Prediction of SST fronts using a Recurrent Neural Network (RNN) in the South Sea of Korea

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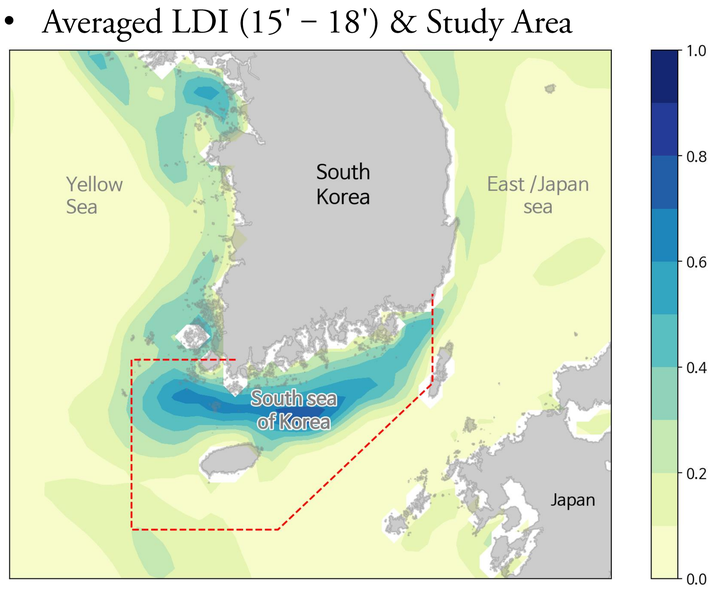
Abstract

- This study aims to identify the distribution of SST fronts and to predict them using an RNN method in the South Sea of Korea.
- In the South Sea of Korea, the main focusing region in this study, the cold coastal waters and the Kuroshio-originated warm waters meet to form the fronts there. In addition, when the southwesterly wind prevails in summer, the upwelling fronts appear.
- We apply a front detection method using line density index (LDI) to the SST daily data from OSTIA in the South Sea of Korea based on Choi et al. (2010).
- Then, the SST fronts represented by LDI are predicted by using an RNN method.

Study area & Data

- In South Sea of Korea, the study area, SST fronts are occurring frequently and intensely.
- OSTIA satellite observation data were used for detecting SST fronts.
- Data to predict the Fronts were from OSTIA, ERA5, GEPCO, NAOJ99, and HYCOM.

• Averaged LDI (15' – 18') & Study Area



	Resolution		Component	Processed Data	Usage
	Spatial	Temporal			
OSTIA	1/20°	1day	SST	Daily LDI	Output
ERA5	1/4°	1hr	Wind	Daily mean U, V	Input
GEPCO	1/120°	-	Topography	Topography	
NAOJ99	1/12°	-	Harmonic constant	Complex Demodulated Tide	
HYCOM	1/12°	3hr	Water temperature	Daily mean W. Temp.	
			Water velocity	Daily mean U, V	
			Salinity	Daily mean S.	

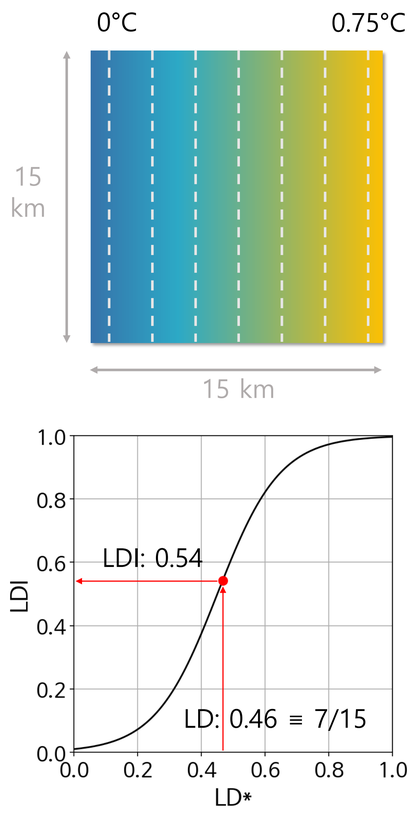
Method 1. SST Fronts Detection

- $LD^* = \frac{Total\ line\ length\ (km)}{Area\ (km^2)} \times TI \times 10$
- $LDI = Sigmoid(LD^*, Slope, X_h)$

$$= \frac{1}{1+\exp(-Slope(LD^* - X_h))}$$

- TI : *Isothermal lines interval*
- $Slope = \ln 99 / X_h$
- $X_m = 99 percentile\ of\ LD^*\ data \approx 0.9$
- $X_h = \frac{X_m}{2}$

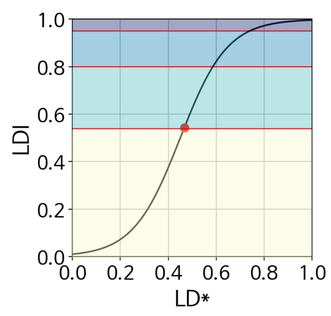
- The SST fronts around Korean peninsula and the mid-latitudes distributes between 0.05 – 0.3 ˚C/km (Choi, 2010).
- In a square grid, which is 15 km long, assuming water temperature changes by 0.05˚C/km with TI= 0.1˚C, 7 isothermal lines are displayed.
- At the time of SST fronts generation, LD is 7/15 (km/km^2), which is converted to LDI as 0.54.



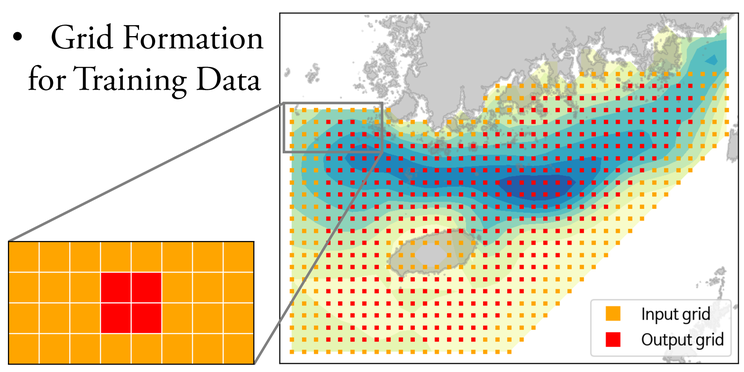
Method 2. SST Fronts Prediction

• SST Fronts Grade

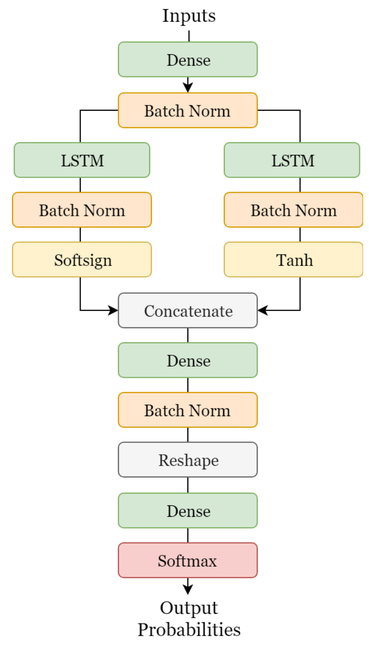
Fronts Strength	LDI Range
Strong	0.95 ≤
Moderate	0.80 – 0.95
Weak	0.54 – 0.80
None	< 0.54



• Grid Formation for Training Data



• Model Structure



• Model Setting

➢ Dataset

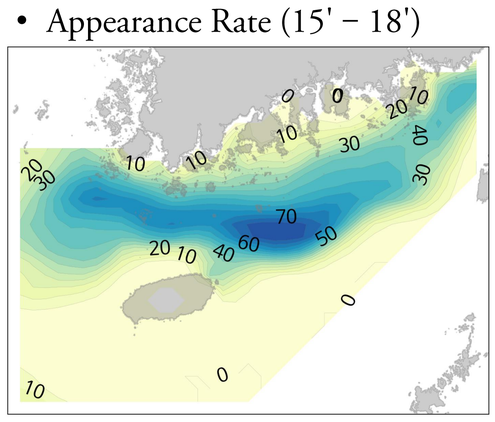
Data	Cut off Criteria
Train & Valid	From 8th day to the end of each month
Test	Up to 7th day of each month

➢ Input, Output Information

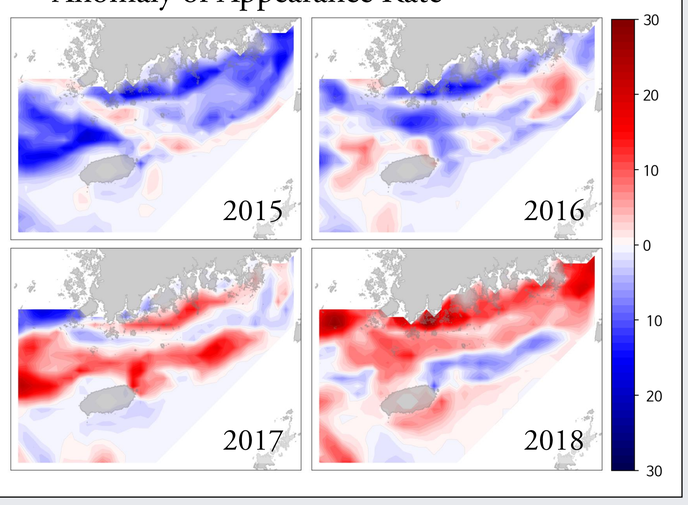
Input	Output	Input t-steps	Out of date (single step)
ERA5, GEPCO, NAOJ99, HYCOM's data, and LD	Fronts Strength	4(D-3 – D-day)	D-day – D+2

Result 1. Distribution of SST Fronts

• Appearance Rate (15' – 18')



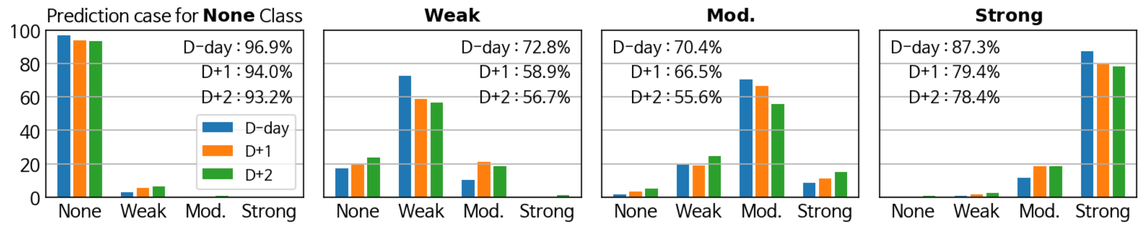
• Anomaly of Appearance Rate



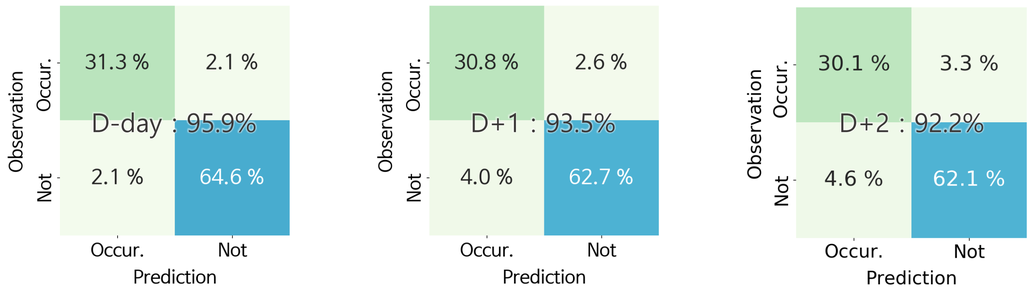
Result 2. SST Fronts Prediction (In Test case)

• Predictive Accuracy

➢ SST Fronts Strength



➢ Occurrence of SST Fronts



Conclusion

- By using LDI algorithm, the strength of SST front can be expressed quantitatively.
- Predictive accuracy for the occurrence of SST front remains over 90% until 2 days after.
- We expect our prediction model would be able to show a better performance by adopting optimized numerical model outputs