C.8 Study site VDG2 (grazed sedge, dwarf shrub, moss tundra)

I *Location*

Name	Location	Latitude	Longitude	Altitude
VDG2	Vaskiny Dachi, Yamal Peninsula, West Siberia, Russian Federation	70.275667°	68.890767°	45 m

Vaskiny Dachi is located southeast of the main Bovanenkova gas field in the central part of the Yamal Peninsula. Vaskiny Dachi is the name of a field camp established by Dr. Marina Leibman. The research sites are located in the watersheds of the Se-Yakha and Mordy-Ykha rivers. The Vaskiny Dachi-1 study site is on a gentle Terrace-IV hill-top, which is on a Kazantsevskaya coastal-marine plain (Terrace IV) at 40-45 m elevation and built of interbedding of clayey and sandy deposits with a considerable amount of organic matter dispersed in the section. [*Walker et al.*, 2009]

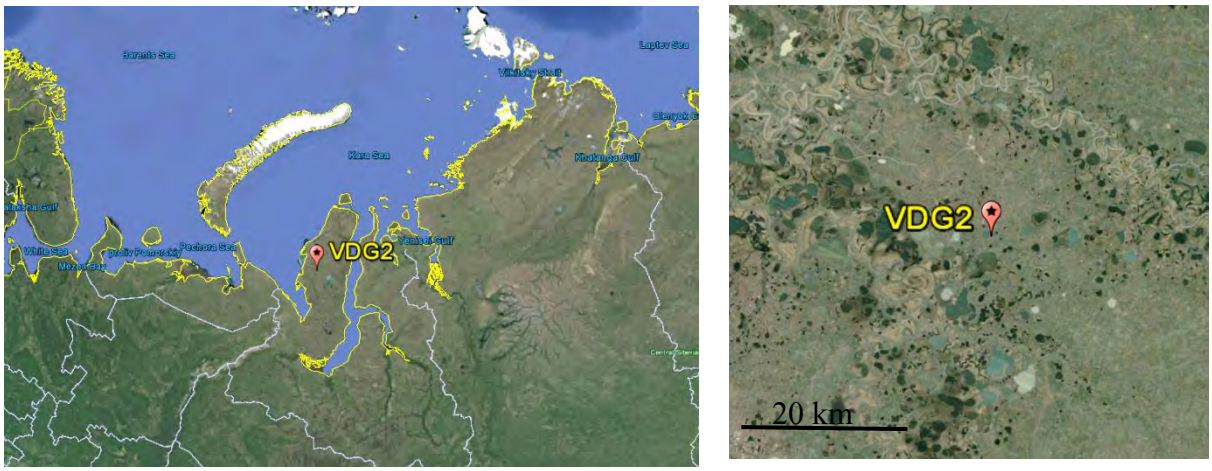

Figure C.8-1: Location of study site VDG2 in Yamal, Russia. *Source:* Google Earth, 2013

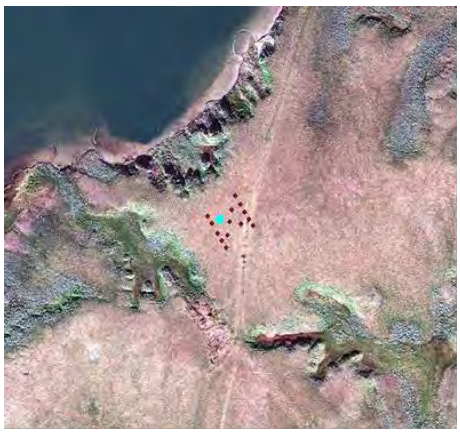

Figure C.8-2: Satellite image of the 100 x 100 m zonal grid at the Vaskiny Dachi study location where the VDG2 site is located. *Source:* Google Earth, 2013

II *Main Vegetation Description*

The soils are clay and the vegetation is heavily grazed sedge – dwarf shrub - moss tundra dominated by *Carex bigelowii*, *Vaccinium vitis-idaea*, *Salix glauca*, *Hylocomium splendens*, and *Aulacomnium turgidum*. The surfaces sometimes have windblown sands, but are mainly tussocky, hummocky or frost-boil tundra and peatland in the lower areas. [*Walker et al.*, 2009]

Figure C.8-3: Overview images of the grazed tundra at the mesic Vaskiny Dachi study location near the VDG2 site. *Source:* [*Heim et al.*, 2012]

III *Vegetation Description of the VDG2 Site*

The focus of the measurements at this goniometer site has been grazed sedge – dwarf shrub - moss tundra. The 1 x 1 m plot was homogeneously grazed by reindeer.

Figure C.8-4: Overview images of the VDG2 vegetation from cardinal directions.

Figure C.8-5: Quasi-nadir image of the VDG2 vegetation (grazed tundra).

IV *Overview of the Spectro-Goniometer Measurements*

Table C.8-1: Overview of the spectro-goniometer measurements at the VDG2 study site.

Name	Day	Starting Time	Duration	SAA	SZA	Sky
VDG2_01	2011-08-29	10:04:03	39 min	124°	69°	cirrostratus
VDG2_02	2011-08-29	11:15:22	38 min	143°	64°	cirrostratus
VDG2_03	2011-08-29	12:31:47	42 min	164°	61°	cirrostratus

Table C.8-2: Spectro-directional data of the VDG2_01 spectro-goniometer measurement.

VDG2_01 (SZA = 69°; SAA = 124°)	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|190	10|202.5	10|225	10|270	10|315	10|337.5	10|350
HCRF EnMAP blue (479 nm)	0.0228	0.0230	0.0217	0.0213	0.0200	0.0198	0.0246	0.0272	0.0223	0.0223	0.0209	0.0211	0.0200	0.0267	0.0240	0.0209	0.0176	0.0201	0.0178	0.0195	0.0267
HCRF EnMAP green (549 nm)	0.0381	0.0393	0.0362	0.0405	0.0343	0.0341	0.0426	0.0458	0.0390	0.0387	0.0384	0.0351	0.0330	0.0450	0.0415	0.0361	0.0302	0.0342	0.0289	0.0343	0.0433
HCRF EnMAP rot (672 nm)	0.0572	0.0575	0.0583	0.0577	0.0499	0.0483	0.0626	0.0690	0.0600	0.0584	0.0587	0.0524	0.0514	0.0687	0.0622	0.0569	0.0480	0.0536	0.0439	0.0529	0.0654
HCRF EnMAP NIR (864 nm)	0.2265	0.2186	0.2154	0.2155	0.1943	0.1842	0.2420	0.2555	0.2217	0.2171	0.2355	0.1957	0.2047	0.2582	0.2269	0.2209	0.2046	0.1949	0.1676	0.2042	0.2414
ANIF EnMAP rot (672 nm)	1.0000	1.0051	1.0197	1.0094	0.8730	0.8447	1.0943	1.2064	1.0489	1.0217	1.0266	0.9162	0.8986	1.2025	1.0878	0.9950	0.8404	0.9375	0.7684	0.9261	1.1438
ANIF EnMAP NIR (864 nm)	1.0000	0.9652	0.9512	0.9517	0.8581	0.8134	1.0686	1.1283	0.9788	0.9587	1.0398	0.8640	0.9040	1.1403	1.0021	0.9756	0.9034	0.8604	0.7400	0.9017	1.0662
Rel. Blue Absorption Depth	0.4046	0.4046	0.3911	0.5215	0.4173	0.4236	0.4324	0.4069	0.4336	0.4214	0.4743	0.3804	0.3895	0.4017	0.4283	0.4161	0.4134	0.4190	0.3579	0.4250	0.3832
Rel. Red Absorption Depth	0.9838	0.9649	0.9386	0.9319	0.9670	0.9432	0.9710	0.9158	0.9198	0.9318	1.0423	0.9193	1.0310	0.9685	0.9294	1.0225	1.1326	0.9070	0.9655	0.9639	0.9363
NDVI (EnMAP)	0.5969	0.5837	0.5741	0.5776	0.5913	0.5846	0.5892	0.5749	0.5742	0.5760	0.6010	0.5777	0.5988	0.5795	0.5698	0.5905	0.6197	0.5686	0.5847	0.5882	0.5738
Nadir Norm. NDVI (AVHRR)	1.0000	0.9743	0.9842	0.9789	0.9928	0.9841	0.9857	0.9666	0.9748	0.9675	1.0110	0.9702	1.0086	0.9684	0.9604	0.9916	1.0365	0.9678	0.9914	0.9922	0.9714
Nadir Norm. NDVI (MODIS)	1.0000	0.9717	0.9750	0.9743	0.9835	0.9784	0.9844	0.9646	0.9726	0.9672	1.0084	0.9679	1.0012	0.9698	0.9580	0.9873	1.0327	0.9634	0.9874	0.9904	0.9679
Nadir Norm. NDVI (EnMAP)	1.0000	0.9779	0.9618	0.9677	0.9906	0.9794	0.9871	0.9632	0.9619	0.9650	1.0069	0.9678	1.0032	0.9709	0.9546	0.9893	1.0381	0.9525	0.9795	0.9855	0.9613

(cont.)

VDG2_01 (SZA = 69°; SAA = 124°)	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)	0.0254	0.0212	0.0210	0.0206	0.0226	0.0192	0.0245	0.0262	0.0277	0.0253	0.0221	0.0208	0.0214	0.0200	0.0234	0.0243	0.0205	0.0222	0.0228	0.0246	0.0226
HCRF EnMAP green (549 nm)	0.0420	0.0366	0.0361	0.0335	0.0378	0.0314	0.0393	0.0425	0.0470	0.0444	0.0371	0.0361	0.0371	0.0322	0.0387	0.0422	0.0350	0.0390	0.0388	0.0406	0.0377
HCRF EnMAP rot (672 nm)	0.0615	0.0550	0.0543	0.0527	0.0567	0.0497	0.0587	0.0655	0.0691	0.0669	0.0606	0.0548	0.0571	0.0499	0.0581	0.0617	0.0544	0.0592	0.0594	0.0627	0.0557
HCRF EnMAP NIR (864 nm)	0.2393	0.2061	0.1955	0.2033	0.2387	0.1905	0.2252	0.2532	0.2572	0.2463	0.2367	0.2248	0.2082	0.1859	0.2218	0.2412	0.2102	0.2169	0.2139	0.2344	0.2303
ANIF EnMAP rot (672 nm)	1.0760	0.9614	0.9504	0.9216	0.9915	0.8688	1.0267	1.1462	1.2090	1.1707	1.0607	0.9590	0.9996	0.8731	1.0166	1.0794	0.9516	1.0362	1.0390	1.0961	0.9736
ANIF EnMAP NIR (864 nm)	1.0565	0.9100	0.8632	0.8978	1.0541	0.8410	0.9942	1.1182	1.1357	1.0875	1.0452	0.9928	0.9195	0.8211	0.9796	1.0650	0.9281	0.9576	0.9445	1.0350	1.0171
Rel. Blue Absorption Depth	0.3774	0.4225	0.4202	0.3808	0.4028	0.3779	0.3490	0.3671	0.4160	0.4321	0.3886	0.4287	0.4325	0.3605	0.3948	0.4218	0.4115	0.4415	0.4287	0.3864	0.4070
Rel. Red Absorption Depth	0.9793	0.9298	0.8934	0.9883	1.1233	0.9720	0.9793	1.0215	0.9561	0.9452	1.0412	1.1009	0.9097	0.9444	0.9596	0.9754	0.9586	0.9189	0.8785	0.9463	1.0913
NDVI (EnMAP)	0.5910	0.5789	0.5651	0.5884	0.6163	0.5863	0.5865	0.5889	0.5764	0.5727	0.5922	0.6079	0.5694	0.5768	0.5848	0.5926	0.5888	0.5709	0.5653	0.5781	0.6108
Nadir Norm. NDVI (AVHRR)	0.9854	0.9737	0.9568	0.9935	1.0207	0.9961	0.9833	0.9940	0.9636	0.9595	1.0092	1.0171	0.9640	0.9807	0.9814	0.9935	0.9947	0.9653	0.9612	0.9858	1.0147
Nadir Norm. NDVI (MODIS)	0.9831	0.9710	0.9568	0.9924	1.0177	0.9901	0.9786	0.9865	0.9598	0.9553	1.0027	1.0127	0.9637	0.9762	0.9776	0.9920	0.9918	0.9642	0.9610	0.9776	1.0109
Nadir Norm. NDVI (EnMAP)	0.9901	0.9699	0.9467	0.9858	1.0324	0.9823	0.9825	0.9866	0.9656	0.9594	0.9920	1.0185	0.9538	0.9663	0.9798	0.9927	0.9864	0.9565	0.9471	0.9685	1.0233

(cont.)

VDG2_01 (SZA = 69°; SAA = 124°)	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)	0.0241	0.0283	0.0300	0.0288	0.0284	0.0282	0.0266	0.0228	0.0226	0.0253	0.0253	0.0258	0.0209	0.0243	0.0267	0.0225	0.0292	0.0338	0.0307					
HCRF EnMAP green (549 nm)	0.0388	0.0460	0.0497	0.0477	0.0486	0.0495	0.0464	0.0389	0.0378	0.0439	0.0421	0.0430	0.0379	0.0427	0.0437	0.0391	0.0473	0.0563	0.0521					
HCRF EnMAP rot (672 nm)	0.0597	0.0694	0.0739	0.0763	0.0762	0.0719	0.0711	0.0574	0.0558	0.0625	0.0614	0.0638	0.0525	0.0603	0.0621	0.0555	0.0710	0.0815	0.0787					
HCRF EnMAP NIR (864 nm)	0.2295	0.2571	0.2691	0.2747	0.2672	0.2588	0.2419	0.2045	0.2060	0.2367	0.2316	0.2376	0.2151	0.2408	0.2315	0.2143	0.2420	0.2836	0.2856					
ANIF EnMAP rot (672 nm)	1.0448	1.2148	1.2932	1.3348	1.3323	1.2572	1.2436	1.0034	0.9758	1.0926	1.0747	1.1167	0.9189	1.0549	1.0860	0.9703	1.2424	1.4250	1.3766					
ANIF EnMAP NIR (864 nm)	1.0132	1.1352	1.1882	1.2128	1.1797	1.1430	1.0680	0.9028	0.9094	1.0451	1.0225	1.0490	0.9497	1.0633	1.0220	0.9465	1.0685	1.2525	1.2609					
Rel. Blue Absorption Depth	0.3666	0.3693	0.3824	0.3901	0.4133	0.4324	0.4219	0.4113	0.3937	0.4352	0.3976	0.3959	0.4654	0.4416	0.3847	0.4361	0.3586	0.3906	0.4099					
Rel. Red Absorption Depth	0.9896	0.9686	0.9500	0.9688	0.9173	0.9332	0.8548	0.8889	0.9269	0.9455	0.9431	0.9433	1.0346	1.0350	0.9665	0.9829	0.8527	0.9237	0.9737					
NDVI (EnMAP)	0.5869	0.5747	0.5690	0.5652	0.5563	0.5654	0.5457	0.5618	0.5738	0.5824	0.5806	0.5764	0.6074	0.5995	0.5770	0.5888	0.5462	0.5538	0.5679					
Nadir Norm. NDVI (AVHRR)	0.9819	0.9628	0.9571	0.9591	0.9431	0.9506	0.9276	0.9517	0.9688	0.9728	0.9712	0.9686	0.9982	0.9895	0.9637	0.9822	0.9256	0.9278	0.9525					
Nadir Norm. NDVI (MODIS)	0.9798	0.9602	0.9525	0.9505	0.9377	0.9461	0.9234	0.9500	0.9661	0.9750	0.9720	0.9674	1.0006	0.9898	0.9626	0.9854	0.9235	0.9269	0.9465					
Nadir Norm. NDVI (EnMAP)	0.9833	0.9628	0.9532	0.9468	0.9321	0.9472	0.9142	0.9413	0.9612	0.9757	0.9727	0.9657	1.0176	1.0043	0.9667	0.9865	0.9150	0.9277	0.9514					

Table C.8-3: Spectro-directional data of the VDG2_02 spectro-goniometer measurement.

VDG2_02 (SZA = 64°; SAA = 143°)	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|190	10|202.5	10|225	10|270	10|315	10|337.5	10|350
HCRF EnMAP blue (479 nm)	0.0217	0.0256	0.0221	0.0215	0.0233	0.0224	0.0273	0.0254	0.0227	0.0258	0.0221	0.0253	0.0261	0.0249	0.0251	0.0225	0.0226	0.0244	0.0231	0.0257	0.0269
HCRF EnMAP green (549 nm)	0.0368	0.0435	0.0366	0.0351	0.0402	0.0370	0.0457	0.0422	0.0374	0.0417	0.0383	0.0431	0.0442	0.0432	0.0415	0.0360	0.0376	0.0393	0.0395	0.0415	0.0438
HCRF EnMAP rot (672 nm)	0.0583	0.0658	0.0595	0.0563	0.0602	0.0578	0.0663	0.0647	0.0572	0.0629	0.0569	0.0640	0.0666	0.0642	0.0639	0.0570	0.0609	0.0611	0.0604	0.0605	0.0648
HCRF EnMAP NIR (864 nm)	0.2209	0.2471	0.2378	0.2203	0.2126	0.2168	0.2543	0.2414	0.2285	0.2450	0.2244	0.2561	0.2652	0.2465	0.2642	0.2417	0.2306	0.2132	0.2303	0.2290	0.2356
ANIF EnMAP rot (672 nm)	1.0000	1.1277	1.0203	0.9652	1.0318	0.9905	1.1363	1.1097	0.9807	1.0783	0.9752	1.0969	1.1419	1.0998	1.0945	0.9774	1.0437	1.0465	1.0357	1.0364	1.1105
ANIF EnMAP NIR (864 nm)	1.0000	1.1186	1.0765	0.9974	0.9625	0.9812	1.1513	1.0926	1.0342	1.1091	1.0159	1.1591	1.2006	1.1157	1.1958	1.0941	1.0438	0.9650	1.0424	1.0365	1.0665
Rel. Blue Absorption Depth	0.4057	0.4054	0.3787	0.3689	0.4295	0.3765	0.3952	0.3954	0.3843	0.3651	0.4146	0.3947	0.3957	0.4226	0.3757	0.3449	0.3812	0.3655	0.4004	0.3542	0.3761
Rel. Red Absorption Depth	0.9373	0.9255	1.0286	1.0310	0.8512	0.9528	0.9490	0.9153	1.0109	0.9846	0.9683	1.0341	1.0350	0.9846	1.0870	1.1454	0.9836	0.8652	0.9667	0.9598	0.9104
NDVI (EnMAP)	0.5822	0.5795	0.5996	0.5929	0.5587	0.5790	0.5865	0.5770	0.5994	0.5914	0.5955	0.6001	0.5985	0.5869	0.6107	0.6182	0.5822	0.5547	0.5843	0.5822	0.5686
Nadir Norm. NDVI (AVHRR)	1.0000	0.9896	1.0284	1.0160	0.9583	0.9944	0.9896	0.9857	1.0215	1.0075	1.0106	1.0131	1.0198	0.9969	1.0291	1.0486	1.0016	0.9525	0.9928	0.9816	0.9698
Nadir Norm. NDVI (MODIS)	1.0000	0.9901	1.0229	1.0100	0.9609	0.9902	0.9910	0.9863	1.0192	1.0057	1.0142	1.0141	1.0193	0.9965	1.0249	1.0407	0.9967	0.9559	0.9964	0.9832	0.9729
Nadir Norm. NDVI (EnMAP)	1.0000	0.9954	1.0300	1.0185	0.9597	0.9946	1.0074	0.9911	1.0297	1.0159	1.0229	1.0308	1.0280	1.0081	1.0490	1.0619	1.0001	0.9529	1.0037	1.0001	0.9768

(cont.)

VDG2_02 (SZA = 64°; SAA = 143°)	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)	0.0243	0.0237	0.0248	0.0218	0.0235	0.0275	0.0280	0.0271	0.0276	0.0287	0.0302	0.0212	0.0225	0.0254	0.0274	0.0256	0.0241	0.0284	0.0240	0.0243	0.0232
HCRF EnMAP green (549 nm)	0.0415	0.0404	0.0416	0.0388	0.0389	0.0470	0.0455	0.0437	0.0452	0.0447	0.0469	0.0343	0.0376	0.0437	0.0442	0.0427	0.0415	0.0472	0.0414	0.0423	0.0394
HCRF EnMAP rot (672 nm)	0.0601	0.0581	0.0587	0.0566	0.0585	0.0687	0.0708	0.0669	0.0708	0.0700	0.0710	0.0558	0.0565	0.0637	0.0670	0.0654	0.0638	0.0699	0.0613	0.0599	0.0560
HCRF EnMAP NIR (864 nm)	0.2447	0.2318	0.2265	0.2289	0.2316	0.2676	0.2705	0.2469	0.2745	0.2666	0.2589	0.2046	0.2056	0.2486	0.2604	0.2601	0.2617	0.2671	0.2387	0.2382	0.2090
ANIF EnMAP rot (672 nm)	1.0307	0.9960	1.0056	0.9700	1.0021	1.1773	1.2136	1.1470	1.2137	1.1995	1.2165	0.9566	0.9678	1.0920	1.1478	1.1211	1.0937	1.1977	1.0501	1.0275	0.9595
ANIF EnMAP NIR (864 nm)	1.1077	1.0493	1.0253	1.0361	1.0482	1.2112	1.2247	1.1179	1.2427	1.2069	1.1720	0.9261	0.9305	1.1252	1.1789	1.1773	1.1849	1.2090	1.0805	1.0784	0.9461
Rel. Blue Absorption Depth	0.4179	0.4069	0.4145	0.4519	0.3767	0.4159	0.3804	0.3640	0.3656	0.3324	0.3324	0.3692	0.3912	0.4169	0.3638	0.3962	0.4126	0.4008	0.4131	0.4318	0.4095
Rel. Red Absorption Depth	1.0354	1.0073	0.9644	1.0299	1.0274	0.9919	1.0074	0.9581	1.0023	0.9788	0.9477	0.9048	0.8859	0.9628	0.9772	0.9836	1.0402	0.9528	0.9705	1.0133	0.9180
NDVI (EnMAP)	0.6055	0.5991	0.5885	0.6035	0.5968	0.5915	0.5852	0.5736	0.5899	0.5842	0.5697	0.5714	0.5690	0.5920	0.5909	0.5981	0.6080	0.5853	0.5915	0.5979	0.5775
Nadir Norm. NDVI (AVHRR)	1.0138	1.0106	0.9917	1.0199	1.0053	1.0011	0.9961	0.9729	1.0068	0.9975	0.9703	0.9854	0.9745	1.0030	1.0071	1.0199	1.0347	0.9928	1.0013	1.0060	0.9746
Nadir Norm. NDVI (MODIS)	1.0178	1.0143	0.9930	1.0242	1.0066	1.0042	0.9960	0.9694	1.0030	0.9922	0.9648	0.9808	0.9735	1.0050	1.0055	1.0195	1.0339	0.9948	1.0067	1.0116	0.9789
Nadir Norm. NDVI (EnMAP)	1.0400	1.0291	1.0110	1.0367	1.0252	1.0160	1.0052	0.9853	1.0133	1.0035	0.9786	0.9814	0.9774	1.0169	1.0150	1.0274	1.0444	1.0053	1.0160	1.0271	0.9920

(cont.)

VDG2_02 (SZA = 64°; SAA = 143°)	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|122.5	30|45	30|90	30|135	30|157.5	30|170			
HCRF EnMAP blue (479 nm)	0.0305	0.0306	0.0261	0.0344	0.0301	0.0293	0.0301	0.0267	0.0298	0.0262	0.0263	0.0262	0.0252	0.0249	0.0265	0.0282	0.0345	0.0299	0.0342					
HCRF EnMAP green (549 nm)	0.0489	0.0535	0.0448	0.0564	0.0526	0.0481	0.0519	0.0418	0.0469	0.0435	0.0458	0.0442	0.0414	0.0413	0.0445	0.0458	0.0553	0.0499	0.0564					
HCRF EnMAP rot (672 nm)	0.0718	0.0747	0.0659	0.0865	0.0753	0.0732	0.0725	0.0633	0.0692	0.0638	0.0650	0.0625	0.0589	0.0576	0.0647	0.0679	0.0832	0.0763	0.0859					
HCRF EnMAP NIR (864 nm)	0.2612	0.2790	0.2465	0.2987	0.2642	0.2532	0.2576	0.2292	0.2618	0.2468	0.2575	0.2465	0.2390	0.2370	0.2356	0.2514	0.2735	0.2600	0.3029					
ANIF EnMAP rot (672 nm)	1.2302	1.2796	1.1290	1.4829	1.2911	1.2544	1.2420	1.0848	1.1863	1.0932	1.1138	1.0704	1.0092	0.9866	1.1085	1.1635	1.4255	1.3080	1.4726					
ANIF EnMAP NIR (864 nm)	1.1822	1.2629	1.1159	1.3522	1.1961	1.1461	1.1663	1.0375	1.1851	1.1171	1.1654	1.1157	1.0817	1.0727	1.0664	1.1382	1.2383	1.1772	1.3713					
Rel. Blue Absorption Depth	0.3586	0.4239	0.4047	0.3709	0.4153	0.3833	0.4256	0.3444	0.3511	0.3933	0.4229	0.4021	0.3883	0.3966	0.3923	0.3801	0.3674	0.3974	0.3768					
Rel. Red Absorption Depth	0.9226	0.9376	0.9600	0.8746	0.8610	0.8427	0.8407	0.9053	0.9615	0.9638	1.0058	0.9869	1.0309	1.0640	0.9060	0.9729	0.8118	0.8579	0.9109					
NDVI (EnMAP)	0.5689	0.5778	0.5783	0.5509	0.5563	0.5515	0.5610	0.5672	0.5818	0.5893	0.5969	0.5957	0.6046	0.6092	0.5692	0.5749	0.5337	0.5463	0.5581					
Nadir Norm. NDVI (AVHRR)	0.9666	0.9657	0.9763	0.9454	0.9523	0.9496	0.9482	0.9707	0.9866	0.9970	1.0048	0.9969	1.0110	1.0199	0.9702	0.9720	0.9166	0.9304	0.9546					
Nadir Norm. NDVI (MODIS)	0.9685	0.9682	0.9749	0.9430	0.9490	0.9470	0.9542	0.9710	0.9884	1.0054	1.0058	1.0052	1.0148	1.0208	0.9723	0.9725	0.9163	0.9314	0.9536					
Nadir Norm. NDVI (EnMAP)	0.9771	0.9825	0.9933	0.9462	0.9556	0.9474	0.9637	0.9743	0.9995	1.0122	1.0254	1.0232	1.0386	1.0464	0.9778	0.9875	0.9168	0.9383	0.9587					

Table C.8-4: Spectro-directional data of the VDG2_03 spectro-goniometer measurement.

VDG2_03 (SZA = 61°; SAA = 164°)	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)	0.0277	0.0316	0.0298	0.0313	0.0303	0.0315	0.0309	0.0303	0.0299	0.0266	0.0282	0.0301	0.0316	0.0315	0.0319	0.0341	0.0319	0.0302	0.0362	0.0290
HCRF EnMAP green (549 nm)	0.0486	0.0522	0.0469	0.0532	0.0478	0.0526	0.0509	0.0493	0.0490	0.0435	0.0478	0.0501	0.0529	0.0502	0.0520	0.0558	0.0501	0.0496	0.0592	0.0485
HCRF EnMAP rot (672 nm)	0.0679	0.0773	0.0742	0.0798	0.0737	0.0771	0.0782	0.0730	0.0749	0.0670	0.0717	0.0733	0.0769	0.0796	0.0825	0.0848	0.0763	0.0795	0.0869	0.0725
HCRF EnMAP NIR (864 nm)	0.2479	0.2716	0.2737	0.2669	0.2546	0.2756	0.2658	0.2588	0.2764	0.2514	0.2623	0.2580	0.2647	0.2889	0.2859	0.2815	0.2810	0.2645	0.2762	0.2935	0.2532
ANIF EnMAP rot (672 nm)	1.0000	1.1389	1.0935	1.1764	1.0856	1.1352	1.1519	1.0749	1.1038	0.9877	1.0563	1.0792	1.1322	1.1731	1.1938	1.2154	1.2495	1.1247	1.1706	1.2796	1.0682
ANIF EnMAP NIR (864 nm)	1.0000	1.0958	1.1043	1.0766	1.0271	1.1120	1.0723	1.0440	1.1152	1.0141	1.0583	1.0407	1.0679	1.1656	1.1536	1.1356	1.1337	1.0671	1.1141	1.1839	1.0216
Rel. Blue Absorption Depth	0.4274	0.4028	0.3520	0.4210	0.3576	0.3999	0.3962	0.3625	0.3795	0.3775	0.4173	0.3939	0.3987	0.3673	0.3897	0.3762	0.3933	0.3595	0.3865	0.3892	0.3969
Rel. Red Absorption Depth	0.9520	0.9175	0.9862	0.8617	0.8710	0.8974	0.8455	0.8917	0.9732	0.9778	0.9445	0.8692	0.8678	0.9536	0.9144	0.8890	0.8388	0.8767	0.8875	0.8333	0.8707
NDVI (EnMAP)	0.5701	0.5569	0.5734	0.5394	0.5511	0.5630	0.5454	0.5601	0.5735	0.5789	0.5707	0.5577	0.5500	0.5679	0.5584	0.5467	0.5363	0.5521	0.5531	0.5433	0.5548
Nadir Norm. NDVI (AVHRR)	1.0000	0.9945	1.0300	0.9692	0.9857	0.9925	0.9806	1.0051	1.0262	1.0368	1.0150	0.9963	0.9782	1.0251	0.9937	0.9909	0.9684	0.9880	1.0003	0.9740	0.9928
Nadir Norm. NDVI (MODIS)	1.0000	0.9913	1.0189	0.9656	0.9807	0.9945	0.9800	1.0039	1.0230	1.0308	1.0138	0.9971	0.9798	1.0165	0.9900	0.9853	0.9648	0.9840	0.9982	0.9749	0.9936
Nadir Norm. NDVI (EnMAP)	1.0000	0.9769	1.0058	0.9462	0.9667	0.9877	0.9567	0.9826	1.0061	1.0155	1.0011	0.9783	0.9648	0.9962	0.9795	0.9590	0.9408	0.9684	0.9703	0.9530	0.9732

(cont.)

VDG2_03 (SZA = 61°; SAA = 164°)	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)	0.0286	0.0312	0.0297	0.0286	0.0317	0.0341	0.0379	0.0319	0.0384	0.0367	0.0369	0.0373	0.0305	0.0319	0.0324	0.0298	0.0300	0.0282	0.0280	0.0297	0.0340
HCRF EnMAP green (549 nm)	0.0492	0.0509	0.0490	0.0478	0.0509	0.0587	0.0612	0.0533	0.0614	0.0597	0.0599	0.0643	0.0496	0.0521	0.0527	0.0470	0.0451	0.0447	0.0463	0.0482	0.0546
HCRF EnMAP rot (672 nm)	0.0726	0.0728	0.0732	0.0739	0.0787	0.0827	0.0907	0.0822	0.0924	0.0989	0.0931	0.0928	0.0768	0.0780	0.0797	0.0712	0.0703	0.0676	0.0703	0.0754	0.0858
HCRF EnMAP NIR (864 nm)	0.2677	0.2716	0.2789	0.2747	0.2765	0.2920	0.3282	0.2900	0.3078	0.3314	0.3102	0.3008	0.2645	0.2897	0.2881	0.2683	0.2686	0.2629	0.2669	0.2590	0.2971
ANIF EnMAP rot (672 nm)	1.0697	1.0726	1.0789	1.0892	1.1599	1.2187	1.3360	1.2108	1.3606	1.4563	1.3715	1.3669	1.1308	1.1489	1.1747	1.0496	1.0351	0.9956	1.0357	1.1108	1.2637
ANIF EnMAP NIR (864 nm)	1.0801	1.0959	1.1251	1.1083	1.1155	1.1780	1.3239	1.1698	1.2419	1.3371	1.2514	1.2137	1.0672	1.1688	1.1623	1.0823	1.0837	1.0605	1.0766	1.0450	1.1987
Rel. Blue Absorption Depth	0.4207	0.3777	0.3739	0.3997	0.3645	0.4190	0.3738	0.4061	0.3725	0.3758	0.3845	0.4334	0.3756	0.3797	0.3850	0.3571	0.3301	0.3671	0.4004	0.3675	0.3607
Rel. Red Absorption Depth	0.9415	0.9621	0.9696	0.9560	0.8972	0.9008	0.9719	0.9167	0.8384	0.8768	0.8508	0.8186	0.8521	0.9339	0.9178	0.9735	0.9912	1.0178	0.9797	0.8656	0.9069
NDVI (EnMAP)	0.5733	0.5773	0.5840	0.5759	0.5567	0.5585	0.5670	0.5583	0.5384	0.5405	0.5383	0.5286	0.5502	0.5758	0.5664	0.5803	0.5853	0.5910	0.5830	0.5491	0.5520
Nadir Norm. NDVI (AVHRR)	1.0216	1.0218	1.0435	1.0349	0.9993	0.9870	1.0104	1.0108	0.9659	0.9881	0.9726	0.9392	0.9883	1.0279	1.0145	1.0326	1.0468	1.0481	1.0396	0.9985	0.9915
Nadir Norm. NDVI (MODIS)	1.0206	1.0203	1.0424	1.0285	0.9961	0.9855	1.0049	1.0058	0.9628	0.9790	0.9712	0.9378	0.9861	1.0315	1.0127	1.0317	1.0439	1.0468	1.0380	0.9930	0.9864
Nadir Norm. NDVI (EnMAP)	1.0057	1.0127	1.0245	1.0102	0.9766	0.9797	0.9946	0.9794	0.9445	0.9482	0.9443	0.9272	0.9652	1.0101	0.9937	1.0180	1.0268	1.0367	1.0227	0.9632	0.9683

(cont.)

VDG2_03 (SZA = 61°; SAA = 164°)	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|122.5	30|45	30|90	30|135	30|157.5	30|170			
HCRF EnMAP blue (479 nm)	0.0341	0.0385	0.0353	0.0393	0.0410	0.0388	0.0381	0.0309	0.0331	0.0321	0.0328	0.0283	0.0285	0.0314	0.0312	0.0365	0.0413	0.0412	0.0410					
HCRF EnMAP green (549 nm)	0.0507	0.0642	0.0572	0.0649	0.0666	0.0670	0.0610	0.0510	0.0551	0.0510	0.0510	0.0447	0.0455	0.0517	0.0484	0.0603	0.0656	0.0694	0.0673					
HCRF EnMAP rot (672 nm)	0.0810	0.0920	0.0857	0.1032	0.1051	0.0995	0.0951	0.0762	0.0773	0.0741	0.0772	0.0682	0.0687	0.0788	0.0731	0.0902	0.1035	0.1068	0.1048					
HCRF EnMAP NIR (864 nm)	0.2808	0.3205	0.2895	0.3233	0.3544	0.3292	0.2940	0.2681	0.2796	0.2698	0.2797	0.2579	0.2550	0.2778	0.2718	0.2999	0.3480	0.3462	0.3346					
ANIF EnMAP rot (672 nm)	1.1927	1.3560	1.2627	1.5210	1.5478	1.4663	1.4012	1.1223	1.1386	1.0922	1.1371	1.0046	1.0127	1.1603	1.0775	1.3286	1.5245	1.5734	1.5433					
ANIF EnMAP NIR (864 nm)	1.1329	1.2932	1.1678	1.3042	1.4296	1.3282	1.1860	1.0817	1.1279	1.0885	1.1285	1.0406	1.0287	1.1208	1.0967	1.2099	1.4039	1.3969	1.3499					
Rel. Blue Absorption Depth	0.3125	0.3912	0.3679	0.3986	0.3858	0.4369	0.3790	0.3987	0.4007	0.3622	0.3360	0.3489	0.3563	0.3902	0.3272	0.3944	0.3550	0.3935	0.3856					
Rel. Red Absorption Depth	0.9101	0.8860	0.8555	0.8068	0.8667	0.8385	0.7764	0.8837	0.9321	0.9376	0.9264	0.9787	0.9561	0.9005	0.9771	0.8486	0.8879	0.8363	0.8070					
NDVI (EnMAP)	0.5525	0.5538	0.5431	0.5159	0.5426	0.5358	0.5111	0.5575	0.5669	0.5689	0.5675	0.5818	0.5753	0.5583	0.5760	0.5376	0.5416	0.5285	0.5232					
Nadir Norm. NDVI (AVHRR)	0.9970	0.9912	0.9762	0.9372	0.9808	0.9641	0.9419	0.9984	1.0035	1.0047	1.0111	1.0343	1.0237	1.0081	1.0226	0.9653	0.9792	0.9532	0.9468					
Nadir Norm. NDVI (MODIS)	0.9889	0.9899	0.9716	0.9316	0.9761	0.9631	0.9398	0.9962	1.0077	1.0058	1.0122	1.0336	1.0235	1.0053	1.0247	0.9661	0.9741	0.9489	0.9393					
Nadir Norm. NDVI (EnMAP)	0.9691	0.9715	0.9527	0.9050	0.9519	0.9398	0.8966	0.9780	0.9944	0.9980	0.9955	1.0206	1.0092	0.9793	1.0104	0.9431	0.9501	0.9272	0.9177					

V *Main Spectral Characteristics*

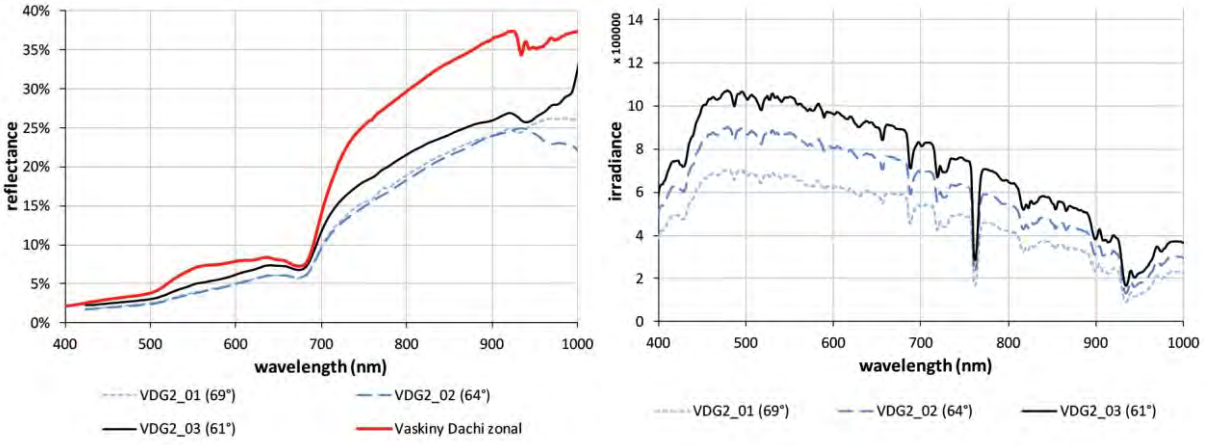

Figure C.8-6: Nadir reflectances and irradiance profiles of the VDG2 site at different sun zenith angles. Left: Comparison of the nadir reflectance signatures with the average zonal vegetation. Right: Comparison of the total irradiance profiles.

VI *HCRF Visualization*

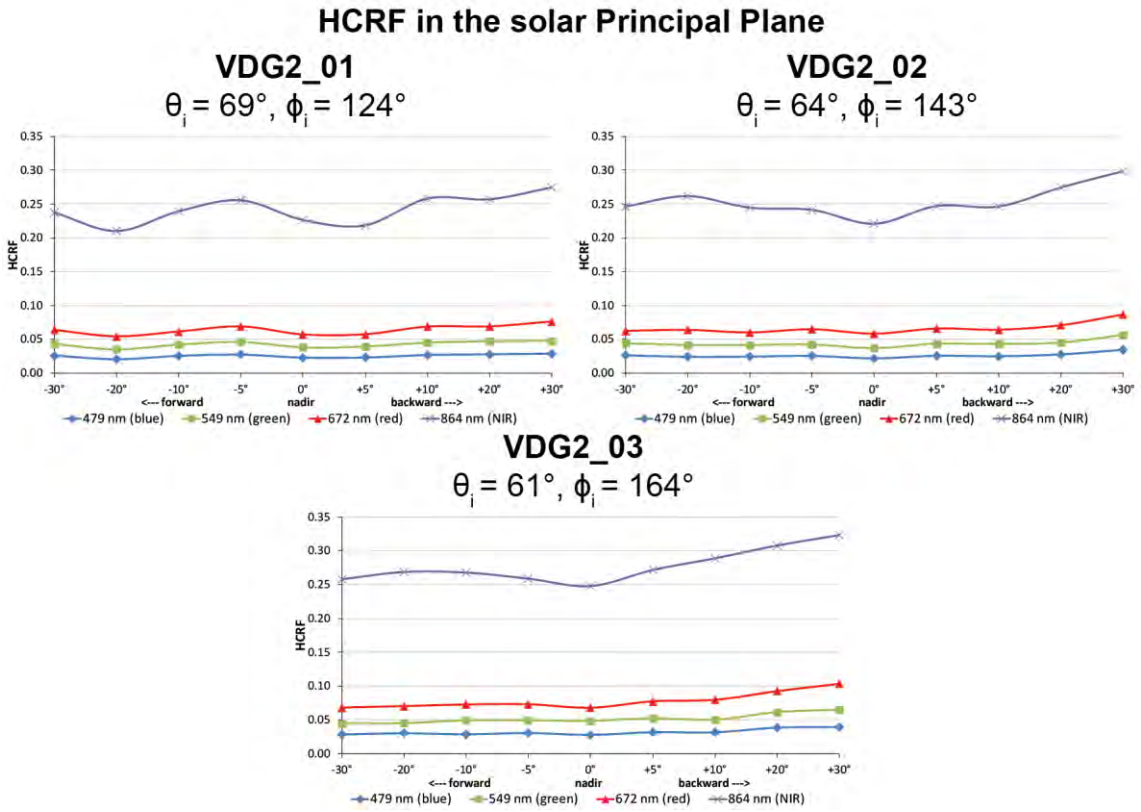

Figure C.8-7: Comparison of the HCRF values at 479 nm (blue), 549 nm (green), 672 nm (red), and 864 nm (NIR) in the solar principal plane of the VDG2 site at different sun zenith angles.

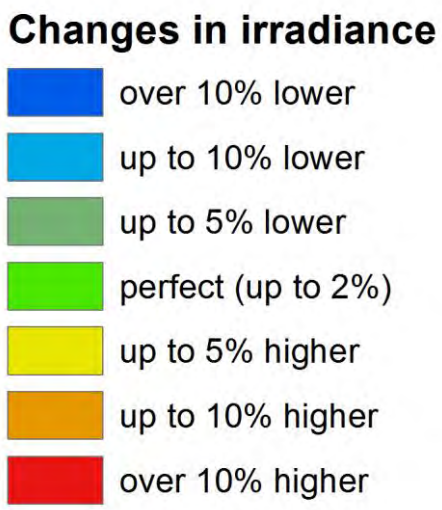

Figure C.8-8: Legend of the outlier indicator graphics shown in Figure C.8-9, C.8-10, and C.8-13

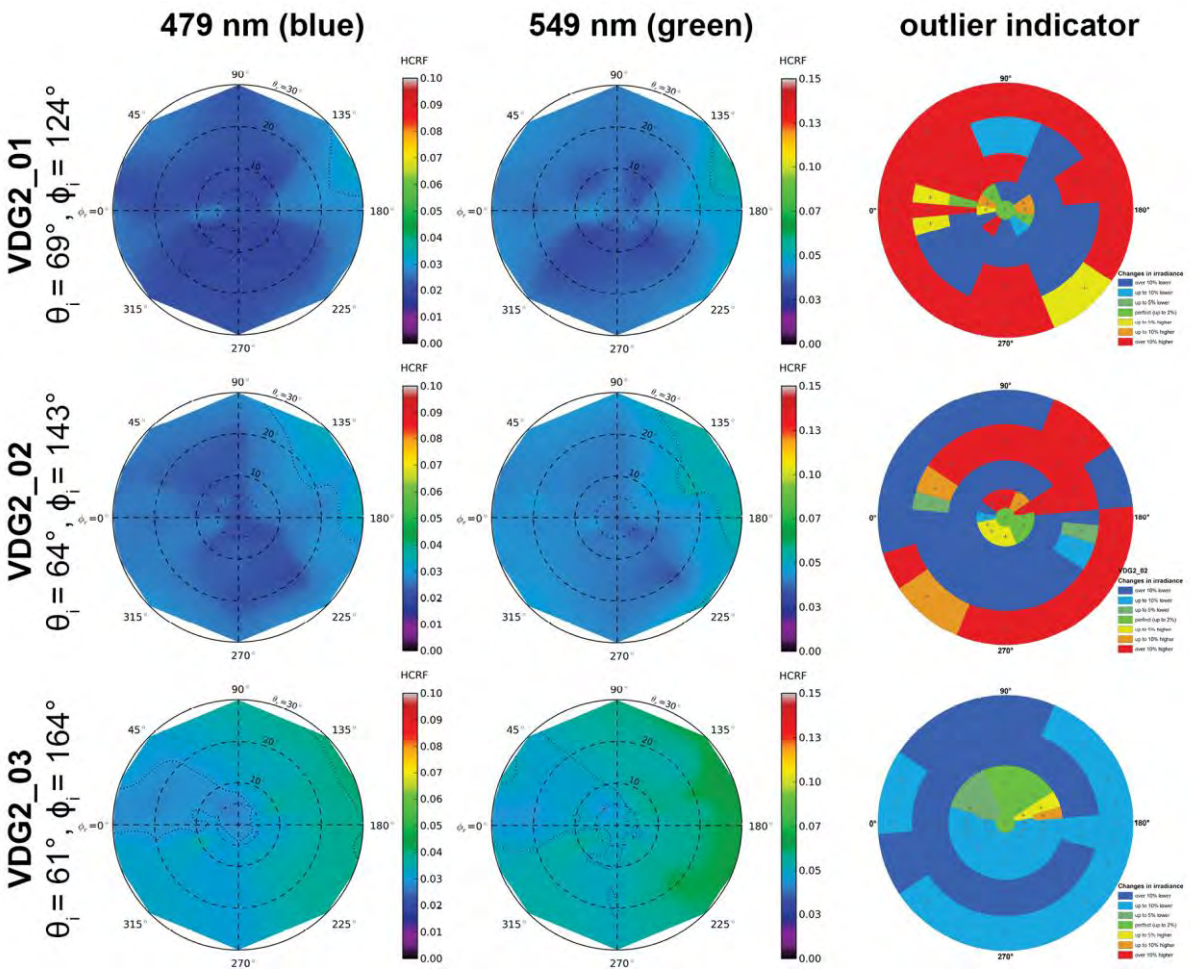

Figure C.8-9: HCRF visualization at 479 nm and 549 nm of the VDG2 site.

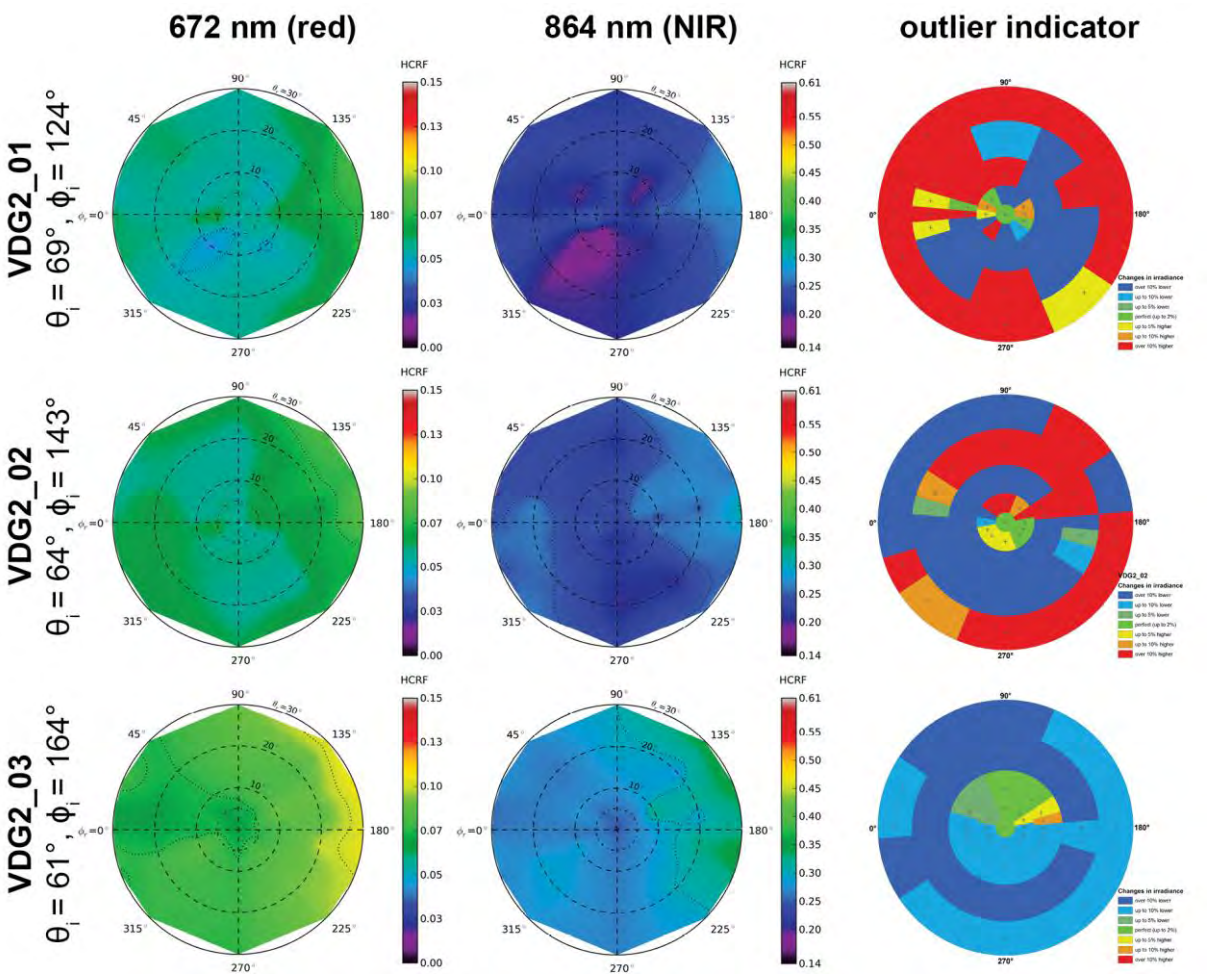

Figure C.8-10: HCRF visualization at 672 nm and 864 nm of the VDG2 site.

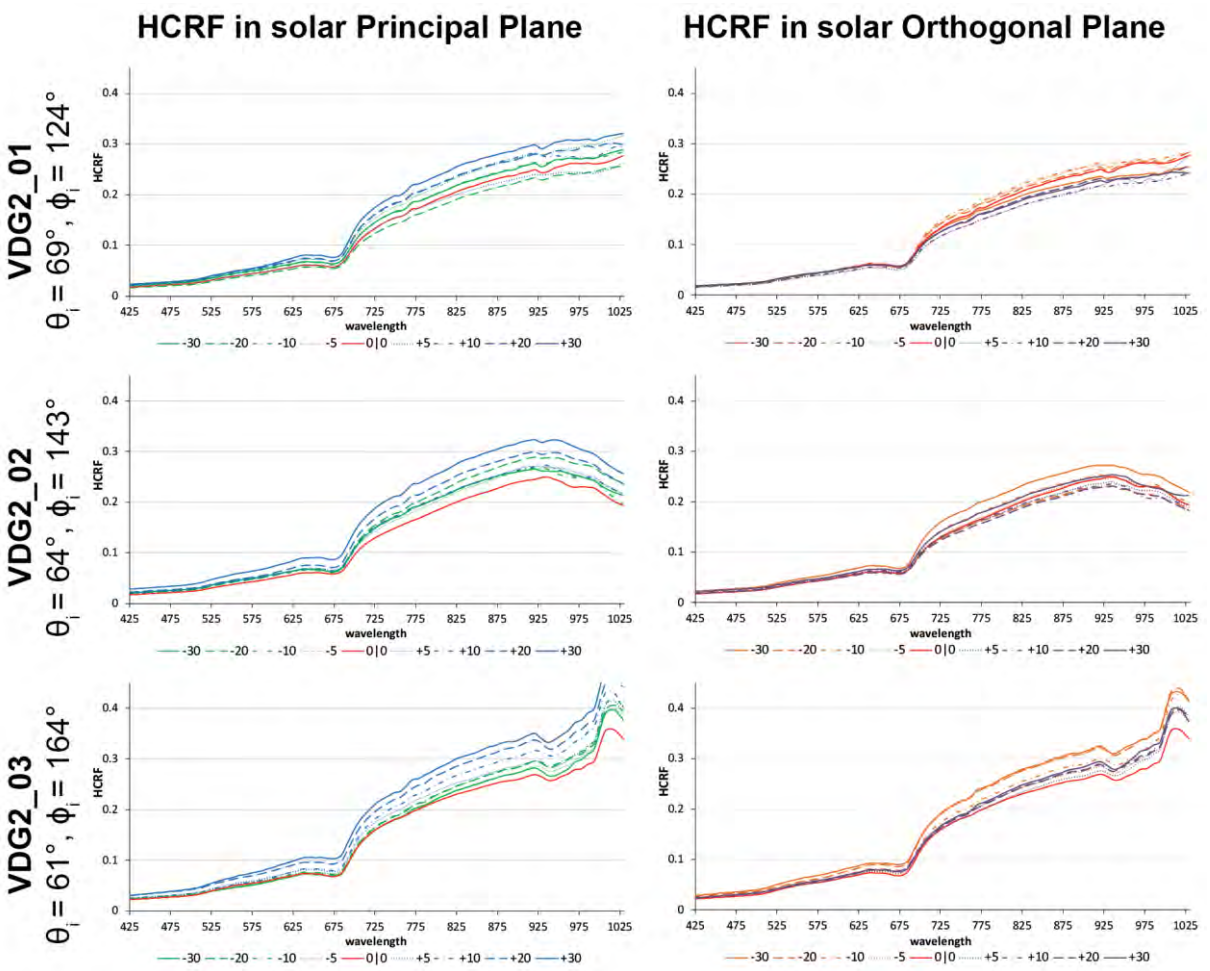

Figure C.8-11: HCRF visualization in principal & orthogonal plane of the VDG2 site.

VII *ANIF Visualization*

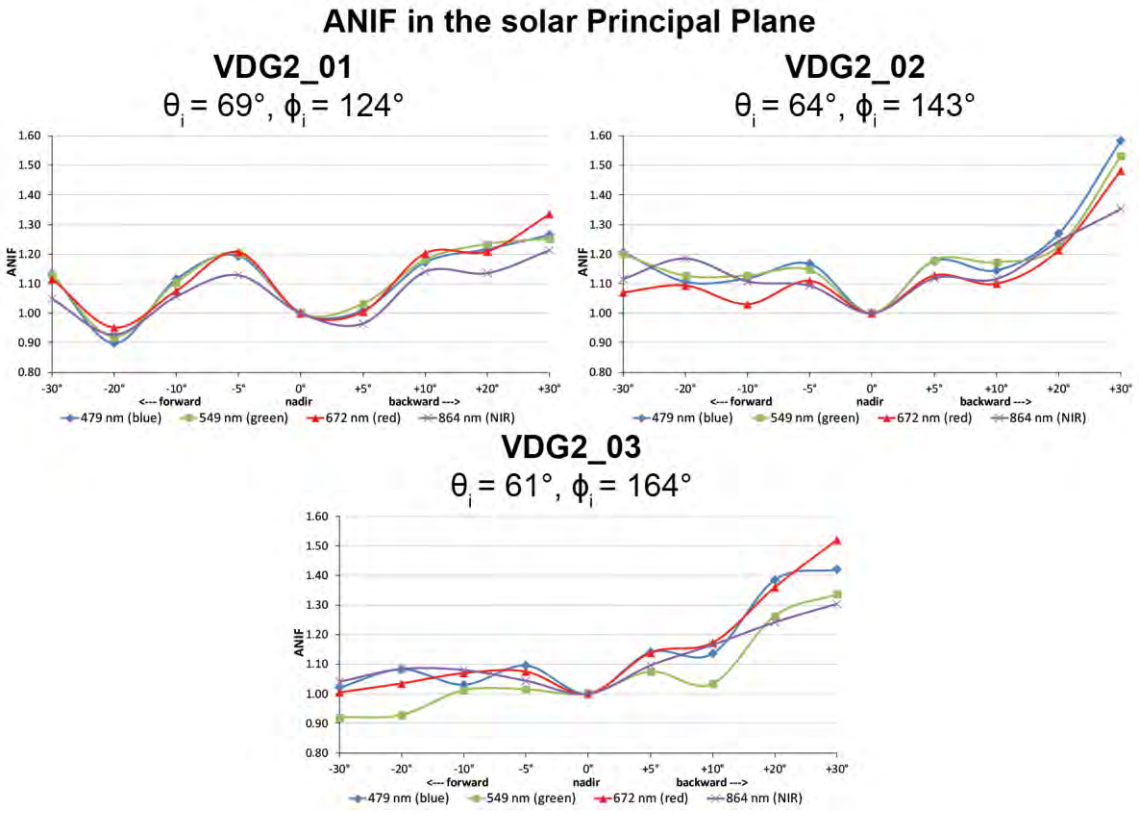

Figure C.8-12: Comparison of the ANIF values at 479 nm (blue), 549 nm (green), 672 nm (red), and 864 nm (NIR) in the solar principal plane of the VDG2 site at different sun zenith angles.

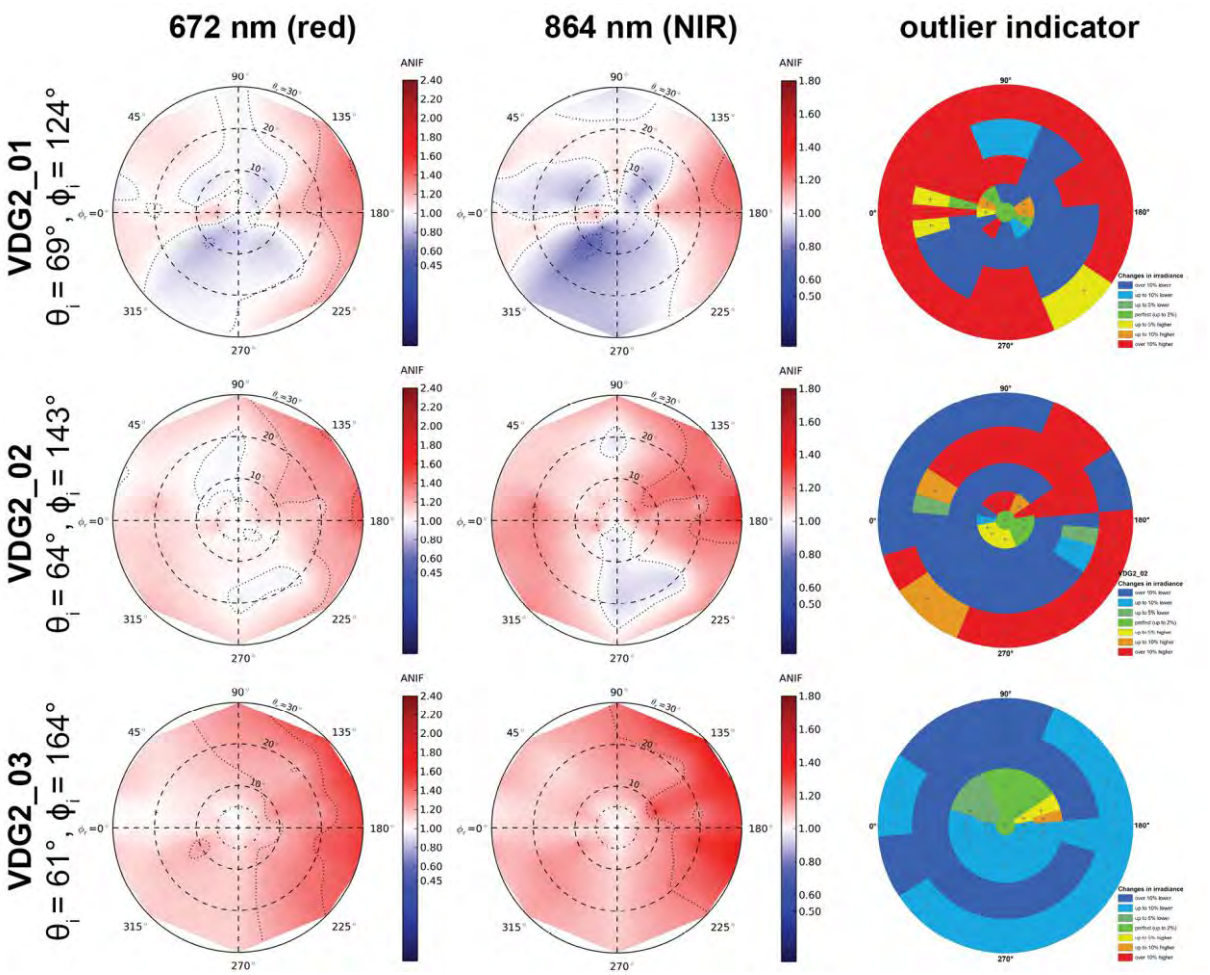

Figure C.8-13: ANIF visualization at 672 nm and 864 nm of the VDG2 site.

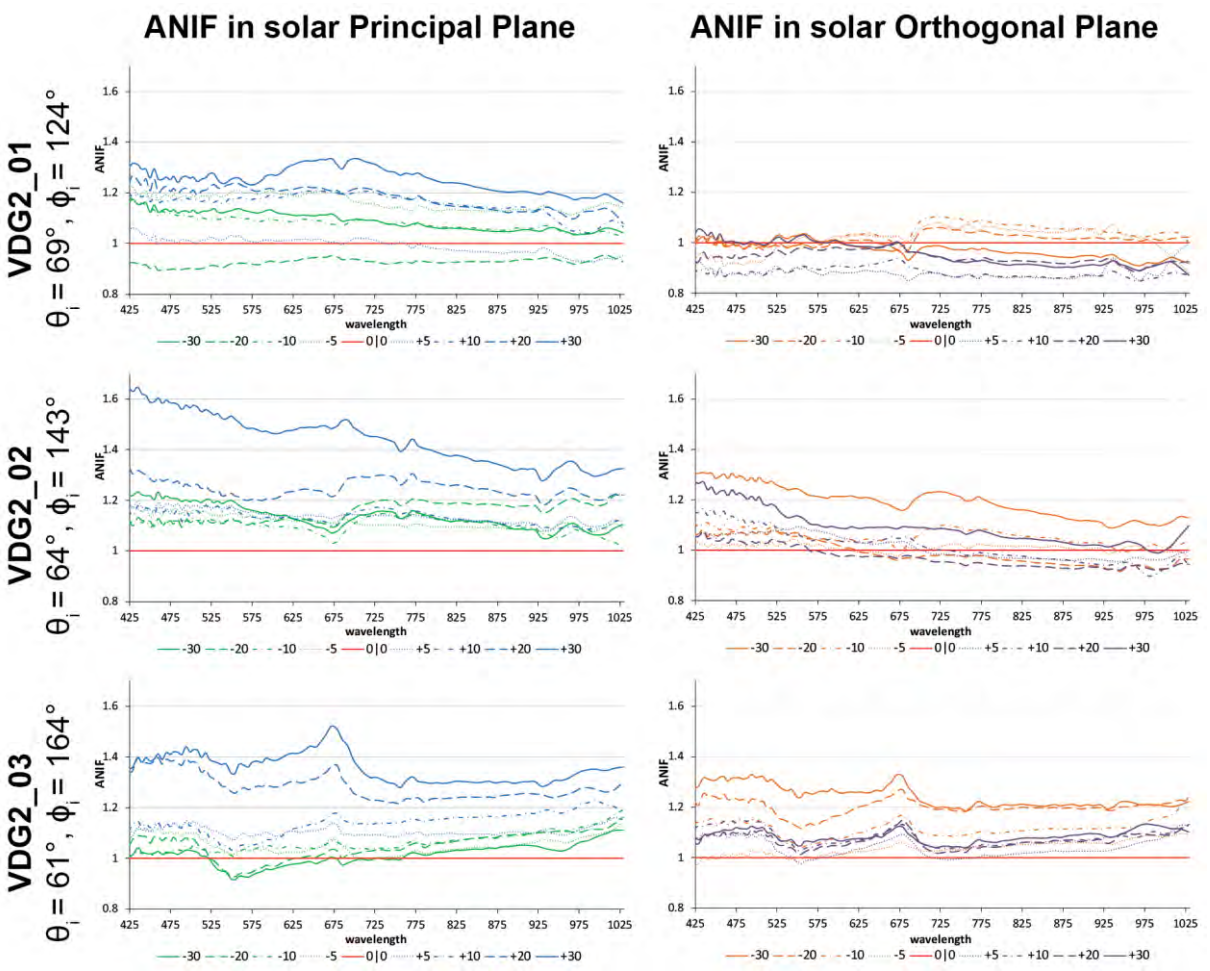

Figure C.8-14: ANIF visualization in principal & orthogonal plane of the VDG2 site.

VIII *ANIX Visualization*

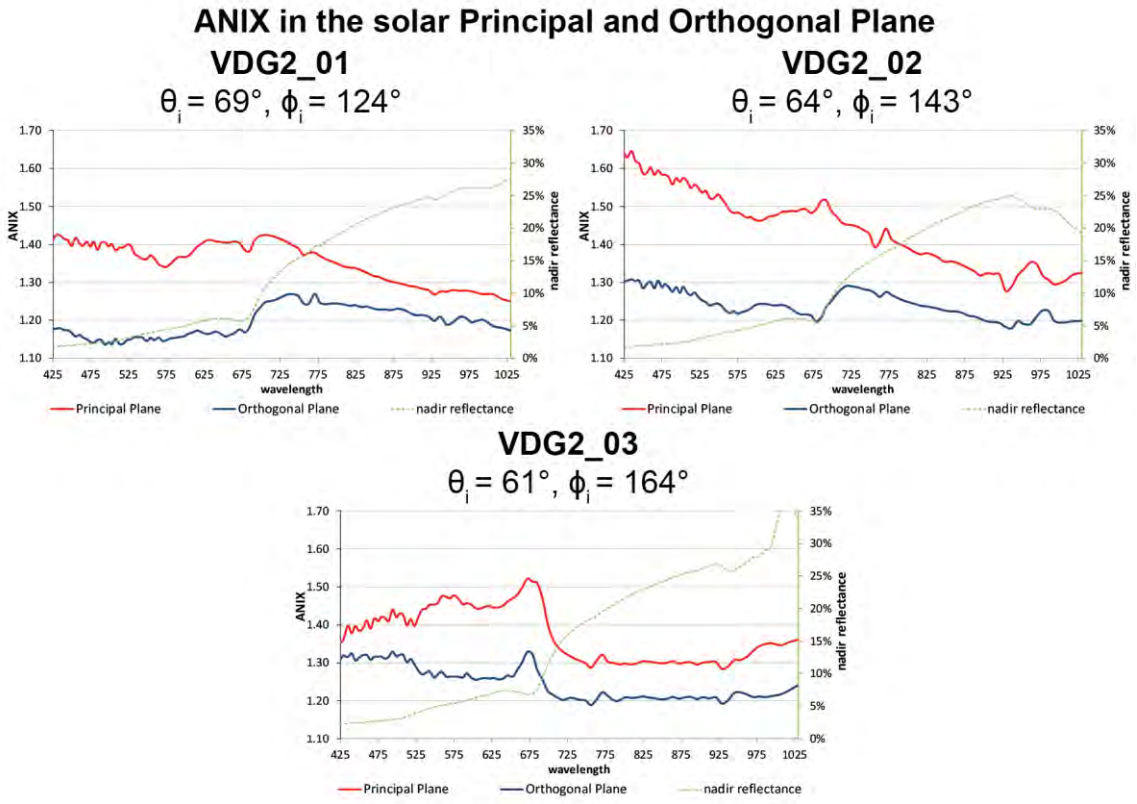

Figure C.8-15: Comparison of the ANIX in the solar principal and orthogonal plane with the nadir reflectance of the VDG2 site at different sun zenith angles.

IX *NDVI and Relative Absorption Depth Visualization*

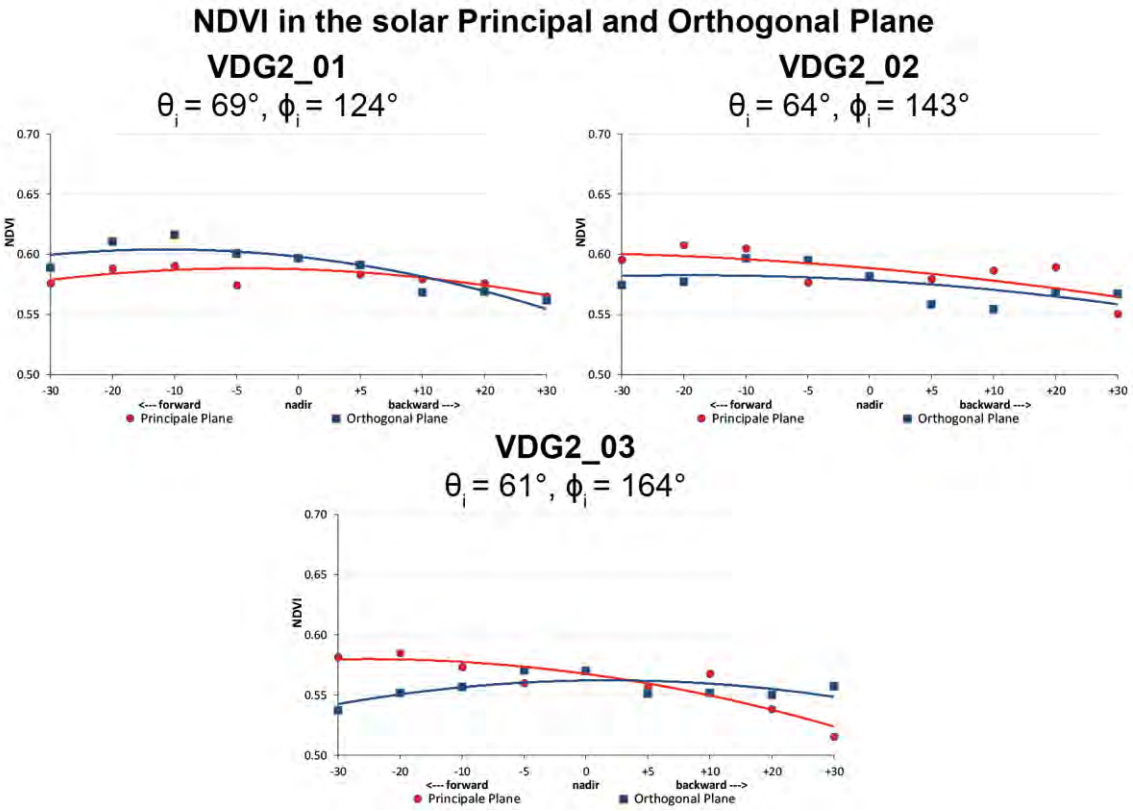

Figure C.8-16: Comparison of the NDVI in the solar principal and orthogonal plane of the VDG2 site at different sun zenith angles.

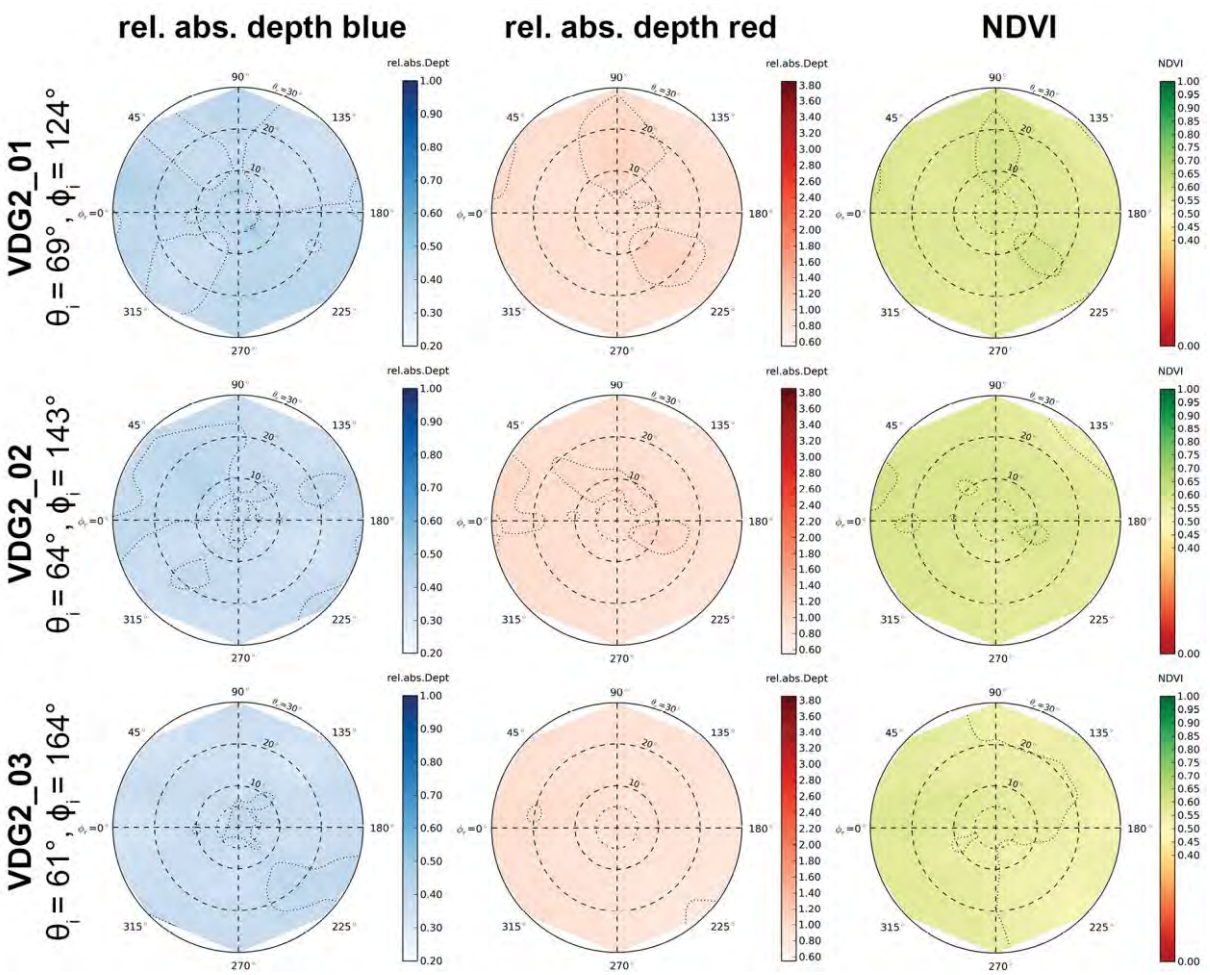

Figure C.8-17: Visualization of relative absorption depth & NDVI of the VDG2 site.

X *NDVI Comparison of Different Sensors*

Table C.8-5: 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

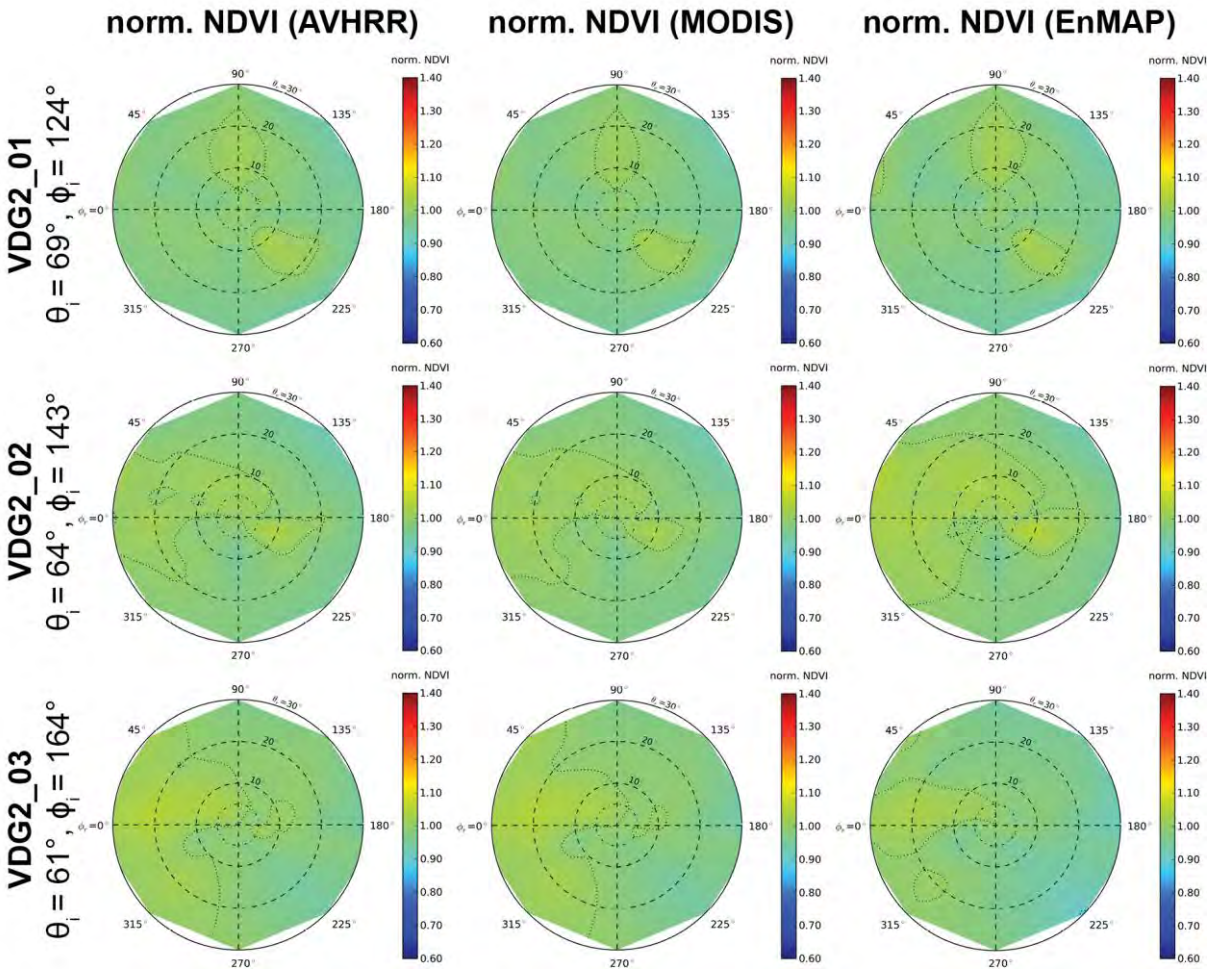

Figure C.8-18: Comparison of AVHRR, MODIS & EnMAP NDVI of the VDG2 site.