Role of SSS in MJO predictability and development of sub-monthly SSS products

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Acknowledgement: Support from **NASA OSST** is acknowledged for the work

Role of SSS in MJO predictability: Background

BLT <10m **BLT >10m**

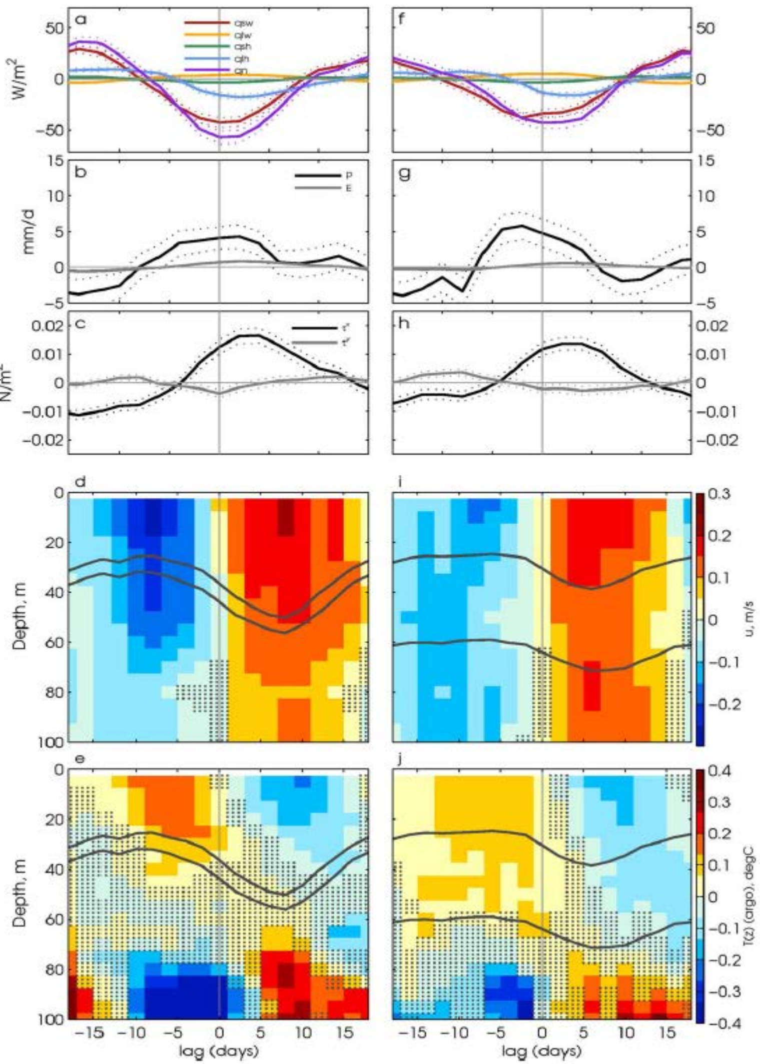
Heat Flux

P/E

Taux/Taxy

U (z)

T (z)

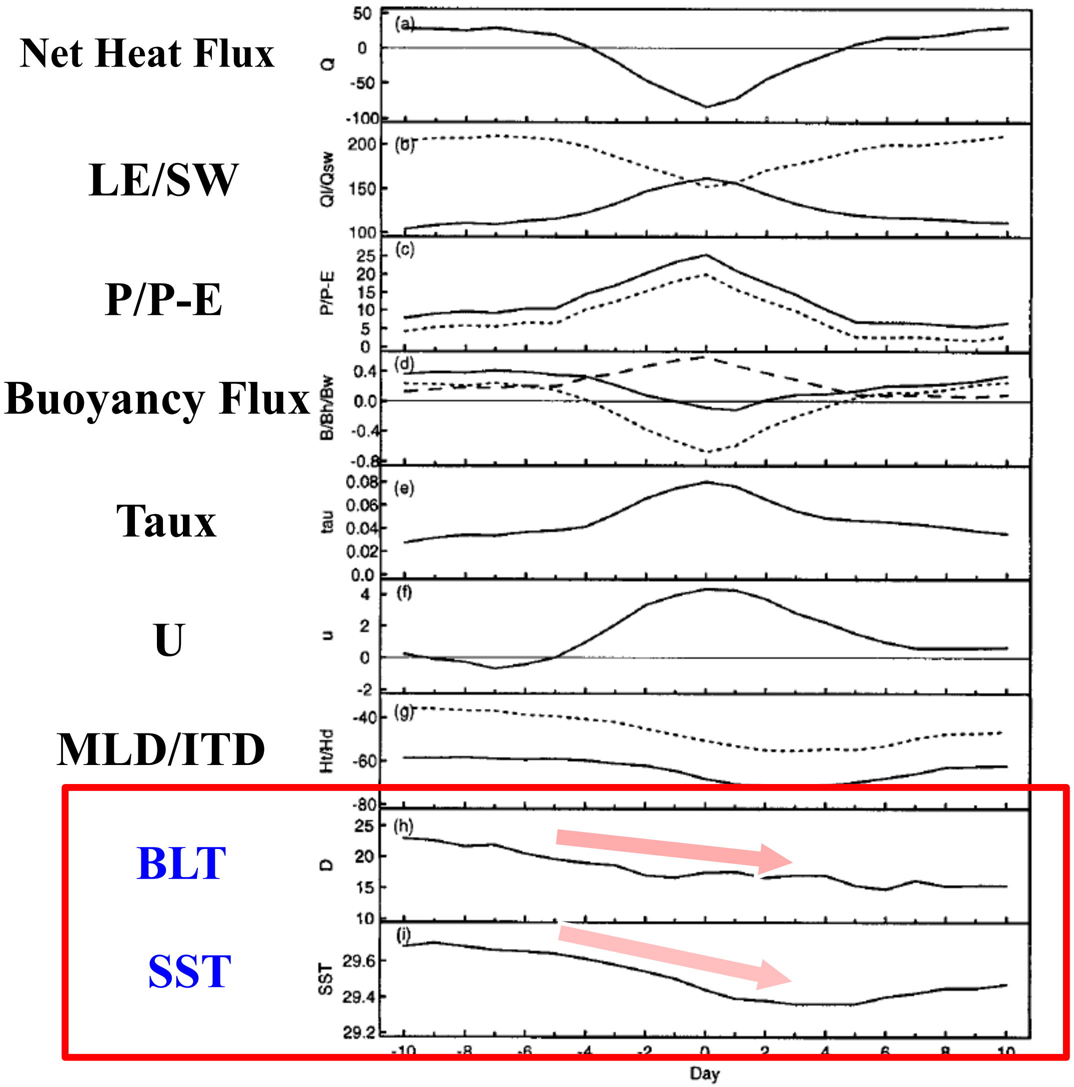


In the tropical Indian Ocean *(90°E, 0°)*

Composite analysis of observations by Kyla Drushka et al. (2014):

Thicker BL
=>Less entrainment cooling
=>Weaker SST response to MJO forcing

Role of SSS in MJO predictability: Background



In the western tropical Pacific *(165°E, 0°)*

Composite analysis of observations by Zhang and McPhaden (2000):

Thinning of BL
=> Interseasonal surface cooling

Role of SSS in MJO predictability: Background

Hypothesis: *SSS => BLT => SST => MJO predictability ?*

DYNAMO Hypotheses

I. Deep convection can be organized into an MJO convective envelope only when the moist layer has become sufficiently deep over a region of the MJO scale; the pace at which this moistening occurs determines the duration of the pre-onset state.

II: Specific convective populations at different stages are essential to MJO initiation.

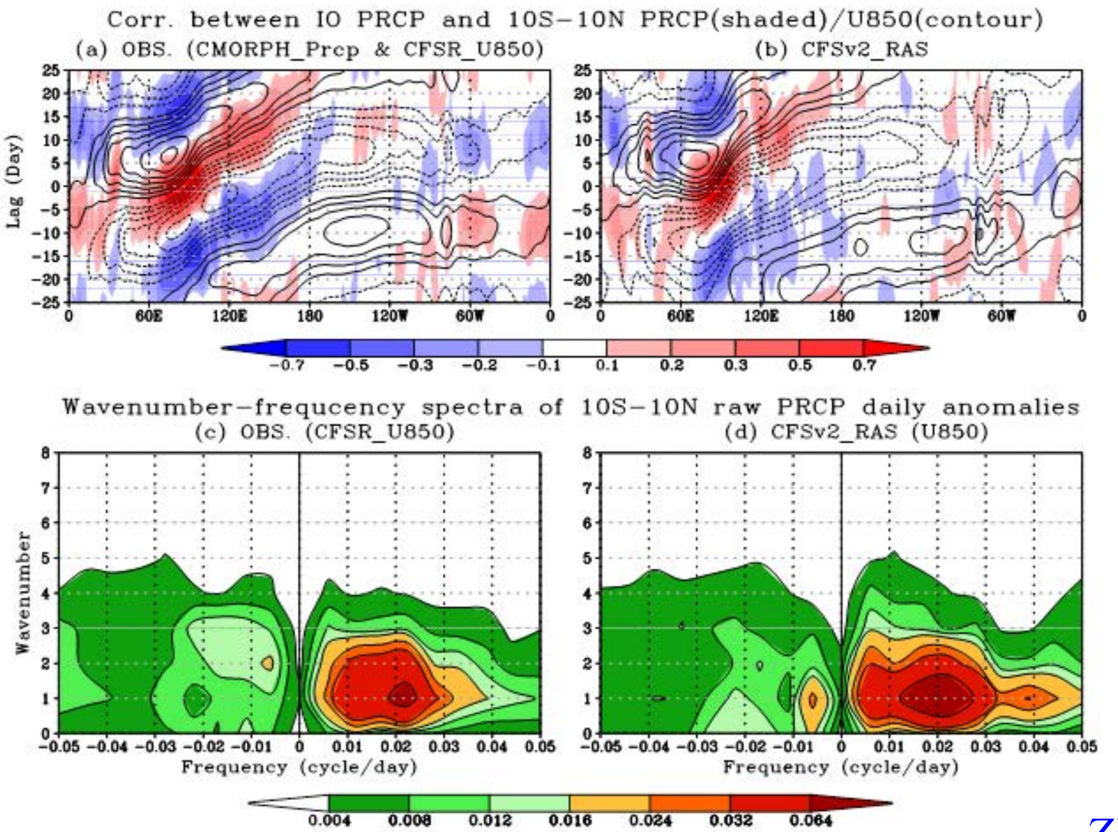
III: The barrier layer, wind- and shear-driven mixing, shallow thermocline, and mixing-layer entrainment all play essential roles in MJO initiation in the Indian Ocean by controlling the upper-ocean heat content and SST, and thereby surface flux feedback.

- **Role of BL in MJO is also one of hypotheses of DYNAMO!**

Approach to test the hypothesis

a perfect model framework with the CFSv2

- **Control configuration :** CFSv2 with RAS convection scheme
  - *NOAA operational model;*
  - *realistic MJO simulations (Zhu et al. 2017)*



Zhu et al. 2017

Approach to test the hypothesis

a perfect model framework with the CFSv2

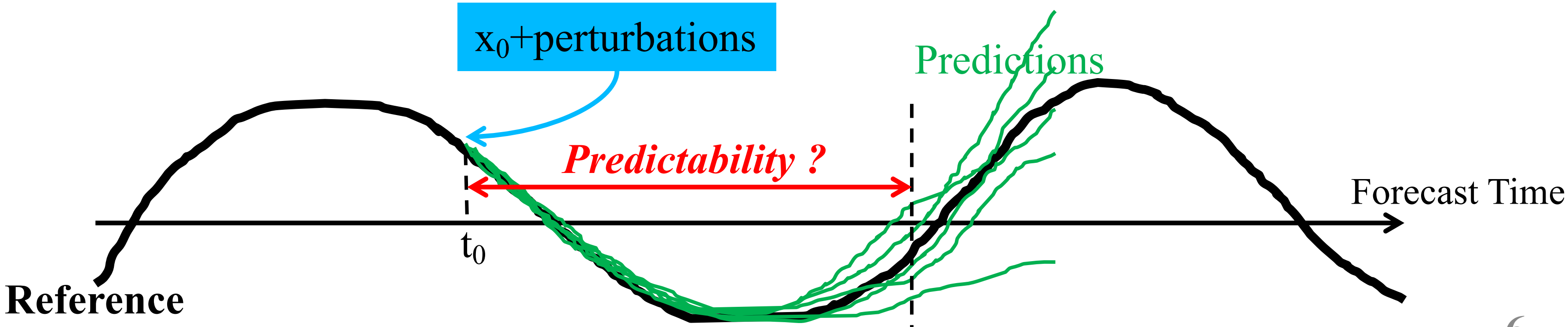
Predictability Experiments

- **CTL**: Potential predictability for CFSv2_RAS;
- **SST1dy**: Same as CTL, but with model SST nudged to climatologies at 1-day time scale (*suppressed SST feedback*);
- **SSS1dy**: Same as CTL, but with model SSS nudged to climatologies at 1-day time scale (*suppressed SSS feedback*).

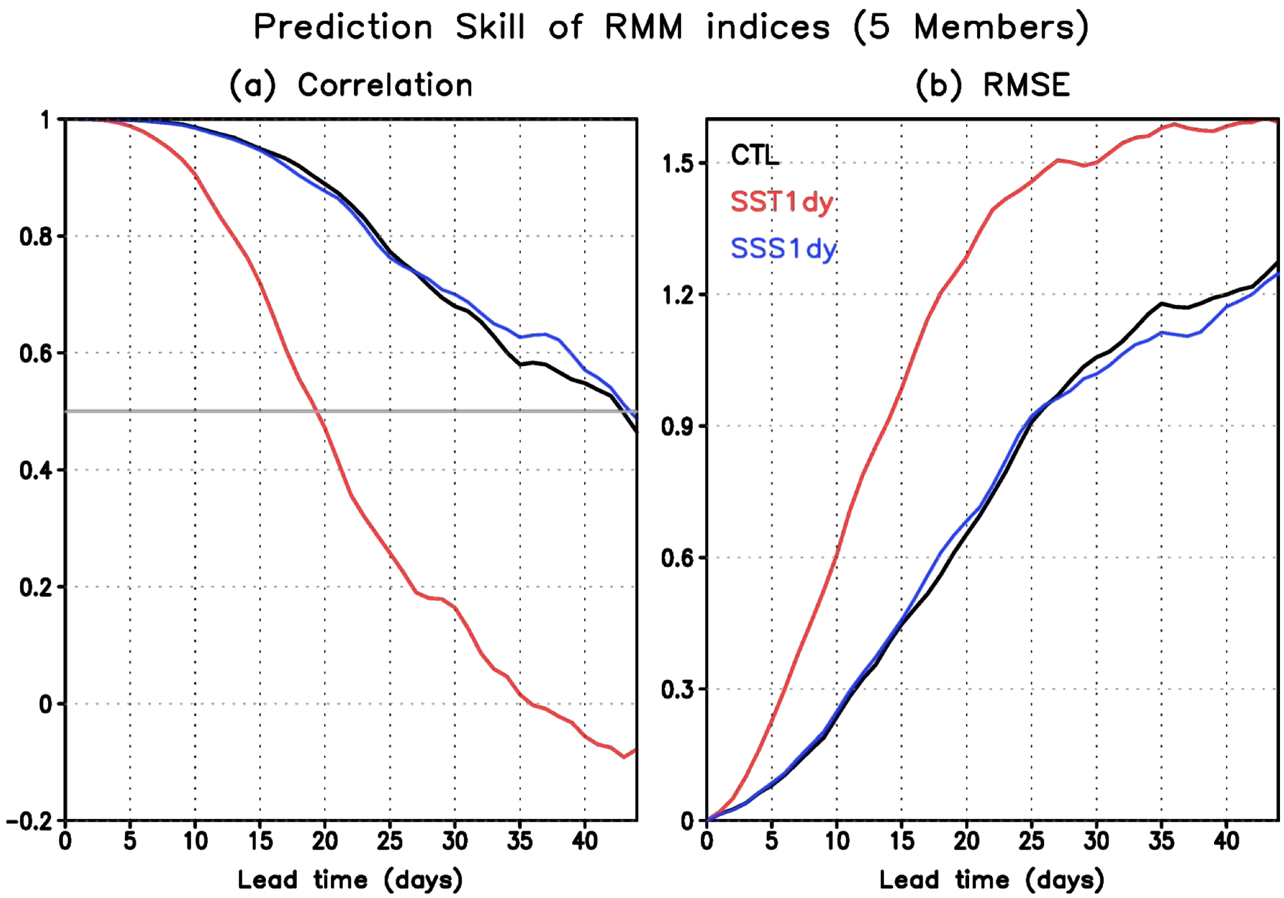
Experimental Design

For 10 model years (CFSv2_RAS), starting from every Nov. 1, 45-day predictions were conducted every 5 days with 5 ensemble members

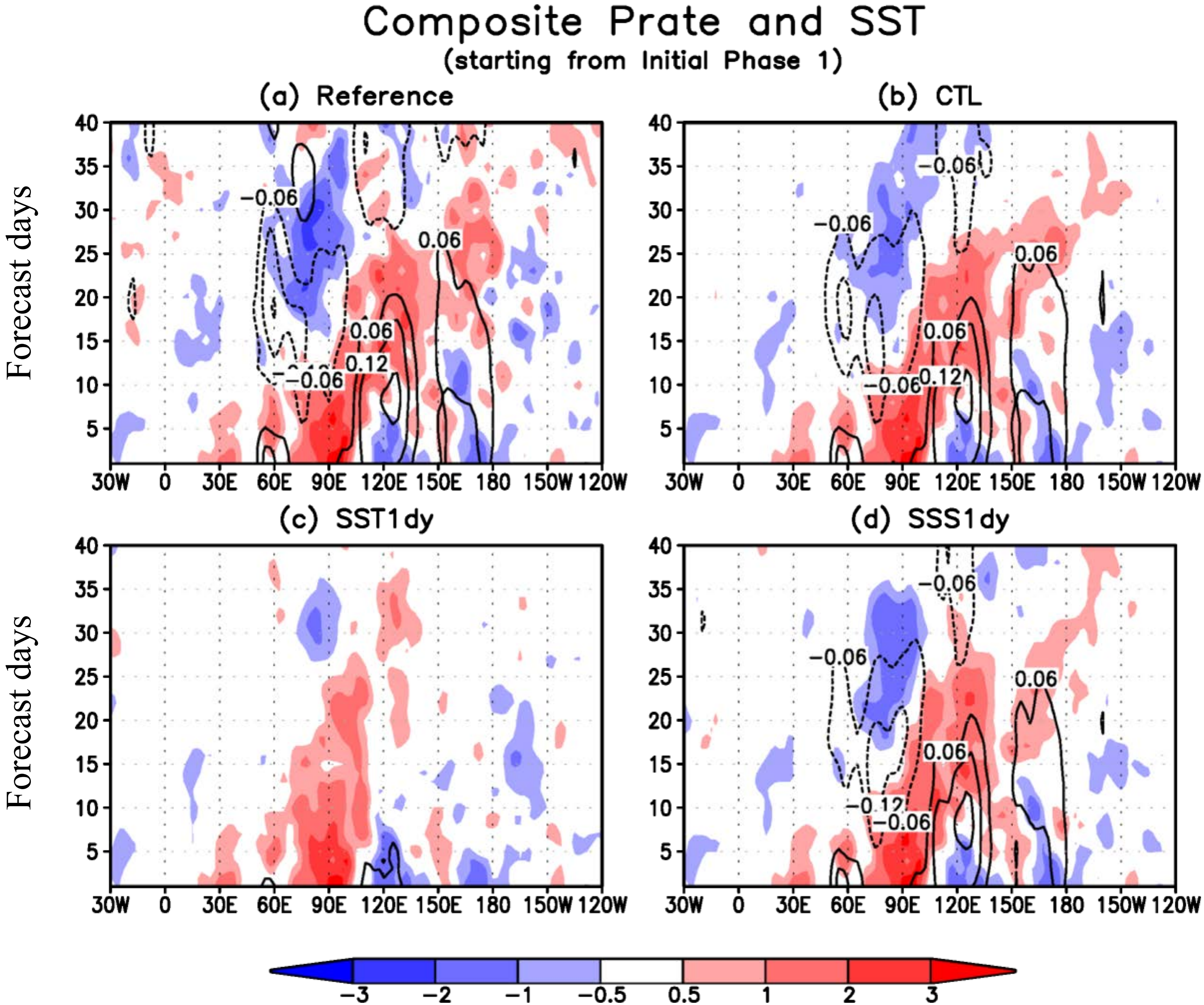
(For each experiment: totally, 10 years x 31 cases x 5 members =1550)

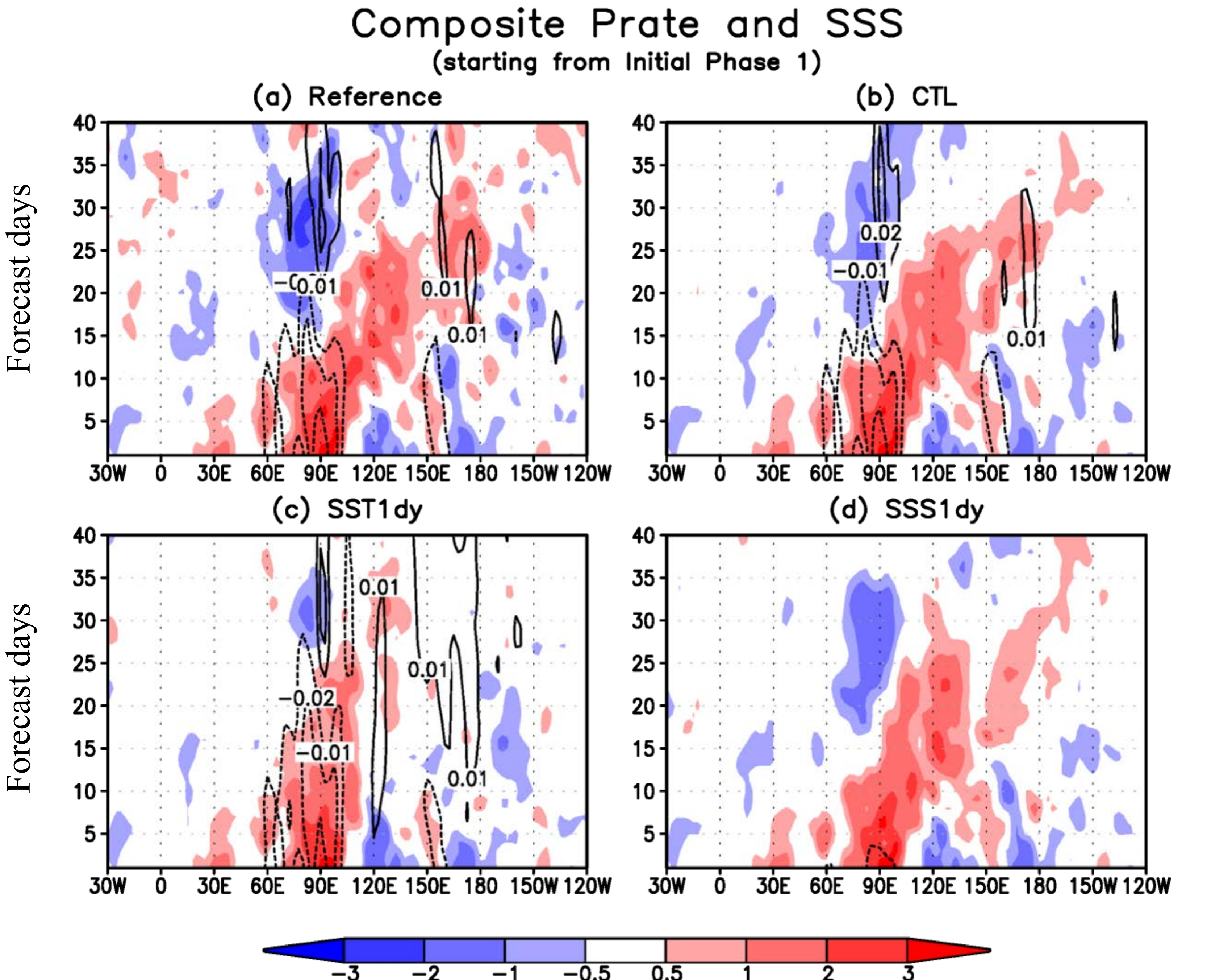


Overall MJO Predictive skill with RMM indices



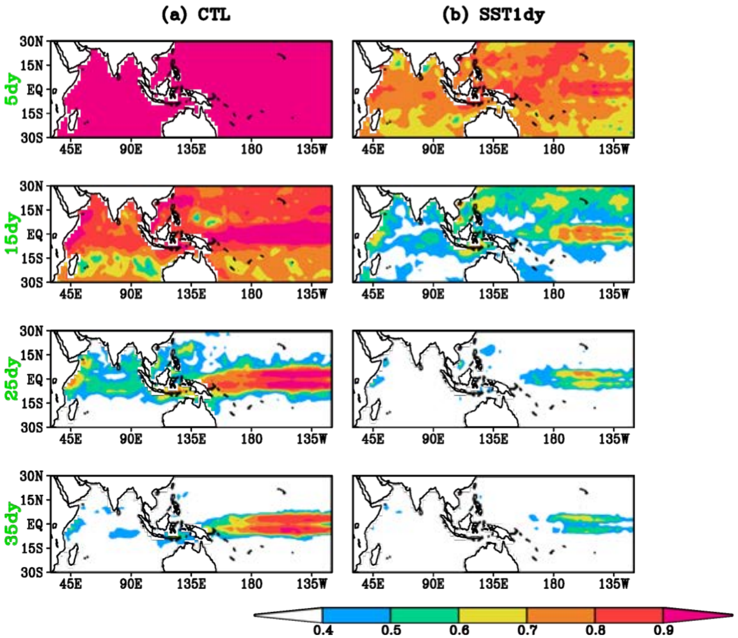
- MJO Potential predictability of ~44 days;
- Decreased to 19 days with suppressed SST feedback;
- **No significant change when the SSS feedback is suppressed.**


Composite Prate and SST
(starting from Initial Phase 1)
(a) Reference
(b) CTL
(c) SST1dy
(d) SSS1dy
Forecast days
40
35
30
25
20
15
10
5
30W
0
30E
60E
90E
120E
150E
180
150W
120W
−0.06
0.06
0.12
−3
−2
−1
−0.5
0.5
1
2
3


Composite Prate and SSS
(starting from Initial Phase 1)
(a) Reference
(b) CTL
(c) SST1dy
(d) SSS1dy
Forecast days
Forecast days
0.01
0.02
−0.01
−0.02
30W 0 30E 60E 90E 120E 150E 180 150W 120W
−3 −2 −1 −0.5 0.5 1 2 3

Predictive skill of daily SSTA

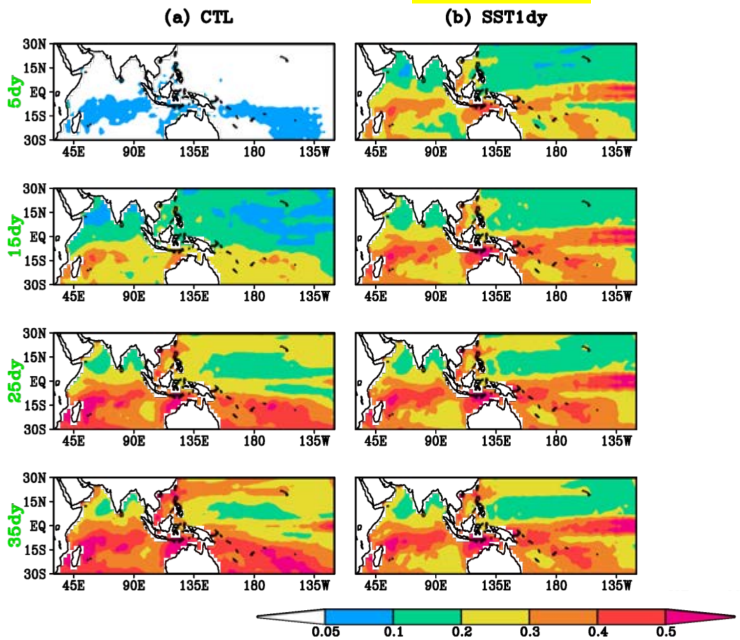
Correlation



Hypothesis:

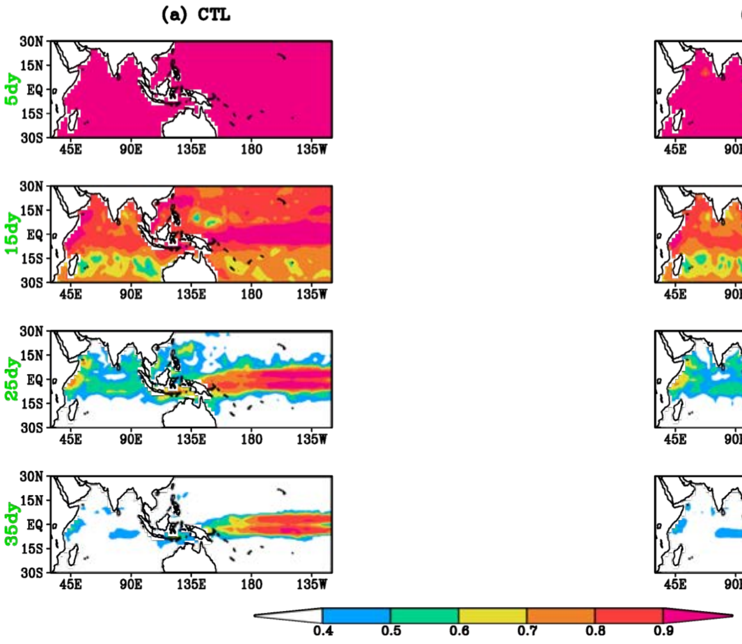
SSS => BLT => SST => MJO predictability ?

RMSE



Predictive skill of daily SSTA

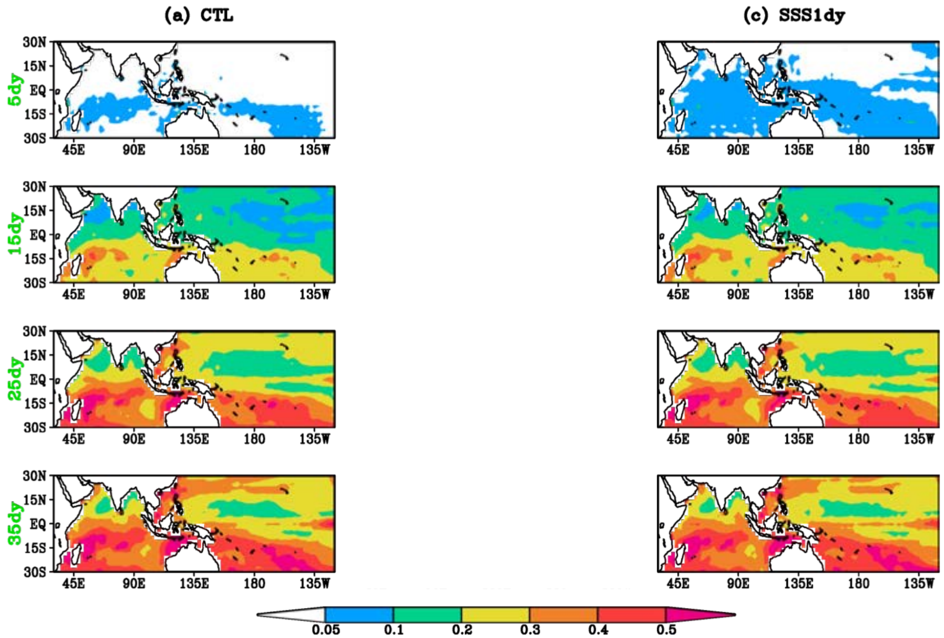
Correlation



Hypothesis:

SSS => BLT => SST => MJO predictability ?

RMSE

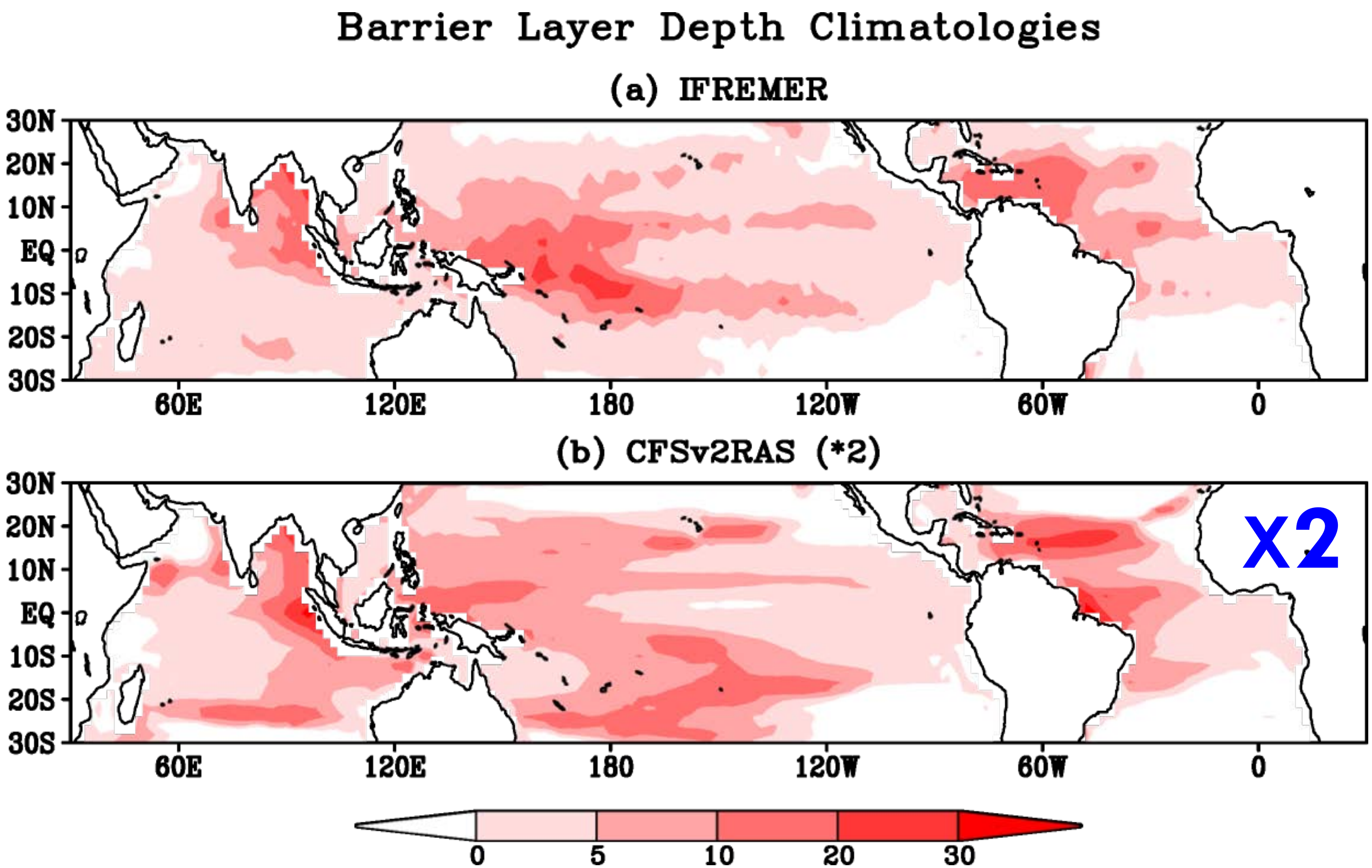


- **SSS nudging shows negligible effect on SST !**

Hypothesis:

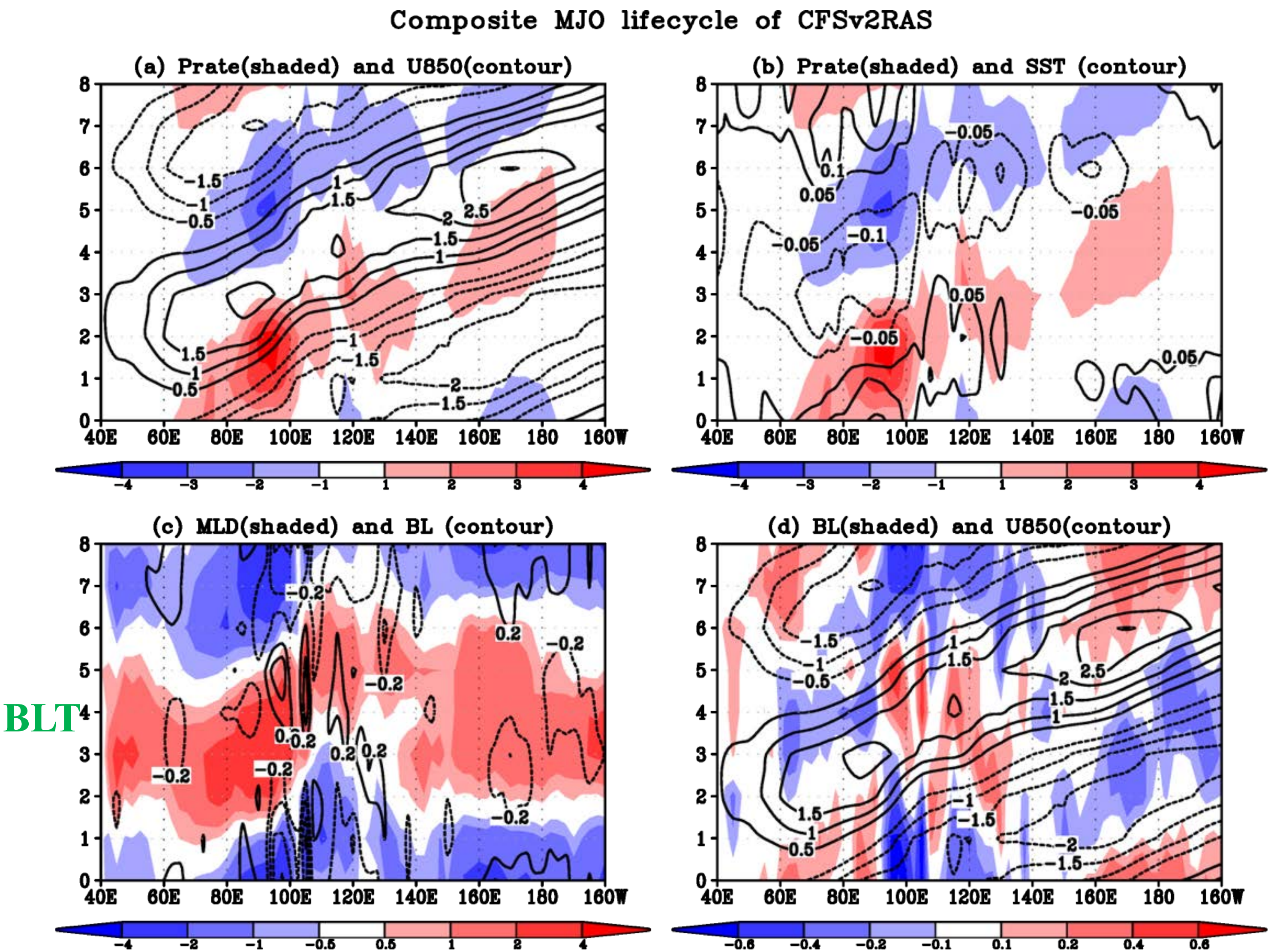
SSS => BLT => SST => MJO predictability ?

BL simulations in CFSv2RAS: climatologically too thin



- CFSv2RAS simulates the distribution relatively well, but only **half of observed** thickness

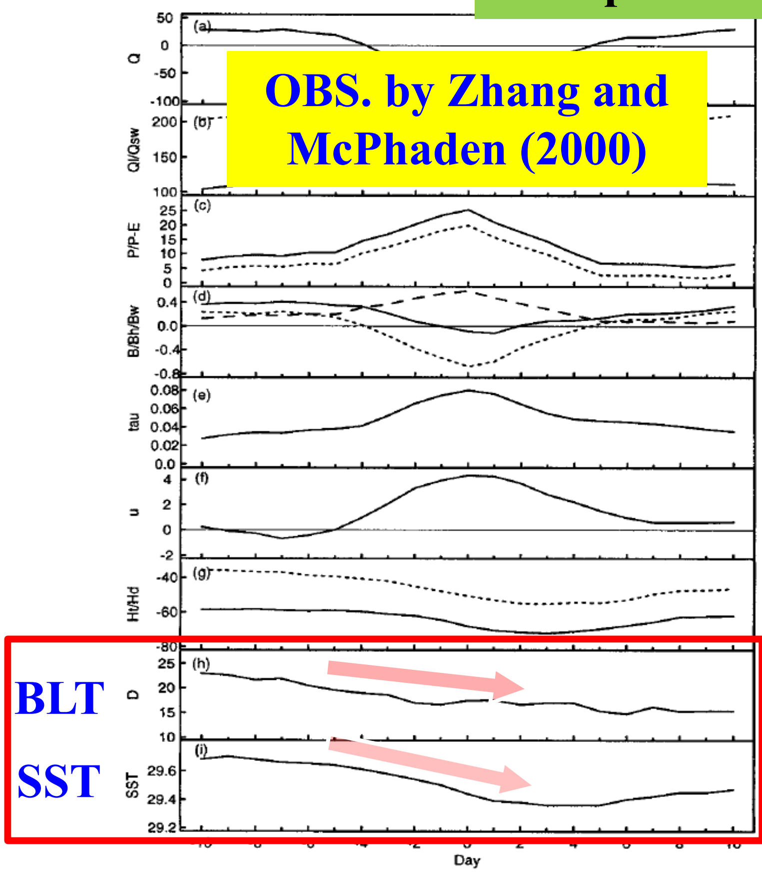
BL simulations in CFSv2RAS: composite MJO BL variation is too small

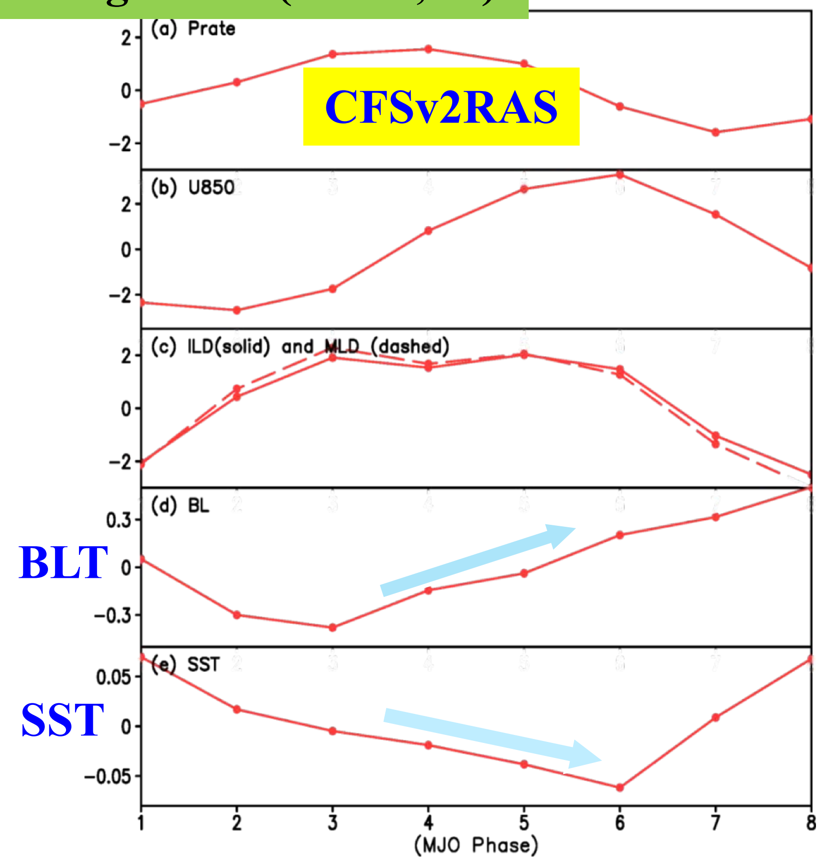


- **CFSv2RAS:** composite BLT anomaly **< 0.5m**;
- **Schiller and Godfrey (2003):** ~ 15m in individual MJO events, but **~ 8m** in composite events;

BL simulations in CFSv2RAS: unrealistic intraseasonal BL-SST relationship

Composite Intraseasonal Signals at (165°E, 0°)





- The BL-SST relationship ***is opposite*** between CFSv2RAS and OBS. By Zhang and McPhaden (2000);
- In CFSv2RAS, the BL thickening seems ***a response*** to westerly winds (Cronin and McPhaden 2002).

Some findings …

1. To the **first** order, CFSv2 did not present significant effect on MJO predictability from SSS, *while significant effect from SST*;

2. CFSv2 exhibits large **biases** in simulating BL: *too thin climatologically, too small intraseasonal variation, and unrealistic intraseasonal BL-SST relationship*;

Future efforts…

- **Model bias** *(too thin BL; too small MJO BL variation; unrealistic SST-BL relationship)*

  => try with CFSv2 with ***1m vertical*** *resolution in upper ocean*

- MJO **event-dependent** effects from SSS

  => Pick ***MJO events*** *with stronger BL signal and correct SST-BL relationship for experiments*

  Both observational (e.g., Drushka et al. 2014) and model (e.g., Schiller and Godfrey 2003) studies suggest that the BLT variance over individual events is considerably larger than the composite average.

Development of In Situ – Satellite Blended Analysis of Global Pentad SSS

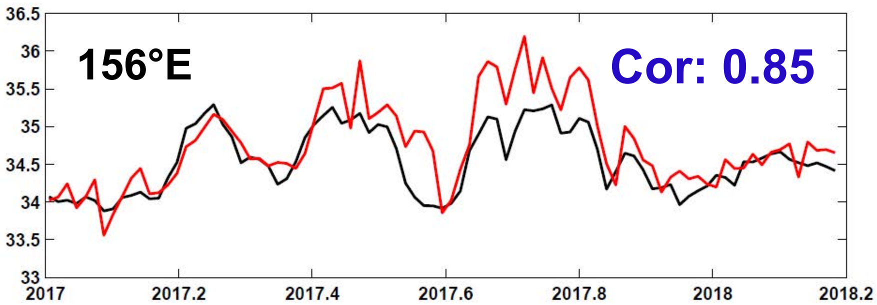
Pingping Xie and Li Ren

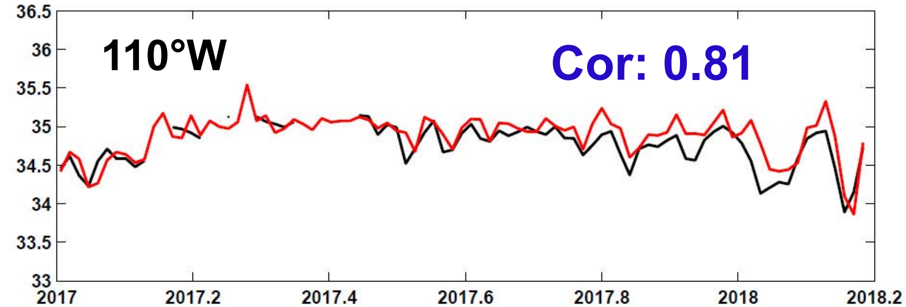
NOAA Climate Prediction Center

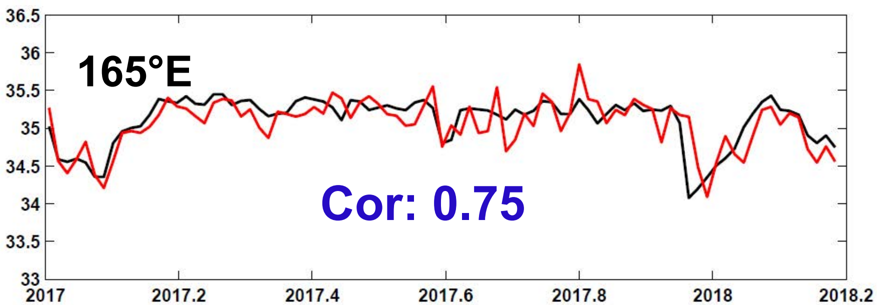
Background

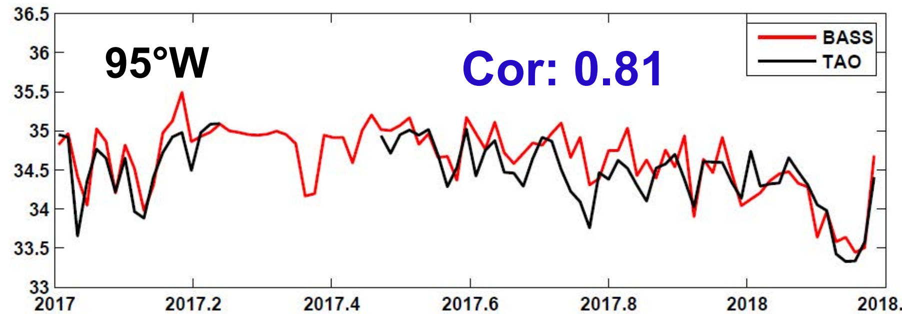
- MONTHLY analysis of global se surface salinity constructed on a 1^{o} lat/lon grid over the global ocean for a period from January2010 to present, updated on a quasi real-time basis;
- Called Blended Analysis of Sea-surface Salinity (BASS), the monthly analysis is defined through blending in situ measurements of NOAA/NODC with retrievals from multiple satellite observations of SMOS, Aquarius, and SMAP;
- A MONTHLY package of global SSS and associated fresh water flux variations is created and provided to the CPC Monthly Ocean Briefing for the operational applications of global ocean monitoring;
  - SSS: BASS monthly blended analysis
  - Evaporation: CFSR evaporation calibrated against OAFlux
  - Precipitation: Bias corrected CMORPH satellite precipitation

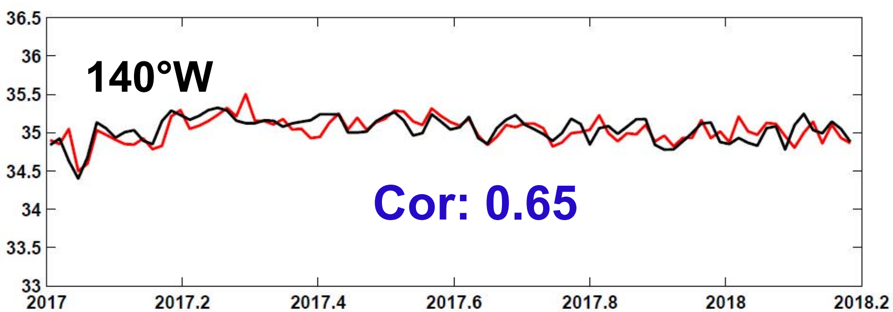
Pentad SSS Comparison with TAO/TRITION: Time Series











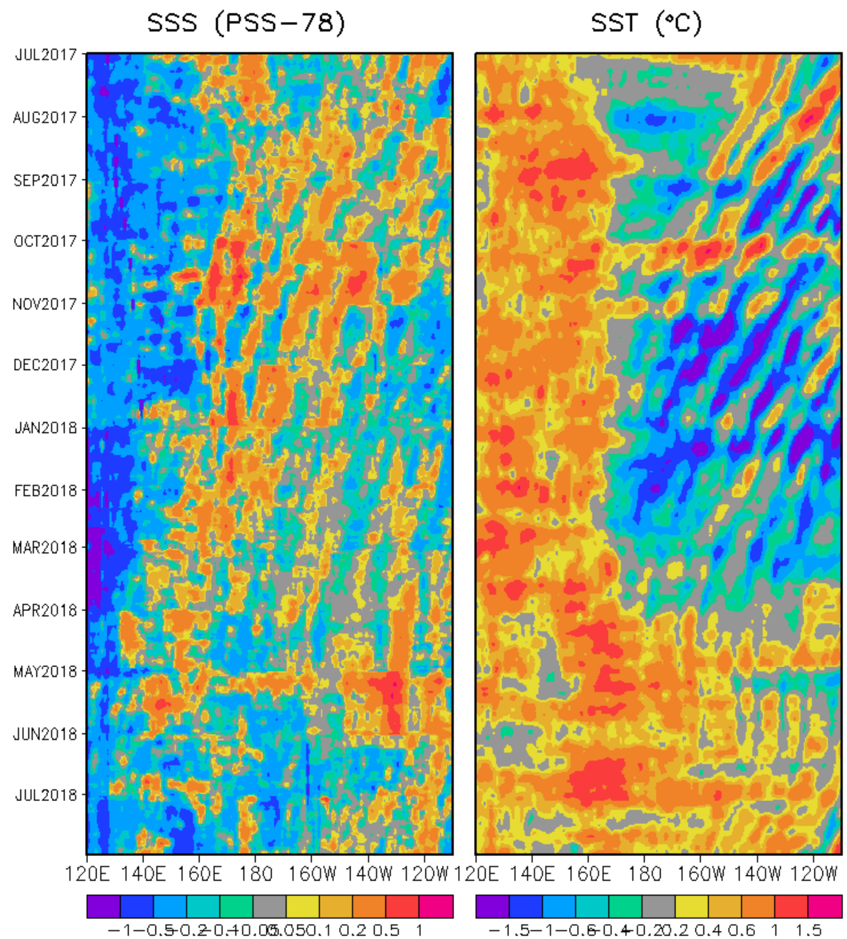
Red Line: BASS

Black Line: TAO

Global Sea Surface Salinity (SSS)

Anomaly Evolution over Equatorial Pacific

- Hovemoller diagram for equatorial SSS and SST anomaly and **(2˚N-6˚N);**
- In the equatorial Pacific Ocean, negative/positive SSS/SST signal appears in the west basin, with the negative SSS signal is between 120°E to 140°E, while the positive SST signal is between 120°E to 170°E. West of 140°E/170°E, positive/negative SSS/SST and negative/positive SSS/SST signals appear alternatively and such signals likely propagate to the west.



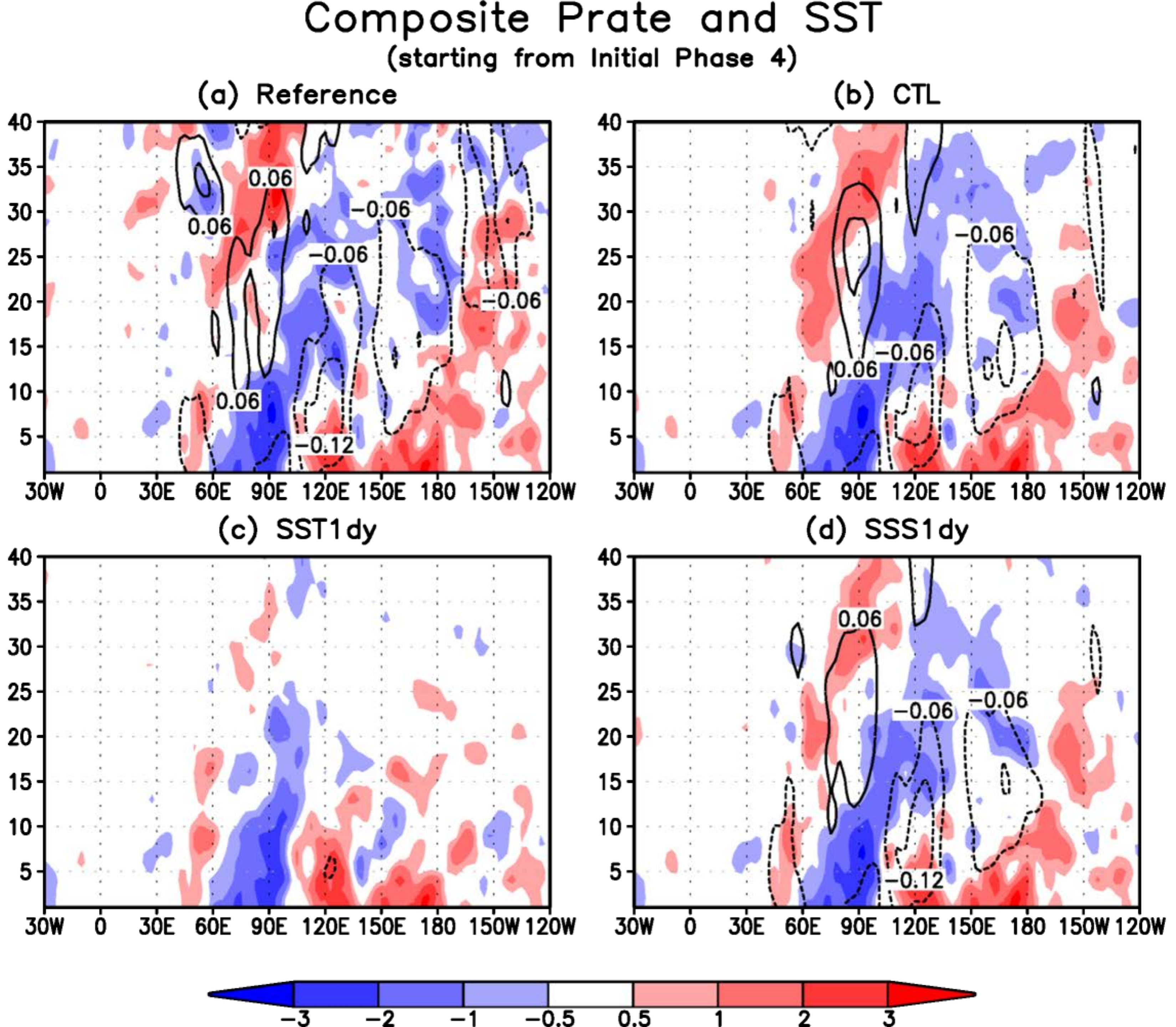
Summary and Future Work

- Pentad Blended Analysis of Sea-surface Salinity (BASS) has been developed and started test routine production (2017-present);
- A pentad package of global SSS and associated fresh water flux has been created and provided to the CPC Global Ocean Briefing;
- Monthly and pentad BASS blended SSS analyses are updated on a quasi real-time basis and available publically through ftp at:

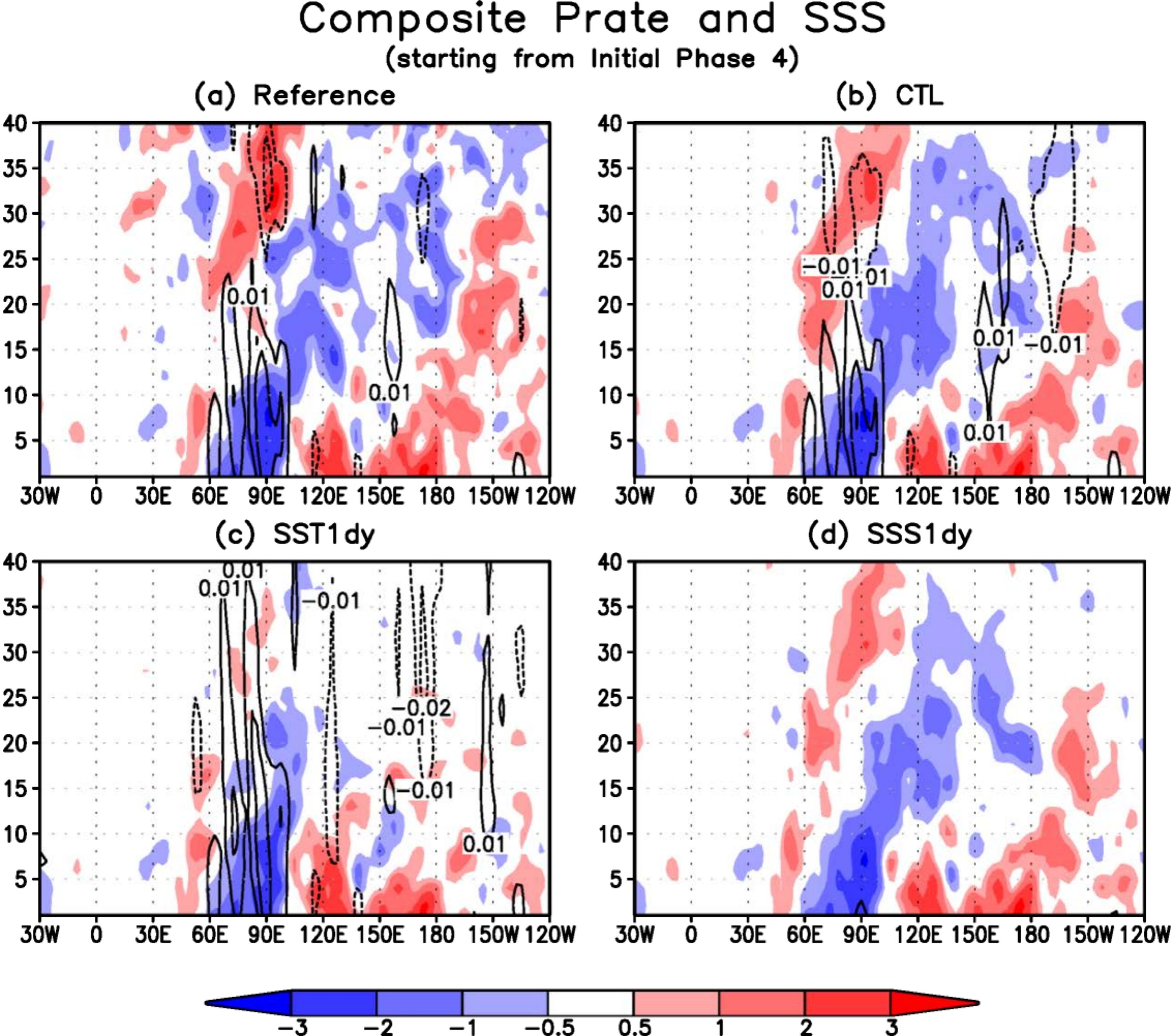
  ftp.cpc.ncep.noaa.gov/precip/BASS/pentad/

- Future work:
  - Through examination of the pentad blending algorithm to complete the development work
  - Communicate with NODC to back extend their in situ data set to earlier periods to facilitate the extension of pentad SSS to years prior to 2015
  - Explore optimal strategy to bring down the time /space resolution to daily / 0.5^{o}lat/lon or finer

Thanks !



Composite Prate and SST
(starting from Initial Phase 4)
(a) Reference
(b) CTL
(c) SST1dy
(d) SSS1dy
0.06
-0.06
-0.12
40
35
30
25
20
15
10
5
30W
0
30E
60E
90E
120E
150E
180
150W
120W
-3
-2
-1
-0.5
0.5
1
2
3



Composite Prate and SSS
(starting from Initial Phase 4)
(a) Reference
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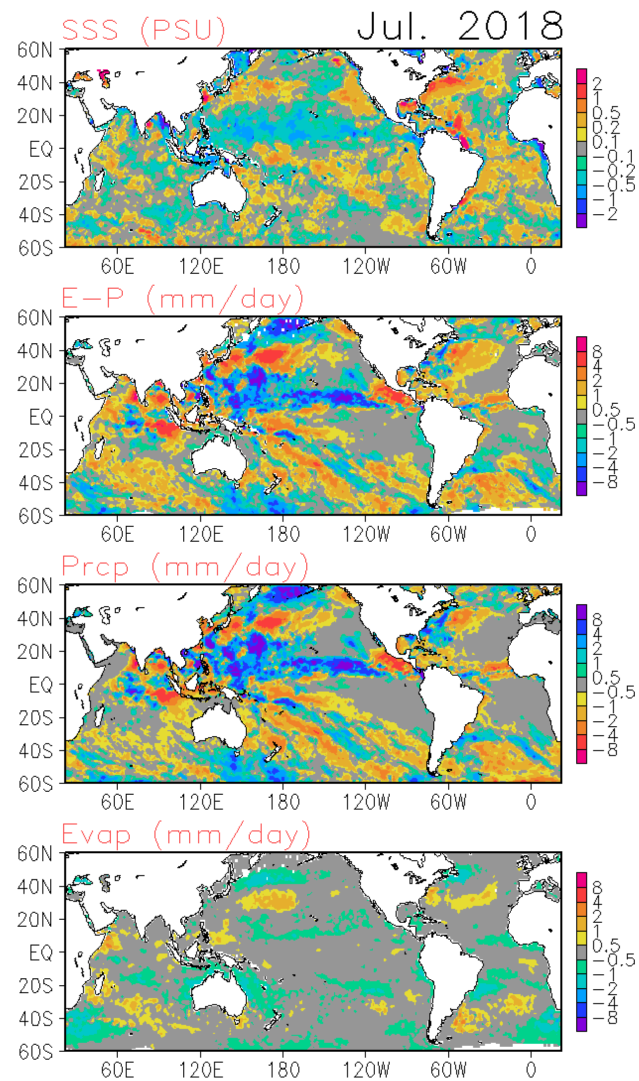
40
35
30
25
20
15
10
5
30W
0
30E
60E
90E
120E
150E
180
150W
120W
0.01
-0.01
-0.02
-3
-2
-1
-0.5
0.5
1
2
3

Global Sea Surface Salinity (SSS)

Anomaly for July 2018

- **New Update: The input satellite sea surface salinity of SMAP from NSAS/JPL was changed from Version 3.0 to Version 4.0 in January 2018.**
- **Attention: There is no SMAP SSS available during this month and the input for the satellite SSS is SMOS only.**
- A large scale of negative SSS signal between equator and 20°N in the N. Pacific Ocean is intensified. Such negative SSS signal is co-incident with heavier precipitation. The SSS in the SPCZ region continues positive with the precipitation being reduced. The reduced precipitation along the Equatorial Atlantic ocean likely causes the positive SSS anomaly in this region. The negative SSS signal in the Sea of Okhotsk is accompanied with slightly reduced precipitation which suggests that the ocean advection/entrainment might cause the SSS anomaly.



- **Data used**

SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
(Xie et al. 2014)
ftp.cpc.ncep.noaa.gov/precip/BASS
Precipitation: CMORPH adjusted satellite precipitation estimates
Evaporation: Adjusted CFS Reanalysis

Objective and Methodology

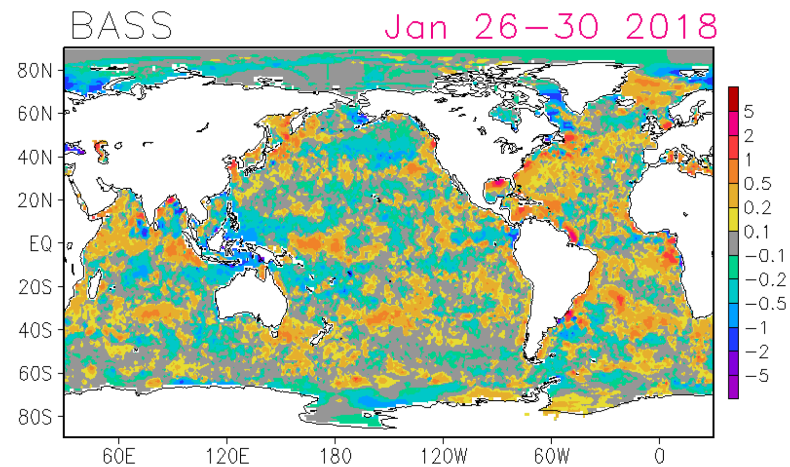
- Objective:
  - *To refine the temporal resolution of the blended SSS analysis from MONTHLY to Pentad; and*
  - *To create SSS / fresh water flux monitoring package on a temporal resolution of pentad (5-day) to capture intra-seasonal variations;*

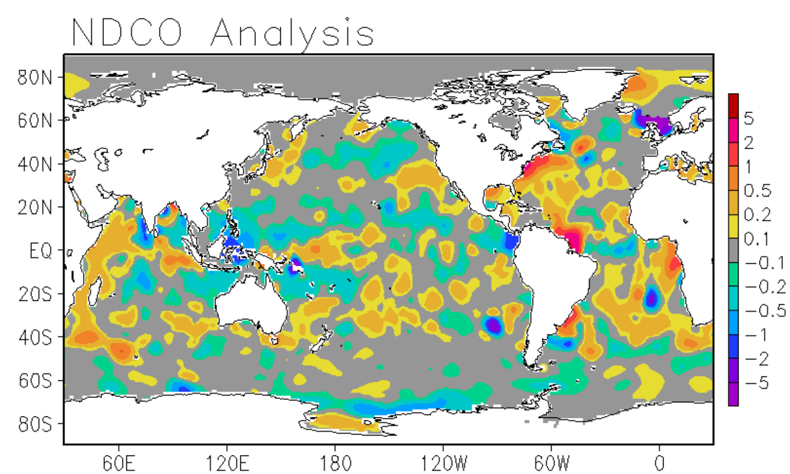
- Methodology
  - *Blended Analysis of SSS on pentad Resolution*
    - Algorithm modified from the original version developed for monthly SSS;
    - Daily updated in situ measurements of pentad mean SSS from NCEI/NODC
    - Level 2 SSS retrievals from SMOS and SMAP gridded into daily mean fields on 1^{o}lat/lon grid
    - Bias correction for raw satellite retrievals through PDF matching against in situ measurements
    - Blending in situ measurements with bias corrected satellite retrievals with an OI technique
    - Final products: An analysis of pentad mean SSS on 1^{o}lat/lon grid over the global ocean for a period from January 2015, updated daily at a latency of 2 days;
  - *Evaporation*
    - CFSR evaporation calibrated against OAFlux
  - *Precipitation*
    - Bias corrected CMORPH satellite estimates

Comparison with NODC Analysis

Example for January 26-30, 2018

- NODC analysis defined by interpolating in situ measurements within 770km through a distance-weighting technique
- Overall similar anomaly patterns
- BASS presents more details
- Differences over costal regions and high-latitude oceans

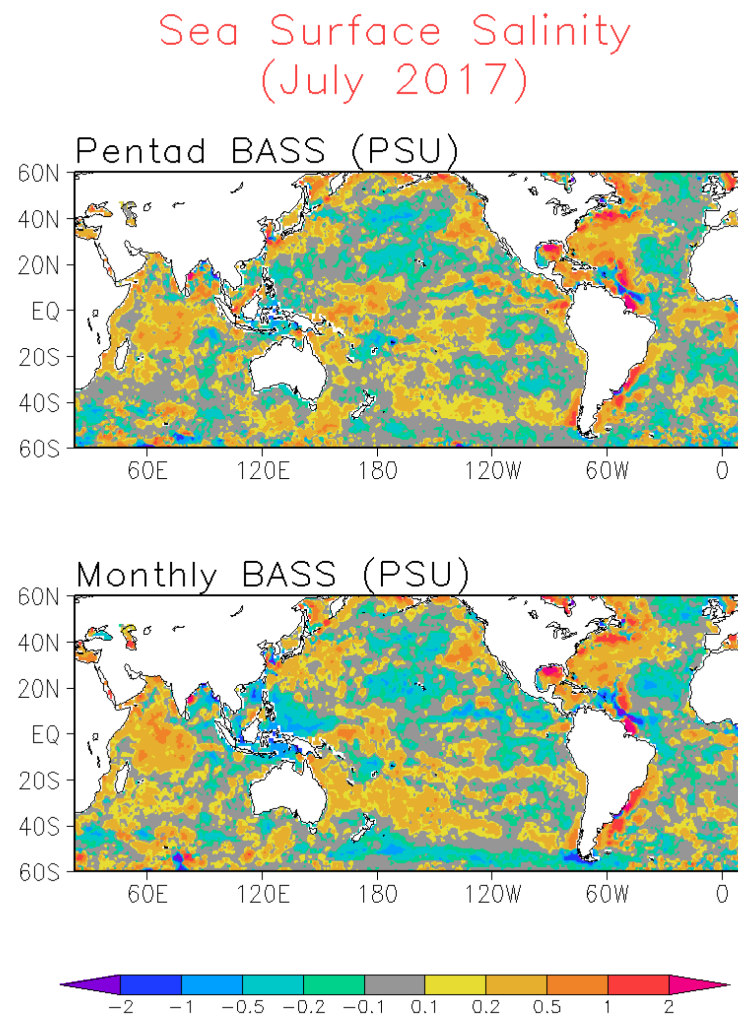




Comparison of monthly and pentad BASS Analyses

Example for January July 2017

- BASS monthly SSS analysis (top) BASS pentad averaged monthly SSS (bottom)
- Overall very similar anomaly patterns
- Agree with each other very well



Pentad Product Example: Hurricane Irma

(8/30/2017 to 9/13/2017)