

Sensitivity study for aquatic ecosystem monitoring with the DESIS hyperspectral sensor

Nicole Pinnel, Peter Gege, Anna Göritz

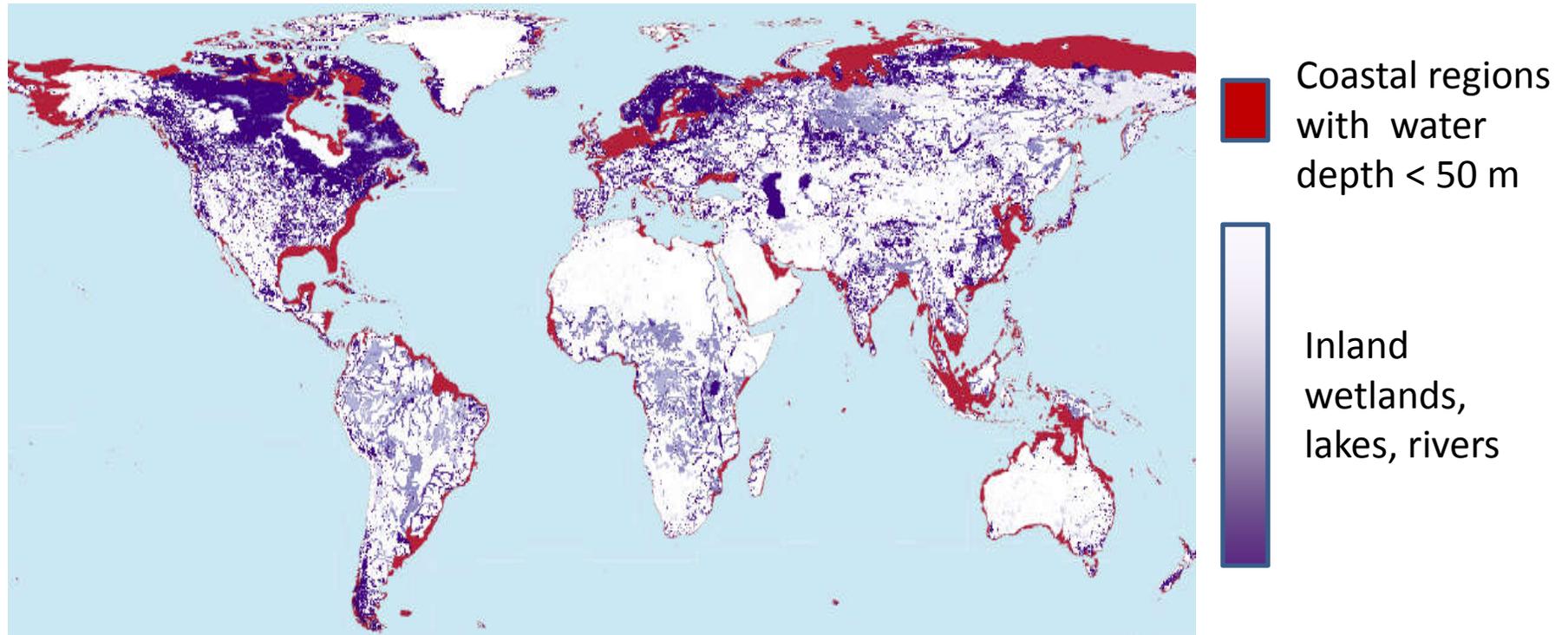


Outline

- Aquatic ecosystem monitoring
- DLR Earth Sensing Imaging Spectrometer (DEGIS)
- Sensitivity analysis for determination of water parameters
- Comparison of simulated spectra and real DEGIS data.
- Conclusion



Aquatic ecosystem monitoring - global relevance



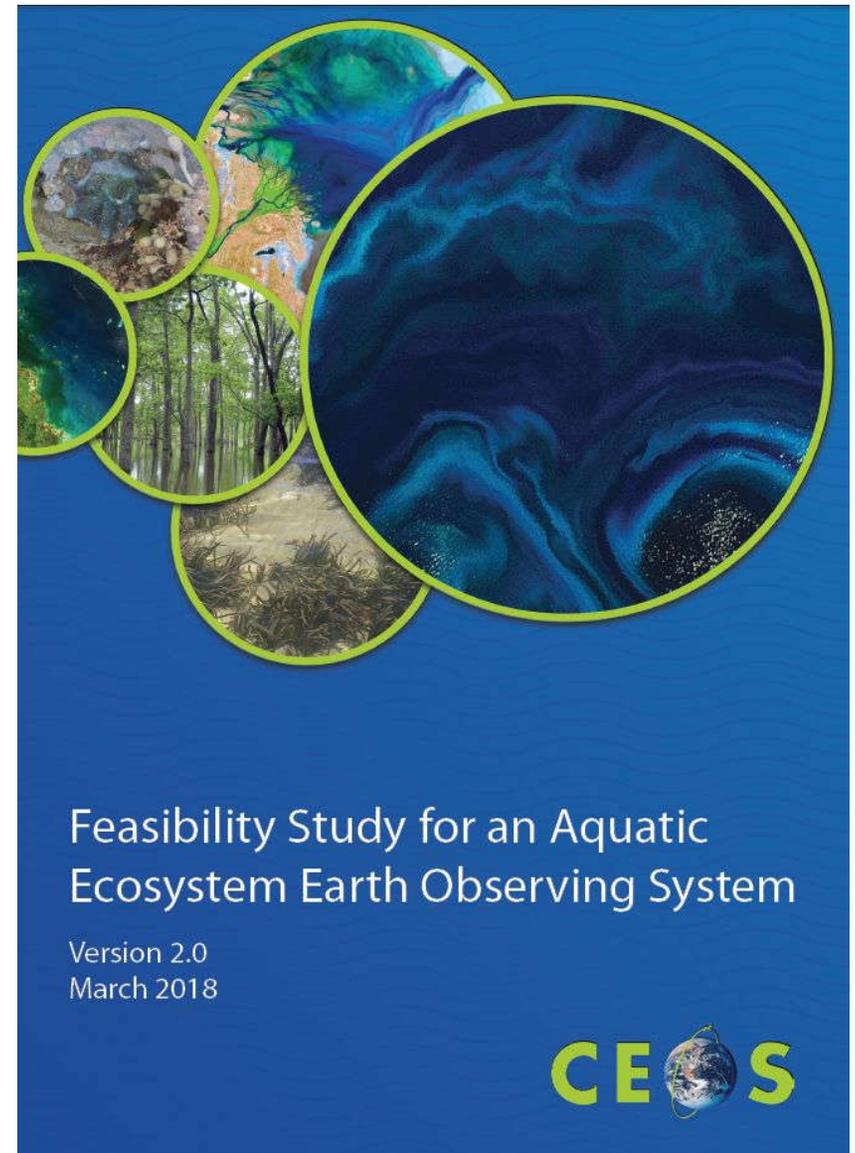
Global distribution of coastal and inland aquatic ecosystems (UNEP- WCMC, 2015)



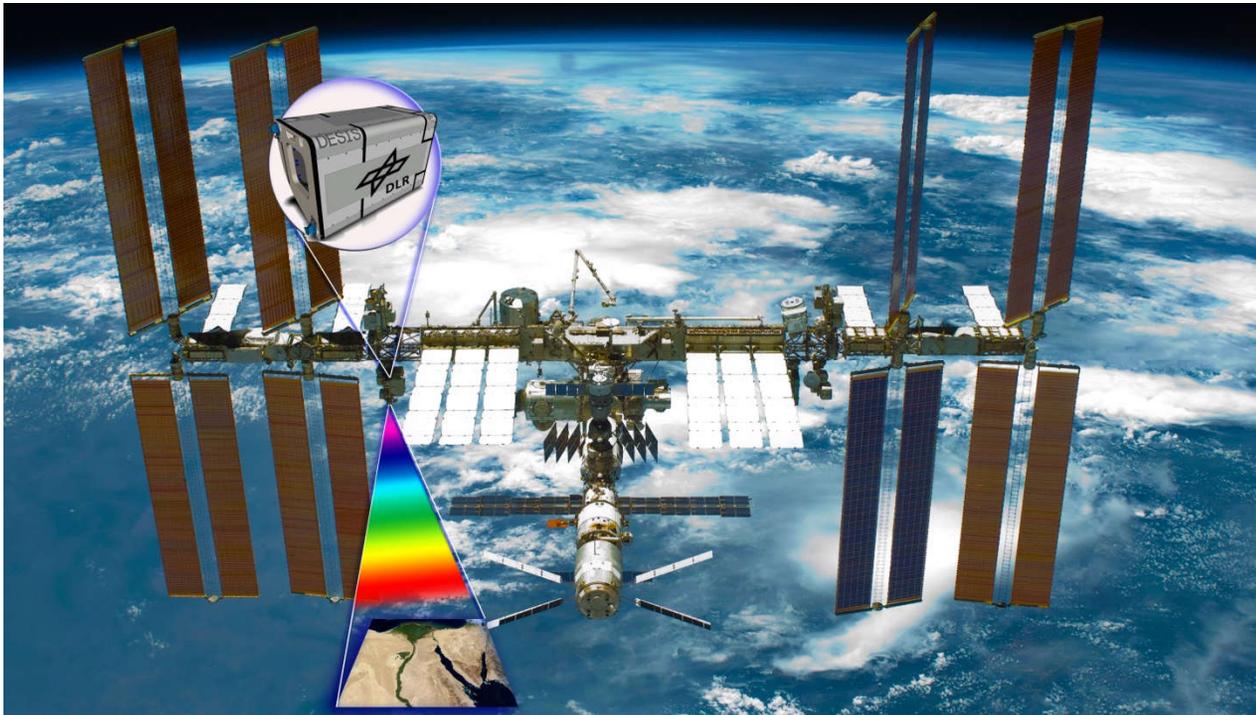
Aquatic ecosystem monitoring

- Key parameters
 - Concentrations: phytoplankton pigments, suspended matter, dissolved organic matter (CDOM)
 - Optical properties: phytoplankton fluorescence, absorption, backscattering, transparency
 - Others: water depth, bottom substrate type and coverage
- Sensor requirements
 - Spectral
 - Radiometric
 - Geometric
 - Temporal coverage

<http://ceos.org/about-ceos/publications-2/>



DLR Earth Sensing Imaging Spectrometer (DESI)



Orbit: ISS (~400 km)

Spectral range: 420 to 1000 nm

Coverage: 55° N to 52° S

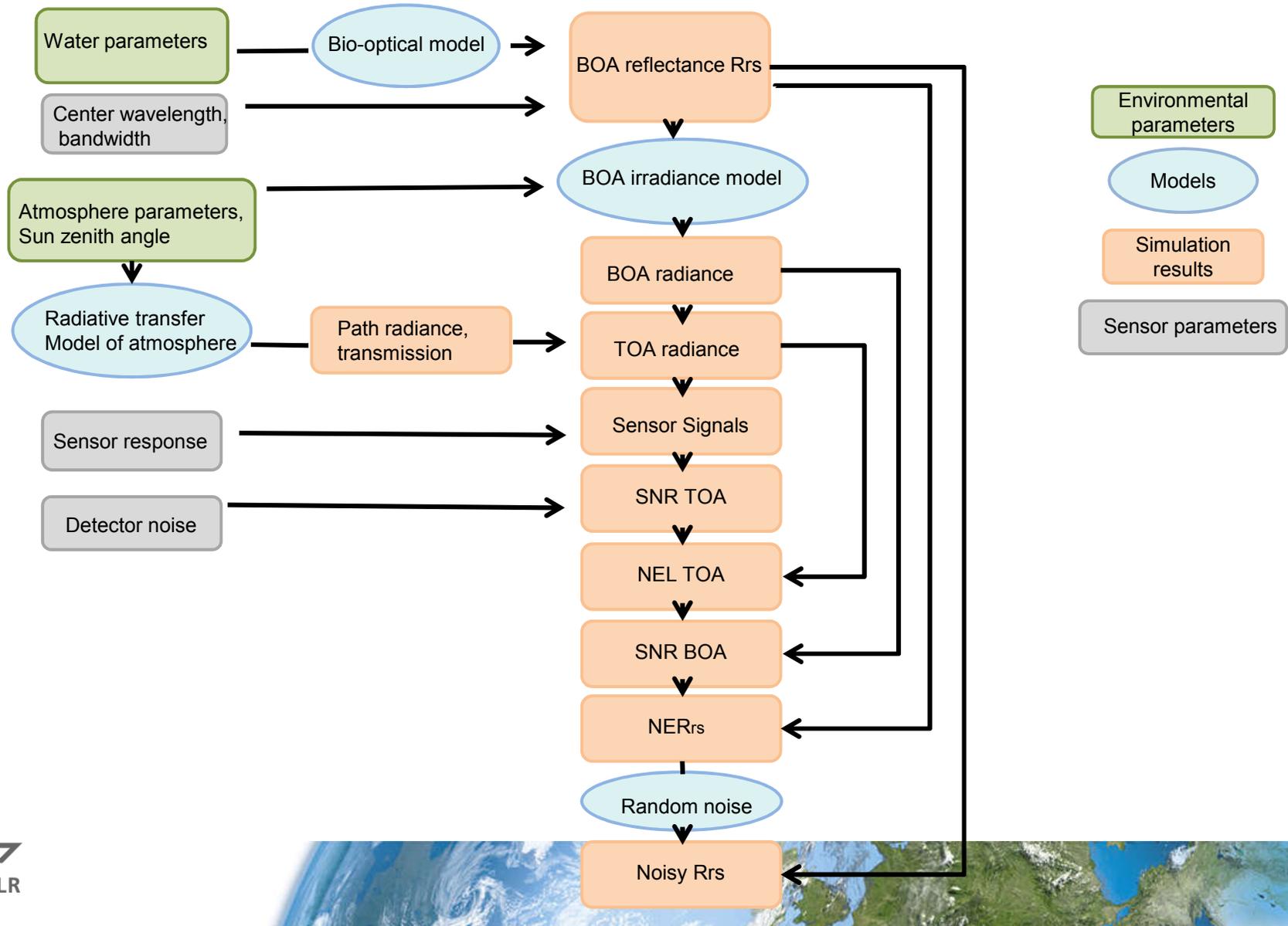
Spatial: 30 m x 30 m

Tilting: -45° to +5° (cross track)
-40° to +40° (along track)

Swath: 30 km @400 km

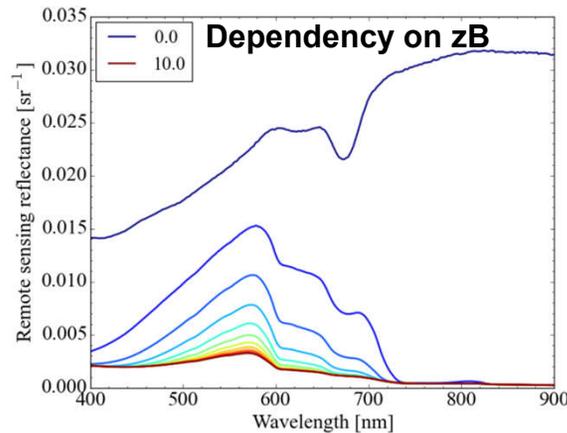
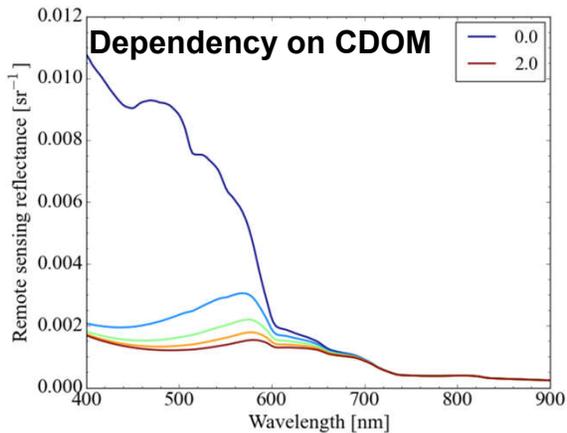
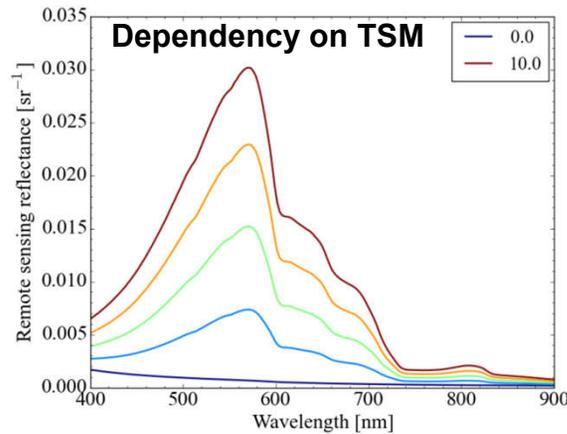
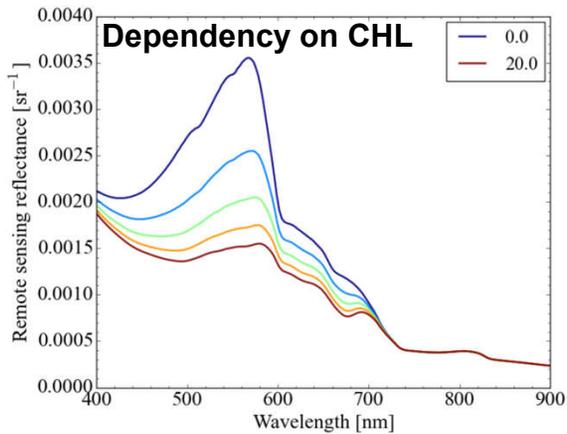


Flow chart forward simulations



Sensitivity analysis for determination of water parameters

Variability of remote sensing reflectance (sr^{-1})

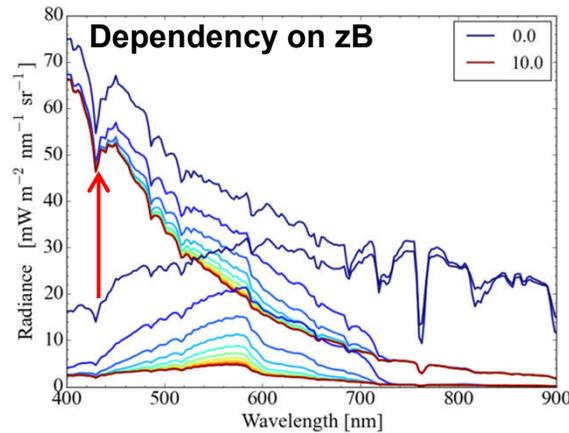
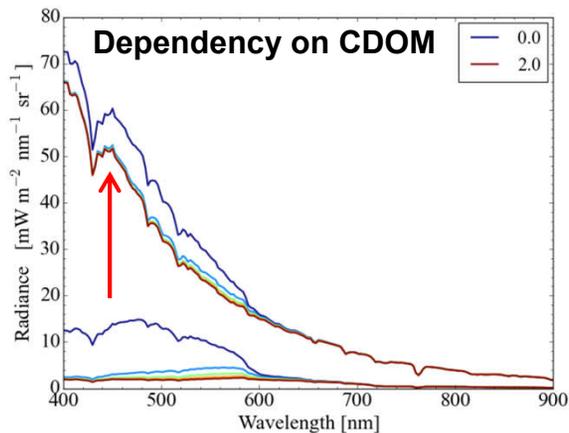
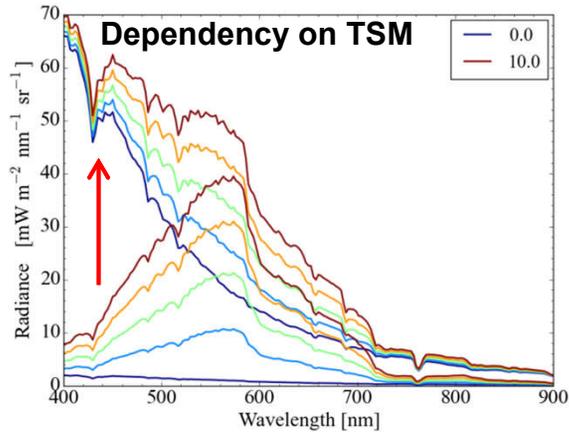
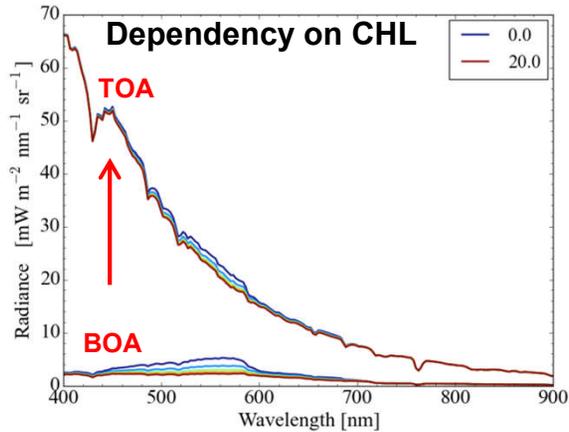


Scenario	Deep water	Shallow water
θ_{sun} [deg]	30, 60	30, 60
VIS [km]	100, 10	100, 10
TSM [mg /l]	1 (0.1-10)	1
CHL [μg /l]	2 (0.2-20)	2
a_{CDOM} [1/m]	0.5 (0.2-2)	0.5
S_{CDOM} [nm^{-1}]	0.014	0.014
zB [m]	1000	1 (0-10)
No sunglint, but skylint included		



Sensitivity analysis for determination of water parameters

Range of upwelling radiance at top of atmosphere and bottom of atmosphere

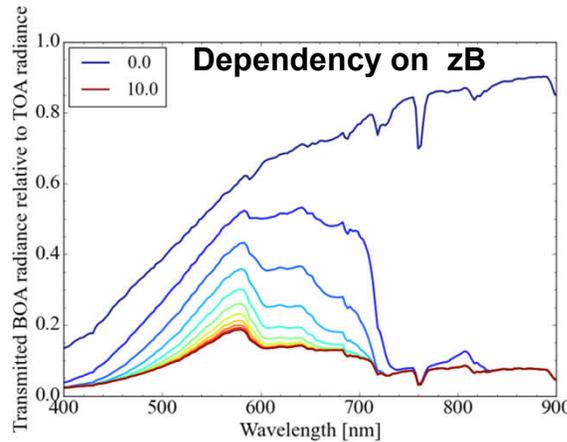
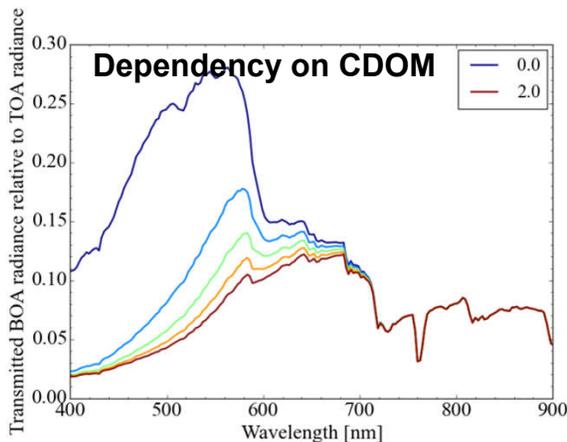
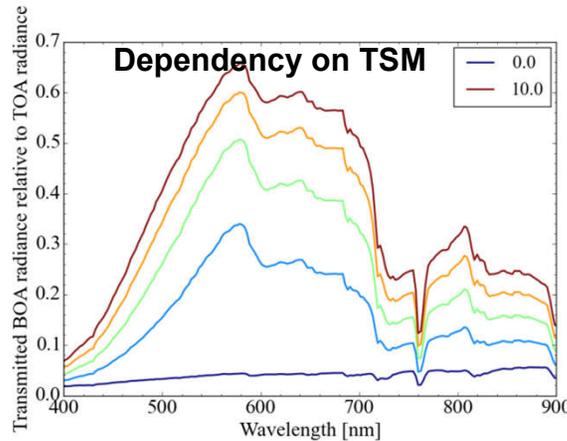
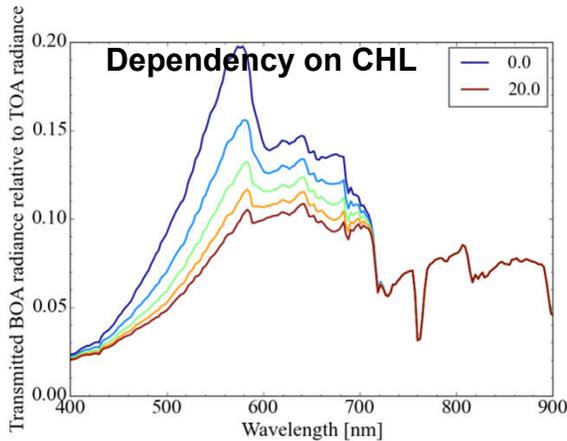


Scenario	Deep water	Shallow water
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No sunglint, but skylight included		



Sensitivity analysis for determination of water parameters

Range of transmitted BOA radiance to TOA radiance



Only a small fraction of upwelling radiance at top of atmosphere comes from water !

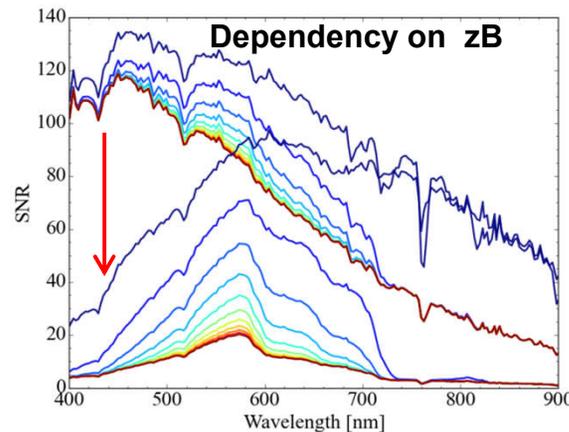
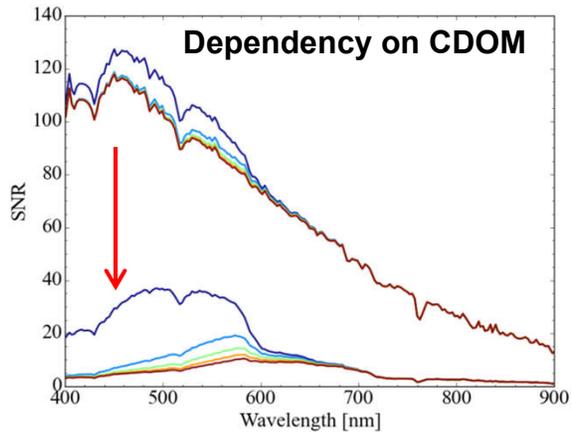
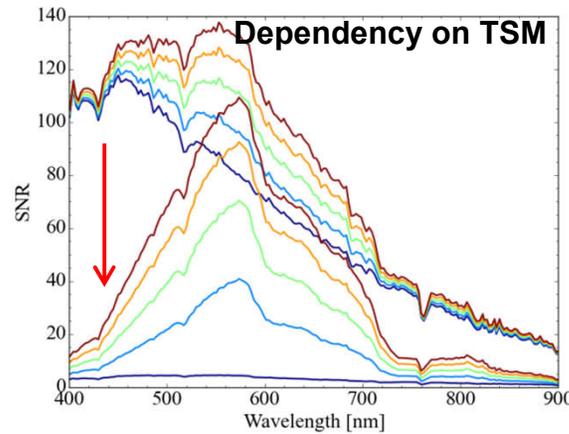
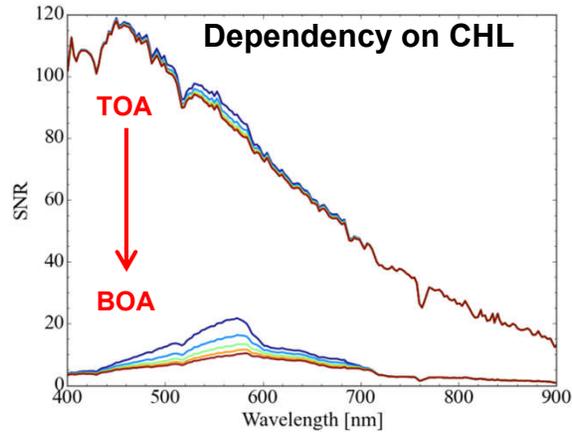
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zB [m]	1000	1 (0-10)

No sunglint, but skylight included



Sensitivity analysis for determination of water parameters

SNR at bottom of atmosphere (BOA) and top of atmosphere (TOA)

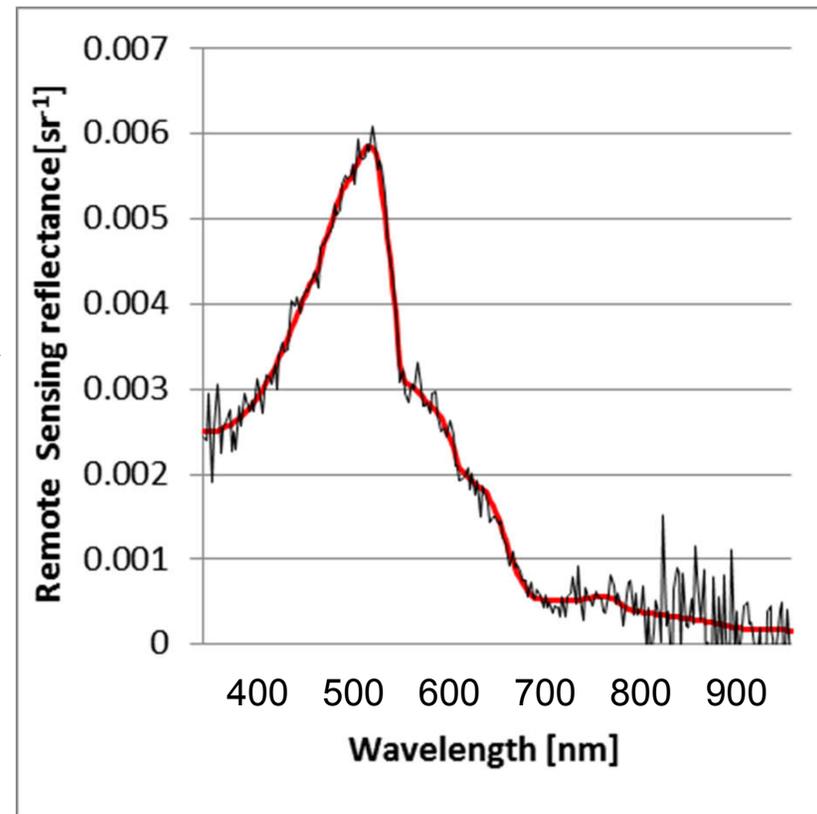
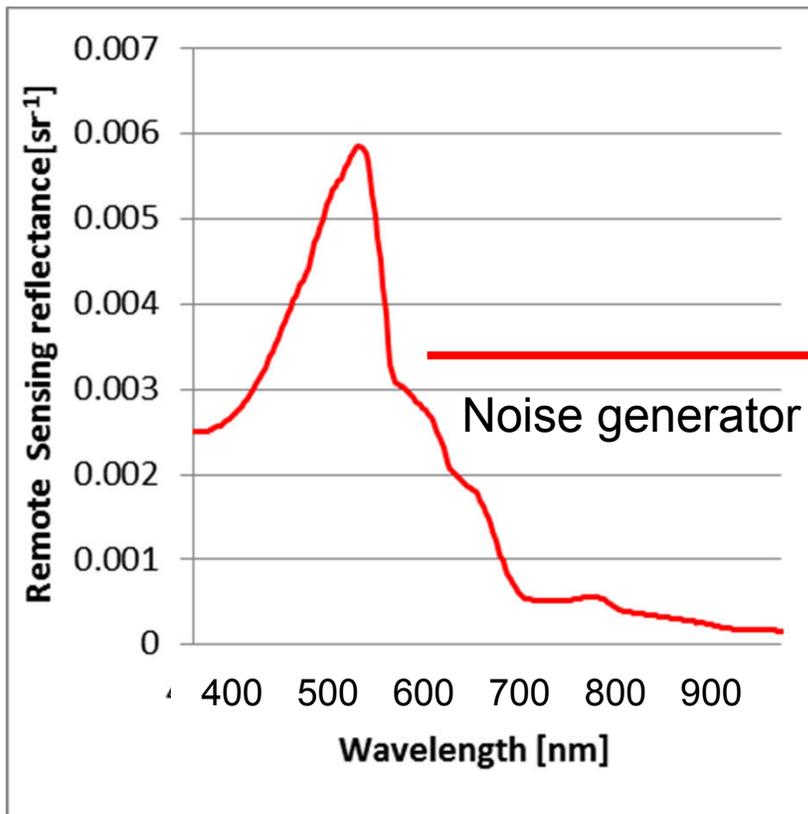


Scenario	Deep water	Shallow water
θ_{sun} [deg]	30, 60	30, 60
VIS [km]	100, 10	100, 10
TSM [mg /l]	1 (0.1-10)	1
CHL [μg /l]	2 (0.2-20)	2
a_{CDOM} [1/m]	0.5 (0.2-2)	0.5
S_{CDOM} [nm^{-1}]	0.014	0.014
zB [m]	1000	1 (0-10)
No sunglint, but skylint included		



Sensitivity analysis for determination of water parameters

Simulation of noisy reflectance spectra

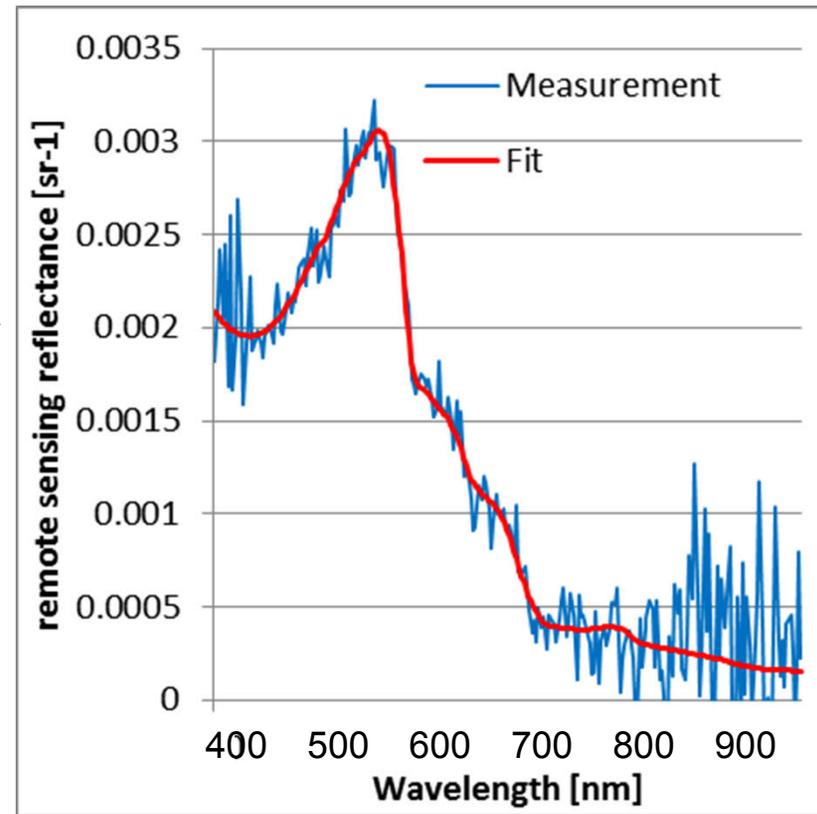
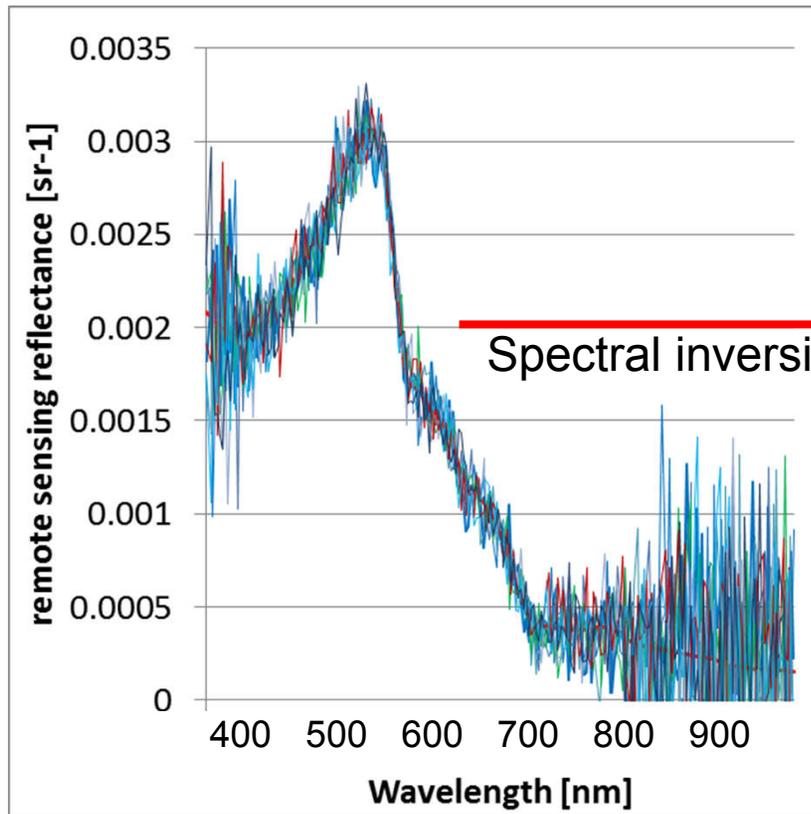


Chl a 2 [µg /l], TSM 1 [mg /l], a CDOM 0.5 [1/m]



Inversion of water parameters from simulated spectra

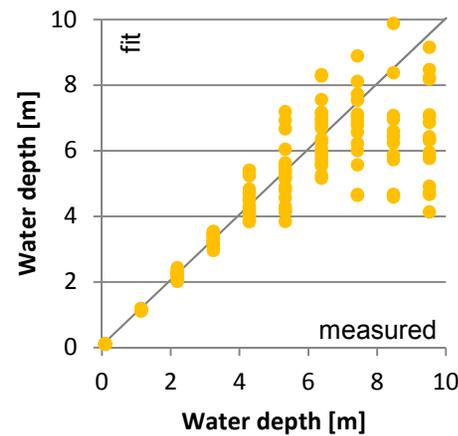
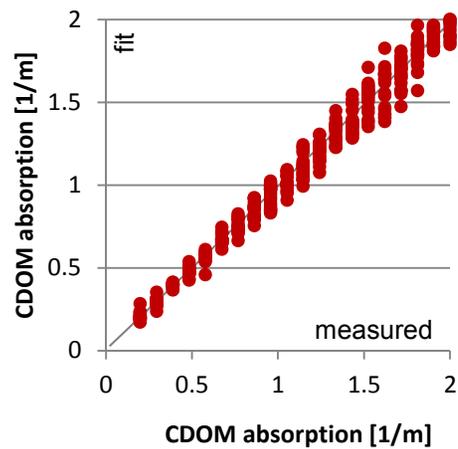
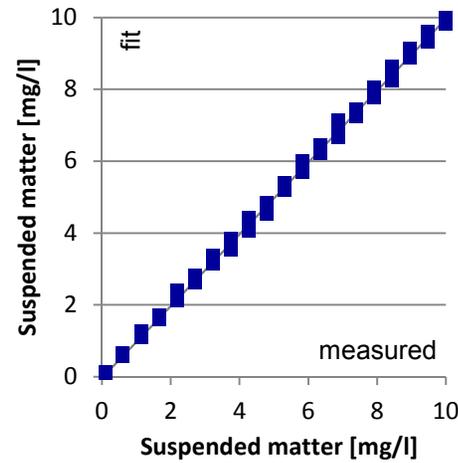
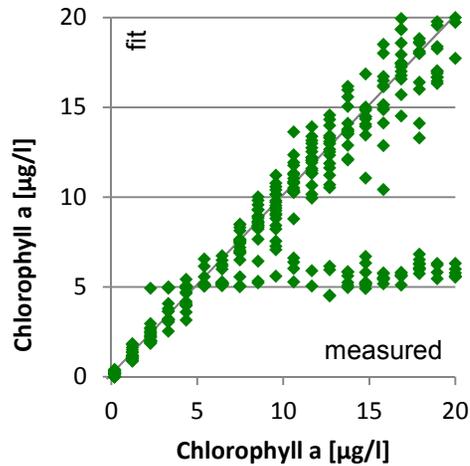
Noise simulated DESIS spectra



Chl a 5 [$\mu\text{g} / \text{l}$], TSM 3 [mg / l], a CDOM 0.5 [$1/\text{m}$]



Inversion of water parameters from simulated spectra

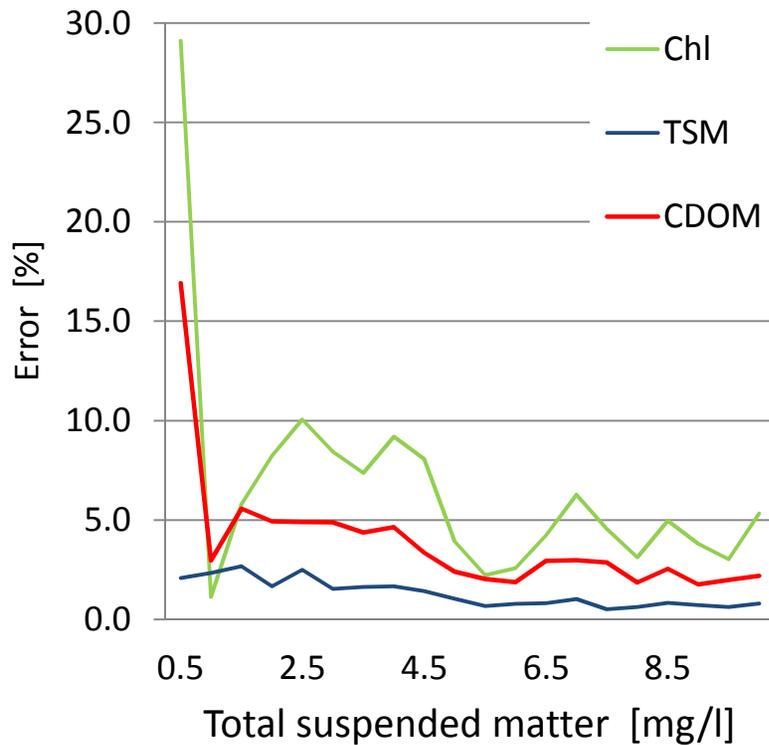


θ_{sun} [deg]	30
VIS [km]	100
TSM [mg /l]	3 (0.1-10)
CHL [$\mu\text{g} /\text{l}$]	5 (0.2-20)
a_{CDOM} [1/m]	0.5 (0.2-2)
S_{CDOM} [nm^{-1}]	0.014
zB [m]	1



Inversion of water parameters from simulated spectra

Sun zenith = 30 °, visibility 100 km



TSM [mg /l]	rel. Error	rel. Error	rel. Error
	[%]	[%]	[%]
	CHL	TSM	CDOM
1	1.13	2.34	2.96
2	8.23	1.67	4.93
3	8.44	1.54	4.89
4	9.20	1.67	4.64
5	3.92	1.03	2.41
6	2.58	0.79	1.87
7	6.28	1.02	2.99
8	3.12	0.62	1.86
9	3.81	0.71	1.76
10	5.34	0.80	2.20

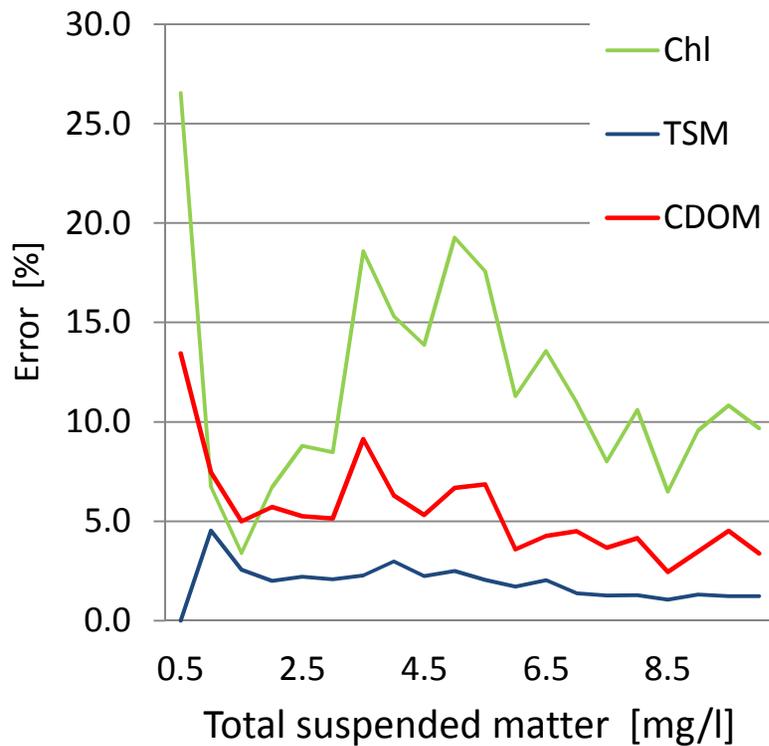
Chl a 5 [µg /l], TSM 3 [mg /l], a CDOM 0.5 [1/m]

Errors are given in %: error = 100*(inv/fwd-1)



Inversion of water parameters from simulated spectra

Sun zenith = 60 °, visibility 10 km

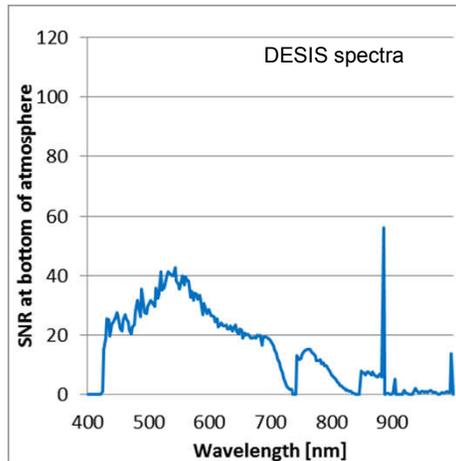
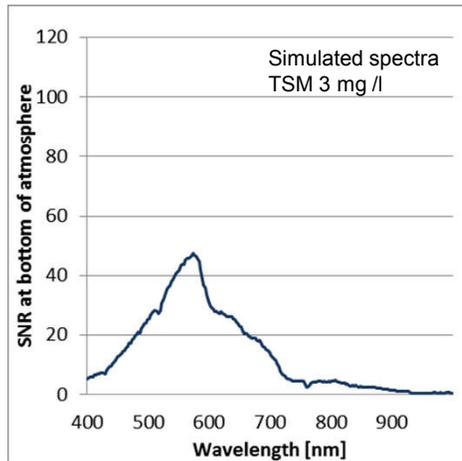
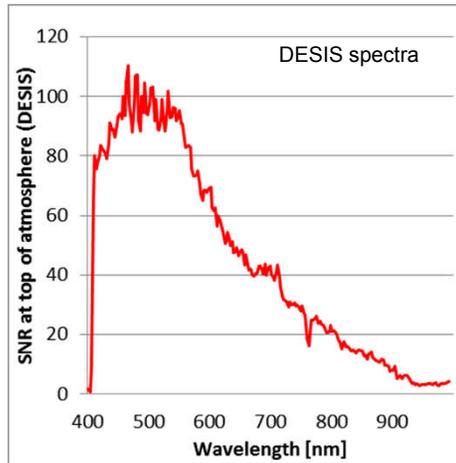
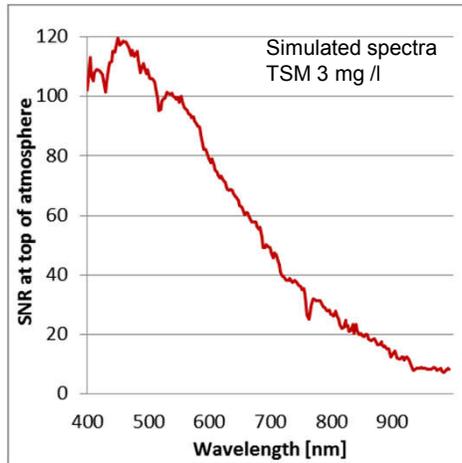


TSM [mg /l]	rel. Error [%] CHL	rel. Error [%] TSM	rel. Error [%] CDOM
1	26.55	0.00	13.45
2	3.40	2.56	4.99
3	8.80	2.21	5.26
4	18.58	2.27	9.13
5	13.87	2.24	5.32
6	17.58	2.05	6.86
7	13.56	2.04	4.26
8	8.01	1.26	3.67
9	6.49	1.06	2.45
10	10.83	1.24	4.51

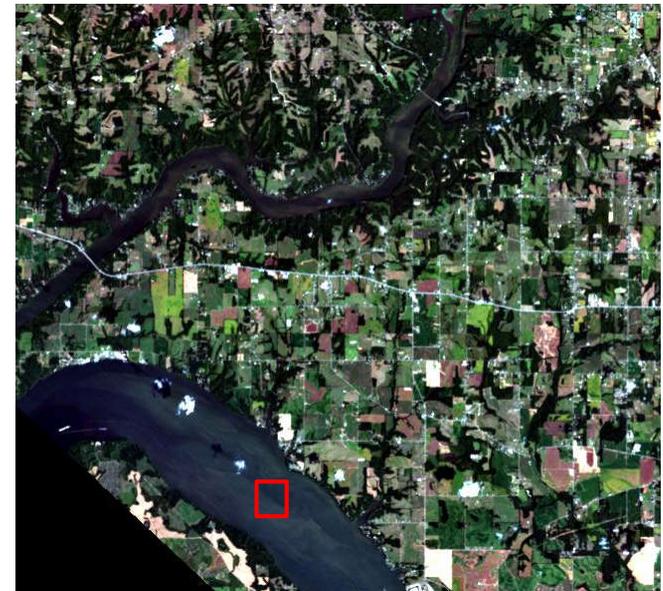
Chl a 5 [µg /l], TSM 3 [mg /l], a CDOM 0.5 [1/m]



Inversion of water parameters from real DESIS spectra



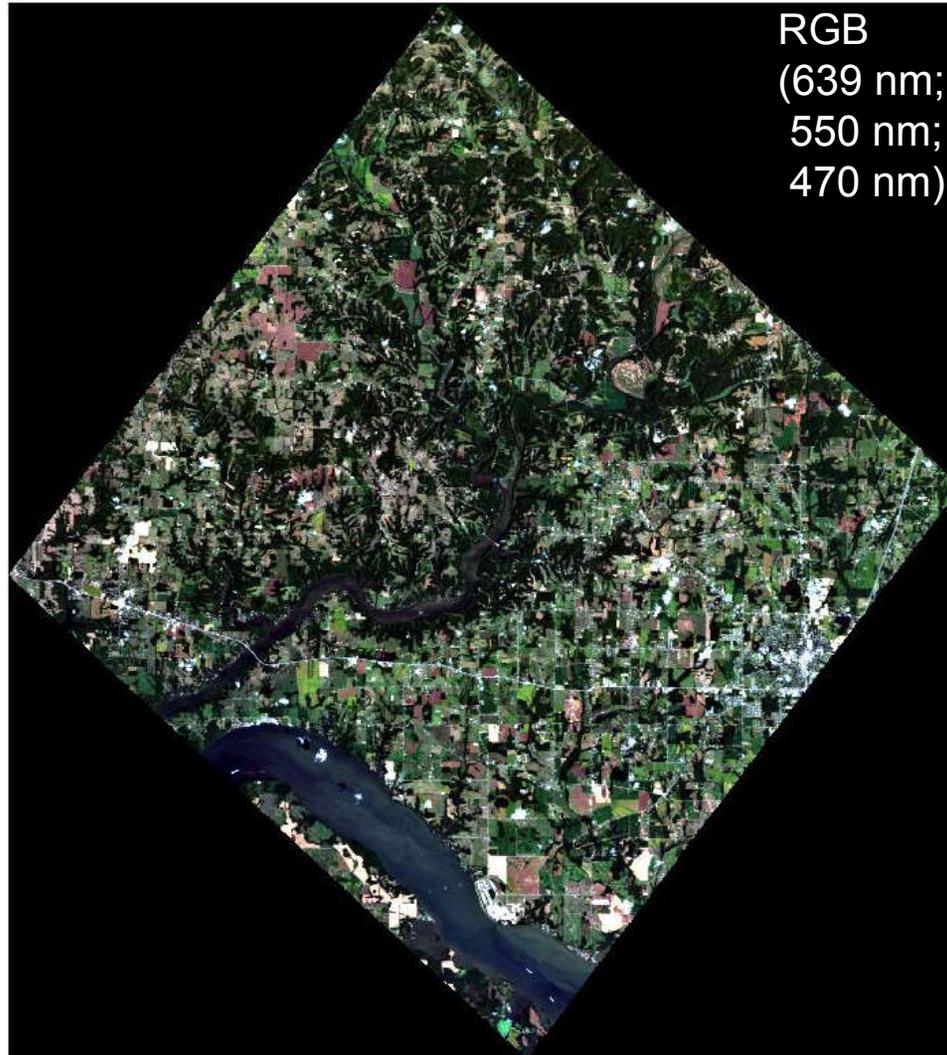
RGB (639 nm; 550 nm; 470 nm)



Tennessee River, Alabama (USA)
4th Sept. 2018



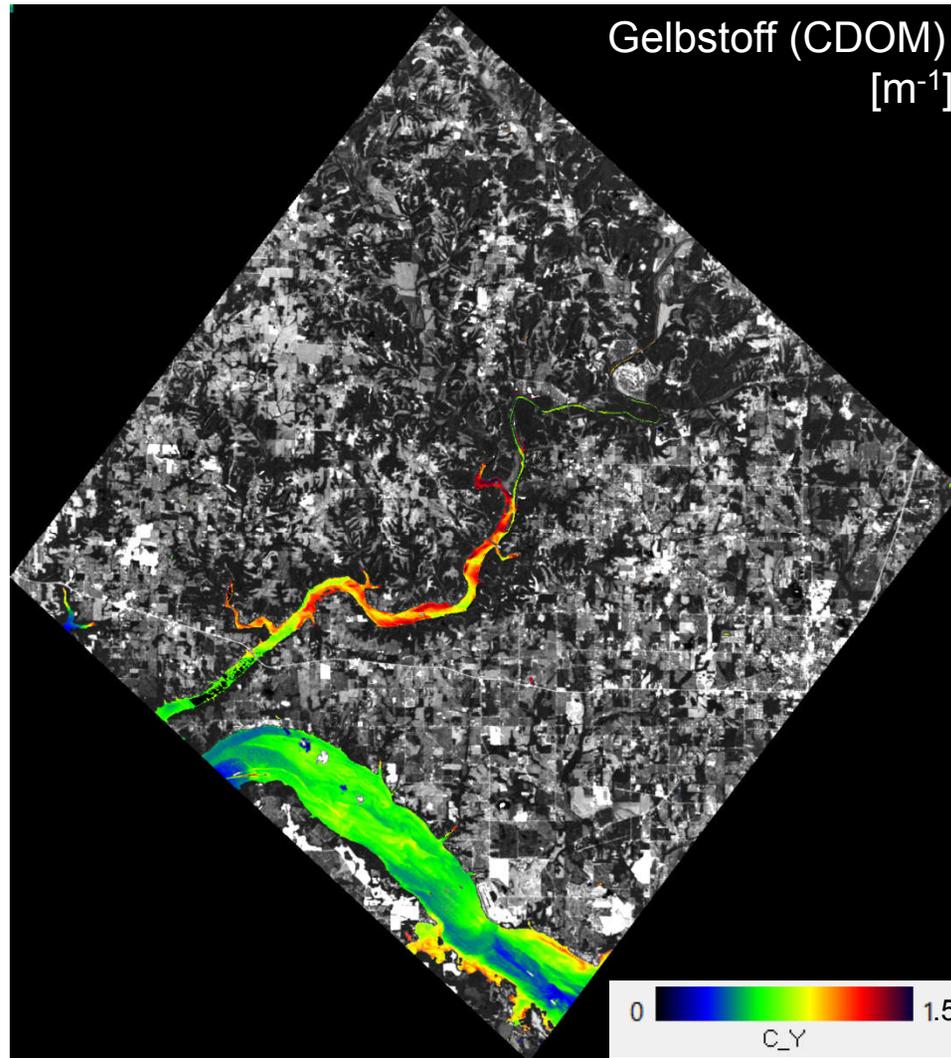
Inversion of water parameters from DESIS



Tennessee River
Alabama (USA)



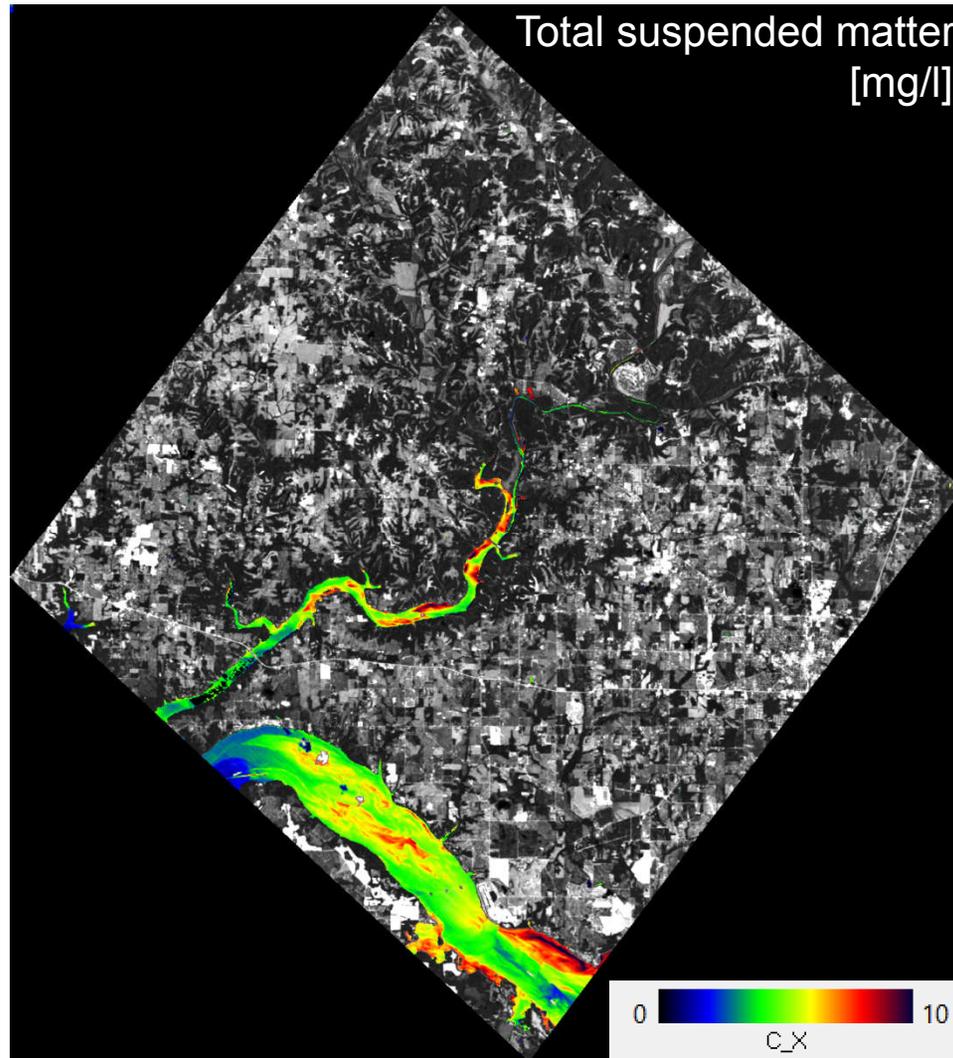
Inversion of water parameters from DESIS (not validated)



Tennessee River
Alabama (USA)



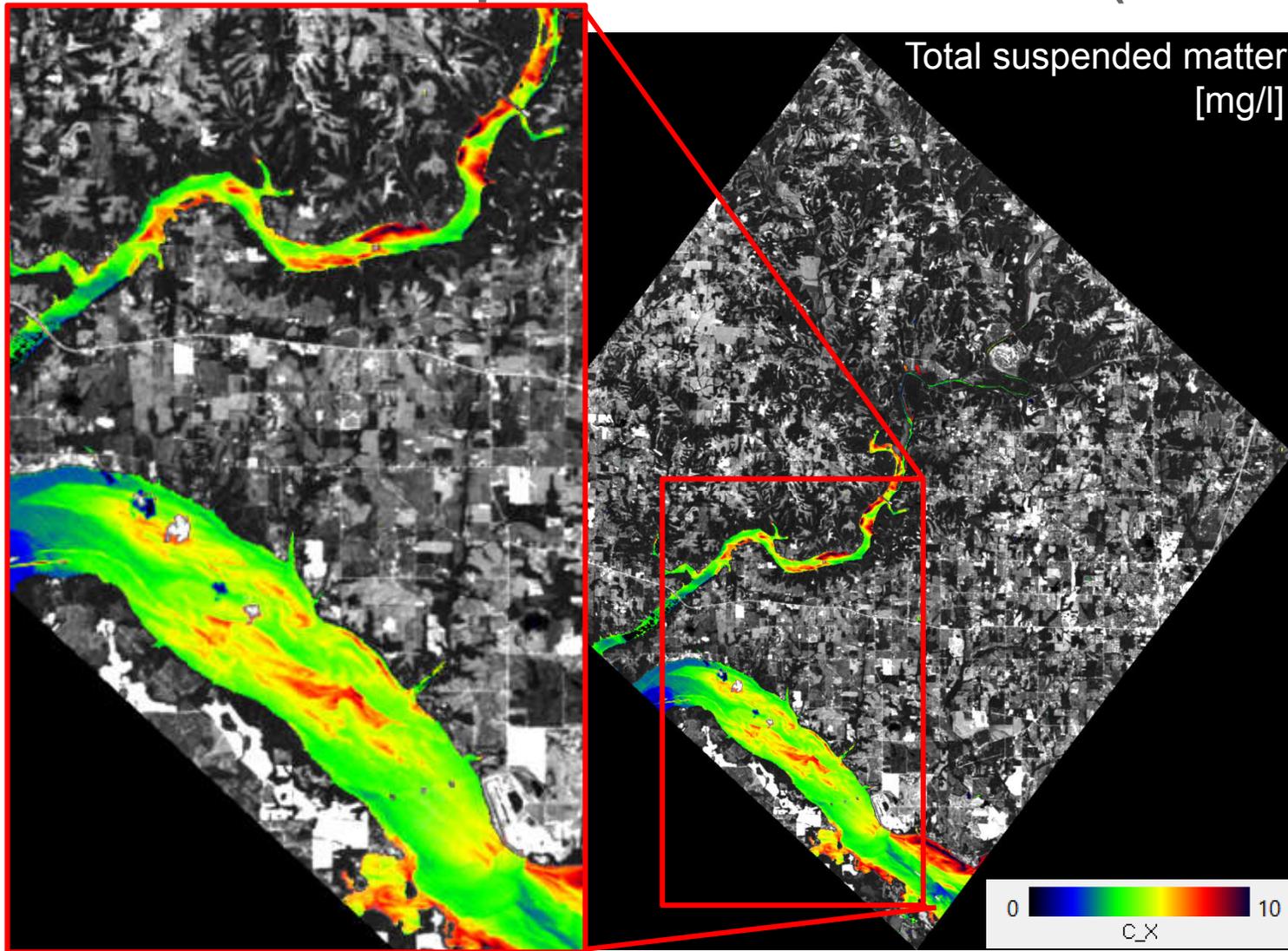
Inversion of water parameters from DESIS (not validated)



Tennessee River
Alabama (USA)



Inversion of water parameters from DESIS (not validated)



Summary

- Simulated retrieval of water constituents was tested on different water constituents concentration and different atmospheric conditions.
- Retrieval worked well within the range of error for CDOM, CHL, TSM and bathymetry
- First inversion results of water parameters from DESIS for TSM and CDOM are very promising



Many thanks to

Kevin Alonso

Martin Bachmann

Rupert Müller

Ralf Reulke

Sebastian Riedel

Ilse Sebastian

and the whole DESIS Team !

