A new paradigm for Ocean Color Satellite Calibration (and validation): HyperNAV

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Design of HyperNAV Systems

HyperPro
Profiler

Hypernav
Freefall Profiler & TSRB

HyperNav on Navis Float

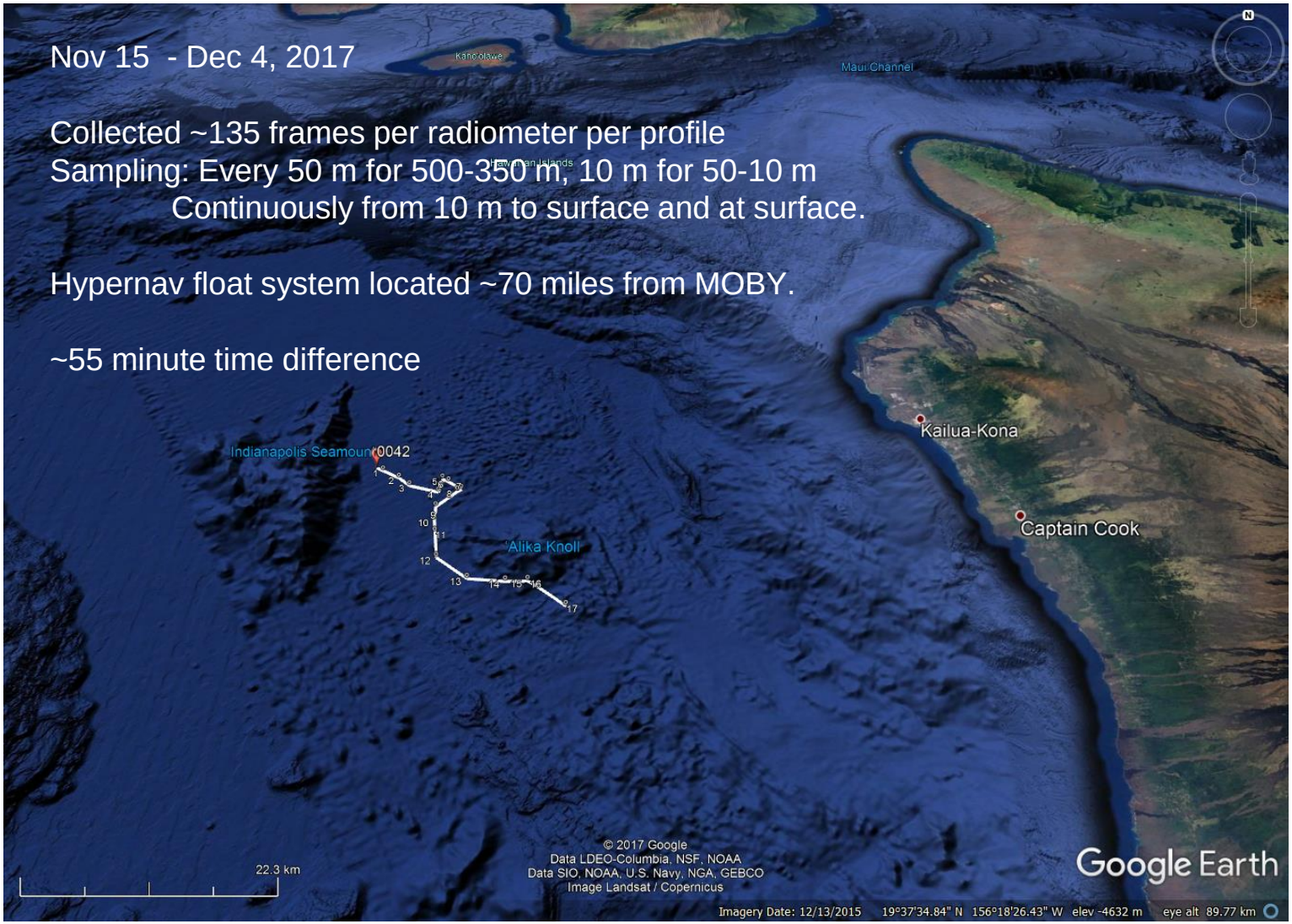
HyperNAV: Advancing Technology

- **Radiometric system:**
  - Spectral radiance resolution: ~2 nm across 350 to 900nm range
  - Spectral accuracy: ~0.1 nm
  - FOV: 9° full angle
  - Typical Noise Equivalent Radiance: 3.5 $\mu W\ cm^2\ nm^{-1}\ sr^{-1}$
  - Integrated shutter for dark measurements, tilt sensors
  - Integration time: 11-1920 ms (adaptive gain feature)
  - Total radiance uncertainty: < 4% in UV-green, 6 % in red
  - Dual radiance heads: 180° apart, integrated tilt sensors

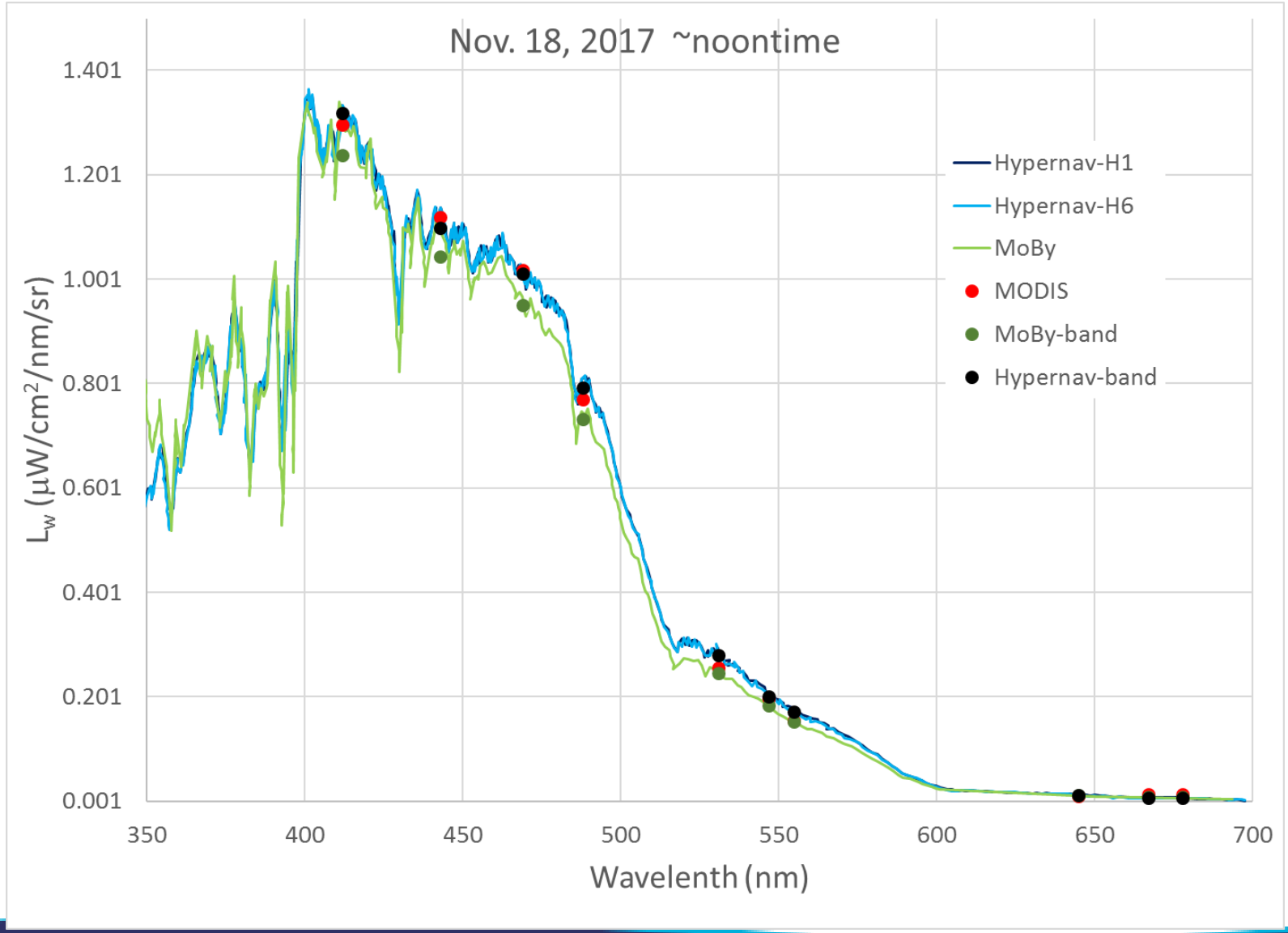
- **Hypernav system:**
  - Integrated with Navis autonomous float
  - Integrated high resolution pressure and optics sensor (chl, b_b, cdom)
  - Full water column profile (1000m rated) up to ~15 cm of sea surface
  - Minimizes shelf shading effects

Radiometric data needed for satellite vicarious calibration & validation.

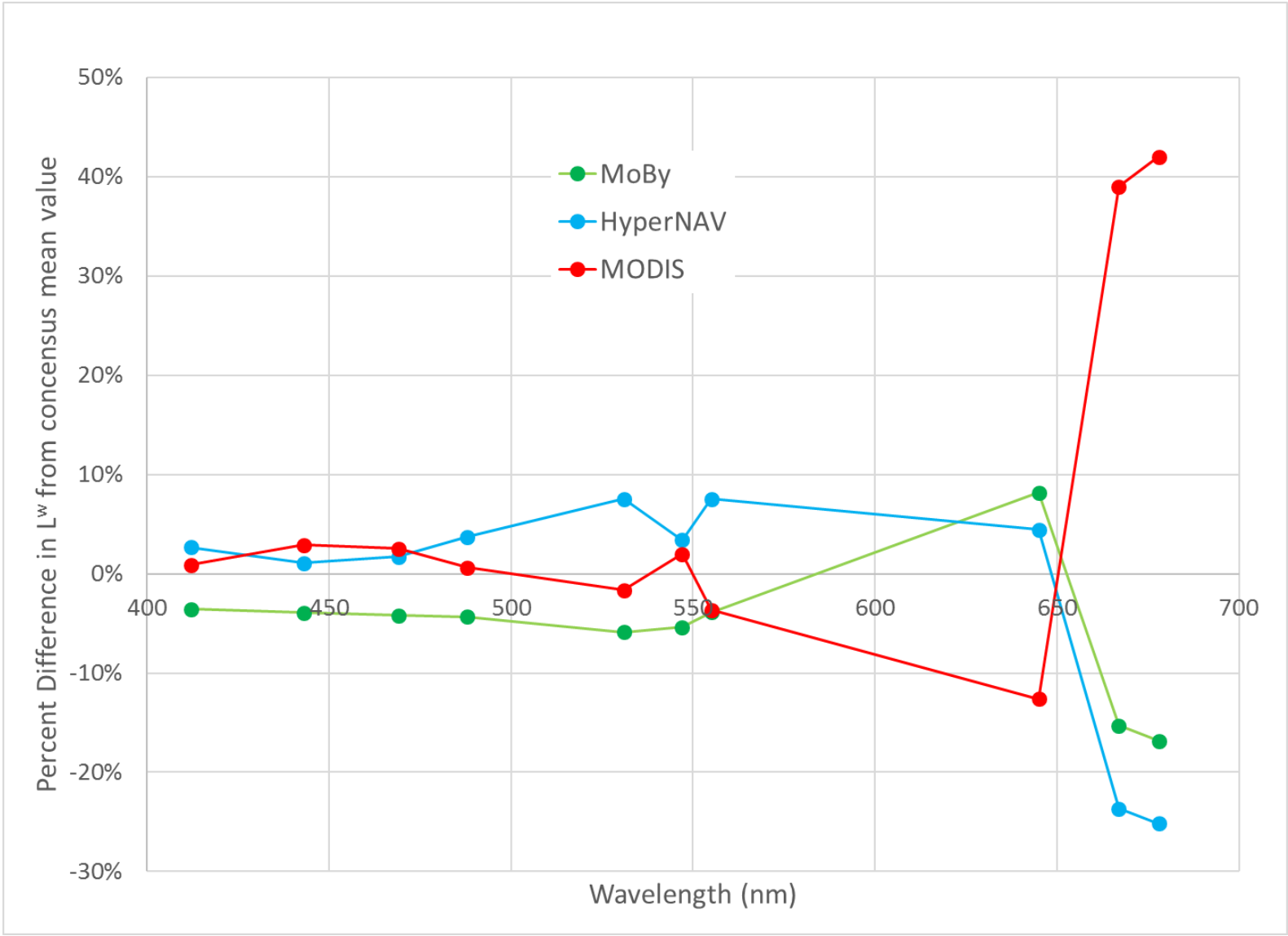
HyperNAV verification deployment



Comparison to MOBY and MODIS



Comparison to MOBY and MODIS



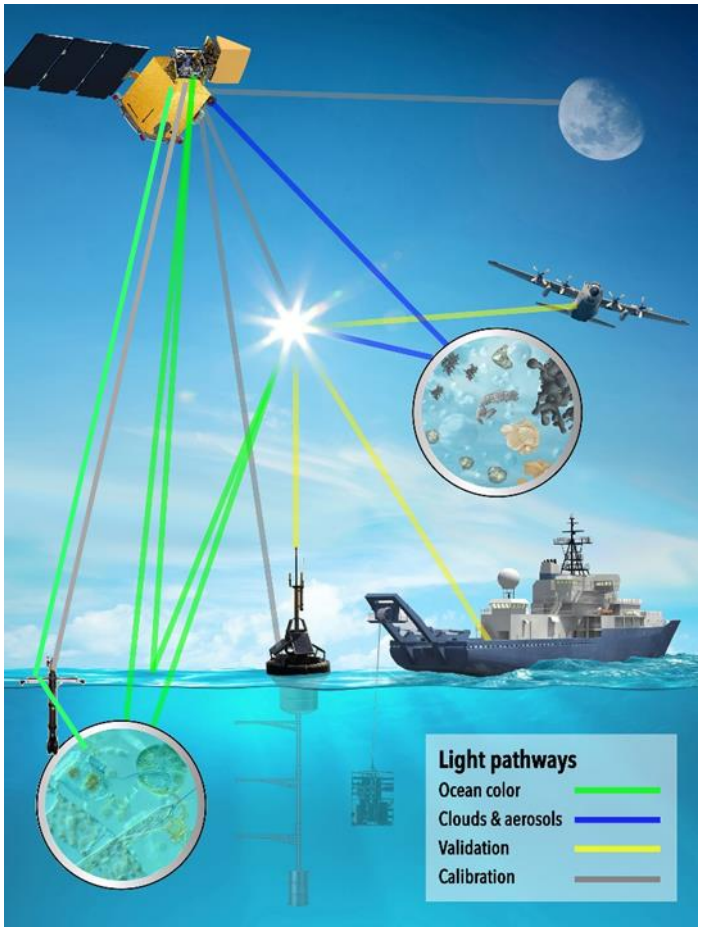
HyperNAV Uncertainties Matrix

Source	380nm	412nm	443nm	490nm	510nm	550nm	665nm	Method
Calibration	1.88	1.87	1.80	1.74	1.68	1.68	1.71	
Irradiance Standard	0.55	0.51	0.48	0.44	0.42	0.4	0.34	Manufacturer certificate
Reflectance Target	1.1	1.1	1	0.9	0.8	0.8	0.9	Manufacturer certificate
Geometric Effects	1.4	1.4	1.4	1.4	1.4	1.4	1.4	Modeling based on Hooker et al (2002)
Reproducibility	0.23	0.23	0.23	0.23	0.23	0.23	0.23	Previous studies (see Orrico et al 2018)
Instrument	1.43	0.71	0.64	0.45	0.66	0.46	1.17	
Polarization	0.9	0.5	0.4	0.1	0.06	0.07	0.5	Laboratory measurements
Thermal	0.08	0.08	0.08	0.08	0.08	0.08	0.08	Laboratory measurements
Immersion	0.43	0.45	0.45	0.36	0.4	0.39	0.3	Laboratory measurements & Feinholz et al. (2017)
Integration Time Linearity	0.05	0.05	0.05	0.05	0.05	0.05	0.05	Laboratory measurements
Counts Linearity	0	0	0	0	0.01	0.03	1	Characterized by NIST
Stray Light	0.12	0.1	0.09	0.08	0.05	0.04	0.09	Characterized by NIST
Wavelength @ Cal	0.19	0.15	0.13	0.09	0.08	0.06	0.03	Laboratory measurements
Wavelength @ Field	1	0.1	0.1	0.2	0.5	0.2	0.1	Field data
Field	2.58	2.55	2.54	2.54	2.62	2.78	5.42	
Self-shading	0.3	0.26	0.22	0.24	0.32	0.56	2.7	Modeling using SimulO software
Tilt Effects	2.2	2.2	2.2	2.2	2.2	2.2	2.2	Field data and Kwiatkowska et al. (2017)
Biofouling	1	1	1	1	1	1	1	Brown et al. (2007)
Wave Focusing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	Estimated from literature
Depth Uncertainty	0.7	0.56	0.54	0.54	0.82	1.14	4	Extrapolated from Voss et al. 2017 and field data
Surface Transmittance	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Modeling based on Quan & Fry (1995)
Total Combined, k=1	**3.5**	**3.2**	**3.2**	**3.1**	**3.2**	**3.3**	**5.8**	

- Radiometric uncertainty below 4% in the UV-green, < 6% in red.
- Calibrations fully traceable – facilities and equipment.
- Independent verification by NMIs (NIST, NPL)

A new strategy for vicarious calibration

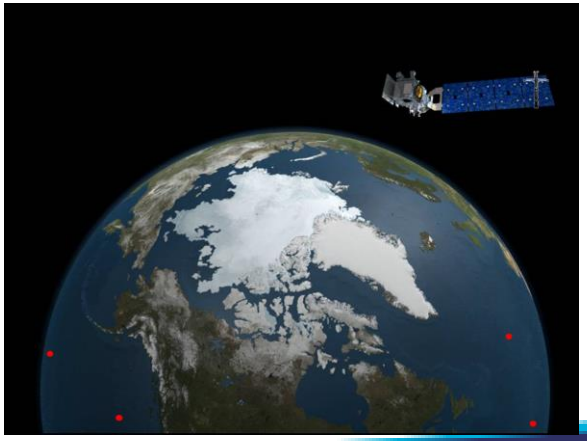
- Risk reduction approach to satellite vicarious calibration.
- Deployment floats at the start of a satellite mission - Rapid characterization of in flight satellite radiometer.
- Augments other moored cal/val sites throughout satellite lifetimes, enables rapid collection of vicarious calibration data.
- Provide radiometric measurements across a broader range of solar angles and geographic regions, to assess the satellite dependencies on out-of-band response, BDRF, etc.
- Reduce the timescale for characterizing the on-orbit satellite radiance using multiple sites.



Next Steps

- Publication of Hypernav design, uncertainties, and field results.
- Proposal preparation to ROSES 2018 A.48 – PACE mission system vicarious calibration.
- Development of spectral irradiance sensor for the HyperNAV
- Conduct additional field deployments to assess repeatability and long term data uncertainties.
  - NOAA VIIRS cal/val cruise May 2019 (free fall mode only)
  - Possible Med. Sea deployments (LOV) – fall 2019
  - **Provide community data** for algorithm development/testing.

Looking for collaboration opportunities!!



Thank You