C.2 Study Site FBG2 (prostrate dwarf shrub community)

I *Location*

Name	Location	Latitude	Longitude	Altitude
FBG2	Franklin Bluffs, Arctic North Slope, Alaska, United States of America	69.67443°	-148.720725°	122 m

At an average elevation of 90 m, Franklin Bluffs is located in Subzone D about 1 km west of the Dalton Highway across from the pipeline access road APL/AMS 130 near green mile marker 375. This access road provides parking at the site. Three 10 x 10 m grids, designated dry, mesic, and wet, have been established at this location in 2002. The goniometer measurements have been carried out next to the moist / zonal site (FB_m/z). [*Barreda et al.*, 2006]

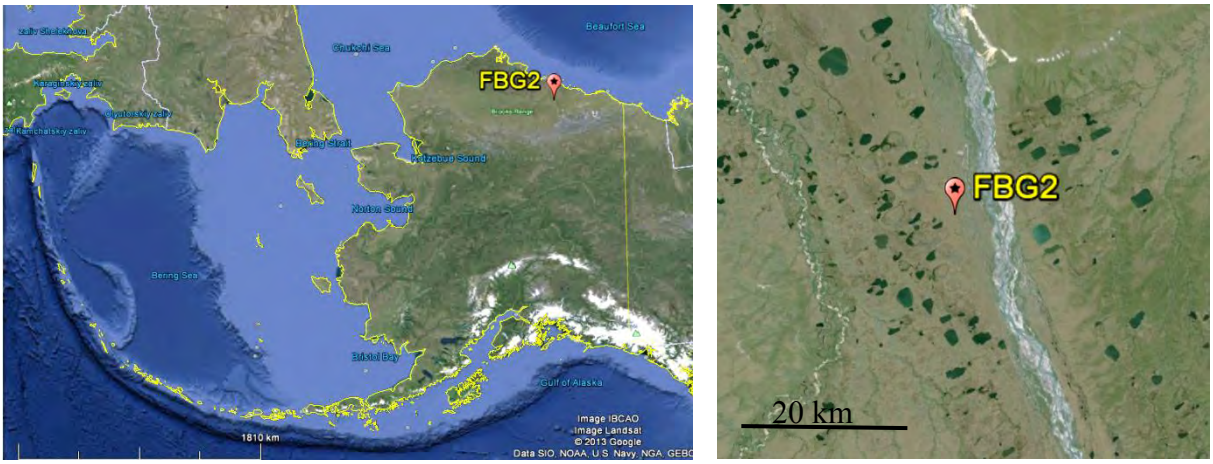

Figure C.2-1: Location of study site FBG2 in Alaska, USA. *Source:* Google Earth, 2013

Figure C.2-2: Aerial photo of a 10 x 10 m zonal grid at the Franklin Bluffs study location near the FBG2 site. *Source:* [*Barreda et al.*, 2006]

II *Main Vegetation Description*

The vegetation at the mesic Franklin Bluffs study location corresponds to the zonal vegetation in subzone D. The zonal plant community of bioclimate subzone D in northern Alaska is *Dryado integrifoliae-Caricetum bigelowii* [*Walker et al.*, 2005], also called moist non-acidic tundra (MNT), or 'nontussock sedge, dwarf-shrub, moss tundra' [*Walker et al.*, 2005]. It occurs on circumneutral to basic soils in association with silty loess that is blown from the major rivers in the eastern part of the Arctic Coastal Plain. The average soil pH of this plant community at Franklin Bluffs is 7.9; the average volumetric soil moisture of the top mineral horizon is 45 %, and average depth of thaw by late summer is 40 cm [*Kade et al.*, 2005]. The dominant plants in MNT are sedges (*Carex bigelowii, Eriophorum angustifolium* ssp. *triste, C. membranacea, C. scirpoidea, E. vaginatum*), prostrate and hemi-prostrate evergreen dwarf shrubs (*Dryas integrifolia, Cassiope tetragona*), prostrate dwarf deciduous shrubs (*Salix arctica, S. reticulata, Arctous rubra*), scattered erect dwarf deciduous shrubs (*Salix lanata, S. glauca*), several forbs (*Papaver macounii, Pedicularis lanata, Saussurea angustifolia, Senecio atropurpureus, Pedicularis capitata, Polygonum viviparum, Cardamine hyperborea, Astragalus umbellatus*), mosses *(Tomentypnum nitens, Hylocomium splendens, Aulacomnium turgidum, Rhytidium rugosum, Hypnum bambergeri, Distichium capillaceum, Ditrichum flexicaule*), and lichens (*Thamnolia subuliformis*, *Cetraria* spp.).

An important component of the MNT is the abundant nonsorted circles, also called frost boils, which are small patterned ground features caused by soil frost heave [*Walker et al.*, 2008; *Washburn*, 1980]. These features cover large parts of most MNT surfaces. The 10 x 10 m zonal grid at Franklin Bluffs has about 30 % cover of nonsorted circles. These features have drier plant communities than the mesic zonal plant communities between the circles, with high cover of lichens and bare soil.

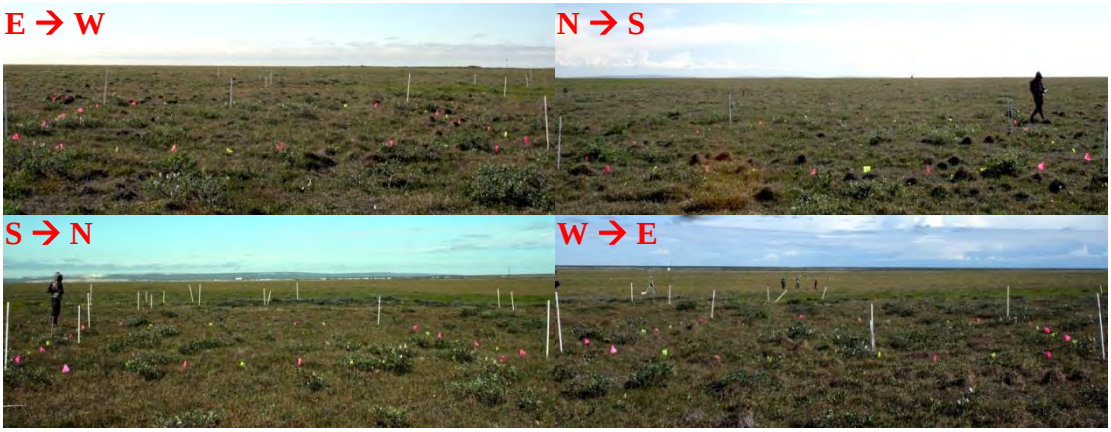

Figure C.2-3: Overview images of MNT tundra at the mesic Franklin Bluffs study location near the FBG2 site. *Source:* [*Buchhorn and Schwieder*, 2012]

III *Vegetation Description of the FBG2 Site*

The focus of the measurements at this goniometer site has been prostrate dwarf deciduous shrubs (Salix). The 1 x 1 m plot is homogeneously covered mainly with *Salix*, but with forbs, mosses and lichens in the understory.

Figure C.2-4: Overview images of the FBG2 vegetation from cardinal directions.

Figure C.2-5: Nadir image of the FBG2 vegetation (prostrate dwarf shrub).

IV *Overview of the Spectro-Goniometer Measurements*

Table C.2-1: Overview of the spectro-goniometer measurements at the FBG2 study site.

Name	Day	Starting Time	Duration	SAA	SZA	Sky
FBG2_01	2012-07-09	09:39:42	18 min	107°	60°	cirrostratus
FBG2_02	2012-07-09	12:04:07	19 min	146°	50°	cirrostratus
FBG2_03	2012-07-09	13:48:12	25 min	180°	47°	cirrostratus

Table C.2-2: Spectro-directional data of the FBG2_01 spectro-goniometer measurement.

FBG2_01 (SZA = 60°; SAA = 107°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	0|0	5|180	5|202.5	5|225	5|270	5|315	5|337.5	5|0	5|22.5	5|45	5|90	5|135	5|157.5	10|180	10|202.5	10|225	10|270	10|315	10|337.5	10|350
HCRF EnMAP blue (479 nm)	0.0445	0.0490	0.0474	0.0433	0.0453	0.0519	0.0459	0.0542	0.0532	0.0469	0.0483	0.0475	0.0531	0.0522	0.0542	0.0489	0.0530	0.0492	0.0441	0.0474
HCRF EnMAP green (549 nm)	0.0722	0.0780	0.0749	0.0663	0.0766	0.0772	0.0717	0.0849	0.0860	0.0802	0.0717	0.0756	0.0782	0.0856	0.0882	0.0753	0.0856	0.0737	0.0696	0.0711
HCRF EnMAP rot (672 nm)	0.0594	0.0646	0.0634	0.0598	0.0622	0.0749	0.0680	0.0770	0.0726	0.0652	0.0707	0.0637	0.0750	0.0718	0.0644	0.0649	0.0735	0.0731	0.0624	0.0667
HCRF EnMAP NIR (864 nm)	0.3581	0.3699	0.3562	0.3140	0.4021	0.3198	0.3370	0.3983	0.4340	0.4338	0.3185	0.3838	0.3646	0.4414	0.4463	0.4216	0.3435	0.3969	0.3388	0.3278
ANIF EnMAP rot (672 nm)	1.0000	1.0883	1.0678	1.0065	1.0474	1.2601	1.1447	1.2956	1.2228	1.0968	1.1903	1.0731	1.2624	1.2092	1.0841	1.1568	1.0926	1.2377	1.2311	1.0511	1.1231
ANIF EnMAP NIR (864 nm)	1.0000	1.0331	0.9948	0.8770	1.1230	0.8932	0.9411	1.1123	1.2121	1.2114	0.8896	1.0719	1.0183	1.2327	1.2465	1.1775	0.9594	1.1084	0.8920	0.9463	0.9155
Rel. Blue Absorption Depth	0.3863	0.3676	0.3746	0.3422	0.4208	0.3186	0.3567	0.3578	0.3784	0.4279	0.3120	0.3609	0.2964	0.3937	0.4298	0.3935	0.3382	0.3909	0.3255	0.3566	0.3161
Rel. Red Absorption Depth	1.9398	1.8290	1.7530	1.5960	2.0927	1.2274	1.5040	1.5984	1.9462	2.1948	1.3546	1.9277	1.5035	2.0175	2.3211	1.9735	1.6031	1.6780	1.2698	1.6775	1.4913
NDVI (EnMAP)	0.7154	0.7025	0.6977	0.6801	0.7320	0.6207	0.6642	0.6761	0.7133	0.7388	0.6367	0.7151	0.6588	0.7201	0.7478	0.7197	0.6822	0.6874	0.6274	0.6888	0.6618
Nadir Norm. NDVI (AVHRR)	1.0000	0.9809	0.9743	0.9541	1.0268	0.8750	0.9326	0.9470	0.9991	1.0375	0.9085	1.0027	0.9279	1.0085	1.0426	1.0012	0.9492	0.9645	0.8891	0.9702	0.9338
Nadir Norm. NDVI (MODIS)	1.0000	0.9818	0.9756	0.9551	1.0266	0.8753	0.9344	0.9491	1.0008	1.0377	0.9072	1.0027	0.9282	1.0089	1.0441	1.0041	0.9518	0.9657	0.8894	0.9715	0.9356
Nadir Norm. NDVI (EnMAP)	1.0000	0.9819	0.9752	0.9506	1.0232	0.8676	0.9284	0.9451	0.9970	1.0327	0.8900	0.9996	0.9209	1.0065	1.0453	1.0060	0.9535	0.9608	0.8769	0.9628	0.9250

(cont.)

FBG2_01 (SZA = 60°; SAA = 107°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	10|0	10|10	10|22.5	10|45	10|90	10|135	10|157.5	10|170	20|180	20|190	20|202.5	20|225	20|270	20|315	20|337.5	20|350	20|0	20|10	20|22.5	20|45	20|90
HCRF EnMAP blue (479 nm)	0.0537	0.0517	0.0496	0.0579	0.0479	0.0519	0.0515	0.0522	0.0592	0.0534	0.0536	0.0502	0.0521	0.0544	0.0480	0.0395	0.0421	0.0459	0.0472	0.0444	0.0483
HCRF EnMAP green (549 nm)	0.0824	0.0808	0.0800	0.0964	0.0749	0.0800	0.0764	0.0814	0.0956	0.0886	0.0887	0.0806	0.0838	0.0808	0.0789	0.0656	0.0688	0.0759	0.0761	0.0718	0.0760
HCRF EnMAP rot (672 nm)	0.0764	0.0720	0.0702	0.0820	0.0685	0.0716	0.0712	0.0716	0.0810	0.0702	0.0728	0.0676	0.0709	0.0793	0.0669	0.0559	0.0596	0.0664	0.0687	0.0623	0.0689
HCRF EnMAP NIR (864 nm)	0.3705	0.3874	0.4018	0.4804	0.3526	0.3728	0.3534	0.3958	0.4469	0.4513	0.4428	0.4062	0.4024	0.3513	0.4168	0.3591	0.3674	0.3847	0.3823	0.3703	0.3730
ANIF EnMAP rot (672 nm)	1.2863	1.2119	1.1822	1.3797	1.1525	1.2053	1.1989	1.2055	1.3636	1.1810	1.2261	1.1384	1.1940	1.3352	1.1264	0.9411	1.0034	1.1181	1.1565	1.0489	1.1600
ANIF EnMAP NIR (864 nm)	1.0348	1.0818	1.1222	1.3417	0.9848	1.0412	0.9871	1.1053	1.2482	1.2605	1.2366	1.1343	1.1237	0.9811	1.1642	1.0030	1.0262	1.0743	1.0677	1.0341	1.0417
Rel. Blue Absorption Depth	0.3412	0.3475	0.3754	0.4128	0.3474	0.3387	0.3018	0.3448	0.3840	0.3995	0.3959	0.3688	0.3735	0.3188	0.3871	0.3941	0.3810	0.3983	0.3819	0.3757	0.3541
Rel. Red Absorption Depth	1.4890	1.6881	1.8284	1.9178	1.6076	1.6041	1.5043	1.7458	1.7783	2.1173	2.0016	1.9109	1.7972	1.3289	2.0240	2.0757	1.9889	1.8703	1.7828	1.8999	1.7270
NDVI (EnMAP)	0.6581	0.6865	0.7024	0.7085	0.6748	0.6778	0.6646	0.6936	0.6931	0.7309	0.7175	0.7145	0.7003	0.6316	0.7233	0.7306	0.7208	0.7055	0.6953	0.7119	0.6881
Nadir Norm. NDVI (AVHRR)	0.9250	0.9650	0.9911	0.9980	0.9536	0.9500	0.9344	0.9689	0.9709	1.0209	1.0017	1.0010	0.9827	0.8989	1.0186	1.0338	1.0215	0.9992	0.9866	1.0061	0.9795
Nadir Norm. NDVI (MODIS)	0.9272	0.9665	0.9923	0.9993	0.9541	0.9507	0.9352	0.9701	0.9726	1.0225	1.0035	1.0018	0.9830	0.8997	1.0199	1.0336	1.0217	0.9997	0.9875	1.0070	0.9806
Nadir Norm. NDVI (EnMAP)	0.9198	0.9597	0.9819	0.9904	0.9433	0.9474	0.9289	0.9695	0.9688	1.0217	1.0029	0.9988	0.9789	0.8829	1.0111	1.0213	1.0076	0.9862	0.9720	0.9951	0.9618

(cont.)

FBG2_01 (SZA = 60°; SAA = 107°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	20|135	20|157.5	20|170	30|180	30|190	30|202.5	30|225	30|270	30|315	30|337.5	30|350	30|0	30|10	30|22.5	30|45	30|90	30|135	30|157.5	30|170
HCRF EnMAP blue (479 nm)	0.0581	0.0616	0.0635	0.0861	0.0840	0.0717	0.0536	0.0482	0.0477	0.0439	0.0462	0.0425	0.0449	0.0443	0.0419	0.0507	0.0683	0.0745	0.0830					
HCRF EnMAP green (549 nm)	0.0915	0.0969	0.1000	0.1341	0.1328	0.1169	0.0882	0.0804	0.0743	0.0769	0.0771	0.0744	0.0719	0.0682	0.0665	0.0769	0.1105	0.1226	0.1323					
HCRF EnMAP rot (672 nm)	0.0781	0.0803	0.0900	0.1127	0.1079	0.0921	0.0726	0.0636	0.0674	0.0594	0.0643	0.0625	0.0652	0.0635	0.0596	0.0726	0.0907	0.0974	0.1069					
HCRF EnMAP NIR (864 nm)	0.4364	0.4251	0.4521	0.5424	0.5276	0.5231	0.4315	0.4191	0.3626	0.4291	0.4073	0.4002	0.3530	0.3329	0.3258	0.3385	0.5139	0.5535	0.5553					
ANIF EnMAP rot (672 nm)	1.3143	1.3520	1.5148	1.8964	1.8171	1.5498	1.2222	1.0709	1.1351	1.0000	1.0829	1.0524	1.0970	1.0691	1.0040	1.2219	1.5270	1.6393	1.7989					
ANIF EnMAP NIR (864 nm)	1.2189	1.1871	1.2625	1.5148	1.4735	1.4609	1.2050	1.1706	1.0126	1.1983	1.1375	1.1177	0.9858	0.9298	0.9098	0.9454	1.4352	1.5459	1.5510					
Rel. Blue Absorption Depth	0.3629	0.3633	0.3687	0.3597	0.3710	0.3909	0.3944	0.4056	0.3500	0.4422	0.4039	0.4467	0.3639	0.3366	0.3557	0.3272	0.3910	0.4062	0.3776					
Rel. Red Absorption Depth	1.7642	1.6579	1.5656	1.5001	1.5439	1.8685	1.9617	2.1701	1.6601	2.4346	2.0707	2.1018	1.7061	1.6288	1.6871	1.4150	1.8434	1.8489	1.6399					
NDVI (EnMAP)	0.6965	0.6822	0.6680	0.6560	0.6603	0.7007	0.7119	0.7364	0.6864	0.7568	0.7272	0.7298	0.6883	0.6796	0.6905	0.6469	0.6999	0.7008	0.6772					
Nadir Norm. NDVI (AVHRR)	0.9695	0.9472	0.9422	0.8993	0.9063	0.9670	0.9957	1.0328	0.9697	1.0638	1.0260	1.0324	0.9759	0.9677	0.9789	0.9134	0.9784	0.9658	0.9283					
Nadir Norm. NDVI (MODIS)	0.9726	0.9517	0.9440	0.9051	0.9130	0.9714	0.9978	1.0340	0.9706	1.0654	1.0273	1.0333	0.9774	0.9689	0.9797	0.9165	0.9825	0.9711	0.9339					
Nadir Norm. NDVI (EnMAP)	0.9736	0.9535	0.9337	0.9170	0.9230	0.9794	0.9951	1.0294	0.9594	1.0578	1.0165	1.0201	0.9621	0.9500	0.9652	0.9042	0.9784	0.9796	0.9467					

Table C.2-3: Spectro-directional data of the FBG2_02 spectro-goniometer measurement.

FBG2_02 (SZA = 50°; SAA = 146°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	0|0	5|180	5|202.5	5|225	5|270	5|315	5|337.5	5|0	5|22.5	5|45	5|90	5|135	5|157.5	10|180	10|202.5	10|225	10|270	10|315	10|337.5	10|350
HCRF EnMAP blue (479 nm)	0.0417	0.0500	0.0389	0.0437	0.0431	0.0440	0.0371	0.0437	0.0414	0.0445	0.0371	0.0363	0.0399	0.0513	0.0467	0.0471	0.0422	0.0438	0.0381	0.0384
HCRF EnMAP green (549 nm)	0.0655	0.0788	0.0622	0.0705	0.0639	0.0659	0.0587	0.0688	0.0668	0.0689	0.0610	0.0545	0.0650	0.0819	0.0744	0.0754	0.0635	0.0627	0.0612	0.0613
HCRF EnMAP rot (672 nm)	0.0554	0.0632	0.0520	0.0572	0.0632	0.0633	0.0493	0.0595	0.0556	0.0573	0.0481	0.0494	0.0515	0.0652	0.0620	0.0583	0.0607	0.0628	0.0506	0.0504
HCRF EnMAP NIR (864 nm)	0.3197	0.3438	0.3017	0.3462	0.2650	0.2859	0.2815	0.3407	0.3321	0.3273	0.3102	0.2562	0.3276	0.3601	0.3320	0.3228	0.3373	0.2661	0.2594	0.3147	0.3211
ANIF EnMAP rot (672 nm)	1.0000	1.1408	0.9379	1.0319	1.1400	1.1413	0.8899	1.0740	1.0029	1.0332	0.8670	0.8904	0.9298	1.1769	1.1187	1.0525	1.1134	1.0952	1.1321	0.9123	0.9088
ANIF EnMAP NIR (864 nm)	1.0000	1.0754	0.9436	1.0830	0.8288	0.8943	0.8805	1.0657	1.0386	1.0237	0.9701	0.8014	1.0246	1.1262	1.0384	1.0096	1.0551	0.8323	0.8114	0.9844	1.0045
Rel. Blue Absorption Depth	0.3551	0.3701	0.3639	0.3747	0.3135	0.3224	0.3599	0.3508	0.3808	0.3437	0.3867	0.3140	0.3800	0.3768	0.3778	0.3652	0.3786	0.3261	0.2806	0.3741	0.3576
Rel. Red Absorption Depth	1.8552	1.7118	1.8439	1.9628	1.2223	1.3496	1.7848	1.8267	1.9373	1.8249	2.1164	1.5825	2.0630	1.7545	1.6840	1.7659	1.7375	1.2769	1.1956	1.9851	2.0754
NDVI (EnMAP)	0.7045	0.6893	0.7060	0.7164	0.6149	0.6376	0.7018	0.7025	0.7132	0.7021	0.7317	0.6769	0.7281	0.6932	0.6852	0.6938	0.6906	0.6285	0.6104	0.7231	0.7288
Nadir Norm. NDVI (AVHRR)	1.0000	0.9619	0.9987	1.0169	0.8875	0.9114	0.9909	0.9981	1.0069	0.9924	1.0282	0.9632	1.0240	0.9693	0.9675	0.9804	0.9748	0.9014	0.8760	1.0221	1.0234
Nadir Norm. NDVI (MODIS)	1.0000	0.9645	0.9981	1.0167	0.8851	0.9098	0.9923	0.9979	1.0075	0.9926	1.0292	0.9623	1.0233	0.9714	0.9688	0.9817	0.9757	0.8986	0.8750	1.0224	1.0246
Nadir Norm. NDVI (EnMAP)	1.0000	0.9785	1.0021	1.0170	0.8728	0.9051	0.9962	0.9972	1.0123	0.9967	1.0386	0.9609	1.0335	0.9840	0.9727	0.9849	0.9804	0.8921	0.8665	1.0265	1.0346

(cont.)

FBG2_02 (SZA = 50°; SAA = 146°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	10|0	10|10	10|22.5	10|45	10|90	10|135	10|157.5	10|170	20|180	20|190	20|202.5	20|225	20|270	20|315	20|337.5	20|350	20|0	20|10	20|22.5	20|45	20|90
HCRF EnMAP blue (479 nm)	0.0434	0.0385	0.0431	0.0357	0.0378	0.0382	0.0404	0.0507	0.0433	0.0441	0.0470	0.0455	0.0439	0.0336	0.0368	0.0379	0.0418	0.0388	0.0388	0.0331	0.0351
HCRF EnMAP green (549 nm)	0.0667	0.0619	0.0674	0.0574	0.0610	0.0574	0.0658	0.0828	0.0707	0.0742	0.0768	0.0708	0.0660	0.0562	0.0577	0.0600	0.0636	0.0588	0.0592	0.0503	0.0553
HCRF EnMAP rot (672 nm)	0.0598	0.0506	0.0550	0.0447	0.0497	0.0508	0.0522	0.0635	0.0594	0.0602	0.0605	0.0592	0.0611	0.0462	0.0495	0.0503	0.0571	0.0527	0.0512	0.0439	0.0490
HCRF EnMAP NIR (864 nm)	0.3172	0.3251	0.3240	0.2790	0.2996	0.2612	0.3338	0.3718	0.3306	0.3511	0.3503	0.3139	0.2853	0.3007	0.2878	0.3089	0.3045	0.2801	0.2755	0.2483	0.2805
ANIF EnMAP rot (672 nm)	1.0794	0.9125	0.9920	0.8067	0.8973	0.9156	0.9416	1.1456	1.0708	1.0864	1.0918	1.0676	1.1025	0.8342	0.8929	0.9067	1.0294	0.9500	0.9235	0.7928	0.8832
ANIF EnMAP NIR (864 nm)	0.9920	1.0168	1.0134	0.8726	0.9370	0.8170	1.0441	1.1631	1.0340	1.0982	1.0956	0.9819	0.8924	0.9405	0.9003	0.9660	0.9524	0.8762	0.8616	0.7768	0.8773
Rel. Blue Absorption Depth	0.3315	0.3669	0.3526	0.3737	0.3722	0.3102	0.3781	0.4009	0.3850	0.4141	0.3943	0.3475	0.3226	0.4018	0.3490	0.3512	0.3222	0.3156	0.3250	0.3177	0.3570
Rel. Red Absorption Depth	1.6499	2.0691	1.9030	2.0058	1.9333	1.5717	2.0820	1.8974	1.7745	1.8717	1.8388	1.6653	1.3805	2.0988	1.8585	2.0048	1.6731	1.6507	1.6807	1.7627	1.7978
NDVI (EnMAP)	0.6826	0.7307	0.7098	0.7237	0.7152	0.6746	0.7295	0.7083	0.6955	0.7072	0.7053	0.6828	0.6472	0.7334	0.7066	0.7201	0.6844	0.6835	0.6865	0.6993	0.7028
Nadir Norm. NDVI (AVHRR)	0.9694	1.0368	1.0024	1.0191	1.0083	0.9506	1.0252	0.9883	0.9778	0.9967	0.9897	0.9621	0.9248	1.0389	0.9985	1.0194	0.9697	0.9736	0.9747	0.9950	1.0024
Nadir Norm. NDVI (MODIS)	0.9701	1.0374	1.0039	1.0197	1.0087	0.9513	1.0244	0.9907	0.9772	0.9969	0.9919	0.9619	0.9230	1.0387	1.0003	1.0199	0.9698	0.9743	0.9754	0.9950	1.0010
Nadir Norm. NDVI (EnMAP)	0.9689	1.0372	1.0076	1.0273	1.0152	0.9576	1.0356	1.0054	0.9873	1.0038	1.0013	0.9692	0.9186	1.0411	1.0030	1.0221	0.9715	0.9703	0.9746	0.9927	0.9976

(cont.)

FBG2_02 (SZA = 50°; SAA = 146°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	20|135	20|157.5	20|170	30|180	30|190	30|202.5	30|225	30|270	30|315	30|337.5	30|350	30|0	30|10	30|22.5	30|45	30|90	30|135	30|157.5	30|170
HCRF EnMAP blue (479 nm)	0.0436	0.0451	0.0419	0.0635	0.0679	0.0625	0.0470	0.0379	0.0354	0.0367	0.0310	0.0287	0.0302	0.0332	0.0328	0.0423	0.0491	0.0535	0.0624					
HCRF EnMAP green (549 nm)	0.0662	0.0711	0.0665	0.0998	0.1052	0.0992	0.0733	0.0588	0.0571	0.0538	0.0482	0.0455	0.0456	0.0509	0.0511	0.0671	0.0750	0.0863	0.0960					
HCRF EnMAP rot (672 nm)	0.0578	0.0594	0.0547	0.0814	0.0885	0.0790	0.0586	0.0504	0.0489	0.0515	0.0438	0.0393	0.0421	0.0462	0.0449	0.0551	0.0647	0.0703	0.0813					
HCRF EnMAP NIR (864 nm)	0.2766	0.3261	0.3124	0.3849	0.4021	0.3919	0.3041	0.2841	0.2886	0.2497	0.2408	0.2368	0.2175	0.2327	0.2496	0.3376	0.3366	0.3930	0.3851					
ANIF EnMAP rot (672 nm)	1.0428	1.0719	0.9862	1.4685	1.5958	1.4258	1.0574	0.9098	0.8814	0.9283	0.7907	0.7093	0.7601	0.8334	0.8099	0.9940	1.1675	1.2674	1.4666					
ANIF EnMAP NIR (864 nm)	0.8651	1.0198	0.9773	1.2039	1.2577	1.2259	0.9510	0.8887	0.9026	0.7812	0.7531	0.7405	0.6803	0.7280	0.7807	1.0559	1.0528	1.2293	1.2044					
Rel. Blue Absorption Depth	0.3198	0.3533	0.3548	0.3629	0.3540	0.3780	0.3490	0.3459	0.3780	0.2933	0.3442	0.3505	0.3153	0.3320	0.3388	0.3591	0.3259	0.3675	0.3386					
Rel. Red Absorption Depth	1.4534	1.7320	1.8176	1.4585	1.3648	1.5355	1.5722	1.7465	1.8963	1.4636	1.6961	1.8788	1.5788	1.5118	1.7130	1.9858	1.6546	1.7976	1.4722					
NDVI (EnMAP)	0.6542	0.6917	0.7021	0.6508	0.6393	0.6644	0.6767	0.6985	0.7104	0.6583	0.6920	0.7152	0.6754	0.6687	0.6951	0.7193	0.6775	0.6967	0.6513					
Nadir Norm. NDVI (AVHRR)	0.9234	0.9710	0.9821	0.9064	0.8885	0.9206	0.9393	0.9893	1.0123	0.9470	0.9901	1.0203	0.9640	0.9536	0.9934	1.0119	0.9541	0.9774	0.9116					
Nadir Norm. NDVI (MODIS)	0.9249	0.9718	0.9827	0.9115	0.8928	0.9254	0.9442	0.9898	1.0138	0.9470	0.9901	1.0194	0.9637	0.9553	0.9940	1.0139	0.9550	0.9790	0.9146					
Nadir Norm. NDVI (EnMAP)	0.9287	0.9819	0.9967	0.9239	0.9076	0.9431	0.9607	0.9915	1.0084	0.9345	0.9823	1.0152	0.9588	0.9493	0.9867	1.0211	0.9617	0.9890	0.9246					

Table C.2-4: Spectro-directional data of the FBG2_03 spectro-goniometer measurement

FBG2_03 (SZA = 47°; SAA = 180°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	0|0	5|180	5|202.5	5|225	5|270	5|315	5|337.5	5|0	5|22.5	5|45	5|90	5|135	5|157.5	10|180	10|202.5	10|225	10|270	10|315	10|337.5	10|350
HCRF EnMAP blue (479 nm)	0.0461	0.0493	0.0493	0.0433	0.0443	0.0472	0.0422	0.0438	0.0440	0.0458	0.0442	0.0478	0.0486	0.0501	0.0549	0.0424	0.0429	0.0471	0.0393	0.0425
HCRF EnMAP green (549 nm)	0.0723	0.0749	0.0745	0.0644	0.0665	0.0743	0.0670	0.0681	0.0678	0.0717	0.0681	0.0740	0.0736	0.0755	0.0824	0.0657	0.0648	0.0708	0.0628	0.0667
HCRF EnMAP rot (672 nm)	0.0620	0.0696	0.0672	0.0606	0.0627	0.0645	0.0571	0.0582	0.0617	0.0634	0.0606	0.0621	0.0679	0.0703	0.0737	0.0764	0.0608	0.0643	0.0518	0.0557
HCRF EnMAP NIR (864 nm)	0.3600	0.3214	0.3241	0.2729	0.2892	0.3699	0.3342	0.3419	0.3152	0.3425	0.3159	0.3430	0.3208	0.3200	0.3624	0.3472	0.2975	0.2838	0.3356	0.3218	0.3379
ANIF EnMAP rot (672 nm)	1.0000	1.1222	1.0842	0.9789	1.0112	1.0404	0.9213	0.9381	0.9959	1.0233	0.9771	1.0021	1.0958	1.1347	1.1879	1.2323	0.9720	0.9806	1.0367	0.8351	0.8992
ANIF EnMAP NIR (864 nm)	1.0000	0.8927	0.9003	0.7579	0.8032	1.0274	0.9282	0.9498	0.8755	0.9513	0.8774	0.9528	0.8911	0.8887	1.0065	0.9645	0.8264	0.7882	0.9321	0.8938	0.9386
Rel. Blue Absorption Depth	0.3531	0.3368	0.3278	0.3144	0.3203	0.3528	0.3589	0.3441	0.3378	0.3534	0.3308	0.3426	0.3232	0.3241	0.3541	0.3249	0.3492	0.3190	0.3140	0.3640	0.3517
Rel. Red Absorption Depth	1.8593	1.3916	1.4657	1.3226	1.3625	1.8396	1.8819	1.8768	1.5665	1.7002	1.6028	1.7392	1.4351	1.3746	1.5195	1.3721	1.5117	1.4023	1.6246	1.9914	1.9525
NDVI (EnMAP)	0.7062	0.6441	0.6565	0.6367	0.6436	0.7030	0.7080	0.7092	0.6724	0.6874	0.6781	0.6933	0.6505	0.6395	0.6622	0.6393	0.6631	0.6471	0.6785	0.7228	0.7168
Nadir Norm. NDVI (AVHRR)	1.0000	0.9164	0.9334	0.9064	0.9141	0.9970	1.0045	1.0035	0.9575	0.9775	0.9644	0.9789	0.9255	0.9128	0.9464	0.9126	0.9504	0.9232	0.9631	1.0243	1.0174
Nadir Norm. NDVI (MODIS)	1.0000	0.9146	0.9322	0.9055	0.9140	0.9972	1.0052	1.0039	0.9564	0.9779	0.9636	0.9801	0.9242	0.9108	0.9442	0.9123	0.9496	0.9217	0.9642	1.0255	1.0175
Nadir Norm. NDVI (EnMAP)	1.0000	0.9120	0.9296	0.9016	0.9114	0.9955	1.0026	1.0044	0.9521	0.9734	0.9603	0.9818	0.9211	0.9056	0.9377	0.9053	0.9390	0.9164	0.9608	1.0236	1.0150

(cont.)

FBG2_03 (SZA = 47°; SAA = 180°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	10|0	10|10	10|22.5	10|45	10|90	10|135	10|157.5	10|170	20|180	20|190	20|202.5	20|225	20|270	20|315	20|337.5	20|350	20|0	20|10	20|22.5	20|45	20|90
HCRF EnMAP blue (479 nm)	0.0428	0.0410	0.0384	0.0394	0.0465	0.0499	0.0481	0.0477	0.0516	0.0530	0.0560	0.0490	0.0440	0.0437	0.0386	0.0412	0.0375	0.0377	0.0391	0.0378	0.0427
HCRF EnMAP green (549 nm)	0.0659	0.0642	0.0598	0.0640	0.0711	0.0794	0.0734	0.0735	0.0777	0.0783	0.0872	0.0748	0.0695	0.0688	0.0601	0.0620	0.0573	0.0581	0.0606	0.0584	0.0640
HCRF EnMAP rot (672 nm)	0.0566	0.0563	0.0529	0.0549	0.0644	0.0651	0.0659	0.0672	0.0701	0.0735	0.0753	0.0672	0.0595	0.0601	0.0523	0.0564	0.0499	0.0516	0.0536	0.0514	0.0602
HCRF EnMAP NIR (864 nm)	0.3225	0.3230	0.3014	0.3207	0.3254	0.3806	0.3240	0.3177	0.3290	0.3150	0.3832	0.3253	0.3343	0.3495	0.2960	0.2885	0.2636	0.2861	0.3069	0.2937	0.2872
ANIF EnMAP rot (672 nm)	0.9136	0.9080	0.8535	0.8854	1.0387	1.0506	1.0631	1.0834	1.1299	1.1854	1.2142	1.0838	0.9600	0.9700	0.8441	0.9089	0.8053	0.8315	0.8643	0.8296	0.9705
ANIF EnMAP NIR (864 nm)	0.8959	0.8973	0.8372	0.8908	0.9037	1.0572	0.8998	0.8826	0.9138	0.8749	1.0643	0.9036	0.9286	0.9708	0.8223	0.8013	0.7878	0.7948	0.8525	0.8158	0.7977
Rel. Blue Absorption Depth	0.3361	0.3454	0.3474	0.3851	0.3333	0.3643	0.3296	0.3390	0.3193	0.3103	0.3566	0.3306	0.3523	0.3515	0.3403	0.3153	0.3242	0.3250	0.3355	0.3305	0.3157
Rel. Red Absorption Depth	1.7927	1.8028	1.7664	1.8399	1.5404	1.8800	1.5098	1.4380	1.4252	1.2566	1.5715	1.4601	1.7843	1.8419	1.7576	1.5421	1.7430	1.7174	1.7914	1.7877	1.4290
NDVI (EnMAP)	0.7012	0.7032	0.7013	0.7077	0.6695	0.7077	0.6619	0.6510	0.6489	0.6216	0.6716	0.6576	0.6977	0.7064	0.6995	0.6732	0.7006	0.6947	0.7027	0.7020	0.6536
Nadir Norm. NDVI (AVHRR)	0.9981	0.9977	1.0008	1.0067	0.9510	0.9990	0.9431	0.9277	0.9174	0.8798	0.9483	0.9310	0.9818	1.0026	0.9946	0.9601	0.9983	0.9872	0.9995	1.0002	0.9310
Nadir Norm. NDVI (MODIS)	0.9955	0.9971	0.9997	1.0062	0.9497	0.9993	0.9419	0.9261	0.9175	0.8805	0.9494	0.9313	0.9935	1.0034	0.9957	0.9616	0.9990	0.9862	0.9994	0.9988	0.9305
Nadir Norm. NDVI (EnMAP)	0.9930	0.9958	0.9931	1.0022	0.9481	1.0022	0.9373	0.9218	0.9189	0.8803	0.9510	0.9312	0.9881	1.0003	0.9906	0.9533	0.9922	0.9837	0.9951	0.9940	0.9255

(cont.)

FBG2_03 (SZA = 47°; SAA = 180°)	Viewing Geometry (Viewing Zenith Angle | Viewing Azimuth Angle)																							
	20|135	20|157.5	20|170	30|180	30|190	30|202.5	30|225	30|270	30|315	30|337.5	30|350	30|0	30|10	30|22.5	30|45	30|90	30|135	30|157.5	30|170
HCRF EnMAP blue (479 nm)	0.0579	0.0512	0.0549	0.0657	0.0651	0.0621	0.0541	0.0402	0.0367	0.0365	0.0358	0.0340	0.0322	0.0340	0.0447	0.0417	0.0541	0.0586	0.0578					
HCRF EnMAP green (549 nm)	0.0887	0.0804	0.0857	0.1005	0.0967	0.0955	0.0861	0.0651	0.0570	0.0551	0.0540	0.0535	0.0507	0.0524	0.0709	0.0657	0.0837	0.0875	0.0869					
HCRF EnMAP rot (672 nm)	0.0758	0.0650	0.0730	0.0875	0.0877	0.0846	0.0738	0.0542	0.0507	0.0503	0.0494	0.0469	0.0433	0.0458	0.0571	0.0573	0.0725	0.0779	0.0786					
HCRF EnMAP NIR (864 nm)	0.3796	0.3676	0.3758	0.3762	0.3538	0.3786	0.3801	0.3426	0.2799	0.2550	0.2549	0.2737	0.2698	0.2703	0.3637	0.3379	0.3603	0.3510	0.3385					
ANIF EnMAP rot (672 nm)	1.2222	1.0486	1.1775	1.4113	1.4153	1.3649	1.1907	0.8740	0.8185	0.8105	0.7964	0.7559	0.6979	0.7390	0.9217	0.9240	1.1691	1.2559	1.2684					
ANIF EnMAP NIR (864 nm)	1.0545	1.0211	1.0438	1.0451	0.9828	1.0516	1.0559	0.9515	0.7775	0.7083	0.7081	0.7602	0.7495	0.7507	1.0104	0.9386	1.0007	0.9751	0.9403					
Rel. Blue Absorption Depth	0.3373	0.3546	0.3479	0.3465	0.3208	0.3536	0.3670	0.3789	0.3457	0.3163	0.3148	0.3496	0.3419	0.3249	0.3557	0.3513	0.3459	0.3085	0.3264					
Rel. Red Absorption Depth	1.5493	1.7696	1.5943	1.2613	1.1640	1.3205	1.6007	1.9992	1.7132	1.5245	1.5249	1.7912	1.9593	1.8429	2.0462	1.8956	1.5331	1.3449	1.2521					
NDVI (EnMAP)	0.6672	0.6995	0.6746	0.6226	0.6026	0.6346	0.6747	0.7269	0.6931	0.6708	0.6755	0.7076	0.7236	0.7101	0.7285	0.7101	0.6650	0.6369	0.6230					
Nadir Norm. NDVI (AVHRR)	0.9374	0.9800	0.9503	0.8714	0.8466	0.8975	0.9531	1.0306	0.9933	0.9555	0.9631	1.0112	1.0290	1.0123	1.0280	1.0145	0.9335	0.8940	0.8736					
Nadir Norm. NDVI (MODIS)	0.9390	0.9820	0.9510	0.8740	0.8478	0.8979	0.9532	1.0315	0.9930	0.9565	0.9652	1.0122	1.0296	1.0119	1.0299	1.0133	0.9365	0.8967	0.8750					
Nadir Norm. NDVI (EnMAP)	0.9448	0.9905	0.9554	0.8817	0.8533	0.8987	0.9555	1.0293	0.9815	0.9498	0.9565	1.0020	1.0247	1.0055	1.0316	1.0056	0.9417	0.9019	0.8822					

V *Main Spectral Characteristics*

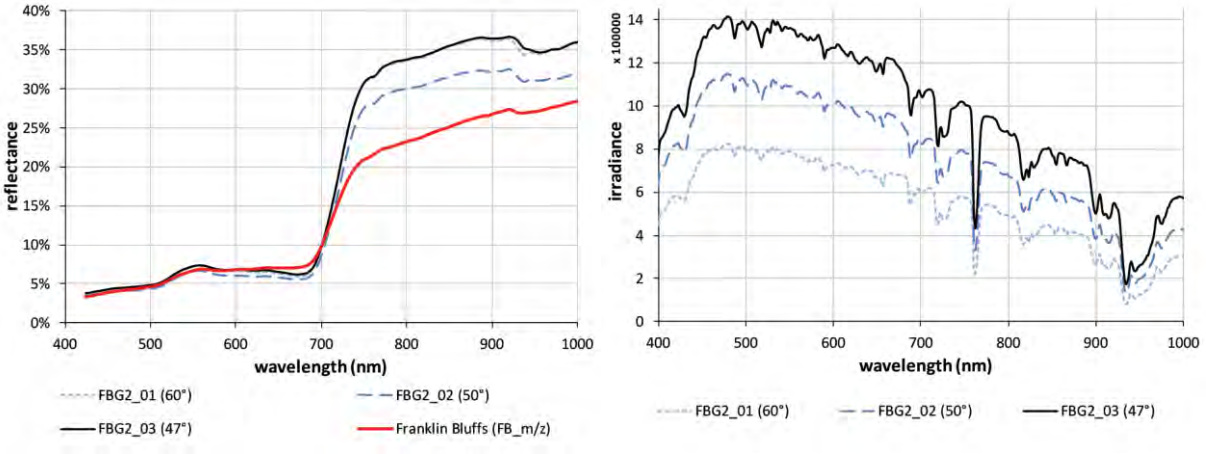

Figure C.2-6: Nadir reflectances and irradiance profiles of the FBG2 site at different sun zenith angles. Left: Comparison of the nadir reflectance signatures with the average zonal vegetation (MNT). Right: Comparison of the total irradiance profiles.

VI *HCRF Visualization*

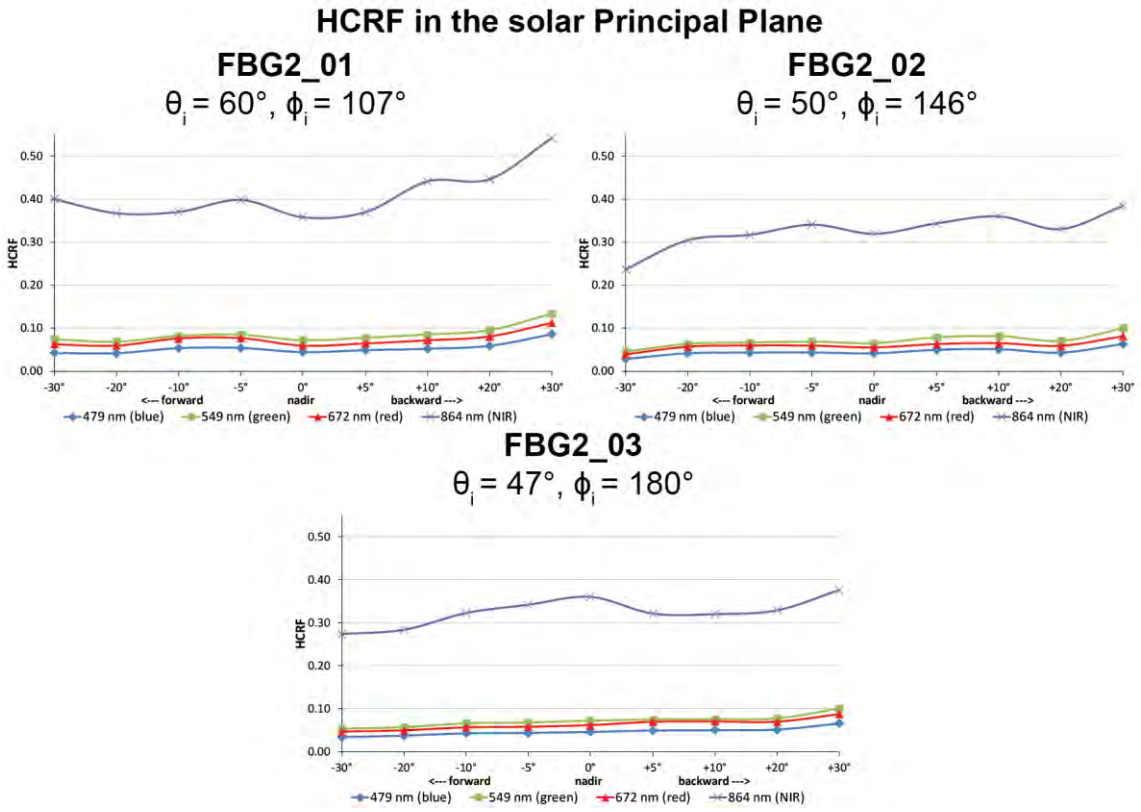

Figure C.2-7: Comparison of the HCRF values at 479 nm (blue), 549 nm (green), 672 nm (red), and 864 nm (NIR) in the solar principal plane of the FBG2 site at different sun zenith angles.

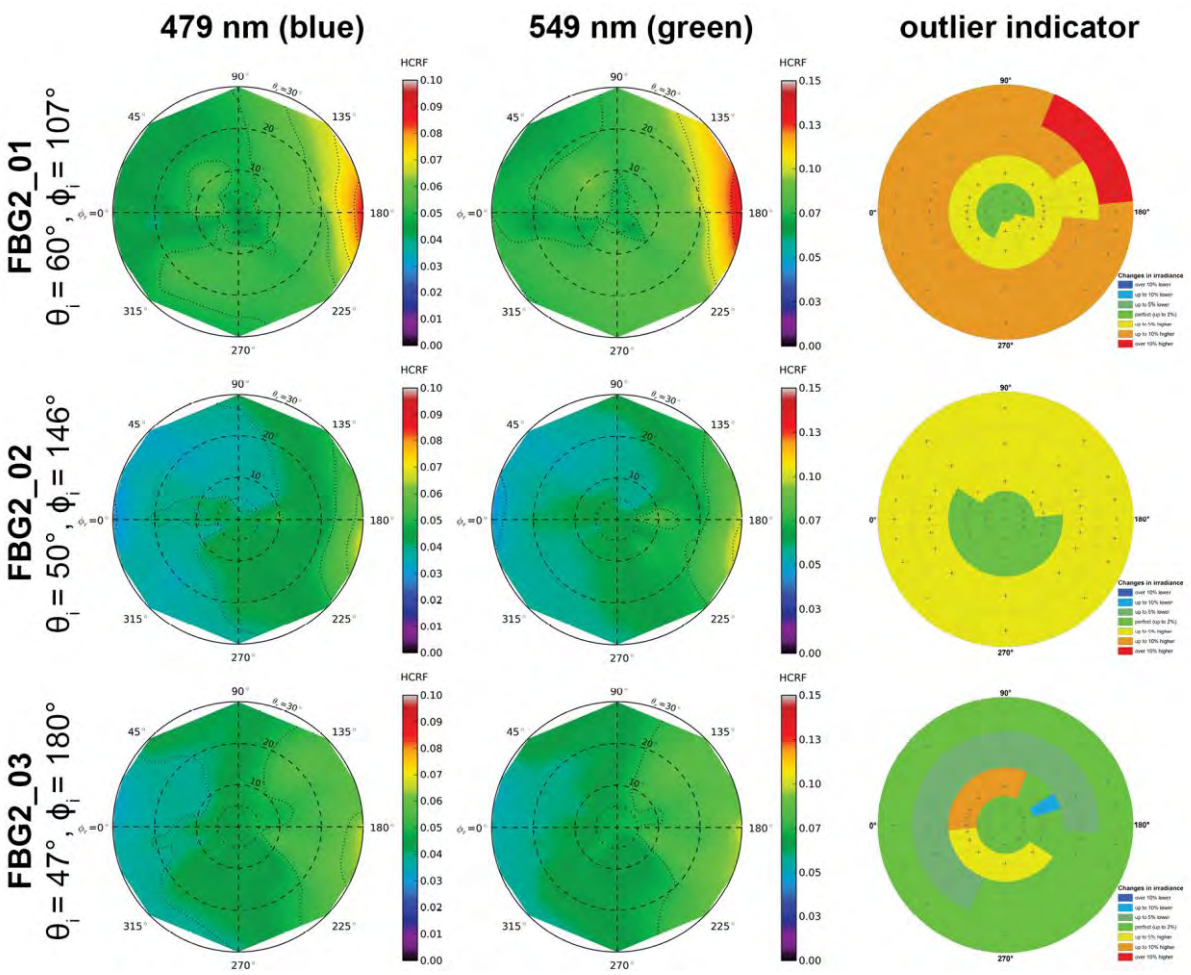

Figure C.2-8: HCRF visualization at 479 nm and 549 nm of the FBG2 site.

Figure C.2-9: Legend of the outlier indicator graphics shown in Figure C.2-8, C.2-10, and C.2-13

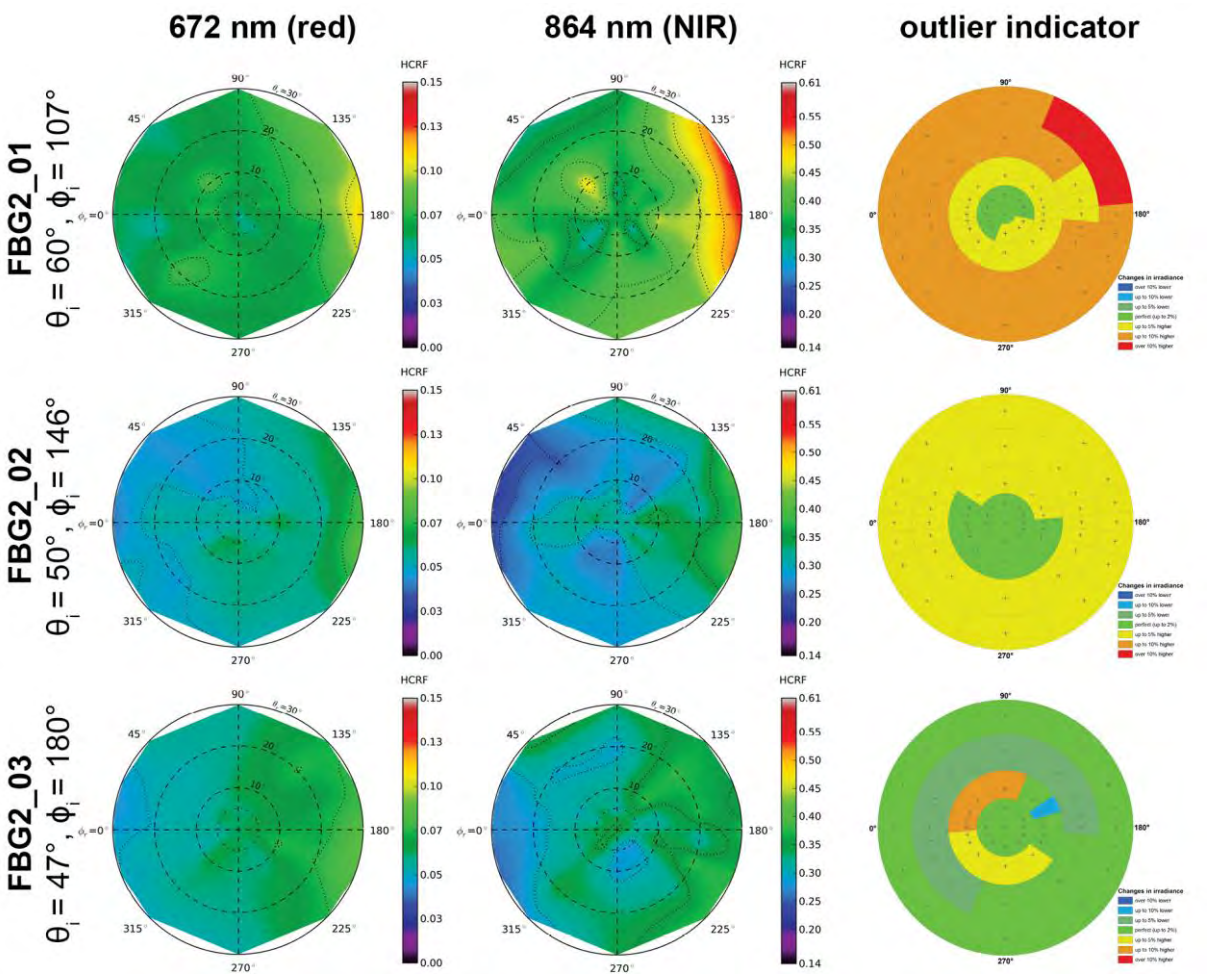

Figure C.2-10: HCRF visualization at 672 nm and 864 nm of the FBG2 site.

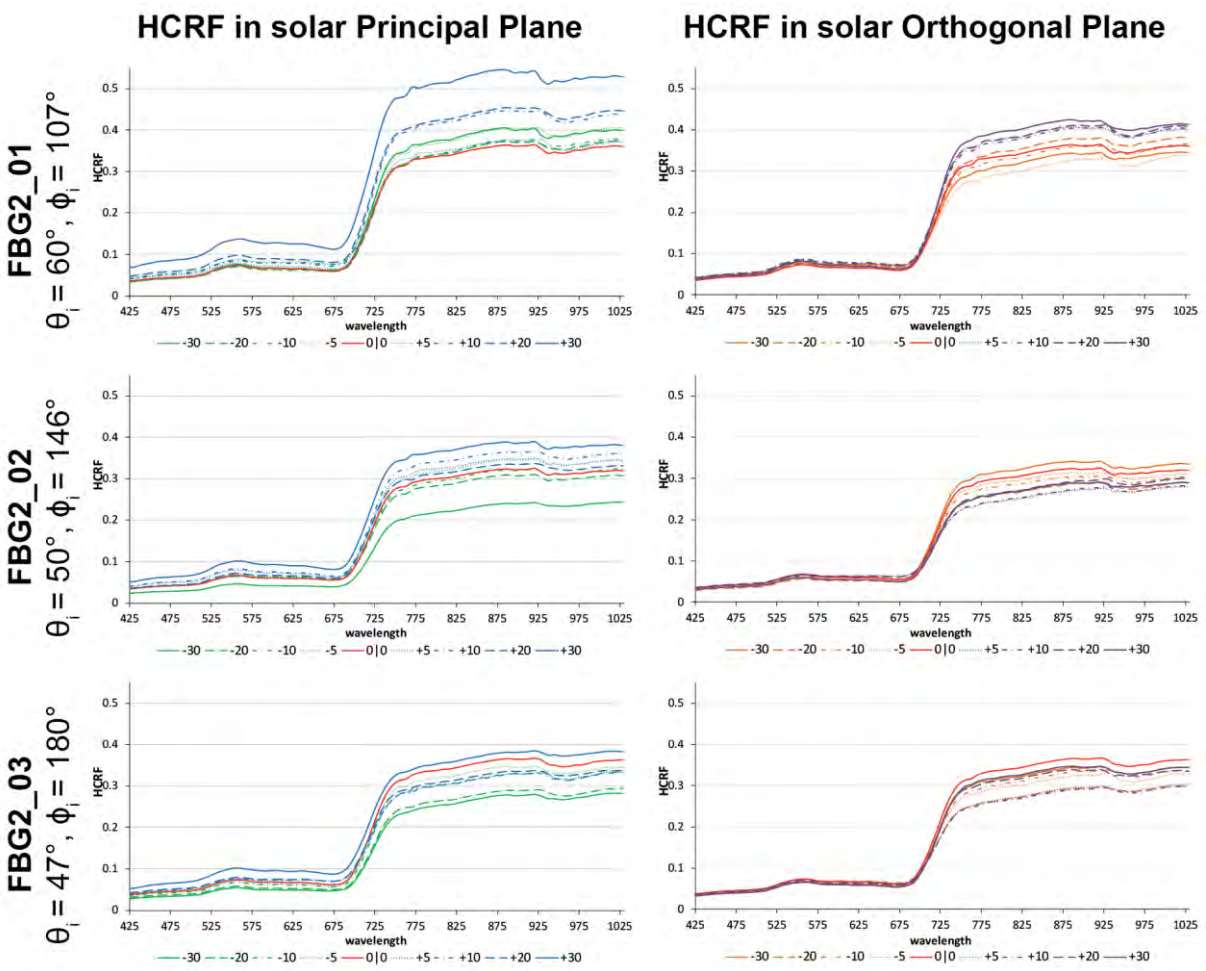

Figure C.2-11: HCRF visualization in principal & orthogonal plane of the FBG2 site.

VII *ANIF Visualization*

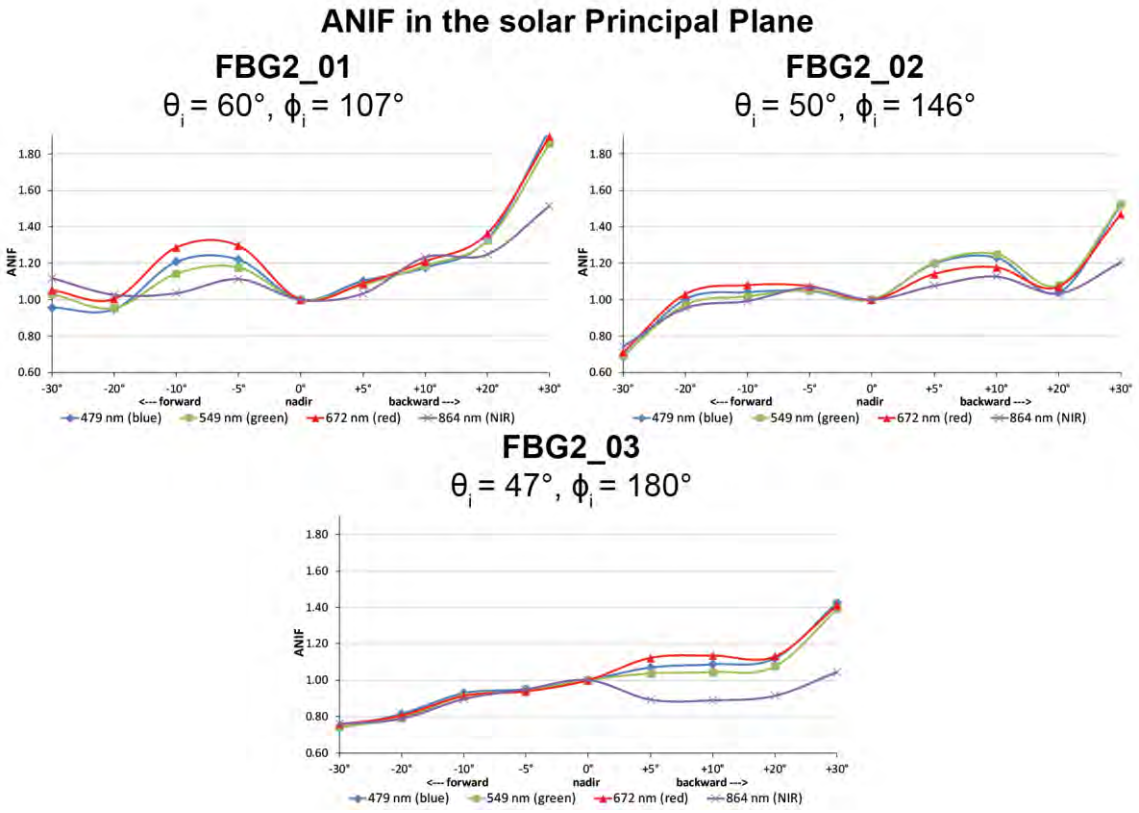

Figure C.2-12: Comparison of the ANIF values at 479 nm (blue), 549 nm (green), 672 nm (red), and 864 nm (NIR) in the solar principal plane of the FBG2 site at different sun zenith angles.

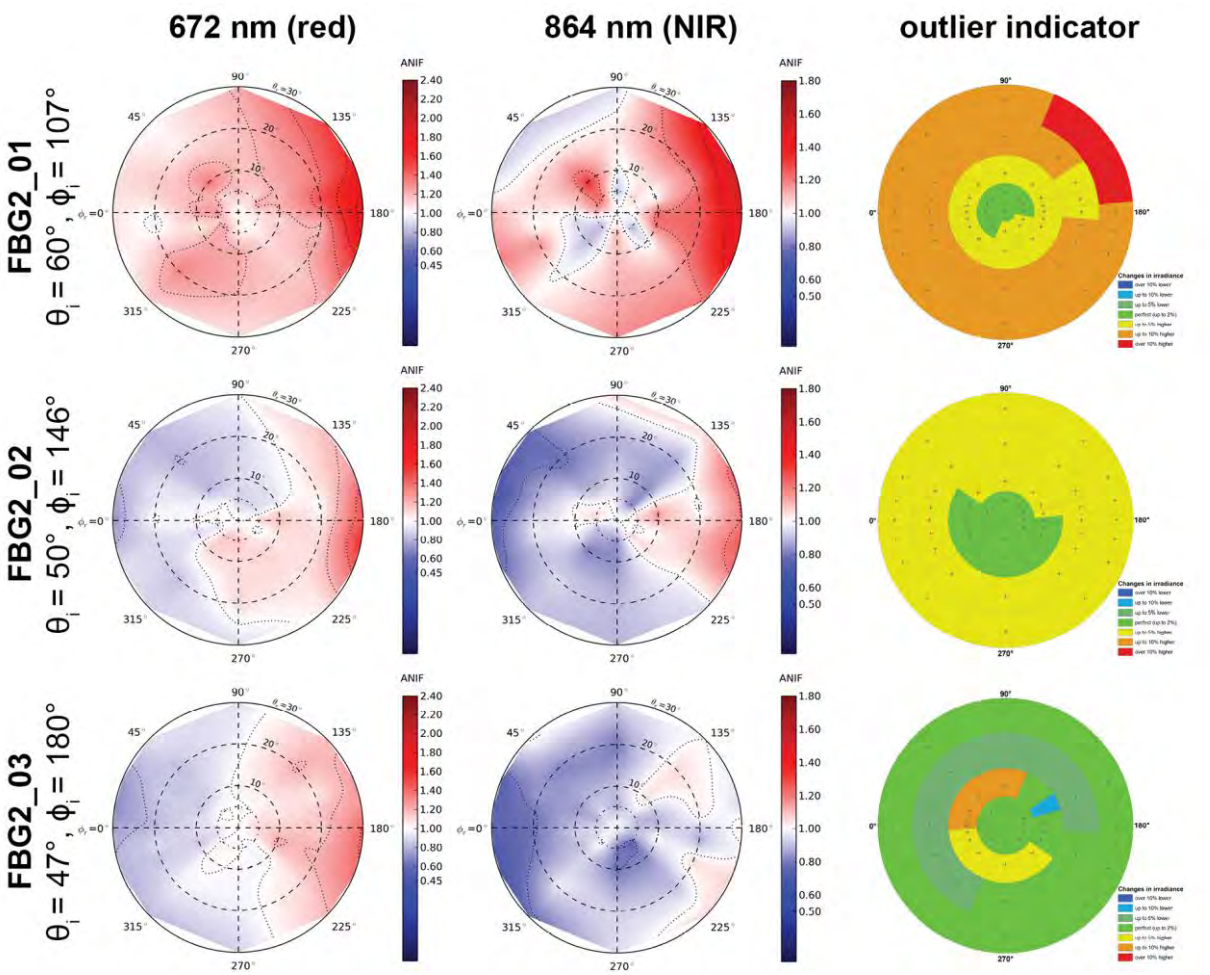

Figure C.2-13: ANIF visualization at 672 nm and 864 nm of the FBG2 site.

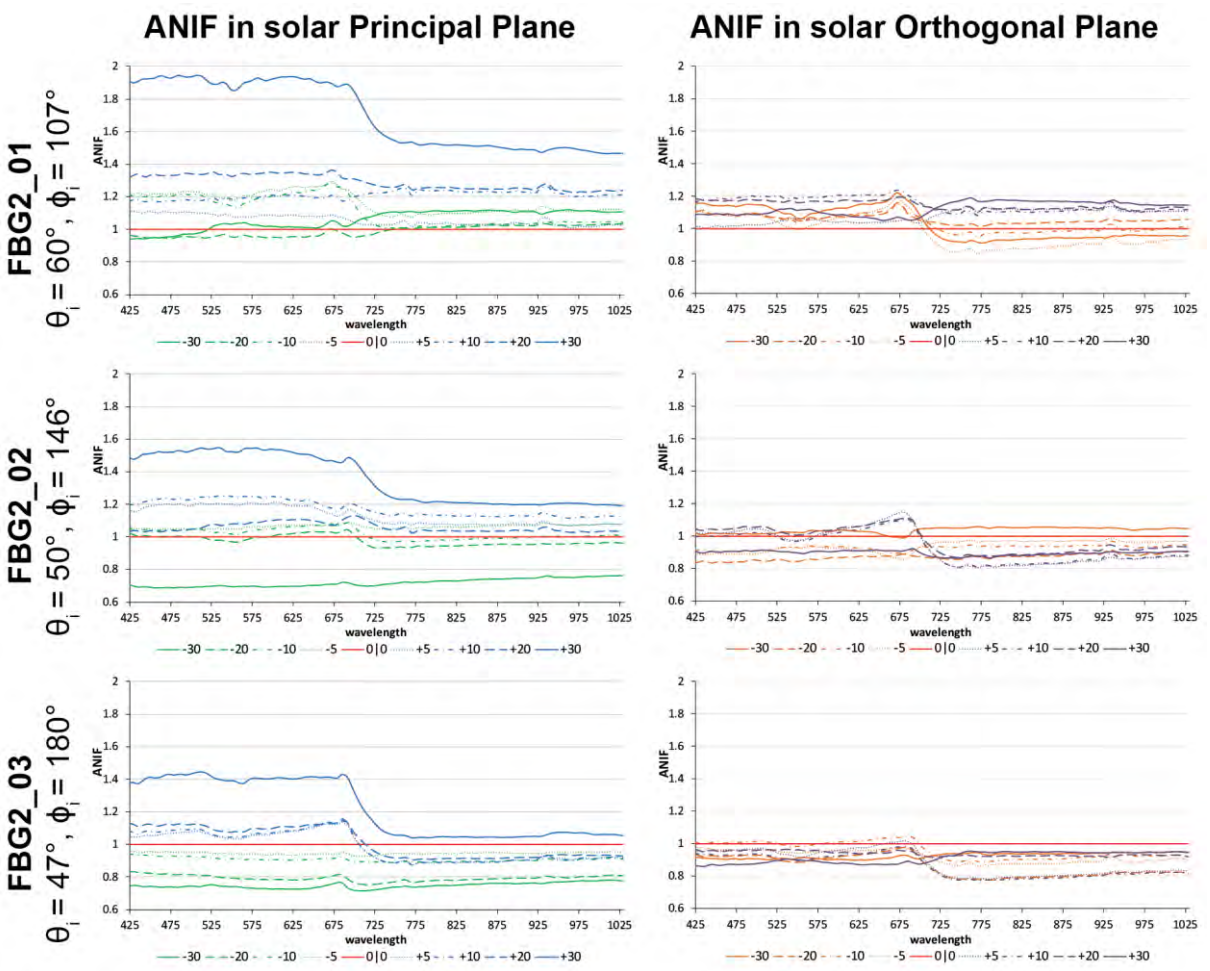

Figure C.2-14: ANIF visualization in principal & orthogonal plane of the FBG2 site.

VIII *ANIX Visualization*

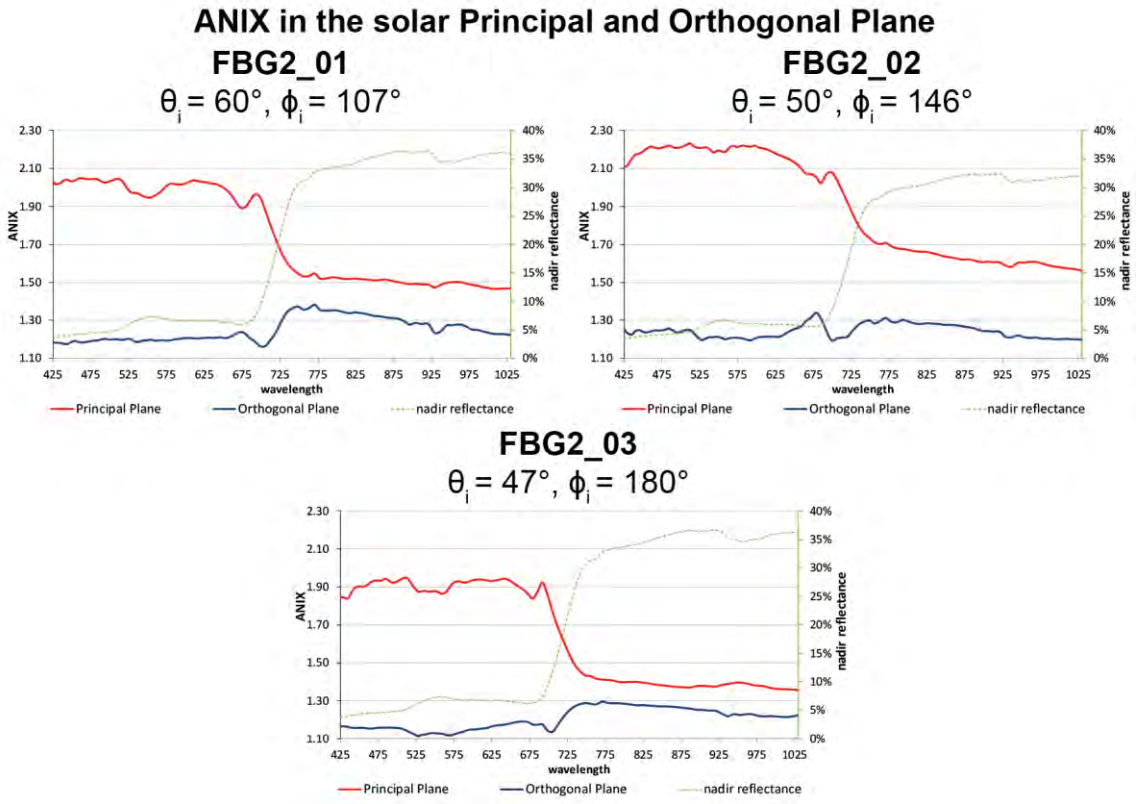

Figure C.2-15: Comparison of the ANIX in the solar principal and orthogonal plane with the nadir reflectance of the FBG2 site at different sun zenith angles.

IX *NDVI and Relative Absorption Depth Visualization*

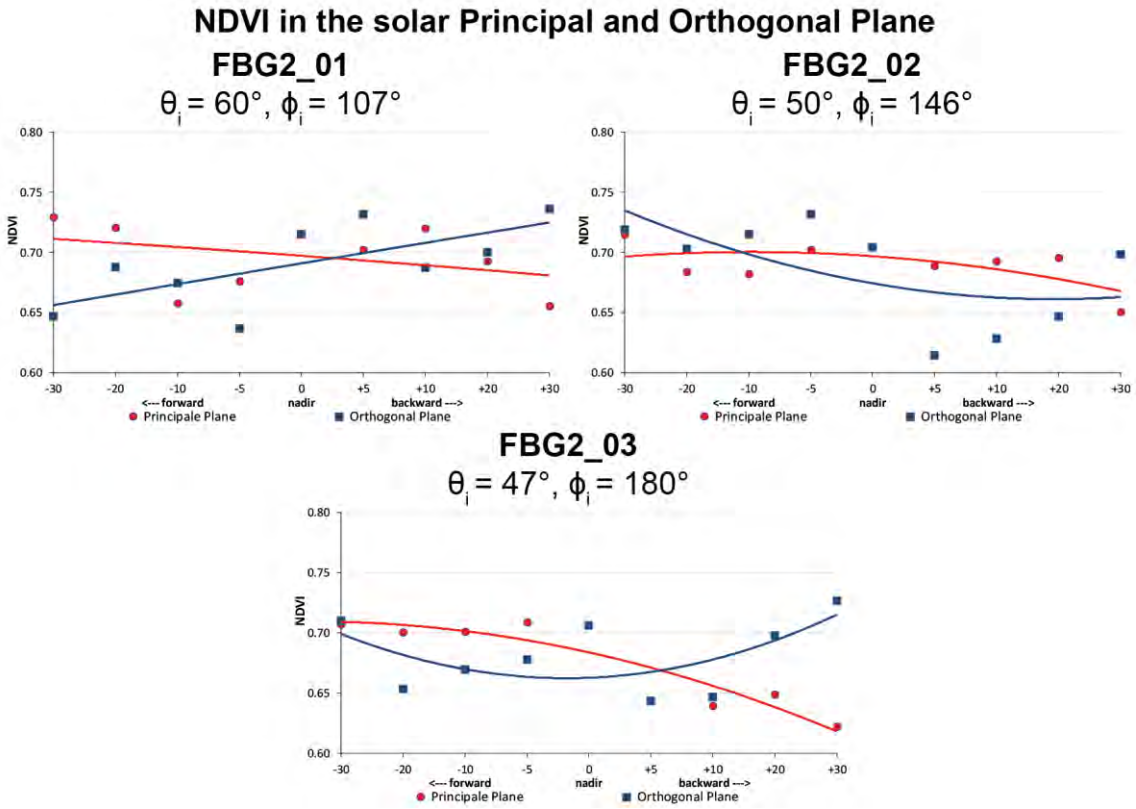

Figure C.2-16: Comparison of the NDVI in the solar principal and orthogonal plane of the FBG2 site at different sun zenith angles.

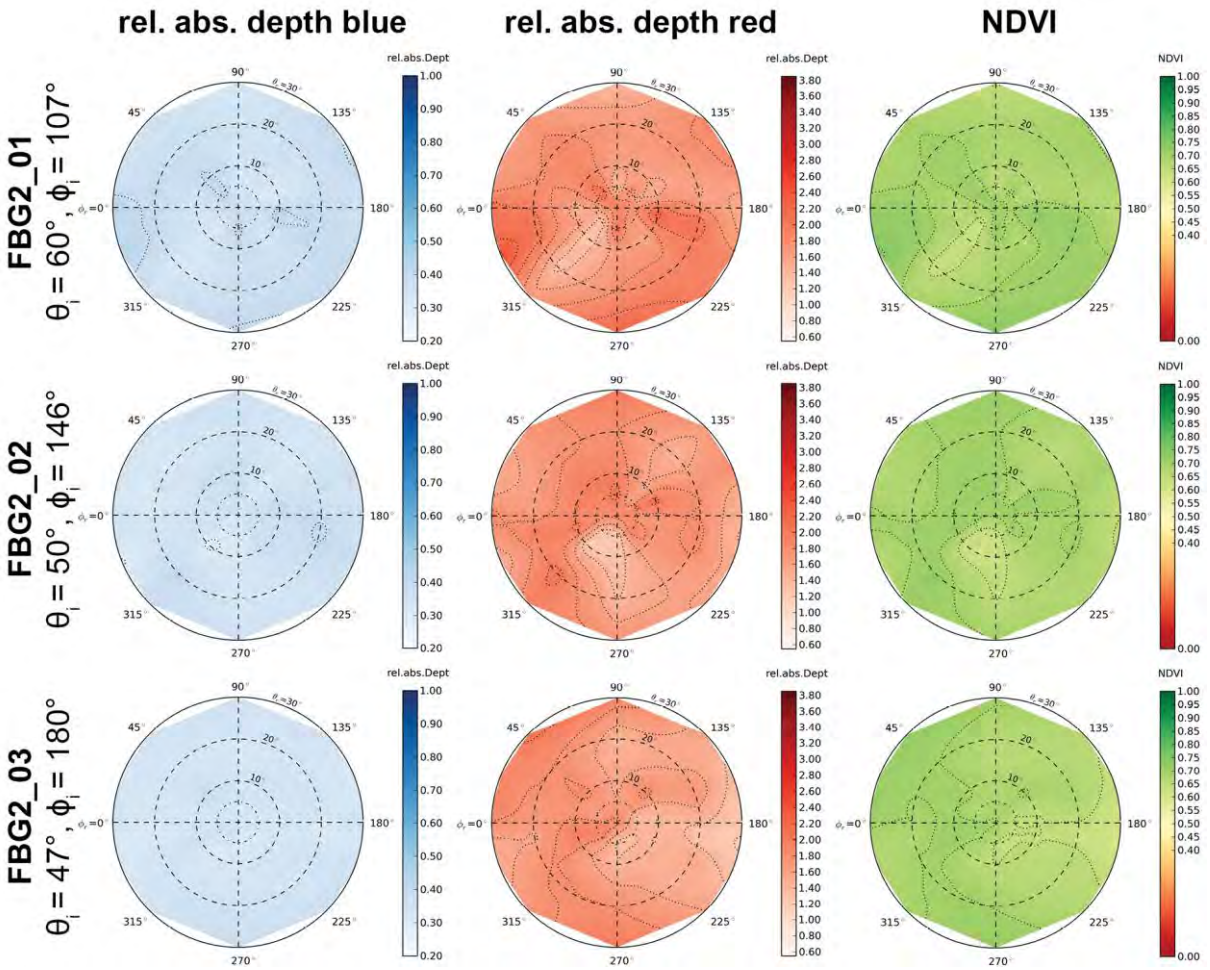

Figure C.2-17: Visualization of relative absorption depth & NDVI of the FBG2 site.

X *NDVI Comparison of Different Sensors*

Table C.2-5: Center wavelengths and band widths of the broadband and narrowband NDVIs, based on the spectral response curves of the AVHRR, MODIS and EnMAP sensors.

NDVI	Sensor	Sensor band	Center wavelength (nm)	band width (nm)
$NDVI_{AVHRR}$ [broadband]	AVHRR/3	red: band 1 NIR: band 2	630 865	100 275
$NDVI_{MODIS}$ [broadband]	MODIS	red: band 1 NIR: band 2	645 859	50 35
$NDVI_{EnMAP}$ [narrowband]	EnMAP	red: band 47 NIR: band 73	672 864	6.5 8

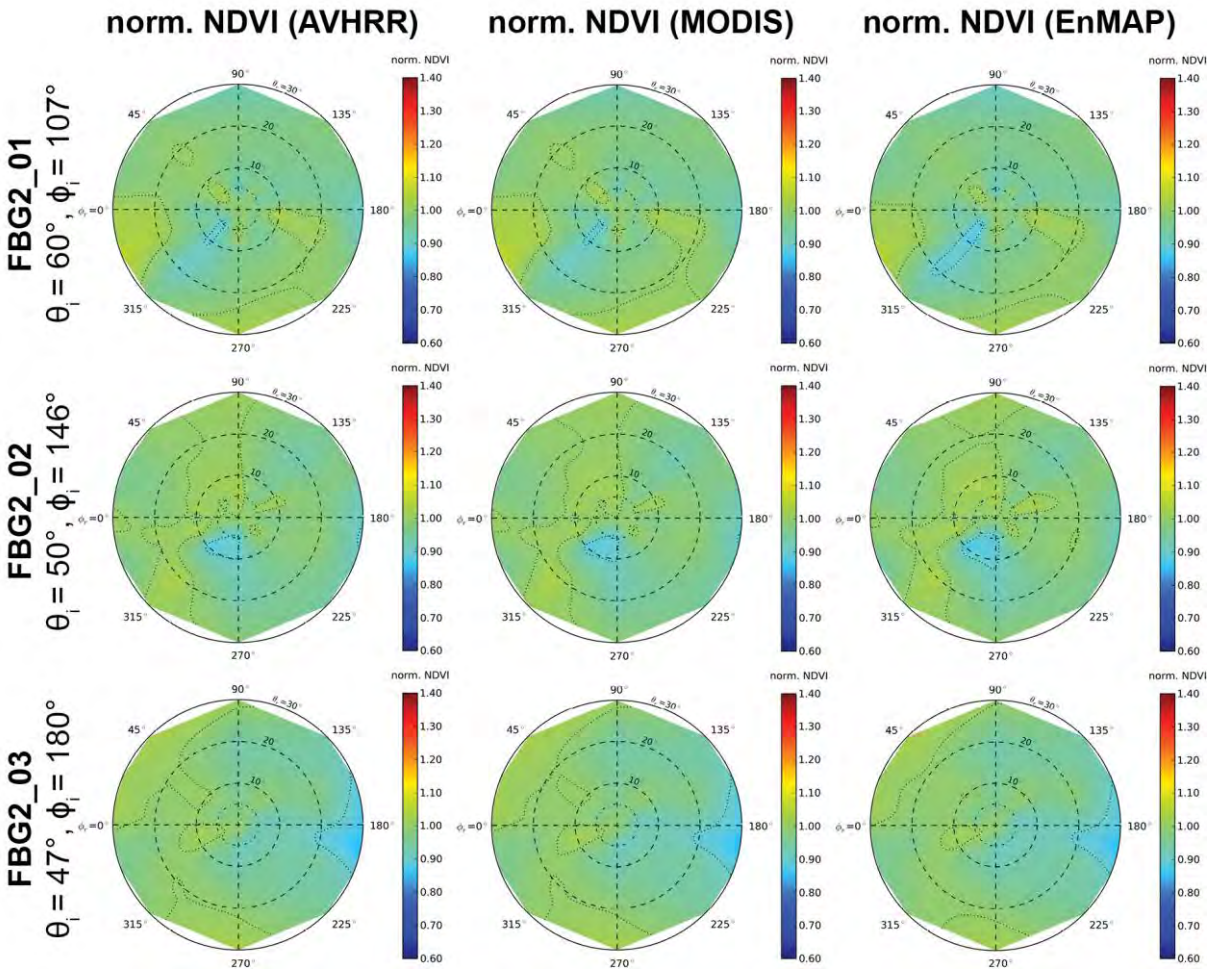

Figure C.2-18: Comparison of AVHRR, MODIS & EnMAP NDVI of the FBG2 site.