Prediction of boreal summer monsoon intraseasonal oscillation in CFSv2: Importance of convection parameterizations and realistic SSTs

Arun Kumar[1], Wanqiu Wang[1] , Meng-Pai Hung[2], and Raghu Murtugudde[2]

1. Climate Prediction Center, NCEP/NWS/NOAA
2. ESSIC, University of Maryland

- **Project Title**: Understanding the role of sea surface temperatures in the simulation and prediction of the monsoon intraseasonal oscillation
- **Objectives**
  - Using CFS understand the impact of sea surface temperatures (SSTs) on the prediction of the Monsoon Intraseasonal Oscillation (MISO)
  - To explore MISO predictability through enhanced representation of SSTs in the CFS

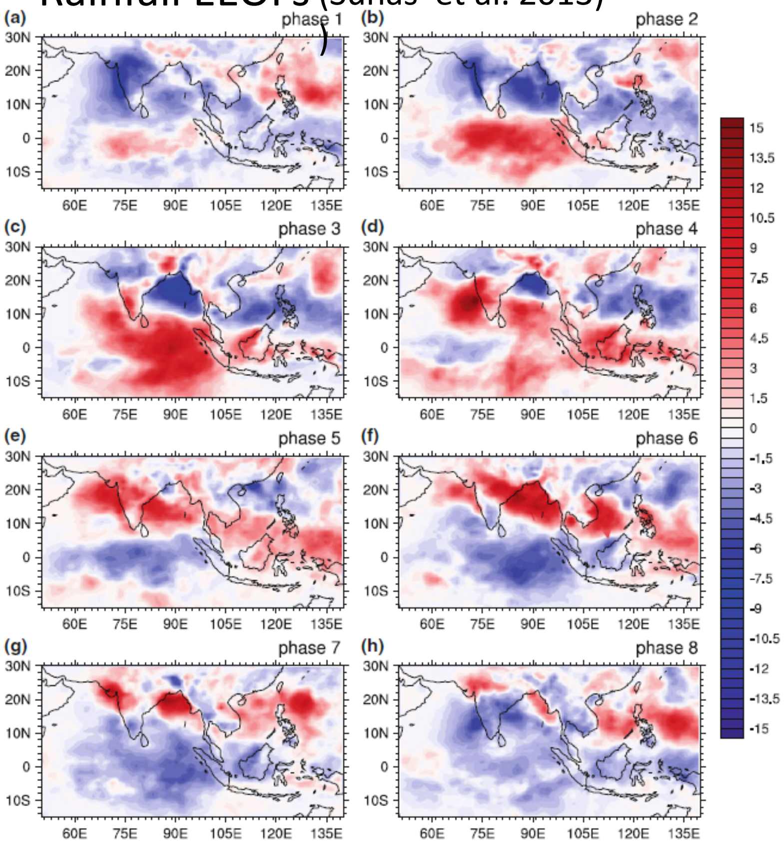
- Progress:
  - Investigated the role of the SST on MISO prediction and its dependence on convection parameterization
  - Started preparing an ocean component with high vertical resolution for improved representation of SSTs

What is MISO?

Different names (e.g., MISO, BSISO)

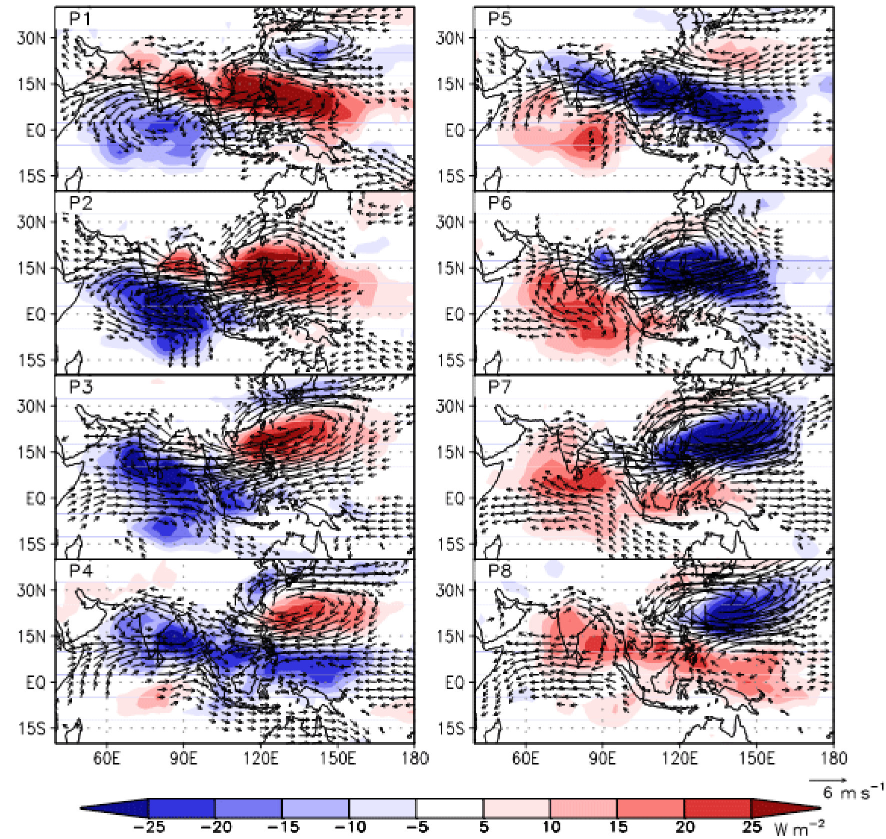
MISO: Boreal summer **M**onsoon **I**ntrasea**S**onal **O**scillation

Rainfall EEOFs (Suhas et al. 2013)



BSISO: **B**oreal **S**ummer **I**ntra**S**easonal **O**scillation

OLR and U850 EOFs (Lee et al. 2013)



- Propagates northward
- Modulates intraseasonal variability over South-East Asia

How is MISO developed and how to improve its prediction?

1. **Internal atmospheric dynamics**
   Wang and Xie (1997)
   Lawrence and Webster (2002)
   Jiang et al. (2004)

2. **Air-sea interaction**
   Krishnamurit et al. (1988)
   Permkumar et al. (2000)
   Kemball-Cook and Wang (2001)
   Sengupta and Ravichandran (2001)
   Fu and Wang (2004)
   Roxy and Tanimoto (2007)
   Wang et al. (2009)
   Sharmila et al. (2013)
   Roxy (2014)

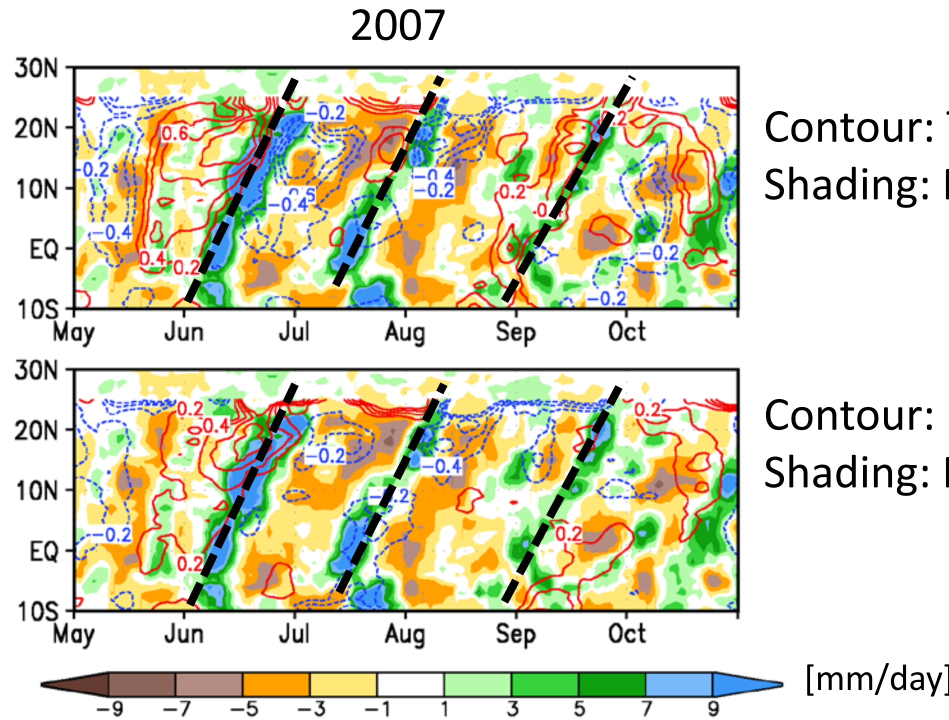
If air-sea interaction is important, accurate simulation of SSTs is also required for models to predict MISO/BSISO. How critical is the presence of accurate SSTs in the prediction?

Evolution of 2007 summer SST and Precip anomalies (65° -95°E average)

TMI: Tropical Rainfall Measuring Mission's (TRMM) Microwave Imager

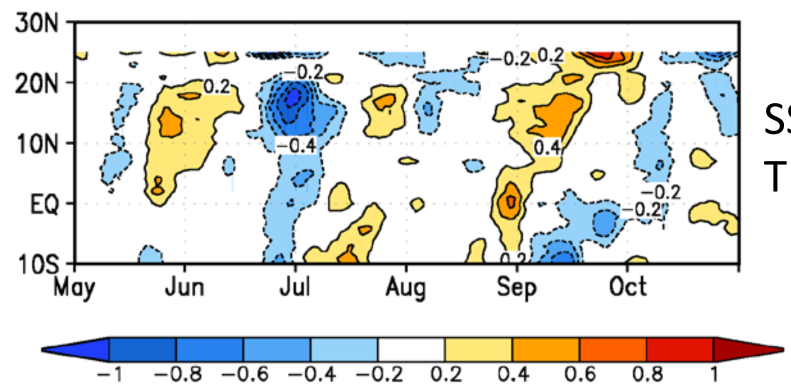
NCDC: National Climate Data Center

- Coherent SST associated with northward propagating precipitation
- SST leads precipitation by 5-15 days
- Large differences between TMI than NCDC



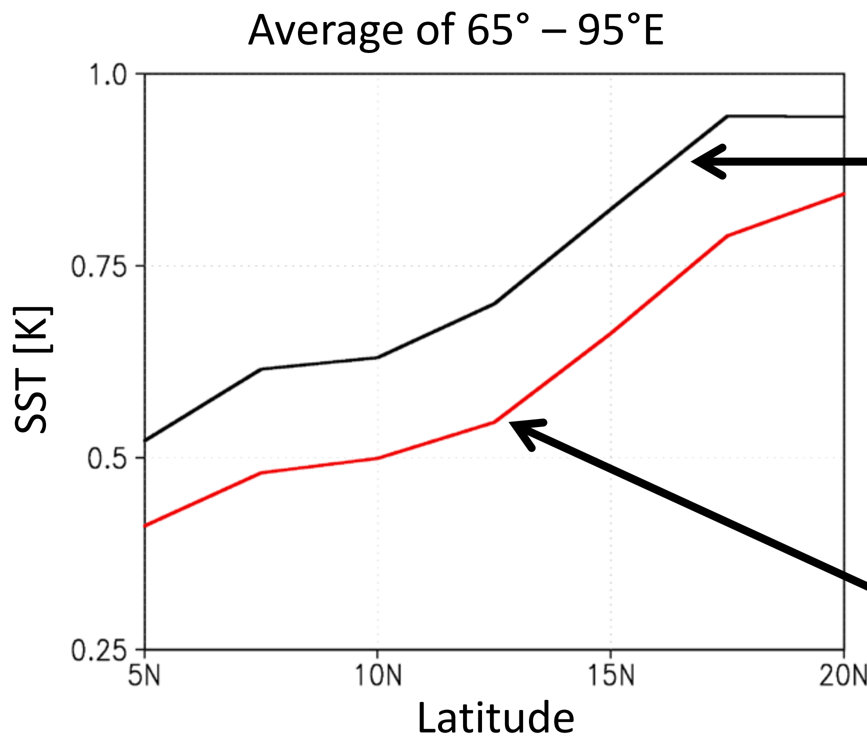
Contour: TMI SST
Shading: Precip

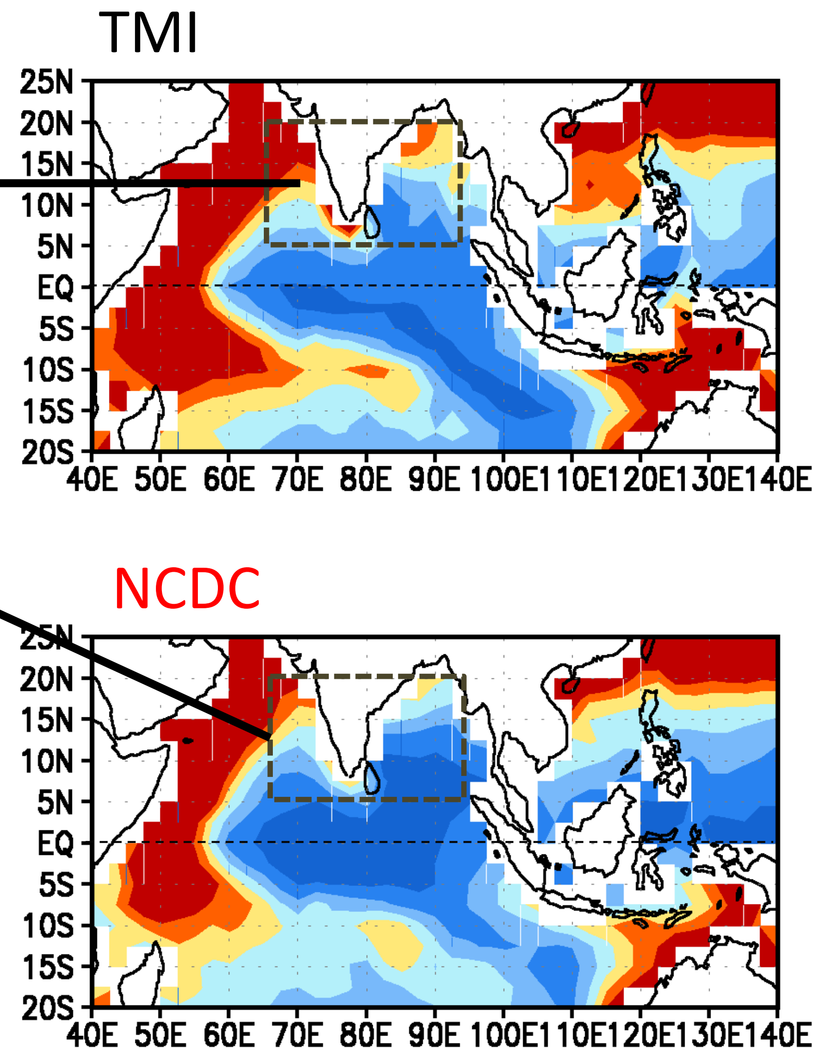
Contour: NCDC SST
Shading: Precip



SST differences (K): TMI-NCDC

Standard Deviation of daily SST (K) in JJAS 1999-2012





- TMI SST anomalies are stronger than NCDC.
- Is such an observational SST uncertainty sufficient to cause the significant differences if they are used to force atmospheric models?

Issues to address

- How important are accurate SSTs in the simulation and prediction of MISO?

- If SSTs are important, do their impacts depend on model physics?

Approach

To Understand the role of SSTs and its dependence on model physics, experiments are carried out with

- Different SSTs
- Different convection schemes

Forecast experiments

1. Model
   - Atmosphere-only GFS
   - T126/L64

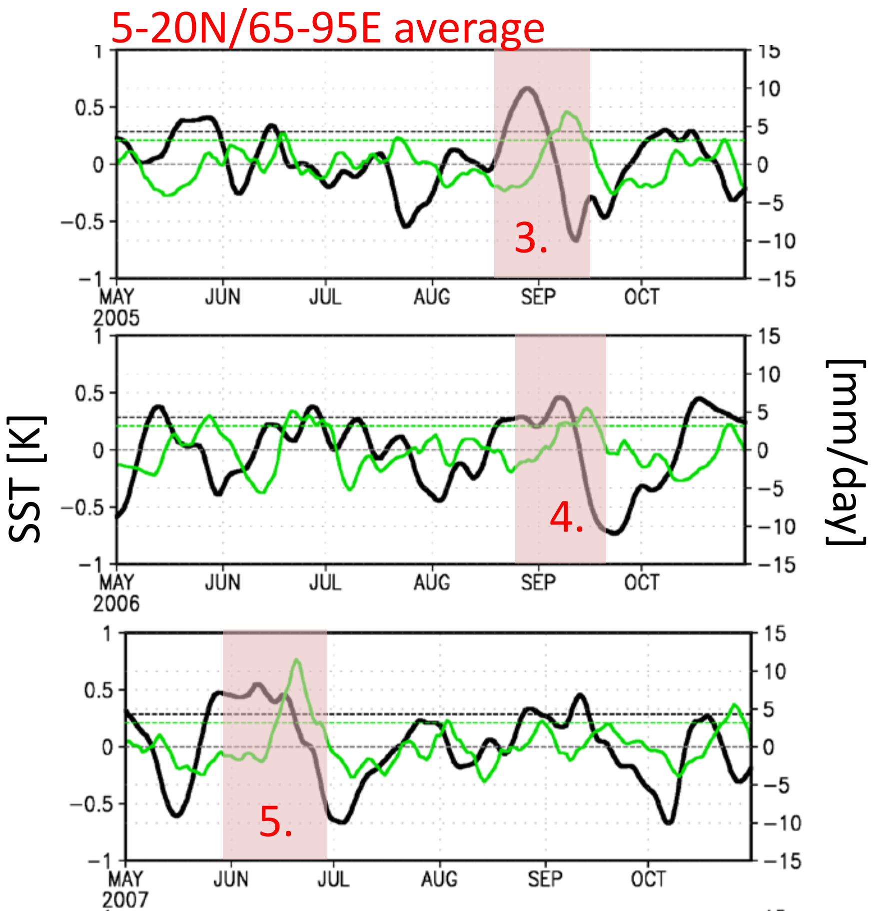
2. Daily SSTs:
   - TMI (TRMM Microwave Imager)
   - NCDC (National Climate Data Center)
   - Clim (TMI and NCDC 1998-2014)

3. Convection parameterizations
   - SAS (Simplified Arakawa Schubert, Pan & Wu 1995), *currently in Operational CFS*
   - SAS2 (Revised SAS, Han & Pan 2011), *currently in Operational GFS*
   - RAS (Relaxed Arakawa Schubert, Moorthi & Suarez 1999)

4. Forecast runs:
   - Experiments for 7 MISO cases
   - Each forecast covers 31 target days
   - Initial conditions: CFSR

Seven MISO cases for CFS experiments

Selection of the cases: i) Strong rainfall anomalies; ii) Associated with strong SST anomalies.

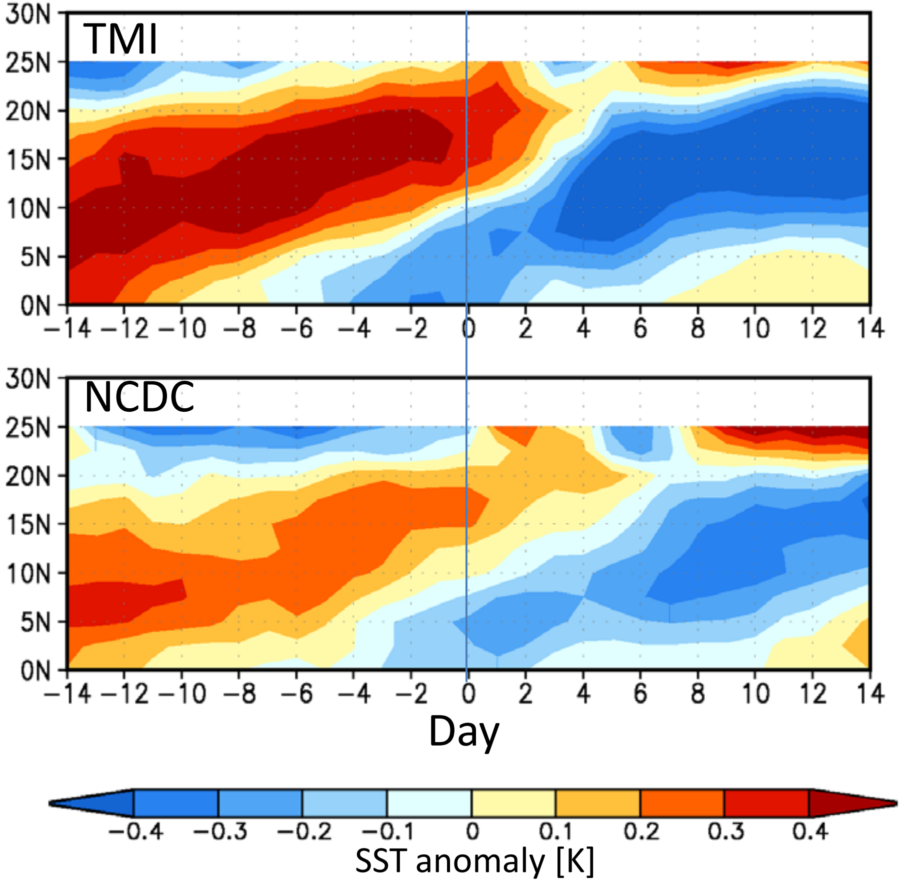


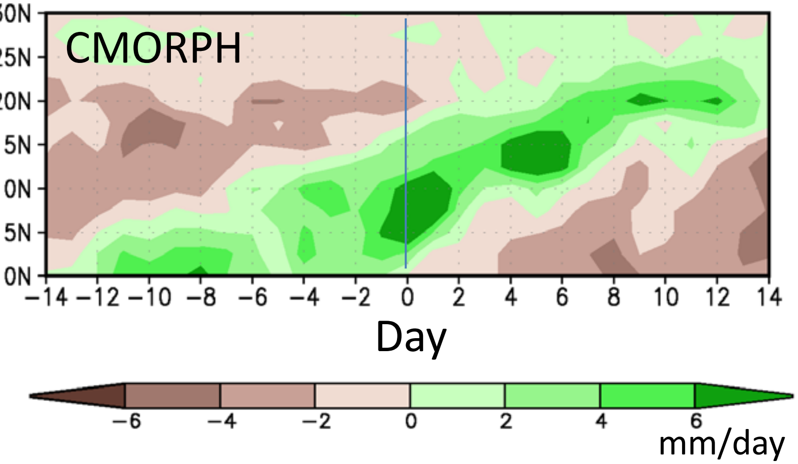
Case	Strong SST (Pr+SST)
1	Sep 9 – Oct 10, 2001
2	Jul 13 – Aug 12, 2004
3	Aug 20 – Sep 19, 2005
4	Aug 24 – Sep 23, 2006
5	Jun 6 – Jul 6, 2007
6	Oct 4 – Nov 3, 2008
7	Jun 20 – July 20, 2009

For each case, forecasts from 31 initial dates (day -15 to day 15) surrounding day 0 when rainfall maxima of the 5° -10°N/65°-95°E average occurs.

65°-95°E average SST, prate and OLR anomalies in 7 strong SST cases

Strong rainfall with SST peak – Seven case average

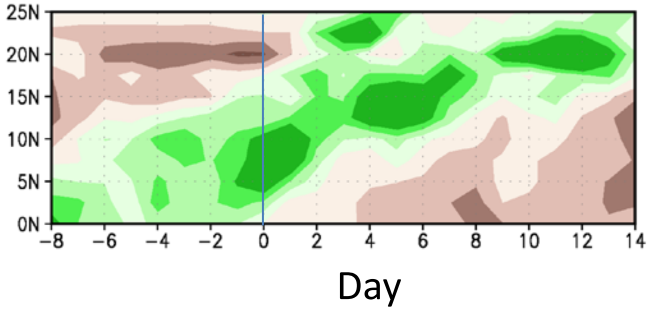


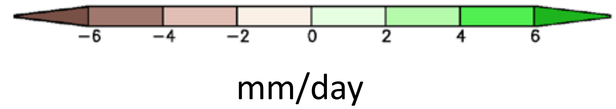


Day 0 is when average rainfall over 5°-10°N/65°-95°E reaches maximum

Composite rainfall anomalies (shaded) and SST (contour) averaged between 65°-95°E

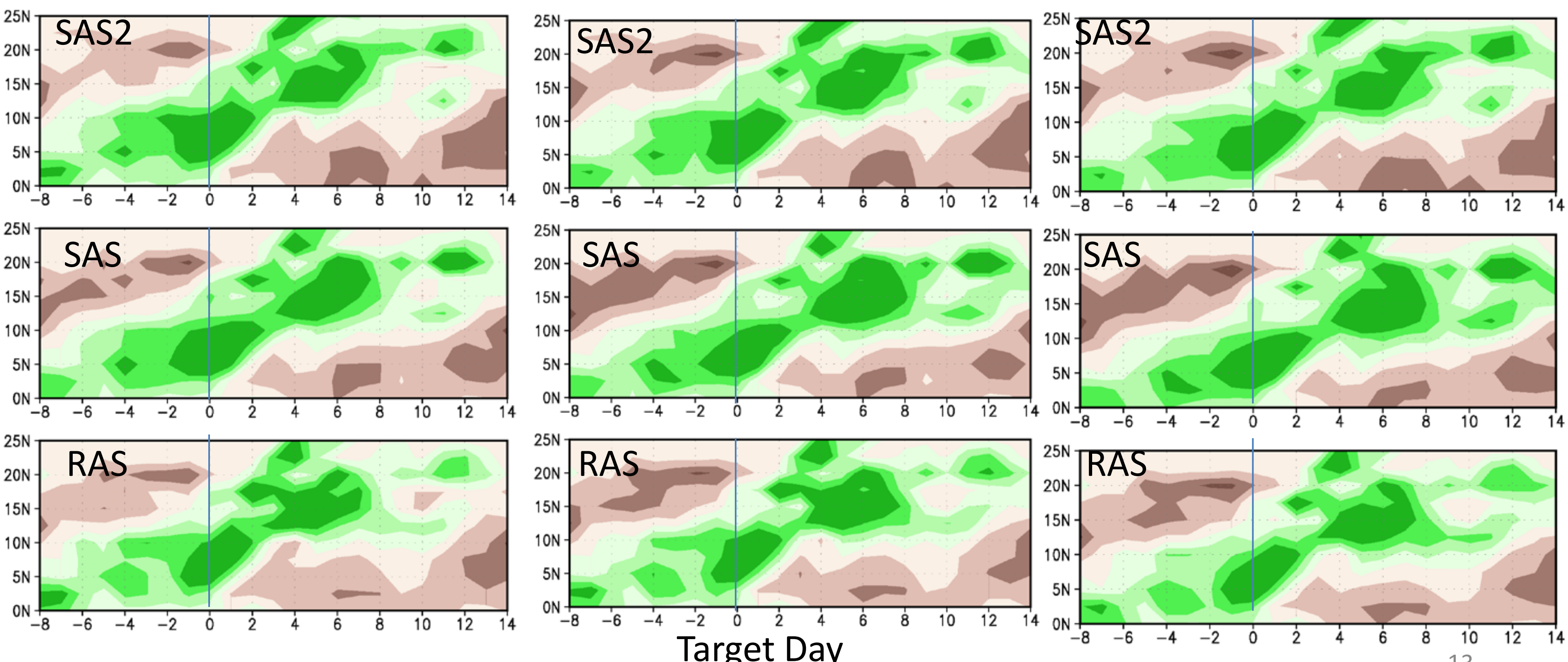
Cmorph





Forecast at 1-day lead

TMI SST | NCDC SST | Clm SST



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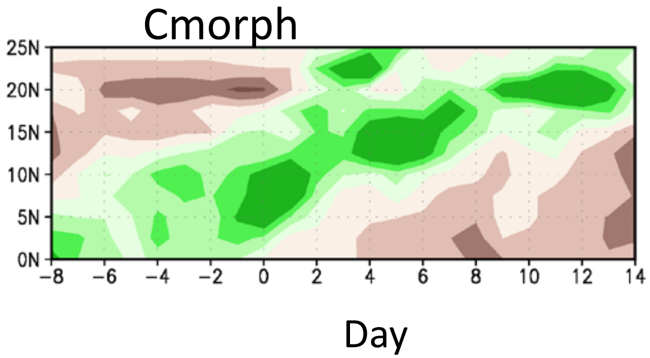
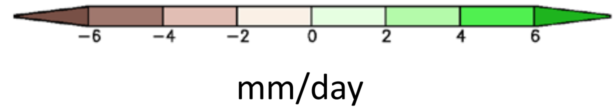
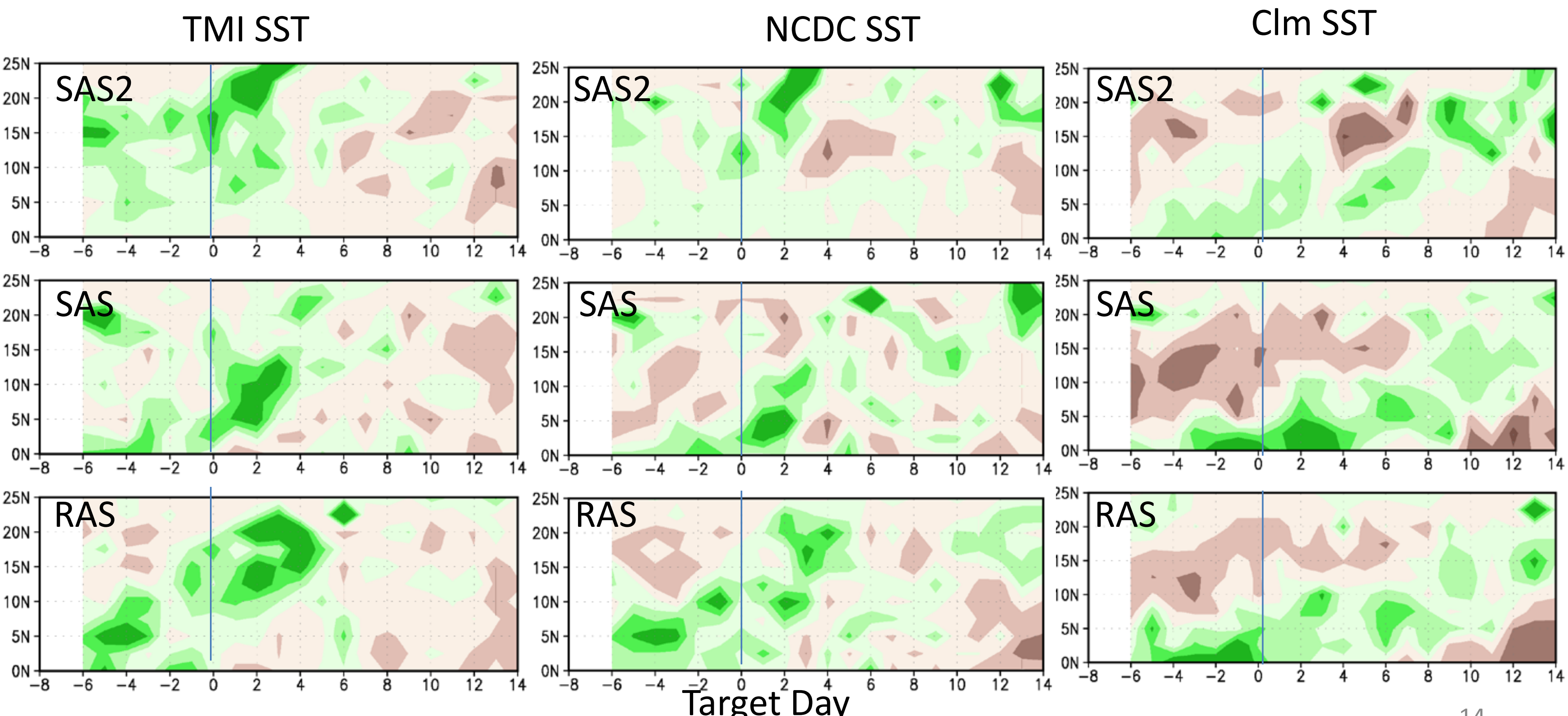
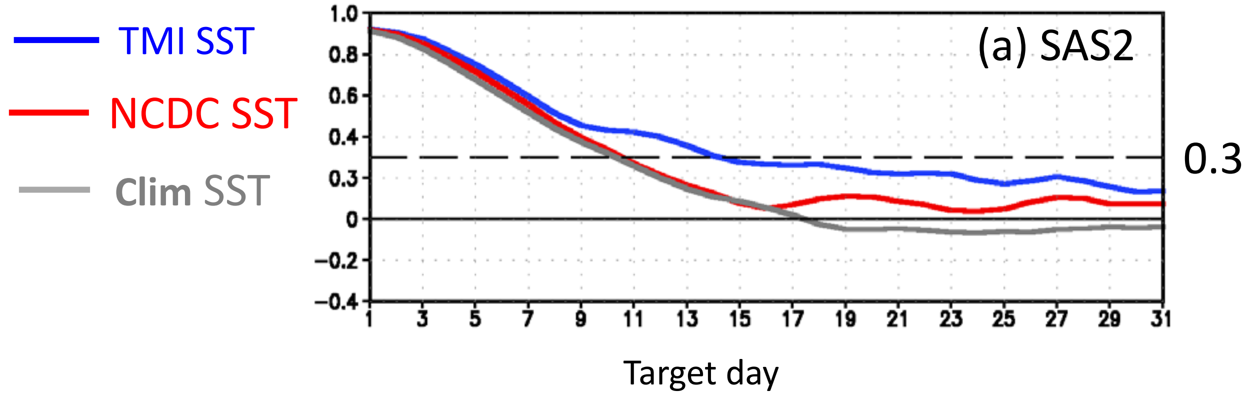




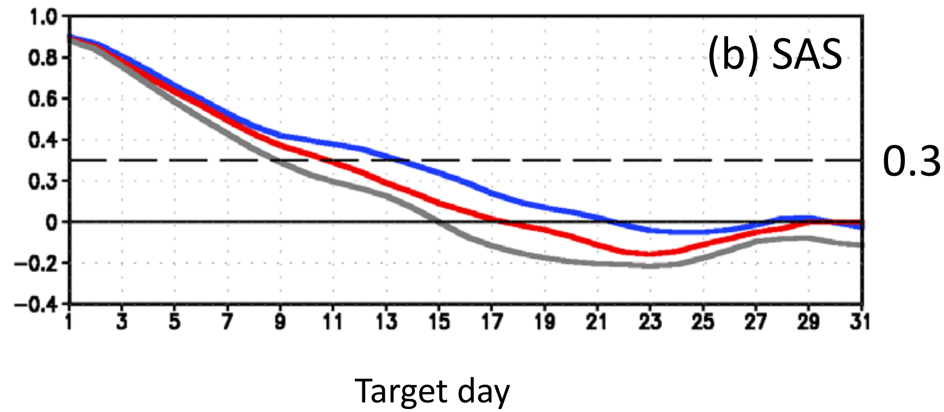
Forecast at 10-day lead



Correlation of BSISO index (Lee et al. 2013) between observation and models

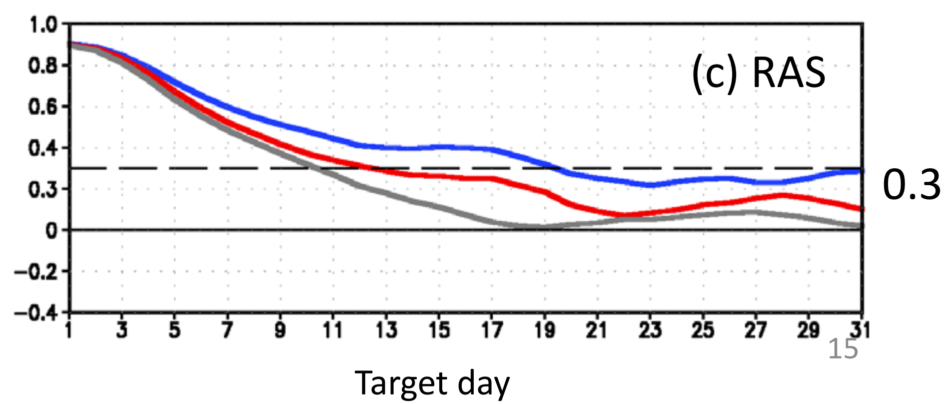


1. Compared to the use of Clm SST, TMI SST results larger improvement than NCDC
2. TMI SST with RAS scheme has better skill than SAS and SAS2.



The days that the skill remains above 0.3

	TMI	NCDC	Clm
SAS2	14	10	10
SAS	13	11	9
RAS	19	12	10



Conclusions

1. Accurate SSTs are important for the prediction of MISO. This indicates the need of atmosphere-ocean models for MISO prediction and the need of improved modeling of upper ocean with enhanced vertical resolution and physical parameterizations.

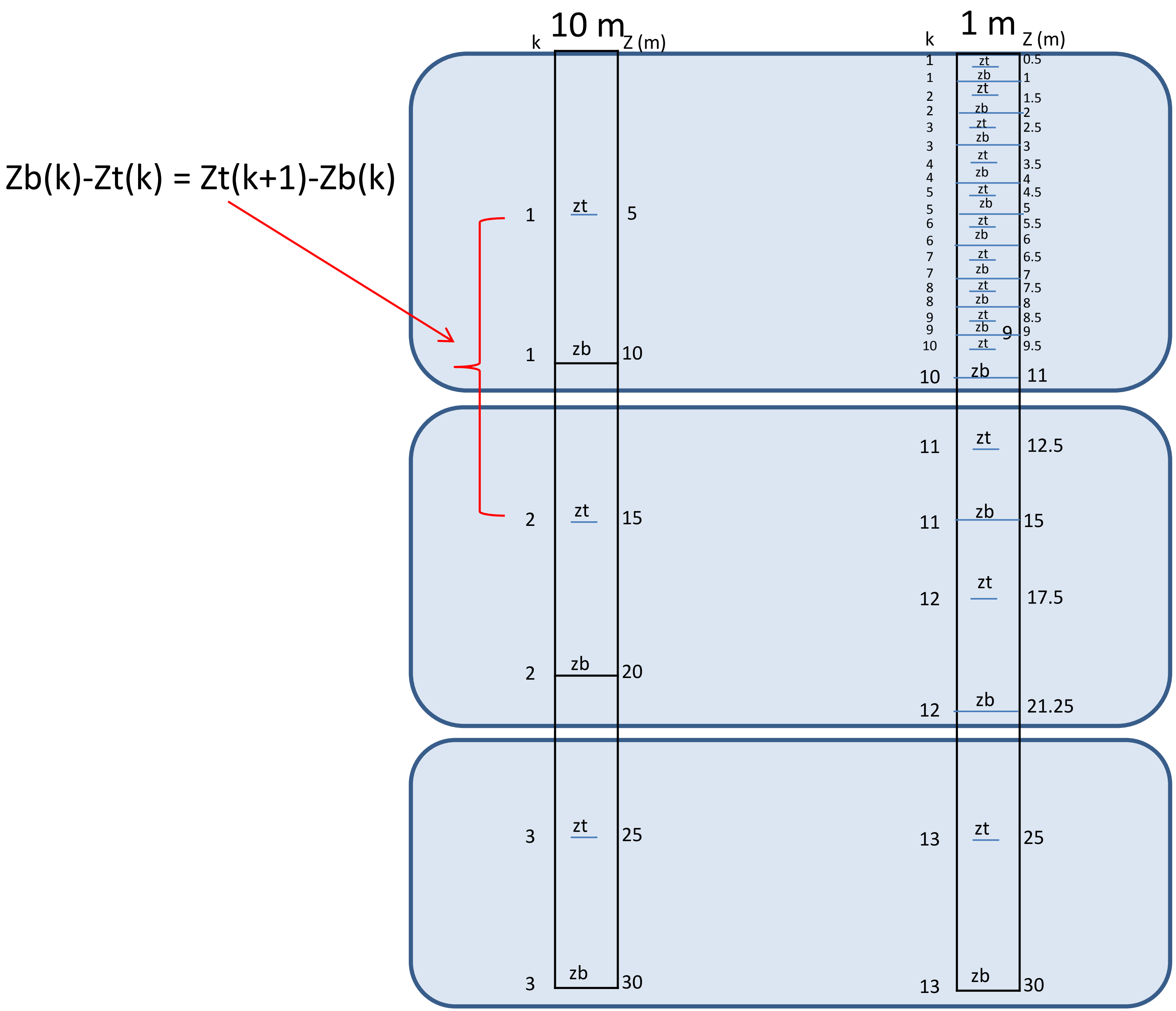
2. The impact of SSTs also depend on model physics. Among the convection schemes tested, RAS has better performance in capturing the observed rainfall variability.

Future work

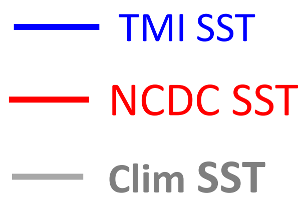
1. Investigate mechanisms causing differences among convection schemes.
   (a) Evolution of specific humidity associated with SSTs
   (b) Differences in moistening/drying among convection schemes

2. Investigate impact of simulated SSTs using coupled atmosphere-ocean models
   (a) Test impact of vertical resolution on MISO prediction in with coupled CFS

MOM Vertical levels/layers



Correlation of 5°-20°N/65°-95°E Prate between observation and models



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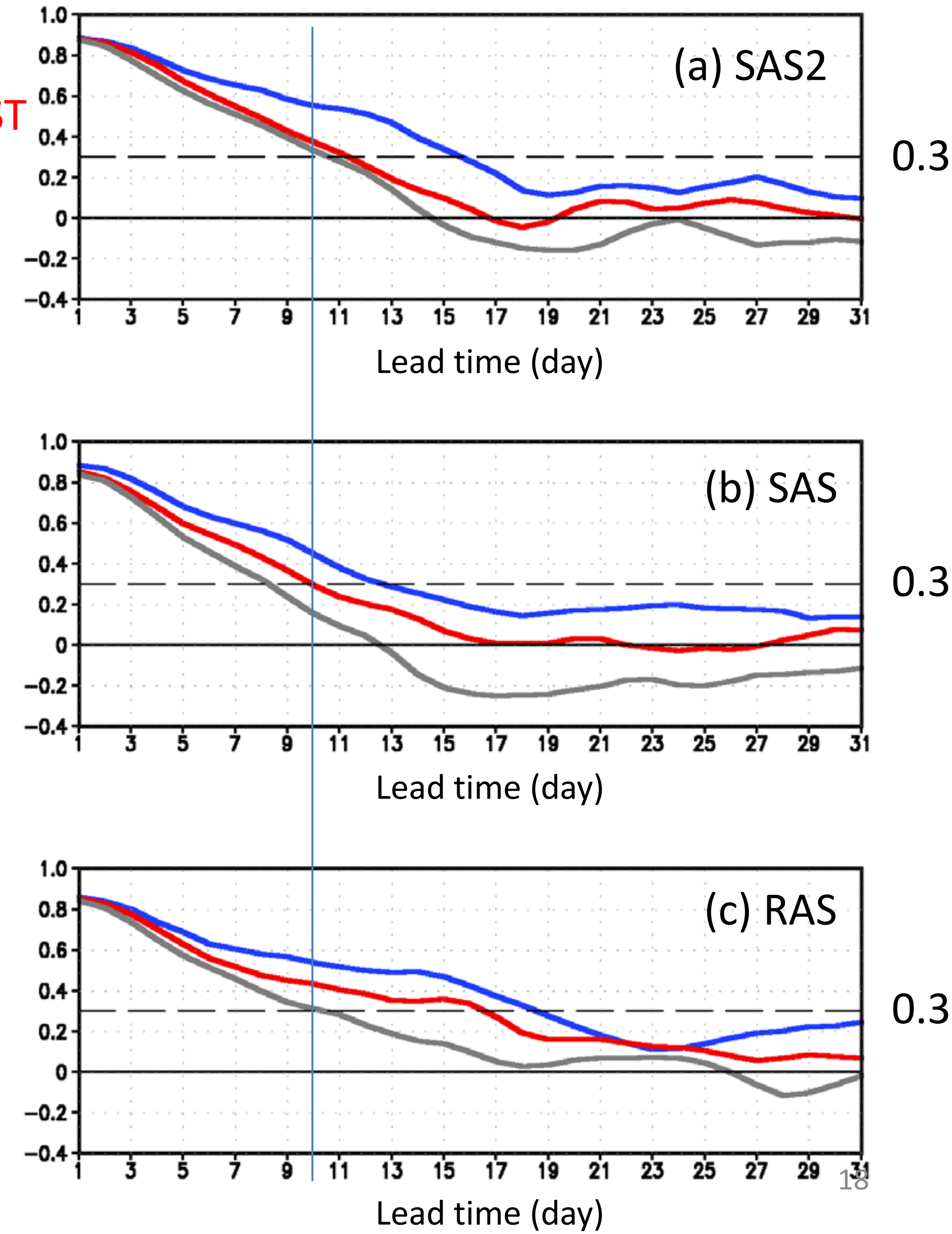

The days that the skill remains above 0.3

	TMI	NCDC	Clm
SAS2	16	11	11
SAS	13	10	8
RAS	**19**	16	10