문서번호 APCC-출장-19-0198(2019-03-22)

결재	선임연구원	과장	부서장	원장
	03/21 김해정	03/22 김형진	03/22 유진호	03/22 권원태
협조				

TRAVEL REPORT FORM
출장보고서

I. **Travel Overview** 출장개요

1. Traveler(s) 출장자

Department 소속	Position 직위(직급)	Name 성명	Note 비고
기후사업본부	선임연구원	김해정	

2. Travel Period 출장기간

2018. 03. 11 ~ 2018. 03. 14 (4일)

3. Occasion and destination 행사 및 출장지

대만기상청 (Central Weather Bureau, Taiwan ROC)

II. **Major Activities** 주요업무 수행내용

1. Main Contents and Activities 주요내용 및 활동

1) 출장 목적

- 여름철 계절내 진동(BSISO) 연구에 대한 공유를 통해 APCC BSISO 예보의 수요자격인 대만기상청 중장기 예보 실무진들의 역량을 도모하고 그들의 의견을 수렴하여 APCC BSISO 예보 및 연구 업무에 내실을 기하고자 대만기상청의 초청을 받아 출장을 수행하였음.

2) 주요내용 및 활동

- 대만기상청에서의 세미나 2회 및 그룹 토의 3회
- 국립대만대학교에서 APCC의 실시간 BSISO 모니터링, 예보, 활용에 대한 강의

※ 세부내용은 [붙임1] 출장주요내용 참고

2. Relevance to APEC Climate Center's Activities 결론 및 소감

1) 결론

- APCC의 BSISO 예보나 연구들은 CWB의 장기예보 실무진들에게 큰 도움이 되는 과업이고 APCC의 현재 BSISO 연구나 향후 계획에 대해서 여전히 그들은 큰 관심을 가지고 있었음.

- 출장자의 2018년 초청 방문 이후 대만의 ISO 연구가 매우 활발해져서 APCC와 협력를 논할 수 있는 수준에 도달하였기에 BSISO 모니터링, 모델 편이 보정, 활용 연구 등에 대한 CWB 측의 적극적인 협력 제안이 있었음. 가능한 범주 안에서 조금씩 연구 협력을 시작하고자 함.

- 대만기상청 및 대만 대기과학계는 기후 예측 및 대외 활동을 통한 사회 및 학계에 대한 APCC의 공헌을 높이 평가하고 있었고 6월에 개최될 APCC Model Provider Meeting에 대한 큰 기대를 가지고 준비에 임하고 있었음.

- CWB는 내년쯤 APCC BSISO 예보로의 참여 모델을 새로운 고해상도 모델로 교체할 계획을 가지고 있었고 이는 6월 Model Provider Meeting에서 상세히 논의하길 기대하고 있음.

2) 소감

[성과] CWB 장기예보 실무진들의 역량이 강화되었고 APCC의 BSISO 연구도 꾸준히 잘 진행이 되어와서 금번 출장에서는 CWB와 APCC의 BSISO 연구 협력의 물꼬를 트게 된 것이 센터의 성과라고 보여짐. 또한 BSISO 라는 공통의 관심사를 가지고 많은 사람들과 다양한 경험치를 토대로 토론할 수 있어 서로의 부족한 지식을 채울 수 있었던 유익한 시간이었음. 이는 연구자로서의 성과라고 생각 됨.

[APCC의 수준 및 시장 상황] APCC의 BSISO 업무 노하우가 전수되어 CWB의 활발한 ISO 모니터링과 대학의 연구들을 이끌어 낼 수 있었으나 이제는 APCC가 이 분야의 연구를 선도하기에는 수적으로 열세하여 (APCC는 2인) ISO 모니터링을 본업으로 하는 현업 기관을 이길 수 없는 상태에 도달하였다고 봄. 대신 모니터링 시 현상을 좀 더 잘 설명할 수 있는 진단 툴을 개발한다던가 BSISO의 예측성 향상을 위한 연구, BSISO 각 모드의 정체성을 이해하고자 하는 연구, 그리고 BSISO 영향을 살펴보는 활용 연구들은 여전히 그들은 시작 단계이므로 APCC는 이에 대한 아이디어를 발굴하고 연구에 집중한다면 사회나 학계에 기여할 수 있는 부분이 많이 있다고 보여 짐. 작년도 대만출장보고서를 관련문서로 지정하였으니 시장의 변화에 대한 격세지감을 함께 느껴보길 희망. [관련문서 APCC-출장-18-0245].

[과학적 견해] BSISO 지수라는 것이 단순히 실제 BSISO 현상을 쉽게 진단하기 위하여 간소화한 툴이란 것을 넘어서서 이제는 모드 1과 모드 2로 분리될 수 밖에 없었던 물리적 차이와 정체성, 변동을 설명하는 정도의 유연성 등을 이해해나가는 노력이 지수 자체에 대한 개선 및 예측 스킬에 대한 개선 뿐만 아니라 다방면으로의 활용을 위해서도 필요하다고 생각됨. 이를 위해서 실제 현상을 꾸준히 모니터링 하는 과정이 아이디어 개발에 있어 중요하다고 보여짐.

3. Suggestions and Remarks 건의사항

III. References (Presented and Collected Materials) 주요 수집자료

(with attachment of any information or report in case of attendance of conferences, workshops and meetings) 학술대회, 워크숍, 회의 등 참석 시 관련 정보 및 문서 첨부

대만기상청 방문 주요내용 및 활동

【 2019. 03. 20. (수) / 기후사업본부 김해정 】

○ 주요내용 및 활동

1. APCC BSISO 예보 및 연구에 대한 CWB의 이해 증진을 위한 세미나

▪ APCC BSISO 예보의 실용화 방안 및 활용 가능성에 관한 소개

- 제목 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis over Western North Pacific

- 출장자의 발표 이후 대만 기후에 대한 ISO의 영향을 연구하는 Prof. Hung (National Taiwan Normal University)의 세미나로 이어져 서태평양 태풍 발생으로의 BSISO 기여 양상에 대해 Prof. Hung 그룹과도 함께 토의함.

- BSISO 발달로 인해 발생할 수 있는 태풍에 있어서 개발된 WNP ISGPI가 현상을 잘 모사하므로 활용하기 유용한 진단 툴이라는 평가를 받음. CWB 모델 평가 시 WNP ISGPI를 적용해보겠다는 의견이 있었음.

- BSISO가 몬순 gyre 발달에 기여하고 몬순 gyre는 북서태평양 태풍 발생의 주요 trigger로 알려져 있음. 8월 태풍 발생에 있어서 WNP ISGPI가 강점을 가지는 이유는 8월이 몬순 gyre 가 활발한 시기이기 때문으로 이해 됨.

- WNP ISGPI의 월별 variance 도 살펴보면 의미 있을 것이라는 Prof. Hung의 제안이 있었음.

▪ 2014년도 이후 세 차례 개최된 APCC의 S2S 교육프로그램에 대한 소개

- 제목 : Introduction to the APCC's S2S Training Program

- S2S 교육프로그램(Training Program, TP) 추진과 운영에 대한 APCC의 노하우를 전수받고자 세미나 요청. 교육 취지, 주제, 커리큘럼뿐만 아니라 행사를 준비하고 진행하는데 필요한 제반 절차에까지 많은 관심을 보였음.

- CWB의 APCC TP 참가자들의 소회를 공유하는 시간이 있었음. 매우 유익하고 실무에 도움이 되는 교육이었다는 의견. 특히, APCC가 오랜 기간(약 6개월) 동안 사전 준비를 거쳤기에 실습을 완수 할 수 있었고 그러한 높은 완성도에 고마움을 표시하였음.

- 약 10:1의 경쟁을 뚫고 참가한 만큼 소중한 기회를 헛되이 보내지 않도록 모든 참가자가 BSISO의 영향 분석 방법 전 과정을 마스터할 수 있게 하자는 실습 목표를 달성하기 위해서 케이스별로 (데이터, 소프트웨어, 참가자 역량 등) 만약의 경우를 대비한 대안들을 준비했던 것이 교육 성공의 비결이자 그간 TP가 society에 대한 APCC의 공헌으로 치하 받을 수 있었던 원인 중 하나라고 생각함. 동시에 CWB에서 역량 높은 참가자를 보내주어 수준 높은 토의를 할 수 있었다고 화답함.

· APCC가 개최하는 행사들은 우리의 대외적 이미지를 만드는 근거가 되므로 추진/운영 시 세심한 준비가 필요하다는 교훈을 얻음.

	
BSISO 기반 WNP ISGPI 개발 연구 소개 모습	APCC S2S TP 소개 모습

2. BSISO 예보 및 연구에 대한 CWB와의 협력 토의

▪ APCC BSISO 예보로의 새로운 CWB 예측모델 자료 도입 계획 공유 (from CWB modeling team)

- 2018년 출장보고자의 CWB 방문 시 APCC에서 분석한 CWB BSISO 예측 스킬을 공유한 이후 CWB는 새 모델 개발을 통한 예측성 개선을 도모하게 되었음.

- 현재 CWB는 계절예측시스템으로 CWB-GFS (T119L40)과 TCWB2T2(T119,2-tier system)을 운영 중.

- BSISO 예보를 위해서는 CWB GEPS MRF의 20개 ensemble mean 예보를 제공 중.

- CWB monthly to seasonal climate forecast 시스템으로 2-tier의 TCWB1T1을 운영하였으나 TCWB1T1(T249, ~25km, 45일 예보)인 1-tier 모델을 개발하였고 이 모델의 hindcast를 현재 생산 중. 내년 경 APCC BSISO 예보로의 제공을 위해 준비 중. CWB는 새 모델 자료 제공에 관한 내용을 6월에 개최될 model provider meeting에서 논의하길 기대하고 있음.

▪ CWB 새 모델의 ISO 모의 능력 및 편차 보정 효과에 대한 논의 (from CWB modeling team)

- 사례 검증을 통해 CWB TCWB1T1의 MJO/BSISO 모의 능력을 보여줌. W3, W4에서도 RMM/BSISO 지수를 잘 모의함.

- 모델의 hindcast가 없는 경우라도 real-time forecast에서 얻어낸 정보로 모델의 편차를 보정할 수 있는 기법을 개발하였고 APCC BSISO 실시간 예보에 편이 보정 방법을 활용하길 제안 함.

  · 가능하다면 추후 W3/W4에 대한 APCC BSISO 실시간 예보 검증과 함께 모델 편이 보정 방법을 통한 예측성 개선 효과도 함께 연구할 수 있기를 희망함. 차년도 연구 주제로 긍정적으로 검토 중.

▪ BSISO 모니터링 및 활용 연구 토의 (with CWB LRF section)

- CWB의 MJO/BSISO 모니터링 및 예측 업무 공유 및 WEEK3&4 예보 업무로의 ISO 지수 활용에 대한 토의

  · 대만의 기온 강수에 대한 BSISO 효과를 3분위 합성장으로 표현하고 causal analysis에 활용하고 있음

- extended-range TC forecast를 위한 CWB의 TC tracker 활용 및 MJO 효과를 포함한 개선 연구 공유

  · CPC의 Tropical Hazard and Benefits Outlook 에서 아이디어를 얻어 NCEP GEFS 기반 TC formation 예측 시스템을 개발하였고 매주 월요일 CPC로 outlook을 제공 중. 개발 중인 새로운 TC tracker 예측 시스템에서 나온 정보는 2019년 온라인으로 제공 계획.

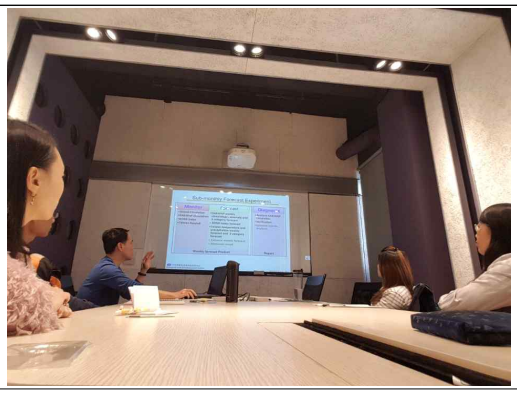
- basic statistic 기반 BSISO의 경년변동 및 2018년도 BSISO activity 소개

  · 1981년 이래 BSISO 활동에 있어서 2018년을 평가하자면 평년 수준의 활동성을 보인 해였음. 그러나 BSISO 경년 변동에 있어서 뚜렷한 decadal trend 가 있기에 최근 10년 동안의 BSISO 활동에 있어서 2018년을 평가하자면 활동이 활발했던 해로 분류 됨. 굳이 지역별로 비교하자면 인도양에 비해서는 서태평양에서의 BSISO 변동이 컸음.

  · 대만 지역에 대한 BSISO fractional variance의 경년 변동은 decadal trend 보다는 약 2.5년 주기의 변동이 뚜렷한데 이는 대만 지역의 기후 변동이 QBO에 영향을 받는다는 기존 이론들과 결부시켜 이해해 볼 수 있음.

  · 연도별 BSISO statistic을 APCC 홈페이지에서 서비스하면 좋겠다는 의견이 있었음.

▪ 출장보고자의 매 년 CWB 방문을 제안 받음. 추후 여건에 따라 결정 할 사안임.



CWB 모델팀과의 토의

CWB 장기예보부문과의 오찬 후 단체사진

모델 편차 보정 효과 관련 회의 후

3. 대만국립대학 대기과학과에서 APCC BSISO 서비스 및 연구에 대한 강의

- 제목 : Real-time BSISO Monitoring, Forecast and Application at APCC

- 강의 전 대학원생 수업에 잠시 참관하게 되었는데 수업 과제로 실제 ISO의 발달을 살펴보는 모니터링 활동을 한다는 것에 놀라웠음. 현상을 개념적/이론적으로 가르치기보다 실제로 관찰하면서 이해하게끔 하는 교육 방법에서 대만 기상학계의 미래를 기대하게 됨.

- 강의 후 BSISO impact에 관한 토의 (with Prof. Mong-Ming Lu & Prof. Chung-Hsiung Sui) : 이론적으로는 BSISO1 모드가 BSISO2 모드에 비해 많은 것을 설명할 수 있지만 특정 현상, 특정 지역, 특정 시기에 있어서는 BSISO2의 기여가 분명 두드러지게 존재하므로 각 모드에 대한 더 나은 이해를 위한 연구들이 필요하다는 것에 공감.

- 출장보고자의 2018년 방문 이후 APCC의 BSISO 모니터링 activity를 따라 Prof.Lu의 그룹과 CWB LRF section도 매 주 수요일에 BSISO 모니터링을 수행하여 왔음. 올 해 BSISO 시즌에는

teleconference로 APCC와 함께 모니터링을 진행하고 싶다는 제안이 있었음.

- 올 해는 APCC에서 BSISO 모니터링 과업이 업무로 책정되지 않음. 그러나 BSISO 연구진들은 당해연도 업무인 BSISO 영향분석의 일환으로 모니터링 활동을 비정기적으로나마 수행할 계획. 따라서 큰 이슈가 있을 때 간헐적으로 CWB/NTU와 BSISO 모니터링 결과물들을 공유하고자 함.

국립대만대학교에서 강의 후 단체사진

※ 세부 일정

날짜	시간	수행내용	비고
3/11 (월)	11:00	대만 도착	
	14:00-15:30	CWB 새 모델의 ISO 모의 능력 및 편차 보정 효과에 대한 논의	
	16:30-18:00	대만국립대학에서 APCC BSISO 연구결과 강의	
	18:00-20:00	Prof. M.M. Lu와의 만찬	
3/12 (화)	10:00-12:00	APCC BSISO 예보의 활용 가능성에 관한 소개	
	12:00-13:30	Deputy Direct General, Mark. Cheng 과의 오찬	
	13:30-14:00	Deputy Director. T.C. Yeh 와의 면담	
	14:00-15:00	APCC에서 개발한 WNP ISGPI 에 대한 토의	
	15:00-17:00	CWB 기후 모델팀과의 토의	
3/13 (수)	10:00-12:00	APCC S2S TP에 관한 소개	
	12:00-13:30	CWB LRF section 과의 오찬	
	14:00-17:00	CWB LRF section과 BSISO 활용에 관한 토의	
	17:30-20:00	기후 모델팀의 BSISO 담당자와의 만찬	
3/14 (목)	11:00	대만 출발	

User needs reliable and actionable information for decision-making.

Goal of S2S project

Many decisions in agriculture, water, disaster risk reduction and health fall into the sub-seasonal to seasonal (S2S) range.
The goal of a new WWRP/THORPEX-WCRP joint research project is to improve forecasts and understanding on the S2S scale, and promote uptake by operational centers and use by the applications community.

The WWRP/WCRP S2S project (2013)

The APCC's Subseasonal Forecasting Activity

(March 11, 2019)

Hae-Jeong Kim*, Yoo-Rim Jung
APEC Climate Center

Mission of the APEC Climate Center

To enhance the socio-economic well-being of member economies by utilizing up-to-date scientific knowledge and applying innovative climate prediction techniques.

Climate Prediction

APCC produces value-added, reliable, and real-time climate prediction information and provides the APEC region with it.

Interdisciplinary Research

APCC leads in the development of interdisciplinary research and application techniques at the climate-environment-society nexus.

Climate Information Services

APCC strives to be a key climate database center to distribute climate data, information products, and related tools.

International Cooperation

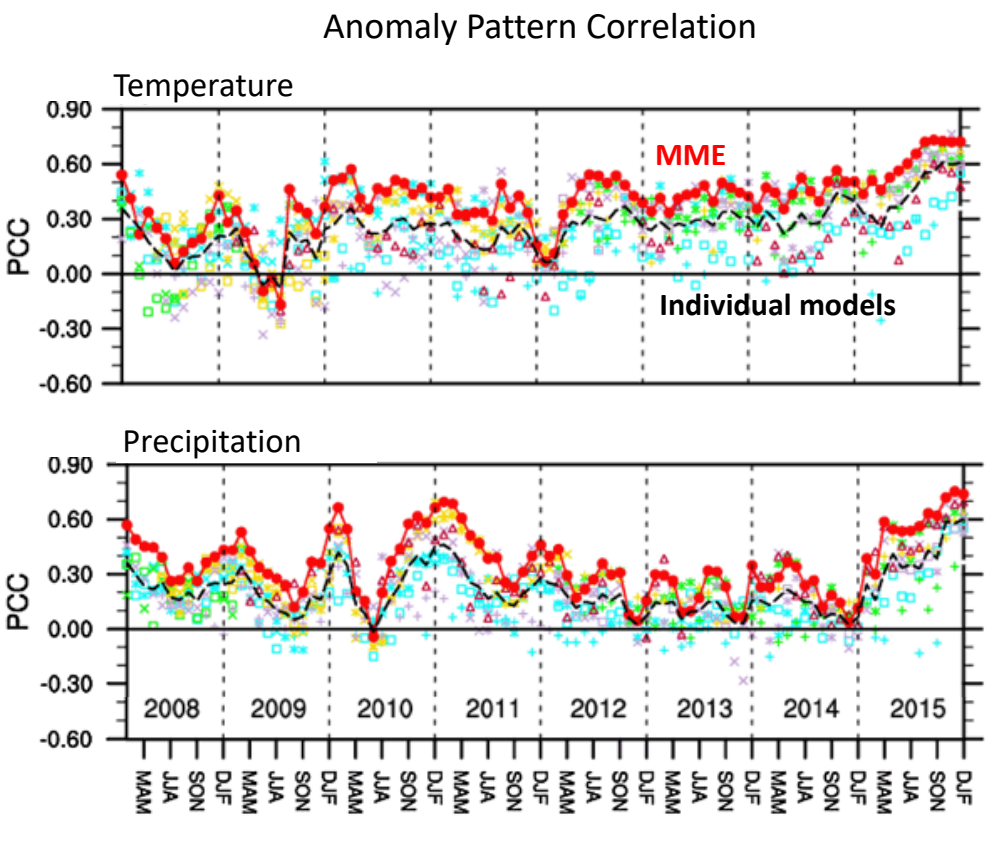
APCC guides developing countries from the APEC region toward building their own capacity to produce reliable climate prediction information.

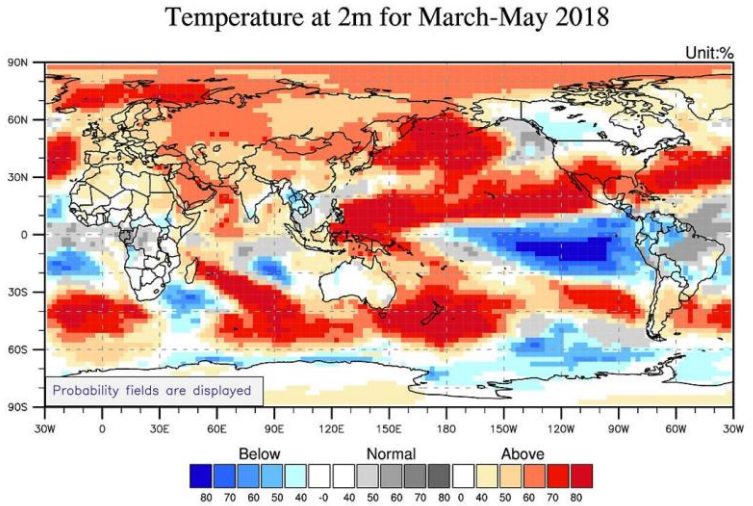
Climate Prediction & Information Service

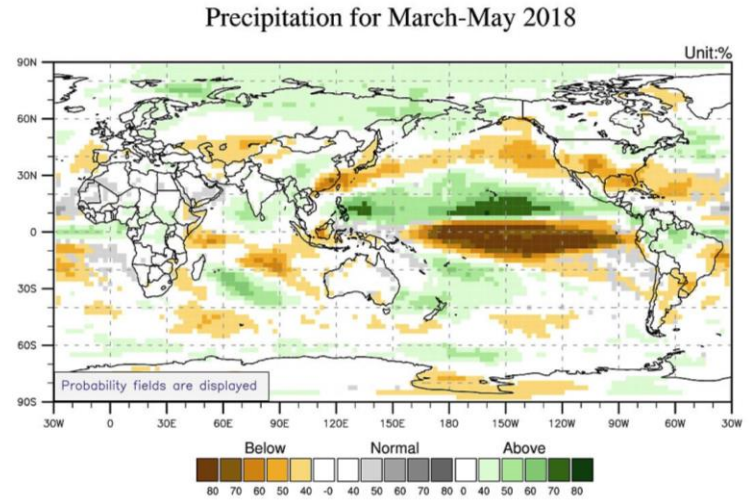
- ✓ ***http://www.apcc21.org***

Seasonal Forecast

- **Producing skillful real-time climate predictions and developing reliable climate prediction system based on a Multi-Model Ensemble (MME) technique.**
- **MME seasonal prediction is one of the most reliable seasonal forecast information at present.**







Min et al. (2017), Climate Dynamics

APCC MME Prediction System

- **The world's largest MME system based on international cooperation to generate monthly rolling 3-month and 6-month MME climate outlooks.**

Multi-institutional Cooperation

Economy	Organization/Institute
Australia	Bureau of Meteorology (BoM)
Canada	Meteorological Service of Canada (MSC)
China	Beijing Climate Center (BCC) Institute of Atmospheric Physics of China (IAP)
Chinese Taipei	Central Weather Bureau of Chinese Taipei (CWB)
Italy	Euro-Mediterranean Center on Climate Change (CMCC)
Japan	Japan Meteorological Agency (JMA)
Korea	Korea Meteorological Administration (KMA) Pusan National University (PNU)
Peru	Servicio Nacional de Meteorología e Hidrología (SENAMHI)
Russia	Hydrometeorological Centre of Russia (HMC) Main Geophysical Observatory of Russia (MGO)
UK	Met Office
USA	Center for Ocean-Land-Atmosphere Studies (COLA) International Research Institute for Climate and Society (IRI) National Aeronautics and Space Administration (NASA) National Center for Environmental Prediction (NCEP) / National Ocean and Atmospheric Administration (NOAA)

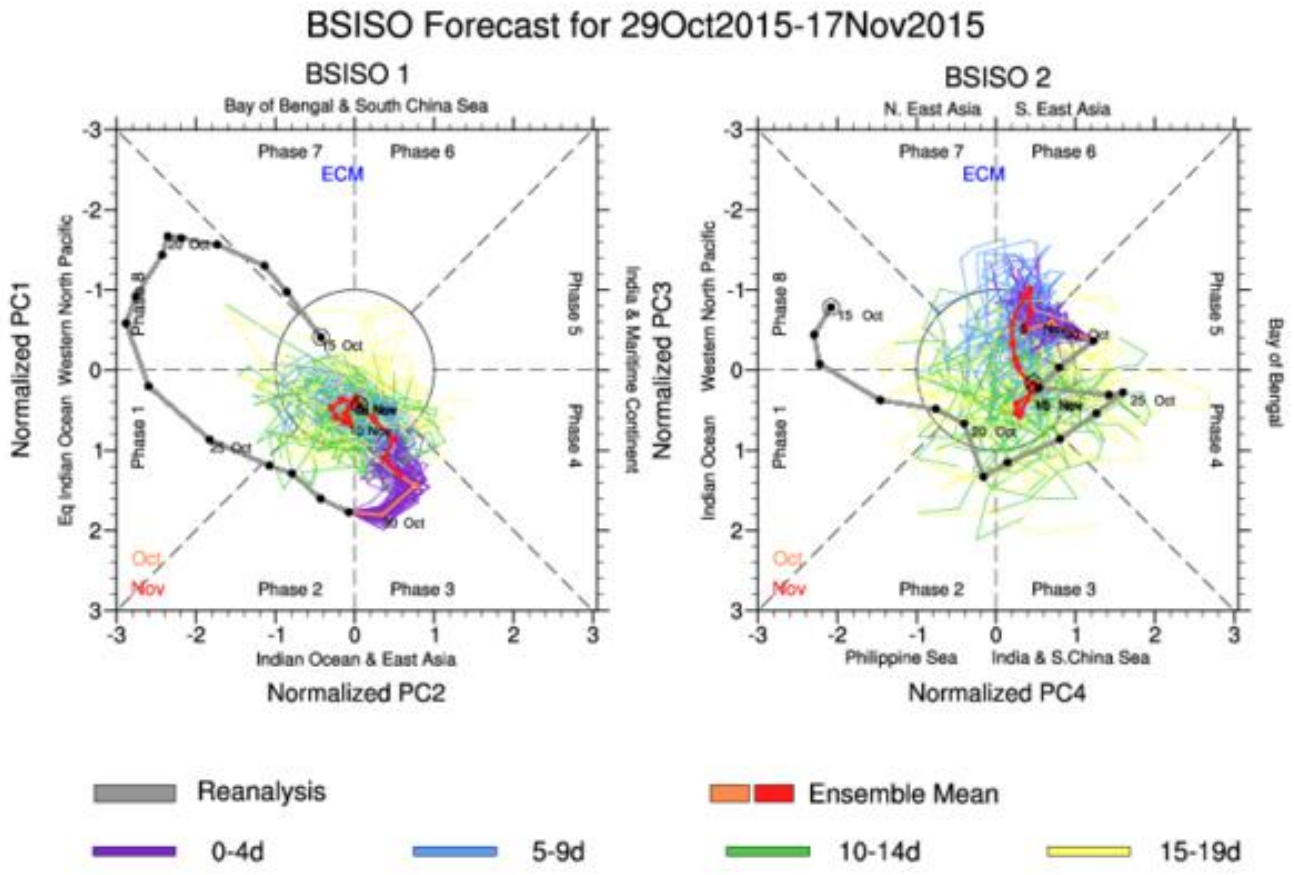
Climate Prediction & Information Service

✓ ***http://www.apcc21.org***

Expansion into subseasonal forecast
by providing BSISO real-time forecasts

BSISO(Boreal Summer Intraseasonal Oscillation) Prediction

- Since 2013, APCC has **expanded climate service** from seasonal to subseasonal timescale **by providing BSISO real-time forecasts** for upcoming 20 days. It is available from **May to October** at APCC webpage and updates everyday.
- For the **real-time forecast**, the Lee et al. (2013) BSISO index is applied.



BSISO(Boreal Summer Intraseasonal Oscillation) Prediction

The dominant mode of variability in the Asian summer monsoon.

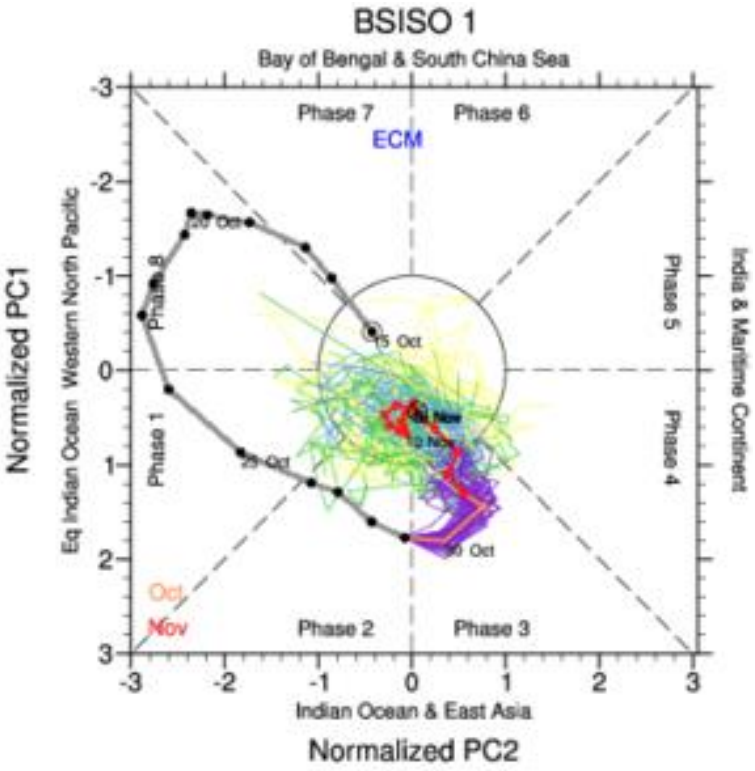
It influences on the *summer monsoon onsets, active/break phases of the monsoon and interacts with a wide range of atmospheric circulation and associated weather*.

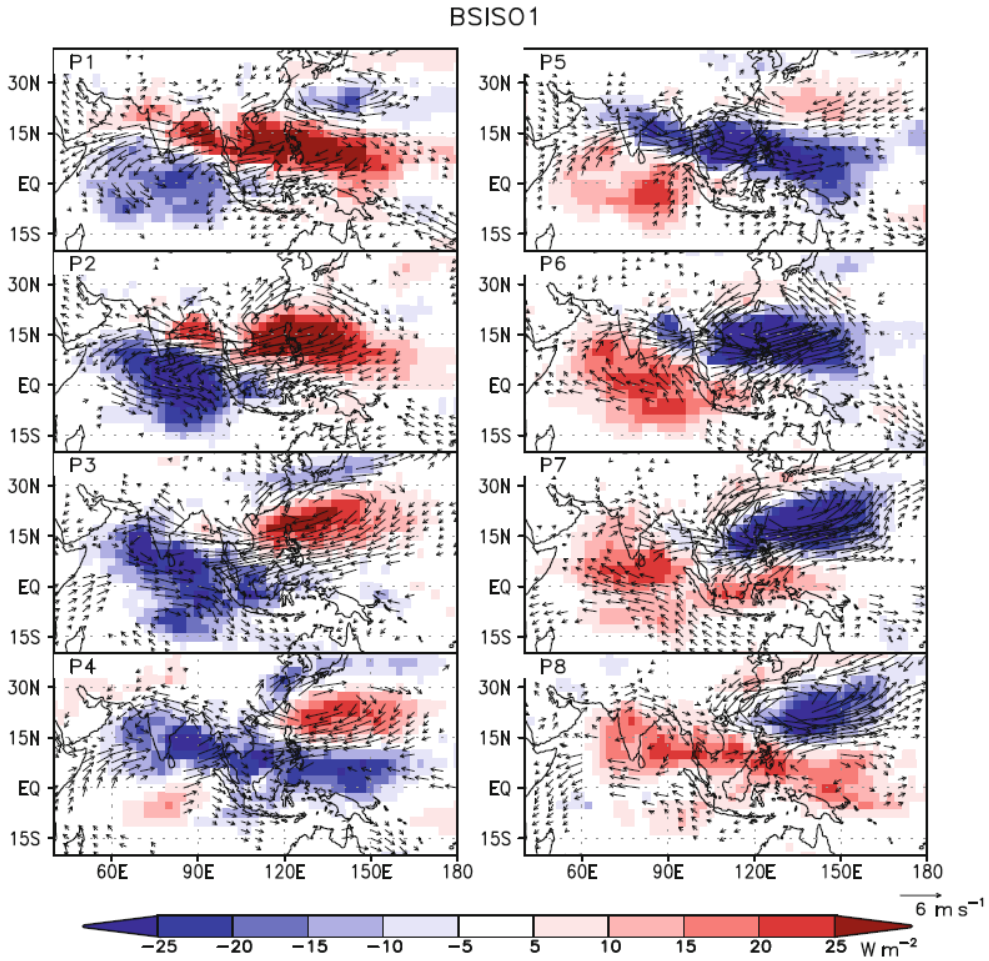
It is also a *possible source of seasonal climate predictability for precipitation* (Wang et al. 2009a; Lee et al. 2010) and *extratropical atmospheric circulation* (Ding and Wang 2005; Lee et al. 2011; Wang et al. 2012).

From Lee et al. (2013)

BSISO(Boreal Summer Intraseasonal Oscillation) Prediction

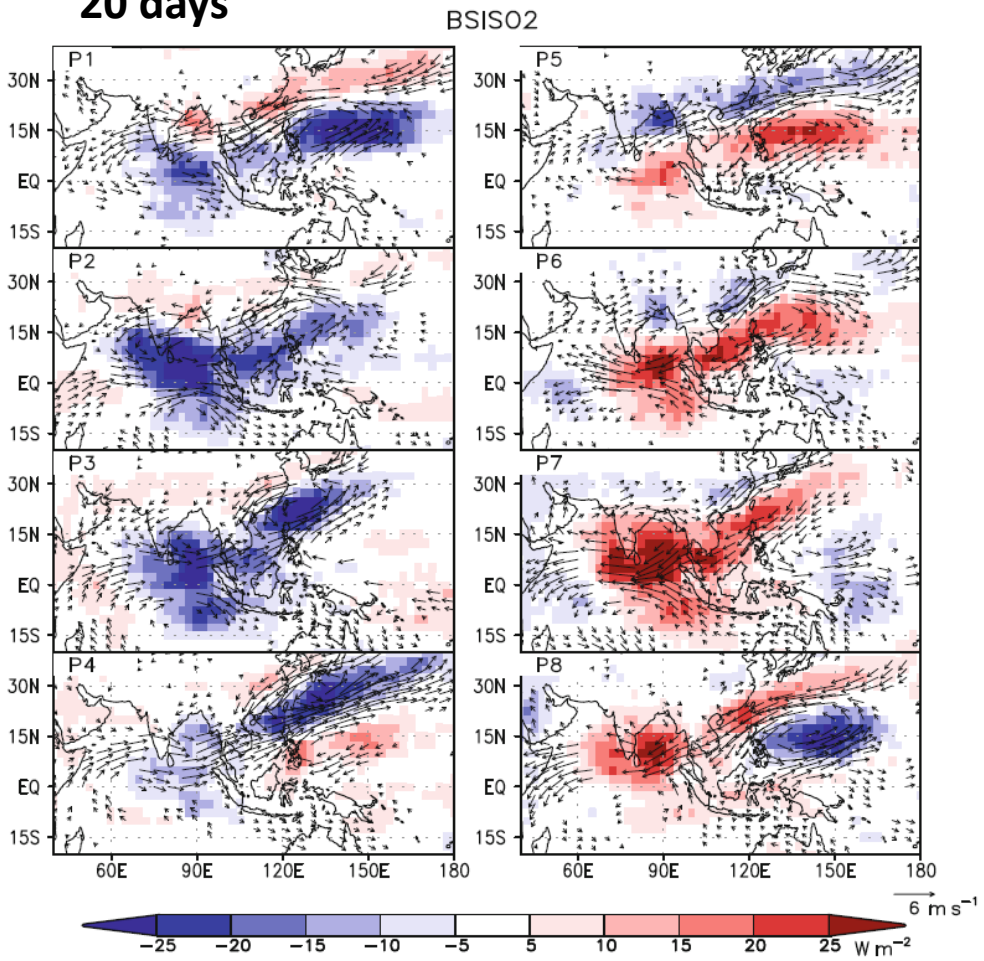
- The wet and dry spells of the BSISO strongly *influence extreme hydro-meteorological events*, major driving forces of natural disasters.
- **BSISO1 : canonical northward propagating BSISO over ASM region with 30-60 days quasi-oscillating period**

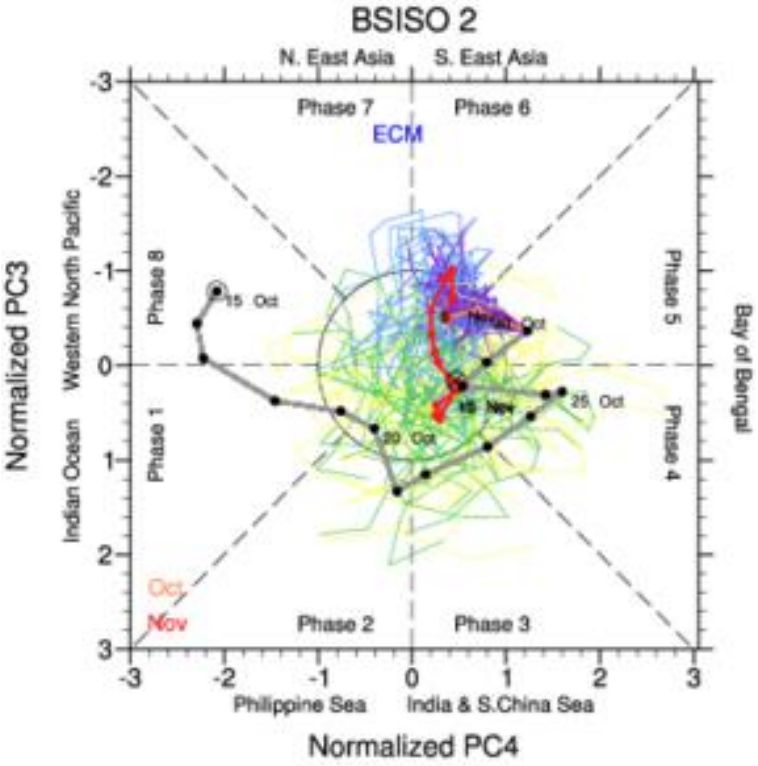




BSISO(Boreal Summer Intraseasonal Oscillation) Prediction

- The wet and dry spells of the BSISO strongly *influence extreme hydro-meteorological events*, major driving forces of natural disasters. Given the extreme impact of the BSISO, its monitoring and forecasting is important.
- **BSISO2 : pre-monsoon and onset mode with periods of both around 30 days and 10-20 days**





APCC BSISO Prediction System

- **Multi-Institutional Cooperation**

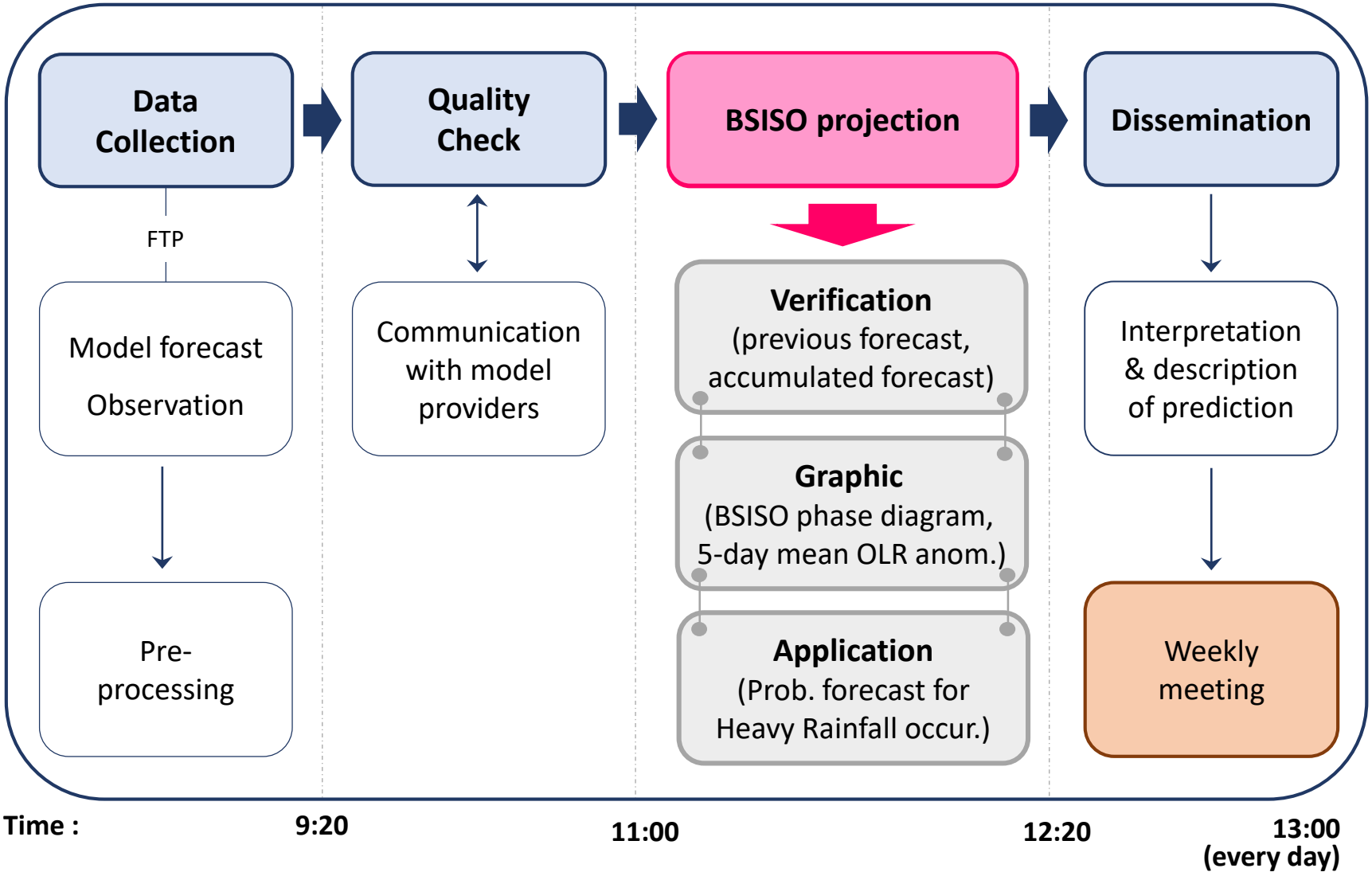
Institute	Model	Ensemble Size	Forecast Period	Update frequency	Resolution
NCEP	Climate Forecast System	4	40 days	Once a day	T126 L64
	Global Forecast System	1	16 days	Once a day	T574, T190 L64
Australia	POAMA 2.4 multi-week model	33	40 days	Twice per week	T47 L17
ECMWF	ECMWF Ensemble Prediction System	51	32 days	Twice per week	T639, T319 L62
Taiwan CWB	CWB EPS T119	6	40 days	Every 5 days	T119 L30

Required data

Specifications for the type and format of data needed from the operational centers in order to participate in the activity

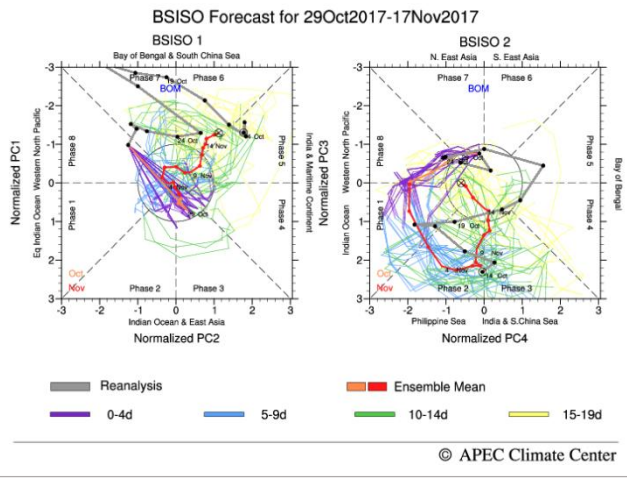
Fields	**OLR, and u850 totals (anomaly fields optional)**
Resolution	2.5° in latitude (10°S, 7.5°S, 5°S, …, 40°N) and longitude (40°E, 42.5°E, 45.0°E, … , 160°E) Daily averaged (00-24Z)
Update frequency	Daily, or less for those systems run at a reduced frequency
Additional data	At beginning of transfer, send analysis data for past 120 days
Format	ASCII

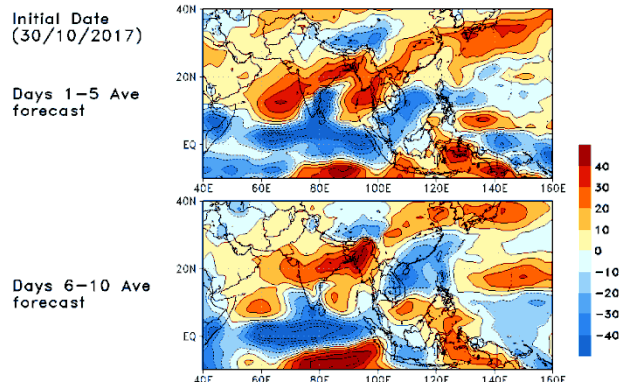
Operation Schedule

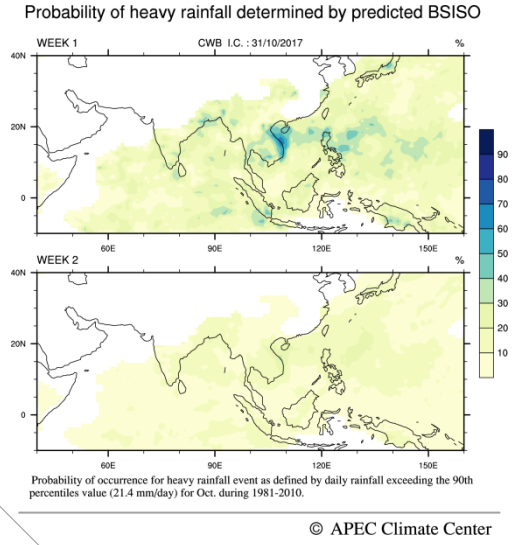


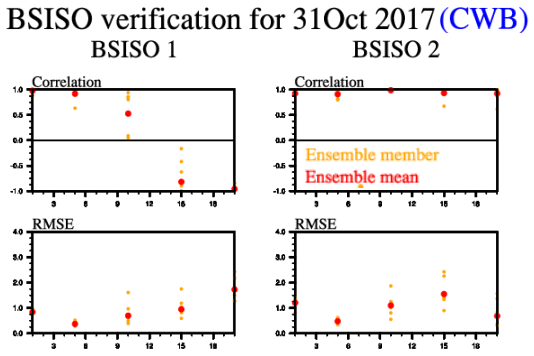
BSISO Forecast Products

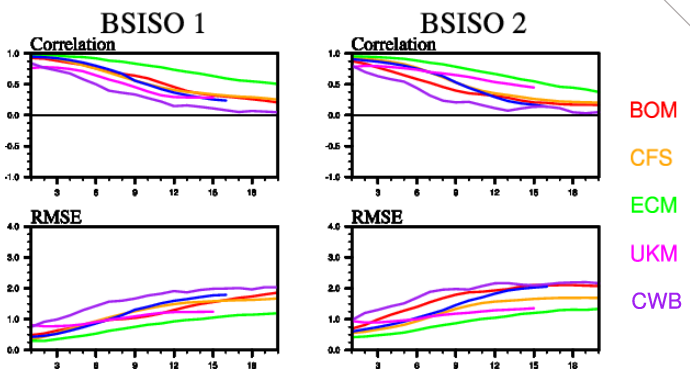
- Daily forecast of BSISO index
- 5-day mean OLR anomaly
- Probability of heavy rainfall for week1&2 predicted by BSISO index
- Verification results (hindcast, realtime forecast)





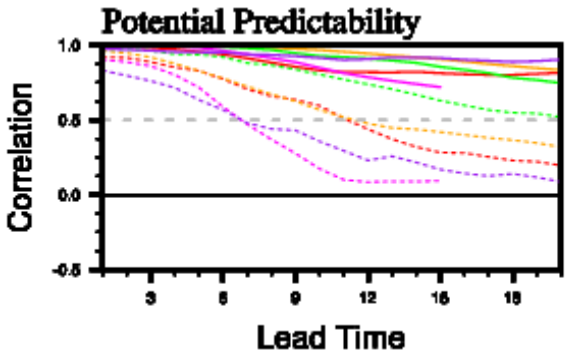




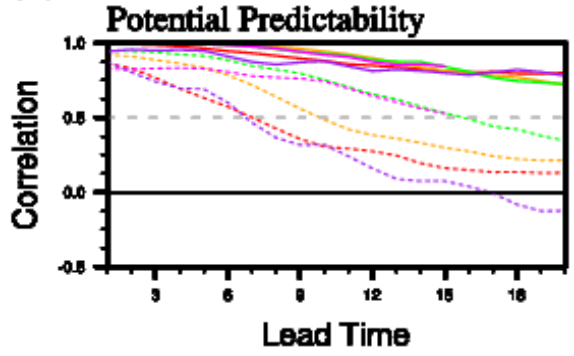


Performance of APCC BSISO

BSISO 1

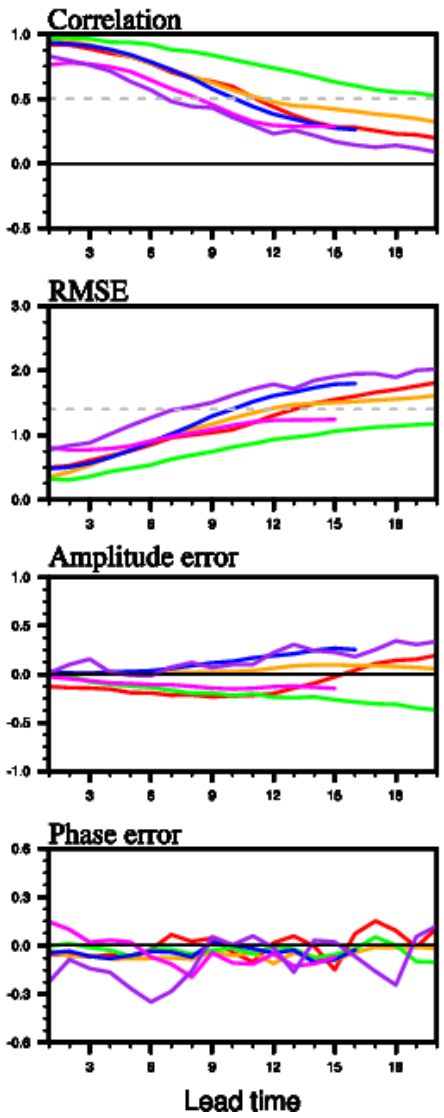


BSISO 2

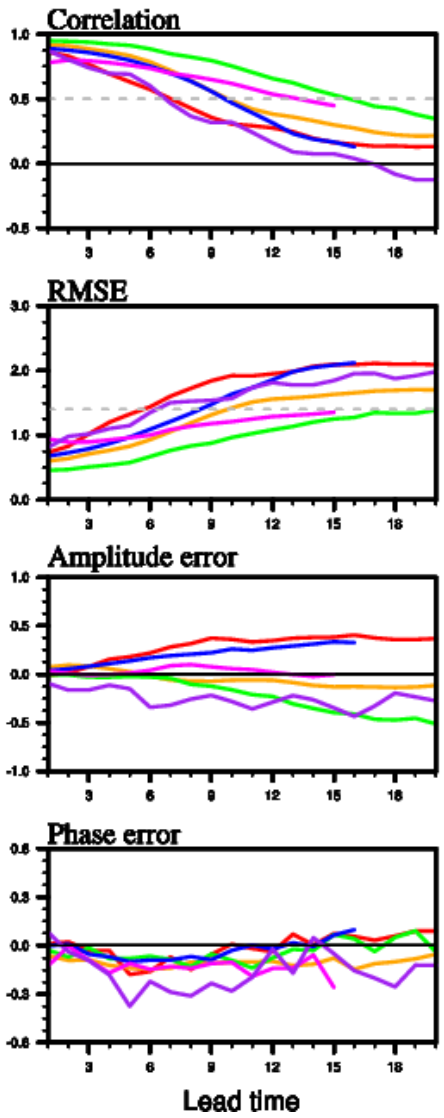


BOM CFS ECM UKM CWB

BSISO 1



BSISO 2



Better forecast? *practical use*

Reliable forecast

Reasonable interpretation

Recognition of the value

Actionable information

BSISO Forecast

Better forecast from better understanding on BSISO

Weekly meeting based on BSISO index forecast

BSISO Forecast

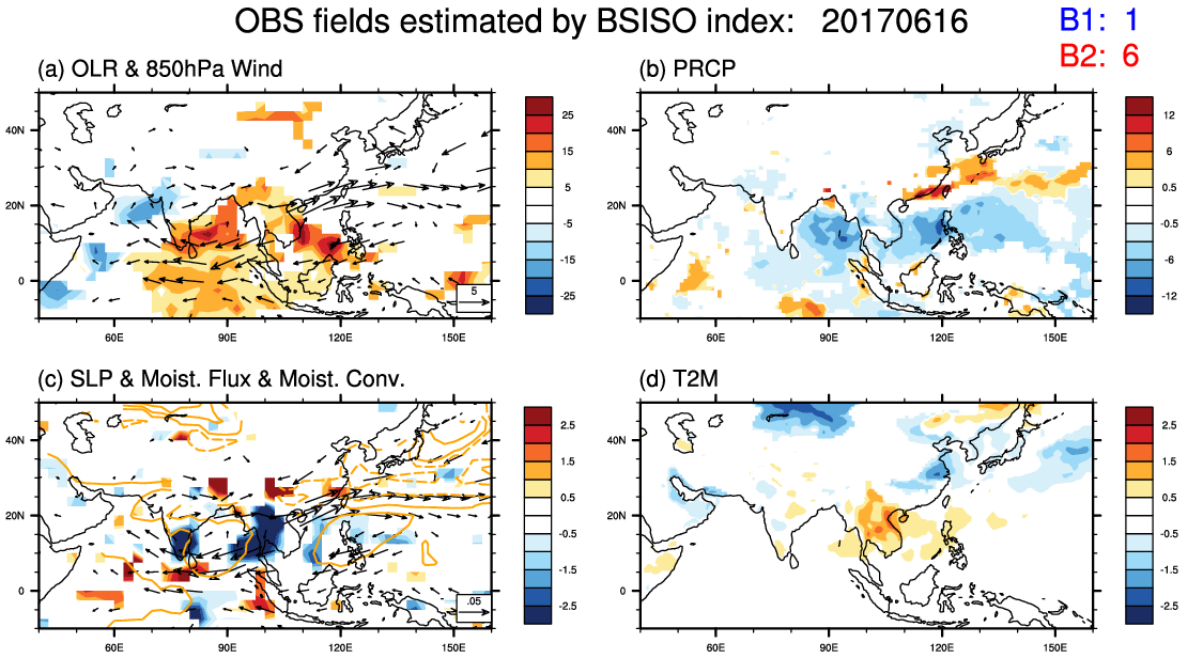
Better forecast from better understanding on BSISO

Weekly meeting based on BSISO index forecast

Before meeting

: Construction of analysis system for BSISO related atmospheric status
Searching climate issues and analyze them for previous week

Verification | Monitoring | Forecast



T2M, SH, RH, MSLP, OLR, Z, OMEGA, U, V, SST, PRCP

from ERA interim, NCEP/DOE, NOAA, GPCP, APHRODITE

BSISO Forecast

Better forecast from better understanding on BSISO

Weekly meeting based on BSISO index forecast

Before meeting

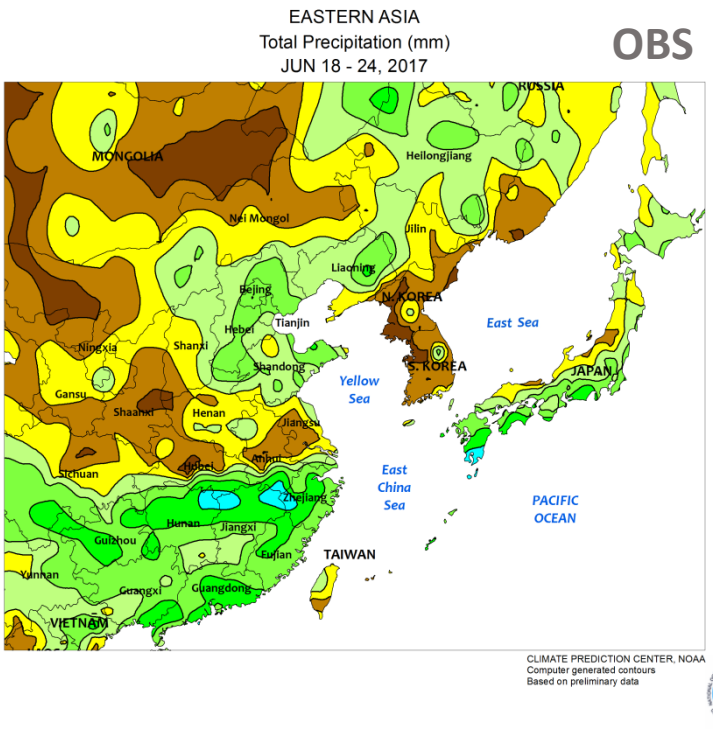
: Construction of analysis system for BSISO related atmospheric status
Searching climate issues and analyze them for previous week

Monitoring

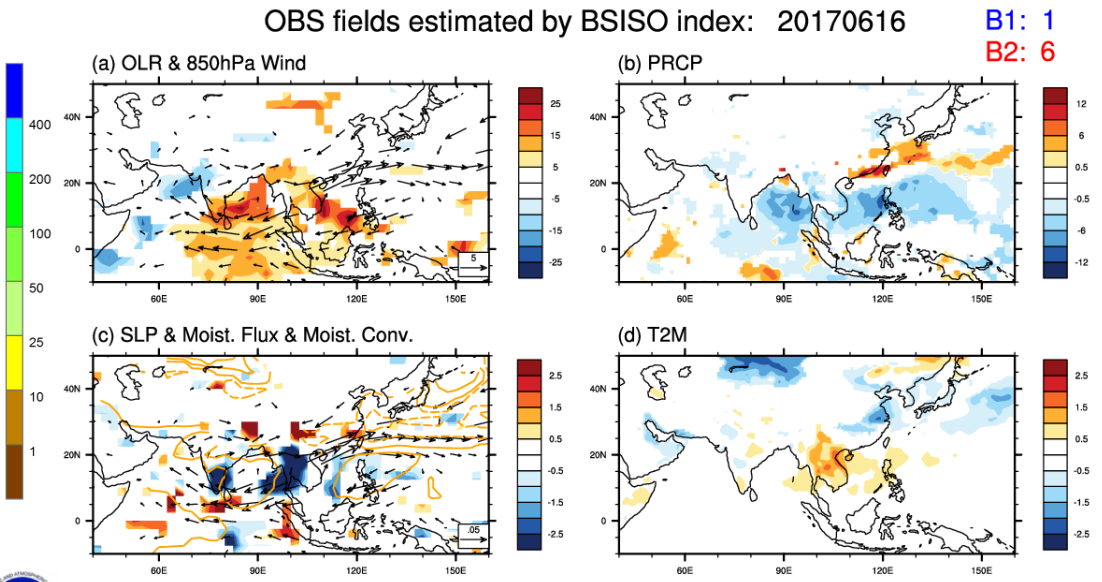
Asia monsoon region

Atmospheric circulation pattern

OBS



BSISO MONITORING



BSISO Forecast

Better forecast from better understanding on BSISO

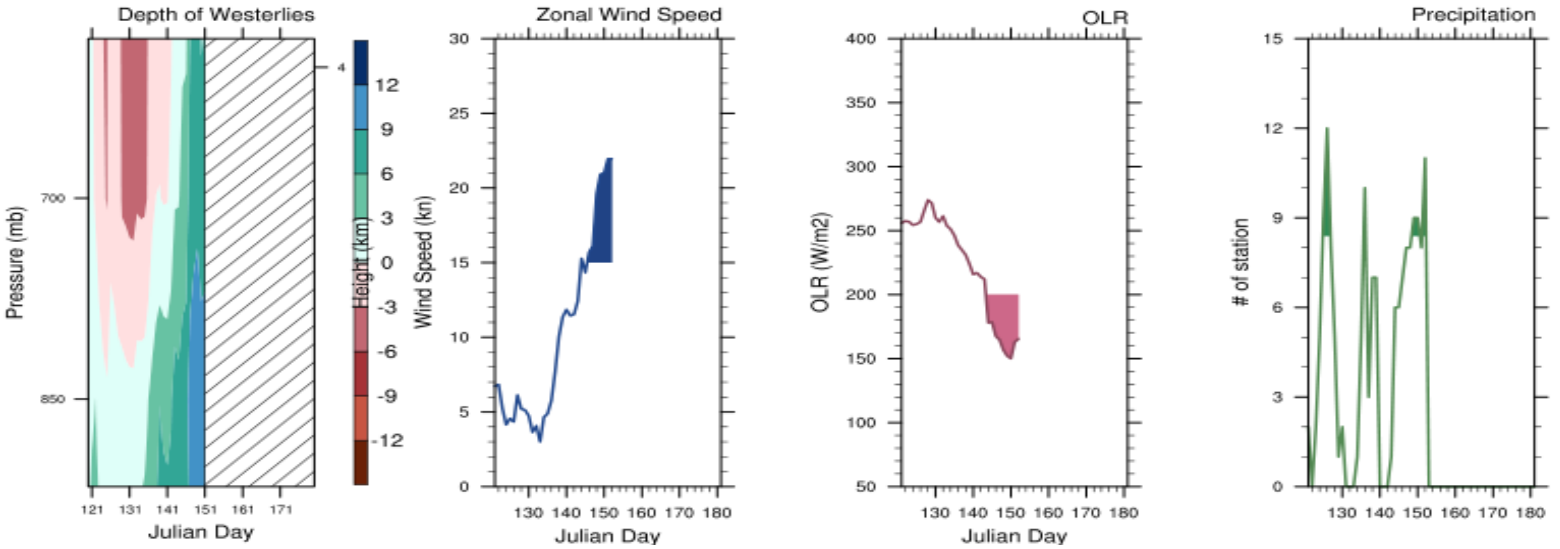
Weekly meeting based on BSISO index forecast

Before meeting

: Construction of analysis system for BSISO related atmospheric status
Searching climate issues and analyze them for previous week

Monitoring

- Asia monsoon region — *Atmospheric circulation pattern*
- India — *Monsoon onset, heat wave*



Possible Onset Date :

149 (5/29) 150 152

❖ **Southwest Monsoon Onset Monitoring (20180604)**

BSISO Forecast

Better forecast from better understanding on BSISO

Weekly meeting based on BSISO index forecast

Before meeting

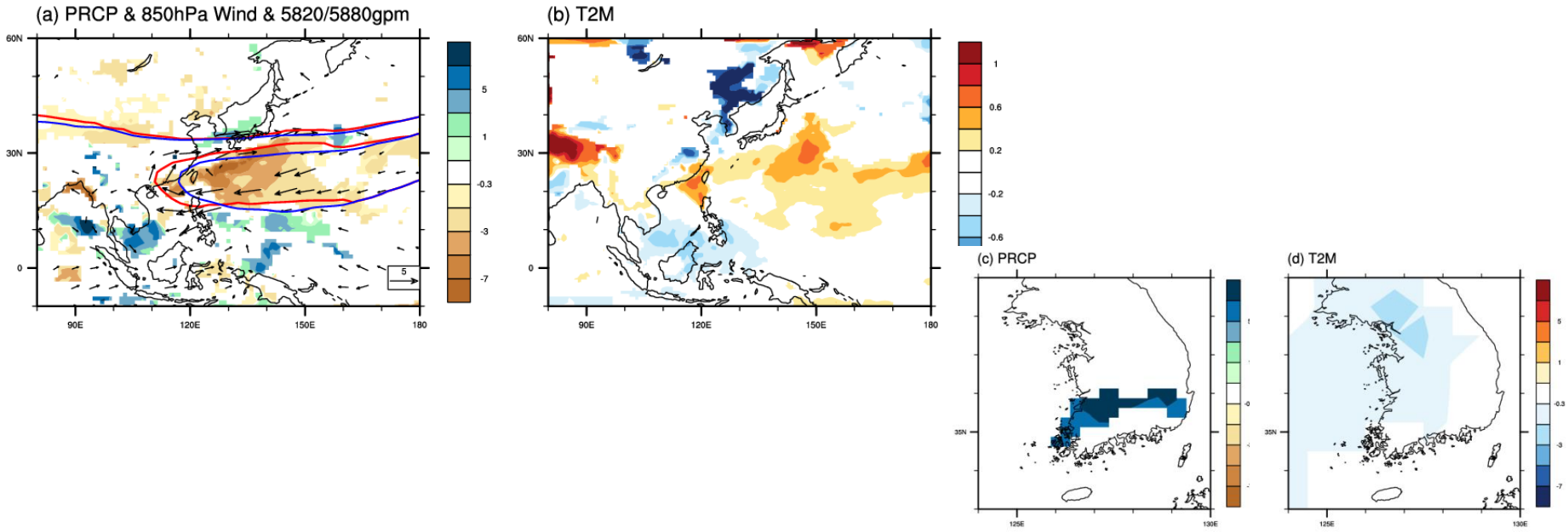
: Construction of analysis system for BSISO related atmospheric status
Searching climate issues and analyze them for previous week

Monitoring

Asia monsoon region	*Atmospheric circulation pattern*
India	*Monsoon onset, heat wave*
S. Korea	*Changma, heat wave*

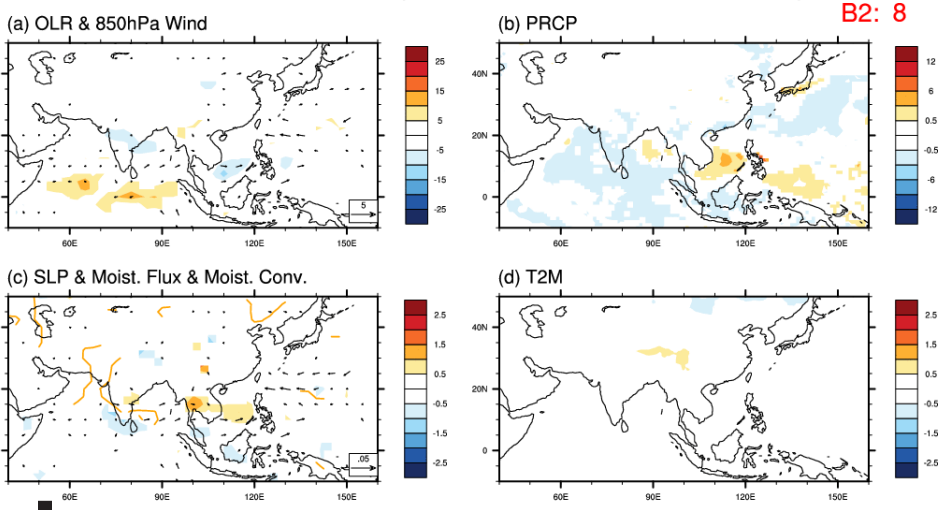
B1: 4
B2: 8

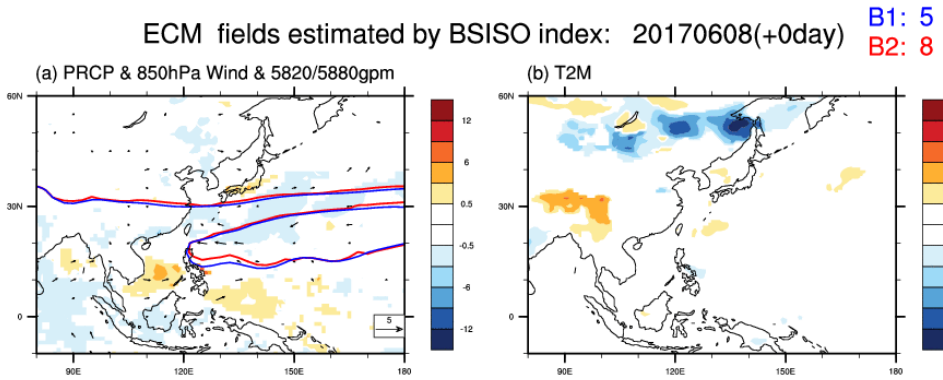
OBS fields estimated by BSISO index: 20160630

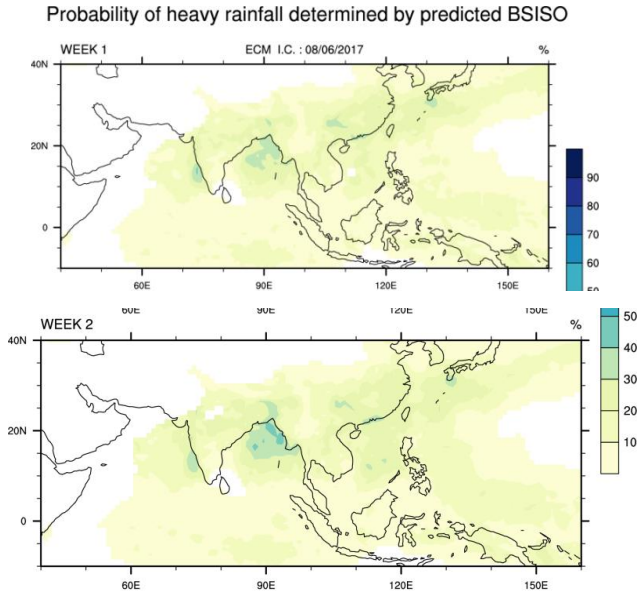


Weekly meeting
based on BSISO index forecast

Forecast







BSISO Forecast

Better forecast from better understanding on BSISO

Weekly meeting based on BSISO index forecast

Before meeting

: Construction of analysis system for BSISO related atmospheric status
Searching climate issues and analyze them for previous week

At meeting

: Discussion on verification for previous week, current status,
and prospect BSISO activity and atmospheric condition for next two weeks

After meeting

: Writing BSISO weekly bulletin

BSISO Forecast

Better forecast from better understanding on BSISO

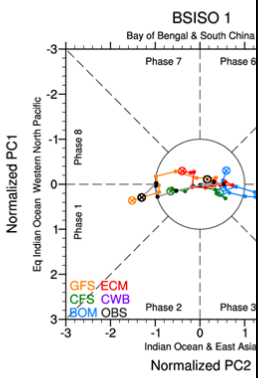
Extended forecast over Asia-monsoon region estimated by BSISO forecasts

Forming into the BSISO Weekly Bulletin (at the pilot stage for regular operation)

❖ **Updated every Monday from May to Oct.**

BSI

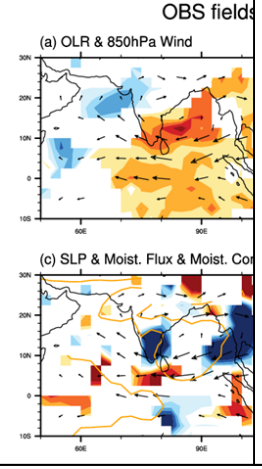
Verification



- Period : 08 June ~ 16 June
- BSISO 1 : nonactive 한 상태로 지
  모델들이 nonactive 한
- BSISO 2 : 약하게 유지되다가 P5-
  모델들이 관측의 경향을

Monitoring

2. Indian monsoon area
   -현재 +IOD
   -BSISO와 관련된 대기 순환장도
   -BSISO 로 인해 Anomalous 동풍
   Indo monsoon 이 약화되거나 북

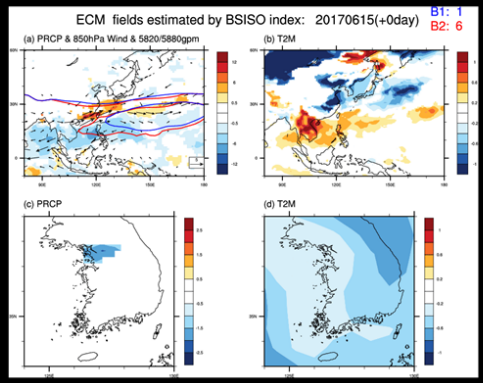


Forecast

1. ECMWF (I.C. 15Jun)
   : BSISO1 : P18→nonactive→P34
   : BSISO2 : P4→nonactive

[S.Korea]

- L15~20 : 장마 전선 남부(심지어 중부) 상륙 (30일)
- 장마비는 평년 or 평년 보다 적을 것으로
- 북태평양 고기압 (5880gpm) 서쪽으로 확장
- L0~5 : 동해안 cool
- L6~14 : 남한(한반도) cool
- L15~20 : 북서부(북한) cool
- 기온 ano 의 중국-한국 동서 대비



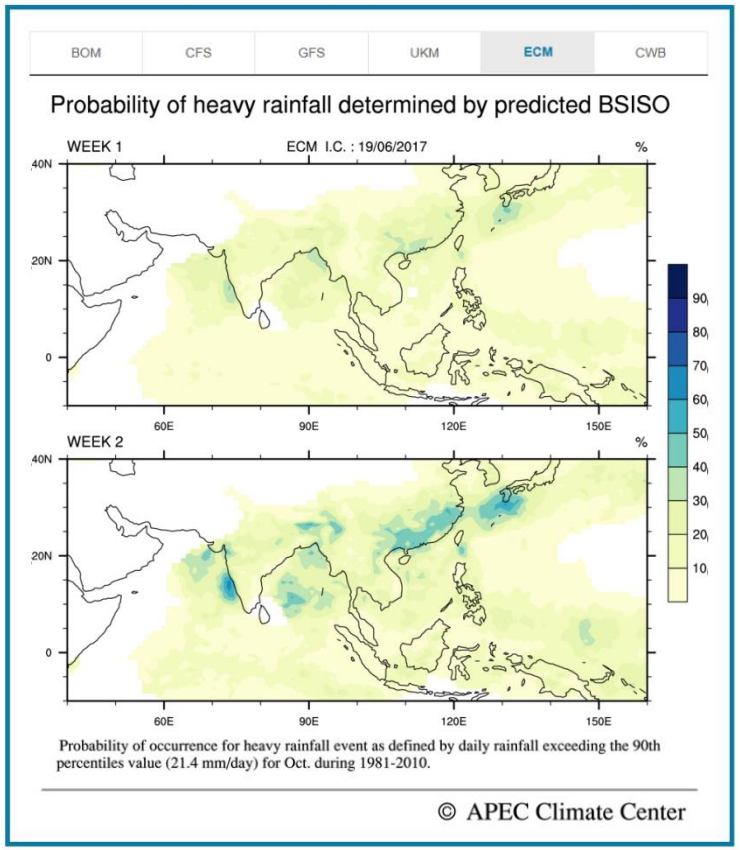
BSISO Forecast

Better forecast from better recognition of the value

Development of a guideline to increase practical use of BSISO forecast

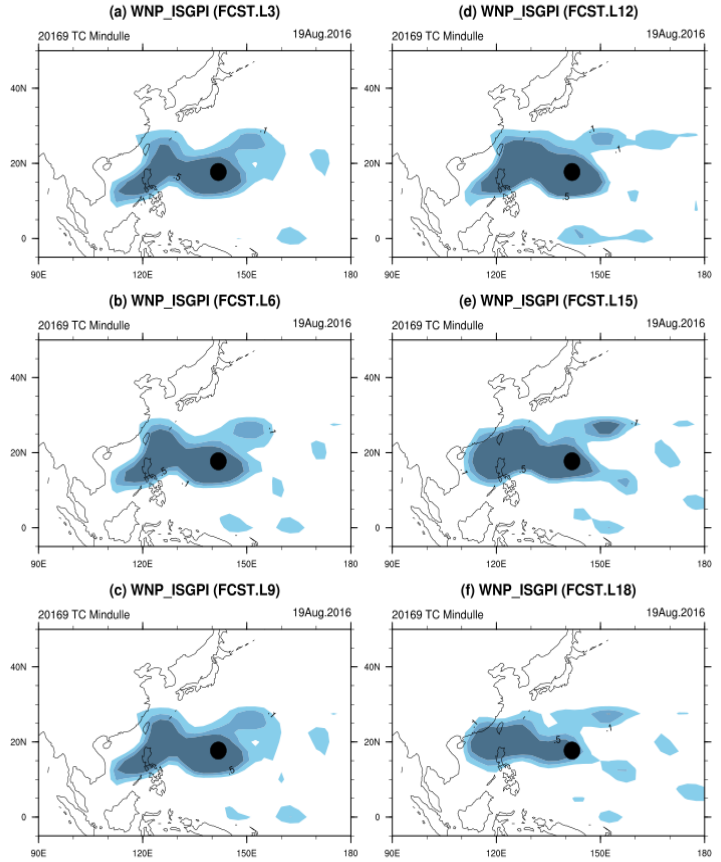
Heavy rainfall forecast based on BSISO index forecast [ECMWF]

❖ Ex> Japan flood, 398mm/4hr, July 6, 2017



ISGPI forecast estimated by BSISO index forecast [ECMWF]

❖ Ex> Tropical Cyclone Mindulle, August 19, 2016



Footprint

2013	2014	2015	2016	2017˙18

*Expanded APCC climate service from seasonal to subseasonal by providing **BSISO forecast***

BSISO Monitoring & Verification

BSISO MME

BSISO Application

to heavy rainfall probability

BSISO Application

WNP TC

Korea heat wave

Monitoring

Forecast

Verification

on BSISO impact

International Cooperation

BSISO Forecast

✓ **APCC's S2S Training Program (1-week)**

- Every 2 years, APCC has trained about 20 participants from developing countries
- 2014 : S2S to cope with high impact weather
- 2016 : S2S to cope with extreme hydrological events
- 2018 : APCC in the forefront of S2S Forecast

Summary

- APEC Climate Center (APCC) is a leading operational center providing seasonal forecast based on the **Multi-Model Ensemble** (MME) prediction system.

- APCC has produced **real-time BSISO forecast** using multi-models based on the international cooperation.

- The goal of APCC's BSISO forecasting activity is to produce better forecast by promoting **practical use** of real-time BSISO information.

Summary

- Along with pursuing **more reliable forecast**, we've made an effort to **improve our understanding** on BSISO forecast and created **user friendly information**.

- In order **to arouse the people to the worth of BSISO** forecast, the possibility of BSISO application is estimated.

- APCC's BSISO forecasting activity has become the origin of **APCC's S2S Training program** that takes places every two years.

THANK YOU

(http://www.apcc21.org)

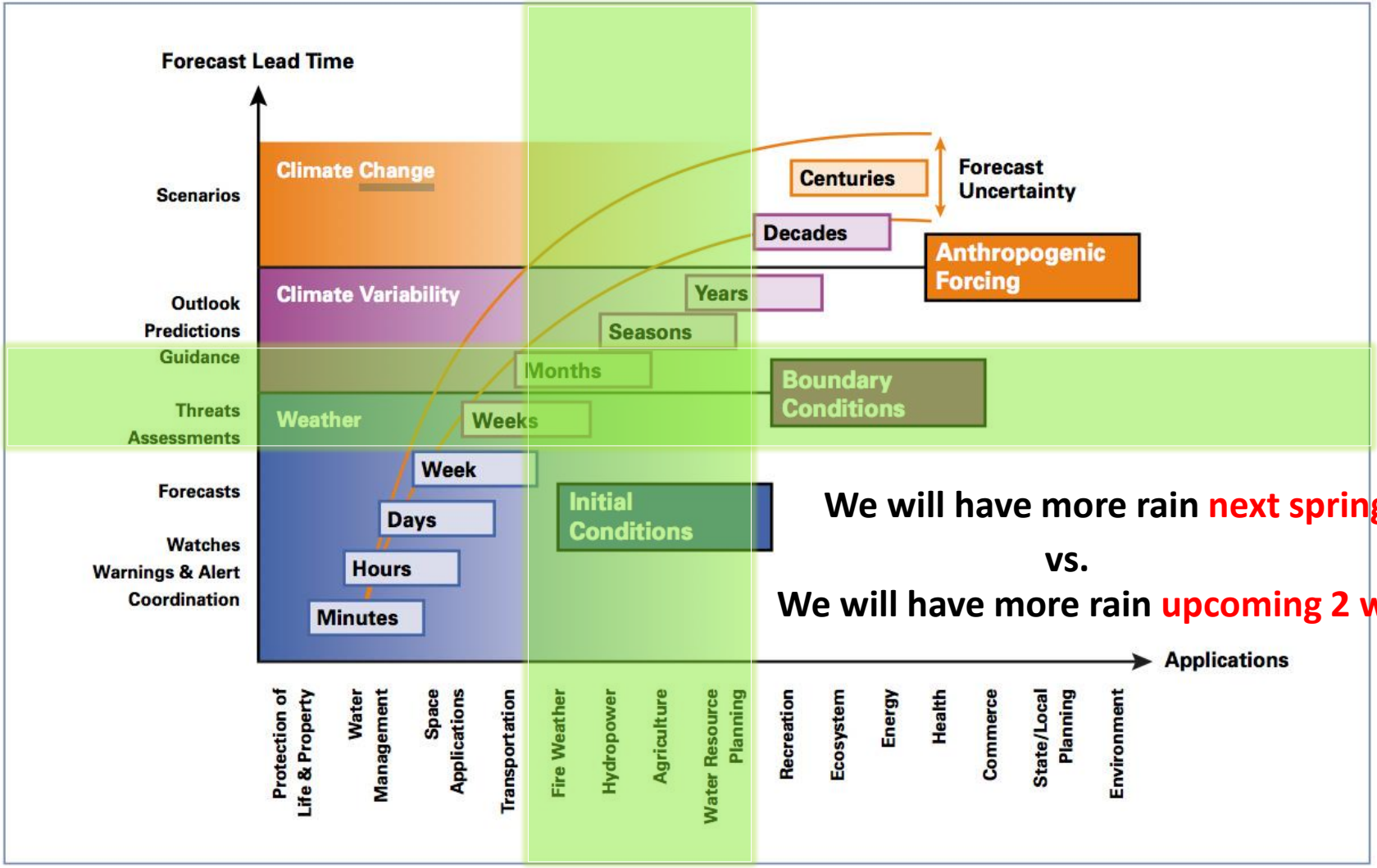
Subseasonal to Seasonal (S2S)

Hae-Jeong Kim
shout@apcc21.org

APCC APEC CLIMATE CENTER

March 11, 2019

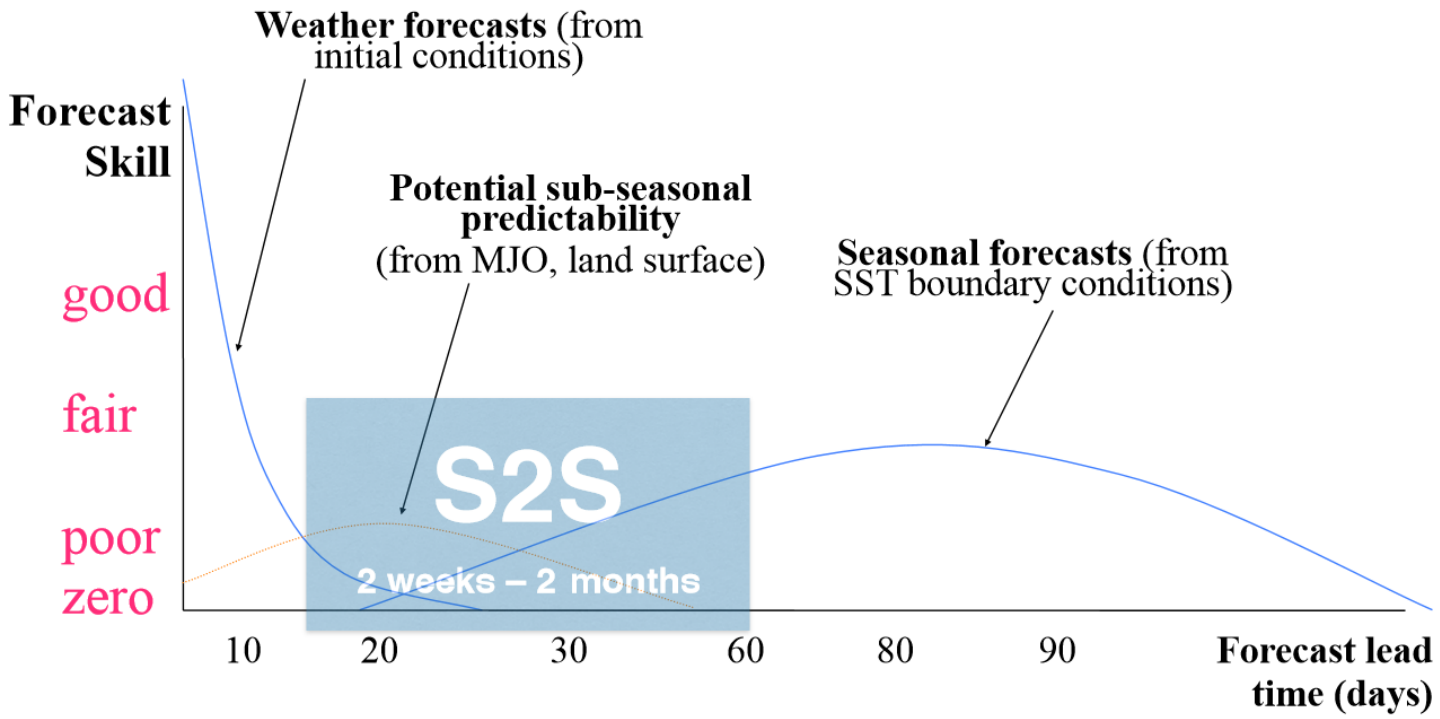
Climate forecast and its application



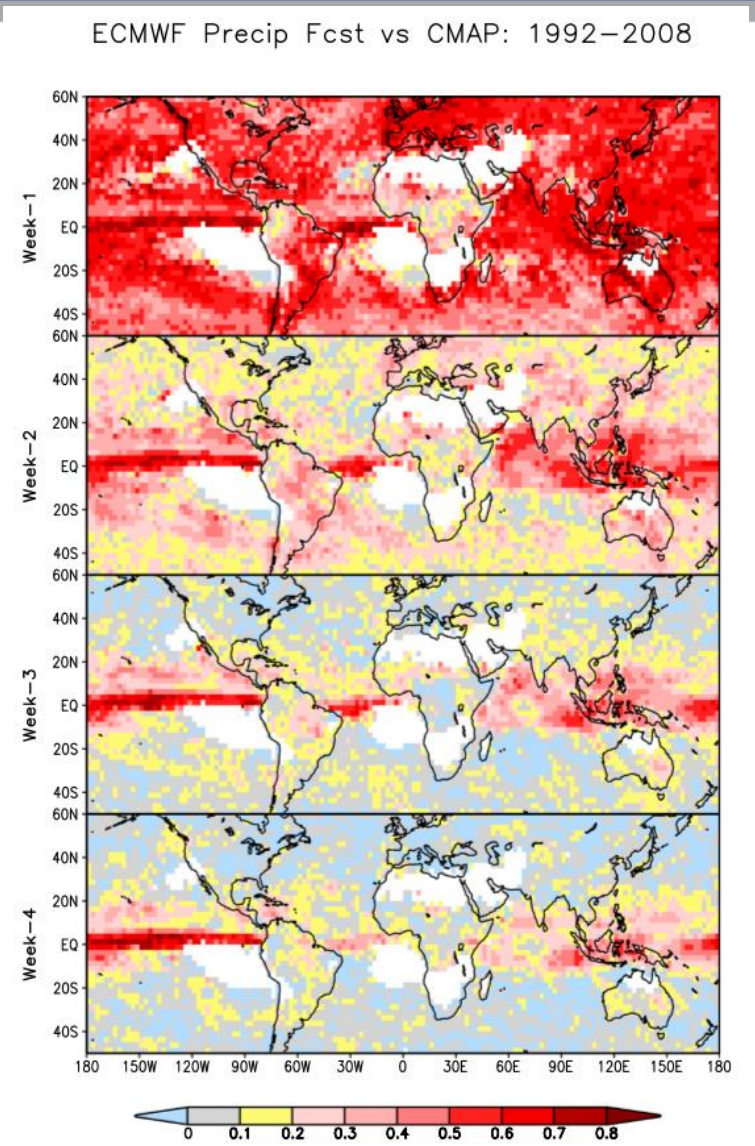
Weekly and monthly forecast become high demand product.

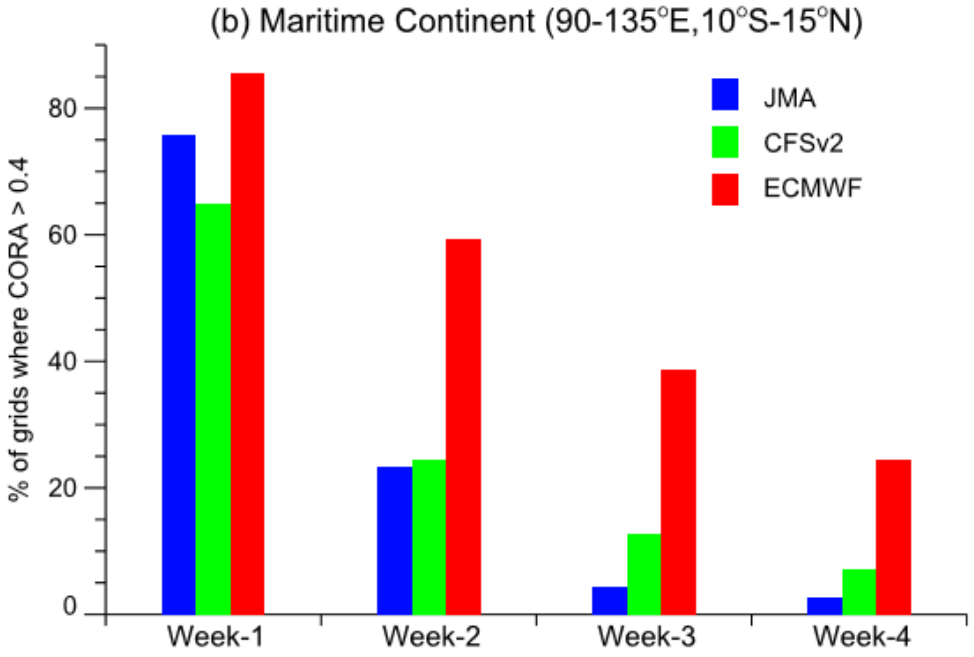
Subseasonal to Seasonal (S2S)

Forecast Lead Times



Subseasonal to Seasonal (S2S)





Li and Robertson (2015)

Subseasonal to Seasonal (S2S)

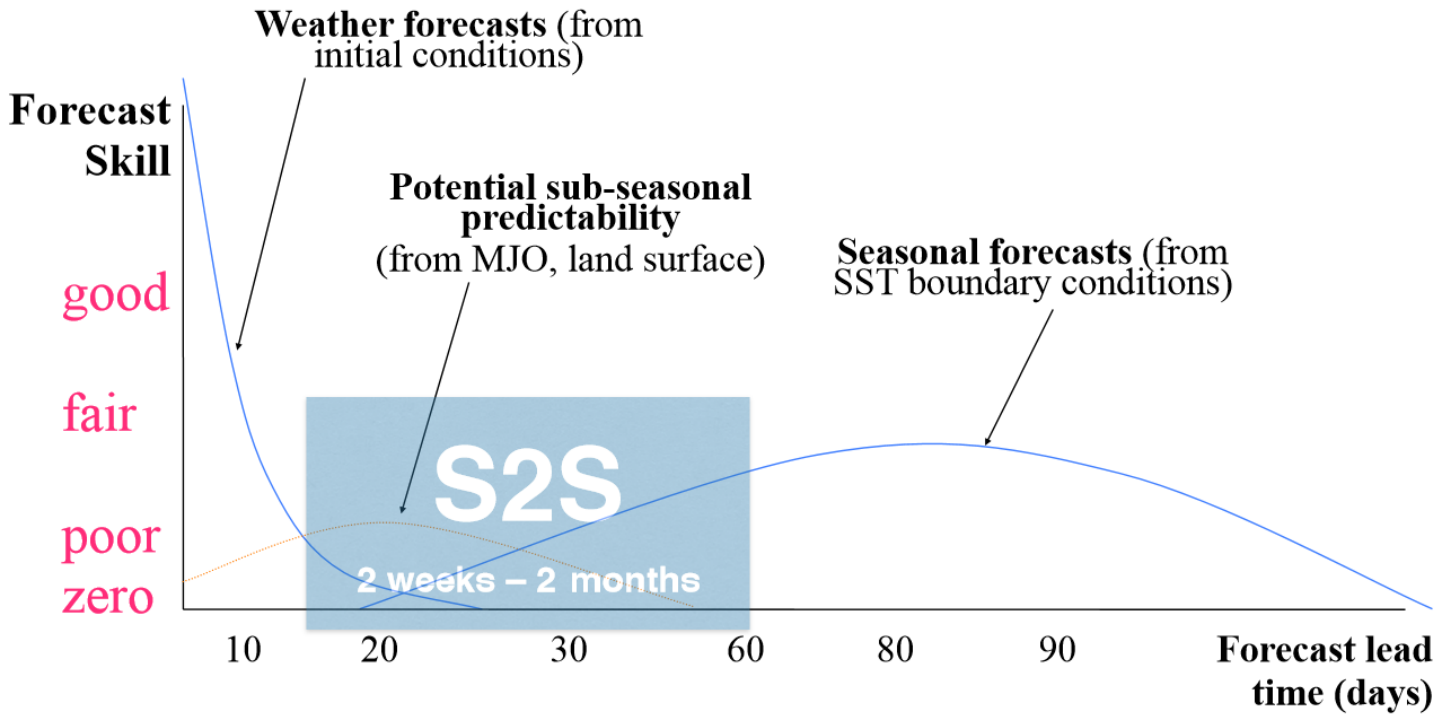
Goal of S2S project

Many decisions in agriculture, water, disaster risk reduction and health fall in the sub-seasonal to seasonal (S2S) range.
This time scale has been considered a "predictability dessert", and received less work than medium-range and seasonal prediction. The goal of a new WWRP/THORPEX-WCRP joint research project is to improve forecasts and understanding on the S2S scale, and promote uptake by operational centers and use by the applications community.

The WWRP/WCRP S2S project (2013)

Subseasonal to Seasonal (S2S)

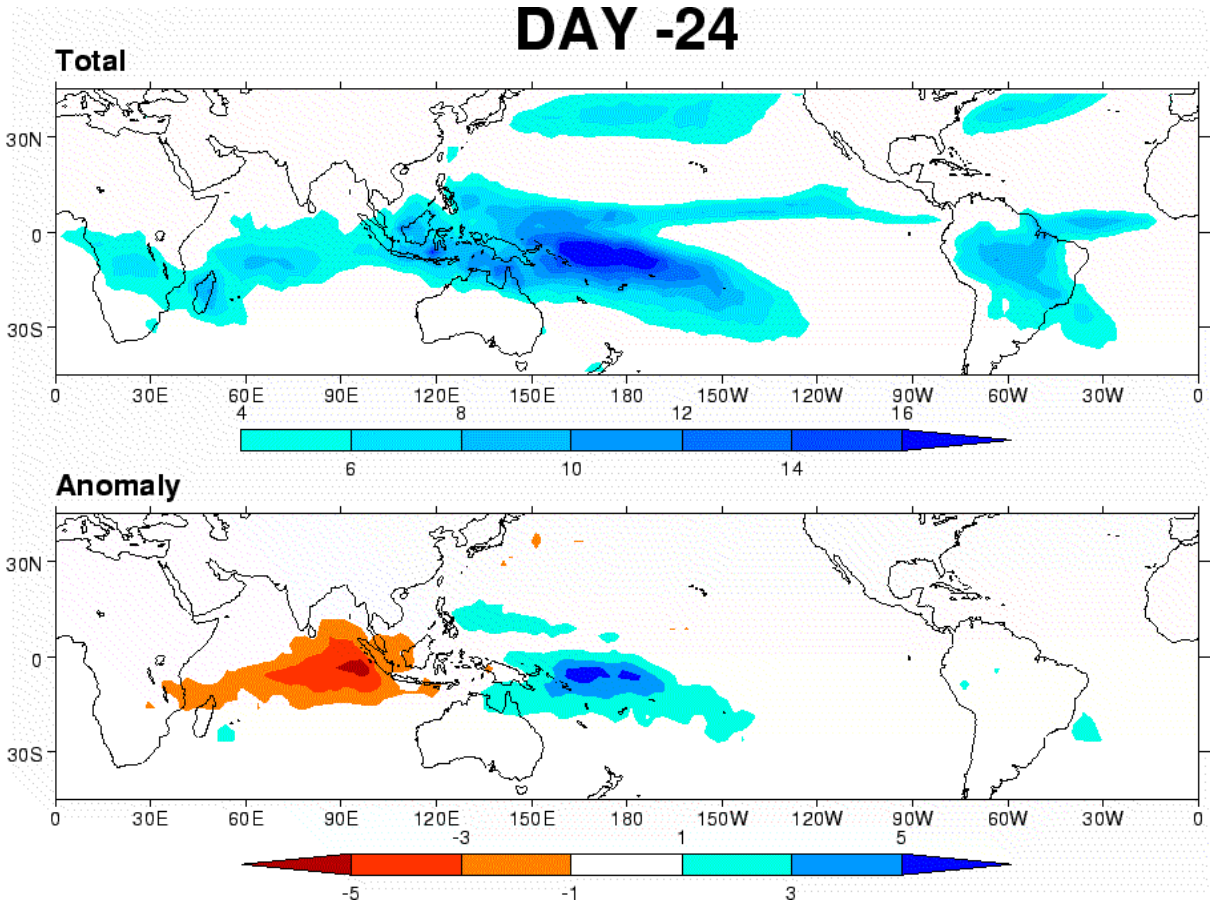
Forecast Lead Times



Key factors to improve S2S forecast skill are MJO and land surface. (predictability source)

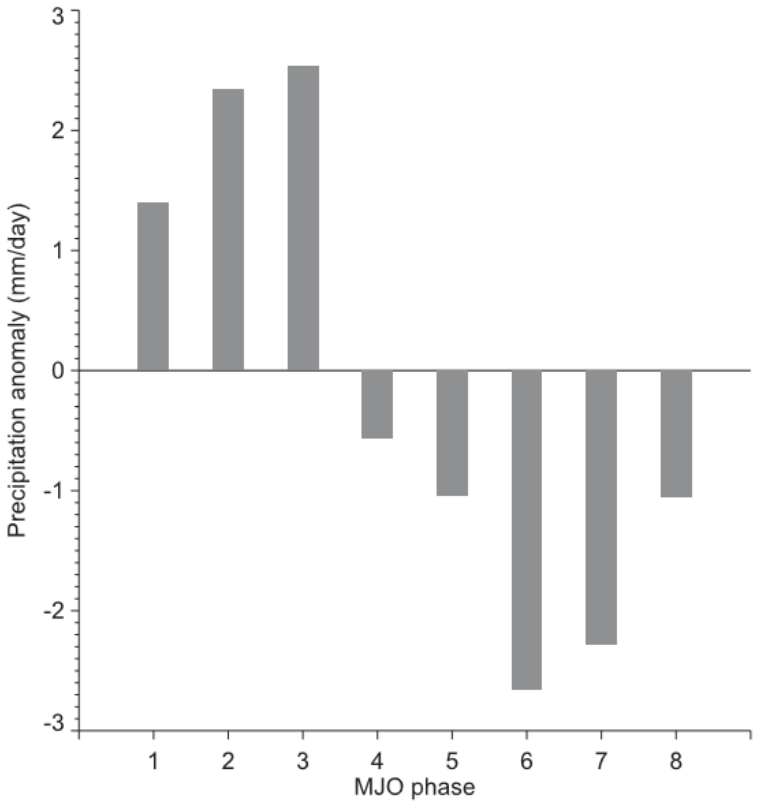
Predictability Source of S2S

Madden Julian Oscillation (MJO)

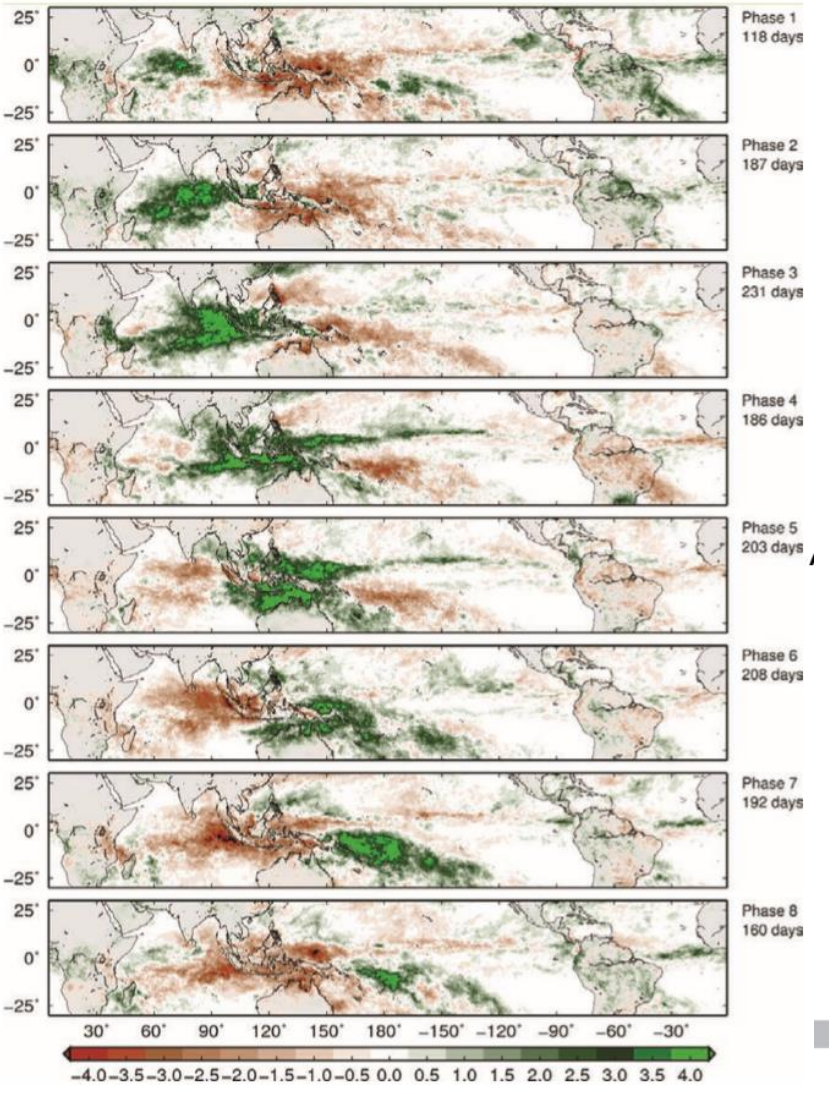


MJO is an *eastward moving* disturbance of clouds, rainfall, winds, and pressure that traverses the planet in the tropics and returns to its initial starting point in 30 to 60 days, on average.

Predictability Source of S2S

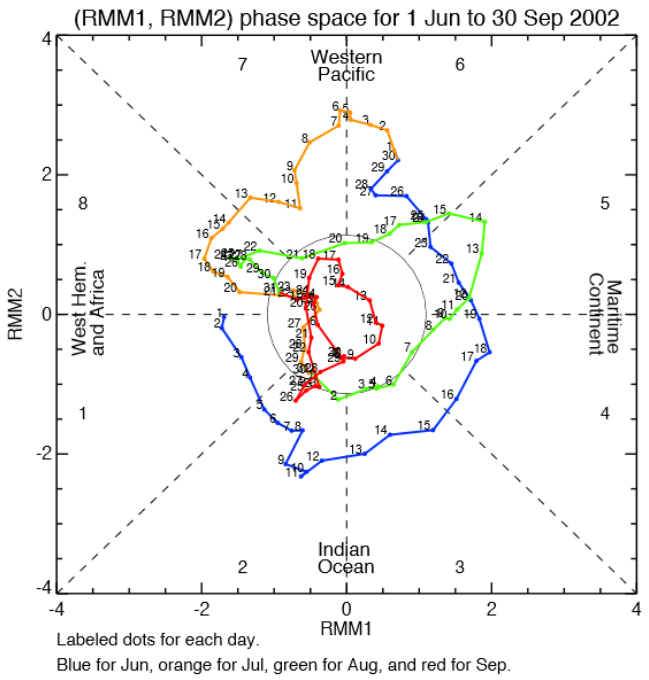


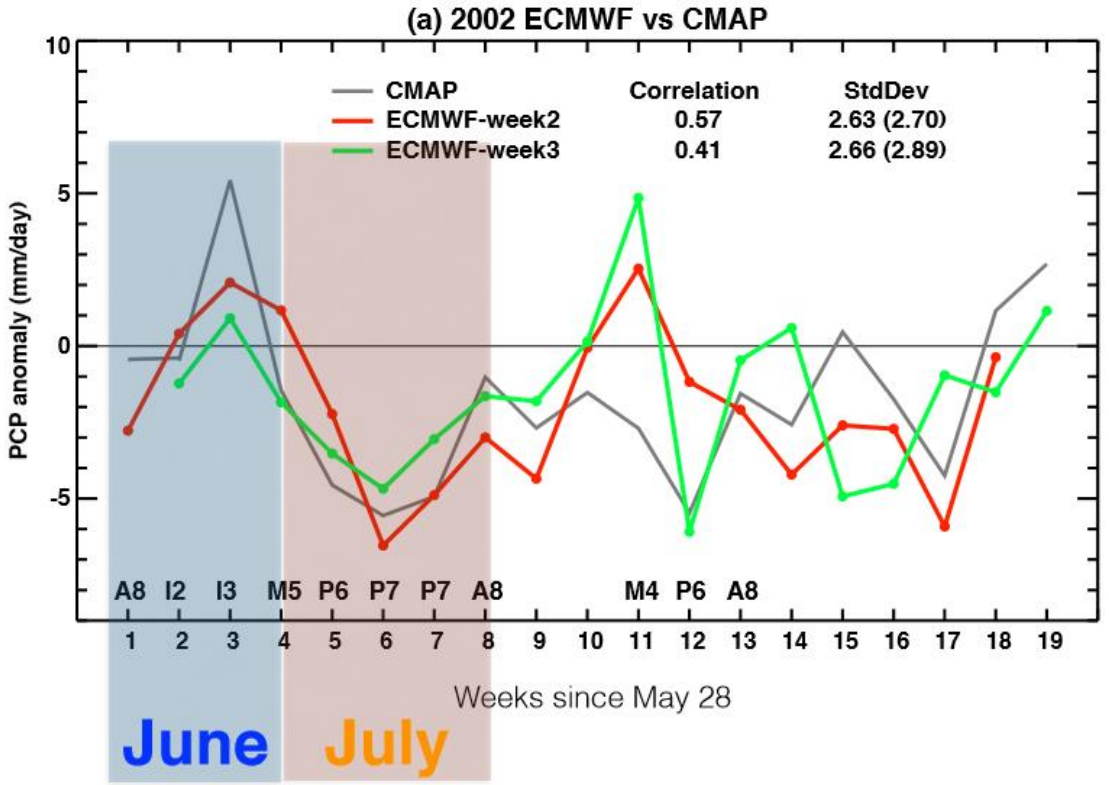
Borneo precipitation anomaly in relation to MJO phase during June– August, 1992–2008. ***Li and Robertson (2015)***



If we know about how MJO acts,
we can expect whether we have rain or not.

Predictability Source of S2S



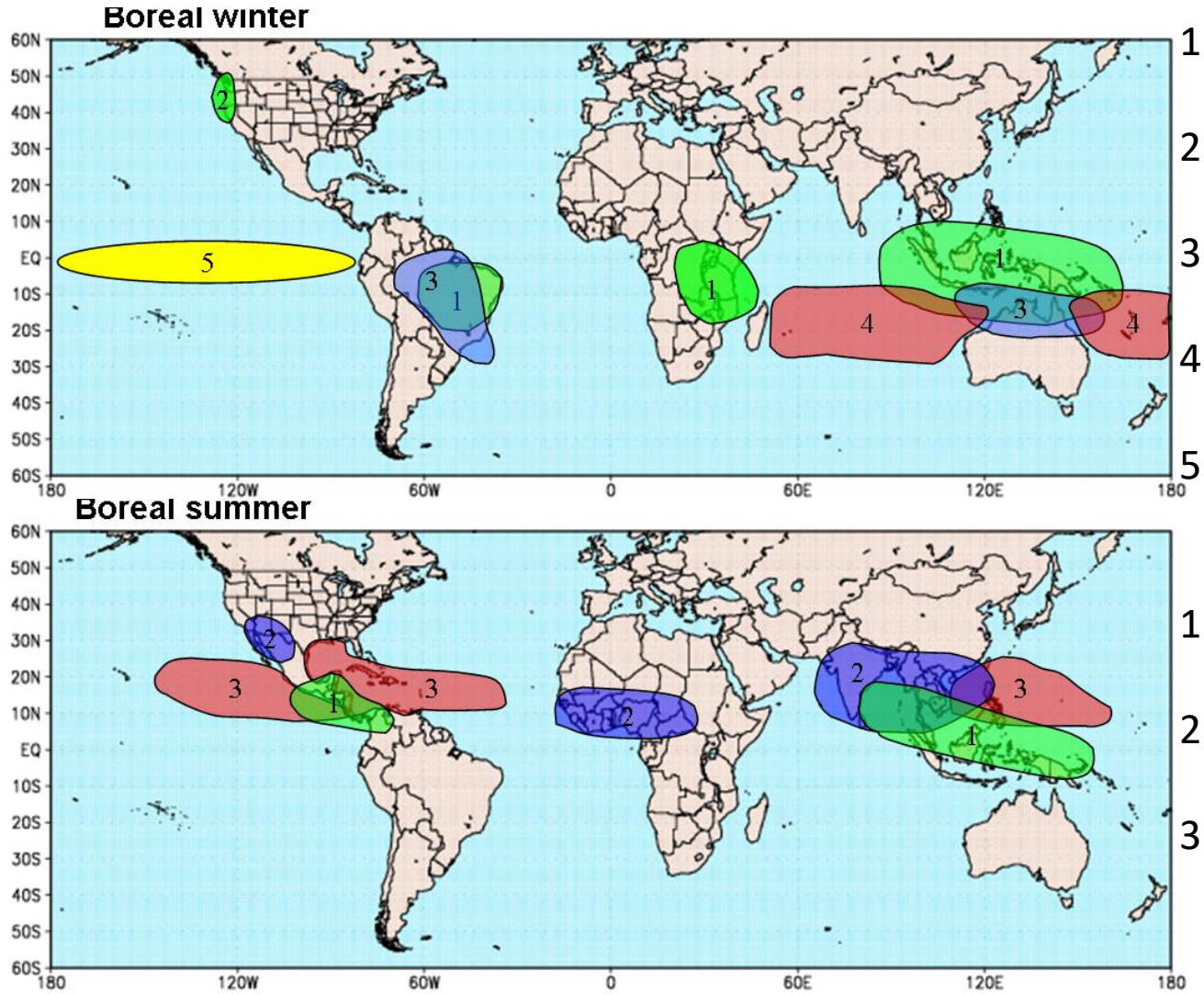


Li and Robertson (2015)

When the MJO is active, we can predict rainfall better.
But when the MJO is not active, we can not predict rainfall well.
→ MJO is the key source of predictability in S2S time scale.

Predictability Source of S2S

Impacts associated with MJO



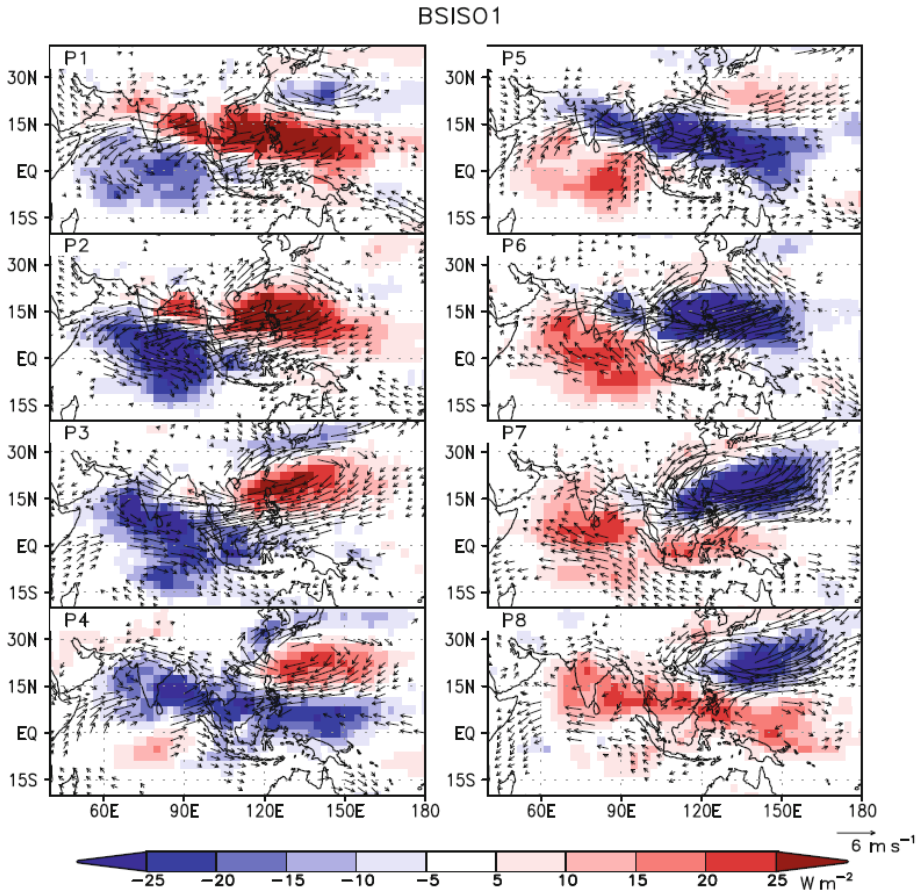
1. Alternating periods of wetter /drier conditions in the tropics
2. ”Pineapple express” heavy rainfall events
3. Modulation of monsoon systems
4. Influence on tropical cyclone development
5. Modulation of ENSO cycle through oceanic Kelvin waves

1. Alternating periods of wetter /drier conditions in the tropics
2. Modulation of monsoon systems
3. Influence on tropical cyclone development

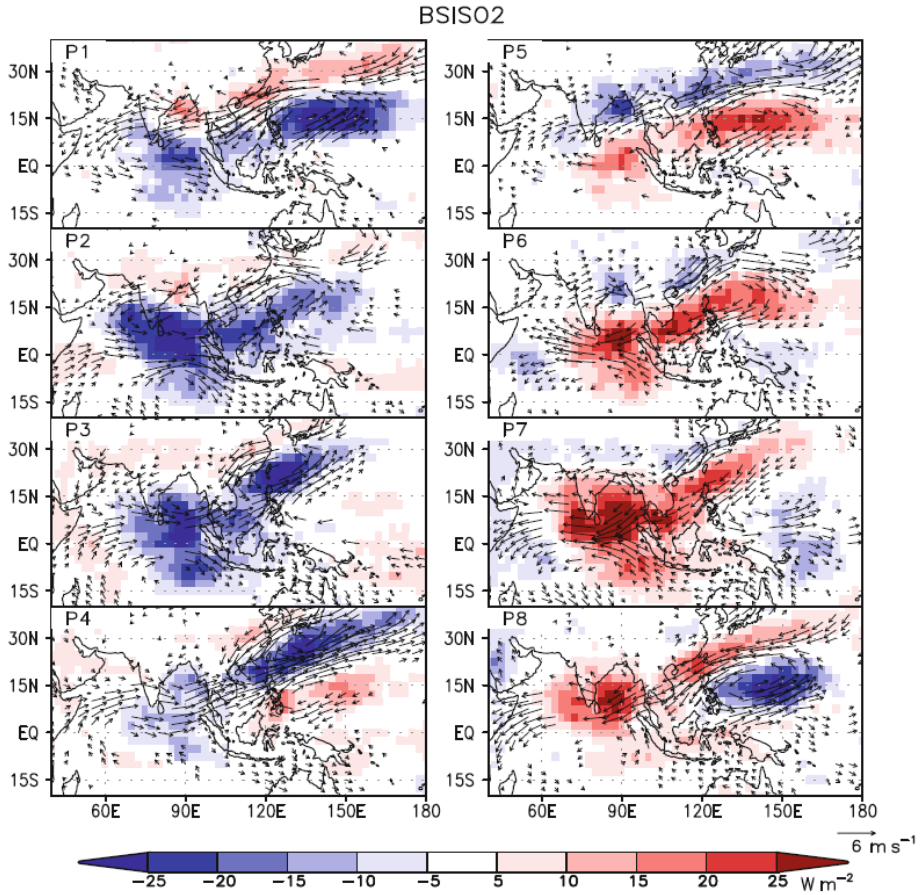
Predictability Source of S2S

Boreal Summer Intraseasonal Oscillation (BSISO)

The canonical northward propagating component



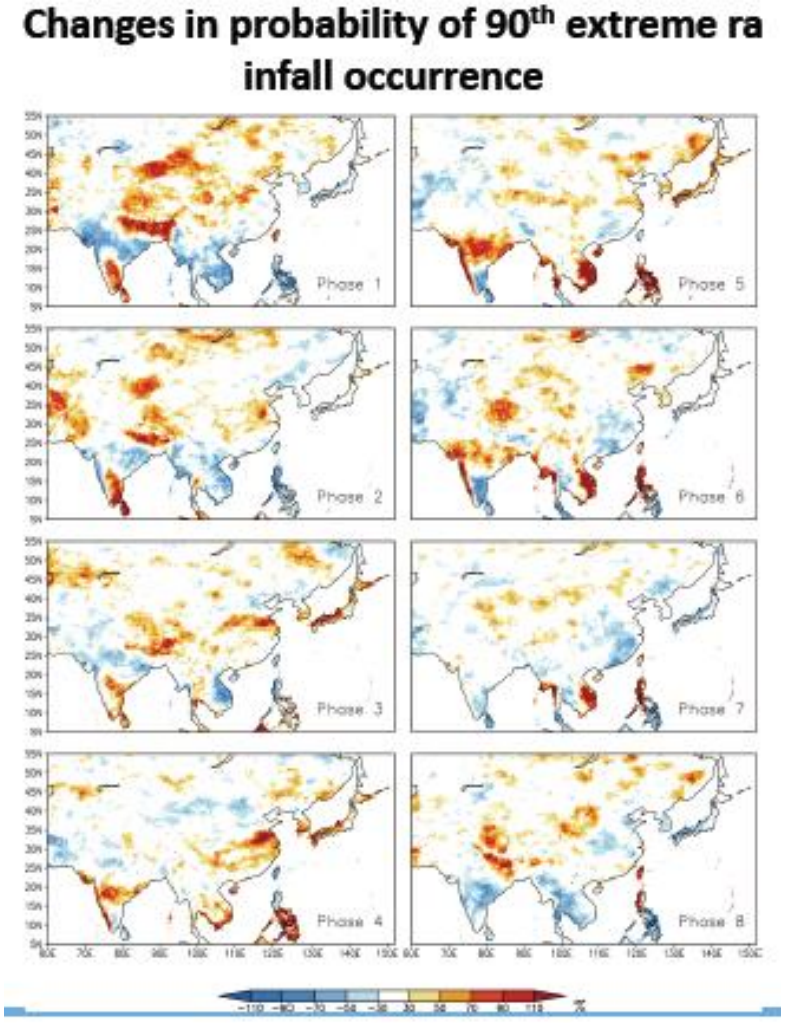
The AMS pre-monsoon and onset component

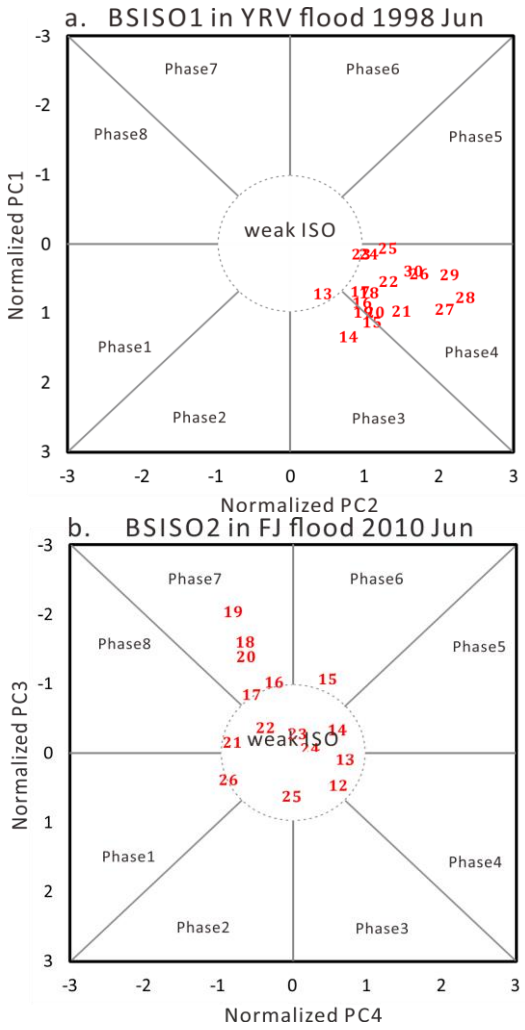


Lee et al. (2013)

Predictability Source of S2S

Impacts associated with BSISO



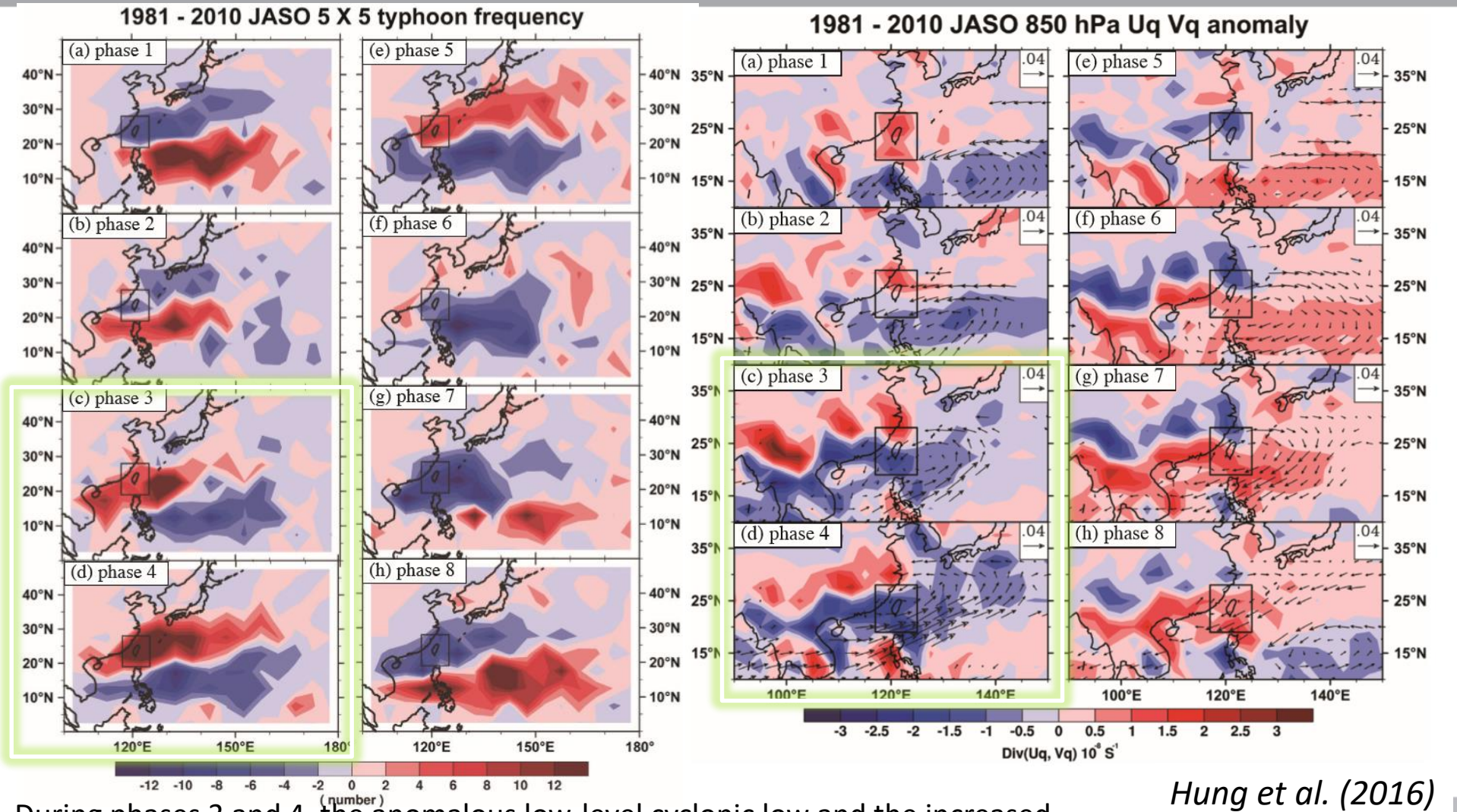


BSISO also has large impact on global weather and climate and can strongly modulate heavy rainfall occurrence and river flood.

Hsu et al. (2015)

Predictability Source of S2S

BSISO Impacts on tropical cyclone development



Hung et al. (2016)

During phases 3 and 4, the anomalous low-level cyclonic low and the increased typhoon frequency directly result in larger rainfall in Taiwan.

Predictability Source of S2S

Summary of sources of S2S predictability

1. MJO/BSISO : as the dominant mode of intraseasonal variability in the tropics that couples with organized convective activity, the MJO/BSISO has a considerable impact not only in the tropics, but also in the middle and high latitudes, and is considered as a major source of global predictability on the sub-seasonal time scale (e.g. Waliser 2011).

2. Soil moisture : memory in soil moisture can last several weeks which can influence the atmosphere through changes In evaporation and surface energy budget and can affect the forecast of air temperature and precipitation in certain areas During certain times of the year on intraseasonal time scales (e.g. Koster et al., 2010).

3. Snow cover : The radiative and thermal properties of widespread snow cover anomalies have the potential to modulate Local and remote climate over monthly to seasonal time scales (e.g. Sobolowski et al., 2010; Lin and Wu 2011).

4. Stratosphere-troposphere interaction : signals of changes in the polar vortex and the Northern Annular Mode/Arctic Oscillation (NAM/AO) are often seen to come from the stratosphere, with the anomalous tropospheric flow lasting up to about two months (Baldwin et al., 2003).

5. Ocean conditions : anomalies in SST lead to changes in air-sea heat flux and convection which affect atmospheric Circulation. The tropical intraseasonal variability (ISV) forecast skill is found to be improved when a coupled model is Used (e.g. Woolnough et al. 2007; Fu et al. 2007).

Not yet fully understood! This is partly what the S2S project is about.

(from S2S Implementation Plan)

Subseasonal to Seasonal (S2S)

User needs reliable and actionable information for decision-making.

Begin monitoring mid-range and short-range forecasts

Update contingency plans

Train volunteers

Sensitize community

Enable early-warning system

Continue monitoring shorter-time-scale forecasts

Mobilize assessment team

Alert volunteers

Warn community

Local preparation activities

Deploy assessment team

Activate volunteers

Distribute instructions to community, evacuate if needed

Summary

1. **Goals of S2S** : filling the gap between weather & climate forecasts & improving use by the applications community

2. **The WWRP/WCRP S2S project** : an international research initiative to address the S2S issues

3. **Sources of S2S predictability** : focus on phenomena with intrinsic time scale of weeks-to-a-season *(MJO, BSISO)*

4. **MJO/BSISO** : strongly influences on hydro-meteorological events

5. **Application** : S2S is more reliable and actionable information for decision-making

Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis over Western North Pacific

(March 12, 2019)

Hae-Jeong Kim*, Yoo-Rim Jung
APEC Climate Center

Footprint

2013	2014	2015	2016	2017˙18

*Expanded APCC climate service from seasonal to subseasonal by providing **BSISO forecast***

BSISO Monitoring & Verification

BSISO MME

BSISO Application
to heavy rainfall probability

BSISO Application
WNP TC
Korea heat wave

Monitoring
Forecast
Verification
on BSISO impact

BSISO
Forecast

Better forecast
from better recognition of the value

WNP TC genesis

Deterministic forecast (ISGPI)

’17’18

BSISO Forecast

Better forecast from better recognition of the value

BSISO-TC activity relationship

WNP TC genesis

Deterministic forecast (ISGPI)

’17’18

A new ISGPI for NH summer

$$ISGPI\_{MJJASO} = (-0.51)^* \omega_{500} + (-0.21)^* V_{zs} + (0.20)^* f\zeta_{r850}$$

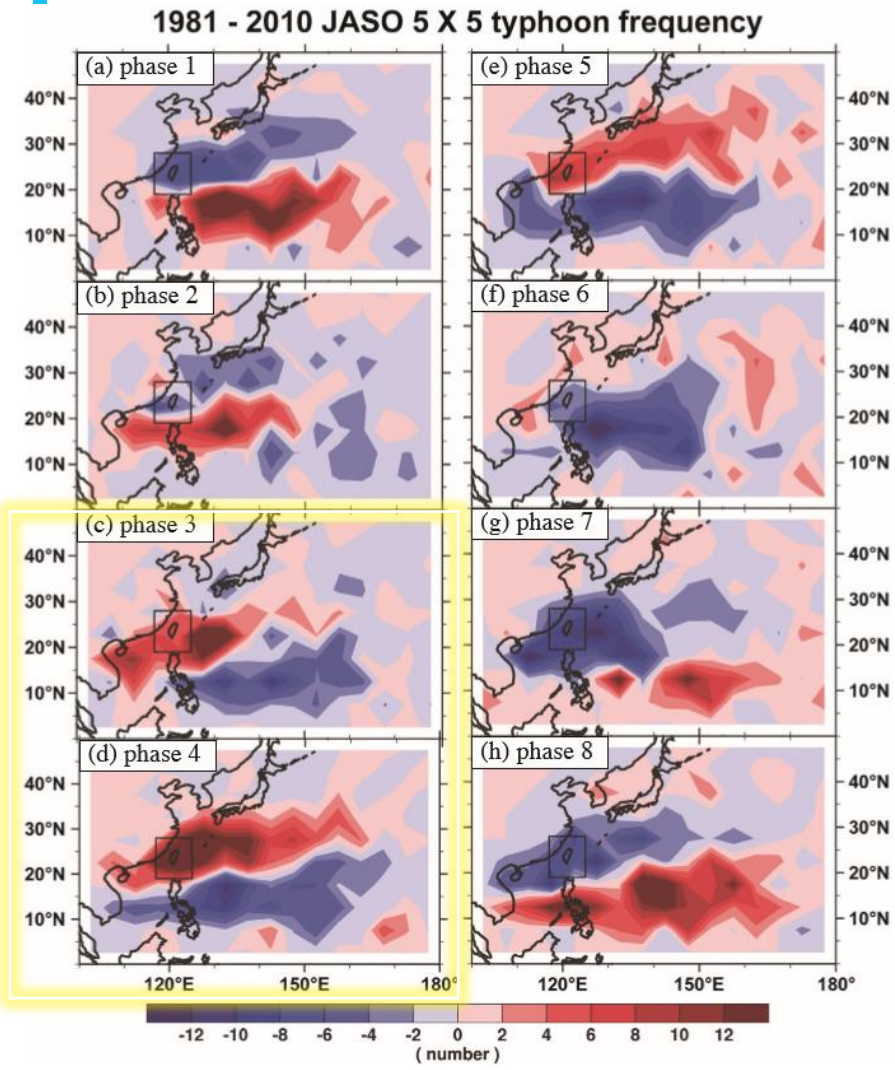
Region	ω_{500}	V_{zs}	$f\zeta_{r850}$	Equation
Globe	0.68[1]	0.72[2]	0.74[3]	$(-0.51)^*\omega_{500} + (0.20)^*f\zeta_{r850} + (-0.21)^*V_{zs}$
IO	0.72[1]	0.79[3]	0.78[2]	$(-0.56)^*\omega_{500} + (0.32)^*f\zeta_{r850} + (-0.12)^*V_{zs}$
WNP	0.75[1]	0.78[2]	0.80[3]	$(-0.55)^*\omega_{500} + (0.22)^*f\zeta_{r850} + (-0.20)^*V_{zs}$
ENP	0.81[1]	0.84[3]	0.84[2]	$(-0.67)^*\omega_{500} + (0.24)^*f\zeta_{r850} + (-0.02)^*V_{zs}$
Western NAT	0.49[3]	0.48[2]	0.45[1]	$(-0.16)^*\omega_{500} + (0.46)^*f\zeta_{r850} + (-0.25)^*V_{zs}$

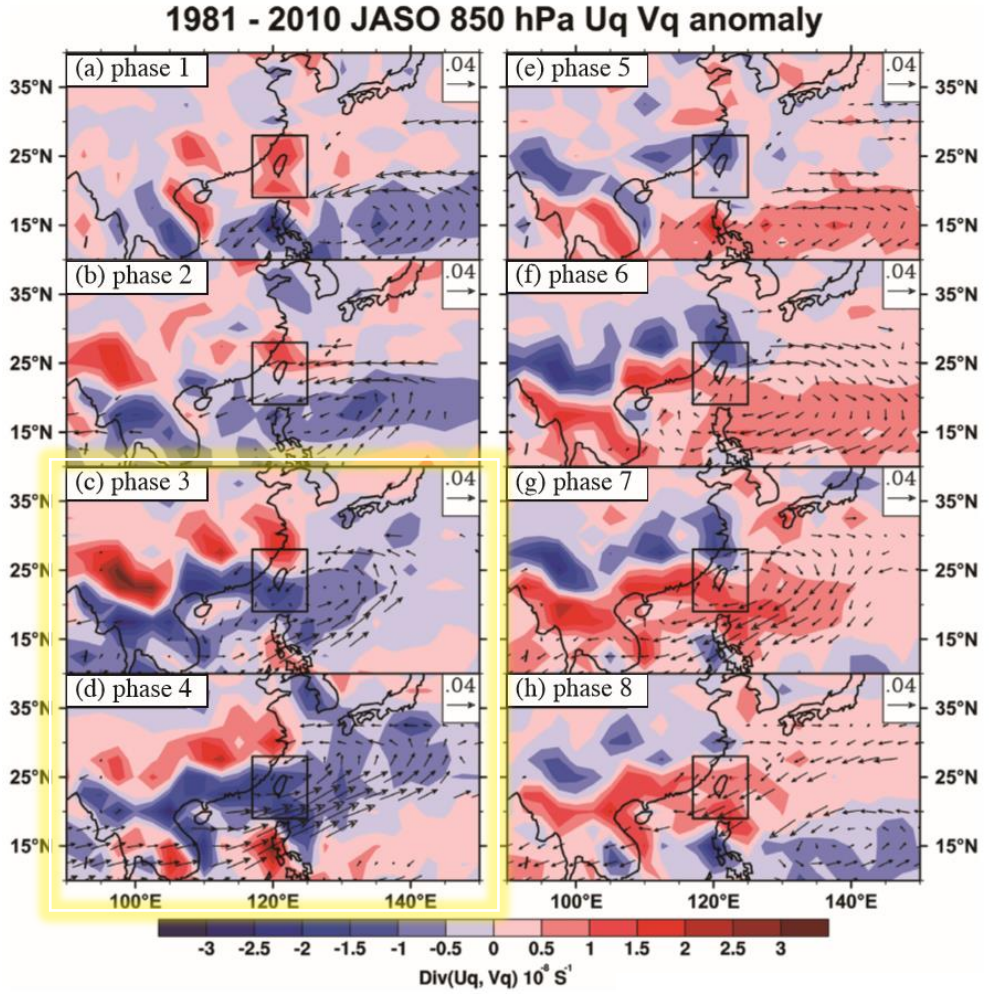
BSISO modulation of tropical cyclone genesis and sub-seasonal prediction - A new intraseasonal GPI for Northern Hemisphere(NH) summer (May-Oct)

[Moon et al., 2017, J. Climate]

Season : MJJASO
Not considering BSISO2 impact

1 WNP TC genesis & BSISO activity





Hung et al. (2016)

Heavy rainfall in Taiwan and the associated WNP typhoon frequency patterns are closely related to the 10 - 30 days BSISO2 phases during the typhoon season (July - October).

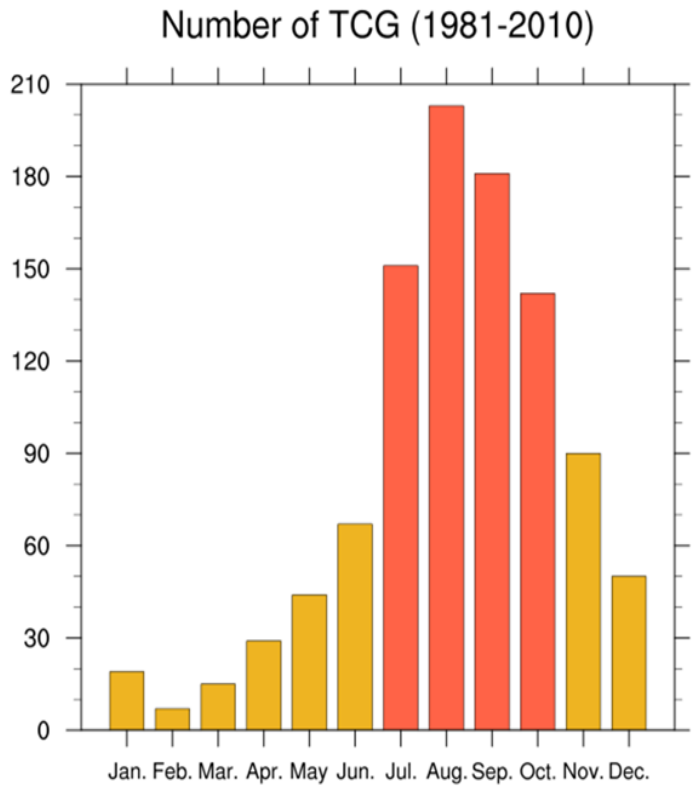
The results indicated that the *active/inactive periods and the associated horizontal patterns of the WNP typhoon frequency are closely related to the BSISO2* phases during the typhoon season (July - October).

BSISO Forecast

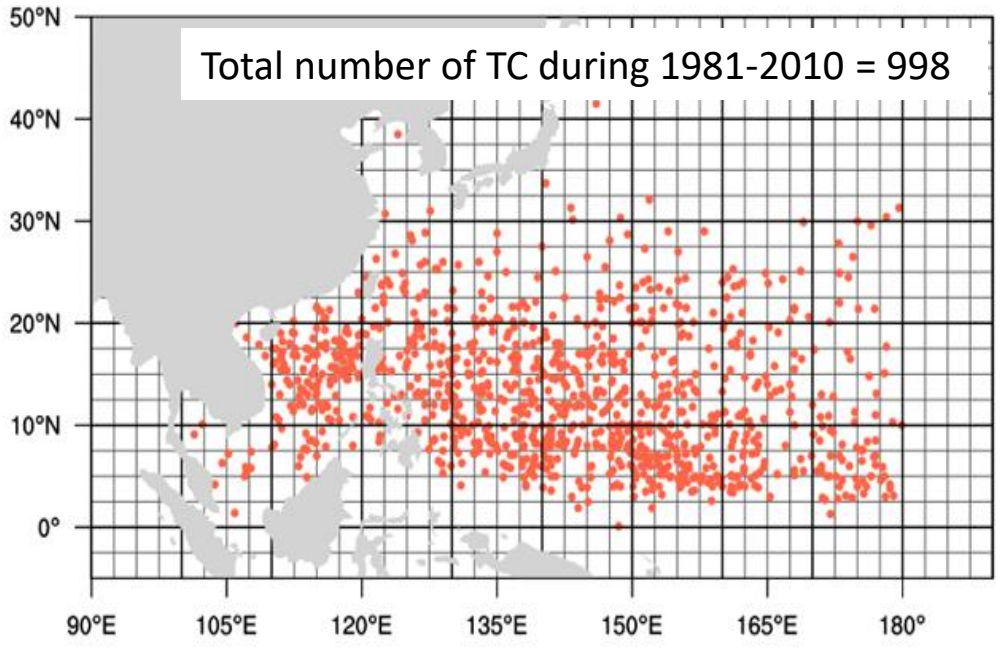
Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

Characteristic of WNP TC genesis



Among them, 677 TCs occurred in JASO (68% of total)
1.5 STD of 12N = 99, JASO is significant month.



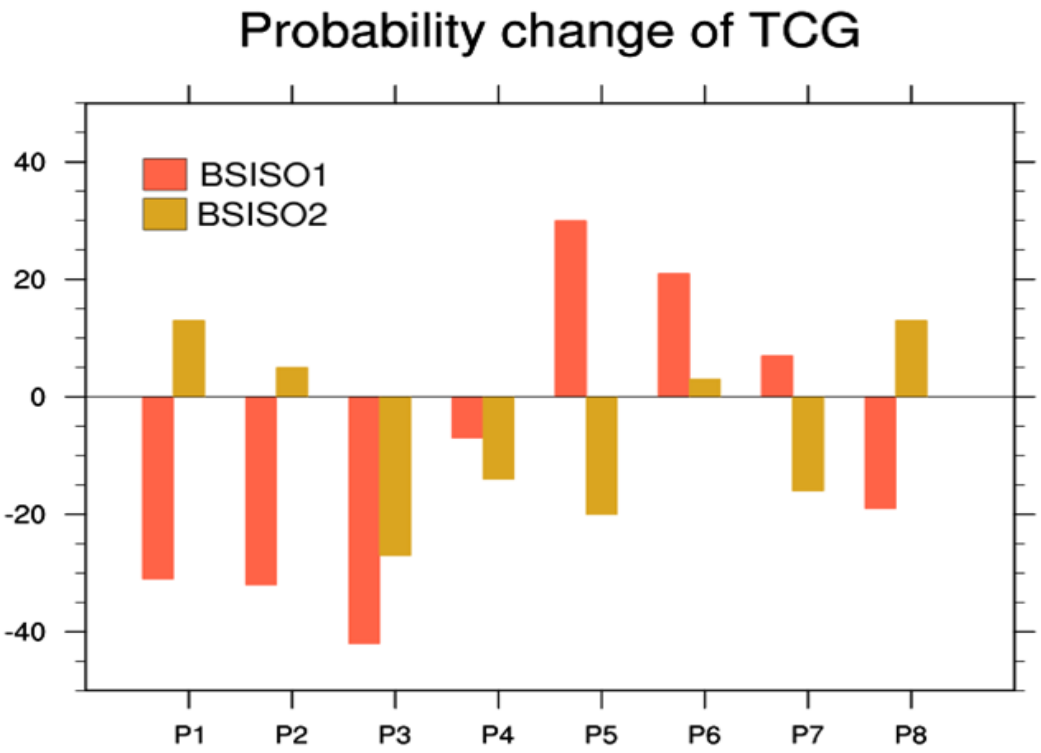
TC datasets from International Best Track Archive for Climate Stewardship (IBTrACS; http://www.ncdc.noaa.gov/ibtracs) v03r09 from 1979 to 2015 (Knapp et al. 2010).

BSISO Forecast

Better forecast from better recognition of the value

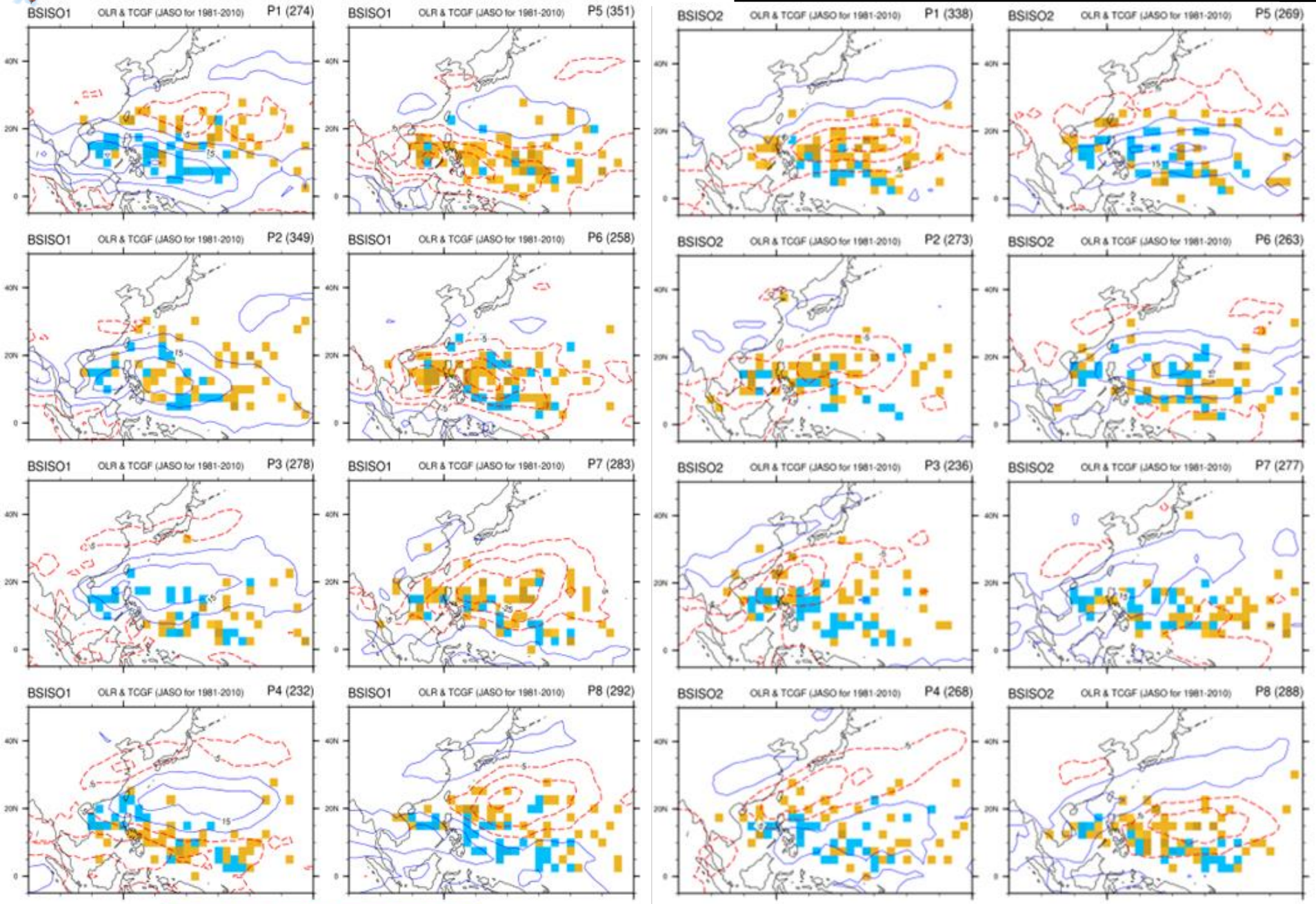
1 WNP TC genesis & BSISO activity

Relationship



Phase	BSISO1	BSISO2
1	0.13	**0.21**
2	0.13	**0.20**
3	0.11	0.14
4	0.18	0.16
5	**0.25**	0.15
6	**0.24**	0.19
7	**0.21**	**0.16**
8	0.16	**0.21**

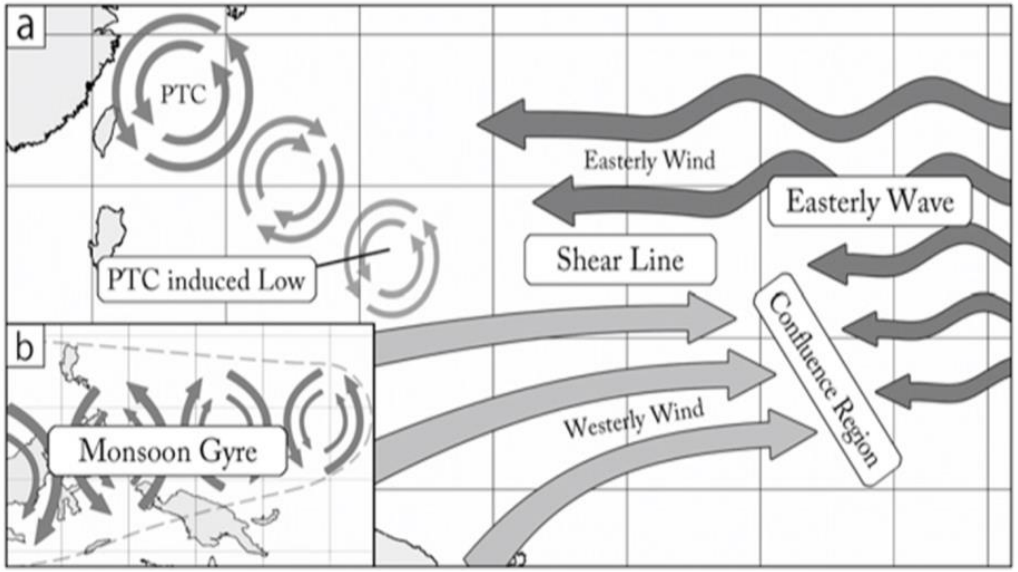
Relationship



BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity



A schematic image of the five flow patterns contributing to TCG From Yoshida and Ishikawa (2013) based on Ritchie and Holland (1999)

Five environmental flow patterns preferred for TCG: monsoon shear line (SL), monsoon confluence region (CR), monsoon gyre (GY), easterly wave (EW), and Rossby wave energy dispersion (RD).

Relationship

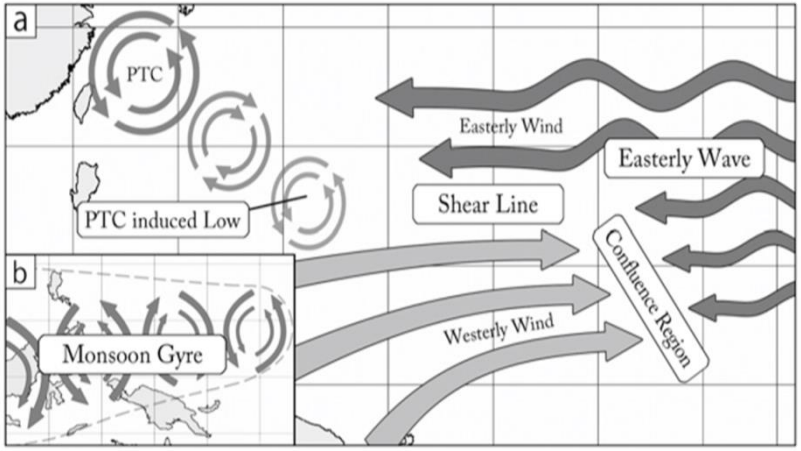
- Monsoon trough : the most favorable environment for the formation of multiday persistent cloud clusters that frequently grow into TCs. *(Gary, 1968, 1999)*
- The trough extends from the Indochina Peninsula in the west to the east of the Philippine Sea, and is accompanied by southwesterly flow on its southern side.→+Vor.→convergence and ascending air→favorable condition of TC genesis
- Of these five patterns, the SL, CR, and GY patterns are related to the monsoon trough.
- SL : cyclonic shear of the horizontal wind along the monsoon trough
- CR : the confluence zone between monsoon westerly and easterly winds

BSISO Forecast

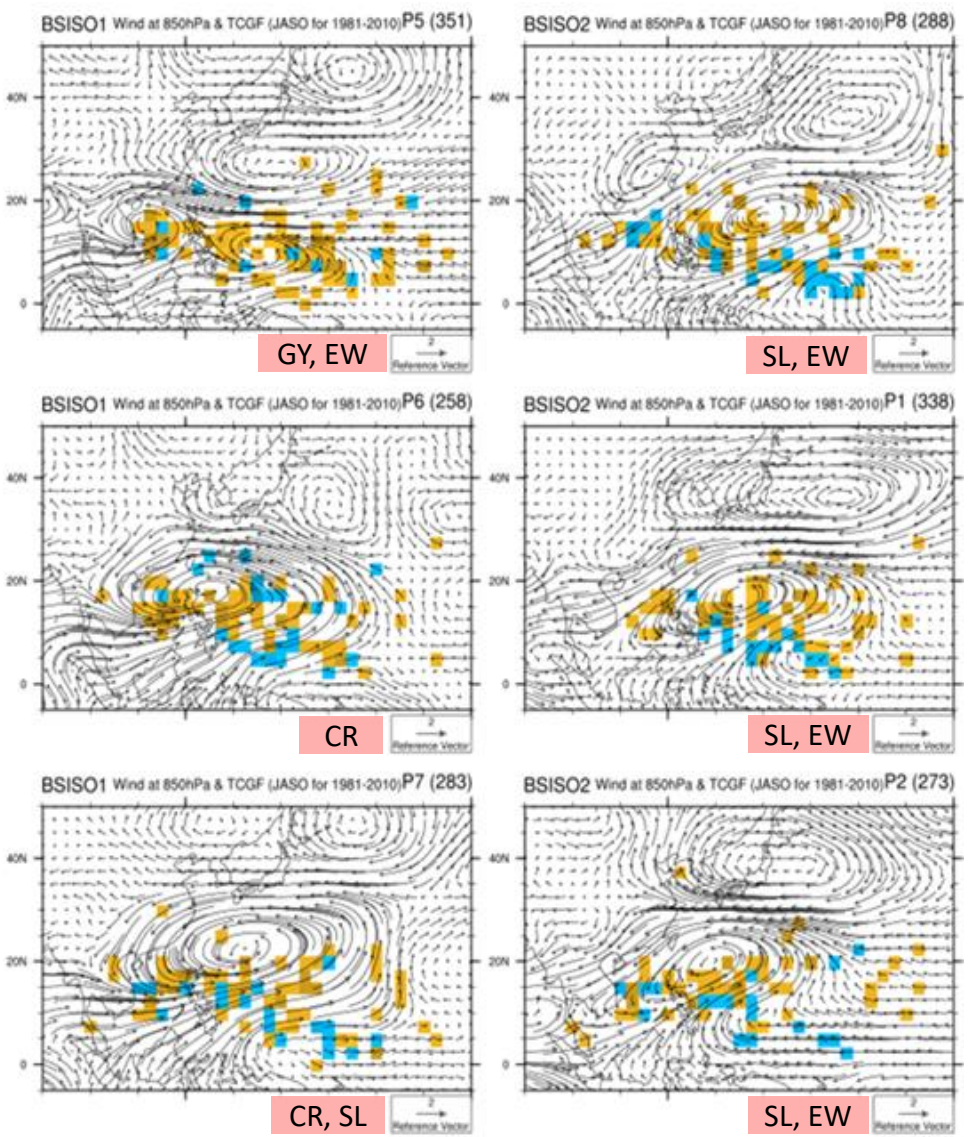
Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

Relationship



- Monsoon trough : best environment in producing tropical cyclone *(Gary, 1968, 1999)*
- SL, CR, and GY patterns are related to the monsoon trough
- SL : cyclonic shear of the horizontal wind along the monsoon trough
- CR : the confluence zone between monsoon westerly and easterly winds

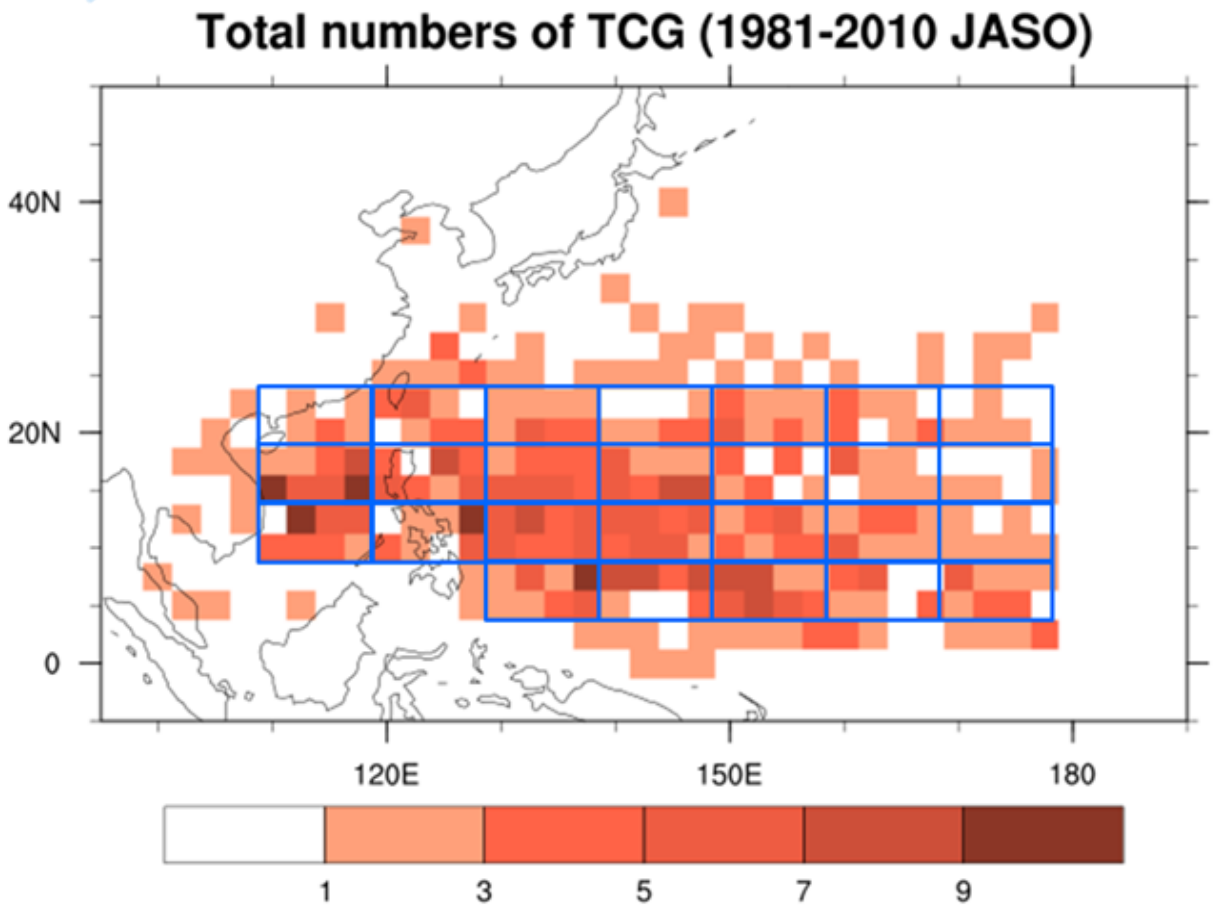


BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development



Total number of sample = 8x2x26 = 416

26 means the number of boxes covering the TCG location

8 BSISO composites

2 BSISO modes

BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development

8 candidate factors as influential factors for controlling TC

	TCGF	V_{ZS}	ω500	ζ_{r850}	RH_{600}	V_S	U_{x850}	U_{y850}
TCGF	1.0	**-0.17**	**-0.72**	**0.69**	**0.57**	**-0.52**	**-0.17**	**-0.67**
V_{ZS}	**-0.17**	1.0	**0.28**	0.06	**-0.50**	**-0.16**	**0.36**	-0.04
ω500	**-0.72**	**0.28**	1.0	**-0.80**	**-0.89**	**0.66**	**0.39**	**0.79**
ζ_{r850}	**0.69**	0.06	**-0.80**	1.0	**0.53**	**-0.79**	-0.01	**-0.91**
RH_{600}	**0.57**	**-0.50**	**-0.89**	**0.53**	1.0	**-0.39**	**-0.49**	**-0.57**
V_S	**-0.52**	**-0.16**	**0.66**	**-0.79**	**-0.39**	1.0	**-0.16**	**0.77**
U_{x850}	**-0.17**	**0.36**	**0.39**	-0.01	**-0.49**	**-0.16**	1.0	0.01
U_{y850}	**-0.67**	-0.04	**0.79**	**-0.91**	**-0.57**	**0.77**	0.01	1.0

Stepwise linear regression

Fisher's F-test

Comparing the correlation coefficients between the TCGF anomaly and candidate factors, it is obvious that w500 has the highest correlation (R= -0.72).

BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development

Selected significant influential factors

BSISO Index	V_{ZS}	ω500	ζ_{r850}	RH_{600}	V_S	U_{x850}	U_{y850}
OLR & U850 [5°N-25°N, 110°E-180°E]	0.747^3	0.717^1	0.743^2	**0.750^4**			
Equation	$(-0.612)\times w500 + (0.318)\times\zeta_{r850} + (-0.120)\times V_{ZS} + (-0.205)\times RH_{600}$						

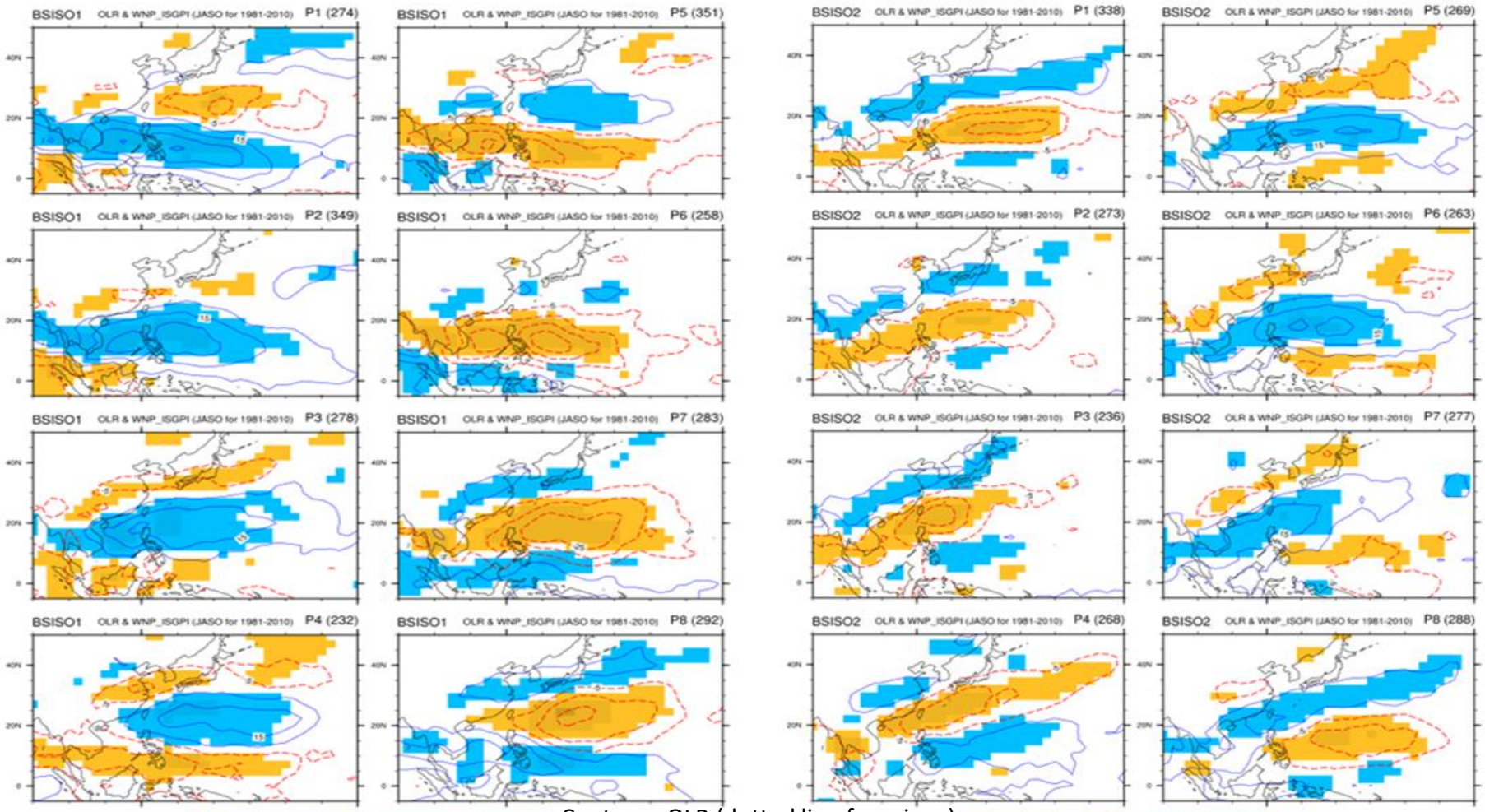
The complex correlation coefficient of the TCGF anomaly with the four factors is 0.74.

BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development



BSISO1 -0.7 -0.3 0.1 0.5 0.9

Contour : OLR (dotted line for minus)
Shading : ISGPI

-0.7 -0.3 0.1 0.5 0.9 BSISO2

BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development

Table 3.4 Distance between TC genesis location and WNP_ISGPI center

Distance (km)	Average	Minimum	Maximum
For all case	497	11	954
For active BSISO	497	11	954
For non-active BSISO	482	77	780

Base year 2017, forecasts 5day(120h) in advance
: (Hurricane) ECMWF about 300 km, UKMO about 400km, NOAA NHC about 370km,NOAA DTC about 740km
: (WNP TC)JTWC about 460km

BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development

Table 3.5 Categorical contingency table for binary event

		Observed		Total
		Yes	**No**	
Forecast	**Yes**	Hits a	False Alarms b	Forecast yes a+b
	No	misses c	Correct rejections d	Forecast no c+d
Total		Observed yes a+c	Observed no b+d	N a+b+c+d

Probability of detection (POD) = $\frac{hits}{hits + misses}$ = 0.36

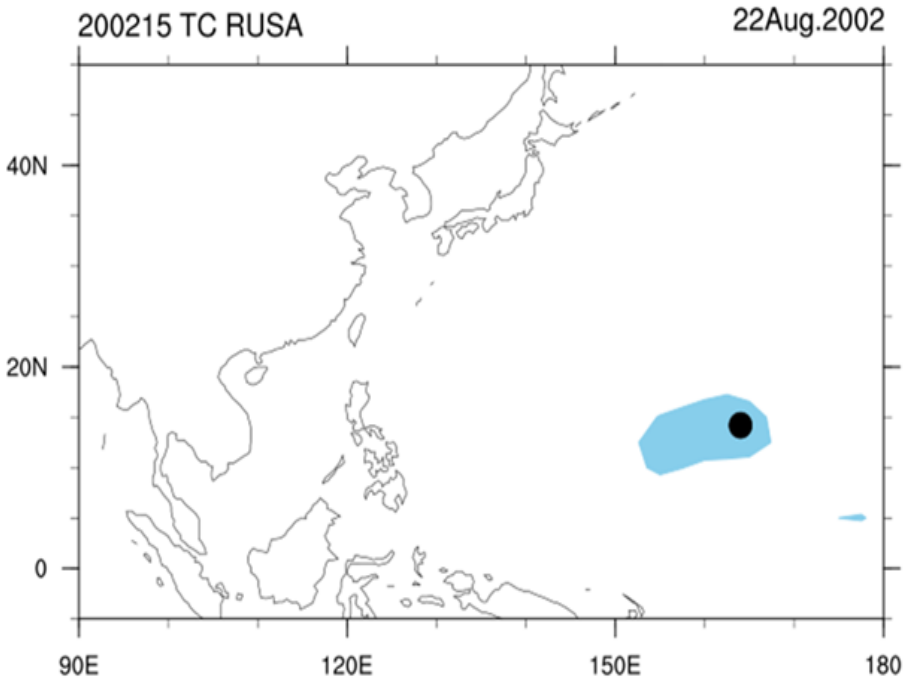
BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

WNP ISGPI development

일시(KST)	중심위치		중심기압	최대풍속		강풍반경	강도	크기	진행방향	이동속도
	위도(°N)	경도(°E)	(hPa)	초속 (m/s)	시속 (km/h)	(km)				(km/h)
2002/08/23 09:00	16.5	161.0	1000	18	65	180	약	소형	서북서	26



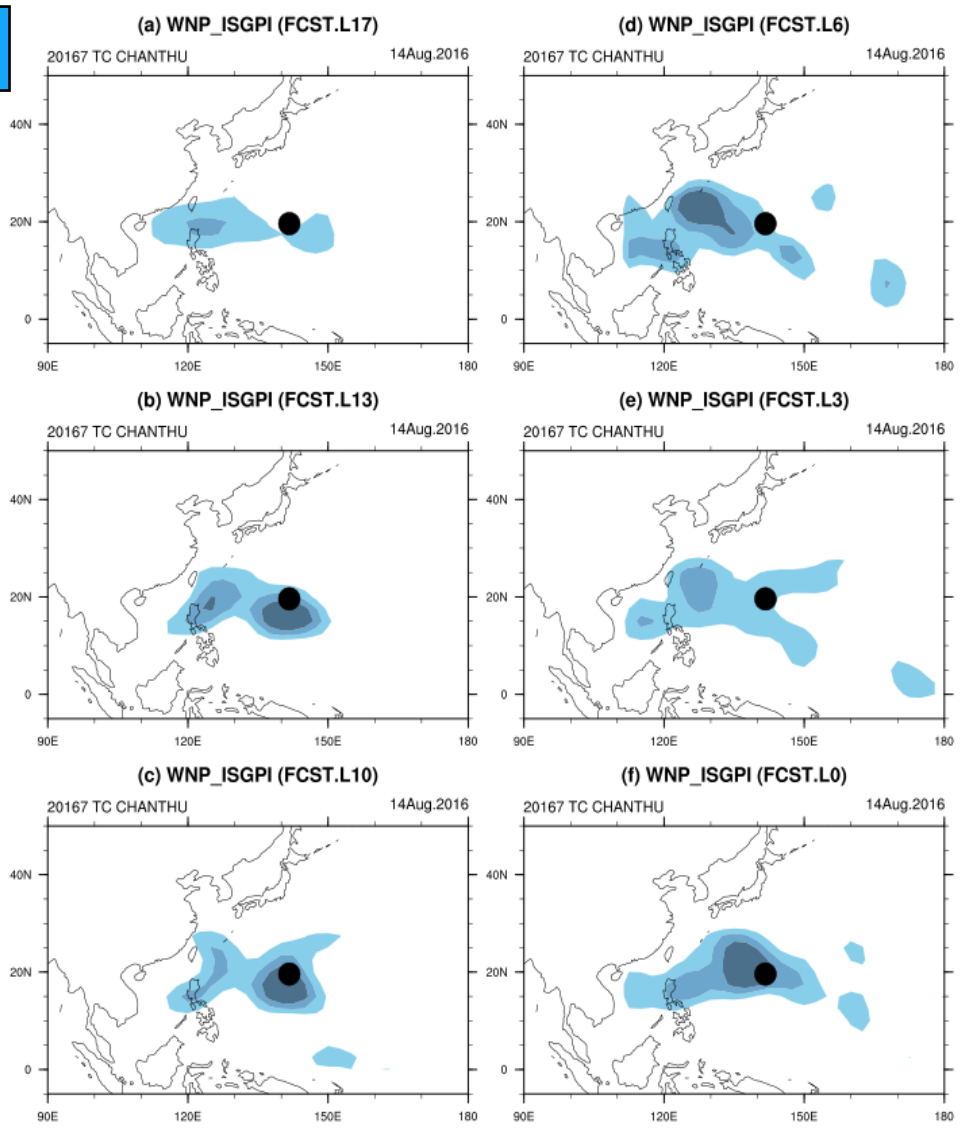
Diff. Distance = 217.808 km

BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

Forecast of WNP ISGPI

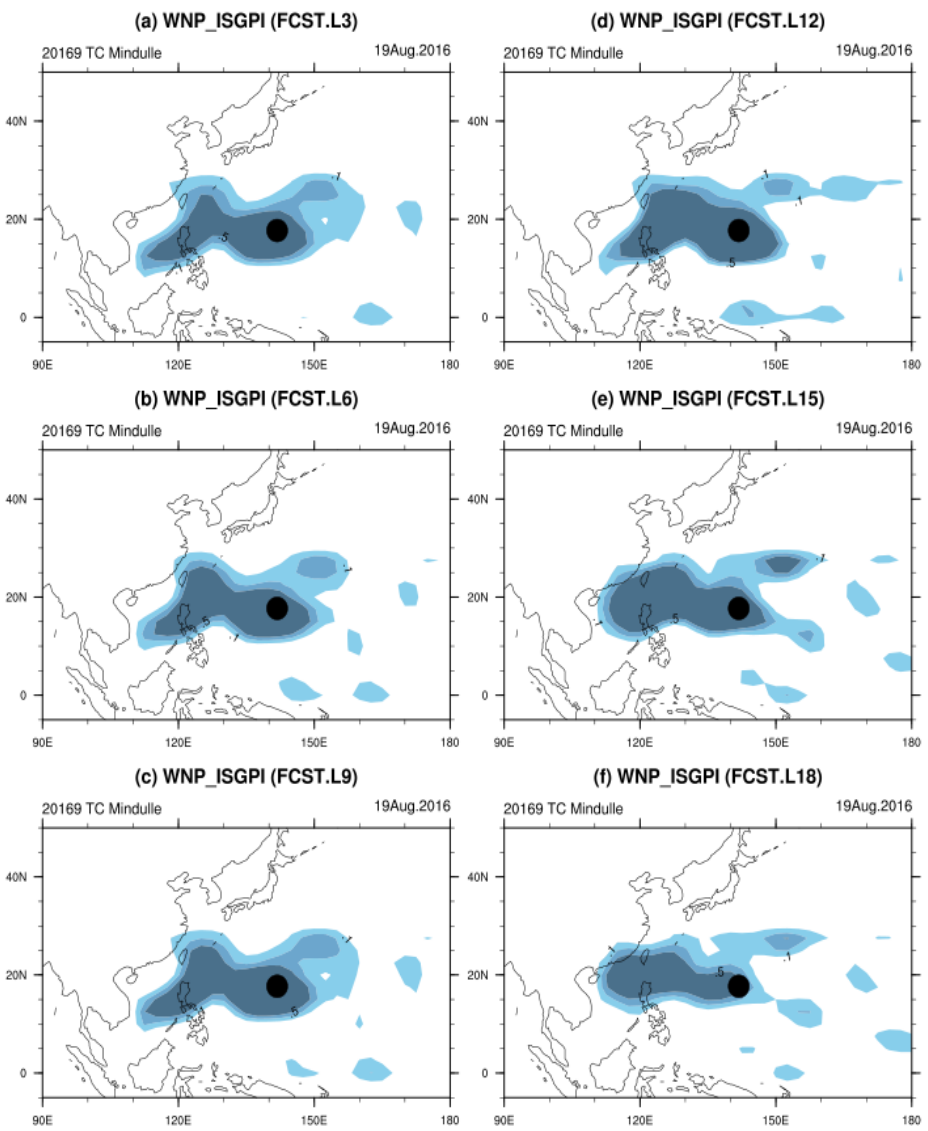


BSISO Forecast

Better forecast from better recognition of the value

1 WNP TC genesis & BSISO activity

- **Forecast of WNP ISGPI**



Summary

- Phase preference
  - BSISO1 : 5,6,7
  - BSISO2 : 8,1,2
- BSISO can influence on large scale zonal wind associated with monsoon trough, which in turn might contribute to make favorable synoptic scale environment to TC genesis.
- Development of WNP ISGPI
- 500km diff. between the location of TC genesis and ISGPI center
- 1/3 of TC can be detected by WNP ISGPI
- ISGPI is more useful for quantifying WNP TC genesis in Aug.
- WNP TC genesis can be predicted 2 weeks in advance

Footprint

2013	2014	2015	2016	2017˙18

*Expanded APCC climate service from seasonal to subseasonal by providing **BSISO forecast***

BSISO Monitoring & Verification

BSISO MME

BSISO Application
to heavy rainfall probability

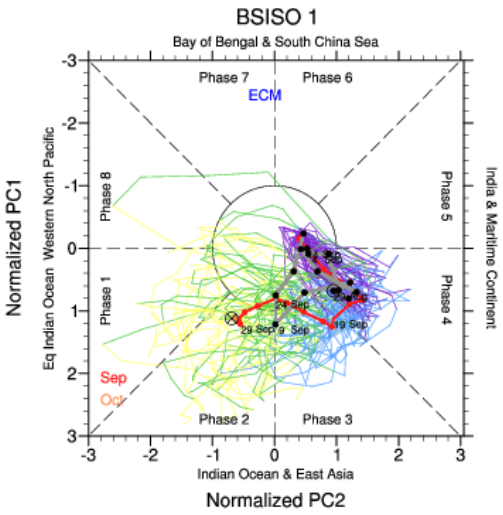
BSISO Application
WNP TC
Korea heat wave

Monitoring
Forecast
Verification
on BSISO impact

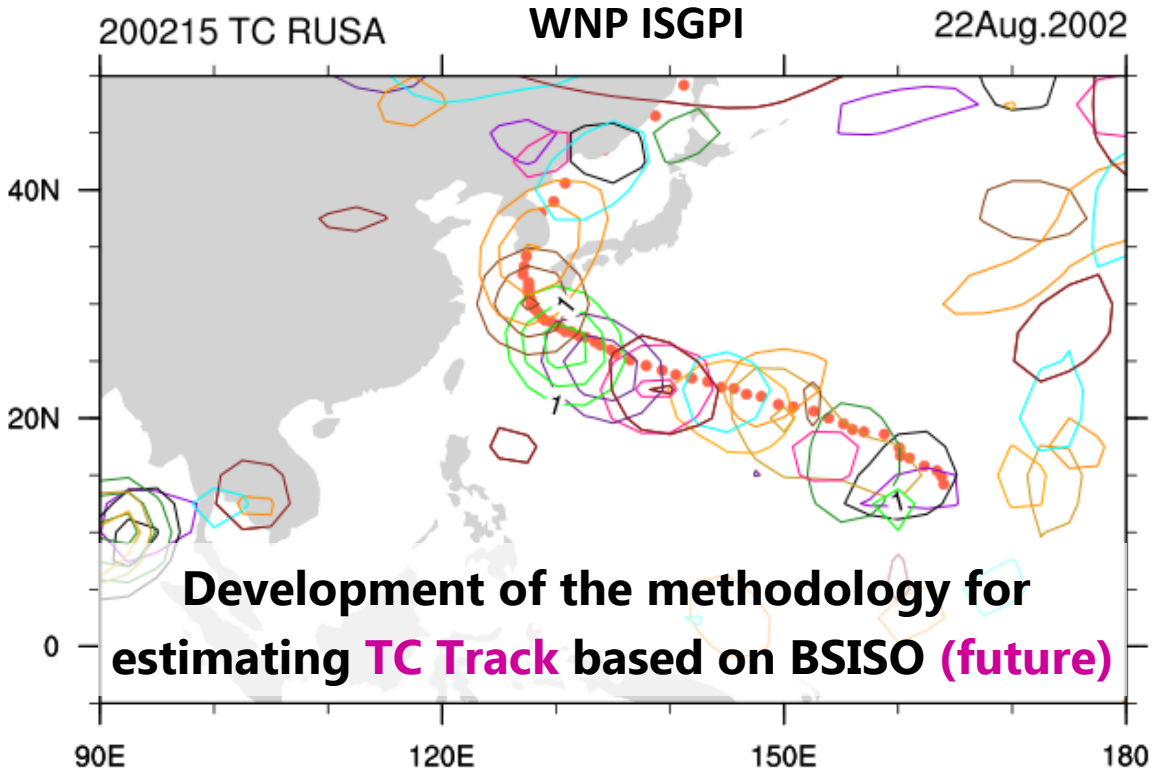
Future work

Development of BSISO forecast technique

Forecast/Monitoring
on Main Driver



Forecast/Monitoring
on its Impact



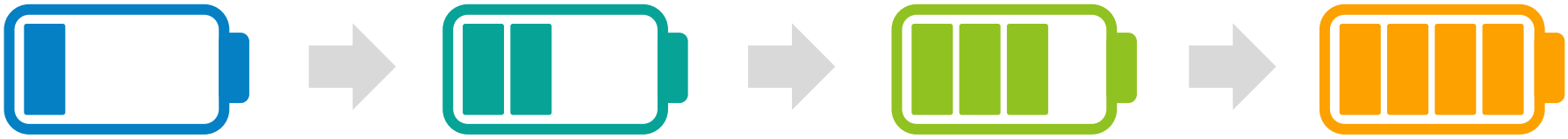

THANK YOU
(http://www.apcc21.org)
APEC
Climate
Center

APCC's S2S Training Program

(March 13, 2019)

Hae-Jeong Kim
APEC Climate Center

Footprint



2013

S2S forecast

2014

APCC-S2S Prediction Project (WMO) Training Course 2014

2016

APCC 2016 Subseasonal to Seasonal (S2S) Training Program

2018

2018 APEC Climate Center Training Program

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

1. Theme

Subseasonal to Seasonal Prediction to Cope with High Impact Weather in Developing Countries

2. Date

16(Thursday)-23(Thursday) October, 2014

3. Venue

APEC Climate Center, Busan, Korea

4. Objectives

The training program aims to improve forecast skill and understanding of the subseasonal to seasonal (S2S) timescale, which is currently one of the key issues in climate science.
S2S, with a special emphasis on high-impact weather, is a very relevant time-scale for many management decisions for disaster risk reduction, water and agriculture, and food security and its prediction can provide early indication of the potential for developing countries in the Asia-Pacific region to suffer from high-impact weather.
The training program is designed to contribute to building the participants' ability to understand and utilize S2S prediction for anticipating, mitigating, and responding to the impacts of extreme events.

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

4. Participants

young scientists from National Meteorological and Hydrological Services (NMHSs) in developing countries, particularly from the APEC region
17 participants from 16 nations

5. Requirement

Applicants should have at least 1 year experience using the Fortran programming language and experience with GrADS software.

Applicants should be fluent in English (oral and written communication) and have understanding of the basic science of climate systems.

They should also have the ability to make a substantive contribution to their own nation with what he/she has learned from APCC.

6. Program

Total 38 hours for 9 subject (Lecture : 22 hr, Hands-on : 16 hr)

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	 Management cations
Day 3 (18 October)	
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	□ Lecture 7: [Dr. Kwanghyung Kim] Application of Climate Prediction in Agriculture □ Hands-On 3: [APCC] Analyzing the Impacts of BSISO
Day 7 (22 October)	**Day 8 (23 October)**
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Hands-On 5: [APCC] Analyzing the Impacts of BSISO □ Participant Presentations □ Closing Ceremony □ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ □ □ □  Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
	Day 4 (19 October)
□ □	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	□ Lecture 7: [Dr. Kwanghyung Kim] Application of Climate Prediction in Agriculture □ Hands-On 3: [APCC] Analyzing the Impacts of BSISO
Day 7 (22 October)	**Day 8 (23 October)**
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Hands-On 5: [APCC] Analyzing the Impacts of BSISO □ Participant Presentations □ Closing Ceremony □ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
Day 3 (18 October)	**Day 4 (19 October)**
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	
Day 5 (20 October)	
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	
Day 7 (22 October)	**Day 8 (23 October)**
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Hands-On 5: [APCC] Analyzing the Impacts of BSISO □ Participant Presentations □ Closing Ceremony □ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
Day 3 (18 October)	**Day 4 (19 October)**
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	□ Lecture 7: [Dr. Kwanghyung Kim] Application of Climate Prediction in Agriculture □ Hands-On 3: [APCC] Analyzing the Impacts of BSISO
Day 7 (22 October)	**Day 8 (23 October)**
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Hands-On 5: [APCC] Analyzing the Impacts of BSISO □ Participant Presentations □ Closing Ceremony □ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
Day 3 (18 October)	**Day 4 (19 October)**
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	e
Day 7 (22 October)	
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
Day 3 (18 October)	**Day 4 (19 October)**
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	□ Lecture 7: [Dr. Kwanghyung Kim] Application of Climate Prediction in Agriculture □ Hands-On 3: [APCC] Analyzing the Impacts of BSISO
Day 7 (22 October)	**Day 8 (23 October)**
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Hands-On 5: [APCC] Analyzing the Impacts of BSISO □ Participant Presentations □ Closing Ceremony □ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
Day 3 (18 October)	**Day 4 (19 October)**
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	□ Lecture 7: [Dr. Kwanghyung Kim] Application of Climate Prediction in Agriculture
Day 7 (22 October)	
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

DAY 1 (16 October)	DAY 2 (17 October)
□ Opening : [APCC, S2S project co-chair, S2S ICO] □ Lecture 1: [Dr. Andrew Robertson] Understanding of S2S □ Lecture 2: [Dr. Hyeong-Seog Kim] Tropical Cyclones □ Welcome Dinner	□ Lecture 3: [Dr. Andrew Robertson] Rainfall Variability and Climate Risk Management for Hydrological and Agricultural Applications □ Lecture 4: [Dr. Kyong-Hwan Seo] Intraseasonal Oscillation □ Orientation: [Dr. Hae-Jeong Kim] Hands-on Session
Day 3 (18 October)	**Day 4 (19 October)**
□ Lecture 5: [Dr. Baek-Min Kim] Cold Waves □ Hands-On 1: [APCC] Analyzing the Impacts of BSISO □ Korean Cultural Experience	□ Korean Cultural Tour
Day 5 (20 October)	**Day 6 (21 October)**
□ Lecture 6: [Dr. Mong-Ming Lu] Understanding of S2S Prediction System □ Hands-On 2: [APCC] Analyzing the Impacts of BSISO	□ Lecture 7: [Dr. Kwanghyung Kim] Application of Climate Prediction in Agriculture □ Hands-On 3: [APCC] Analyzing the Impacts of BSISO
Day 7 (22 October)	**Day 8 (23 October)**
□ Lecture 8: [Dr. Eun-Pa Lim] S2S Forecasting and its Application Activities at BOM □ Hands-On 4: [APCC] Analyzing the Impacts of BSISO	□ Hands-On 5: [APCC] Analyzing the Impacts of BSISO □ Participant Presentations □ Closing Ceremony □ Program Survey

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

4. Level of participants satisfaction

Overall	Evaluation of lecture and lecturer
Satisfaction for whole program (lecture and hands-on, environment etc)	Evaluation about preference of lecture, ability of delivery on points, language, encouraging
4.65/5.0	4.60/5.0

Main Comments :

New concept of subseasonal forecast to most of participants, but helpful because of well –organized story flow between lectures

The lectures related to BSISO and MJO is helpful rather than the lectures related to long range variability since most of participants are young scientists NMHSs who taking in charge of short range forecast.

2014 APCC–Subseasonal to Seasonal Prediction Project (WMO) Training Course

Subseasonal to Seasonal Prediction to Cope with High Impact Weather in Developing Countries

APCC 2016 Subseasonal to Seasonal (S2S) Training Program

1. ***Theme***

   S2S as a new epoch in climate-based application: Using S2S prediction to cope with extreme hydrological events in developing countries

2. Date

27 June – 2 July 2016

3. Venue

APEC Climate Center, Busan, Korea

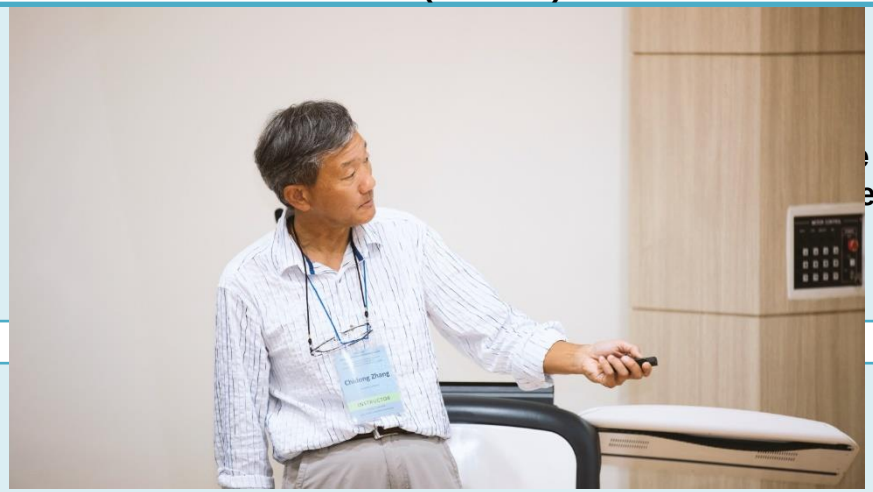
4. Objectives

To increase capacity of participant countries on using S2S prediction methods and to increase understanding of various S2S climate-based applications

5. Participants

19 participants from 10 countries
young scientists from National Meteorological and Hydrological Services (NMHSs) in developing countries, particularly from the APEC region

APCC 2016 Subseasonal to Seasonal (S2S) Training Program

DAY 1 (27 June)	DAY 2 (28 June)
□ Opening/Orientation □ Lecture 1: [Dr. Eun-Pa Lim] Introduction of S2S and understanding the prediction system □ Lecture 2: [Dr. Chidong Zhang] Intraseasonal oscillation and its impacts I □ Welcome Dinner	
Day 3 (29 June)	
□ Lecture 4: [Dr. Il-Ju Moon] Tropical Cyclones: understanding TC and its impacts, TC from the perspective of S2S and its impacts on rainfall predictions □ Lecture 5: [Dr. Baek Min Kim] Cold Wave: understanding its impact and S2S predictions □ Hands-On 2: [APCC] BSISO impact on local precipitation using gridded data	□ Lecture 6: [Dr. Lynette Bettio] S2S and water resource management □ Hands-On 4: [APCC] BSISO impact on local precipitation using station data
Day 5 (1 July)	**Day 6 (2 July)**
□ Lecture 7: [Dr. Lynette Bettio] Case studies in the world of S2S and water resource management □ Hands-On 5: [APCC] Analysis of large circulation for the better understanding about BSISO impact on local precipitation	□ Participant Presentations □ Closing Ceremony □ Korean Cultural Tour □ Closing Dinner

APCC 2016 Subseasonal to Seasonal (S2S) Training Program

DAY 1 (27 June)	DAY 2 (28 June)
□ Opening/Orientation □ Lecture 1: [Dr. Eun-Pa Lim] Introduction of S2S and understanding the prediction system □ Lecture 2: [Dr. Chidong Zhang] Intraseasonal oscillation and its impacts I □ Welcome Dinner	□ Lecture 3: [Dr. Chidong Zhang] Intraseasonal oscillation and its impacts II □ Hands-On 1: [APCC] Introduction of APCC's BSISO forecasting activities and pre-processing of rainfall data in the target research area □ Korean Cultural Experience
Day 3 (29 June)	**Day 4 (30 June)**
□ Lecture 4: [Dr. Il-Ju Moon] Tropical Cyclones: understanding TC and its impacts, TC from the perspective of S2S and its impacts on rainfall predictions □ Lecture 5: [Dr. Baek Min Kim] Cold Wave: understanding its impact and S2S predictions □ Hands-On 2: [APCC] BSISO impact on local precipitation using gridded data	□ Hands-On 3: [APCC] BSISO impact on local precipitation using gridded data □ Lecture 6: [Dr. Lynette Bettio] S2S and water resource management □ Hands-On 4: [APCC] BSISO impact on local precipitation using station data
Day 5 (1 July)	**Day 6 (2 July)**
□ Lecture 7: [Dr. Lynette Bettio] Case studies in the world of S2S and water resource management □ Hands-On 5: [APCC] Analysis of large circulation for the better understanding about BSISO impact on local precipitation	□ Participant Presentations □ Closing Ceremony □ Korean Cultural Tour □ Closing Dinner

APCC 2016 Subseasonal to Seasonal (S2S) Training Program

4. Level of participants satisfaction

Main Comments :

Many participants indicated their satisfaction with the workshop and stated that it was a great opportunity. They stressed that the lecturers were very knowledgeable and had deep experiences on their presented topics.

There was also a sense of increase in interest in S2S, MJO, BSISO, etc. Many participants mentioned that the knowledge and experience provided by this training program will be useful and practical back in their respective countries.

Participants applauded all lecturers for being informative, descriptive, detailed, and knowledgeable.

Participants particularly very much enjoyed the hands-on sessions.

APCC 2016 Subseasonal to Seasonal (S2S) Training Program

2018 APEC Climate Center Training Program

1. ***Theme***

   APCC in the Forefront of S2S Forecast: Leading the way in the fight against extreme phenomena

2. Date

23 July – 28 July 2018

3. Venue

APEC Climate Center, Busan, Korea

4. Participants

19 participants from 10 countries
young scientists from National Meteorological and Hydrological Services (NMHSs) in developing countries, particularly from the APEC region

5. Program

Total 22.5 hours for 14 subject

6. Lecturers

11 APCC research fellows

2018 APEC Climate Center Training Program

DAY 1 (23 July)	DAY 2 (24 July)
□ Opening/Orientation □ Lecture 1: [Dr. Yun-Young Lee] Introduction to Climate Variability & Prediction □ Lecture 2: [Dr. Suryun Ham] Understanding the climate prediction system □ Lecture 3: [Dr. Young-Mi Min] Overview of APCC Operational Multi-Model Ensemble Seasonal Prediction System □ Orientation for Hands-on Sessions □ Welcome Dinner	
Day 3 (25 July)	**Day 4 (26 July)**
□ Lecture 8: [Dr. Ji-Hyun Oh] Subseasonal Prediction and its Application □ Lecture 9: [Dr. Ok-Yeon Kim] Subseasonal-to-Seasonal Prediction for Tropical Cyclone Activity in the South Pacific □ Hands-On 1: [APCC] BSISO Impact using Station Data	□ Hands-On 2: [APCC] BSISO Impact using Station Data □ Hands-On 3: [APCC] BSISO Impact on Atmospheric Circulation □ Hands-On 4: [APCC] BSISO Impact on Atmospheric Circulation □ Korean Cultural Tour
Day 5 (27 July)	**Day 6 (28 July)**
□ Hands-On 5: [APCC] Lab □ Hands-On 6: [APCC] Lab □ Participant Presentations □ Closing Ceremony □ Closing Dinner	□ Korean Cultural Tour

2018 APEC Climate Center Training Program

DAY 1 (23 July)	DAY 2 (24 July)
□ □ □ □  del □ □	□ Lecture 4: [Dr. Ja-Yeon Moon] Understanding Intraseasonal Variability □ Lecture 5: [Dr. Hae-Jeong Kim] APCC's Subseasonal Forecasting Activity □ Lecture 6: [Dr. Yoo-Bin Yhang] S2S prediction and downscaling □ Lecture 7: [Dr. Hae-Jeong Kim] Enhancing the Practical Usefulness of APCC's BSISO Information □ Korean Cultural Experience
Day 3 (25 July)	**Day 4 (26 July)**
□ Lecture 8: [Dr. Ji-Hyun Oh] Subseasonal Prediction and its Application □ Lecture 9: [Dr. Ok-Yeon Kim] Subseasonal-to-Seasonal Prediction for Tropical Cyclone Activity in the South Pacific □ Hands-On 1: [APCC] BSISO Impact using Station Data	□ Hands-On 2: [APCC] BSISO Impact using Station Data □ Hands-On 3: [APCC] BSISO Impact on Atmospheric Circulation □ Hands-On 4: [APCC] BSISO Impact on Atmospheric Circulation □ Korean Cultural Tour
Day 5 (27 July)	**Day 6 (28 July)**
□ Hands-On 5: [APCC] Lab □ Hands-On 6: [APCC] Lab □ Participant Presentations □ Closing Ceremony □ Closing Dinner	□ Korean Cultural Tour

2018 APEC Climate Center Training Program

DAY 1 (23 July)	DAY 2 (24 July)
□ Opening/Orientation □ Lecture 1: [Dr. Yun-Young Lee] Introduction to Climate Variability & Prediction □ Lecture 2: [Dr. Suryun Ham] Understanding the climate prediction system □ Lecture 3: [Dr. Young-Mi Min] Overview of APCC Operational Multi-Model Ensemble Seasonal Prediction System □ Orientation for Hands-on Sessions □ Welcome Dinner	□ Lecture 4: [Dr. Ja-Yeon Moon] Understanding Intraseasonal Variability □ Lecture 5: [Dr. Hae-Jeong Kim] APCC's Subseasonal Forecasting Activity □ Lecture 6: [Dr. Yoo-Bin Yhang] S2S prediction and downscaling □ Lecture 7: [Dr. Hae-Jeong Kim] Enhancing the Practical Usefulness of APCC's BSISO Information □ Korean Cultural Experience
Day 3 (25 July)	**Day 4 (26 July)**
□ Lecture 8: [Dr. Ji-Hyun Oh] Subseasonal Prediction and its Application □ Lecture 9: [Dr. Ok-Yeon Kim] Subseasonal-to-Seasonal Prediction for Tropical Cyclone Activity in the South Pacific □ Hands-On 1: [APCC] BSISO Impact using Station Data	□ Hands-On 2: [APCC] BSISO Impact using Station Data □ Hands-On 3: [APCC] BSISO Impact on Atmospheric Circulation □ Hands-On 4: [APCC] BSISO Impact on Atmospheric Circulation □ Korean Cultural Tour
Day 5 (27 July)	**Day 6 (28 July)**
□ Hands-On 5: [APCC] Lab □ Hands-On 6: [APCC] Lab □ Participant Presentations □ Closing Ceremony □ Closing Dinner	□ Korean Cultural Tour

2018 APEC Climate Center Training Program

7. Level of participants satisfaction

Score : 4.68/5.00

General Review:

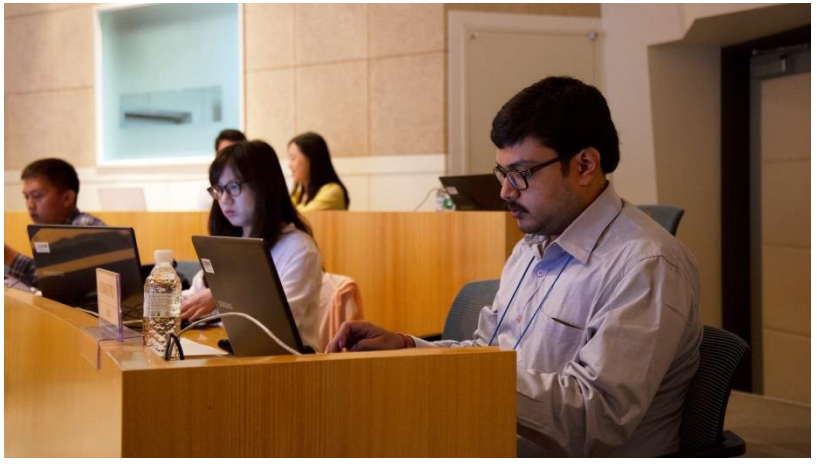
There is big interest on S2S theory, application and Hands-on from participants even though S2S is relatively new area.

Every participants prepared their own observational data for their country and all of the data were available in Hands-on session by checking them before TP, which in turn every participants could practice the Hands-on effectively.

There are several opinion that the participants will utilize what he/she has learned from APCC to prediction for their own nation.

2018 APEC Climate Center Training Program

Hands-on session in APCC TP



Participants presentation in APCC TP

Closing ceremony in APCC TP

Korean Cultural Tour in APCC TP

Korean Cultural Experience in APCC TP

Korean Cultural Experience

- Lecturer :「Community on promoting Korean sprit and culture」members

  (1 lecture, 1 assistant)

- Lectures on Korean culture such as Korean history, Korean alphabet, etiquette, pop culture etc.

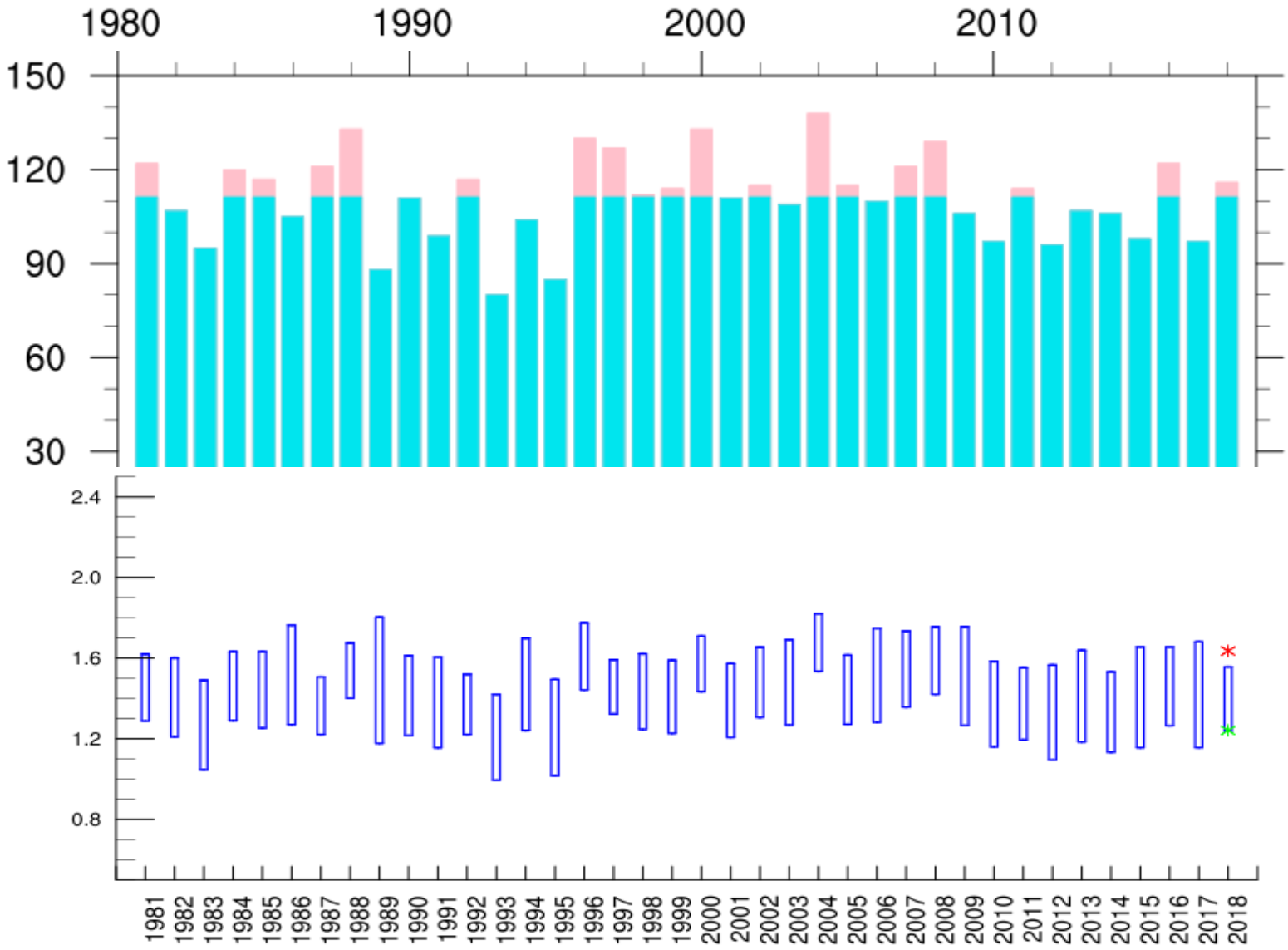
- Experience on wearing Korean traditional clothes, traditional tea tasting, learning etiquette etc

Korean Cultural Experience in APCC TP

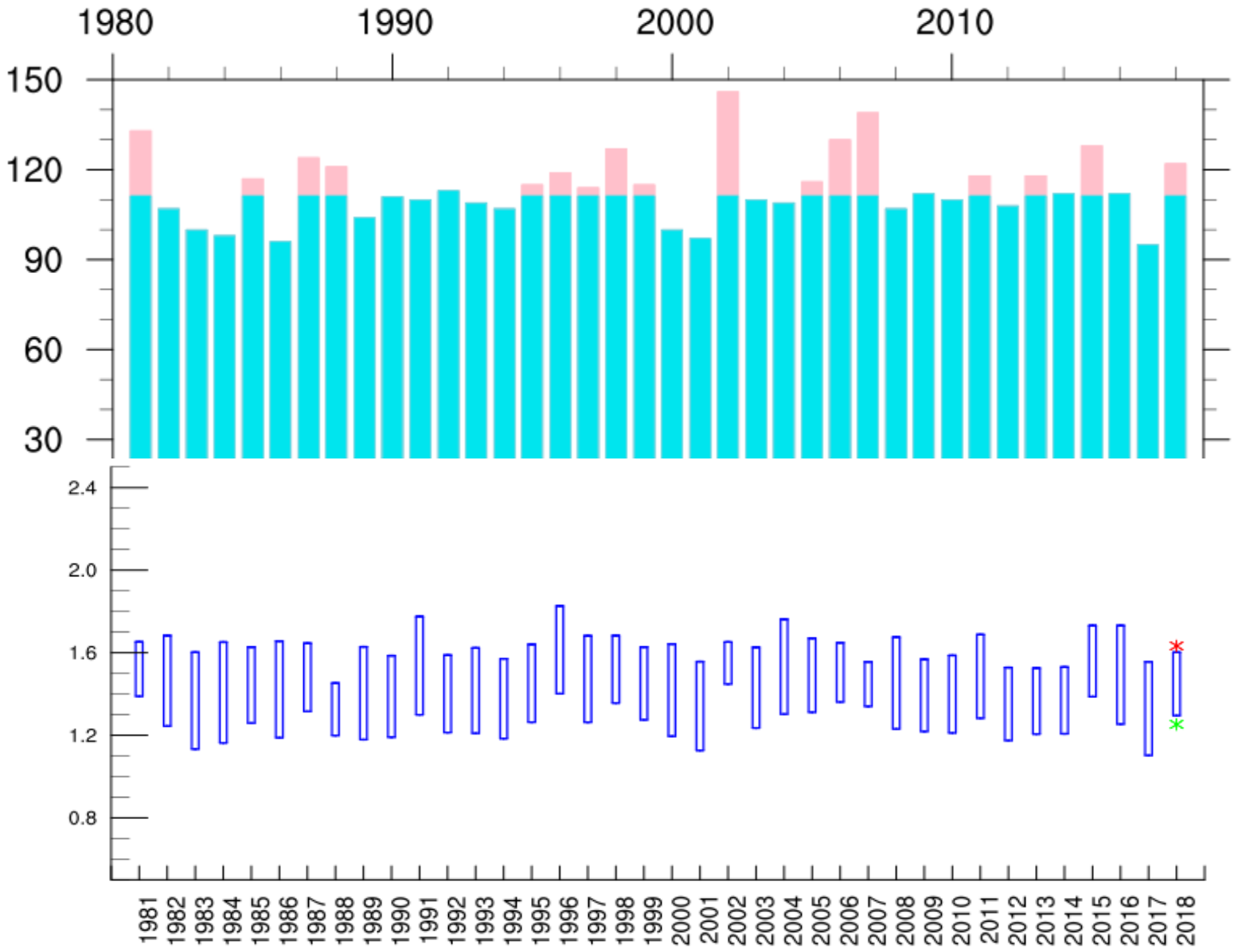
Statistics

Based on BSISO indices

Statistics BSISO1

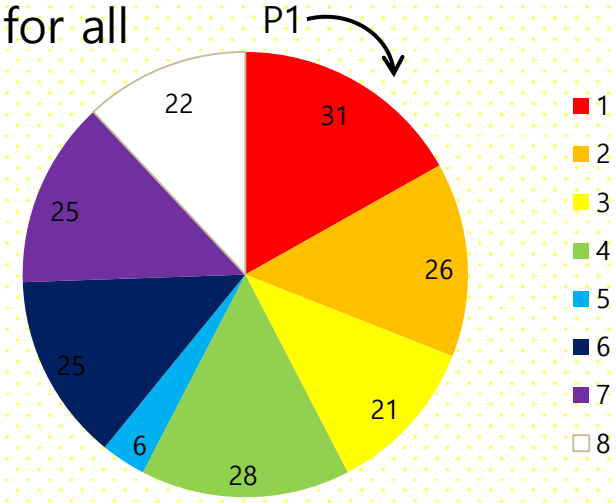


Statistics BSISO2

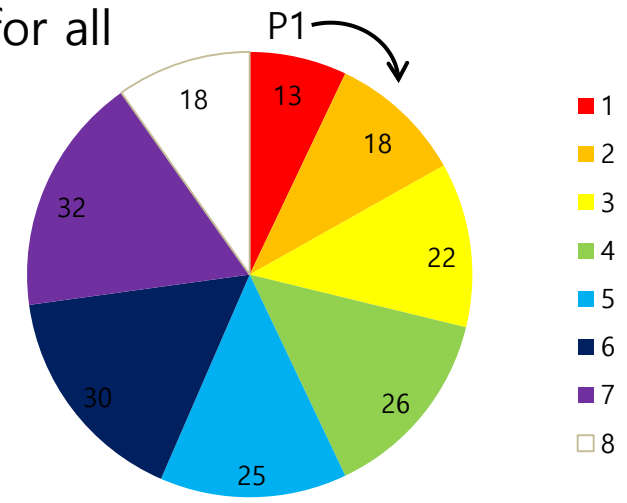


of day for each phase in 2018

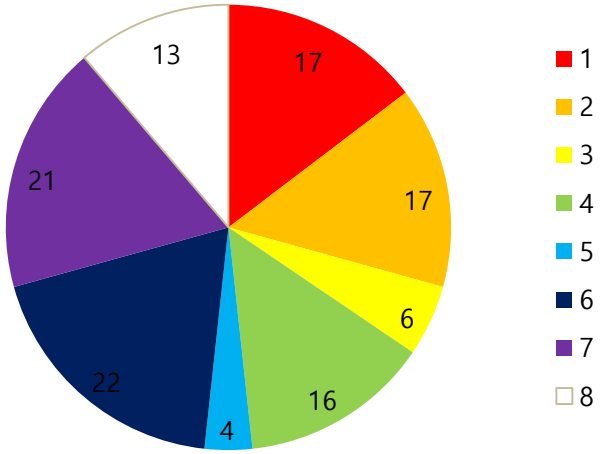
BSISO1 for all
12 67



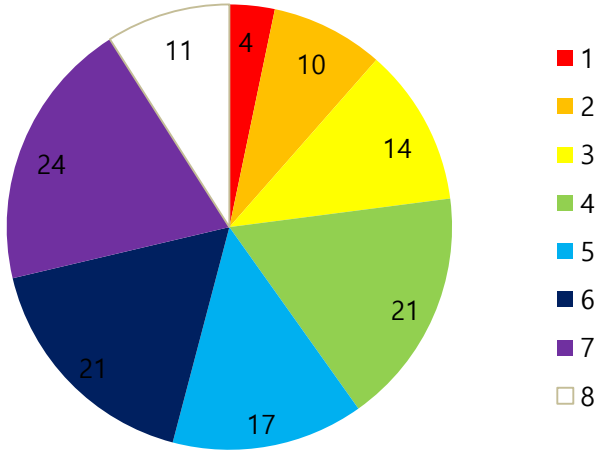
BSISO2 for all
4567

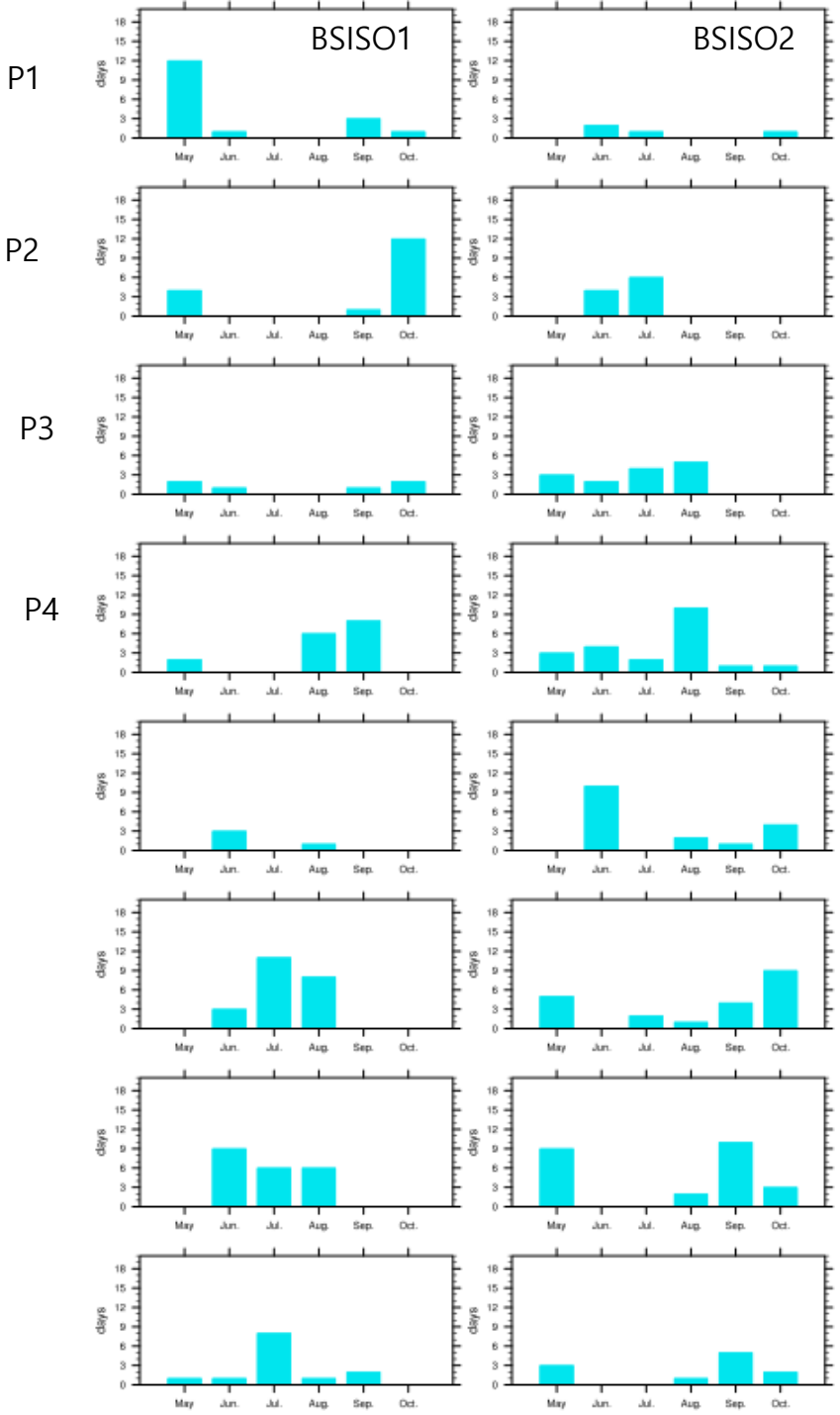


BSISO1 for strong days



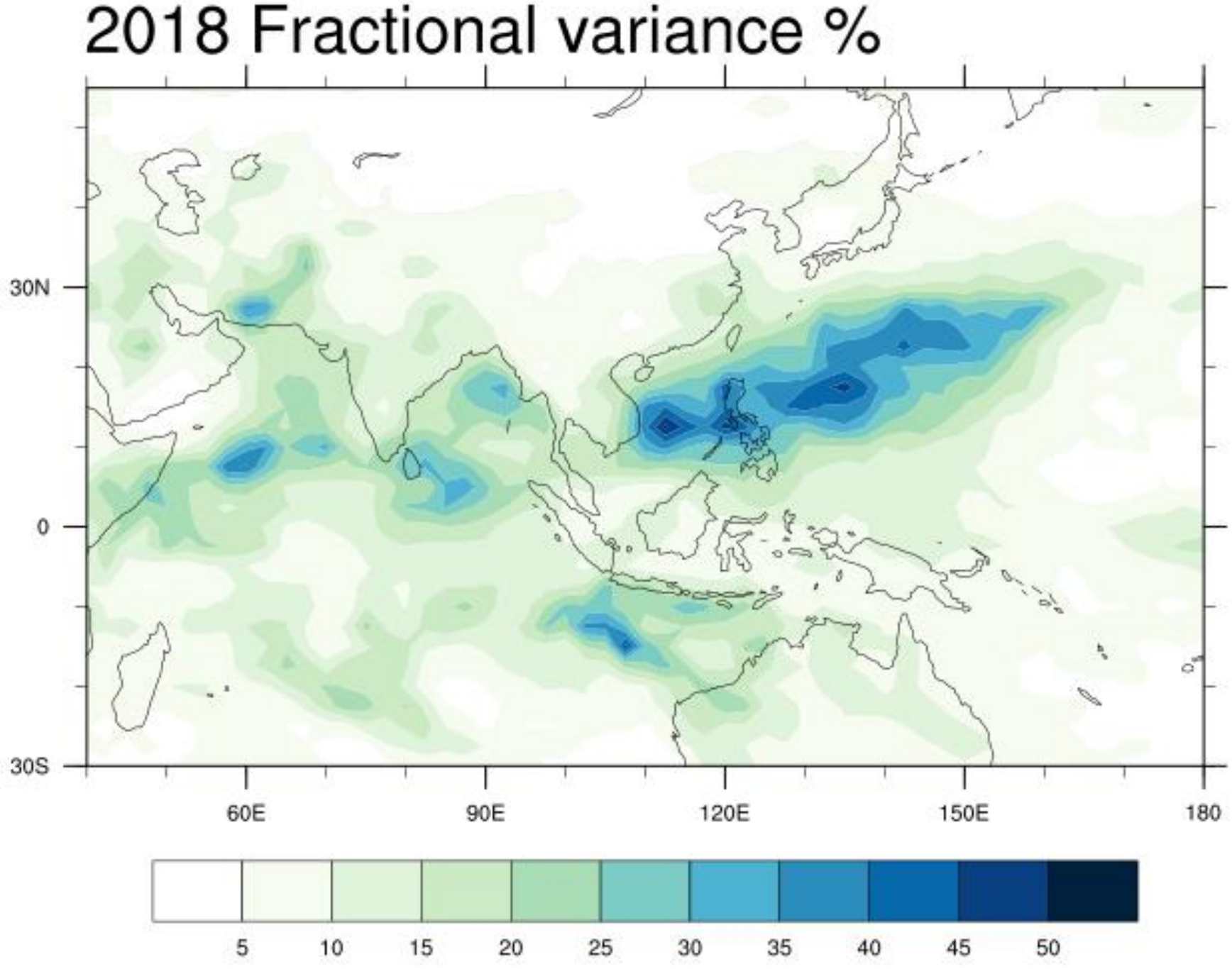
BSISO2 for strong days



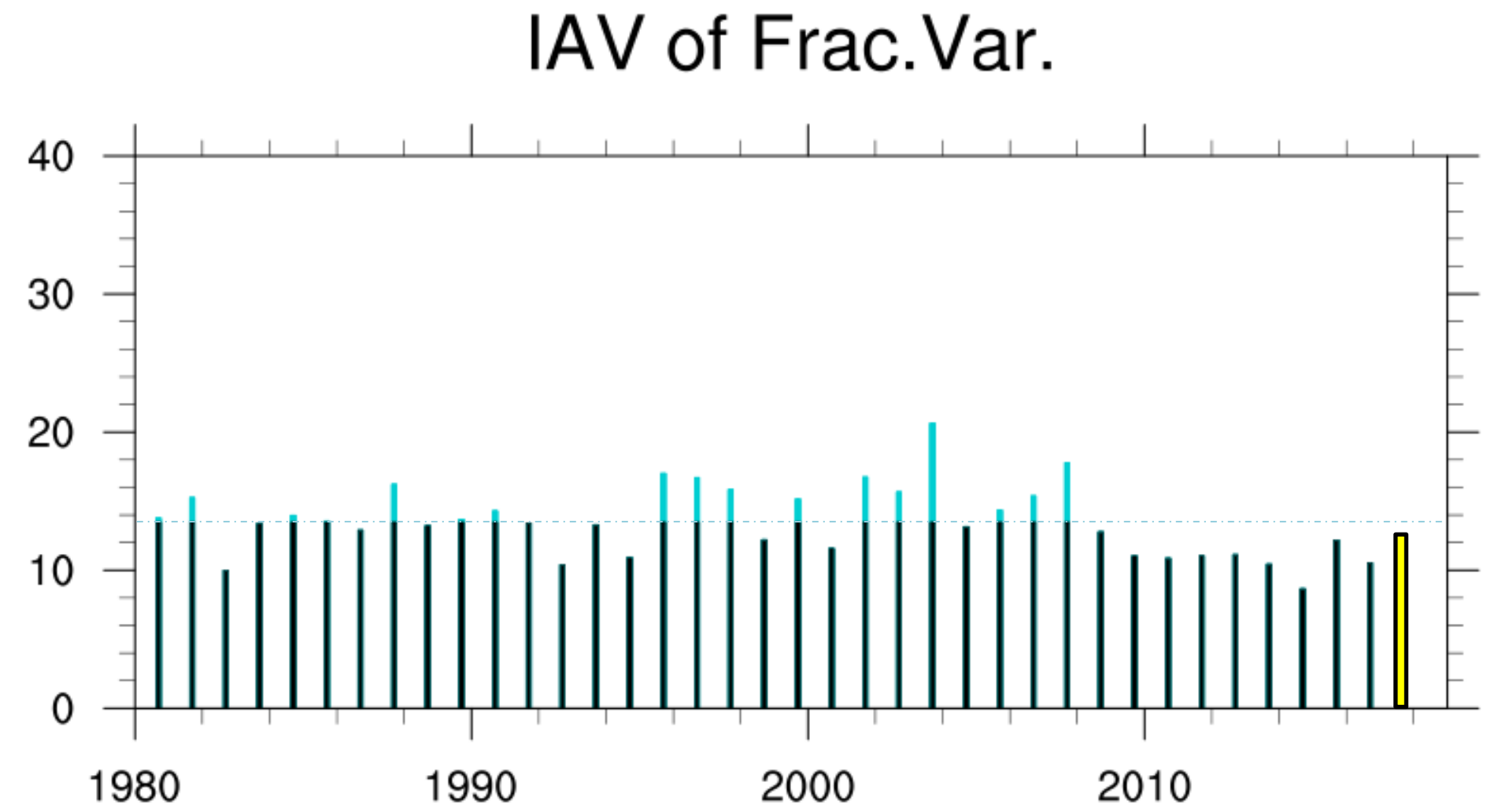

BSISO1
BSISO2
P1
P2
P3
P4
days
May
Jun.
Jul.
Aug.
Sep.
Oct.

Statistics

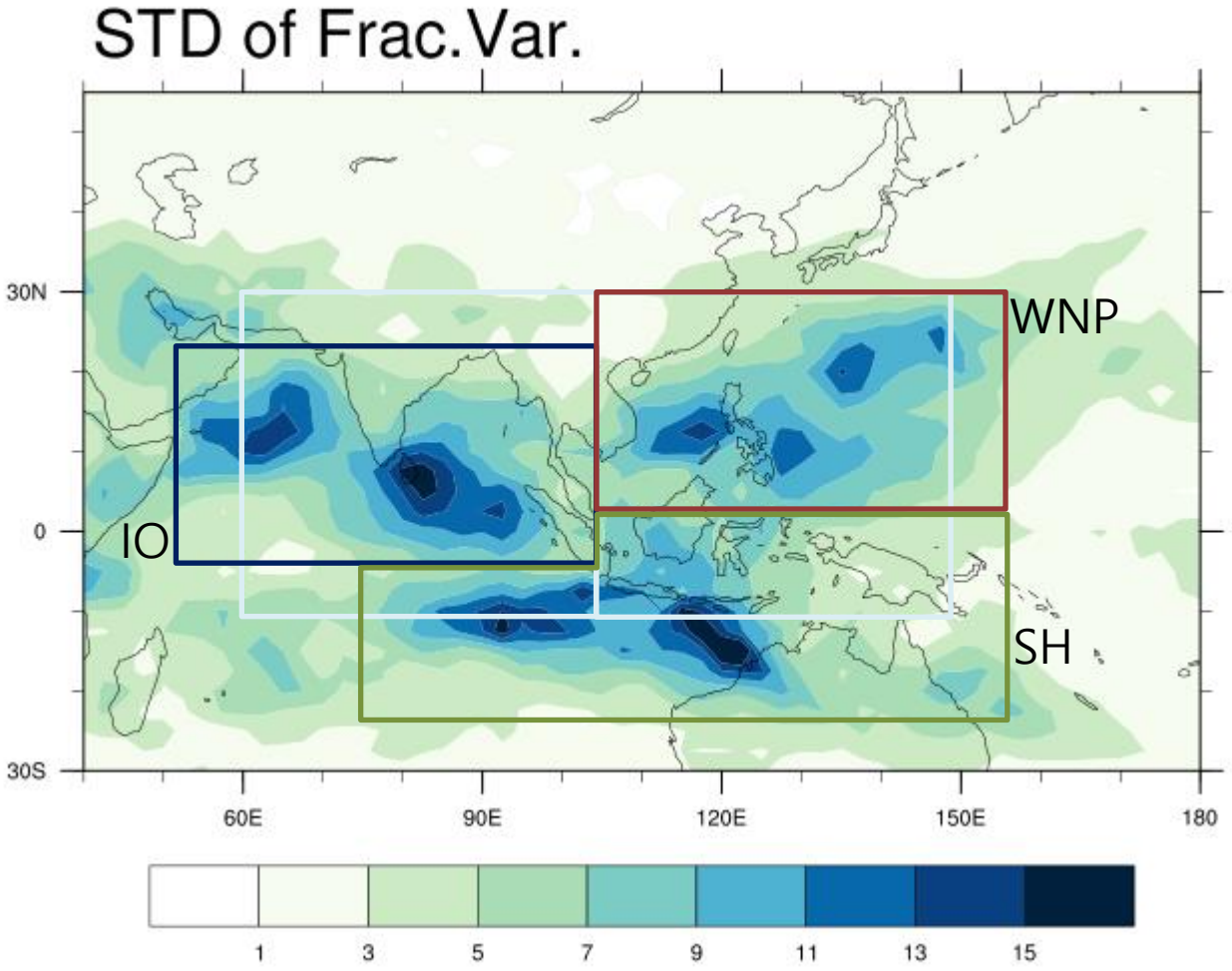
Based on BSISO anomaly


2018 Fractional variance %
30N
0
30S
60E
90E
120E
150E
180
5
10
15
20
25
30
35
40
45
50

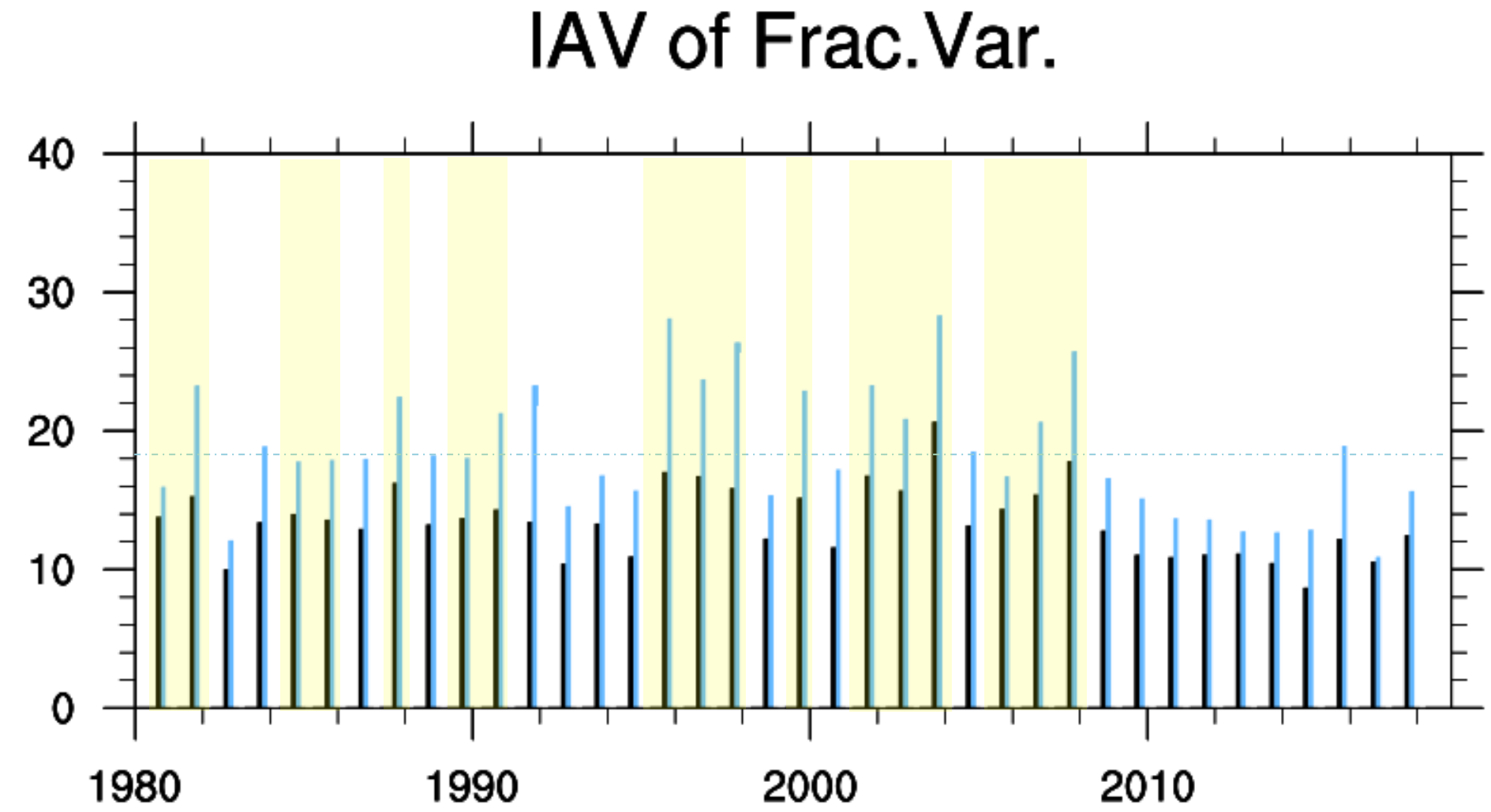
Interannual variability of fractional variance for ASM region



Regional IAV

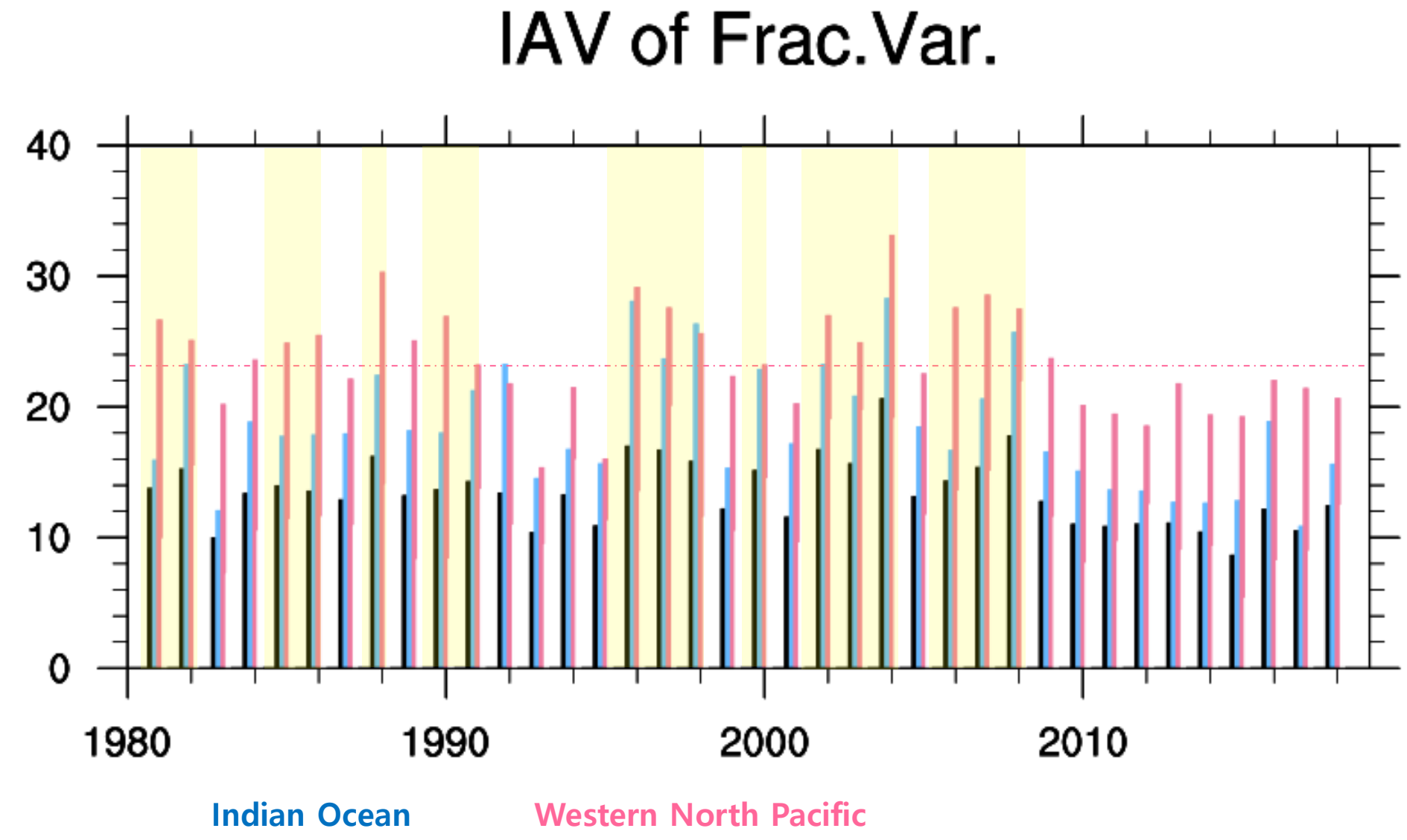


Interannual variability of fractional variance for ASM region

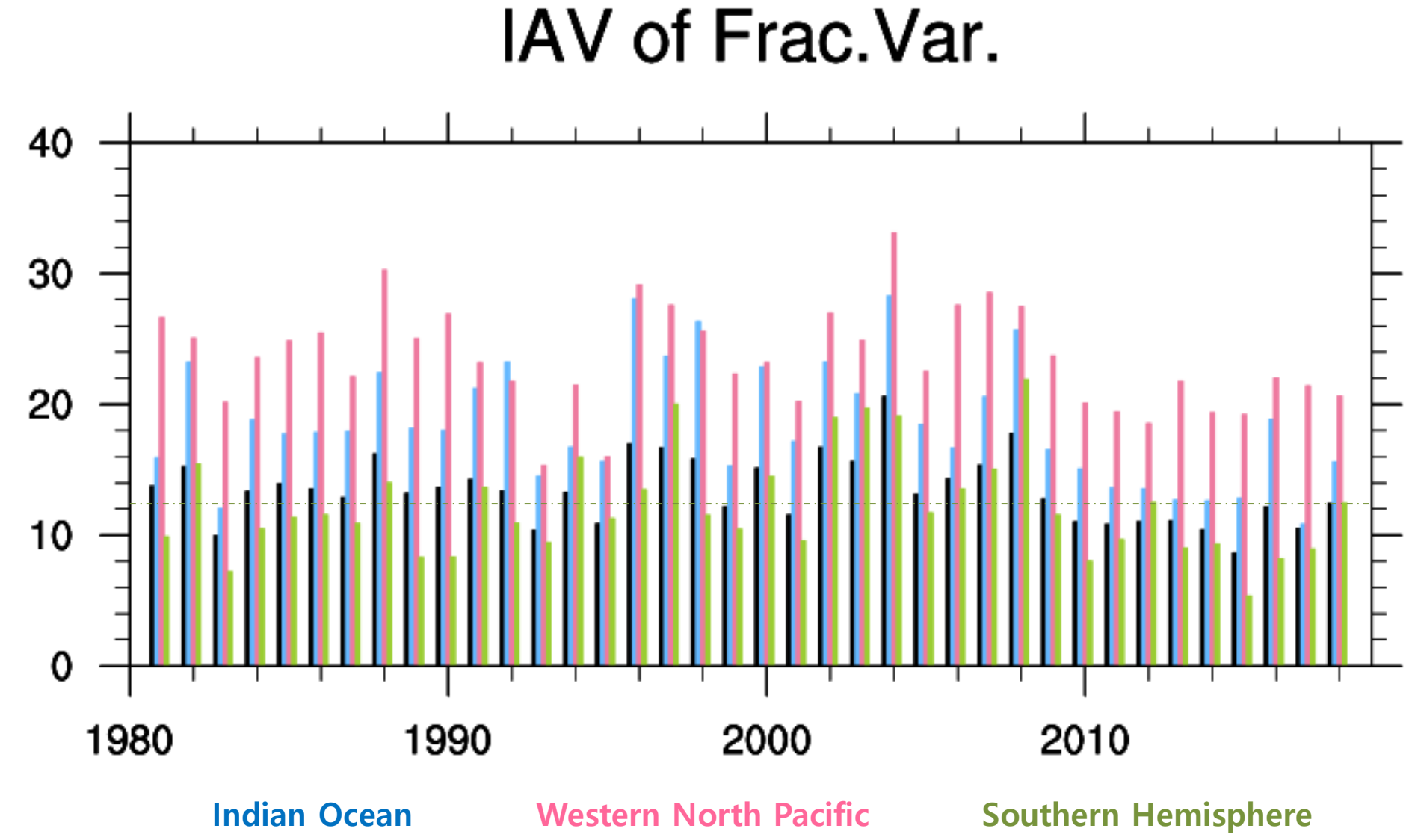


Indian Ocean

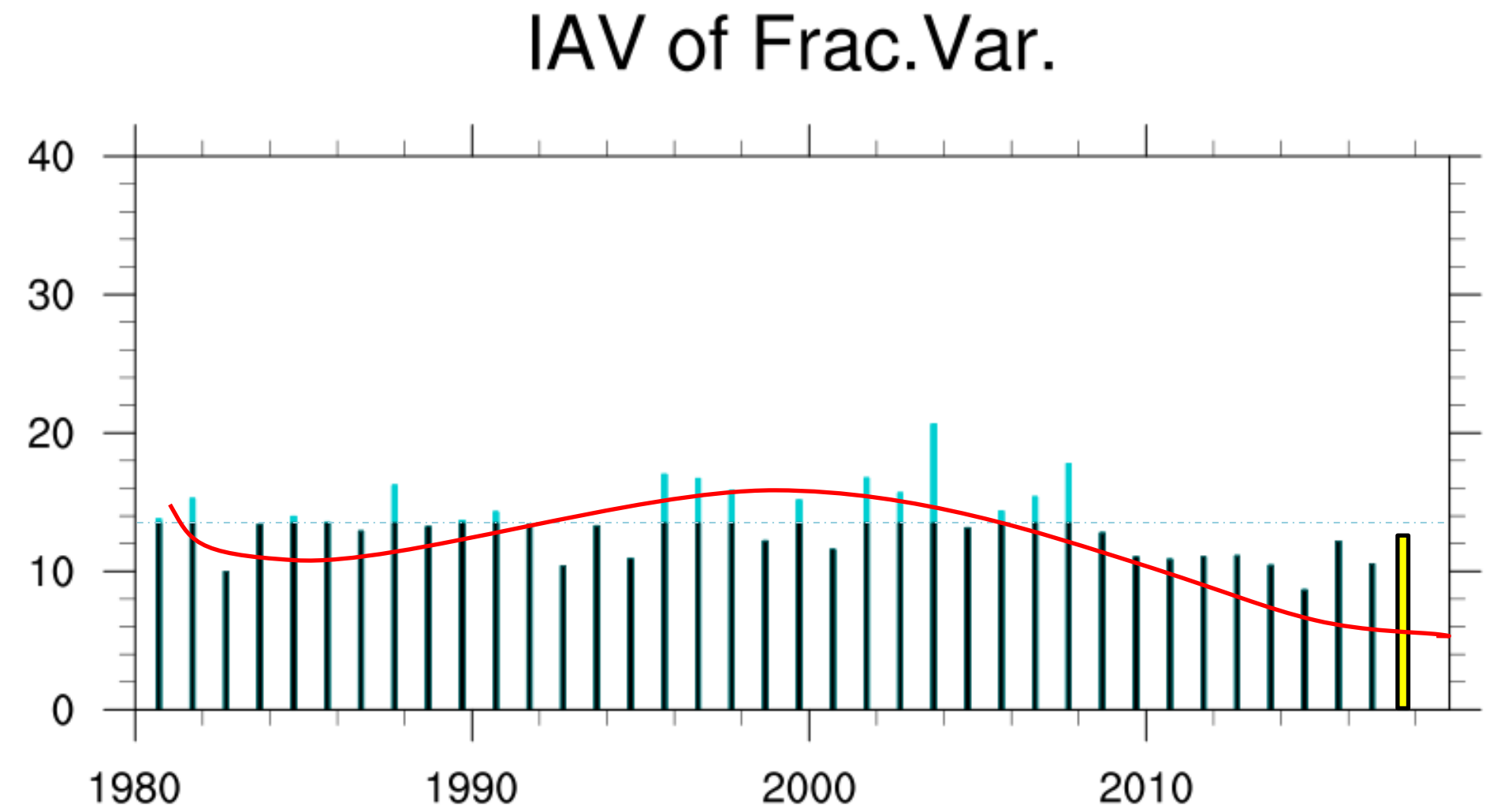
Interannual variability of fractional variance for ASM region



Interannual variability of fractional variance for ASM region

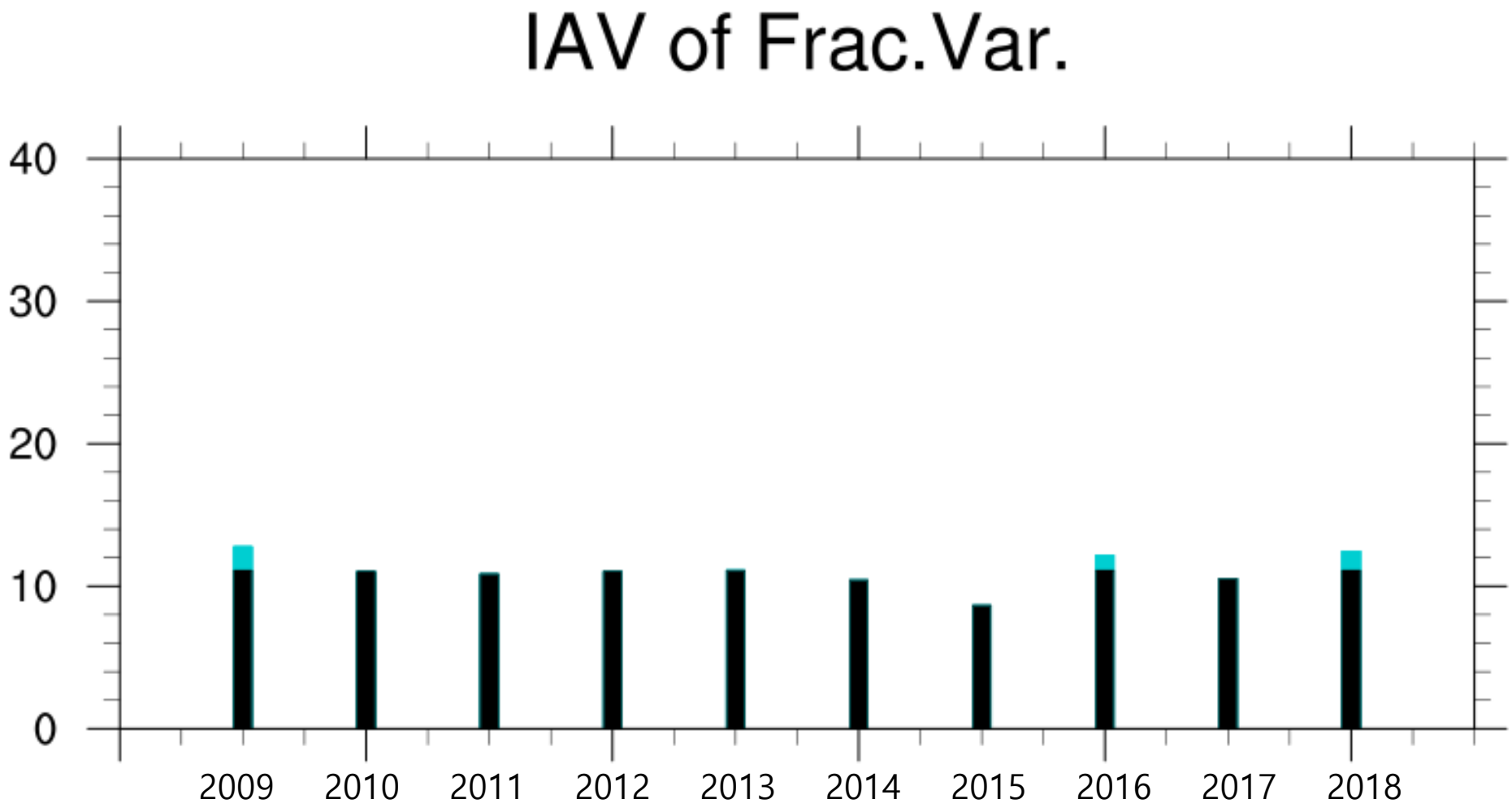


Interannual variability of fractional variance for ASM region

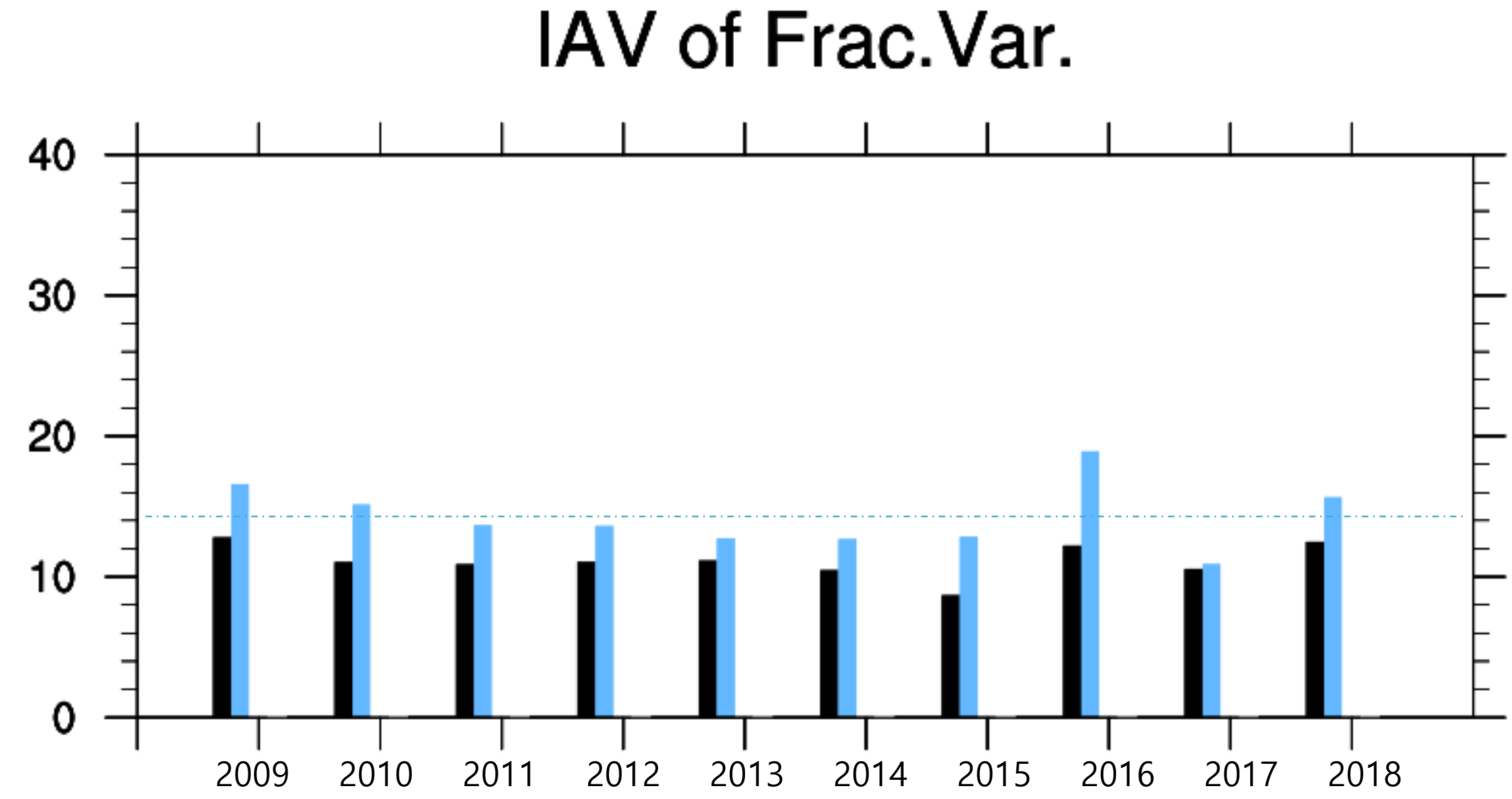


Recent 10 years

Interannual variability of fractional variance for ASM region

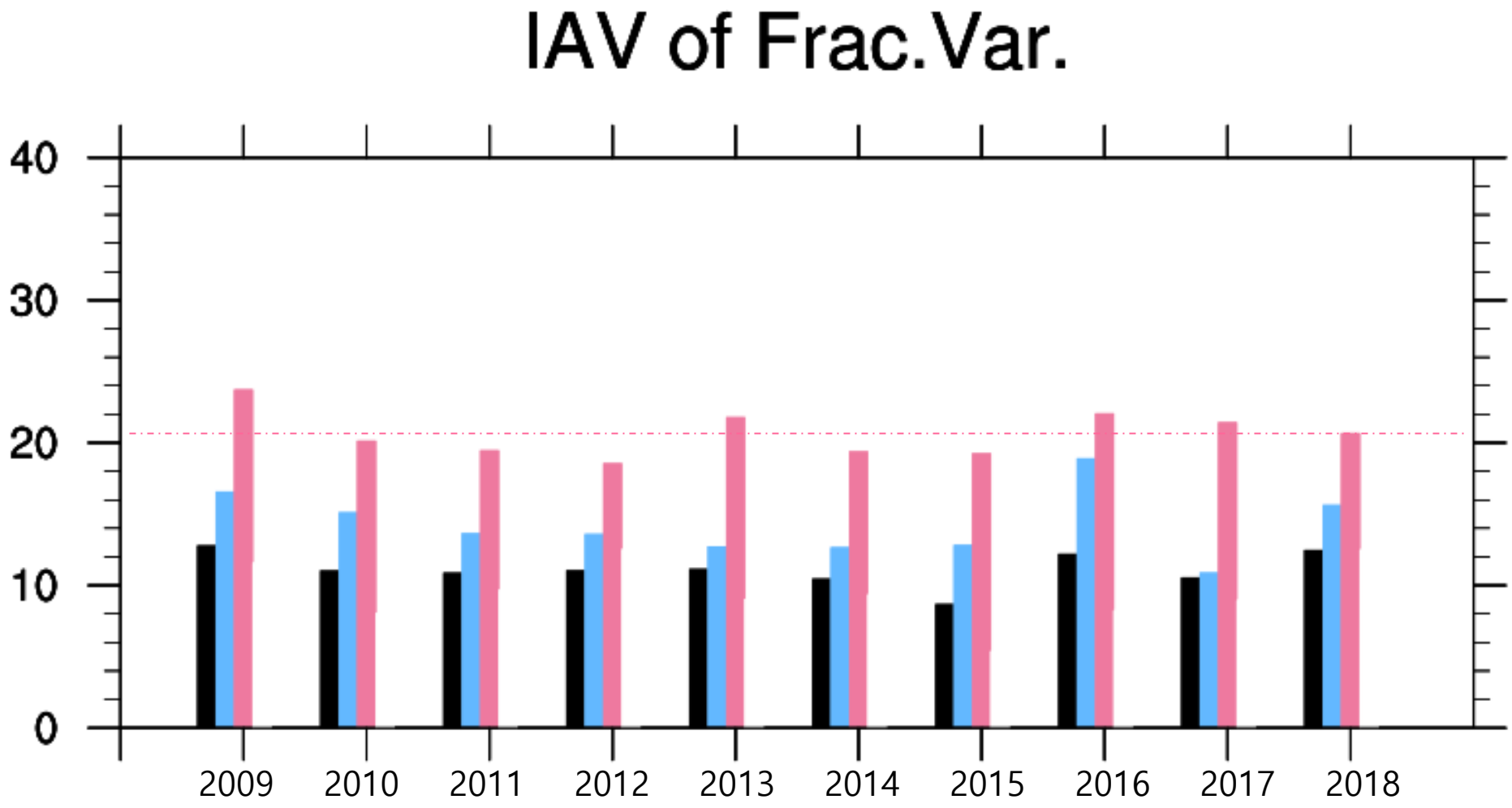


Interannual variability of fractional variance for ASM region

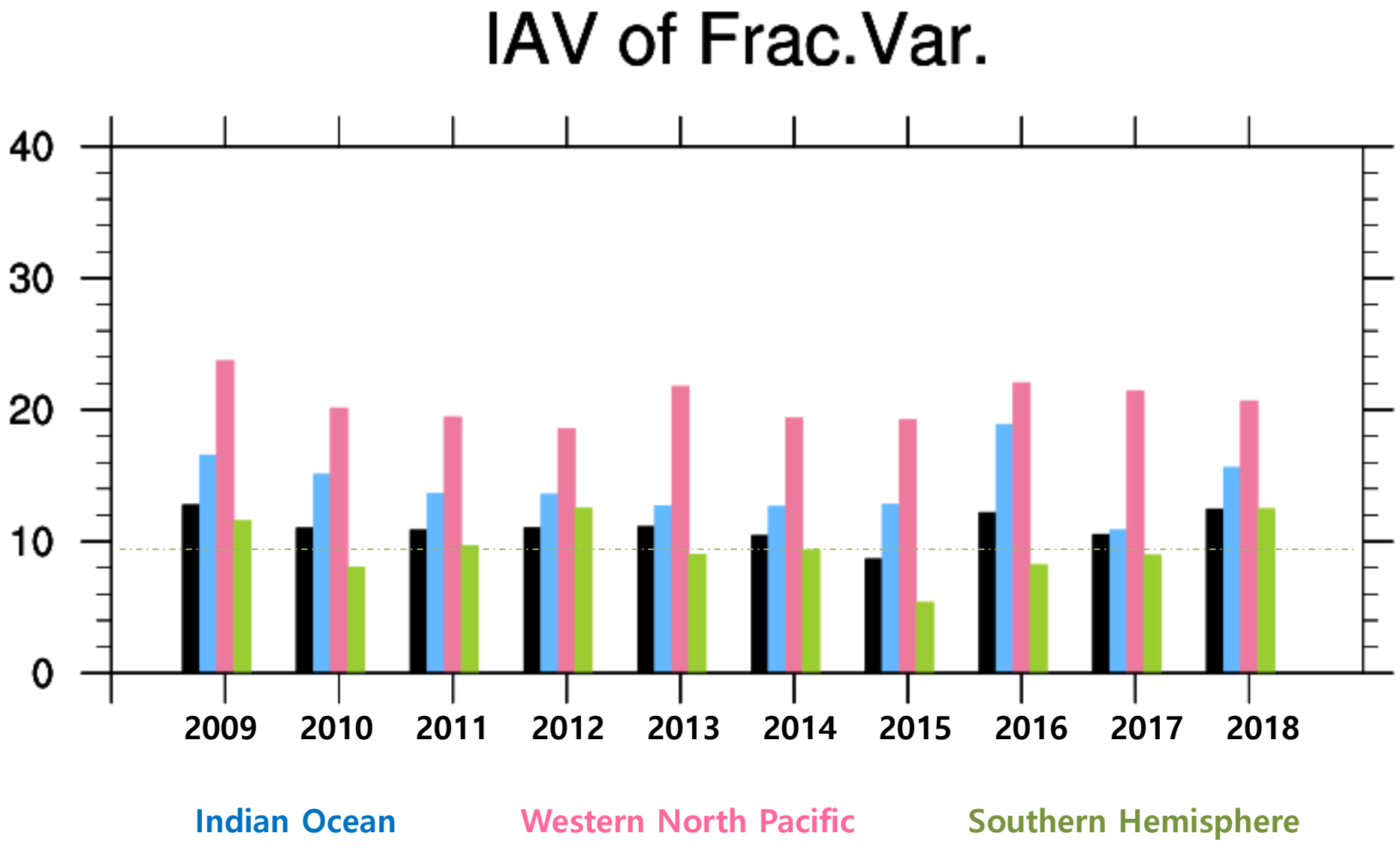


Indian Ocean

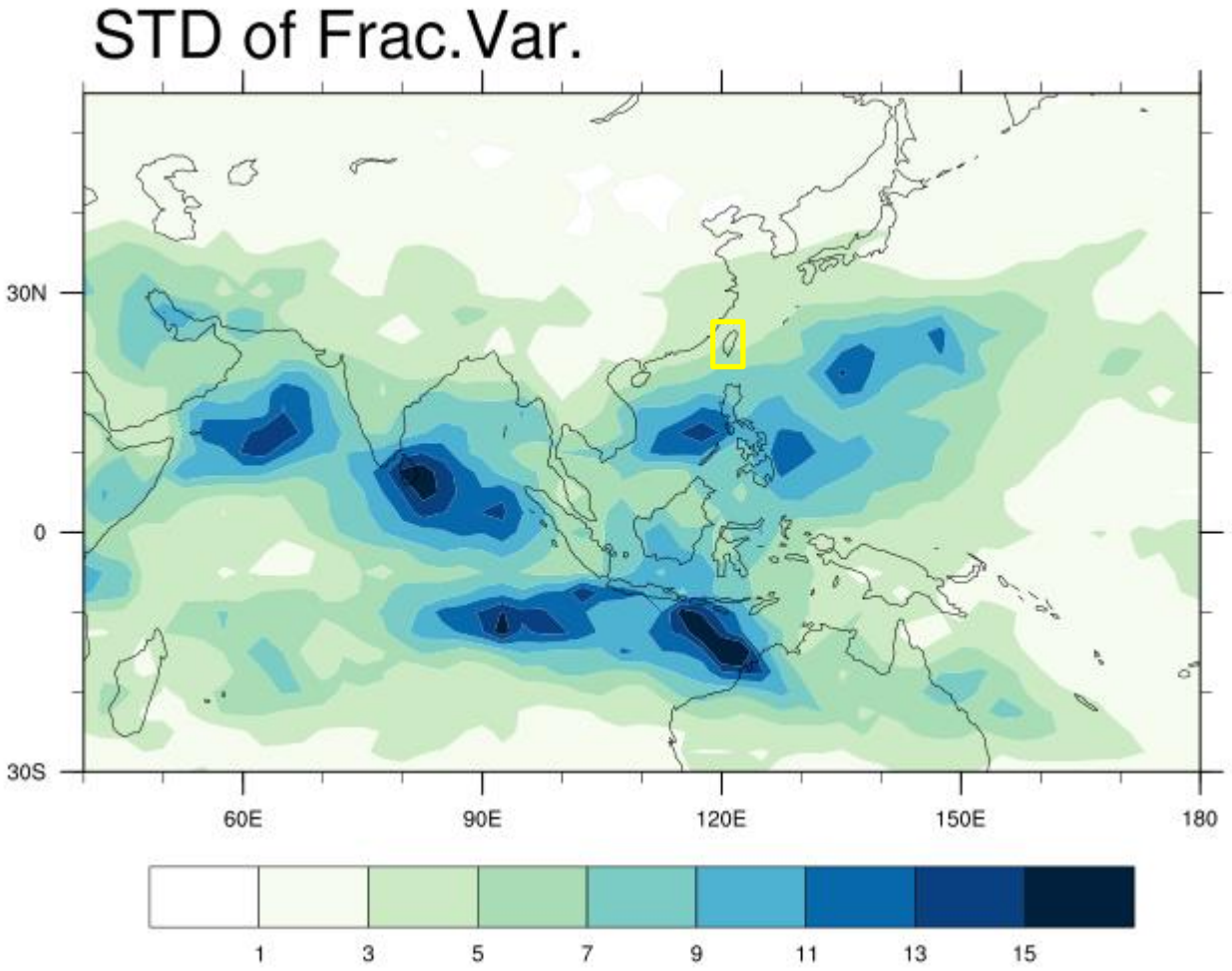
Interannual variability of fractional variance for ASM region



Interannual variability of fractional variance for ASM region

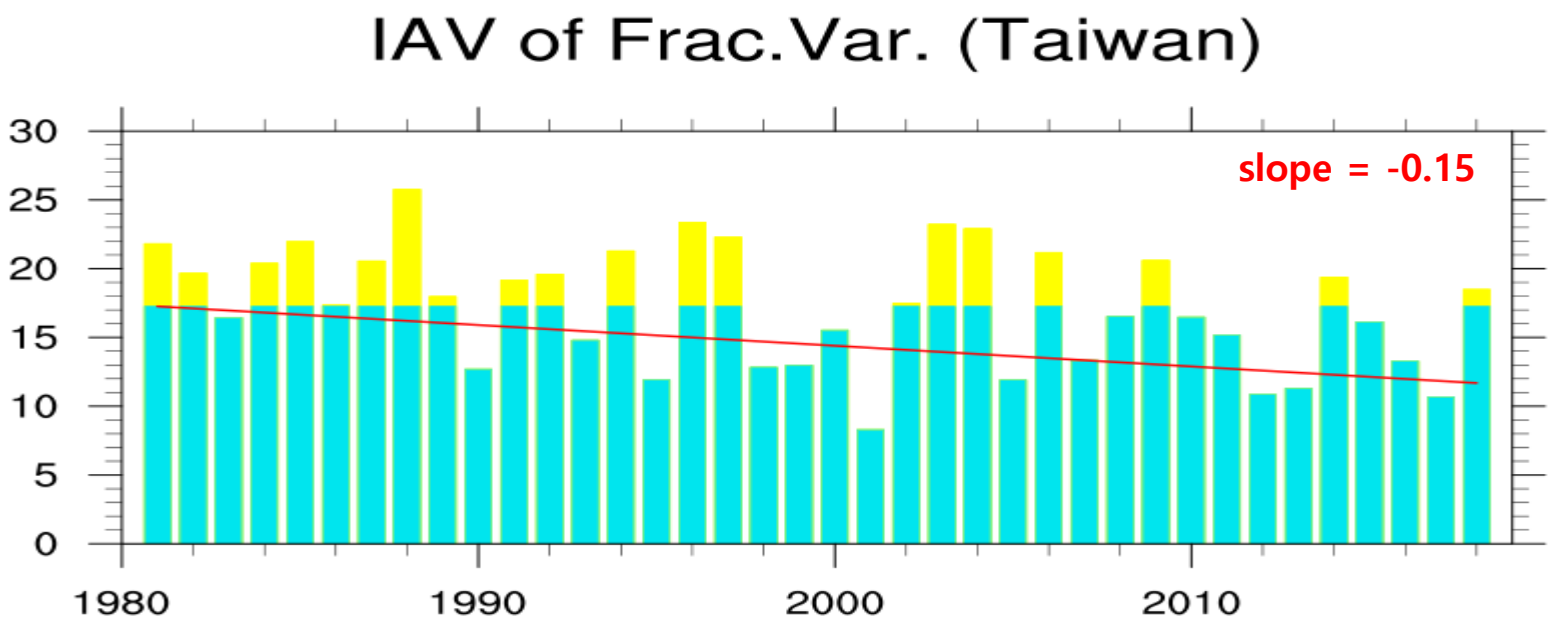


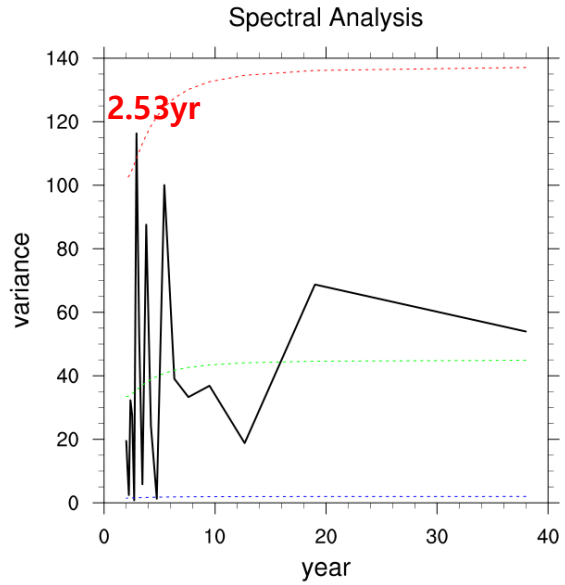
Local IAV



Taiwan= [120-122°E, 20-27°N]

Interannual variability of fractional variance for Taiwan region





Interannual variability of fractional variance for ASM region