Semi-Analytic Inversion Modeling

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Three activities

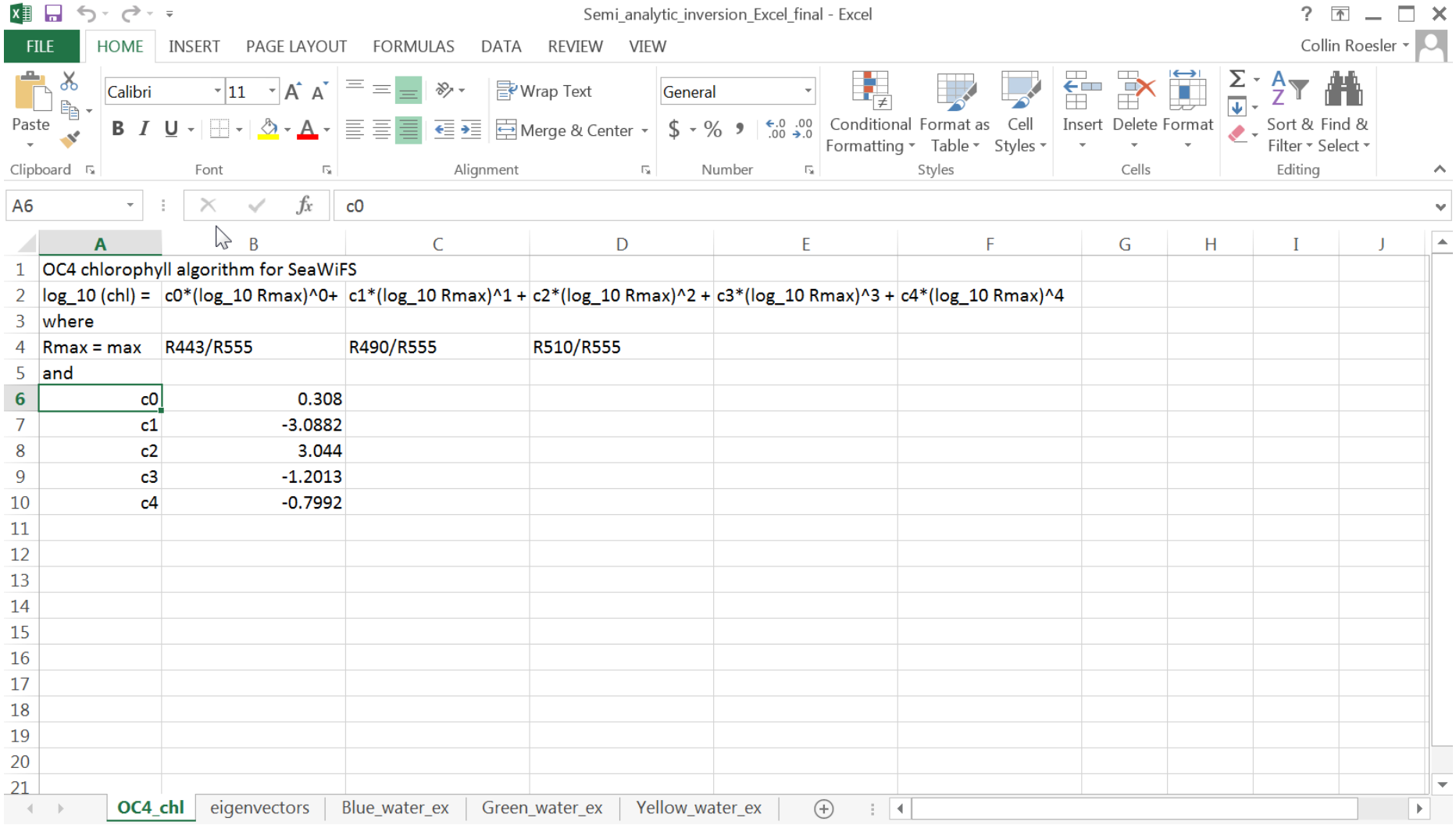
- Gaining intuition for semi-analytic inversion
- Quantitative semi-analytic inversion
- Generalize IOP inversion GUI

Excel version Semi_analytic_inversion_Roesler.xls

- OC4 Chl algorithm
- Roesler and Perry 1995 eigenvectors
- Three example reflectance spectra
  - Blue water
  - Green water
  - Yellow water

Excel version

- OC4 chl algorithm



Excel version

- Roesler and Perry 1995 eigenvectors

Semi_analytic_inversion_Excel_final - Excel

Collin Roesler

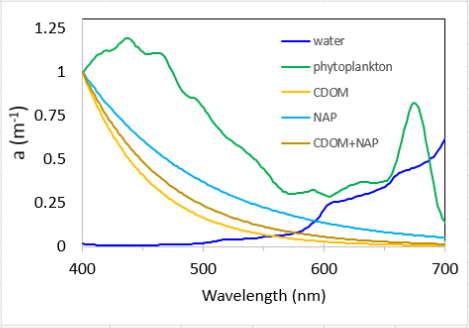
FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW

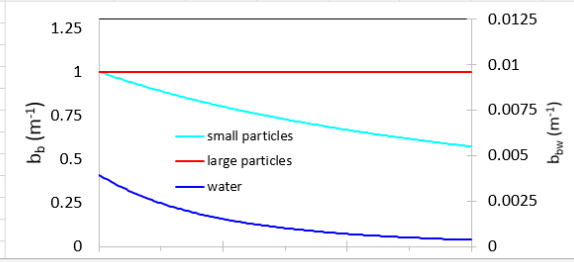
Normal Page Break Preview Page Layout Custom Views | Ruler Formula Bar Gridlines Headings | Zoom 100% Zoom to Selection | New Window Arrange All Freeze Panes Split Hide Unhide View Side by Side Synchronous Scrolling Reset Window Position | Switch Windows | Macros

Workbook Views Show Zoom Window Macros

D3 0.018

	A	B	C	D	E	F	H	I	J
1		absorption					backscattering		
2				S_CDOM	S_NAP	avg CDM		eta	eta
3	tuneable slopes			0.018	0.01	0.0145		-1	0
4									
5	wavelength	water	phytoplankton	CDOM	NAP	CDOM+NAP	water	small particles	large particles
6	400	0.0146	1	1	1	1	0.003947	1	1
7	402	0.0132	1.007087961	0.964640293	0.980198673	0.971416464	0.0038632	0.995024875	1
8	404	0.012	1.02778155	0.930530896	0.960789439	0.943649947	0.0037817	0.990099009	1
9	406	0.011	1.04339679	0.897627596	0.941764534	0.916677096	0.0037022	0.985221673	1
10	408	0.0101	1.06194498	0.865887748	0.923116346	0.890475223	0.0036248	0.980392154	1
11	410	0.0092	1.079406892	0.835270211	0.904837418	0.865022293	0.0035494	0.975609753	1
12	412	0.0085	1.091600358	0.805735302	0.886920437	0.840296898	0.0034759	0.970873783	1
13	414	0.0079	1.102626076	0.777244738	0.869358235	0.816278241	0.0034042	0.966183571	1
14	416	0.0073	1.103467941	0.749761592	0.852143789	0.792946123	0.0033344	0.961538457	1
15	418	0.0069	1.113977677	0.723250242	0.835270211	0.77028092	0.0032664	0.956937794	1
16	420	0.0065	1.123346821	0.697676326	0.818730753	0.748263568	0.0032	0.952380947	1
17	422	0.0063	1.116584743	0.673006696	0.802518798	0.726875549	0.0031353	0.947867292	1
18	424	0.0059	1.121798876	0.649209377	0.786627861	0.706098876	0.0030722	0.94339622	1
19	426	0.0056	1.130163213	0.626253524	0.771051586	0.685916074	0.0030107	0.938967129	1
20	428	0.0053	1.140537164	0.604109383	0.755783741	0.666310167	0.0029506	0.934579432	1
21	430	0.0052	1.155826521	0.582748252	0.740818221	0.647264667	0.0028921	0.93023255	1
22	432	0.005	1.168780382	0.562142445	0.726149037	0.628763554	0.0028349	0.925925917	1
23	434	0.0049	1.181381202	0.542265253	0.711770323	0.610791269	0.0027792	0.921658977	1
24	436	0.005	1.188713576	0.523090913	0.697676326	0.593332695	0.0027248	0.917431183	1
25	438	0.0052	1.191212014	0.504594572	0.683861409	0.576373149	0.0026717	0.913241999	1
26	440	0.0054	1.186025039	0.486752256	0.670320046	0.559898367	0.0026198	0.909090899	1
27	443	0.0058	1.16329468	0.461164715	0.650509095	0.536064923	0.0025693	0.902934526	1
28	444	0.0061	1.143660212	0.452937605	0.644036099	0.528347681	0.0025199	0.900900788	1
29	446	0.0065	1.137875784	0.436922258	0.631283646	0.513246009	0.0024716	0.896860975	1
30	448	0.0071	1.122885153	0.421472815	0.618783392	0.498575623	0.0024245	0.892857131	1
31	450	0.0078	1.111777965	0.40656966	0.60653066	0.484324569	0.0023785	0.888888877	1

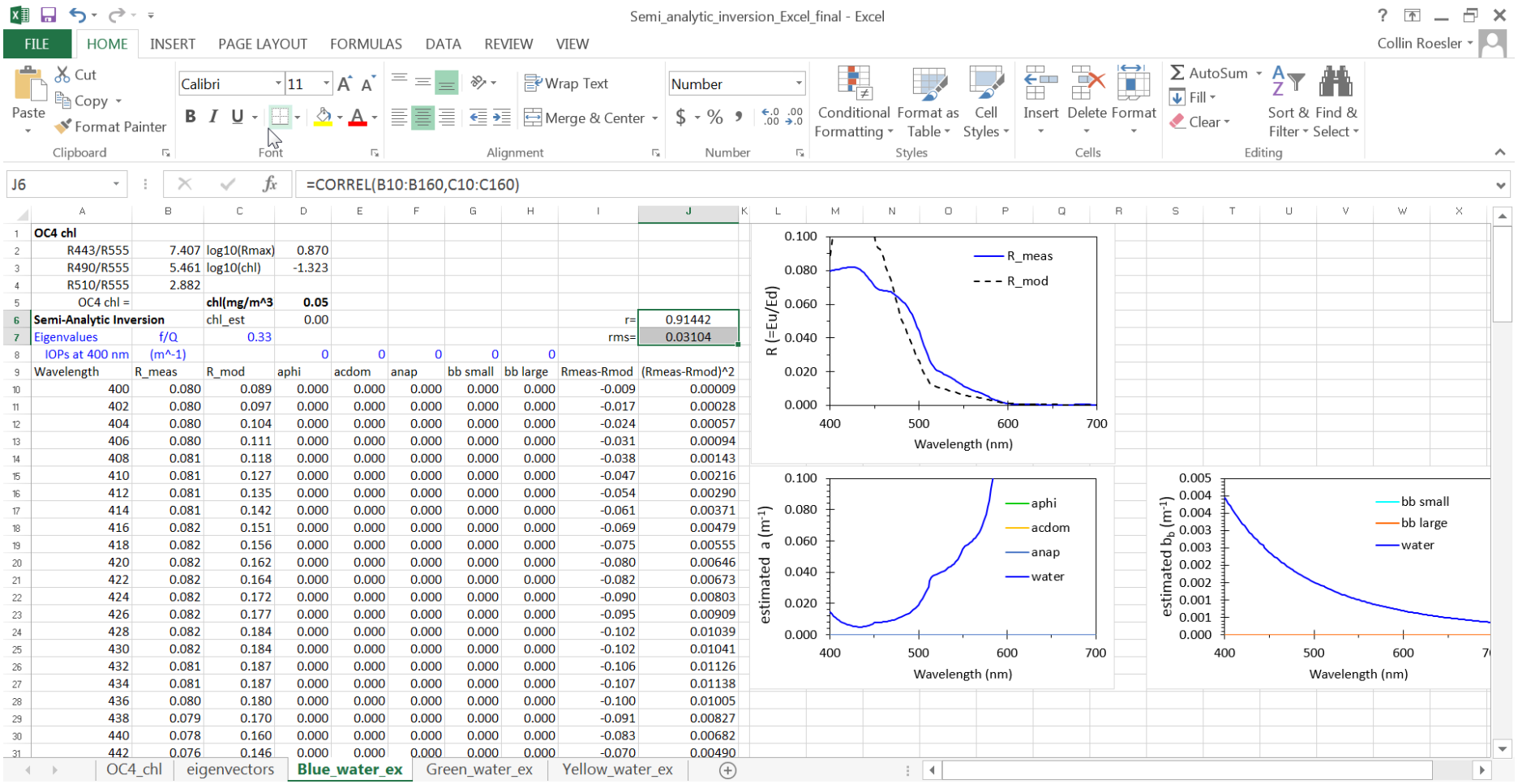




OC4_chl | eigenvectors | Blue_water_ex | Green_water_ex | Yellow_water_ex

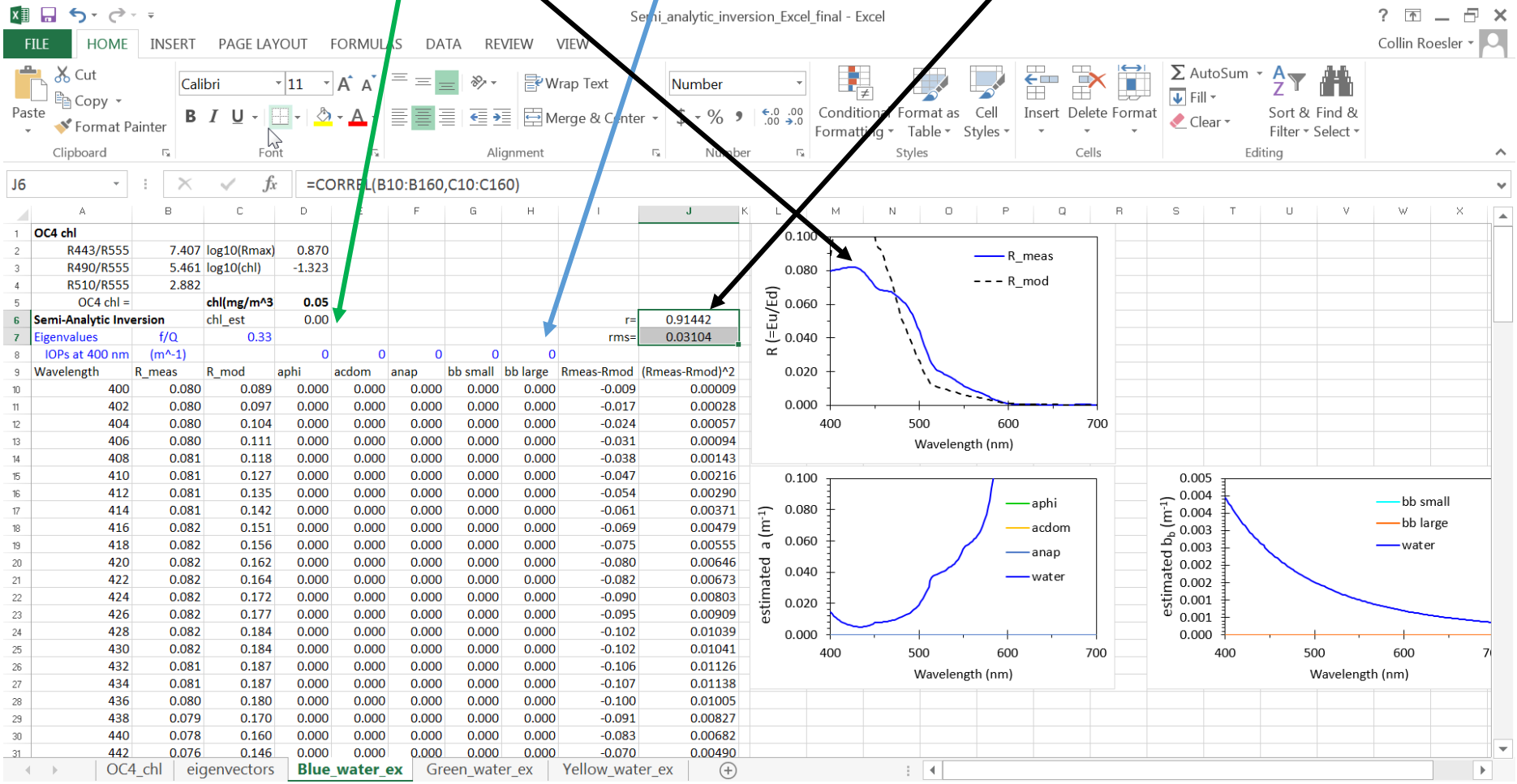
Excel version

- Measured Reflectance spectra



Excel version

- Try changing the eigenvalues (in blue) to improve the fit of the modeled R to the measured R.
- Note how the chl_est, correlation (r) and the rms error values update
- Compare your values with your colleagues



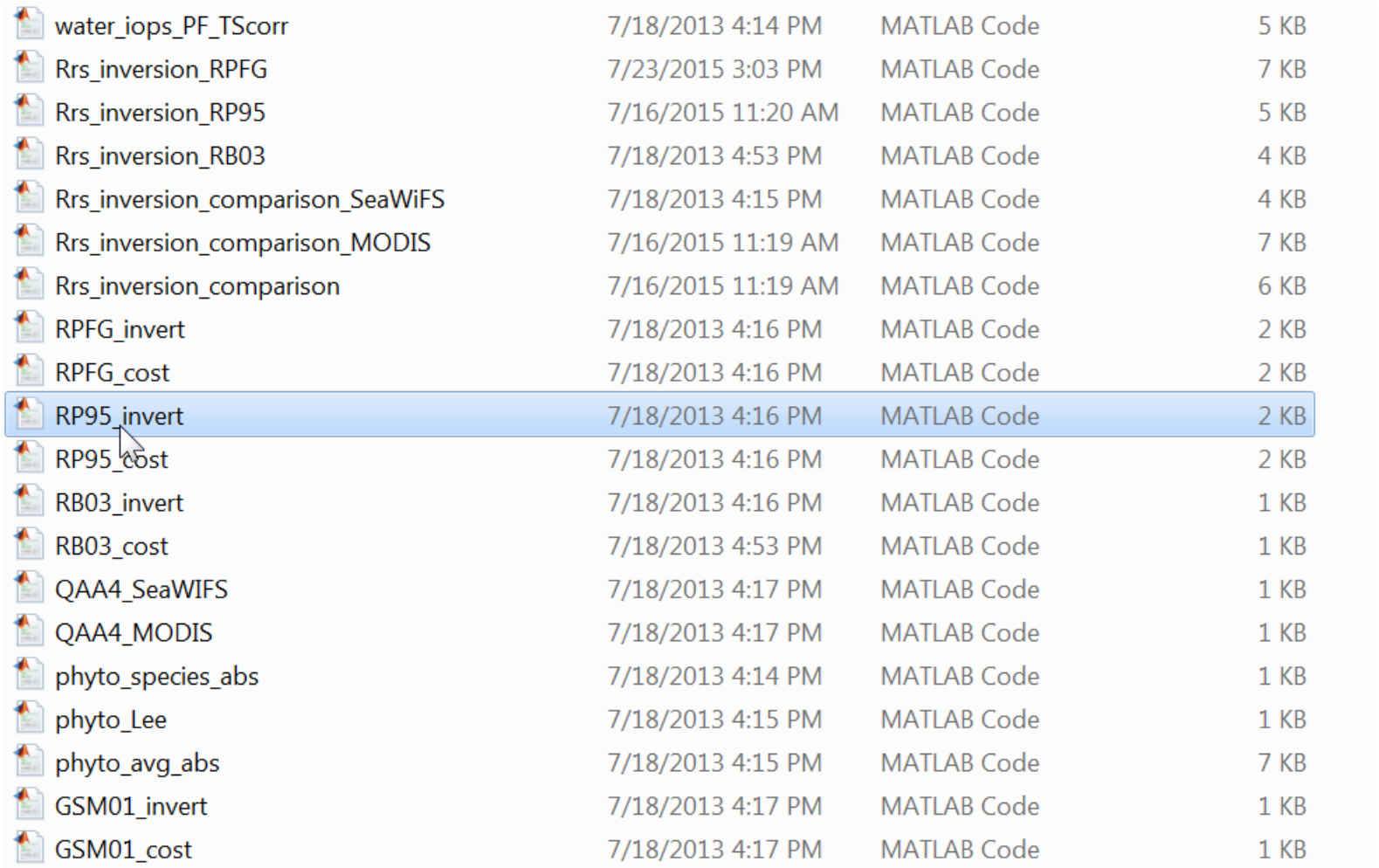
	A	B	C	D	E	F	G	H	I	J
1	**OC4 chl**									
2	R443/R555	7.407	log10(Rmax)	0.870						
3	R490/R555	5.461	log10(chl)	-1.323						
4	R510/R555	2.882								
5	OC4 chl =		**chl(mg/m^3**	**0.05**						
6	**Semi-Analytic Inversion**		chl_est	0.00					r=	0.91442
7	Eigenvalues	f/Q	0.33						rms=	0.03104
8	IOPs at 400 nm	(m^-1)		0	0	0	0	0		
9	Wavelength	R_meas	R_mod	aphi	acdom	anap	bb small	bb large	Rmeas-Rmod	(Rmeas-Rmod)^2
10	400	0.080	0.089	0.000	0.000	0.000	0.000	0.000	-0.009	0.00009
11	402	0.080	0.097	0.000	0.000	0.000	0.000	0.000	-0.017	0.00028
12	404	0.080	0.104	0.000	0.000	0.000	0.000	0.000	-0.024	0.00057
13	406	0.080	0.111	0.000	0.000	0.000	0.000	0.000	-0.031	0.00094
14	408	0.081	0.118	0.000	0.000	0.000	0.000	0.000	-0.038	0.00143
15	410	0.081	0.127	0.000	0.000	0.000	0.000	0.000	-0.047	0.00216
16	412	0.081	0.135	0.000	0.000	0.000	0.000	0.000	-0.054	0.00290
17	414	0.081	0.142	0.000	0.000	0.000	0.000	0.000	-0.061	0.00371
18	416	0.082	0.151	0.000	0.000	0.000	0.000	0.000	-0.069	0.00479
19	418	0.082	0.156	0.000	0.000	0.000	0.000	0.000	-0.075	0.00555
20	420	0.082	0.162	0.000	0.000	0.000	0.000	0.000	-0.080	0.00646
21	422	0.082	0.164	0.000	0.000	0.000	0.000	0.000	-0.082	0.00673
22	424	0.082	0.172	0.000	0.000	0.000	0.000	0.000	-0.090	0.00803
23	426	0.082	0.177	0.000	0.000	0.000	0.000	0.000	-0.095	0.00909
24	428	0.082	0.184	0.000	0.000	0.000	0.000	0.000	-0.102	0.01039
25	430	0.082	0.184	0.000	0.000	0.000	0.000	0.000	-0.102	0.01041
26	432	0.081	0.187	0.000	0.000	0.000	0.000	0.000	-0.106	0.01126
27	434	0.081	0.187	0.000	0.000	0.000	0.000	0.000	-0.107	0.01138
28	436	0.080	0.180	0.000	0.000	0.000	0.000	0.000	-0.100	0.01005
29	438	0.079	0.170	0.000	0.000	0.000	0.000	0.000	-0.091	0.00827
30	440	0.078	0.160	0.000	0.000	0.000	0.000	0.000	-0.083	0.00682
31	442	0.076	0.146	0.000	0.000	0.000	0.000	0.000	-0.070	0.00490

Matlab codes

- Three m-files associated with inversion
  - Driver program (e.g., Rrs_inversion_RP95.m)
  - Invert function (e.g., RP95_invert.m)
  - Cost function (e.g., RP95_cost.m)
- Data files
  - Eigenvectors (e.g., function phyto_avg_abs.m)
  - Reflectance spectra (e.g., Rrs_E_WestCoast.dat)
- Output files

Matlab codes

m files



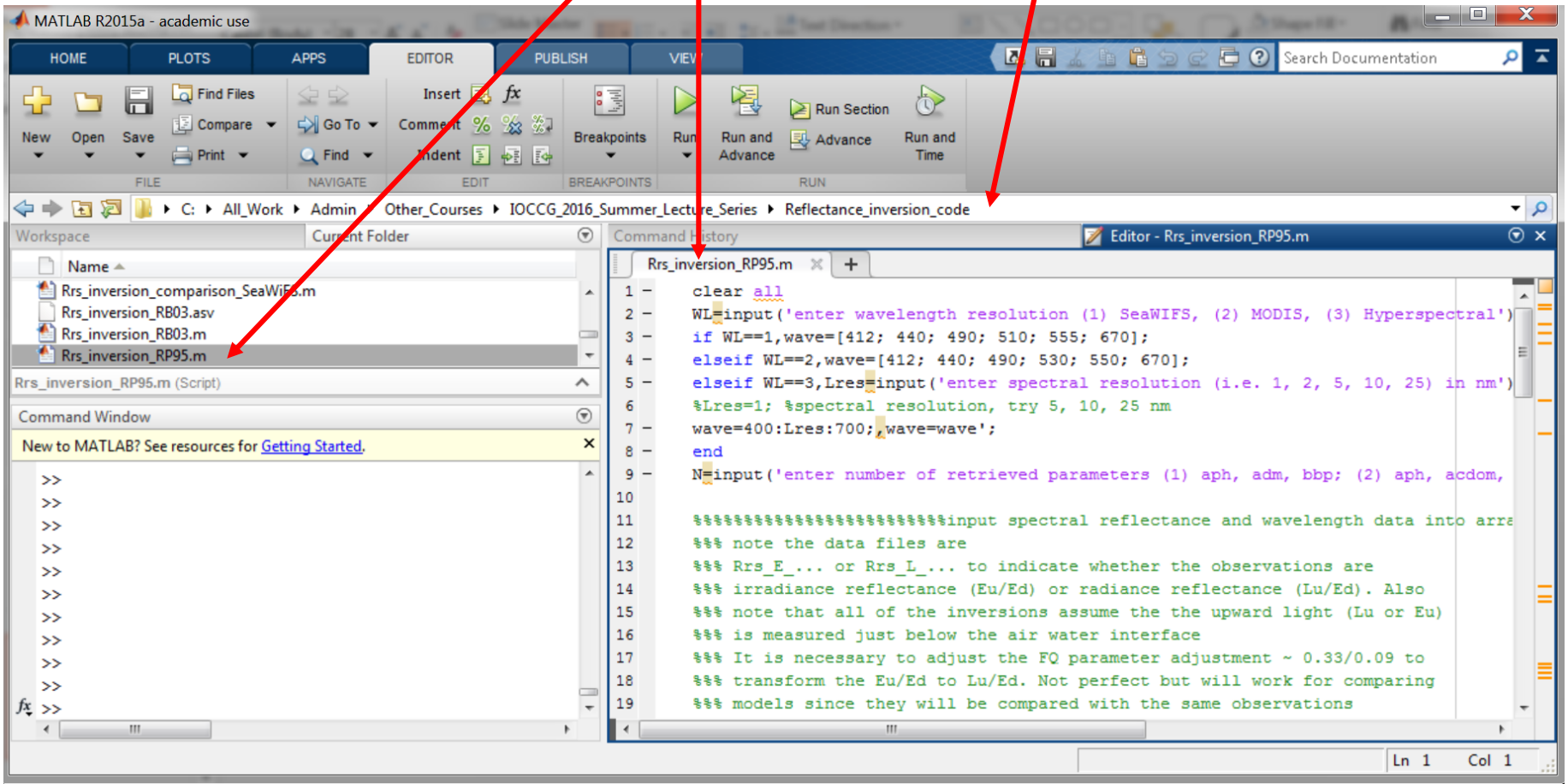
water_iops_PF_TScorr	7/18/2013 4:14 PM	MATLAB Code	5 KB
Rrs_inversion_RPFG	7/23/2015 3:03 PM	MATLAB Code	7 KB
Rrs_inversion_RP95	7/16/2015 11:20 AM	MATLAB Code	5 KB
Rrs_inversion_RB03	7/18/2013 4:53 PM	MATLAB Code	4 KB
Rrs_inversion_comparison_SeaWiFS	7/18/2013 4:15 PM	MATLAB Code	4 KB
Rrs_inversion_comparison_MODIS	7/16/2015 11:19 AM	MATLAB Code	7 KB
Rrs_inversion_comparison	7/16/2015 11:19 AM	MATLAB Code	6 KB
RPFG_invert	7/18/2013 4:16 PM	MATLAB Code	2 KB
RPFG_cost	7/18/2013 4:16 PM	MATLAB Code	2 KB
RP95_invert	7/18/2013 4:16 PM	MATLAB Code	2 KB
RP95_cost	7/18/2013 4:16 PM	MATLAB Code	2 KB
RB03_invert	7/18/2013 4:16 PM	MATLAB Code	1 KB
RB03_cost	7/18/2013 4:53 PM	MATLAB Code	1 KB
QAA4_SeaWIFS	7/18/2013 4:17 PM	MATLAB Code	1 KB
QAA4_MODIS	7/18/2013 4:17 PM	MATLAB Code	1 KB
phyto_species_abs	7/18/2013 4:14 PM	MATLAB Code	1 KB
phyto_Lee	7/18/2013 4:15 PM	MATLAB Code	1 KB
phyto_avg_abs	7/18/2013 4:15 PM	MATLAB Code	7 KB
GSM01_invert	7/18/2013 4:17 PM	MATLAB Code	1 KB
GSM01_cost	7/18/2013 4:17 PM	MATLAB Code	1 KB

Matlab codes
data files

Rrs_L_HL_simulation.dat	7/18/2013 4:16 PM	DAT File	7 KB
Rrs_E_WestCoast.dat	7/18/2013 4:16 PM	DAT File	18 KB
Rrs_E_PugetSound.dat	7/18/2013 4:16 PM	DAT File	24 KB
Rrs_E_GulfMaine.dat	7/18/2013 4:16 PM	DAT File	18 KB
Rrs_E_DabobBay.dat	7/18/2013 4:16 PM	DAT File	18 KB
phyto_species_abs.dat	7/18/2013 4:14 PM	DAT File	20 KB

How to start

- Navigate windows explorer to folder Reflectance_inversion_code
- Start Matlab and navigate **Matlab** to this folder
- Open Rrs_inversion_RP95.m
- Run program (piecemeal or all at once)



Things to try

1. First Select Reflectance data set (lines 21 – 26)

   Uncomment out the desired data set (no %)

   Comment out the undesired data sets (%)

Rrs_inversion_RP95.m

```
13      %%% Rrs_E_... or Rrs_L_... to indicate whether the observations are
14      %%% irradiance reflectance (Eu/Ed) or radiance reflectance (Lu/Ed). Also
15      %%% note that all of the inversions assume the the upward light (Lu or Eu)
16      %%% is measured just below the air water interface
17      %%% It is necessary to adjust the FQ parameter adjustment ~ 0.33/0.09 to
18      %%% transform the Eu/Ed to Lu/Ed. Not perfect but will work for comparing
19      %%% models since they will be compared with the same observations
20      %%%%
21 -    dat=load('Rrs_E_WestCoast.dat');,FQ=0.09/0.33;%from Roesler and Perry 1995 paper
22      %dat=load('Rrs_E_DabobBay.dat');,FQ=0.09/0.33;%from Roesler and Perry 1995 paper
23      %dat=load('Rrs_E_GulfMaine.dat');,FQ=0.09/0.33;%from Roesler and Perry 1995 paper
24      %dat=load('Rrs_E_PugetSound.dat');,FQ=0.09/0.33;%from Roesler and Perry 1995 pape
25
26      %dat=load('Rrs_L_HL_simulation.dat');, FQ=1;% from Curt's simulated data set, see
```

Things to try

1. How well does a low spectral resolution, 3 component model fit to measured R spectra?

- Select Reflectance data set (lines 21 – 26) before you run
- Select SeaWiFS Wavelengths
- Select 3 component model
- Look at output spectra
  - How well did 3 component model reconstruct measured R?
  - What was the range of the retrieved IOP spectra?
- The program prints the following to the command screen
  - Eigenvalues for each eigenvector you included in the run
  - Chlorophyll (mg/m3)
  - You can save these into a Matlab array or into an excel spread sheet so you can compare between runs

Things to try:

2. How do retrieved eigenvalues depend upon spectral resolution?

- Run the same data set and same 3 component model but increase spectral resolution.
  - How does the increased spectral resolution change the fit of the modeled R to the measured R?
  - What is the variability in the retrieved eigenvalues?
  - What can you conclude about inversion and spectral resolution?

Things to try:

3. A. How does the number of retrieved eigenvalues impact the modeled reflectance? B. and does it change in the spectral resolution is increase?

- A. Run the same data set at SeaWIFS wavelengths selecting an increasing number of modeled components (eigenvectors).
  - How does the number of eigenvectors change the fit of the modeled R to the measured R?
  - Are the retrieved values realistic?
  - What is the variability in the retrieved eigenvalues?
  - What can you conclude about inversion and the number of components?
- B. Repeat at higher spectral resolution
  - What are you conclusions regarding the number of components retrieved (eigenvalues)?

Things to try:

4. Do these results vary depending upon the data set used? Either run them yourself or coordinate with a colleague to do similar runs with different data sets.

- Look at the range of reflectance spectra provided and the range of retrieved eigenvalues. Note this is not a tuned model (because it doesn't need to be). What can you conclude about simple reflectance inversions?

- There is one critical step missing from the analysis, do you know what it is? What do you need to remedy it?

Things to try:

5. Now you can move onto other models:

A. Rrs_inversion_comparison.m

- Choose your data set
- Uses Modis wavelength
- Runs GSM, QAA and RP95
- Questions to think about
  - How well do the three models retrieve R?
  - In weather forecasting many models are run to find common patterns and identify variability. What can you conclude from the three runs?

Things to try:

5. Now you can move onto other models:

B. Rrs_inversion_RPFG.m

- Choose your data set
- Select wavelength resolution
- Select number of components including the 4 phyto eigenvectors
- Questions to think about
  - How well does the PFT model(s) retrieve R? Does the modeled R fit better with 1 or 4 phyto eigenvectors?
  - As you increase the number of other components retrieved, does it change the phyt eigenvalues? Do you see patterns?

Things to try:

5. Now you can move onto other models:

C. Rrs_inversion_RB03.m

- Choose your data set
- Select wavelength resolution
- Questions to think about
  - How well does the RB03 model(s) retrieve R? Does the modeled R fit better or worse than the RP95?
  - Are the retrieved values of beam c, γ, $b_b(\lambda)$, b_b/b reasonable?

Generalize IOP code

- Jeremy Werdell
- GUI-interfaced Matlab code
- Self explanatory to run
- Many options
- Easy to modify

Werdell, P.J., Franz, B.A., Bailey, S.W., Feldman, G.C., Boss, E., Brando, V.E., Dowell, M., Hirata, T., Lavender, S.J., Lee, Z. and Loisel, H., 2013. Generalized ocean color inversion model for retrieving marine inherent optical properties. *Applied Optics*, *52*(10), pp.2019-2037.

How to start

- Navigate to folder GIOP_July2014
- navigate Matlab to GIOP_July2014 folder
- Open run_giop.m
- Read through program, particularly comments
- Make selections, enter data
- Run