# Update on APL-UW Airborne Remote Sensing


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# Compact Airborne System for Imaging the Environment (CASIE): Specifications

## Synthetic Aperture Radar

- Along-track and cross-track interferometric
- L- and C-band
- 3 km imaging area

## Thermal Infrared Cameras

- Dual uncooled thermal cameras
- 640 × 480 pixel resolution
- 25° and 40° fields-of-view
- External temperature reference

## Lidar

- 690 nm wavelength ('eye safe')
- 3000 Hz sampling
- 6.4 cm resolution
- 1000 m range

Also have fixed visible wavelength cameras, a gimballed camera system, and radiometers.

# Compact Airborne System for Imaging the Environment (CASIE): Applications

## Synthetic Aperture Radar

- Ocean currents
- River flow
- Ocean waves
- Ocean fronts
- Internal waves
- Topographic mapping

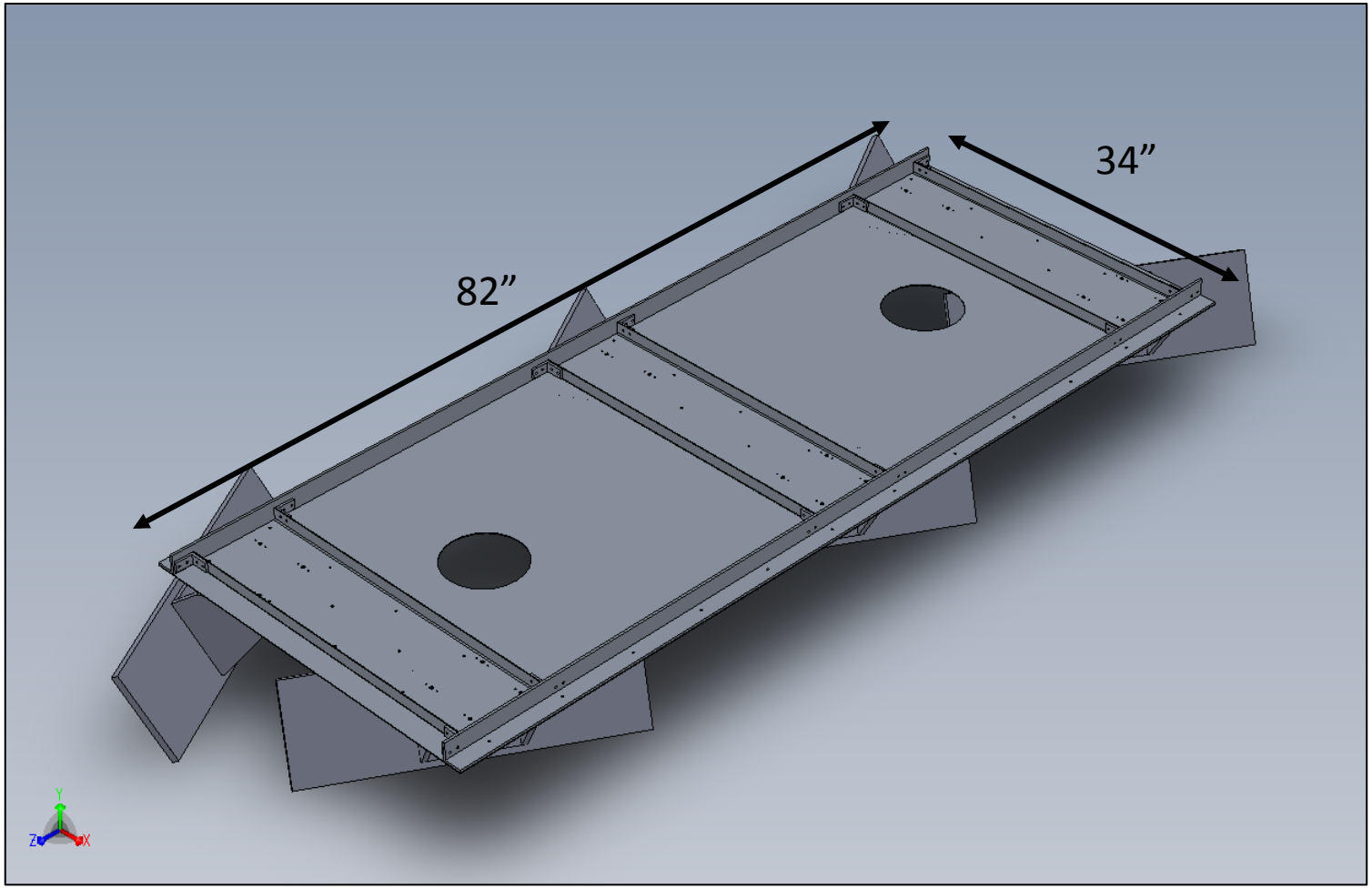
## Thermal Infrared Cameras

- River temperature
- Water body mapping
- Ocean waves
- Ocean fronts
- Internal waves

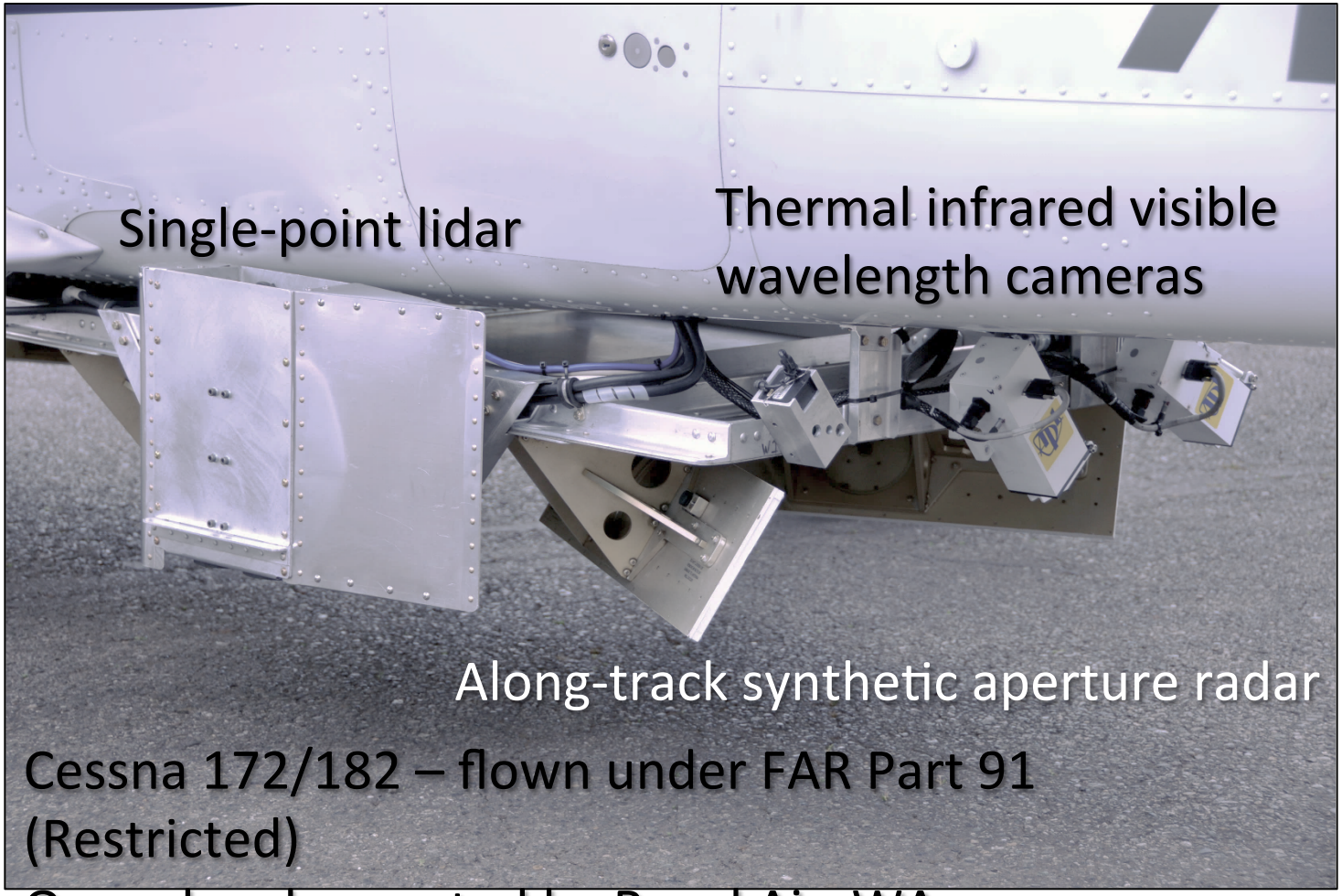
## Lidar

- Ocean wave height
- Topographic mapping

# Radar Antenna Mount (RAM)



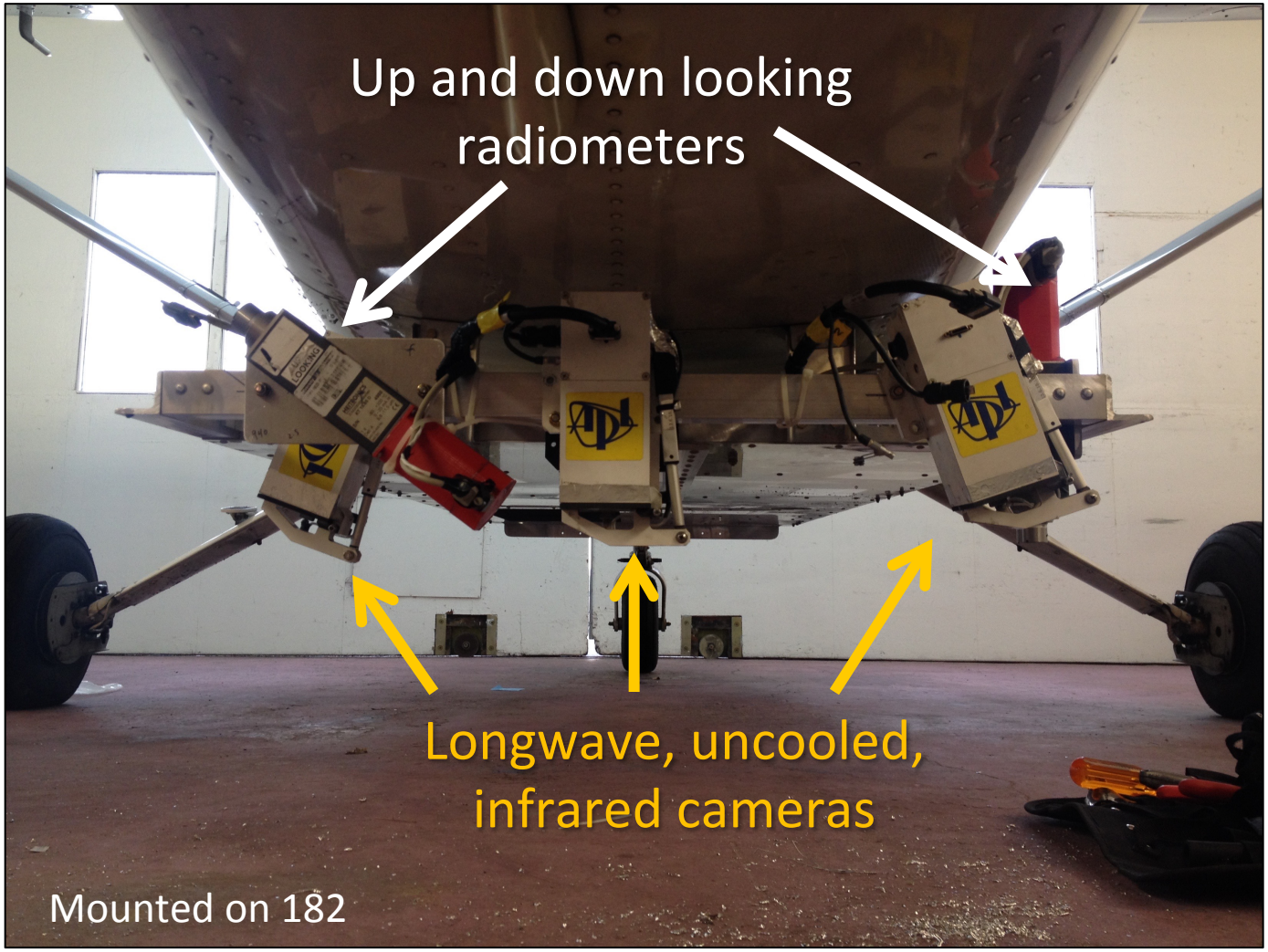
# Compact Airborne System for Imaging the Environment (CASIE) - RAM




Cessna 172/182 – flown under FAR Part 91 (Restricted)

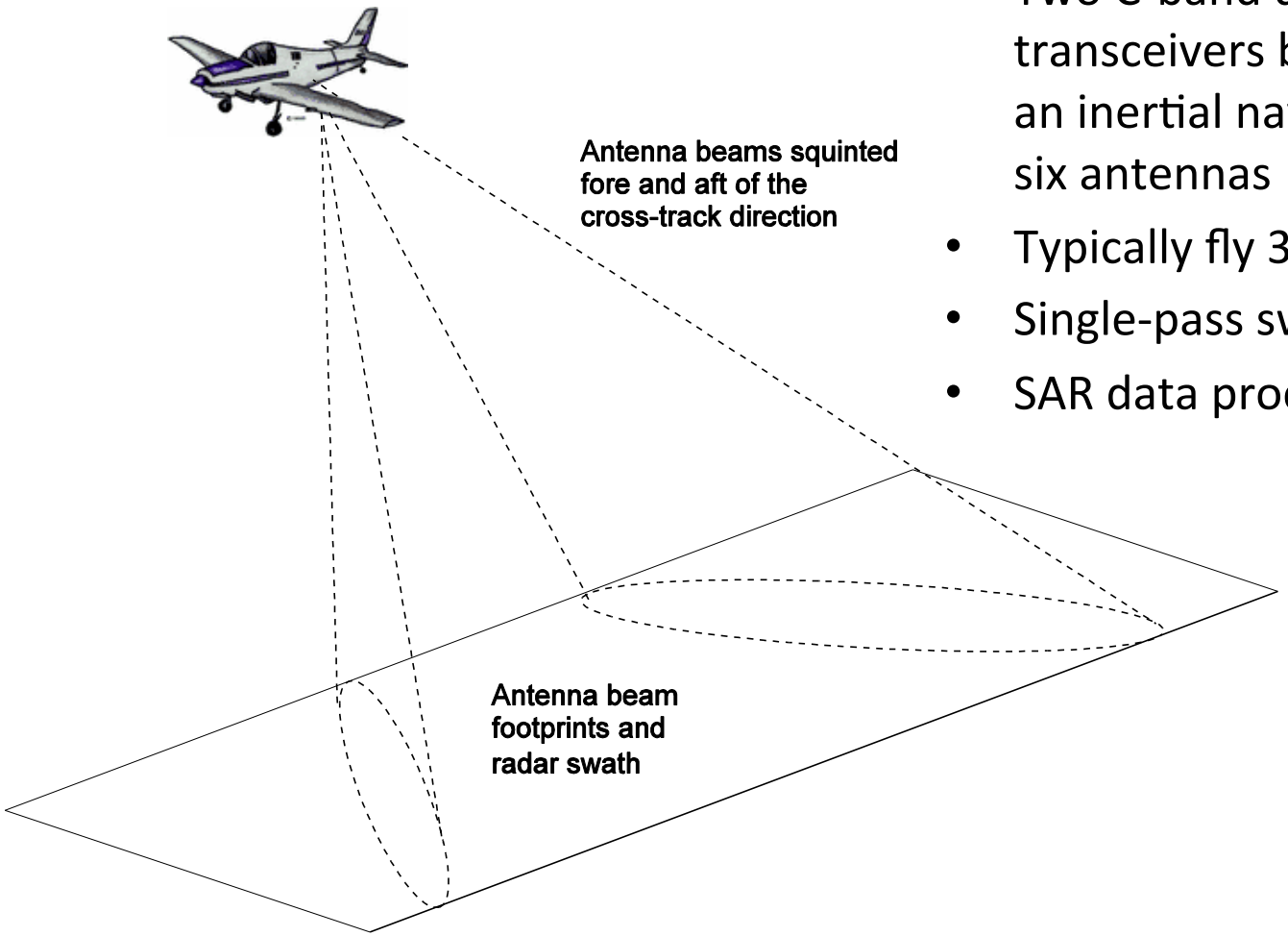
Owned and operated by Regal Air, WA

# CASIE – Camera Only Platform (COP)



# CASIE – Camera Only Platform (COP)

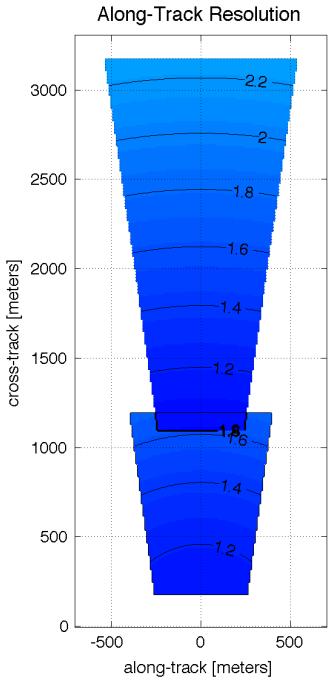
# Dual-Beam ATI SAR

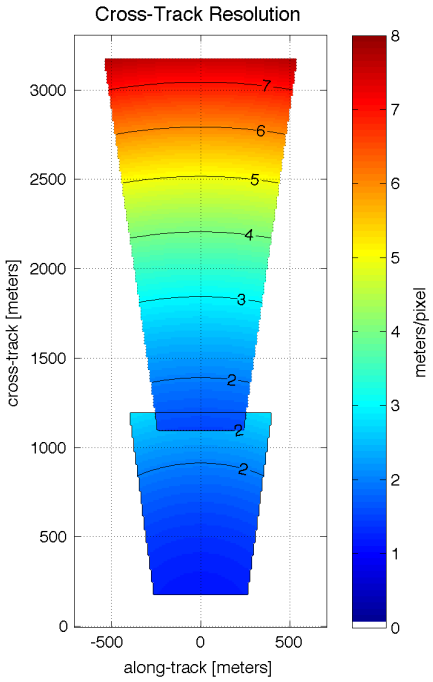



- Two C-band dual-channel transceivers built by Artemis Inc., an inertial navigation system, and six antennas
- Typically fly 3000 ft AGL, 90 knots
- Single-pass swath is ~3 km
- SAR data processed with GPUs

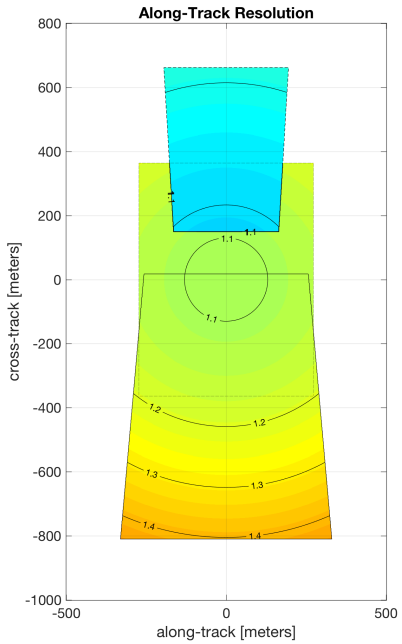
# Thermal imaging cameras

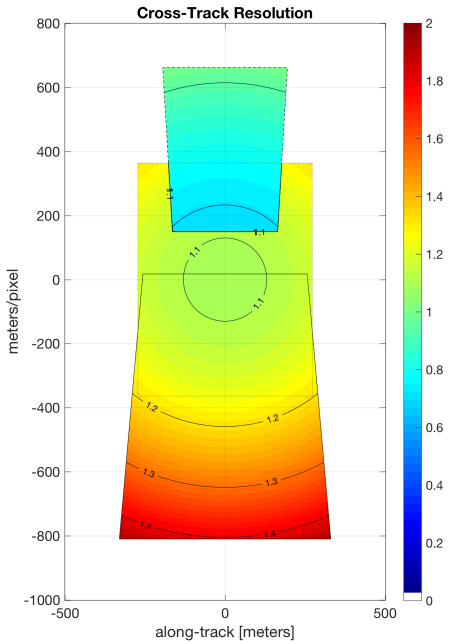
## Oblique view resolution




## Nadir view resolution



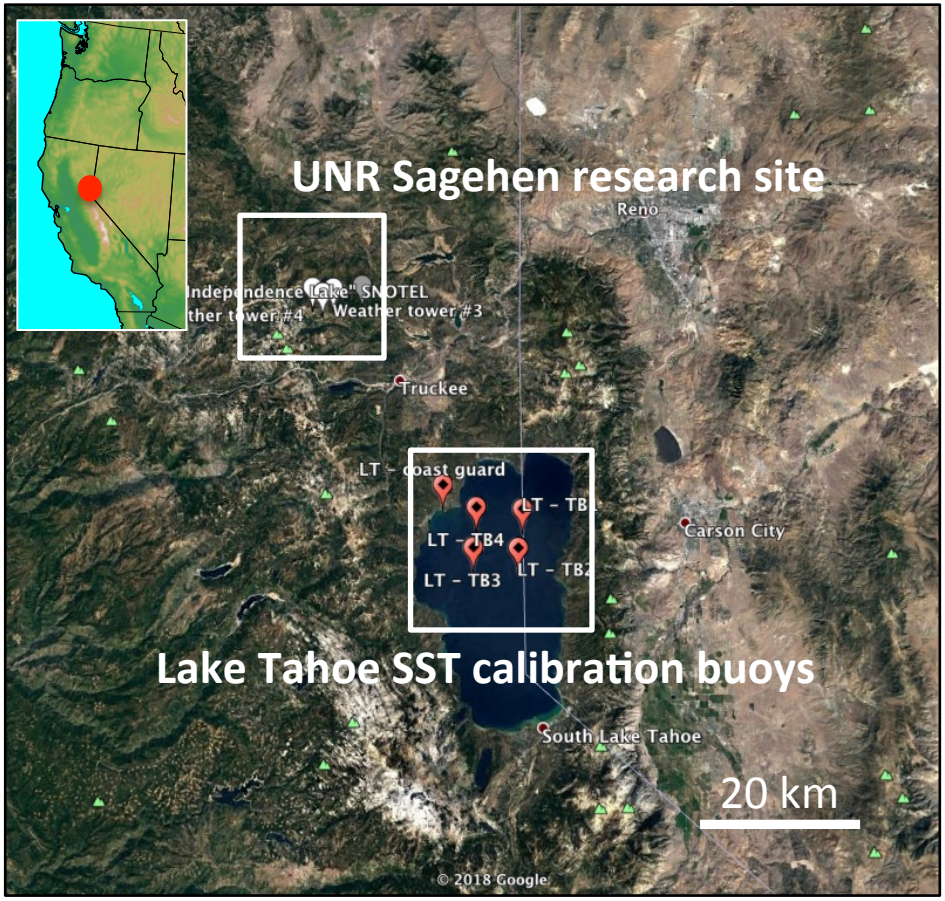

← Plane flight direction

- Two longwave IR (8-12 micron) uncool cameras
- Single-pass swath is ~3 km
- Georectified w/ IMU and GPS data

# APL – Past and Present Projects

| Year | Project | Location | Science Hours | Agency |
|---|---|---|---|---|
| 2012 | RIVET | NC | 50 | ONR |
| 2012 | CMOP | OR | 20 | NSF |
| 2012 | SWASH | WA / ID | 30 | DARPA |
| 2013 | AirSWOT | CA | 20 | APL/UW |
| 2013 | RIVET II | OR | 80 | ONR |
| 2013 | CMOP | OR | 20 | NSF |
| 2014 | Oso Landslide | WA | 6 | APL/UW |
| 2014 | DopplerScatt | WA | 6 | NASA/JPL |
| 2014 | Snow Temperature | CA | 20 | NASA |
| 2015 | Inner Shelf Pilot | CA | 20 | ONR |
| 2016 | Small Boat Detection | WA | 20 | NATO |
| 2016 | DopplerScatt | CA | 30 | NASA/JPL |
| 2016 | Multi-freq. ATI SAR | WA | 20 | ONR |
| 2016 | Snow Temperature | CA | 25 | NASA |
| 2017 | Snow Temperature, II | CA | 8 | NASA |
| 2017 | Inner Shelf | CA | 85 | ONR |

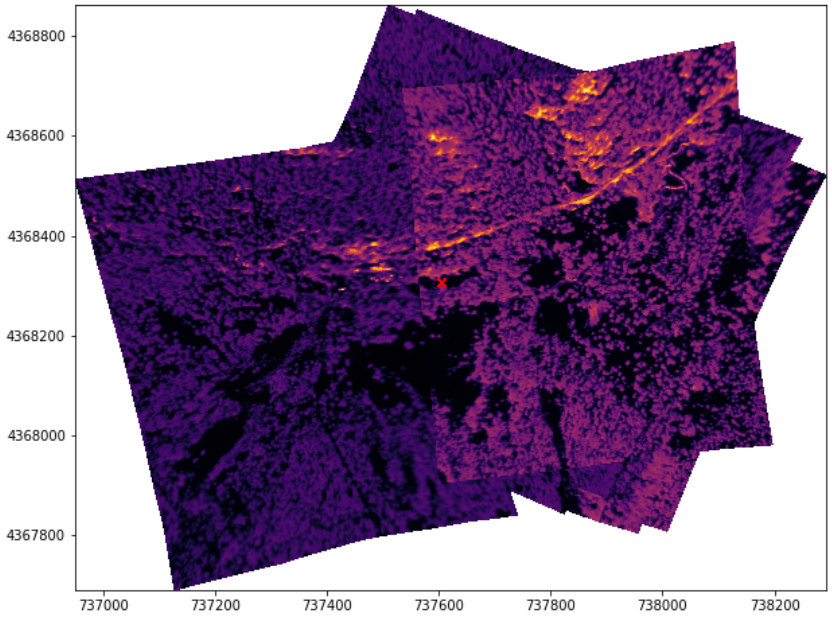
# Mountain Snow Temperature: April 2017, Yosemite NP and Sagehen UAS comparison




- Address satellite tree/ snow mixed pixel issues
- Compare w/ UAS observation

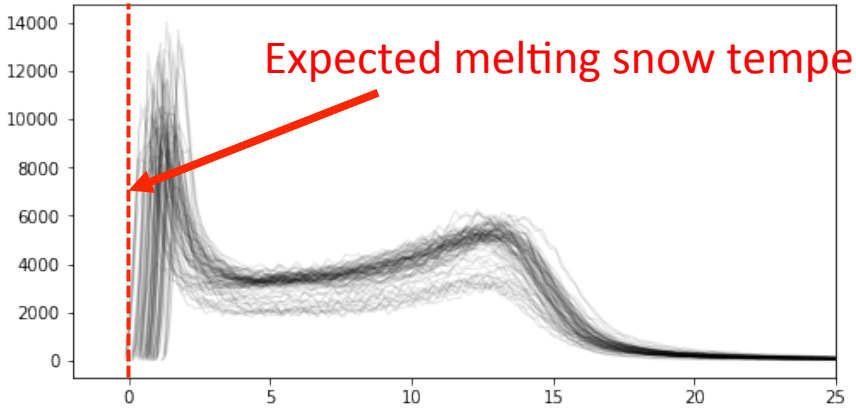
PI: Jessica Lundquist (Mt. Hyd. Res. – UW CEE) (UNR and OSU collaborators)

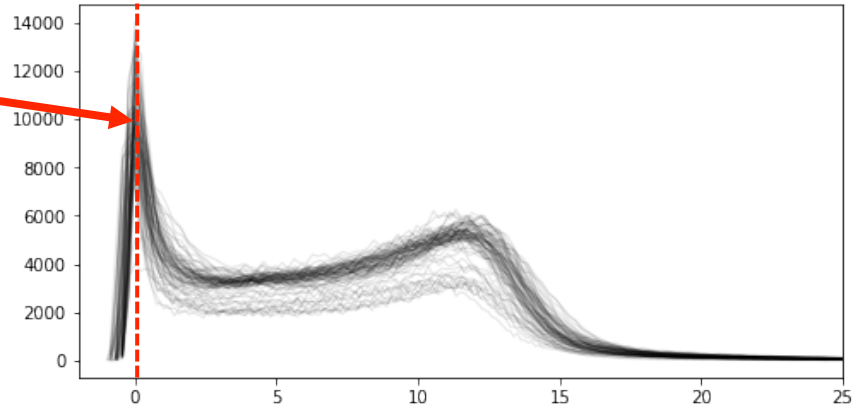
# Sagehen IR corrections
## (by Steven Pestana, Jessica Lunquist, UW-CEE)




**Aircraft TIR - histogram "correction"**

- IR image data (uncooled) has ambient temperature drift
- Histograms show similarity w/apparent offset
- Use "snow peak" (0 C) to re-align histograms and offset IR data



# Sagehen UAS

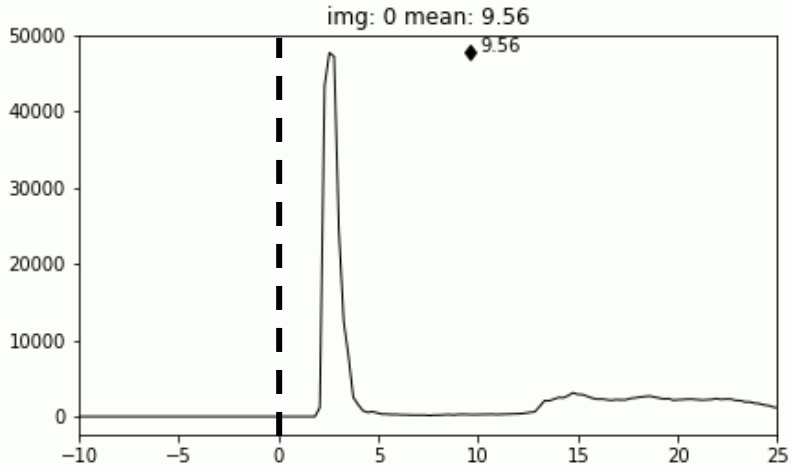

**AirCTEMPs**
**Center for Transformative Environmental Monitoring Programs**
(Oregon State University)
http://ctemps.org/

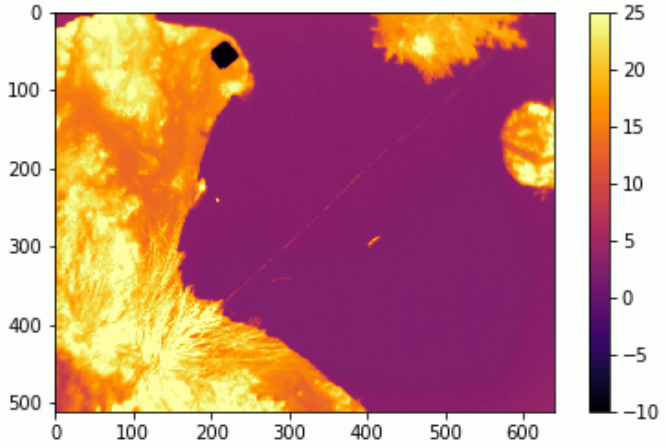
**TIR Camera:** ICI 8640 P

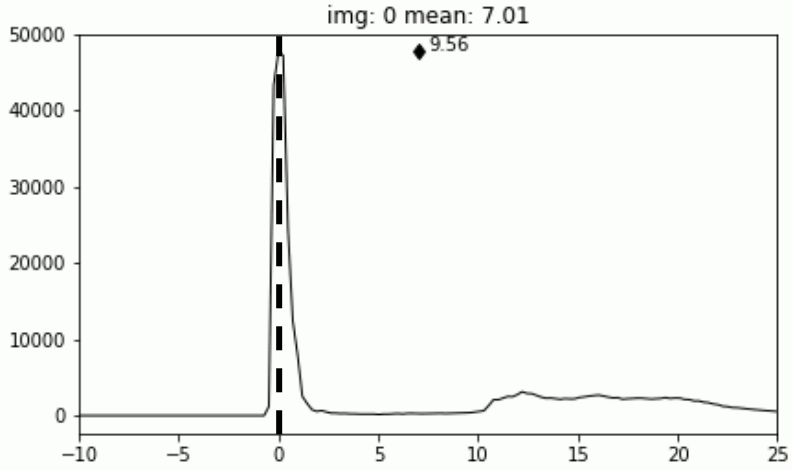

GoPro Hero3

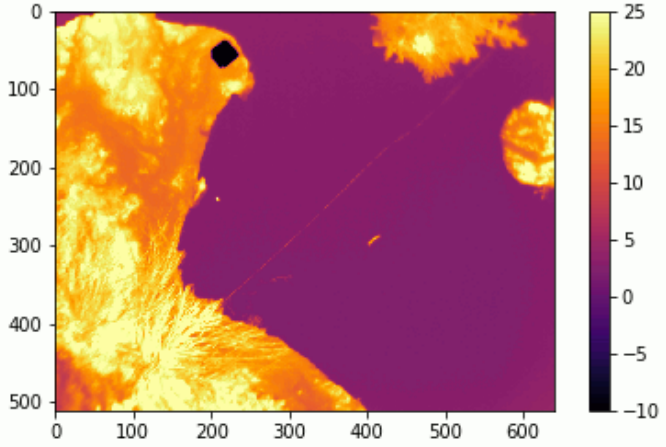
Adrian Harpold, UNR
Tihomir Kostadinov, UNR
Jessica Lundquist, UW
Henry Pai, UNR
Scott Tyler, OSU

# Sagehen UAS data correction
## (by Steven Pestana, Jessica Lundquist, UW-CEE)



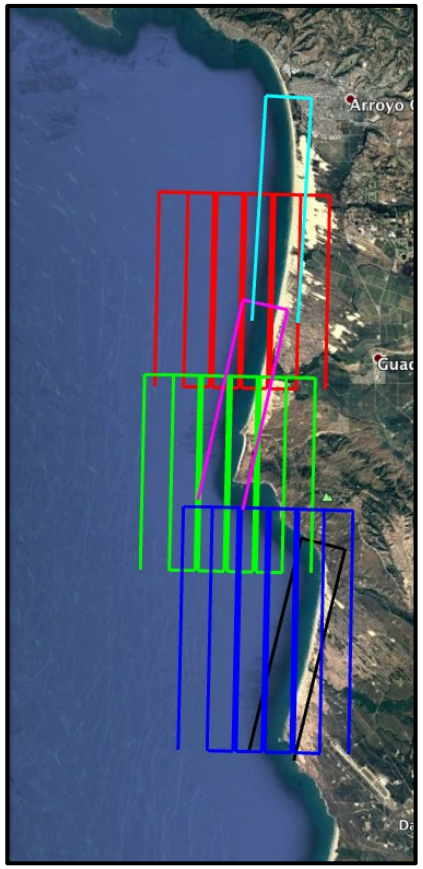



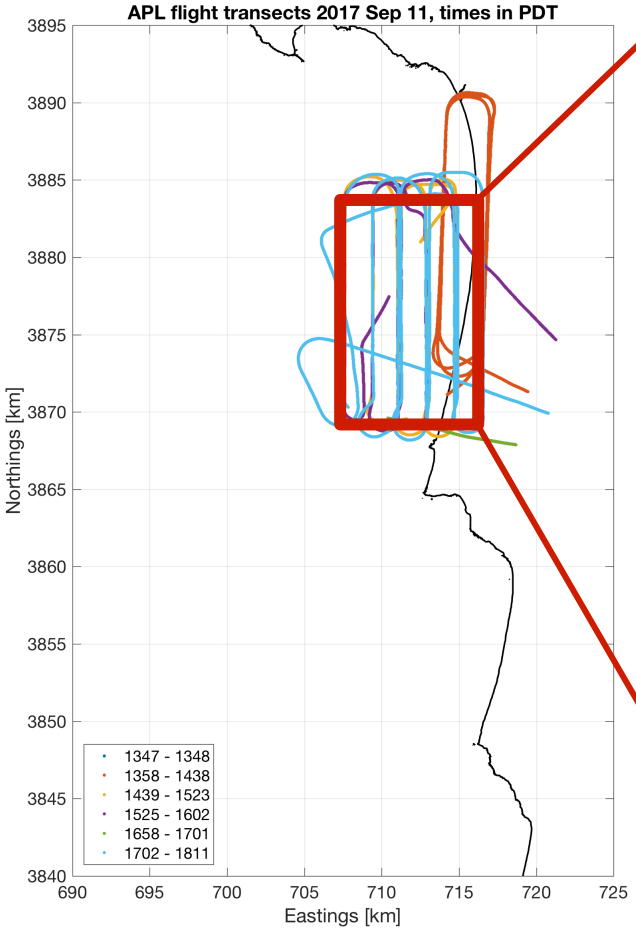



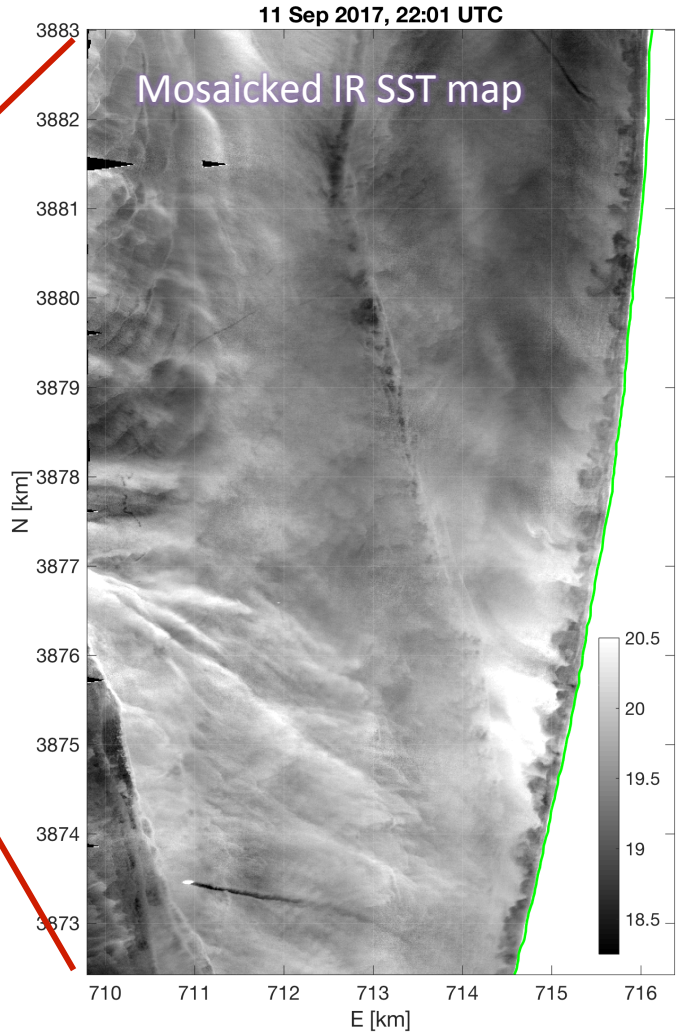
# 2017 Inner Shelf Experiment (ONR, Sept & Oct)

Planned flight paths



Executed flight paths

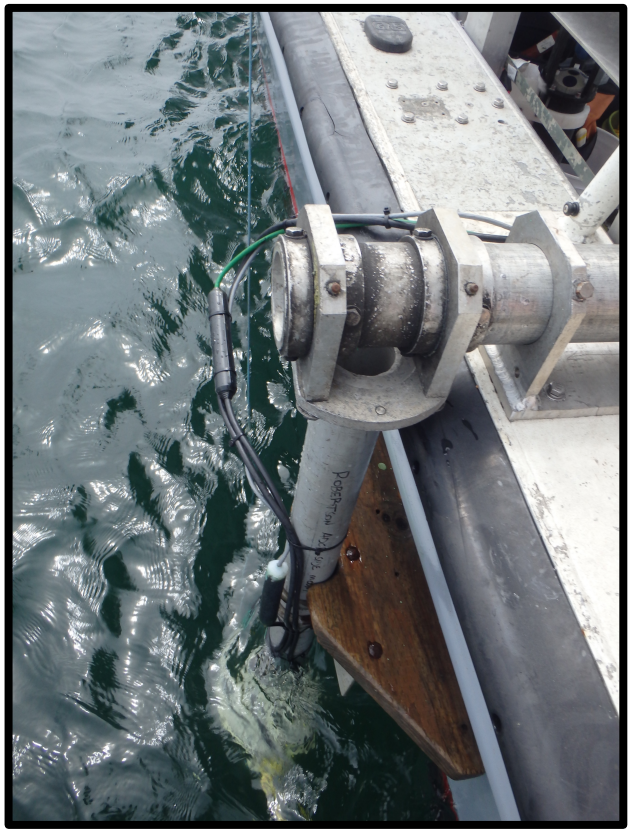


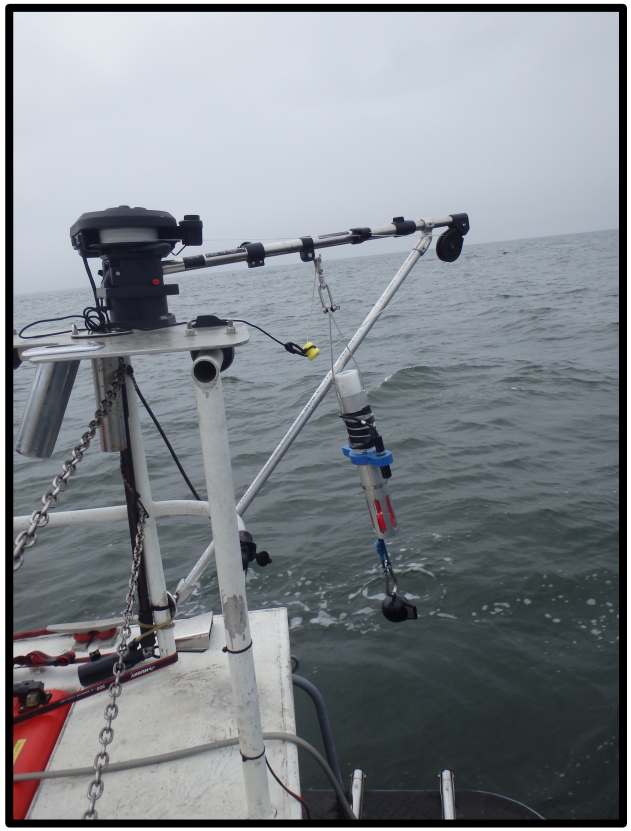
# Inner Shelf in situ observations

## Small boat surveying configuration

**RDI ADCP (w/optics)**



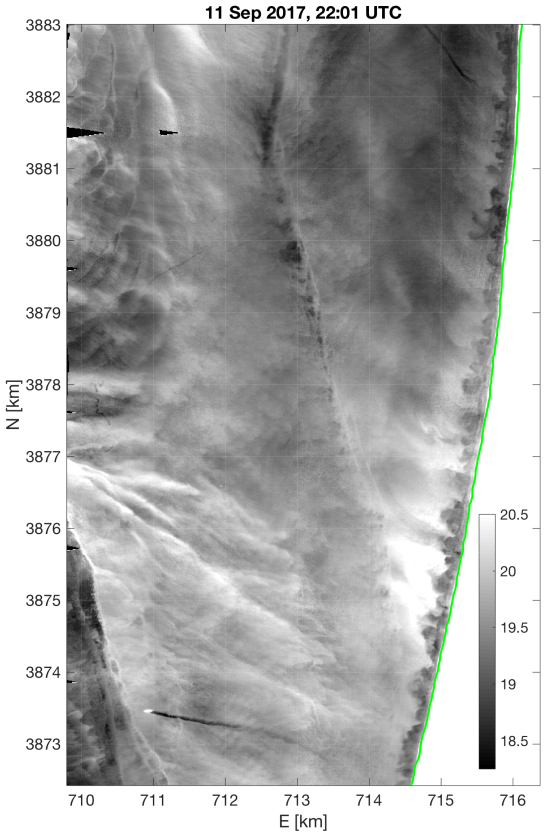
**Profiling RBR CTD (w/optics)**

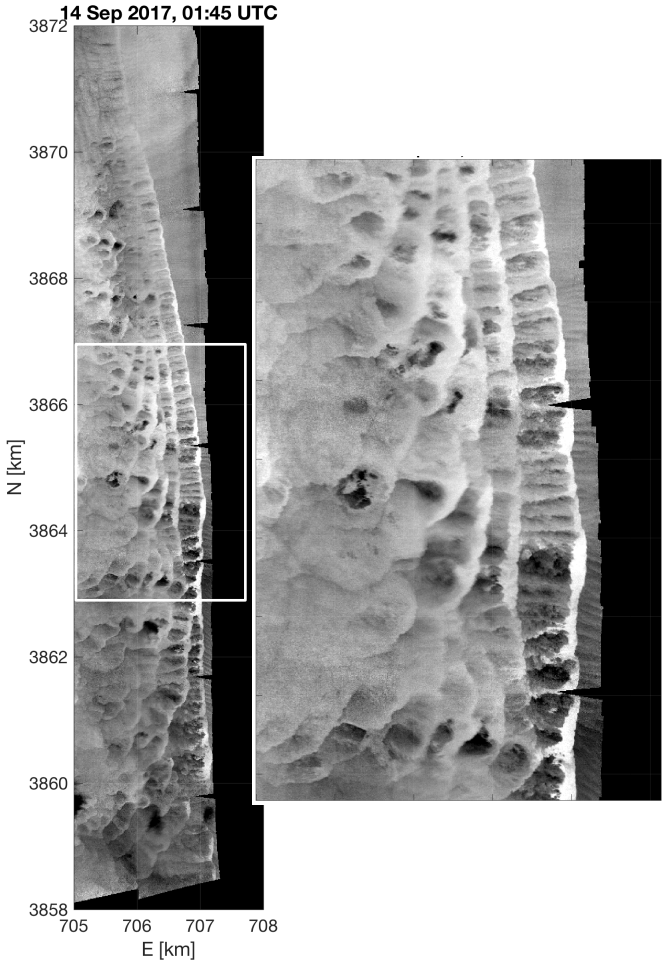


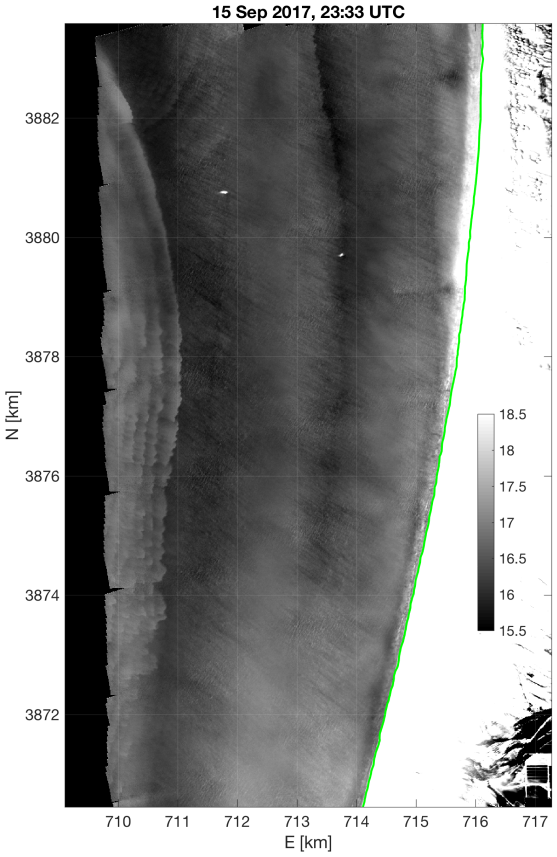
**KT15 radiometer (SST)**

# Inner Shelf SST observations

Sampled a wide range of internal waves/bores and surface fronts



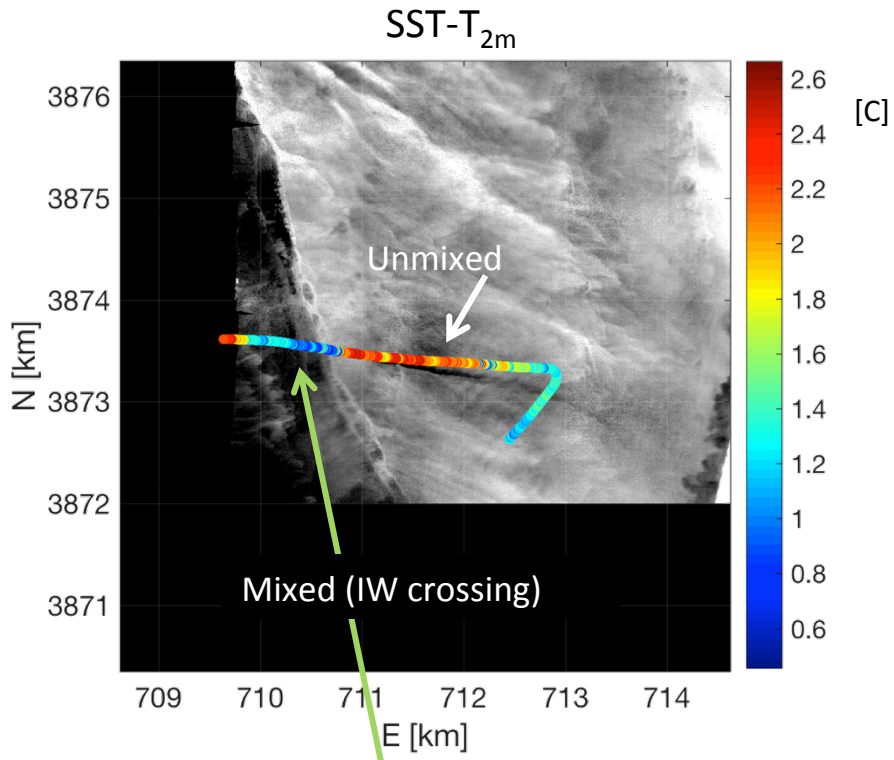



# Inner Shelf – internal waves, low winds

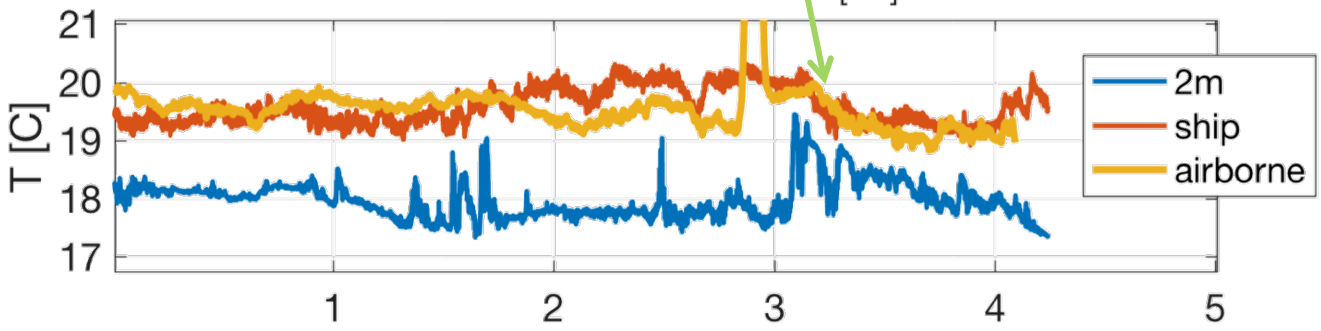
## SST under Low Winds

- WS 1-2 m/s and solar forcing
- Diurnal warm layer (2-3 m deep)
- Surface mixing by the IW packet
- SST is reversed from the in situ measurement
- Need understating of diurnal warming to interpret comparisons with modeling




Remotely sensed SST (ship, plane)

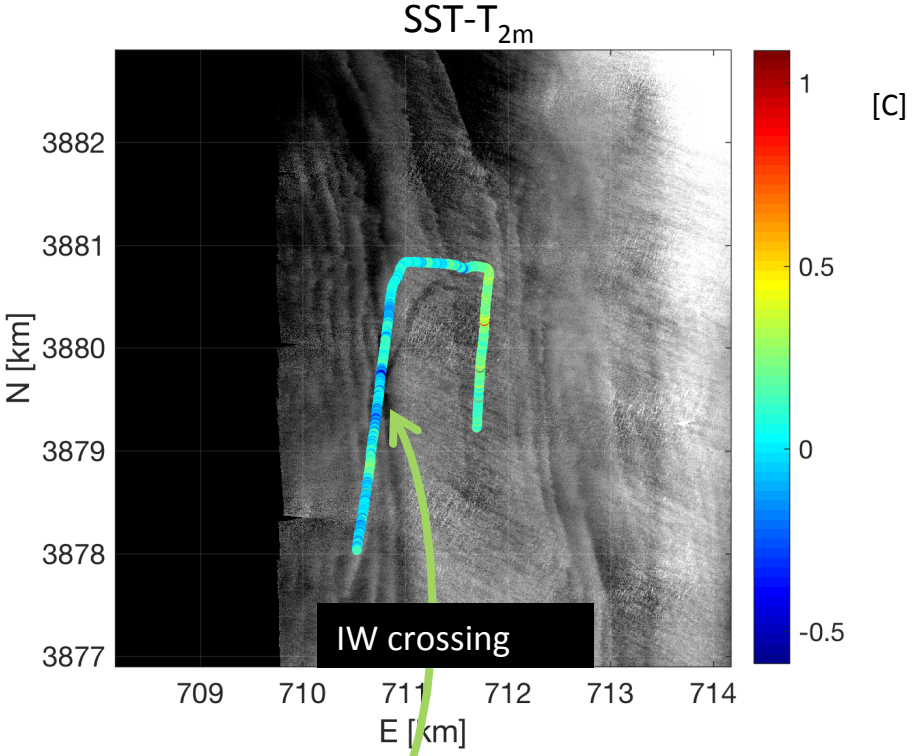
In situ (ship)



# Inner Shelf – internal waves, high winds

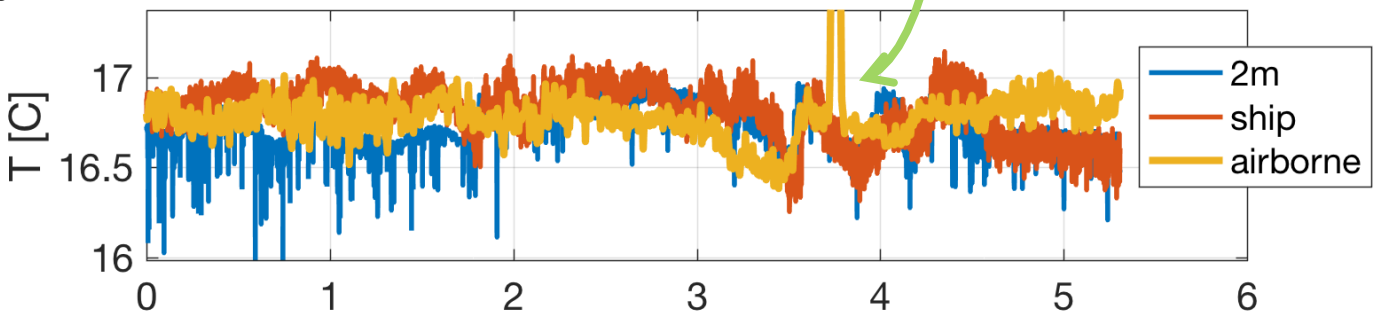
## SST under high winds

- WS 7 m/s
- Well mixed surface
- SST is consistent with the in situ measurement
- Need understating of diurnal warming to interpret comparisons with modeling



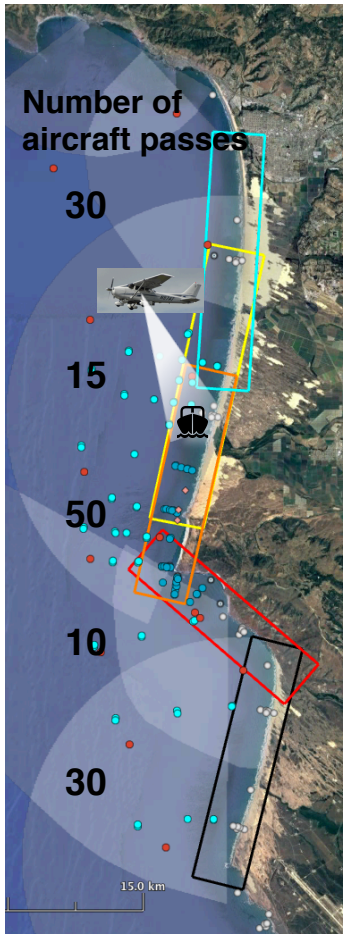

Remotely sensed SST (ship, plane)

In situ (ship)

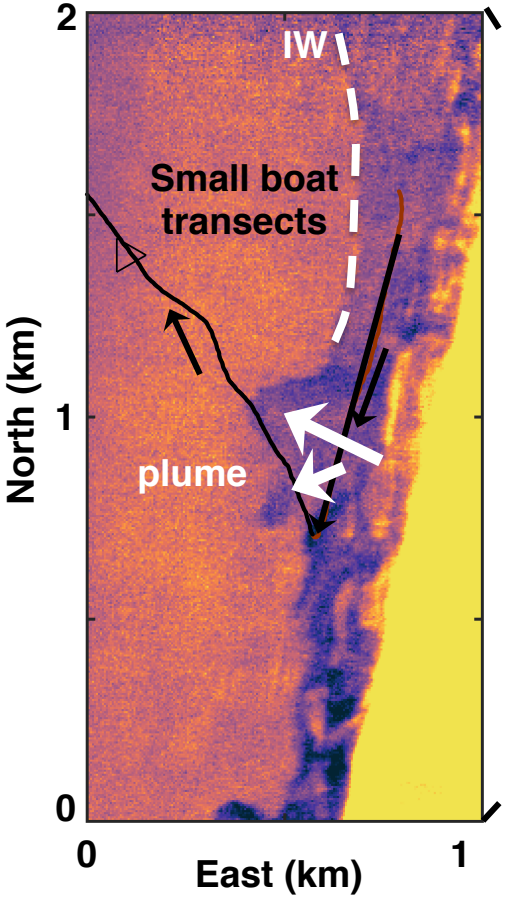


# Surfzone – Inner Shelf Exchange

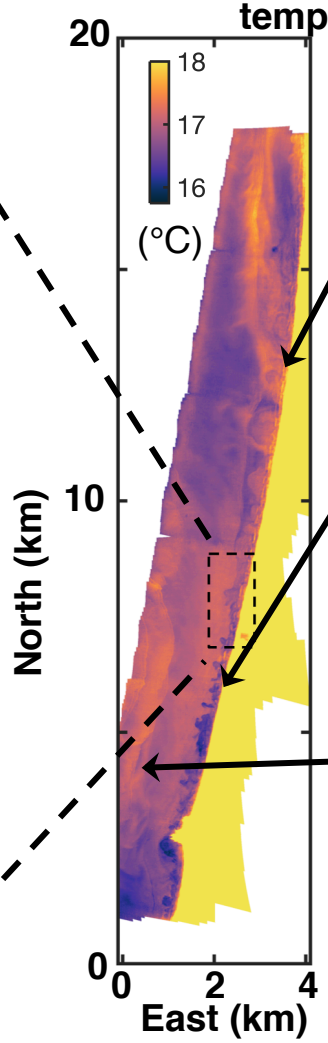
**Along-coast aircraft and in situ surveys**




**Slicing through a rip plume after an internal wave hit the surf zone**




**Modulation of exchange by stratification, surf temperature, and morphology**




Warm plumes
- Buoyant
- Thin in vertical
- Broad in horizontal
- Easily mixed away

Cold plumes
- Intermediate density
- Mid water-column exit
- Mix to full water column
- Sharp boundary

IW/fronts
- Depression vs elevation
- Vertical velocity structure
- Thermocline, diurnal layer