

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 ?
- Emissivity measurement:
 - <https://www.calex.co.uk/find-correct-emissivity-setting-infrared-temperature-sensor/>
- **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>
- <https://www.sciencedirect.com/science/article/pii/S1569843224005405>
- <https://www.mdpi.com/2072-4292/17/15/2746>
- DJI Thermal Format Conversion
 - <https://www.mdpi.com/1424-8220/24/19/6267>
- <https://www.sciencedirect.com/science/article/abs/pii/S1350449523001998>

Code

- https://github.com/DanGeospatial/dji_m3t_rpeg_to_tif/

☐ 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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