

Pelagic Fisheries Research Program

<http://www.soest.hawaii.edu/PFRP/>

Errors in estimating latitude from light measurements

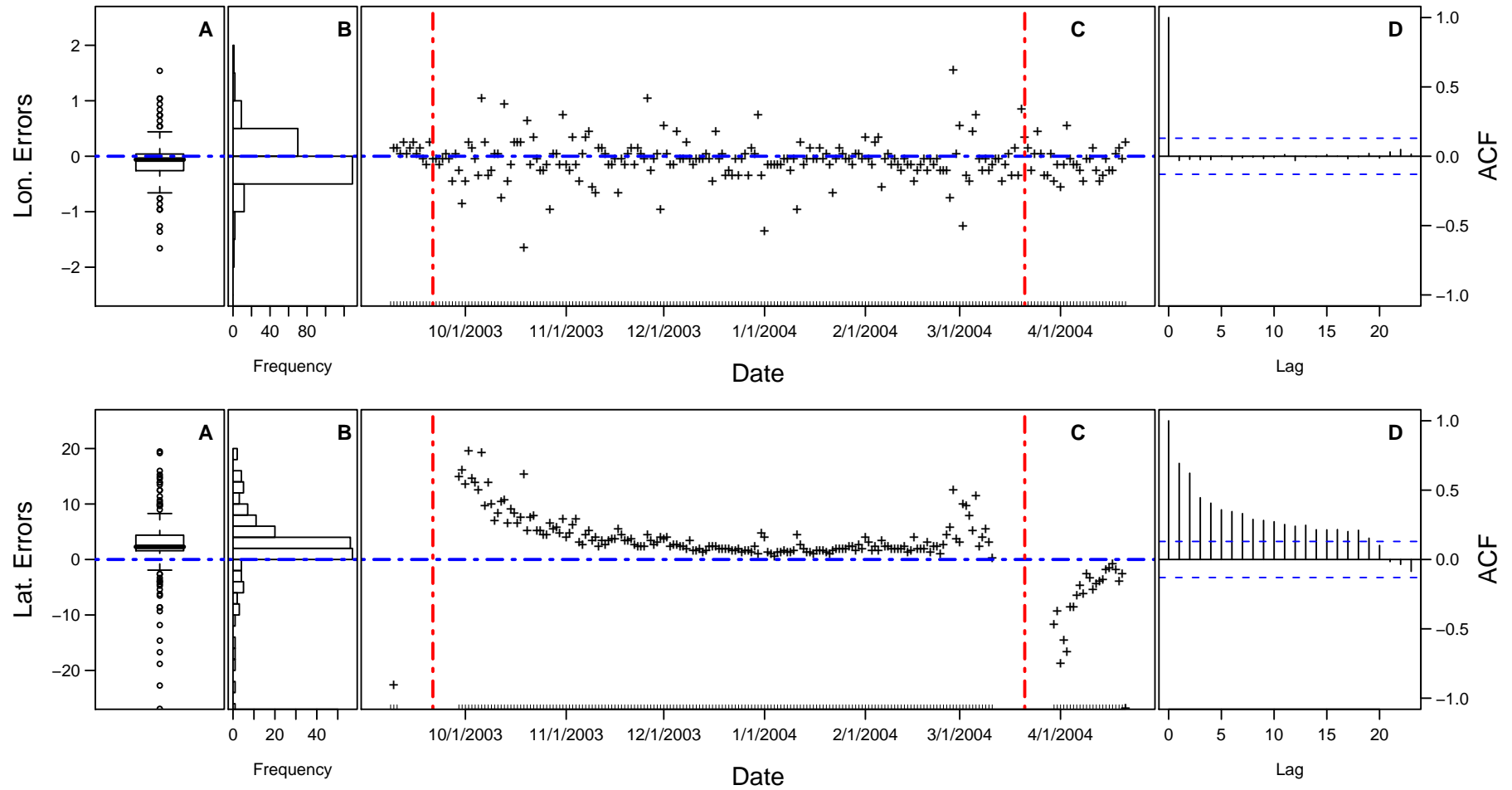
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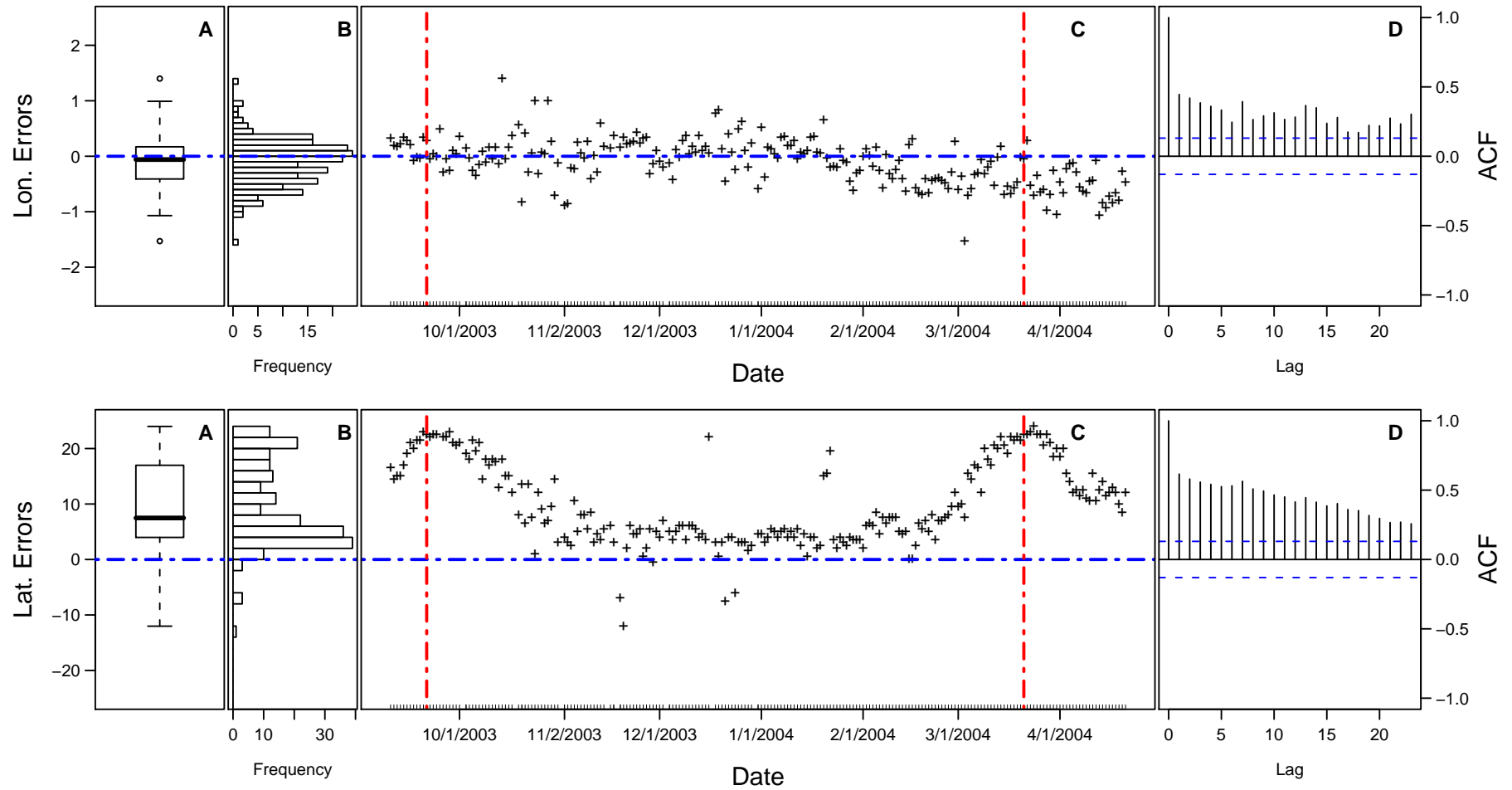
Geolocation Errors For tag a1124

Tag a1124



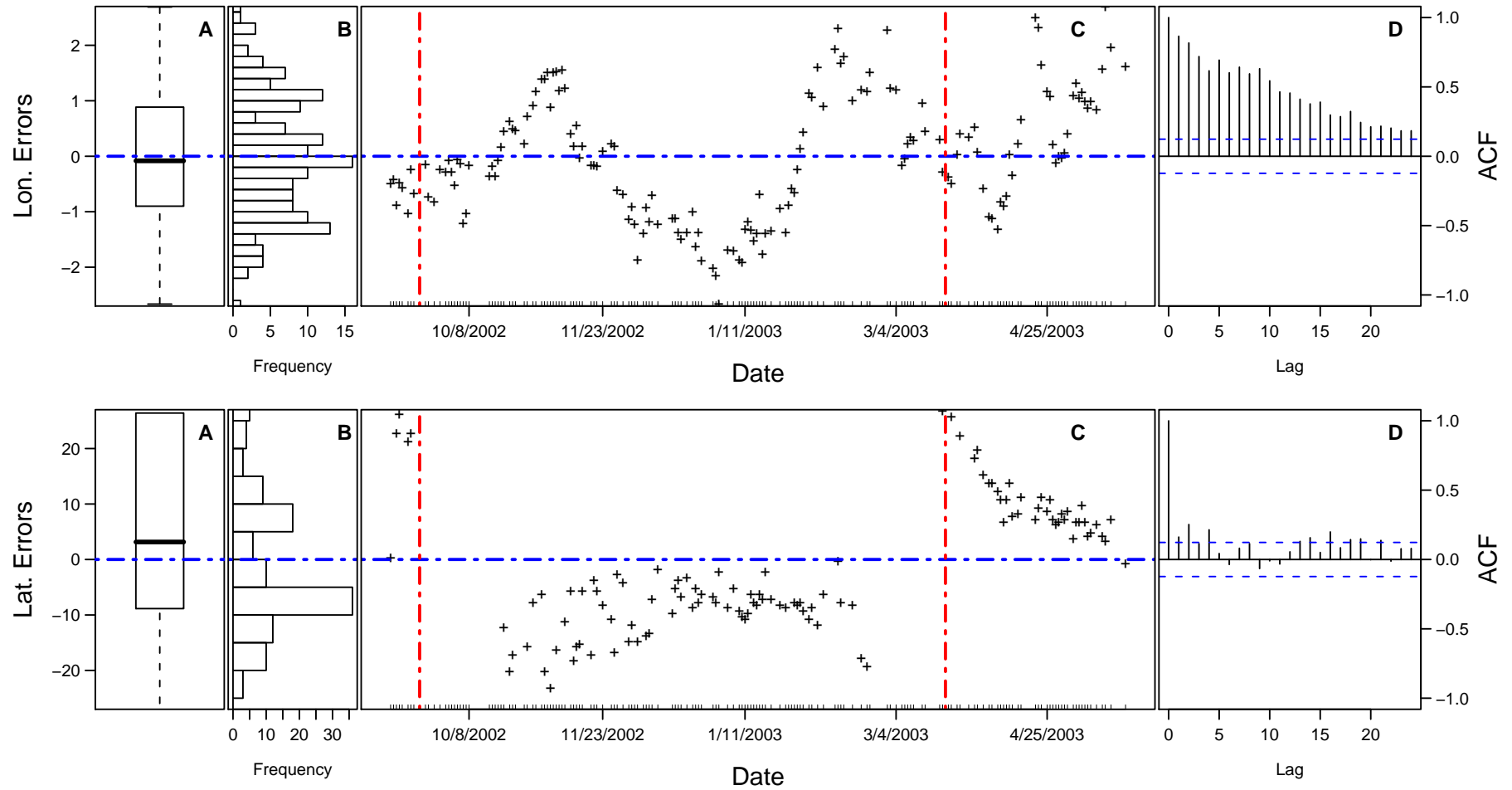
Geolocation Errors For tag 390139

Tag 390139



Geolocation Errors For tag 21760

Tag 21760



Computing Latitude (φ) From Solar Coordinates

Astronomical coordinate transformation

$$\sin h = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos H \quad (1)$$

At sunrise or sunset $h = 0$, so

$$\varphi = \tan^{-1} \left(-\frac{\cos H}{\tan \delta} \right), \quad (2)$$

but an archival tag does not “see” the sun and we do not really know the altitude h .



Error Amplification (1)

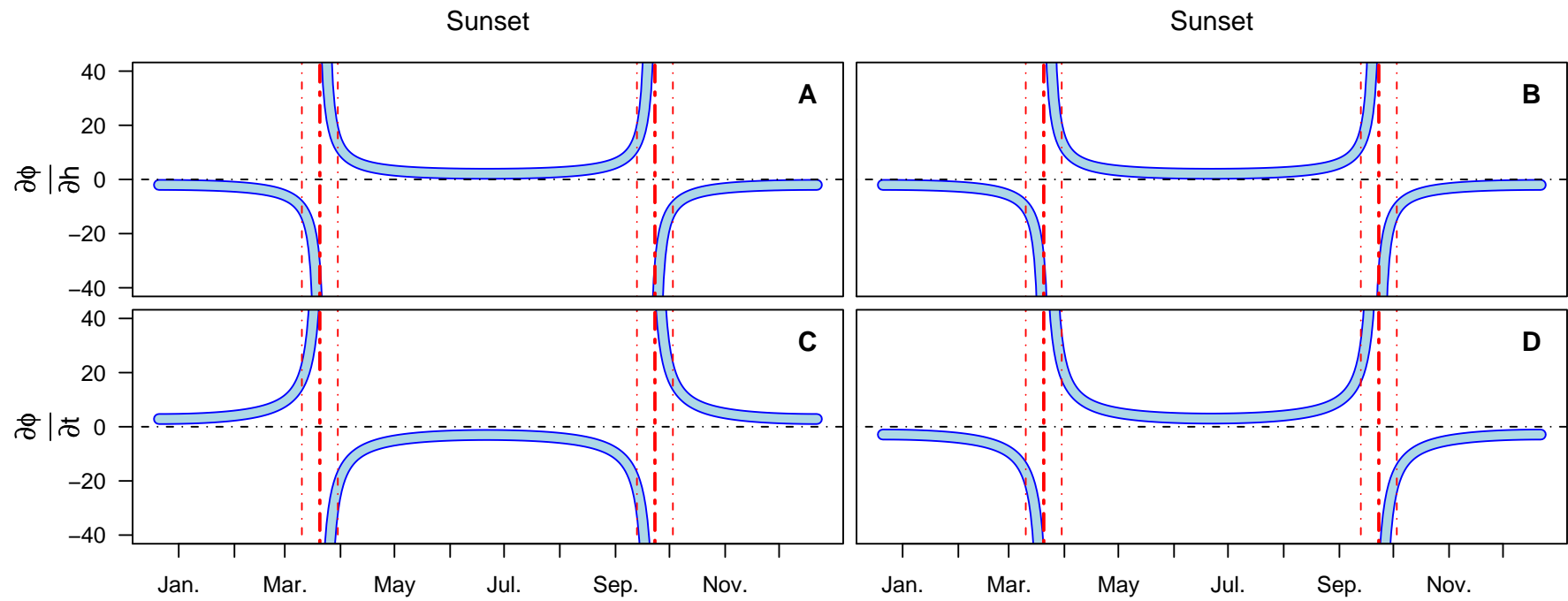
$$\frac{\partial \varphi}{\partial h} = \frac{\cos h}{\cos \varphi \sin \delta - \sin \varphi \cos \delta \cos H} \quad (3)$$

$$\frac{\partial \varphi}{\partial t} = \frac{2 \cos \varphi \cos \delta \sin H}{\cos \varphi \sin \delta - \sin \varphi \cos \delta \cos H} \quad (4)$$



Error Amplification (2)

Latitude -35



Kalman Filter Measurement Equation

$$y_i = z(\alpha_i) + d_i + \varepsilon_i, \quad i = 1, \dots, T \quad (5)$$

$$d_i = \begin{pmatrix} b_x \\ b_{y_i} \end{pmatrix} \quad \varepsilon_i = N(0, H_i) \quad H_i = \begin{pmatrix} \sigma_x^2 & 0 \\ 0 & \sigma_{y_i}^2 \end{pmatrix} \quad (6)$$

$$b_{y_i} = b_h \left(\frac{\partial \varphi}{\partial h_{up}} + \frac{\partial \varphi}{\partial h_{dn}} \right) + b_{t_{up}} \frac{\partial \varphi}{\partial t_{up}} + b_{t_{dn}} \frac{\partial \varphi}{\partial t_{dn}} = d_{i2} \quad (7)$$

$$s_{y_i}^2 = s_o^2 + s_h^2 \left(\left(\frac{\partial \varphi}{\partial h_{up}} \right)^2 + \left(\frac{\partial \varphi}{\partial h_{dn}} \right)^2 \right) + s_t^2 \left(\left(\frac{\partial \varphi}{\partial t_{up}} \right)^2 + \left(\frac{\partial \varphi}{\partial t_{dn}} \right)^2 \right) = H_{i2,2} \quad (8)$$



kftrack Fit For Tag a1124

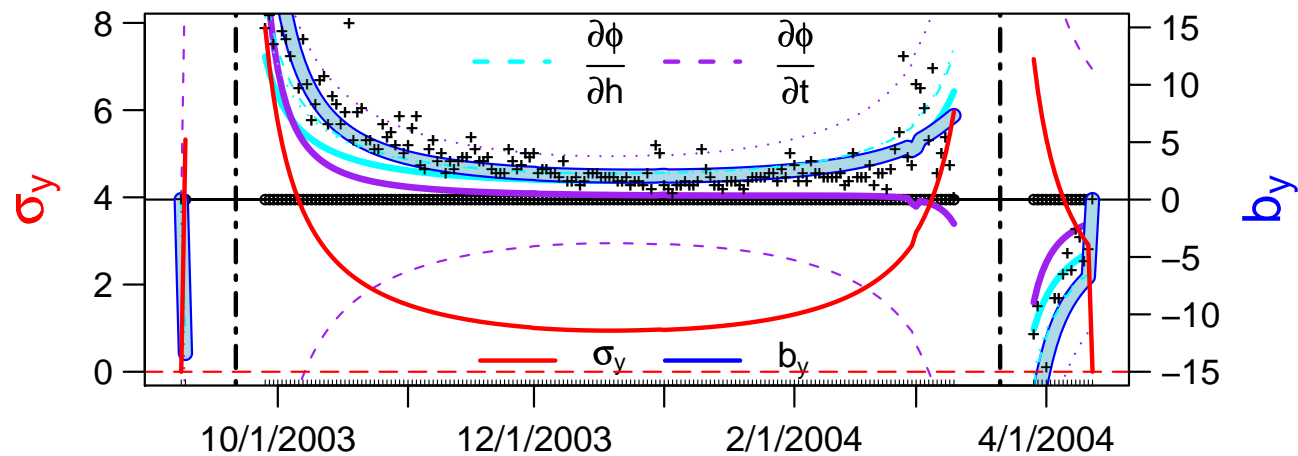
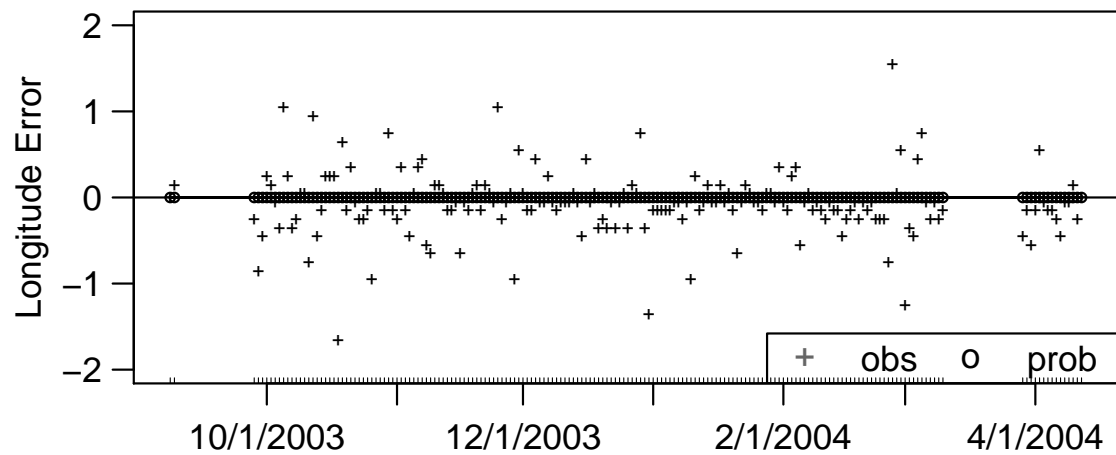
../mooring/a1124/ta1124.dat

L = 420.5, n = 10 eqx = 3

D = 0.0, sx = 0.39, sy = 0.00

bx = -0.09, by = 0.00

bh = 0.36, sh = 0.00; btup = -3.87, btdn = -3.79, st = 0.35



kftrack Fit For Tag 390139

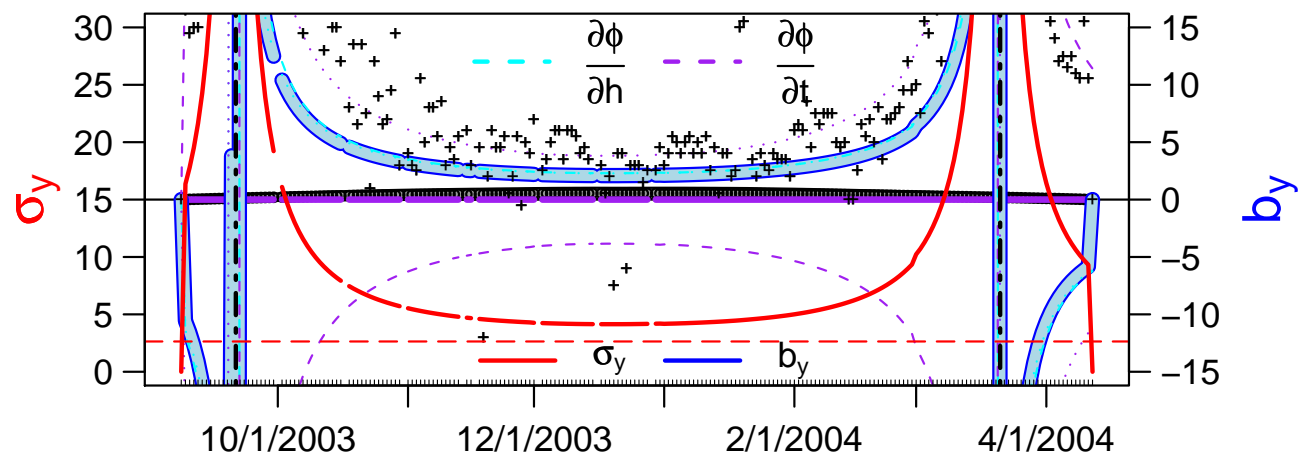
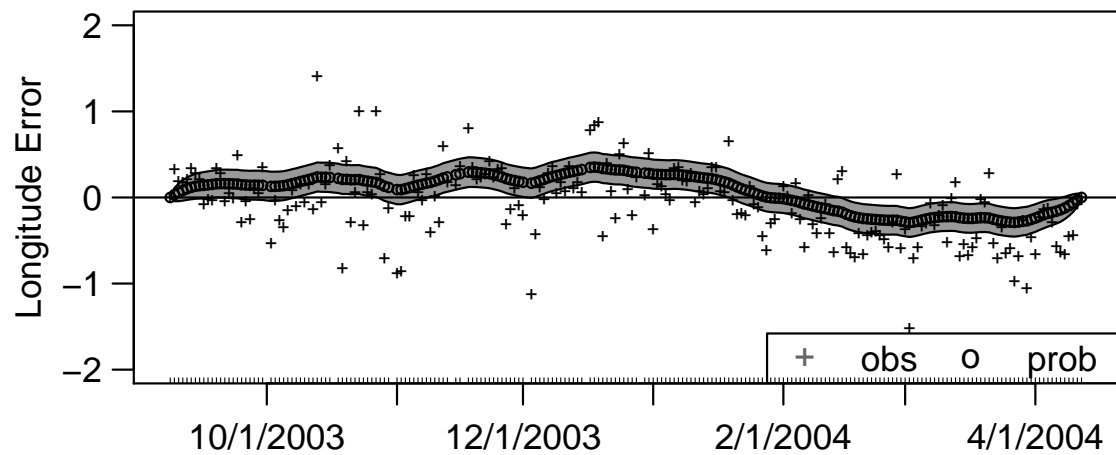
../mooring/390139/t390139.dat

$L = 841.7$, $n = 7$ eqx = 3

$D = 2.5$, $s_x = 0.34$, $s_y = 2.64$

$b_x = -0.14$, $b_y = 0.00$

$b_h = 0.45$, $s_h = 1.97$; $b_{tup} = 0.00$, $b_{tdn} = 0.00$, $s_t = 0.00$



kftrack Fit For Tag 21760

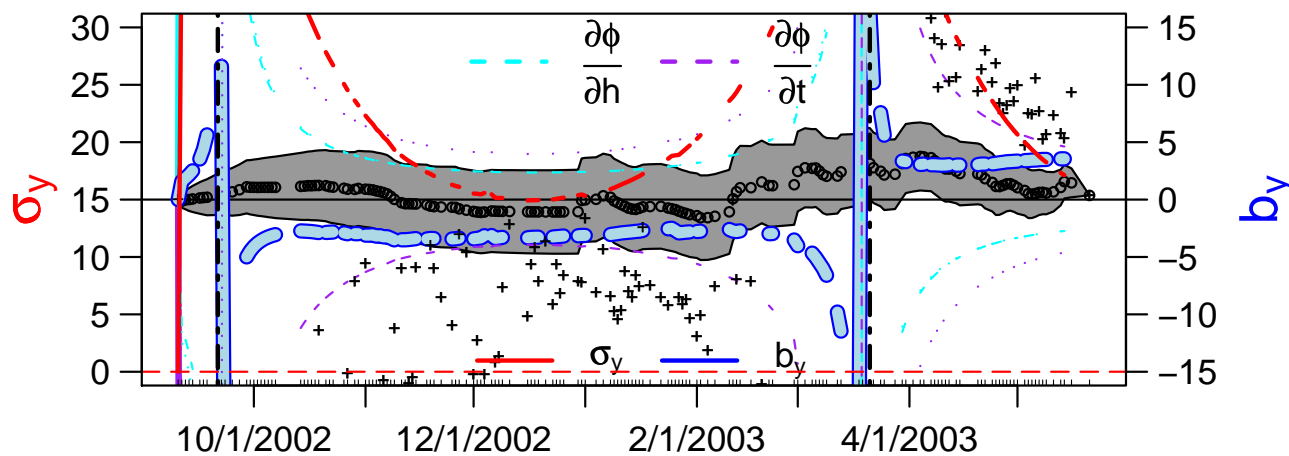
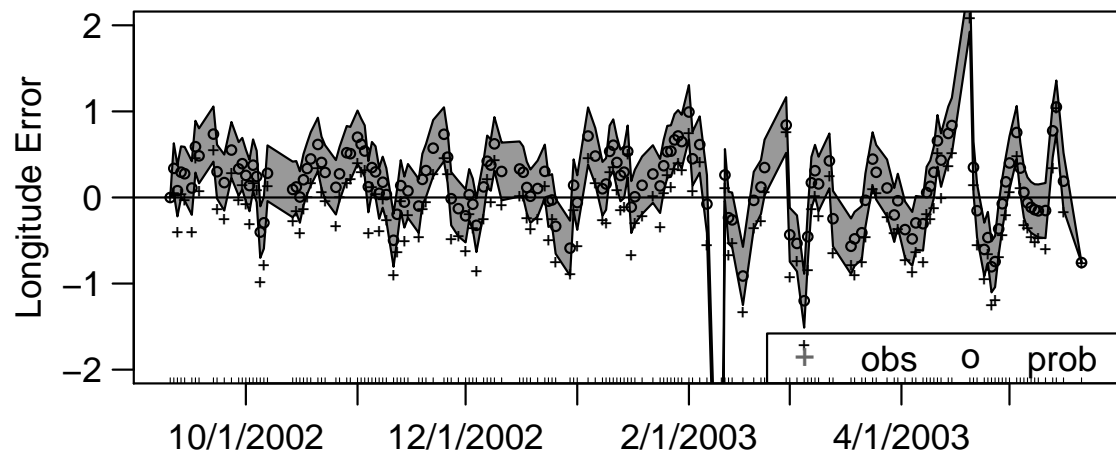
../mooring/21760/t21760.dat

$L = 848.6$, $n = 12$ eqx = 3

$D = 153.6$, $s_x = 0.19$, $s_y = 0.00$

$b_x = -0.34$, $b_y = 0.00$

$b_h = -5.72$, $s_h = 0.00$; $b_{tup} = -3.17$, $b_{tdn} = 3.02$, $s_t = 5.62$



Conclusions

- Simple application of the standard astronomical coordinate transformation is inappropriate for light-based geolocation
- Error propagation analysis is a potentially helpful means to correct latitude bias
- How to “fix” your tracks:
 - If you have light data from tag, re-analyse with appropriate method
 - If you have SST estimates from tag, use `kfsst`
 - Otherwise use `kftrack`
- Next steps: complete error propagation analysis and include in updated Kalman filter models



kftrack Fit For Tag 587

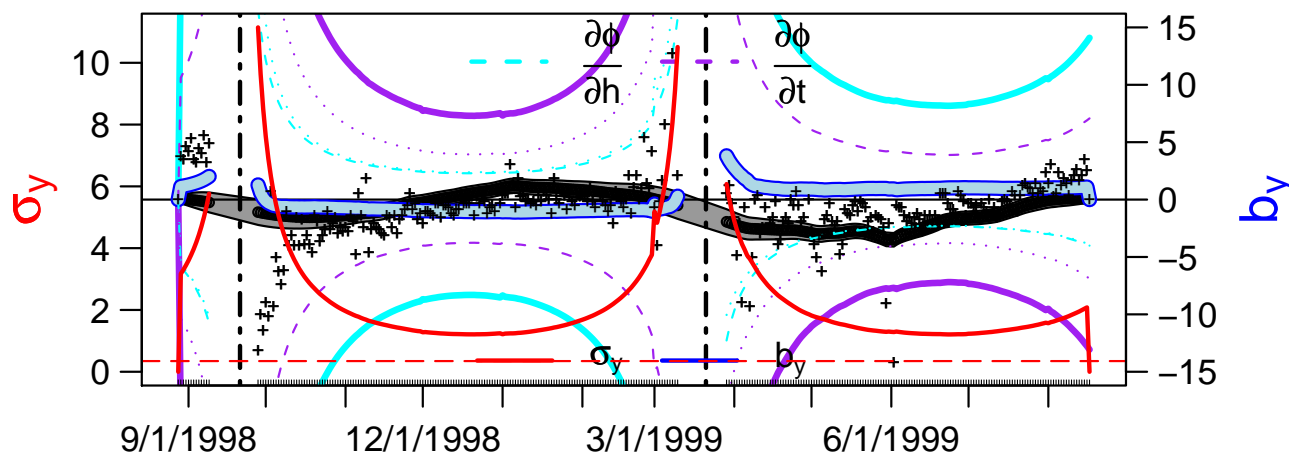
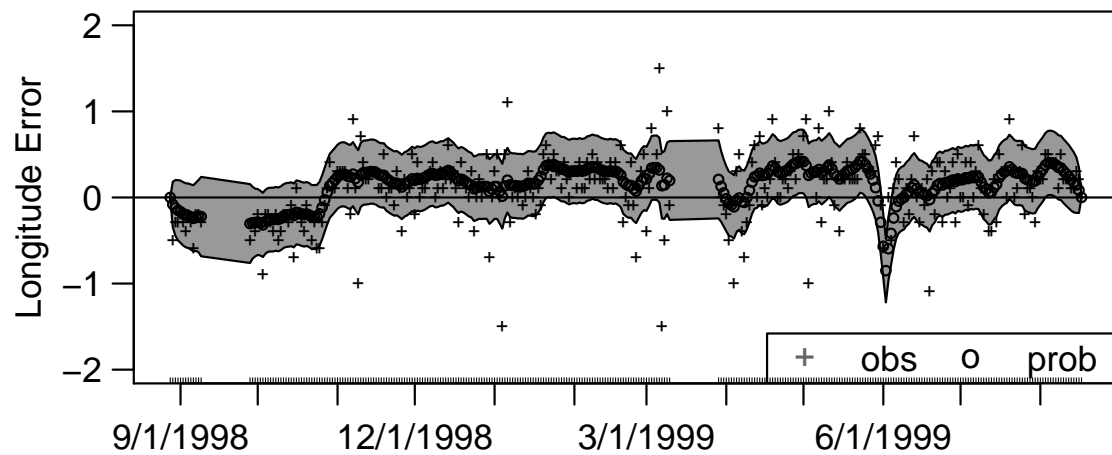
../mooring/587/t587.dat

$L = 924.8$, $n = 10$ eqx = 3

$D = 36.9$, $sx = 0.45$, $sy = 0.35$

$bx = -0.08$, $by = 0.00$

$bh = -1.78$, $sh = 0.00$; $btup = -0.60$, $btdn = 1.28$, $st = 0.43$



kftrack Fit For Tag 935

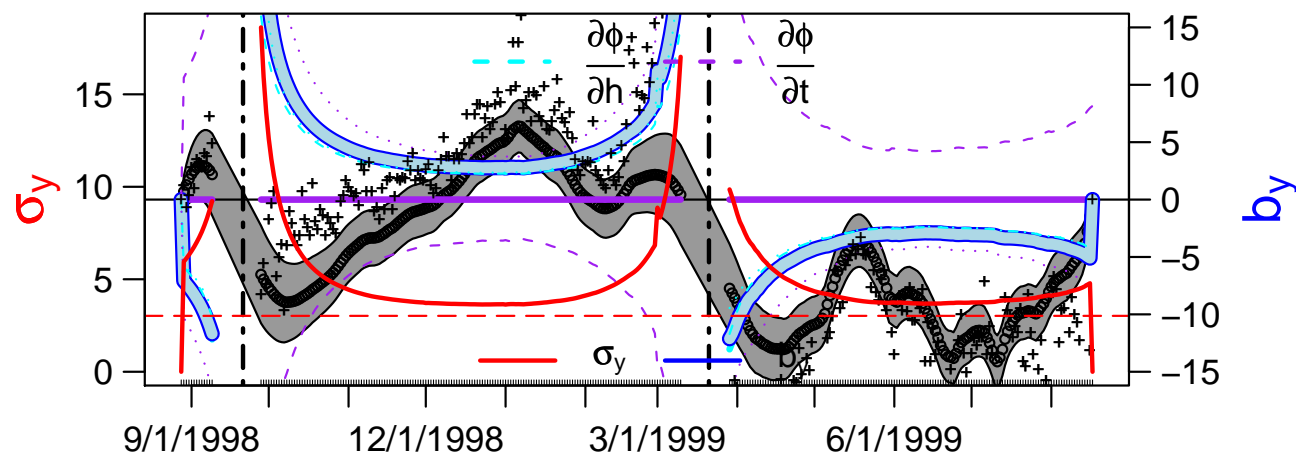
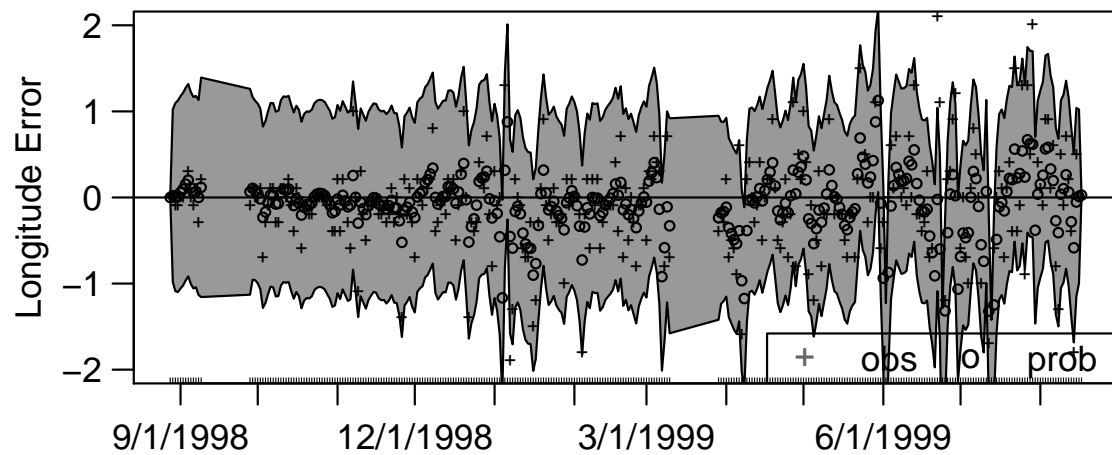
../mooring/935/t935.dat

$L = 1505.7$, $n = 7$ eqx = 3

$D = 875.0$, $sx = 0.87$, $sy = 3.02$

$bx = -0.07$, $by = 0.00$

$bh = 0.62$, $sh = 1.25$; $btup = 0.00$, $btdn = 0.00$, $st = 0.00$



kftrack Fit For Tag 97-218

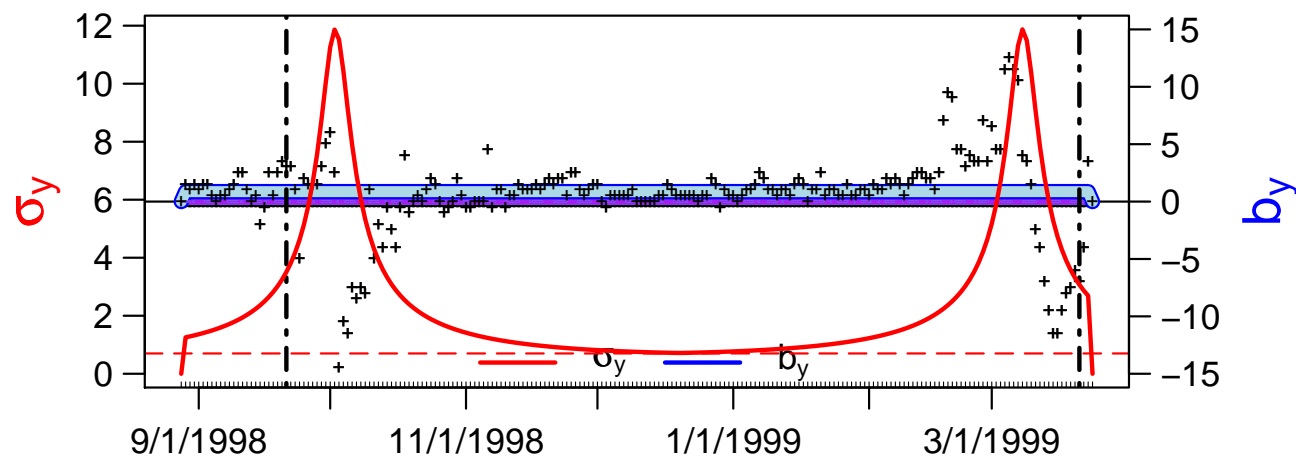
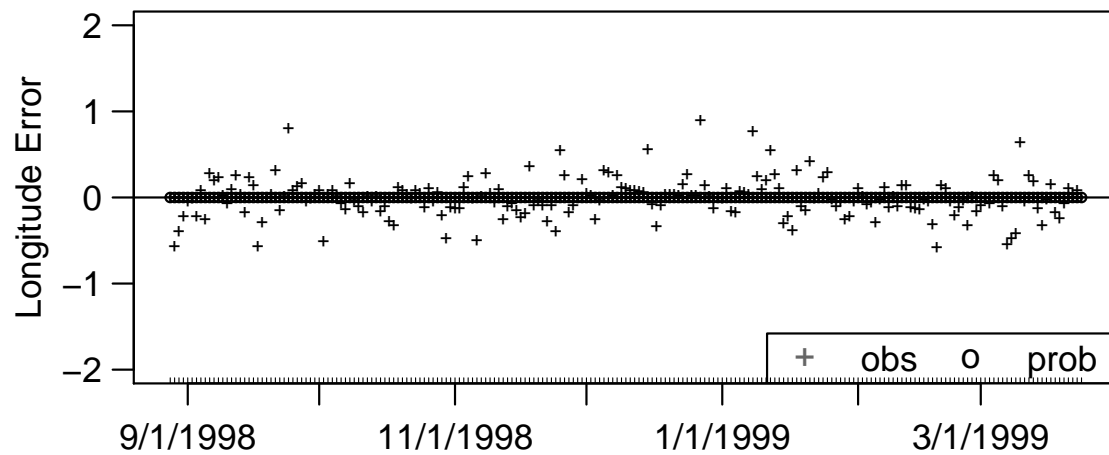
../mooring/97-218/t97-218.dat

$L = 386.8$, $n = 7$ eqx = 1

$D = 0.0$, $s_x = 0.23$, $s_y = 0.70$

$b_x = -0.01$, $b_y = 0.87$

$b_x = -0.01$, $b_y = 0.87$



kftrack Fit For Tag 97-219

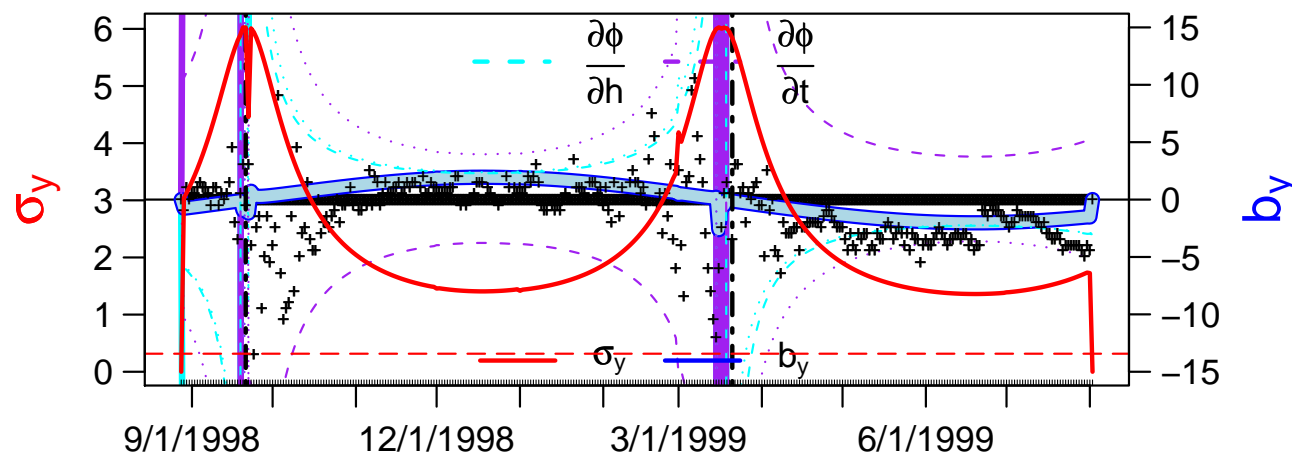
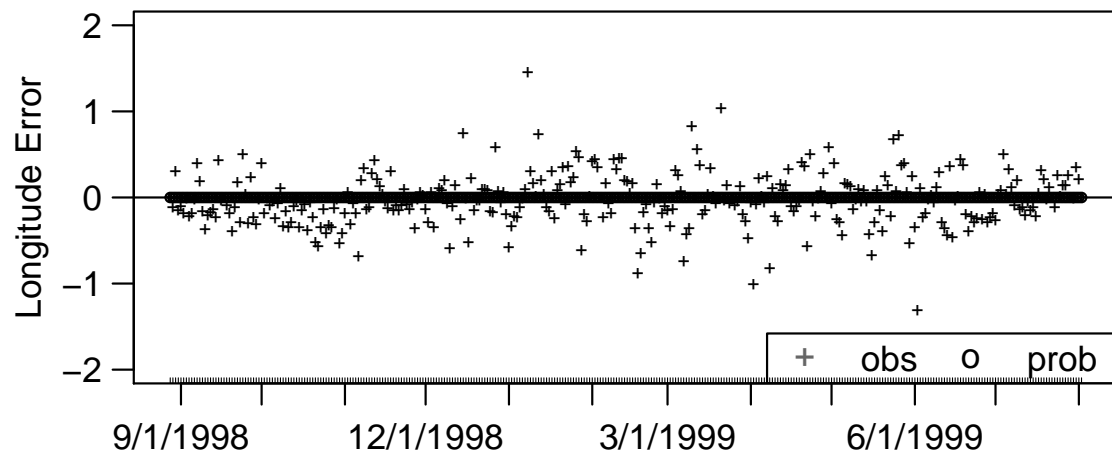
../mooring/97-219/t97-219.dat

$L = 811.5$, $n = 10$ eqx = 3

$D = 0.0$, $s_x = 0.31$, $s_y = 0.32$

$b_x = -0.03$, $b_y = 0.00$

$b_h = 4.32$, $s_h = 0.85$; $b_{tup} = 2.37$, $b_{tdn} = -2.37$, $s_t = 0.00$



kftrack Fit For Tag 97-224

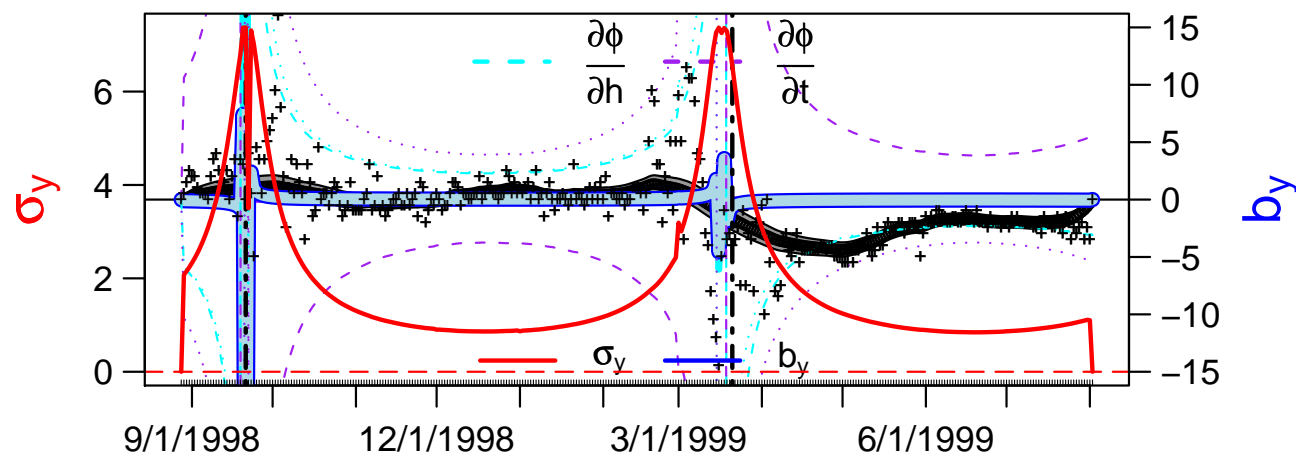
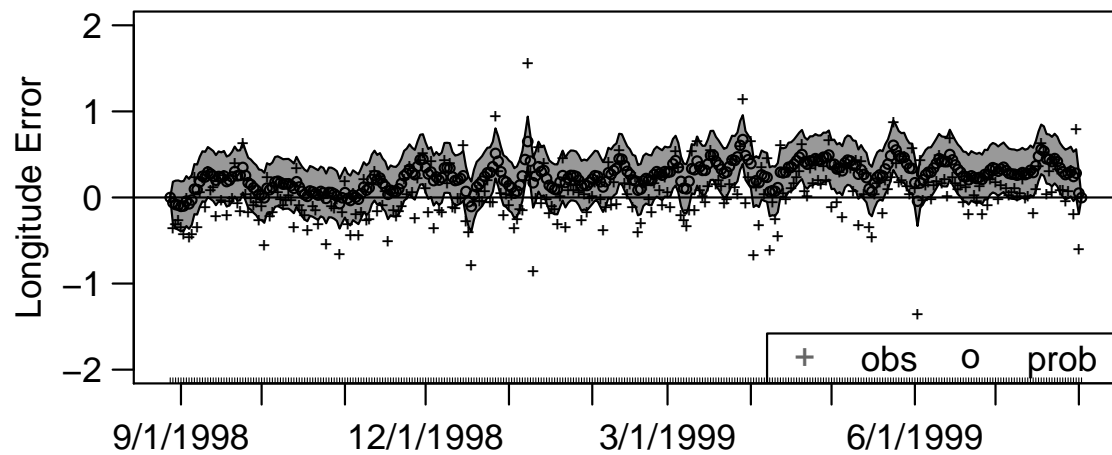
../mooring/97-224/t97-224.dat

$L = 778.0$, $n = 7$ eqx = 3

$D = 41.3$, $sx = 0.26$, $sy = 0.00$

$bx = -0.20$, $by = 0.00$

$bh = 0.01$, $sh = 0.53$; $btup = 0.00$, $btdn = 0.00$, $st = 0.00$



kftrack Fit For Tag 99-190

../coral_sea_3/99-190-sst/t99-190.dat

$L = 1450.4$, $n = 10$ eqx = 3

$D = 50.5$, $sx = 0.57$, $sy = 1.87$

$bx = -0.69$, $by = 0.00$

$bh = 5.39$, $sh = 1.26$; $btup = 2.95$, $btdn = -2.53$, $st = 0.00$

