



Supplement of

The effects of ocean surface waves on global intraseasonal prediction: case studies with a coupled CFSv2.0–WW3 system

Ruizi Shi et al.

Correspondence to: Fanghua Xu (fxu@mail.tsinghua.edu.cn)

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Table S3 shows the NDBC buoy total numbers, identifiers, longitudes and latitudes.

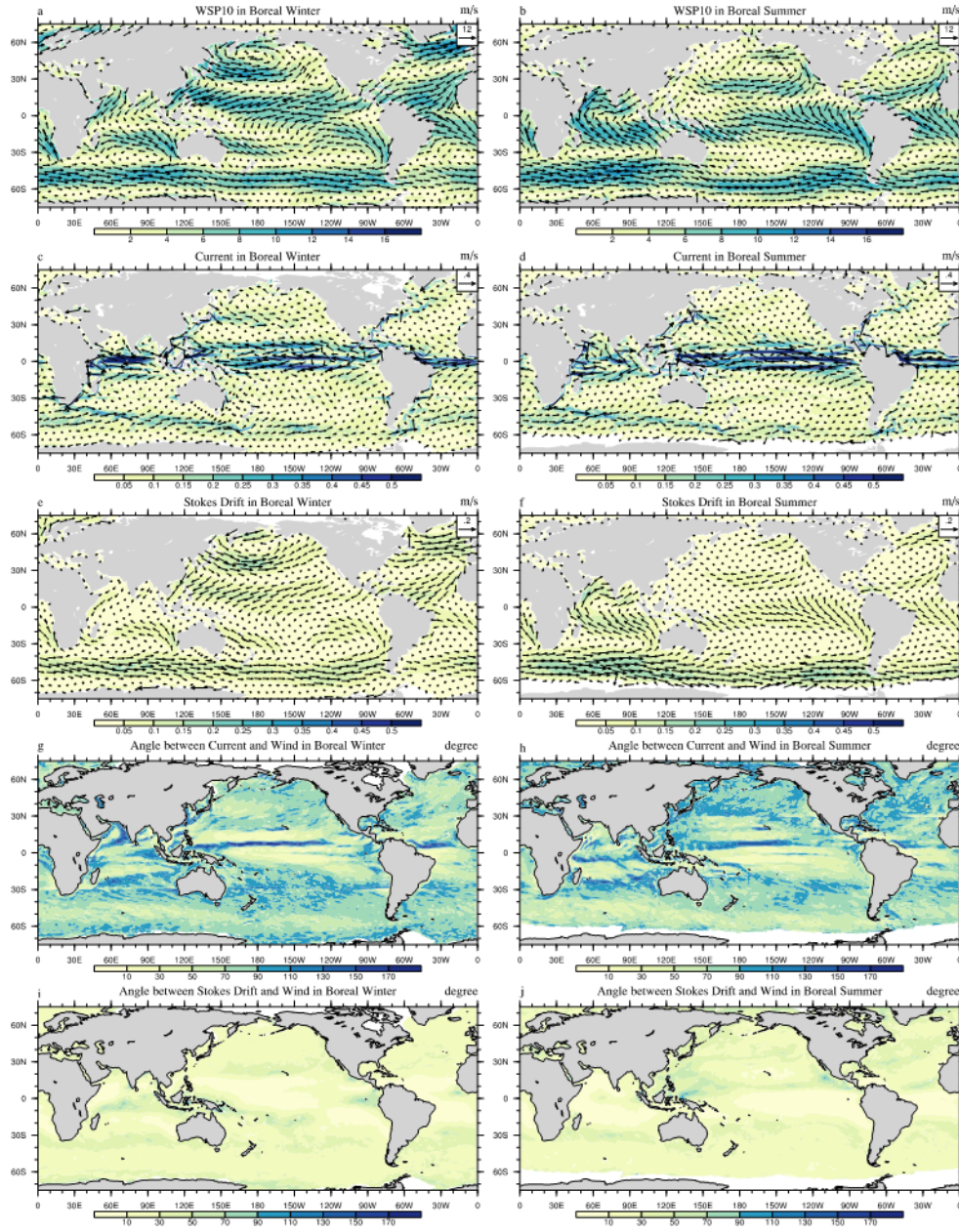


Figure S1. a, b: the 53-day average 10-m wind (m/s) in Jan-Feb, 2017 and Aug-Sep, 2018; c, d: the average ocean surface current (m/s) in Jan-Feb, 2017 and Aug-Sep, 2018; e, f: the average surface Stokes drift (m/s) in Jan-Feb, 2017 and Aug-Sep, 2018; g, h: the average angle between surface current and 10-m wind; i, j: the average angle between surface Stokes drift and 10-m wind.

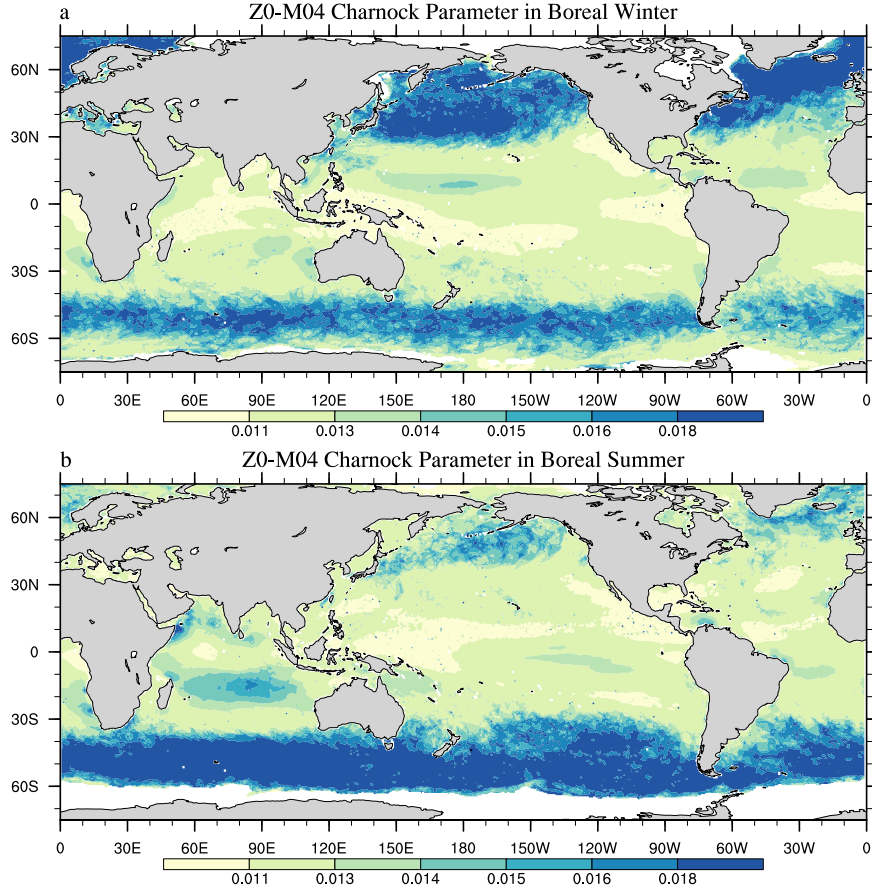


Figure S2. The Charnock parameter C_{ch} obtained by ST4-M04 in boreal winter (a) and summer (b)

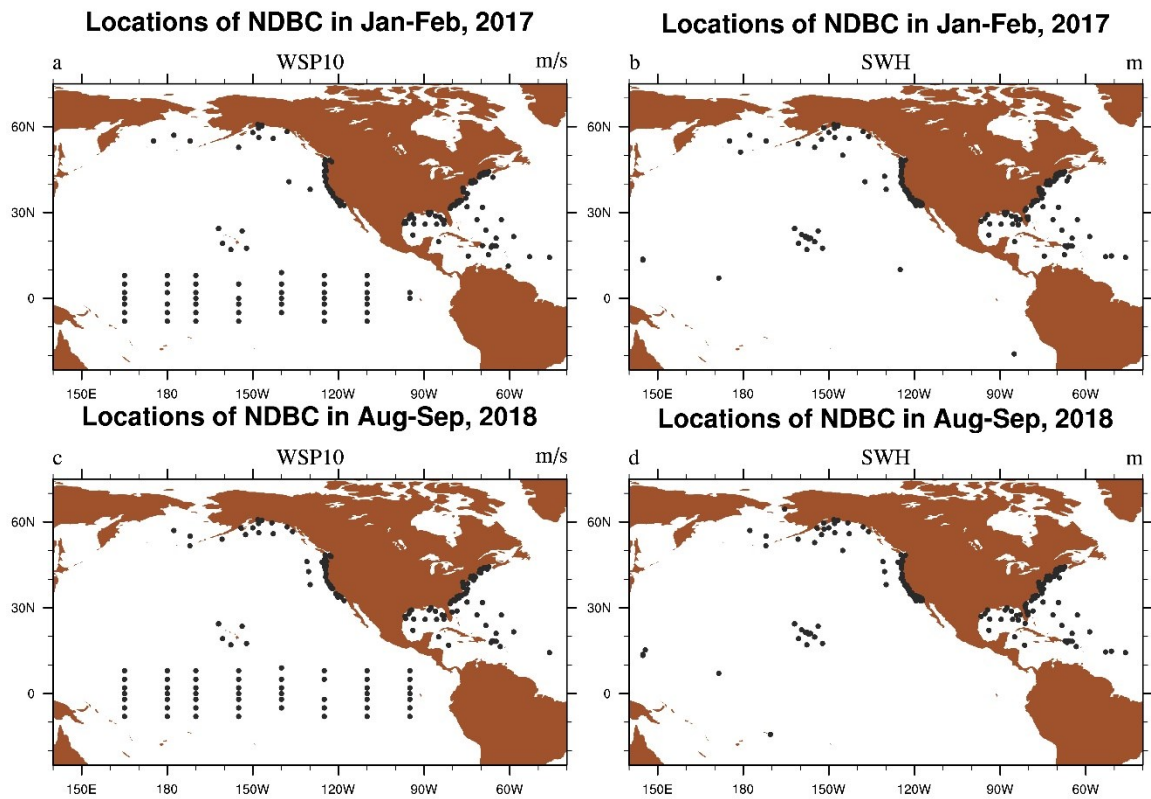


Figure S3. The locations of NDBC buoy data: a&b for WSP10 and SWH data in Jan-Feb, 2017; c&d for WSP10 and SWH data in Aug-Sep, 2018.

Table S1. The 28-day global RMSEs and daily runtime for SST, SWH and WSP10 in the ALL experiment with different coupling steps in Jan, 2017. In 1_STEP_ALL experiment, three model components are coupled every time step, and in 5_STEP_ALL (10_STEP_ALL) they are coupled every 5 (10) steps. Particularly, in 10_STEP_WW3, only the WW3 is coupled every 10 time steps, whereas the GFS and the MOM4 remain the one time step coupling frequency as the original settings in CFS. Note that the original one time step in CFS is 180 s, and 10 time steps are 1800 s.

Experiments	SST (°C) RMSE	SWH (m) RMSE	WSP10 (m/s) RMSE	Daily runtime (s)
1_STEP_ALL	0.88	1.09	3.94	25677
5_STEP_ALL	0.88	1.09	3.88	19546
10_STEP_ALL	0.88	1.23	4.25	19012
10_STEP_WW3	0.88	1.10	3.95	19171

Table S2. The correlation coefficient, RMSE and skill score of SWH in WW3 simulations versus Jason-3 observation at 00:00 on Jan 3, 2017; the simulated SWHs were generated by a stand-alone WW3 model (without coupling) with different input-dissipation source terms (ST) and wind forcings (CCMP and ERA5); the RMSE and skill score (SS) are calculated as $RMSE = \sqrt{\sum_{i=1}^n (\hat{y}_i - y_i)^2 / n}$ and $SS = 1 - \frac{\sum_{i=1}^n (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^n (|\hat{y}_i - \bar{y}| + |y_i - \bar{y}|)^2}$, respectively, where $\hat{y}_i$ is simulated value, y_i is Jason-3 data and $\bar{y}$ is the average, $i=1, n$ and $n=2613$ is the total number of measurements in the Jason-3 orbit.

Experiments	Correlation Coefficient (P<0.01)	RMSE	Skill Score
ERA-5 ST2	0.76	0.42	0.85
ERA-5 ST3	0.77	0.41	0.86
ERA-5 ST4	0.82	0.37	0.89
ERA-5 ST6	0.82	0.49	0.86
CCMP ST4	0.69	0.54	0.78
CCMP ST2	0.68	0.59	0.76

Table S3. The NDBC buoy total numbers (Num), identifiers (ID), longitudes (LON) and latitudes (LAT).

201701-02 WSP10 Num=162			201701-02 SWH Num=166			201808-09 WSP10 Num=172			201808-09 SWH Num=176		
ID	LON	LAT	ID	LON	LAT	ID	LON	LAT	ID	LON	LAT
41002	285.04	31.99	32012	274.92	-19.43	41002	285.04	31.99	41002	285.04	31.99
41004	280.90	32.50	41002	285.04	31.99	41004	280.90	32.50	41004	280.90	32.50
41008	279.13	31.40	41004	280.90	32.50	41008	279.13	31.40	41008	279.13	31.40
41013	282.24	33.44	41008	279.13	31.40	41009	279.82	28.51	41009	279.82	28.51
41024	281.52	33.84	41025	284.64	35.03	41010	281.52	28.88	41010	281.52	28.88
41025	284.64	35.03	41040	306.96	14.55	41013	282.24	33.44	41013	282.24	33.44
41029	280.38	32.80	41041	313.91	14.31	41024	281.52	33.84	41025	284.64	35.03
41033	279.59	32.28	41043	295.21	21.03	41025	284.64	35.03	41040	306.96	14.55
41037	282.64	33.99	41044	301.37	21.58	41029	280.38	32.80	41041	313.91	14.31
41038	282.29	34.14	41046	291.62	23.82	41033	279.59	32.28	41043	295.21	21.03
41040	306.96	14.55	41047	288.51	27.51	41037	282.64	33.99	41044	301.37	21.58
41041	313.91	14.31	41048	290.43	31.83	41038	282.29	34.14	41046	291.62	23.82
41043	295.21	21.03	41049	297.06	27.49	41041	313.91	14.31	41047	288.51	27.51
41044	301.37	21.58	41052	295.24	18.25	41043	295.21	21.03	41048	290.43	31.83
41046	291.62	23.82	41053	293.90	18.47	41044	301.37	21.58	41049	297.06	27.49
41047	288.51	27.51	41056	294.54	18.26	41046	291.62	23.82	41052	295.24	18.25
41048	290.43	31.83	41060	308.98	14.82	41047	288.51	27.51	41053	293.90	18.47
41049	297.06	27.49	41108	281.98	33.72	41048	290.43	31.83	41056	294.54	18.26
41052	295.24	18.25	41110	282.29	34.14	41049	297.06	27.49	41060	308.98	14.82
41053	293.90	18.47	41112	278.71	30.71	41052	295.24	18.25	41110	282.29	34.14
41056	294.54	18.26	41113	279.47	28.40	41053	293.90	18.47	41112	278.71	30.71
41064	283.05	34.21	41114	279.78	27.55	41056	294.54	18.26	41113	279.47	28.40
42001	270.34	25.94	41115	292.72	18.38	41062	284.91	35.78	41114	279.78	27.55
42002	266.35	26.06	41116	279.81	28.52	41063	284.06	34.78	41115	292.72	18.38
42003	274.39	25.93	41159	283.05	34.21	41064	283.05	34.21	41117	278.92	30.00
42012	272.45	30.06	42001	270.34	25.94	42001	270.34	25.94	41118	279.41	28.61
42013	277.08	27.17	42002	266.35	26.06	42002	266.35	26.06	41159	283.05	34.21
42019	264.66	27.91	42003	274.39	25.93	42003	274.39	25.93	42001	270.34	25.94
42020	263.31	26.97	42012	272.45	30.06	42012	272.45	30.06	42002	266.35	26.06
42022	276.26	27.51	42019	264.66	27.91	42013	277.08	27.17	42003	274.39	25.93
42023	276.91	26.01	42020	263.31	26.97	42019	264.66	27.91	42012	272.45	30.06
42035	265.57	29.22	42035	265.57	29.22	42020	263.31	26.97	42019	264.66	27.91
42036	275.48	28.50	42036	275.48	28.50	42022	276.26	27.51	42020	263.31	26.97
42039	273.99	28.79	42039	273.99	28.79	42023	276.91	26.01	42035	265.57	29.22
42040	271.77	29.21	42040	271.77	29.21	42035	265.57	29.22	42039	273.99	28.79
42043	265.10	28.98	42055	266.06	22.12	42039	273.99	28.79	42040	271.77	29.21
42044	262.95	26.19	42056	275.06	19.82	42040	271.77	29.21	42055	266.06	22.12
42045	263.50	26.22	42058	285.45	14.78	42043	265.10	28.98	42056	275.06	19.82
42047	266.40	27.90	42059	292.52	15.25	42045	263.50	26.22	42057	278.58	16.91
42055	266.06	22.12	42067	271.42	30.05	42055	266.06	22.12	42060	296.67	16.43
42056	275.06	19.82	42085	293.47	17.87	42056	275.06	19.82	42079	278.76	24.54

42058	285.45	14.78	42097	276.35	25.70	42057	278.58	16.91	42085	293.47	17.87
42059	292.52	15.25	42098	277.07	27.59	42060	296.67	16.43	42097	276.35	25.70
42067	271.42	30.05	42099	275.73	27.35	42085	293.47	17.87	42098	277.07	27.59
42085	293.47	17.87	43010	234.97	10.05	44007	289.86	43.53	42099	275.73	27.35
42088	299.48	11.30	44005	290.87	43.20	44009	285.30	38.46	44005	290.87	43.20
42090	290.42	18.43	44007	289.86	43.53	44013	289.35	42.35	44007	289.86	43.53
44005	290.87	43.20	44011	293.41	41.07	44014	285.16	36.61	44008	290.75	40.50
44007	289.86	43.53	44013	289.35	42.35	44017	287.95	40.69	44009	285.30	38.46
44013	289.35	42.35	44014	285.16	36.61	44018	289.86	42.21	44013	289.35	42.35
44014	285.16	36.61	44017	287.95	40.69	44025	286.84	40.25	44014	285.16	36.61
44017	287.95	40.69	44024	294.09	42.33	44027	292.70	44.28	44017	287.95	40.69
44024	294.09	42.33	44025	286.84	40.25	44029	289.43	42.52	44018	289.86	42.21
44025	286.84	40.25	44027	292.70	44.28	44030	289.57	43.18	44025	286.84	40.25
44027	292.70	44.28	44029	289.43	42.52	44032	290.65	43.72	44027	292.70	44.28
44029	289.43	42.52	44030	289.57	43.18	44033	291.00	44.06	44029	289.43	42.52
44030	289.57	43.18	44032	290.65	43.72	44034	291.89	44.10	44030	289.57	43.18
44032	290.65	43.72	44033	291.00	44.06	44037	292.12	43.50	44032	290.65	43.72
44033	291.00	44.06	44034	291.89	44.10	44039	287.35	41.14	44033	291.00	44.06
44034	291.89	44.10	44037	292.12	43.50	44040	286.42	40.96	44034	291.89	44.10
44037	292.12	43.50	44039	287.35	41.14	44042	283.67	38.03	44037	292.12	43.50
44039	287.35	41.14	44040	286.42	40.96	44058	283.74	37.57	44039	287.35	41.14
44040	286.42	40.96	44042	283.67	38.03	44062	283.59	38.56	44040	286.42	40.96
44042	283.67	38.03	44056	284.29	36.20	44063	283.55	38.96	44042	283.67	38.03
44058	283.74	37.57	44058	283.74	37.57	44064	283.91	37.00	44056	284.29	36.20
44062	283.59	38.56	44062	283.59	38.56	44065	286.30	40.37	44058	283.74	37.57
44065	286.30	40.37	44065	286.30	40.37	44066	287.36	39.62	44062	283.59	38.56
44069	286.91	40.70	44066	287.36	39.62	44069	286.91	40.70	44063	283.55	38.96
44072	283.73	37.20	44072	283.73	37.20	44072	283.73	37.20	44064	283.91	37.00
46001	212.05	56.23	44089	284.68	37.75	46001	212.05	56.23	44065	286.30	40.37
46006	222.62	40.77	44090	289.67	41.84	46002	229.50	42.66	44066	287.36	39.62
46011	238.98	34.96	44091	286.23	39.77	46005	228.92	46.13	44072	283.73	37.20
46012	237.12	37.36	44093	284.51	36.87	46011	238.98	34.96	44086	284.58	36.00
46013	236.70	38.25	44097	288.87	40.97	46012	237.12	37.36	44087	283.85	37.03
46014	236.03	39.23	44098	289.83	42.80	46013	236.70	38.25	44089	284.68	37.75
46015	235.16	42.75	44099	284.28	36.92	46014	236.03	39.23	44090	289.67	41.84
46022	235.47	40.75	44100	284.41	36.26	46022	235.47	40.75	44091	286.23	39.77
46025	240.96	33.76	46001	212.05	56.23	46025	240.96	33.76	44095	284.67	35.75
46026	237.16	37.75	46002	229.50	42.66	46026	237.16	37.75	44097	288.87	40.97
46027	235.62	41.85	46006	222.62	40.77	46027	235.62	41.85	44098	289.83	42.80
46028	238.10	35.77	46011	238.98	34.96	46029	235.52	46.14	44099	284.28	36.92
46029	235.52	46.14	46012	237.12	37.36	46035	182.30	57.02	44100	284.41	36.26
46035	182.30	57.02	46013	236.70	38.25	46042	237.60	36.79	46001	212.05	56.23
46041	235.26	47.35	46014	236.03	39.23	46050	235.45	44.67	46002	229.50	42.66
46042	237.60	36.79	46015	235.16	42.75	46053	240.16	34.24	46005	228.92	46.13
46047	240.49	32.40	46022	235.47	40.75	46054	239.53	34.27	46011	238.98	34.96

46050	235.45	44.67	46025	240.96	33.76	46059	230.05	38.09	46012	237.12	37.36
46053	240.16	34.24	46026	237.16	37.75	46060	213.18	60.59	46013	236.70	38.25
46054	239.53	34.27	46027	235.62	41.85	46069	239.79	33.68	46014	236.03	39.23
46059	230.05	38.09	46028	238.10	35.77	46072	187.91	51.67	46025	240.96	33.76
46060	213.18	60.59	46029	235.52	46.14	46073	188.00	55.01	46026	237.16	37.75
46061	213.17	60.24	46035	182.30	57.02	46075	199.18	53.98	46027	235.62	41.85
46066	204.99	52.77	46041	235.26	47.35	46076	211.99	59.47	46028	238.10	35.77
46069	239.79	33.68	46042	237.60	36.79	46077	205.82	57.90	46029	235.52	46.14
46070	175.18	55.01	46047	240.49	32.40	46078	207.42	55.56	46035	182.30	57.02
46073	188.00	55.01	46050	235.45	44.67	46080	209.96	57.95	46042	237.60	36.79
46076	211.99	59.47	46054	239.53	34.27	46081	211.72	60.80	46047	240.49	32.40
46080	209.96	57.95	46059	230.05	38.09	46082	216.63	59.68	46050	235.45	44.67
46081	211.72	60.80	46060	213.18	60.59	46083	221.98	58.27	46053	240.16	34.24
46083	221.98	58.27	46061	213.17	60.24	46084	223.90	56.62	46054	239.53	34.27
46085	217.12	55.88	46066	204.99	52.77	46085	217.12	55.88	46059	230.05	38.09
46086	241.95	32.50	46069	239.79	33.68	46086	241.95	32.50	46060	213.18	60.59
46087	235.27	48.49	46070	175.18	55.01	46087	235.27	48.49	46066	204.99	52.77
46088	236.82	48.33	46071	179.01	51.13	46088	236.82	48.33	46069	239.79	33.68
46092	237.97	36.75	46073	188.00	55.01	46089	234.23	45.93	46072	187.91	51.67
46097	235.70	44.64	46075	199.18	53.98	46092	237.97	36.75	46073	188.00	55.01
46098	235.04	44.38	46076	211.99	59.47	46096	235.87	46.17	46075	199.18	53.98
46100	235.03	46.85	46078	207.42	55.56	46097	235.70	44.64	46076	211.99	59.47
46120	237.60	47.76	46080	209.96	57.95	46098	235.04	44.38	46077	205.82	57.90
51000	206.21	23.53	46081	211.72	60.80	46099	235.43	46.99	46078	207.42	55.56
51001	198.00	24.45	46083	221.98	58.27	46100	235.03	46.85	46080	209.96	57.95
51002	202.26	17.04	46084	223.90	56.62	46125	237.37	47.91	46081	211.72	60.80
51003	199.36	19.20	46085	217.12	55.88	46128	235.46	43.29	46082	216.63	59.68
51004	207.75	17.53	46086	241.95	32.50	51000	206.21	23.53	46083	221.98	58.27
51101	197.93	24.36	46087	235.27	48.49	51001	198.00	24.45	46084	223.90	56.62
T0N110W	250.00	0.00	46088	236.82	48.33	51002	202.26	17.04	46085	217.12	55.88
T0N125W	235.00	0.00	46108	208.17	59.60	51003	199.36	19.20	46086	241.95	32.50
T0N140W	220.00	0.00	46114	237.66	36.70	51004	207.75	17.53	46087	235.27	48.49
T0N155W	205.00	0.00	46211	235.76	46.86	51101	197.93	24.36	46088	236.82	48.33
T0N165E	165.00	0.00	46213	235.27	40.30	T0N110W	250.00	0.00	46089	234.23	45.93
T0N170W	190.00	0.00	46214	236.54	37.94	T0N140W	220.00	0.00	46108	208.17	59.60
T0N95W_	265.00	0.00	46215	239.14	35.20	T0N155W	205.00	0.00	46114	237.66	36.70
T2N110W	250.00	2.00	46217	240.57	34.17	T0N165E	165.00	0.00	46211	235.76	46.86
T2N125W	235.00	2.00	46218	239.22	34.45	T0N170W	190.00	0.00	46213	235.27	40.30
T2N140W	220.00	2.00	46219	240.13	33.22	T0N180W	180.00	0.00	46214	236.54	37.94
T2N165E	165.00	2.00	46221	241.36	33.86	T0N95W_	265.00	0.00	46215	239.14	35.20
T2N170W	190.00	2.00	46222	241.68	33.62	T2N110W	250.00	2.00	46217	240.57	34.17
T2N180W	180.00	2.00	46224	242.53	33.18	T2N140W	220.00	2.00	46218	239.22	34.45
T2N95W_	265.00	2.00	46225	242.61	32.93	T2N155W	205.00	2.00	46219	240.13	33.22
T2S110W	250.00	-2.00	46229	235.45	43.77	T2N165E	165.00	2.00	46221	241.36	33.86
T2S125W	235.00	-2.00	46232	242.58	32.52	T2N170W	190.00	2.00	46222	241.68	33.62

T2S140W	220.00	-2.00	46237	237.37	37.79	T2N180W	180.00	2.00	46224	242.53	33.18
T2S155W	205.00	-2.00	46239	237.90	36.34	T2N95W_	265.00	2.00	46225	242.61	32.93
T2S165E	165.00	-2.00	46240	238.09	36.63	T2S110W	250.00	-2.00	46229	235.45	43.77
T2S170W	190.00	-2.00	46242	242.56	33.22	T2S125W	235.00	-2.00	46232	242.58	32.52
T2S180W	180.00	-2.00	46243	235.87	46.22	T2S140W	220.00	-2.00	46235	242.83	32.57
T5N110W	250.00	5.00	46244	235.64	40.90	T2S155W	205.00	-2.00	46237	237.37	37.79
T5N125W	235.00	5.00	46246	214.83	50.02	T2S165E	165.00	-2.00	46239	237.90	36.34
T5N140W	220.00	5.00	46248	235.36	46.13	T2S170W	190.00	-2.00	46240	238.09	36.63
T5N155W	205.00	5.00	46251	240.44	33.77	T2S180W	180.00	-2.00	46242	242.56	33.22
T5N165E	165.00	5.00	46253	241.82	33.58	T2S95W_	265.00	-2.00	46243	235.87	46.22
T5N170W	190.00	5.00	46254	242.73	32.87	T5N110W	250.00	5.00	46244	235.64	40.90
T5N180W	180.00	5.00	46255	240.35	33.40	T5N125W	235.00	5.00	46246	214.83	50.02
T5S110W	250.00	-5.00	46256	241.80	33.70	T5N140W	220.00	5.00	46248	235.36	46.13
T5S125W	235.00	-5.00	46257	239.23	34.44	T5N155W	205.00	5.00	46251	240.44	33.77
T5S140W	220.00	-5.00	46258	242.50	32.75	T5N165E	165.00	5.00	46253	241.82	33.58
T5S155W	205.00	-5.00	46259	238.50	34.77	T5N170W	190.00	5.00	46254	242.73	32.87
T5S165E	165.00	-5.00	51000	206.21	23.53	T5N180W	180.00	5.00	46256	241.80	33.70
T5S170W	190.00	-5.00	51001	198.00	24.45	T5N95W_	265.00	5.00	46258	242.50	32.75
T5S180W	180.00	-5.00	51002	202.26	17.04	T5S110W	250.00	-5.00	46259	238.50	34.77
T8N110W	250.00	8.00	51003	199.36	19.20	T5S125W	235.00	-5.00	46262	241.00	33.70
T8N125W	235.00	8.00	51004	207.75	17.53	T5S140W	220.00	-5.00	46263	236.09	39.37
T8N165E	165.00	8.00	51101	197.93	24.36	T5S155W	205.00	-5.00	46264	208.31	57.48
T8N170W	190.00	8.00	51201	201.88	21.67	T5S165E	165.00	-5.00	46265	194.53	64.47
T8N180W	180.00	8.00	51202	202.32	21.42	T5S170W	190.00	-5.00	51000	206.21	23.53
T8S110W	250.00	-8.00	51203	202.99	20.79	T5S180W	180.00	-5.00	51001	198.00	24.45
T8S125W	235.00	-8.00	51204	201.88	21.28	T5S95W_	265.00	-5.00	51002	202.26	17.04
T8S155W	205.00	-8.00	51205	203.58	21.02	T8N110W	250.00	8.00	51003	199.36	19.20
T8S165E	165.00	-8.00	51206	205.03	19.78	T8N125W	235.00	8.00	51004	207.75	17.53
T8S170W	190.00	-8.00	51207	202.25	21.48	T8N155W	205.00	8.00	51101	197.93	24.36
T8S180W	180.00	-8.00	51208	200.43	22.29	T8N165E	165.00	8.00	51202	202.32	21.42
T9N140W	220.00	9.00	51210	202.24	21.48	T8N170W	190.00	8.00	51205	203.58	21.02
			52200	144.79	13.35	T8N180W	180.00	8.00	51206	205.03	19.78
			52201	171.39	7.08	T8N95W_	265.00	8.00	51207	202.25	21.48
			52202	144.81	13.68	T8S110W	250.00	-8.00	51208	200.43	22.29
		ssbn7	281.52	33.84		T8S125W	235.00	-8.00	51209	189.50	-14.27
						T8S155W	205.00	-8.00	51210	202.24	21.48
						T8S165E	165.00	-8.00	51211	202.04	21.30
						T8S170W	190.00	-8.00	51212	201.85	21.32
						T8S180W	180.00	-8.00	51213	203.00	20.75
						T8S95W_	265.00	-8.00	52200	144.79	13.35
						T9N140W	220.00	9.00	52201	171.39	7.08
									52202	144.81	13.68
									52211	145.66	15.27
								frfn7	284.26	36.19	
								ssbn7	281.52	33.84	

