

# Thermal Remote Sensing

## Drone - DJI Mavic Enterprise 3 Thermal

- <https://enterprise.dji.com/de/mavic-3-enterprise>
- <https://copterpro.de/shop/drohnen-komplettsets/djimavic3enterprise/>

## Calibration Field Targets

- Prior to + after flight measure targets with handheld thermometer. Or place thermocouples + logger under panels!?
- 30×30 cm ?
- **High-emissivity**
  - Matte black-painted aluminum
  - $\epsilon \approx 0.97$
  - Purpose: Temperature reference
  - **Coatings / Foils:**
    - <https://www.nextel-coating.com/de/shop/artikel/nextel-velvet-coating-811-21-9218-schwarz>
    - <https://de.acktar.com/tiefschwarz-beschichtete-folien-filme-2/>
- **Low-emissivity**
  - Polished aluminum sheet
  - $\epsilon \approx 0.04-0.06$
  - Purpose: Reflected apparent temperature

## IR Thermometers

- <https://www.conrad.com/en/p/fluke-566-ir-thermometer-display-thermometer-30-1-40-650-c-contact-measurement-122370.html>
- <https://www.voelkner.de/products/542871/Fluke-568EX-Infrarot-Thermometer-Optik-501-40-800-C-Kontaktmessung.html>
- [https://www.reichelt.de/de/de/shop/produkt/infrarot-thermometer\\_568\\_ir\\_und\\_kontakt\\_-40\\_bis\\_800\\_c-110173](https://www.reichelt.de/de/de/shop/produkt/infrarot-thermometer_568_ir_und_kontakt_-40_bis_800_c-110173)
- **Calibration:**
  - <https://www.fluke.com/de-de/mehr-erfahren/blog/kalibrierung/infrared-thermometer-calibration>

## Lab Temperature Calibration (potential field use?)

- <https://www.conrad.de/de/p/voltcraft-irs-350-kalibrator-kalibriert-iso-2236161.html>
- <https://www.messbar.de/kalibrierstrahler-optris-br400-fuer-waermebildkamas>
- <https://www.messbar.de/Optris-BR20AR-Referenzstrahler>

## Research Papers

- WUR  Calibration + Processing
  - <https://www.sciencedirect.com/science/article/pii/S1569843224005405>

## ☐ IDEAS

- Use a Sous Vide (keeps temp stable) in a pot for experiment flights
  - Maybe two? one for low temp one high

## Must do's for data acquisition

- [https://dl.djicdn.com/downloads/zenmuse\\_xt/en/sUAS\\_Radiometry\\_Technical\\_Note.pdf](https://dl.djicdn.com/downloads/zenmuse_xt/en/sUAS_Radiometry_Technical_Note.pdf)

## Leaf Temperature Measurement for Validation

- Example: <https://www.implexx.io/temperature/leaf-temperature-sensor/>
- Thermocouple on a clamp
- Use thermocouple of IR-Thermometer
- 3D-Printed clamp: <https://www.printables.com/model/974751-clamp-print-in-place>



## Field Mission Sheet

- **Pre-Flight**
  - Record air temperature, relative humidity, wind speed.
  - Measure true temperature of high-emissivity target (IR thermometer or thermocouple).
  - Measure apparent temperature of low-emissivity target (reflected sky).
  - **Set camera:**
    - Emissivity = 0.98
    - Reflected temperature = from low- $\epsilon$  target

- Atmospheric temp = air temp
- RH = measured RH
- Image type = radiometric JPEG/TIFF
- **In-Flight**
  - Hover ~10 m for 30 s (thermal stabilization).
  - Capture targets at start of mission (low altitude, nadir view).
  - Fly survey (consistent height/speed).
  - Re-capture targets at end of mission.
  - Log times, environmental data.
- **Post-Flight Processing**
  - Extract target pixel temperatures.
  - Compute correction  $T_{\text{true}} = a * T_{\text{drone}} + b$  using measured vs observed target temps.
  - Apply correction to thermal mosaic.
  - Validate canopy temps vs spot measurements.

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