Report on the South Pacific Convergence Zone-Southwest Pacific Ocean meeting – 6.30pm Thurs 13 Dec 2007

This meeting followed a poster and oral session organized at the AGU Fall meeting 2007 on "Dynamics of the Southwest Pacific Ocean and the South Pacific Convergence Zone (SPCZ) ", to discuss the overarching issues and necessary future research, in relation with the SPICE experiment (www.ird.nc/UR65/SPICE). We thank Howard Diamond (NOAA/NCDC) for supporting this meeting through the PRIDE initiative.

Sessions OS08a/OS8b conveners and abstract:

Alexandre Ganachaud, IRD/NOAA/PMEL
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Dean Roemmich, SIO
Jim Renwick, NIWA

"Dynamics of the Southwest Pacific Ocean and the South Pacific Convergence Zone (SPCZ)"

The Southwest Pacific is a region of complex ocean and atmosphere circulation. The South Pacific Convergence Zone (SPCZ) is a prominent feature of the atmosphere that varies substantially on synoptic, seasonal, and interannual timescales. Under the Trade winds and the influence of the SPCZ, thermocline waters are transported westward within the South Equatorial Current (SEC). The SEC splits into strong zonal jets upon encountering island archipelagoes, and crosses the Coral
Sea before bifurcating at the Australia/PNG coast and advecting to the equator in low-latitude western boundary currents and to high latitudes in the East Australian Current and Tasman Sea extensions. Because thermocline waters carry the atmospheric imprints from the subtropical gyre center, their transit in the Coral Sea corresponds to a major circulation pathway that controls the redistribution of subtropical water to the equator and to the Southern Ocean. The associated transports are potentially of great importance to tropical climate prediction as changes in either the temperature or the amount of water arriving at the equator have the capability to modulate the ENSO cycle and thereby produce basin-scale climate feedbacks. The state of the atmosphere and subsequent upper-layer ocean circulation variability is largely governed by the wind stress curl of the SPCZ, whose formation, shape and behavior are neither well understood nor well modeled, despite its prominent role in the Southern Hemisphere energy budget. This session is intended to highlight the latest progress and foster new research on the Southwest Pacific oceanic and atmospheric circulation, possible interaction between the SPCZ and the ocean circulation, and their significance to the basin-scale and global climate system.

Follow-up workshop participants (organized by A. Ganachaud and W. Kessler):

Participants:
Swadhin Behera, FRCGC/JAMSTEC
Bruce Cornuelle, SIO
Sophie Cravatte, LEGOS/IRD
Thierry Delcroix, LEGOS/IRD
Alexandre Ganachaud, LEGOS/IRD/PMEL/JISAO
Neil Holbrook, Macquarie University/UTAS
Billy Kessler, PMEL/NOAA
Ben Lintner, UCLA
Angela Maharaj, Macquarie University
Angélique Melet, LEGI
Tangdong Qu, IPRC
Ken Ridgway, CMAR
Ken Takahashi, GFDL/NOAA
Matthew Widlansky, Georgia Tech
Laura Zamboni, UCLA

Represented:
George Kiladis, ESRL/NOAA
Roberto Mechoso, UCLA
David Neelin, UCLA
Jim Renwick, NIWA

Executive summary:

The SPCZ suffers major model biases, with the "double ITCZ", the misrepresentation of its southward veering and of the related dry zone to its east. The different biases were discussed, and possibilities for future research orientations.
The impression was that modelling experiments and development, and analyses of existing remote and in situ data would be of great value in understanding the factors controlling the evolution of the SPCZ. However, an extensive campaign for a process study may be difficult to justify, as the processes generating/determining the SPCZ may be similar to those occurring in other convection/transition regions.
Two types of measurements might be worth considering: 1) air-sea flux sampling (IMET buoy and enhancement towards the east of the voluntary observing ship network and 2) open-sea calibration of island soundings. Because southwest Pacific soundings are made from islands, they are biased by the island effect on local convection, therefore potentially misrepresenting large-scale conditions. Ship-based soundings could be made during SPICE cruises in an attempt to calibrate island data.
SPICE contributors will be conducting modelling and field experiments between 2008 and 2012, west of 170°E, near the western edge of the SPCZ. Development of atmospheric modelling components with SPICE is very welcome. In terms of in situ observations, improved air-sea fluxes are part of SPICE objectives, and their extension to the west to cross the SPCZ zone is readily justifiable. Measurements of opportunity such as soundings may be done during SPICE cruises. Complementary process studies can take advantage of the ship or other infrastructure/context and may be developed in parallel.

Main points presented and discussed:

- *Intro (A. Ganachaud)*
    - SPICE: a (soon-to-be?) CLIVAR programme: 2007-2012 to understand the role of the southwest Pacific in the climate system
    - SPICE operations/research are financed through national funding; the CLIVAR umbrella would be a support to coordination / help for getting national recognition.
    - The atmospheric component in SPICE consists at the moment of CGCM experimental work and local air-sea flux measurements: there is opportunity for developments.
    - How do SPCZ flaws impact ocean/decadal climate modeling? Open question
- *SPCZ and/or SACZ and air-sea feedbacks: what factors are important? (K. Takahashi):*
    - Concerning SST under the SPCZ and SACZ:
        - Northeasterly jet (reduced wind speed versus Trade winds and evaporation)
        - PBL moisture and evaporation
        - Longwave fluxes (clouds, water vapor ? –refer to Cravatte et al's poster)
        - Negative shortwave feedback from clouds
    - Concerning the dry zone
        - Low humidity above the PBL
        - Strength of the Trade winds (for advection and evaporation)
        - Orography-the Andes, but details of the peaks above 3000m are not determinant.
- *Would better observing efforts on the location of the SPCZ margin help constrain models ? (B. Lintner)*
    - Poor representation of the SPCZ south of the Equator in most CGCMs
    - Mechanism: Trade winds bring into the SPCZ cool and dry air from the stratocumulus region in the Southeastern Pacific
    - Need for a better understanding of the physical processes that determine the margins of deep convection: Simple models suggest that the edge of the convective zone is sensitive to vertical motion, wind projected onto vertical moisture structure, or moisture at the source region
    - Sparse in situ observations; satellite data lack the vertical structure/need several years to obtain statistical measurements
    - Would need a dedicated observational program to validate mechanism between SPICE (southwest) and VOCALS (southeast) regions (suggestion for aircraft measurements from 170E to 135W near 10/15°S in addition to ship-of-opportunity programs
- *What do coupled models get wrong? (S. Behera)*
    1. Too strong easterlies over north-equatorial Pacific related to poor resolution of mountains over Central America. The strong divergences related to accelerating winds in the north equatorial Pacific reduce the

eastward extension of northern ITCZ. This could influence the barrier layer there.

2. Weak and not realistic subtropical high in southeastern Pacific, probably related to biases in model tropical and extra-tropical weather disturbances. Here we have a chicken-egg problem between subtropical high and SPCZ.
3. Opposite zonal gradient in the equatorial SST of Atlantic Ocean which influences the equatorial easterlies in the Pacific. Stronger than normal equatorial easterlies reduces the cross-equatorial flow in eastern Pacific. Those cross equatorial flows are important for getting realistic Walker and Hadley circulations.

- CGCM intercomparison: Although lower in resolution compared to several others, the MRI model captures the SPCZ better than other. Besides the right tuning of model physics, the flux-corrections might be helping that model simulation. The model bias will be further explored using high resolution CGCMs of FRCGC/JAMSTEC/ESC. It appears the easterlies that cross to the Pacific from Atlantic over the Central America are not well resolved. Most models fail to reduce the wind speed of easterlies. We will investigate if we could decelerate those easterlies by introducing low-level mountains of Central America in the high resolution model.
- Intend to increase the resolution of the model first and if this doesn't work then explore the PBL and also deep convection schemes.
- The barrier layer (oceanic salt stratification in the mixed isothermal surface layer that controls the downward penetration of mechanical forces into the ocean) may be important – test in a model that gets the barrier layer right (Cravatte?). Resolution of the barrier layer in both western and eastern Pacific might reduce model biases.
- Most models also fail to resolve the east-west zonal gradient in SSTs of the Atlantic. We will explore this model bias by increasing model resolution and changing model physics. The problem needs to be tackled for the whole South Hemisphere, including the Atlantic SACZ.

- *SPCZ impacts on ocean dynamics (B. Kessler)*
  - Wind curl variations associated with the SPCZ have a large effect on the ocean by changing the thermocline gradient across the South Equatorial Current. This signal is a principal feature of both annual and interannual variability of the subtropical gyre circulation. The Rossby waves produced by the SPCZ curl radiate these signals to the western boundary, resulting in variability of the:
    - Strength of the gyre (SEC transport)
    - Western boundary transport

- *Regional impacts (J. Renwick)*
  - Regional downscaling/seasonal and climate change prediction
  - Tasman box heat content
  - SPCZ effects on higher latitude circulation

- *Further discussions*
    - Possibilities for ship measurement to calibrate against island data (because of local orographic effect/cloud over island). Would also need numerical simulation at high resolution to plan such experiment (duration/intensity).
    - Another possibility is to do a sensitivity analysis of the land-sea fluxes vs air-sea fluxes in a model domain in the vicinity of the SPCZ
    - Possibilities for 6-hourly sounding versus 1/day for some more intensive period ?