Studying Decadal Climate Variability
Using Satellite Scatterometer Data

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SOI & PDO indices
showing phase change of decadal signals at the end of the 20th century
Observed SST & SSH exhibit opposite decadal tendencies before & after year 2000 over much of Indo-Pacific domain.
SSH time series (black) further illustrate the phase change around 2000

- Tropical Pacific leads other regions.
- SSH leads SST?
- Need wind obs. to understand SSH & SST
Opposite trends in large-scale wind stress curl (WSC) over much of Indo-Pacific before & after 2000


ERS


QSCAT

X $10^{10}$ Pa/m/yr
WSC help understand SSH & oc. circulations

Decadal slowdown of MOC in IO (Lee 2004)

Decadal spinup of S. Pac. subtropical gyre (Roemmich et al. 2007)

Weakening N. Atl. subpolar gyre (Hakkinen & Rhines 2004)
Trade winds affect climate variability by forcing meridional ocean circulations (MOCs) to redistribute heat between tropics & subtropics, which modulate ocean-atmosphere coupling.

Satellite data critical to the study of these MOCs and heat transports:
- Scatterometer data: divergence of warm surface water (Ekman flow)
- Altimeter data: convergence of cold subsurface water (geostrophic flow)
Decadal variation of trade winds & climate variability

Lee and McPhaden (2008)

Bias between satellites a big issue!
Opposite changes of SSH differences between E & W coasts: thus opposite roles of Pacific & IO meridional geostrophic flow (lower branch of MOCs)
Tropical Pacific wind control E-W SSH differences (and thus lower limb of MOCs) in Pac. & IO through oceanic tunnel.

Stronger trade cause SSH pile-up in the west near equator.

Off-equatorial curl enhance SSH rise in the west.

SSH signals here not forced locally.
Off-equatorial wind stress curl cause anomalous gyres in western Pacific, resulting in counteracting geostrophic flows in western boundary currents & interior (Lee and Fukumori 2003)
Scatterometer & altimeter obs. brought new insight about MOC structure & maintenance mechanism of tropical heat content

• 2-D (y-z) meridional transport stream function masks out counteracting roles of interior & WB flows;
• existing in-situ obs system do not cover WB flows adequately.
Scatterometer & altimeter data only cover the past 16 years, are the anti-correlated Dec. Var. between tropical Pacific & South Indian Oceans ubiquitous features in general?
Anti-correlated decadal variability in NCEP’s trade winds in tropical Pacific (4°S-4°N) & Indian Ocean (9°-15°S)

Are the multi-decadal changes real? Wind stress obs need to resolve/discern a 0.001 N/m² decade-to-decade difference (< 1 m/s). What’s the required obs accuracy?
Atlantic Meridional Overturning Circulation (AMOC) and Climate

AMOC helps maintain a warmer climate in N. America & Europe.

Bryden et al. (2005): Slowing of the AMOC

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<th>Table 1</th>
<th>Meridional transport in depth classes across 25° N</th>
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<td>Shallow</td>
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| Values of meridional transport are given in Sverdrups. Positive transports are northward.
QuikSCAT wind – important element for monitoring the Atlantic MOC

RAPID Program’s AMOC monitoring system

(1) From submarine cable
(2) From QuikSCAT
(3) From mooring arrays

Total = (1) + (2) + (3)

Cunningham, Kanzow, Rayner et al. (2007)
Bias between sensors limit the scope for studying dec & longer variability/changes.
Summary

• Scatterometer data have demonstrated its potential in studying decadal variability.

• Sustained and consistent scat. measurements are critical to further the understanding of decadal and longer variability – bias significantly hampers progress.

• Accuracy needed to resolve multi-decadal and longer time scales variability is more stringent than that of dec. var.