

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
- **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

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- ϵ 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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