**Figure S1: Number of data in a month during 2012-2019 for Pasadena, Ascension, Garmisch, Manaus, Sodankyla, Reunion, Anmyeondo, Darwin, Burgos, Wollongong, and Hefei.**
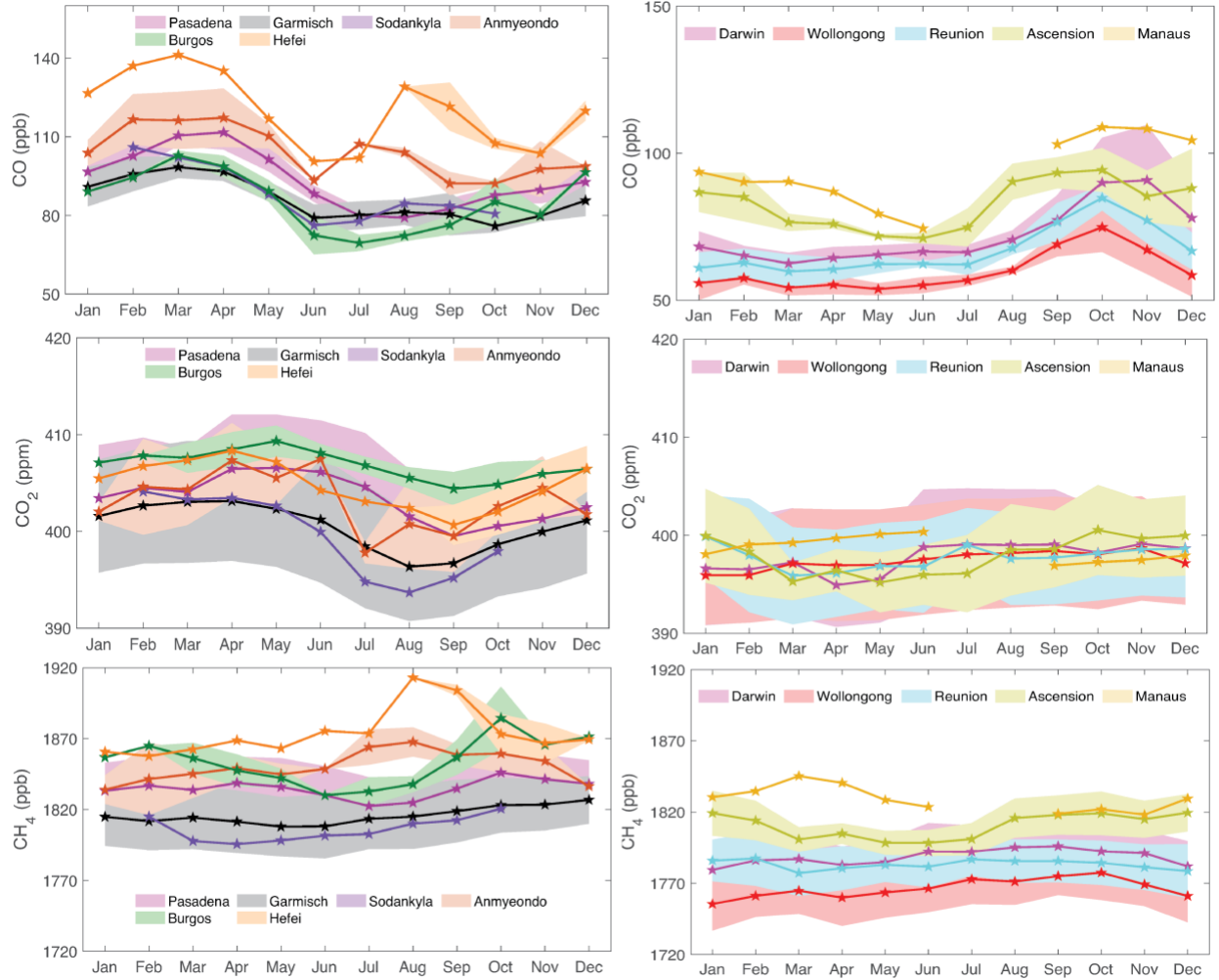
**Figure S2: Average monthly variation of CO, CO₂, and CH₄ over the Northern Hemispheric locations (Pasadena, Garmisch, Sodanklya, Anmyeondo, Burgos, Hefei) and Southern Hemispheric locations (Darwin, Wollongong, Reunion, Ascension, Manaus) during 2012-2019. Shading corresponds to the standard deviation during each monthly averaging period.**
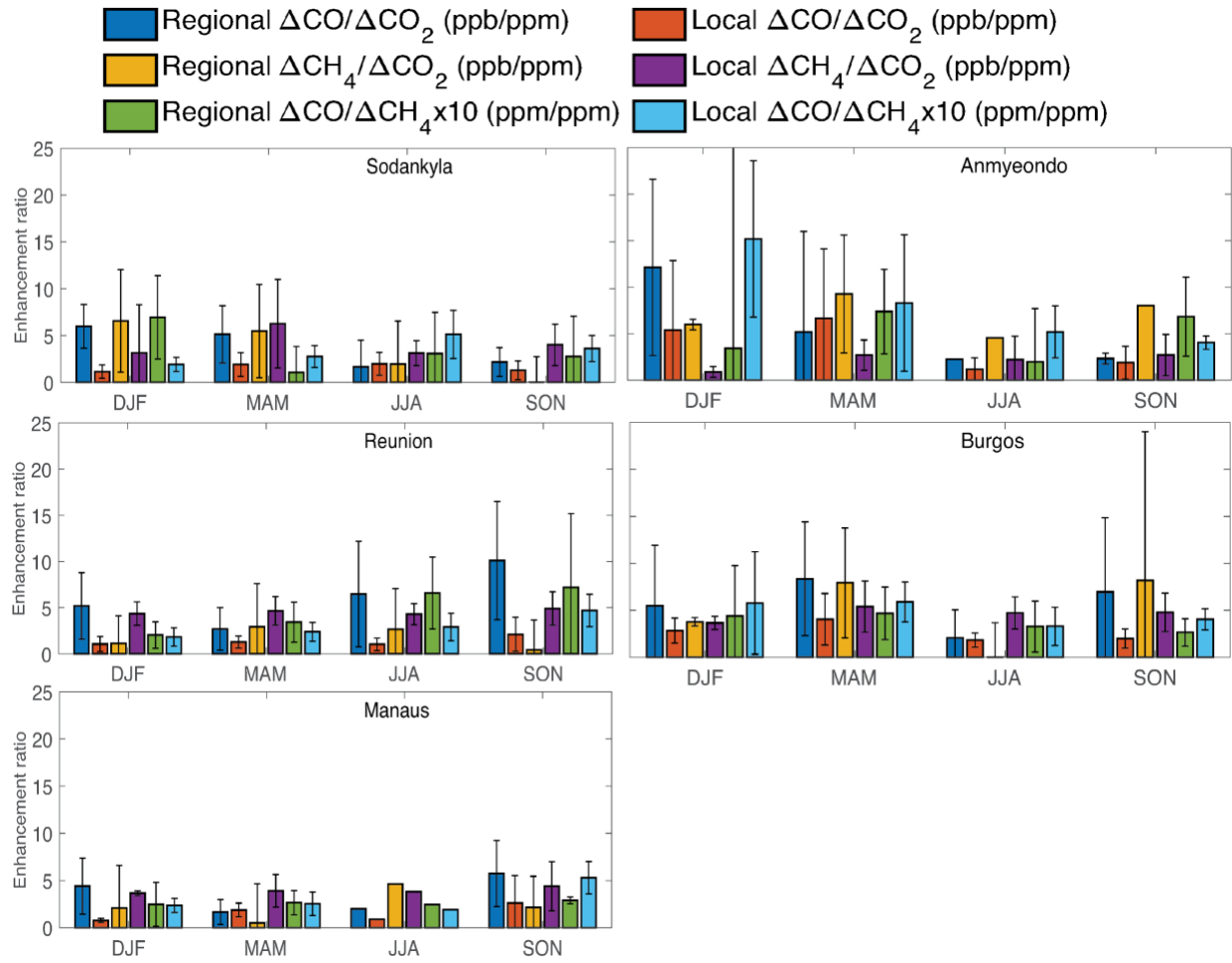
**Figure S3: Average seasonal variation of regional and local enhancement ratio of CO/CO₂, CH₄/CO₂ and CO/CH₄ over Sodankyla, Anmyeondo, Reunion, Burgos, and Manaus during 2012-2019.**
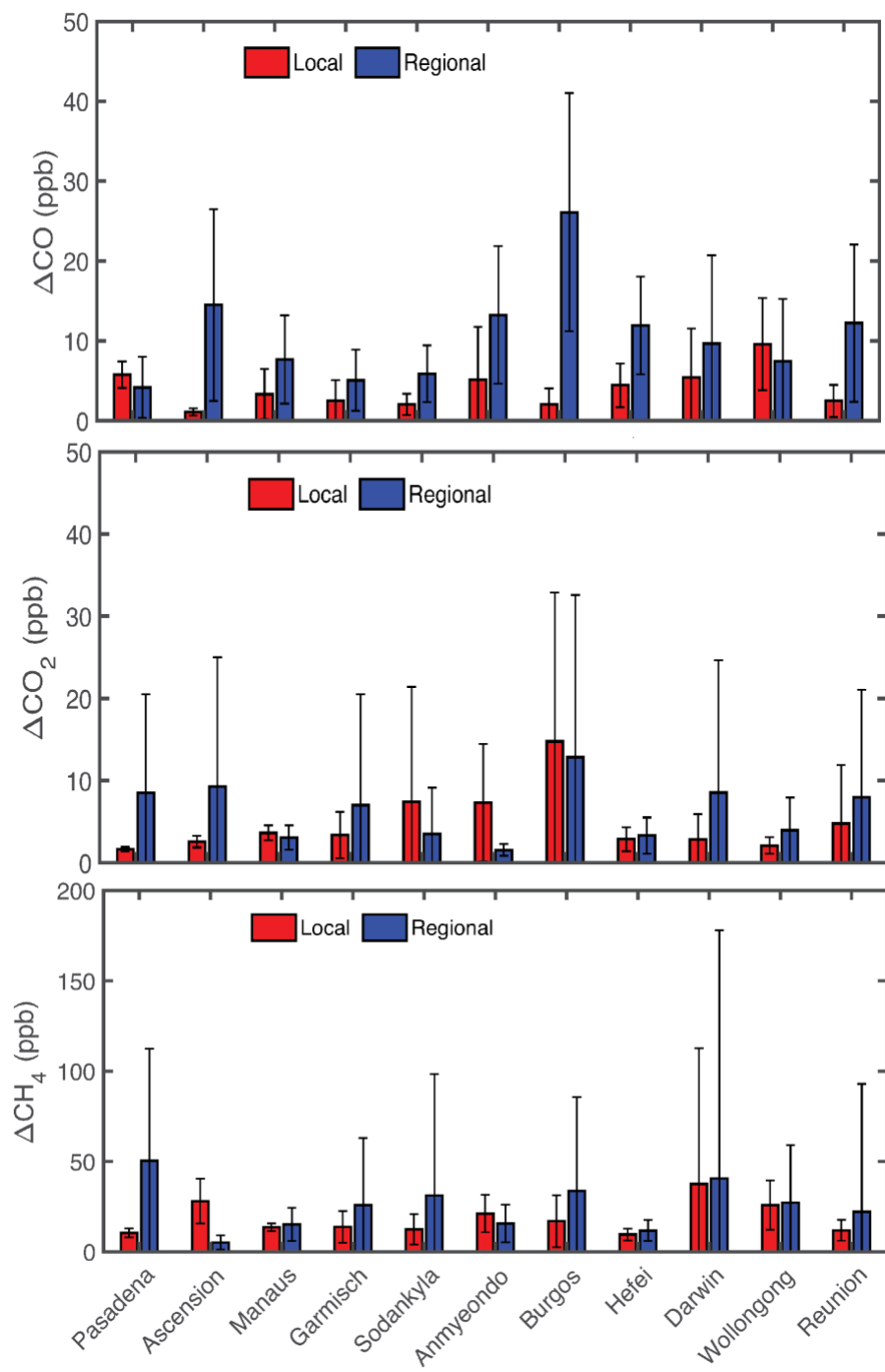
**Figure S4: The relative increase in CO, $CO_2$ ,and $CH_4$ from the regional and local enhancements over Pasadena, Ascension, Manaus, Garmisch, Sodankyla, Anmyeondo, Burgos, Hefei, Darwin, Wollongong and Reunion during 2012-2019.**
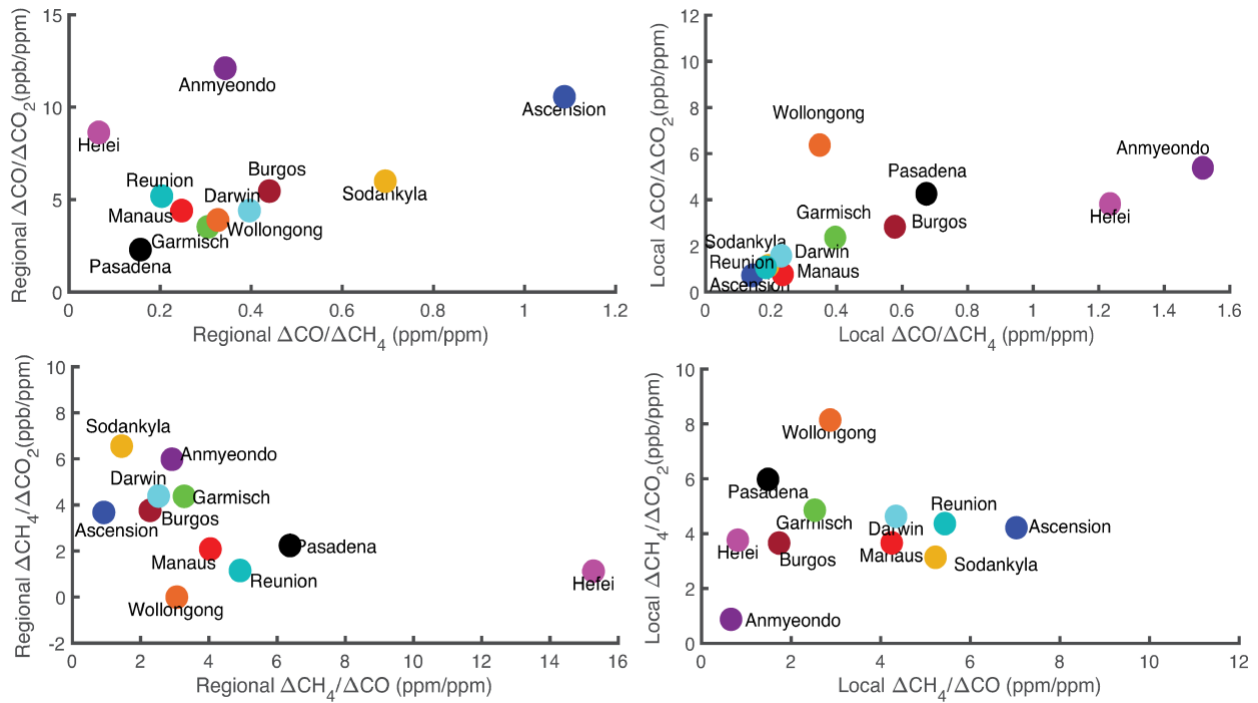
**Figure S5:** Scatter plot of average regional and local $CO/CO_2$ vs $CO/CH_4$ and $CH_4/CO_2$ and $CH_4/CO$ during DJF months.
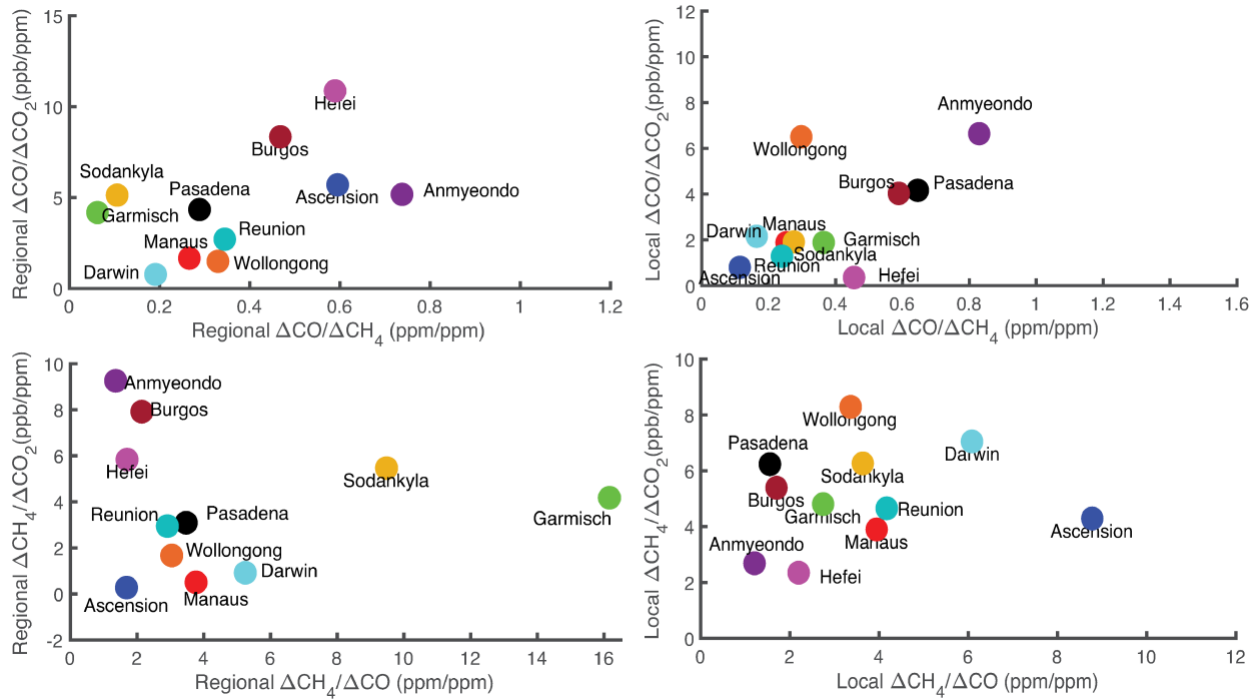
**Figure S6:** Scatter plot of average regional and local $CO/CO_2$ vs $CO/CH_4$ and $CH_4/CO_2$ and $CH_4/CO$ during MAM months.
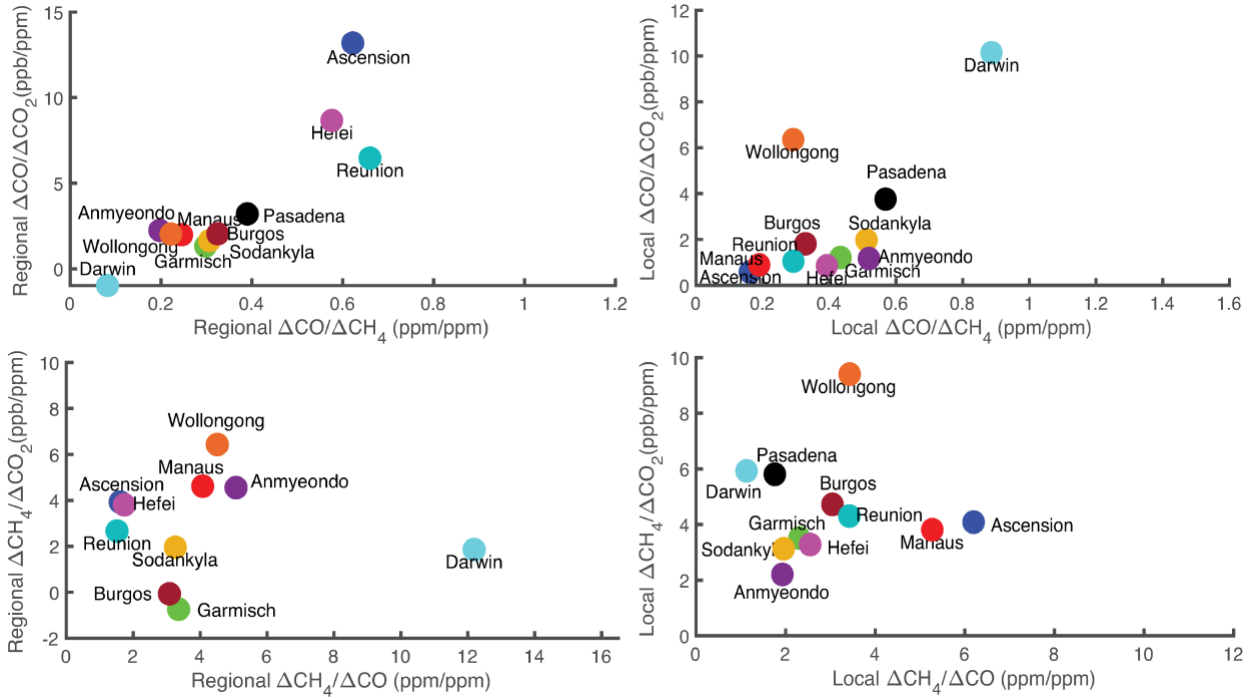
**Figure S7: Scatter plot of average regional and local CO/CO₂ vs CO/CH₄ and CH₄/CO₂ and CH₄/CO during JJA months.**
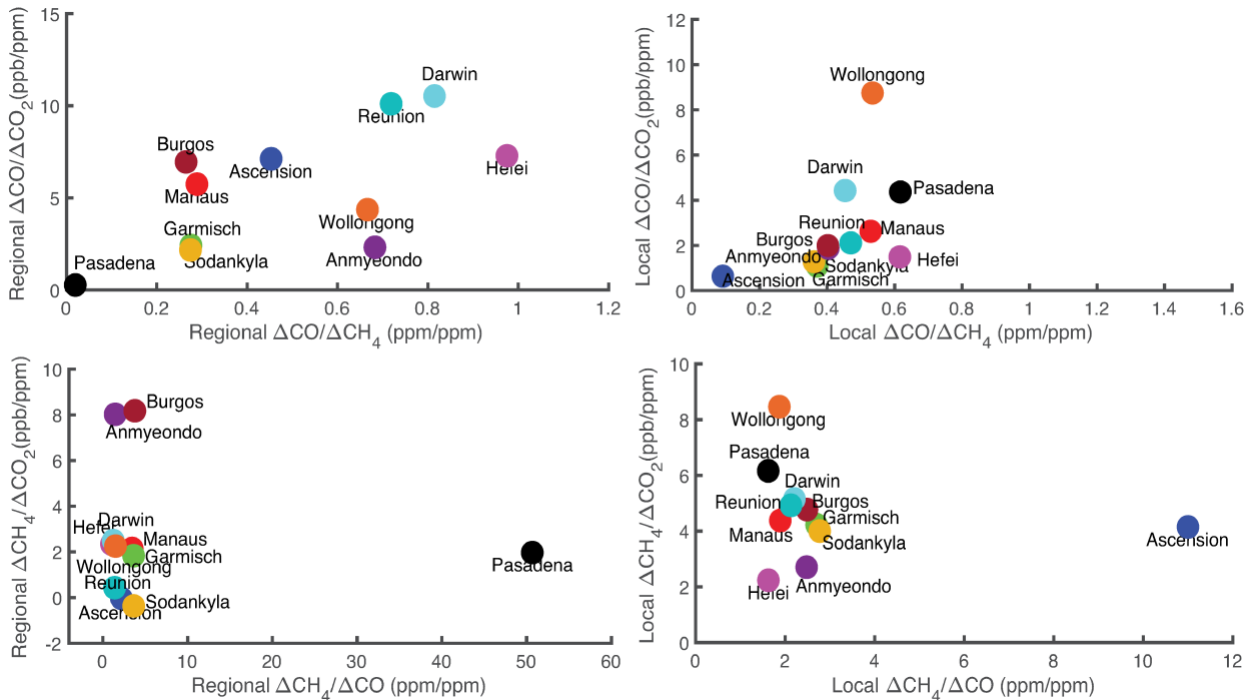
**Figure S8: Scatter plot of average regional and local CO/CO₂ vs CO/CH₄ and CH₄/CO₂ and CH₄/CO during SON months.**

**Table S1: Number of monthly data points used to generate Figure 5 and seasonal averages of regional enhancement ratios during 2012-2019.**

| Locations | Regional enhancement ratio of $CO/CO_2$ | | | | Regional enhancement ratio of $CH_4/CO_2$ | | | | Regional enhancement ratio of $CO/CH_4$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DJF | MAM | JJA | SON | DJF | MAM | JJA | SON | DJF | MAM | JJA | SON |
| Pasadena | 21 | 19 | 8 | 18 | 15 | 13 | 0 | 9 | 21 | 17 | 18 | 20 |
| Ascension | 12 | 7 | 5 | 15 | 12 | 7 | 6 | 6 | 12 | 4 | 6 | 4 |
| Manaus | 3 | 2 | 1 | 2 | 2 | 3 | 1 | 2 | 3 | 3 | 1 | 2 |
| Garmisch | 22 | 18 | 7 | 14 | 18 | 17 | 3 | 14 | 21 | 21 | 19 | 19 |
| Sodankyla | 4 | 24 | 12 | 4 | 4 | 17 | 8 | 10 | 4 | 19 | 22 | 12 |
| Anmyeondo | 2 | 4 | 1 | 2 | 2 | 4 | 1 | 1 | 2 | 3 | 2 | 2 |
| Burgos | 3 | 5 | 3 | 6 | 3 | 5 | 3 | 5 | 3 | 6 | 6 | 5 |
| Hefei | 4 | 3 | 3 | 5 | 4 | 3 | 2 | 5 | 4 | 3 | 3 | 5 |
| Darwin | 11 | 10 | 14 | 9 | 17 | 13 | 19 | 12 | 10 | 14 | 16 | 13 |
| Wollongong | 16 | 20 | 20 | 19 | 17 | 19 | 20 | 19 | 13 | 14 | 18 | 17 |
| Reunion | 9 | 11 | 10 | 17 | 13 | 14 | 13 | 14 | 10 | 12 | 8 | 9 |

**Table S2: Number of monthly data points used to generate the Figure 5 and seasonal average of local enhancement ratios during 2012-2019.**

| Locations | Local enhancement ratio of $CO/CO_2$ | | | | Local enhancement ratio of $CH_4/CO_2$ | | | | Local enhancement ratio of $CO/CH_4$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DJF | MAM | JJA | SON | DJF | MAM | JJA | SON | DJF | MAM | JJA | SON |
| Pasadena | 21 | 20 | 19 | 21 | 17 | 16 | 10 | 19 | 21 | 19 | 18 | 21 |
| Ascension | 12 | 7 | 10 | 15 | 12 | 8 | 12 | 16 | 12 | 7 | 10 | 13 |
| Manaus | 3 | 3 | 1 | 2 | 3 | 3 | 1 | 2 | 3 | 3 | 1 | 2 |
| Garmisch | 22 | 21 | 20 | 18 | 19 | 23 | 20 | 18 | 22 | 23 | 22 | 19 |
| Sodankyla | 4 | 24 | 22 | 14 | 4 | 24 | 22 | 13 | 4 | 24 | 22 | 14 |
| Anmyeondo | 3 | 4 | 3 | 3 | 3 | 5 | 3 | 3 | 5 | 5 | 5 | 2 |
| Burgos | 3 | 5 | 3 | 6 | 3 | 6 | 6 | 6 | 3 | 6 | 6 | 5 |
| Hefei | 4 | 3 | 3 | 6 | 4 | 3 | 3 | 6 | 4 | 3 | 3 | 5 |
| Darwin | 17 | 16 | 20 | 15 | 17 | 17 | 21 | 18 | 15 | 15 | 16 | 14 |
| Wollongong | 16 | 20 | 20 | 19 | 17 | 20 | 20 | 19 | 13 | 14 | 19 | 17 |
| Reunion | 17 | 16 | 12 | 17 | 17 | 17 | 15 | 18 | 10 | 12 | 8 | 9 |