1 *Supplement of*

2 **Global total precipitable water variations and trends during 1958-2021**

3 Nenghan Wan et al.

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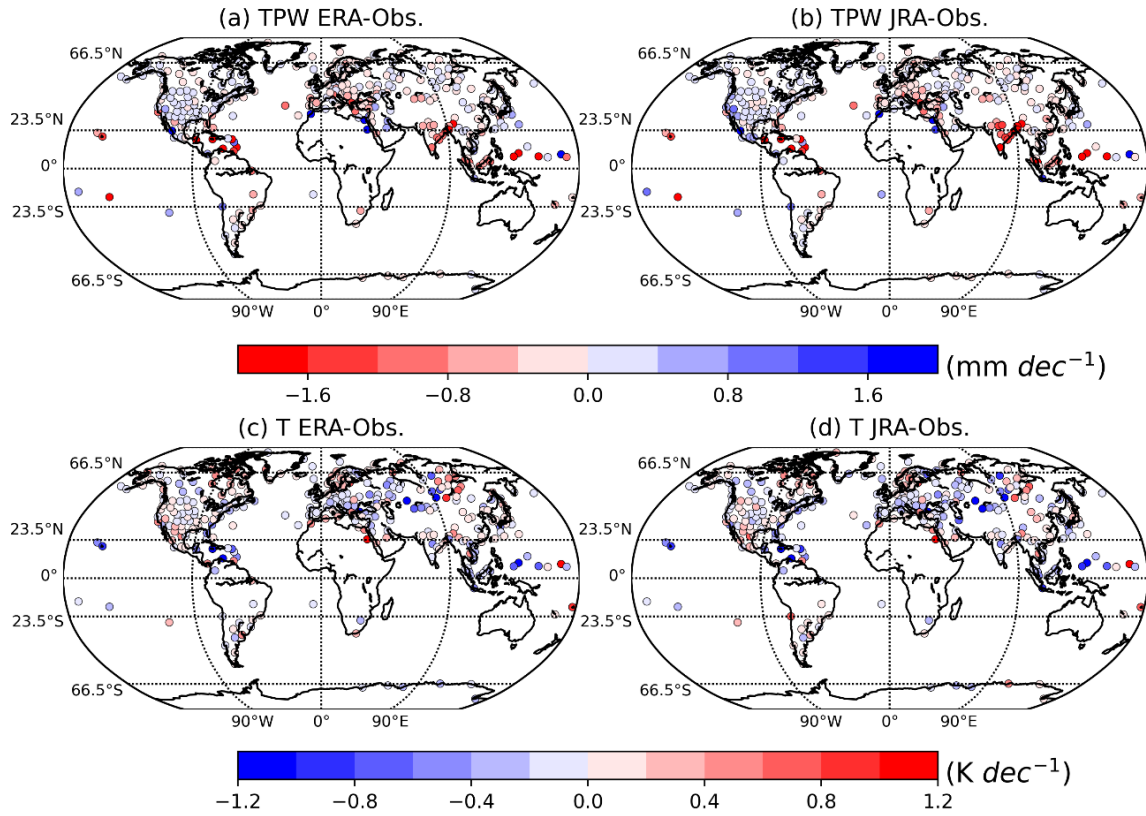
7 **Figure S1.** Trend comparisons with radiosondes: **(a-b)** TPW trends' difference (mm dec[-1]) between
8 radiosonde observations and ERA5 and JRA-55 from 1979-2019. **(c-d)** Same as **(a-b)** but for temperature
9 trends' difference (K dec[-1]). A total of 331 radiosonde observations were used in the analysis.
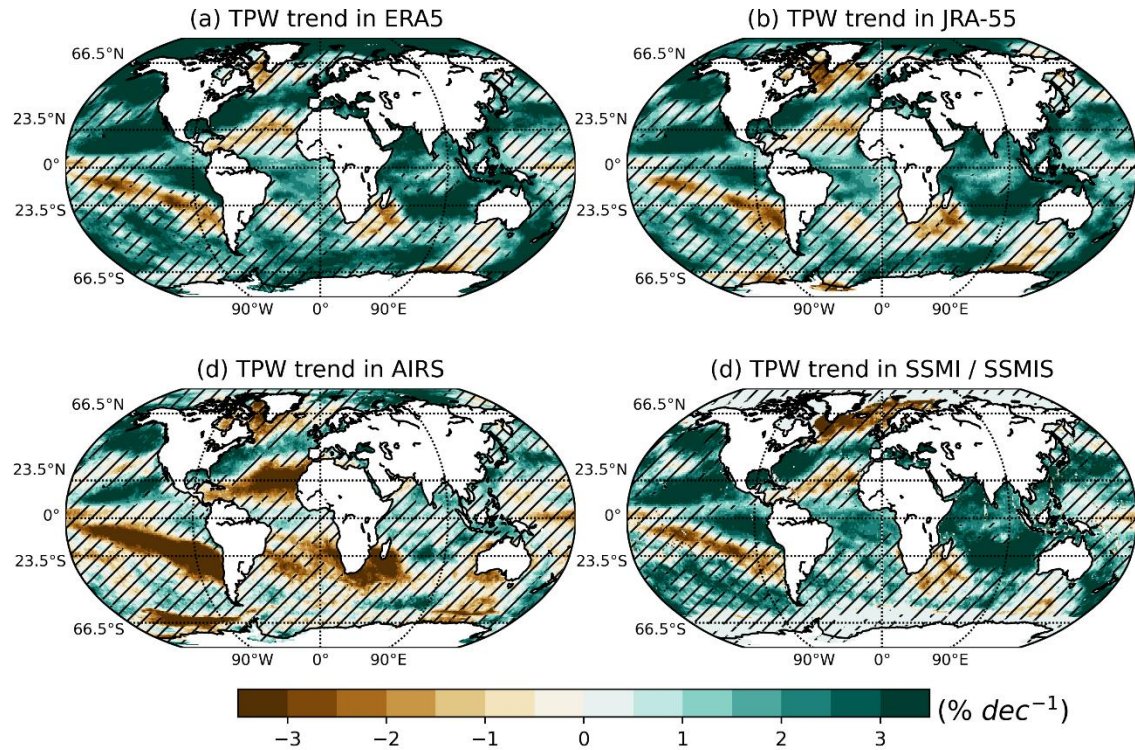
Figure S2. Trend comparisons with satellite observations from 2003-2021: Total precipitable water (TPW) trends over oceans for **(a)** ERA5, **(b)** JRA-55, **(c)** AIRS satellite, and **(d)** SSMI satellite. The hatch areas represent trends that are not significant at a 95% confidence level.

14 **Table S1.** Discontinuity positions of TPW in ERA5 and JRA-55 during 1958-2021 over regions, and
15 coincident changes in the observing systems that might be used in the assimilation.

Dataset	Regions	TPW		
		Dates (yyyy-mm)	Stepsize (mm)	Detected Discontinuities*
ERA5	Land	1991-07	-0.43	Approx. discontinuity position detected when changing assimilation data from HIRS NOAA-10 to NOAA-12
		1997-09	0.65	/
		1999-02	0.65	Approx. discontinuity position detected when changing assimilation data from NOAA-12 to NOAA-11
	Ocean	1977-01	-0.81	Approx. discontinuity position detected when changing assimilation data from DMSP14 SSMI to 15
		2001-06	0.66	/
		2009-06	0.51	Approx. discontinuity position detected when assimilation of METEOSAT 7 GEOS data
		2015-05	0.36	Approx. end of DMSP 13 and the start of assimilation of DMSP 17 SSMI
	North American	1977-03	0.59	Approx. discontinuity position detected when assimilation of multiple satellites e.g., AMSR-2, CRIS
		2014-07	-0.53	/
JRA-55	Land	1991-07	0.60	/
	Tropical land	1972-02	-0.50	/
		1982-06	0.86	/
		1991-06	-1.46	/
		1997-09	0.85	/
		1999-02	0.93	/
	NH polar	1960-09	-1.18	/
		2003-07	-0.38	Approx. discontinuity position detected when assimilation of AMSU and MHS satellite in Jun. 2003
	North American	1963-11	0.31	/

16 * These discontinuity points are matched if the difference between metadata events and discontinuities
17 detected was within ±3 months. The metadata events were taken from references (Hersbach et al., 2020;
18 Kobayashi et al., 2015).

19 **Table S2.** Dates of discontinuities of T_{2m} in ERA5 and JRA-55 during 1958-2021 over specific regions, and
20 coincident changes in the observing system or changes of the input to the assimilation system.

Dataset	Region	T_{2m}		
		Dates (yyyy-mm)	Stepsize (K)	Detected Discontinuities*
ERA5	Land	1963-11	-0.39	/
		1973-12	-0.22	Approx. discontinuity position detected after assimilation of DROP Sonde
	Ocean	1964-02	-0.18	/
	North American	1963-11	-0.54	/
	Tropical land	1973-09	-0.38	Approx. discontinuity position detected after assimilation of DROP Sonde
	NH polar	2004-12	1.05	Approx. discontinuity position detected after assimilation of METEOSAT 8 GEOS
JRA-55	Land	1973-10	-0.35	/
	Ocean	1978-11	0.17	Approx. discontinuity position detected after end assimilation of use VTPR in Feb 1979
		2015-07	0.21	/
	Tropical land	1960-12	-0.40	/
		1973-03	-0.52	Approx. discontinuity position detected after assimilation of VTPR in Jan 1973
		1976-10	0.38	/
	NH polar	1962-08	-0.90	/
		2004-12	0.95	Approx. discontinuity position detected after end assimilation of SSM/I in Dec 2004
	North American	1997-11	0.61	Approx. discontinuity position detected after TMI in Feb. 1998

21 * These discontinuity points are matched if the difference between metadata events and discontinuities
22 detected was within ±3 months. The metadata events were taken from references (Hersbach et al., 2020;
23 Kobayashi et al., 2015).

24 **Table S3.** Dates of discontinuities of T_s in ERA5 and JRA-55 during 1958-2021 over regions, and
25 coincident changes in the observing system or changes of the input to the assimilation.

Dataset	Region	T_s		
		Dates (yyyy-mm)	Stepsize (K)	Detected Discontinuities*
ERA5	Land	1963-11	-0.50	/
		1973-12	-0.34	Approx. discontinuity position detected after assimilation of DROP Sonde
	Ocean	1970-05	-0.19	/
	North American	1964-02	-0.57	/
	Tropical land	1970-06	-0.47	/
	NH polar	2004-12	1.11	Approx. discontinuity position detected after assimilation of METEOSAT 8 GEOS
JRA-55	Land	1971-01	-0.52	/
	Ocean	1963-12	-0.17	/
	Tropical land	1978-11	-0.66	Approx. discontinuity position detected after assimilation of HIRS and SSU in Nov. 1978
		1976-07	-0.15	/
	North American	1997-10	0.51	Approx. discontinuity position detected after assimilation of TMI in Feb. 1998

26 * These discontinuity points are matched if the difference between metadata events and discontinuities
27 detected was within ±3 months. The metadata events were taken from references (Hersbach et al., 2020;
28 Kobayashi et al., 2015).

29 **Table S4.** Trends of TPW, T_{2m}, T_s calculated on raw and adjusted time series and their difference during
30 1958-2021 over regions.

Dataset	Regions	TPW trend (mm dec^{-1})			T_{2m} trend (K dec^{-1})			T_s trend (K dec^{-1})		
		raw	adj.	diff.	raw	adj.	diff.	raw	adj.	diff.
ERA5	NH polar	0.11	0.11	0.00*	0.44	0.33	-0.11	0.48	0.36	-0.11
	Land	0.17	0.29	0.13	0.25	0.31	0.06	0.24	0.38	0.14
	North American	0.17	-0.01	-0.18	0.28	0.31	0.04	0.25	0.27	0.02
	Ocean	0.15	-0.18	-0.33	0.13	0.13	0.00	0.11	0.14	0.03
	Tropical land	0.29	0.29	0.00*	0.21	0.27	0.06	0.16	0.22	0.07
JRA-55	NH polar	0.12	0.09	-0.03	0.47	0.42	-0.04	0.50	0.50	0.00*
	Land	0.19	0.31	0.12	0.23	0.31	0.08	0.20	0.30	0.10
	North American	0.21	0.25	0.04	0.23	0.13	-0.11	0.21	0.14	-0.07
	Ocean	0.22	0.22	0.00*	0.10	0.05	-0.05	0.11	0.12	0.01
	Tropical land	0.38	0.80	0.42	0.16	0.19	0.03	0.13	0.14	0.01

31 *represents there were no discontinuities detected.
32
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