UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

SST ERRORS GROWTH IN THE TROPICAL PACIFIC OCEAN FROM HIGH RESOLUTION COUPLED MODEL

Isabel Silveira . Paquita Zuidema . Benjamin Kirtman

30th Conference on Climate Variability and Change
Baltimore, MD 28-29 July 2017

Introduction

- Significant *SST errors* in the tropical oceans *are common in coupled ocean-atmosphere general circulation models*. These systematic errors can develop quickly (*fast errors*) or may result from model drift (*saturated errors*);

- The *saturated errors* can easily *reach larger magnitudes* than the desired *climate signals*, calling the prediction into question;

- One hypothesis holds that the *errors may decrease* if a *model's resolution is increased* and more of the *sub-grid-scale processes* become *resolvable*, such as mixing and stratification;

- Simulations with eddy-resolving, eddy-permitting, and eddy-parameterized resolutions for a global coupled climate model showed *systematic improvements* in many aspects of the climate *with increasing resolution* (*Delworth et al., 2012*).

- *Local air-sea feedbacks* are significantly *modified by the increased ocean resolution* (eddy-resolving). *High-resolution simulation* in the extra-tropics there is compelling evidence of *stronger forcing of the atmosphere by SST* variability arising from ocean dynamics. *This coupling* is very *weak or absent in the low-resolution model* (*Kirtman et. al, 2012*).

Our goal is to compare the evolving of SST errors in a set of hindcasts generated by Community Climate System Model (CCSM4) for two oceanic model resolutions, where the higher resolution is eddy-resolving and the lower resolution is eddy-parameterized.

- *Does increasing resolution decrease SST errors?*
- *Is this effect valid for long and free-running integrations?*
- *Which regions presented greater differences between the two experiments?*

Community Climate System Model (CCSM4)

High-Resolution

- 0.1° oceanic (~11km)
- Eddy-resolving (< 18.5 km)
- 0.5° atmospheric (~55 km)

Low-Resolution

- 1.125° oceanic (~125 km)
- Eddy-parameterized (> 111 km)
- 0.9° atmospheric (~100 km)

- Hindcasts: 12 months free running integrations
- From 1982 to 2003, daily
- Initialized by real-time oceanic and atmospheric reanalysis (CFSR) every January 1st
- Global Coupled Model

Fast and Saturated Errors Calculation

Auto-Comparison

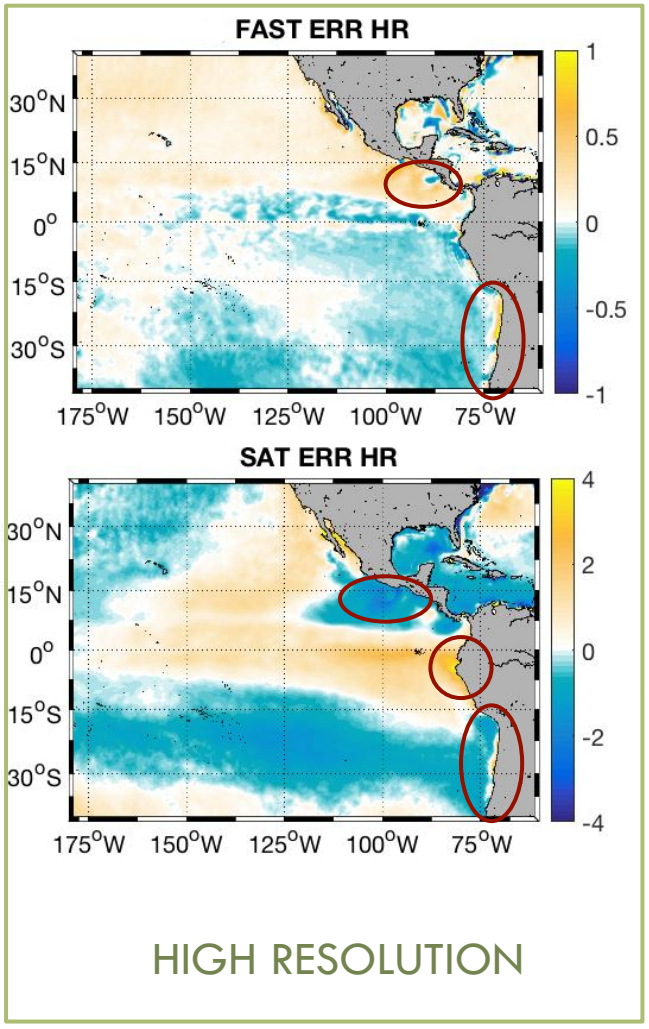
Fast Errors

$$Fast_{Er} = ErJan1_{y}^{st} - \frac{1}{n}\left(ErJan2_{y}^{nd} + ErJan6_{y}^{th}\right);$$

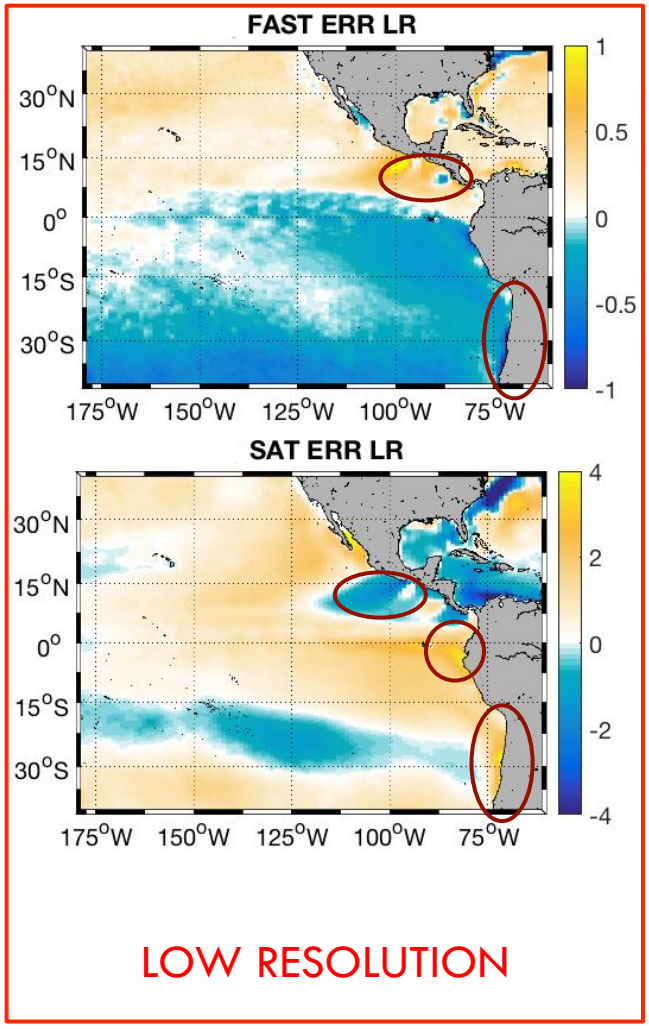
Saturated Errors

$$Sat_{Er} = \frac{1}{n}\left(ErJan1_{y+1}^{st} + .. + ErJan5_{y+1}^{th}\right) - \frac{1}{m}\left(ErDec27_{y}^{st} + .. + ErDec31_{y}^{st}\right);$$

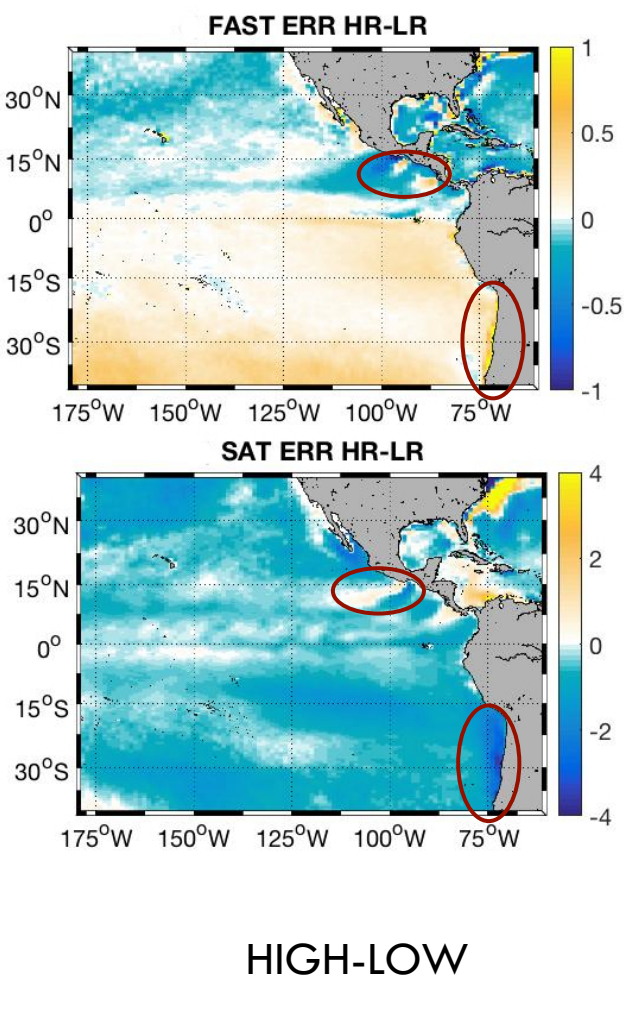
Fast and Saturated SST Errors



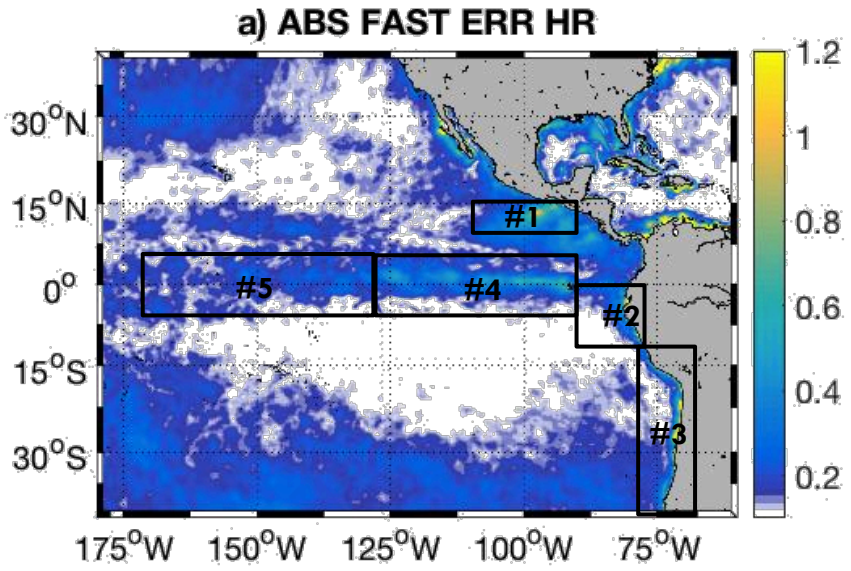
HIGH RESOLUTION

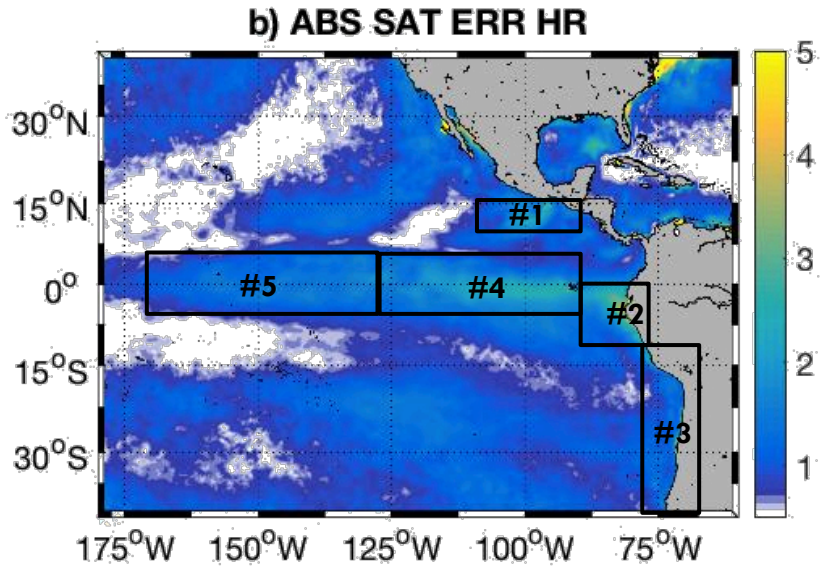


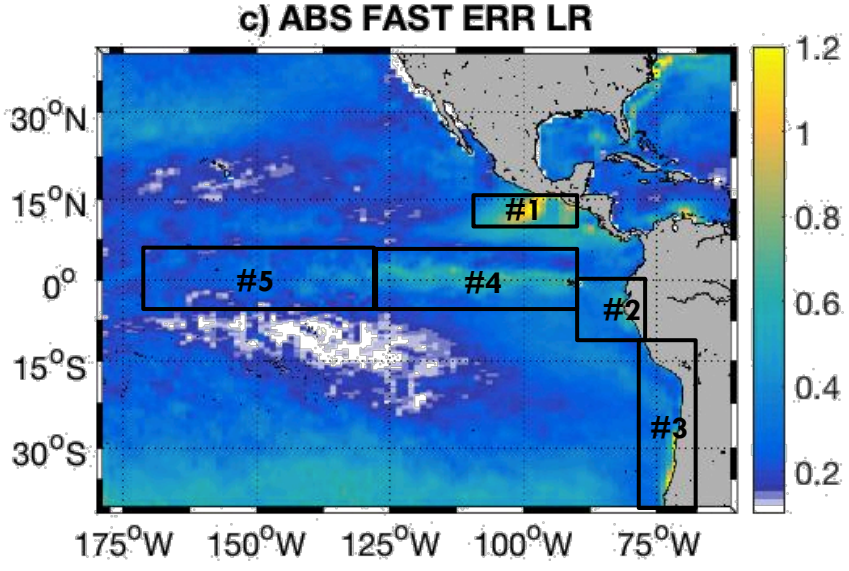
LOW RESOLUTION

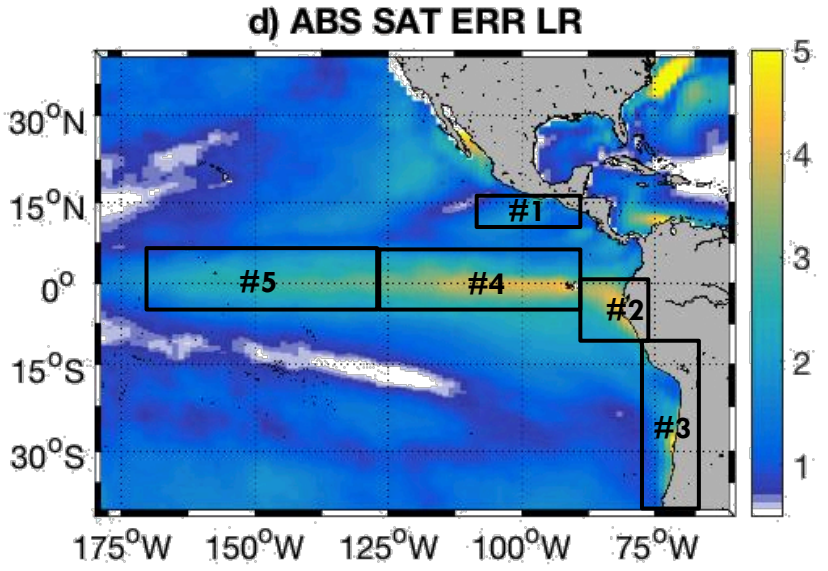


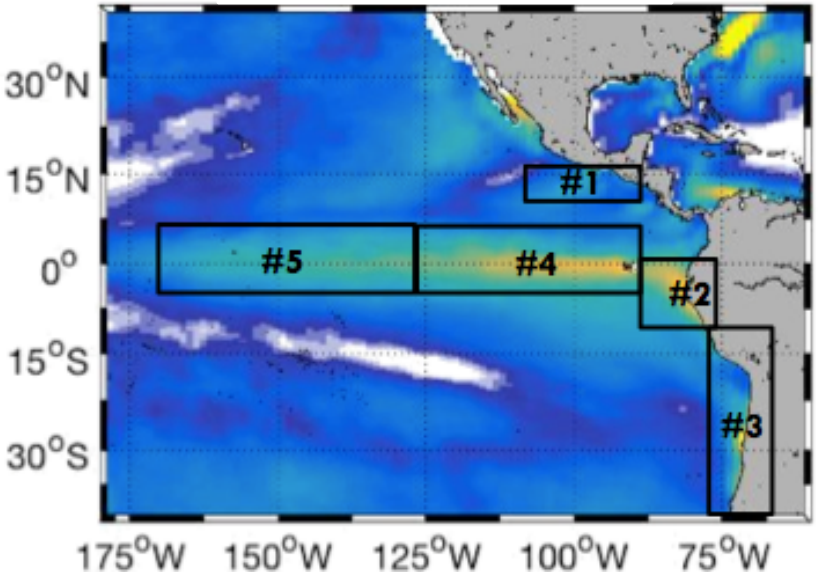
HIGH-LOW


a) ABS FAST ERR HR
30°N
15°N
0°
15°S
30°S
175°W
150°W
125°W
100°W
75°W
#1
#2
#3
#4
#5
1.2
1
0.8
0.6
0.4
0.2

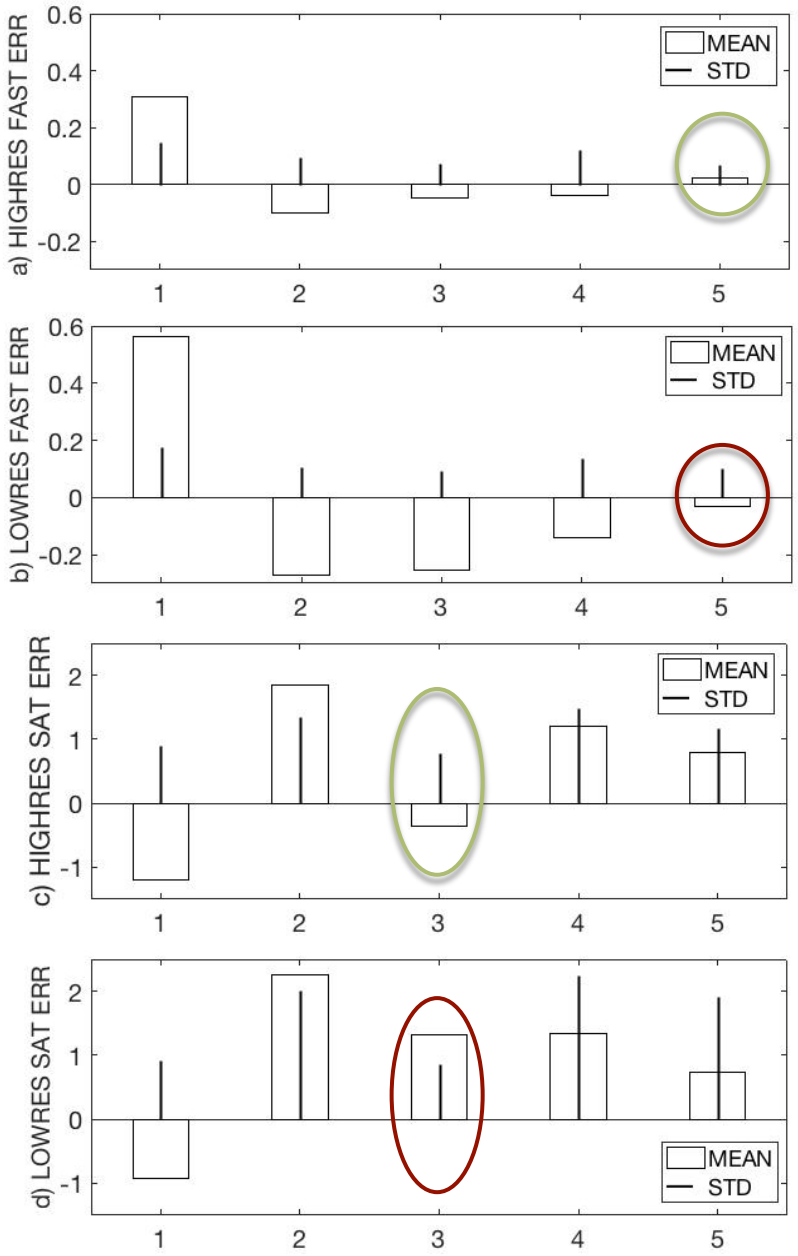

b) ABS SAT ERR HR
30°N
15°N
0°
15°S
30°S
175°W
150°W
125°W
100°W
75°W
#1
#2
#3
#4
#5
5
4
3
2
1

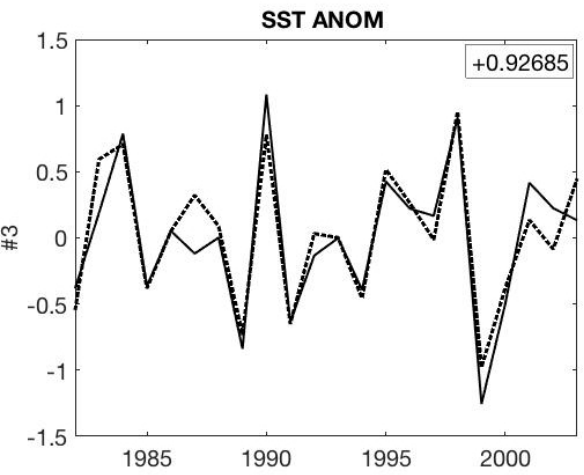

c) ABS FAST ERR LR
30°N
15°N
0°
15°S
30°S
175°W
150°W
125°W
100°W
75°W
#1
#2
#3
#4
#5
1.2
1
0.8
0.6
0.4
0.2


d) ABS SAT ERR LR
30°N
15°N
0°
15°S
30°S
175°W
150°W
125°W
100°W
75°W
#1
#2
#3
#4
#5
5
4
3
2
1

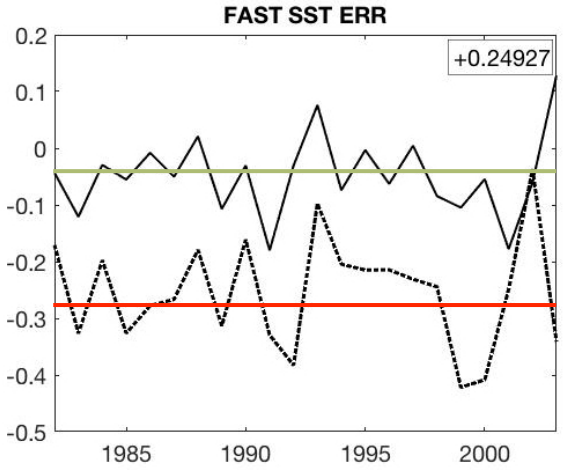


- Signal inversion from fast to saturated errors;
- Only #5 inverted signal from high to low resolution for fast errors
- Only #3 inverted signal from high to low resolution for saturated errors

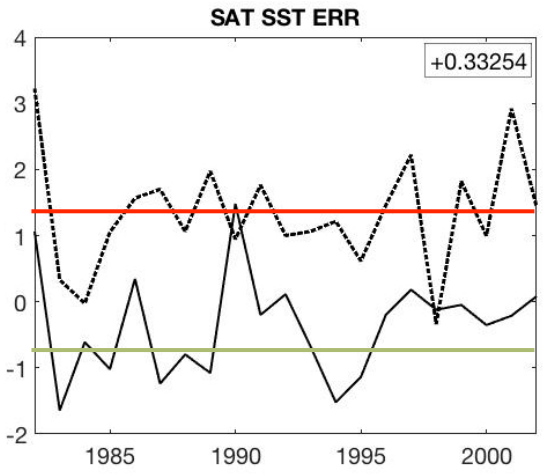


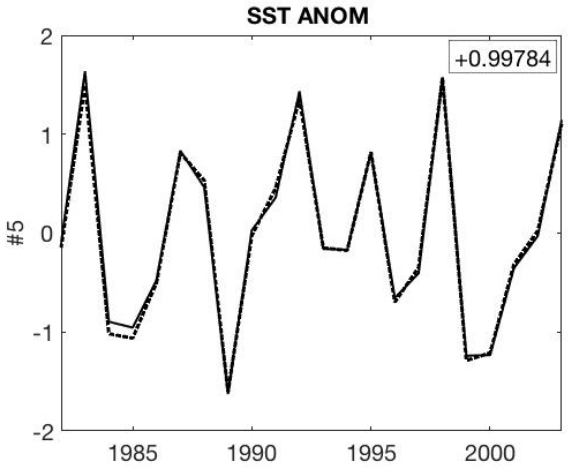

SST ANOM
+0.92685
#3
1.5
1
0.5
0
-0.5
-1
-1.5
1985
1990
1995
2000

#3

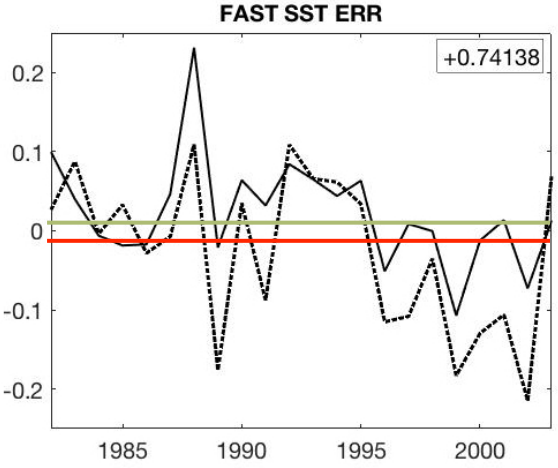

FAST SST ERR
+0.24927
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1985
1990
1995
2000

#3

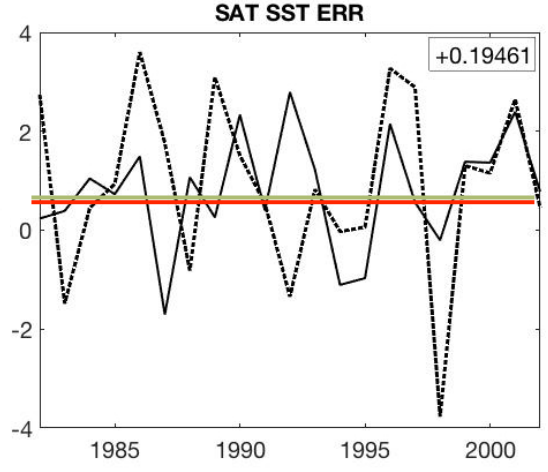

SAT SST ERR
+0.33254
4
3
2
1
0
-1
-2
1985
1990
1995
2000


SST ANOM
+0.99784
#5
2
1
0
-1
-2
1985
1990
1995
2000

#5

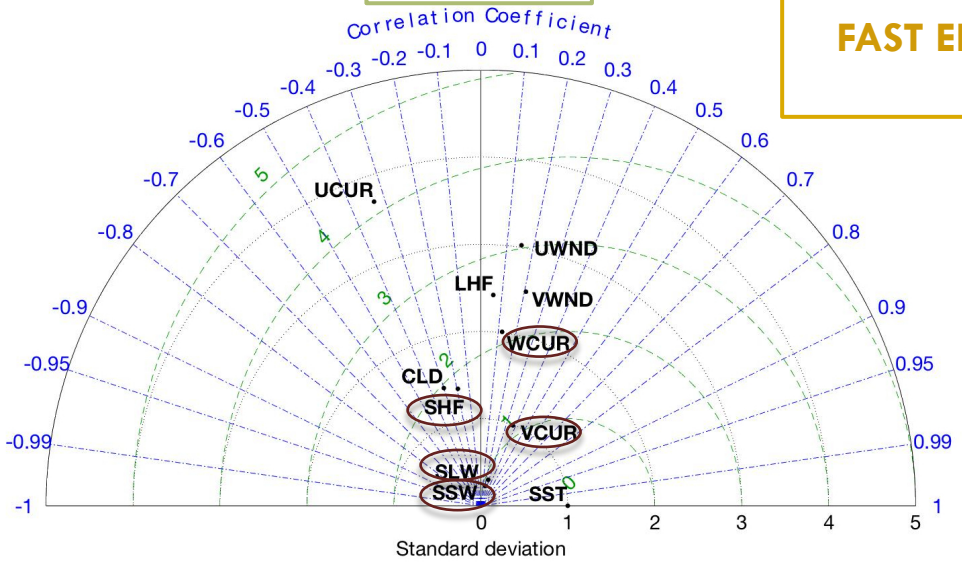

FAST SST ERR
+0.74138
0.2
0.1
0
-0.1
-0.2
1985
1990
1995
2000

#5


SAT SST ERR
+0.19461
4
2
0
-2
-4
1985
1990
1995
2000

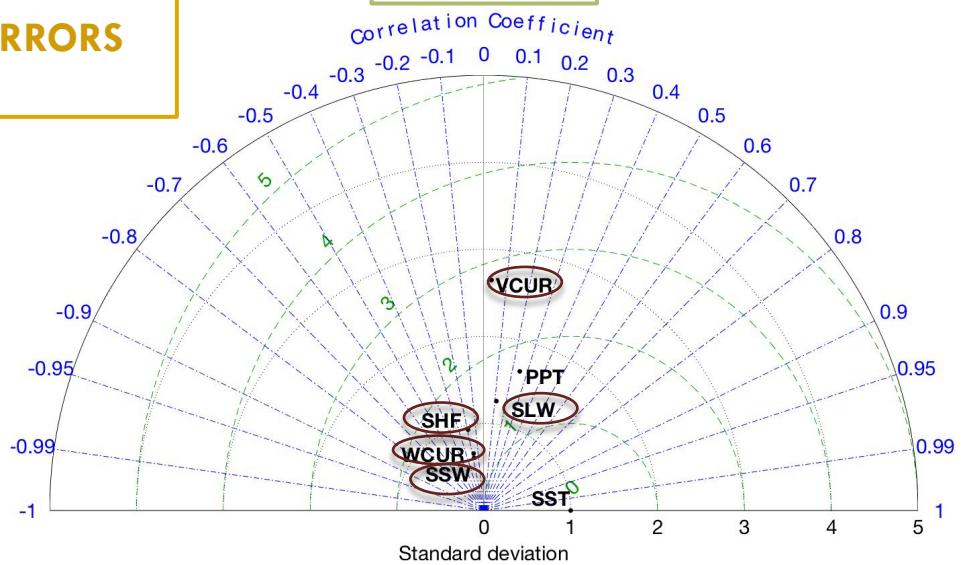
HIGHRES
LOWRES

HR #3

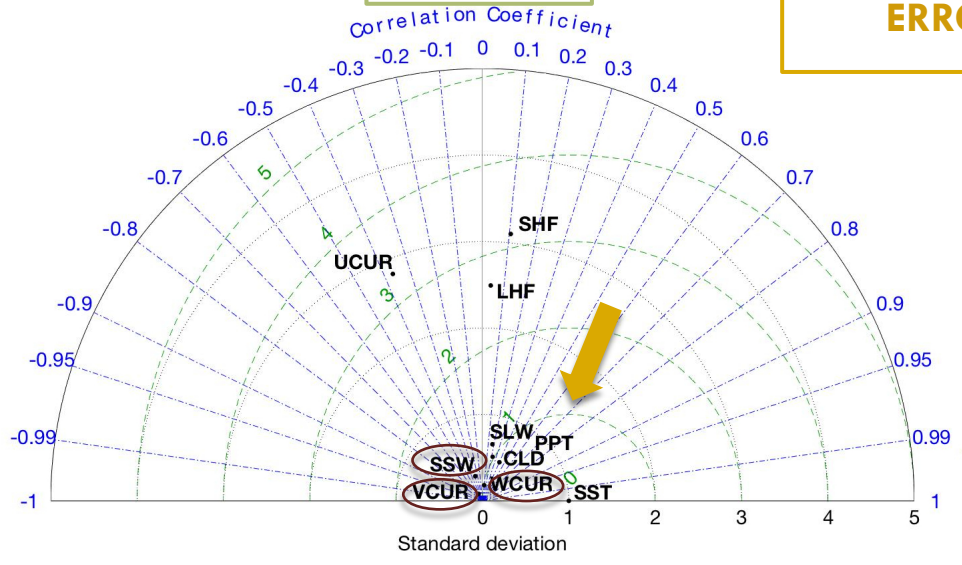


FAST ERRORS

LR #3

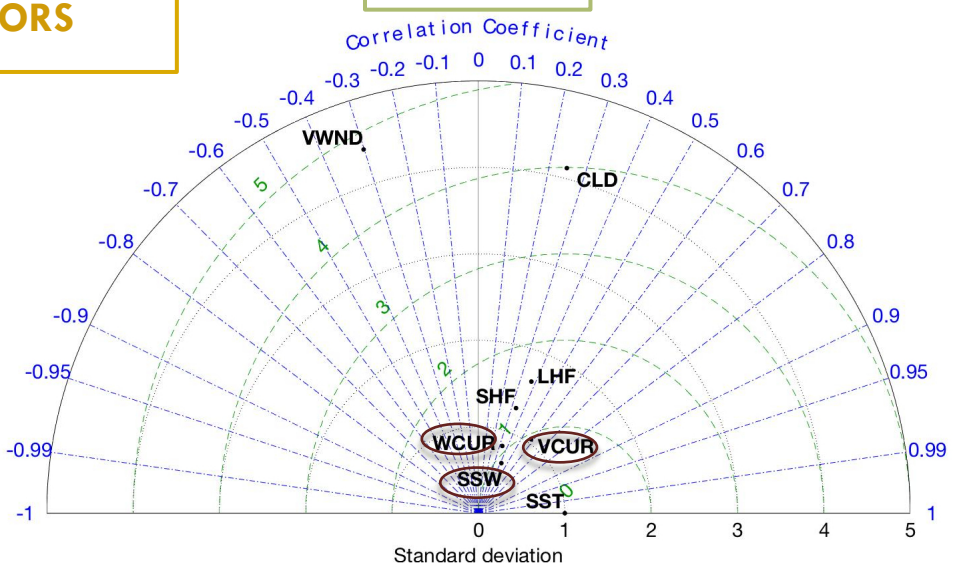


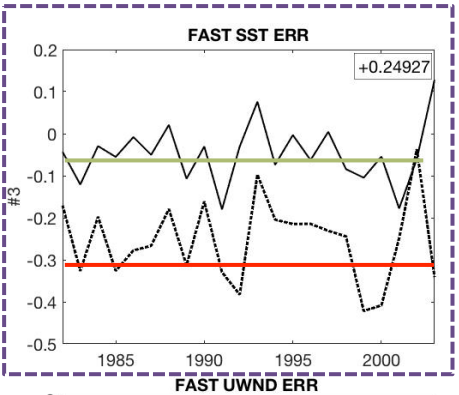
HR #3

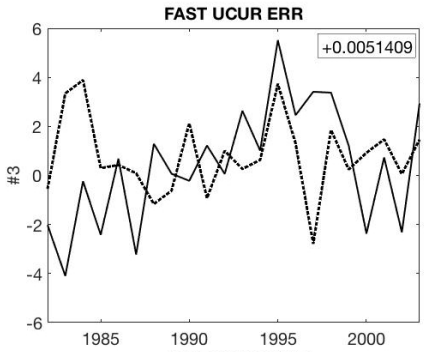


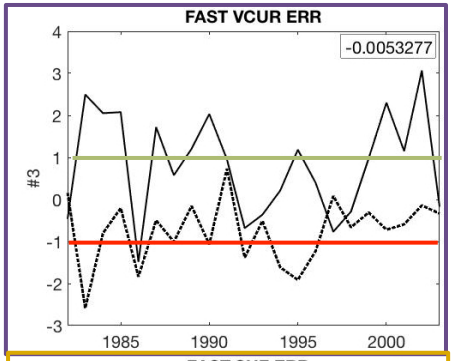
SATURATED ERRORS

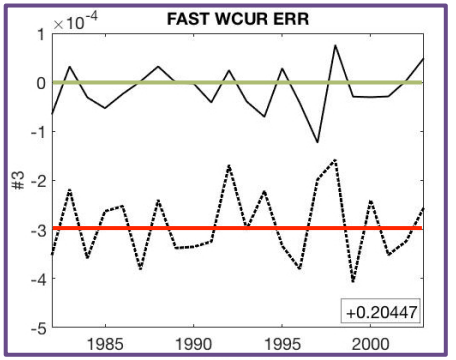
LR #3

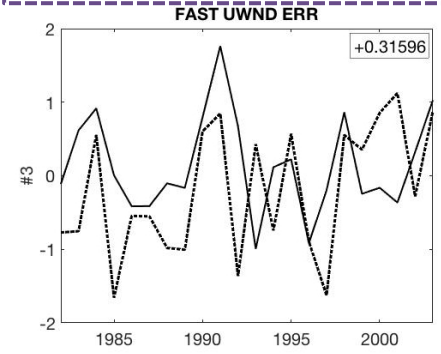


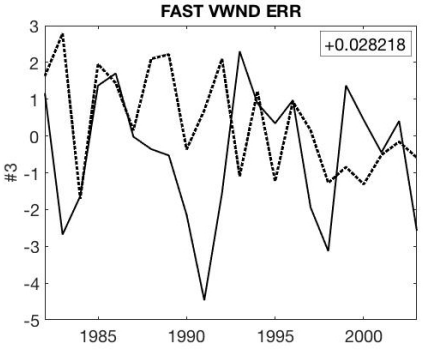


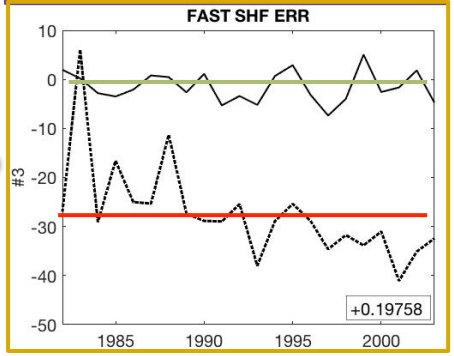


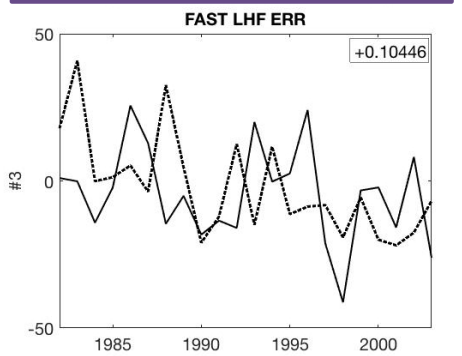


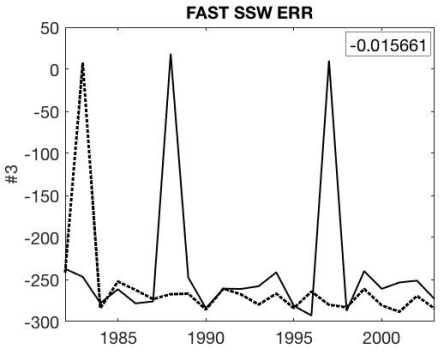


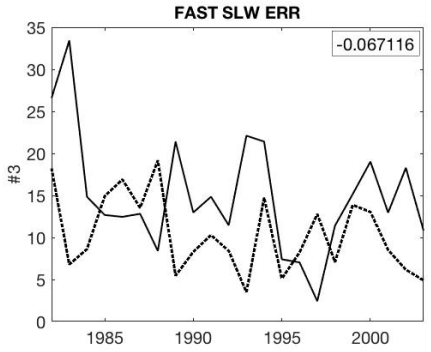


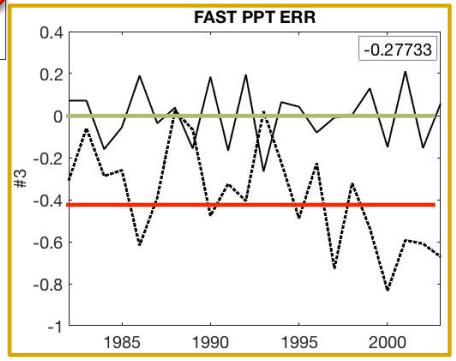


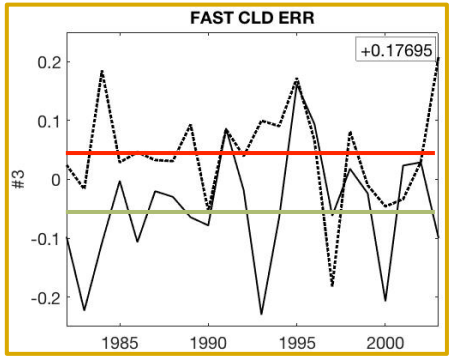








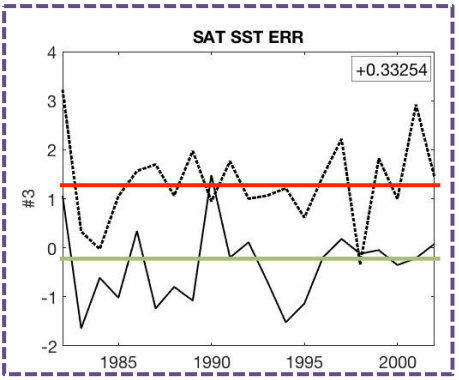


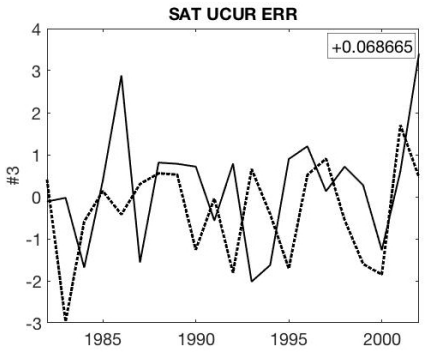


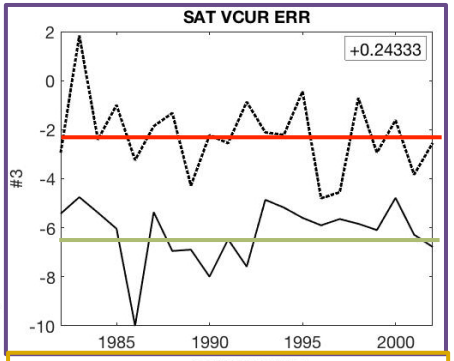
HIGHRES

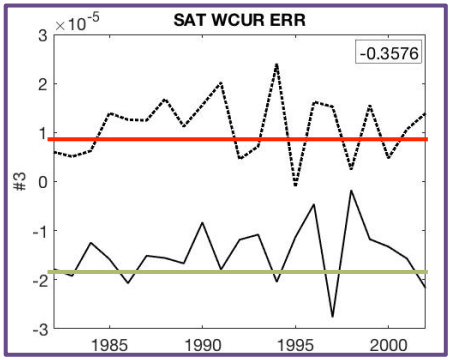
LOWRES

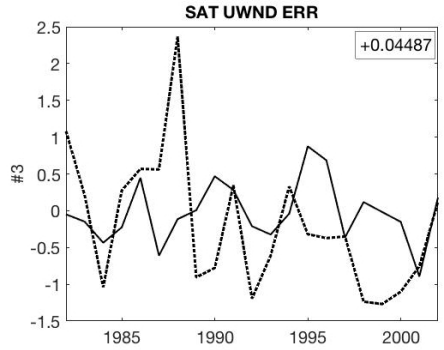
FAST ERRORS

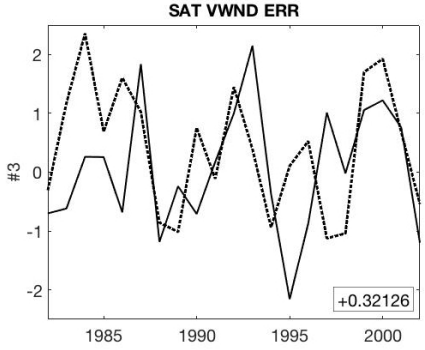






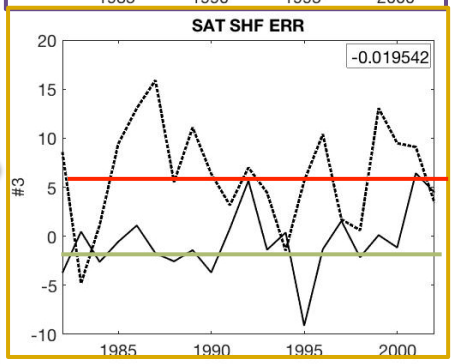


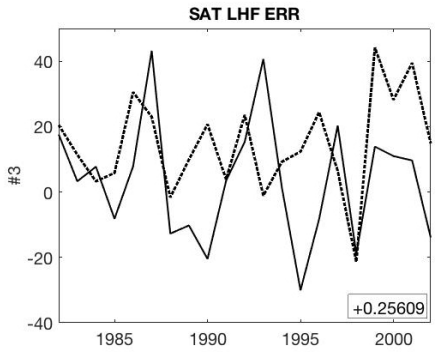


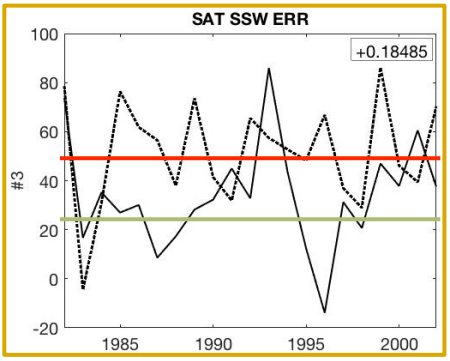


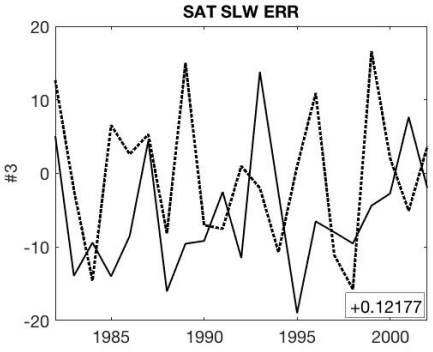
HIGHRES

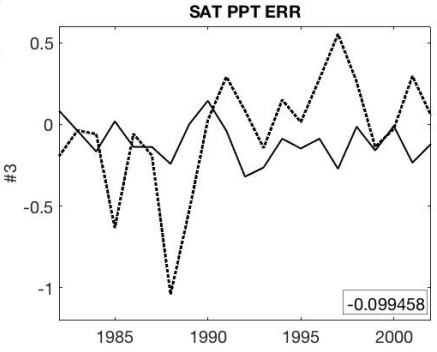
LOWRES

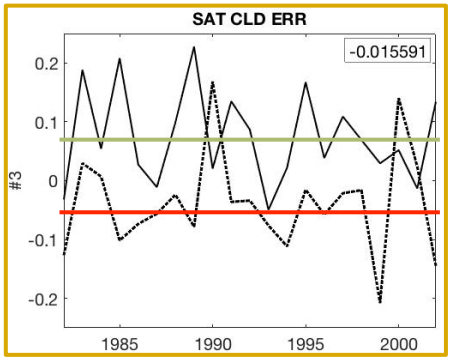












SATURATED ERRORS

- *Does increasing resolution decrease SST errors?*
  - YES, SST errors in low resolution are always higher than those in high resolution;
  - Both fast and saturated errors presented similar spatial patterns for both resolutions.
- *Is this effect valid for long and free-running integrations?*
  - YES, however … saturated errors are always greater than the fast errors;

- *Which regions presented greater differences between the two experiments?*
  - The largest differences are in regions of relatively large ocean eddy activity, as oceanic fronts and boundary currents.
  - The greatest divergence between resolutions occurred in SE Pacific for saturated errors.
  - While the low resolution suggests that SST saturated errors are related to upwelling, short wave radiation and meridional advection …
  - High resolution adds cloud cover and cloud type to this equation, what is an evidence of stronger forcing of the atmosphere by the SST variability arising from the ocean dynamics.

Thank you!

isilveira@rsmas.miami.edu