Modular Aerial Sensing System (MASS)

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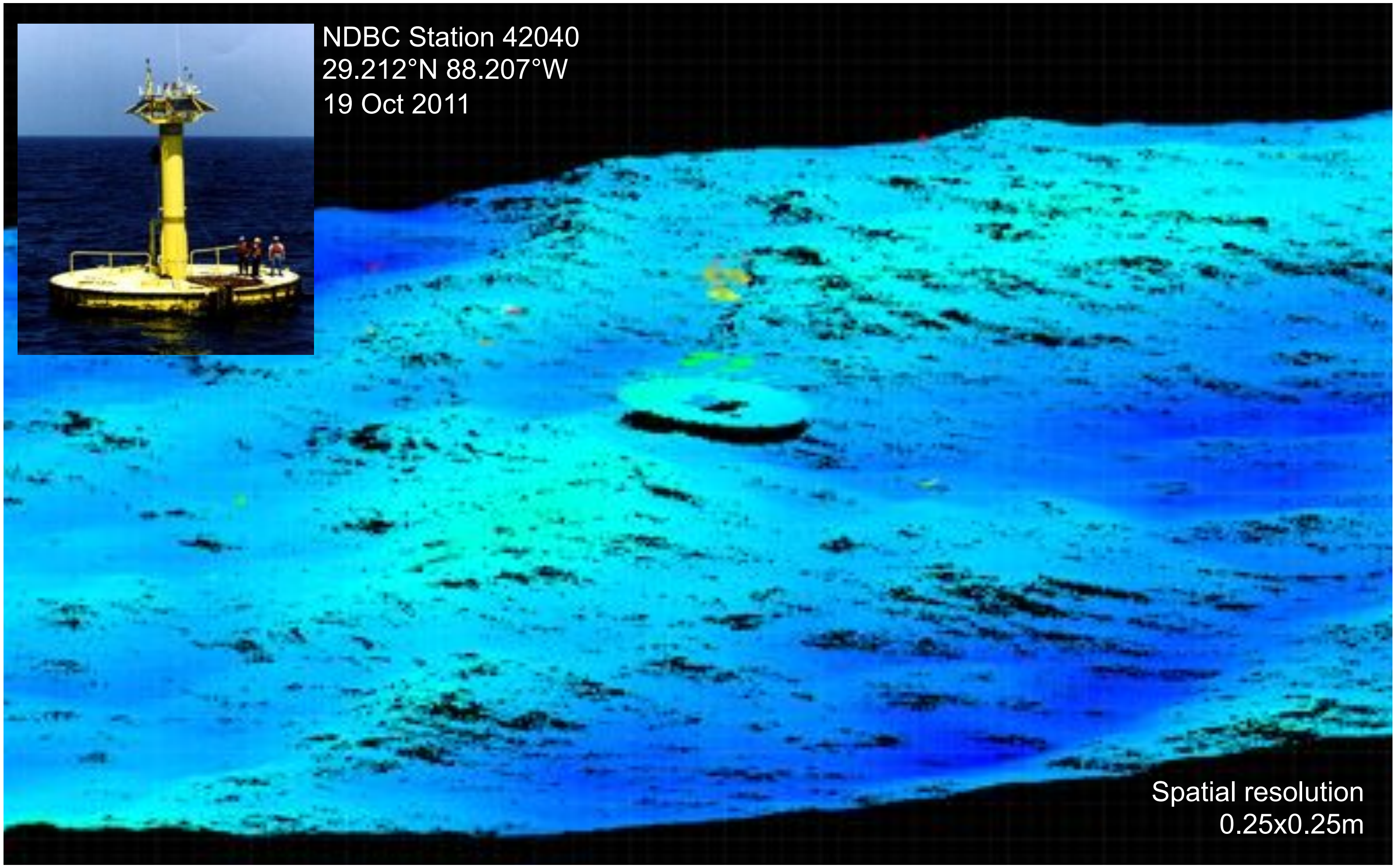
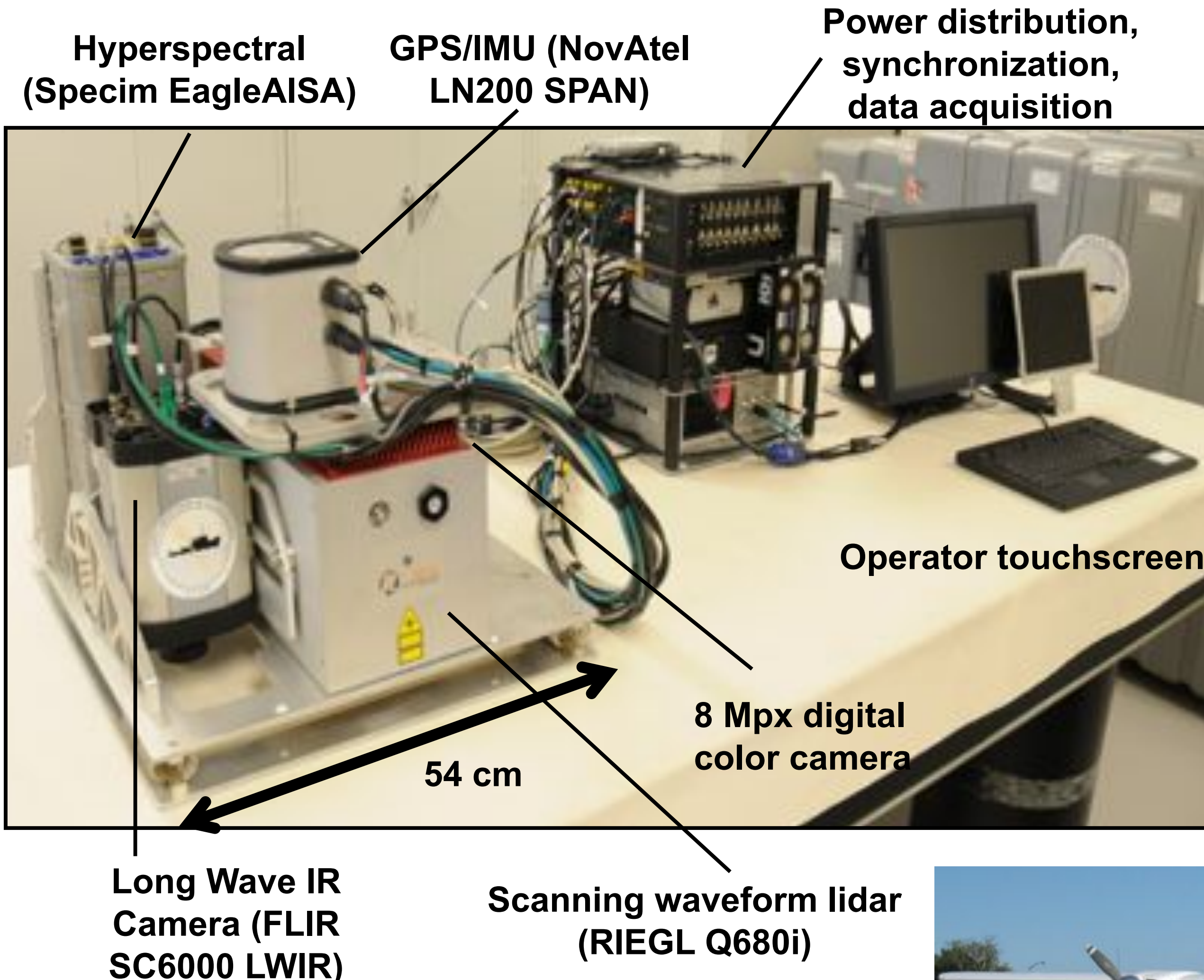
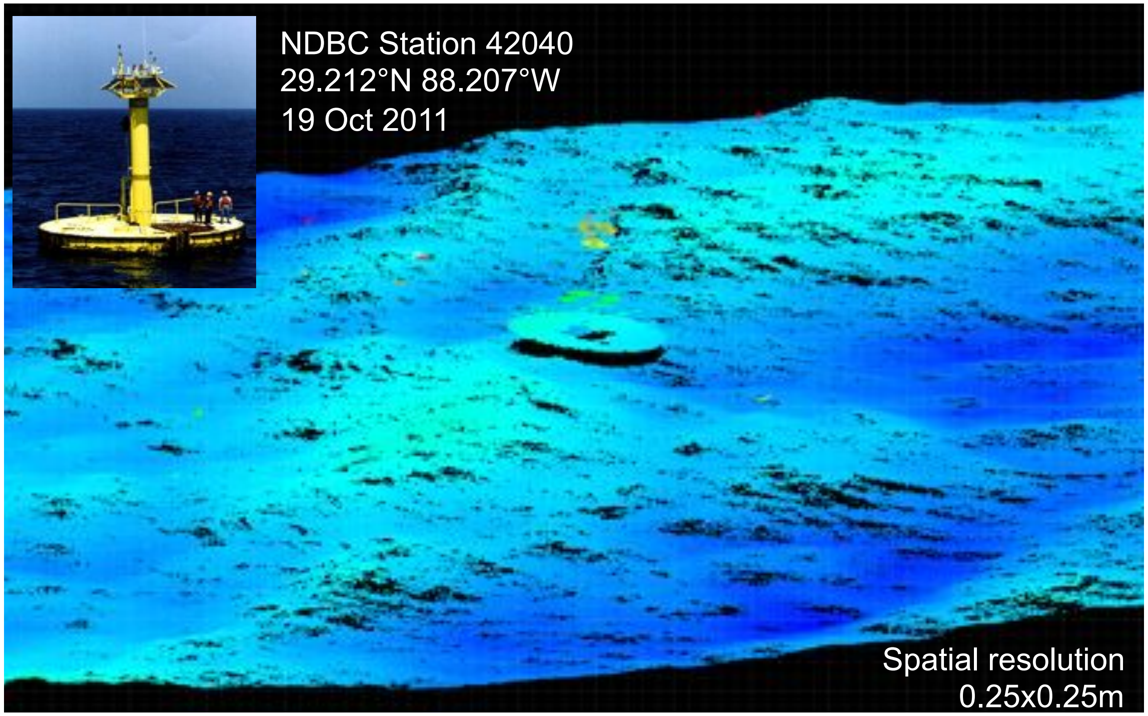


SIO Modular Aerial Sensing System (MASS) - NSF funded
Lightweight, aircraft independent (need belly hole)



Weight	120 kg total (including acquisition rack) 79 kg without hyperspectral
Power requirements	600 W total, 400 W without hyperspectral

SIO Modular Aerial Sensing System (MASS)

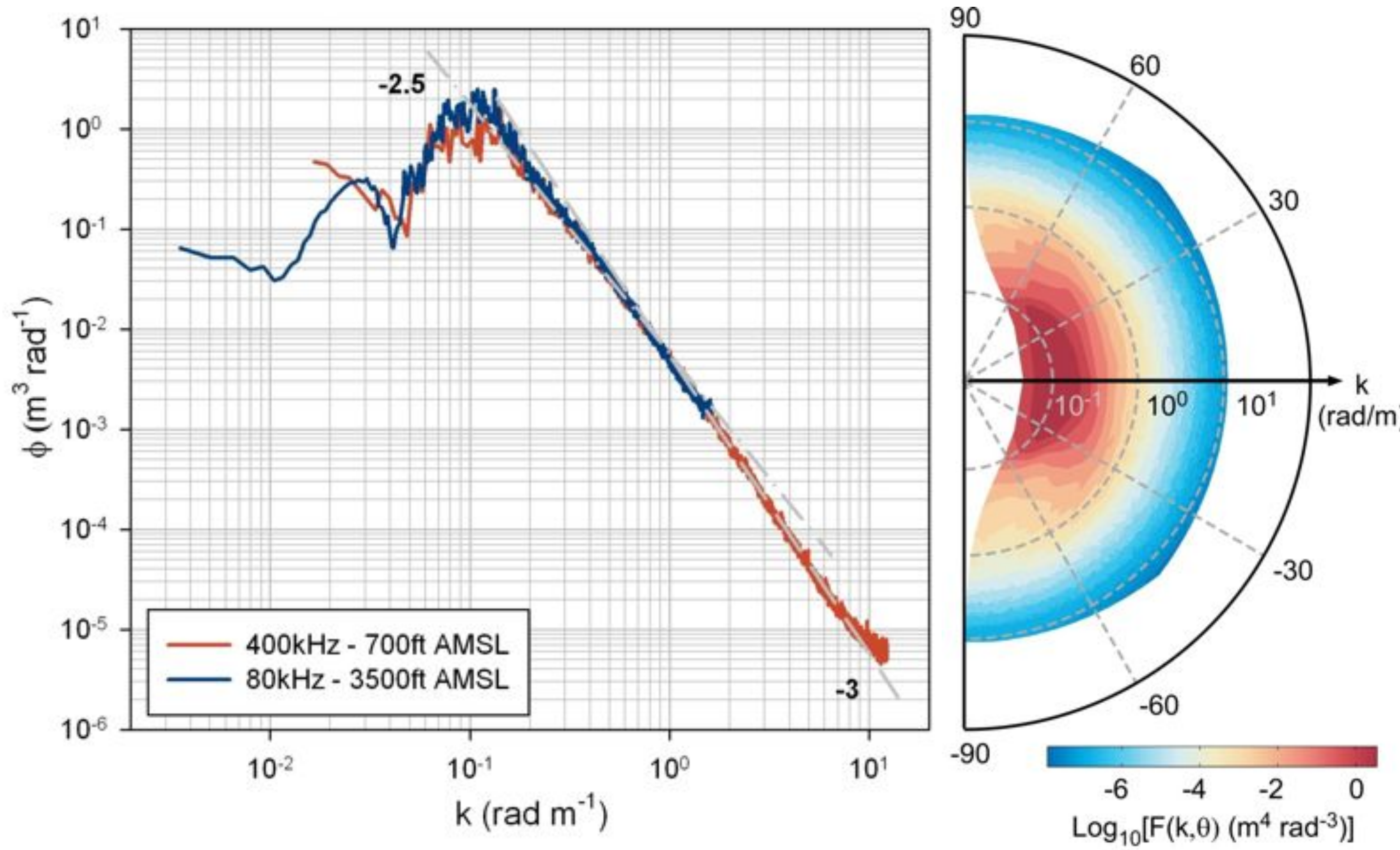


Example of surface elevation as measured from the MASS during a recent experiment in the Gulf of Mexico, flying above NDBC buoy #42040. (wind~12m/s, Hs = 3.1m)

Rapid processing capability

Instrumentation		Measurement
Scanning Waveform Lidar	Riegl Q680i	Surface wave, surface slope, directional wave spectra (vert. accuracy ~2-3cm)
Long-wave IR Camera	FLIR SC6000 (QWIP)	Ocean surface processes, wave kinematics and breaking, frontal processes
High-Resolution Video	JaiPulnix AB-800CL	Ocean surface processes, wave kinematics and breaking, frontal processes
Hyperspectral Camera	Specim EagleAISA	Ocean surface and biogeochemical processes
GPS/IMU Novatel SPAN-LN200		Georeferencing, trajectory

MASS - Wave Directional Observations down to wavelengths of 0.8m

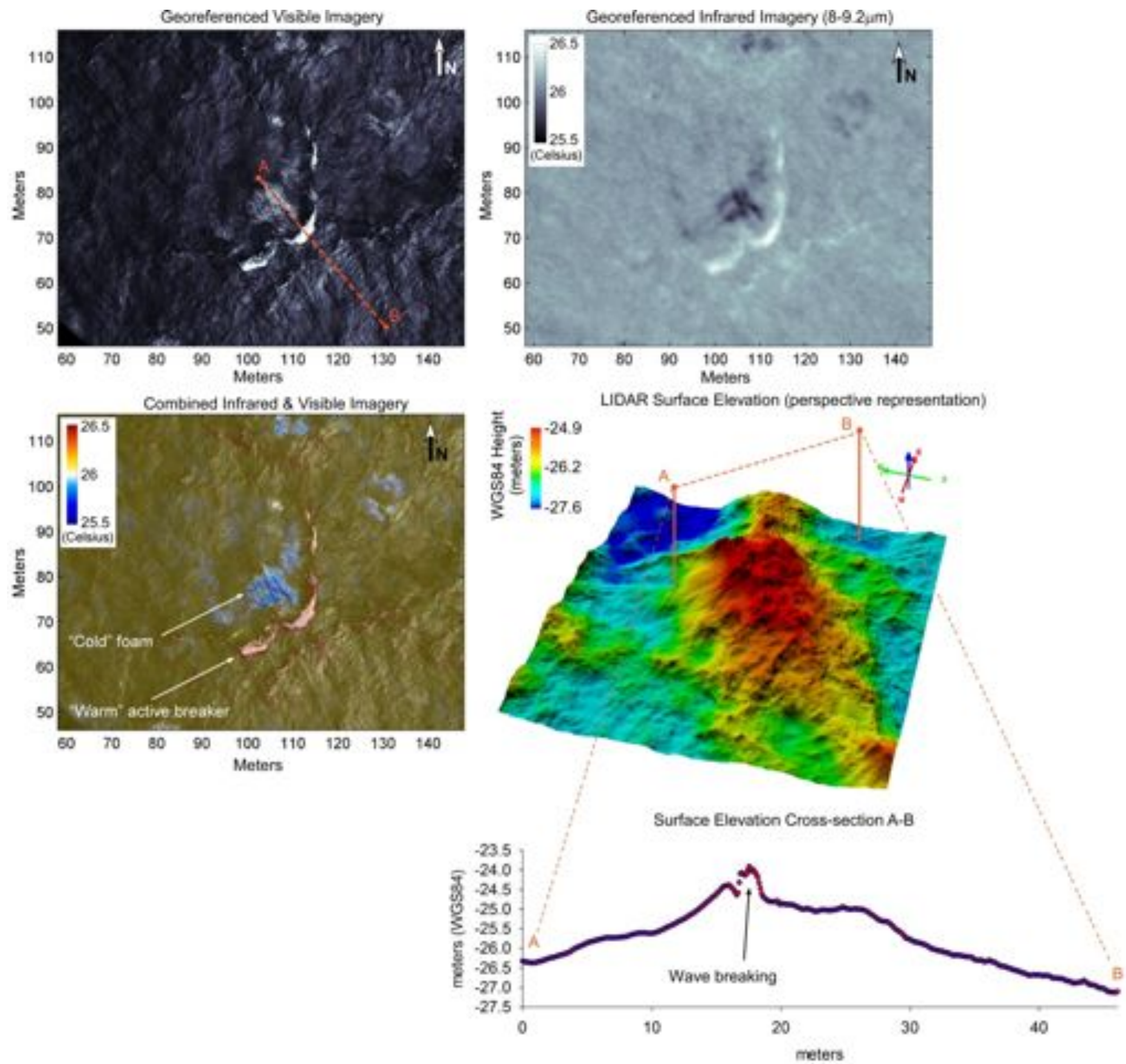


(left) Omnidirectional wavenumber spectra for two passes flown at two different altitudes: 1100 m AMSL in blue, swath width 800 – 1000 m, spatial resolution of 1.2 m; 200 m AMSL in red 200 m swath, 12 – 25 cm spatial resolution from sea surface topography data recorded using the MASS on 4 Aug 2011 in the Santa Barbara Channel. These data give spectra down to wavelengths of 0.8 – 0.9 m, with directional resolution there of 0.2°, and 3.6° at the peak of the spectrum, λ = 64 m. Note -5/2 and -3 spectral slopes. (right) Directional spectrum from the sea surface topography recorded at 200m AMSL.

MASS - High-Resolution Measurements of Breaking Waves (IR & Visible)

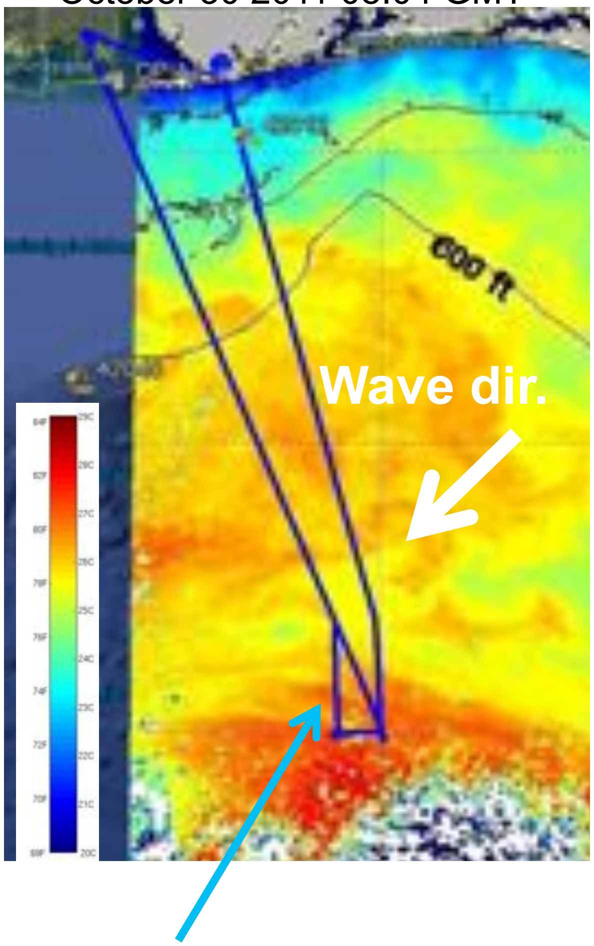
Sample georeferenced images of a breaking wave in the visible and infrared (8-9.2µm) bands during a recent experiment in the Gulf of Mexico. Note that the foam is colder (blue) due to rapid cooling ($T_{water} - T_{atm} \approx 8°C$) while the active breaker is warmer (red), disrupting the surface skin layer and bringing warmer water from below.

Also shown is a perspective view of the sea surface elevation for the same breaking wave color coded for WGS84 height (World Geodetic System 1984 datum). The lower panel shows the profile of the transect A-B marked in the georeferenced visible image.

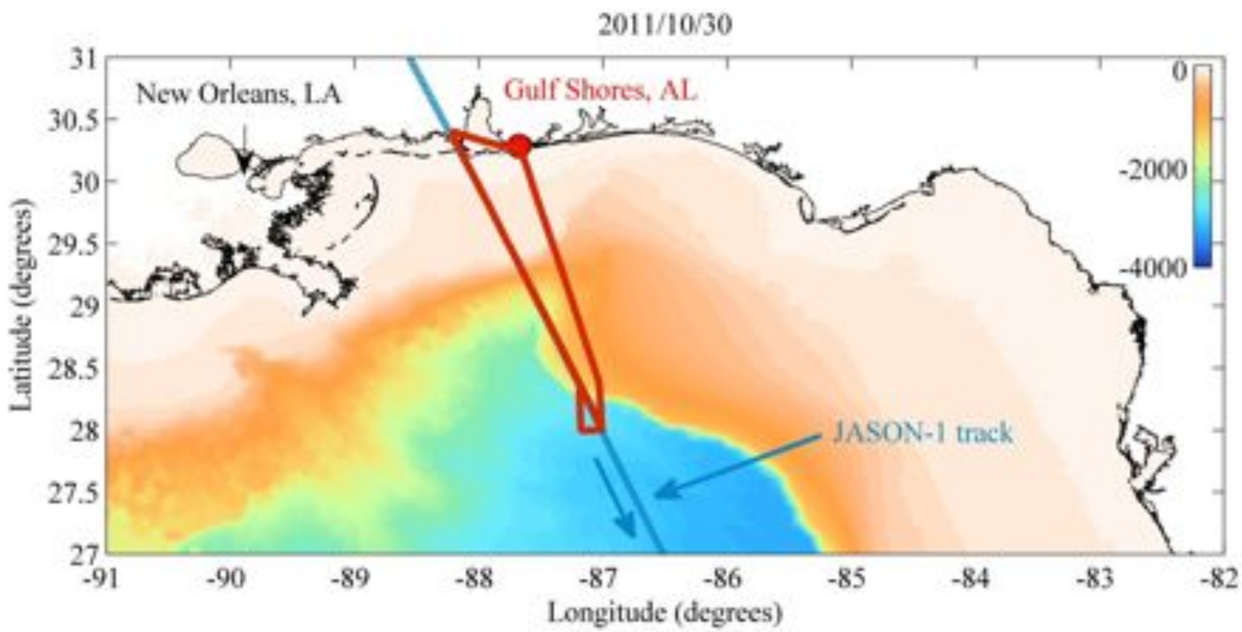


The Gulf of Mexico Experiment – October 2011
Coincident MASS flight and Jason-I satellite overpass

AVHRR NOAA-19
October 30 2011 08:04 GMT



Flight track on 2011/10/30
Enhanced breaking & SST front

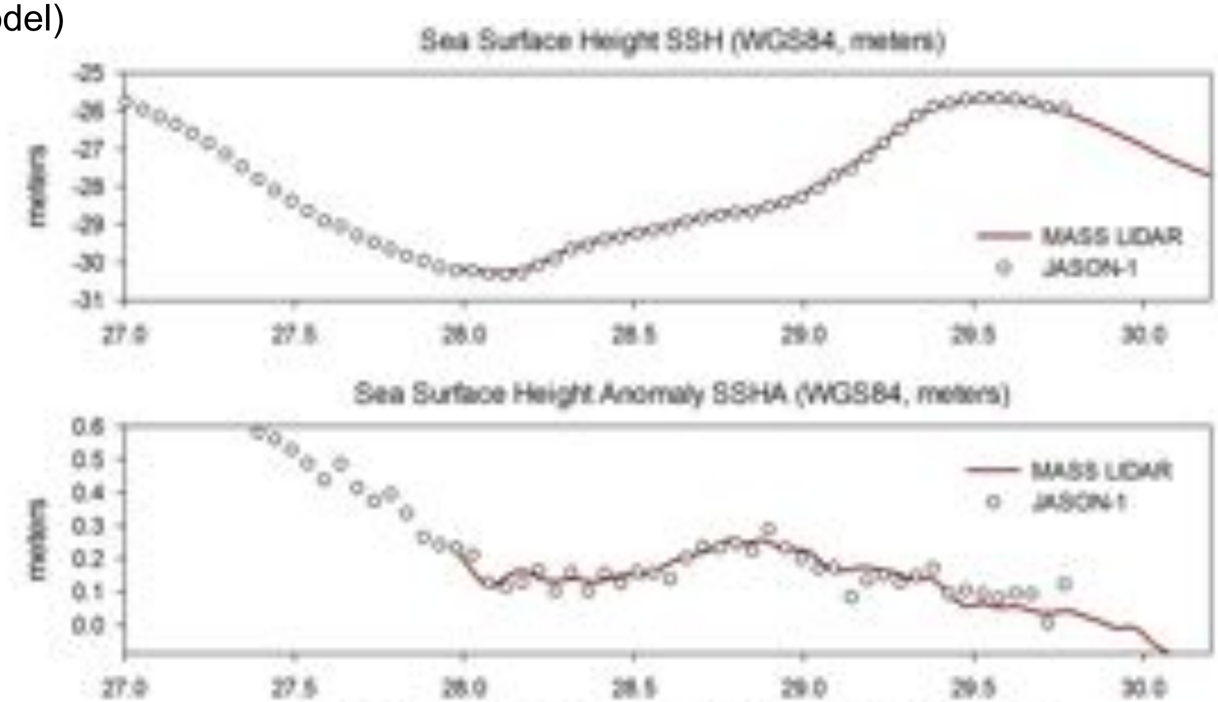


SSHA from Airborne and Satellite Altimetry

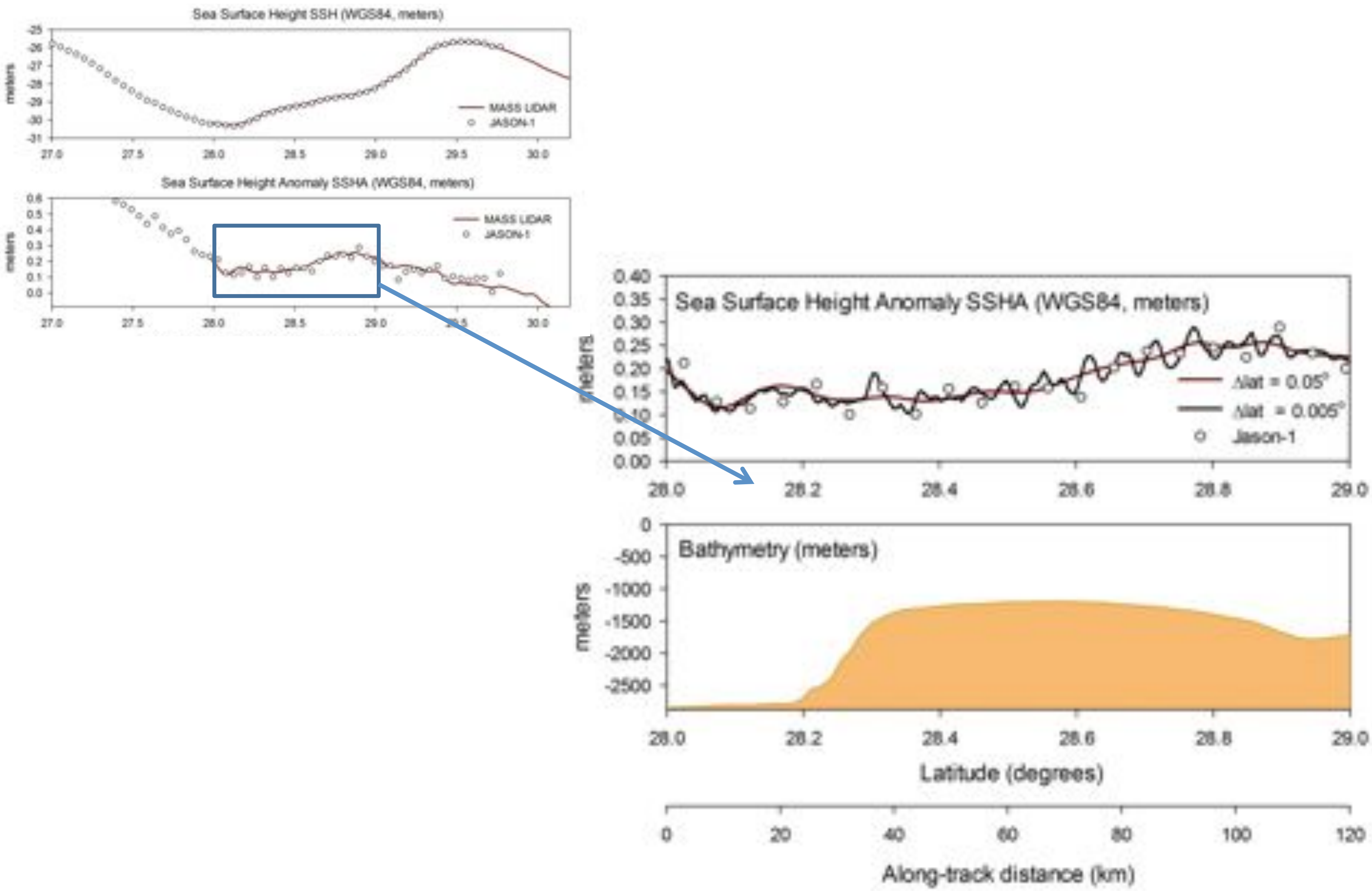
$$ssha_{lidar} = ssh_{lidar} - mean\_sea\_surface_{Satellite}$$

$$-ocean\_tides - Tidal\_loading - solid\_earth\_tides - pole\_tide$$

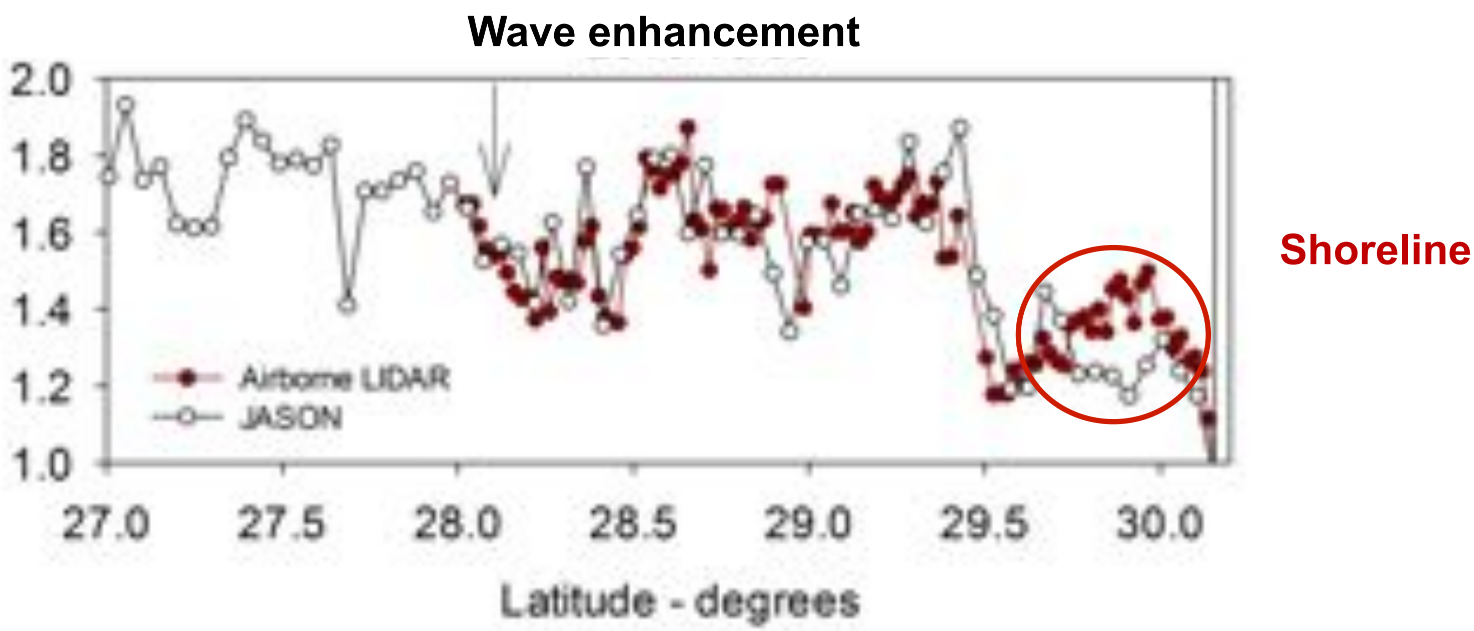
Ocean tides: Corrections for solid earth and sea surface height variations due to the attraction of the Sun and Moon (FES2004 model)
Solid earth tides: Corrections for solid earth variations due to the attraction of the Sun and Moon (McCarthy and Petit, IERS Conventions 2003)
Pole tides: Corrections for variations due to the attraction of the Sun and Moon.
Tidal loading: Corrections for height variations due to changes in tide-induced forces acting on the Earth's surface (FES2004 model)



High-Resolution SSHA from Airborne Altimetry

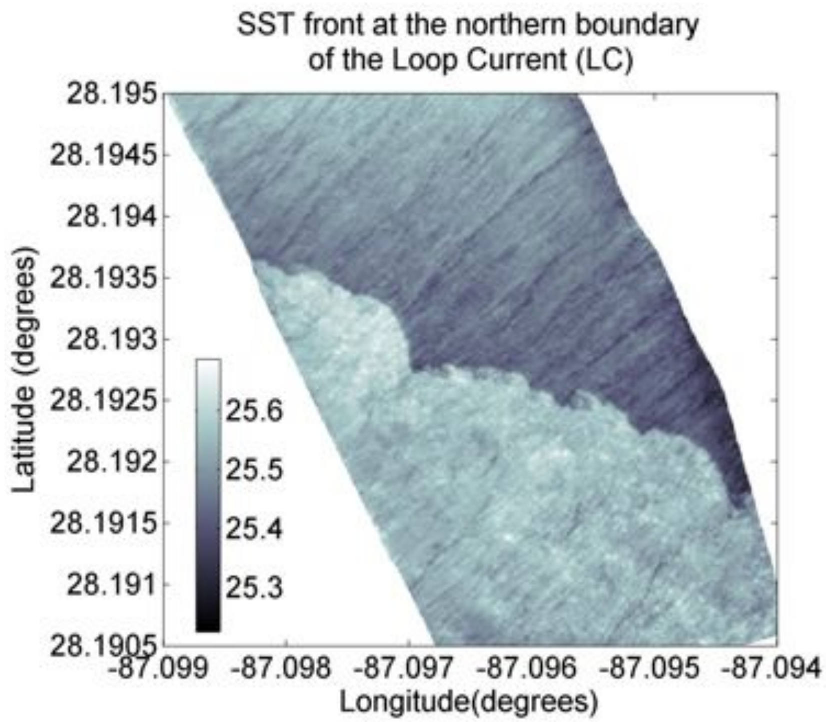


SWH from Airborne and Satellite Altimetry



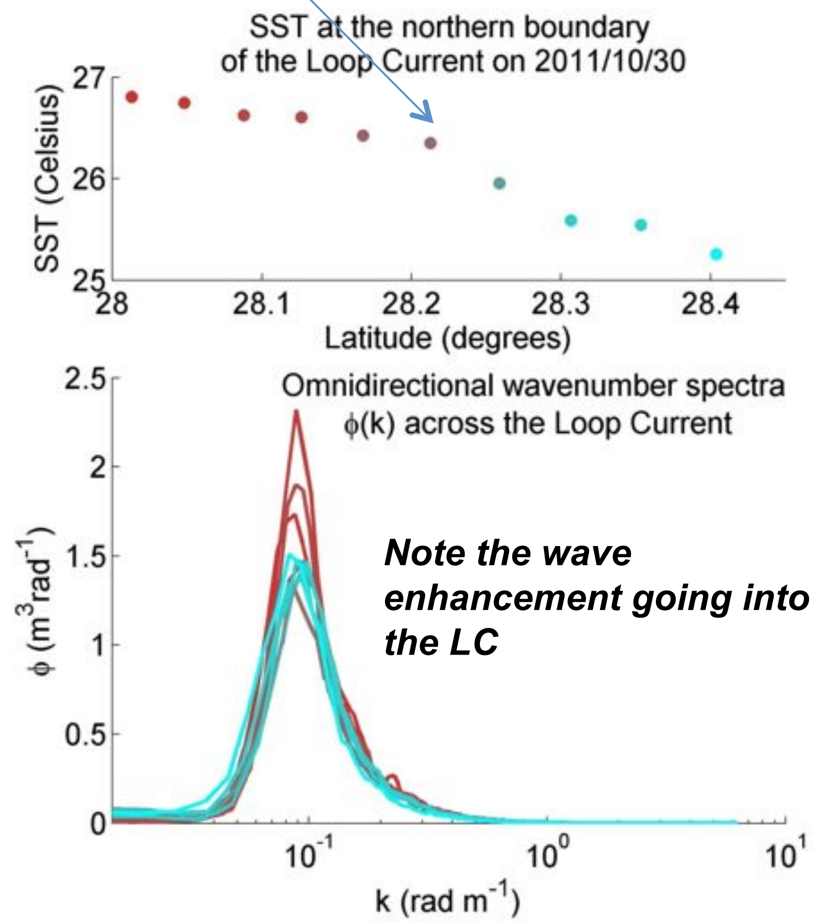
Significant Wave Height (SWH) measured by the MASS Lidar and Jason-I satellite altimeter. Note the divergence between the airborne and satellite measurements closer to shore.

Wave Enhancement at SST Front

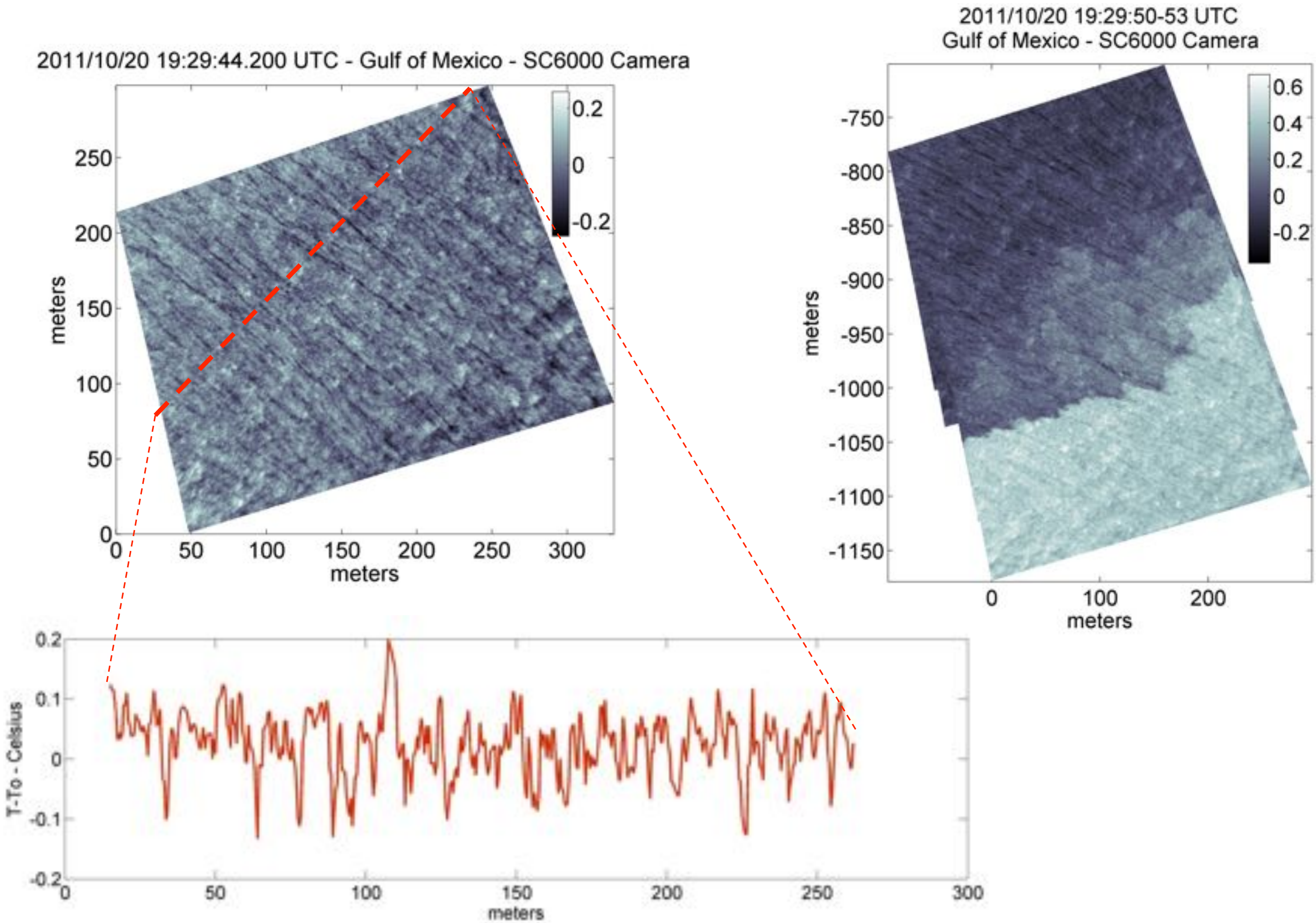


(left) Sea surface temperature imagery of the northern edge of the Gulf of Mexico Loop Current on October 30 2011. (right) Evolution of the omnidirectional wavenumber spectrum as the aircraft flew across the Loop Current . The color scale represents the average SST over the length of the wave record (4 km) used in the spectral analysis, also shown as a function of latitude in the upper panel.

Northern edge
of the LC



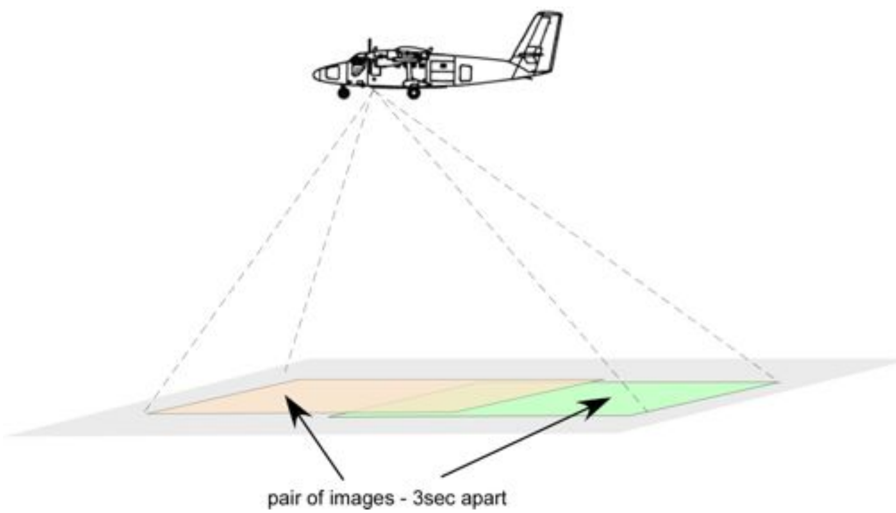
Measurements of Langmuir Cells using the Infrared camera

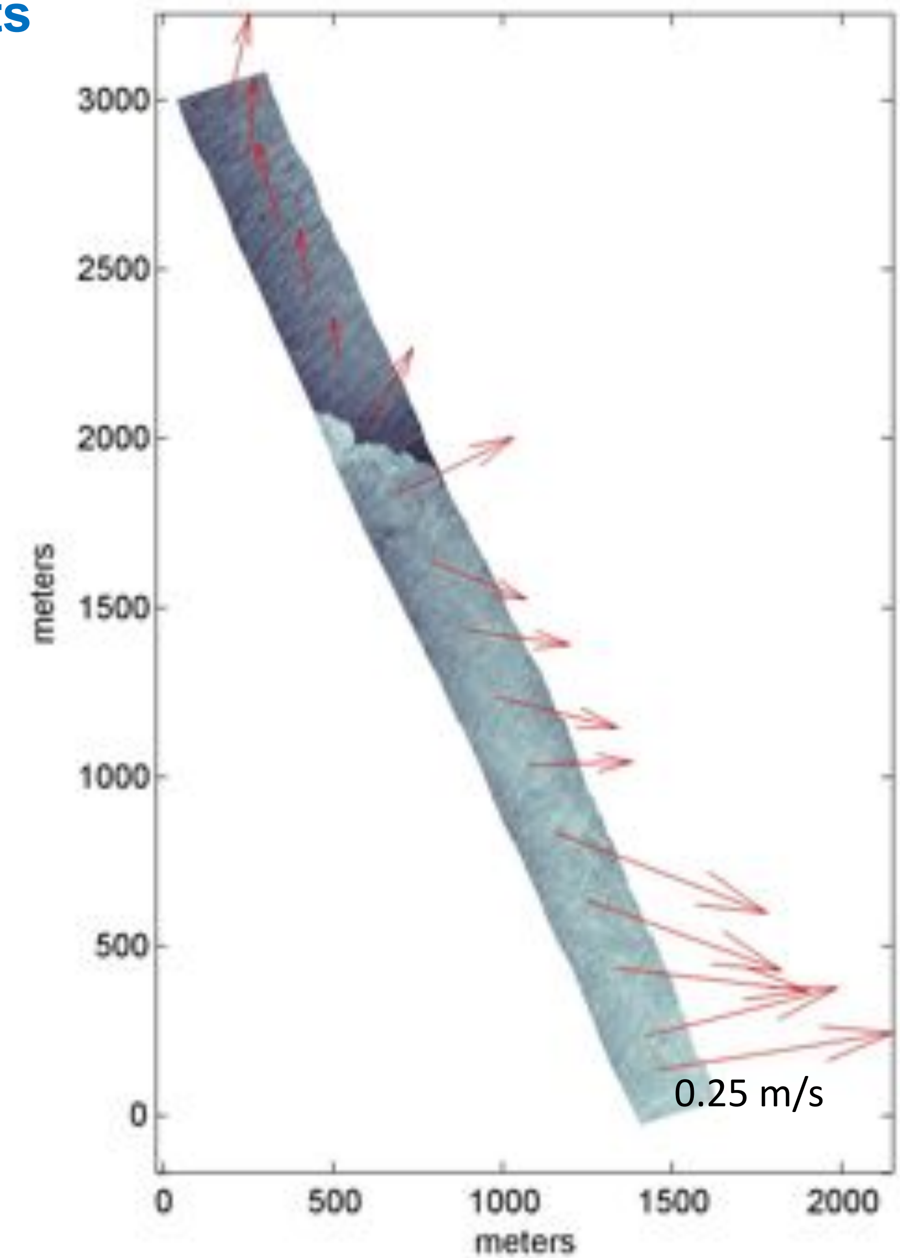


Fs = 50Hz – QWIP sensor

Tracking temperature structure patterns at the ocean surface to estimate surface currents (through Optical Flow techniques)

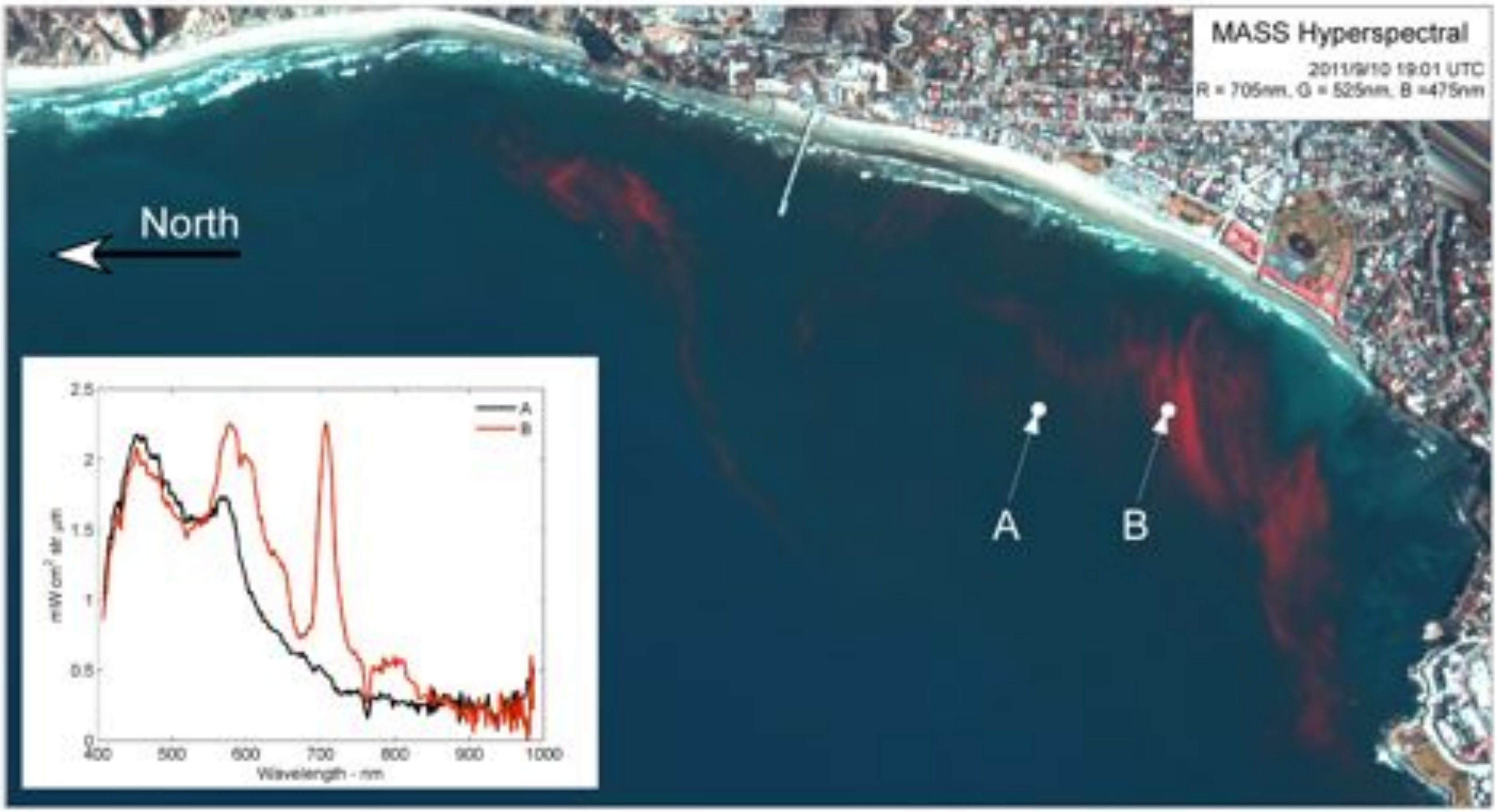
dt ~ 3-4sec (700ft)





Velocities averaged over 200m, 3sec

Georeferenced hyperspectral imagery recorded by the MASS during a red tide – Dinoflagellate - bloom off La Jolla Shores in September 2011.



Spectrally calibrated wavenumber spectra at location A & B are shown in the insert, highlighting the spectral response of the dinoflagellates.

Summary & future work

Over the past two years, we have integrated a novel, portable, high-resolution airborne topographic lidar with video and hyperspectral imaging systems.

The scanning waveform lidar is coupled to a highly accurate GPS/inertial measurement unit permitting airborne measurements of the sea surface elevation and whitecap coverage with swath widths of up to 800 m under the aircraft track over water, and horizontal spatial resolution as low as 0.2 m.

the process of setting up a recharge facility to make this capability available to the broader Community

Two ONR-funded projects in September and November 2013 (total ~100 flight hours)

SPAWAR-funded projected, by end of 2013 (San Clemente island, ~30 flight hours)