

Warping Time and Space: Spatial Correlation of Temporal Variations



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Outline

- Seasonal Monitor Network
 - Sites, Baselines
 - Equipment
 - Network, Software
- Spatial Correlation
- ASF Filtering
- Conclusions
- Future



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Seasonal Monitor Network



Seasonal Monitors

- Monitor Sites Installed at
 - USCGA, New London CT
 - URI, Kingston RI
 - Volpe, Cambridge MA
 - FAATC, Atlantic City NJ
 - OU, Athens OH
 - Staten Island, NY



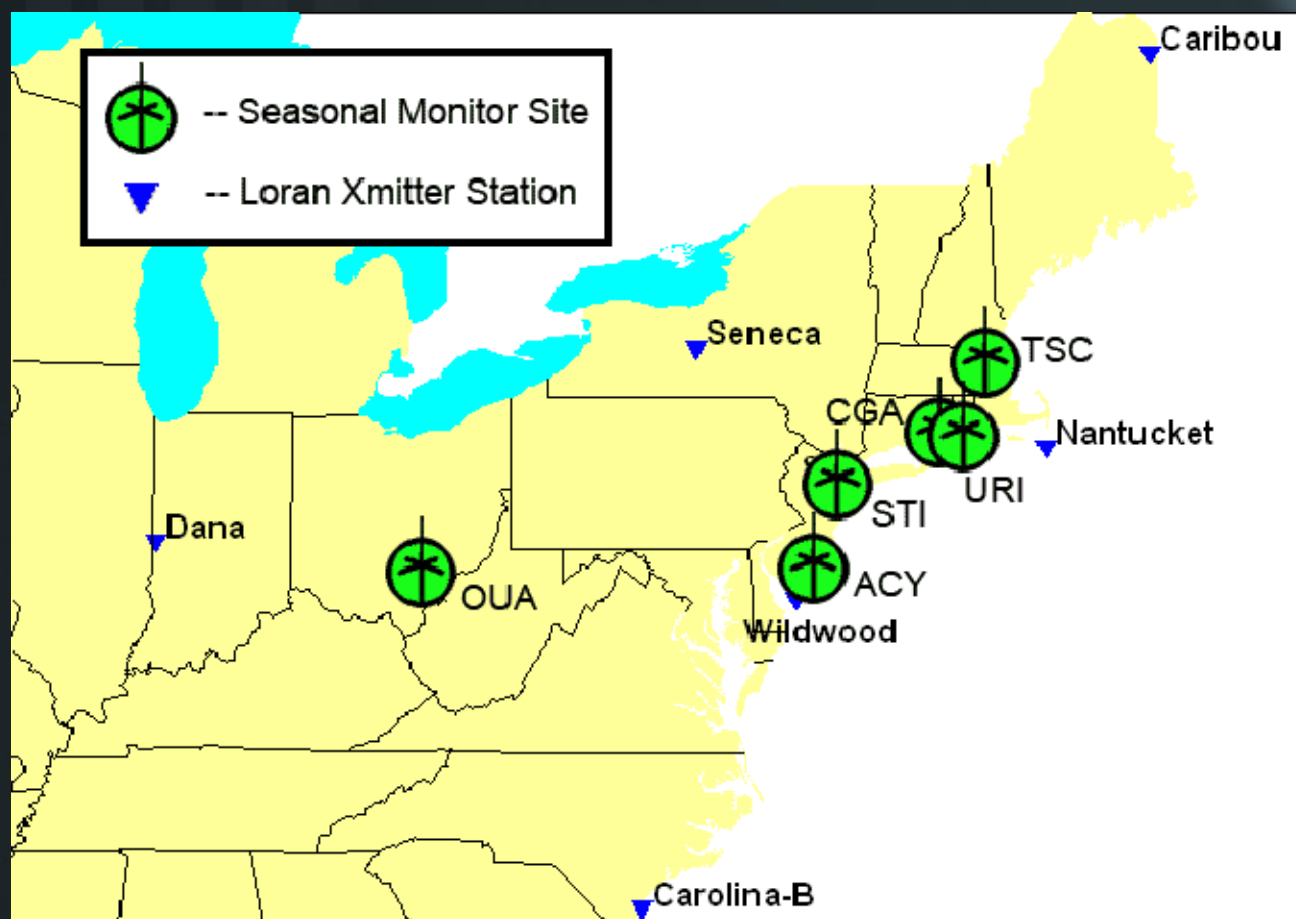
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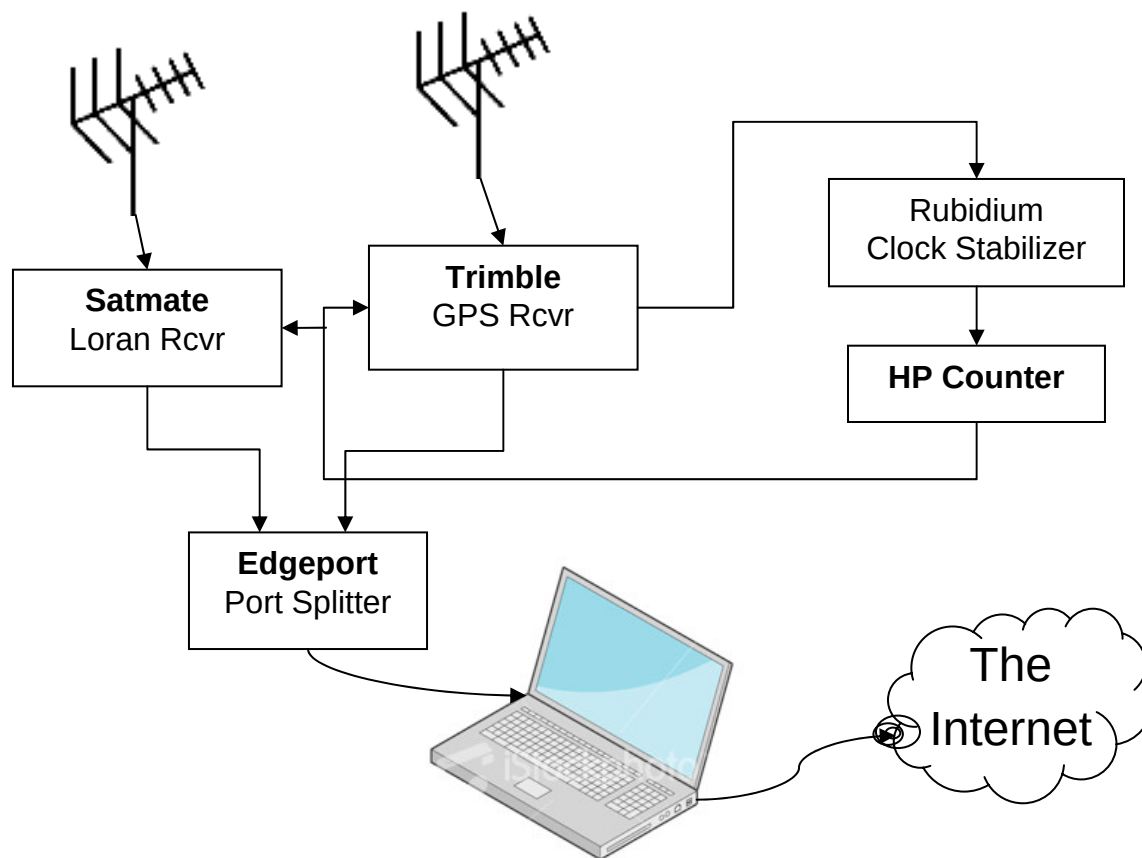
Site Locations



Seasonal Monitor Unit



System Description



Seasonal Monitor Data



- ASFs plus other Loran & GPS information saved at 1 minute intervals
 - All information is also transmitted across the Internet to a server located at CGA
 - Enables sites to be monitored at CGA
 - All data available at CGA
 - ASFs transmitted to LSU as differential Loran corrections



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CGA Data Server



Alion Seasonal Monitors Server 1.2 Beta 8

INCOMING IPs

```

12.75.134.174 10/16/2006 10:49:55
12.75.137.147 10/16/2006 16:51:54
12.75.134.71 10/17/2006 04:54:44
12.75.136.73 10/17/2006 10:55:44
12.75.134.168 10/17/2006 16:56:43
12.75.134.194 10/17/2006 22:58:43
12.75.134.57 10/18/2006 04:59:38
12.75.135.25 10/18/2006 11:01:37
12.75.141.147 10/18/2006 17:02:37
12.75.141.136 10/18/2006 23:03:37

```

INCOMING Receiver/Integration Clients

```

Data\SeasonalMonitors-LRN2-USCGA-313-Integration.txt 10/16/2006 23:58:49
Data\SeasonalMonitors-LRN7-STI-060-Integration.txt 10/16/2006 23:58:58
Data\SeasonalMonitors-LRN4-ACY-285-Integration.txt 10/17/2006 00:01:14
Data\SeasonalMonitors-LRN6-URI-315-Integration.txt 10/17/2006 00:01:29
Data\SeasonalMonitors-LRN3-OU-213-Integration.txt 10/17/2006 00:04:28
Data\SeasonalMonitors-LRN5-VOLPE-295-Integration.txt 10/17/2006 00:19:20
Data\SeasonalMonitors-LRN2-USCGA-314-Integration.txt 10/17/2006 23:58:56
Data\SeasonalMonitors-LRN5-VOLPE-296-Integration.txt 10/18/2006 00:00:02
Data\SeasonalMonitors-LRN4-ACY-286-Integration.txt 10/18/2006 00:01:14
Data\SeasonalMonitors-LRN6-URI-316-Integration.txt 10/18/2006 00:01:28

```

Start TCP/IP Logging Stop TCP/IP Logging Waiting to Accept a client Quit

INCOMING Data

```

Data\SeasonalMonitors-LRN4-ACY-292-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 9960 H 9960
10232006 152130 02 192130.00 39.44974077 -74.56634665 2 6 1.90 41.6 69.3548000000 120 0.0125 0.0
Data\SeasonalMonitors-LRN6-URI-322-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 9960 H 9960
10232006 152136 02 192136.00 41.48820282 -71.52650223 2 8 1.10 78.1 12.2674000000 120 0.0152 0.0
Data\SeasonalMonitors-LRN2-USCGA-320-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 9960 H 9960
10232006 152105 02 192203.00 41.37206705 -72.09994015 2 7 1.20 40.6 90.5659000000 120 0.0045 0.0
Data\SeasonalMonitors-LRN7-STI-067-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 9960 H 9960
10232006 151926 02 192220.00 40.60033585 -74.05786827 1 6 1.40 39.3 27.1032000000 120 0.0037 0.0
Data\SeasonalMonitors-LRN5-VOLPE-302-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 9960 H 9960
10232006 152415 02 192223.00 42.36410495 -71.08560778 2 7 1.20 66.1 84.8920000000 120 0.0081 0.0
Data\SeasonalMonitors-LRN3-OU-220-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 8970 H 8970
10232006 151956 02 192226.00 39.20924468 -82.22391305 2 8 1.20 235.4 68.8843000000 120 0.0038 0.0
Data\SeasonalMonitors-LRN4-ACY-292-Integration.txt
CompDate C.Time F1 GPS:
mmddyyyy hhmmss ag Time Lat: Lon: Qual Sat hDop Height Counter Num 9960 H 9960
10232006 152230 02 192230.00 39.44974057 -74.56634723 2 6 1.90 41.4 69.3476000000 120 0.0125 0.0

```



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Server-side Software



ASF data is managed by two programs on the server side at USCGA

- First program collects updates of ASF data at one sample for every site
 - All past data is also kept for historical view
- Second program, wxXMTR, converts data for dLoran transmission
 - Raw ASFs are converted into offsets from a base ASF value



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DLoran System



- ASF offset updates sent to LSU by FTP
- LSU generates LDC messages and makes available for widespread access
- LORAN stations, like in Seneca, NY download these messages over FTP
- LORAN station transmits the messages by LDC on the 9th pulse



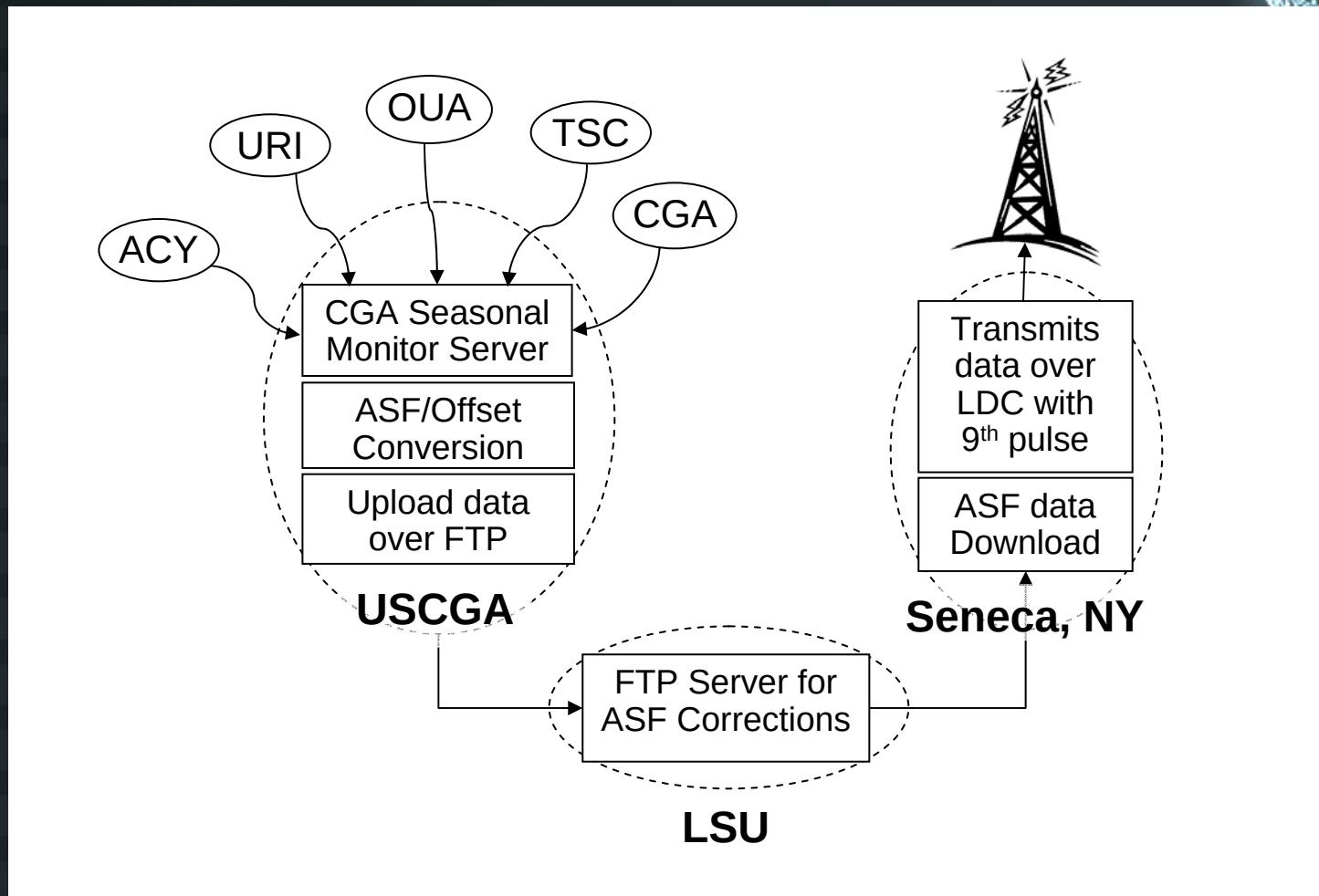
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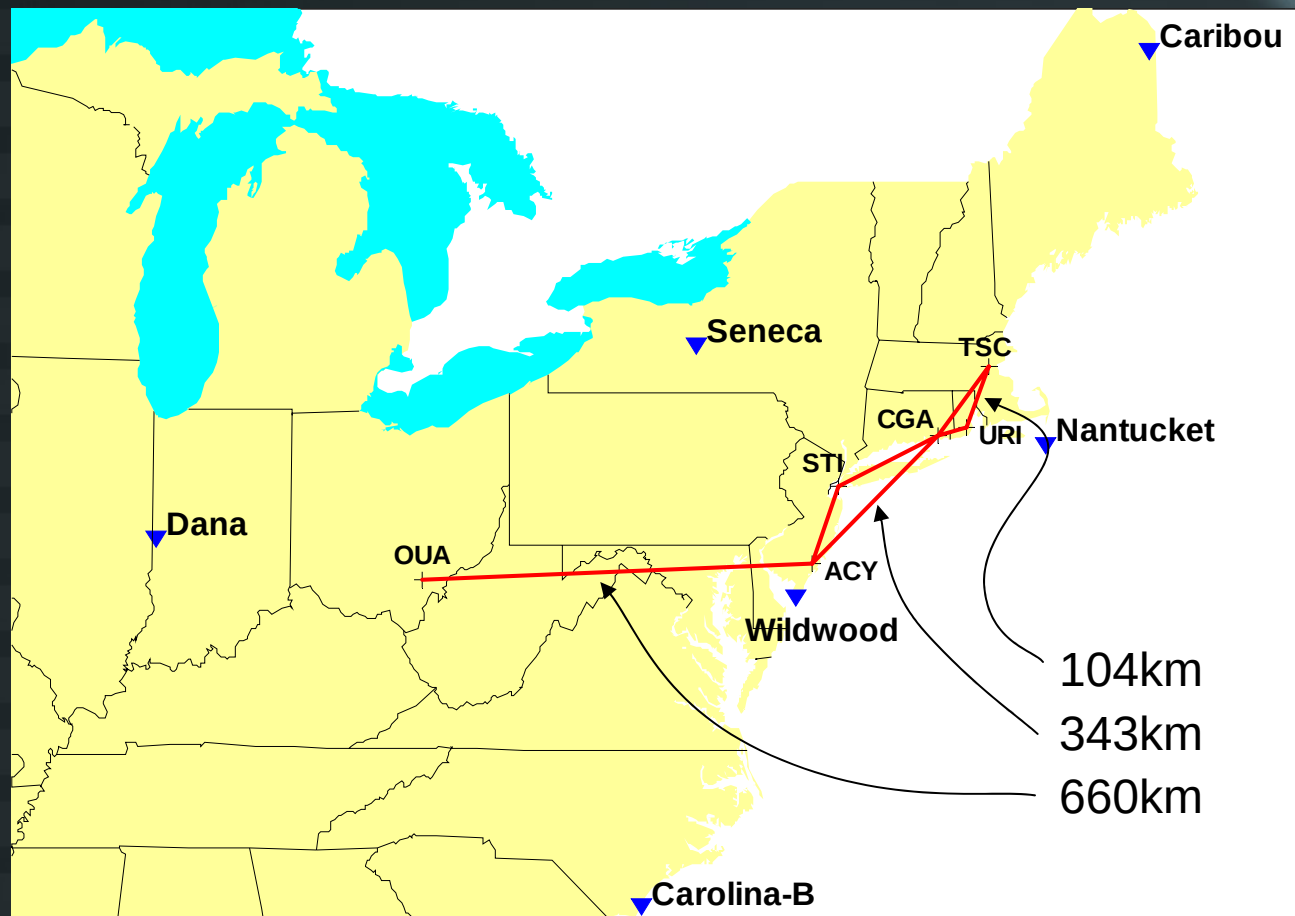
DLoran System Diagram



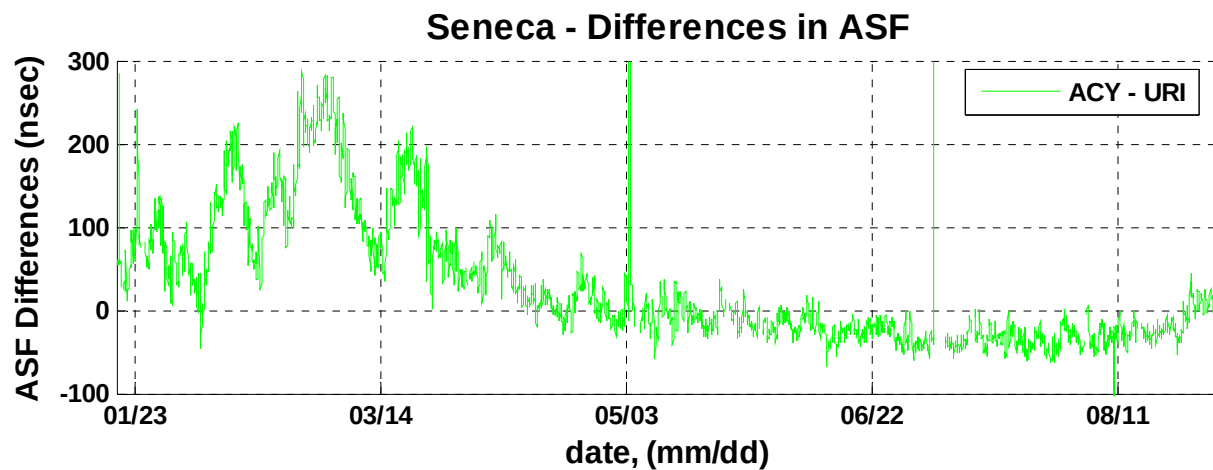
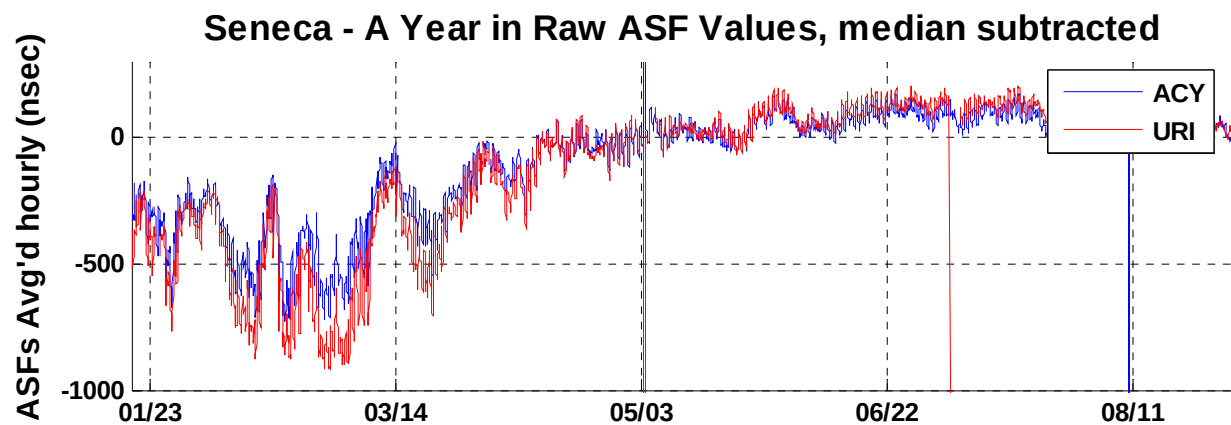
Spatial Correlation



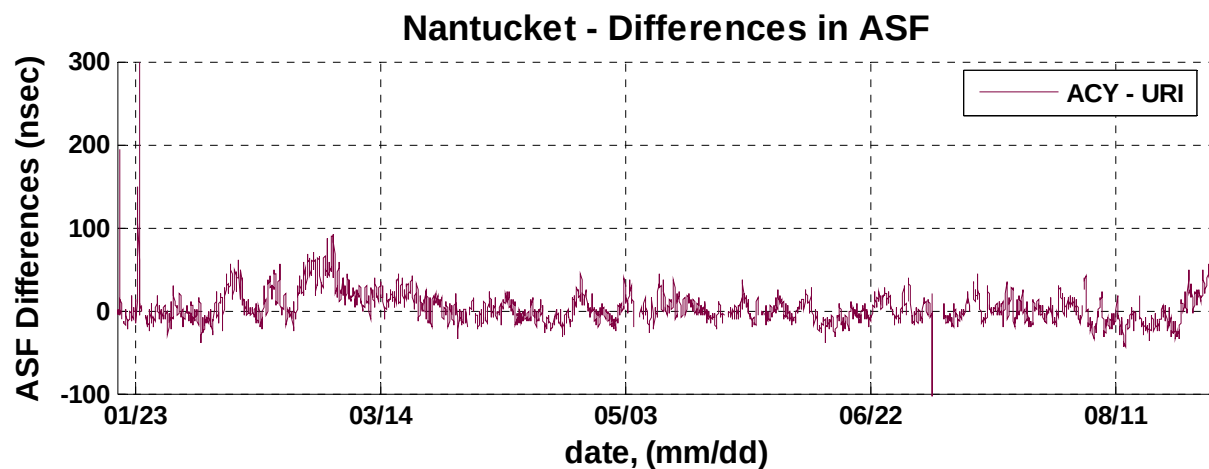
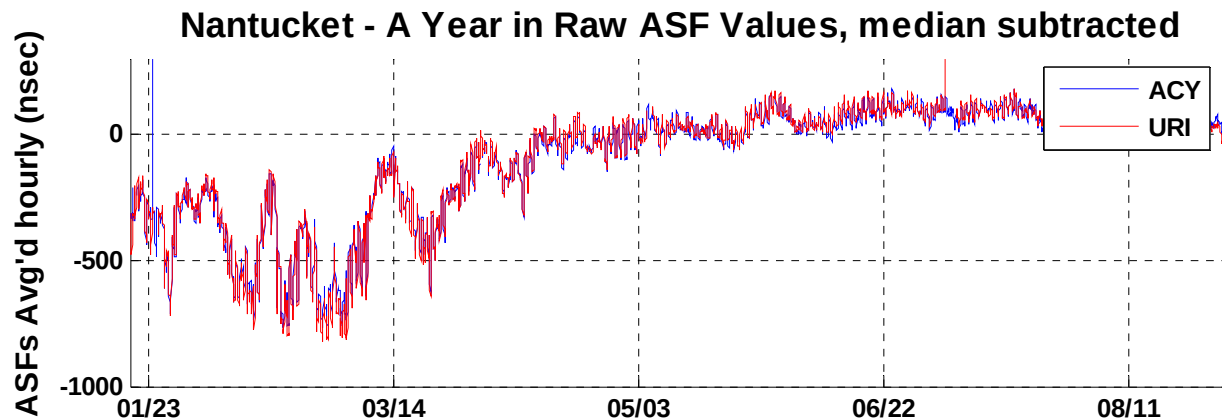
Baselines



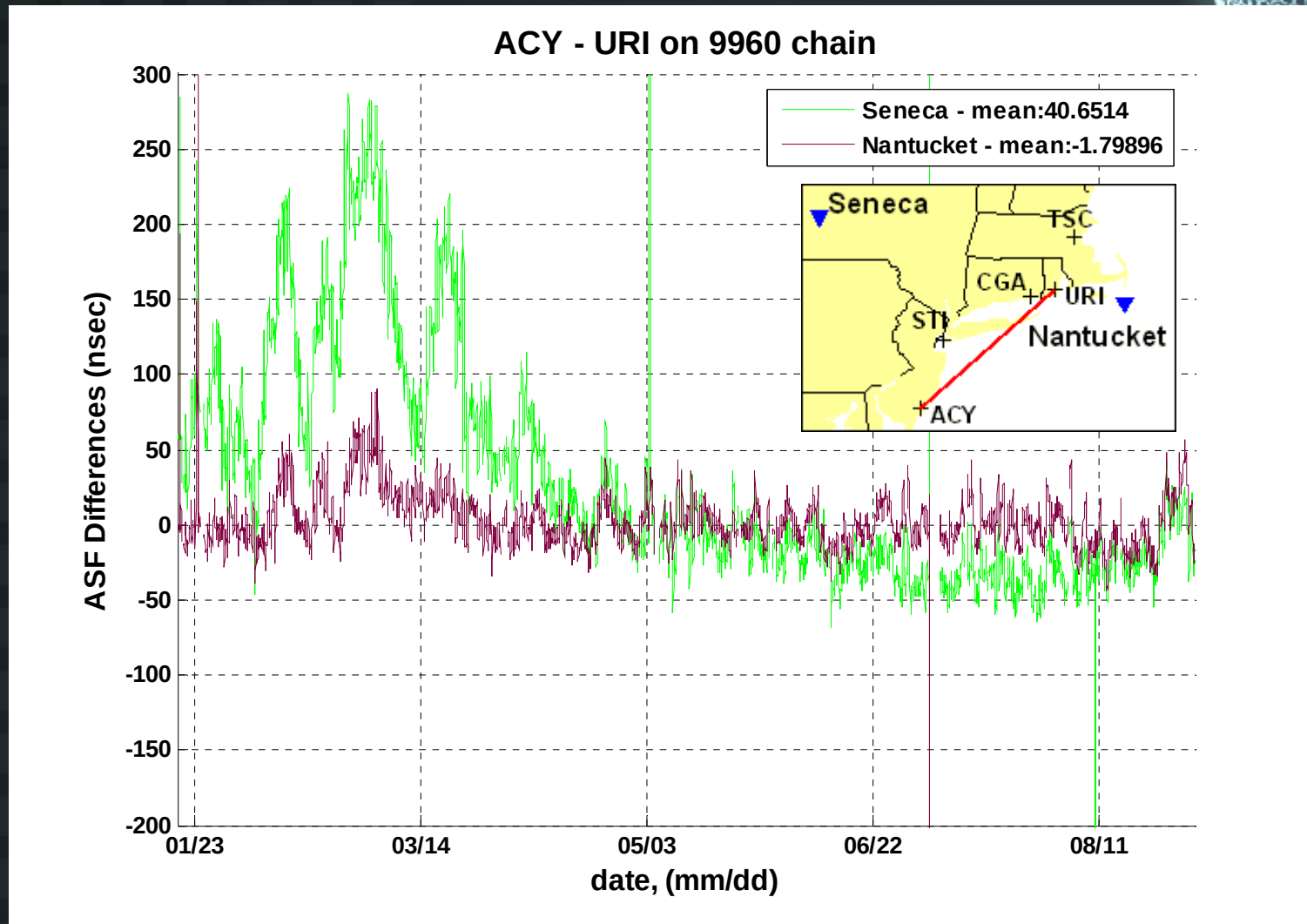
ASF Differences



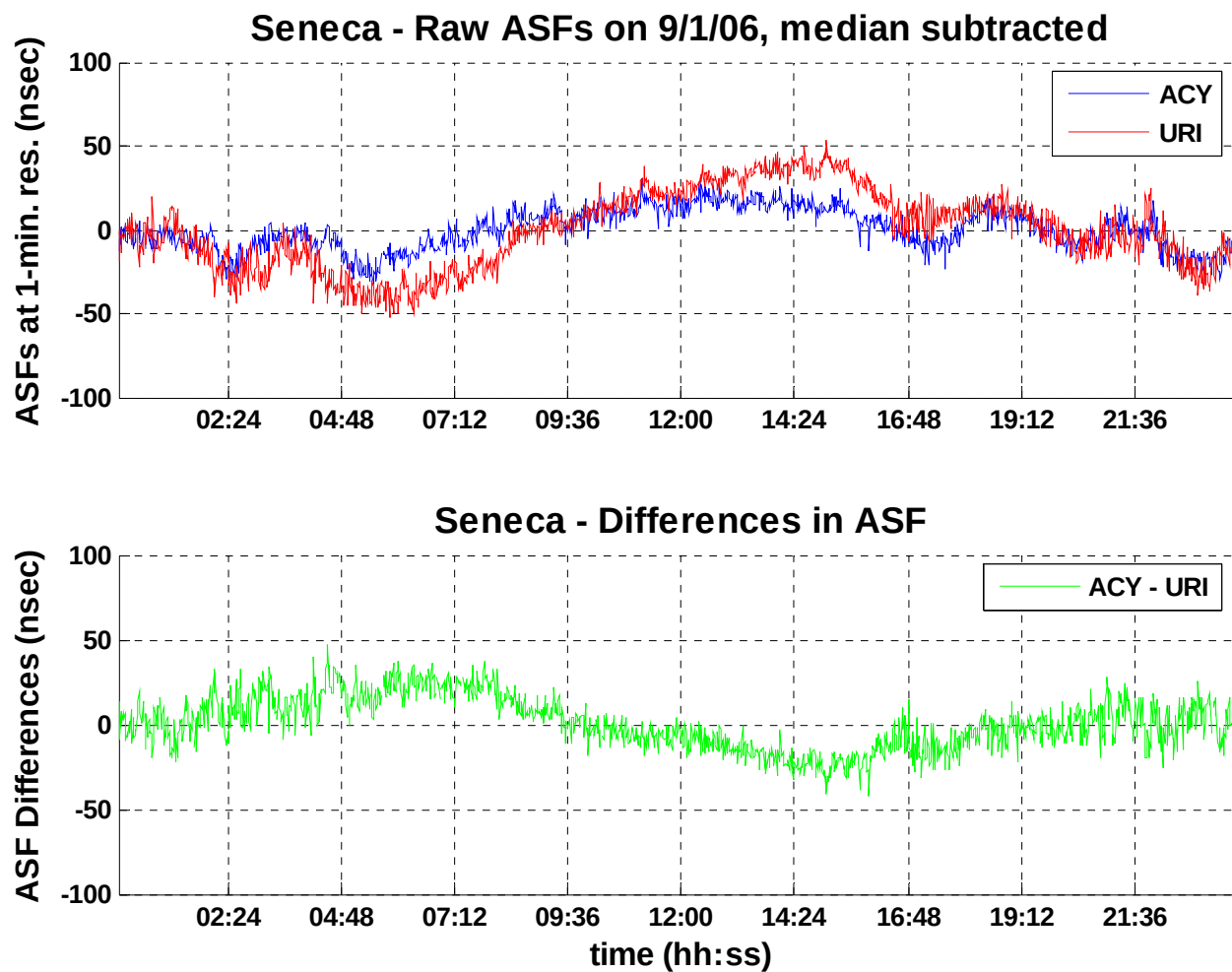
ASF Differences



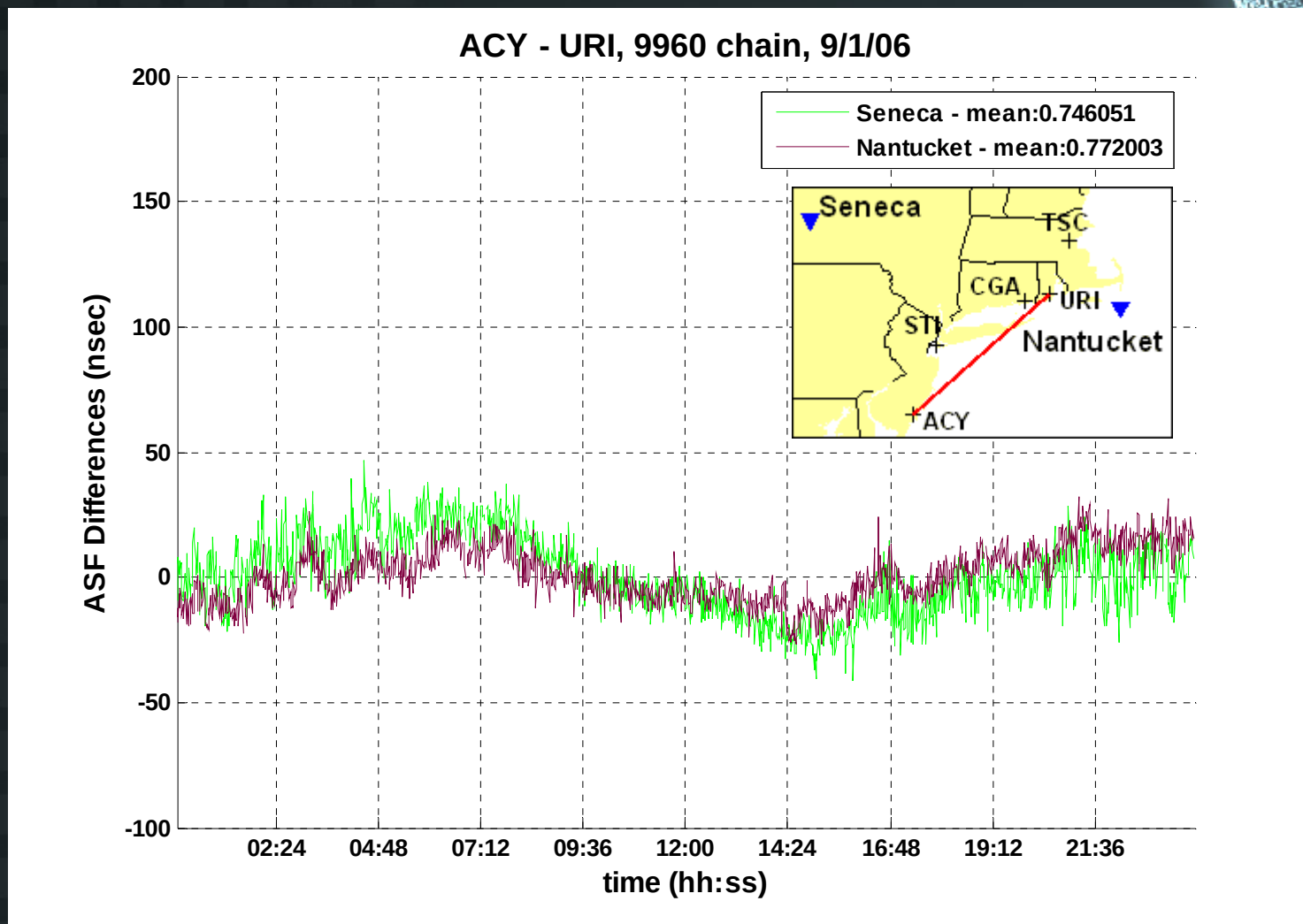
Difference Comparison



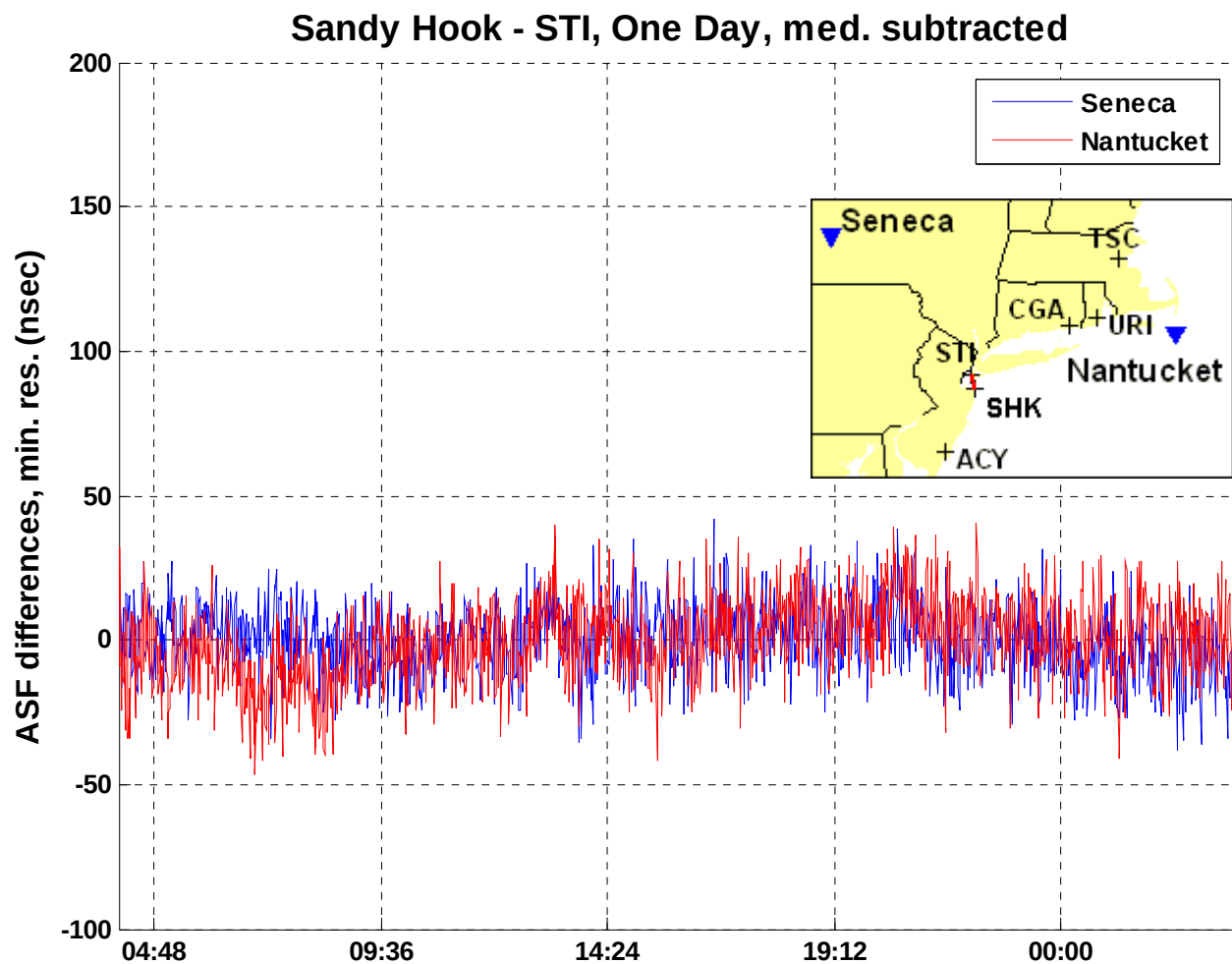
Short-term Differences



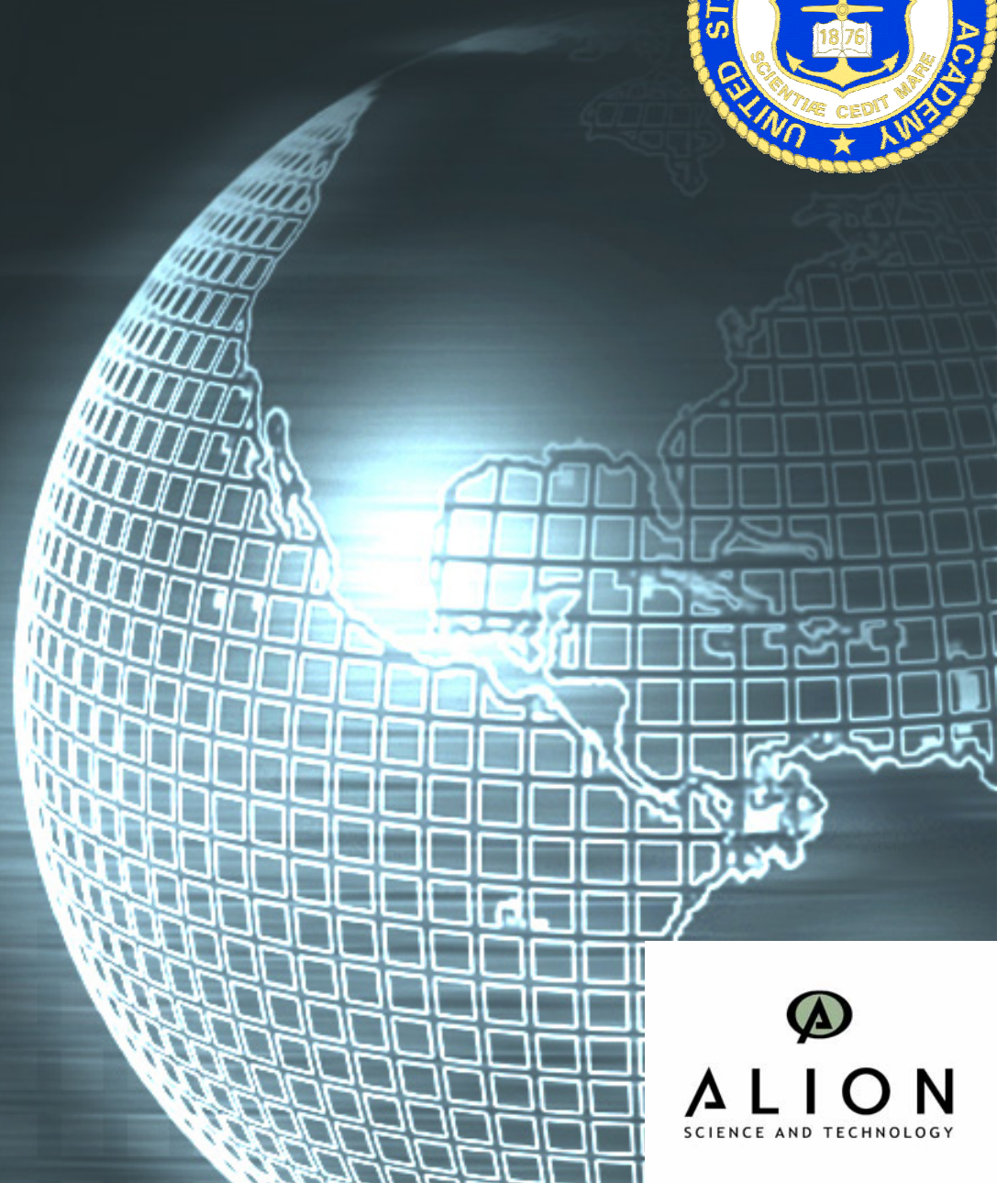
Short-term Comparisons



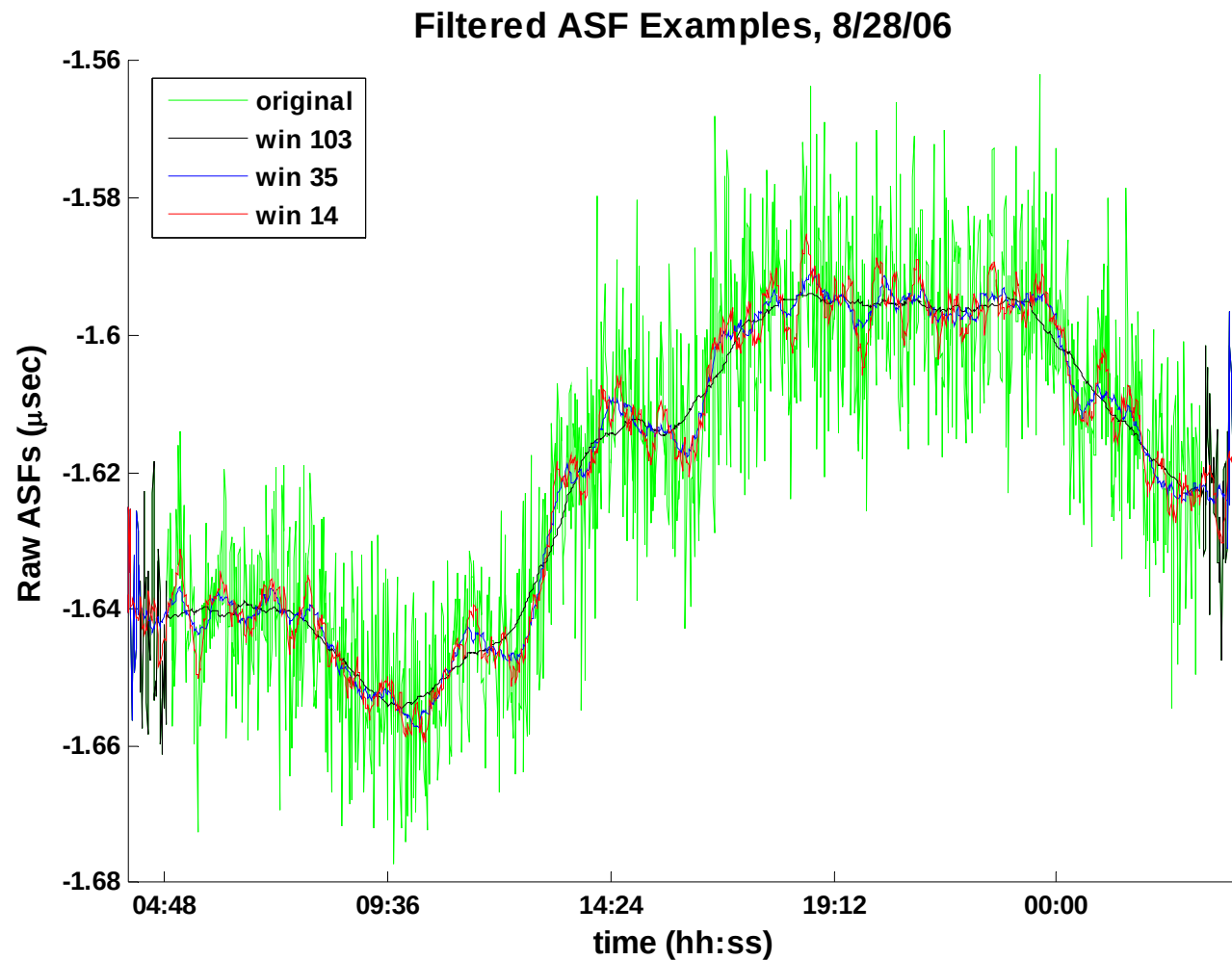
Short Baseline Differences



ASF Filtering



Moving Average Filter



Conclusions

- Seasonal Monitors Work!
- Obvious correlation in ASFs of nearby sites
 - Depends on local topography
 - Placement of monitors dependent on worst-case correlations
- Land-path stations experience more variation
- Most extreme variations occur in Winter



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Future Work

- Continue collecting Seasonal Monitor data
- Determine best choice for updates at points between Seasonal Monitors
- Identify relevant ASF variation and differentiate from random noise
- Find acceptable compromise between rate of update and quality of update
- Investigate predictive filters based on signal history



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 - LTJG Kevin Shmihluk



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