

## Calibration results

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### Normalized Residuals

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Reprojection error (cam0): mean 0.201123025904, median 0.171551281451, std: 0.141000376483  
Reprojection error (cam1): mean 0.200232851709, median 0.166932413607, std: 0.155339245678  
Gyroscope error (imu0): mean 2.14927696331, median 1.9552005514, std: 1.30493371613  
Accelerometer error (imu0): mean 3.86435095156, median 3.53817144345, std: 1.92915432222  
Gyroscope error (imu1): mean 2.10153792663, median 1.90017332682, std: 1.22075674856  
Accelerometer error (imu1): mean 3.96677870762, median 3.64765765566, std: 1.98236765639

### Residuals

-----

Reprojection error (cam0) [px]: mean 0.201123025904, median 0.171551281451, std: 0.141000376483  
Reprojection error (cam1) [px]: mean 0.200232851709, median 0.166932413607, std: 0.155339245678  
Gyroscope error (imu0) [rad/s]: mean 0.00412105886901, median 0.00374893357654, std: 0.00250210129086  
Accelerometer error (imu0) [m/s<sup>2</sup>]: mean 0.185653651434, median 0.169983124233, std: 0.0926816815011  
Gyroscope error (imu1) [rad/s]: mean 0.0040295232578, median 0.00364342347443, std: 0.00234069899387  
Accelerometer error (imu1) [m/s<sup>2</sup>]: mean 0.190574552035, median 0.175243131756, std: 0.0952381909684

### Transformation (cam0):

-----

T\_ci: (imu0 to cam0):

```
[[-0.99992177  0.00101728 -0.01246679 -0.002861 ]  
 [-0.00095182 -0.99998573 -0.00525591  0.00195351]  
 [-0.01247196 -0.00524363  0.99990847 -0.007899 ]  
 [ 0.         0.         0.         1.         ]]
```

T\_ic: (cam0 to imu0):

```
[[-0.99992177 -0.00095182 -0.01247196 -0.00295743]  
 [ 0.00101728 -0.99998573 -0.00524363  0.00191498]  
 [-0.01246679 -0.00525591  0.99990847  0.00787287]  
 [ 0.         0.         0.         1.         ]]
```

timeshift cam0 to imu0: [s] (t\_imu = t\_cam + shift)  
-0.00437394732453

### Transformation (cam1):

-----

T\_ci: (imu0 to cam1):  
[[-0.99994846 -0.00718941 -0.007169 0.05516194]  
[ 0.00722675 -0.99996039 -0.00519591 0.00147901]  
[-0.00713136 -0.00524745 0.9999608 -0.00778967]  
[ 0. 0. 0. 1. ]]

T\_ic: (cam1 to imu0):  
[[-0.99994846 0.00722675 -0.00713136 0.05509286]  
[-0.00718941 -0.99996039 -0.00524745 0.00183465]  
[-0.007169 -0.00519591 0.9999608 0.0081925 ]  
[ 0. 0. 0. 1. ]]

timeshift cam1 to imu0: [s] ( $t_{imu} = t_{cam} + \text{shift}$ )  
-0.00436507885593

Baselines:

-----  
Baseline (cam0 to cam1):  
[[ 0.99995229 0.00817876 0.00534067 0.05804901]  
[-0.00817865 0.99996655 -0.00004214 -0.00049818]  
[-0.00534084 -0.00000154 0.99998574 0.00009394]  
[ 0. 0. 0. 1. ]]  
baseline norm: 0.0580512223984 [m]

Gravity vector in target coords: [m/s<sup>2</sup>]  
[-0.03266627 -0.02454238 -9.80646488]

Calibration configuration

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cam0

-----

Camera model: pinhole  
Focal length: [728.1770031250996, 727.3894701751576]  
Principal point: [414.2942514149049, 255.7069141355465]  
Distortion model: radtan  
Distortion coefficients: [0.20762555146236308, -0.4955749497837143, -0.0002779881885316375, 0.003545685007027422]  
Type: aprilgrid

Tags:  
Rows: 6  
Cols: 6  
Size: 0.041 [m]  
Spacing 0.0123 [m]

cam1

-----  
Camera model: pinhole  
Focal length: [727.1725137449881, 726.8115675278939]  
Principal point: [356.92923618674763, 243.8586245220697]  
Distortion model: radtan  
Distortion coefficients: [0.22398500804238267, -0.5963532686811098, -6.387822740689075e-05, 0.0006764963105578315]  
Type: aprilgrid  
Tags:  
Rows: 6  
Cols: 6  
Size: 0.041 [m]  
Spacing 0.0123 [m]

IMU configuration  
=====

IMU0:

-----  
Model: scale-misalignment  
Update rate: 460.0  
Accelerometer:  
Noise density: 0.00224  
Noise density (discrete): 0.0480426477205  
Random walk: 7.53e-05  
Gyroscope:  
Noise density: 8.94e-05  
Noise density (discrete): 0.0019174163867  
Random walk: 2.66e-05  
T\_i\_b  
[[ 1. 0. 0. 0.]

```
[ 0. 1. 0. 0.]
[ 0. 0. 1. 0.]
[ 0. 0. 0. 1.]]
time offset with respect to IMU0: 0.0 [s]
Gyroscope:
M:
[[ 1.33883784 0.      0.      ]
 [ 0.00238961 1.34266677 0.      ]
 [-0.00264221 -0.00598647 1.31035403]]
A [(rad/s)/(m/s^2)]:
[[ 0.00032575 0.00095191 0.00017915]
 [-0.00030269 -0.0001023 0.00003899]
 [-0.00111571 -0.00024241 -0.0000907 ]]
C_gyro_i:
[[ 0.99996104 0.00067951 0.00880097]
 [-0.00064303 0.99999119 -0.00414736]
 [-0.00880371 0.00414154 0.99995267]]
Accelerometer:
M:
[[ 4.21173889 0.      0.      ]
 [ 0.00117534 4.21914951 0.      ]
 [-0.03466983 0.03086039 4.17703728]]
```

IMU1:

```
-----
Model: scale-misalignment
Update rate: 460.0
Accelerometer:
Noise density: 0.00224
Noise density (discrete): 0.0480426477205
Random walk: 7.53e-05
Gyroscope:
Noise density: 8.94e-05
Noise density (discrete): 0.0019174163867
Random walk: 2.66e-05
T_i_b
[[-0.99995283 -0.00964178 -0.00117019 0.05991194]
 [ 0.00966189 -0.99978013 -0.01861041 -0.00115093]
 [-0.0009905 -0.01862083 0.99982613 -0.00005047]
 [ 0.      0.      0.      1.      ]]
```

time offset with respect to IMU0: 0.0 [s]

Gyroscope:

M:

```
[[ 1.34014965 0.      0.      ]
 [ 0.00228146 1.33950425 0.      ]
 [-0.00429039 -0.01317476 1.31190156]]
```

A [(rad/s)/(m/s<sup>2</sup>)]:

```
[[ 0.0004654 0.00093046 -0.00017125]
 [-0.00028152 0.00002639 0.0000792 ]
 [ 0.00123686 0.00026002 -0.00007466]]
```

C\_gyro\_i:

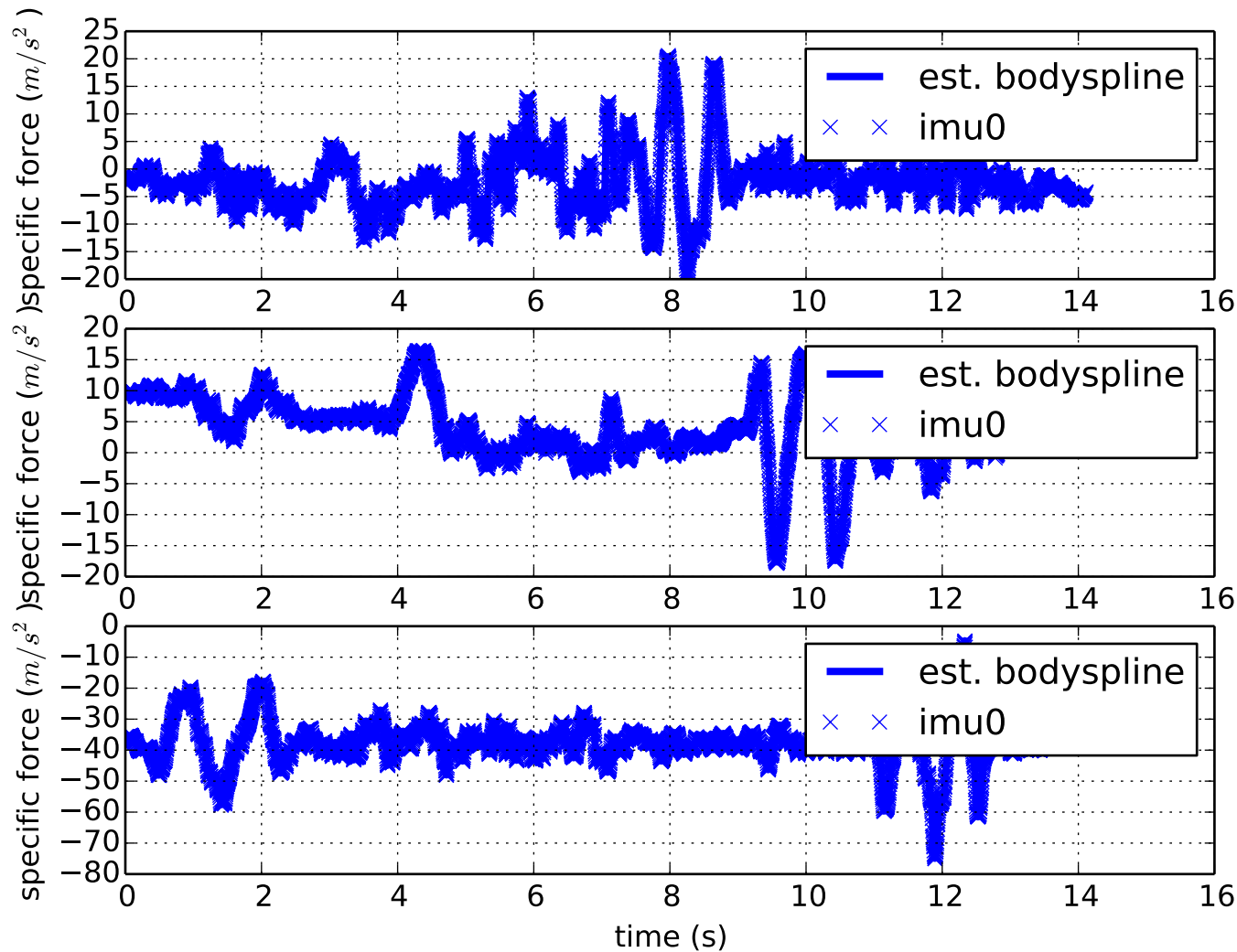
```
[[ 0.99999165 0.00063932 -0.00403747]
 [-0.00062889 0.99999647 0.00258276]
 [ 0.0040391 -0.0025802 0.99998851]]
```

Accelerometer:

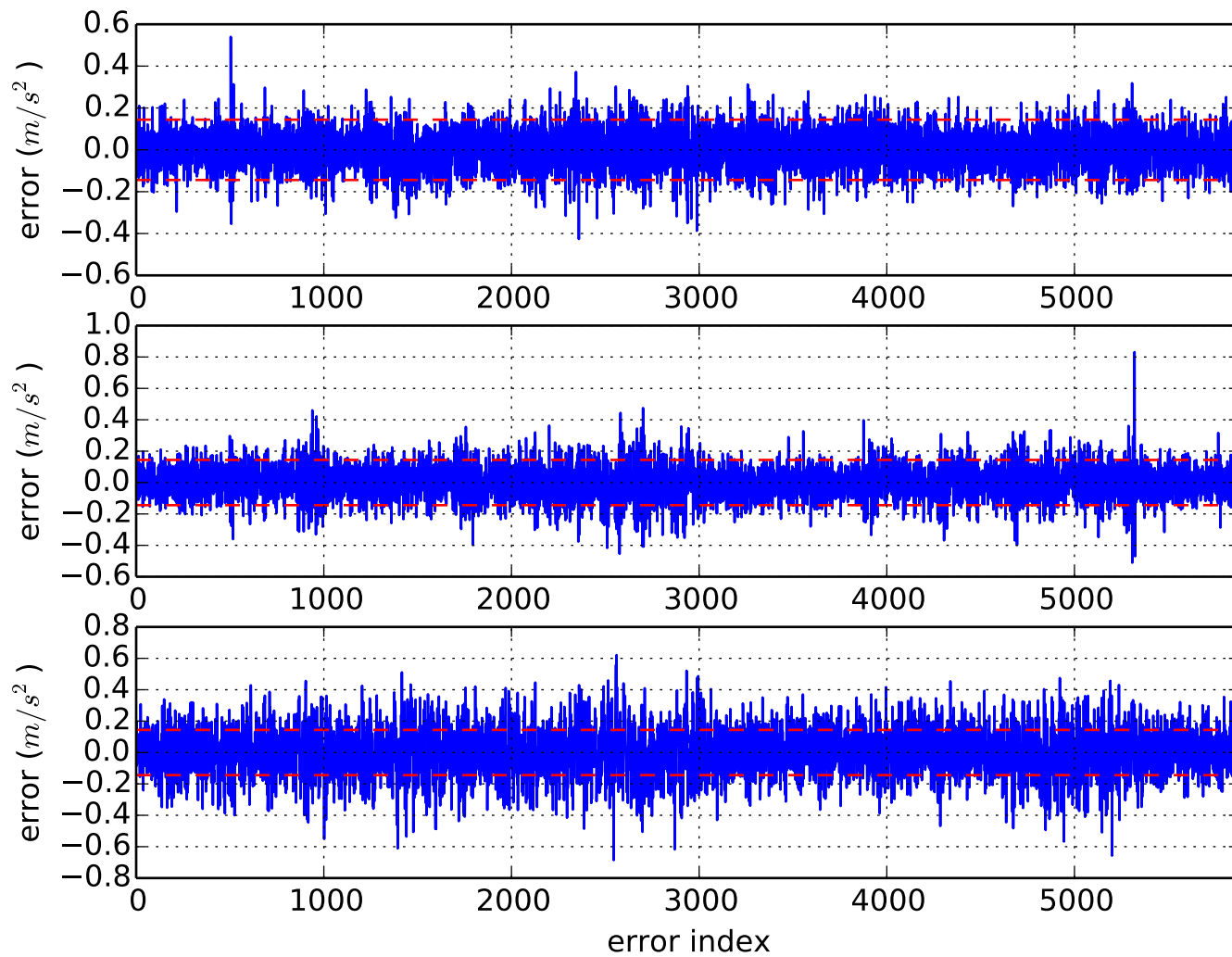
M:

```
[[ 4.20724368 0.      0.      ]
 [ 0.0149163 4.22496053 0.      ]
 [ 0.00766314 -0.05685492 4.17532787]]
```

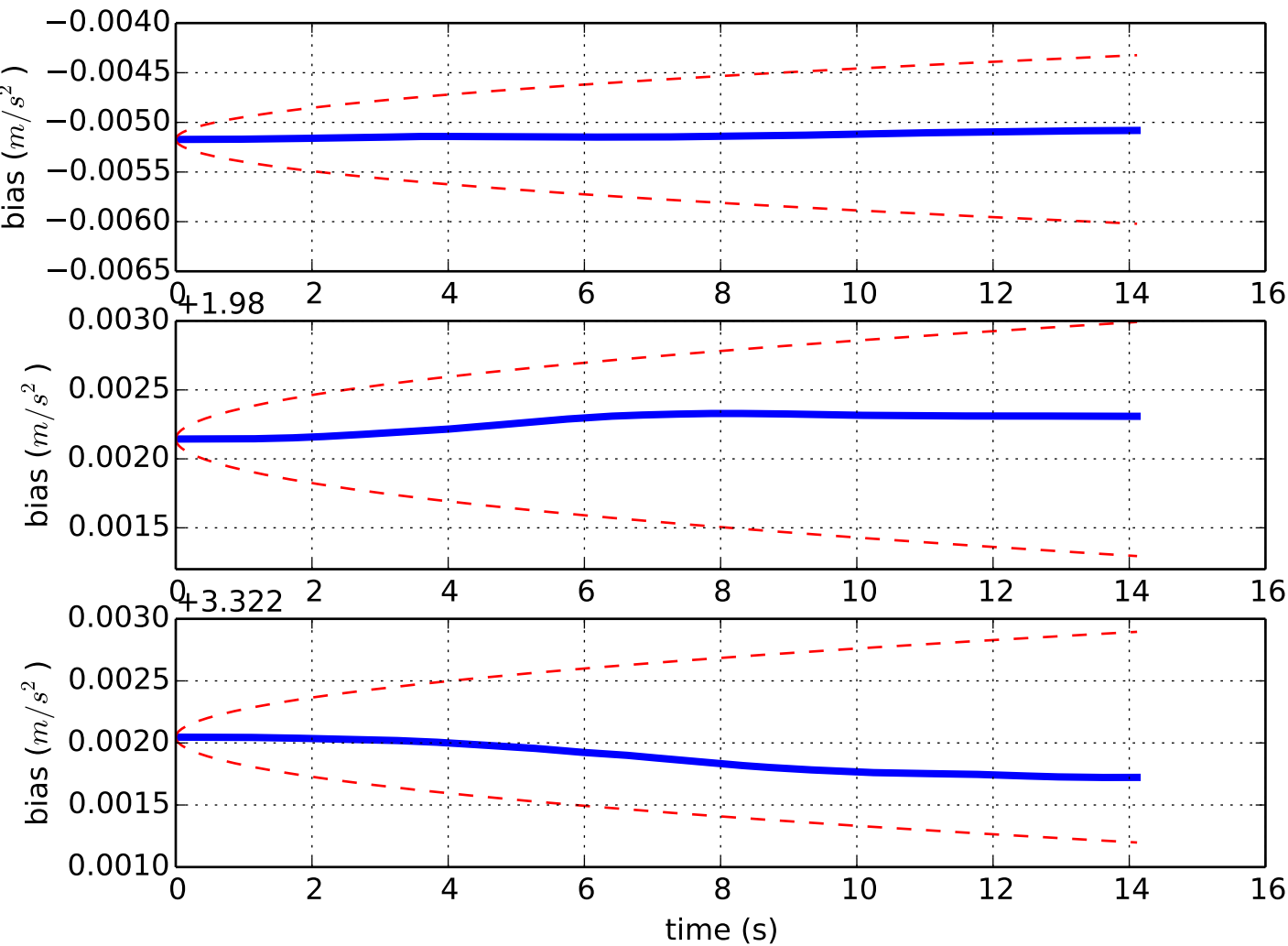
Comparison of predicted and measured specific force (imu0 frame)



imu0: acceleration error

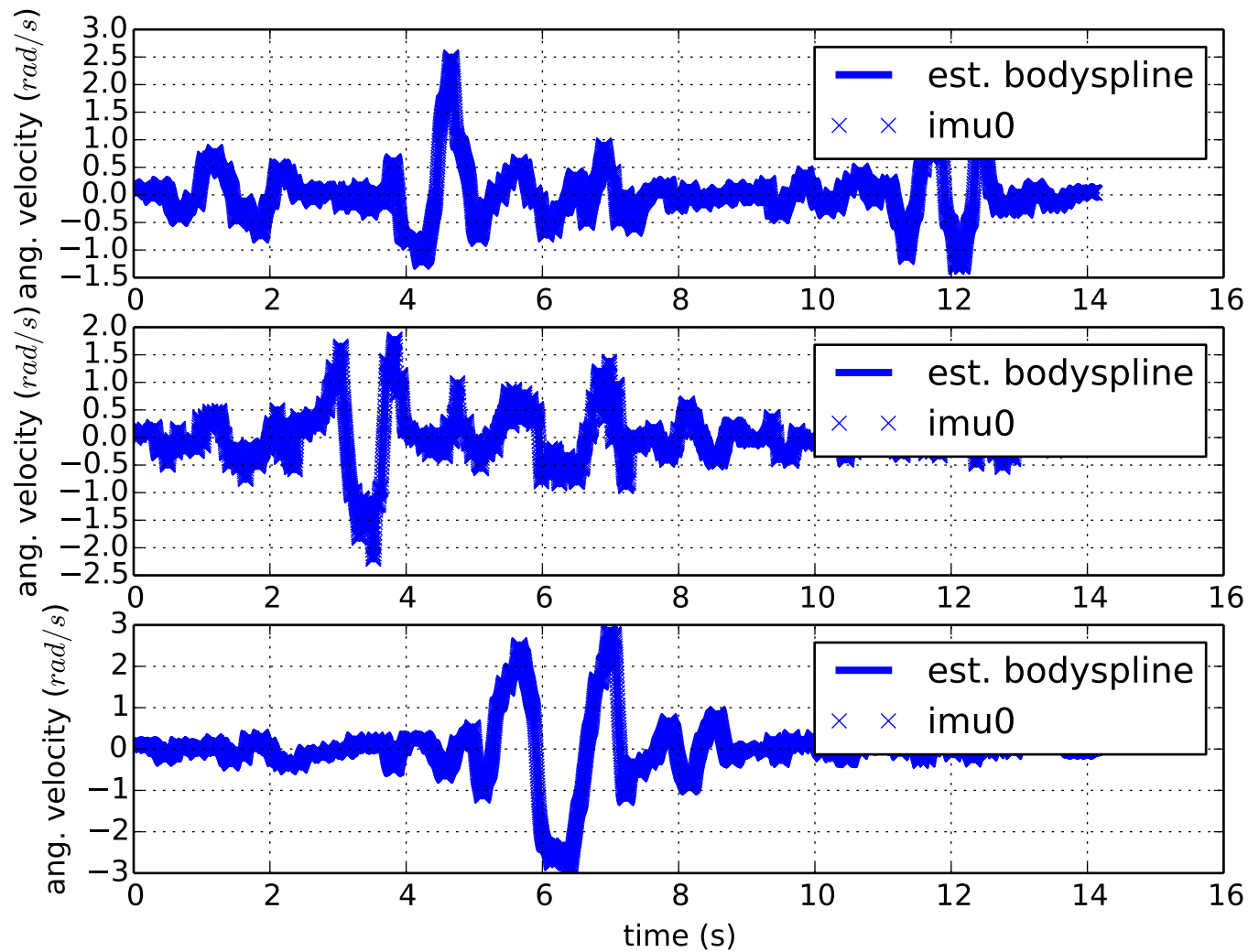


imu0: estimated accelerometer bias (imu frame)

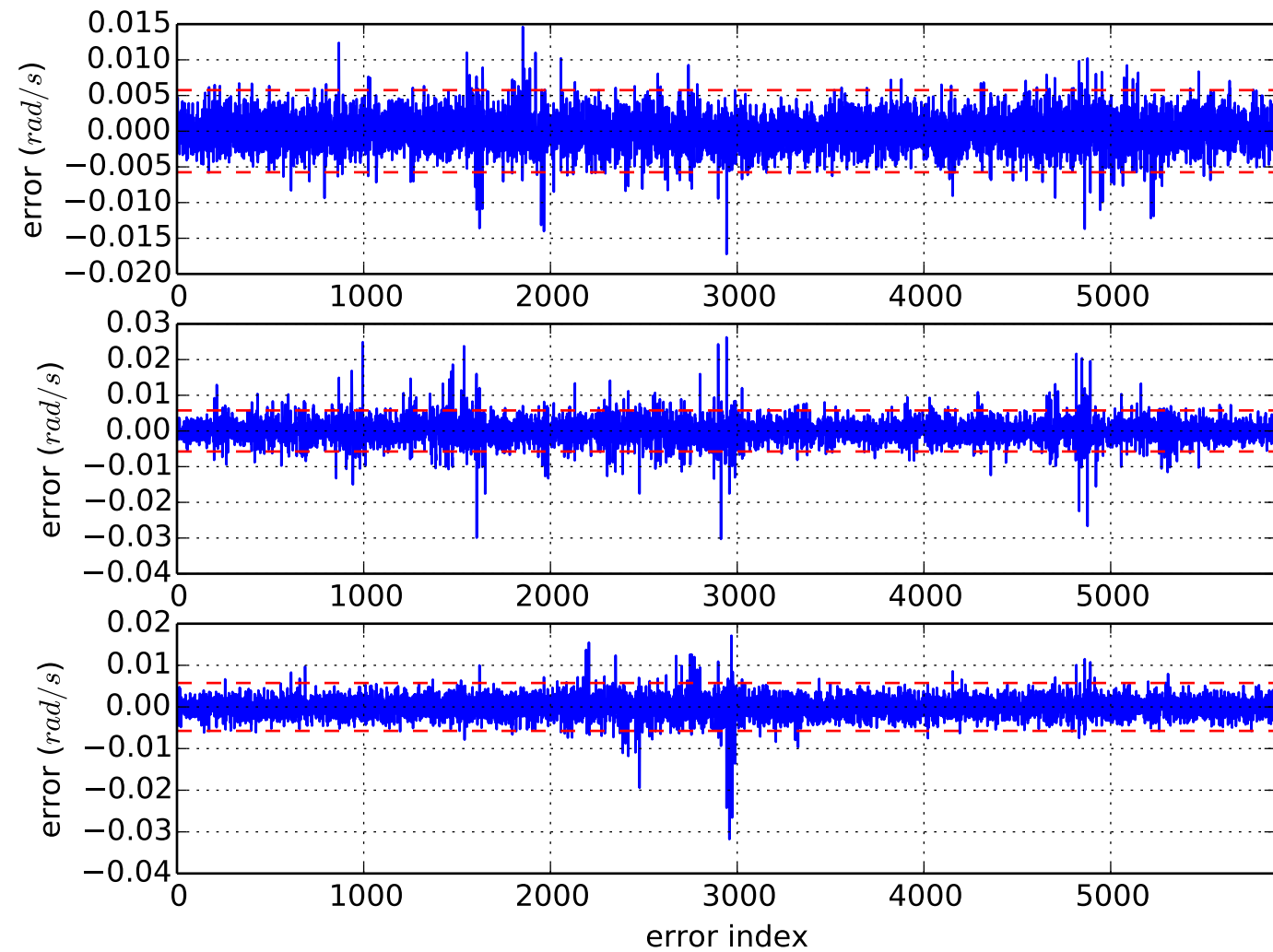




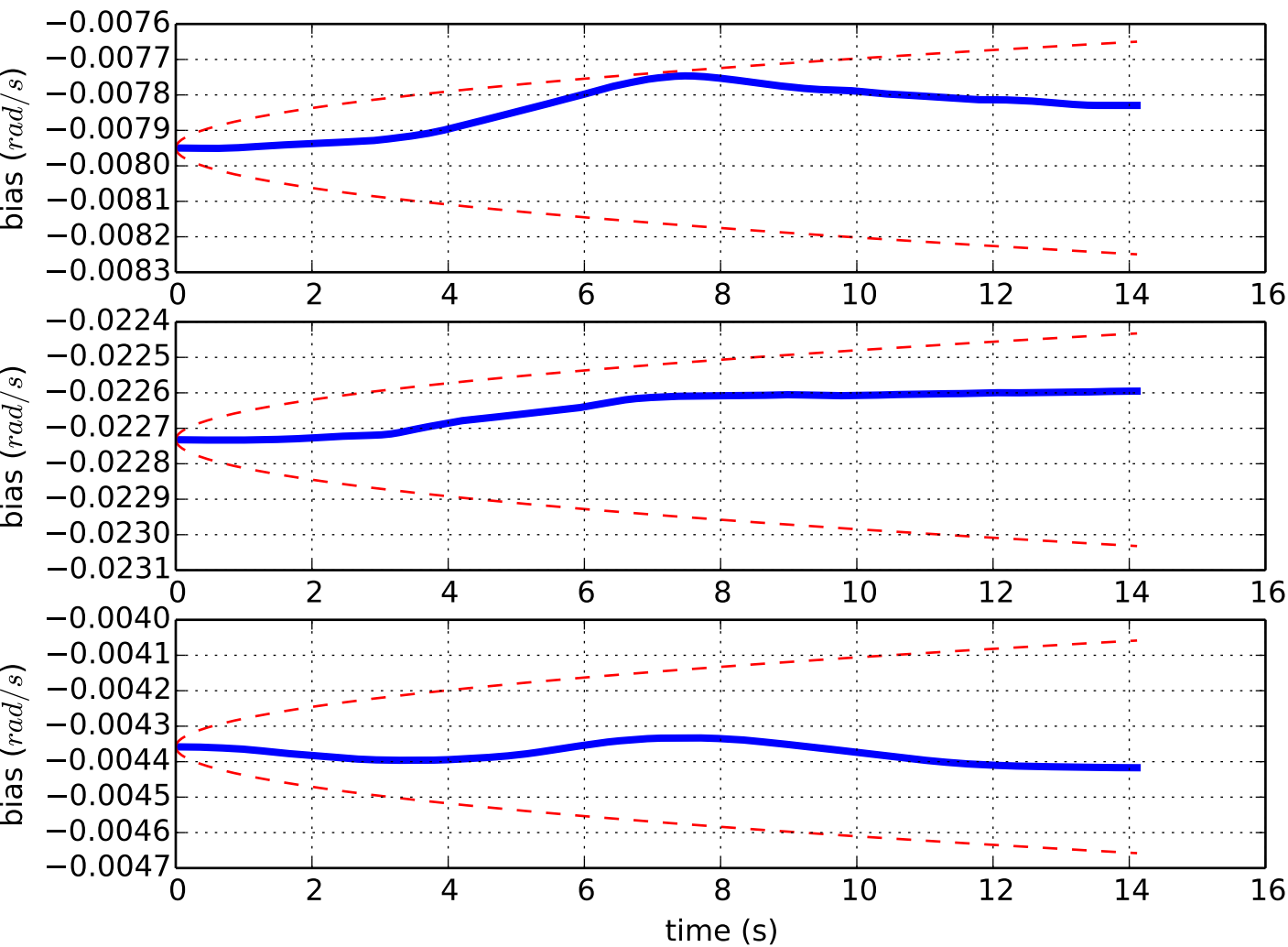
Comparison of predicted and measured angular velocities (body frame)



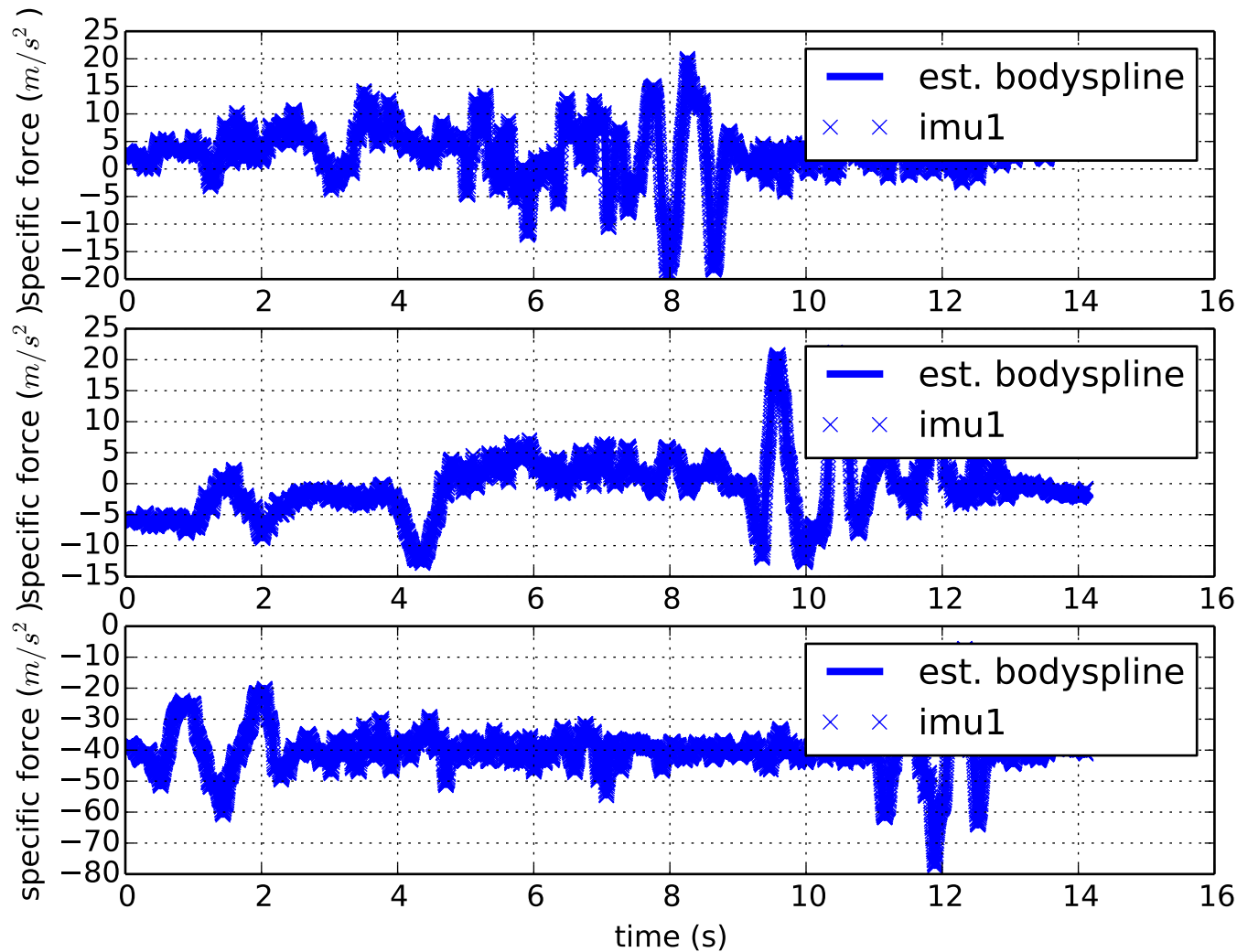
imu0: angular velocities error



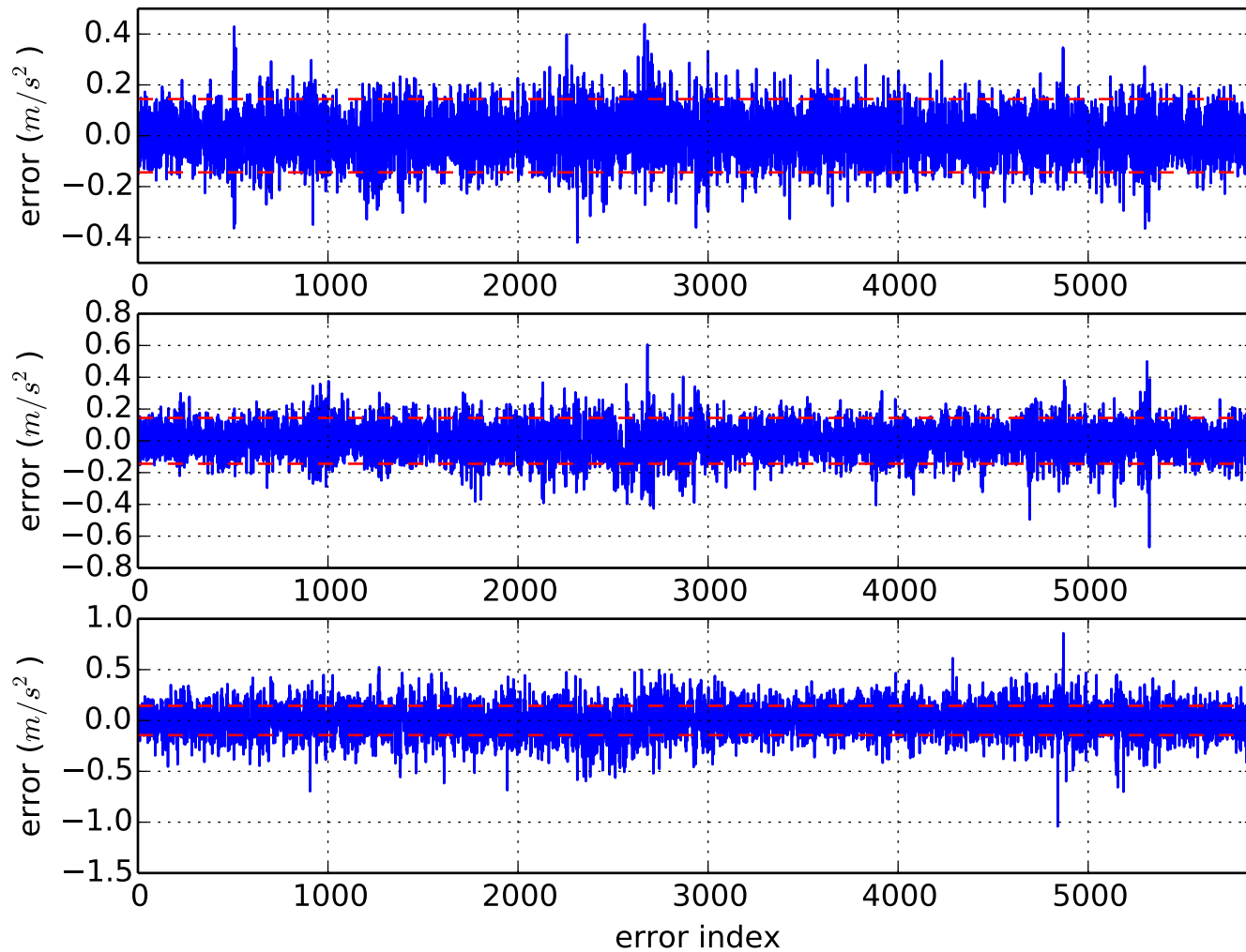
imu0: estimated gyro bias (imu frame)



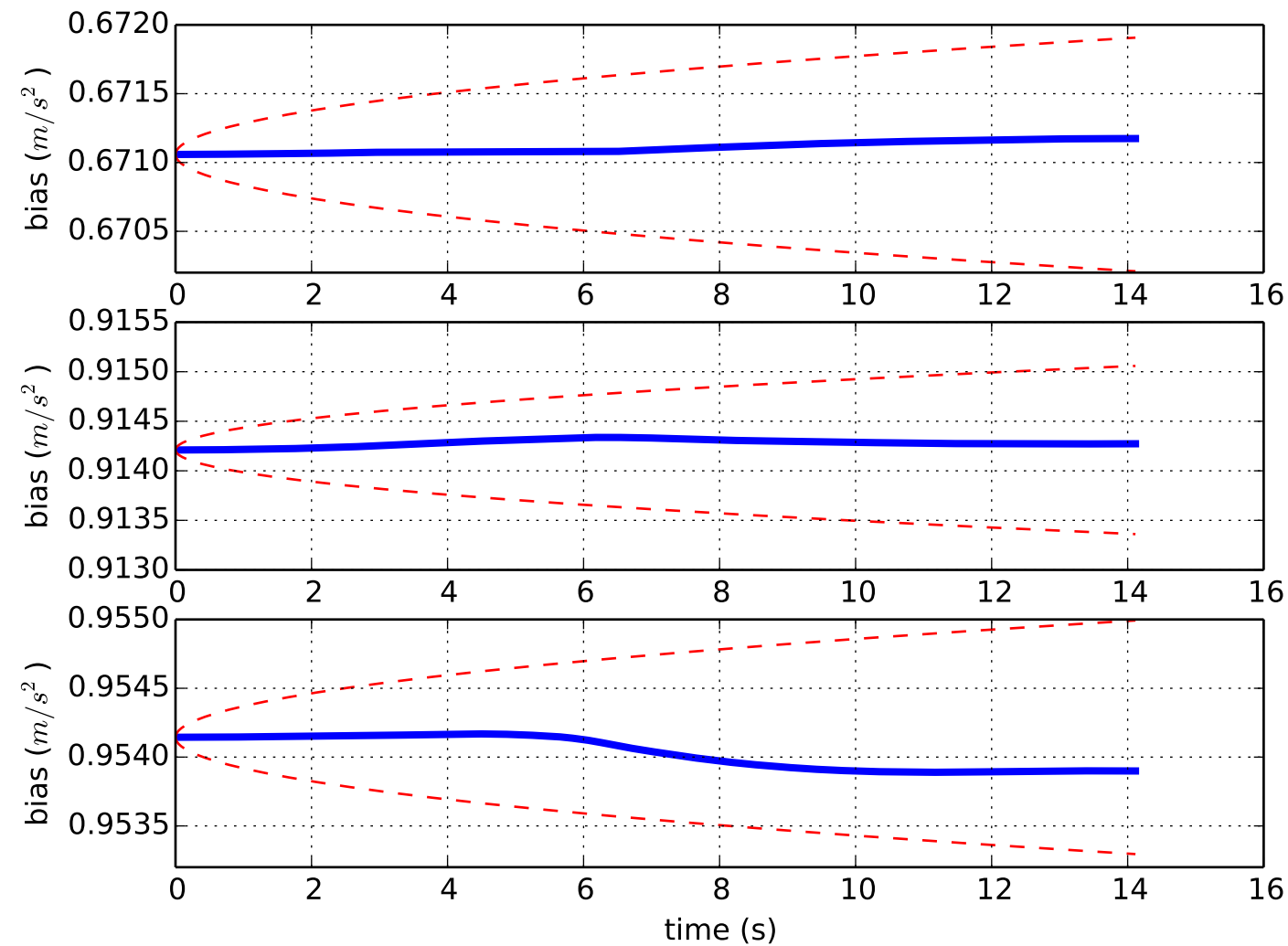
Comparison of predicted and measured specific force (imu0 frame)



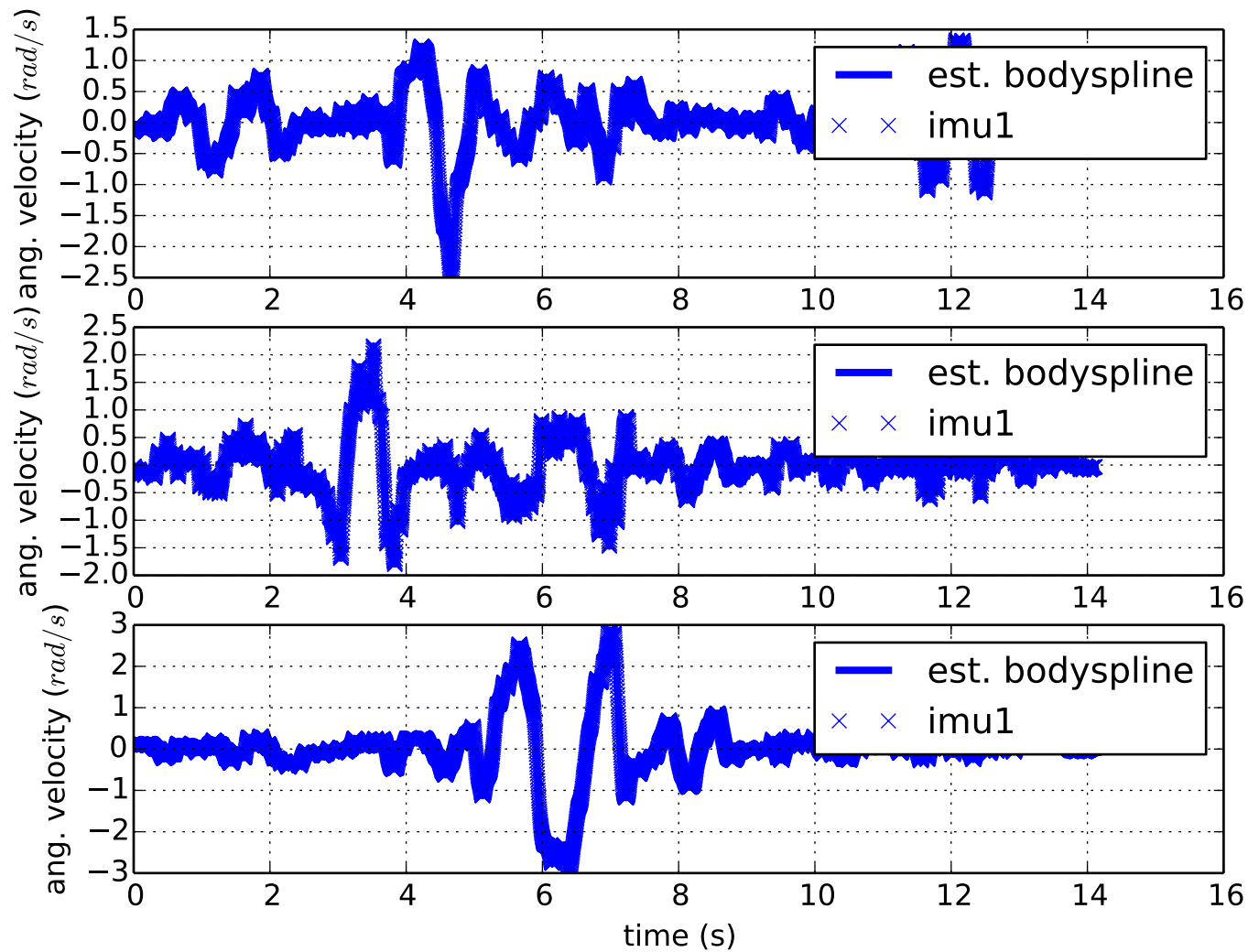
imu1: acceleration error



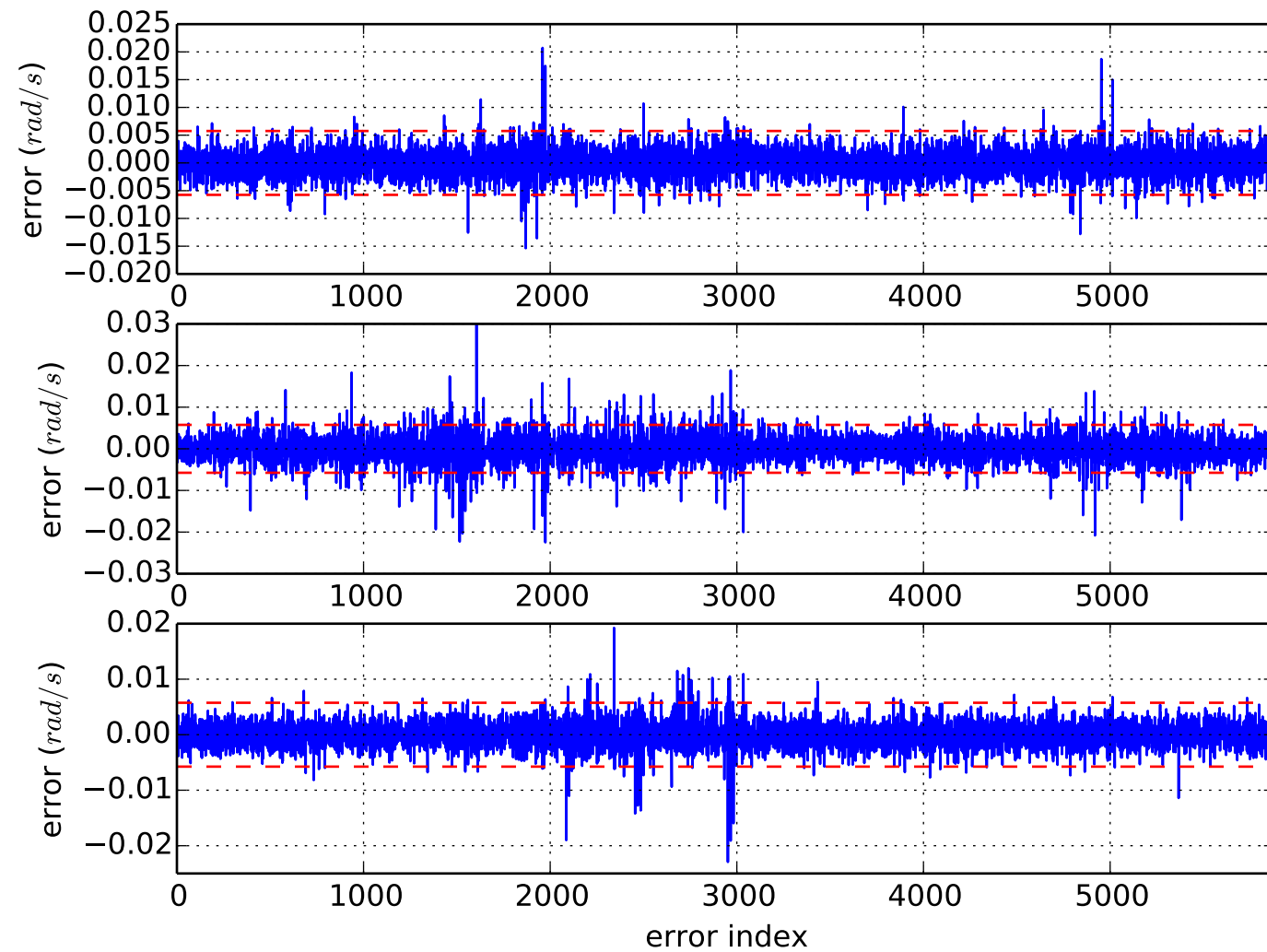
imu1: estimated accelerometer bias (imu frame)



Comparison of predicted and measured angular velocities (body frame)

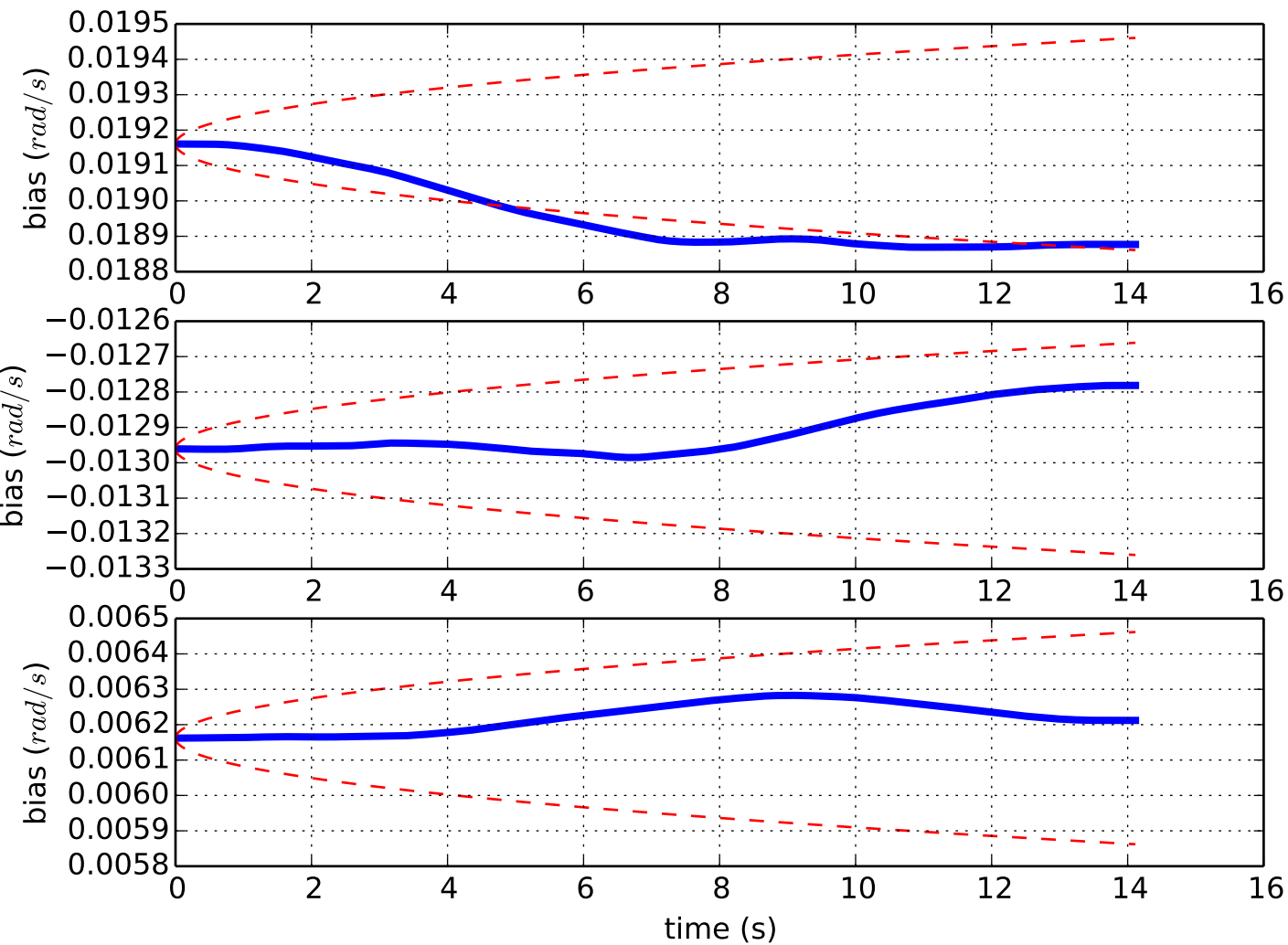


imu1: angular velocities error

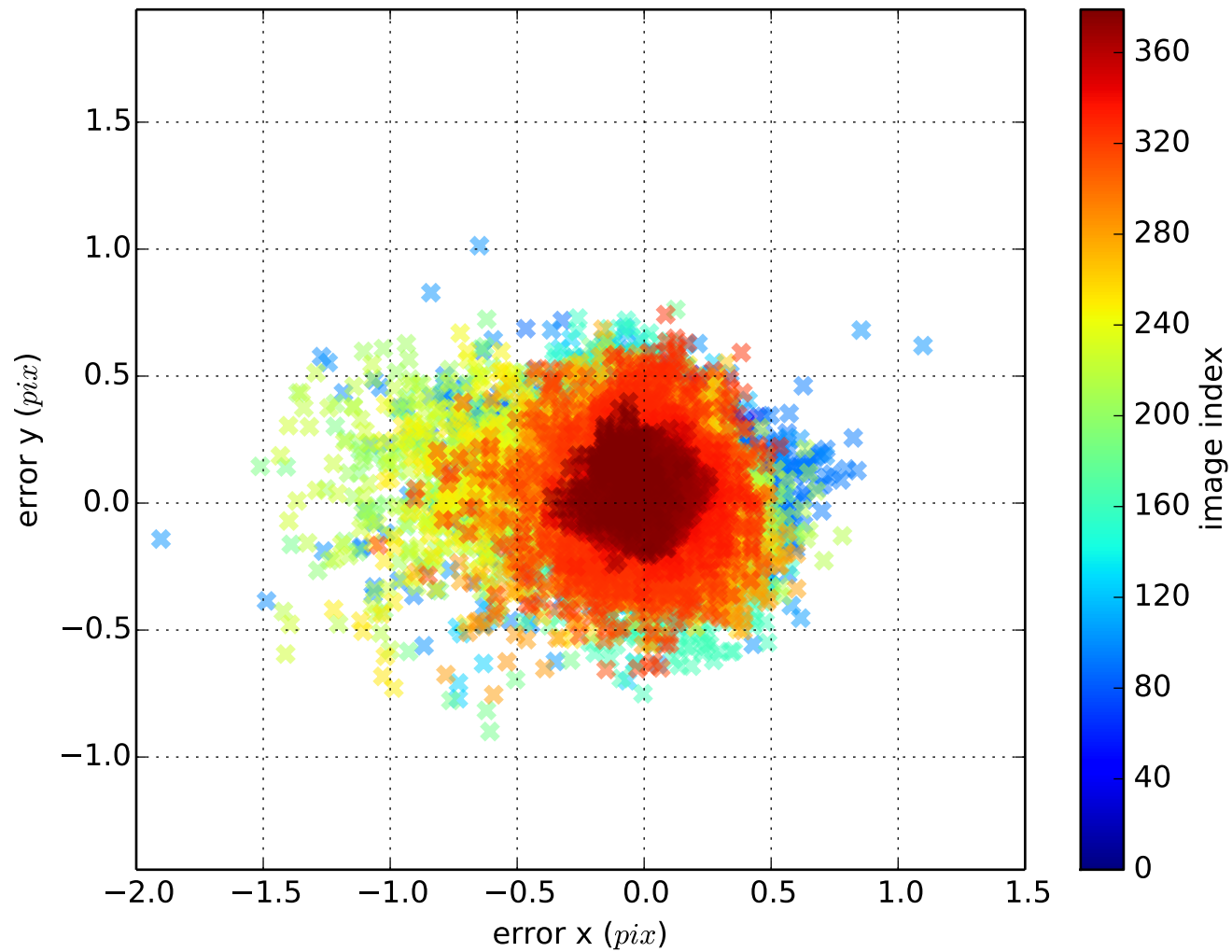




imu1: estimated gyro bias (imu frame)



cam0: reprojection errors



cam1: reprojection errors

