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 ?
- Unknown emissivity measurement:
  - https://www.calex.co.uk/find-correct-emissivity-setting-infrared-temperature-sensor/
- **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/
- Nextel Emissivity Measurement Paper
- Angle dependant
  - **Table 1 Directional total and hemispherical total emissivities of Nextel 811–21 in the wavelength range from 5 μm to 20 μm at 25 °C and from 4 μm to 20 μm at 120 °C with their corresponding standard uncertainties**

    From: High-Accuracy Emissivity Data on the Coatings Nextel 811–21, Herberts 1534, Aeroglaze Z306 and Acktar Fractal Black

Angle	Nextel 811–21 ε (25 °C)	$u(\varepsilon)$ (k=1)	Nextel 811–21 ε (120 °C)	$u(\varepsilon)$ (k=1)
10°	0.971	0.012	0.9717	0.0058
20°	0.971	0.013	0.9719	0.0057
30°	0.971	0.013	0.9685	0.0057
40°	0.966	0.012	0.9684	0.0057
50°	0.966	0.012	0.9609	0.0058
60°	0.949	0.012	0.9518	0.0058
70°	0.912	0.013	0.9168	0.0057
ε_{hem}	0.941	0.012	0.9381	0.0056

- **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-501-40-800

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-waermebildkameras
- 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

Software / Code

- https://github.com/DanGeospatial/dji_m3t_rpeg_to_tif/
- https://www.dji.com/de/downloads/softwares/dji-dtat3
- https://www.dji.com/de/downloads/softwares/dji-thermal-sdk
- https://github.com/SanNianYiSi/thermal_parser
- https://docs.webodm.net/how-to/process-thermal-images/
- https://webodm.net/thermaltools

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.
  - Apply correction to thermal mosaic.
  - Validate canopy temps vs spot measurements.

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

Permanent link:
https://wiki.eolab.de/doku.php?id=eolab:thermal:start

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