Supplement of:

Can the assimilation of water isotopologue observation improve the quality of tropical diabatic heating and precipitation?

Khosrawi et al.

In the supplement we provide some additional figures and tables that complement those in the manuscript.

Figure S1 to S3 complement Fig.1 and Fig.2 of the paper and show the spatial and temporal averaged vertical profiles of the mena difference (MD), Root mean square difference (RMSD) and skill, respectively, for all parameters for the PREPBUFR experiment.

Figure S4 complements Fig. 4 of the paper and show the cross sections for Q_1, Q_2 and ω separated by regions (Asia (1), America (2) and Africa (3)).

Figure S5 to Fig. S7 complement Fig. 6 and show the spatial and temporal averaged vertical profiles of the MD, the RMSD and skill for ω, Q_1 and Q_2 separated by regions (Asia, America and Africa) for the PREPBUFR experiment.

Figure S8 to S10 show the spatial and temporal averaged vertical profiles of MD, RMSD and skill, respectively, for all parameters for the noDAvsDA experiment.

Figures S11 and S11 complement Figures 9 and 10 of the paper and show the time series of the ensemble mean at 500 hPa for ω, Q_1 and Q_2.

Tables S1 to S4 complement Figures 7 and 8 of the paper and provide the amount of improvement/degradation in skill derived from the vertical profiles and time series for the PREPBUFR and noDAvsDA experiment for the tropics and separated by regions. Positive values denote an improvement while negative values denote a degradation.

Tables S5 to S8 complement Figure 13 and 14 and provide the amount of improvement/degradation in skill derived from the vertical profiles and time series for the PREPBUFR and noDAvsDA experiment separated into upward/downward branches. Positive values denote an improvement while negative values denote a degradation.

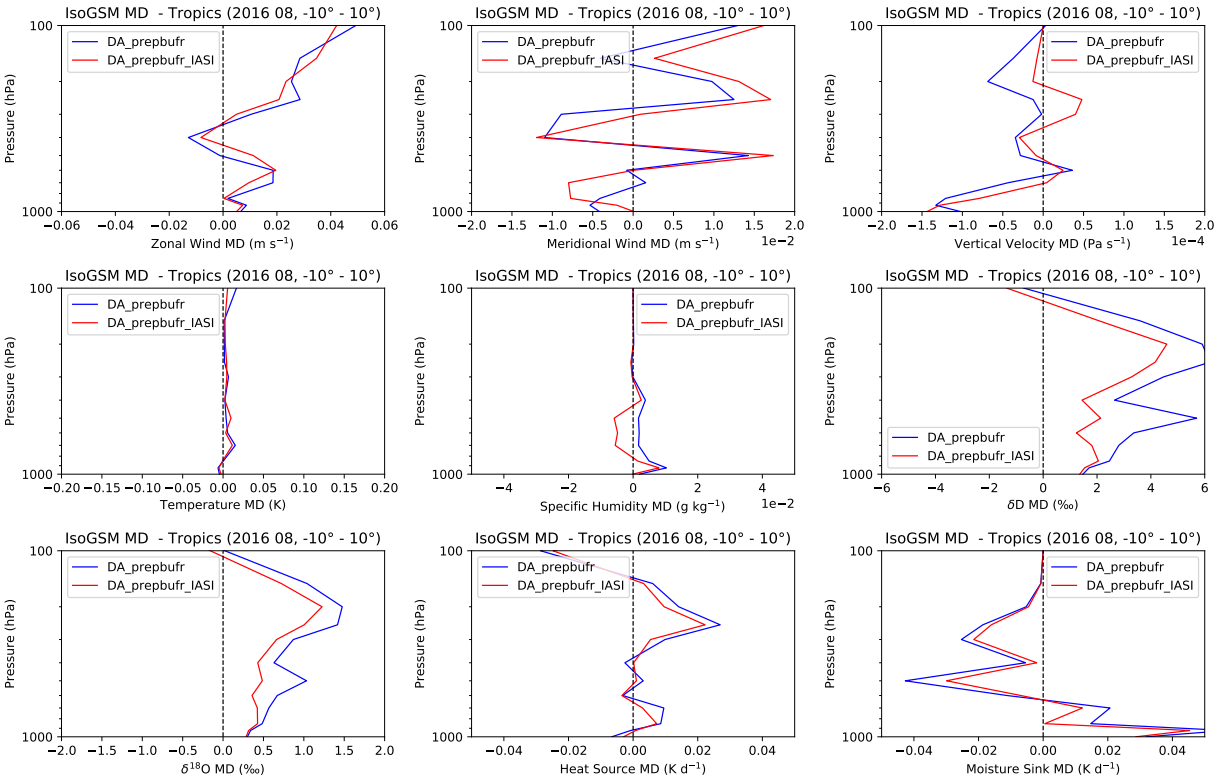

Figure S1: Spatial and temporal averaged vertical profiles of the MD between the ensemble mean of each assimilation run and the Nature run for all parameters for the tropics (PREPBUFR experiment).

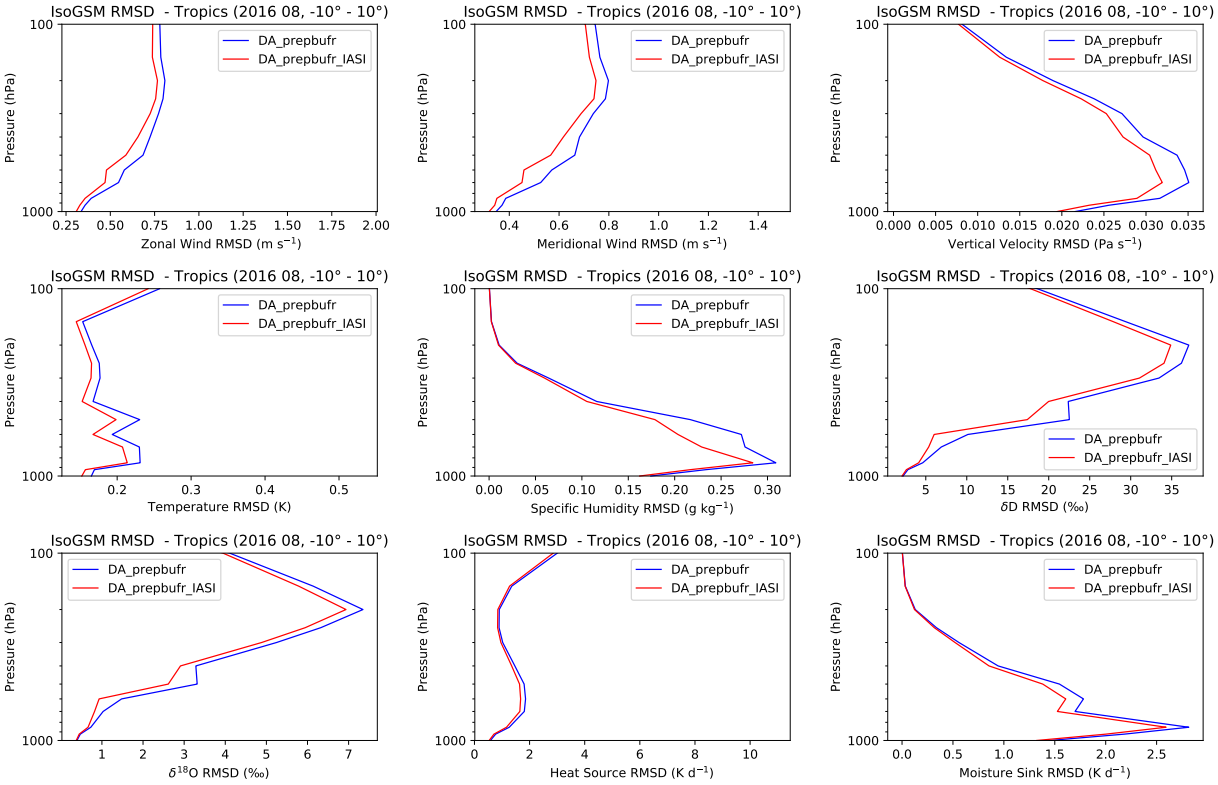

Figure S2: Spatial and temporal averaged vertical profiles of the RMSD of the two assimilation runs for all parameters for the tropics (PREPBUFR experiment).

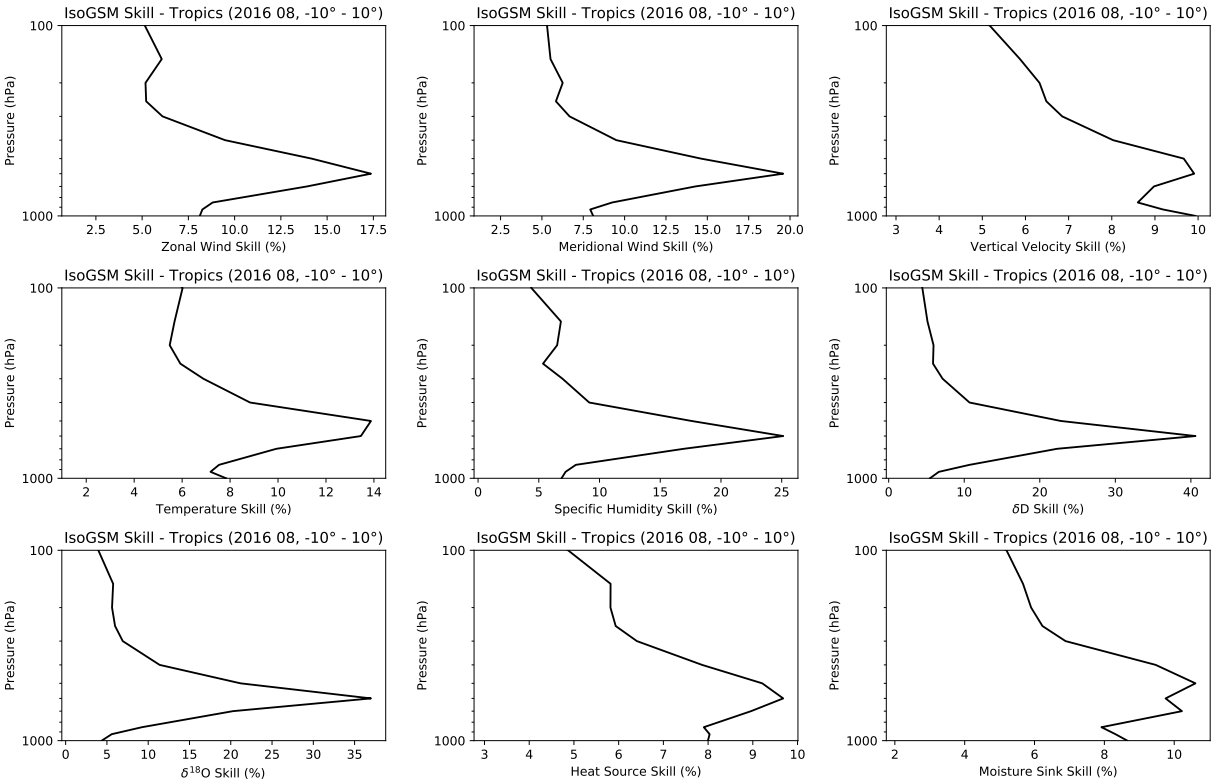

Figure S3: Spatial and temporal averaged vertical profile of the improvement in skill when additionally to the conventional observations IASI δD is assimilated. The profiles are shown for all parameters for the tropics (PREPBUFR experiment)

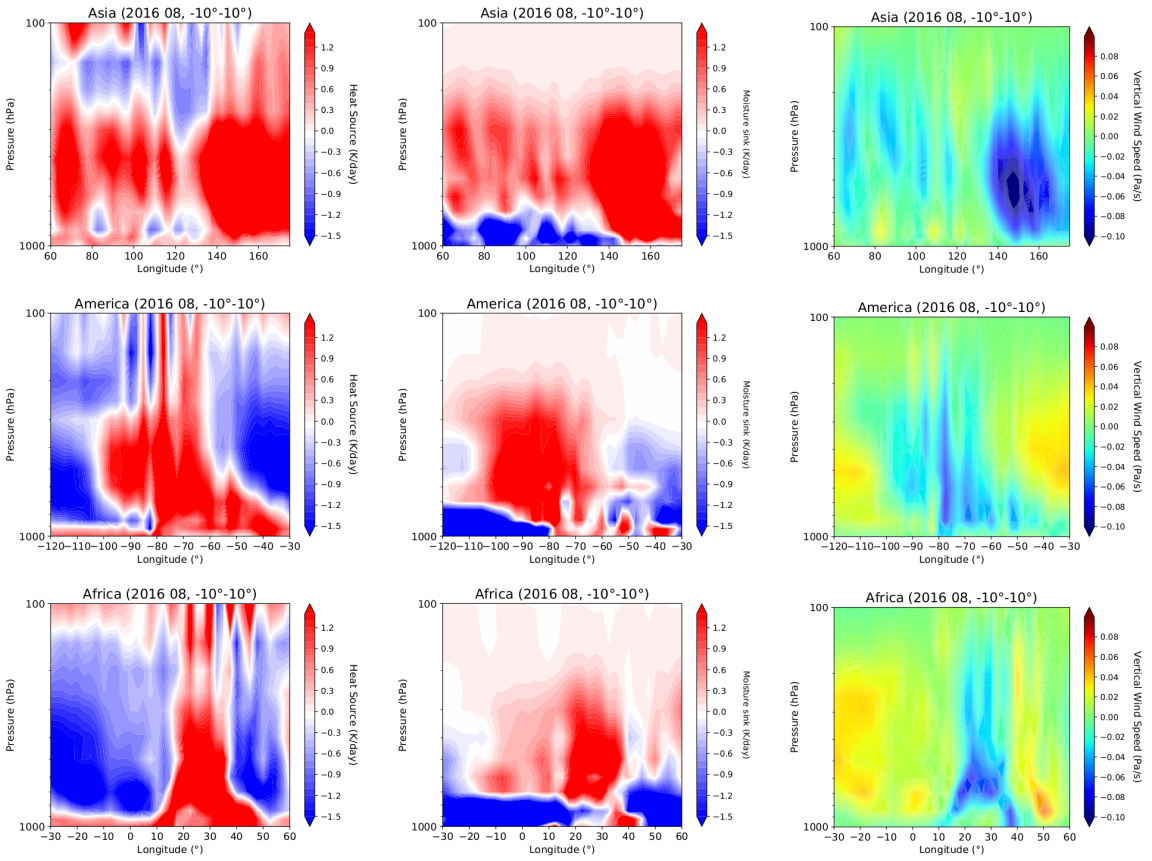

Figure S4: Cross sections for heat source (Q_1), moisture sink (Q_2) and vertical wind (ω), from left to right) for the tropics, Asia (1), America (2) and Africa (3) (from top to bottom) for August 2016 (10°S to 10°N).

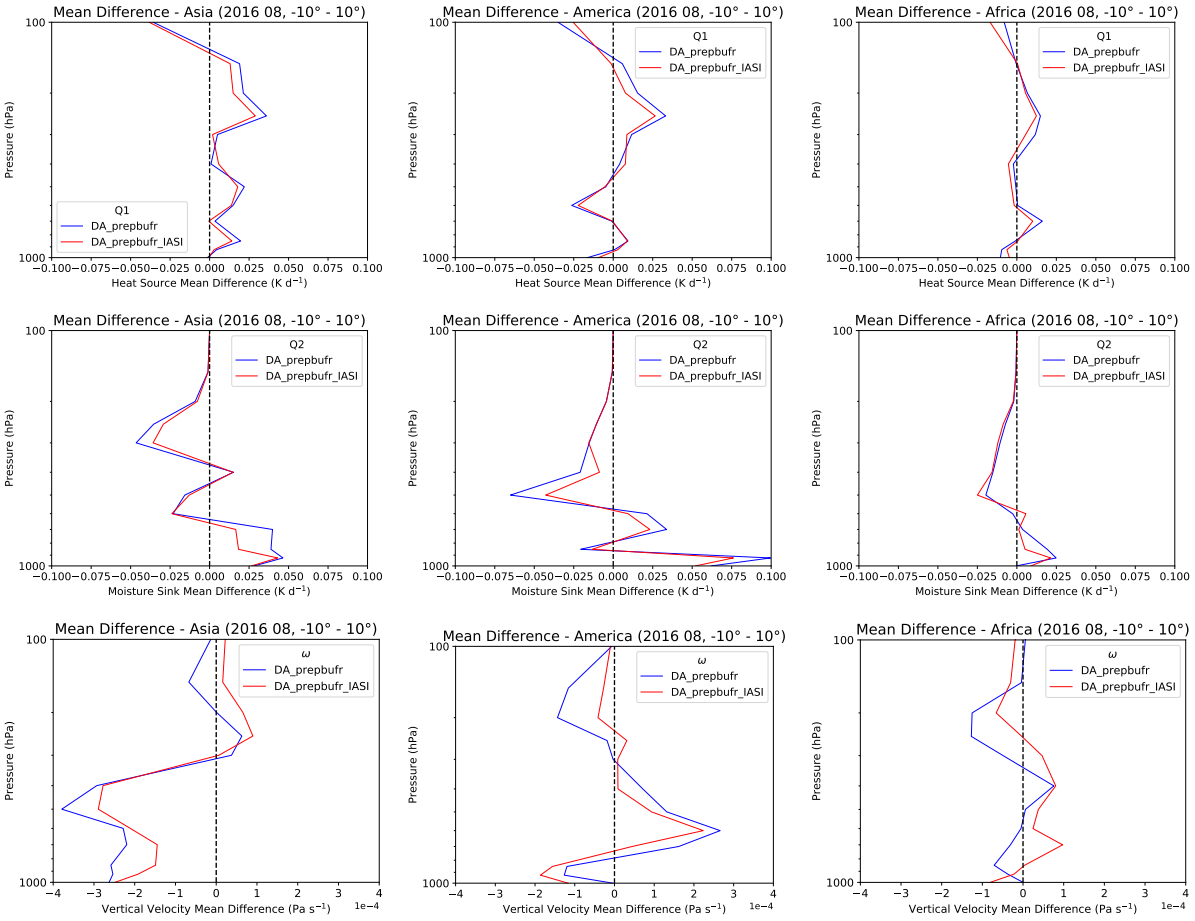

Figure S5: Spatial and temporal averaged vertical profiles of the MD for the heat source (Q_1), moisture sink (Q_2) and vertical wind (ω), top to bottom) for Asia (left), America (middle) and Africa (right).

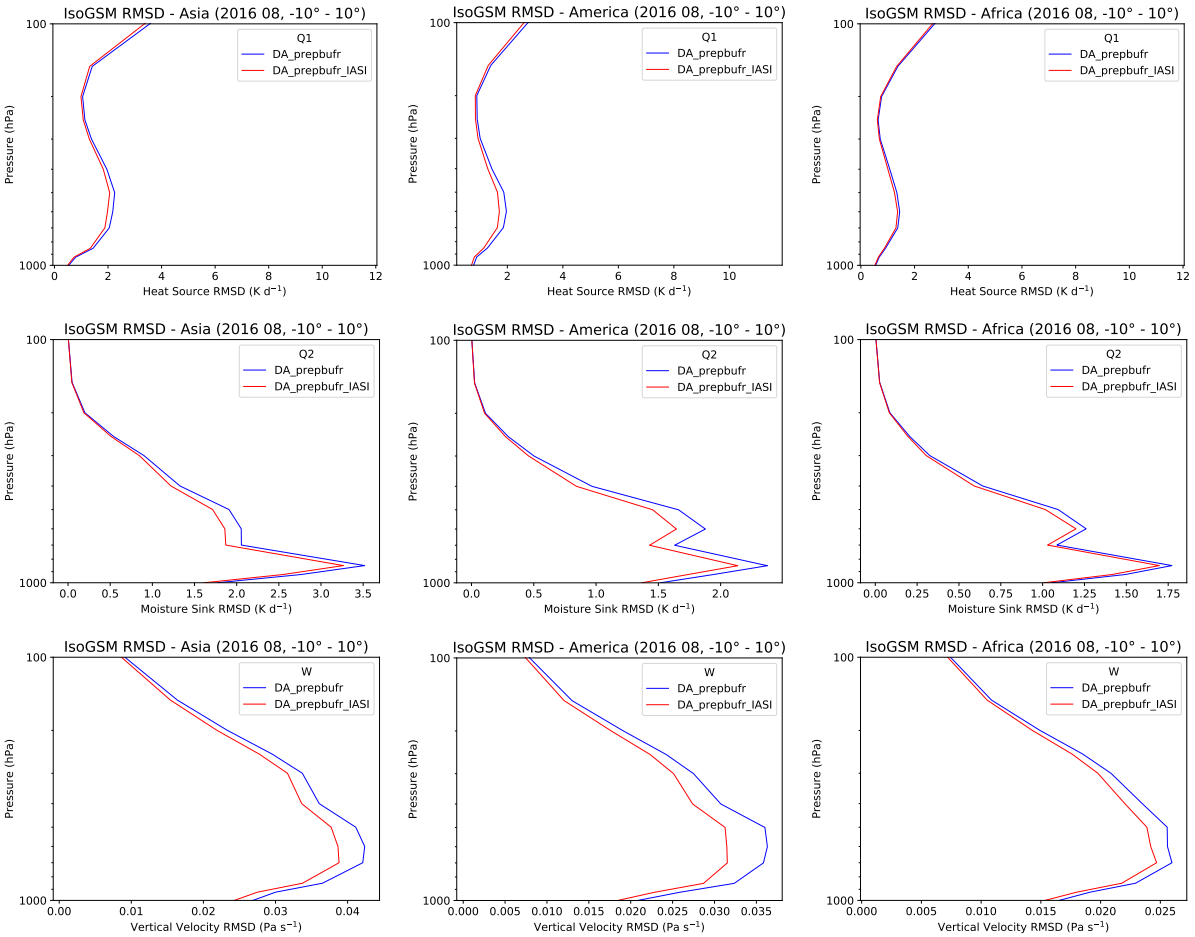

Figure S6: Spatial and temporal averaged vertical profiles of the RMSD for the heat source (Q_1), moisture sink (Q_2) and vertical wind (ω), top to bottom) for Asia (left), America (middle) and Africa (right).

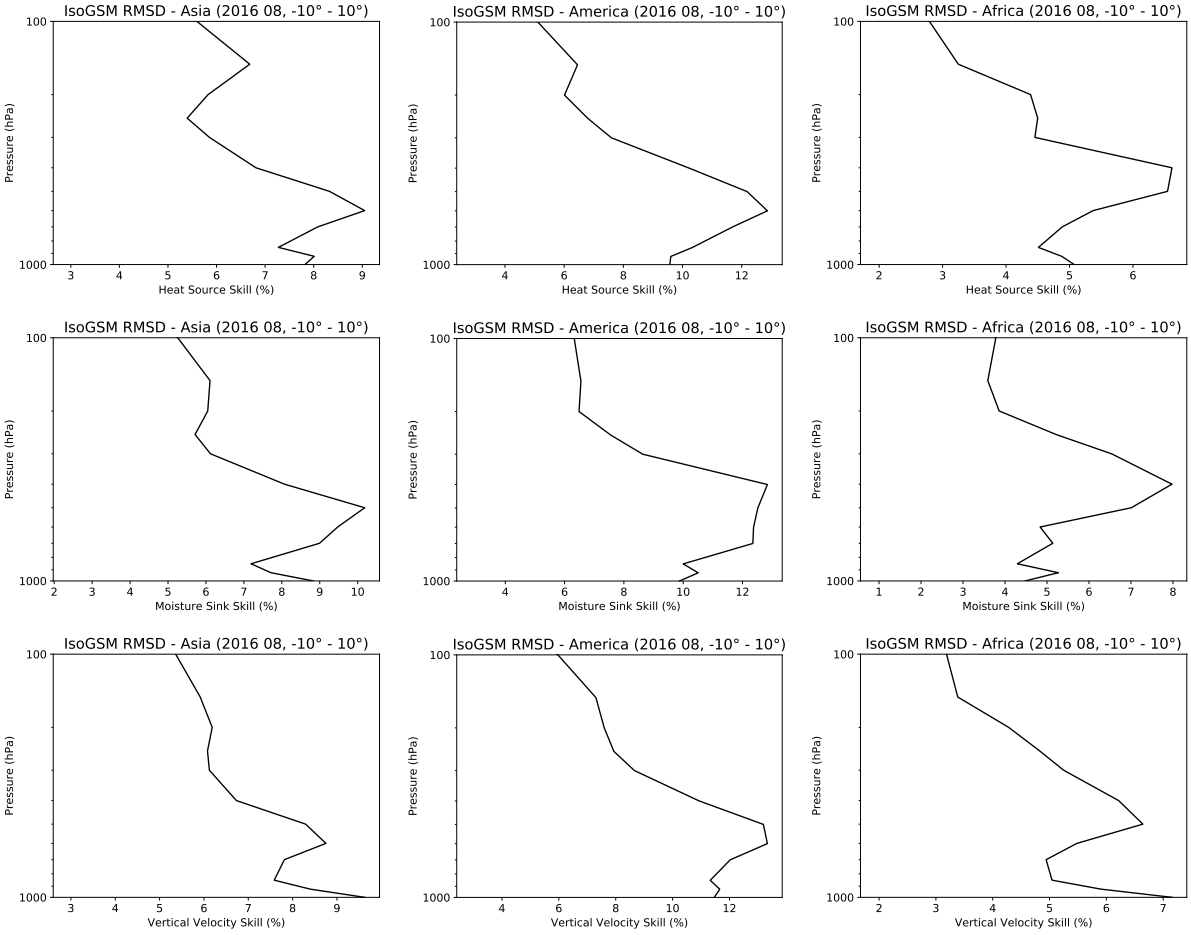

Figure S7: Spatial and temporal averaged vertical profiles of the improvement in skill when additionally to the conventional observations IASI δ is assimilated. Shown are the heat source (Q_1), moisture sink (Q_2) and vertical wind (ω), top to bottom) for Asia (left), America (middle) and Africa (right).

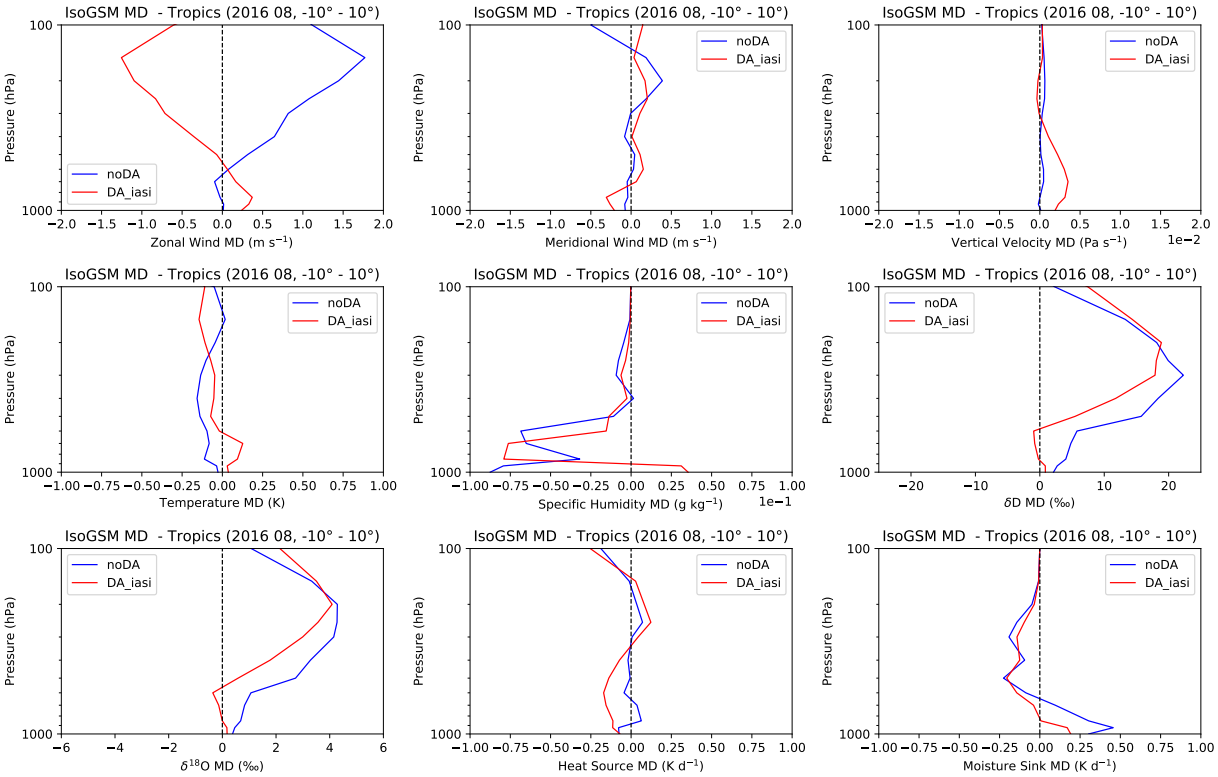

Figure S8: Spatial and temporal averaged vertical profile of the MD between the ensemble mean of the assimilation run and the Nature run for the tropics (noDAvsDA experiment).

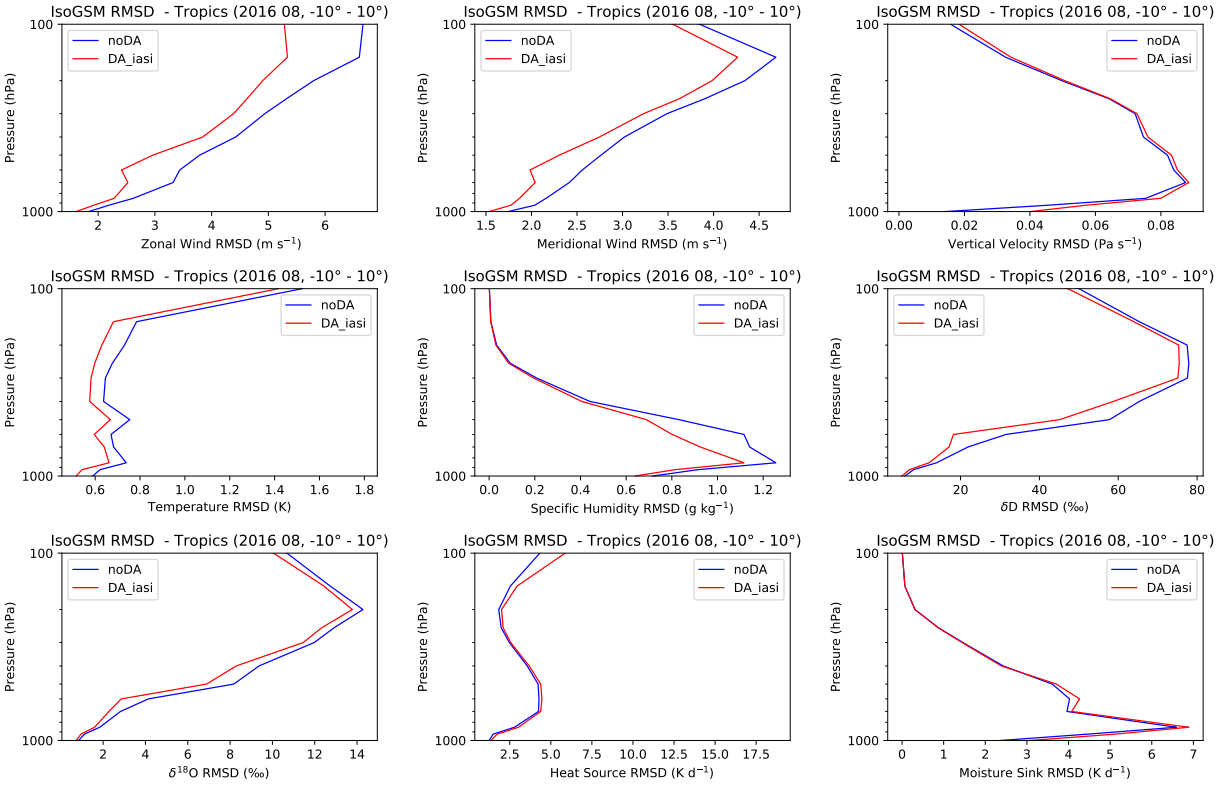

Figure S9: Spatial and temporal averaged vertical profile of the RMSD between the ensemble mean of the assimilation run and the Nature run for the tropics (noDAvsDA experiment).

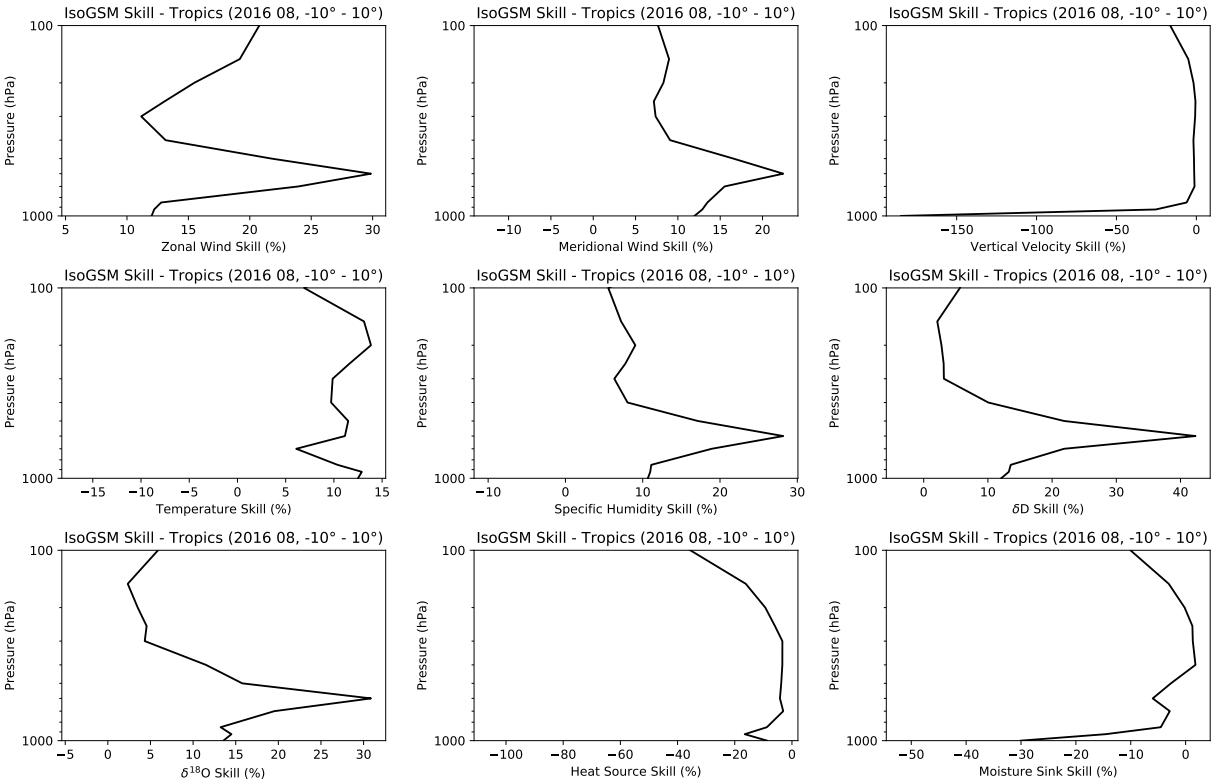

Figure S10: Spatial and temporal avergaed profile of the improvement in skill when IASI δD is assimilated additionally to the conventional observations for the tropics (noDAvsDA experiment)

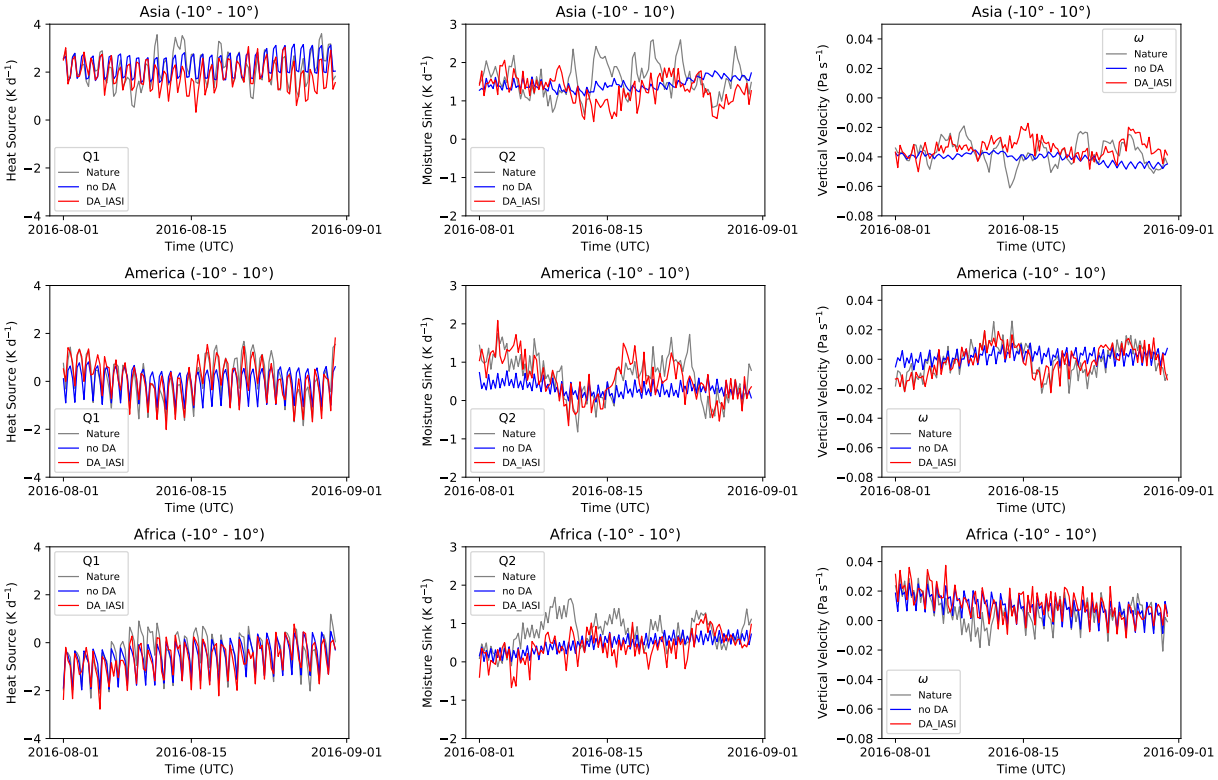

Figure S11: Time Series of the heating source (Q_1), moisture sink (Q_2) and vertical velocity (ω), from left to right) for Asia, America and Africa (from top to bottom) for the assimilation experiments with and without assimilation of the mocked IASI data (noDAvsDA) for the tropics (10°S to 10°N) at 500 hPa.

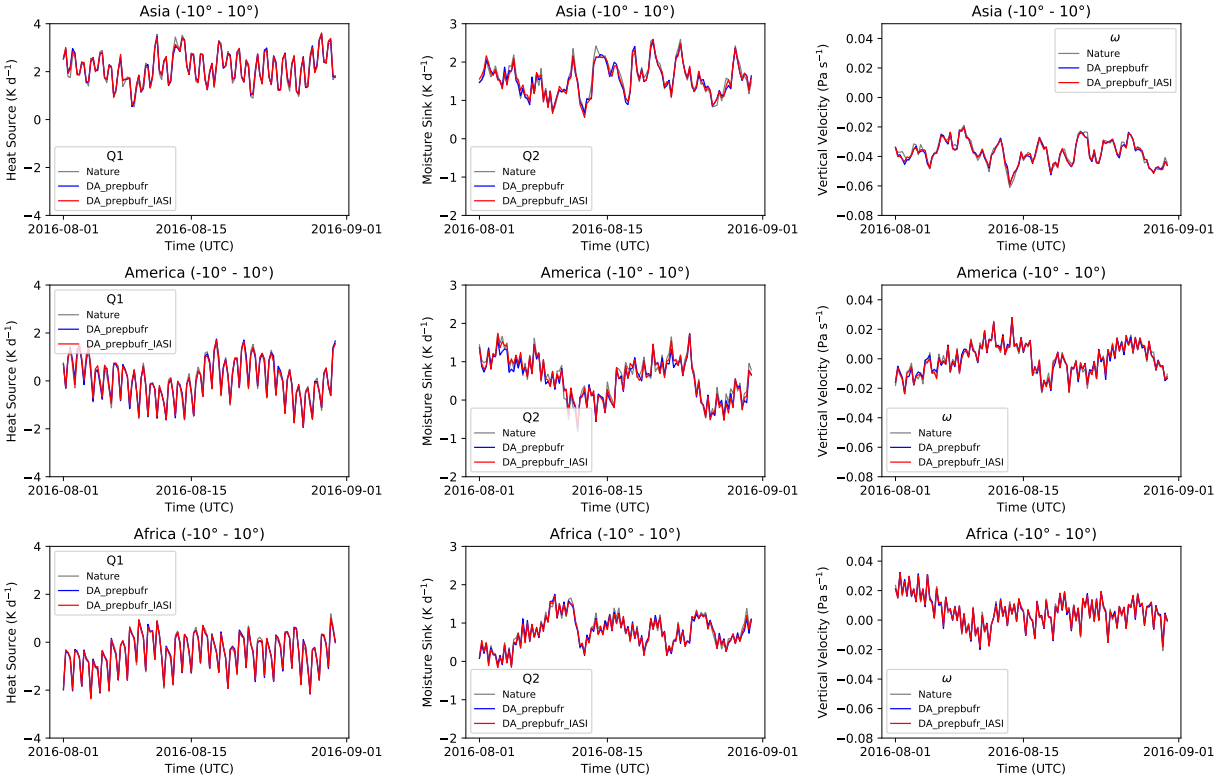

Figure S12: Same as S11, but here the time series are shown for the assimilation experiment with the conventional assimilation included (PREPBFUR)

Table S1: Improvement in analysis skill (in $\%$) in the tropical troposphere (10°S to 10°N) for the PREPBFUR experiment derived from the vertical profiles (an arithmetic average of the skill over all pressure levels from 1000 to 10 hPa). The analysis skill is given for the entire tropics and for the selected longitudinal regions (Asia, America and Africa).

Parameter	Asia	America	Africa	Tropics
U	6.53	13.86	4.15	9.33
V	6.82	13.82	3.94	9.78
ω	7.41	10.49	5.37	8.17
T	6.71	11.24	4.51	8.42
Q	7.58	13.26	5.73	10.60
δD	13.02	12.51	10.77	13.02
δ^{18}O	12.97	11.08	10.04	12.12
Q1	7.19	9.39	4.95	7.60
Q2	7.68	9.97	5.29	8.15

Table S2: Same as Tab. S1, but for the noDAvsDA experiment. Note, here for ω, Q_1 and Q_2 and trimmed mean instead of an arithmetic mean has been used.

Parameter	Asia	America	Africa	Tropics
U	7.65	21.86	19.60	16.79
V	8.32	15.67	14.58	12.16
ω	-1.69	-5.66	-7.08	-4.98
T	4.12	14.35	18.34	11.15
Q	5.95	16.29	16.67	12.30
δD	8.39	15.92	15.30	13.29
δ^{18}O	8.74	15.09	12.20	12.15
Q1	-2.57	-9.21	-7.51	-7.06
Q2	-2.01	-2.09	-3.67	-3.49

Table S3: Improvement in analysis skill (in %) in the tropical troposphere (10°S to 10°N) for the PREPBFUR experiment derived from the time series at 500 hPa (except rain, which refers to the accumulated rain at ground). The analysis skill is given for the entire tropics and for the selected longitudinal regions (Asia, America and Africa).

Parameter	Asia	America	Africa	Tropics
U	9.92	20.99	8.71	15.83
V	10.45	20.34	6.36	16.07
ω	8.46	14.70	7.74	11.23
T	12.46	18.45	6.31	15.01
Q	12.65	22.41	10.22	18.73
δD	24.25	20.30	17.49	21.48
δ^{18}O	24.86	17.85	15.83	19.32
Q1	8.34	14.00	7.64	10.79
Q2	10.40	14.00	8.27	12.54
RAIN	8.19	13.65	5.21	10.73

Table S4: Same as Tab. S3, but for the noDAvsDA experiment.

Parameter	Asia	America	Africa	Tropics
U	18.30	27.29	24.77	21.31
V	11.51	15.52	19.61	15.72
ω	1.57	3.56	1.39	2.38
T	-3.14	16.27	18.62	11.41
Q	10.05	19.81	18.10	16.79
δD	27.44	12.28	19.16	17.26
δ^{18}O	25.28	4.85	1.67	8.52
Q1	1.43	3.06	-0.38	1.89
Q2	0.52	3.32	-0.35	1.85
RAIN	3.97	13.45	7.79	6.81

Table S5: Improvement in analysis skill (in $\%$) in the tropical troposphere (10°S to 10°N) for the PREPBFUR experiment derived from the vertical profiles. The analysis skill is given for the selected longitudinal regions of the upward and downward branches of the atmospheric circulation (Up1 America, Up2 Africa, Up3 West Pacific, Up4 Asia, Down1 West Pacific and Down2 Atlantic).

Parameter	Up1 Am	Up2 Af	Up3 WP	Up4 Asia	Down1 WP	Down2 Atl
U	9.29	4.99	9.49	4.99	15.22	3.83
V	9.53	4.50	10.04	5.93	15.88	4.26
ω	8.13	6.47	10.40	5.18	10.49	4.48
T	8.15	5.22	9.75	4.90	12.71	4.49
Q	9.02	6.21	12.02	5.92	16.40	6.35
δD	7.48	11.00	15.85	11.43	17.07	11.00
δ^{18}O	6.71	10.40	15.49	11.69	16.32	10.07
Q1	7.54	5.96	10.09	5.14	9.50	4.50
Q2	8.08	6.07	10.75	5.20	10.11	4.79

Table S6: As Tab. S5, but for the noDAvsDA experiment. Note, here for ω, Q_1 and Q_2 and trimmed mean instead of an arithmetic mean has been used.

Parameter	Up1 Am	Up2 Af	Up3 WP	Up4 Asia	Down1 WP	Down2 Atl
U	16.41	17.01	11.56	27.19	5.06	24.80
V	11.89	14.79	10.11	15.48	8.22	13.56
ω	-3.37	-8.01	-2.69	-4.41	-16.06	-10.06
T	13.43	18.94	3.56	9.22	3.11	20.81
Q	13.05	18.52	8.74	15.94	2.62	16.75
δD	13.42	17.56	14.83	17.89	4.08	14.98
δ^{18}O	13.11	16.78	14.79	16.79	4.39	9.91
Q1	-2.36	-4.32	-3.25	-5.25	-15.80	16.74
Q2	0.72	-1.17	-2.28	-4.89	14.50	-7.74

Table S7: Improvement in analysis skill (in $\%$) in the tropical troposphere (10°S to 10°N) for the PREPBFUR experiment derived from the time series at 500 hPa (except rain, which refers to the accumulated rain at ground). The analysis skill is given for the selected longitudinal regions of the upward and downward branches of the atmospheric circulation (Up1 America, Up2 Africa, Up3 West Pacific, Up4 Asia, Down1 West Pacific and Down2 Atlantic)

Parameter	Up1 Am	Up2 Af	Up3 WP	Up4 Asia	Down1 WP	Down2 Atl
U	8.71	9.25	12.93	9.91	23.15	8.89
V	11.76	6.54	14.45	10.61	23.62	8.27
ω	8.20	8.57	10.42	6.21	12.66	5.97
T	13.60	4.53	12.42	9.47	19.20	8.20
Q	13.38	10.77	13.45	14.97	24.30	11.10
δD	14.10	26.41	23.42	21.99	23.46	11.73
δ^{18}O	12.45	23.19	20.84	25.18	21.58	10.90
Q1	8.03	8.33	9.73	6.50	11.81	5.81
Q2	8.91	8.91	13.44	7.91	11.94	7.09
RAIN	5.48	5.11	9.73	5.81	10.80	3.79

Table S8: As Tab. S7, but for the noDAvsDA experiment.

Parameter	Up1 Am	Up2 Af	Up3 WP	Up4 Asia	Down1 WP	Down2 Atl
U	28.23	27.97	18.58	6.50	26.42	23.21
V	12.67	20.31	12.28	10.42	19.11	17.57
ω	1.66	4.10	1.23	-2.48	-12.22	-7.50
T	14.52	20.68	-2.15	-3.56	10.30	21.11
Q	22.82	22.37	15.96	6.10	22.52	12.11
δD	21.23	29.45	18.71	29.94	11.54	10.36
δ^{18}O	17.91	22.71	15.30	27.44	9.82	7.80
Q1	0.97	3.03	0.94	-3.32	-17.97	-13.30
Q2	1.70	1.83	-0.91	-3.80	-14.09	-12.33
RAIN	8.14	8.92	6.05	-1.89	5.98	11.60