

OCEAN COLOUR SIGNAL OF CLIMATE CHANGE

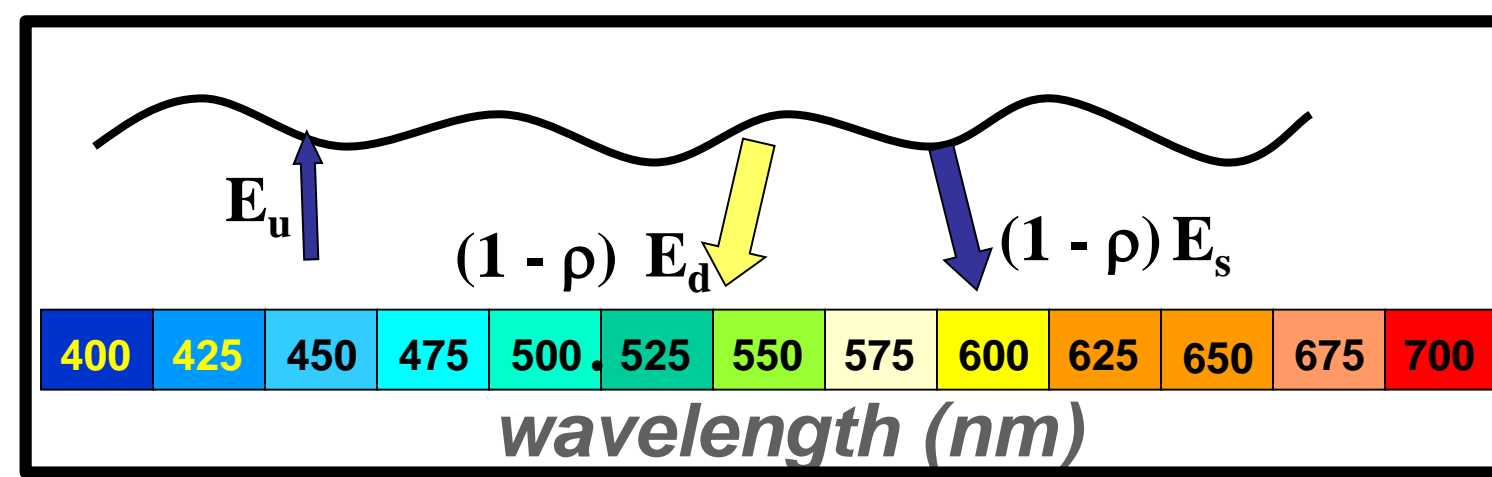
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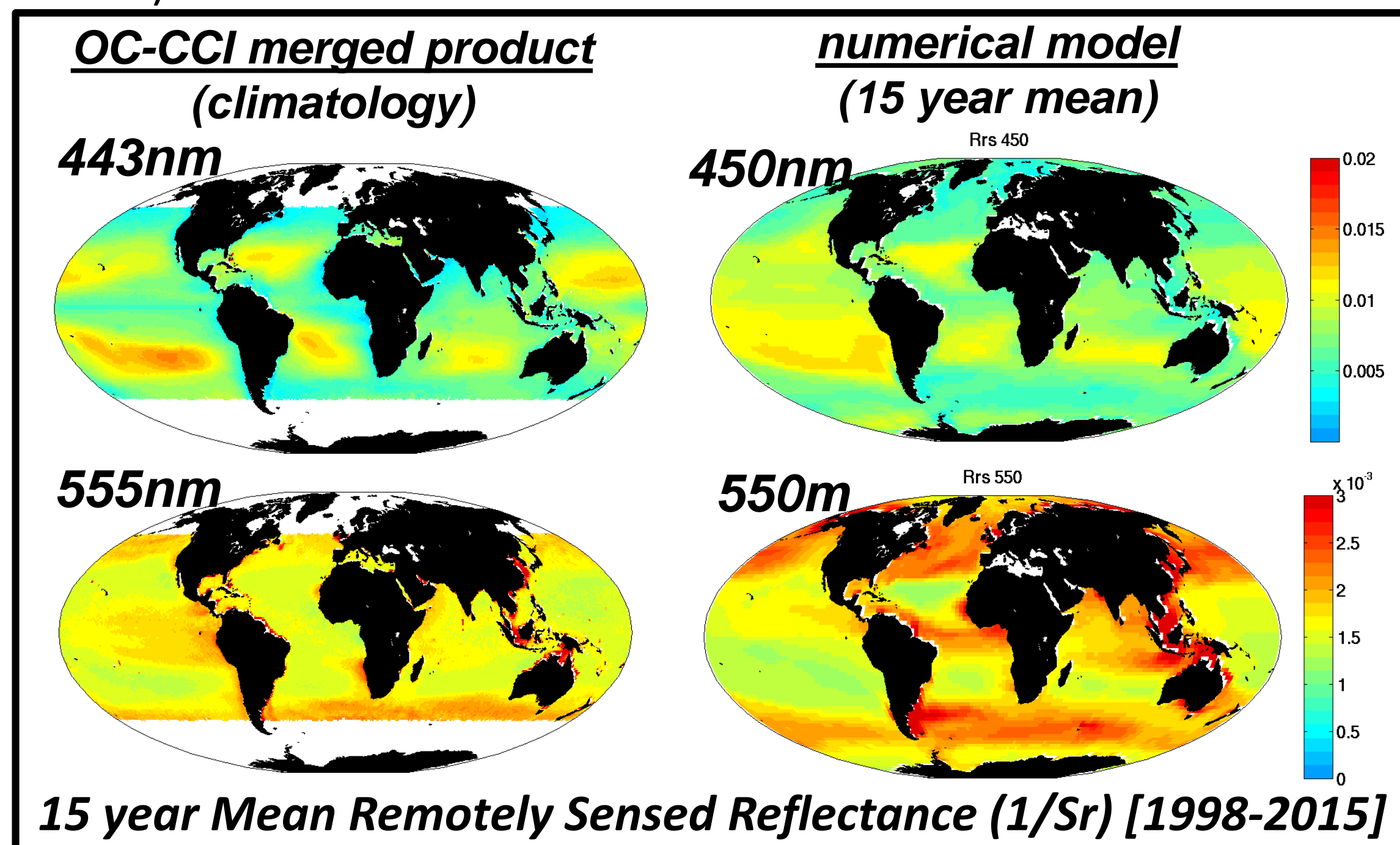
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MODEL DESCRIPTION

- Earth System Model of Intermediate Complexity (MIT-IGSM)
- Three-dimensional ocean (MITgcm), 2x2.5deg resolution
- Ecosystem-biogeochemical model (Dutkiewicz et al, 2015) with C,N,P,Fe, Si cycling, 7 phytoplankton functional types, 2 grazers
- Three stream radiative transfer model (down direct, down diffuse, upwelling) with irradiance in 25nm wavebands based on OASIM (Gregg and Casey, 2009)



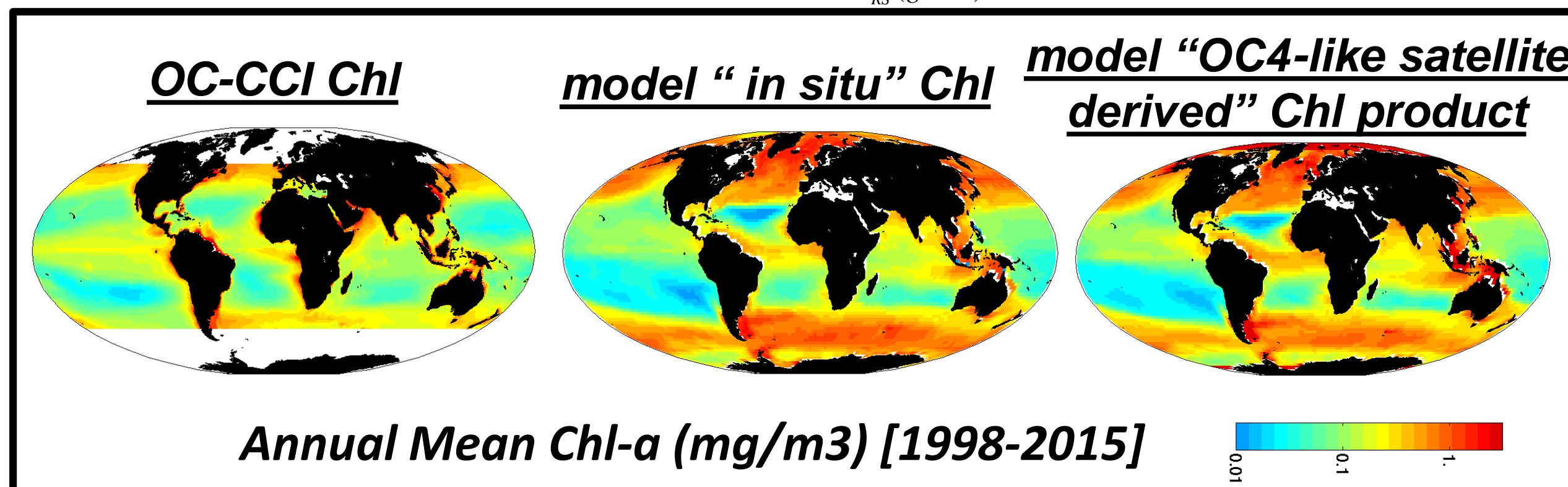
- Explicit absorption and scattering by water molecules, NAP, CDOM, 9 different phytoplankton type
- Model output includes surface reflectance (similar to seen by a satellite)



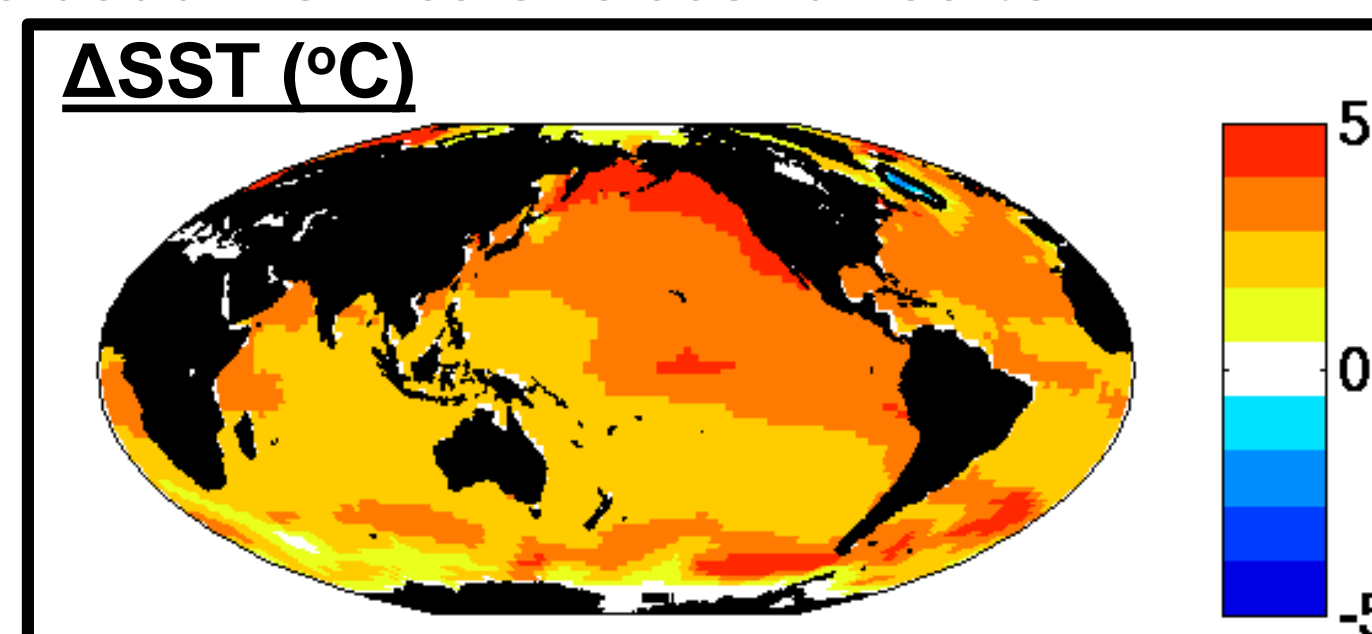
- Model resolves Chl-a for each phytoplankton as "state-variables"; we call this actual model Chl "in situ" here. However, reflectance can be used to derive a Chl-a product similar to that provided by satellite, here we use a OC4-like approach:

$$MBR = \frac{R_{RS}(blue)}{R_{RS}(green)} \quad y = a_0 + a_1 \cdot \chi + a_2 \cdot \chi^2 + a_3 \cdot \chi^3 + a_4 \cdot \chi^4$$

$$\chi = \log_{10}(MBR), \quad Chl = 10^y$$

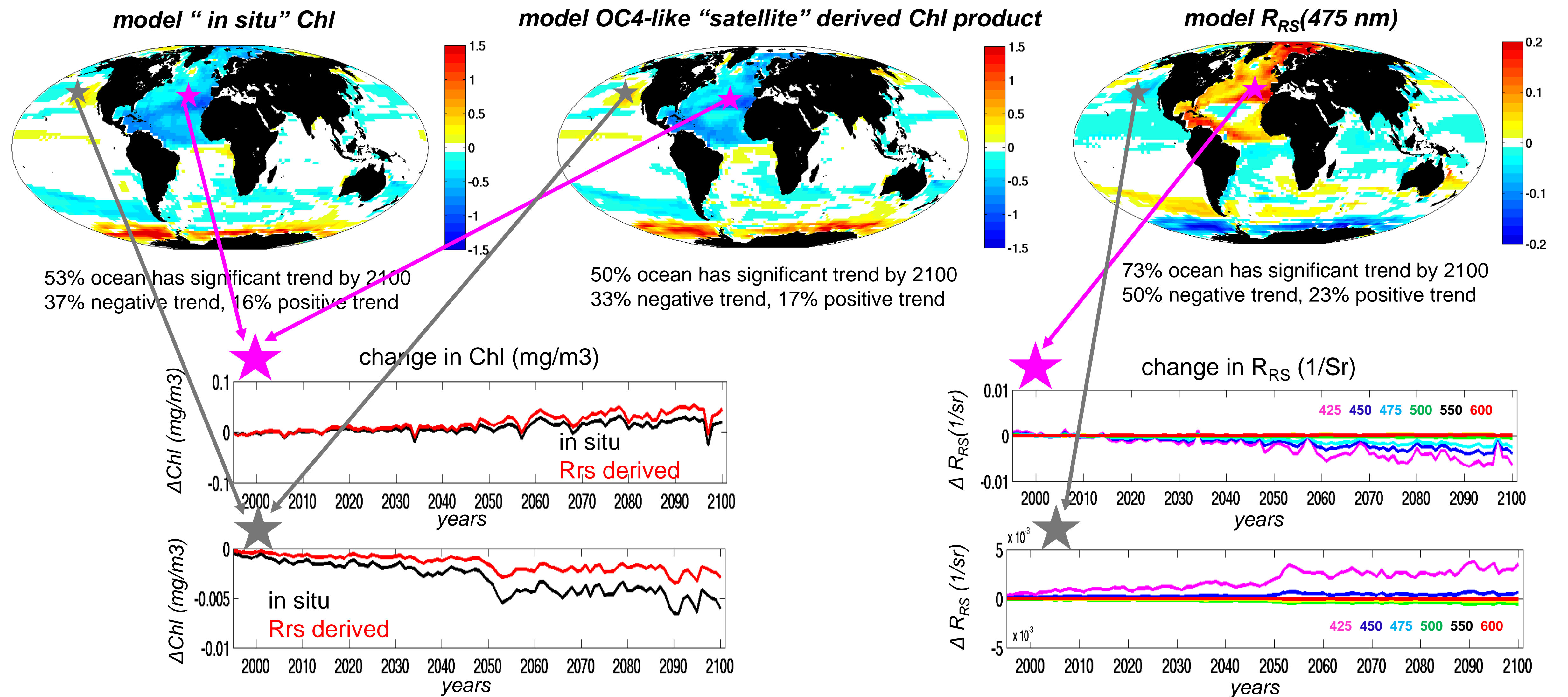


- Model simulates a "business as usual" emissions scenarios to the year 2100. The oceans become warmer, more stratified (reducing nutrient supply, and altering light environment).

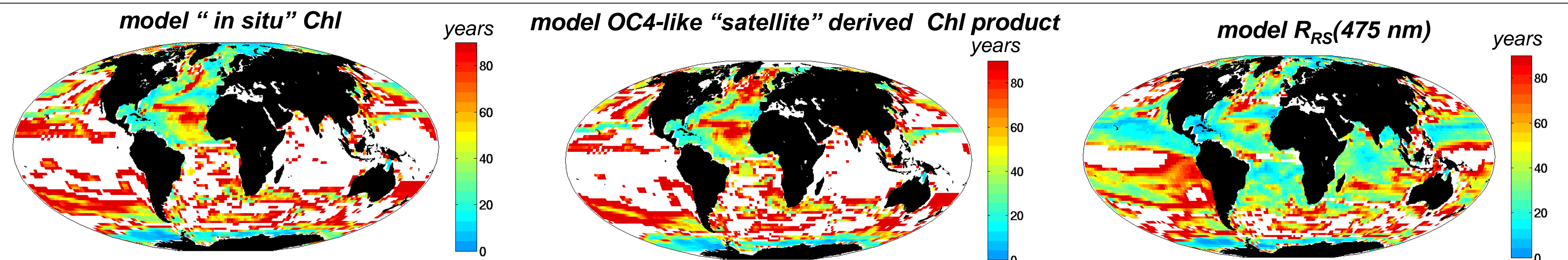


SIGNALS OF CLIMATE CHANGE

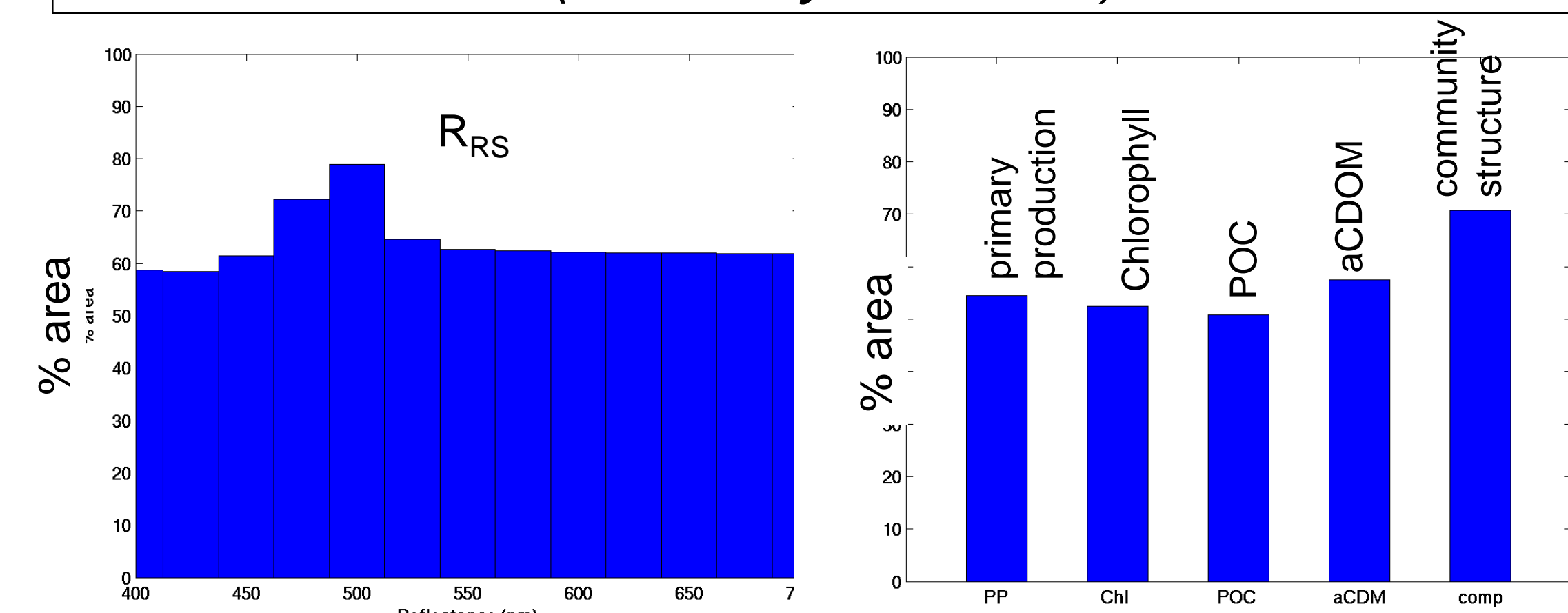
Trend over 21st Century (%/year) relative to 1998-2013 mean (only regions with statistically significant trend are shown)



Time of Emergence (years from 1995) using Keller et al (2014) formulation: $T_{oE} = \frac{2 \cdot STD}{linear\ trend}$ (only regions with statistically significant trend are shown)



Area of Ocean with Significant Trend over 21st Century (for variety of metrics)



TAKE HOME

- Reflectance has stronger signal of climate change than many other ecosystem metrics (e.g. Chl), because it integrates many ecosystem changes (e.g. CDOM, phytoplankton community changes etc) more regions have significant trend, time of emergence occurs earlier
- Reflectance from 475-525nm have strongest signal model captures decrease in variability in these wavebands (also seen in OC-CCI product)
- OC4 algorithm developed for current day may not work later in century Chl derived from OC4-like algorithm diverges from in situ Chl over time

References

- Dutkiewicz, S., A. Hickman, O. Jahn, W.W. Gregg, C.B. Mouw, and M.J. Follows. Capturing optically important constituents and properties in a model. Biogeosciences, 12, 4447-4481, 2015
- Gregg W.W. and N.W. Casey. Skill assesment of a spectral ocea-atmosphere radiative model. J. Marine Systems, 76, 49-63, 2009

