Observations of chromophoric dissolved and detrital organic matter using remote sensing in Antarctic waters: Validation, dynamics and regulation

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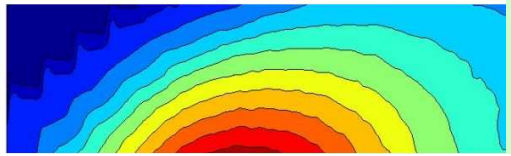
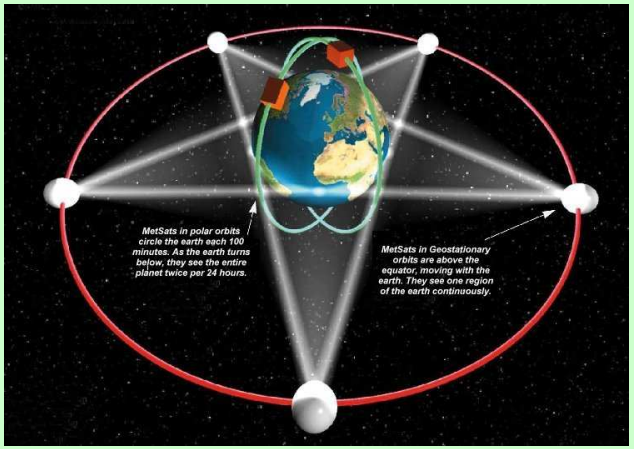
International DOM Spectroscopy Workshop



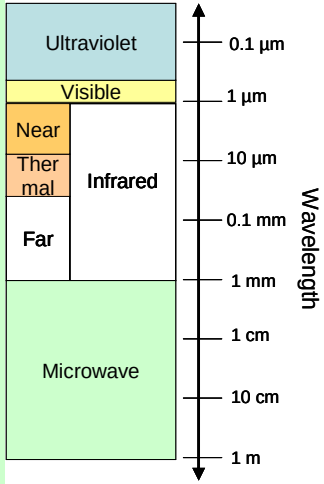
International DOM spectroscopy workshop
Granada, May 20th 2010



Development of remote sensing:

Determination of biogeochemical parameters from the space

Sensors situated in polar-orbiting satellites



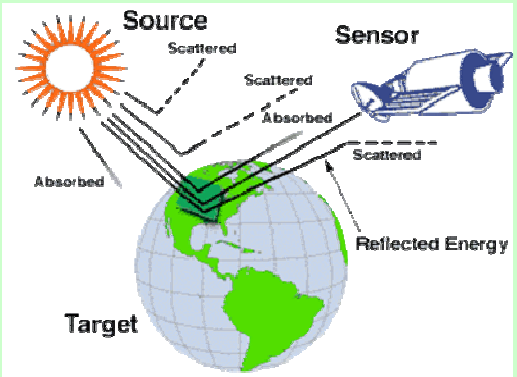
Sensor	Application
TOMS	Ozone
Goes VISSR DMSP OLS NOAA AVHRR Goes Next imager Landsat MSS/TM SPOT HRV CZCS SeaWIFS	Weather Land Use Geomorphology IOPs
NOAA AVHRR	Vegetation
NOAA AVHRR Goes VAS Goes Next imager Goes Next Sounder	Sea surface temp. Nighttime clouds Water vapor
SSMR SSM/I Altimeter SAR	Ice conc. Snow cover Sea surface topography Surface roughness

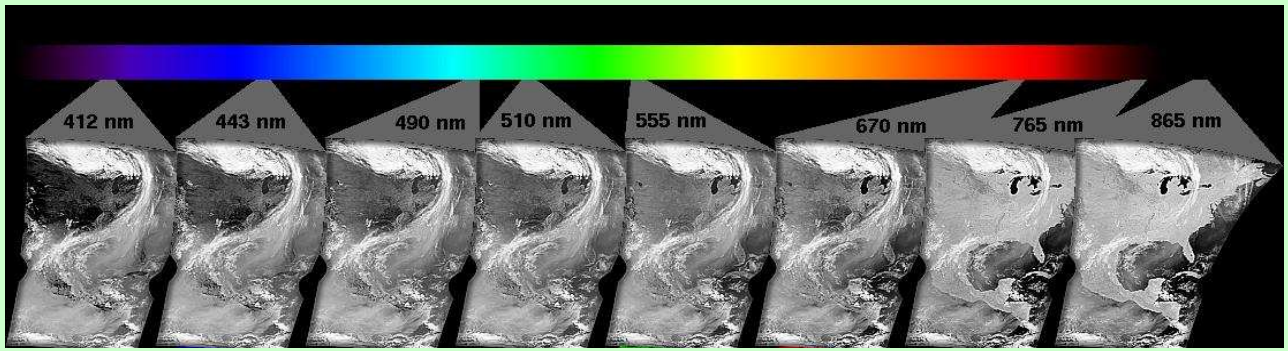
Different wavelengths are used for different applications

Ocean Color Remote Sensing

Two principal sensors: SeaWIFS and MODIS:

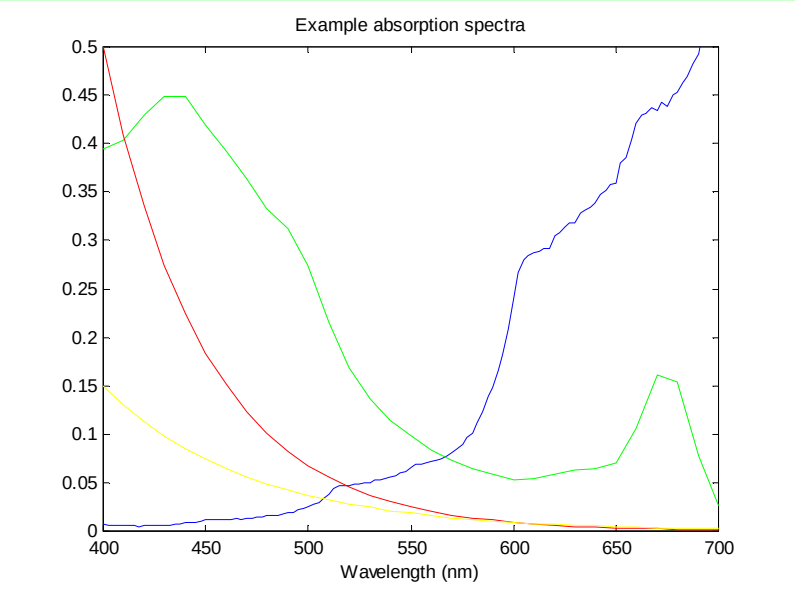
Passive sensors that measure reflected radiation at 7 discrete wavelength bands (visible and infrared)

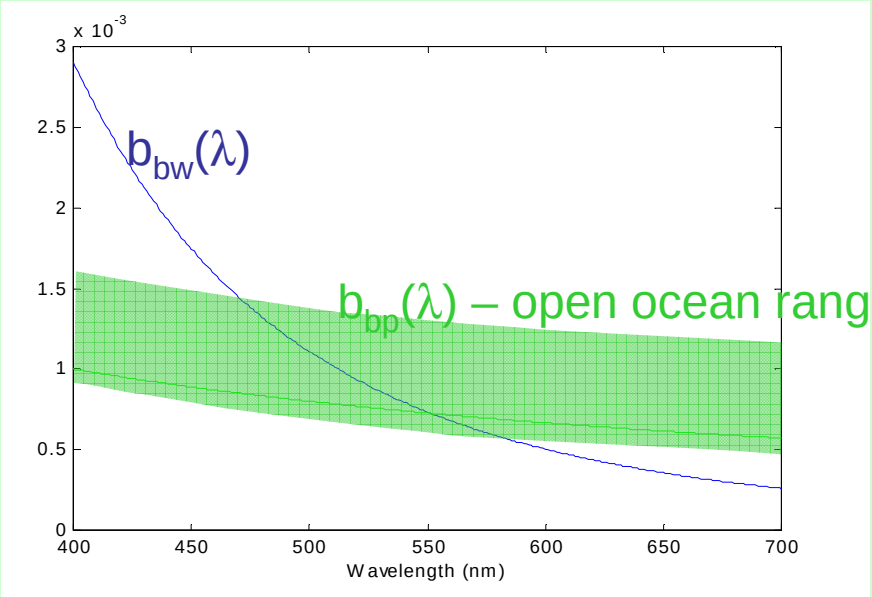




What do we want to measure?

Inherent Optical Properties:
Absorption and backscattering of water, pigments, CDOM and detrital particles

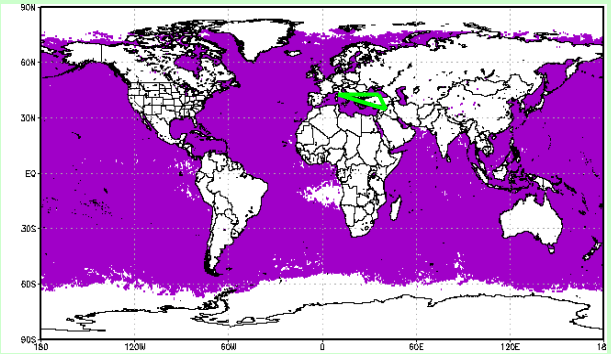




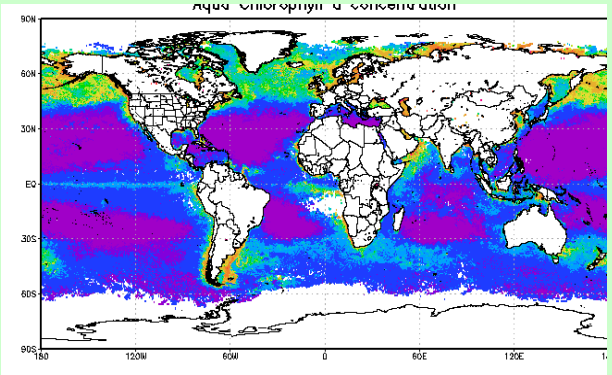
The development of ocean color satellite oceanography

✓ Allows information about broad areas of the ocean

✓Allows to obtain data at a daily basis or near-real time



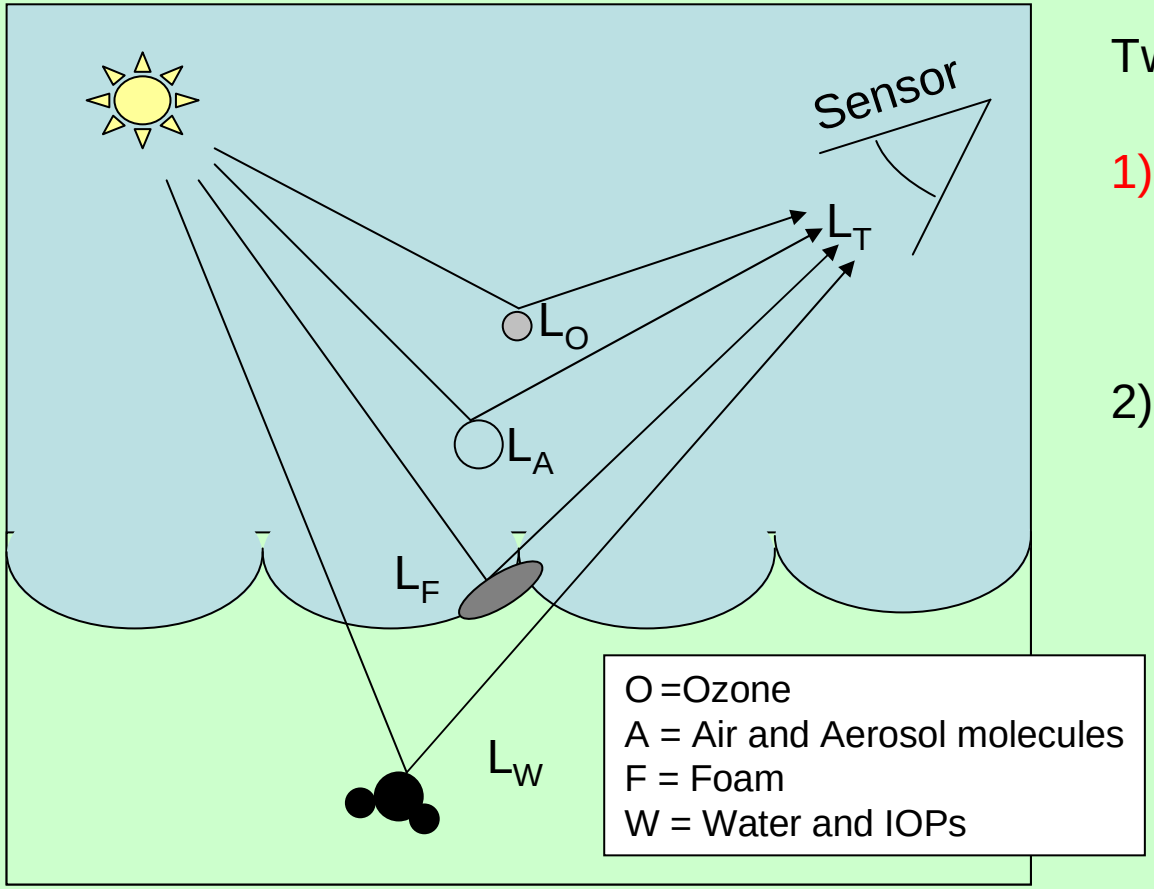
My data after 30 days on a boat



Seawifs data after 1 day cycle

Remote sensing of ocean color

Aim: To get information of inherent optical properties (IOPs) from total reflected radiance



Two steps:

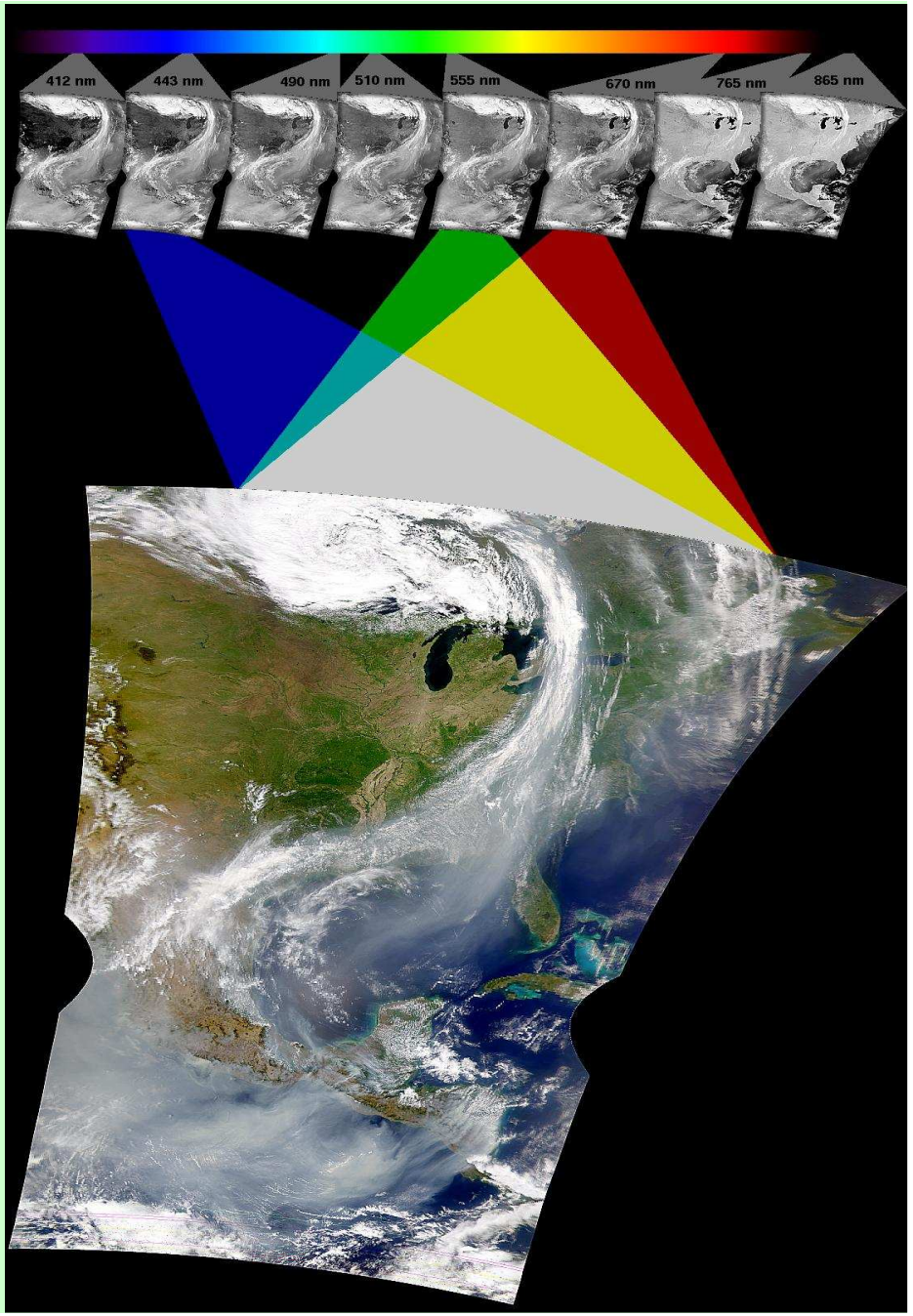
1) Atmospheric correction to retrieve water-leaving radiance (L_W)

2) Algorithms to retrieve biogeochemical variables from L_W

L_W: function of water and inherent optical properties (IOPs)

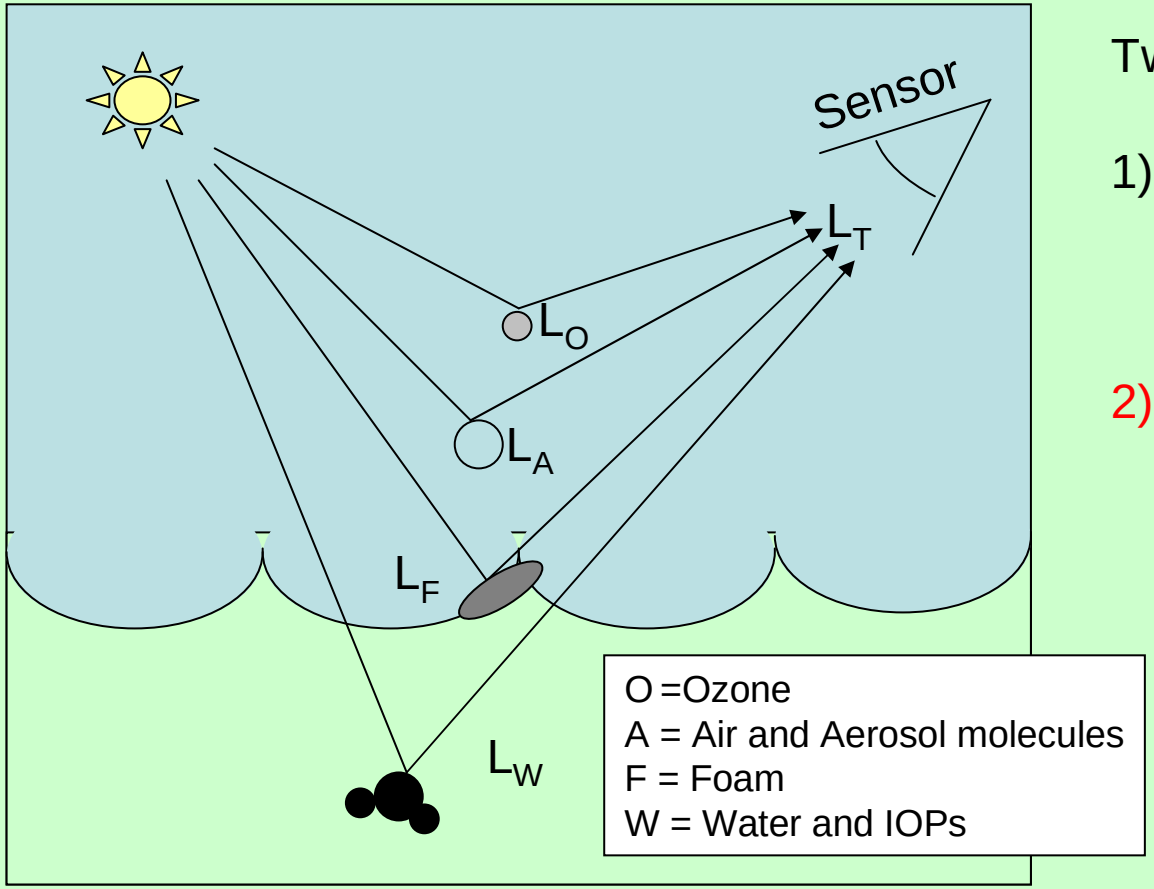
Application of atmospheric correction algorithms

Band	Center λ (nm) SeaWIFS	Center λ (nm) MODIS	Purpose
1	412	412	CDOM and detritus
2	443	443	CDM- pigment
3	490	488	Pigment algorithm
4	510	531	Pigment algorithm
5	555	551	Pigment algorithm
6	670	667	Atmospheric correction
7	765	748	Atmospheric correction
8	865	869	Atmospheric correction



Remote sensing of ocean color

Aim: To get information of inherent optical properties (IOPs) from total reflected radiance



Two steps:

1) Atmospheric correction to retrieve water-leaving radiance (L_W)

2) Algorithms to retrieve biogeochemical variables from L_W

L_W: function of water and inherent optical properties (IOPs)

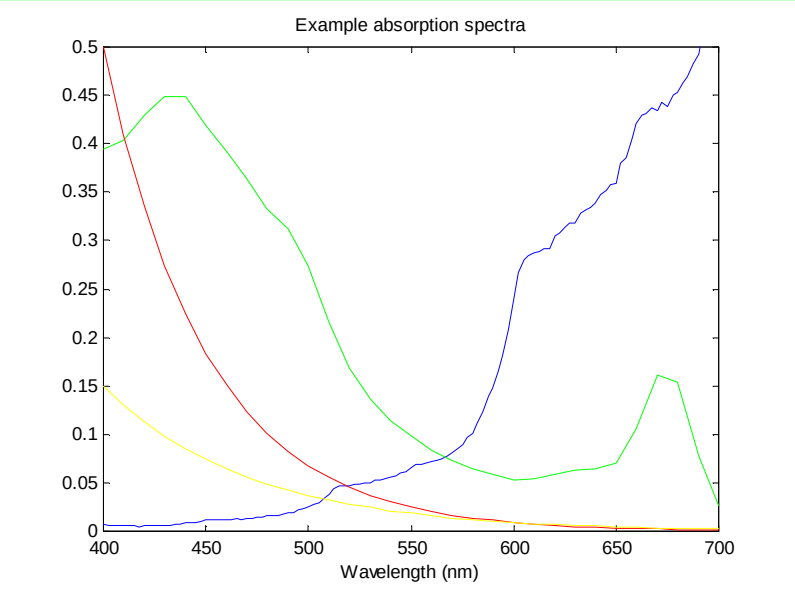
Algorithms to retrieve IOP´s from L_W

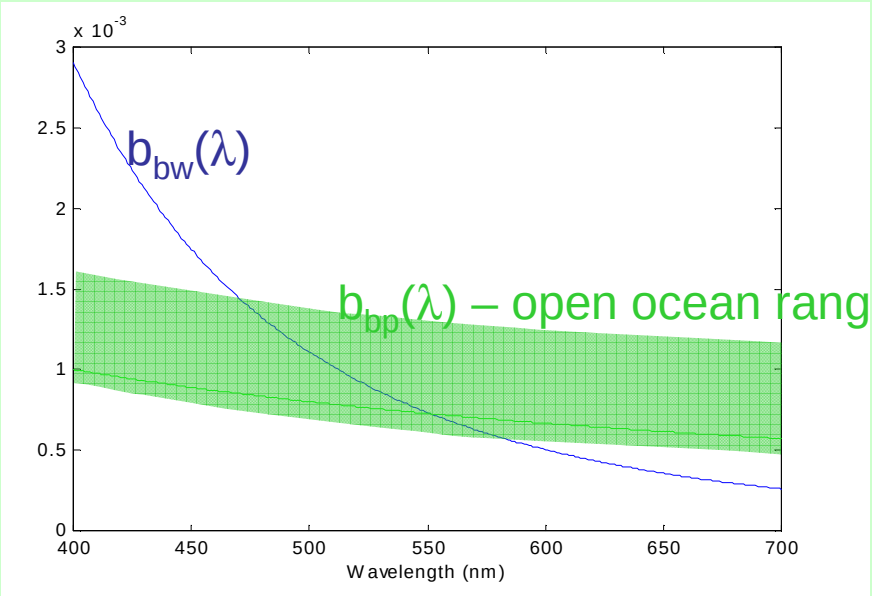
Absorption and backscattering of water, pigments, CDOM and detrital particles

$$L_W = f\,(a_T + b_T)$$

$$a_T(\lambda) = a_w(\lambda) + a_{ph}(\lambda) + a_{cdm}(\lambda) + a_{det}(\lambda)$$

$$b_T(\lambda) = b_{bw}(\lambda) + b_{bp}(\lambda)$$

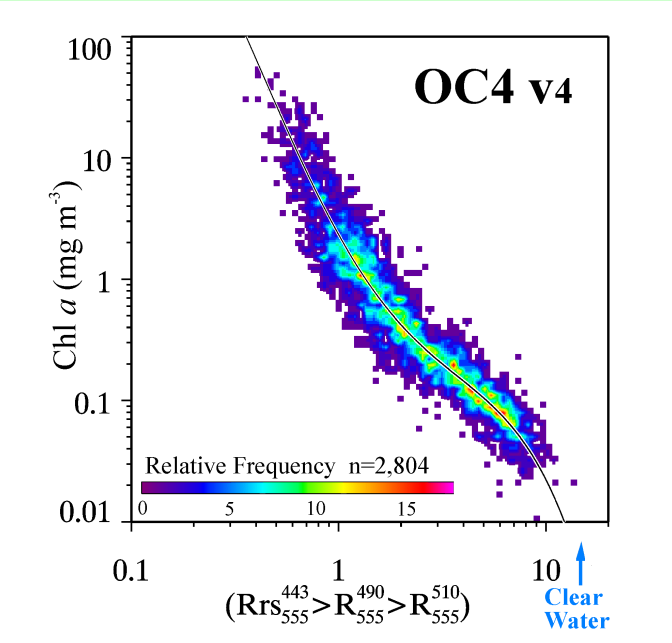




To retrieve IOP's (primarily chl a) from L_W:

Empiric algorithms:

- ✓ L_W= f(chl)
- ✓ Assume covariation between chl and other IOPs
- ✓Not always valid



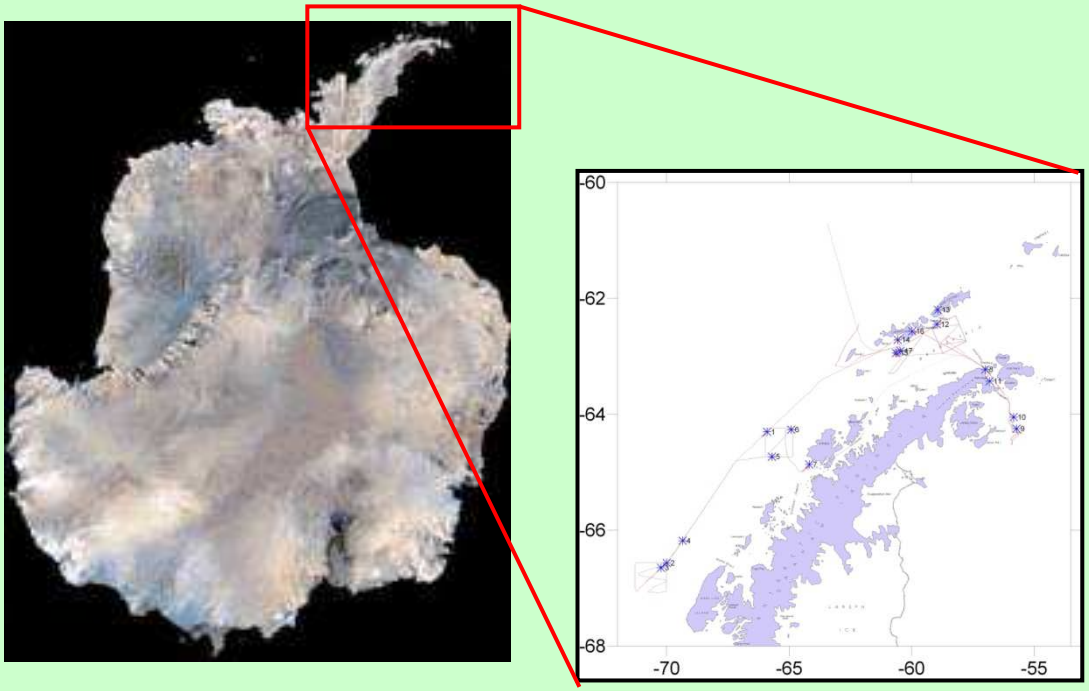
Semianalytic algorithms: Retrieve inherent optical properties independently

GSM algorithm (Garver-Siegel-Maritorena)

$$L_{WN}(\lambda) = \left(\frac{tF_0(\lambda)}{n^2_{sw}}\right)\sum_{m=1}^{2} g_m \left\{ \frac{b_{bw}(\lambda) + BBP\left(\lambda_0/\lambda\right)^{\eta}}{b_{bw}(\lambda) + BBP\left(\lambda_0/\lambda\right)^{\eta} + a_w(\lambda) + Chl^{*}_{a_{ph}}(\lambda) + CDM\exp[-S(\lambda - \lambda_0)]} \right\}^{m}$$

The Antarctic Peninsula

- Highly productive area limited to ice-free periods
- In high latitude regions, frequent satellite measurements are difficult to obtain
- Previous studies have reported an underestimation of satellite data of chlorophyll a when using global algorithms



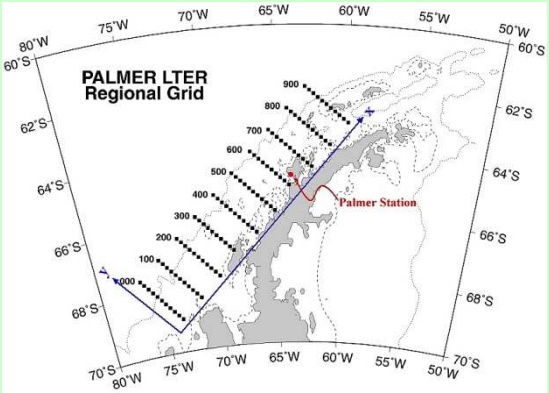
Our Goals:

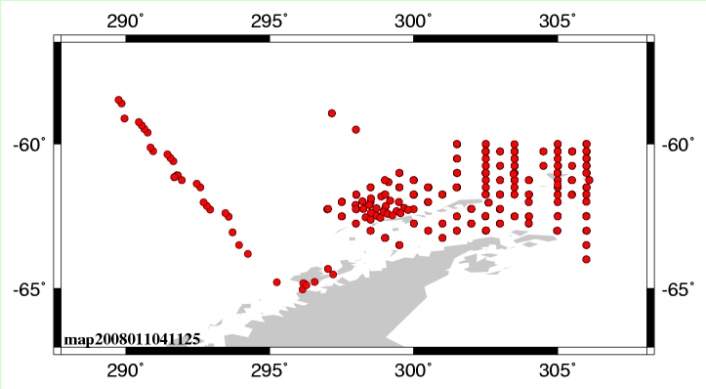
✓ To validate the GSM algorithm for satellite determinations of CDOM in the Antarctic Peninsula, and test CDM as a potential source of chl a underestimations

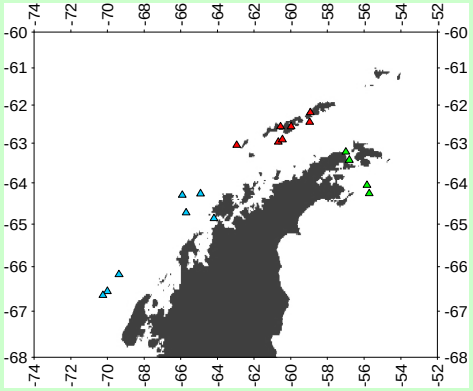
✓ To describe spatial and temporal dynamics of CDM in the area and their potential drivers using satellite data

Field database:

- ✓ Palmer LTER: Karen Patterson. 1997-1999
- ✓ SeaBASS: Greg Mitchell 2000-2002
- ✓ ICEPOS: 2004-2005







Satellite database:

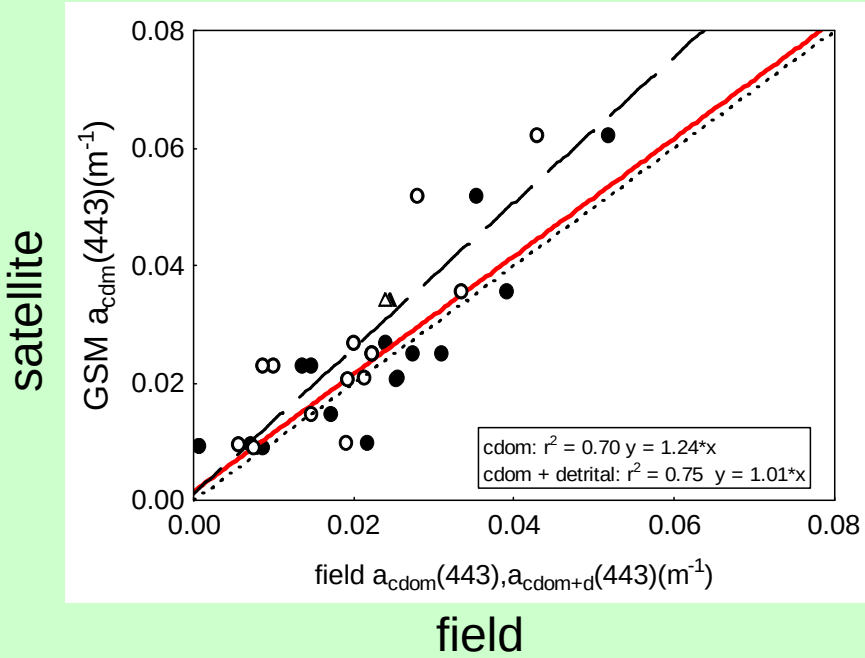
GSM CDM products

- ✓ 1997-2001: SeaWIFS
- ✓ 2002-2005: merged(SeaWIFS+MODIS)

http://www.icess.ucsb.edu/OCisD/

Validation

20 match-ups

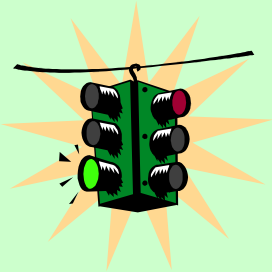


<u>when considering only field CDOM:</u>

✓ Slope > 1
✓ $r^2 = 0.70$

<u>when considering field CDOM + detrital absorption:</u>

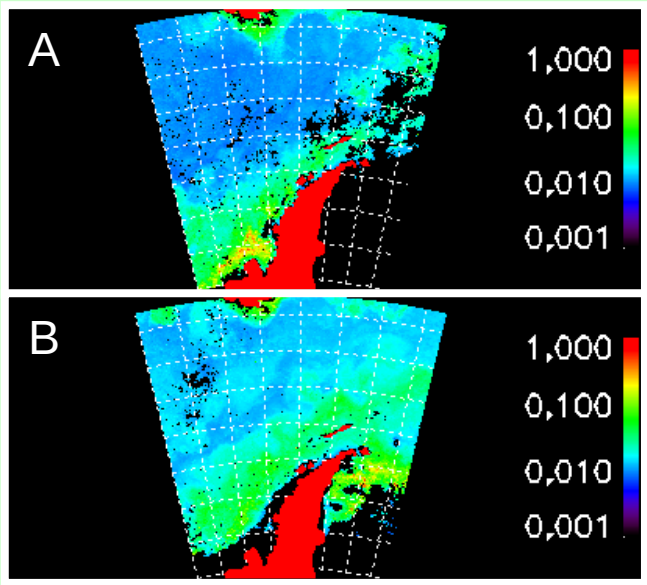
✓ Slope = 1
✓ $r^2 = 0.75$



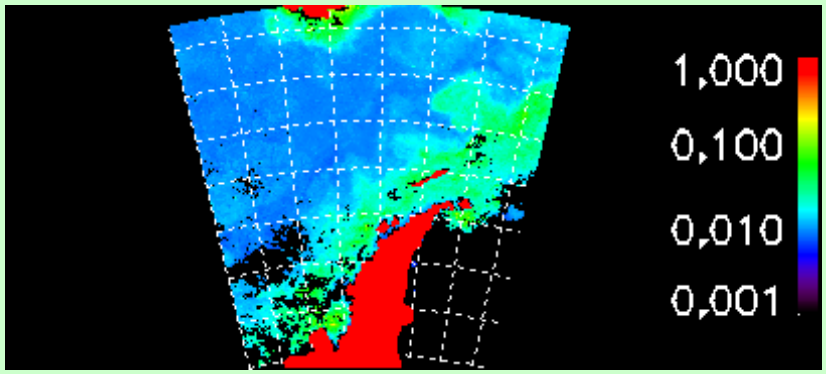
The GSM algorithm seems accurate
to obtain CDM data in the Antarctic Peninsula

CDM spatial distribution

✓ high CDM near land and areas of recent ice melting



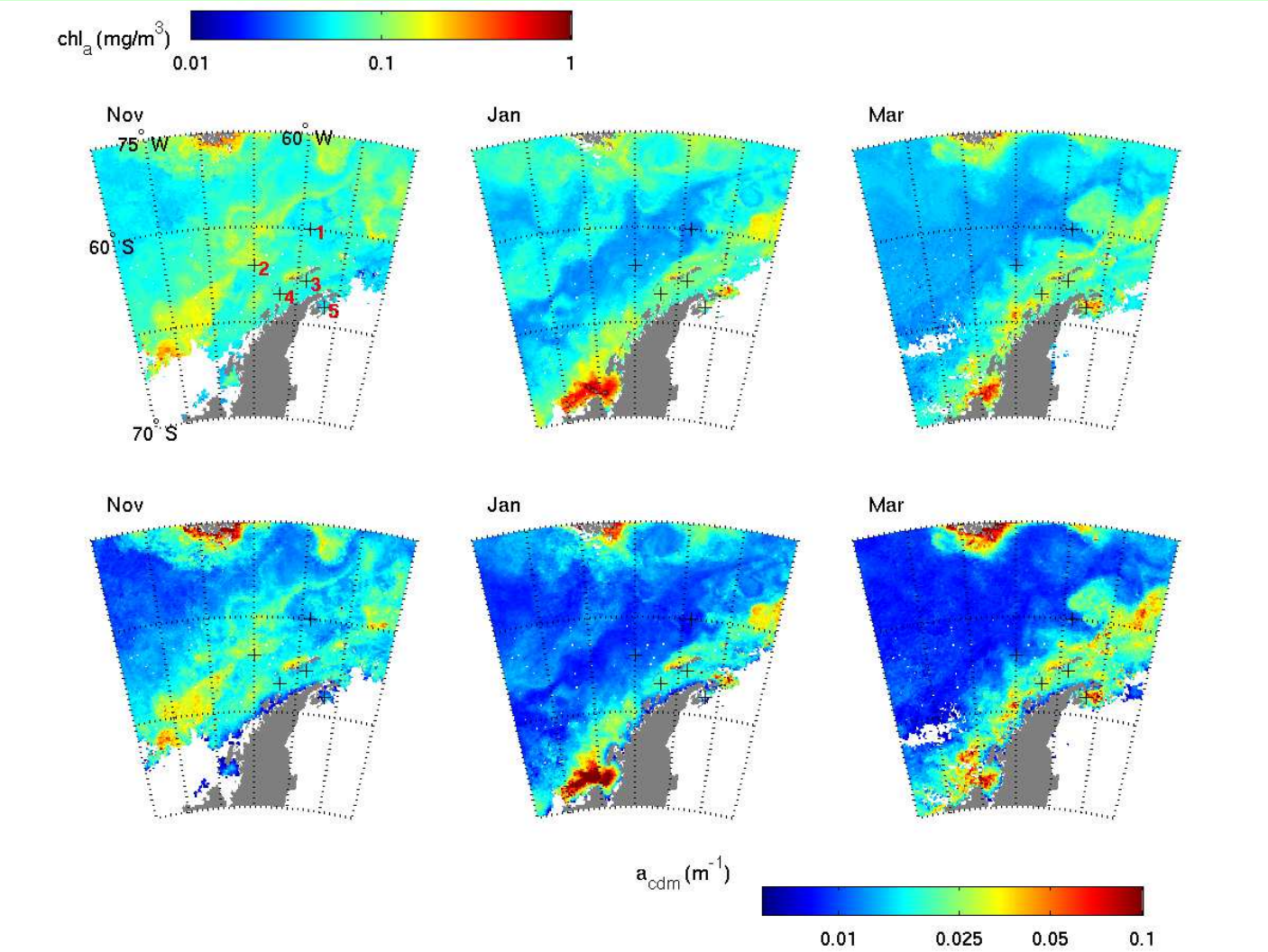
CDM seasonal dynamics



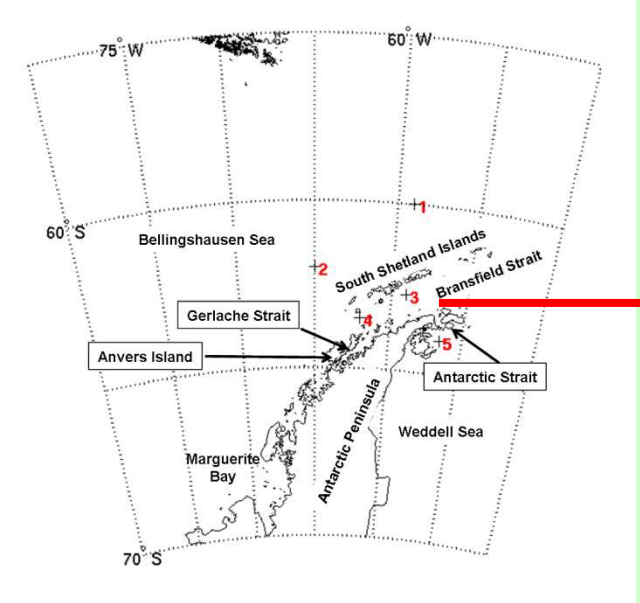
✓ Highest CDM at the end of austral spring

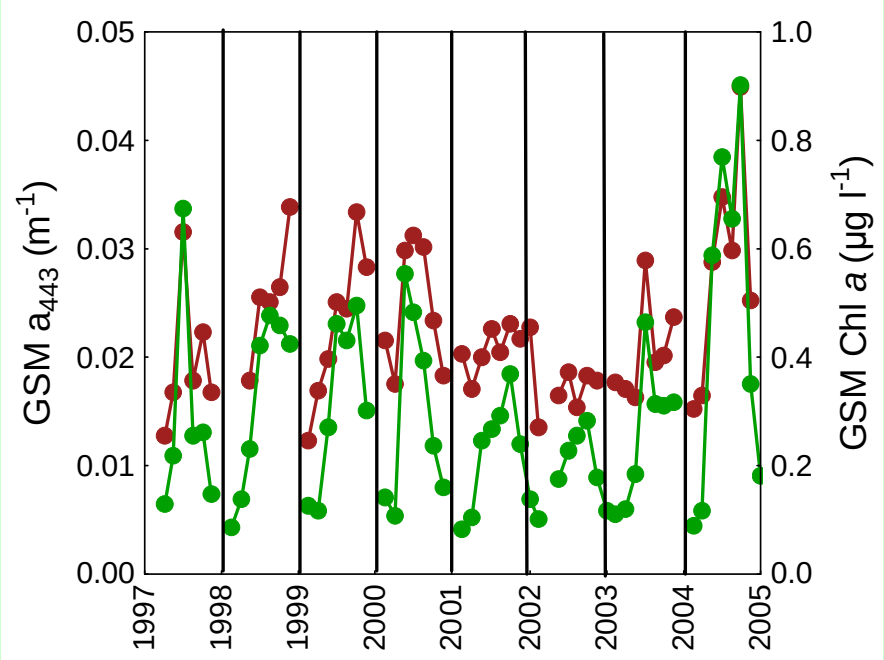
✓ Dynamics from homogeneous to patchy pictures

Good correspondance between CDM and chlorophyll a spatial distributions



CDM Drivers /Seasonal



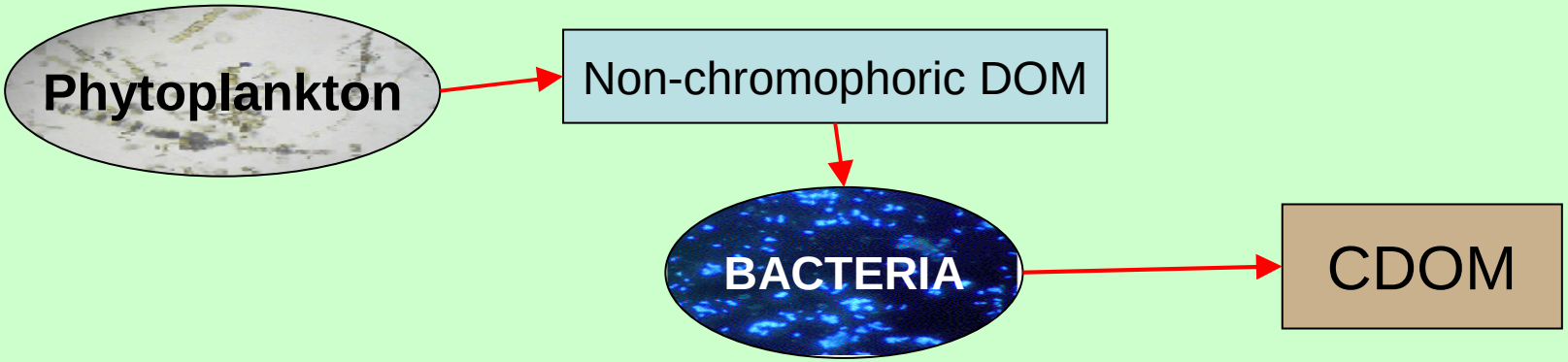


CDM absorption					
Location	1	2	3	4	5
Chl a	0.79*	0.87*	0.89*	0.83*	0.91*

Seasonal dynamics of chlorophyll a and CDM are also related

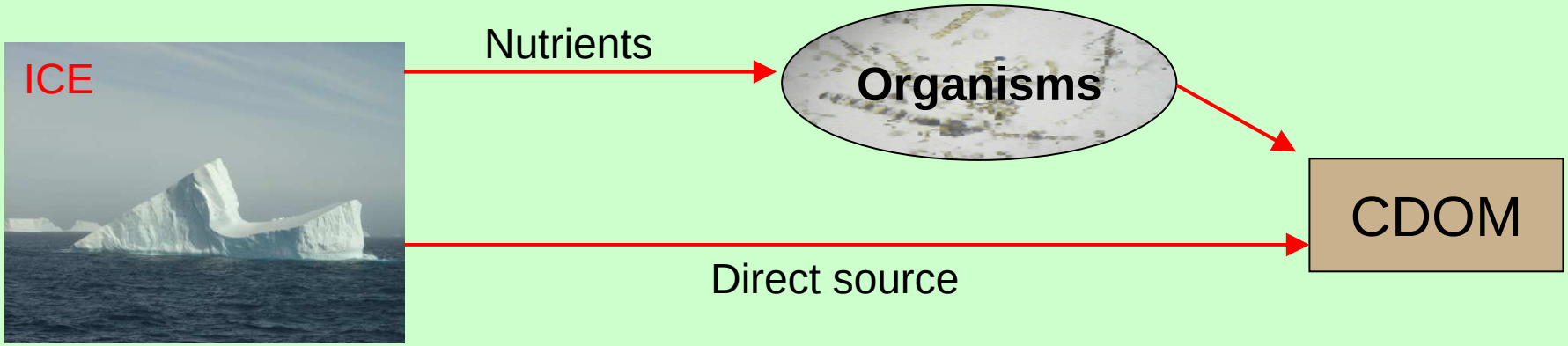
CDM Drivers /Seasonal

CDM has an ultimate algal source?



CDM and chlorophyll are driven by the same factors?

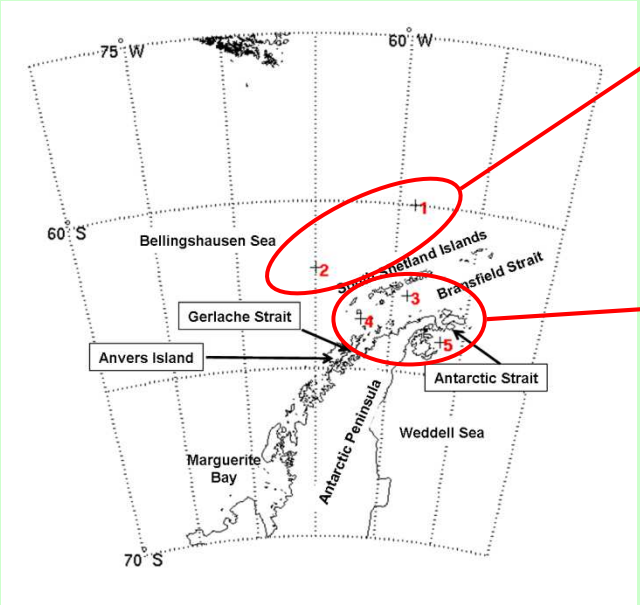
✓ Antarctic Ecosystem: Seasonally driven by the dynamics of the ice cap

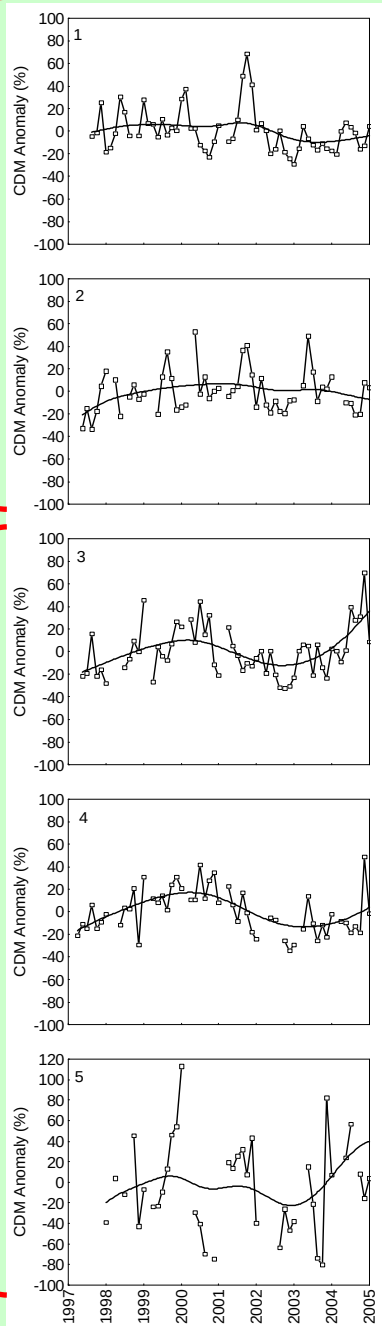


Long-term dynamics

$$\text{CDM Anomaly} = \frac{\text{CDM}_a - \overline{\text{CDM}}_a}{\text{CDM}_a} \text{x}100$$

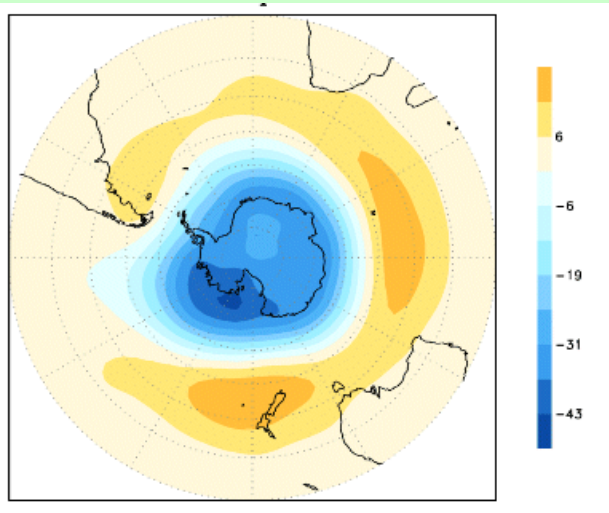
8 year time series





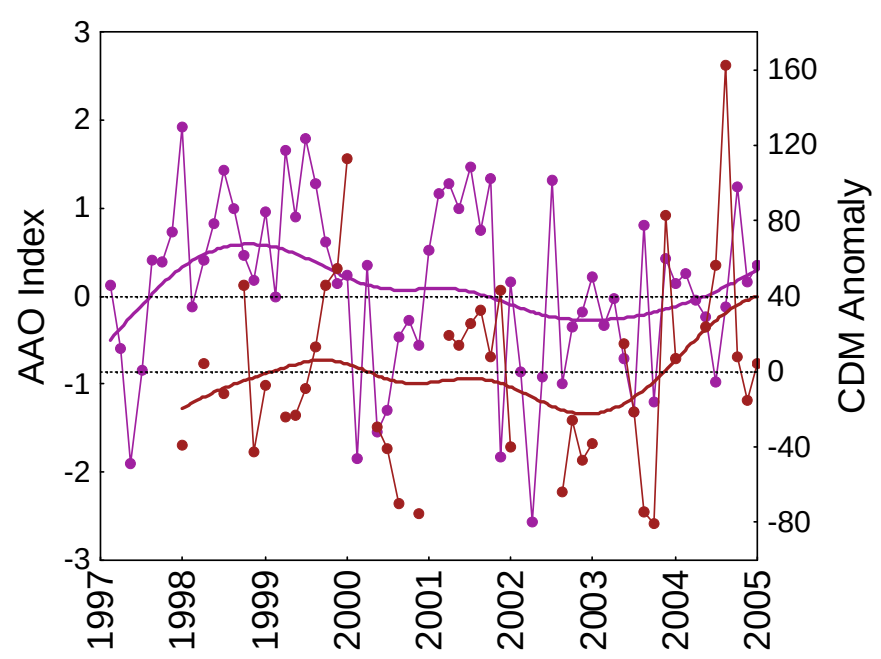
CDM Drivers /Interannual

AAO Index:
Difference of atmospheric pressures at sea level between 40 and 65 S



Positive AAO around Antarctic Peninsula:

- ✓ Increase Sea Surface Temperature
- ✓ Decrease ice extent
- ✓ Increase chl *a*



Positively related to CDM anomaly

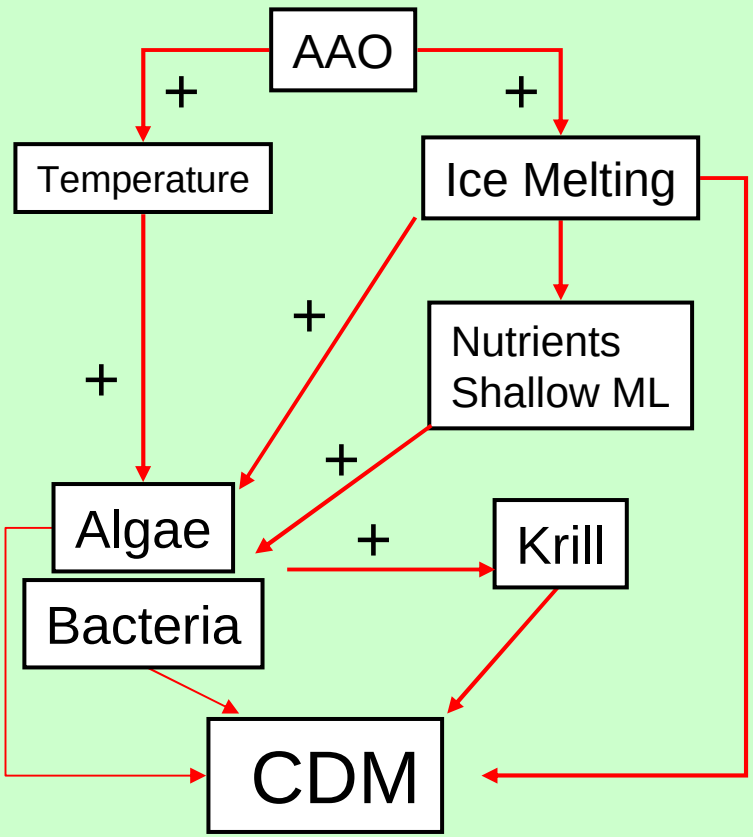
CDM around Antarctic Peninsula:

Seasonal drivers:

- ✓ Phytoplankton
- ✓ Ice advance and retreat

Climatic forcings:

- ✓ Antarctic Oscillation Index



Thanks!!!

Organizers of DOM Spectroscopy Workshop
Crew of R/V Hesperides and UTM
Institute For Computational Earth System Science (UCSB)
You all for your attention!!!