Comparative Retrospective Assessment of Biogeochemical Model Outputs for Fish and Foodweb Modelling in the Baltic Sea

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Workshop on Uncertainties of Scenario Simulations
SMHI, Norrköping, Sweden
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ECOSUPPORT

-will combine different models and outputs to enable modelling of entire Baltic foodweb

-to be used for scenario simulations of how Baltic Sea foodweb will respond to changes in forcings such as:

- -climate
- -nutrient loading (eutrophication, oligotrophication)
- -fishing

-will present some ideas and concepts re. methodology and very preliminary results – work still in progress

Foodweb-Fish related Workpackage

WP3: Impact on the foodweb (including fish – cod, herring, sprat)

3.1 Process validation of foodweb models
3.2 Scenario simulations of the food web
3.3 Quantification of uncertainty of future food web projections

Scenario Simulations of Biology

Some considerations:

-the biology is dependent in various ways on the physics

- e. g., rates proportional to temperature, salinity, nutrients, O_2

-we have several oceanographic and NPZD models which will make projections of variables (e. g., temperature, O_2) which affect fish biology

Scenario Simulations of Biology

Some considerations:

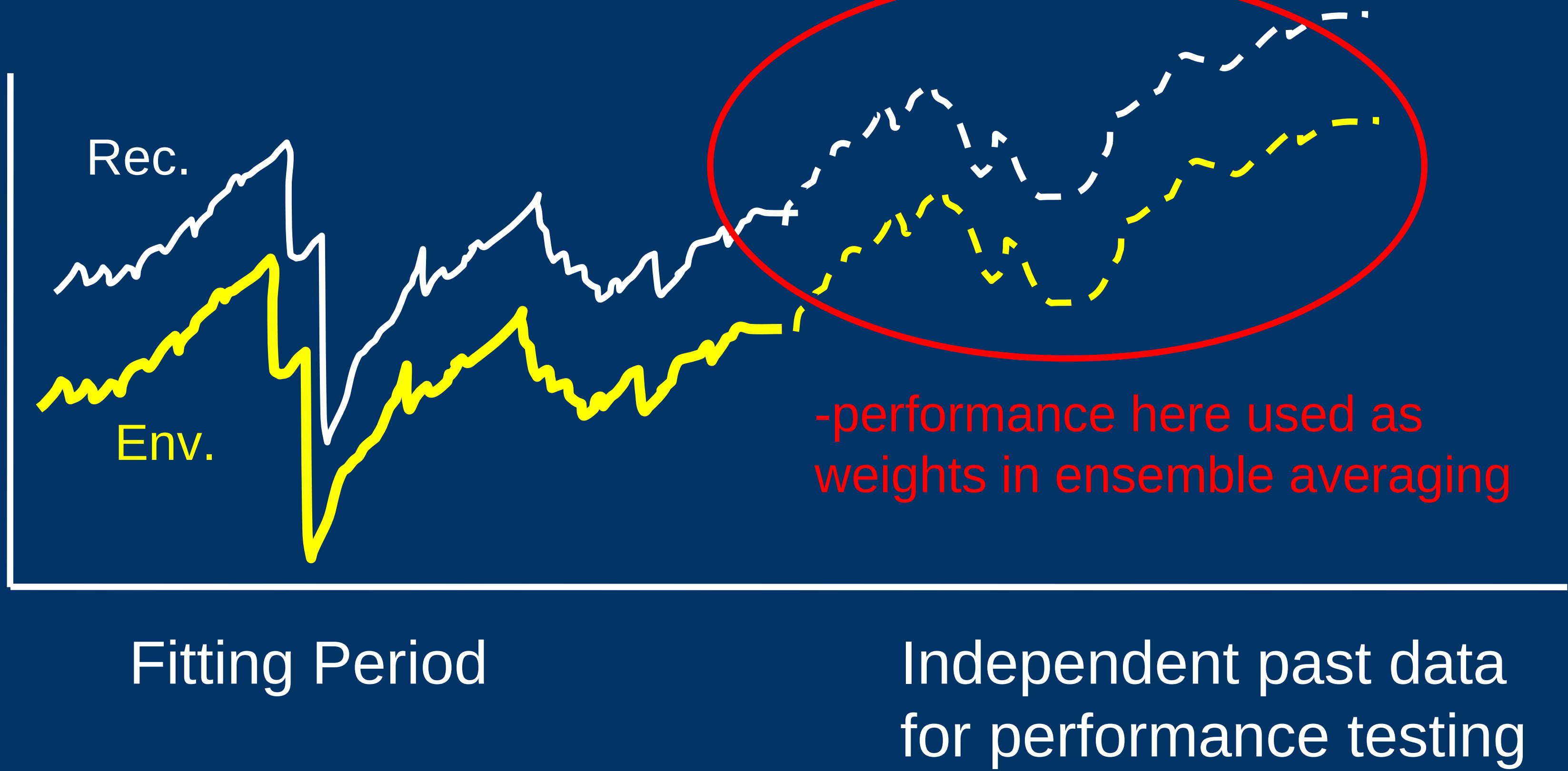
-the biology is dependent in various ways on the physics
- e. g., rates proportional to temperature, salinity, nutrients, O_2

-we have several oceanographic and NPZD models which will make projections of variables (e. g., temperature, O_2) which affect fish biology

-need to quantify how well the models reproduce *independent* "history" so we know how much confidence we can have in projections

-if models can't reproduce well the past, they likely won't give us good projections about the future.

Future Projections with Validated Models of the Independent Past



Scenario Simulations of Biology

Model validation is important pre-requisite for future projections.

1. quantifies uncertainty of model outputs

2. can help choice of models to use, or how to combine model outputs, if there are ***multiple*** models available for the same response
   - e. g., whether and how to construct ensemble averages

Combining Model Outputs

Within ECOSUPPORT, models are combined in two ways:

1. We have several models linked in sequential fashion for a given set of Scenarios or forcings (CO_2, nutrients, fishing).

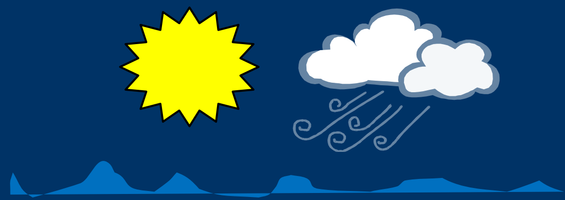
-how can those be combined?

2. We have several chains of linked models, for a given set of scenarios or forcings (CO_2, nutrients, fishing).

-how can those be combined?

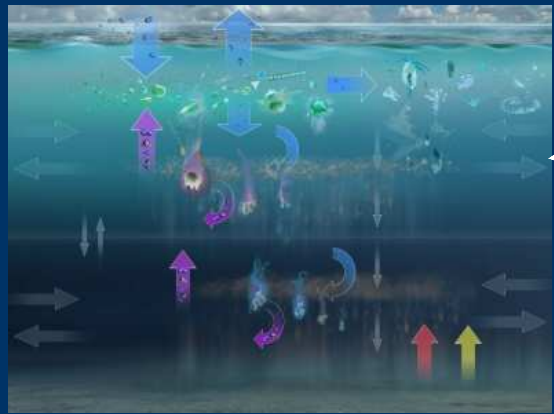
Model Outputs Linked Sequentially

Atmos.-Ocean



T, S, ...

NPZD



Habitat (RV), zooplankton, ...

Fish/foodweb

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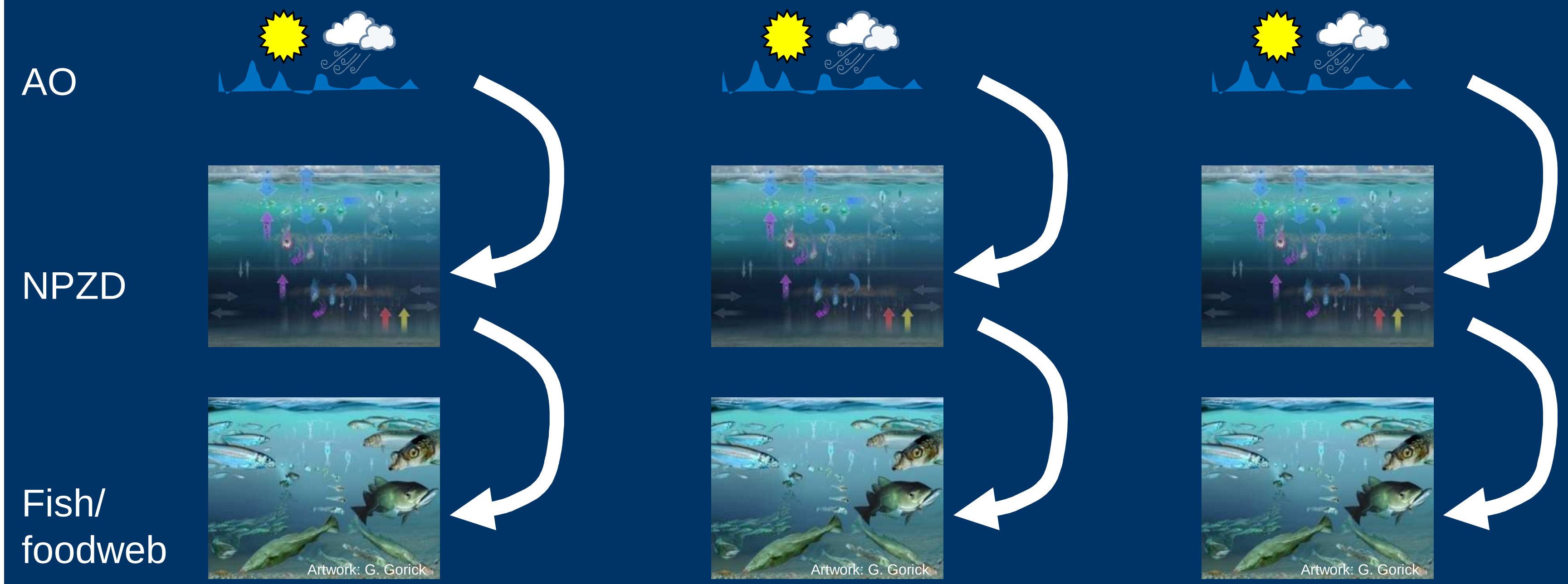
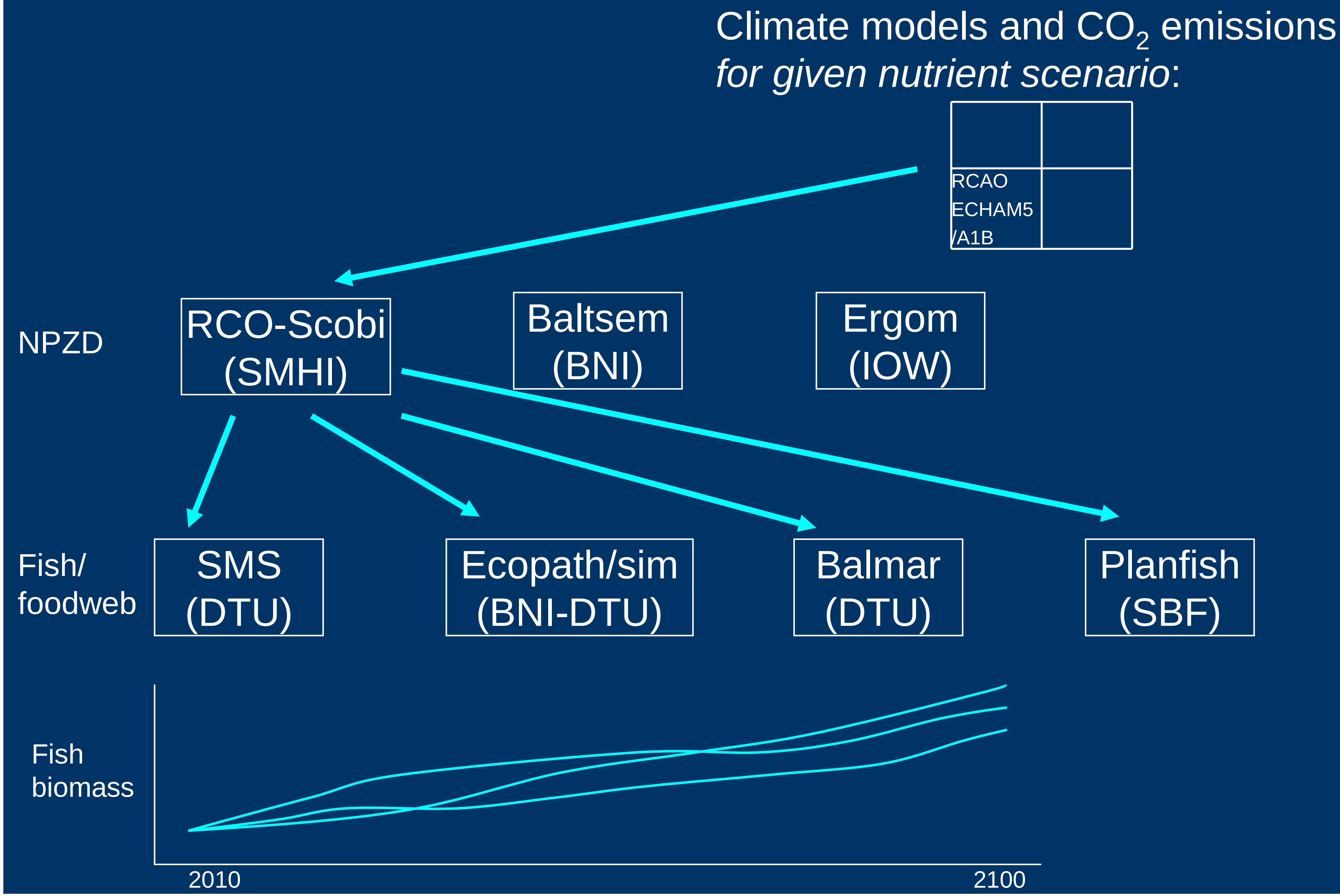
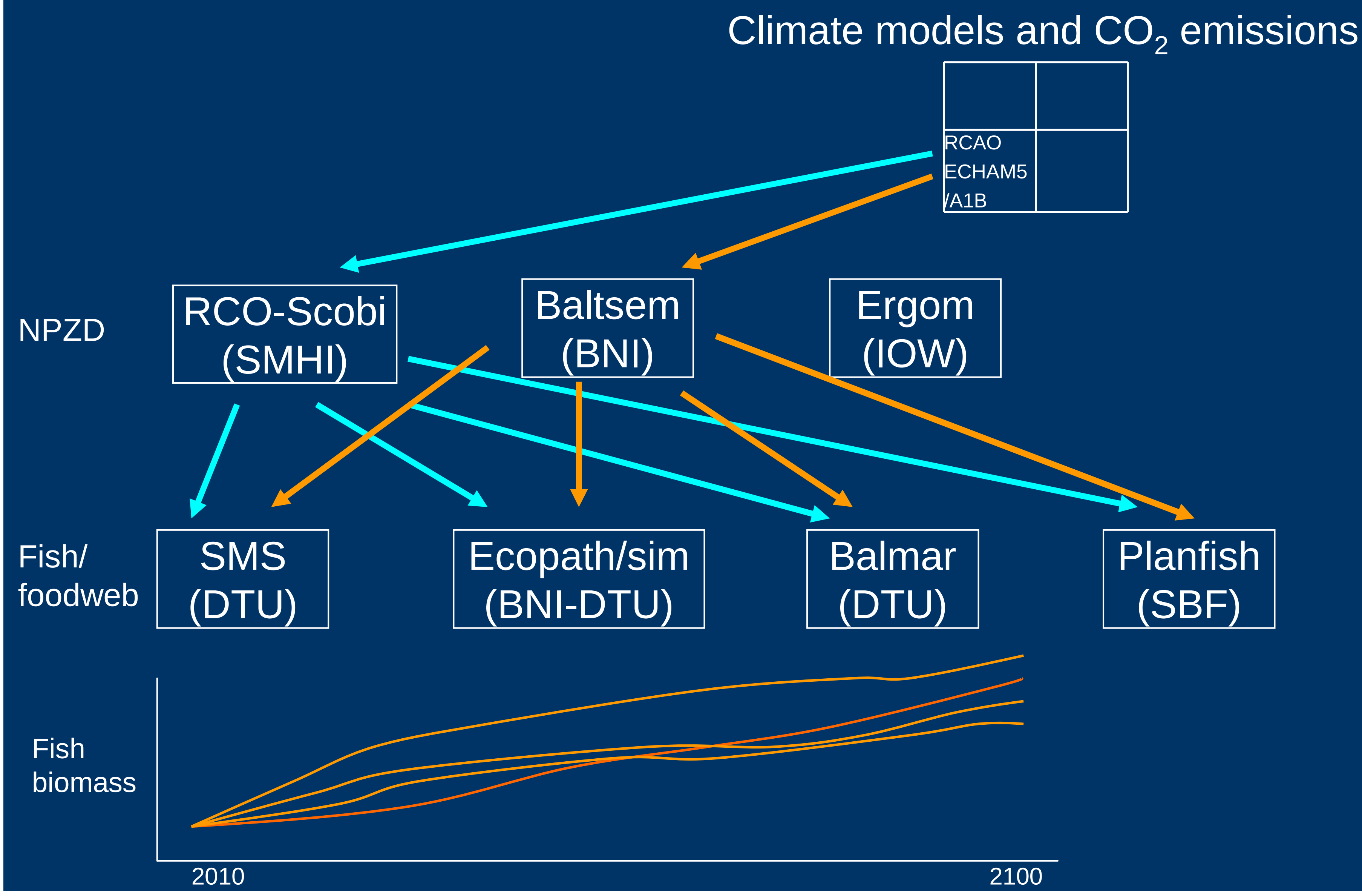
Outputs Combined Across Models



Inter-Linking Models within ECOSUPPORT



Inter-Linking Models within Eco-Support



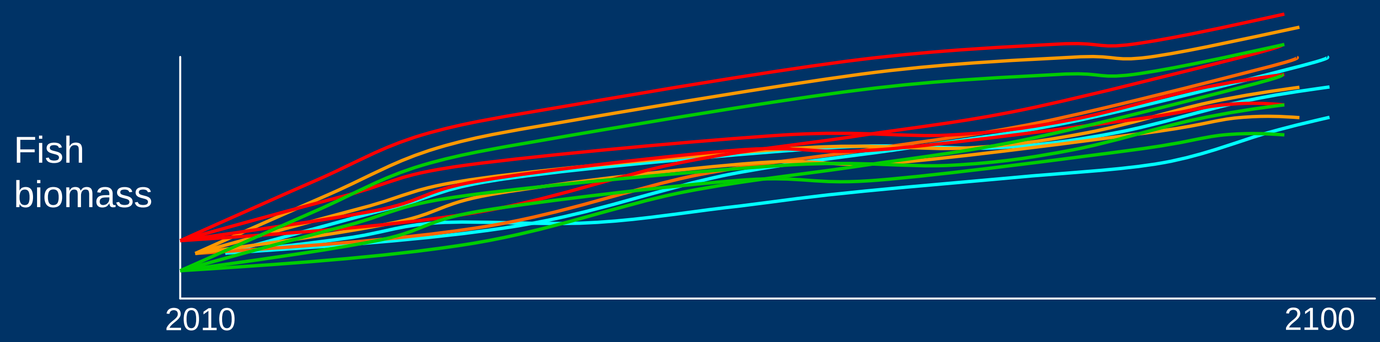
Dealing with Uncertainties

Will use approach of "ensemble averaging" across model outputs
-same approach applied in climatology, IPCC, etc.

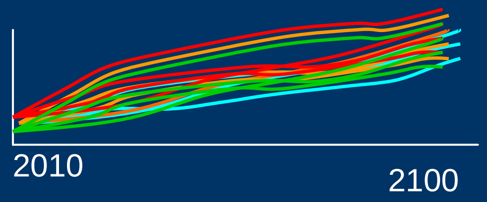
-calculate average and uncertainty (variability) for same set of forcings but with different models

-for a given CO2, nutrient and fishing scenario, have following time series:

2 climate models x 3 NPZD models x 4 foodweb/fish models = 24 time series



Questions



How should model outputs be combined into 1 time series?

Some options:

1. simple unweighted average across models

2. account for past performance :
-select only the model with best fit to observed data, or

3. weigh outputs according to past performance with observed data, and calculate weighted average

-we will attempt option 3.

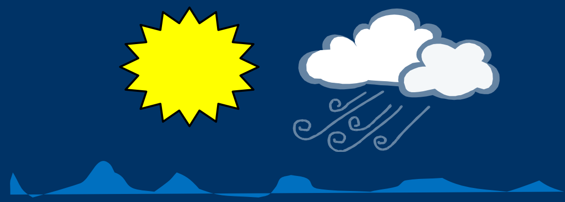
Case Studies for Learning and Methodological Development

-temperature (e.g ., for sprat recruitment)

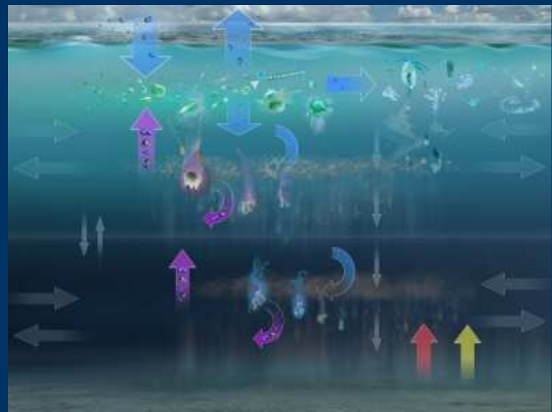
-cod reproductive volume

Model Outputs Linked Sequentially

Atmos.-Ocean



NPZD



Fish/foodweb

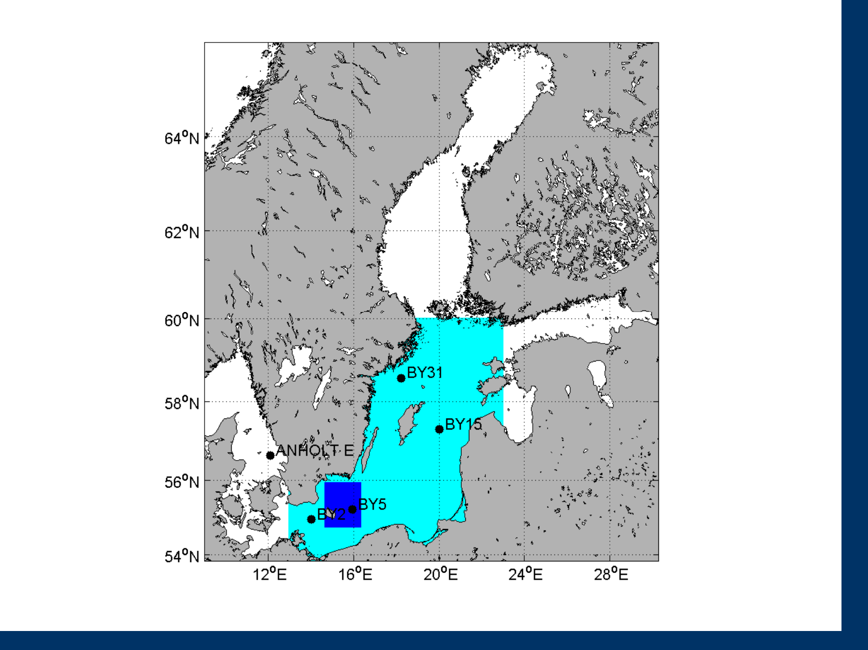
Temperature

Temperature effects on sprat recruitment

Modelled Data Available

Monthly temperature data near halocline (45-65 m) for Bornholm Basin, 1970-2007 from SCOBI and ERGOM

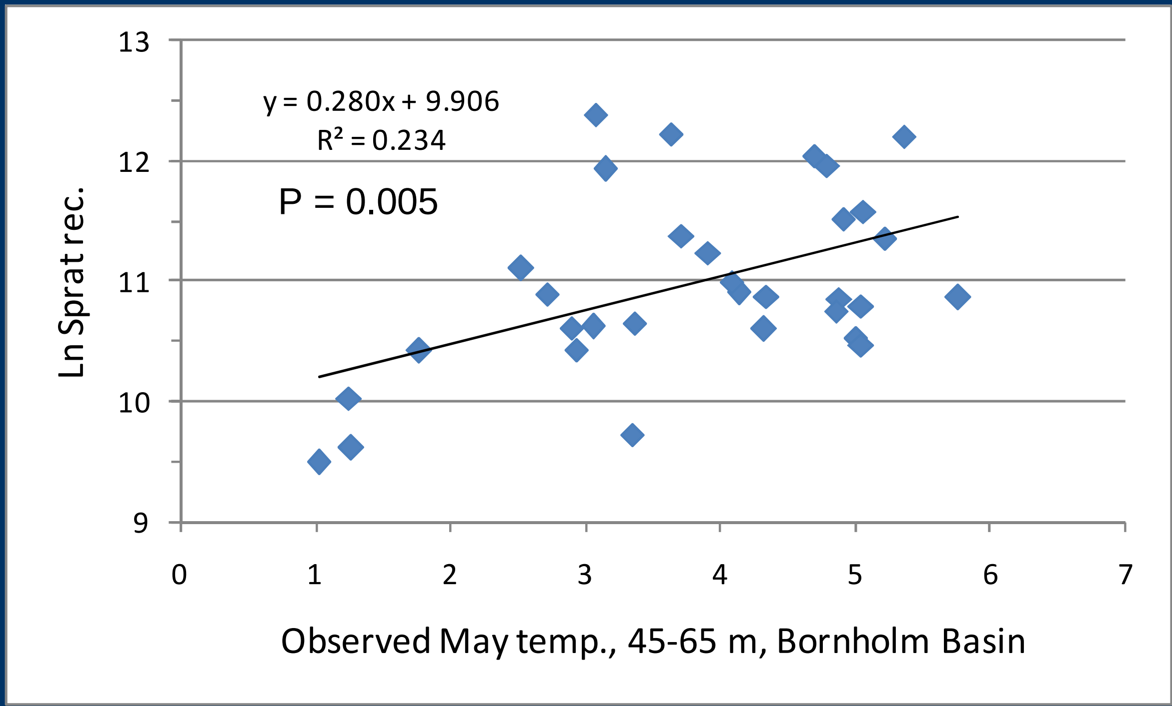
Monthly temperature data in surface (0-10 m) for Baltic Proper, 1970-2007, from SCOBI and ERGOM



Temperature Validations and Comparisons

-temperature affects processes such as sprat recruitment

-yearclasses 1974-2005; sprat data from ICES WGBFAS 2010
-temperature data from MacKenzie et al. 2008 CJFAS



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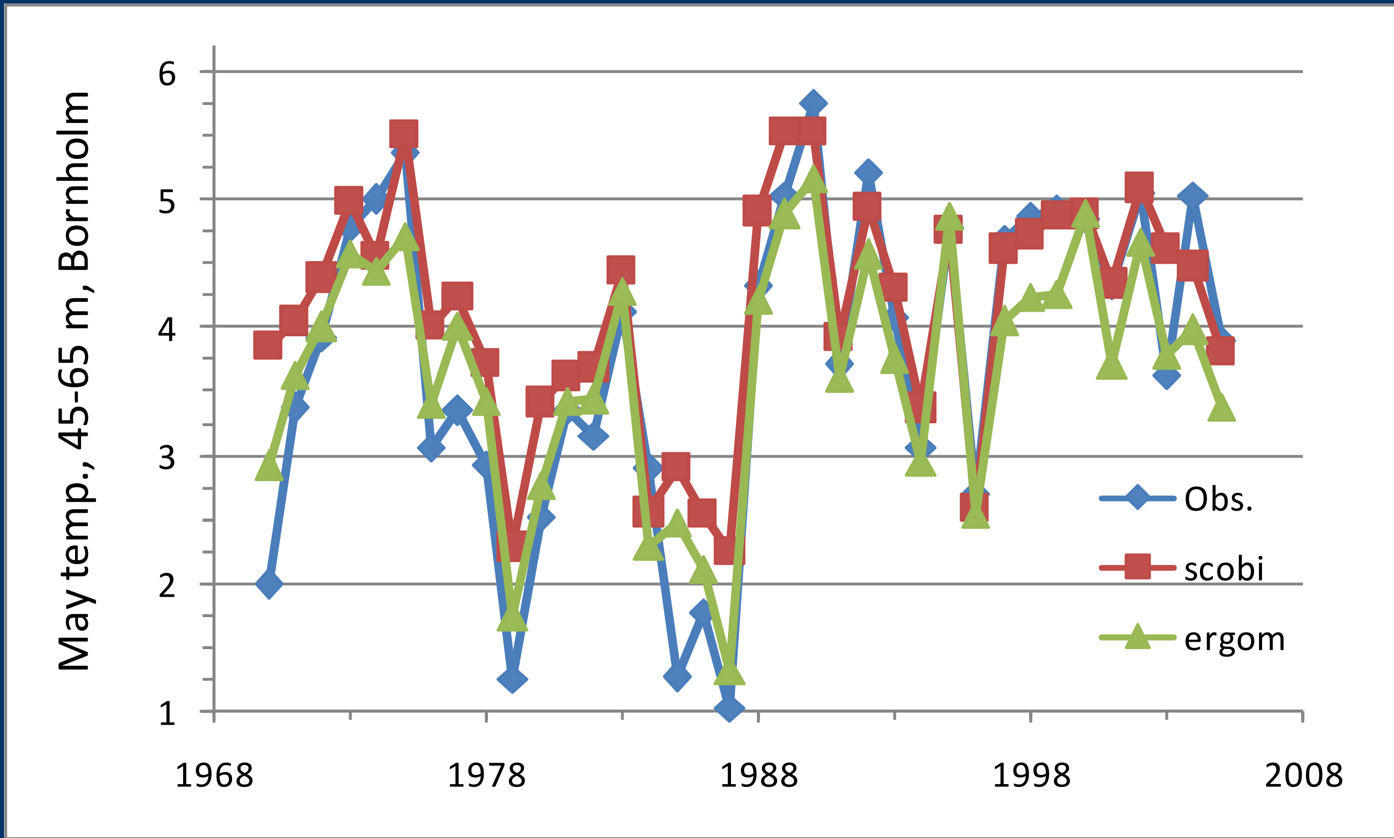
Temperature Validations and Comparisons

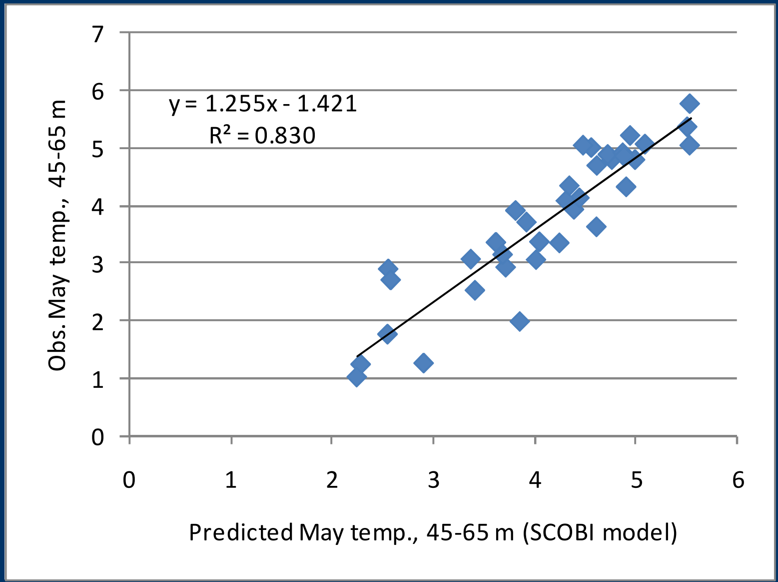
May temperature at 45-65 m, Bornholm Basin



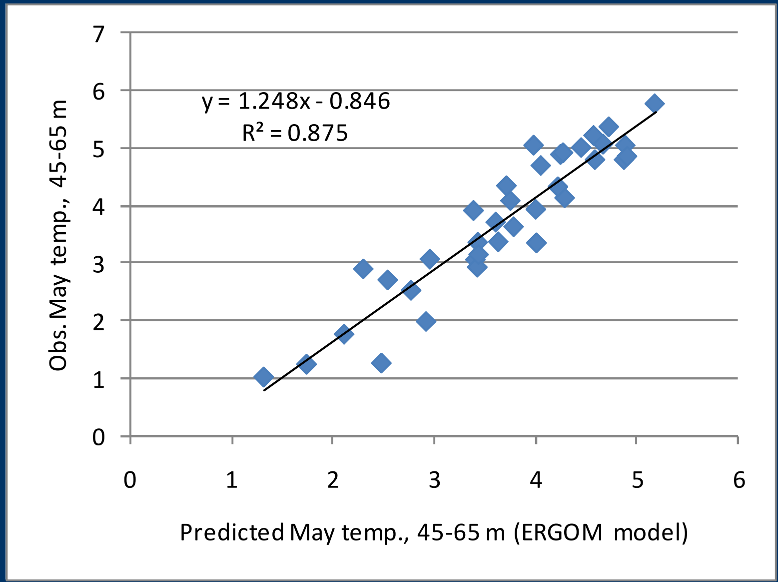
Temperature Validations and Comparisons

May temperature at 45-65 m, Bornholm Basin

RCO-SCOBI



ERGOM

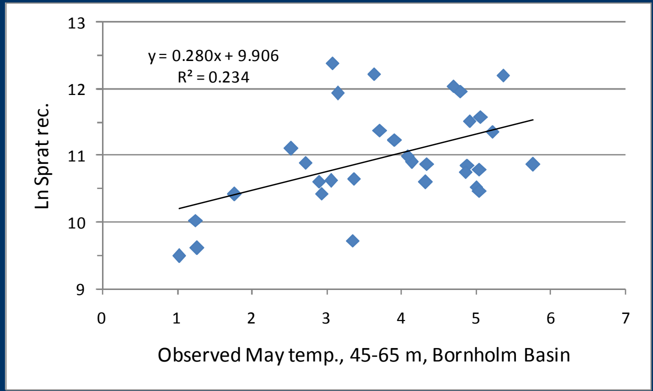


-very good correspondance between observed and modelled spring temperatures!

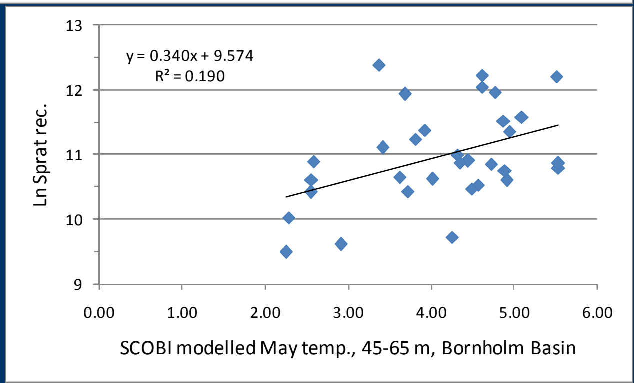
-are same temperatures which affect sprat recruitment...

Do Modelled Temperatures also Explain Sprat Recruitment Variability?

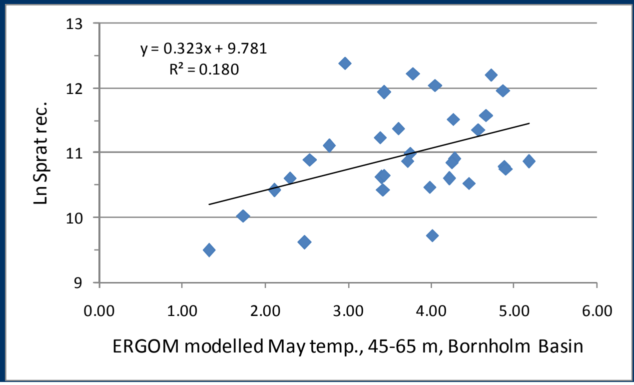
1974-2005



Observed temp.
R^2 = 0.23; P = 0.005



RCO-SCOBI temp.
R^2 = 0.19; P = 0.012



ERGOM temp.
R^2 = 0.18; P = 0.015

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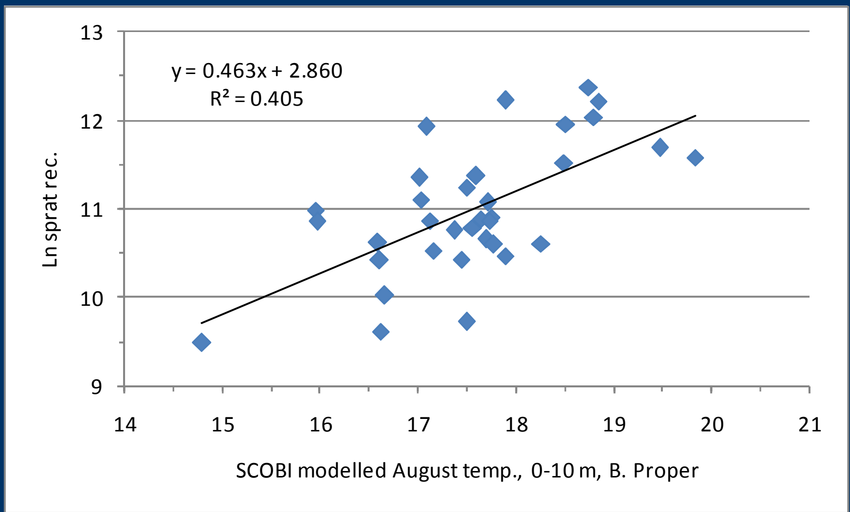
Modelled Summer Temperatures and Sprat Recruitment 1974-2007

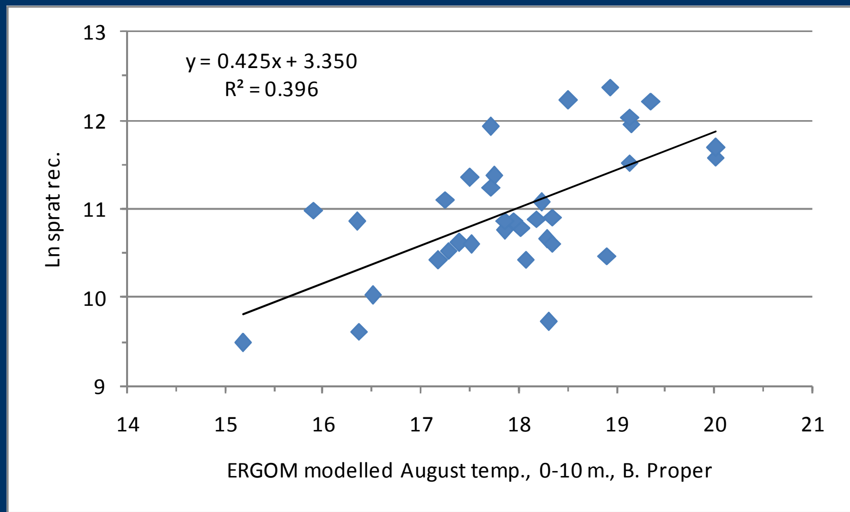
Summer surface temperature explains more variabilitly in recruitment than spring deep temperatures (Baumann et al. 2006)

-check whether modelled summer temperatures also explain sprat rec. var.

RCO-SCOBI temp.; P < 0.0001



ERGOM temp.; P < 0.0001



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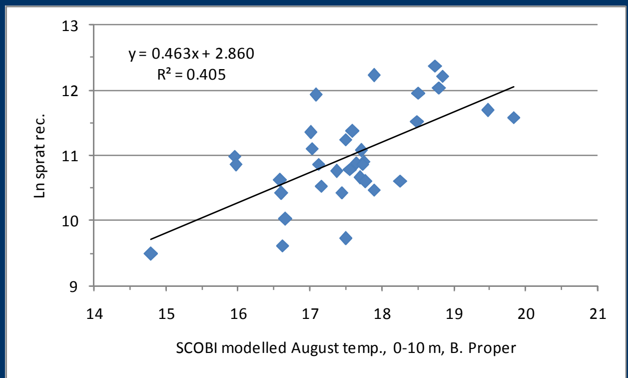
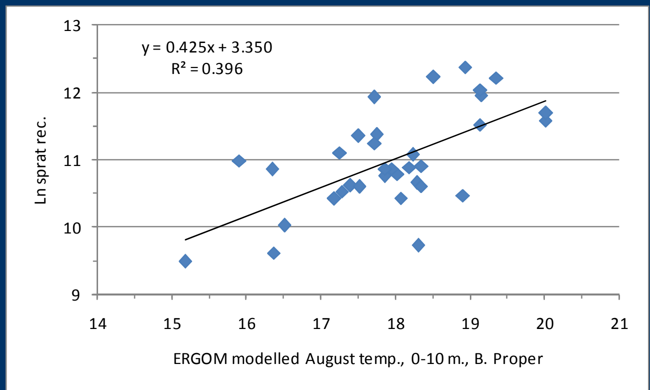
Combining Model Outputs

In this specific case, both models perform nearly equally well

-weightings would be nearly equal





-is *not (!)* the case with other variables – e. g., cod reprod. volume

Conclusions

-AO and NPZD models give good representation of some key hydrographic and biological vairables that affect sprat and cod recruitment

-some of those variables themselves explain similar levels of variability in recruitment as observed data

-need to continue and expand analyses (Baltsem model to be included)

-some ways to proceed with ensemble averaging are possible

-very promising possibilities to use AO and NPZD models for projections of sprat and cod recruitment

-thank you

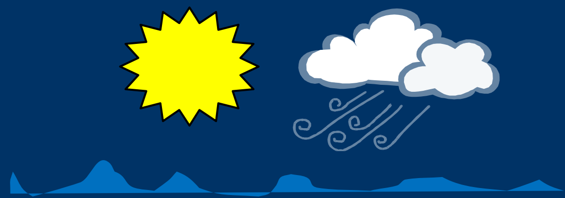
Case Studies for Learning and Methodological Development

-temperature (e.g ., for sprat recruitment)

-cod reproductive volume – a habitat indicator for cod spawning and reproduction (based on salinity and oxygen concentration)

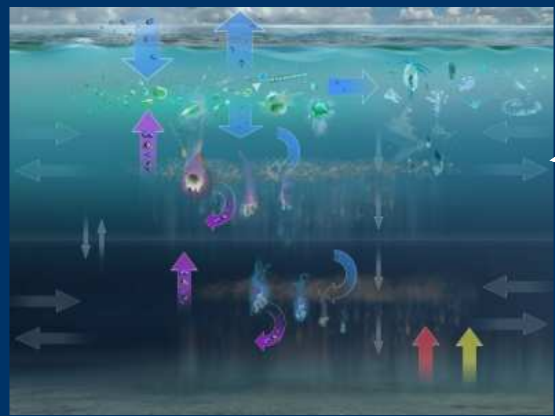
Model Outputs Linked Sequentially

Atmos.-Ocean



T, S, ...

NPZD

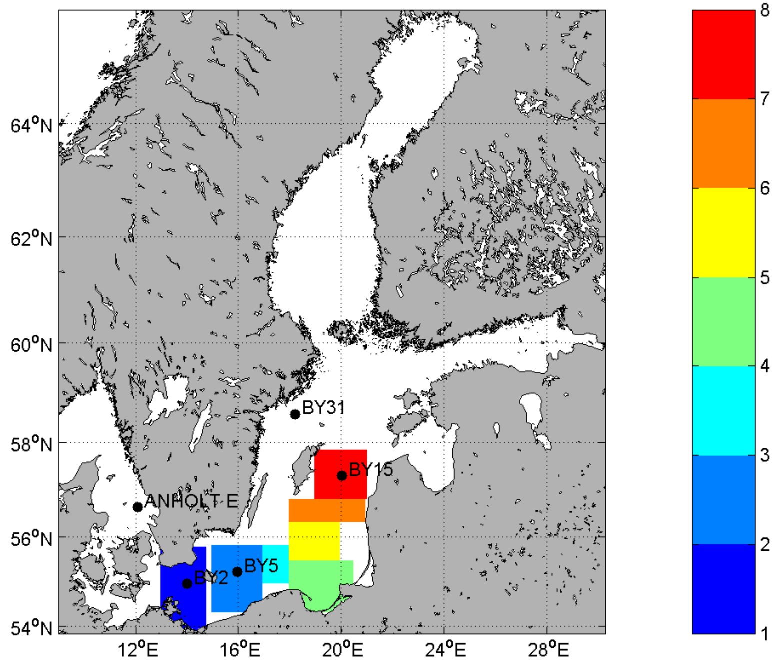


Cod reproductive volume

Fish/foodweb

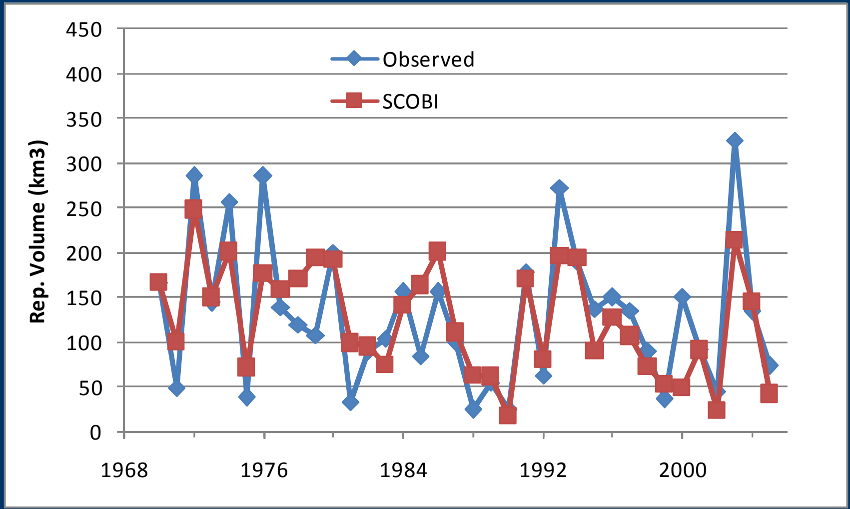
Modelled Data Available

Cod reproductive volumes by basin and month, 1970-2005 from SCOBI and ERGOM

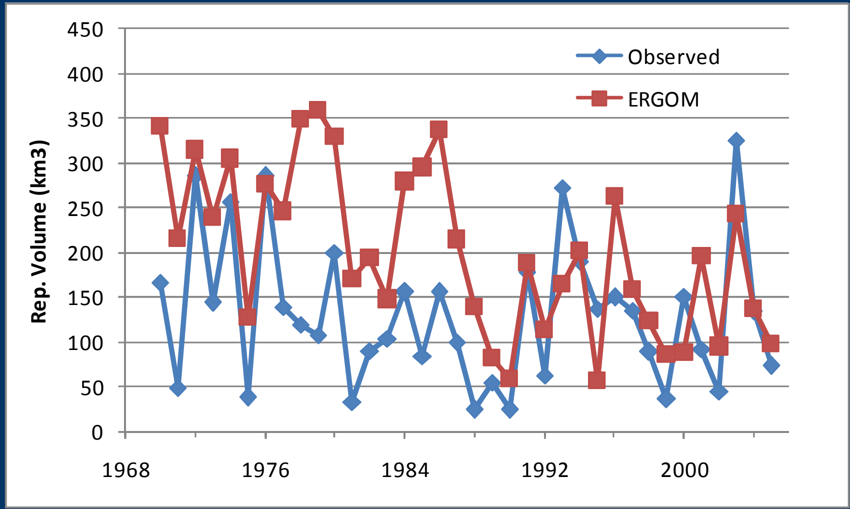


Model Fitting

RCO-SCOBI

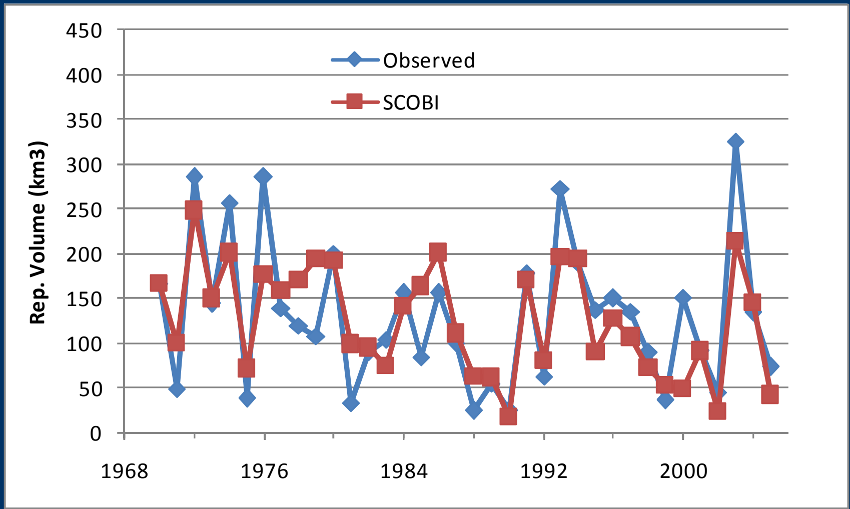


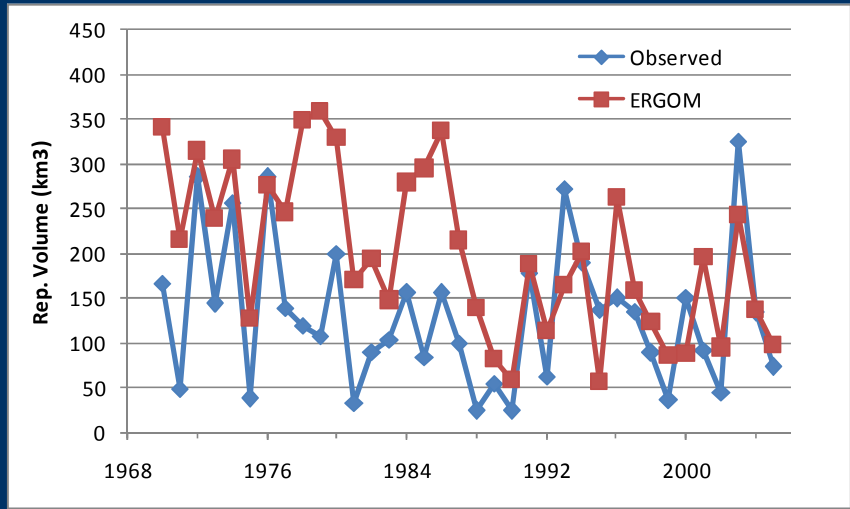
ERGOM

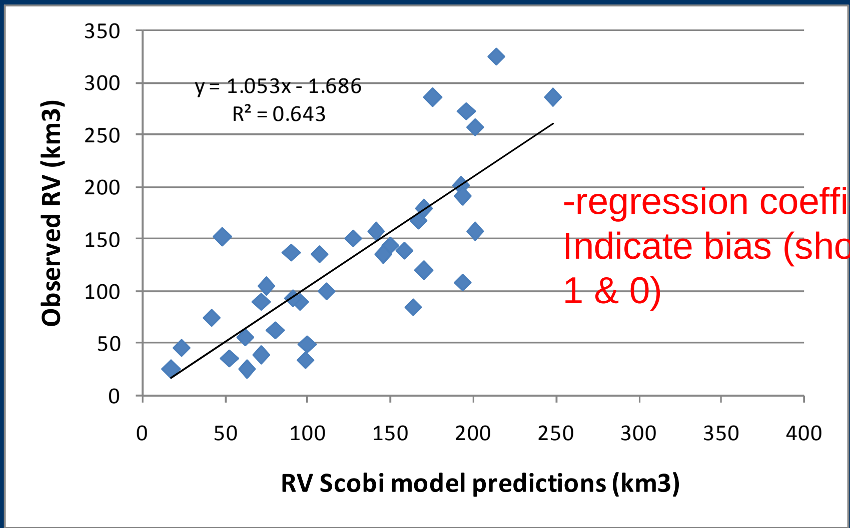


Model Fitting 1970-2005

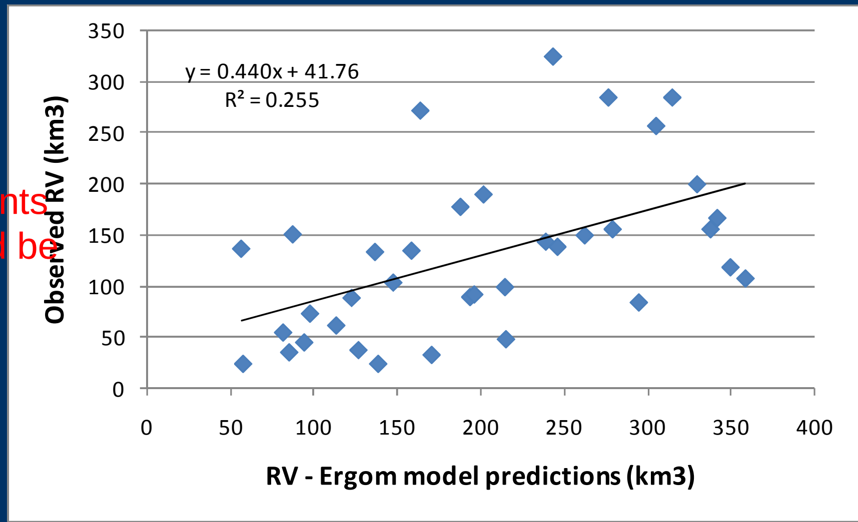
RCO-SCOBI | ERGOM







-regression coefficients
Indicate bias (should be
1 & 0)



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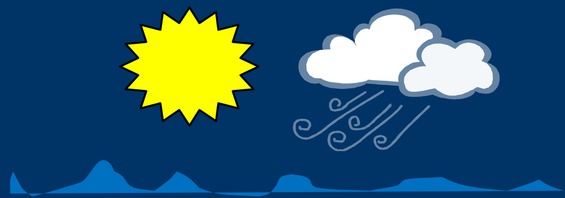
Model Comparisons of Forecasts

-both models track the past and “forecasted” data quite well

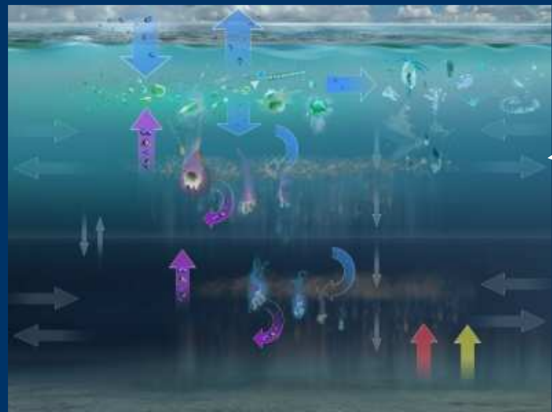
-one model explains more variation and has less biased results

Model Outputs Linked Sequentially

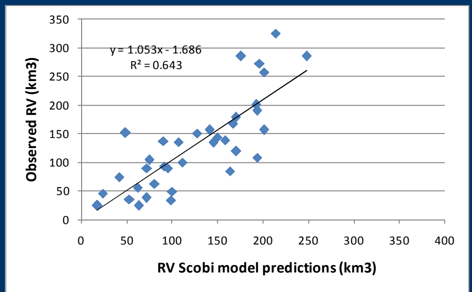
Atmos.-Ocean



T, S, ...



NPZD



-RV uncertainty from NPZD models is quantifiable
-can be implemented in cod rec. models

Habitat (RV), zooplankton, ...

Fish/ foodweb

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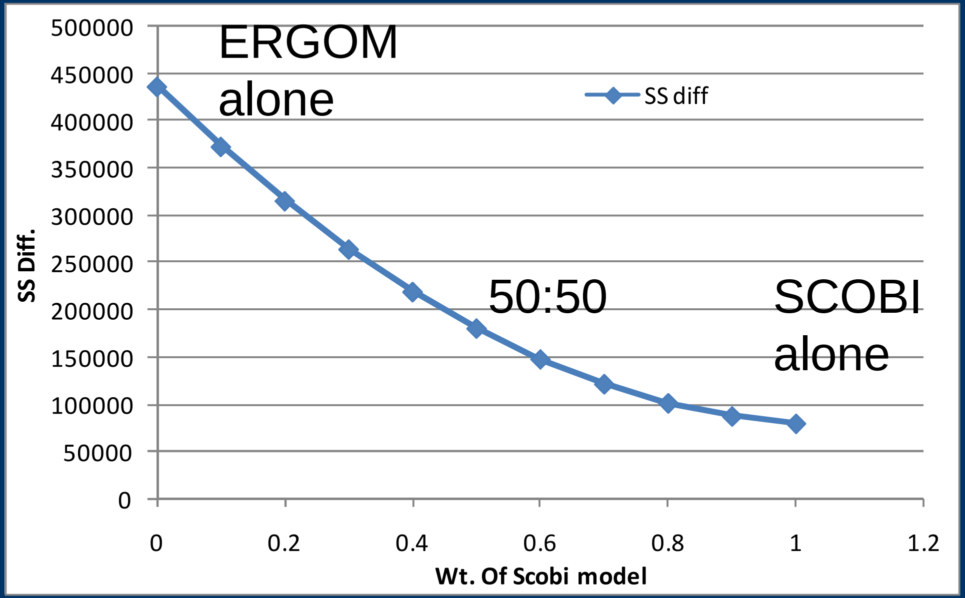
Sensitivity to Weighting in Ensemble Averages

	August	Model 1 SCOBI	Model 2 ERGOM	wt-scobi	wt-ergom	wt. Pred.	Observed Pliksh	(o-p)2
Bornholm_	1970	167	342	1	0	167	167	0.1
Bornholm_	1971	100	215	1	0	100	48.6	2614.4
Bornholm_	1972	248	315	1	0	248	285	1380.9
Bornholm_	1973	150	239	1	0	150	144	34.7

-calc. sum of squared differences (= SSE, SSRes)

-compare SS Diff. for different weightings of the two models.



-best model always penalized by weighting with less effective model

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Conclusions

-AO and NPZD models give good representation of some key hydrographic and biological vairables that affect cod and sprat recruitment (!)

-some of those variables themselves explain similar levels of variability in recruitment as observed data (!)

-need to continue and expand analyses (3rd model included)

-some ways to proceed with ensemble averaging are possible

-very promising possibilities to use AO and NPZD models for projections of cod and sprat recruitment

-thank you

Questions

How is uncertainty and variability in an AO model output (for a given scenario) passed forward into the NPZD or fish models?

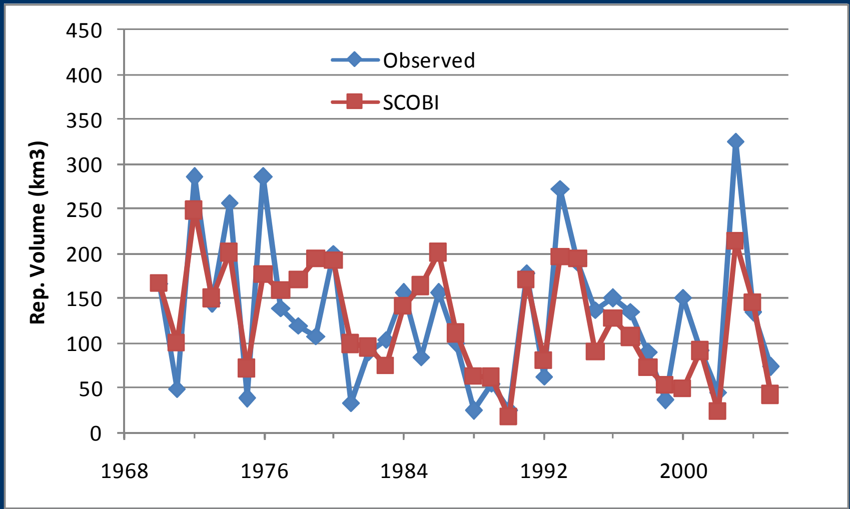
Is this possible to do?

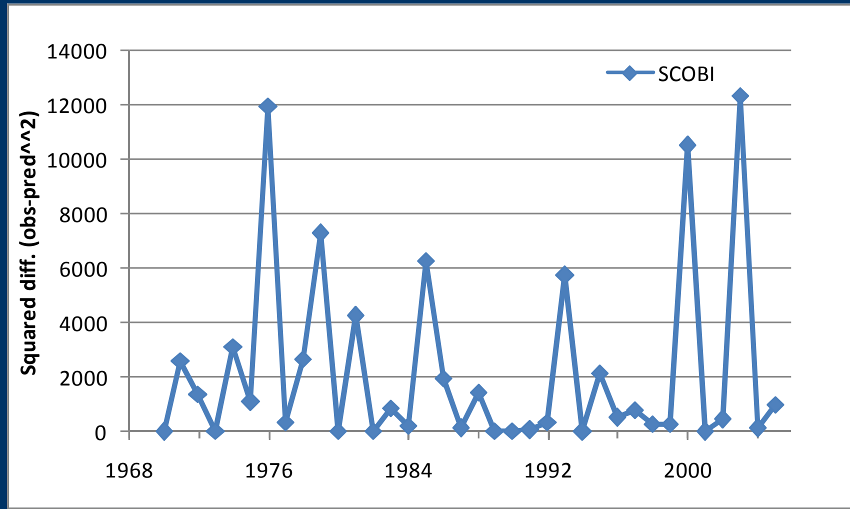
Modelling the Future

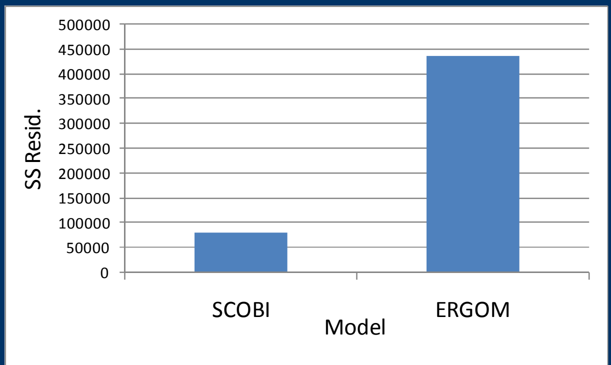
Confidence in estimating past variations

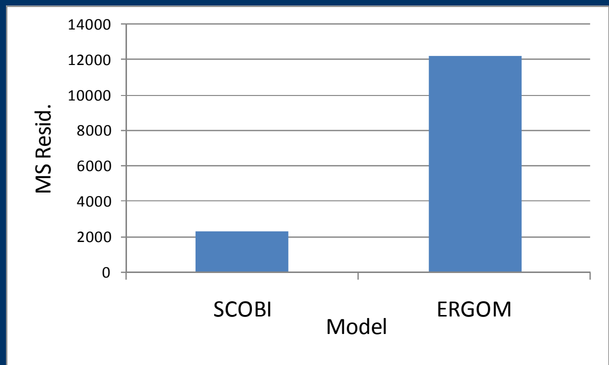
Applications for future projections

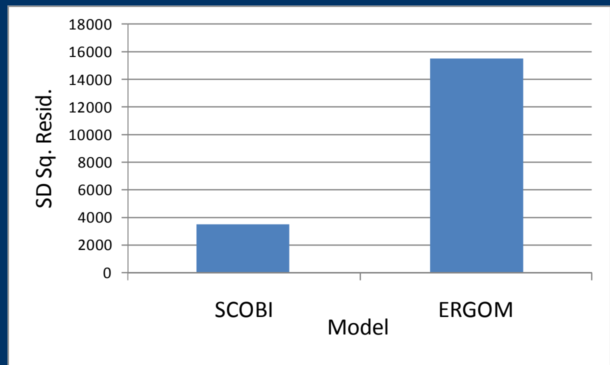
Residual Diagnostics and Uncertainties











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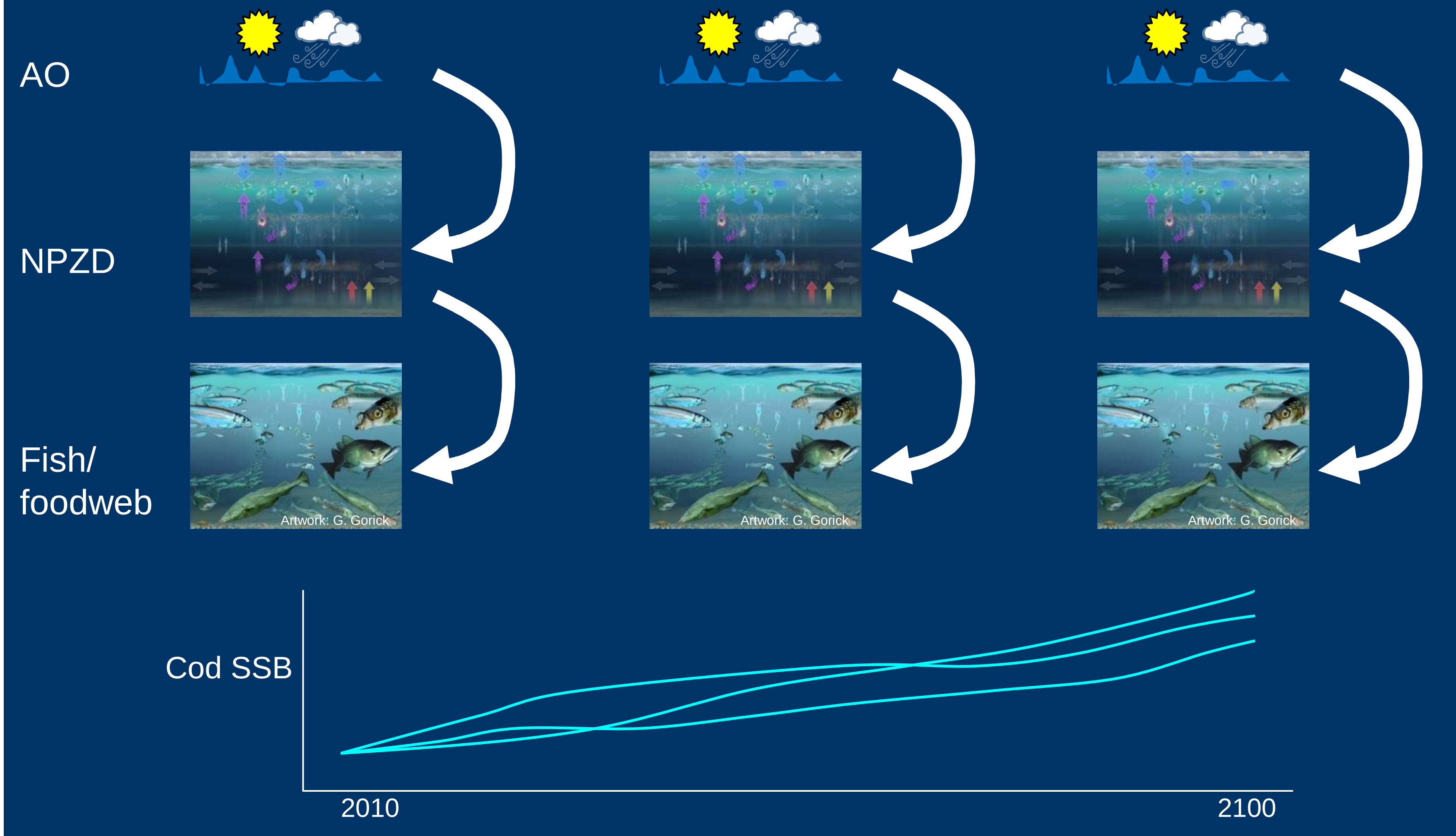
Or account for past performance :
-select only the model with best fit to observed data
-weigh outputs according to past performance with observed data, and calculate weighted average

Outputs Combined Across Models



Future Projections with Validated Models of the Past