CyanoSCape

Freshwater Phytoplankton and Floating Aquatic Vegetation Biodiversity of the South African Cape

Liane Guild, Jeremy Kravitz, and Juan Torres-Perez, NASA Ames Research Center, Moffett Field, CA
Marie Smith and Lisl Lain, Council for Scientific and Industrial Research, Cape Town, SA
Wilson Mugera Gitari, Rabelani Mudzielwana, and Glynn Pindihama, Univ. of Venda, Thohoyandou, SA

Abstract

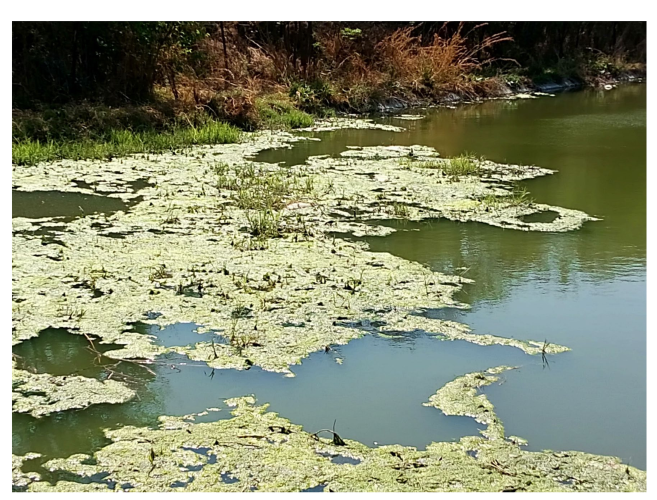
In Southern Africa, the impacts of anthropogenic activities on biodiversity and ecosystem services are exacerbated by the climate crisis. Rapid land use change and the lack of emphasis on environmentally sustainable agricultural practices has hindered hydrological processes and compromised riverine and aquatic ecosystems. This poses obvious risks to natural/indigenous aquatic biodiversity and long-term ecosystem sustainability. Phytoplankton serve as the foundation of the freshwater food web. The diversity of phytoplankton includes photosynthesizing bacteria (cyanobacteria), plant-like diatoms, dinoflagellates, and green algae. Nutrient run-off from agricultural fertilizers and urban overflows, warm temperatures, abundant light availability and compromised hydrological systems provide an ideal environment for cyanobacteria to flourish and can incur significant effects on the biodiversity of the overall phytoplankton assemblage. These conditions also provide a favorable environment for the overgrowth of floating aquatic vegetation (FAV), which is often invasive and associated with reduced aquatic biodiversity.

The algal biodiversity of the GCFR's freshwater systems is not well characterized. Hyperspectral optical observations (e.g, BioSCape campaign) are expected to facilitate the improvement of current phytoplankton diversity, as the sensitivity is sufficient that the distinctive, fine spectral features of different phytoplankton groups can be detected. This will enable testing emerging algorithms and inform the development of new algorithms for use with upcoming hyperspectral satellite missions in this decade.

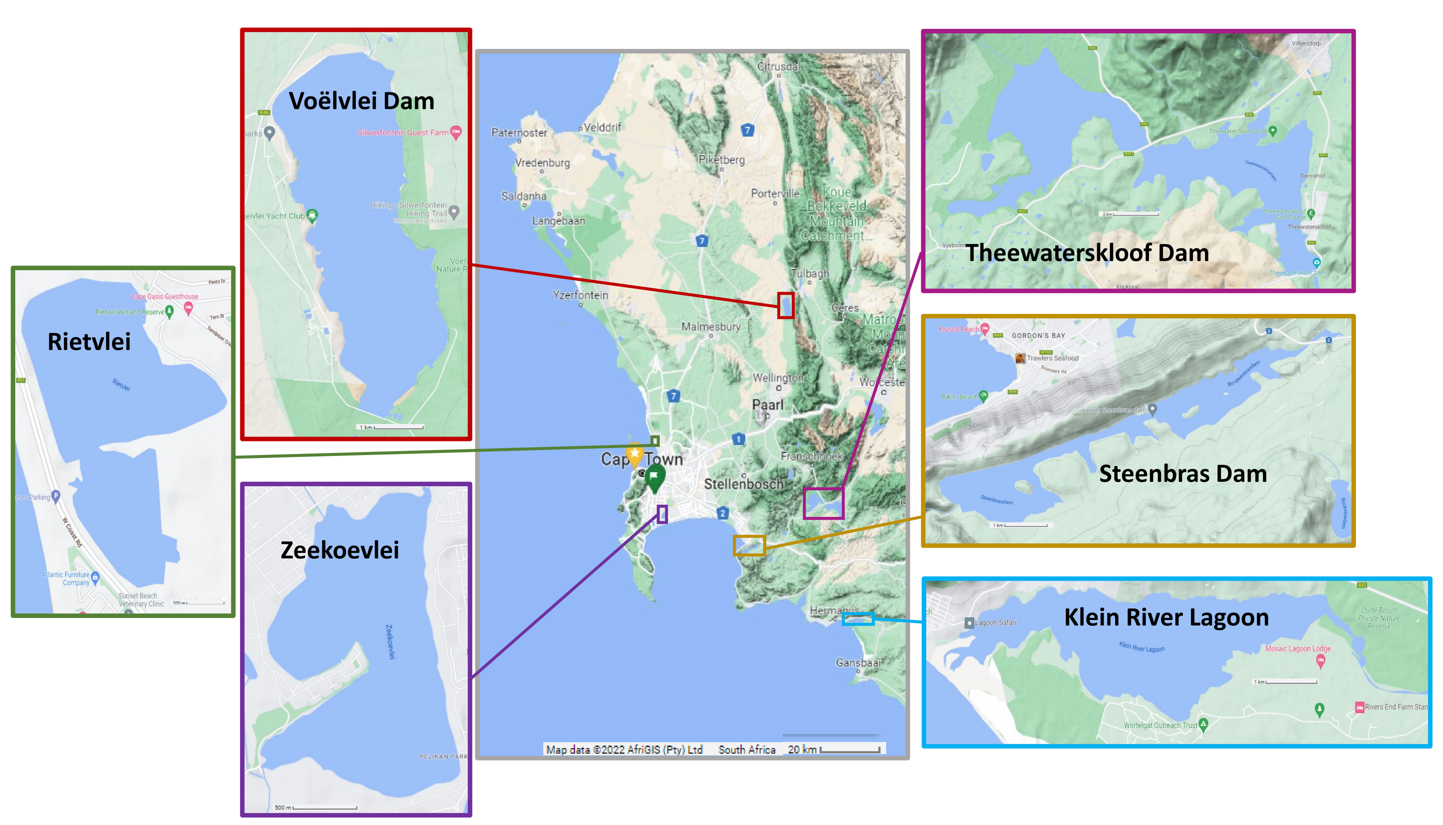
Innovations in optical sensor sensitivity and next generation machine learning capabilities considerably enhance the potential for accurate and rapid detection of phytoplankton, presence, extent, and diversity and additionally, invasive FAV.

Goal

The overarching goal of this project is to utilize hyperspectral data, with recently developed and next-generation algorithms, to determine the biodiversity of freshwater systems phytoplankton assemblage with emphasis on genus level distinction, as well as monitor the prevalence and diversity of FAV.



Study Sites

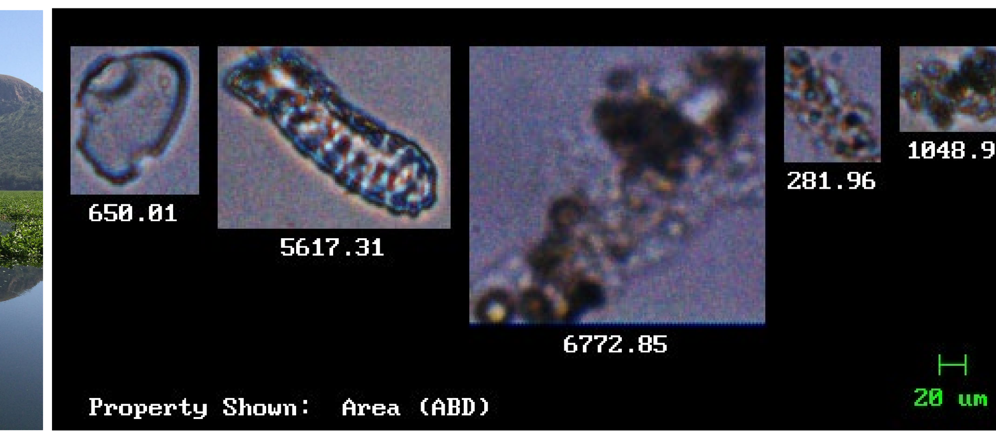


1 - Klein River Lagoon (natural) – adjacent to Walker Bay
2 - Theewaterskloof Dam
3 - Rietvlei (natural) – adjacent to wetland
4 - Voëlvlei Dam
5 - Zeekoevlei (urban wetland)
6 - Steenbras Dam

Objectives

1. Phytoplankton and Floating Aquatic Vegetation Diversity

- **Fieldwork**
- Field sites: 4-5 stations during overflights
  - **Field spectroscopy**: GER1500 (283-1092 nm) and ASD (350-2500 nm).
  - **Apparent optical properties** (AOPs) with the C-OPS instrument
  - **Water sampling** for microscopic analysis of phytoplankton and cyanobacteria
- During overflights - Microtops II sunphotometer – aerosol optical thickness for atm correction
- **Laboratory**
- **Flow imaging microscopy** (FlowCAM)
  - Phytoplankton Identification (including cyanobacteria) and enumeration
- **Chlorophyll a fluorometric and HPLC pigment analysis**

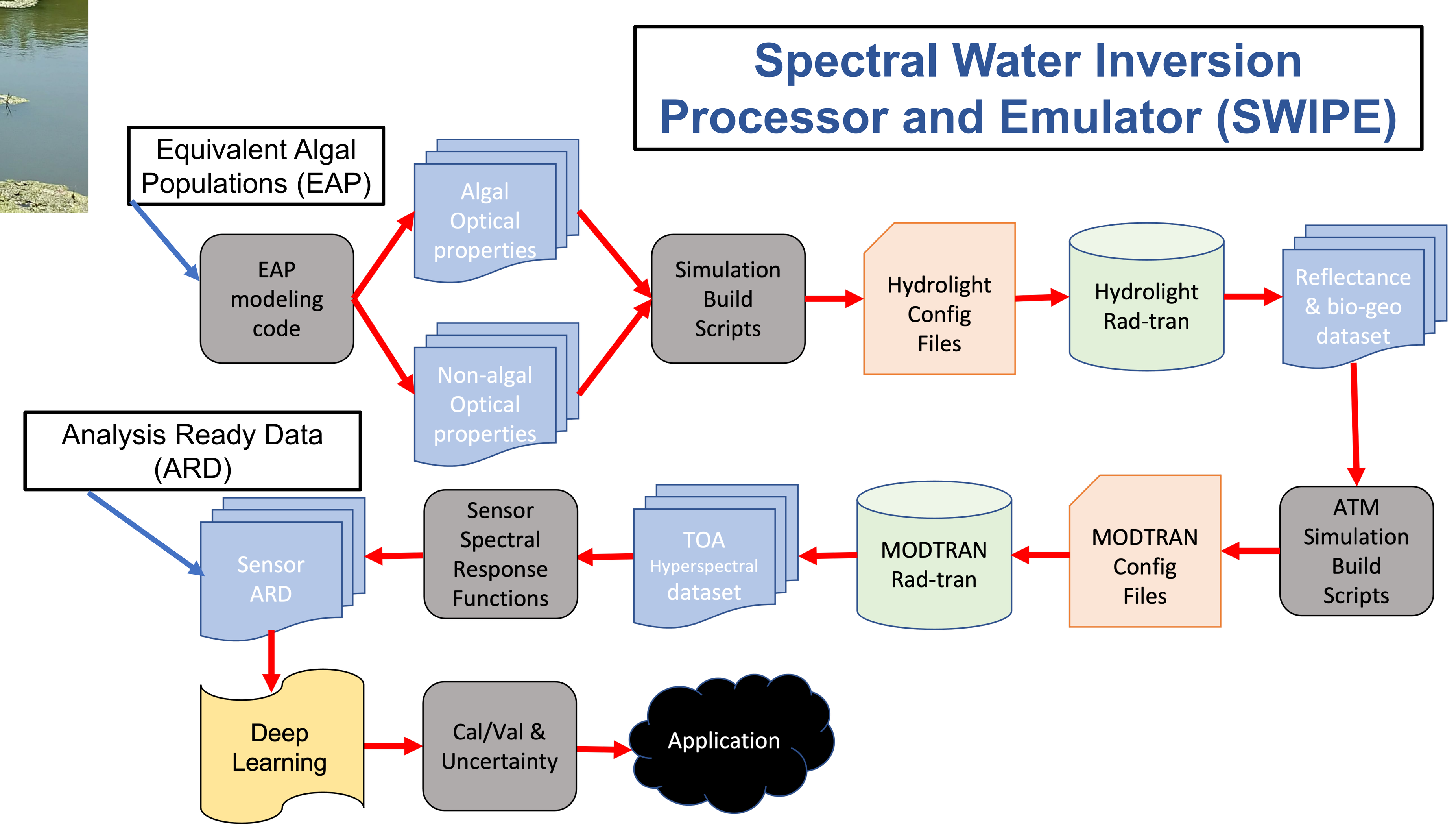



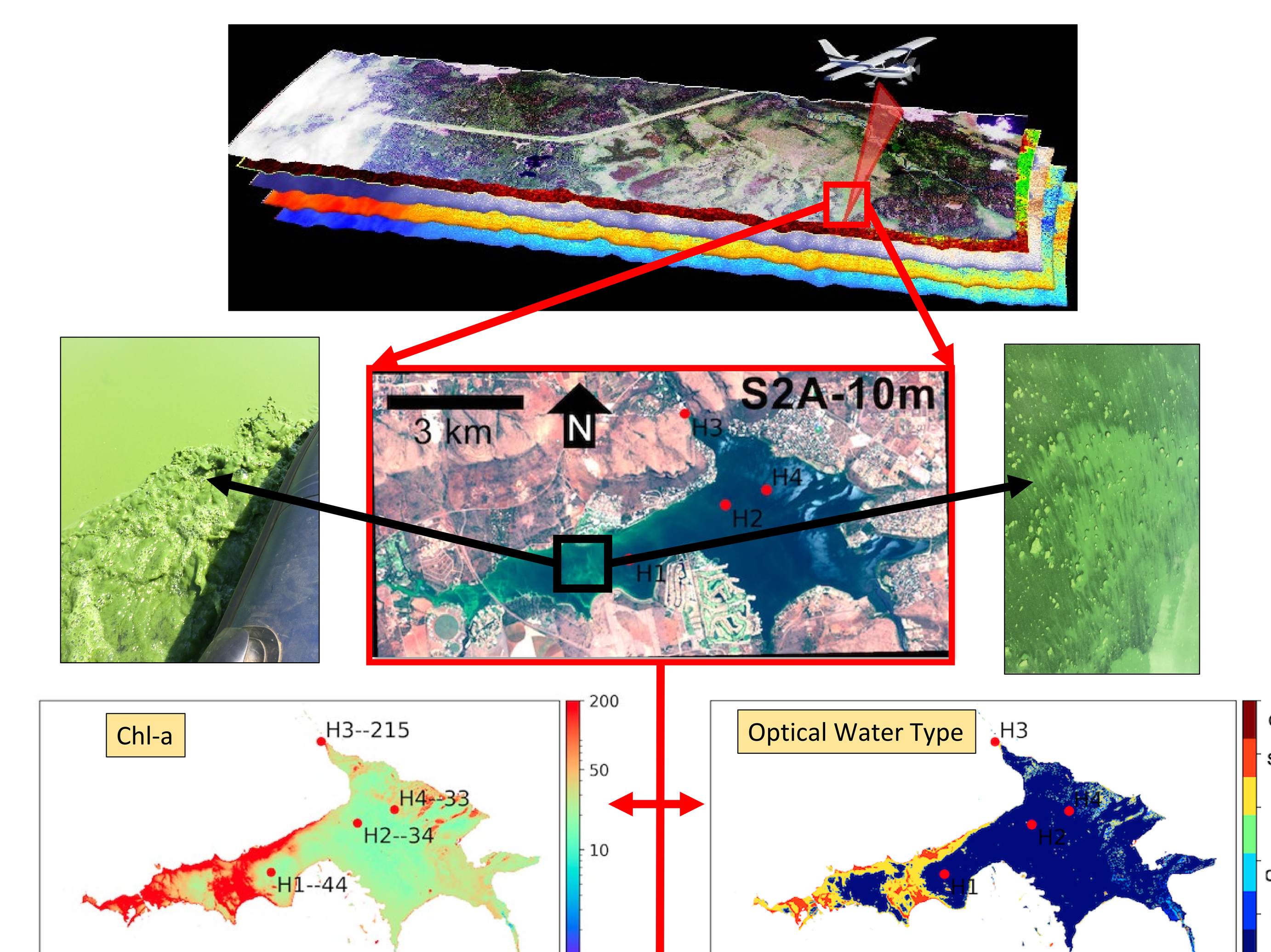
Left: Example invasive FAV found in Hartbeespoort Dam, SA. Right: Example phytoplankton community found in irrigation canals and farm dams of Hartbeespoort Dam. Harmful cyanobacteria can be identified using FlowCam microscopy (from left to right: *Anabaena* [650.01]; Dinoflagellate spp. [5617.31]; *Microcystis* [6772.85, 281.96, 1048.99]. Photos: Univ. of Venda.

2. Hyperspectral Delineation of Phytoplankton Assemblage and Floating Aquatic Vegetation Biodiversity

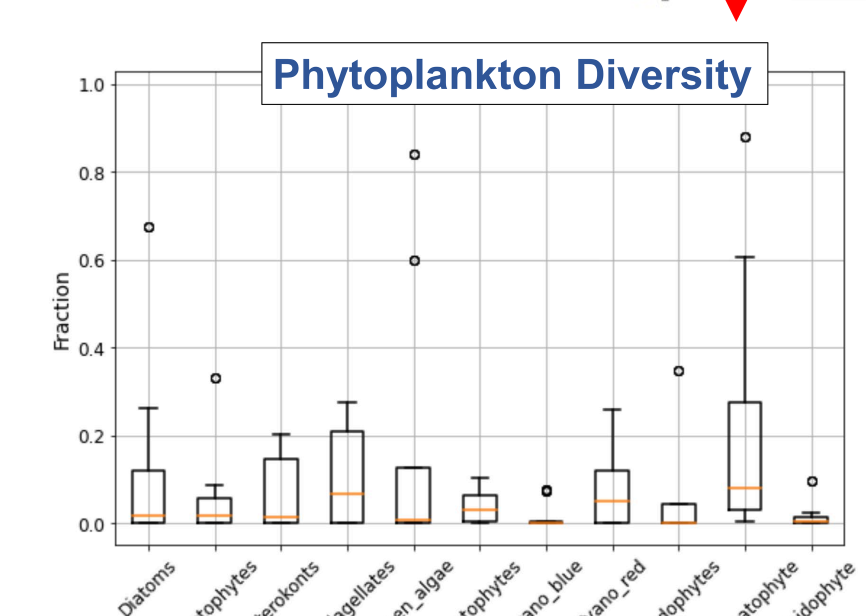
- Remote sensing
  - **Seasonality of phytoplankton and FAV.** Build on historic time series (MERIS, Mathews 2014) with Landsat 8 OLI, and Sentinel 2 MSI, Sentinel 3 OLCI. Review MODIS, VIIRS for scale.
  - **Opportunistic satellite data collection during airborne campaign** (+/- 1 hr of airborne flight over field sites) Landsat and Sentinel (possibly MODIS, VIIRS).
  - **AVIRIS-NG and PRISM hyperspectral data.** Opportunities for PRISMA and DESIS coverage of sites?

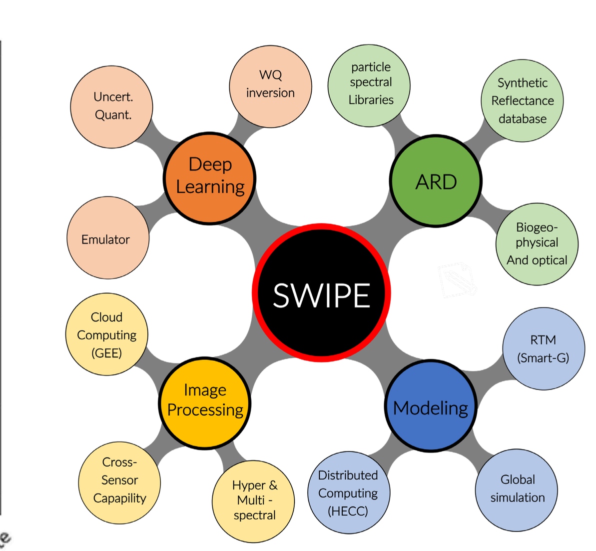
Preliminary Modeling Work for Hartbeespoort Dam, SA (Kravitz et al.)





- Radiative Transfer Modeling will produce a synthetic dataset to train an emulator to output Phytoplankton Functional Type (PFT) products
- Machine learning and artificial neural network will be used for Phytoplankton Class/PFT level
- Additionally mapping floating aquatic vegetation and connection with cyanobacteria blooms





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