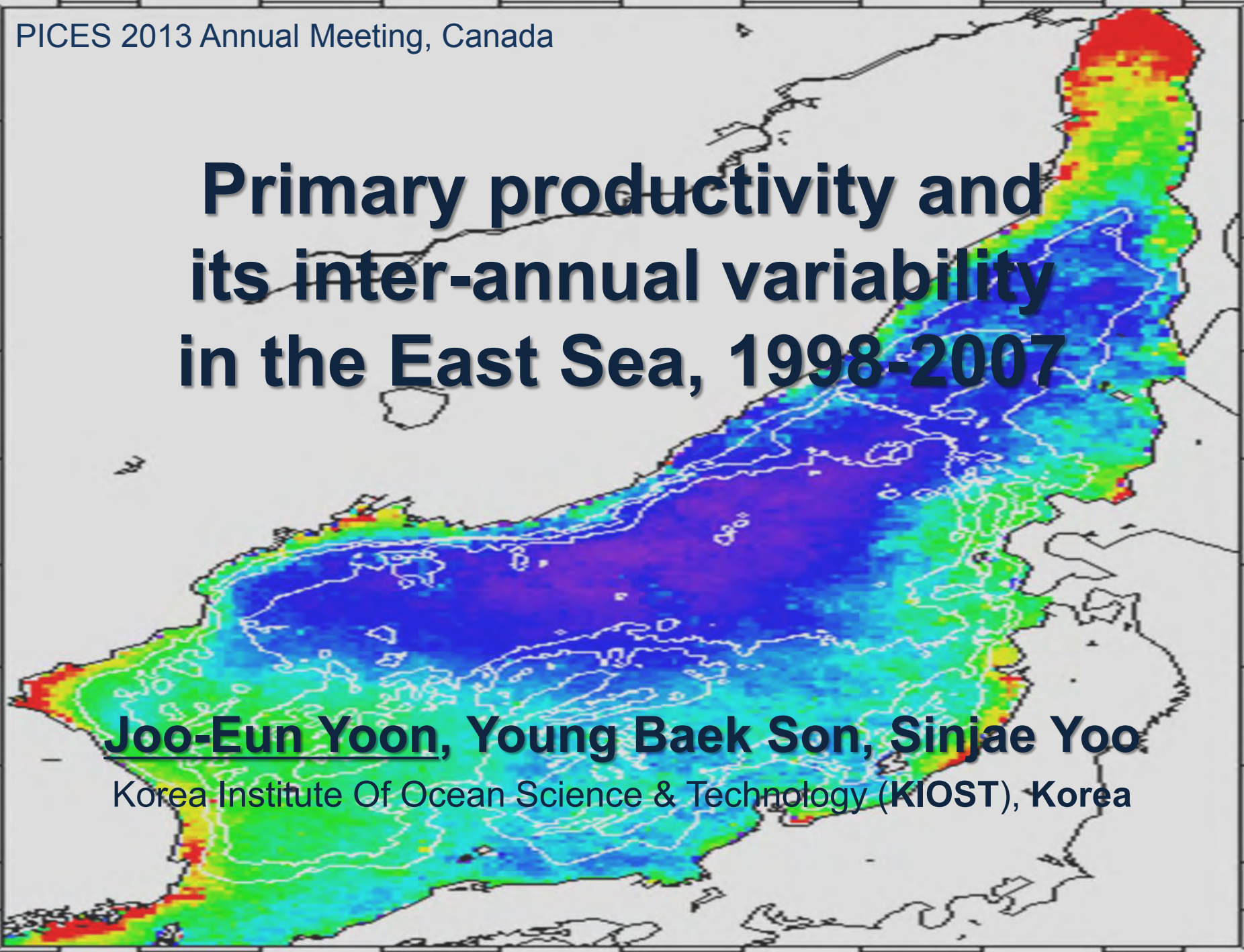
PICES 2013 Annual Meeting, Canada

Primary productivity and its inter-annual variability in the East Sea, 1998-2007

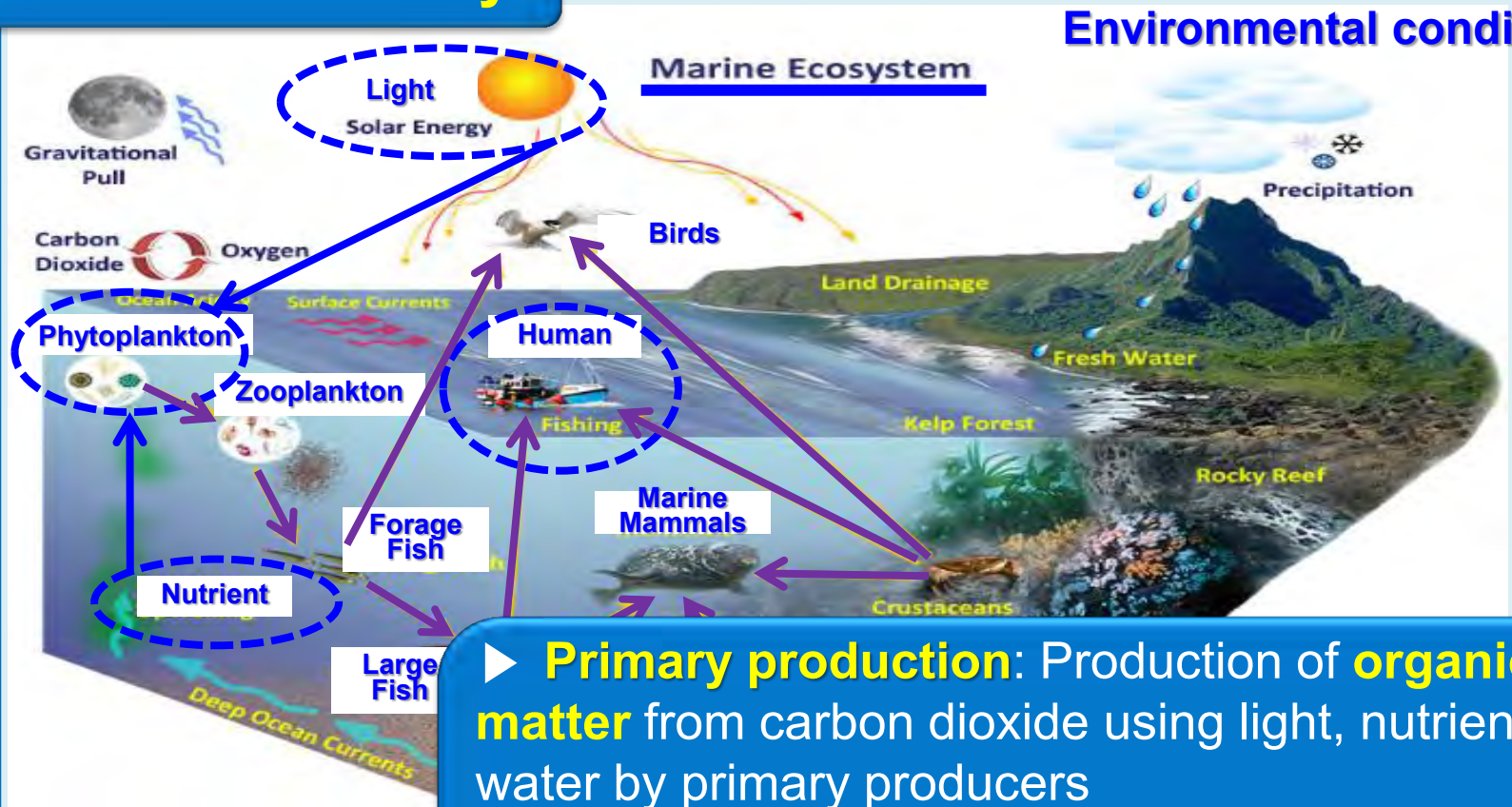


Joo-Eun Yoon, Young Baek Son, Sinjae Yoo

Korea Institute Of Ocean Science & Technology (**KIOST**), **Korea**

Climate variability and primary productivity

Climate variability



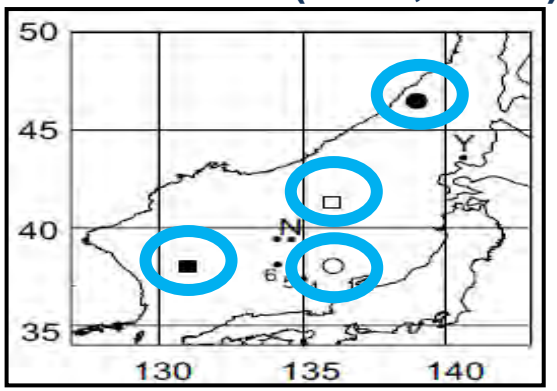
▶ **Primary production**: Production of **organic matter** from carbon dioxide using light, nutrient, and water by primary producers

- **The base of ecological energy transfer**

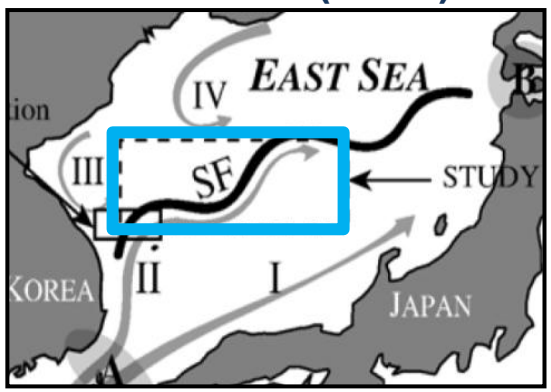
▶ It is important to understand how **climate variability is linked to primary productivity**

Previous studies

Yamada et al (2004, 2005)



Kim et al (2007)



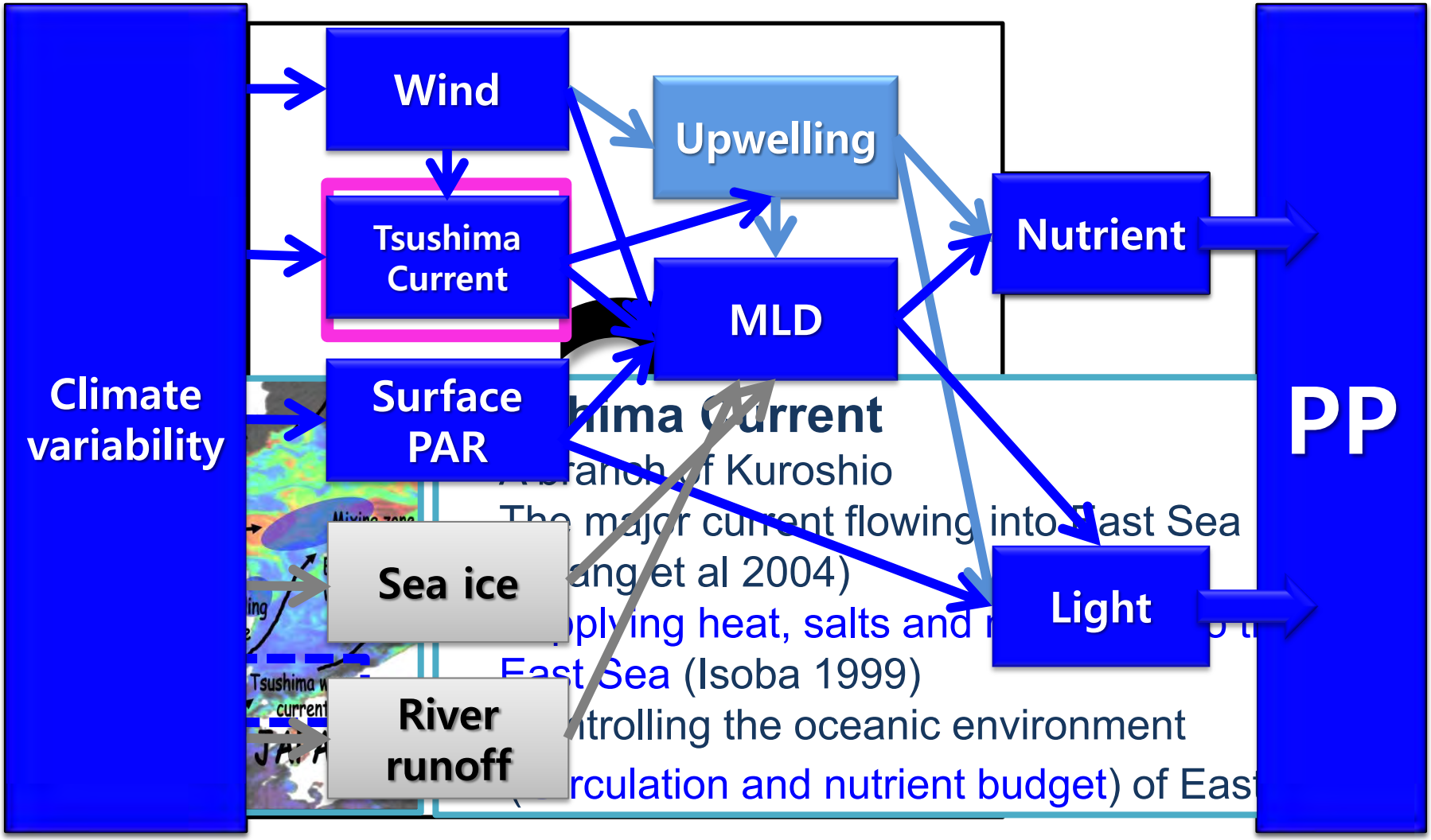
" Relationship between phytoplankton blooming and wind speed"

The limitations

1. **Areas** - Four locations and sub-polar front
2. **Physical factors** – Wind speed and MLD
3. **Study period** - Five year
4. No relationship with climate variability

→ We do not understand sufficiently **how climate variability is linked to primary productivity** in the East Sea

How is the climate variability linked to primary productivity in the East Sea?



Objective

In this study,
We attempt to understand how the inter-annual variability of primary productivity is linked to the physical factors and climate variability in the East Sea for 1998-2007 periods

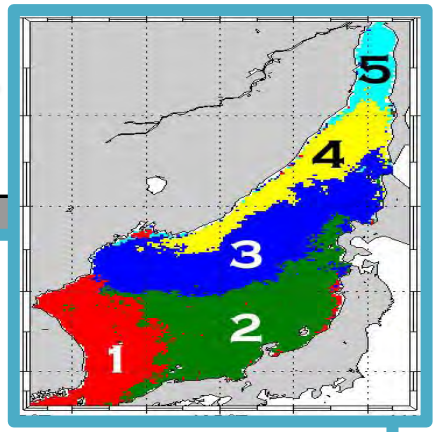
Data & Methods (1)

SeaWiFS L3 monthly 9km AVHRR L3

CHL, Surface PAR, Euphotic depth + **SST** → **KI algorithm** (Kameda and Ishizaka 2005) → **PP**

PP → logarithm, The seasonality was removed → **EOF analysis** Empirical Orthogonal Functions → **EOF 1-7 MODE** Contain 50 % of PP variance

MODE 1-7 → ***k*-means clustering** →



For the five areas,

1. Climate variability – PP
2. Climate variability – Physical factors
3. Physical factors – PP

Different linkages

Data & Methods (2)

Climate indices	
EAWM (East Asian Winter Monsoon)	**Zhou et al 2007**, **Sea level pressure (SLP)** difference between 110–120°E, 20–45°N and 150–160°E, 20–45°N **for wintertime (Dec-Feb)**
SH (Siberian High)	**Panagiotopoulos et al 2005**, **SLP** averaged **for wintertime (Dec-Feb)** over the region 80–120°E, 40–65°N
MEI (Multivariate ENSO Index)	**Wolter and Timlin 1993**, The first unrotated Principal Component (PC) of **all six observed fields** combined over the tropical Pacific (SLP, the surface wind – U/V, SST, surface air temperature, and total cloudiness fraction of the sky)
AO (Arctic Oscillation)	**Thompson and Wallace 2000**, **SLP** anomalies poleward of 20°N
AL (Aleutian Low pressure)	**Beamish et al 1997**, The mean area (km2) with **SLP** lower than or equal to 1005 hPa **for wintertime (Dec-Mar)**
PDO (Pacific Decadal Oscillation)	**Trenberth and Hurrell 1994**, The leading PC of North Pacific **monthly SST** variability poleward of 20°N

Data & Methods (3)

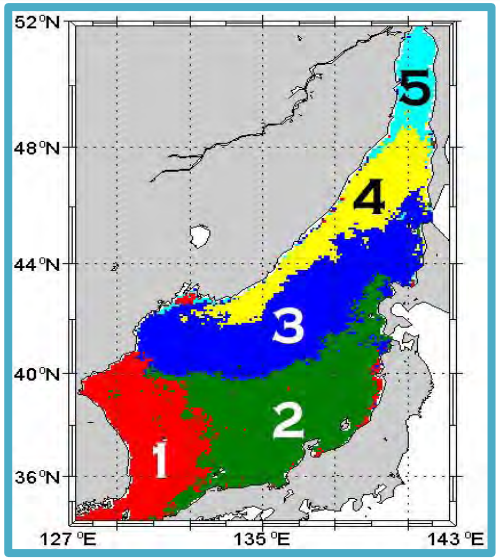
Physical factors	
MLD (Mixed Layer Depth)	**Estimating the Circulation and Climate of the Ocean, Phase II (ECCO2)** Monthly 1/8 degree, **Temperature, Salinity data** **Definition by de Boyer Montegut et al 2004**
Wind speed	**Special Sensor Microwave/Imager (SSM/I)** NASA, Monthly 25 km
Surface PAR	**SeaWiFS**, NASA L3 Monthly 9 km
Volume Transport of Tsushima Current	**Fukudome et al 2010** Acoustic Doppler current profiler (ADCP) data

Results & Discussion

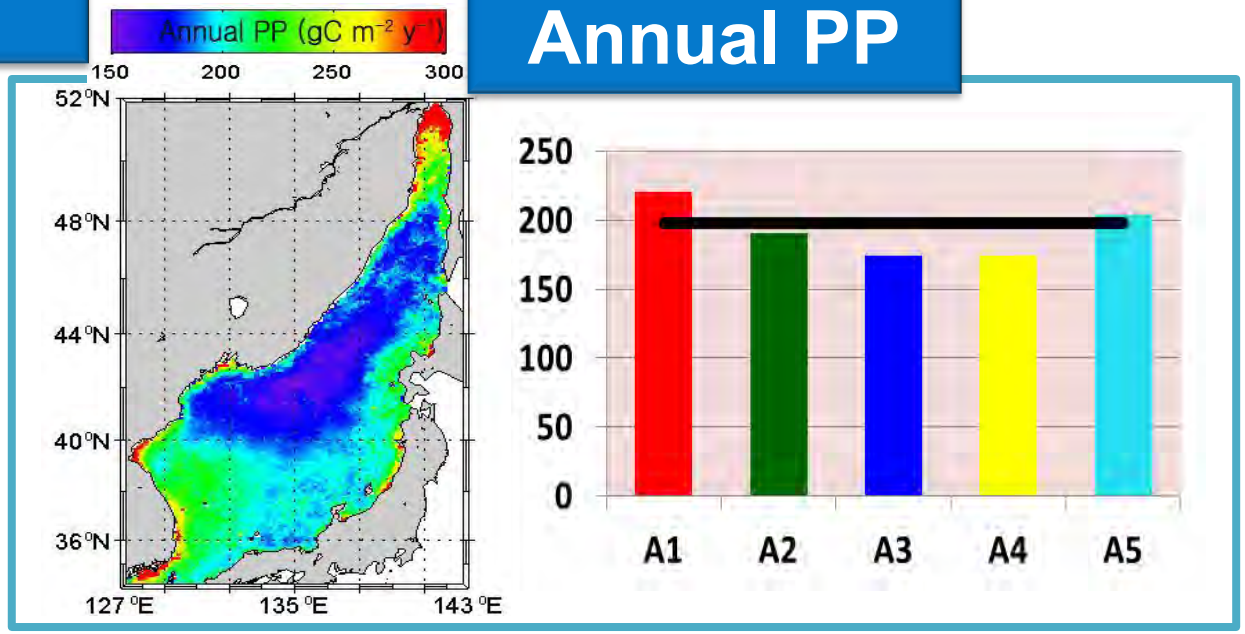
Results & Discussion

5 Areas

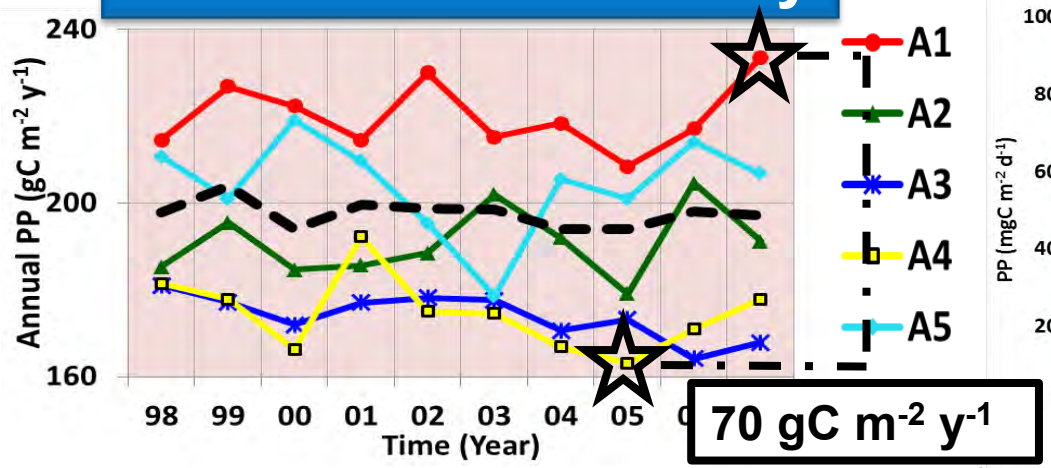
Classified by EOF analysis and *k*-means clustering



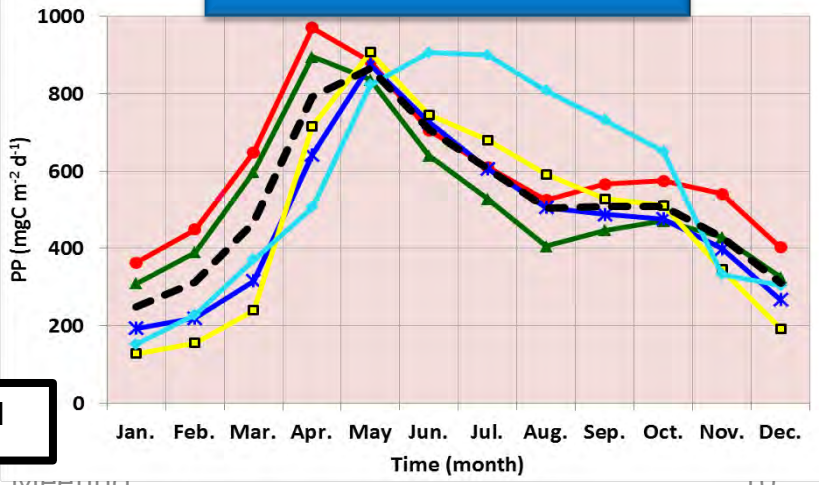
Annual PP



Inter-annual variability



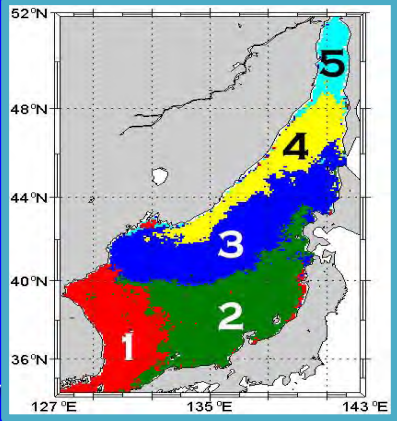
Seasonal PP



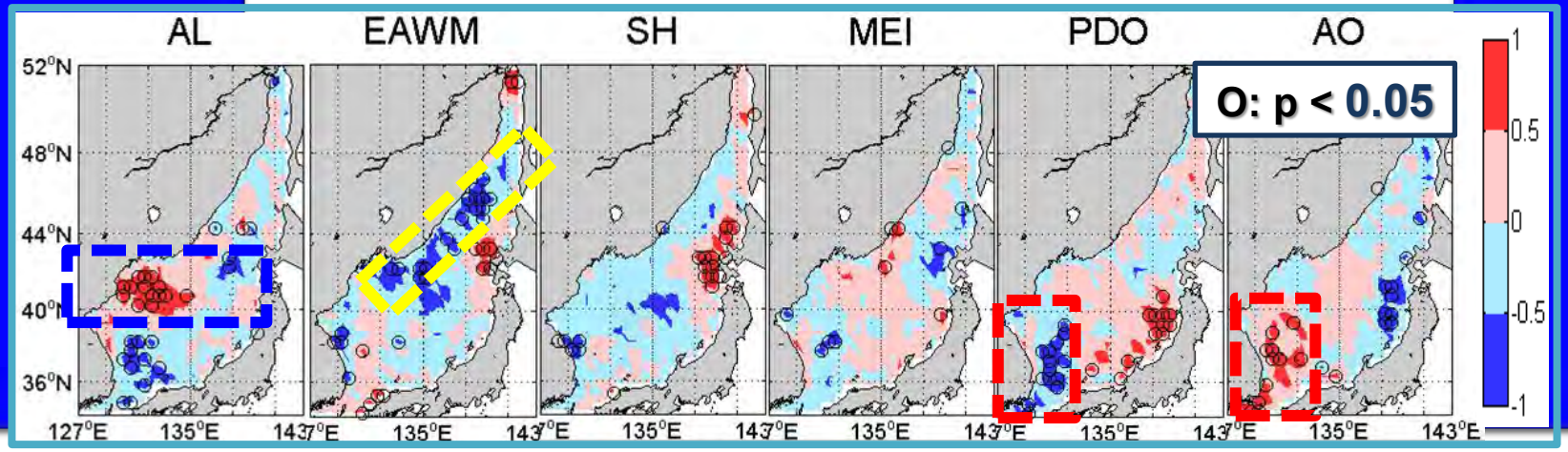
Winter climate variability & Annual PP

Correlation between
Winter climate variability & Annual PP

Non-parametric method (Spearman's correlation)

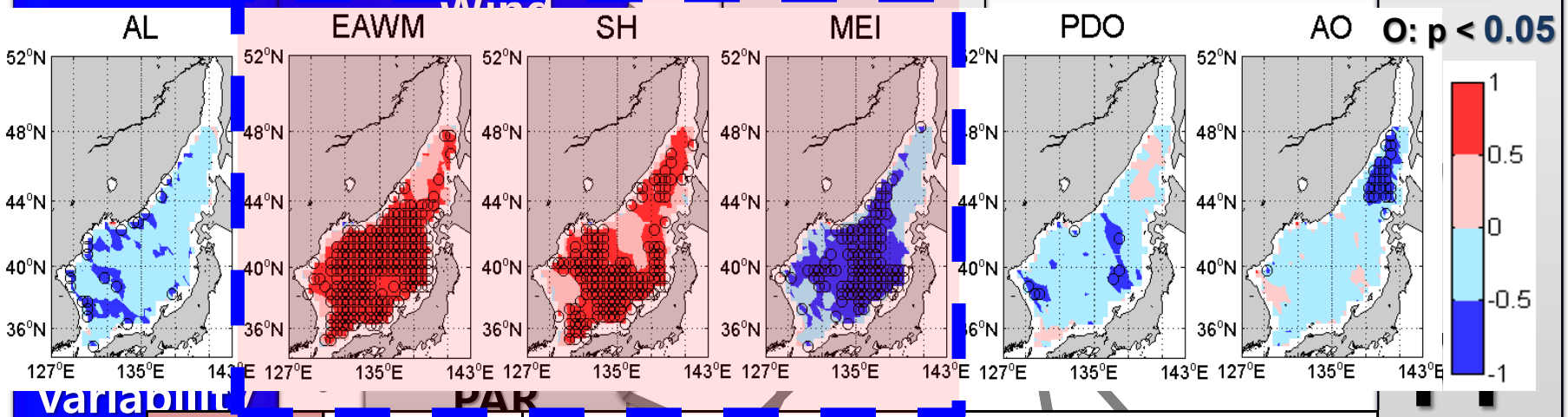


p<0.01 / p<0.05 / p<0.1	Dec.-Mar.	Dec.-Feb.				
	AL	EAWM	SH	MEI	PDO	AO
A1	-0.346	0.042	-0.418	-0.321	**-0.636**	**0.685**
A2	-0.188	0.091	-0.091	0.006	0.321	-0.152
A3	**0.709**	-0.515	-0.212	0.285	0.164	0.055
A4	0.079	**-0.855**	-0.430	0.164	0.236	-0.115
A5	-0.321	0.176	0.285	-0.297	-0.042	-0.212



Winter climate variability & Wind speed

Correlation between
Winter climate variability & Wind speed (Feb-Apr)

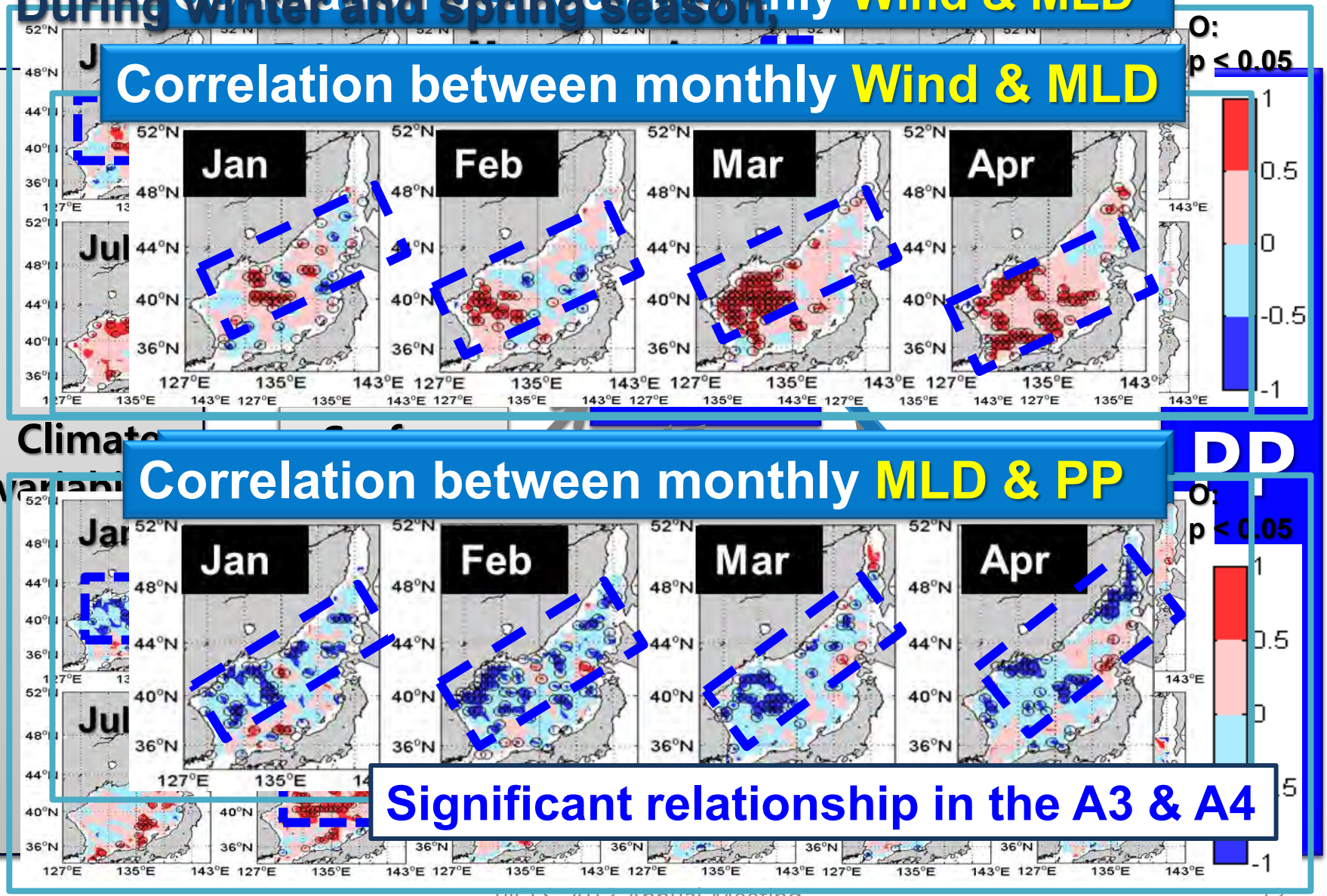


p<0.01	Dec-Mar	Dec-Feb				
p<0.05 / p<0.1	AL	EAWM	SH	MEI	PDO	AO
A1	-0.552	0.794	0.685	-0.576	-0.321	-0.212
A2	-0.406	0.794	0.830	-0.758	-0.467	-0.090
A3	-0.515	0.733	0.649	-0.527	-0.370	-0.200
A4	-0.406	0.661	0.685	-0.467	-0.139	-0.430
A5	-0.358	0.479	0.709	-0.600	-0.261	-0.249

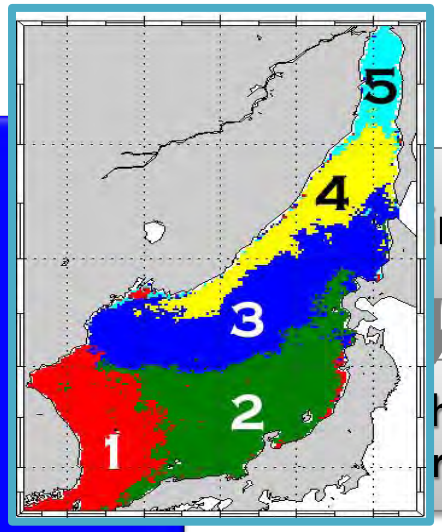
MLD

During winter and spring season,

Correlation between monthly Wind & MLD



Surface PAR



Winter climate variability & Surface PAR

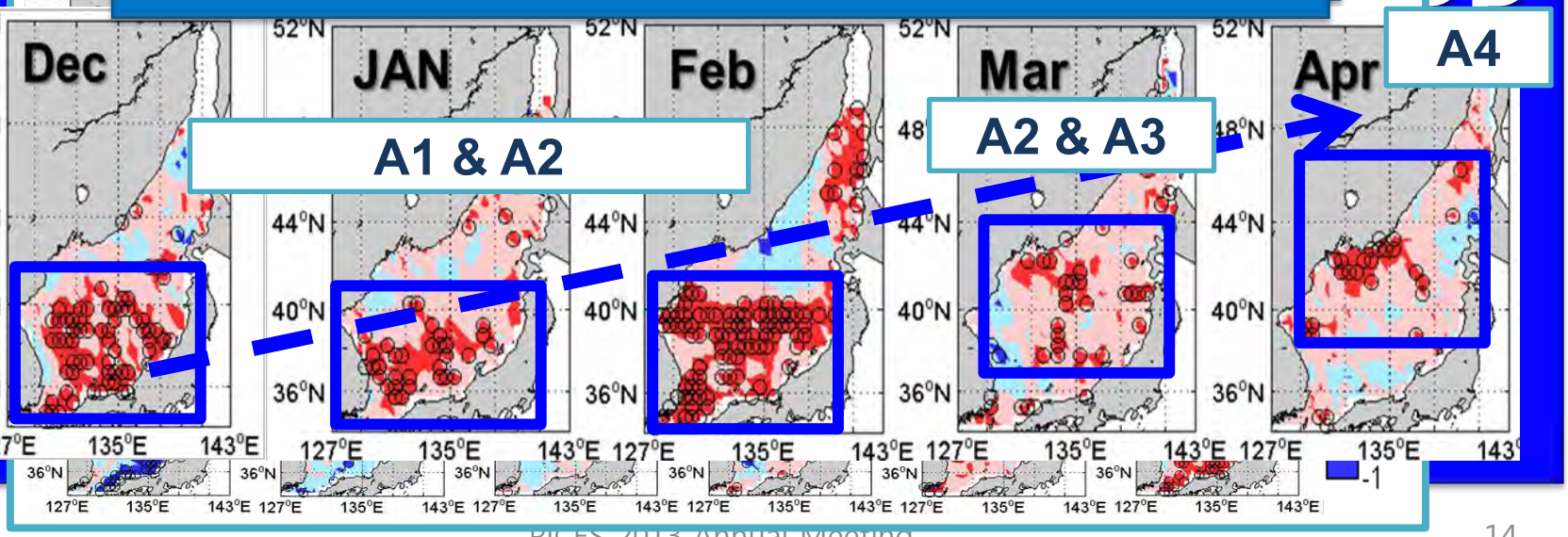
Significant relationship ($p<0.05$)

Feb: SH, EAWM ------ (-)

Mar: AL, MEI ------ (+)

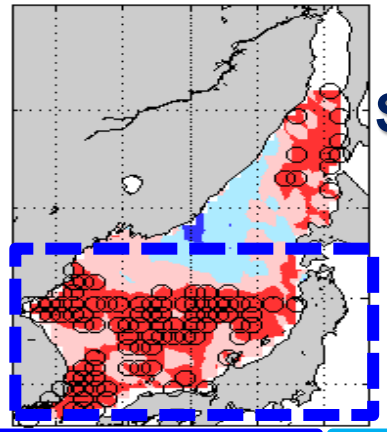
Apr: SH ------ (-)

Correlation between Surface PAR & PP



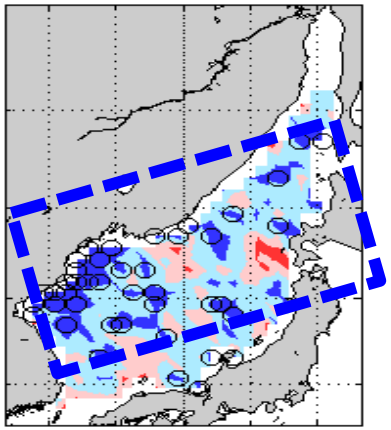
Light limitation

During winter season (Feb),



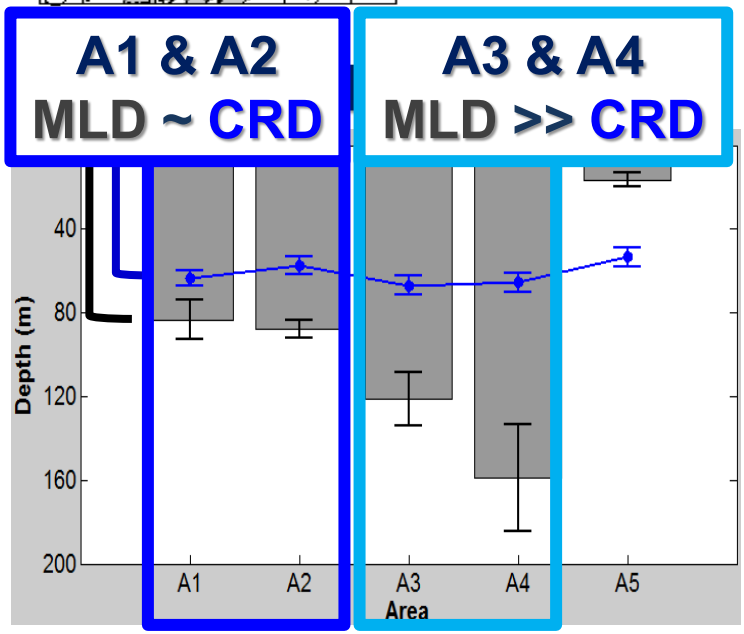
Surface **PAR & PP**

Southern Area
A1 & A2



MLD & PP

Northern Area
A3 & A4

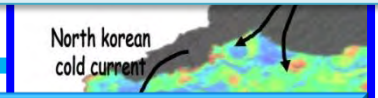


During winter season,
For MLD > CRD
(Light is limited)

MLD ~ CRD : PP ∝ Surface PAR

MLD >> CRD : PP ∝ 1/MLD

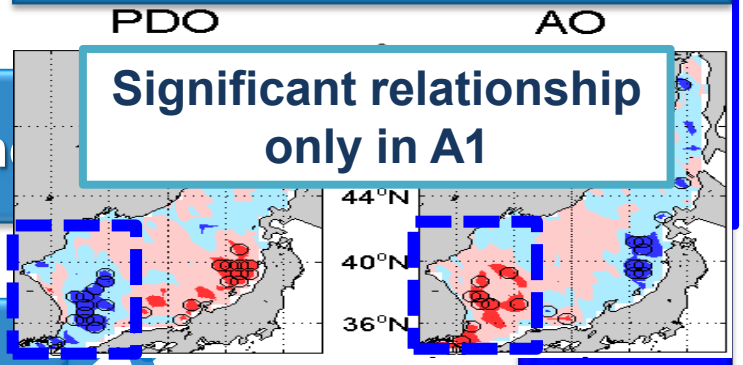
Tsushima Current



Correlation between Climate variability & Volume transport

p<0.01 p<0.05 p≤0.1	The Significant relationship with AO and PDO					
	Jan	Mar	Apr	Jul	Aug	Dec
AO	0.553		0.683		-0.600	0.633
PDO		-0.691		-0.594		

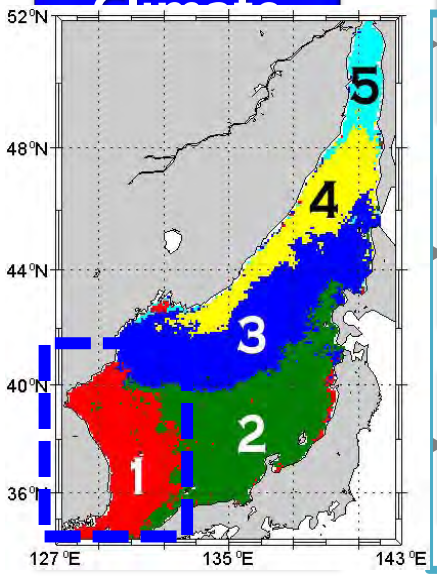
Winter climate variability & Annual PP

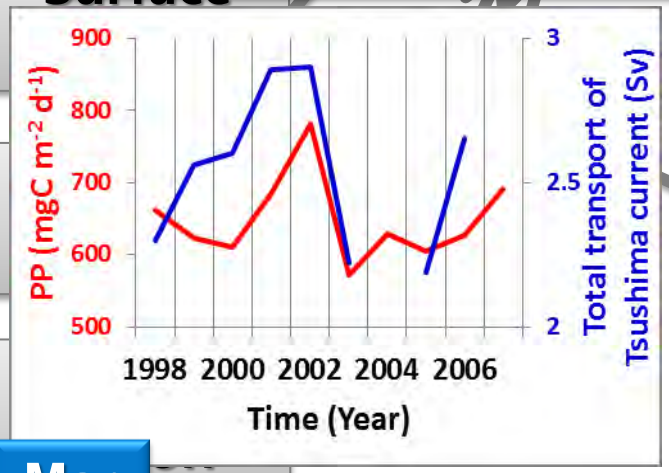


Significant relationship only in A1

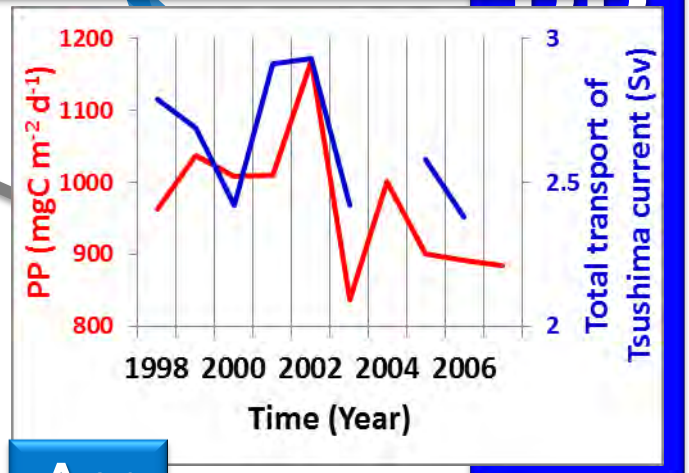
MLD

Correlation between PP & Volume transport (A1)





Mar r=0.806, p<0.05

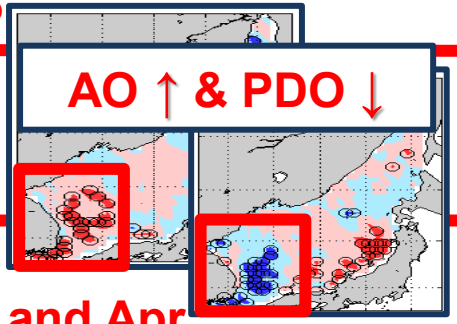


Apr r=0.767, p<0.05

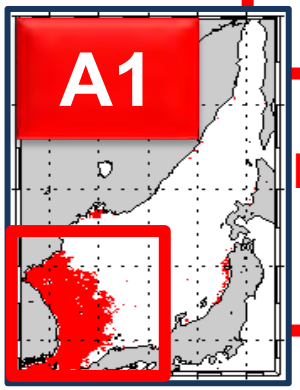
A schematic summary of the linkages between the climate variability, physical factors and primary productivity in the East Sea for 1998-2007 periods

Summary

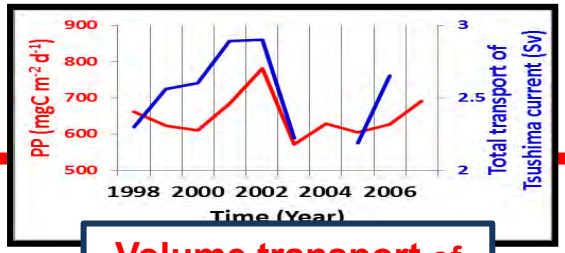
For annual PP



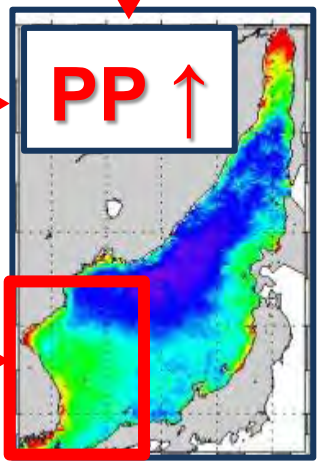
AO ↑ & PDO ↓



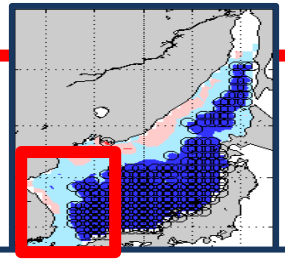
In Mar and Apr



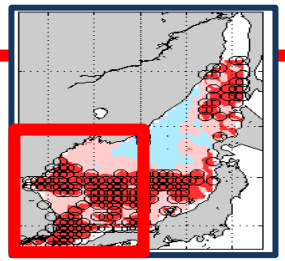
Volume transport of Tsushima Current ↑



In winter (Dec-Feb)

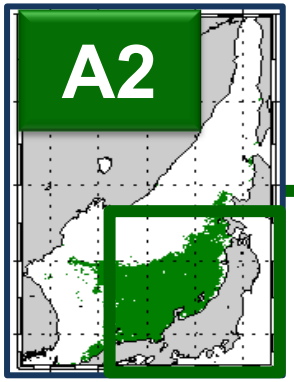


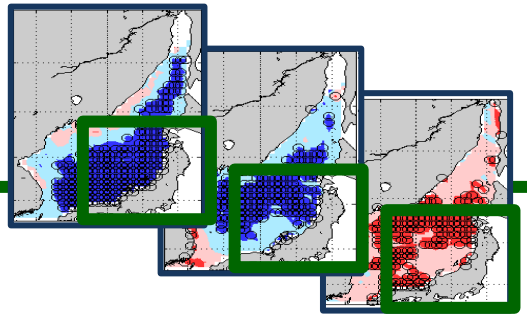
SH ↓ → surface PAR ↑



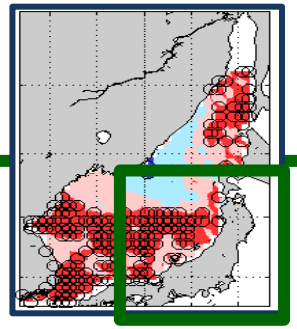
Surface PAR ↑

In winter and early spring (Dec-Mar)

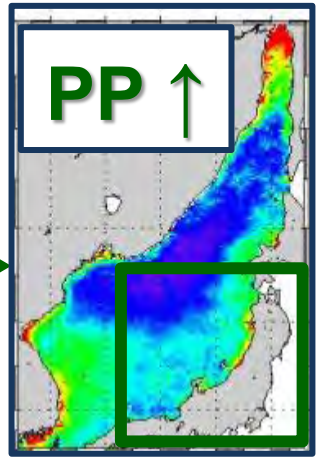




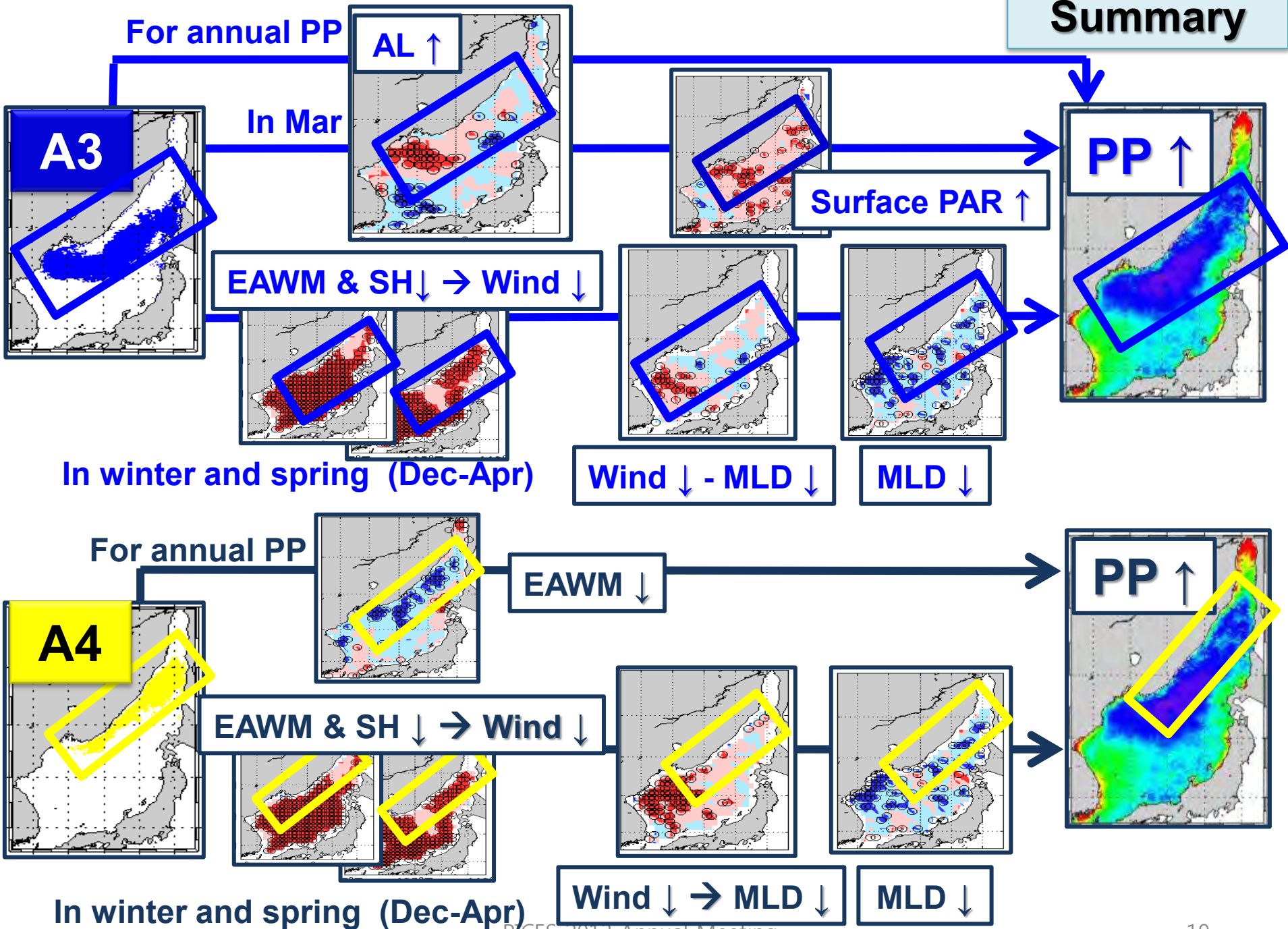
SH & EAWM ↓ and AL ↑
→ Surface PAR ↑

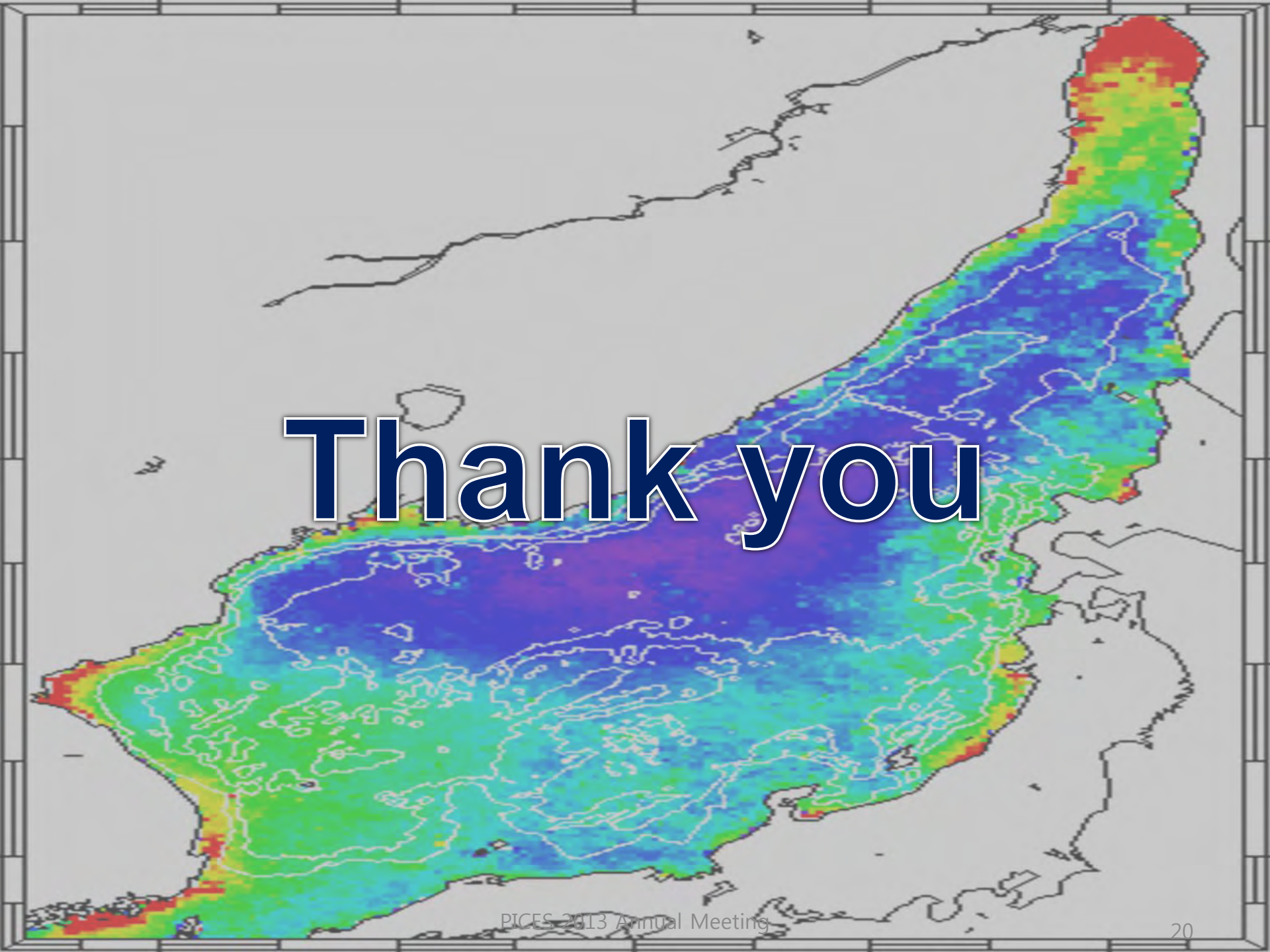


Surface PAR ↑



Summary


For annual PP
AL ↑
A3
In Mar
Surface PAR ↑
PP ↑
EAWM & SH↓ → Wind ↓
In winter and spring (Dec-Apr)
Wind ↓ - MLD ↓
MLD ↓
For annual PP
EAWM ↓
A4
PP ↑
EAWM & SH ↓ → Wind ↓
Wind ↓ → MLD ↓
MLD ↓
In winter and spring (Dec-Apr)


Thank you