Air-Sea Coupling in the Indian Ocean
An ONR Department Research Initiative (DRI)

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ONR's Department Research Initiatives (DRI)

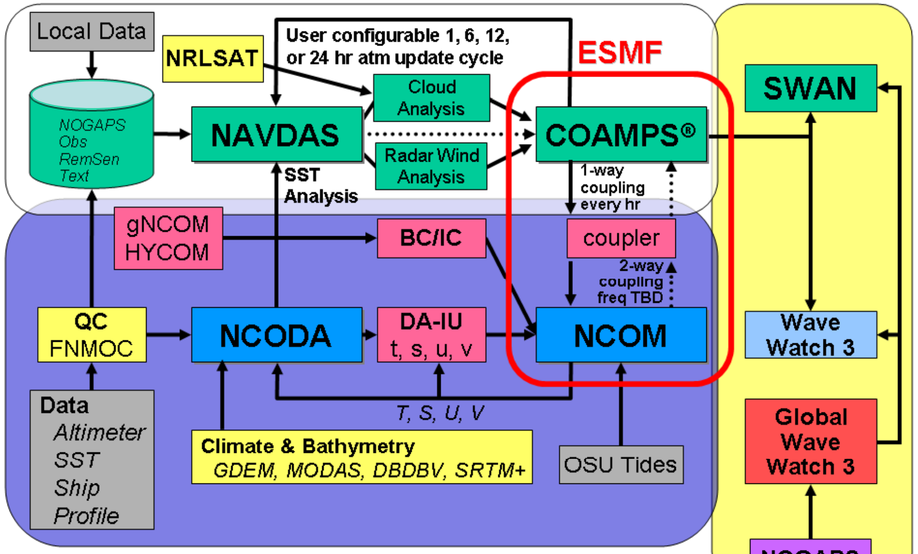
"Department Research Initiatives" are five-year efforts focused on making progress on a particular science topic. They involve interdisciplinary teams of scientists assembled by ONR that work together on a collaborative effort.

A Sampling of Recent DRIs:

- Circulation Dynamics of the South China Sea and Vietnam Shelf, FY11-FY15
- Origins of the Kuroshio and Mindanao Currents, FY10-FY14
- **Air-Sea Coupling in the Indian Ocean - MJO, FY10-FY14**
- Scalable Lateral Mixing and Coherent Turbulence, FY09-FY13
- Internal Wave Generation in Straits, FY09-FY13
- Impact of Typhoons on the Ocean in the Western Pacific, FY08-FY12
- Tidal Mud Flats Initiative, FY07-FY11
- High-Resolution Wave-Air-Sea Interactions, FY07-FY11
- Philippine Archipelago Circulation and Strait Dynamics, FY06-FY10

Coupled Modeling and Prediction

Many coupled models (atm-ocean; atm-wave-ocean) have been developed and are being used for both research and operational prediction



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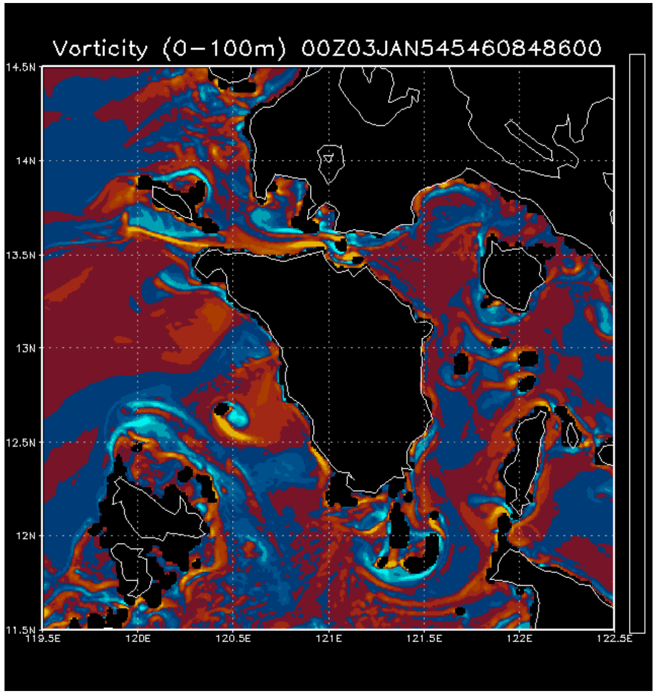


Are the relevant coupled processes adequately represented?

Can these processes be parameterized in coarser models?

MJO DRI
Air-Sea Coupling in the Indian Ocean

Overall Goal :

A better understanding of coupled (ocean-wave-atmosphere) physical processes and the numerical representation of these modes in coupled models

Concentration will be on the detailed physics of the

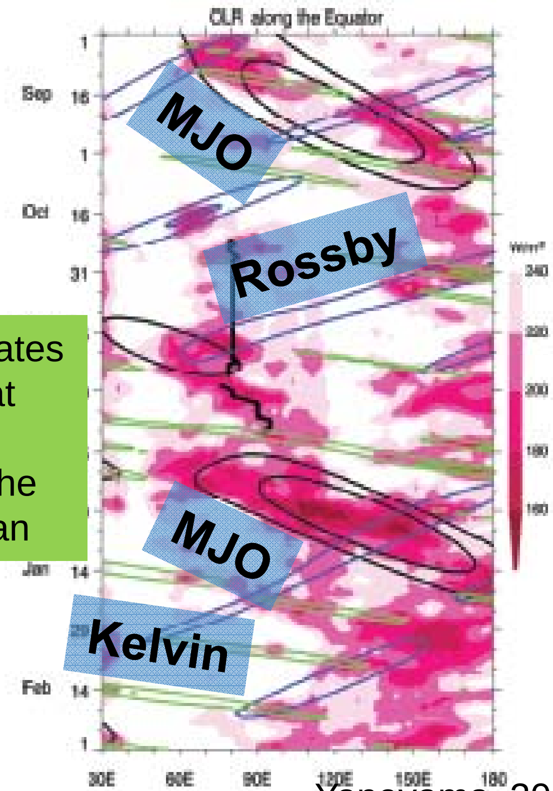
- **upper ocean mixed layer**
- **surface fluxes**
- **atmospheric boundary layer**

and the role these all play in coupled mode propagation

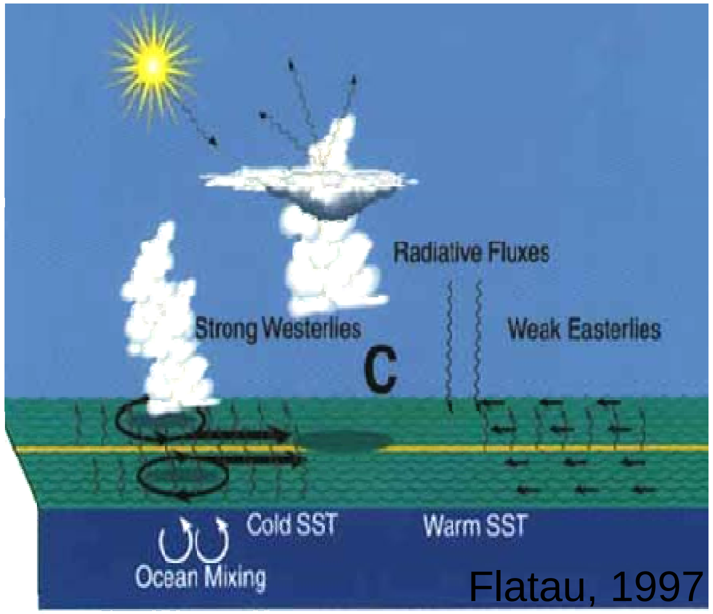
Coupled Processes in MJO

1. Decreased mixing/ high surface solar heating under clear skies, weak winds, dry/stable atmosphere during MJO suppressed phase.
2. Strong SST diurnal cycle develops leading to isolated convection.
3. Moistening of the mid-troposphere, increased cloudiness (weaker surface solar heating), increased rain events (fresher/ stable ocean surface layer), better mixed OML with weaker afternoon warm layer.
4. Increased widespread convection develops and propagates, associated with reversal in surface wind direction, stronger winds, and change in wind/wave mixing

Mode propagates eastward at ~5m/s, or 18km/hr in the Indian Ocean



Yoneyama, 2008



Flatau, 1997

Scientific Goals for the DRI

Through a combination of modeling and observational studies, we hope to better understand…

The submesoscale coupled processes that result in larger-scale impacts on the coupled system in the Indian Ocean

- What processes control coupled propagating features that persist? (latitude/location, background structure, planetary waves, etc)
- What are their spatial and temporal time scales?
- Includes: role of diurnal cycle, cold pools, barrier layers, organized convection, BL rolls, Langmuir cells, surface waves, etc on ocean-atmosphere feedback

How to represent the above processes in predictive models

- What vertical resolutions are required to adequately capture the processes?
- Do improved representation and parameterization lead to improved predictability?
- How to build scale-dependent parameterizations that better represent the fluxes and propagating coupled modes, across model resolutions that may only partially represent such processes

Detailed Scientific Goals for the DRI

Through a combination of modeling and observational studies, we (collectively) hope to better understand…

- the 3D structure of local convective cells (including the surface winds, surface fluxes, and the ocean response – waves, mixing)
- whether improved representation/parameterization of MJO-related processes lead to improved predictability
- cloud evolution, and how it is impacted by air-sea coupling
- role of microphysical atmospheric parameterizations on the coupled phenomena in the tropics
- the processes, on fine scales, that result in larger-scale impacts on the coupled system in the Indian Ocean
- the spatial variability of these fine-scale processes, and how that evolves over time into larger-scale features
- the vertical resolutions required to adequately capture the processes
- which spatial and time-scales are actually important (that lead to fluxes that change the large-scale circulation)
- role of diurnal cycle, cold pools, barrier layers, organized convection, BL rolls, Langmuir cells, surface waves, etc on ocean-atmosphere feedback
- what controls coupled propagating features that persist (latitude/location, background structure, planetary waves, etc)
- how to build scale-dependent parameterizations that better represent the fluxes and propagating coupled modes, across model resolutions that may only partially represent such processes
- how to capture the impact of brief, extreme events that may result in the majority of the air-sea flux exchange, in models that do not resolve these scales

DRI Participants: Observational Campaign

(Just lead PI's on the grants - many others also involved)

- Jim Moum, Oregon State
- Rob Pinkel, UCSD/Scripps
- Jim Edson, University of Connecticut
- Simon de Szoeke, Oregon State

R/V Revelle

- Piotr Flatau , UCSD/Scripps
- Darek Baranowski, UCSD/Scripps

R/V Mirai

- Qing Wang, Naval Postgraduate School
- Djamal Khelif, Univ. of California, Irvine
- G.D. Emmitt, Simpson Weather Associates
- Alan Brewer, NOAA/ESRL
- Ralph Foster, University of Washington

NOAA P3 Aircraft (tentative)

- Chidong Zhang, RSMAS (for coordination with DYNAMO)

DRI Participants: Modeling Effort

(Just lead PI's on the grants - many others also involved)

- Maria Flatau, NRL-Montery
- Sue Chen, NRL-Monterey
- Toshiaki Shinoda, NRL-Stennis
- Tommy Jensen, NRL-Stennis

COAMPS

NRL Coupled Model
- COAMPS (atmos)
- NCOM (ocean)
- SWAN (waves)

- Art Miller, UCSD/Scripps
- Raghu Murtuguude, University of Maryland
- Hyodae Seo, WHOI

SCOAR

SIO Coupled Model
- RSM (atmos)
- ROMS (ocean)

•Eric Skyllingstad, Oregon State

LES Modeling of the ABL

Potential Additions

(Waiting on facilities decisions by NOAA)

- Ken Melville, UCSD/Scripps

Ship-based UAV
ScanEagle on Revelle
- Surface fluxes
- IR SST

- Chris Zappa, Columbia University/LDEO

WAMOS Wave Radar
On Revelle

- Hans Graber, Miami/RSMAS/CSTARS

High-Resolution Remote Sensing
- **SAR**
- **Visible**
- **Hyperspectral**

Proposed US Aircraft Observations

Coupled Air-Sea Processes (funded by ONR): **FUNDED**

Q. Wang, D. Khelif, L. Mahrt, S. Chen

Deep convection/MJO initiation (proposed to NOAA): **Pending**

S. Chen, D. Jorgensen, A. Vintzileos

Aerosol/Cloud Microphysics (proposed to NSF & NOAA):

D. Noone, C. Fairall, P. Chuang **Pending**

Dropsonde Observations of Atmos Profiles (proposed to NSF):

Q. Wang, S. Chen **Pending**

P3 Aircraft Request to NOAA

NOAA WP-3D

AIRCRAFT CHARACTERISTICS

Crew: 7-8; Scientists: up to 12

Operational Airspeed: 170-250 KIAS [210 KIAS]

Max Take off Weight: 135,000 lbs.

Service Ceiling: 27,000 Feet

Low Altitude Range: 2,500 Nautical Miles (4,600 Km) [9.5 hours]

High Altitude Range: 3,800 Nautical Miles (7,000 km) [11.5 hours]

Aircraft Sampling Objectives for the DRI

- **To better understand the physics of air-sea coupling and improve physical parameterization of the coupled air-sea processes associated with MJO;**

- **To obtain coincident measurements of the lower atmosphere, PBL, air-sea interface (fluxes and wave field), and the upper ocean (AXCTDs/AXBTs/AXCP) that are adequate for coupled model evaluation and verification; and**

- **To provide a valuable data set for data assimilation in fully coupled models.**

END

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