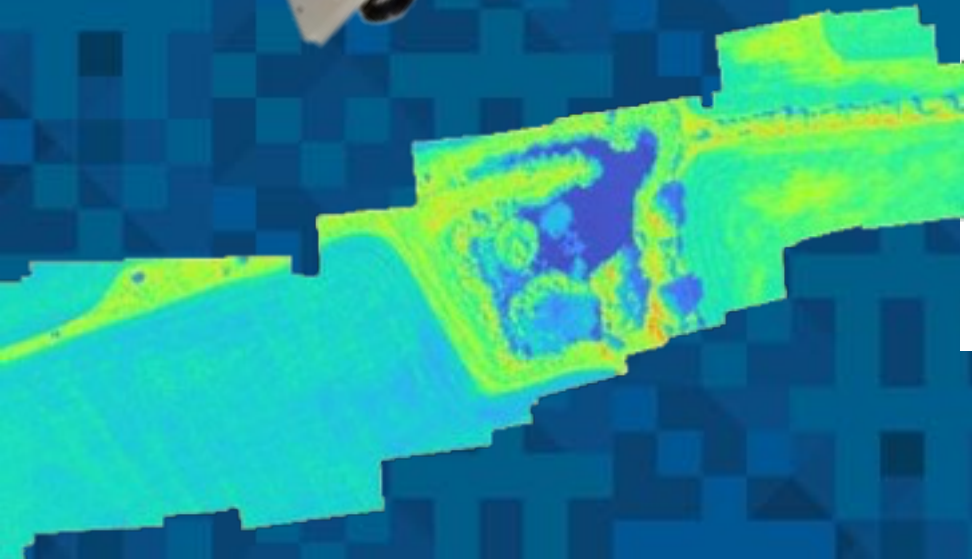
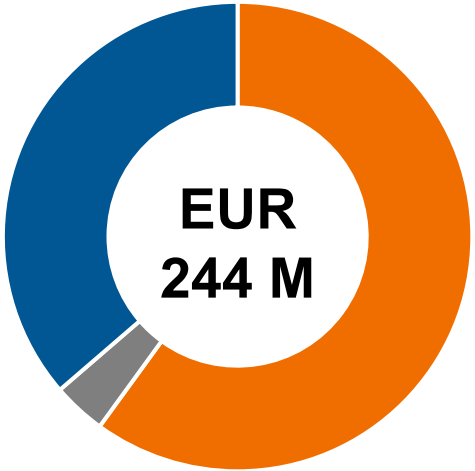


New algorithms and sensors for imaging spectroscopy of vegetation

Matti Mõttus, Olli Ihalainen,
Antti Näsilä, Alexander Kokka

VTT Technical Research Centre of Finland

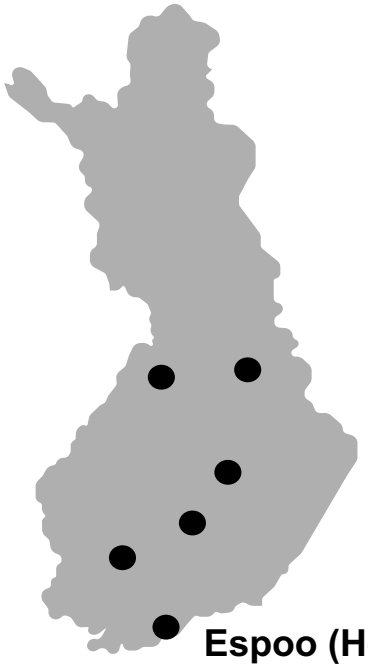


Owned by Ministry of Economic Affairs and Employment

2,129
employees

> 440
patent families

27%
of Finnish innovations have links with VTT's competences



Espoo (Helsinki)
1,520 employees
Energy, smart cities, microelectronics, new bioprocesses

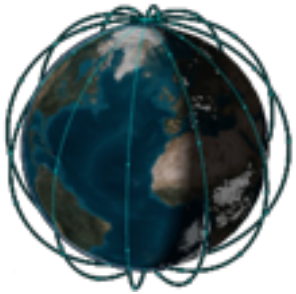
149 M€ Turnover
8 M€ Other operating income
87 M€ Government grant

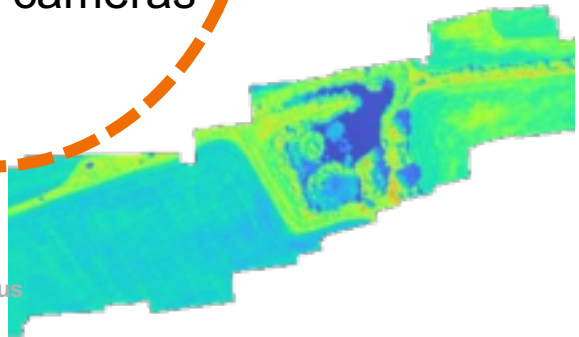
VTT Technical Research Centre of Finland

Research teams working on (among other topics)

- Hyperspectral remote sensing
- Data platforms for spatial data and algorithms
- Spectral cameras

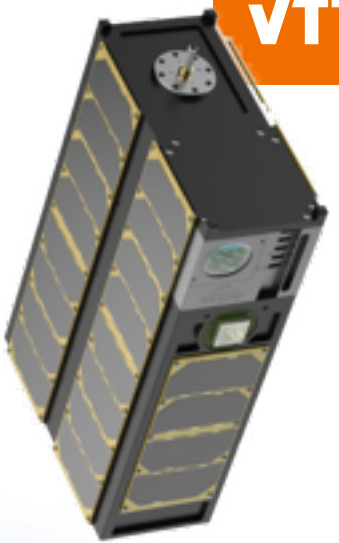
- Satellite constellation design
- Distributed networks
- Satellite-based communications
- etc.





Hyperspectral Imaging (HSI)

- Remote sensing is driven by data
  - Hyperspectral data still scarce
  - Drones are nice, but not covering large areas
  - **Small(er)sat constellation?**
- Space-proven imaging technology developed at VTT
  - Future mission: ASPECT onboard HERA
  - Technology available today: e.g., Kuva Space (www.kuvaspace.com)



Proposal:
HSI system for inland water and agriculture

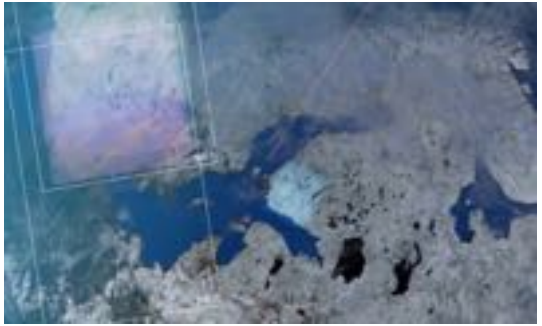
Sample solution

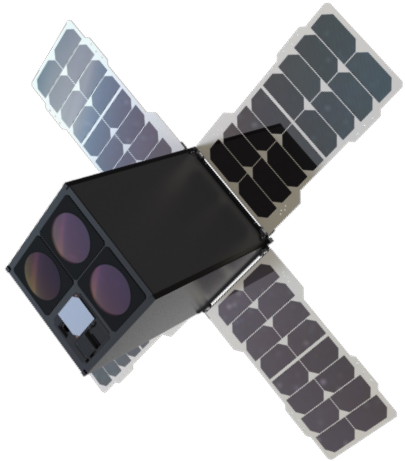
- Three cameras
  - Panchromatic VIS
  - VNIR hyperspectral
  - SWIR hyperspectral
- Spectral range ca. 500 – 1600 nm
- Spectral resolution 10 nm
- Equal swath
- Pansharpening possibility
- Diverse application areas

PAN:
Pixel size: 6.5 µm
Pixel size: 6000 x 6000
Read noise: 1.2 e- (TBC)
Dark current: 50 e-/s/pix (TBC)
Focal length: 300 mm
F#: TBD
Effective aperture: TBD
GSD: 10 m

VNIR:
Pixel size: 6.5 µm
Image size: 2048 x 2048
Read noise: 1.2 e- (TBC)
Dark current: 50 e-/s/pix (TBC)
Focal length: 110 mm
F#: 2.5
Effective aperture: 44 mm
GSD: 30 m
Spectral bandwidth: 10 nm

SWIR:
Pixel size: 10 µm
Image size: 1280 x 1024
Read noise: 35 e-
Dark current: 6200 e-/s/pix (TBC)
Focal length: 105 mm
F#: 3
Effective aperture: 35 mm
GSD: 47 m
Spectral bandwidth: 10 nm





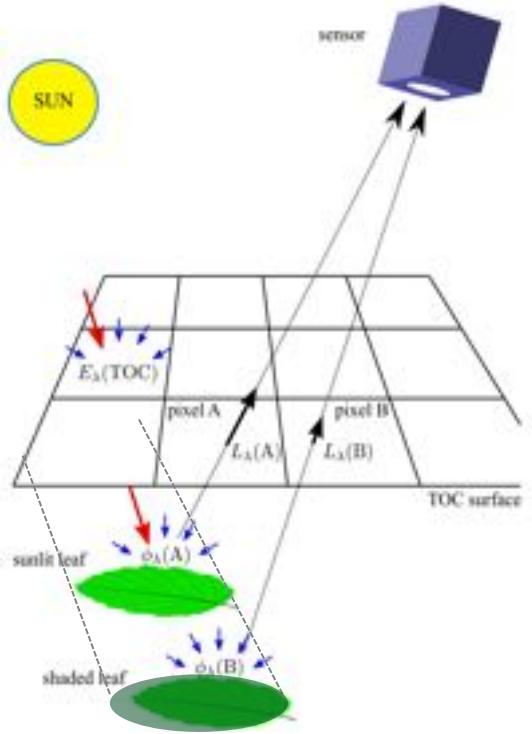
HSI applications for vegetation

- Still limited by data.
  - Campaigns are expensive and limited in scope
    - Can PRISMA and EnMAP save the day?
  - NEON is an excellent initiative!
  - We know information is there:
    e.g., spectral diversity ~ biodiversity.
  - More collaboration in Europe needed.
- But also limited by methods!
  - Analysis based on full spectrum needed
  - Physical models which cope with variations in geometry and illumination
    - Especially relevant for global EO data
    - Existing global vegetation products based on physical models

Theory of spectral invariants

Parameterization of vegetation scattering based on the radiative transfer theory

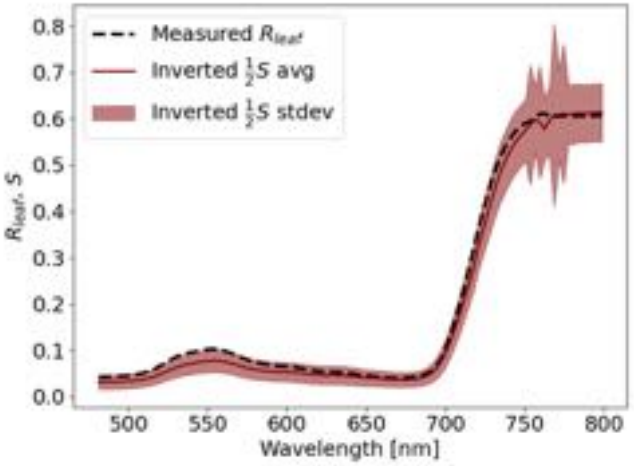
- Used in e.g. MODIS LAI product
  - Conceived by Y. Knyazikhin (Boston University)
  - Includes the *recollision probability* (quantifying diffuse irradiance) and *escape factor* (direct irradiance)
- Can be used to retrieve the light conditions on (average) leaf in the pixel and leaf spectrum
  - Further analysis on leaf spectrum, e.g., pigments, photosynthetic status, …
- Enables computer-efficient algorithms for material detection and biochemical characterization of vegetation



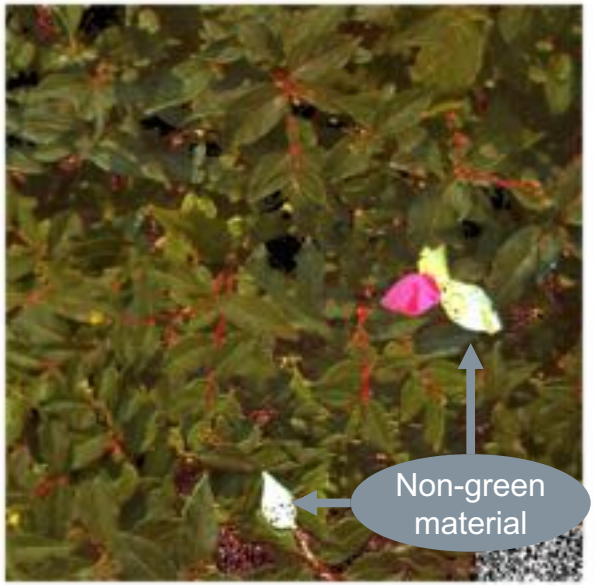
P-theory for vegetation: first results

Olli Ihalainen *et al*.

Leaf spectrum (*S*) from HSI ↓



Removing shadows from ultra high resolution hyperspectral image ↓
(retrieval of leaf reflectance for each pixel)



New algorithms and sensors for imaging spectroscopy of vegetation

- Solutions exist and data are becoming available
- High frequencey satellite observations still far from reality
- Physical algorithms and models need scientific attention
  - Methods exist, but majority of IS research still based on empirical correlations
  - Promise in mapping vegetation productivity and diversity

beyond

the obvious

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