How dissimilar are the large-scale hydroclimatic precursors and predictability of anomalous monthly rainfall in east and west Japan?

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Background & Motivation

- Variability of rainfall over Japan, is linked to Sea Surface Temperature (SST) anomalies in the Pacific through **Pacific-Japan (PJ)** and **East Asia-Pacific (EAP) teleconnections** (Feng and Hu, 2004; Huang, 2004; Ha et al., 2012; Zhang et al., 2014; Wu et al. 2016; Li, 2018)
- **Indian Ocean Dipole (IOD)** is also known to affect the rainfall variability over Japan (Saji and Yamagata, 2003)
- Below- and above-normal rainfall events over east and west Japan are not always concurrent, neither are their causal agents identical
- Furthermore, rainfall patterns in the two seasons, June to August (summer) and December to February (winter) are quite distinct

Inter- and intra-seasonal rainfall variations in EJ and WJ require an individual assessment of hydroclimatic teleconnection

Objective & methodological approach

To extract the **hydroclimatic teleconnection** features from global SST fields that influence **inter-seasonal and intra-seasonal** rainfall variability in EJ and WJ

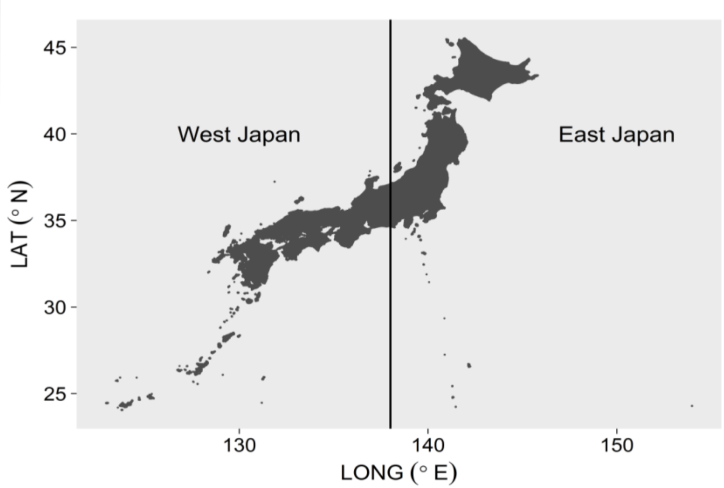
For this, we use the concept of Global Climate Pattern (GCP) (Chanda and Maity, 2015)

To utilize the hydroclimatic teleconnection information for the development of a model for the **season-wise prediction** of monthly rainfall for EJ and WJ

For this, we compare 2 approaches:

1. Hybrid GM-Copula approach (Dutta and Maity, 2018)
2. Machine Learning approach, namely Support Vector Regression (SRV).

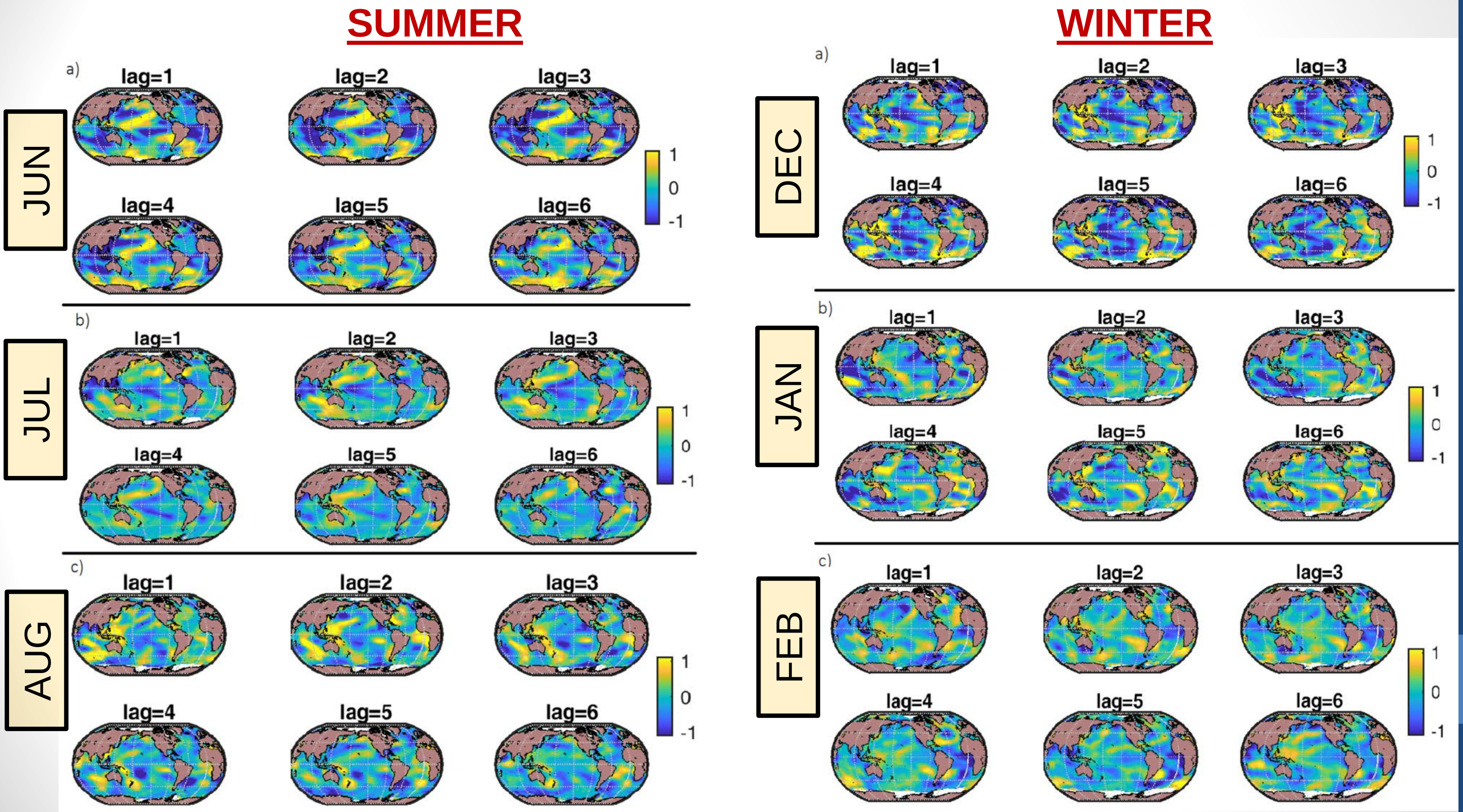
Study Area and Data



- Climate is different over east and west Japan (JMA: http://www.data.jma.go.jp/gmd/cpd/longfcst/en/ tourist.html)
- Precipitation pattern is different on the east and west of 138°E (Ohba et al., 2015)

Name of the variable	Source	Spatial Resolution	Period
Sea Surface Temperature (SST) (ºC)	National Oceanic and Atmospheric Administration (NOAA) Extended Reconstructed V5	2º lat x 2º lon	1979- 2015
Rainfall	Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources’ (APHRODITE) (Yatagai et al. 2012)	Aggregated over EJ and WJ	1979-2015

Global SST patterns for monthly rainfall in West Japan (WJ)



Selected SST zones for west Japan

Season	Month	Symbol	Lag (months)	Latitude	Longitude
Summer	Jun	**SST1**	1	0° to 20° N	180° to 140° W
		SST2	1	25° N to 35° N	145° E to 180°
		SST3	1	15° S to 5° S	145° W to 130° W
		SST4	2	15° S to 5° N	85° E to 115° E
	Jul	**SST1**	1	5° N to 15° N	100° E to 125° E
		SST2	2	5° N to 20° N	135° E to 155° E
		SST3	2	25° S to 15° S	80° E to 110° E
	Aug	**SST1**	1	0 to 15° N	115° E to 145° E
		SST2	1	40° S to 30° S	75° E to 95° E
		SST3	2	35° N to 45° N	160° E to 170° E
Winter	Dec	**SST1**	1	5° S to 5° N	170° E to 170° W
		SST2	1	45° S to 35° S	80° E to 100° E
		SST3	2	-5° S to 10° N	95° E to 135° E
	Jan	**SST1**	1	15° S to 0°	45° E to 85° E
		SST2	1	35° S to 25° S	45° E to 85° E
		SST3	1	-15° S to 10° S	180° to 160° W
	Feb	**SST1**	1	35° N to 45° N	150° W to 140° W
		SST2	2	0 to 20° N	115° E to 125° E
		SST3	2	30° S to 20° S	105° W to 85° W

Input variables further selected via the GM-Copula approach are in boldface

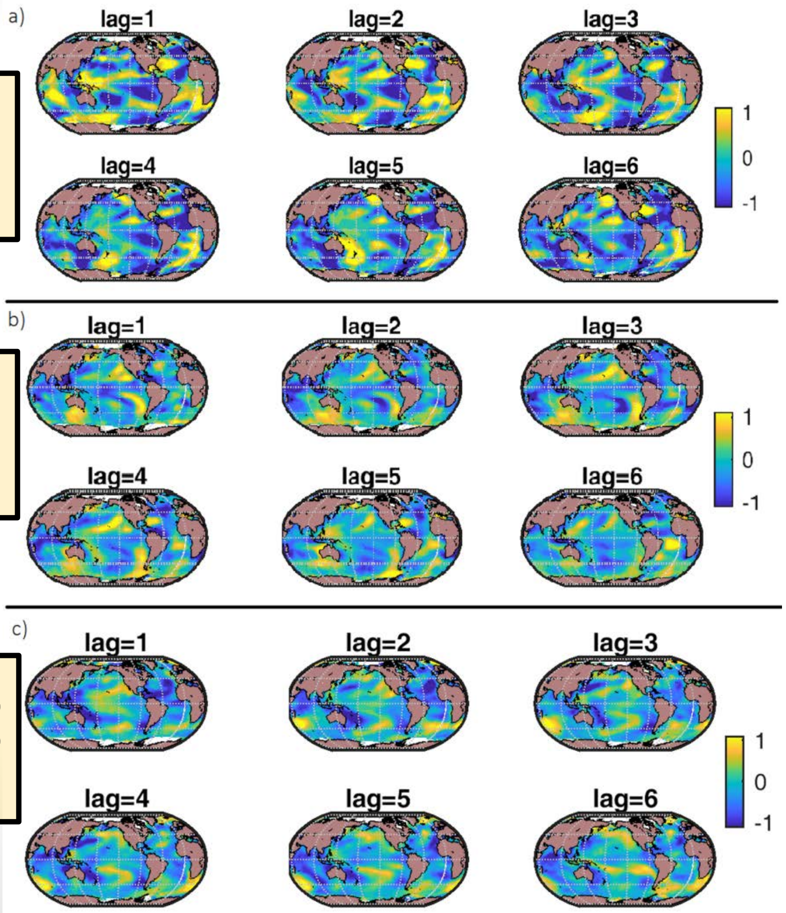
Global SST patterns for monthly rainfall in East Japan (EJ)

SUMMER

JUN

JUL

AUG

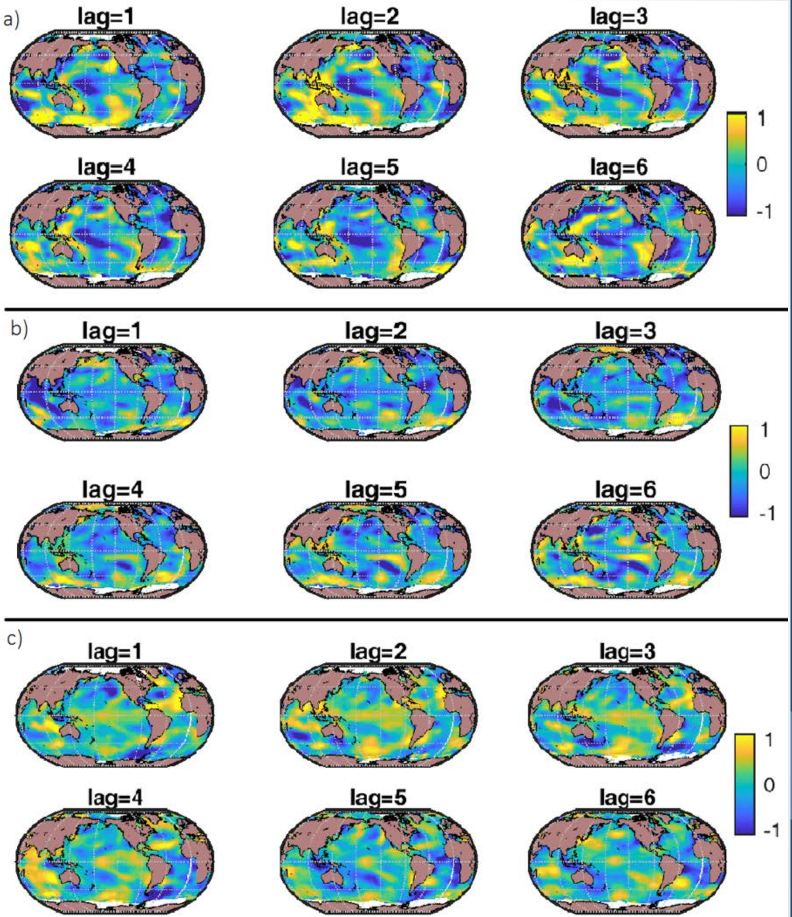


WINTER

DEC

JAN

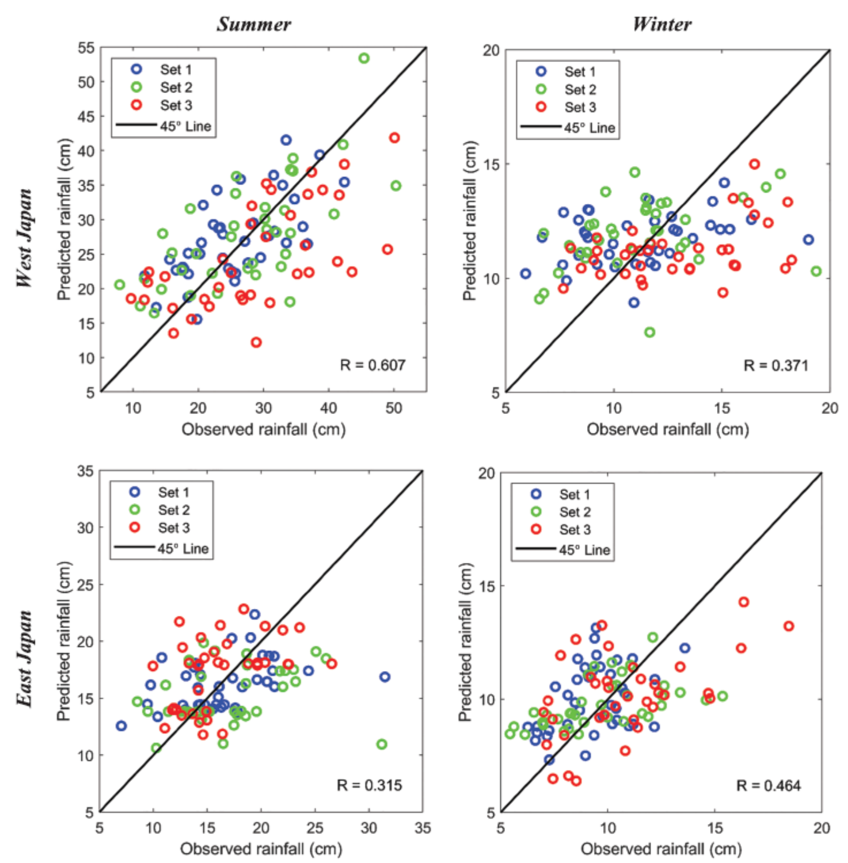
FEB



Selected SST zones for **east Japan**

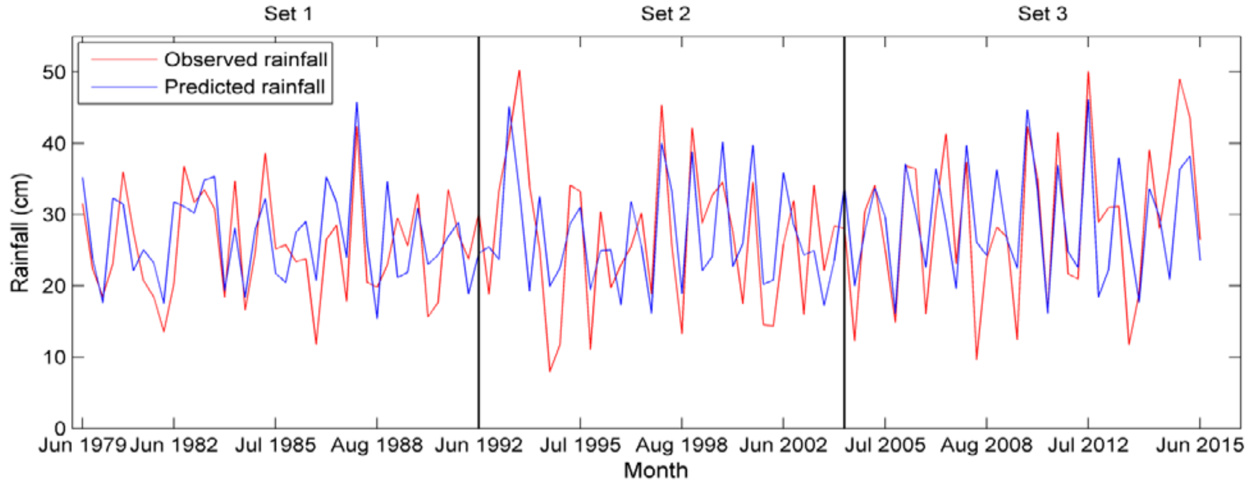
Season	Month	Symbol	Lag (months)	Latitude	Longitude
Summer	Jun	SST1	1	0° to 15° N	140° E to 155° E
		SST2	1	15° S to 0°	90° E to 125° E
		SST3	1	30° S to 15° S	70° E to 90° E
		SST4	1	75° S to 45° S	165° E to 180°
		SST5	1	15° S to 0°	130° W to 100° W
		SST6	1	30° N to 40° N	75° W to45° W
		SST7	1	45° N to 65° N	40° W to10° W
		SST8	1	40° S to 25° S	0° to 25° E
		SST9	2	5° N to 15° N	145° Wto125° W
	Jul	**SST1**	1	0° to 15° N	100° E to 130° E
		SST2	1	5° S to 5° N	60° E to 90° E
		SST3	1	55° S to 35° S	120° E to 150° E
		SST4	1	10° N to 30° N	140° W to120° W
		SST5	1	40° S to 20° S	110° W to80° W
	Aug	**SST1**	1	15° N to 30° N	140° W to 120° W
		SST2	1	10 ° N to 20° N	120° E to 150° E
		SST3	1	15° S to 0°	135° E to 175° E
		SST4	2	45° S to 30° S	45° E to 75° E
Winter	Dec	SST1	1	5° S to 5° N	60° E to 90° E
		SST2	1	20° N to 40° N	140° W to120° W
		SST3	1	10° S to 5° N	170° E to 170° W
		SST4	1	45 ° S to 25° S	135° Wto115° W
		SST5	2	10° S to 10° N	125° E to 145° E
	Jan	**SST1**	1	5° S to 10° N	60° E to 85° E
		SST2	2	45° N to 55° N	170° E to 170° W
	Feb	SST1	1	20° S to 5° S	90° E to 120° E
		SST2	1	15° N to 40° N	40° W to15° W
		SST3	1	30° N to 45° N	145° W to135° W
		SST4	2	0° to 20° N	90° E to 120° E

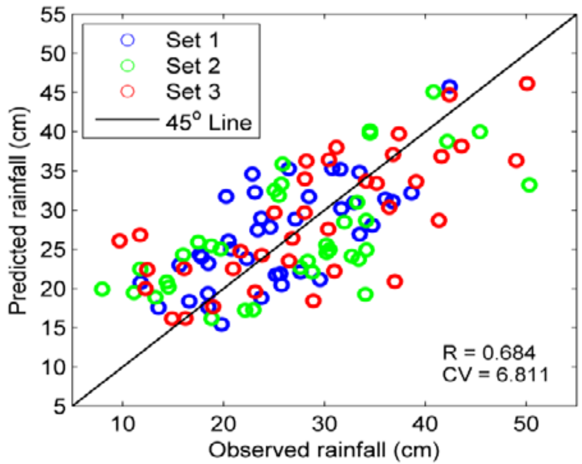
Performance of Seasonal Prediction using SVR

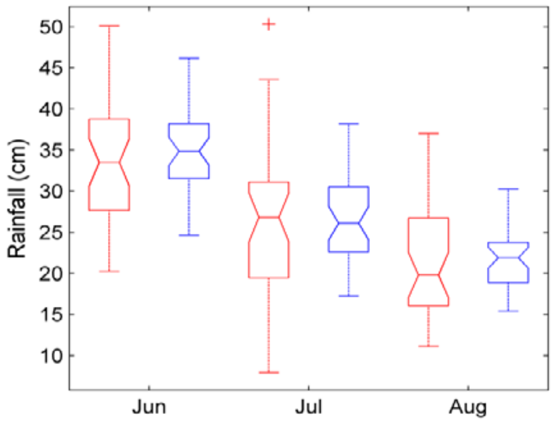


Region	Season	Fold	Testing period				
			R	RMSE (cm)	NSE	Dr	R^2
West	Summer	Set 1	0.64	5.62	-0.01	0.45	0.41
		Set 2	0.65	7.45	0.05	0.49	0.42
		Set 3	0.63	8.24	0.54	0.42	0.39
	Winter	Set 1	0.37	3.15	-0.99	0.33	0.13
		Set 2	0.50	3.12	0.27	0.00	0.25
		Set 3	0.42	2.75	0.37	0.33	0.18)
East	Summer	Set 1	0.45	4.08	-2.69	0.10	0.20
		Set 2	0.34	4.63	-3.62	0.09	0.11
		Set 3	0.43	3.71	-0.77	0.36	0.18
	Winter	Set 1	0.38	1.73	-0.65	0.35	0.14
		Set 2	0.52	2.07	-3.07	0.00	0.27
		Set 3	0.45	2.40	-0.83	0.25	0.20

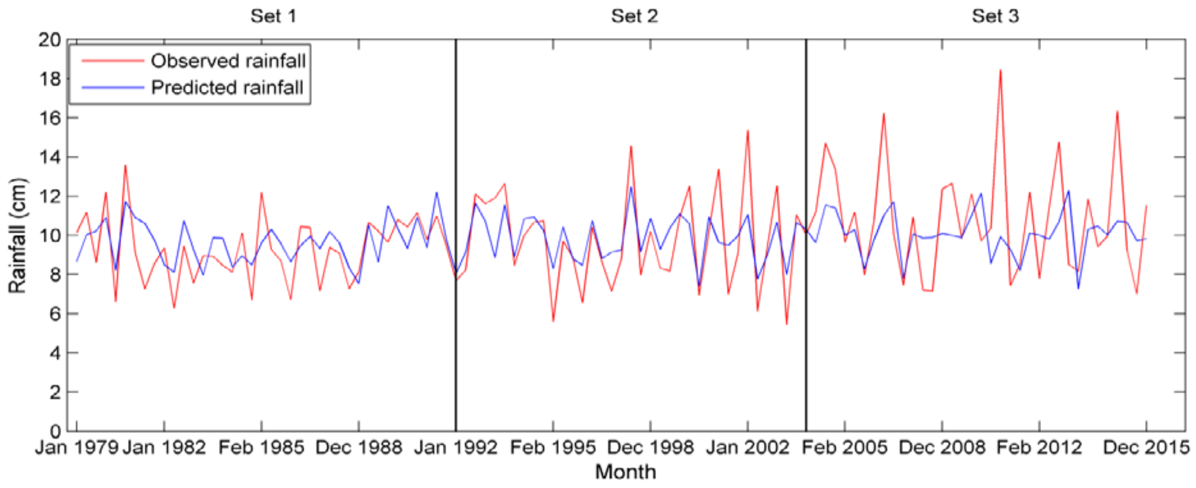
Summer rainfall Prediction performance using GM-Copula for west Japan

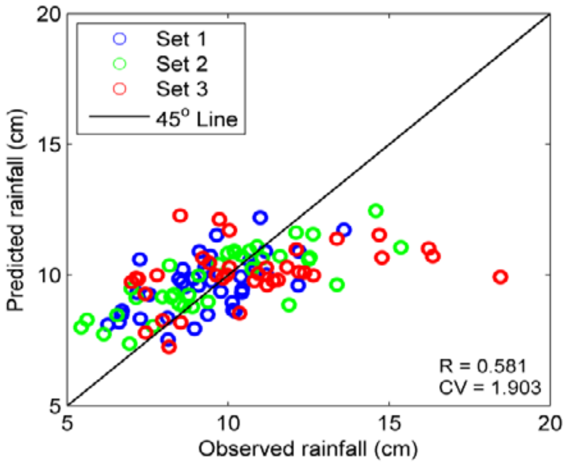


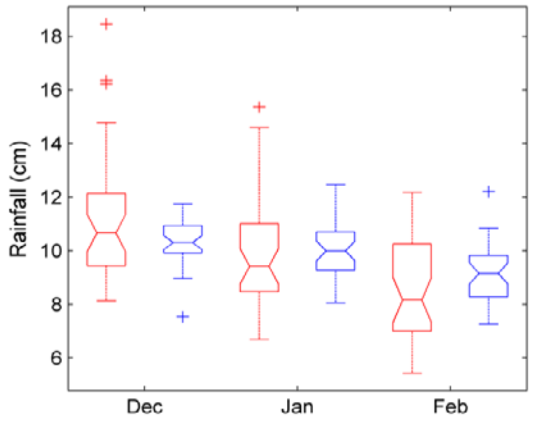




Winter rainfall Prediction performance using GM-Copula for east Japan







Seasonal Prediction performance using GM-Copula

Region	Season	Fold	Testing period				
			R	RMSE (cm)	NSE	Dr	R^2
West	Summer	Set 1	0.68	5.71	0.39	0.58	0.47
		Set 2	0.66	7.46	0.42	0.57	0.43
		Set 3	0.70	7.06	0.48	0.65	0.49
	Winter	Set 1	0.58	2.86	0.31	0.53	0.34
		Set 2	0.50	3.13	0.24	0.51	0.25
		Set 3	0.64	2.28	0.39	0.65	0.41
East	Summer	Set 1	0.65	3.48	0.41	0.60	0.43
		Set 2	0.50	4.04	0.25	0.56	0.25
		Set 3	0.70	3.07	0.47	0.65	0.49
	Winter	Set 1	0.56	1.44	0.27	0.52	0.31
		Set 2	0.75	1.57	0.51	0.67	0.56
		Set 3	0.45	2.64	0.13	0.54	0.20

Findings from the study

- Rainfall anomalies over the west Japan are influenced by the teleconnections originating in the tropical Pacific and Indian Ocean whereas the rainfall anomalies over the east Japan are associated with the high-latitude SST anomalies.
- Using the GCP approach, many teleconnection patterns are identified, which go beyond the traditional teleconnection patterns due to ENSO, El Niño Modoki, AMO and IOD.
- The potential of SVR is appreciable but the GM-Copula approach gives superior prediction performance for rainfall over EJ and WJ. This may be due to the establishment of conditional independence structure among the variables that prunes the redundant information in the predictor pool.
- Satisfactory prediction performance of is obtained for both the regions and for all the months of both the seasons with a slightly better performance in summer.

Further reading:
Maity, R., K. Chanda, R. Dutta, J.V. Ratnam, M. Nonaka, S. Behera (2020), Contrasting features of hydroclimatic teleconnections and the predictability of seasonal rainfall over east and west Japan, Meteorological Applications, Royal Meteorological Society (RMetS), In Press, doi: DOI:10.1002/met.1881.

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THANK YOU