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eawag aquatic research

Retrieval of optical properties in a turbid lake via reflectance inversion

Problem

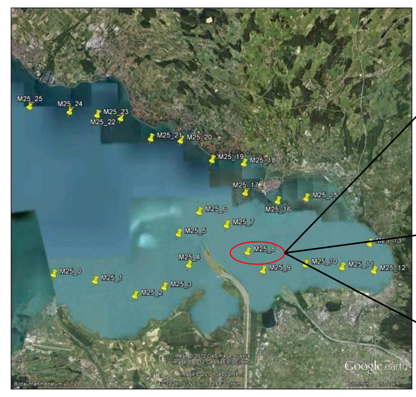
- Remote-sensing reflectance $R_{rs}(\lambda)$ contains information on water optically active constituents (AOCs)
- We could model $R_{rs}(\lambda)$ and match observations to retrieve AOCs
- Spectral matching neds knowledge of the mass-specific inherent optical properties (IOPs)

Implementation: Ecolight + genetic algorithms

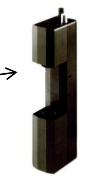
Ecolight 5.0 (Sequoia Scientific Inc.)
Water constituents:
-H_20
-chla (z-const.)
-CDOM (z-const):
$a_{CDOM}(\lambda)=a_{CDOM}(440)e^{-S(\lambda-440)}$
-TSM(z): measured

Genetic algorithms
- Freely available toolbox
- Running under GNU Octave

Field work: transect in Lake Constance

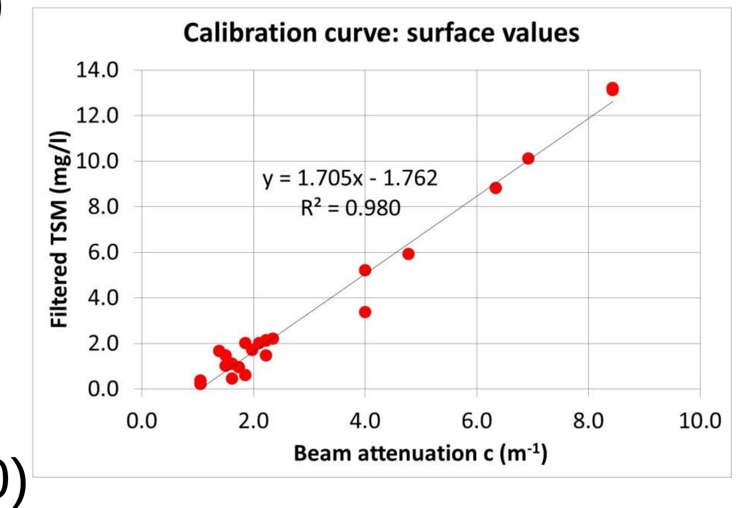



Water Insight Spectrometer (WISP-3) → $R_{rs}(\lambda)$

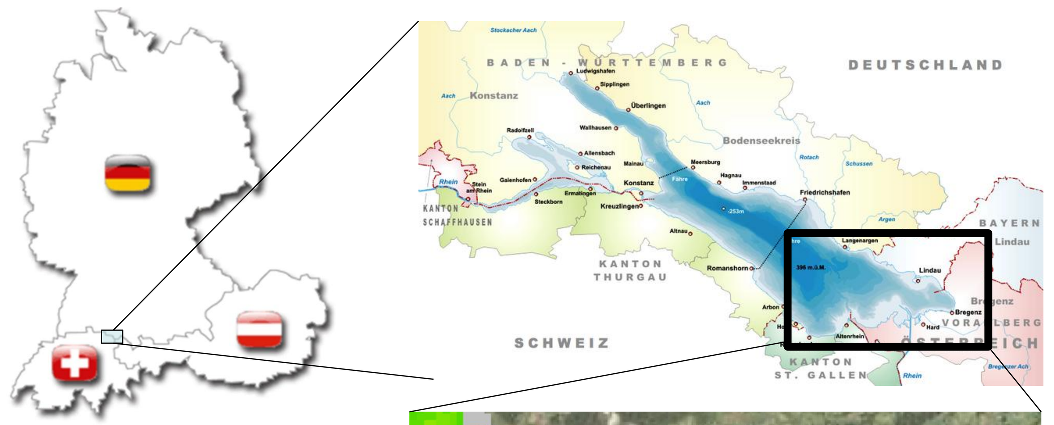

WET Labs C-Star transmissometer → c(z)

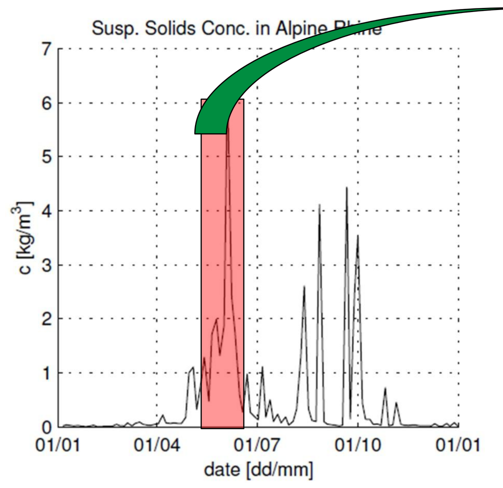

Whatman GF/F filters (1μm pore size) → TSM(z=0)

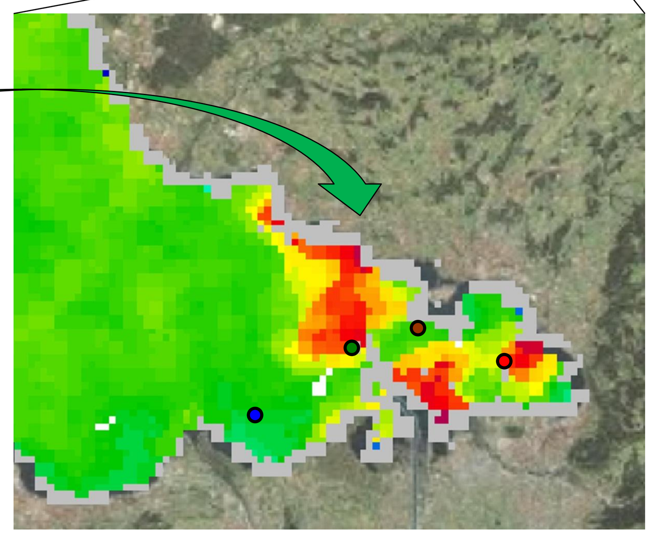
Extension to TSM(z)

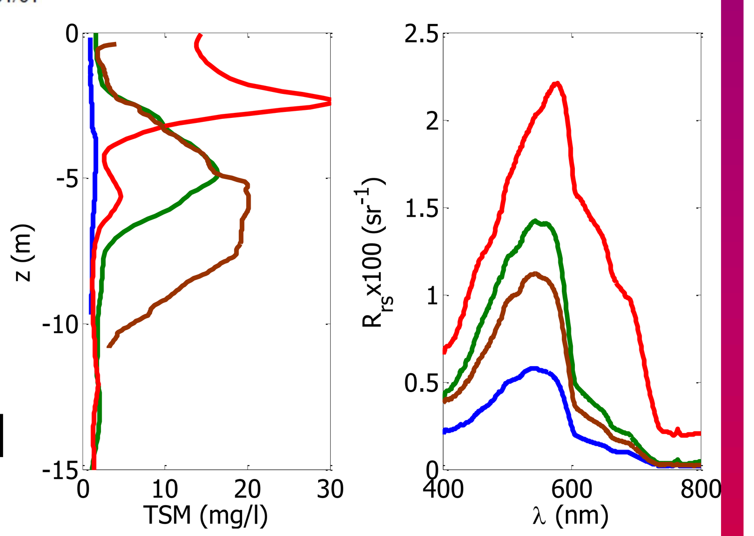


Site description: Lake Constance









- Late May: peak in particle discharge
- Particles spread into the lake
- Large horizontal and vertical variability among points
- Effect on the measured $R_{rs}(\lambda)$

Key idea: TSM(z) profiles cause the variability in $R_{rs}(\lambda)$, but the IOPs are constant

Modelling and Results

Unknowns:
- chla
- S, $a_{CDOM}(440)$
- $a^*_{TSM}(\lambda)$, $b^*_{TSM}(\lambda)$

$R_{rs}(\lambda)$ meas. (WISP) → Ecolight ← - TSM(z) - Other parameters

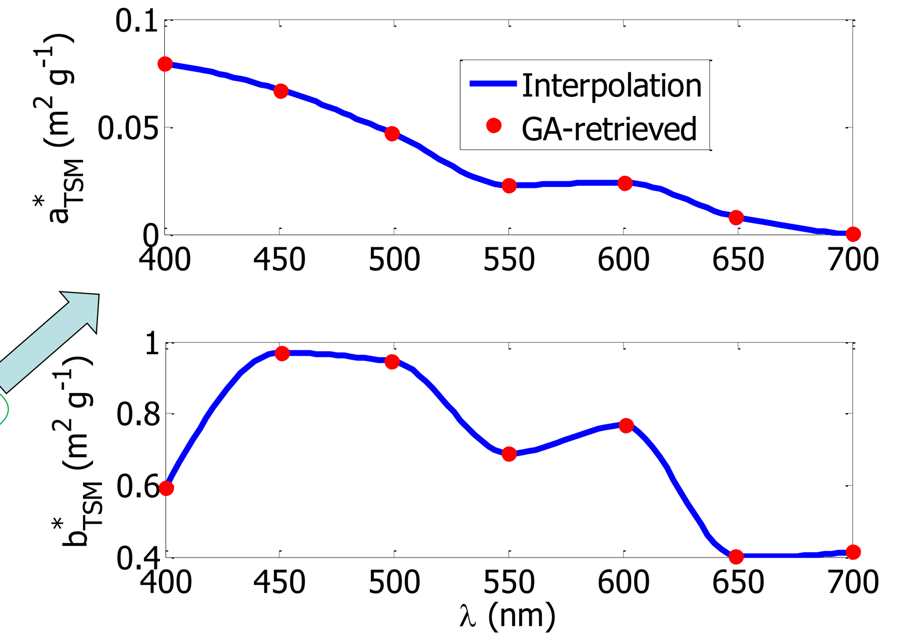
Goal function to minimize

$$f=\left\| \frac{R_{rs,WISP}(\lambda_k)-R_{rs,Eco}(\lambda_k)}{R_{rs,WISP}(\lambda_k)} \right\|$$

λ=400:50:700 nm

→ Genetic algorithms →

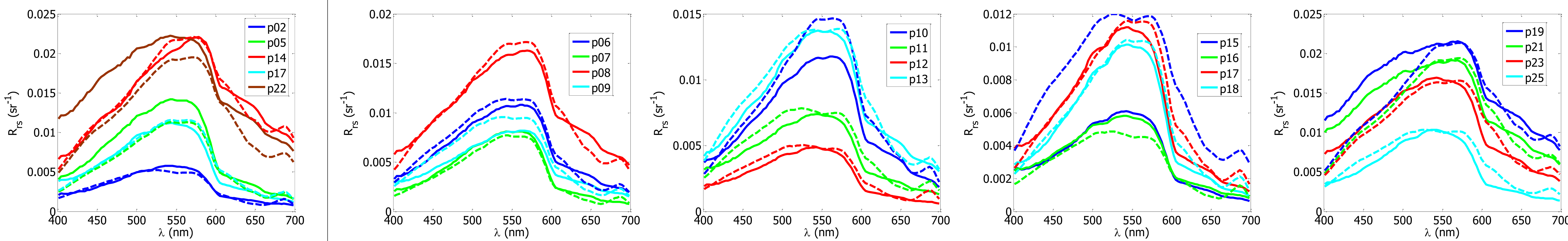
Solution
Chla=0.7
S=0.012
$a_{CDOM}(440)=0.19$
$a^*_{TSM}(\lambda)$, $b^*_{TSM}(\lambda)$



Comparison: measured (—) vs. modelled (--) $R_{rs}(\lambda)$ for every point in the dataset

Calibration set: RMS=1.88%

Validation set: RMS=3.02%



Goals

- To couple an IOP model to a genetic algorithms (GA) optimisation routine
- To retrieve the OACs, and other unknown parameters via spectral inversion in a lake optically dominated by particles (TSM)

Conclusions

- The method finds the spectral shape of the IOPs by fitting modelled reflectances to simulated
- The method has been calibrated in a small subset, leaving the rest for validation
- The RMS error doesn't increase substantially when calculated for the validation sub-set
- The method is flexible and easily extendable to any kind of available magnitudes to be considered as known or optimizable
- The method is dependent on the quality of the $R_{rs}(\lambda)$ measurement
- Some points show discrepancies. Probable causes
  - Noisy measurements
  - Boundary layer effect in TSM(z)
  - spatial variability of chl-a, CDOM, $a^*_{TSM}(\lambda)$, $b^*_{TSM}(\lambda)$

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