Hyperspectral (imaging) and digital soil mapping: remote sensing on steroids.

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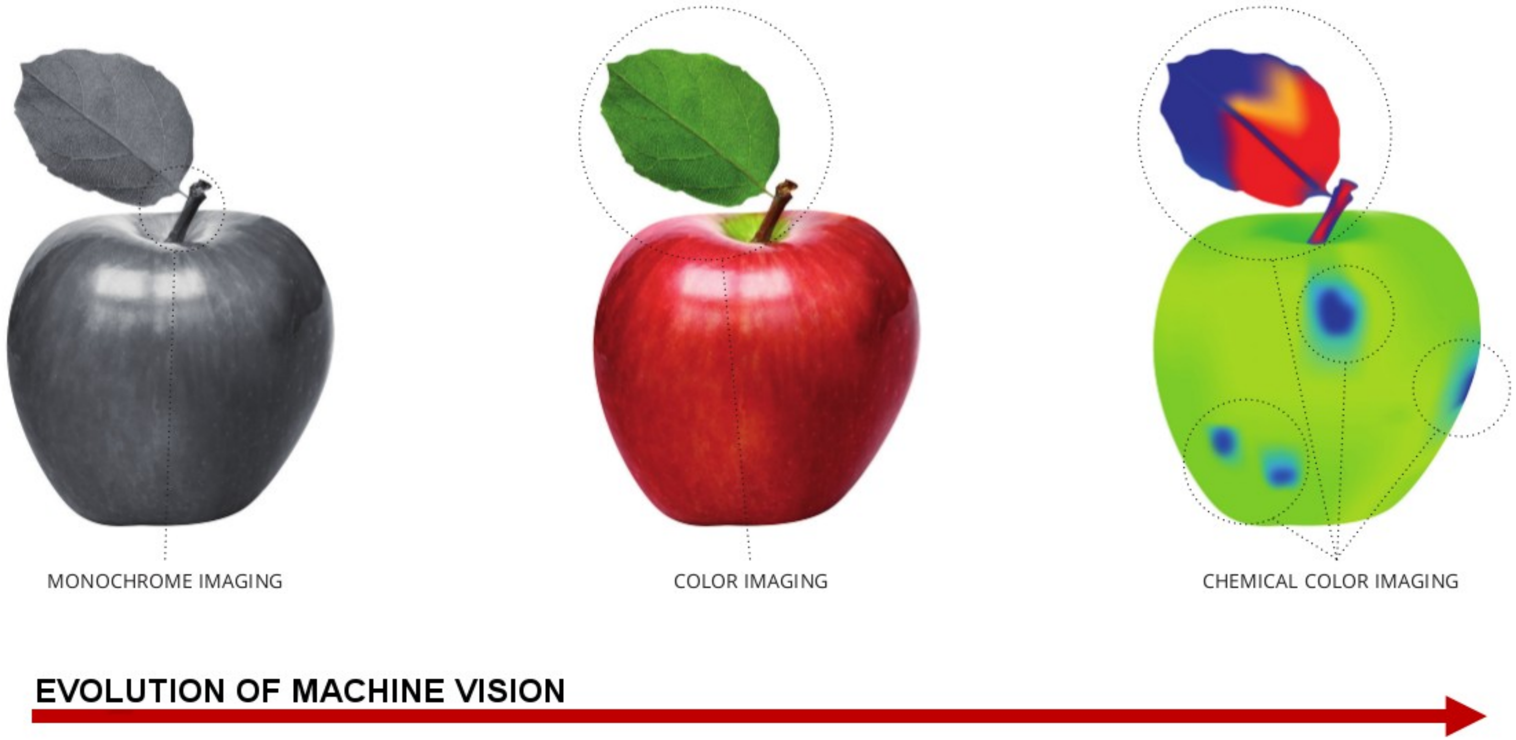
RS and n-SPECTRALITY

- Multispectral (40 – 150 nm: Sentinel-2, Aster)
- Superspectral (15 – 40 nm: VENµS)
- Hyperspectral (5 – 15 nm; EO-1 Hyperion, EnMAP)
- Ultraspectral (3 – 5 nm; Spider-Man, Dr. Manhattan, Aristotle)

n-SPECTRALITY and CV

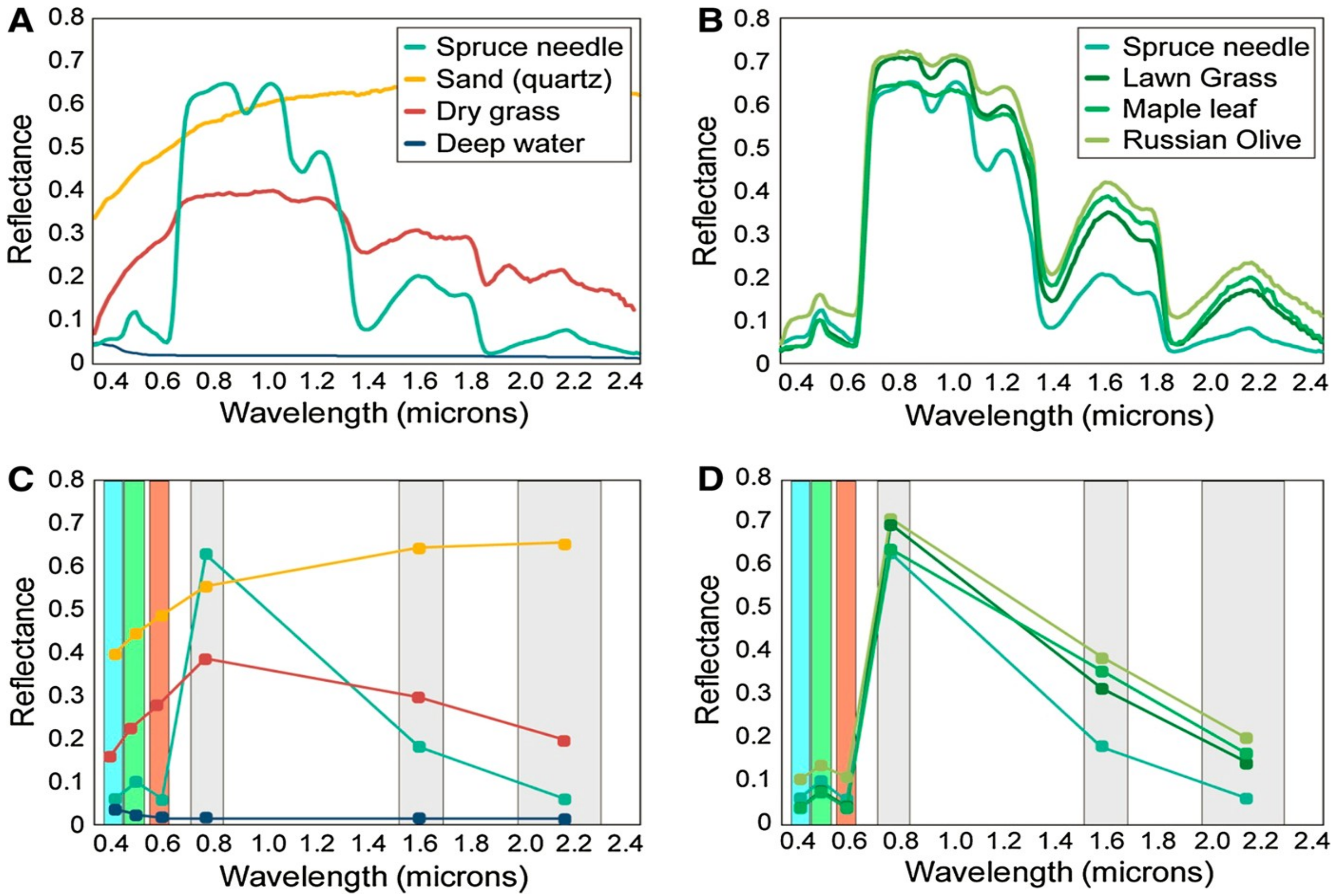


Source: Perception Park, 2019

n-SPECTRALITY and CV

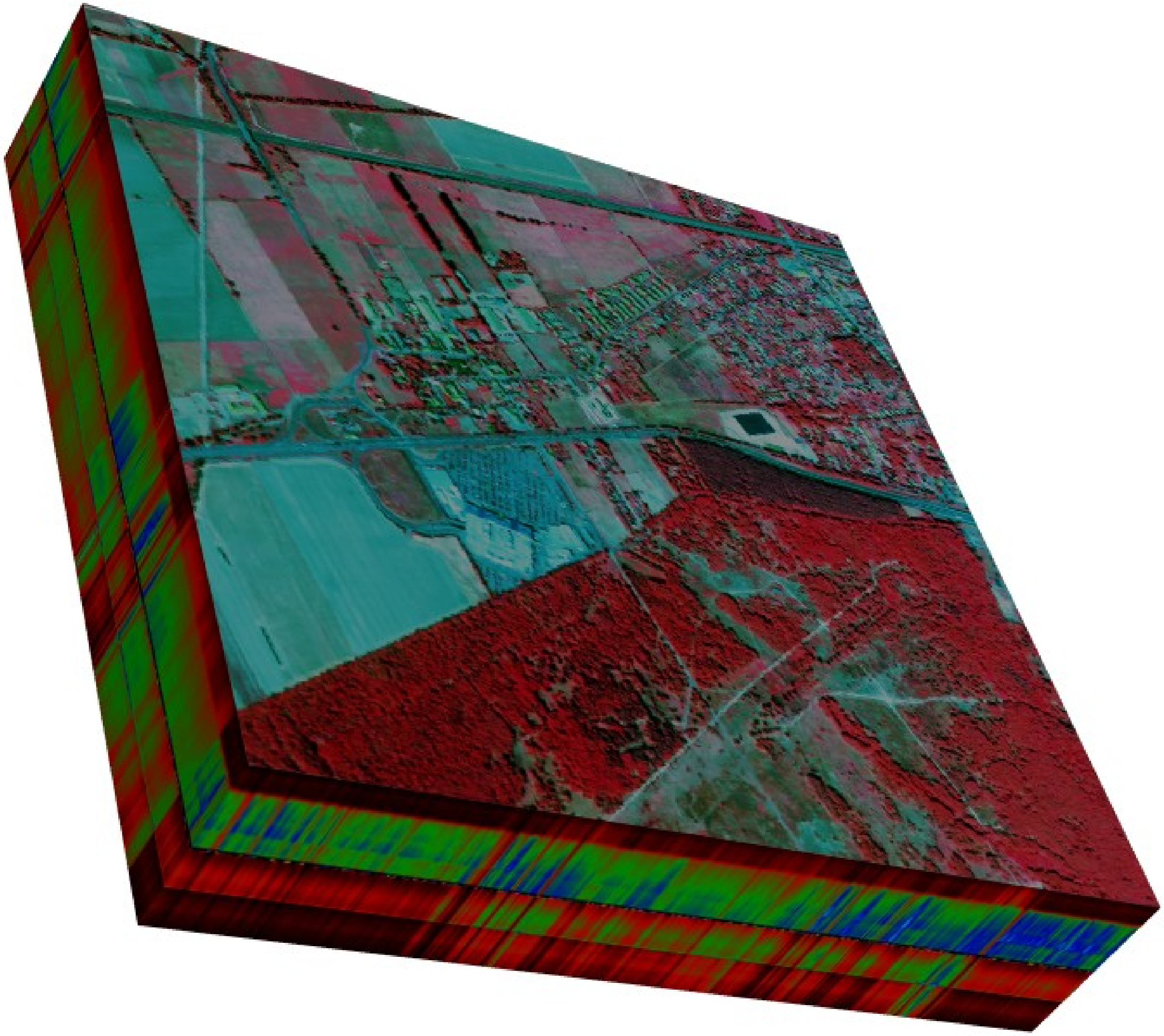
Source: NASA and Themis Vision Systems LLC.

RS and n-SPECTRALITY



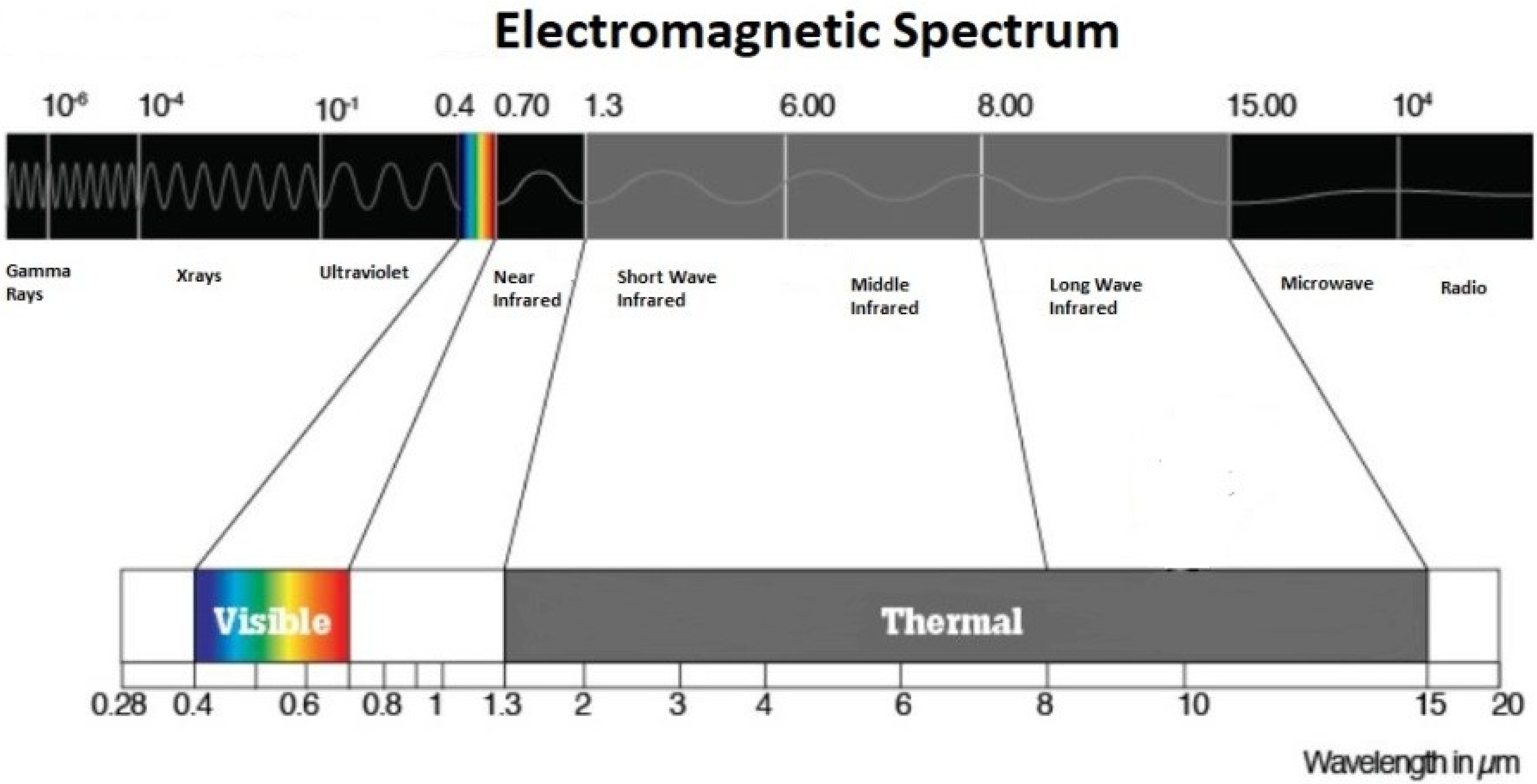
Source: Bradley, 2013

HSI



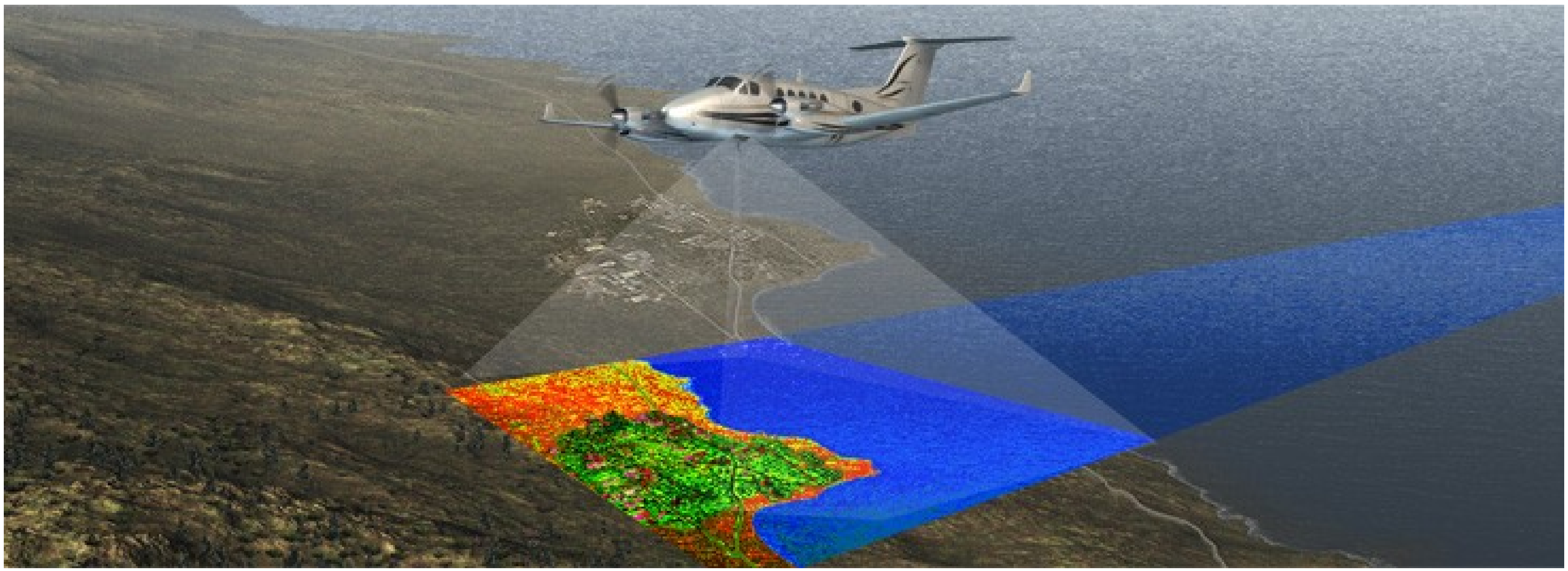
Hyperspectral imaging, imaging spectrometry

HSI and EM



Source: Dronezone, 2019

Hi-res HSI and RS



Source: HySpex, Itres, Northrop Grumman

Hi-res HSI and RS

- Different objects have different spectral signature
- With higher spectral resolution we can differentiate very similar objects
- With higher spatial resolution it is easier to find spectra of endmembers

RS applications

- Agriculture: diseases, nutrient efficiency …
- Ecology: biodiversity, habitats …
- Forestry: biomass, damage detection, diseases and insects …
- Geology and pedology: mineral composition, SOM, water storage capacity, geochemical quantification …

Ground ~~truth~~ data

- Accurate results need accurate measurements (OCD)
- We are dealing with physical parameters
- We calibrate RS data with proximal sensed data (XRF, XRD, ...)

Case study – soil surface

- RS sensor: hyperspectral SWIR (sunny and dry day)
- Proximal sensor: field or laboratory spectroradiometer
- GNSS

Soil measurements

- Soil sampling and preparation: ISO 10381-1, -4 + pH, H_20:
  sampling, storing, first filtering, drying, crushing,
  sieving (2 mm), coning, quartering

- Spectral analysis: 30 – 50 avg. reflectance measurements

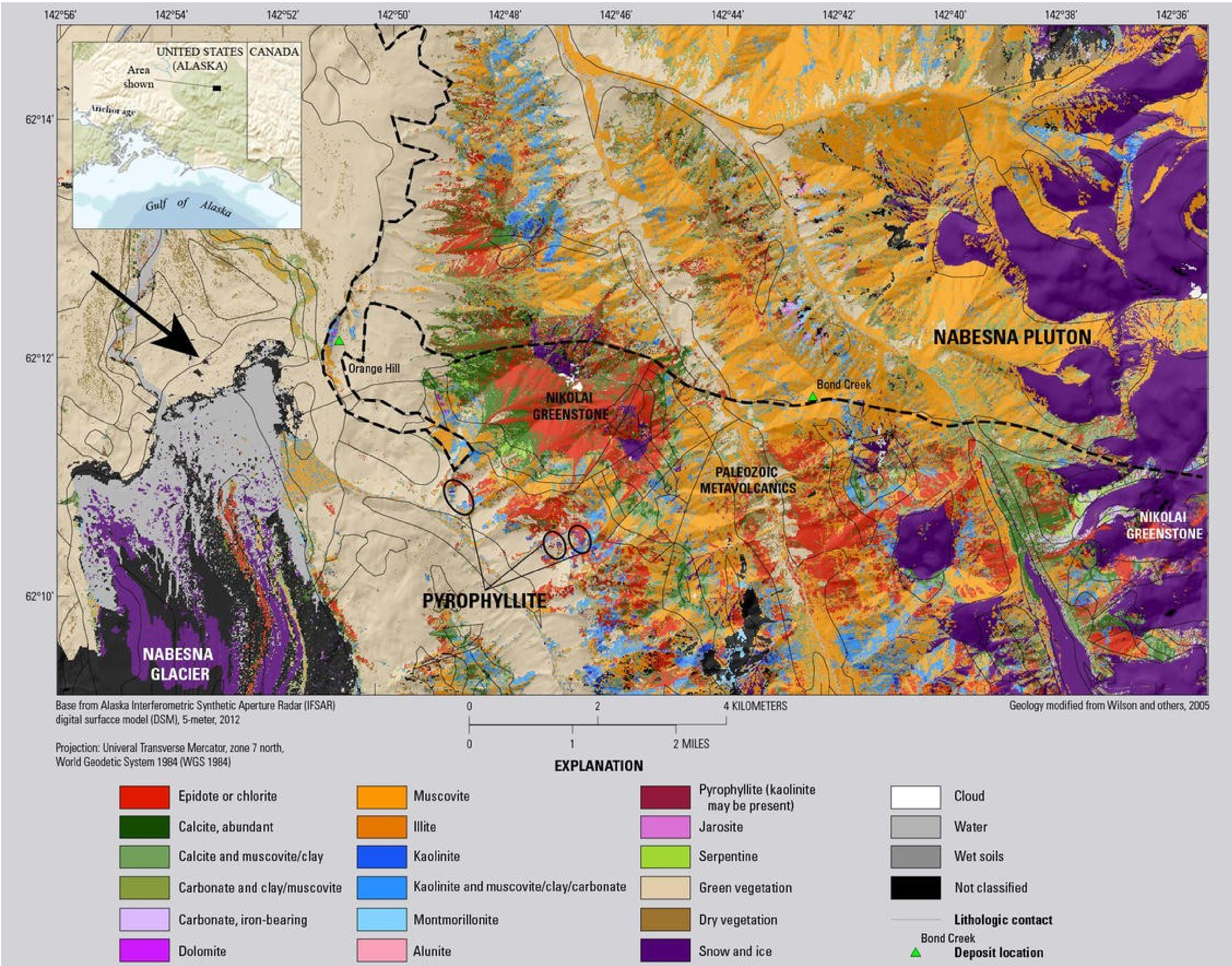
- Spectroradiometer calibrated on white surface
  (high reflectance panels as Spectralon©)

- Upscaling, downscaling spectral data

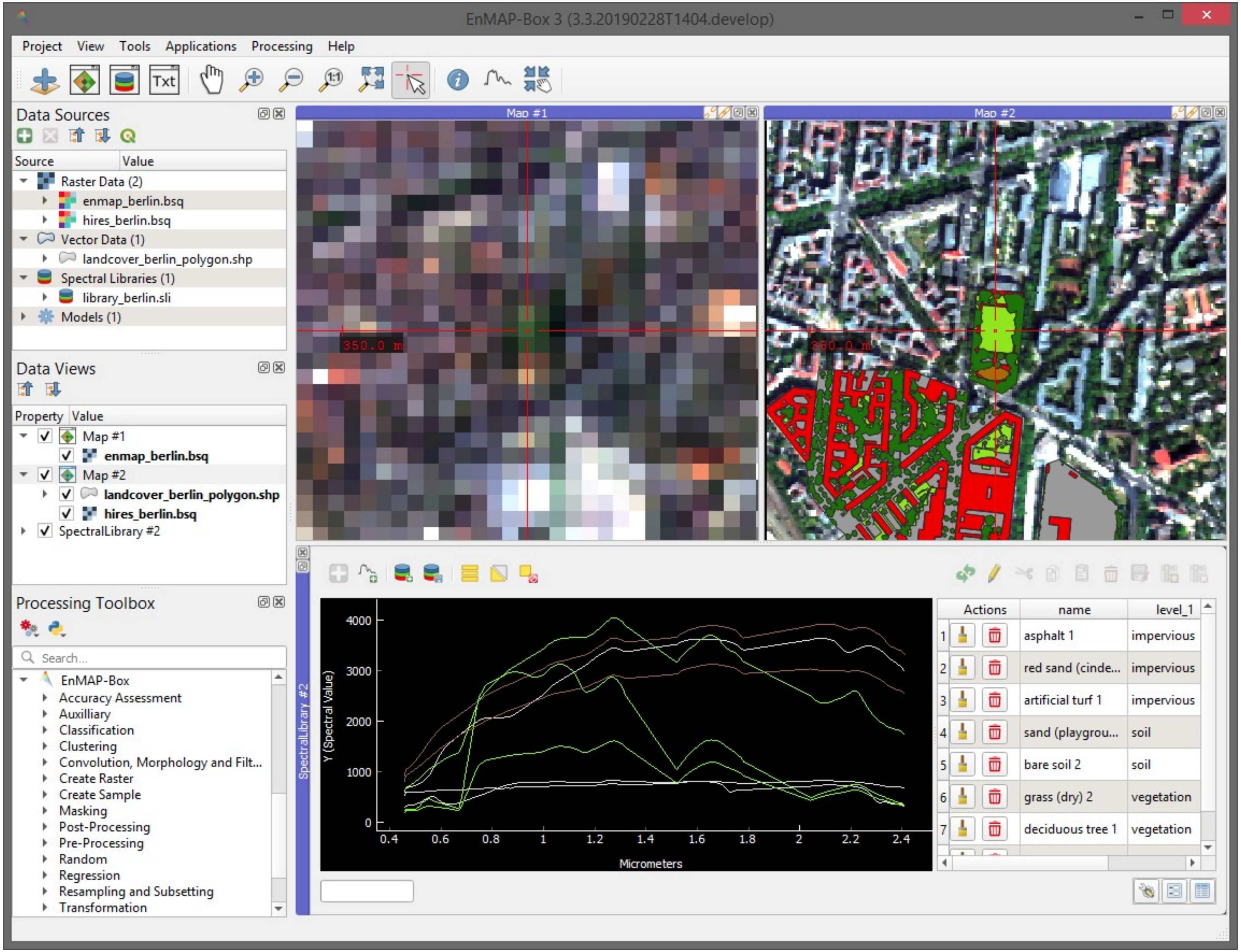
- Spectral masking – water, methane, nOise

Data (pre)processing

- Spectroradiometry reflectance cropping/resampling
- Signal-to-noise-ratio maximization (Savitzky - Golay filter ...)
- Radiance to reflectance conversion
- Data join with other covariates (pH, moisture, SOM, texture ...)
- Spectral unmixing – subpixel analysis (MESMA ...)
- Classification / regression mapping (PLSR, SVM, Cubist ...)



Source: USGS, 2017



EnMAP-Box: integracija v QGIS + scikit-learn, astropy, scipy

Future challenges

- Spatial accuracy and spectral accuracy (topography ...)
- Hyperspectral time-series (EnMAP is coming soon!!!)
- Full waveform scanning (hyperspectral LiDAR)
- Hypercube and 3D object-based analysis
- Data storage again and again

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