Salinity Processes Upper-ocean Regional Study (SPURS)

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2012-2013 Sea Surface Salinity (Aquarius)

SPURS-1

SPURS-2

2014 US CLIVAR Summit
Trends in Atlantic Salinities

Atlantic Ocean Salinity Changes
1990s compared to 1950s

from Curry et al. (2003; Nature)
Salty areas are getting saltier, fresh areas are getting fresher, indicating intensification of the water cycle.

Mean SSS

50 yr trend in SSS

→ Sea surface salinity extrema are of special interest

Durack and Wijffels, 2010, *J. Climate*
Salinity, the Global Water Cycle, and SPURS

• The water cycle is a key climate change issue (major societal impact)
• Most of the water cycle involves the oceans (i.e., evaporation and precipitation are mainly over oceans)
• Salinity trends suggest that the water cycle is accelerating at a much greater rate than models predict—salinity is a sensitive indicator
• SPURS is designed to study the oceanic processes that influence upper-ocean salinity
Salinity Processes Upper-ocean Regional Study (SPURS)

- SPURS aims to improve understanding of the physical processes influencing upper-ocean salinity in the N. Atlantic salinity-maximum region, in support of two broad goals:
  - To better understand the relationship between the global water cycle and ocean salinity
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  – To better understand the relationship between the global water cycle and ocean salinity
  – To better understand the processes affecting sea surface salinity on regional to small scales
SPURS aims to improve understanding of the physical processes influencing upper-ocean salinity in the N. Atlantic salinity-maximum region, in support of two broad goals:

- To better understand the relationship between the global water cycle and ocean salinity
- To better understand the processes affecting sea surface salinity on regional to small scales

- Interagency within the US (NASA, NOAA, NSF)
- International (US, Spain, France, Ireland, UK)
- 1-year field campaign concluded Oct 2013
Tools for the SPURS Study:

- Floats
- Gliders
- Drifters
- Moorings
- Ships
- AUVs
- Satellites
- CTD & Micro-structure profiling
SPURS field program started in N. Atlantic Salinity Maximum with Sept.-Oct. 2012 cruise of R/V Knorr

- All assets deployed successfully: moorings, gliders, floats, drifters, Wave Gliders, etc.
- Salinity max surveyed and found to have record high Surface Salinity \( \sim 37.8 \)

→ Supports Durack and Wijffels finding of increasing Salinity variance and intensification of the Water Cycle
Multi-scale sampling in SPURS:
Multi-scale sampling in SPURS: in the global observing system

The SPURS “large box”
Multi-scale sampling in SPURS: the SPURS “large box”

Aquarius salinity, March 2012
Multi-scale sampling in SPURS: the SPURS “small box”

Aquarius salinity, March 2012
Multi-scale sampling in SPURS: inside the “small box”

Mapped in situ data showing variability “inside an Aquarius pixel”
Programmatic aspects of SPURS:

• SPURS is currently in the early analysis phase (fieldwork completed last fall)

• Data management has been excellent
  – Program included a dedicated (i.e., funded) data management effort from inception
  – Data management plan developed and made clear at the same time fieldwork was being planned
  – The data management team collected data from fieldwork PIs at each stage (real-time during campaign, preliminary data, quality-controlled data).
  – The data management team will shepherd the QC’ed data into a permanent data archive center (PO.DAAC)

    ➔ This timely sharing has made a real difference in making the data more useful to the other team members and the project as a whole.

• The education/outreach effort was successful for the same reasons

• There has been good integration of modeling (planning, fieldwork, interpretation, assimilation)
Plans for a SPURS-2 experiment in a high precipitation region
SPURS-2 science questions

• 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 (atmospheric mesoscale) to the regional scale of the east Pacific fresh pool?
• What local and non-local effect does the freshwater flux have on the ocean and what are the feedbacks on the atmosphere?
Plans for a SPURS-2 experiment in a high precipitation region

- Open workshop held, April 2014
- Site selected in eastern Pacific ITCZ region
Plans for a SPURS-2 experiment in a high precipitation region

→ Open workshop held, April 2014
→ Site selected in eastern Pacific ITCZ region
→ Anticipated start of fieldwork summer 2016, to last one year
BACK-UP
Salinity Processes in the Upper Ocean Regional Study (SPURS)

SPURS history and timeline:
• US CLIVAR Salinity Working Group (May 2006 meeting; 2007 report)
• “Salinity” issue of Oceanography (Mar. 2008)
• NASA Salinity Workshop (Dec. 2009)
• Aquarius and SMOS salinity satellites (~2011)
• SPURS Planning Meeting (Feb. 2011)
• SPURS field campaign (Sept 2012-Sept 2013)
Evaporation Minus Precipitation (cm/yr) CI = 20 (cm/yr)

Salinity (psu)

SPURS study region
Salinity, the Global Water Cycle, and SPURS

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Global (ocean) evaporation trends in 4 surface flux products (Yu, 2007, J. Climate)

10 cm/yr $\rightarrow$ 8 W/m$^2$ latent heat flux
Trends in Atlantic Salinities

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Science Summary:

- Salinity trends suggest water cycle intensification is much greater than models can explain. This is a key global change issue!
- In order to understand these trends oceanographers must determine how ocean processes (surface fluxes, mixing, subduction/advection) are responding to warming, increasing winds and water cycle intensification.
- SPURS is designed to address such physics on diurnal to seasonal time scales.
SPURS-2 Scientific Questions

The workshop held in Pasadena April 16-18, 2014 identified several key scientific questions for the SPURS-2 field program:

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

• What local and non-local effect does this freshwater flux have on the ocean and what are the feedbacks on the atmosphere?

• Where does the fresh water go, with input from the scales of raindrops to meso-scale fresh patches to the east Pacific fresh pool?

• How does the ocean integrate the fresh water forcing and destroy the salinity variance created at the surface?
Buoy/mooring measurements:

(1) Measurements of surface meteorology and radiation for air-sea fluxes

(2) Direct turbulent flux measurements (wind stress, latent heat flux/evap, sensible heat flux)

(3) Measurements of T, S, and U with good vertical and temporal resolution (<5m in upper 90 m)
Surface forcing at the SPURS buoy: (3-week running averages)

- **Surface heat flux** (mean = 31 W/m²)
- **Evaporation rate** (net = 1.6 m)
- **Precipitation rate** (net = 71 cm)
- **Wind speed**

Data spans from October 2012 to September 2013.
Temperature and salinity at the mooring:

Salinity

Temperature

\[ \Delta \sigma_o = 0.6 \text{ kg/m}^3 \]
Preliminary mixed-layer temperature balance:

Evaluated for 3-week running average:

\[
\frac{\partial \bar{T}}{\partial t} = \bar{u} \cdot \nabla \bar{T} - \hat{T}_{-h} \left( \frac{\partial h}{\partial t} w - h + u \cdot \nabla h \right) - \frac{Q_{-h}}{\rho c_p h} + \frac{Q_o}{\rho c_p h} \frac{1}{h} \nabla \int_{-h}^{0} \hat{u} T dz
\]
Knorr & Endeavor Met Systems

- Direct covariance flux system.
- 2 open path LI-7500 hygrometers
- 3 aspirated RH/T sensors
- GPS compass
- Downwelling solar and IR sensors
- 2 Self-siphoning rain gauge
- Sea-snake

SPURS Central Mooring

- 2 DCFS
  - Sonic Anemometers/ Thermometers
  - MotionPakII AMU
  - Compass
- 2 LI-7200
  - Closed-Path IRGA
  - Blower
Preliminary Flux Results

Surface Stress (N/m²)

Momentum Flux (N/m²)

Latent Heat Flux (W/m²)

$f_{Sc}(0) (g^{2}/kg^{2})$