Evaluation of the first year of operational Sentinel-2A data for retrieval of suspended solids in medium- to high-turbidity waters

Supplementary Material

Isabel Caballero, François Steinmetz and Gabriel Navarro

We present here the signal separation between atmosphere and water of all the Sentinel-2A images corrected with POLYMER Atmospheric Correction model (Figure S1-S6). The images show the maps of water reflectance (ρw) and atmospheric reflectance (ρatm) of the red (665 nm) and NIR (865 nm) bands used for the calibration of the multi-conditional model for Total Suspended Solids retrieval. The atmospheric reflectance corresponds to the atmospheric component and sun glint, not including the water component and the Rayleigh scattering. These figures are not properly land masked and some inland pixels are clearly not water. Note the different color scales for each day.

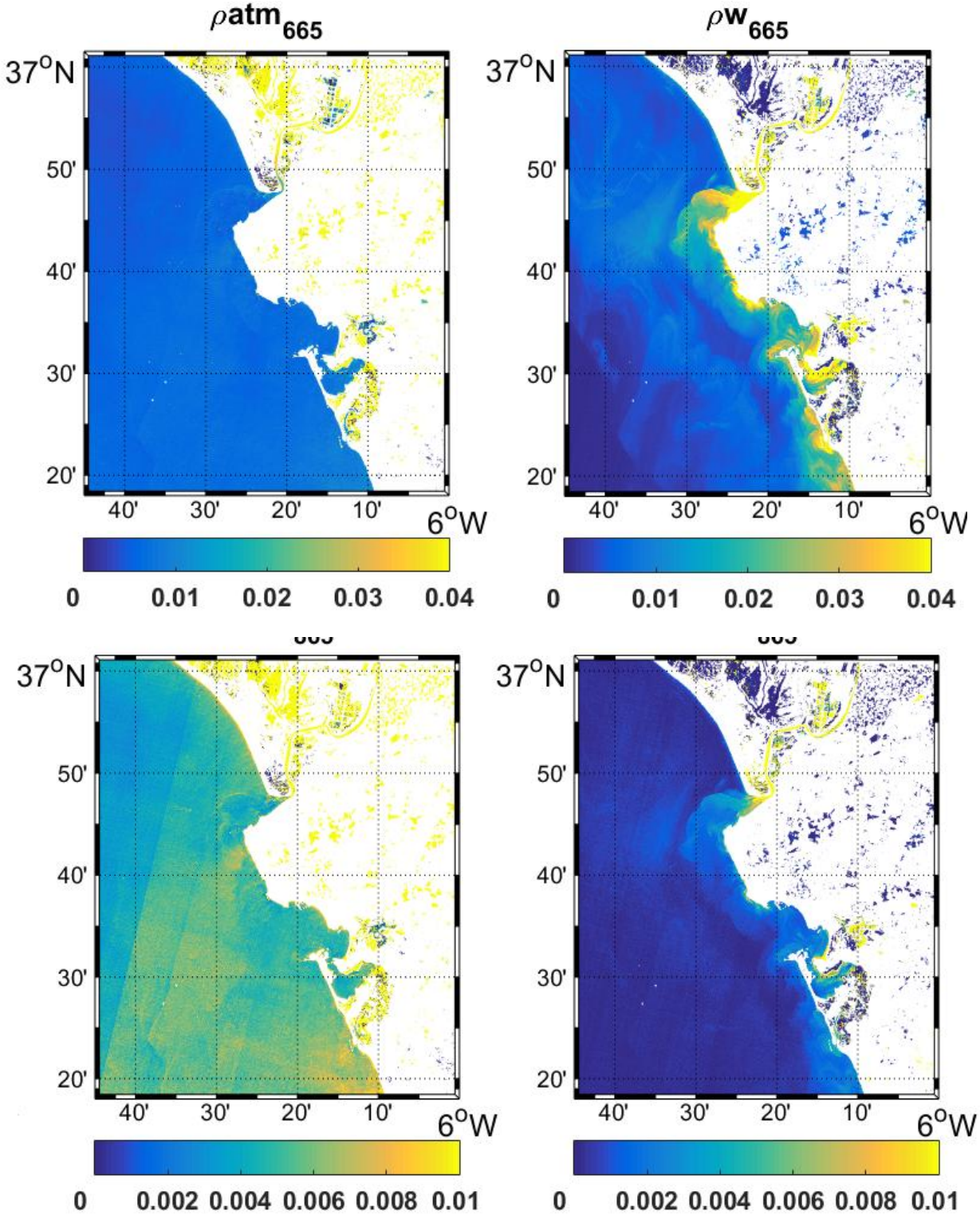

Figure S1. Maps of signal separation of atmosphere (ρatm) and water (ρw) for red (665 nm) and NIR (865 nm) bands, respectively. Sentinel-2A image of 8 March 2016 with POLYMER AC model (60 m).

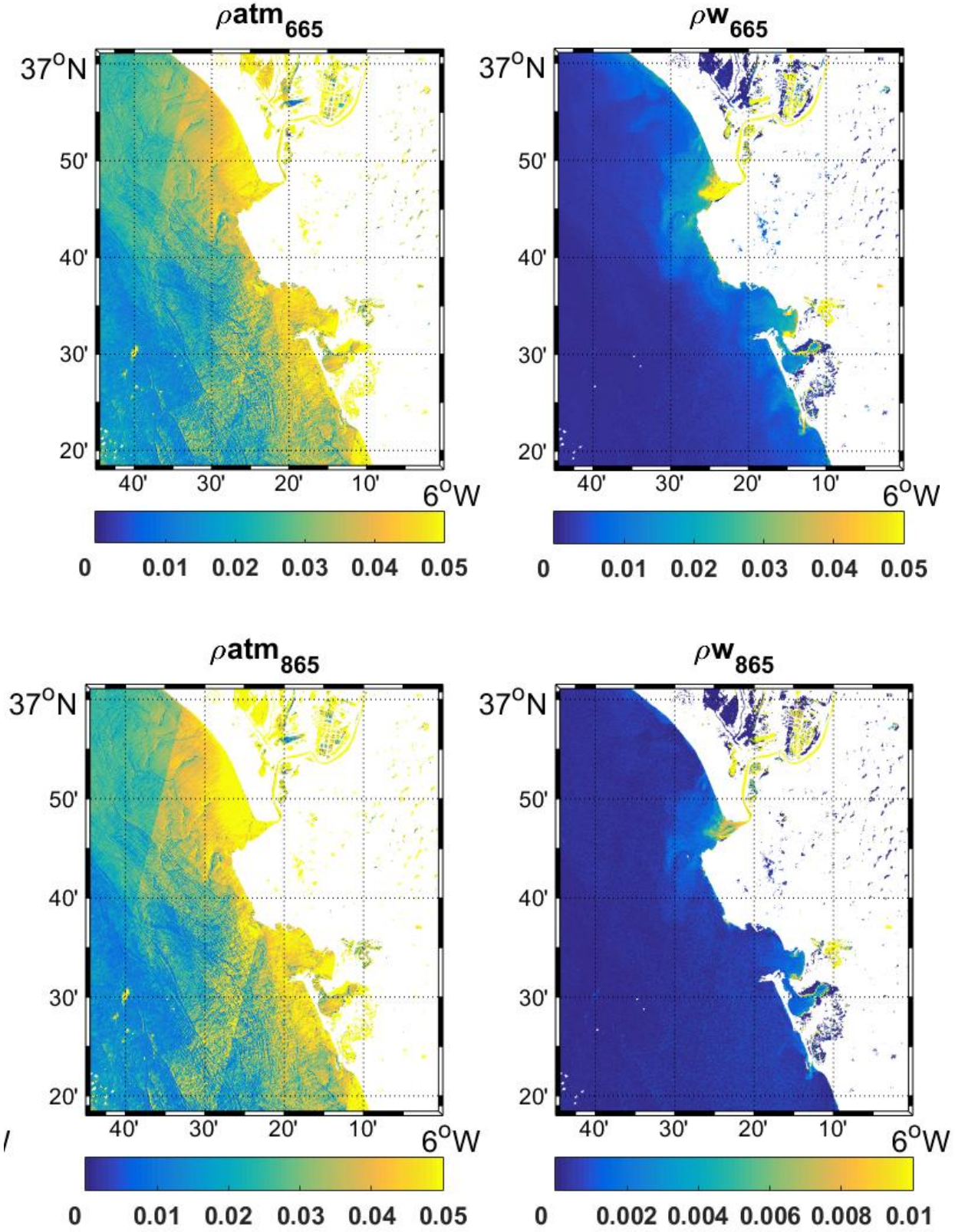

Figure S2. Maps of signal separation of atmosphere (ρatm) and water (ρw) for red (665 nm) and NIR (865 nm) bands, respectively. Sentinel-2A image of 27 May 2016 with POLYMER AC model (60 m). In situ sampling was carried out during this day.

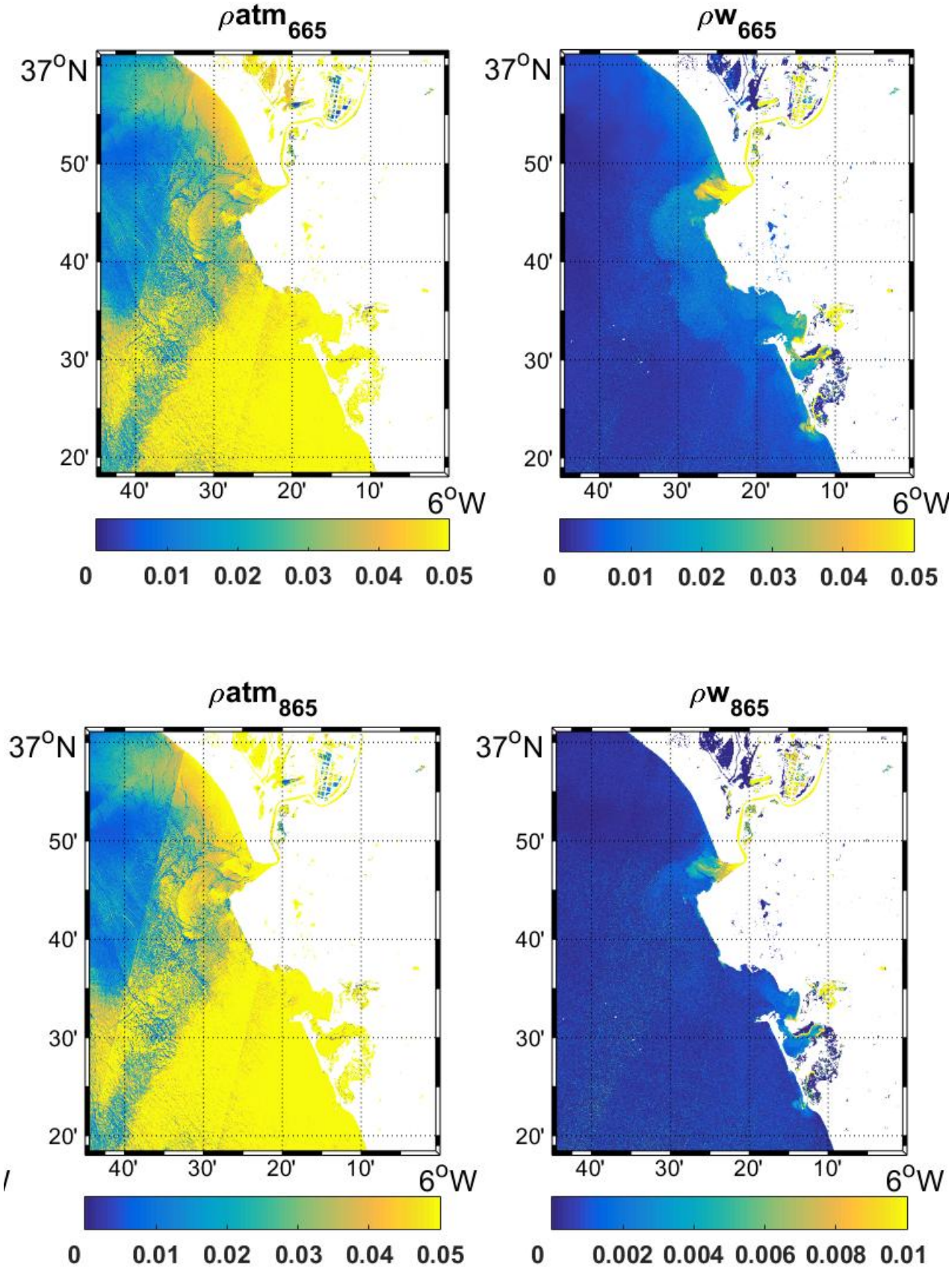

Figure S3. Maps of signal separation of atmosphere (ρatm) and water (ρw) for red (665 nm) and NIR (865 nm) bands, respectively. Sentinel-2A image of 6 June 2016 with POLYMER AC model (60 m). In situ sampling was carried out during this day.

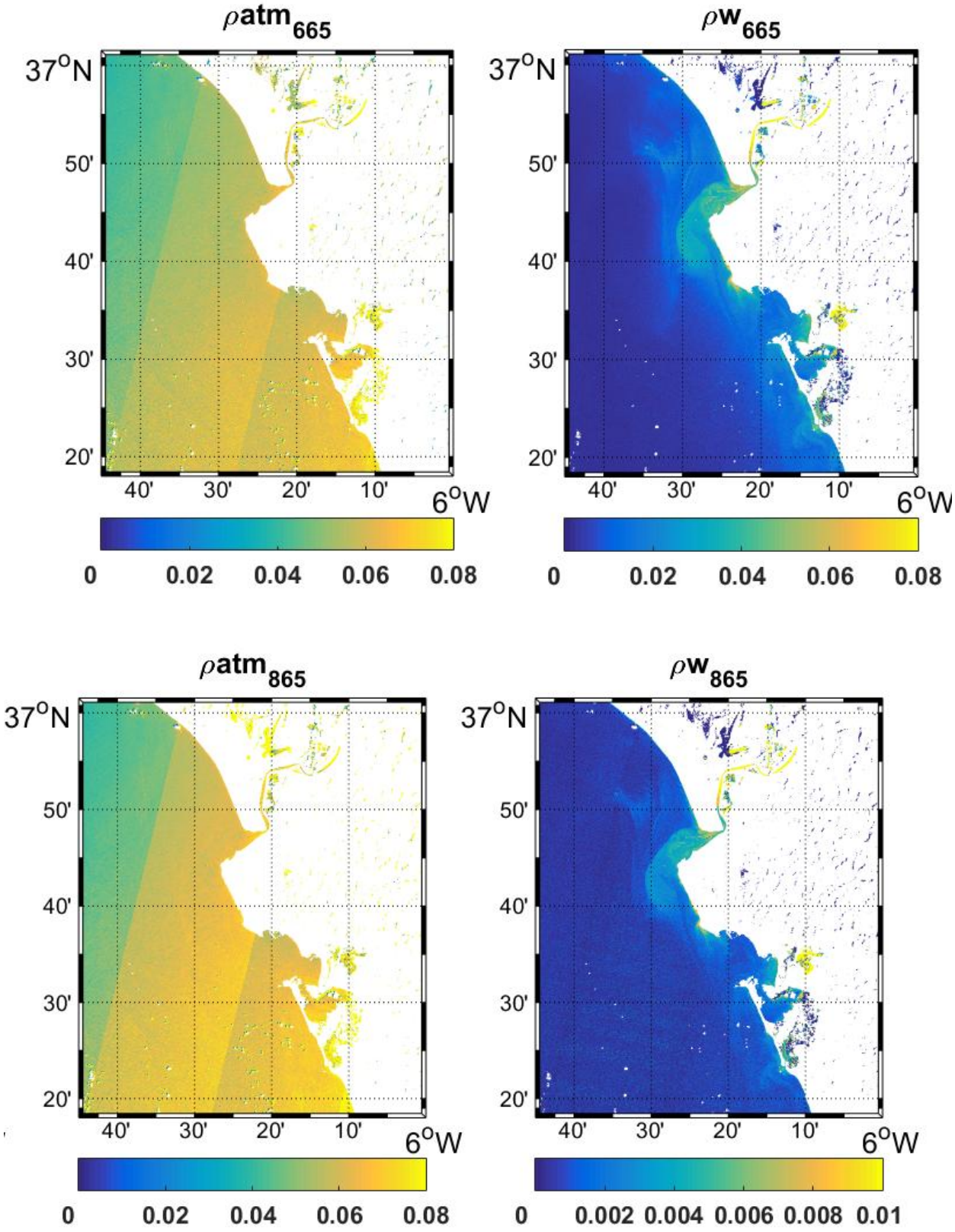

Figure S4. Maps of signal separation of atmosphere (ρatm) and water (ρw) for red (665 nm) and NIR (865 nm) bands, respectively. Sentinel-2A image of 16 June 2016 with POLYMER AC model (60 m). In situ sampling was carried out during this day.

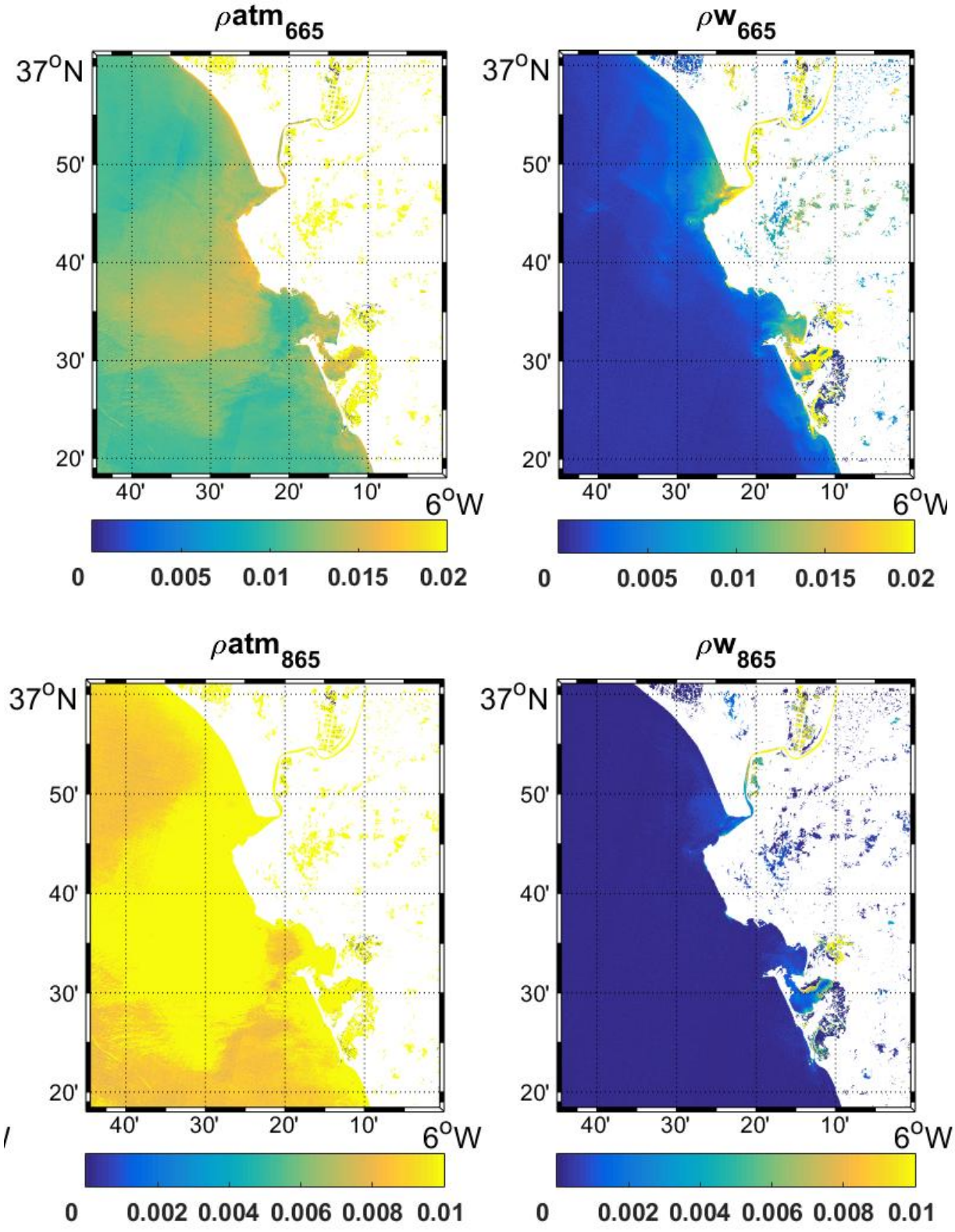

Figure S5. Maps of signal separation of atmosphere (ρatm) and water (ρw) for red (665 nm) and NIR (865 nm) bands, respectively. Sentinel-2A image of 24 September 2016 with POLYMER AC model (60 m).

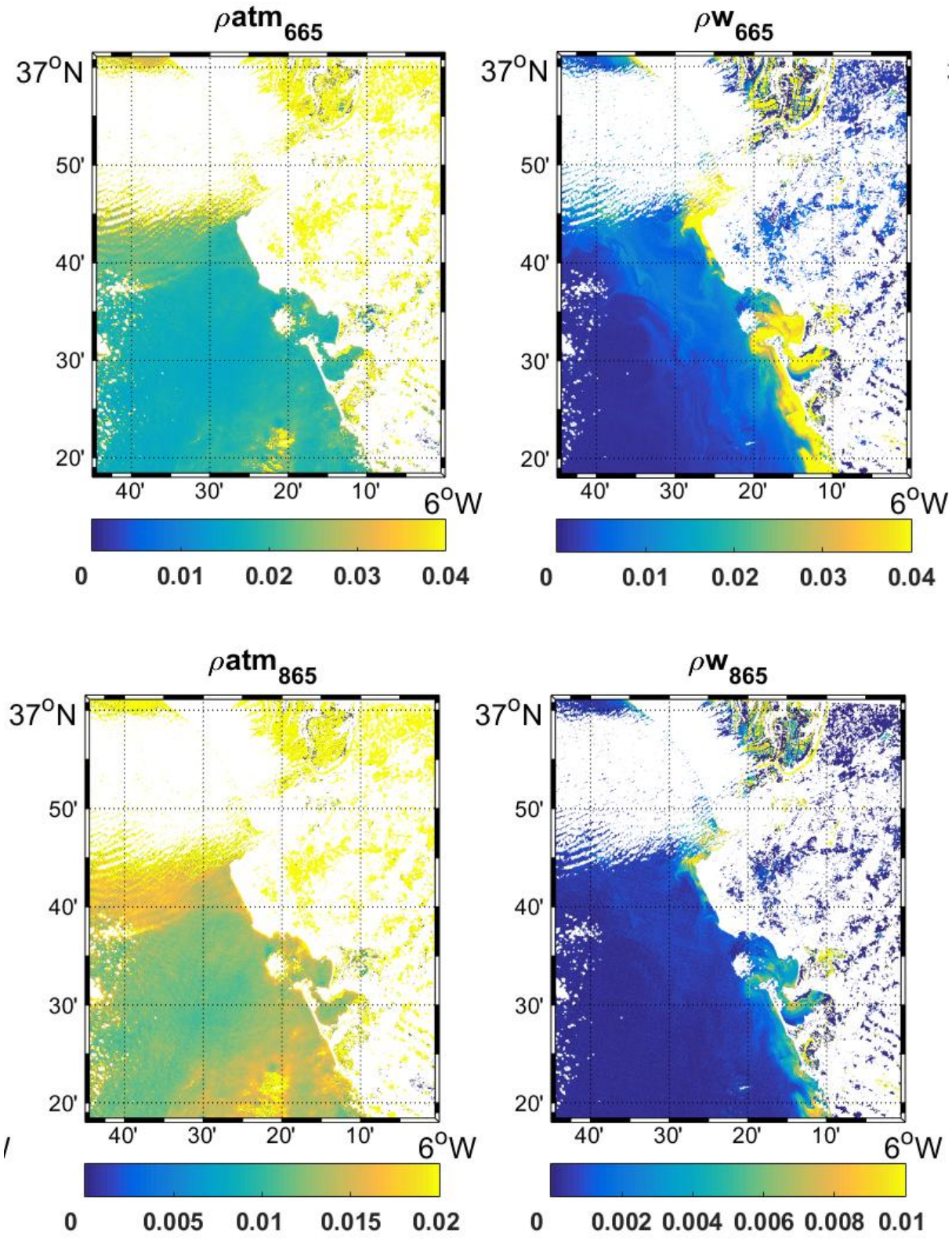

Figure S6. Maps of signal separation of atmosphere (ρatm) and water (ρw) for red (665 nm) and NIR (865 nm) bands, respectively. Sentinel-2A image of 13 December 2016 with POLYMER AC model (60 m). In situ sampling was carried out during this day.

Table S1. Performance indicators of the comparison between atmospherically corrected spectra at different wavelengths by POLYMER and ACOLITE procedures in the Guadalquivir estuary and Cadiz Bay Region of Interest (ROI) on 8 March and 24 September 2016. Pearson coefficient of correlation (r), Root Mean Square Error (RMSE) and bias displayed. Parameters a and b correspond to the values of the linear fit both intercept and slope, respectively.

Statistic	r	b	a	RMSE	Bias	N-values
B1 (444 nm) Guadalquivir	0.9181	1.052	0.0044	0.0070	0.0057	186048
B1(444 nm) Cadiz	0.9723	1.2001	0.0027	0.0086	0.0079	23700
B2 (497 nm)Guadalquivir	0.9853	1.081	-0.0061	0.0047	-0.0035	186029
B2 (497 nm) Cadiz	0.9935	1.1078	-0.0055	0.0032	-0.0017	23650
B3 (560 nm) Guadalquivir	0.9946	1.024	-0.0023	0.0027	-0.0015	186050
B3 (560 nm) Cadiz	0.9971	1.0352	-0.0015	0.0018	-0.000085	23620
B4 (664 nm) Guadalquivir	0.9866	1.033	0.0001	0.0016	0.00047	186050
B4 (664 nm) Cadiz	0.9844	1.0342	0.0010	0.0018	0.0013	23500
B5(704 nm) Guadalquivir	0.9659	1.003	0.0004	0.0016	0.00050	186022
B5 (704 nm) Cadiz	0.9652	0.9583	0.0014	0.0015	0.0012	23550
B6(740 nm) Guadalquivir	0.7076	0.875	0.0008	0.0015	0.00068	186018
B6 (740 nm) Cadiz	0.6640	0.7206	0.0016	0.0016	0.0013	23532
B7 (783 nm) Guadalquivir	0.7738	0.984	0.0008	0.0016	0.00086	186066
B7 (783 nm) Cadiz	0.7184	0.7827	0.0018	0.0015	0.0014	23563
B8a(865 nm) Guadalquivir	0.5990	0.823	0.001	0.0016	0.0010	185022
B8a (865 nm) Cadiz	0.4538	0.4511	0.0018	0.0016	0.0014	23562

Table S2. Performance indicators of the comparison between atmospherically corrected spectra at different wavelengths by POLYMER and ACOLITE strategies in the Guadalquivir estuary and Cadiz Bay Region of Interest (ROI) on 13 December 2016 (coincident with in-situ sampling). Pearson coefficient of correlation (r), Root Mean Square Error (RMSE) and bias displayed. Parameters a and b correspond to the values of the linear fit both intercept and slope, respectively.

Statistic	r	b	a	RMSE	Bias	N-values
B1 (444 nm) Guadalquivir	0.71	1.1139	0.0202	0.0206	0.0291	48902
B1(444 nm) Cadiz	0.77	1.0331	0.0229	0.0215	0.0235	16498
B2 (497 nm) Guadalquivir	0.93	0.9859	0.0125	0.0151	0.0172	48716
B2 (497 nm) Cadiz	0.95	1.1002	0.0121	0.0168	0.0173	16648
B3 (560 nm) Guadalquivir	0.94	0.9335	0.0088	0.0066	0.0071	48246
B3 (560 nm) Cadiz	0.92	0.9789	0.0061	0.0051	0.0047	16590
B4 (664 nm) Guadalquivir	0.98	0.9811	0.0062	0.0071	0.0062	48825
B4 (664 nm) Cadiz	0.97	0.9857	0.0058	0.0054	0.0048	16581
B5(704 nm) Guadalquivir	0.97	0.9689	0.0059	0.0062	0.0053	48911
B5 (704 nm) Cadiz	0.94	0.9457	0.0062	0.0062	0.0061	16469
B6(740 nm) Guadalquivir	0.71	0.7987	0.0065	0.0056	0.0054	48919
B6 (740 nm) Cadiz	0.69	0.7792	0.0058	0.0058	0.0055	16444
B7 (783 nm) Guadalquivir	0.79	0.7854	0.0051	0.0059	0.0054	48918
B7 (783 nm) Cadiz	0.68	0.7544	0.0056	0.0051	0.0049	16620
B8a(865 nm) Guadalquivir	0.77	0.7959	0.0040	0.0041	0.0038	48120
B8a (865 nm) Cadiz	0.69	0.7766	0.0032	0.0039	0.0031	16236

Table S3. Date and timing (UTC) of Sentinel-2A data acquisition, mean discharge (three previous days) from Alcalá del Rio dam (m^3/s), mean precipitation (three previous days) at Sanlúcar de Barrameda (mm), tidal amplitude, and timing of low and high tides at the Bonanza tidal Gauge in Sanlúcar de Barrameda.

Number	Date/ Timing (UTC)	Discharge (m^3/s)	Hydraulic regime	Precipitation (mm)	Tidal range (m)	Timing (UTC) High Tide/Low Tide
15	24 September 2016 11:12	18	Tidally-dominated	0	1.56	06:36/13:10
16	4 October 2016 11:09	23.6	Tidally-dominated	0	2.35	14:01/07:41
17	14 October 2016 11:17	19.7	Tidally-dominated	9.5	2.94	10:43/16:52
18	23 November 2016 11:23	108.5	Intermediate	2.7	1.59	09:00/15:24
20	23 December 2016 11:16	28.33	Tidally-dominated	0	1.39	09:12/15:25
21	2 January 2017 11:14	18.2	Tidally-dominated	0	2.2	14:30/08:43
22	12 January 2017 11:20	13.3	Tidally-dominated	0	2.9	04:44/11:21
23	1 February 2017 11:18	18.6	Tidally-dominated	0.46	2.4	05:09/11:43

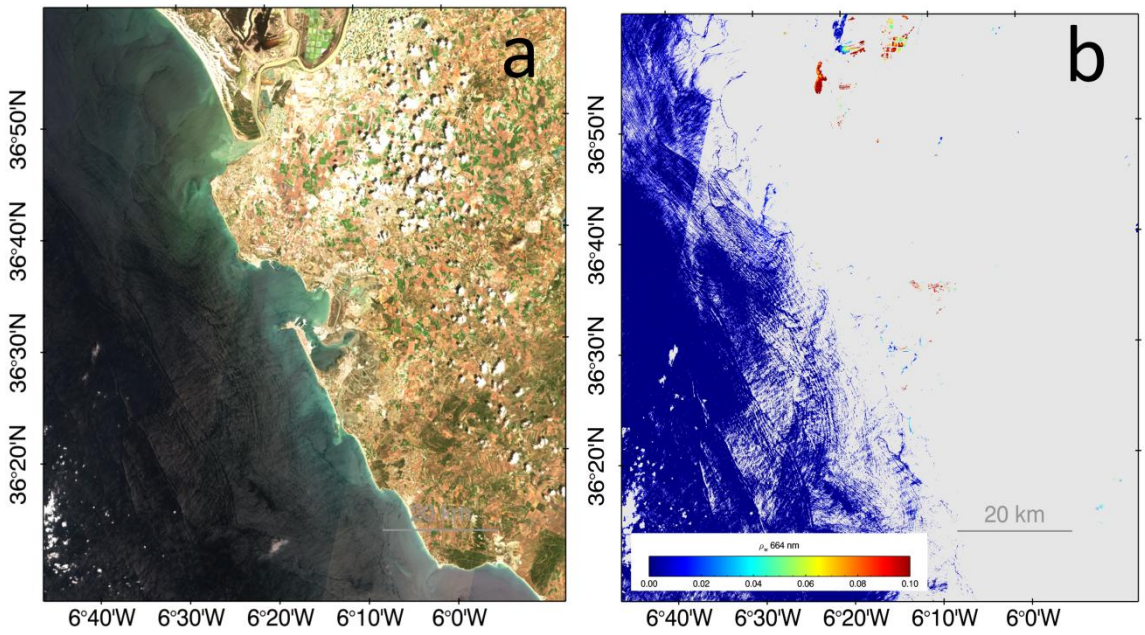

Figure S7. Sentinel-2 image on 27 May 2016 after ACOLITE correction showing moderate sunglint issues on the: (a) true-colour Red-Green-Blue (RGB) composite (B4-B3-B2), (b) water reflectance (ρw) at 664 nm (B4). Standard ACOLITE flags were used with masked pixels for sunglint.