문서번호 APCC-출장-19-0548(2019-07-16)

결재	선임연구원	과장	부서장	원장
	07/16 김해정	07/16 김형진	07/16 유진호	07/16 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

2019. 06. 09. ~ 06. 15.

3. Occasion and destination 행사 및 출장지

다윈 컨벤션 센터, 호주

II. **Major Activities** 주요업무 수행내용

1. Main Contents and Activities 주요내용 및 활동

○ 출장자 발표 세션 및 제목

발표자	발표 일시	제목	비고
김해정	6/11,12	Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis	붙임1

○ 출장일정

날 짜	주요 수행내용
6/9(일) ~ 6/10(월)	• 한국(부산-인천) 출발 → 호주(시드니) 경유 → 호주(다윈) 도착
6/11(화) ~ 6/12(수)	• 학회 참석 - 열대저기압의 생성 과정 및 변동에 관한 연구 동향 파악 - YMC 프로그램과 MC 관련 연구 동향 파악 - 인도 몬순 발달 기작에 관한 논의 - 날씨와 기후 변동에 대한 열대 대류의 역할 • 포스터 발표
6/13(목) ~ 6/14(금)	• 학회 참석 - 열대 기후 변동의 역학, 원격상관에 관한 동향 파악 - ACCESS-S 개발, 예측성, 활용 동향 파악 - 기후변동에 대한 모델링 및 방법론 동향 파악
6/15(토)	• 호주(다윈) 출발 → 호주(브리즈번) 경유 → 한국(인천-부산) 도착

○ 주요 연구 성과 및 연구 동향 [붙임2] 참조

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

○ 열대기상학에 대한 최근 동향을 습득할 뿐만 아니라 ENSO, 인도양, 아시아 몬순 시스템, 열대 파동들 간의 연결에 있어 큰 그림을 보는 시각 형성에 도움이 되는 학회였음.

○ 일본은 이미 TC 예보를 할 때 BSISO 정보를 중요한 요소로 인식하고 있음. NICAM 모델의 TC 예측성과 BSISO 예측성을 각각 확인 한 바 있고 그 결과에 힘입어 향후 계획 두 가지를 수립. ① TC genesis 측면에서 TC의 extended-range forecast를 위해 MJO/BSISO 예측을 활용하는 연구, ② TC intensity와 track에 대한 MJO/BSISO 영향을 살펴보는 모델 실험. 두 번째 계획은 2018년 출장자의 최종발표 시 추후 확장할 필요가 있다고 언급했던 연구 내용과 유사함.

○ TC에 대한 ISO의 영향은 이미 잘 알려져 있고 북반구 여름철에는 BSISO 정보가 MJO 보다 더 유용하다는 인식도 점차 확산되고 있어 BSISO에 대한 중국, 일본, 대만 등 아시아 몬순 지역의 기상 예보 실무진 및 연구자들의 관심 또한 증가하는 추세. 그러나 주변국들의 관심에 비해 한국에서는 BSISO 관심도는 낮은 편이라 아쉬움. 물론 지리적인 위치가 주변국에 비해 BSISO이 기여가 낮은 곳이라는 점도 낮은 관심도의 이유 중 하나임. 그러나 우리나라 기후에 대한 ENSO의 영향이 명

확하지 않고 ENSO event의 빈도가 빈번하지 않음에도 불구하고 그와 관련된 많은 연구가 진행되고 있음을 자각해볼 때 BSISO에 대한 연구가 부족하기 때문에 관심 또한 저조한 것이 아닌가 라는 생각도 하게 됨. 센터 역시 주요 먹거리 연구에 관심과 노력이 집중되어야하는 상황이지만 APCC가 BSISO 정보 서비스를 하고 있는 만큼 소수 연구라도 센터에서 필요하고 가치 있는 일을 하는 것으로 인식되길 희망함.

○ 출장자에 의해 개발된 WNP ISGPI가 실무적으로 잘 사용될 수 있게 더 다듬어져 추후 열대저기압에 대한 현업 예보뿐만 아니라 기작 연구에 있어서도 잘 활용될 수 있기를 기대함.

○ 호주기상청은 monsoon onset 보다는 rainfall onset 컨셉을 적용하여 우기 시작 날짜에 대한 지역 예보를 시작했는데 사용자가 진정 원하는 혹은 이해할 수 있는 예측 정보가 무엇인지 항시 조사하고 그에 맞는 컨텐츠를 생산하도록 노력할 필요가 있음에 공감하였음.

○ 반면 혹은 그 연장선에서 또 생각해보면 예보 사용자에게 있어서 강수 정보만 중요할까라는 의구심이 생기는데 가령 예를 들자면 몬순(특히 장마) 시즌 동안 실제 비가 오는 날보다는 비는 오지 않지만 흐리고 후텁지근한 날씨가 더 빈번하다면 사람들의 실제 생활에는 후자의 영향이 더 큰 것인데, 그 환경을 만드는 대규모 요인들에 대한 연구도 필요할 듯함. 즉, 몬순의 정의, 개념에 따라 특정 현상과 몬순의 연관성에 대한 연구 결과가 달라질 수 있을 것이라 생각하고 한반도 여름철 기후에 대한 BSISO의 영향을 살펴 볼 때 이러한 점을 좀 더 고려할 필요가 있으리라 판단됨.

○ 호주는 다양한 climate drivers의 영향이 뚜렷하게 나타나는 지역이라서 응용 분야로의 ENSO, MJO 정보 활용이 활발히 이루어지고 있어 기상뿐만 아니라 기후 응용 분야에 있어서도 선진국다운 입지를 갖추고 수 있었음.

○ 최근 전 세계적으로 유튜브가 새로운 정보 습득의 창구와 홍보 채널로 각광받고 있음. 한 학회 참가자의 발표에서 유튜브를 활용하여 분석 방법론(EMD)을 소개한 사례를 접하게 되어 이러한 추세가 연구 분야로도 확대되고 있음을 알 수 있었음.

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

2019 호주기상학회-열대 기상 국제 컨퍼런스 (AMOS-ICTMO) 국외출장

【 2019. 06. 15. (토) / 기후사업본부 김해정 】

Ⅰ. 출장 개요

○ 배경 및 목적

- ICTMO (International Conference on Tropical Meteorology and Oceanography)의 열대 대류 활동에 관한 전반의 주제를 다룬 세션에서 APCC의 BSISO 연구 결과를 발표.

- Australian Meteorology and Oceanographic Society (AMOS)와 연계하여 개최되는 본 컨퍼런스 참석을 통해 기상선진국인 호주 기상학계의 최근 연구 동향을 파악.

○ 출장기간 : 2019. 06. 09. ~ 06. 15.

○ 출장지 : 다윈 컨벤션 센터, 호주

○ 출장자 : 기후사업본부 선임연구원 김해정

○ 출장자 발표 세션 및 제목

발표자	발표 일시	제목
김해정	6/11,12	Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis

Ⅱ. 주요 연구 성과 및 연구 동향 파악

1. 주요 연구 동향

1) Maritime Continent (MC)와 Years of Maritime Continent (YMC)

■ Maritime Continent는 대류권과 성층권 간의 가장 활발한 상호작용이 이루어지는 강한 대류의 중심 구역이므로 지구 기후 시스템에서 중요한 역할을 하지만 이곳의 복잡한 육지, 해양, 지형 분포 때

문에 여전히 대기-해양 상호작용의 과정과 변동을 충분히 이해하거나 예측하고 있지 못함.

■ 당면한 MC-MJO 이슈들

① Barrier Effect : MJO 이동, 발달에 MC가 장벽 역할을 함.

- Barrier effect의 원인 : (intrinsic effect) 1. 지형 2. 에너지 원천이 해양인데 육지에 의한 지표에서의 증발 감소 3. 육지에서의 일변동 (incidental effect) 4. 수분 분포 등 대규모 순환

- Barrier Effect를 극복하며 계속 발달할 수 있는 메커니즘 : air-sea interaction 원활 (해양에서의 온도와 강수가 육지보다 중요), 안정적인 diurnal cycle (지형보다는 soil moisture가 일변동 크기를 줄이는데 관여), starting well structured MJO event

② 모델 결함 : MC 지역에 음의 SST 바이어스, 양의 강수 바이어스, MJO의 diurnal cycle 모의하는데 어려움. 낮은 해상도의 모델은 convection error를 resolve 하지 못하고 고해상도 모델은 scale 간 interaction과 self-organized convection을 약하게 모의

- 모델 에러 이유 : 1.complexity, 2. two ways multi-scale interaction (large scale-small scale)

■ 이러한 문제를 풀기위해 요구되는 것들 : 종합적이고 체계적인 관측, 고해상도 수치 모형, 관측, 모델링, 기상학, 해양학 등 다학제간 전문가 팀

→ 이를 위해서 YMC 관측 프로젝트 생성 (2017-2020)

2) YMC 프로그램 활동 소개

■ YMC 프로젝트는 MC 지역의 날씨 기후 해양을 이해하고 모의하는데 있어서 당면한 문제들을 해결하기 위해 만들어짐. 국제 YMC 프로젝트는 지역적 다중 규모 대기와 해양 변동과 관측, 모델링, outreach를 통해 그것의 전 지구적 영향을 이해하고 예측하는데 개선의 과정을 더 신속히 처리하기 위해 다양한 국가들의 노력에 집중해옴. 그 중 세 가지 field campaign 소개.

① Equatorial Line Observations (ELO, 2019)는 CCKWs(convectively coupled equatorial Kelvin waves)와 MJO의 메커니즘을 조사.

② TerraMaris (2019-2020)는 MC 지역에서 대기 convection 안에 scale interactions(특히 diurnal cycle 과 intraseasonal variability), 그들과 해양의 interactions 그리고 지구 기후에 대한 그들의 영향을 조사.

③ RV investigator의 크루즈 연구 (Oct-Dec 2019)는 MJO의 한 주기를 샘플링을 통한 대류 일변화 과정, 대기-해양 상호작용, 해양 모델 모수화 개선을 지원하기 위한 해양 연직 혼합 과정, 인도네시아 Throughflow의 크기와 변동을 더 정량화하기 위한 관측 등을 수행.

■ 이러한 관측 캠페인을 통해 모델을 개선(모수화 등)시킴으로써 모델 바이어스를 감소시킬 수 있을 뿐만 아니라 기후 시스템에서의 주요 과정에 대한 우리의 이해를 한 단계 높일 수 있음.

■ 국제 YMC 프로그램은 다국/다학제간 협력을 통해 자료 수집과 분석을 진행 중이므로 Maritime Continent와 관련된 이슈에 있어 돌파구를 이끌어낼 거라 기대함.

3) MC 연구들

■ YMC-Sumatra 2017 캠페인으로부터 수집한 27일의 관측자료 분석을 통해 MC지역 강수의 일변동 중 밤과 이른 아침에 강수가 육지로부터 멀리 이동하는 것(offshore-ward migration)에 대한 주된 물리적 메커니즘을 찾고자 하였고 낮과 이른 저녁에 발생하는 경계층에서의 강한 onshore-ward wind와 고도에 따른 offshore-ward wind shear가 중요한 조건이 될 수 있고 이러한 조건은 대류시스템의 자가되먹임 과정에 호조건임을 확인하였음.

■ YMC-2015, YMC-2017 캠페인 기간 동안의 ISO 분석을 통해 MJO와 local convection 사이의 상호작용과 MJO dynamics에서 수분의 중요성에 대한 이해를 높이고 barrier effect에 대한 개선을 꾀하고자 하였음. 그 결과 ISO와 고주파 변동 사이의 관계가 육지와 해양에서 서로 다르고 이는 해수면온도 분포와 같은 환경적인 조건에 따라 변할 수 있음을 확인함. 즉, 육지에서는 인도양에 강한 대류가 있는 엘니뇨 상태에서 고주파 변동에 의한 수분 이류는 ISO 이류와 비슷하고 반면 MC지역에 강한 대류가 있던 라니냐 상태에서는 그 관련성이 유의하지 않음. 반면, 해양에서는 엘니뇨해 라니냐해 모두 공통된 관련성이 나타나는데, 고주파 변동에 의해 대류권 하층 moistening이 MJO 발달 전에 나타나고 MJO가 발달

하여 활발할 때 대류권 상층에 moistening/하층에서는 drying 이 있음.

■ MJO에 대한 더 나은 이해와 예측(convective initiation, eastward propagation, multiscale variability) 그리고 수치 모델에서의 MJO 예측 스킬과예측성 평가을 위해 대규모 강수 20년 TRMM 분석한 연구에서 MJO 강수를 추적하는데 유용한 LPT(large-scale precipitation tracking) 활용했는데 LPT는 대류의 동서와 남북 구조 그리고 MJO의 계절 변동과 경년 변동을 잘 추적할 수 있었음. 관측에서는 MJO의 동진에 있어서 MC barrier effect의 효과가 북반구 겨울철동안 가장 두드러졌고 모델은 barrier effect를 과대모의 하는 경향. 또한 모델은 관측보다 MJO 전파 속도를 훨씬 더 천천히 모의하였고 북반구 여름철에 MJO를 모의하는데 어려움을 가지고 있었음.

4) 날씨와 기후 변동에 대한 열대 대류의 역할 : 열대-온대 관련성

■ MJO와 헤들리 워커 순환 관계 분석을 통해 MJO가 열대/아열대지역을 넘어 중위도 날씨에도 영향을 줄 수 있음을 확인 : 강화된 MJO 대류대가 동쪽으로 이동함에 따라 local Hadley cir. 이 강화됨. 태평양에서 local Walker cir.은 MJO 위상이 7,8,1일 때 약화되고 4, 5, 6일 때 강화됨. 강화된 대류에 의해서 중위도 제트는 상층 발산 지역에서 강해지고 수렴역에서 약화됨. 제트에서 섭동은 로스비파의 downstream development를 유도하여 중위도 wave train을 형성.

■ CCKW(convectively coupled Kelvin wave)는 동쪽으로 전파하는 종관 규모 열대 섭동이며 ITCZ에서 전반적인 대류 활동에 중요한 역할을 하는데 특히 태평양 영역 강수에 상당한 영향을 줌. 태평양에서 Kelvin wave(K-wave)를 활성화 시키는 메커니즘을 살펴본 연구에서 아열대 Rossby disturbance가 상층 기압골과 상호작용할 때 동쪽으로 전파하는 파동(MAM에는 K-wave, DJF에는 short-lived eastward propagating disturbance (non K-wave))을 활성화하는데 중요한 역할을 하는 것을 확인. 동시에 아열대 로스비파가 상층 기압능과 관련될 때 동태평양에서 K-wave를 약화시킬수도 있음을 제안. MAM 의 경우, 북서태평양에서부터 아열대 로스비 섭동이 열대로 전파되고 동태평양에서 K-wave를 강화시키고 JJA 에는, 남서태평양으로부터 전파되는 온대 로스비 섭동이 중앙 태평양에서 K-wave의 시작에 영향을 주고 그리고 나서 ITCZ 축을 따라 동태평양으로 이동. ITCZ의 남쪽 영역에서

meridional shallow overturning cir.은 K-wave가 있을 때 강하고 short-lived eastward propagating disturbance 가 있을 때 약함.

5) 날씨와 기후 변동에 대한 열대 대류의 역할 : 대기 상하층 관련성

■ 최근 MJO 이론들은 주로 대류권 하층, 중층과 경계층에서의 process 들을 강조.

① Convectively coupled Kelvin-Rossby wave theory

② Moisture mode theory : moisture-convection feedback과 수분 수송

③ Multi-scale interaction theory : 종관 규모 wave의 효과

■ 그러나 QBO(Quasi-biennial oscillation)와 관련된 mean state와 대류권계면 높이 변화가 MJO를 조절할 수 있다는 것을 주장함으로써 성층권이 MJO 대류 강화에 있어서 주된 요인 중 하나임을 제안함. 북반구 겨울철 QBOE(easterly QBO) 동안 더 강한 cloud-radiation feedback, 더 강한 대류, 강화된 MJO 활동이 나타나고 이는 QBO와 연관된 대류권계면의 변화에 반응하는 MJO의 length-scale 변화와도 관련이 있음. 기후 모델은 이러한 QBO-MJO 관계를 잘 모의함.

■ 이러한 QBO-MJO 관련성은 QBO에 대한 다른 CCW의 민감도에도 관심을 갖게 함. QBOE-MJO강화 기작은 유독 DJF 기간 동안에만 나타나고 다른 CCW나 계절내, 고주파 대류 변동에서는 나타나지 않음. MAM QBOE 동안에는 Kelvin wave가 약하게 강화되는 경향이 있고 이 메커니즘은 MJO 강화 때와 비슷함. 그러나 다른 CCEW (convectively coupled equatorial wave)에는 QBO의 영향이 적은데 이는 대류권 상층에서의 대류 연직구조의 기울기가 대류불안정을 만드는데 덜 효과적이기 때문. QBOE동안 차가운 열대 대류권계면은 권운이 형성되기 좋은 조건이고 이 권운은 존재하는 QBOE는 냉각시키고 아래쪽 대기는 가열되게 만드는데 이러한 cloud-radiative forcing 은 MJO가 강화되고 이 MJO는 강화되는데 일차적인 driver가 됨.

■ 대류가 조직화되는데 있어서 성층권 하부 연직 shear의 영향을 살펴 본 연구에서는 성층권 하부 shear가 증가할 때 대류권 convection의 전파와 자기조직화 활동에 작지만 robust 한 변화가 있고 직접적이기 보다는 간접적인 영향이 있음을 시사하며 중력파

-대류 커플링과 성층권-대류권 상호작용에 대한 기초적인 이해를 돕는데 기여함.

■ 전지규 규모의 섭동인 MJO, 적도 로스비파 그리고 캘빈파 중 MJO와 로스비파에 대해 살펴 봄. 간단한 선형 모델 실험을 통해 두 모드를 추출하고 동쪽으로 그리고 서쪽으로 전파하는 WISHE(wind-induced surface heat exchange)-moisture mode가 MJO와 적도 로스비파의 기본적인 특성(global mode, coupled with convection, eastward and westward propagation)을 설명함을 보여줌. MJO는 성층권과의 상호작용으로 phase speed와 성장률이 조금씩 변화됨.

■ Kiladis의 기조연설에서는 현업 예보 시스템에서의 예측성 평가에 기반하여 강수량 예측에 있어서 초기조건의 중요성을 언급함. 열대지역에서의 강수량 예측에 있어서 equatorial wave activity-convection coupling의 개선이 필요함. 아열대지역 예측 스킬은 몇 주 혹은 더 선행하는 시간에서의 열대지역 예측 스킬과 양의 상관관계가 있으므로 열대지역의 예측성 개선을 통해 아열대지역 예보 개선을 리드할 수 있음을 주장.

■ 기후온난화 상태에서 MJO의 변화를 살펴본 연구 결과에서는 지구온난화에 따라 대류권 하층의 수증기의 평균 연직 경도가 증가함을 보임. 대류권 온도 또한 증가하는데 상층으로 갈수록 더 크게 증가하므로 정적안정도가 증가. 증가된 정적안정도는 수평과 연직 운동을 약화시켜 상층운의 넓이가 덜 넓어질 것임. 수분 경도 증가가 강한 정적안정도보다 더 크게 작용하여 더 강한 MJO 대류를 조성. 더 따뜻한 기후는 대류권을 더 두껍게, 대류 더 깊게, 장파 복사로 인한 가열을 더 약하게, 그리고 전파를 더 빠르게 만들 것임.

6) 열대 기후 변동: 역학, 원격상관 그리고 영향

■ 극한 엘니뇨 발생에 대한 잠재적인 원인을 열대지역에서 찾고자 하는 기존의 연구와 달리 북태평양에서 부터의 trigger도 있음을 살펴본 연구가 있음. 그에 따르면 북동태평양 고위도에서 쿠로시오 해류를 따라 음의 아노말리역이 형성되고 이에 수반되는 강한 저기압성 아노말리가 14개월 이후에 발생하는 극한 엘니뇨 발달에 중요한 역할을 한다고 제안. 저기압성 아노말리는 열대 태평양 중앙에서의 해양 열용량을 증가시키는 강한 남서풍 아노말리를 유도하면서 대기해양 상호작용에 의해 적도방향으로 이동함. 그 결과

열대 중앙 태평양에서 증가된 열용량은 뒤따르는 겨울철에 극한엘니뇨의 발달에 좋은 조건을 제공함. 이러한 결과는 극한 엘니뇨를 예측하는데 더 장기적인 precursor가 있고 이를 활용하는 것이 필요하다는 것을 제안함.

■ 남반구에서 ENSO는 SAM(Southern annular mode)과 상당히 관련되어 있는데 OND 계절 동안 강한 동태평양 엘니뇨와 SAM이 음의 상관관계가 있음. CMIP5의 온실기체 배증 실험에서는 적도 동태평양에서 약화된 upwelling으로 인해 SST의 동서방향 경도가 강화됨. POAMA를 사용한 엘니뇨 예측 실험에서는 엘니뇨가 더욱 약해지고 엘니뇨와 SAM과의 음의 상관관계도 약해짐.

■ 워커 순환의 변화는 대규모 순환을 변화시킬 수 있다고 잘 알려져 있음. 지구온난화 하에서 인도양 warming은 지속될 것임. 워커 순환과 관련된 강수 패턴에 대해 인도양에서의 장기 warming의 영향을 살펴보면 인도양 온난화가 태평양에서의 워커 순환을 강화시키고 ITCZ 남하, 여름 아시아 몬순 약화, 동아프리카 강수 trend 증가를 유도함. 또한 대서양에서도 지역적으로 워커셀에 영향을 주어 NAO trend 강화에 기여.

■ 인도 여름 몬순의 주된 makers로 ① seasonal heating, ② moisture process (150hPa에서 Tibetan easterly jet 중요)를 꼽을 수 있는데 ENSO 역시 중요한 external driver 임. 엘니뇨 해에 인도 여름 몬순 강수가 약화되는데 그 메커니즘으로 ① 엘니뇨로 인해 워커 순환이 변화되어 서태평양에 양의 heat source 아노말리가 만들어지고 로스비 반응에 의해 인도 지역에 고기압성 순환 아노말리가 자리 잡기 때문. ② 태평양 중앙에서의 warming이 상층 대류권에서 발산를 만들어내고 이는 로스비파의 source가 됨. 이 로스비파는 북아프리카아시아 제트류에 의해 인도되고 이와 연관된 양의 와도 아노말리는 중앙아시아에서 호우를 만듦. 이 양의 와도 아노말리의 효과로 이 지역이 냉각되고 결국 인도 상층 대류권에서 약한 온도 경도를 만듦. 이는 인도에서 몬순 flow를 흐트러뜨리고 엘니뇨해 동안 약한 몬순을 갖게 됨. 인도 여름 몬순과 관련된 ENSO는 1990년대 이후로 상당히 약화되었고 최근 수십 년 동안 북서태평양에서의 강해진 저기압성 순환이 ENSO-몬순 연결의 약화에 기여했을 것이라 추측됨. ENSO와 몬순 변동뿐만 아니라 다른 driver(대서양 효과, 에어로졸 등)와의 상호작용 및 ENSO-몬순 관계 안에 어떤 프로세스가 포함되어 있는지 이해하는 것이 중요함. 모델의 제약에도 불구하고 다양한 시간 규모에서 예측은 개선이 되고 있는 중이고 더 나은 모델과 자료동화에 대한 노력이

필요하다는 것은 너무나도 당연한 숙제임.

7) ACCESS-S

■ FWFA and NCEP 프로젝트의 일환으로 POAMA를 대체할 계절 예측 모델로 ACCESS-S 모델링 프레임워크가 개발되어 호주의 계절 예측 스킬이 개선되었고 다양한 product가 개발되고 있음. ENSO, MJO와 같은 climate driver를 포함하여 강수와 기온 확률 예보 등 다양한 product가 발표됨. 호주 북부 지역에 대한 모델 성능, 과거 모델과 현재 모델의 성능 차이도 발표 됨. 또한 호주 북부 지역의 우기 rainfall onset과 관련된 climate drivers에서 예측 스킬이 개선됨을 보여 줌. 여기서 rainfall onset은 9월 1일 이후로 50mm 강수가 누적될 때. 보정 후 median onset date의 예측에서 상당한 개선이 있음을 제시하였고 이전 예측시스템인 POAMA2보다 더 나은 성능을 가지고 있어 의사 결정에 부가가치를 창출할 수 있음.

8) 열대저기압의 과정, 변동, 변화

■ 열대저기압(Tropical cyclone, TC)과 해양의 상호작용이 대기와 해양 사이의 에너지 교환을 책임지는 주요한 메커니즘 임. 주된 대기-해양 feedbacks :

① positive feedback은 증발이 강화되어 잠열이 만들어져 태풍에게 있어서 이용 가능한 에너지가 증가하는 조건.

② negative feedback은 해수면에서 wind stress가 증가하면 shear-induced mixing에 의해서 차가운 해수가 용승하여 대기로의 전체 열 플럭스가 감소하기 때문에 TC 강도를 약화시키는 조건.

■ SST warming에 대한 열대저기압 생성의 민감도를 알아보는 실험으로부터 SST가 증가함에 따라 GPI가 증가하는 관련성뿐만 아니라 near-surface gustiness(warming에 따라 감소)가 충분히 높은 값을 가지고 중층 대류권의 상대습도(warming에 따라 증가)가 적절히 조합될 때 TC 발생에 최적의 상태가 만들어진다는 것을 알 수 있었음.

■ TC 발생에 있어서 대기-해양 negative feedback 과정의 cooling effect는 해양의 초기 상태, TC 강도, TC 이동 속도와 TC 크기의 함수. 작은 크기의 TC뿐만 아니라 TC-해양 상호작용도 잘 재현하기 위하여 0.25도의 고해상도 모델을 사용하였고 TC indicator로

Power Dissipation index (PDI, Emanuel, 2005)를 사용. daily보다는 hourly로 접합을 할 때 강한 TC가 잘 모의되었고 hourly로 접합할 때 PDI 바이어스가 70%에서 7%로 감소하여 TC-해양 상호작용의 모의 능력은 대기-해양 접합 빈도에 매우 의존적임을 밝혀냄.

9) 기후변동과 변화에 대한 모델링, 예측 그리고 전망

■ ACCESS-CM2 모델 실험을 통해 남태평양에서 수십년 변동이 고정되어 있고 이는 적도 태평양에서의 십년 변동을 30%까지 감소시키고 극한 엘니뇨와 라니냐의 크기를 감소시킨다는 것을 밝혀 냄.

■ 경년 혹은 십년 예측에 있어서 예측 품질은 초기장, 온실가스 농도 증가와 같은 외부강제에 기인하는 long-term change와 모델에서 내부적으로 발생하는 변동으로부터 결정됨. 십년 예측에 있어서 예측 한계를 살펴보는 프레임워크를 만들었고 이 프레임워크는 초기화, 외부강제와 내부 변동에 대한 반응과 같은 예측 시스템의 각 구성성분들을 강화했을 때 달성할 수 있는 개선의 최대치를 정의함. 처음 두 해 리드타임 동안은 초기화로 인해 예측을 상당히 개선할 수 있었고 좀 더 긴 리드타임에 있어서 예측 품질은 모델 성능에 더 의존적임을 알 수 있었음. 또한 태평양에서의 long-term 변동을 개선하는 것이 십년 예측성과 관련하여 개선되어야하는 모델의 주요한 요소임을 제시 함.

■ non-stationary 하고 non-linear 한 자연 현상을 물리적 모드로 분리함에 있어서 EOF는 몇 가지 결함이 있고 이를 완화하기 위해서 EMD (Empirical Mode Decomposition)라는 non-stationary 기법이 개발됨. 이후 좀 더 robust한 결과를 얻기 위해 EEMD(ensemble EMD)가 개발되었고 공간적 locality와 시간적 locality 이슈 둘 다를 다루기 위해서 MEEMD(multi-dimensional EEMD)가 개발됨. 최근에 MEEMD는 기후 분석에 자주 쓰이고 있지만 여전히 개발 단계라서 종종 부적절하게 활용되고 있어 발표를 통해 MEEMD를 제대로 활용한 결과들을 보여 줌.

2. 주요 연구 성과

1) 북서태평양 열대저기압 발생에 있어서 BSISO의 특정 위상들이 상당한 기여를 하고 있음을 밝혔고 두 현상 간의 관련성을 토대로 개발한 WNP ISGPI(Intraseasonal genesis potential index)의 유용성을 소개하였음.

2) 일본 해양 과학 기술 센터(JAMSTEC)의 Dr.Tomoe Nasuno를 통해

JAMSTEC에서도 BSISO와 북서태평양 열대저기압의 관계에 대해서 꾸준히 관심을 가지고 있고 그들은 Kikuchi의 BSISO 지수를 주로 활용한다는 것을 알게 됨. 최근 38(3)년간 long-term 자료를 사용하여 북서태평양 열대저기압 모니터링(예보) 전반에 대한 검증을 한 출장자의 발표와 달리, 주로 단일 열대저기압 발생에 대해서 NICAM의 예측 능력을 확인하고 발생 역학을 해석하는 과정에서 BSISO의 기여 여부를 고려하는 식의 연구들을 통해 BSISO-TC 개연성을 설명하고자 하였음을 확인.

3) MJO 정보를 활용하여 TC 예보를 하고 그 결과를 검증한 경험이 많은 Matthew Wheeler와 Paul Gregory로부터 TC 검증 시 BSS 기법 사용을 추천 받았고 이것이 가능하기 위해서는 ISGPI와 같은 deterministic forecast 보다는 확률값으로 TC 정보를 산출하는 과정이 필요. 이는 향후 가능한 연구 과제로 제시한 바 있음.

4) 올 해 남서아시아 몬순 onset이 늦은 이유는 아라비아 해에서의 warm pool이 늦게 발달되었고 또한 onset 전에 벵갈만 지역에서 TC가 발생하여 해양 온도를 낮추었기 때문. 인도강수-TC 발생 연관성에 의하면 올 해 인도는 평년보다 건조(엘니뇨 영향으로 추정됨)하므로 올 가을 monsoon TC는 덜 발생할 듯함.

5) 비록 BSISO 현상이 적도에서부터 15° 정도 북쪽으로 치우쳐 나타나 아시아 몬순 지역 이외의 지역에서는 큰 관심의 대상이 아니었으나, 남반구 열대 대기 변동에 있어서도 10~15% 정도 설명력을 가지고 있어 MJO의 영향을 크게 받는 호주가 남반구 겨울철에는 BSISO의 영향도 고려해 볼 필요가 있음을 알릴 수 있는 좋은 기회였음.

Ⅲ. 결론 및 소감

○ 열대기상학에 대한 최근 동향을 습득할 뿐만 아니라 ENSO, 인도양, 아시아 몬순 시스템, 열대 파동들 간의 연결에 있어 큰 그림을 보는 시각 형성에 도움이 되는 학회였음.

○ 일본은 이미 TC 예보를 할 때 BSISO 정보를 중요한 요소로 인식하고 있음. NICAM 모델의 TC 예측성과 BSISO 예측성을 각각 확인 한 바 있고 그 결과에 힘입어 향후 계획 두 가지를 수립. ① TC genesis 측면에서 TC의 extended-range forecast를 위해 MJO/BSISO 예측을 활용하는 연구, ② TC intensity와 track에 대한 MJO/BSISO 영향을 살펴보는 모델 실험. 두 번째 계획은 2018년 출

장자의 최종발표 시 추후 확장할 필요가 있다고 언급했던 연구 내용과 유사함.

○ TC에 대한 ISO의 영향은 이미 잘 알려져 있고 북반구 여름철에는 BSISO 정보가 MJO 보다 더 유용하다는 인식도 점차 확산되고 있어 BSISO에 대한 중국, 일본, 대만 등 아시아 몬순 지역의 기상 예보 실무진 및 연구자들의 관심 또한 증가하는 추세. 그러나 주변국들의 관심에 비해 한국에서는 BSISO 관심도는 낮은 편이라 아쉬움. 물론 지리적인 위치가 주변국에 비해 BSISO이 기여가 낮은 곳이라는 점도 낮은 관심도의 이유 중 하나임. 그러나 우리나라 기후에 대한 ENSO의 영향이 명확하지 않고 ENSO event의 빈도가 빈번하지 않음에도 불구하고 그와 관련된 많은 연구가 진행되고 있음을 자각해볼 때 BSISO에 대한 연구가 부족하기 때문에 관심 또한 저조한 것이 아닌가 라는 생각도 하게 됨. 센터 역시 주요 먹거리 연구에 관심과 노력이 집중되어야하는 상황이지만 APCC가 BSISO 정보 서비스를 하고 있는 만큼 소수 연구라도 센터에서 필요하고 가치 있는 일을 하는 것으로 인식되길 희망함.

○ 출장자에 의해 개발된 WNP ISGPI가 실무적으로 잘 사용될 수 있게 더 다듬어져 추후 열대저기압에 대한 현업 예보뿐만 아니라 기작 연구에 있어서도 잘 활용될 수 있기를 기대함.

○ 호주기상청은 monsoon onset 보다는 rainfall onset 컨셉을 적용하여 우기 시작 날짜에 대한 지역 예보를 시작했는데 사용자가 진정 원하는 혹은 이해할 수 있는 예측 정보가 무엇인지 항시 조사하고 그에 맞는 컨텐츠를 생산하도록 노력할 필요가 있음에 공감하였음.

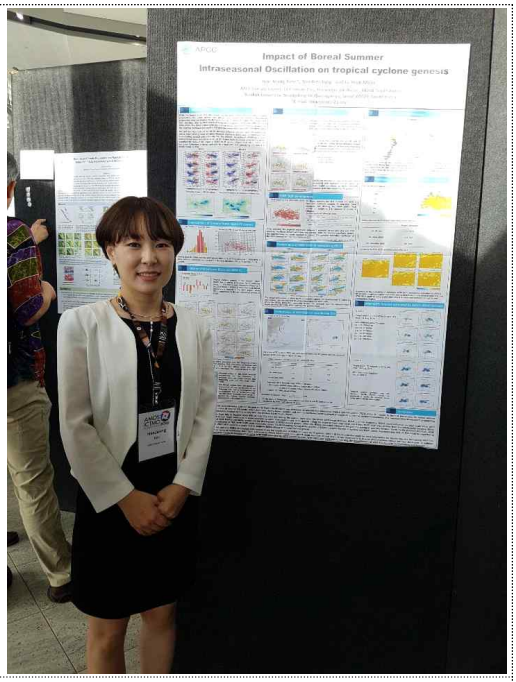
○ 반면 혹은 그 연장선에서 또 생각해보면 예보 사용자에게 있어서 강수 정보만 중요할까라는 의구심이 생기는데 가령 예를 들자면 몬순(특히 장마) 시즌 동안 실제 비가 오는 날보다는 비는 오지 않지만 흐리고 후텁지근한 날씨가 더 빈번하다면 사람들의 실제 생활에는 후자의 영향이 더 큰 것인데, 그 환경을 만드는 대규모 요인들에 대한 연구도 필요할 듯함. 즉, 몬순의 정의, 개념에 따라 특정 현상과 몬순의 연관성에 대한 연구 결과가 달라질 수 있을 것이라 생각하고 한반도 여름철 기후에 대한 BSISO의 영향을 살펴 볼 때 이러한 점을 좀 더 고려할 필요가 있으리라 판단됨.

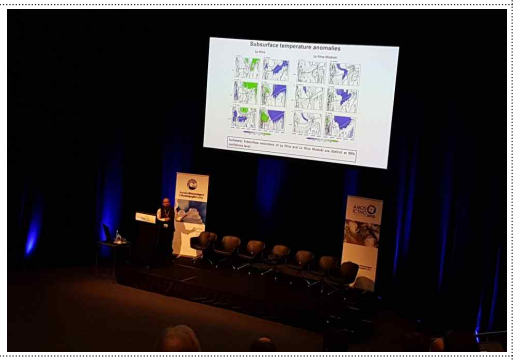
○ 호주는 다양한 climate drivers의 영향이 뚜렷하게 나타나는 지역이라서 응용 분야로의 ENSO, MJO 정보 활용이 활발히 이루어지고 있어 기상뿐만 아니라 기후 응용 분야에 있어서도 선진국다운 입지를 갖추

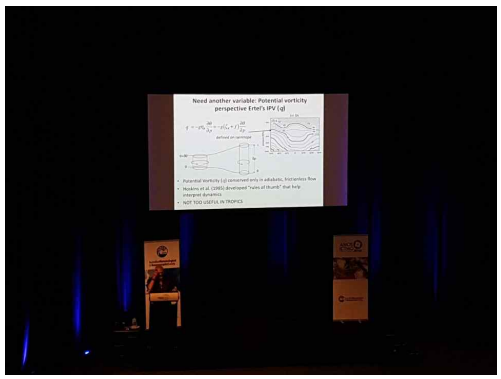
고 수 있었음.

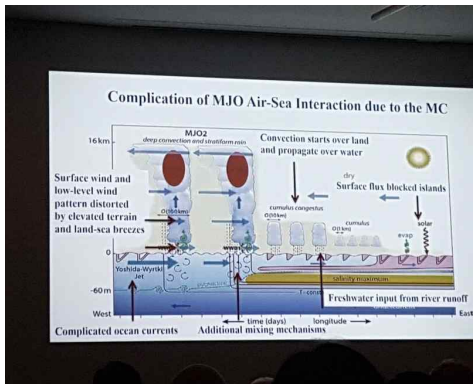
○ 최근 전 세계적으로 유튜브가 새로운 정보 습득의 창구와 홍보 채널로 각광받고 있음. 한 학회 참가자의 발표에서 유튜브를 활용하여 분석 방법론(EMD)을 소개한 사례를 접하게 되어 이러한 추세가 연구 분야로도 확대되고 있음을 알 수 있었음.

Ⅳ. 출장 사진









[AMOS-ICTMO 2019 출장자 세부 일정]

날 짜		세부 일정
6/11(화)	오전	• Plenary Lecture 참석 : Dr. Rosemary Hill • RH Clarke Lecture 참석 : Prof. Christian Jakob • Oral session 참석 : 19. Impact and risk assessment for weather extremes • Oral session 참석 : 32. Tropical cyclones: climate processes, variability and change
	오후	• Oral session 참석 : 33. Tropical cyclone dynamics and forecasting • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 15:00-16:00 • Oral session 참석 : 32. Tropical cyclones: climate processes, variability and change
6/12(수)	오전	• Oral session 참석 : 31. Maritime Continent earth system science and the Years of Maritime Continent • Plenary Lecture 참석 : Prof. Ashok Karumuri • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 10:30-11:00 • Invited Talk 참석 : Dr. George Kiladis • Oral session 참석 : 17. Extreme temperature events: attribution of events, processes and impacts
	오후	• Workshop 참석 : Lost in Translation? Delivering high impact science for climate resilient decision making • Oral session 참석 : 21. Closing the loop: weather and climate impacts and risks described for agriculture and business. • Oral session 참석 : 30. The role of organised tropical convection for weather and climate variability • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 15:00-16:00
6/13(목)	오전	• Oral session 참석 : 36. Tropical oceanography: processes and dynamics • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 10:30-11:00

		• Oral session 참석 : 35. Variability and dynamics of Indo-Pacific ocean exchange and roles in air-sea coupling
	오후	• Poster session 참석 : 34. Tropical climate variability: dynamics, teleconnections and impacts • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 15:00-16:00
6/14(금)	오전	• Plenary Lecture 참석 : Prof. Peter Webster • Oral session 참석 : 23. Automation and the changing role of the forecaster • Oral session 참석 : 29. Climate application for the tropics • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 10:30-11:00 • Invited Talk 참석 : Prof. Chidong Zhang • Oral session 참석 : 16. High-impact weather • Oral session 참석 : 24. Education, outreach and public engagement in weather, climate and ocean science • Oral session 참석 : 28. Processes in global and regional monsoons
	오후	• Oral session 참석 : 16. High-impact weather • Oral session 참석 : 24. Education, outreach and public engagement in weather, climate and ocean science • Oral session 참석 : 33. Tropical cyclone dynamics and forecasting • Poster 발표 : Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis 15:00-16:00 • Oral session 참석 : 09. Wave dynamics • Oral session 참석 : 28. Processes in global and regional monsoons

Impact of Boreal Summer Intraseasonal Oscillation on tropical cyclone genesis

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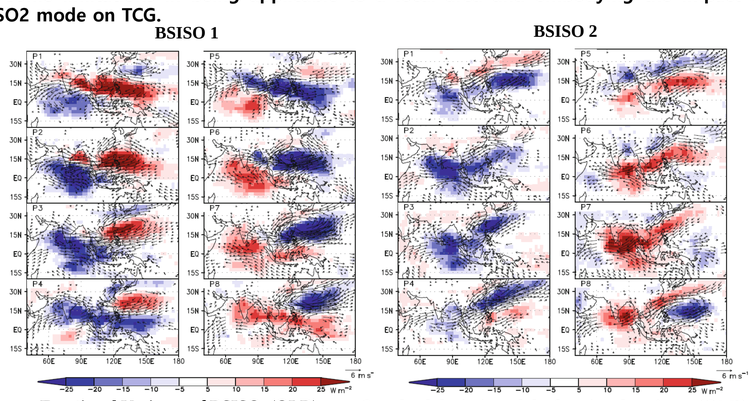
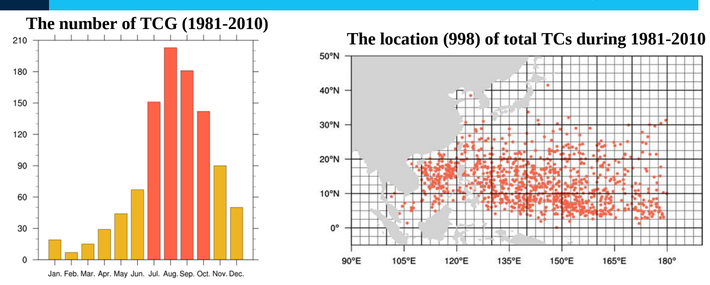
What is BSISO?

While the boreal winter ISO (also known as the MJO) shows predominantly eastward propagation, the boreal summer ISO (BSISO) also exhibits northward/northwestward propagation over the Western North Pacific-East Asian (WNP-EA) region (Murakami 1984, Chen and Chen 1993; Kemball-Cook and Wang 2001; Kajikawa and Yasunari 2005; Yun et al. 2009, 2010). The BSISO indices were designed to better represent fractional variance and the observed northward propagating ISO over the entire ASM region than the RMM index.

The wet and dry spells of the BSISO strongly influence extreme hydro-meteorological events, major driving forces of natural disasters. Especially, BSISO plays an important role in modulating tropical cyclone activity over the Western North Pacific (WNP) by altering environmental conditions (Zhao et al., 2018). A new index has been proposed to better quantitatively measure the impact of BSISO on TC genesis (Moon et al, 2018), but it still has some limitations in being applicable to a local area and embodying the impact of BSISO2 mode on TCG.

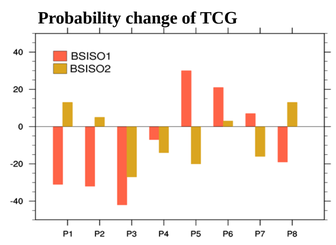


Characteristic of Western North Pacific TC genesis

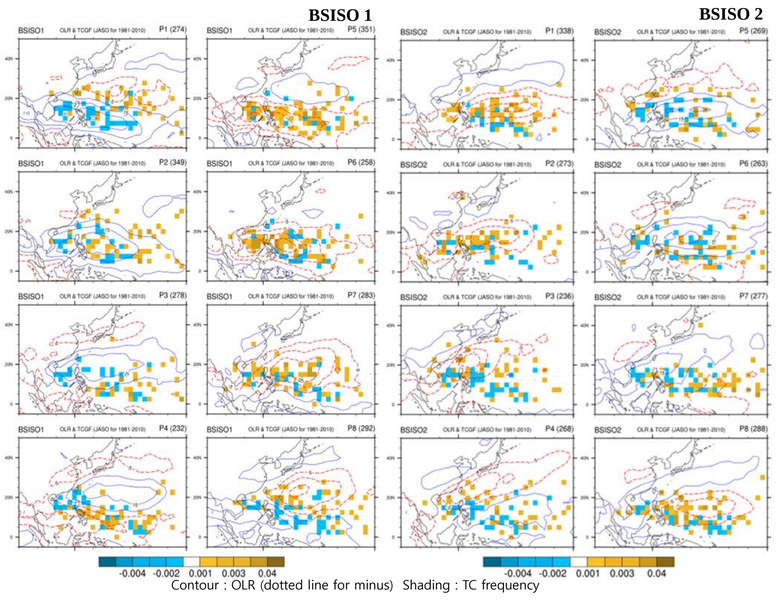


Among total TCs (998) over the WNP during 1981-2010, 677 TCs occurred in JASO (68% of total), which is significant months over 1.5 standard deviation (99) of TC number for 12 months.

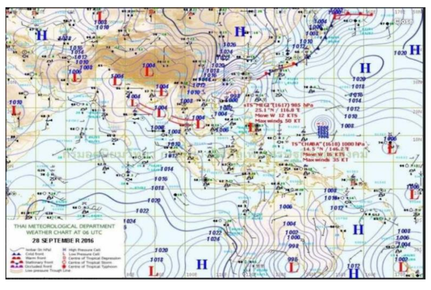
Relationship between BSISO and WNP TC



Tropical cyclone genesis in the Western North Pacific has a strong preference for a particular phase. The TCG is more frequent in Phase 5,6,7 (8,1,2) of BSISO 1 (BSISO 2) when the major BSISO convection is located in the WNP region, while TCG is suppressed in the non-convective phases of BSISO.



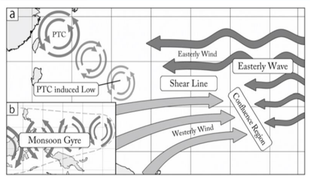
Eight-phase evolution of major convection (OLR) anomalies and TCG frequency (TCGF) anomalies by BSISO index are shown. The negative OLR anomalies correspond with increased TCGF anomalies through phase 1 to 8 for each BSISO mode. This eight relationship is more evident over the WNP with maximum TCG centered along the 10°-20°N band.



Monsoon trough is the most favorable environment for the formation of multiday persistent cloud clusters that frequently grow into TCs (Gary, 1968, 1999).

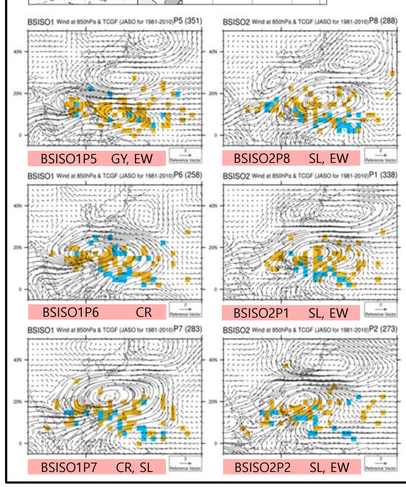
The trough extends from the Indochina Peninsula in the west to the east of the Philippine Sea, and is accompanied by southwesterly flow on its southern side. The flow cause favorable condition of TC genesis by making positive vorticity, convergence and ascending air.

Relationship btw BSISO and WNP TC



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).

From Ritchie and Holland (1999)

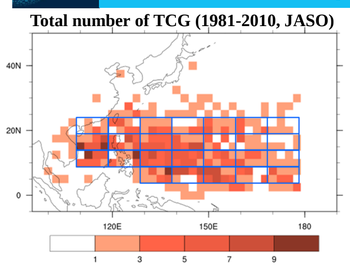


Of these five patterns, the SL, CR, and GY patterns are related to the monsoon trough. SL is cyclonic shear of the horizontal wind along the monsoon trough, CR is the confluence zone between monsoon westerly and easterly winds .

Phase preference
- BSISO1 : P5,P6,P7
- BSISO2 : P8,P1,P2

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.

WNP ISGPI development



26 Boxes covering the TCG location are used to form the statistical samples in step-wise linear regression for deriving the WNP ISGPI. Total number of sample is 416 (8phases X 2mode X 26boxes).

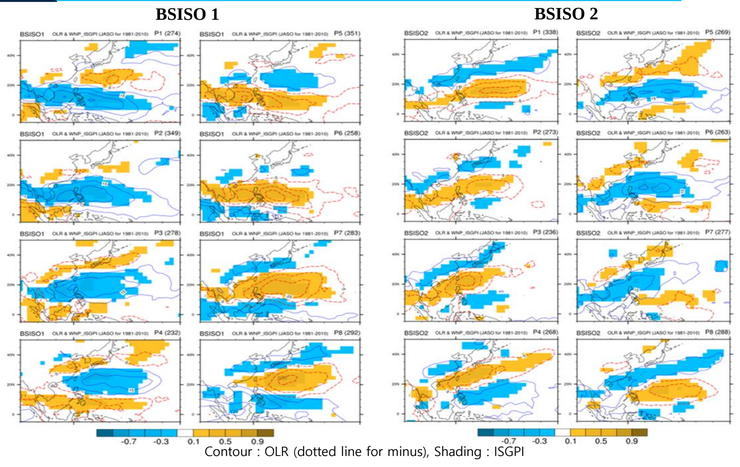
Selected significant influential factors

BSISO Index	V_{ZS}	ω500	ζ_{850}	RH_{600}	V_S	U_{s850}	U_{s850}
OLR & U850 [5°N-25°N, 110°E-180°E]	0.747[3]	0.717[1]	0.743[2]	**0.750[4]**			
Equation	$(-0.612)\times\omega500+(0.318)\times\zeta_{850}+(-0.120)\times V_{ZS}+(-0.205)\times RH_{600}$						

After analyzing the stepwise regression between 8 potential factors and observed TCGF anomaly, significant influential factors are selected. With the selected significant factors, the corresponding regressed equation is derived. The complex correlation coefficient of the TCGF anomaly with the four factors is 0.75.

Borrowed the methodology from Moon et al. (2018)

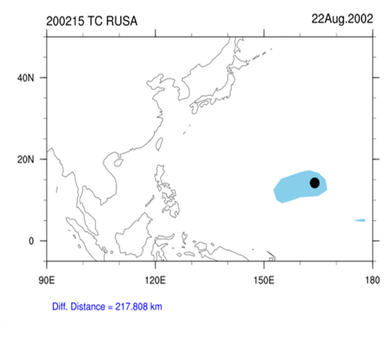
Performance of WNP ISGPI in reproducing BSISO



The global distribution of WNP ISGPI successfully capture the development of BSISO in each phases. We can also find the phase-dependence of WNP ISGPI.
When the BSISO convection anomalies become the strongest over the Western North Pacific (B1:P567,B2:P128), WNP ISGPI has the positive value.

Performance of WNP ISGPI in reproducing TCG

A case of TC RUSA in 2002



For a case of TC RUSA in 2002, the difference between real TC genesis and the center of positive WNP ISGPI area is about 217 km.

Distance between TC genesis location and WNP ISGPI center

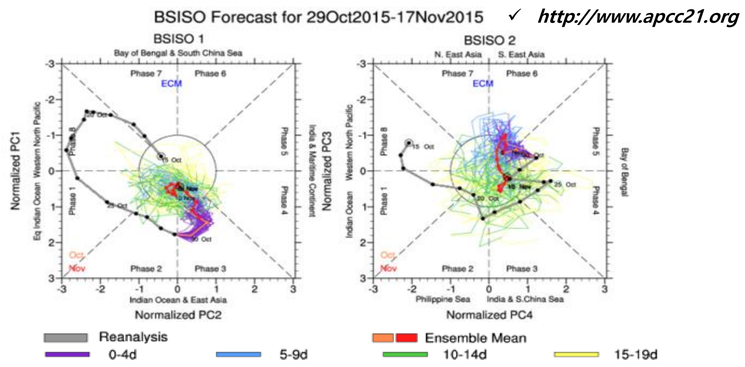
Distance (km)	Average	Minimum	Maximum
For all case	497	11	954
For active BSISO	497	11	954
For non-active BSISO	482	77	780

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

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

On the basis of 500km difference, around one third of real TC genesis can be reproduced by WNP ISGPI during 30 years.

APCC's real-time BSISO forecast

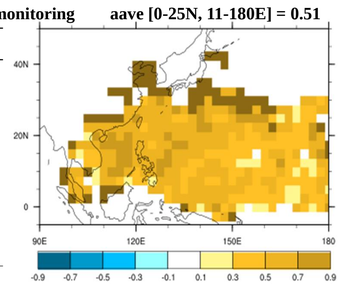


APCC has scaled up the climate information services to intraseasonal forecast by providing the Boreal Summer Intraseasonal Oscillation (BSISO) forecasts since 2013. Given the importance of BSISO influence on TC genesis, APCC's BSISO information could be more informative for monitoring and forecasting WNP TCG through the application of WNP ISGPI.

Performance of estimated WNP ISGPI by APCC 's BSISO info.

Probability of detection for TCG location using WNP ISGPI monitoring

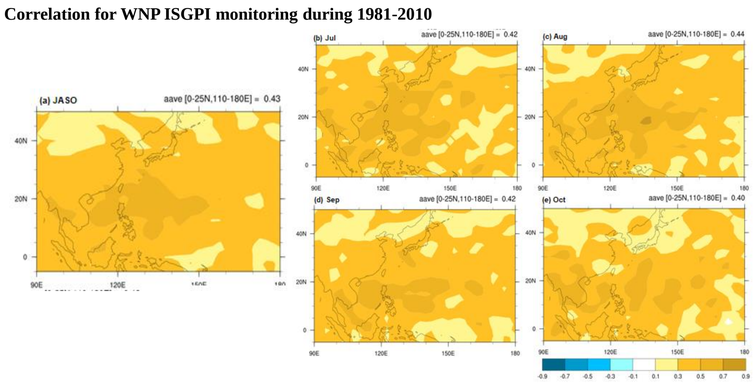
	POD
JASO	0.34
Jul.	0.33
Aug.	0.35
Sep.	0.34
Oct.	0.33



Pattern correlation for WNP ISGPI monitoring during 1981-2010

	Pattern Correlation
For all case	0.32 (677)
For active BSISO	0.43 (235)
For non-active BSISO	0.06 (109)

Correlation for WNP ISGPI monitoring during 1981-2010



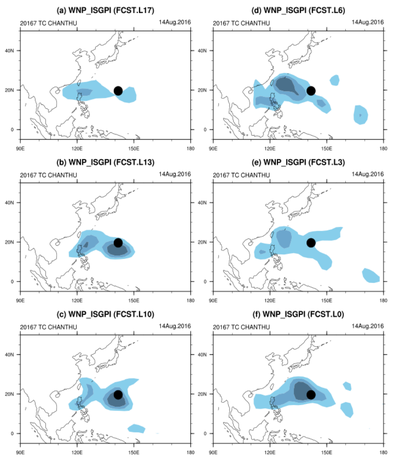
According to the probability of detection, WNP ISGPI monitoring estimated by APCC's BSISO index might be a good tool to be able to detect about one third of total TCG, the WNP ISGPI could be more useful when BSISO is active and monsoon trough is well developed in August.

WNP ISGPI forecast estimated by APCC's BSISO forecast

CASE 1

Target event : TC CHANTHU in 2016 (#7)
Date : 14 Aug, 2016

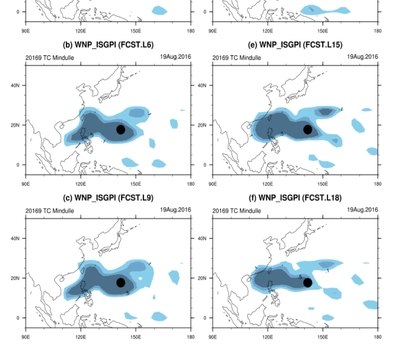
With Different Initial Condition
L17 : IC. 20160728
L13 : IC. 20160801
L10 : IC. 20160804
L6 : IC. 20160808
L3 : IC. 20160811
L0 : IC. 20160814



CASE 2

Target event : TC Mindulle in 2016 (#9)
Date : 19 Aug, 2016

With One Initial Condition
(I.C. 20160801)



Tropical cyclone genesis over the Western North Pacific could be predicted 2 weeks in advance when using APCC's BSISO information.

Conclusion

In this study, local intraseasonal genesis potential index over the Western North Pacific (WNP ISGPI) was developed to quantify the anomalous tropical cyclone genesis (TCG), which is induced by both of two modes for boreal summer intraseasonal oscillation (BSISO). BSISO is one of tropical ISO mode, which dominates during boreal summer and exhibits northward/northwestward propagation as well as eastward movement. The northward/northwestward propagating variability plays an important role in modulating tropical cyclone activity over the Western North Pacific (WNP).

The main TC season in the WNP was from July to October when 68% of total TCs occurred. During the season, there were the phase preferences between BSISO and TCG frequency. BSISO could influence on large scale zonal wind associated with monsoon trough, which in turn might contribute to make favorable synoptic scale environment to TC genesis. Using the stepwise linear regression and F-test, WNP ISGPI was derived from the relationship between BSISO and WNP TCG. The global distribution of WNP ISGPI successfully reproduced the development of BSISO in each phases. When the BSISO convection anomalies became the strongest over the Western North Pacific (B1:P567,B2:P128), WNP ISGPI had the positive value. On the reproduction of TCG, WNP ISGPI could reasonably detect TCG likelihood by having distance error of 500km between the eye of cyclone and ISGPI center. Approximately 36% of TCG could be expected to be detect by the WNP ISGPI. Therefore, WNP ISGPI could be a useful tool to diagnose BSISO effects on tropical cyclone genesis.

APCC has provided the information for real-time BSISO monitoring and forecast. Given the importance of BSISO influence on TC genesis, APCC's BSISO information could be more informative for monitoring and forecasting WNP TCG through the application of WNP ISGPI. In terms of monitoring, WNP ISGPI estimated by APCC's BSISO index could detect about one third of total TCG and was more useful in August when monsoon trough was well developed. In addition, TC genesis over the WNP could be predicted 2 weeks in advance when using WNP ISGPI estimated by APCC's BSISO forecast. WNP ISGPI was applicable to not only the quantification of WNP TCG but also its monitoring and forecast.

Detailed Session List

Friday, 14 September 2018

ID: 01
ICTMO/AMOS: AMOS

Theme 01. Oceans

01. Ocean extreme events and their impacts

Ocean extremes (e.g. temperature, sea level), can have significant socio-economic impacts on coastal communities (e.g. infrastructure, fisheries, aquaculture and tourism). Marine heatwaves, for example, have been associated with the redistribution and/or mortality of certain marine species and changes in ecosystem structure. Sustained high spatial and temporal resolution observational datasets and recent developments in ocean modelling have improved our ability to investigate marine extremes, leading to new understanding, improved predictability and longer-term projections. In this session we invite observational and modelling studies aimed at characterising and understanding the local processes, large-scale drivers and long-term changes in marine extremes and/or their impacts. Conjointly with this session, IMOS will be holding a half day workshop to learn how to access and analyse IMOS data. Contributors to this session who use IMOS data are also invited to provide examples at this workshop on how the data presented was accessed and visualised for their talks.

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CONVENOR 4:
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ID: 02
ICTMO/AMOS: AMOS

Theme 01. Oceans

02. Dynamics of the Southern Hemisphere oceans

The Southern Hemisphere oceans encapsulate key elements of the Earth's climate system: Indo-Pacific warm pool, Indonesian Throughflow, vast Southern Ocean linking three ocean basins, and the cold Antarctica. They host interactions across climate modes such as the El Niño-Southern Oscillation, Indian Ocean Dipole, Southern Annular Mode and air-sea processes that impact water-mass formation, sea level and global thermohaline circulation. However, sparsity of Southern Ocean observations limits understanding and modelling of processes across these elements.

Launched in 2017, the Centre for Southern Hemisphere Oceans Research (CSHOR) aims to advance scientific understanding of the southern hemisphere oceans and their role in our climate. We solicit a broad scope of presentations on the above research areas, including the response to greenhouse warming and interactions between low- and high-latitudes, ranging from observation-based to modelling studies, from basin-scale to regionally-focused investigations, with the aim to prompt collaborations between CSHOR and the broad climate science communities.

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OTHER CONVENORS
Wenju Cai, Steve Rintoul, Matt England, Ming Feng and Bernadette Sloyan

ID: 03
ICTMO/AMOS: AMOS

Theme 01. Oceans

03. Bridging spatial scales in the ocean: From the submesoscale to the mesoscale

Ocean dynamics operate on a wide range of spatial and temporal scales, from inter-basin exchanges to sub-mesoscale frontal and instability processes, with various energy pathways in between. With recent technological and computational improvements, the range of scales we can observe and model in our oceans is wider than ever. In this session we welcome oceanographic studies with a particular emphasis on dynamics and processes interacting across different spatial scales.

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ID: 04
ICTMO/AMOS: AMOS

Theme 01. Oceans

04. From the shelf to the deep: Antarctic and Southern Ocean processes

The oceans encircling the Antarctic continent have a unique impact on Earth's climate, including controlling the basal melting of ice shelves that contributes to global sea level rise, and the formation of Antarctic Bottom Waters that fill the global abyssal ocean. Recent advances in ocean/ice observations and numerical modelling are providing new insight into the structure and dynamics of Antarctic continental shelf waters, the Antarctic Circumpolar Current, and the Southern Ocean overturning circulation. In this session, we welcome contributions on physical and biogeochemical processes of the Southern Ocean and Antarctic coastal ocean, and their response to change. Both observational and numerical modelling advances are encouraged.

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ID: 05
ICTMO/AMOS: AMOS

Theme 01. Oceans

05. Advances in ocean observing, modelling and prediction

Numerical modelling and forecasting of ocean variability across a range of time and space scales is an area of active research. Continual increases in the availability of computational power allow higher resolution and more detailed and extensive modelling studies as well as more optimal data assimilation methods. At the same time this poses challenges in terms of the adequacy of our observing system to constrain these scales as well as their predictability.

This session invites abstracts on aspects of ocean observing, modelling and analysis across a range of time and space scales. Studies may include, for example, numerical model development, data assimilation, observing system design, operational forecasting, ensemble forecasting, verification, case studies and coupled modelling.

Abstracts relating to all forms of ocean variability are welcome, including but not limited to: general ocean circulation, ocean mixing, wind waves, air-sea interaction, the carbon cycle and ecosystem dynamics.

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ID: 06
ICTMO/AMOS: AMOS

Theme 01. Oceans

06. Wave dynamics

Waves are a major mechanism for the transport of energy and momentum within the ocean and atmosphere, and at the air-sea interface. Waves also determine the timescale of the transient response to changes in forcing. Some of the many types of waves include Rossby waves, inertia-gravity waves, Kelvin waves, tidal waves and surface gravity waves. All of these waves play an important role in the climate system. For example, atmospheric Rossby waves are responsible for the mid-latitude weather systems over southern Australia; inertia-gravity waves are responsible for deep-ocean mixing that helps sustain the ocean's overturning circulation; equatorial Kelvin waves play an important role in ENSO. This session welcomes theory, modelling and observational studies focusing on the dynamics of waves and their role in the atmosphere, ocean and climate systems.

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ID: 07
ICTMO/AMOS: AMOS

Theme 02. Atmosphere

07. Tropics to ice: clouds, aerosol, composition and chemistry

The atmosphere of Australia's tropical north is complex, being regularly influenced by regional biomass burning, long-range transported anthropogenic emissions, and clean marine air. The baseline air pollution station at Gunn Point (20 km NE of Darwin) has been providing high quality atmospheric composition data since 2010, and has hosted a number of intensive research campaigns.

In direct contrast, the Southern Ocean and Antarctica are among the cleanest regions on Earth, providing opportunity to study a pristine atmosphere and pre-industrial conditions. A range of recent and ongoing activities involving research stations, vessels, and expeditions are yielding vast amounts of new data and insights into this part of Earth's atmosphere.

This session provides a forum for presentation of observational and modelling studies of clouds, aerosols, composition and chemistry of the atmosphere, from the tropics to the ice, and is motivated by furthering our understanding of climate and air quality processes.

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ID: 08
ICTMO/AMOS: AMOS

Theme 02. Atmosphere

08. Australian rainfall: processes, interactions and extremes

Rainfall is fundamental to maintaining our water resources and sustaining life on our planet. Australia has some of the most variable rainfall in the world yet our observations are lacking, our understanding of the large scale and small scale processes and interactions that influence it is limited and our climate models cannot reliably generate either regional means or extremes. The aim of this session is to draw on research concerned with a wide range of Australian rainfall aspects: from the processes that form it, to the large scale interactions that influence it, to advances in observing systems and monitoring, to improvements in how it can be simulated by models. We plan to organise the session around several sub-sections including 1) background control and large-scale influences, 2) spatial and temporal organisation of convective systems, 3) tropical to mid-latitude interactions, 4) observations and climate model evaluation. We particularly welcome abstracts that focus on rainfall extremes.

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ID: 09
ICTMO/AMOS: AMOS

Theme 02. Atmosphere

09. Atmosphere to land surface processes

This is a general session inviting oral and poster presentations relating to atmosphere - land surface processes not covered by other sessions.

LEAD CONVENOR:
AMOS-ICTMO committee.

ID: 10
ICTMO/AMOS: AMOS

Theme 03. Climate Variability & Change

10. Modelling, prediction and projections of climate variability and change

Climate models are important for understanding the dynamics of the atmosphere and ocean and for predicting and projecting climate variability and change. Models provide climate information crucial for planning, mitigation and adaptation across all sectors of society. International climate modelling centres are currently performing climate simulations for CMIP6, using their newly developed models. In Australia, CSIRO, the Bureau of Meteorology (BOM) and Australian universities have been developing version 2 of the Australian Community Climate and Earth System Simulator (ACCESS-2.0) and version 1.5 of ACCESS-ESM (Earth System Model) to participate in CMIP6.
Climate models are important for understanding the dynamics of the atmosphere and ocean and for predicting and projecting climate variability and change. Models provide climate information crucial for planning, mitigation and adaptation across all sectors of society. International climate modelling centres are currently performing climate simulations for CMIP6, using their newly developed models. In Australia, CSIRO, the Bureau of Meteorology (BOM) and Australian universities have been developing version 2 of the Australian Community Climate and Earth System Simulator (ACCESS-2.0) and version 1.5 of ACCESS-ESM (Earth System Model) to participate in CMIP6.
This session invites oral and poster presentations covering model evaluation, understanding and predicting climate, the variability modes (e.g., SAM, MJO, IOD, ENSO and IPO), and their changes under global warming. Presentations comparing observations with ACCESS, ACCESS-ESM and other CMIP simulations, as well as evaluating forecast skills (e.g., of the BOM ACCESS-S seasonal prediction system and the CSIRO CAFÉ decadal forecasting system) are encouraged.

LEAD CONVENOR:
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ID: 11
ICTMO/AMOS: AMOS

Theme 03. Climate Variability & Change

11. Limiting global warming to 2°C: Pathways and implications for Australia

The recent Paris Agreement aims to limit global warming to well-below 2°C. This is an ambitious target that will require deep cuts in (net) greenhouse gases. This net decrease will most likely come through both cuts in fossil fuel emissions (positive emissions) and implementation of carbon dioxide removal (negative emissions). The timescales of the implementation of these changes will be central to whether the Paris Agreement succeeds.

This session invites contributions on the range of science required for achieving the Paris Agreement, what the resulting impacts will be compared to a higher emissions scenario, and also the benefits of meeting the aspiration target of 1.5°C compared to 2°C. The aim is to discuss potential low emission pathways and associated climate projections compared to other pathways, trade-offs and the also implications of temporarily exceeding the 2°C warming target for Australia, its ecosystems and the services it provides.

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ICTMO/AMOS: AMOS

Theme 03. Climate Variability & Change

12. Regional climate modelling and its applications

There are a growing number of regional climate modelling ensembles being produced using dynamical and/or statistical approaches. These regional climate projections are aimed at providing data at scales relevant for climate change impacts and adaptation research. As such, they must be evaluated against local to regional scale datasets appropriate for the system of interest. This session invites presentations on all aspects of the creation, evaluation and application of regional climate modelling outputs. This includes presentations on regional climate projection techniques, ensemble creation, uncertainty quantification, the results of evaluations and bias correction, inter-comparison of different regional modelling outputs, investigation of specific regional climate changes, and application of regional climate projections to investigate specific climate change impacts on various human and natural systems.

LEAD CONVENOR:
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ID: 13
ICTMO/AMOS: AMOS

Theme 03. Climate Variability & Change

13. Understanding variability and changes in Southern Hemisphere circulation

Recent decades have seen large-scale changes to average circulation patterns in the southern hemisphere, associated with both greenhouse warming and changes in Antarctic ozone. Variability and change have been investigated with a range of approaches addressing the expansion of the tropics, trends in the Southern Annular Mode and subtropical ridge, ENSO variability, shifts in the midlatitude jet and storm tracks and associated changes in surface climate, ocean circulation and Antarctic sea ice extent. Many of these changes are projected to continue throughout the 21st century, under the combined influence of continued anthropogenic climate change and ozone recovery. This session will bring together researchers studying all aspects of southern hemisphere circulation variability and change to highlight the latest results and projections, and build a deeper discussion and understanding of how results intersect and where the key gaps are for future research.

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ID: 14
ICTMO/AMOS: AMOS

Theme 03. Climate Variability & Change

14. Palaeoclimates and palaeo-environments: proxies and modelling advances

There is an increasing demand for both palaeoclimate and more general palaeo-environmental records to place present-day climate and environmental changes in a longer-term context. Such records are invaluable for improving assessments of future risks and uncertainties associated with climate change and extreme events. Palaeoclimate records also provide crucial constraints on climate models, including their climate sensitivity and the simulation of natural climate patterns on time scales from seasons through to millions of years.

We welcome contributions related to all aspects and time scales of past climate, including those that bridge the gap between past and future changes in the climate system. The session spans palaeoclimate and palaeo-environmental reconstructions, climate modelling, data-model comparisons, and palaeoclimate synthesis efforts. Presentations combining multiple datasets or methods, with a focus on understanding underlying dynamical processes, are encouraged. This year, we especially welcome contributions related to the tropics.

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ID: 15
ICTMO/AMOS: AMOS

Theme 03. Climate Variability & Change

15. General climate session

This is a general session inviting oral and poster presentations relating to weather and climate not covered by other sessions.

LEAD CONVENOR:
AMOS-ICTMO committee.

ID: 16
ICTMO/AMOS: AMOS

Theme 04. Extreme events

16. High-impact weather

High-impact weather (HIW) events are a significant threat to life and property, and cause large economic losses each year. It is therefore vital that we continue to improve our understanding of and ability to predict such events. This session will be devoted to studies of HIW, including severe thunderstorms and their associated hazards (damaging winds, large hail, heavy rain, and tornadoes), severe turbulence, fire weather, tropical cyclones, hazardous winter weather, and floods. Relevant topics include the physical processes and predictability of HIW, the production, communication, and application of forecasts of these events, and the effects of natural variability and climate change on their frequency and severity. We will welcome contributions from the research and forecast communities, as well as end users of HIW forecast/research products such as emergency managers and the insurance industry.

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ID: 17
ICTMO/AMOS: AMOS

Theme 04. Extreme events

17. Extreme temperature events: attribution of events, processes and impacts

Extremes of temperatures pose risks to infrastructure, the environment, industry and human health. While recent studies have provided evidence of changes in climate extremes such as extreme heat and heatwaves, many challenges and knowledge gaps remain. How are anthropogenic and natural influences affecting extremes of temperature? What are the processes behind observed and simulated extremes? What are the socio-economic and environmental impacts of extreme temperatures? This session will focus on studies on a broad selection of heat extremes. Contributions are invited on past, present and future changes in trends in extremes and extreme events, using observation-based data and climate model simulations.

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ID: 18
ICTMO/AMOS: AMOS

Theme 04. Extreme events

18. Drought: variability, processes and prediction

Drought is one of Australia's most ubiquitous climate phenomena, yet the true nature of its variability and its underlying causal processes remain elusive. Furthermore, "drought" is often ill-defined and can mean anything from an acute month-long rainfall deficit to multi-decadal drying involving complex land, ocean and atmosphere interactions. Although one of Australia's longest studied phenomenon, drought remains one of the least well-understood climate extremes in terms of constraining its variability, understanding its underlying processes and reducing the uncertainties associated with its prediction.

This session aims to present the latest in drought research from a diverse range of perspectives from the palaeoclimate, observational and modelling communities. Studies using a variety of definitions (e.g. meteorological, agricultural, hydrological) and occurring on sub-seasonal (e.g. flash drought) to multi-decadal (e.g. megadrought) time scales are invited. In particular, research examining drought variability and change, drought processes and simulation and the prediction of drought are welcomed.

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ID: 19
ICTMO/AMOS: AMOS

Theme 05. Impacts & Risks

19. Impact and risk assessment for weather extremes

Physical impacts of extreme weather events are challenging to predict in a quantitative manner. Sources of uncertainty in assessing impacts of past events, in vulnerability relations and exposure data make it difficult to build robust models for predicting the impacts of future events. Key datasets are relatively short compared to the recurrence interval of extremes that drive overall risk, or to establish design criteria. Links between hazards and damage to infrastructure are complicated by myriad permutations of construction methods, interacting hazards and demographic changes. Uncertainty in short-term weather forecasts alone leads to a range of impact outcomes, presenting challenges for emergency management planning.

This session will focus on quantifying and managing impacts of extreme weather events including (but not limited to) tropical cyclones, drought, thunderstorms, bushfires, and heatwaves. Specifically, the development and utility of connected models of extreme weather and their impacts. Submissions may present observations, models or tools for quantifying impacts from extreme weather events; describe challenges to quantifying the impacts of extreme events; or discuss risk management solutions.

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Theme 05. Impacts & Risks

20. Urban climate

Land-use modifications due to urbanization can modify the energy balance in cities; this in turn affects the urban thermal environment, resulting impacts include the urban heat island (UHI) effect. With greater than 50% of the world's population living in urban areas it is imperative we understand the impact of both cities on climate and climate on cites.

Research that would be of relevance to this session include: urban heat island studies, urban weather forecasting, urban canopy models, representation of urban areas in climate models, urban areas and extreme events, urban air quality, urban climate and health, and urban climate mitigation strategies.

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Theme 05. Impacts & Risks

21. Closing the loop: Weather and climate impacts and risks described for agriculture and business.

Weather and climate risk and impact are often described in the units of the phenomena, which are the units of comfort to the researcher. This session will try to close the loop taking the extra steps to convert weather and climate risks and impacts into the language of business and agriculture. In some cases the translation will enable balance sheet impacts to be examined, in others intermediate common units may be found. Profitability often declines in businesses and agriculture as they absorb extreme weather impacts. The session will endeavour to examine the changes to business practises that may be required as events once considered isolated become normalised. In these scenarios the impact of extreme events may be reduced, but there may be a more chronic effect on business margins.

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Theme 05. Impacts & Risks

22. Energy systems and the weather/climate nexus

The nexus between energy systems and climate and weather systems is becoming more and more important. Weather and climate have always impacted on the demand for electricity and other fuels for heating and cooling, and have also affected hydro and thermal power stations. But as the penetration of wind and solar electricity generation technologies increases, the role of weather is now crucial. In this session we welcome presentations on extreme weather event impact on energy demand and infrastructure, energy resource assessment, forecasting for wind and solar output and integration of energy systems incorporating variable renewable energy power.

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Theme 06. Data, Services & Outreach

23. Automation and the changing role of the forecaster

What is the prognosis for forecast automation? Improvements to model skill, increased resolution and more advanced post-processing methods all support a greater potential for the automation of routine forecasts. Any step-change in automation will bring with it changes to the work carried out by operational forecasters, with the potential to free up time for higher-value work.

This session will facilitate an open discussion of the scientific questions underpinning greater automation along with questions about the changing nature of operational forecasting work.

Contributions are solicited on the following topics:

- Presentation of latest results of comparative verification of guidance and published forecasts;
- The challenge of extremes, warnings and high impact weather;
- Changes to the nature of forecasting work - where do humans add the most value in the forecasting process?
- What changes to service definitions and standards are needed to support automation?
- Risk and responsibility - does an automated forecast need supervision?

Contributions from operational forecasters are encouraged.

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Theme 06. Data, Services & Outreach

24. Citizen science: weather, climate and ocean science with the public

Citizen science is loosely defined as non-scientists contributing to the design, data collection or analysis of a research project and is a growing component of many scientific fields, including weather, climate and ocean science.

Incorporating non-professionals in scientific research has many economic, social and educational benefits, but there are also challenges, particularly associated with data quality, participant engagement and ethical considerations.

In this session we will showcase how these components of citizen science are tackled within the weather, climate and and ocean sciences. We welcome contributions from anyone developing or running a citizen science project, or anyone working with data from citizen science efforts. Topics include but not limited to:

- Funding, regulation and support for citizen science in Australia
- How to design a successful, sustainable citizen science project
- Tools to assist in the collection of quality data
- How to engage and retain participants
- Scientific benefits of citizen science

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Theme 06. Data, Services & Outreach

25. Education and outreach: experiences, ideas and challenges

Science engagement is key to communicating research science beyond the workplace, and can be achieved in a variety of ways. The education and outreach session welcomes contributions from all education sectors and industry working in weather and climate to showcase and exchange ideas, tools and practical tips on pedagogy and student/community engagement with the sciences related to weather and climate. This session is a regular feature of the AMOS annual conference, encompassing a range of interesting topics and attracting wide participation. The session presentations will promote discussion around new ways and challenges in engaging the wider community in various AMOS-related sciences. This session will be run as short talks and posters if there is a high number of quality abstracts.

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Theme 06. Data, Services & Outreach

26. Big data in oceanography and meteorology: challenges, applications and data products.

Oceanographers and meteorologists are drowning in a tide of data. Data availability has increased steadily in recent years due to the move towards higher resolution modelling and the increase in observations. Observational density has increased because of an increase in frequency of measurements, introduction of new single and multi-instrument datasets and new remote-sensing platforms. As a result, studies of geophysical fluid dynamics are becoming increasingly data driven. In order to derive valuable insights and knowledge from large volumes of data, new methods and techniques are emerging in the field of big data for visualization, analysis, and data dispensation. Vast numbers of datasets are being published and released freely for analysis and sharing.

We invite talks that are broadly related to the field of big data and data products. We encourage presentations on analysis of data from the syntheses of programmes such as IMOS and CMIP5 analyses, projects that deliver products and insights to end users, or that focus on pattern analysis and identification of complex relationships, predictive modelling using supervised and unsupervised algorithms, tools for handling large datasets and for increasing computational efficiency, novel applications of statistical learning and high volume time series analysis, blending of diverse datasets, reproducibility of analysis, inherent structural uncertainties in data, best practices in big datasets and guidance on recommended use for new and existing datasets.

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Theme 06. Data, Services & Outreach

27. Indigenous weather & climate

There exists considerable interest and a growing body of research within our science community on the weather and climate knowledge of the indigenous peoples of Australia, the Torres Strait Islands and the Pacific Islands. Developed over countless generations, this knowledge serves to counterpoint current approaches based on the geophysical and statistical sciences. Through respectful and collaborative engagement with Indigenous communities, current research includes the collection, synthesis, interpretation and exchange of knowledge on specific weather events and patterns, seasonal and inter-annual climate variability, and longer-term climate change. This session invites contributions on related work that shows how Indigenous peoples understand and interpret their climatic environment, how this knowledge can inform current scientific approaches, and how it forms an important constituent of Indigenous identity and connection to place.

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Theme 07. ICTMO

28. Processes in global and regional monsoons

Climate variability and change pose significant challenges for humans to develop adaptation strategies in the tropical/monsoon regions across the globe. But global climate models are struggling to correctly simulate many tropical processes. Tropical rainfall is organized in large-scale structures of the monsoons and the ITCZ and understanding large-scale influences and their coupling with small scale cloud and precipitation processes could lead to a better description of tropical rainfall. Making this link across scales and testing models against past changes are key challenges in weather and climate science.

This session aims to provide an insight into the latest understanding of global and regional monsoons in paleo-, historical, and future climates. We are interested in both large-scale and small scale processes and dynamics in climate models and observations. We are particularly interested in attempts to constrain projections based on information provided by observations or paleoclimate information, or based on simulation of processes at the small scale and their rectification onto the large-scale. Additionally, studies exploring impacts of tropical monsoons on extratropical climate through global teleconnections and diagnosing features of moisture transport, including the "atmospheric river", within the monsoon system are also encouraged. We also encourage submissions on advancements in monsoon modelling.

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Theme 07. ICTMO

29. Climate application for the tropics

Many parts of the global tropics, especially the land-masses where people live, produce their food, and base much of their industry, is impacted by an especially variable climate, especially in terms of rainfall. This has a large impact on the people and economies of the tropics, making it a region ripe for climate application work. Further, multi-week to seasonal climate model forecast accuracy for this region is lagging far behind the expected potential predictability. This session invites contributions on all aspects of applied climate science with a geographical focus on the tropics, especially presentations incorporating end-user needs. We particularly welcome contributions from the Northern Australian Climate Program and similar applied climate science programs focussing on SE Asia. Topics of interest include flash-drought, multi-year drought, rainy season onset, and rainy season bursts and breaks. Contributions focussing on all industries, including mining, energy, tourism, and agriculture are welcome.

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Theme 07. ICTMO

30. The role of organised tropical convection for weather and climate variability

We invite presentations on all aspects of organised tropical convection from the mesoscale to planetary scale, including its initiation, maintenance, and feedbacks within equatorial waves and the Madden-Julian Oscillation. This session will also concern the dynamics and thermodynamics of convectively coupled waves and the MJO, their sensitivity to variations in background conditions including the QBO, the 2-way interaction between organised convection and the extratropics, and the simulation and prediction of tropical convection and its role in weather and climate variability.

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Theme 07. ICTMO

31. Maritime Continent earth system science and the Years of Maritime Continent

The Maritime Continent (MC) is a unique mixture of islands and ocean straddling the equator to the north of Australia, located within the Indo-Pacific warm pool that experiences the globally highest mean sea surface temperatures and acts as the anchor for the largest centre of deep atmospheric convection. It therefore has a strong influence on both nearby and global weather and climate. In this session we solicit submissions on all aspects of earth systems science focused on the MC region, including atmospheric convection, atmospheric circulations and waves, ocean vertical mixing, biogenic emissions, model biases, land-atmosphere interactions, and troposphere-stratosphere exchange. In particular, the international field campaign Years of the Maritime Continent (YMC) is currently in progress since July 2017 through early 2020. Thus, contributions from this campaign and/or associated research are strongly encouraged.

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Theme 07. ICTMO

32. Tropical cyclones: Climate processes, variability and change

The extreme rainfall, violent winds, and storm surges which accompany tropical cyclones are an annual threat to Australia and to many regions of the global tropics. Despite recent advancements of observing systems and computer models, there still is considerable uncertainty about the effects of climate variability and change on tropical cyclones, including future projections of tropical cyclone frequency, intensity, and geographic location. This session welcomes observational, modelling, and theoretical studies that contribute to our understanding of tropical cyclones and climate, from subseasonal to interannual timescales and beyond. Process-based studies aimed at developing more fundamental knowledge of the connection between tropical cyclones and climate are particularly encouraged.

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Theme 07. ICTMO

33. Tropical cyclone dynamics and forecasting

This session will showcase recent research on tropical cyclones with a special focus on dynamics and forecasting. It will showcase also approaches to overcome forecasting challenges in the Australian region. Research in other regions that could be applied to Australia will be welcomed. The session will include cyclone risk mitigation and investigations into the particular wind, rainfall and storm tide hazards.

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Theme 07. ICTMO

34. Tropical climate variability: dynamics, teleconnections and impacts

The tropical region is home to Earth's most prominent modes of climate variability. This includes the El Niño Southern Oscillation (ENSO), Indian Ocean Dipole, and Atlantic variability which are important sources of climate variability in the tropics and beyond. These tropical modes are known to influence weather patterns, rainfall and temperature extremes over vast regions globally. Their significant influence on weather and climate makes a better understanding of their dynamics and impacts crucial for improved predictions.

Despite each of these modes having been extensively studied, many aspects of their dynamics, interaction across variability modes, and teleconnections to regional climate, remain elusive. Such knowledge gaps ultimately limit skill in seasonal forecasts and future projections for regional climates. This session invites contributions of studies that address the dynamics, impacts, and teleconnection of tropical modes of variability, including, but not limited to, ENSO theory and diversity; seasonal forecasting; interbasin interactions; model representation and climate change projections.

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Theme 07. ICTMO

35. Variability and dynamics of Indo-Pacific ocean exchange and roles in air-sea coupling

The Indonesian Seas provide a conduit linking the equatorial Pacific and Indian Ocean warm pools. This link is commonly known as the Indonesian Throughflow. Variability of ocean circulation in the tropical Indo-Pacific plays important roles in modulating the variability of the Indo-Pacific warm pool, which influences the evolution of dominant climate modes, such as ENSO, Indian Ocean Dipole, and the Madden-Julian Oscillation. Better understanding of the ocean processes is vital as this region controls the equatorial and mid-latitude atmospheric circulation by regulating local convection and heat transport to the mid-latitudes. These interactions occur at a wide range of spatial and temporal scales. This session seeks contributions on oceanic circulation variability and dynamics of the Indo-Pacific ocean exchange, including the role of ocean mixing and air-sea interactions in the Indonesian Seas, at times scales ranging from diurnal, intra-seasonal, interannual, decadal to the centennial.

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Theme 07. ICTMO

36. Tropical oceanography: processes and dynamics

The tropical oceans include a wide range of unique dynamics and influence both regional and global climate on time-scales ranging from intraseasonal to decadal. This general session seeks contributions on any tropical oceanography topic, with a particular emphasis on ocean processes and dynamics in models, observations and theory, and how they are influenced by and contribute to climate variability such as ENSO and the IPO. Topics may include, but are not limited to, equatorial upwelling, cold tongue physics and biogeochemistry, low-latitude western boundary currents, zonal jets, vertical and lateral mixing, equatorial waves, tropical ocean heat uptake and variability, the oceans role in air-sea coupling, model process representation and projections of future change.

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Theme 08. Cryosphere

37. Cryosphere general session

This is a general session inviting oral and poster presentations relating to Antarctic, Arctic or Alpine science not covered by other sessions.

LEAD CONVENOR:
AMOS-ICTMO committee.

Theme 09. Communicating AMOS Sciences

38. Communicating AMOS sciences

In times of information overload, scepticism and fake news how do we communicate our science to inform the community, turn the tide of political inaction and garner support for continued research?

Abstracts are sought on topics that explore:

- issues to be considered or overcome in the quest to effectively communicate AMOS sciences (such as understanding science generally and AMOS science specifically, communication barriers, communicating risk and uncertainty
- innovative approaches to communicating AMOS sciences – through traditional and new media, storytelling, creative arts, etc.
- case studies of communication activities that have been successful, and those that haven't, with a view to sharing lessons learned.

Submissions on this topic will be considered for inclusion in the program of a two-day Communicating AMOS sciences side event being held in conjunction with AMOS-ICTMO 2019.

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