

How does LAGEE estimates areas of influence?

Alber Sánchez
alber.ipia@inpe.br



Research assistant - TreesLab
National Institute for Space Research - INPE
Brazil

July 1, 2024

Overview I

Introduction

How are IAs currently estimated?

New proposal for estimating Areas of Influence

Final remarks

Introduction.

About LaGEE

- ▶ Greenhouse Gas Laboratory (LaGEE)
<https://www.ccst.inpe.br/lagee>
- ▶ Established in 2003.
- ▶ Part of the Earth System Science Center (CCST) at the National Institute for Space Research in Brazil (INPE).
- ▶ Principal Investigator: Dr. Luciana Gatti.



What are the LaGEE's Areas of Influence?

Areas (or regions) of Influence (AI) are...

- ▶ Areas covered by the set of back-trajectories starting at the vertical profiles' sampling points over a time period.
- ▶ Derived from backtrajectory models forced by meteorological input (mainly horizontal wind fields).
- ▶ AI are calculated from single back trajectories released from each measurement point.
- ▶ Trajectories are binned to create an ensemble which is used to define an AI over most of the depth of the atmospheric profile over three months [1].

Uses of Areas of Influence

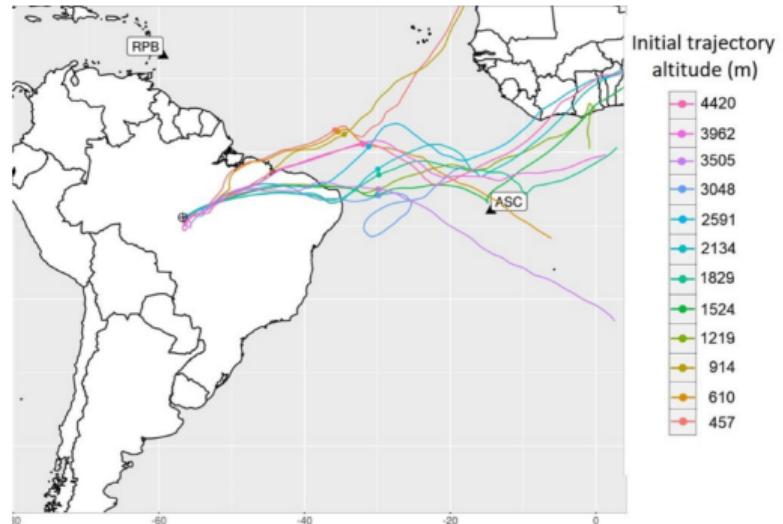
- ▶ Combine and compare GHG flux estimates from upwind areas to sample sampling sites of vertical atmospheric profiles.
- ▶ Determine the average value of metereological variables such as temperature and precipitation in the upwind area of a sampling sites of vertical profiles.

Areas of influence are NOT...

- ▶ AI aren't intended to be used to calculate GHG fluxes.
- ▶ Areas of Influence are not Footprints:
 - ▶ Footprints are determined from an ensemble of randomly perturbated back-trajectories released at each measurement point.
 - ▶ Footprints are typically used as sensitivity matrices in Bayesian estimates of GHG fluxes in inversions.
 - ▶ Footprints project fluxes into mole fraction deviations [1].
 - ▶ Footprints are defined in [2, 3].

What is a trajectory?

- ▶ A organized set of positions in space and time of a particule or an air parcel produce by an atmospheric model.
- ▶ A back-trajectory is a trajectory running on reverse, from the destination to the source.



Trajectories ending at sampling site TAB on April 20th 2011. Source: [1].

Hysplit

- ▶ Atmospheric transport and dispersion model.
- ▶ Compute simple air parcel trajectories.
- ▶ Complex transport, dispersion, chemical transformation, and deposition simulations.
- ▶ Back trajectory analysis to determine the origin of air masses.
- ▶ Computation is an Lagrangian-Eulerian hybrid.



Air Resources Laboratory
*Investigating processes in the
Earth's Boundary Layer*

Area of Influence - Method

- ▶ Get trajectories from HySplit.
- ▶ Compute trajectory density using a one-degree grid covering Brazil.
- ▶ Bin trajectories into 3-month intervals.

Publication

DOI:10.3390/atmos11101073 [1]

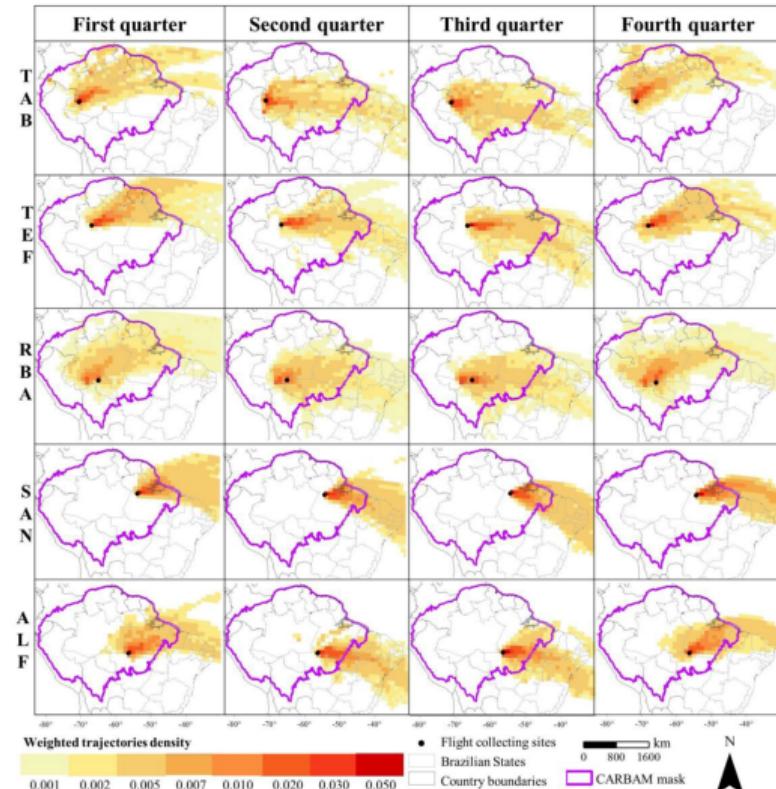


Article

Determination of Region of Influence Obtained by Aircraft Vertical Profiles Using the Density of Trajectories from the HYSPLIT Model

Henrique L.G. Cassol ^{1,*†}, Lucas G. Domingues ^{2,3,*†}, Alber H. Sanchez ³, Luana S. Basso ³, Luciano Marani ³, Graciela P. Tejada ³, Egidio Arai ¹, Caio Correia ^{3,4}, Caroline B. Alden ⁵, John B. Miller ⁶, Manuel Gloor ⁷, Liana O. Anderson ⁸, Luiz E. O. C. Aragão ¹ and Luciana V. Gatti ^{3,4,*}

Areas of Influence - Results



Areas of influence. Source: [1].

How are the Areas of Influence currently estimated at LaGEE?

About LaGEE's code

- ▶ LaGEE has an online repository of code ([click here](#)).
- ▶ The code to process LaGEE's Als is written as an *R* package called *cqmaTools*.
- ▶ *cqmaTools* contains a directory for scripts, including the script for estimating the Areas of Influence.
- ▶ *cqmaTools* depends on outdated packages (e.g. *sp*), difficulting its installation.



Script Areas of Influence

- ▶ The actual script used for the AIs in LaGEE is different from the one at GitHub.
- ▶ Cassol et al. states that there are some IDL code involved during AI estimation. That code is missing from LaGEE's code repository.
- ▶ The script analyzed here is called `influence_area_simuladas.R` and it was provided by Luciano Marani on 2024/06/27.

Script *influence_area_simuladas.R*

- ▶ Dependencies:
 - ▶ The development version of *cqmaTools*.
 - ▶ The deprecated *raster* package.
- ▶ Inputs:
 - ▶ A path to a directory with trajectory files.
 - ▶ A path to a directory with station data.
- ▶ Outputs:
 - ▶ Raster plot by site, by year, by trimester.
 - ▶ A text with the data used for the plot.

Processing in *influence_area_simuladas.R* |

- ▶ Allow trajectories under 3500 m.
- ▶ Allow up to 4 missing neighbors for each center cell in a 3x3 window.
- ▶ Allow longitudes from -80 to -30.
- ▶ Allow latitudes from -40 to 10.
- ▶ Plot total:
 - ▶ `mean_trajectory` is the number of vertices in a site divided by the number of vertices in a year for that site.
 - ▶ The threshold is 0.025
- ▶ Plot by year:
 - ▶ `mean_trajectory` is the number of vertices in a year.
 - ▶ The threshold is the maximum value of `mean_trajectory` times the threshold (0.025).
- ▶ Plot by trimester:
 - ▶ `mean_trajectory` is the number of vertices in a trimester.

Processing in *influence_area_simuladas.R* II

- ▶ The threshold is the maximum value of `mean_trajectory` times the threshold (0.025).
- ▶ Plot by trimester (total):
 - ▶ `mean_trajectory` is the number of vertices in a trimester divided by the number of vertices in a trimester for that site.
 - ▶ The threshold is the maximum value of `mean_trajectory` times the threshold (0.025).

New proposal for estimating Areas of Influence.

New proposal for estimating Areas of Influence

- ▶ No smoothing.
- ▶ No fill in AI holes.
- ▶ Only consider trajectories that don't go below 100 or above 3500 meters.
- ▶ Just compute trajectories' vertex frequency over the grid.
- ▶ New script `compute_frequency_grid.R`.

Final remarks.

Take home message

- ▶ The LaGEE's R code is available at <https://github.com/INPE-LAGEE>.
- ▶ Get these slides at https://github.com/albhasan/slides/lagee_influence_area.



References I

- [1] Henrique L. G. Cassol et al. "Determination of Region of Influence Obtained by Aircraft Vertical Profiles Using the Density of Trajectories from the HYSPLIT Model". In: *Atmosphere* 11.10 (Oct. 2020), p. 1073. ISSN: 2073-4433. DOI: 10.3390/atmos11101073. (Visited on 07/12/2022).
- [2] C. Gerbig et al. "Toward Constraining Regional-scale Fluxes of CO₂ with Atmospheric Observations over a Continent: 2. Analysis of COBRA Data Using a Receptor-oriented Framework". In: *Journal of Geophysical Research: Atmospheres* 108.D24 (Dec. 2003), 2003JD003770. ISSN: 0148-0227. DOI: 10.1029/2003JD003770. (Visited on 06/28/2024).
- [3] Lei Hu et al. "Enhanced North American Carbon Uptake Associated with El Niño". In: *Science Advances* 5.6 (June 2019), eaaw0076. ISSN: 2375-2548. DOI: 10.1126/sciadv.aaw0076. (Visited on 06/28/2024).