
LEIF ERIKSON TRIAL
FOREST PARK
PORTLAND, OR
SEQUENTIAL IMPORTANCE SAMPLING
v.
AUXILIARY

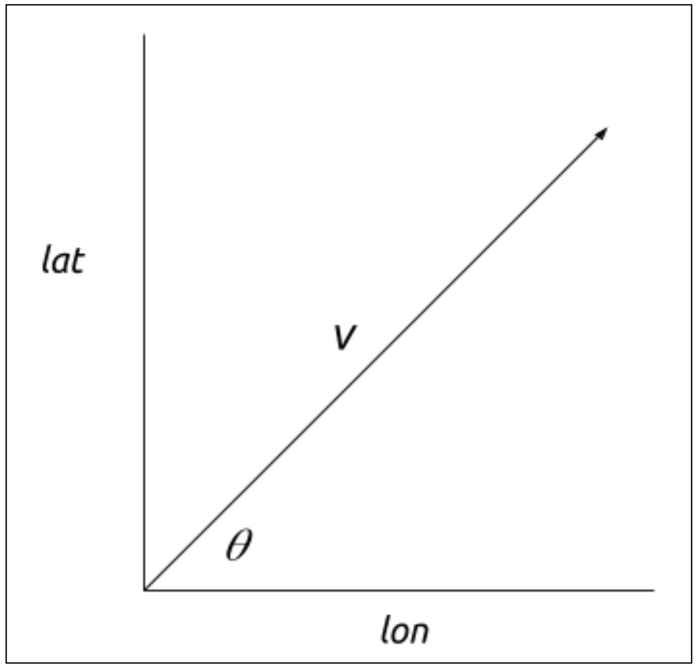
OUTLINE

- STATE SPACE MODEL
- SYNTHETIC SIMULATIONS
  - SISR
  - AUXILIARY
- REAL DATA
- IMPROVEMENTS AND FUTURE WORK

MEASUREMENT MODEL

GARMIN FORERUNNER 235

LONGITUDE (m)
LATITUDE (m)

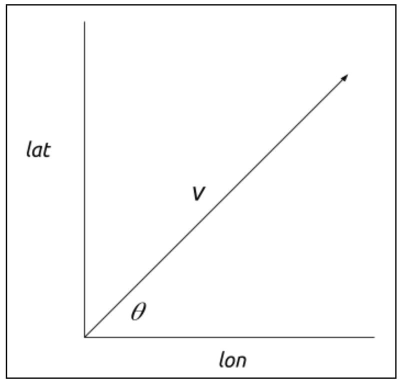


$$y_n = \begin{bmatrix} vincenty(lon_n) \\ vincenty(lat_n) \end{bmatrix} + [u_n]$$

$$where\ u_n \sim N_2(0, \Sigma_u)$$

PROCESS MODEL

LONGITUDE (m)
LATITUDE (m)
HEADING (rad)
VELOCITY (m/s)
AVG VELOCITY (m/s)



PRIOR KNOWLEDGE

RUNNER ON KNOWN PATH

2 BEHAVIORS:
- NEARLY CONSTANT VELOCITY
- STOPPED TO REST

POPULATION PACE AVERAGES

$$x_{n+1} = \begin{bmatrix} lon_{n+1} \\ lat_{n+1} \\ \theta_{n+1} \\ v_{n+1} \\ m_{n+1} \end{bmatrix} = \begin{bmatrix} lon_n + v_n * \cos(\theta_n) \\ lat_n + v_n * \sin(\theta_n) \\ A(lon_n, lat_n) \\ \beta * m_n \\ \alpha * m_n + (1-\alpha) * v_n \end{bmatrix} + \begin{bmatrix} w_{lon} \\ w_{lat} \\ w_\theta \\ w_v \\ w_m \end{bmatrix}$$

$$w_n = \begin{bmatrix} w_{lon} \sim N(0, \sigma^2{}_{lon}) \\ w_{lat} \sim N(0, \sigma^2{}_{lat}) \\ w_\theta \sim N(0, \sigma^2{}_\theta) \\ w_v \sim N(0, \sigma^2{}_v) \\ w_m = 0 \end{bmatrix}$$

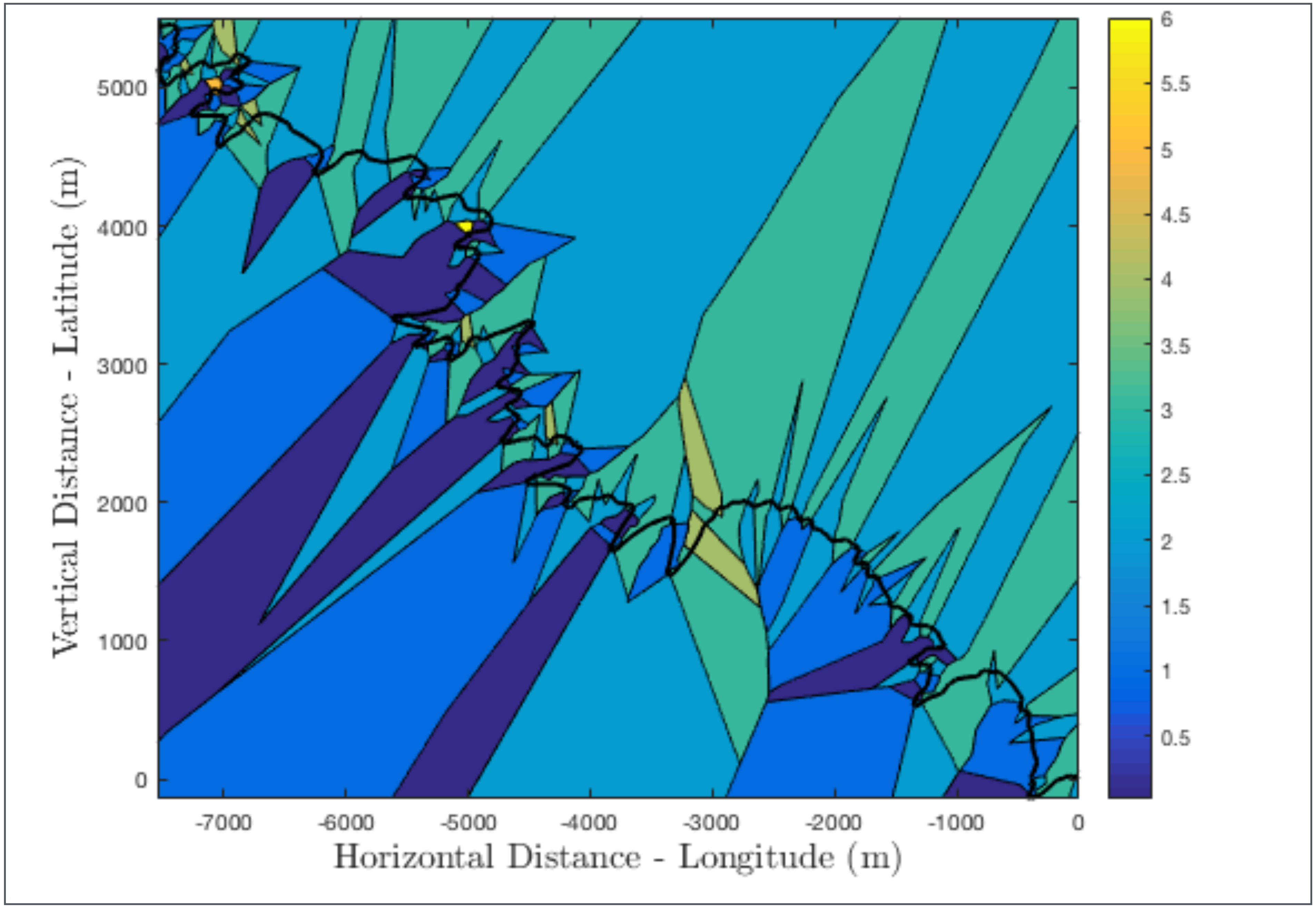
A= nearest neighbor approximation

β = binomial random variable with a p (β = 1) = 0.9

$\alpha = 0.95$

HEADING APPROXIMATION

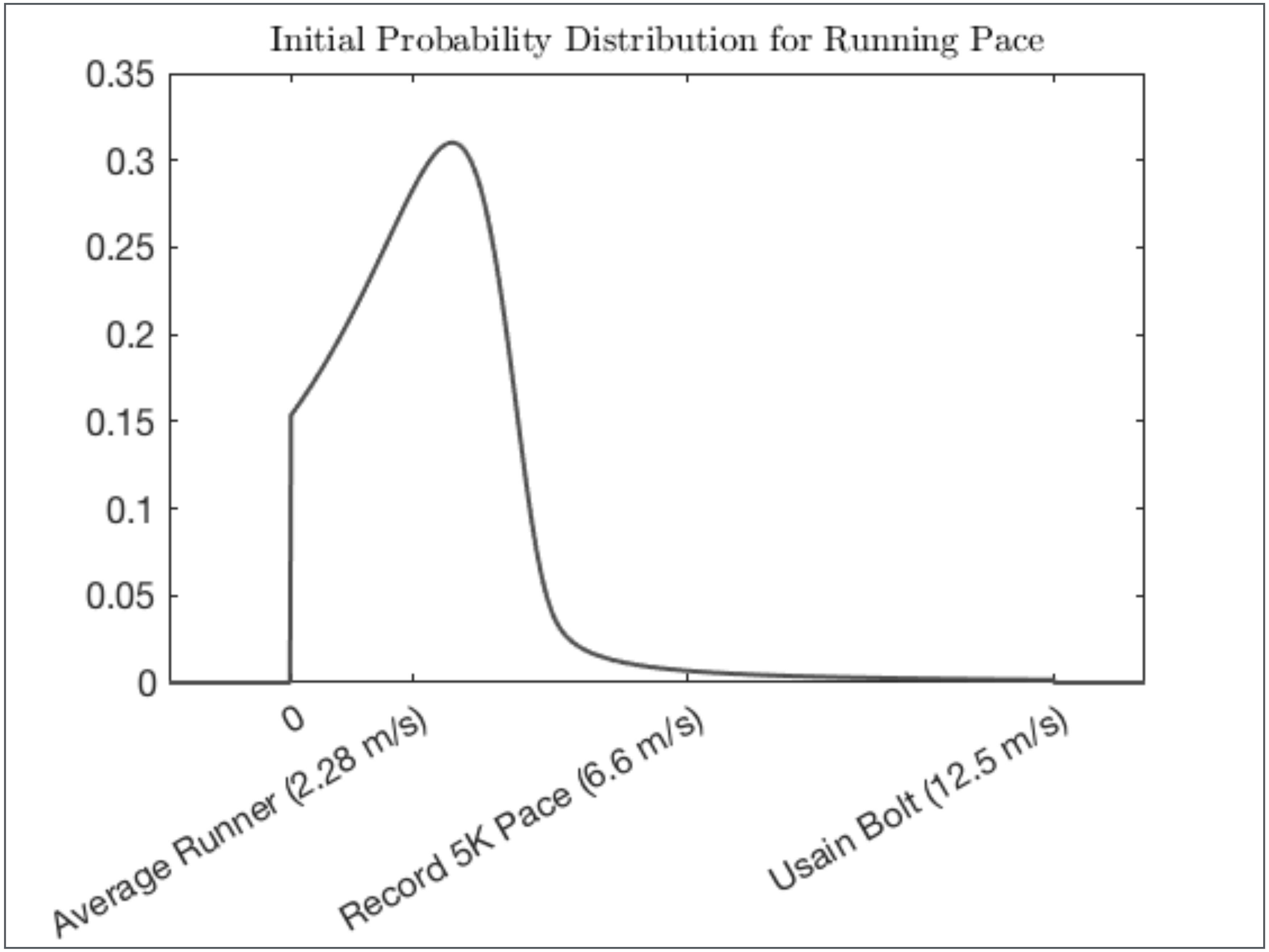
$$x_{n+1} = \begin{bmatrix} lon_{n+1} \\ lat_{n+1} \\ \theta_{n+1} \\ v_{n+1} \\ m_{n+1} \end{bmatrix} = \begin{bmatrix} lon_n + v_n * \cos(\theta_n) \\ lat_n + v_n * \sin(\theta_n) \\ A(lon_n, lat_n) \\ \beta * m_n \\ \alpha * m_n + (1-\alpha) * v_n \end{bmatrix} + \begin{bmatrix} w_{lon} \\ w_{lat} \\ w_\theta \\ w_v \\ w_m \end{bmatrix}$$



https://www.trailrunproject.com/

VELOCITY INITIALIZATION

$$x_{n+1} = \begin{bmatrix} lon_{n+1} \\ lat_{n+1} \\ \theta_{n+1} \\ v_{n+1} \\ m_{n+1} \end{bmatrix} = \begin{bmatrix} lon_n + v_n * \cos(\theta_n) \\ lat_n + v_n * \sin(\theta_n) \\ A(lon_n, lat_n) \\ \beta * m_n \\ \alpha * m_n + (1-\alpha) * v_n \end{bmatrix} + \begin{bmatrix} w_{lon} \\ w_{lat} \\ w_\theta \\ w_v \\ w_m \end{bmatrix}$$



http://www.pace-calculator.com/5k-pace-comparison.php

PARAMETER VALUES

MEASUREMENT MODEL

$$y_n = \begin{bmatrix} vincenty(lon_n) \\ vincenty(lat_n) \end{bmatrix} + [u_n]$$

$$where\ u_n \sim N_2(0, \Sigma_u)$$

$$\boxed{\Sigma_u = \begin{bmatrix} 9m^2 & 0 \\ 0 & 9m^2 \end{bmatrix}}$$

PROCESS MODEL

$$x_{n+1} = \begin{bmatrix} lon_{n+1} \\ lat_{n+1} \\ \theta_{n+1} \\ v_{n+1} \\ m_{n+1} \end{bmatrix} = \begin{bmatrix} lon_n + v_n * \cos(\theta_n) \\ lat_n + v_n * \sin(\theta_n) \\ A(lon_n, lat_n) \\ \beta * m_n \\ \alpha * m_n + (1-\alpha) * v_n \end{bmatrix} + \begin{bmatrix} w_{lon} \\ w_{lat} \\ w_\theta \\ w_v \\ w_m \end{bmatrix}$$

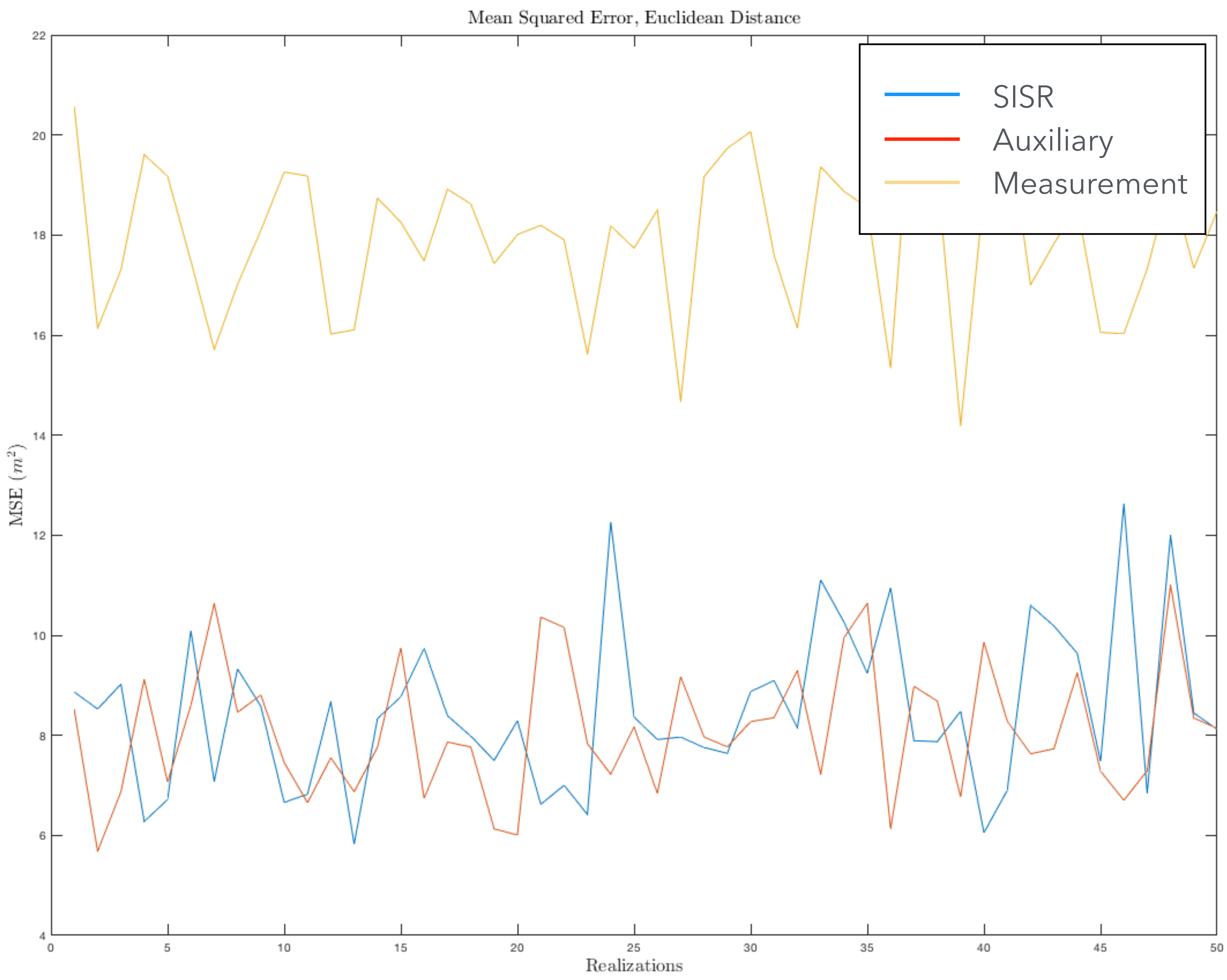
$$w_n = \begin{bmatrix} w_{lon} \sim N(0, \sigma^2{}_{lon}) \\ w_{lat} \sim N(0, \sigma^2{}_{lat}) \\ w_\theta \sim N(0, \sigma^2{}_\theta) \\ w_v \sim N(0, \sigma^2{}_v) \\ w_m = 0 \end{bmatrix}$$

$$\boxed{\begin{aligned} \sigma^2{}_{lon} &= 2m^2 \\ \sigma^2{}_{lon} &= 2m^2 \\ \sigma^2{}_\theta &= 0.75rad^2 \\ \sigma^2{}_v &= 0.9m^2 / s^2 \end{aligned}}$$

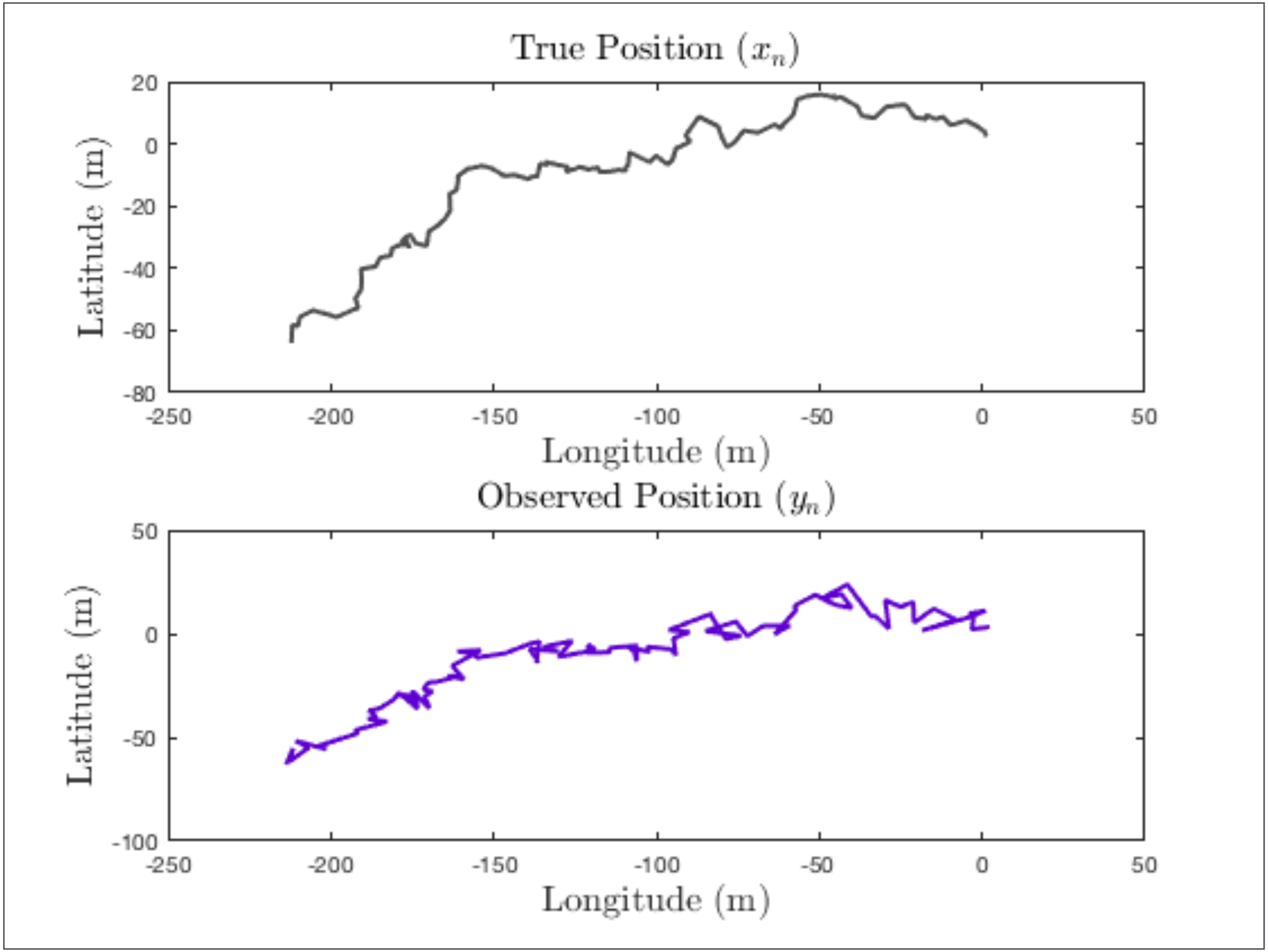
FILTER

# PARTICLES	= 1000
RESAMPLING EFFECTIVE THRESHOLD	= 100
IMPORTANCE DENSITY	= PRIOR

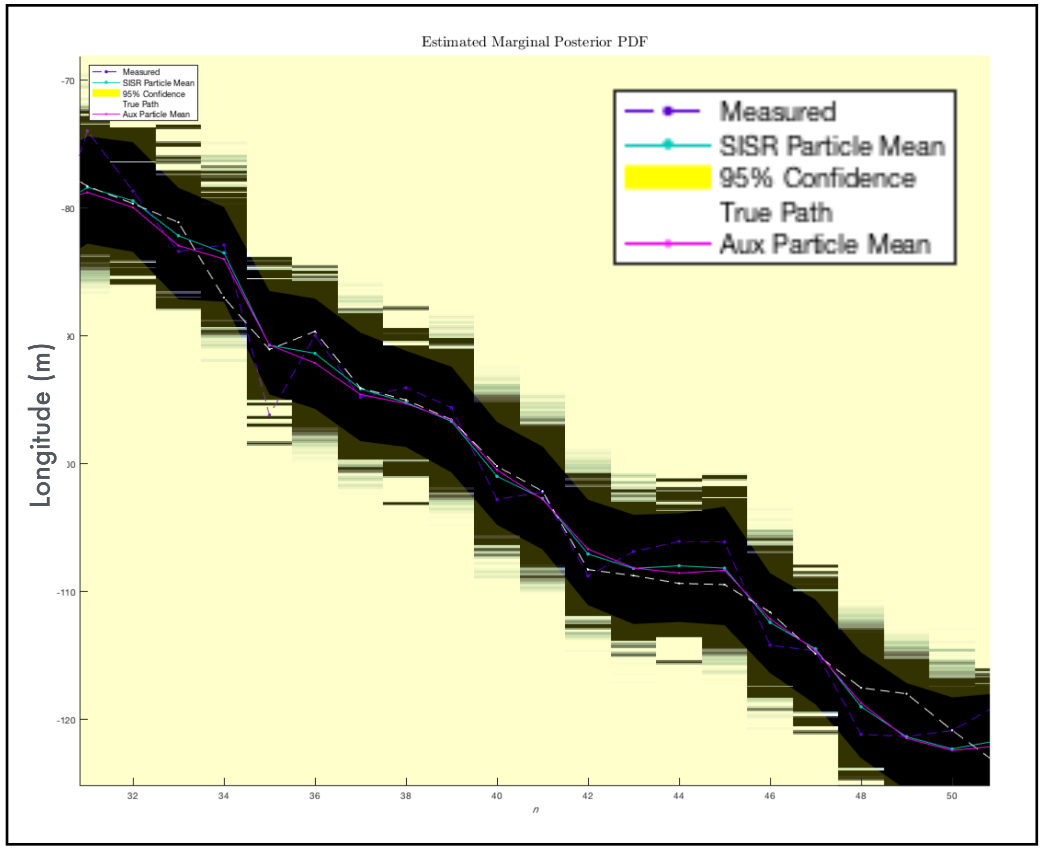
50 SIMULATIONS: 100 TIMES STEPS, 1000 PARTICLES

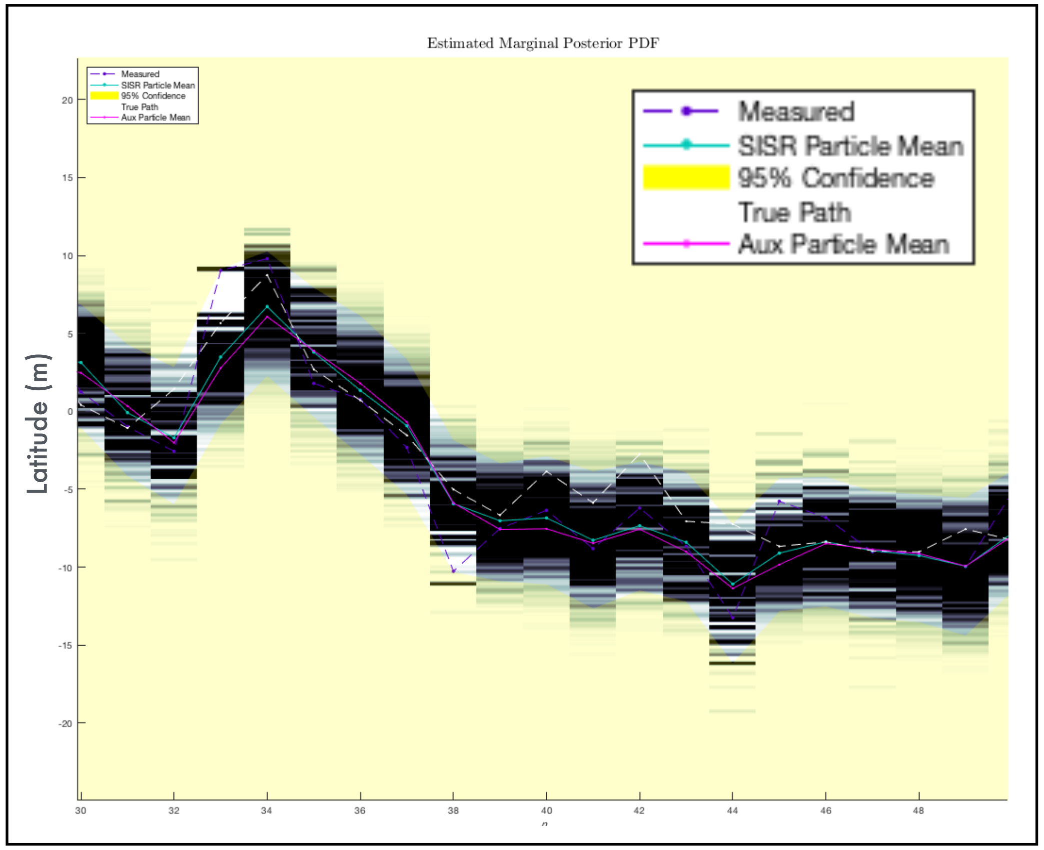


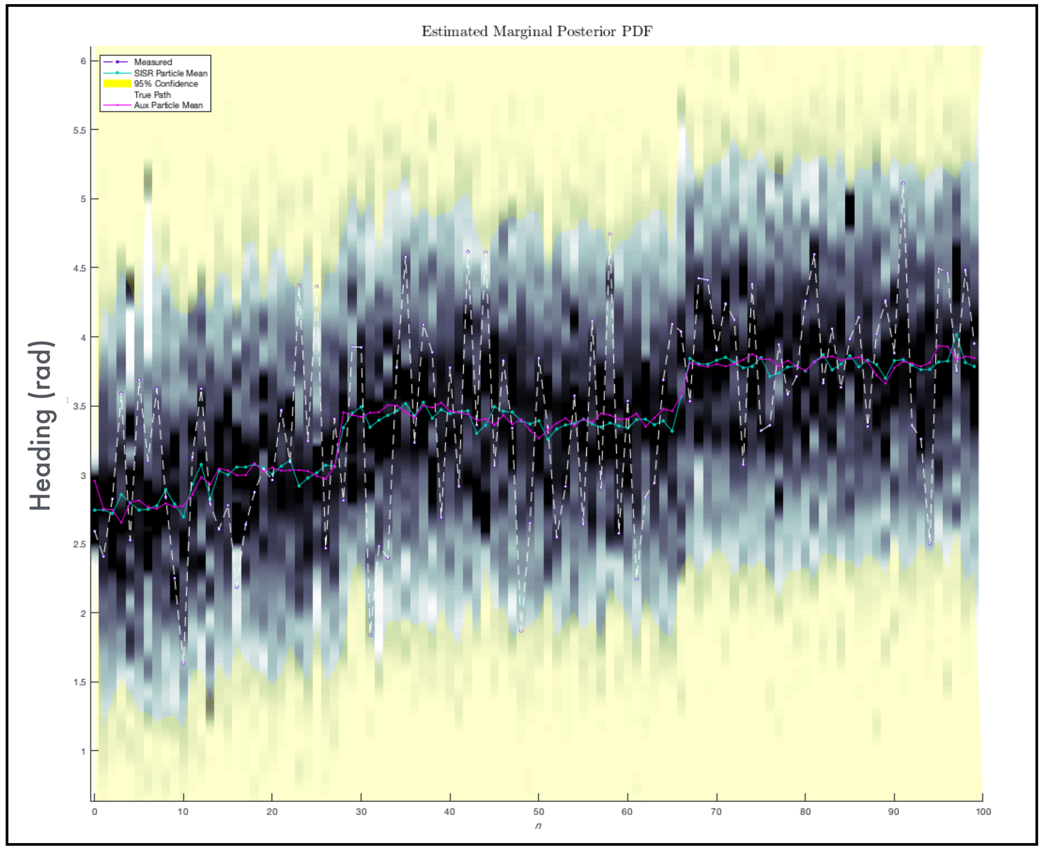
SIMULATION - SYNTHETIC DATA

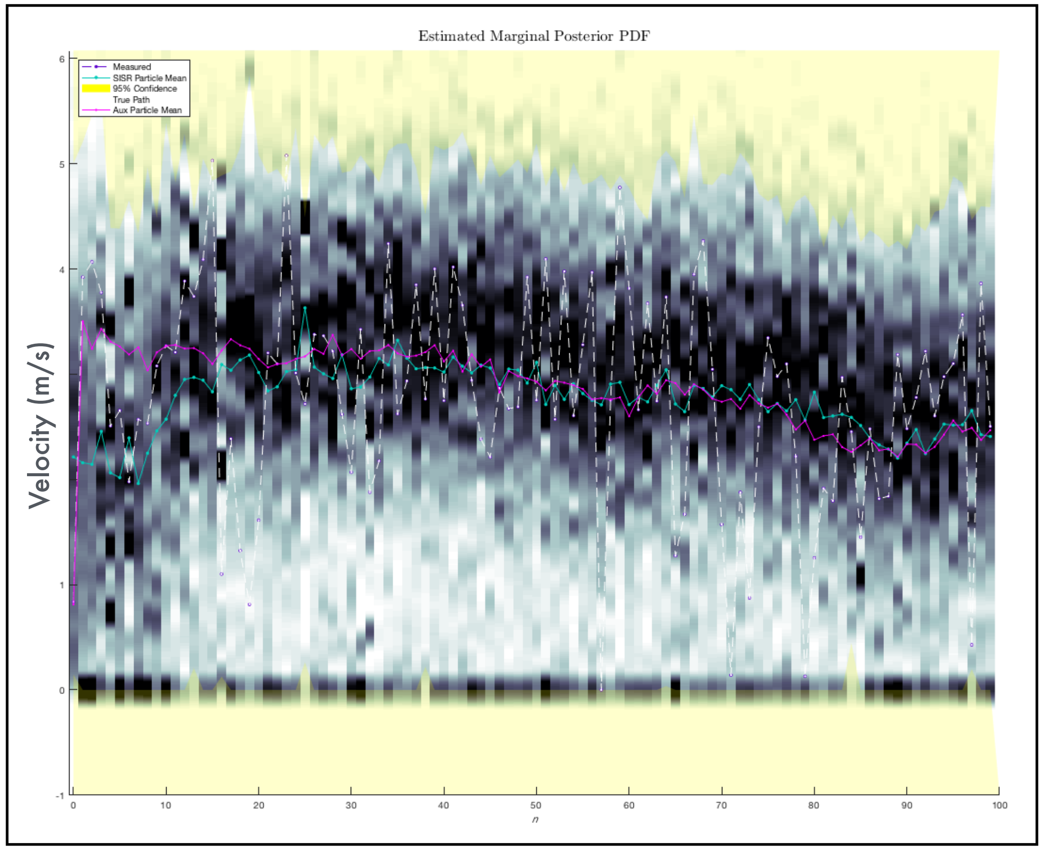


SIMULATION POSTERIOR PDF





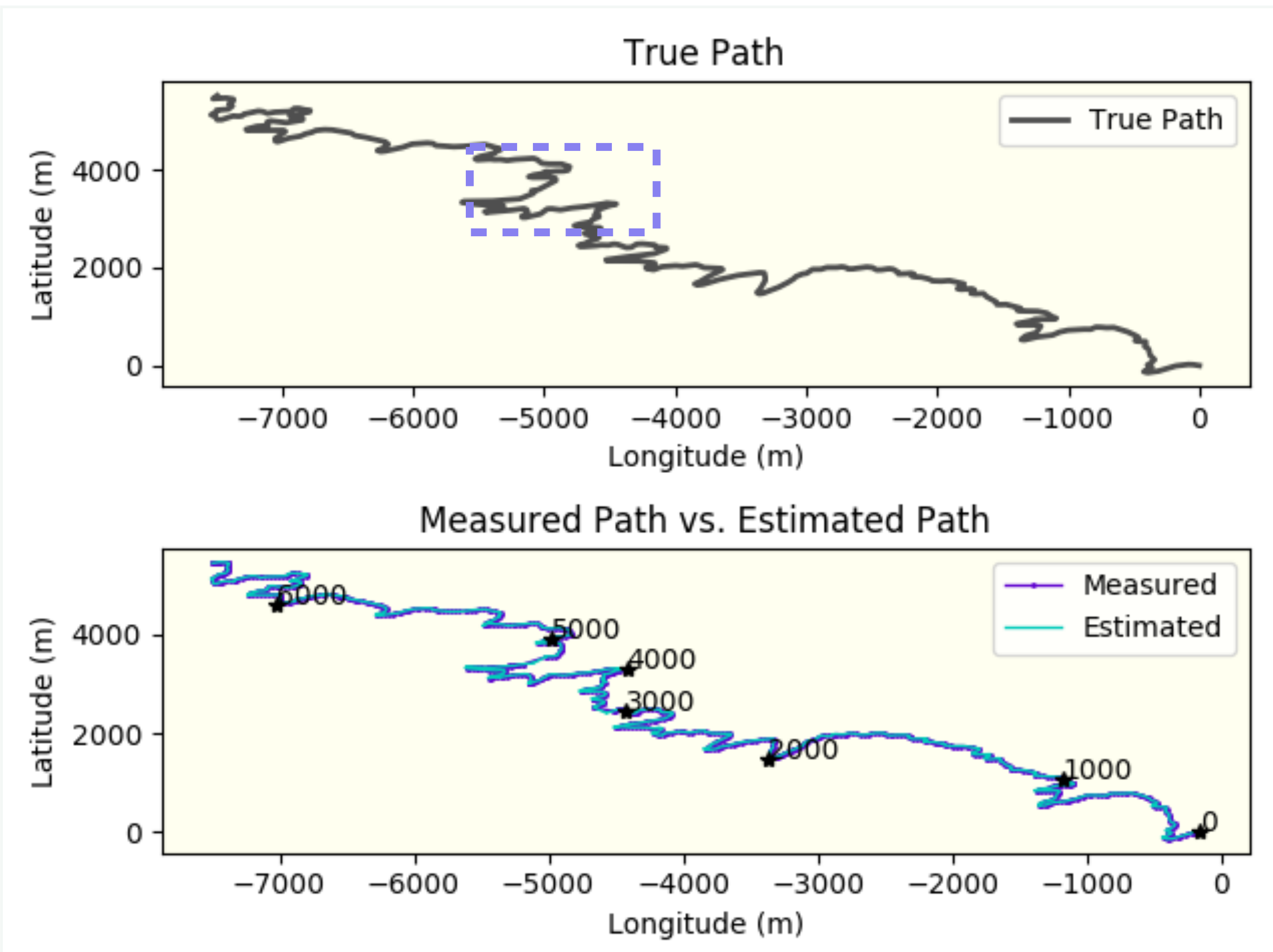




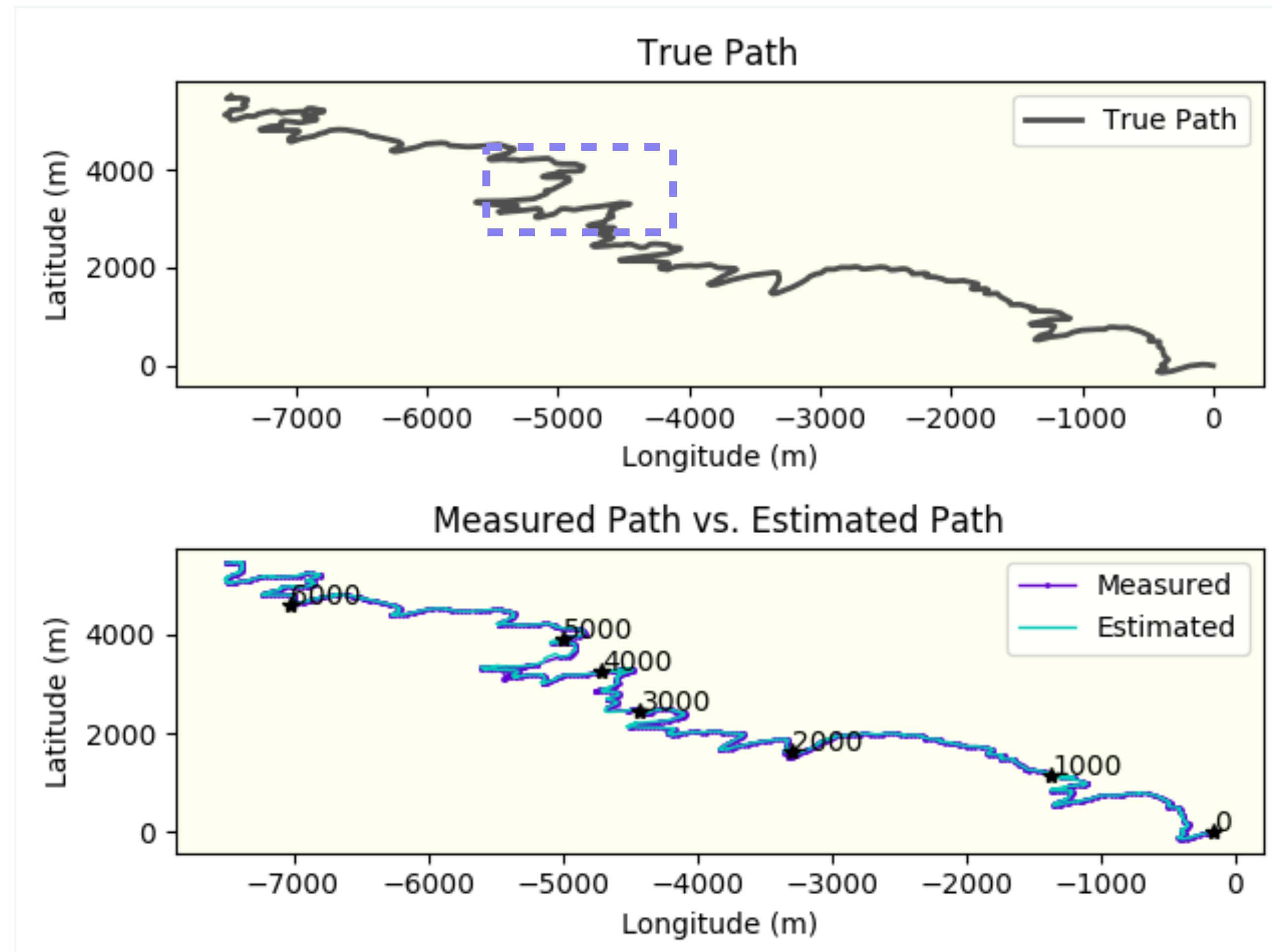
REAL DATA RESULTS

GARMIN FORERUNNER 235
936 DATA POINTS
IRREGULAR TIME INTERVALS
TRAVERSES ENTIRE LENGTH OF LEIF ERIKSON

SEQUENTIAL IMPORTANCE SAMPLING



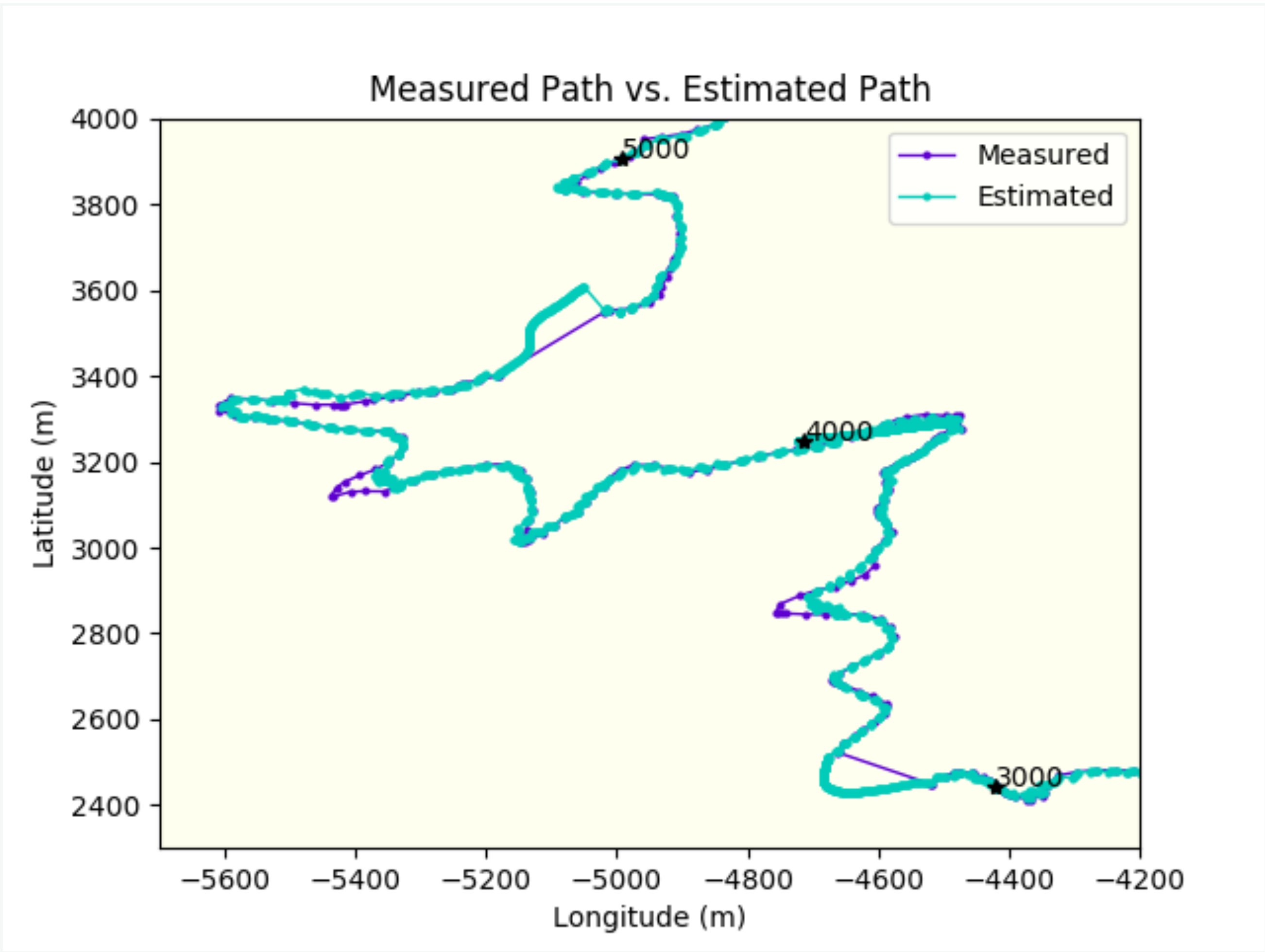
AUXILIARY



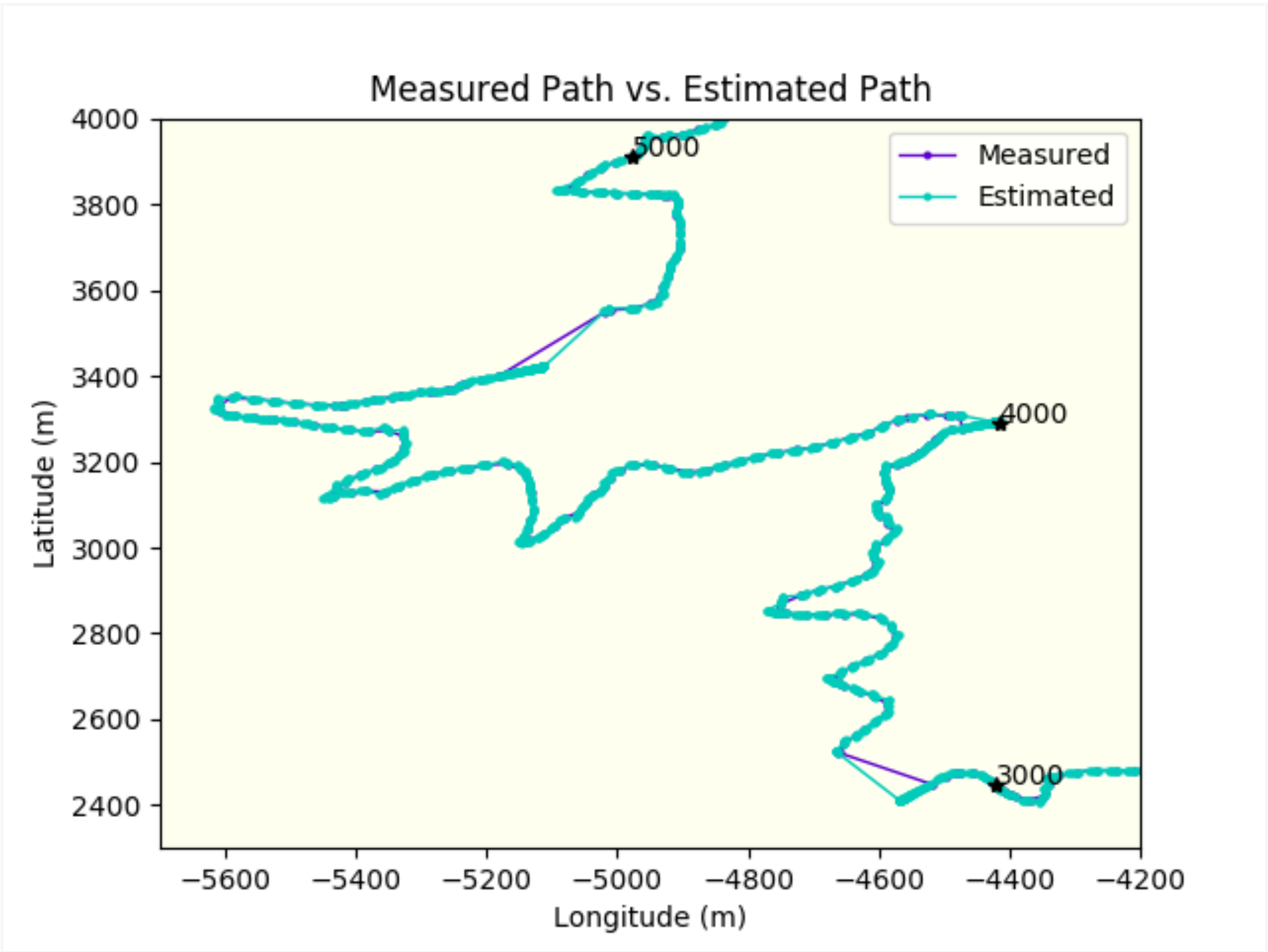
REAL DATA RESULTS

936 DATA POINTS
IRREGULAR TIME INTERVALS
TRAVERSES ENTIRE LENGTH OF LEIF ERIKSON

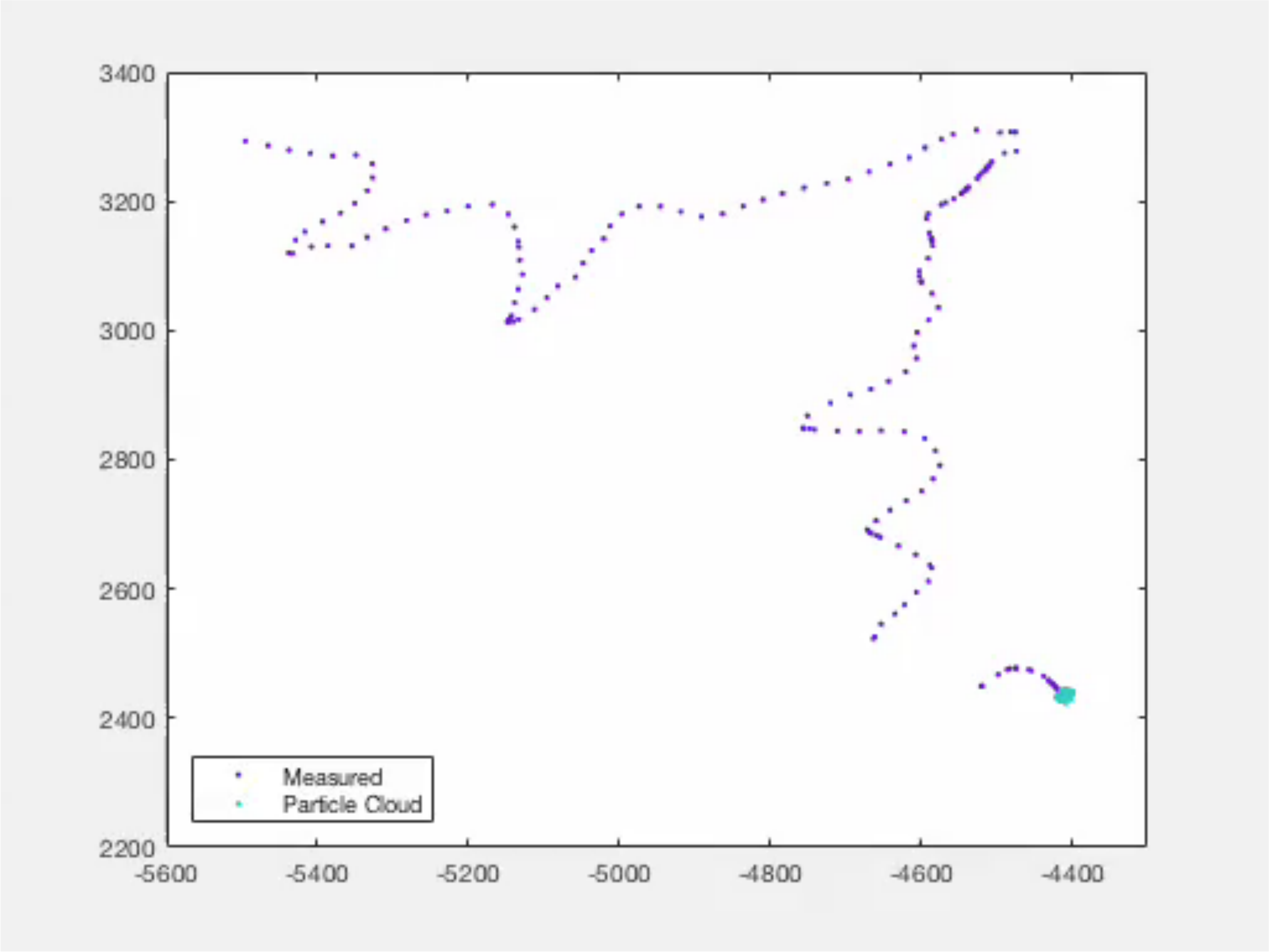
SEQUENTIAL IMPORTANCE SAMPLING



AUXILIARY



SIS



3400
3200
3000
2800
2600
2400
2200
-5600
-5400
-5200
-5000
-4800
-4600
-4400
Measured
Particle Cloud

IMPROVEMENTS & FUTURE WORK

- BETTER HEADING APPROXIMATION
- SIMPLER PROCESS MODEL

$$x_{n+1} = \begin{bmatrix} lon_{n+1} \\ lat_{n+1} \\ \theta_{n+1} \\ v_{n+1} \end{bmatrix} = \begin{bmatrix} lon_n + v_n * \cos(\theta_n) \\ lat_n + v_n * \sin(\theta_n) \\ \theta_n \\ v_n \end{bmatrix} + \begin{bmatrix} w_{lon} \\ w_{lat} \\ w_\theta \\ w_v \end{bmatrix} \qquad w_n = \begin{bmatrix} w_{lon} \sim N(0,\sigma_{lon}) \\ w_{lat} \sim N(0,\sigma_{lon}) \\ w_\theta \sim wC(0,\sigma_\theta) \\ w_v \sim N(0,\sigma_v) \end{bmatrix}$$

- MORE PARTICLES (5K OR 10K)