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
  - ε≈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
  - ε≈0.04-0.06
  - Purpose: Reflected apparent temperature

IR Termometers

- 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-501-40-800C-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-waermebildkameras
- 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 $ Ttrue = a * Tdrone + b $ using measured vs observed target temps.
    - Apply correction to thermal mosaic.
    - Validate canopy temps vs spot measurements.

From:
https://wiki.eolab.de/ - **HSRW EOLab Wiki**

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Last update: **2025/10/14 14:56**