Coupled air-sea modeling in island regions

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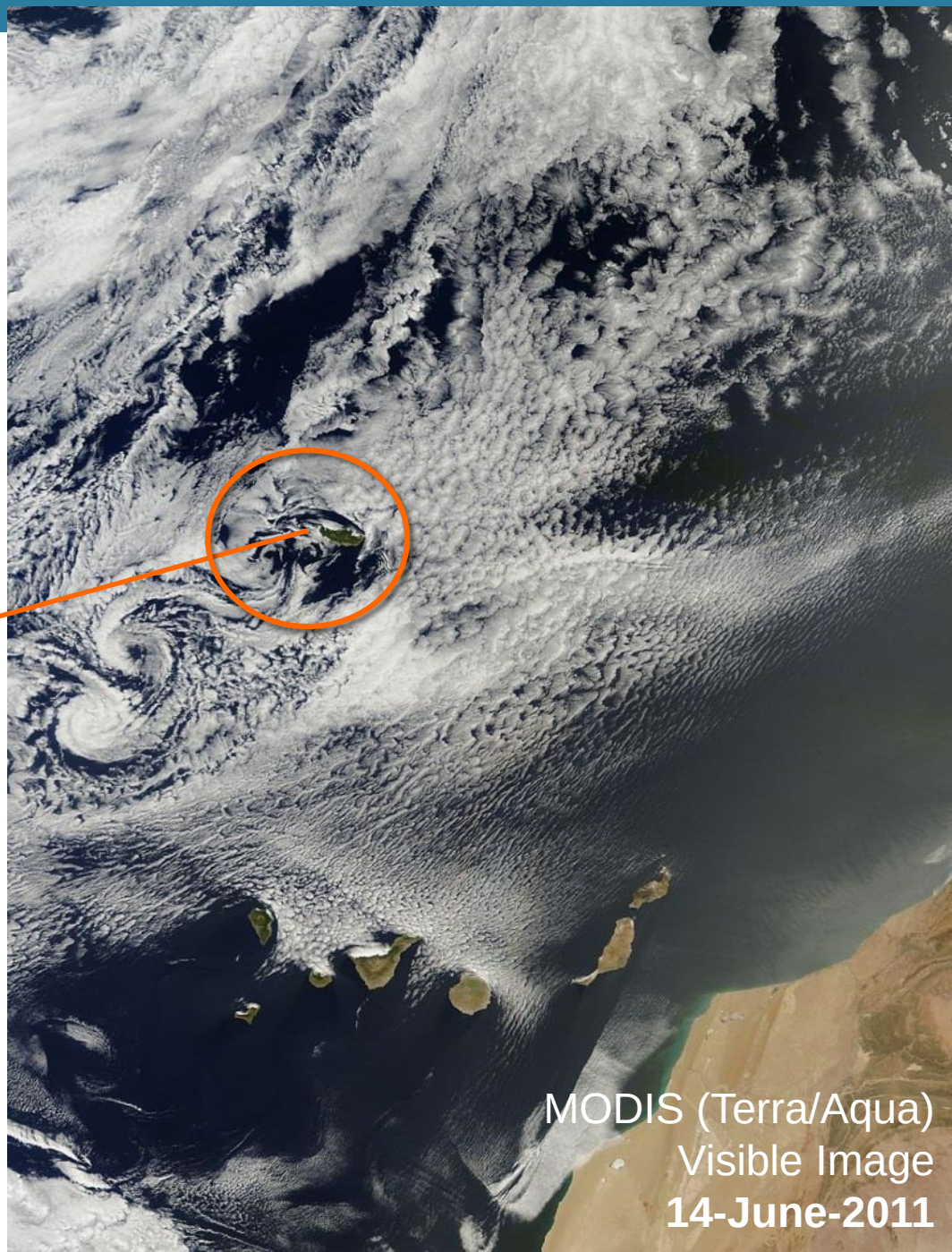
AGU PUBLICATIONS

Atmospheric Wake

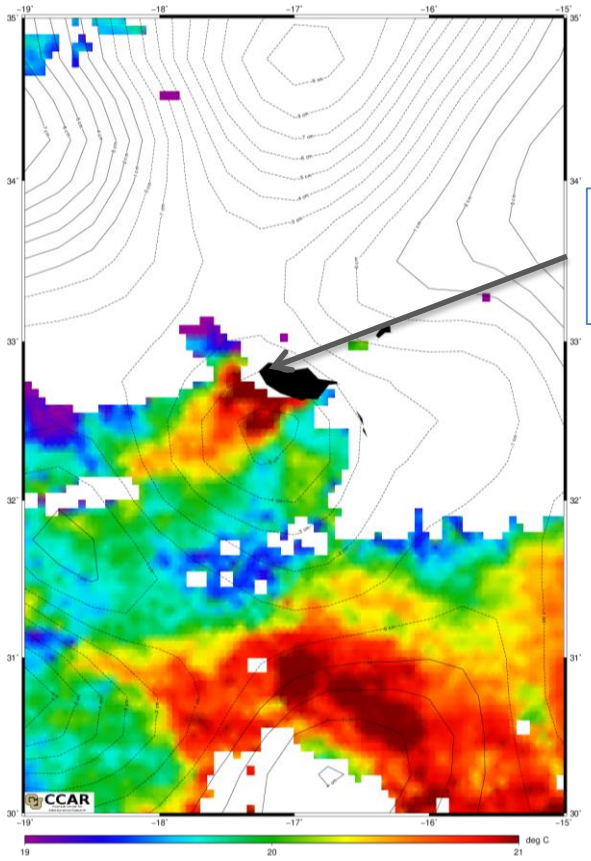
Ocean exposure to high solar radiation in the leeward side due to atmosphere wake

Not predictable with uncoupled systems and/or
Not captured by (global) model grid resolution



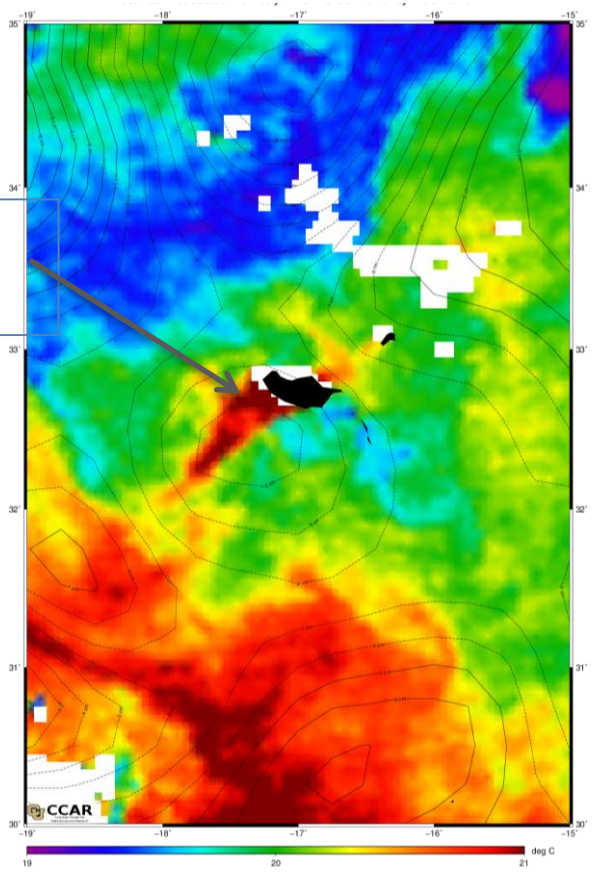
Observed Impact on Ocean SST

15 June 2011



+2º C in wake region

20 June 2011

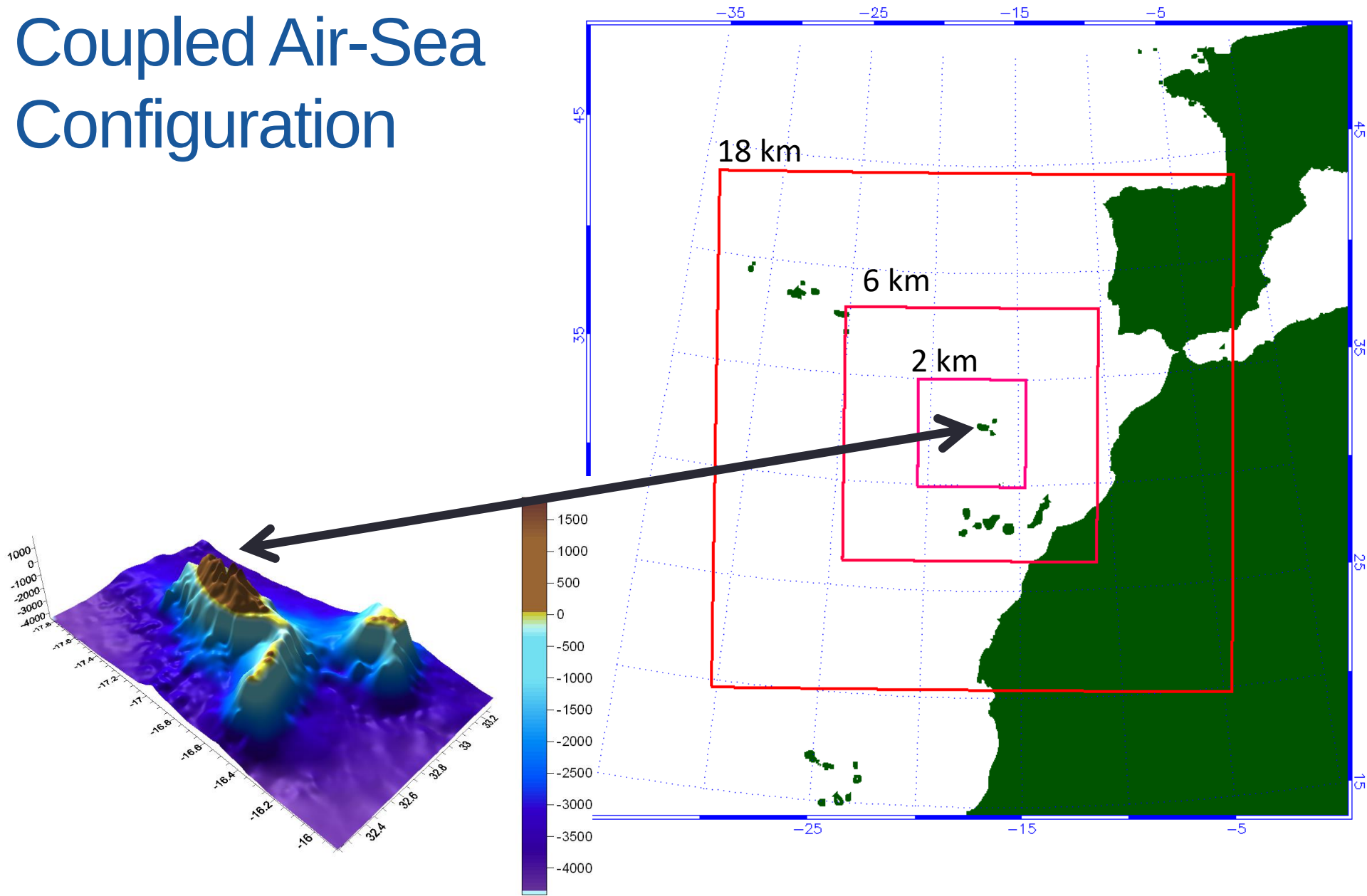


MODIS SST daily average

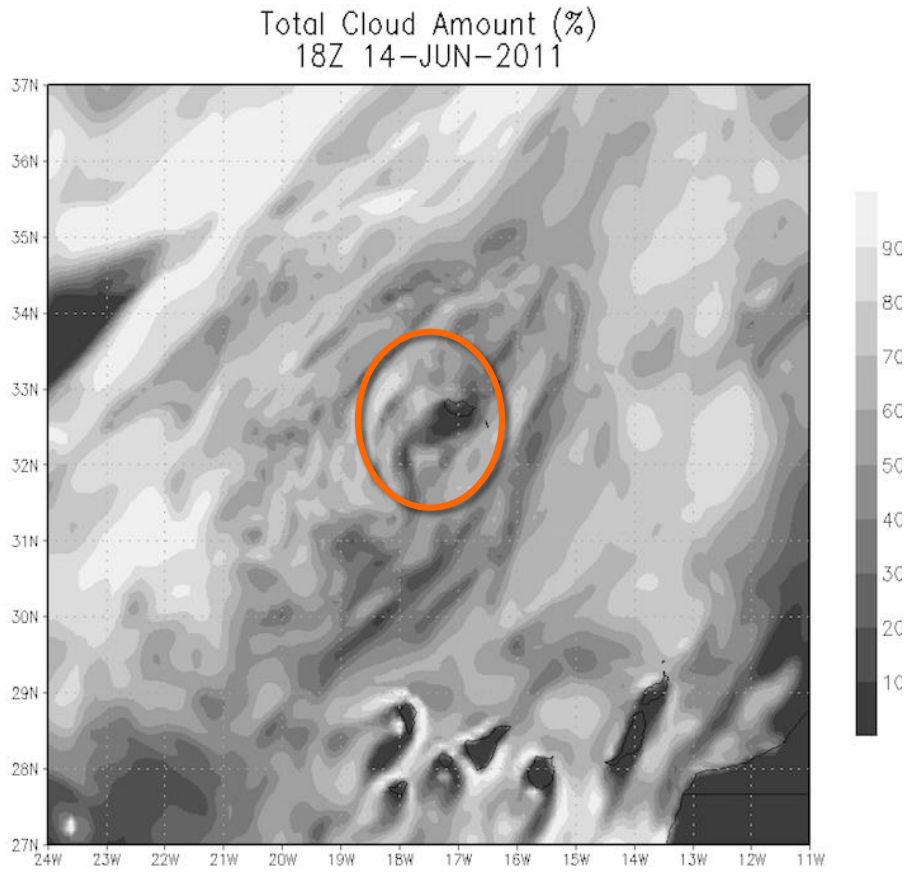
Motivating questions

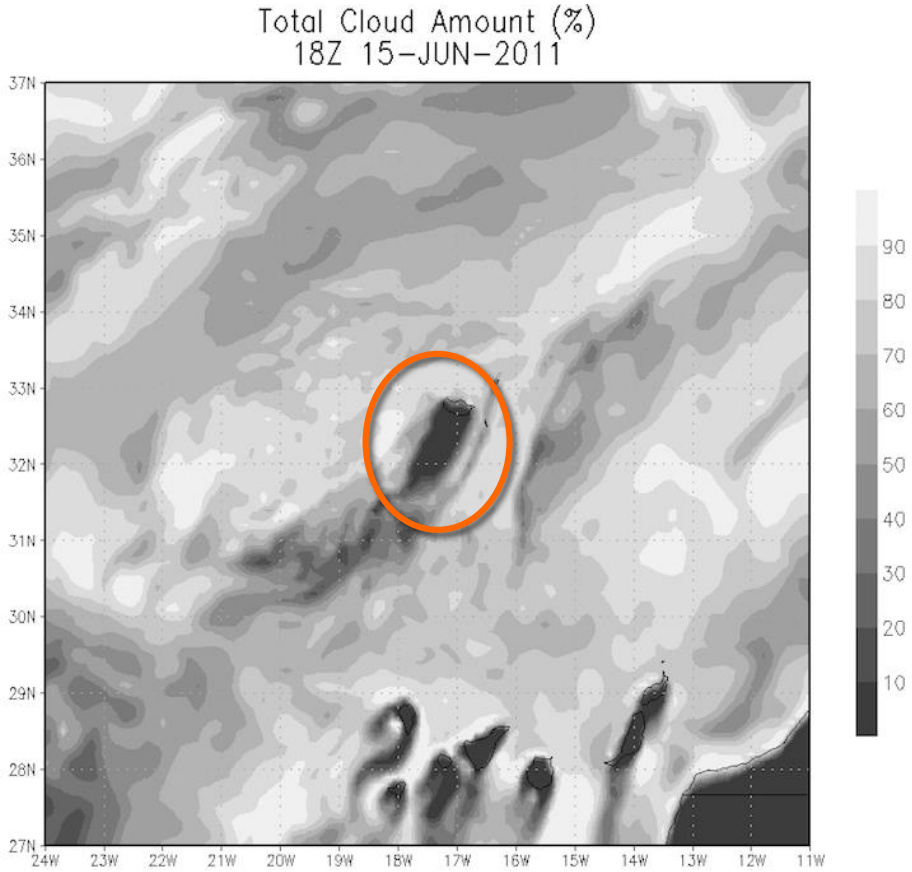
- How do warm wakes leeward of islands form?
- What is the interaction and evolution of atmospheric and oceanic boundary layers?
- What is the nature of the terrain influences on the flows?

Coupled Air-Sea Configuration



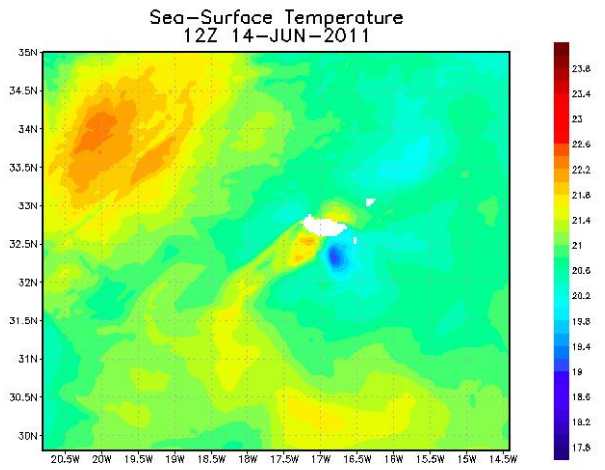
Model Cloud Fraction

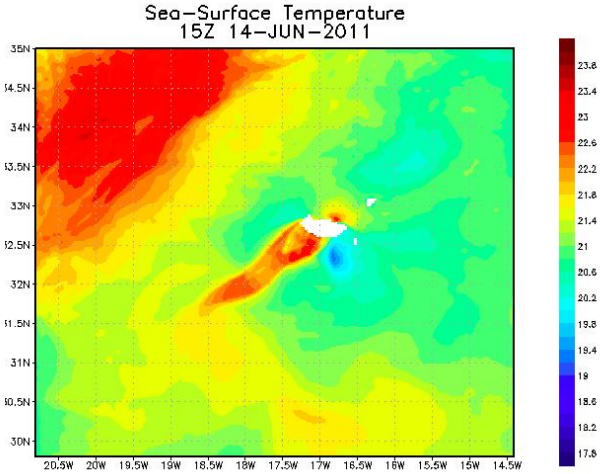


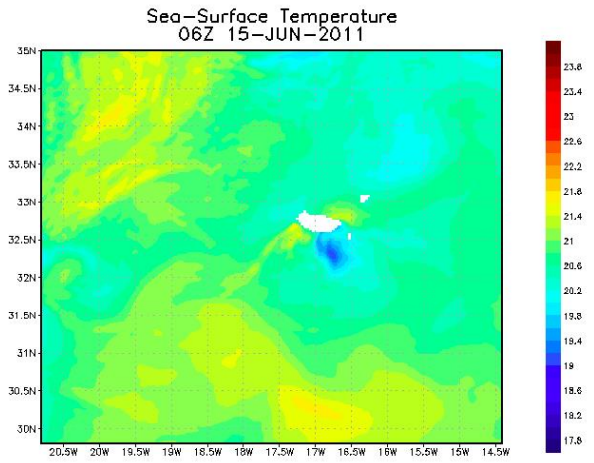


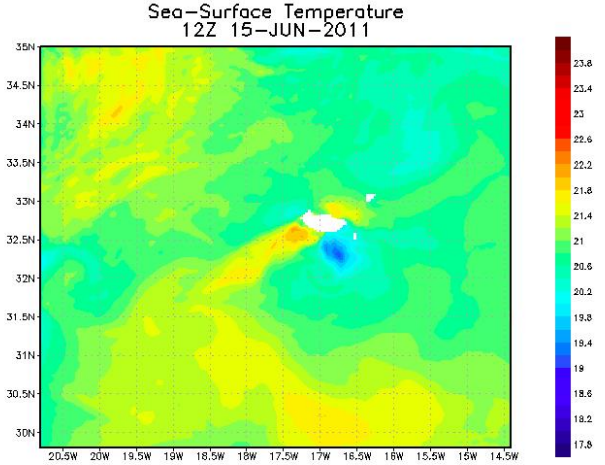
Reduced cloud coverage in the lee

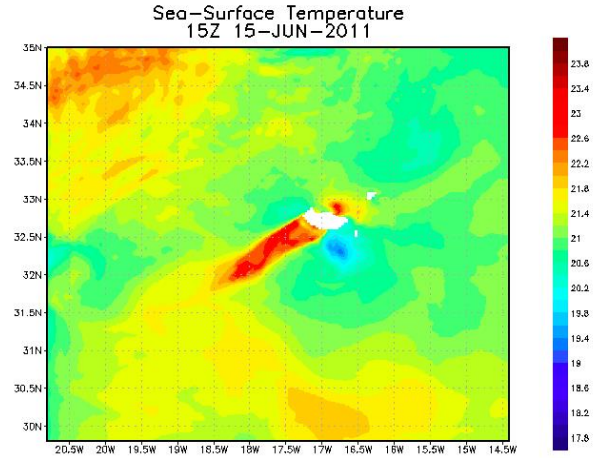
SST Evolution

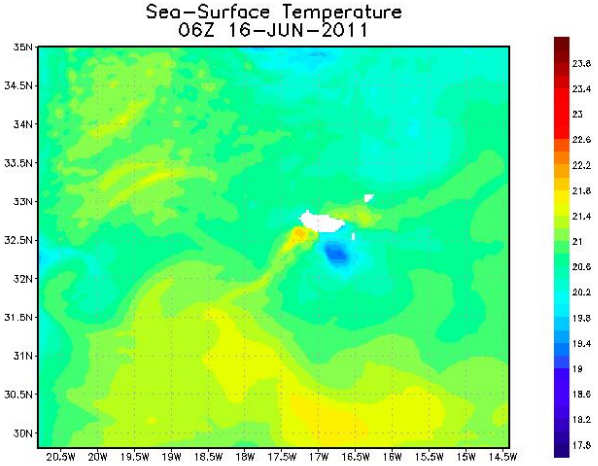




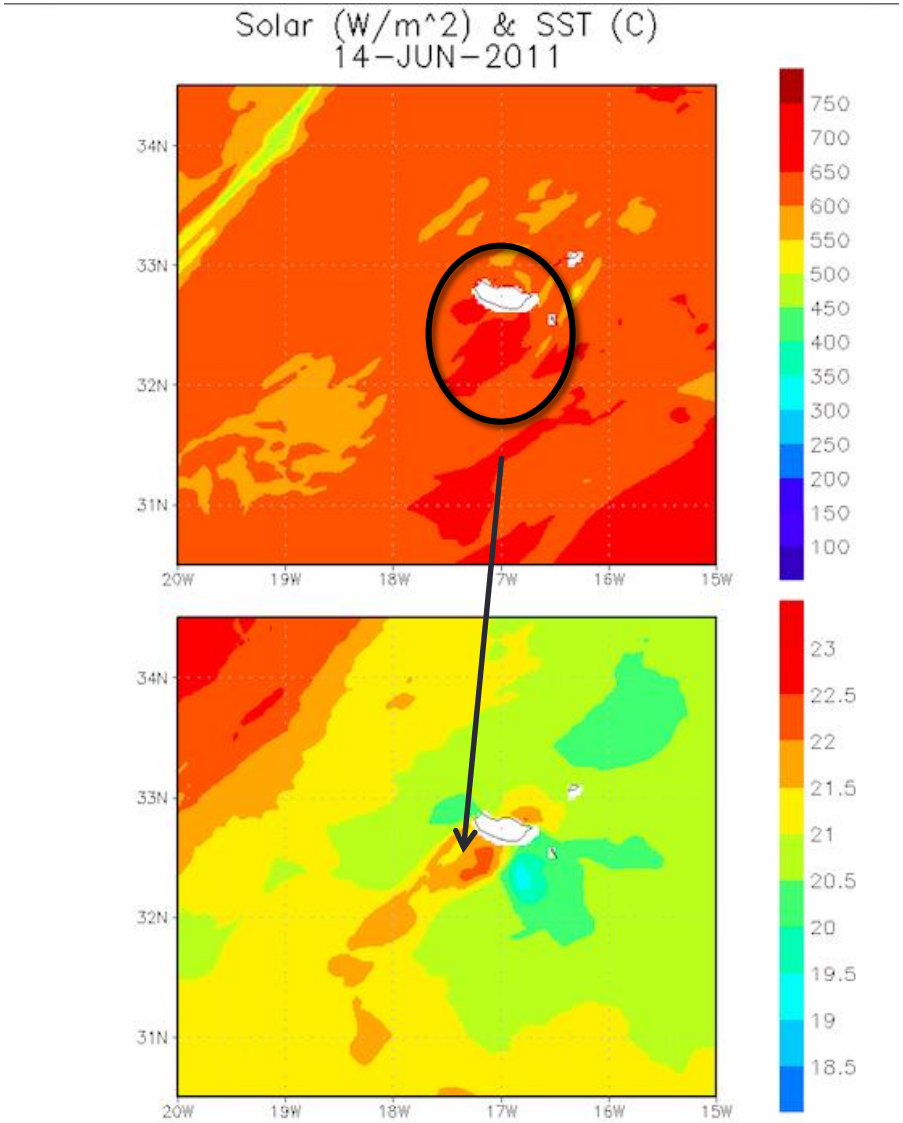






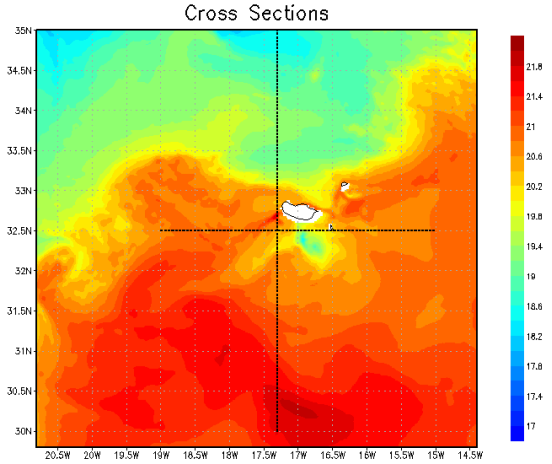


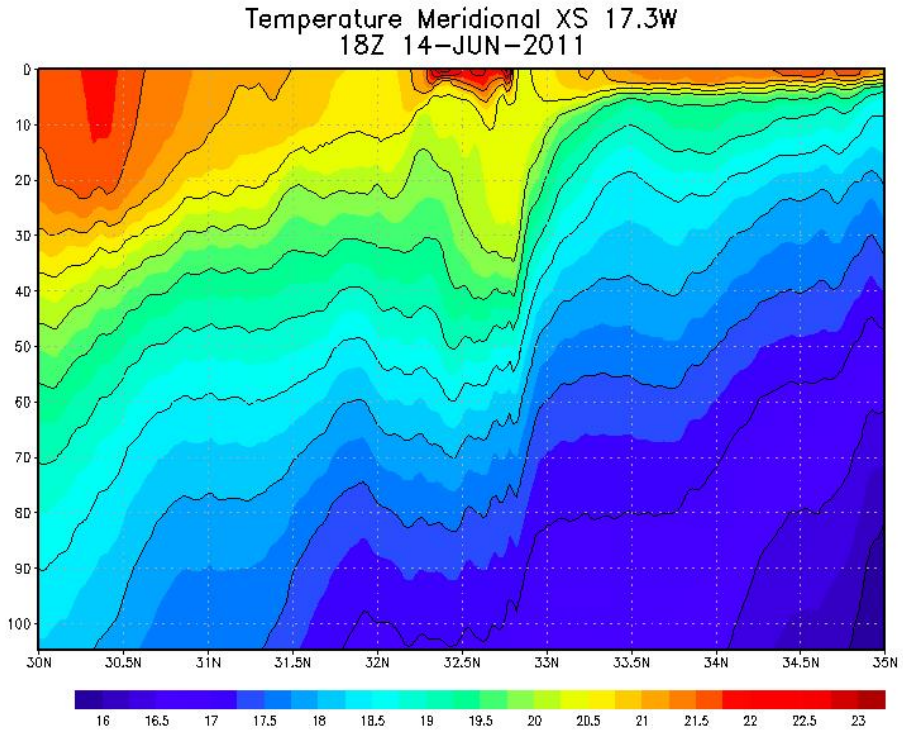
Warm Wake: Solar & SST

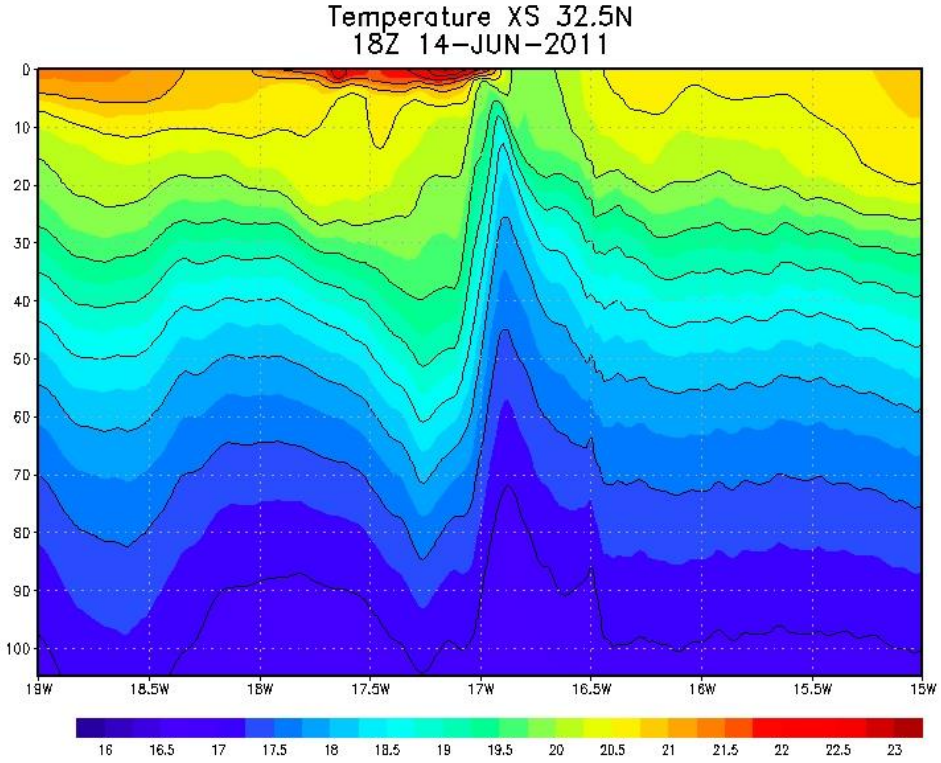


daytime average

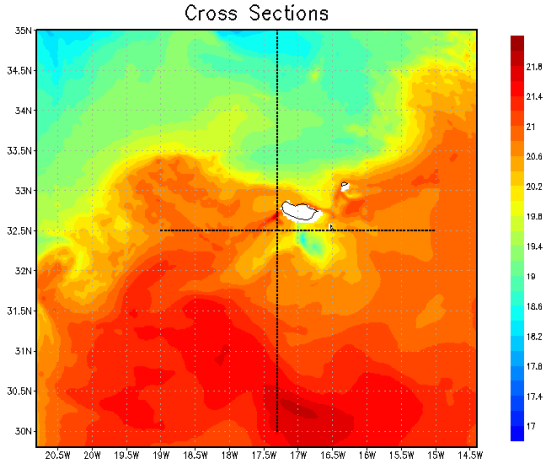
Lee Ocean Warming

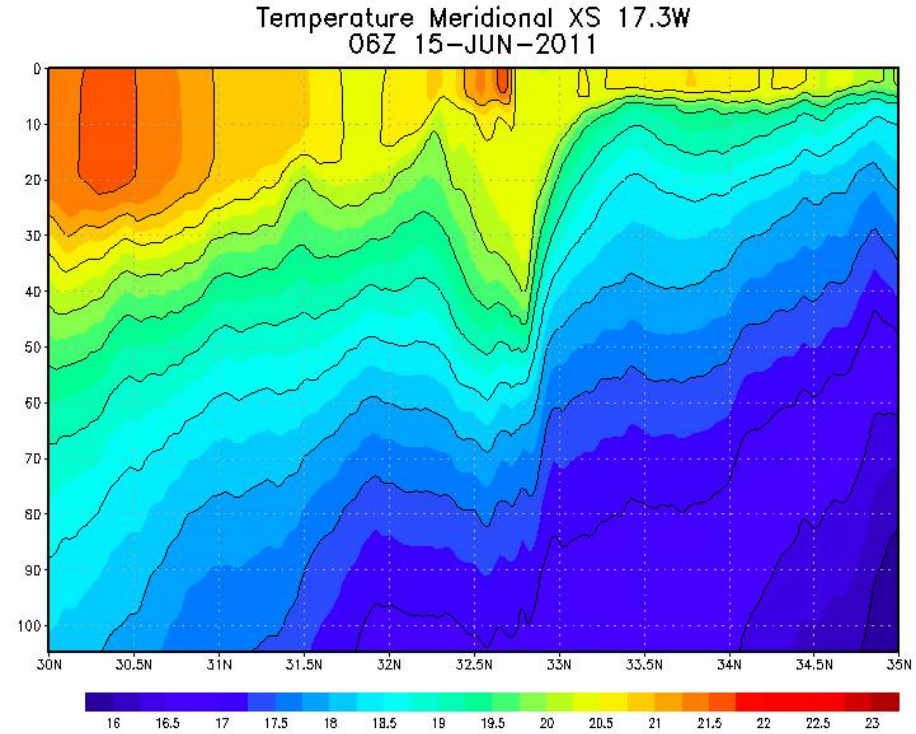


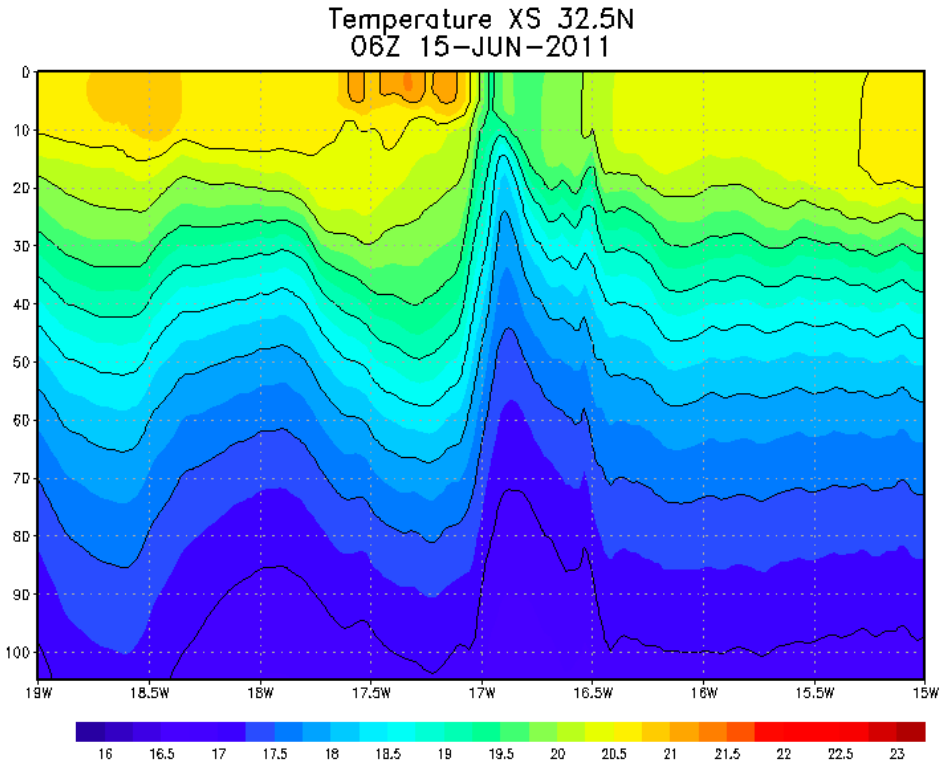




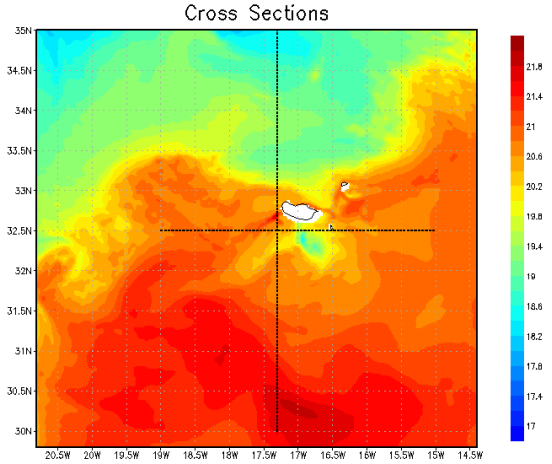
Night-time Dissipation

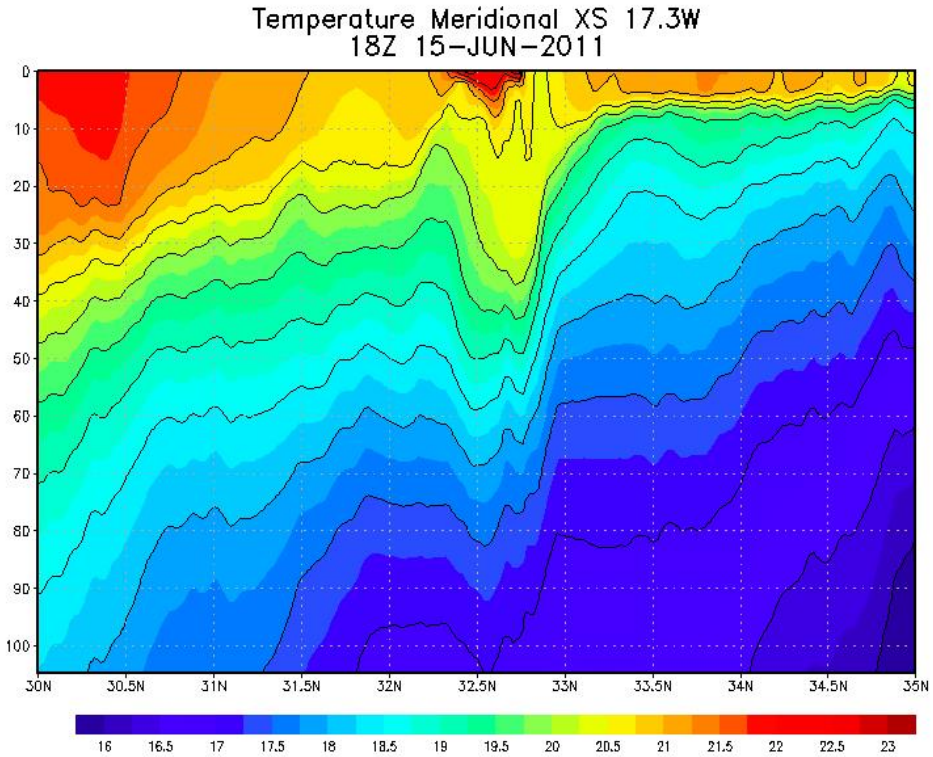


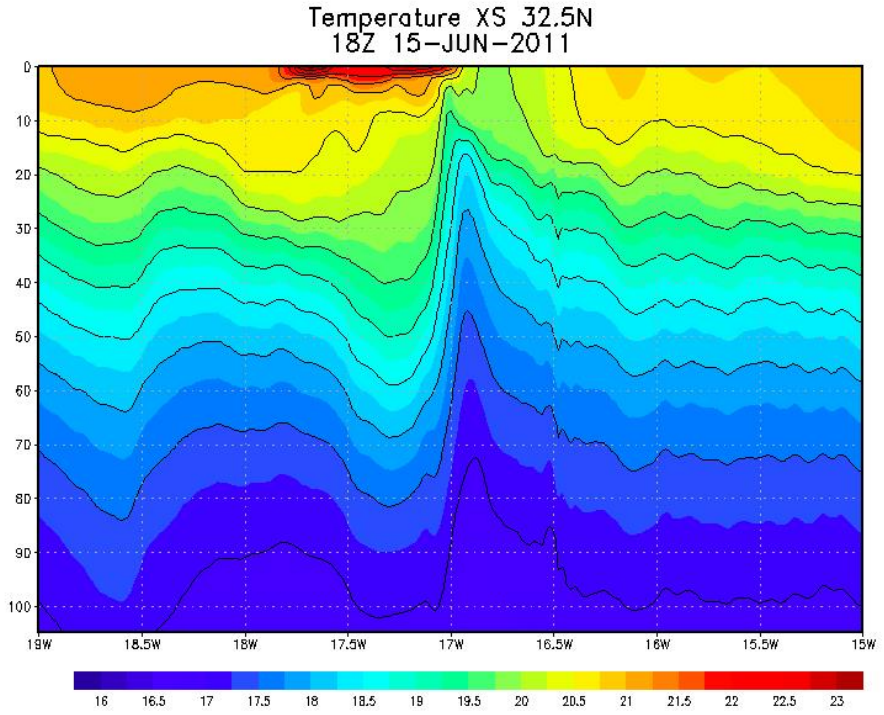




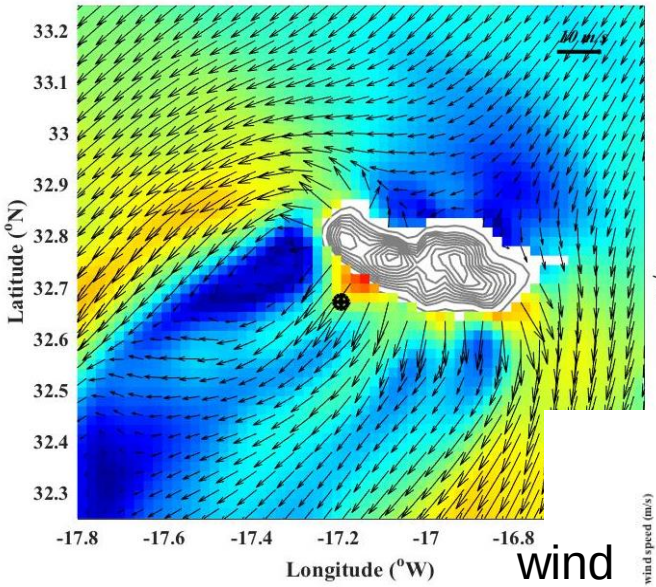
Lee Ocean Warming (2nd Day)

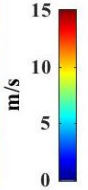




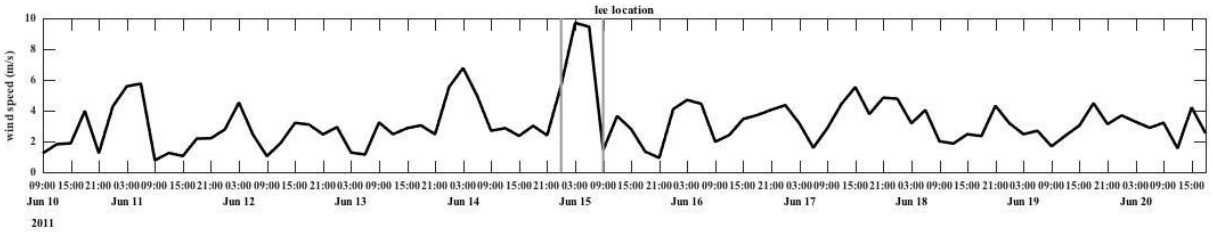


Downslope Flows



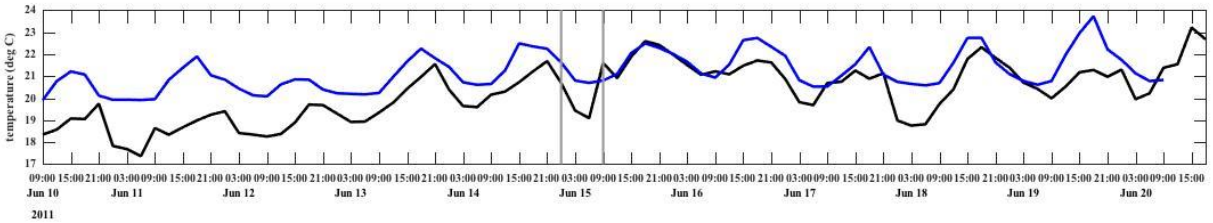


wind

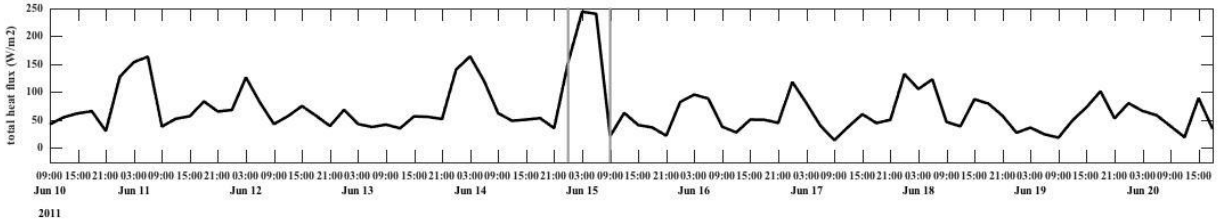


Strong sea to air heat fluxes beneath cold downslope winds

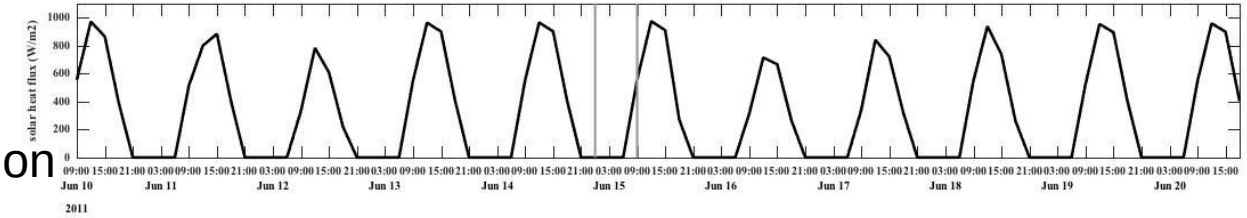
SST/air temp



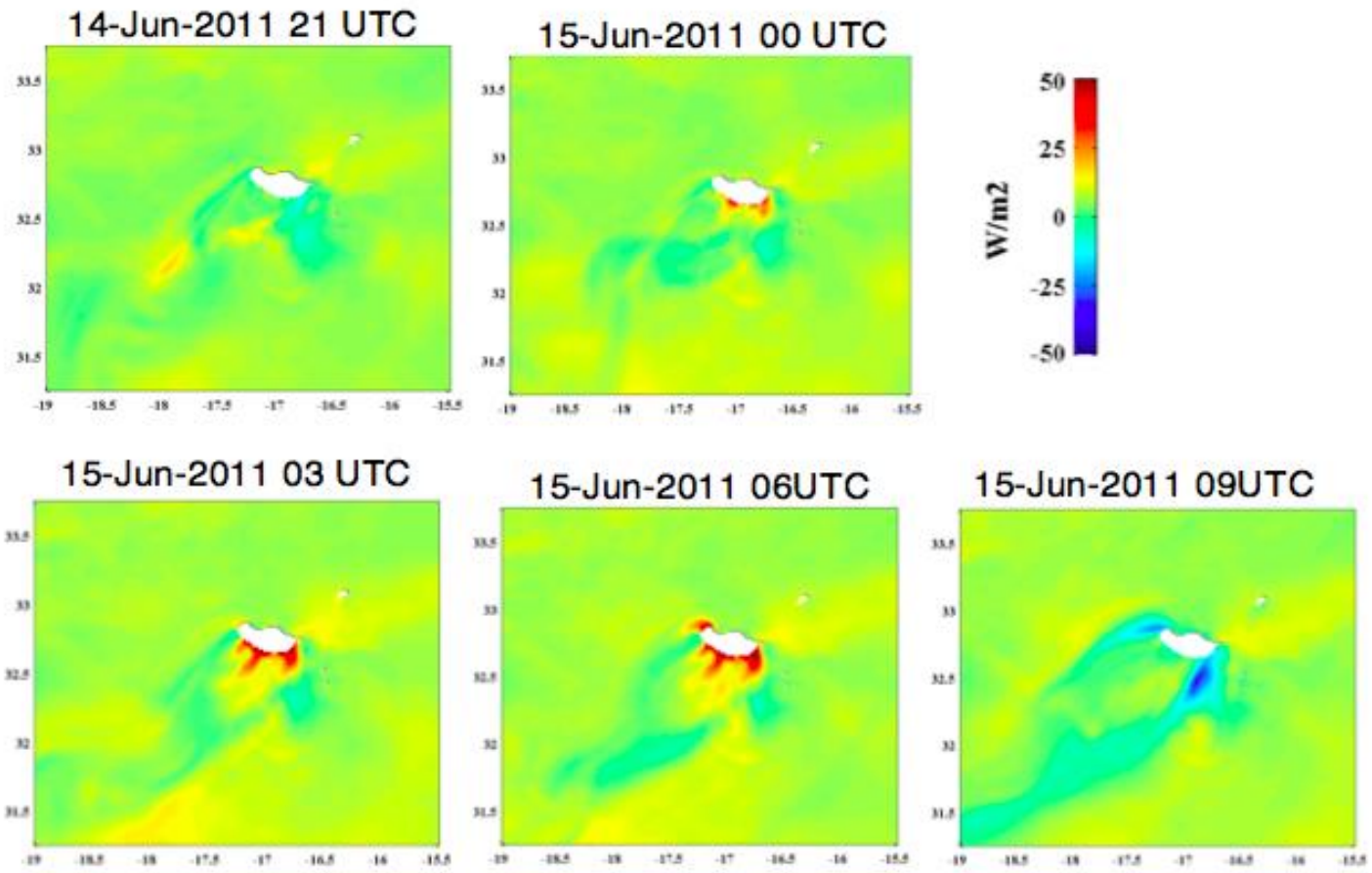
heat flux



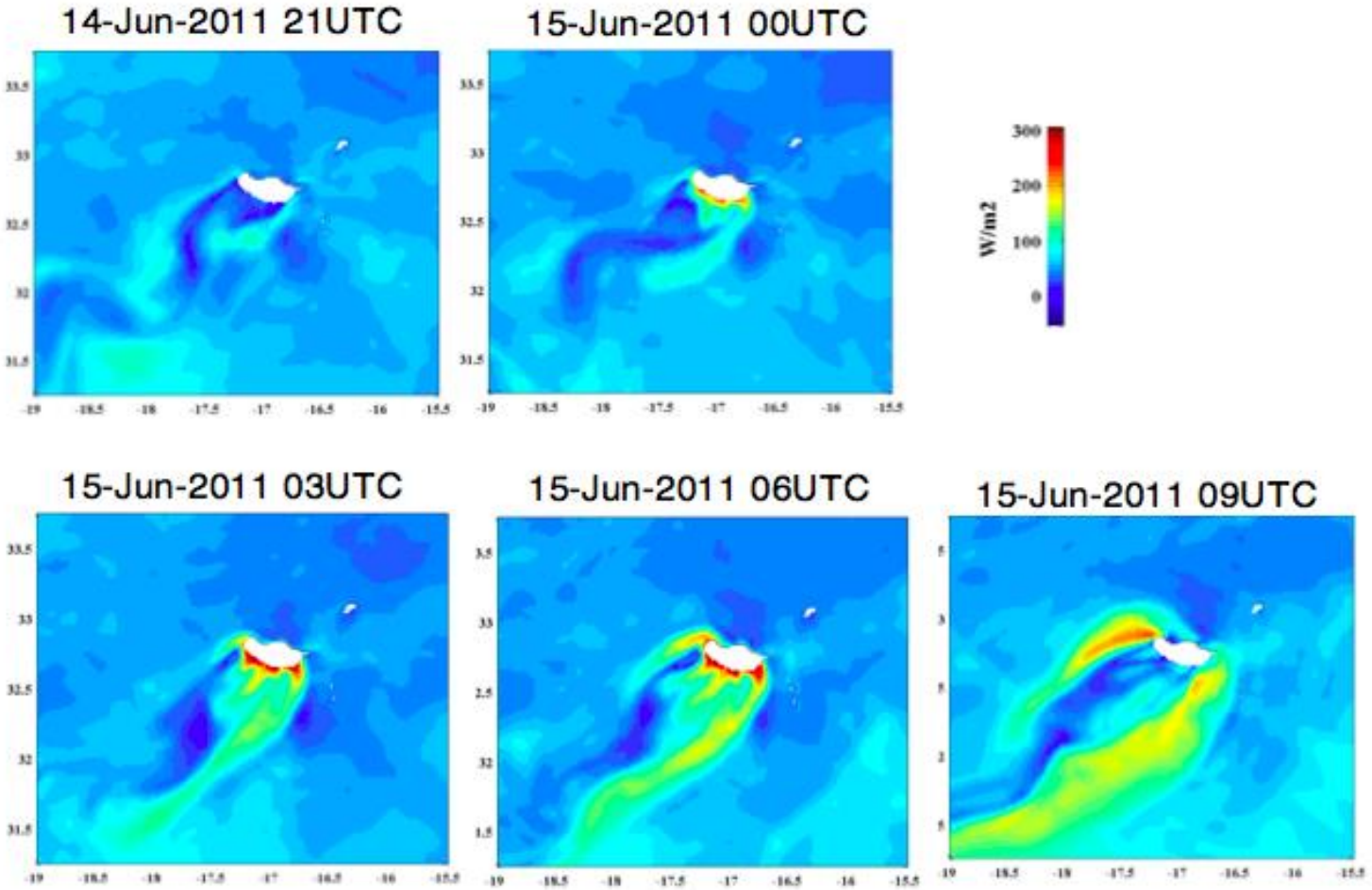
solar radiation



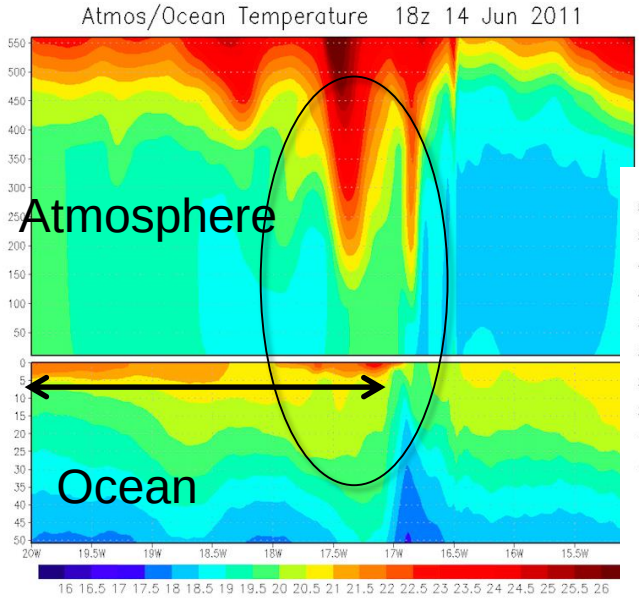
Sensible heat flux



Latent heat flux

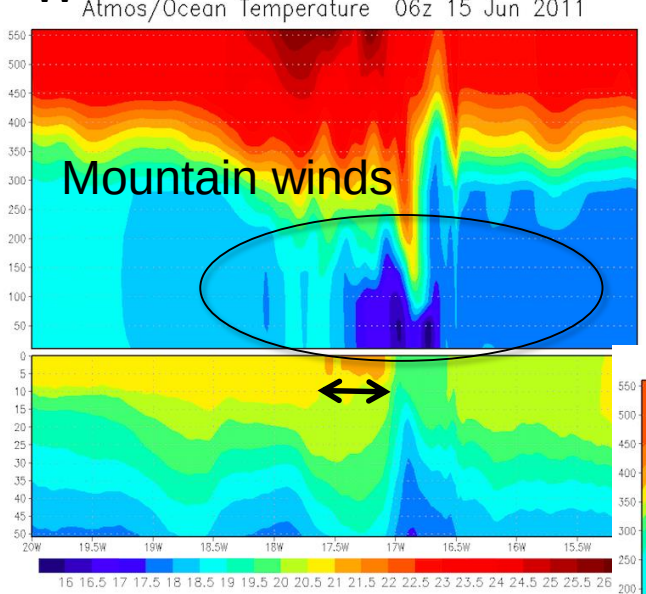


Boundary Layer Interaction

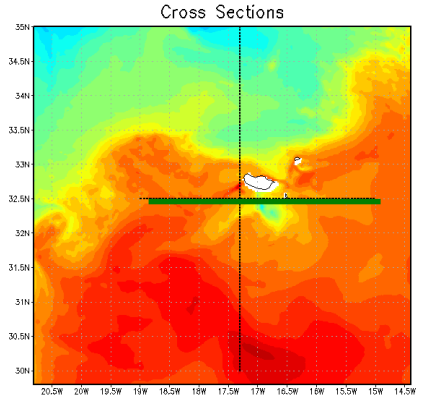


Daily air-sea warming (expansion)

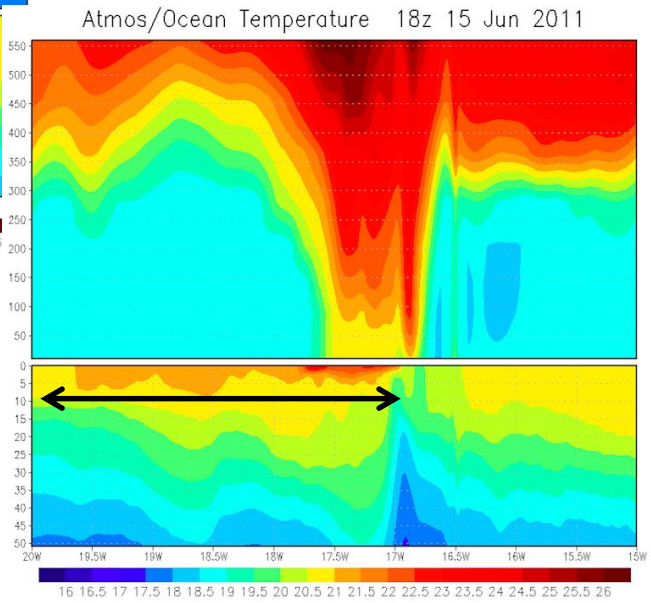
W E



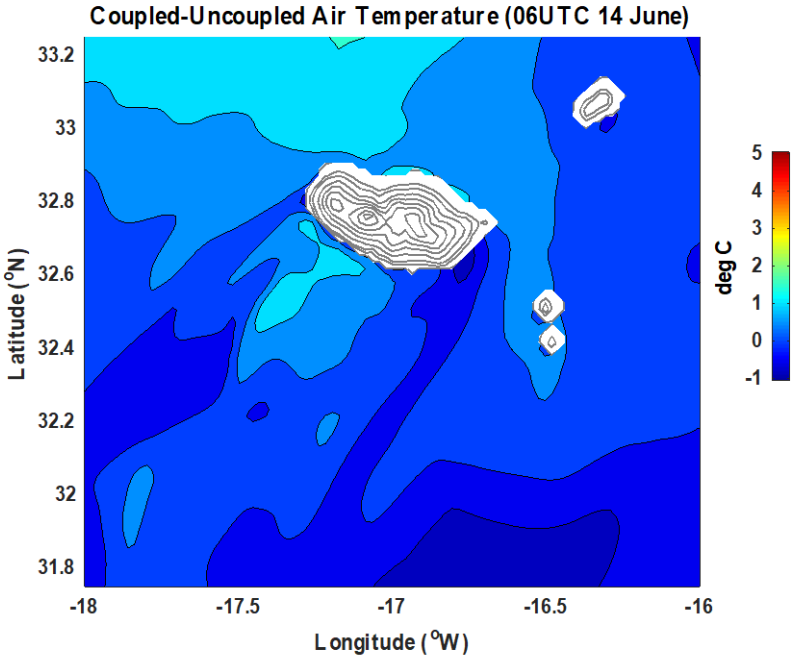
Night cooling w/ memory (contraction)

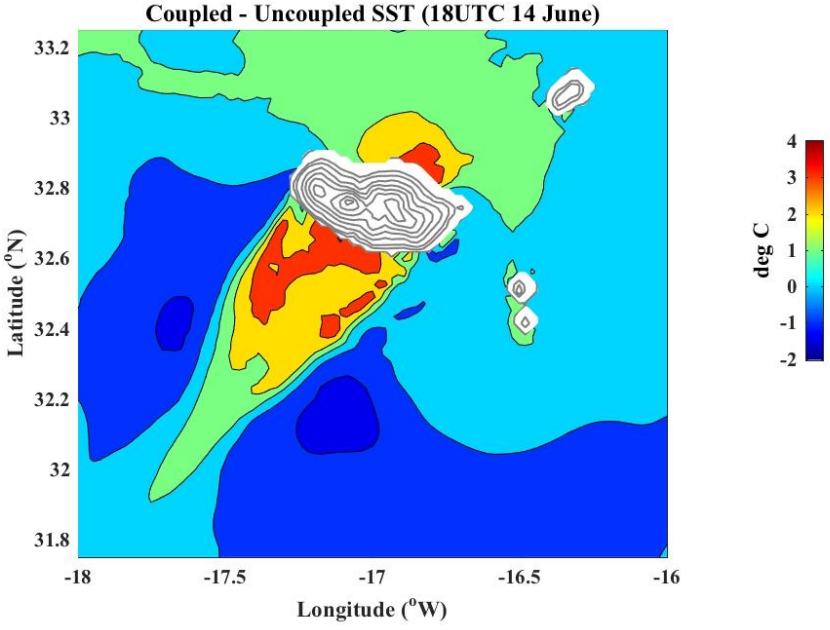


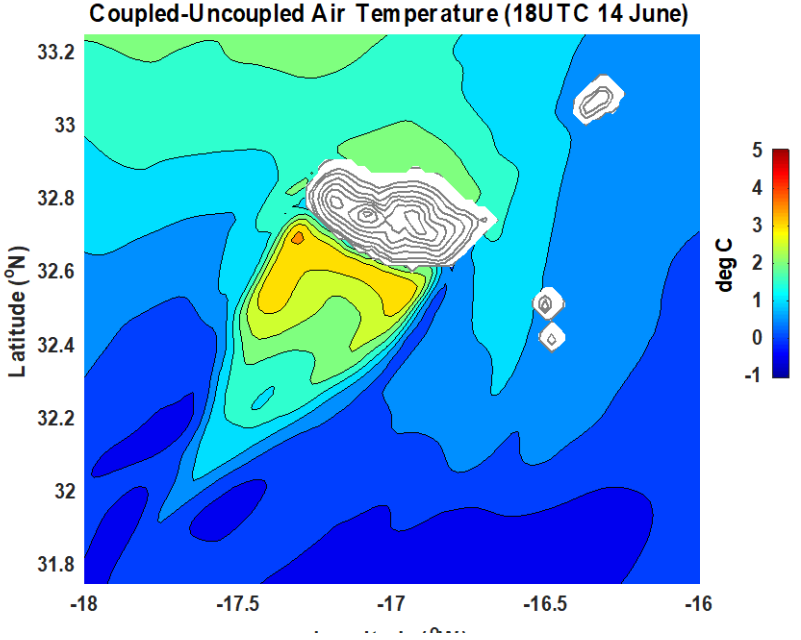
Daily air-sea warming (expansion)



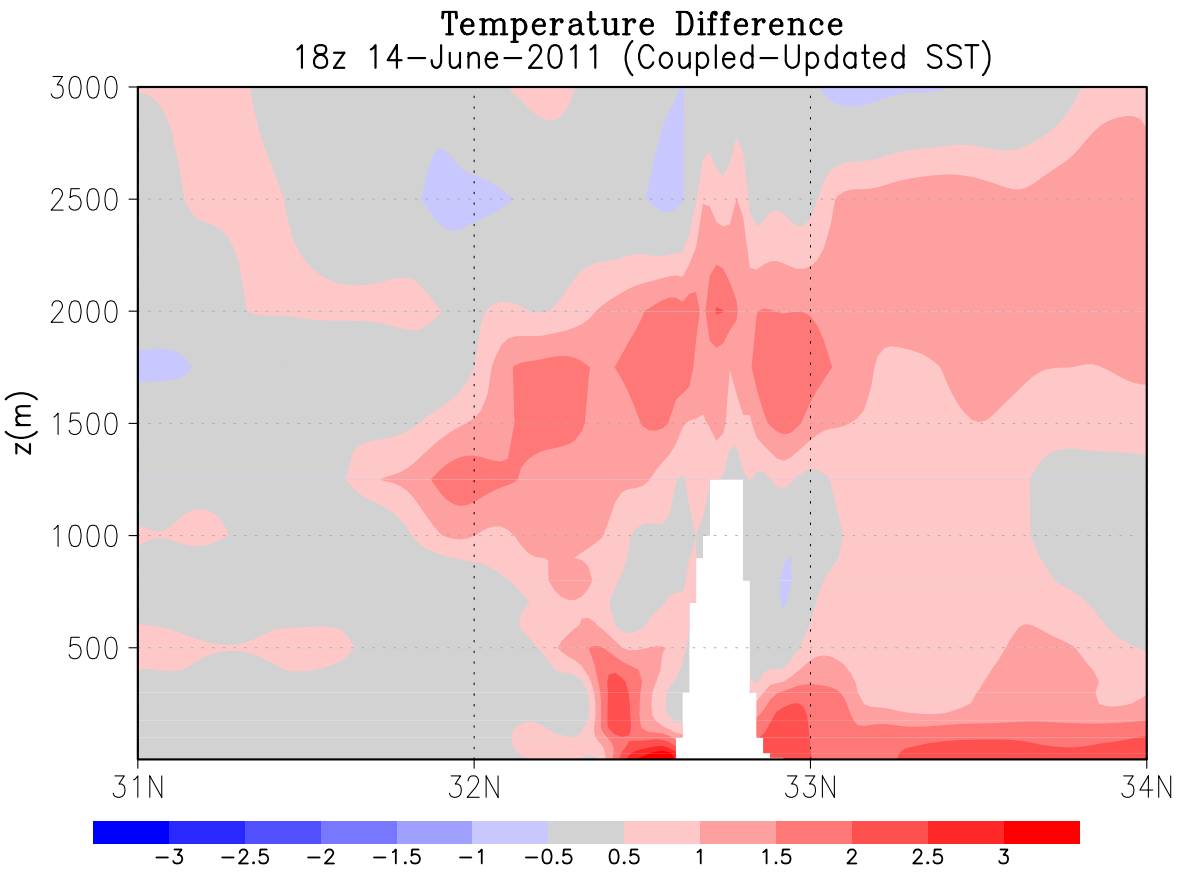
Sensitivity run







Sensitivity run



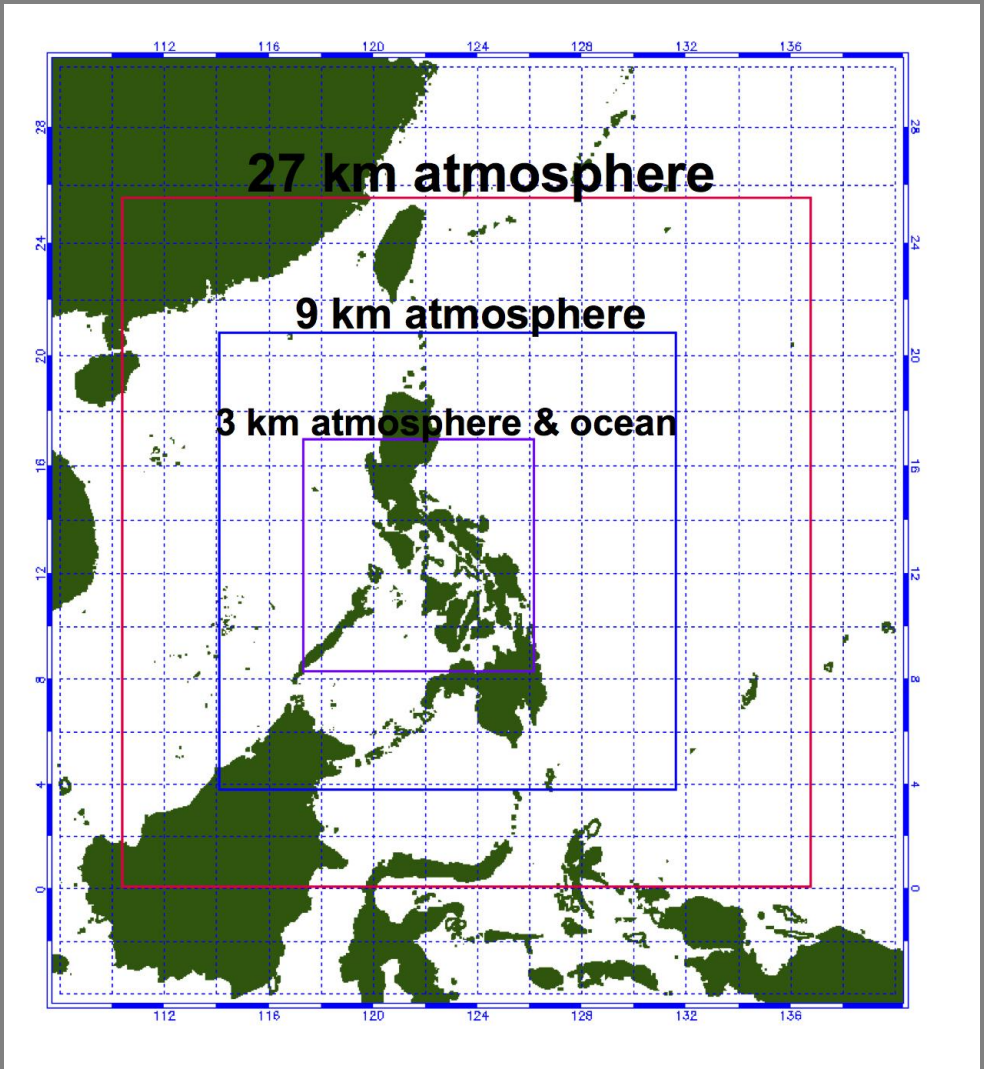
Madeira Summary

- Coupled air/sea study of a June 2011 wake region showed the ability to resolve dynamic processes for the first time:
  - vortex shedding and atmospheric wake
  - generating dynamic WARM (SST) OCEAN WAKE
  - feedback onto the atmosphere via heat fluxes
  - Role of cold mountain winds in air/sea interaction
- Suggests islands as important geographical settings for regional Earth System Models to emulate

Pullen J., R. Caldeira, J. D. Doyle, P. May, and R. Tomé (2017), Modeling the Air-Sea Feedback System of Madeira Island, *Journal of Advances in Modeling Earth Systems (JAMES),* in press 2017.

Model configuration: 2-way coupled

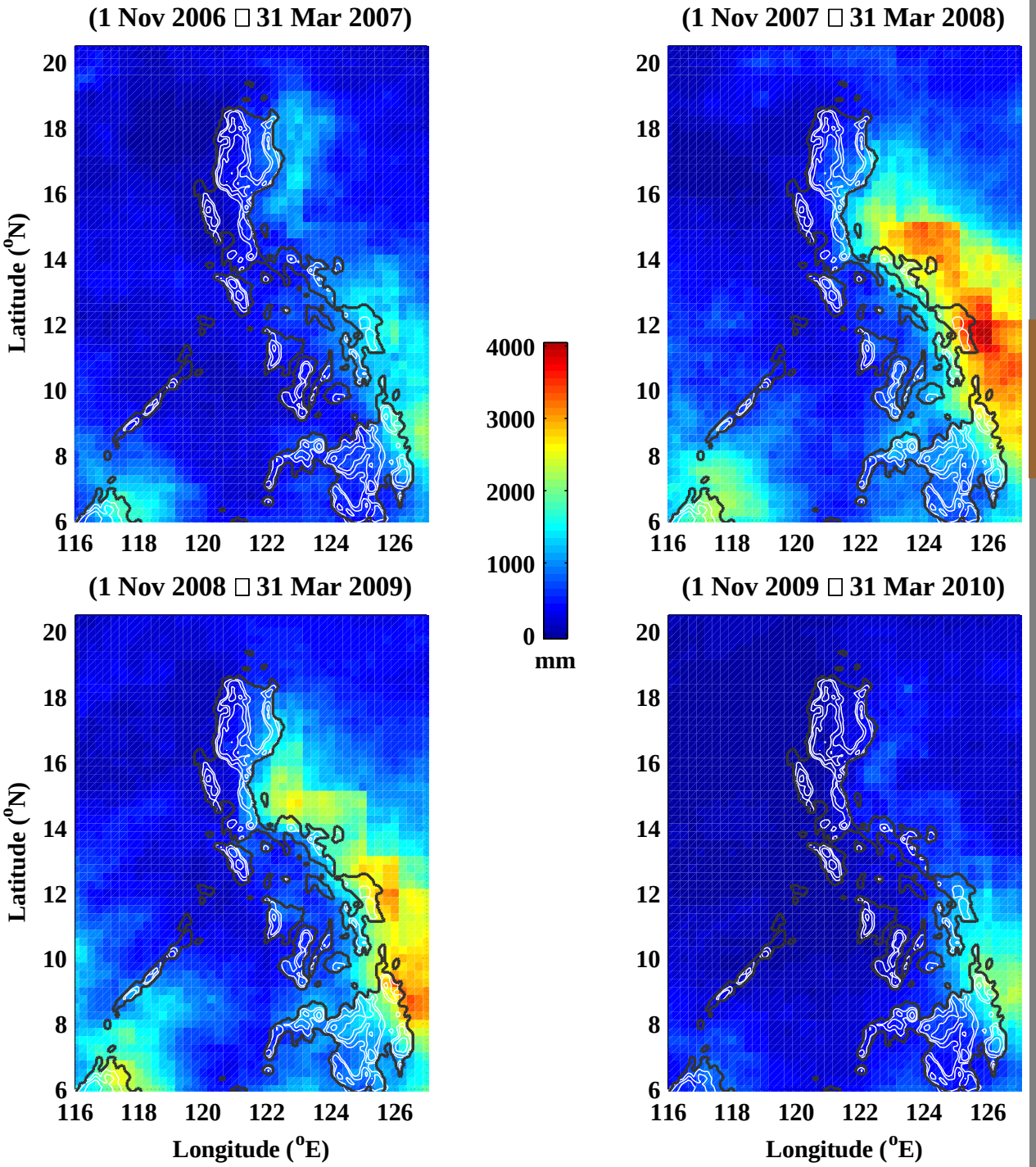
- COAMPS (27, 9, 3 km) data-assimilating (MVOI)
- NOGAPS i.c.'s & b.c.'s
- 40 levels



(12 min coupling frequency using ESMF)

- NCOM (3 km)
- global HYCOM/NCODA i.c.'s & b.c.'s
- 40 levels

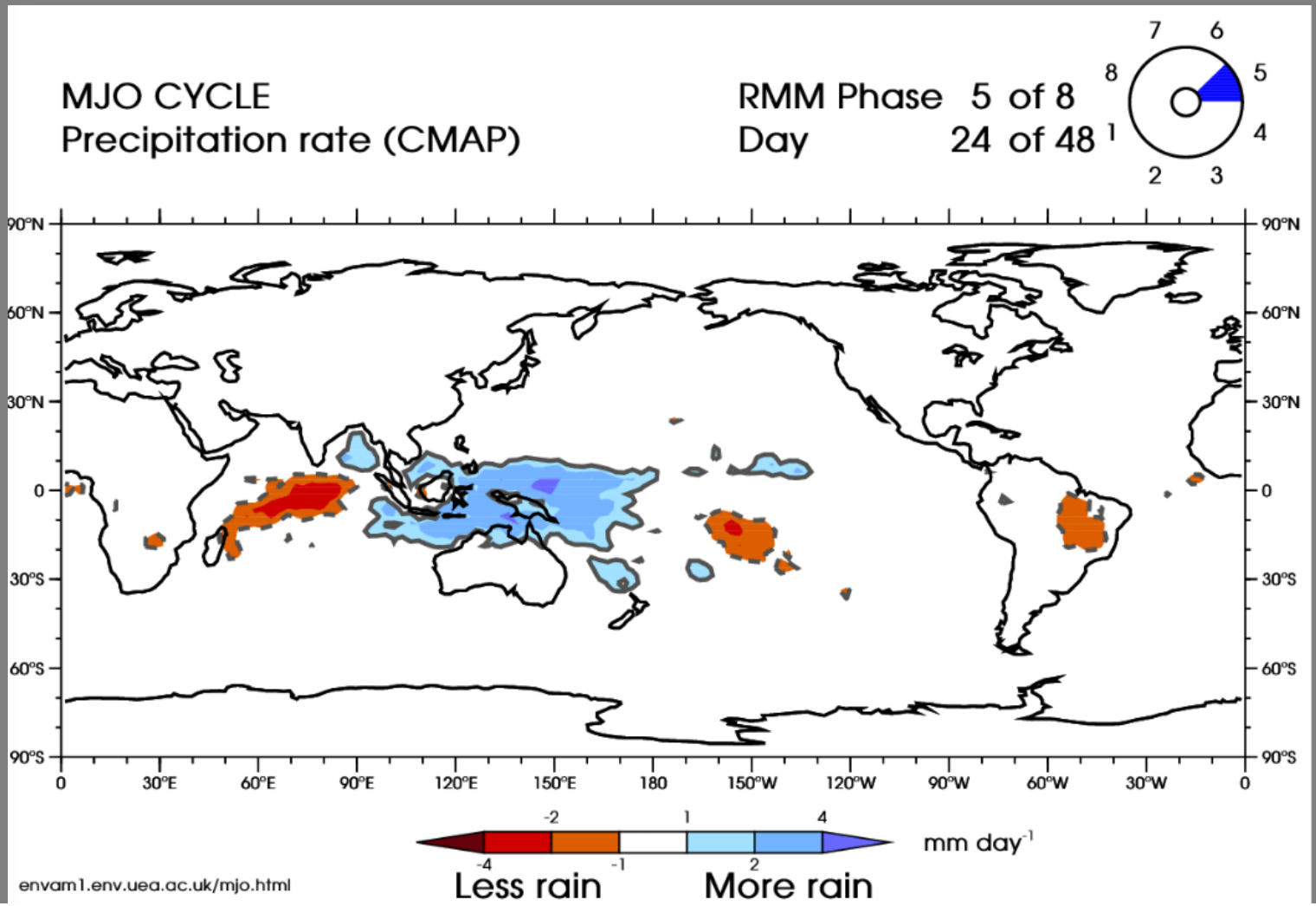
Satellite Rain Totals



Wettest winter in 40 years

J. Pullen, A.L. Gordon, M. Flatau, J. D. Doyle, C. Villanoy and O. Cabrera, “Multiscale influences on extreme winter rainfall in the Philippines,” *Journal of Geophysical Research-Atmospheres*, 120(8), 3292-3309, 2015.

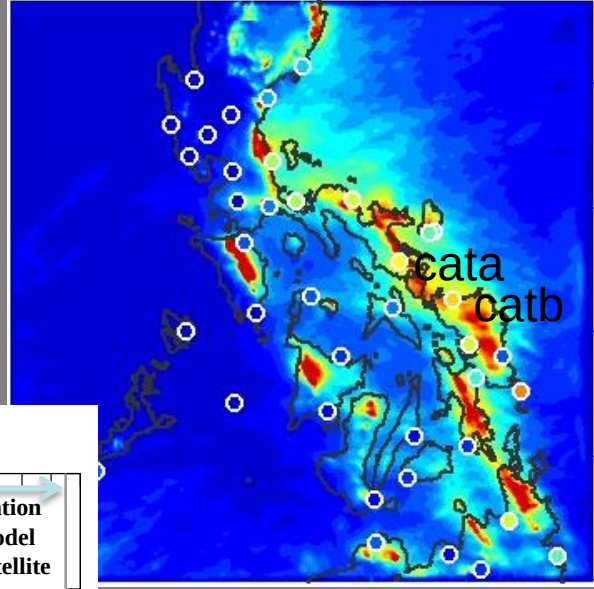
Madden-Julian Oscillation



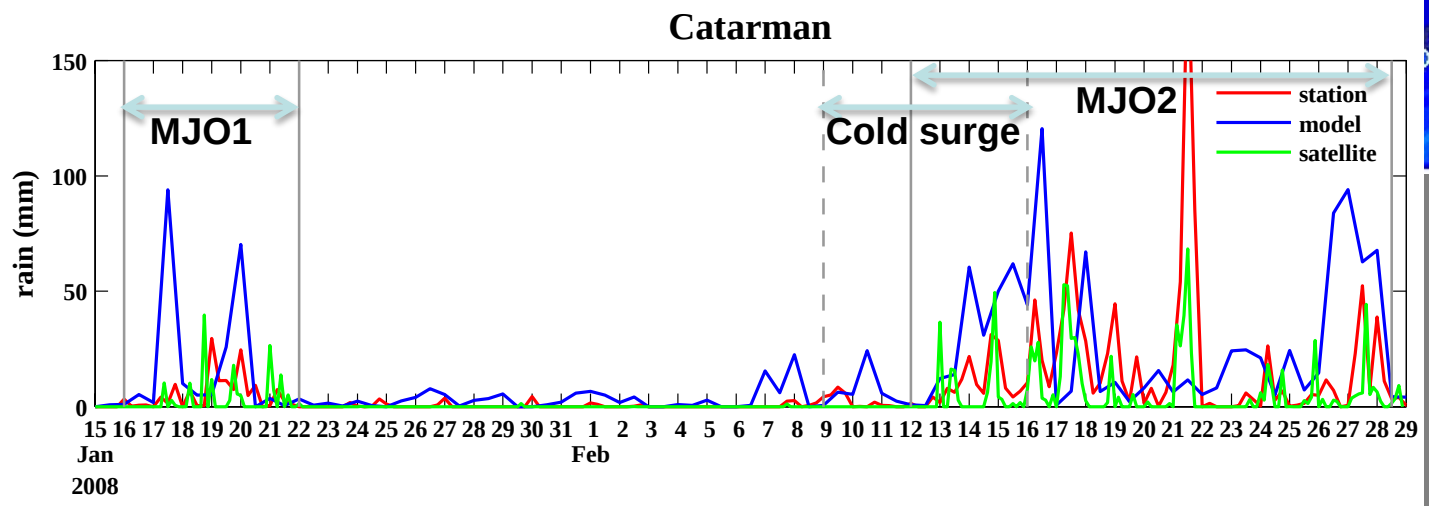
As a prime example of intraseasonal variability, the Madden–Julian Oscillation affects—and is pivotal to predicting—both weather and climate.

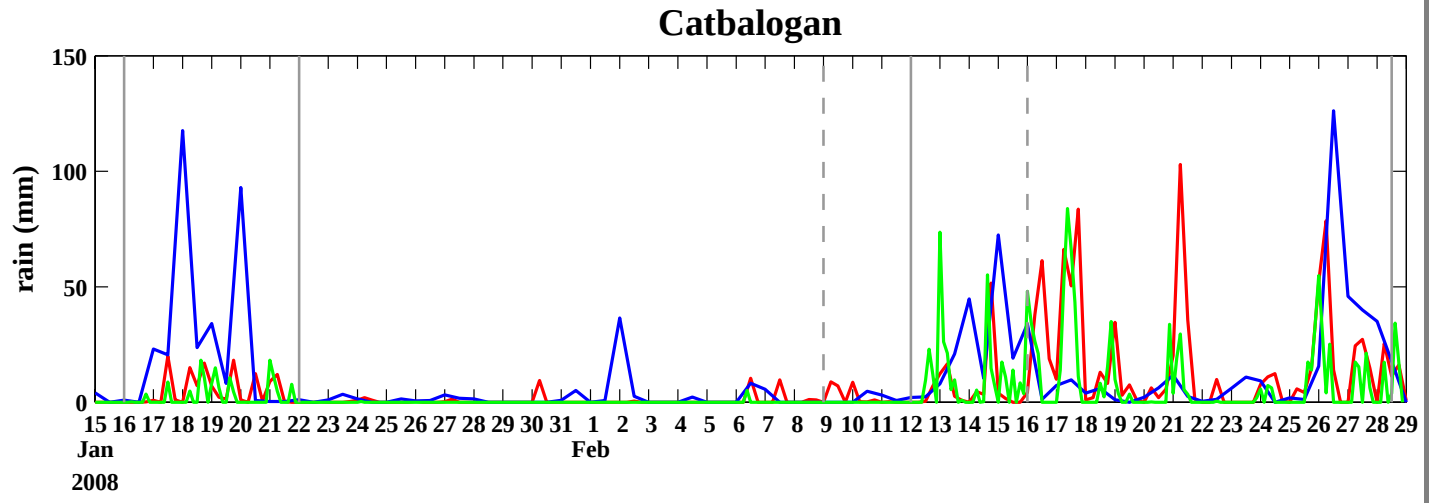
Zhang, MJO: Bridging Weather and Climate, BAMS, 2013

Rainfall distributions



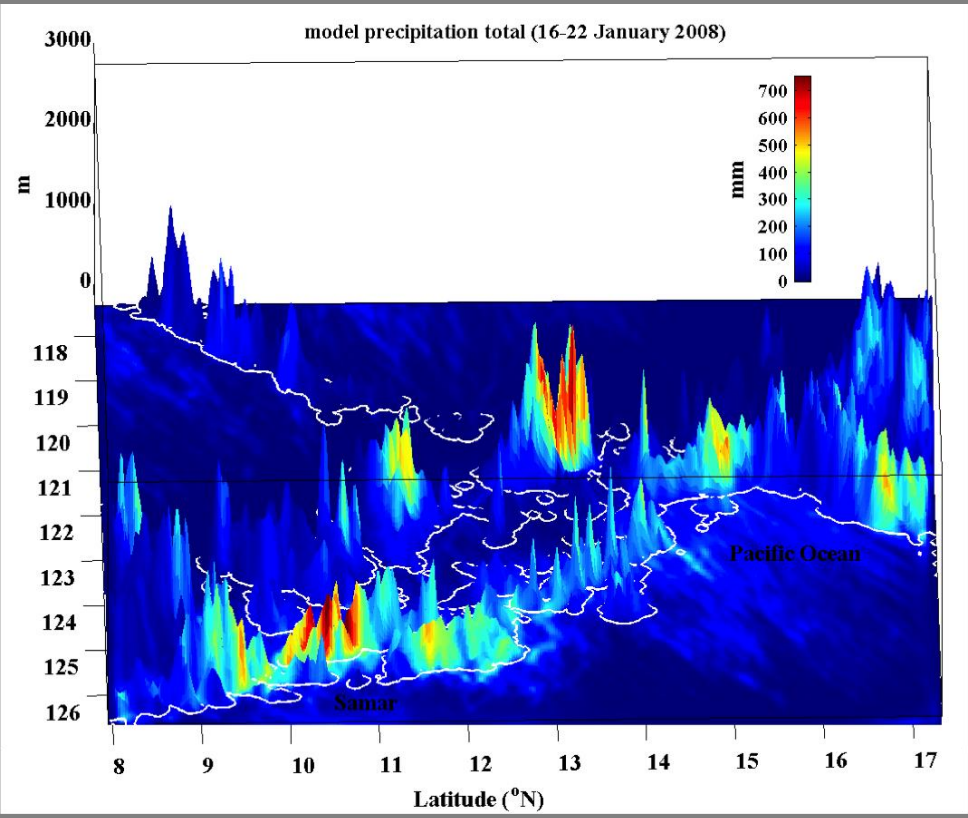
COAMPS
+ rain
gauge



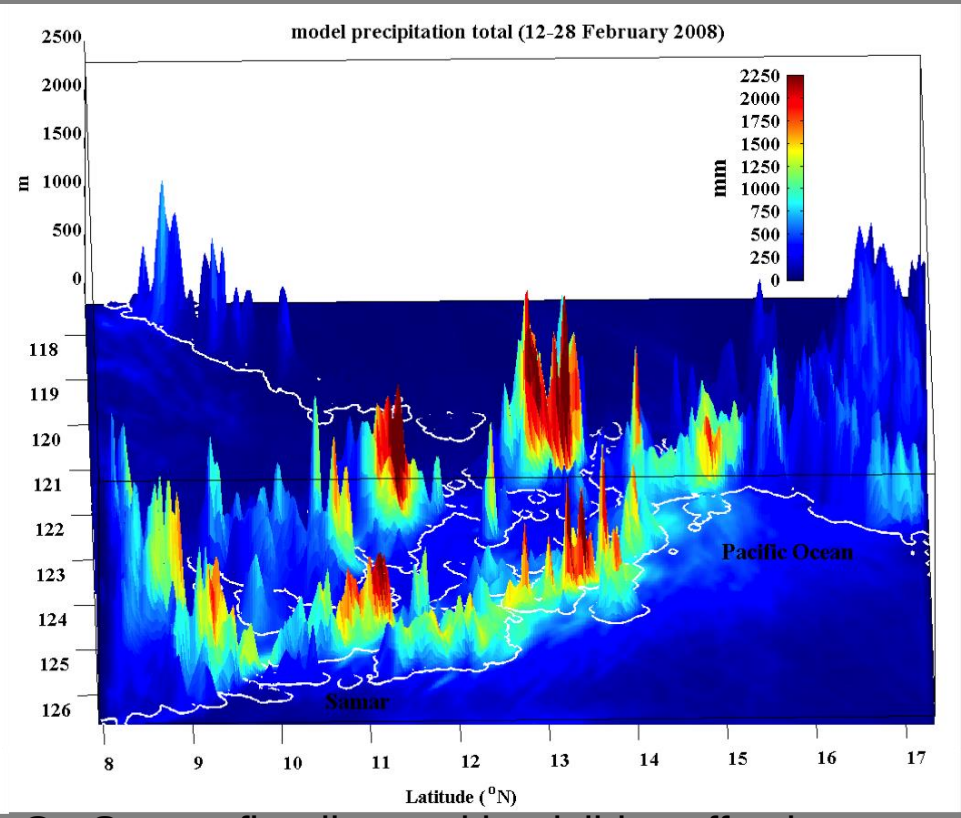


MJO event model precipitation

Event 1

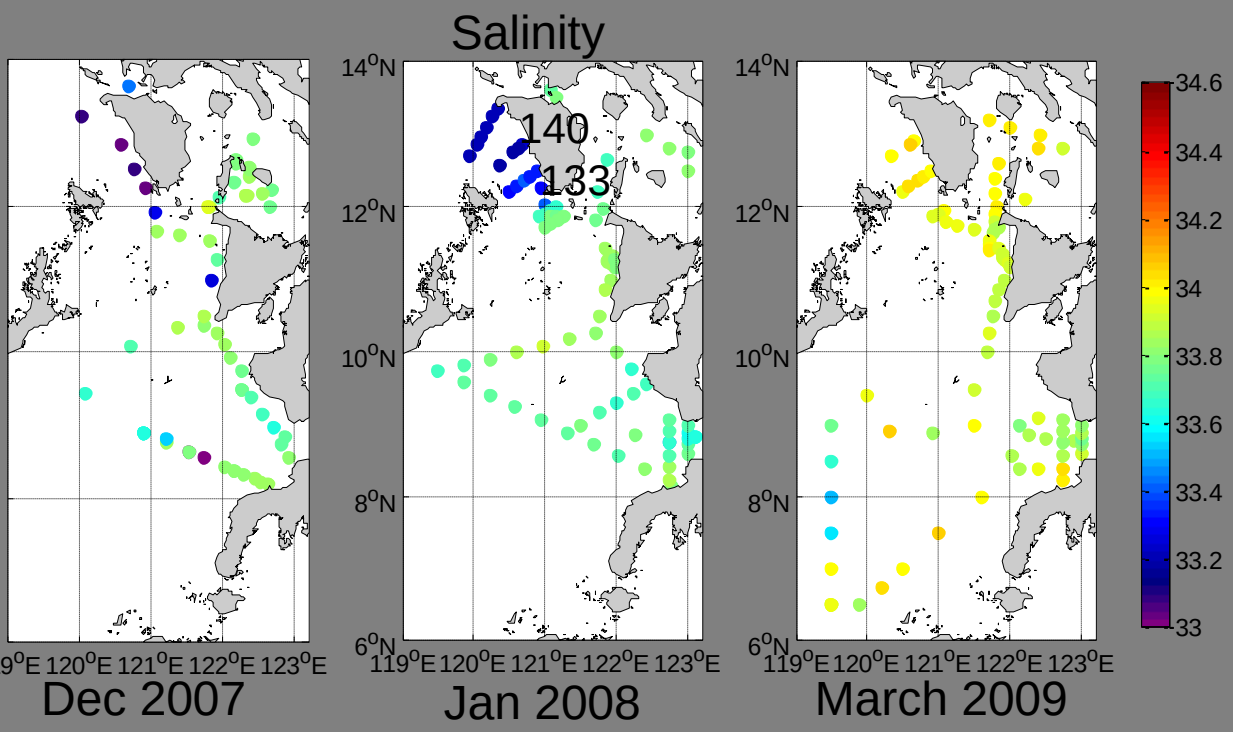


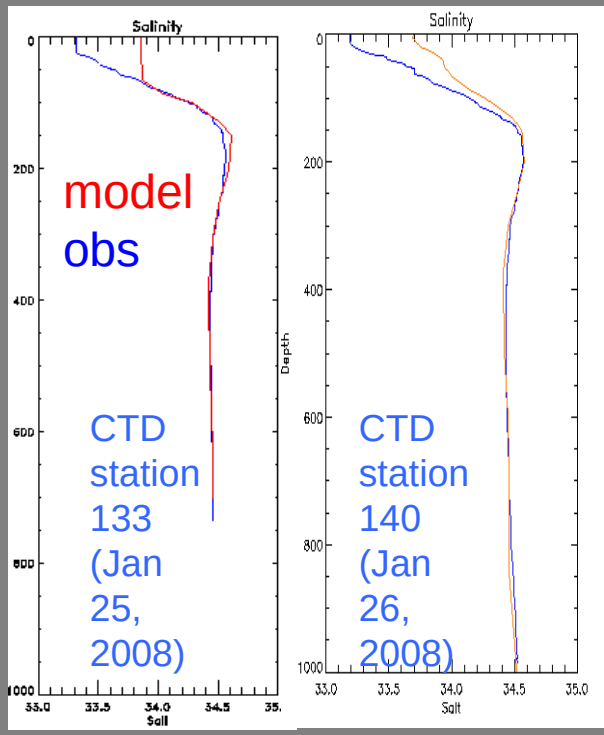
Event 2

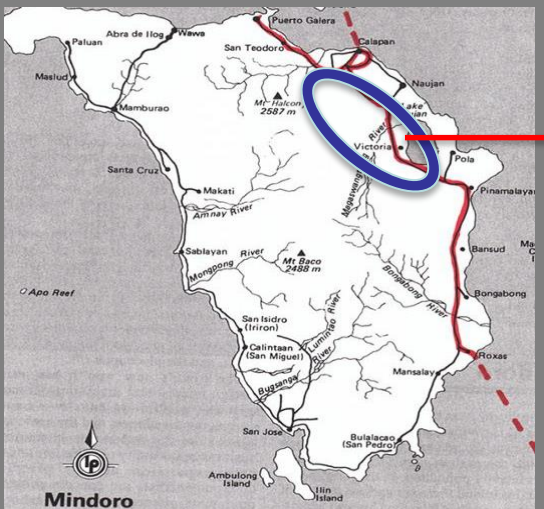


On Samar, flooding and landslides affecting over 45,000 people was reported during event 2 (National Disaster Coordinating Council (NDCC), 2008)

Role of Rivers

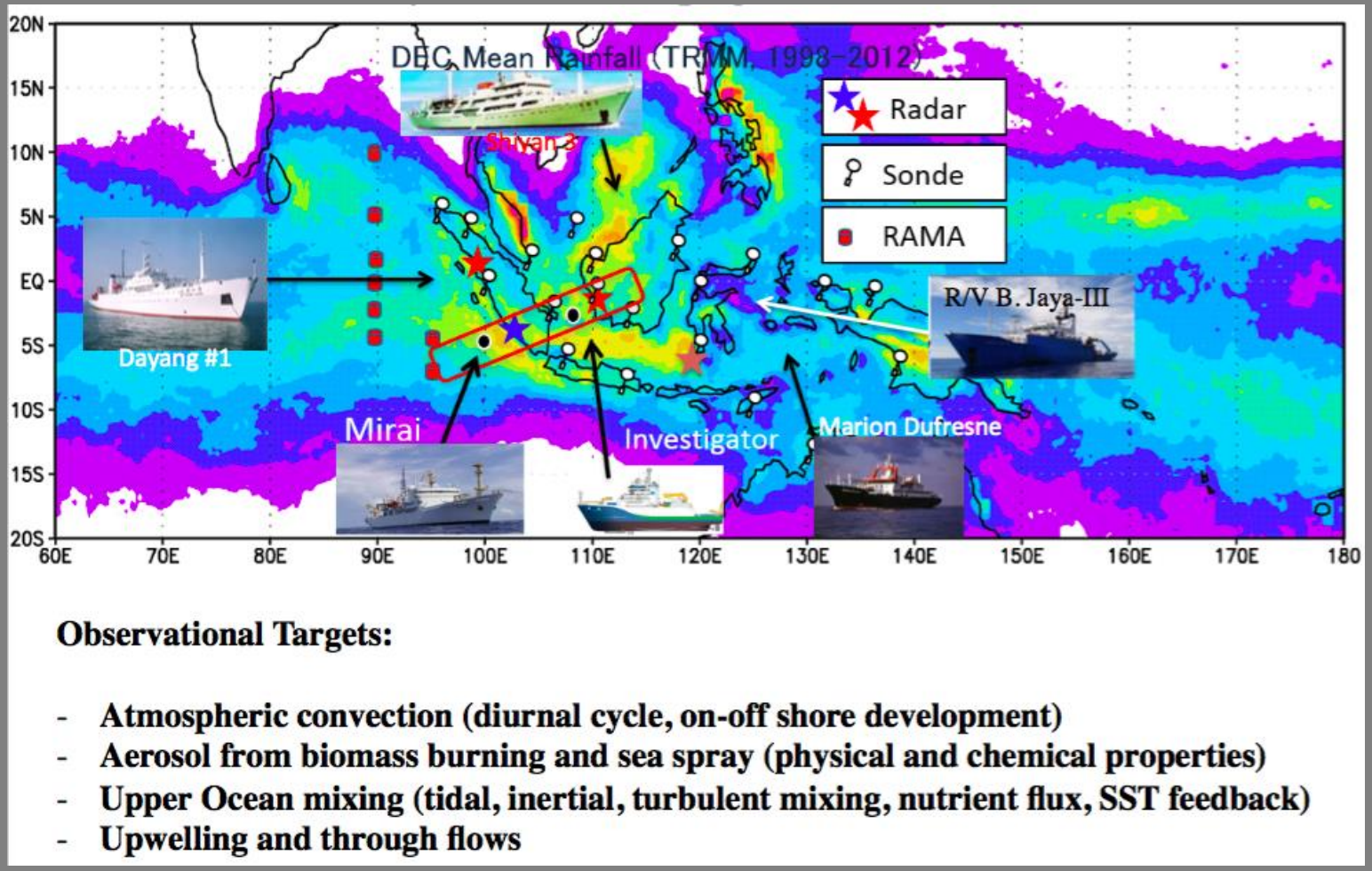






Location of 19 Feb rain-induced river flooding & evacuations affecting over 15,000 people in 20 villages (NDCC, 2008), during MJO event 2

Years of the Maritime Continent (2017-2019)



Observational Targets:

- **Atmospheric convection (diurnal cycle, on-off shore development)**
- **Aerosol from biomass burning and sea spray (physical and chemical properties)**
- **Upper Ocean mixing (tidal, inertial, turbulent mixing, nutrient flux, SST feedback)**
- **Upwelling and through flows**

ONR Propagation of Intra-Seasonal Tropical Oscillations (PISTON)

New program to link models COAMPS/WRF-Hydro+land surface by Navy/NOAA/NASA/NCAR