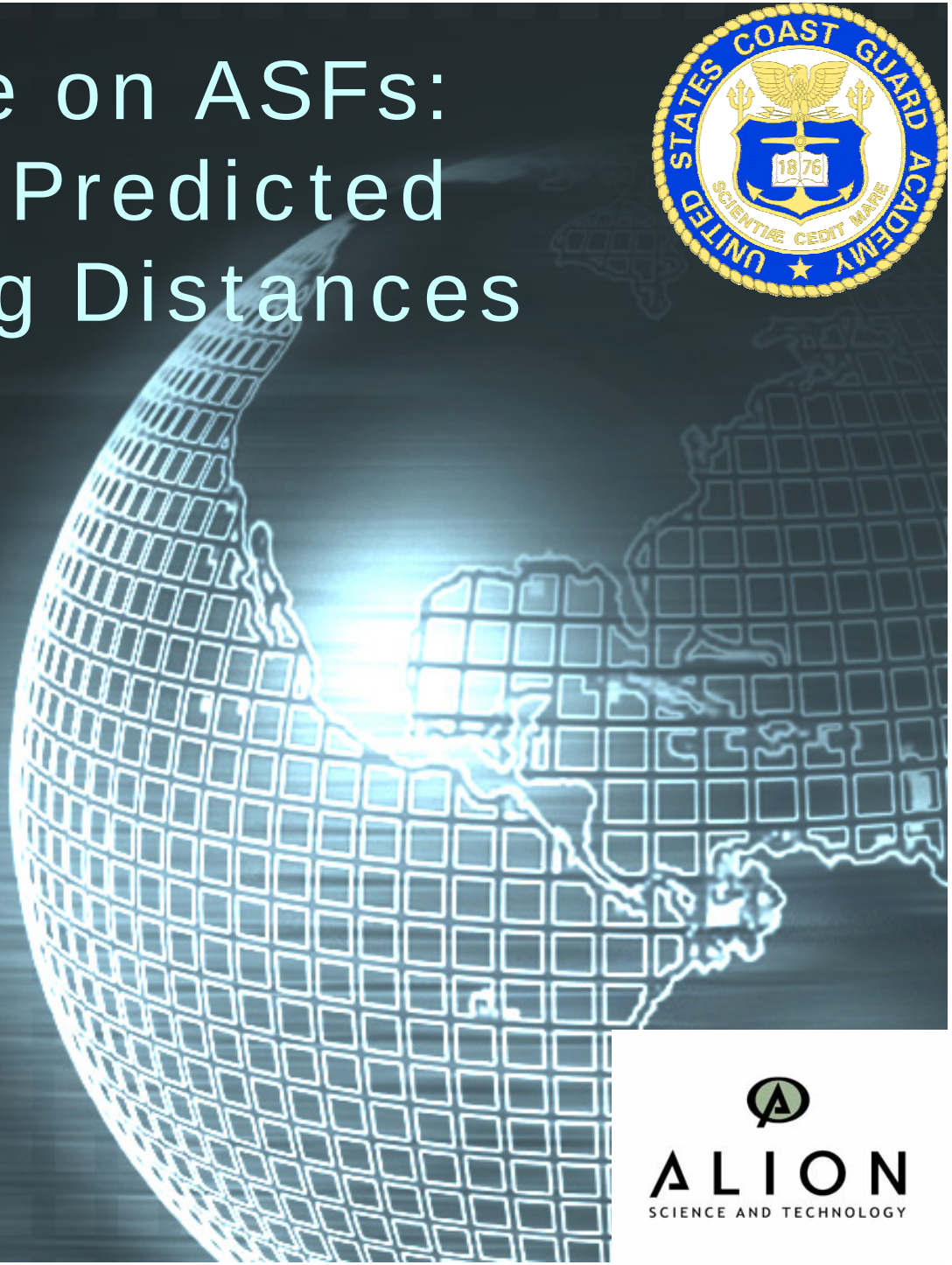
The Big Picture on ASFs: The Validity of Predicted ASFs Over Long Distances

ILA 35

24-25 October 2006

Groton, CT



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ALION SCIENCE AND TECHNOLOGY

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Outline

- Background
- Previous BALOR validation work
- Long Baseline Data
- Continental Predicted Grid and validity
- Conclusions

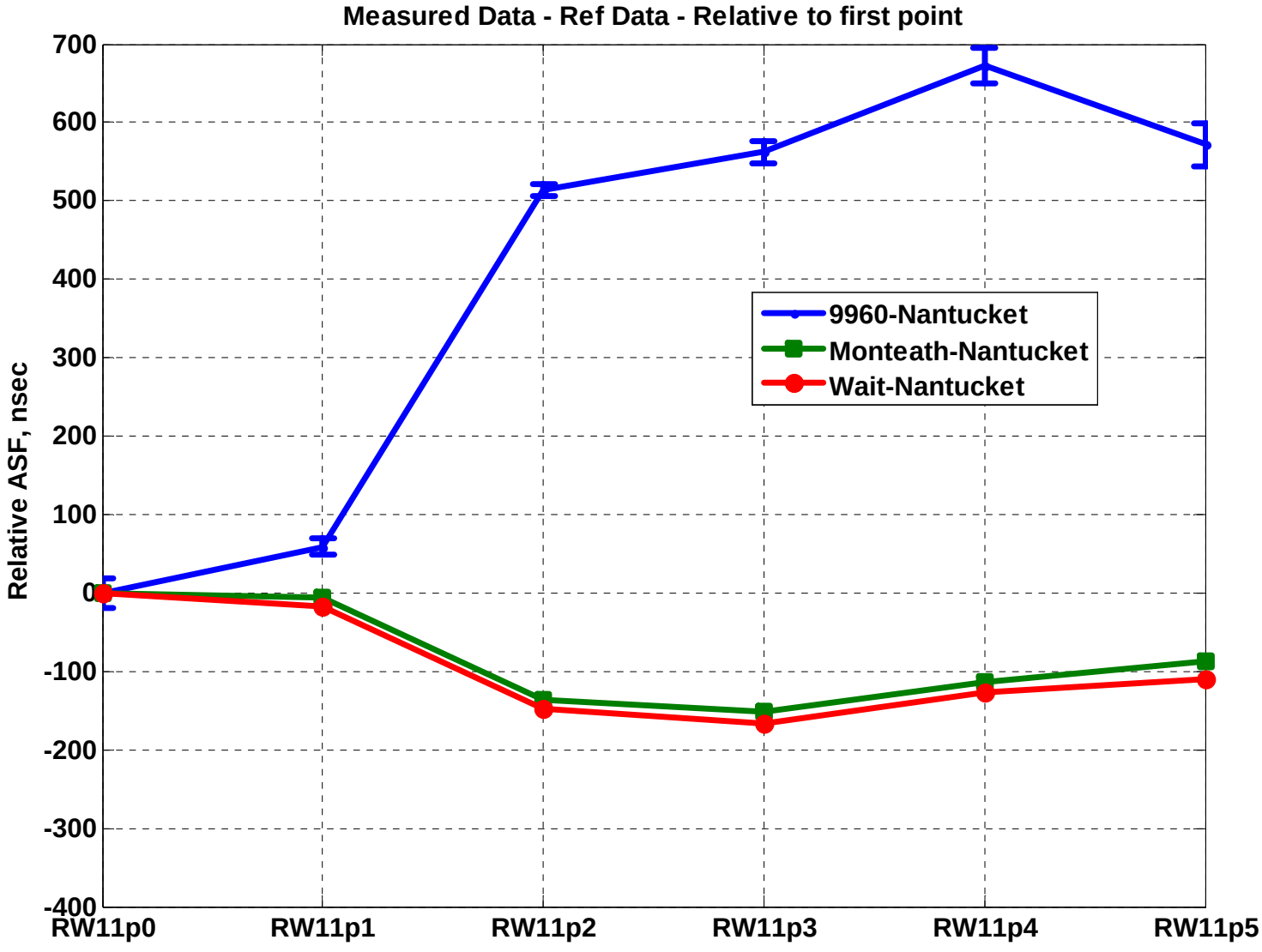
Background

- Predicted ASFs for enroute navigation (RNP 1) CONUS
- Predicted ASFs for airport areas to reduce field data collection required to certify airport
- Predicted ASF grids to aid in surveys for Harbor Approach and Entry grids

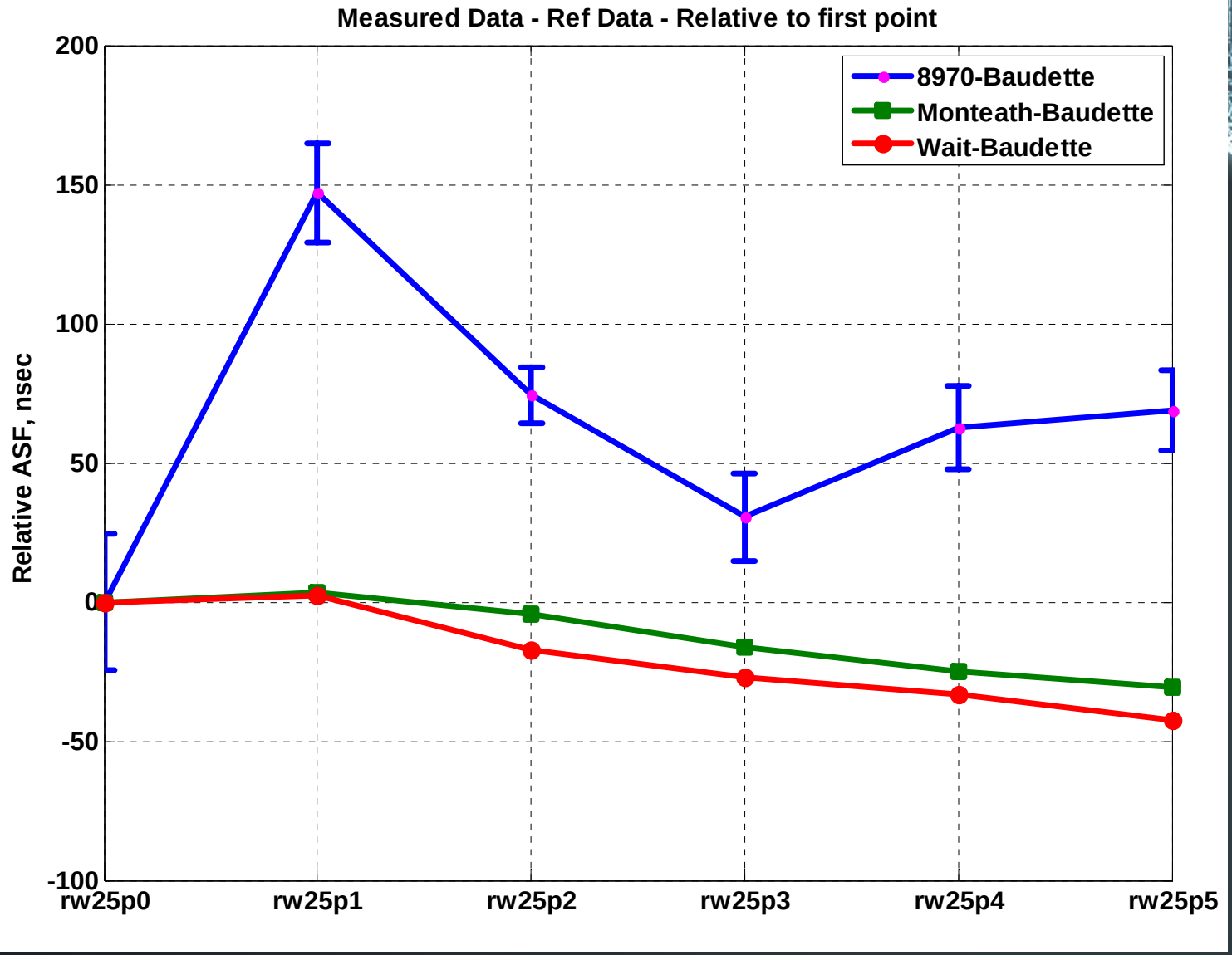
Previous BALOR Validation

- Evaluated Balor suitability for harbor approach and entry pre-survey studies
- Compared Balor generated pASF grids for Non-Precision airport approach

Nantucket at PWM



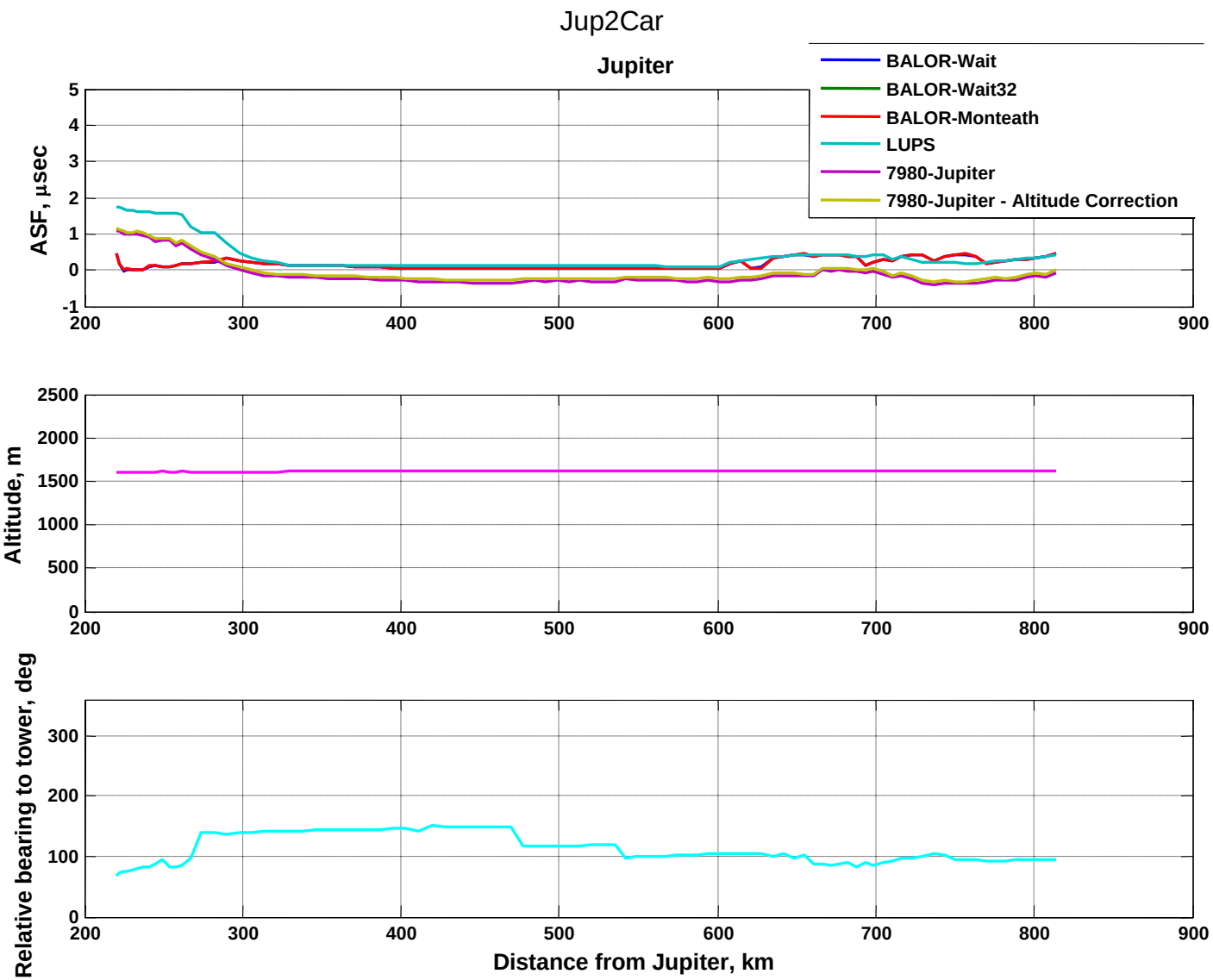
Baudette at LPR



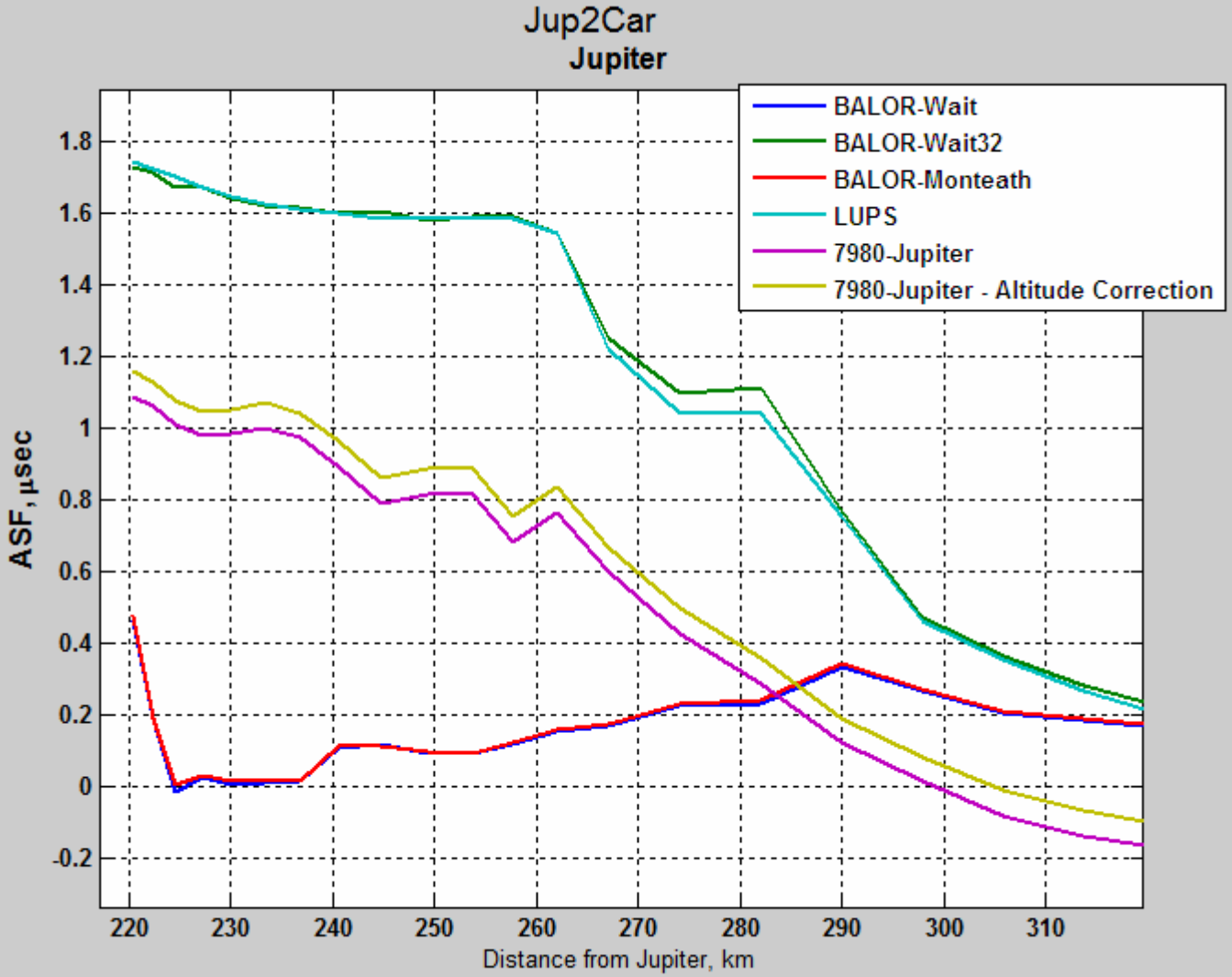
Long Baseline Flights

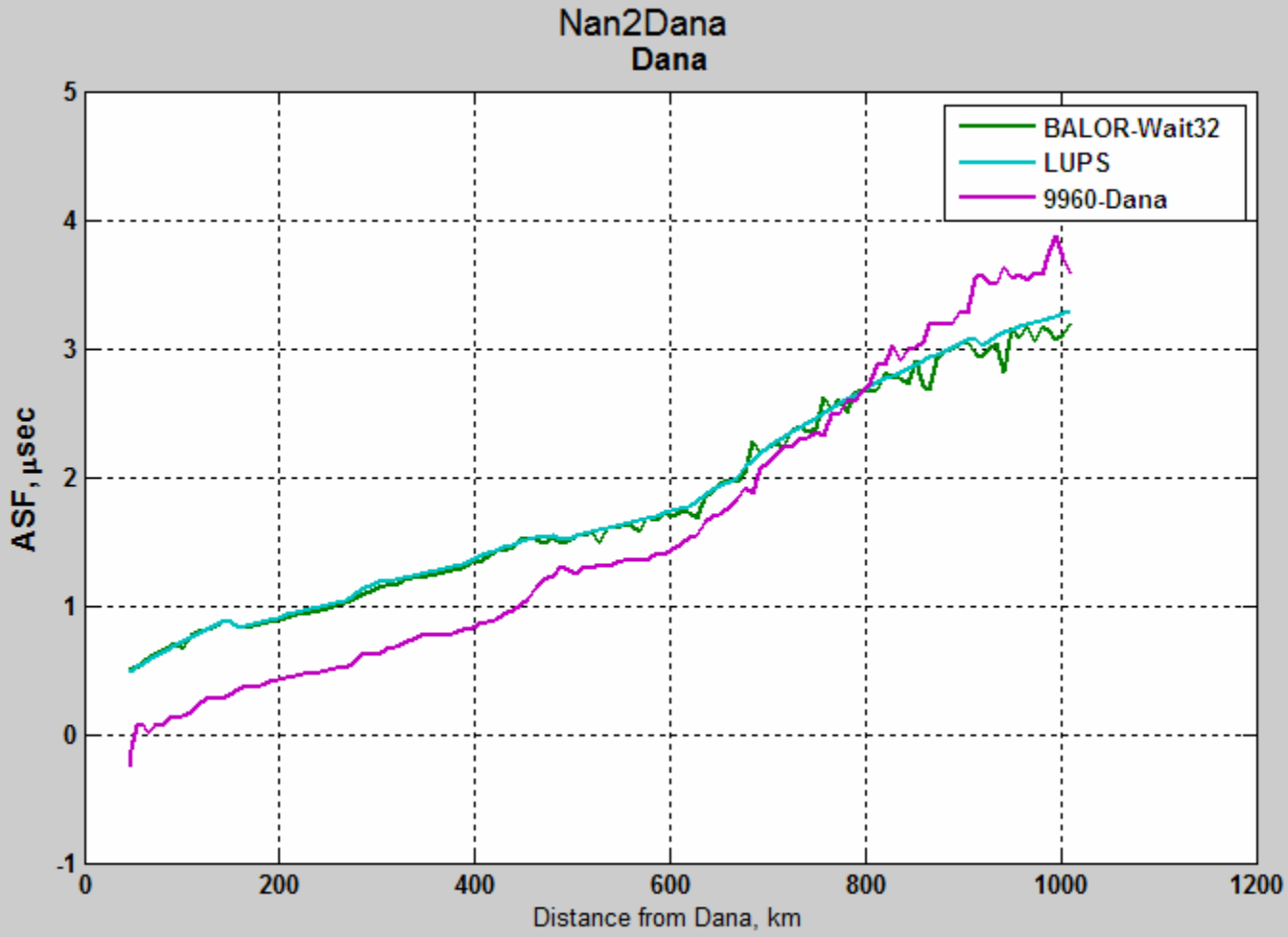
- Flight performed 26-30 June
- Measured compared to predicted ASFs
  - BALOR – Wait
  - BALOR – Monteath
  - BALOR v3.2 Wait
  - LUPS
  - Measured
    - Rcvr averaging removed
    - Altitude compensation based on analysis from ILA34 paper…
  - Altitudes, Relative Bearings to Towers also plotted

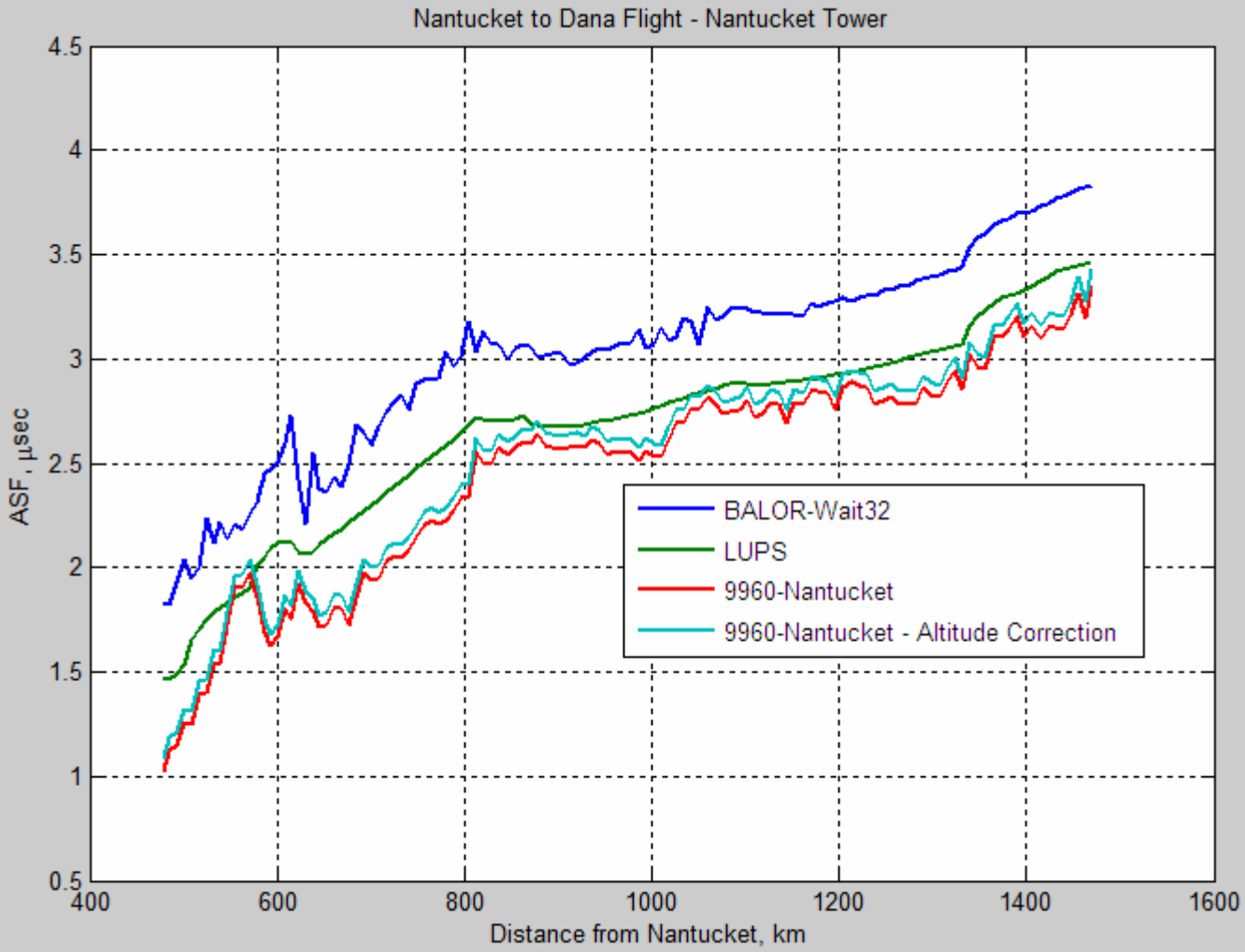

Seneca
Nantucket
Wildwood
Boise-City
Carolina-B
Grangeville
Malone
Jupiter

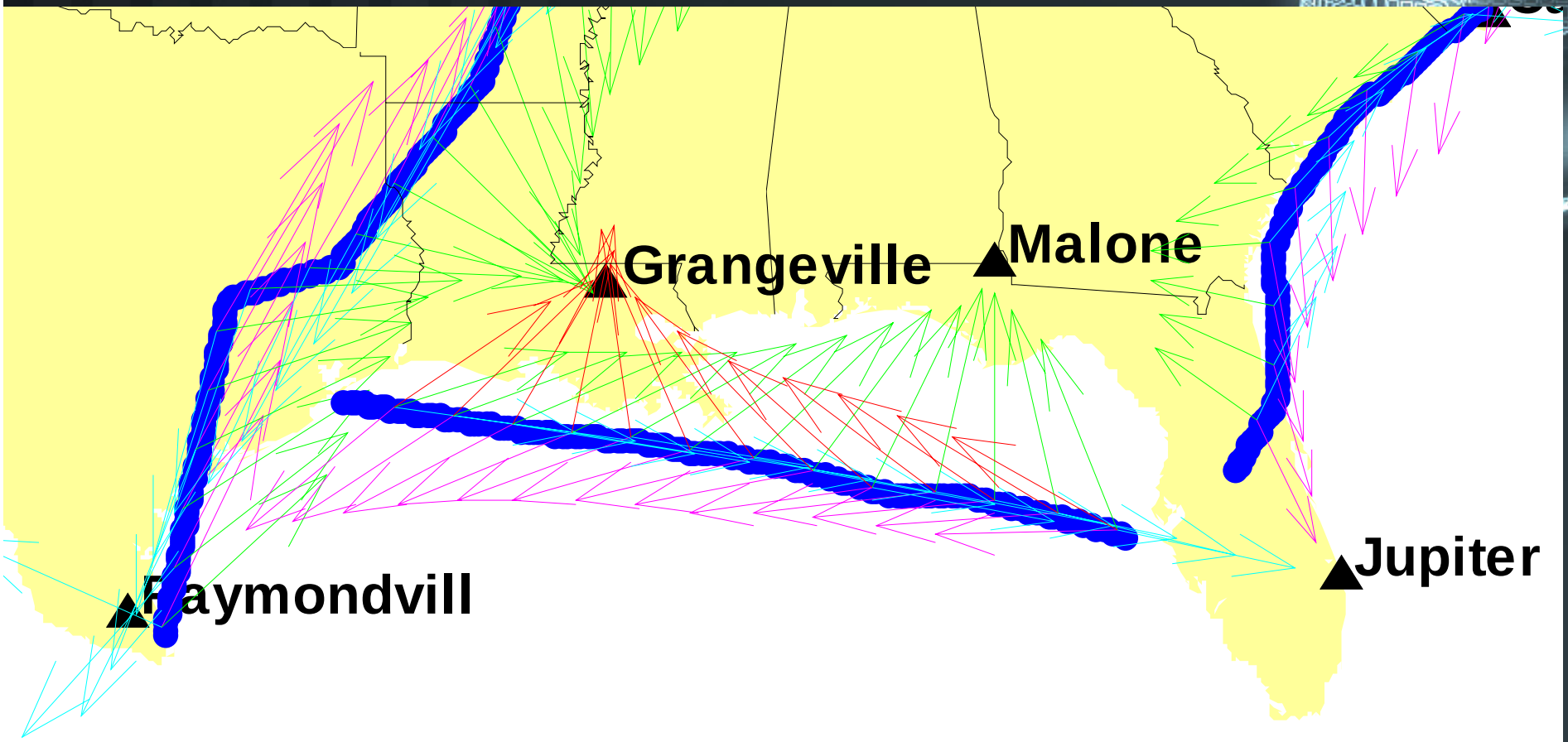

Jup2Car
Jupiter
BALOR-Wait
BALOR-Wait32
BALOR-Monteath
LUPS
7980-Jupiter
7980-Jupiter - Altitude Correction
ASF, µsec
Altitude, m
Relative bearing to tower, deg
Distance from Jupiter, km

Difference between methods

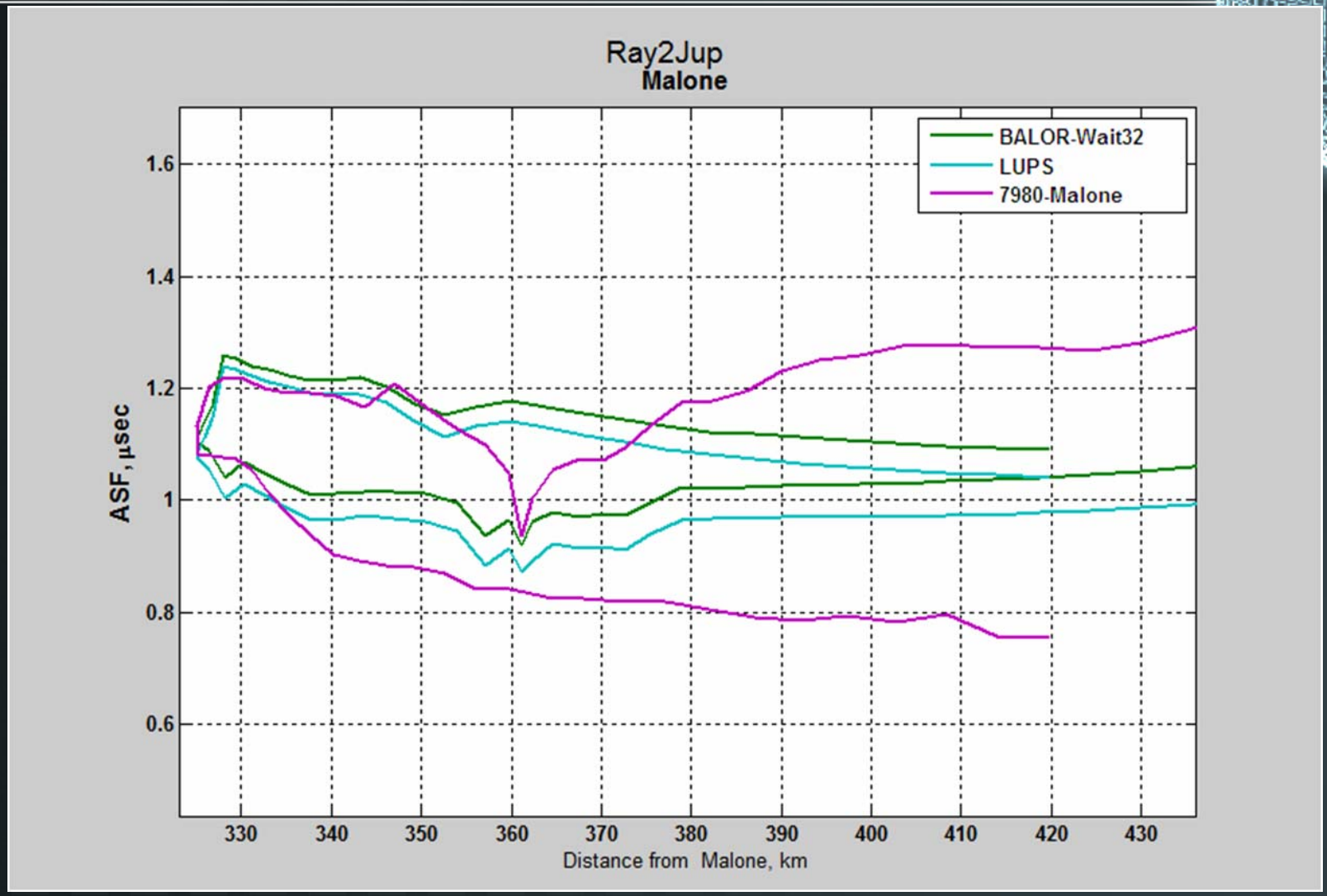



Nan2Dana
Dana
BALOR-Wait32
LUPS
9960-Dana
ASF, µsec
Distance from Dana, km
5
4
3
2
1
0
-1
0
200
400
600
800
1000
1200


Nantucket to Dana Flight - Nantucket Tower
ASF, µsec
Distance from Nantucket, km
BALOR-Wait32
LUPS
9960-Nantucket
9960-Nantucket - Altitude Correction
4.5
4
3.5
3
2.5
2
1.5
1
0.5
400
600
800
1000
1200
1400
1600


Grangeville
Malone
Raymondvill
Jupiter

Directional effect of H-field antenna on measured data



Measures of "goodness"

- Nantucket to Dana leg
  - Nantucket RMSE
    - 137 nanoseconds Wait 3.2
    - 115 nanoseconds Lups
  - Dana RMSE
    - 365 nanoseconds Wait 3.2
    - 335 nanoseconds Lups
  - Nantucket bias
    - 4059 nanoseconds Wait 3.2
    - 3705 nanoseconds Lups
  - Dana bias
    - 3699 nanoseconds Wait 3.2
    - 3729 nanoseconds Lups

Difference in accuracy between paths for Lups method

- Average Lups RMSE
  - path Car2Nan 106 nanoseconds
  - path Dana2Ray 244 nanoseconds
  - path Jup2Car 110 nanoseconds
  - path Nan2Dana 221 nanoseconds
  - path Ray2Jup 129 nanoseconds

Difference in accuracy between methods

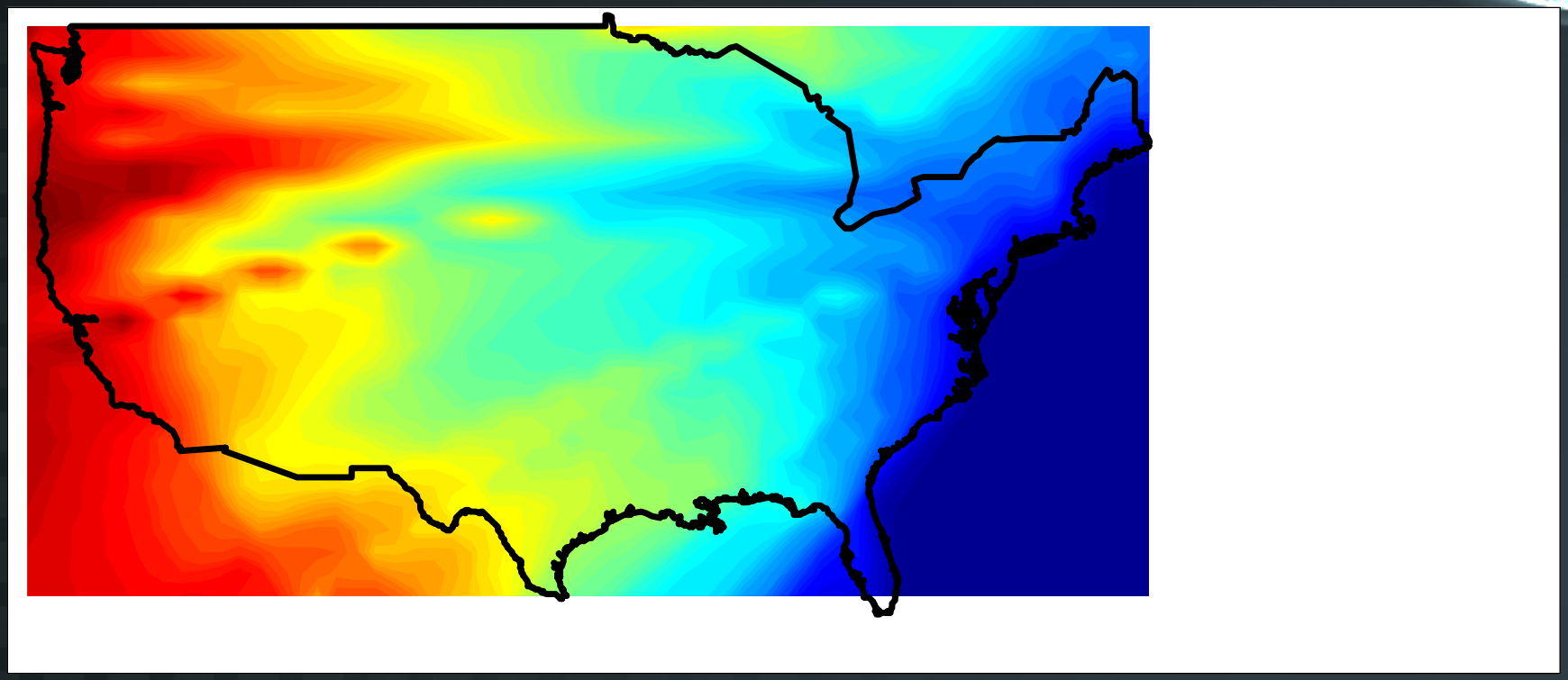
- RMSE averaged for all five paths sorted by pASF method
  - Lups 164 nanoseconds
  - Wait32 181 nanoseconds
  - Moneath 231 nanoseconds
  - Wait31 251 nanoseconds

CONUS Grid

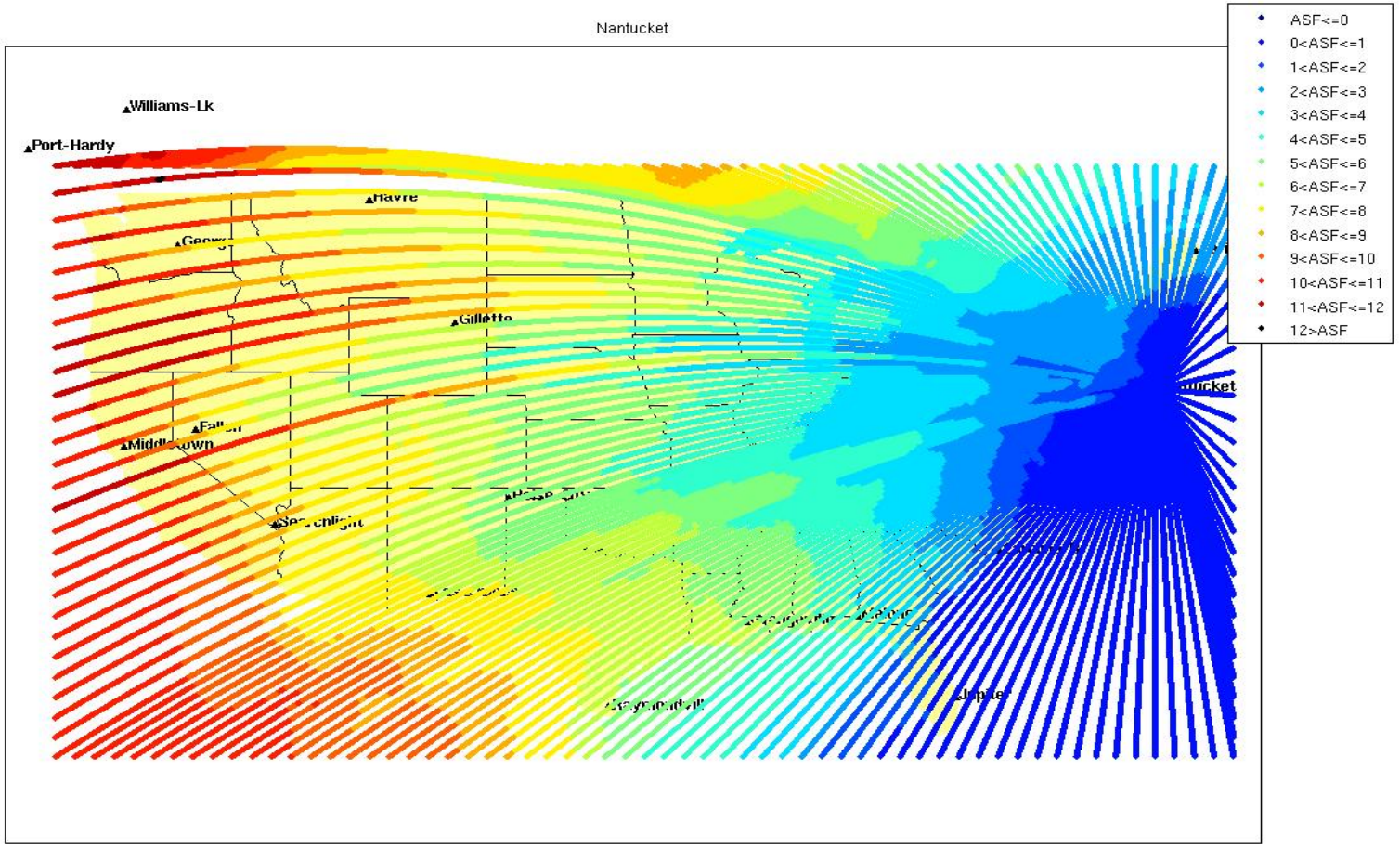
- Examine performance in the position domain
- Compute CONUS grids and apply to measured data
  - BALOR 32
  - LUPS

Nantucket pASFs contour plot

pASFs grid generated using Balor v3.2 Wait method

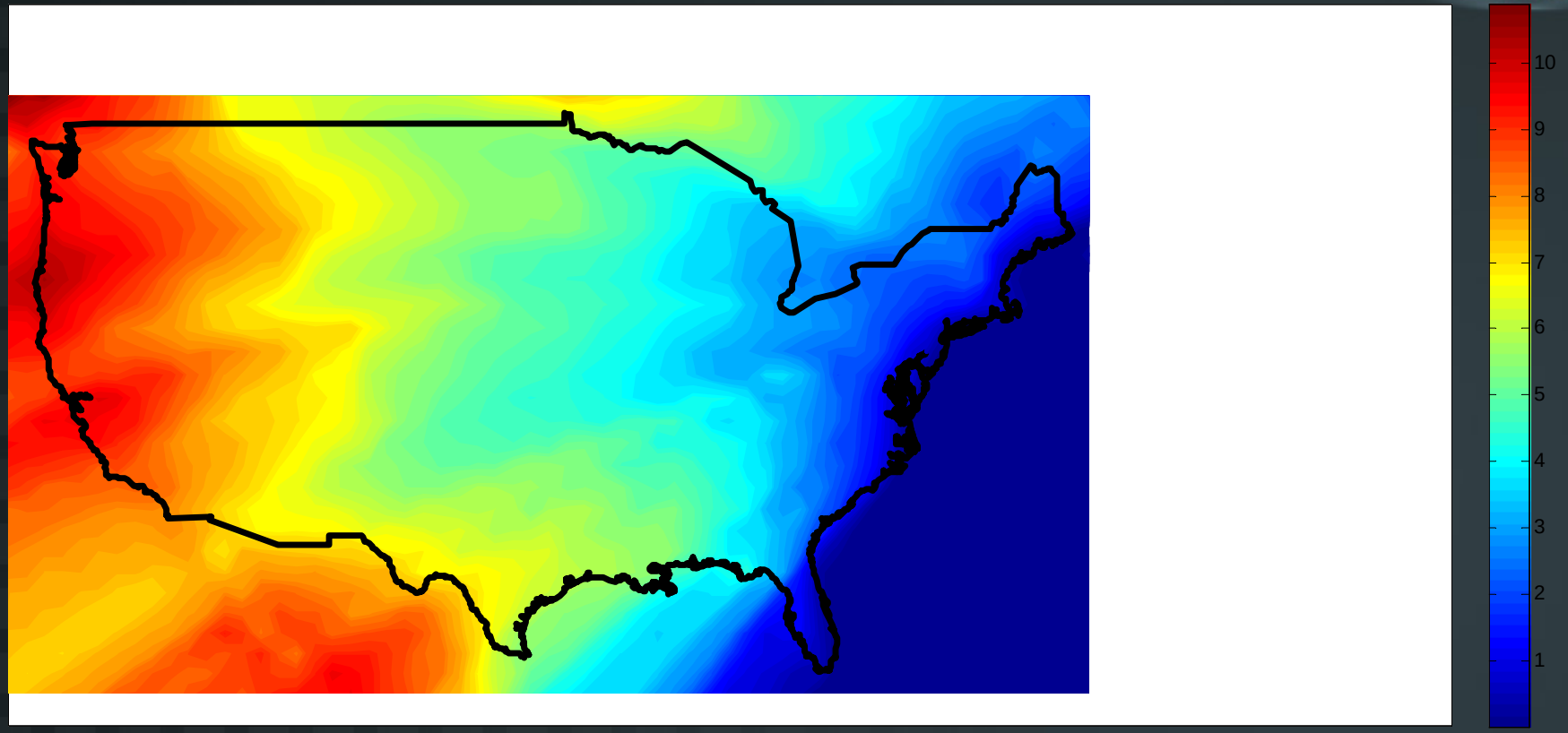


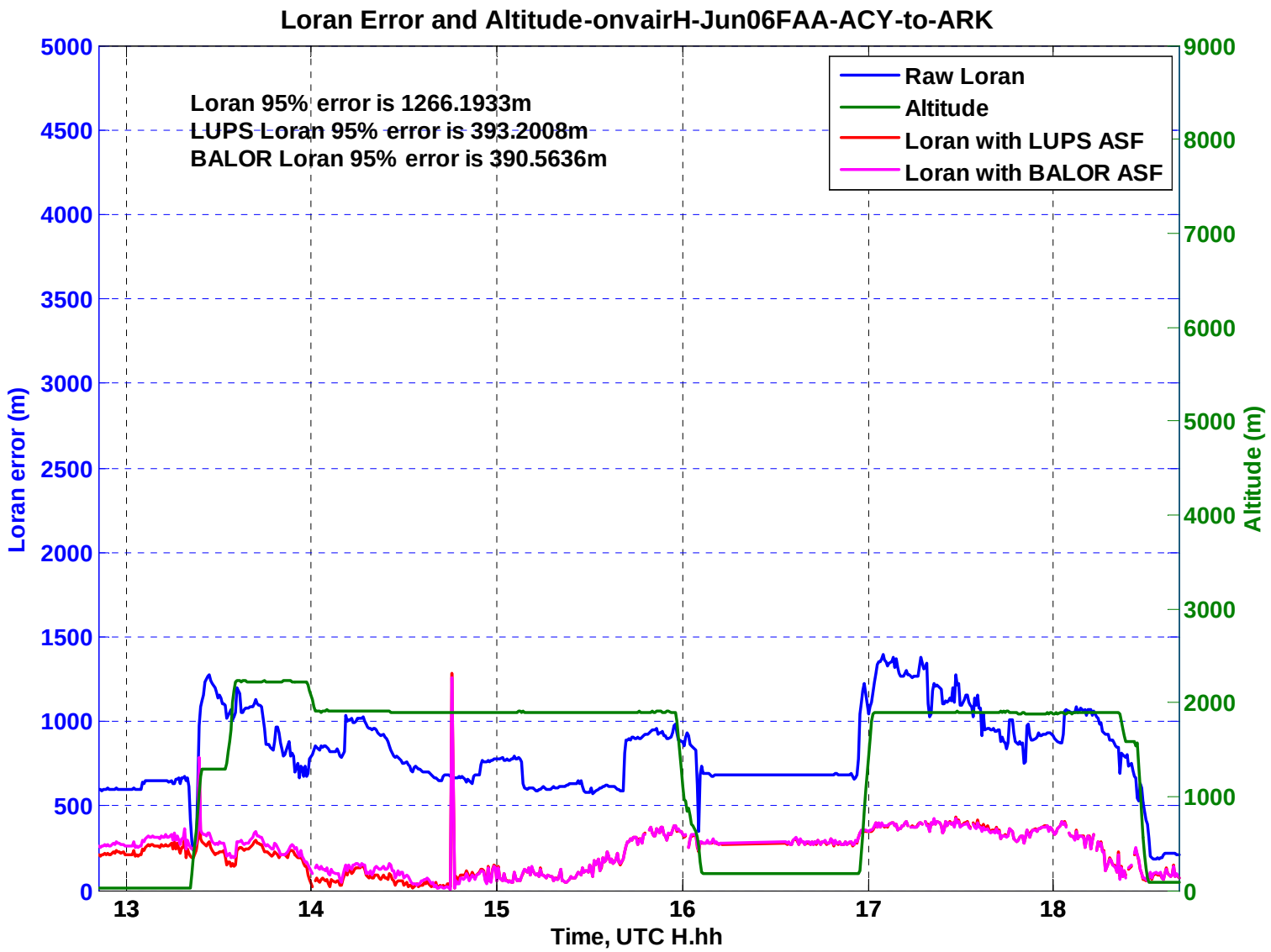
Balor computes ASFs along radials

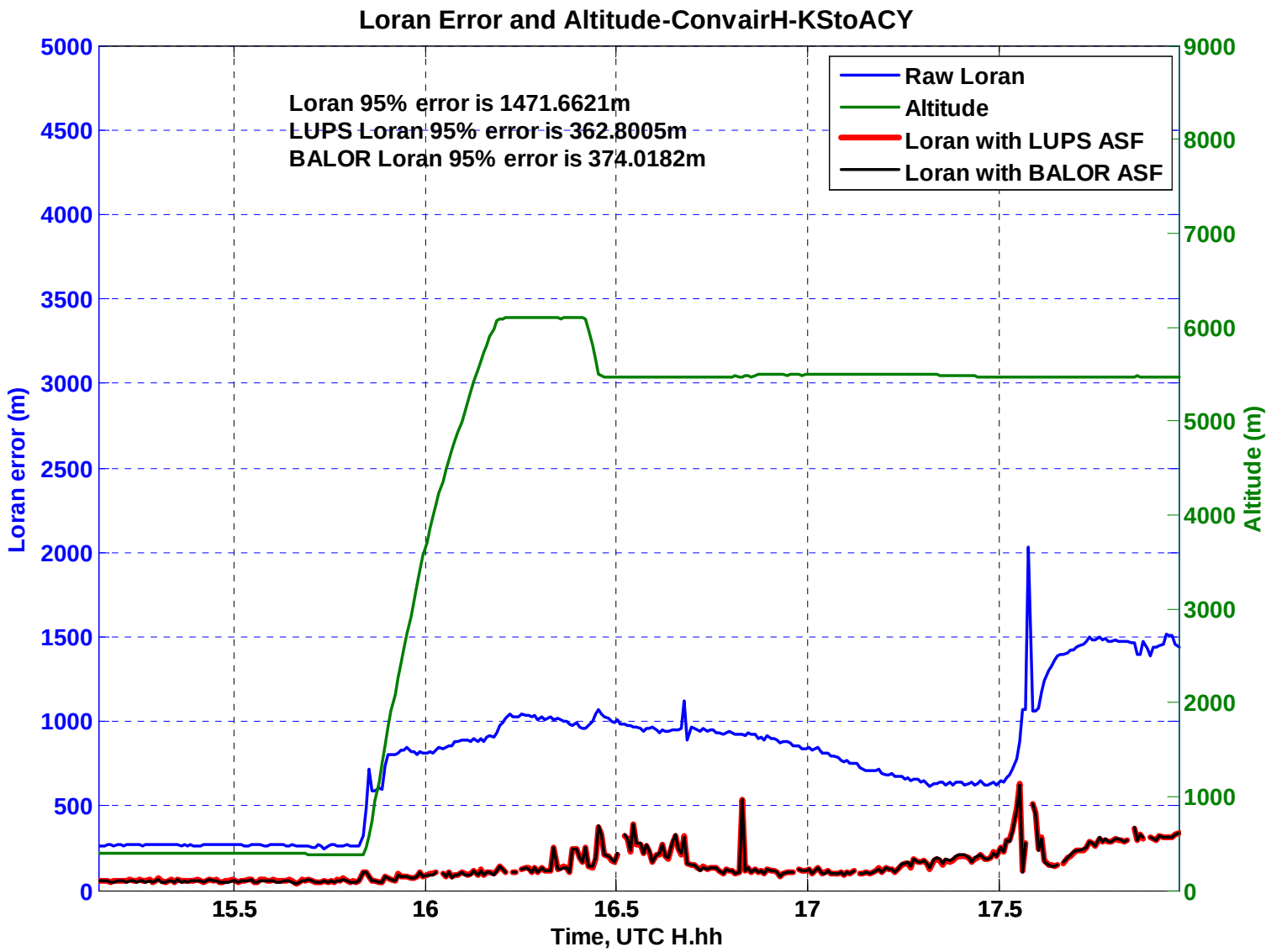


Nantucket pASFs contour plot

pASFs grid generated using LUPS method




Loran Error and Altitude-onvairH-Jun06FAA-ACY-to-ARK
Loran 95% error is 1266.1933m
LUPS Loran 95% error is 393.2008m
BALOR Loran 95% error is 390.5636m
Raw Loran
Altitude
Loran with LUPS ASF
Loran with BALOR ASF
Loran error (m)
Altitude (m)
Time, UTC H.hh
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
6000
7000
8000
9000
13
14
15
16
17
18


Loran Error and Altitude-ConvairH-KStoACY
Loran 95% error is 1471.6621m
LUPS Loran 95% error is 362.8005m
BALOR Loran 95% error is 374.0182m
Raw Loran
Altitude
Loran with LUPS ASF
Loran with BALOR ASF
Loran error (m)
Altitude (m)
Time, UTC H.hh
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
15.5
16
16.5
17
17.5

Conclusions

- Using pASF improves accuracy compared to not using pASFs for enroute
  - Accuracy not sufficient for NPA or HEA
  - May be good enough for enroute (ADS-B)
  - Accuracy may be improved by pinning down the predicted grid with measured airport ASFs
- Balor Wait v 3.2 method – calculation speed is improved, some improvement in accuracy
- Lups method – fast, best accuracy, uses simple prediction method
- Balor Monteath and Wait v 3.1 – inferior compared to previous 2 methods

Acknowledgements

- Alion Team
  - Christian Oates, Mark Wiggins, Ken Dykstra, & Ruslan Shalaev
- ASF Working Group

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