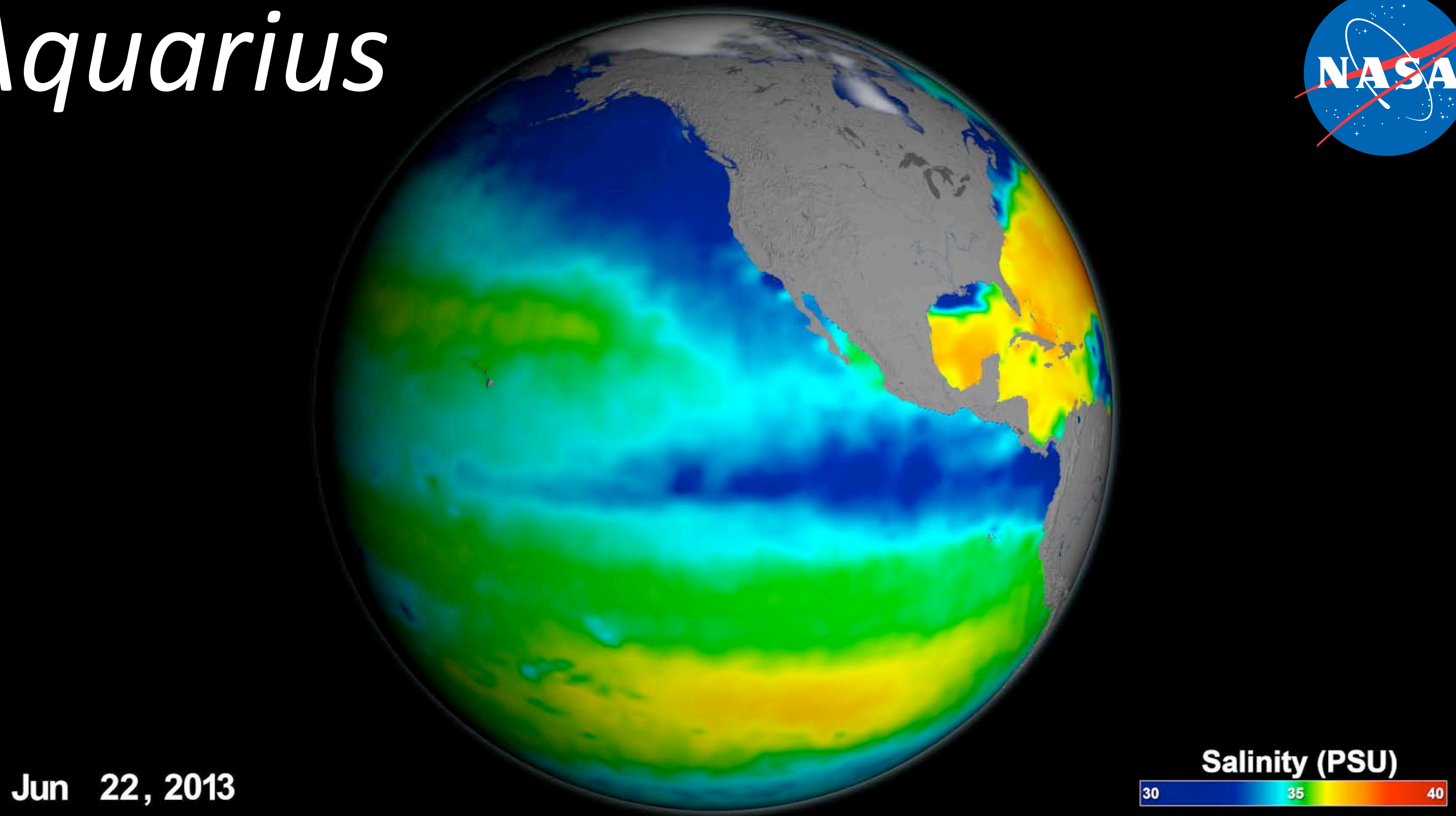
Early Results from SPURS-2

Luc Rainville (APL-UW)

Craig Lee, Kyla Drushka, Charlie Eriksen
Tom Farrar
Andrey Shcherbina
Elizabeth Thompson
Luca Centurioni, Verena Hormann
Ben Hodges, Ray Schmitt
and the SPURS PIs

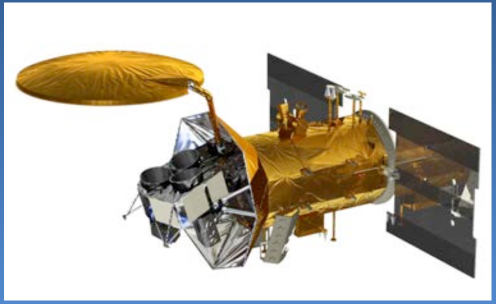
Aquarius



NASA's Goddard Space Flight Center Scientific Visualization Studio

First space-based global observations of ocean surface salinity.
25 August 2011 through 7 June 2015

Currently, global salinity is retrieved from SMAP measurements



What are the physical processes responsible controlling the upper ocean salinity balance: air-sea interactions, mixing, oceanic transport, etc.

SPURS programs involve coordinated field work, numerical models, and remote-sensing:

Towed Surface Salinity Profiler, Asher et al., UW
SPURS Data Management System, Bingham et al., UNC
Multi-scale Modeling and Data Assimilation, Chao et al., RSS
Near-surface Turbulence: Lagrangian Floats, D'Asaro et al., UW
Toward a Salinity Budget (flux mooring), Farrar et al., WHOI
Multiscale Autonomous Surveys, Fratantoni et al., WHOI
Characteristics SSS Fluctuations, Gordon et al., LDEO
Upper Ocean Salinity from Glider Surveys, Lee et al., UW
Multi-Scale Modeling and Data Assimilation, Li et al., JPL
Measurements of T, S, Wind Speed, and Rainfall (floats), Riser et al., UW

Microstructure and Mixing, Schmitt et al., WHOI (NSF)
SSS Drifters for SPURS, Centurioni et al., SIO (NOAA)
Prawler Mooring, Kessler et al., NOAA/PMEL (NOAA)
Sustained Ocean Observations, Goni et al., NOAA/AOML (NOAA).

Lagrangian Floats: Shcherbina, D'Asaro, Harcourt, Maximenko
Wave Gliders: Hodges, Schmitt
Towed Surface Salinity Profiler: Asher, Jessup, Drushka
Surface meteorology: Clayson, Edson
Data management: Bingham, Li, Li
Hydrography: Sprintall
Sea snake: Schanze
Surface drifters: Centurioni, Chao, Maximenko
Seagliders: Rainville, Eriksen, Drushka, Lee
Argo floats: Riser, Yang
Mooring: Farrar, Plueddemann, Edson, Zhang, Yang, Kessler
Modeling: Li, Bingham, Li

PICO moorings: Kessler (NOAA)
Rain lenses: Drushka, Asher, Jessup, Rainville (NSF)

SPURS - 2

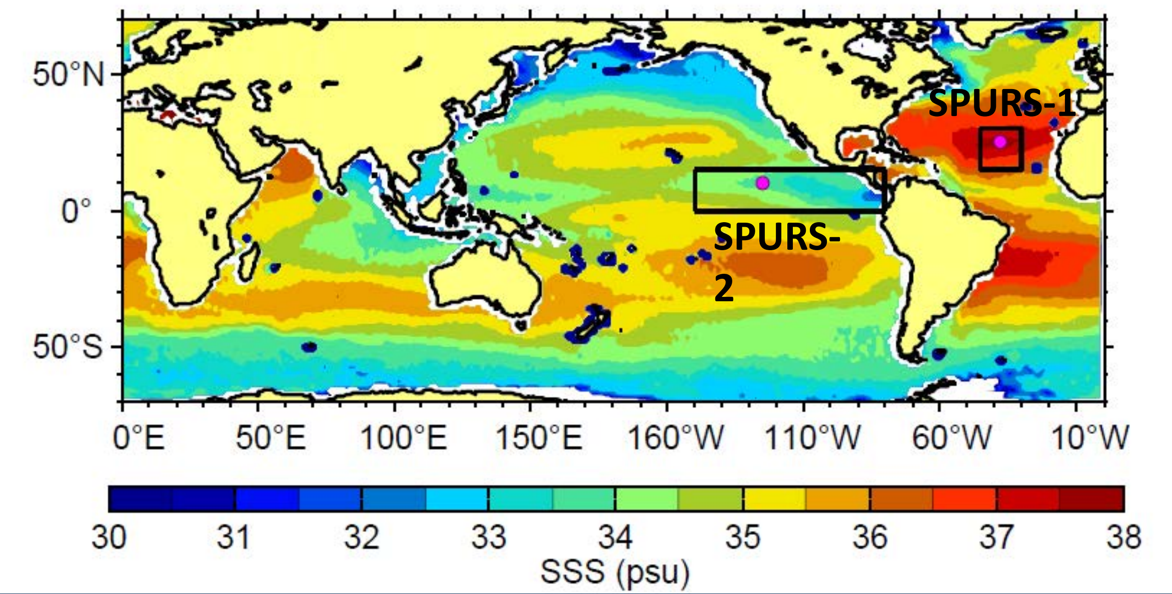
Salinity Processes in the Upper Ocean Regional Study

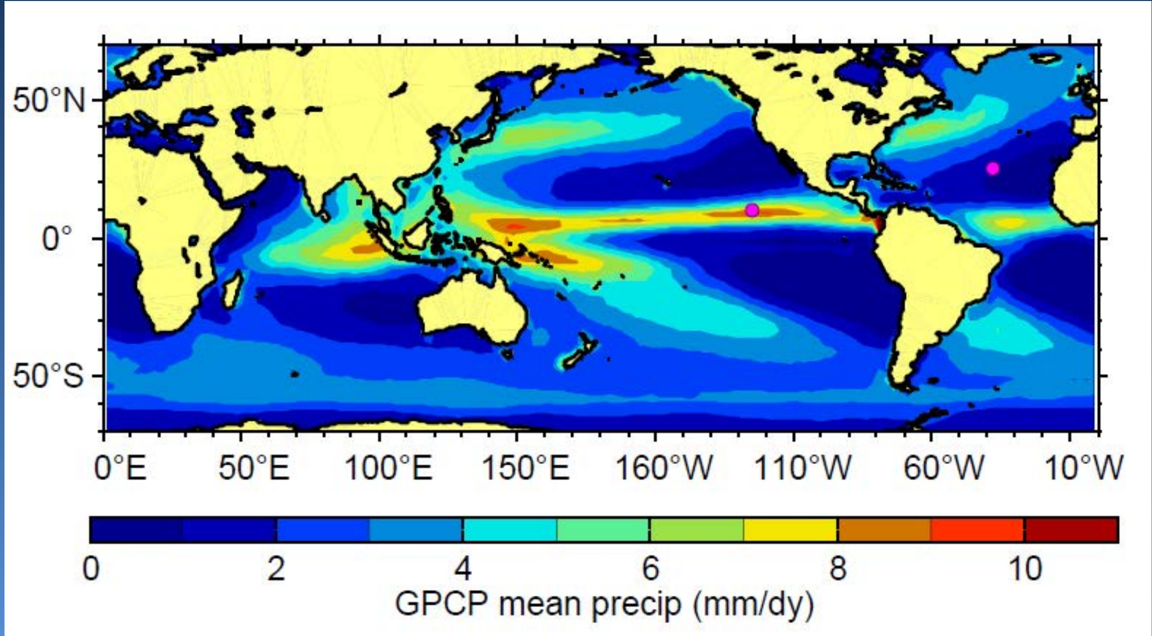
What governs the structure and variability of upper-ocean salinity near the ITCZ?

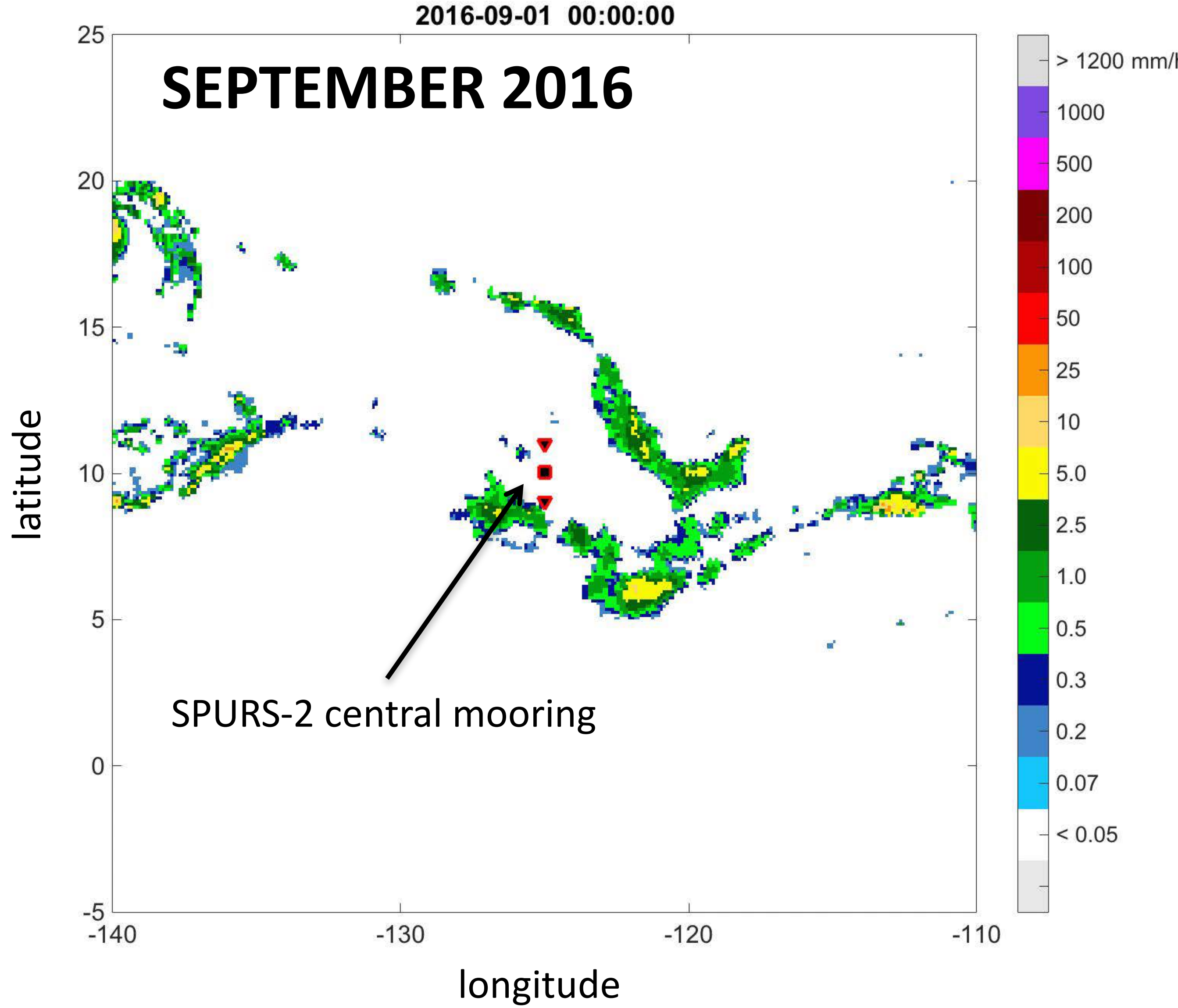
Where does the fresh water go, and how does the ocean distribute it from the small scales of the input (clouds) to the regional scale of the east Pacific fresh pool?

What local and non-local effect does the freshwater flux have on the ocean?

How does ocean salinity feedback on the atmosphere?







Rain is patchy
Rain is episodic
Rain is intense

GPM IMERG rain rate

30 min
0.1° grid spacing

Data compiled by E. Thompson, APL

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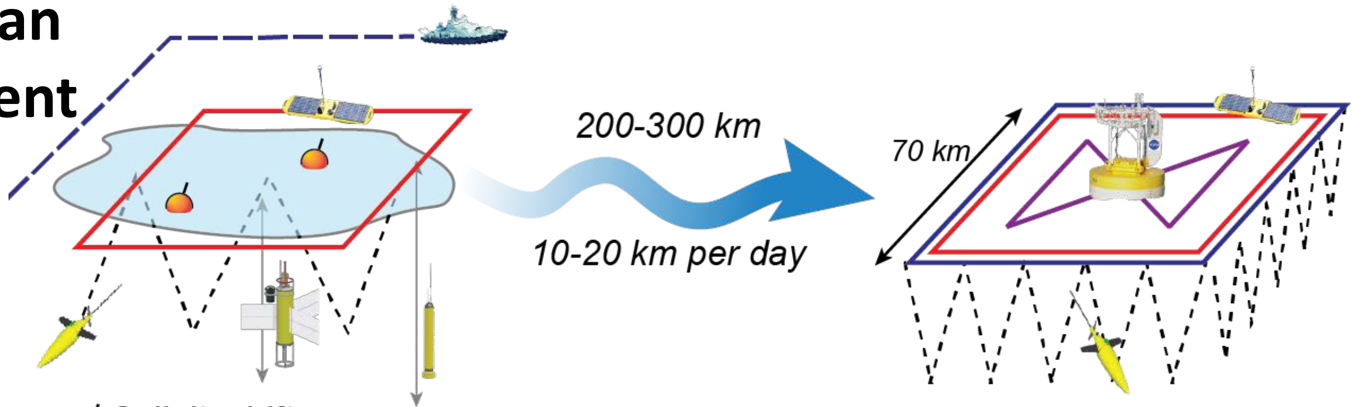
Salinity Processes in the Upper Ocean Regional Study

Lagrangian component

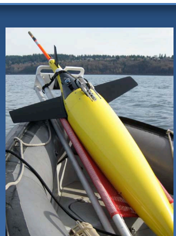
Eulerian component

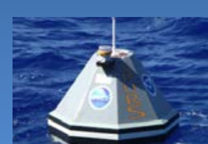


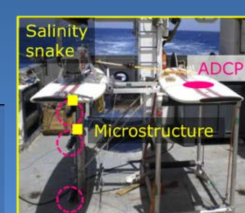
Salinity drifters
Lagrangian float (MLF)
Profiling (APEX) floats
Seaglider*
Waveglider*
Shipboard/SSP surveys

* return to mooring after ~2 weeks

Moorings
Seagliders
Wavegliders







Use of schooner *Lady Amber* for SPURS-2

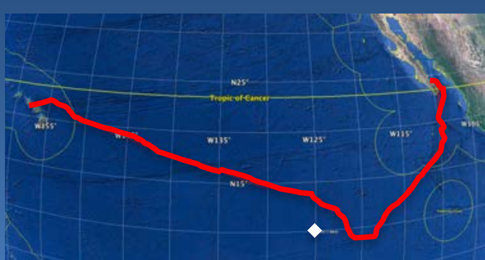
A novel and flexible observational approach, motivated by a need to capture the highly dynamical oceanic circulation at the isolated SPURS-2 site.

April 2016 to December 2017

9 cruises, every 2 months for 1.5 years.

- Deploy surface drifters and floats every 2 months,
- Recover, service, and redeploy autonomous instruments (Wave Gliders, Seagliders, MLF, etc.)
- Near-surface and atmospheric measurements during regular visits to the site.

1st cruise:
9 Jun – 5 Jul 2016

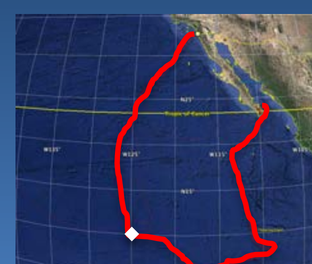


- Deployed 15 surface drifters

2nd cruise:
29 Aug – 25 Oct 2016

- Deploy 15 surface drifters
- Serviced Wave Glider
- Underway sampling (T,S, atmos.)

3rd cruise:
1 Dec 2016 – 15 Jan 2017



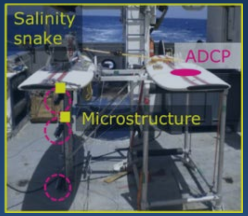
- Deployed 15 surface drifters
- Recovered Mixed Layer Lagrangian Float
- Recovered 2 Wave Gliders, deployed one.
- Underway sampling (T,S, atmosphere)

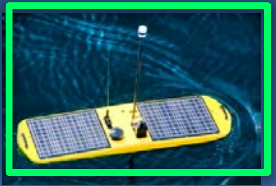
4th cruise:
????

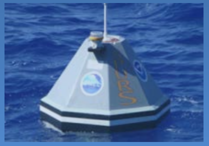
- **Recover 3 Seagliders**
- **Deploy 3 Seagliders**
- Deploy 15 surface drifters
- Deploy MLF
- Service Wave Gliders

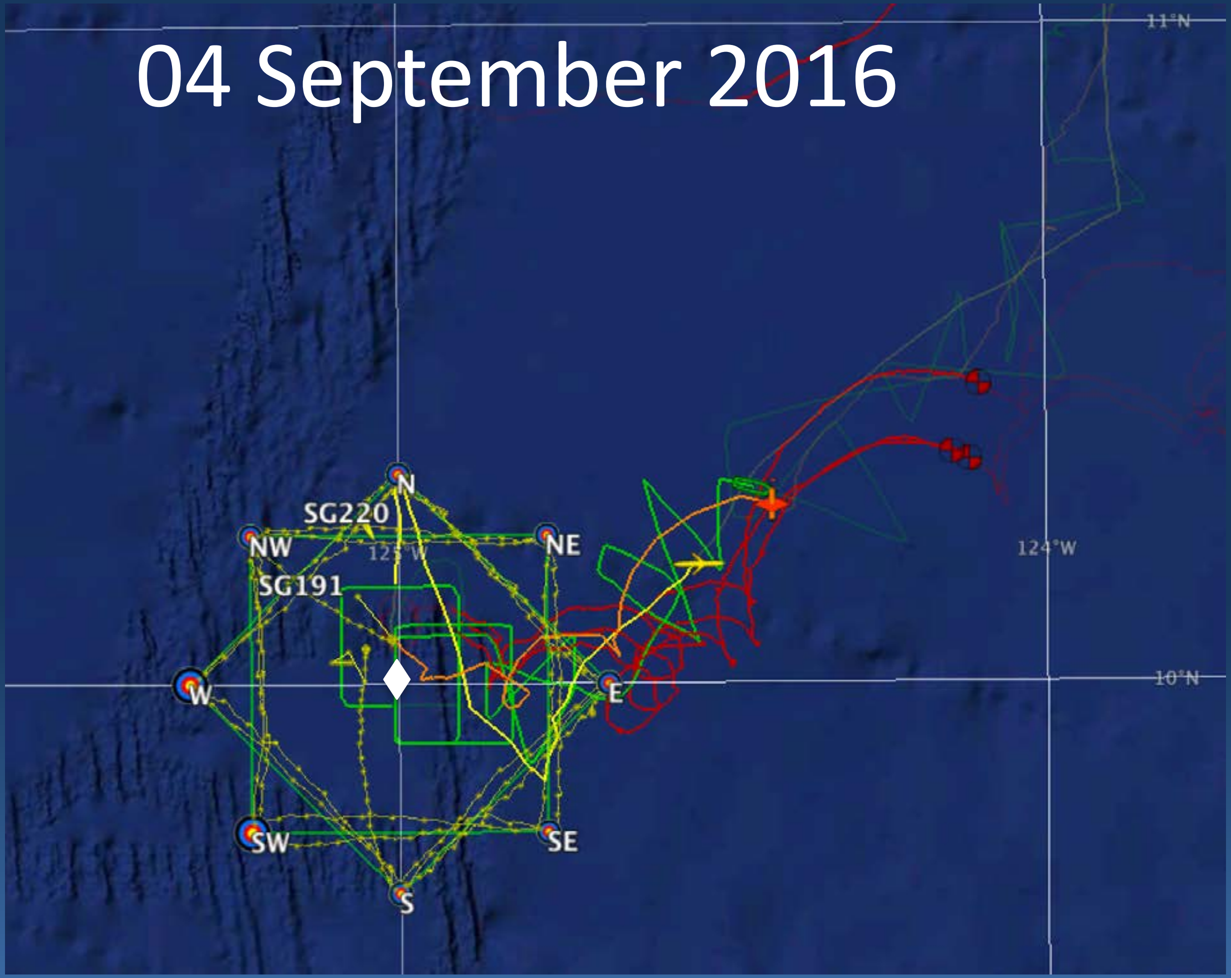
SPURS-2

Salinity Processes in the Upper Ocean Regional Study









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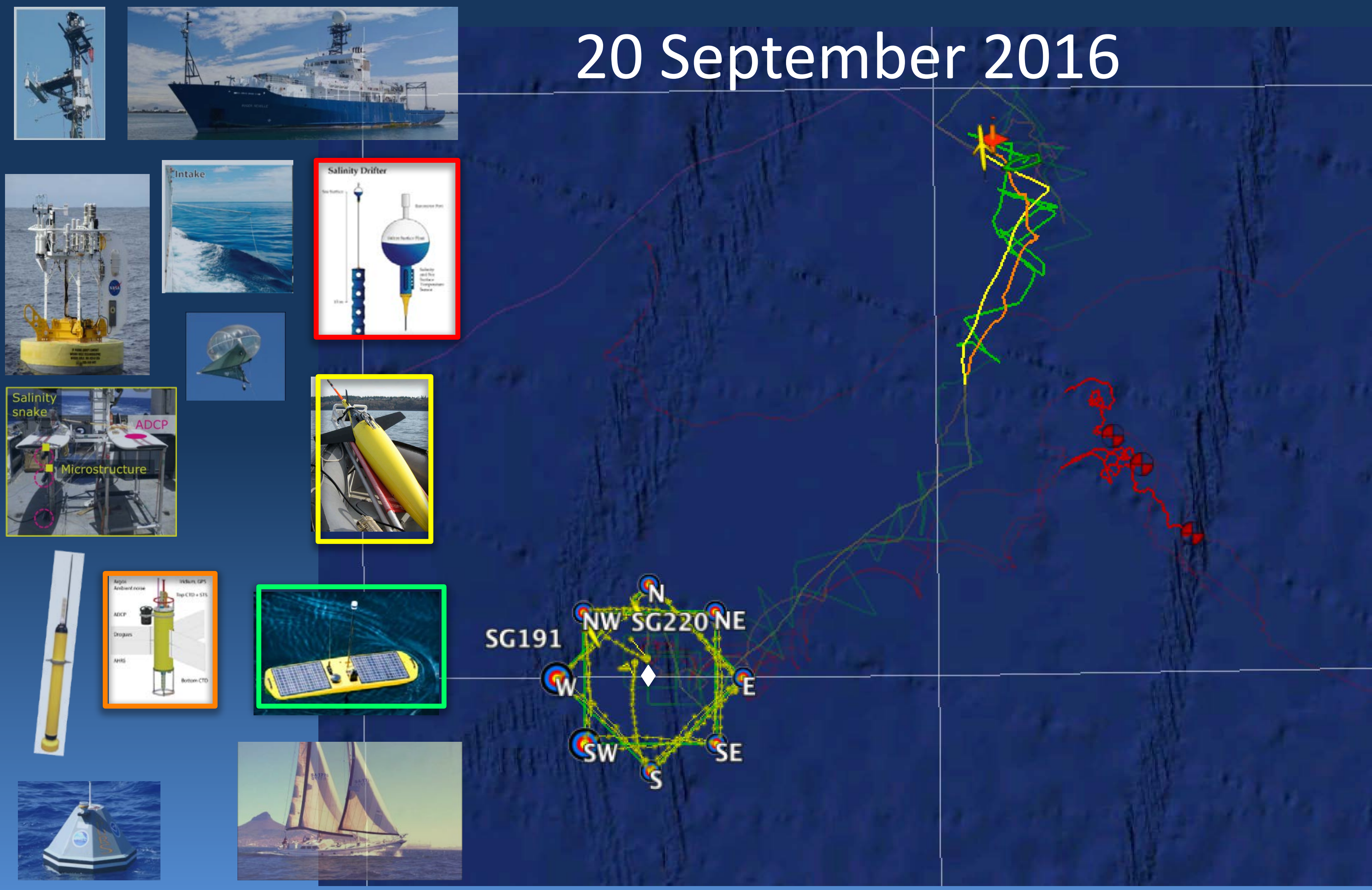
Salinity Processes in the Upper Ocean Regional Study

20 September 2016



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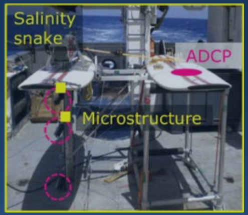
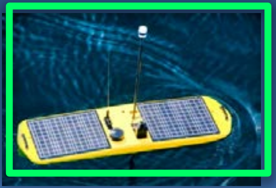
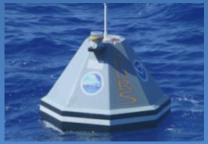
Salinity Processes in the Upper Ocean Regional Study

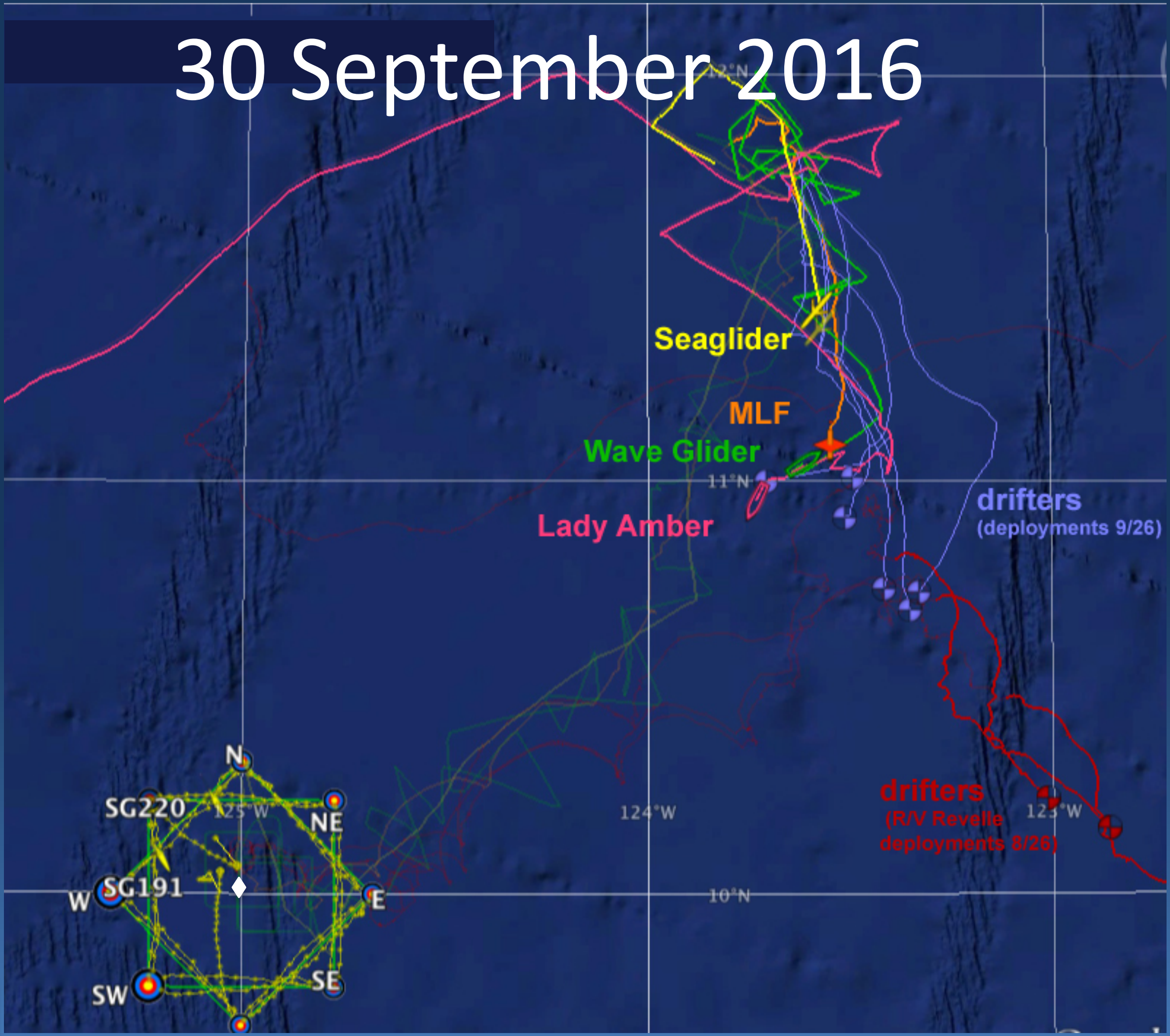










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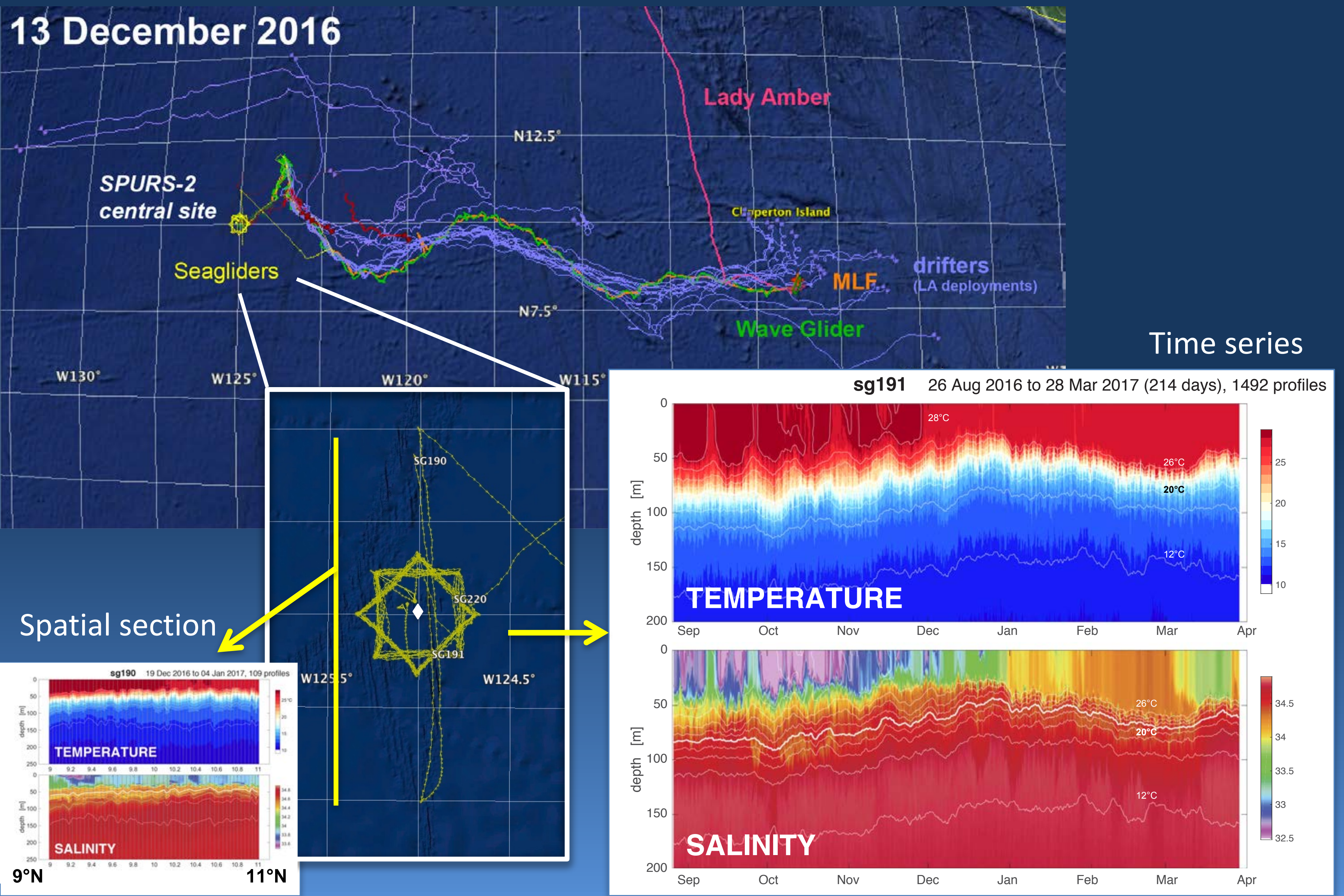
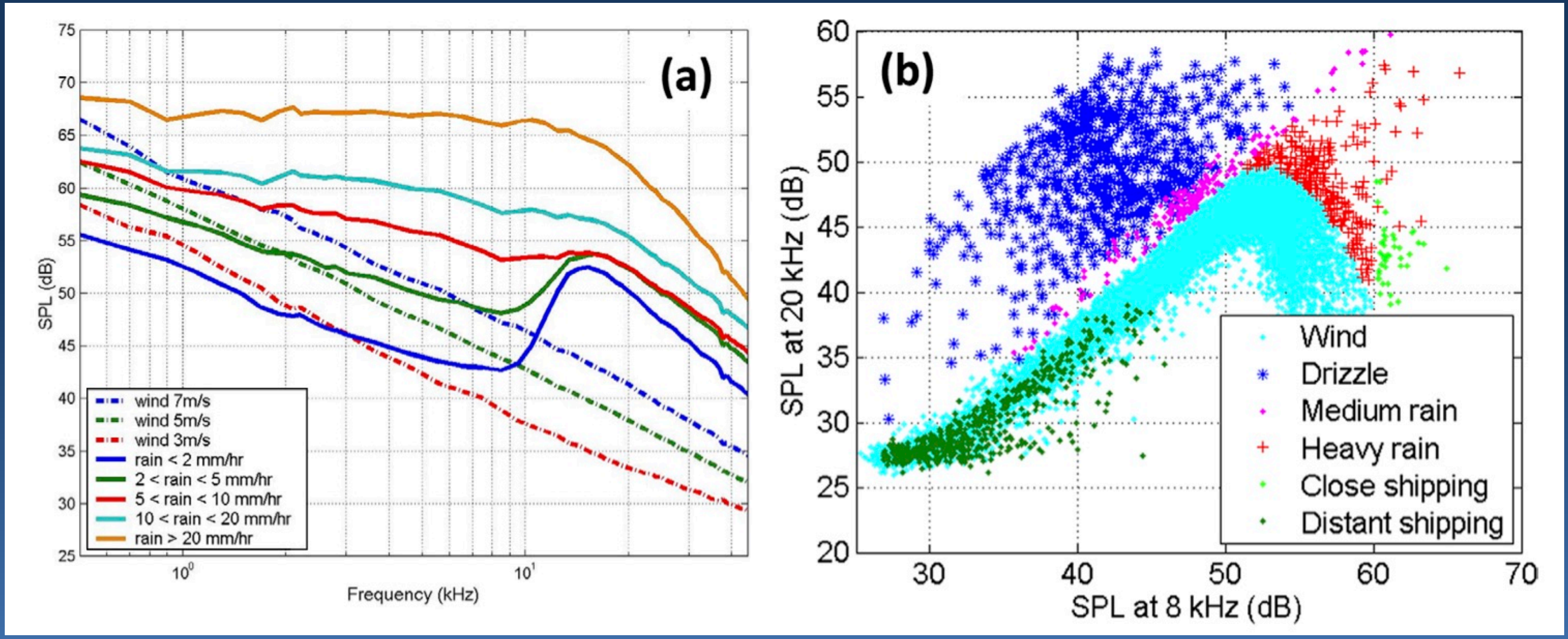
Salinity Processes in the Upper Ocean Regional Study



Measuring rain using passive acoustics

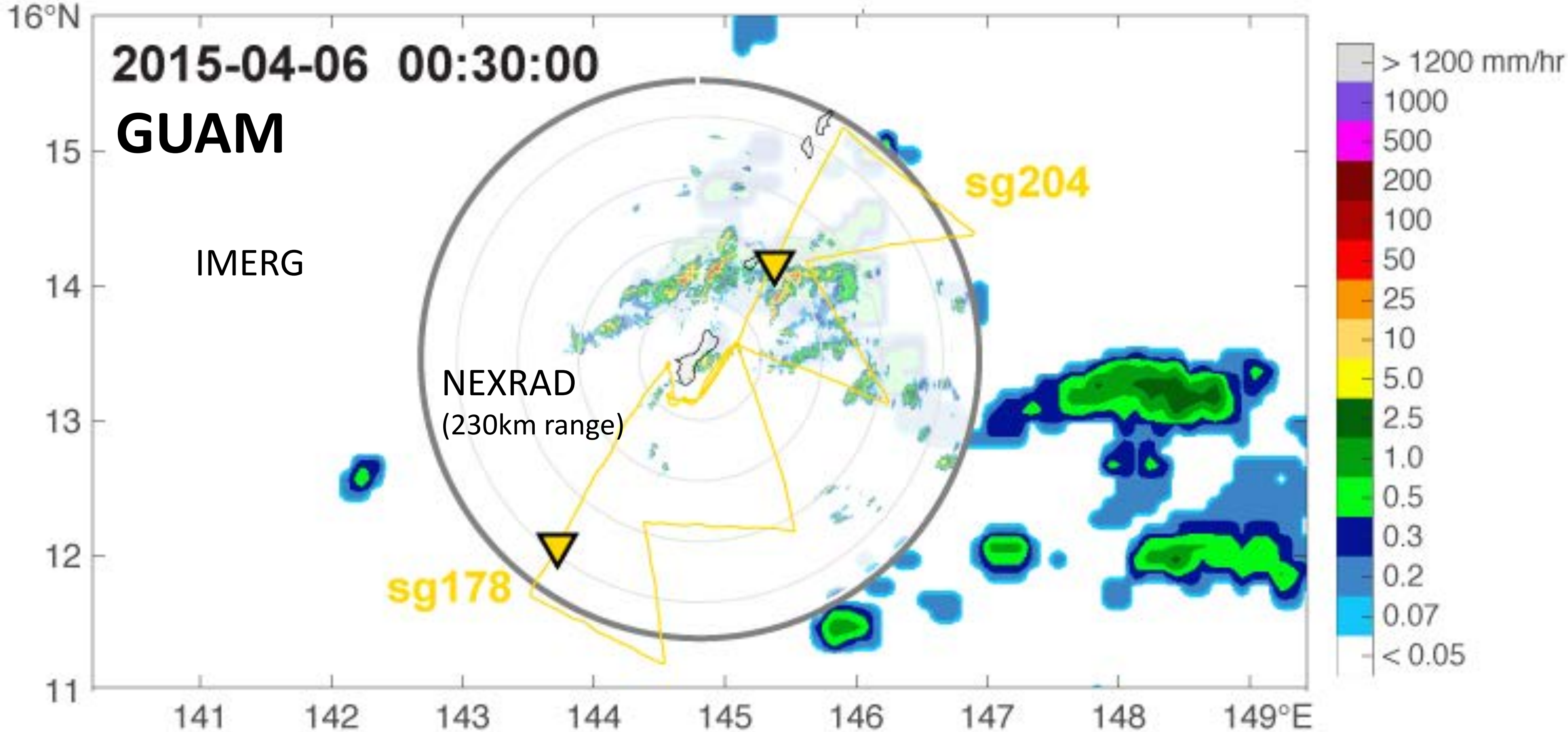
Listening to the noise that wind and rain make.

Jie Yang
Geoff Schilling, Barry Ma, Jason Gobat
Jeff Nystuen, Svein Vagle



Yang et al. 2015 (TOS)

Floats (Riser, Yang)
Moorings
Gliders



Rainville & Shilling, OSST

NEXRAD weather radar on Guam

2 Seaglider missions, recording continuously at 200 kHz (ONR, for Marine Mammals).

Glider data from G. Shilling, J. Lubby, APL

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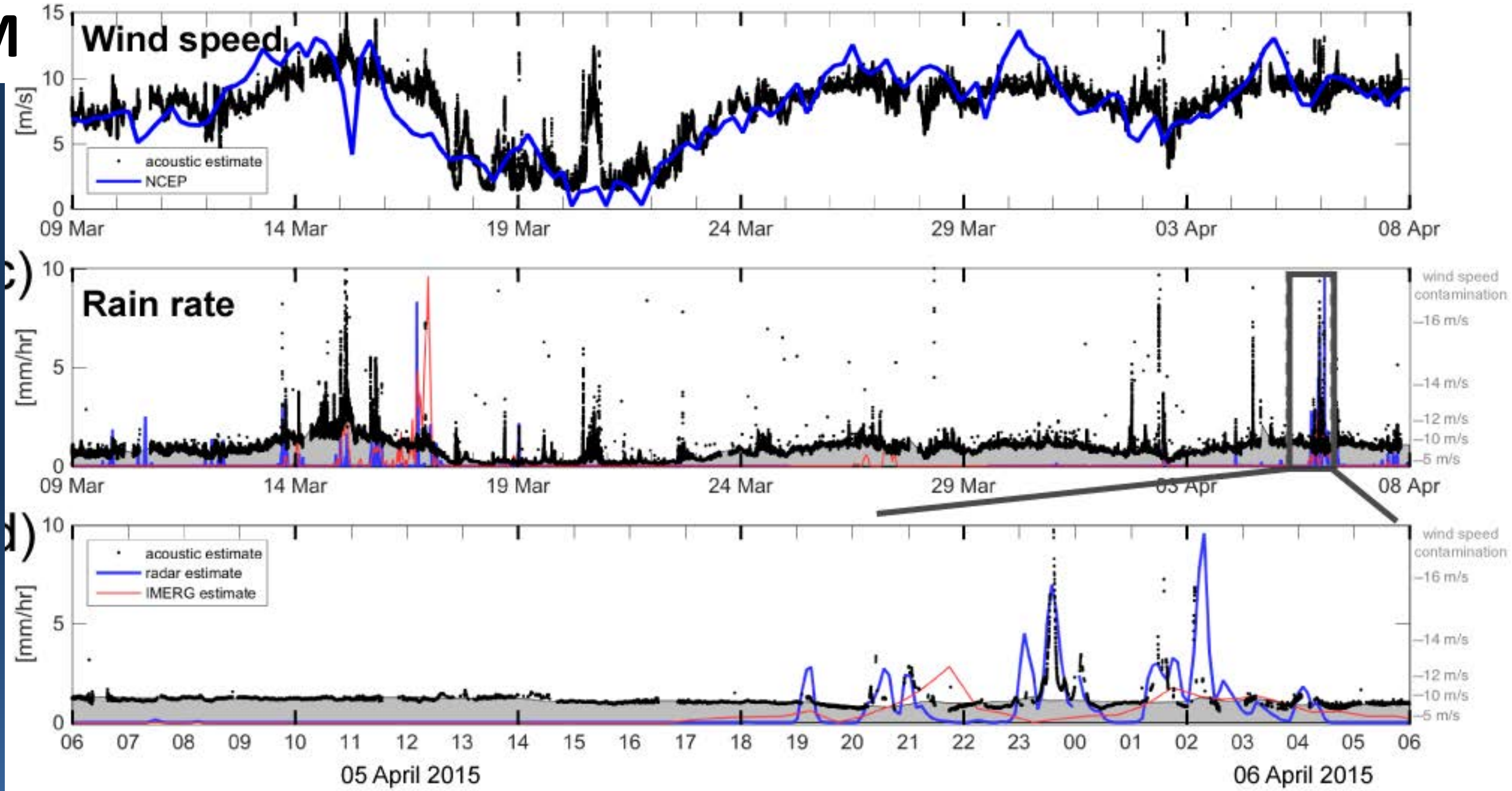
Salinity Processes in the Upper Ocean Regional Study

GUAM



Here, we have an acoustic estimate (sound pressure level spectrum) every 5 sec…

Glider data from G. Shilling, J. Lubby, APL

SPURS - 2
Salinity Processes in the Upper Ocean Regional Study

GUAM

IMERG

Global

30 min

12 km +

(shaded inside NEXRAD range)

NEXRAD

230km radius from radar

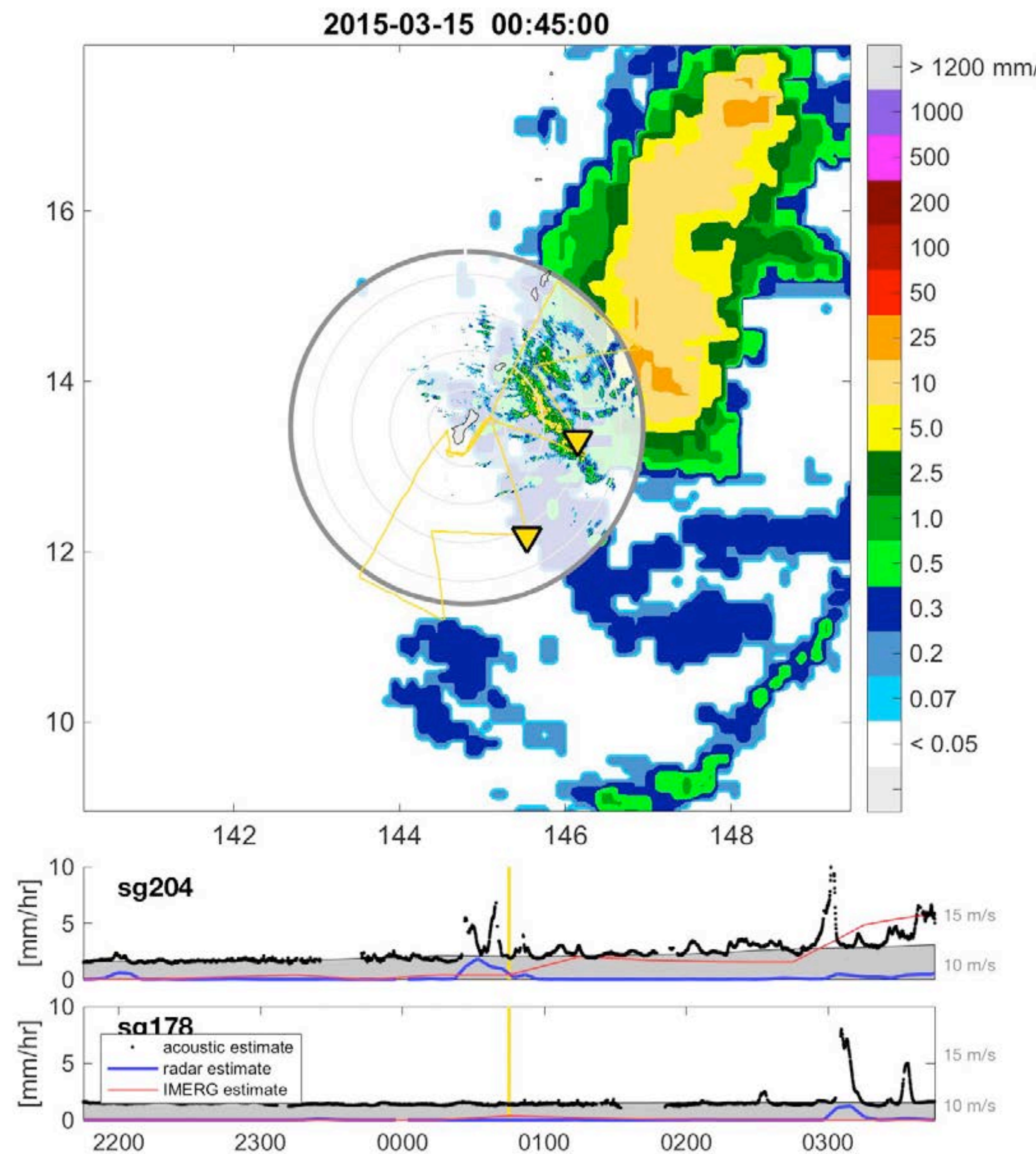
15 min

about 1-2km

Glider acoustic estimates

NEXRAD estimates

IMERG estimates

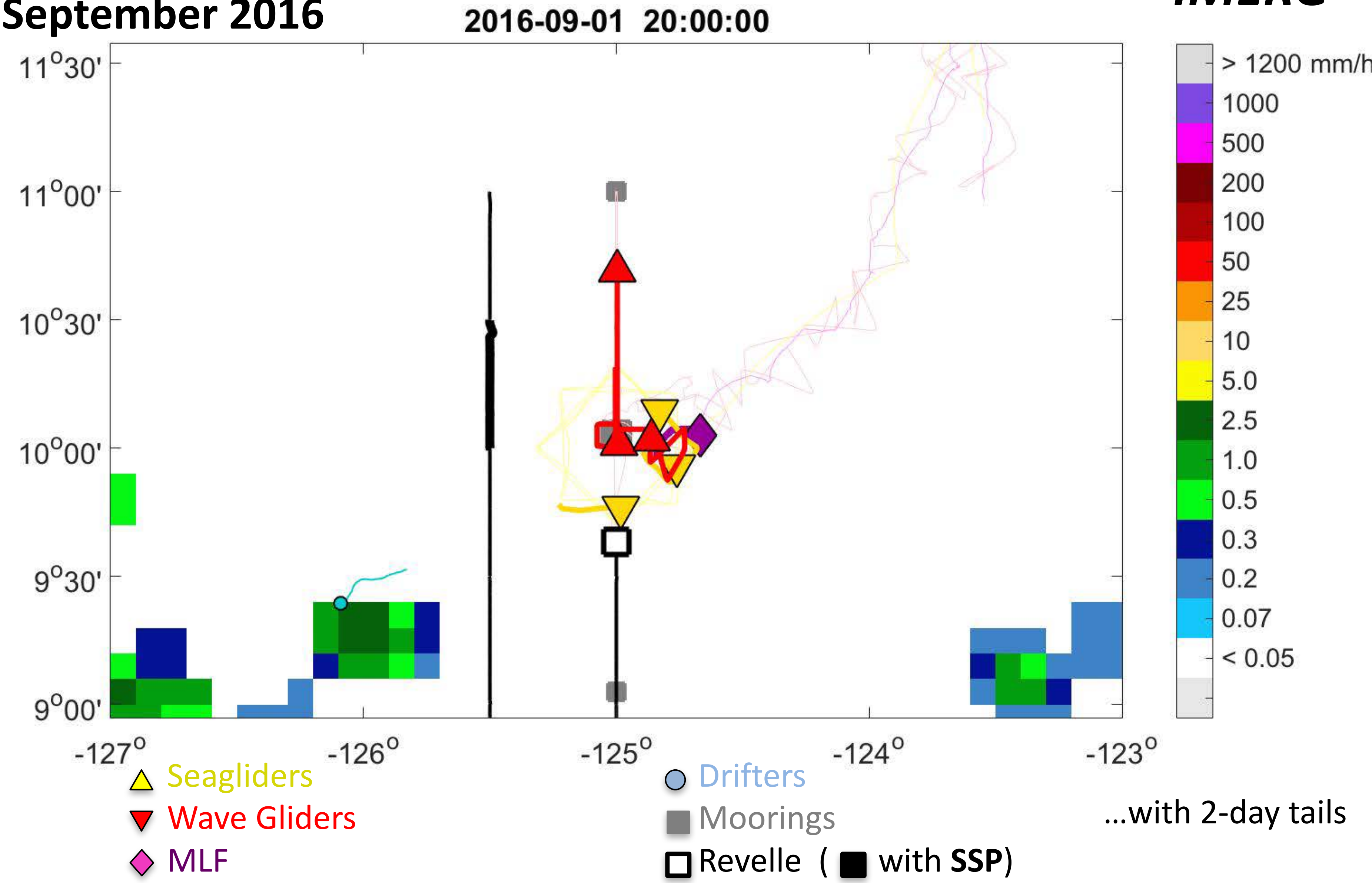


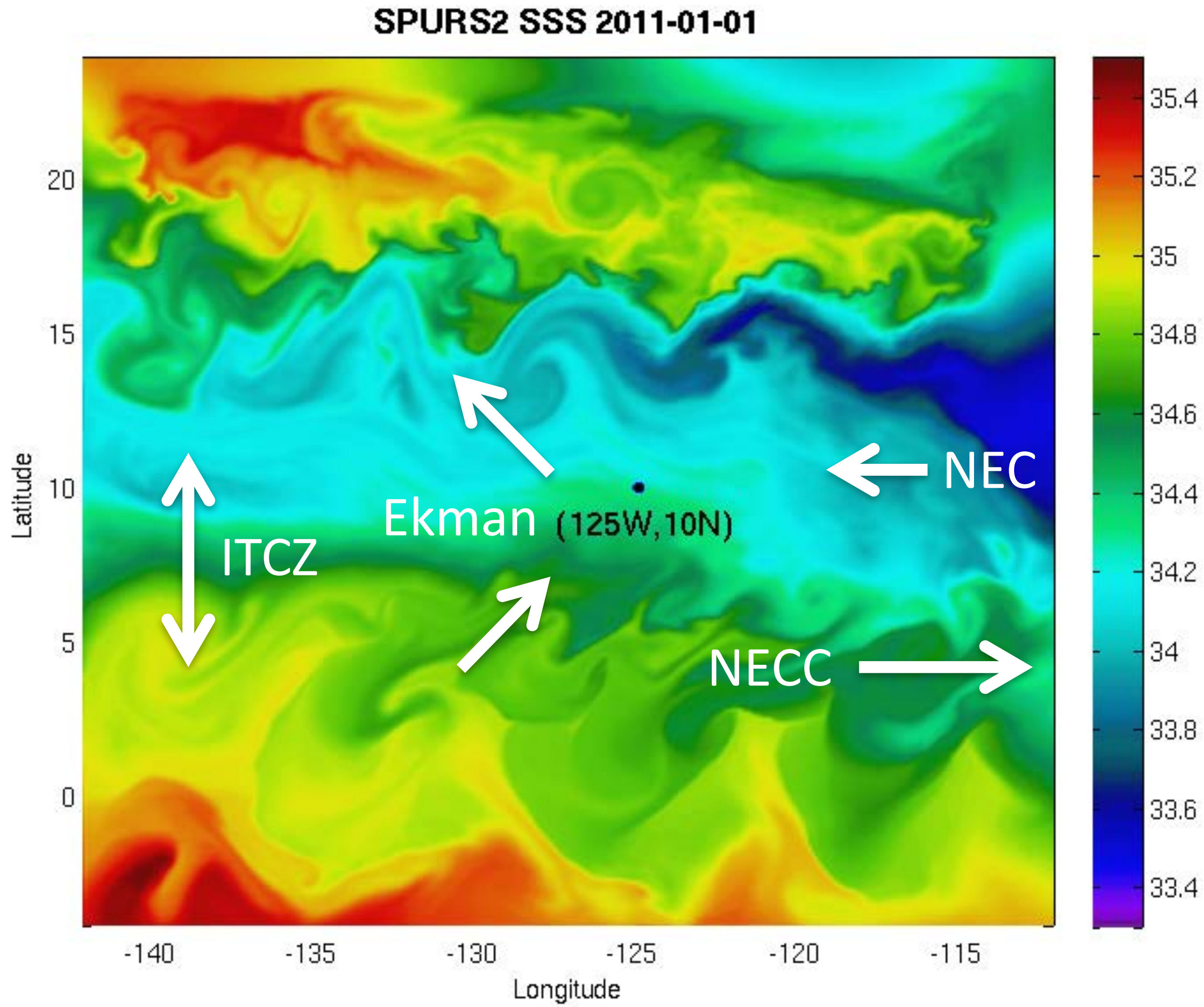
SPURS - 2

Salinity Processes in the Upper Ocean Regional Study

SPURS-2
September 2016

IMERG





SSS in 9km ROMS run from Zhijin Li, JPL

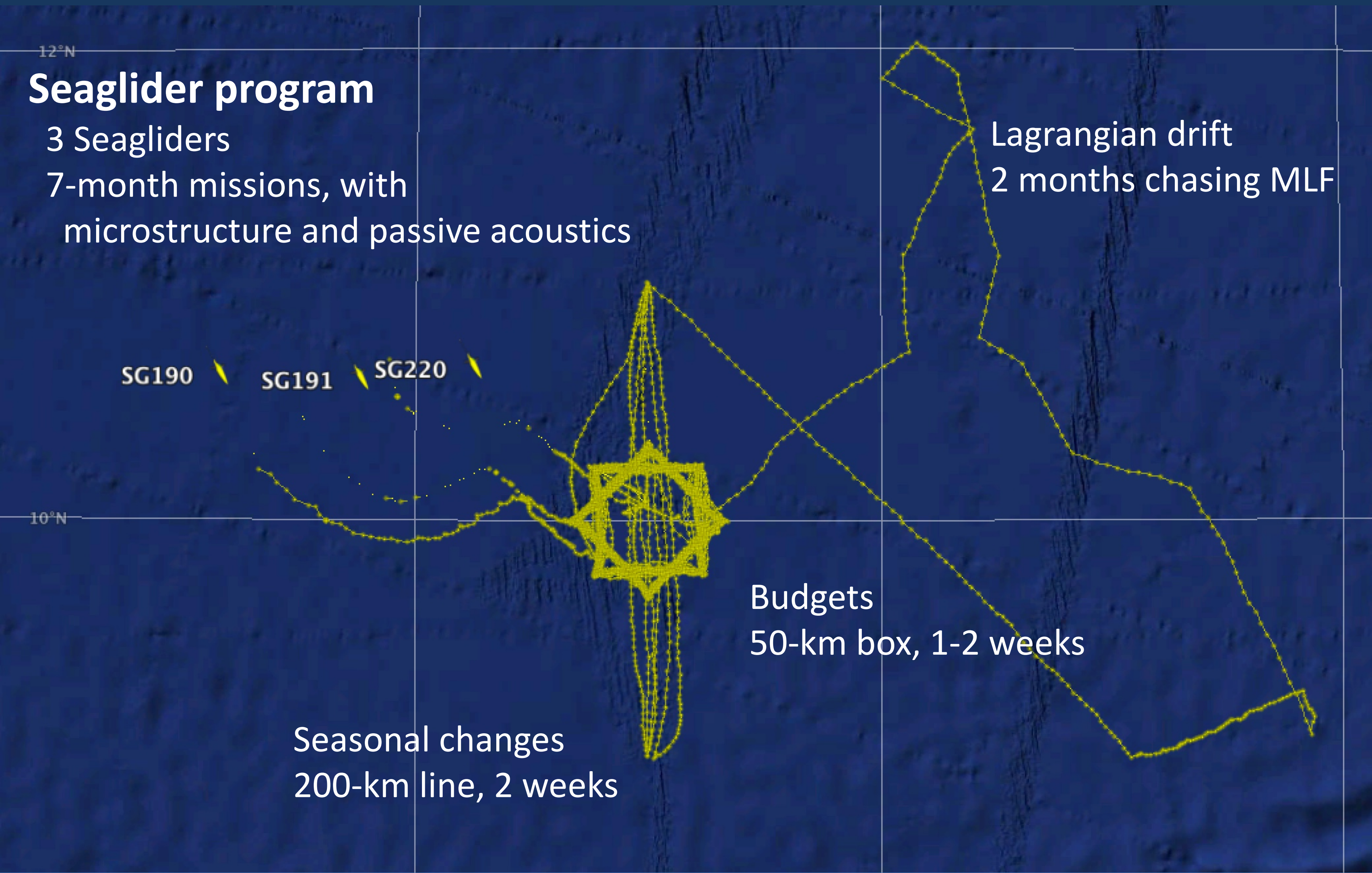
SPURS - 2

Salinity Processes in the Upper Ocean Regional Study

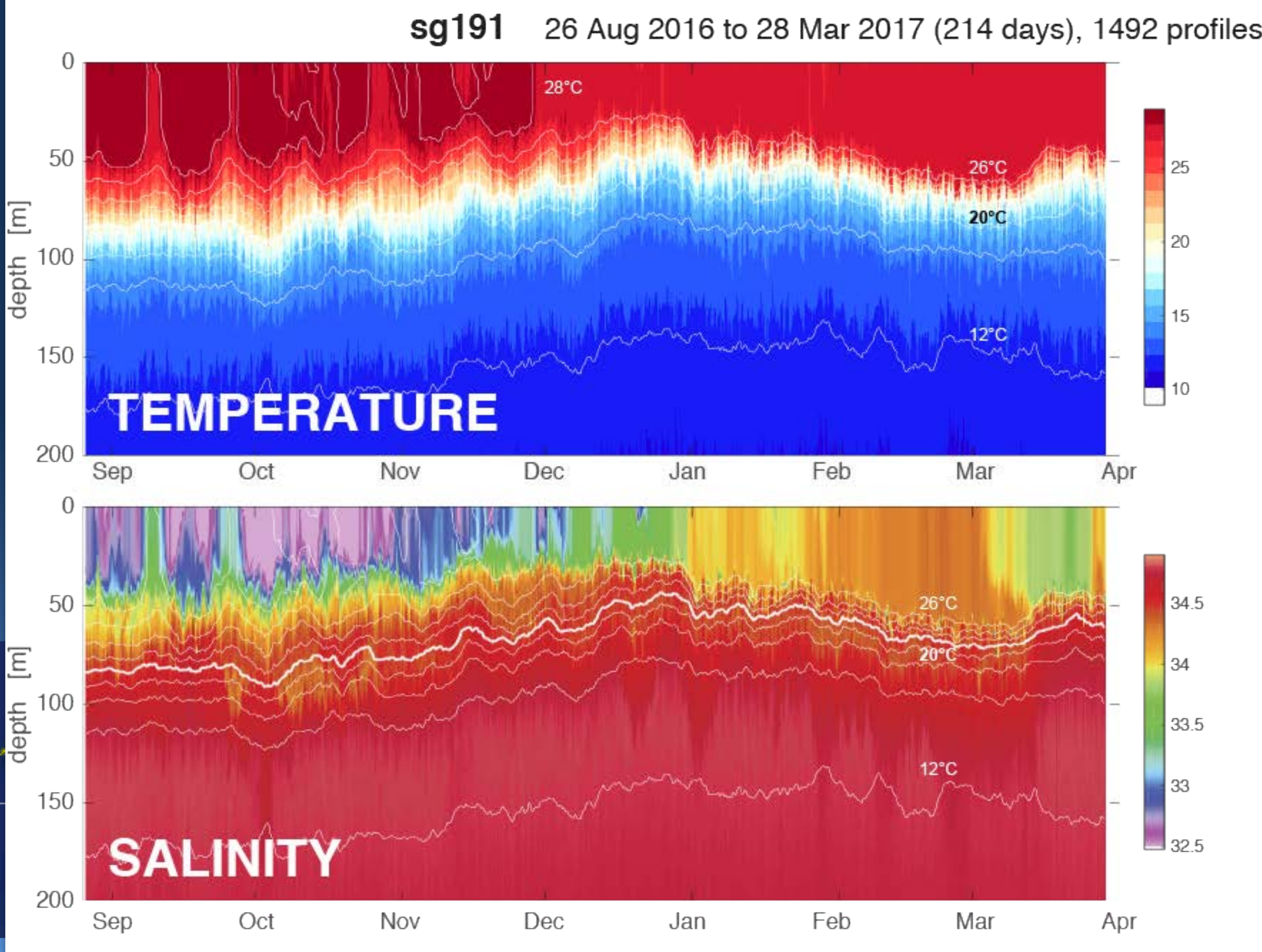
Seaglider program

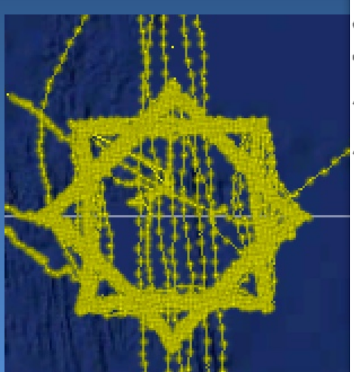
3 Seagliders

7-month missions, with microstructure and passive acoustics



Budgets around the mooring





Turbulence estimates from Seagliders

Extended (many months) dissipation measurement from an autonomous platform.

Fully integrated system developed at APL/UW

Low-power, little impact on flight and endurance.

Real-time turbulence profile after each dive.

Sampling in both directions, resolving the diffusive rolloff at high wavenumbers. Data quality comparable to free-falling.

Successful deployments, up to 7-months

Persistent measurements of temperature microstructure and shear microstructure

Turbulence estimates from Seagliders

Real time processing.

Overview of the method:

glider

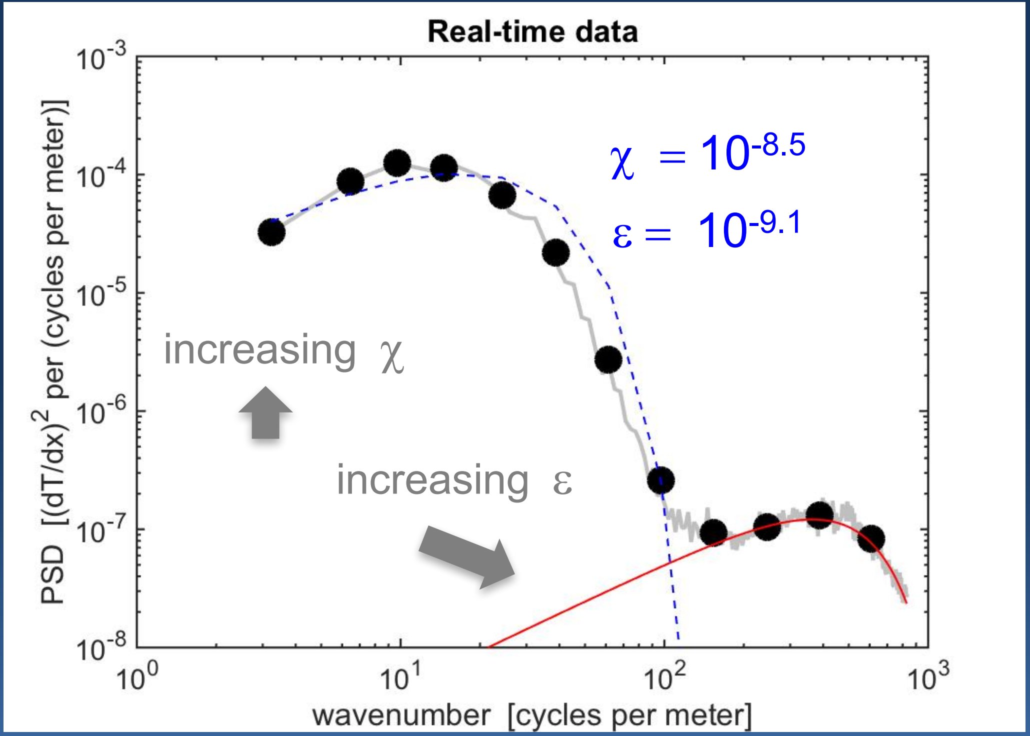
Temperature microstructure measured with FP07s at 400 Hz.

Spectra are calculated onboard on 10s blocks (1-2 m).

Log-averaged spectra (12 points per block) are sent back at the end of each dive.

basestation

Estimate χ and ε by fitting the Batchelor spectrum to the data (Ruddick et al. 2000).



- Near-real time profile of turbulence
- Adaptive sampling

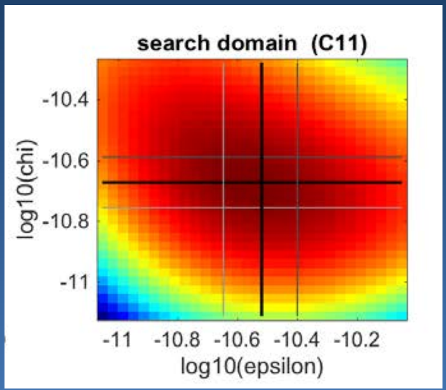
SPURS, sg191, dive 100

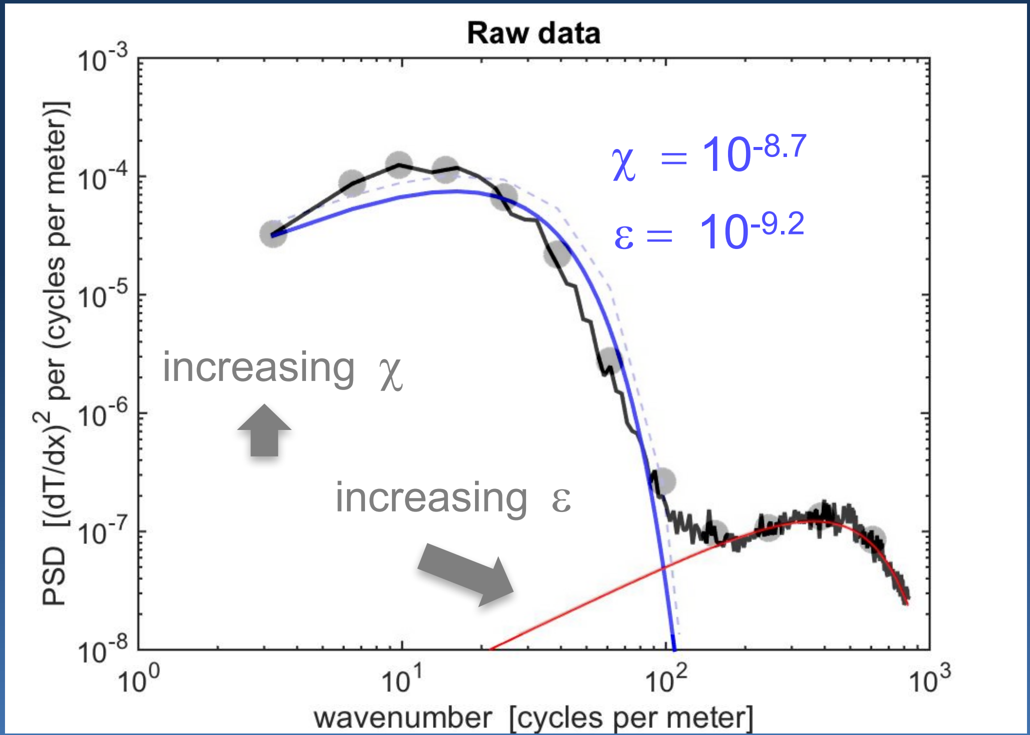
Turbulence estimates from Seagliders

Raw data (400 Hz) are saved onboard and processed upon recovery.

Estimate χ and ε by fitting the Batchelor spectrum to the data (Ruddick et al. 2000).

Get an estimate of error from misfit.

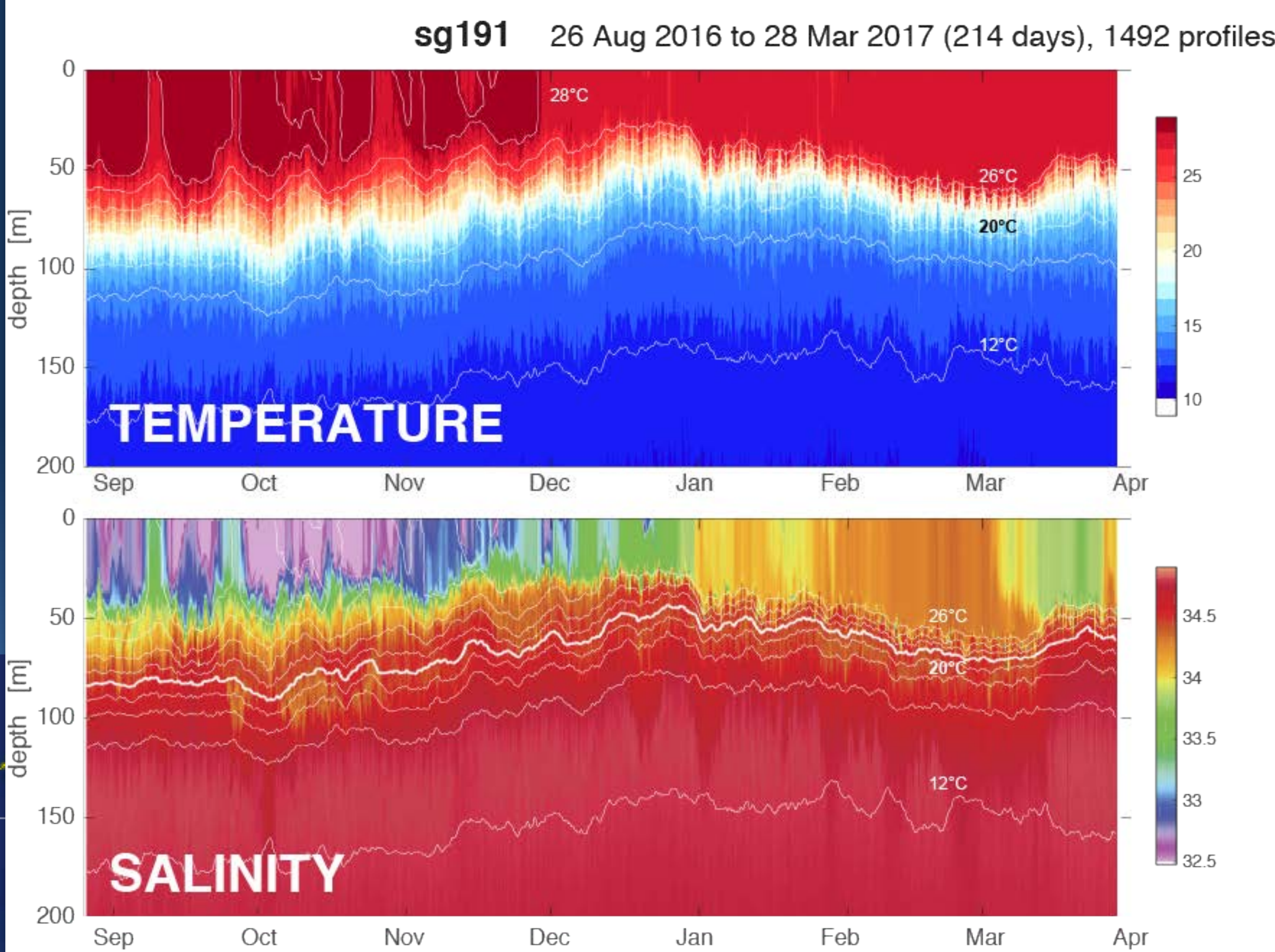


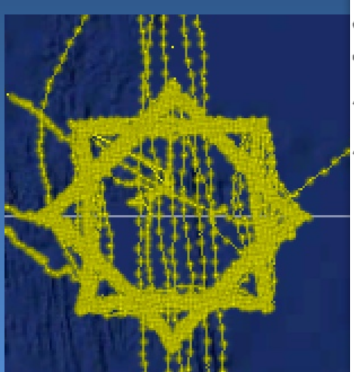


- Similar method for shear

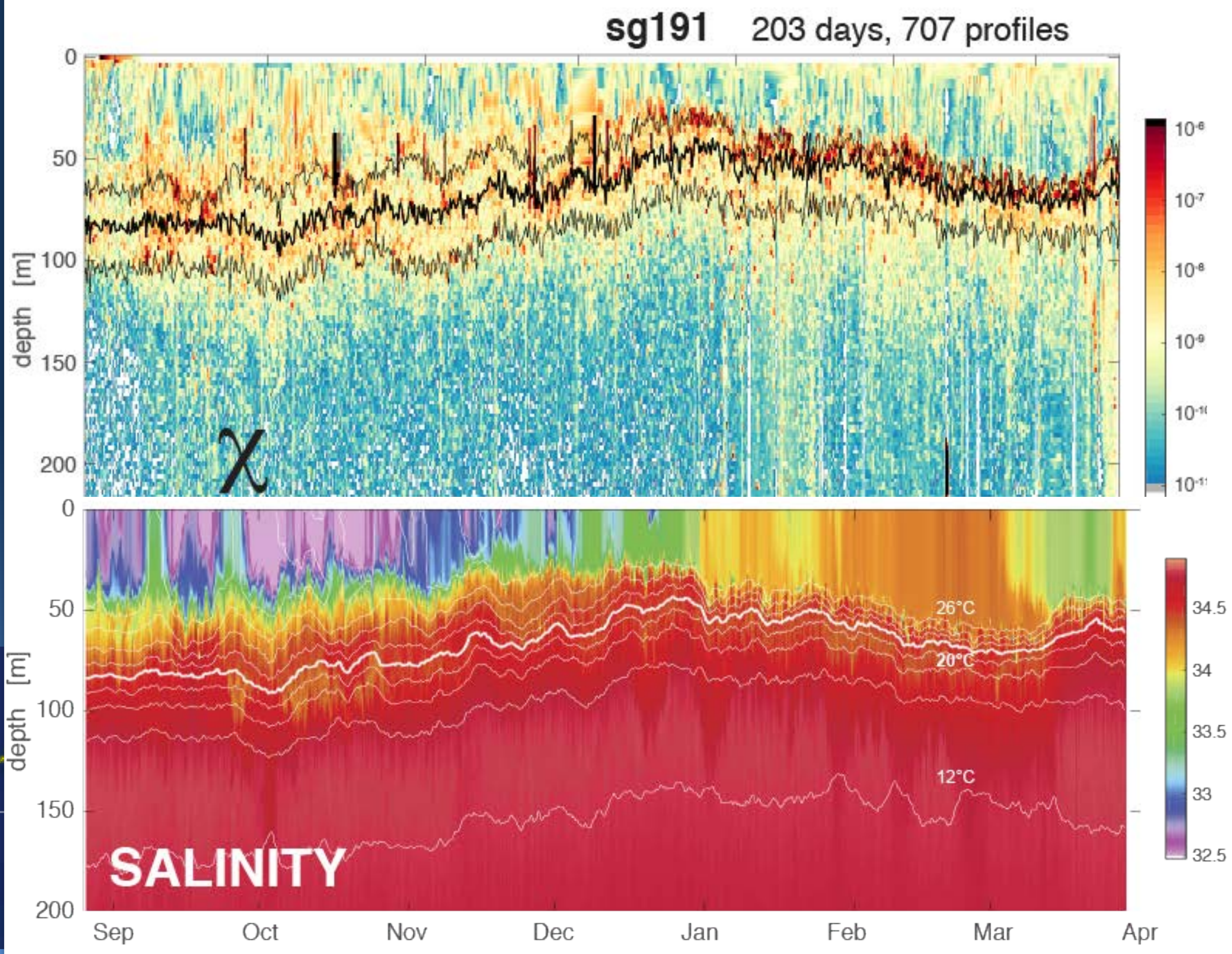
SPURS, sg191, dive 100

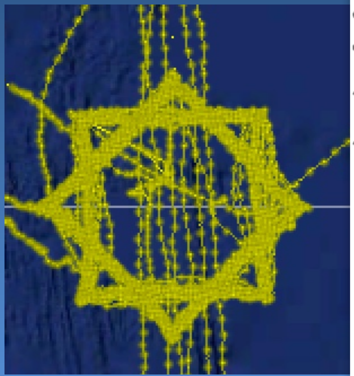
Budgets around the mooring



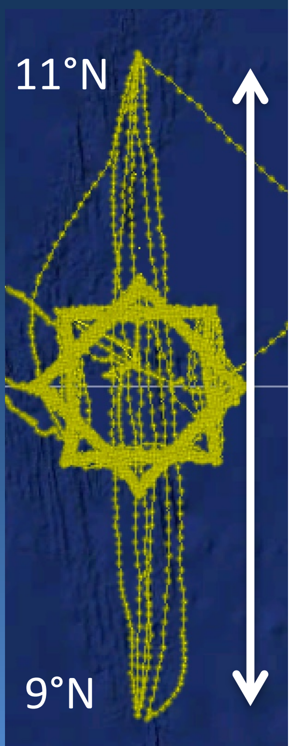


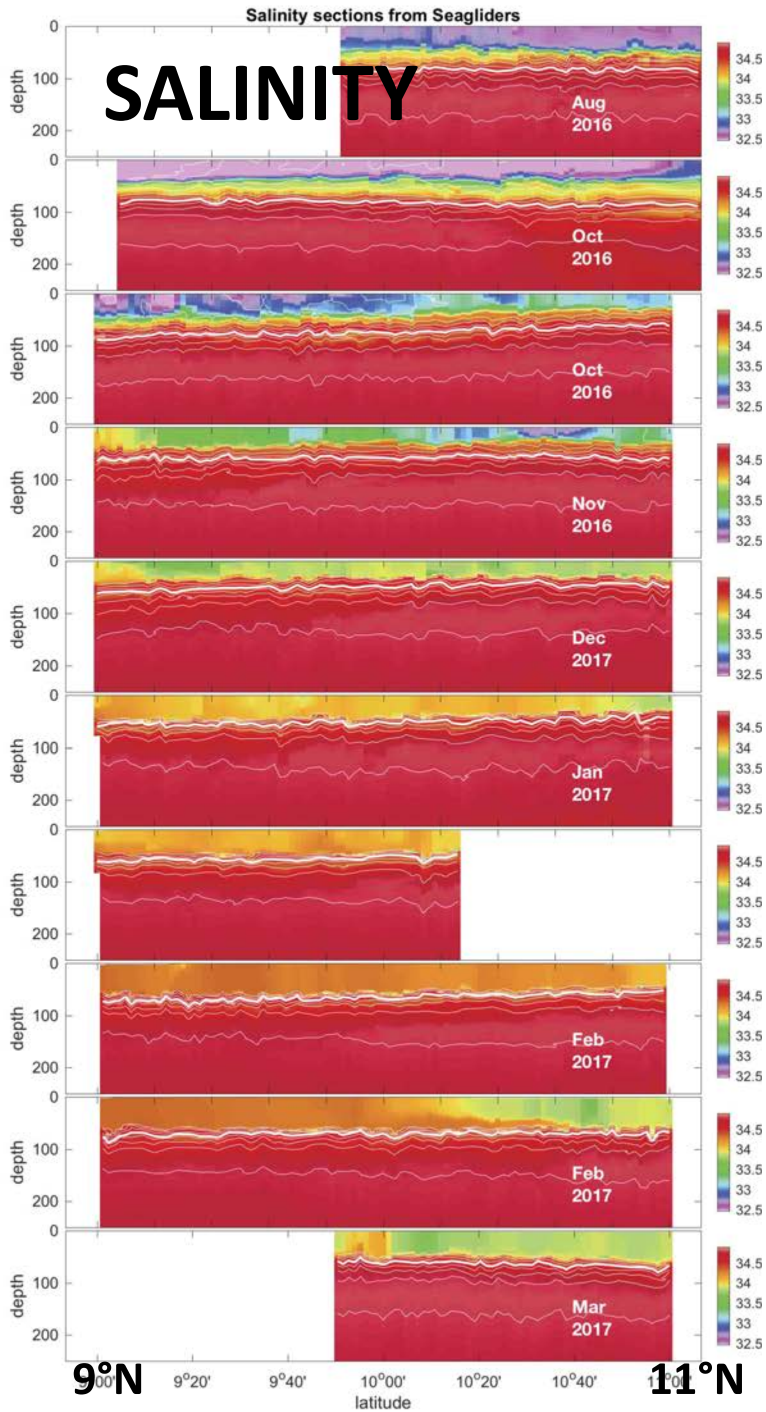
Budgets around the mooring

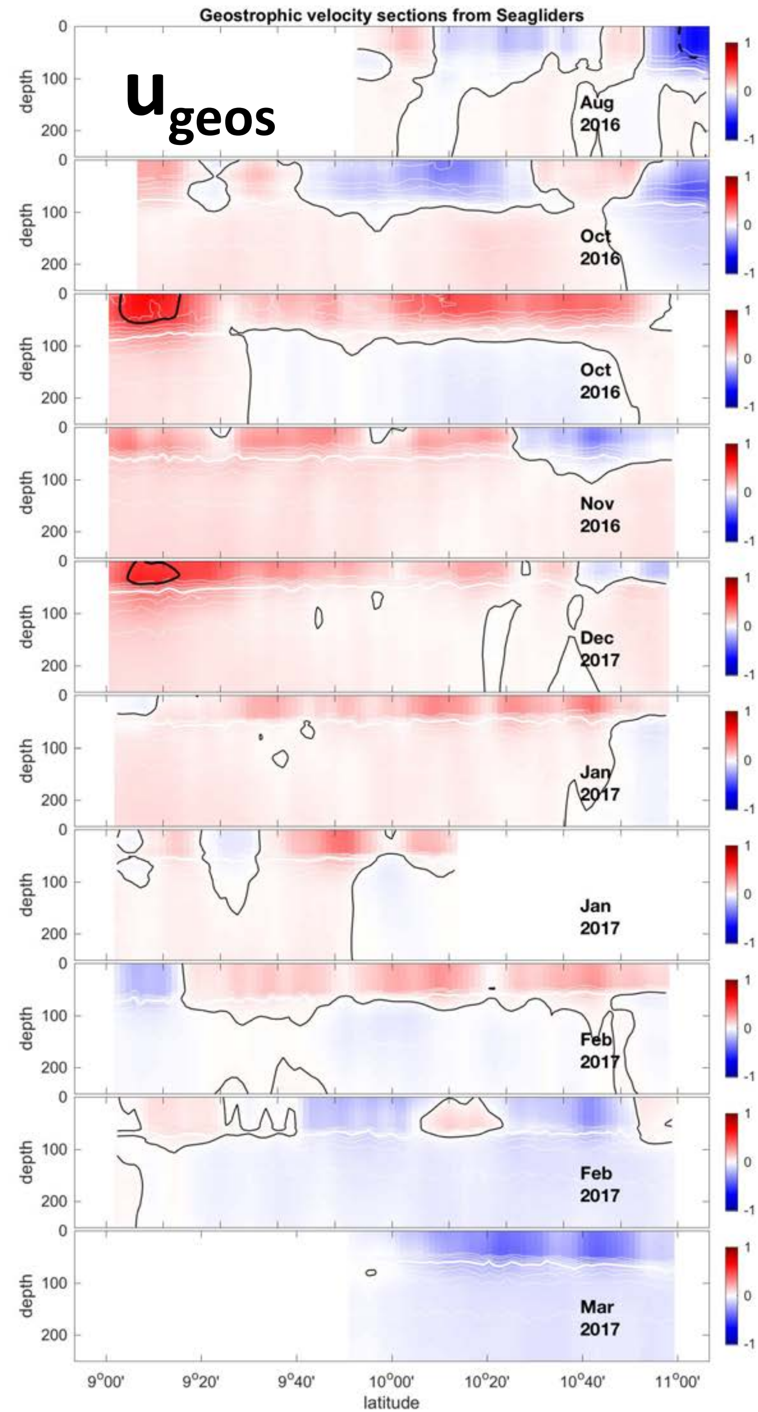




Seasonal changes

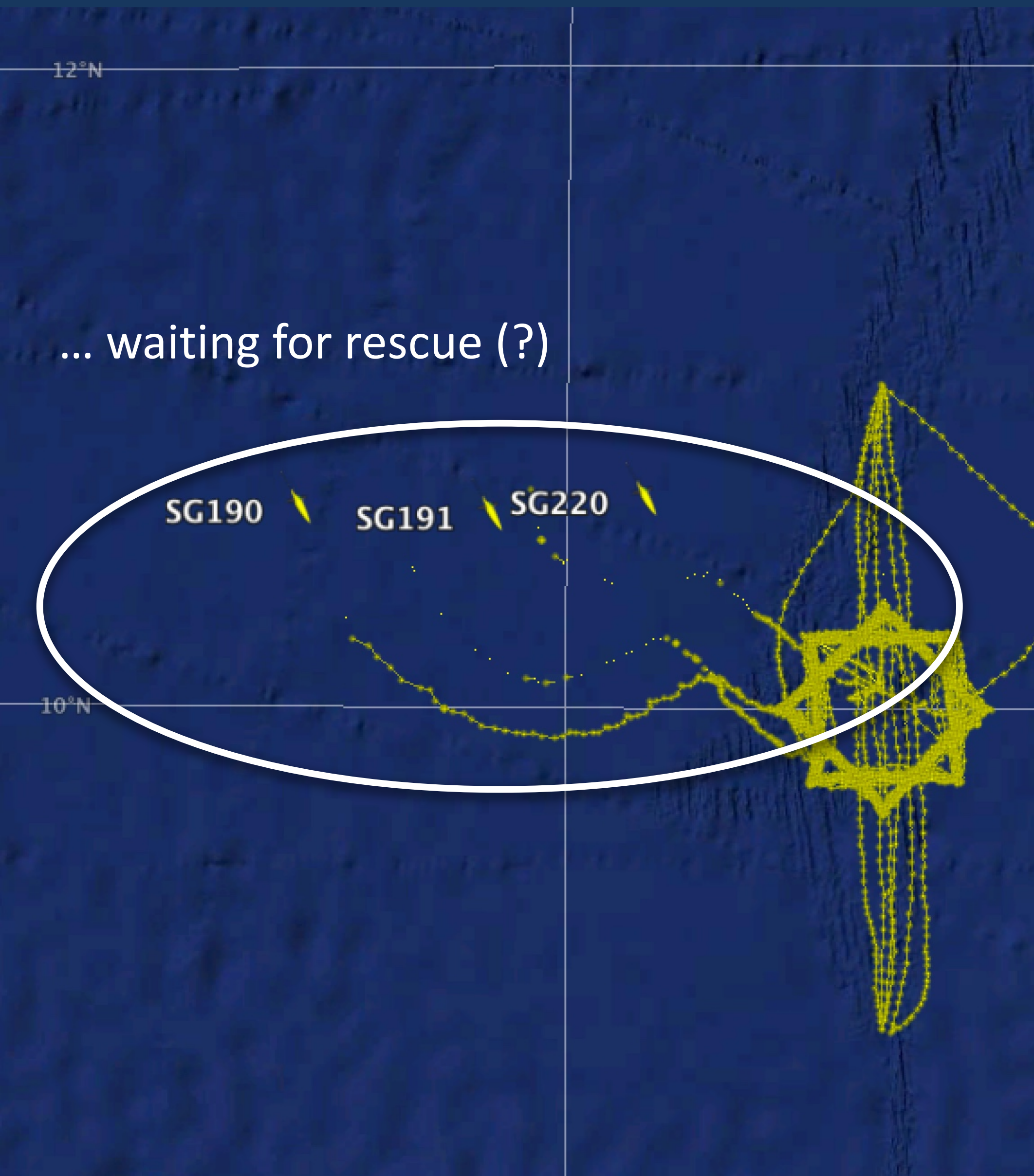






SPURS - 2

Salinity Processes in the Upper Ocean Regional Study



The Lady Amber has been able to do the turnaround cruise (Seagliders, Wave Gliders) yet.

Power-saving mode (loitering at depth)

Recover to get raw microstructure and raw passive acoustics

3 gliders ready to deploy

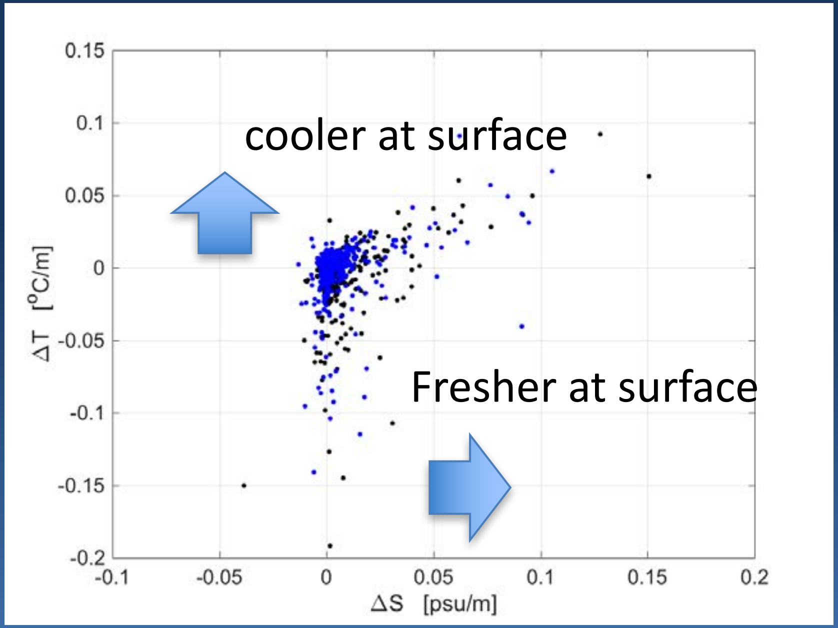
We continue to work with Lady Amber, hopefully doing 5 or more cruises in the next 10-12 months.

In SPURS-2, the use of autonomous platforms enables us to capture many different events (persistence), which is essential to link the different scales important for the water cycle.

Collaboration with Farrar, Hodges, Riser, etc., for resolving gradients and tendencies.

Patchiness of the rain: PALs, moorings, ships.

From rain event to large scale: ships, Wave Gliders, Moorings, remote sensing, Argo, etc.



3500 profiles within 50km of the mooring over 7 months