

1 Supplementary material for  
2 **Gravitational Separation in the Stratosphere – A New Indicator of Atmospheric**  
3 **Circulation**

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1 **Supplementary Tables**

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3 **Table S1.** Measured values of  $\delta(^{15}\text{N})$  of  $\text{N}_2$ ,  $\delta(^{18}\text{O})$  of  $\text{O}_2$ ,  $\delta(\text{Ar}/\text{N}_2)$  and  $\delta(^{40}\text{Ar})$  over  
 4 Sanriku, Japan on June 4, 2007. All the values are normalized to the mass number  
 5 difference of 1, and expressed as deviations from the measured values at 14.5 km.

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Altitude (km)	$\delta(^{15}\text{N})$ (per meg)		$\delta(^{18}\text{O})/2$ (per meg)		$\delta(\text{Ar}/\text{N}_2)/12$ (per meg)	$\delta(^{40}\text{Ar})/4$ (per meg)
	MAT-252	Delta-V	MAT-252	Delta-V		
17.0	10.0	2.1	4.5	7.9	4.5	11.4
18.5	-7.3	-6.8	-10.7	-11.0	-10.4	-16.1
21.0	-17.9	-18.5	-26.0	-25.0	-26.8	-29.6
23.0	-12.0	-20.1	-6.2	-13.3	-11.2	-18.9
26.0	-12.2	-28.2	-17.8	-22.7	-23.4	-20.5
28.3	-30.6	-31.7	-37.0	-23.1	-23.6	-23.1
29.9	-20.0	-37.0	-29.2	-34.1	-32.3	-32.0
31.3	-41.1	-44.2	-43.5	-45.7	-45.8	-51.5
32.8	-45.7	-44.0	-46.7	-50.0	-49.1	-50.9

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**Table S2.** Measured  $\langle\delta\rangle$  values and CO<sub>2</sub> age over Sanriku, Japan on June 8, 1995, expressed as deviations from the tropospheric value.

Altitude (km)	$\langle\delta\rangle$ (per meg)	CO <sub>2</sub> age (years)
13.6	-8.1	
16.6	-6.3	0.62
18.0	12.8	3.46
20.3	-8.3	4.20
22.3	-2.0	3.82
24.5	-24.8	4.64
26.7	-43.6	4.93
28.8	-28.1	4.63
30.6	-27.3	4.97
32.4	-38.9	5.15
33.8	-50.3	4.97

**Table S3.** Same as in Table S2 but for on May 31, 1999.

Altitude (km)	$\langle\delta\rangle$ (per meg)	CO <sub>2</sub> age (years)
18.7	-29.8	3.28
20.8	-27.6	2.96
23.1	-17.5	
25.6	-35.2	5.46
27.3	-77.9	5.96
34.5	-91.9	5.75

1 **Table S4.** Same as in Table S2 but for on August 28, 2000.

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Altitude (km)	$\langle \delta \rangle$ (per meg)	CO <sub>2</sub> age (years)
15.0	3.9	1.98
17.1	-4.0	1.88
18.7	14.0	2.48
20.9	-7.6	4.49
22.7	-14.9	4.33
25.8	-62.8	5.04
27.7	-49.0	5.02
29.3	-60.3	4.75

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15 **Table S5.** Same as in Table S2 but for on May 30, 2001.

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Altitude (km)	$\langle \delta \rangle$ (per meg)	CO <sub>2</sub> age (years)
14.9	7.8	1.40
16.8	-11.2	
18.8	-28.2	2.49
20.8	-48.3	4.84
23.1	-33.0	4.72
23.8	-9.4	4.69
25.7	-7.0	4.47
27.6	-33.1	4.31
29.4	-35.5	4.68
33.8	-32.1	4.79

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1 **Table S6.** Same as in Table S2 but for on September 4, 2002.

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Altitude (km)	$\langle\delta\rangle$ (per meg)	CO <sub>2</sub> age (years)
15.9	9.8	1.80
16.4	12.5	1.71
18.7	-9.1	1.48
20.6	-17.9	4.12
24.0	-24.0	5.46
25.4	-4.6	
27.7	-31.1	6.38
31.8	-42.2	6.19
34.0	-73.8	5.70

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16 **Table S7.** Same as in Table S2 but for on September 6, 2004.

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Altitude (km)	$\langle\delta\rangle$ (per meg)	CO <sub>2</sub> age (years)
14.7	0.9	1.44
16.5	7.4	0.21
18.7	-4.1	1.91
21.0	-18.6	3.64
23.0	-33.3	4.75
24.8	-36.0	4.48
27.0	-53.1	5.22
29.5	-99.0	5.75
31.5	-43.5	5.77
32.9	-34.9	5.77
35.7	-74.2	5.75

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1 **Table S8.** Same as in Table S2 but for on June 3, 2006.

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Altitude (km)	$\langle\delta\rangle$ (per meg)	CO <sub>2</sub> age (years)
20.8	-15.7	4.12
23.0	-22.3	4.54
24.8	-24.5	4.39
27.2	-40.6	4.62
31.0	-48.9	4.71
32.9	-59.8	5.33
34.4	-36.1	5.58

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14 **Table S9.** Same as in Table S2 but for on June 4, 2007.

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Altitude (km)	$\langle\delta\rangle$ (per meg)	CO <sub>2</sub> age (years)
14.5	-1.8	0.98
17.0	5.4	1.62
18.5	-10.8	3.18
21.0	-23.7	4.63
23.0	-10.9	4.42
26.0	-16.8	4.51
28.3	-35.6	5.02
29.9	-26.4	4.97
31.3	-44.1	5.31
32.8	-48.0	5.36

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1 **Table S10.** Same as in Table S2 but for over Taiki, Japan on August 22, 2010.

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Altitude (km)	$\langle \delta \rangle$ (per meg)	CO <sub>2</sub> age (years)
15.3	17.8	1.40
16.8	11.7	1.26
18.8	2.4	2.36
22.9	-2.2	4.74
28.5	-33.8	5.03
29.2	-26.5	5.11
33.2	-28.4	5.46
34.3	-61.0	5.51

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