Detecting inland coastal flooding with TinyCamML: a low-cost, cellular-connected, privacy-aware camera with on-device ML

Evan B. Goldstein[1*], Elizabeth Farquhar[2], Philip Bresnahan[3], Bentley Settin[3], Jacob Stasiewicz[1], Katherine Anarde[2]

[1]Sediment [2]NCSU [2]UNCW

*Corresponding Author: evan@sediment.science

Inland Coastal Flooding

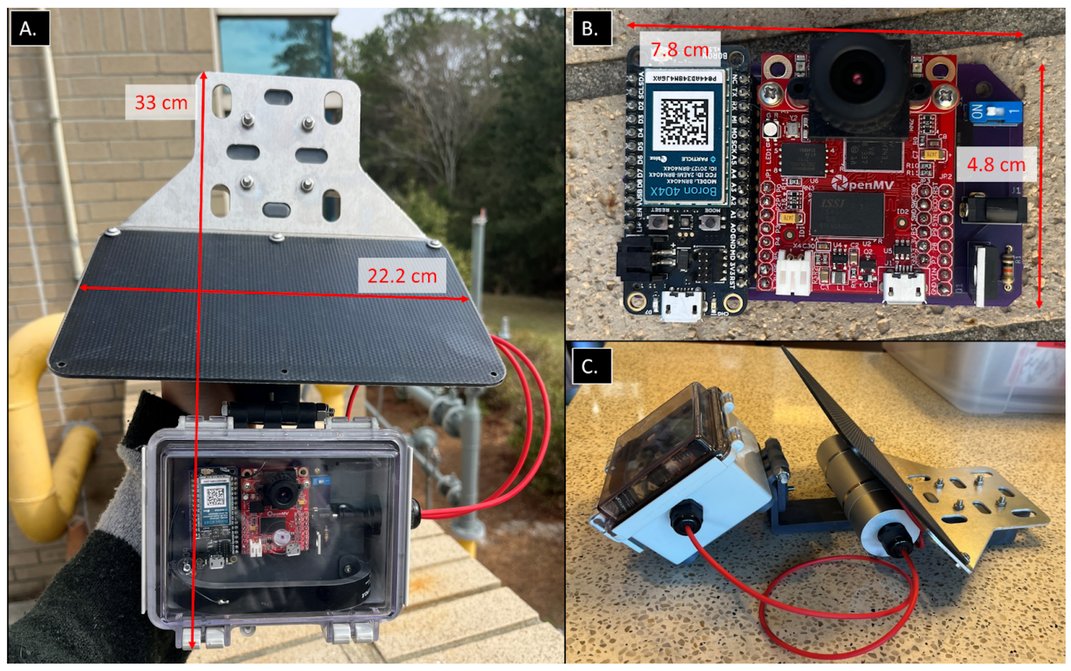
- Local, ephemeral, can be difficult to observe, monitor, and measure.

An example from Carolina Beach, NC over ~3 hour timespan

We present TinyCamML - a low-cost, cell-connected, privacy-preserving microcontroller-based camera with onboard ML to report flooded conditions.

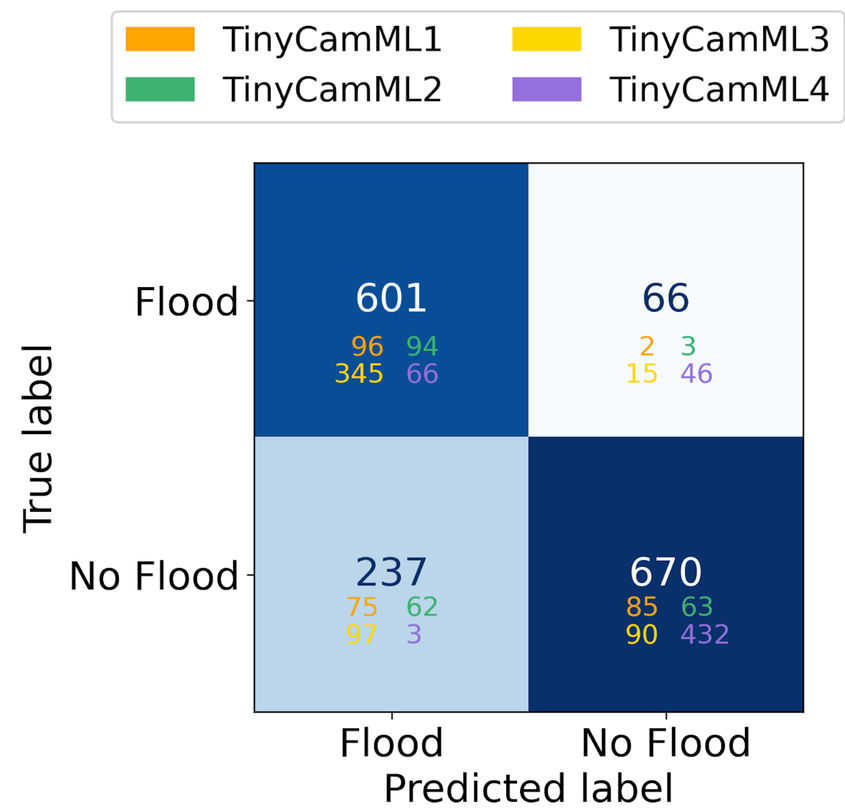
Hardware

- Solar Panel + battery (*Voltaic*)
- Cell connection (*Particle Boron*)
- Camera w/ ML (*OpenMV H7+*)
- Custom PCB
- Enclosure (*Polycase*)
- Custom Mounts (*3D printed*)



ML Model

- MobileNetV2
- Trained with 15k pictures from local deployments, SUDs (Gold et al., 2023 WRR), Sazara et al. (2019) - 50/50 flood/no flood
- Synthetic flooded pictures made using ClimateGAN (Schmidt et al., 2022)
- Model has 85% Binary Acc. on test set



- 81% Binary Acc. on Deployment

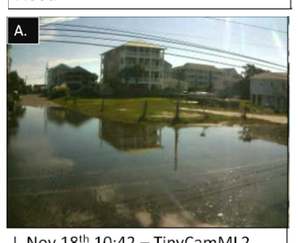
Software:

During daylight hours, TinyCamML:

- Takes a picture every 6 minutes
- Processes image using ML model
- Reports model results over cell (to google sheet) - '1' (flooded) or '0' (not flooded)
- *Note - picture is not sent (privacy, bandwidth), but can be saved locally (training data).

Deployment on Nov. 14-18, 2024 ; Carolina Beach, NC

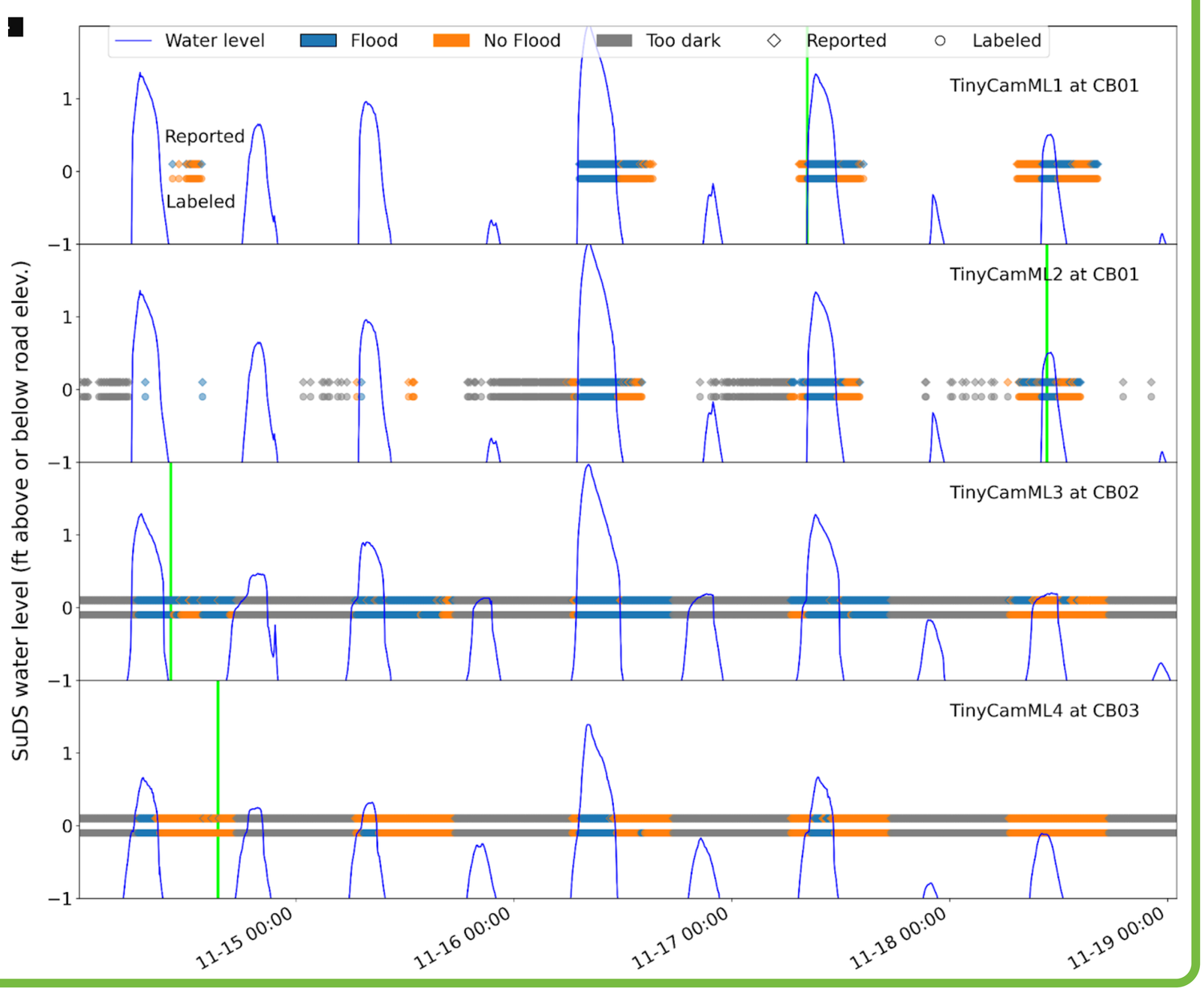
II. Nov 17th 8:18 – TinyCamML1 "No Flood"



I. Nov 18th 10:42 – TinyCamML2 "Flood"

III. Nov 14th 10:12 – TinyCamML3 "Flood"

IV. Nov 14th 15:24 – TinyCamML4 "No Flood"



Next Steps:

- Deploy many devices to observe flooding events. Can be used to understand road network functioning (i.e., Aldabet et al., 2022 Earth's Future)
- Continue to refine flooding model by incorporating new data from deployed devices
- Develop new models (i.e., number of people/ cars that traverse flood waters)
- Find other ephemeral events that can be captured using TinyCamML (and develop new ML models to deploy on devices)