



Understanding the Evolution of Anvil Top Characteristics with Geostationary Satellite Imagery



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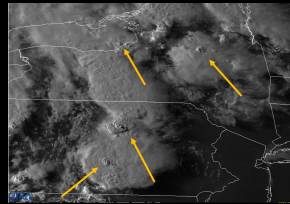
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MOTIVATION

- ☁ Overshooting tops (OTs) form when updrafts overshoot their level of neutral buoyancy.
- ☁ They are indicative of strong thunderstorms, often associated with severe hazards on the ground¹.
- ☁ OTs are also responsible for the transport of trace gases across the tropopause².
- ☁ OTs are an indicator of strong convective mass flux, but their relationship to anvil properties is not well known.



Yellow arrows pointing to OTs within GOES visible satellite imagery

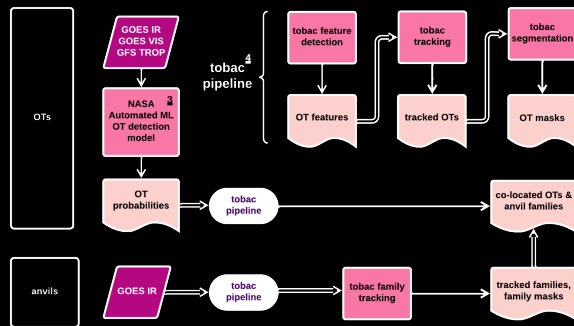
STUDY GOALS

The overarching goal of this work is to investigate how OT characteristics are related to the structural and temporal properties of their parent anvils. More specifically, we ask the following questions:

1. How many distinct OTs does an anvil produce, and at what point in its lifecycle does OT production peak?
2. Do longer-lived anvils produce more OTs than shorter-lived anvils?
3. Do larger anvils produce more OTs than smaller anvils?
4. Do larger anvils sustain OTs that are bigger, longer-lived, or taller compared to OTs in smaller anvils?

METHODS

Separate OT and anvil databases are made from 3 years (2023-2025) of GOES-E 1-min mesosector images during the typical convective season (March-August). *tobac*⁴ thresholds used with the ML OT detection model³ were chosen to match those in Itterly et al. (2025).⁵



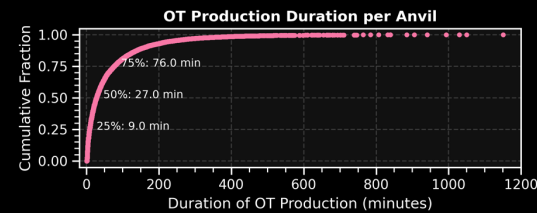
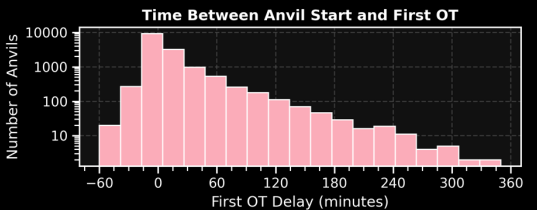
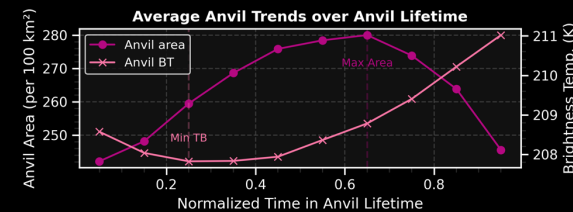
Flowchart visualizing how *tobac* is used on ML model output to create OT and anvil databases with shared family ID

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RESULTS

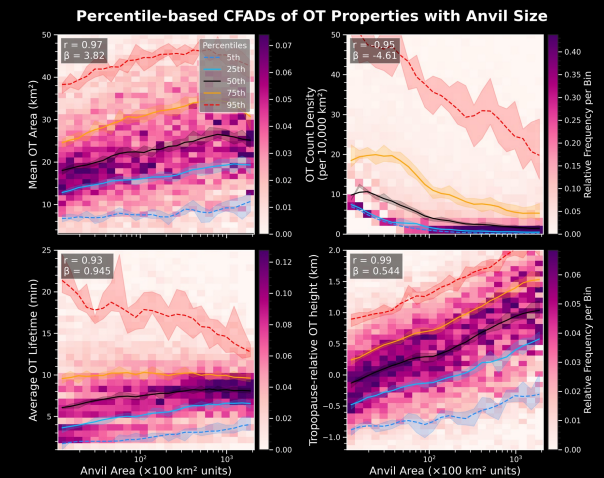
Category	Metric	Value
Summary	Total unique anvils	66,904
	Total unique OTs	219,726
	Anvils that produced OTs	19,733
	Fraction	29.5%
Lifetime Distributions (minutes)	OTs - Mean	8.6
	OTs - Max	180.0
	Anvils - Mean	66.1
	Anvils - Max	1,578.0
OTs per Anvil	Mean	16
	Median	4
	Mode	1

- ☁ OTs have an average lifetime that is shorter than the current temporal resolution of global geostationary observations (10 min.)
- ☁ The distribution of OTs per anvil is highly skewed due to the presence of rare large, long-lived anvil clusters with many OTs



- ☁ Anvils spend the most time in the mature and dissipating stages
- ☁ OTs are most numerous at the early anvil stages or even before an anvil is identified
- ☁ OT production duration is dominated by short-duration events with a long tail of rare, very long-lived OT-producing storms

RESULTS



- ☁ Top left: OT area weakly increases with anvil area, suggesting that larger anvils can support broader overshooting tops
- ☁ Top right: OT count density decreases weakly with anvil area, indicating that larger anvils tend to have fewer OTs per unit area
- ☁ Bottom left: Weak to no relationship between OT lifetime and anvil area
- ☁ Bottom right: OT height increases linearly with increasing anvil area

CONCLUSIONS

Our results show that overshooting tops are relatively transient cloud top features, and their occurrence and characteristics are strongly linked to anvil size. Most OT events are short-lived and occur frequently during the early stages of the anvil lifecycle. Large, longer-lived OTs are sometimes produced by large, longer-lived anvils. Large anvils may also support taller OTs, although the OT count density decreases. The findings highlight the importance of high-resolution temporal observations of OT dynamics. INCUS will provide additional information and insights into the CMF and dynamics of those OTs it may see.

REFERENCES

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