Supplementary material to

Abrupt excursion in water vapor isotopic variability during cold fronts at the Pointe Benedicte observatory in Amsterdam Island

Amaëlle Landais[1,*], Cécile Agosta[1,*], Françoise Vimeux[1,2], Olivier Magand[3], Cyrielle Solis[1], Alexandre Cauquoin[4], Niels Dutrievoz[1], Camille Risi[5], Christophe Leroy-Dos Santos[1], Elise Fourré[1], Olivier Cattani[1], Olivier Jossoud[1], Bénédicte Minster[1], Frédéric Prié[1], Mathieu Casado[1], Aurélien Dommergue[6], Yann Bertrand[6], Martin Werner[7]

[1] Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

[2] HydroSciences Montpellier (HSM), UMR 5569 (UM, CNRS, IRD), 34095 Montpellier, France

[3] Observatoire des Sciences de l'Univers à La Réunion (OSU-R), UAR 3365, CNRS, Université de La Réunion, Météo France, 97744 Saint-Denis, La Réunion, France

[4] Institute of Industrial Science (IIS), The University of Tokyo, Kashiwa, Japan.

[5] Laboratoire de Météorologie Dynamique, Institut Pierre - Simon Laplace, Sorbonne Université / CNRS / École Polytechnique – IPP, Paris, France

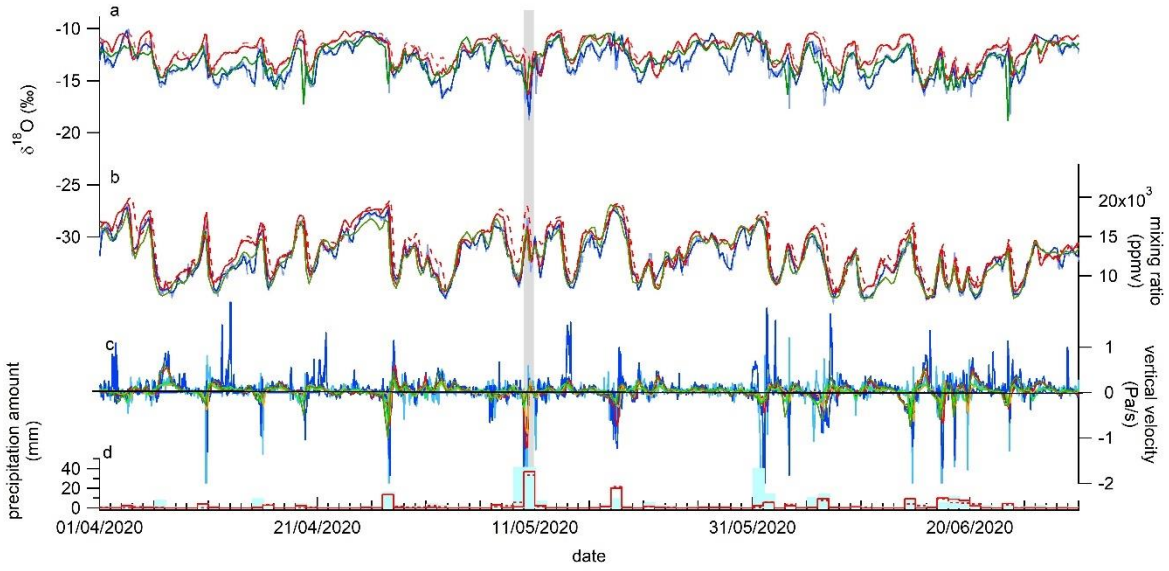
[6] Univ. Grenoble Alpes, CNRS, INRAE, IRD, Grenoble INP[T], IGE, 38000 Grenoble, France ([T]Institute of Engineering and Management Univ. Grenoble Alpes)

[7] Alfred Wegener Institute, Helmholtz Centre for Marine and Polar Research, D-27570 Bremerhaven, Germany

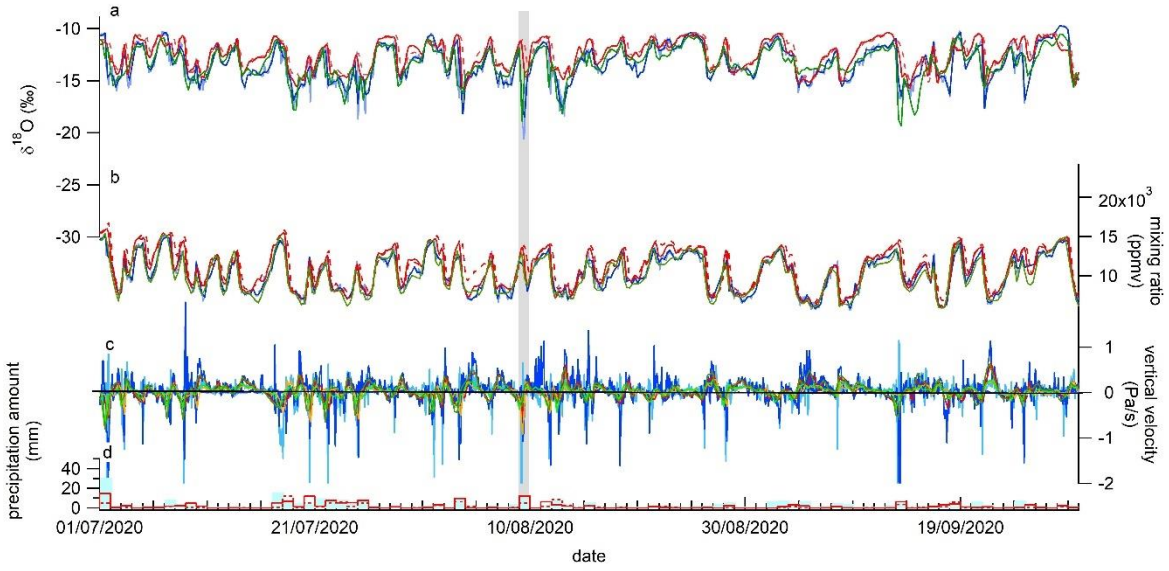
* corresponding authors who contributed equally to the study: amaelle.landais@lsce.ipsl.fr and cecile.agosta@lsce.ipsl.fr

1. Data model comparison over the two-year series

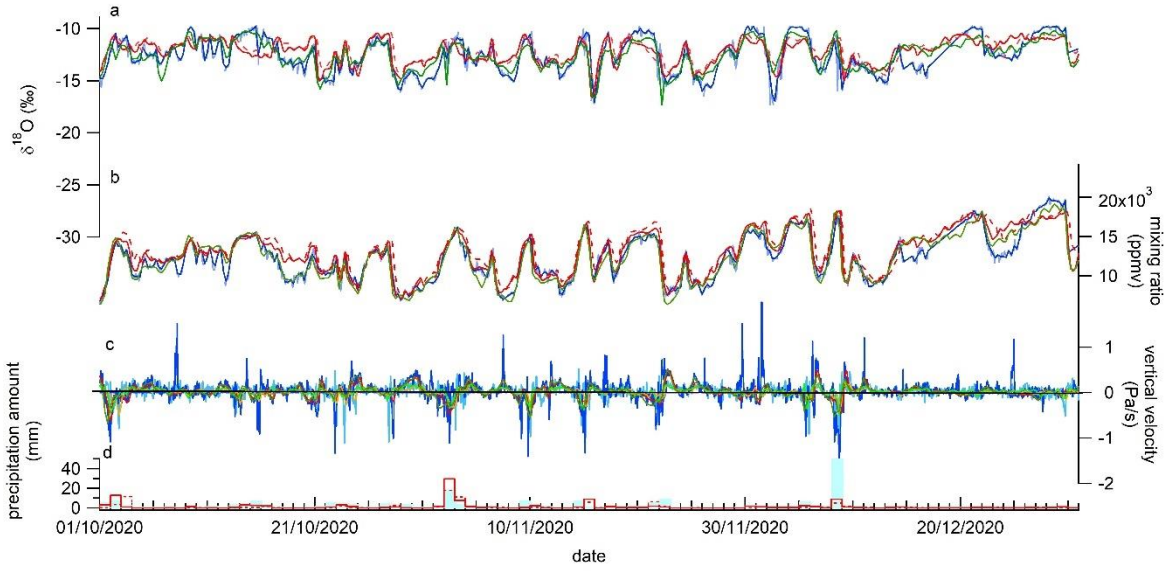
i



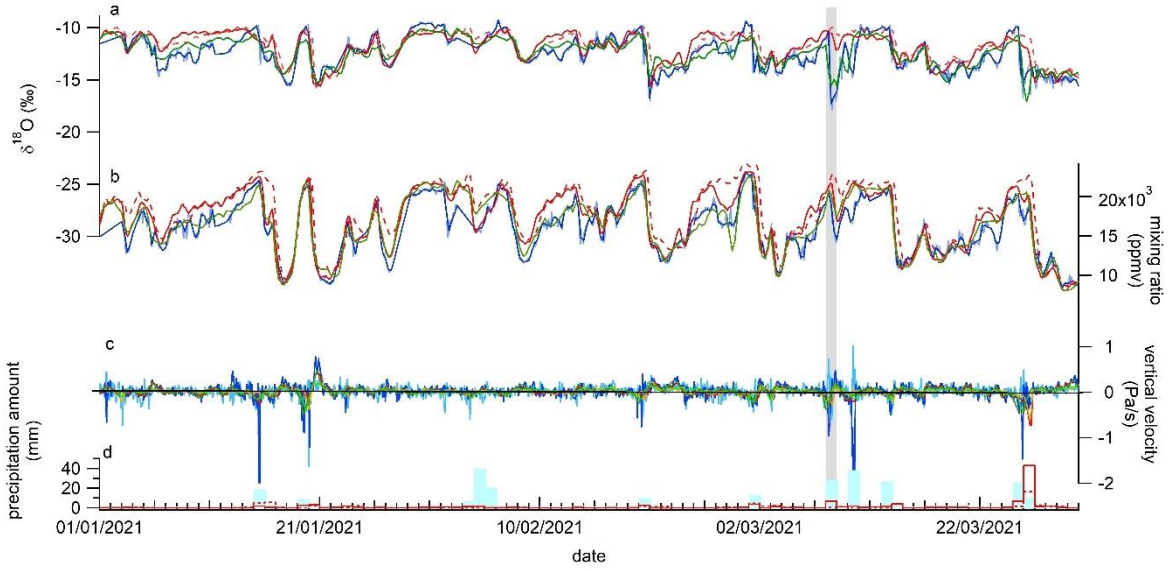
ii



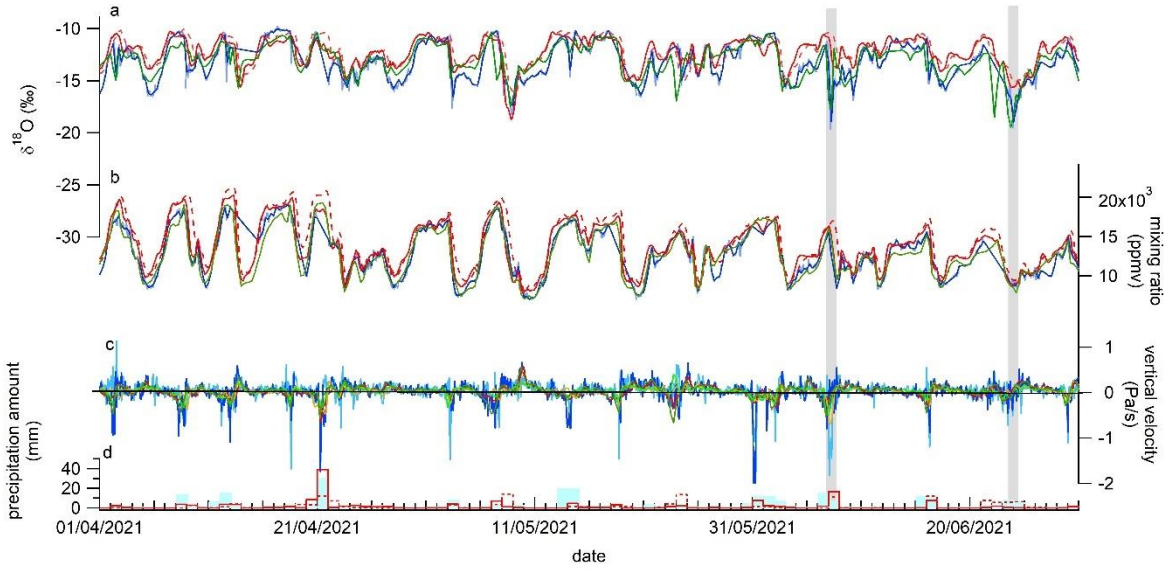
iii


a
b
c
d
δ18O (‰)
mixing ratio (ppmv)
vertical velocity (Pa/s)
precipitation amount (mm)
01/10/2020
21/10/2020
10/11/2020
30/11/2020
20/12/2020
date

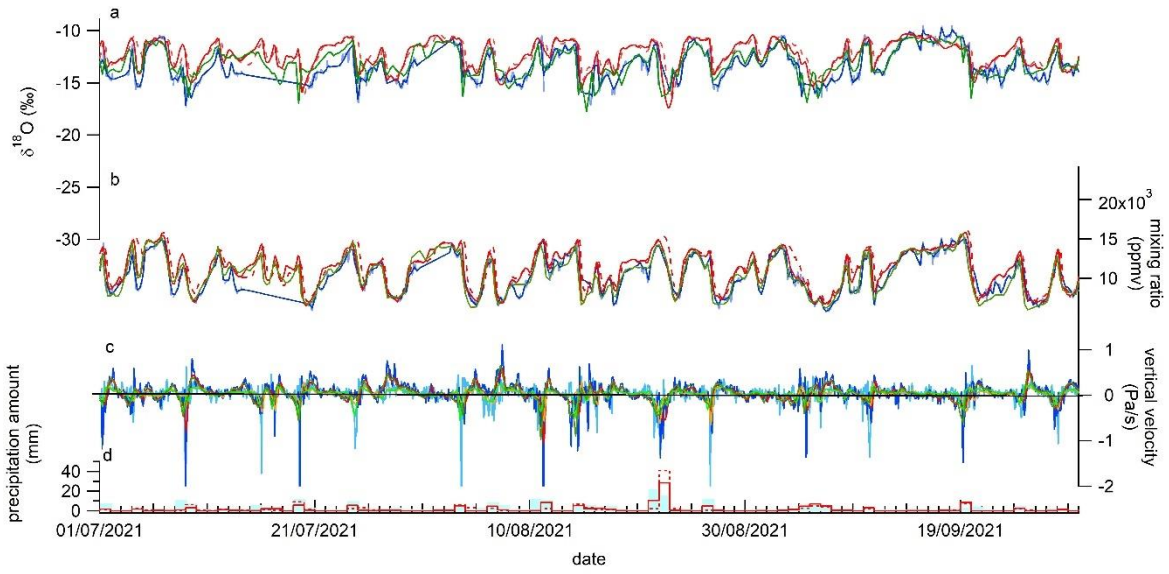
iv


a
b
c
d
δ18O (‰)
mixing ratio (ppmv)
vertical velocity (Pa/s)
precipitation amount (mm)
01/01/2021
21/01/2021
10/02/2021
02/03/2021
22/03/2021
date

v


a
b
c
d
δ18O (‰)
mixing ratio (ppmv)
vertical velocity (Pa/s)
precipitation amount (mm)
01/04/2021
21/04/2021
11/05/2021
31/05/2021
20/06/2021
date

vi


a
b
c
d
δ18O (‰)
mixing ratio (ppmv)
vertical velocity (Pa/s)
precipitation amount (mm)
01/07/2021
21/07/2021
10/08/2021
30/08/2021
19/09/2021
date

vii

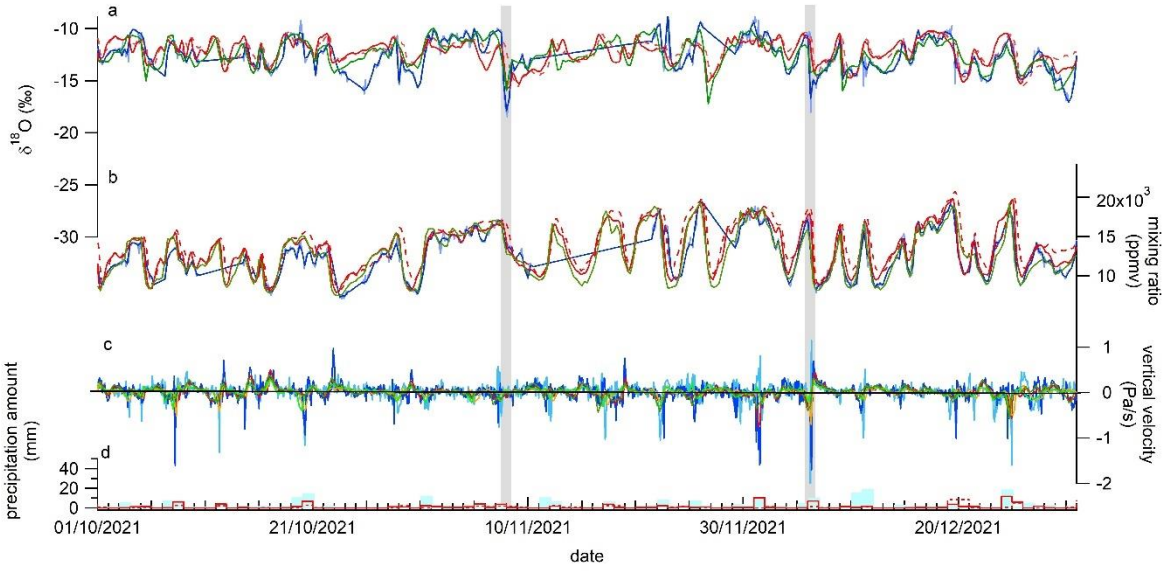


Figure S1: Data model comparison (April 2020 – December 2021) : water vapor $\delta^{18}O$ from our data set (light blue on hourly average, dark blue resampled at a 6-hour resolution), the ECHAM6-wiso model (green, surface level, 6h resolution) and the LMDZ-iso model (red, surface level, 3h resolution) at very low resolution (VLR, dashed line) and at low resolution (solid line) (a) ; mixing ratio from our data set (light blue on hourly average, dark blue resampled at a 6 hours resolution), the ECHAM6-wiso model (green, surface level, 6h resolution) and the LMDZ-iso model (red, surface level, 3h resolution, dashed line for VLR and solid line for LR) (b) ; vertical velocity from the ERA5 reanalyses (500 hPa, blue, 850 hPa, light blue), from the ECHAM6-wiso model (500 hPa, green, 850 hPa, light green), from the LMDZ-iso model at LR (500 hPa, red, 850 hPa, orange) (c) ; Precipitation amount from the meteorological record in light blue, from the ECHAM6-wiso model in green and from the LMDZ-iso model in red (dashed line VLR and solid line LR) (d). The grey rectangles highlight the negative $\delta^{18}O$ excursions.

2- Backtrajectories obtained with the flexpart model

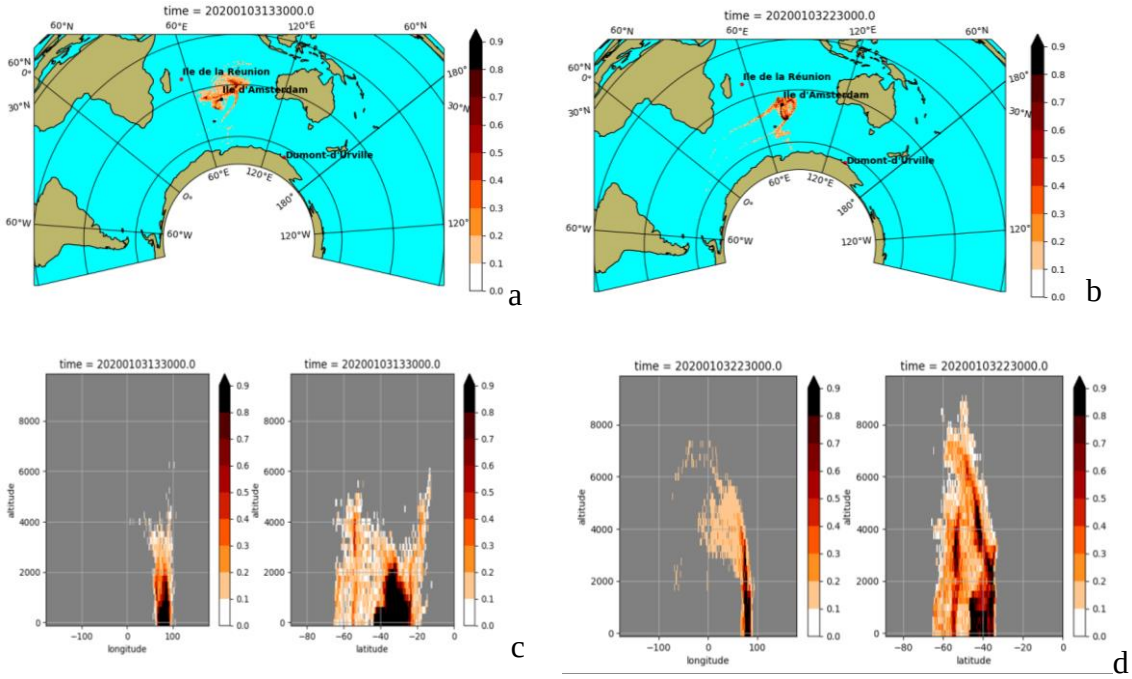


Figure S2: FLEXPART footprints in 2D projections for the event of the 3rd-4th of January. The colors on each grid point of these projections represent the density of particles over the ten-day back trajectories (1000 particules per launch). A dark red color indicates a zone with a high concentration of particles, hence a region from which a large part of the air mass originates. a: latitude-longitude projection of the FLEXPART back trajectory footprint for the 3rd of January 2020 at 13h30. b: same as a for the 3rd of January 2020 at 22h30. c: left is the longitude-altitude projection of the FLEXPART back trajectory footprint for the 3rd of January 2020 at 13h30; right is the latitude-altitude projection of the FLEXPART back trajectory footprint for the 3rd of January 2020 at 13h30. d: same as a for the 3rd of January 2020 at 22h30.

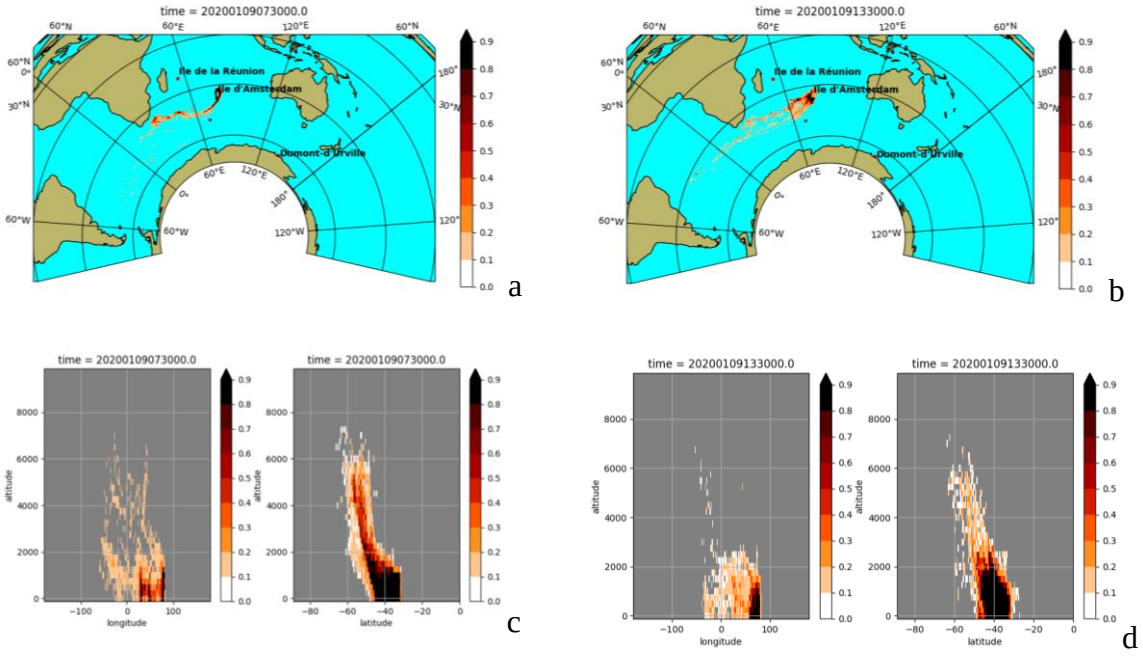
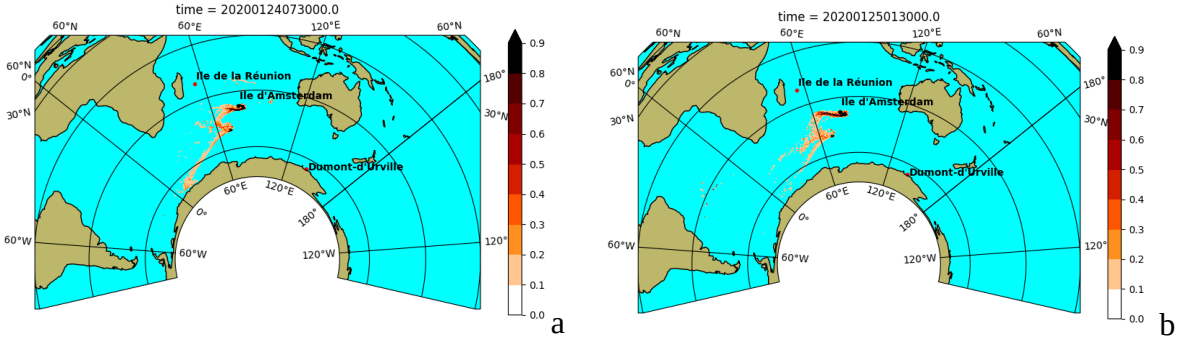


Figure S3: FLEXPART footprints in 2D projections for the event of the 9th of January. The colors on each grid point of these projections represent the density of particles over the ten-day back trajectories (1000 particules per launch). A dark red color indicates a zone with a high concentration of particles, hence a region from which a large part of the air mass originates. a: latitude-longitude projection of the FLEXPART back trajectory footprint for the 9th of January 2020 at 7h30. b: same as a for the 9th of January 2020 at 13h30. c: left is the longitude-altitude projection of the FLEXPART back trajectory footprint for the 9th of January 2020 at 7h30; right is the latitude-altitude projection of the FLEXPART back trajectory footprint for the 9th of January 2020 at 13h30. d: same as a for the 9th of January 2020 at 13h30.



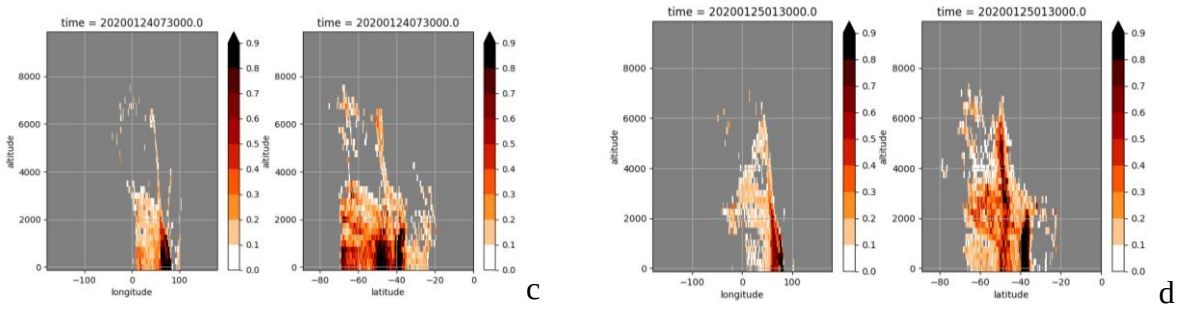
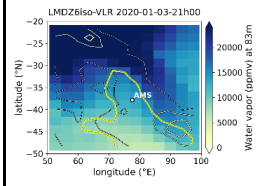
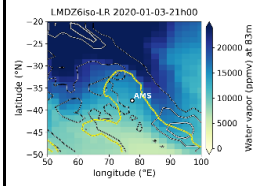
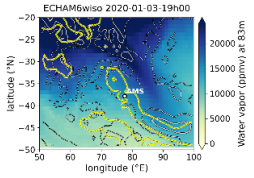
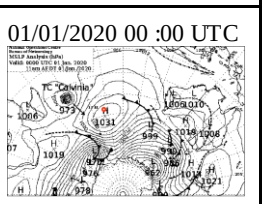
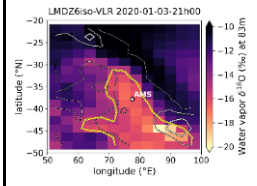
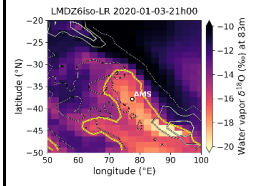
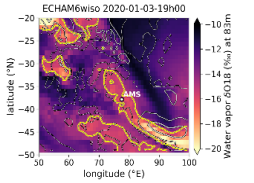
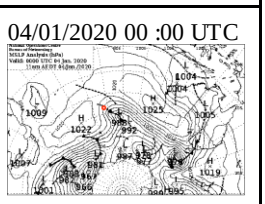
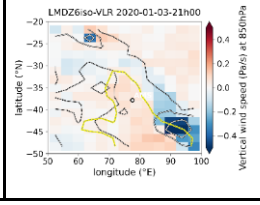
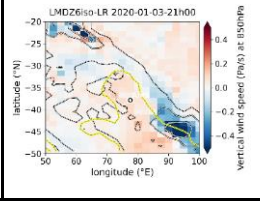
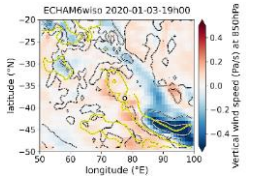
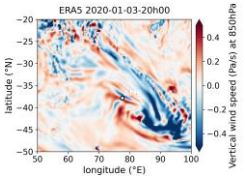
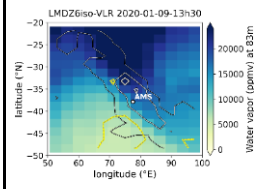
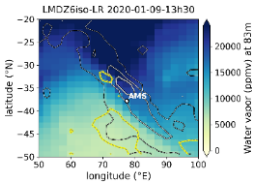
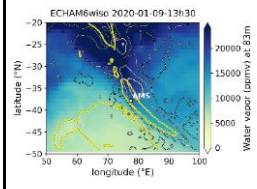
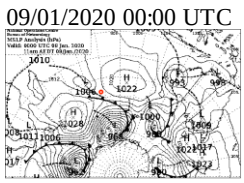
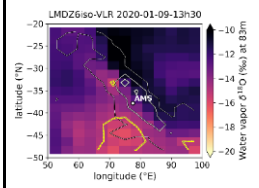
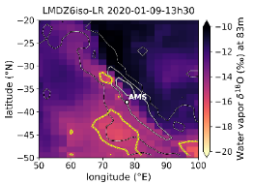
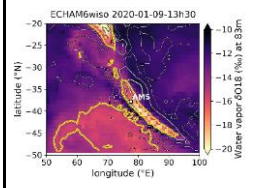
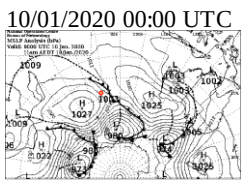
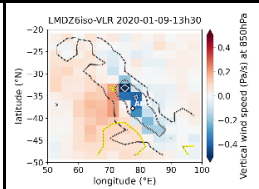
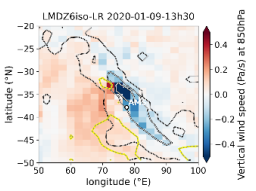
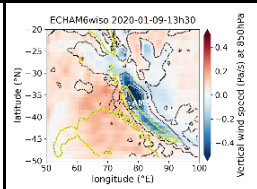
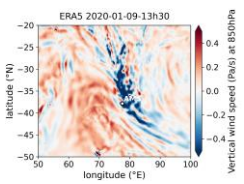


Figure S4: FLEXPART footprints in 2D projections for the event of the 21st of January. The colors on each grid point of these projections represent the density of particles over the ten-day back trajectories (1000 particules per launch). A dark red color indicates a zone with a high concentration of particles, hence a region from which a large part of the air mass originates. a: latitude-longitude projection of the FLEXPART back trajectory footprint for the 21st of January 2020 at 7h30. b: same as a for the 21st of January 2020 at 13h00. c: left is the longitude-altitude projection of the FLEXPART back trajectory footprint for the 21st of January 2020 at 7h30; right is the latitude-altitude projection of the FLEXPART *back* trajectory footprint for the 21st of January 2020 at 13h30. d: same as a for the 21st of January 2020 at 13h00.

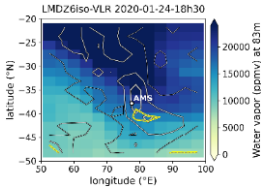
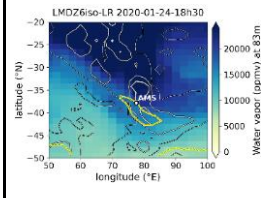
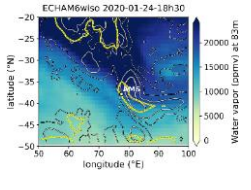
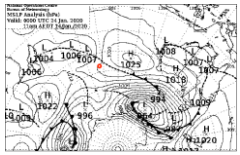
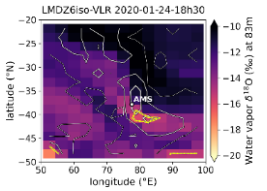
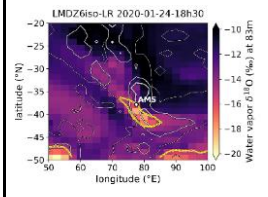
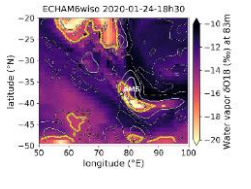
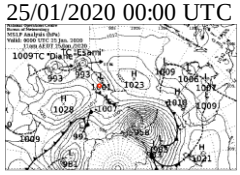
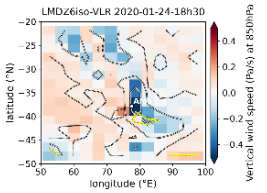
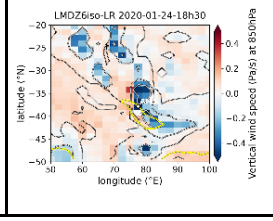
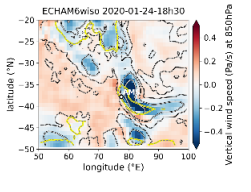
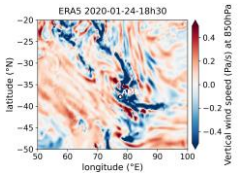
2. <u>Model outputs for the 4 events over the period January – March 2020</u>

03/01/2020	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q_v at the surface (83 m)				
$\delta^{18}O_v$ at the surface (83 m)				
Vertical velocity (850 hPa)				

09/01/2020	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q_v at the surface (83 m)				
$\delta^{18}O_v$ at the surface (83 m)				
Vertical velocity (850 hPa)				

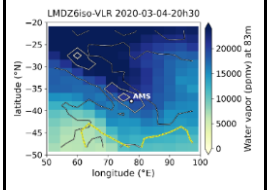
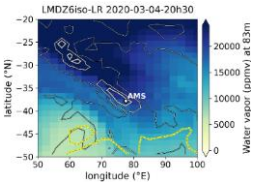
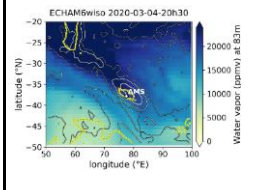
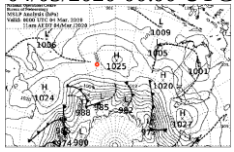
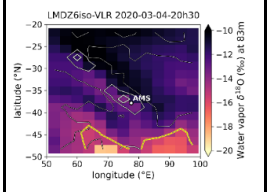
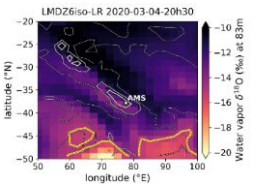
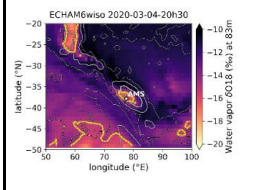
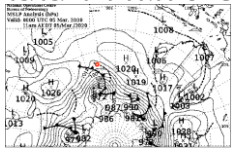
136

137

24/01/2020	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q_v at the surface (83 m)				24/01/2020 00:00 UTC 
$\delta^{18}O_v$ at the surface (83 m)				25/01/2020 00:00 UTC 
Vertical velocity (850 hPa)				

138

139
140

04/03/2020	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q_v at the surface (83 m)				04/03/2020 00:00 UTC 
$\delta^{18}O_v$ at the surface (83 m)				05/03/2020 00:00 UTC 

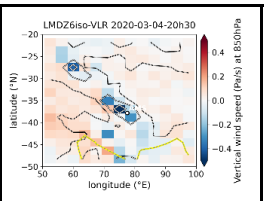
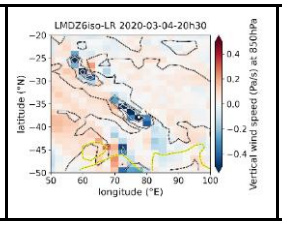
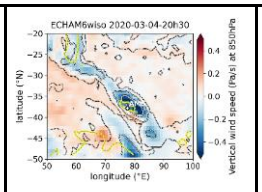
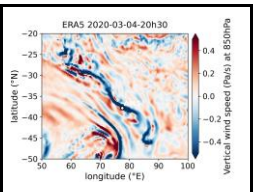
Vertical velocity (850 hPa)				

Figure S5*: Modeled water mixing ratio and $d^{18}O_v$ at the surface and vertical velocity at 850 hPa for the 4 events of the beginning of 2020 as modeled by LMDZ6 with very low resolution (1st column), low resolution (2nd column), ECHAM6-wiso (3rd column) and ERA5 (4th column). Yellow contours indicate –15‰ contour of surface water vapor $\delta^{18}O$. Black contours: precipitation contours at 0.5, 10, and 50 mm day-1 (thin, medium and thick lines respectively). Weather analysis chart are provided once a day at 00:00 UTC by the Analysis Chart Archive service of the Australian Government Bureau of Meteorology (http://www.bom.gov.au/australia/charts/archive/index.shtml). Red dot on weather charts displays Amsterdam Island location.*

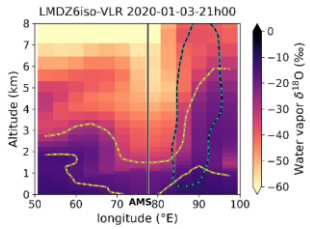
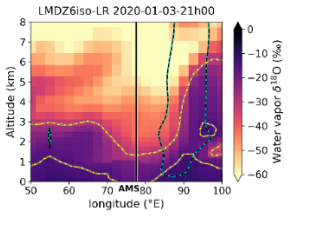
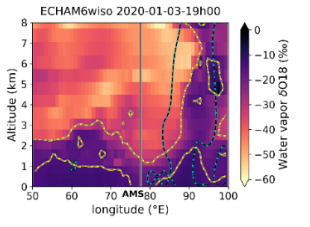
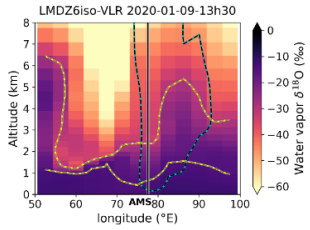
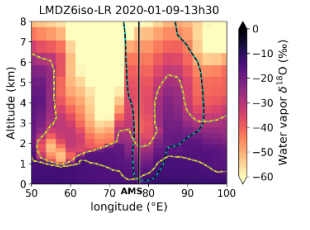
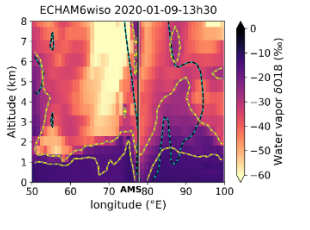
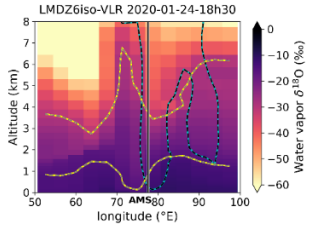
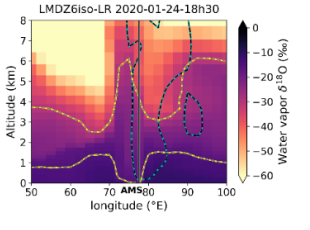
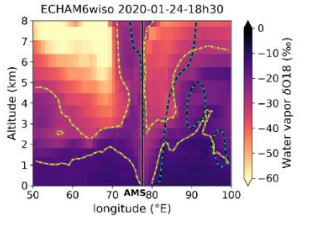
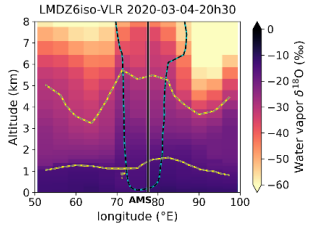
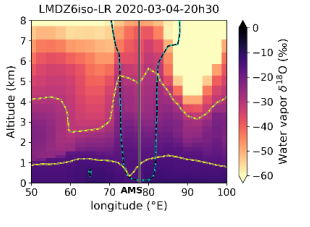
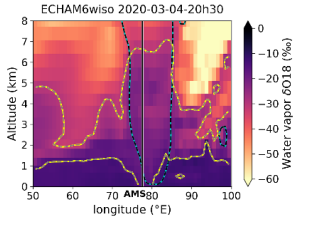
	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso
03/01/2020			
09/01/2020			
24/01/2020			
04/03/2020			

Figure S6 : $\delta^{18}O$ of water vapor plotted on a cross section of longitude (x) versus altitude (y) at the Amsterdam latitude as modeled by LMDZ6 with very low resolution (left), low resolution (middle) and ECHAM6-wiso (right). Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface air water vapor $\delta^{18}O$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendence). The vertical black line denotes Amsterdam Island latitude.

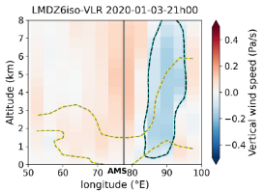
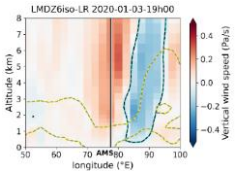
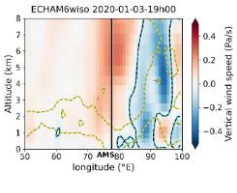
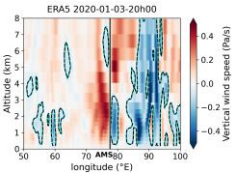
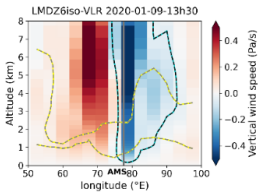
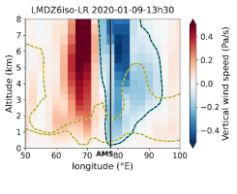
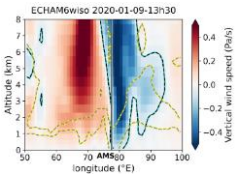
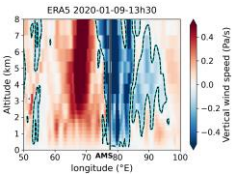
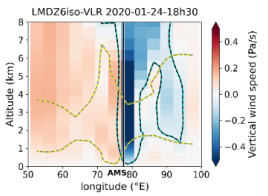
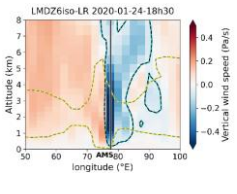
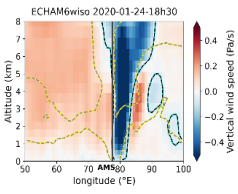
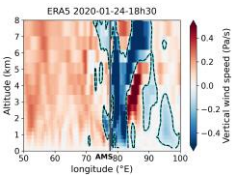
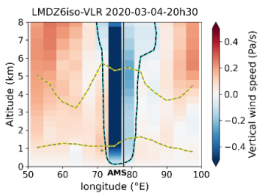
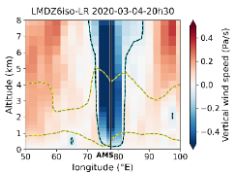
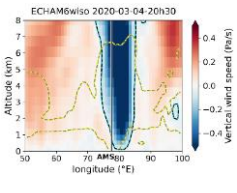
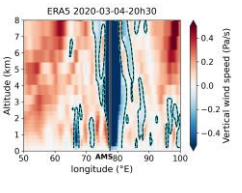
	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	ERA5
03/01/2020				
09/01/2020				
24/01/2020				
04/03/2020				

Figure S7: Vertical velocity plotted on a cross section of longitude (x) versus altitude (y) at the Amsterdam latitude as modeled by LMDZ6 with very low resolution (1st column), low resolution (2nd column), ECHAM6-wiso (3rd column) and ERA5 (4th column). Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface air water vapor $\delta^{18}O$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendence). The vertical black line denotes Amsterdam Island latitude.

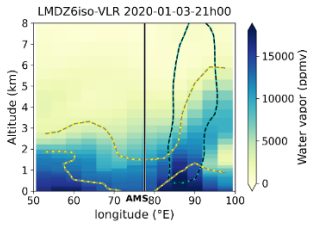
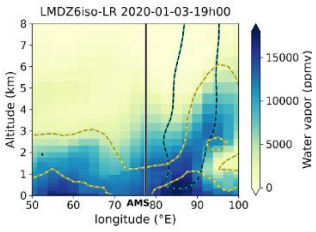
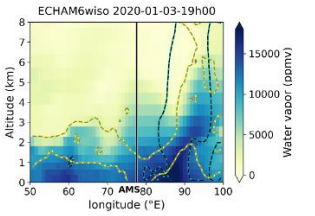
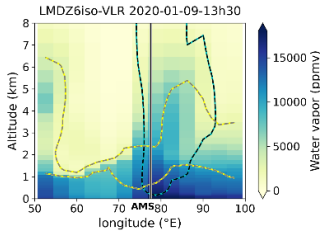
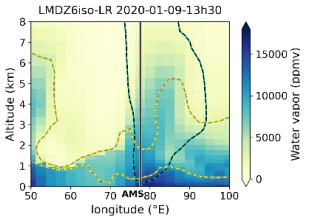
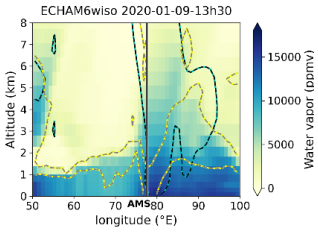
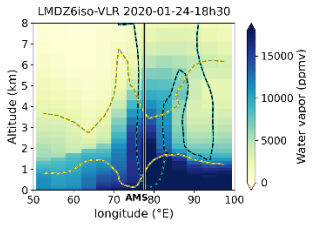
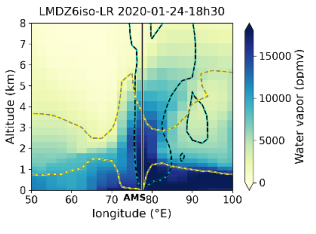
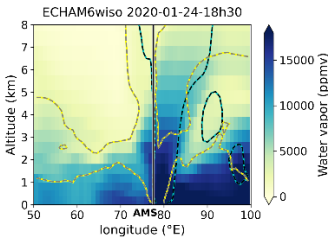
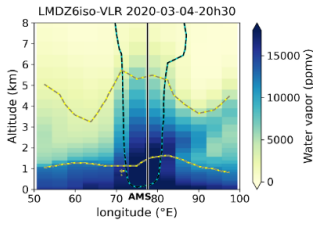
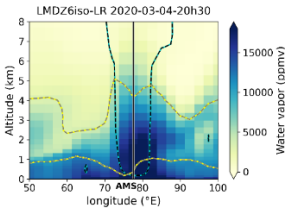
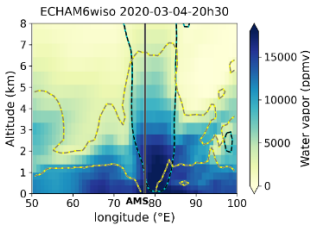
	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso
03/01/2020			
09/01/2020			
24/01/2020			
04/03/2020			

Figure S8: Humidity plotted on a cross section of longitude (x) versus altitude (y) at the Amsterdam latitude as modeled by LMDZ6 with very low resolution (left), low resolution (middle) and ECHAM6-wiso (right). Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface air water vapor $\delta^{18}O$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendence). The vertical black line denotes Amsterdam Island latitude.

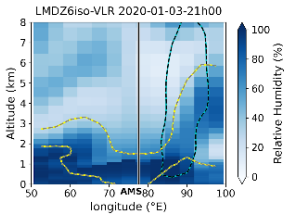
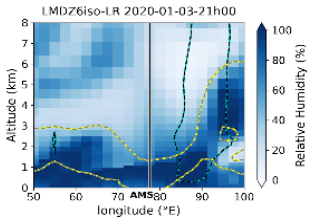
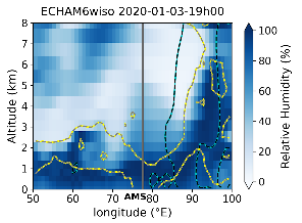
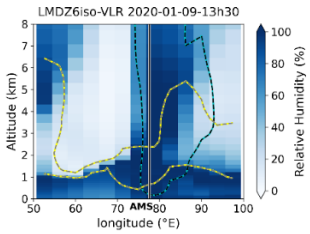
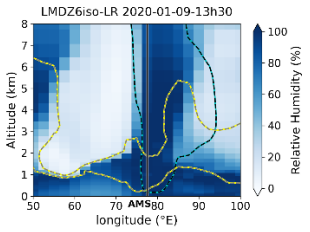
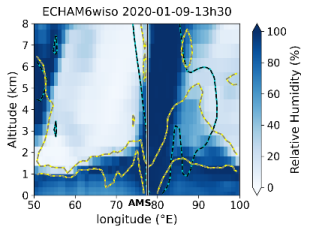
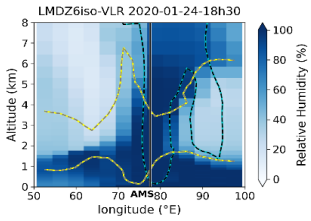
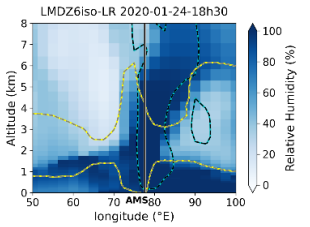
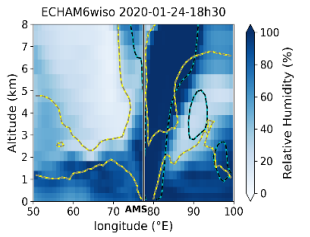
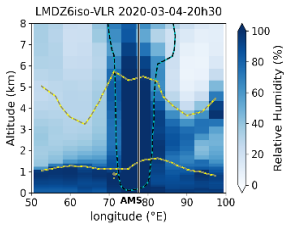
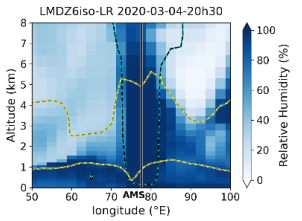
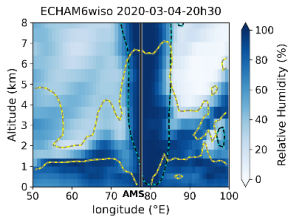
	LMDZ-iso-VLR (~3°)	LMDZ-iso-LR (~2°)	ECHAM6-wiso (~1°)
03/01/2020			
09/01/2020			
24/01/2020			
04/03/2020			

Figure S9: Relative humidity plotted on a cross section of longitude (x) versus altitude (y) at the Amsterdam latitude as modeled by LMDZ6 with very low resolution (left), low resolution (middle) and ECHAM6-wiso (right). Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface air water vapor $\delta^{18}O$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendence). The vertical black line denotes Amsterdam Island latitude.

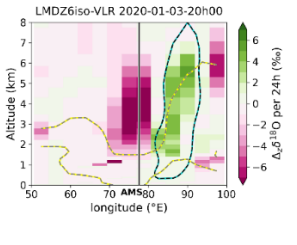
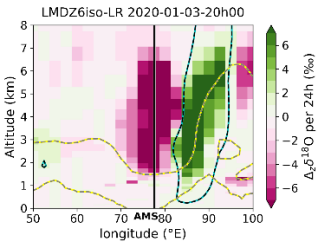
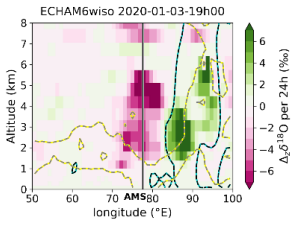
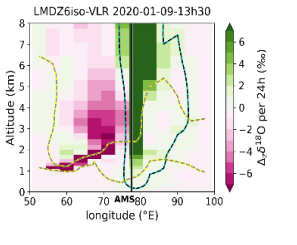
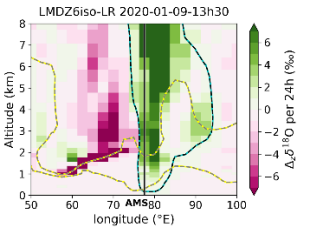
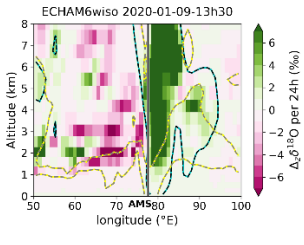
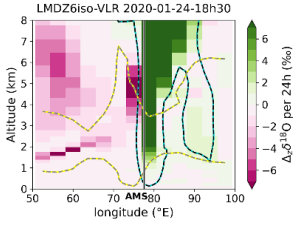
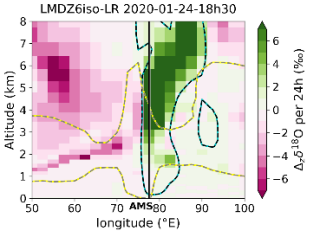
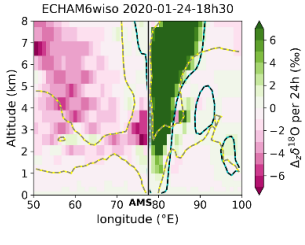
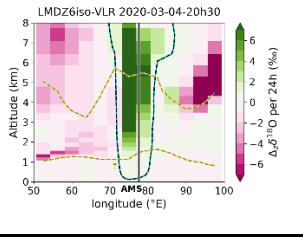
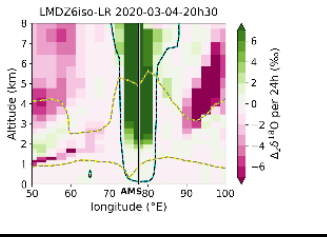
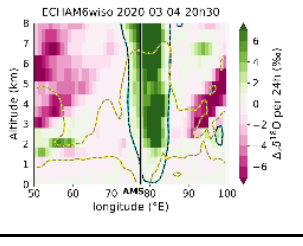
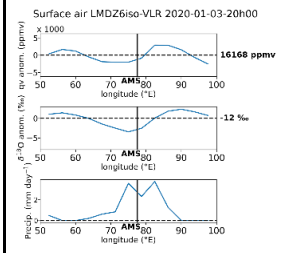
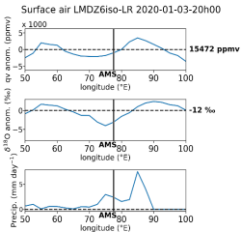
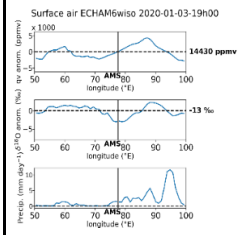
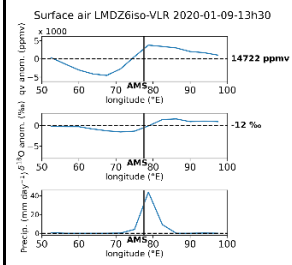
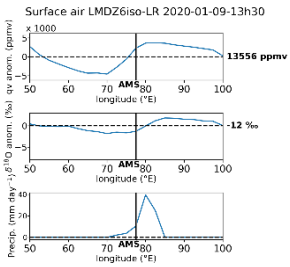
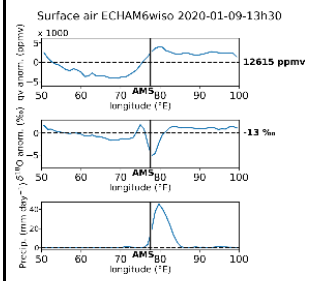
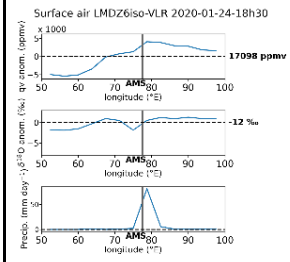
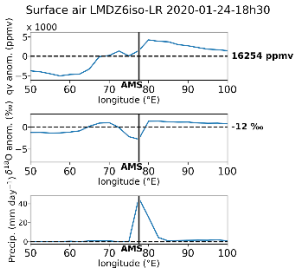
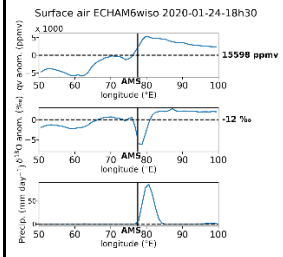
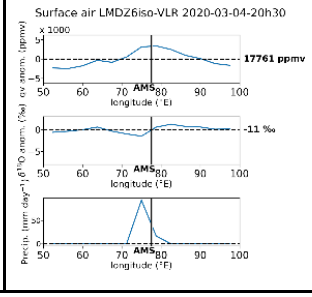
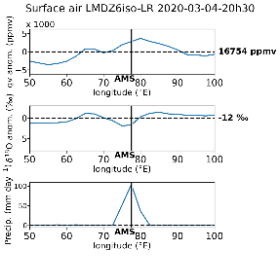
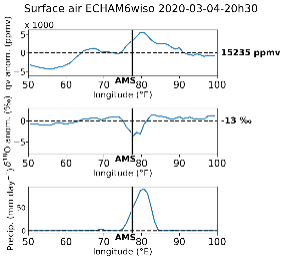
	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso
03/01/2020			
09/01/2020			
24/01/2020			
04/03/2020			

Figure S10: Vertical advection of delta per 24h (calculated as $dq_{adv_z} / q_{surf} \times(\delta^{18}O - \delta^{18}O_{surf})$, positive for increase of delta at the surface and negative for decrease of delta at surface) on a cross section of longitude (x) versus altitude (y) at the Amsterdam latitude as modeled by LMDZ6 with very low resolution (left), low resolution (middle) and ECHAM6-wiso (right). Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface air water vapor $\delta^{18}O$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendence). The vertical black line denotes Amsterdam Island latitude.

206

	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso
03/01/2020			
09/01/2020			
24/01/2020			
04/03/2020			

207
208

209 **Figure S11** : Surface signal (q_v on the top, $\delta^{18}O_v$ on the middle and precipitation on the bottom) as
210 modeled by LMDZ6 with very low resolution (left), low resolution (middle) and ECHAM6-
211 wiso (right).

212

213
214
215
216
217