Southwest Pacific Ocean Circulation and Climate Experiment (SPICE)

Part II. Implementation Plan

October 2008

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On the cover: Salinity on density surface 25.2 kg/m^3 in the Ocean General Circulation Model for Earth Simulator (OFES) simulation at 0.1° resolution. Snapshot on January 31st, simulation year 46.

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1. Introduction

South Pacific thermocline waters are transported in the westward-flowing South Equatorial Current from the subtropical gyre center toward the southwestern Pacific Ocean—a major circulation pathway that redistributes water from the subtropics to the equator and to the Southern Ocean. The transit in the Coral Sea is potentially of great importance to tropical climate prediction because changes in either the temperature or the amount of water arriving at the equator have the capability to modulate El Niño-Southern Oscillation (ENSO) cycle and thereby produce basin-scale climate feedbacks. The southern fate of thermocline waters is, comparably, of major influence on Australia and New Zealand's climate; its seasonal and interannual evolution influences air-sea heat flux and atmospheric conditions, and it participates in the combined South Indian and Pacific Ocean "supergyre." Substantial changes in this circulation have been observed over the past 50 years and continue in global climate projections. The subtropical gyre has been spinning up in recent years with possible consequences for ENSO modulation and for the East Australian Current (EAC), whose influence has moved south, dramatically affecting the climate and biodiversity of Tasmania.

Despite its apparent importance to the climate system, few observations are available to diagnose the processes and pathways of transport through the complicated geography of the southwest Pacific. The South Pacific Convergence Zone is poorly documented; the region is remote, and the large temporal variability and strong narrow currents in complex bathymetry pose serious challenges to an observing system. Numerical model results are sensitive to parameter choices and forcing, and the results are uncertain because of the lack of in situ data for validation. The existing observational network (Argo, VOS XBT sampling, and satellite winds and altimetry) is beginning to provide a large-scale picture, but the complex circulation and western boundary currents require further dedicated study.

A first report (Ganachaud *et al.*, 2007) lays out the scientific background and identifies the open issues in the southwest Pacific Ocean. The present document describes a proposed implementation for an international, regionally coordinated experiment, the Southwest PacIfic Ocean Circulation and Climate Experiment (SPICE). The plan integrates both observational and modeling analysis, and we put forward an overall coordination strategy and an incentive to develop specific collaborative projects to address SPICE issues.

2. SPICE Objectives, Benefits, and Legacy

The goal of SPICE is to observe, simulate, and understand the role of the southwest Pacific Ocean circulation in (a) the large-scale, low-frequency modulation of climate from the Tasman Sea to the equator, and (b) the generation of local climate signatures whose diagnosis will aid regional sustainable development. This goal will be realized through four specific efforts, which are discussed in detail in the SPICE Scientific Background document (Ganachaud *et al.*, 2007a):

1. Analysis of the southwest Pacific role in global coupled models;
2. Development of an observational program to survey air-sea fluxes and currents in the Coral, Solomon, and Tasman Seas, and their inflows and outflows, with special attention to the strong boundary currents and jets;
3. Combination of these observations with focused modeling efforts to devise a sustained monitoring program to adequately sample the time variability of the currents and their heat and mass transports;
4. Using remotely and locally sampled meteorological fields, and the ocean analysis, determination of the air-sea heat and freshwater fluxes and water mass transformations that occur in the region, and their effects on the local and global climate. A focus here may be the design of a process study to observe, model, and understand the South Pacific Convergence Zone.

These objectives were established to serve primarily CLIVAR objective 1 ("describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial timescales, through the collection and analysis of observations and the development and application of models of the coupled climate system in cooperation with other relevant climate research and observing programmes"). SPICE objective 1 will help identify key features (e.g., SPCZ, meridional oceanic heat transports), and their impacts in global climate simulations on seasonal and decadal timescales. SPICE objectives 2 and 3 are to understand the relevant air-sea fluxes and oceanic currents, and to design a sustained observing system that will help improve climate modeling and ultimately prediction (seasonal prediction of local climate; decadal prediction of the large-scale climate, including ENSO). SPICE objective 4 embraces the transition into operational benefits through local oceanic impacts on the environment (downscaling). This includes local sea surface temperature (impacts on coral reefs; coastal/island climate and cyclone trajectories), sea level rise and its predictability, and capacity building (Pacific Island countries training for specific applications).

SPICE is purposely oriented toward appropriate long-term monitoring to serve climate prediction, and to foster projects and collaborations with other fields such as ocean and weather prediction, coral and ecosystem monitoring, and climate-related diseases. The expected SPICE legacy will be a monitoring system for climate-important quantities, operational tools for local applications along with training and appropriate data accessibility, and more generally a better understanding of (1) local climate impacts and predictability, (2) fundamental climate processes involved in subtropical-tropical exchanges and western boundary current variability, and (3) SPCZ dynamics.

3. Overall Organization and Timetable

SPICE IS REGIONALLY FOCUSED, but integrates basin-scale studies of the ocean-atmosphere system. The large-scale context, including the basin scale South Pacific circulation and its connection with equatorial processes and climate variability, is addressed within CLIVAR and related projects. The priorities that are specific to SPICE were set as follows (Fig. 1):

1. South Pacific Convergence Zone: formation, variability, air-sea interactions;
2. South Equatorial Current inflow: jet formation, bifurcation on Australia, western boundary currents;
3. Tasman Sea circulation: EAC/EAUC variability; heat balance and air-sea fluxes in the Tasman Sea;
4. Gulf of Papua and Solomon Sea circulation: western boundary current and interior pathways, flow through the Solomon Straits;
5. Downscaling and environmental impacts of climate and oceanic environment changes: cyclones; sea level rise; coral reef sustainability; coastal ecosystems.

The proposed approach is collaborative and cost-effective, based on existing human and technical resources, and fits within timetabled southwest Pacific activities (Fig. 2). The plan will rely heavily on ocean and atmosphere modeling that will be combined with three types of observations: (1) process studies to acquire basic knowledge in the north Coral Sea region, (2) monitoring where necessary, and (3) regional adaptation of global observing programs. The following two sections describe the modeling and observational issues and approach.

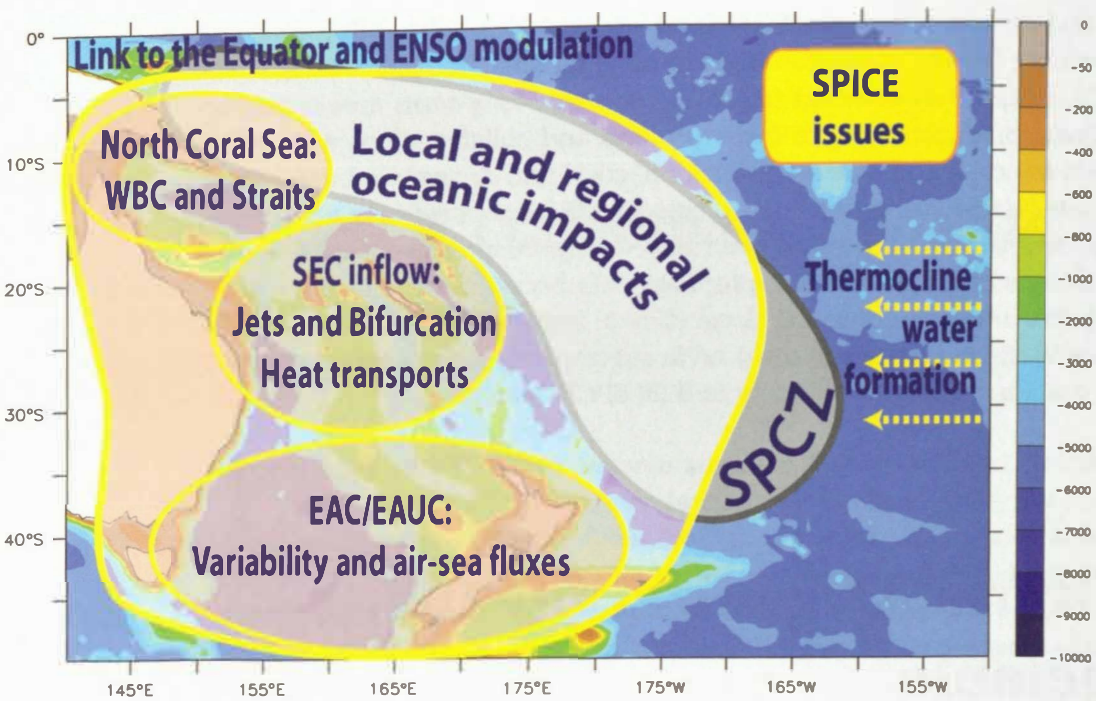

Figure 1: Main issues addressed within SPICE. Thermocline water formation and junction to the Equator are addressed within larger-scale programs.

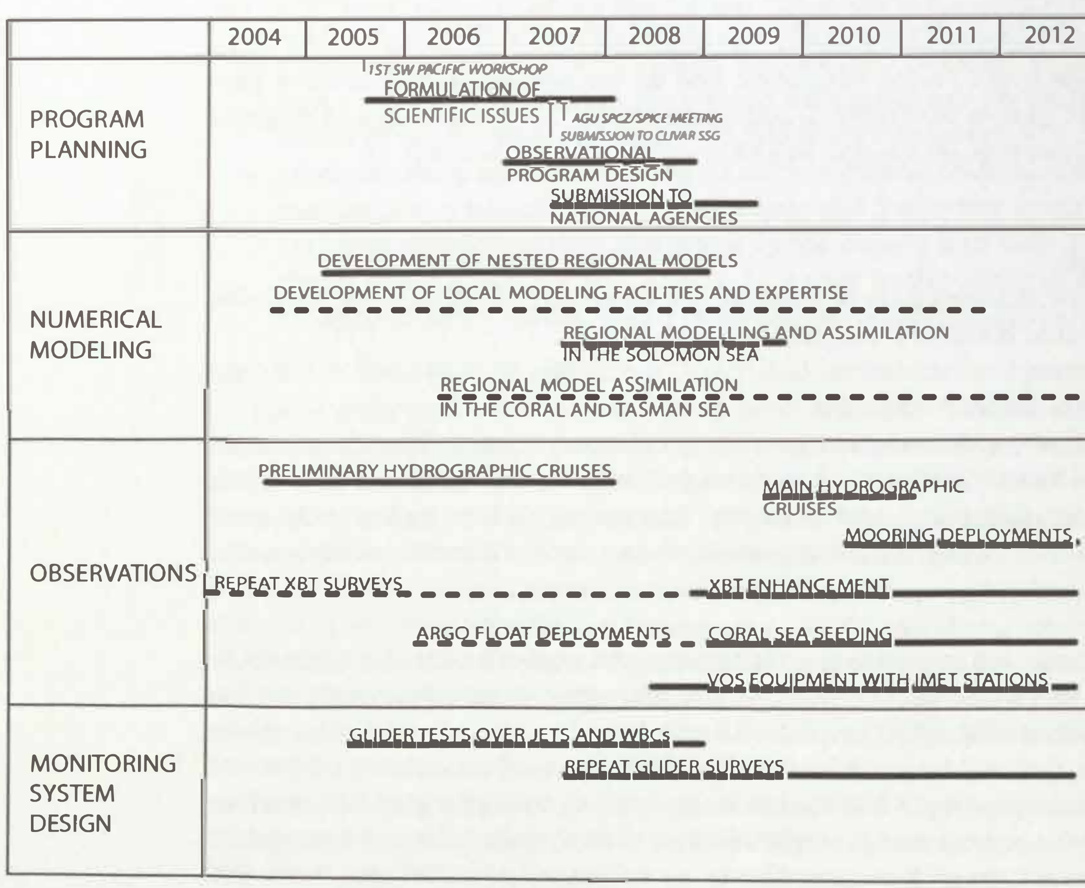

Figure 2: Timetable of major southwest Pacific activities relevant to SPICE objectives.

4. Modeling Strategy

THE SPICE PROGRAM IS STIMULATED by the need to improve climate prediction at both large scales and regional scales to allow island communities to benefit from climate research. Model experiments will provide the necessary linkage between the large-scale questions (e.g., how the subtropical gyre waters get to the Equator) and the regional issues (e.g., what are the detailed pathways and impacts in the SW Pacific) through downscaling. A variety of numerical models that include the region (Fig. 3), validated against observations, will help to understand dynamical aspects that cannot be adequately observed and to identify the observable features, thereby providing guidance to design the in situ observing program. Model types range from the global, coupled system to local, high-resolution nested models (Fig. 3, middle). The latter will be extensively used for this purpose, with downscaling and upscaling to evaluate mesoscale and island effects. Important operational oceanography projects concern the Southwest Pacific (e.g., Bluelink, Mercator, and SODA). BLUElink and Mercator are assimilating systems that offer a nowcast and forecast estimate of the true ocean state that are supported operationally, providing information throughout the experiment. The current operational BLUElink system provides $0.1° \times 0.1°$ resolution in the experiment region and $0.9° \times 0.1°$ resolution in the South Pacific, as shown in Fig. 4, within a single-system downscaling to represent the fine scale bathymetric pathways. This approach can provide a useful verification to both the proposed regional high-resolution simulation of ocean and climate during the experiment period. In 2010 the operational BLUElink system will be upgraded to have eddy-resolving resolution in the South Pacific. The assimilating systems can provide realistic boundary conditions to regional models; in return, regional studies contribute to improve the truthfulness of large-scale models.

SPCZ issue and connection with VOCALS: Although precipitation plays a key role in tropical climate and its variability, the South Pacific Convergence Zone is not well simulated in coupled models, which generally fail to reproduce its southeastward bend, instead tending to generate a zonal SPCZ (double ITCZ, Mechoso *et al.*, 1995). This is a major modeling challenge that needs to be better understood in terms of cause and implications. Biases are apparent in the simulation of both the precipitation climatology and its sensitivity to anomalous climate forcings. The elimination of this error is a principal goal of the VOCALS program (Wood *et al.*, 2006). VOCALS focuses on multiple aspects of ocean-atmosphere coupling, including errors in ocean dynamics and associated effects on surface flux exchange or the parameterization of low-level marine stratus clouds.

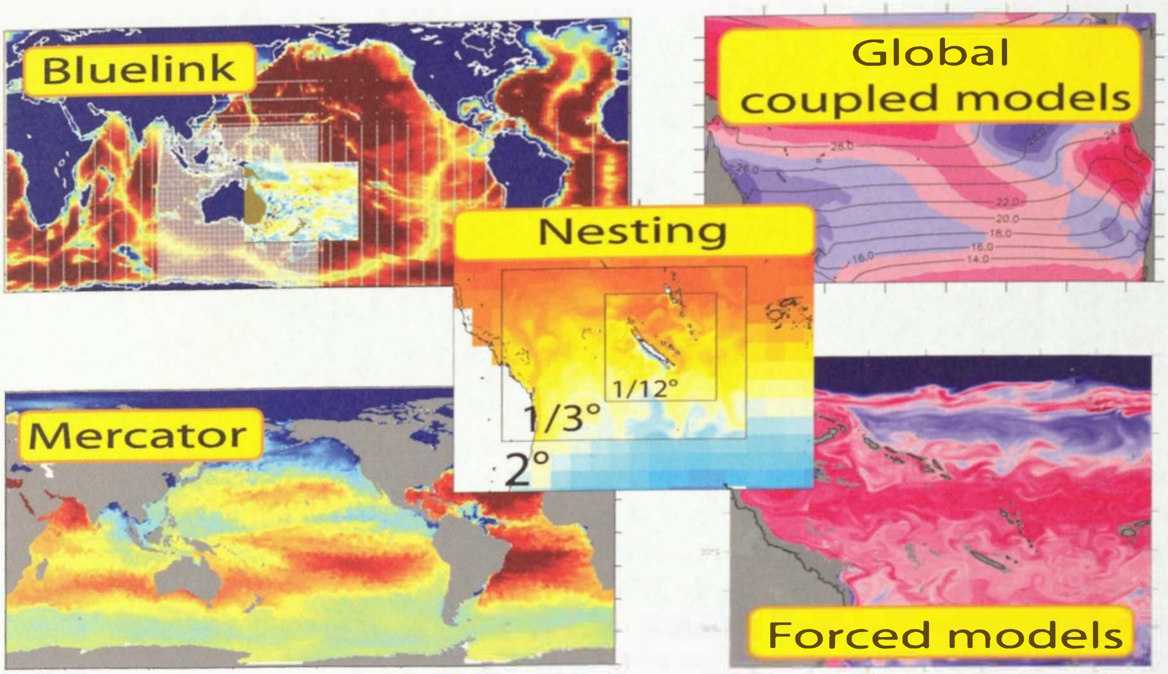

Figure 3: The modeling approach will rely on a range of models from coarse climate models to high-resolution, nested regional models. Upper left: the BLUElink (`www.marine.csiro.au/bluelink`) operational model grid and southwest Pacific subdomain. Lower left: the Mercator French operational model (`www.mercator-ocean.fr`). Middle: nesting of the Noumea ROMS model from the 2° Mercator grid to 1/12° grid around New Caledonia (`www.ird.nc/UR65/ROMS`). Upper right: an IPCC-IR4 global coupled model. Lower right: the OFES high-resolution model.

This double ITCZ feature can be compounded by, and even interpreted as, an eastern extension of the SPCZ "diagonal": e.g., models may produce an excessively zonally oriented SPCZ, precipitation that extends too far into the eastern dry descent region, or precipitation that fills in the region between the observed SPCZ position and the equator. This interpretation highlights that severe biases often occur in the eastern SPCZ region, where the southeasterly trades enter the convection zone. Feedbacks among inflow into a convection zone, its moisture characteristics, and parameterized convection, are known from other applications (e.g., Neelin *et al.*, 2003) and may well contribute to the biases in the SPCZ. Other potential contributions to SPCZ bias may include eastern Pacific cloud feedbacks or circulation errors, or ocean model biases (Dai *et al.*, 2003; Takahashi and Battisti, 2007; Kirtman and DeWitt, 1997; Davey *et al.*, 2002).

Even if models simulate approximately correct precipitation climatologies relative to the observations, the sensitivity of the models to perturbations in climate variables such as temperature, moisture, or wind may not be correct. Such "sensitivity biases" may provide insight into mechanisms of interest, such as a model's ability to simulate the interannual variability. At the same time, they may facilitate the testing of hypotheses about processes controlling the climatology, offering potential solutions for bias mitigation. As an illustration,

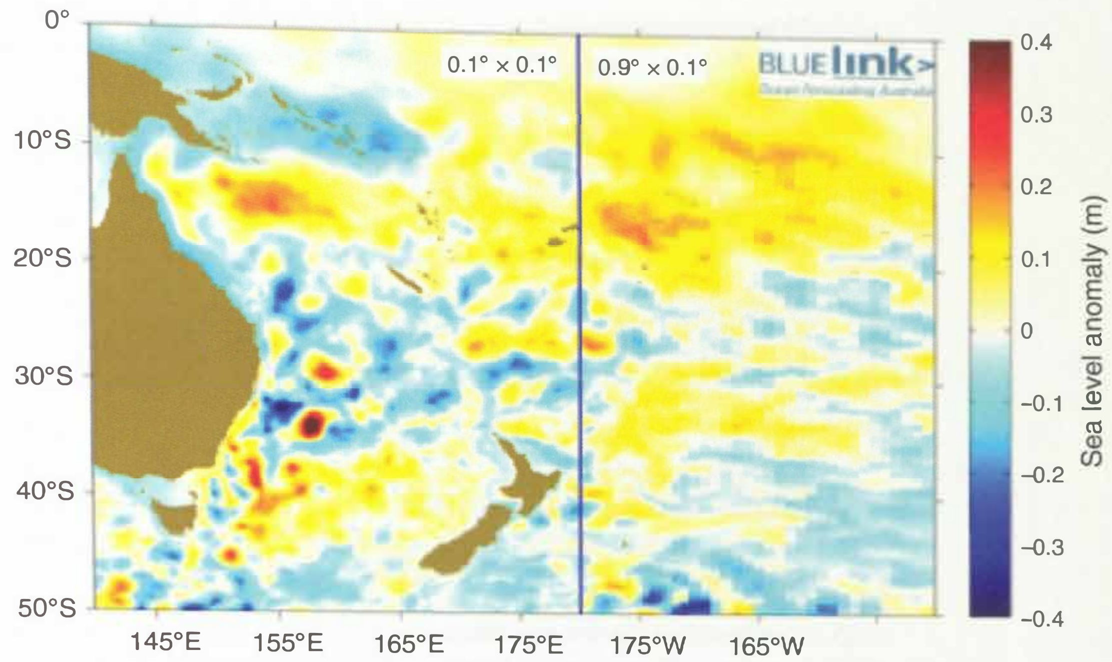

Figure 4: BLUElink ocean prediction system (`www.bom.gov.au/bluelink`) sea level anomaly with 0.1° × 0.1° resolution in the SPICE region and 0.9° × 0.1° in the South Pacific.

consider how the high-frequency variations of the SPCZ could elucidate the significance of inflow to the spatial characteristics of the SPCZ. For anomalously strong (low-level) trade wind inflow from the eastern Pacific toward the SPCZ, lower tropospheric moisture along the eastern SPCZ margin will be lowered, thereby inhibiting convection and precluding the SPCZ from expanding as far to the east (Lintner and Neelin, 2008). Models with convection schemes lacking appropriate sensitivity to lower tropospheric moisture, or those that produce insufficiently large horizontal gradients in moisture between the eastern Pacific dry zone and the SPCZ would, under similar trade wind perturbations, underestimate the changes to the eastern edge of the SPCZ.

Evaluation of such mechanisms in models, such as those in the Coupled Model Intercomparison Project-3 (CMIP3) archive hosted at Lawrence Livermore National Laboratories, and comparison to existing observations, can inform analysis of observations collected under SPICE, and may aid in the design of future SPCZ observations.

4.1 Modeling Challenges

Numerical simulations of the oceanic and atmospheric circulation will confront the issues brought up in the scientific background document (Ganachaud *et al.*, 2007), ordered according to the spatial scales of interest:

1. **Teleconnections.** Some aspects of the connections between the southwest Pacific Ocean and atmosphere and the basin-scale climate system need to be identified. Teleconnections include the remote atmospheric forcing, the oceanic pathways to the equator, and its influence on equatorial thermocline waters. On basin scales, those have been debated over the past 10 years, and a focus on the southwest Pacific role is proposed here.

2. **SPCZ.** A survey on how the current coupled atmosphere-ocean models simulate SPCZ formation, climatology, and variability will be coordinated. The analysis will be guided by recent developments such as the simple theory for convective margins (Lintner and Neelin, 2007), which emphasizes the interplay of inflow moisture from the dry region, inflow rate, convergence/evaporation, and convective threshold. The evolution of the flow from the stratocumulus-covered region along the coast of South America, to the transition region of shallow cumuli, and the region of deep convection in the SPCZ, will be examined in detail.

3. **Thermocline water pathways**

   a. **Jets.** The Southwest Pacific thermocline circulation in large-scale models faces important flaws. The formation and dynamics of the narrow oceanic jets is not very well understood. Large-scale models produce jets with weak variability because of their limited resolution. A better understanding of the jet dynamics and their formation in the complex topography of New Caledonia and Vanuatu is important to describe how SEC waters reach the Australian boundary currents.

   b. **Bifurcation.** The SEC bifurcation against Australia occurs over a large meridional extent, varies in time and depth, and encounters the Queensland Plateau and the complex Great Barrier Reef system. Its position and variability is crucial to the amount of equatorward water implied by the basin-scale circulation (Qu and Lindstrom, 2002; Kessler and Gourdeau, 2007), with associated current reversals and possible local impacts on the Great Barrier Reef ecosystem.

      Most published simulations find the bifurcation north of its observed position. Because of the spatial scales involved, an observation system is difficult to establish, and comprehending the bifurcation will heavily rely on accurate modeling.

   c. **Solomon Sea and route to the equator.** The thermocline water flow within the Solomon Sea is unexplored. High-resolution models prove highly sensitive to details in their configuration. Because the thermocline route associated with each strait differs importantly, their relative contribution needs to be modeled accurately. Climate simulations use an oceanic resolution that is too coarse to represent the Solomon Sea and its straits, sometimes forcing the equatorward flow to circumvent the Solomon Sea so that most thermocline waters reach the EUC via an incorrect route. How such a deviation changes the time lag and water mass transformation before SEC waters reach the Equator needs to be understood.

d. **EAC.** The high variability in the EAC region is associated with complex interaction between boundary currents, eddies, and deep topographic features. The EAC separation, the Tasman Sea variability involving eddy and mean flow interactions, and its reattachment north of New Zealand are not well understood.

e. **Tasman Outflow.** The Indian Ocean fate of SEC waters via the Tasman Outflow south of Tasmania determines the partition of intermediate and lower thermocline waters between those two basins. The Tasman Outflow transport needs to be better comprehended. It involves interaction between EAC variability, the amount of water returned to the subtropical gyre via the STCC, and the Tasman Sea.

4. **Variability of the ocean-atmosphere system.** Both ocean and atmosphere vary considerably on seasonal, interannual, and decadal timescales within the equatorial and subtropical region, resulting in fluctuations in the SEC strength, bifurcation latitude, and boundary current transports. The dynamics of those variations involve thorny interactions between oceanic waves, islands, and oceanic flow patterns (Maharaj *et al.*, 2005, 2007; Kessler and Gourdeau, 2007). The challenge is to further explore this variability using intermediate-complexity ocean modeling techniques to better understand the mechanisms and their contributions.

5. **Oceanic impacts**

   a. **Pacific Island Countries.** Coastal ocean circulation near islands involves large-scale components as well as topographic effects on both ocean and atmosphere on scales smaller than 10 km. Ocean temperature results from large-scale currents superimposed with local effects such as upwelling. While sea surface conditions affect cloudiness, wind strength, cyclone trajectories, and biological dynamics, ocean imprint is essentially unknown in the Southwest Pacific islands.

   b. **Australia and New Zealand.** The substantial warming in Tasmania associated with an observed shift in the subtropical gyre is expected to be associated with important changes in rainfall and atmospheric circulation along the coast. Similarly, changes in oceanic conditions are expected to influence the Great Barrier Reef and coastal New Zealand ecosystems.

   c. **Global climate.** The impact of anthropogenic climate change, concomitant with natural variability, will vary substantially with location. To generate climate projections that can be useful to local communities, global climate projections need to be downscaled, incorporating local ocean influence.

4.2 Modeling Objectives

The aforementioned challenges can be addressed through appropriately designed modeling experiments to, specifically,

1. Improve the realism of the southwest Pacific geography/bathymetry in large-scale models;
2. Understand the Southwest Pacific dynamics and relation with basin-scale climate;
3. Help optimize observational design strategies;
4. Simulate the small spatial-scale features associated with boundary currents, jets, islands, and straits, and upscale this into climate models;
5. Understand ocean-atmosphere interaction at regional, coastal, and island scales;
6. Adapt, or downscale, global climate projections into results that are useful to island communities;
7. Develop models based on low-cost infrastructure so that participating countries can create or use their own modeling capacities.

4.3 Modeling Approach

The SPICE modeling activities will draw upon regional expertise and computing facilities hosted in research centers (Melbourne, Wellington, Noumea, Hawaii, UCLA). We propose to address the SPICE objectives using a variety of models and interlaced approaches. Six types of model will be used: (1) basin-scale general circulation model (GCM) with typical resolution ranging from 20 km–200 km, (2) coupled GCM, data-assimilating (3) reanalyses, (4) operational GCMs, (5) regional (nested) models with typical resolution of 2 km–20 km, and (6) process, or simplified, models. Objectives 1 and 2 depend upon 4 and possibly 5. Conversely, objectives 4 and 5 rely upon large-scale models, forced or assimilated to provide boundary conditions to regional, high-resolution models ("downscaling"). The use of ocean-atmosphere coupled models to address objective 5 entails detailed knowledge of the oceanic conditions before coupling. Objective 6 is based on IPCC climate projections downscaled with a regional climate model, e.g., REMO. This approach, along with that of objective 5, will not only help to test and improve IPCC projection in the Southwest Pacific, but also respond to a high demand of Pacific Island countries who are the most vulnerable to changes in oceanic and atmospheric conditions. Overall, regionally improved models are expected to help identify large-scale model deficiencies and prompt their correction. Such improvement may be implemented through "upscaling" by embedding a regional model in a large-scale model during integration.

4.4 Numerical Models

Basin scale or global scale GCMs, forced: Analysis of existing basin-scale or global ocean GCMs is useful in identifying the dynamics of the South Pacific

Ocean. An analysis of the French NEMO model (ORCA05 configuration at 0.5° horizontal resolution; 31 levels) pinpointed the main mechanisms driving the seasonal variability of the southwest Pacific gyre system (Kessler and Gourdeau, 2007). The Japan/U.S. OFES simulation (0.1° horizontal resolution, 54 levels) output is currently available and preliminary studies revealed rich small-scale structures in the southwest Pacific (Richards *et al.*, 2006). Further analyses on at least those two models (e.g., McCreary *et al.*, 2007), combined with the limited available observations, will help understanding of the current system and guide further observations and model improvements such as topography in the straits, e.g., in the Solomon Sea.

Global scale GCMs, coupled: The oceanic and atmospheric conditions in the southwest Pacific need to be analyzed in the existing model simulations (IPCC-AR4/WRCP CMIP3 Multi-Model Data). This will allow validation of the past and present conditions, and identification of the mechanisms and processes characterizing the role of the southwest Pacific with respect to the basin-scale processes. Wind-stress sensitivity experiments using CGCMs will allow further distinction of the mechanisms involving oceanic and atmospheric (air-sea fluxes and SPCZ) dynamics. Analysis of IPCC simulations will also lead to identification of key indexes and their future projection, such as the potential for tropical cyclones.

Data-assimilating GCMs: Both reanalysed and operational ocean nowcasts and forecasts will be available for the SPICE region. Current analysis products include the global SODA (`www.atmos.umd.edu/~ocean`), ECCO (`www.ecco-group.org`), and BRAN (`www.cmar.csiro.au/ofam1`). Current operational systems include BLUElink (`www.bom.gov.au/oceanography/forecasts` and `godae.bom.gov.au`) and Mercator (`www.mercator.eu.org`). Over the time-frame of SPICE several of these systems will undergo system upgrades offering improved resolution and performance. The objectives of the BLUElink ocean prediction project are to estimate and predict the ocean state and circulation in the Australian region which has been implemented as an operational system at the Bureau of Meteorology to service the Australian public. BLUElink is a global system with enhanced resolution in all of the regional seas around Australia, including the Coral Sea and Indonesian Throughflow. The timescales of interest are short- to medium range, providing a 7-day forecast twice per week. BLUElink resolves mesoscale ocean variability to a resolution of 10 km at present and extends to 180°E, therefore including all of the Coral Sea. The performance of this system is evaluated through a series of ocean reanalyses (BLUElink ReANalysis, BRAN) 1992–present, making use of historical observations including satellite altimetry, satellite sea surface temperature, and in situ observations. The BLUElink project is supportive of observational programs that contribute to the real-time network and can be routinely assimilated by the operational system. Any delayed-mode observations would also contribute to posterior validation and ocean reanalyses. The Coral Sea heat content is a particular target to support (a) coupled atmosphere-ocean modeling for tropical cyclone forecasting, (b) forecasts of coral bleaching within the GBR as a service to GBRMPA and (c) Naval sonar applications. The Coral Sea circulation is also critical for (a) surface current validation and skill assessment, and (b) spatial and temporal variability of the boundary current systems along Australia's east coast.

The Mercator global ocean prediction project will provide operational products and reanalyses in the southwest Pacific region for validation and boundary/initial conditions to regional models. Mercator and BLUELink work together under the GODAE framework.

Regional coupled ocean-wave-atmosphere systems and regional ocean data assimilation schemes are currently being developed within BLUElink and will be used to investigate short-range prediction and predictability as well as operational coupled tropical cyclone forecasting.

Regional models, forced: Downscaling. Regional models can be nested in the aforementioned large-scale models to provide higher resolution and topography and parameters that are adapted and tuned to a specific region/experiment. Adaptive mesh refinement tools have demonstrated their efficiency over the southwest Pacific (e.g., AGRIF, `www-lmc.imag.fr/IDOPT/AGRIF` used in conjunction with the oceanic NEMO and ROMS models). This "downscaling" approach will be used, as well as its atmospheric equivalent (WRF), to address issues including ocean dynamics, ocean impacts on the ecosystem, local ocean-atmosphere interactions, and cyclones. Tools such as AGRIF have a "two-way" scheme that allows feedback of the fine grid model onto the coarse one, so that the large-scale model benefits from improved simulation of fine, point-wise structures (e.g., straits or islands) through "upscaling." High-resolution models will also be nested in idealized climatological reanalyses and IPCC projections. An improved knowledge of the physical circulation will broaden the range of applications with, for instance, biogeochemical modeling using the SEAPODYM model.

Regional models, coupled: Regional ocean-atmosphere coupled models will permit better understanding of specific ocean-atmosphere interactions (island cloud formation; tropical cyclones) and their evolution with time. ROMS and WRF are experimentally used in a coupled configuration. The BMRC is also leading a BLUElink project to develop a regional coupled model for the tropical regions of Australia, i.e., the North West Shelf and the Coral Sea. This regional ocean model has been configured to cover the entire region that is influenced by tropical cyclones. The model is based on MOM4 and will nest in both the ocean reanalysis and the ocean forecast system. The initial target is to improve the representation of upper ocean heat content for use in coupled regional modeling. Improvements to resolution in the horizontal and vertical will be assessed relative to cost and stability. This modeling effort may be extended to focus on higher-resolution modeling of the ocean circulation through improved representation of reef mixing parameterizations for the GBR. The coupled modeling will involve research and development of coupled atmosphere-wave and coupled atmosphere-ocean models. This improvement would benefit from regional atmospheric-ocean boundary-layer observations.

Process models: Process models are generally used to understand mechanisms of ocean or atmosphere systems. Reduced-gravity (first baroclinic-mode) ocean shallow-water models have been shown to reproduce important aspects of the seasonal and interannual variability in the South and southwest Pacific (e.g., Holbrook and Bindoff, 1999; Bowen *et al.*, 2006; Qiu and Chen, 2006;

Kessler and Gourdeau, 2007). While much simpler than GCMs, reduced-gravity models tend to capture the important ocean dynamic processes fundamental to the Pacific Ocean (e.g., Perkins and Holbrook, 2001; McGregor *et al.*, 2004, 2007). Despite the obvious strengths of first baroclinic-mode models, a more detailed understanding of the role of bathymetry and the first few baroclinic modes in the southwest Pacific region as implied by satellite altimeter observations (Maharaj *et al.*, 2005, 2007) would be expected to benefit from process modeling studies that take better account of the vertical structure. Other linear models will be used in the same context, such as the "Island Rule" that explains the boundary current structures on the east coast of islands (Gourdeau *et al.*, 2007), and analytic planetary models (McCreary *et al.*, 2007).

4.5 Data-Model Intercomparison

The BLUElink team has defined model intercomparison metrics for the Australian and Indian Ocean domain in collaboration with other partners of the Global Ocean Data Assimilation Experiment (`www.godae.org`). This region includes the Coral Sea, and the metrics should be re-evaluated within SPICE to take advantage of the observing system improvements and the dominant characteristics of the circulation, in collaboration with the Mercator group. The GODAE metrics for the South Pacific have been jointly prepared by the BLUElink, Mercator, and Japanese groups and will serve as a reference for SPICE.

4.6 Sharing Model Output

SPICE will encourage sharing of model simulations within the "CLIVAR data policy" to foster intercomparison and local, non-commercial applications. Model simulations can be made available either directly through a local LAS/ opendap server, or through the PRIDE data server.

BLUElink and Mercator ocean nowcast and prediction data will be available for SPICE researchers on an opendap server (`godae.bom.gov.au/www.mercator-ocean.fr`) through a user registration. BLUElink reanalyses will also be provided by a opendap server through the registration as (`www.cmar.csiro.au/ofam1/`). See Section "data sharing and policy" below.

4.7 Current and Proposed Regional Modeling Projects

Table 1 presents a non-exhaustive list of modeling projects that relate to SPICE objectives.

Table 1: A non-exhaustive list of modeling projects that relate with SPICE objectives.

Topic/Project	Objectives	Institution(s)	PI(s)	Sponsor	Funded
Large Scale					
Large-scale air-sea coupling in connection to ENSO and regional ocean variability	2	UH/IPRC	A. Timmermann B. Qiu N. Schneider	NSF	TBS
SPCZ formation, climatology, and variability in CGCMs	1,2	UCLA	C.R. Mechoso D. Neelin B. Lintner	TBD	TBS
Diagnosing and improving convective processes in large-scale ocean-atmosphere interaction	1,2	UCLA	D. Neelin B. Lintner	NOAA	Yes
BLUElink-Coral Sea	3,4,5	BOM/OMFG	G. Brassington	Bureau of Meteorology	Yes
Seasonal and interannual variability in the NEMO-ORCA 0.5° GCM	1,2	IRD/PMEL	L. Gourdeau W. Kessler	IRD NOAA/PMEL LEFE	Yes
Role of Coral Sea and remotely forced Rossby waves on ENSO and PDV	2,7	Macquarie U. UTas BoM	S. McGregor N. Holbrook S. Power	Macquarie University	Yes
Variability of the circulation in the SPICE region from high-resolution ocean models	1,2,4	UH/IPRC/ JAMSTEC	K. Richards T. Qu P. Dutrieux B. Taguchi H. Saski	NSF/JAMSTEC	Yes
Circulation in the Solomon Sea from high-resolution nested models	1,3,4	IRD/LEGOS/ LEGI	L. Gourdeau	IRD/LEGI	Yes
Development of a continuously stratified model to investigate planetary wave and flow effects in the southwest Pacific	2,7	UTAS	N. Holbrook	UTAS	TBS
Downscaling of IPCC AR4 projections	1,6	UH/IPRC	K. Richards A. Timmermann	NSF/NOAA	TBS
Interior versus western boundary pathways of South Pacific waters as identified from ECCO	2	UH/IPRC CALTECH/JPL	T. Qu I. Fukumori	NSF/NASA	Yes
Climate change detection in the South Pacific gyre	2,7	UTAS Macquarie U. BoM	N. Holbrook I. Goodwin S. Power	ARC	S
Regional scales and impacts					
NZ regional modeling	2,4	NIWA	G. Rickard M. Hadfield	FRST(NZ)	Yes
Coastal circulation and upwelling in New Caledonia	4	IRD	P. Marchesiello J. Lefevre A. Vega	ZONECO, Noumea PNEC	Yes
Vulnerability of the South Pacific Islands to tropical cyclones altered by ENSO and climate change	6	IRD	C. Menkes P. Marchesiello M. Lengaigne	ANR IRD	Yes
Tuna and climate variability in the Southwest Pacific	6	IRD CPS	P. Marchesiello S. Nichol	ZONECO, Noumea	Yes
Infrastructure					
Low-cost cluster computer facility and regional modeling expertise	7	IRD	J. Lefevre P. Marchesiello	IRD	Yes

S = submitted
TBS = to be submitted

5. In Situ Observations

Analogous to high-resolution models nested in global circulation models, the detailed regional SPICE observations will complement large-scale observation programs, focusing on their unresolved aspects. Satellite ocean observations are inadequate to observe small scales and/or subsurface flows of interest. The Argo array provides CTD profiles over the water column; however, the Coral and Tasman seas are poorly sampled by Argo. As a result, in the Coral Sea most of our knowledge comes from numerical models and climatologies based on scanty data. In the Tasman Sea area, the observation database is better supplied, and the high variability calls for targeted process experiments and monitoring. While investigations and further analysis of large-scale climatologies will be necessary, a major observational effort is needed in the Coral, Tasman, and Solomon seas. The South Pacific Convergence Zone (SPCZ) was identified as a major issue that directly relates to the southwest Pacific Ocean and climate. A major SPCZ-focused field program has been envisaged during the design of SPICE, and a specific workshop was organized on this issue in December 2007. Because of the size and remoteness of the SPCZ, a dedicated field experiment would be costly and would need to involve a large number of scientists and laboratories. Given the present state of knowledge, it was decided to give priority to numerical model and analytical approaches complemented with analysis of remote sensing data and reanalysis products, without precluding a future SPCZ field experiment.

5.1 Observational Challenges

The SPICE field observations are designed to address the following issues raised in the scientific background document (Ganachaud *et al.*, 2007):

1. **Southwest Pacific air-sea fluxes and heat content.** Surface heat content is known to substantially affect weather and climate. On regional scales, ocean heat content is closely related to seasonal weather extremes in the Tasman Sea region. In the Coral Sea, it preconditions cyclone trajectories and intensity. On coastal or island scales, surface water properties can affect weather systems such as the Australian "east coast lows," and weather, winds, and cloud formation near islands. Air-sea exchanges are not accurately known in the southwest Pacific, and both flux products and upper ocean heat content sampling need to be improved. While recent studies have indicated that ocean advection processes are important in the Tasman Sea (Roemmich *et al.*, 2005), the relative contributions of

advection and heat storage compared to the surface heat flux are poorly understood, especially on interannual to decadal timescales. The Tasman Sea heat balance requires a specific study with an improved understanding of the heat flux components, particularly their variability, and how heat is partitioned between the atmospheric fluxes and recirculated within the gyre.

2. **Thermocline pathways**

   a. **SEC inflow and bifurcation.** The amount of thermocline water transported by the SEC into the Coral Sea, as well as its redistribution to the Equator and to the EAC system, has direct climate implications for the Equator and the Tasman Sea surroundings. It needs to be observed comprehensively, and to some extent monitored.

   b. **Jets.** The formation process of the jets on the east coasts of Vanuatu and New Caledonia, and the pathways and delays needed for this water to cross the Coral Sea determines part of the total time lag to the Equator or to the Tasman Sea. Those processes, delays, and transports are not well understood, and the spatial characteristics of the jets require observational description.

   c. **Solomon Sea.** The transit of thermocline waters in the Solomon Sea occurs in interleaved currents amid complex reef and island systems. Climatologies suggest that the source of Solomon Sea water merges western boundary flow from the coast of Australia (the NQC) and SEC waters that arrive directly from the southeast. The exits to the north redistribute this inflow among the narrow straits of Vitiaz, St. Georges, and Solomon, each of which implies a different pathway to the Equatorial Undercurrent. The flow structure, transports, and water mass transformation induces delays and can modify properties of the EUC waters. The ocean physics of this zone is almost unexplored.

3. **Tasman Sea**

   a. **EAC and partition.** Robust estimates of the mean and seasonal cycle of each inflow and outflow component of the circulation in the Tasman Sea needs to be established, as well as identification of the source, strength, property variability, and pathways of the major water masses. From a large-scale perspective, the partition of the western boundary flow between the Pacific and Indian Ocean gyres is of major interest. Understanding this partition requires determining the mean and time-varying components of the EAC, the Tasman Front, STCC, and the Tasman Outflow, their variations on interannual to decadal timescales, and the effects of anthropogenic change.

4. **Impacts**

   a. **Coastal circulation.** The ocean circulation and biogeochemical properties are poorly known near most Pacific Island nations. How does the large-scale ocean circulation interact with regional climate and ocean circulation near the Pacific Islands? How does the ocean circulation and its variations affect ecosystems and populations? These are questions of major concern to all southwest Pacific nations. Climate change and projected ocean circulation changes will have a strong, potentially dramatic impact on the southwest Pacific countries, and there is an urgent need to understand current physical and biochemical ocean conditions, along with atmospheric characteristics and their evolution.

b. **Corals.** Coral reefs, which constitute the most important natural resource as well as a natural shield against storm surges in many islands, are under serious threat from sea surface temperature rise and increase in ocean acidity through anthropogenic CO_2 dissolution. Coral reef health is monitored within specific programs (e.g., UNESCO-funded Coral Reef Initiative in the South Pacific program, `www.crisponline.net`; Great Barrier Reef management at AIMS, `www.aims.gov.au`). Those will benefit from an improved knowledge of temperature and sea level changes associated with changes in the ocean circulation, from the basin scale to the island scale and on timescales from months to decades.

5.2 Observational Objectives

The goal of the SPICE field program is to measure and monitor key climate-relevant quantities to help address the aforementioned challenges. The objectives are:

- To complete large-scale surveys of the Coral, Solomon, and Tasman Sea inflows and outflows with special attention to the WBC and LLWBC;
- To test and apply large-scale in situ and remote monitoring of key climate quantities, some of which are identified as air-sea fluxes, SEC inflow, Solomon and Tasman Sea inflows and outflows;
- To simultaneously observe/monitor those quantities in different parts of the basin to accomplish regional mass, heat, and freshwater budgets;
- To carry out regional-scale process surveys on island- and coastal scales to address local specificities, with possible monitoring.

5.3 Observational Approach

Although many aspects remain to be settled in focused projects, the broad outline of the SPICE field program is clear. It will rely on extensive regional collaboration, on the existing infrastructures and teams, and on regional adaptation of global observation programs. An important aspect will be the requirement for quasi-simultaneity of some observations in different parts of the basin. Exploratory surveys will be needed to identify key quantities that require monitoring. Experimental monitoring will precede the design of a long-term monitoring system. SPICE observations have distinct large-scale and regional-scale components, presented in the following two sections. This in situ observation plan will be completed with remote observations (e.g., SST, SSH, SSS) calibrated and adapted on the region.

The existing and proposed operations are presented for each aspect and geographical area in Section 5.3.1–5.3.2; the proposed infrastructure and technology are laid out in Section 5.4.

5.3.1 Large-scale operations

Based on SPICE objectives, existing observation and monitoring programs will be reinforced in the Coral and Tasman Sea. Those are Argo, the AWS network, IMOS, the SOOP-IP network, the XBT/HRXBT network, and satellite products (Fig. 5). A specific field experiment is proposed to complete the large-scale efforts. Figure 6 provides an overview. Oceanographic operations are organized in three sub-regions: Coral Sea, Tasman Sea, and Solomon Sea.

a. Air-sea fluxes. Improved estimates of exchanges of heat between the atmosphere and the ocean can be accomplished through in situ and remote measurements. Direct measurements include hull SST and IMET stations installed on voluntary observing ships (BOM), moored IMET stations, XBT and HR-XBT lines, and Argo floats with specific equipment. Such in situ measurements are used to calibrate high-resolution satellite SST measurements.

b. Coral Sea. The strategy to measure the SEC inflow to the Coral Sea is based on regular surveys between the northern tip of New Caledonia and the southeastern tip of the Solomon Islands. Because the Solomon Islands form a continuous shallow barrier, such sections (Fig. 4) provide an estimate of the total inflow between 23°S and the three northern Solomon Sea straits (5°S). Two hydrographic cruises have been made to provide an initial description of the flow, in July 2005 and November 2006. During both cruises, an experimental glider was deployed which successfully demonstrated the feasibility of those measurements in this remote region (Gourdeau *et al.*, 2007). The glider data provided accurate estimates of the transport of narrow near-shore currents. The SEC inflow monitoring will be continued, with regular seasonal surveys sampling temperature, salinity, and currents down to at least 2000 m. In addition to hydrographic cruises whose recurrence is necessarily limited, VOS will be used to deploy deep XBT probes together with Argo floats (see below) between New Caledonia, Vanuatu, and the Solomon Islands. It should be supplemented by surveys south of New Caledonia to estimate the southern branch of the SEC, the SCJ (Ganachaud *et al.*, 2008).

It is only recently (2006) that Argo floats have begun to infiltrate the Coral Sea. On the basis of the average currents in the Coral Sea, a deployment every 6 months between New Caledonia and the Solomon Islands would fulfill the 3°-spacing Argo requirement. Deploying floats equipped with oxygen sensors will be of major importance, as this measurement is a key parameter to identify water mass origins and pathways (Sokolov and Rintoul, 2000; Qu and Lindstrom, 2002, 2004; Maes *et al.*, 2007).

c. Tasman Sea. Changes in the heat content in the Tasman Sea are currently monitored using data from the Wellington-Sydney XBT line, Argo floats

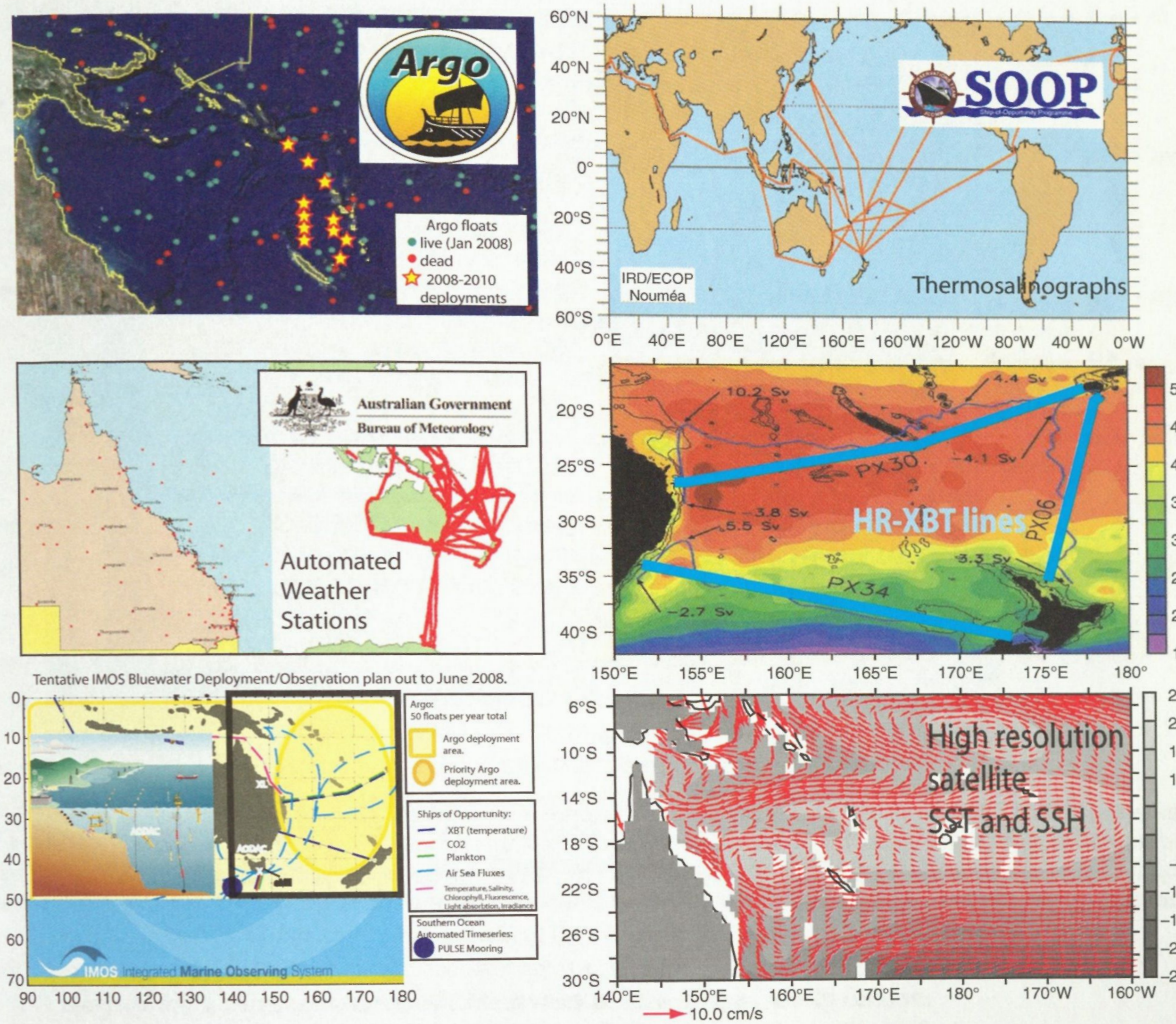

Figure 5: Existing large-scale observation and monitoring programs that cover the southwest Pacific. From upper left, and anti-clockwise: Argo in the Coral and Solomon seas and current seeding plans; BOM AWS networks on land and VOS; IMOS observation program; SST/SSH satellite measurements that require specific local treatments; HR-XBT lines (figure adapted from Roemmich *et al.*, 2005); SOOP-IP VOS thermosalinograph IRD network.

in the Tasman Sea, and, by inference, altimetric sea surface height. To continue to estimate heat storage, the level of Argo deployments in the Tasman Sea should be maintained or increased and adapted to the shallow topography in the eastern Tasman Sea. The region will also be frequently sampled by ships hull SST sensors from AWS ships (see section 5.3.1.a above). An inflow/outflow observation system over the Tasman Sea is proposed to improve the current heat budget monitoring, along with a combination from satellite altimeter, Argo floats, and other measurements (e.g., Willis *et al.*, 2004). The system is based on two glider lines and a mooring array (Fig. 6). A first, exper-

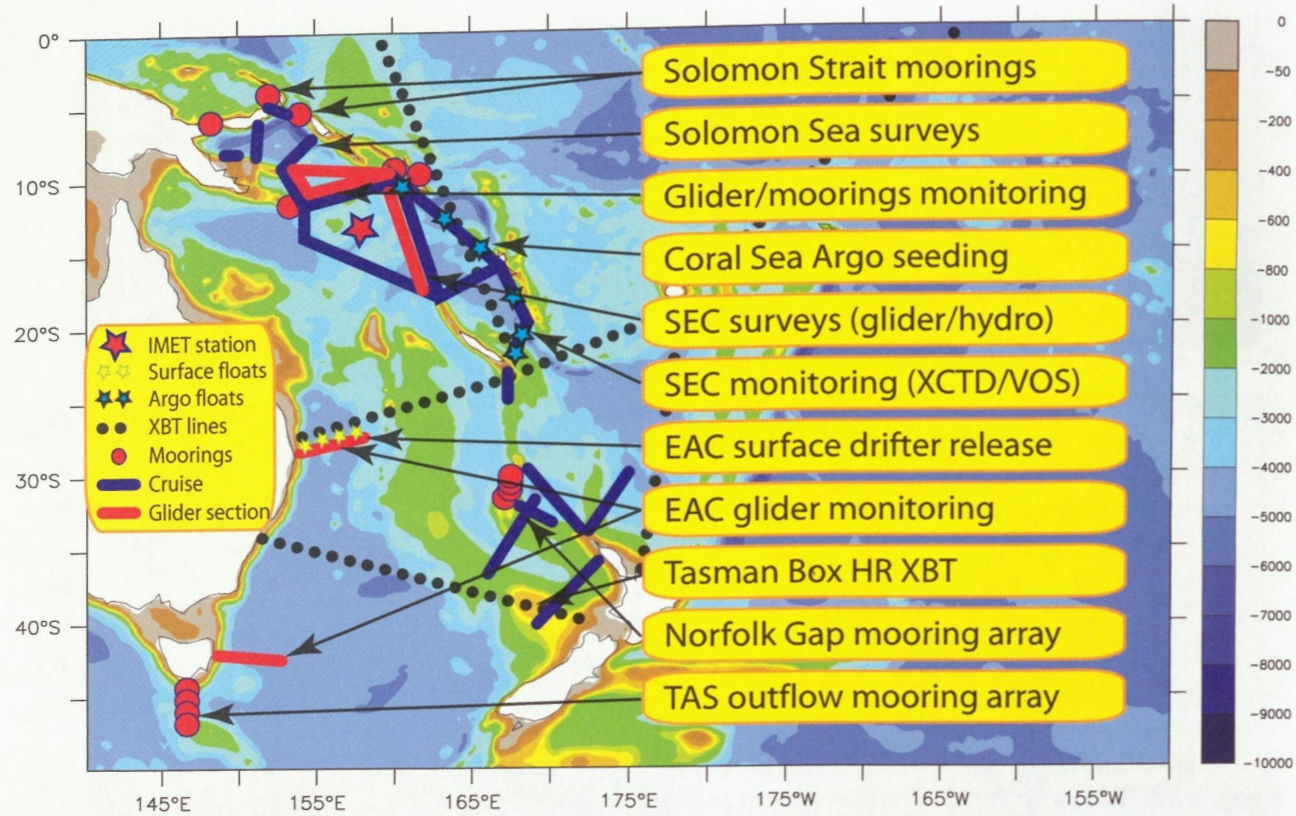

Figure 6: SPICE field experiment. Simultaneous measurements in different parts of the basin will allow analysis and monitoring of the mass/heat budget within the area. Exploratory surveys will be followed by experimental monitoring, with a possible long-term monitoring outcome. All components are planned by participating teams; some are already funded.

imental glider survey will be tested off Tasmania to monitor the Tasman Outflow. This will be extended to a glider monitoring of the EAC inflow off Brisbane (28°S), supplemented with Lagrangian measurements through regular release of surface drifters (about 30 drifters/years from the Brisbane-Fiji VOS line within the East Australia Circulation surface Drifter Program). Additional XBT probes will be released along a section of the PX30 line similar to that proposed by the glider to increase the XBT sampling to approximately monthly. These additional probes (BOM program) will supplement the high-density transects currently conducted by CSIRO. To the east, a mooring array has been deployed for 1 year over the Norfolk Gap, where the Tasman Front passes between Norfolk and New Zealand, and extended monitoring is under consideration. And to the South, plans are underway to deploy a mooring array just south of Tasmania, to monitor the Tasman Outflow.

d. Solomon Sea. Exploratory observations are particularly crucial in the little-documented Solomon Sea, where the current structure is complicated and the entire northward SEC outflow occurs through narrow straits. Because the three Solomon Sea straits (Vitiaz Strait, St. George Channel and Solomon Strait) are the choke point of the northward-flowing SEC waters, mooring lines should be deployed there to provide an efficient monitoring of their mass and heat transport on seasonal to interannual timescales (Fig. 6). The 1985–1986 6-month WEPOCS mooring data suggests two moorings are needed in both Vitiaz and Solomon Straits, as there appears to be significant horizontal shear in these passages. Single moorings are planned in St. Georges Strait and the "Indispensable" Channel (10°S, 161.5°E). Each mooring will consist of velocity measurements from upward/downward-looking ADCPs to fully resolve the surface-to-subthermocline flow in each passage. These surface observations were not resolved by the earlier WEPOCS mooring measurements. Discrete current meters will measure the deeper currents. Temperature-salinity measurements will also be made at discrete points along the mooring lines, with higher resolution in the surface to thermocline layers. Nearly all of this instrumentation is already available at CSIRO and SIO.

Hydrographic CTD surveys and preliminary monitoring will be critical in different parts of the Solomon Sea. The use of gliders will be tested and possibly maintained there, because the region is remote and difficult to access regularly with an oceanographic ship. A first CTD survey at 11.5°S was accomplished in August 2007 to estimate the net inflow from the south, corroborated with an experimental glider monitoring of the LLWBC over that same latitude. Hydrographic and possibly glider surveys inside the Solomon Sea will be needed to understand how this inflow distributes within the Solomon Sea and what water mass transformations occur before it exits.

A comprehensive monitoring system will be proposed to survey total mass and heat transport into the Solomon Sea. The array consists of endpoint moorings measuring geostrophic mass transport, a set of inverted echosounders plus pressure sensors (PIES) along the section to resolve vertically integrated heat content and flow across the section, and the aforementioned gliders to deliver the temperature distribution and flow in the upper 1000 m. It would be complementary to the Strait's monitoring, assuring that there is no leakage through smaller passages and that there are no systematic biases in either technique. Such methodology is being developed and demonstrated in the California Current under the NOAA funded CORC initiative, and would be migrated to the Solomon Sea after successful operation off California.

e. SEC inflows, outflows, and bifurcation. Monitoring simultaneously the aforementioned transports will provide an unprecedented description of the SEC water pathways and associated heat transports. Those include (Fig. 6): the SEC inflow near 163°E, the EAC transport at 28°S, and the Solomon Sea meridional transport at either 10°S (South Solomon Sea) or 6°S (Solomon Sea Straits). These measurements, if concomitant and associated with appropriate modeling experiments, will provide a description of the bifurcation of thermocline water in the southwest Pacific and its redistribution to the Tasman Sea and to the Equator. They will also provide an indirect estimate of the NCJ bifurcation processes, as they reach the coast of Australia, which cannot be directly observed because of its large latitudinal range and the partitioning due to its encounter with the North Queensland Plateau.

f. Analyses of existing large-scale datasets. While in situ observations in the southwest Pacific have been scant thus far, efforts have been made to consolidate information from both in situ and remotely sensed data into gridded datasets (e.g., the Digital Atlas of Southwest Pacific upper Ocean Temperatures

(DASPOT, Holbrook and Bindoff, 2000) and the CSIRO Atlas of Regional Seas (CARS, Dunn and Ridgway, 2002), AVHRR, T/P, Jason1 (Willis *et al.*, 2003)). These have contributed to our understanding of the seasonal and interannual variability, water masses, and heat storage variability. Update and analysis of these datasets will continue as new instruments are deployed to provide new insights and guidance to the fieldwork planning. A working knowledge of the historical datasets will also help to provide a more seamless transition from the XBT to Argo data era.

5.3.2 Regional scale operations

Regional SPICE or SPICE-related operations aim at comprehending (a) local impacts of oceanic and climate variations on the local environment, and (b) small-scale processes that relate and possibly influence the large-scale circulation. Regional studies have necessarily diverse objectives, and will integrate, in most cases, biochemical, fish, or environmental scopes. Because of such diversity, SPICE cannot integrate detailed regional operations. However, the proposed regional collaboration will provide a natural incentive to coordination with the large-scale operations.

a. Regional process studies. Several aspects of the large-scale thermocline water circulation are interrelated with small scales (e.g., jet formation processes, WBC dynamics against the contorted Australia-PNG coastline, standing eddies on the EAUC pathway). Because those interactions between strong currents and topographic obstacles impact nutrient availability and biology, specific field studies associating physical and biochemical aspects will be required. Variations in oceanic conditions' influence on meteorological processes will, similarly, entail multidisciplinary experiments. Regional process studies—some of which are ongoing—will include focused regular CTD-O_2-LADCP surveys in coastal regions with biochemical sampling, mooring lines, and meteorological parameter measurements.

b. Regional monitoring. Continuous, in situ measurements of the sea surface temperature, the sea surface height, and the sea surface salinity from the Pacific Islands can be determinant to understanding large-scale ocean circulation as well as local conditions and their impacts (e.g., sea level, coral reefs, cyclone trajectories). Coastal station networks already exist, notably the Tsunami Warning System in the South Pacific (`www.bom.gov.au/pacificsealevel`), the Integrated Marine Observing System (IMOS, www.imos.org.au) on Australian coasts, and the IRD time series (`www.ird.nc/ECOP/siteecopuk/cadres.htm`) on the French Islands. SPICE should support the network of existing time series extension, perpetuation, and possibly association with other types of measurements (e.g., CO_2 monitoring).

5.4 Proposed Observations and Infrastructure

The SPICE field program is based on existing infrastructures, regional and remote. This includes the Hobart CMAR, the Noumea IRD center, Wellington NIWA, and Scripps Oceanographic Institution.

a. Hydrography. Standard hydrographic surveys consist of observations of temperature, salinity, and velocities over the water columns—or at least 2000 m. SPICE-proposed hydrographic sections are high resolution and integrate oxygen measurements to identify water mass origins. Temperature and salinity allow calculation of the velocity relative to a given depth, which, combined with ADCP and/or drifter measurements, provide a detailed description of the velocity field. Hydrographic vessels that can be made available to SPICE projects include the 66 m RV *Southern Surveyor* (CSIRO-Hobart), the 28-m RV *ALIS* (IRD-Nouméa), large ships from the French national fleet (`www.ifremer.fr/flotte/navires`), the 70-m RV *Tangaroa*, and 28-m RV *Kaharoa* (NIWA-Wellington), and associated hydrographic instruments and engineers from the respective institutes.

b. Gliders. Gliders are autonomous underwater platforms that are moved over the water column by modifying their buoyancy and "glide" using wings that confer a horizontal velocity associated with their vertical displacements. Gliders orient themselves to accomplish the equivalent of a slow hydrographic section associated with a variety of measurements including temperature and salinity, over the upper water column. The present technology has been tested in the Coral Sea (Gourdeau *et al.*, 2007), then in the Solomon Sea (Kessler *et al.*, 2008), providing successful, repeated measurements of the transports across a 900 km distance and across strong currents. Gliders are expected to be an important contribution to monitor boundary current, especially in regions of difficult accessibility. Gliders are currently operated in collaboration between Scripps Oceanographic Institution, NOAA, and IRD. The CSIRO (CMAR-Hobart) was funded to purchase gliders and develop an operational facility.

c. XBT from VOS. Expendable Bathythermograph (XBT) probes deployed from commercial vessels on their routes have been able to provide repeated measurements of the upper 400 m water column in different parts of the world and over the past 35 years (`www.jcommops.org/soopip`). XBT data are the main source of knowledge of oceanic variability, especially in the southwest Pacific Ocean where little other data exist. Over 10 years of XBT measurements are now available along each transect of the "Tasman box" (Fig. 6) between Australia (28°S), Fiji (18°S, 178°E), and New Zealand, with sampling typically occurring approximately four times each year (Roemmich *et al.*, 2005). These high-density transects are fundamental to the proposed observation network. Funding is secured to maintain them in the next 5 years, and to upgrade (deeper probes; higher frequency is considered within the SPICE context). XBT lines between Fiji and Honolulu and Noumea and Japan are currently maintained (Fig. 6). A new line between Noumea and Guadalcanal is being started to monitor the SEC inflow using a combination of Argo float releases and XBT probes.

d. Drifters. Floats from the Argo program (`www.argo.ucsd.edu`) will be deployed during SPICE. The present Argo coverage is very low in the Coral and Tasman seas because of the topographic configuration: floats get entrained in boundary currents close to the coast and are pushed toward the shore by the prevailing winds during their surface phase, and eventually beach. The long ARGOS surface transmission times may be a major cause of this drift. But, to our knowledge, about half the floats that crossed the Coral Sea have so far "survived" the WBC transit, and while this area would be opportune for float deployments with fast Iridium® transmitters (thereby reducing the surface drift), it appears reasonable to continue deploying standard floats. Floats equipped with an oxygen sensor will be especially relevant as strong oxygen gradients permit efficient identification of water origins.

Satellite-tracked surface drifting buoys provide a convenient platform to measure surface velocities and temperature or more properties in some cases (Lumpkin and Pazos, 2006). Regular deployment is planned during all seafaring cruises. Through a collaboration of the Bureau of Meteorology, NOAA, and the University of Melbourne, floats will be deployed to monitor specifically the Lagrangian properties and transport of the East Australia Current ("the East Australia circulation surface drifter program"). Preliminary deployments have started; the target is to deploy 30 drifters/year for 5 years off the coast of Queensland using volunteer ships.

e. Moored instruments. Moored subsurface current meters, including upward-looking ADCPs, are capable of providing the needed time series of the currents and transports in the Solomon Straits, and have proven relevant in the Indonesian Straits during the recent International Nusantara STratification ANd Transport program (INSTANT) project (`www.ldeo.columbia.edu/res/div/ocp/projects/instant.shtml`). Nearly all of this instrumentation and expertise is already available at CSIRO and SIO; deployment and maintenance will be carried out during hydrographic surveys in collaboration with IRD.

There are presently no moored surface stations in the Tasman-Coral Sea. Surface meteorological moorings are essential to obtaining high-quality meteorological observations of wind, air, and sea temperature, humidity, pressure, radiation, precipitation, and salinity which can be used to infer air-sea fluxes. Such instrumentation will be deployed in the Southern Ocean within the Integrated Marine Observing Network (IMOS), an Australian, government-funded 4.5-year program to provide infrastructure to observe the coastal and open ocean around Australia. While similar instrumentation in the SPICE region would be of high value to the determination of air-sea fluxes, its deployment and maintenance costs are very high, and no funding source has been identified at this point. A Deep Ocean Assessment and Reporting of Tsunamis (DART) buoy will be installed, and a cost-effective solution to equip this buoy with meteorological sensors is under consideration.

The moorings, inverted echosounders/pressure sensors (PIES), and gliders necessary to the South Solomon Sea integral transport measurement system would be provided by SIO, with funding from the NOAA CORC project. Two moorings are required at the end points of the section carrying enough microcat T/S sensors to calculate dynamic height differences along the section. The PIES instruments will be located on the seafloor and measure bottom pressure with extreme precision, as well as acoustic travel time to the sea surface as a proxy for heat content/dynamic height. Their (and the mooring) data will be interrogated and telemetered to shore by the gliders. Several gliders would operate along the section simultaneously to provide sufficient temporal resolution for the transport changes to be captured.

f. Surface measurements from VOS. VOS equipped with real-time transmitting automatic weather stations (AWS) provide repeated data that are highly valuable to air-sea flux estimation. There are currently eight vessels that participate in the Australian Volunteer Observing Fleet (AVOF) program, the New Zealand RV *Tangaroa* and the Noumea-based RV *ALIS*. Their routes include coastal Australia (Queensland to South Australia), Bass Strait, and the Tasman Sea (Fig. 5). The network is being extended, and several of these ships will be fitted with ship hull SST sensors through the IMOS program (previous section). There is some capacity to take advantage of these ships for additional observations, such as surface drifter or XBT deployments.

Sea surface salinity (SSS) measurements have proven useful to understand important aspects of climate variations in the South Pacific as those reflect the precipitations—notably the SPCZ and the ocean circulation. A network of manual and automated sea surface temperature and salinity measurement systems mounted on commercial ships using a water intake has been covering the southwest Pacific Ocean since 1956. This network now transmits its data in real time (`www.jcommops.org/soopip/` and `www.legos.obs-mip.fr/observations/sss/`). The importance of SSS in the climate system has motivated the development by European and USA/Argentina space agencies of dedicated satellite missions (SMOS and Aquarius) to enhance global observations, and the in situ network is expected to establish a ground basis for calibration.

5.5 SPICE-Related Observational Projects

Table 2 provides a non-exhaustive list of the observational projects that respond to the aforementioned SPICE objectives and challenges.

Table 2: A non-exhaustive list of the observational projects that respond to the aforementioned SPICE objectives and challenges.

Topic/Project	Obs. Component	Institution(s)	PI(s)	Sponsor	Funded
SEC Inflow					
South Equatorial Current and jets from modeling and observations	5.3.1.b	IRD PMEL Scripps	L. Gourdeau W. Kessler R. Davis	IRD-LEFE NOAA CORC	Yes
Solomon Sea					
Solomon Sea inflow from the South	5.3.1.d	IRD PMEL Scripps	C. Maes/L. Gourdeau W. Kessler R. Davis	IRD NOAA CORC	Yes
Circulation in the Solomon Sea from models and observations	5.3.1.d	IRD PMEL	S. Cravatte A. Ganachaud G. Eldin	LEFE/IDAO ANR OPBC	Yes S Yes
Transports through the Solomon Straits	5.3.1.d	CSIRO Scripps IRD	J. Sprintall S. Wijffels A. Ganachaud	NSF Australia ANR	S S S
Integral mass/heat transport entering the Solomon Sea	5.3.1.d	Scripps	U. Send R.Davis D. Rudnick	NOAA, 5-year program approved	Annual renewals pending
Tasman Sea					
EAC glider monitoring from Hobart and Brisbane	5.3.1.c	CSIRO	S. Wijffels	CSIRO IMOS	Yes
Tasman Front at Norfolk Ridge	5.3.1.c	NIWA	P. Sutton M. Bowen	FRST	Field completed
HRXBT Brisbane-Fiji and Sydney-Wellington	5.3.1.c	CSIRO	K. Ridgway	CSIRO	Yes
East Australia Circulation Surface Drifter Program	5.3.1.c	BOM/NOAAU Melbourne	G. Brassington	BOM/NOAA	Yes
Tasman Outflow Mooring array	5.3.1.c	CSIRO	K. Ridgway	IMOS	TBS
Population connectivity in two oceans: a multispecies comparative study	5.3.1.c	Macquarie U. UTAS CSIRO	L. Beheregaray N. Holbrook P. England R. Babcock	ARC	S
Climatological Data					
Historical rainfall maps and South Pacific Convergence Zone (SPCZ) reconstruction for 1951–2007	5.3.1.a	NIWA NOAA/NCDC U. Melbourne, IBIMET-CNR	A. Lorrey	NOAA	Yes
Relative importance of bathymetry, mean flow, and wind stress in altimetric signatures of Rossby waves	5.3.1.f	Macquarie U. NOCS UTas	A. Maharaj P. Cipollini N. Holbrook	Macquarie U. ARC	TBS
Operational Programs					
AWS and SST on VOS	5.3.1.a	BOM		Yes	
High-resolution SST analysis over the Australian domain	5.3.1.a	BOM/AIMS		BOM	Yes
Regional Applications					
Coastal circulation and upwelling in New Caledonia	5.3.2.a	IRD	P. Marchesiello A. Ganachaud	ZONECO	Yes

6. Data Management and Availability

The availability of SPICE data should follow the CLIVAR policy (www.clivar.org/data/data_policy.php), which includes quality controls and free, unrestricted access. SPICE involves different types of data, each of which is in most cases associated with existing servers or programs (e.g., Argo floats, operational oceanography projects). A central web page will inform about planned experiments and redirect toward appropriate data servers.

An important issue will be to make Southwest Pacific data available for research, training, and applications (e.g., availability under useful formats). The Pacific Region Integrated Data Enterprise (PRIDE, apdrc.soest.hawaii.edu/PRIDE/) is a NOAA-sponsored program to create integrated data products to address issues related to vulnerability of coastal and island communities to climate, marine ecosystems, and climate-related risk management. In line with that, the U.S. Global Climate Observing System (GCOS) Program manages NOAA's activities at the Asia-Pacific Data Research Center (APDRC, apdrc.soest.hawaii.edu/). The APDRC has in turn developed the infrastructure necessary to make data resources readily accessible and usable to researchers and general users. The APDRC, via the U.S. GCOS Program, will be able to integrate servers for new model simulations and data types related to SPICE.

7. Applications and Training

The bridge between the large-scale ocean and atmosphere circulation and their local impacts on environment and eventually sustainability will be established in collaboration with regional agencies and universities. On basin and global scales, the ultimate purpose of SPICE and follow-ups is to improve climate prediction. Such improvement will be of direct benefit to Pacific Island Countries (PICs) whose climate is strongly influenced by ENSO. But a major SPICE objective is to improve knowledge and prediction of the ocean conditions in the southwest Pacific, pertaining to a wide range of temporal and spatial scales, from basin scales to island effect scales. During SPICE, tools will be developed (e.g., database access, model simulation diagnostics), as well as independent projects that are specific to a location or process. This development must include appropriate training to serve local interests and respond to the demand from Pacific Island country governments to improve their appreciation of vulnerability to changes in the oceanic and climate environment and their capacity to respond to such changes.

SPICE, in collaboration with the Pacific Islands Global Ocean Observing System (PI-GOOS, hosted by SOPAC, the Pacific Islands Applied Geoscience Commission, based in Suva, Fiji), will endorse and encourage training initiatives. Training can cover a wide range of topics, some of which were already mentioned in this document (e.g., sea level rise, oceanic conditions and coral health, tropical cyclones) with specific research or application projects, classes on database usage and developing capacity building in operational oceanography.

8. SPICE Legacy

SPICE is a process study to identify southwest Pacific features that are relevant to climate. The efficacy and reliability of the proposed measurements on climate prediction will be assessed through the modeling efforts. This will pinpoint the key quantities that may lead to the development of a long-term South Pacific monitoring system to deliver data for initialization and calibration of climate forecasts. Regionally, SPICE will lead to improved ocean condition knowledge and forecasts, with direct applications to Pacific Island countries.

Through the CLIVAR data policy, measurements and model outputs will be made publicly available through appropriate data servers (see Section 6). Relevant training will help build the capacity in local communities to use southwest Pacific data and forecasts for pertinent response to societal demand.

9. References

Bowen, M.M., P.J.H. Sutton, and D. Roemmich (2006): Wind-driven and steric fluctuations of sea surface height in the southwest Pacific. *Geophys. Res. Lett., 33,* L14617, doi:10.1029/2006GL026160.

Dai, Y., R. Yu, X. Zhang, Y. Yu, and J. Li (2003): The impact of low-level cloud over the eastern subtropical Pacific on the "double ITCZ" in LASG FGCM-0. *Adv. Atmos. Sci., 20,* 461–474.

Davey, M., M.M. Huddleston, K.R. Sperber, P. Braconnot, F. Bryan, D. Chen, R. Colman, C. Cooper, U. Cubasch, P. Delecluse, D. DeWitt, L. Fairhead, G. Flato, C. Gordon, T. Hogan, M. Ji, M. Kimoto, A. Kitoh, T. Knutson, M. Latif, H. Le Treut, T. Li, S. Manabe, C. Mechoso, G. Meehl, S. Power, E. Roeckner, L. Terray, A. Vintzileos, R. Voss, B. Wang, W. Washington, I. Yoshikawa, J. Yu, S. Yukimoto, and S. Zebiak (2002): STOIC: A study of coupled model climatology and variability in tropical ocean regions. *Climate Dyn., 18,* 403–420.

Dunn, J.R., and K.R. Ridgway (2002): Mapping ocean properties in regions of complex topography. *Deep-Sea Res., 49,* 591–604.

Ganachaud, A., W. Kessler, S. Wijffels, K. Ridgway, W. Cai, N. Holbrook, M. Bowen, P. Sutton, B. Qiu, A. Timmermann, D. Roemmich, J. Sprintall, S. Cravatte, L. Gourdeau, and T. Aung (2007): Southwest Pacific Ocean Circulation and Climate Experiment. Part I. Scientific Background. NOAA OAR Special Report/International CLIVAR Project Office, CLIVAR Publication Series No. 111. (`www.ird.nc/UR65/SPICE`).

Ganachaud, A., L. Gourdeau, and W. Kessler (2008): Bifurcation of the subtropical south equatorial current against New Caledonia in December 2004 from a hydrographic inverse box model. *J. Phys. Oceanogr., 38,* 2072–2084.

Gourdeau, L., W.S. Kessler, R.E. Davis, J. Sherman, C. Maes and E. Kestenare (2007): Zonal jets entering the Coral Sea. *J. Phys. Oceanogr.,* in press.

Holbrook, N.J., and N.L. Bindoff (1999): Seasonal temperature variability in the upper southwest Pacific Ocean. *J. Phys. Oceanogr., 29,* 366–381.

Holbrook, N.J., and N.L. Bindoff (2000): A digital upper ocean temperature atlas for the southwest Pacific: 1955–1988. *Aust. Meteorol. Mag., 49,* 37–49.

Kessler, W.S. (2008): Gliders in the Solomon Sea. Presentation at Western Pacific Geophysics Meeting, Cairns, Australia, 31 July 2008.

Kessler, W.S., and L. Gourdeau (2007): The annual cycle of circulation of the southwest subtropical Pacific, analysed in an ocean GCM. *J. Phys. Oceanogr., 37,* 1610–1627.

Kirtman, B.P., and D.G. DeWitt (1997): Comparison of atmospheric model wind stress with three different convective parameterizations: Sensitivity of tropical Pacific Ocean simulations. *Mon. Wea. Rev., 125,* 1231–1250.

Lintner, B.R., and J.D. Neelin (2007): A prototype for convective margin shifts. *Geophys. Res. Lett., 34,* L05812, doi:10.1029/2006GL027305.

Lintner, B. R. and J. D. Neelin (2008): Eastern margin variability of the South Pacific Convergence Zone. *Geophys. Res. Lett., 35,* L16701, doi:10.1029/2008GL034298.

Lumpkin, R., and M. Pazos (2006): Measuring surface currents with Surface Velocity Program drifters: the instrument, its data, and some recent results. Chapter 2 in *Lagrangian Analysis and Prediction of Coastal and Ocean Dynamics (LAPCOD),* A. Griffa, A.D. Kirwan, A.J. Mariano, T. Ozgokmen, and T. Rossby (eds.), Cambridge Univ. Press, Cambridge, UK, 39–67.

Maes, C., L. Gourdeau, X. Couvelard, and A. Ganachaud (2008): What are the origins of the Antarctic Intermediate Waters transported by the North Caledonian Jet? *Geophys. Res. Lett.,* in press.

Maharaj, A.M., P. Cipollini, and N.J. Holbrook (2005): Observed variability of the South Pacific westward sea level anomaly signal in the presence of bottom topography. *Geophys. Res. Lett., 32,* L04611, doi:10.1029/2004GL020966.

Maharaj, A.M., P. Cipollini, N.J. Holbrook, P.D. Killworth, and J.R. Blundell (2007): An evaluation of the classical and extended Rossby wave theories in explaining spectral estimates of the first few baroclinic modes in the South Pacific Ocean. *Ocean Dyn., 57*(3), 173–187, doi:10.1007/s10236-006-0099-5.

McCreary, J.P., R. Furue, T. Jensen, H.-W. Kang, B. Bang, T. Qu, and T. Miyama: Interactions between the Indonesian Throughflow and circulations in the Indian and Pacific Oceans. *Prog. Oceanogr.,* in press.

McGregor, S., N.J. Holbrook, and S.B. Power (2004): On the dynamics of interdecadal thermocline depth and sea surface temperature variability in the low to mid-latitude Pacific Ocean. *Geophys. Res. Lett., 31,* L24201, doi:10.1029/2004GL021241.

McGregor, S., N.J. Holbrook, and S.B. Power (2007): Interdecadal sea surface temperature variability in the equatorial Pacific Ocean. Part I: The role of off-equatorial wind stresses and oceanic Rossby waves. *J. Climate, 20,* 2643–2658.

Mechoso, C.R., A.W. Robertson, N. Barth, M.K. Davey, P. Delecluse, P.R. Gent, S. Ineson, B. Kirtman, M. Latif, H. Le Treut, T. Nagai, J.D. Neelin, S.G.H. Philander, J. Polcher, P.S. Schopf, T. Stockdale, M.J. Suarez, L. Terray, O. Thual, and J.J. Tribbia (1995): The seasonal cycle over the Tropical Pacific in General Circulation Models. *Mon. Wea. Rev., 123,* 2825–2838.

Neelin, J.D., C. Chou, and H. Su (2003): Tropical drought regions in global warming and El Niño teleconnections. *Geophys. Res. Lett., 30*(24), 2275, doi:10.1029/2003GL018625.

Perkins, M.L., and N.J. Holbrook (2001): Can Pacific Ocean thermocline depth anomalies be simulated by a simple linear vorticity model? *J. Phys. Oceanogr., 31,* 1786–1806.

Qiu, B., and S. Chen (2006): Decadal variability in the large-scale sea surface height field of the South Pacific Ocean: Observations and causes. *J. Phys. Oceanogr., 36,* 1751–1762.

Qu, T., and E. Lindstrom (2002): A climatological interpretation of the circulation in the western south Pacific. *J. Phys. Oceanogr., 32,* 2492–2508.

Qu, T., and E. Lindstrom (2004): Northward Intrusion of Antarctic Intermediate Water in the Western Pacific. *J. Phys. Oceanogr., 34,* 2104–2118.

Richards, K., N. Maximenko, F. Bryan, and H. Sasaki (2006): Zonal jets in the Pacific Ocean. *Geophys. Res. Lett., 33,* L03605, doi:10.1029/2005GL024645.

Roemmich, D., J. Gilson, J. Willis, P. Sutton, and K. Ridgway (2005): Closing the time-varying mass and heat budgets for large ocean areas: The Tasman Box. *J. Climate, 18,* 2330–2343.

Sokolov, S., and S. Rintoul (2000): Circulation and water masses of the southwest Pacific: WOCE section P11, Papua New Guinea to Tasmania. *J. Mar. Res., 58,* 223–268.

Takahashi, K., and D.S. Battisti (2007): Processes controlling the mean tropical Pacific precipitation pattern. Part II: The SPCZ and the southeast Pacific dry zone. *J. Climate, 20,* 5696–5706.

Willis, J.K., D. Roemmich, and B. Cornuelle (2003): Combining altimetric height with broadscale profile data to estimate steric height, heat storage, subsurface temperature, and sea-surface temperature variability. *J. Geophys. Res., 108*(C9), 3292, doi:10.1029/2002JC001755.

Wood, R., and the VOCALS Scientific Working Group (2006): VOCALS-Regional Experiment: Scientific Programme overview, `www.eol.ucar.edu/projects/vocals`.

10. Glossary of Acronyms (for Parts I and II)

AAIW	Antarctic Intermediate Water
ACC	Antarctic Circumpolar Current
ADCP	Acoustic Doppler Current Profiler
AGRIF	Adaptive Grid Refinement In Fortran
AGU	American Geophysical Union
AIMS	Australian Institute of Marine Science
ANR	Agence Nationale de la Recherche (Funding agency, France)
APDRC	Asia-Pacific Data Research Center
ARC	Australian Research Council
AVHRR	Advanced Very High-Resolution Radiometer
AVOF	Australian Volunteer Observing Fleet
AWS	automatic weather stations
BMRC	Bureau of Meteorology Research Centre
BODAS	BLUElink Ocean Data Assimilation System
BOM	Bureau of Meteorology (Australia)
BRAN	BLUElink ReANalysis
CARS	CSIRO Atlas of Regional Seas
CGCM	coupled general circulation model
CALTECH	California Institute of Technology
CLIVAR	Climate Variability and Predictability
CMAR	CSIRO Marine and Atmospheric Research
CMIP3	Coupled Model Intercomparison Project-3
COADS	Comprehensive Ocean-Atmosphere Data Set
CORC	Consortium on the Ocean's Role in Climate
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTD	Conductivity-Temperature-Depth
DART	Deep-ocean Assessment and Reporting of Tsunamis
DASPOT	Digital Atlas of Southwest Pacific upper Ocean Temperatures
EAC	East Australia Current
EAUC	East Auckland Current
ECC	East Cape Current
ECCO	Estimating the Circulation and Climate of the Ocean
ENSO	El Niño-Southern Oscillation

ERS1/2	European Remote-Sensing Satellites1/2
ERSST	Extended Reconstructed Sea Surface Temperature
EUC	Equatorial Undercurrent
FRST	Foundation for Research, Science and Technology
GBR	Great Barrier Reef (Australia)
GBRUC	Great Barrier Reef Undercurrent
GCM	general circulation model
GCOS	Global Climate Observing System
GODAE	Global Ocean Data Assimilation Experiment
HRXBT	High-Resolution Expendable Bathythermograph
IMET	Improved Meteorology system for marine meteorological observations
IMOS	Integrated Marine Observing System
INSTANT	International Nusantara Stratification and Transport
IPCC	Intergovernmental Panel on Climate Change
IPCC-AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
IPRC	International Pacific Research Center
IRD	Institut de Recherche pour le Développement
ITCZ	Intertropical Convergence Zone
JAMSTEC	Japan Marine Science and Technology Center
JPL	Jet Propulsion Laboratory
LADCP	lowered acoustic Doppler current profiler
LAS	Live Access Server
LEFE	Les Enveloppes Fluides de l'Environement (Funding agency, France)
LEGI	Laboratoire des Ecoulements Géophysiques et Industriels
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LLWBC	low-latitude western boundary current
MOM4	Modular Ocean Model 4
MOMA	Modular Ocean Model—Array processor version
NCDC	National Climatic Data Center
NCJ	North Caledonian Jet
NEMO	Nucleus for European Modeling of the Ocean (NEMO)
NGCC	New Guinea Coastal Current
NGCUC	New Guinea Coastal Under Current
NIWA	National Institute of Water and Atmospheric Research
NOCS	National Oceanography Centre, Southampton
NQC	North Queensland Current
NOAA	National Oceanic and Atmospheric Administration
NTIS	National Technical Information Service
NVJ	North Vanuatu Jet
NSF	National Science Foundation

OAR	Oceanic and Atmospheric Research [NOAA]
OFES	Ocean General Circulation Model For the Earth Simulator
OMFG	Ocean and Marine Forecasting Group
ORCA	A Global Ocean configuration of OPA (Ocean Parallélisé)
PACSWIN	PACific Source Water Investigation
PBECS	Pacific Basin Extended Climate Study
PDV	Pacific Decadal Variability
PIES	Pressure Gauge Equipped Inverted Echo Sounder
PI-GOOS	Pacific Islands Global Ocean Observing System
PINs	Pacific Island Nations
PMEL	Pacific Marine Environmental Laboratory [NOAA]
PNEC	Programme National d'Etudes Cotières
PNG	Papua New Guinea
PRIDE	Pacific Region Integrated Data Enterprise
PSU	practical salinity units
REMO	Max-Planck Institut für Meteorologie Regional climate Model
RiCom	River, Coast and ocean model
ROMS	Regional Ocean Modeling System
RV	Research Vessel
SAM	South Annular Mode
SAMW	SubAntarctic Mode Water
SCJ	South Caledonian Jet
SEAPODYM	Spatial Ecosystem And Population Dynamics Model
SEC	South Equatorial Current
SECC	South Equatorial Countercurrent
SIO	Scripps Institution of Oceanography
SLW	Subtropical Lower Water
SMOS	Soil Moisture and Ocean Salinity
SODA	Simple Ocean Data Assimilation
SOEST	School of Ocean and Earth Science and Technology
SOOP-IP	Ship Of Opportunity Programme Implementation Panel
SOPAC	South Pacific Applied Geoscience Commission
SPCZ	South Pacific Convergence Zone
SPESMW	South Pacific Eastern Subtropical Mode Water
SPICE	Southwest Pacific Ocean Circulation and Climate Experiment
SPMW	South Pacific Mode Water
SPREP	Pacific Regional Environment Programme
SSG	Scientific Steering Group
SSH	Sea Surface Height
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
START	Global Change System for Analysis, Research, and Training
STCC	Subtropical Countercurrent

STF	Subtropical Front
STMW	Subtropical Mode Water
SVJ	South Vanuatu Jet
T/P	TOPEX/Poseidon
TAO	Tropical Atmosphere Ocean
TF	Tasman Front
TO	Tasman Outflow
UCLA/AOS	University of California Los Angeles/Department of Atmospheric and Oceanic Sciences
UH	University of Hawaii
UNESCO	United Nations Educational, Scientific and Cultural Organization
USP	University of South Pacific
UTas	University of Tasmania
VAMOS	Variability of the American Monsoon Systems (CLIVAR/WCRP)
VOCALS	VAMOS Ocean-Cloud-Atmosphere-Land Study
VOS	Voluntary Observing Ship
WBC	Western Boundary Current
WE	Wairarapa Eddy
WEPOCS	Western Equatorial Pacific Ocean Circulation Study
WOCE	World Ocean Circulation Experiment
WRCP	World Climate Research Programme
WRF	Weather Research and Forecasting
XBT	eXpandable Bathy Thermograph
XCTD	expendable conductivity-temperature-depth
ZONECO	Zone Economique Exclusive de Nouvelle Calédonie (Applied oceanic and shore research, New Caledonia)