Argos 3 PMT Equipped SVP Drifter

Considerations for Environmental Sampling

Clearwater Instrumentation, Inc.

Argos 1 and 2

- In short:
  - Argos has handled data the same since its inception
  - Drifter is “dumb”, unaware of Argos satellite overpasses (some have used a sun-based guess to improve hits)
  - Drifter takes samples, formats messages and transmits to Argos Satellites every 90 +/- 9 seconds

SVP Data Operations for Argos 1 and 2

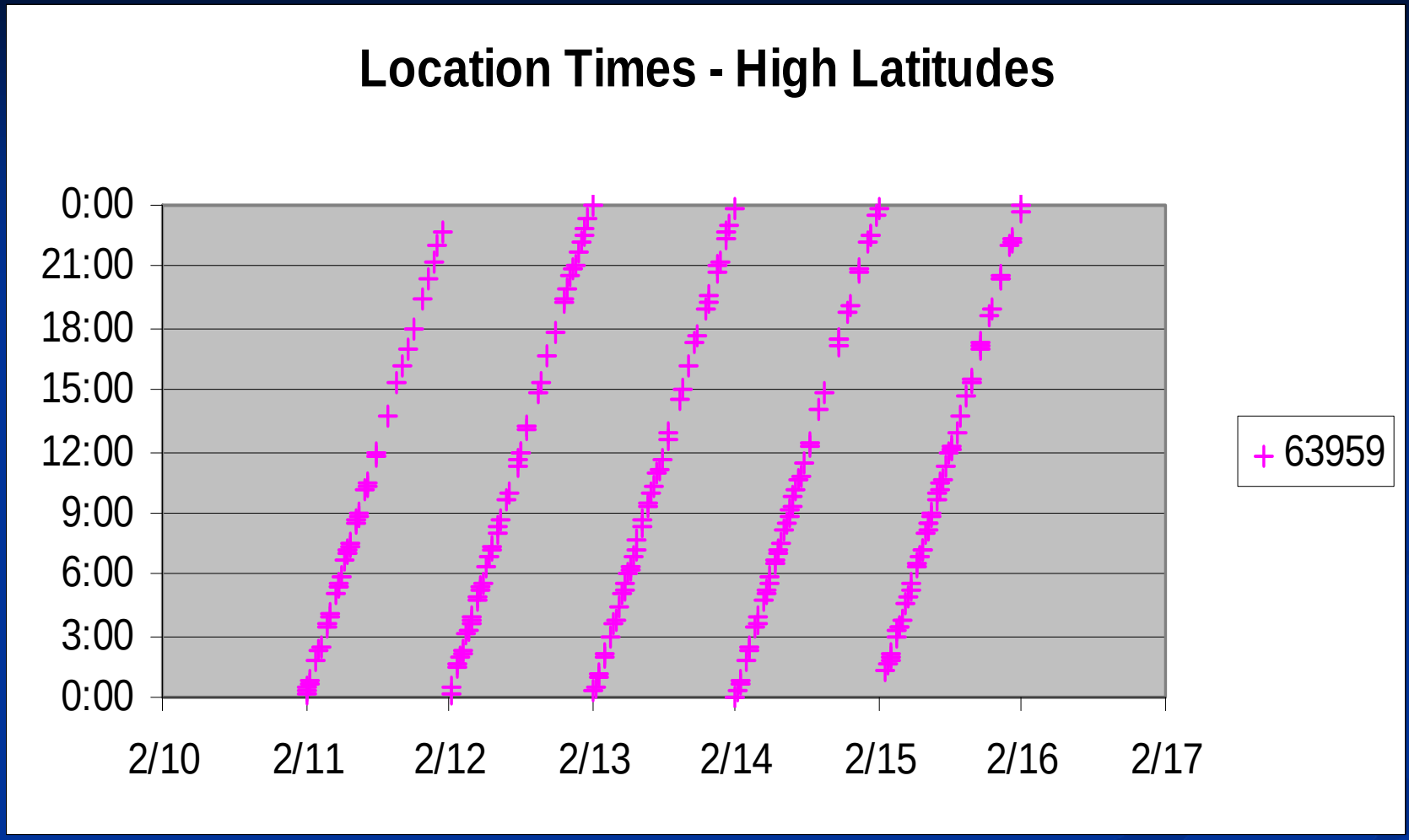
- Direct Measurements: Sea Surface Temperature and Air Pressure sampled at regular intervals.
  - SST every 15 minutes
  - Air Pressure every hour
- Updated measurements immediately transferred to message buffer over-writing older data.
  - DBCP format for AP includes one previous measurement (1 hour or 3 hours age)
- Indirect Measurements:
  - Time and locations of measurements
  - Sea Surface velocity measurement implied from the location time series

SVP Data Operations for Argos 1 and 2

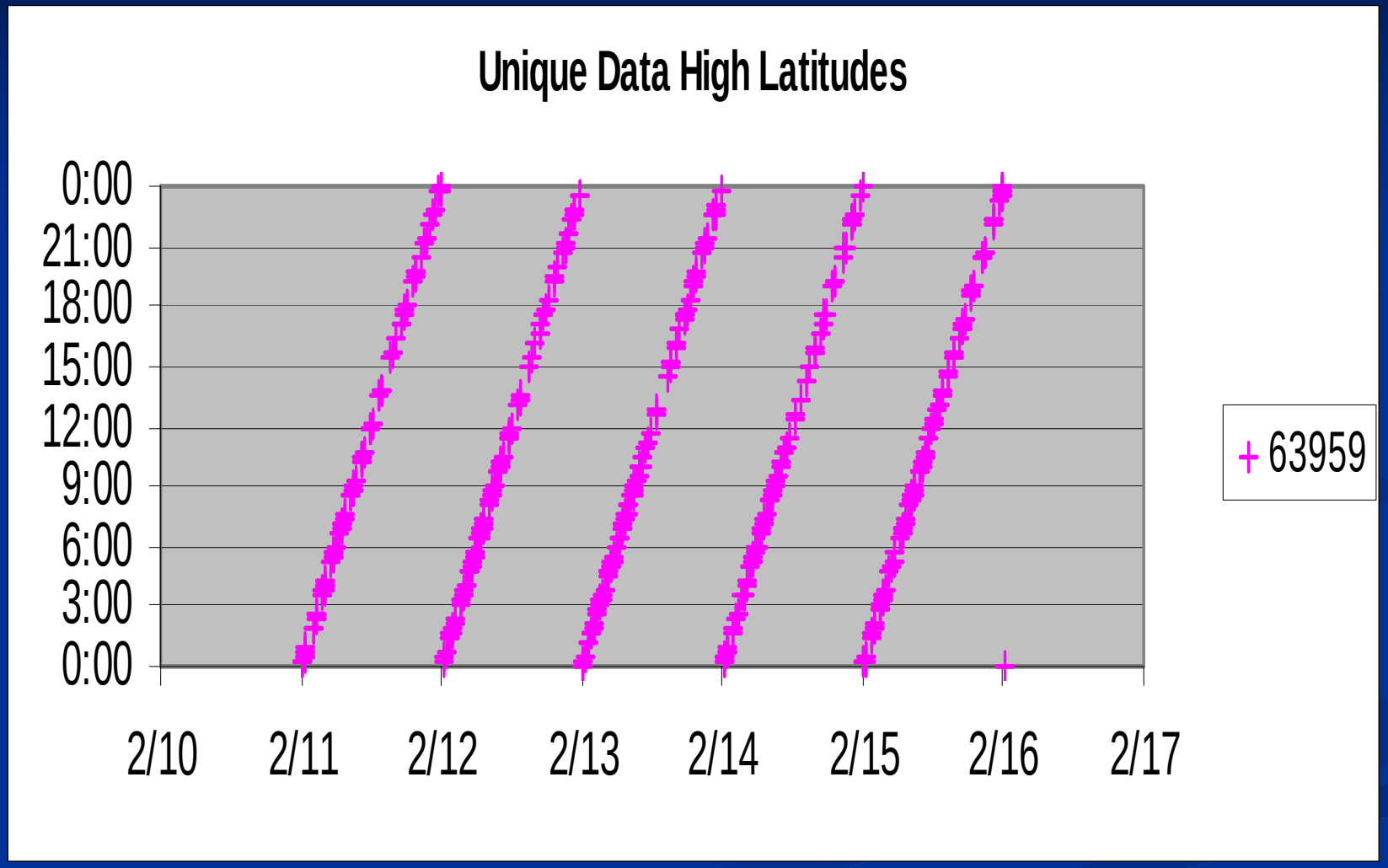
- Data sample time based on accurate Argos message data timestamp
  - SST Sample time is
    - between 0 -15 minutes old relative to timestamp
  - AP contains data age, minutes passed since AP sample taken
    - AP sample time is
      - Argos message data timestamp – data age
- Data location from Argos analysis of Doppler shift
  - Latitude and longitude to precision of +/- 0.001 deg, or about 100 m, equal to the accuracy of a class 3 fix

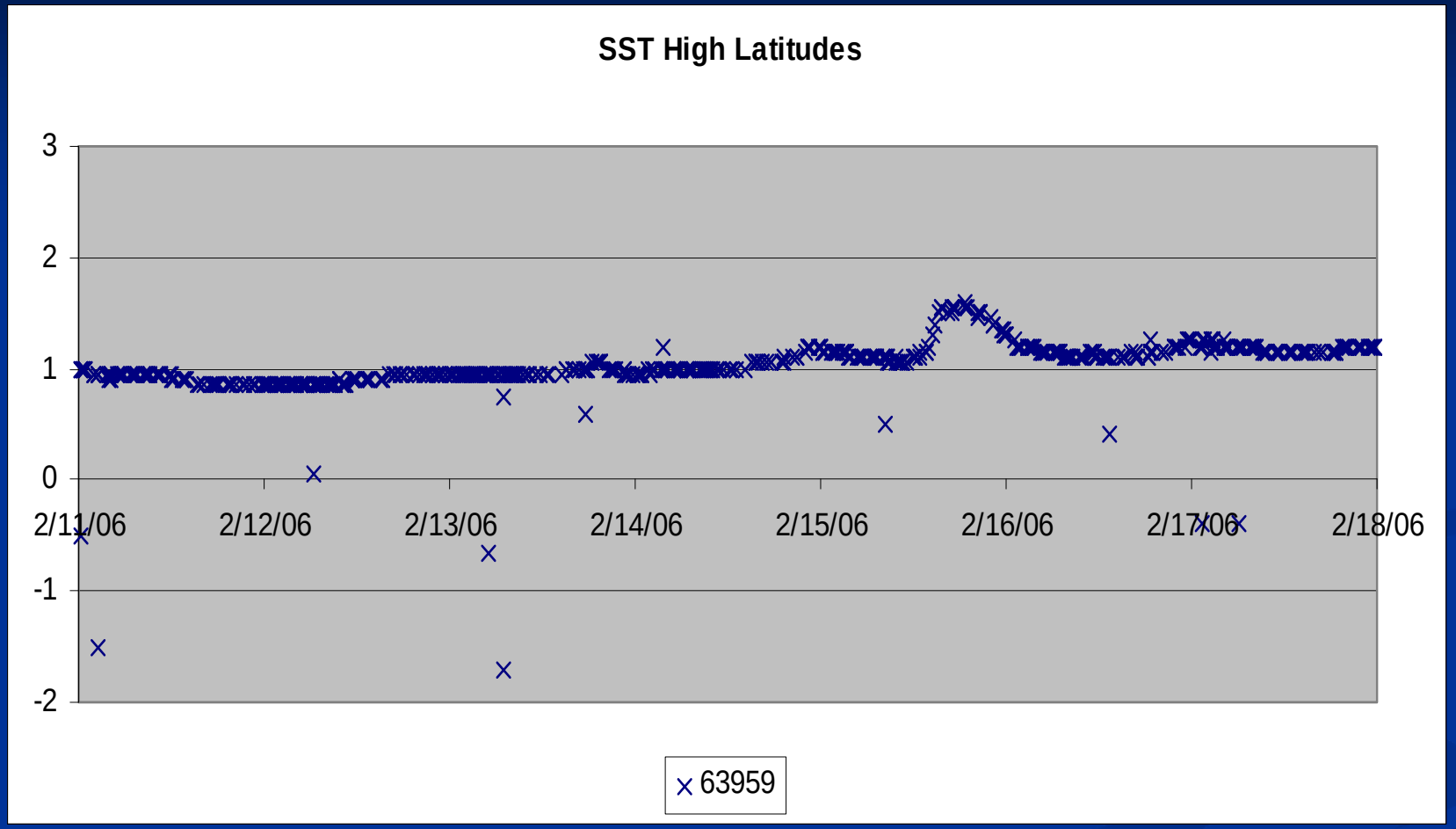
Argos 2 SVP Data Stream Today

- SST
  - From the drifter
    - 96 15-minute samples per day
    - Approximately 960 transmissions (~1/90s)
  - At the satellite: 21 North, low latitudes
    - Argos systems receives
      - 90 messages per day
    - User receives approximately
      - 10 locations
      - 40 unique messages per day
  - At the satellite: 66 South, High latitudes
    - Argos systems receives
      - 340 messages per day
    - User receives
      - 47 locations (see chart)
      - 75 unique messages per day

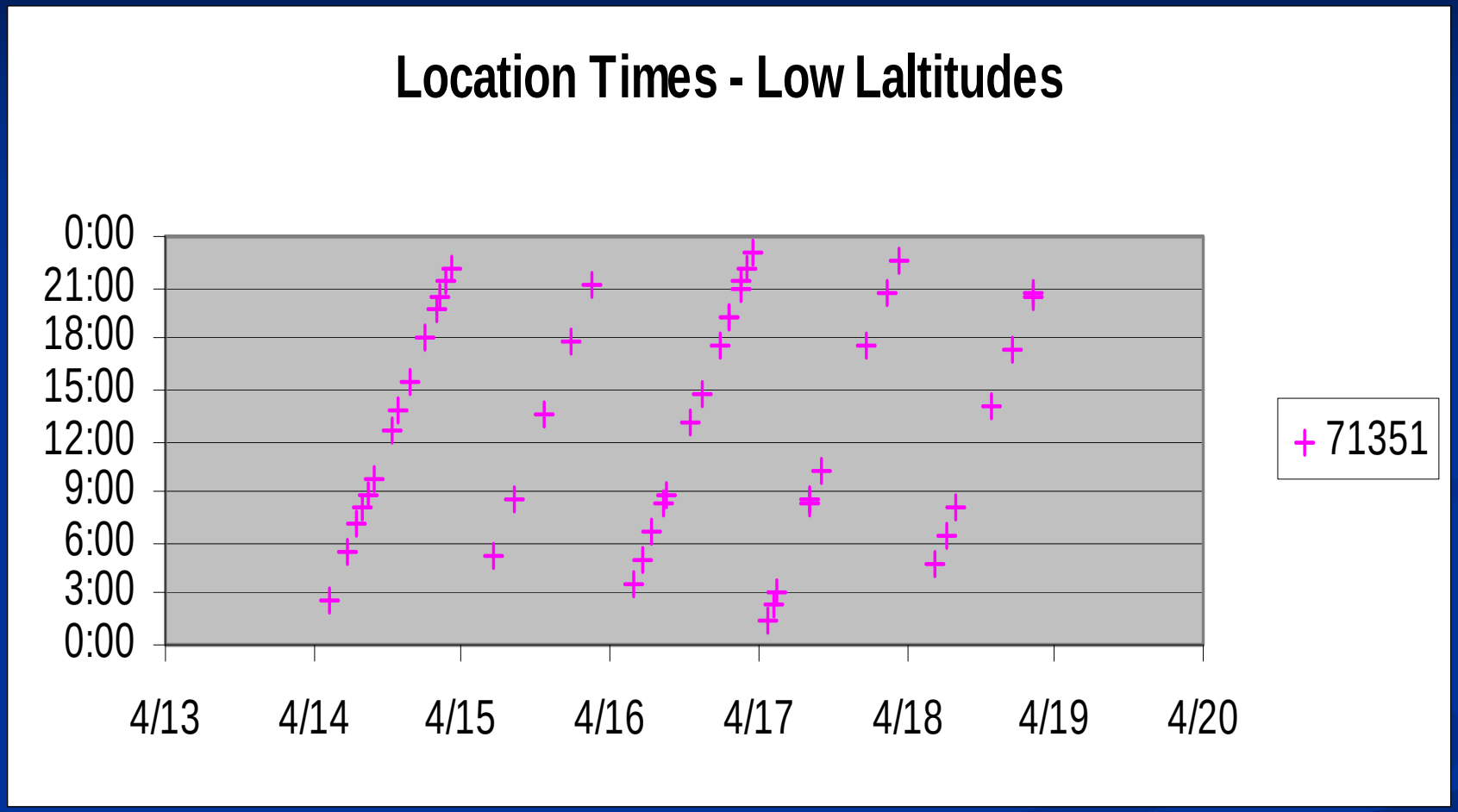


- Locations = velocity measurements

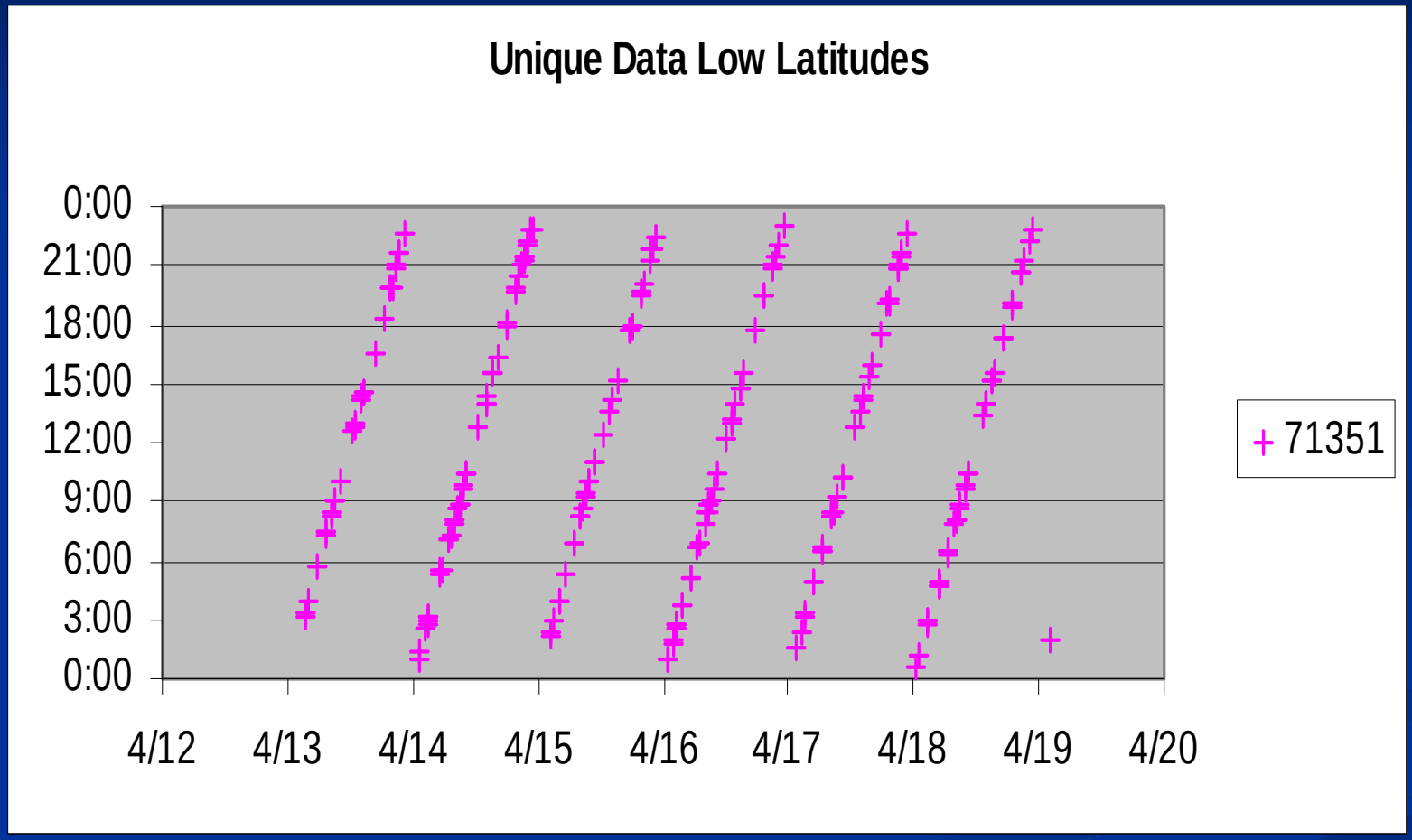

Unique Data High Latitudes
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
2/10
2/11
2/12
2/13
2/14
2/15
2/16
2/17
63959

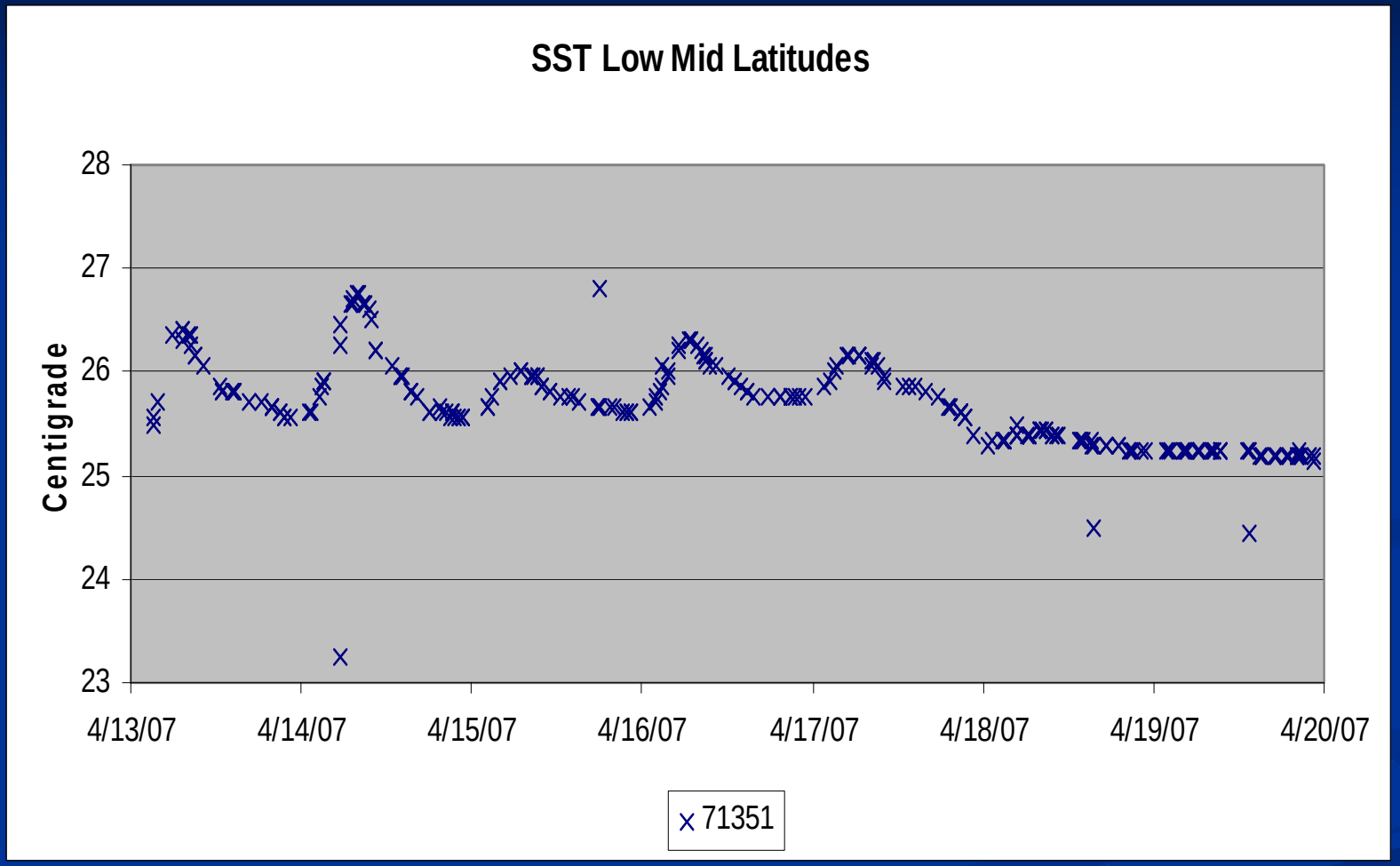


Outliers not removed.



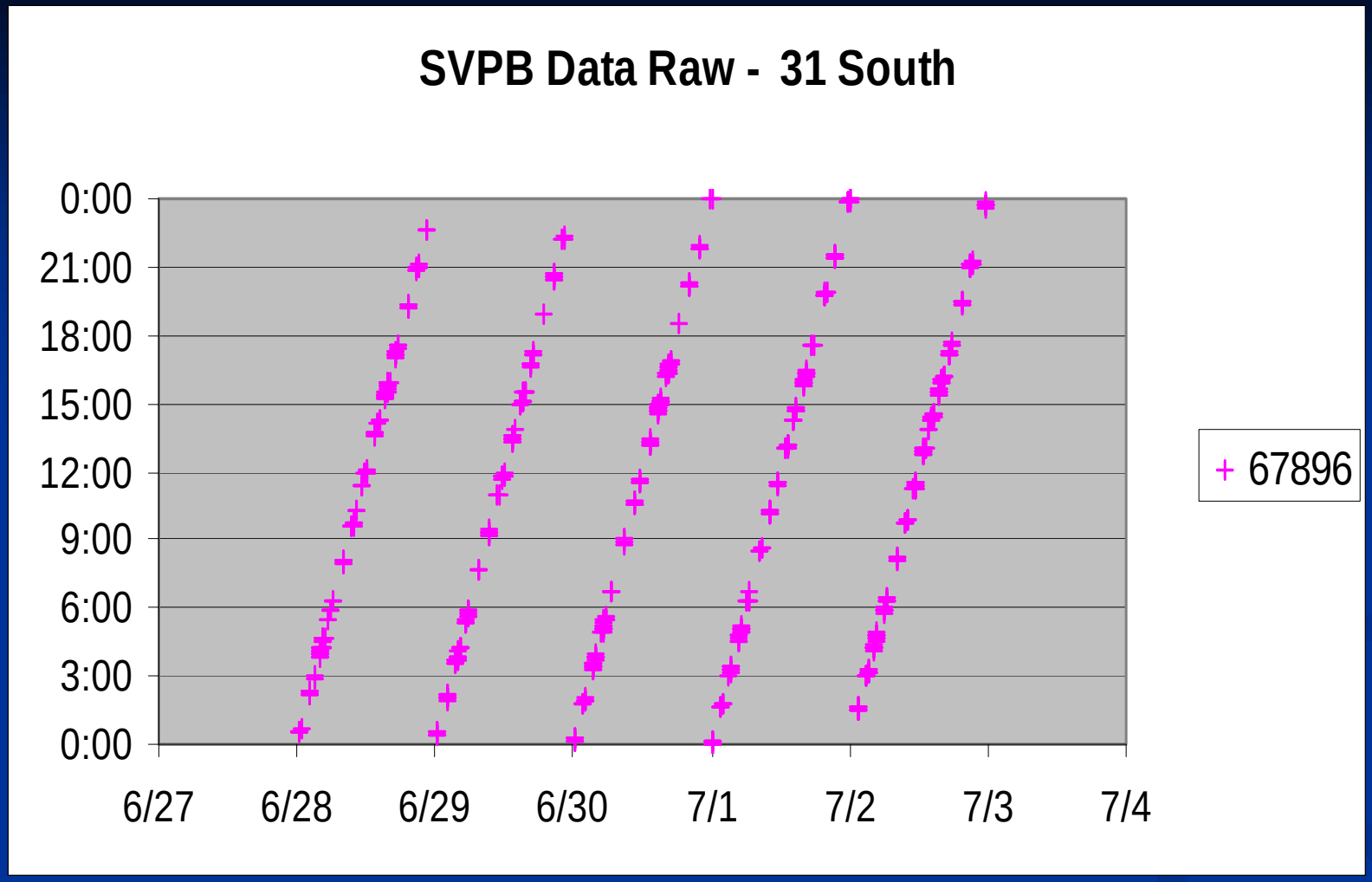
- Locations = velocity measurements

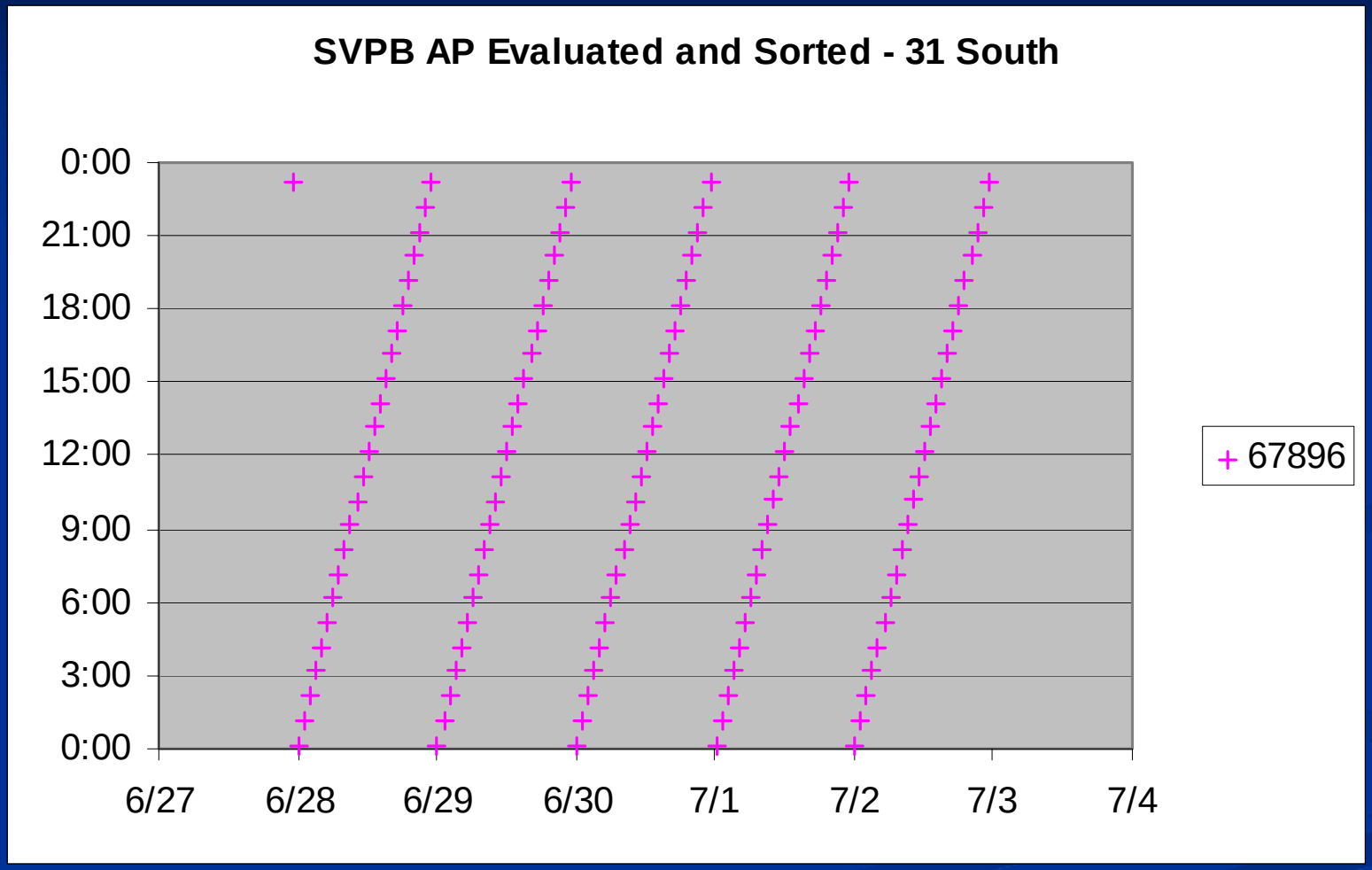

Unique Data Low Latitudes
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
4/12
4/13
4/14
4/15
4/16
4/17
4/18
4/19
4/20
71351


SST Low Mid Latitudes
Centigrade
28
27
26
25
24
23
4/13/07
4/14/07
4/15/07
4/16/07
4/17/07
4/18/07
4/19/07
4/20/07
71351

Argos 2 SVPB Data Stream

- SVPB Air Pressure
  - From the drifter
    - 24 hourly samples of air pressure daily
    - Approximately 960 transmissions (~1/90s)
  - 31 South, low latitudes
    - Argos systems receives
      - 116 “unique” messages per day (each message has a different time stamp)
    - User receives
      - 17 locations
      - 24 unique messages per day of air pressure


SVPB Data Raw - 31 South
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
6/27
6/28
6/29
6/30
7/1
7/2
7/3
7/4
67896


SVPB AP Evaluated and Sorted - 31 South
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
6/27
6/28
6/29
6/30
7/1
7/2
7/3
7/4
67896

Argos 2 in Summary

- 960 data transmissions sent
- 100 – 400 data messages received, increasing with latitude
- 10 – 47 locations determined, increasing with latitude
- Time based on drifter clock and Argos message time stamp

Argos 3 PMT

- PMT is "aware" of Argos system through downlink messaging from Argos 3 satellite
  - UT time kept by PMT real-time clock
  - Drifter position updated occasionally
  - PMT calculates and maintains rise and set times for all Argos satellites
  - 2-way communication between PMT and Argos 3
- "We are not in Kansas anymore."
  - Implementation of Argos 3 for drifting buoys requires a new approach to sampling environmental and surface velocity data.

Major System Enhancements in PMT

- Stores messages in FIFO queue
- Aware of satellite passes
- Can ransmit only when satellites visible
- Short messages intervals for Argos 3 passes and “interactive mode” with message acknowledgment
- Pseudo-acknowledgment for Argos 1 and 2
- PMT-generated checksums
- Real time clock

Pseudo Acknowledgment

- New concept in managing data transmissions
  - Because PMT knows when to expect satellite passes
  - Data is transmitted only when a satellite is visible
  - Probability of message reception increases with each transmission:
    - 1 = 50 - 60%
    - 2 = 75 – 88%
    - 3 = 84 - 94%
  - Message reception is assumed to be assured with 3 transmissions of the message: “pseudo acknowledgment” or pseudo ack

SVP Message Management on the PMT

- As before, SVP generates messages as scheduled:
  - One SST every 15 minutes
- SSTs pushed onto the queue:
  - SST01, SST02, SST03……SSTn
- In the advent of an pass of Argos 2, messages are sent as follows with "pseudo acknowledgment set to 3 transmissions at ~ 90 s intervals:
  - SST01, SST01, SST01, SST02, SST02, SST02, SST03, SST03, SST03……
  - Until the satellite is no longer visible to the PMT

SVP Message Management

- Upon and Argos 3 pass messages are sent:
  - At intervals as short as 5 seconds if an acknowledgment is received
  - At longer intervals until 3 have been sent and "pseudo acknowledgment" is assumed
- So a typical session with Argos 3 might look like this:
  - SST01, SST02, SST03, SST04, SST04, SST05……
  - Until the satellite is no longer visible to the PMT

Data Management by the Drifter with PMT

- Without a timestamp in the data the identification of sample time becomes problematic
- It is possible to upload too much data to the PMT and for the data to become severely back-logged.
- So, what does the data stream from an SVP PMT arriving to the user look like?

SVP and PMT

- Clearwater has operated two proto-type SVP drifters with slightly different configurations of PMT operation
- PMT 82233
  - Pseudo ack on 3 transmissions for Argos 2
  - State 1:
    - 15-minute SST sampling no checksum, no timestamp: 96 samples/day
  - State 2:
    - 30-minute SST sampling with checksum and timestamp, 48 samples per day

SVP PMT 82233

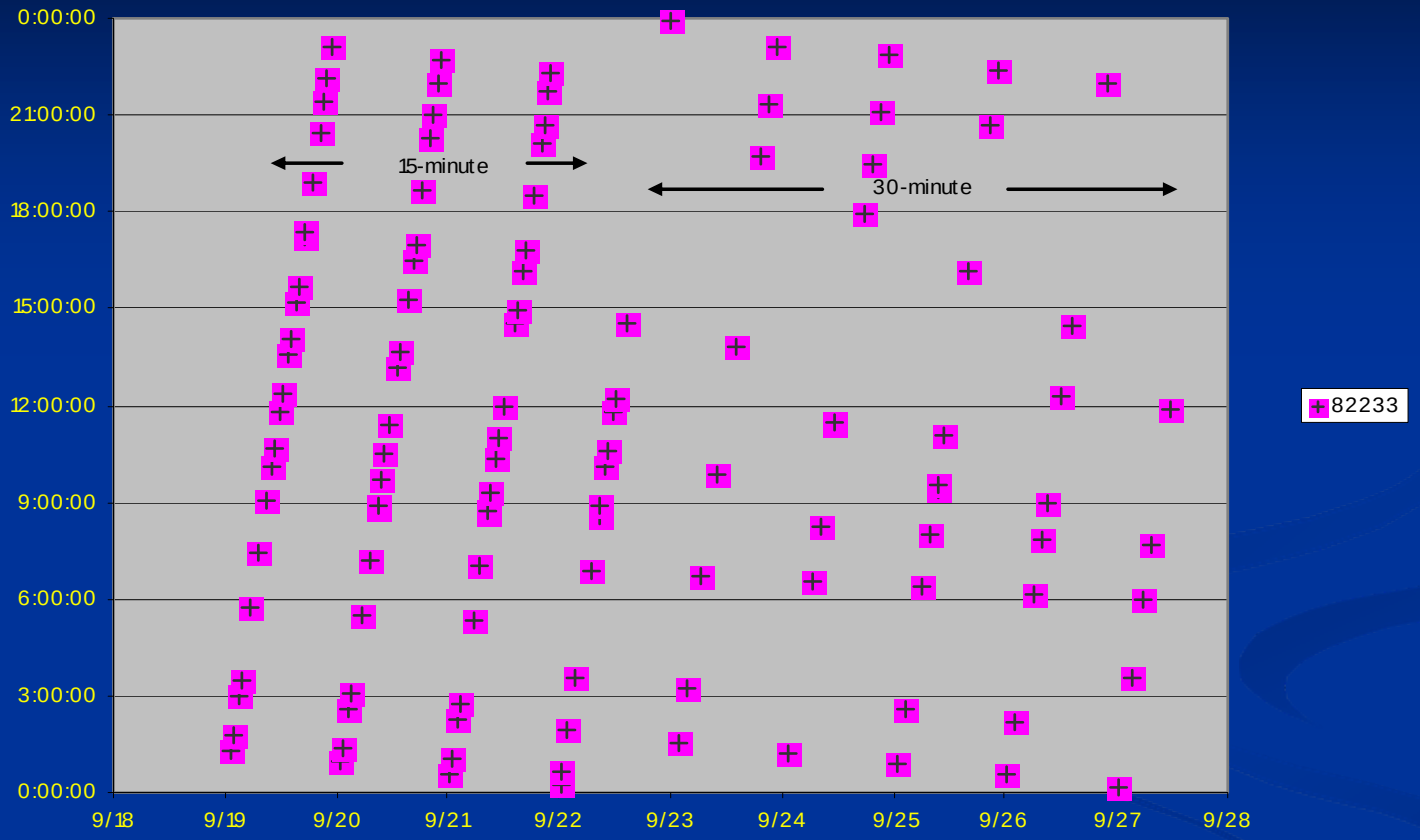
- With 30-minute SST samples
  - 48 SST measurements daily
  - 144 Messages sent = 3 x 48 , approximately
  - 75 messages received daily by all satellites with pseudo ack
  - 38 unique message
  - About 20 locations per day

SVP PMT 82233

- With 15-minute SST samples
  - 96 SST measurements daily
  - 238 Messages sent = 3 x 79 , approximately
  - 166 messages received daily by all satellites with pseudo ack
  - 79 unique message
  - About 8 locations per day

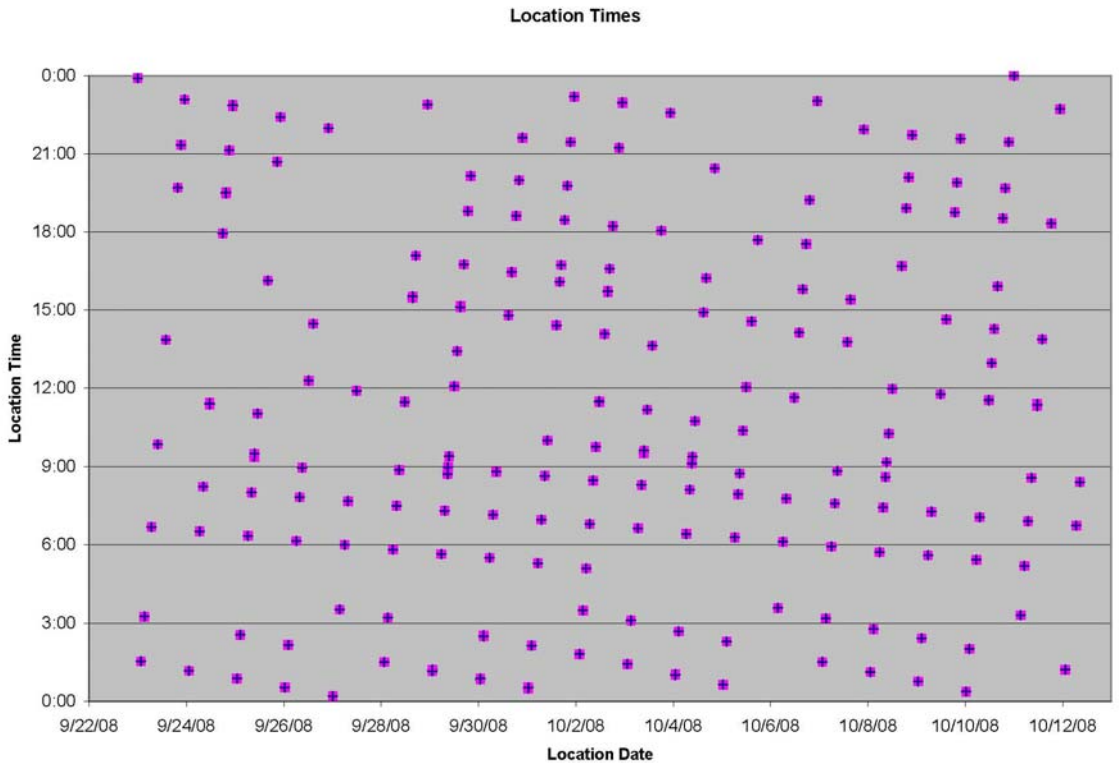
82233

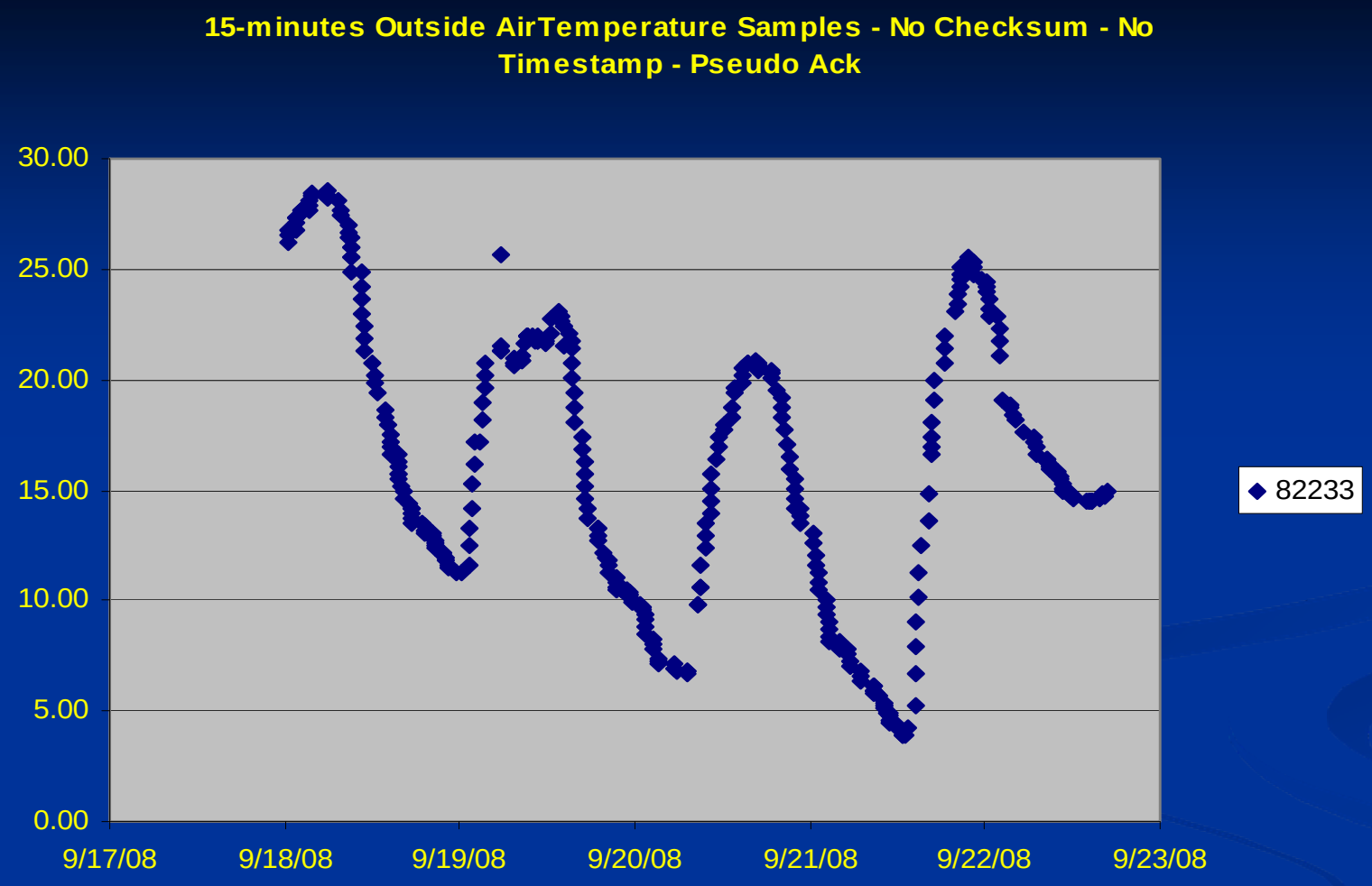
Location Times



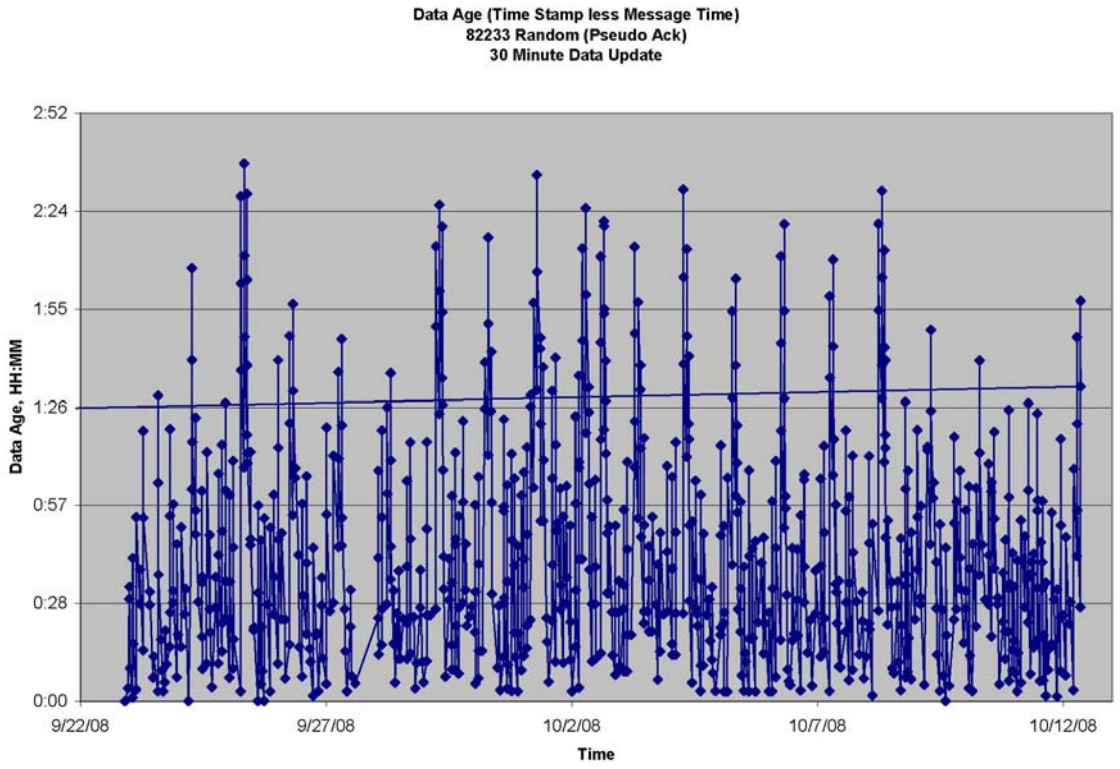
- Notice the reduction in locations as Temperature sampling is reduced from 15 to 30 minutes
- More samples = more locations
- Or use PMT "housekeeping" function to generate short, empty messages that permit maximizing locations.
- Or use GPS

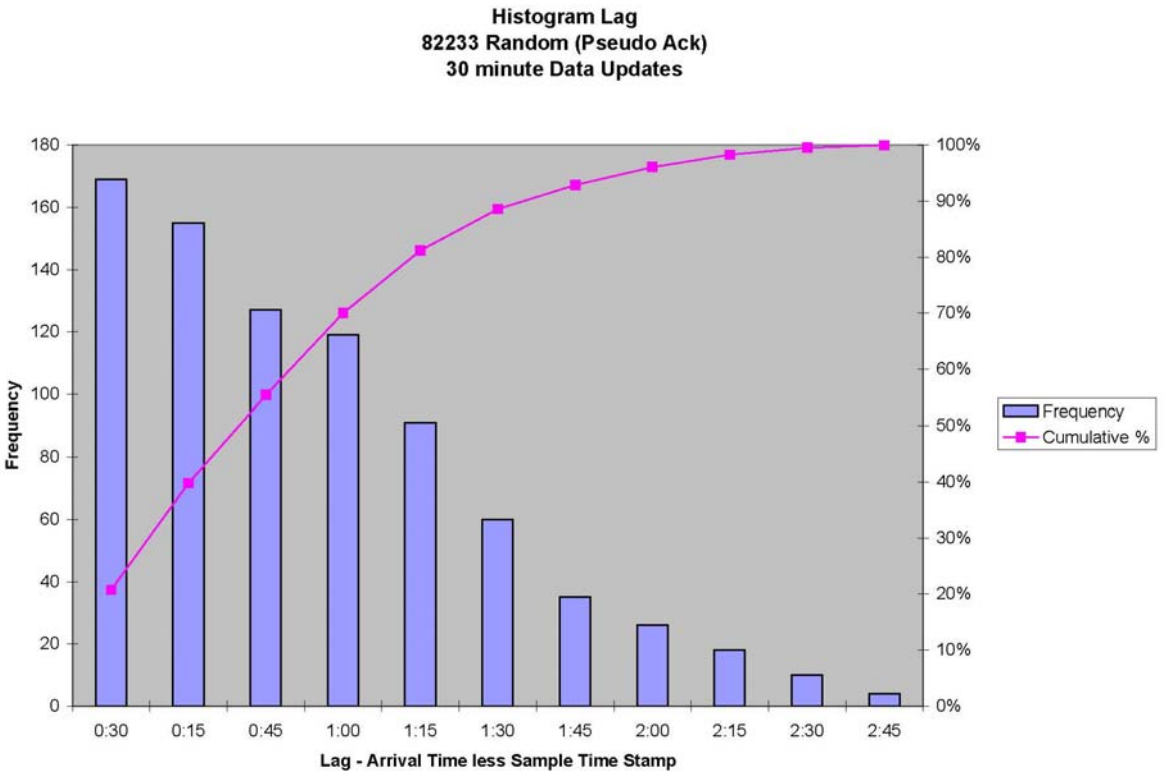
82233


Location Times
Location Time
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
9/22/08
9/24/08
9/26/08
9/28/08
9/30/08
10/2/08
10/4/08
10/6/08
10/8/08
10/10/08
10/12/08
Location Date

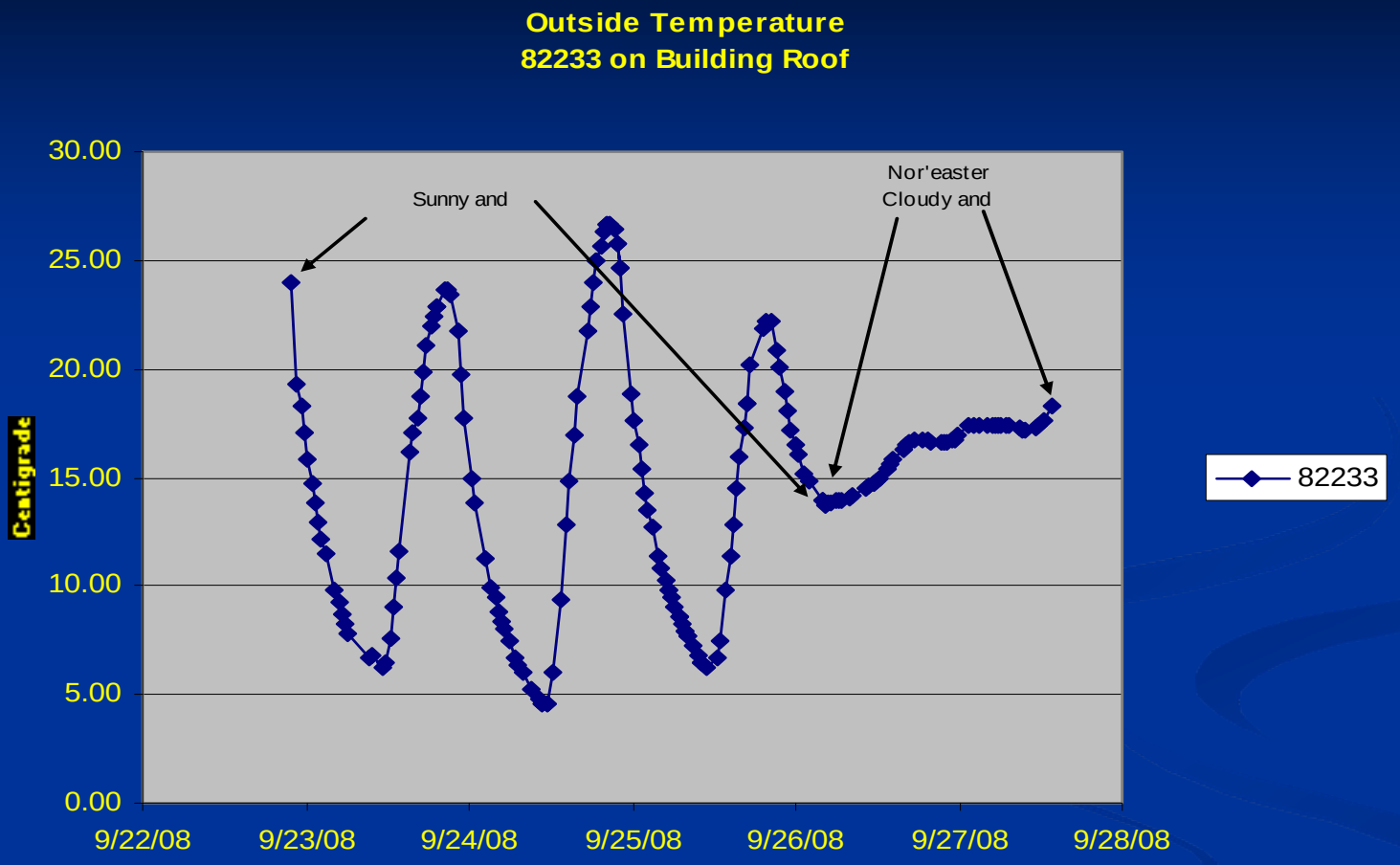


- Notice the roughness of the plot. This is randomness added by loss of time base when sample time is equated to message time and to delay in FIFO queue

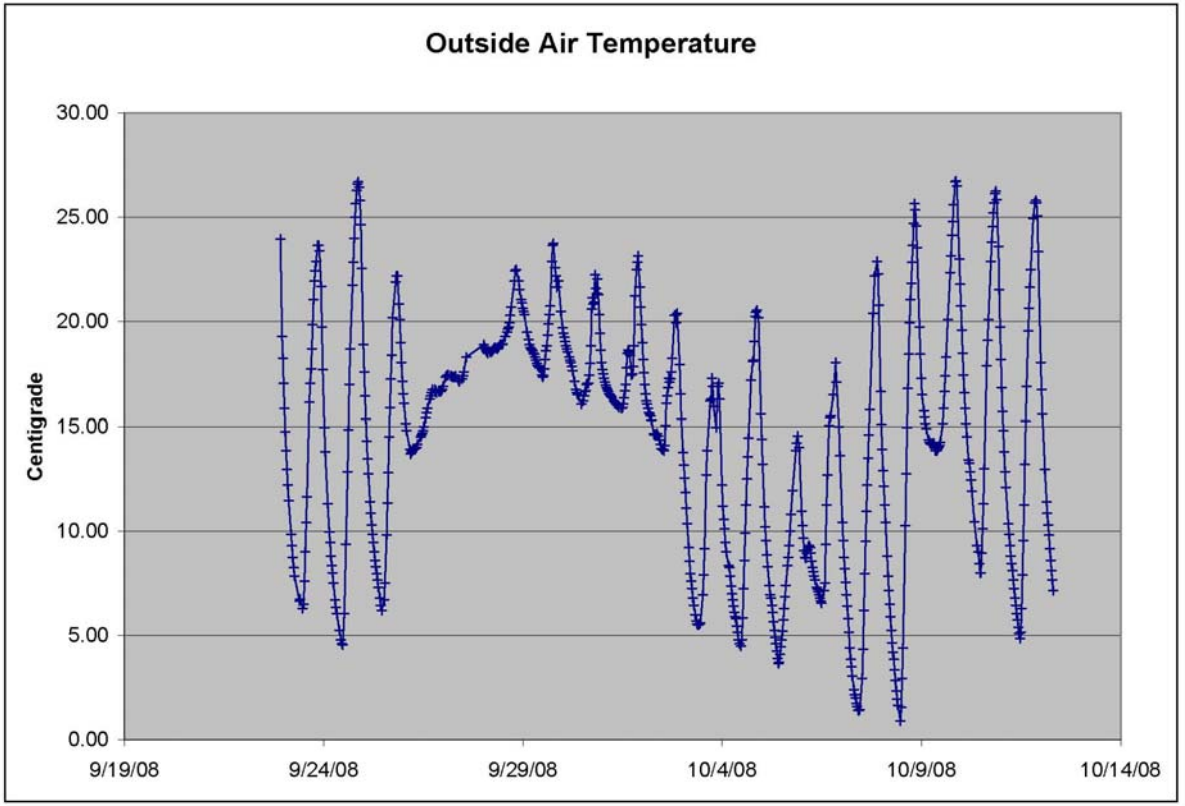

Data Age (Time Stamp less Message Time)
82233 Random (Pseudo Ack)
30 Minute Data Update
Data Age, HH:MM
2:52
2:24
1:55
1:26
0:57
0:28
0:00
9/22/08
9/27/08
10/2/08
10/7/08
10/12/08
Time


Histogram Lag
82233 Random (Pseudo Ack)
30 minute Data Updates
Frequency
180
160
140
120
100
80
60
40
20
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0:30
0:15
0:45
1:00
1:15
1:30
1:45
2:00
2:15
2:30
2:45
Lag - Arrival Time less Sample Time Stamp
Frequency
Cumulative %

82233



- Adding time-stamp reduces noise caused by time jitter


Outside Air Temperature
Centigrade
30.00
25.00
20.00
15.00
10.00
5.00
0.00
9/19/08
9/24/08
9/29/08
10/4/08
10/9/08
10/14/08

Most Recent Summary Statistics

- Unique Messages: 814
- Total Messages Received: 1719
  - Good: 1645, 96%
  - Failed: 74, 4%
- Days of data: 19.4
- Ave. Messages/day: 88.4
- Ave. Unique Messages/day: 41.9

SVP and PMT

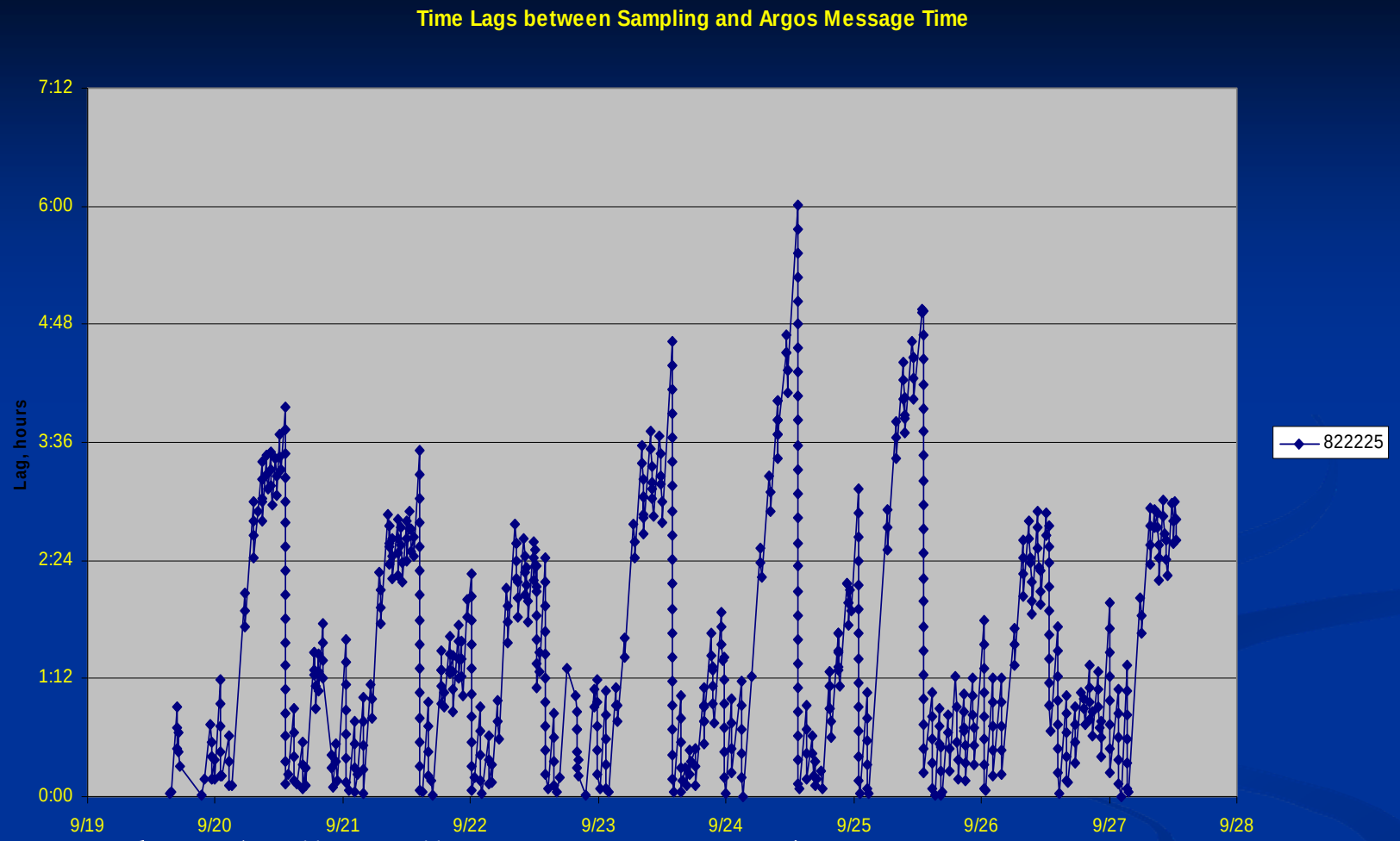
- PMT 82225
  - Pseudo acknowledgement on 3 transmissions for all satellites including Argos3 and “interactive” with acknowledgment to Argos3
  - PMT-generated checksum: two-bytes
  - Timestamp from PMT (PMT RTC regularly updated from the Argos 3 downlink): yymmddhhmmss
  - 15-minute SST sampling: 96 samples per day

SVP PMT 82225

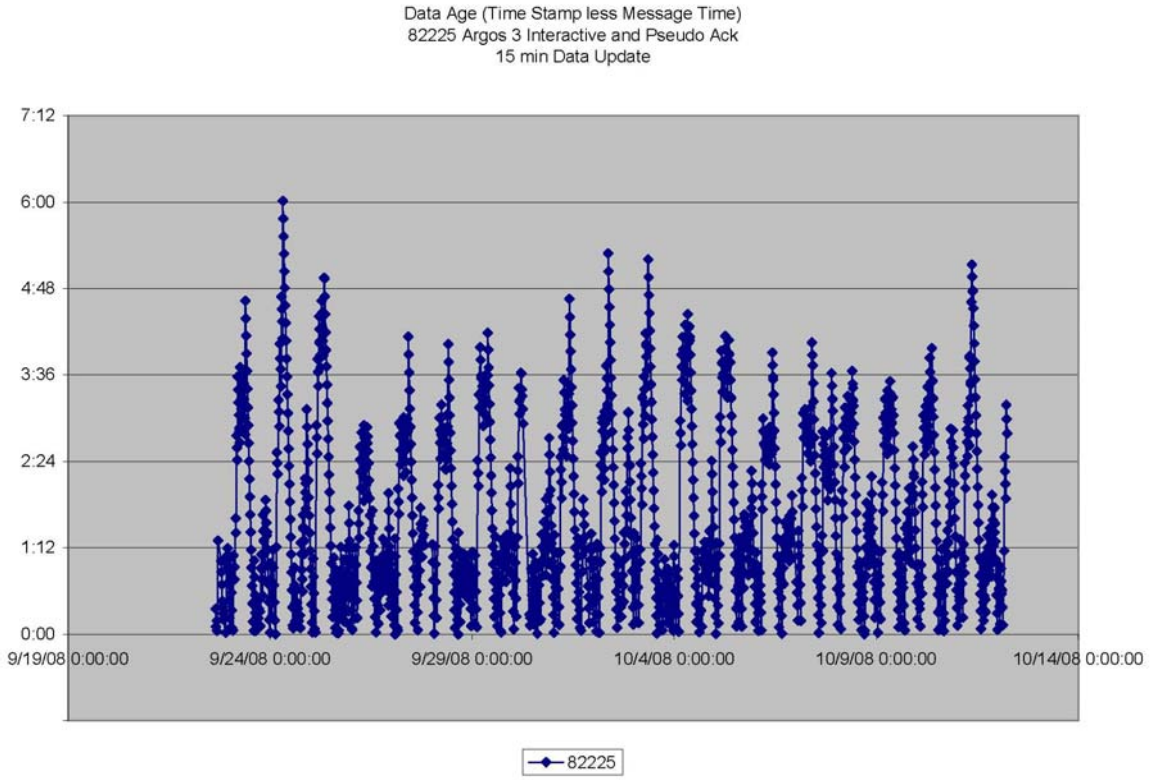
- With 15-minute samples:
  - 96 SST samples taken by SVP
  - 238 messages sent by SVP PMT daily on the average
  - 166 messages received by satellite
  - 79 unique SST samples received daily
  - About 19 locations per day

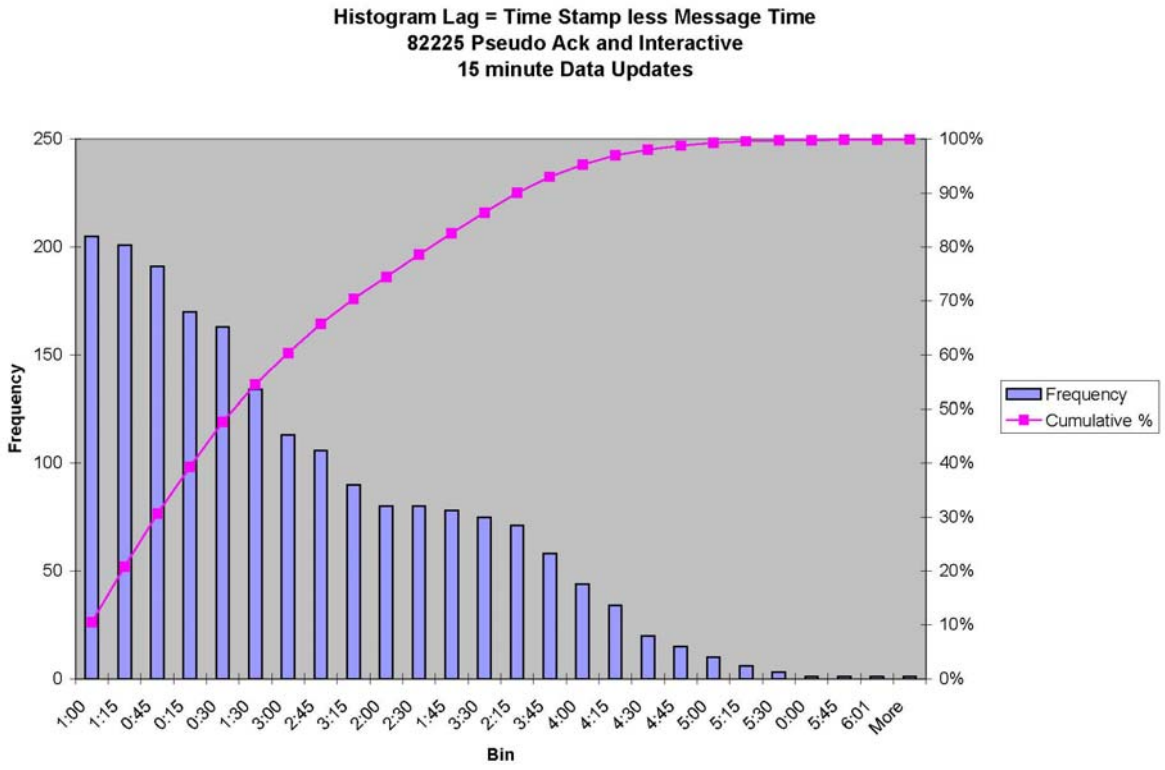
Cautionary Notes

- Caution:
  - Possibility for data accumulation and eventual buffer overflow
  - 15-minute samples may be too many small samples to push toward PMT.
  - May need to combine samples or update less frequently
  - E.g. sample. send 2 samples half-hourly or four samples hourly

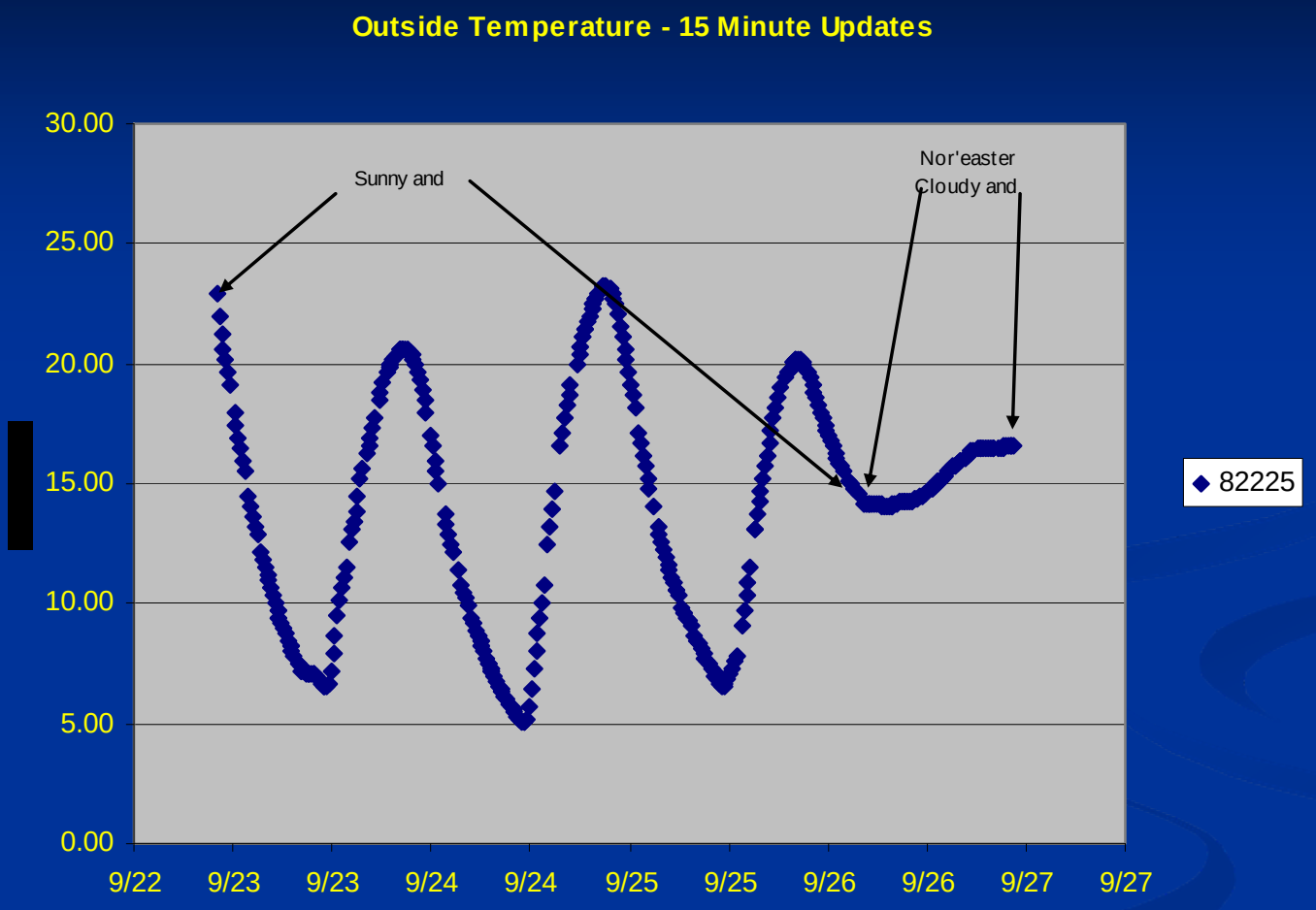


- Pseudo ack all satellites, interactive Argos 3
- Build up of samples in queue as data cannot be pumped fast enough to Argos 2
- Rapid decrease of lag with Argos 3 pass.

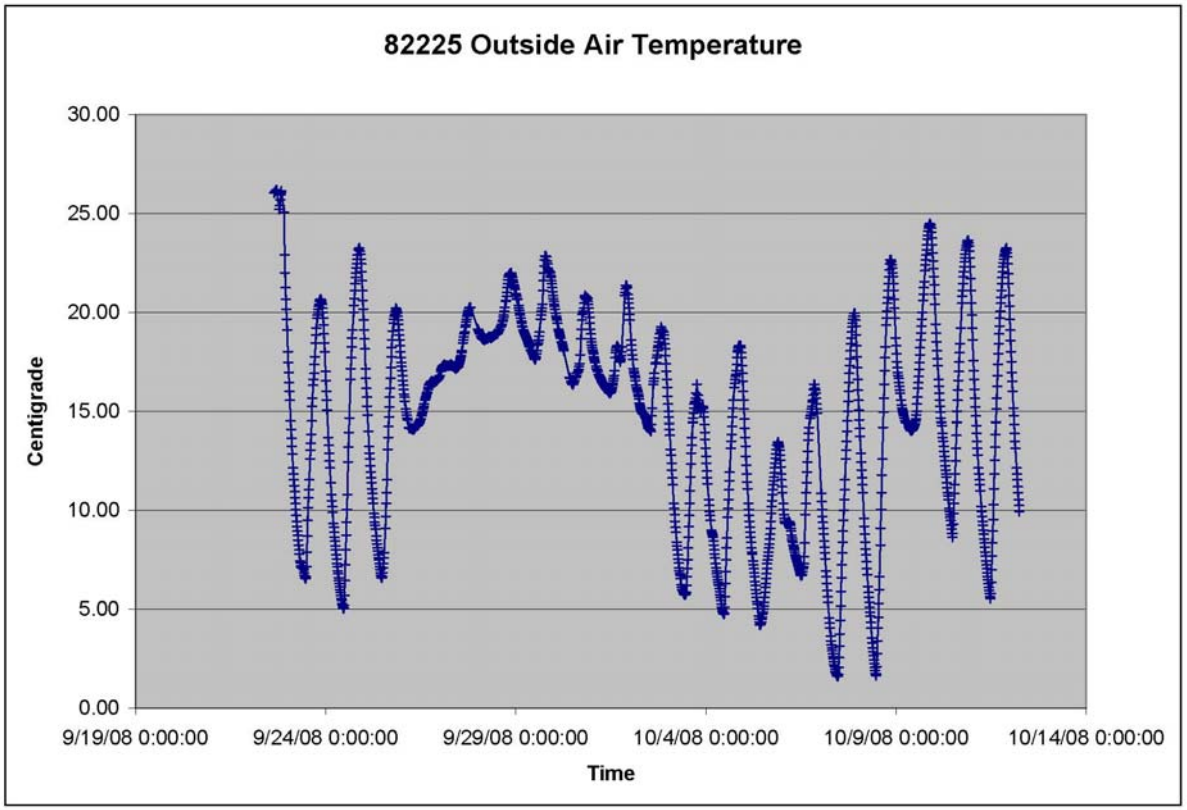

Data Age (Time Stamp less Message Time)
82225 Argos 3 Interactive and Pseudo Ack
15 min Data Update
7:12
6:00
4:48
3:36
2:24
1:12
0:00
9/19/08 0:00:00
9/24/08 0:00:00
9/29/08 0:00:00
10/4/08 0:00:00
10/9/08 0:00:00
10/14/08 0:00:00
82225

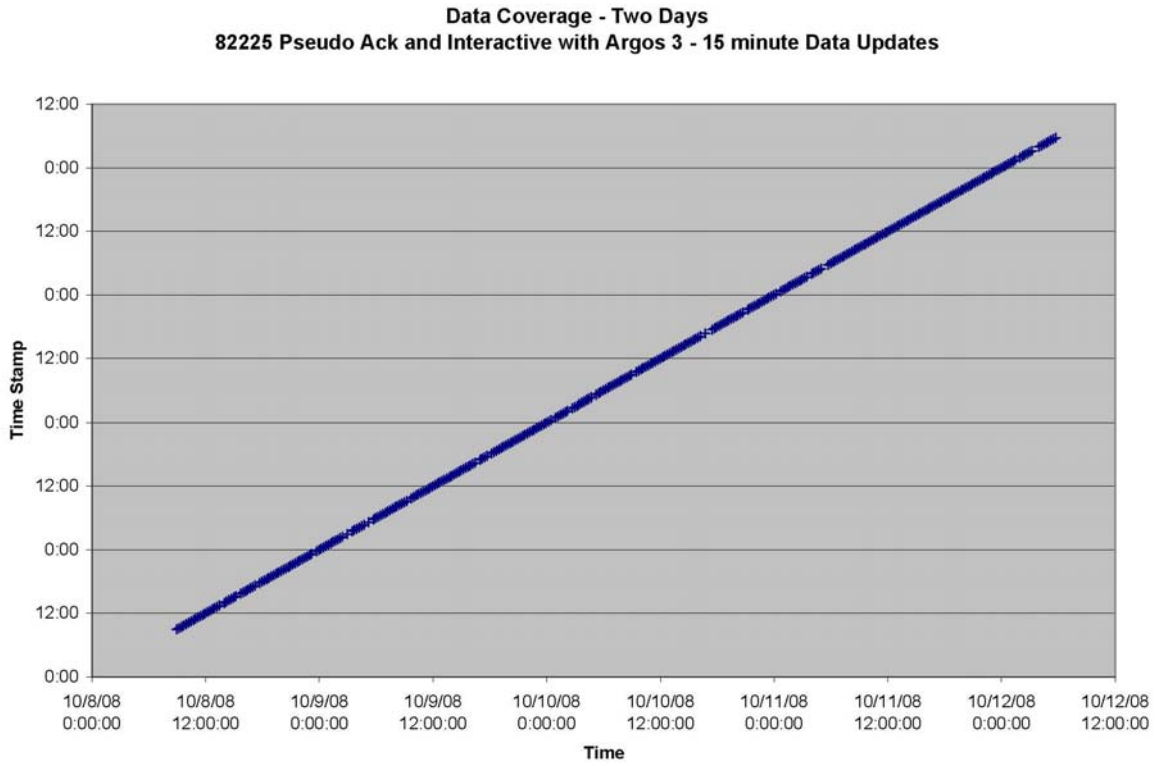

Histogram Lag = Time Stamp less Message Time
82225 Pseudo Ack and Interactive
15 minute Data Updates
Frequency
250
200
150
100
50
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Frequency
Cumulative %
1:00
1:15
0:45
0:15
0:30
1:30
3:00
2:45
3:15
2:00
2:30
1:45
3:30
2:15
3:45
4:00
4:15
4:30
4:45
5:00
5:15
5:30
0:00
5:45
6:01
More
Bin

PMT 82225

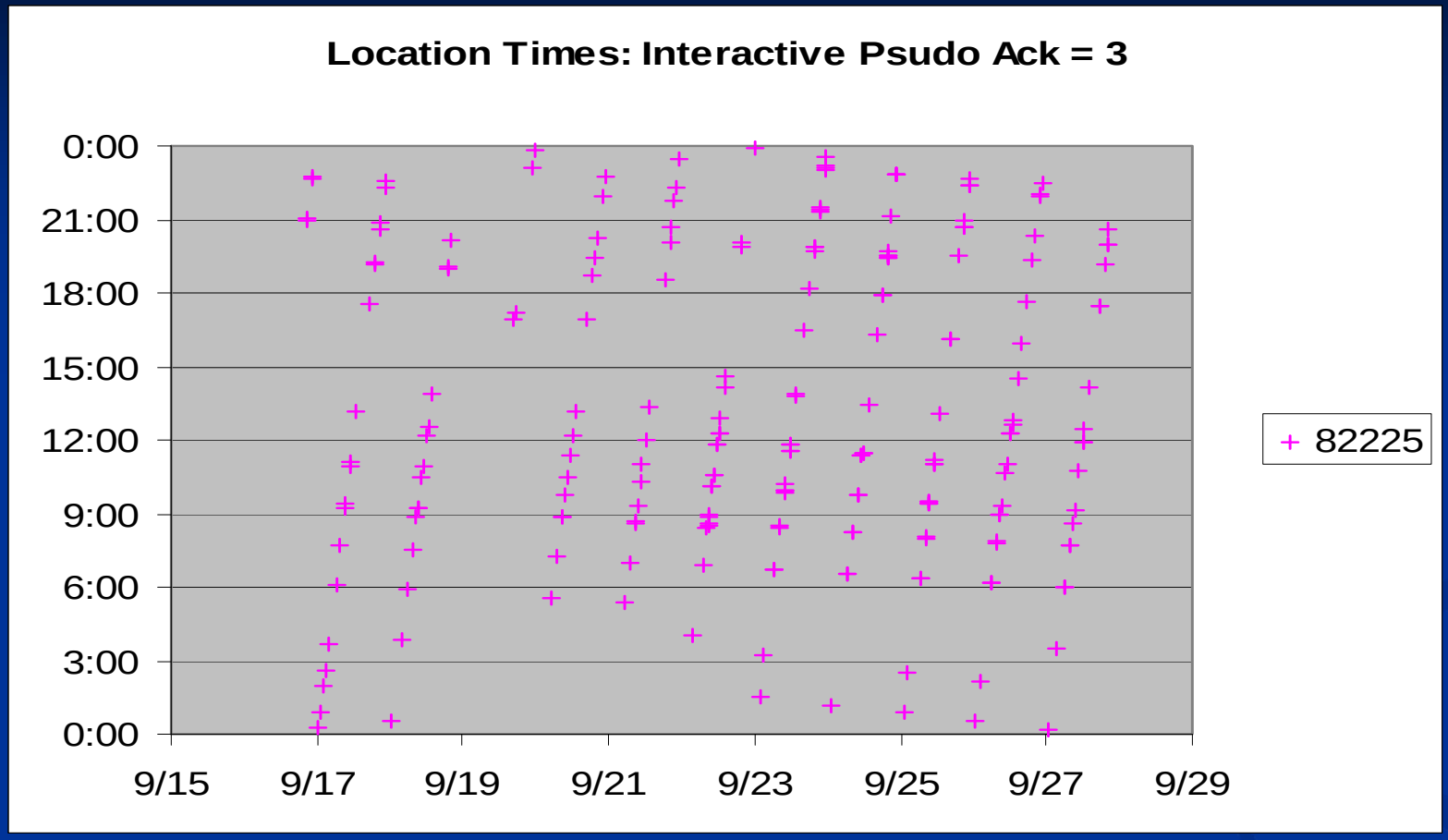


- Data are smoother because time jitter is absent

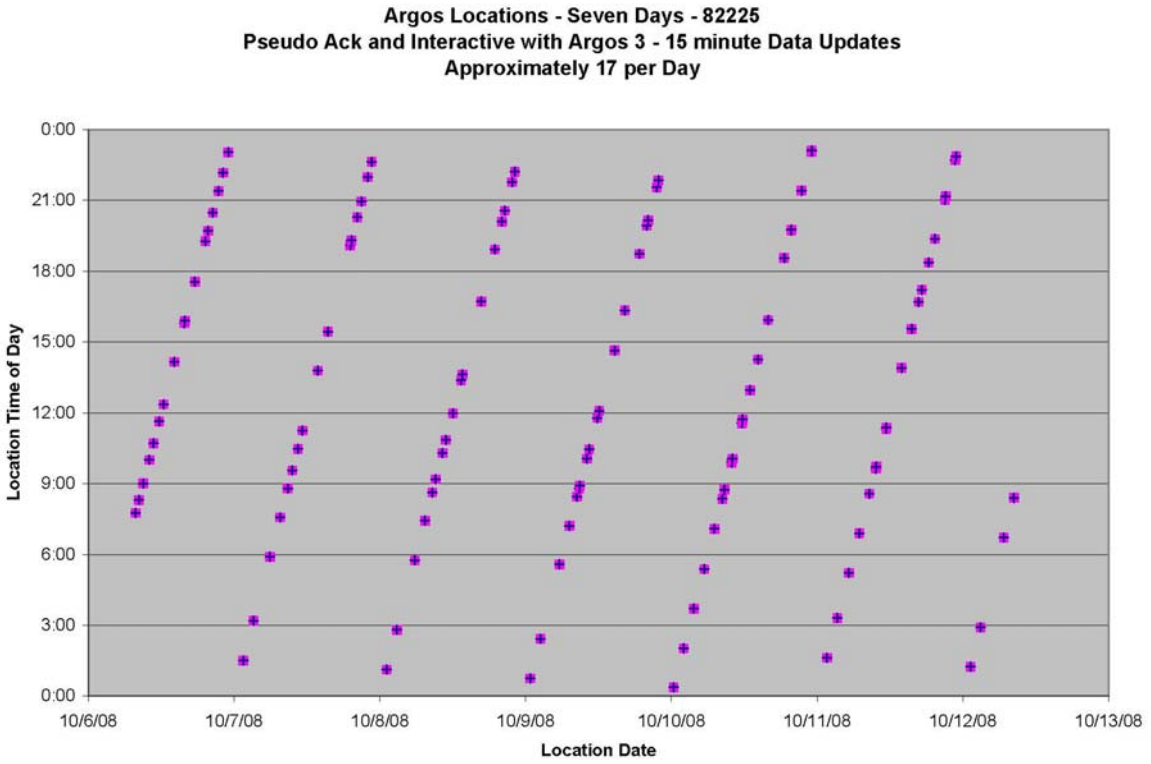

82225 Outside Air Temperature
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Centigrade
9/19/08 0:00:00
9/24/08 0:00:00
9/29/08 0:00:00
10/4/08 0:00:00
10/9/08 0:00:00
10/14/08 0:00:00
Time


Data Coverage - Two Days
82225 Pseudo Ack and Interactive with Argos 3 - 15 minute Data Updates
Time Stamp
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
12:00
0:00
10/8/08 0:00:00
10/8/08 12:00:00
10/9/08 0:00:00
10/9/08 12:00:00
10/10/08 0:00:00
10/10/08 12:00:00
10/11/08 0:00:00
10/11/08 12:00:00
10/12/08 0:00:00
10/12/08 12:00:00
Time

PMT 82225



- Implications for velocity measurements


Argos Locations - Seven Days - 82225
Pseudo Ack and Interactive with Argos 3 - 15 minute Data Updates
Approximately 17 per Day
Location Time of Day
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
10/6/08
10/7/08
10/8/08
10/9/08
10/10/08
10/11/08
10/12/08
10/13/08
Location Date

82225 Summary Statistics

- Unique Messages: 1951
- Total Messages received: 3167
  - Good Messages: 3048, 96%
  - Failed Messages: 119, 4%
- Days of Data, 19.6
- Ave. Messages per day: 161.6
- Ave. Unique Messages: 99.6

Observations

- Reverse the queue to First in Last Out? Otherwise, most recent data received keeps getting older.
- Active queue management to prevent memory overflow and very old messages.
- Concatenate data to reduce number of messages. But…
- Lower number of messages means fewer locations, less data for velocity measurement, Unless…..
- Use PMT housekeeping to generate empty messages during pass to ensure as many Argos locations as possible, Or…..
- Add GPS to sample location at specific times

Questions

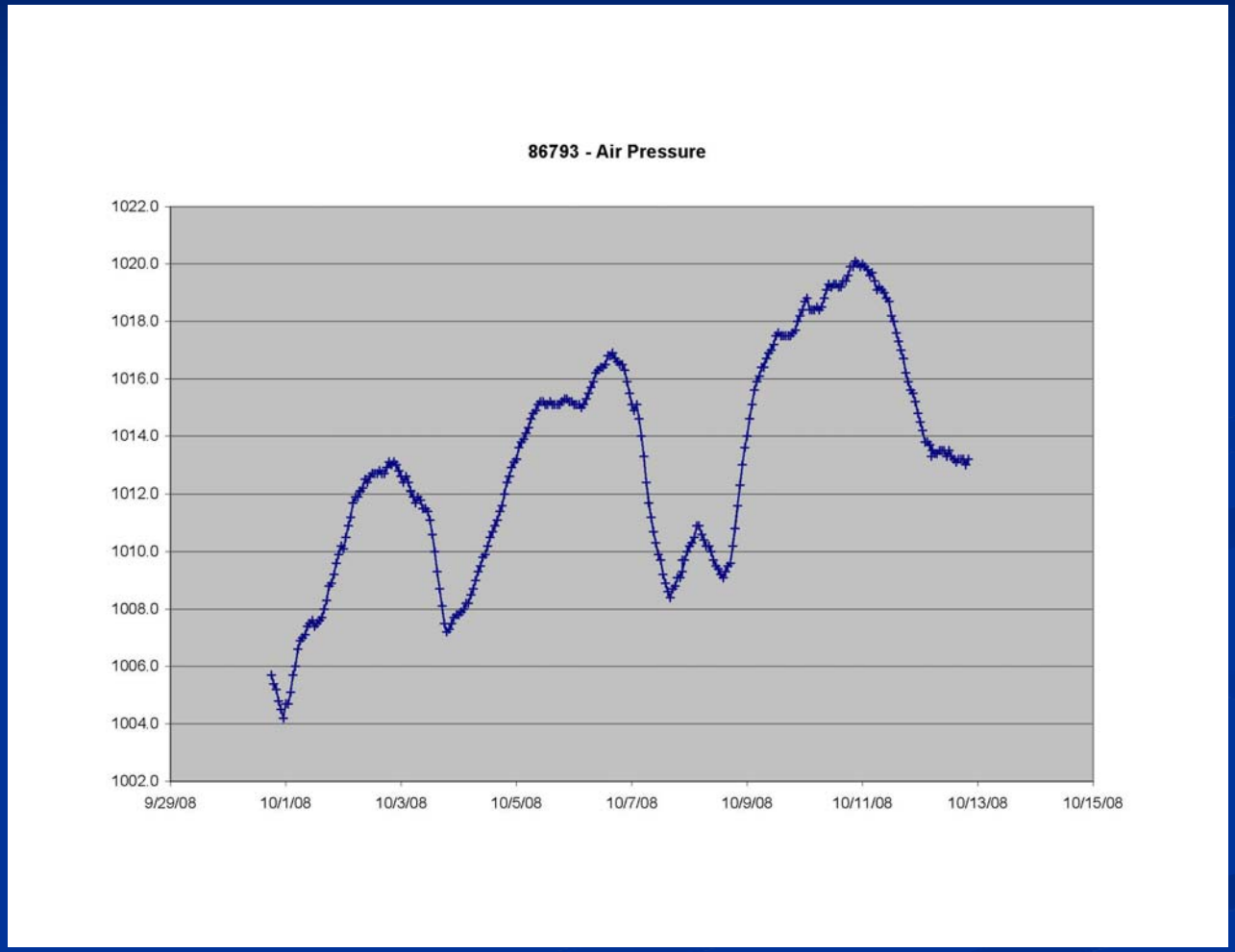
- What are power requirements of various options:
  - Increase location frequency by use of housekeeping messages or GPS
  - On-board GPS also could limit PMT receiver use, although PMT receiver management is possible. Satellite pass predictions are outdate only slowly on a drifter because of the size of the satellite footprint (5000 km) compared the velocity of a drifter (5 miles per day)
  - It appears that the power requirements could easily be reduced 50% over the current PTT; this could be greater with longer samples containing more data points.

Future Considerations

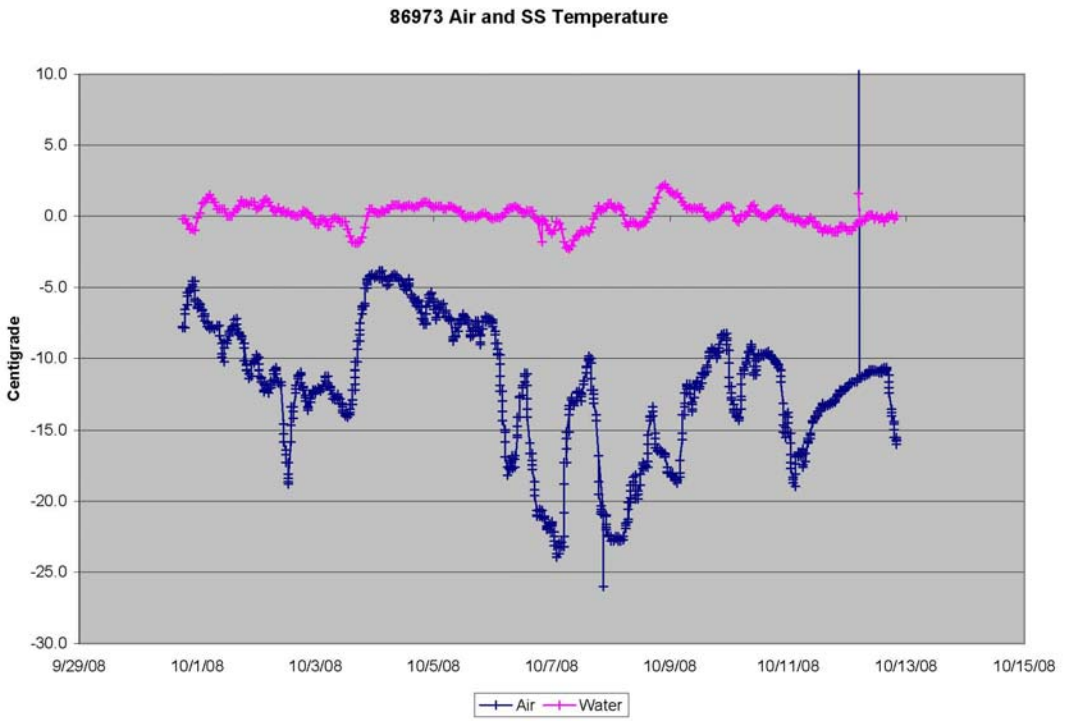
- What are our requirements for taking oceanographic and meteorological data.
  - PMT promises much more control over data sampling
  - Sample time can be accurately and absolutely controlled.
  - Platform location can be managed by increasing/decreasing the number of messages
  - GPS offers the possibility of scheduled locations and velocity measurements.

86973 AXIB Ice Buoy
LBI, Inc. Hull and Clearwater Electronics
U.S. National Ice Center

86973 AP


86793 - Air Pressure
1022.0
1020.0
1018.0
1016.0
1014.0
1012.0
1010.0
1008.0
1006.0
1004.0
1002.0
9/29/08
10/1/08
10/3/08
10/5/08
10/7/08
10/9/08
10/11/08
10/13/08
10/15/08

86973 Air and SS Temperature



86973 – 539 Messages from One Day!