

Introduction to **KIOST Ocean Climate Seasonal Prediction Modeling and Outlook Service**

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Contents

Ocean Climate Solutions Research Division, KIOST

Operational Seasonal Prediction Modeling Systems

- KOSMOS
- KOSM
- HIPO

Operational Seasonal Prediction Examples

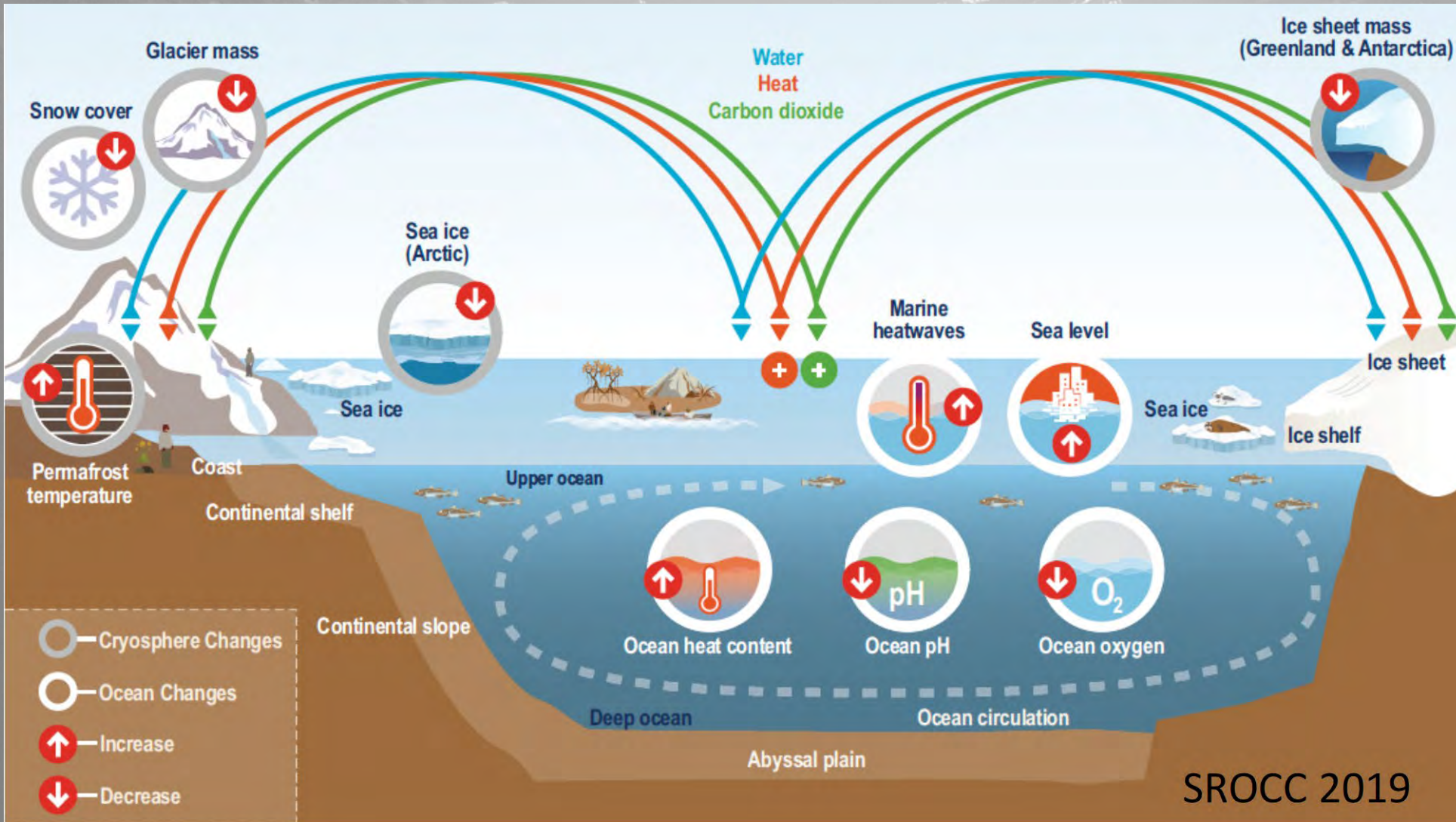
- Monthly Ocean Climate Reviews & Previews – Satellites & CFSv2
- SST Prediction
- ADT Prediction
- Pacific Tropical Cyclones Activities Previews

Further applications under development

- KOSM based NWPacific Ocean state prediction
- KOSM based Indian Ocean SCTR variability & prediction

Summary

Oceans are at risk ...



SROCC 2019

More frequent & severe Extreme Events

Ocean Climate Disaster

- ✓ Coastal erosion & floodings
- ✓ Marine ecosystem disturbances
- ✓ Food crisis

Risks for all mankind

Ocean Climate Solutions Research Division

*Exploring Ocean Science based Climate Change Solutions
for Sustainable Ocean Climate*

(the mean state and trends of marine environments and ecosystems)

Ocean Circulation & Climate Res. Dep.

- Monitoring and assessment of ocean circulation & climate change
- Ocean and Earth system modelling

Ocean Climate Response & Marine Ecosystem Res. Dep.

- Ecosystem change, impacts and adaptations
- Carbon Dioxide Reduction as climate change response
- Marine geology and geotectonics

R2O&S

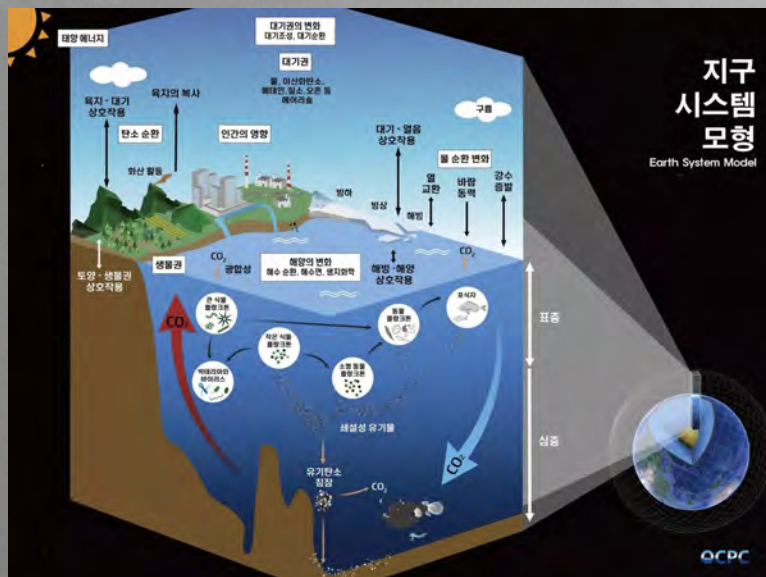
Ocean Climate Prediction Center

- Development & Operation of climate prediction system
- Monthly review and seasonal/climate outlook information service
- Development & Dissemination of science communication contents

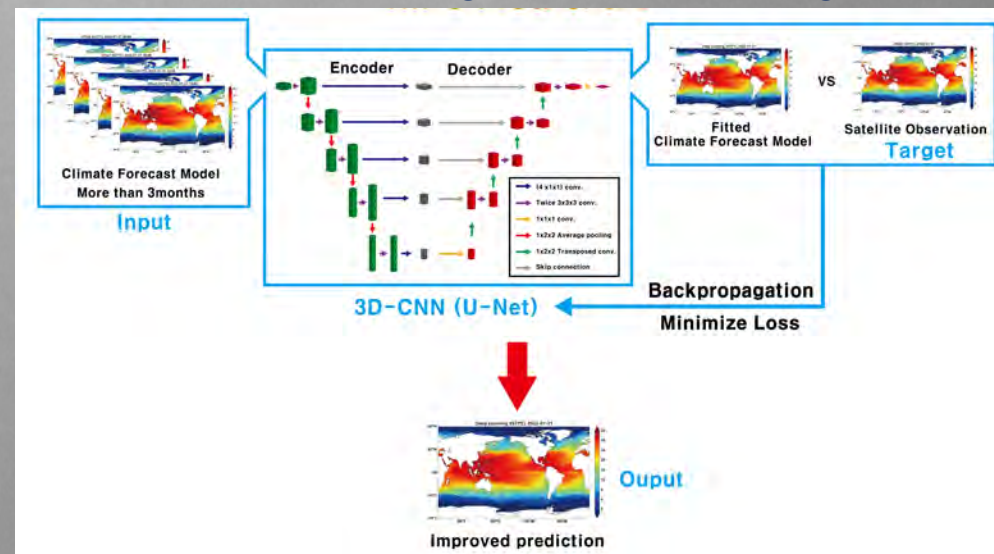
Operational Modeling Systems

- KOSMOS: based on KIOST Earth System Model
- KOSM: Ocean System Model part of KOSMOS but higher resolution
- HIPO: Hybrid (NOAA/CFSv2 + Machine Learning) prediction tool

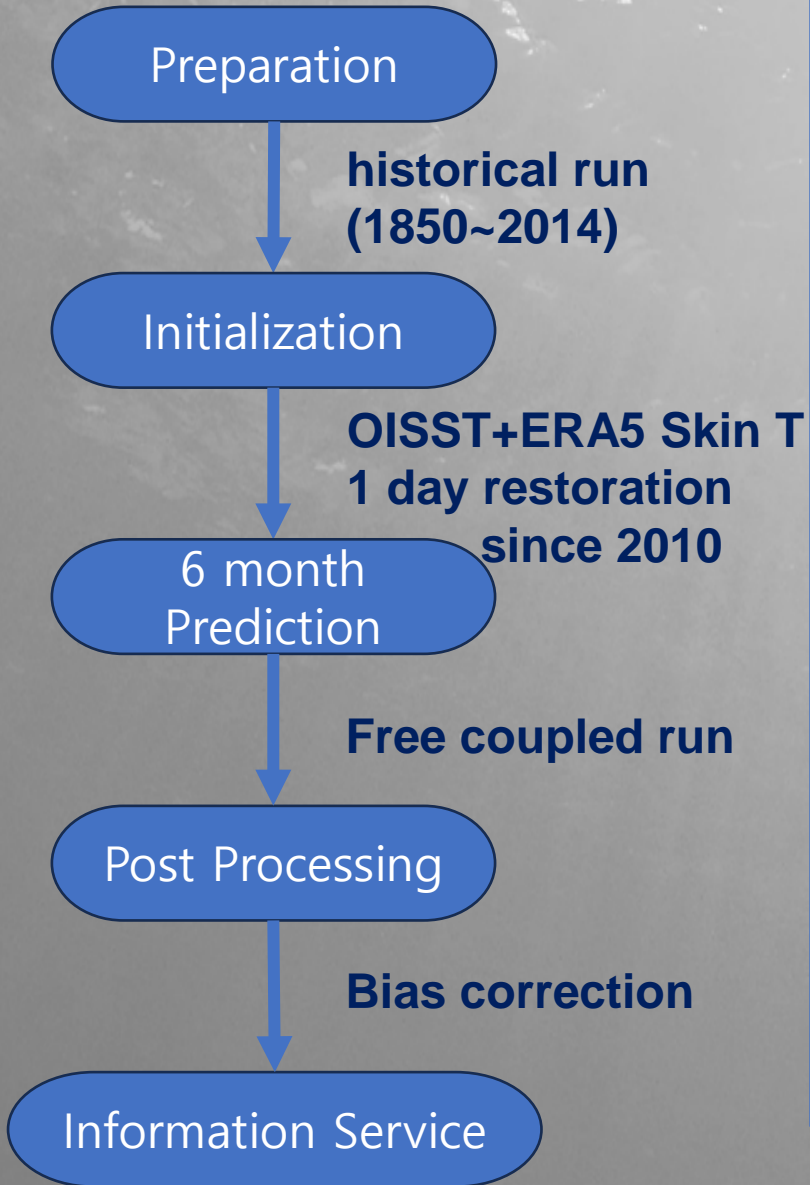
Earth System Model



Machine Learning / Artificial Intelligence



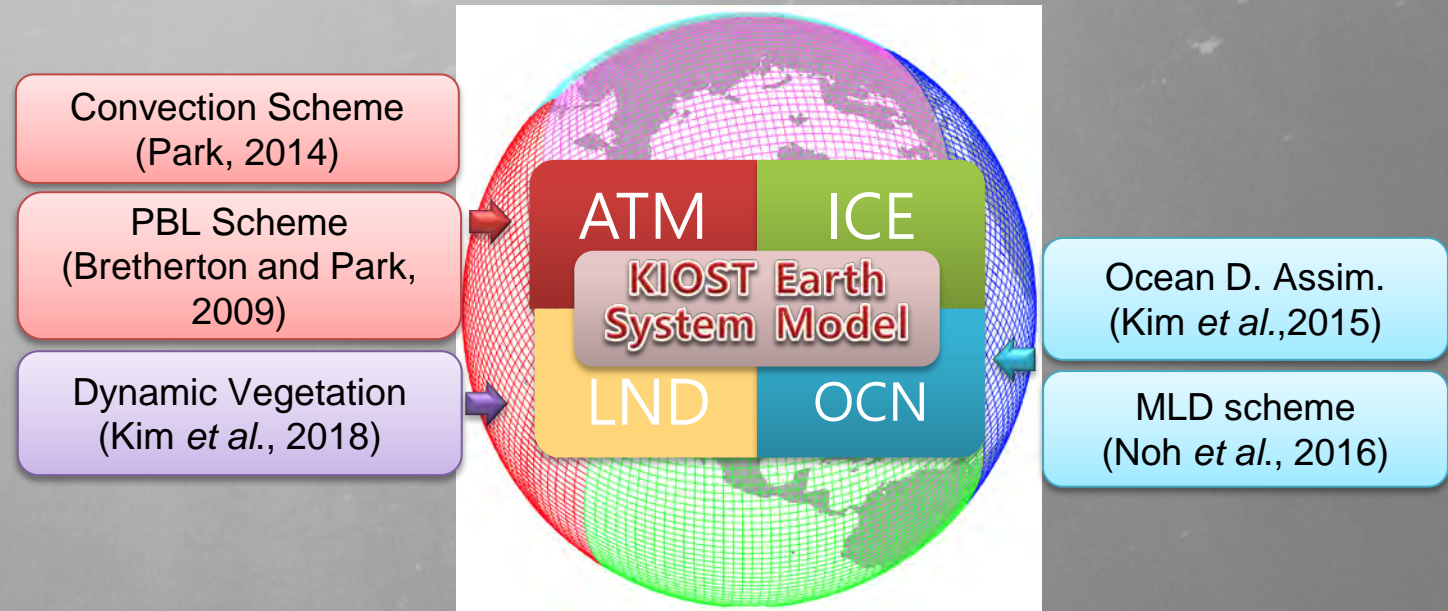
KOSMOS, a KIOST-ESM based Seasonal Prediction System



Framework adopted from GFDL CM2.5



Applying new physics
Some of them have been newly developed



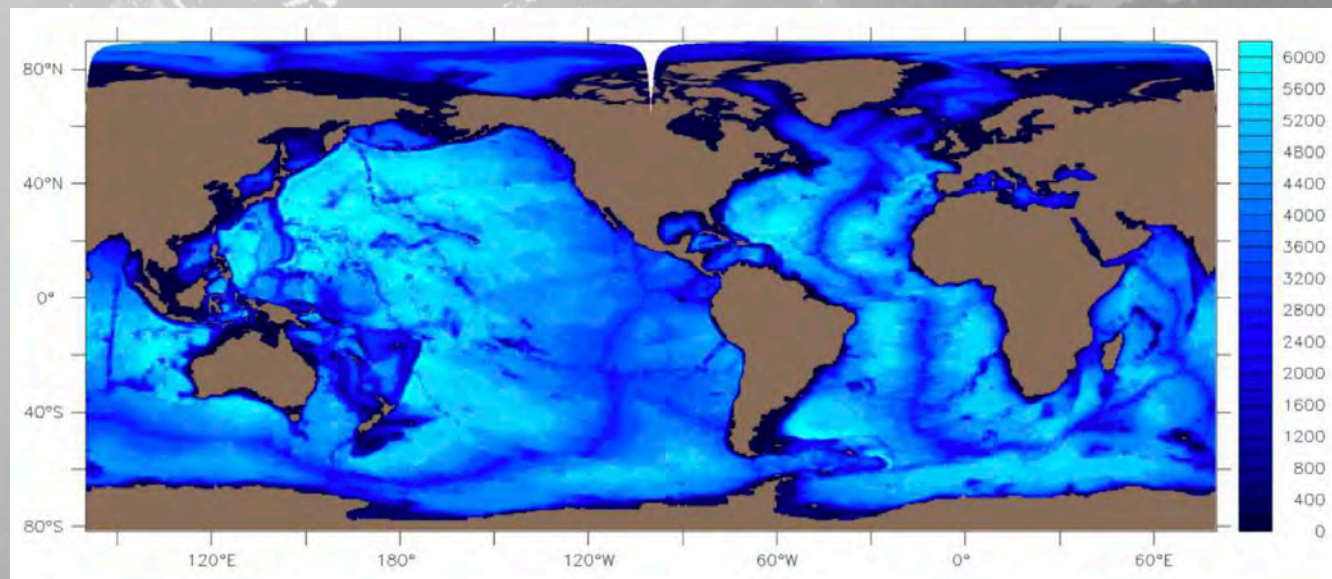
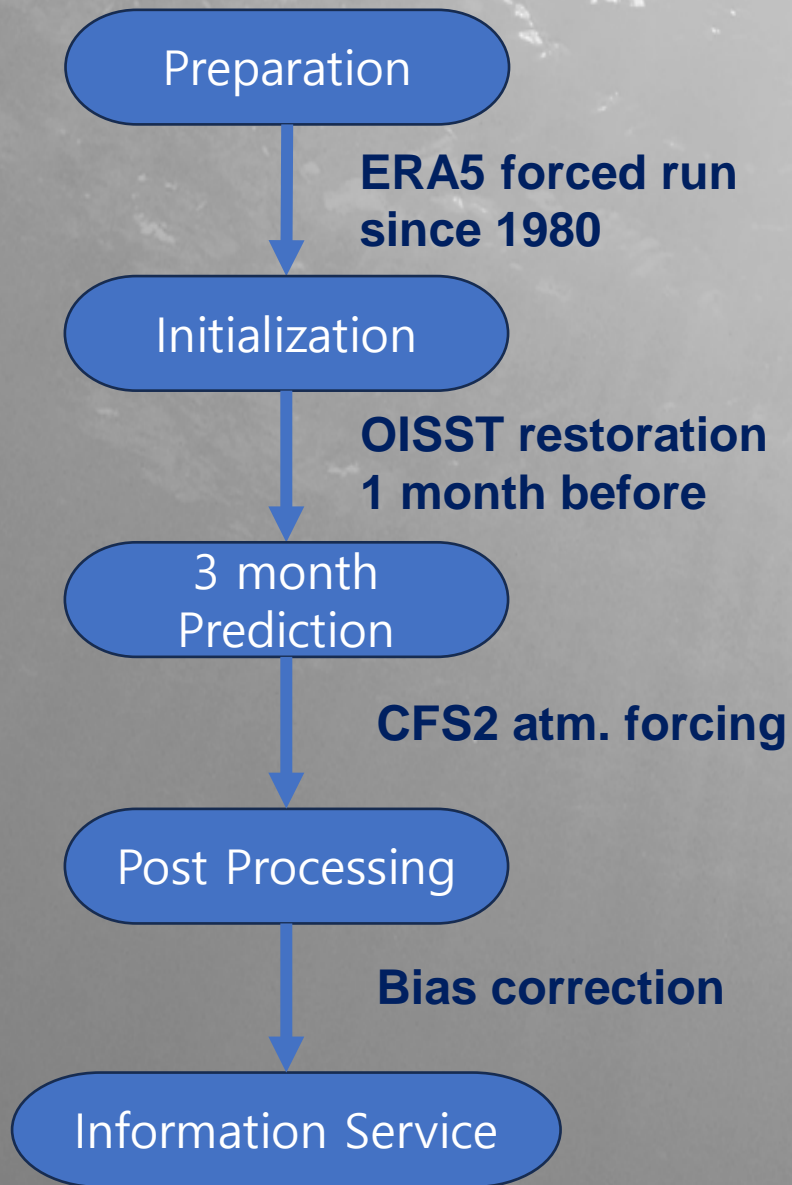
Pak et al., 2020



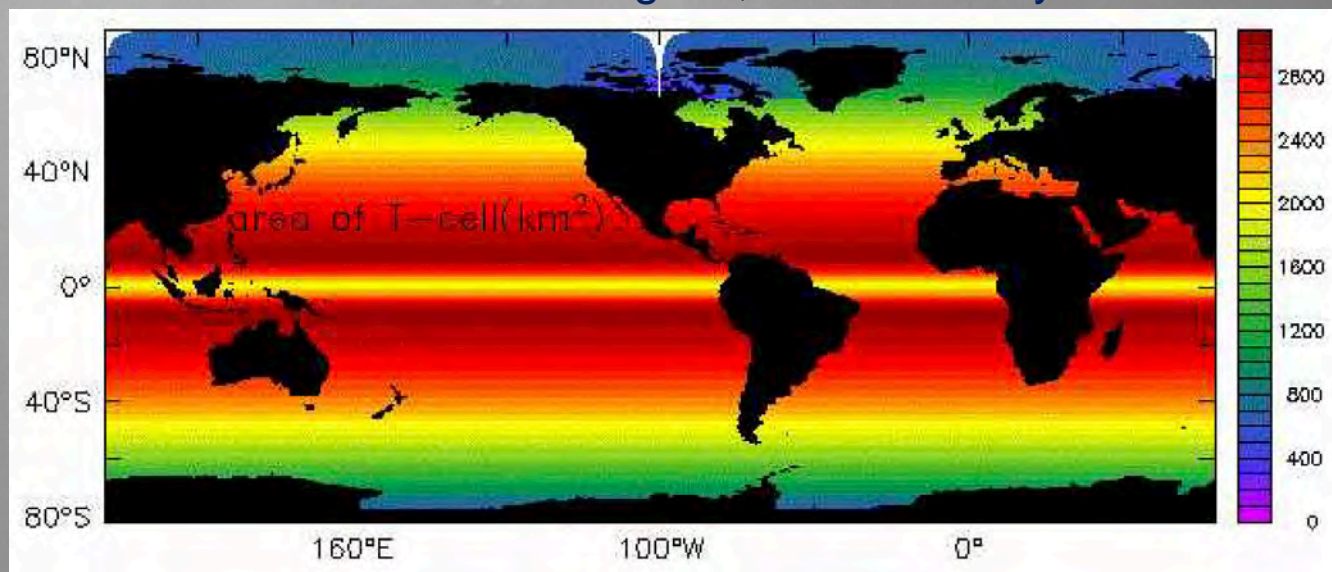
UNIST



KOSM, based on MOM5+GIS+TOPAZ2



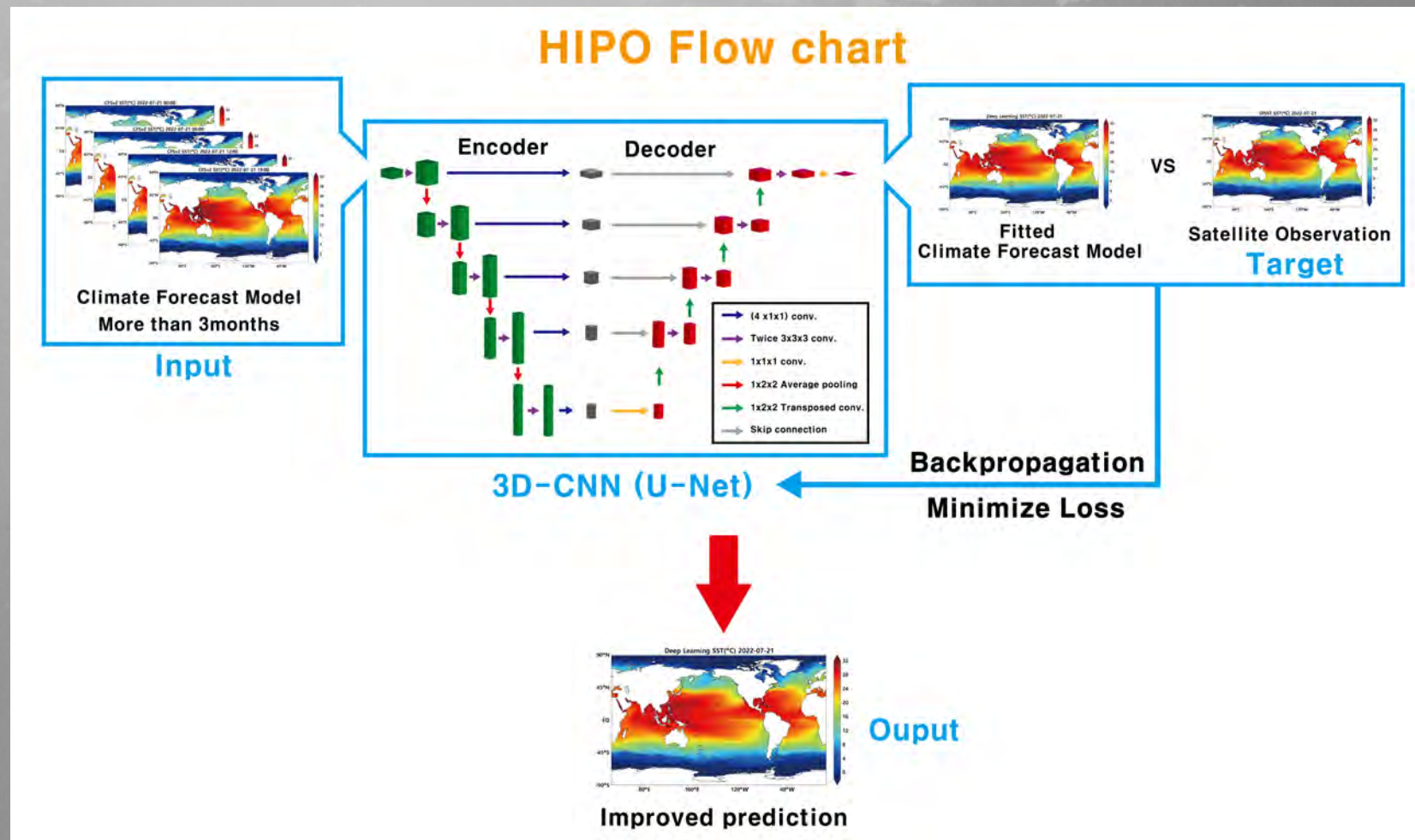
0.3° ~ 0.5° horizontal grids, 52 vertical layers



HIPO : (AI filter for CFSv2)

Hybrid Intelligence seasonal Prediction system for Ocean climate

- 3D-CNN based U-shaped structure
- Extract increasingly abstract and high-level features through encoder path
- The decoder is to up-sample the feature maps and learn to reconstruct the segmented output
- To minimize the difference between seasonal forecast model output and Satellite Observation

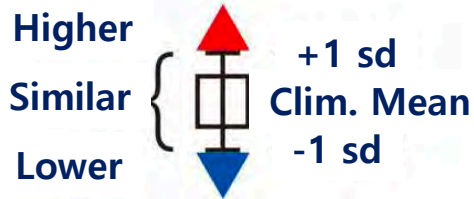


Operational Prediction Examples

- Ocean Climate Monthly Review & Preview
- SST Prediction based on KOSMOS
- ADT Prediction based on HIPO
- NWPacific Tropical Cyclone Activity Prediction

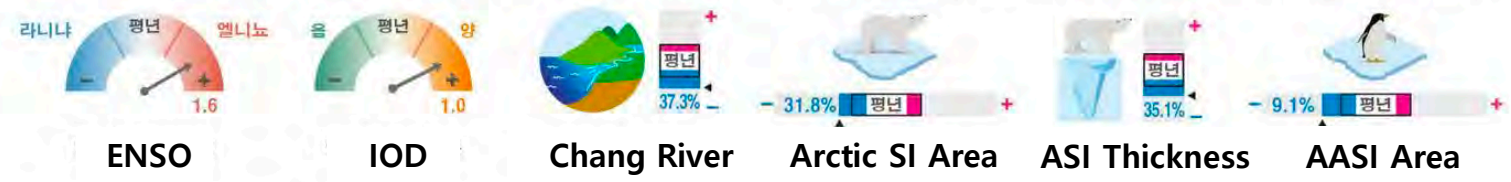
Monthly Ocean Climate Review

September 2023
 Ocean Climate
 Monthly Review
 Oct. 16, 2023



과거 30년 자료의 월 평균값에서 표준 편차를 더한 값(상한)과 뺀 값(하한)을 평년구간으로 설정하고, 각 해역별 당월 평균값을 평년구간과 비교하여 평년과 비슷함(☐), 평년보다 높음/많음(▲), 평년보다 낮음/적음(▼)으로 표시함

Var/Reg	Global	EAS	ES	YS	ECS
ADT (cm)	+7.0 ▲	+7.9 ▲	+10.1 ▲	+9.8 ▲	+8.9 ▲
SST (°C)	+0.6 ▲	+1.2 ▲	+2.3 ▲	+1.6 ▲	+1.1 ▲
T2m (°C)	+0.8 ▲	+1.6 ▲	+2.6 ▲	+1.7 ▲	+1.6 ▲
Precipitation (%)	+5.1 ▲	☐	☐	☐	-42.2 ▼
SLP (hPa)	☐	☐	☐	☐	☐
WS10 (m/s)	☐	☐	☐	☐	☐
SWH(m)	+0.1 ▲	-0.3 ▼	-0.2 ▼	-0.2 ▼	-0.4 ▼
M. Wave Period (s)	☐	☐	-0.5 ▼	☐	☐



Monthly Ocean Climate Preview

DJF 2023~2024

Ocean Climate
Monthly Preview

Oct. 31, 2023

KIOST AMOP
OCPC 해양기후예측센터
OCEAN CLIMATE PREDICTION CENTER



과거 30년 자료의 월 평균값에서 표준 편차를 더한 값 (상한)과 뺀 값 (하한)을 평년구간으로 설정하고, 각 해역별 3개월 예측 평균값을 평년구간과 비교하여 평년과 비슷함 (☐), 평년보다 높음/많음 (▲), 평년보다 낮음/적음 (▼)으로 표시함

Var/Reg	Global	EAS	ES	YS	ECS
ADT	▲	▲	☐	☐	☐
SST	▲	▲	▲	▲	▲
T2m	▲	▲	▲	▲	▲
Precipitation	☐	☐	☐	☐	☐
SLP	☐	☐	☐	☐	☐
WS10m	☐	☐	☐	☐	▼
SWH	☐	☐	☐	☐	☐
M. Wave Period	☐	☐	☐	☐	☐



ENSO



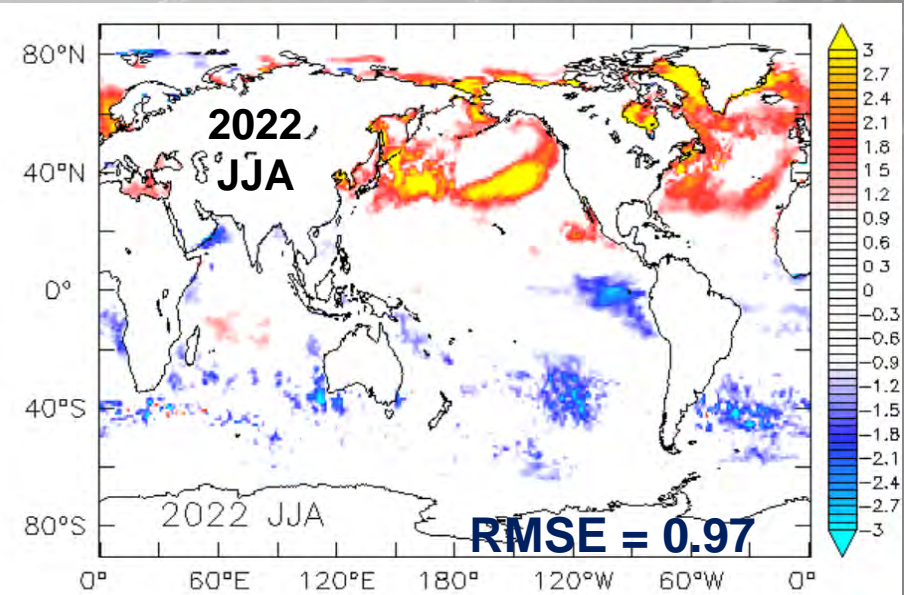
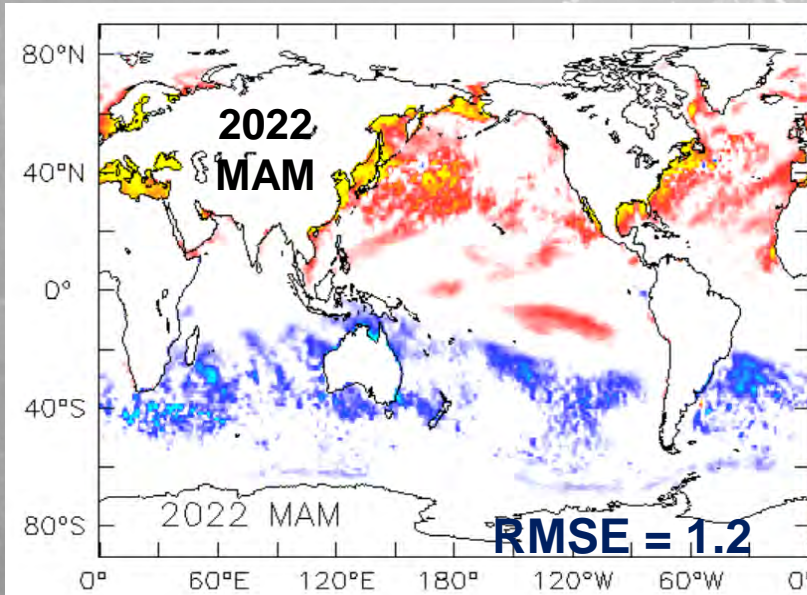
IOD



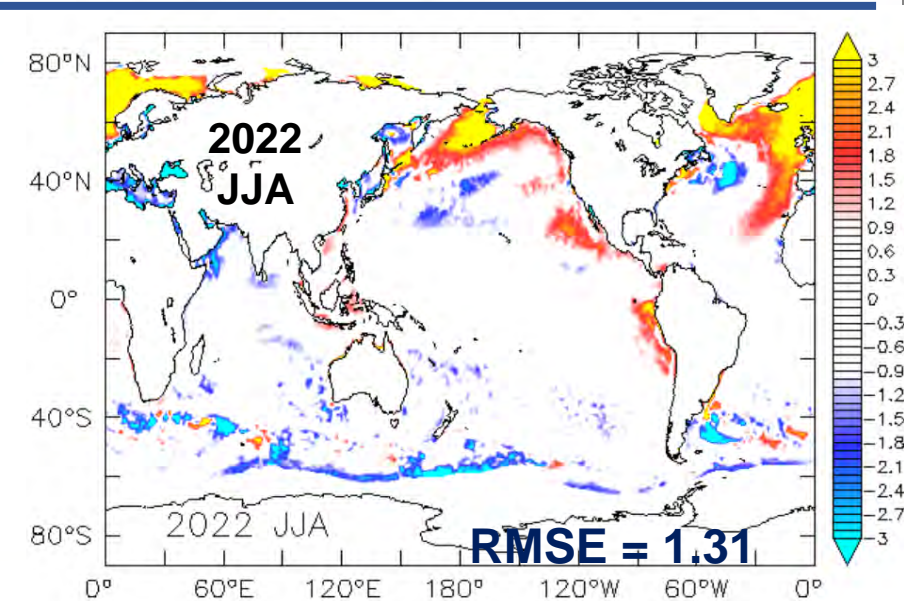
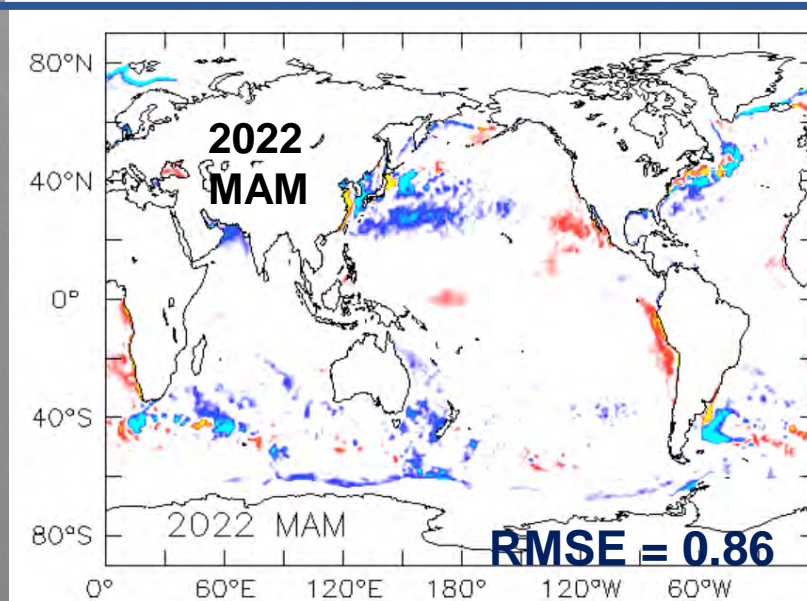
Arctic SI Area

SST prediction RMSEs, MAM/JJA

KOSMOS

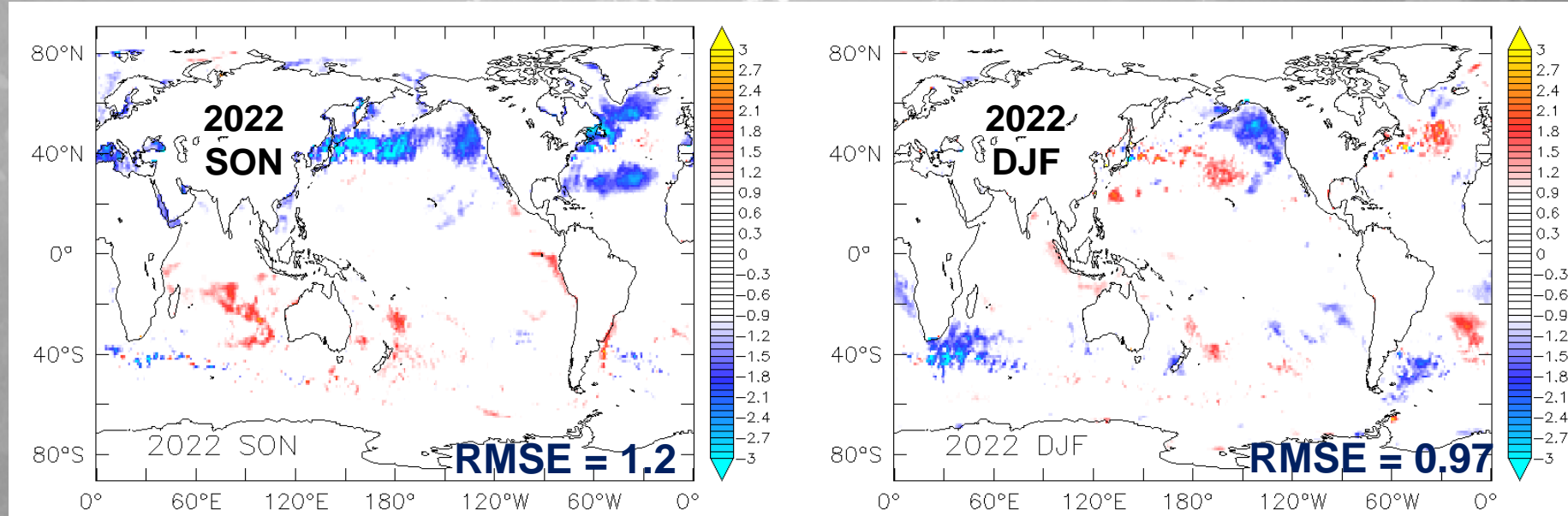


CFS2+

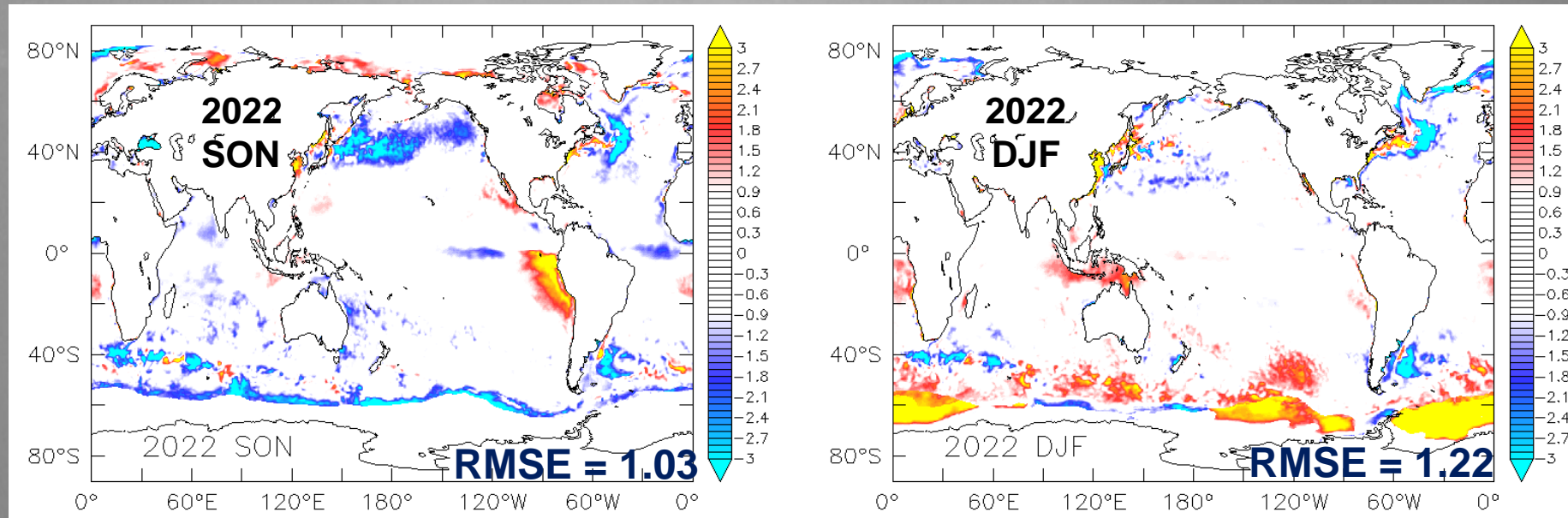


SST prediction RMSEs, SON/DJF

KOSMOS

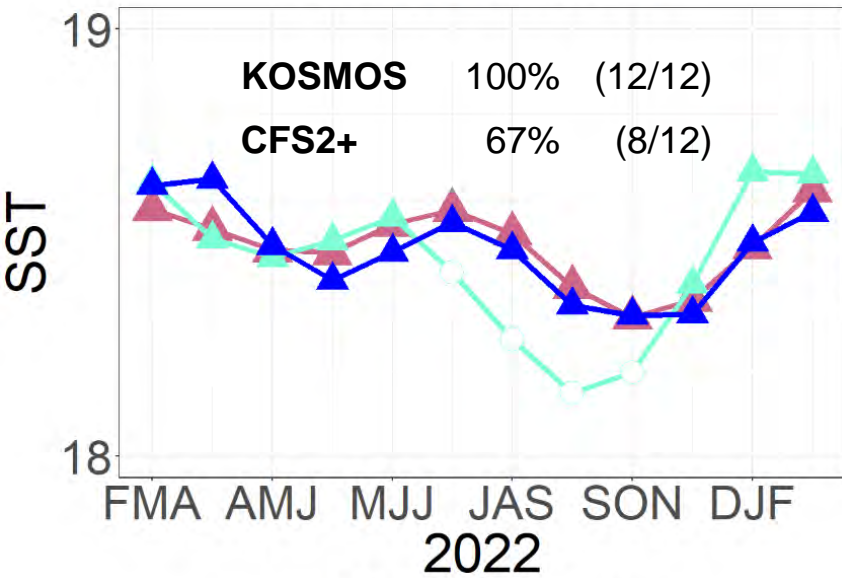


CFS2+

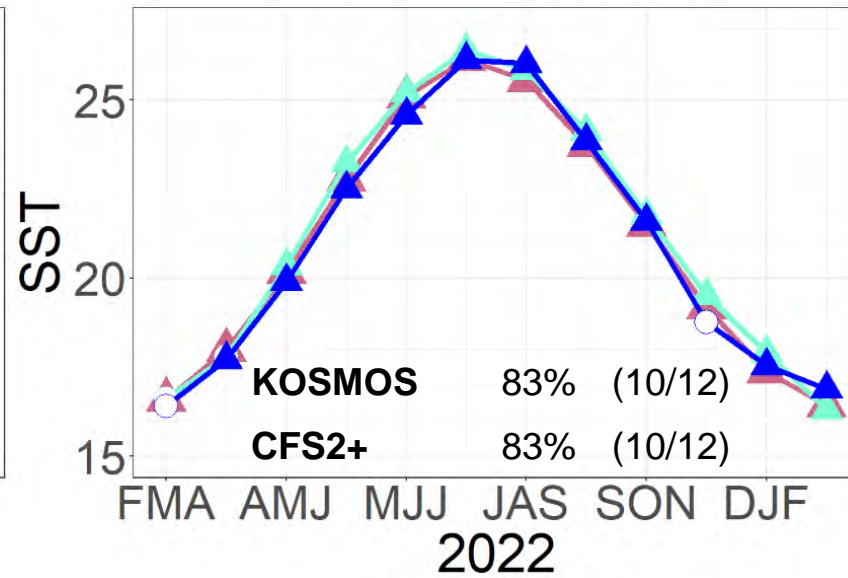


Regional & Seasonal SST prediction skills

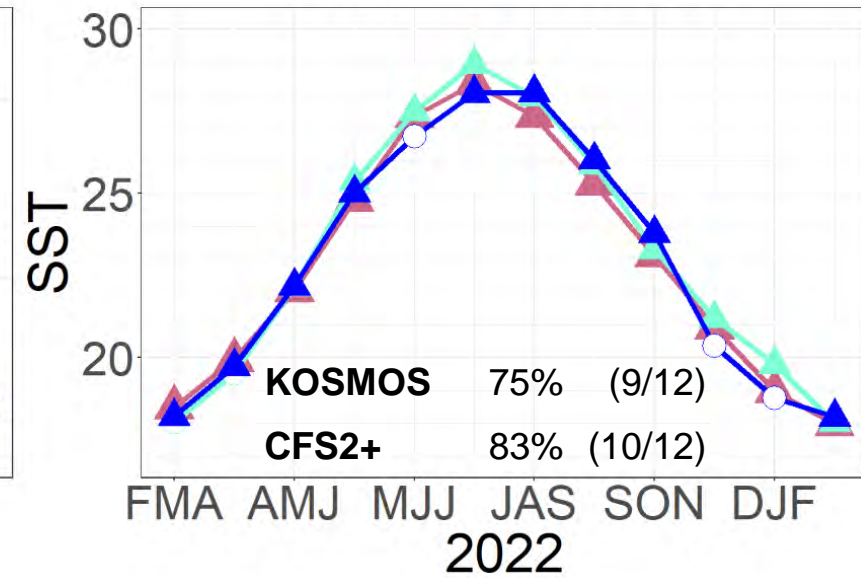
Global Ocean



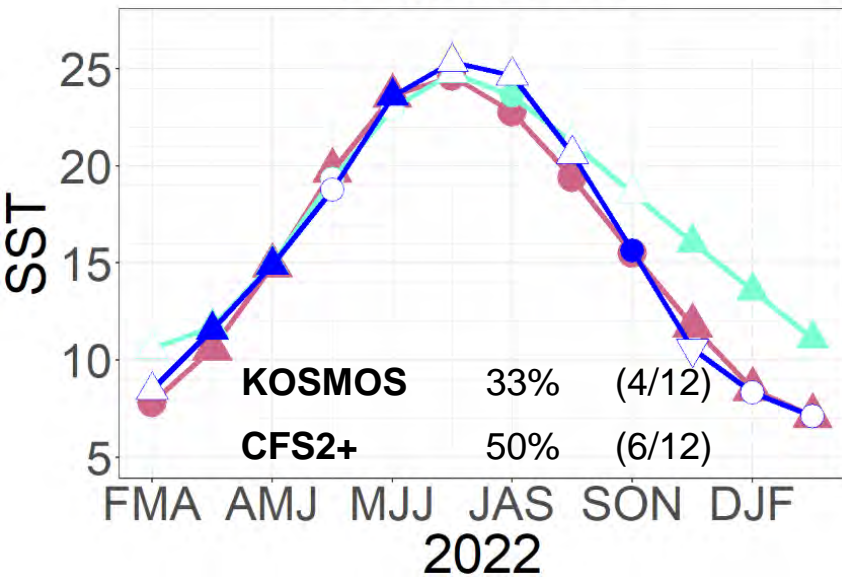
East Asian Seas



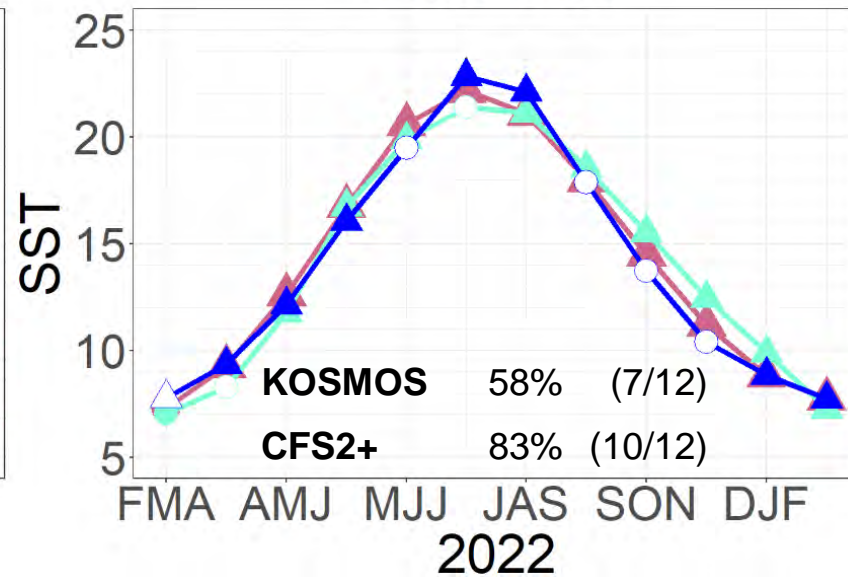
East China Sea



Yellow Sea



East Sea

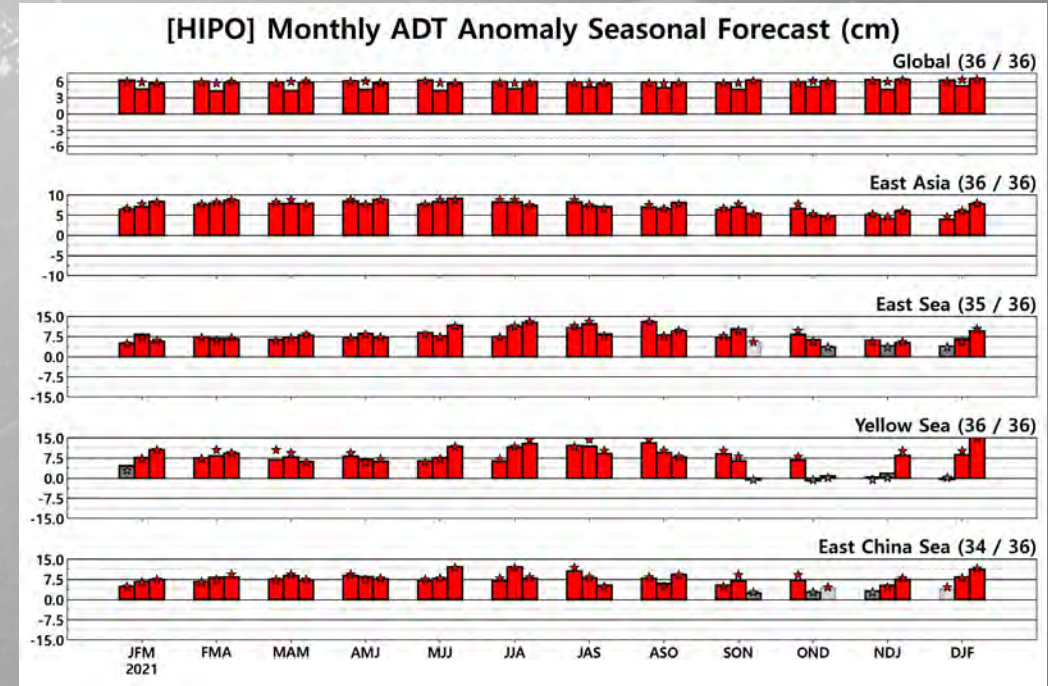


OISST —
CFS2+ —
KOSMOS —

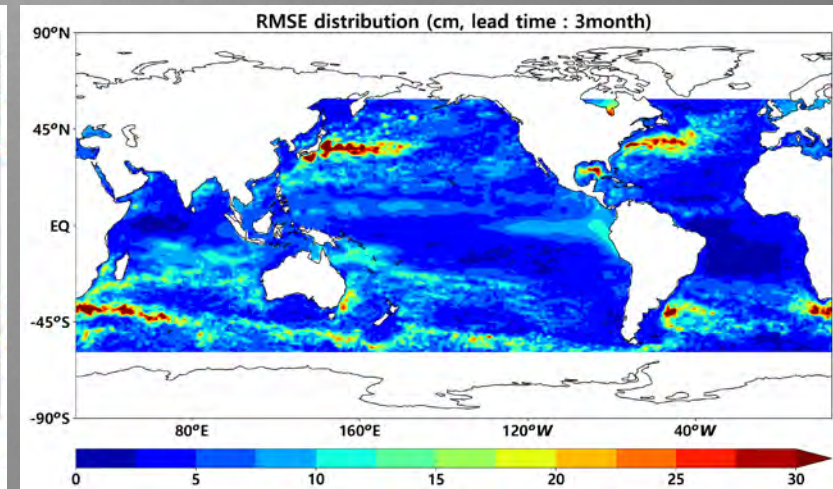
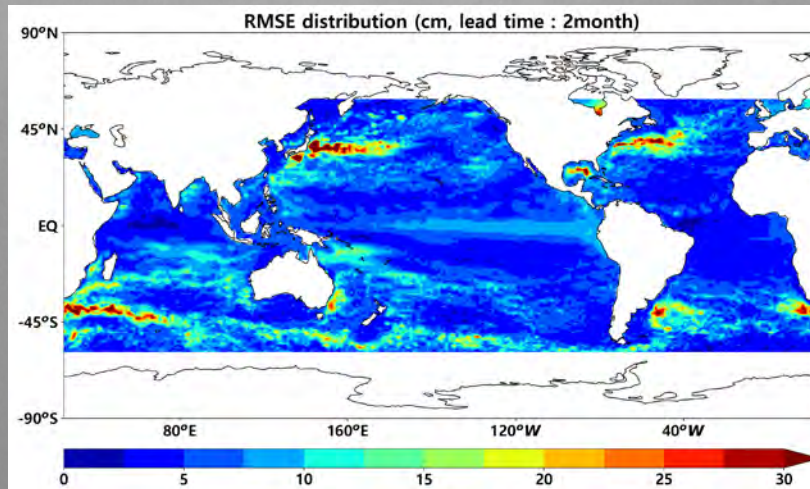
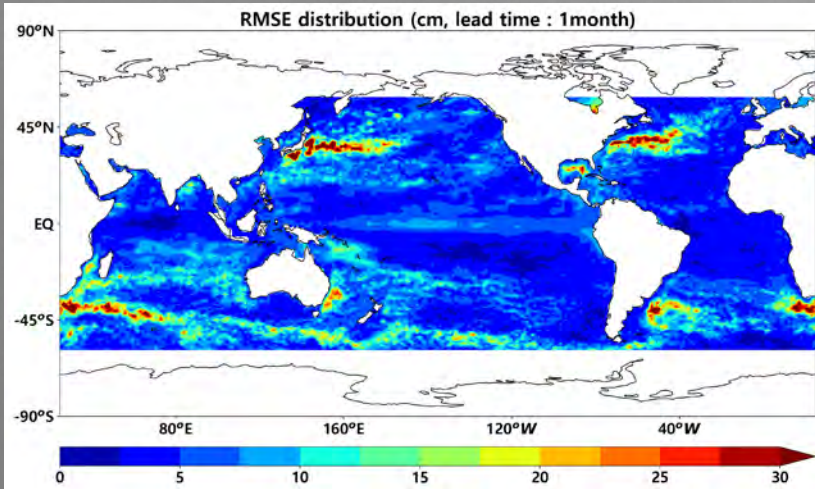
State	higher	similar	lower
hit	▲	●	▼
miss	△	○	▽

ADT prediction by HIPO – training period

- Input data : CFSv2 (6hourly, 1°) ADT, SST
- Label data : CMEMS (daily, 1/4°) ADT
- Learning period : 2011.04 ~ 2022.06 with each lead time including 1,2,3 months
- Output resolution : Global 1° & East Asian Sea 1/4°, daily

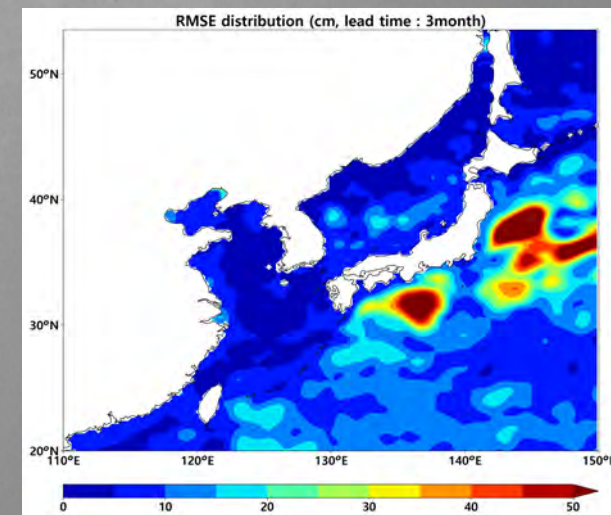
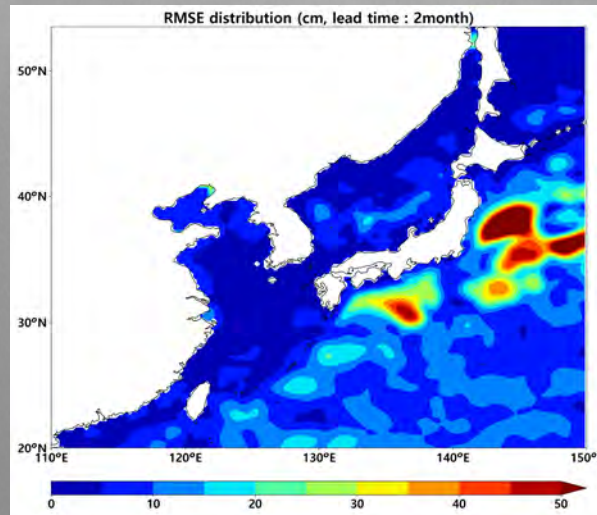
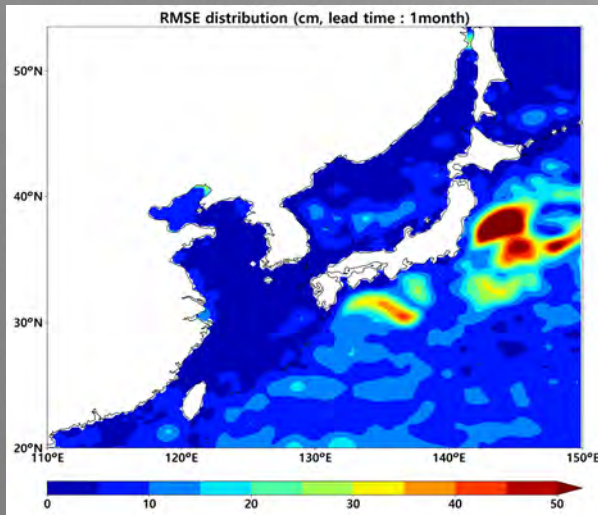
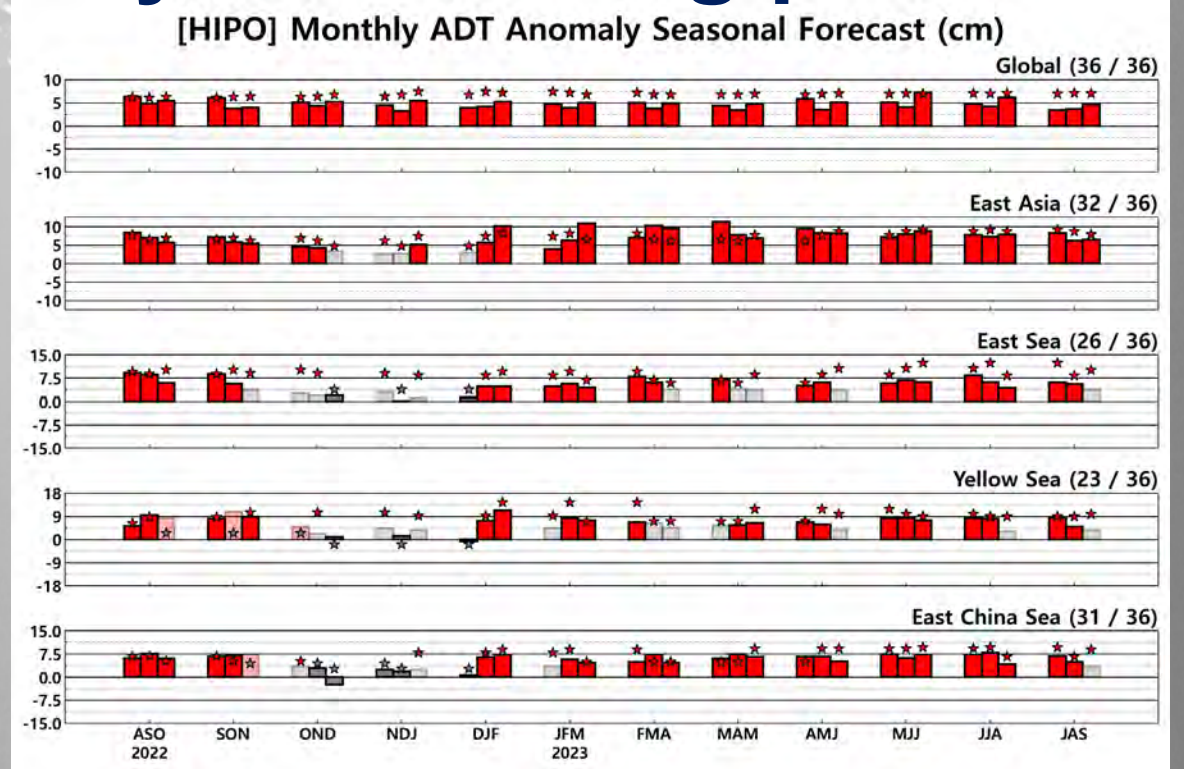


High RMSE in high speed currents (WBCs and ACC)



ADT prediction by HIPO – beyond training period

- Relatively lower predictability beyond training period
- Relatively higher RMSE – generally underestimate!



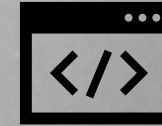
NWP Tropical Cyclone Activity Seasonal Outlook



Statistical model prediction

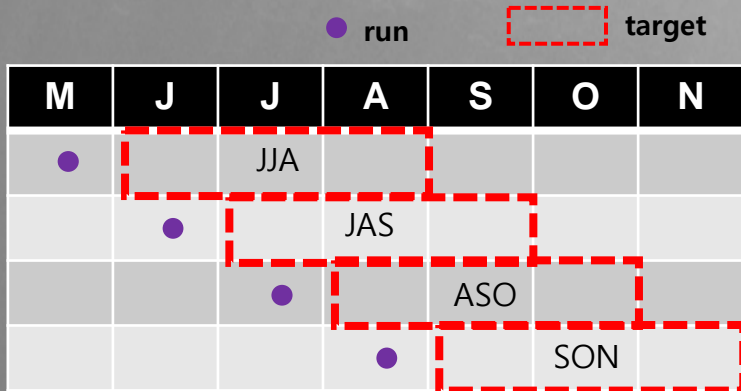


ENSO phase-based analogy approach



CFS forecast-based analysis

Four forecasts a year



Final decision

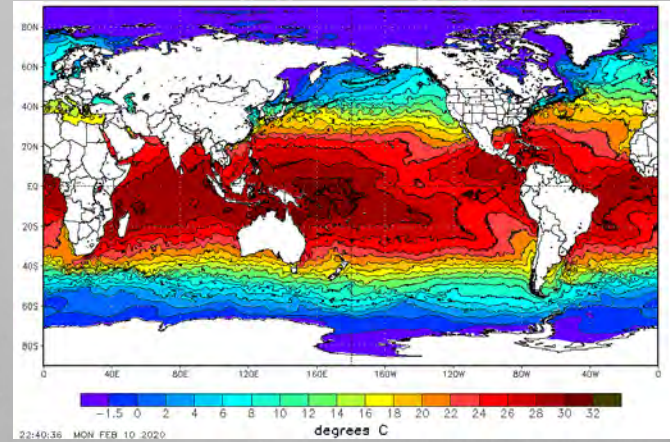
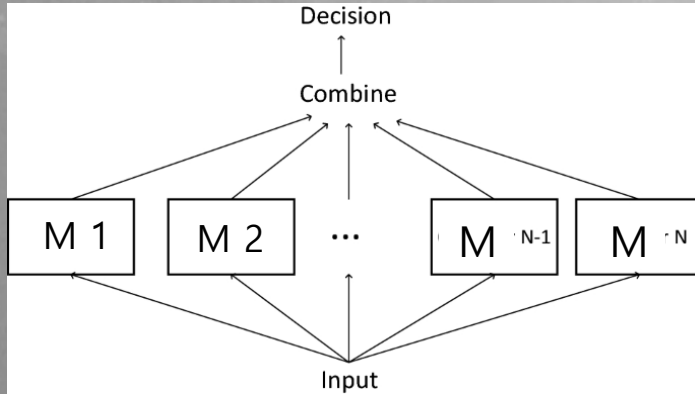
Example)

“For the months x1 to x3 in 2022, **the number of typhoons** is expected to be similar to the average (14.2).

The location of typhoon occurrences is anticipated to be slightly more to the northwest than usual, and **the track** is expected to have a tendency to move northwestward.”

Statistical model - genesis frequency forecast

Multi-linear regression model-based Ensemble forecast



“Selecting grid points with high predictability for each predictor”

Input data

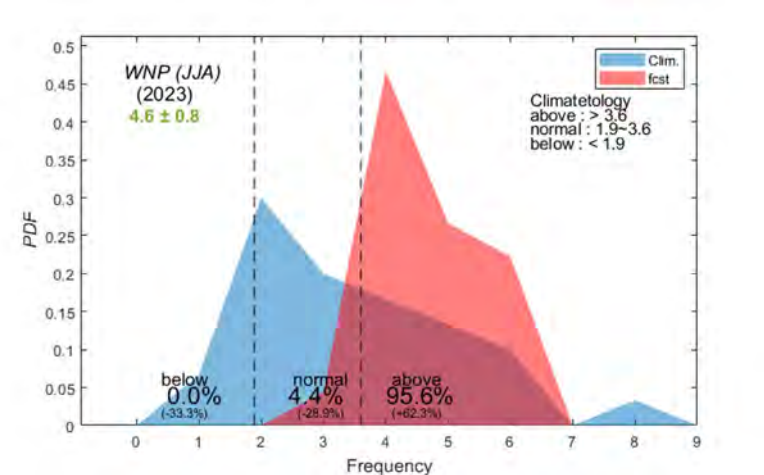
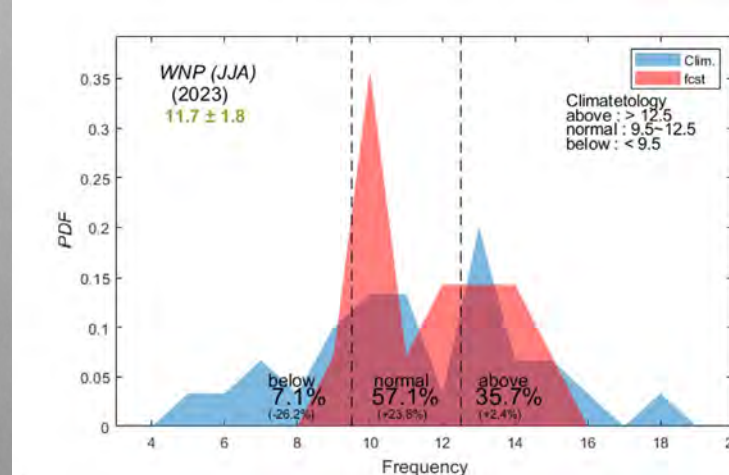
- NCEP Reanalysis 2
- NOAA RE SST V5
- JTWC best track

Predictands

- Frequency of above tropical storm (> 34kt)
- Frequency of major tropical cyclone (above cat3)

Predictor pool

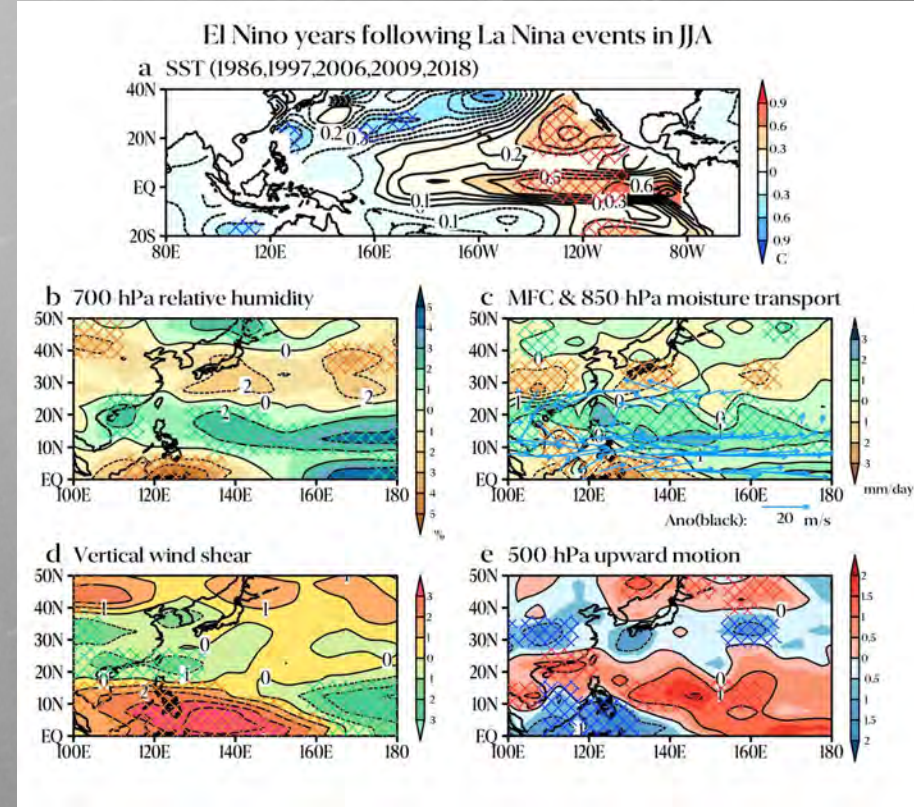
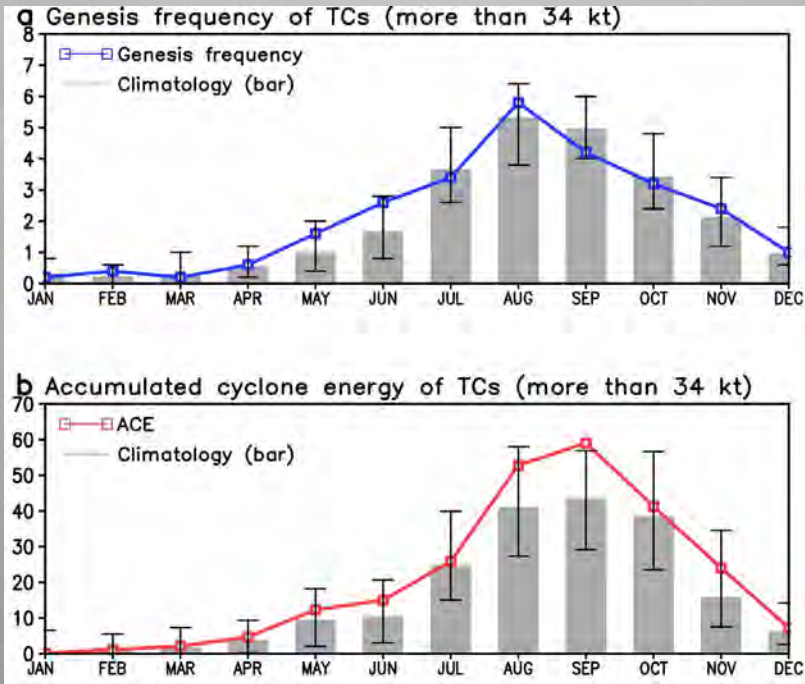
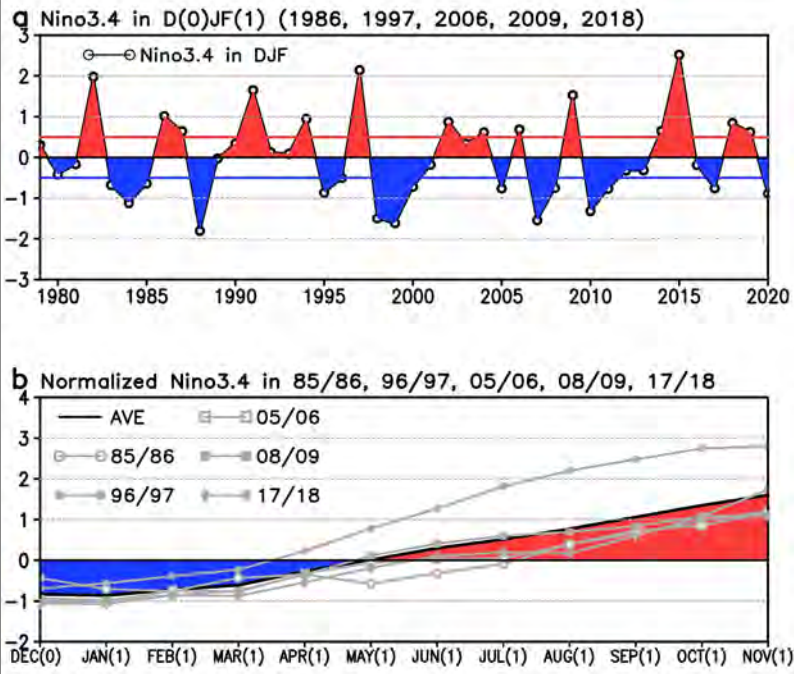
Predictor	Description
MSLP	Mean sea-level pressure
SST	Sea surface temperature
W850	Vertical velocity at 850 hPa
U200	Zonal wind at 200 hPa
HGT500	Geo-potential height at 500 hPa
SH200	200 hPa to 850 hPa vertical wind shear
SH500	500 hPa to 850 hPa vertical wind shear
RHLO	Relative humidity 850~700 hPa



Predicting the probability density function of typhoon genesis frequency

ENSO phase-based analogy test

Analogy analysis based on the phase change scenarios of ENSO



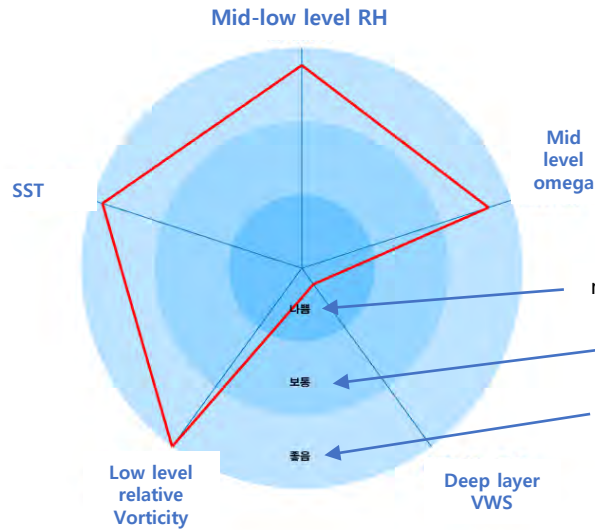
Ex) La Nina → El Nino
(year 1986, 1997, 2006, 2009, 2018)



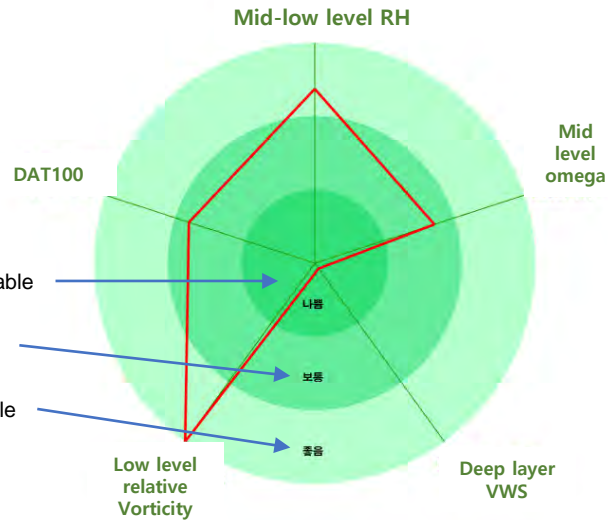
Composite analysis

CFSv2 forecast-based analysis

Genesis-related environmental condition



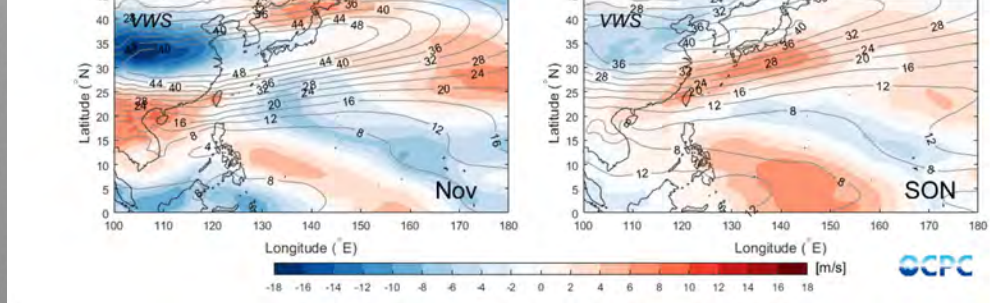
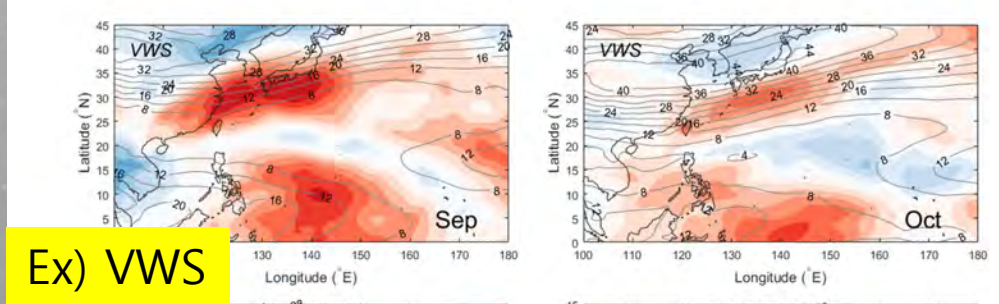
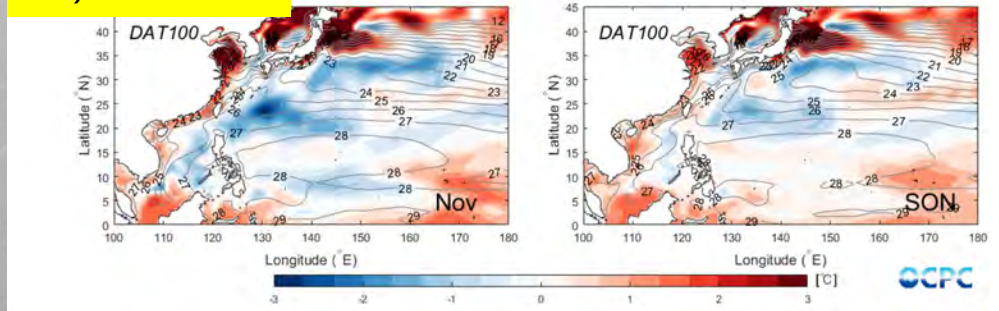
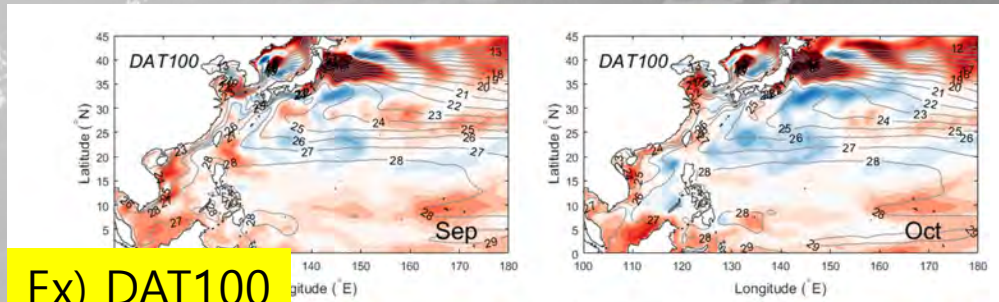
Development-related environmental condition



not favorable
normal
favorable

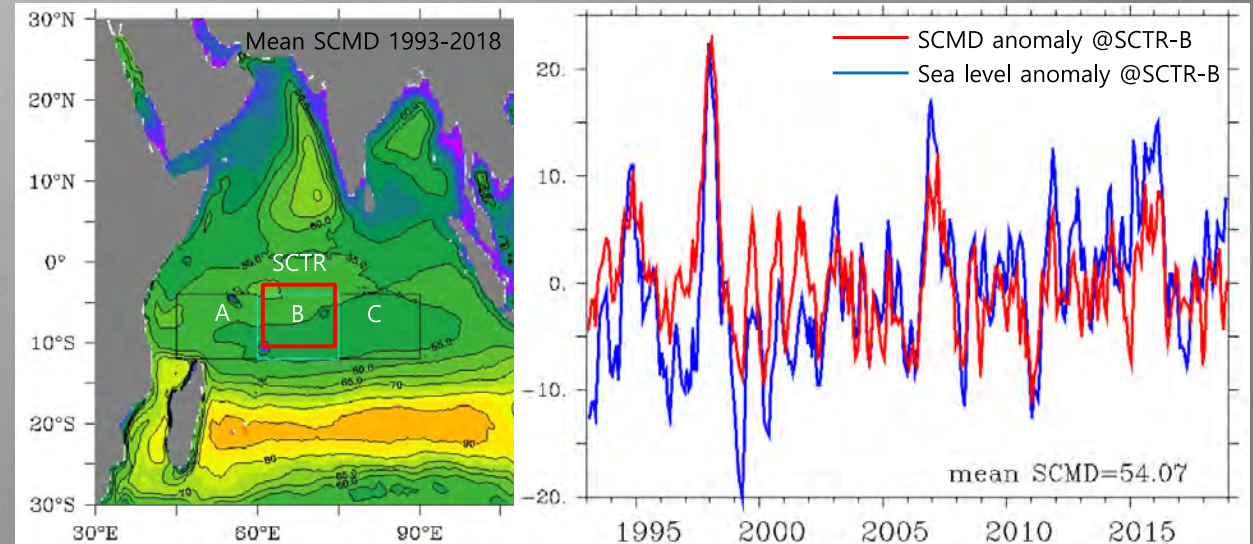
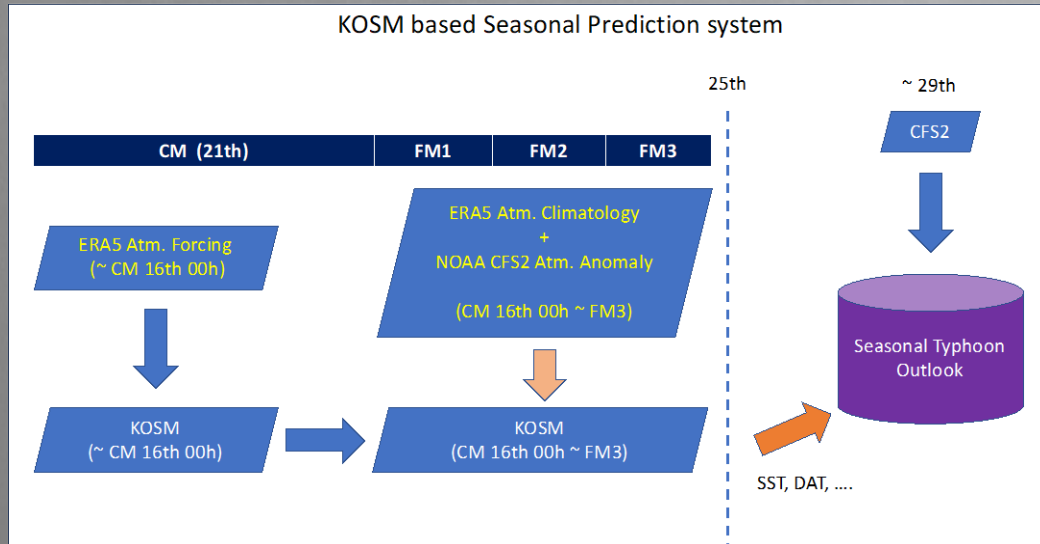
Genesis density or Track density weighted "A" = $\sum_{lon} \sum_{lat} \rho(lon, lat) \times A(lon, lat)$

SST, DAT100, OHC, VWS, low-level relative Vorticity, RH, GPH etc.



Further Applications – under development

- KOSM(MOM5+SIS+TOPAZ2) based NWPacific Ocean state prediction
- KOSM based tropical Indian Ocean variability and prediction - biogeochemical variability of Seychelles-Chagos Thermocline Ridge region

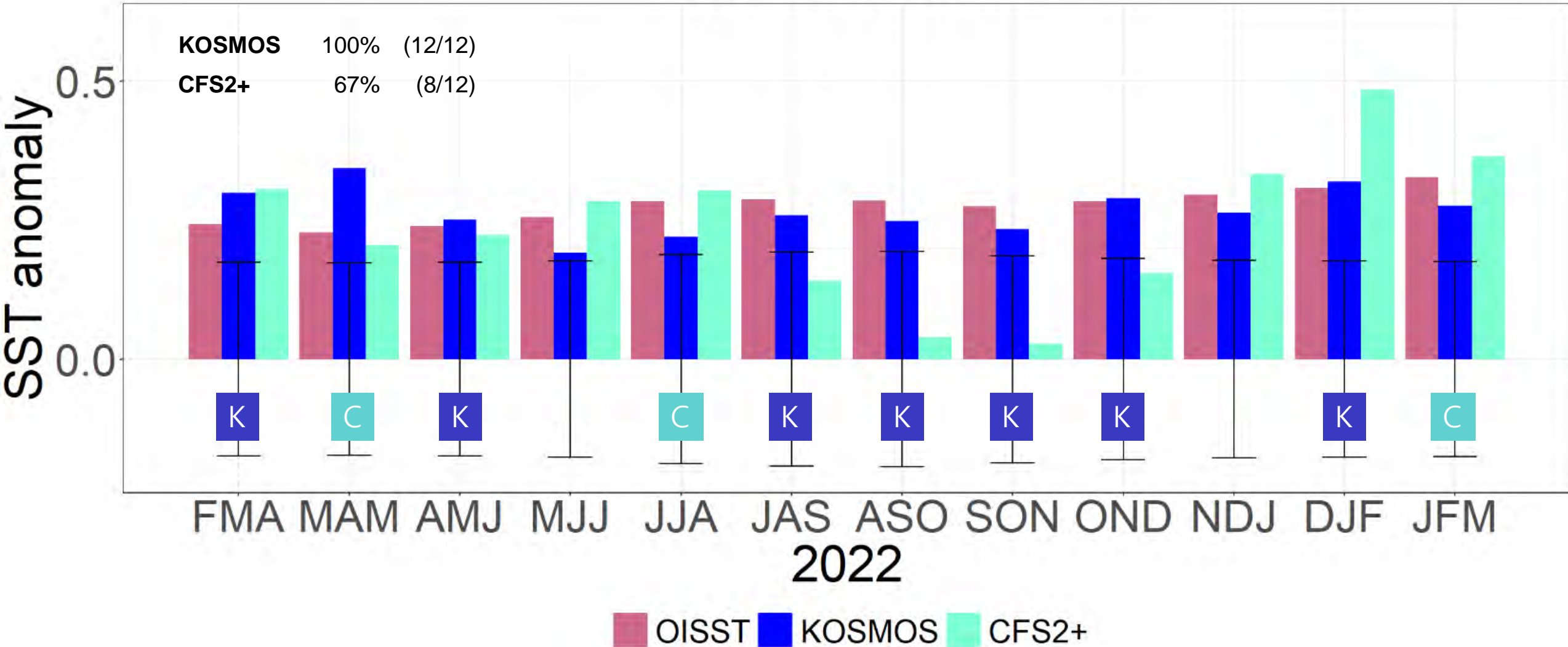


Summary

- KIOST-OCPC started its pilot seasonal prediction and outlook service by comparing the NOAA/CFS2 based seasonal prediction results with the analysis of satellite derived ocean climate variables as well as atmospheric reanalysis data.
- To enhance the seasonal outlook service, Machine Learning based filter for CFS2 SST/ADT is developed (HIPO) and applied to the 3 month prediction of Absolute Dynamic Topography.
- Two dynamic seasonal prediction models, KOSMOS and KOSM, are developed and tested for 3 month prediction and the pilot performance of single variable such as SST prediction is a bit encouraging but there is still long way to go.
- In addition to the refinement of model dynamics and initialization method, machine-learning based improvement would be an option or a good compliment.

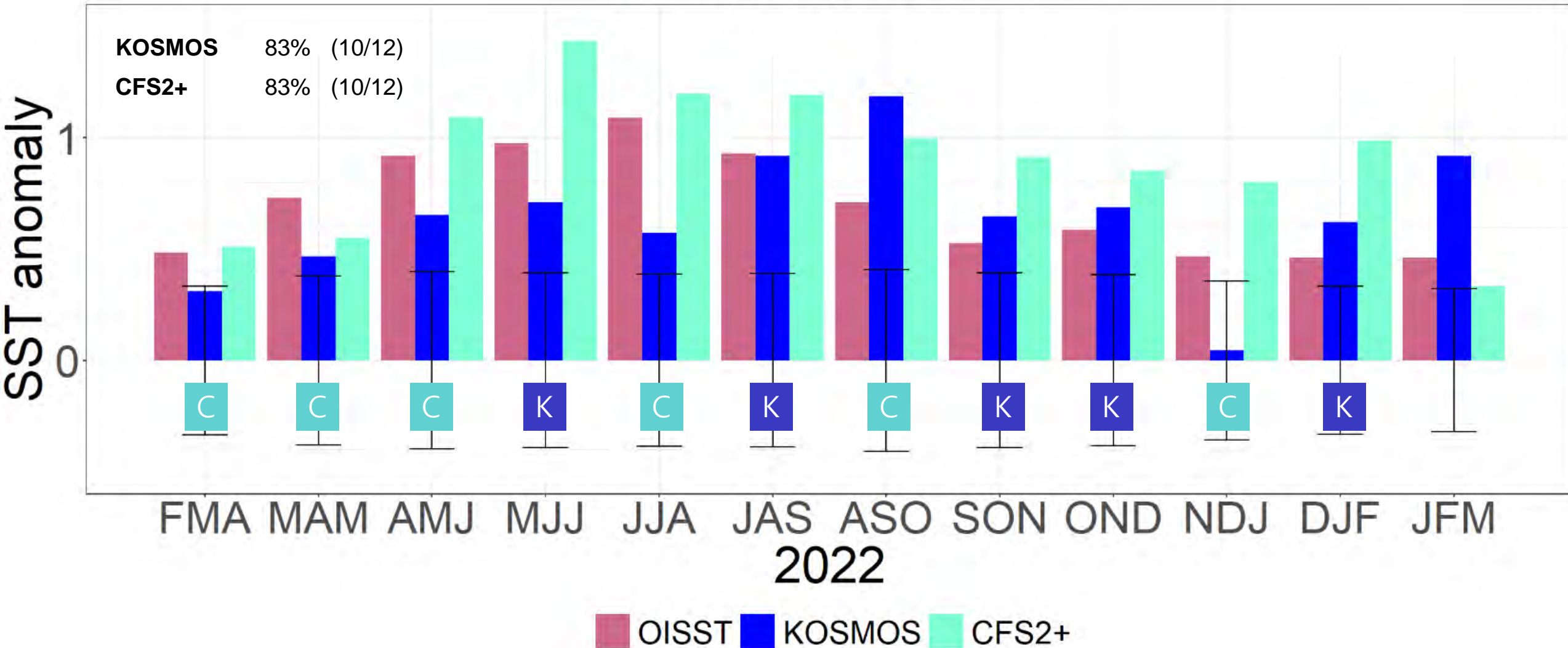
SST prediction anomaly in 2022

Global Ocean



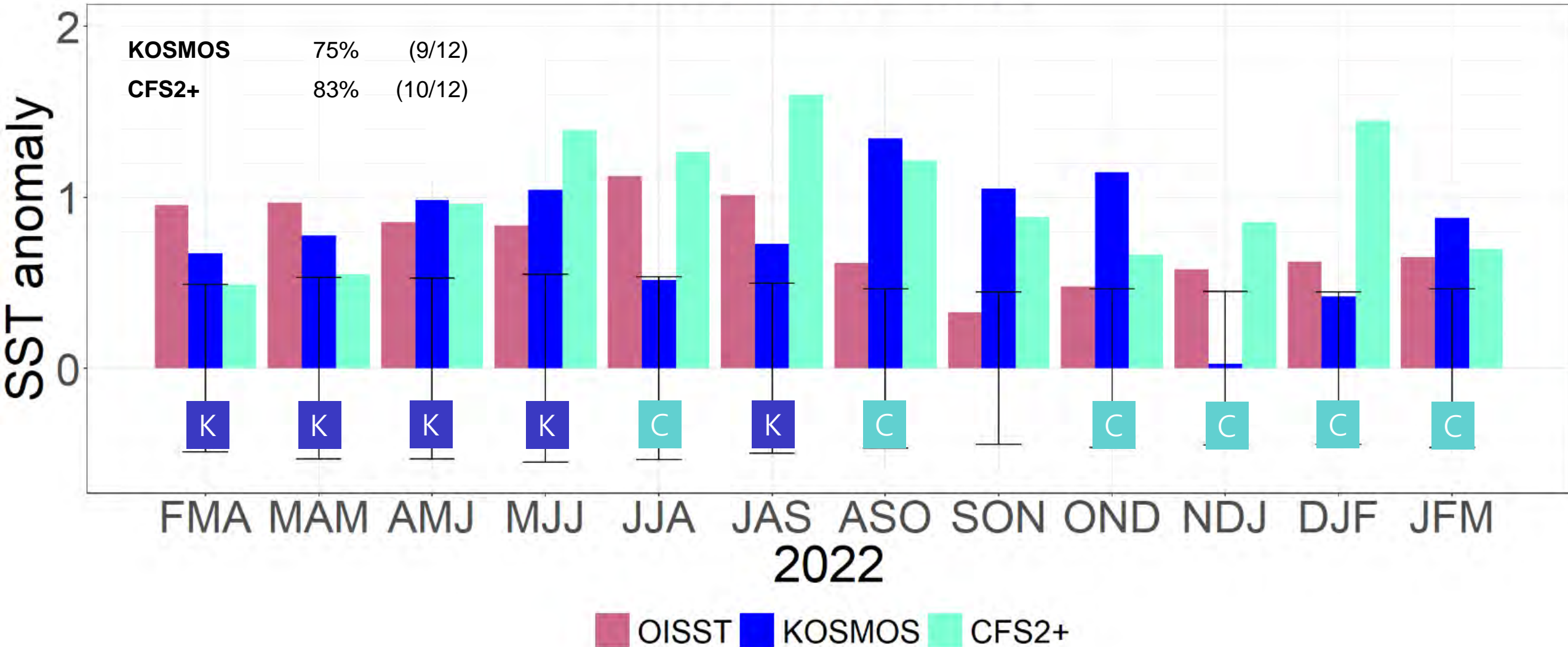
SST prediction anomaly in 2022

East Asian Seas



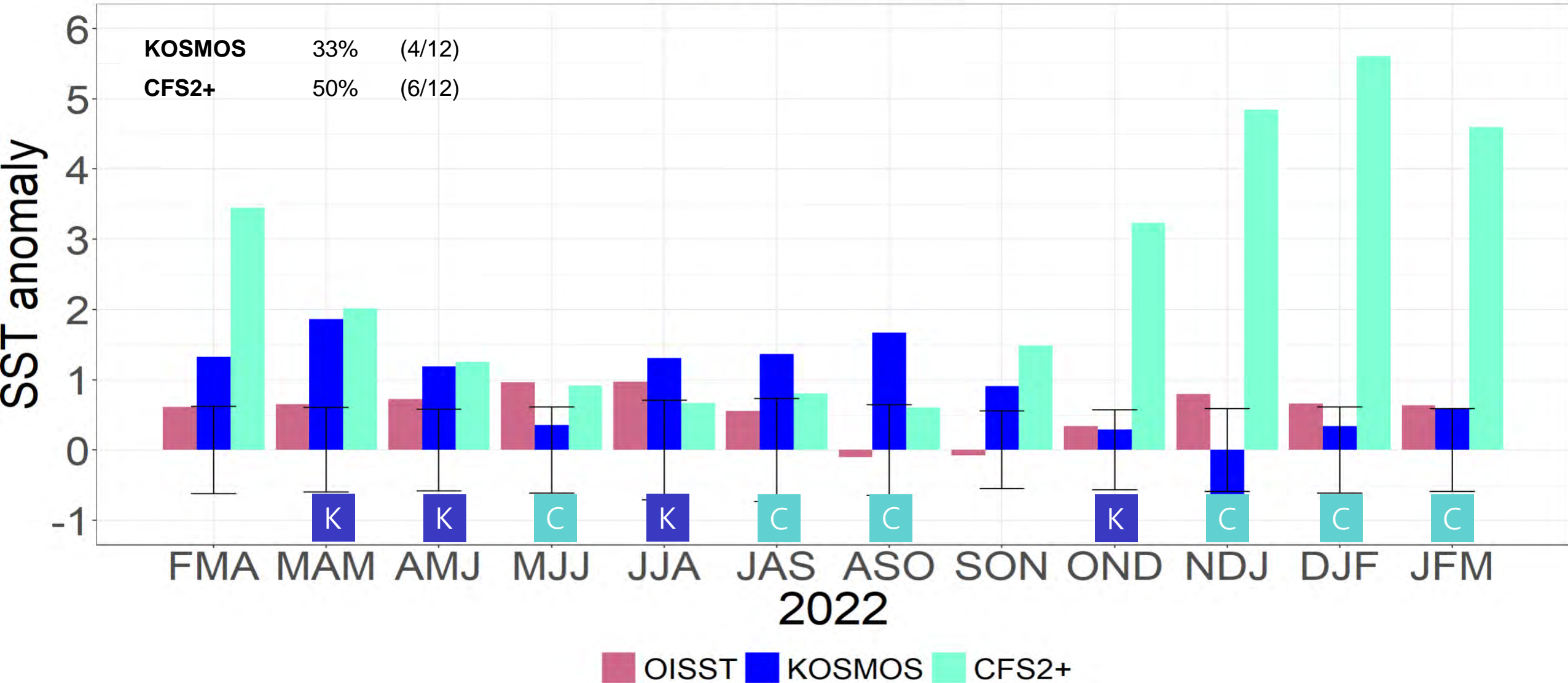
SST prediction anomaly in 2022

East China Sea



SST prediction anomaly in 2022

Yellow Sea



SST prediction anomaly in 2022

East Sea

