



ATMOSPHERIC & SPACE TECHNOLOGY RESEARCH ASSOCIATES

SCIENCE + TECHNOLOGY + APPLICATIONS // *Bringing it all together*

GNSS Reflectometry for Water Level Measurements in Challenging Locations

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Description of sensor

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



- New type of water level sensor
 - Accurate real-time measurement of water levels and extraction of tidal constituents
- Features:
 - Low-cost
 - Non-contact
 - Low-profile
 - Remote-deployable
 - No maintenance



Using "Noise" as a new "Signal"

❖ Science

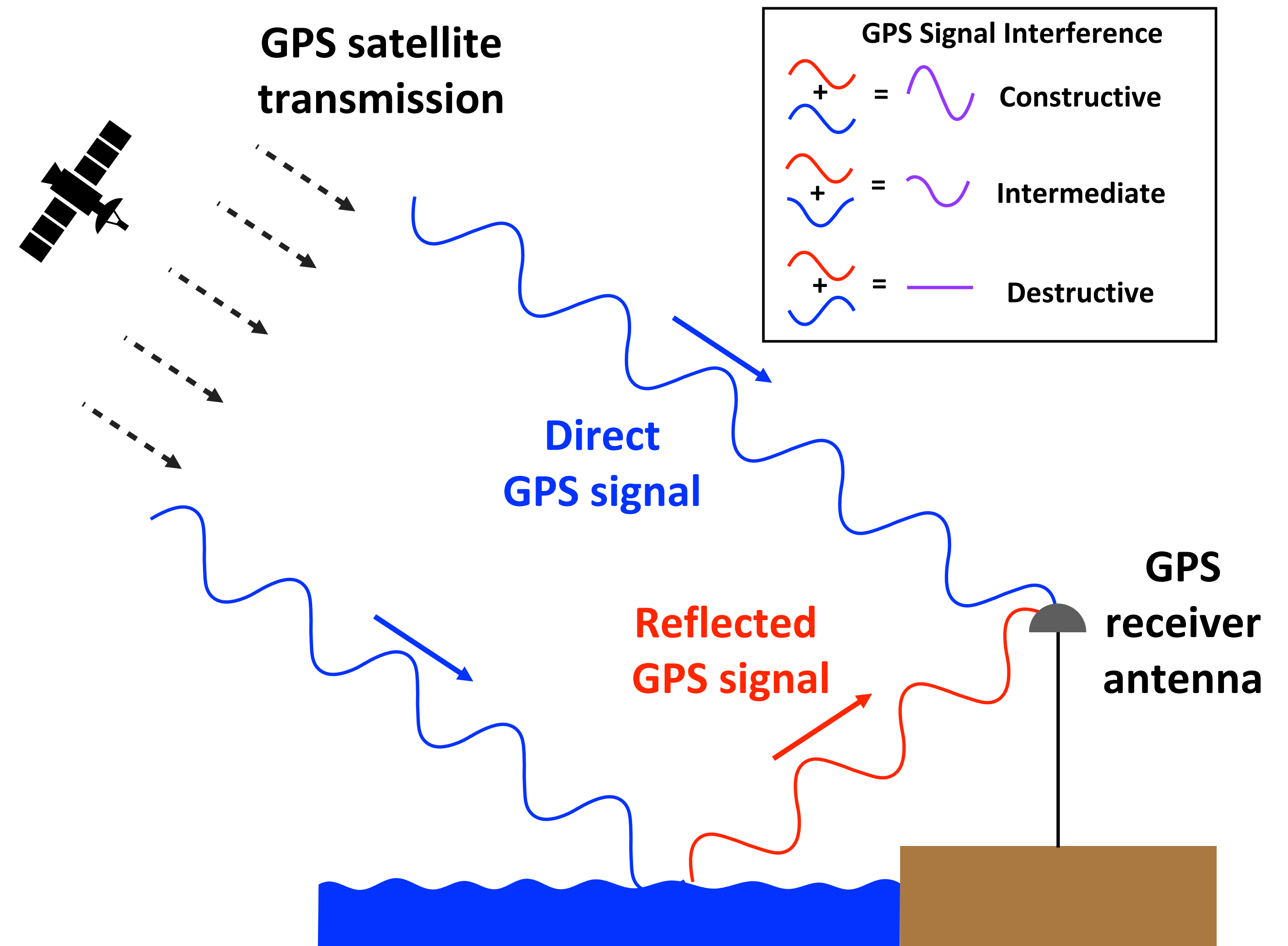
❖ Technology

❖ Applications

Bringing It All Together



- GPS Multipath (reflections) add noise to typical measurements
- Multipath causes interference
- As satellites rise and set, interference fringes contain information about antenna height above reflecting surface



Based on Work by Kristine Larson

Installation Requirements

❖ Science

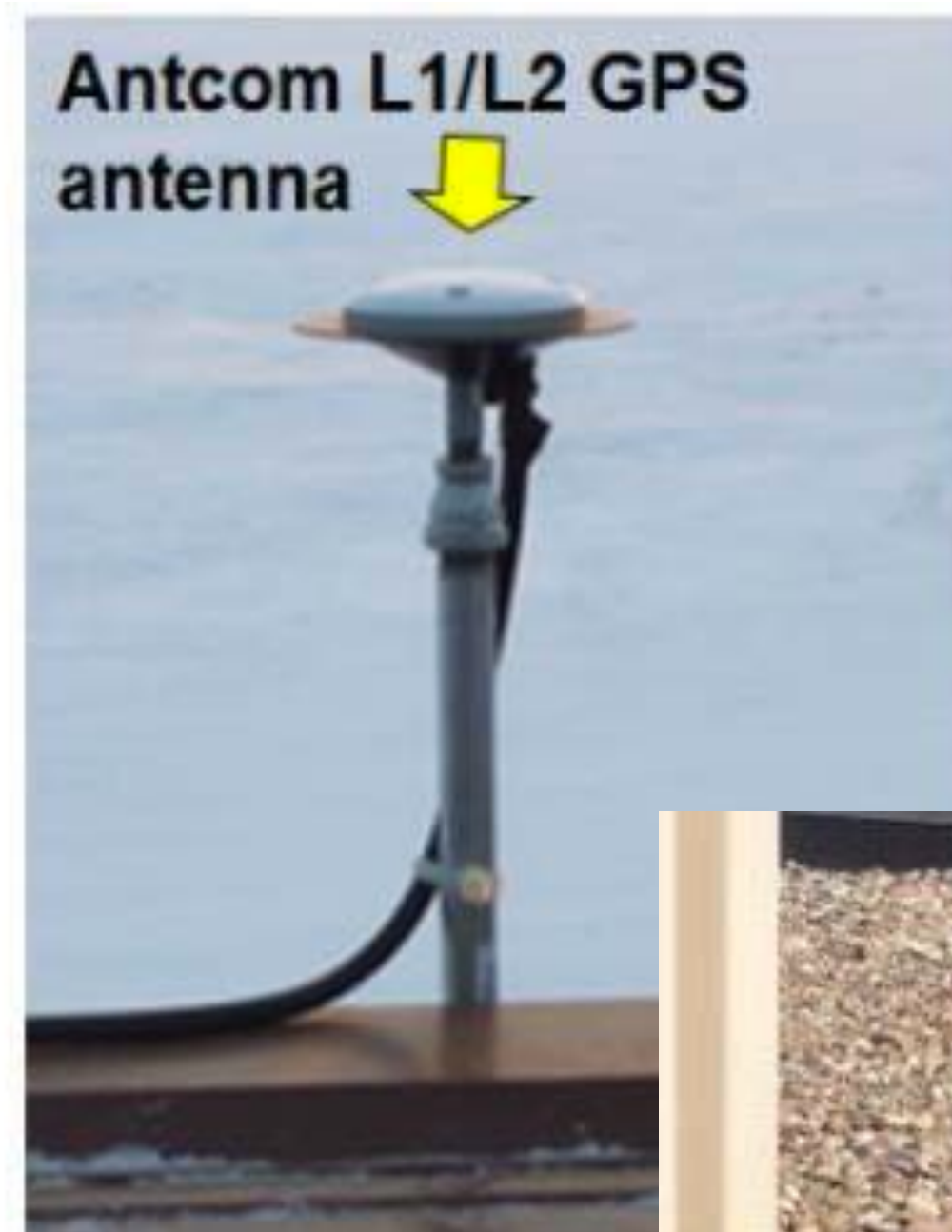
❖ Technology

❖ Applications

Bringing It All Together



- Two types of installations
 - Completely stand-alone
 - Solar panels & Battery & Iridium Comms
 - Land-powered
 - AC power & Cellular or Ethernet Comms
- Requirements:
 - Location to mount GPS antenna
 - Location for small electronics box
- Specifications
 - <2.5 Watts for GPS receiver
 - < 5 Watts total for GPS & comms & storage
 - Antenna is 5" x 5" x 2"
 - Total system size < 1 cubic foot (not incl. solar panels)
 - Total system weight < 10 lbs (not incl. solar panels)
 - On-board processing of data to generate water level measurements



Pilot Study Install Locations

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



- Pilot Study was contracted by AOOS in Seward for ready comparison with existing NOAA tidal gauge
- Sensors were installed at two locations in Seward and both provided quality data
- Sensors were installed from April 2017 to July 2018
- Additional location scouted, planned, and installed by AOOS, JOA Surveys, and ASTRA
- Sensor was installed in Homer in July 2018, taken down in April 2019
- Remote site sensor package testing at ASTRA
 - Autonomous, solar&battery powered, iridium/cell comms



Ideal Location : Always Over Water

- ❖ Science
 - ❖ Technology
 - ❖ Applications
- Bringing It All Together*



**Ideal pier location with
great view of the water**



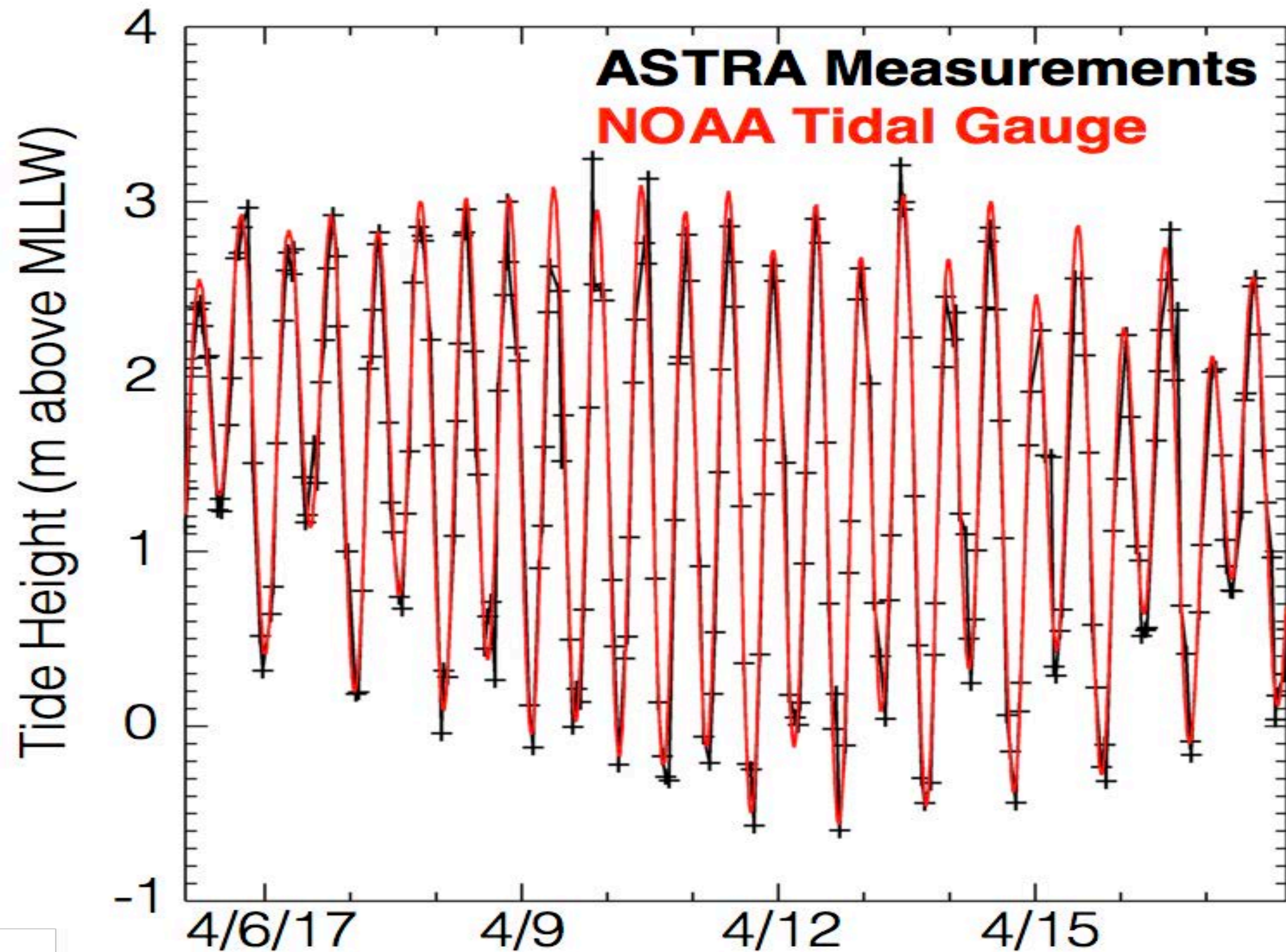
Accurate Measurements

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



- Over 14 months of continuous water level data
- 5 meter tidal swings
- Good comparison with nearby NOAA Tide Gauge

Non-Ideal Location : Wide Intertidal Zone

❖ Science

❖ Technology

❖ Applications

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High Tide



Low Tide



250 meter intertidal zone

Data Quality

❖ Science

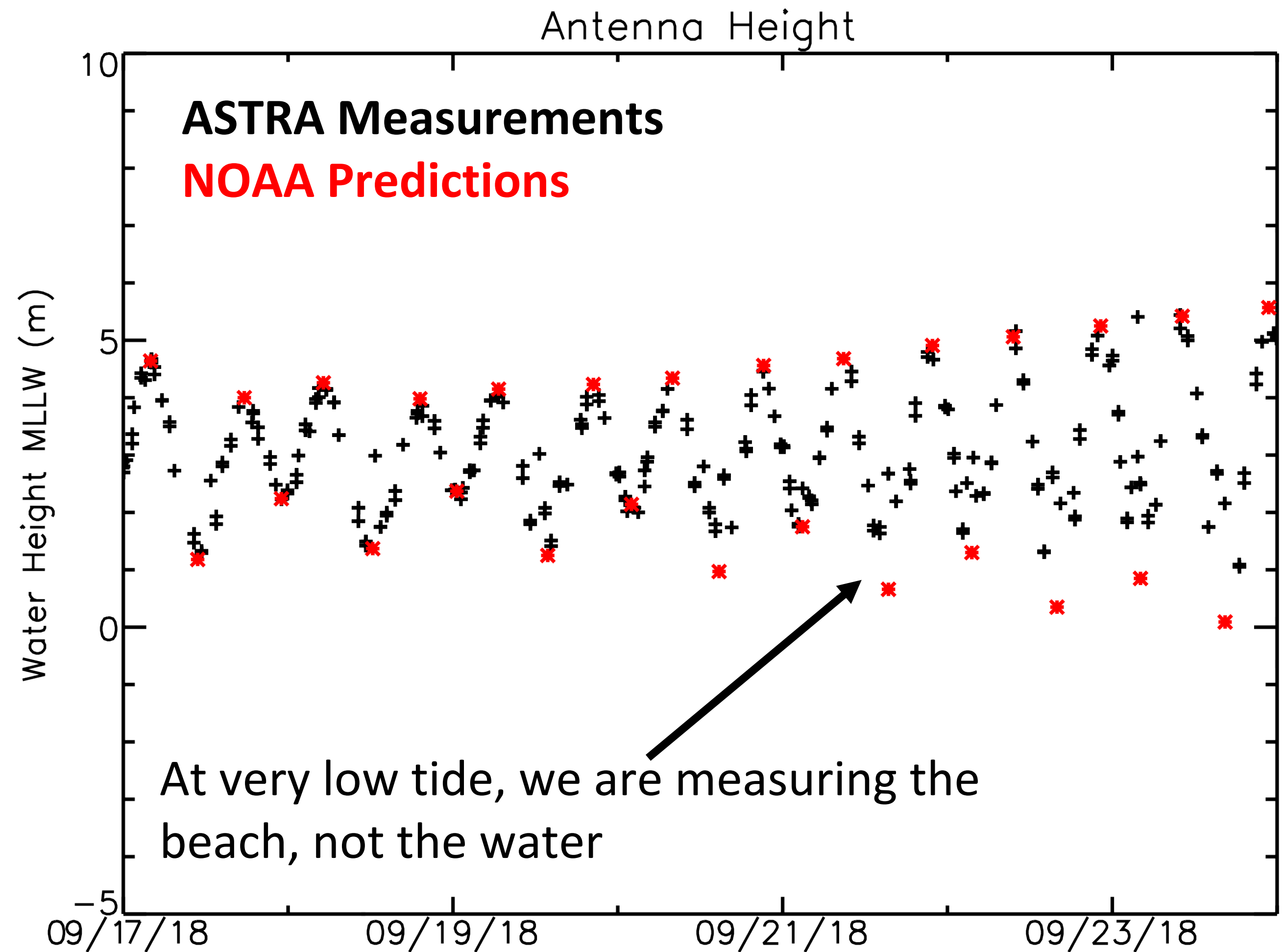
❖ Technology

❖ Applications

Bringing It All Together



- ASTRA Measurements agree with respect to NOAA high/low tide predictions
- Site tuning is key to ensure system operates effectively



Site-Specific Tuning

❖ Science

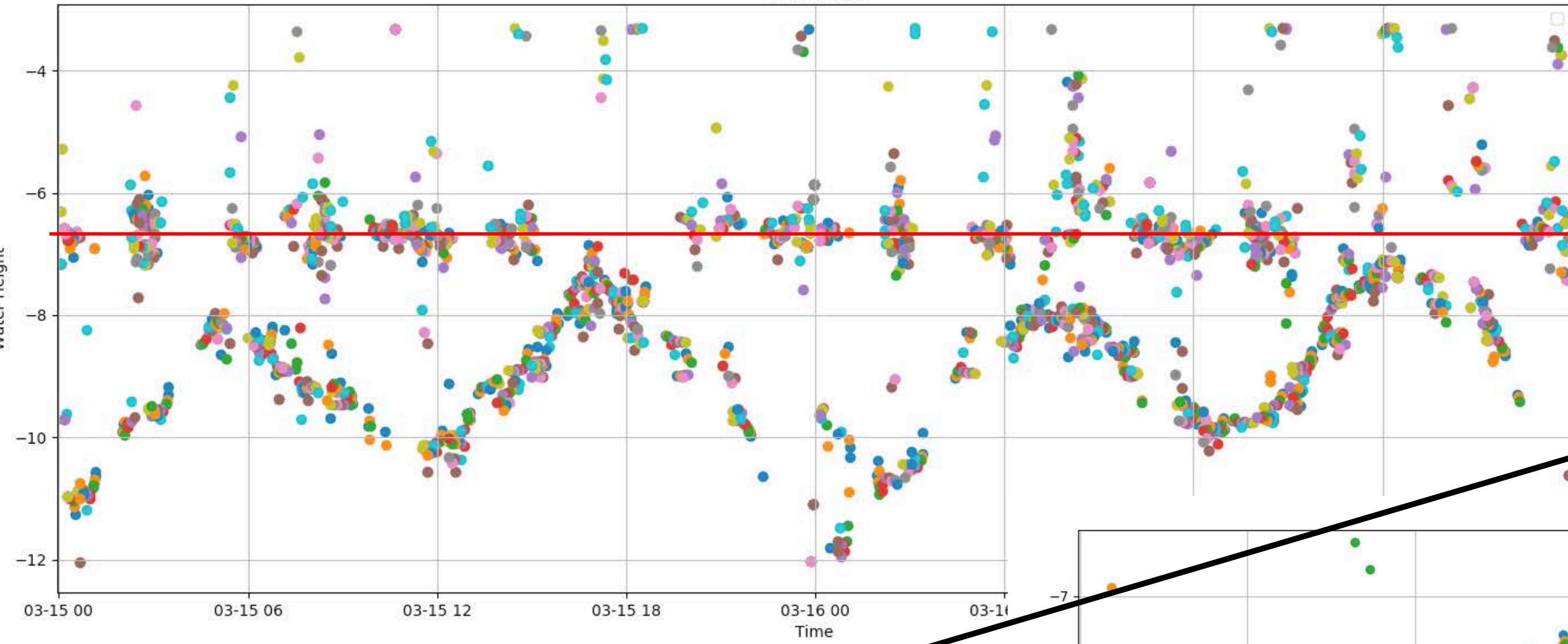
❖ Technology

❖ Applications

Bringing It All Together



scatter plot

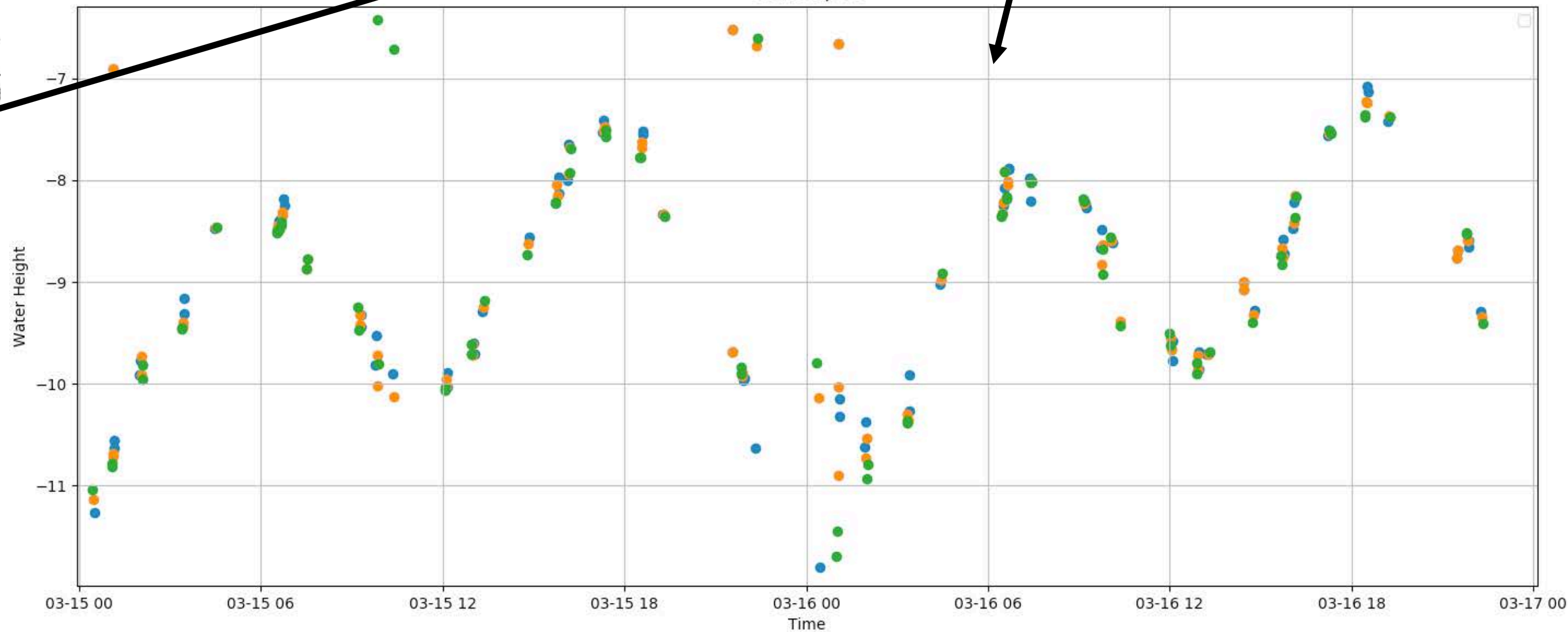


All Data Possible

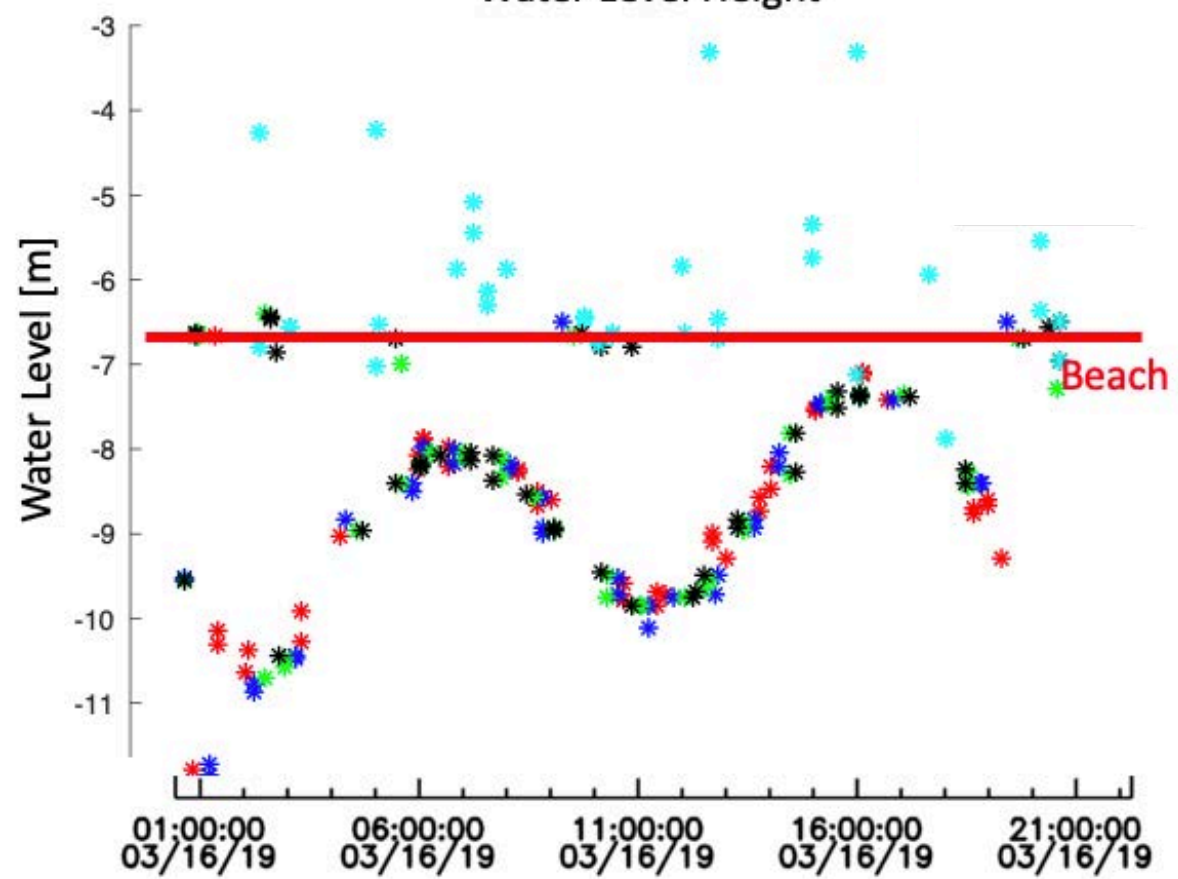
Beach Line

Reduced "Cleaner" Subsets

scatter plot



Water Level Height



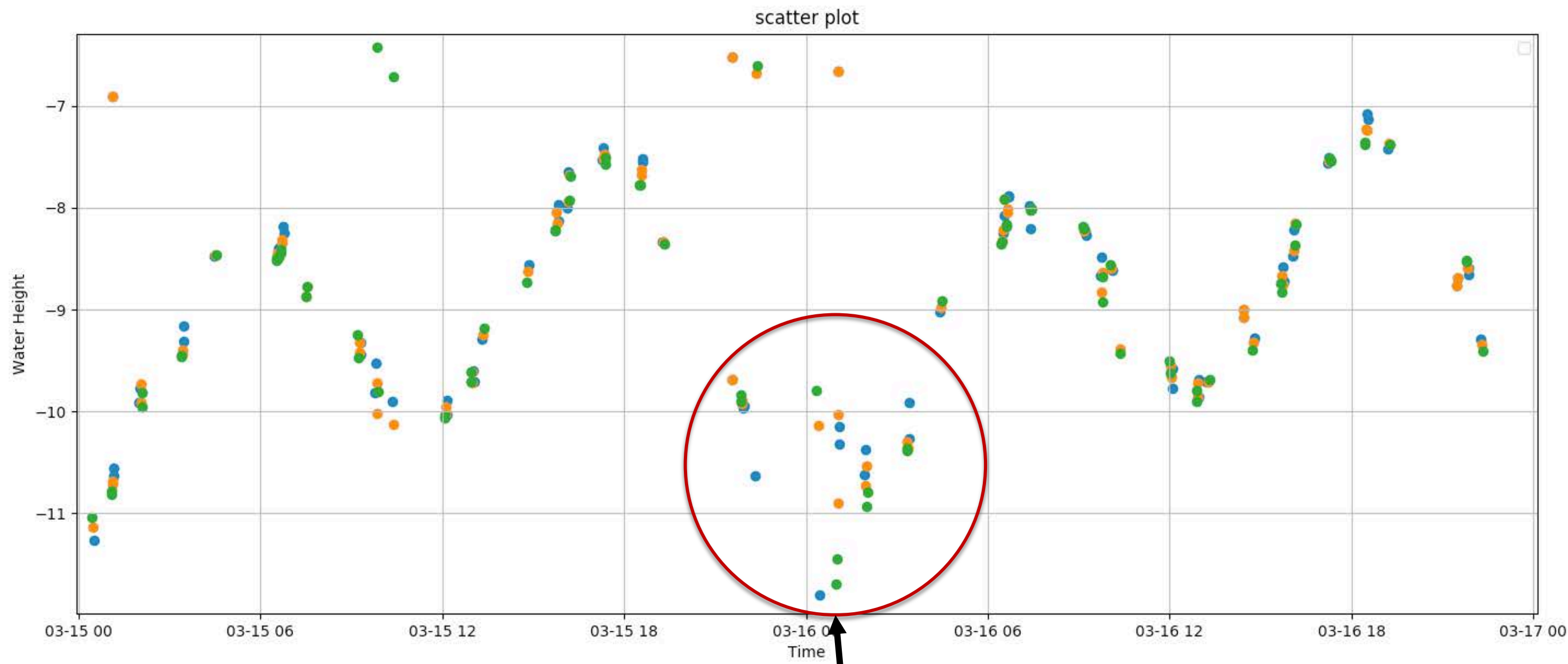
Site-Specific Tuning

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



Seeing Wet Sand, Water Pools, or Actual Water?



Low-Tide Nuances

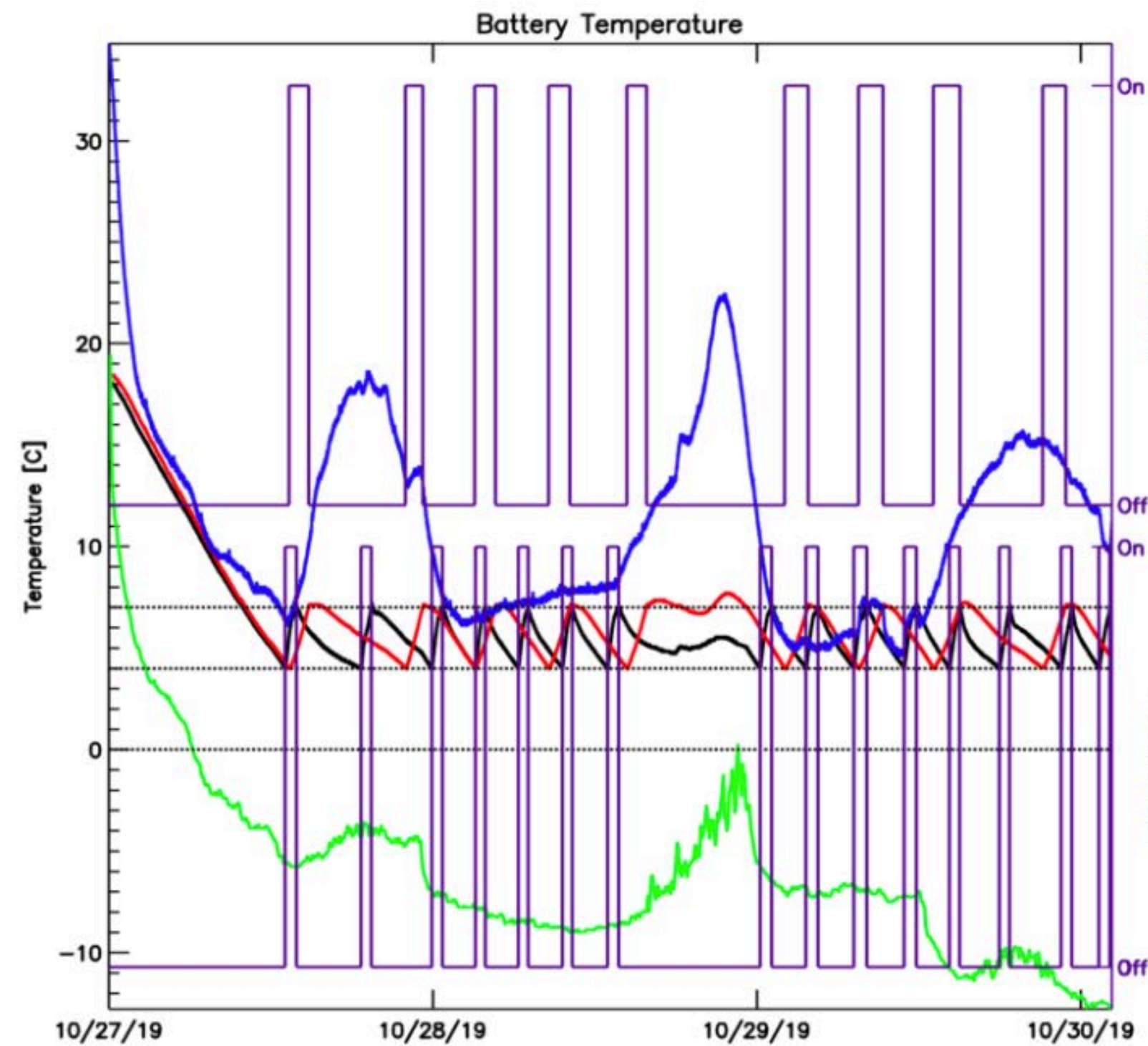
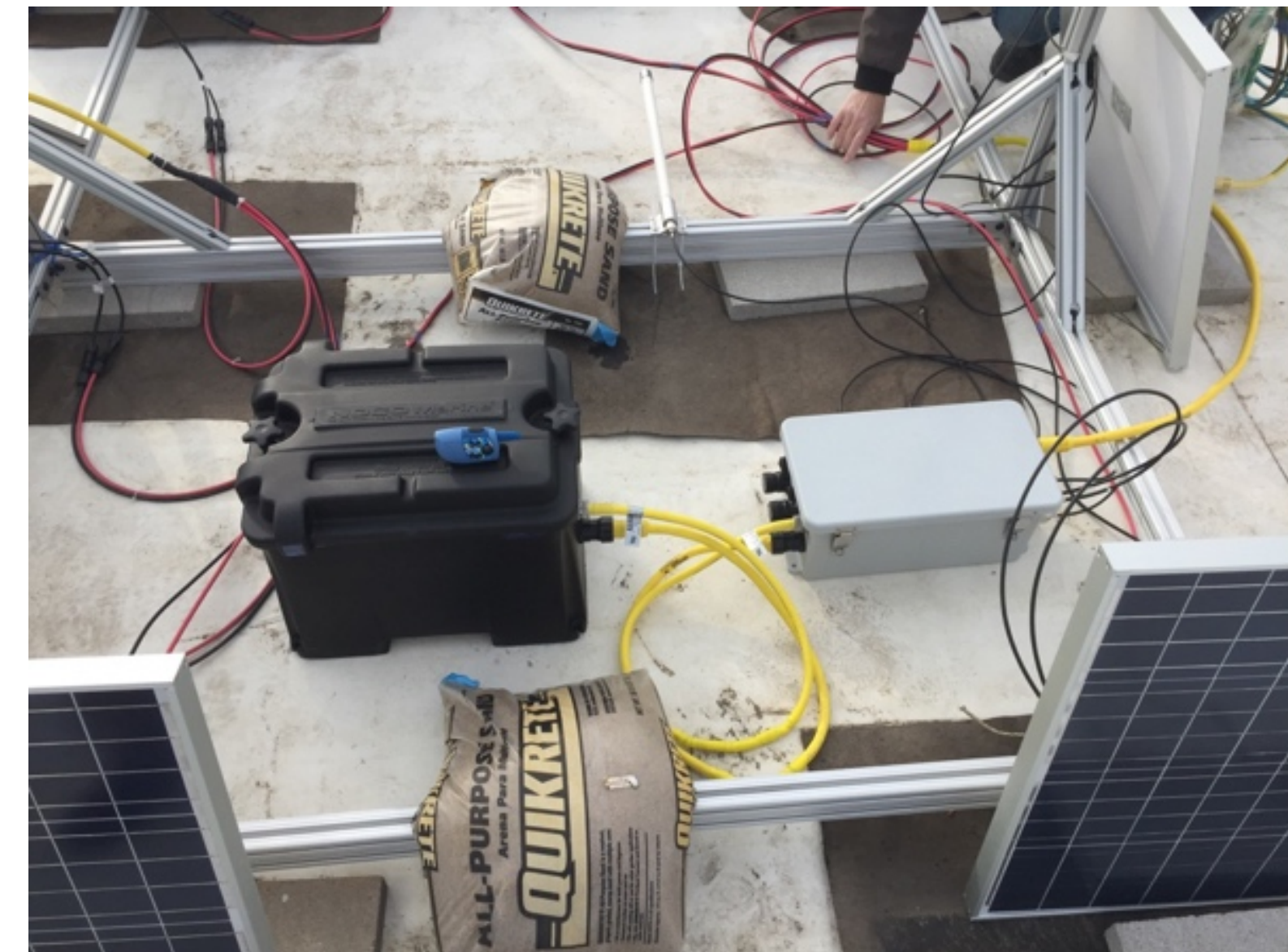
Standalone "Off Grid" System

❖ Science

❖ Technology

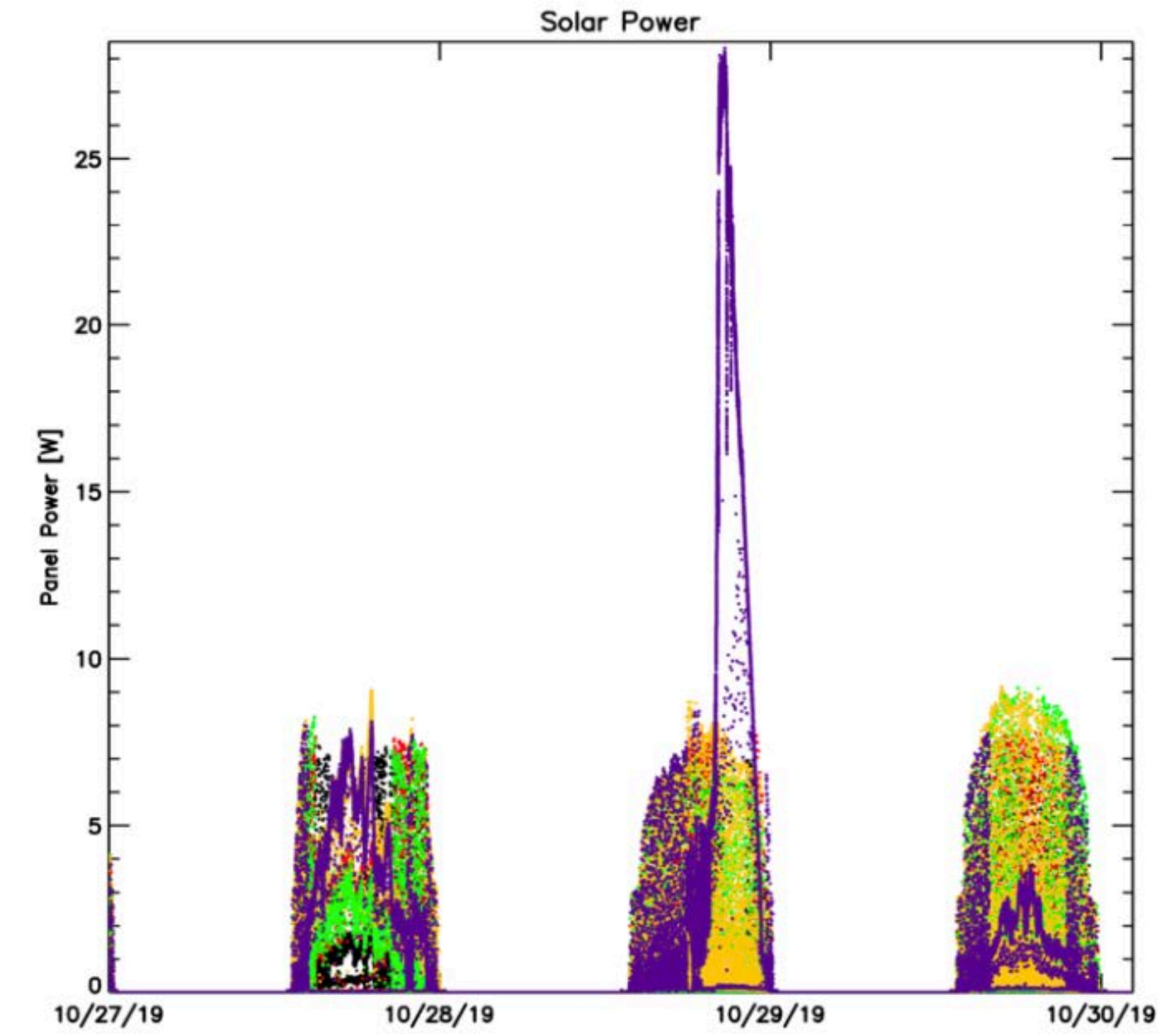
❖ Applications

Bringing It All Together



Batt 1
Batt 2
Power Board
Outside

Battery Temperatures



MPPT 0
MPPT 1
MPPT 2
MPPT 3
MPPT 4
MPPT 5

Solar Power

Future Install Locations

❖ Science

❖ Technology

❖ Applications

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- Considerations for permanent deployment in Utqiagvik, AK of autonomous, on-board processing system or Seward package (depending on final install location).
- Other sites in AK potential candidates?
- To be installed in Summer 2020 (TBR based on COVID-19 situation)



Utqiagvik Site Location

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



- Surveying ideal location in Utqiagvik
- Current challenges include finding site close enough to water (or high enough) to install location
- Discussions on-going with AOOS, JOA team, others
- Location Specifics:
 - <1m Tide vs 5m Tide
 - Potentially not being on-shore, how far can we be set back and have system perform well?
 - How high up can we be at location?
 - Ex: Wells Fargo is 400ft from shore



Summary

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



- Accurate water level measurements
 - < 5 cm tidal constituents
- Installations possible in remote locations – including locations with a wide intertidal zone
- Next stage with AOOS to deploy permanent installation of system for continual operations

