1 Supplementary material to

3	Abrupt excursion in water vapor isotopic variability during cold fronts at
4	the Pointe Benedicte observatory in Amsterdam Island
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Figure S1: Data model comparison (April 2020 – December 2021) : water vapor δ^{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 δ^{18} O excursions.



87 <u>2- Backtrajectories obtained with the flexpart model</u>









Figure S3: FLEXPART footprints in 2D projections for the event of the 9th of January. The 101 colors on each grid point of these projections represent the density of particles over the ten-102 103 day back trajectories (1000 particules per launch). A dark red color indicates a zone with a 104 high concentration of particles, hence a region from which a large part of the air mass 105 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 106 longitude-altitude projection of the FLEXPART back trajectory footprint for the 9th of 107 108 January 2020 at 7h30; right is the latitude-altitude projection of the FLEXPART back 109 trajectory footprint for the 9th of January 2020 at 13h30. d: same as a for the 9th of January 2020 at 13h30. 110





112 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 tend 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 116 high concentration of particles, hence a region from which a large part of the air mass 117 originates. a: latitude-longitude projection of the FLEXPART back trajectory footprint for 118 21st of January 2020 at 7h30. b: same as a for the 21st of January 2020 at 13h00. c: left is the 119 longitude-altitude projection of the FLEXPART back trajectory footprint for the 21st of 120 January 2020 at 7h30; right is the latitude-altitude projection of the FLEXPART back 121 trajectory footprint for the 21st of January 2020 at 13h00. 122 2020 at 7h30; right is the latitude-altitude projection of the FLEXPART back 121 trajectory footprint for the 21st of January 2020 at 13h30. d: same as a for the 21st of January 122 2020 at 13h00. 123 2. 124 2. 125 2. 126 2. 127 2.		
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03/01/20 20	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q _v at the surface (83 m)	LMLZEGISo-VLR 2020-01-03-21000 -23 -24 -29 -29 -29 -29 -29 -29 -29 -29	LND266isoLR 2020-01-03-21h00 -2 -2 -2 -2 -2 -2 -2 -2 -2 -2	ECHAM6wiso 2020-01-03-19h00 	01/01/2020 00 :00 UTC
$\delta^{18}O_v$ at the surface (83 m)	LADZ6650 VLR 2020-01-03-2100 -29 -29 -29 -29 -29 -29 -29 -29	LMD26iso-LR 2020-01-03-21h00 -25 -25 -25 -25 -25 -25 -25 -25	ECHAM6wiso 2020-01-03-19000 -25 -25 -25 -25 -25 -25 -25 -25	04/01/2020 00 :00 UTC
Vertical velocity (850 hPa)	LMDZ6500-VLR 2020-01-03-2100 	UMD264soLR 2020 01.03-21000 0.4 92 020 0 0.4 02 0 0.4	ECHAMMewiso 2020-01-03-19000 -25 -25 -25 -25 -25 -25 -25 -25	ERA5 2020 01-03-20h00 -2

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09/01/20 20	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q _v at the surface (83 m)	LMDZ6rso-VLR 2020 01-09-13h30 -20 -20 -20 -20 -20 -20 -20 -2	LMD26iso-LR 2020-01-08-13h30 -25 -25 -25 -25 -25 -25 -25 -25	ECHAM66viko 2020-01-09-13h30 -2050	09/01/2020 00:00 UTC
$\delta^{18}O_v$ at the surface (83 m)	LMDZ6iso-VLR 2020-01-09-13n30 -25 -25 -25 -25 -25 -25 -25 -25	LMD264so-LR 2020-01-09-13h30 -25 -25 -25 -25 -25 -25 -25 -25	ECHAM6wiko 2020-01-09-13h30 -25 -25 -25 -25 -25 -25 -25 -25	10/01/2020 00:00 UTC
Vertical velocity (850 hPa)	LMDZ6iso-VLR 2020-01-09-13h30 -26 -26 -26 -26 -26 -26 -26 -26	LMD26iso-LR 2020-01-09-13h30 -25 -25 -35 -55 -50 -50 -50 -50 -50 -50 -5	ECHAM6eviso 2020-01-09-13h30 -22 -23 -24 -25 -25 -25 -25 -25 -25 -25 -25	Construction of the second sec

24/01/2 020	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q _v at the surface (83 m)	LMDZ6liso-VLR 2020-01-24-18h30 -25 -25 -25 -25 -50 -50 -50 -50 -50 -50 -50 -5	MD26isoLR 2020-01-24-18130 -20 -20 -20 -20 -20 -20 -20 -2	ECHAMGWISG 2020-01-24-3B930 	24/01/2020 00:00 UTC
$\delta^{18}O_v$ at the surface (83 m)	LMDZGliso VLR 2020-01-24-18h30 -25 -25 -25 -25 -55 -55 -55 -25 -2	UMD264so-LR 2020-01-24-18h30 -25 -25 -25 -25 -25 -25 -25 -25	CHAM6wiso 2020-01-24-38930 -20 -20 -20 -20 -20 -20 -20 -2	25/01/2020 00:00 UTC
Vertical velocity (850 hPa)	LMDZ6iso-VLR 2020-01-24-18h30 -20 -20 -20 -20 -20 -20 -20 -2	LMD2Giso-LR 2020-01-24-18h30 -2	ECHAM6wiso 2020-01-24-181:30 -25 -25 -25 -25 -25 -25 -25 -25	ERA5 2020-01-24-18h30 -2-2- -2-2

04/03/202 0	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso	Weather analysis chart and ERA5 vertical velocity
q _v at the surface (83 m)	LHDZ6iso-VLR 2020-03-04-20h30 -23 -24 -25 -25 -25 -25 -25 -25 -25 -25	10026iso-LR 2020-03-04-20130 -23 -24 -25 -55 -55 -55 -55 -55 -55 -55	CEIAMMerics 2020-03-04-201-30 -25 -25 -25 -25 -25 -25 -25 -25	04/03/2020 00:00 UTC
$\delta^{18}O_v$ at the surface (83 m)	LMDZ6iso.VLR 2020-03-04-20h30 -29 -29 -29 -29 -29 -29 -29 -29	UMDZ6iso-LR 2020-03-04-20h30 -29 -29 -29 -29 -29 -29 -29 -29	CEHAMGwise 2020-03-04-20530 -25 -25 -25 -25 -25 -25 -25 -25	05/03/2020 00:00 UTC



142 *Figure S5*: Modeled water mixing ratio and $d^{18}O_v$ at the surface and vertical velocity at 850 hPa for

143 the 4 events of the beginning of 2020 as modeled by LMDZ6 with very low resolution (1st column),

- 144 *low resolution (2nd column), ECHAM6-wiso (3rd column) and ERA5 (4th column). Yellow contours*
- 145 indicate -15% contour of surface water vapor $\delta^{18}O$. Black contours: precipitation contours at 0.5, 10,
- 146 and 50 mm day-1 (thin, medium and thick lines respectively). Weather analysis chart are provided

147 once a day at 00:00 UTC by the Analysis Chart Archive service of the Australian Government Bureau

148 of Meteorology (http://www.bom.gov.au/australia/charts/archive/index.shtml). Red dot on weather

149 charts displays Amsterdam Island location.

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Figure S6 : δ^{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 δ^{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 ERA5 ECHAM6-wiso 03/01/20 -VLR 2020-01-03-21 20 09/01/20 20 LMDZ6iso-VLR 2020-01-24-18h3 20-01-24-18h3 24/01/20 ECHA 20 LMDZ6iso-VLR 2020-03-04-20h30 2020-03-04-20h30 ERA5 2020-03-04-201 2020-03-04-20h30 04/03/20 20 itude (°E)

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165 **Figure S7**: Vertical velocity plotted on a cross section of longitude (x) versus altitude (y) at the

166 Amsterdam latitude as modeled by LMDZ6 with very low resolution (1st column), low resolution

167 (2nd column), ECHAM6-wiso (3rd column) and ERA5 (4th column). Yellow contours indicate -30‰

168 (upper) and -15% (lower) contours of surface air water vapor $\delta^{18}O$. Black contours indicate contours

169 of -0.05 Pa s⁻¹ vertical velocity (ascendence). The vertical black line denotes Amsterdam Island

- 170 latitude.
- 171
- 172



Figure S8: Humidity plotted on a cross section of longitude (x) versus altitude (y) at the Amsterdam

- 177 latitude as modeled by LMDZ6 with very low resolution (left), low resolution (middle) and
- 178 ECHAM6-wiso (right). Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface
- 179 air water vapor δ^{18} O. Black contours indicate contours of -0.05 Pa s⁻¹ vertical velocity (ascendence).
- 180 The vertical black line denotes Amsterdam Island latitude.



184

186187 Figure S9: Relative humidity plotted on a cross section of longitude (x) versus altitude (y) at the

- 188 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
- 190 surface air water vapor δ^{18} O. Black contours indicate contours of -0.05 Pa s⁻¹ vertical velocity
- 191 (ascendence). The vertical black line denotes Amsterdam Island latitude.
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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.



	LMDZ-iso-VLR	LMDZ-iso-LR	ECHAM6-wiso
03/01/2020	Surface air LMDZ6iso-VLR 2020-01-03-20h00 y 1000 100 100 100 100 100 100 100	Surface air LMD2/Giso-LR 2020-01-03-20000 1000 11072 ppmv 50 60 70 AM\$20 90 100 50 60 70 AM\$20 90 100	Surface air ECHAMGwiso 2020-01-03-19h00 14:19 ppmv 16:00 10:00 16:00 10:00
09/01/2020	Surface air LMDZ6iso-VLR 2020-01-09-13h30	Surface air LMDZ6iso-LR 2020-01-09-13h30 1000 13556 ppmv 13556 ppmv 13556 ppmv 13556 ppmv 13556 ppmv 1000 100 100 100 100 100 100 1	Surface air ECHAM6wiso 2020-01-09-13h30 3 1020 12613 ppmv 12613 ppmv 1263 ppmv 12
24/01/2020	Surface air LMDZ6iso-VLR 2020-01-24-18h30 x 1000 y 1	Surface air LMDZ6iso-LR 2020-01-24-18h30	Surface air ECHAM6wico 2020-01-24-18h30 3000 50 60 70 AM9 80 90 100 Corgicular (12) 50 60 70 AM9 80 90 100 Corgicular (12) Corgicular (12) Corgic
04/03/2020	Surface air LMDZ6iso-VLR 2020-03-04-20h30 3 2000 17761 ppmv 2 50 60 70 AMS 0 90 100 11 % 5 5 6 60 70 AMS 0 90 100 5 5 6 60 70 AMS 0 90 100 5 5 60 70 AMS 0 90 100 5 5 60 70 AMS 0 90 100	Surface air LMDZ6iso-LR 2020-03-04-20h30 3 2000 5 0 60 70 AMS 80 90 100 6 0 70 AMS 80 90 100 6 0 70 AMS 80 90 100 12 % 12 % 10 100 10 100 100	Surface bir ECHAM6wiso 2020-03-04-20h30

209Figure S11 : Surface signal (q_v on the top, $\delta^{18}O_v$ on the middle and precipitation on the bottom) as210modeled by LMDZ6 with very low resolution (left), low resolution (middle) and ECHAM6-

211 wiso (right).