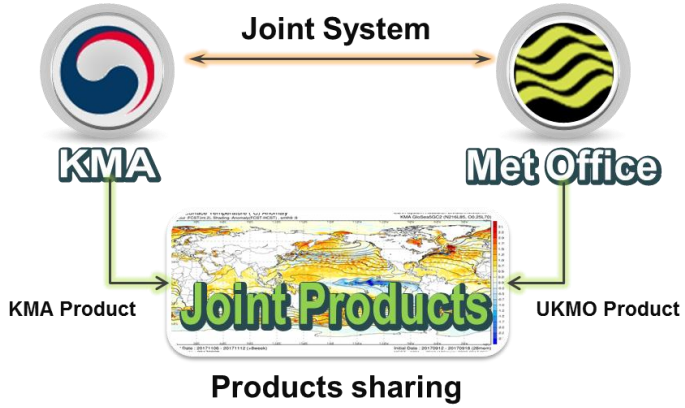
기상청 현업 기후예측시스템의 운영 및 개발 계획

2022. 6. 30.

국립기상과학원 기후연구부
기후모델개발팀

책임운영기관
국립기상과학원

Climate Prediction System at KMA



2010 June
- Joint Seasonal Forecasting System Arrangement

2013
- GloSea4 (125km)

2014
- GloSea5-GA3 (60km)

2015

2016
- GloSea5-GC2 (60km)

2017

2018
- KMA NEMOVAR Initialization
- Land Initialization
  (JULES-JRA55 soil moisture)
- River discharge

2019

2020
- Hindcast extension
  (1991-2010→ 1991-2016)

2021
- GloSea6-GC3.2 (60km)

Coupling Strategies for HadGEM3 family

- Coupler coupling between UM-JULES and NEMO-CICE
  - Master-slave couplings for UM-JULES and NEMO-CICE
- Coastal tiling
  - Land fractions used for land processes (JULES model): exact conservation for flux variables
- Melting heats from UM
  - Surface temperature except SST calculated from JULES
  - Top and bottom sea ice melting heat fluxes from UM assuming zero-layer thermodynamics

GloSea5-GA3→GloSea5-GC2 주요 변경 사항

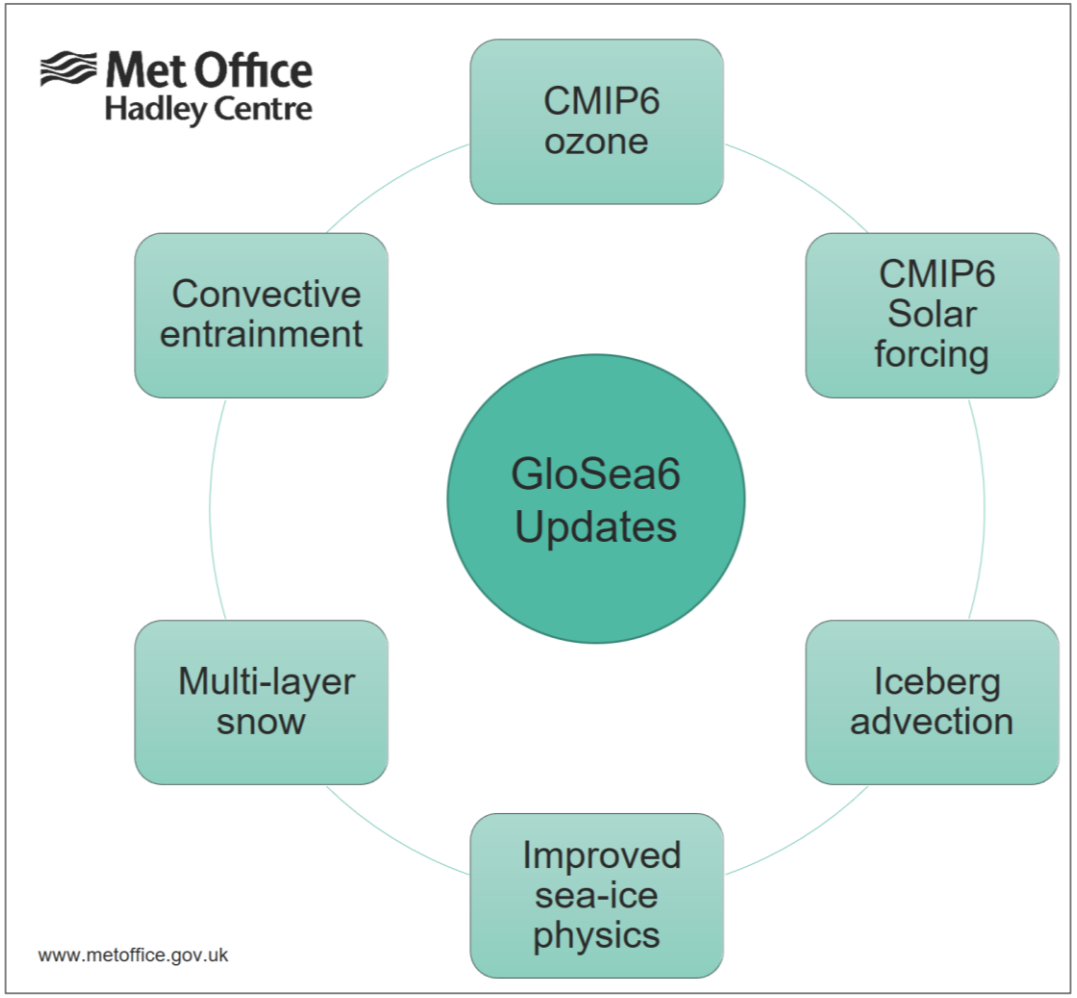
[Dynamics] : GA3(New Dynamics) vs. GC2(End Game)
- **increased scalability of CPUs** in multi-process computing → overcome computing time limit
- calculate sub-grid diffusion instead of giving constant number → **increased accuracy in small scale phenomena simulation**

[Physics] : UM version GA3.0 -> GA6.0
- increased entrainment rate in **convective parameterization**
- convection safety check
- included **gravity wave** drag scheme
- used **global albedo climatology**

[Hindcast period] :
- **GA3: from 1996 to 2009** (16yrs)
- **GC2: from 1991 to 2010** (20yrs)

Global Coupled		→	GC2 NEW
‖			‖
Global Atmosphere	GA3 UMvn8.4	→	GA6.0 UMvn8.6
+	+		+
Global Land	JULESvn4.7	→	GL6.0 JULESvn4.7
+	+		+
Global Ocean	NEMOvn3.4	→	GO5.0 NEMOvn3.4
+	+		+
Global Sea Ice	CICEvn4.1	→	GSI6.6 CICEvn4.1

GloSea5→GloSea6 주요 변경 사항



Global Coupled	GC2	→	GC3.2
	II		II
Global Atmosphere	GA6.0 UMvn8.6	→	GA7.2 UMvn11.5
	+		+
Global Land	GL6.0 JULESvn4.7	→	GL8.0 JULESvn5.6
	+		+
Global Ocean	GO5.0 NEMOvn3.4	→	GO6.0 NEMOvn3.6
	+		+
Global Sea Ice	GSI6.0 CICEvn4.1	→	GSI8.1 CICEvn5.2.1

모델 개선 사항

대기(UM) **vn8.6 → vn11.5**	**역학**	• 최적 보전 필터 기법 도입 • Hermite cubic 연직 내삽법 사용	**물리**	• 미세물리 개선 • 구름물리 개선 • 적운 모수화 개선	
지면(JULES) **vn4.7 → vn5.6**	다층 적설 표현 기법 채택	파장에 의존하는 알베도 도입	보다 정확한 강수 비율 계산법 도입		
해양(NEMO) **vn3.4 → vn3.6**	비선형 자유 수면파와 가변 체적층 사용	라그랑지안 빙산 모델 도입	운동량 이류 계산 개선	남극으로 확장된 격자 (eORCA025)	
해빙(CICE) **vn4.1 → vn5.1.2**	다층 열역학 도입	염분에 의존하는 해수의 어는점 설정	준암시적 결합 채택		

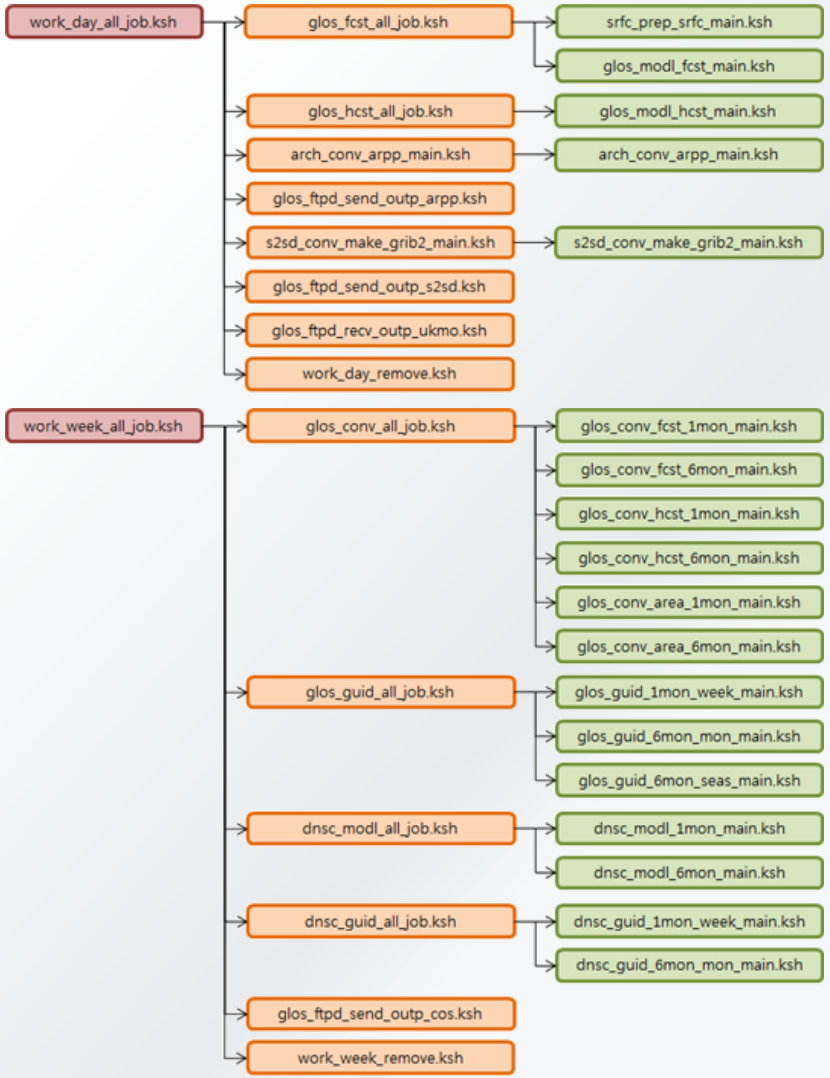
GloSea 현업 운영 비교

구분		Hindcast		Forecast	
		KMA GloSea5	KMA GloSea6	KMA GloSea5	KMA GloSea6
기간		1991~2016 (26yr)	**1993~2016 (24yr)**	2016 ~	2021 ~
초기장	대기	ECMWF ERA-int		KMA NWP analysis	
	지면	KMA JULES-JRA55	KMA JULES-**ERA5**	KMA JULES-JRA55	KMA JULES-**ERA5**
	해양/해빙	UKMO NEMOVAR		**KMA NEMOVAR**	
모델	수행시간	00UTC on 1st, 9th, 17th, 25th		00UTC everyday	
	예측기간	255days	252days	2mem (75days), 2mem (240days)	2mem (72days), 2mem (240days)
앙상블	추계방법	SKEB2	**SKEB2+SPT**	SKEB2	**SKEB2+SPT**
	멤버	3mem X 26years =78mem	3mem X **24years** **=72mem**	2mem (75days), 2mem (240days)	2mem (72days), 2mem (240days)

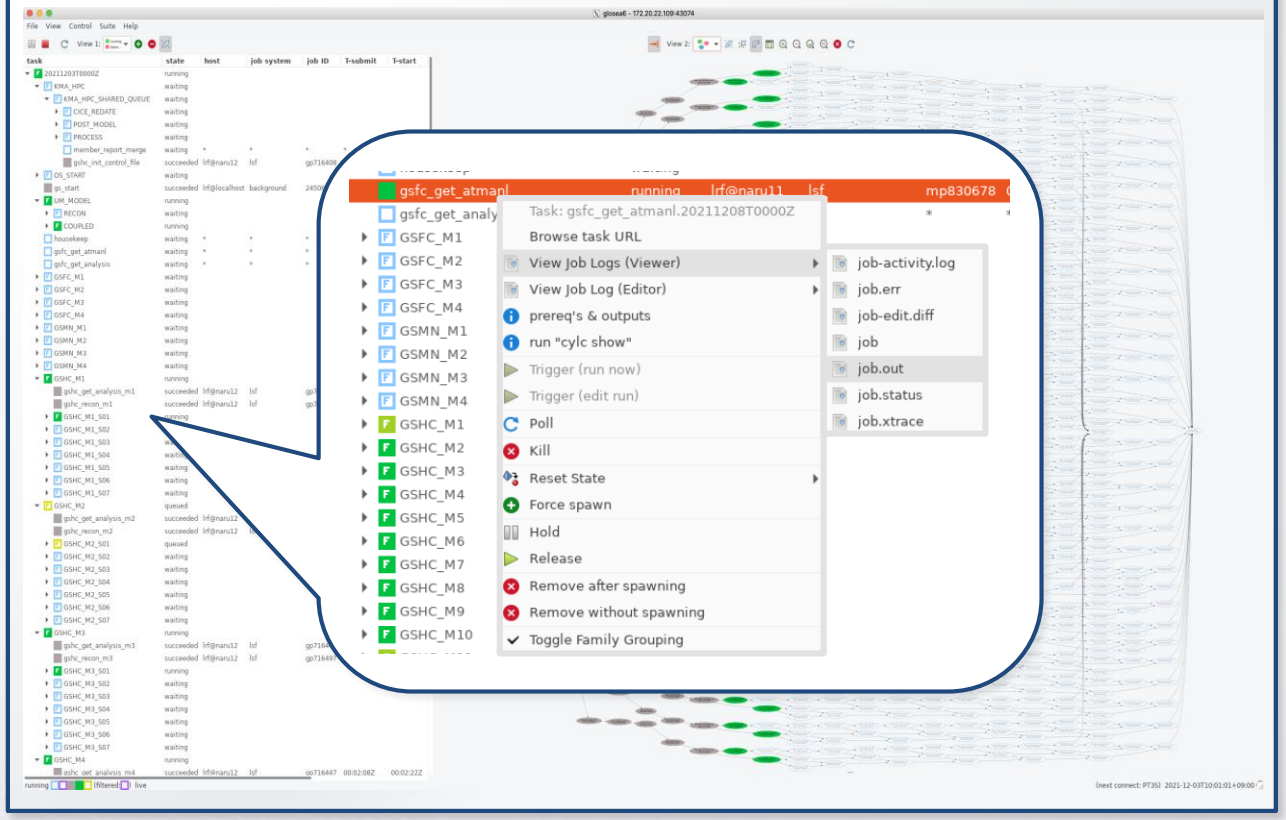
FCST: 1개월 예측 - 7-days lagged x 4 SKEB = 28멤버
3개월 예측 - 21-days lagged x 2 SKEB = 42멤버

구동 체계 변경: Shell → Rose/Cylc

기존 shell script 체계



Rose/Cylc suite 체계: cylc gui 창



Rose/Cylc suite 체계 구축 효과

- GUI 기반 조작 → 작업 관리 및 로그 확인 편의성 증가
- Cylc 그래프 → 진행 현황 파악 용이, 병렬 작업 동시 모니터링 가능
- 영국과 동일한 현업체계로 업그레이드 시간단축

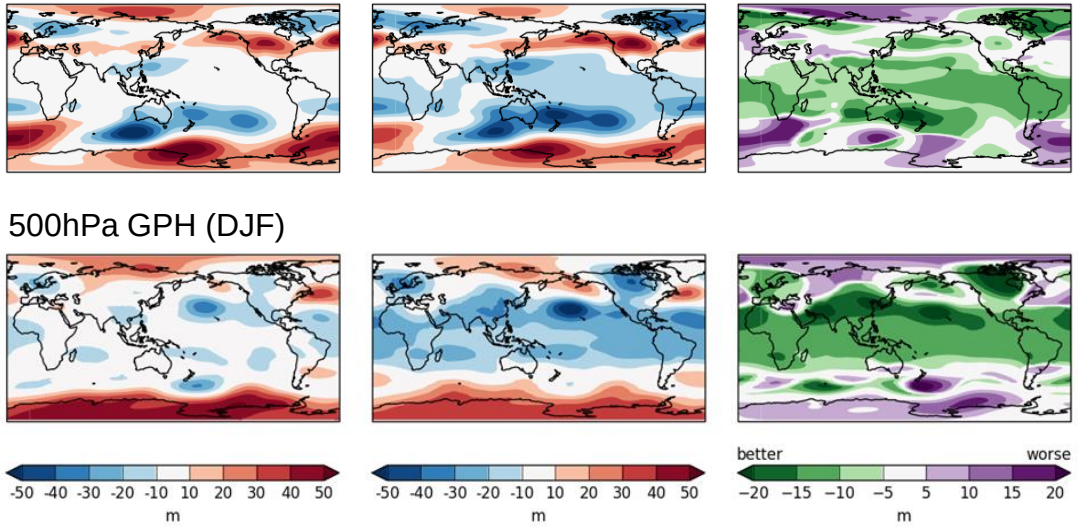
GloSea5대비 **GloSea6 편차**

Glosea6 bias | GloSea5 bias | bias improvement

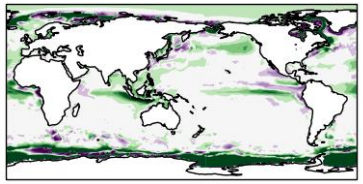
glosea6- glosea5

better worse

500hPa GPH (JJA)

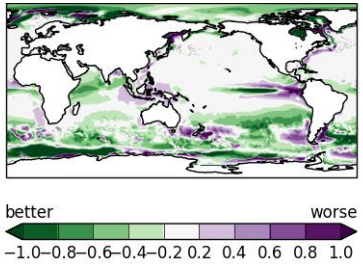


SST(JJA)

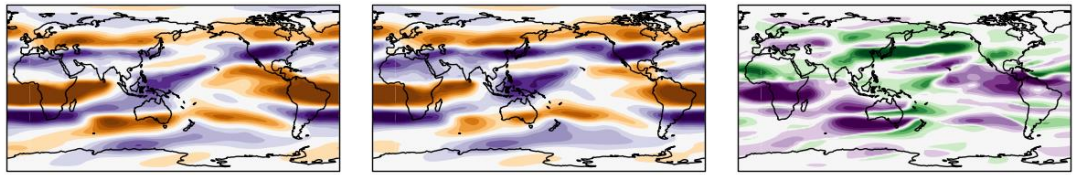


500hPa GPH (DJF)

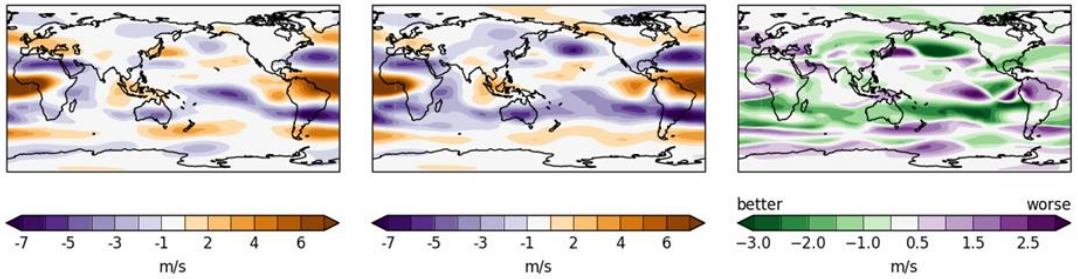
SST(DJF)



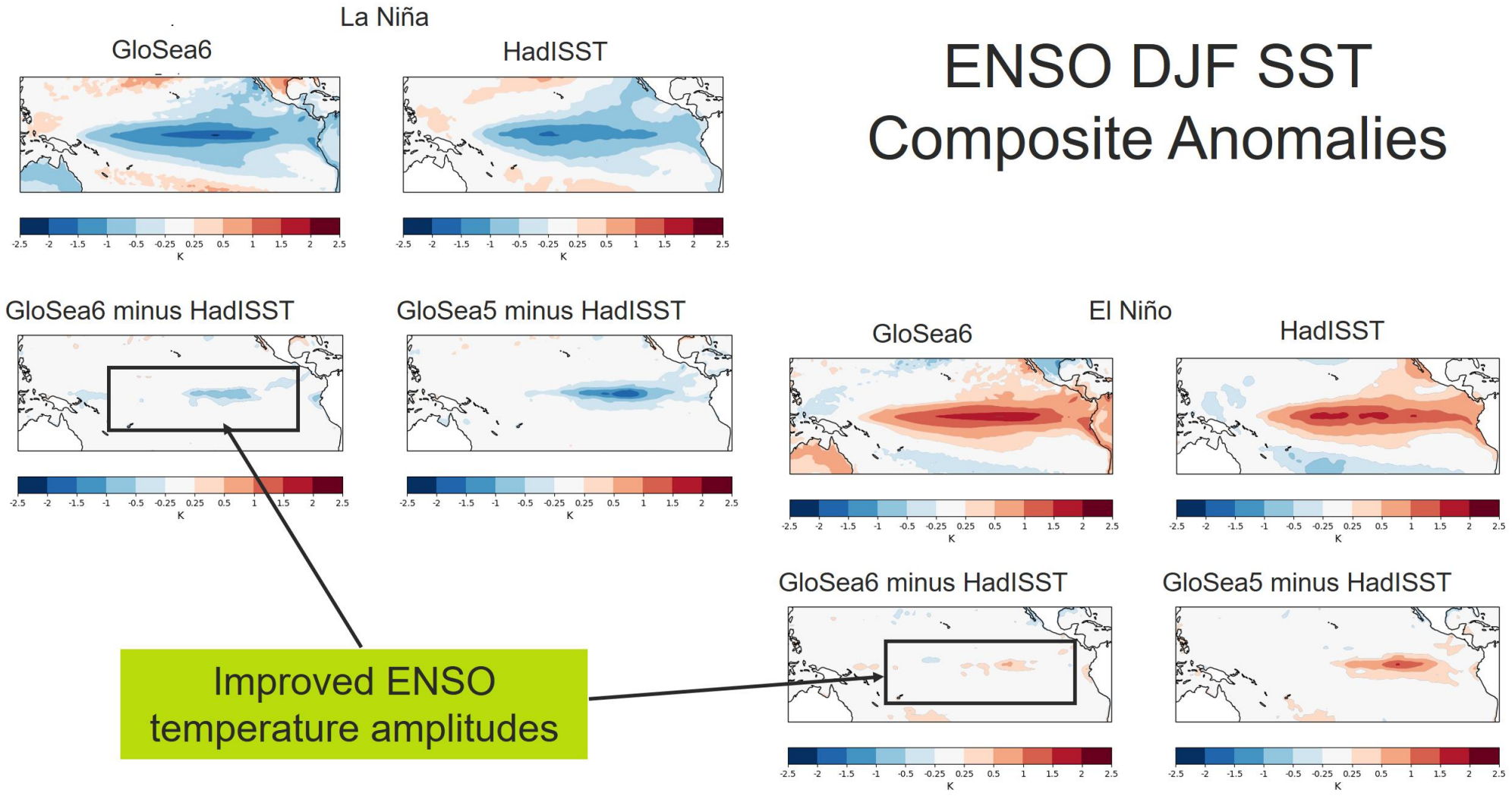
200hPa U (JJA)



200hPa U (DJF)

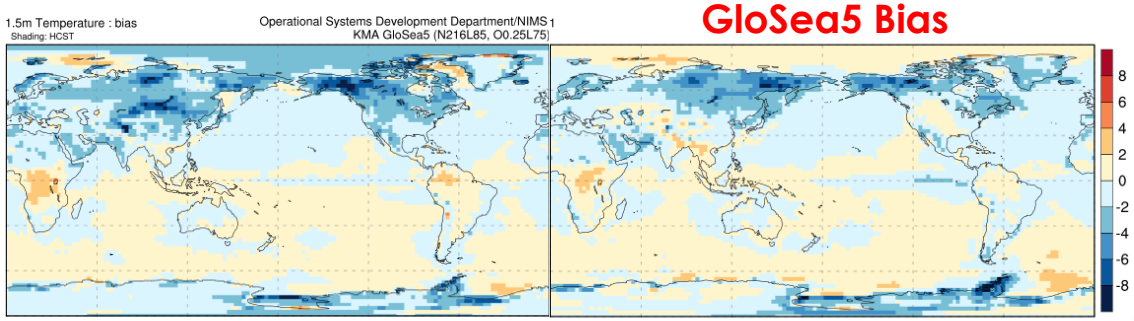


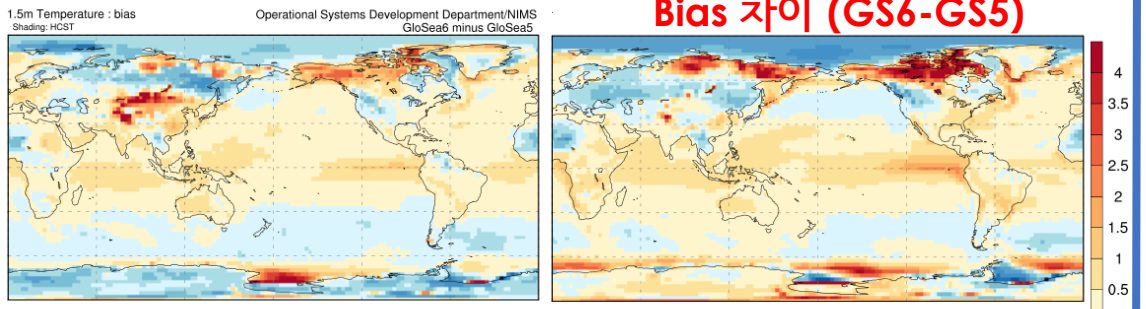
ENSO DJF SST Composite Anomalies

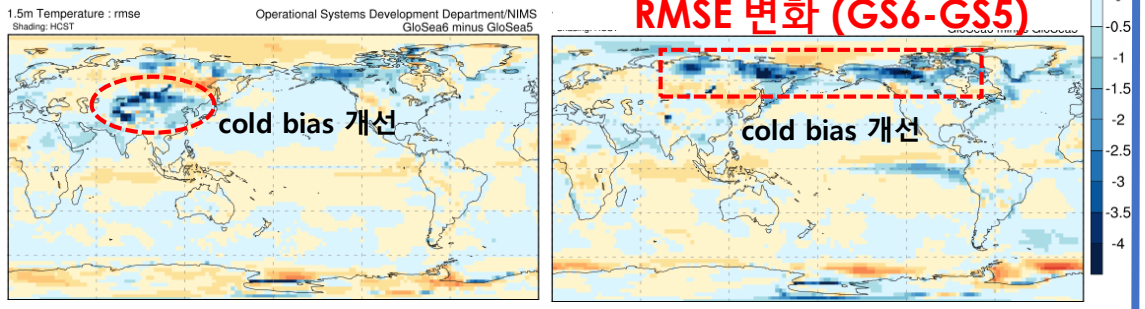


1개월 예측장(+01m) 오차

T15m







3개월 예측장(+03m) 오차

T15m

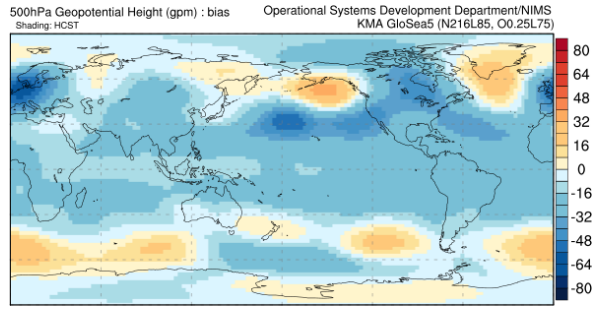
GloSea5 Bias

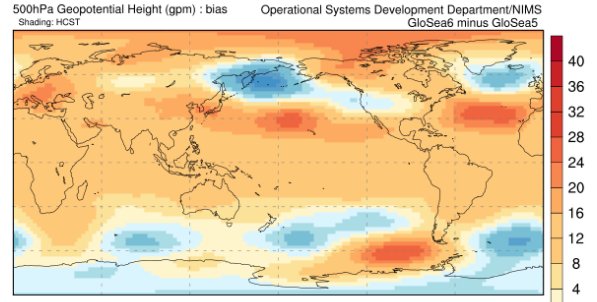
Bias 차이 (GS6-GS5)

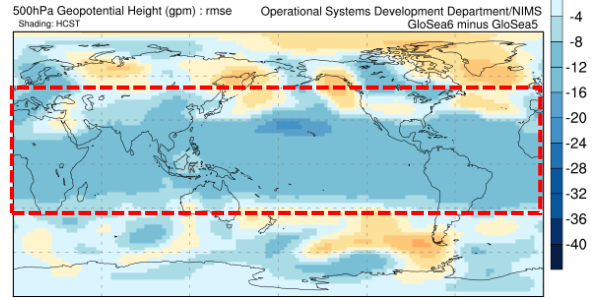
RMSE 변화 (GS6-GS5)

1개월 예측장(+01m) 오차

Z500



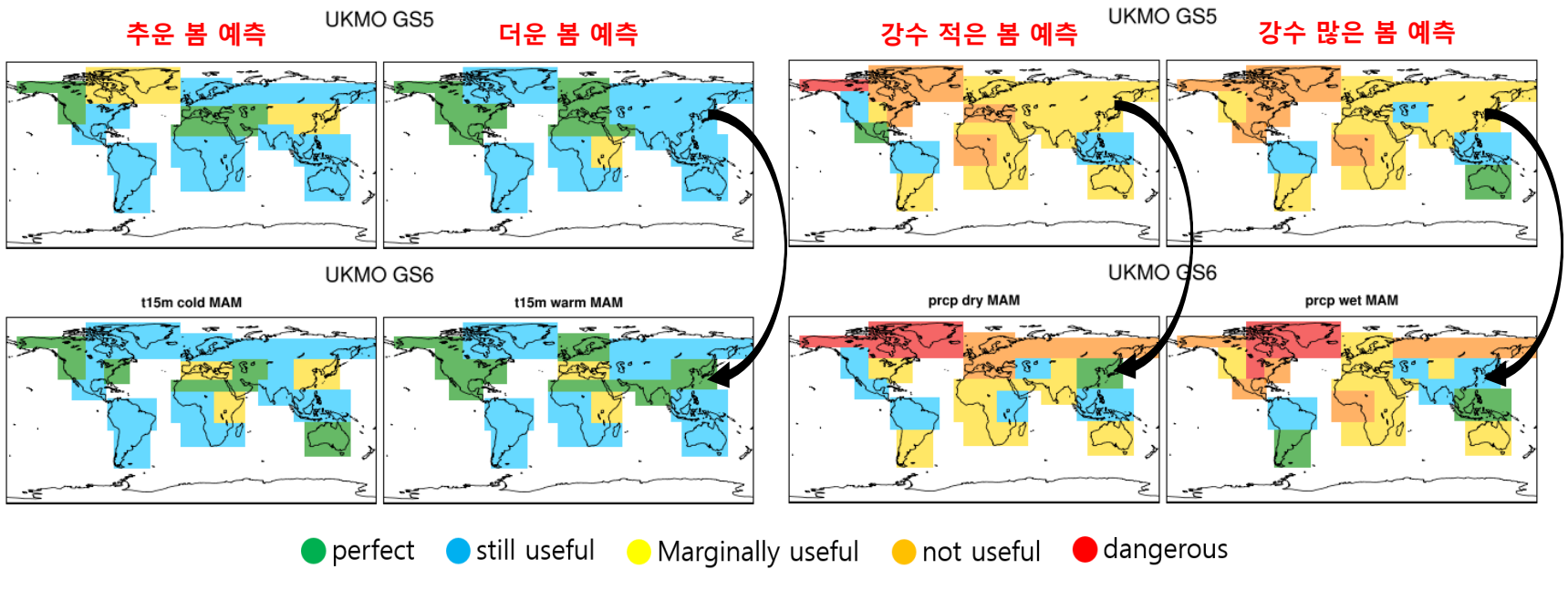




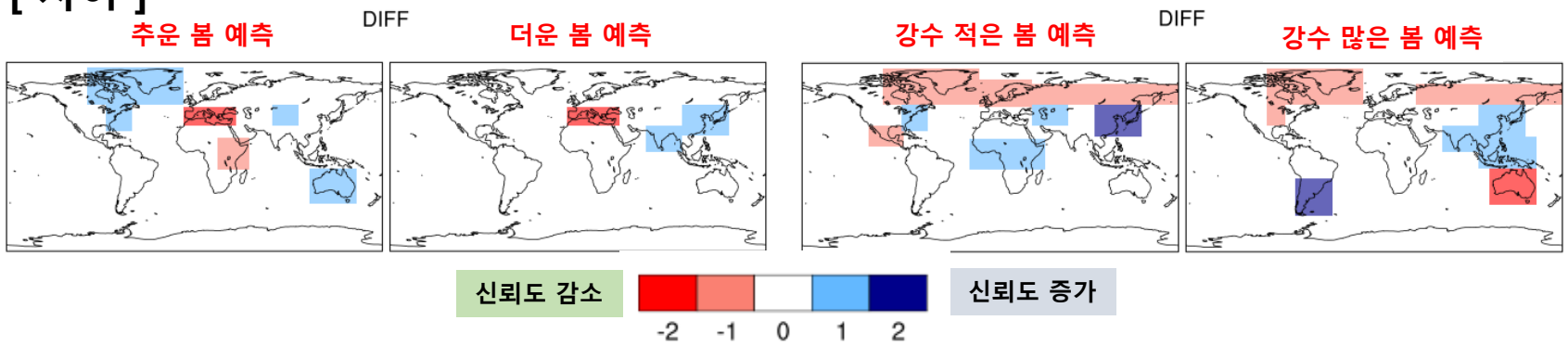
- 자료: 영국기상청 2월 hindcast
- HCST의 cold bias개선
- 오차 개선 원인: 지면적설(zero layer→multi-layer) 깊이 반영

- 전반적인 Z500 개선 * 3개월도 유사

GloSea5대비 **GloSea6 봄철 신뢰도 비교** (HCST 1993-2016)



[차이]



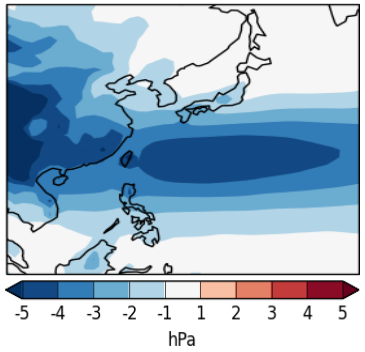
➢ **GS6의 동아시아 예측 신뢰도: 더운 봄, 강수 예측의 신뢰도 1-2단계 상승**

앙상블 확대 영향

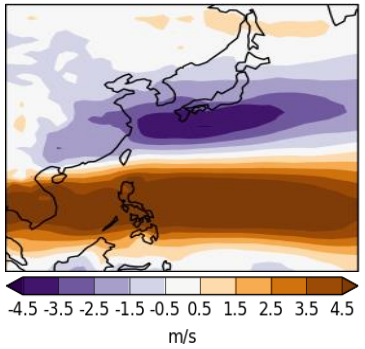
(Hindcast SKEB2: 3mem→ 7 mem / 1 month:144 → 336mem)

Bias (JJA)

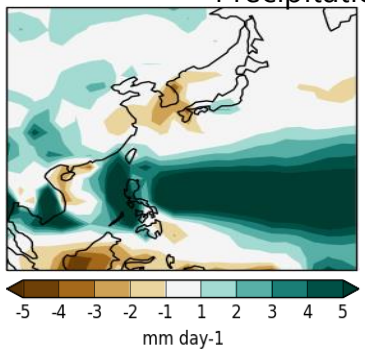
MSLP



850U

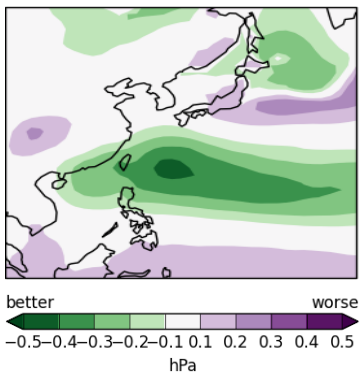


Precipitation

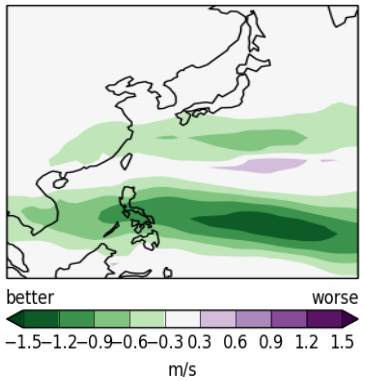


Difference of absolute bias (June) 7mem-3mem

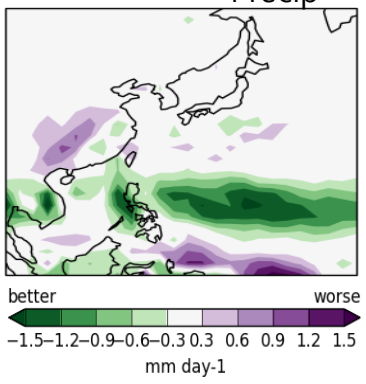
MSLP



850 U

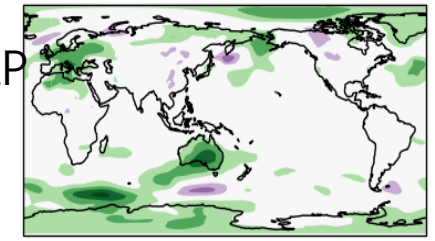


Precip

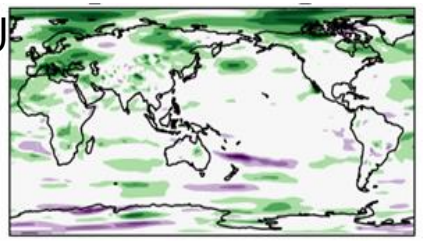


Correlation (JJA)

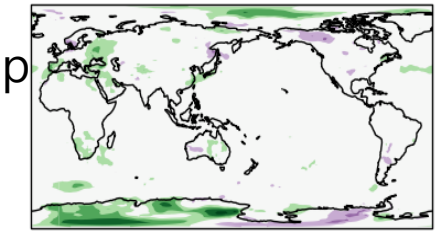
MSLP



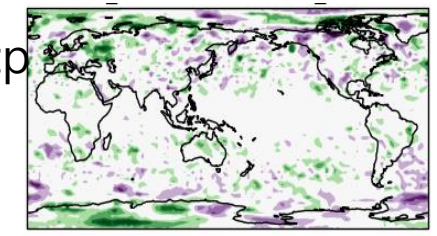
850U

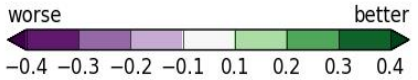


Temp



Precp

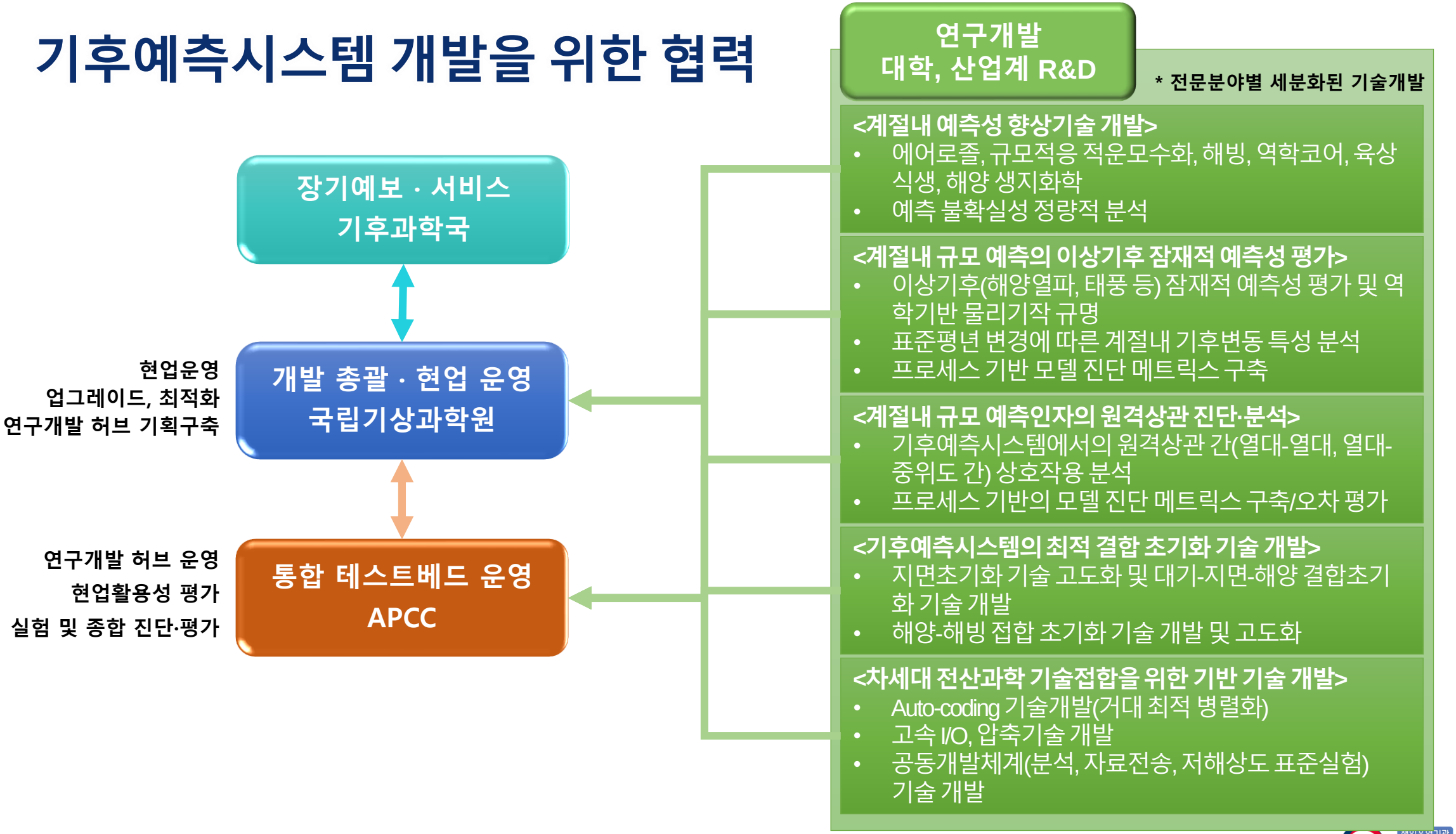




기후예측시스템 개발 계획

	2021	2022	2023	2024	2025	2026	2027	2028
기후예측시스템 및 운영기술	GloSea6 도입 및 현업화	하천유출개선 앙상블 확대 H:3 → 7, F:4 → 8			GloSea-GC5 도입 및 현업화			
모델링기술	고해상도 앙상블 생산체계 개발 N512O025, N216O12		고해상도 앙상블 자료 생산		규모적응 적운모수화 고해상도 하천유출(1º→0.25º)			
초기화기술	GODAPS2 현업화	지면초기화 확대(토양온도)	위성관측 지면 자료동화 해양재분석자료생산체계개발및개선	약결합 초기화		중결합 초기화		
공동개발 체계	공동개발 현업화 시험서버 구축	현업화 시험서버 운영		공동개발 체계 운영(과학원-APCC-학계 R2O 강화) 미래전산 대비 차기 운영체계(LFRic-proto) 도입				

기후예측시스템 개발을 위한 협력



감사합니다