Spatial trends of benthic secondary productivity in the Arctic Ocean

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Spatial trends of benthic secondary productivity in the Arctic Ocean

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Motivation :

In the context of global climate change, the Arctic system has experienced substantial and rapid changes with potential effects on marine ecosystem health. In this light, description of the current state of the Arctic's ecosystems is increasingly needed. In parallel, large and valuable historical databases existed in published and unpublished records from the Arctic that had never been synthesized.

We consider that benthic secondary production (i.e. the amount of organic material produced through time) may represent a useful, quantitative tool for the assessment of Arctic ecosystem health and functioning, mainly because:
1) It incorporates all of the information relative to the health status of a biological system (i.e. growth, reproduction, survival...)
2) It represents the cumulative responses of a biological system to its abiotic and biotic environment.

Objectives:

1- Describe the spatial pattern of benthic secondary productivity in the Arctic Ocean from shared and public data
2- Show that sharing data could lead to 'productive' project.

Method:

1) Benthic biomass data (and associated environmental parameters) were gathered from retrospective large datasets and ongoing studies, from published, unpublished sources and online databases.

2) Geostatistical and modeling approaches (the Random Forest algorithm) are used to correlate environmental variables with biological observations. The resulting model is used to assess benthic productivity distribution patterns in the Arctic ocean from predictor variables.

See below the several steps of the study ...

Step 1: Collection of Biological Data and associated environmental data (input Data)

- 1500 stations (Fig. 1)
- Variables: Benthic Biomass and abundances
- Benthic secondary production is calculated from biomass and abundances data using Artificial Neural Network model [1]
- Environmental parameters (depth, temperature, salinity...) are also reported for these stations

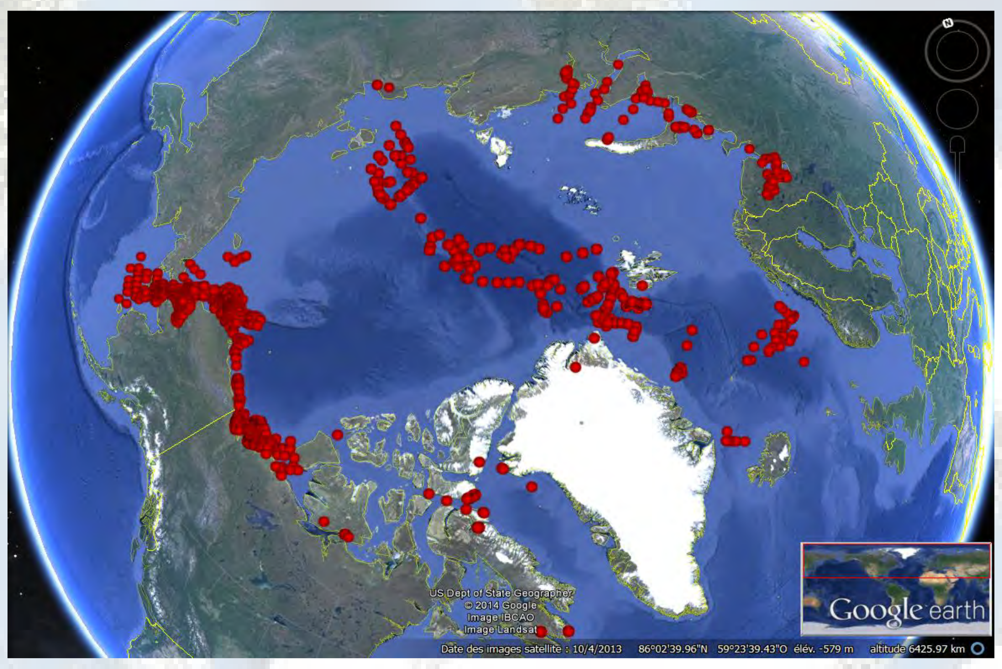


Fig. 1. Benthic fauna sampling locations


Fig. 2. Example of benthic Arctic community

Step 2: Random Forests model

It is used to :
(1) model the relationship between environmental parameters and response variables (i.e. productivity), and
(2) predict seafloor secondary productivity from environmental predictors.

Random Forests is:
- A machine-learning algorithm [2]
- It is an assemblage of a large number of classification **or** regressions trees with binary divisions
- Each tree of the Forest is grown from a bootstrap sample of response variable. Each tree uses a series of rules to recursively split the dataset into binary groups in order to maximize differences in offspring branches (Fig. 3).

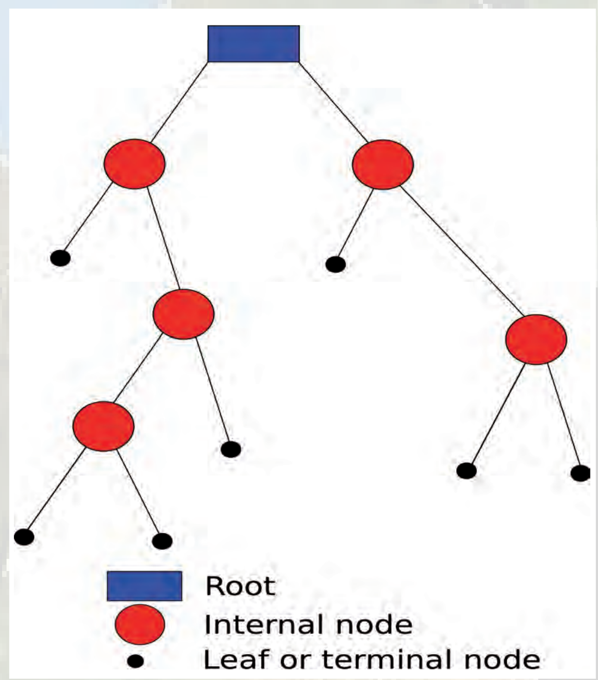


Fig. 3. Principle of the Random Forests (Figure by Horning, N.)

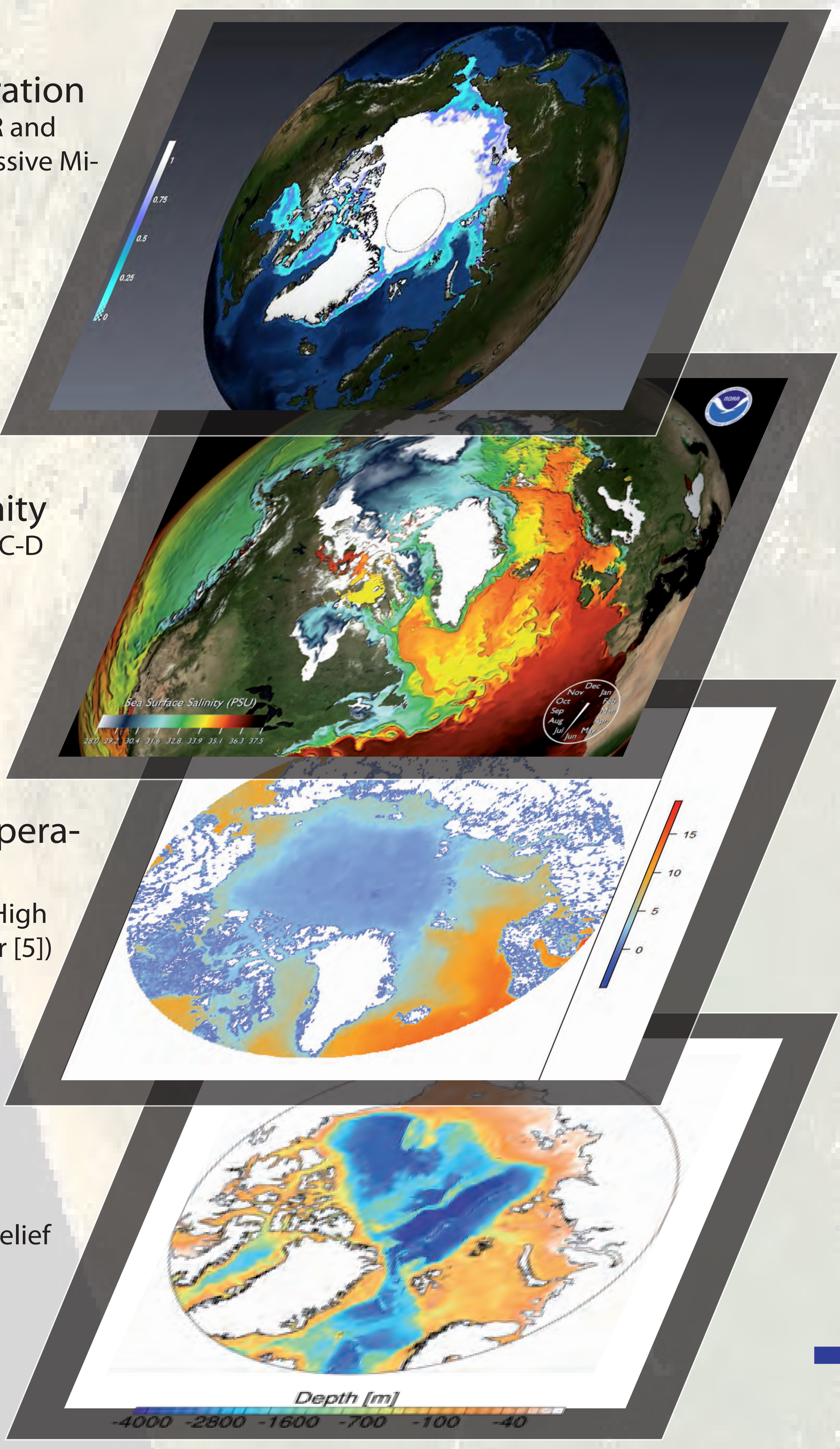
Step 3: Use of environmental predictors

Sea Ice Concentration (from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data [3])

Sea Surface Salinity (from the Aquarius/SAC-D mission [4])

Sea Surface Temperature (from Advanced Very High Resolution Radiometer [5])

Bathymetry (from ETOPO1 global relief model [6])



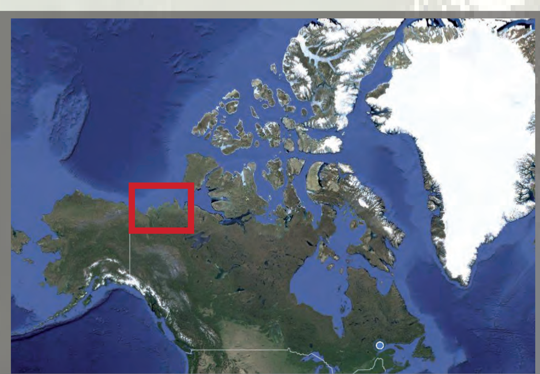
Predictors variables:
PP: Primary production
SST: Sea surface Temperature
SAL: Bottom salinity
TEMP: Bottom temperature
CHLA: Chlorophyll *a*
Ice cover
Depth

Fig. 4. Map of remotely-sensed data for several environmental parameters in the Arctic.
Image courtesy of the National Snow and Ice Data Center, University of Colorado, Boulder

Step 4: Secondary productivity prediction and model validation (coming soon....)

A test example:

Prediction of the distribution of the benthic biomass in the Mackenzie shelf (Beaufort Sea)



Predictor variables used: bathymetry (Fig. 5a) and sediment properties [7] (Fig. 5b). Sampling stations with available benthic biomass data are added in (Fig. 5a).
Prediction of benthic biomass distribution in the Mackenzie Shelf (Random Forests regression) from bathymetry and sediment properties is presented in Fig. 5 c).

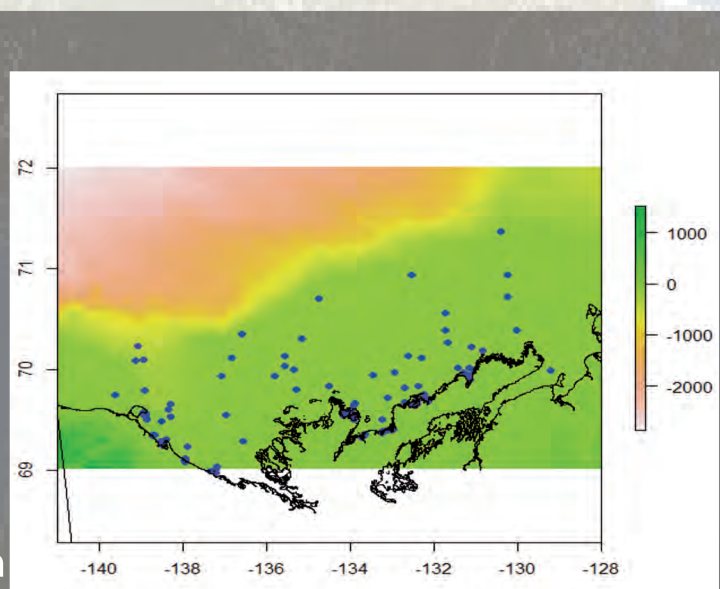


Fig. 5 a)

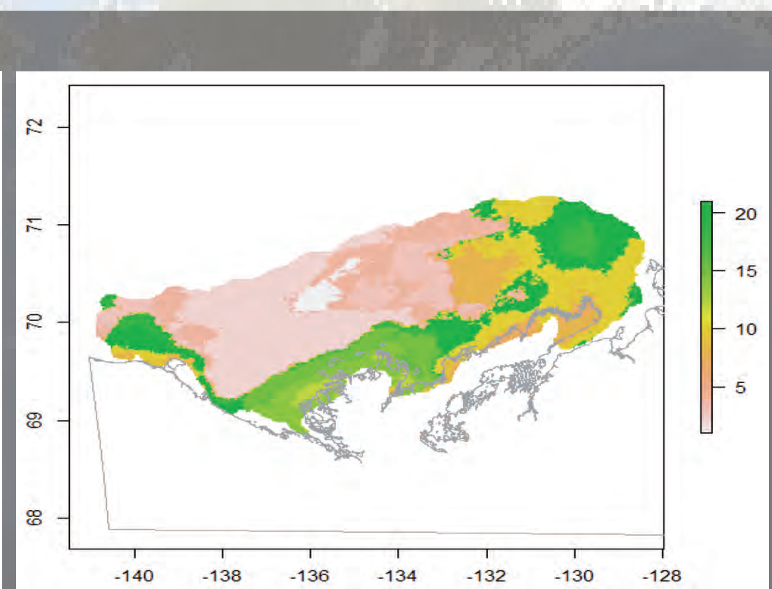


Fig. 5 b)

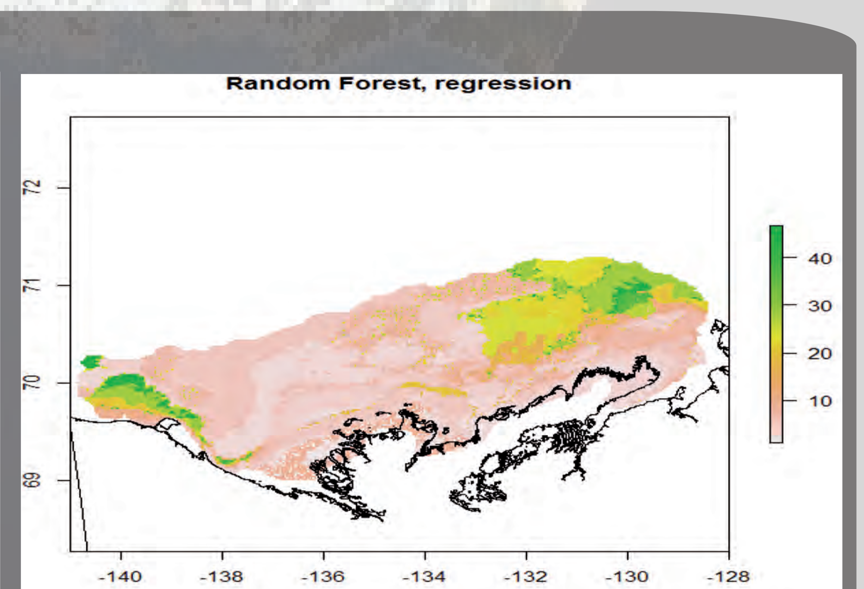


Fig. 5 c)

Take home message:

Our approach offers an effective tool to:
1) identify areas of potential high biological activity (ecological "hotspots").
2) facilitate the evaluation of marine protected areas and the development of ecosystem-based management approach.
3) show that data sharing and collaborations can be transformed into useful information

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