

Review: “Instantaneous radiative forcings due to the first indirect effect linked to warm clouds in the Amazon”

The manuscript provides a quantification of the instantaneous radiative forcing due to aerosol-cloud interactions (IRF_{aci}) over the central Amazon Basin using datasets from the GoAmazon2014/5 campaign. The authors synthesize ground-based remote sensing (T3 site), in-situ aircraft measurements (G-1 and HALO), and radiative transfer modeling (libRadtran) to estimate forcing under two distinct reference states. While the study addresses a critical gap in regional climate benchmarks, several methodological ambiguities and potential physical contradictions require a **major revision** before the work can be considered for publication.

Major Comments:

1. **Physical Contradiction and the Twomey Effect Mechanism:** a fundamental concern exists regarding the application of the LWC - r_{eff} relationships derived in Section 2.5. The Twomey effect is physically defined as an increase in cloud albedo and optical depth due to an increase in droplet number concentration (N_d) and therefore a decrease in r_{eff} for a constant liquid water content (LWC).

The Problem of Fixed N_d : By deriving and utilizing fitted relationships between LWC and r_{eff} for specific scenarios (Clean vs. Polluted), the authors effectively assume a fixed N_d for a given scenario.

Contradiction in Forcing Drivers: If the IRF within a given scenario is driven by a change in r_{eff} while N_d remains fixed, it contradicts the Twomey effect. Specifically, if a negative IRF (larger albedo) is attributed to a larger r_{eff} under these fixed-fit conditions, the physics would be inverted. The authors must verify that a negative IRF corresponds to a reduction in r_{eff} as aerosol loading increases.

2. **Methodological Validity of Atmospheric Reference States:** The study relies on two distinct "clean" reference states to calculate IRF_{aci} (Eq. 10).

Fixed Reference Issues: The use of a fixed irradiance value (689.9 W m^{-2}) derived from the campaign's 19 cleanest days is problematic. Radiative forcing variations under a fixed reference are likely dominated by natural shifts in cloud macro-properties (height, fraction, LWP) driven by thermodynamic and dynamic environments rather than aerosol effects. The conclusion that these results serve as a benchmark is weakened by this seasonal contamination.

Representativeness of HALO Data: The seasonal reference approach utilizes only two HALO flights (AC09 and AC18) to define the background for the entire polluted dry season. It is unclear if these two specific days are statistically representative of the broader seasonal variability in a region as dynamic as the Amazon. A sensitivity analysis or justification for the representativeness of these flights is required.

3. Consistency of Aircraft Sampling and Microphysics: The derivation of r_{eff} from flight medians across IOP 1 and IOP 2 (Fig. 3) requires more context regarding the sampling strategy.

Flight Patterns: The authors must clarify if the flight patterns for the G-1 during IOP 1 (wet) and IOP 2 (dry) were consistent. Discrepancies in sampling altitudes or cloud types (cumulus vs. stratocumulus) between the two periods could introduce significant biases in the LWC - r_{eff} fits.

Vertical Profiling: It is unclear if the r_{eff} values represent layer averages or specific flight levels. Since r_{eff} typically increases vertically from the cloud base, the "middle layer" median approach in Table 3 must be justified against observed vertical microphysical profiles.

4. Radiative Transfer Model Configuration: The description of the libRadtran setup in Sections 2.6 and 2.7 is insufficient for reproducibility.

Input Requirements: While LWC and r_{eff} are cited, it is unclear if the model requires the full droplet size distribution (N_d) as an input.

Isolation of Aerosol Effects: The authors must explain how they isolate the aerosol-induced change in optical properties from changes in other macroscopic cloud properties (e.g., cloud base/top heights) during the IRF calculation.

Minor Comments

Line 80 and 87: The Value-Added Products (VAPs) should be formally identified. The cloud fraction product from Riihimaki et al. (2019) is the RADFLUXANAL VAP, and the cloud boundary product is the ARSCL (Active Remote Sensing of Clouds) VAP.

Line 84-85: Clarify if the Liquid Water Path (LWP) was self-derived or sourced from the MWRRET VAP. Please provide the estimated uncertainty for the LWP retrieval, as it directly impacts the LWC_{ground} calculation.

Figure 1 includes CCN but omits AOD, while Figure 2 includes AOD but omits CCN. Both parameters are essential for a complete assessment of the scenario identification.

Figure 2: Address the sparse nature of the MFRSR AOD data outside the day 150-270 window.

In Section 2.5 (Lines 221-225), provide more detail on how the r_{eff} database was extended.