Adaptive improvement of habitat suitability index (HSI) model for neon flying squid in central North Pacific by using ocean forecasts and real-time fishery reports

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outline

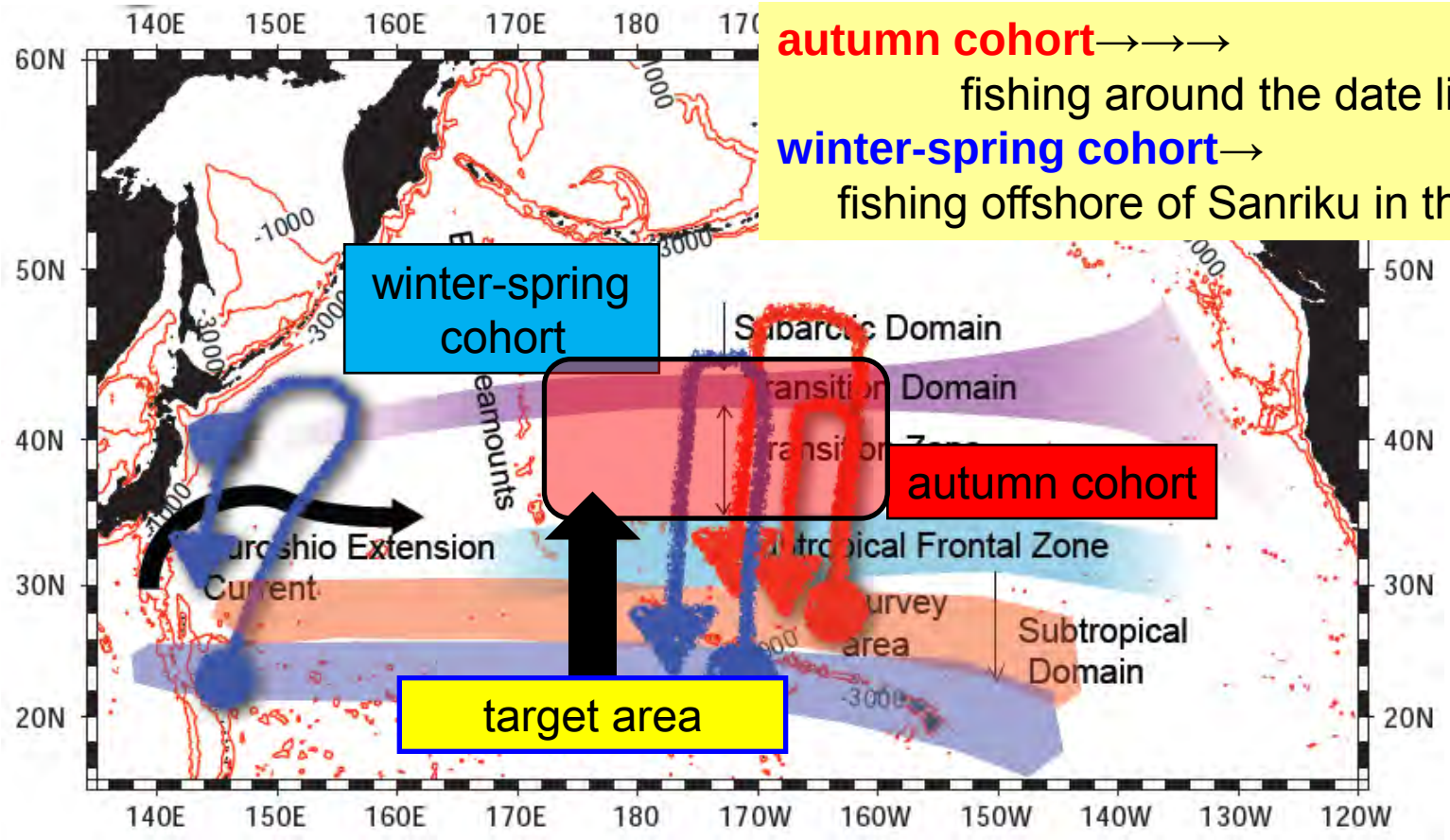
1. Introduction
2. Purpose
3. Methodology – model construction
4. Results
5. Concluding remarks

neon flying squid

(*Ommastrephes bartramii*)

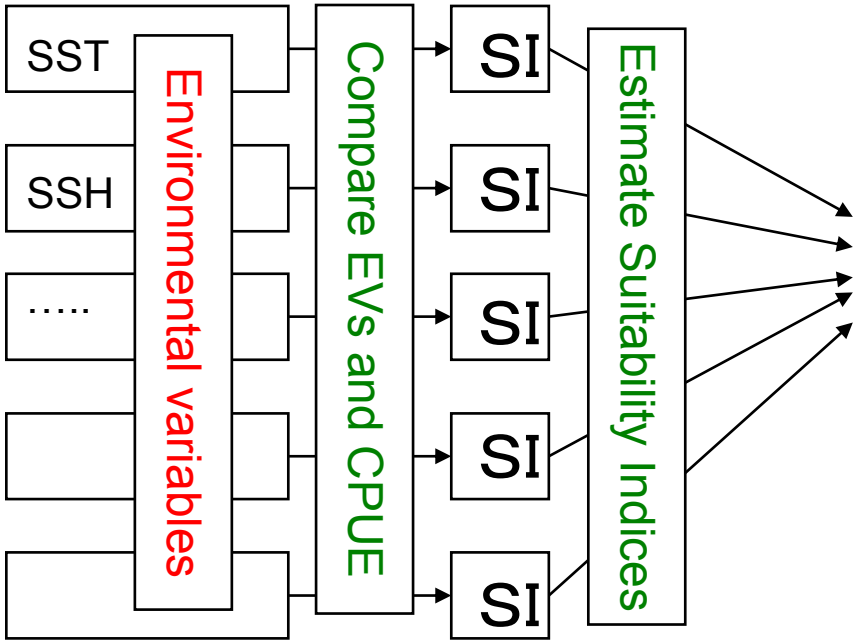
- **widely distributed in the North Pacific**
- **1-year lifespan and seasonal migration**
- **important for pelagic ecosystem and Japanese fisheries**

autumn cohort→→→
fishing around the date line in summer
winter-spring cohort→
fishing offshore of Sanriku in the next winter



Habitat Suitability Index (HSI) model

- is widely used as a tool for ecological impact assessment.
- describes the relations between fish abundance and environmental variables, estimates the level of habitat suitability as an HSI score.

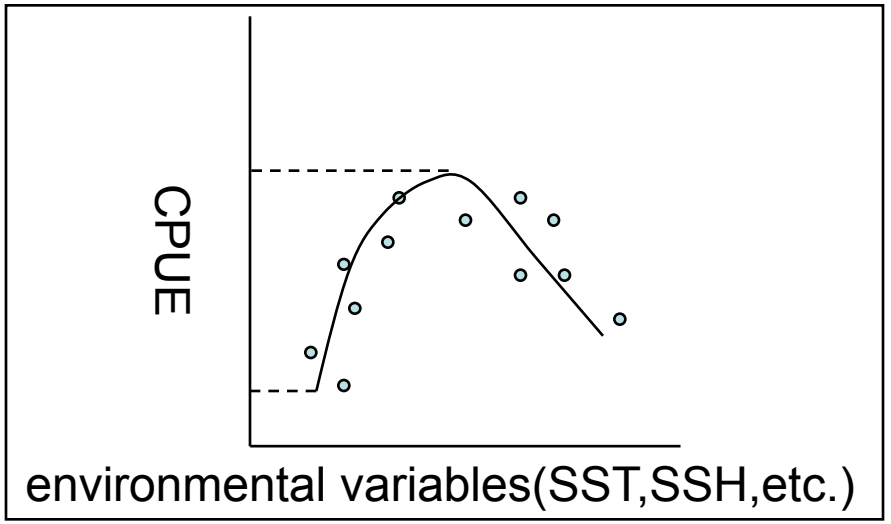


SI：Suitability index

HSI

HSI=f(Si1, Si2, Si3, ・・・)

Habitat Suitability Index



For predicting squid HSI …

HSI model development

squid catch data

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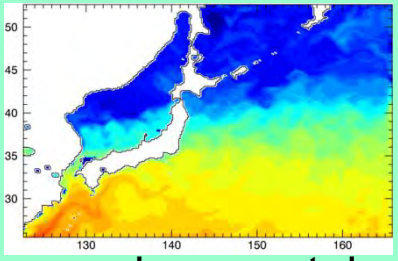
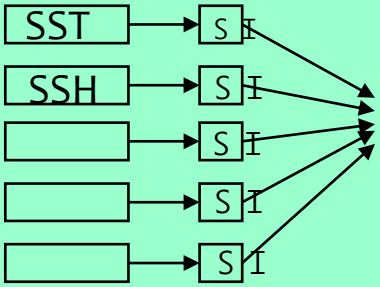
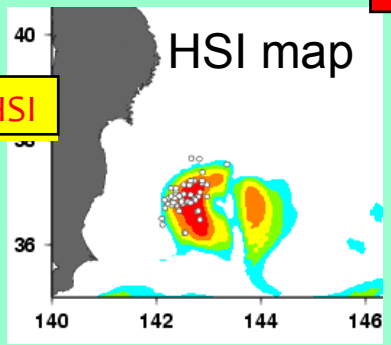


ocean environmental data in the past

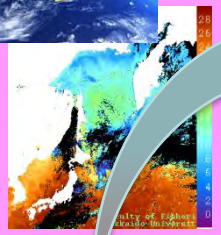
integration analysis

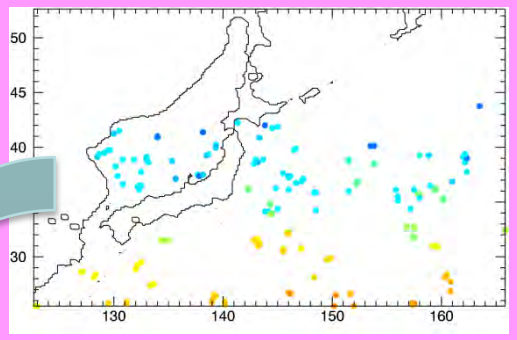




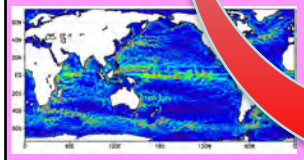
ocean state prediction

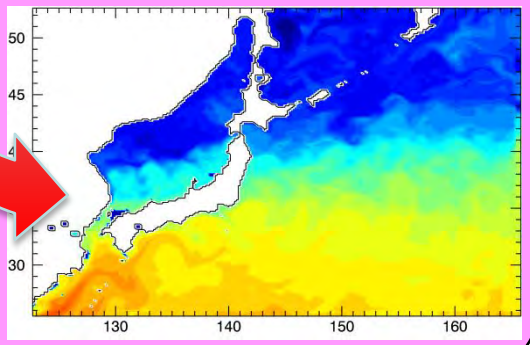
data assimilation & forecast





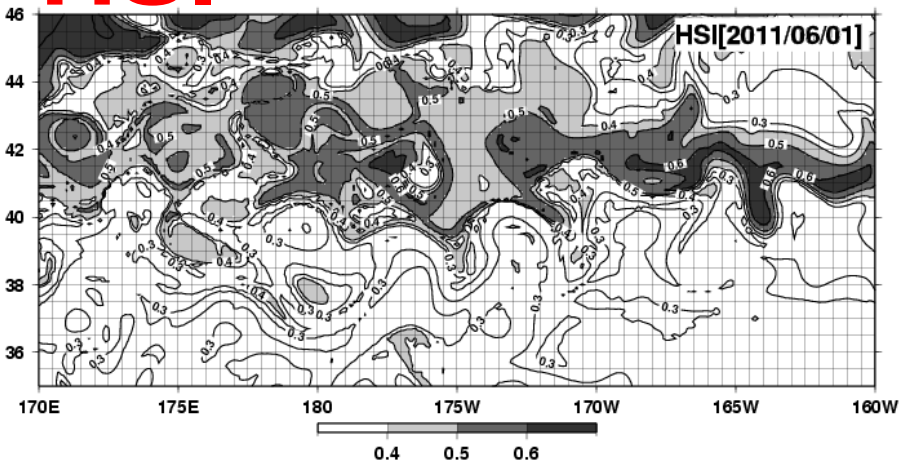
real-time prediction



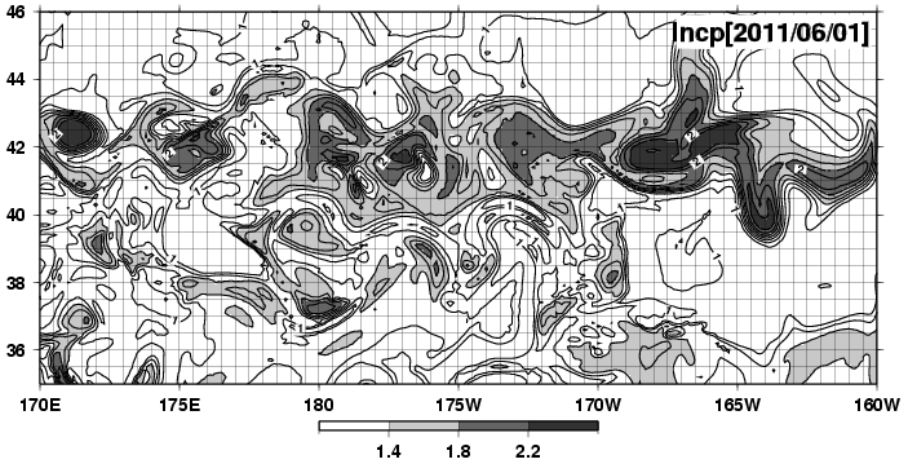


four habitat models

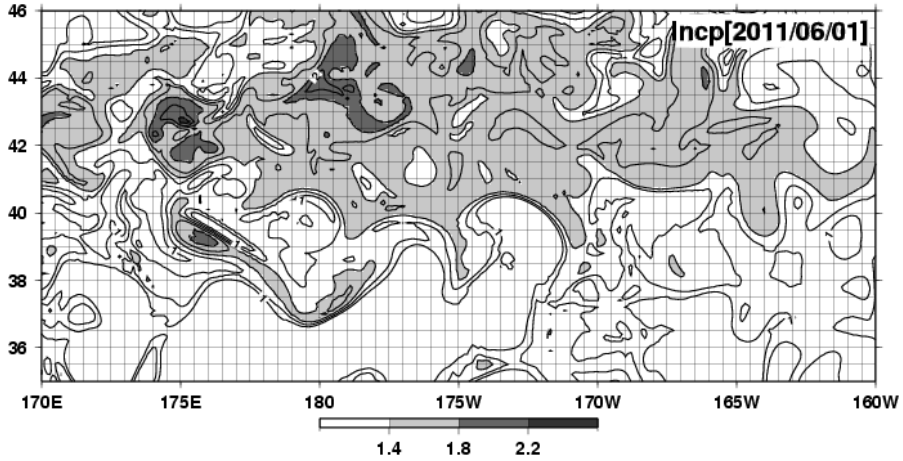
HSI



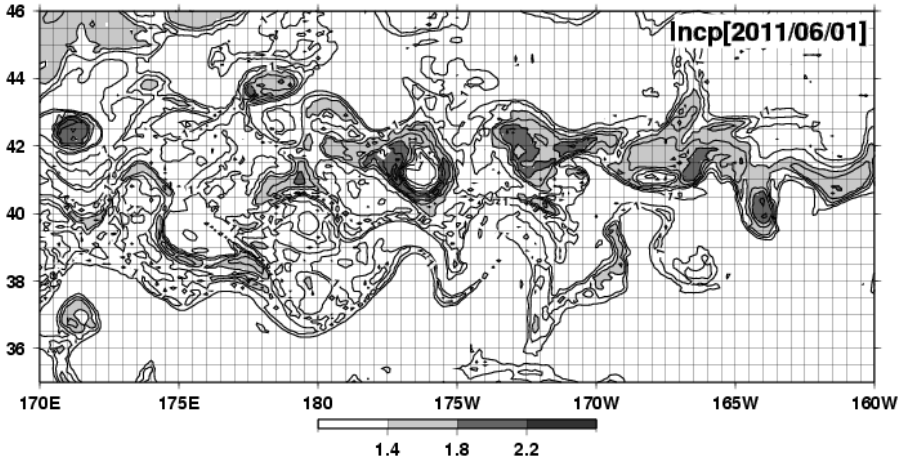
SVM



GAM



RF



Operational prediction and web delivery

satellite

Japanese commercial fishing vessels

cloud server

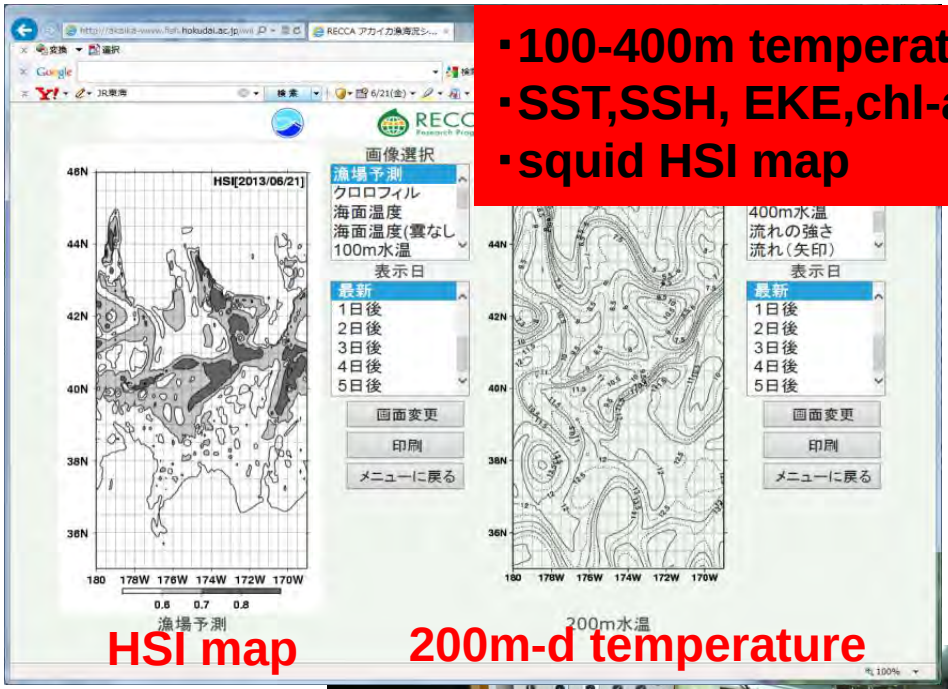
web site

HSI mapping

JAMSTEC OPeNDAP server

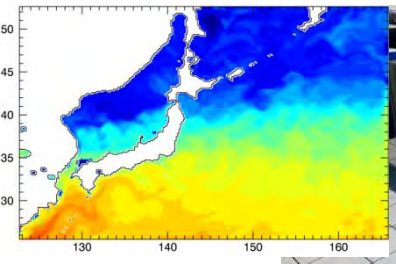
real-time ocean state prediction

- 100-400m temperature
- SST,SSH, EKE,chl-a
- squid HSI map



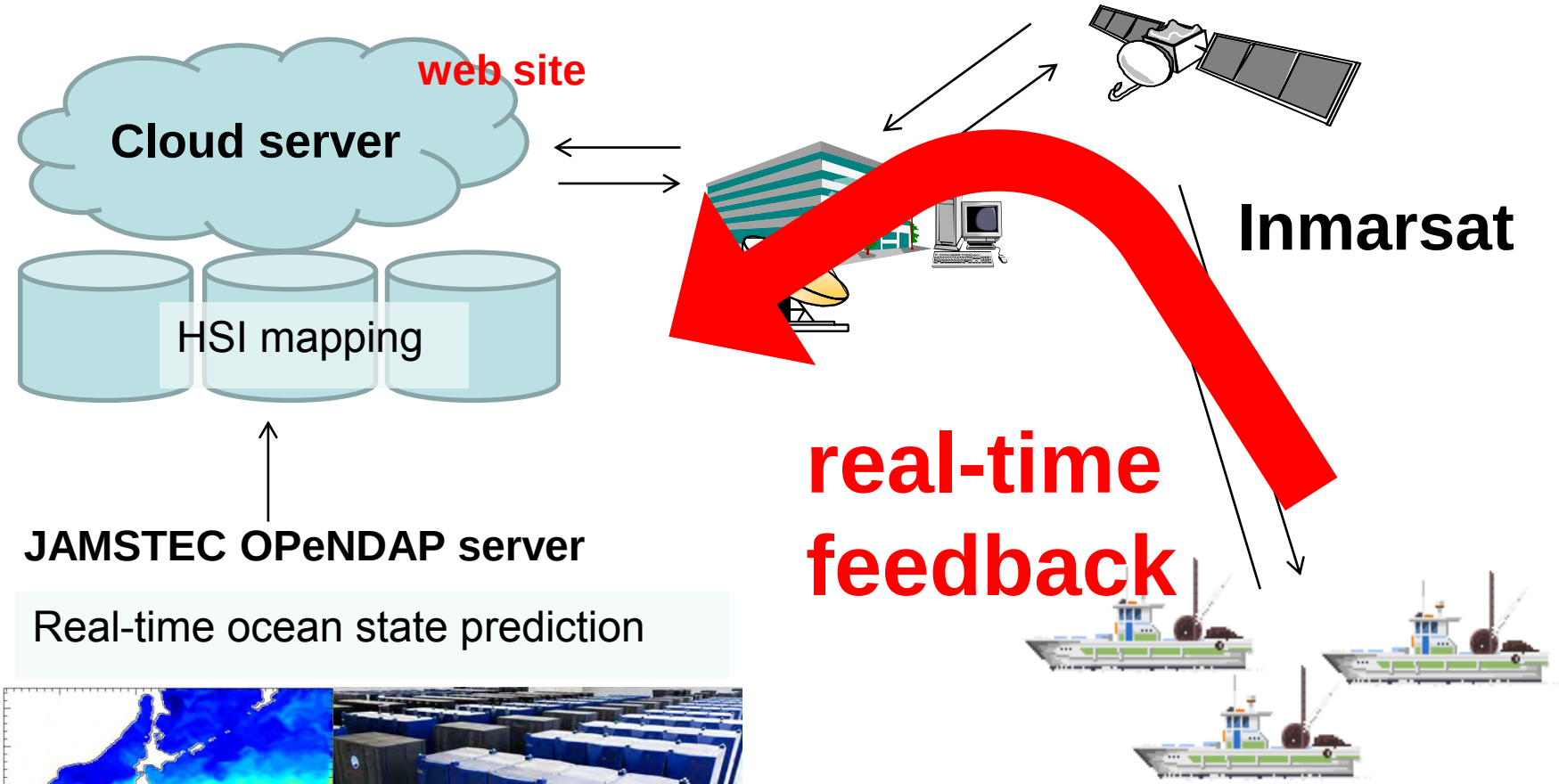
HSI map

200m-d temperature

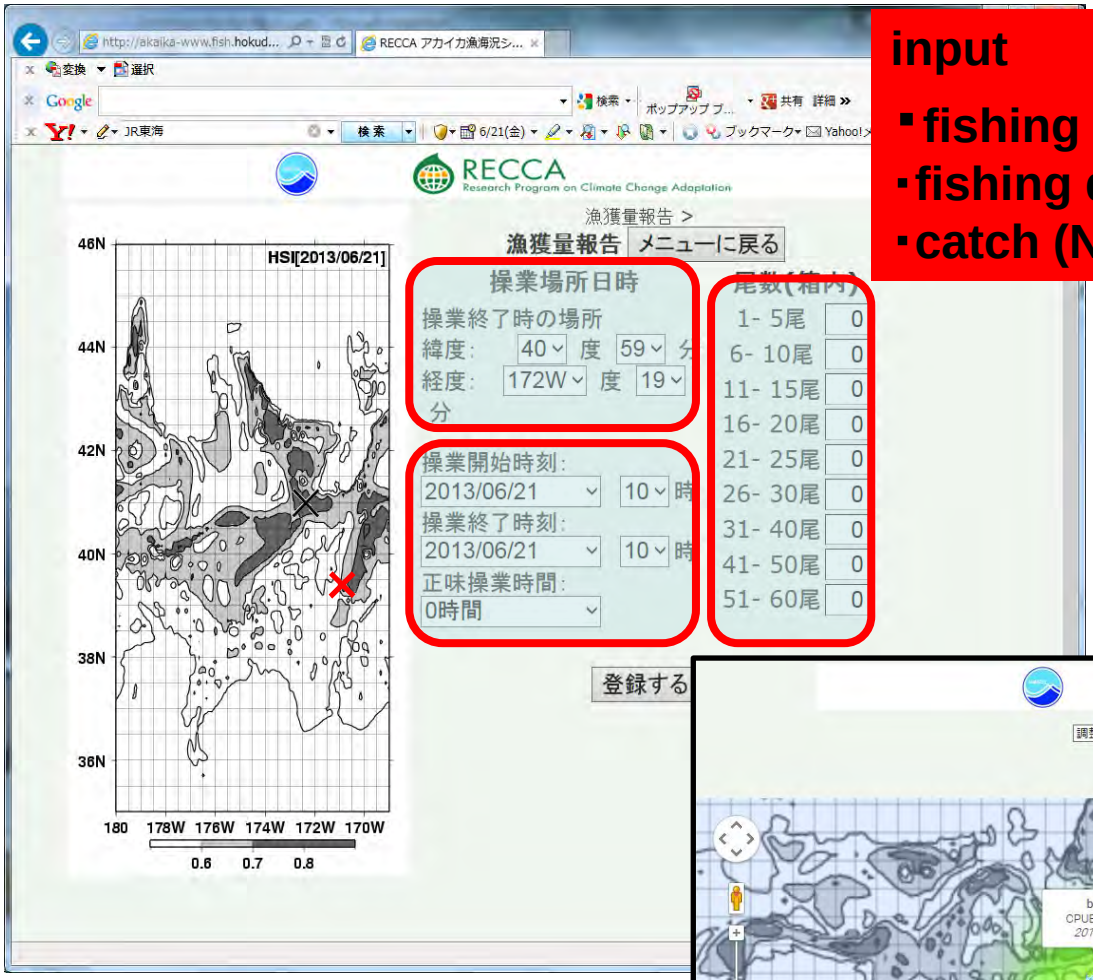


Earth Simulator

operational prediction system for neon flying squid HSI



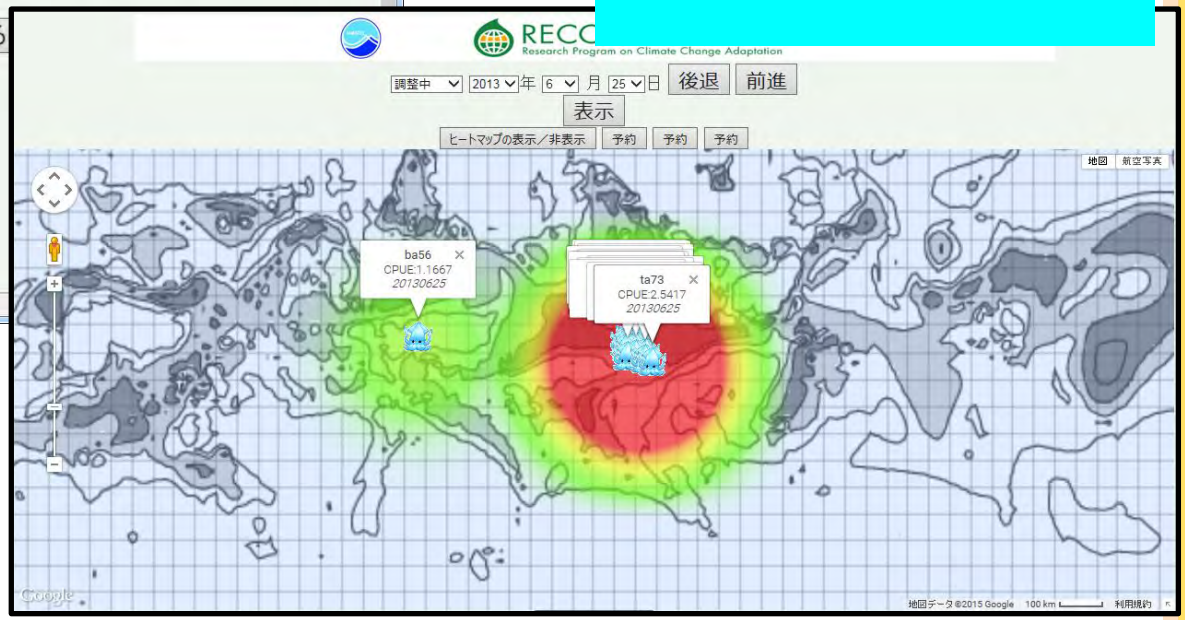
real-time report of squid catch from fishermen



input

- **fishing location (lat.,lon.)**
- **fishing date**
- **catch (N. of boxes)**

monitor and access fishery report data



We would like to make good use of these fishery report data to improve the habitat model.

purpose

- to develop a method of an adaptive improvement of the habitat model for the neon flying squid for practical use using real-time daily fishery report data provided from the squid fishermen

data

- Fishery data

  Commercial fisheries data of neon flying squid
  from June to July during **1999-2012**

  (by Aomori Prefectural Industrial Technology Research Center)

  the dates of fishing, fishing locations, CPUE(No./hour/machine)

- 4D-VAR ocean data assimilation product

  FORA(Four-dimensional variational Ocean ReAnalysis)
  Temperature, Salinity, Current velocity(U,V),
  Sea surface height (0.1deg, vertical 54 levels, daily)

FORA is now available.
http://synthesis.jamstec.go.jp/FORA/e/

methodology

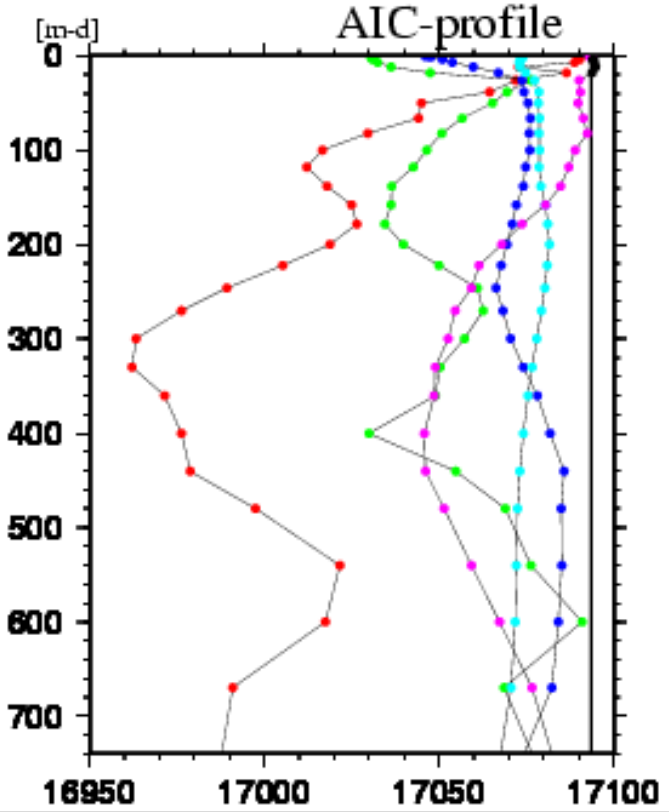
Support Vector Machine (SVM)

$$ln(CPUE) = f(p_1, p_2, \cdots, p_m) + \varepsilon$$

p_i: ocean environmental variables
ε: error

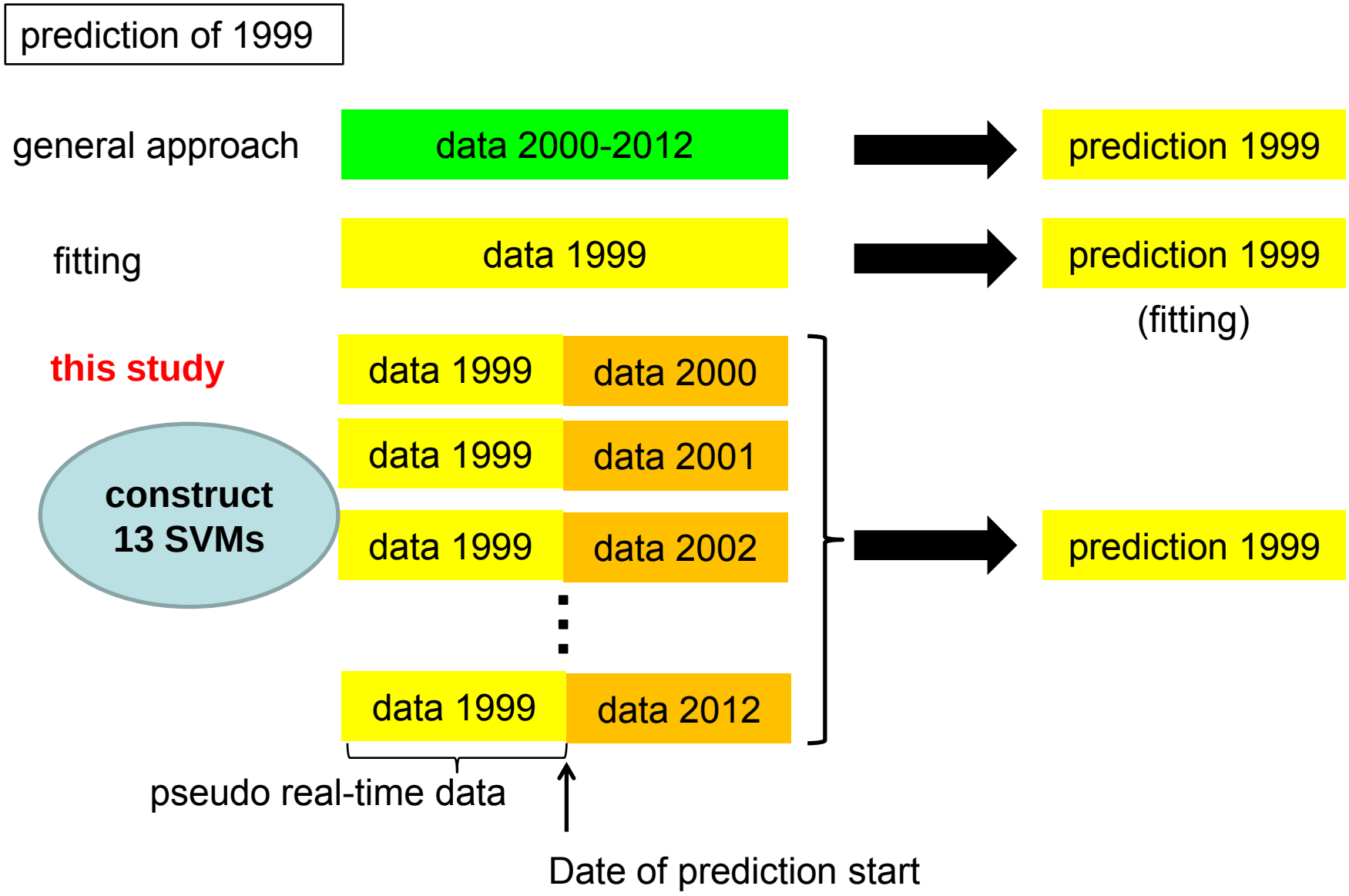
Selected 10 ocean environmental variables

- sea surface temperature (SST)
- sea surface height (SSH)
- horizontal gradient of SSH (∇SSH)
- mixed layer depth (MLD)
- T330m (temperature)
- T118m
- S400m (salinity)
- S178m
- U246m (zonal velocity)
- Vs400m (scalar velocity)

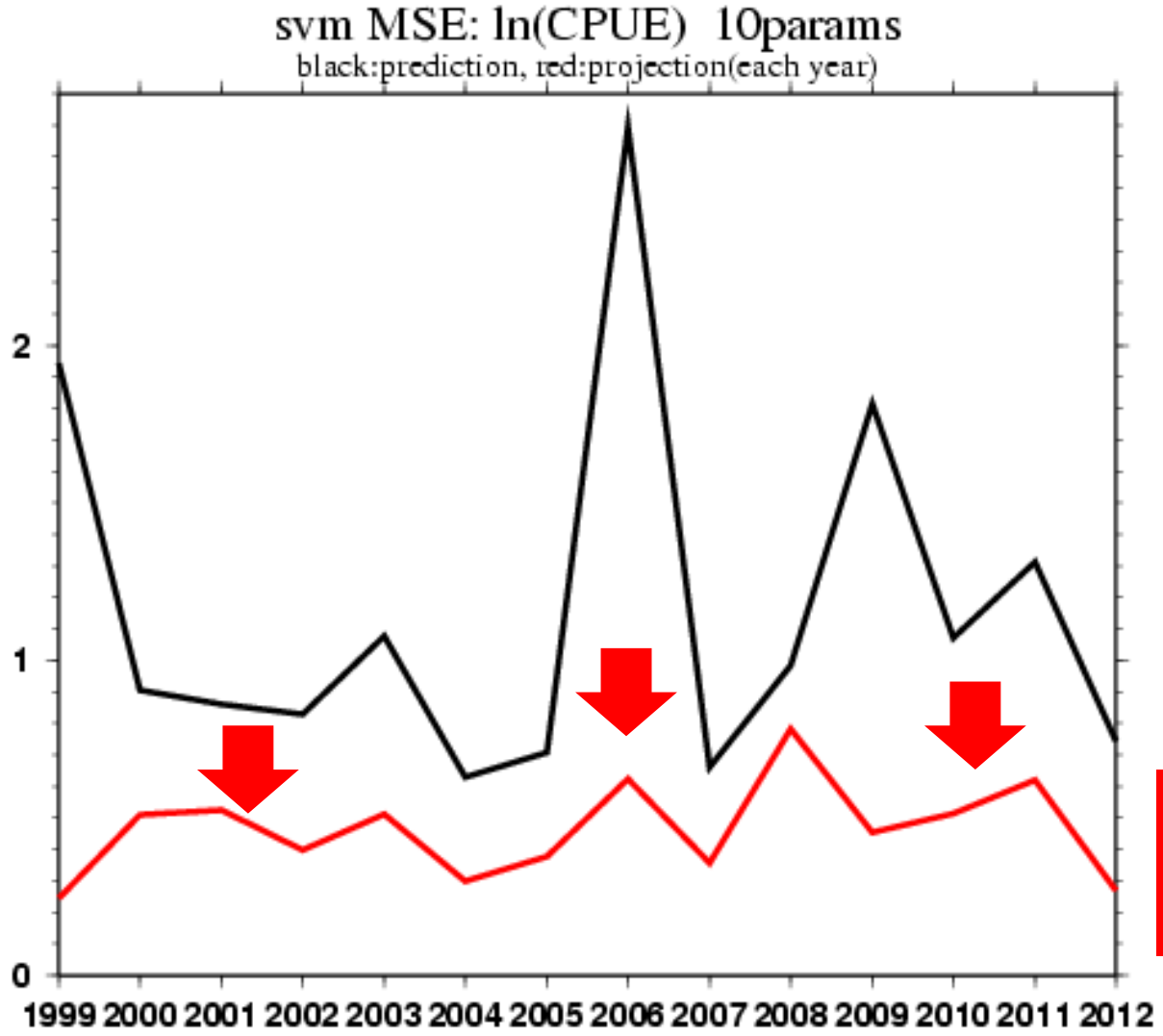


red:temperature, green:salinity, blue:zonal velocity, aqua:meridional velocity, pink:scalar velocity

SVM construction



mean square errors of SVM prediction

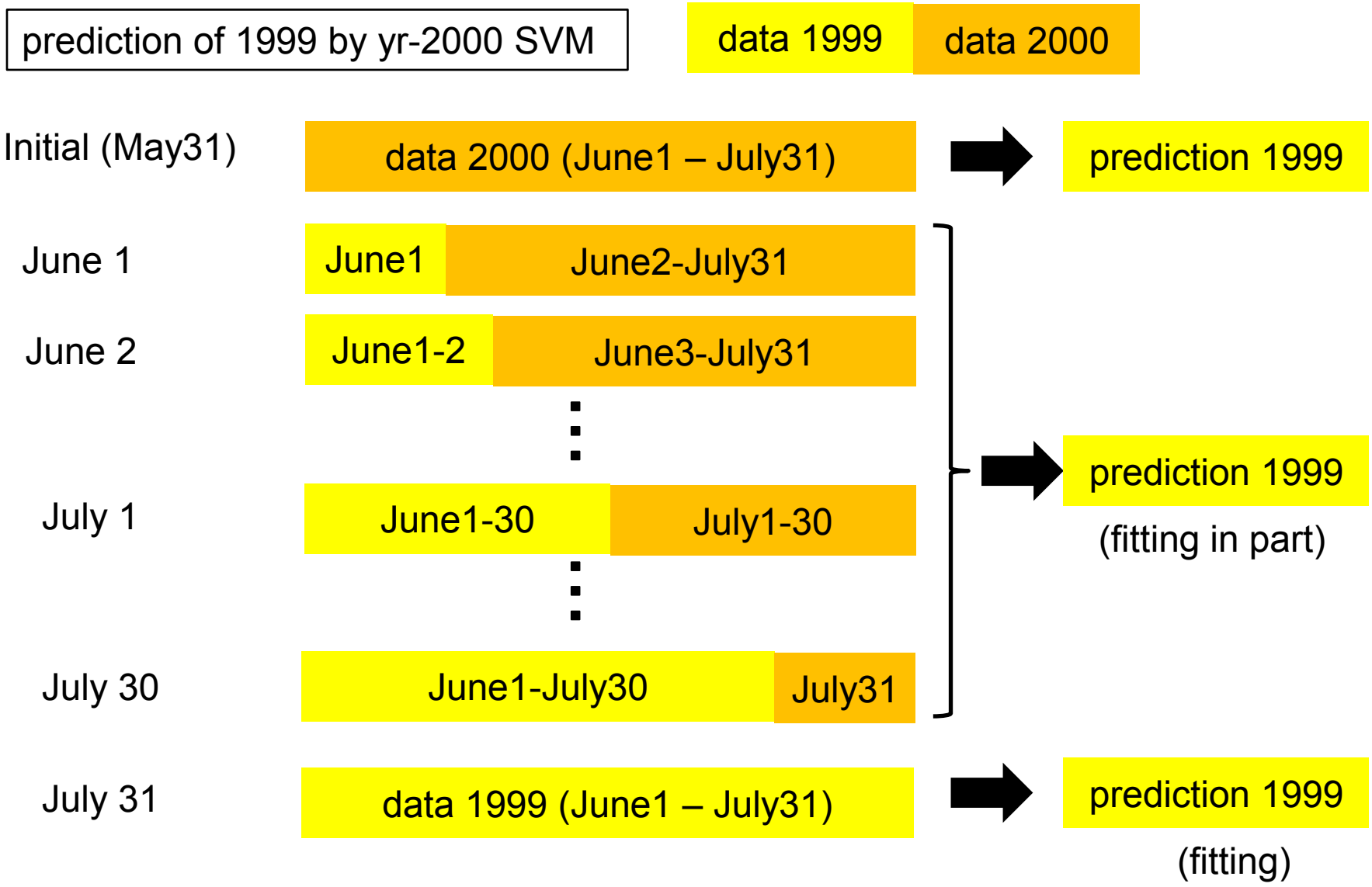


Black: general SVM (MSE of 1999 was calculated by SVM using 2000-2012 data.)

Red: fitting SVM (MSE of 1999 was calculated by SVM using 1999 data.)

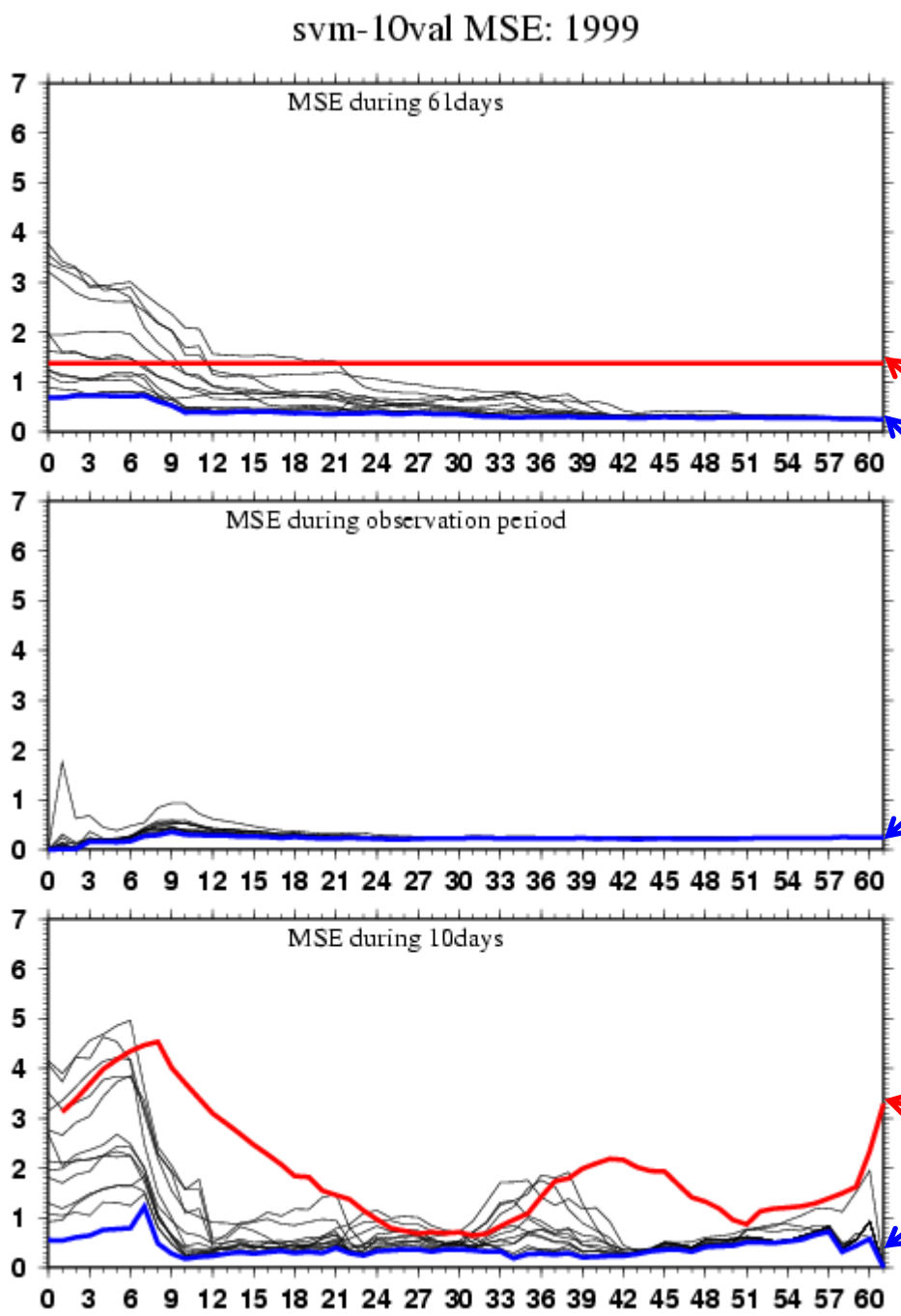
develop a method to approximate the MSE from black to red quickly

sequential model updating



We constructed 13 models for predicting a target year.

results



Mean Square Errors of 1999 prediction

data 1999 | data (another year)

(top) MSE from June1 to July 31

red line : MSE of general SVM

blue line: the least MSE in 13 SVMs

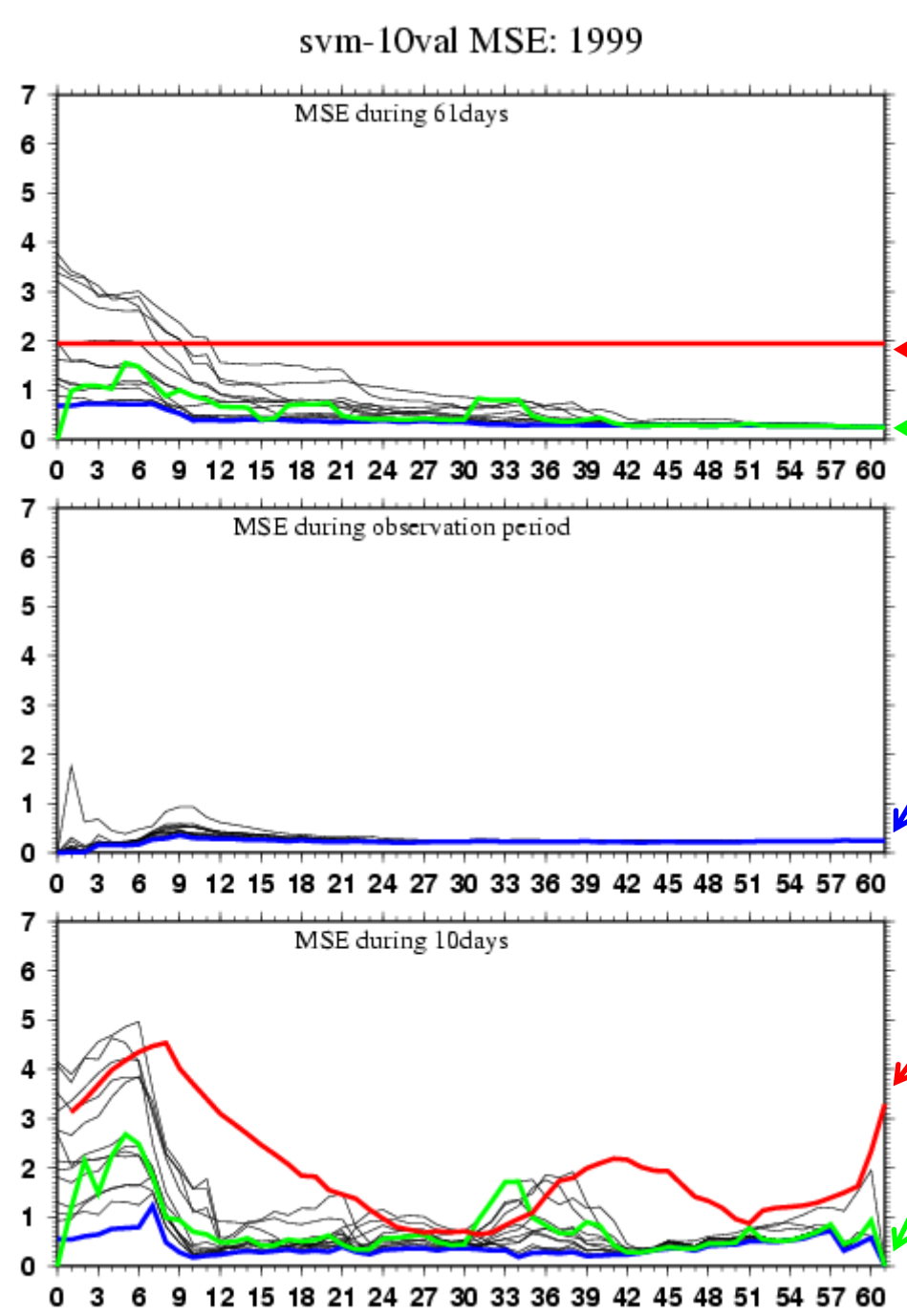
(middle) MSE during fitting period

blue line: the least MSE in 13 SVMs

(bottom) MSE during first 10 days in prediction period

red line : MSE of general SVM

blue line: the least MSE in 13 SVMs



Mean Square Errors of 1999 prediction

(top) MSE from June1 to July 31

red line : MSE of general SVM

green line: selected cases of the least MSE in projection (middle)

(middle) MSE during fitting period

blue line: the least MSE in 13 SVMs

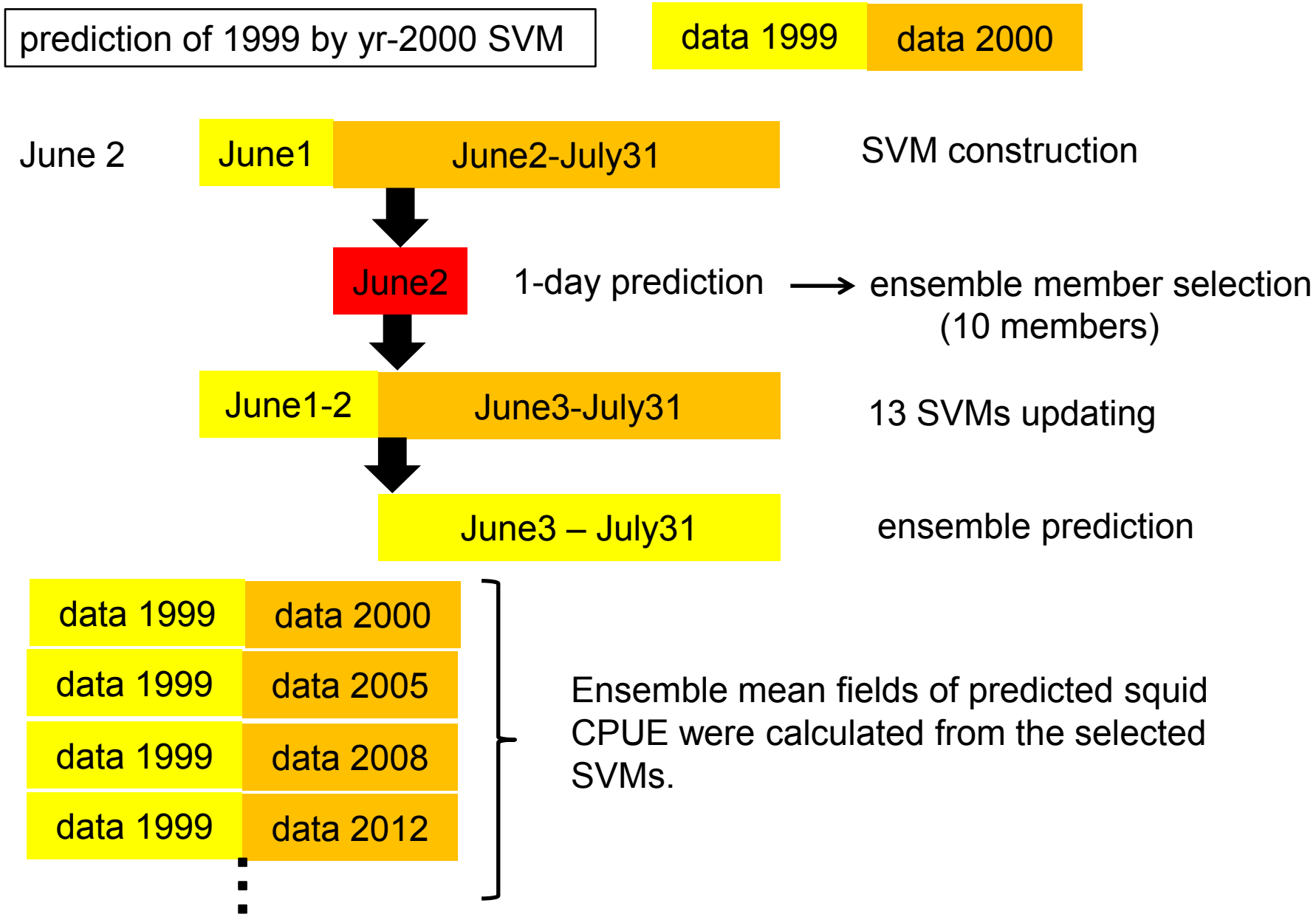
(bottom) MSE during first 10 days in prediction period

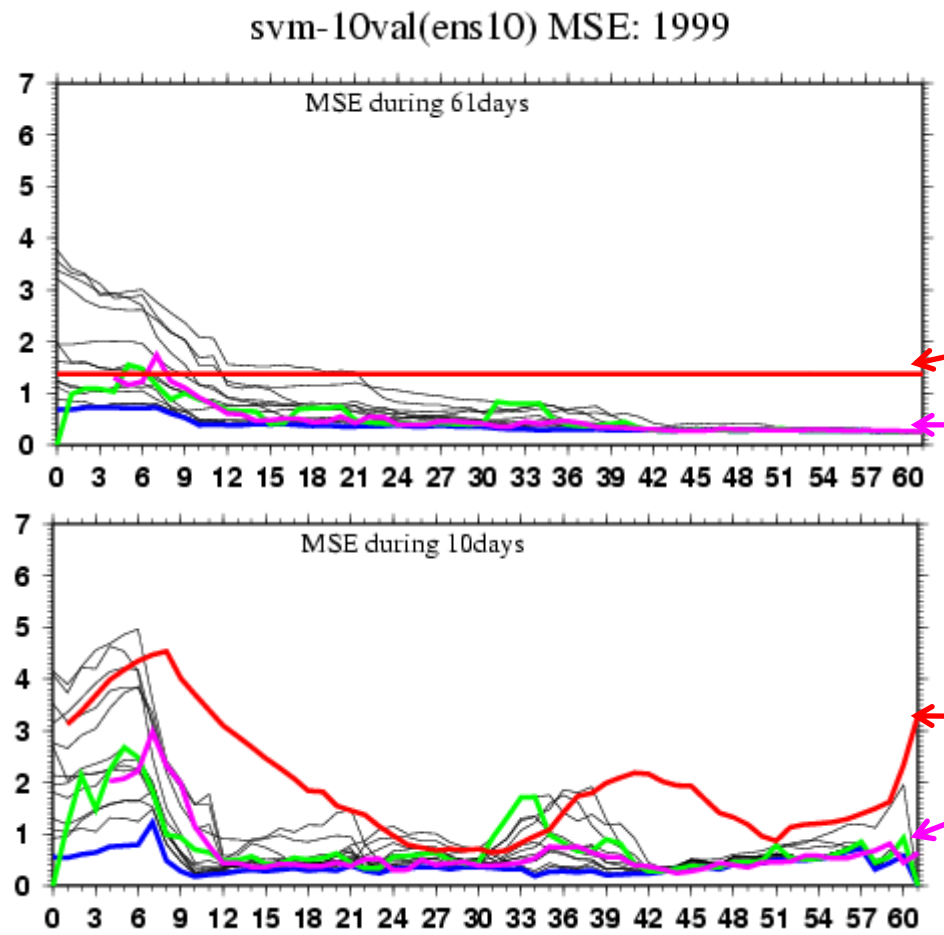
red line : MSE of general GAM

green line: selected cases of the least MSE in projection (middle)

We do not always detect the least MSE case from the fitting results!

1-day prediction and ensemble





Mean Square Errors of 1999 prediction

(top) MSE from June1 to July 31

red line : MSE of general SVM

pink line: MSE of ensemble mean SVM

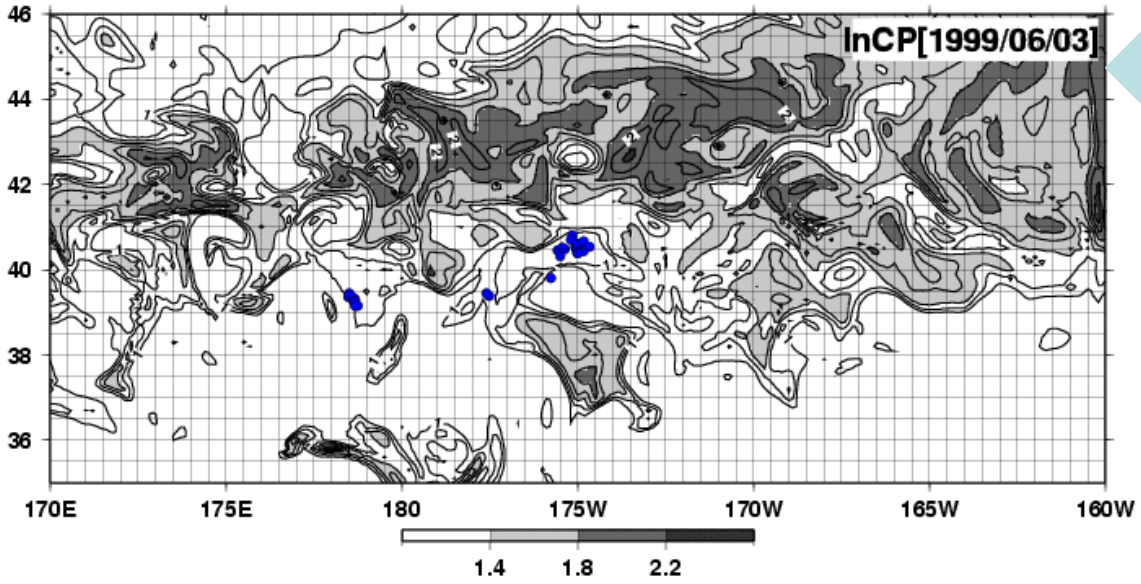
(bottom) MSE during first 10 days in prediction period

red line : MSE of general SVM

pink line: MSE of ensemble mean SVM

MSE of the ensemble SVM is smaller than that of the general SVM during the fishing season.

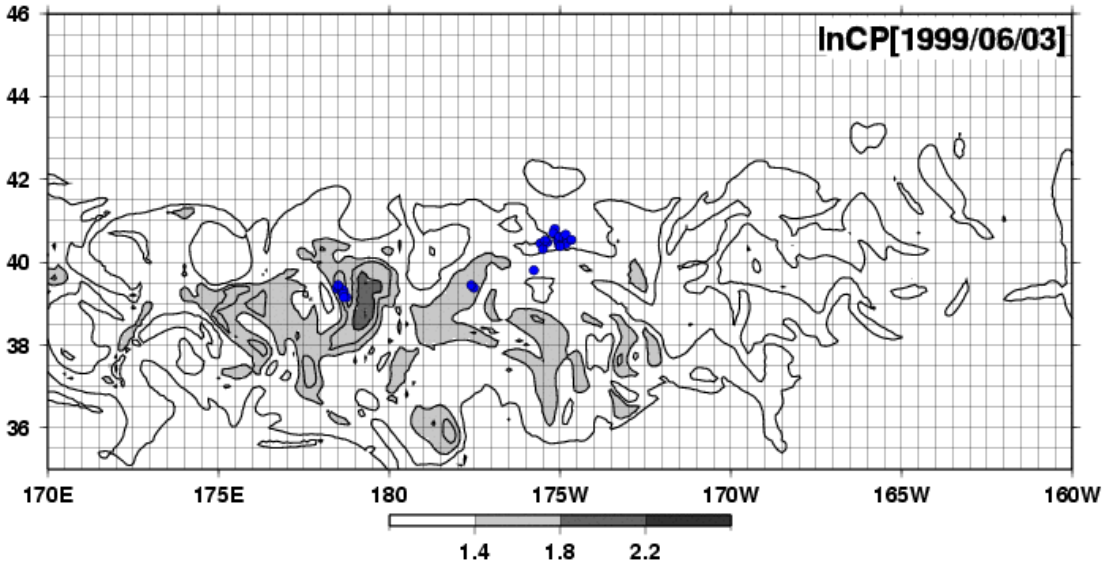
Comparison of habitat maps



general SVM

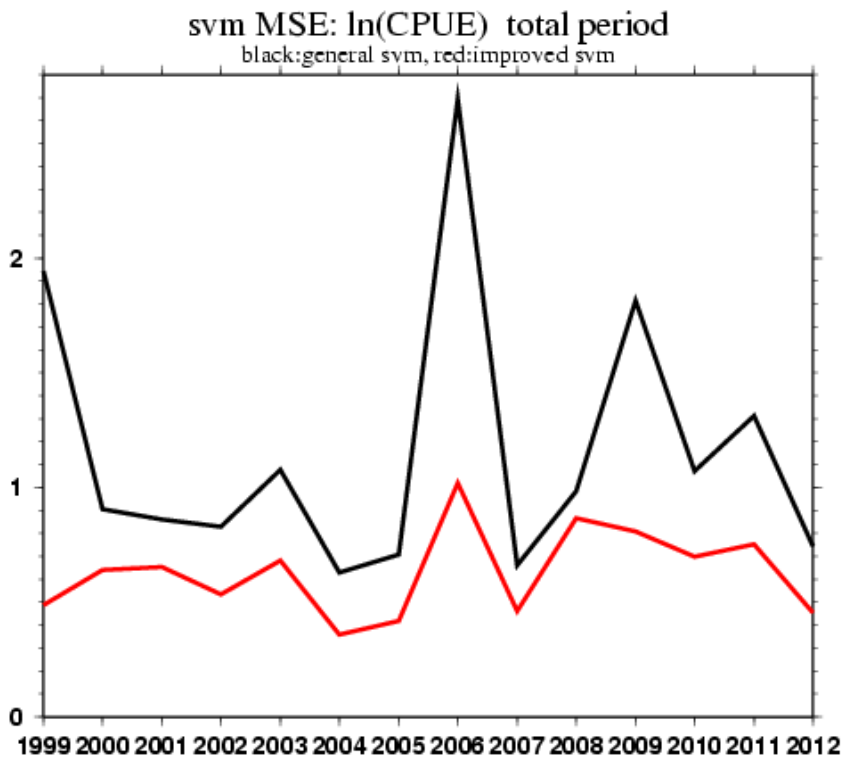
blue dot: actual fishing point

ensemble SVM

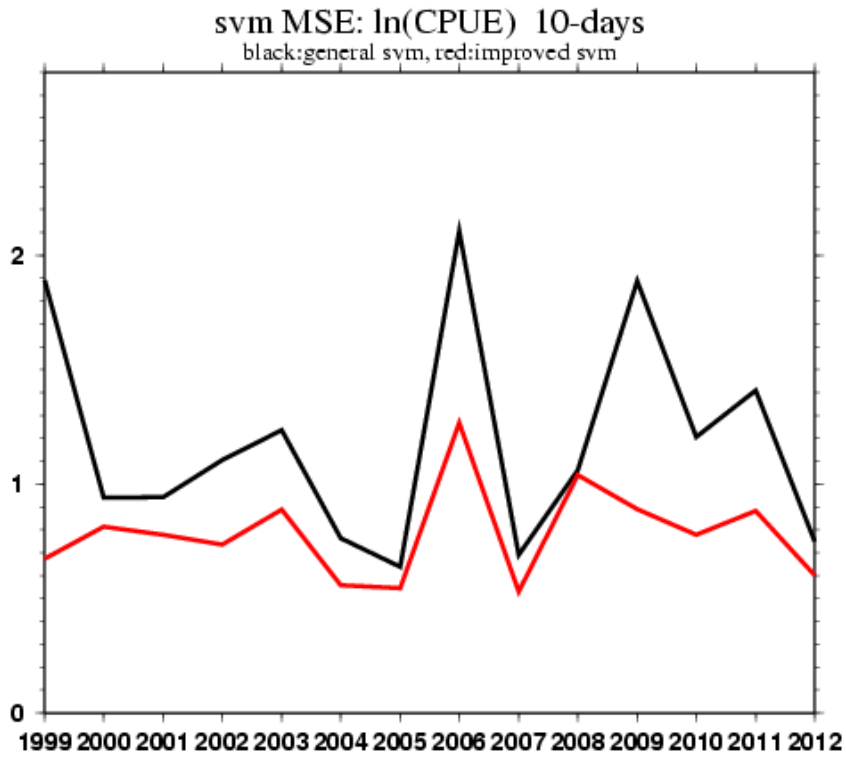


MSE of each year

total period (June3-July31)



10 days



Black: general SVM, red: improved SVM

Concluding remarks

- We developed a method of an adaptive improvement of HSI model by using real-time daily fishery reports provided from the squid fishermen. The HSI model constructed in advance were sequentially modified by updating the fishery report data.
- The remarkable improvement can be seen in the sequentially modified HSI model in which the information of ocean environments in the actual fishing ground was reflected.
- The results suggest that the adaptive modification of the HSI model could be practically useful for the accurate estimate of the potential fishing zone.

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Thank you