US-Korea Workshop on Dynamical Seasonal Prediction, APCC, 22-25 June 2010

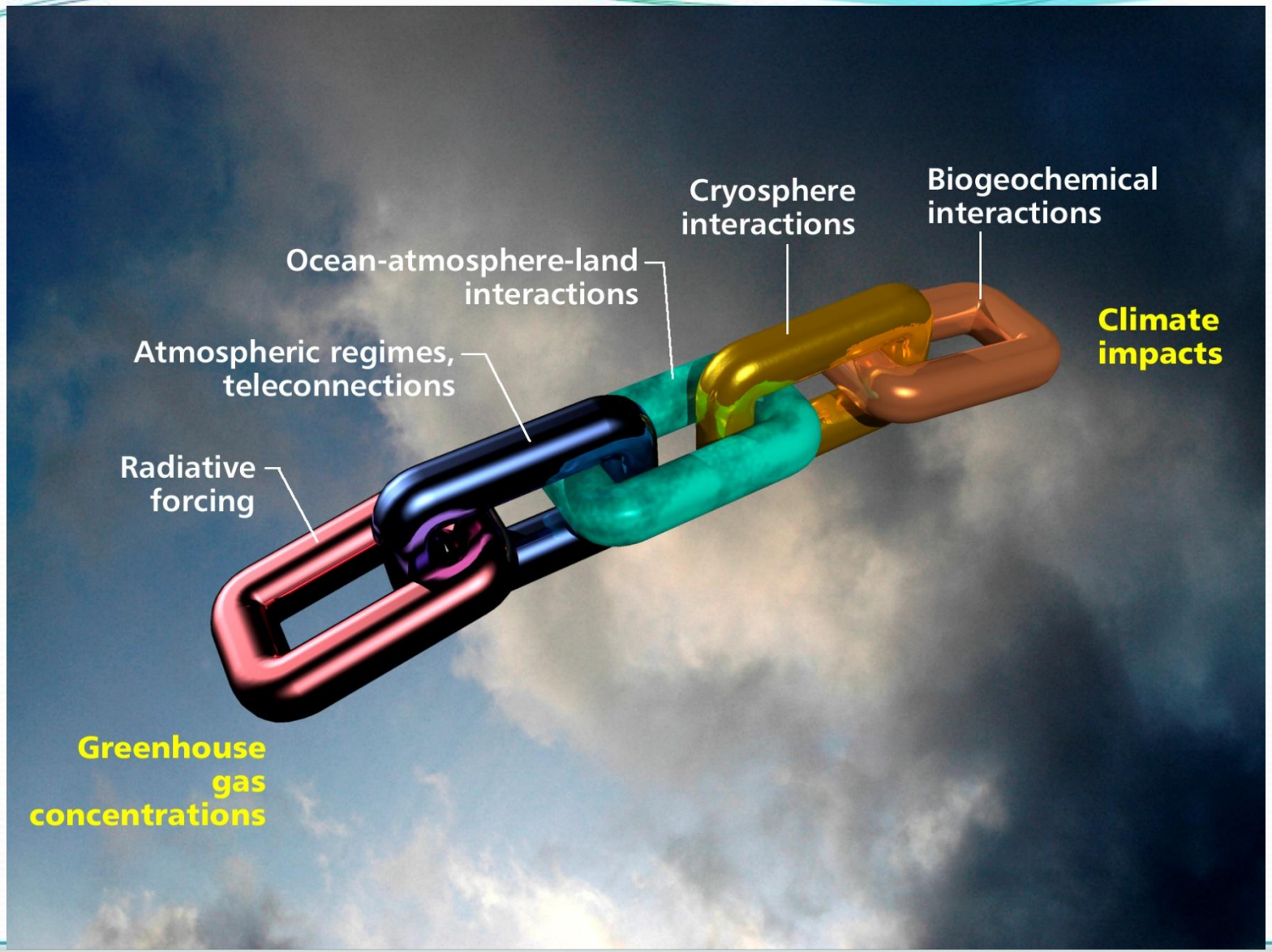
INTRASEASONAL TO SEASONAL PREDICTABILITY OF MONSOON OF HIGH-RESOLUTION MODELS

Emilia K. Jin

Department of Atmospheric, Oceanic, and Earth Sciences
George Mason University (GMU)
Center for Ocean-Land-Atmosphere Studies (COLA)

James Kinter, Deepthi Achuthavarier and Project Athena Team

Seamless Prediction



Toward Seamless Prediction: Calibration of Climate Change Projections Using Seasonal Forecasts (Tim Palmer, 2008, BARMS)

Objectives

Considerably improved prediction of the changes in the statistics of regional weather and climate variations, especially of extreme events and high-impact weather, are required to assess the impacts of climate change and variations, and to develop adaptive strategies to ameliorate their effects on water resources, food security, energy, transport, coastal integrity, environment and health (*World Modeling Summit Declaration, 2008*).

Resolution: Can increasing weather and climate model resolution to accurately resolve mesoscale phenomena dramatically improve the fidelity of the models in simulating the mean climate and the distribution of variances and covariances of climate?

Process-resolving: Can explicitly resolving important processes in the atmosphere without parameterization even further improve the fidelity of the models, especially in describing the regional structure of weather and climate?

Computational Resource

- **Dedicated supercomputer** at NICS for Oct'09 – Mar'10
  - **Athena**: Cray XT4 - 4512 quad-core Opteron nodes (18048)
    #30 on Top500 list (November 2009) – dedicated Oct'09 – Mar'10
  - **Kraken**: Cray XT5 - 8256 dual hex-core Opteron nodes (99072)
    #3 on Top500 list (November 2009) – allocation of 5M SUs

Athena 166 TeraFlops Cray XT4

4512 nodes
@ 4 cores,
2 GB mem

Dedicated High-End Computing System

Kraken 1.03 PetaFlops Cray XT5

8256 nodes
@ 12 cores,
16 GB mem

Allocated

Models

Name	Model	Dynamics	Physics	Boundary Condition
NICAM	JAMSTEC Nonhydrostatic Icosahedral Atmospheric Model	Fully compressible non-hydrostatic system	Mass and total energy conservation, Cloud microphysics (Grabowski, 1998)	SST specified & slab ocean
ECMWF IFS	ECMWF Integrated Forecast System	Spectral model	Hydrostatic, Mass flux convection scheme	SST specified

Experimental Design

	Resolution	Grid Size	Time Period	Duration	# of Cases
NICAM	GL10	7 km	21 May – 31 Aug 2001-2009 (except 2003)	103 days	8
ECMWF IFS	T2047	10 km	21 May – 31 Aug 2001-2009	103 days	9
	T1279	15 km	1 Nov – 30 Nov 1960-2007	13 months	48
	T511	39 km			
	T159	125 km			

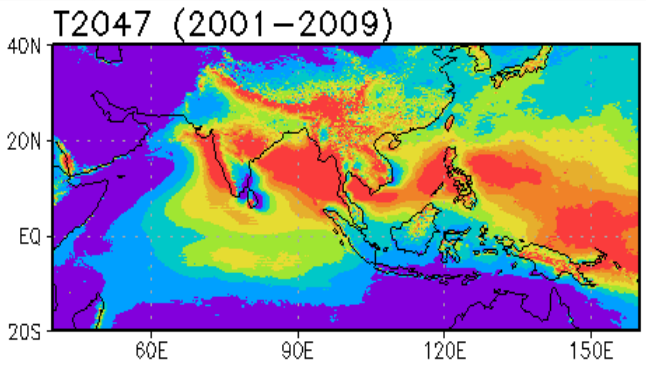
For more detailed information, Prof. Kinter's Presentation on Wednesday (23 June), 1:30 pm

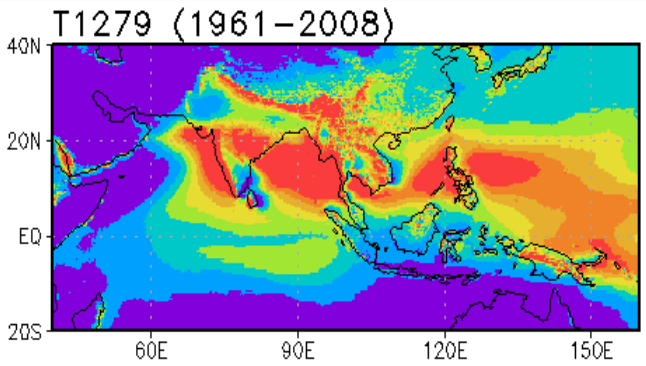
Climatology of JJA Precipitation

Starting from 21 May

Starting from 1 Nov

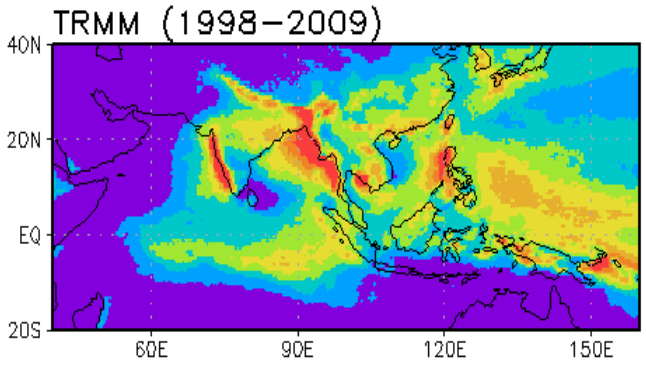
IFS T12047 10 km

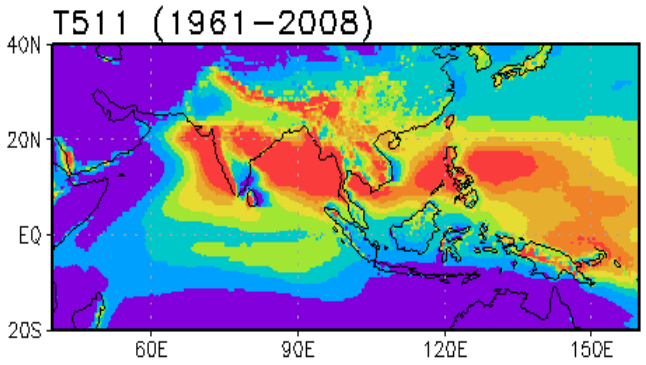




IFS T1279 15 km

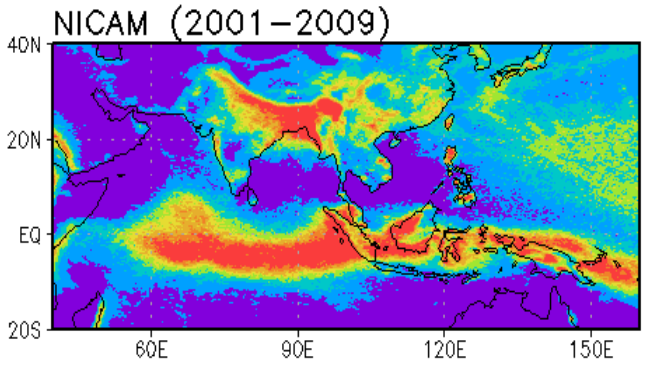
TRMM 25km

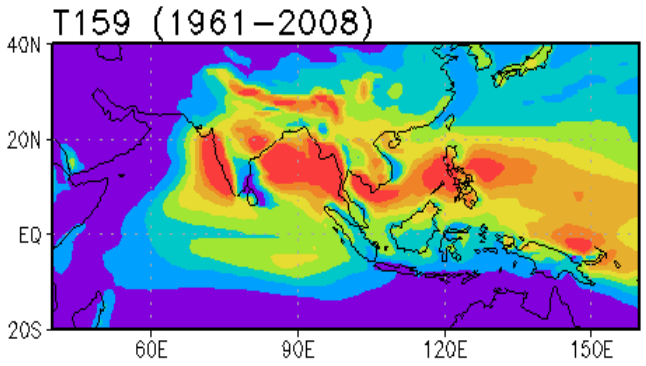




IFS T1511 39km

NICAM 7 km





IFS T1159 125 km

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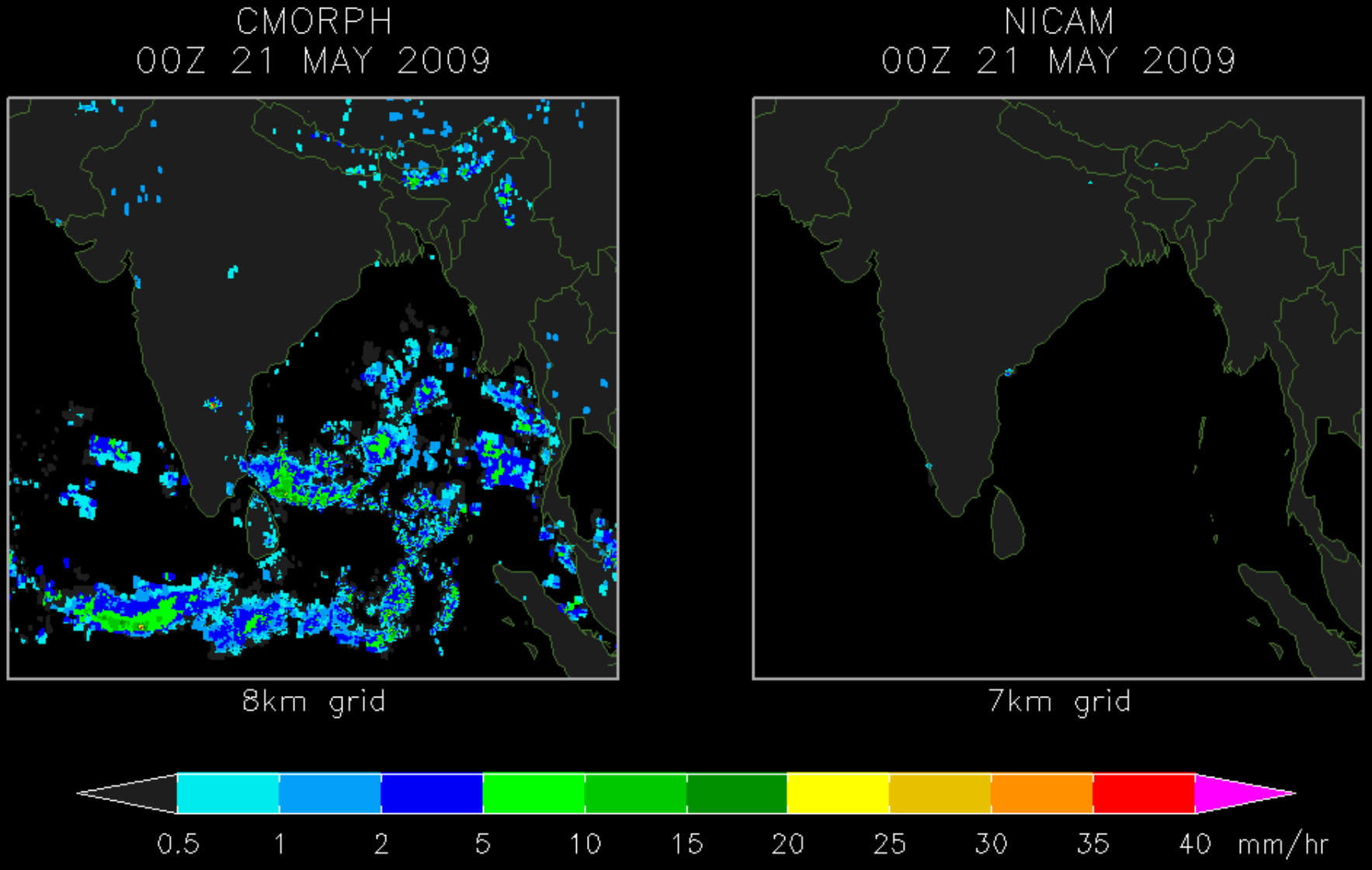
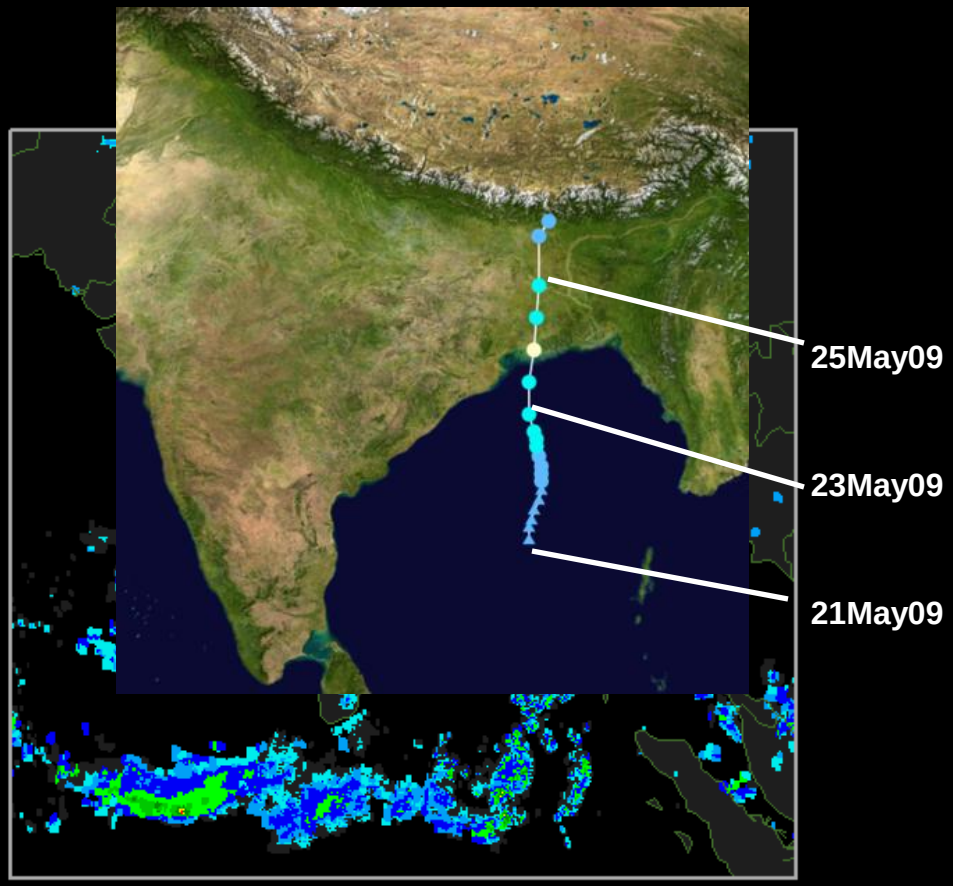
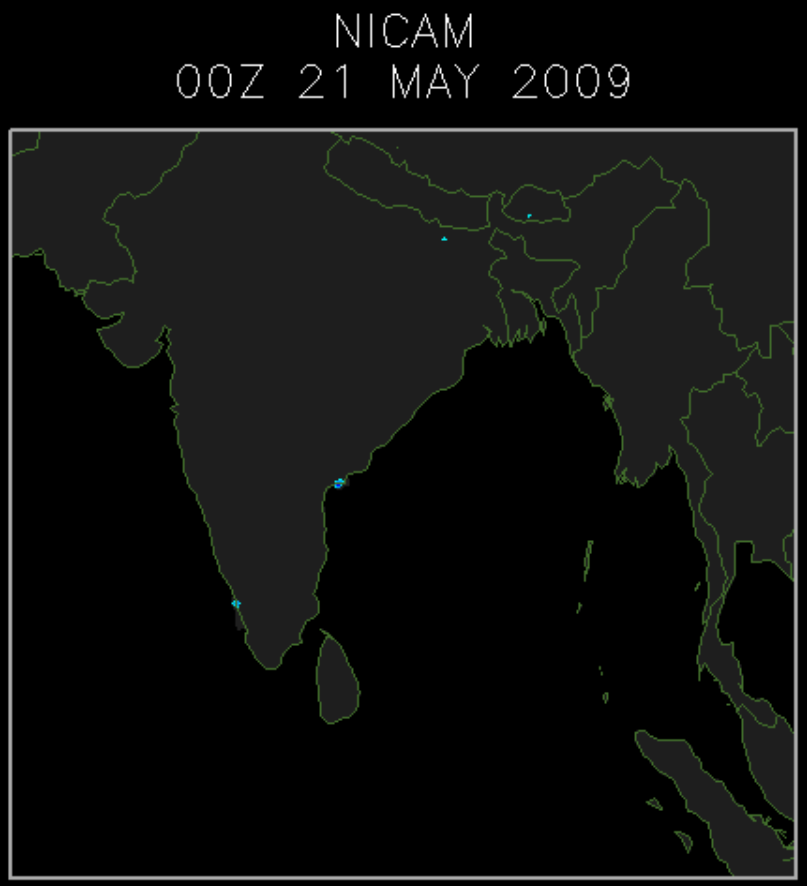
Tropical Cyclone Alia (May 2009)



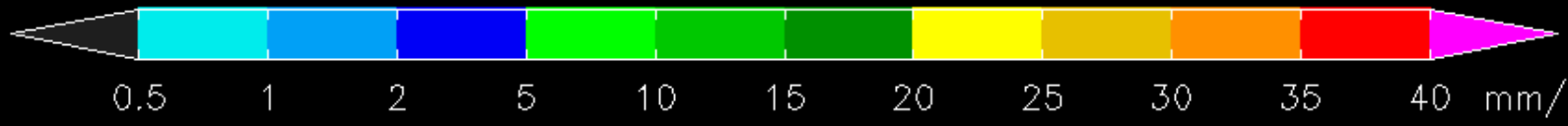
Tropical Cyclone Alia (May 2009)



8km grid

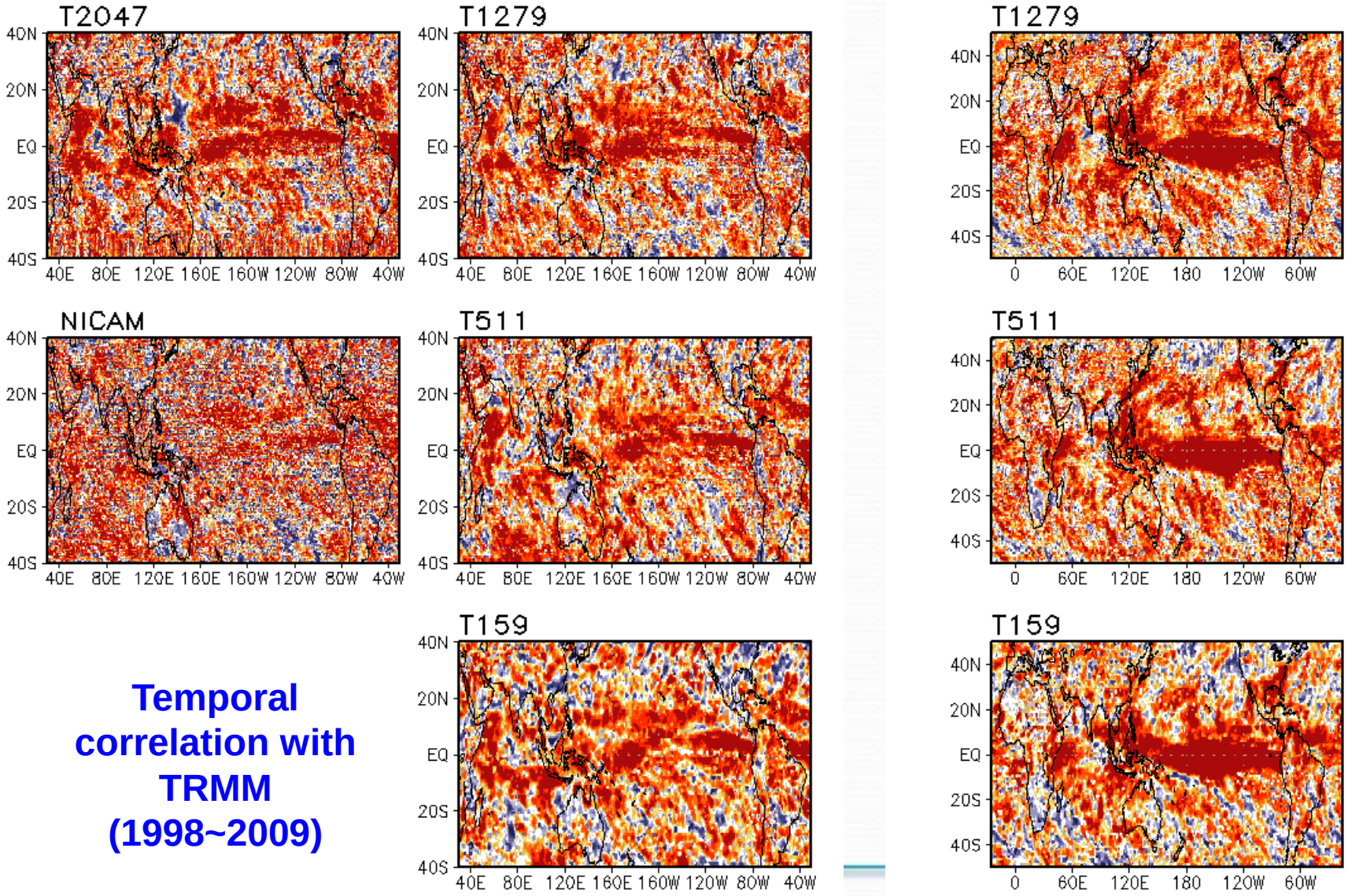


7km grid



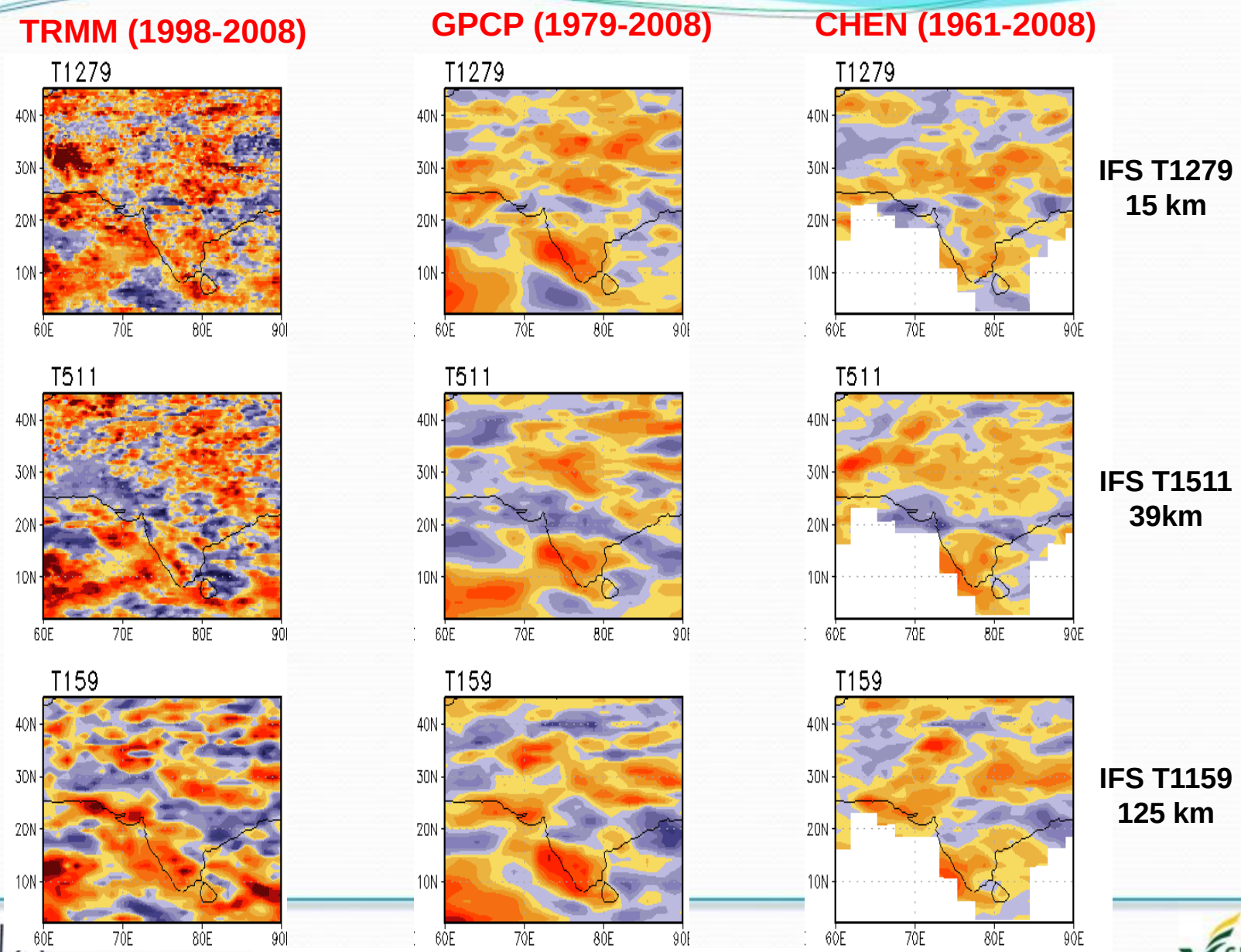
Forecast Skill of Precipitation Anomalies

JJA **DJF**

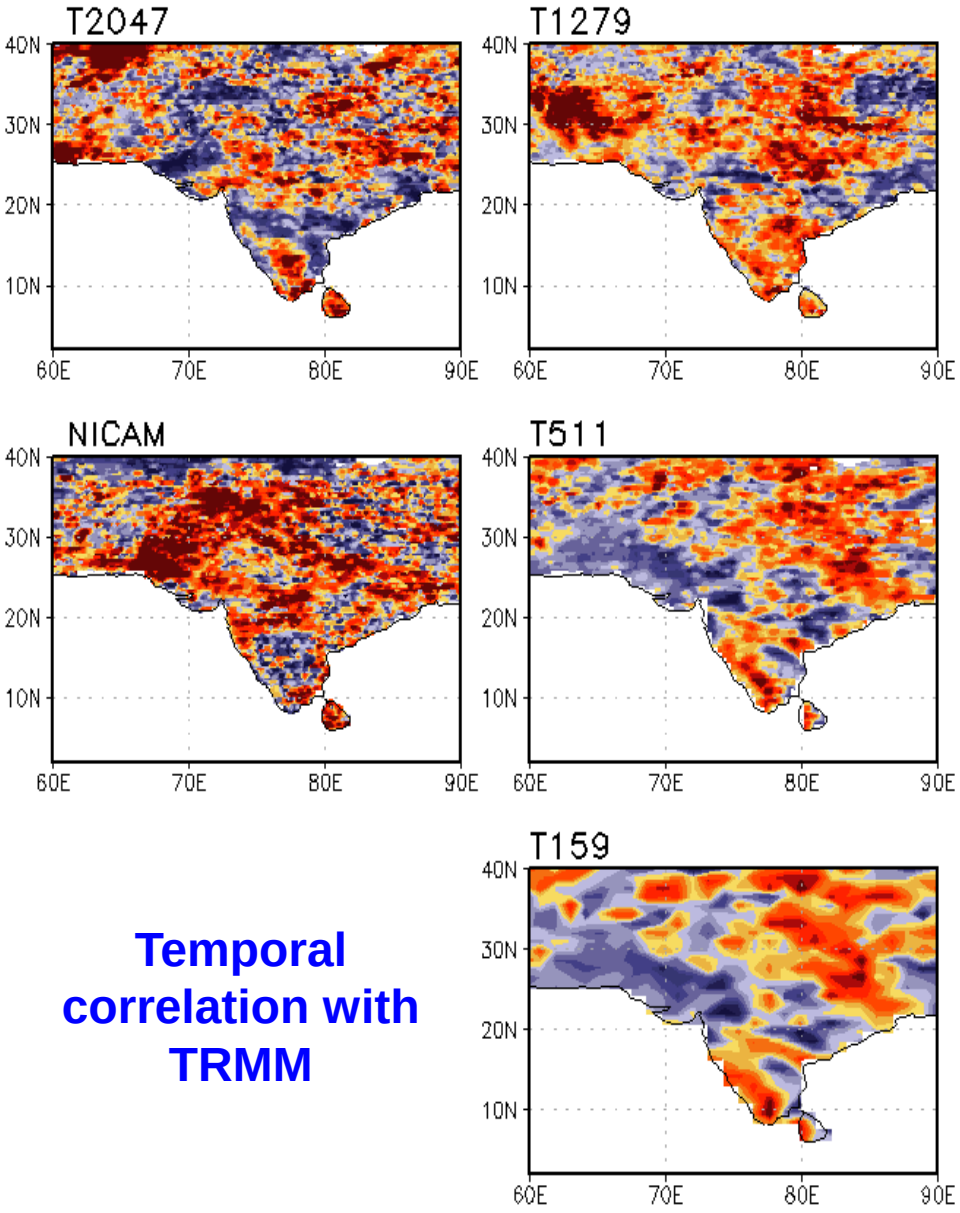


Temporal correlation with TRMM (1998~2009)

Forecast Skill of JJA Precipitation Anomalies over India

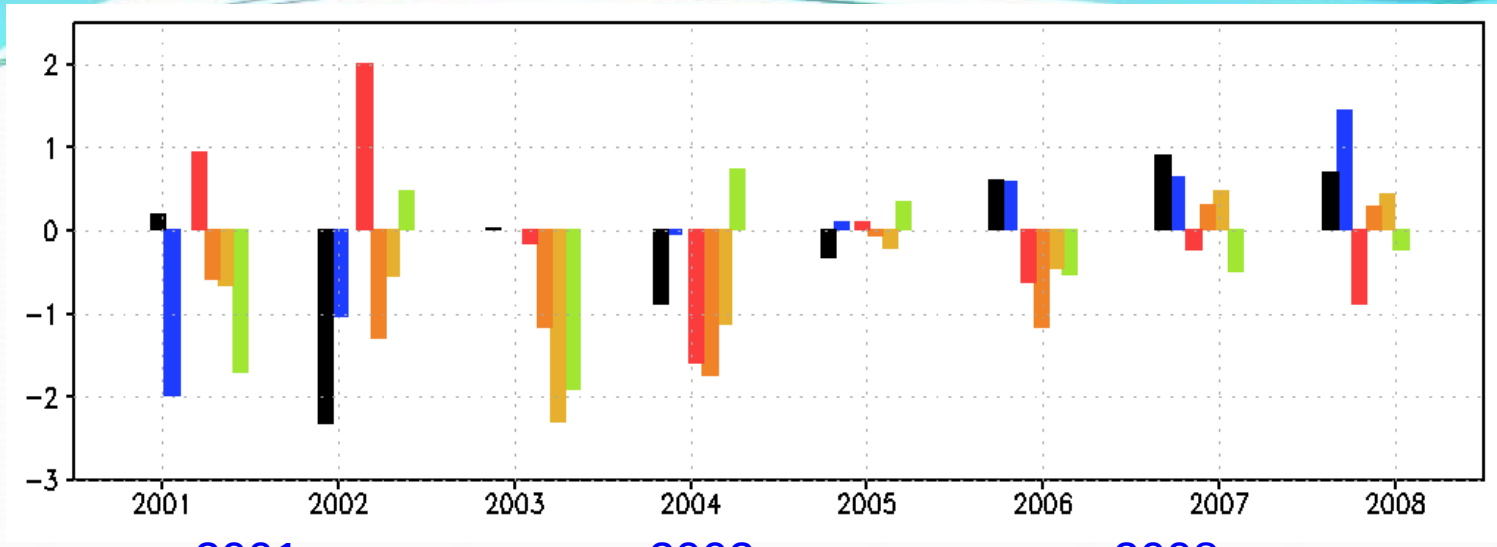


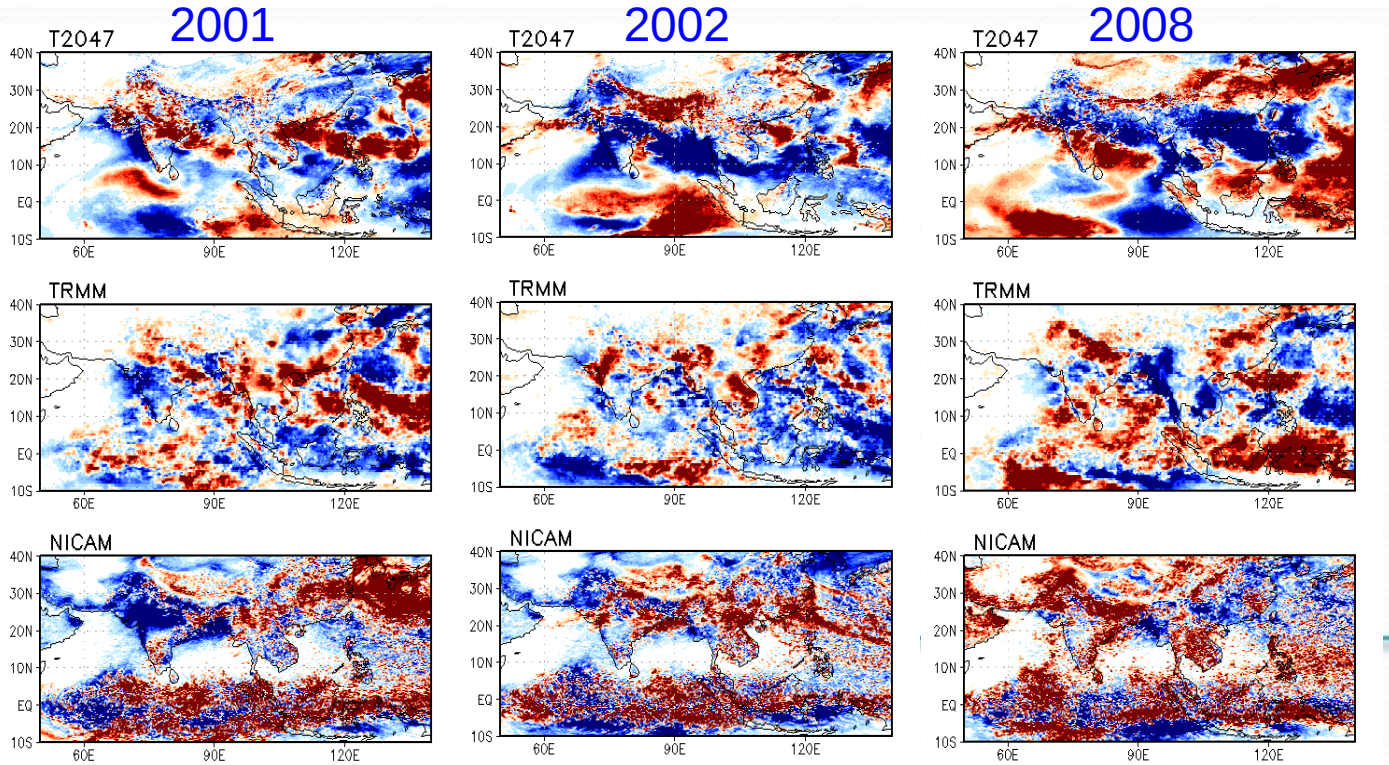
Forecast Skill of JJA Precipitation Anomalies over India



Temporal correlation with TRMM

JJA Indian Monsoon Rainfall Index for 2001-2008





IFS 10 km

TRMM 25 km

NICAM 7 km

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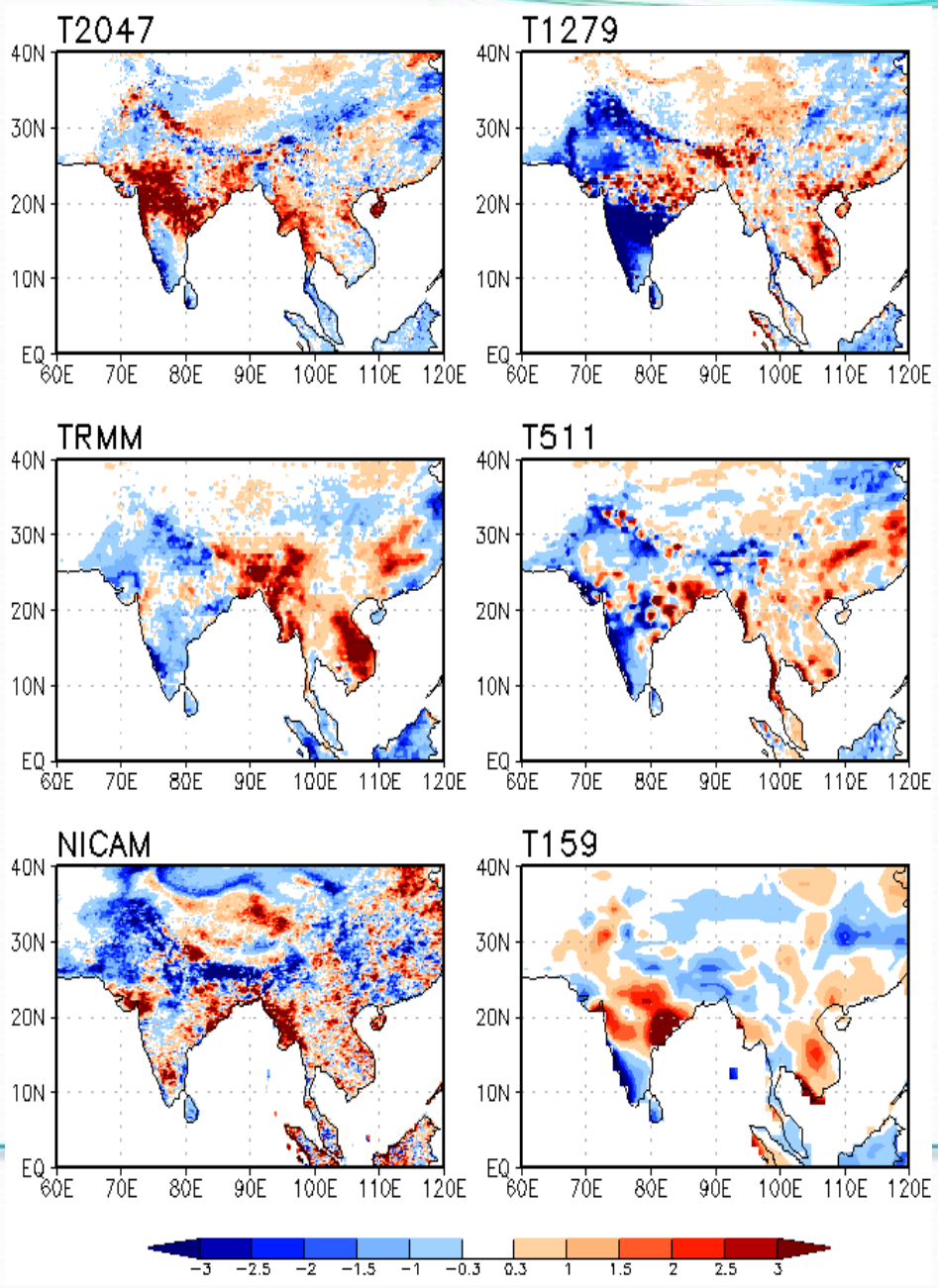
Composite of Negative IMR JJA Precipitation Anomalies

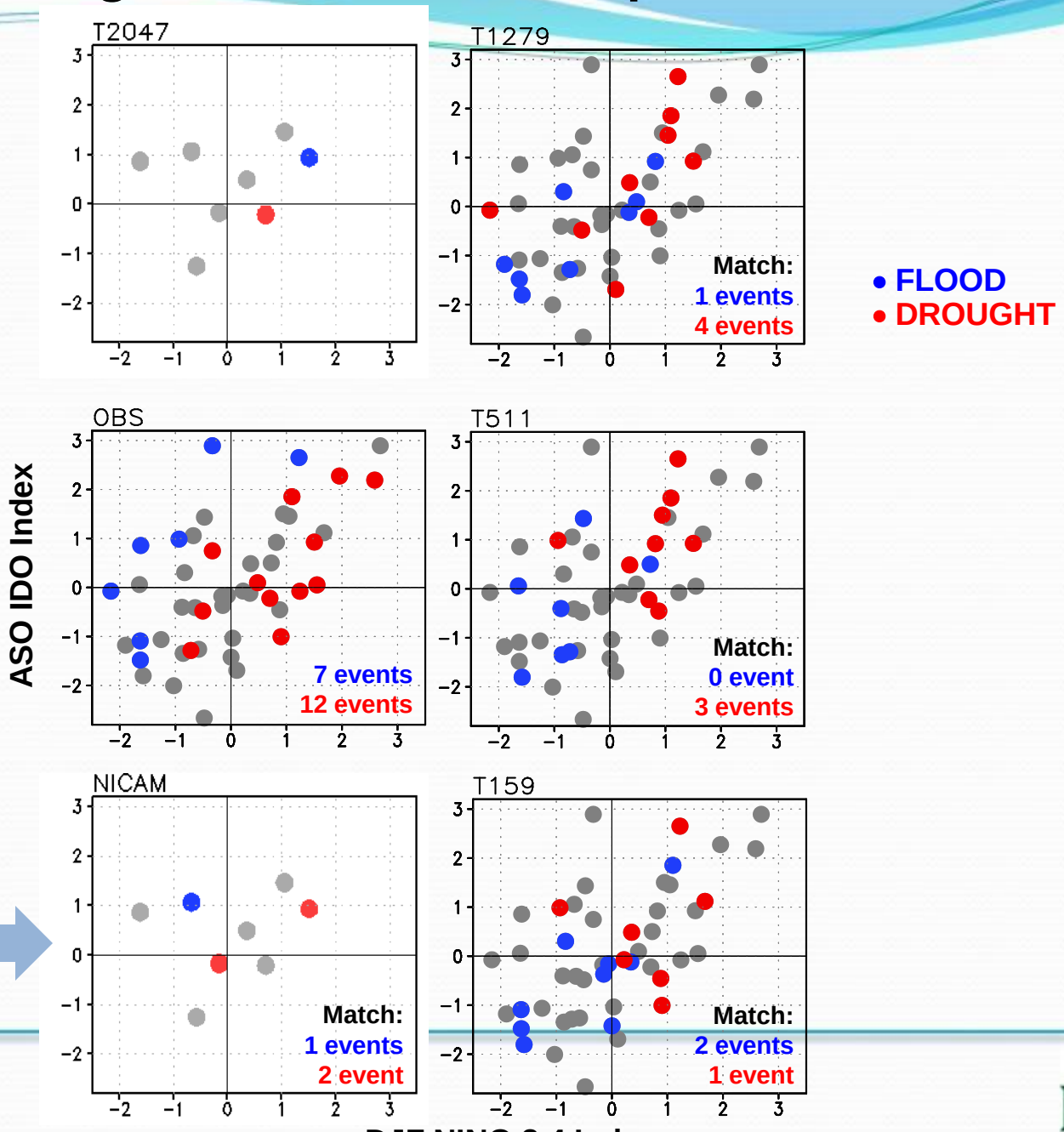
Negative IMR

Case: 65 66 68 72 74 79 82 85 86 87 02 04



Composite of Negative IMR JJA Precipitation Anomalies

Relationship between JJAS IMR and SST Indices

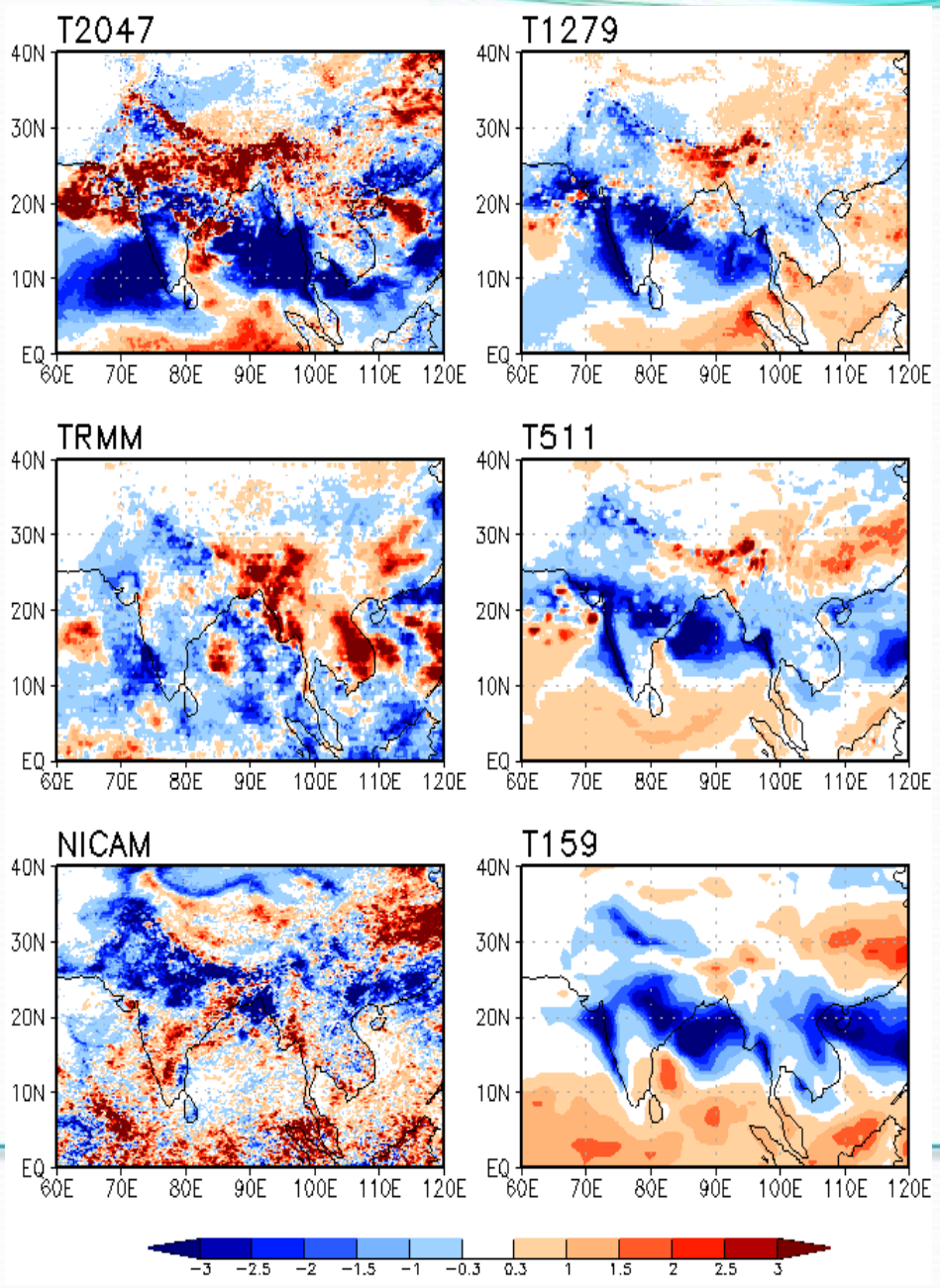


ACC (TRMM, NICAM)=0.66

Composite of Negative IMR JJA Precipitation Anomalies

Negative IMR defined based on Model's own standard deviation

Case: **04**



Case: **85 87** 88 92 94 **02** 03 **04** 06

Case: 65 66 68 72 74 79 82 85 86 87 02 04

Case: 63 69 76 83 **87** 94 **02** 03 **04**

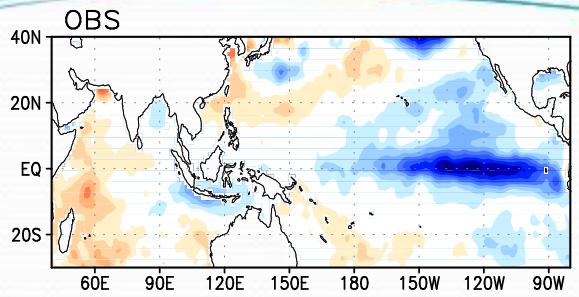
Case: **01 02**

Case: **68** 69 83 91 93 94 03

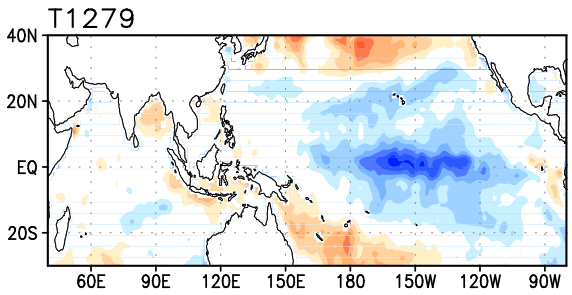
Composite JJA SST Anomalies based on IMR Index

Positive IMR

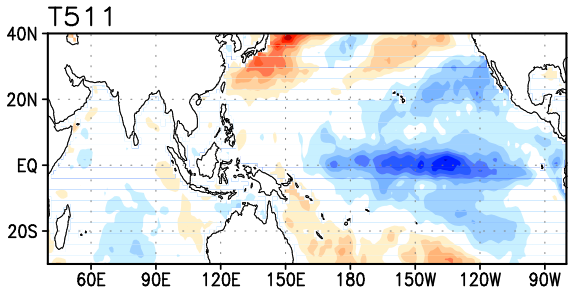
Case: 61 70 75 83 88 94 07



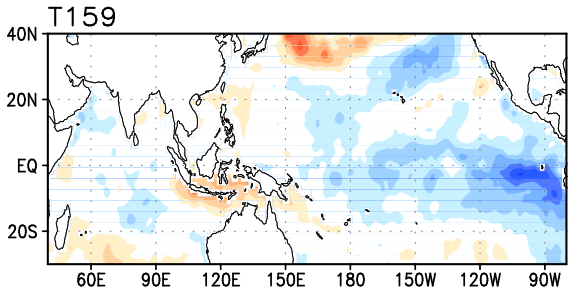
Case: **70** 73 74 76 79 90 98 00



Case: 67 71 74 77 95 98 99

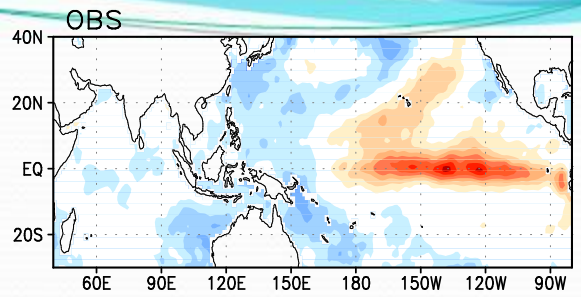


Case: **70 75** 78 80 87 89 90 98 00

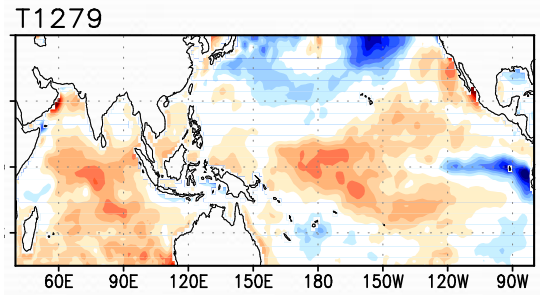


Negative IMR

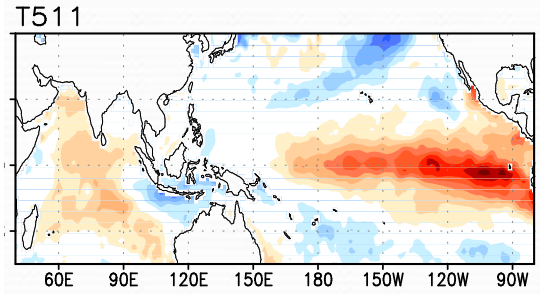
Case: 65 66 68 72 74 79 82 85 86 87 02 04



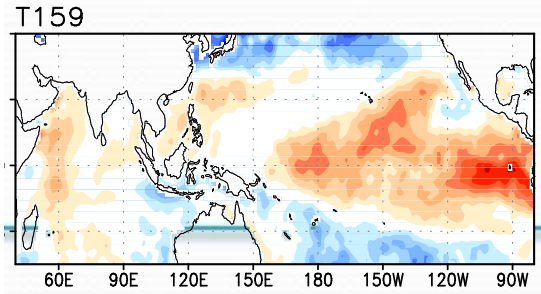
Case: **85 87** 88 92 94 **02** 03 **04** 06

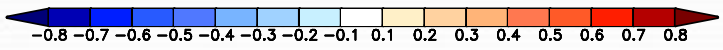


Case: 63 69 76 83 **87** 94 **02** 03 **04**



Case: **68** 69 83 91 93 94 03

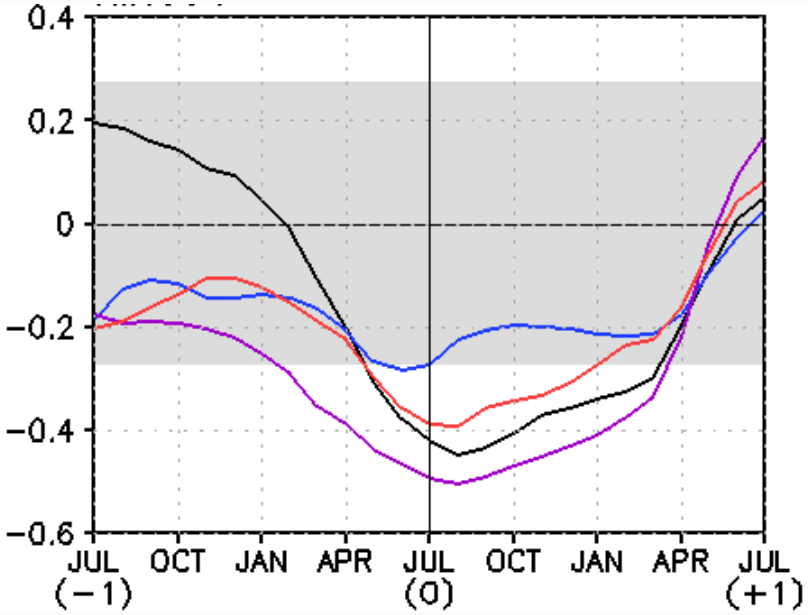




ENSO-Monsoon Relationship

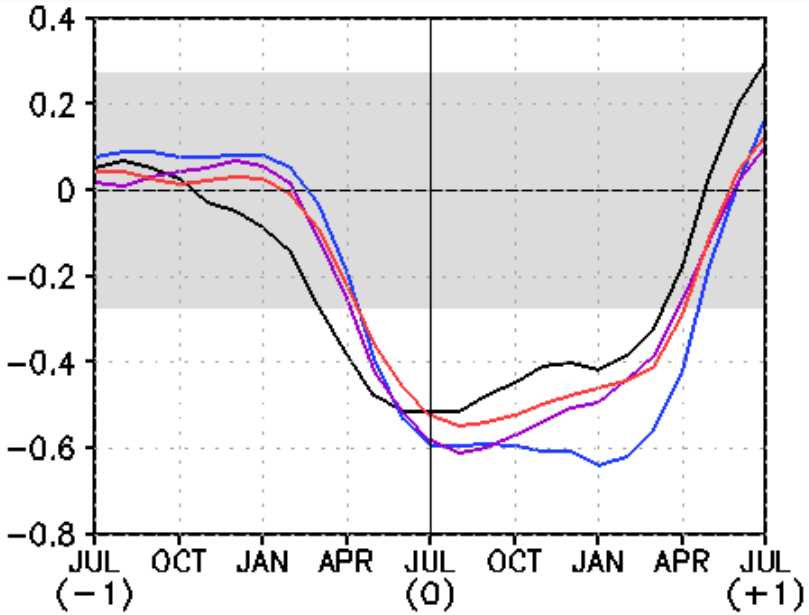
Lead-lag Corr. bet. NINO34 and JJA Indian Monsoon Indices

Indian Monsoon Rainfall index



N34 lead N34 lag

Indian Monsoon Circulation Index



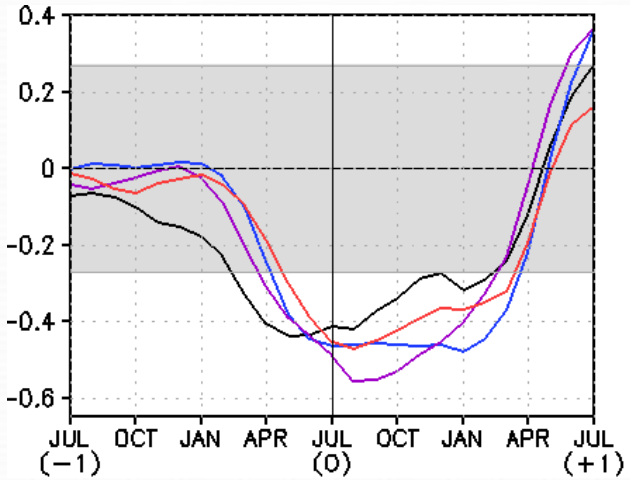
N34 lead N34 lag

Obs.
IFS T1279
IFS T511
IFS T159

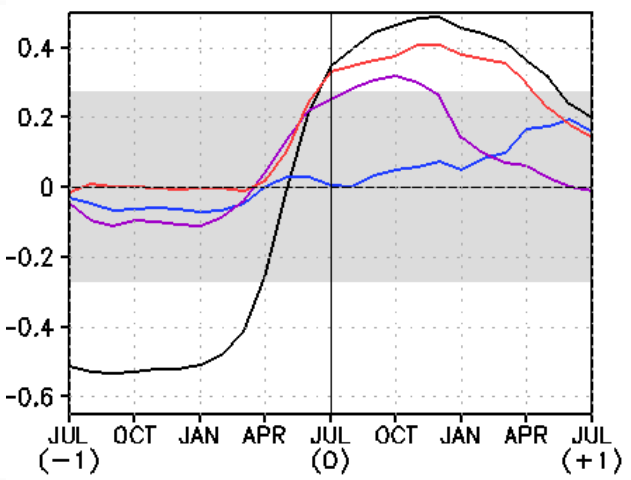
ENSO-Monsoon Relationship

Lead-lag Corr. bet. NINO34 and JJA Monsoon Indices

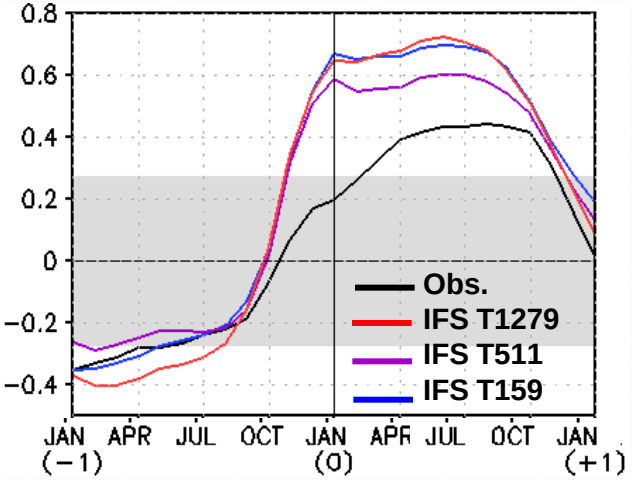
Webster and Yang Index



Western North Pacific



Australian Summer Monsoon



Webster and Yang Index:

U850(0ºN–20ºN, 40ºE–110ºE)-U200(0ºN–20ºN, 40ºE–110ºE)

Western North Pacific Summer Monsoon Index :

U850(5ºN–15ºN, 100ºE–130ºE) minus U850(20ºN–30ºN, 110ºE–140ºE)

Australian Summer Monsoon Index:

U850(10ºS–Eq, 120ºE–150ºE) minus U850(10ºS–Eq., 120ºE–150ºE)

ACC (1961-2008)

	WY	WNPMI	ASM
T159	0.37	0.31	0.23
T511	0.38	0.18	0.16
T1279	0.29	0.13	0.32

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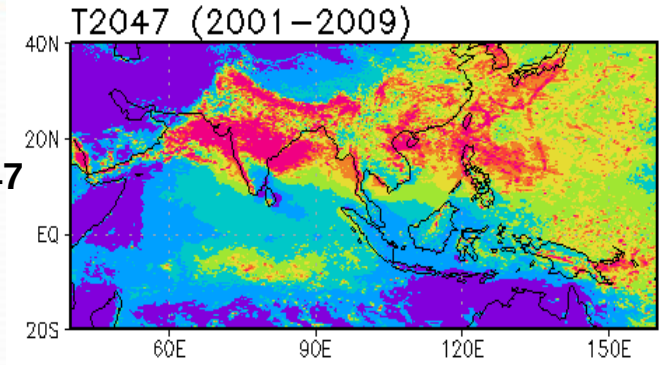
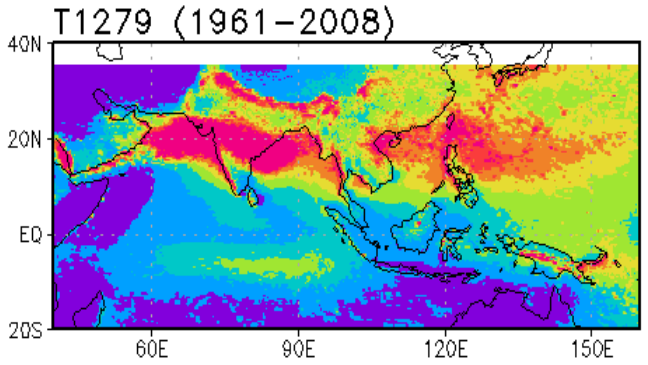
Standard Deviation of JJA Daily Precipitation Anomalies

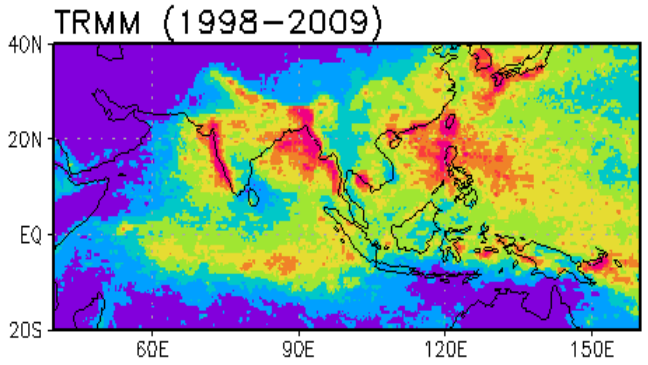
IFS T12047
10 km

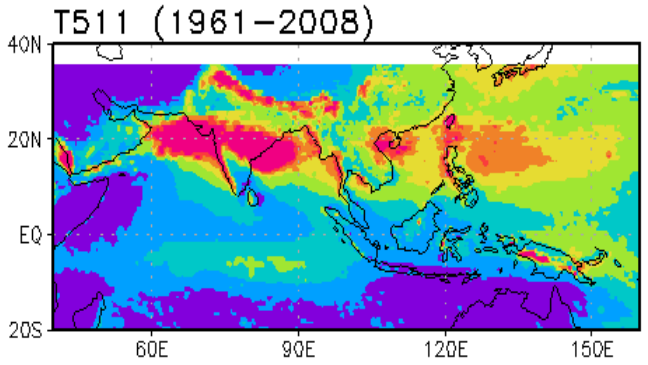




IFS T1279
15 km

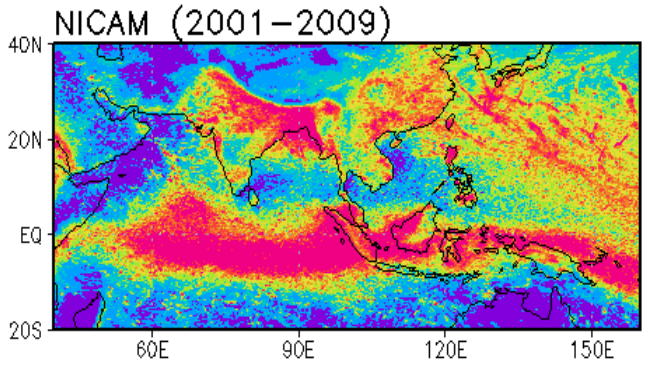
TRMM
25km

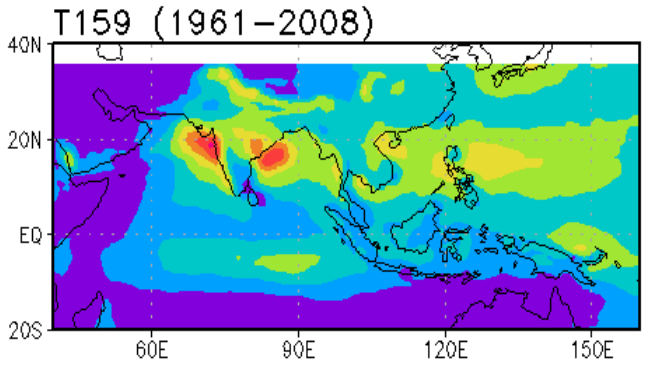




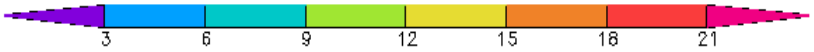
IFS T1511
39km

NICAM
7 km

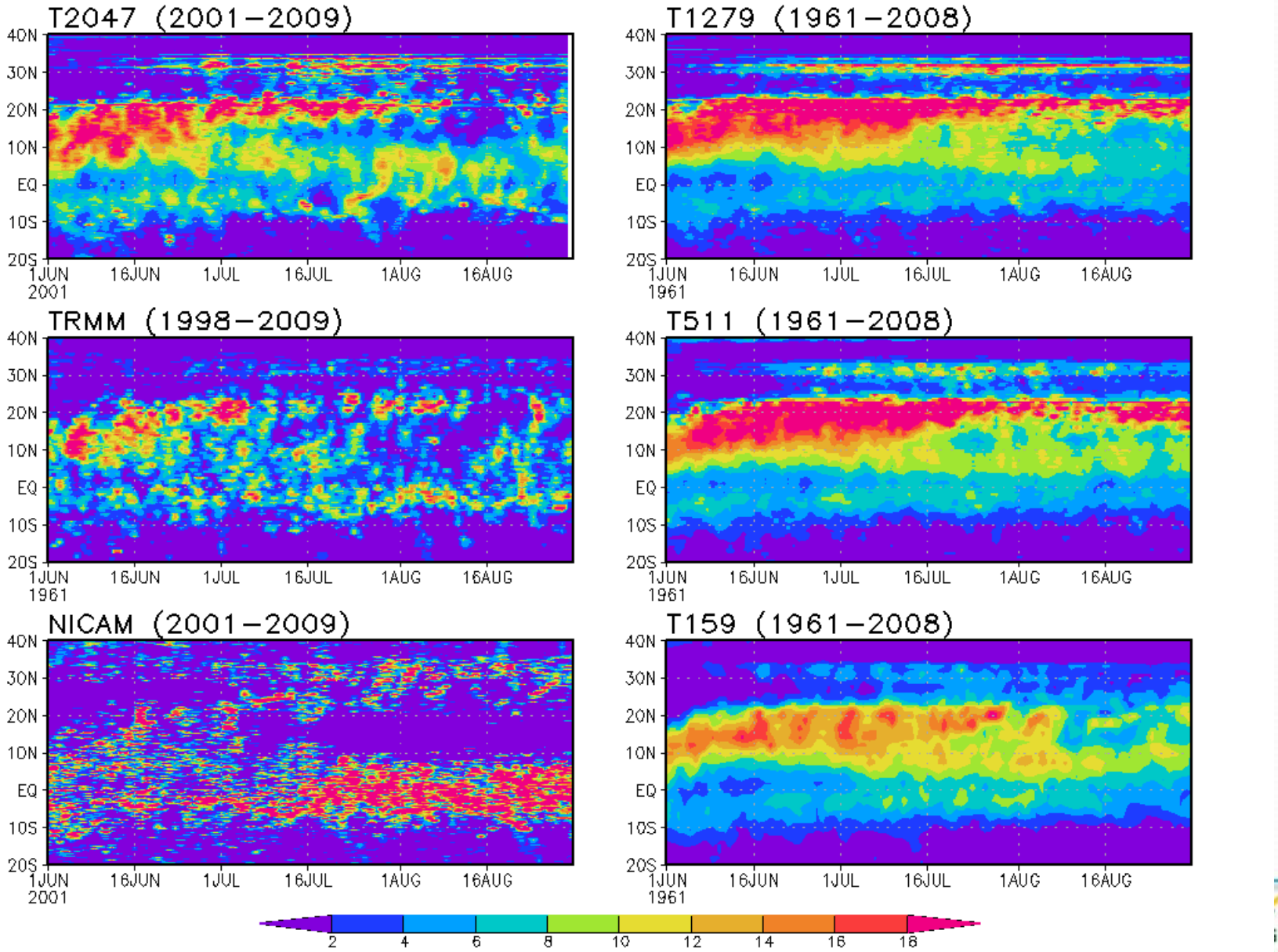




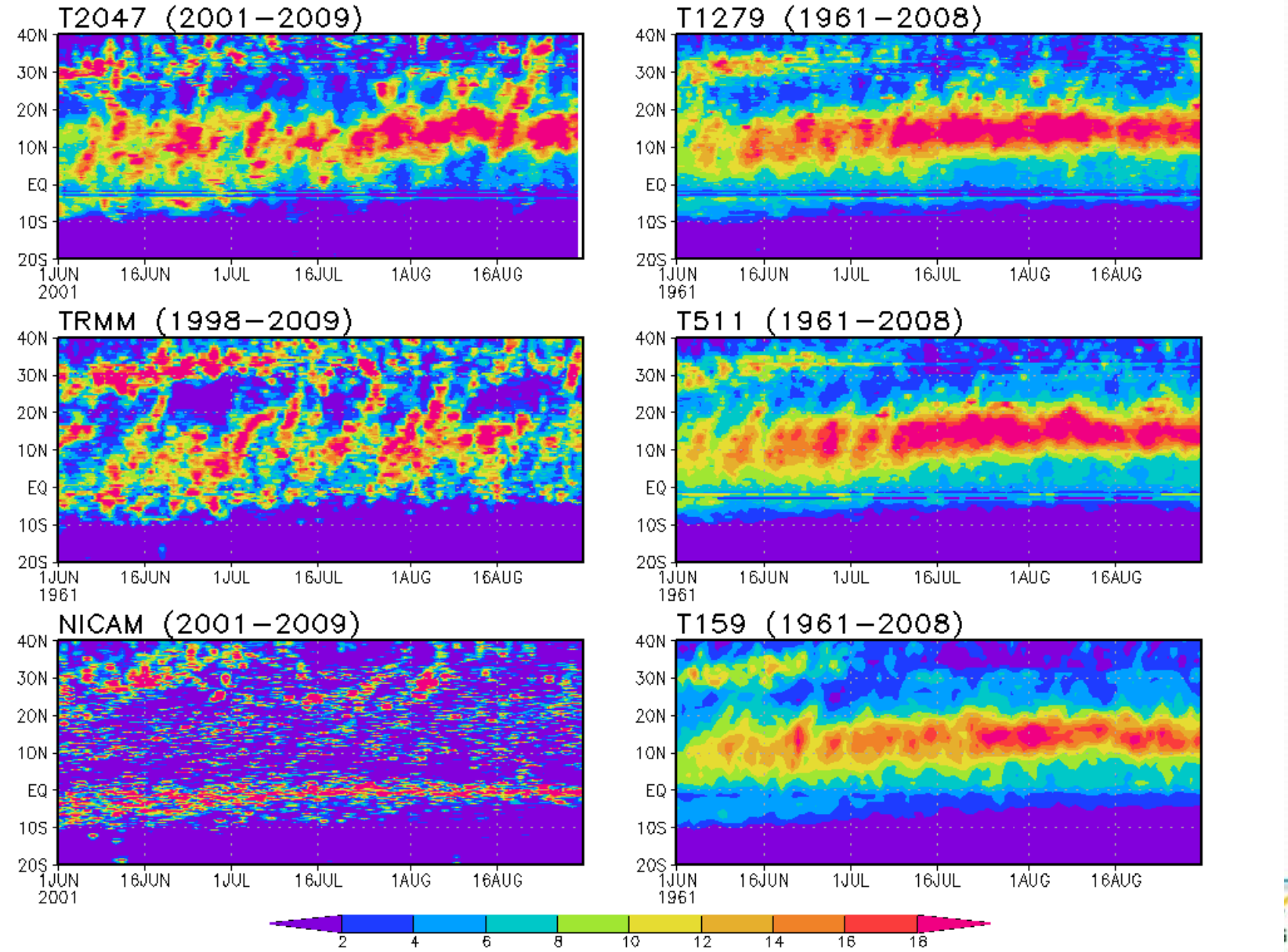
IFS T1159
125 km



Time-latitude Cross section (70°E) of Daily Precipitation Climatology

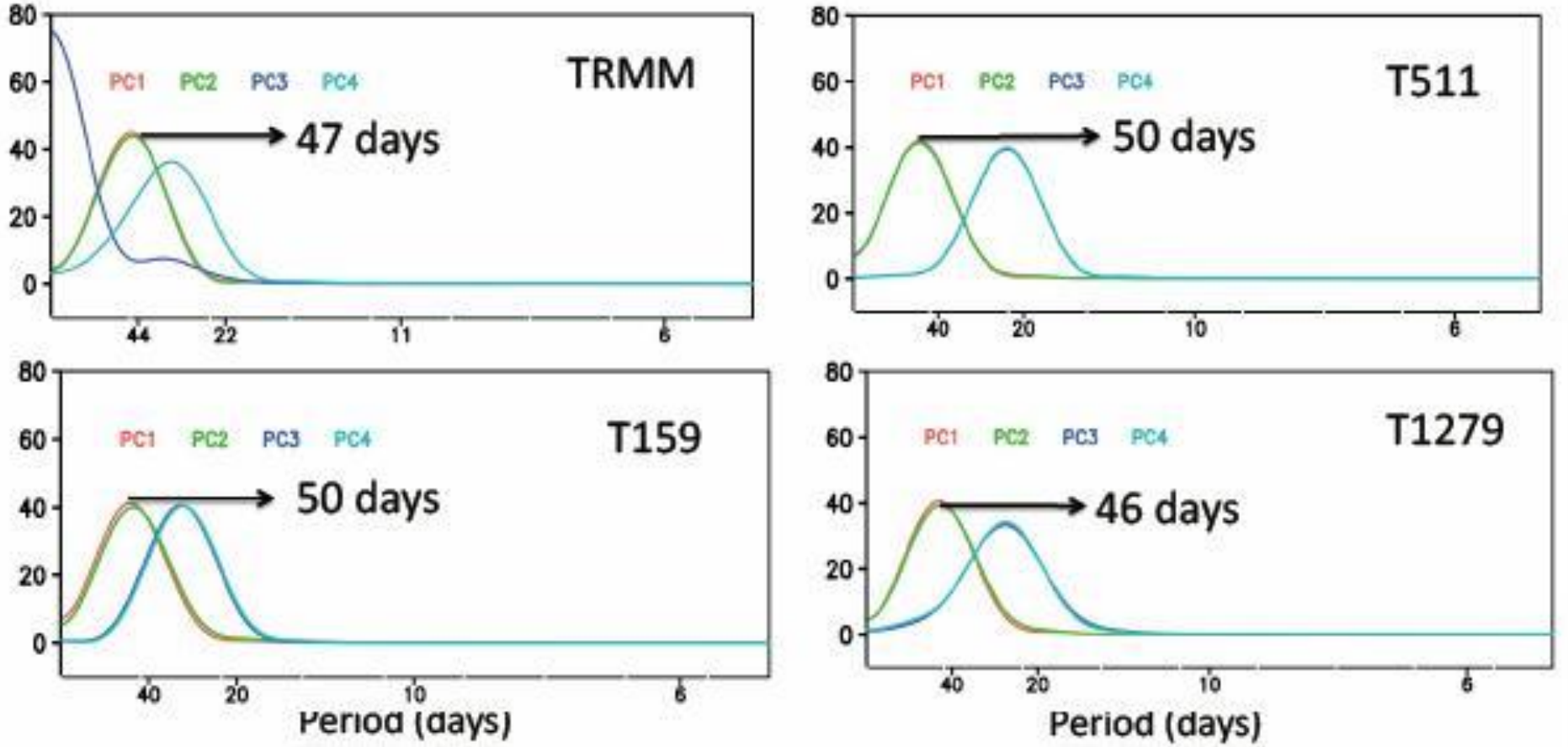


Time-latitude Cross section (130°E) of Daily Precipitation Climatology

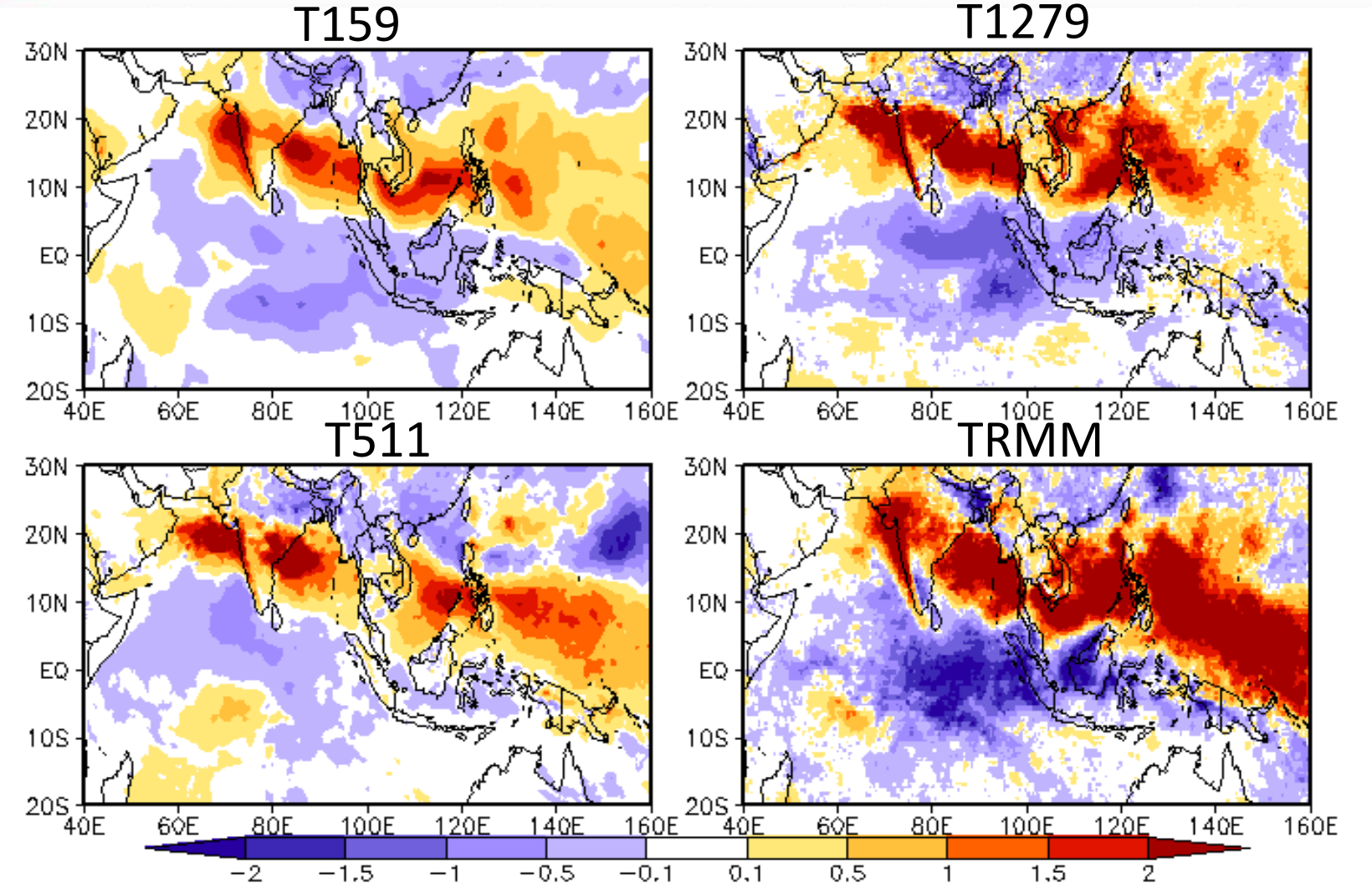


Northward Propagating Summer Intraseasonal Oscillation

Oscillating Mode



Northward Propagating Summer Intraseasonal Oscillation



Summary

The monsoon simulated in Athena runs shows:

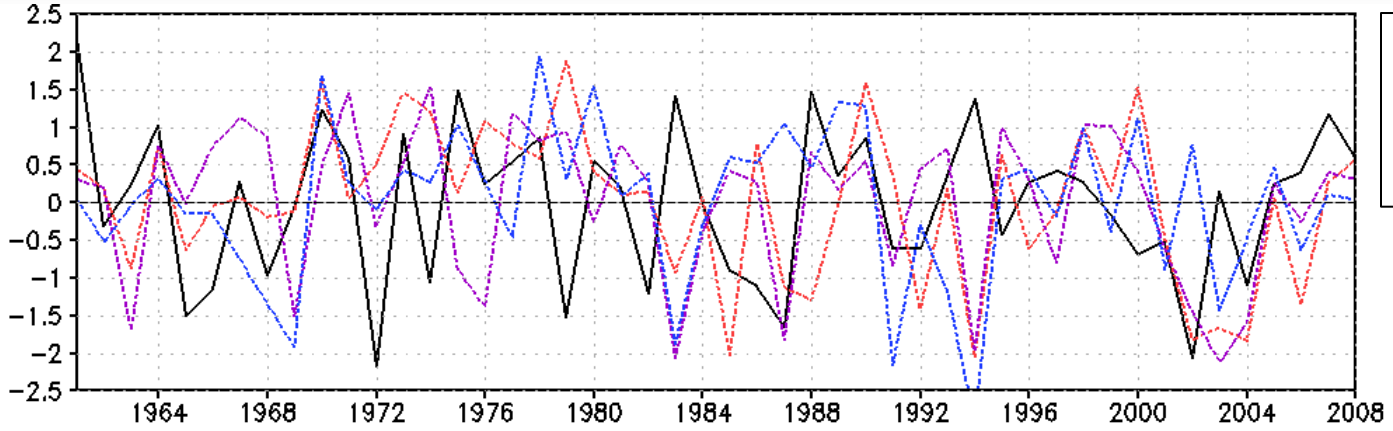
- The cloud-system-resolving model outperforms the parameterizing convection models to simulate Indian monsoon rainfall.
- The increase of horizontal resolution generally improves the forecast skill of Indian monsoon rainfall. While, the linear relationship is not clear between resolution and monsoon forecast skill in other monsoon regions - the western North Pacific monsoon, Australian monsoon, East Asian monsoon regions, etc.
- The forecast skill of monsoon circulation has no clear relationship with respect to the increase of resolution. However, the ENSO-monsoon relationship shows moderate improvement in higher resolution more than 125km.
- The monsoon simulated with prescribed SST tends to exaggerate the impact of ENSO.
- The spatial (orographic features) and temporal characteristics of subseasonal variability of monsoon rainfall shows more realistic representation in higher resolution.

THANK YOU!

ANY QUESTIONS?

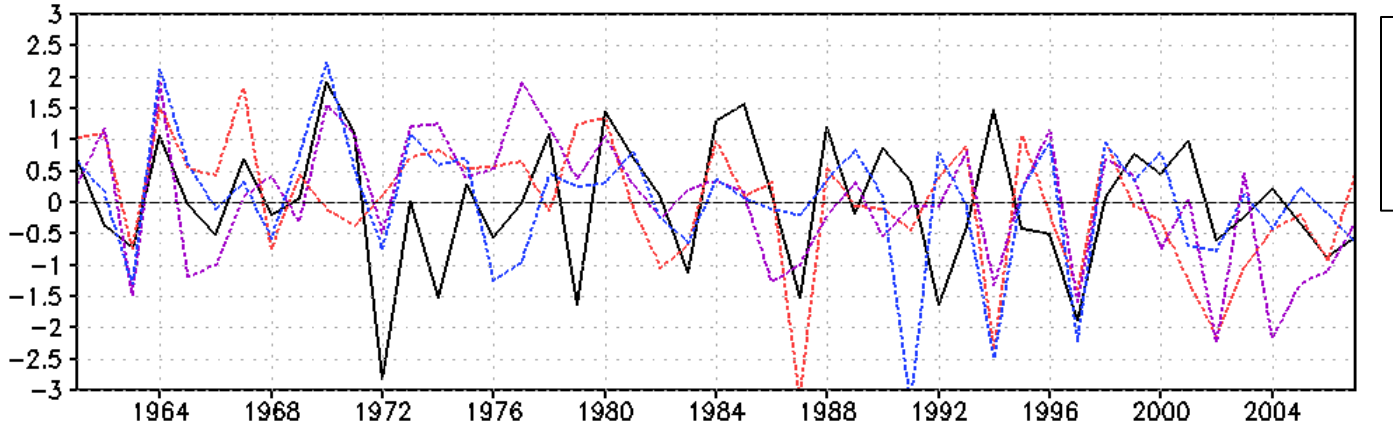
JJA Indian Monsoon Indices

Indian Monsoon Rainfall index (IMR): Rainfall over India



Obs.
IFS T1279 (ACC=0.12)
IFS T511 (ACC=0.04)
IFS T159 (ACC=0.00)

Indian Monsoon Circulation Index 1 (MCI1):
U850(5ºN–20ºN, 40ºE–80ºE)-U200(5ºN–50ºN, 40ºE–80ºE)



Obs.
IFS T1279 (ACC=0.14)
IFS T511 (ACC=0.27)
IFS T159 (ACC=0.26)

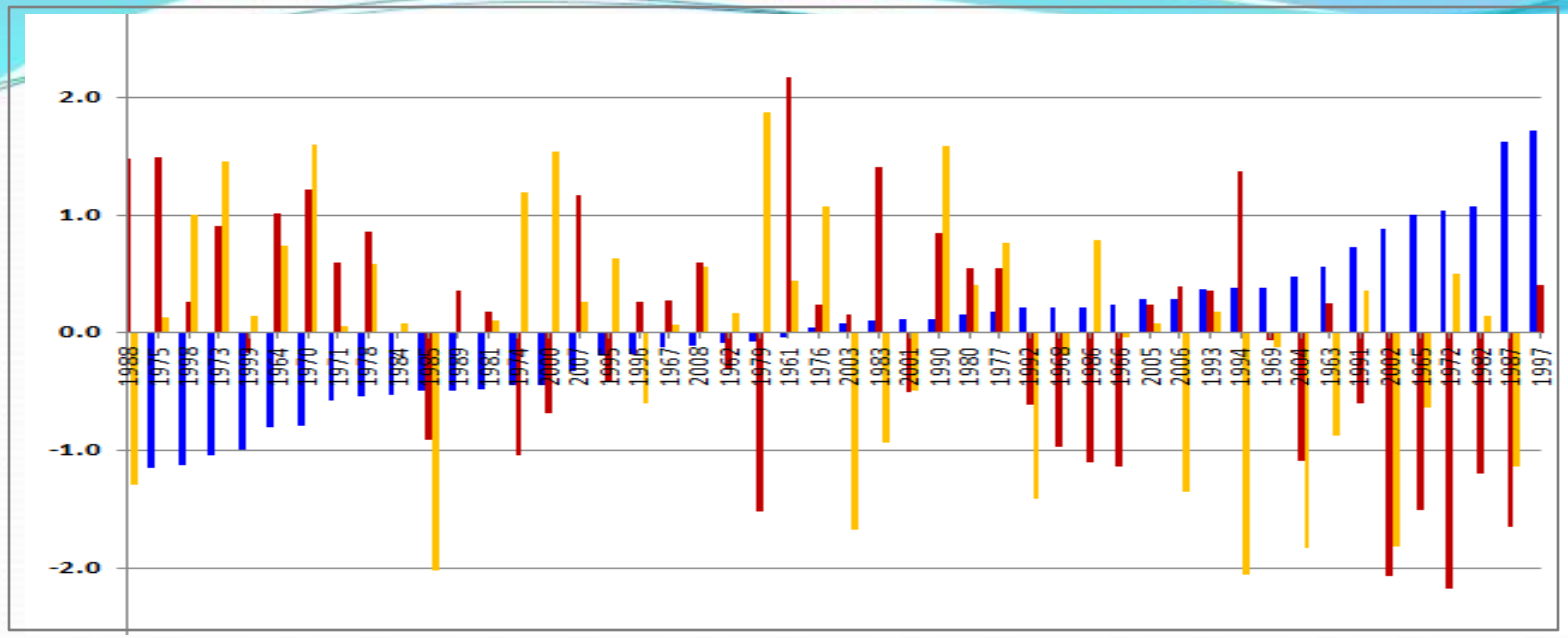
YEAR

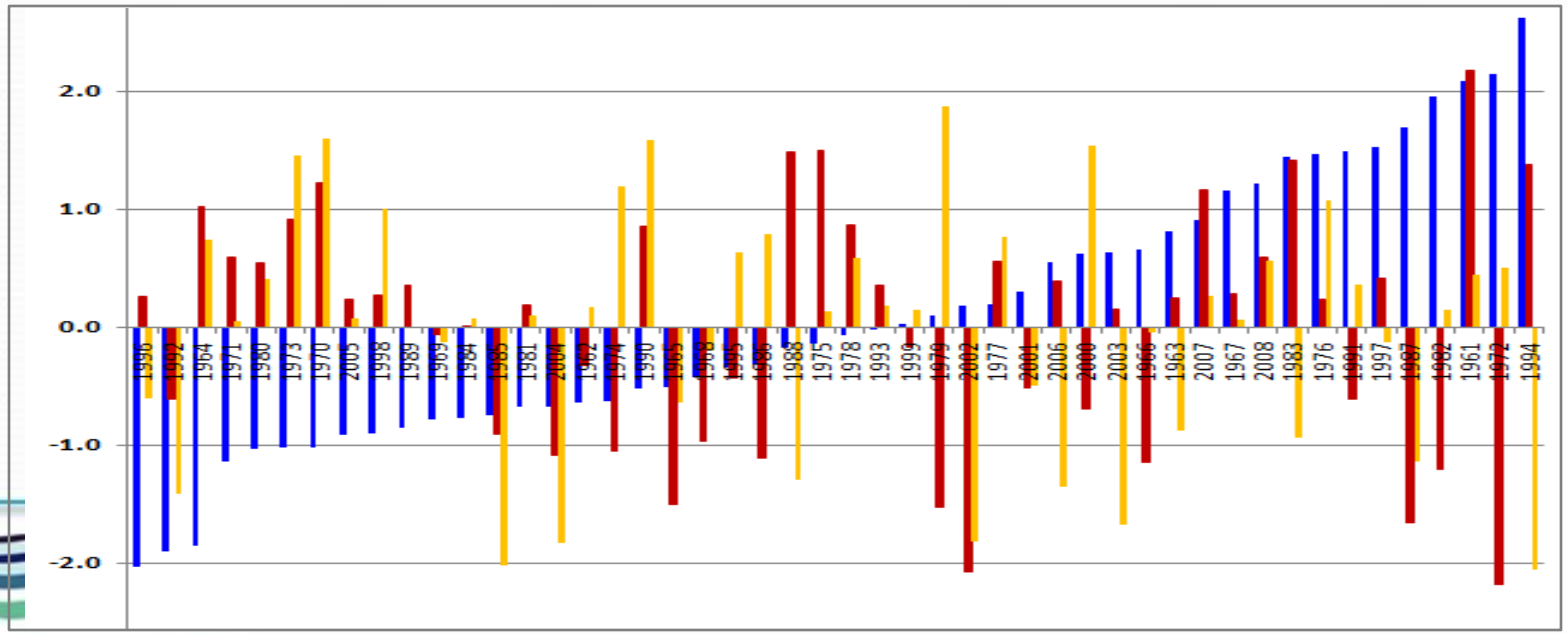
ACC: Anomaly correlation coefficient between TRMM and model during 1961-2008

COLA Center for Ocean-Land-Atmosphere Studies

GEORGE MASON UNIVERSITY

Relationship bet. Indian Monsoon Rainfall and SST indices

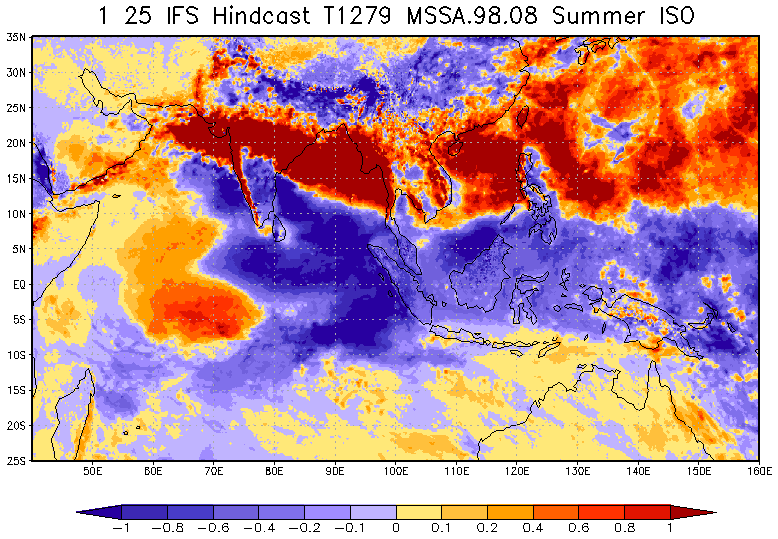




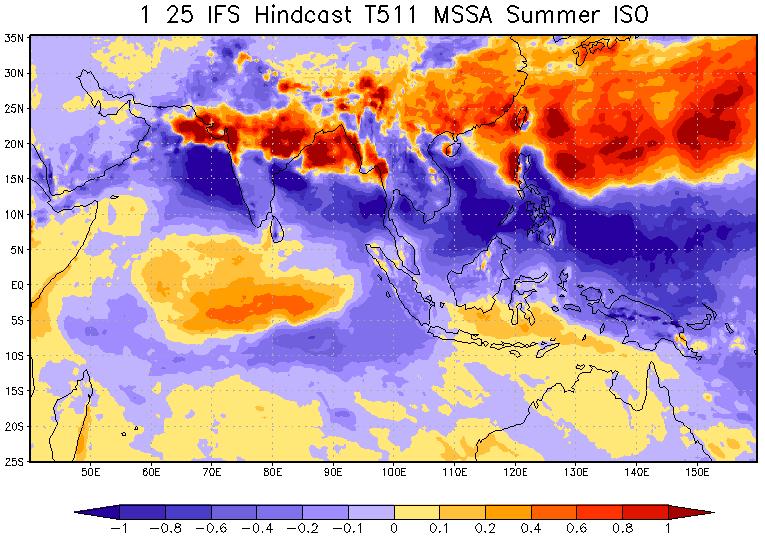
IMR index is normalized.

Northward Propagating Summer Intraseasonal Oscillation

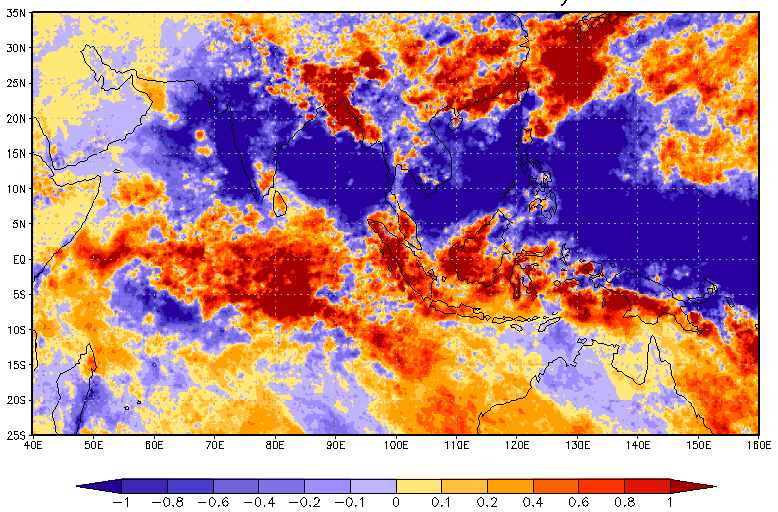
T1279 20-100day filtered



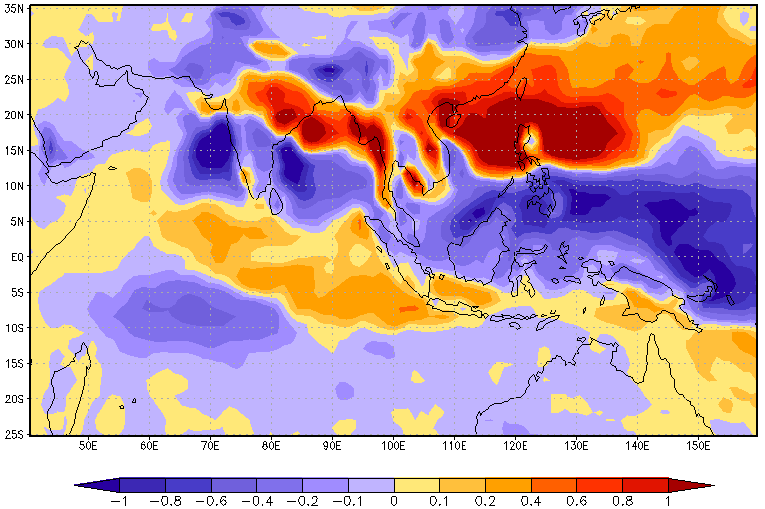
T511 20-100day filtered



TRMM



T159 20-100day filtered



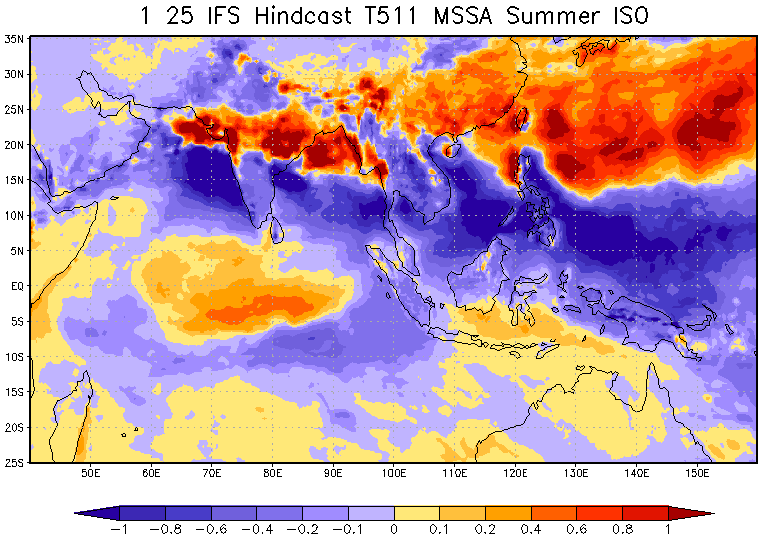
Northward Propagating Summer Intraseasonal Oscillation

Multi-channel Singular Spectrum Analysis (MSSA) of JJAS Rainfall

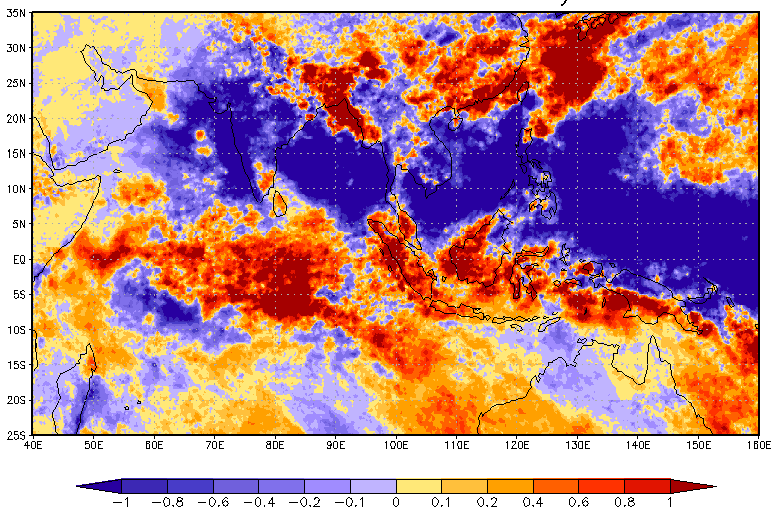
➔45-day Oscillatory mode

➔Its cycles of variability are correspond to the life cycles of active/break periods of monsoon rainfall over India (Kristinamurthy and Shukla 2007)

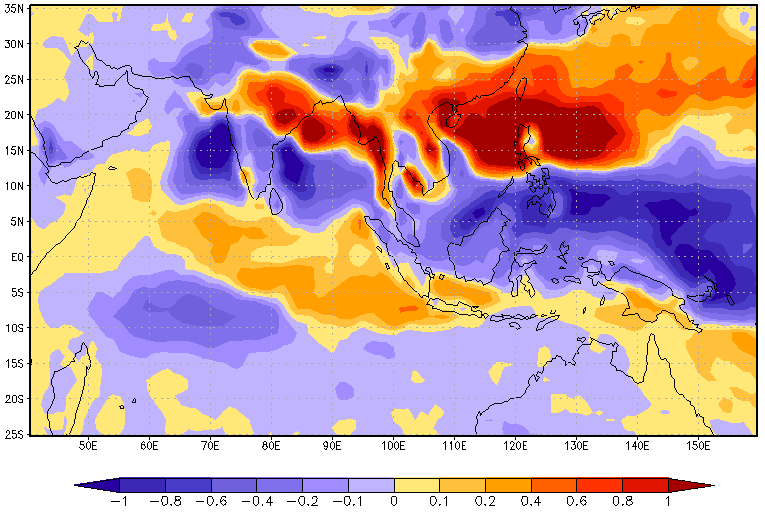
T511 20-100day filtered



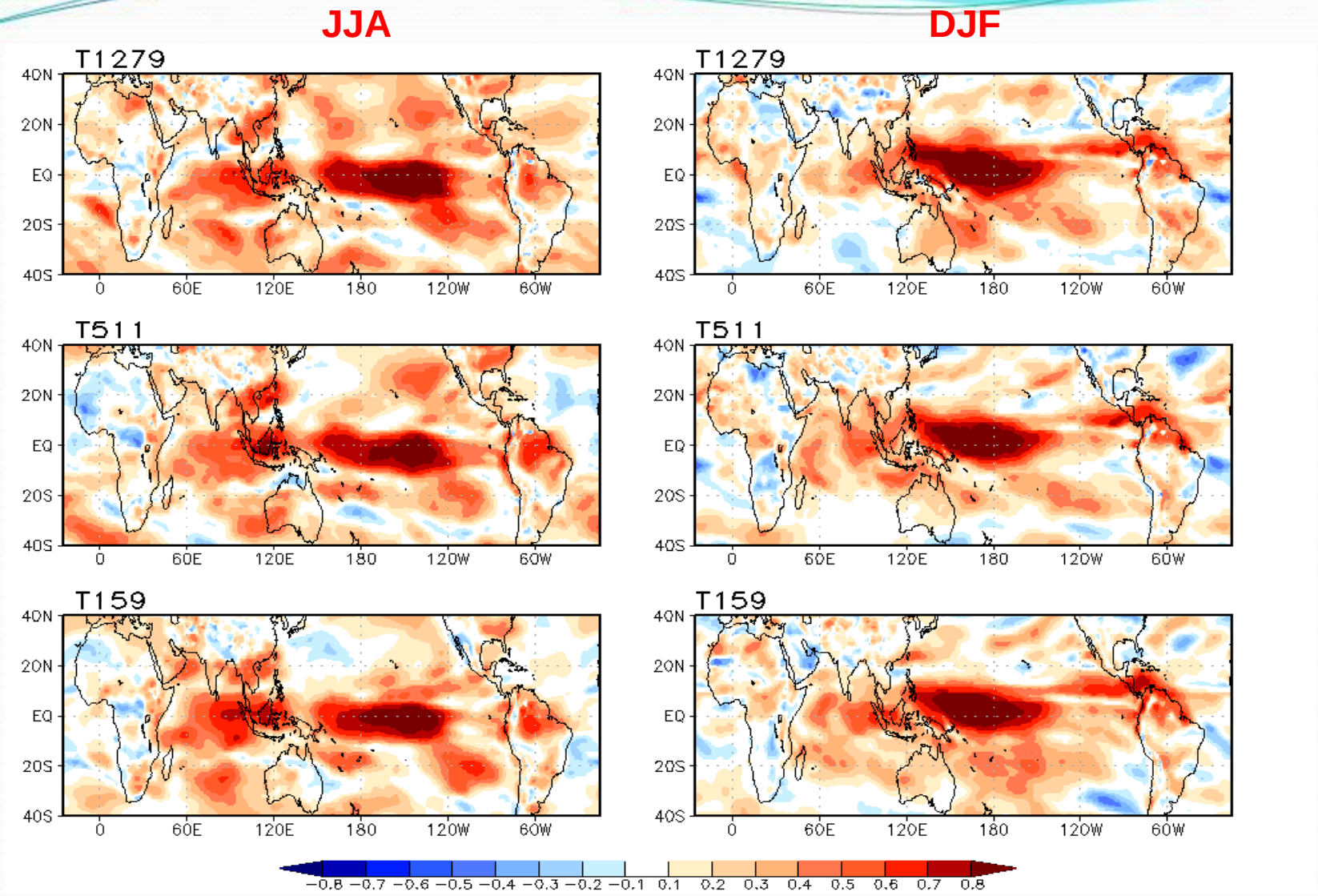
TRMM



T159 20-100day filtered



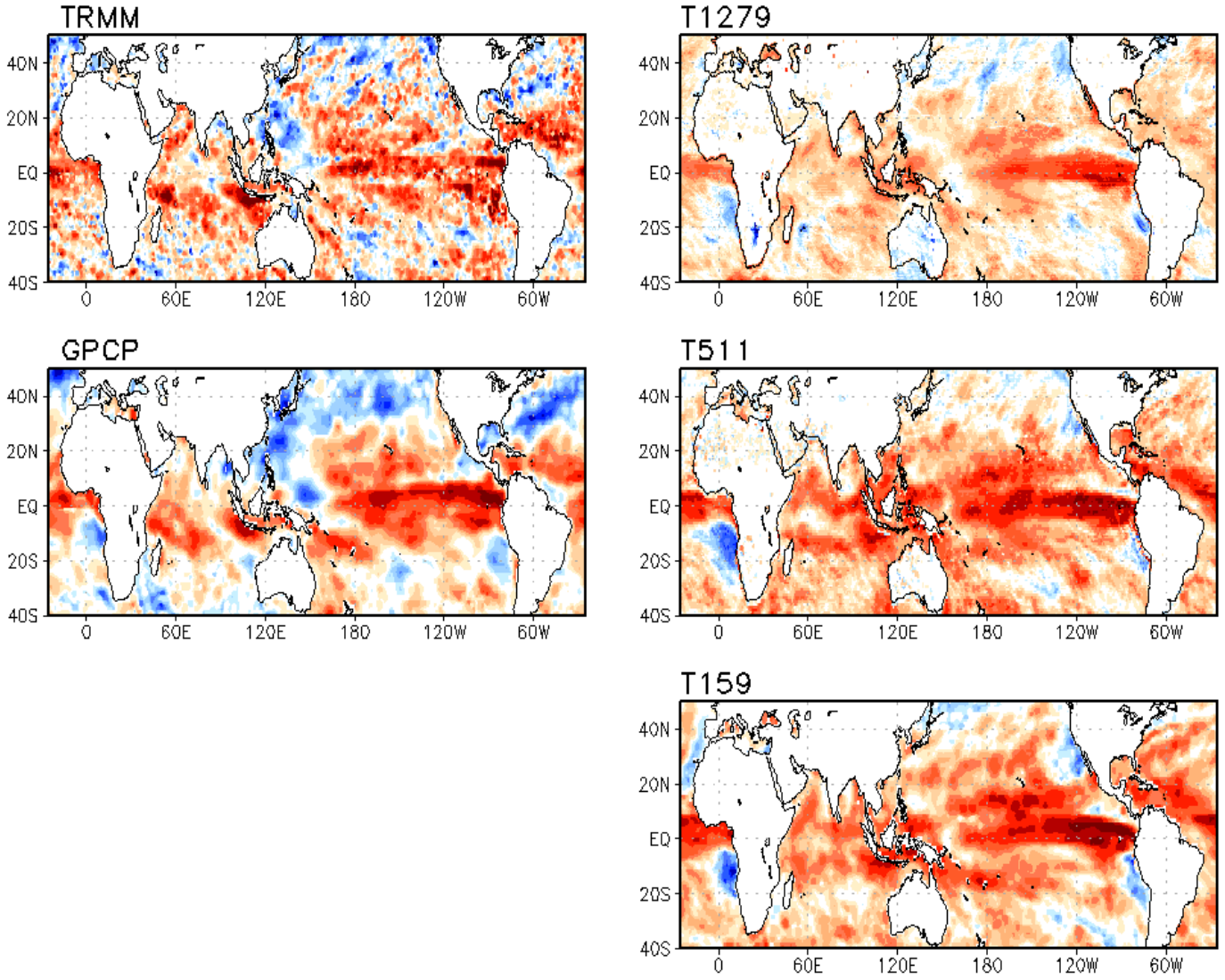
Forecast Skill of 850 hPa Zonal Wind Anomalies



Temporal correlation with ERA40 (1979-2008)

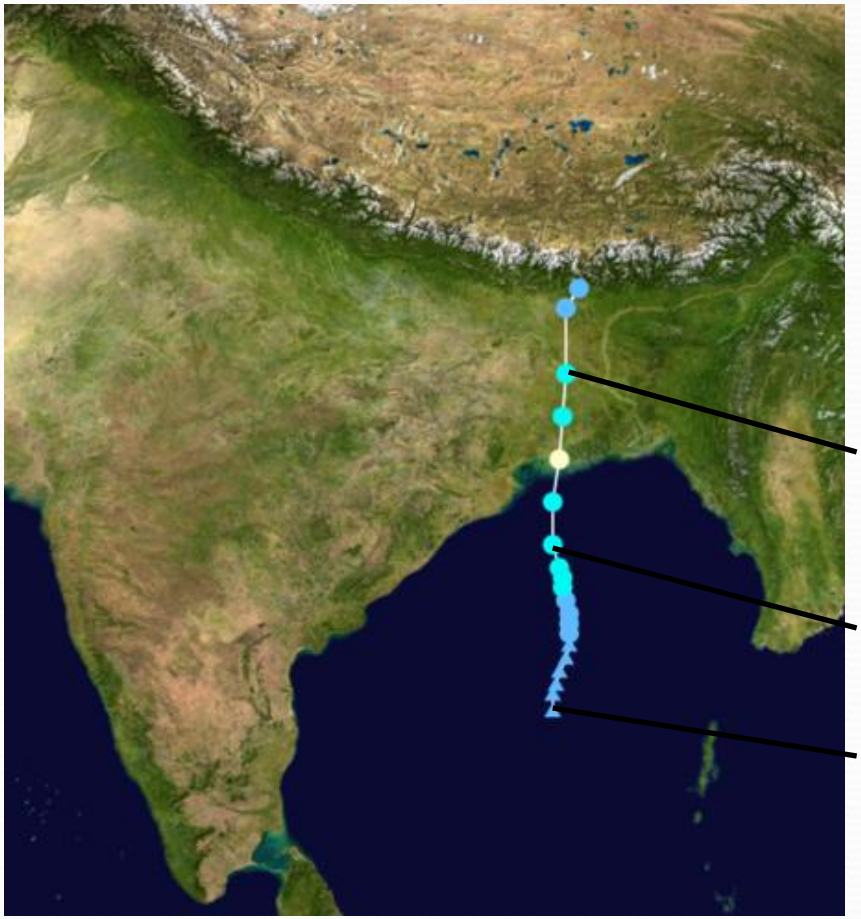
Monsoon Convergence Zone:

Relationship bet. JJA SST and Precipitation



May 2009 – Tropical Cyclone Aila

NICAM simulation accurately predicted development, evolution and track of Aila over 5-day period



Tropical Cyclone Aila made landfall in India on the Bangladesh border region on May 25 as a borderline category 1 hurricane. TC Aila had sustained winds of 65 - 75 mph at landfall. Approximately 150,000 people were left homeless in India, and at least 45 people have died. In Bangladesh,10,000 people are homeless, and 89 have died with hundreds missing. The death toll is expected to rise.

Credit: NOAA