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Towards Improved Estimates of Ocean Heat Flux: The Role of Optics

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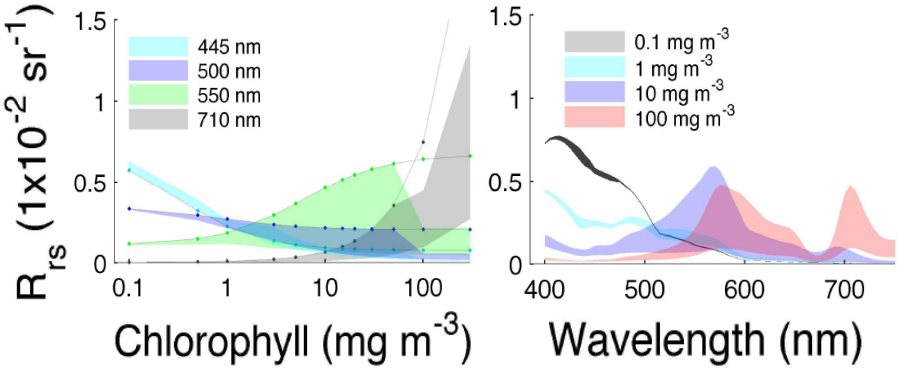
Thanks to Diane Knapett and Stephane Saux-Picart.

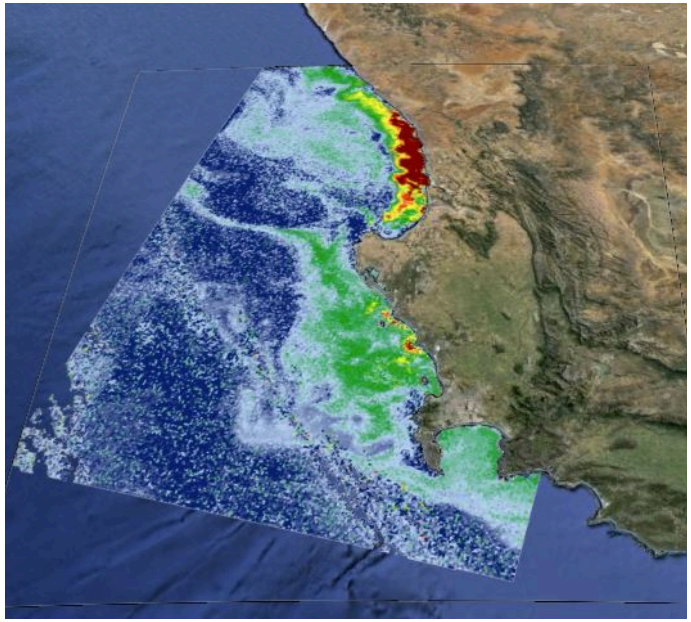
Overview

- Personal introduction
- Recap on role of optics
- PML current work plan
- Optical model development
- Initial results
- Satellite data processing
- Thoughts and remaining questions

Personal introduction

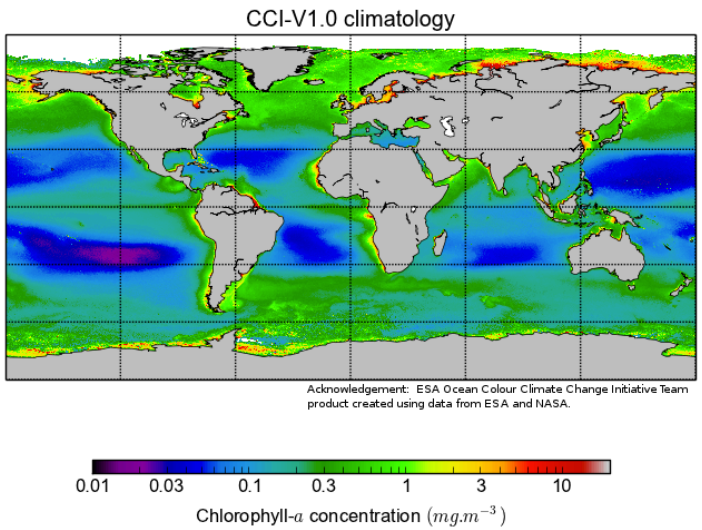
- Recently graduated with a PhD from University of Cape Town.
- Background is in optics – sensitivity of ocean colour signals to variability in phytoplankton communities and application to Harmful Algal Bloom detection.
- Just started new position at PML in general marine Earth observation.
- Continuing Stephane's and Diane's work on TIEOHF



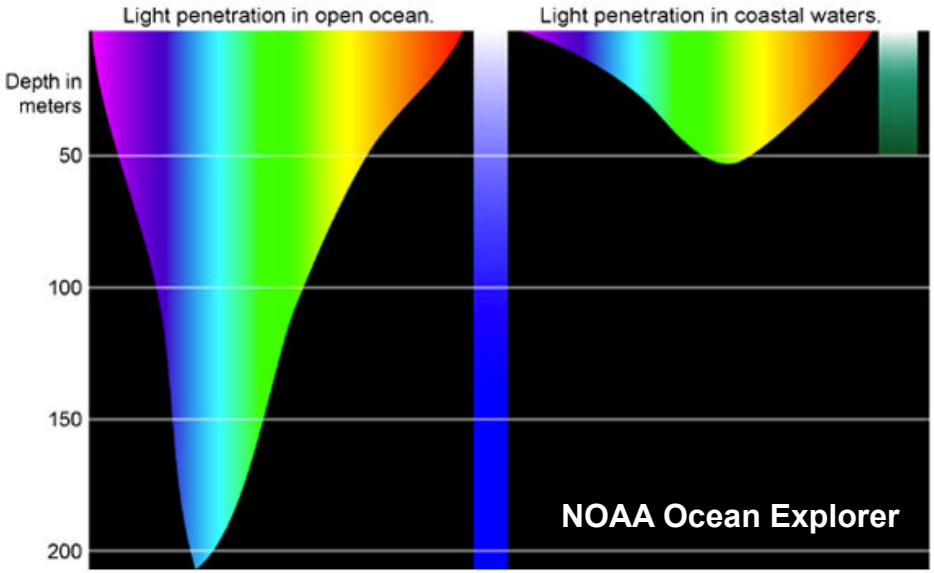


Role of optics in understanding ocean heat flux

- Light is absorbed (and scattered) by constituents present in water.
- Absorption varies with depth and is wavelength dependent.
- Phytoplankton (represented by [Chl a]) are highly variable throughout oceans.
- Need to incorporate the effects of variable phytoplankton on absorption and attenuation.



Spectral light penetration in ocean
[Chl a] 0.01 mg m^{-3} [Chl a] 10 mg m^{-3}



PML current work plan

Under task 3. “Examine the sensitivity of estimated fluxes and the oceanic heat budget to changes in the optical properties of the water, using ocean-colour data and a light transmission model, combined with a General Ocean Turbulence model.”

- Two main areas of focus at present:

1. Sensitivity of SST, MLD and air-sea heat flux to variability in attenuation coefficient.

2. Generation of maps of variability in heat budget calculations, with satellite data as inputs.

Optical model development

Calculate irradiance attenuation profiles
Dependence on [Chl a], other constituents
Dependence on sun zenith angle

↓

Fit exponential function to irradiance profile.

↓

Input extinction files to GOTM

↓

Sensitivity of SST/MLD/air-sea flux

- Use of atmospheric and ocean optical models.
- Assume uniform distribution of [Chl](z) (for now!).
- Optimisation routine derives general relationship for I(z) profiles.
- Extinction files generated from this for GOTM.
- Comparison to typical assumptions made i.e. Jerlov.

Optical model development: Status and next Steps

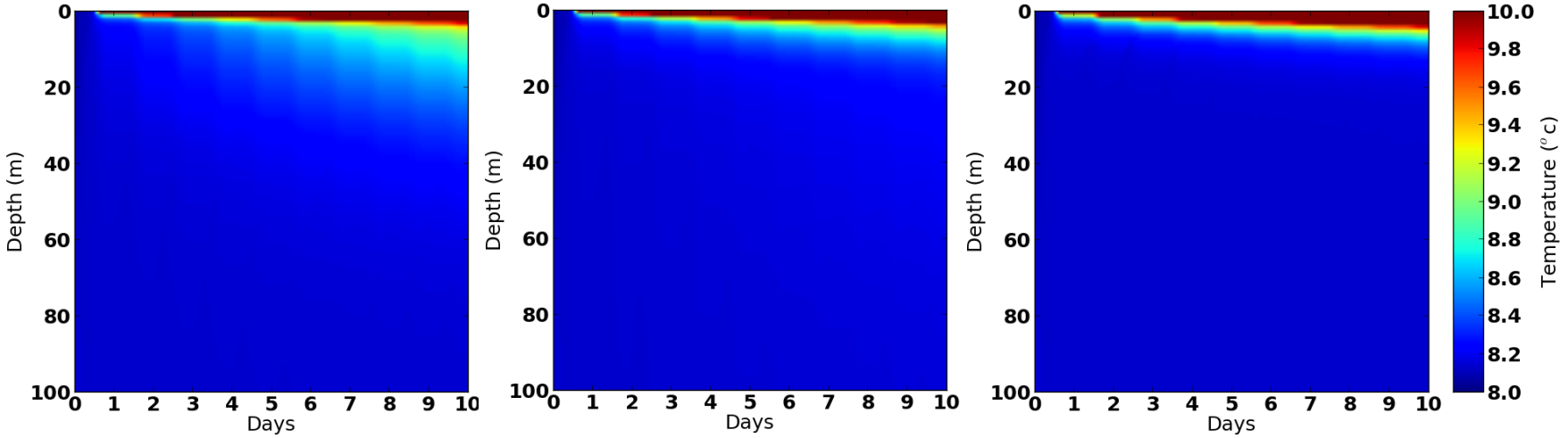
- Development of experiments coupling GOTM model with optical model:
  - Extension of optical model to UV range ✔
    - Need to improve parameterisation of depth dependence in phytoplankton absorption in the 350-400 nm range.
  - Addition of updated phytoplankton and related parameters
    - 3 component model of Brewin *et al*., (2014)
      - 3 size classes: small, medium and large cells. ✔
      - Related ([Chl a] dependent) CDOM absorption and particle backscattering.
  - Realistic forcing.
    - Time dependent attenuation profiles ✔
      - 7am to 5pm.
      - GOTM currently run at 1 hour time step for 10 days.
    - Other things to consider:
      - Meteorology – wind in particular. Several experiments have been run…

Initial results - Temperature structure - No wind mixing

Standard Jerlov type 1A

Chl 0.01 mg m^{-3}

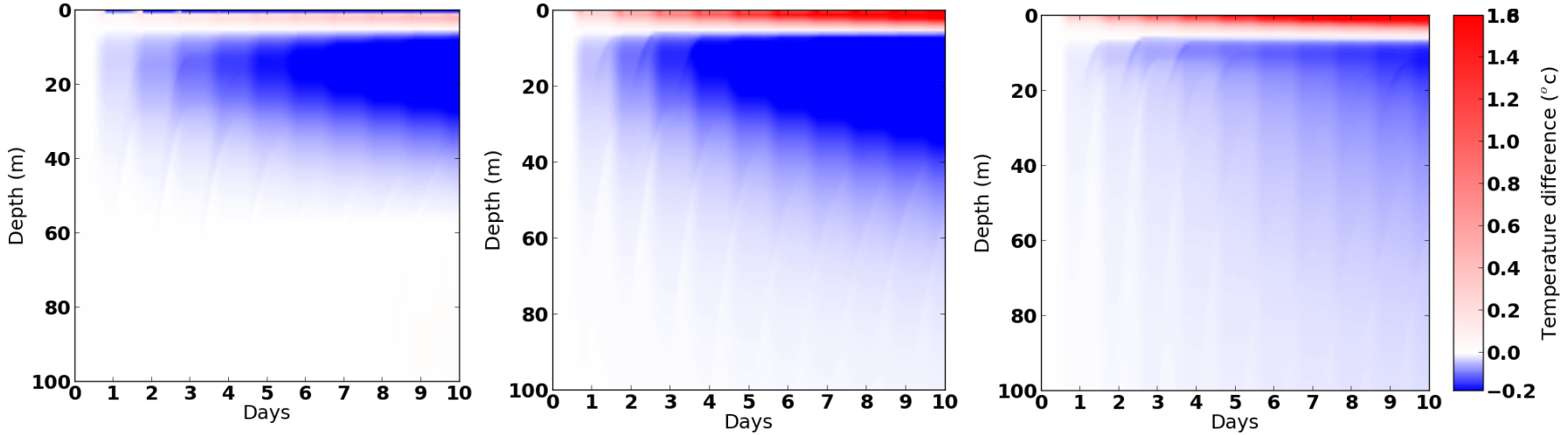
Chl 10 mg m^{-3}



Jerlov vs Chl 0.01 mg m^{-3}

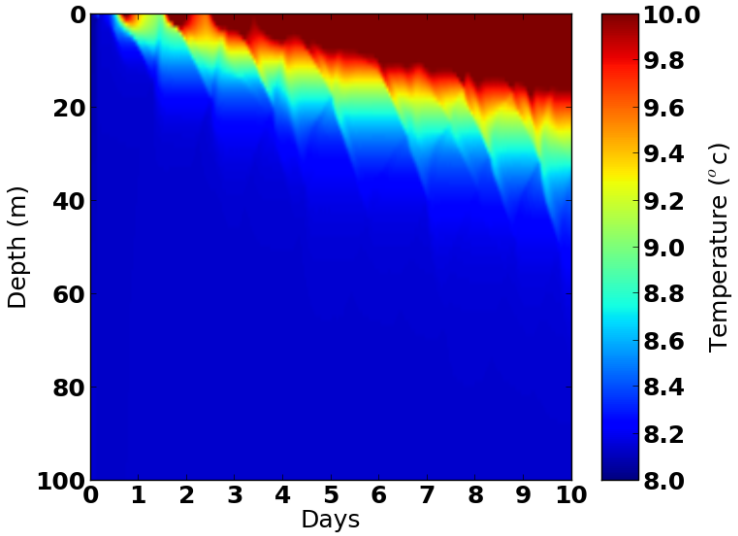
Jerlov vs Chl 10 mg m^{-3}

Chl 0.01 vs 10 mg m^{-3}

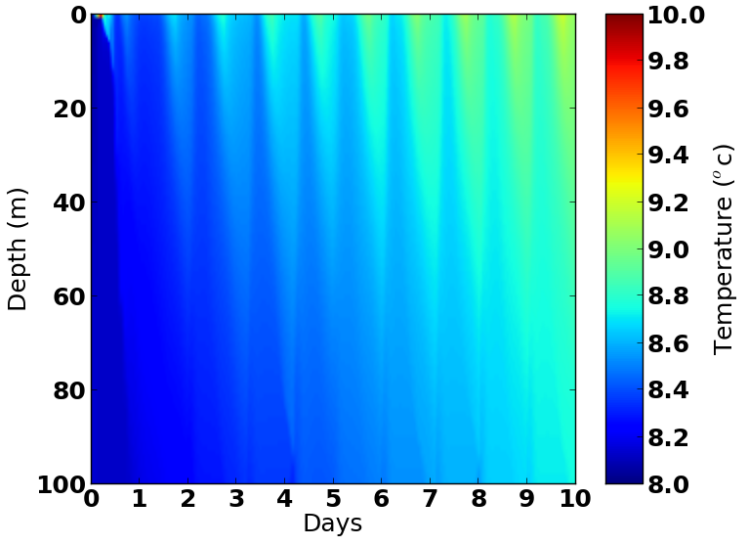


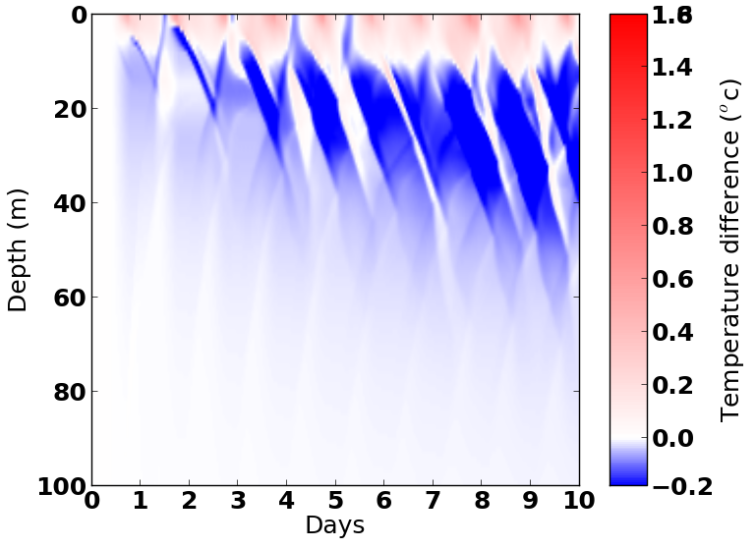
Initial results – Temperature structure with wind mixing

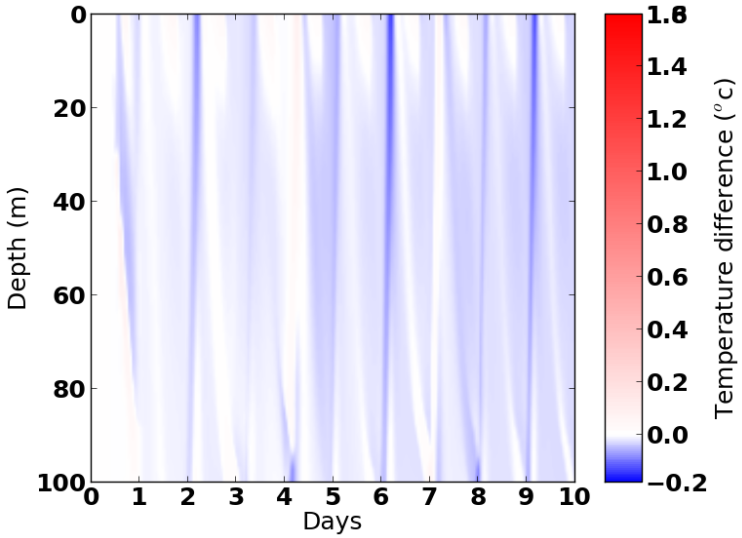
- Lower wind



- Higher wind

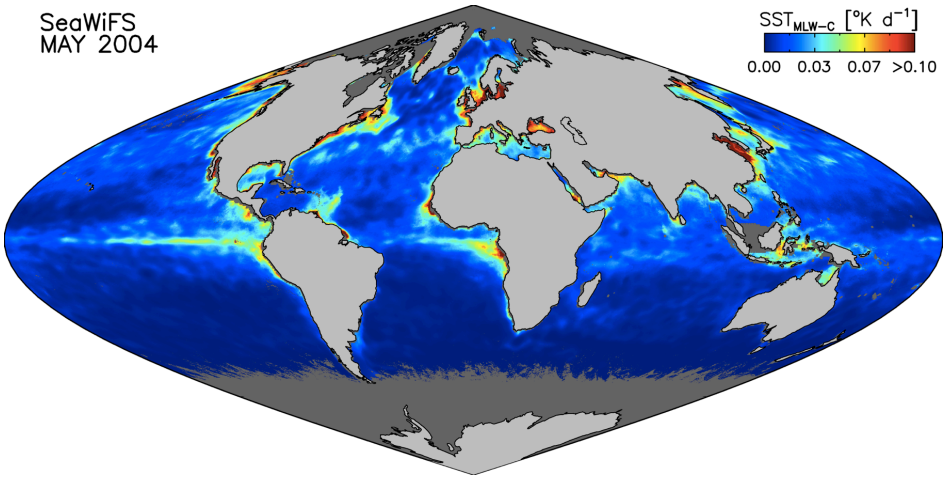






Satellite data processing

- Decide on best parameterisation for K.
- Include UV and effect of solar zenith angle.
- Apply using OC-CCI data.



Chlorophyll a product

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Derive attenuation coefficient (K)

↓

PAR surface product

↓

PAR at depth – at MLD (using MLD product)

↓

Difference in Heating due to variable optical components

Thoughts and remaining questions

- Metrics needed – calculation of MLD and heat flux from GOTM.
- Experimental structure – increase run time/change meteorology?
- Non-uniform [Chl] needs looking at.
- Greater range of [Chl]? Different locations?
- Other optical constituents i.e. in coastal locations?
- Ideal output variables from GOTM/Ocean Colour?
- Toolkits for GOTM analysis
- Selection of subdomains etc based upon variability in optical properties?
- Cloud/Portal – Provide Chl based LUTs for model parameterisation/likely sensitivity on regional basis/flags.

Thank you