# Scope 3 Emissions from Student Travel

Category Overview: Definition, Boundary, Methodology, and Preliminary Results

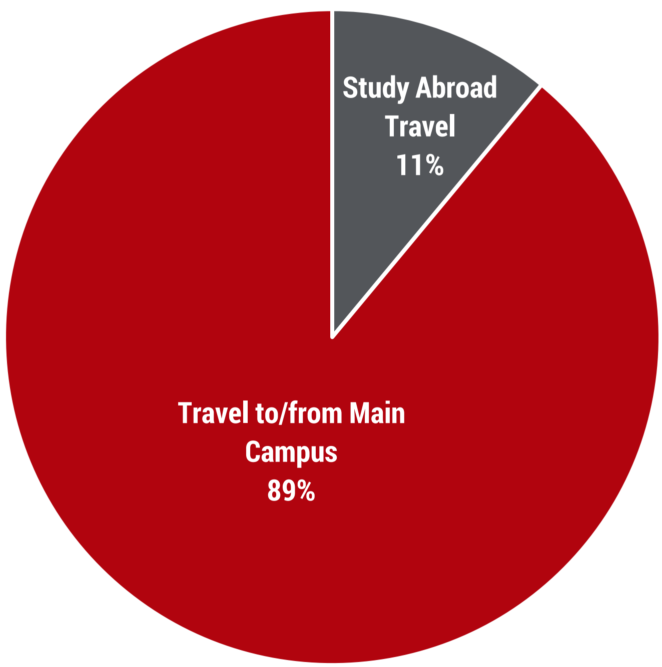
## Executive Summary

Student travel emissions are calculated on a regular basis for Stanford University by the Scope 3 Emissions Program in Business Affairs. This paper details the boundary and methodology for developing baseline student travel emissions for calendar year 2019. More information on the Scope 3 Emissions Program and baseline calculations in other scope 3 emissions categories can be found in the Stanford University CY2019 Scope 3 Emissions Program Description & Inventory.

Student travel emissions at Stanford include greenhouse gases associated with all travel to/from main campus and study abroad, including air travel and ground transportation. Student travel generates relatively high emissions at 115,389 metric tons of carbon dioxide equivalent (MTCO2e) in 2019. For perspective, this is equal to 66% of Stanford's peak combined scope 1 & 2 emissions of 198,349 MTCO2e in 2011.

The breakdown of Stanford's emissions in the student travel category between travel to/from the main campus and travel to/from study abroad programs is illustrated in Figure 1:

**<u>Figure 1:</u> Breakdown of Emissions from Student Travel by Travel Type**

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The emissions from travel to/from main campus are based on a survey administered early in 2020 to a random sample of students on air and ground travel during university breaks in 2019. Emissions from study abroad travel are based on data from 36 academic programs, including the Bing Overseas Study Program, Sophomore College, the Haas Center for Public Service, and academic grant and fellowship programs, among others. In total, air travel accounts for approximately 95% of student travel emissions, with ground transport accounting for the other 5%.

Calculation of air travel emissions in both categories involved the following steps:

- Calculation of flight distance for each trip based on airport codes
- Estimation of direct greenhouse gas emissions based on flight distance
- Application of a radiative forcing factor that captures the impact of non-$CO_2$ emissions

Emissions for ground transportation were calculated in a similar manner, using either the reported or estimated mileage of each trip.

Two 3rd-party tools and an internally developed methodology were used to calculate student travel emissions. Our recommendation is to use the internally developed methodology going forward. The student travel survey and study abroad data collection should be refined, repeated on an annual basis, and compared with emerging sources of student travel data from booking platforms to both track emissions and improve accuracy over time.

## Category Definition

Because mitigation strategies for student travel differ significantly from those for university-sponsored employee travel, the Scope 3 Emissions Working Group resolved to account for student travel emissions as a separate category within the university's scope 3 emissions reporting.

The working definition for this category is any emissions related to both undergraduate and graduate student travel to and from the main campus or an overseas campus at the beginning or end of an academic quarter, over the Thanksgiving break, or for September studies. Student intra-quarter travel, like leisure trips during the quarter, for example, is excluded from our boundary. This travel has been divided into two major types: travel to/from the main campus and travel related to study abroad and other academic programs.

Study abroad travel includes all travel for students who are participating in an academic program, either domestically or overseas. While the term "study abroad" denotes international travel, this definition is expanded here to include both domestic and international travel, like how the Bing Overseas Study Program (BOSP) includes domestic campuses in Washington D.C. and New York. This category aims to include all BOSP travel—the most well-known of the study abroad programs—but also other travel associated with any academic program, such as Sophomore College, the Haas Center for Public Service, and student travel for grants and fellowships.

Finally, the definition also includes all relevant greenhouse gases, which comprise direct aviation emissions from carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide($N_2O$), for which there are custom emissions factors, as well as indirect emissions from additional gases and particles, which are captured through the application of a radiative forcing factor.

## Boundary

Table 1 illustrates common traveler types at the university and funding sources and the respective scope 3 categories to which they have initially been assigned. The detailed definition, boundary, and methodology for calculating business travel emissions are included in the report "Scope 3 Emissions from Business Travel." Emissions associated with visitors' travel to campus (not funded by the university) for Stanford-sponsored events will be considered Visitor Travel and detailed in a separate report.

**Table 1: Scope 3 Emissions Category Designation by Traveler Type & Funding Source**

| Traveler Type & Funding Source | Business Travel | Student Travel | Visitor Travel | Excluded |
|---|---|---|---|---|
| Employee travel directly funded by university or reimbursed | ✓ | | | |
| Employee travel funded by others | | | | ✓ |
| Student travel directly funded by university (i.e., student researchers, student athletes) | ✓ | | | |
| Visitor travel directly funded by university | ✓ | | | |
| Student travel to/from main campus, funded by students and families, scholarships, or stipends | | ✓ | | |
| Student travel for study abroad programs, funded by students and families, scholarships, or stipends | | ✓ | | |
| Parent/other student visitor travel to Stanford-sponsored events (i.e., Convocation, Commencement) | | | ✓ | |
| Student intra-quarter travel (leisure, trips during abroad programs) | | | | ✓ |
| All other visitor travel for Stanford-sponsored events (athletic events, conferences, etc.) not funded by Stanford | | | ✓ | |

## Calculation Methodology

Scope 3 emissions are notoriously difficult to accurately quantify because the indirect nature of the emissions means institutions have difficulty ascertaining accurate input data and emissions factors. When data and emissions factors are not perfectly accurate, assumptions need to be made that can dramatically influence the magnitude of the emissions. Thus, in any given scope 3 emissions calculation, there may be a significant margin of error.

For example, some calculation methodologies use spend data as the primary input, and therefore deploy corresponding spend-based emissions factors. These are convenient if the data is only available in dollars, which often occurs because the data is pulled from purchasing platforms that do not automatically track other metrics. On the other hand, other calculation methodologies incorporate more detailed input data based on the relevant units for each category; for example, for student travel, the most relevant unit is passenger miles traveled. These methodologies in turn deploy distance-based emissions factors that are widely considered to be more accurate.

To experiment with different calculation methodologies and attempt to quantify the margin of error between them, the Office of Sustainability elected to use three distinct approaches to quantify emissions as applicable to each category. The approaches are explained below.

- **Internal calculations:** To the extent that publicly available emissions factors could be identified for each category, sustainability staff and student researchers applied these emissions factors to the data collected to generate emissions estimates.
- **The Sustainability Indicator Management & Analysis Platform (SIMAP):** Created by the University of New Hampshire, the SIMAP tool helps universities quantify emissions in scope 1, 2, and some scope 3 categories that are particularly applicable to higher education, including commuting, business travel & study abroad, student travel to/from home, food, paper, and waste & wastewater. The tool is publicly available for a minor membership fee of $600 per year.
- **VitalMetrics Carbon360 Platform:** Carbon360 is a proprietary, cloud-based solution developed at the University of Santa Barbara and now owned by VitalMetrics. The tool pulls emissions factors from a combination of databases to make it simple for customers to calculate scope 1, 2, and 3 emissions across the fifteen categories defined by the GHG Protocol. This tool cost Stanford $10,000 in its first year to deploy.

Initial quantification of emissions in this category was completed by the Office of Sustainability prior to creation of the Scope 3 Emission Program. The Office of Sustainability benefited from significant support from Abby Bauer, a student in Professor Paul Brest's 2020 policy practicum. Many of the details below were determined with support from Abby's research findings.

## Travel To & From Main Campus

A survey in early 2020 collected data from a sample of students on all travel to/from the main campus, by any mode. This includes student travel to and from their homes during breaks, any other student travel during breaks, and transportation to and from the airport. In some cases, intra-quarter travel was also reported in the survey and included, but this data was not collected comprehensively.

## Data Collection

Student researcher Abby Bauer assisted the Office of Sustainability in designing the survey on student travel in calendar year 2019. The survey was distributed in March 2020 to a random sample of 1,000 undergraduate students and 1,000 graduate students, provided by Institutional Research & Decision Support (IR&DS). The survey contained 26 questions, 22 of which asked about specific travel locations, dates, and modes throughout calendar year 2019. The other four questions addressed the representativeness of 2019 travel, student offset preferences, and general comments. A complete list of survey questions can be found in the Appendix.

**Table 2: Student Travel Survey Respondent Breakdown by Student Type and Origin**

| Student Type | International | Domestic | Unclassified |
|---|---|---|---|
| Graduate | 50 | 127 | 1 |
| Undergraduate | 28 | 157 | 3 |
| Unclassified | 14 | 55 | 7 |

Of the 2,000 students who received the survey, the response rate was around 30%, with 595 students responding. Of these 595 responses, 442 respondents produced viable flight paths for analysis, since 45 indicated not flying to or from Stanford during the academic year, and 108 respondents' answers were removed during data cleaning. Those 45 who did not fly to/from campus reported either staying in the Bay Area or around campus during breaks or taking alternative modes of transportation. During data cleaning, another 108 respondents' answers were unable to yield discernable flight paths for analysis, either due to no airport codes being provided, mismatching destination and arrival airports, or unidentifiable airport codes.

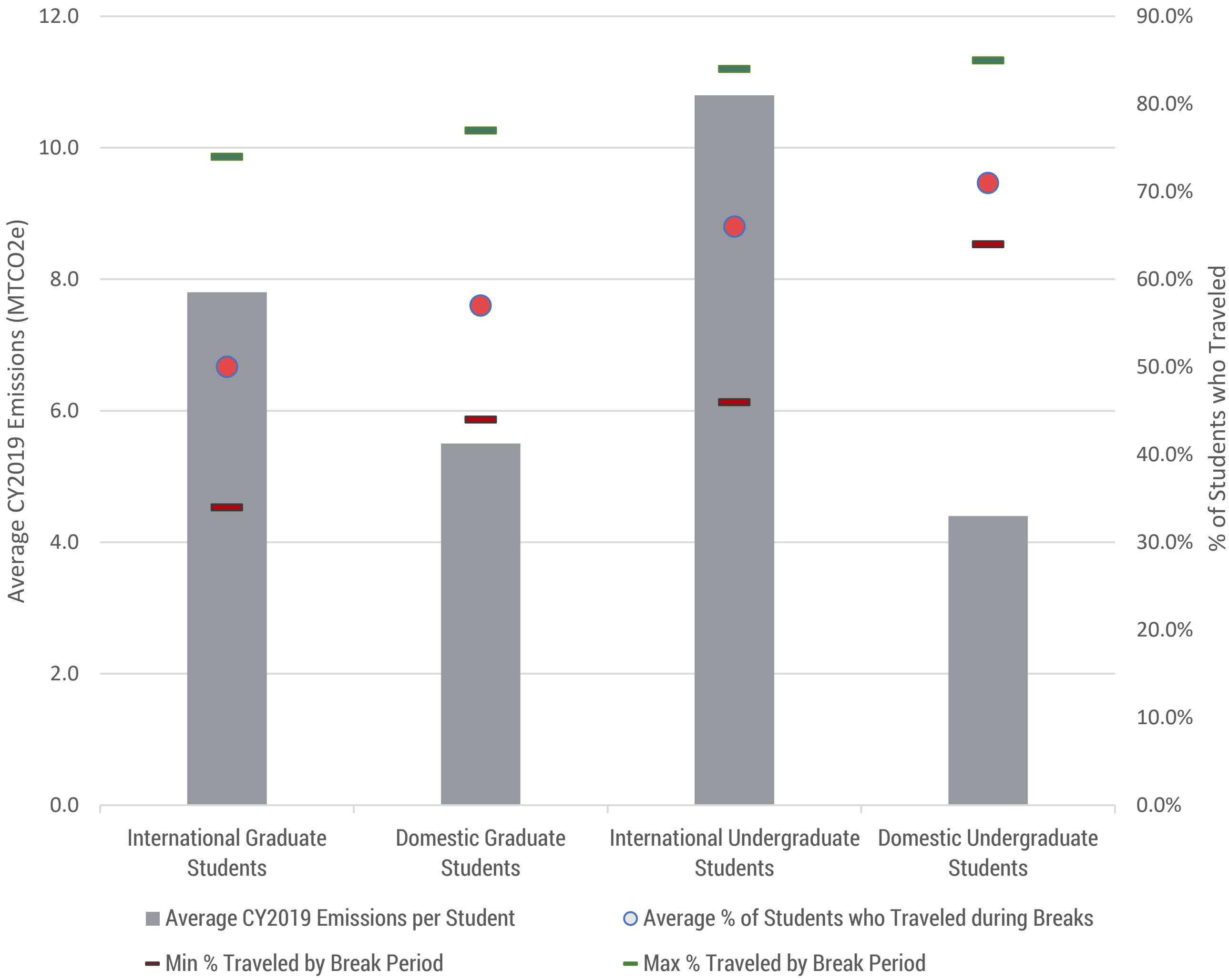
The 442 resulting respondents were classified as undergraduate or graduate, and domestic or international, with the breakdown of respondents included in our analysis by demographic category shown in Table 2.The methodology for classifying graduate and undergraduate students was to match respondent email addresses with those provided by IR&DS, which were in turn linked to their status as an undergraduate or graduate student. Some students did not use their Stanford email address when filling out the survey, so could not be classified as undergraduate or graduate based on this method. Finally, domestic or international origin was ascertained from students' responses to the question "Please list your home City, State/Province, and Country." However, 28 respondents did not provide the required information to flag as either domestic or international. In future surveys, questions will be included requiring students to self-identify by graduate or undergraduate status, and as international or domestic in origin, which will eliminate this complication.

Demographic-specific insights on travel behavior are provided in Figure 2 and Table 3 and are discussed based on those students for which demographic data was available. Future survey questions will also collect data on the program with which each student is affiliated. For example, students in the Graduate School of Business likely travel more frequently than other graduate students do.

The 442 student respondents who indicated flying during CY2019 provided departure and destination airport codes. The individual trips with airport codes were then aggregated into a single database and run through a script that assigned a flight distance by trip. When more than two airport codes were reported during a single break period, these responses were interpreted as multi-leg trips, with emissions estimated from each flight leg separately. However, the survey did not inquire as to whether flights were nonstop, so distances may be underestimated for some trips, as many students likely omitted layovers. Students' responses for Spring Break and Thanksgiving Break were assumed to be round trips, with the assumption that students' last flight was from the last airport code reported to their usual airport near campus. For example, if a student reported flying "SFO, SGN, BKI" for Spring Break, a final flight was assumed to have been between BKI and SFO, making for a 3-leg trip. The beginning of the school year, winter break (2018-2019), winter break (2019-2020), and the end of the school year were treated as one-way trips. In total, 2,425 one-way flights were included in this analysis reported by students. Additionally, since study abroad travel data was collected separately, flights that were labeled as study abroad in the survey were excluded from this analysis. However, because there was not a consistent methodology for labeling trips as study abroad—and because there are countless locations in which students may study abroad—it is possible that there is some double counting.

Using this methodology, we can evaluate travel patterns by student type and origin. Figure 2 shows the average emissions associated with each student type and origin, compared to the percentage of students who travel in the same categories.

**<u>Figure 2:</u> Average Emissions & Percentage of Student Travelers by Student Type**




There are a few key takeaways from Figure 2:

- Undergraduate students travel more often during breaks than graduate students do
- International student travel leads to higher average emissions due to longer flights when these students travel home

The results of this data by break period are shown below in Table 3 and Figure 3. Table 3 indicates that:

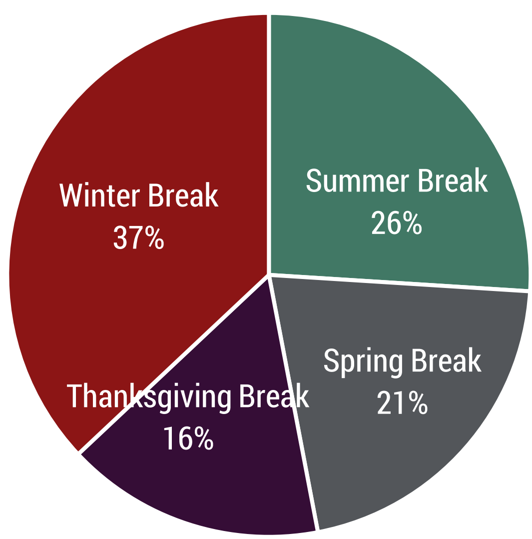
- International students travel the least during Thanksgiving
- Domestic students travel the least during spring break
- All students are most likely to travel during Winter Break

**Table 3: Percentage of Student who Travel by Break Period, Student Type and Origin**

| Break Name | International Graduate Students | Domestic Graduate Students | International Undergraduate Students | Domestic Undergraduate Students |
|---|---|---|---|---|
| Winter Break | 74% | 77% | 84% | 85% |
| Spring Break | 42% | 44% | 61% | 64% |
| Summer Quarter | 52% | 49% | 71% | 68% |
| Thanksgiving | 34% | 57% | 46% | 67% |
| **Average** | **50%** | **57%** | **66%** | **71%** |

Finally, Figure 3 illustrates the emissions associated with student travel to/from the main campus for each break period. Emissions from student travel during the winter holidays and summer quarter account for the highest percentage of emissions out of all break periods.

**Figure 3: Percentage of Student Travel Emissions by Break Period**




The data in Figures 2 & 3 and Table 3 can inform mitigation strategies for emissions from student travel to/from main campus by break period and by traveler type.

## Tool Details & Outputs

## Internal Calculations

### Air Travel

To calculate air travel emissions internally, the mileage for each one-way trip was multiplied by publicly available emissions factors released each year by the U.S. Environmental Protection Agency. These emissions factors are available for all directly emitted greenhouse gases from aviation: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). The emissions factors account for varying airplane fuel efficiency for different flight lengths, as shown in Table 4. They also factor in aircraft fuel burn by size of plane, freight, and load factor (average number of seats occupied) to derive different emissions factors for different flight lengths. In particular, the most fuel intensive portion of each flight is take-off. Thus, the average fuel efficiency for shorter flights is lower; for long-haul flights, the increased plane size and weight offset this and lead to higher emissions factors.

**Table 4: 2020 EPA Air Travel Emission Factors**

| Trip Length | CO2 (kg/passenger mile) | CH4 (g/passenger mile) | N2O (g/passenger mile) | Overall CO2e (kg/passenger mile) |
|---|---|---|---|---|
| Short Haul (less than 300 miles) | 0.215 | 0.007 | 0.007 | 0.217 |
| Medium Haul (between 300 and 2,300 miles) | 0.133 | 0.0006 | 0.004 | 0.134 |
| Long Haul (over 2,300 miles) | 0.165 | 0.0006 | 0.005 | 0.166 |

In addition to carbon dioxide, methane, and nitrous oxide, which can be directly accounted for using the emissions factors above, other more reactive gases and particles are also emitted from the burning of jet fuel. These include nitric oxide (NO), nitrogen dioxide (NO2), water vapor, sulphates, and soot. The climate impact of these additional gases and particles is more variable and thus more difficult to quantify. Scientists have addressed this to date by proposing a "radiative forcing factor" that aggregates the variable impact of these gases and particles into a single multiplier that is applied to CO2 emissions. Emissions from CH4 and N2O are then added on top of this figure. However, there is a lack of consensus in the scientific community regarding the exact magnitude of the radiative forcing factor, as discussed in depth in our Radiative Forcing Memo. For now, Stanford uses a radiative forcing factor of 2.7, as published by the International Panel on Climate Change (IPCC) and consistent with the factor used by over 200 institutions currently reporting air travel emissions via SIMAP.

The CO2 emissions factors in Table 4 were multiplied by the number of passenger miles flown for the sample population in CY2019 within each flight distance range and converted from kilograms to metric tons. The radiative forcing factor of 2.7 was subsequently applied to the total CO2 emissions. Then, the emissions factors for methane (CH4) and nitrous oxide (N2O) in Table 4 were multiplied by the gases' respective global warming potentials (GWPs) and by the number of passenger miles flown in CY2019 by flight distance and converted to metric tons. This process converts all emissions into MTCO2e so they can be added together to calculate total emissions, including radiative forcing.

This process was completed for the sample population and extrapolated proportionally to the entire student population of 18,876 students resulting in total estimated air travel mileage of 229,070,609 miles and 97,237 MTCO2e for travel to/from the main campus. The scaling method used accounts for the fact that some students do not fly to campus: 442 students reported flying, and 45 reported not flying, so a sample size of 487 was used to scale emissions to the entire student population.

## Ground Transport

The survey found that 91% of students use air travel as their primary mode of travel home or elsewhere during breaks. The other 9% use ground transport as their primary mode of travel, or stayed on campus during breaks. Thus, two major sources of ground transport emissions were tallied for travel to/from the main campus based on the survey results:

- Emissions from the 91% of students traveling to and from the airport
- Emissions from the 9% of students for whom ground transport is their primary mode of travel

For both major sources of ground transport, emissions were calculated based on six modes of transit included in the survey:

- Railway
- Bus
- Rideshare/taxi – alone
- Rideshare/taxi – shared with someone else
- Someone I know drives me
- I drive myself

The emissions factors used internally derive from the Environmental Protection Agency (EPA) and are shown in Table 5.

**<u>Table 5:</u> Emissions Factor by Transit Mode used for Internal Ground Transport Estimates**

| Transit Mode | Emissions Factor (kg CO2e/passenger-mile) |
|---|---|
| Railway | 0.12 |
| Bus | 0.06 |
| Rideshare/taxi – alone | 0.35 |
| Rideshare/taxi – shared with someone else | 0.17 |
| Someone I know drives me | 0.35 |
| I drive myself | 0.35 |

Table 6 below shows the various methods used for tallying student ground transport based on the data available in the survey results. This data was combined with survey data regarding the primary mode of transit to/from the airport for each student for each route to calculate miles traveled by mode type.

**<u>Table 6:</u> Methodology for Determining Emissions by Ground Transport Route Type**

| Route | Methodology for determining emissions |
|---|---|
| From Airport to Stanford | Data was collected from the survey regarding the most used Bay Area airport (SJC, SFO, or OAK) for each student. Exact distances between each airport and campus were used to calculate the total miles traveled roundtrip. |
| From Home to Airport | Data was not available from the survey regarding the distance from a student's home to the airport. Thus, a national average of 25.72 miles[1] was used to estimate total miles traveled by the sample population for roundtrip travel. |
| Non-Air Trips[2] | Data from the survey regarding destination city was used to calculate the exact distance between campus and the destination for each student trip. |

Publicly available emissions factors from the EPA were assigned to each transit mode, as shown in Table 5. Because the final four transit modes are all passenger vehicles, the same emissions factor was assigned, with one exception: the "rideshare/taxi

[1] Pearson, Mark. "How Far are People on Average from Their Nearest Decent-Sized Airport?" 2012. https://www.mark-pearson.com/airport-distances/

[2] Students were not explicitly asked about all ground transport trips in the survey; while all ground transport "home trips" should be accounted for, other ground transport trips were not comprehensively reported.

– shared with someone else" mode was assigned an emissions factor of exactly half that of the others, assuming that the ride was split between two people going to the same destination.

Using this methodology and extrapolating to the entire student population, total estimated ground transport emissions came out to be 5,377 MTCO2e.

## SIMAP

The SIMAP tool asks for each of the following inputs for each mode of transportation, including air travel, automobile, carpool, public bus, and train to calculate emissions in the travel to/from main campus category:

- Total number of students traveling to/from campus
- Percent of trips by mode
- Average number of trips per student by mode
- Average passenger or vehicle miles per trip by mode

The survey data were manipulated in the following ways to produce the corresponding statistics by mode:

- Total number of students traveling to/from campus was defined as the total undergraduate and graduate student population
- Percent of trips by mode was calculated using survey data
- Average number of trips per student by mode was calculated by taking the total trips by mode for the sample population and dividing by the total number of respondents
- Average passenger or vehicle miles per trip by mode was calculated by taking the total mileage by mode for the sample population and dividing by the total number of respondents

These inputs were multiplied by SIMAP's emissions factors, as shown in Table 7. These emissions factors are derived from the US GHG Inventory and the Bureau of Transportation Statistics. SIMAP then applies a radiative forcing factor of 2.7 to the calculated CO2 emissions. There is an option in the SIMAP tool to use 1.9 as a radiative forcing factor instead.

These inputs produced a total emissions output from SIMAP of 31,533 MTCO2e across all modes of travel, which is less than one third of the total emissions calculated using the internal methodology. This is primarily due to the use of averages instead of individually calculated emissions per trip.

**Table 7. Emission Factors by Transit Mode used in SIMAP**

| Transit Mode | Emissions Factor (kg CO2e/passenger mile) |
|---|---|
| Air (all distances) | 0.16 |
| Train | 0.12 |
| Public Bus | 0.33 |
| Taxi/Ferry/Rental Car | 0.36 |
| Personal Mileage Reimbursement | 0.36 |

## VitalMetrics

The VitalMetrics Carbon 360 tool follows the precise categories defined by the GHG Protocol and thus does not have a separate category for travel to/from main campus. To circumvent this, travel to/from main campus inputs were simply added to employee travel inputs in the Business Travel category. The appropriate proportion of emissions outputs based on the data inputs were then assigned to the travel to/from main campus category.

The Carbon360 tool can accommodate data inputs in either passenger kilometers or dollars spent, depending on institutional data availability. The Office of Sustainability elected to enter data in passenger kilometers as the unit data was assumed to be more accurate than the spend data. The inputs for travel to/from main campus were determined using data from the student survey in the requested categories. Table 8 below shows the travel categories requested by VitalMetrics, the format of the data input by the Office of Sustainability and the methodology for determining each input. Total travel to/from main campus emissions for VitalMetrics sum to 45,622 MTCO2e.

**Table 8: VitalMetrics Carbon 360 Calculation Methodology by Transit Mode**

| Travel mode | Input data unit | Methodology for determining input data | Emissions Total for Travel to/from Main Campus (MTCO2e) |
|---|---|---|---|
| Air | Passenger-km | Total extrapolated mileage for full student population from air trips reported in student travel survey | 42,545 |
| Bus and other mass transit | Passenger-km | Extrapolated mileage for full student population from trips to/from the airport reported in student travel survey | 420 |
| Passenger car or taxi | Passenger-km | Total extrapolated mileage for full student population from trips to/from the airport AND home/other driving trips reported in student travel survey | 2,849 |
| Railway travel | Passenger-km | Total extrapolated mileage for full student population from trips to/from the airport AND home/other railway trips reported in the student survey. | 40 |
| Reimbursement for use of private vehicle | Passenger-km | Not applicable for travel to/from main campus | N/A |
| Hotel and other accommodations | Dollars | Not applicable for travel to/from main campus | N/A |

## Results Comparison

It is difficult to directly compare emissions and emissions factors by mode since each tool categorizes transit modes differently. Instead, Table 9 shows total emissions in the travel to/from main campus category for each tool, highlights five impactful calculation considerations for emissions accuracy over which the tools differ, and indicates with check marks which tools employ each strategy.

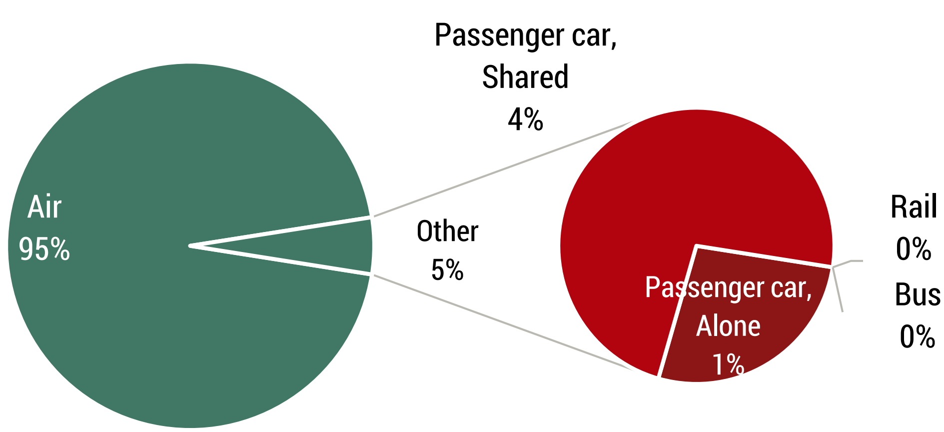
**Table 9: Summary of Tool Outputs for Travel to/from main campus**

| Tool | Includes air travel & ground transport | Includes radiative forcing factor | Uses precise distances (not averages) | Uses emissions factors specific to length of flight | Emissions factor transparency | Total Travel to/from main campus Emissions (MTCO2e) |
|---|---|---|---|---|---|---|
| Internal | ✓ | ✓ | ✓ | ✓ | ✓ | 102,614 |
| SIMAP | ✓ | ✓ | | | ✓ | 31,533 |
| VitalMetrics | ✓ | | ✓ | | | 45,622 |

It is clear from Table 9 that Stanford's internal calculation methodology incorporates the most precise inputs and emissions factors. While it generates emissions that are much higher than those reported by SIMAP and VitalMetrics, it is primarily the use of variable emissions for different flight lengths and the inclusion of a radiative forcing factor that increase Stanford's internally calculated estimates relative to the other tools. We recommend that the internally developed methodology continue to be used. That said, staff will continue to improve the internal calculation methodology to the extent possible, including continued exploration into the appropriate radiative forcing factor, refinement of the student travel survey, and integration of student travel data from other emerging sources, such as a booking platform called Student Universe that is managed by the Stanford Travel Program and is currently available for all student travel bookings.

Based on the recommended internal methodology, Figure 4 displays the final breakdown of emissions by mode type in the travel to/from main campus category.

**Figure 4: Breakdown of Emissions for Travel To/From Main Campus by Transit Mode using Internal Methodology**



# Study Abroad: Travel Associated with an Academic Program

## Data Collection

Student researcher Abby Bauer led the original effort to quantify study abroad travel. She researched the various academic programs that include travel and compiled a list of contacts for each program. She reached out to each contact to request information regarding student travel for their programs in calendar year 2019. To assist the program staff with this effort, she included a student travel template in the form of an Excel spreadsheet that delineated the specific information we would need for emissions calculations, including number of students traveling, arrival airport, and departure airport as the highest priority information. She also included "medium priority" and "low priority" information, such as information regarding non-air travel and hotel stays, respectively. She also confirmed with each contact whether the travel was paid for by the university or by the student; if the travel was paid for by the university, it was removed from the study abroad category and instead included as university-sponsored business travel.

In the process of reaching out to various program contacts, Abby learned that the Office of International Affairs tracks international travel as well and was able to get a list of all international travel locations submitted to them in 2019, which she cross-referenced with travel destinations submitted by program contacts to avoid double counting. Some fellowship programs also house their travel information in a database called SOLO, which Abby was able to reference as well. Across these multiple data sources, Abby was able to collect a list of study abroad destinations for students traveling through a total of 36 programs in 2019.

However, the staff and databases mostly did not track information regarding departure cities; they simply accounted for the number of students traveling and to what locations. To bridge this gap, the assumption was made that students were traveling from one of three regions of the United States based on the proportion of the student population from each region. SFO was assigned as the departure airport code for the west coast region; IAH as the airport code for the Midwest region; and JFK as the airport code for the east coast region. In the future, improved tracking of actual student flight patterns by study abroad offices and/or central databases would eliminate the need for this significant assumption.

Based on this method, flight paths and airport codes were assigned for 6,853 one-way flights across 3,236 students traveling, as reported by program offices and databases. These flight paths were then run through the same script as the travel to/from main campus described above to calculate miles traveled for each flight. The aggregated 28,606,510 miles traveled were, in turn, entered into the same three calculation tools to derive emissions estimates.

Finally, some data associated with study abroad travel was included in the results of the travel to/from main campus survey. For air travel, abroad locations that were not specified as home travel were simply removed from the travel to/from main campus category to avoid double counting with the data collected separately regarding study abroad travel. However, 25 international railway trips associated with study abroad programs were reported in the travel to/from main campus survey that were not collected separately. Emissions from these trips were added into the study abroad category, with mileage quantified via Google Maps using the departure and arrival cities listed for each railway trip.

## Tool Inputs

## Internal Calculations

The air emissions factors in Table 4 were applied to the mileage for each flight based on the length of the flight, as well as the radiative forcing factor of 2.7. This resulted in a per flight emissions total that was summed across all trips. Railway emissions were also calculated using the railway emissions factor in Table 5, resulting in total emissions across both air and railway travel of 12,776 MTCO2e.

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### SIMAP

The air emissions factor in Table 7 was applied to the total mileage flown, as well as the radiative forcing factor of 2.7. Railway emissions were also calculated using the railway emissions factor in Table 5, resulting in total emissions across both air and railway travel of 12,587 MTCO2e.

### VitalMetrics

The air emissions factor in Carbon 360 was applied to the total mileage. A radiative forcing factor was not applied. Railway emissions were also calculated using the railway emissions factor in Table 5, resulting in total emissions across both air and railway travel of 4,480 MTCO2e.

### Results Comparison

The results and conclusions for study abroad travel are very similar to those for travel to/from main campus. The one major difference between the study abroad travel category and the travel to/from main campus category is that SIMAP does use exact mileage as the input for this category, whereas it uses averages in the travel to/from main campus category. Thus, the internally estimated emissions and the SIMAP estimated emissions are much closer to one another in the study abroad category than they are for the travel to/from main campus category. Ultimately, it is still recommended that the internal methodology be followed in future years, as the emissions factors it uses are more precise than those used by SIMAP. Using the internal results, study abroad travel equates to 11% of total student travel emissions.

It is also worth noting that air emissions for study abroad travel comprise 99.99% of the total calculated here using the internal methodology, with the remainder attributed to railway travel. Of course, there are other ground transport emissions associated with study abroad travel, such as travel to and from the airport, that have not been accounted for using any of the approaches described above. However, we can expect that the proportion of emissions for ground transport in the study abroad category would be similar to, if not less than, the emissions from ground transport in the travel to/from main campus category—at about 3% or less—and thus are negligible. As a future refinement, sustainability staff could attempt to collect data and/or make assumptions to include ground transport emissions in the study abroad category, but significant time should not be spent on this effort due to the low magnitude of ground transport emissions overall and the lack of effective interventions.

## Conclusion

Despite the use of three different approaches to calculating student travel emissions, emissions in both the travel to/from main campus and study abroad categories were most precisely estimated using the internal methodology. This is primarily due to the factors illustrated in Table 8, including integration of a radiative forcing factor and distance-specific air emissions factors, overall emissions factor transparency, and methodological precision. Using the results from the internal approach, total emissions from student travel total 115,389. The breakdown of aggregated emissions across travel to/from main campus and study abroad travel by mode type is shown in Figure 5.

**<u>Figure 5:</u> Total Student Travel Emissions by Mode Type**

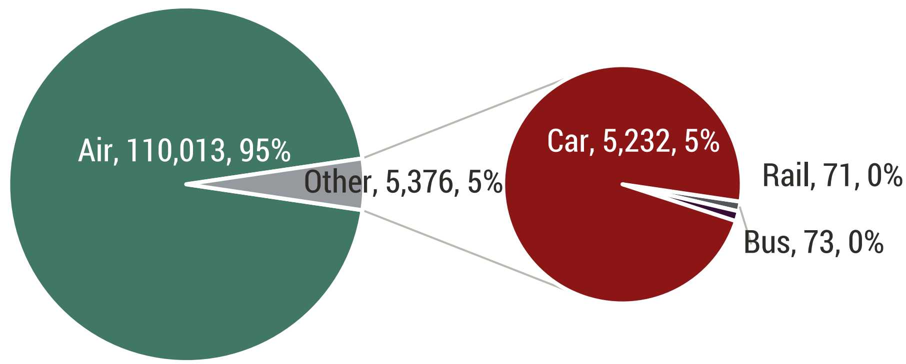


Figure 6 demonstrates that 95% of student travel emissions stem from air travel. Based on this and other findings, staff have developed the following recommendations for calculating student travel emissions in future years:

- Continue to use the internal methodology to calculate emissions
- Refine the radiative forcing factor as needed, based on the scientific data available and input from the Scope 3 Emissions Working Group
- Conduct a student travel survey every year to collect up to date data and track changes over time
- Refine the student travel survey in the following ways:
    - Ask additional demographic questions to better identify correlations, such as graduate or undergraduate, academic program, whether they receive financial aid, etc.
    - Refine wording on some questions
    - Inquire about direct vs. nonstop flights
    - Consider adjusting or eliminating questions related to ground transport, as they comprise only 5% of total student travel emissions
- Improve study abroad data collection
    - Work with high impact programs to improve tracking of departure cities
    - Collect lodging data as applicable
    - Include ground transport estimates as time allows, but do not update them every year

Ultimately, the recommendations above are strategies to improve data collection related to student travel. Because there is no centralized way to collect student travel data, each of these data collection strategies and refinements will need to be implemented by Scope 3 Emissions Program staff and/or students working in conjunction with the program. Ideally, the refinements listed above can be made while data collection methods are streamlined, reducing work for both the Scope 3 Emissions Program and distributed program staff and students who provide the data.

# Appendix: Student Travel Survey Questions

1. Please provide your home City, State/Province, and Country (e.g. Palo Alto, CA, USA). *If you have multiple home cities, please list the city you most commonly travel to and from during Stanford breaks.*
2. How do you travel between your home and Stanford? *Please choose the mode you use most frequently and/or for the majority of your commute.*
    a. *Airplane*
    b. *Railway*
    c. *Bus/Mass Transit*
    d. *Rideshare/Taxi – Alone (e.g. UberX)*
    e. *Rideshare/Taxi – Shared with someone else (e.g. UberPool)*
    f. *Someone I know drives me*
    g. *I drive myself and park*
    h. *I don't use a motorized vehicle to travel between home and Stanford*
3. Please list all airport code(s) you use in your home city (e.g. EWR for Newark Airport).
4. How do you travel between your home and the airport? *Please choose the mode you use most frequently and/or for the majority of your commute.*
    a. *Railway*
    b. *Bus/Mass Transit*
    c. *Rideshare/Taxi – Alone (e.g. UberX)*
    d. *Rideshare/Taxi – Shared with someone else (e.g. UberPool)*
    e. *Someone I know drives me*
    f. *I drive myself and park*
    g. *I don't fly between home and Stanford*
5. Which airport code do you use in the Bay Area? *Please choose the airport you use most frequently.*
    a. *SFO*
    b. *SJC*
    c. *OAK*
    d. *Other – please provide airport code.*
    e. *I don't fly between home and Stanford.*
6. How do you travel between the airport and campus? *Please choose the mode you use most frequently and/or for the majority of your commute.*
    a. *Railway*
    b. *Bus/Mass Transit*
    c. *Rideshare/Taxi – Alone (e.g. UberX)*
    d. *Rideshare/Taxi – Shared with someone else (e.g. UberPool)*
    e. *Someone I know drives me*
    f. *I drive myself and park*
    g. *I don't fly between home and Stanford*

7. Please indicate the option below that best describes your travel to and from Stanford during each of the following time periods in 2019 and 2020. *If you indicate "I traveled somewhere else" for any of the time periods, please list all relevant airport codes (or destination city if you drove) in the corresponding text box. You can open this link in a new window to look up airport codes if needed.*

| | I traveled to and/or from my home city. | I stayed or was already in the Bay Area. | I traveled somewhere else. (Please list airport codes in text box) |
|---|---|---|---|
| Winter Break 2018-19 | ○ | ○ | ○ |
| Spring Break (March 2019) | ○ | ○ | ○ |
| End of school year (June 2019) | ○ | ○ | ○ |
| Beginning of school year (September 2019) | ○ | ○ | ○ |
| Thanksgiving Break (November 2019) | ○ | ○ | ○ |
| Winter Break 2019-2020 | ○ | ○ | ○ |

8. In 2019, did you travel home at any point that has not been included in the above? *If yes, how many times?*
9. In 2019, did you travel between campus and anywhere else for Stanford-related activities that has not been included in the above? Examples include conferences, athletic events, or study abroad. *If yes, please list all airport code(s) for the cities to which you traveled, separating each code with a comma. If you drove, please list the destinations.*
10. How does your travel in 2019 compare to your travel in other years?
    a. I traveled more in 2019 than in other years
    b. I traveled about the same amount in 2019 as in other years
    c. I traveled less in 2019 than in other years.
11. If you had an opportunity to offset your greenhouse gas emissions from travel related to Stanford, would you participate?
    a. Yes
    b. No
    c. It depends on the program and cost
    d. I already purchase offsets
    e. Other
12. Is there anything else you'd like us to know about your Stanford-related travel? Please feel free to comment here on COVID-19 related travel in 2020 if you'd like to.

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# Internal Review Process

**Internal Approvers**
Not Applicable

**Internal Collaborators**
Institutional Research & Decision Support (IR&DS)
Student Researchers

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