University of Southampton

Evaluation of the MERIS Terrestrial Chlorophyll Index

Paul Curran & Jadunandan Dash
University of Southampton
United Kingdom

Remote sensing of vegetation

What is it?

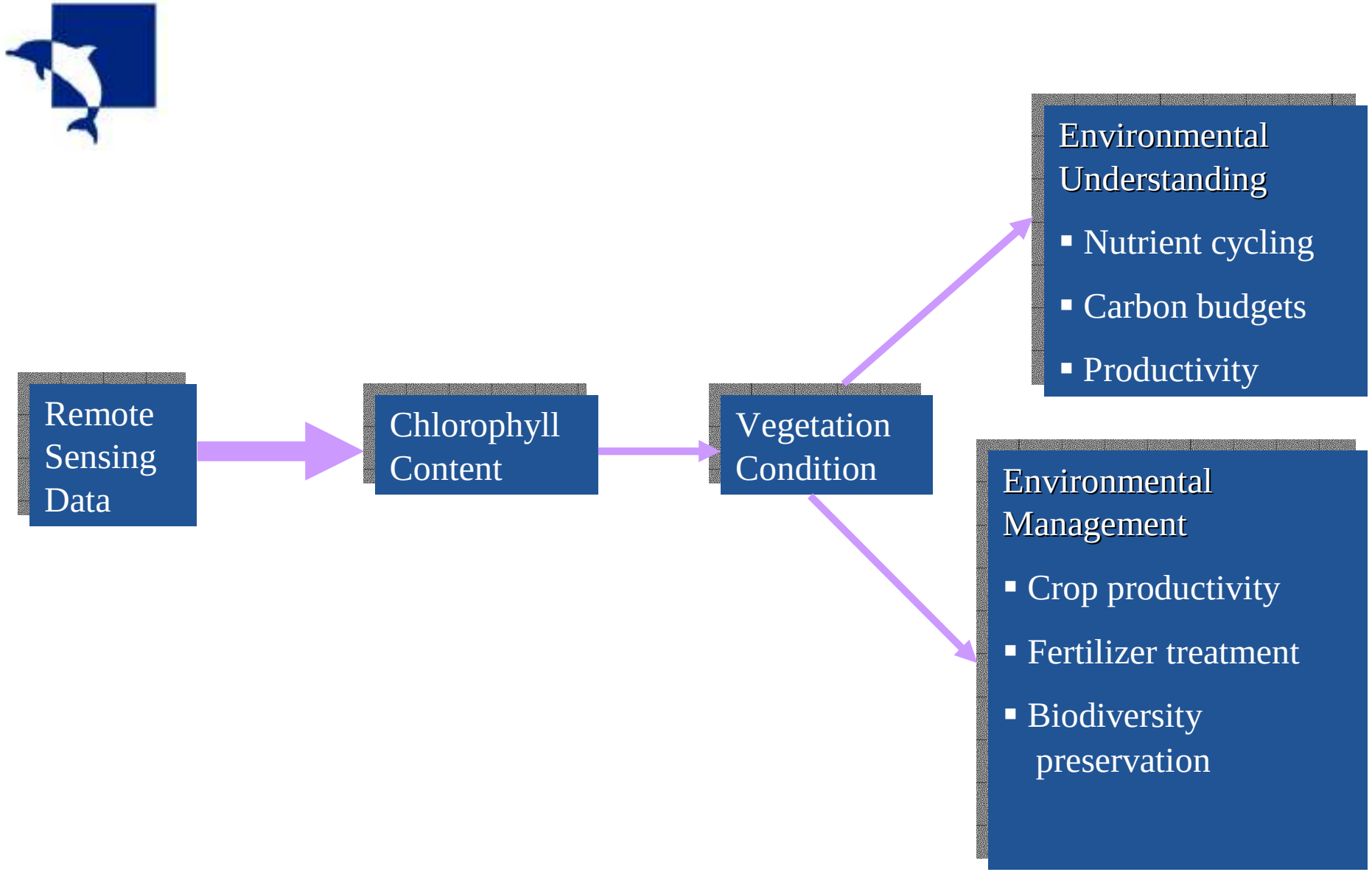
MERIS: *individual bands*, classify

How much is there?

MERIS: *MGVI* (*f*APAR-LAI) ESA level 2 product

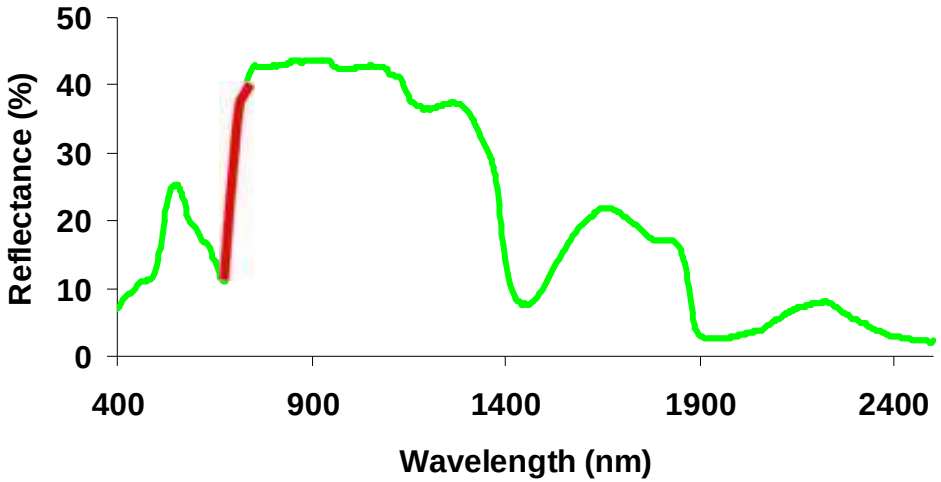
What condition is it in?

MERIS: *MTCI* (chlorophyll content) ESA level 2 product

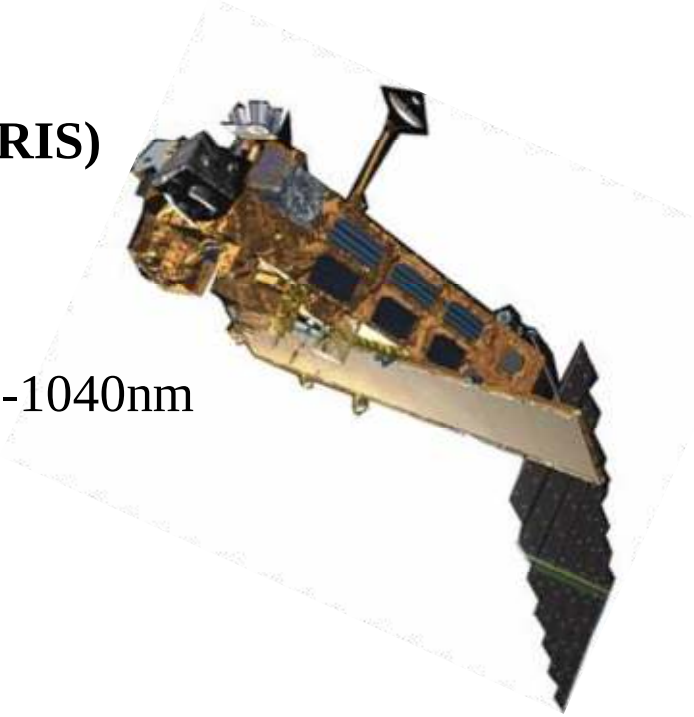

Remote Sensing Data
Chlorophyll Content
Vegetation Condition
Environmental Understanding
Nutrient cycling
Carbon budgets
Productivity
Environmental Management
Crop productivity
Fertilizer treatment
Biodiversity preservation

Red edge position (REP):

- links remotely sensed data and chlorophyll content
- is defined as the ***point of maximum slope*** of the curve in red / near infrared region



MEdium Resolution Imaging Spectrometer (MERIS)



- Onboard ESA's Envisat
- 15 programmable bands in region of 390-1040nm
- Pushbroom imaging spectrometer
- 1150km swath on ground
- Two spatial resolutions
  - Full resolution (FR)-300m
  - Reduced resolution (RR)-1200m
- Global coverage in 3 days

MERIS to estimate REP at a landscape scale

We have

- *Large volumes* of discontinuous spectral data
- *High variation* in chlorophyll values

We require

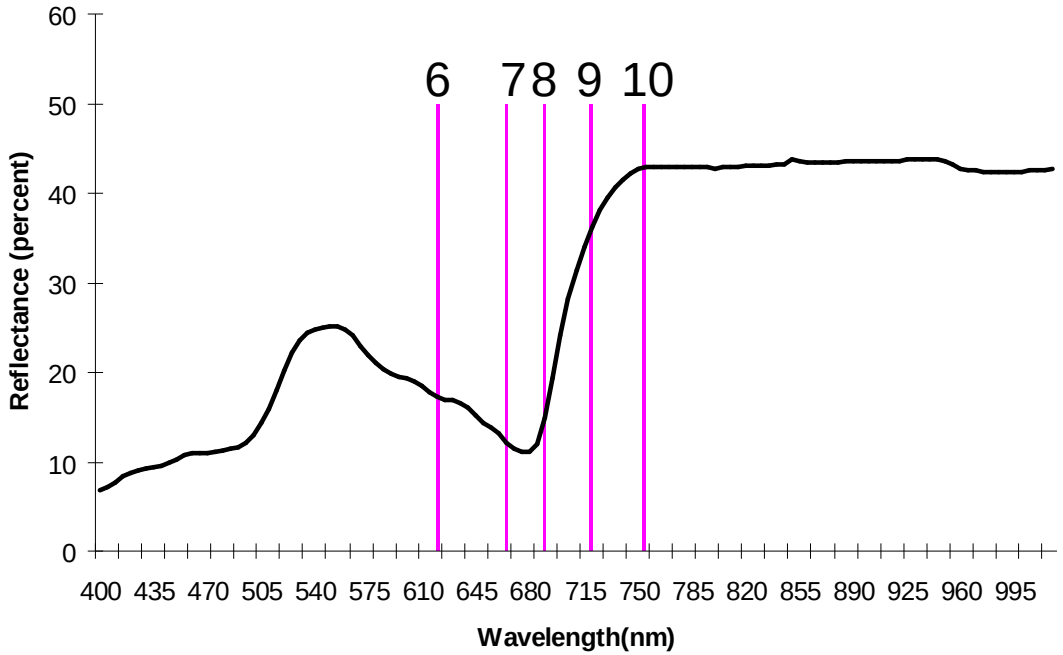
- *Unique* value for an index
- *Automation*

Problems with REP estimation techniques in literature

- Designed for small volumes of continuous spectral data
- Insensitive to high chlorophyll values
- REP value depends on technique used
- Two-step process, requires user intervention

In some respects MERIS is well suited ▸ high SNR (around 600:1 in blue wavelengths to around 250:1 in near-ir wavelengths over vegetation)
▸ well-placed wavebands

Band no	Central wavelength (nm)
1	412.5
2	442.5
3	490
4	510
5	560
6	620
7	665
8	681.25
9	708.75
10	753.75
11	760.625
12	778.75
13	865
14	885
15	900



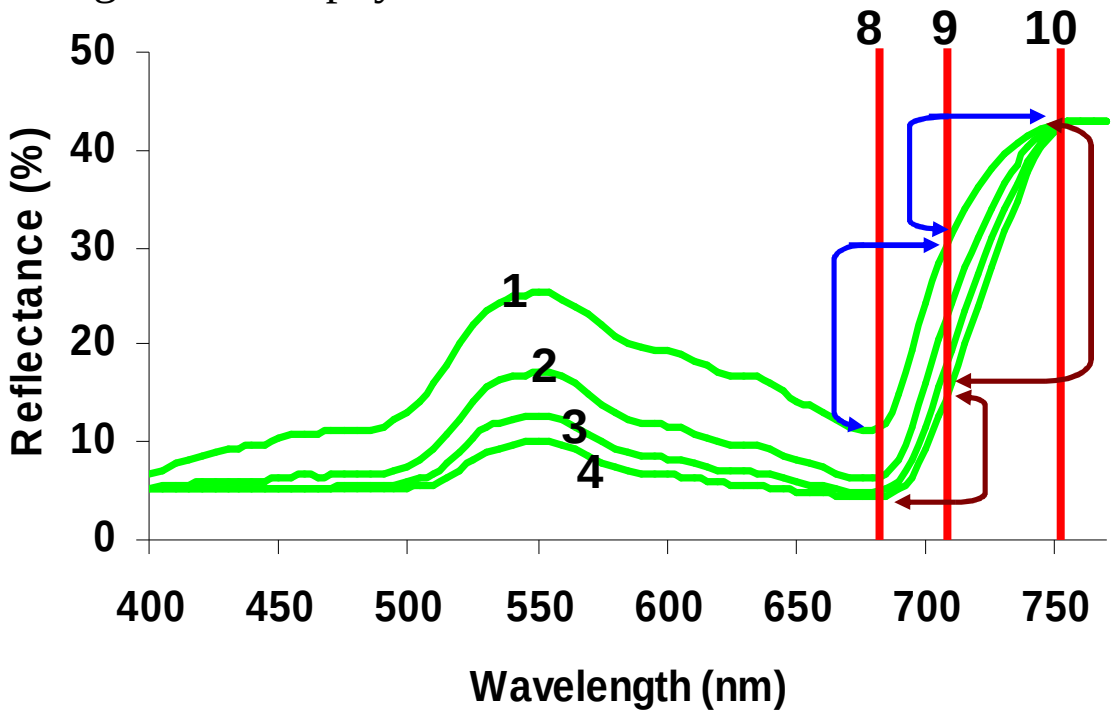
Position of MERIS standard band setting on a vegetation reflectance spectrum

Designing the MERIS Terrestrial Chlorophyll Index (MTCI)

Requirements:

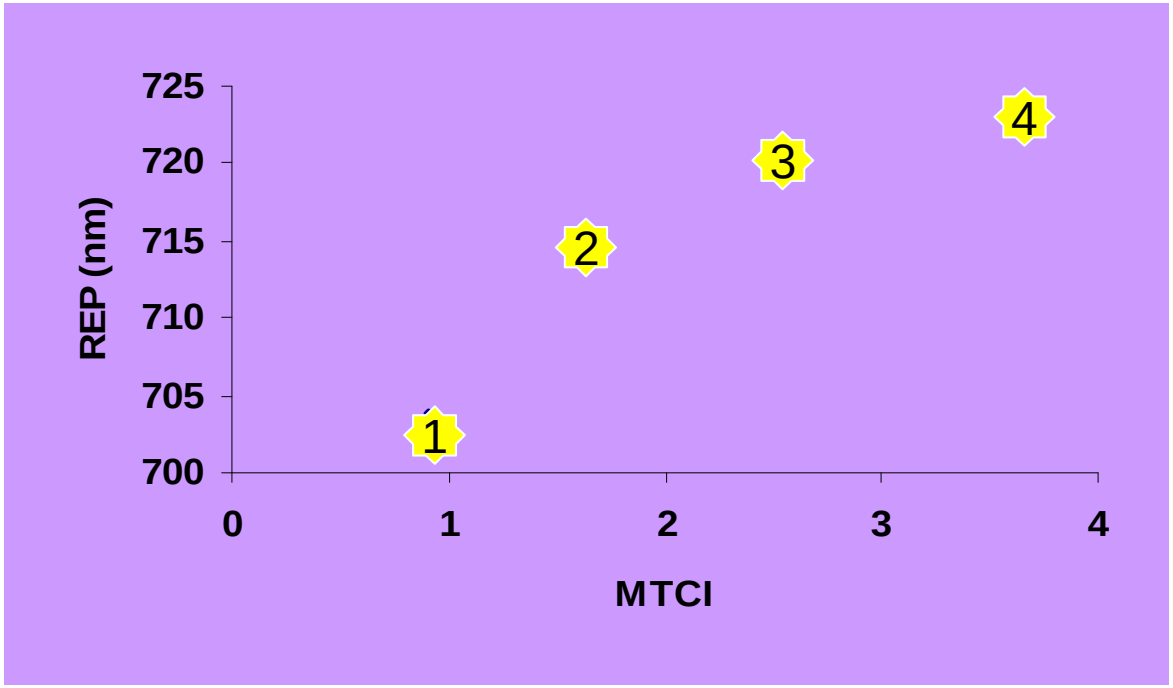
(i) Easy to calculate from MERIS data

(ii) Sensitive to wide range of chlorophyll contents

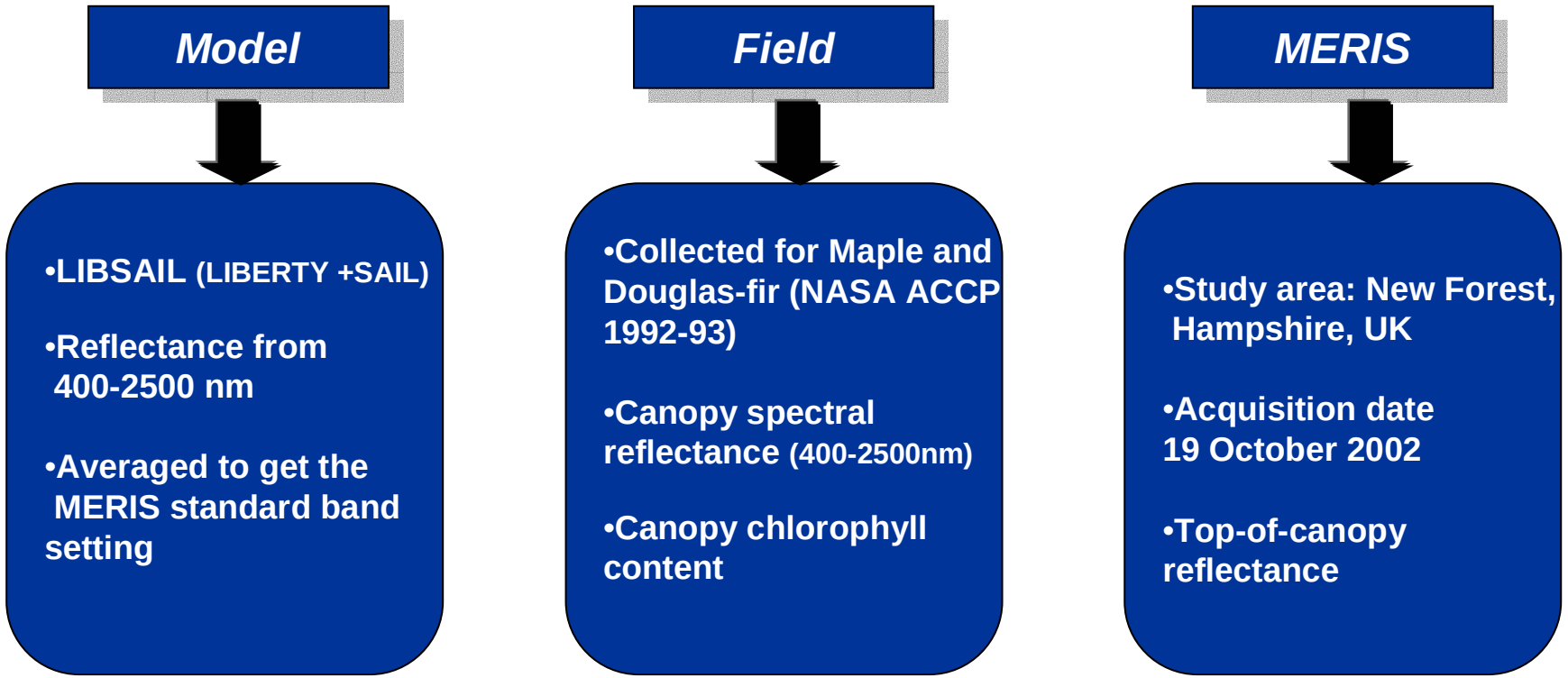


Equation

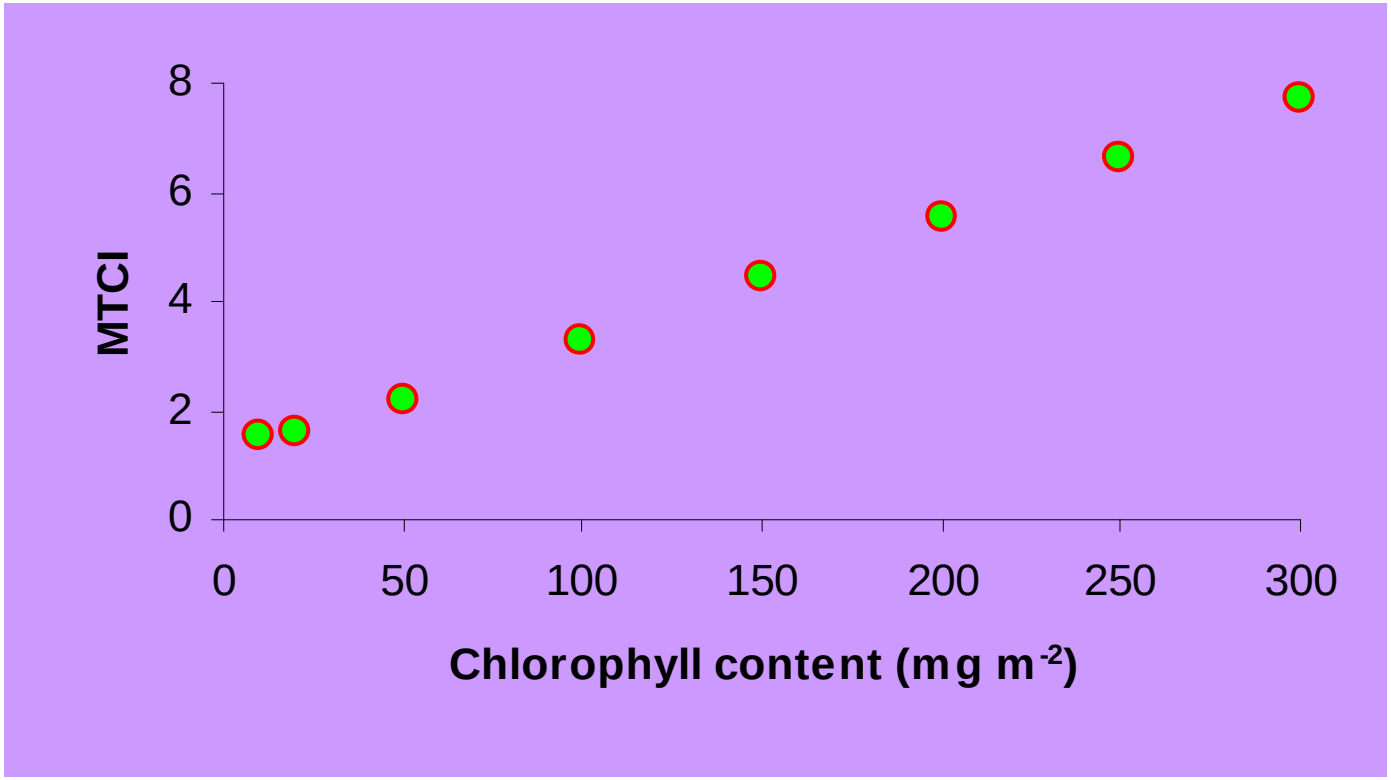
$$MTCI = \frac{R_{Band10} - R_{Band9}}{R_{Band9} - R_{Band8}} = \frac{R_{753.75} - R_{708.75}}{R_{708.75} - R_{681.25}}$$



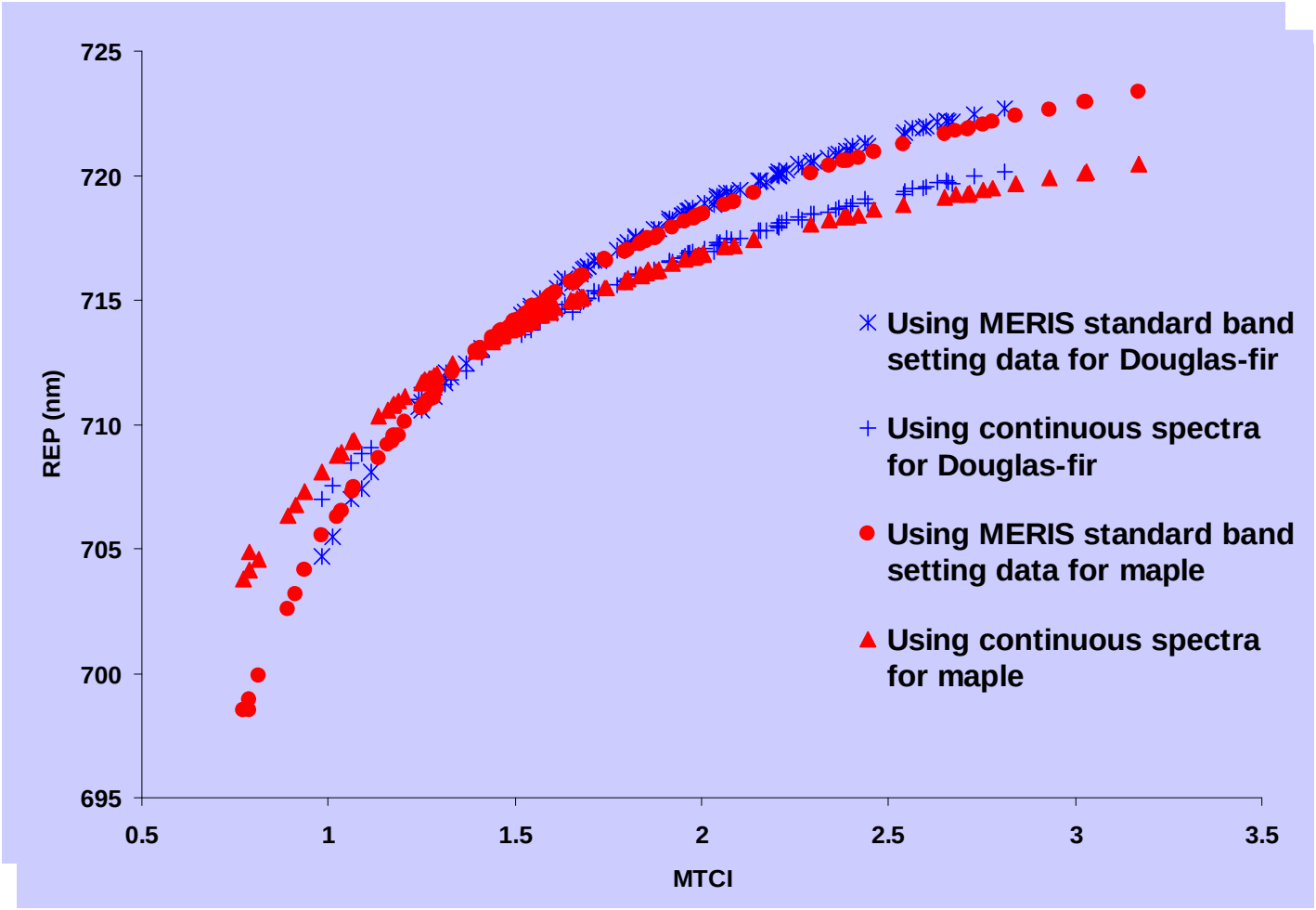
Preliminary evaluation



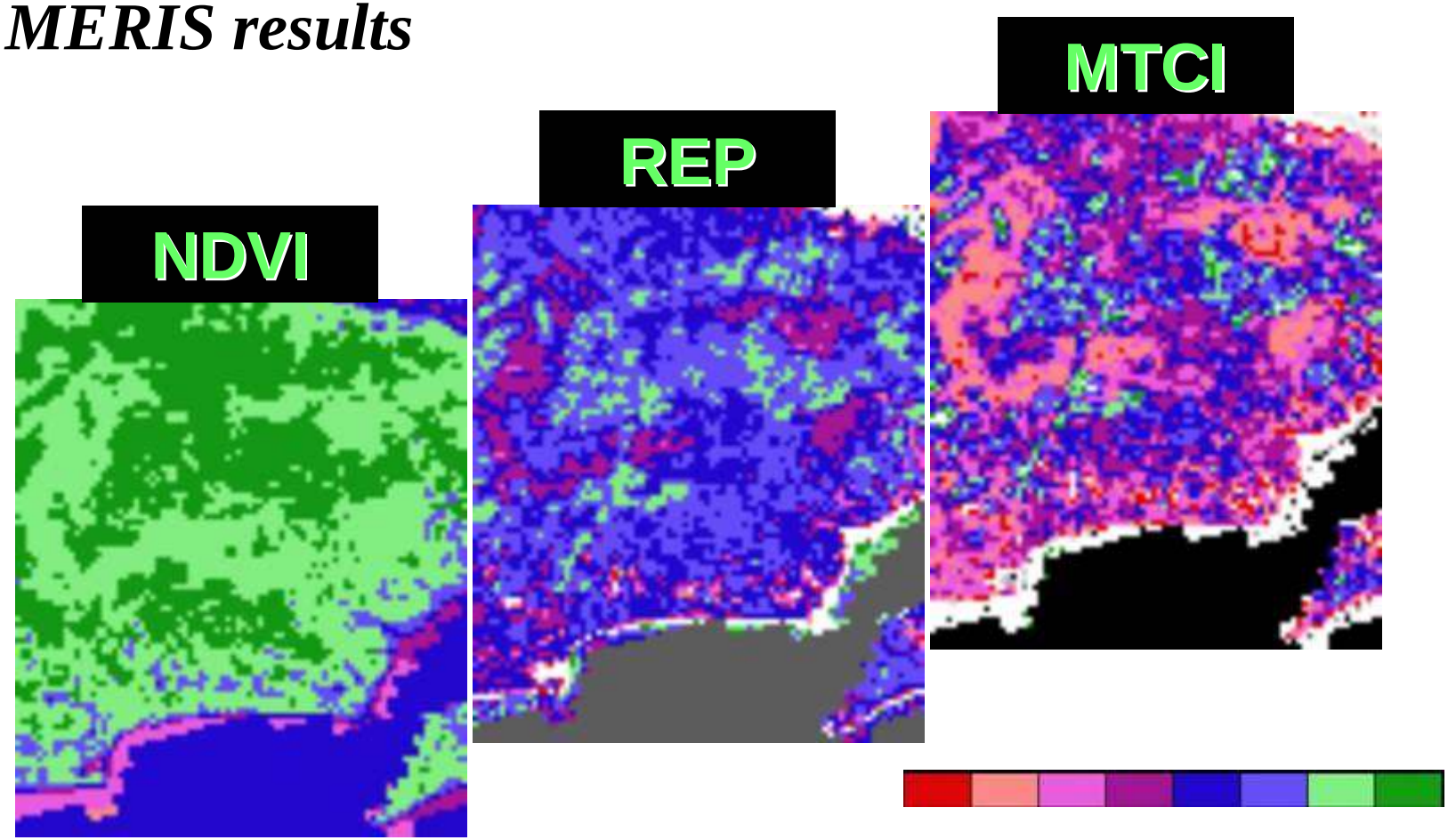
Model results



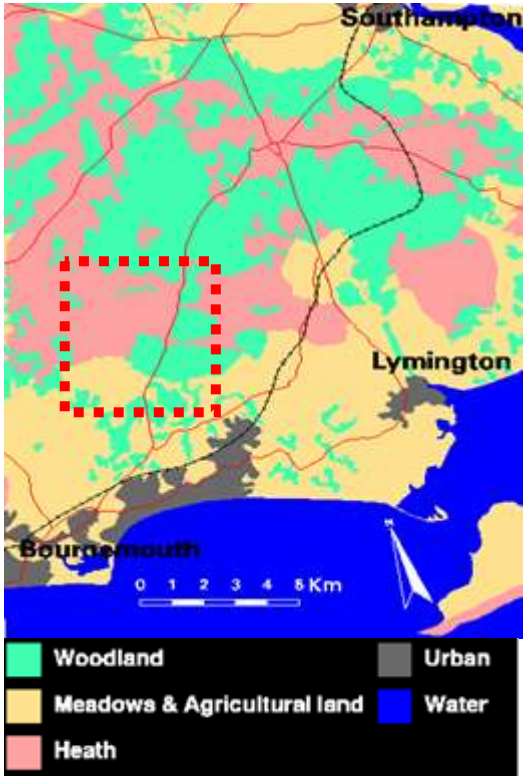
Field results

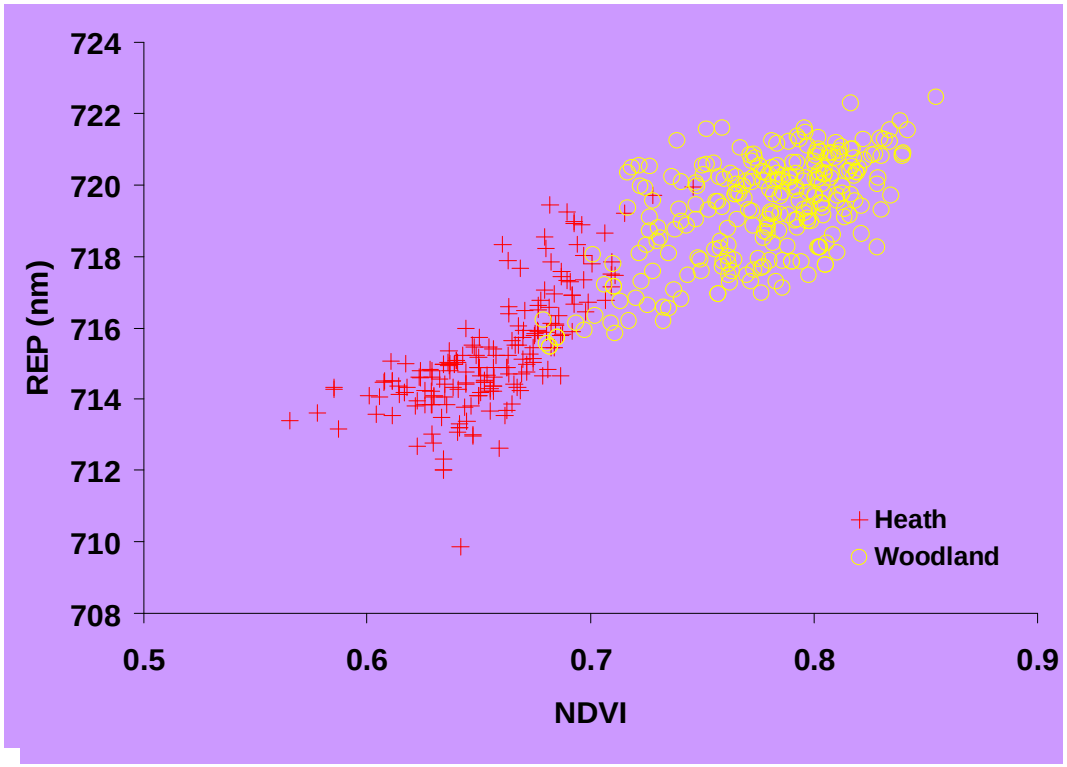


MERIS results



MERIS results





Observed Issues and Recommendations

New L2 products

- Need for defining new L2 land products by fully exploiting the capabilities of the MERIS instrument not available from other sensors.
  - ➢ ESA response:
  - for the land community at present we have MGVI, NDVI, rectified reflectances at 665 and 865nm, DDV AOT, surface pressure.
  - new MERIS Terrestrial Chlorophyll Index (MTCI) will be provided in the L2 product replacing the NDVI.
  - algorithms for experimental MERIS products, i.e.LAI, fraction cover, chlorophyll content, surface reflectance under development; shall be made available in source code under the BEAM software
- Need for defining new atmospheric L2 products:
  - Aerosol path radiance at 665 nm
  - Particular Matter: PM 10
  - Aktinic fluxes

Background to preliminary evaluation:

Dash, J. & Curran, P.J. (2004) The MERIS terrestrial chlorophyll index. *International Journal of Remote Sensing*, 25 (autumn).

Four evaluations underway at Southampton University

Experiments **–** greenhouse, field

Time series **–** four sites

Surrogate chlorophyll content **–** Vietnam

Non-canopy variables **–** simulations

Experiments *– greenhouse experiment*

spinach, low / medium / high levels of fertilization, weekly chlorophyll content and MTCI measurement

field experiment

grassland, low / medium / high levels of fertilization, monthly chlorophyll content and MERIS MTCI measurement

Time series **–** four sites (joint with JRC Ispra)

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New Forest
Country: United Kingdom
Site: Mixed forest
Dominant species: Oak, Pine, Heath

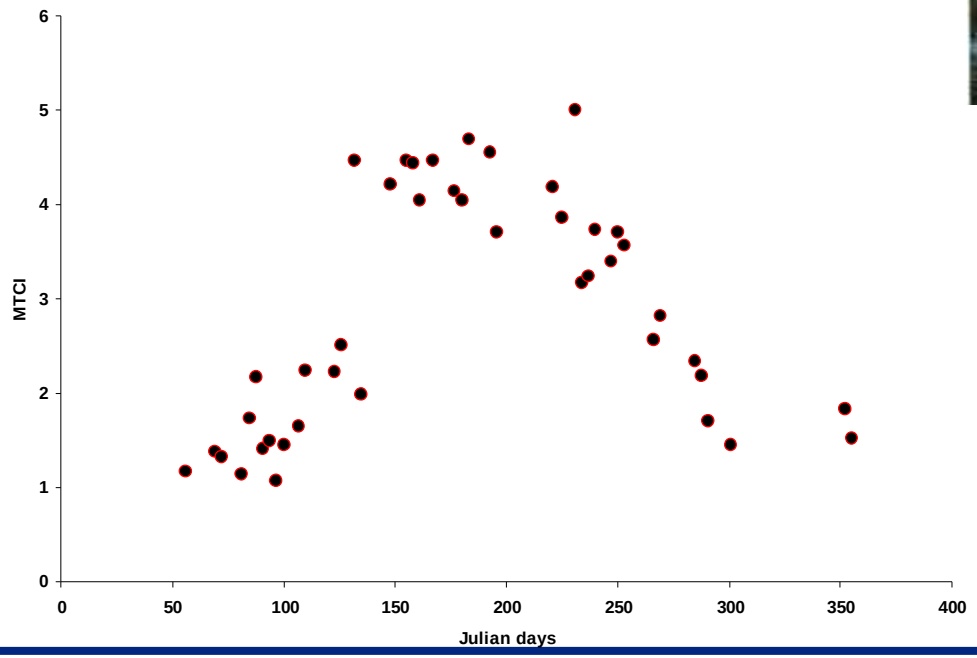
Hainich
Country: Germany
Site: Hardwood forest
Dominant species: Beech

Loobos
Country: Netherlands
Site: Coniferous forest
Dominant species: Scots Pine

Pavia
Country: Italy
Site: Agriculture
Dominant species: Rice

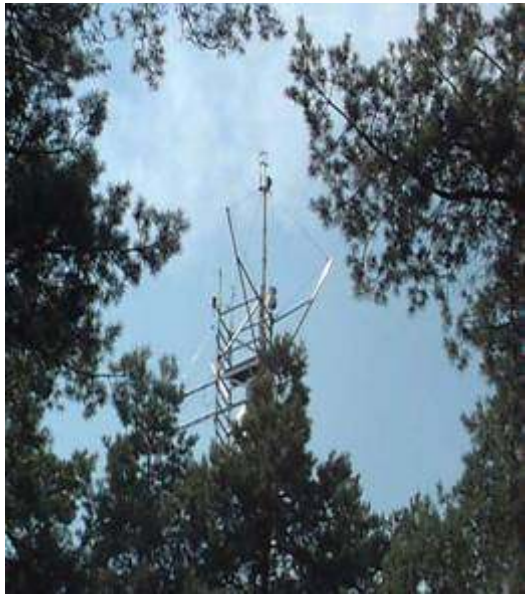
Hainich

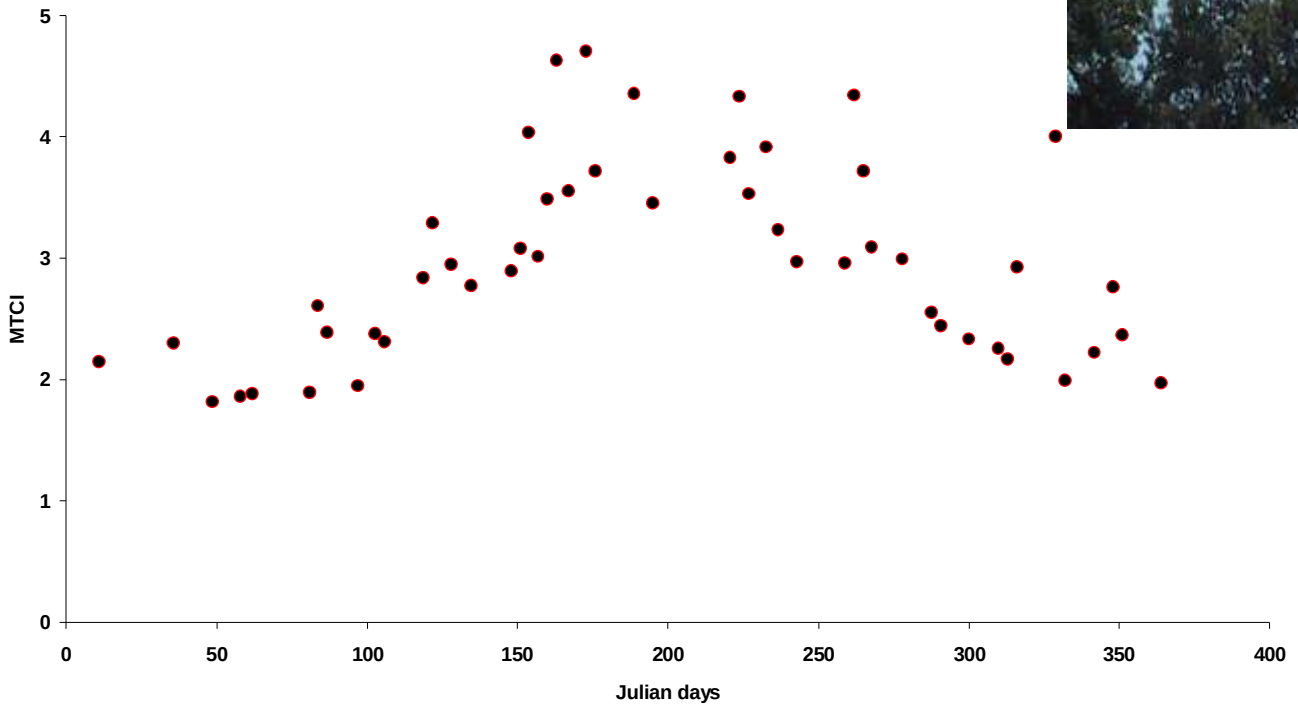
Country: Germany
Site: Hardwood forest
Dominant species: Beech



Loobos

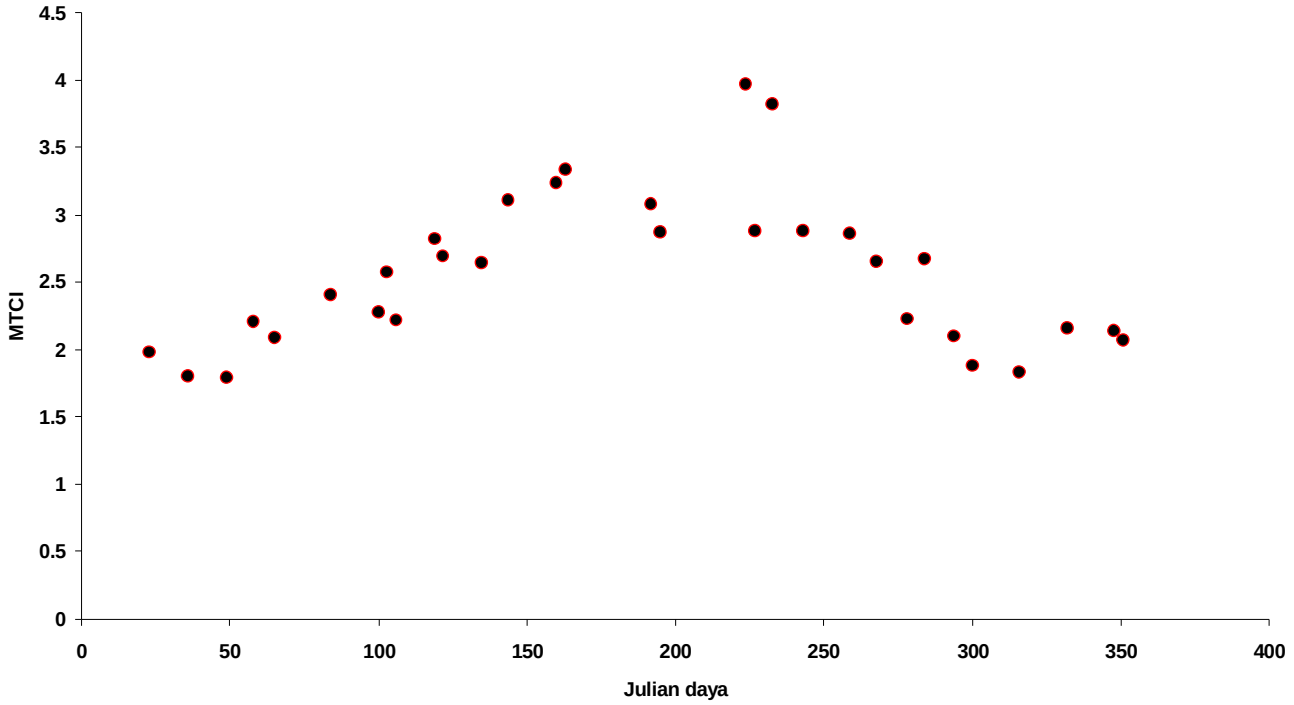
Country: Netherlands
Site: Coniferous forest
Dominant species: Scots Pine





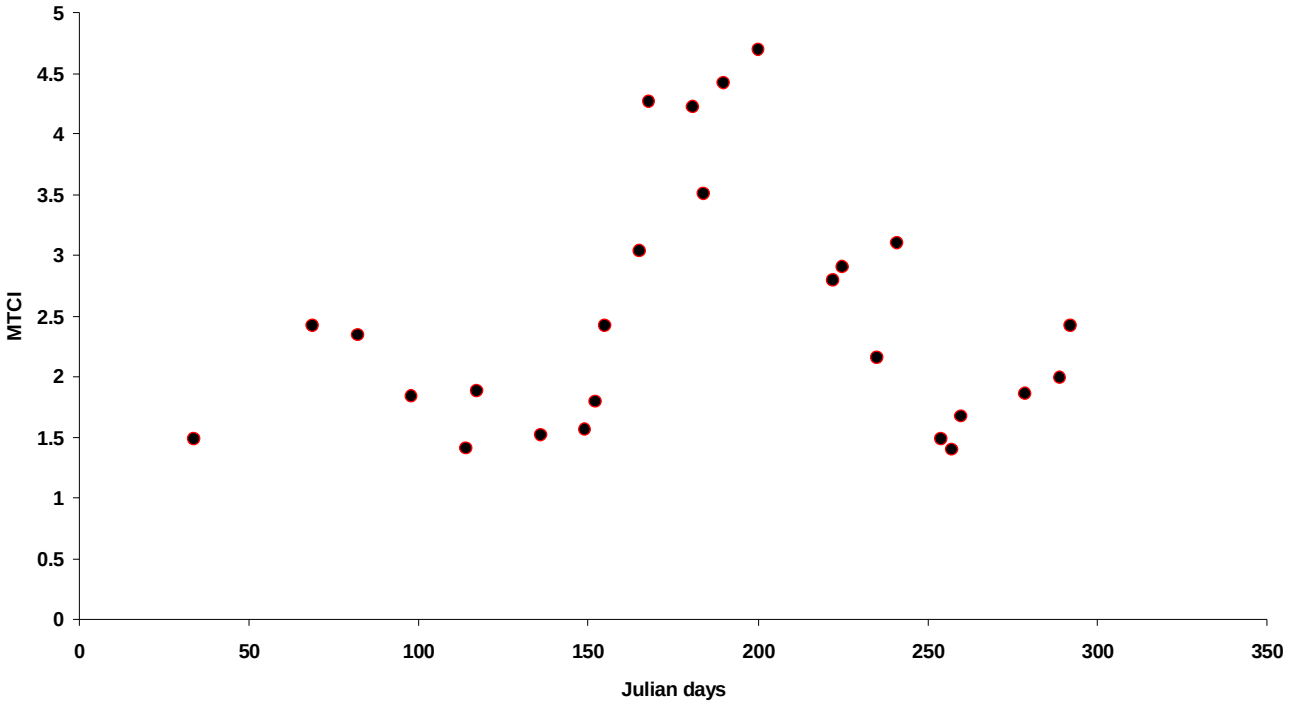
New Forest

Country: United Kingdom
Site: Mixed forest
Dominant species: Oak, Pine, Heath



Pavia

Country: Italy
Site: Agriculture
Dominant species: Rice



Surrogate chlorophyll content

Aims

(i) Determine relationship between Agent Orange deposition and current MTCI in forests

(ii) Identify defoliation hotspots

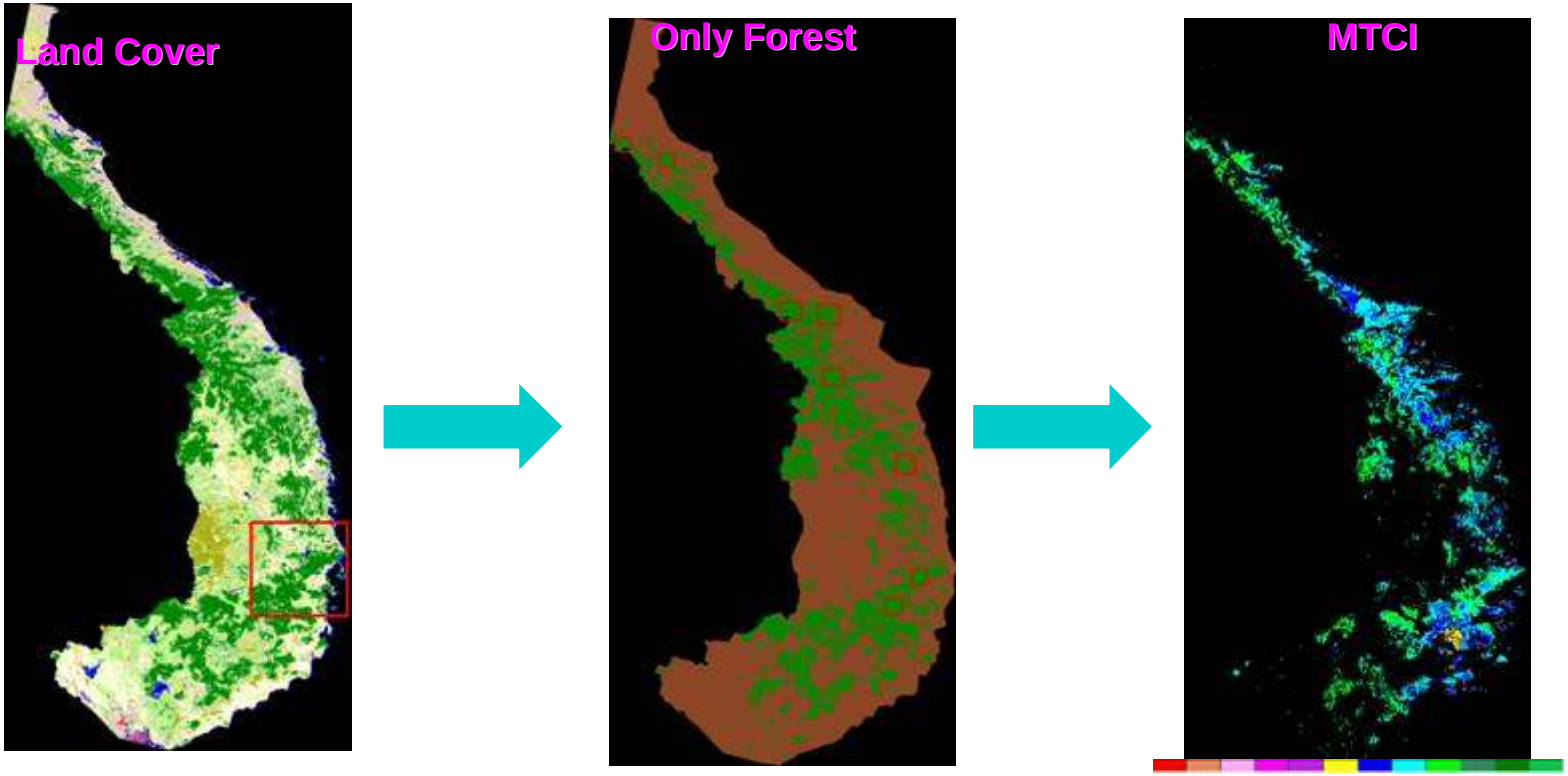
Inputs

(i) MERIS images covering southern Vietnam

(ii) Agent Orange data (HERBS files)

(iii) Land cover and topography

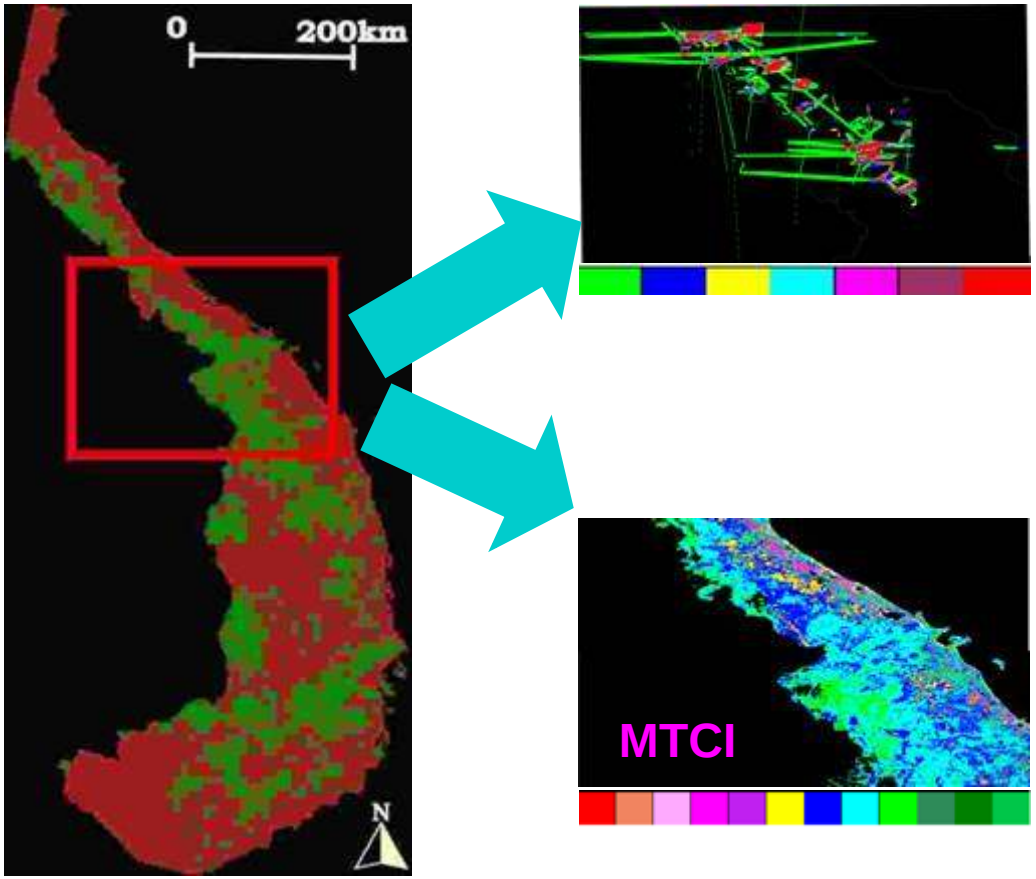
Surrogate chlorophyll content



Surrogate chlorophyll content

- Initial results for 10 provinces: negative relationship between Agent Orange deposition and MTCI

- Further per-pixel investigation of the Agent Orange deposition / MTCI relationship is underway for large forest regions



Non-canopy variables: use a mix of leaf / vegetation canopy / atmospheric models and MERIS data to investigate the effects of the following on the MTCI / chlorophyll content relationship

- Spatial resolution
- Soil brightness
- Atmospheric scattering
- Atmospheric absorption
- Solar & sensor angle / azimuth

Conclusions

- The MTCI is the second of two land products from MERIS
- MTCI is conceptually simple and is related to chlorophyll content; chlorophyll content is, in turn, related to vegetation condition
- Evaluations, preliminary and ongoing are encouraging
- Prediction: remote sensing conferences in 2005 / 6 will see further evaluations of the MTCI