

Time bias analysis and prediction: a prototype service

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Content

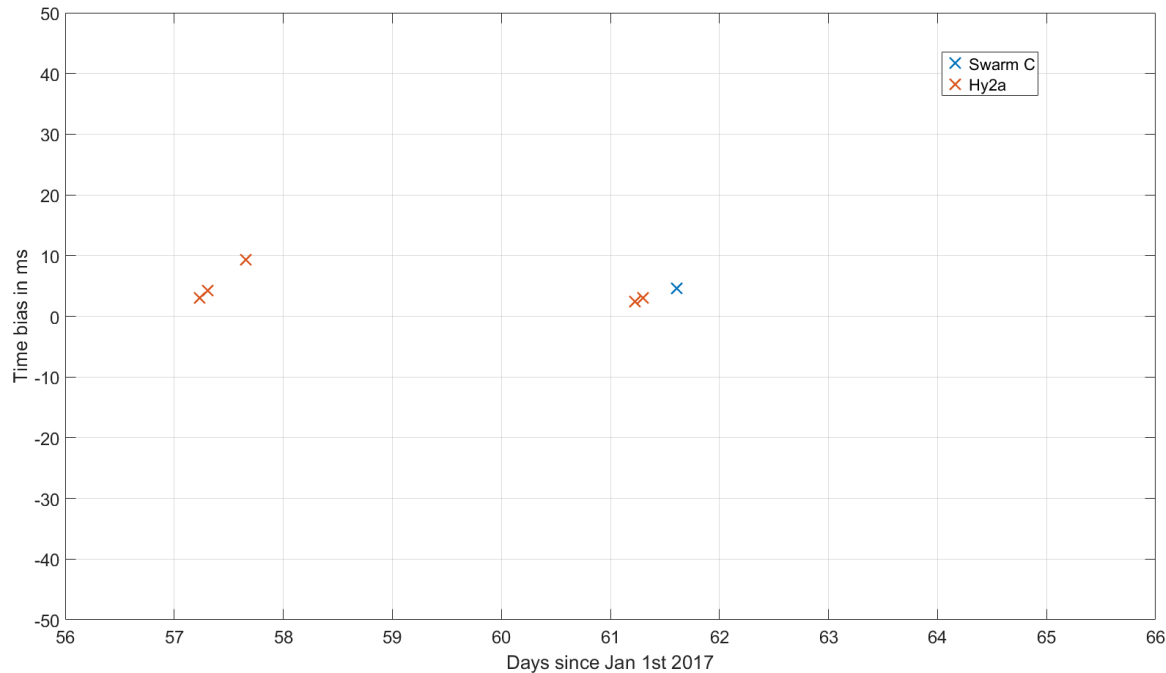
- Prediction quality and time bias
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- Summary

Prediction quality and time bias

- Satellite position prediction quality affects the tracking performance of stations and with that of the network
- Mostly only effects low flyers (e.g. Swarm, Grace, Hy2a, etc.)
- Range biases (RBs) are continuously monitored and distributed via various reports but Time Biases (TBs) are not
- Effect of large TBs
 - Acquisition time increases or satellite cannot be found at all
 - In particular in combination with clouds and other parameters that have to be optimized (Tx beam and Rx telescope pointing, beam divergence, etc.)
- Currently no reports or monitoring service for the TB of predictions and no requirements for prediction providers

Time bias analysis

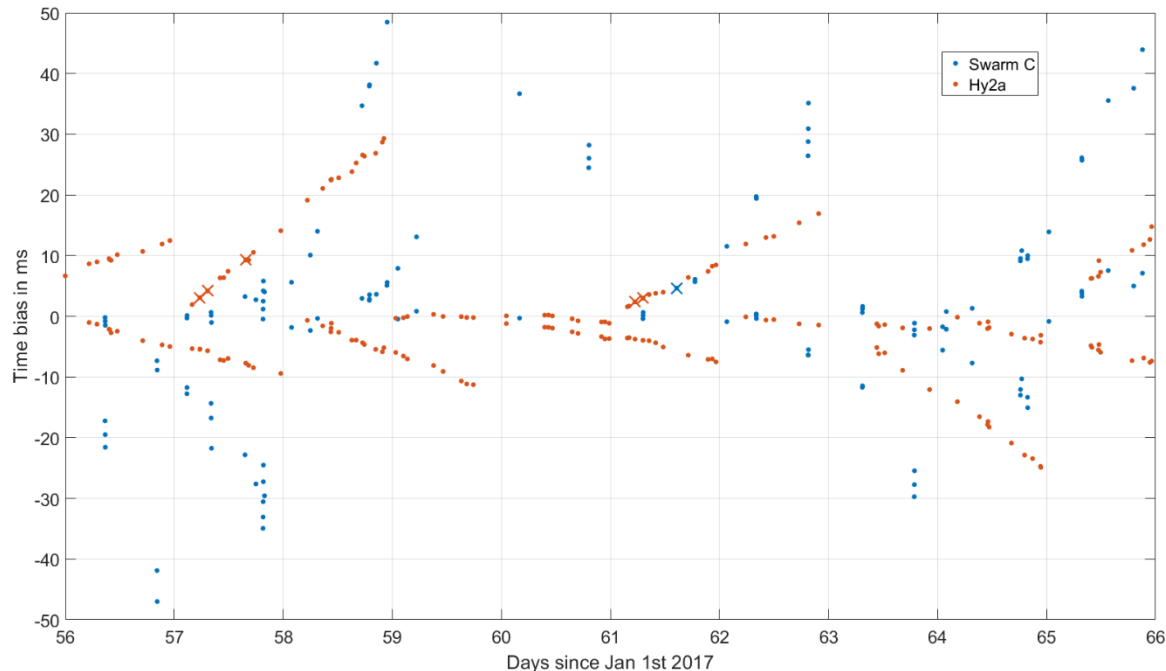
- Our own passes are of course available (FR CRD), but only few
- Concurrent estimation of RB and TB from passes



TB values estimated from passes collected from POT3 station.

Time bias analysis

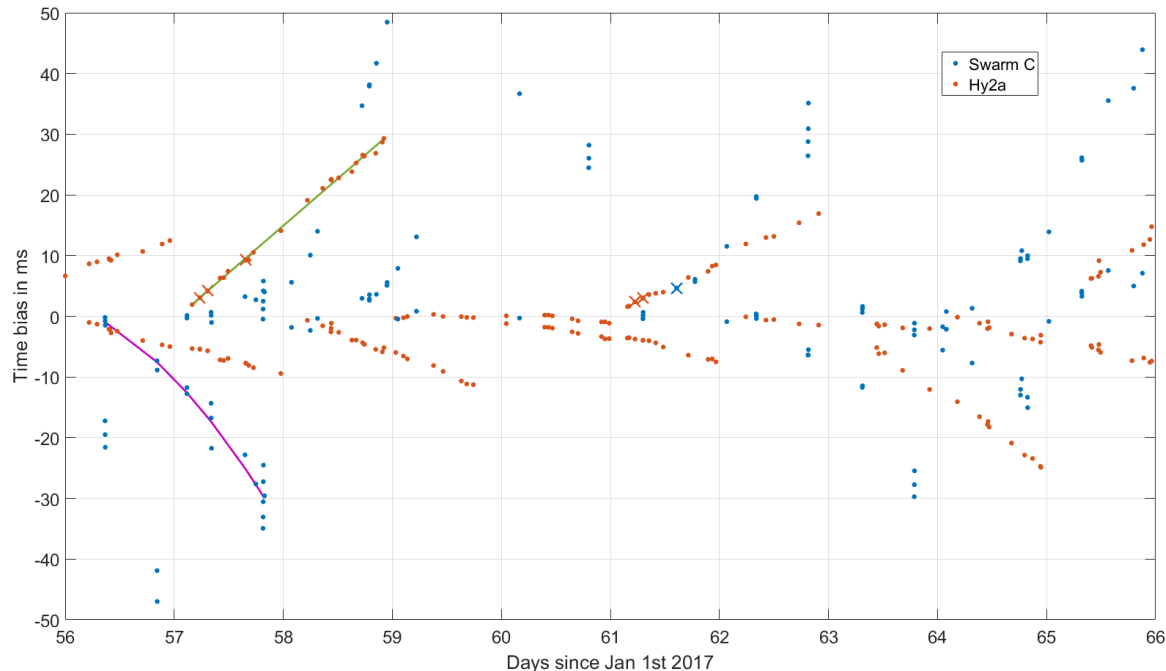
- Our own passes are of course available (FR CRD), but only few
- Concurrent estimation of RB and TB from passes
- EDC database holds passes from stations world wide (NPT CRD)
- Issues: sometimes short passes with a low number of NPs, reduced data rate (FR vs. NPs) and uncombined segments



TB values estimated from passes collected from stations world wide.

Time bias analysis

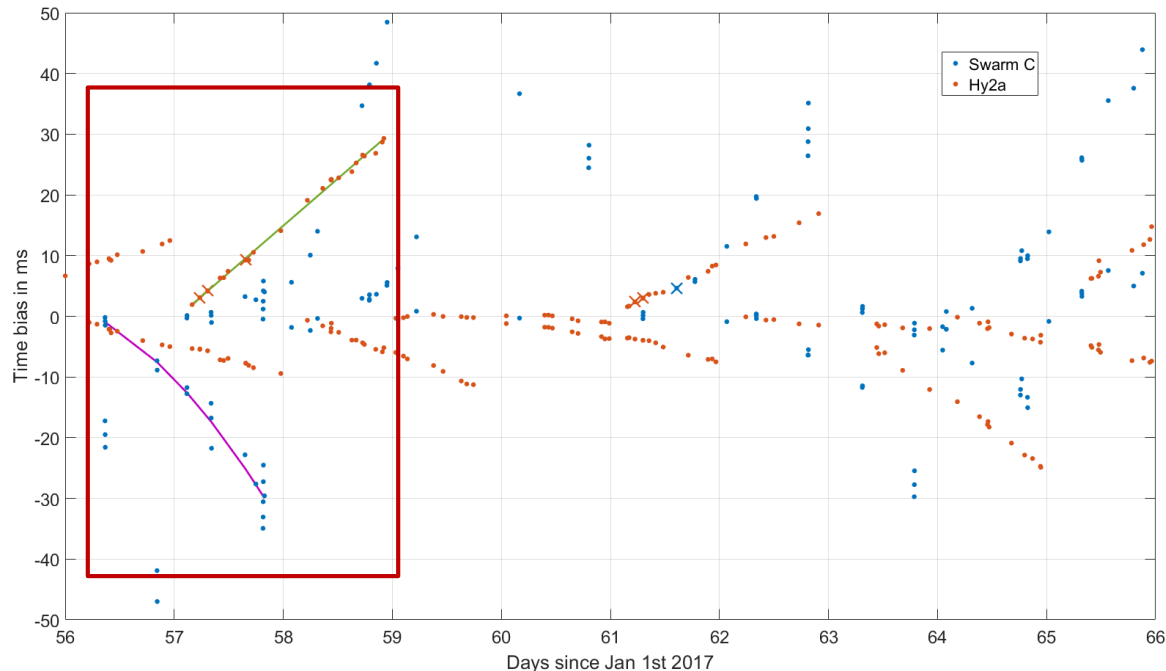
- Typically linear or parabolic trends over time depending on the satellite and the prediction provider
- These fits can be used to predict the TB in real time and to evaluate the quality of the predictions
- Predicted TB values can be used as a priori value during tracking



TB values estimated from passes collected from stations world wide. Fits (1st and 2nd order) are added to the trend of TB values of two predictions.

Time bias analysis

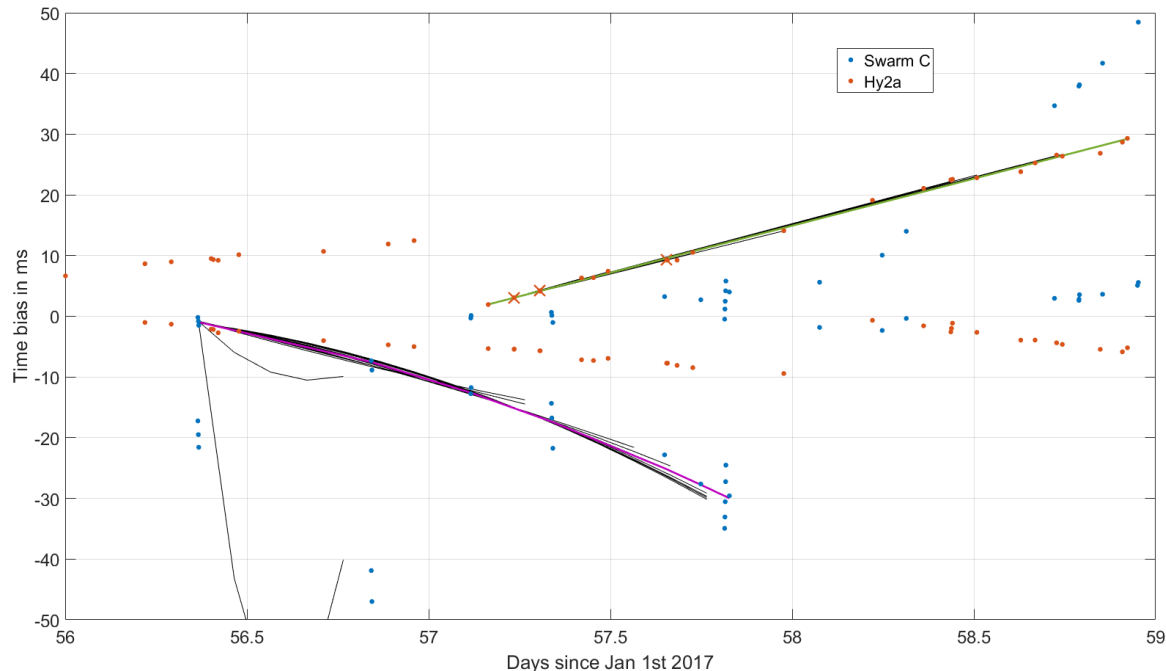
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Time bias prediction

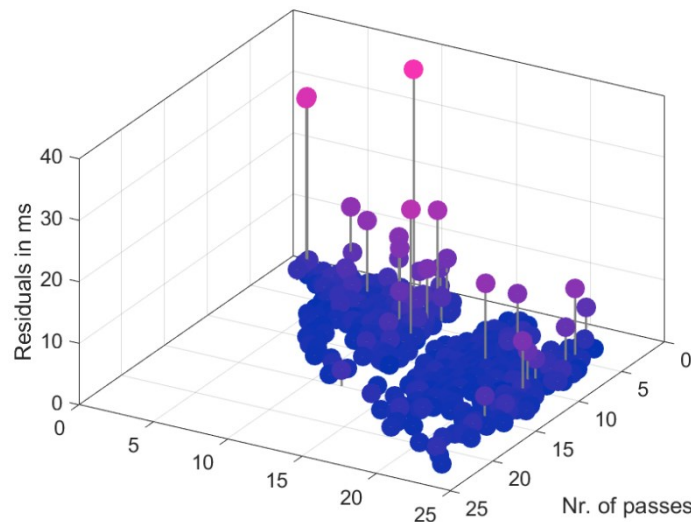
- Fits applied to TB values stepwise from 2/3 ... to all
- Interpolation to the time of the next pass for prediction
- Residual = observed – predicted time bias value
- Check on the prediction performance



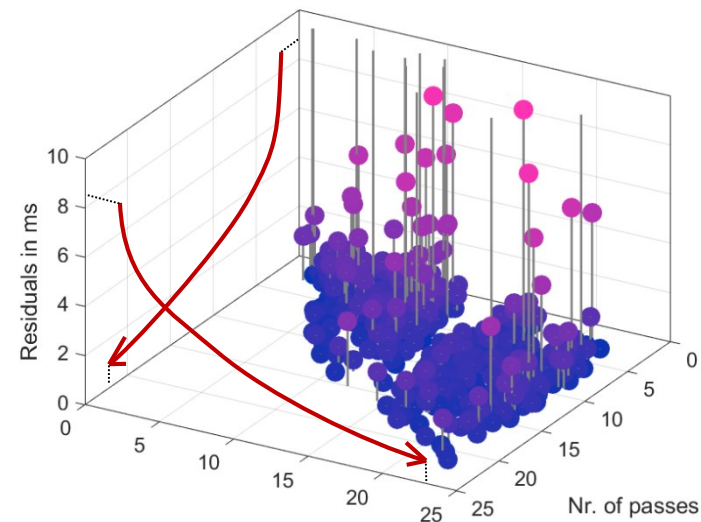
Detail of TB values estimated from passes collected from stations world wide. Stepwise fits (1st and 2nd order) are added to the trend of TB values of two predictions.

Time bias prediction

- Results:
 - With more passes and over time the residuals become smaller with outliers
- But:
 - Time of a pass \neq pass submission time to EDC (after shift vs. after calibration)
- Performance improvement:
 - Reducing pass submission times if possible (e.g. after calibration and not after shift)



Time after prediction start in hours



Time after prediction start in hours

Differences between predicted and actual TB values for Hy2a using a 1st order fit. TB values covering the first 100 days of 2017 were used for this analysis

Prototype service

- Enhanced fitting
 - < 4 TB values -> last TB value is shown
 - < 5 TB values -> first order (linear) fit
 - >= 5 TB values -> second order (parabola) fit
- Currently provided in text format via internal URL which shows
 - the satellites (Swarm, Grace, Cryosat 2, Jason 2&3, Envisat, Topex, Kompsat 5, ...)
 - the prediction (various providers)
 - the number of passes currently available for fitting
 - overall RMS of the former values to the fit

Target	Provider	HTS7491	HTS7481	HTS7471	ESA7471
beaconc	HTS	1.0 (0.3 / # 13)	-12.4 (0.6 / # 31)	14.2 (0.7 / # 29)	
	SGF	SGF7501	SGF7491	SGF7481	
cryosat2	ESA	-0.1 (0.0 / # 12)	5.4 (0.1 / # 31)	13.1 (0.1 / # 29)	
	HTS	ESA7501	ESA7491	ESA7481	-30.8 (0.2 / # 31)
envisat	AAS	HTS7491	HTS7481	HTS7471	
	DLR	2.3 (0.2 / # 10)	-9.5 (0.8 / # 22)	-11.9 (1.0 / # 31)	
GFZ	AAS	AAS7491	AAS7481		
	DLR	-1.6 (NaN / # 3)	2.1 (0.4 / # 8)		
GFZ	DLR	DLR7491	DLR7481	DLR7471	
	GFZ	2.6 (NaN / # 3)	9.7 (0.6 / # 8)	13.3 (0.6 / # 11)	
GFZ	GFZ	GFZ7502	GFZ7501	GFZ7493	GFZ7492
	GFZ	0.2 (NaN / # 1)	1.1 (NaN / # 1)	0.0 (NaN / # 2)	232.8 (NaN / # 2)

Screenshot of the current status of the TB prediction service.

Prototype service

- Even with outliers in the prediction of the TB values the information about the sign (+/-) and/or the magnitude helped because
 - Faster and easier acquisition of targets
 - More passes with more data/NPs
- Required for autonomous operation in particular with multiple parameters that have to be optimized
- In future a graphical representation shall be included in the service
 - Better evaluation of the data distribution
 - Better evaluation of the fit quality
 - Better evaluation of the potential quality of the predicted value

Summary

- Satellite position prediction quality affects station and network performance in particular for low flying satellites
- Range biases are monitored & reported, time biases are not
- Passes from stations world wide retrieved via the EDC database Api allow to monitor the time bias trend of predictions
- Time biases can be predicted continuously and in real time
- Currently a text based prototype service that improved POT3 performance which could be made publically available
- Prediction becomes better with time and more passes
- Stations interested in using this service could help improving the performance by quickly submitting relevant passes to EDC
- Monitoring prediction quality, improving the network productivity and maybe deriving requirements for providers

Thank you for your attention!