Statistical characteristics of subarctic vegetation on the basis of ground hyperspectral measurements

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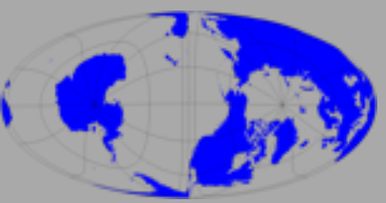
Land cover classification from spectral imagery

- One of the core methods in remote sensing
- Well established, with many available decision algorithms
- Spectral unmixing is attractive but limited by spectral diversity of the data
- Hyperspectral airborne and satellite data increasingly available



Spectral diagnostics and spectranomics

- Reflectance spectrum contains information about the characteristics of the target material (e.g. phenology, chlorosis…)

- Usefulness increases dramatically with higher spectral resolution

SLAP:
Spectral Library of Arctic Plants

- Collaboration between Geography Faculty, Moscow State University, Russian Federation, & Scott Polar Research Institute, University of Cambridge, UK

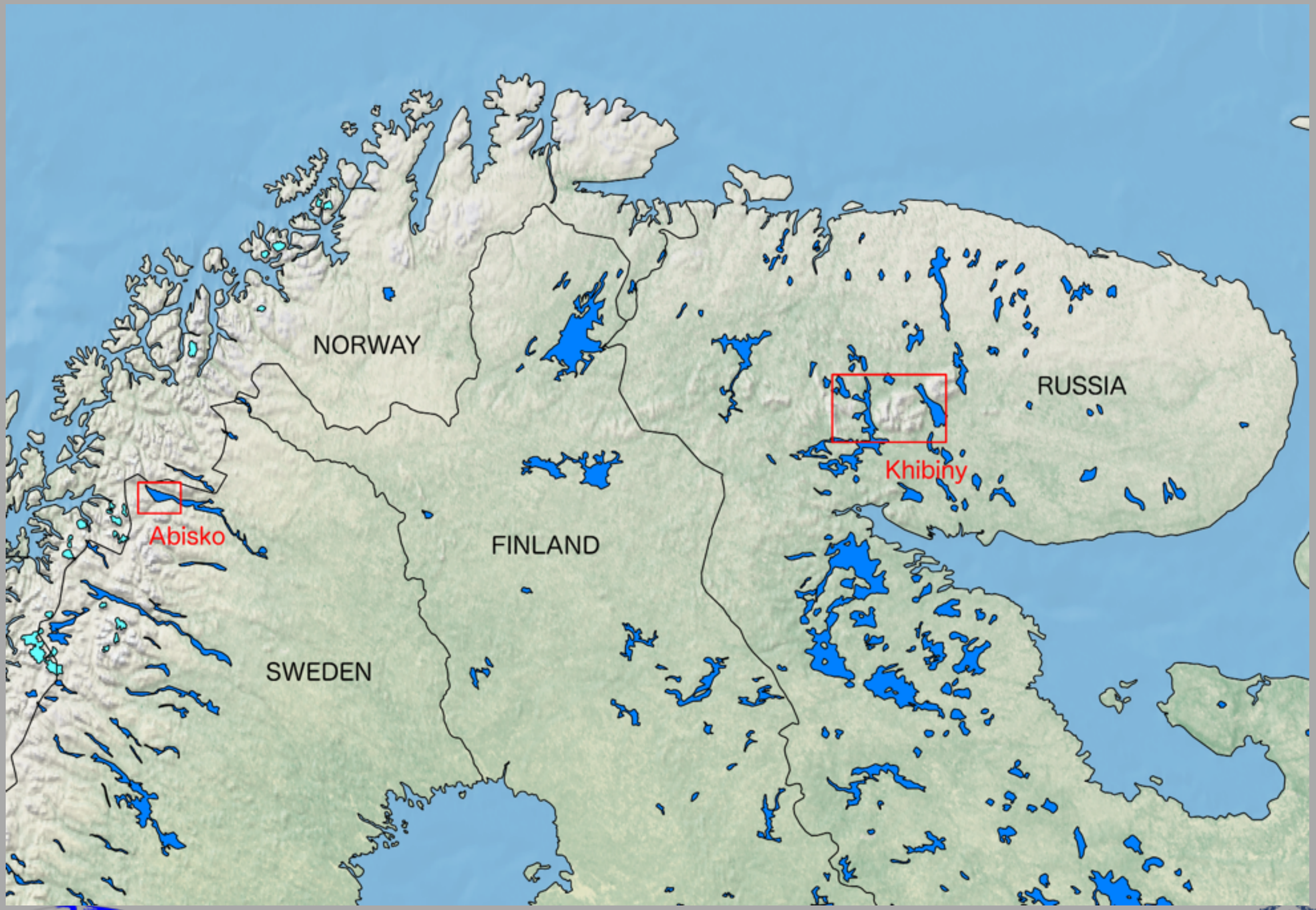
- Described at ICRSS Reykjavik 2014

- Measurement activities in Abisko (Sweden) 2002 and Khibiny mountains (Russia) 2012-2016…

- Methodological development is one goal

- Intention is to make spectra freely available online

- Other contributions will be welcomed

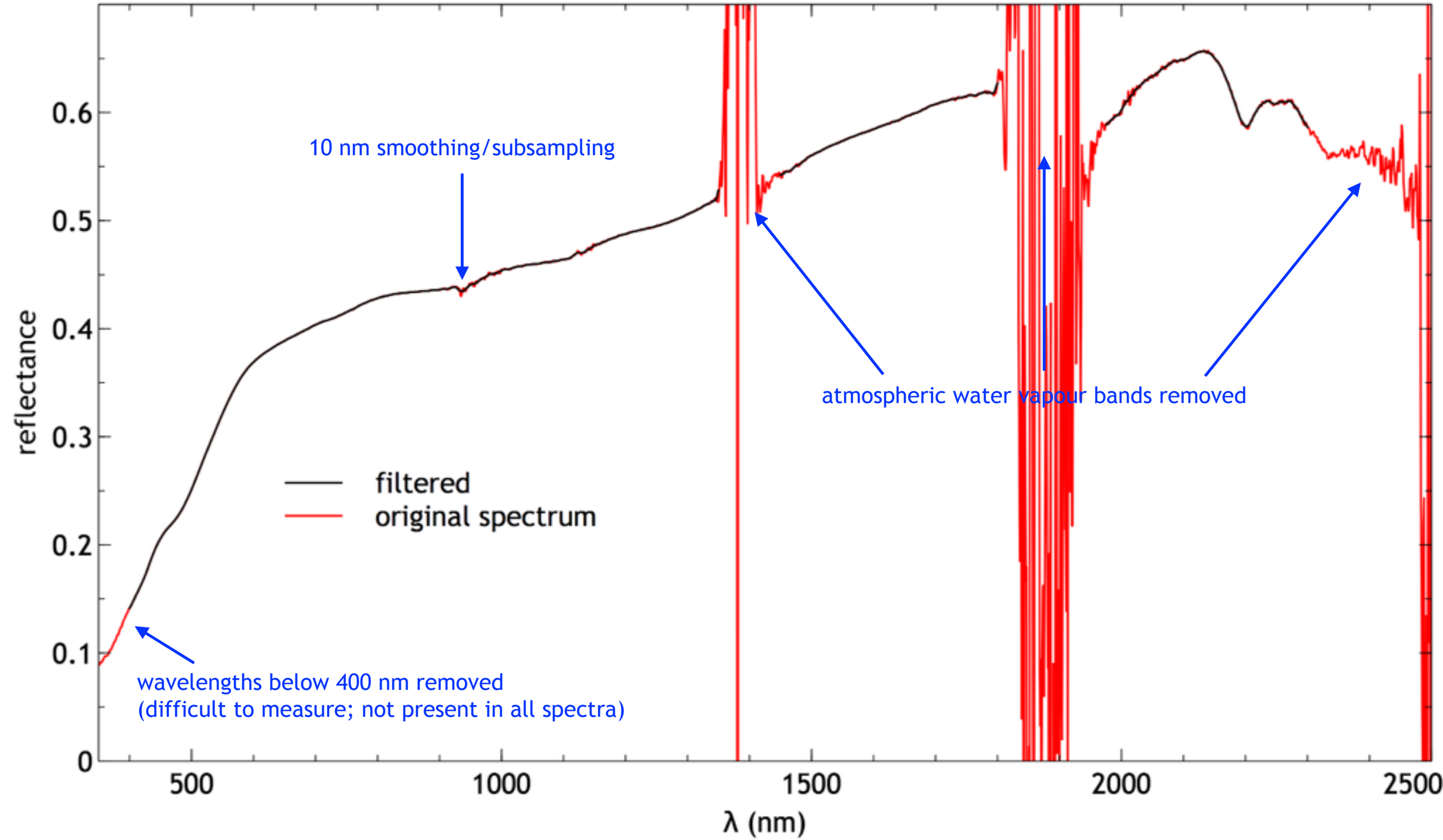

NORWAY
RUSSIA
Khibiny
Abisko
FINLAND
SWEDEN


Unit 16568 Plant Probe

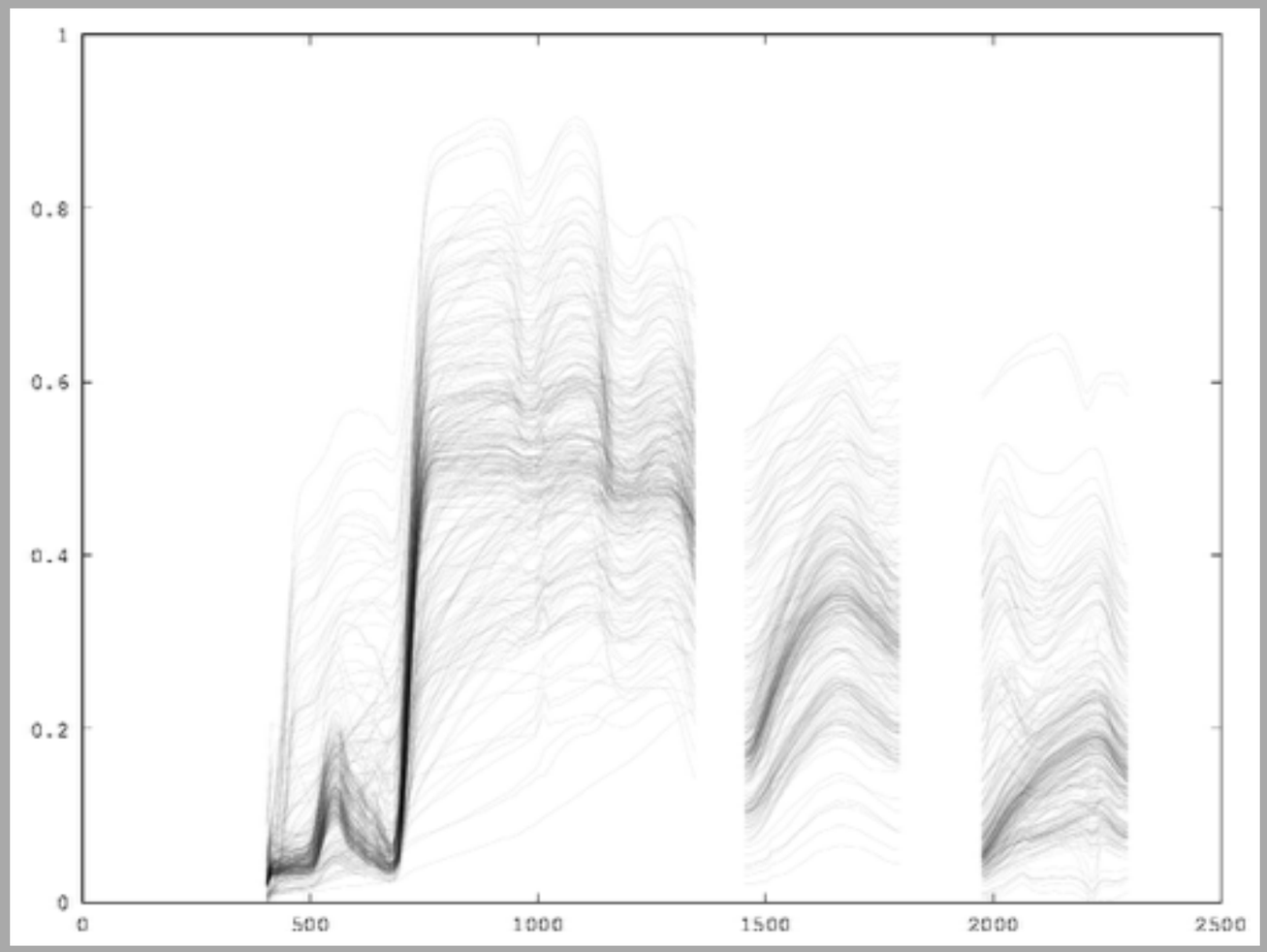

Plant Probe

We now have a lot of spectra, covering a range of functional types and phenological stages. Questions to investigate today:

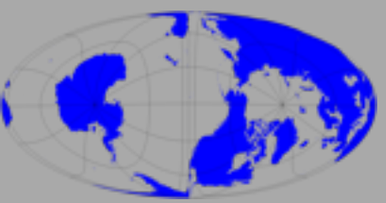
- Are there ‘generic’ spectra?
- Do they relate to functional type?
- Do they have common spectral characteristics?
- What are the key wavelengths for distinguishing between them? (Maybe we don’t need hyperspectral, but what *do* we need?)


10 nm smoothing/subsampling
atmospheric water vapour bands removed
wavelengths below 400 nm removed
(difficult to measure; not present in all spectra)
filtered
original spectrum
reflectance
λ (nm)
0
0.1
0.2
0.3
0.4
0.5
0.6
500
1000
1500
2000
2500

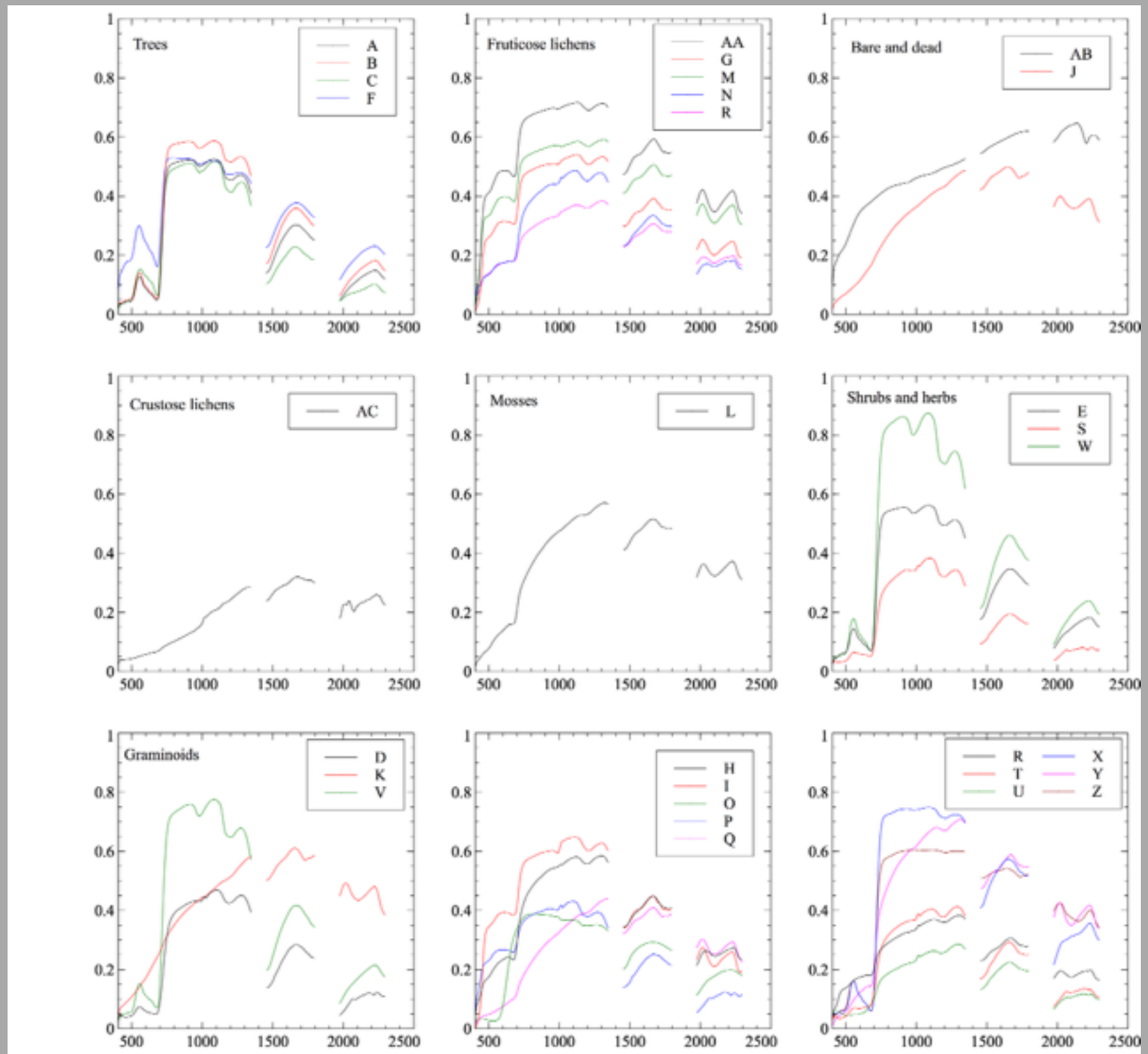
289 spectra each represented by 163 data points.



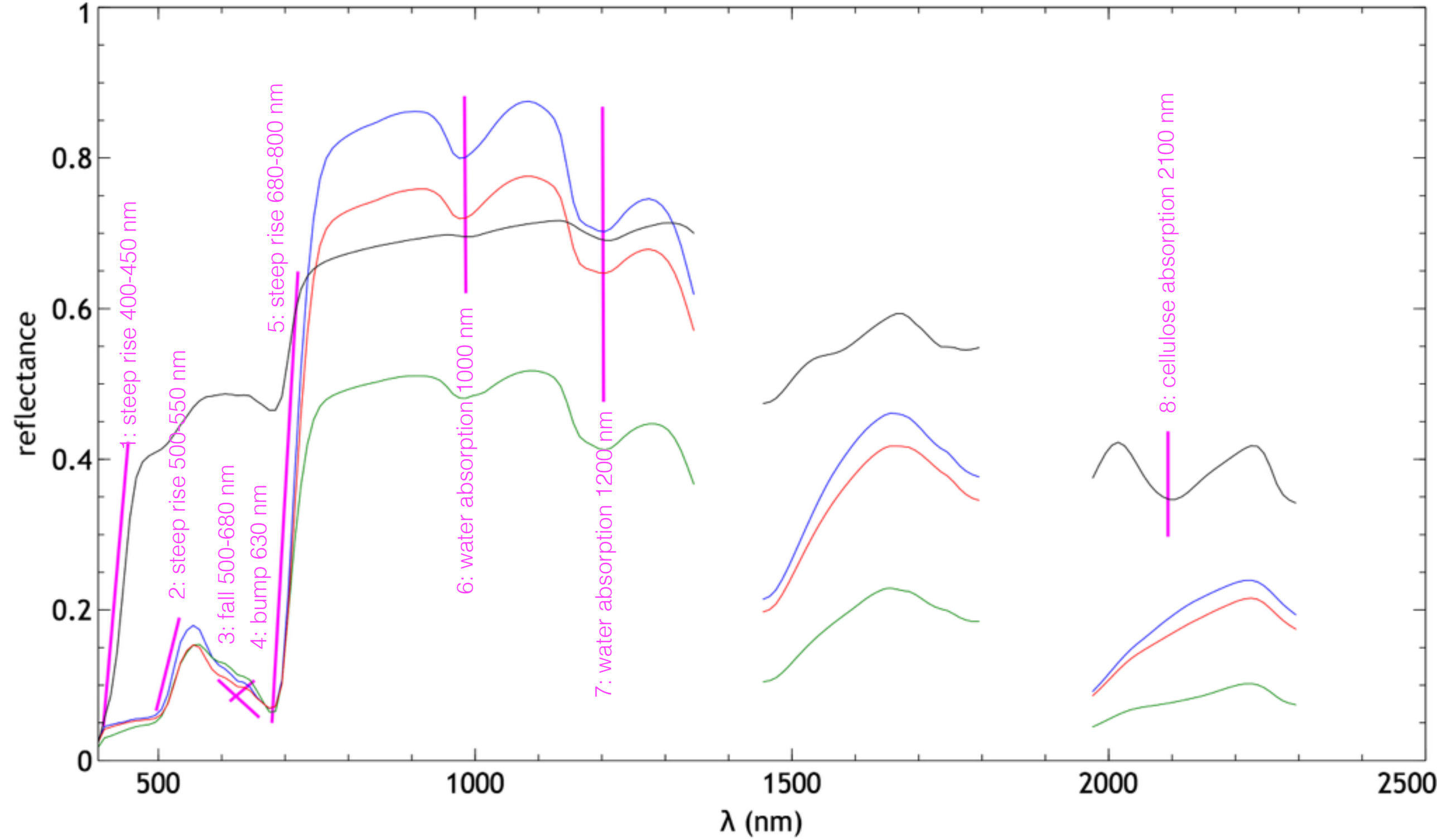
Apply robust statistical clustering algorithm to identify groups of spectra with high intra-group similarity and high inter-group dissimilarity: produces 29 groups.



Some of the 29 spectral groups are obviously associated with particular functional types; others are mixed.
Some persistent spectral features



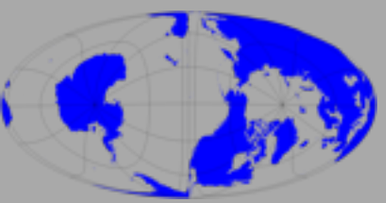
Spectral features



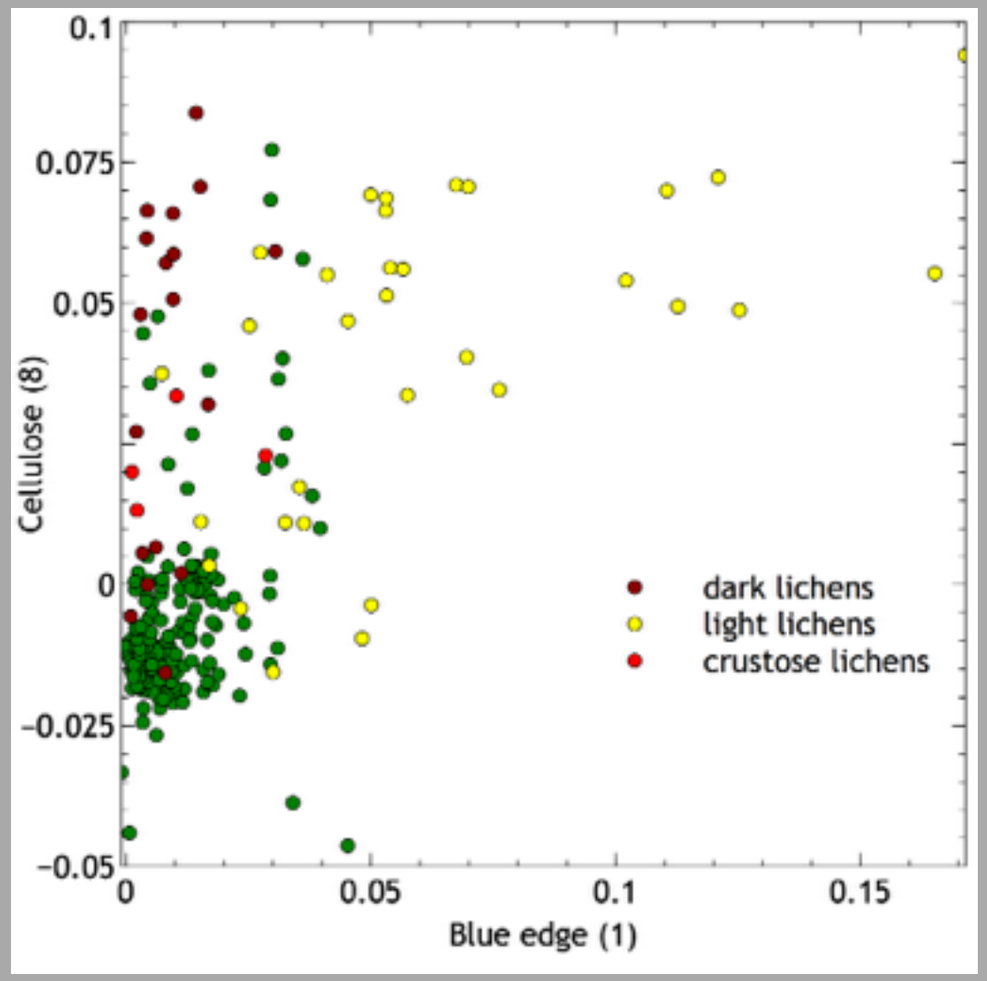
Quantify spectral features using indices:

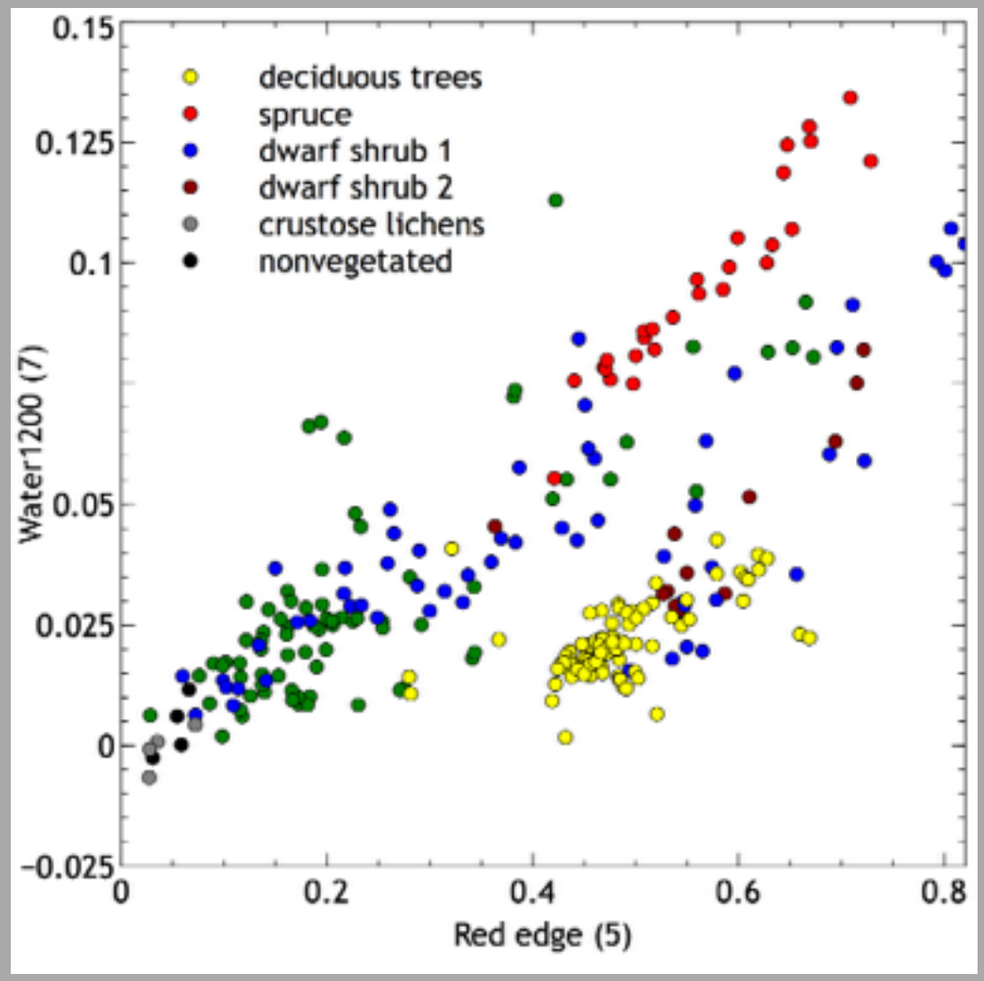
1:	-[450] + [500]	‘blue edge’ in some lichens
2:	-[500] + [550]	Chl blue absorption
3:	+[550] - [680]	Chl red absorption
4:	-0.5[550] + [630] -0.5[680]	‘Spruce bump’
5:	-[680] + [800]	red edge
6:	+0.5[900] - [980] +0.5[1100]	water 1
7:	+0.5[1100] -[1200] +0.5[1300]	water 2
8:	+0.5[2000]-[2100]+0.5[2200]	cellulose

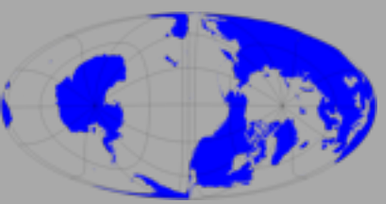
Notation: e.g. index 4 means -0.5xr_{550} + r_{630} - 0.5xr_{680} where r_n is reflectance at wavelength *n* nm.



Light-coloured fruticose lichens, crustose lichens, spruce needles & non vegetated surfaces are spectrally distinct. Some dwarf shrubs similar to deciduous trees.



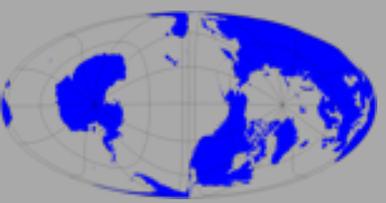




Statistical separability of functional types using spectral indices

Assess by using index values to classify and using Cohen Kappa values to measure separability

Crustose lichens
Non-vegetated surfaces
Spruce
Deciduous trees
Fruticose lichens
Mosses
Graminoids
Dwarf shrubs



Trickiest discriminations, and most effective indices (kappa in parentheses):

DS-GS 4 (0.44)
FL-M 3 (0.47)
DS-T 7 (0.60)
GS-M 5 (0.66)
DS-M 1 (0.75)
DS-S 7 (0.75)
DS-FL 8 (0.78)

… all others have K>0.8

Usefulness of indices (how often they give good discrimination):

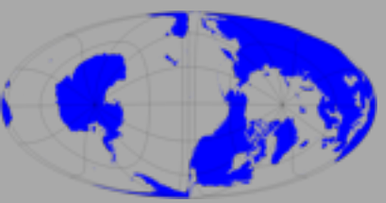
5:	red edge	-[680] + [800]
7:	water 2	+0.5[1100] -[1200] +0.5[1300]
8:	cellulose	+0.5[2000]-[2100]+0.5[2200]
3:	Chl red	+[550] - [680]
2:	Chl blue	-[500] + [550]
4:	spruce bump	-0.5[550] + [630] -0.5[680]
6:	water 1	+0.5[900] - [980] +0.5[1100]
1:	blue edge	-[450] + [500]

Conclusions

- We can indeed identify ‘generic’ spectra amongst vegetation (and non vegetated) surfaces
- These are well characterised by their behaviour at a few key wavelengths, which can form the basis of a number of spectral indices with discriminatory capability
- Groups (functional types) can largely be separated using these indices.
- Most common indices are red edge and 1100 nm water, followed by cellulose and chlorophyll features.
- ‘Specialist’ (less common) indices sometimes needed.

Dataset is already quite large, but…

- coverage of different functional types is variable, and
- geographically limited



Bigger context

International collaboration on definition of protocols and standards, collection of spectra?

Connection to airborne & spaceborne hyperspectra (Aviris, Casi, Hyperion…)?

Just arctic? or antarctic too?

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Thank you for your attention!