Dynamical vs statistical seasonal forecasting and their application in agriculture

11th of the East Asia Winter Climate Outlook Forum@Tokyo

Nov. 6th, 2023

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Today’s contents

1. Dynamical vs statistical seasonal forecasting

2. Application of seasonal forecasting in agriculture.

Dynamical VS statistical seasonal forecasting

Systematic Global Evaluation of Seasonal Climate Forecast Skill for Monthly Precipitation of JMA/MRI-CPS2 Compared with a Statistical Forecast System Using Climate Indices

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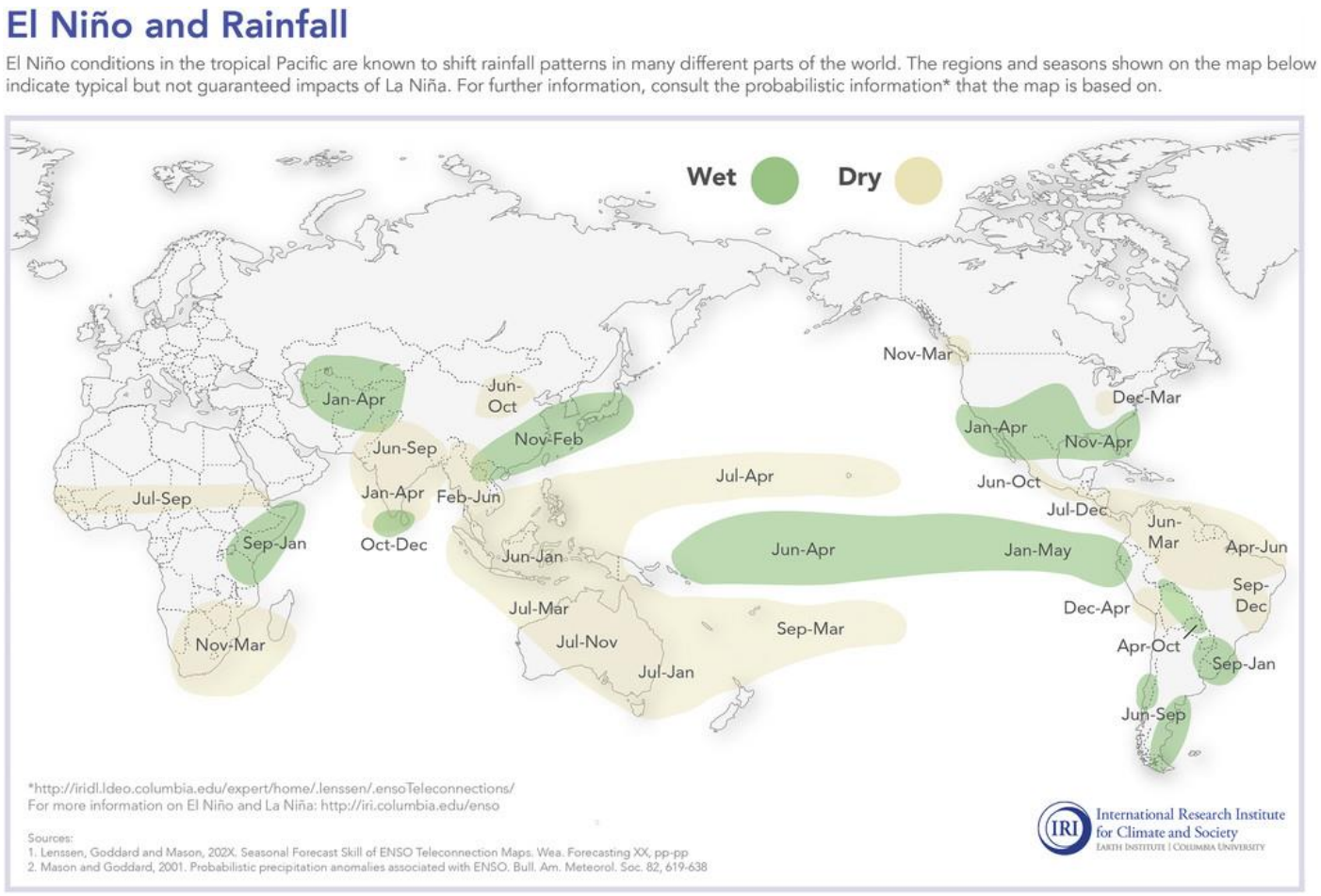
(Manuscript received 29 March 2022, in final form 20 February 2023)

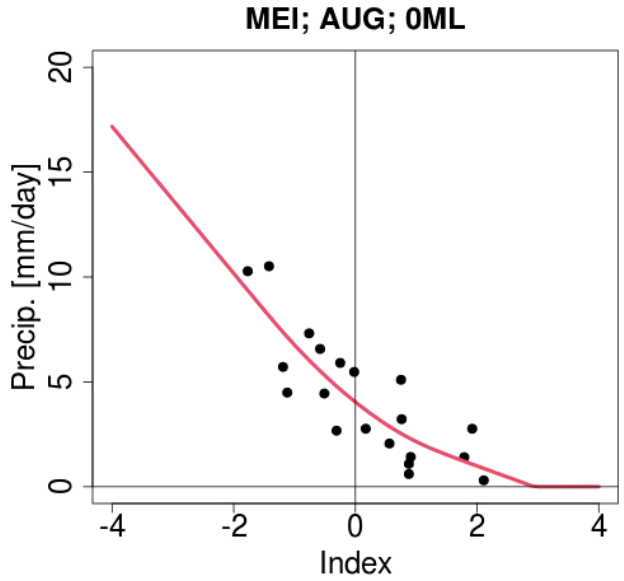
Abstract

This study aimed to systematically and globally evaluate the monthly precipitation forecasts of Japan Meteoro

What is statistical seasonal forecasting (St-SF)?



By using strong correlation between reginal climates and large scale phenomena like ENSO, NAO, etc.



- St-SF relies on **strong stability and teleconnection**
  - Time Lag correlation

$$P(T+L) \sim Idx(T)$$

T: Present
L: lead time

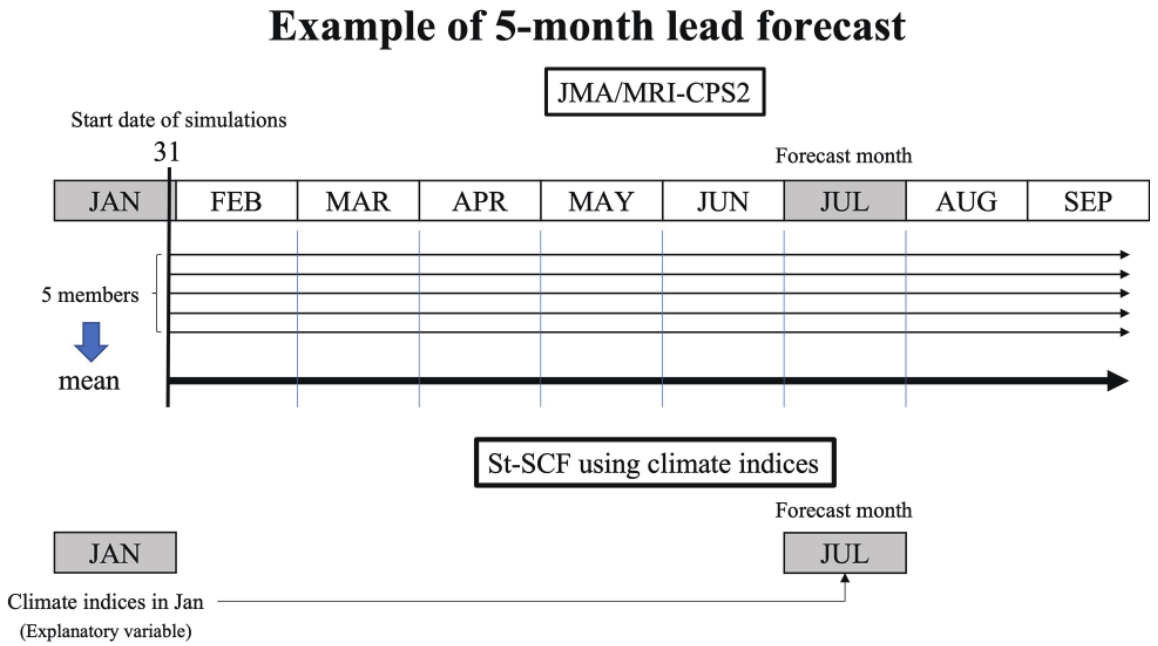
Advantages and disadvantages

	Advantage	Disadvantage
Dynamical	Understanding	High cost
Statistical	Low cast	Little for Understanding

Which is better： Dynamical vs Statistical?
in terms of forecasting performance??

Method and materials

Item	Description
Variable	Precipitation
Area	Global
Spatial resolution	2.5° × 2.5° (144 column; 73 rows)
Period	2001–2020
Time resolution	Monthly
Lead month of prediction	0–5 months
Evaluation of forecast skill	Deterministic: Mean squared skill score (MSSS), MSSS-rp, and MSSS-hi Probabilistic: area under receiver operation characteristic curve (AUC), AUC-av, AUC-r0.5, and AUC-hi
Observation	Global Precipitation Climatology Project (GPCP) v2.3 (regrided)
Dynamical model	JMA/MRI-CPS2 (bias-corrected)
Statistical model	Seventeen climate indices

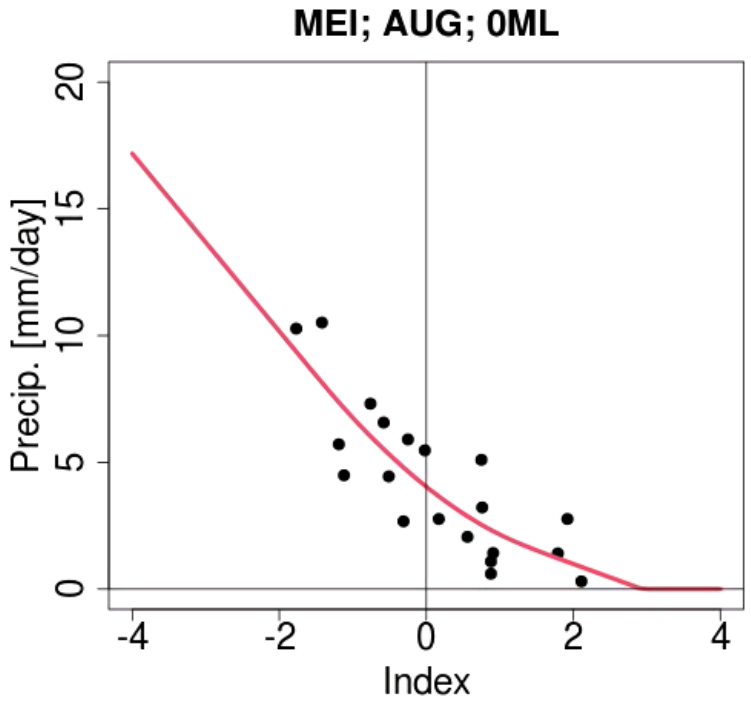


Statistical model

17 climate indices

Category	Name	Long name	URL
Teleconnections	PNA	Pacific North American Index	ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/pna_index.tim
	WP	Western Pacific Index	ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/wp_index.tim
	EA/WR	Eastern Atlantic/Western Russia	ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/eawr_index.tim
	NAO	North Atlantic Oscillation	ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/nao_index.tim
	NOI	Northern Oscillation Index	https://www.pfeg.noaa.gov/products/PFEL/modeled/indices/NOIx/data/noix.txt
ENSO	MEI v2	Multivariate ENSO Index	https://psl.noaa.gov/enso/mei/data/meiv2.data
	Nino 1+2	Extreme Eastern Tropical Pacific SST (0-10S, 90W-80W)	http://www.cpc.ncep.noaa.gov/data/indices/ersst5.nino.mth.91-20.ascii
	Nino 3	Eastern Tropical Pacific SST (5N-5S, 150W-90W)	http://www.cpc.ncep.noaa.gov/data/indices/ersst5.nino.mth.91-20.ascii
	Nino 4	Central Tropical Pacific SST (5N-5S) (160E-150W)	http://www.cpc.ncep.noaa.gov/data/indices/ersst5.nino.mth.91-20.ascii
	Nino 3.4	East Central Tropical Pacific SST (5N-5S) (170-120W)	http://www.cpc.ncep.noaa.gov/data/indices/ersst5.nino.mth.91-20.ascii
SST: Pacific (except ENSO)	TPI (IPO)	Tripole Index for the Interdecadal Pacific Oscillation (unfiltered)	https://psl.noaa.gov/data/timeseries/IPOTPI/tpi.timeseries.ersstv5.data
SST: Atlantic (except WHWP)	TNA	Tropical Northern Atlantic Index	https://www.esrl.noaa.gov/psd/data/correlation/tna.data
	TSA	Tropical Southern Atlantic Index	https://www.esrl.noaa.gov/psd/data/correlation/tsa.data
Atmosphere	QBO	Quasi-Biennial Oscillation	https://www.esrl.noaa.gov/psd/data/correlation/qbo.data
	SOI	Southern Oscillation Index	https://www.esrl.noaa.gov/psd/data/correlation/soi.data
	AAO	Antarctic Oscillation	http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/aao/monthly.aao.index.b79.current.ascii
	AO	Antarctic Oscillation	http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/monthly.ao.index.b50.current.ascii

$$PRE_{i,j,LM}(Y,M) = \max\left\langle f_{i,j,M,LM}\left\{IDX_j[Y,M-(LM+1)]\right\},0\right\rangle$$

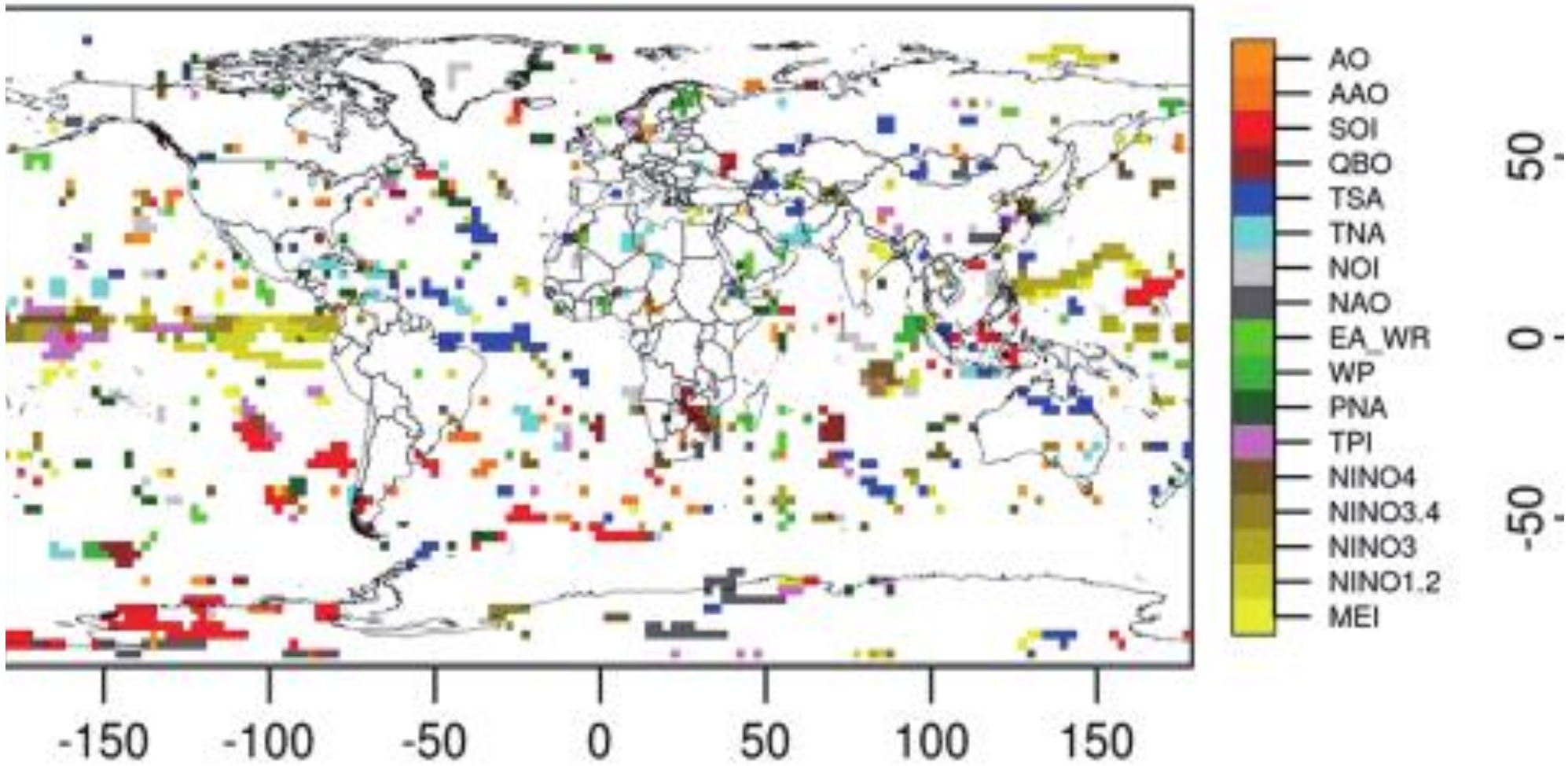


A spline curve is fitted

STEP1: 17 statistical model are developed for each grid

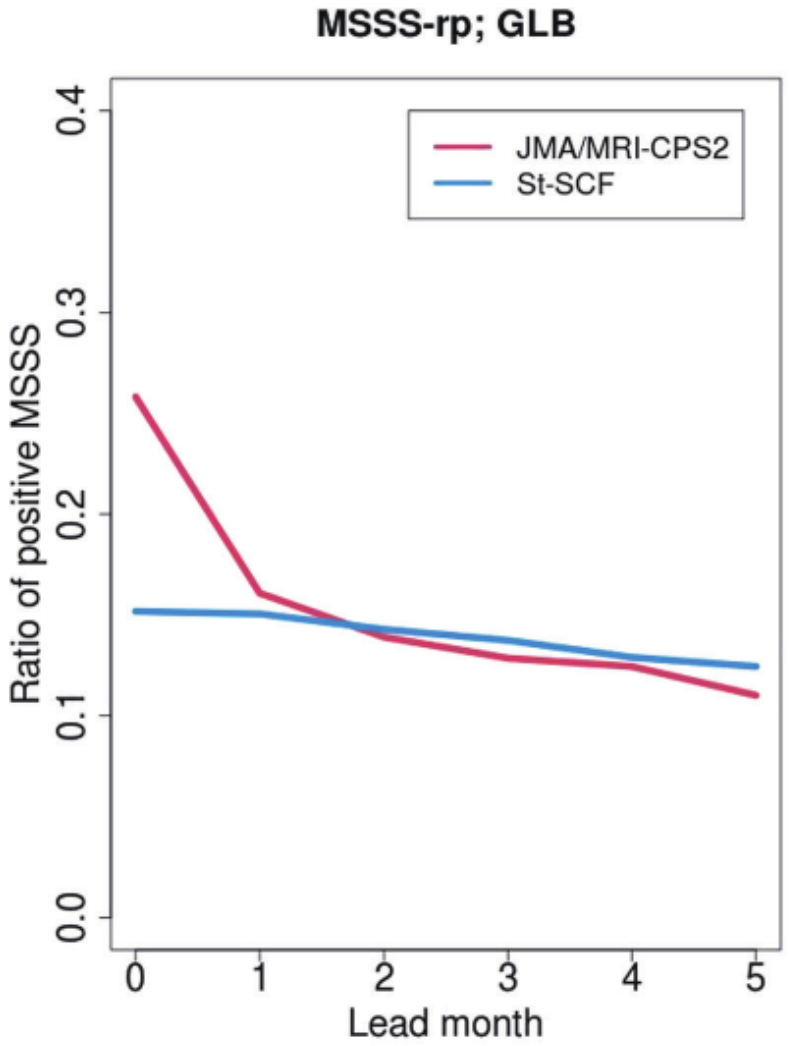
STEP2: The model with highest performance is selected for each grid.

ndex with Max. MSSS; JUN; 0ML

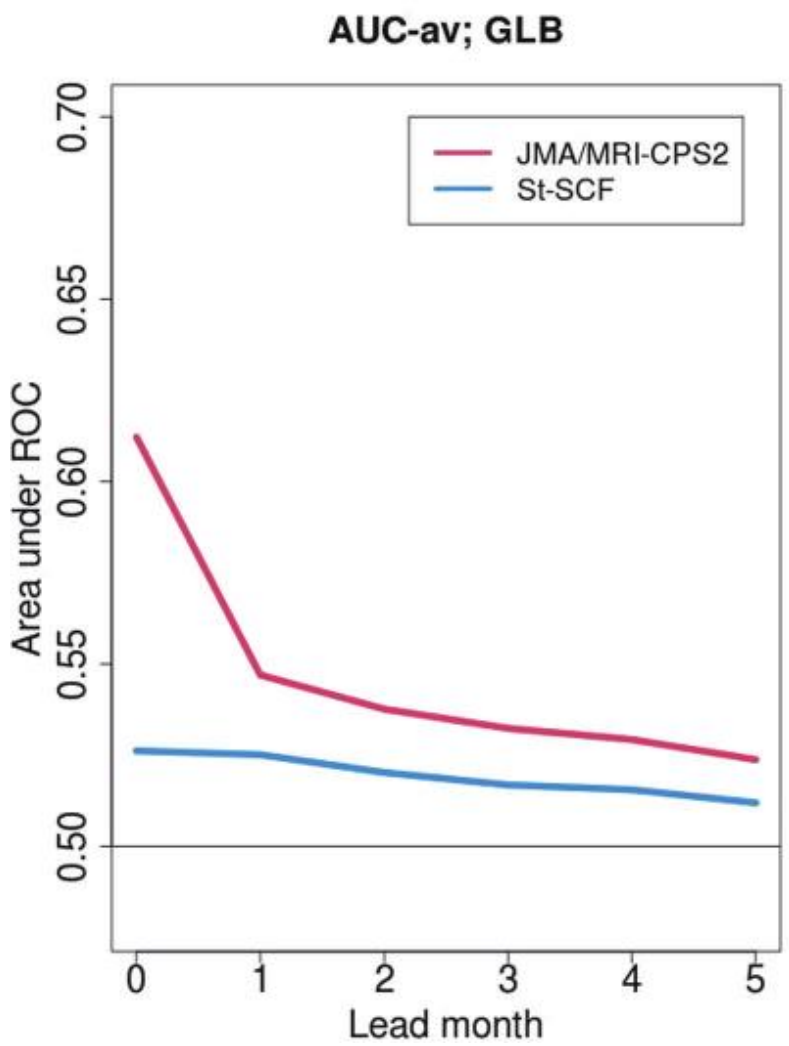


Results

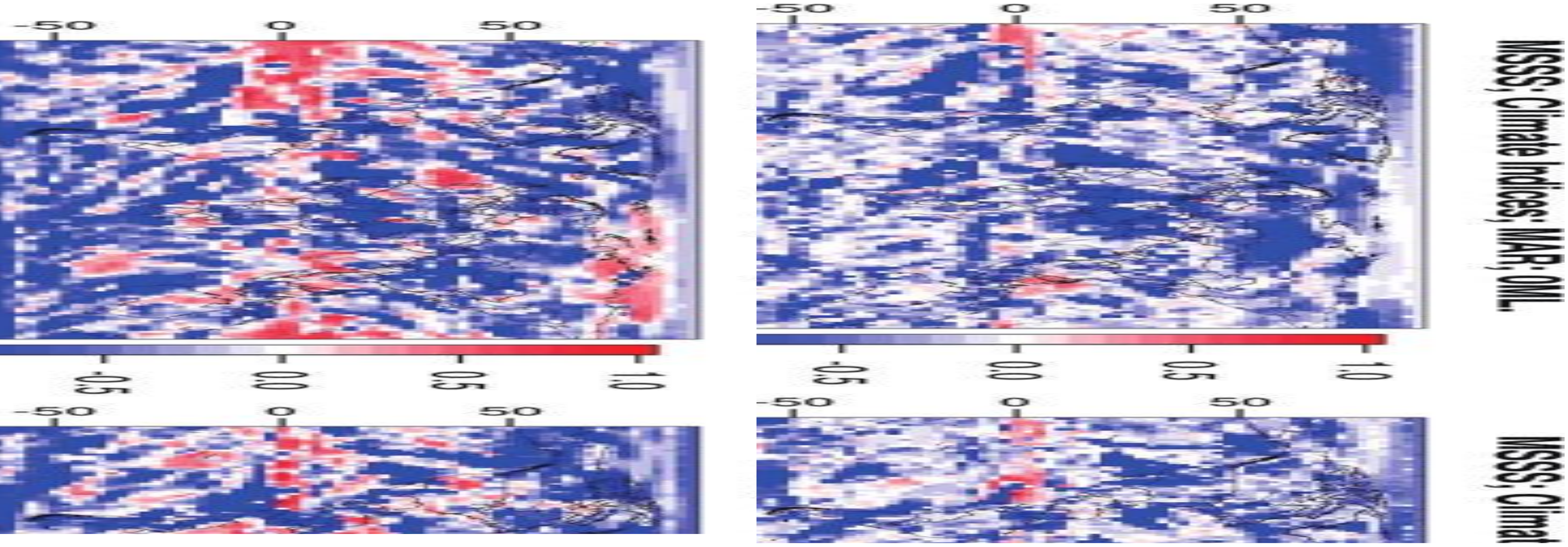
Deterministic



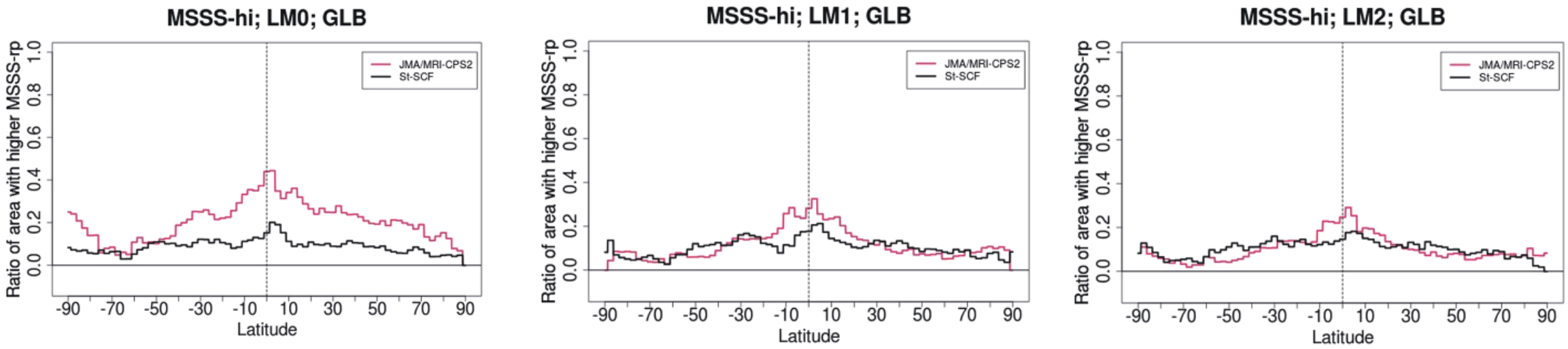
Probabilistic



- Dy-SF has higher performance for zero-month forecasting than St-SF
- For one and more month forecasting, both have similar performance

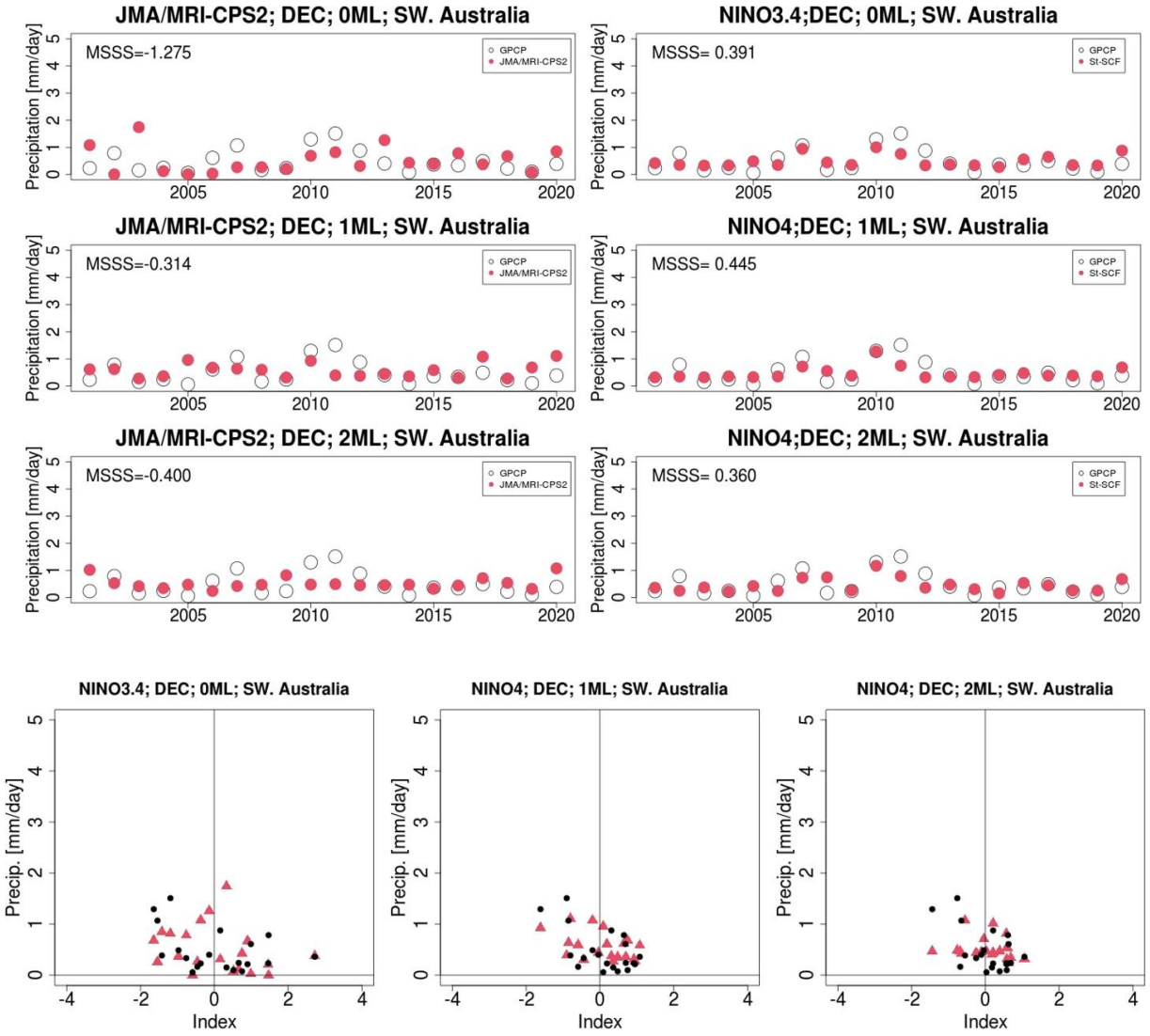


It is clear that Dy-SF has higher performance



- **For zero-month forecasting, Dy-SF has higher performance globally, but especially at low latitude.**
- For more than one-month forecasting, there is no difference.

Can St-FS contribute to improvement of Dy-FS?



By comparing St-FS and Dy-FS, we can find area where St-FS has higher performance than Dy-FS

In such areas, there might be robust dynamics between climate indices and precipitation, but **Dy-FS does not represent** the dynamics well.

By analyzing such area, Dy-FS could be improved.

Is this an easy way to find robust dynamics which Dy-FS can improve??

Because there might be robust dynamics!!

Summary on Dynamical VS statistical SF

- For zero-month forecasting
  - ✓Dy-SF has higher performance for zero-month forecasting than St-SF
  - ✓globally, but especially at low latitude.

- For one and more month forecasting
  - ✓both have similar performance

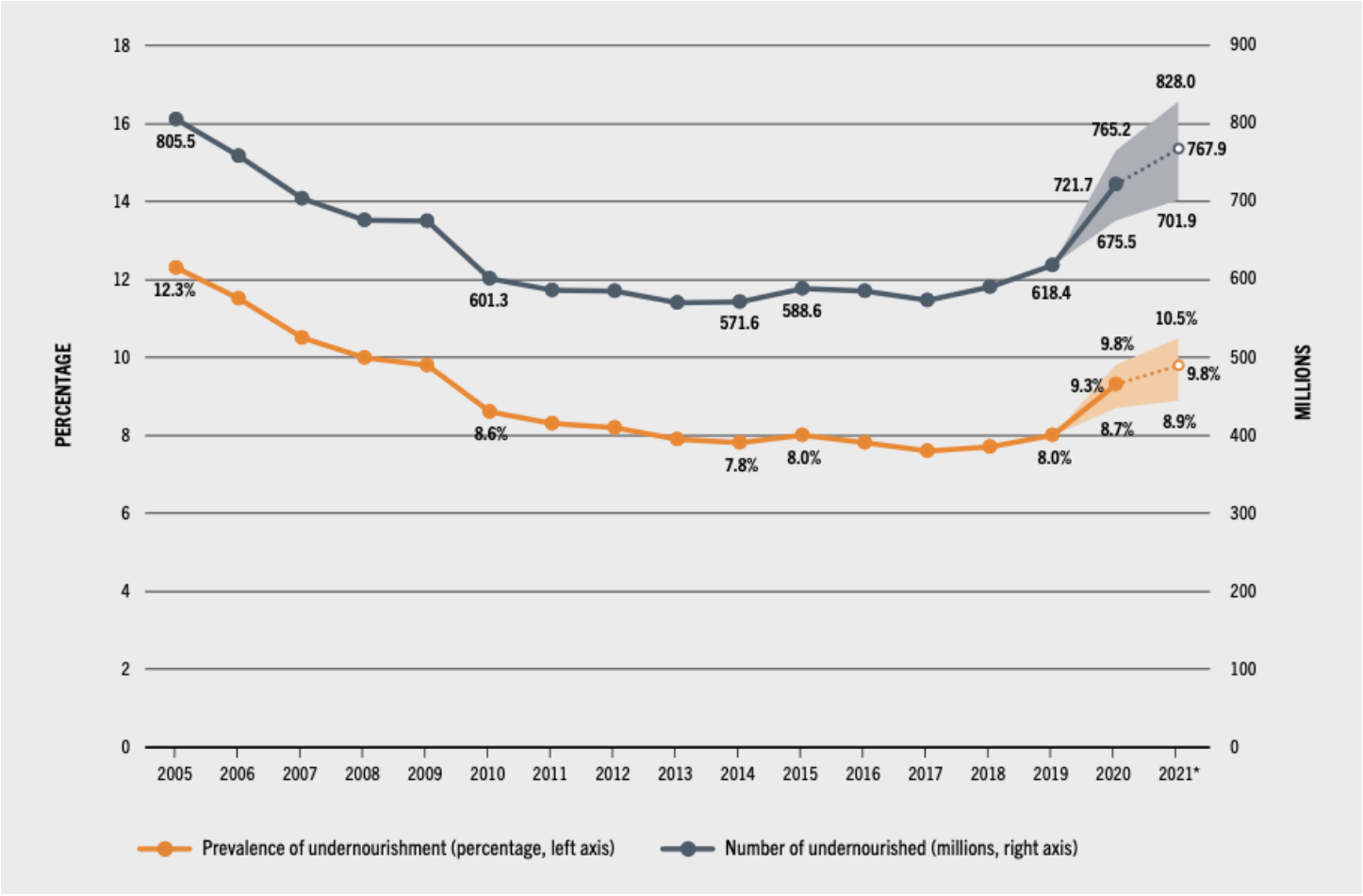
- By comparing St-SF and Dy-SF, it is possible to find robust dynamics which Dy-SF does not represent well and can improve.

Application of seasonal forecasting in agriculture

Global Crop Growth Monitoring and Yield Forecasting System

Crop-MoniCast

Food insecurity: Undernourished People



Since 2014, the number of hunger people turned to increase

1. Conflict
2. **Climate extremes and variability**
3. Economic shocks

4. COVID-19 (since 2020)

FAO (2022)

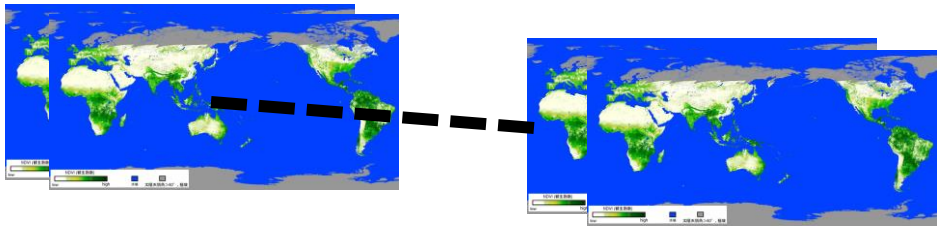
Climate change has become so significant that it can affect the global food security index

Crop MoniCast: Global Crop Monitoring and Yield Forecasting System

(i)Monitoring Subsystem

①Satellite data (from JAXA)

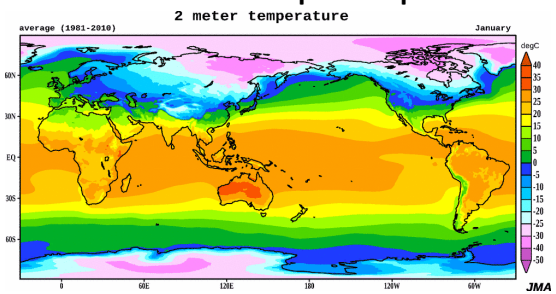
LAI (Leaf Area Index)



Data assimilation

Reanalysis climate data (JMA)

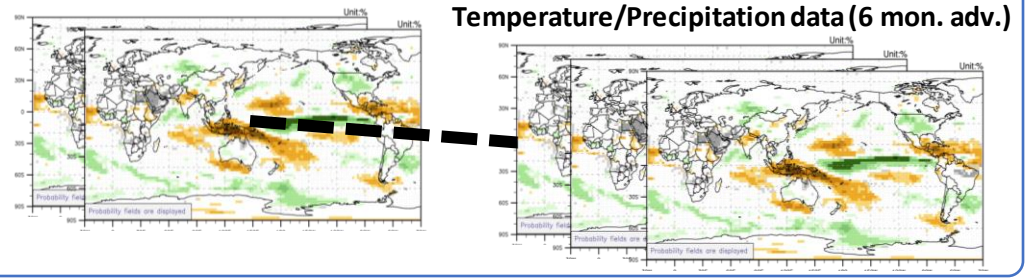
Climate data up to the present



(ii)Yield Forecasting Subsystem

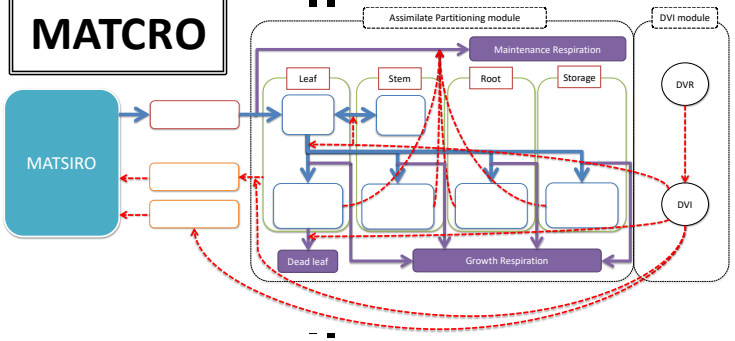
②Seasonal forecast data (from JMA/MRI)

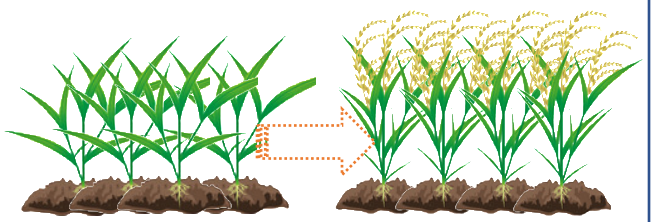
Temperature/Precipitation data (6 mon. adv.)



③Crop model

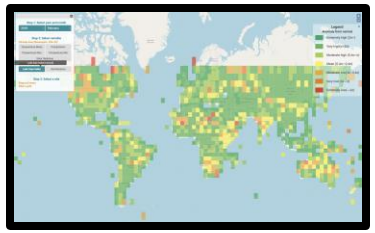
MATCRO



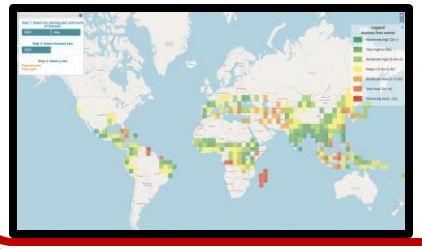


Monitoring(Present)

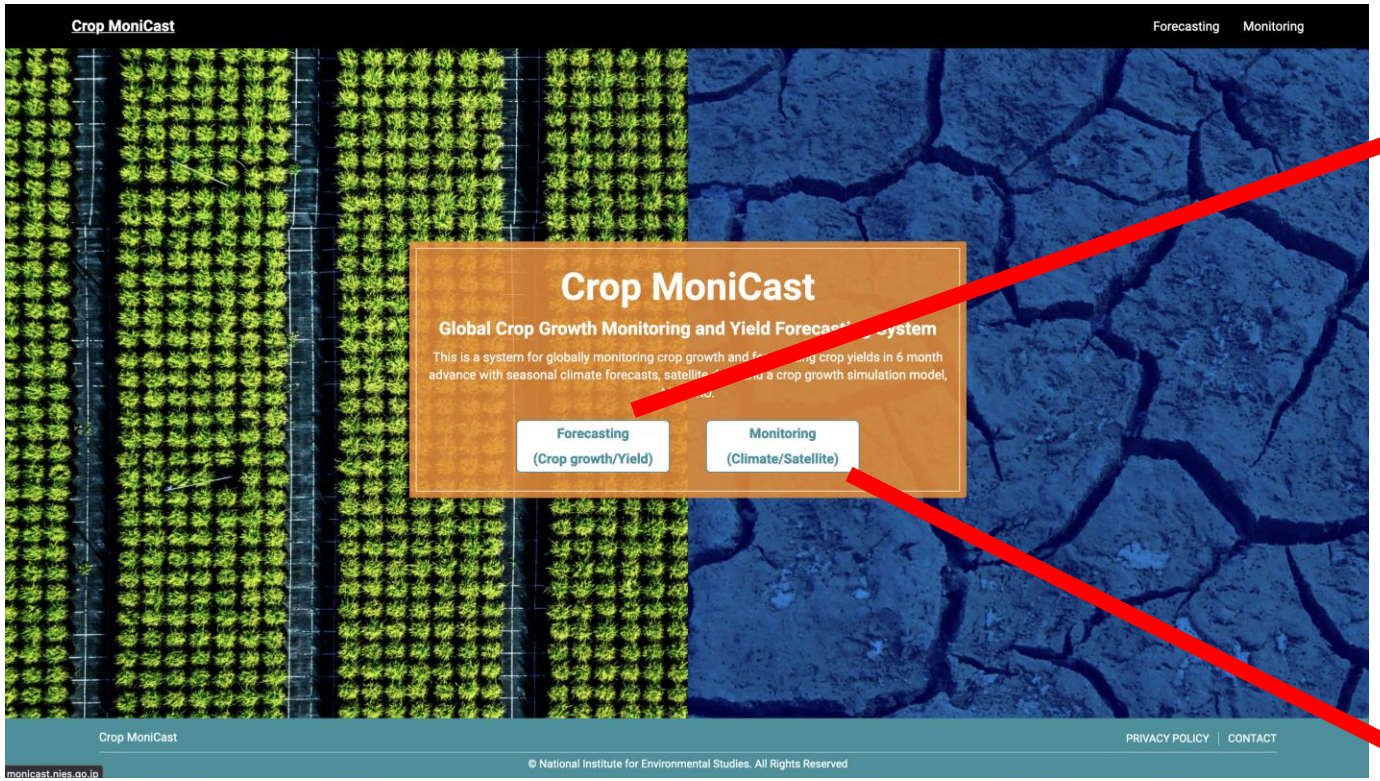
①Crop Monitoring：Utilizing satellite and meteorological data up to the present, the current crop growth status is estimated.



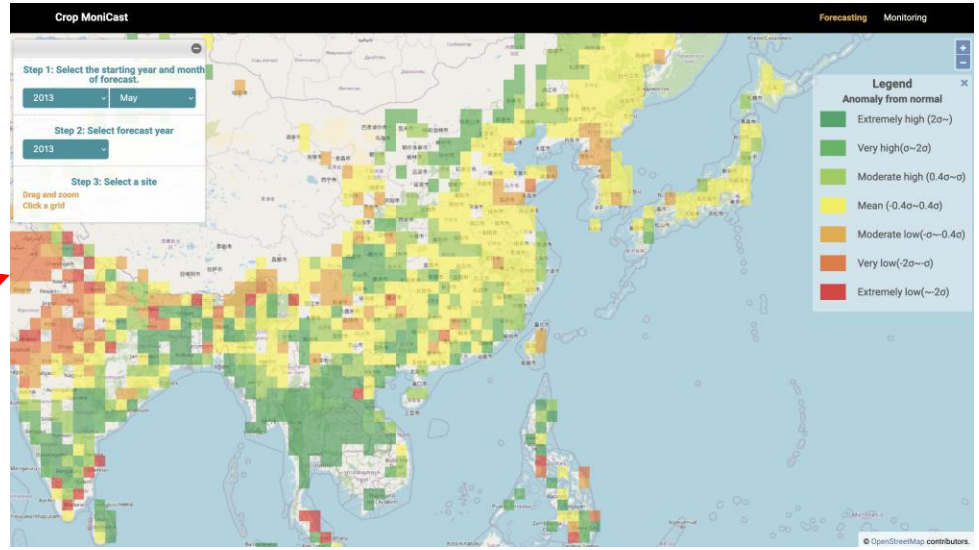
Forecasting(6 mon. adv.)



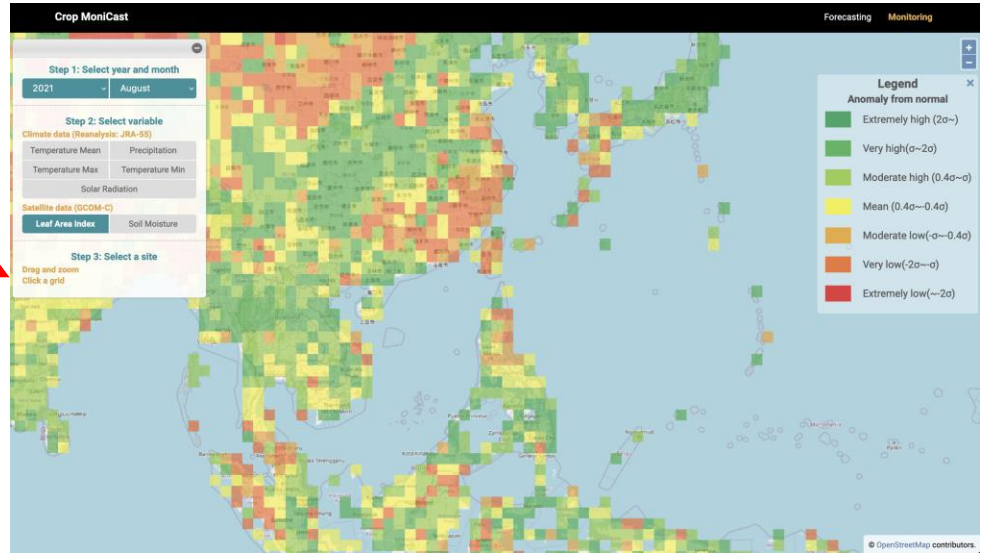
②Yield forecasting：Using the current growth estimation as an initial value, crop yield prediction is conducted with seasonal forecasts.



Front page of Global Crop Monitoring and Yield Forecasting
「Crop MoniCast」



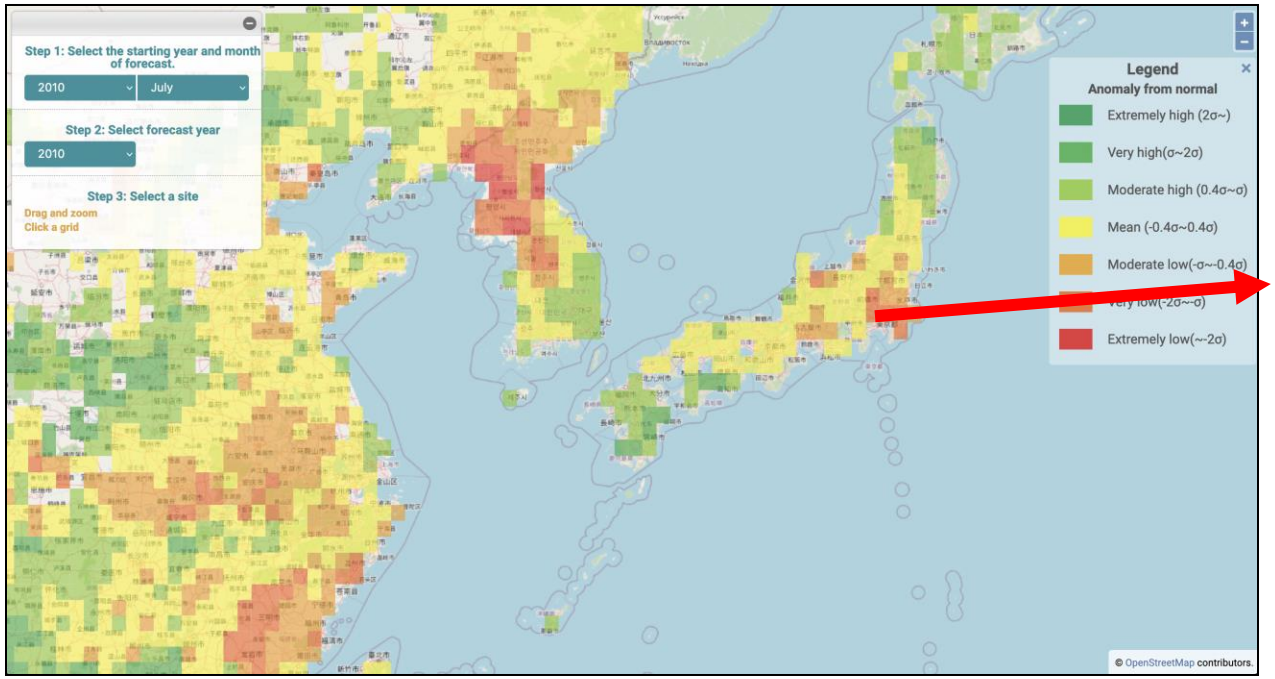
Crop yield forecasting

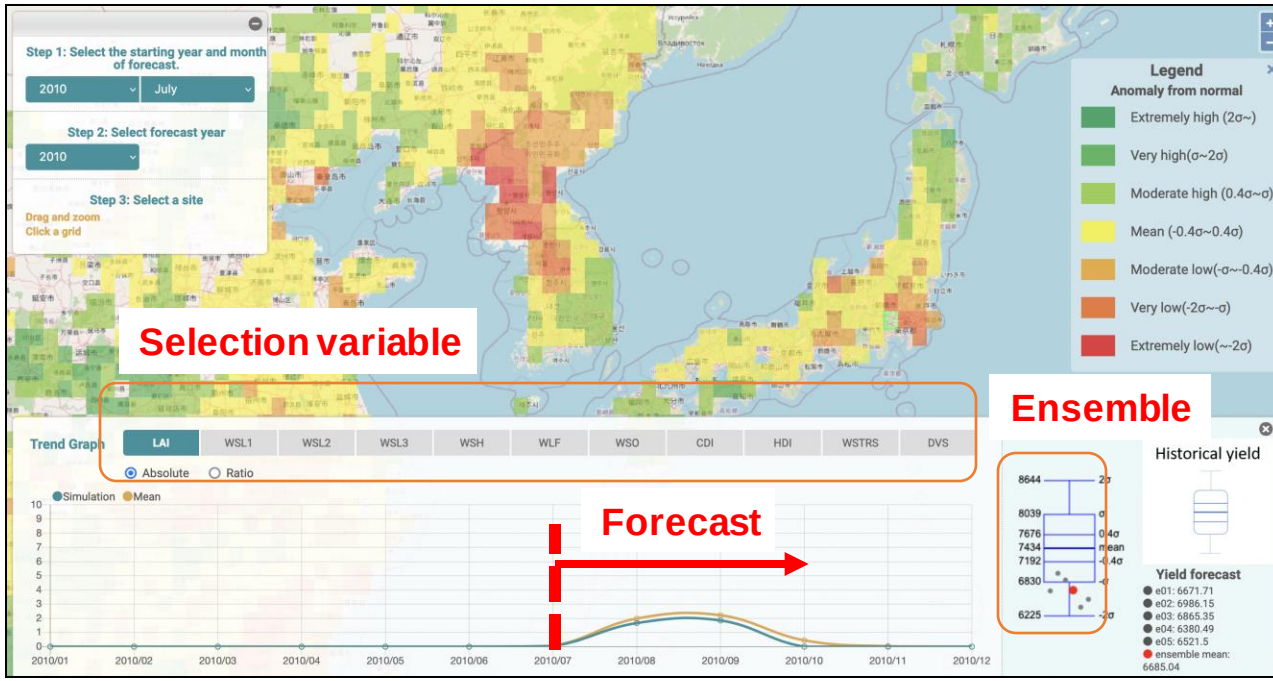


Crop growth monitoring

Under construction…

Crop yield forecasting





Orange：mean, Green：forecast

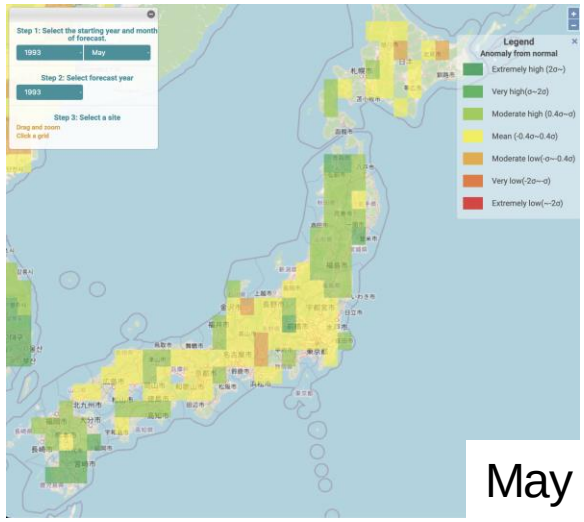
Step1：Selection: start month

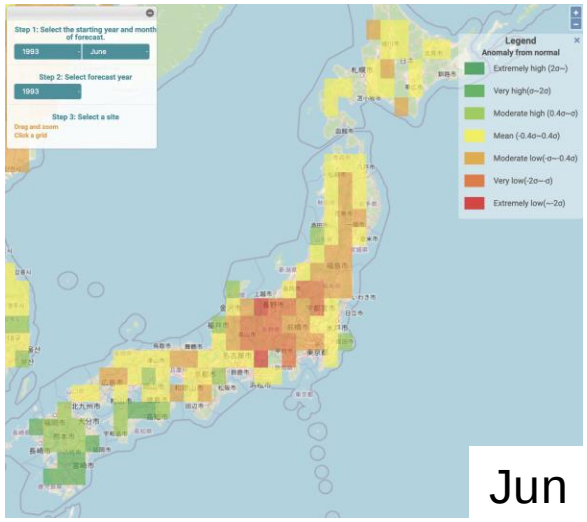
Step2：Selection: Forecast year

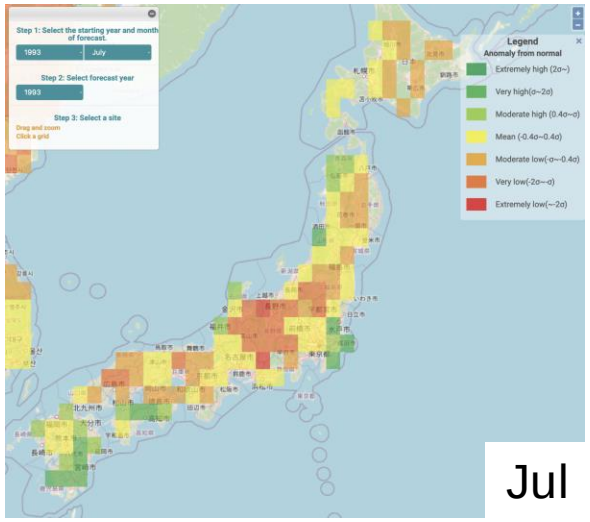
Step3：Click grid for detail information

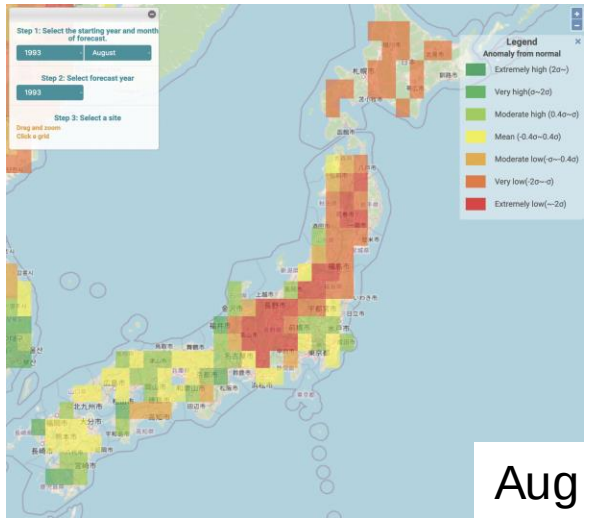
You can easily see forecasted crop yields

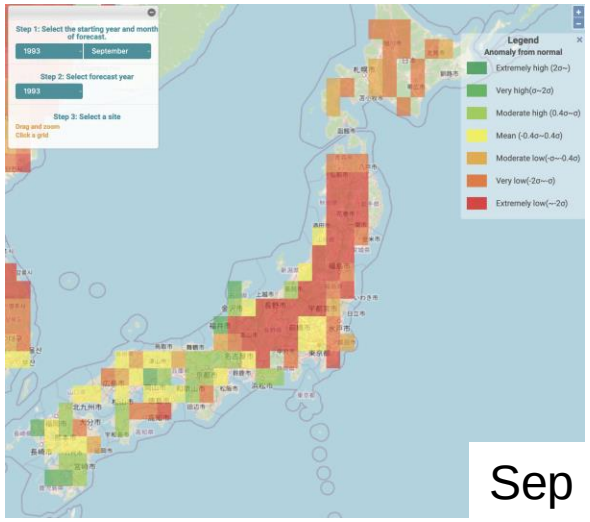
Performance

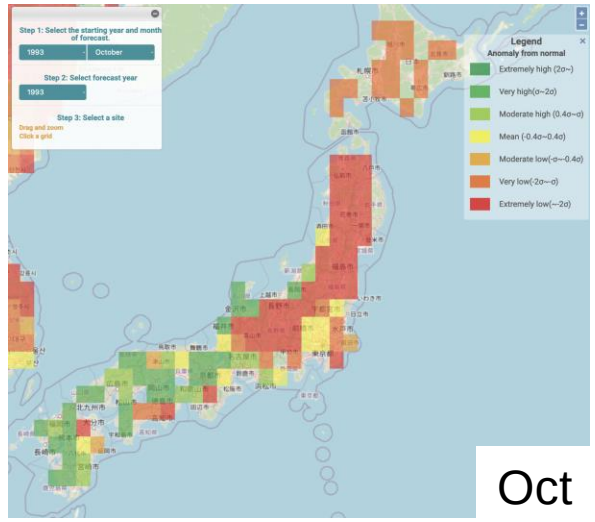












The system successfully forecasted the failure in 1993 in Japan

Summary and challenges

- We are developing Crop-MoniCast
  - Global crop monitoring and yield forecasting system

- We are preparing for opening the system for public
  - by Apr. 2024
  - Rice only
  - Ver. 1

- 4 major crops (Rice, Wheat, Maze, and Soybean)
- Downscaling with ML/DL
  - with Drs. Nakaegawa and Takaya (MRI)