



Southwest Pacific Ocean Circulation and Climate Experiment (SPICE)

Reporting: Janet Sprintall (Scripps Institution of Oceanography)

USA PIs: Billy Kessler (NOAA/PMEL); Uwe Send (SIO)

French (LEGOS-IRD Toulouse) PIs: Alex Ganachaud, Sophie Cravatte, Gerard Eldin, Lionel Gordeau, Bughsin (Natasha) Djarth, Angelique Melet

Papua New Guinea (UPNG) PIs: Chalapan Kaluwin, Moyap Kilepak

Japan (JAMSTEC) PIs: Takuya Hasegawa, Kentaro Ando

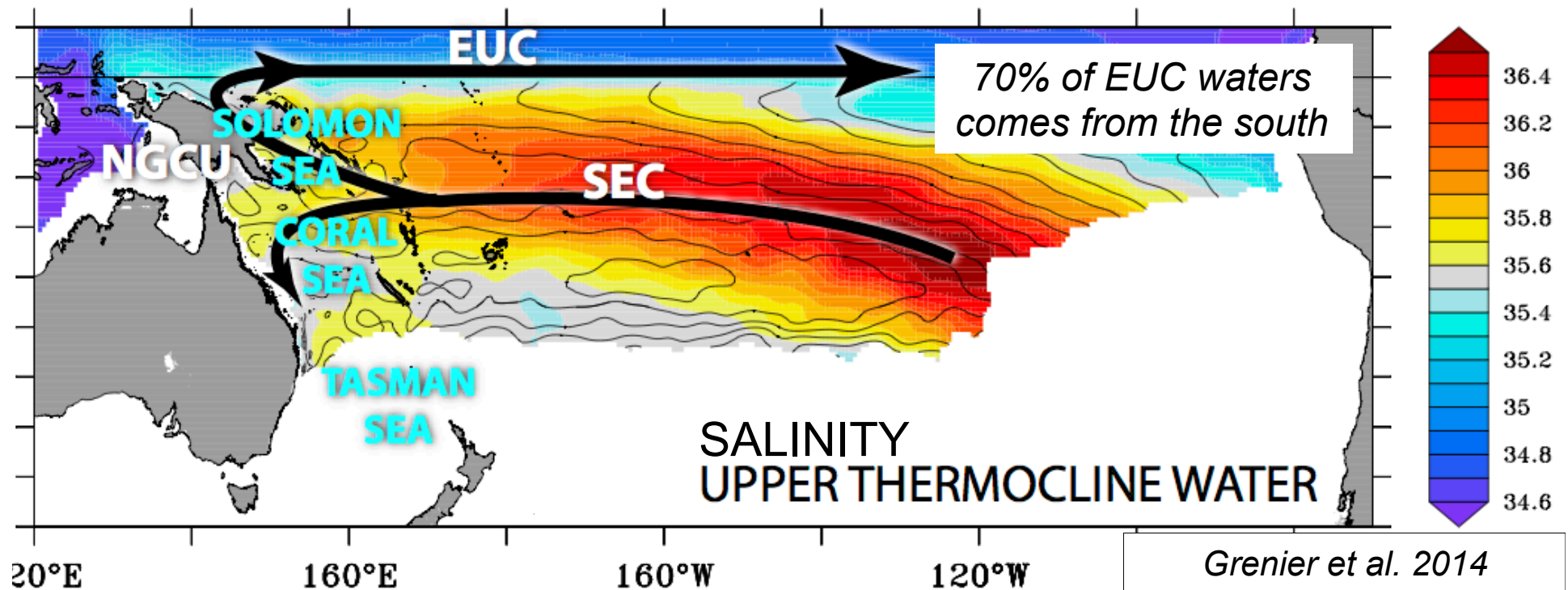
U.S Students: Marion Alberty (SIO); Waen (Arachaporn) Anutaliya (SIO)

French Students: Cyril Germineaud (U. Toulouse, France)

PNG Students: George Amba (UPNG)

Numerous International PIs from Australia, New Zealand, IRD Noumea etc. etc.

SPICE Motivation: Oceanic connection subtropics to equator



- The region is remote, and the large temporal variability and strong narrow currents in a complex bathymetry pose serious challenges to both observation and numerical modeling
- *The goal of SPICE is to observe, model and understand the role of the Southwest Pacific ocean circulation in the large-scale, low-frequency modulation of climate and the generation of local climate signatures*
- *Do changes in the regional transport of mass/heat matter to climate?*

Implementation: Time Line

2005: First SPICE Workshop, Malanda Australia

2007: SPICE Scientific Background Document

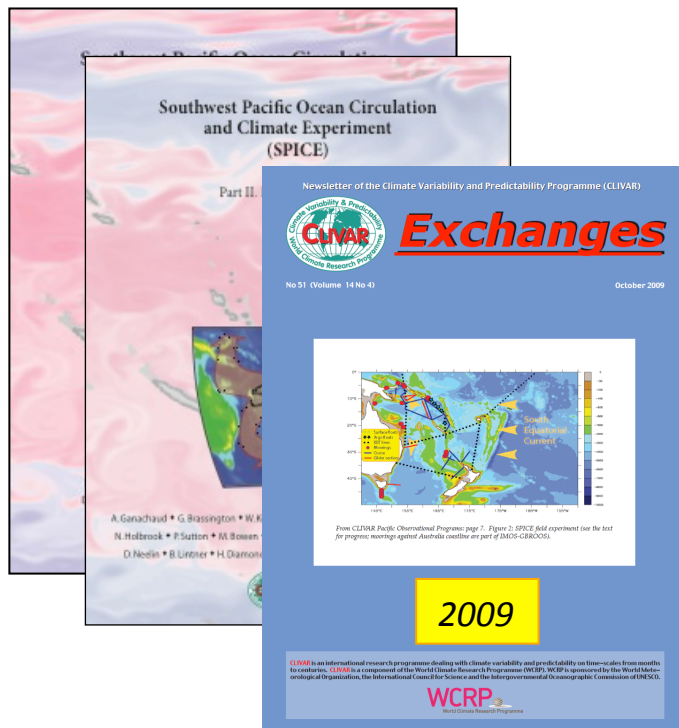
2008: SPICE Implementation Plan

2008: Endorsement by International CLIVAR

... numerous presentations on progress...

2013: Advances from SPICE, Ganachaud et al (2013) CLIVAR Exch.

2015: Special JGR Issue (SPICE and NPOCE results)



Advances from the Southwest Pacific Ocean Circulation and climate experiment (SPICE)

A. Ganachaud^{1,2}, Bowen M.³, Brassington G.⁴, Cai W.⁵, Cravatte S.^{2,1}, Davis R.⁶, Gourdeau L.¹, Hasegawa T.⁷, Hill K.^{8,9}, Holbrook N.¹⁰, Kessler W.¹¹, Maes C.¹, Melet A.^{12,13}, Qiu B.¹⁴, Ridgway, K.¹⁵, Roemmich D.⁶, Schiller A.¹⁵, Send U.⁶, Sloyan B.¹⁵, Sprintall J.⁶, Steinberg C.¹⁶, Sutton P.¹⁷, Verron J.¹², Widlansky M.^{14,18}, Wiles P.¹⁹

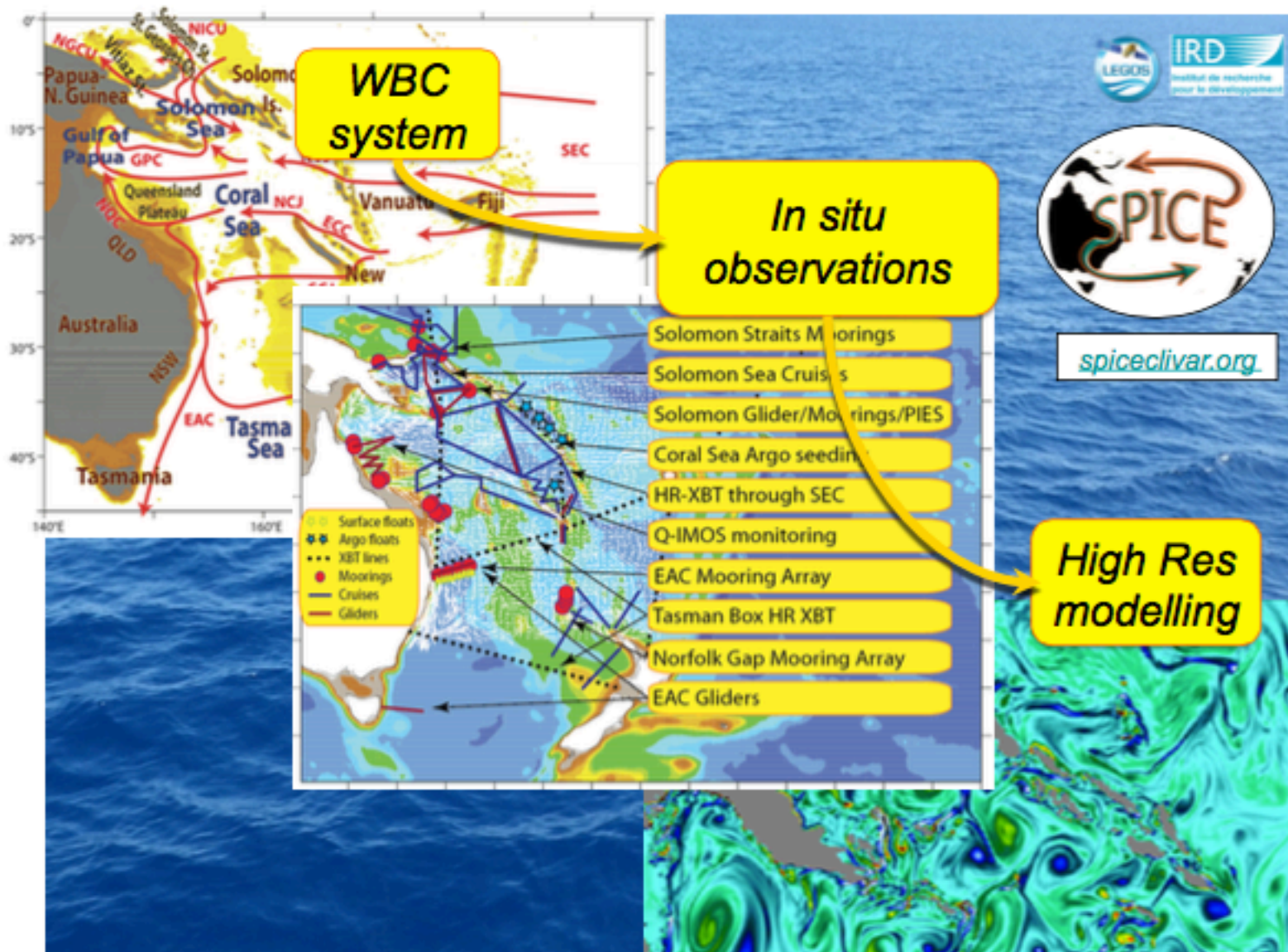
19 institutes
7 countries

Implementation: TimeTable

Southwest Pacific Ocean and Climate Circulation Experiment

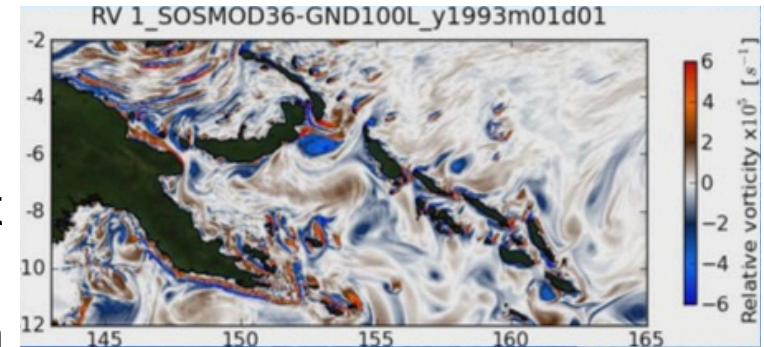
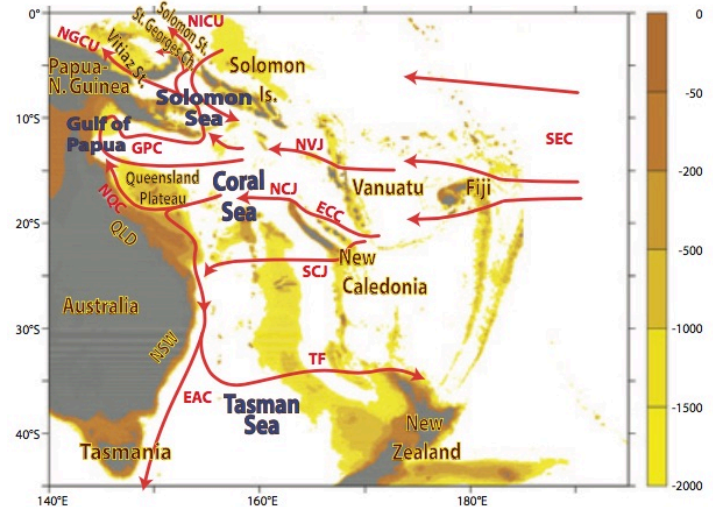
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PROGRAM PLANNING	1ST SW PACIFIC WORKSHOP FORMULATION OF SCIENTIFIC ISSUES		AGU SPCZ/SPICE MEETING	ENDORSEMENT CLIVAR SSG					WESTERN PACIFIC JGR ISSUE		
		OBSERVATIONAL PROGRAM DESIGN SUBMISSION TO NATIONAL AGENCIES				SPCZ workshop		NPOCE-SPICE OSS, Qingdao	SPICE SPECIAL SESSION AT 10ICSHMO, Noumea		
NUMERICAL MODELING	DEVELOPMENT OF NESTED REGIONAL MODELS			DEVELOPMENT OF LOCAL MODELING FACILITIES AND EXPERTISE			REGIONAL MODELLING AND ASSIMILATION IN THE SOLOMON SEA 1/12° 1/36°				
	REGIONAL MODEL ASSIMILATION IN THE CORAL AND TASMAN SEA										
OBSERVATIONS	PRELIMINARY HYDROGRAPHIC CRUISES			MOORING DEPLOYMENTS IQLD			MAIN HYDROGRAPHIC CRUISES			SOLOMON/NICU EAC	
	REPEAT XBT SURVEYS			XBT ENHANCEMENT							
	ARGO FLOAT DEPLOYMENTS			CORAL SEA SEEDING							
	VOS EQUIPMENT WITH IMET STATIONS										
MONITORING SYSTEM DESIGN	GLIDER TESTS OVER JETS AND WBCs			REPEAT GLIDER SURVEYS IN THE SOLOMON SEA			REPEAT GLIDER SURVEYS IN THE TASMAN/CORAL SEA				

Multi-Pronged Simultaneous Approach



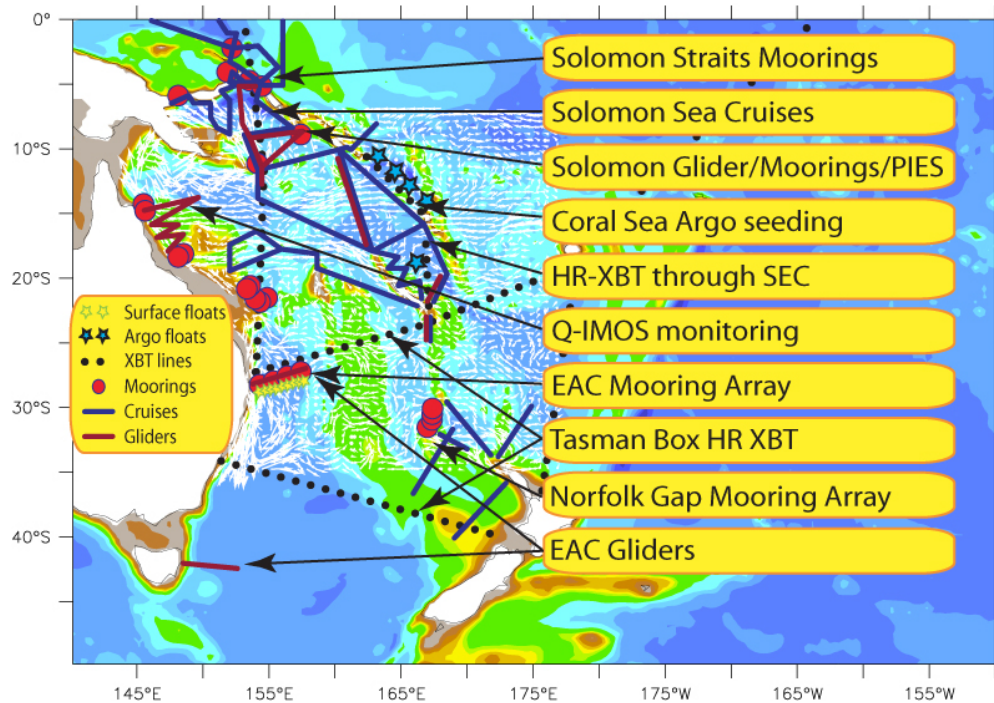
Implementation: Modeling

- ◆ Global and regional models (e.g. BlueLINK, Mercator Ocean etc), at eddy-resolving spatial scales ($<10\text{km}$), to explore mesoscale activity, multi-decadal climate trends and link coastal impacts to regional and global climate phenomena (ENSO, SAM, PDO etc.)
- ◆ Specific studies include:
 - The jet-like structures in the SPICE area;
 - The eddy dynamics in boundary currents e.g. East Australian & Gulf of Papua Current
 - The shelf-scale upwelling processes
 - The dynamical drivers of SST anomalies in the Coral Sea and associated coral bleaching events.



3 km ($1/36^\circ$) Nested
Djath et al., 2014a,b;
Melet et al. 2010; 2011; 2013

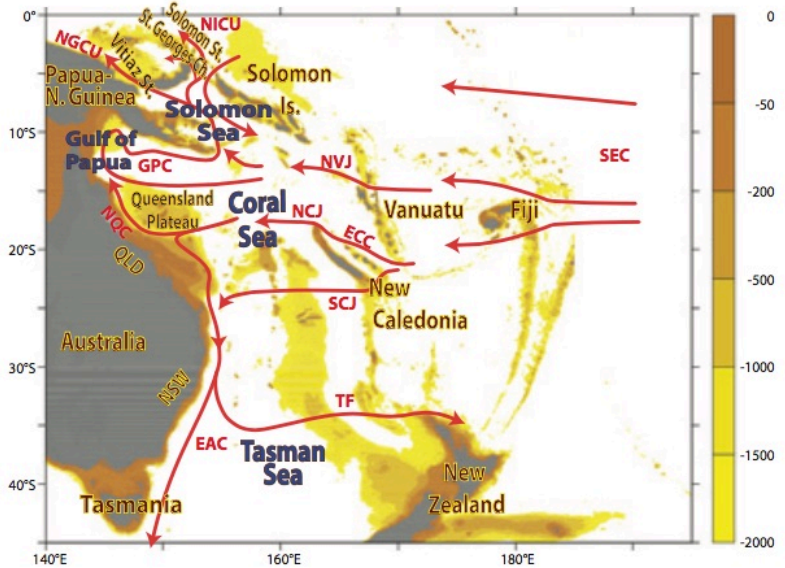
Implementation: Observations



- Complete large-scale surveys of the Coral, Solomon, and Tasman Sea inflows and outflows with special attention to the WBC;
- Test large scale monitoring of key climate quantities such as the thermocline inflows and outflows and air-sea fluxes;
- Observe simultaneously in different parts of the basin to accomplish regional mass, heat, and freshwater budgets;
- Achieve island-scale process studies to address regional variability

Science Results: SPICE Legacy (to date)

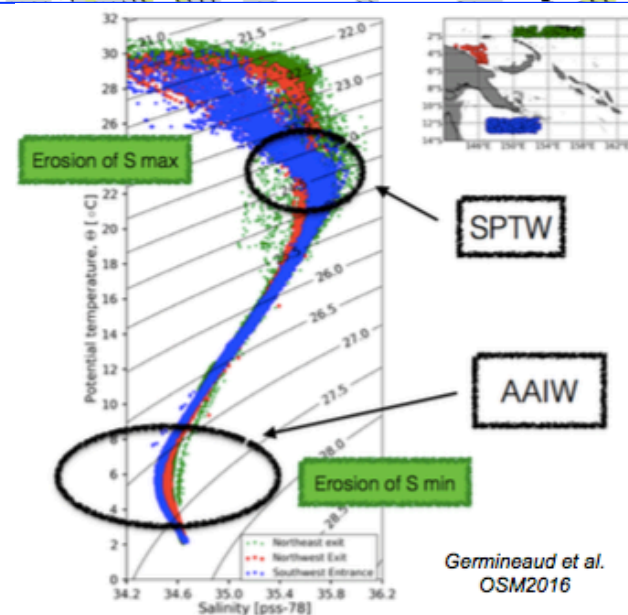
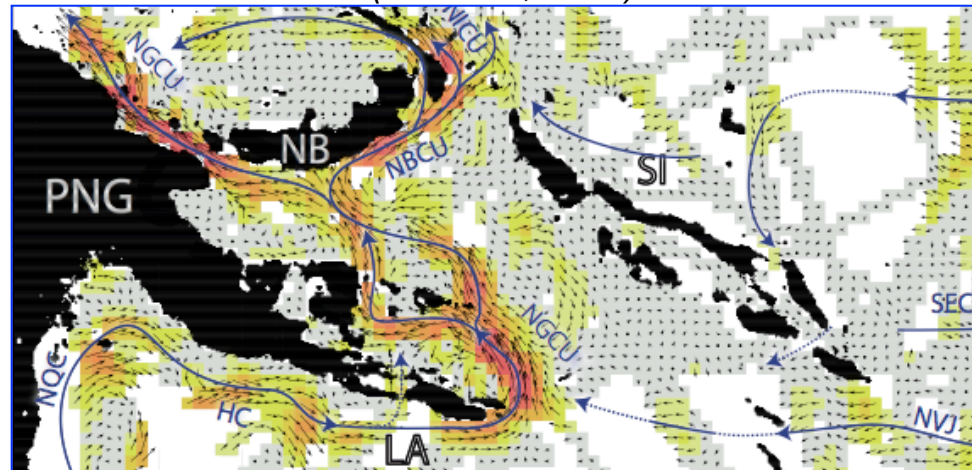
- See Ganachaud et al., (JGR, 2014) and other papers in the 2014 special JGR (eds: Dunxin Hu (China); Alex Ganachaud (France); Wenju Cai (Australia); Billy Kessler (USA); Janet Sprintall (USA))
- A renewed description of the oceanic pathways to the equator: jets, WBCs, direct NVJ path to the Solomon Sea and EUC water origins as well as their seasonal and interannual variations;
- Discovery of the deep extension of the New Caledonia Jet and Gulf of Papua Current versus the broad and shallow North Vanuatu Jet;
- Unprecedented description of Solomon Sea circulation - inflows, outflows, and their partitions;
- Discovery of the Tasman Front/EAC interplay and opposite variations on decadal timescales;
- Improved understanding of the southeastward tilt of the SPCZ in relationship with SST, wind and rainfall.



Science: Focus on Solomon Sea

- *Low Latitude WBC transits the Solomon Sea on way to the equator*
- *intense flows encounter complex and steep topography*
- *Deep reaching boundary currents*
- *3 narrow exit passages*
- *High mixing suspected induces water mass transformation*
- *Least documented sea of the southwest Pacific with few prior observations*
- *Models showed large discrepancies in pathways of flow*

Thermocline Currents (100-300m) ADCP Climatology
(Cravatte, 2011)



Implementation: SPICE Solomon Sea Programs

Hydrographic Surveys

Pandora (July 2012)
MoorSPICE (February 2015)
Cassiopee (August 2015)

Moorings:

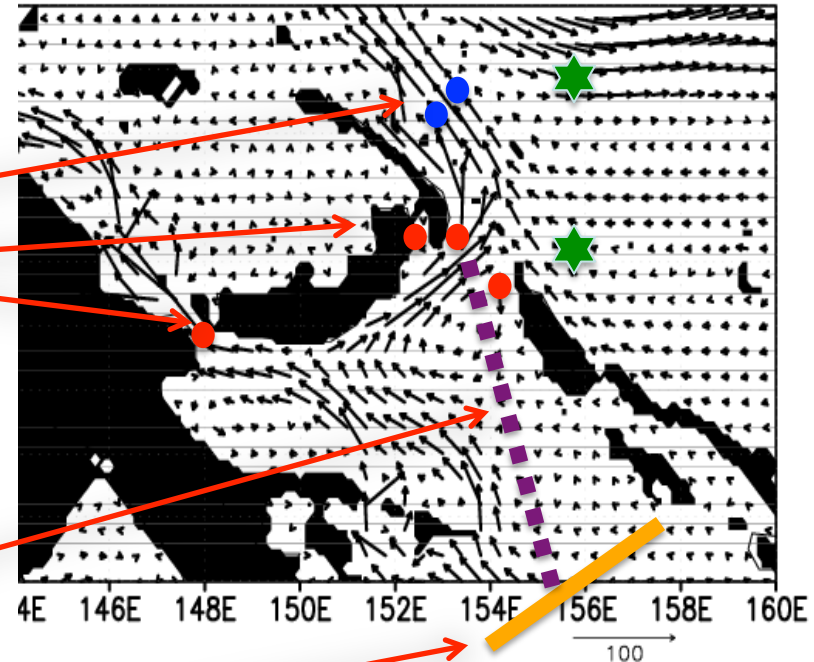
3-year 2012-2015
Vitiaz Strait, St. Georges Channel and Solomon Strait,
and east of the New Ireland.
(France, Japan, Papua New Guinea and the U.S.)

VOS:

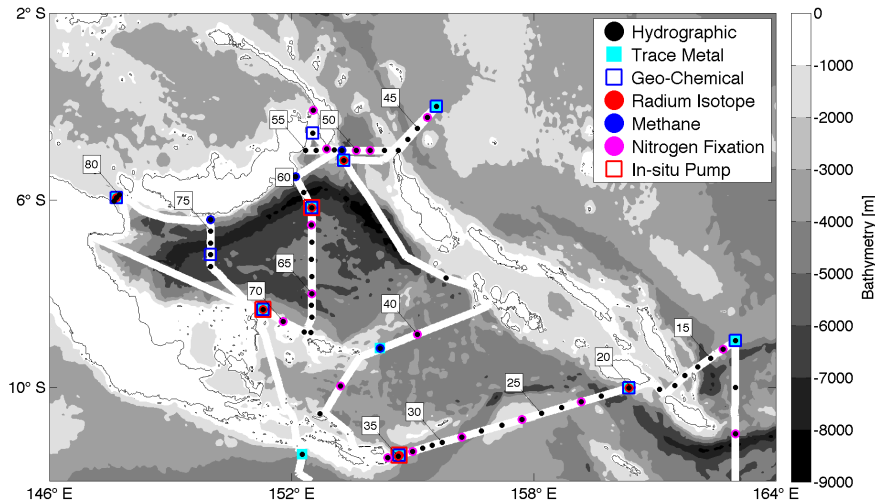
HR-XBT: New Caledonia and Vanuatu.
HR-XBT PX05 Brisbane - central Solomon Sea
Enhanced Argo float and drifter deployments

Gliders (Spray Glider):

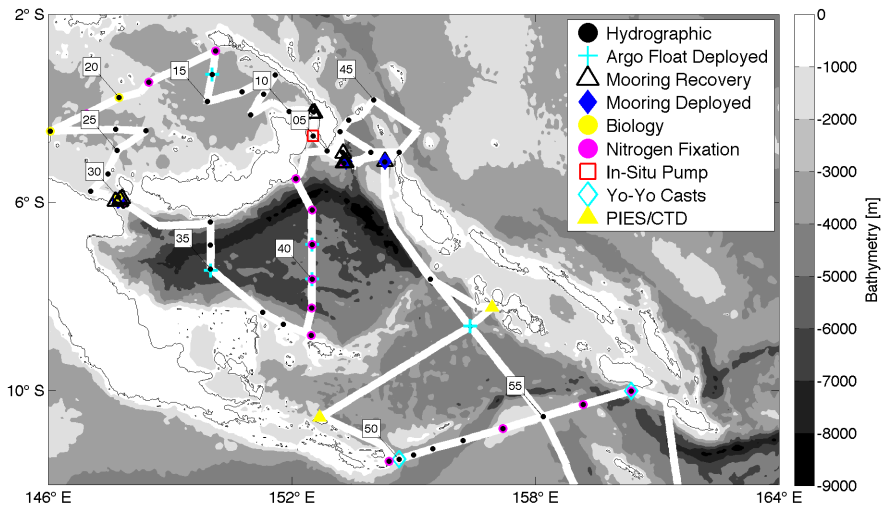
Monthly series since 2007;
Supplemented with Pressure Inverted Echo Sounders
Mass and heat transports
(US, France, Papua New Guinea, Solomon Islands)



Solomon Sea Hydrographic Surveys

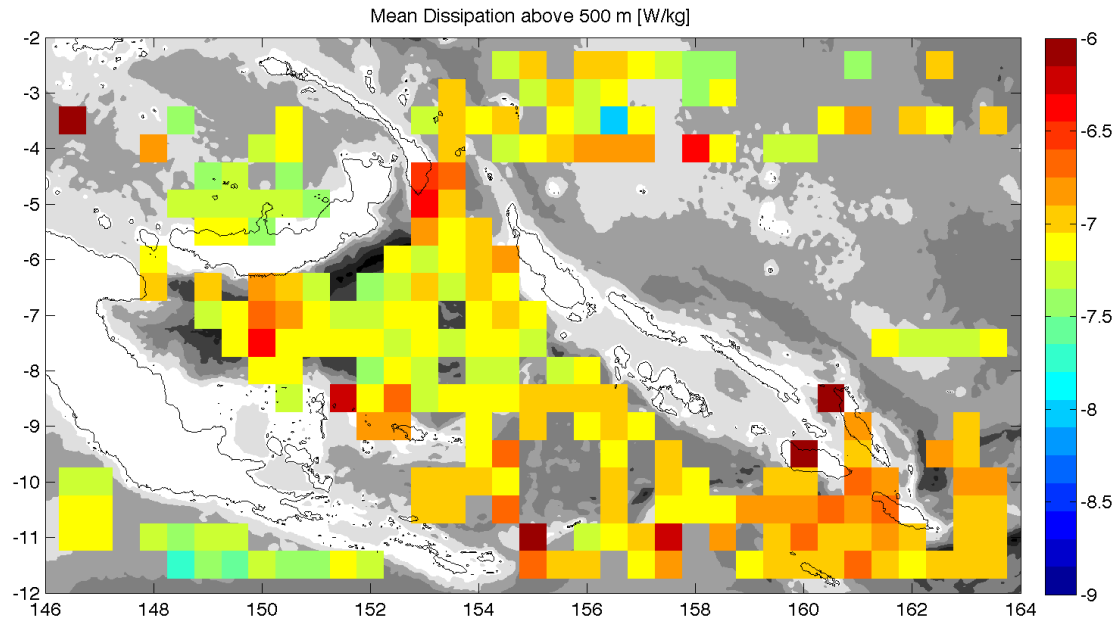


Pandora: August 2012 (SE trades)
R/V L'Atalante (France)
 170 CTD/O₂/LADCP casts
 Biogeochemistry: N₂ fixation, trace elements
 Mooring Deployments



MoorSPICE: February 2014 (NW monsoon)
R/V Thompson (US)
 78 CTD/O₂/LADCP casts (repeats)
 Biology: N₂ fixation
 Mooring Recovery & redeployments

SPICE Solomon Sea: Science



*Mixing:
Elevated
dissipation near
straits and
bathymetry*

Using CTD/LADCP and Argo Profiles to parameterize the rate of TKE in the Solomon Sea using Thorpe scales and Fine Scale Parameterization based on Shear/Strain (e.g. Polzin et al., 2014)

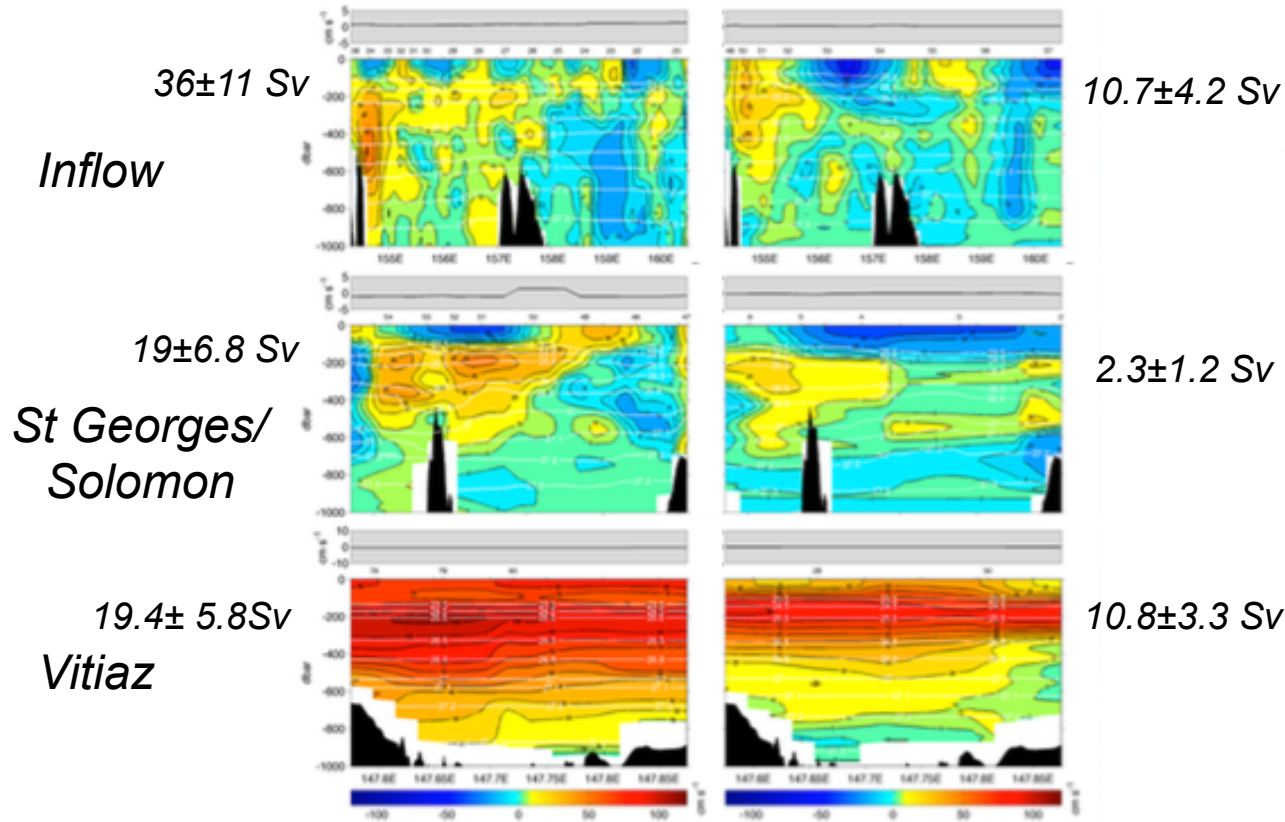
SIO Student Marion Alberty

Chapter 1: Spatial patterns of mixing in the Solomon Sea

Supervisors: Janet Sprintall (SIO), Jen MacKinnon (SIO), Alex Ganachaud (IRD)

SPICE Solomon Sea: Science

(L)ADCP Velocities
 July 2012 February 2014



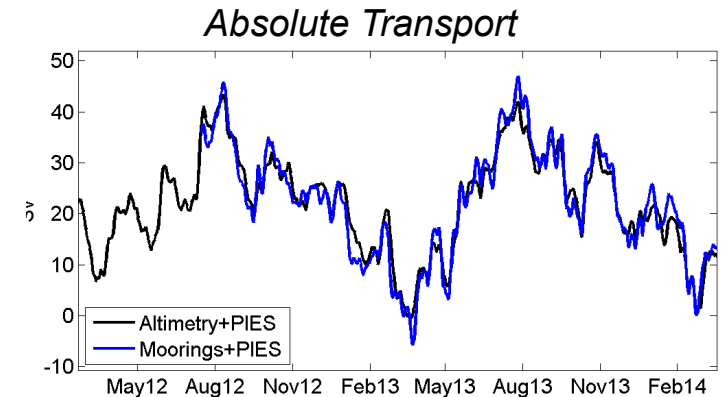
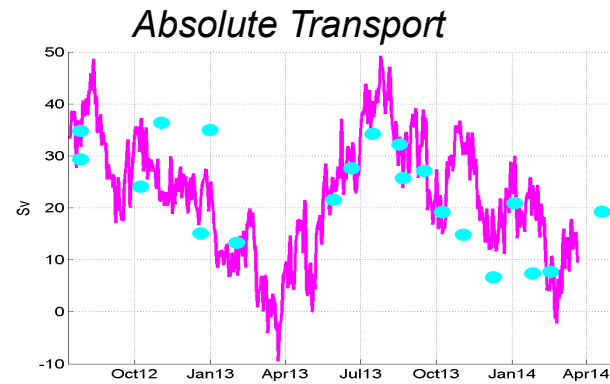
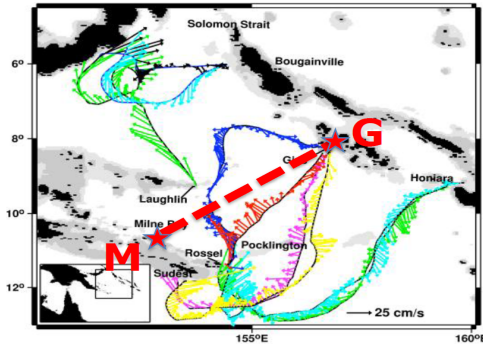
Inverse model of circulation within the Solomon Sea and how this changes with contrasting strong and weak trades

LEGOS Student: Cyril Germaineaud

Chapter 1: Pathways and water mass properties of the thermocline and intermediate waters in the Solomon Sea

Supervisors: Alex Ganachaud (IRD), Sophie Cravatte (IRD), Janet Sprintall (SIO)

SPICE Solomon Sea: Science



Compute the time series of absolute transport from *dynamic height moorings, bottom pressure sensors, and mean dynamic topography*, and compare it with *glider transects*

SIO Student: Waen (Arachaporn) Anutaliya

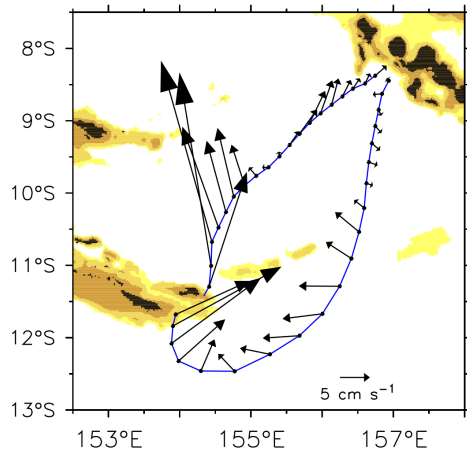
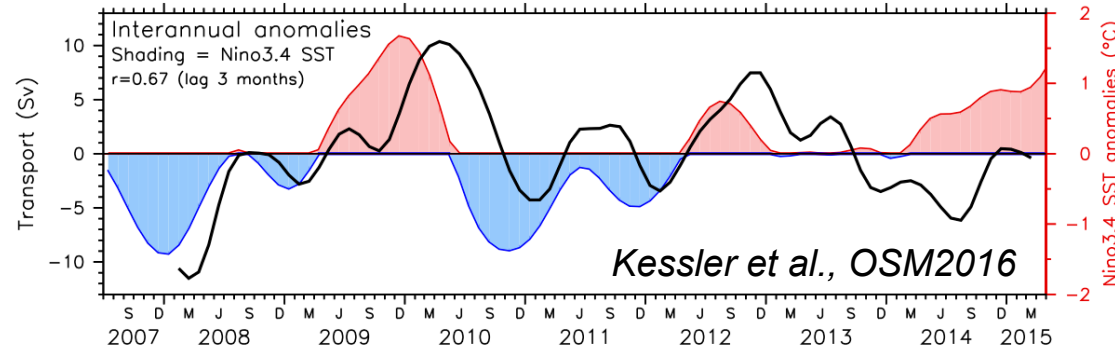
Chapter 1: Transport from PIES/Dynamic Height Moorings in the Solomon Sea

Supervisors: Uwe Send (SIO), Janet Sprintall (SIO), Julie MacClean (SIO)

SPICE Solomon Sea: Science

Solomon Sea transport and Nino3.4

Spray glider. 54 coast-to-coast sections. Missions 078006–156027.



WBC measurements of Solomon Sea from gliders show strong New Guinea Coastal Current trapped to topography, and strong correlation with ENSO (enhanced equatorward transport during El Nino)

*PIs: Kessler (PMEL) and Davis (SIO)
Davis et al. (2012); Kessler et al. (in prep.)*

SPICE Solomon Sea Science: What's Next?

- *Continuing analysis as part of thesis work for students include looking at transport variability through the straits from the mooring time series (ongoing 1-2 year effort expected)*
- *“Chapeau” paper in progress: overview and first-look of all measurements collected as part of the two hydrographic cruises (Ganachaud et al.)*
- *Synthesis of all concurrent time series data (moorings, gliders, PIES) to examine variability in inflows and outflows, storage effects and water mass transformation etc.*
- *Ongoing modeling effort to improve mixing parameterizations and sub-mesoscale variability etc.*

SPICE Solomon Sea: Data Management

- PIs have a password-protected data management site to allow data sharing among SPICE researchers prior to official release
- Links to freely available data collected as part of SPICE (e.g. HR-XBT, Argo) are provided on official web site spiceclivar.org
- Hydrographic data sets from Solomon Sea are all quality controlled and submitted to respective US (NODC) and French data archives.
- Mooring (temperature, salinity and velocity) data presently being quality controlled and will be made available through Ocean Sites web in their netcdf format
- Making data products (e.g. transports) available in future through official web site

SPICE: What Worked?

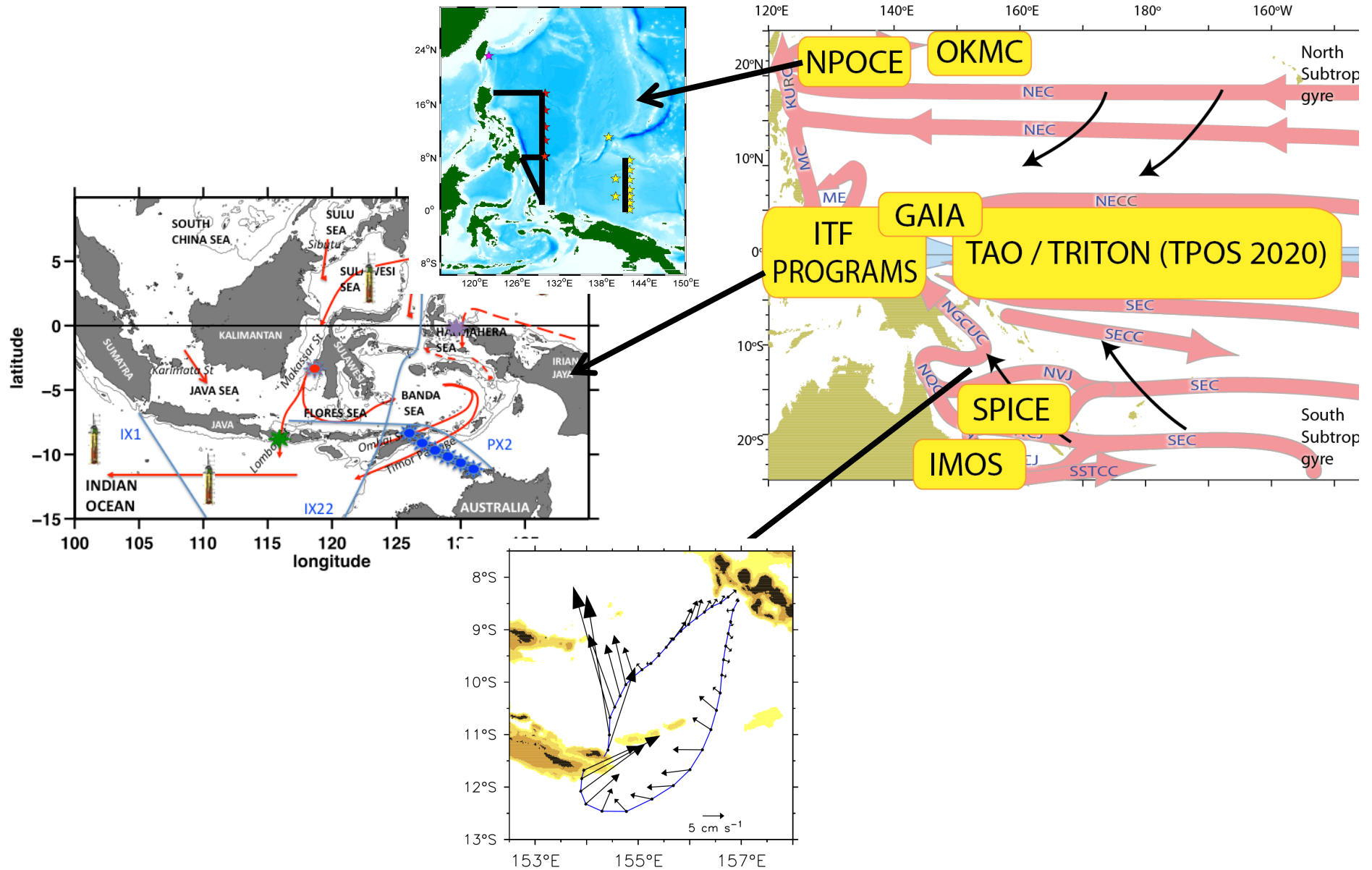
- *International collaboration was key in successfully organizing ship time; sharing instrument resources and technicians; sharing supervision of students*
- *Student/personnel exchanges between France and US*
- *Frequent F2F meetings at international conferences*
- *Capacity building workshop at University of Papua New Guinea in November 2013 (106 students!) encouraged participation by regional partners in cruises and data analysis*



SPICE: Remaining Challenges

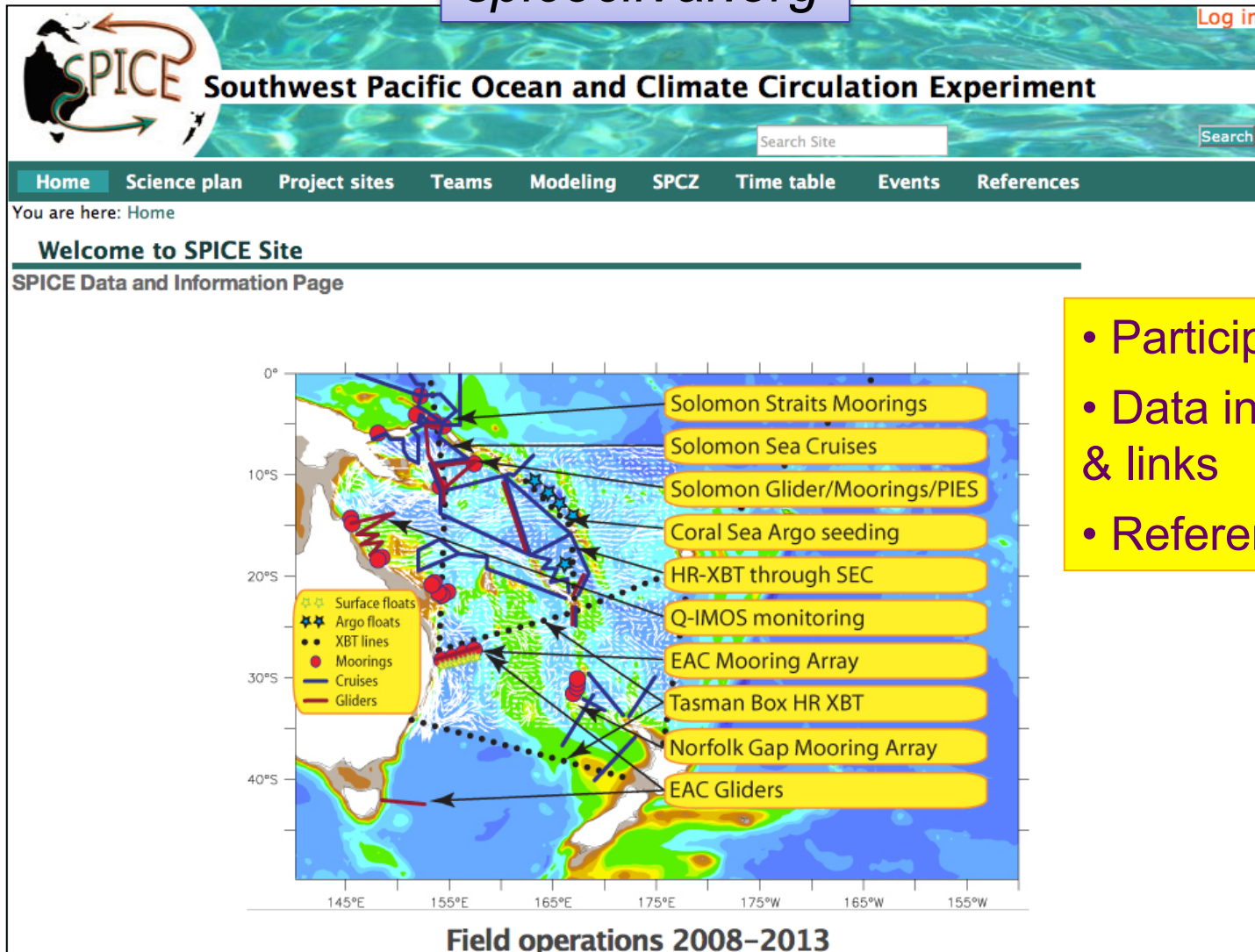
- *Modeling challenges:*
 - *Need high resolution ($1/36^\circ$) to fully resolve key features like narrow jets between islands, sub-mesoscale phenomena, but computational burden to run at basin-scale over multi-decades.*
 - *Inaccurate/missing topography*
 - *Missing sub-grid scale parameterizations for both vertical and horizontal mixing (including tidal effects)*
- *Observations still needed:-*
 - *direct mixing from microstructure*
 - *aliasing of short surveys means longer time series to resolve interannual/decadal changes*
 - *SPCZ formation, variability and longitudinal tilt (poorly represented in coupled climate models)*
- *Many open science questions:-*
 - *Is there a WBC east of the Solomon Islands (as models suggest)?*
 - *Interannual partitioning through the straits and what drives this?*
 - *Main regions and mechanisms responsible for mixing the subtropical anomalies along different water pathways and how much is ultimately transferred to the EUC?*
 - *....*

Sustained Measurements through Coordination of Pacific WBCs: The West Pacific Task Team (CLIVAR; TPOS-2020)



Thank you!

spiceclivar.org



- Participants
- Data information & links
- References