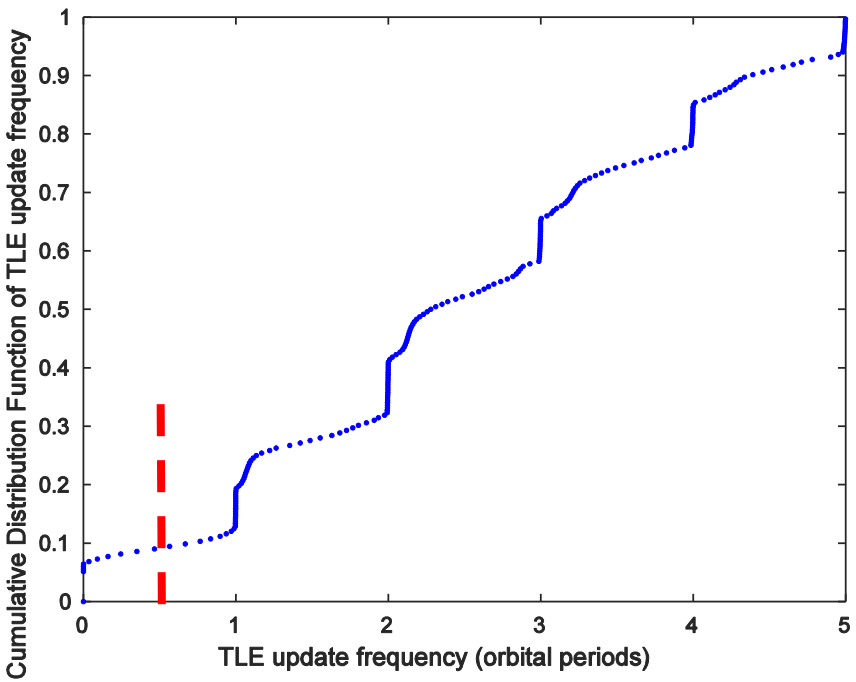


Corrections

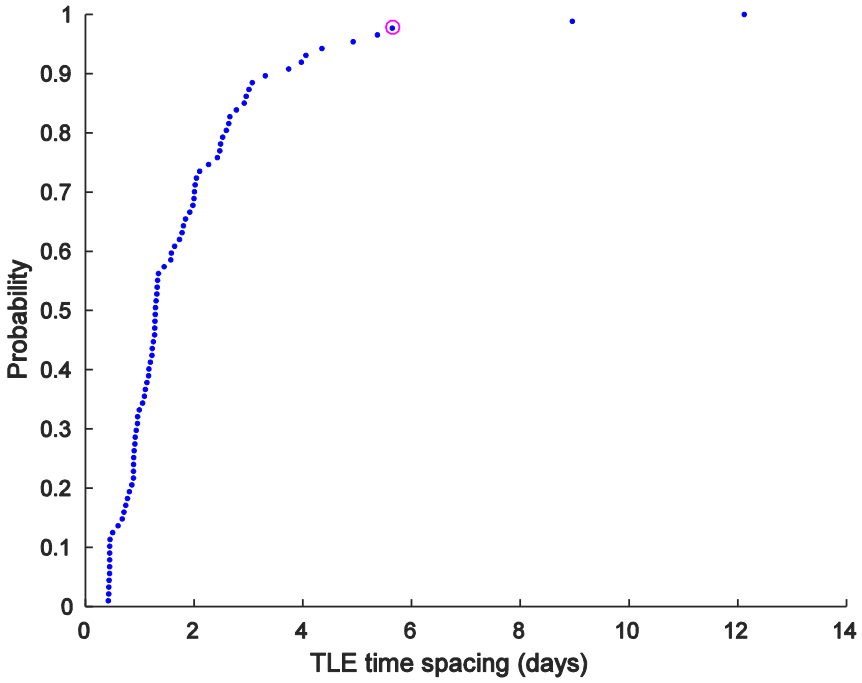
Before 2011

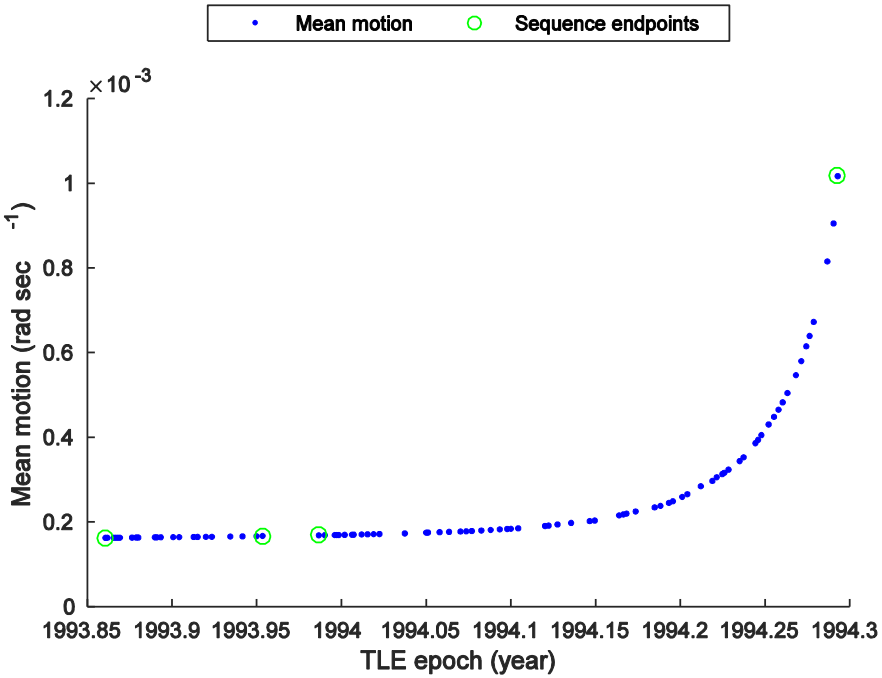


After 2011

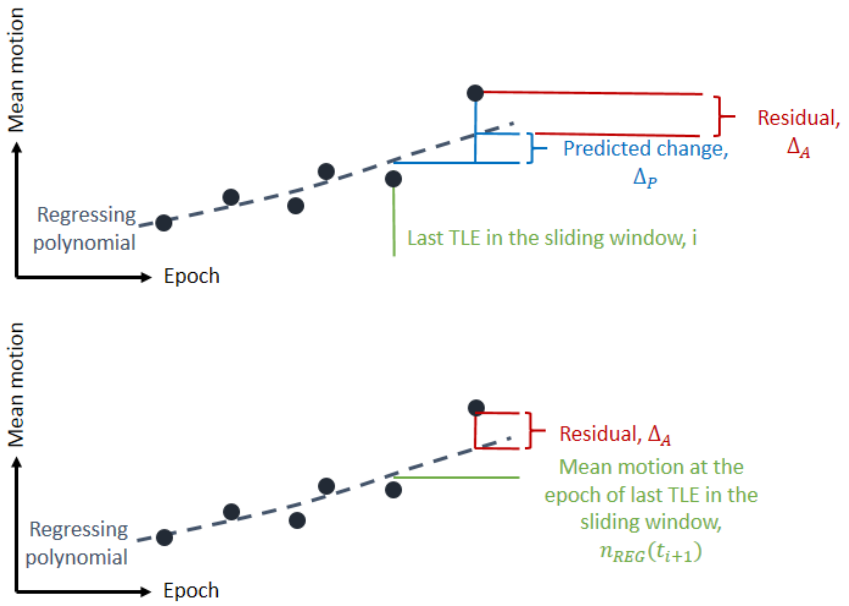


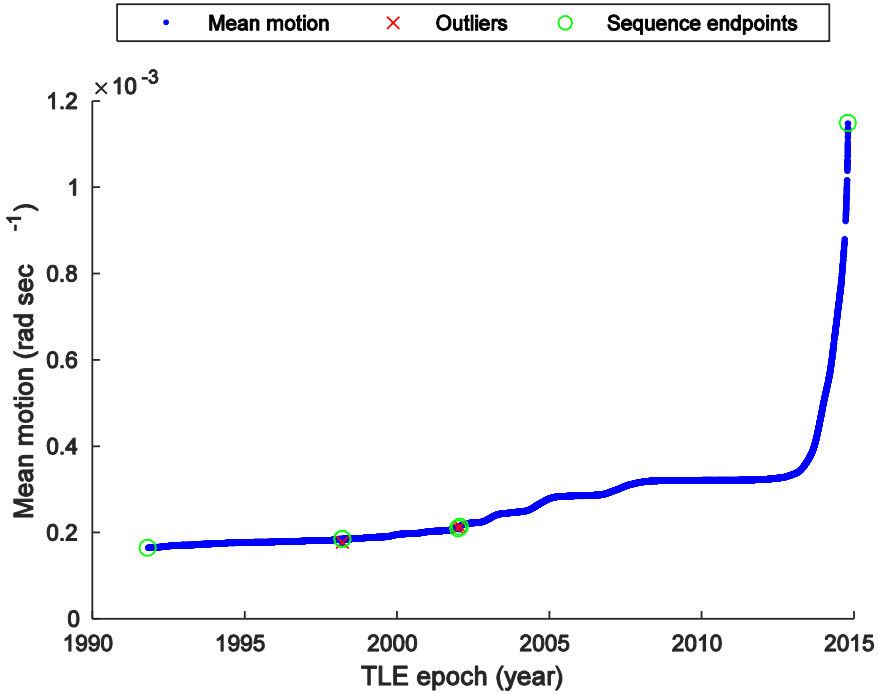
Time gaps


Probability
TLE time spacing (days)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
2
4
6
8
10
12
14

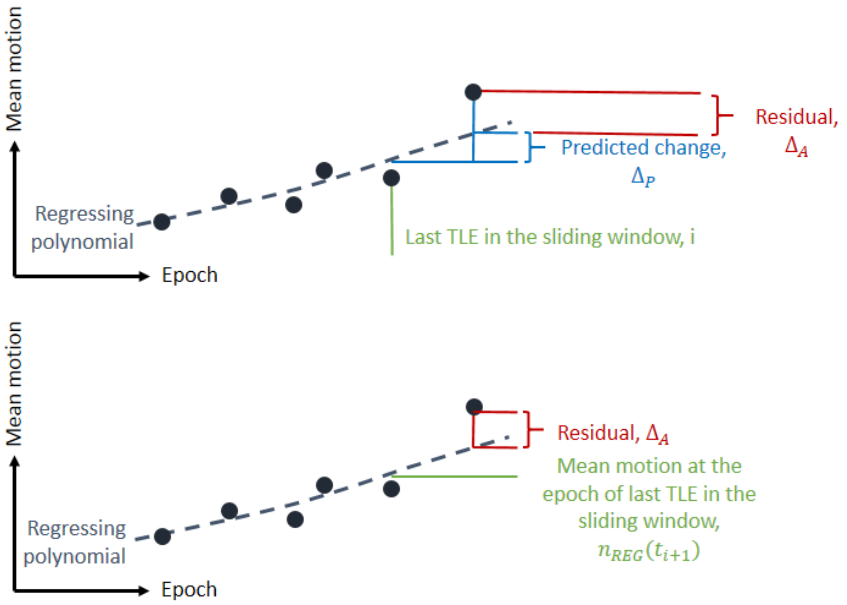

Mean motion
Sequence endpoints
×10^-3
Mean motion (rad sec^-1)
TLE epoch (year)
0
0.2
0.4
0.6
0.8
1
1.2
1993.85
1993.9
1993.95
1994
1994.05
1994.1
1994.15
1994.2
1994.25
1994.3

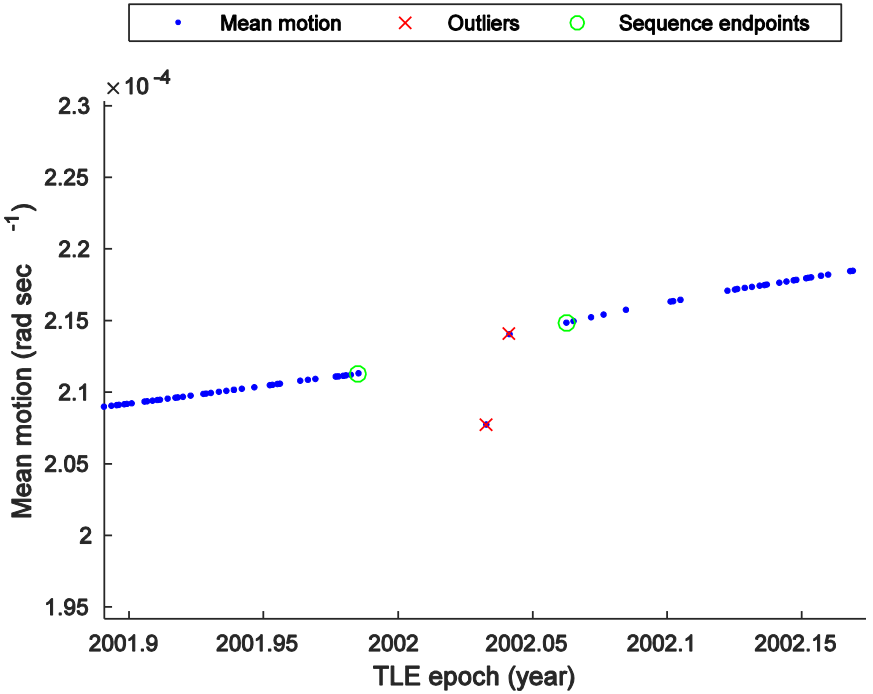
Mean motion outliers



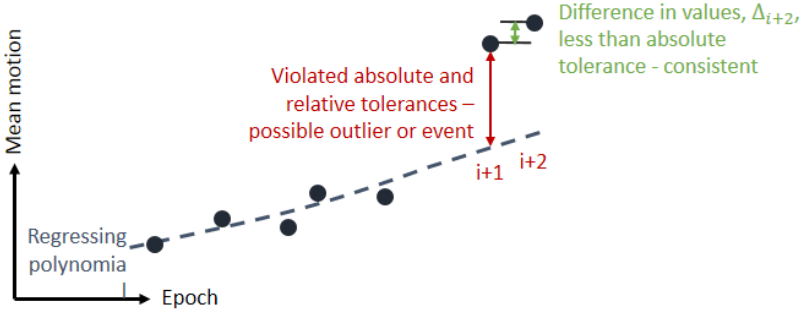


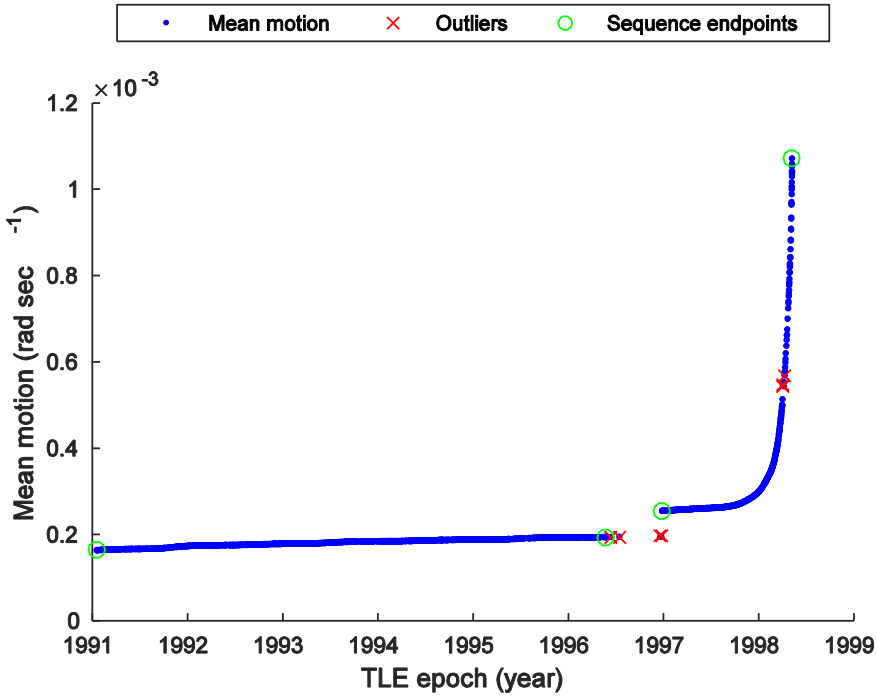
Mean motion outliers



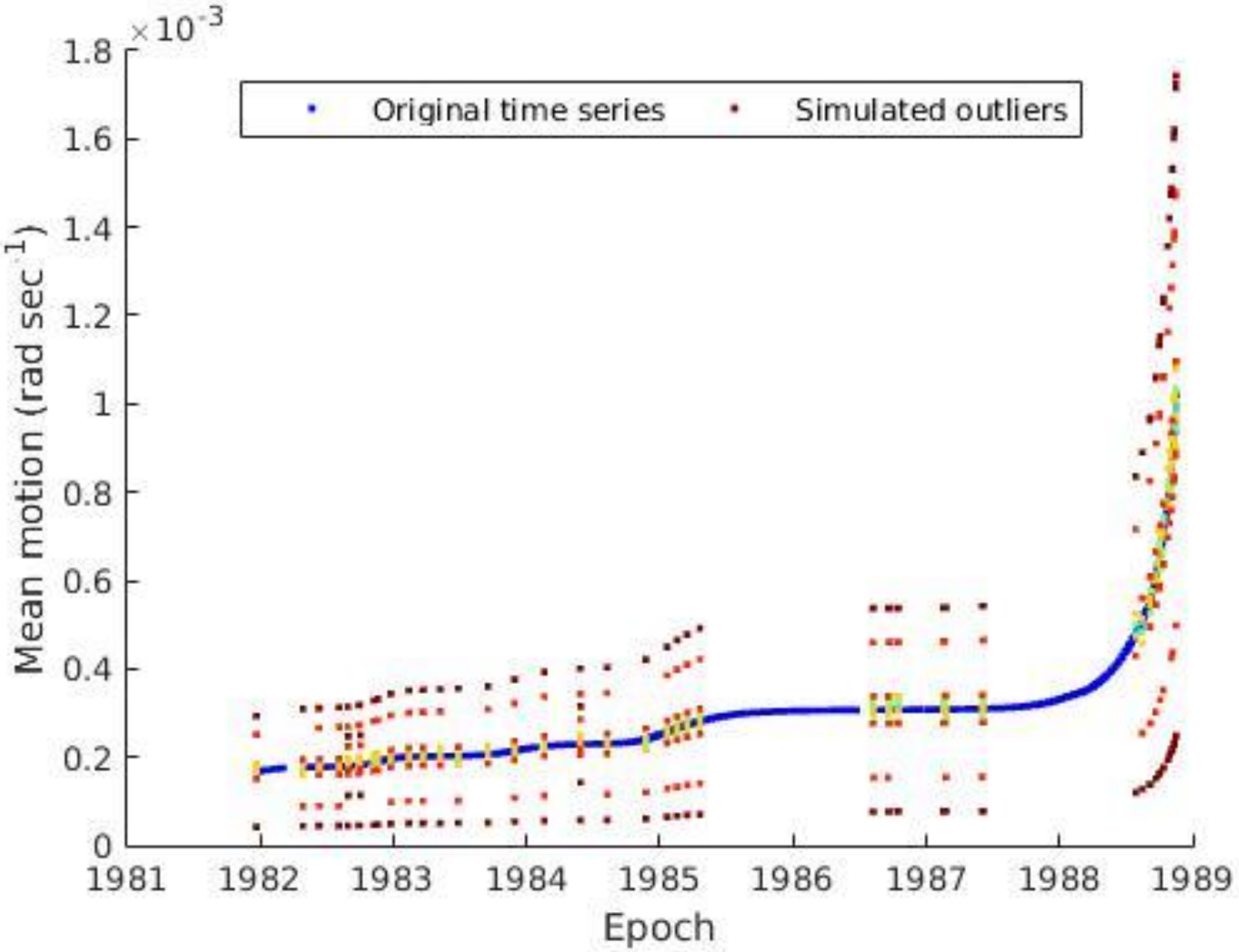


Events – change BC and SRPC

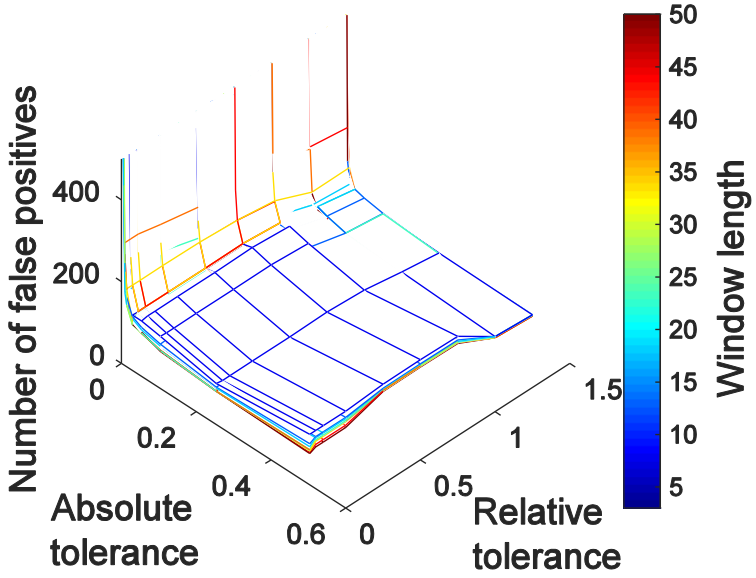


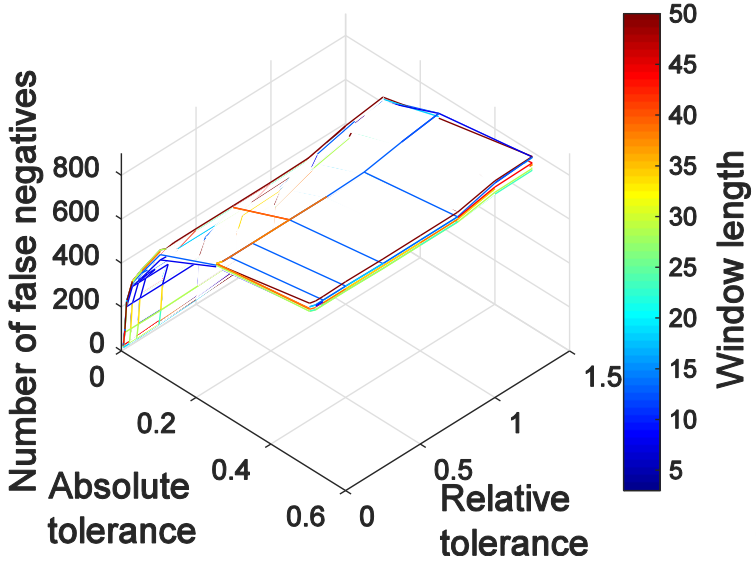


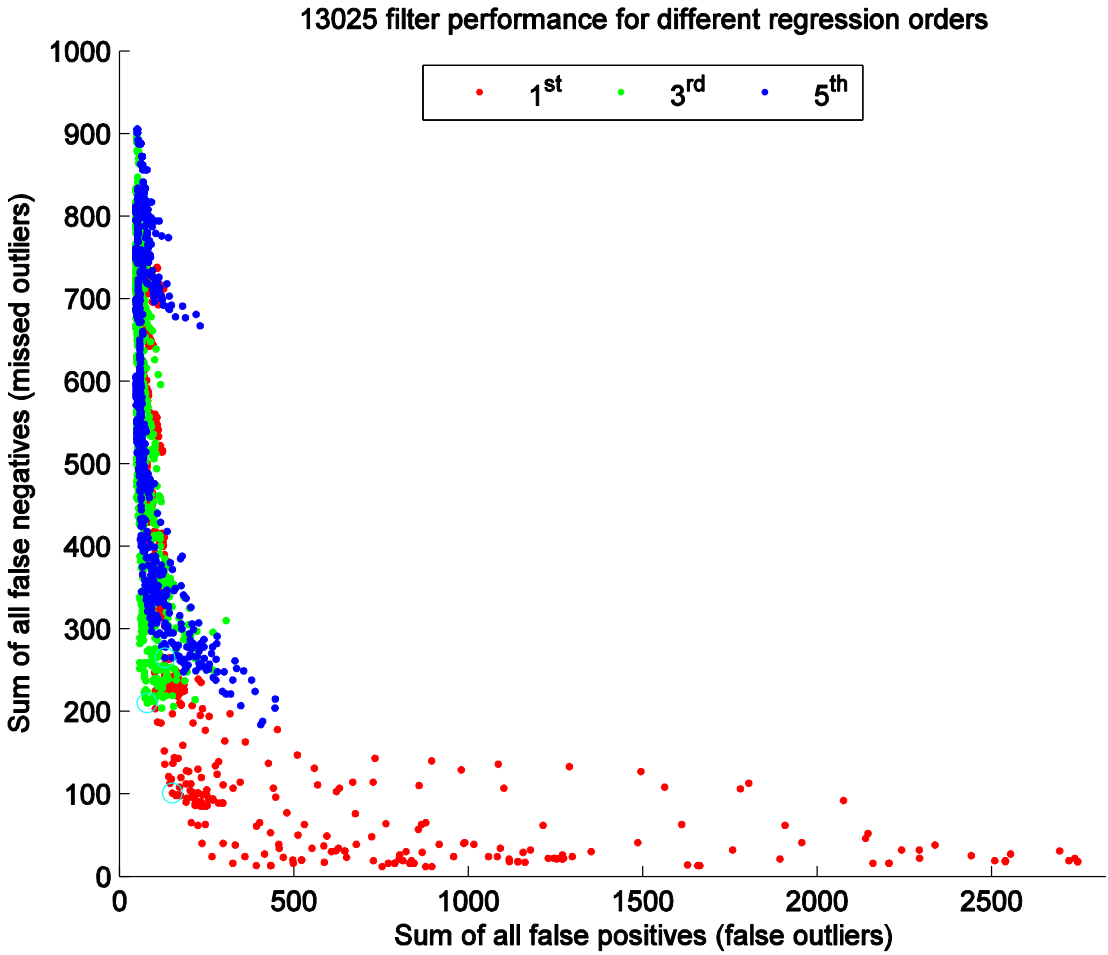
Mean motion filter tuning



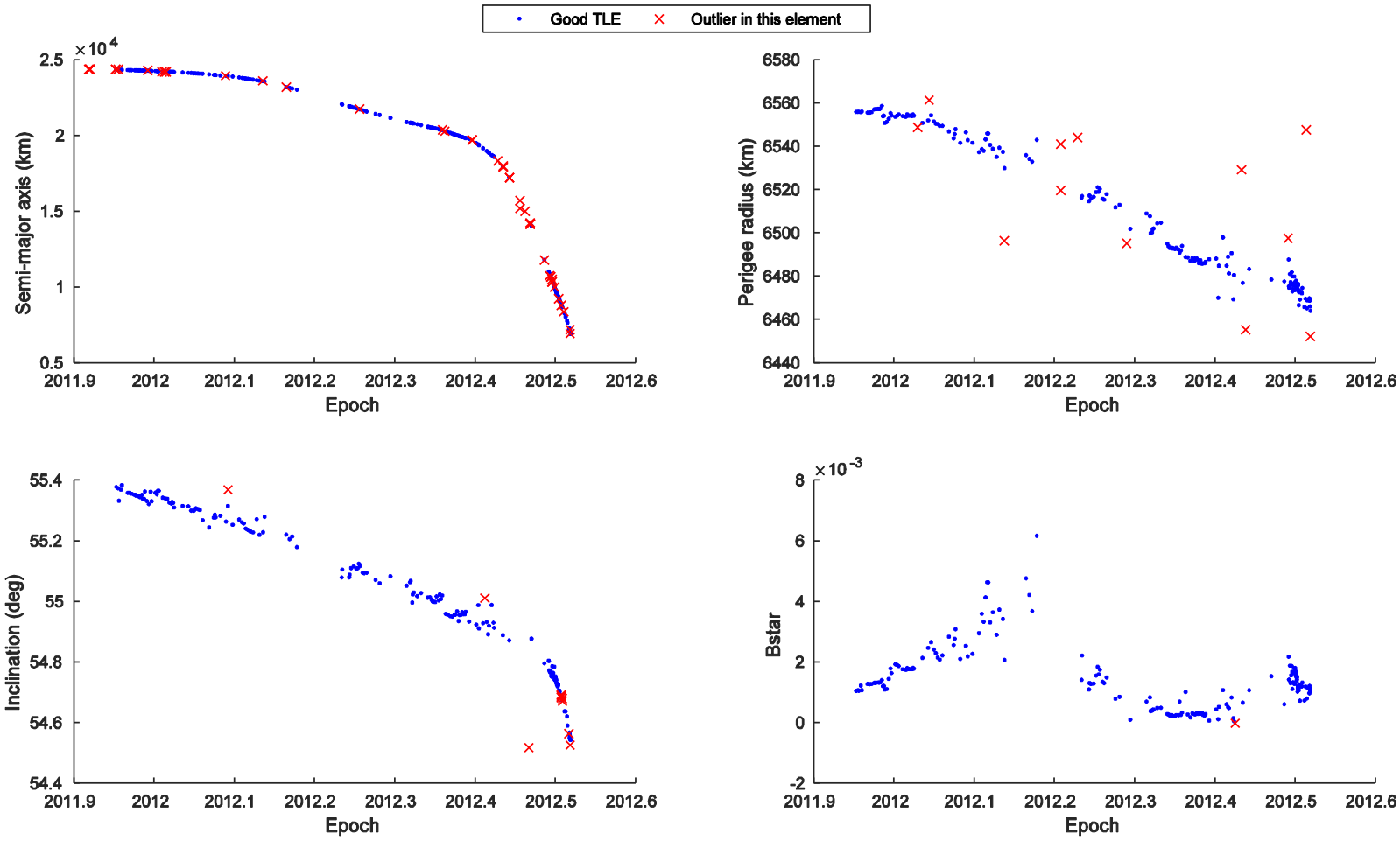
Mean motion filter tuning



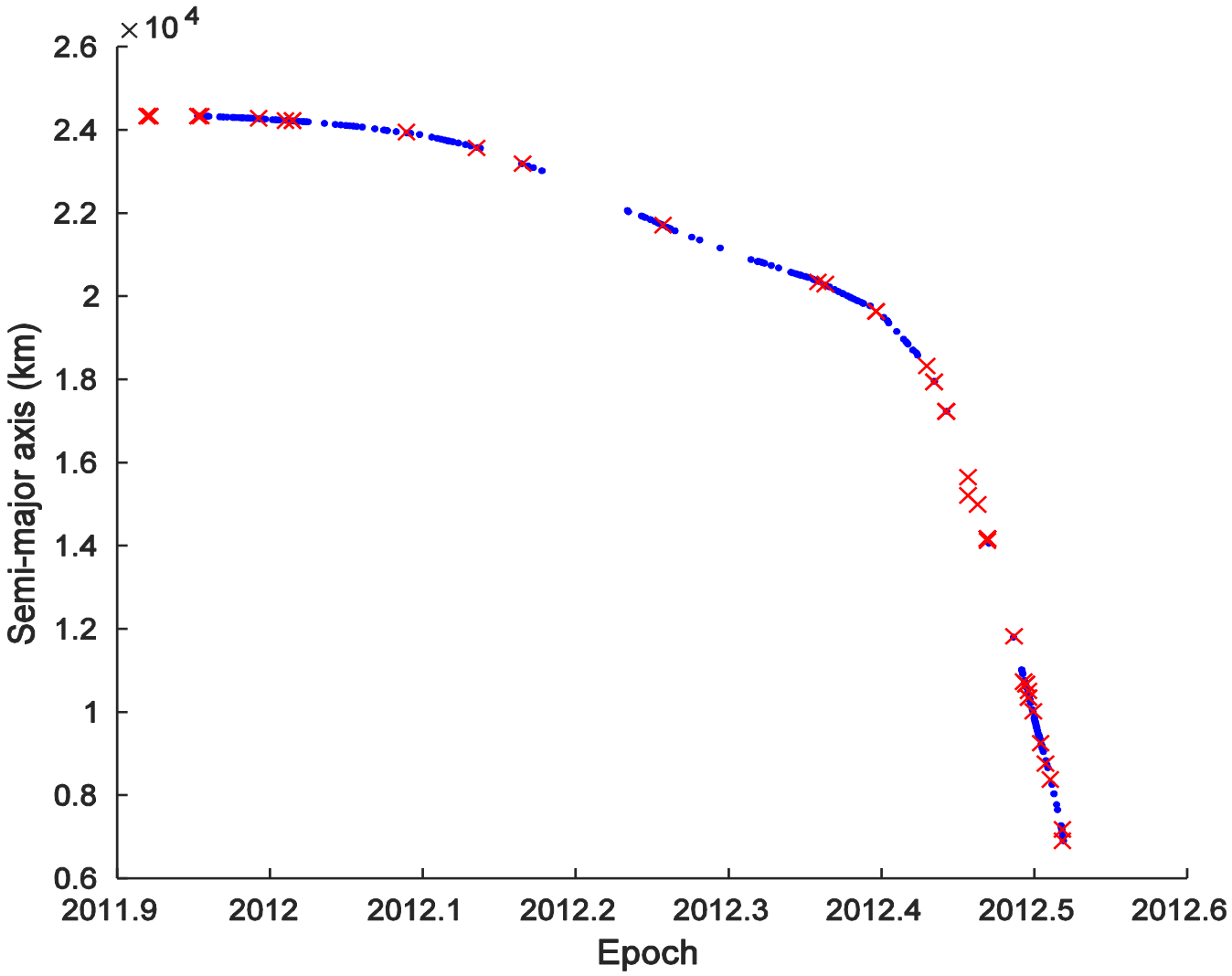




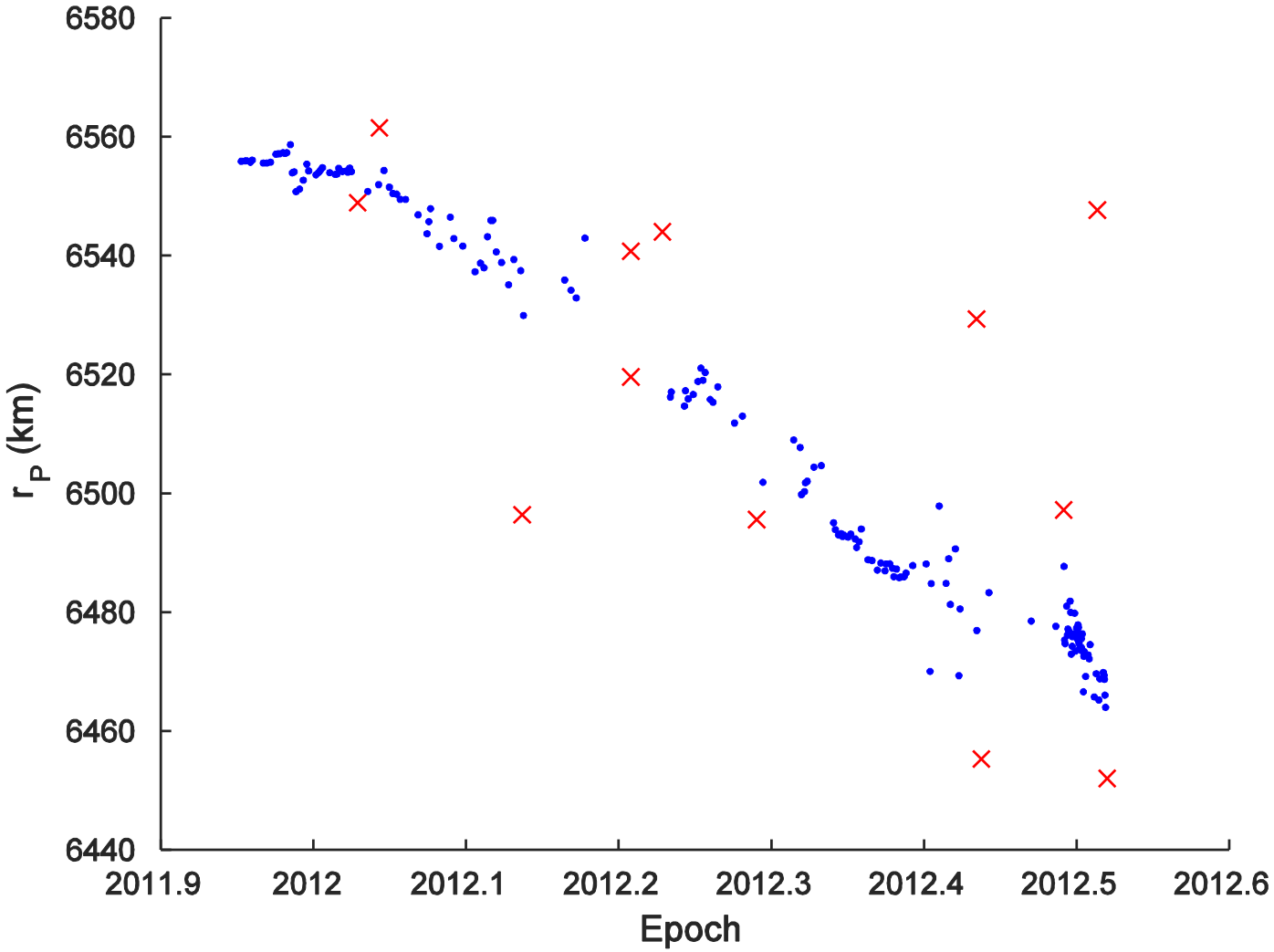
Outliers in n, e, *i*, and *B**



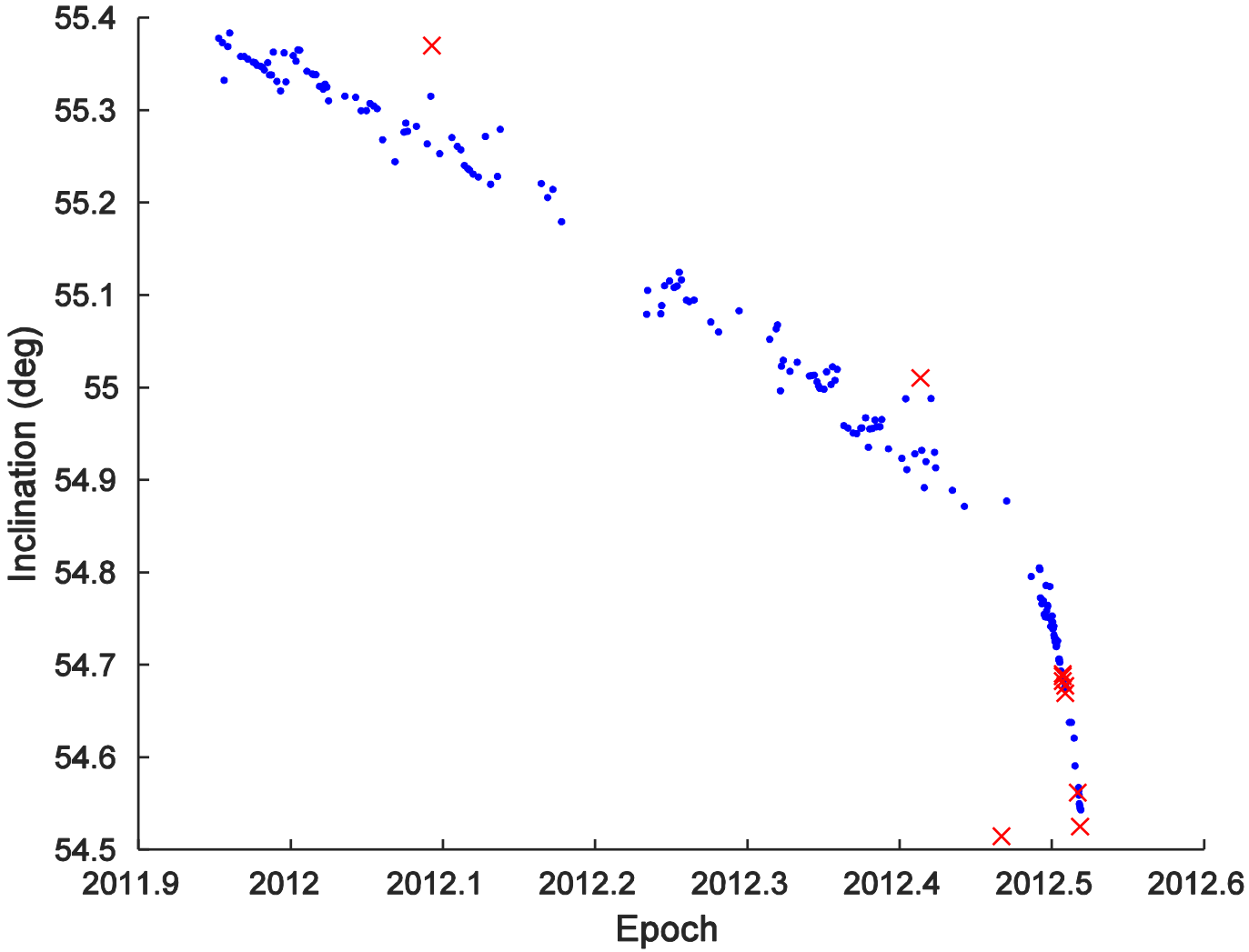
Outliers in n



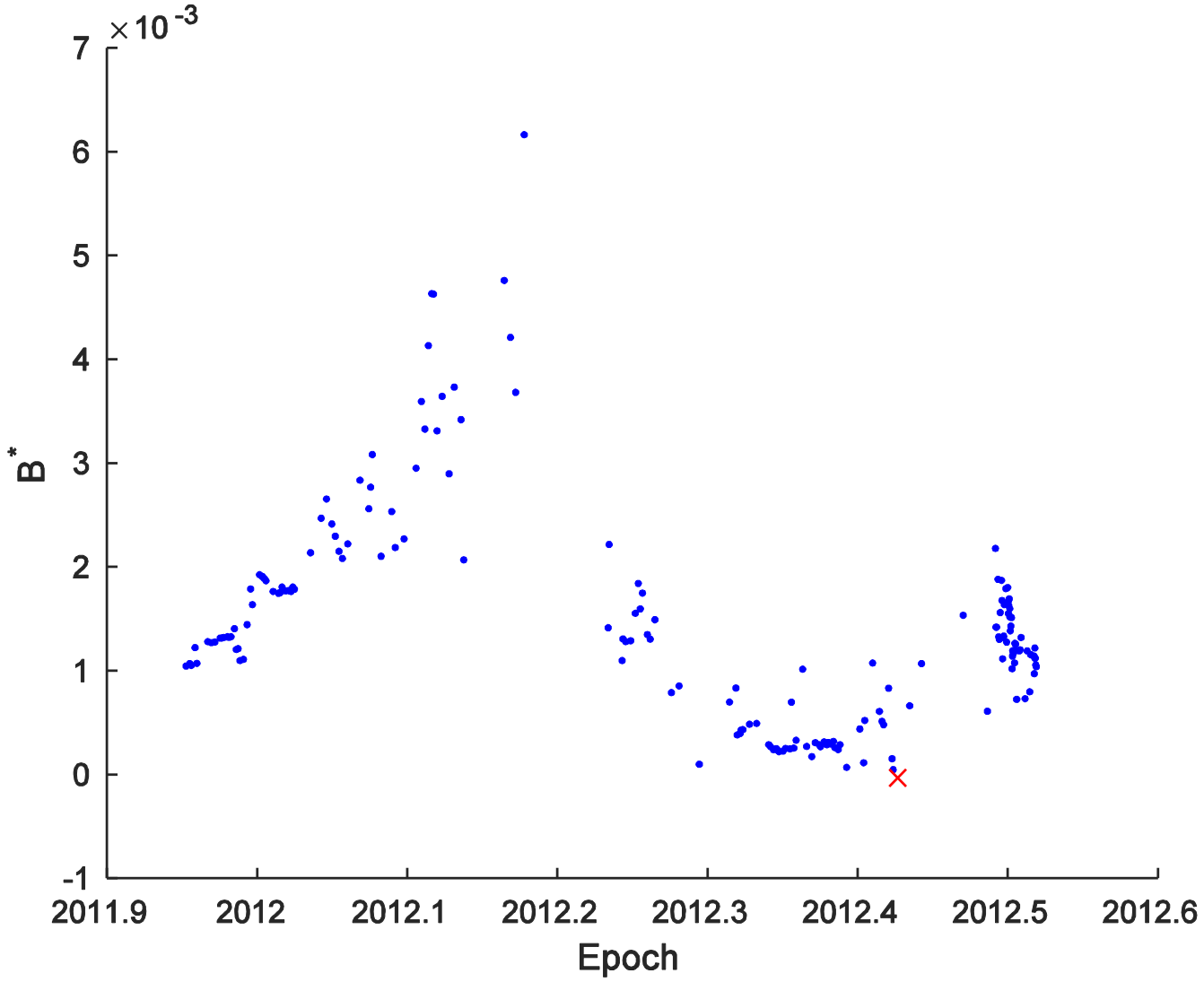
Outliers in *e*



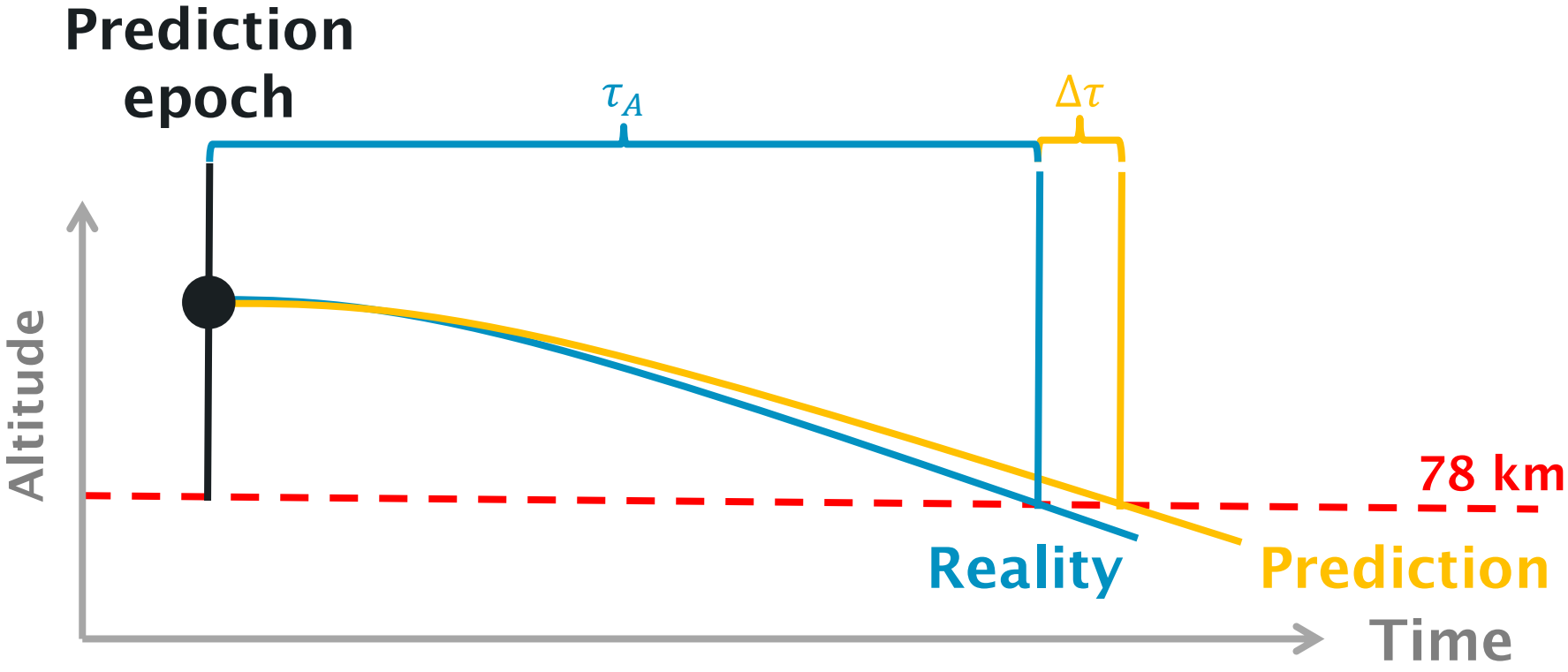
Outliers in *i*



Outliers in B^*

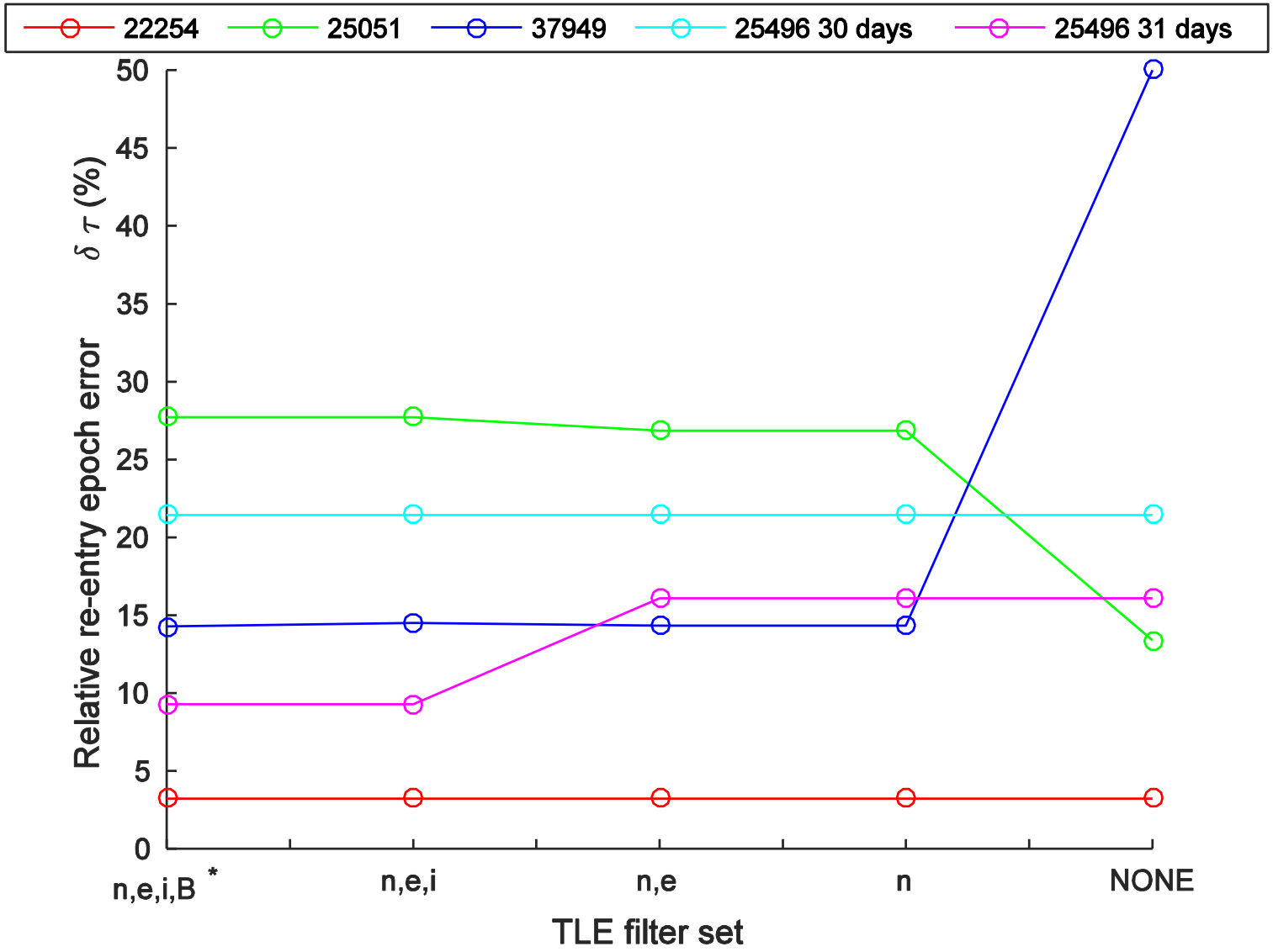


Re-entry prediction error

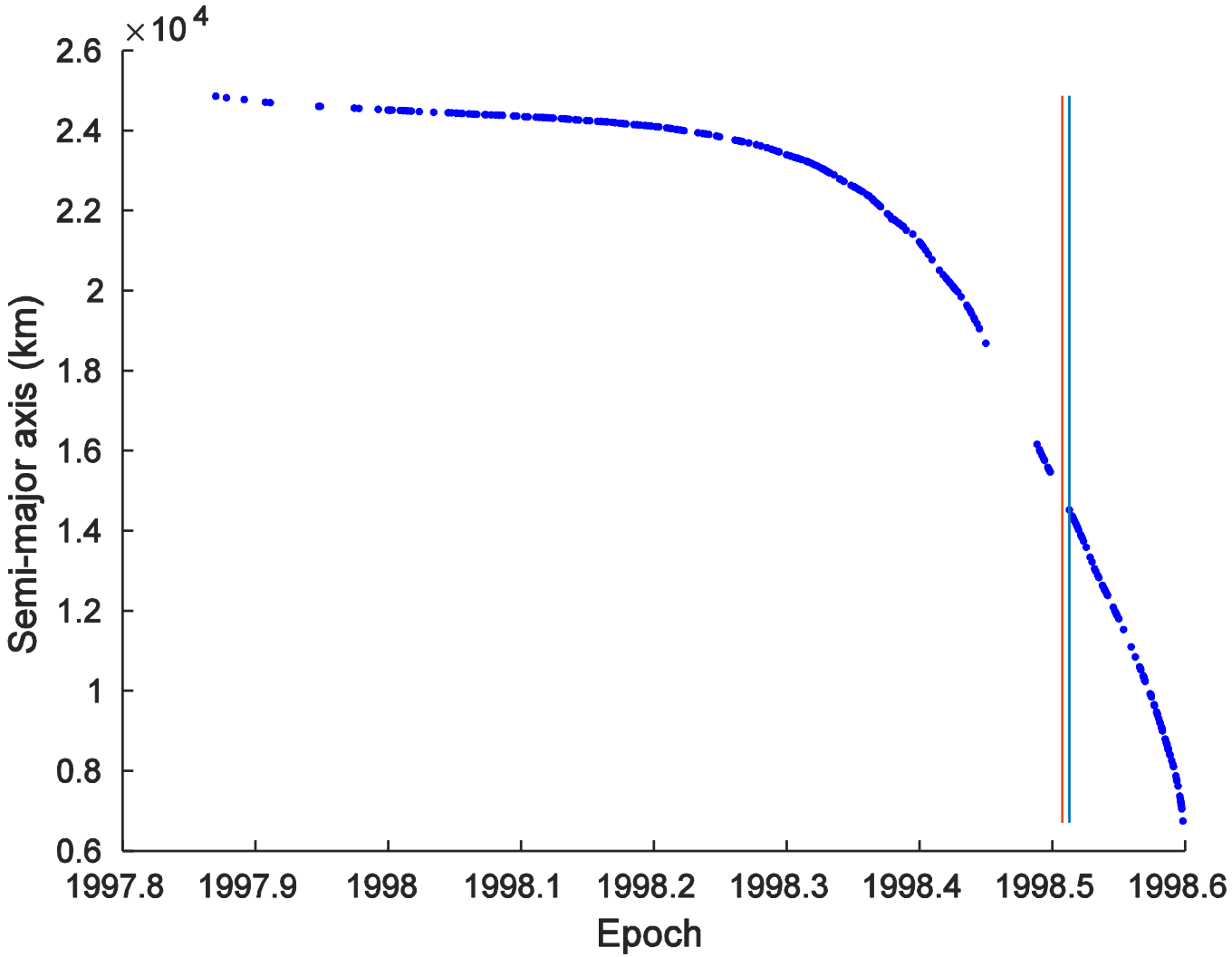


Relative error: $\delta\tau = \frac{\Delta\tau}{\tau_A}$

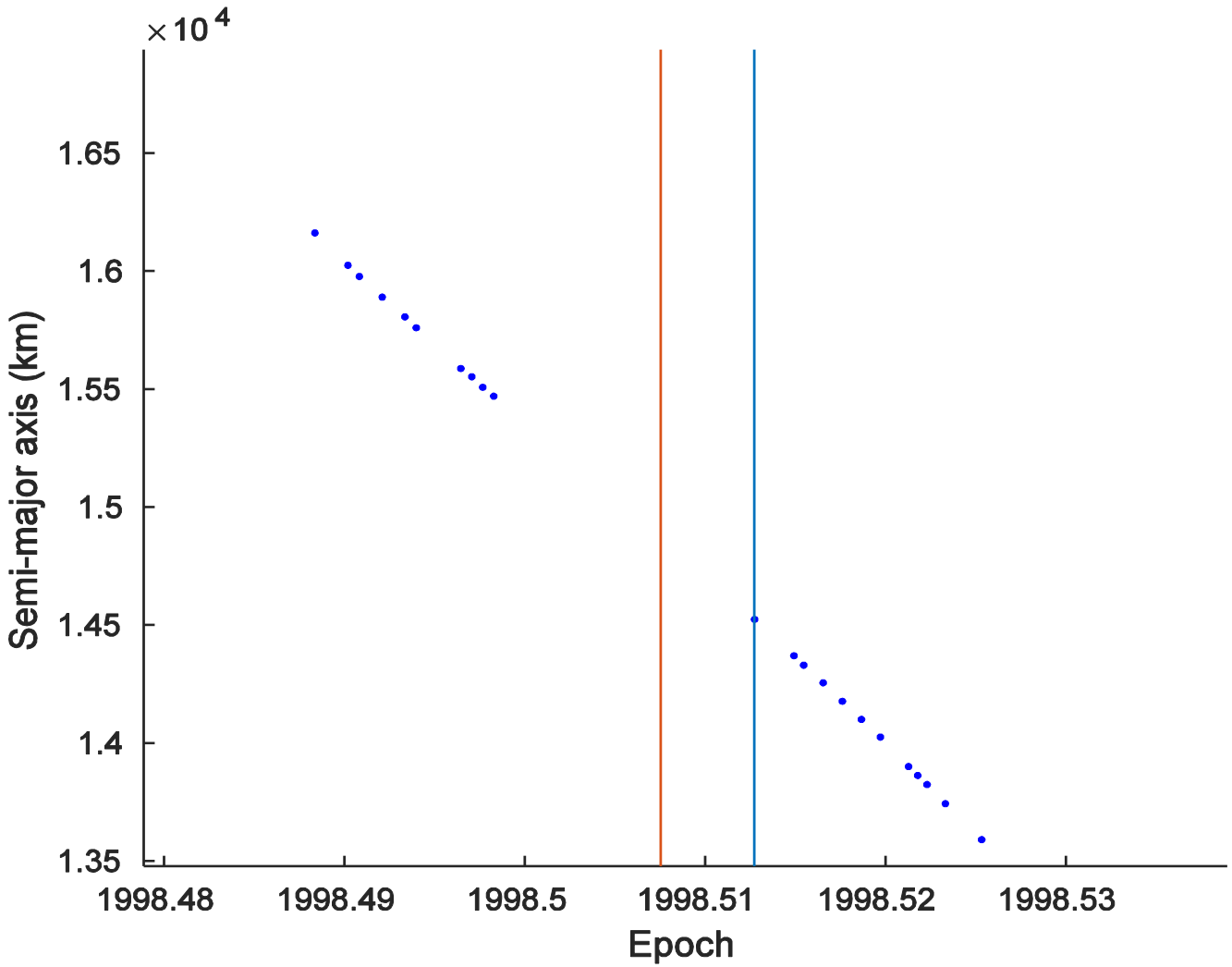
Effects of filtering on prediction accuracy



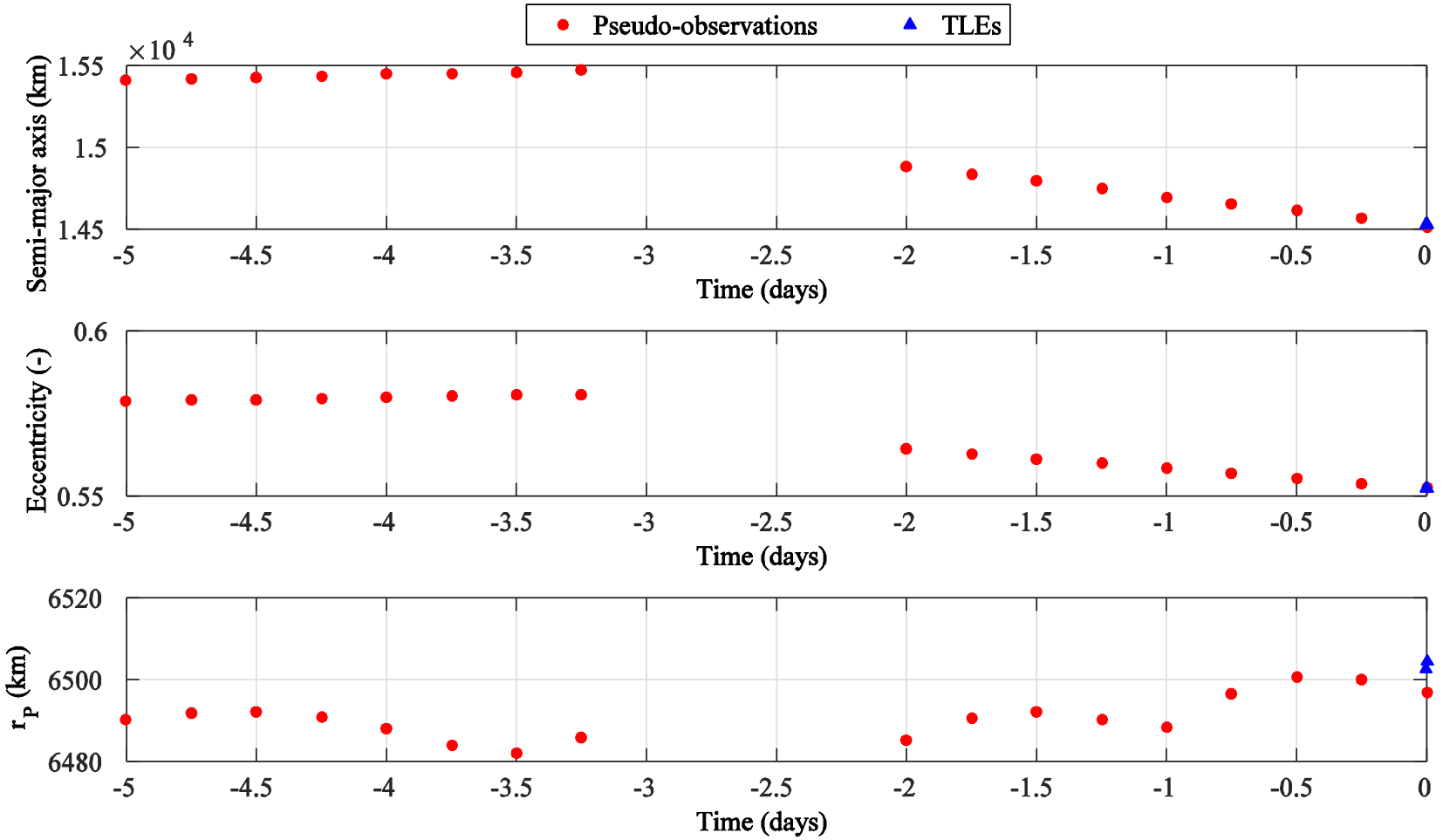
When we filter too many TLEs



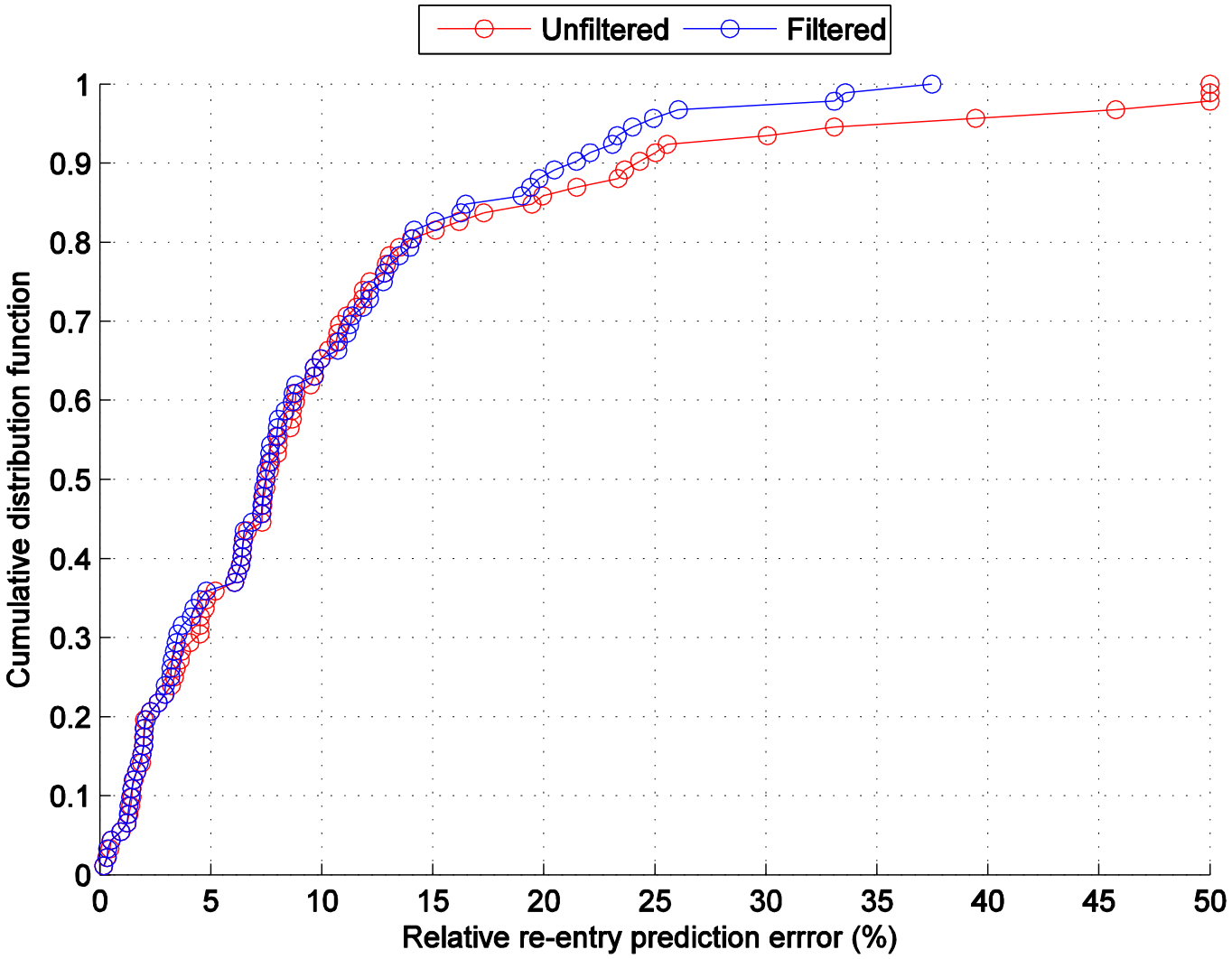
When we filter too many TLEs



When we DO NOT filter TLEs



Importance of filtering



Conclusions and recommendations

- Filtering of the TLEs is key to get good predictions, however it isn't always necessary
- Filter in all orbital elements you're using
- Be wary that the TLEs change with time (2011, 2013…)
- Outliers => robust statistics

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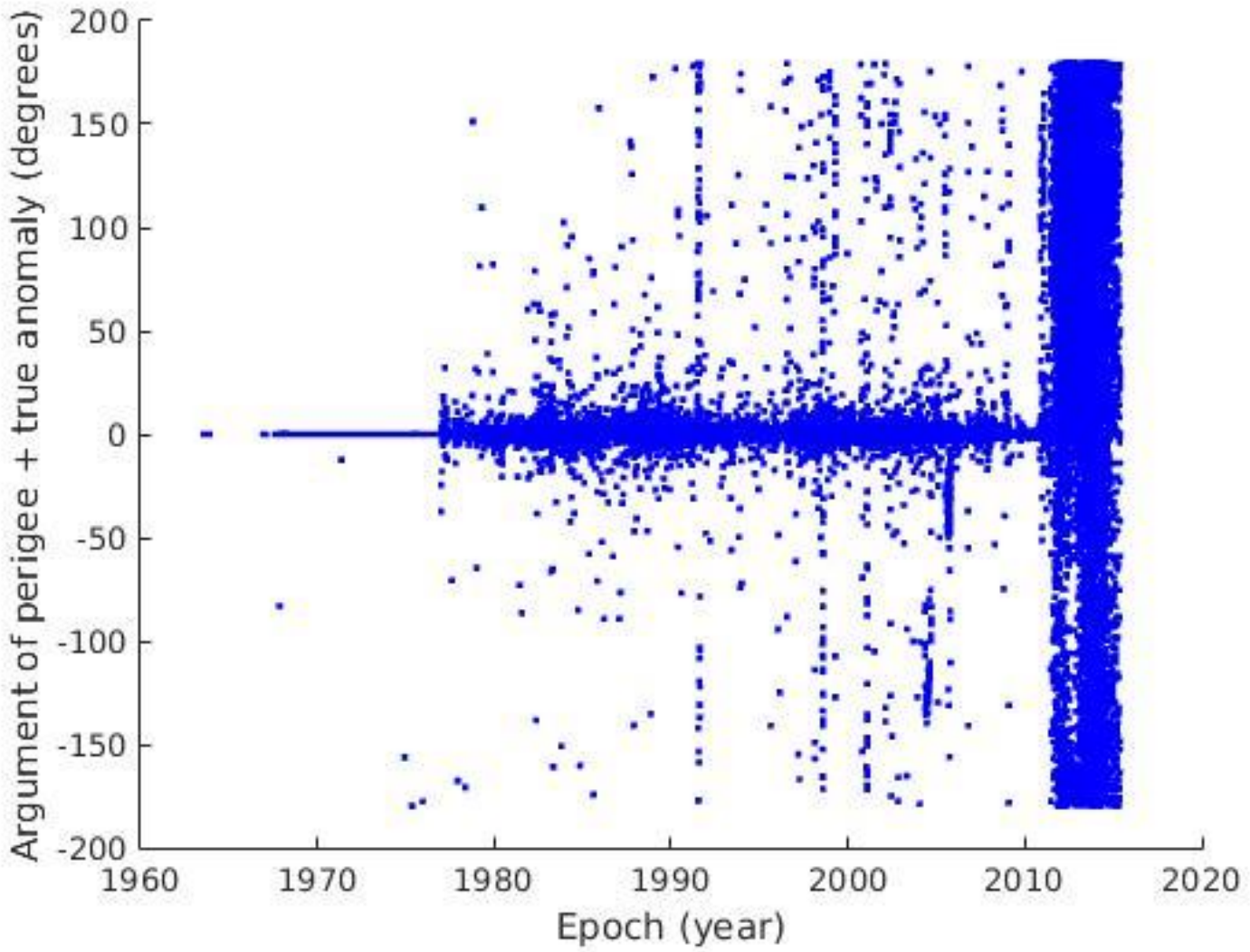
Changes in TLE generation process



Why do we care

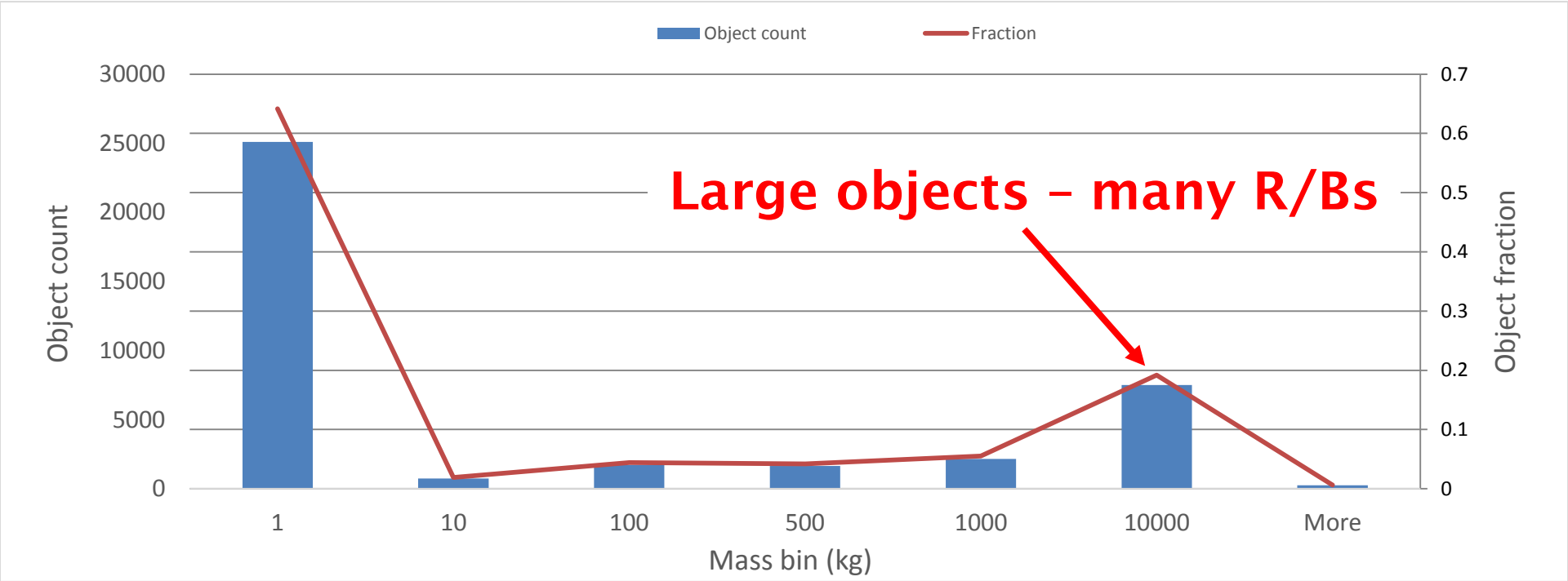
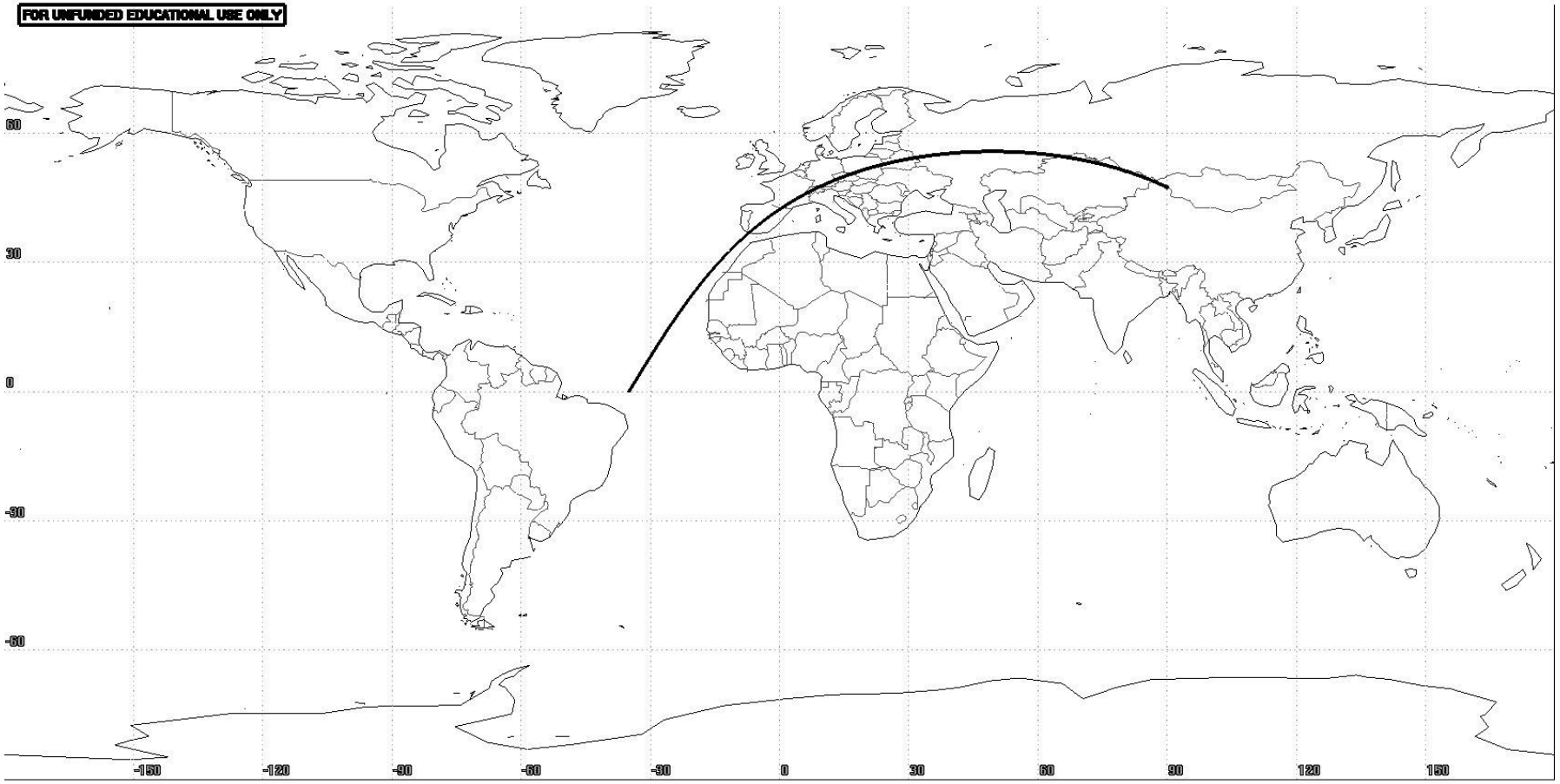


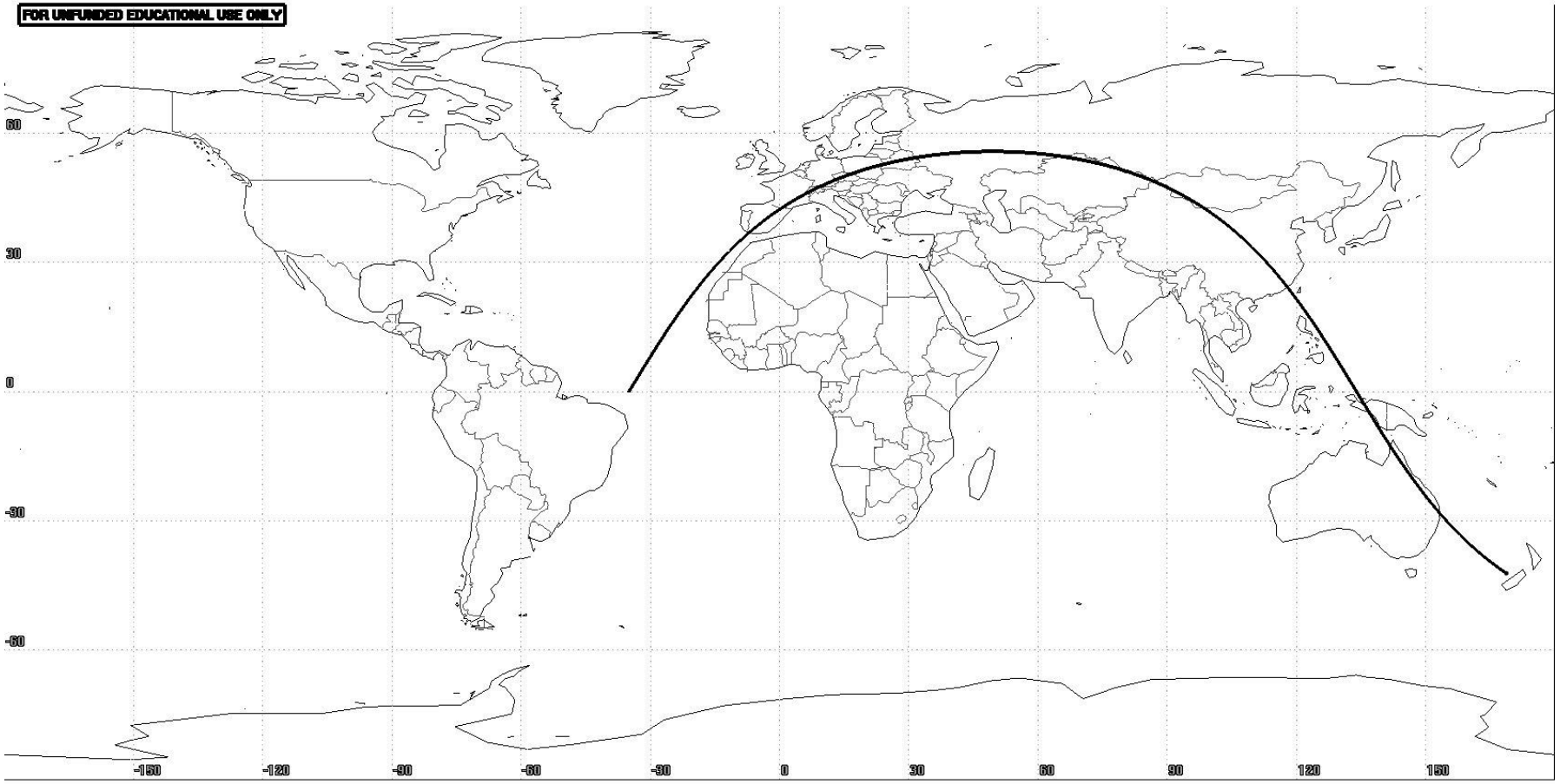
Image credit: NASA

We don’t know the re-entry epoch too well



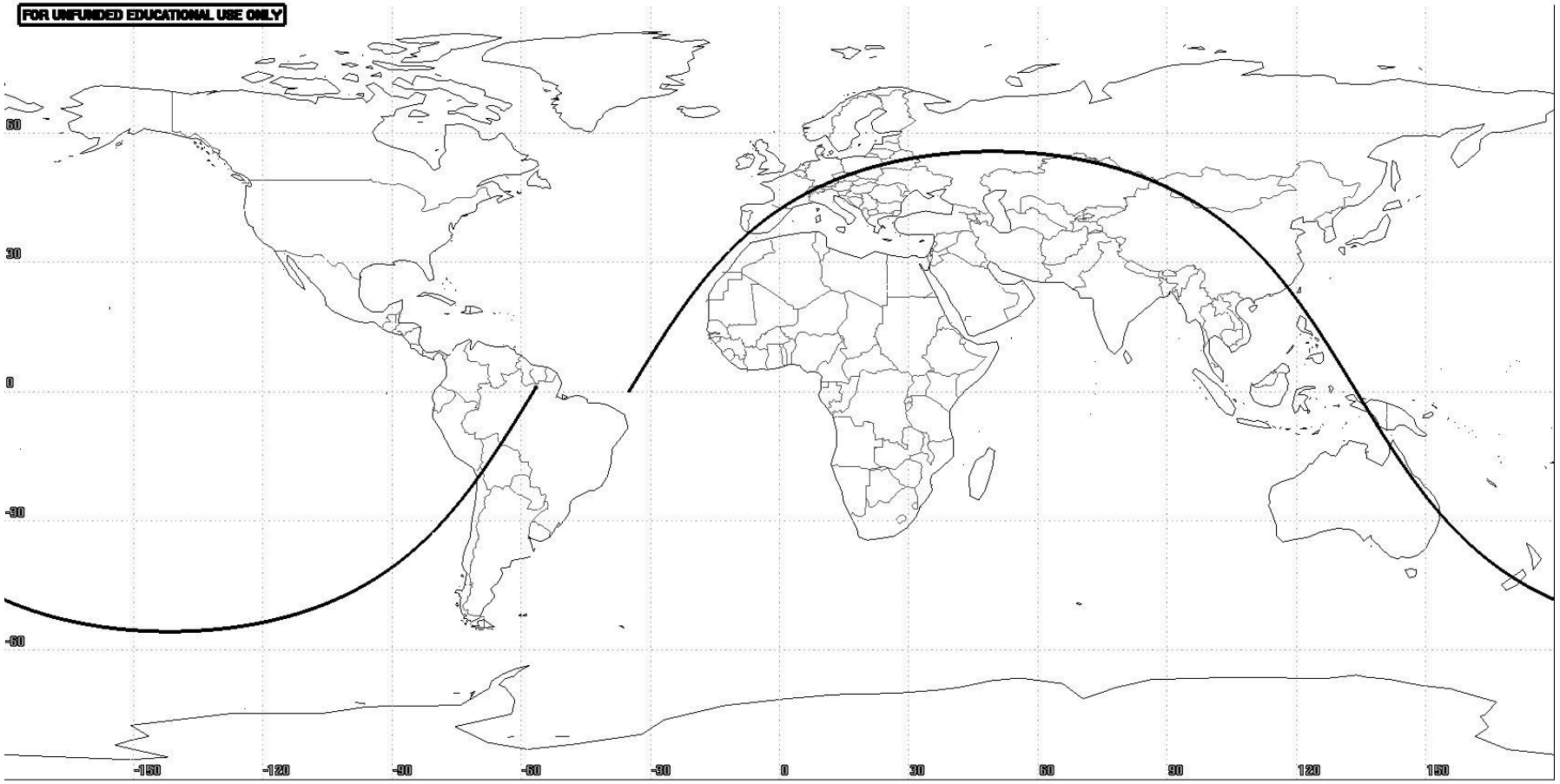
24 hours lead time.

We don’t know the re-entry epoch too well



48 hours lead time.

We don’t know the re-entry epoch too well



74 hours lead time.