OPTICAL SIGNATURES OF CLIMATE CHANGE IMPACTS ON PHYTOPLANKTON

Stephanie Dutkiewicz
Massachusetts Institute of Technology

Anna Hickman *(University of Southampton)* , **Oliver Jahn** *(MIT),*
Erwan Moneir *(MIT)*

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GOALS

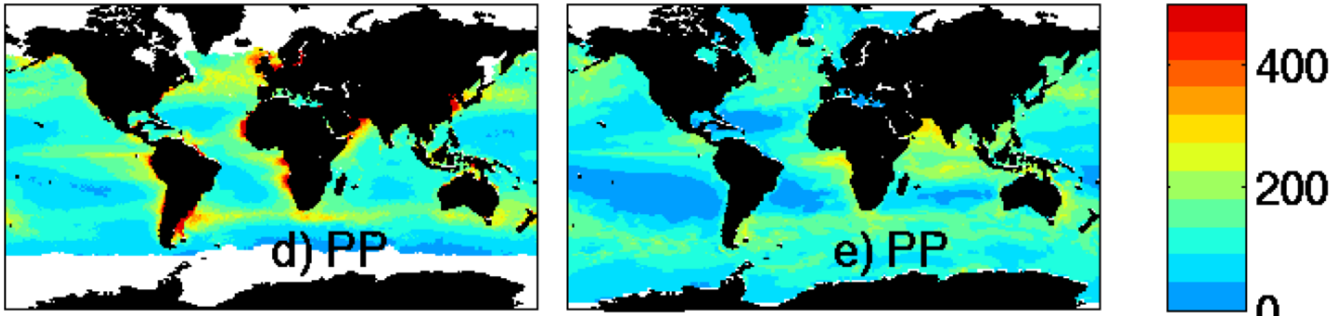
- How will ocean colour be impacted by climate change?
- How much information about the changes to ecosystems will be captured by ocean colour?

NUMERICAL MODEL DETAILS

- Earth System of Intermediate Complexity (MIT-IGSM)
- Three dimensional ocean physics (MITgcm)
  2^ox2.5^o resolution, 23 levels
- <u>Biogeochemistry</u>: C, N, P, Fe, Si, O2, Alkalinity
- <u>Ecosystem</u>: 7 phytoplankton functional types, 2 grazers

(Dutkiewicz et al, Biogeoscience, 2015)

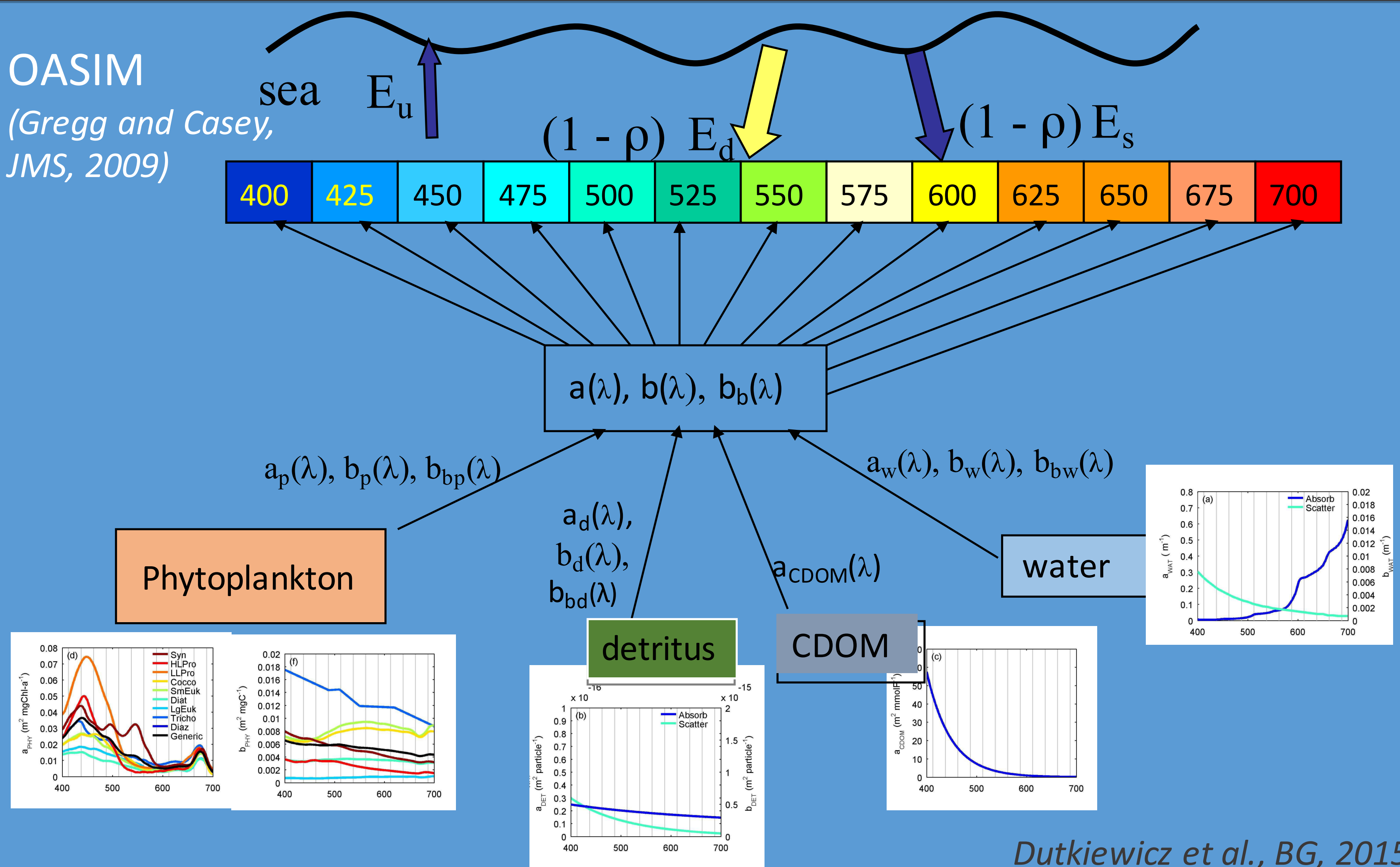
Primary Production (gC/m2/y)



satellite derived ***(Behrenfeld and Falkowski, 1997)***

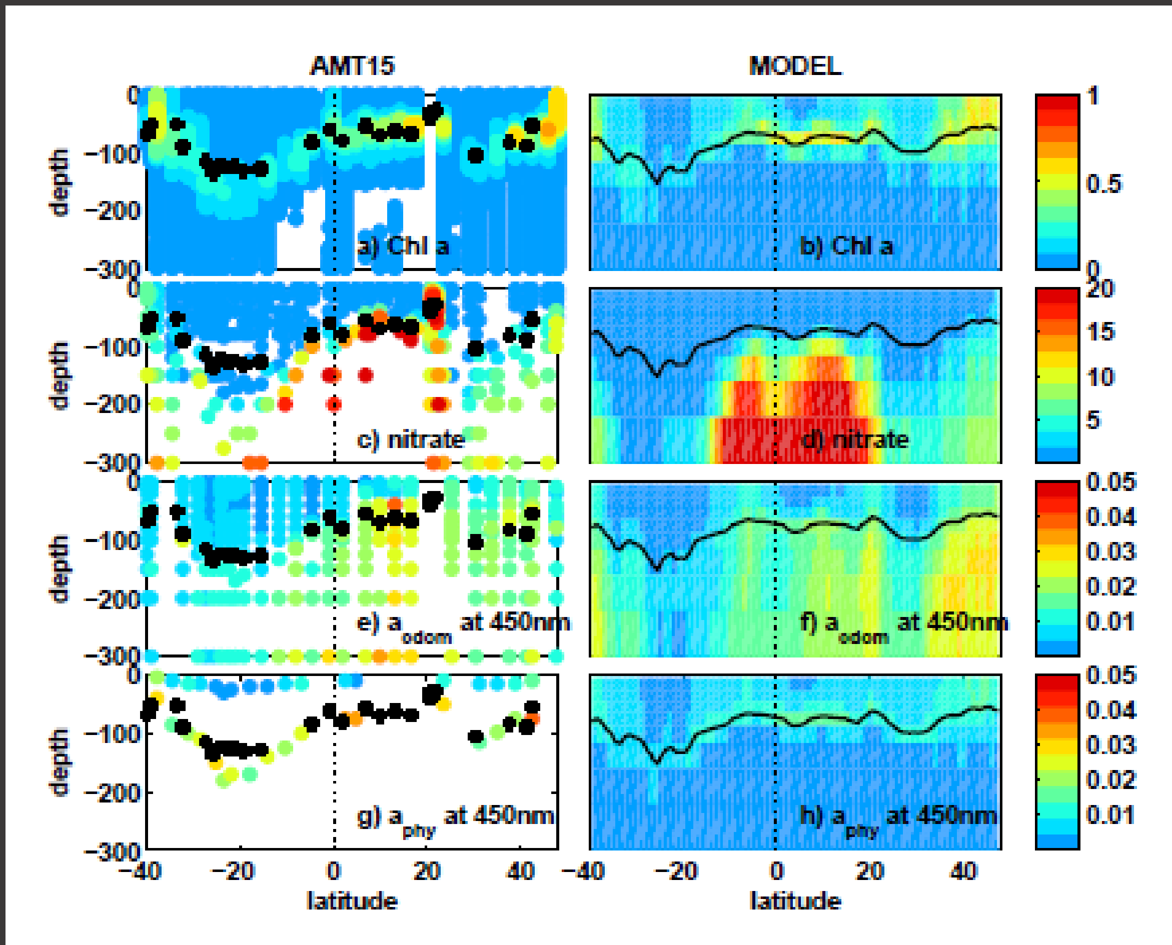
numerical model

NUMERICAL MODEL DETAILS



Dutkiewicz et al., BG, 2015

NUMERICAL MODEL DETAILS



Chl a

NO_3

a_{CDOM}

a_{phy}

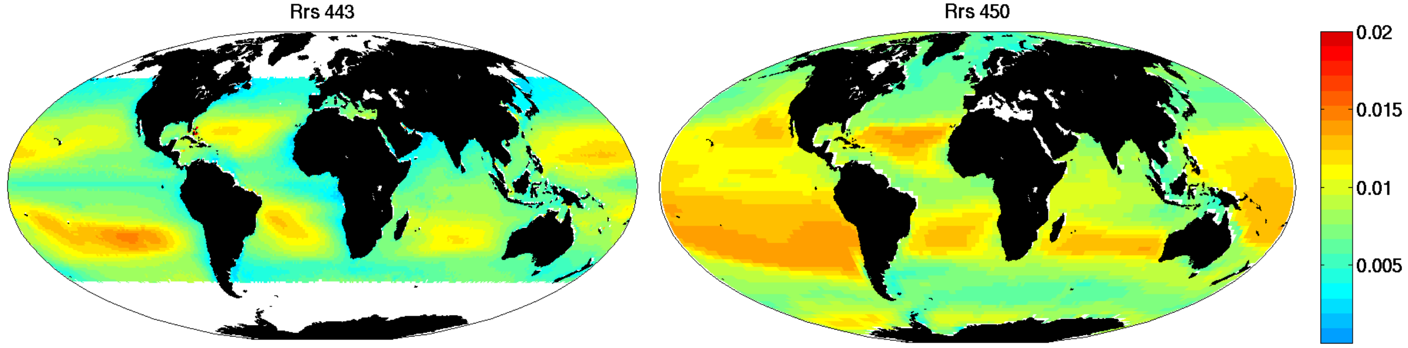
Dutkiewicz et al., BG, 2015

NUMERICAL MODEL DETAILS

Optics: *(Dutkiewicz et al, Biogeoscience, 2015)*

- spectral irradiance (25nm bands from 400-700nm)
- 3-stream radiative transfer
- absorption by water, CDOM, NAP, phytoplankton
- scattering by water, NAP, phytoplankton
- provides reflectance as output

Remotely Sensed Reflectance (1/sr)

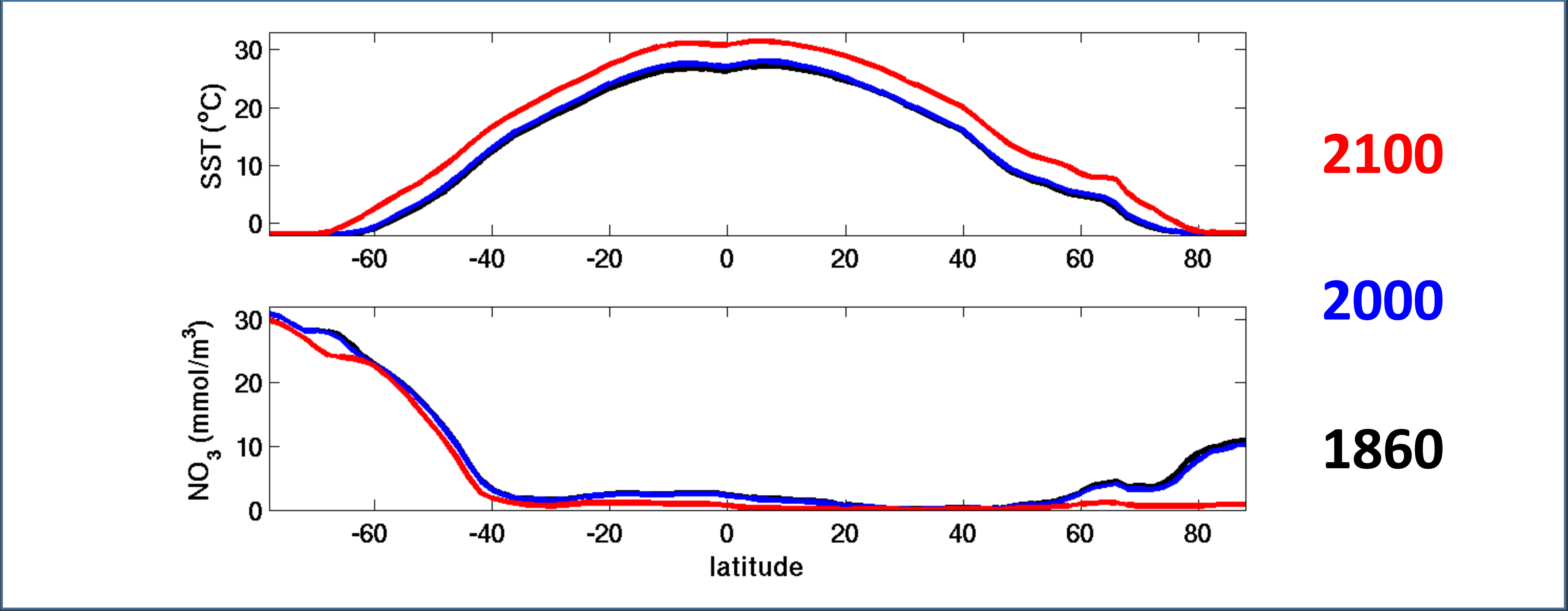


OC-CCI merged product (at 443nm)

numerical model (at 450nm)

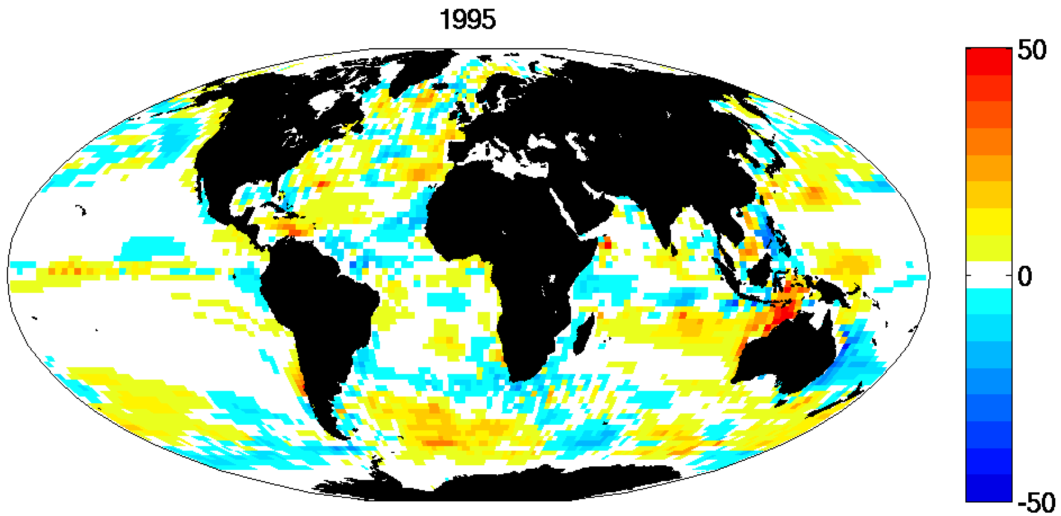
CLIMATE CHANGE SIMULATION

"Business as Usual" Emissions Scenario



- warmer
- more stratified, changing circulation
- lower nutrient supply

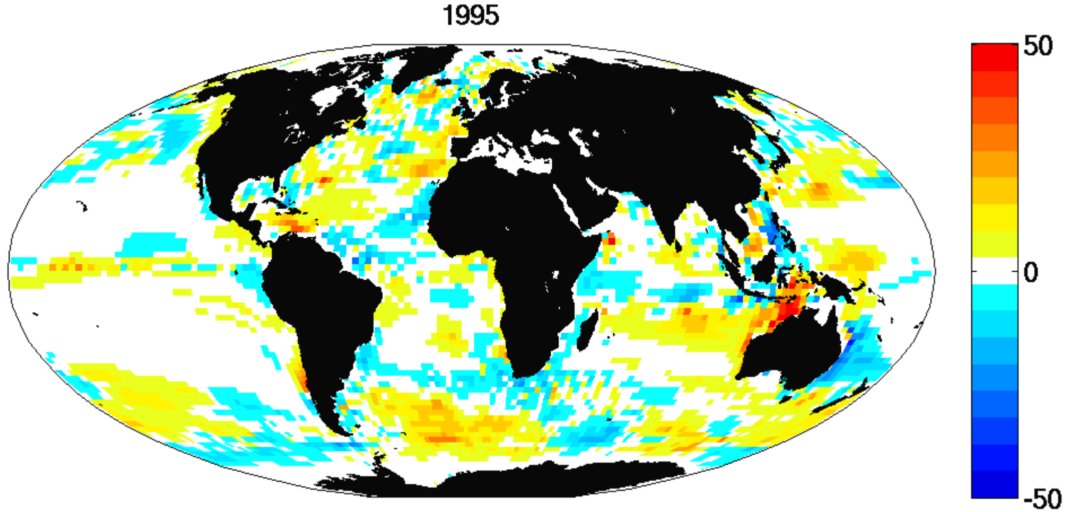
PRIMARY PRODUCTION CHANGE



relative to current day 16 year mean (1998-2015)

PRIMARY PRODUCTION CHANGE

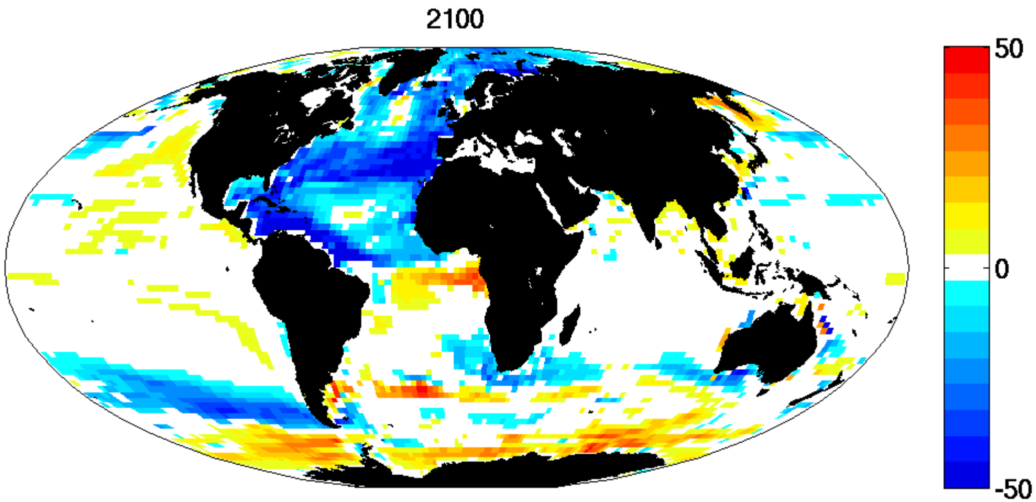
Note: this is climate model, interannual variability timing (e.g. El Nino) do not match actual years



Change in Primary Production (gC/m2/y) relative to current day 16 year mean (1998-2015)

PRIMARY PRODUCTION CHANGE

only regions with significant trend shown



Change in Primary Production (gC/m2/y)
relative to current day 16 year mean (1998-2015)

- 54% ocean has statistically significant trend by 2100

GOALS

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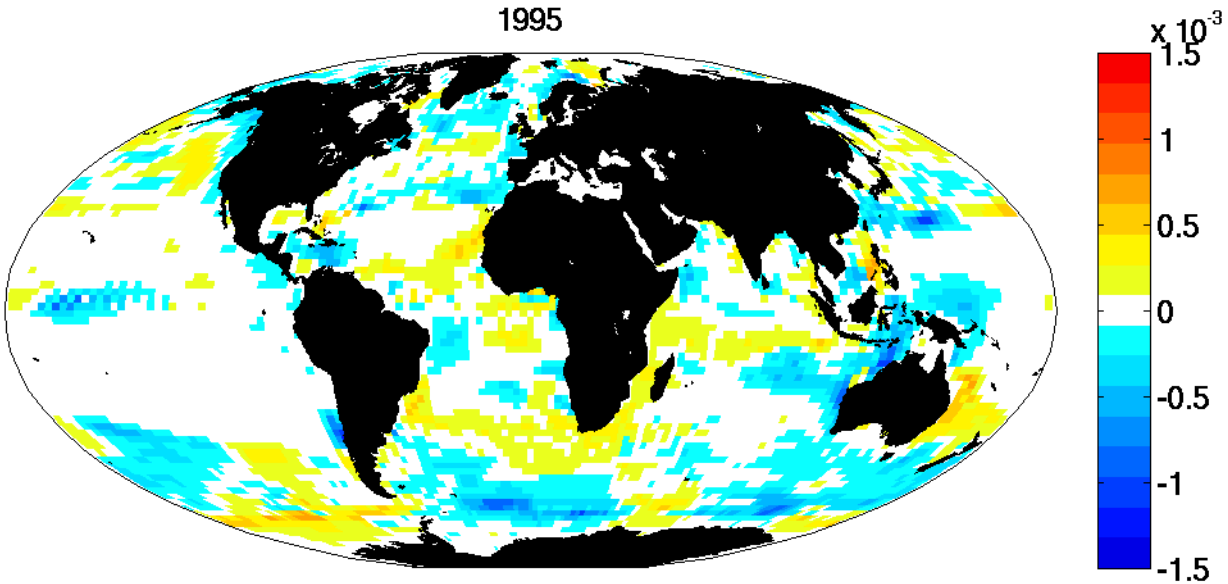
- How much information about the changes to ecosystems will be captured by ocean colour?

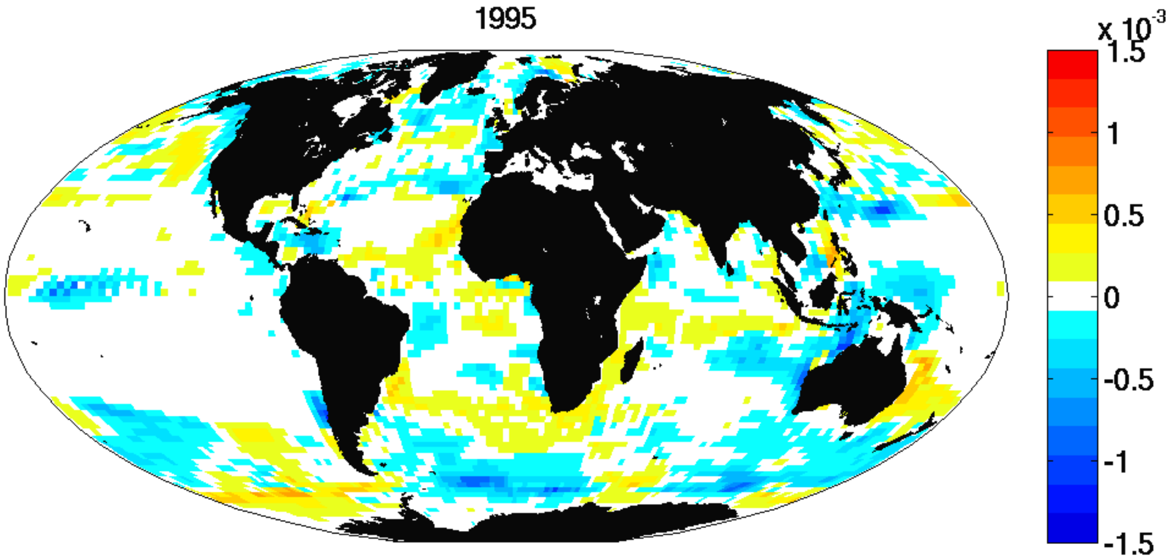
OPTICAL SIGNATURE OF CLIMATE CHANGE



Change in reflectance at 475nm (1/sr)
relative to current day 16 year mean (1998-2015)

OPTICAL SIGNATURE OF CLIMATE CHANGE

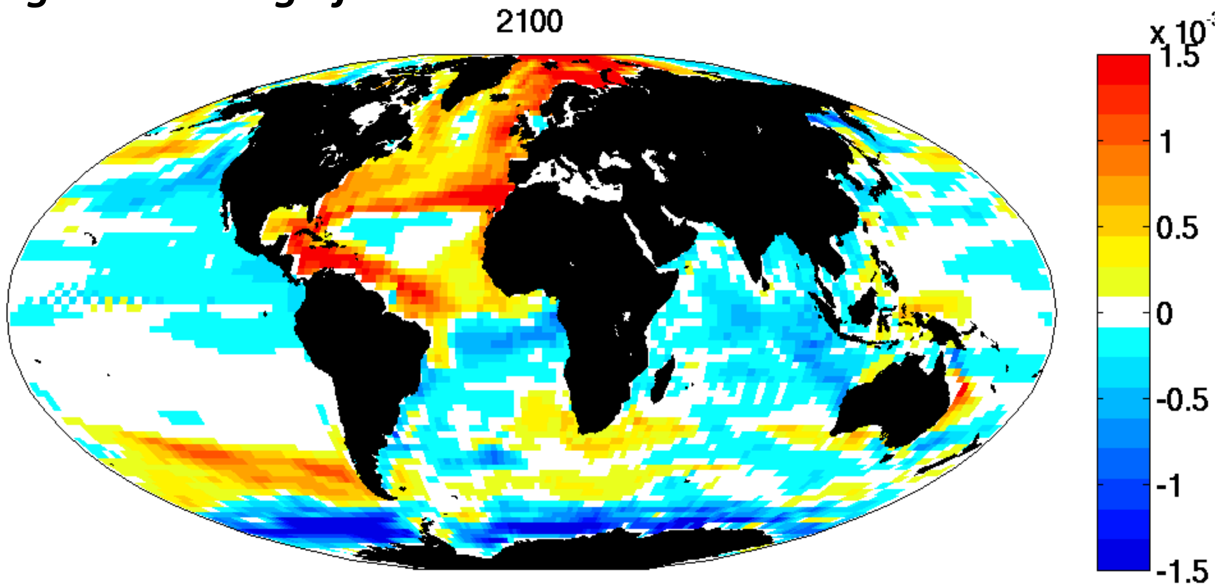
Note: this is climate model, interannual variability timing (e.g. El Nino) do not match actual years



Change in reflectance at 475nm (1/sr) relative to current day 16 year mean (1998-2015)

OPTICAL SIGNATURE OF CLIMATE CHANGE

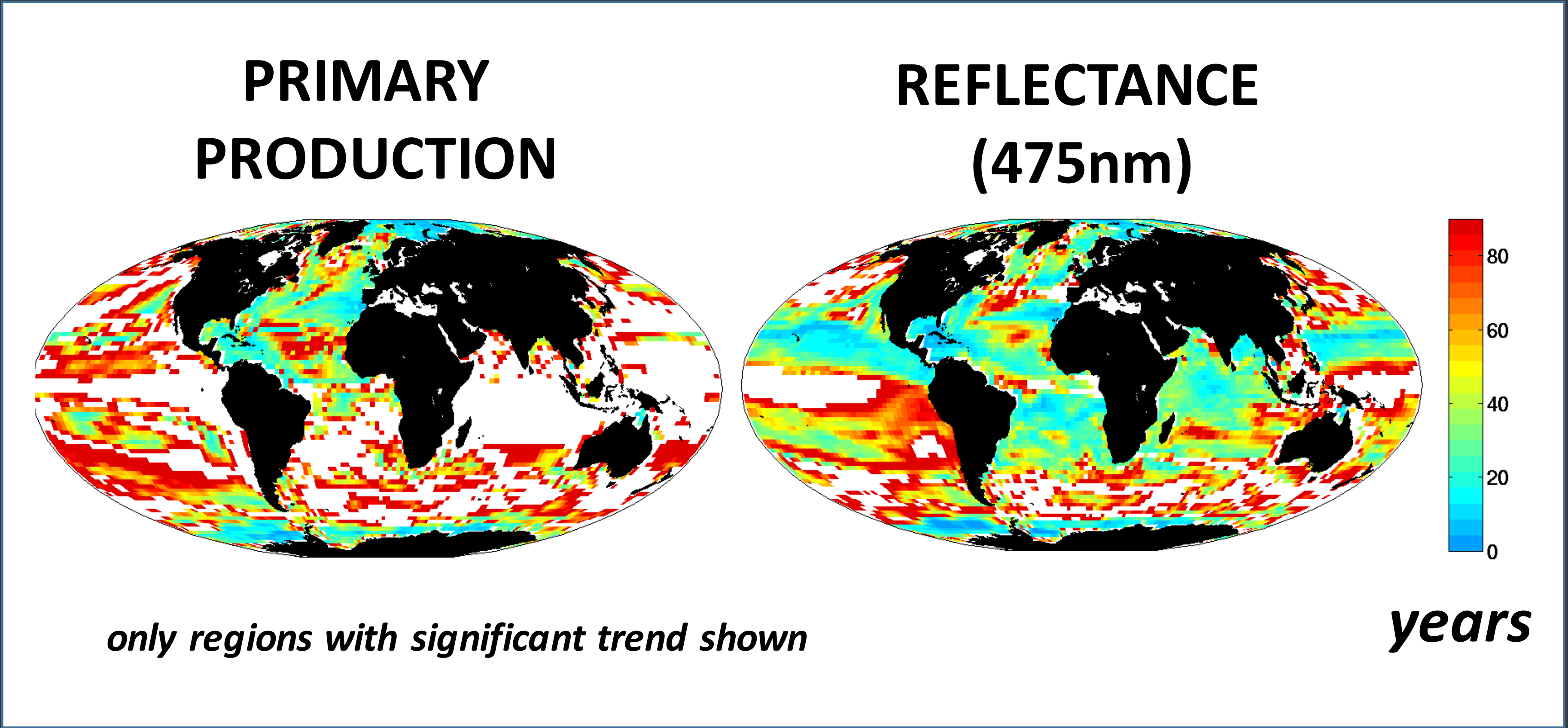
only regions with significant trend shown



Change in reflectance at 475nm (1/sr)
relative to current day 16 year mean (1998-2015)

- **73% ocean has significant trend by 2100 for reflectance at 475nm**

TIME TO EMERGENCE

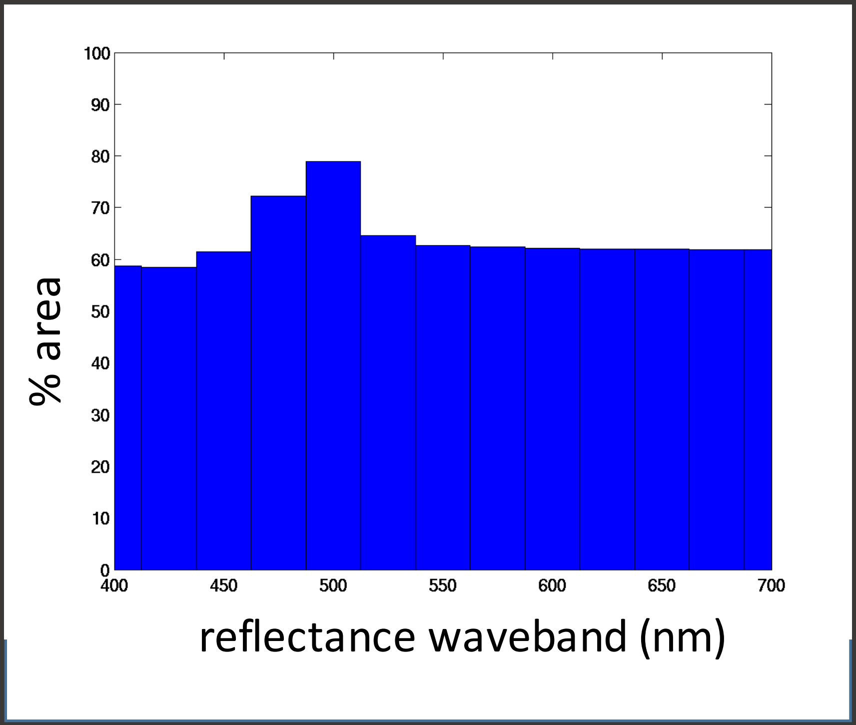


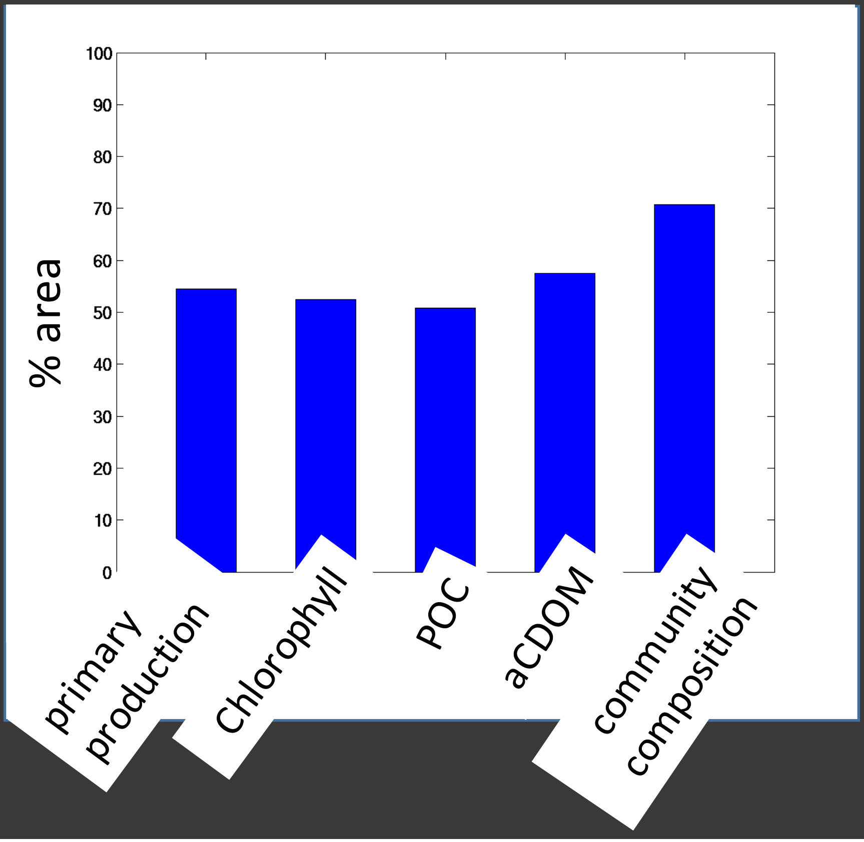
$$ToE = \frac{2*STD}{linear\ trend}$$

Keller et al., BG, 2014

SIGNATURES OF CLIMATE CHANGE

% area of ocean with significant trend by 2100 (relative to 1998-2015 mean)

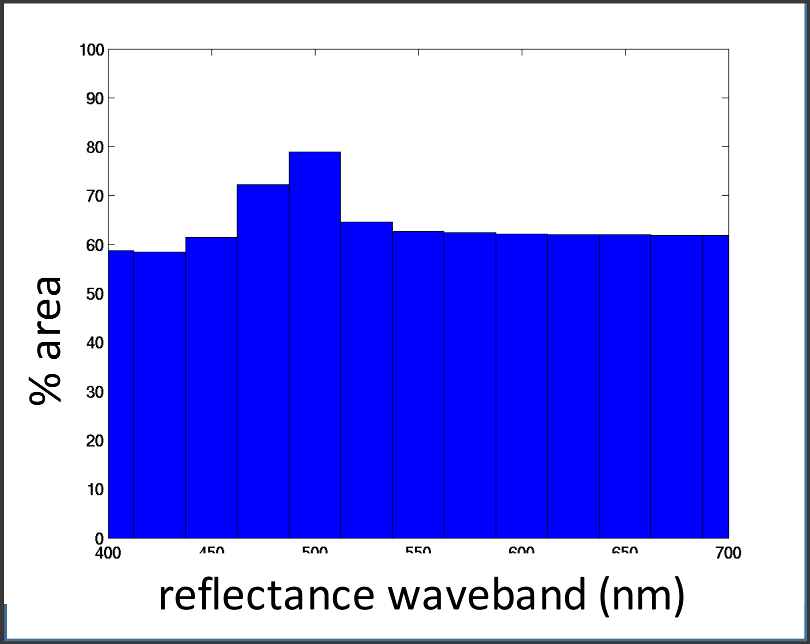




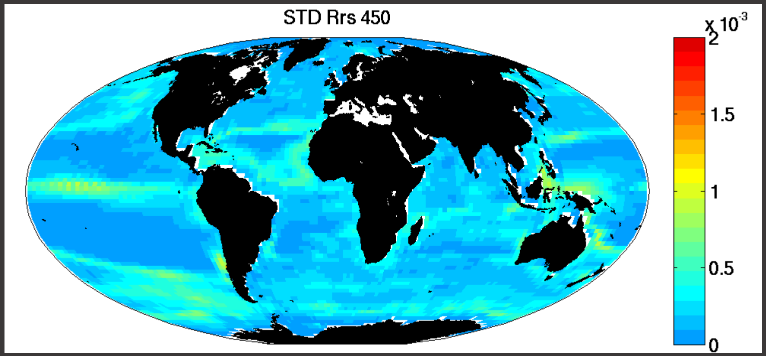
- **475-500nm reflectance show stronger trend that other metrics of climate change: they integrate the many different components**

OPTICAL SIGNATURE OF CLIMATE CHANGE

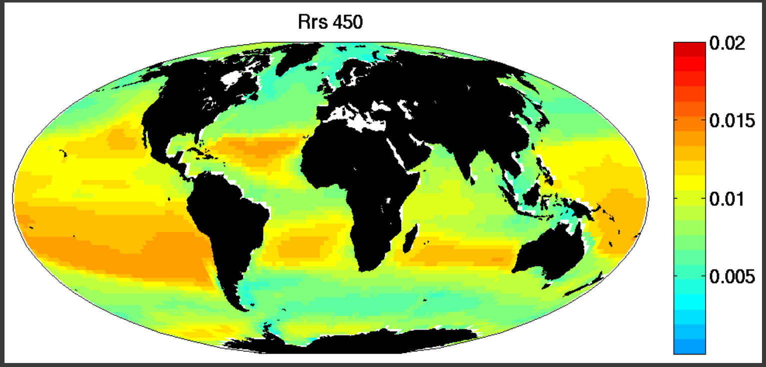
% area of ocean with significant trend by 2100 (relative to 1998-2015 mean)



STD of annual means (1998-2015) 450nm "interannual variability"

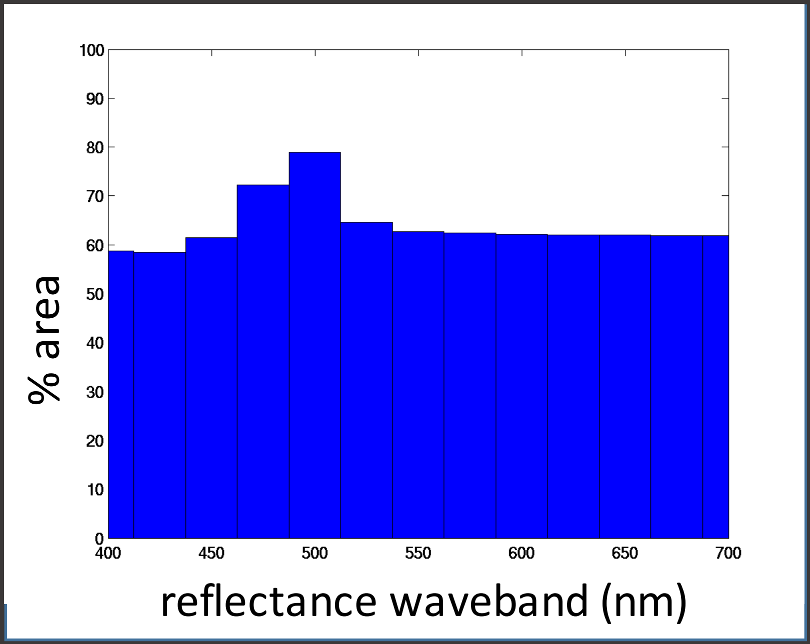


Mean at 450nm (1998-2015)

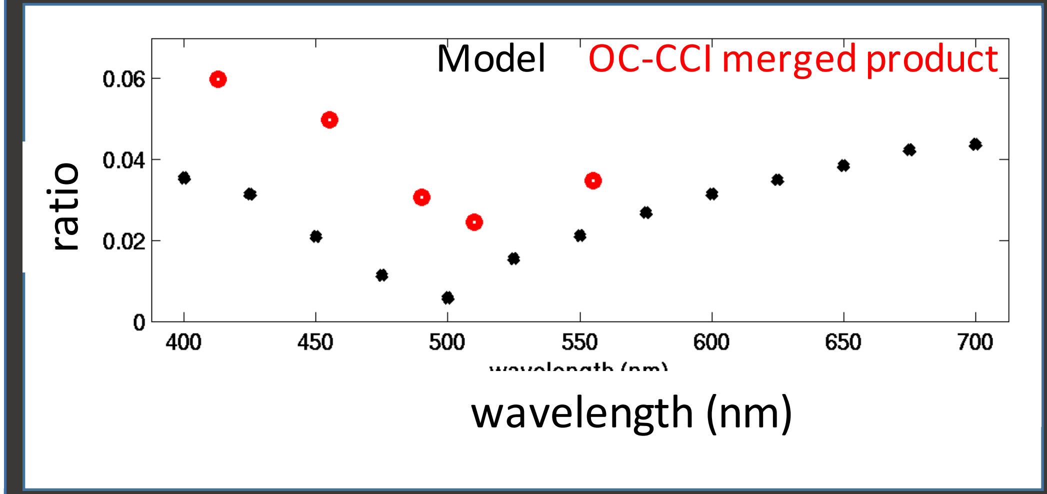


OPTICAL SIGNATURE OF CLIMATE CHANGE

% area of ocean with significant trend by 2100 (relative to 1998-2015 mean)

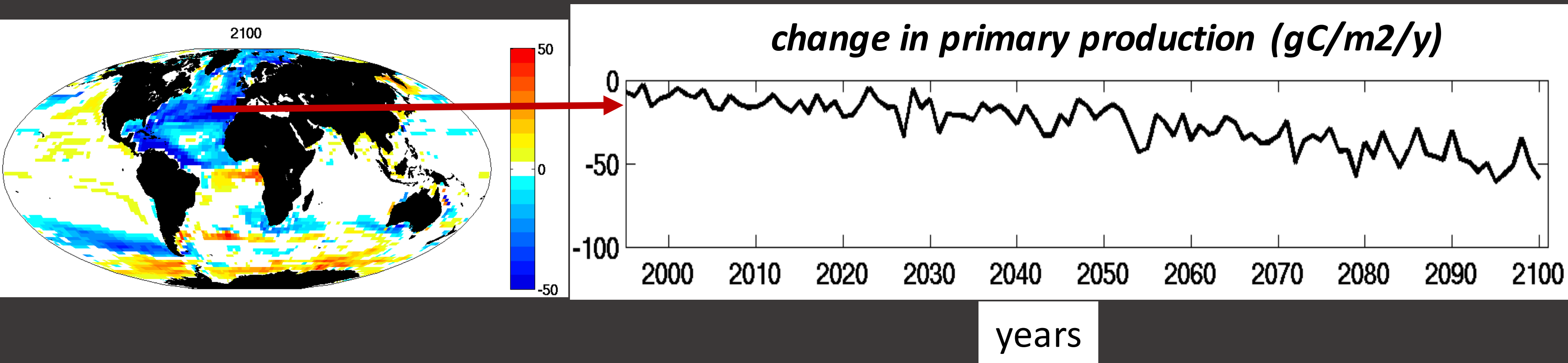


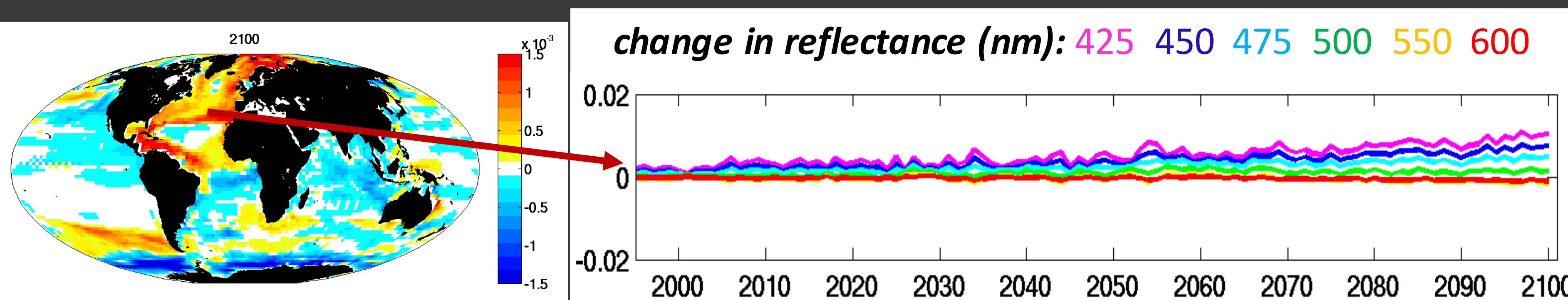
ratio of interannual variability to mean in each waveband



- **475-500nm wavebands reflectance show strongest trend over 21st Century**
- **current day interannual variability (relative to mean) is lowest**

SIGNATURE OF PRIMARY PRODUCTION CHANGE





- **Primary production and reflectance (400, 425,450,475nm) are strongly (anti-)correlated over >90% of the ocean**

SUMMARY

- Reflectance has stronger signal of climate change than many other ecosystem metrics (e.g. primary production)
  - more regions have significant trend
  - time of emergence of signal occurs earlier
- Reflectance from 475-500nm have strongest signal
- Reflectance 400-475nm has strong anti-correlation with primary production
- Numerical model can be useful tool to explore ocean colour changes in a future world