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

Principal Investigator

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Collaborators

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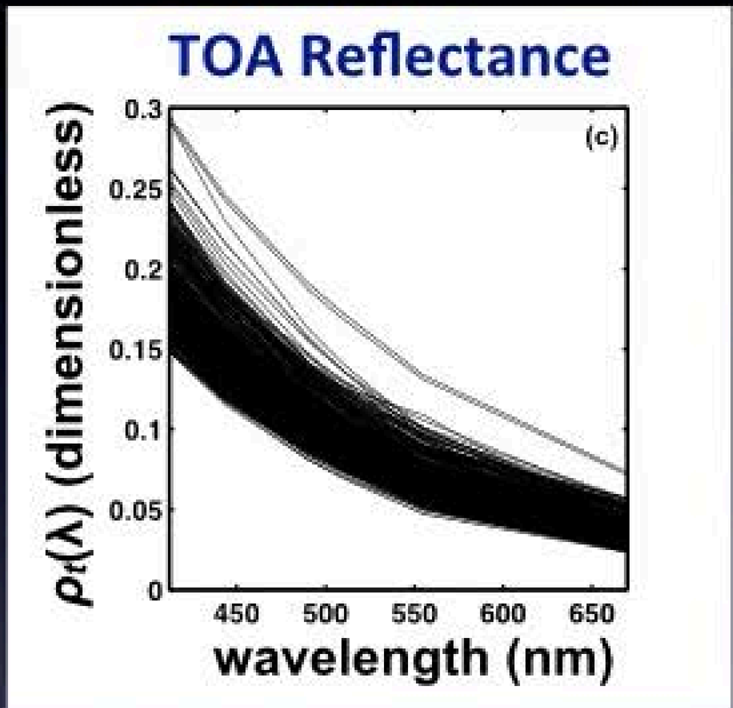
TOA EOF-Based Algorithms for IOPs

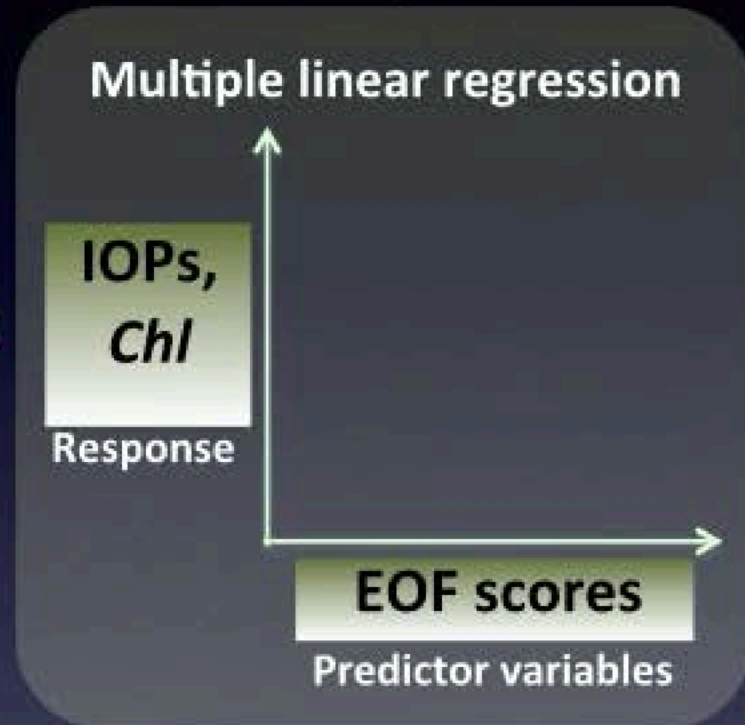
1.



2. EOF analysis

stepwise selection of EOF scores

3. Model to estimate IOPs/Chl



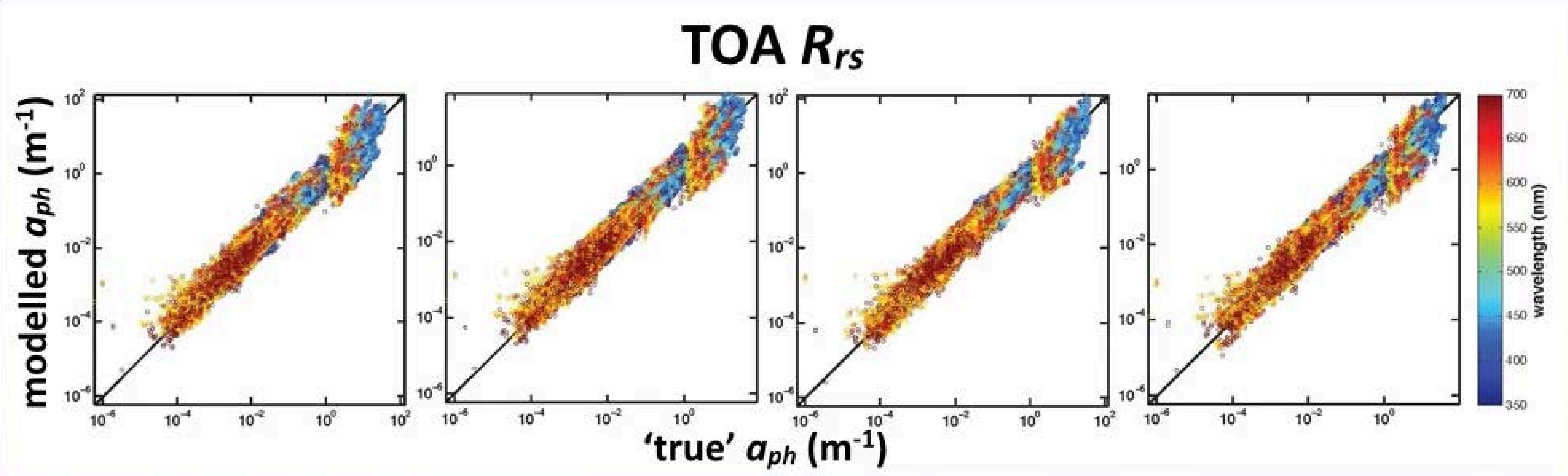
- Evolution of an approach developed for *in situ* hyperspectral data
- Intended to circumvent the need for 'perfect' atmospheric correction in challenging scenarios (coastal/optically complex waters)
- Initially tested on multispectral NOMAD satellite matchup dataset

Synopsis of Progress

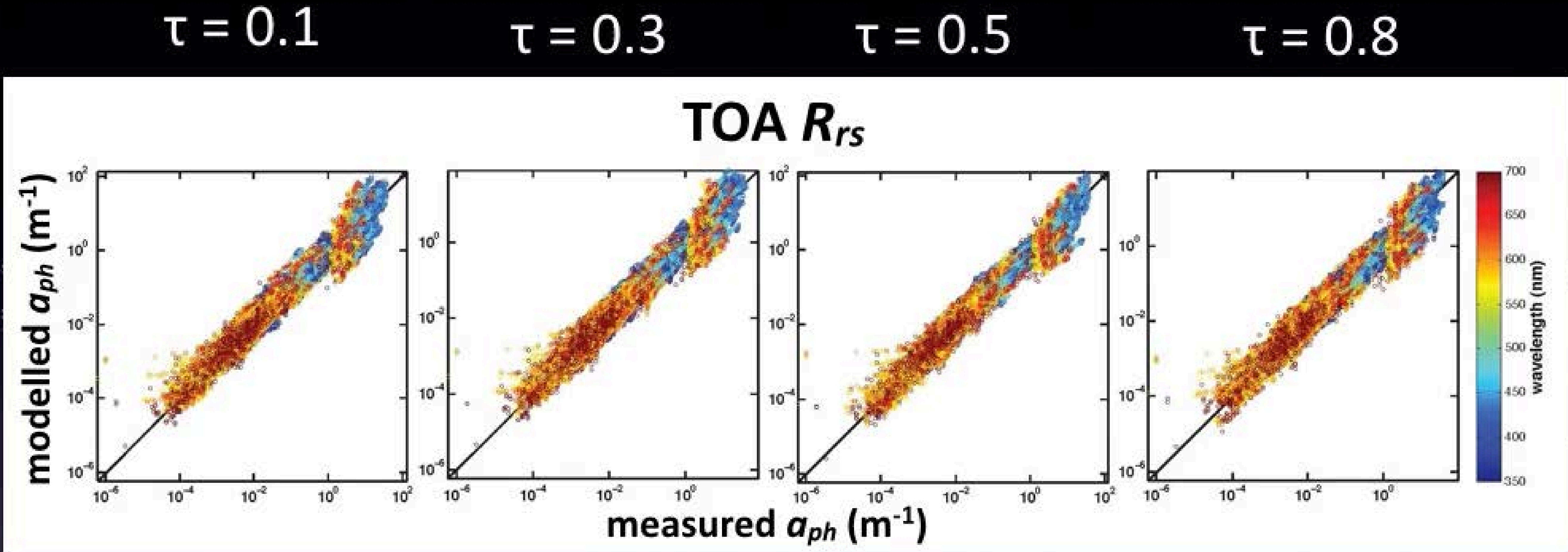
- TOA synthetic dataset was constructed using coupled atmosphere-ocean model - Zhongping Lee & team
  - a_{ph} spectra collected from SEABASS
  - Other IOPs modelled using similar approach to IOCCG Report #5
  - Good representation of 'real' world measured IOPs
- Parameters varied: a_{ph}, a_g, a_d,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

Synopsis of Progress

τ = 0.1 τ = 0.3 τ = 0.5 τ = 0.8



Synopsis of Progress



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

Challenges

- EOF approach applied to *in situ* hyperspectral reflectance revealed potential problems with objective score selection criteria
- Occasionally, higher order scores that are essentially noise are selected as predictors - *likely instrumental*
- Gives rise to spectral discontinuities (spikes) in modelled spectral parameters
- Currently experimenting with methods to identify and eliminate this problem (e.g. signal:noise criterion)

EOF approach implemented to detect cyanobacterias blooms in the Baltic Sea

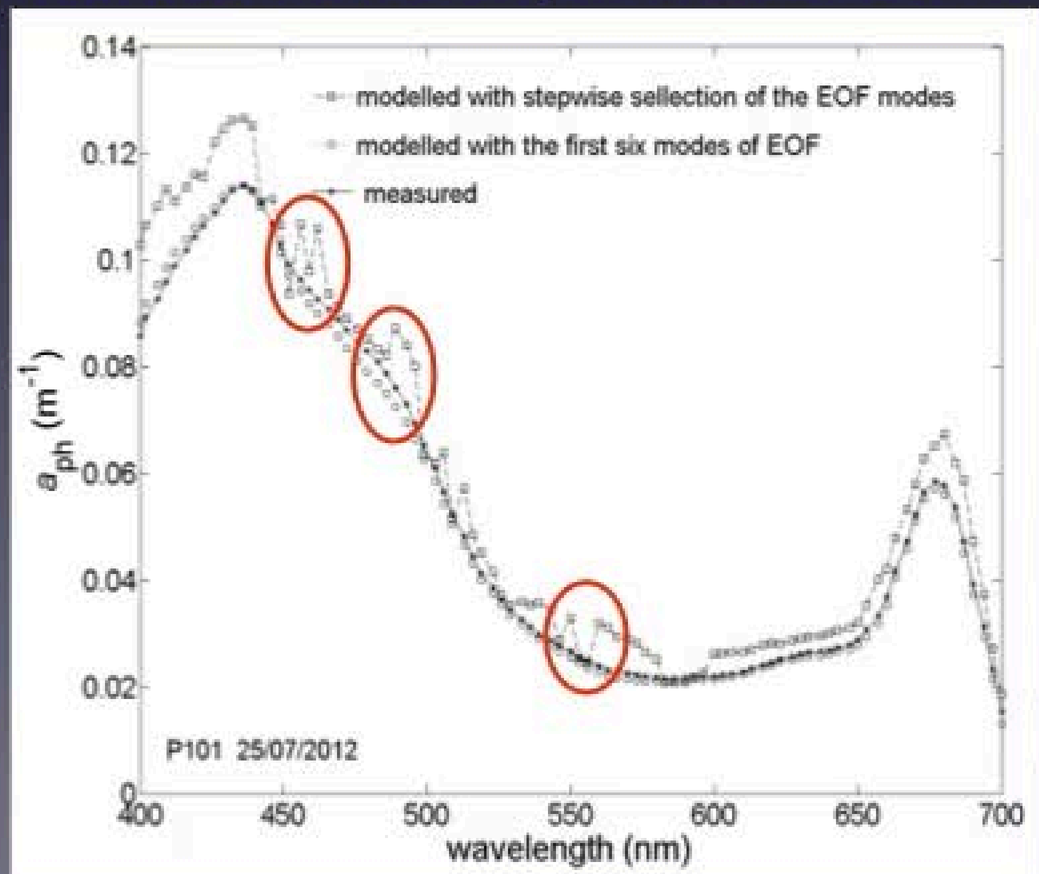


Figure courtesy of Monika Woźniak: Woźniak, Craig, et al. in review

Recent Developments - Machine Learning

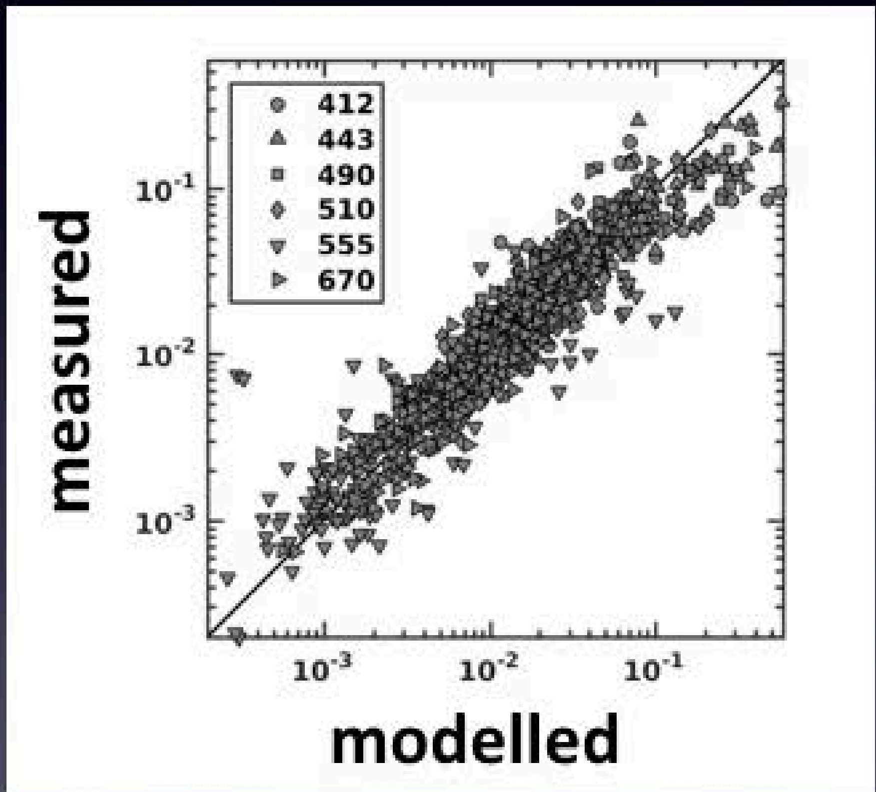
- EOF approach is essentially a basic form of machine learning
- Have recently begun a collaboration with computer scientist, Thomas Trappenberg (Dalhousie University)
- Exploring the possibility of using machine learning techniques commonly applied to other image classification problems
- State of the art machine learning now tries to use as much data as possible:
  - Don't try to be too clever initially - more (imperfect) data may still contain useful information!
  - Pre-training approaches help to constrain the final model

Recent Developments - Machine Learning

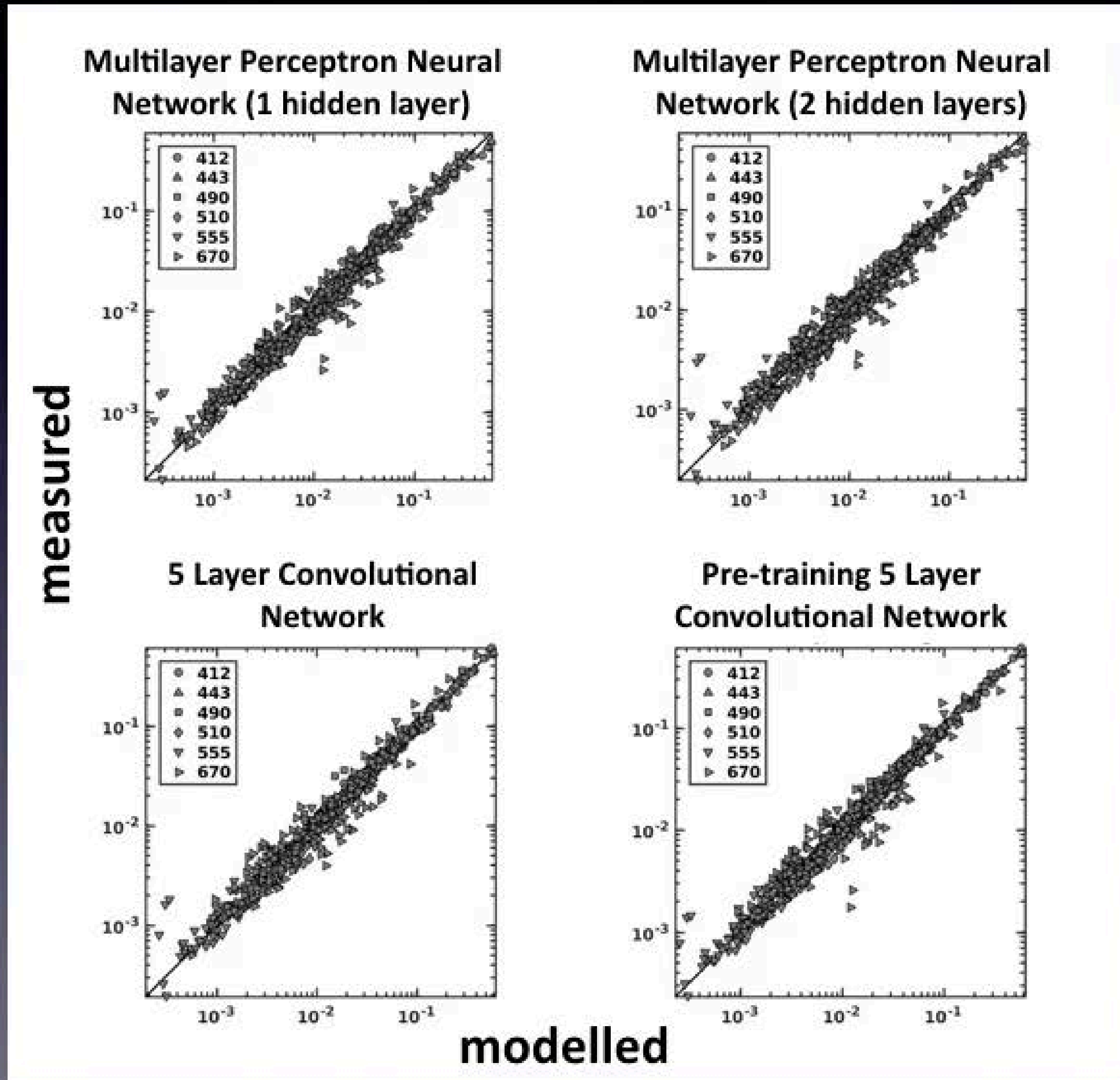
- Different ‘flavours’ of machine learning algorithms were applied to the TOA NOMAD dataset originally used for developing the EOF models
  - Multilayer perceptron neural network
  - Convolutional neural network
  - Convolutional neural network with pre-training

Examples of Machine Learning Prediction of a_{ph}

TOA EOF Algorithm

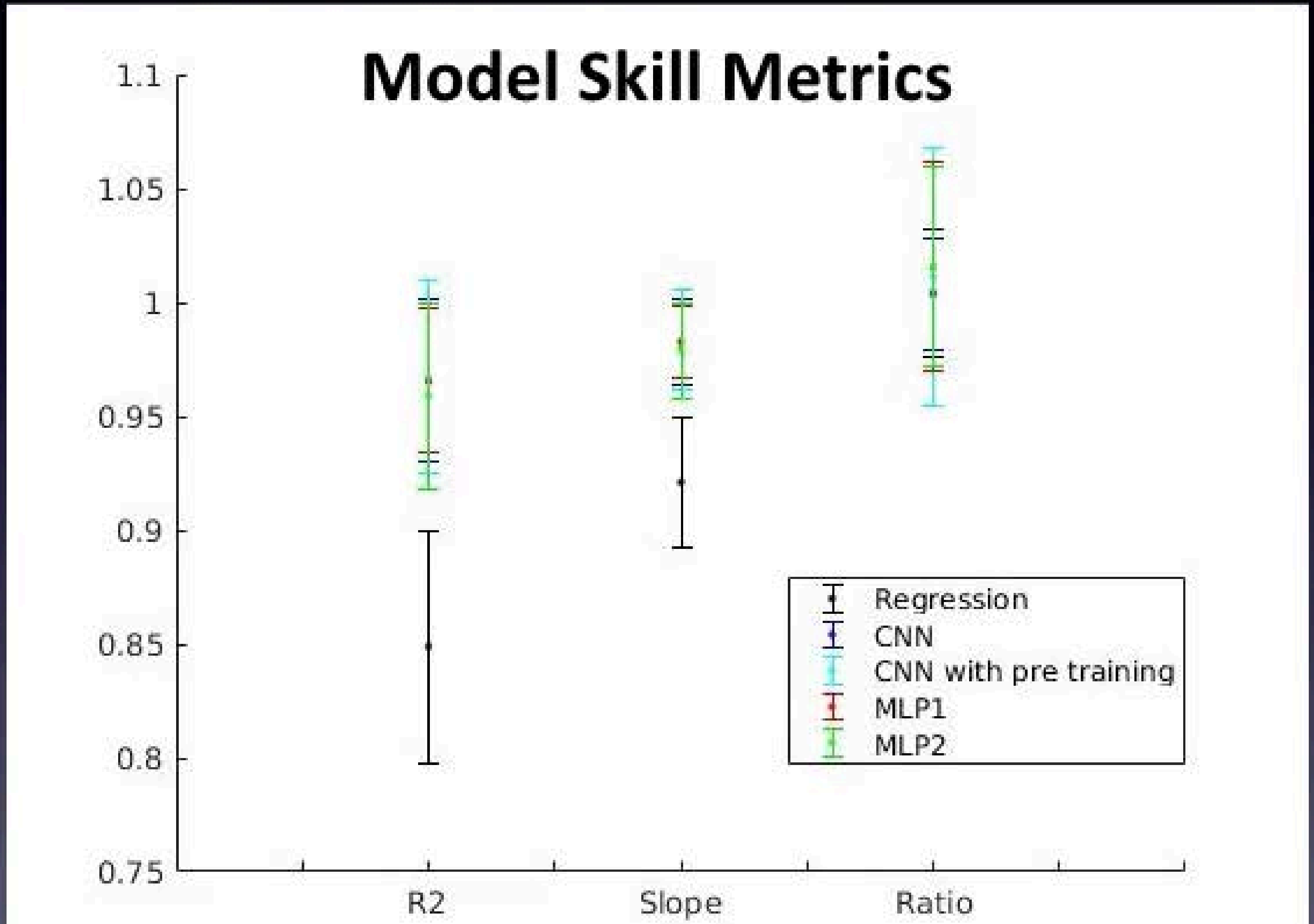


Machine Learning Approaches



Models developed in Trappenberg Lab: 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.

Preliminary Machine Learning Results

- Machine learning approaches are able to replicate and slightly improve upon EOF TOA results
- These models were developed with 'bare bones' information - TOA spectra & corresponding IOPs
- Provision of metadata for each of the data points may improve models further (e.g. lat, lon, season, sza,...) - the more data the better!
- 'Unlabelled' data (i.e. spectra without accompanying IOPs) may also be used to improve the models
- Compiled hyperspectral PACE dataset could prove an excellent test case

Questions…?