atmosphere

MDPI

Supplementary Materials

Evaluation of Regional Air Quality Models over Sydney and Australia: Part 1 Meteorological Model Comparison

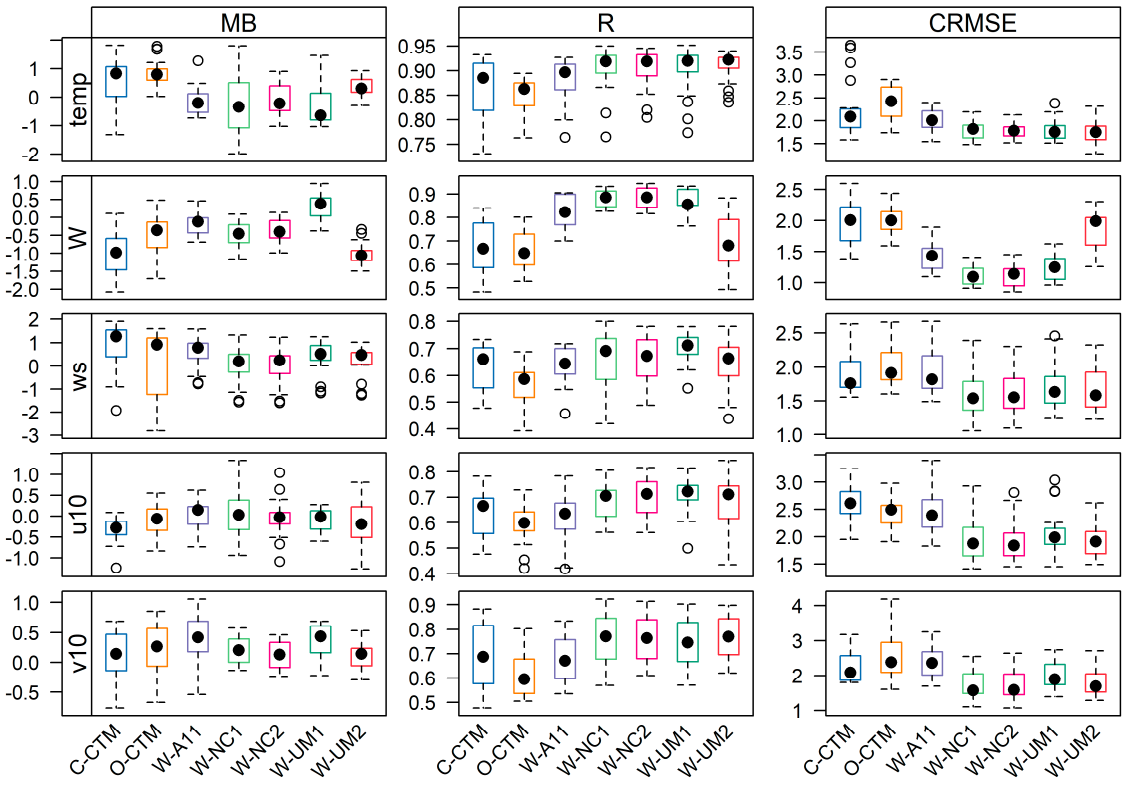

Figure S1. Box and whisker plots of (left) mean bias (MB), (middle) correlation coefficient (R) and (right) centred root mean square error (CRMSE) for the seven BoM stations for (**a**) air temperature (°C), (**b**) mixing ratio (g/kg), (**c**) wind speed (ms^{-1}), (**d**) zonal and (**e**) meridional winds (ms^{-1}).

Table S1. Statistics for temperature (°C) for each model and campaign.

Model	Campaign	Mean Obs	Mean Model	σ Obs	σ Model	MB	MGE	CRMSE	R	IOA
C-CTM	MUMBA	22.5	23.4	4.6	4.8	0.9	1.6	2.1	0.9	0.8
	SPS1	22.0	23.1	4.1	4.6	1.2	1.8	2.0	0.9	0.7
	SPS2	16.0	15.4	4.4	5.2	-0.6	2.2	2.9	0.8	0.7
O-CTM	MUMBA	22.5	23.2	4.6	4.8	0.7	1.9	2.4	0.9	0.7
	SPS1	22.0	22.6	4.1	4.7	0.8	1.8	2.4	0.9	0.7
	SPS2	16.0	17.0	4.4	3.8	1.0	2.2	2.6	0.8	0.7
W-A11	MUMBA	22.5	22.1	4.5	4.9	-0.4	1.5	2.1	0.9	0.8
	SPS1	22.0	21.6	4.1	4.4	-0.2	1.6	2.1	0.9	0.7
	SPS2	16.0	16.1	4.4	4.3	0.1	1.6	2.0	0.9	0.8
W-NC1	MUMBA	22.5	21.2	4.5	4.6	-1.3	1.8	1.8	0.9	0.7
	SPS1	22.0	21.9	4.1	4.3	0.05	1.5	1.8	0.9	0.8
	SPS2	16.0	16.4	4.4	4.6	0.4	1.6	2.0	0.9	0.8
W-NC2	MUMBA	22.5	22.2	4.5	4.4	-0.3	1.4	1.8	0.9	0.8
	SPS1	22.0	21.9	4.1	4.3	0.1	1.5	1.9	0.9	0.8
	SPS2	16.0	16.0	4.4	4.4	0.03	1.4	1.8	0.9	0.8
W-UM1	MUMBA	22.5	21.7	4.5	4.6	-0.7	1.4	1.7	0.9	0.8
	SPS1	22.0	21.3	4.1	4.3	-0.6	1.6	1.9	0.9	0.7
	SPS2	16.0	16.3	4.4	4.2	0.3	1.5	1.9	0.9	0.8
W-UM2	MUMBA	22.5	22.7	4.5	4.5	0.2	1.2	1.7	0.9	0.8
	SPS1	22.0	22.3	4.1	4.0	0.4	1.3	1.6	0.9	0.8
	SPS2	16.0	16.5	4.4	4.0	0.5	1.6	1.9	0.9	0.8

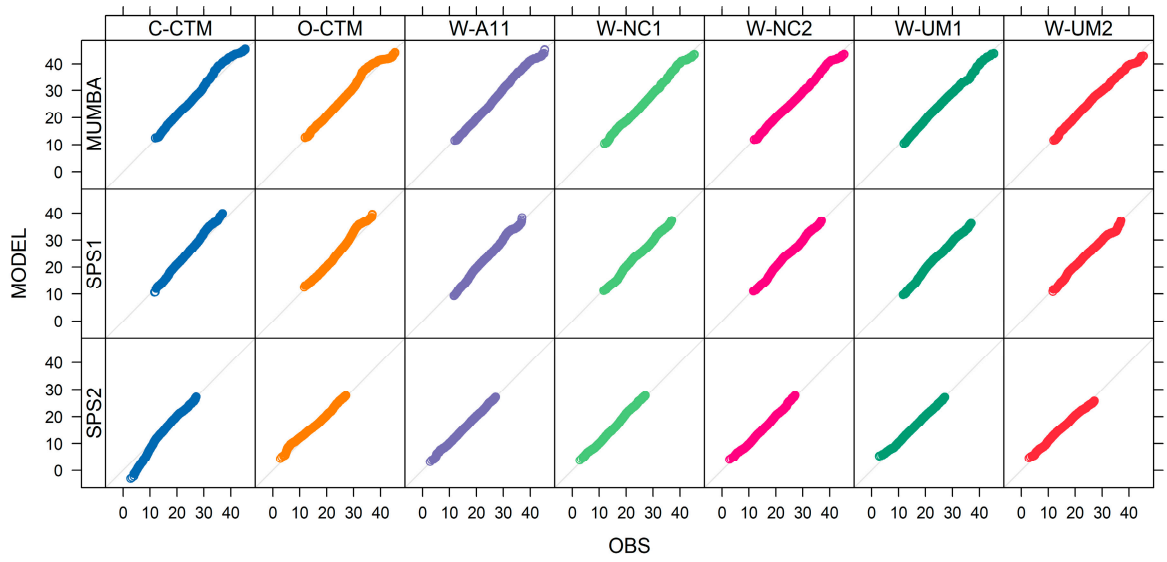

Figure S2. Quantile-Quantile plots for temperature (°C) comparing observations and models grouped by each campaign.

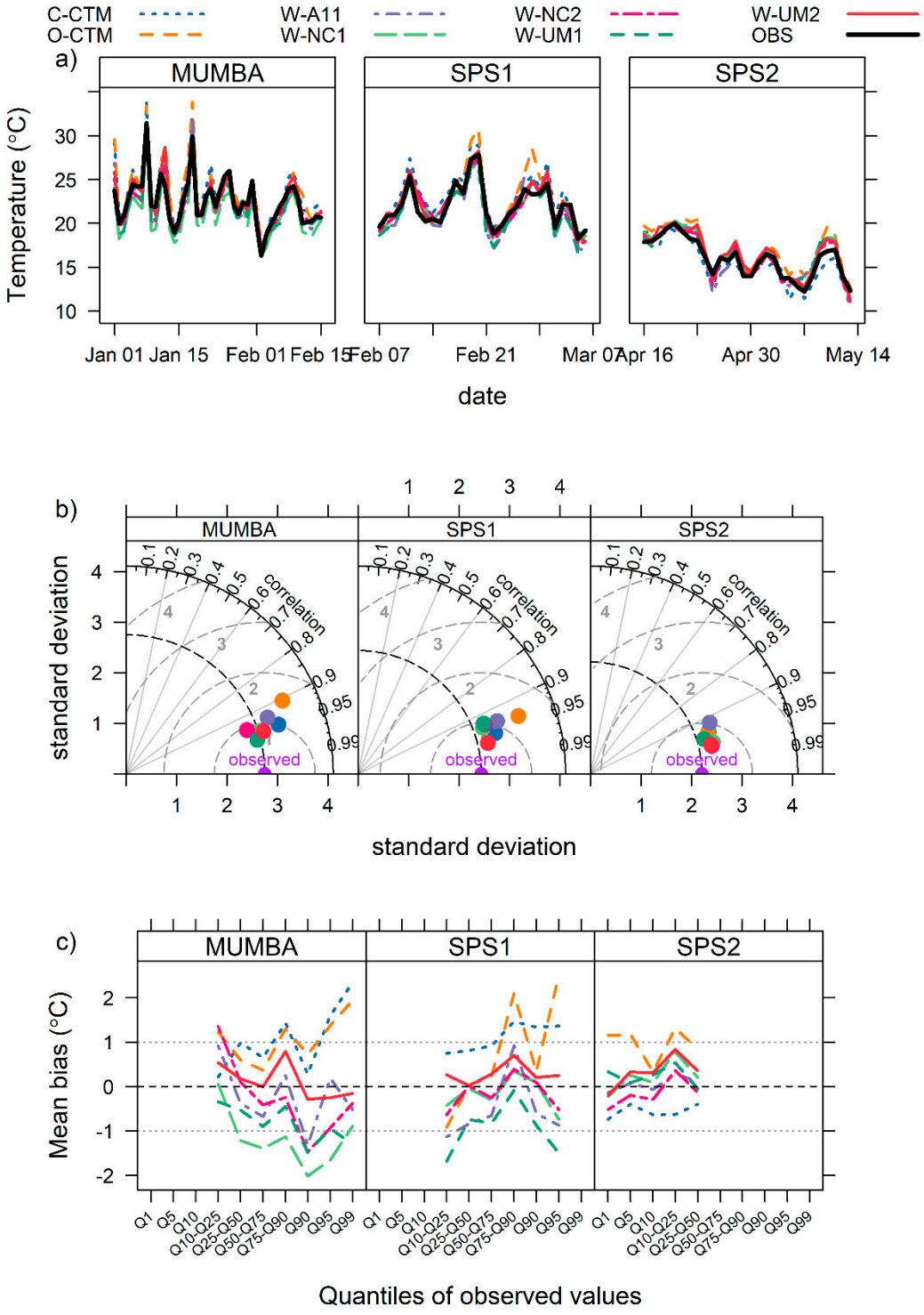

Figure S3. Air temperature (°C) comparing daily observations and models grouped by each campaign (MUMBA, SPS1 and SPS2) for (**a**) mean diurnal cycle (observations are shown in black), (**b**) Taylor diagrams and (**c**) mean bias split by quantile bins.

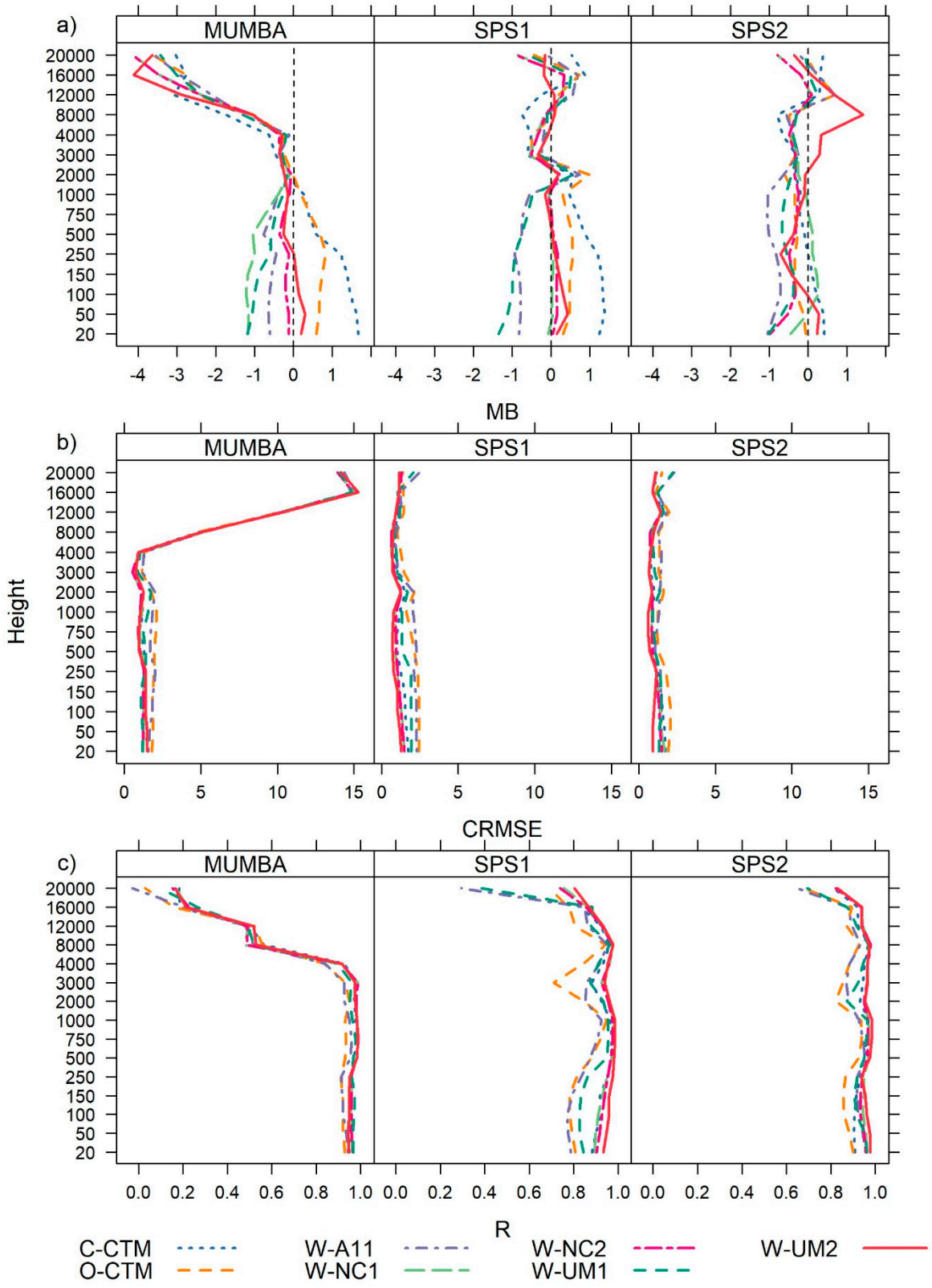

Figure S4. Vertical profile of (**a**) mean bias (MB), (**b**) centred root mean square error (CRMSE) and (**c**) correlation coefficient (R) for temperature (°C) during each campaign (MUMBA, SPS1 and SPS2). The observations are from the twice daily radiosondes released at the BoM Sydney Airport site.

Table S2. Statistics for mixing ratio of water (g/kg) for each model and campaign.

Model	Campaign	Mean Obs	Mean Model	σ Obs	σ Model	MB	MGE	CRMSE	R	IOA
C-CTM	MUMBA	11.8	11.3	2.1	2.6	-0.5	1.6	2.1	0.6	0.5
	SPS1	11.3	9.8	2.5	2.5	-1.6	2.0	2.3	0.6	0.5
	SPS2	8.3	7.4	2.6	2.5	-1.0	1.4	1.7	0.8	0.7
O-CTM	MUMBA	11.8	11.7	2.1	2.8	-0.3	1.7	2.3	0.6	0.5
	SPS1	11.3	10.4	2.5	2.4	-1.1	1.8	2.2	0.6	0.6
	SPS2	8.3	8.2	2.6	2.5	-0.3	1.4	1.8	0.7	0.7
W-A11	MUMBA	11.8	11.9	2.1	2.3	-0.1	1.1	1.5	0.8	0.7
	SPS1	11.3	11.7	2.5	2.6	0.04	1.2	1.7	0.8	0.7
	SPS2	8.3	8.3	2.6	2.7	-0.5	1.0	1.2	0.9	0.8
W-NC1	MUMBA	11.8	11.5	2.1	2.0	-0.4	0.8	1.1	0.9	0.8
	SPS1	11.3	11.4	2.5	2.4	-0.2	0.9	1.4	0.8	0.8
	SPS2	8.3	7.7	2.6	2.4	-0.8	1.0	1.0	0.9	0.8
W-NC2	MUMBA	11.8	11.7	2.1	2.0	-0.3	0.8	1.1	0.8	0.8
	SPS1	11.3	11.4	2.5	2.4	-0.2	0.9	1.4	0.8	0.8
	SPS2	8.3	7.9	2.6	2.5	-0.6	0.9	1.0	0.9	0.8
W-UM1	MUMBA	11.8	12.5	2.1	2.3	0.5	1.1	1.3	0.8	0.7
	SPS1	11.3	12.2	2.5	2.5	0.5	1.2	1.4	0.8	0.7
	SPS2	8.3	8.6	2.6	2.7	-0.1	0.8	1.0	0.9	0.8
W-UM2	MUMBA	11.8	11.1	2.1	2.4	-0.9	1.6	2.1	0.6	0.5
	SPS1	11.3	10.4	2.5	2.5	-1.2	1.7	2.1	0.7	0.6
	SPS2	8.3	7.6	2.6	2.6	-0.9	1.3	1.5	0.8	0.7

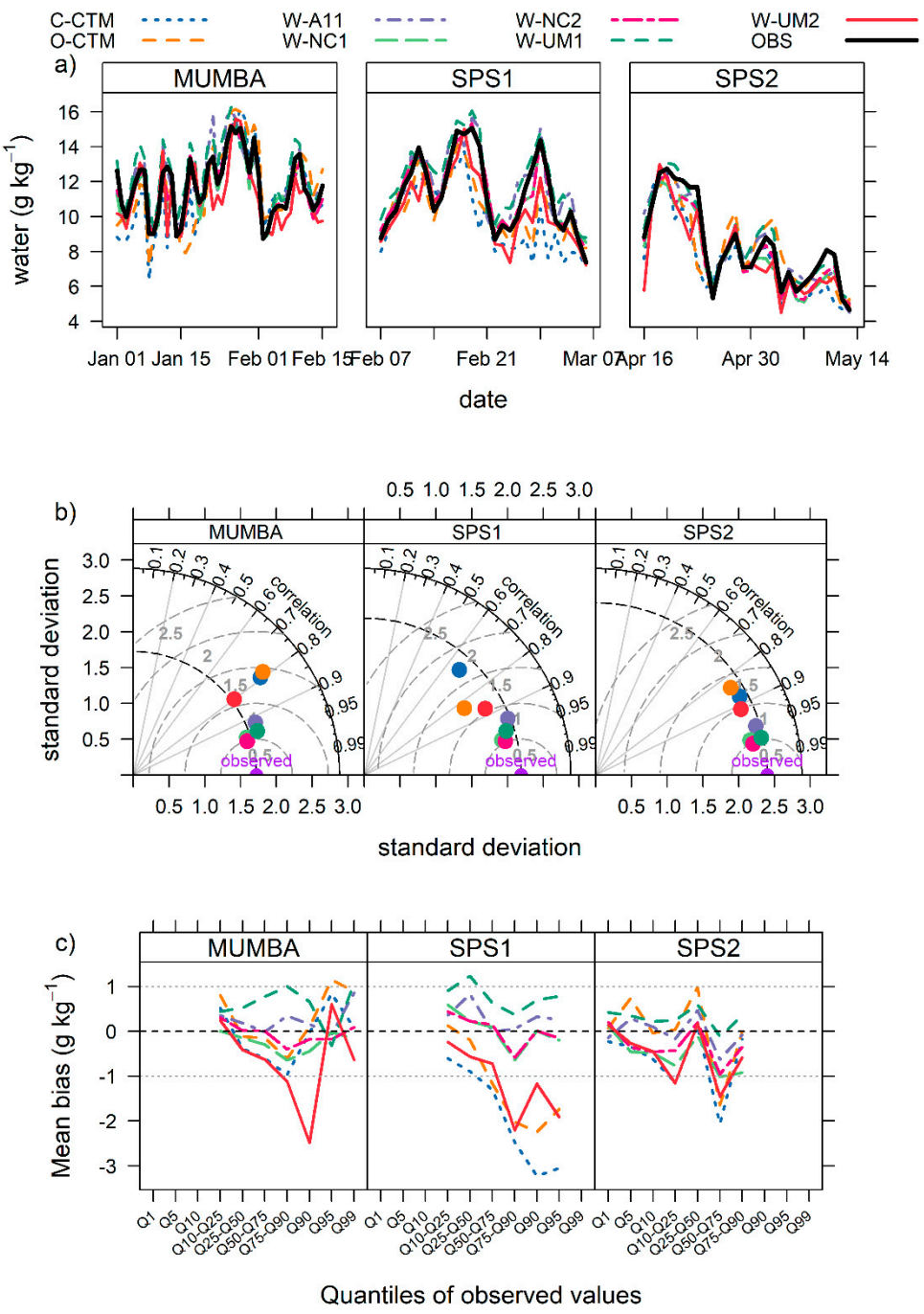

Figure S5. Mixing ratio of water (g/kg) comparing daily observations and models grouped by each campaign (MUMBA, SPS1 and SPS2) for (**a**) mean diurnal cycle (observations are shown in black), (**b**) Taylor diagrams and (**c**) mean bias split by quantile bins.

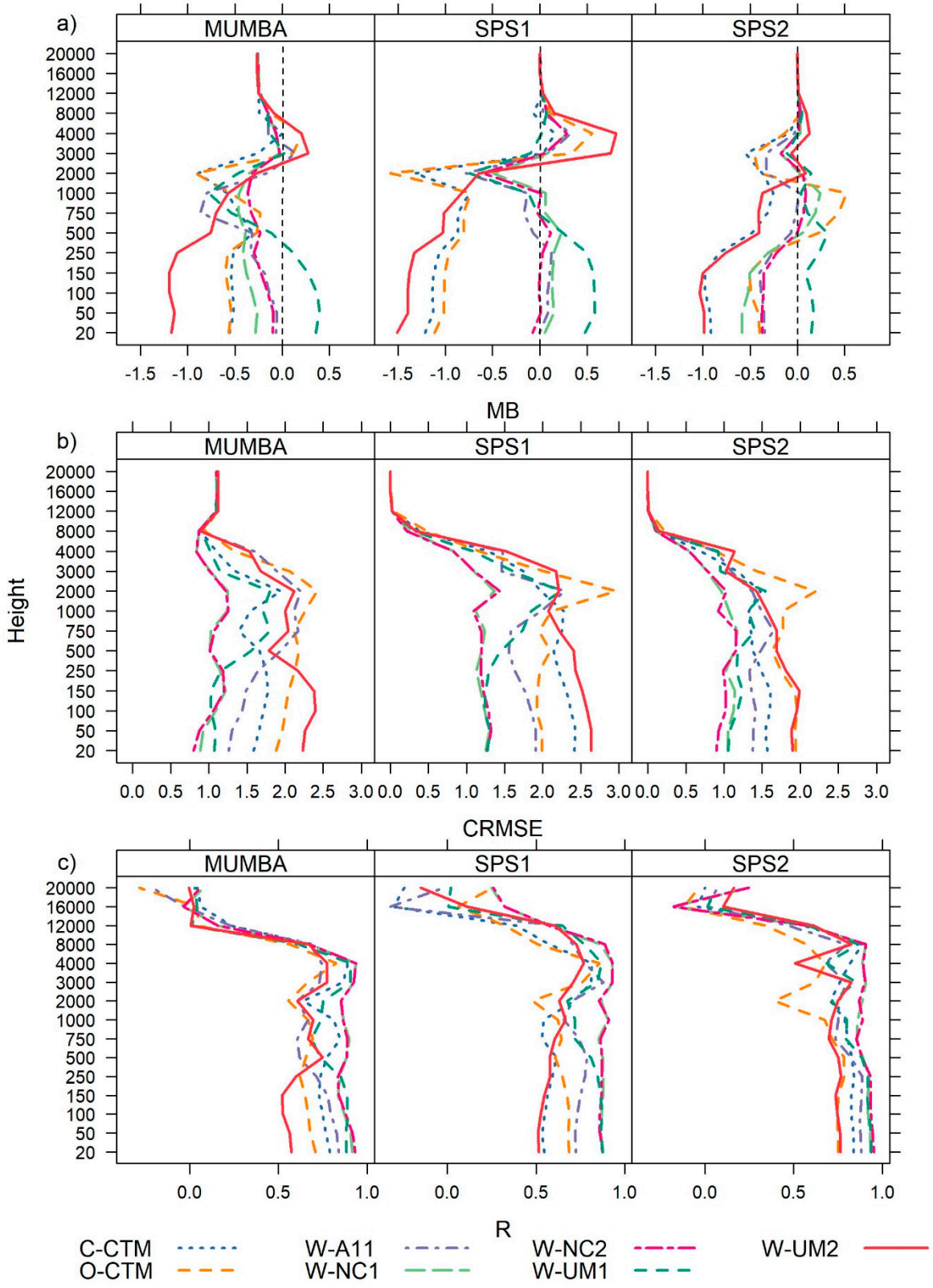

Figure S6. Vertical profile of (**a**) mean bias (MB), (**b**) centred root mean square error (CRMSE) and (**c**) correlation coefficient (R) for mixing ratio of water (g/kg) during each campaign (MUMBA, SPS1 and SPS2). The observations are from the twice daily radiosondes released at the BoM Sydney Airport site.

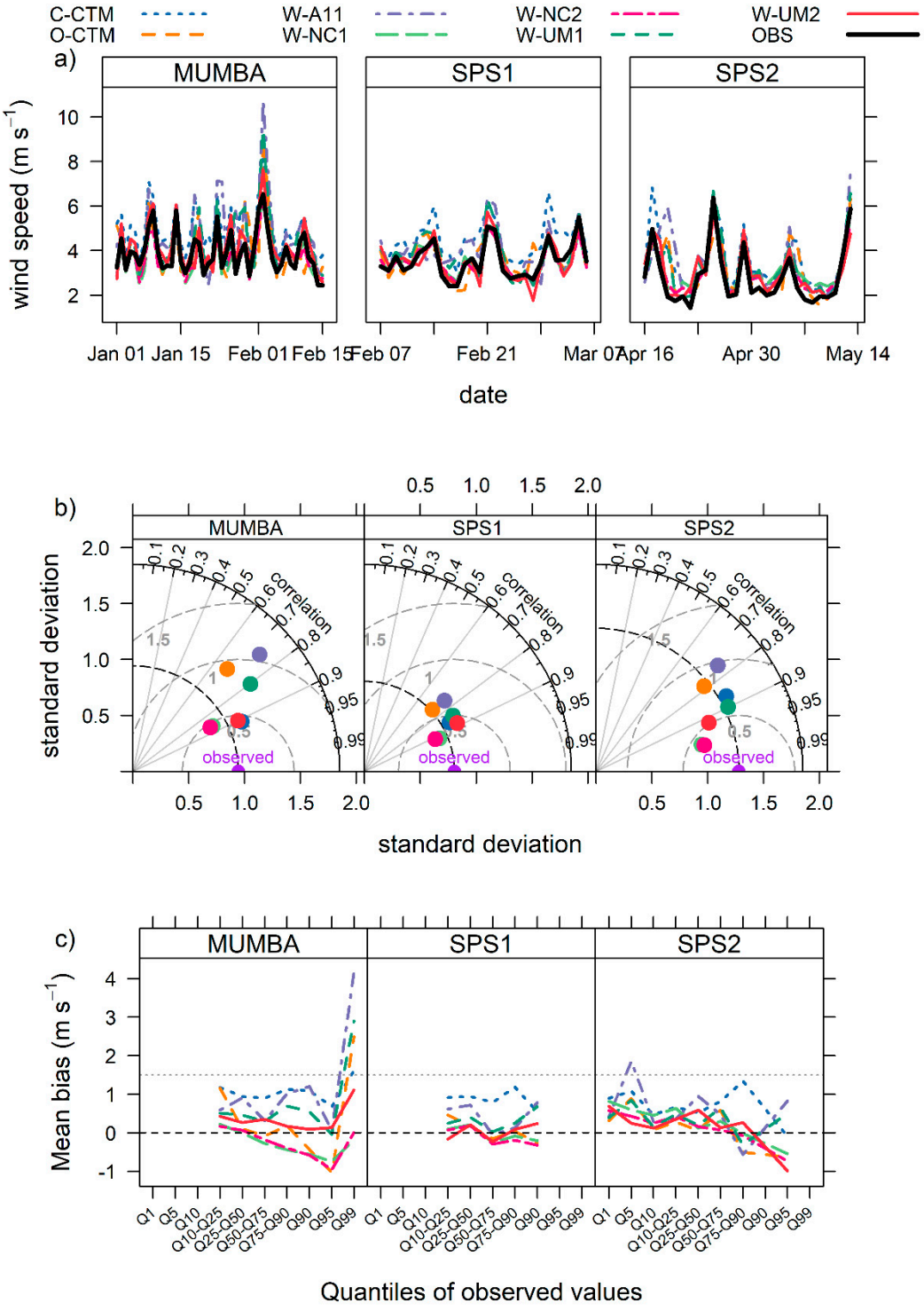

Figure S7. Wind speed (ms^{-1}) comparing daily observations and models grouped by each campaign (MUMBA, SPS1 and SPS2) for (**a**) mean diurnal cycle (observations are shown in black), (**b**) Taylor diagrams and (**c**) mean bias split by quantile bins.

Table 3. Statistics for wind speed (ms^{-1}) for each model and campaign.

Model	Campaign	Mean Obs	Mean Model	σ Obs	σ Model	MB	MGE	CRMSE	R	IOA
C-CTM	MUMBA	3.9	4.9	2.7	2.6	1.0	2.0	2.3	0.6	0.5
	SPS1	3.6	4.5	2.5	2.3	0.8	1.7	2.1	0.6	0.6
	SPS2	2.8	3.5	2.4	2.2	0.7	1.7	2.2	0.6	0.5
O-CTM	MUMBA	3.9	4.0	2.7	2.3	0.1	2.0	2.7	0.4	0.5
	SPS1	3.5	3.6	2.5	2.0	-0.1	1.8	2.4	0.5	0.5
	SPS2	2.8	3.0	2.4	2.0	0.2	1.8	2.3	0.5	0.5
W-A11	MUMBA	3.9	4.7	2.7	2.8	0.8	1.7	2.2	0.7	0.6
	SPS1	3.6	4.0	2.5	2.3	0.4	1.5	1.9	0.7	0.6
	SPS2	2.8	3.4	2.4	2.3	0.6	1.6	2.1	0.6	0.6
W-NC1	MUMBA	3.9	3.7	2.7	2.1	-0.2	1.3	1.7	0.8	0.7
	SPS1	3.6	3.5	2.5	1.9	0.1	1.3	1.7	0.7	0.7
	SPS2	2.8	3.2	2.4	1.9	0.4	1.6	2.0	0.6	0.6
W-NC2	MUMBA	3.9	3.7	2.7	2.1	-0.2	1.3	1.8	0.8	0.7
	SPS1	3.6	3.5	2.5	1.9	0.1	1.3	1.7	0.7	0.7
	SPS2	2.8	3.0	2.4	1.8	0.2	1.5	1.9	0.6	0.6
W-UM1	MUMBA	3.9	4.4	2.7	2.7	0.5	1.5	2.0	0.7	0.7
	SPS1	3.6	3.8	2.5	2.3	0.3	1.4	1.8	0.7	0.6
	SPS2	2.8	3.2	2.4	2.2	0.4	1.4	1.8	0.7	0.6
W-UM2	MUMBA	3.9	4.2	2.7	2.3	0.3	1.4	1.8	0.7	0.7
	SPS1	3.6	3.6	2.5	1.9	0.1	1.4	1.8	0.7	0.6
	SPS2	2.8	3.0	2.4	1.8	0.2	1.5	1.9	0.6	0.6

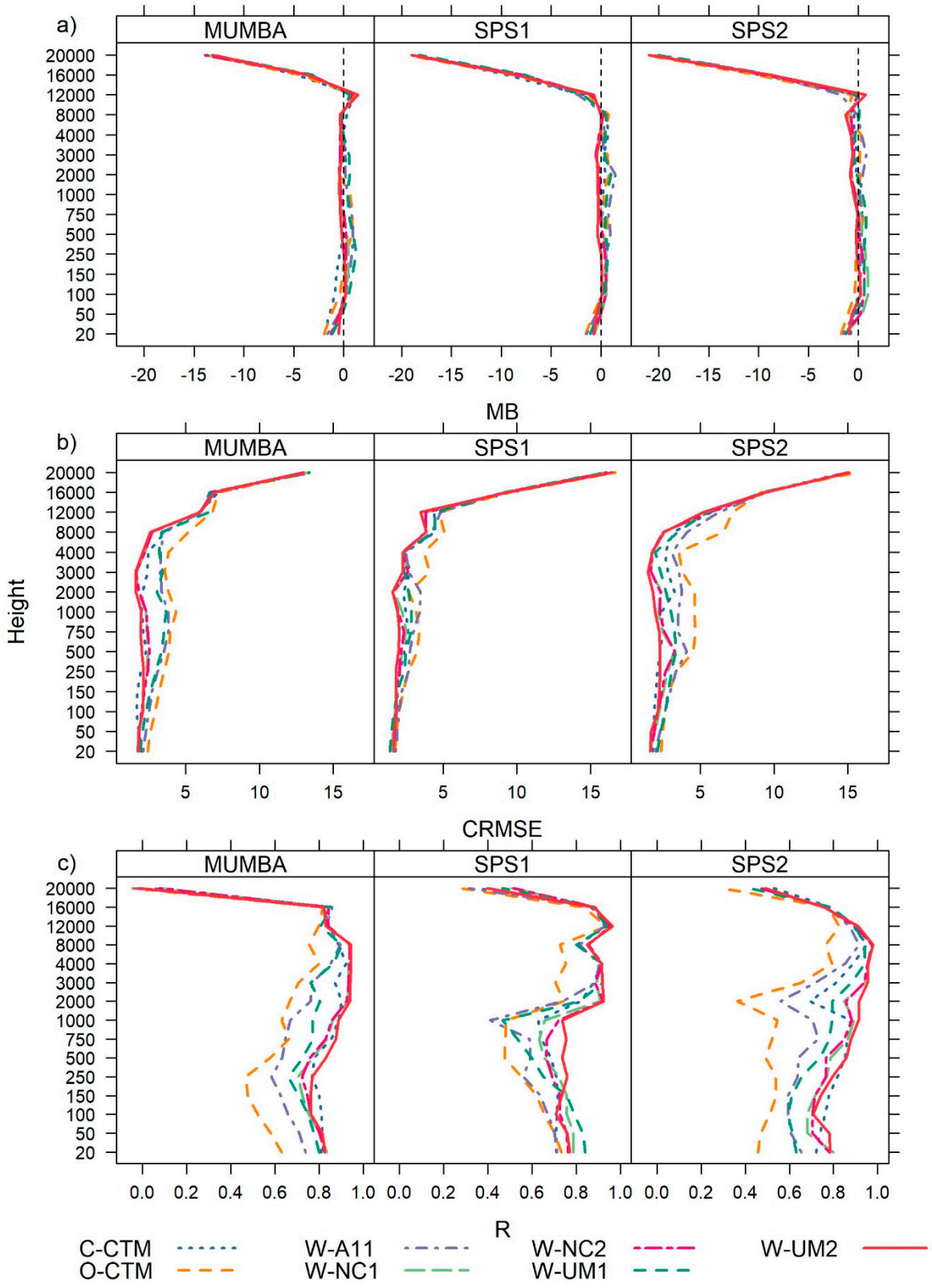

Figure S8. Vertical profile of (**a**) mean bias (MB), (**b**) centred root mean square error (CRMSE) and (**c**) correlation coefficient (R) for wind speed (ms^{-1}) during each campaign (MUMBA, SPS1 and SPS2). The observations are from the twice daily radiosondes released at the BoM Sydney Airport site.

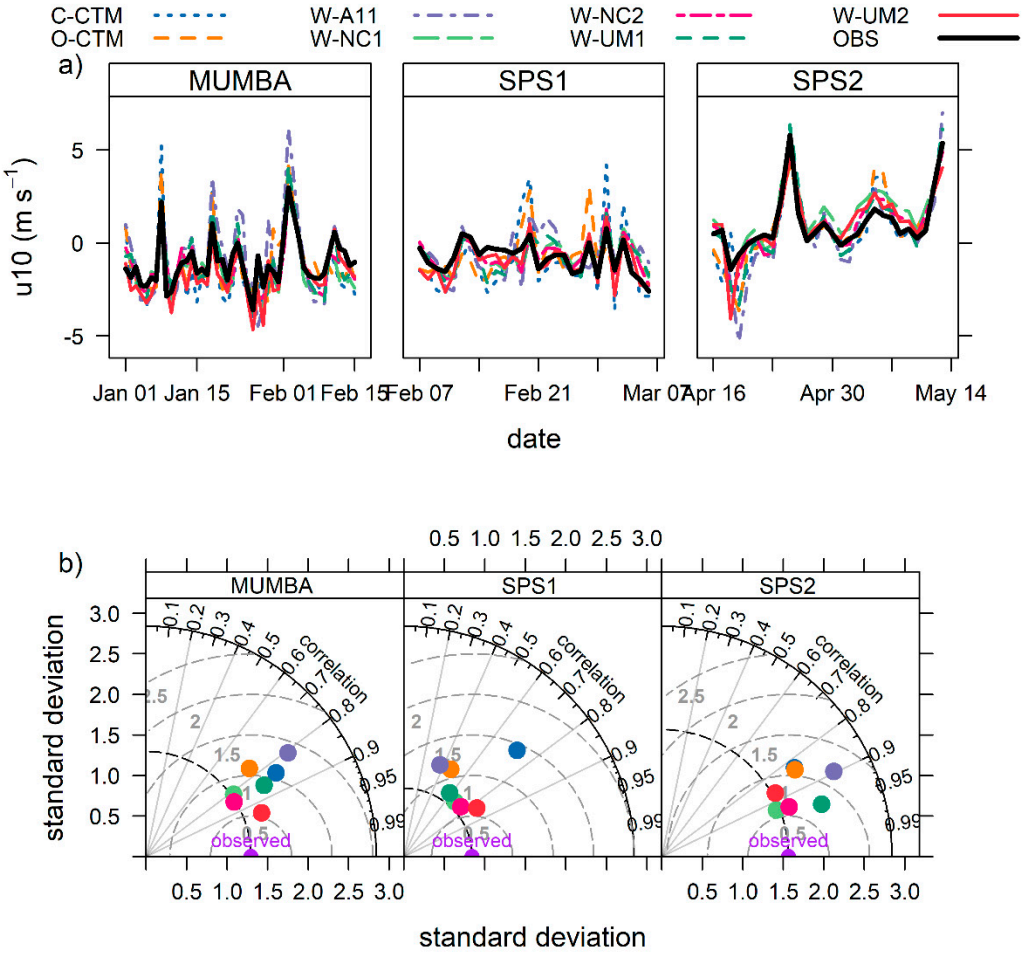

Figure S9. Zonal winds (ms^{-1}) comparing daily observations and models grouped by each campaign (MUMBA, SPS1 and SPS2) for (**a**) mean diurnal cycle (observations are shown in black) and (**b**) Taylor diagrams.

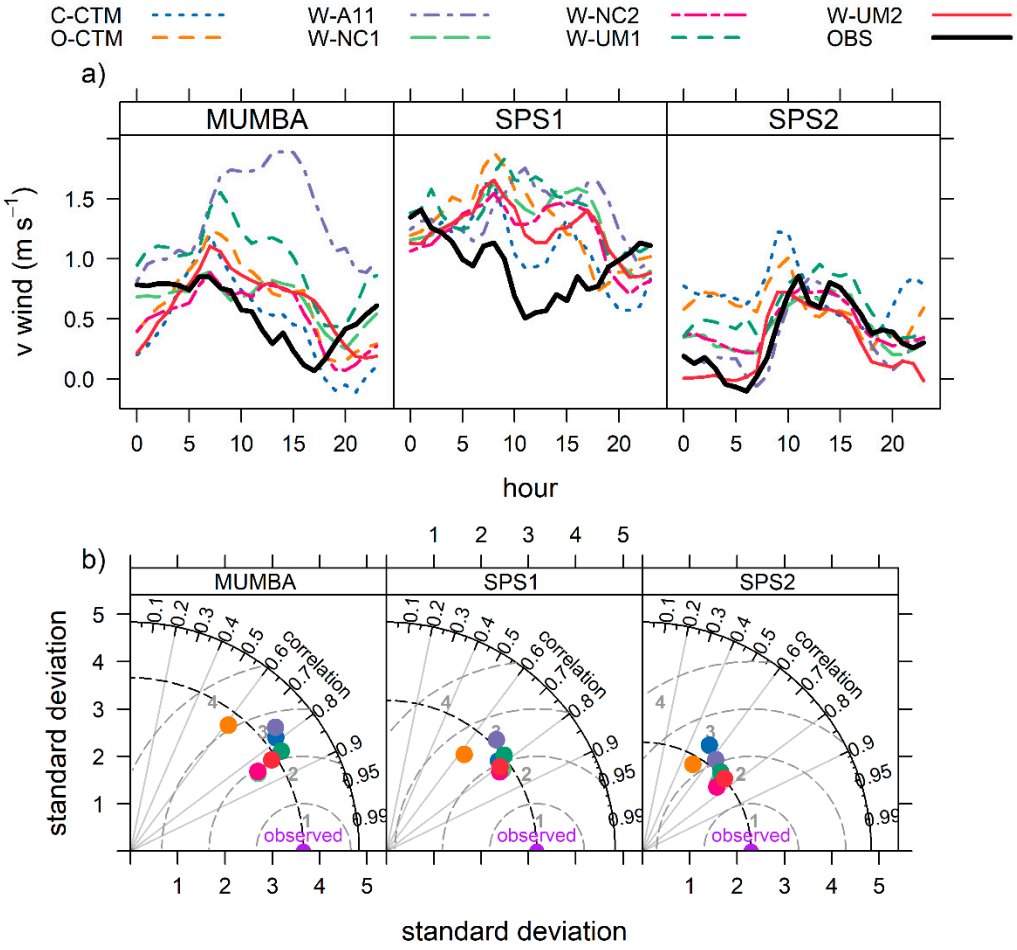

Figure S10. Meridional winds (ms^{-1}) comparing hourly observations and models grouped by each campaign (MUMBA, SPS1 and SPS2) for (**a**) mean diurnal cycle (observations are shown in black) and (**b**) Taylor diagrams.

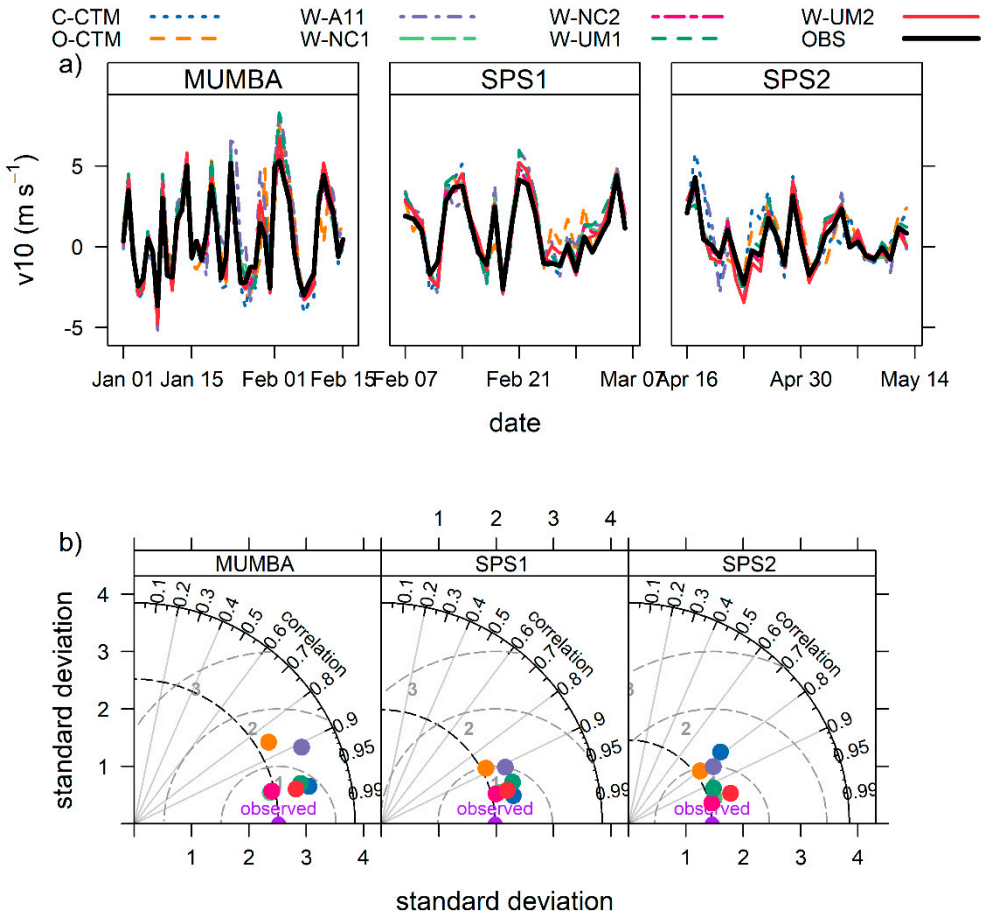

Figure S11. Meridional winds (ms^{-1}) comparing daily observations and models grouped by each campaign (MUMBA, SPS1 and SPS2) for (**a**) mean diurnal cycle (observations are shown in black) and (**b**) Taylor diagrams.

Table S4. Statistics for zonal (U) and meridional (V) winds (ms^{-1}) for each model and campaign.

Variable	Model	Campaign	Mean Obs	Mean Model	σ Obs	σ Model	MB	MGE	CRMSE	R	IOA
U	C-CTM	MUMBA	-1.1	-1.6	2.7	3.6	-0.5	2.0	2.6	0.69	0.5
		SPS1	-0.8	-1.0	2.5	3.7	-0.3	2.1	2.8	0.64	0.5
		SPS2	1.0	0.9	2.6	3.0	-0.2	1.9	2.6	0.57	0.5
	O-CTM	MUMBA	-1.1	-1.2	2.7	2.9	-0.1	1.8	2.4	0.62	0.6
		SPS1	-0.8	-0.8	2.5	2.7	0.0	1.8	2.6	0.51	0.5
		SPS2	1.0	0.9	2.6	2.7	-0.1	1.8	2.4	0.59	0.5
	W-A11	MUMBA	-1.1	-0.8	2.6	3.4	0.3	1.9	2.5	0.69	0.6
		SPS1	-0.8	-0.6	2.5	2.8	0.1	2.0	2.6	0.51	0.5
		SPS2	1.0	0.8	2.6	3.2	-0.3	1.8	2.4	0.67	0.5
	W-NC1	MUMBA	-1.1	-1.5	2.6	2.3	-0.4	1.5	1.9	0.72	0.6
		SPS1	-0.8	-0.6	2.5	2.4	0.1	1.6	2.1	0.64	0.6
		SPS2	1.0	1.6	2.6	2.5	0.6	1.7	2.1	0.65	0.5
	W-NC2	MUMBA	-1.1	-1.3	2.6	2.5	-0.2	1.4	1.9	0.73	0.7
		SPS1	-0.8	-0.7	2.5	2.4	0.0	1.6	2.0	0.65	0.6
		SPS2	1.0	1.1	2.6	2.6	0.1	1.6	2.1	0.67	0.6
	W-UM1	MUMBA	-1.1	-1.2	2.6	3.1	-0.2	1.6	2.2	0.71	0.6

		SPS1	-0.8	-0.7	2.5	2.7	0.0	1.7	2.2	0.64	0.6
		SPS2	1.0	0.9	2.6	2.9	-0.1	1.5	2.0	0.74	0.6
	W-UM2	MUMBA	-1.1	-1.6	2.6	2.7	-0.5	1.5	1.9	0.75	0.6
		SPS1	-0.8	-1.0	2.5	2.3	-0.2	1.5	2.0	0.66	0.6
		SPS2	1.0	1.1	2.6	2.4	0.1	1.6	2.2	0.62	0.6
V	C-CTM	MUMBA	0.5	0.5	3.7	3.9	-0.1	1.9	2.5	0.79	0.7
		SPS1	0.9	1.1	3.2	3.1	0.1	1.6	2.1	0.78	0.7
		SPS2	0.4	0.7	2.3	2.6	0.3	1.8	2.4	0.53	0.4
	O-CTM	MUMBA	0.5	0.7	3.6	3.4	0.1	2.3	3.1	0.61	0.6
		SPS1	1.0	1.3	3.2	2.8	0.2	1.9	2.6	0.63	0.6
		SPS2	0.4	0.6	2.3	2.1	0.2	1.7	2.2	0.50	0.5
	W-A11	MUMBA	0.5	1.3	3.6	4.0	0.8	2.0	2.7	0.76	0.6
		SPS1	0.9	1.4	3.2	3.2	0.4	1.9	2.5	0.70	0.6
		SPS2	0.4	0.3	2.3	2.5	0.0	1.5	2.1	0.62	0.5
	W-NC1	MUMBA	0.5	0.6	3.6	3.2	0.1	1.4	1.9	0.85	0.7
		SPS1	0.9	1.3	3.2	2.9	0.4	1.5	1.8	0.82	0.7
		SPS2	0.4	0.4	2.3	2.1	0.1	1.2	1.6	0.74	0.6
	W-NC2	MUMBA	0.5	0.5	3.6	3.2	0.0	1.4	1.9	0.85	0.7
		SPS1	0.9	1.2	3.2	2.8	0.3	1.4	1.8	0.82	0.7
		SPS2	0.4	0.4	2.3	2.1	0.1	1.2	1.5	0.76	0.6
	W-UM1	MUMBA	0.5	1.0	3.6	3.8	0.4	1.6	2.2	0.83	0.7
		SPS1	0.9	1.4	3.2	3.2	0.4	1.6	2.1	0.78	0.7
		SPS2	0.4	0.6	2.3	2.3	0.2	1.3	1.8	0.70	0.6
	W-UM2	MUMBA	0.5	0.6	3.6	3.6	0.1	1.5	2.0	0.84	0.7
		SPS1	0.9	1.2	3.2	2.9	0.3	1.5	1.9	0.80	0.7
		SPS2	0.4	0.3	2.3	2.3	-0.1	1.3	1.6	0.75	0.6

Table S5. Statistics for Planetary Boundary Layer Height (m) for each model and campaign for morning (AM) and afternoon (PM).

Variable	Model	Campaign	Mean Obs	Mean Model	σ Obs	σ Model	MB	MGE	CRMSE	R	IOA
AM	C-CTM	MUMBA	255	425	223	319	169	245	321	0.3	0.4
		SPS1	132	476	236	476	344	391	486	0.2	-0.2
		SPS2	92	175	143	196	84	107	169	0.5	0.4
	O-CTM	MUMBA	257	234	221	250	-23	176	238	0.5	0.5
		SPS1	132	213	236	289	81	157	268	0.5	0.5
		SPS2	92	134	143	145	43	105	135	0.6	0.4
	W-A11	MUMBA	257	363	221	278	106	198	254	0.5	0.5
		SPS1	132	376	236	360	243	267	304	0.5	0.1
		SPS2	92	143	143	176	52	113	182	0.4	0.3
	W-NC1	MUMBA	257	305	221	194	48	177	227	0.4	0.5
		SPS1	132	301	236	345	168	218	317	0.5	0.3
		SPS2	92	176	143	184	85	118	166	0.5	0.3
	W-NC2	MUMBA	257	278	221	172	22	164	210	0.5	0.6
		SPS1	132	316	236	314	184	245	307	0.4	0.2
		SPS2	92	157	143	163	65	105	160	0.5	0.4

	W-UM1	MUMBA	257	259	221	255	3	163	241	0.5	0.6
		SPS1	132	210	236	274	77	203	351	0.1	0.3
		SPS2	92	98	143	132	6	81	122	0.6	0.5
	W-UM2	MUMBA	258	301	225	203	43	183	230	0.4	0.5
		SPS1	132	305	236	287	173	260	337	0.2	0.2
		SPS2	92	245	143	218	153	166	191	0.5	0.0
PM	C-CTM	MUMBA	1048	1229	1273	1577	181	314	576	0.9	0.8
		SPS1	1196	854	562	654	-343	527	624	0.5	0.3
		SPS2	985	972	439	601	-13	442	573	0.4	0.4
	O-CTM	MUMBA	1048	1173	1273	1129	125	634	942	0.7	0.6
		SPS1	1196	932	562	752	-264	837	1059	-0.3	0.0
		SPS2	985	994	439	385	9	448	535	0.2	0.4
	W-A11	MUMBA	1048	1188	1273	1260	140	377	459	0.9	0.8
		SPS1	1196	874	562	475	-322	580	792	-0.2	0.3
		SPS2	985	903	439	330	-82	309	397	0.5	0.6
	W-NC1	MUMBA	1048	722	1273	967	-326	579	1278	0.4	0.7
		SPS1	1196	889	562	408	-307	468	707	0.0	0.4
		SPS2	985	1096	439	443	111	388	461	0.5	0.5
	W-NC2	MUMBA	1048	818	1273	982	-230	616	1352	0.3	0.7
		SPS1	1196	984	562	480	-213	382	523	0.5	0.5
		SPS2	985	885	439	544	-100	418	550	0.4	0.5
	W-UM1	MUMBA	1048	1039	1273	1158	-8	288	389	1.0	0.8
		SPS1	1196	829	562	509	-367	650	820	-0.2	0.2
		SPS2	985	859	439	449	-126	380	473	0.4	0.5
	W-UM2	MUMBA	1048	666	1273	314	-382	676	1282	0.1	0.6
		SPS1	1196	886	562	309	-310	418	536	0.4	0.5
		SPS2	985	878	439	382	-107	376	477	0.3	0.5