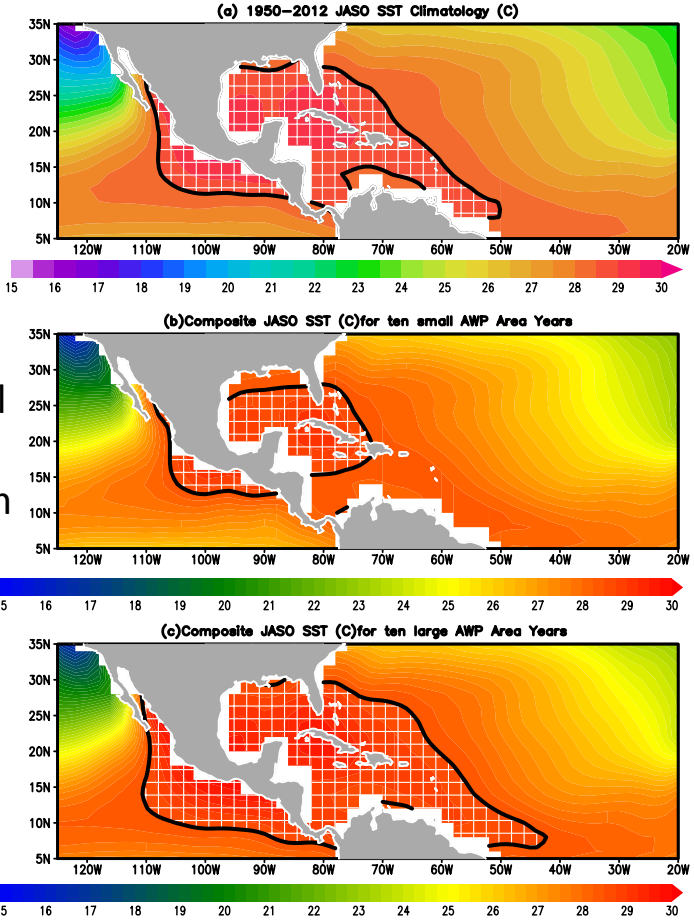
The Sensitivity of Regional Coupled Ocean-Atmosphere Simulations over the Intra-Americas Seas to the Prescribed Bathymetry

Vasu Misra and Akhilesh Mishra
Florida State University

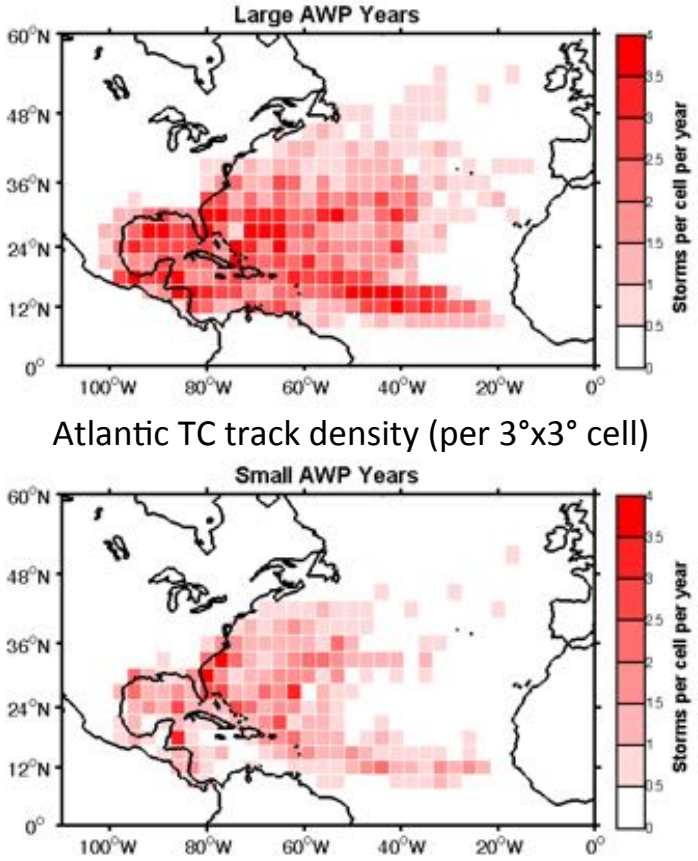
IASCliP Virtual Workshop, September 11, 2015

AWP interannual variability and modulation of Atlantic TC activity (Observations)

Large Interannual variations of the warm pool



Modulates Atlantic tropical cyclone activity



Atlantic TC track density (per 3°x3° cell)

Modulates CONUS hydroclimate (not shown)

The area of the Atlantic Warm Pool in CMIP5 models

Large systematic cold SST bias displayed by a majority of the CMIP5 models

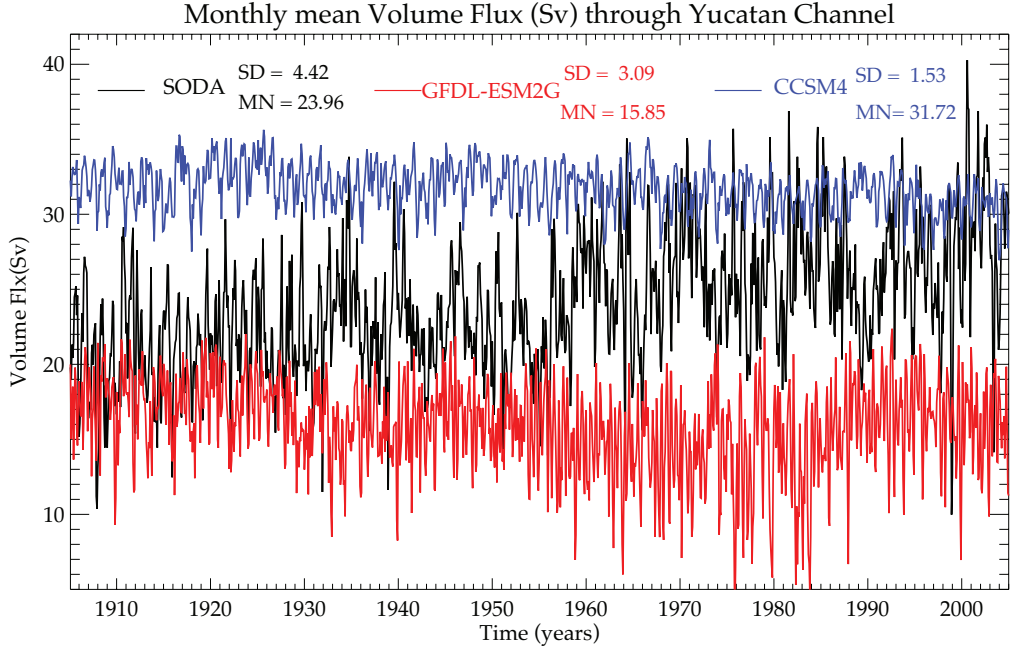
Seasonal Cycle of AWP Area

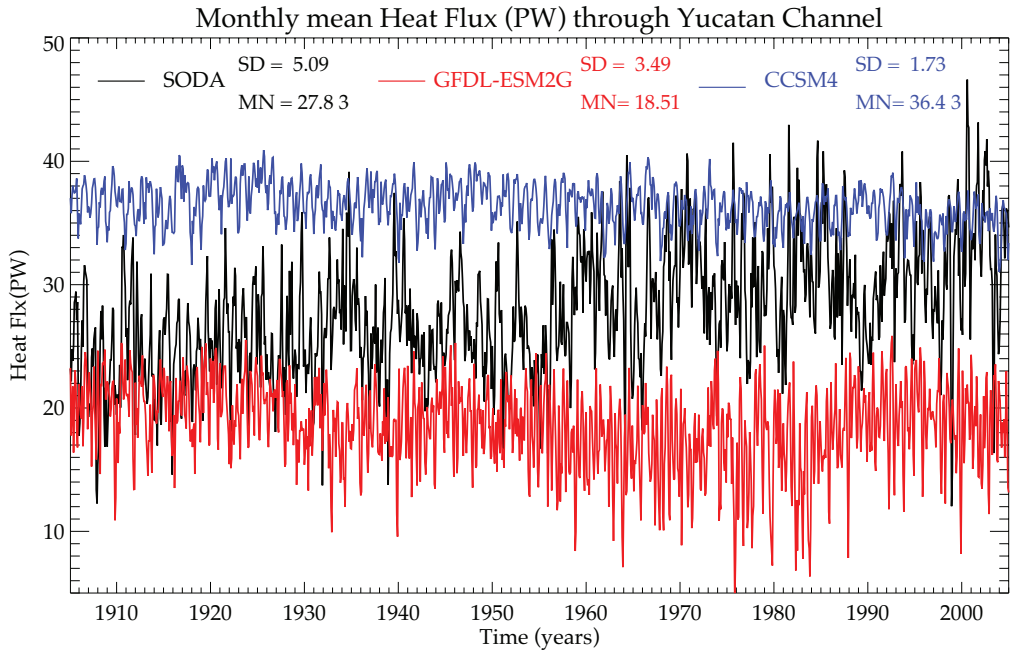
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ERSST v3	0.00	0.00	0.00	0.01	0.05	0.40	2.49	3.71	3.99	1.63	0.07	0.00
BCC-CSM1-1	0.00	0.00	0.00	0.00	0.00	0.01	0.29	0.68	0.38	0.02	0.00	0.00
CanESM2	0.00	0.00	0.00	0.01	0.00	0.03	0.29	0.83	0.78	0.15	0.01	0.00
CCSM4	0.00	0.00	0.00	0.02	0.02	0.04	0.51	1.31	1.12	0.12	0.00	0.00
CNRM-CM5	0.00	0.00	0.00	0.01	0.02	0.07	0.27	0.79	0.85	0.28	0.03	0.01
CSIRO-Mk3.6	0.00	0.00	0.00	0.00	0.04	0.43	2.06	2.99	3.09	1.42	0.26	0.00
GFDL-CM3	0.00	0.00	0.00	0.00	0.00	0.06	0.54	1.18	0.76	0.11	0.00	0.00
GFDL-ESM2G	0.00	0.00	0.00	0.00	0.00	0.01	0.18	0.81	0.81	0.22	0.01	0.00
GFDL-ESM2M	0.00	0.00	0.00	0.00	0.00	0.01	0.14	0.70	0.64	0.26	0.02	0.00
GISS-E2-H	0.00	0.00	0.02	0.09	0.19	0.26	0.31	0.70	1.02	0.90	0.24	0.01
GISS-E2-R	0.00	0.00	0.02	0.16	0.40	0.68	1.73	3.55	3.83	2.85	1.04	0.09
HadGEM2-ES	0.05	0.04	0.06	0.10	0.21	0.33	0.57	1.37	1.48	0.57	0.21	0.10
INM-CM4	0.01	0.00	0.00	0.01	0.02	0.00	0.01	0.06	0.02	0.00	0.00	0.01
IPSL-CM5A-LR	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.21	0.07	0.01	0.00	0.00
MIROC5	0.00	0.00	0.00	0.02	0.04	0.09	0.11	0.23	0.26	0.12	0.02	0.00
MPI-ESM-LR	0.00	0.00	0.00	0.00	0.00	0.08	0.71	2.05	2.45	1.01	0.14	0.01
MRI-CGCM3	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.39	0.38	0.18	0.01	0.00
NorESM1-M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00

0.00 0.05 0.10 0.15 0.20 0.30 0.40 0.60 0.80 1.00 1.25 1.50 1.75 2.00 2.50 3.00 3.50 4.00

AREA OF 28.5°C MONTHLY AVERAGED ISOTHERM (10^6 km^2)

There is also diversity in the magnitude of the cold bias displayed by CMIP5





A large disparity in flow and heat transport through the Yucatan Channel

SODAv2.2.4

POP, horizontal res. 0.25°x0.40° , 40 vertical levels (Carton et al., 2008)

CCSM4

Ocean: POP2 with modifications, horizontal res. 1.125° in longitude, 0.27°-0.64° variable in latitude, 60 vertical levels (Danabasoglu et al., 2012)

Atmosphere: CAM4, horizontal res. 0.9°x1.25°, 27 vertical levels (Neale et al. 2013)

GFDL-ESM2G

Ocean: GOLD , 1° tripolar 360x210L63, (Hallberg and Adcroft, 2009; Dunne et al., 2012)

Atmosphere: 2.5° x 2.0°, 24 vertical levels (Dunne et al. 2013)

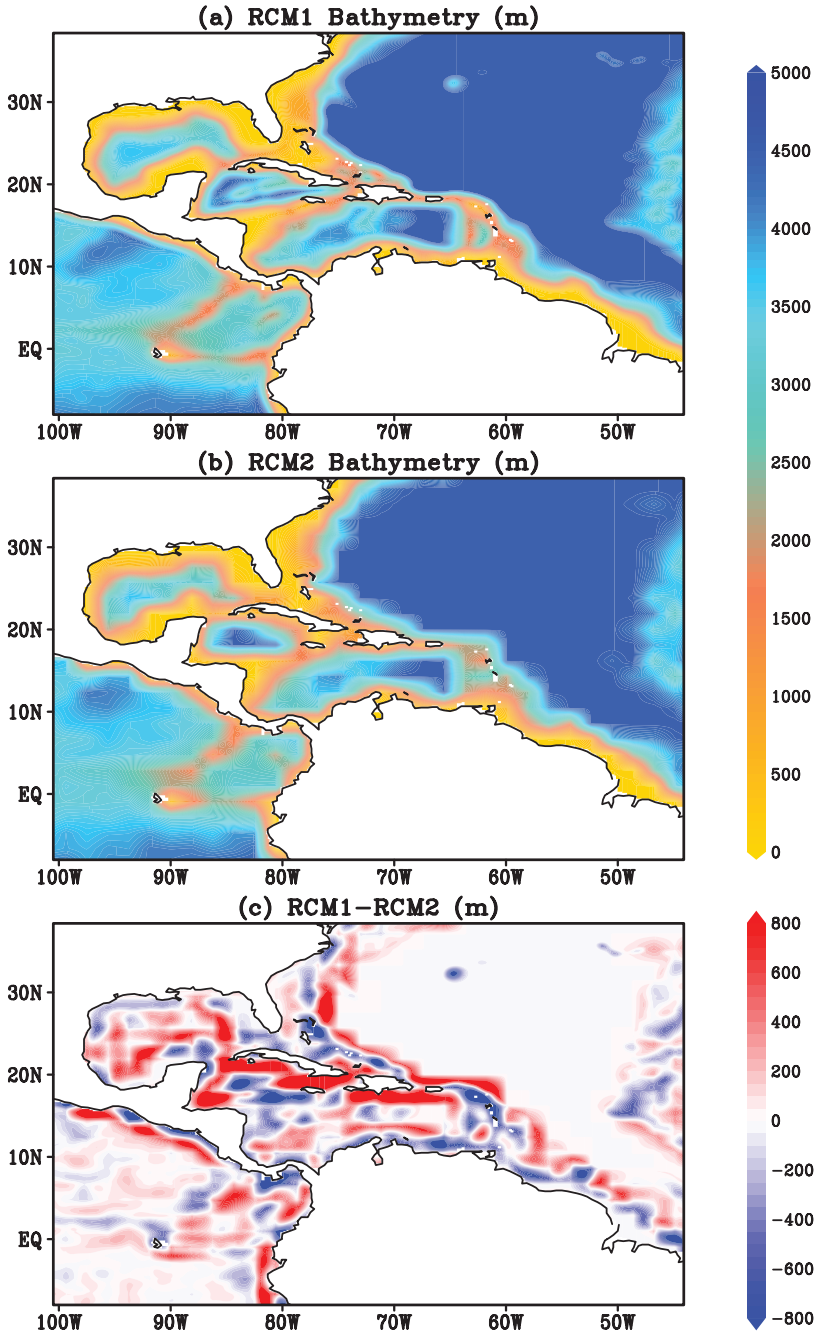
Regional climate model experiments

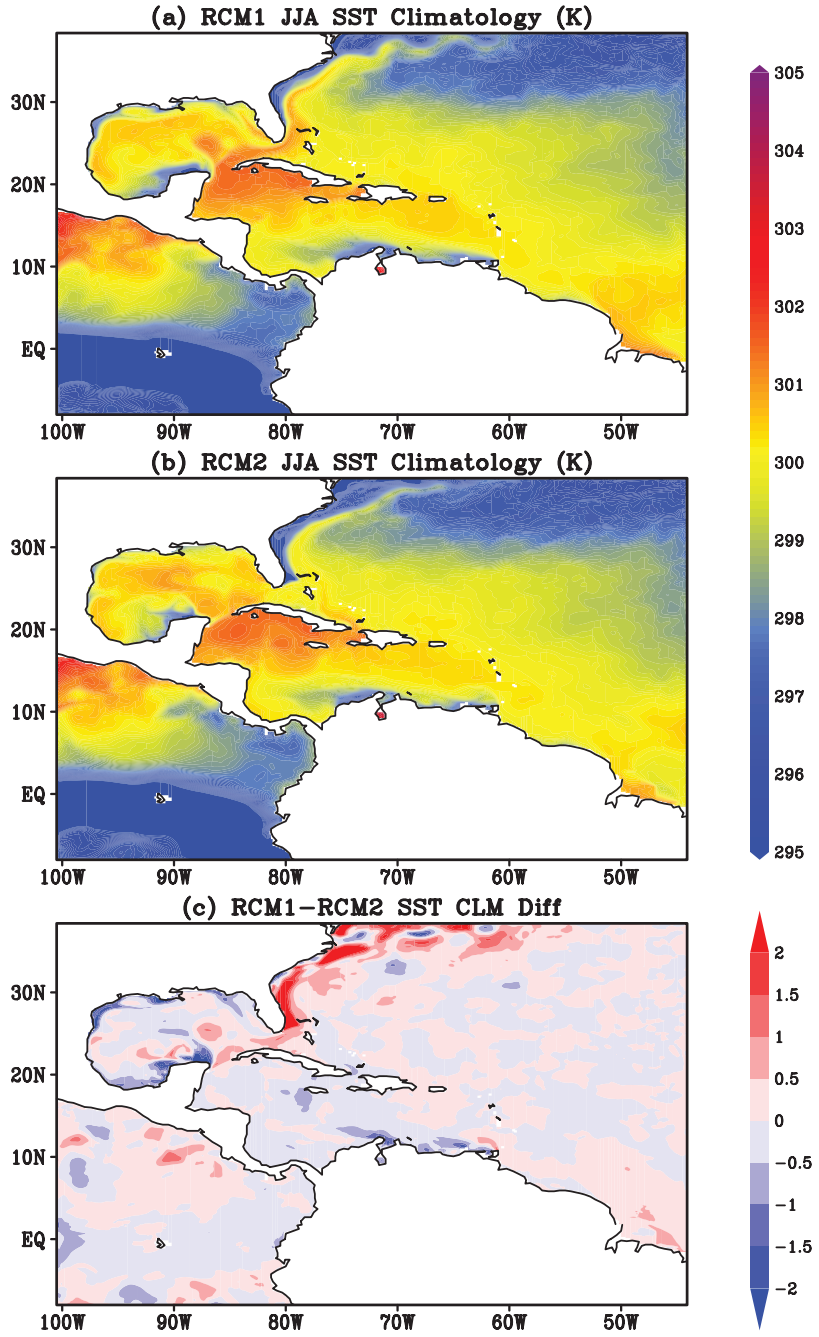
- Two identical RCM's run independently for 32 years at 15km grid resolution forced by ocean (SODA v2) and atmospheric (NCEP R2) reanalysis.
- RCM: Regional Spectral Model coupled to ROMS
- RCM1: Run with fine scale bathymetry from ETOPO5
- RCM2: Run with coarser bathymetry (smoothed version of the above)

Fine bathymetry

Coarse bathymetry

Fine-Coarse (difference) bathymetry

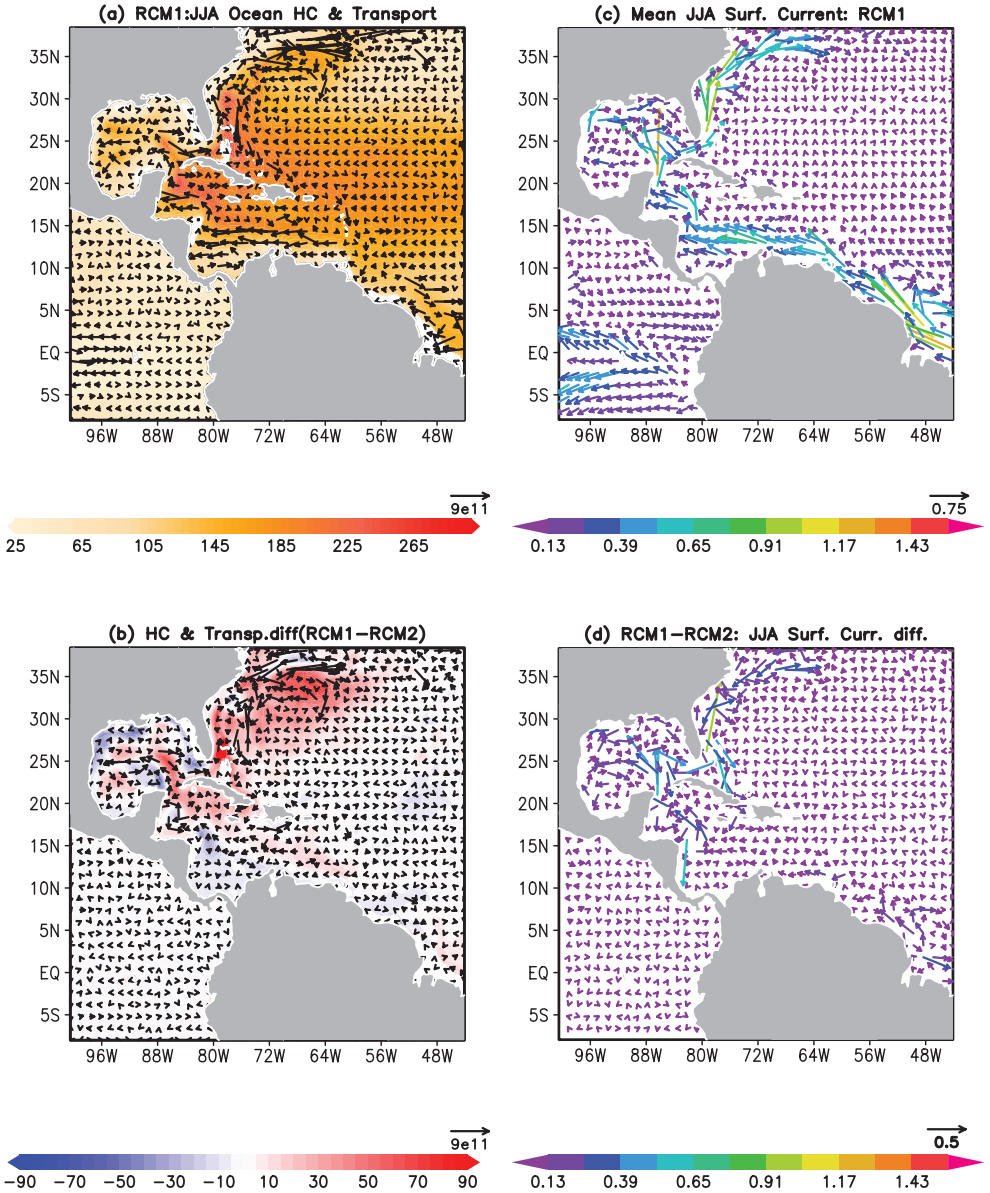




SST simulation from RCM experiments

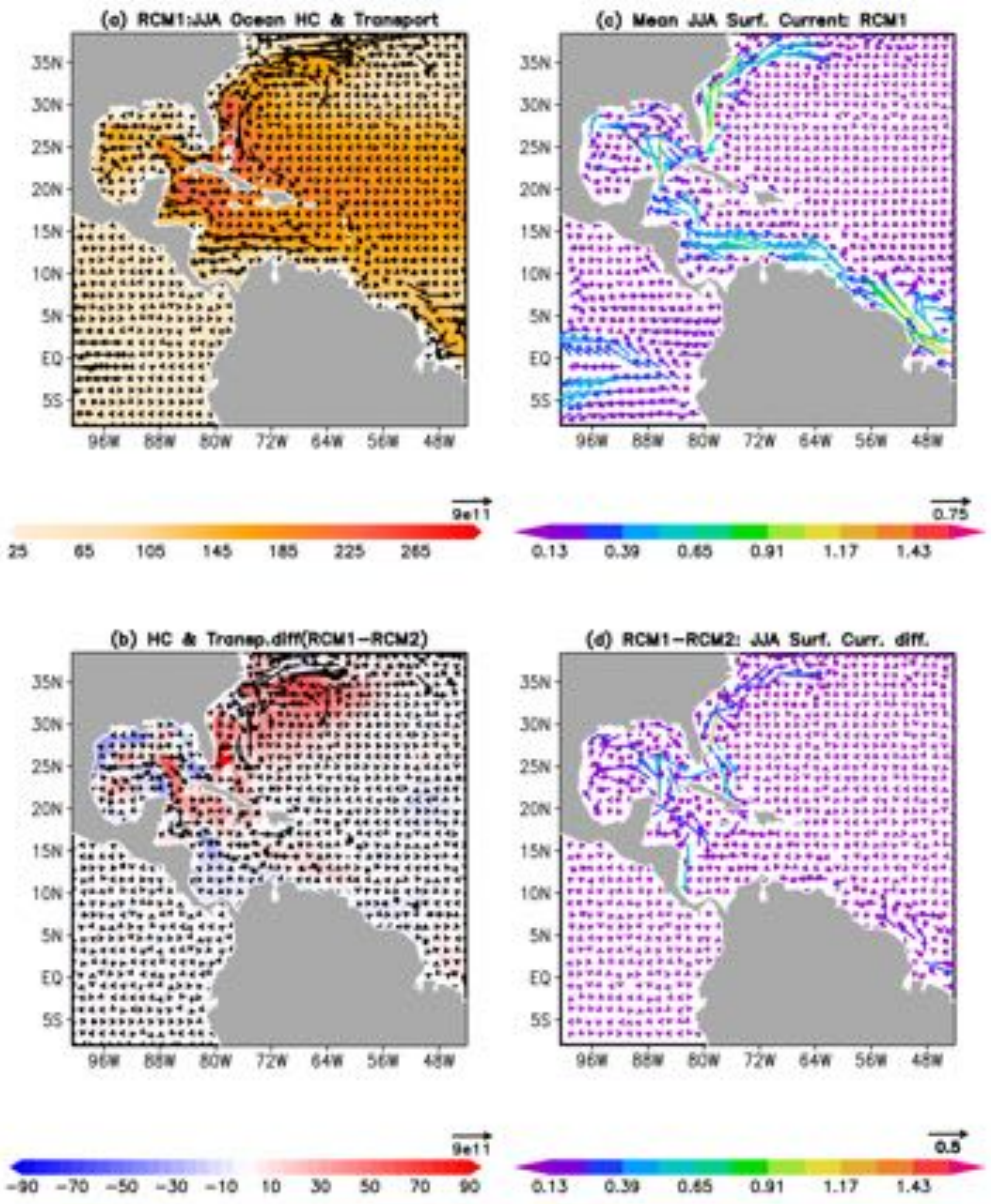
RCM1 integration with finer bathymetry warms the SST in the Gulf of Mexico and along the Gulf Stream

Simulation of heat content, heat transport and surface ocean current



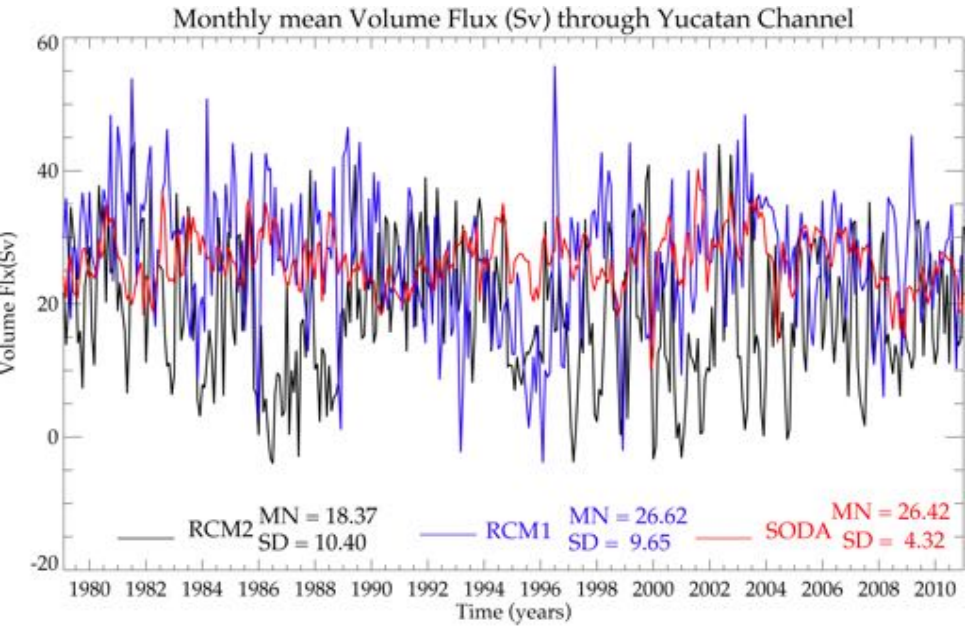
The RCM1 integration (with finer bathymetry) raises the heat content in the IAS and the surface ocean currents are stronger relative to RCM2.

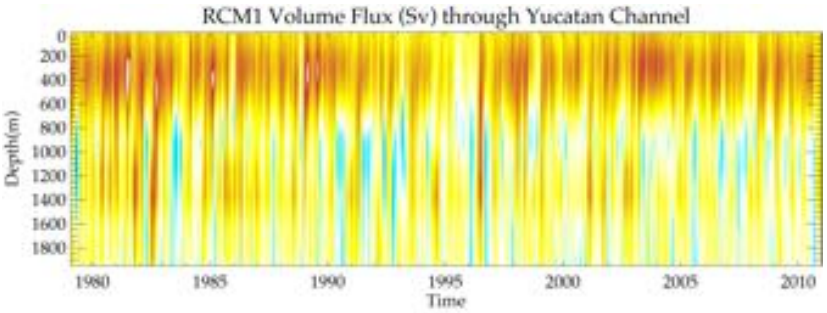
Simulation of heat content, heat transport and surface ocean current

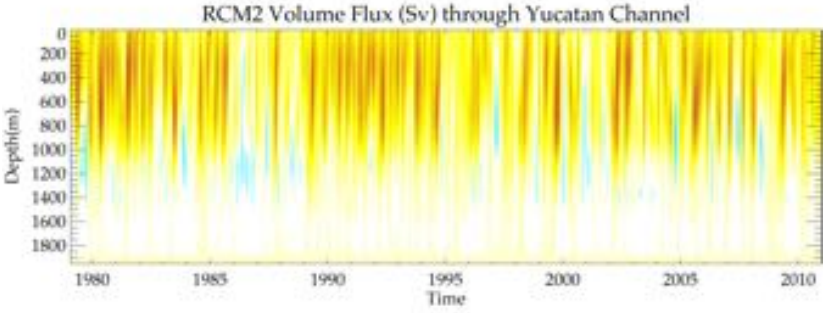


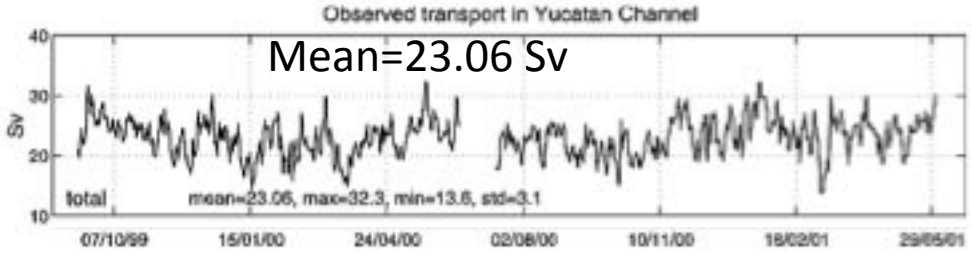
The RCM1 integration (with finer bathymetry) raises the heat content in the IAS and the surface ocean currents are stronger relative to RCM2.

Volume Transport (Sv) through Yucatan Channel in RCM1 and RCM2





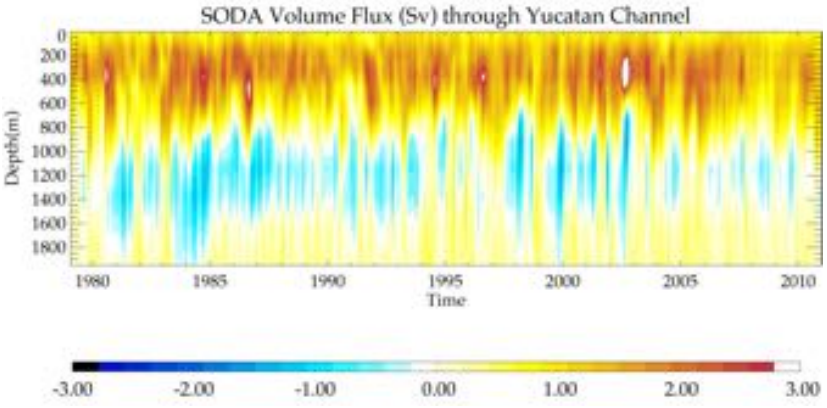


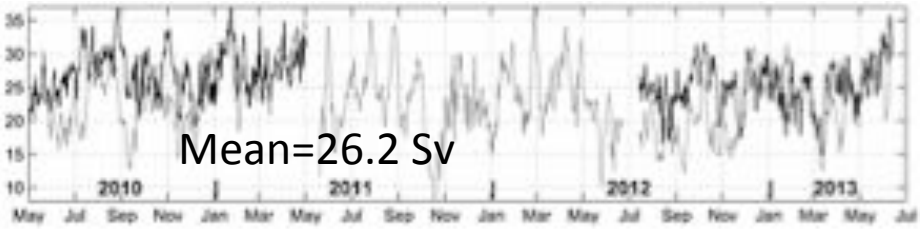


Oct. 2009

From Candela et al. 2003

May 2011



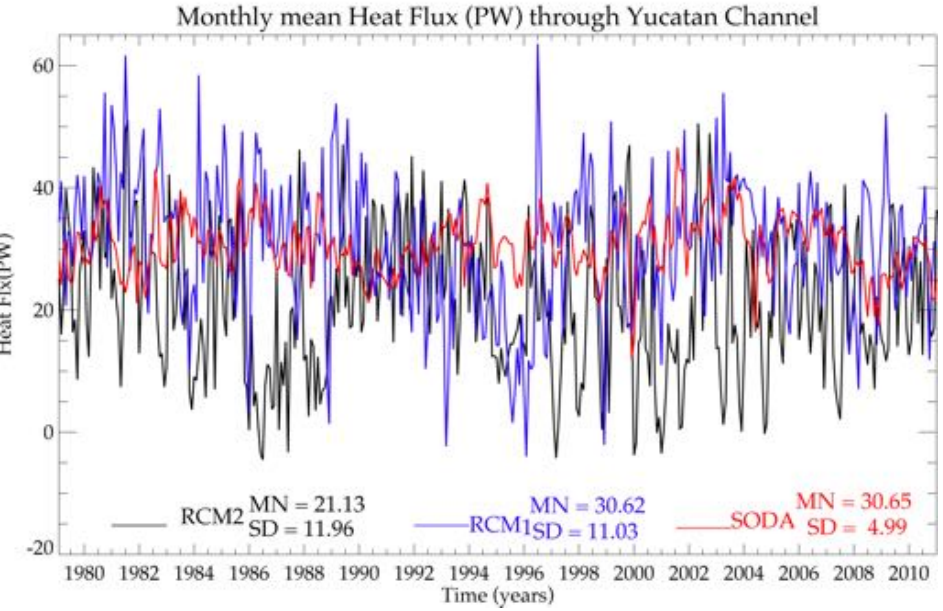


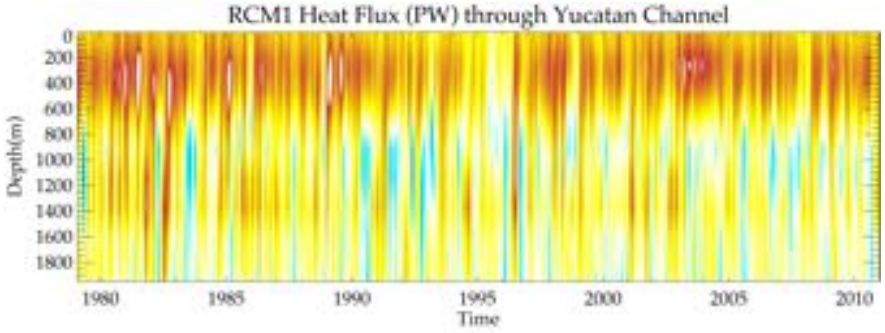
May 2010

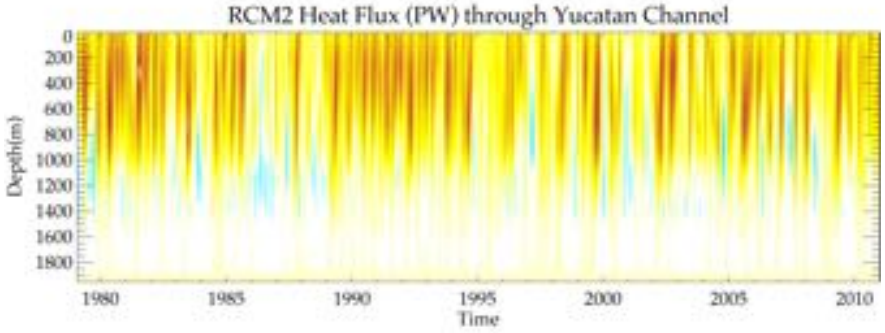
From Athie et al. 2015

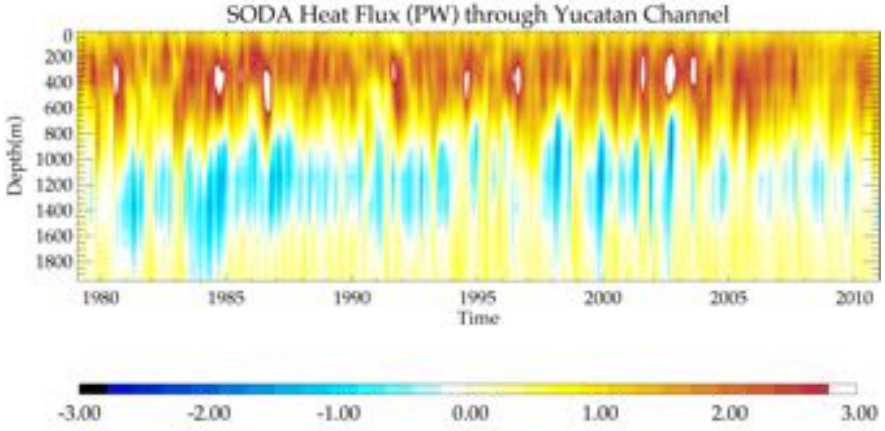
Jul 2013

Heat Transport (Sv) through Yucatan Channel in RCM1 and RCM2









Conclusions

- The cold bias of the Atlantic warm pool in CMIP5 models is significant—the area is underestimated by over 200% in majority of models!
- Two of the CMIP5 models show large differences in the transport through Yucatan Channel; the one with the higher transport displayed larger AWP than with the lower transport but yet both displayed cold SST bias in the IAS region
- The RCM experiments with different bathymetry confirmed that transport through Yucatan Channel does affect the SST and heat content of the IAS
- The transport through the Yucatan Channel can be modulated by bathymetry because it dictates the potential vorticity through changes to depth of the water column—you don't even preserve the large-scale forcing transport (SODA transport is comparable to RCM1 but RCM2 is way too less)
- Improving transport through YC will not necessarily fix all problems of bias in IAS but we are looking at a tractable problem.