Derivation of Inherent Optical Properties from Satellite Top of Atmosphere Measurements in Optically Complex Waters

Principal Investigator

Susanne Craig, NASA Goddard/USRA

Collaborators

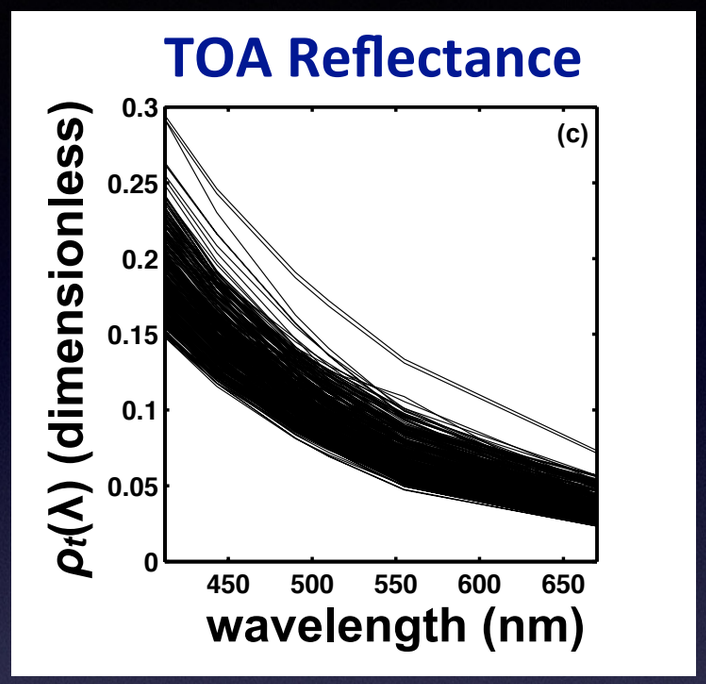
Zhongping Lee, University of Massachusetts, Boston

David Miller, NRL

PACE Science Team Meeting 16-18 January 2018 - Harbor Branch Oceanographic Institute, FAU, FL

TOA EOF-Based Algorithms for IOPs

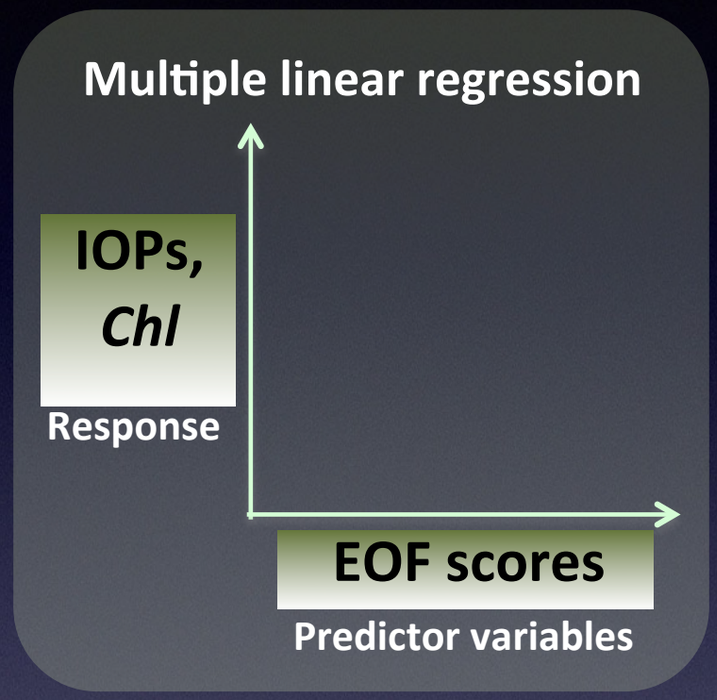
1.



2. EOF analysis

stepwise selection of EOF scores

3. Model to estimate IOPs/Chl



- Evolution of an approach developed for *in situ* hyperspectral data
- Intended to circumvent the need for 'perfect' atmospheric correction in challenging scenarios (coastal/optically complex waters)
- Initially tested on multispectral NOMAD satellite matchup dataset

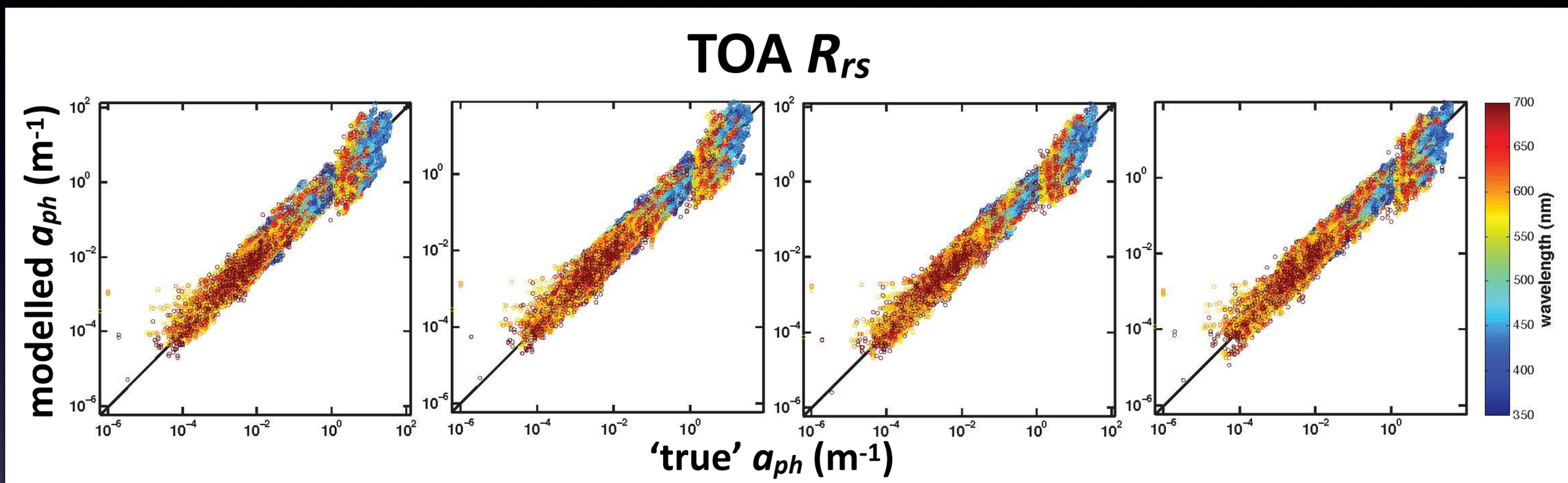
Central Objective

Characterise algorithm performance for a wide range of water & atmospheric conditions

- TOA synthetic dataset was constructed using coupled atmosphere-ocean model - Zhongping Lee & team
  - a_{ph} spectra collected from SeaBASS
  - Other IOPs modelled using similar approach to IOCCG Report #5
  - Good representation of 'real' world measured IOPs
- Parameters varied: a_{ph}, a_g, a_d, b_{bph}, b_{bd}, AOD (τ), absorbing aerosols (O_3, O_2, water vapour), sza

Synthetic Data Set Results - Example a_{ph}

τ = 0.1 τ = 0.3 τ = 0.5 τ = 0.8



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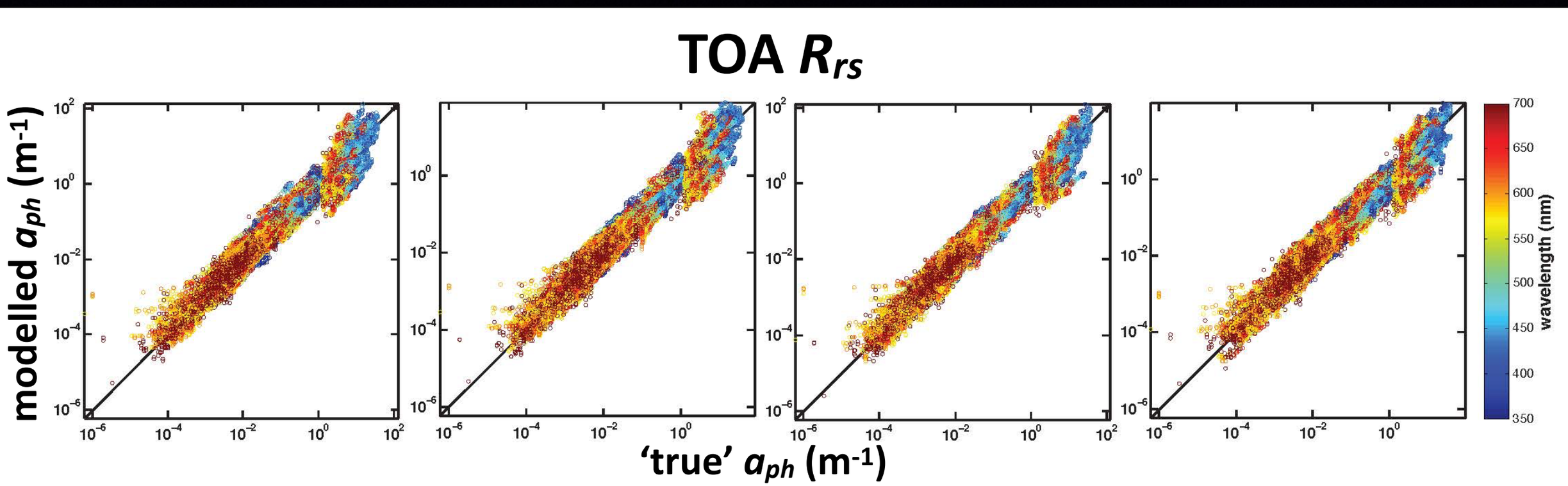


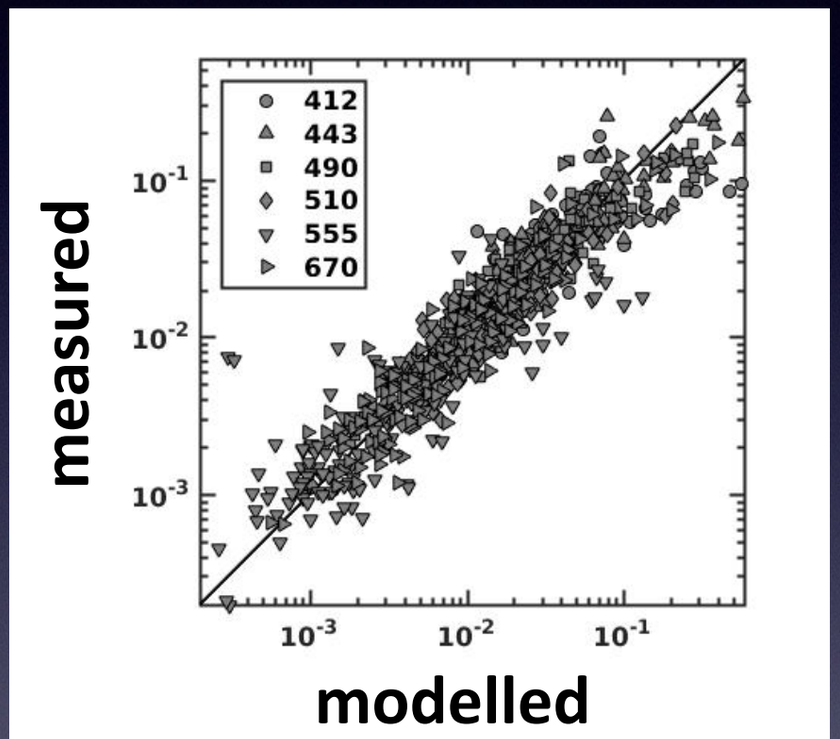
Approach performs well for all IOPs over a wide range of water constituent concentrations & AODs, with absorbing gases present

Recent Developments - Machine Learning

- EOF approach is essentially a basic form of machine learning
- In collaboration with computer scientists, exploring machine learning techniques (commonly applied to other image classification problems) to ocean colour
- Different 'flavours' of machine learning algorithms were applied to the TOA NOMAD SeaWiFS-to-in situ dataset originally used for developing the EOF models
  - Multilayer perceptron neural network
  - Convolutional neural network
  - Convolutional neural network with pre-training

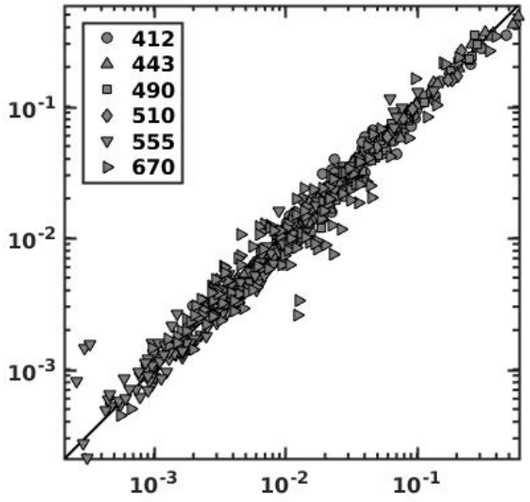
Examples of Machine Learning Prediction of a_{ph}

TOA EOF Algorithm

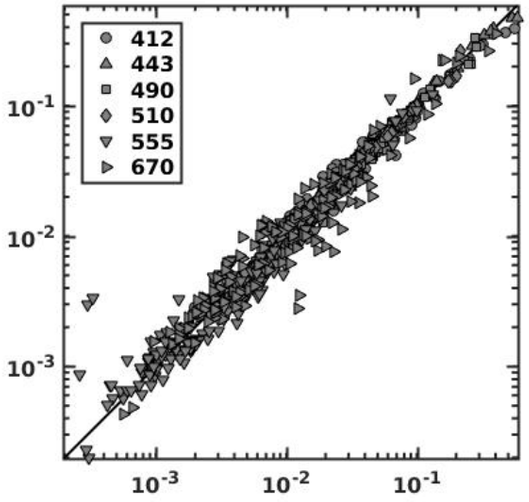


Machine Learning Approaches

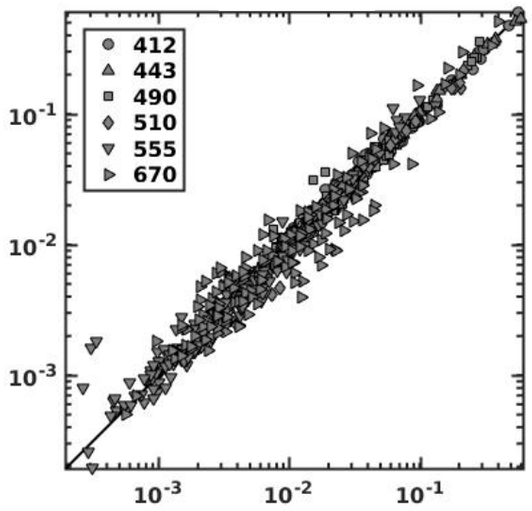
Multilayer Perceptron Neural Network (1 hidden layer)



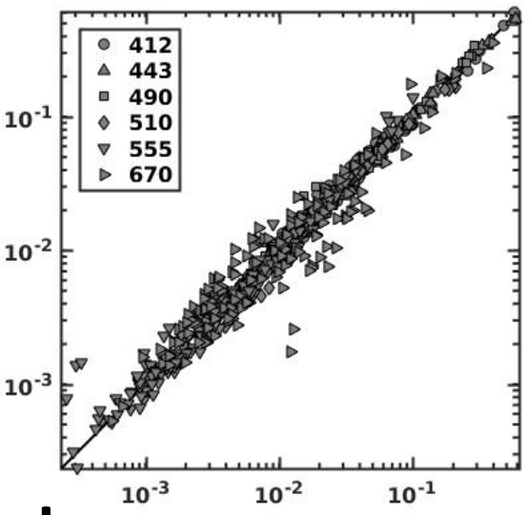
Multilayer Perceptron Neural Network (2 hidden layers)



5 Layer Convolutional Network



Pre-training 5 Layer Convolutional Network

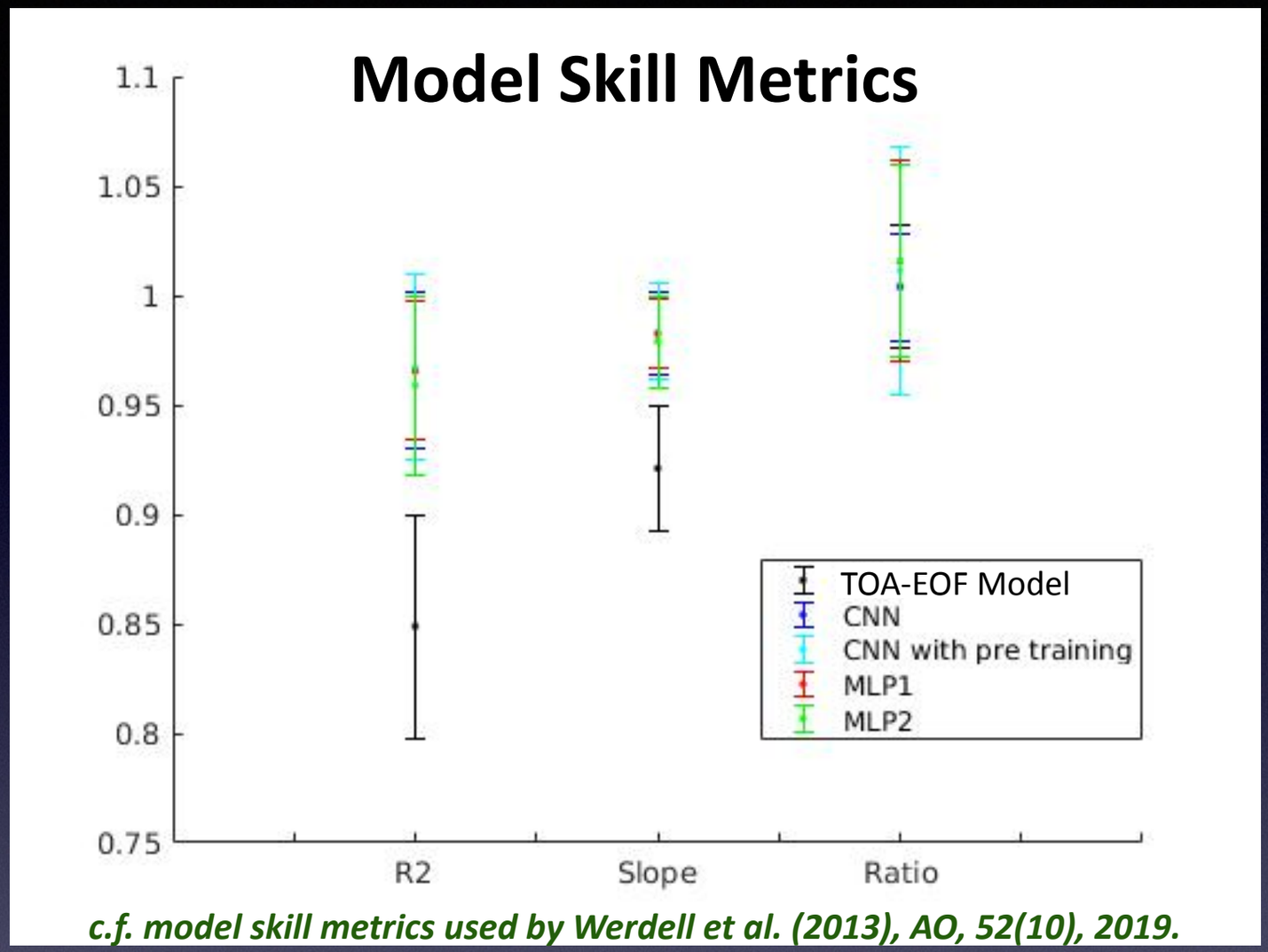


measured

modelled

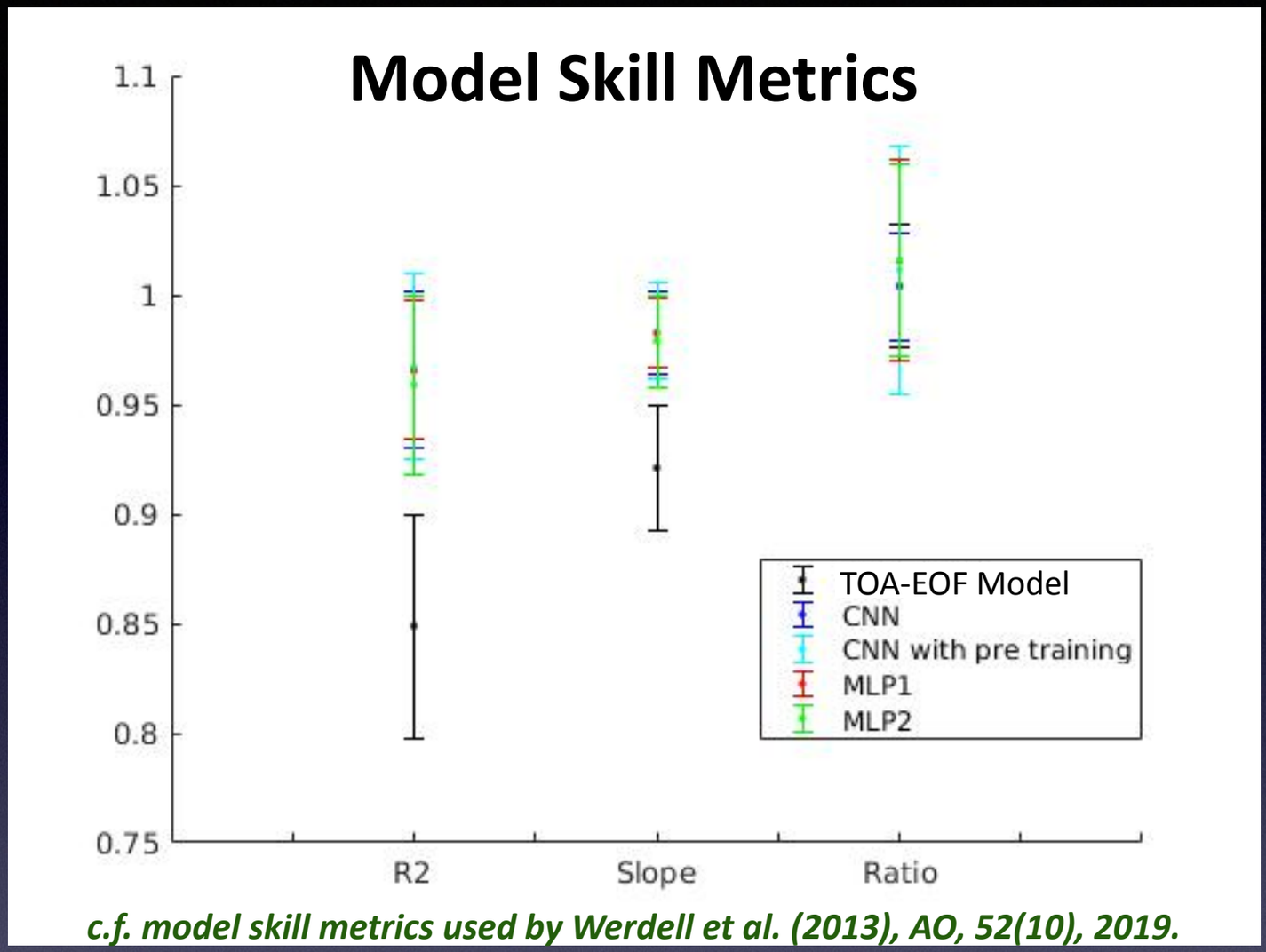
Models developed in Trappenberg Lab (Dalhousie University): Hossein Parvar, Yoshima Kubu

Examples of Machine Learning Prediction of a_{ph}



c.f. model skill metrics used by Werdell et al. (2013), AO, 52(10), 2019.

Examples of Machine Learning Prediction of a_{ph}



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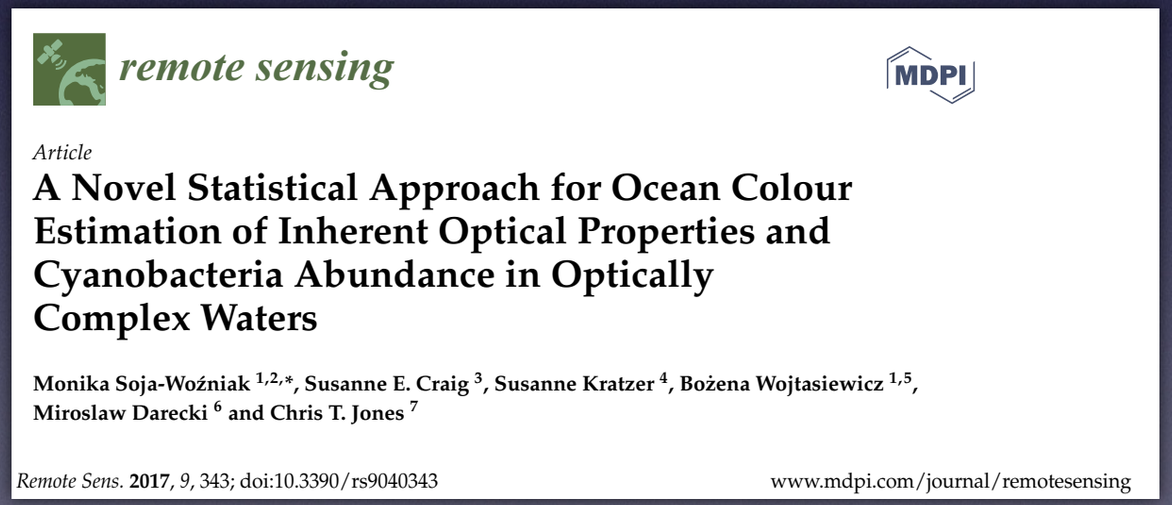
Further machine learning trials are underway using:

- the synthetic TOA dataset
- inclusion of metadata as predictor variables

Status of Proposal Deliverables

- Core objective of synthetic TOA database creation and algorithm sensitivity analysis achieved ✔
- Manuscript describing TOA-EOF algorithm ready for submission ✔
- Synthetic TOA dataset sensitivity analysis manuscript in preparation ✔
- Utility of approach for HICO and aircraft datasets to be tested
- Extension of EOF algorithm to accurate identification of a phytoplankton class (cyanobacteria) published ✔



remote sensing

MDPI

Article

A Novel Statistical Approach for Ocean Colour Estimation of Inherent Optical Properties and Cyanobacteria Abundance in Optically Complex Waters

Monika Soja-Woźniak [1,2,*], Susanne E. Craig [3], Susanne Kratzer [4], Bożena Wojtasiewicz [1,5], Miroslaw Darecki [6] and Chris T. Jones [7]

Remote Sens. **2017**, *9*, 343; doi:10.3390/rs9040343 www.mdpi.com/journal/remotesensing

Recommended Further Work

- Testing of operational implementation strategies - GSFC
- Investigation of utility of approach to identify phytoplankton size classes/ functional types
- Further investigation of machine learning approaches
- These approaches should not be neglected because they are not classically mechanistic - many scientific fields have converged on these methods because they provide the correct answer. Let's look to other disciplines and collaborate, collaborate, collaborate!!

Knowledge Gaps Critical to PACE Success

- The ability to accurately resolve phytoplankton community composition from ocean colour is pressing, and clearly identified in the PACE SDT Report:

*"SQ-1: What are the standing stocks, **compositions**, and productivity of ocean ecosystems? How and why are they changing?"*

- To gain traction on this question, 'gold standard' datasets must be collated/acquired & techniques developed to fully exploit them:

reflectance + unambiguous metrics of community composition *(e.g. flow cytometry, imaging flow cytometry, holographic imagery,…)* + sophisticated data analysis