



Seventh Framework Programme
 Theme 9 Space FP7-SPA.2009.1.1.02
 Monitoring of climate change issues (extending core service activities)

Grant agreement for: Collaborative Project (generic).

Project acronym: **MONARCH-A**

Project title: **MONitoring and Assessing Regional Climate change in High latitudes and the Arctic**

Grant agreement no. 242446

Start date of project: 01.03.10

Duration: 36 months

Project coordinator: Nansen Environmental and Remote Sensing Center, Bergen, Norway

D 3.2.2 “CaCO₃ production time series as gridded data sets for the time of available high quality remotely sensed data for the Arctic Ocean”

Due date of deliverable: 29.02.2012

Actual submission date: 06.03.2012

Organization name of lead contractor for this deliverable: NIERSC

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Project co-funded by the European Commission within the Seventh Framework Programme, Theme 6 Environment		
Dissemination Level		
PU	Public	
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RE	Restricted to a group specified by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	X



ISSUE	DATE	CHANGE RECORDS	AUTHOR
1	6/3/2012	Complete version	D.Petrenko
2	8/3/2012	Improved layout	K. Lygre

SUMMARY

1. For both pelagic and coastal zones of the Arctic Basin the Behrenfeld and Falkowski (1997) algorithms showed the best comparison results with in situ data.
2. In the pelagic zone the best *chl* data were those provided by MEASURES + Modified BOREALI.
3. In the shelf zone the best results on *chl* were attained when using the BOREALI algorithm.
4. Concentrations of a) *E. huxleyi chl* b) coccoliths c) diatomic *chl* were retrieved by Modified BOREALI.
5. Concentration of inorganic carbon in water column (15m) were obtained by using coccoliths concentration.
6. All data (Primary production, *E. huxleyi chl*, coccoliths, diatomic *chl*, inorganic carbon) presented as gridded data at NIERSC FTP ftp://niersc.spb.ru/Monarch_A/
7. The trends in PP both across the pelagic and shelf Arctic waters are rising, and the cumulative trend in PP over the entire ice free Arctic constituted 16.3% over 13 years (1998-2010) or ~ 14,6% over 12 years (1998-2009).
8. The trend in the production of inorganic carbon in the Arctic proved to be declining for the time-period studied:- -61.4%
9. The dynamics in PP and inorganic carbon production is conditioned by the variations in the external forcing. PP production increase is thought to be mostly driven by general warming in the Arctic region, whereas the inorganic carbon production decline is believed to be a result of the onset of the negative phase in the summer-time NAO variations.



MONARCH-A CONSORTIUM

Participant no.	Participant organisation name	Short name	Country
1 (Coordinator)	Nansen Environmental and Remote Sensing Center	NERSC	NO
2	The University of Sheffield	USFD	UK
3	Universität Hamburg	UHAM	NO
4	Centre National de la Recherche Scientifique	CNRS	FR
5	Scientific foundation Nansen International Environmental and Remote Sensing Center	NIERSC	RU
6	Universitetet i Bergen	UiB	NO
7	Danmarks Tekniske Universitet	DTU	DK
8	Institut Francais de Recherche pour l'Exploitation de la Mer	IFREMER	FR

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1 Algorithms and input parameters

Three different algorithms for the retrieval of PP were tested for the Arctic Basin: a) Behrenfeld *et al.*, 1997 b) Behrenfeld *et al.*, 2005 and c) Marra *et al.*, 2003.

Table 1 shows the input parameters that were employed to run the above PP models

chl- concentration of phytoplankton chlorophyll (mg m^{-3})

PAR- photosynthetically active radiation ($\text{mol photons m}^{-2} \text{d}^{-1}$)

SST- sea surface temperature ($^{\circ}\text{C}$)

$K_d(490)$ - diffuse irradiance attenuation coefficient at $\lambda = 490 \text{ nm}$ (m^{-1})

DL – day length (hr)

$b_{b,p}$ - backscattering coefficient (m^{-1})

MLD - mixed layer depth (m)

Algorithm	Parameter						
	<i>chl</i>	PAR	SST	$K_d(490)$	DL	$b_{b,p}$	MLD
Marra <i>et al.</i> , 2003	+	+	+				
Behrenfeld and Falkowski, 1997	+	+	+	+	+		
Behrenfeld <i>et al.</i> , 2005	+	+	+	+	+	+	+

Table 1 Spaceborne input parameters required for running the PP-retrieval algorithms tested in the present research

According to Walsh *et al.*, 2005 the entire Arctic Ocean tracts can be portioned into pelagic and shelf zones (Fig. 1).

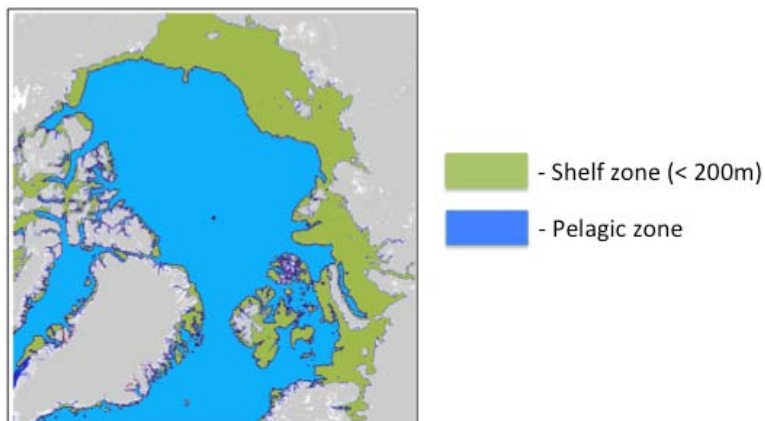


Figure 1 Repartition of the shelf and pelagic zones in the Arctic Basin (after Walsh *et al.*, 2005).

Apart from PP algorithms, tested were the quality of L3 data on of the phytoplankton chlorophyll (*chl*) retrieved by different bio-optical algorithms:

- 1 NASA OC3/OC4
- 2 NASA GSM
- 3 Ocean Colour MEASURES Project on the Oregon State University website (<http://www.science.oregonstate.edu/ocean.productivity/>)
- 4 BOREALI
- 5 Modified BOREALI

For the pelagic zone only algorithms bulleted 1-3 were tested.

By their optical properties, shelf waters differ crucially from pelagic waters. Thus, use of the standard chl retrieval algorithms was impossible, and the BOREALI algorithm was exploited (Korosov *et al.*, 2009a). The BOREALI algorithm is based on the Levenberg-Marquardt procedure with the employment of a) the hydro-optical model accounting for the main colour-producing agents (CPAs), and b) spectral remote sensing reflectance values provided from different satellite sensors. The algorithm retrieves the concentrations of:

- chlorophyll
- mineral suspended matter
- dissolved organics

For the areas of *E. huxleyi* blooms a modified BOREALI algorithm has been employed (Korosov *et al.*, 2009b). This modified algorithm retrieves the concentrations of

- *E. huxleyi* chl
- coccoliths
- diatomic chl

The main specific feature of the modified BOREALI model from the basic BOREALI model is the utilizations of a hydro-optical model accounting for the optical impact of *E. huxleyi*, diatomic alga and coccoliths. The mixed layer depth was set to 15 m.

Tested were different combinations of PP and chl retrieval algorithms. As a result, it was revealed that:

- a) in all cases the Behrenfeld and Falkowski (1997) showed the best comparison results with in situ data
- b) in the pelagic zone the best *chl* data were those provided by MEASURES + Modified BOREALI
- c) in the shelf zone the best results on *chl* were attained when using the BOREALI algorithm

2 Products specification

Retrieved were mean monthly PP fields for the time period 1998-2010 (March-October) for the pelagic area at a spatial resolution of 4 km.

Data are available on FTP NIERSC ftp://niersc.spb.ru/Monarch_A/

Data on PP are in the folder «Primary Production»

The ftp directory structure is described below:

/kind of sensor

- MODIS
- SeaWiFS

/ MODIS / ocean colour data sources:

-**oc_mod**(OceanColour SeaDAS/NASA: chlorophyll concentrations were retrieved by algorithm standard OC3)

-**oc_mod_gsm**(OceanColour SeaDAS/NASA: chlorophyll concentrations were retrieved by GSM/NASA algorithm)

-**bhr_mod**(Oregon State University data set: Ocean Colour MEASURES Project data (<http://adsabs.harvard.edu/abs/2008AGUFMIN51B1156M>): chlorophyll concentrations were retrieved by GSM + procedure of cloudiness partial removal)

/ SeaWiFS / ocean colour data sources:

-**oc_swf**(OceanColour SeaDAS/NASA: chlorophyll concentrations were retrieved by algorithm standard OC4)

-**oc_swf_gsm**(OceanColour SeaDAS/NASA: chlorophyll concentrations were retrieved by GSM/NASA algorithm)

-**bhr_swf**(Oregon State University data set: Ocean Colour MEASURES Project data (<http://adsabs.harvard.edu/abs/2008AGUFMIN51B1156M>): chlorophyll concentrations were retrieved by GSM + procedure of cloudiness partial removal)

hdf file naming convention

xxxx_mm_yyyy.mat.hdf

xxxx- abbreviation of the PP retrieving algorithm which have been applied :

- a) Bhr97 – The Behrenfeld algorithm 1997
- b) Bhr2005 – The Behrenfeld algorithm 2005
- c) Marra – The Marra algorithm 2003

(units of mgC / m**2 per day)

mm- month

yyyy = year

hdf = file type

internal variable is “pp”

You also can find all data as matlab data (“.mat”)

Coordinate grids are presented as 2 files:

- a) latitude – “lat.hdf” – internal variable is “latitude”
- b) longitude – “lon.hdf” – internal variable is “longitude”

Apart from PP data, retrieved were mean monthly concentrations [2002-2010, March-October] of:

- *E. huxleyi chl* ($\mu\text{gChl/l}$)
- coccoliths ($10^6/l$)
- diatomic *chl* (mgChl/l)
- inorganic carbon (mgC/l) (within the water column 0-15 m)

All above data (MODIS L3) are at the spatial resolution of 4 km.

Data are placed on FTP NIERSC ftp://niersc.spb.ru/Monarch_A/

P data are stored in the folder «Inorganic Carbon»

The ftp directory structure is described below:

/kind of sensor

-MODIS

hdf file naming convention

xxxx_mm_yyyy.mat.hdf

xxxx- abbreviation of the retrieved parameter :

- **cc** – concentration of coccoliths (internal variable is “cc”)
- **cf** – concentration of chl *E. huxleyi* (internal variable is “cf”)
- **chl** – concentration of diatomic chl (internal variable is “chl”)
- **C** – concentration of inorganic carbon (internal variable is “C”)

mm- month

yyyy = year

hdf = file type

You also can find all data as matlab data (“.mat”)

Coordinate grids are presented as 2 files:

- c) latitude – “latC.hdf” – internal variable is “latitude”
- d) longitude – “lonC.hdf” – internal variable is “longitude”

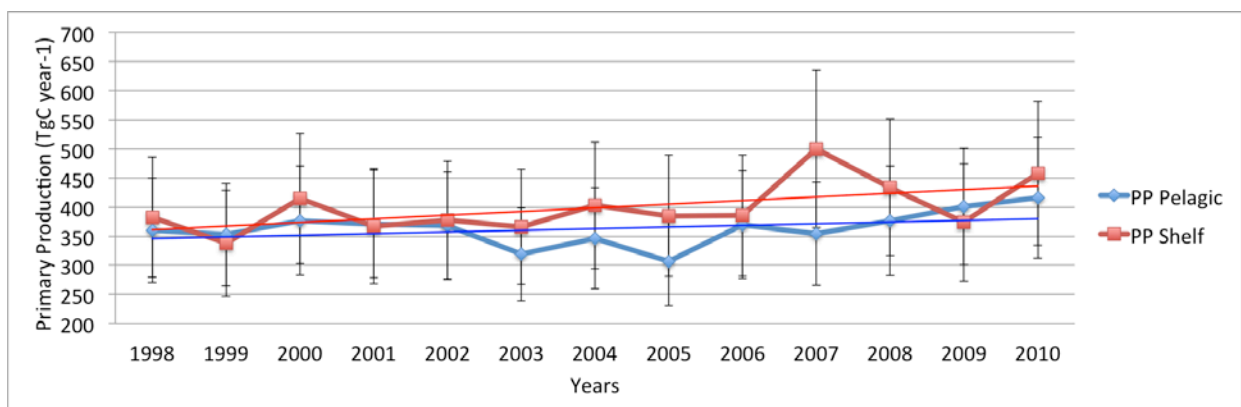


Figure 2 Temporal variations and trends in annual PP in the ice-free pelagic and shelf zones of the Arctic Ocean.

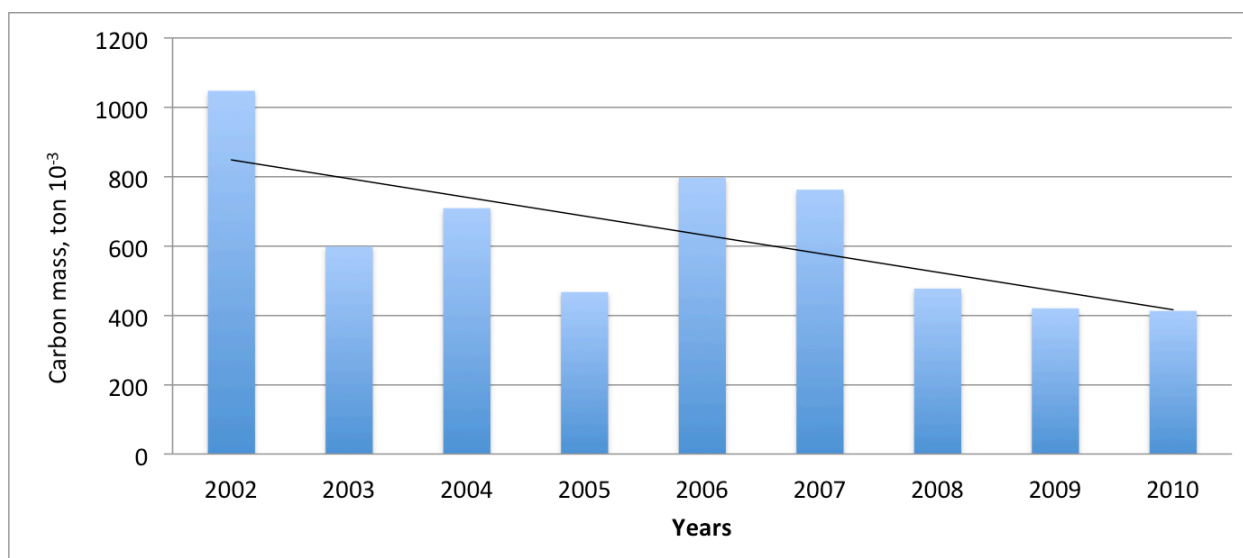


Figure 3 Interannual variations of and trend in inorganic carbon mass in the *E. huxleyi* blooms in the Entire Arctic over 2002 – 2010.

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