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Atmospheric rivers and associated precipitation patterns during the ACLOUD and PASCAL campaigns near Svalbard (May–June 2017): case studies using observations, reanalyses, and a regional climate model

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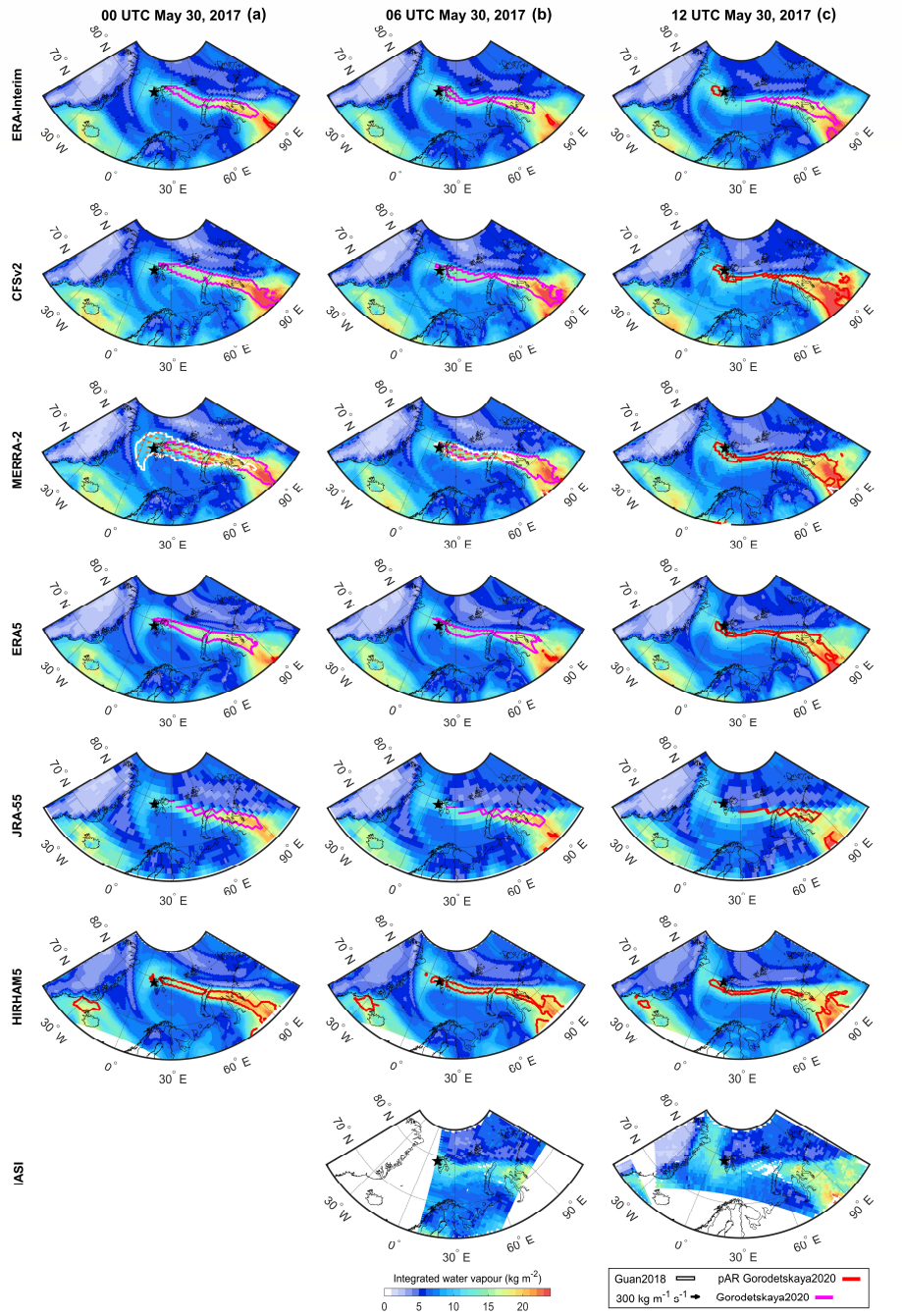

Figure S1. Maps of integrated water vapour (IWV, kg m^{-2}, colour shading) for the 30 May 2017 event, 6 hours before the IWV peak **(a)**, during the peak **(b)** and 6 hours after the peak **(c)** based on reanalyses (ERA-Interim, CFSv2, MERRA-2, ERA5, JRA-55), HIRHAM5 model and IASI observations. Magenta line shows AR shape (based on Gorodetskaya2020) and red line shows the shape of pARs ($IWV \geq IWV_{thres}$, based on Gorodetskaya2020). White line shows AR shape (based on Guan2018) and black arrows show integrated vapour transport (IVT, kg m^{-1} s^{-1}), both based only on MERRA-2 reanalysis. Black star shows Ny-Ålesund location.

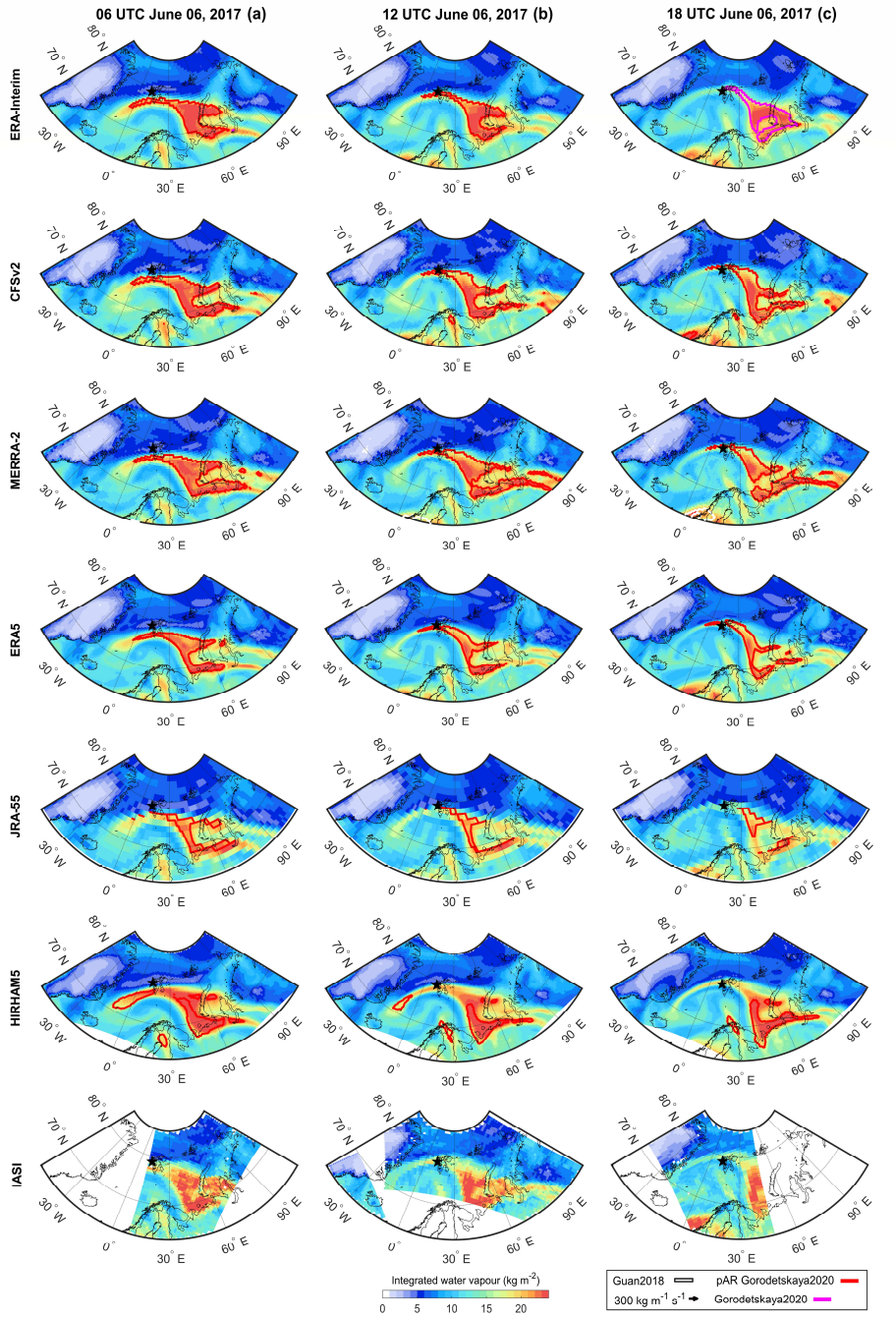

Figure S2. Same as Figure S1, but for the 6 June 2017 event.

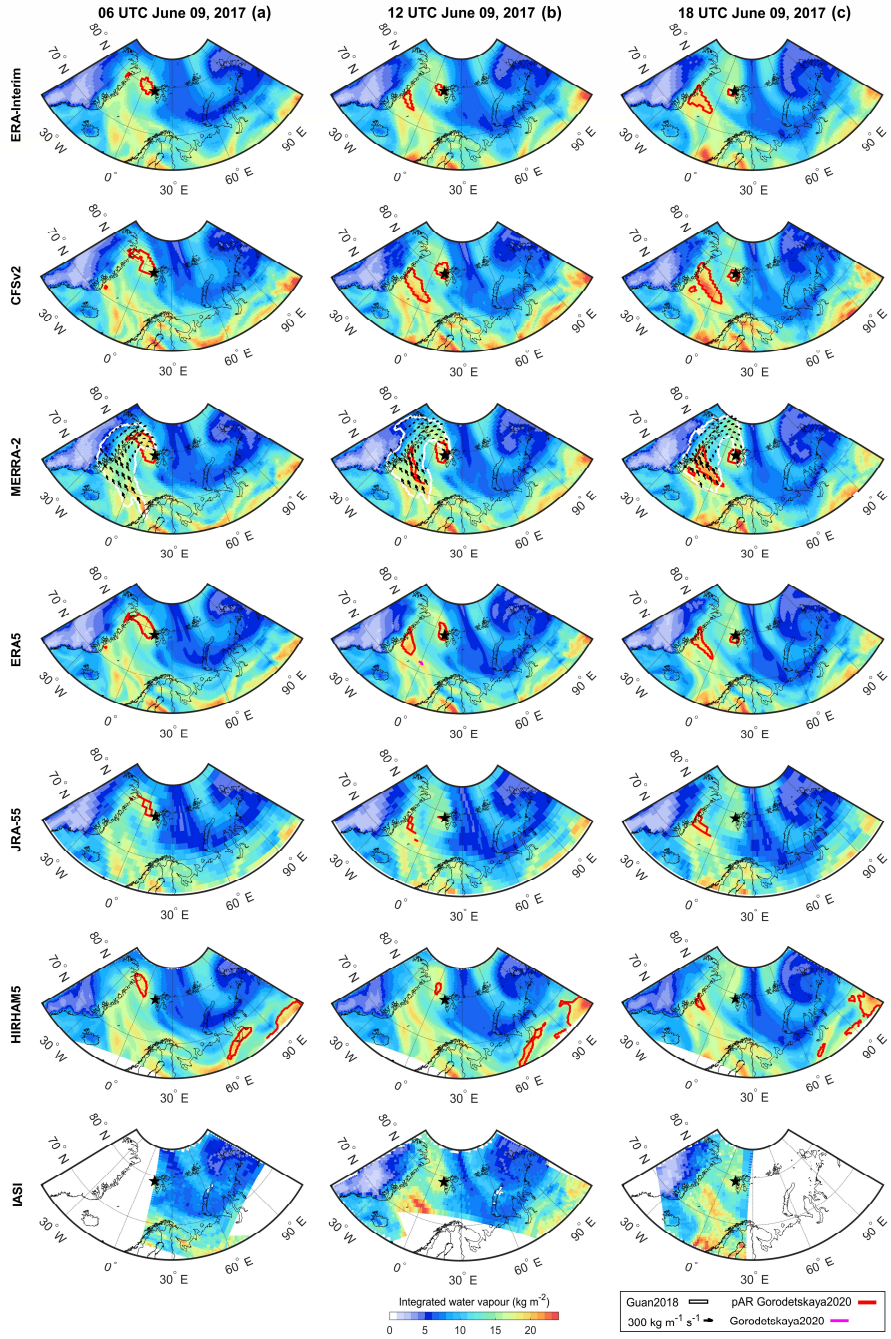

Figure S3. Same as Figure S1, but for the 9 June 2017 event.

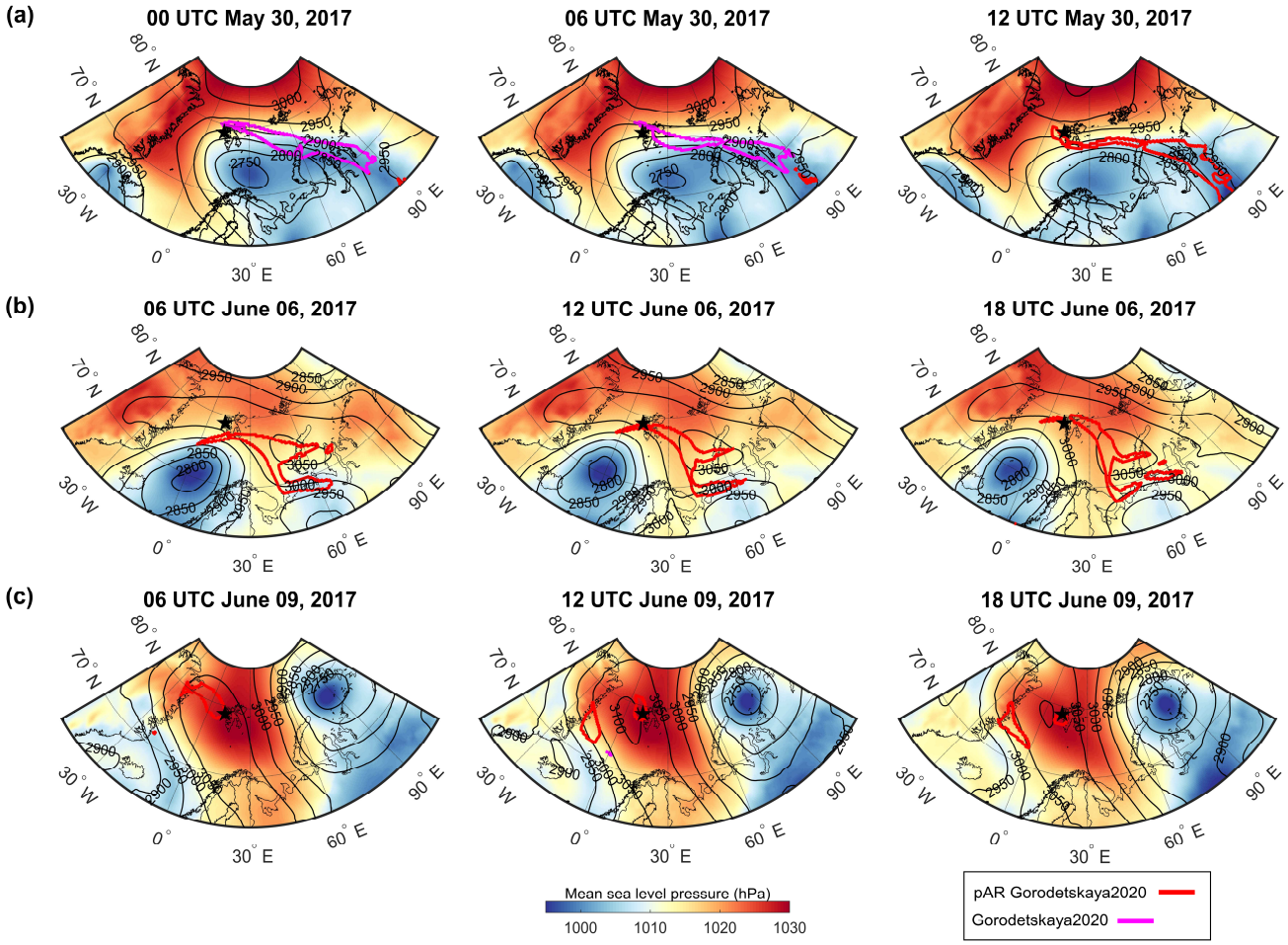

Figure S4. Maps of mean sea level pressure (hPa, colour shading) and geopotential height at 700hPa (m, contours) based on ERA5 reanalysis during the 30 May event [first row, **(a)**], 6 June event [second row, **(b)**] and 9 June event [third row, **(c)**]. Magenta line shows AR shape (based on Gorodetskaya2020) and red line shows the shape of pARs (IWV≥IWV_{thres}, based on Gorodetskaya2020). Black star shows Ny-Ålesund location.

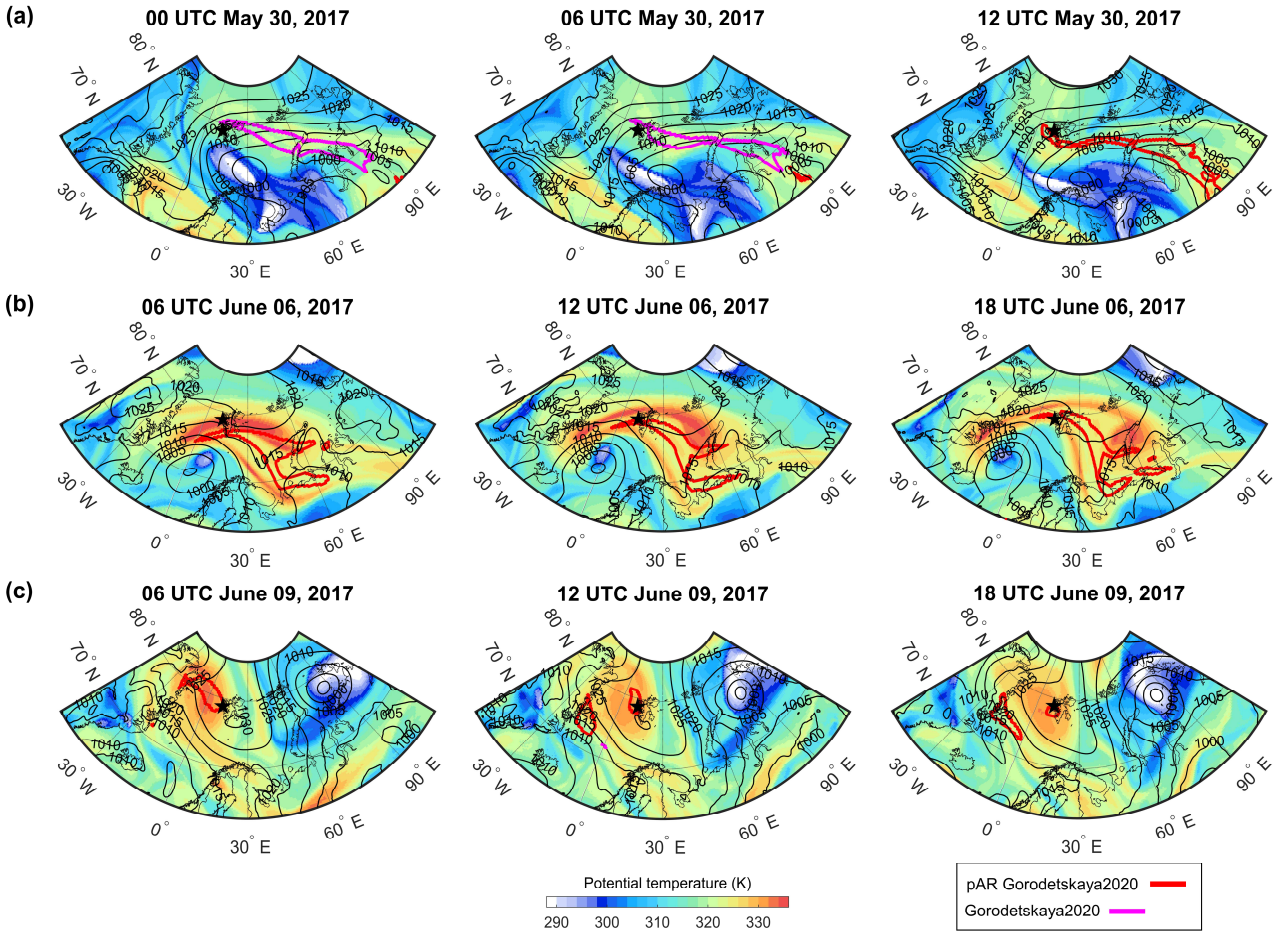

Figure S5. Maps of potential temperature at 2 PVU (K, colour shading) and mean sea level pressure (hPa, contours) based on ERA5 reanalysis during the 30 May event [first row, **(a)**], 6 June event [second row, **(b)**] and 9 June event [third row, **(c)**]. Magenta line shows AR shape (based on Gorodetskaya2020) and red line shows the shape of pARs (IWV≥IWV_{thres}, based on Gorodetskaya2020). Black star shows Ny-Ålesund location.

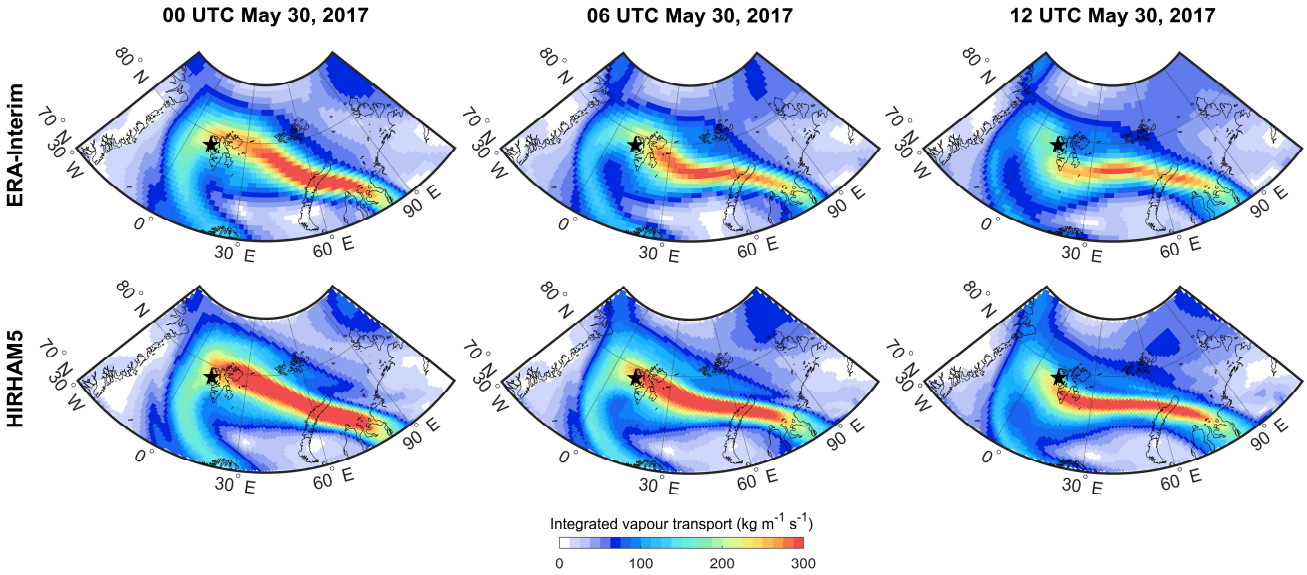

Figure S6. Maps of integrated vapour transport (kg m^{-1} s^{-1}, shading) based on ERA-Interim reanalysis (first row) and HIRHAM5 model (driven by ERA-Interim fields) (second row) during the 30 May 2017 event. Black star shows Ny-Ålesund location.

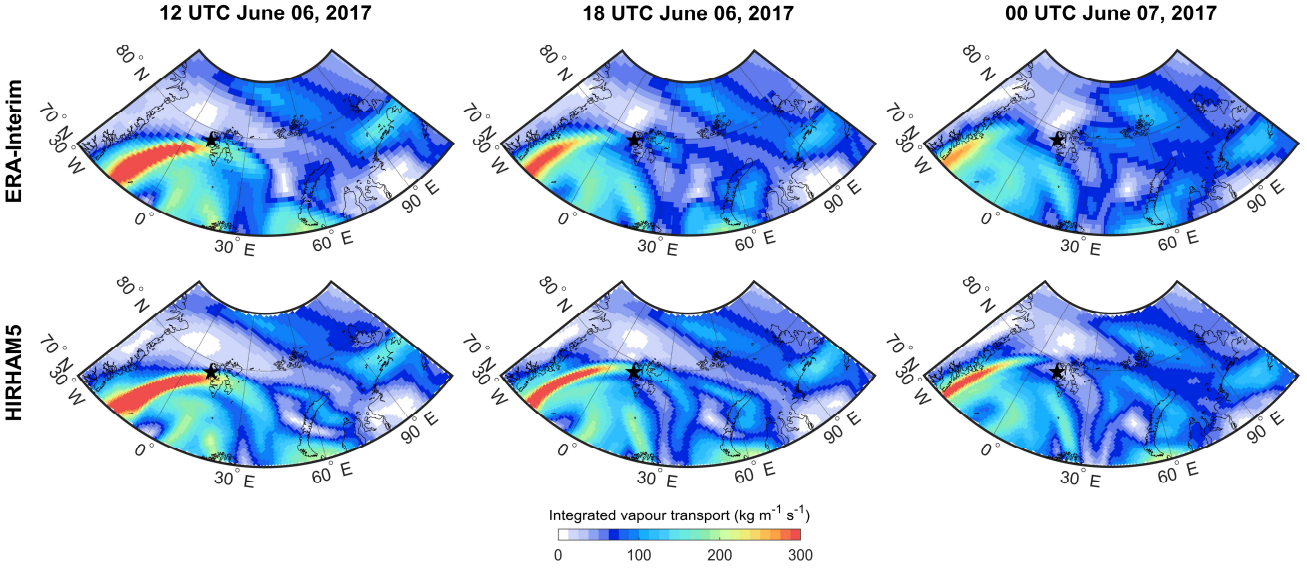

Figure S7. Same as Figure S6, but for the 6 June 2017 event.

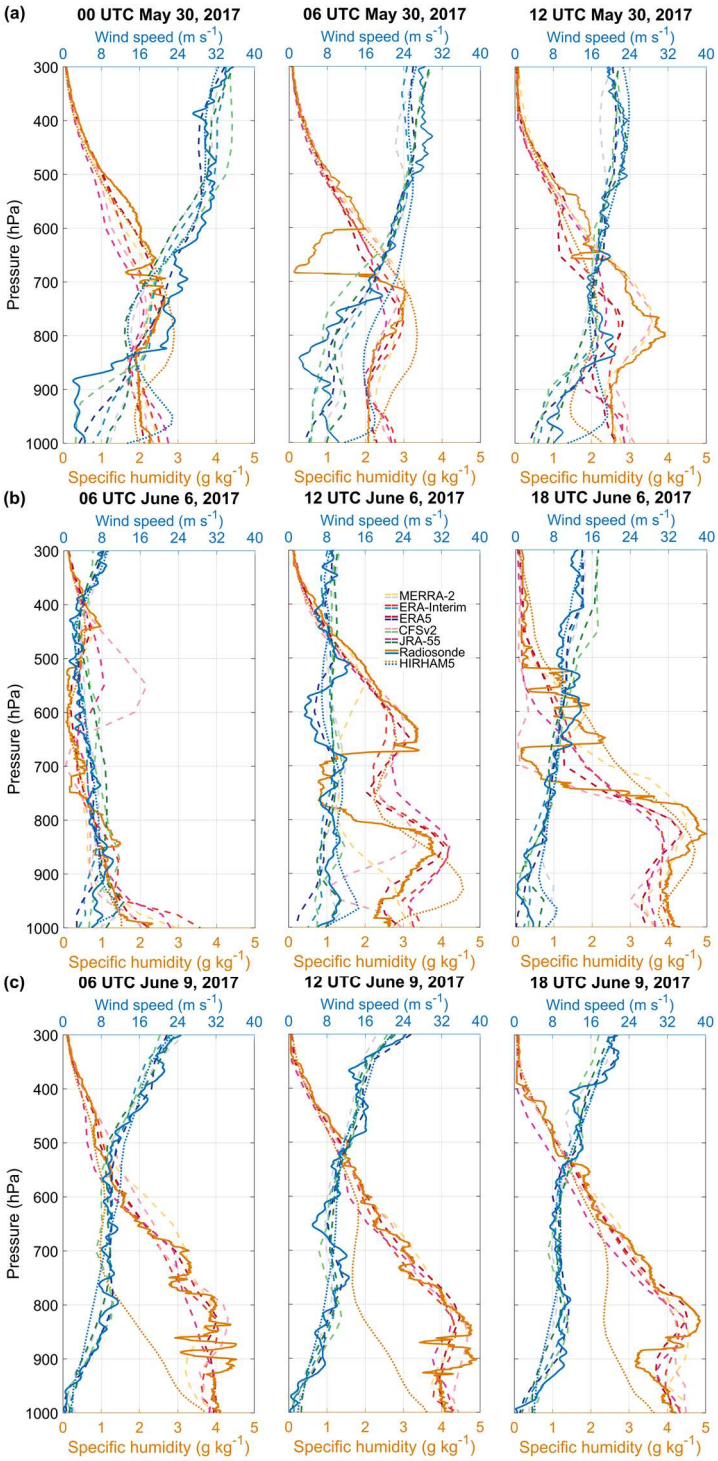

Figure S8. Vertical profiles of specific humidity (g kg^{-1}, pink/orange colours) and wind speed (m s^{-1}, blue/green colours) at Ny-Ålesund based on radiosonde (solid lines), reanalyses (ERA-Interim, ERA5, CFSv2, JRA-55, MERRA-2, dashed lines) and HIRHAM5 model (dotted lines), during 30 May event [first row, **(a)**], 6 June event [second row, **(b)**] and 9 June event [third row, **(c)**].

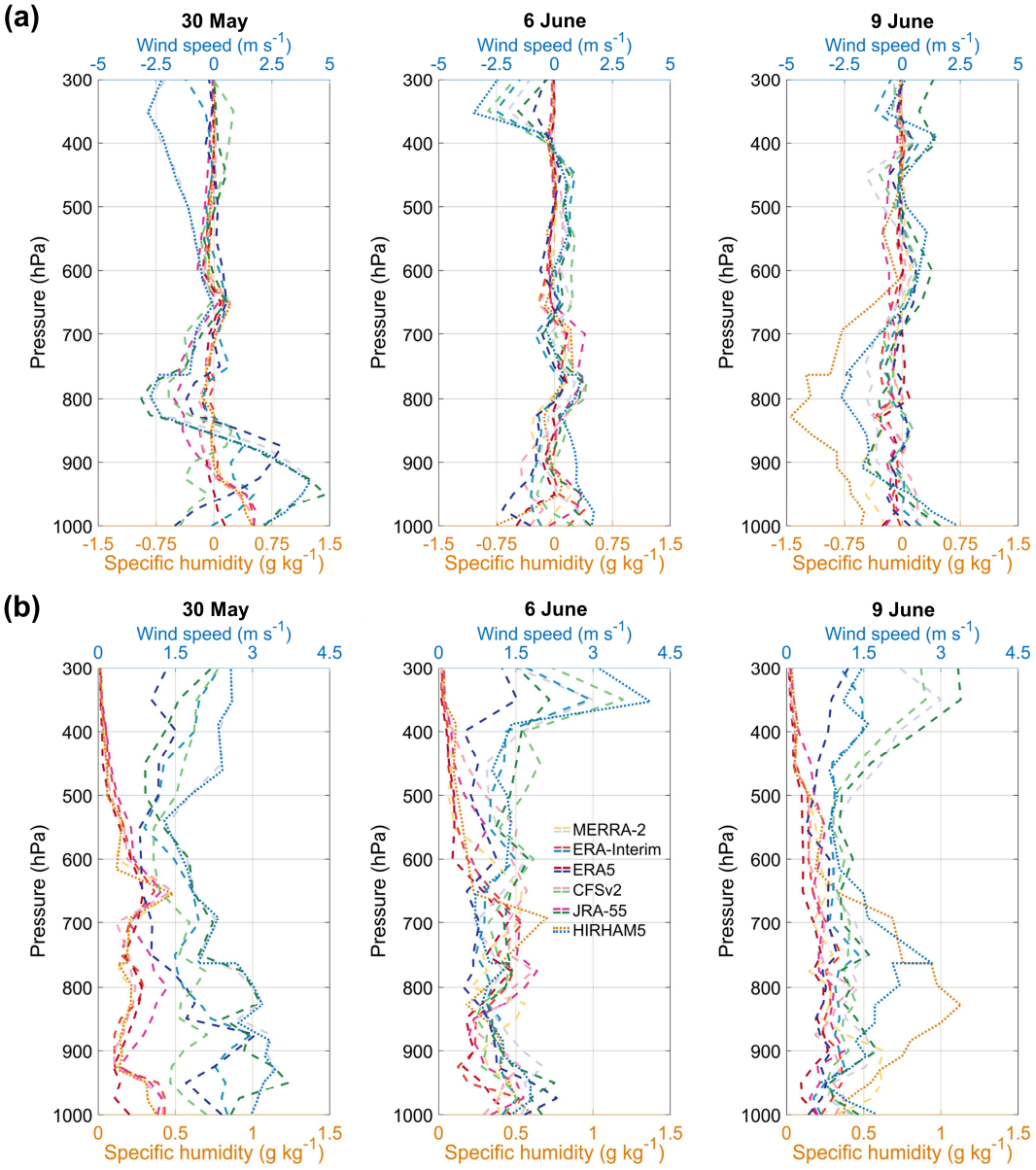

Figure S9. Vertical profiles of specific humidity (g kg^{-1}, pink/orange colours) and wind speed (m s^{-1}, blue/green colours) bias [first row, **(a)**] and RMSE [second row, **(b)**] at Ny-Ålesund based on reanalyses (ERA-Interim, ERA5, CFSv2, JRA-55, MERRA-2, dashed lines) and HIRHAM5 model (dotted lines) compared to the radiosondes (reference, 6 hours temporal resolution), during 48 hours periods (24 hours before and after the event reached Ny-Ålesund) for the 30 May event (first column), 6 June event (second column) and 9 June event (third column).

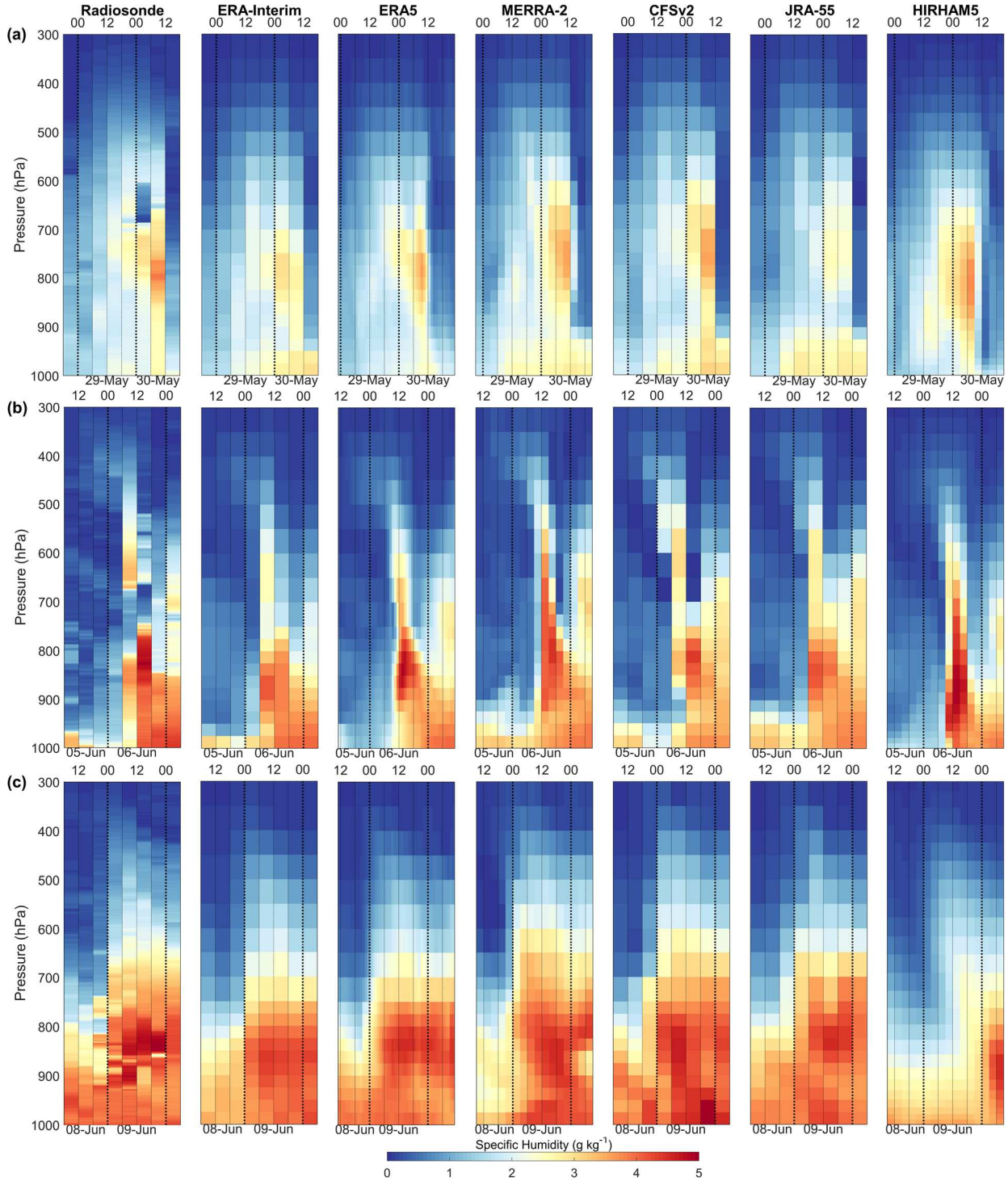

Figure S10. Temporal evolution of the vertical profiles of specific humidity (g kg^{-1}) based on radiosondes, reanalyses (ERA-Interim, ERA5, MERRA-2, CFSv2, JRA-55), and HIRHAM5 model, during 30 May 2017 event [first row, **(a)**], 6 June 2017 event [second row, **(b)**] and 9 June event [third row, **(c)**], at Ny-Ålesund. Time steps on the x-axis mark the end of observations/reanalyses/model.

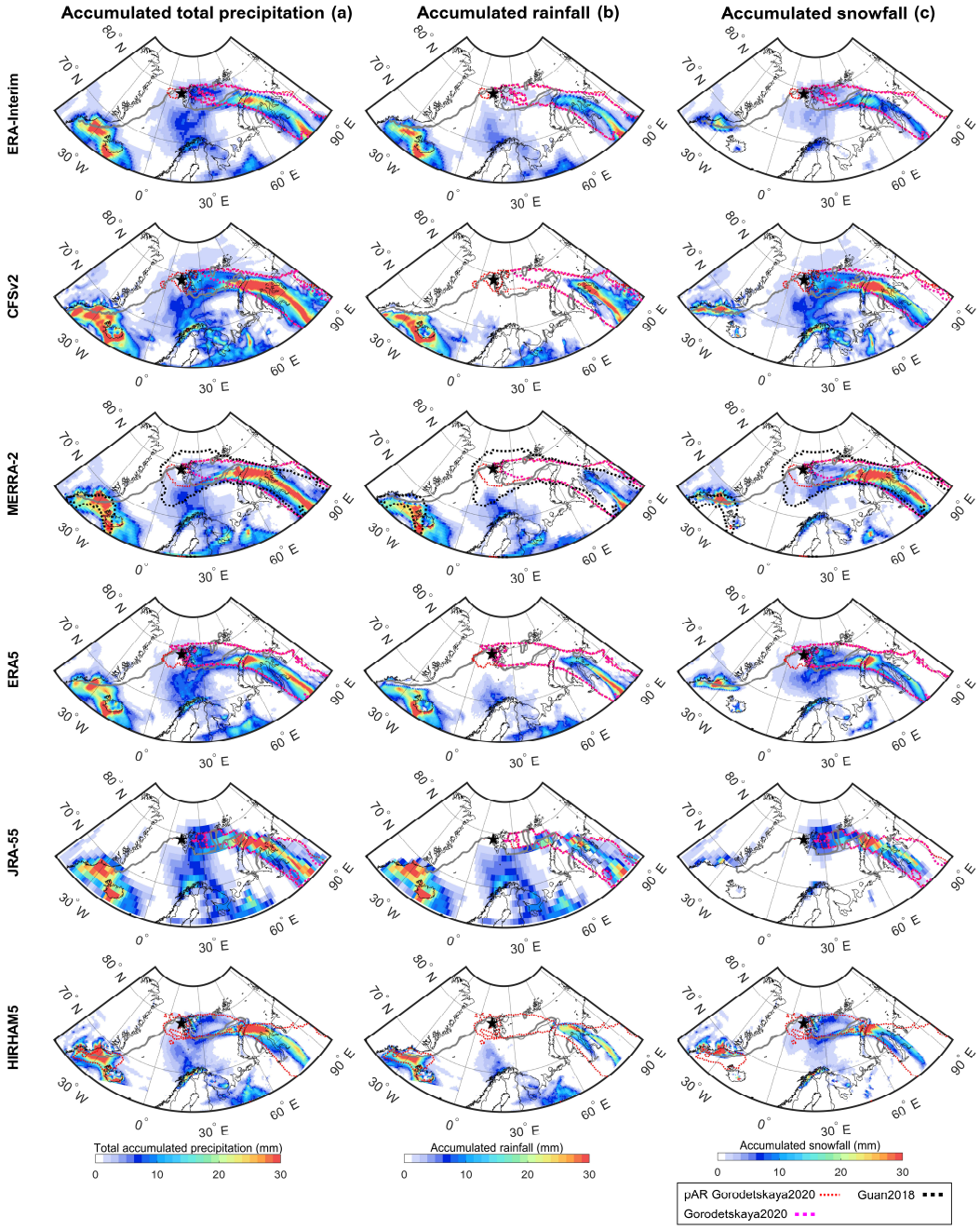

Figure S11. Maps of the total accumulated precipitation [mm, first column, **(a)**], accumulated rainfall [mm, second column, **(b)**] and accumulated snowfall [mm, third column, **(c)**] for the 30 May event during a 48 hours period (24 hours before and after the event reached Ny-Ålesund, shown by black star) based on reanalyses (ERA-Interim, CFSv2, MERRA-2, ERA5, JRA-55) and HIRHAM5 model. Grey lines show the sea-ice fraction using a 15% threshold (thin line represents 24 hours before the event and thick line 24 hours after the event). Magenta and red lines show the AR and pAR shapes, respectively, based on Gorodetskaya2020. Black line shows the AR shape based on Guan2018 (available only for MERRA-2). The AR shape lines here encompass the total area of the ARs/pARs during the 48 hours period.

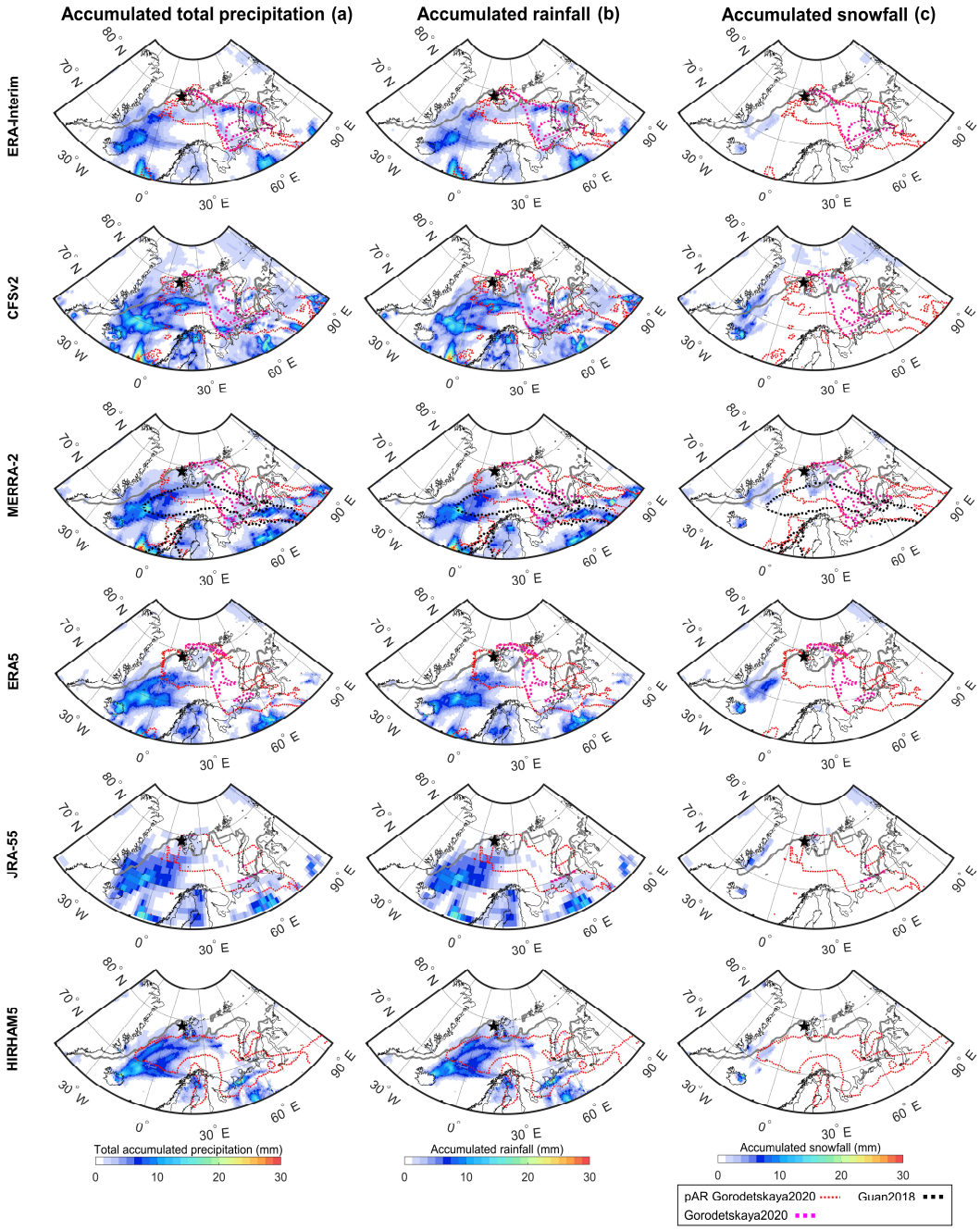

Figure S12. Same as Figure S11, but for the 6 June 2017 event.

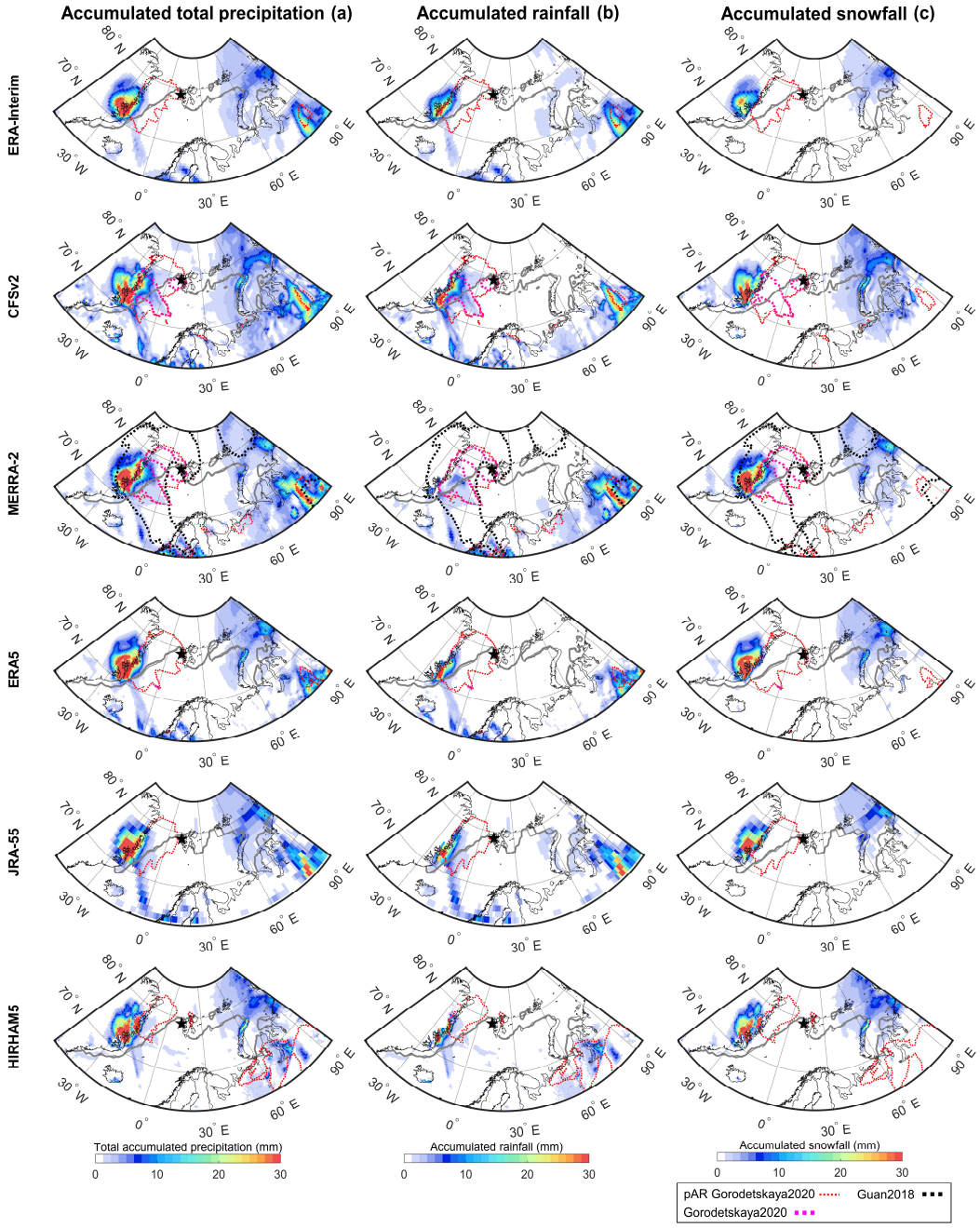

Figure S13. Same as Figure S11, but for the 9 June 2017 event.

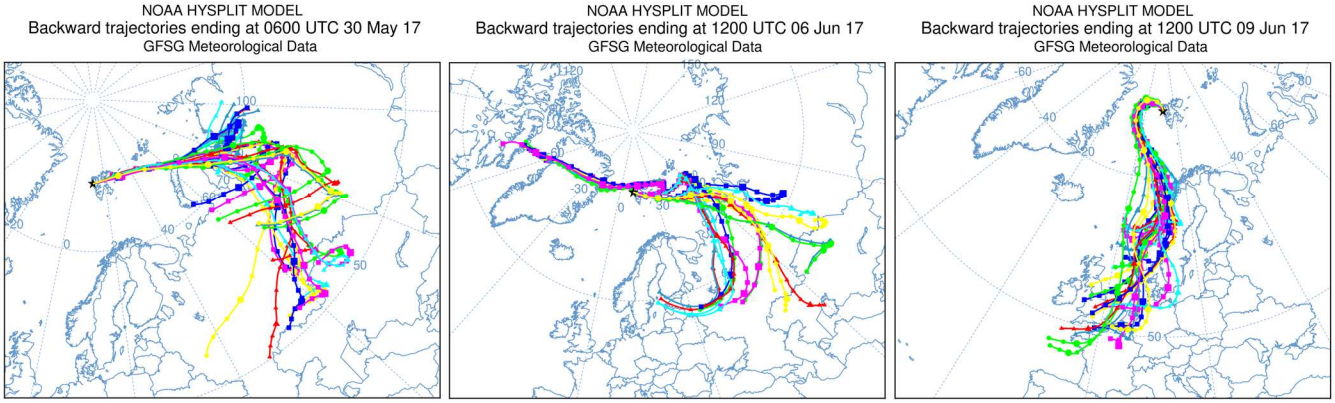

Figure S14. Computed ensemble of back trajectories (different colours) at 6 hours intervals (markers) ending at 06 UTC 30 May (left panel), 12 UTC 6 June (middle panel) and 12 UTC 9 June (right panel), at 800 hPa, from Ny-Ålesund (black star), using HYSPLIT model.

Table S1. Integrated water vapour (IWV, kg m^{-2}) and integrated vapour transport (IVT, kg m^{-1} s^{-1}) bias and RMSE during the 24 hours before and after the IWV peak at Ny-Ålesund (48-hours period), for the reanalyses (ERA-Interim, ERA5, MERRA-2, CFSv2, JRA-55), HIRHAM5 model and observations (HATPRO, GNSS and IASI), using the radiosondes as a reference (6 hours temporal resolution).

	Variable	30 May		6 June		10 June	
		RMSE	Bias	RMSE	Bias	RMSE	Bias
Era-Interim	IWV	1.1	0.2	1.1	0.2	0.6	-0.5
	IVT	28.8	2.2	8.9	2.4	7.2	-3.4
ERA5	IWV	1.1	-0.3	0.8	-0.1	0.3	-0.2
	IVT	23.2	-1.1	3.5	0	3.9	0.2
MERRA-2	IWV	0.9	0.2	1.2	0	1.3	-0.6
	IVT	24.2	3.9	18.5	9.3	12.2	-9.2
CFSv2	IWV	0.9	-0.3	1.5	0.1	0.8	0
	IVT	19.5	-8.6	12.6	3.7	5.2	-0.6
JRA-55	IWV	1.5	-1.1	1.4	0.6	1.2	-0.9
	IVT	29.9	-10.5	17.3	12.9	13.6	-10.1
HIRHAM5	IWV	5.2	-0.2	4.9	-0.2	11.9	-3.5
	IVT	140.6	19.6	87.1	19.2	105.6	-28.8
HATPRO	IWV	0.4	0.3	1.3	0.3	0.9	0.6
GNSS	IWV	0.8	-0.6	1.5	-1.1	0.9	-0.8
IASI	IWV	1.4	0.6	6.3	-4.0	5.3	-4.1

Table S2. Integrated water vapour (IWV, kg m^{-2}) and integrated vapour transport (IVT, kg m^{-1} s^{-1}) amplitude and integrated during the event, and event duration (hours) of the AR shapes based on Gorodetskaya2020 (AR Go), of the shapes of pARs based on Gorodetskaya2020 ($IWV \geq IWV_{thres}$) (pAR Go) and the AR shapes based on Guan2018 (only for MERRA-2 reanalysis) (AR Gu) based on reanalyses (ERA-Interim, ERA5, MERRA-2, CFSv2 and JRA-55) and HIRHAM5 model, at Ny-Ålesund, during 30 May, 6 June and 9 June 2017 events.

	Events	ERA-Interim	ERA5	MERRA-2	CFSv2	JRA-55	HIRHAM5
IWV amplitude (kg m^{-2})	30 May	8.1	9.8	9.9	9.6	7.7	11.1
	6 June	11.8	14.5	15.9	10.5	13.0	17.4
	10 June	8.2	9.2	11.2	10.0	7.9	8.2
IVT amplitude (kg m^{-1} s^{-1})	30 May	166.3	179.0	170.3	152.8	141.1	242.7
	6 June	114.5	119.4	177.9	123.1	140.3	177.0
	9 June	99.03	115.3	101.5	110.1	85.7	76.9
IWV integrated during event (kg m^{-2})	30 May	74.5	70.3	75.0	70.5	63.0	70.7
	6 June	81.6	79.3	79.8	80.4	85.0	78.3
	9 June	125.2	128.2	124.6	129.4	121.2	98.3
IVT integrated during event (kg m^{-1} s^{-1})	30 May	988.9	959.0	1003.8	891.9	874.2	1145.3
	6 June	301.7	280.0	363.1	312.8	395.9	452.8
	9 June	834.3	866.5	781.5	859.7	774.0	605.7
Event duration (hours)	30 May	pAR Go: 0 AR Go: 0	pAR Go: 2 AR Go:0	pAR Go: 9 AR Go: 3 AR Gu: 18	pAR Go: 6 AR Go: 0	pAR Go: 0 AR Go: 0	pAR Go: 6
	6 June	pAR Go: 0 AR Go: 0	pAR Go: 4 AR Go: 0	pAR Go: 6 AR Go: 0 AR Gu: 0	pAR Go: 6 AR Go: 0	pAR Go: 6 AR Go: 0	pAR Go: 0
	9 June	pAR Go: 12 AR Go: 0	pAR Go: 14 AR Go: 0	pAR Go: 21 AR Go: 6 AR Gu: 18	pAR Go: 30 AR Go: 0	pAR Go: 6 AR Go: 0	pAR Go: 0