문서번호 APCC-출장-17-0749(2017-07-03)

결재	선임연구원	팀장	부서장	원장
	06/30 함수련	대결 06/30 이우섭	07/03 유진호	07/03 정홍상
협조				

TRAVEL REPORT FORM
출장보고서

I. Reporter 보고자

Department 소속	Position 직위(직급)	Name 성명	Travel Date 날짜	Note 비고
기후연구팀	선임연구원	함수련, 양유빈	6/17-6/25	

II. Major Activities 주요업무 수행내용

1. Main Contents and Activities 주요내용 및 활동

5th WGNE workshop on system errors in weather and climate models 참석 및 발표 (6/19-23), 캐나다 몬트리올 Centre Mont-Royal

함수련 선임연구원:
발표제목: Seamless coupled Prediction System (SCoPS): Assessment of the APCC model retrospective seasonal forecast (1982-2013)

양유빈 선임연구원:
발표제목: Evaluation of regional climate model for trends of extreme indices over East Asia

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

Modeling error에 대한 워크샵이니 만큼 NCEP, ECMWF, GFDL 등 많은 현업 기관 및 학교 관련자들이 모형 개발 및 개선을 비롯한 모형 전반의 특성에 대한 유익한 연구결과를 공유, 토론하였다. 모형의 계통적 오차와 관련된 연구들 외에도 대기-해양-빙권 모형의 영향, 대기 경계층과 관련한 불확실성, 모형 해상도, MJO를 비롯한 기후특성, 모형의 성능을 평가/진단하기 위한 방법들이 발표되었다.

지금까지 대기-해양의 결합 효과가 기후 모형에 미치는 영향에 대해서는 많이 강조되어 왔다. 최근들어서는 해양뿐만 아니라 빙권 모형이 가지고 있는 중요성이 제기되고 있으며, 모형 해상도와 더불어 계통적 에러를 줄일 수 있는 방안으로 부각되고 있다. 또한, 해수면 온도와 지표 플럭스 사이의

상호작용이 대기대순환 및 강수와 연관되어 모형의 에러를 크게 줄이는 효과를 가져온다. 많은 GCM에서 문제가 되고 있는 double ITCZ 문제 역시 지표 플럭스의 개선 및 해수면 온도의 에러와 크게 연관이 있다고 밝혔다. JMA, ECMWF, NCAR 등의 기관 모형에서 모의하는 MJO 특성 역시 토론되었다. 대부분의 기관들이 3주까지는 신뢰도있는 MJO 예측 성능을 보이고 있으며, 해수면 온도와 강수의 오차가 MJO의 예측에도 영향을 미친다고 밝혔다. 또한 해상도가 모형 초기에러를 더 키웠을 때, MJO 예측에도 크게 차이를 만들 수 있다고 제시했다. 앙상블 예보를 하고 있는 기관들에서는 그 에러를 줄일 수 있는 방법으로 stochastic parameterization을 제시했다. CESM, ECMWF 등의 기관에서 stochastic physics를 이용하여 ENSO, inter-, intra-annual variability 등에서의 개선을 가져왔다고 밝혔다.

또한, 미국 National Livermore 연구소에서는 CMIP5의 모형들의 성능들을 비교, 검증하기 위한 새로운 진단 툴을 소개하여 많은 주목을 받았다. 각 모형의 스킬을 한 눈에 파악할 수 있는 새로운 진단 툴은 아직 정식 오픈이 되지 않았지만, 추후 MME 참여모형들의 비교 검증이나, in-house모형의 성능 검증 등 센터내에서도 유용하게 사용될 수 있을 것으로 판단된다. 앙상블 스프레드나 stochastic 관련 연구들 역시 센터내 모형에 적용하여 모형의 계통적 오차를 줄일 수 있는 방법이라 여겨진다. 또한 많은 현업 기관 및 학계의 연구들을 통해 최근 모델의 개선 및 개발이 다시 주목받고 있는 상황임을 확인할 수 있는 자리였다.

III. References 참고사항

(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

- 발표자료첨부

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1. Presented and Collected Materials 주요 수집자료

2. Suggestions and Remarks 건의사항

Evaluation of Regional Climate Model for Trends of Extreme Indices over East Asia

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(ybyhang@apcc21.org)

Introductiaon

The climate over East Asia has experienced a gradual warming throughout the 20th century. The change of the mean climate state could lead to a change of climate extremes due to a shift in the temperature distribution. Negative impacts of climate change on society and ecosystems are mostly expected to arise from extreme events, which highlights the need to identify climate extremes (Sillmann and Roeckner 2008).

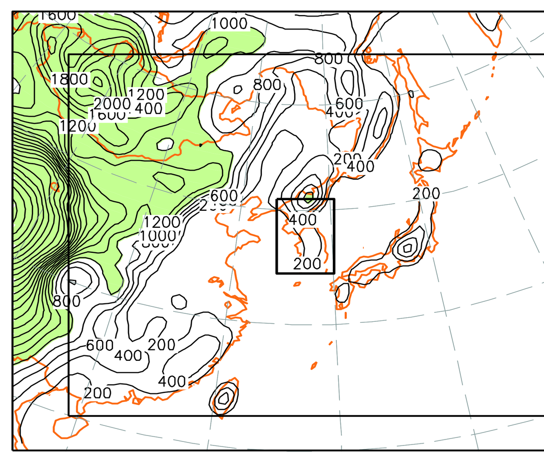
Although changes of climate extremes should be considered as critical factors of climate change impact, intensive examination of their characteristics is relatively limited so far. One of the main reason is related to a lack of reliable and homogeneous long-term daily time series of both observations and simulation data.

As climate extremes may have a complex spatial and temporal variation and East Asia is characterized by complicated mountainous terrain, high resolution information appropriate for analysis at the regional or local scale is needed to better understand climate extremes and their application to impact assessments over East Asia.

The major objective of this study is to demonstrate that the dynamical downscaling is capable of reproducing small-scale detail focusing on precipitation and surface temperature in terms of extreme indices.

Experimental Design

- Model : GRIMs (Hong et al. 2013)
- Period: 1 Jan 1979 - 31 Dec 2008 (30 years)
- Grid : 109×86 (horizontal resolution : 50km)
- BDY : NCEP/DOE Reanalysis Ⅱ data (R2)



To comprehensively investigate the characteristics of climate extremes, we select indices that consider frequency, intensity, and duration properties.

Table 1. Abbreviation and definition of the indices of extremes based on maximum and minimum temperature and precipitation used in this study.

Variable	Abbreviation (unit)	Definition of extreme indices
Temperature	FD (days)	Number of frost days with Tmin below 0°C
	HD (days)	Number of hot days with Tmax above 30°C
	TX95 (°C)	Averaged Tmax above 95th percentile
	TN5 (°C)	Average Tmin below 5th percentile
	HW (days)	Maximum duration of consecutive hot days
	FW (days)	Maximum duration of consecutive frost days
Precipitation	PN50 (days)	Number of days with precipitation above 50mm
	PX1D (mm)	Greatest 1-day total precipitation
	MDRY (days)	Maximum duration of consecutive dry days
	MWET (days)	Maximum duration of consecutive wet days

Trends of temperature-based extreme indices

To examine the temporal and spatial structure of trend in temperature- and precipitation-based extreme indices, extreme indices of RCM are compared to those of MERRA temperature (Rienecker et al. 2011) and CPC daily precipitation (Xie et al. 2007).

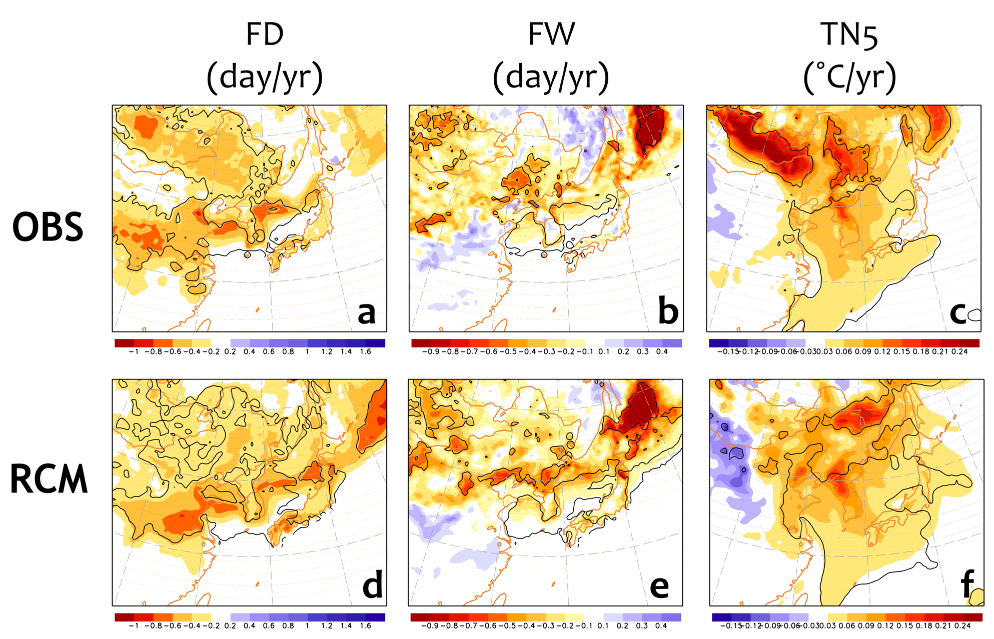


Fig. 1. *Linear trend of minimum temperature-based indices* from reanalysis (a-c), and the model (d-f). Contour lines indicate the 95% confidence levels based on a two-sided Student's t test.

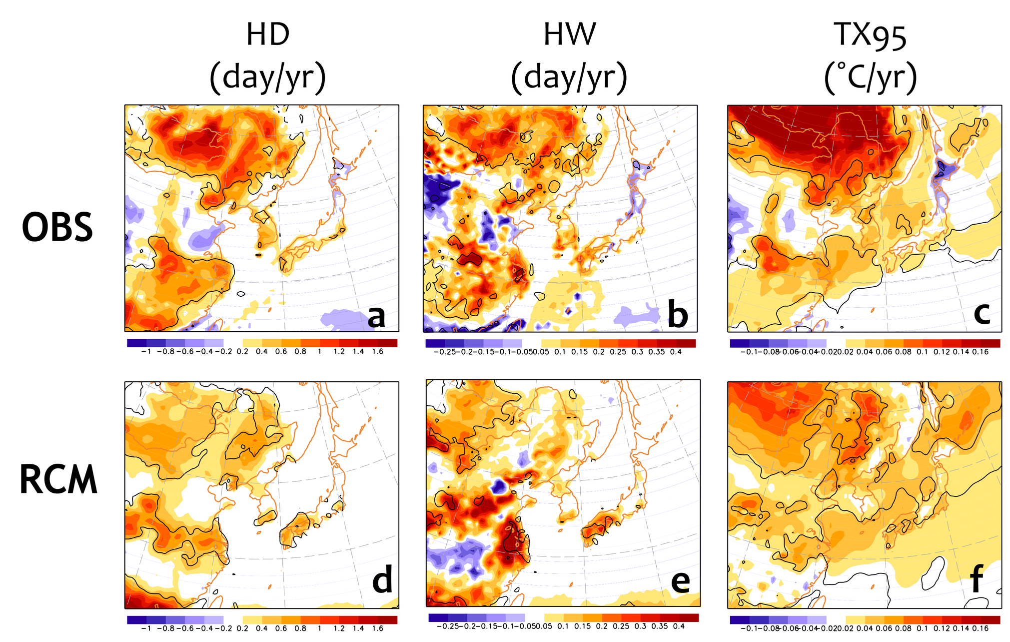


Fig 2. *Linear trend of maximum temperature-based indices* from reanalysis (a-c), and the model (d-f). Contour lines indicate the 95% confidence levels based on a two-sided Student's t test.

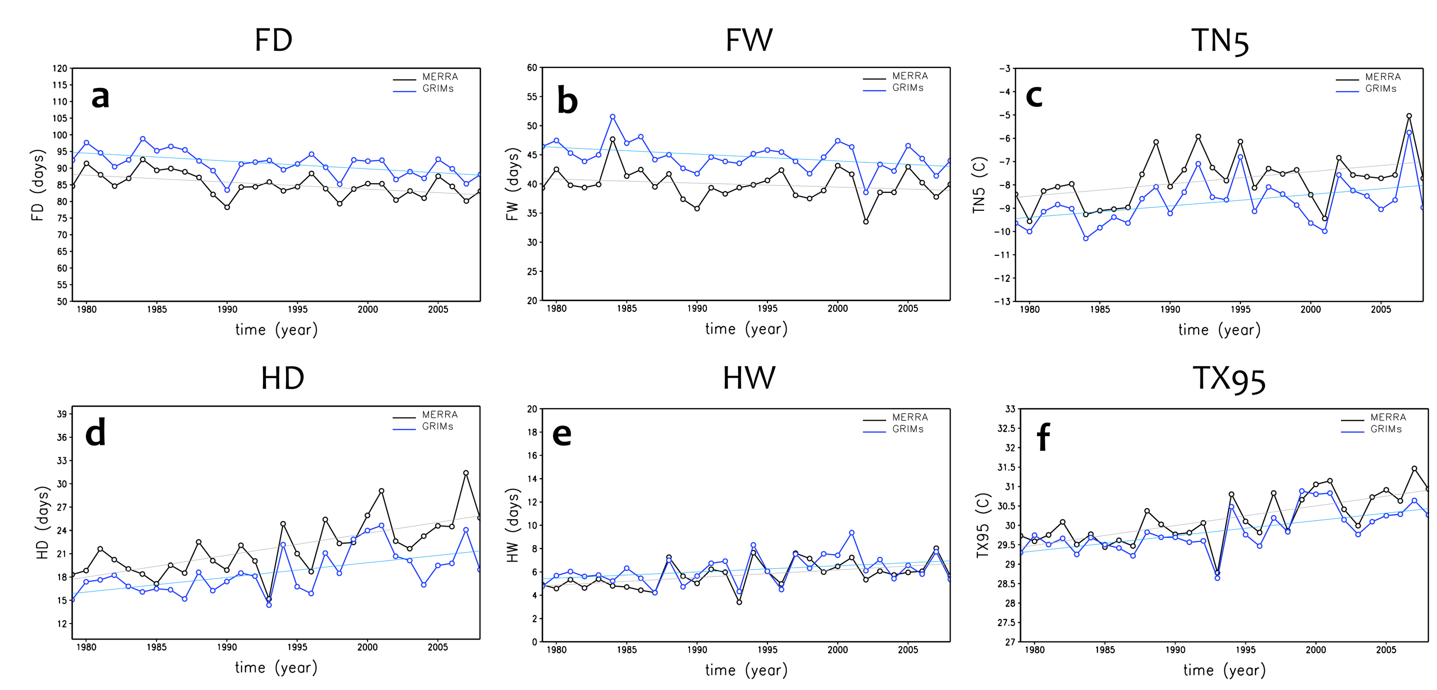


Fig. 3. Time-series of temperature-based indices averaged over East Asia.

- The observation and model show decreased trend of frost days over East Asia (Figs. 1a and 1d). Also, maximum duration of consecutive frost days are shortened during 30 years (Figs. 1b and 1e). Minimum temperature shows increased trend with strong positive signal in high latitudes (Fig. 1c). The RCM reproduces the warming trend, however underestimates the magnitude (Fig. 1f).
- Otherwise, extreme indices related to maximum temperature represent increasing trend in Fig. 2. Positive signals of HD and HW are significant over land except in 30N-40N. The RCM simulate similar characteristics to the observation. Although the RCM The model follows that characteristics.
- Regarding the change of the temperature magnitude, there are mostly significant positive trends in both simulations and observations throughout the entire region. The model successfully captures the general pattern of the trend, but it shows less significance in high latitudes.

- The structure of the temporal evolution depends on the index type. The extreme indices based on minimum temperature remain constant (FD, FW) or slightly increase (TN5), whereas the extreme indices based on maximum temperature show a increasing trend in HD and TX95.
- The model is able to realistically capture this asymmetric characteristic shown by observed climatological patterns despite systematic biases. The RCM tends to simulate more frost days (Figs. 3a, 3b), and less hot days (Fig. 3d), which indicates that GRIMs underestimates surface temperature. However, the qualitative aspects, in terms of the direction and slope of the trend are in good agreement with the observed estimate

Trends of precipitation-based extreme indices

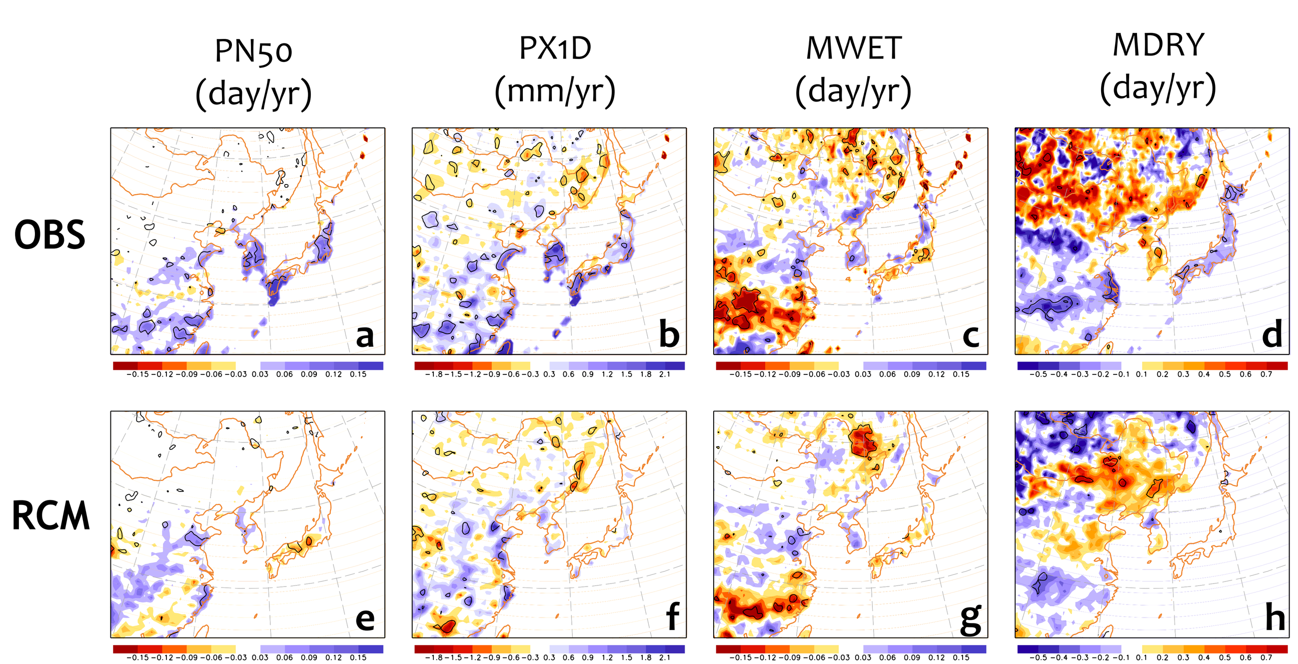


Fig. 4. *Linear trend of precipitation-based indices* from reanalysis (a-d), and the model (e-h). Contour lines indicate the 95% confidence levels based on a two-sided Student's t test.

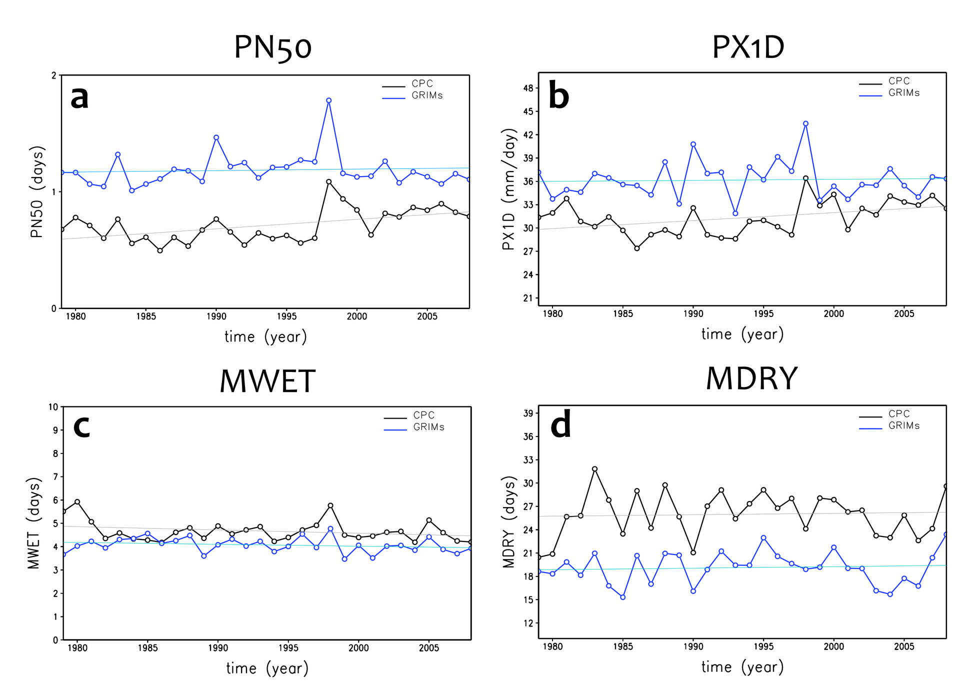


Fig. 5. Time-series of precipitation-based indices averaged over East Asia.

- To show the trend of extreme indies in spatial, linear trend during 30 years is presented in Fig. 4. The increasing trend is apparent over South China in indices related to intensity (Figs. 4a and 4b). Although the model quantitatively overestimates in the region, the increasing trend is well captured in the simulation (Figs. 4e and 4f). However, the simulation still shows deficiency over Korea.
- According to increased trend of rainfall intensity, duration of wet days are also longer (Fig. 4c). In spite of deficiency in intensity, the model can simulate increased wet days (Fig. 4g). This is due to the model deficiency of producing excessive occurrences of very weak precipitation intensity, which is a commonly noted problem in precipitation produced by climate models. In case of MDRY, the observed trend shows opposite signals in North and South area (Fig. 4d). The model agrees this trend, but simulates weaker signals than observation (Fig. 4h).

- The extreme indices based on precipitation remain constant or slightly increase. Although the model tends to overestimate the indices related to intensity and frequency (PN50 and PX1D), simulated peaks follows well observation in 1983, 1990, and 1998 (Figs. 5a and 5b).
- In the case of MWET, GRIMs shows a good agreement with the observation both in quantity and trend (Fig. 5c). However, simulated dry days are much less than observation. This is due to the model deficiency of producing excessive occurrences of very weak precipitation intensity, which is a commonly noted problem in precipitation produced by climate models.

Summary & Conclusion

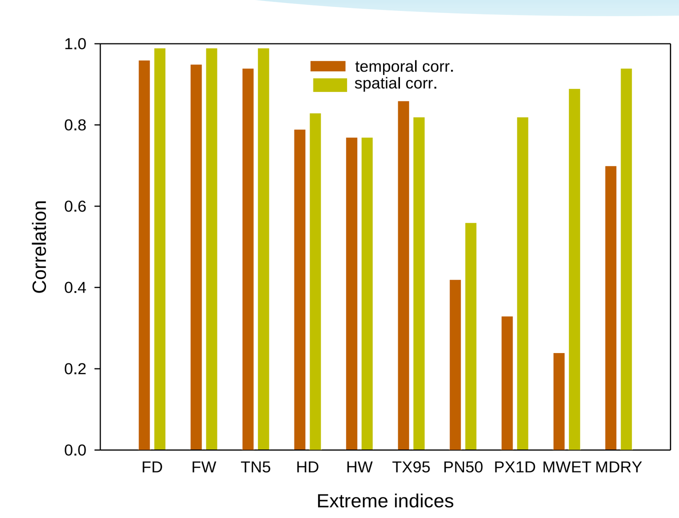


Fig. 6. *Temporal and spatial correlation* of minimum and maximum temperature-based, and precipitation-based extreme indices

✓ We examined temporal and spatial structure of trends in precipitation-based and temperature-based extreme indices simulated by the Regional Model Program of Global/Regional Integrated Model System (GRIMs-RMP).

✓ During the Last 30 years from 1979 to 2008, the model reasonably have simulated the temporal and spatial pattern of the trend. Although overestimation of minimum temperature and underestimation of maximum temperature occured, the regional climate model captured observed direction and magnitude well in the indices based on temperature.

✓ The indices related to rainfall tended to be overestimated over East Asia except for Korea and Japan. However, the trend showed agreement with observation.

✓ The results allow us to be optimistic about the RCM ability in the simulation of important extreme event of precipitation and surface temperature in East Asia. This type of study can also provide meaningful climate statistics and insight into climate change impact study.

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Seamless coupled prediction system (SCoPS): Assessment of the APCC model restropective seasonal forecast (1982-2013)

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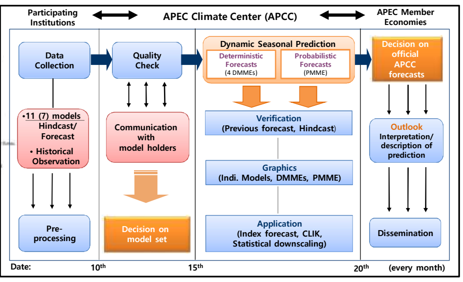
Background

- APCC had produced 3-month-leading seasonal prediction data by multi-model-ensemble (MME) skill since 2005.
- At present, 16 agencies from the world are participating for monthly-rolling 3-month seasonal prediction. APCC-MME has various model set.
- Monthly-rolling 6-month-leading seasonal prediction has established since Sep.2013; 7 agencies are participating.

Time Schedule of MME Forecast



Purpose

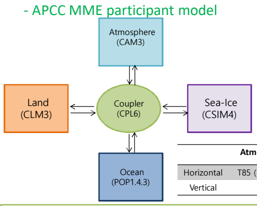
- The APCC has developed the in-house global climate prediction system with a research group of the University of Hawaii to improve the seasonal forecast skills.
- SCoPS consists of high-resolution atmosphere-ocean-land-sea ice coupled model with improved Integrated AO initialization schemes for predicting subseasonal to seasonal climate.
- For operational providing seasonal climate prediction, the capabilities of this system should be analyzed for various target seasons, different regions and time periods with a wide range of variables

➔ **Evaluation of forecast skills from the SCoPS hindcast (compare to the CCSM3 hindcast)**

APCC in-house models

1. Community Climate System Model version 3 (CCSM3)

- APCC MME participant model



	Atmosphere	Ocean
Horizontal	T85 (1.4°x1.4°)	gx1v3(0.3°-1°)
Vertical	L26	L40

- NCAR in USA
- Coupling frequency : 1/day
- 78 CPUs in APCC HPC (ATM:32, LSM:12, OCN:24, CSIM:8, Coupler:2)
- Integration time : approx. 5hr/7month
- Reference : Collins WD, Bitz CM, Blackmon ML, Bonan GB, Bretherton CS, Carton JA, Chang P, Doney SC, Hack JJ, Henderson TB et al (2006) The community climate system model version 3 (CCSM3). J Clim 19(11):2122–2143

Initialization method: Ocean Temp. 3D nudging

CCSM3

- CCSM3 POP1.4.3
- Ocean Temp. nudging
- Global/40 levels
- 5 days relaxation time
- Jan 1, 1982 ~ recent

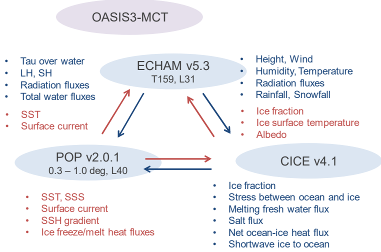
Pentad 3D Ocean Temp. → Daily 3D Ocean Temp. (Linear Interpolation)

- Initial condition of CCSM3 Hindcast simulation
- Restart files of ATM, LSM, OCN, ICE

- Hindcast Simulation with ICs from Ocean Temp. Nudging
  - Ensemble members : 10
  - Ensemble generation methods: Time lagged forecasting method [Brankovic et al. 1990]
    - ATM/LSM/ICE ICs: the 1^{st}, 6^{th}, 11^{th}, 16^{th}, 21^{st} , and the last 5 days of every month
    - Ocean IC: 22 ~ 26^{th} every month
  - Hindcast period: 1982~2014 (33 years)
  - 7month integration

2. Seamless Coupled Prediction System (SCoPS)

- Newly developed model



Initialization method: Integrated Atm.-Ocn. initialization

SCoPS

- Integrated Atmosphere-Ocean Initialization : combining 3-D atmospheric initialization and the advanced Ensemble Adjustment Kalman Filter (EAKF) methods
- Jan 1, 1982 ~ recent
- 50S – 50N, till 400meter

CFSR atmosphere variable, XBT & ARGO ocean variable (Forecast: ARGO only)

- Initial condition of SCoPS Hindcast simulation
- Restart files of ATM, OCN, ICE

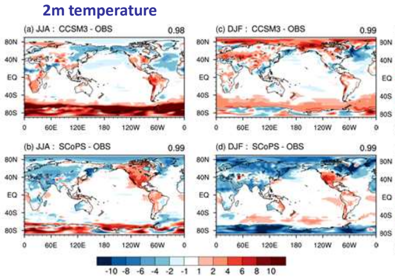
- Hindcast Simulation
  - Total Ensemble members : 10
  - Time lagged forecasting with perturbation ensemble spread by ENKF
  - - ATM/OCN/ICE ICs: the 1^{st}, 5^{th} of every month
    - 5 perturbation initial data
  - Hindcast period: 1982~2014 (33 years) / Forecast period: 2015~
  - 7month integration

Results

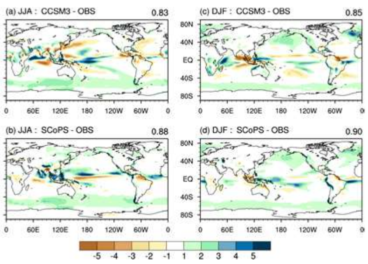
Global / Large-scale fields

Climatological summer and winter biases

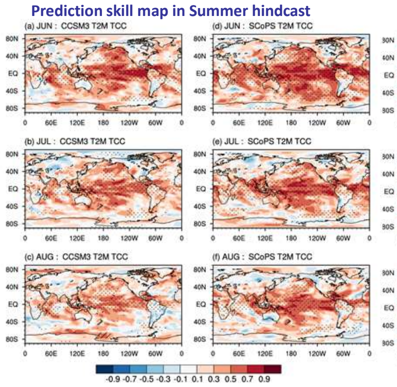
2m temperature



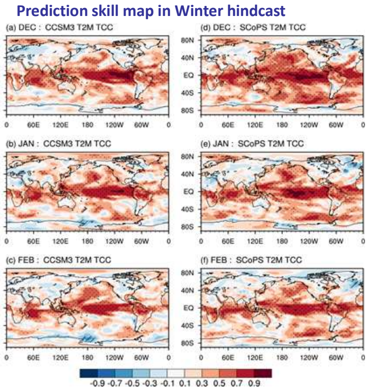
Precipitation



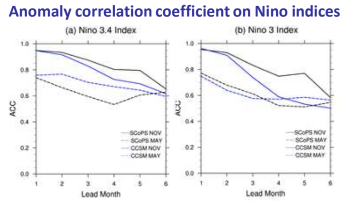
Prediction skill map in Summer hindcast



Prediction skill map in Winter hindcast

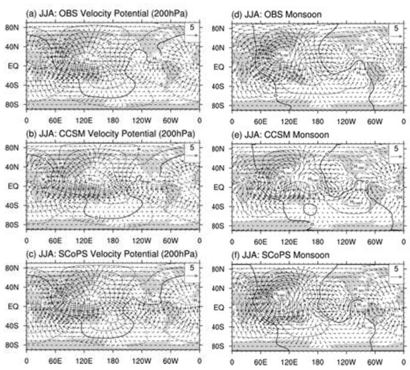


Anomaly correlation coefficient on Nino indices



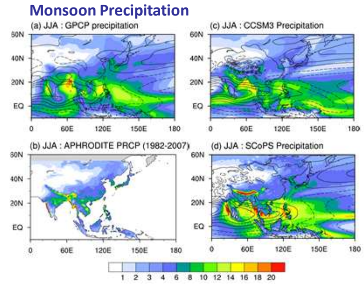
- Following Tanaka et al. 2004, Tellus
- The velocity potential at the 200 hPa level contains information concerning the overall intensity of the tropical circulations of Hadley, Walker and monsoon. These tropical circulations are driven by different dynamical causes. They assume that information is contained in the zonal mean field of the velocity potential. Also, they assume that information on Walker and monsoon circulation is contained in the deviation field from the zonal mean. Secondly, they define the monsoon circulation as part of the seasonal change of the deviation field. Finally, they define Walker circulation as the remainder which is the annual mean of the zonal deviation field. All seasonal cycles were deposited in the monsoon. However, they expect that the present definition retrieves a large fraction of the tropical circulation.

200hPa Velocity Potential & Monsoon circulation

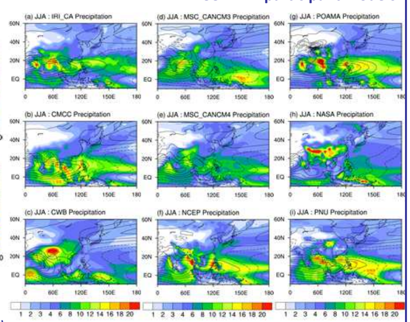


Regional / East Asia Summer Monsoon

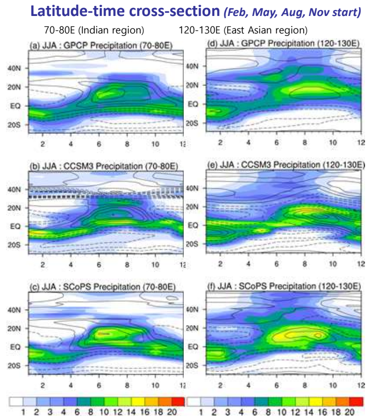
Monsoon Precipitation



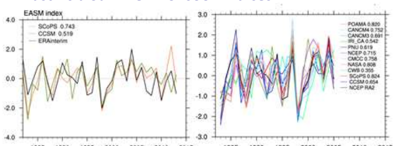
APCC MME participant models



Latitude-time cross-section *(Feb, May, Aug, Nov start)*



East Asia Summer Monsoon Indices

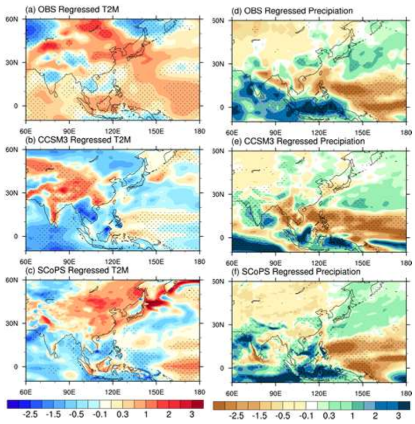


EASM index, Lee et al. (2014)
- Defined as the 850hPa zonal wind anomaly difference between the average of 5-10N and 130-150E and that of 25-30N and 110-130E.

SCoPs exhibits a realistic simulation of the summer monsoon in East Asia, as well as its seasonal evolution.

Seasonal cycle of precipitation and 850 hPa zonal wind at two longitude bands (70-80E and 120-130E) are shown in these figures. As the SCoPS and CCSM3 hindcast runs are available up to 7 months from the initial time, 4 hindcast data from the Feb., May, Aug., Nov. initialized runs were synthesized to examine the complete annual cycle of precipitation and wind.

Anomaly Regressed T2m and Precipitation onto EASM index



Future issues

Development of Subseasonal to Seasonal (S2S) Prediction system

" Bridging the gap between weather and climate"

- To improve forecast skill and understanding on the subseasonal to seasonal timescale with special emphasis on high-impact weather events
- On the time range between two weeks and a season (e.g. 15-60 days)