Forward and Inverse Modeling of Ocean Color

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Radiative Transfer Theory
SMS 598(4)
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Acknowledgements

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- Curtis Mobley for the project idea and assistance, and for the fabulous lectures, the dedication, and for the mathematics.
- Emmanuel Boss and Collin Roesler for similar reasons (also MJ Perry for SMS 598(3))
- Trisha and others "behind the scenes" who made this possible
- ME weather, which fulfilled my dreams of lots of

- The meadows and the forests, for being soooo reflective in the 550 nm range. And so serene and beautiful
- The Damariscotta river and the Atlantic for smelling so nice, and heading such an impressive tidal range.
- The HTSRB and the HyperPro buoys for being cute and hyperspectral.

Outline

- Part I → SSA approximation (forward)
- Part II →the GSM algorithm, sensitivity analysis for two reflectances.

Introduction

- Complicated to solve in 3D in its full differential glory
- We need practical approximations for FORWARD modeling to link water constituents →IOPs →AOPs →Remotely sensed ocean color.
- Having a functional relationship (not necessarily analytical) will let us use the INVERSE model to estimate biogeochemical parameters from Rrs

L'équation du transfert radiatif

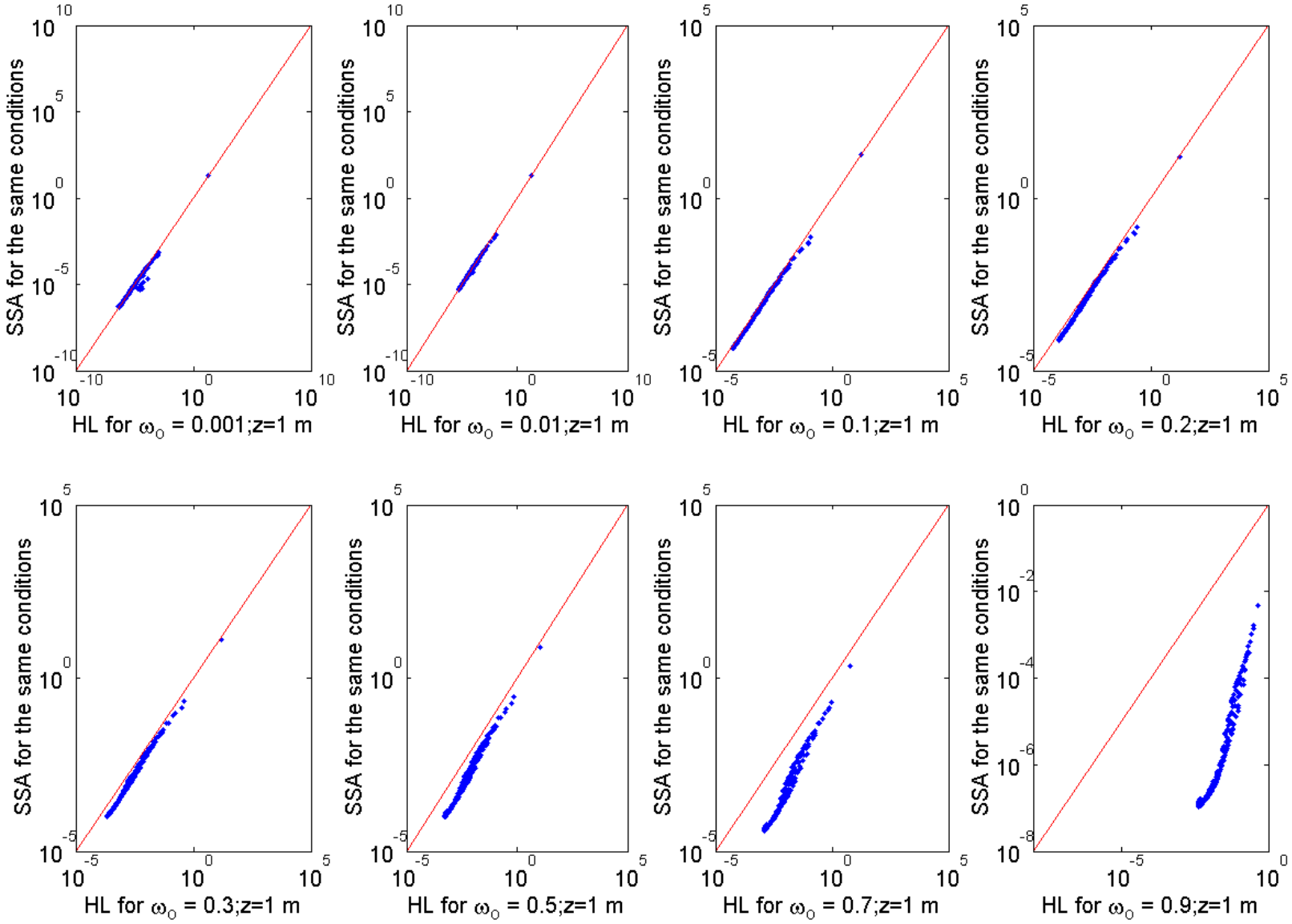
$$\mu \frac{dL(\zeta,\mu,\phi)}{d\zeta} = -L(\zeta,\mu,\phi) + \omega_0 \int \tilde{\beta}(\mu,\phi \rightarrow \mu',\phi') L(\zeta,\mu',\phi') d\Omega$$

- Single Scattering Approximation (SSA)
- Ignore all terms in infinite series after the first scattering term
- Quasi-SSA if forward scattering is counted as unscattered light → famousRrs = f(bb/(a+bb)) relationship

The SSA

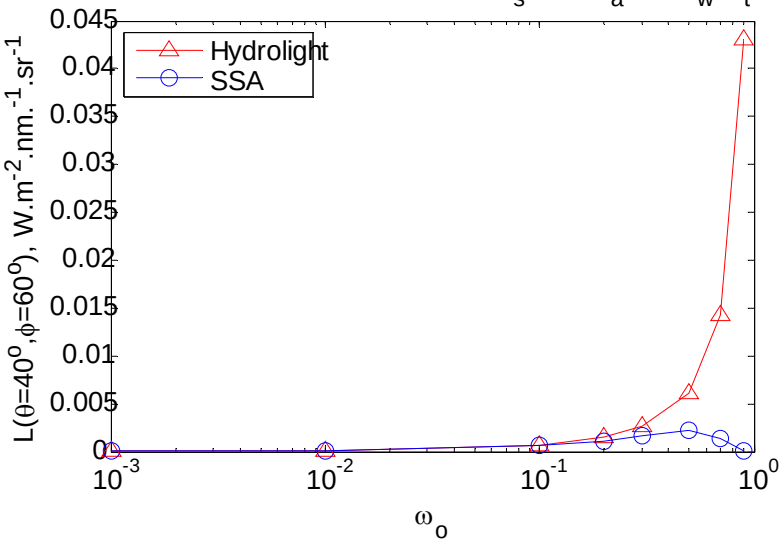
- Hydrolight runs for ω_o = 0.001, 0.01,0.1,0.3,0.5,0.7,0,9
  - Idealized black sky with sun zenith angle 42.1 (30 in the water), calm seas (no wind), a_t = 0.8 1/m homogeneous; infinite bottom.
- Coded the SSA solution (as given by Mobley lecture) for the same inputs and the same quad discretization as HL.
- Compare SSA performance against HL for the different ω_o.

The SSA – full radiance distribution @ 1m



The SSA – selected directions radiance

Black Sky;z = 1 m; Ed = 1 $W.m^{-2}.nm.^{-1}$; $\theta_s = 42.1^o_a$--> 30^o_w; a_t=0.8 m^{-1}



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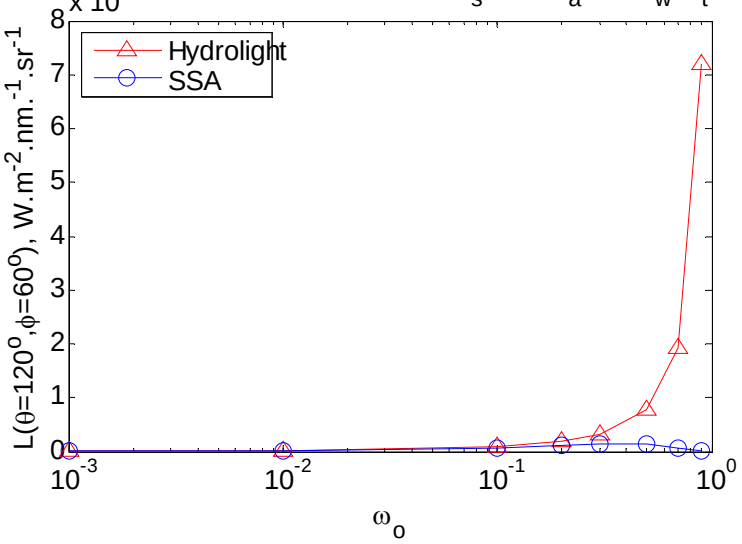

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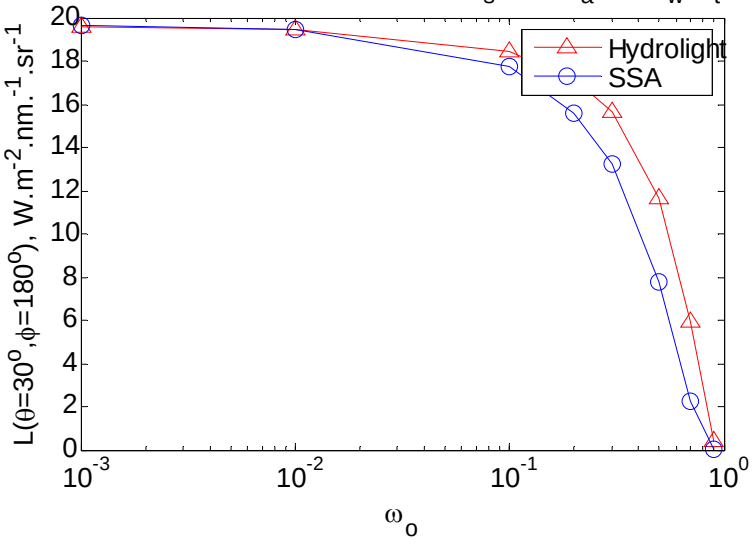

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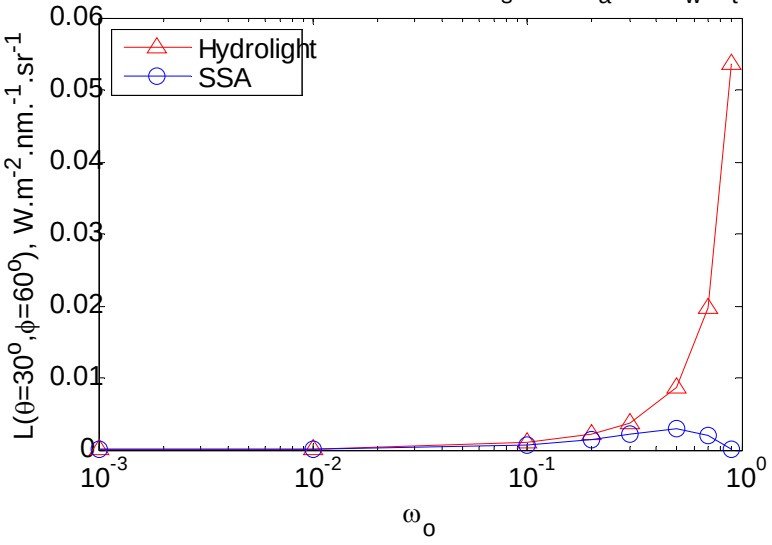
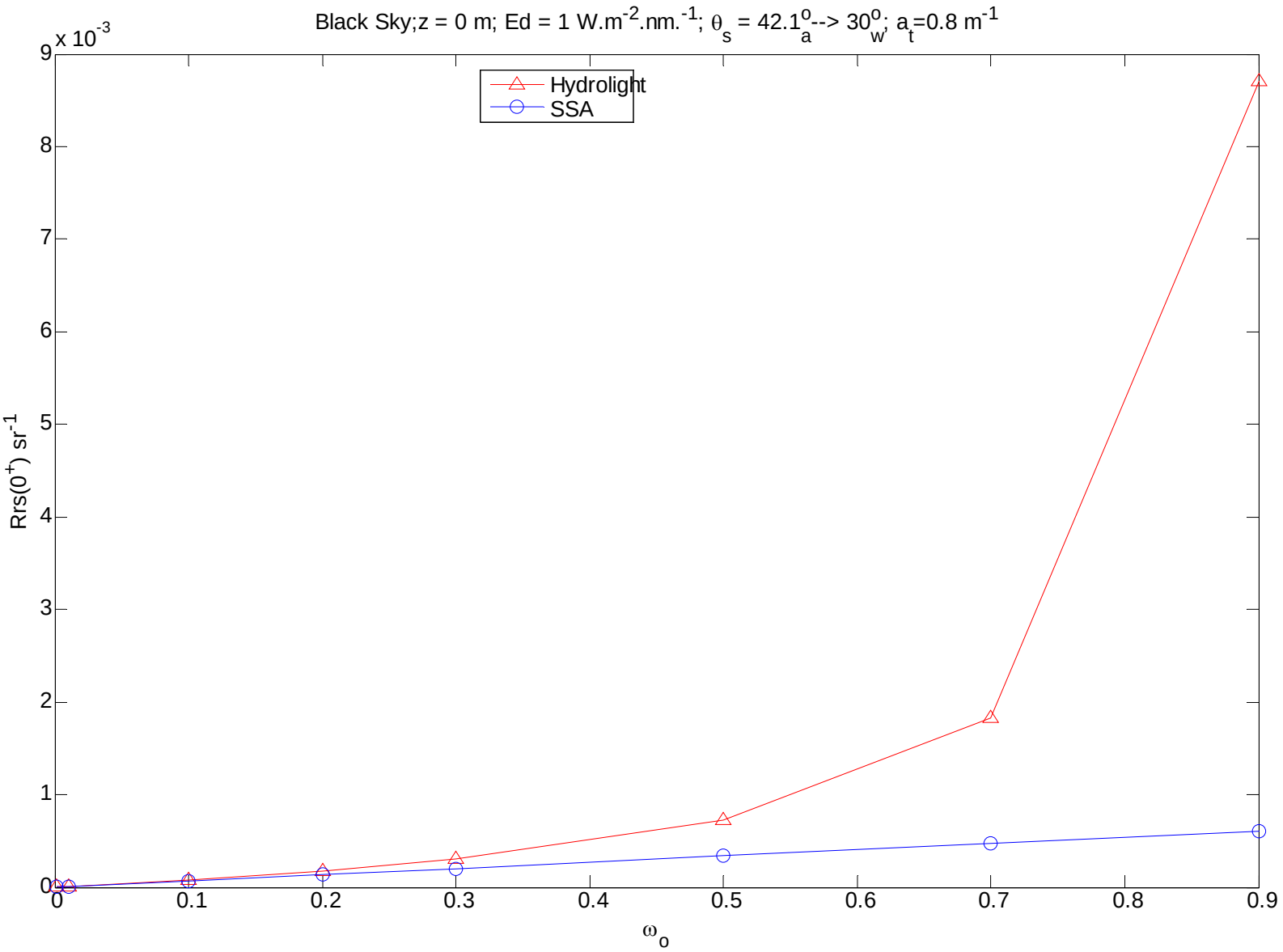


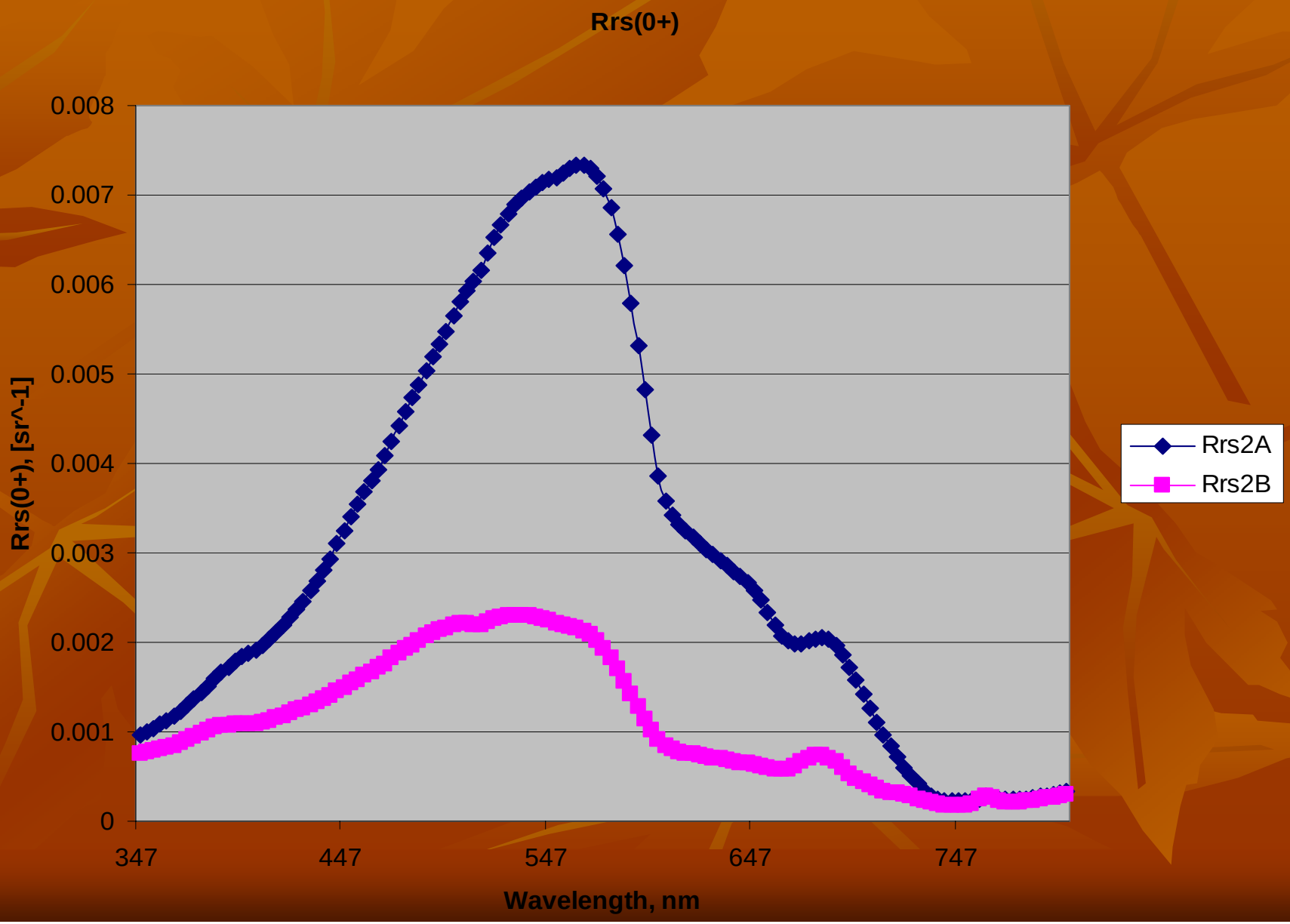
The SSA - RRS


Black Sky;z = 0 m; Ed = 1 W.m-2.nm.-1; θs = 42.1oa--> 30ow; at=0.8 m-1
x 10-3
Hydrolight
SSA
Rrs(0+) sr-1
ωo
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2
3
4
5
6
7
8
9

The Garver Siegel Maritorena model

- Semianalytical, λ = [412,443,490,510,555]
- Retrievals are 3: [chl], ag(443) + ad(443), bbp(443)
- Parameters are 7: specific Chl a, slope of CDOM (S), slope of backscattering (η).
- Tuned by simulated annealing for the global ocean (Maritorena et al. 2002)
- Sensitivity analysis for S and η follows. a_{phi}* left as tuned in Maritorena et al. 2002

The Inverted Reflectances



Initial Retrieval Comparisons – GSM vs. Roesler/Perry 1995

Station A, Off DMC Dock

23-Jul-04 Lat: 43:56.37 Lon:69:34.97 Time:13:55

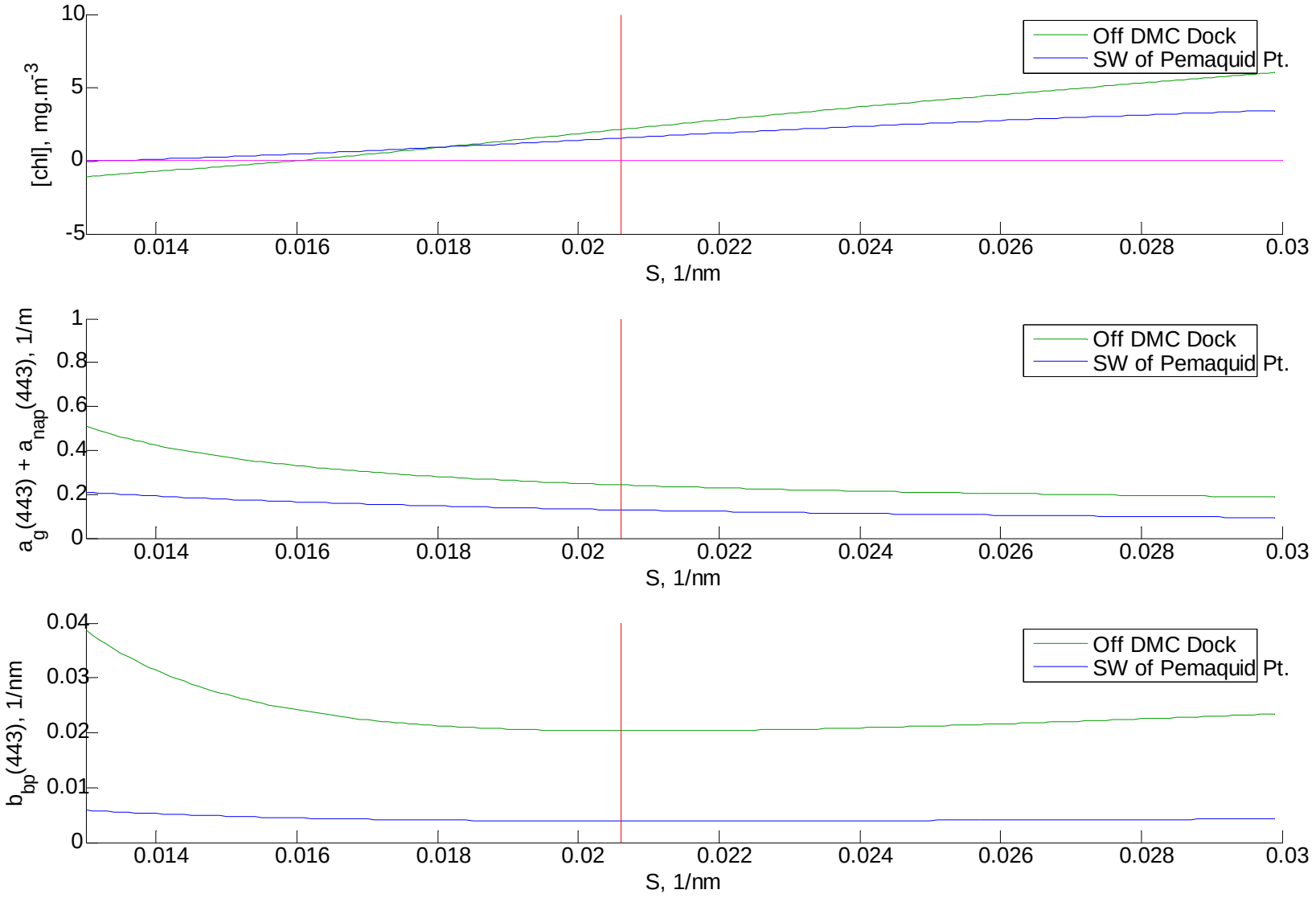
	a_phi	S	n/η	[chl], mg/m3	ag(443) + anap(443), 1/m	bbp(443), 1/m
GSM – Maritorena et al. 2002 params	GSM 02	0.0206	1.0337	2.1328	0.2424	0.0203
Hyper RP	CR avg.	0.0145	0 1	0.1827	0.3732	0.0161 0.0045
Hyper RP	CR avg.	0.01 0.02	0 1	1.3146	0.2535 N0.1169	0.0157 0.0069
RP @ GSM lambda	CR avg.	0.0145	0 1	1.02	0.306	0.045 -0.0167

Station B – off of Pemaquid Pt.

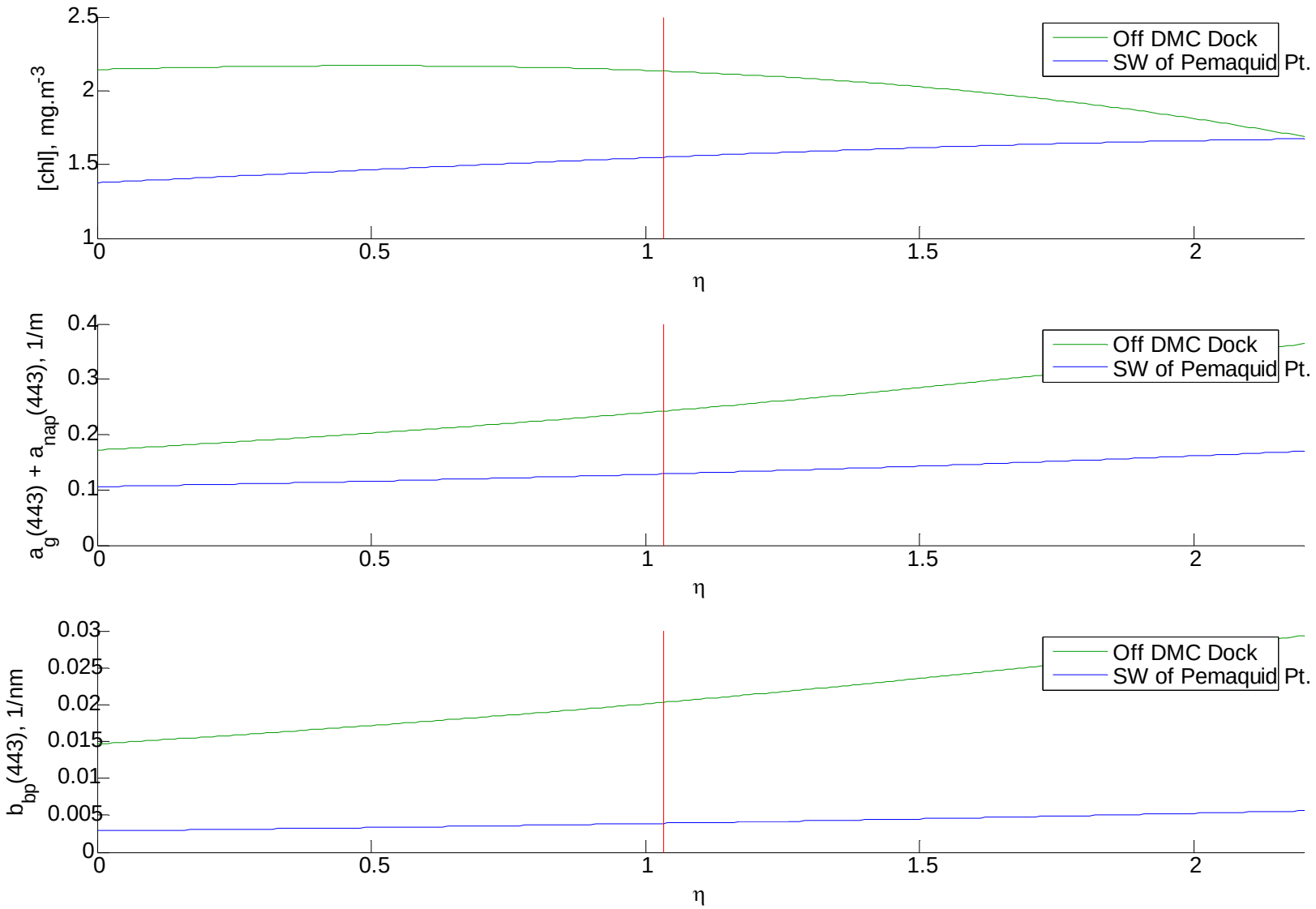
23-Jul-04 lat:43:48.06 lon:69:32.63 time:15:55

	a_phi	S	n/ η	[chl], mg/m3	ag(443) + anap(443), 1/m	bbp(443), 1/m
GSM – Maritorena et al. 2002 params	GSM 02	0.0206	1.0337	1.5502	0.1288	0.0039
Hyper RP	CR avg.	0.0145	0 1	0.8828	0.2158	0.0024 0.0024
Hyper RP	CR avg.	0.01 0.02	0 1	0.8571	0.0899 0.1352	0.0028 0.0024
RP @ GSM lambda	CR avg.	0.0145	0 1	1.00	0.187	0.0032 0.0019

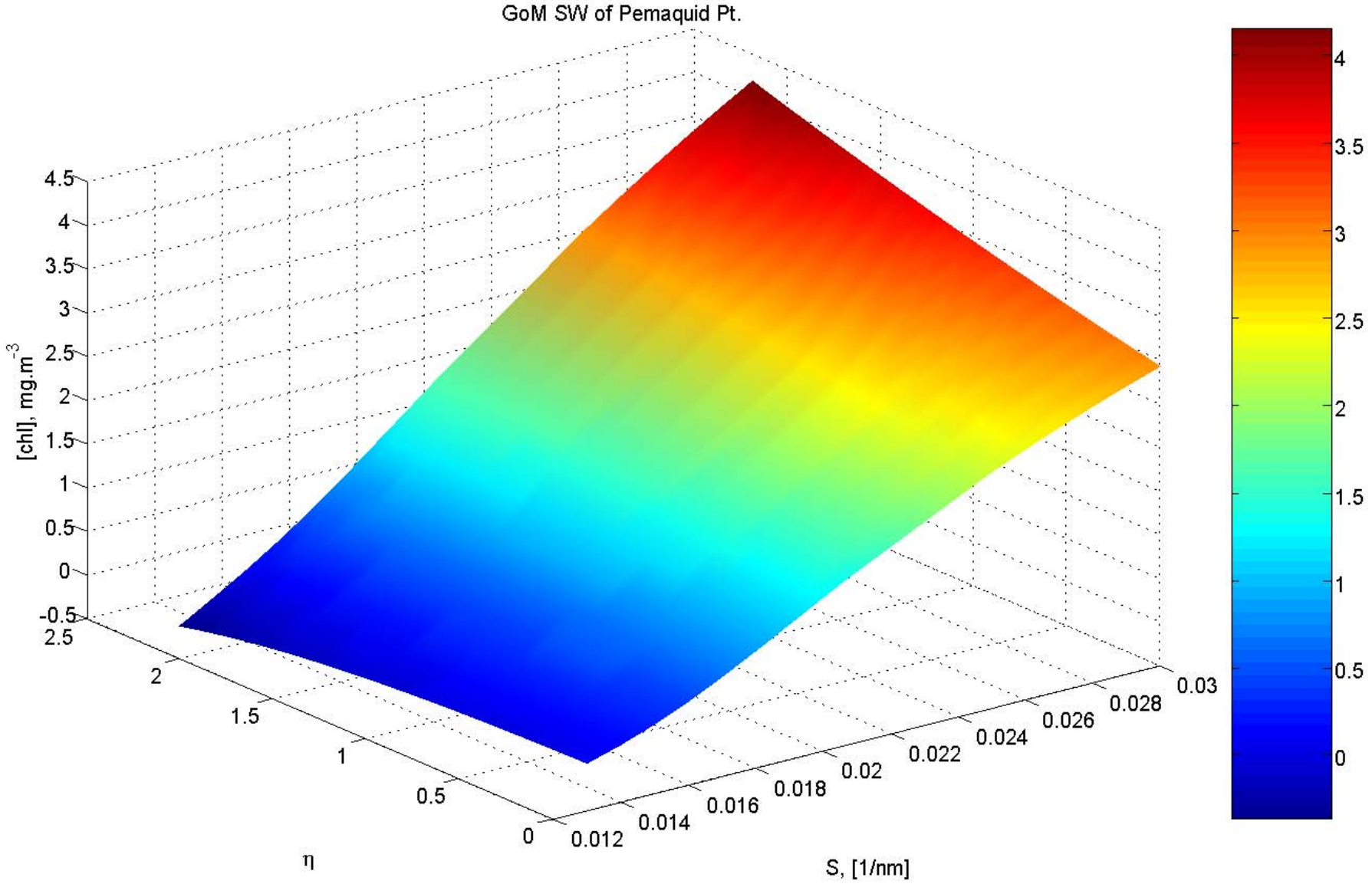
GSM Sensitivity Analysis – vary S; η = 1.0337



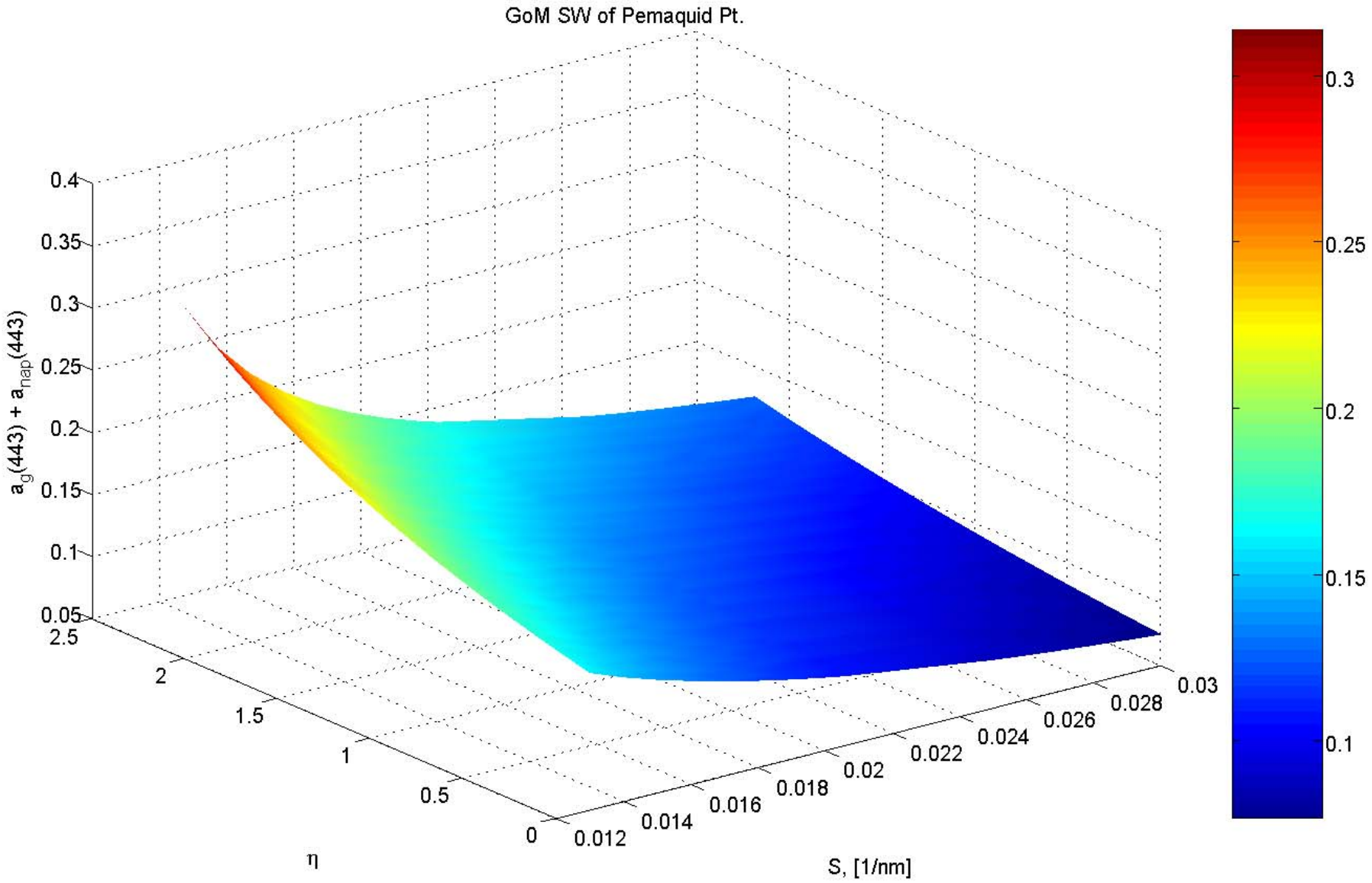
GSM Analysis –vary η; S = 0.0206



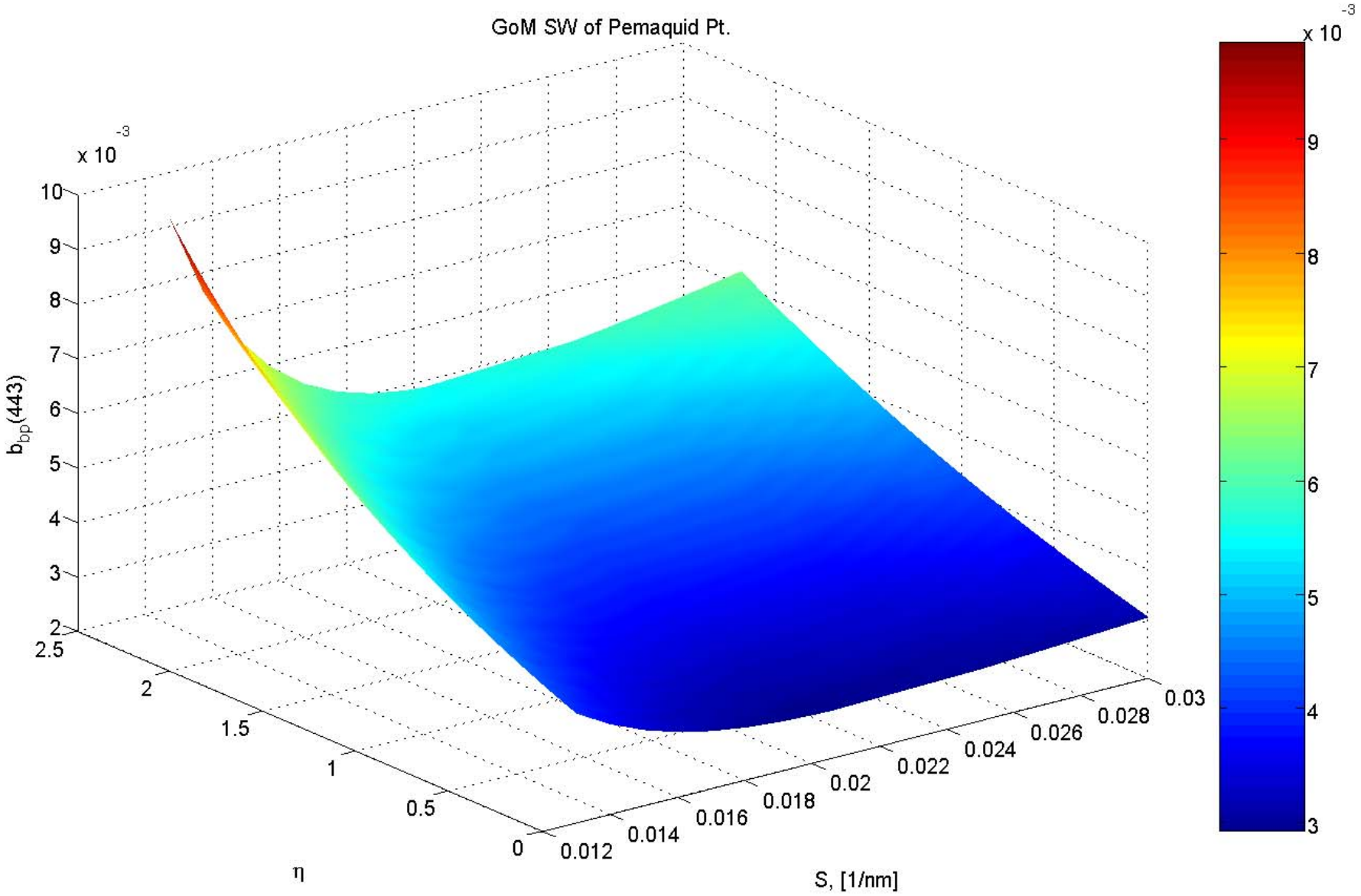
GSM sensitivity – 3D



GSM Sensitivity – 3D



GSM Sensitivity – 3D



The End