Computation of Flux Footprint and Overlay on Satellite Image

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INTRODUCTION

Flux footprint - Flux footprint (also known as atmospheric flux footprint or footprint) is an upwind area where the atmospheric flux measured by an instrument is generated.

Three main categories which are commonly used to calculate:

(a) Analytical or analytical-like models (e.g., Kljun et al., 2015; Kormann & Meixner, 2001).

(b) Lagrangian stochastic particle dispersion models (e.g., Flesch et al., 1995; Kljun et al., 2002).

(c) Large eddy simulation (e.g., Leclerc et al., 1997; Steinfeld et al., 2008).

=> From above model we use Kormann and Meixner method based on the parameter we have received from flux tower.

INTRODUCTION

Analytical or Analytical-like Models : These models are based on simplified mathematical equations that approximate atmospheric transport. They use assumptions about flow conditions and turbulence to calculate the movement of substances, like gas or particles, in the atmosphere.

Advantages :

1. Computationally efficient due to simplified equations, making them fast and easy to implement.
2. Ideal for basic footprint modeling and can be run on limited computational resources.

OBJECTIVES

1. Use a model to calculate the flux footprint of a source based on emission rates, meteorological conditions, and terrain characteristics.

2. Overlay the computed flux footprint onto high-resolution satellite imagery to visualize its spatial distribution.

- # Study Area

Location :- Flux tower near Department of Agricultural Meteorology, Anand Agriculture University, Anand.

Latitude :- 22.53° N

Longitude :- 72.98° S

• Parameters

zm :- Measurement height above displacement height (m).

z0 :- Roughness length (m).

umean :- mean wind speed at zm (m/s).

ol :- obukhov length (m).

sigmav :- standard deviation of lateral velocity fluctuations (m/s).

ustar :- vector of friction velocity (m/s).

wind_dir :- wind direction in degrees.

METHODOLOGY

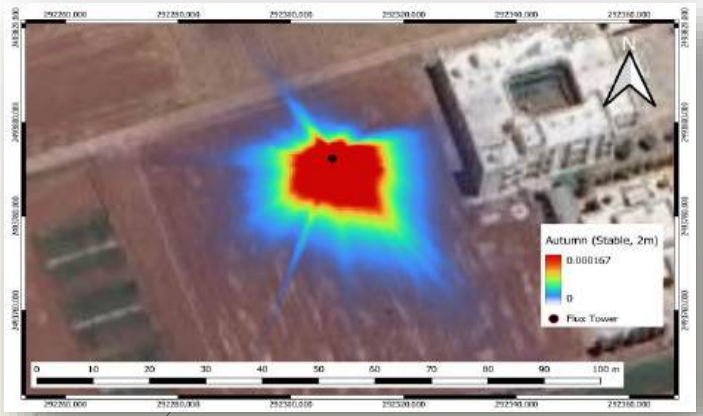
Data collection(2009) from flux tower

Flux footprint calculation using model (Kormann & Meixner)

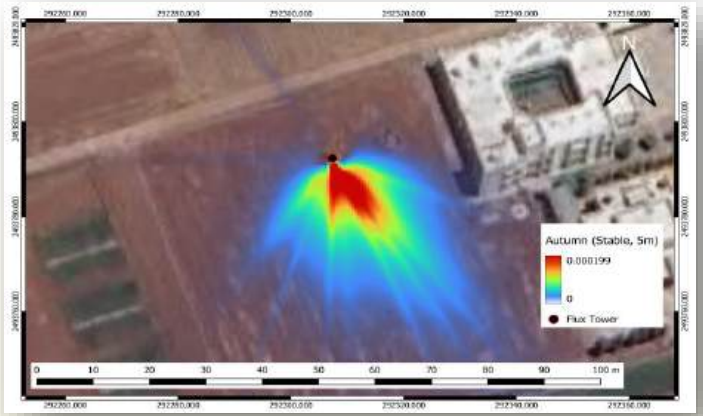
Footprint overlay on satellite image

Generate map using QGIS

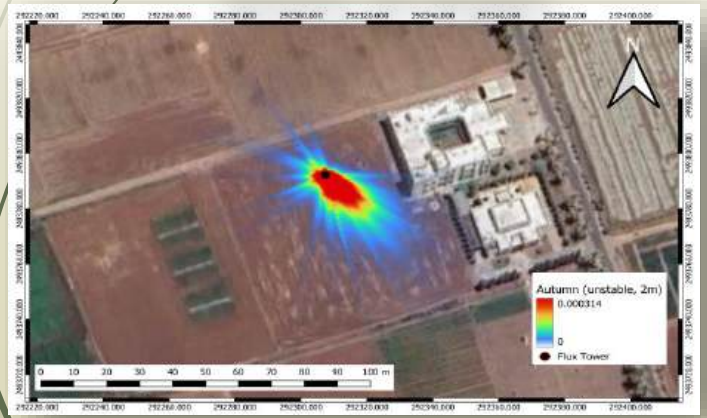
Result



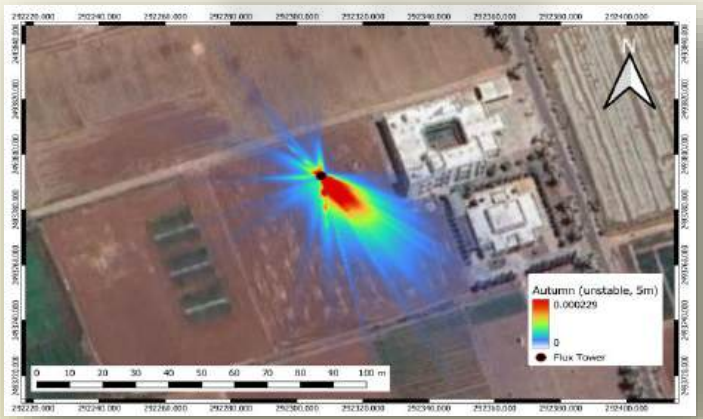
Autumn_2m (Stable)



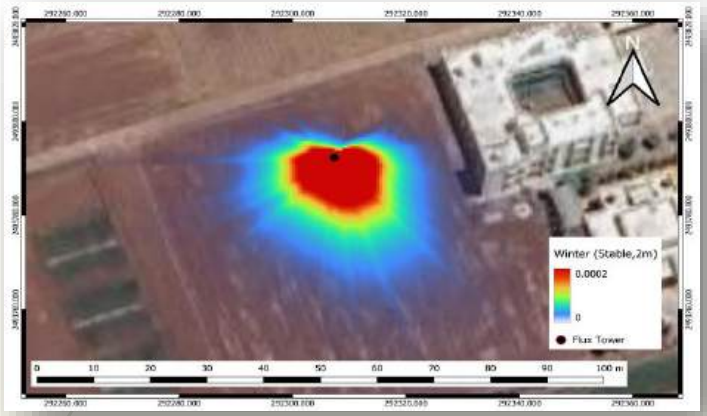
Autumn_5m (Stable)



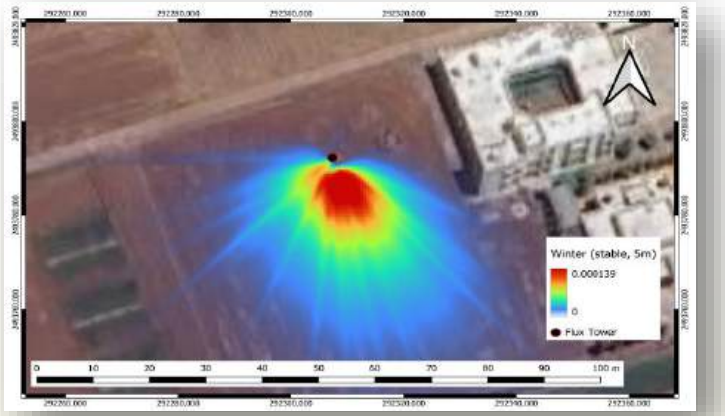
Autumn_2m (Unstable)



Autumn_5m (Unstable)

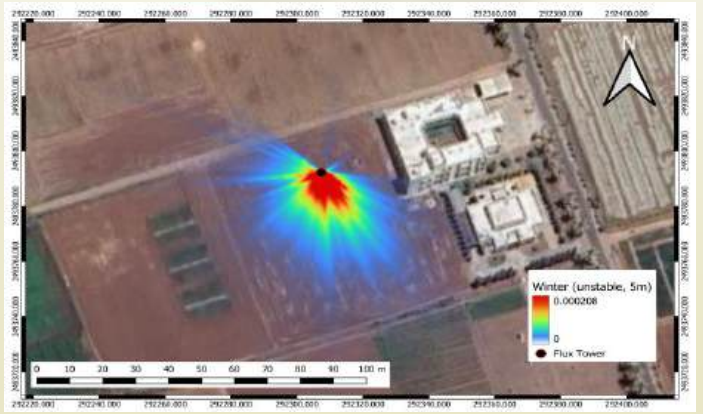


Winter_2m (Stable)



Winter_5m (Stable)

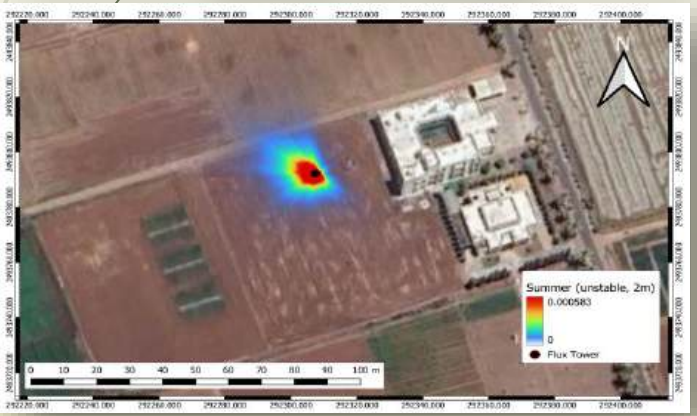
Winter_2m (Unstable)



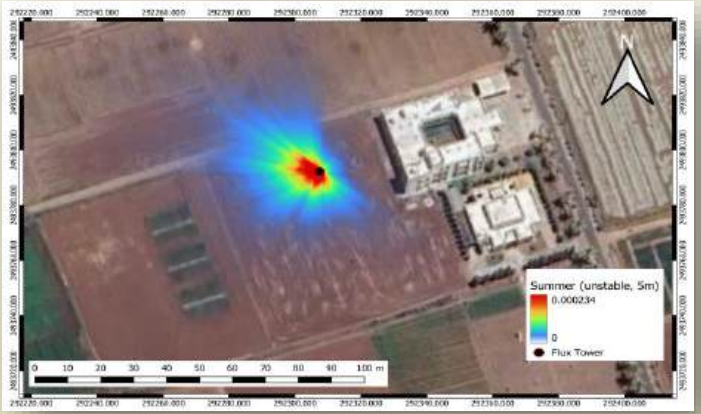
Winter_5m (Unstable)

Summer_2m (Stable)

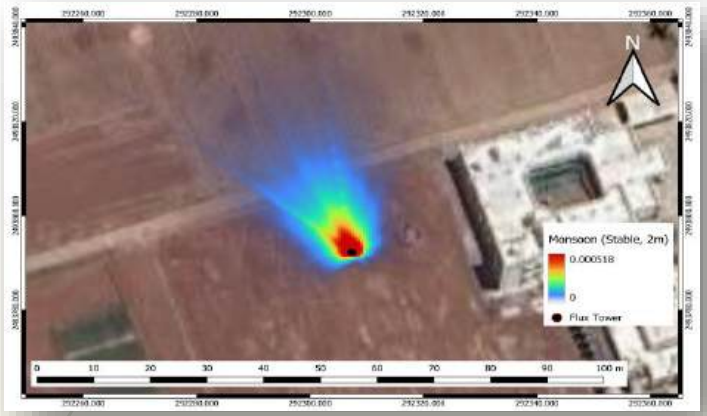
Summer_5m (Stable)



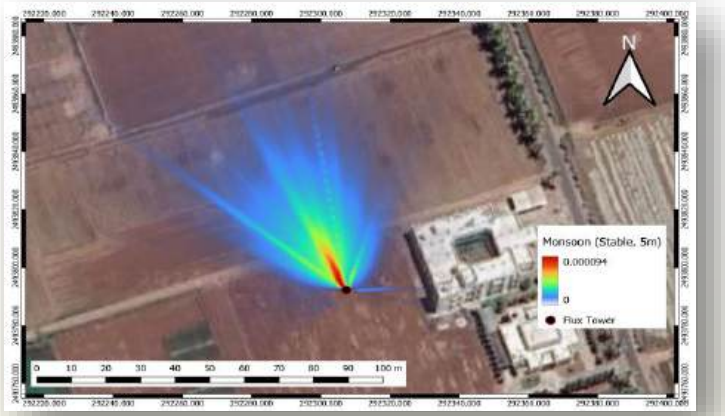
Summer_2m (Unstable)



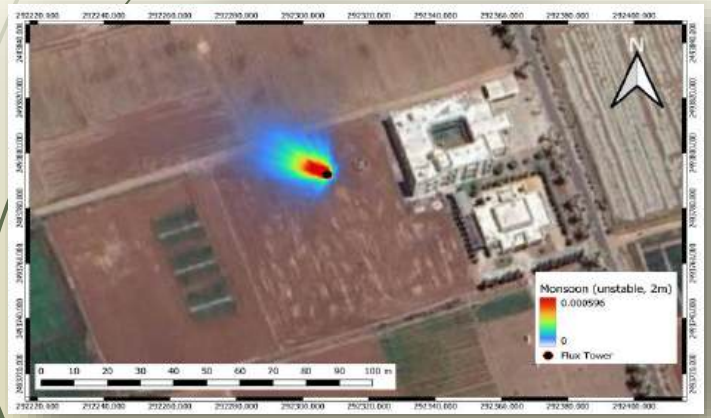
Summer_5m (Unstable)



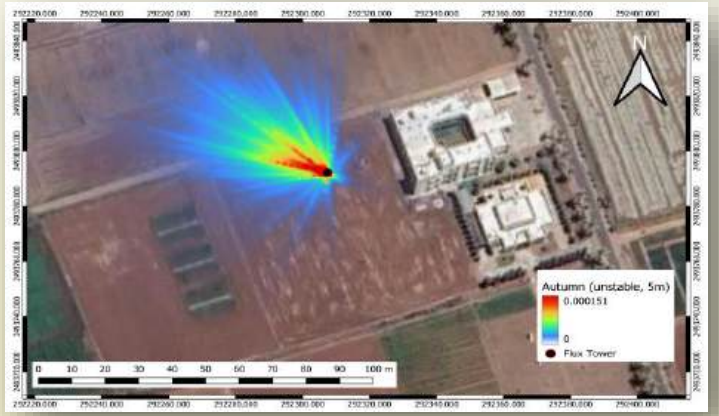
Monsoon_2m (Stable)



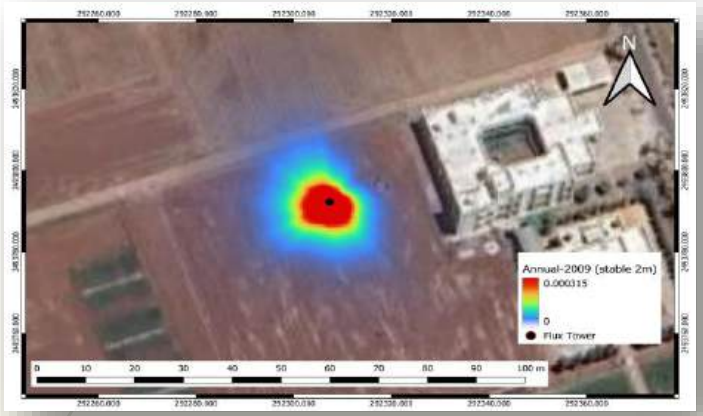
Monsoon_5m (Stable)



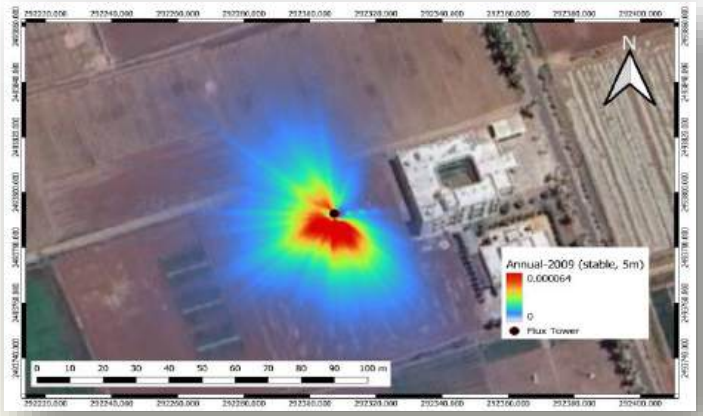
Monsoon_2m (Unstable)



Monsoon_5m (Unstable)

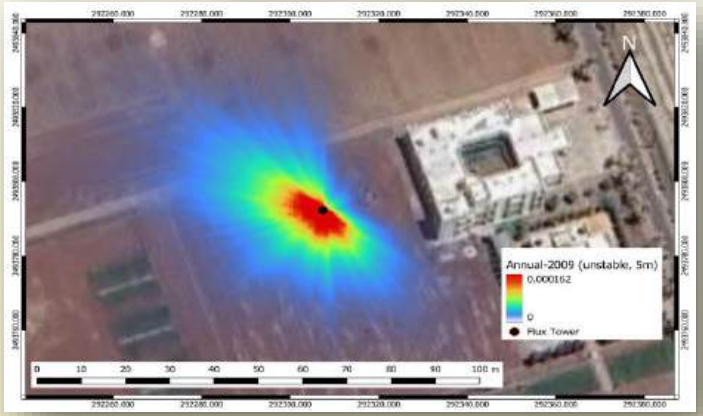


Annual_2m (Stable)



Annual_5m (Stable)

Annual_2m (Unstable)



Annual_5m (Unstable)

Result

- **Autumn Season**

The flux footprint analysis shows that in stable atmospheric conditions, the flux influence is more concentrated and localized, while in unstable conditions, it spreads over a larger area. The flux coming more from the South or South east direction. Additionally, the footprint area increases with the height of the flux tower, indicating that higher measurements capture a broader influence. The dominant wind direction is towards the east or southeast.

- **Winter Season**

The flux footprint maps indicate that the primary flux direction appears to be toward the southwest across both stable and unstable conditions, likely influenced by local wind or terrain factors.

- **Summer Season**

The flux footprint analysis shows that higher measurement heights and stable atmospheric conditions lead to larger dispersion areas, while unstable conditions concentrate flux closer to the source. The footprint expands notably at 5m compared to 2m, with stable conditions amplifying this effect in south-west direction. Suggesting that airflow or the primary wind direction influences flux spread toward this area.

- **Monsoon Season**

The flux footprint analysis shows that during the monsoon season, the prevailing wind direction is likely the northwest. Under stable atmospheric conditions, the flux footprint remains more concentrated near the tower, while under unstable conditions, it disperses more widely in north-west direction.

Conclusion

1. Stable vs. Unstable Conditions
   Stable conditions :- Footprints are more concentrated and localized.
   Unstable conditions :- Footprints are more spread out and cover a larger area.

2. Height Effect (2m vs. 5m)
   2m height :- Smaller, more localized footprint.
   5m height :- Larger, more dispersed footprint.

3. Season wise Flux Footprint
   As seasons change, shifts in wind patterns and atmospheric conditions can alter the direction of flux footprints.

4. Overall Trend
   Stability and lower measurement heights result in smaller, more concentrated flux areas, while instability and higher heights lead to larger, more dispersed footprints.


THANK YOU