SENSORIAMENTO REMOTO AGRÍCOLA: ANÁLISES QUANTITATIVAS

Projeto PROCAD

Rogério C. Campos

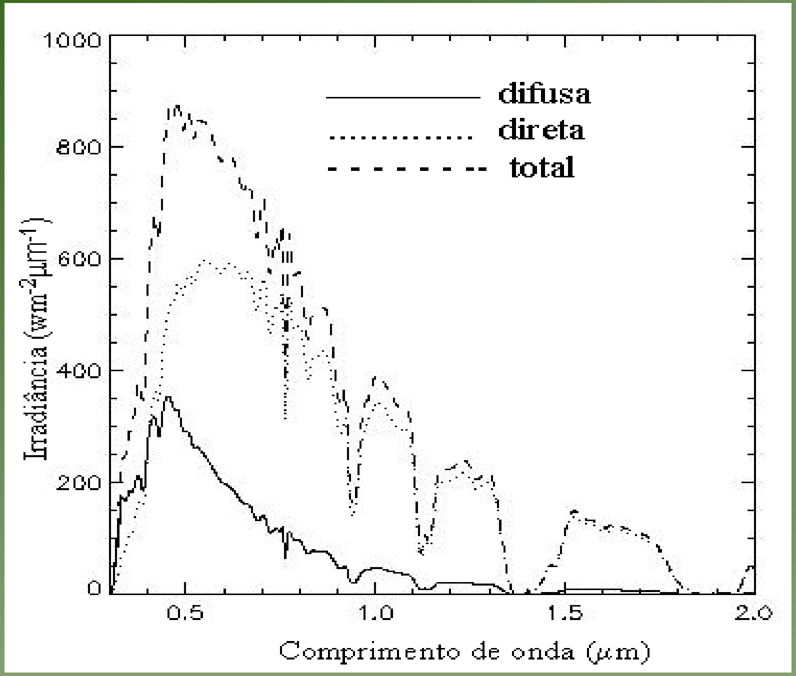
SENSORIAMENTO REMOTO DO FUNCIONAMENTO DA BIOSFERA

✓ **Atmosfera, Superfície e Habitabilidade**

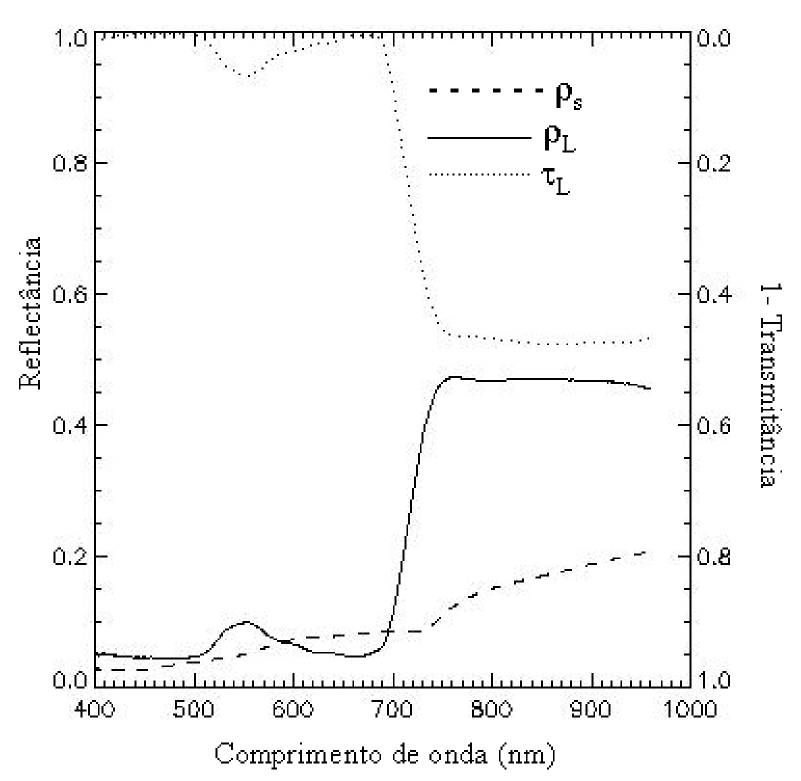
✓**Programas (International Geosphere Biosphere Program)**

✓**Definições sobre demanda e análise dos dados (*feedback* da comunidade científica)**

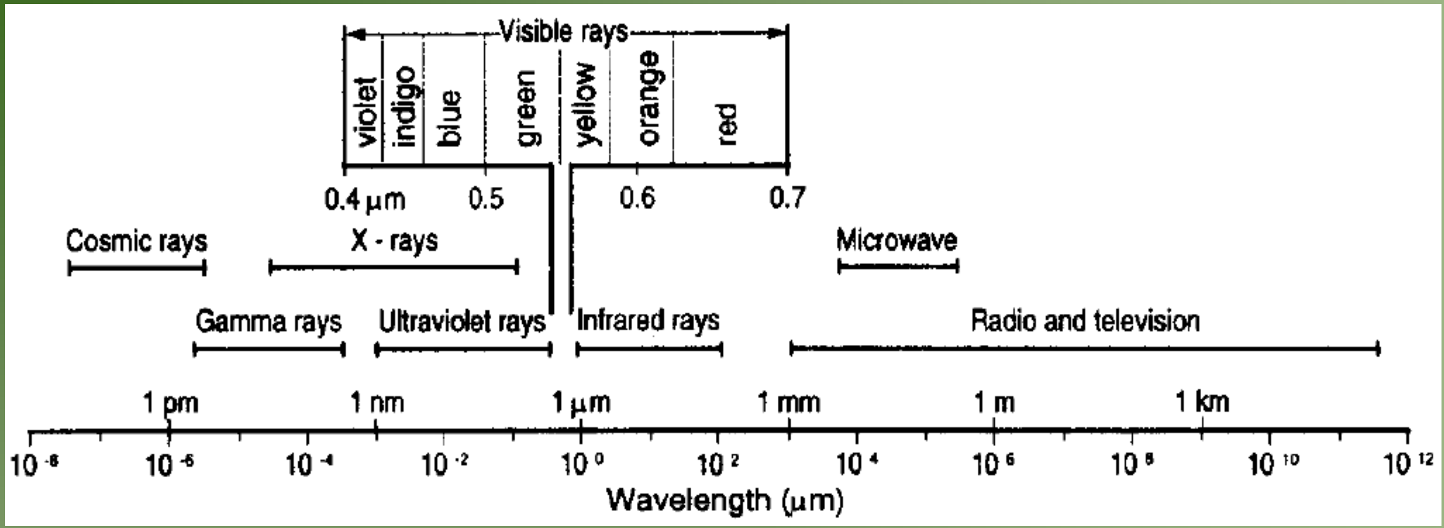
Princípios físicos - natureza e propriedade da radiação



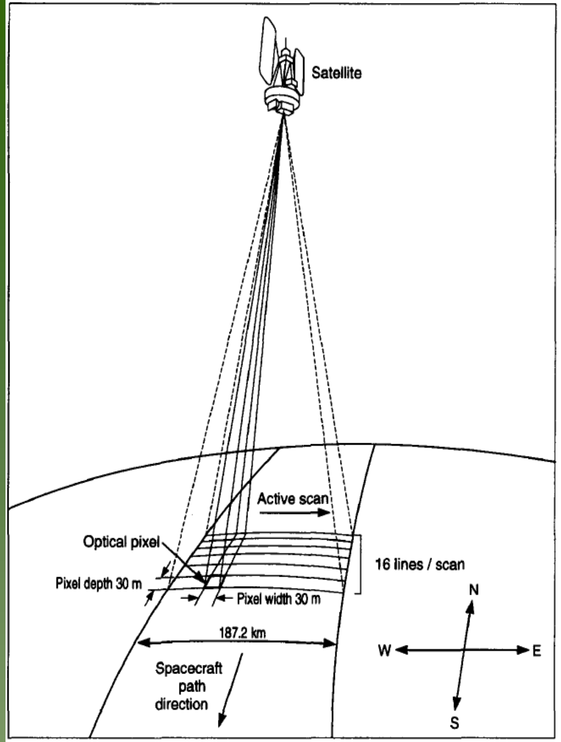
Princípios físicos - proriedade óptica do alvo



CONDIÇÕES AGRONÔMICAS



- ✓Monitoramento do estado (condição) vegetação: RER
- ✓Condições do ambiente de produção: REE (Emissão)
- ✓Umidade do solo: REM (Microondas)
- ✓Estress Ambiental: RER e REE (Reflexão e Emissão)



NÍVEIS DE AQUISIÇÃO DE DADOS

FieldSpec Pro FR

Spectron SE-590 esfera integradora Li-Cor 1800-12S

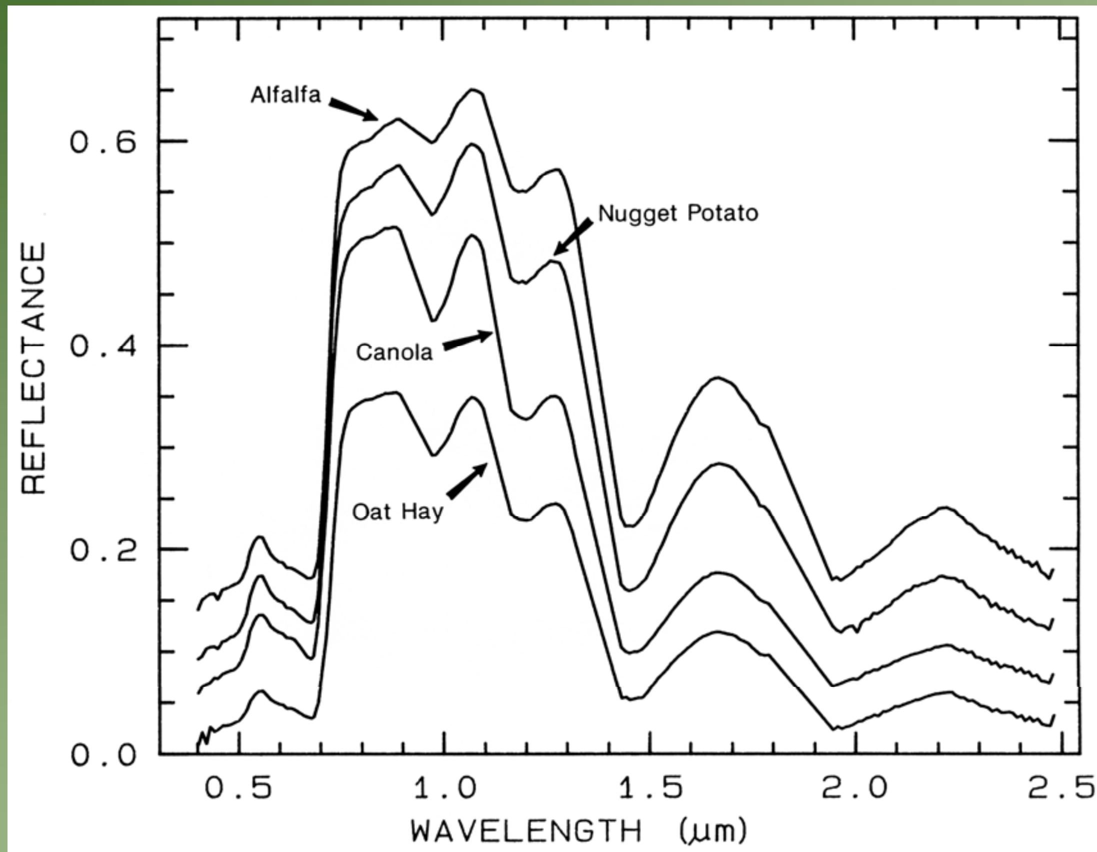
CONFIGURAÇÕES (CAPACIDADE/RESOLUÇÕES)

Satellite: sensor	*Channel no.*	*Spectral resolution*	*Spatial resolution (m) at nadir*	*Sample swath*	*Repeat cycle*	*Lifetime*
GMS:VISSR[a]	1	500–750 nm	1250	hemisphere	hourly	1978–present
	2	10·5–12·5 μm	5000			
NOAA:AVHRR[b]	1	580–680 nm	1100	2700 km	every 12 h	1981–present
	2	725–1100 nm	1100			
	3	3·55–3·93 μm	1100			
	4	10·5–11·3 μm	1100			
	5	11·5–12·5 μm	1100			
LANDSAT:MSS[c]	4	500–600 nm	80	185 km	every 16 d	1972–present
	5	600–700 nm	80			
	6	700–800 nm	80			
	7	800–1100 nm	80			
LANDSAT:TM[d]	1	450–520 nm	30	185 km	every 16 d	1983–present
	2	520–600 nm	30			
	3	630–690 nm	30			
	4	769–900 nm	30			
	5	1·55–1·75 μm	30			
	7	2·08–2·35 μm	30			
	6	10·4–12·5 μm	120			

The Question

What plant species are present in a remote sensing image?

Species Identification



Not all vegetation looks the same! We can use this to help identify different species using RS.

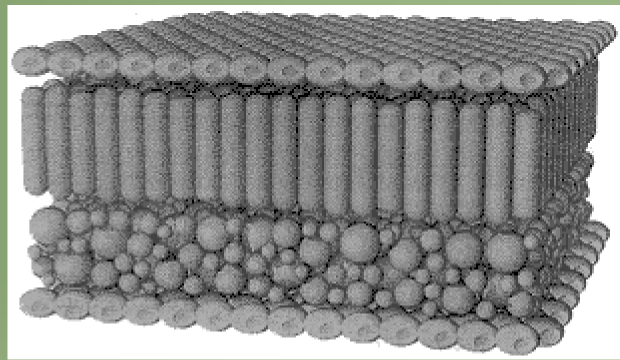
Species Identification

Why do the spectra of different species vary?

- Cellular differences (protein, cellulose and lignin, water, pigments, etc…) **{factor 1, scattering/absorbing properties of canopy components (leaves)}**
- LAI, leaf angle, and leaf shape differences **{factor 2, architecture}**
- Trunk, stem and branch differences (size, number, color) **{factor 2, architecture}**
- Crown size and shape **{factor 2, architecture}**

Cellular Differences

- PROSPECT (Jacquemoud et al., 1996): models the light path through a simulated leaf with differing structural and chemical properties.
  - Structural differences included rough, medium and smooth epidermis
  - Chemical differences included differences in protein, cellulose and lignin, and water.
- The structural and chemical properties were derived from real leaves.
- Found differences in modeled reflectance with different properties, and these matched real-world reflectance curves.

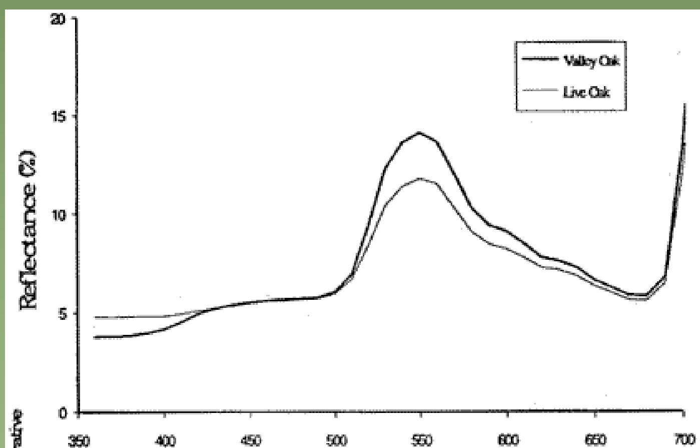


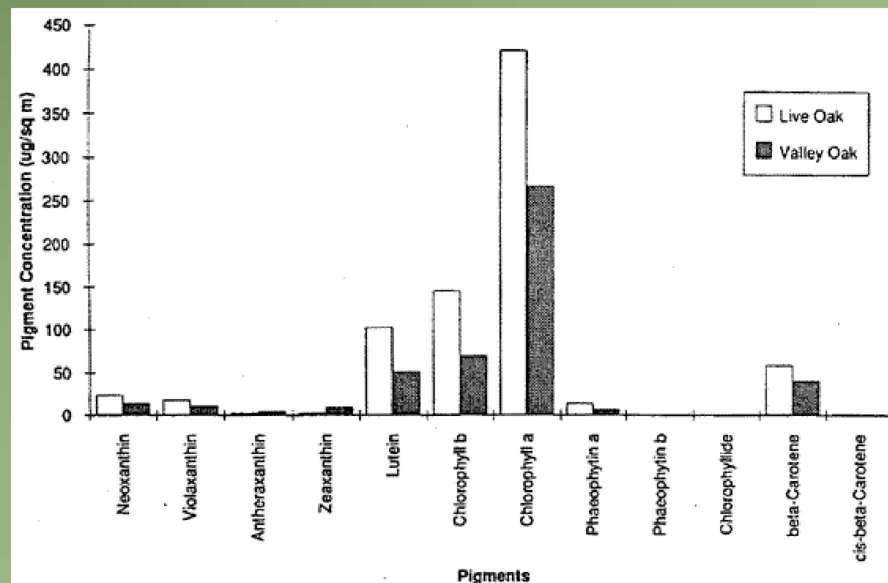
Factor 1: scattering/absorbing properties of canopy components (leaves)

Cellular Differences: Pigments

Pigments can and will vary between species, even closely related ones.

Mature Valley vs. Live Oak reflectance and pigment contents:



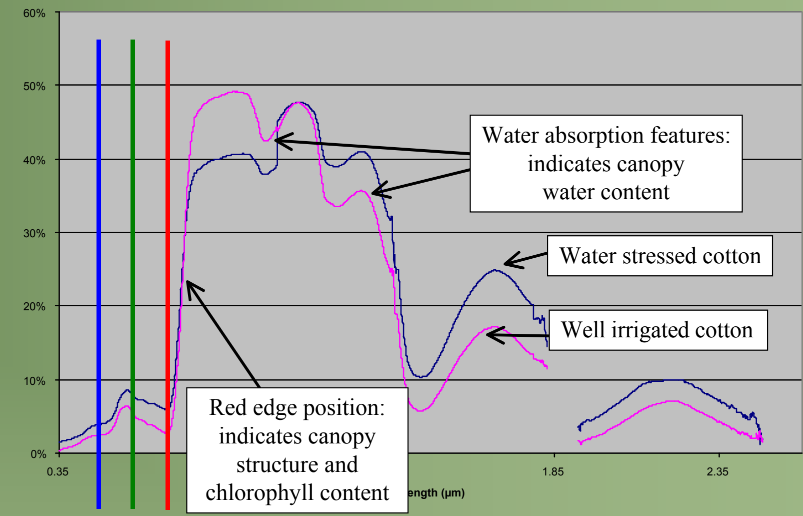


Ustin et al. 1998

Factor 1: scattering/absorbing properties of canopy components (leaves)

Cellular Differences: Water

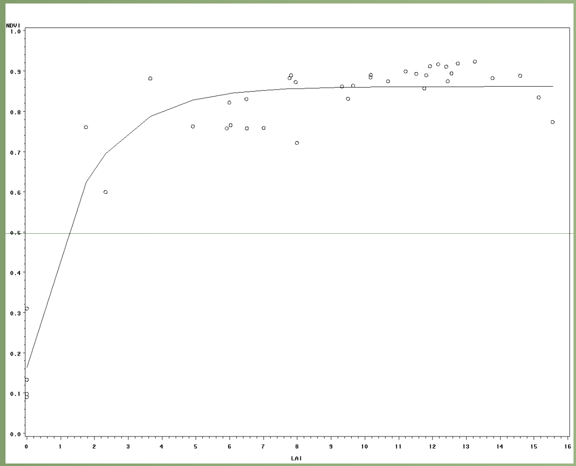
- Water absorption features can help determine the amount of water in a leaf.
- Water differences can indicate different species, or different stress levels within a species.

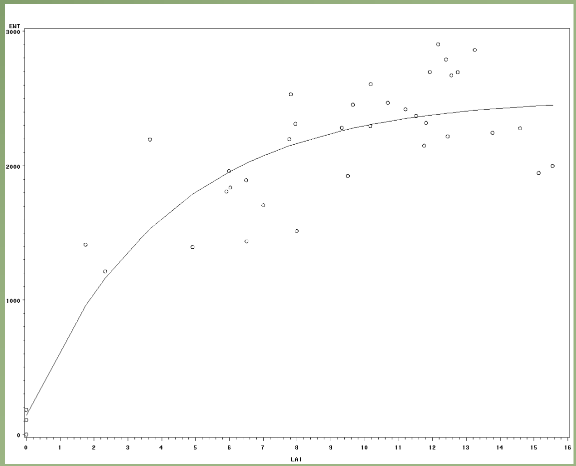


Greenberg et al. 2001, healthy and water stressed cotton spectra.

Canopy Level Differences, LAI

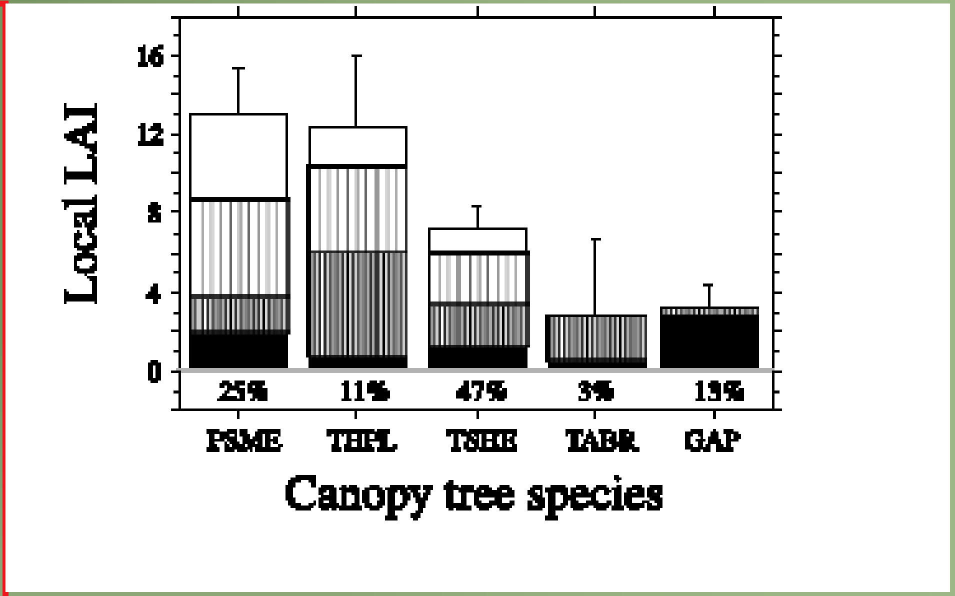
- All things being equal, LAI intercepts light according to Beer's Law in the visible.
- Detection of LAI usually requires indices or proxy variables:
  - NDVI vs. LAI
  - EWT vs. LAI (Roberts et al., in review)





Canopy BRF & LAI Differences

- The relationship between LAI and canopy reflectance depends on species, age/growth, scale of measurement, distribution of leaves in a crown, leaf angle distribution, and many other factors.
- *==>> Key Point:* LAI is important, but differences in LAI do not necessarily mean differences in species nor differences in canopy reflectance — and vice versa.



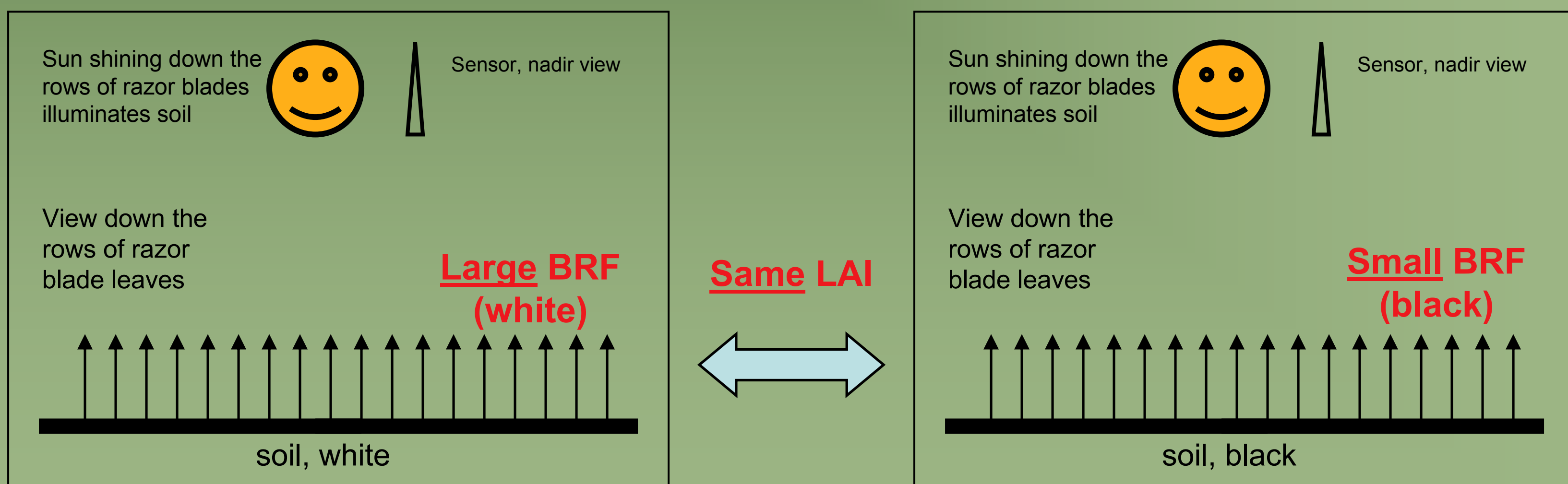
LAI vs. canopy species at WRCCF, Thomas and Winner 2000. Shading refers to different canopy strata.

Canopy BRF & LAI Differences

Consider 'pathological' example A: Two 'razor blade' canopies...

- Factor 1, Same leaves (black), different soil (white/black)
- Factor 2, Same 'LAI' in each canopy.
- Factor 3, Same view/illumination directions

- One canopy LAI value corresponds to two canopy reflectances
- ==>> Conclusion: the relationship between BRF and LAI is not unique <<==



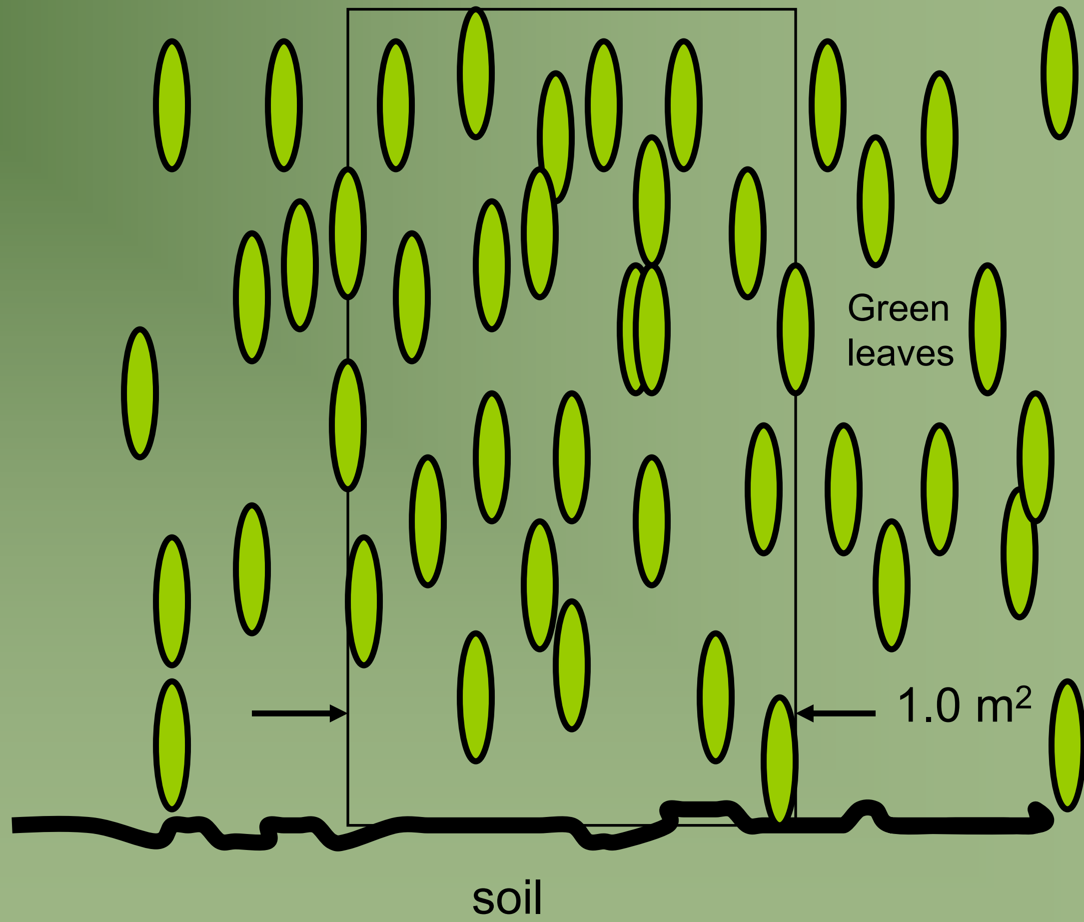
Factor 2: architecture, examples

LAI and Ecosystems

Vegetation Type	Dominant Species	LAI	Source
Temperate deciduous forest	*Quercus, Castanea, Carpinus Populus, Fagus* spp.	1.8 - 7.7	Dufrene and Breda (1995)
Temperate deciduous forest	*Quercus rubra, Acer rubrum*	3.2 - 5.5	M. Martin, *pers. comm.*
Temperate deciduous forest	*Quercus and Acer* spp.	5.0, 0.75*	Hutchison et al. (1986)
Temperate deciduous woodland	*Castanea sativa*	1.5 - 11.0	Ford and Newbould (1971)
Temperate evergreen forest	*Nothofagus solandri*	5.5 - 7.9	Hollinger (1989)
Temperate grassland	*Sorghastrum nutans, Panicum virgatum, Andropogon gerardii*	1.2 - 3.3	Welles and Norman (1991)
Temperate grassland	*Avena, Bromus, Stipa* spp., others	0.2 - 1.2	Gamon et al. (1995)
Temperate grassland	*Andropogon* spp., *Sorghastrum nutans*	0.5 - 3.5	Asrar et al. (1984)
Tropical deciduous forest	*Guapira macrocarpa, Plumeria rubra, Lonchocarpus constrictus, Bursera instabilis,* others	3.3 - 5.4	Maass et al. (1995)
Tropical grassland/pasture	*Brachyaria* and *Pennisetum* spp.	0.25 - 9.1	Asner and Townsend (*unpub.*)
Tropical moist forest[1]	many - Amazon Basin	3.8 - 7.1	Asner and Townsend (*unpub.*)
Tropical rain forest	*Micrandra, Eperua*, many others	2.8 - 9.8	Klinge and Herrera (1983)
Tropical rain forest	many - Amazon Basin	5.2 - 7.5	Jordan and Uhl (1978) Saldarriaga (1985)
Tropical rain forest[1]	not given - Puerto Rico	2.2 - 8.6	Jordan (1969)
Tropical rain forest[1]	*Cecropia, Vismia, Miconia* spp.	3.4 - 4.8	Honzak et al. (1996)

Definition of Leaf Area Index, LAI

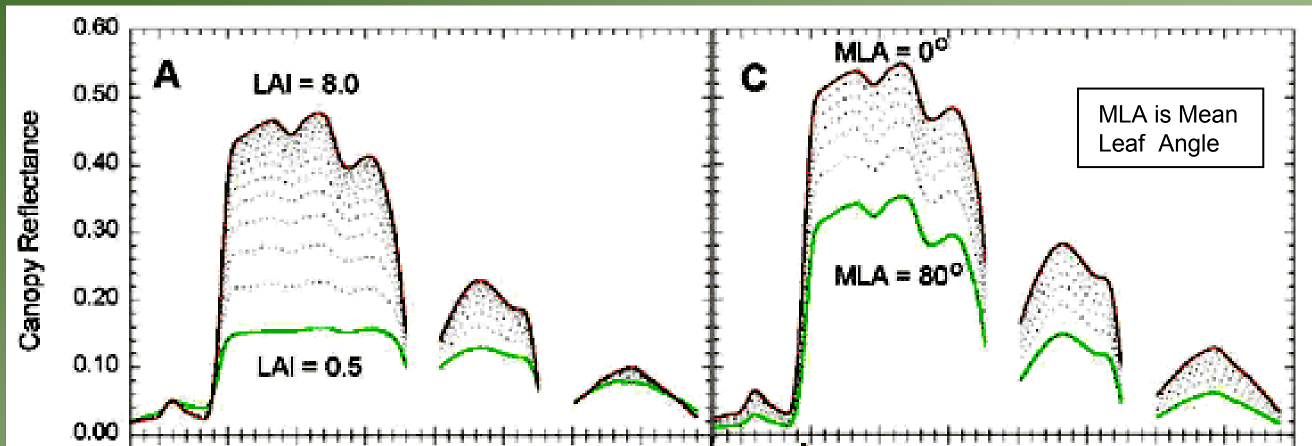
- One sided green leaf area per unit ground area
- Example: Total square meters of one side of green leaves above 1.0 square meter of soil
- LAI units: [m^2 of leaf area]/[m^2 of ground] e.g. dimensionless



Leaf Angles Distribution

- Plants can dynamically change the angle of their leaves to increase or decrease the amount of EMR (and increase or decrease the heat loading).
- Leaves range from planophile (horizontally oriented) to erectophile (vertically oriented).
- Leaf angle probability density function is approximately spherical in many canopies i.e. canopy leaf area is distributed in angle like the area on a sphere.
- The angle of incident solar radiation and the angle of the leaf affect the at-sensor reflectance.

LAI/Leaf Angle and Spectra



Spectral Index

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Asner, 1998

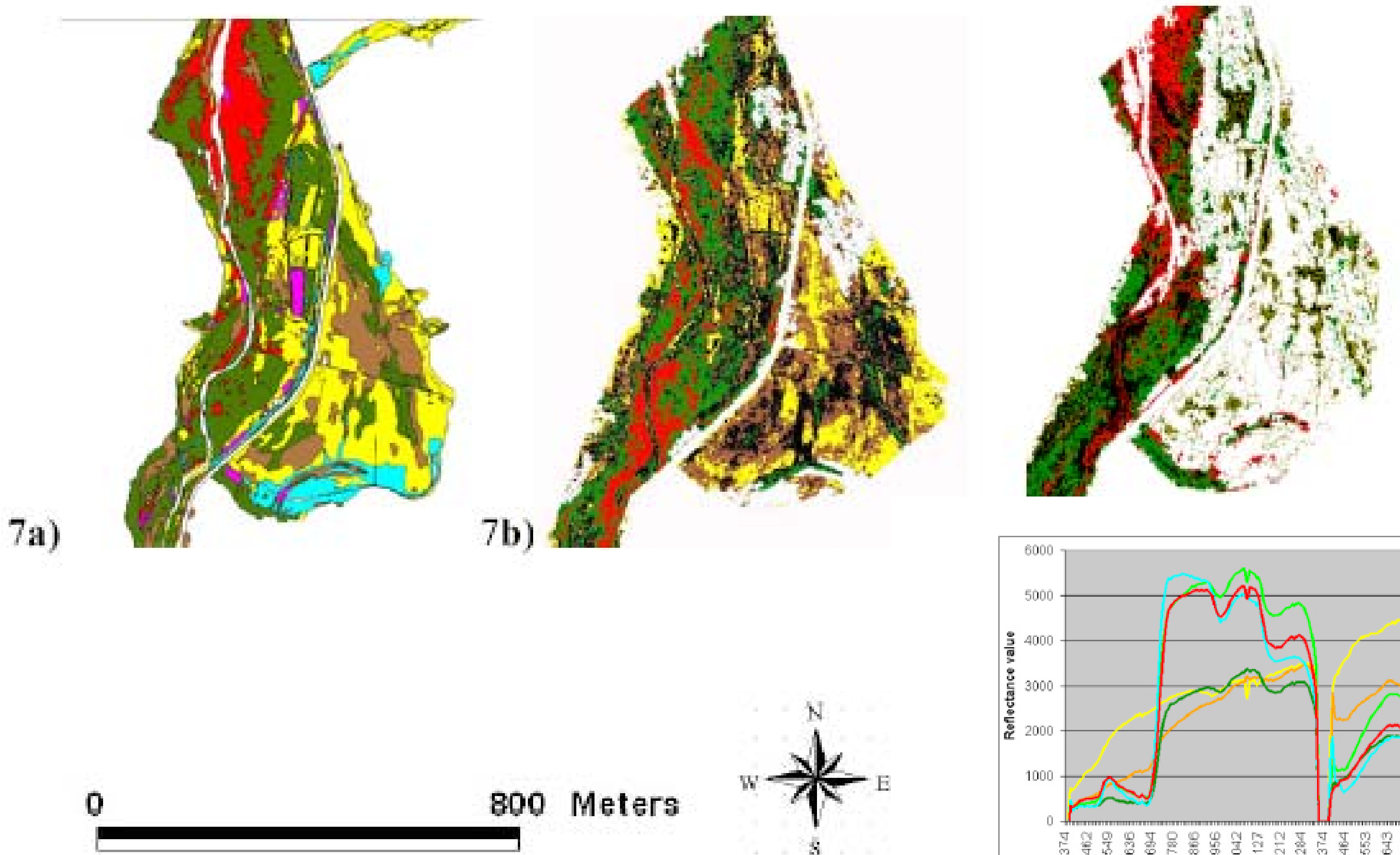
Factor 2: architecture

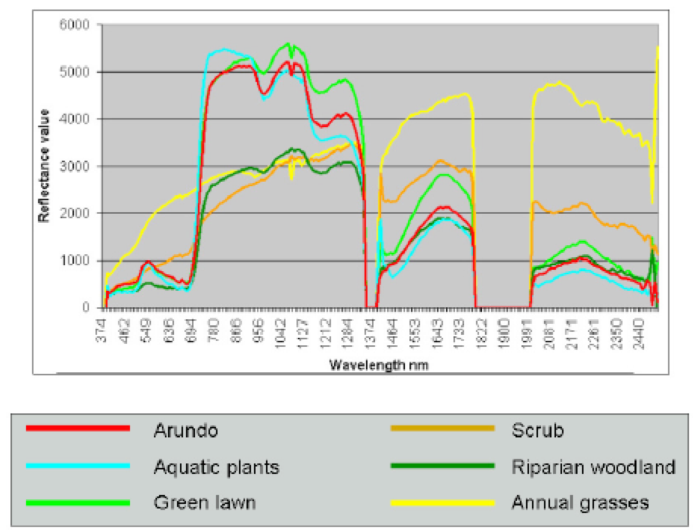
Crown Shape

- The shape of crowns is diagnostic of certain species.
- Example: coniferous (conical) vs. deciduous (spherical)
- Hyperspatial imagery can be used to assess the actual shape.

Putting it all together....example 1

Mapping Invasive Species



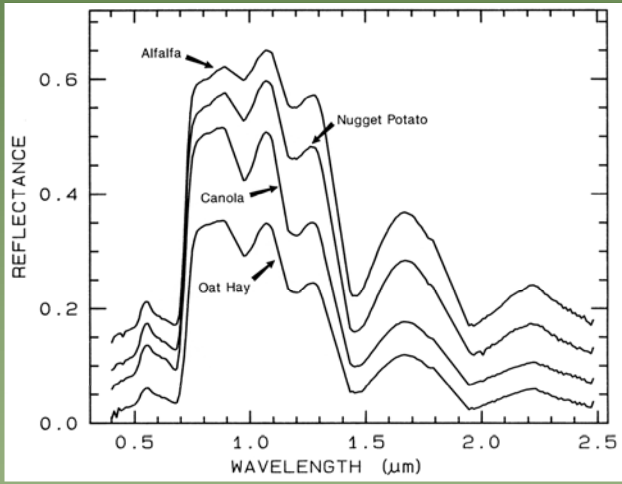


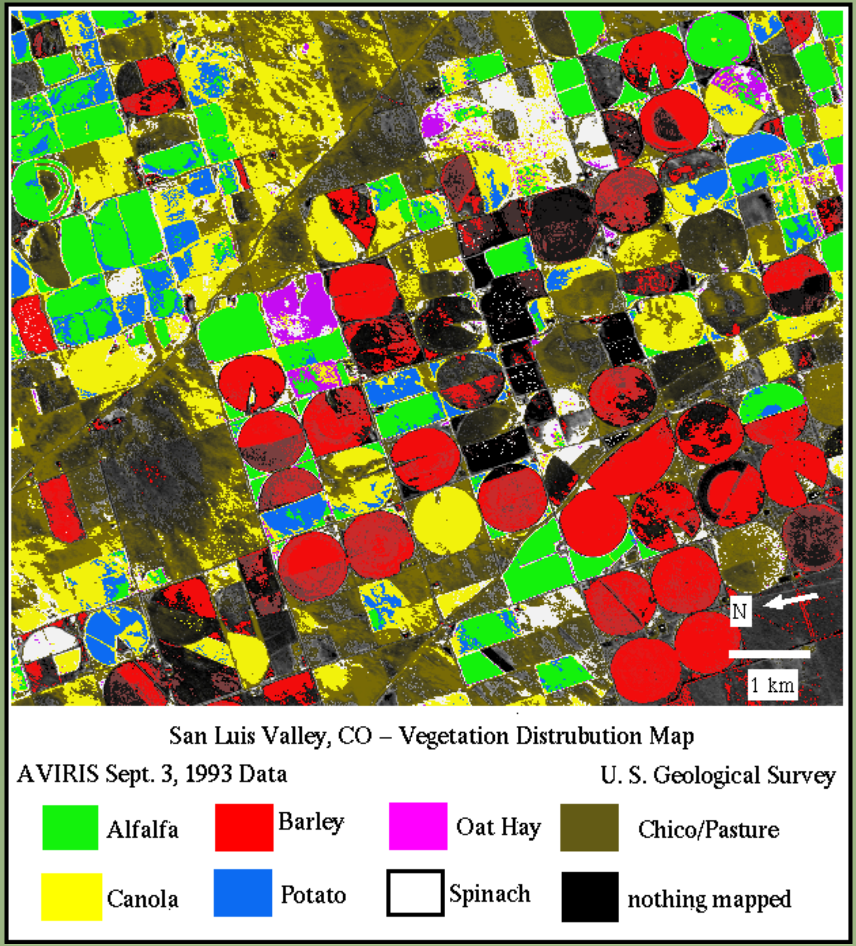
DiPietro, 2002

Putting it all together....example 2

Mapping Crop Types

- Clark et al. 1995: used AVIRIS, Tricorder and reference spectrum to differentiate different CO crops.



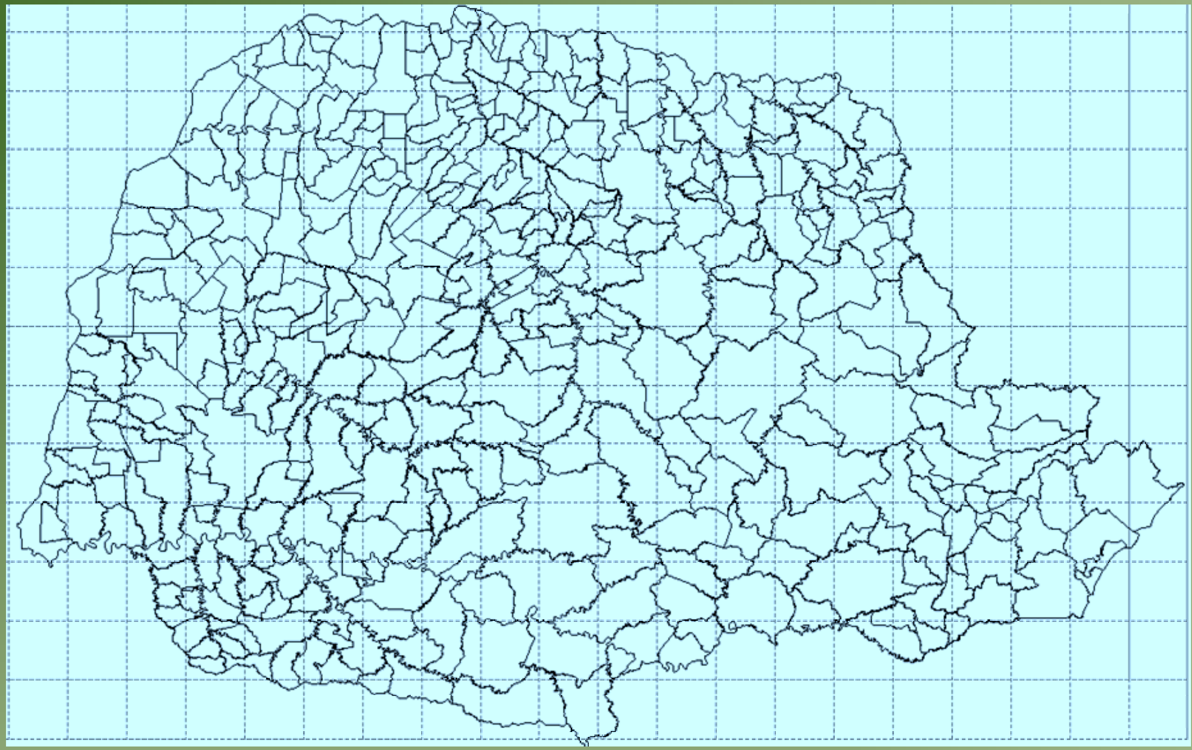


Mapeamento da soja no estado do Paraná

Universidade de São Paulo
Escola Superior de Agricultura “Luiz de Queiroz”
Grupo de Estudos em Seguro e Risco
Núcleo de Sensoriamento Remoto

Paraná

- $199.880\ km^2$
- Concentra 20% da produção nacional de soja



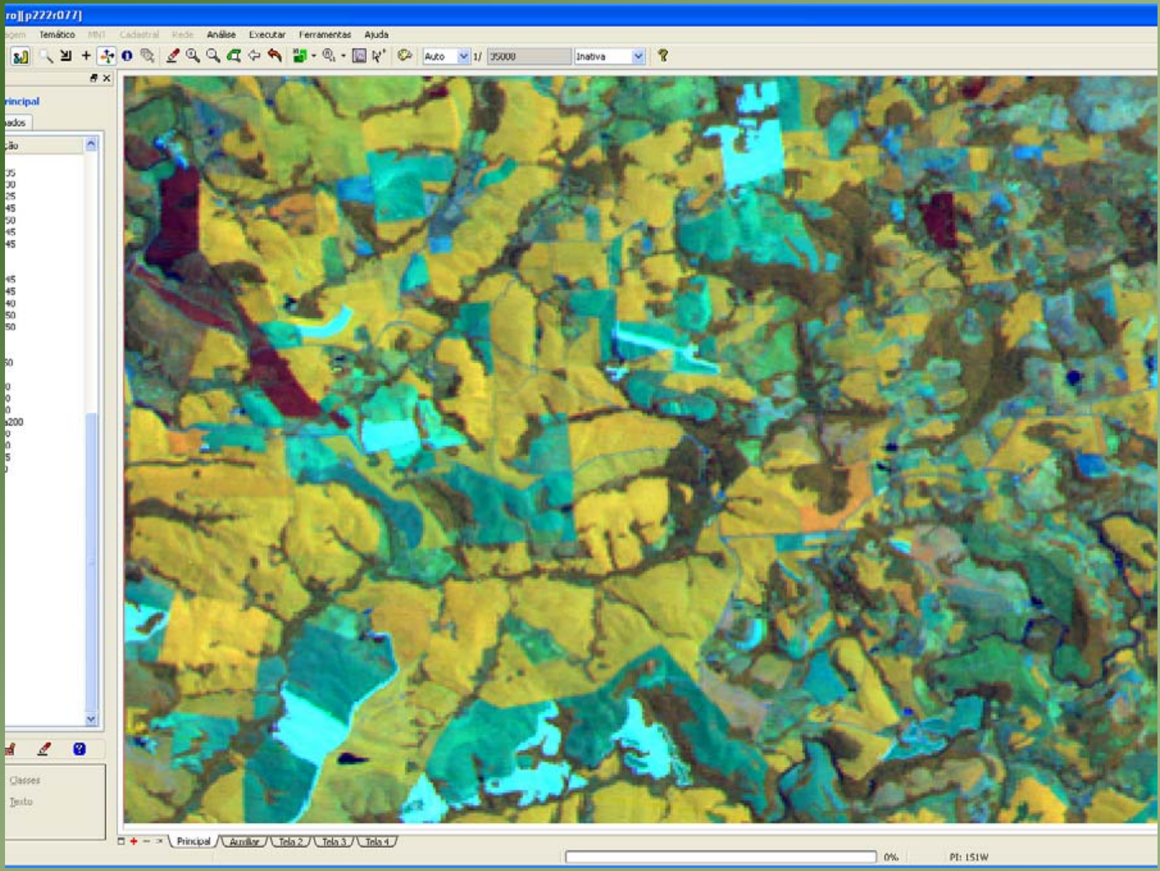
- Foi elaborada uma grade regular
- Cada unidade corresponde a uma variação de 20’ Norte/Sul e 20’ Leste/Oeste
- Cada unidade será mapeada separadamente
- No estado há um total de 179 unidades
- A área de cada uma equivale aproximadamente a 115 mil ha

Metodologia para o mapeamento

- Download dos dados –Imagens Landsat 5 TM bandas 3/4/5

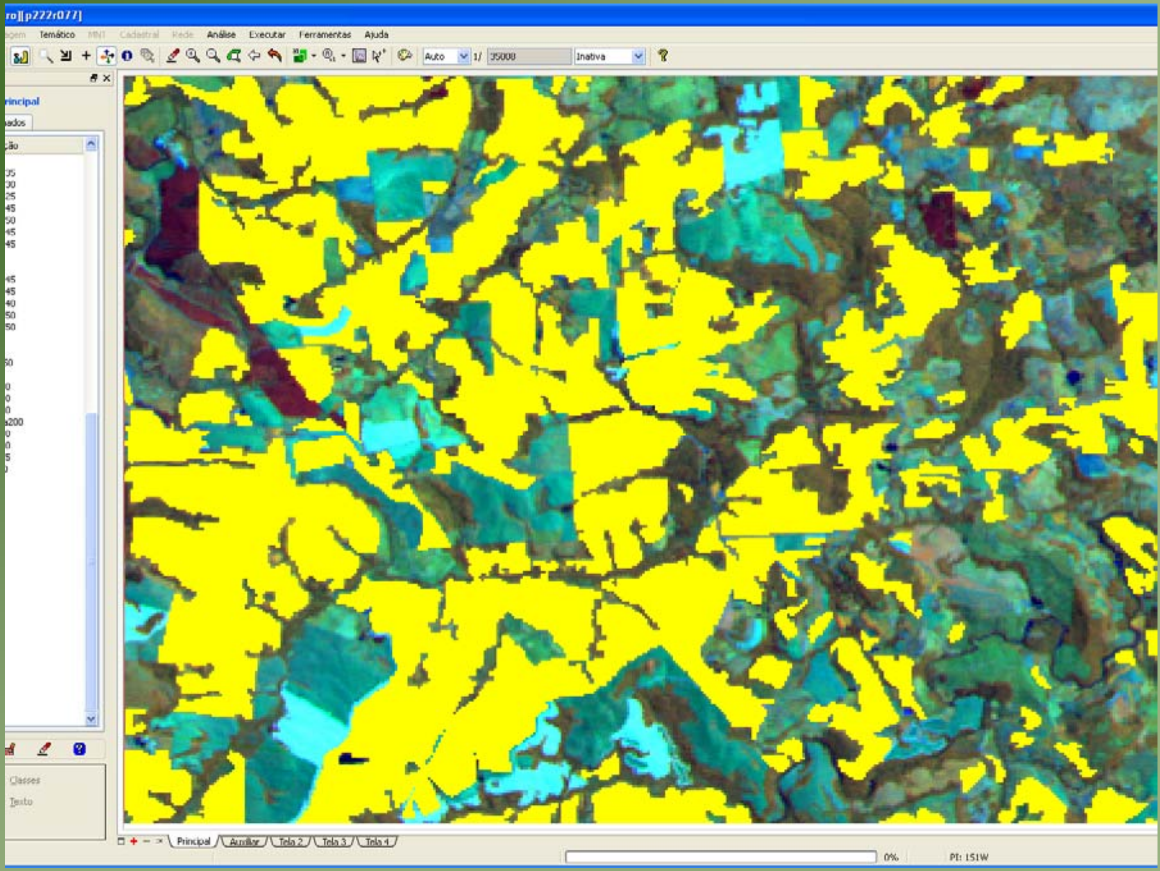
- Registro das imagens

- Processamento – 1)segmentação 2)classificação 3)edição



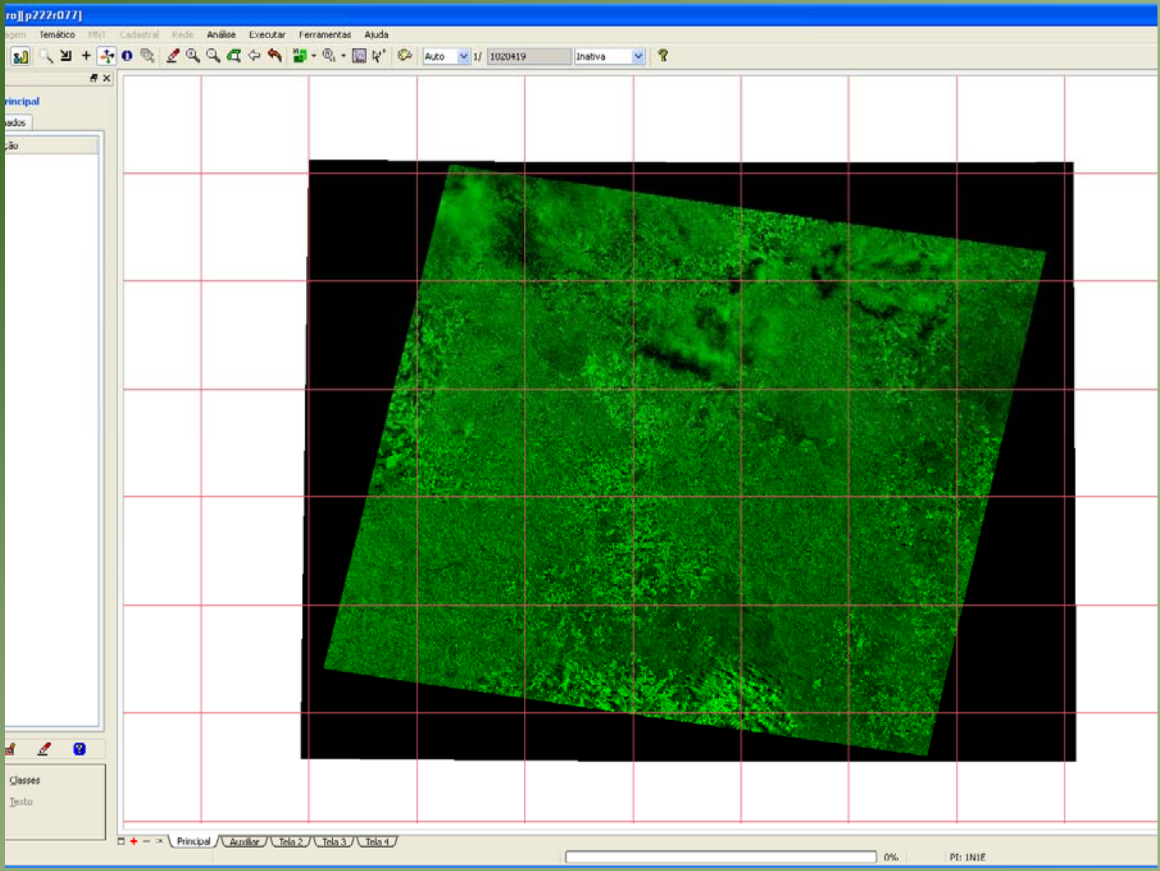
Landsat TM

Composição RGB-453,
vermelho:banda4
verde:banda5
azul:banda3



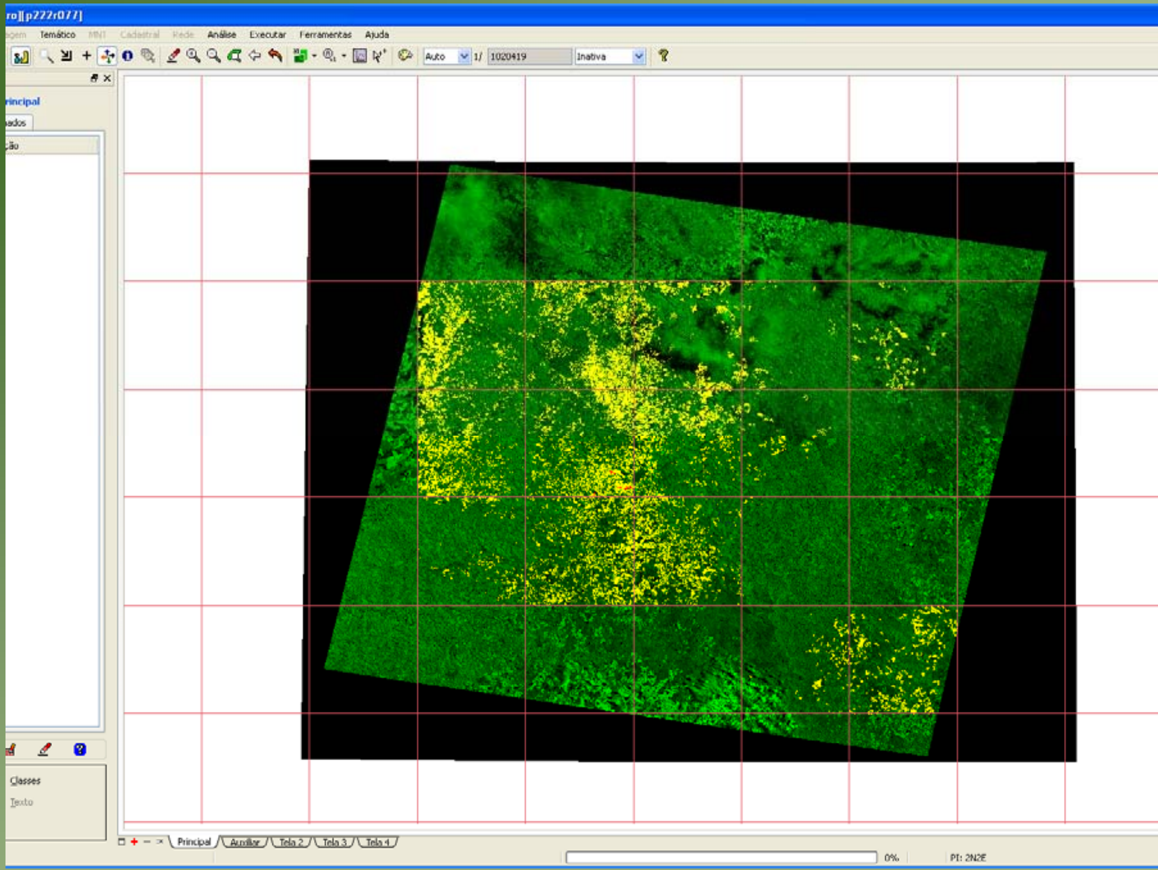
Landsat TM

Mapeamento das lavouras de soja



Landsat TM

Imagem da Orbita 222 Ponto 77, data 03/03/2009



Landsat TM

Imagem da Orbita 222 Ponto 77, data 03/03/2009, com soja mapeada

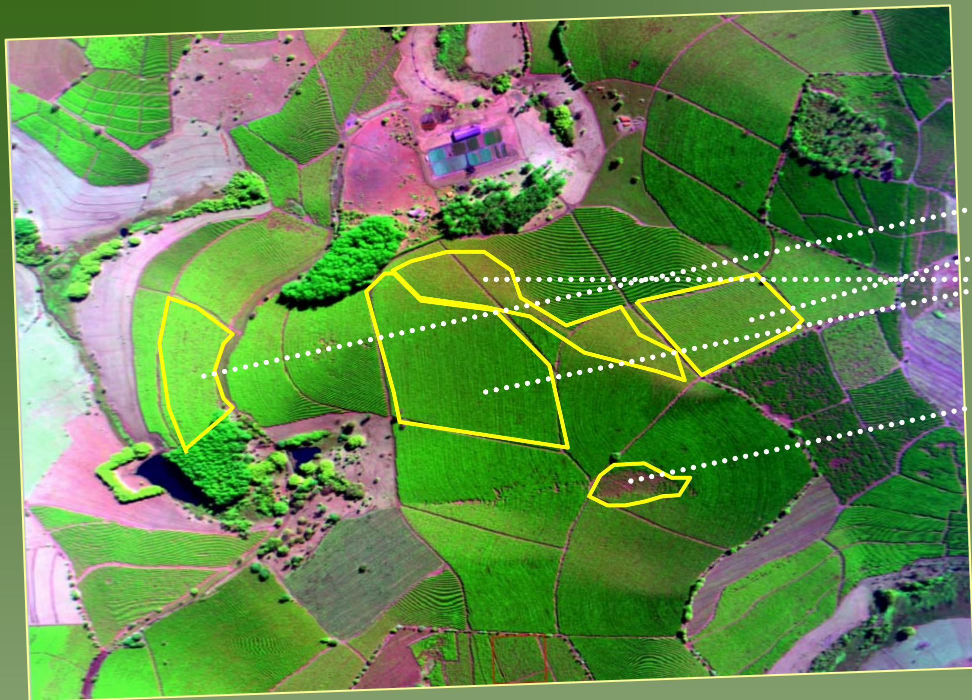
Limitações

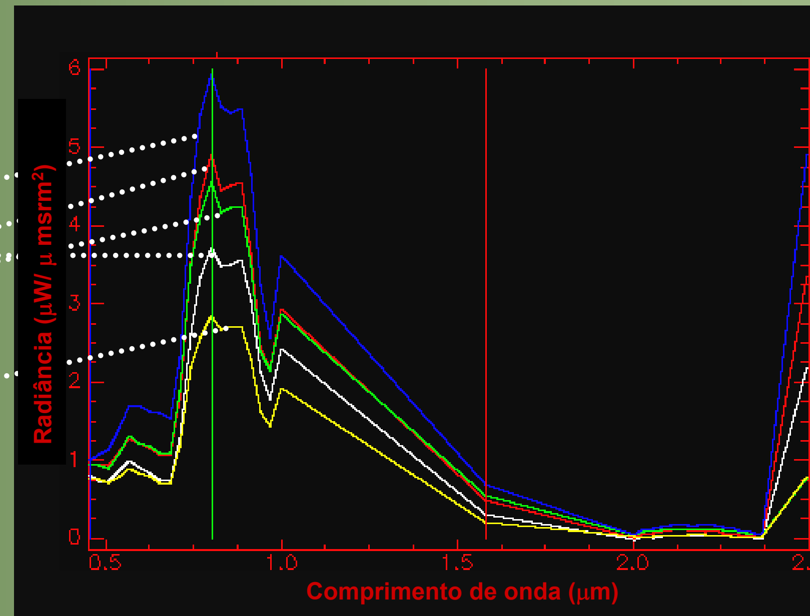
- Cobertura por nuvens
- Dependência de uma única fonte de dados(Landsat 5)
- Baixa resolução temporal

Expectativas futuras

- Aumentar resolução temporal (satélite MODIS)
- Prever área colhida mensalmente
- Agregar dados agrometeorológicos
- Estimar produtividade
- Expandir para todo Brasil

MODELOS EMPÍRICOS X MODELOS FÍSICOS





Parâmetros agronômicos externos

(altura da planta, dimensões da copa, espaçamento, direção do plantio, solo (substrato))

Parâmetros agronômicos internos

(IAF, DAF,Ca+b, água....)

Campo de radiação em estandes agrícolas esparsos

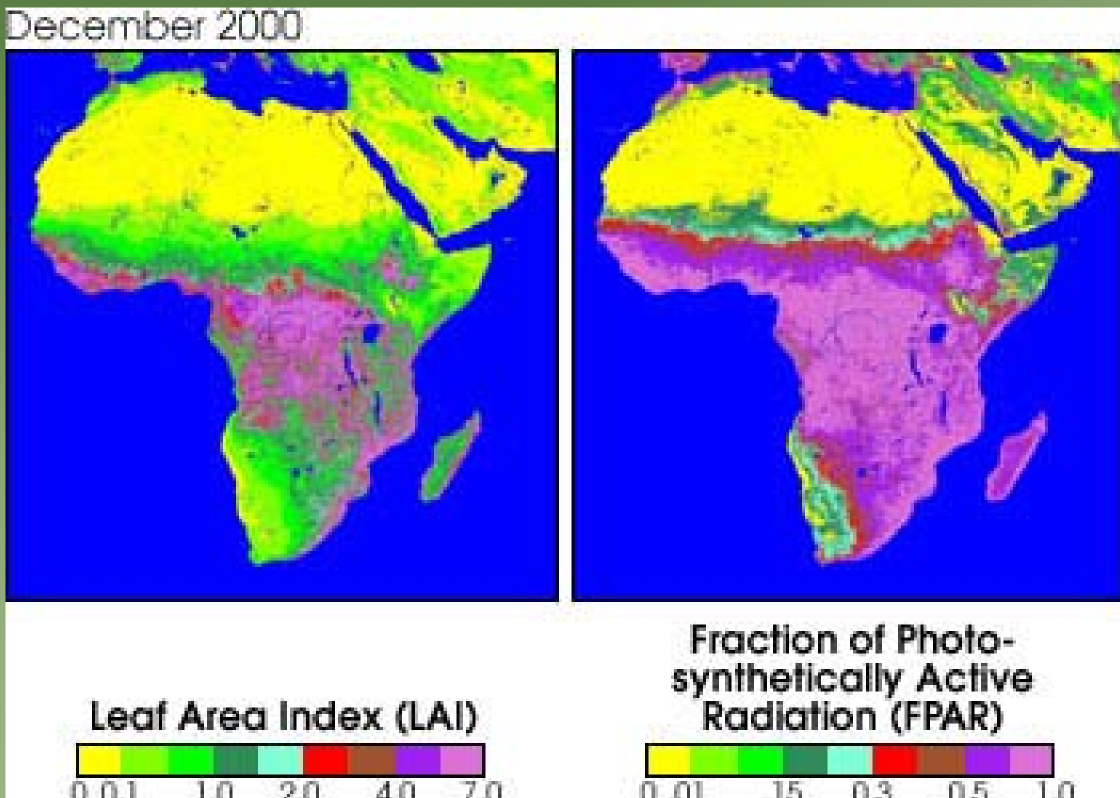
Topografia

Geometria de observação e iluminação

MT RADIAÇÂO

✓Estratégias para assimilar dados quantitativos de SR em modelos de funcionamento dos processos solo-vegetação-atmosfera

Base física de MTR



Qual a função do MTR?

Quais os critérios para a escolha do MTR?

Quais os *Inputs*?

HIPÓTESE DE MTR

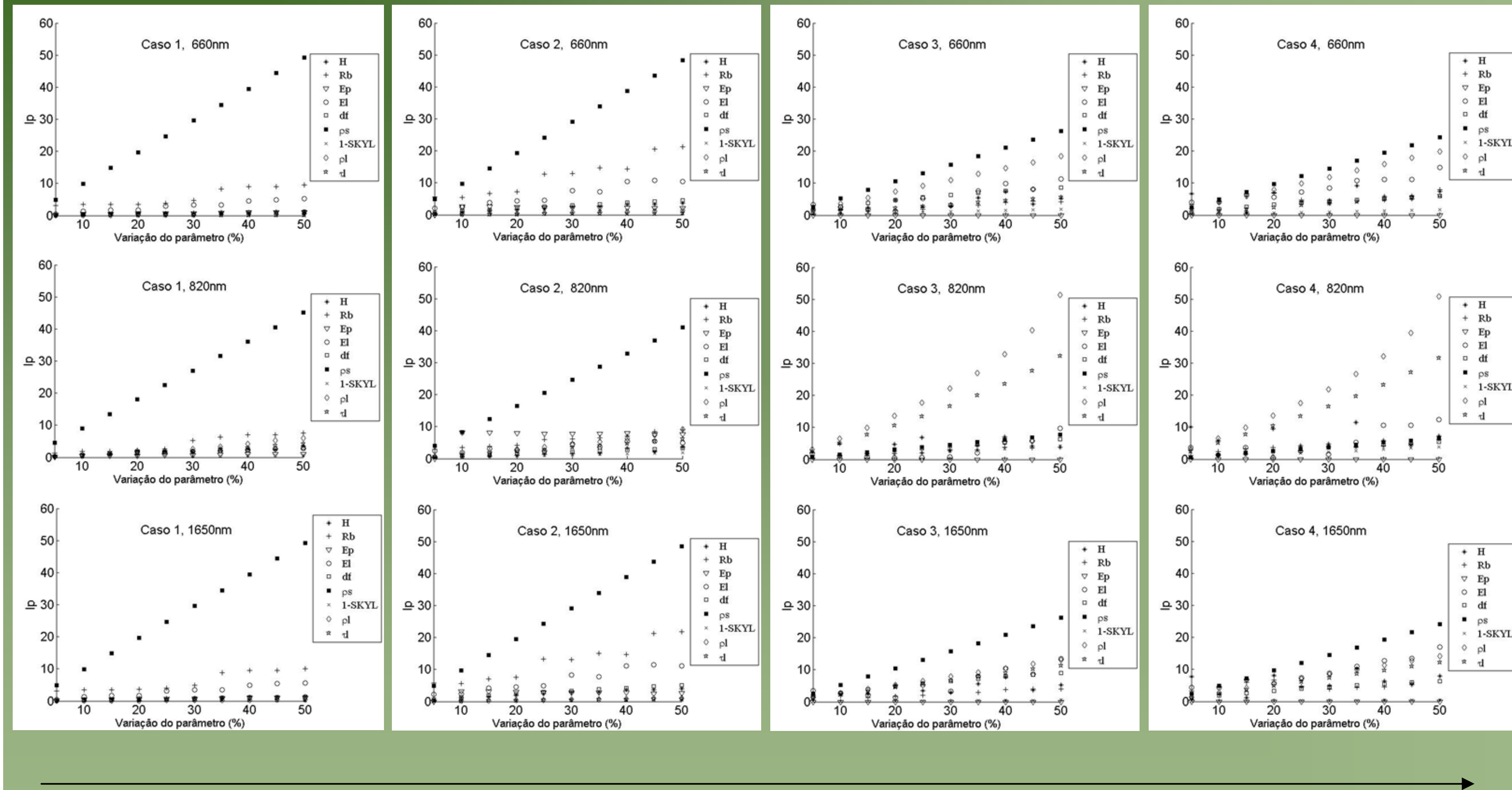
Ciclo de culturas anuais e semi-perenes

Problema direto – Modelagem física

FRB=MTR(Estrutura(ti), Geometria(ti), Bioquímica(ti))

Problema inverso – Inversão numérica

(Estrutura(ti), Geometria(ti), Bioquímica(ti))=Imagem(FRB)



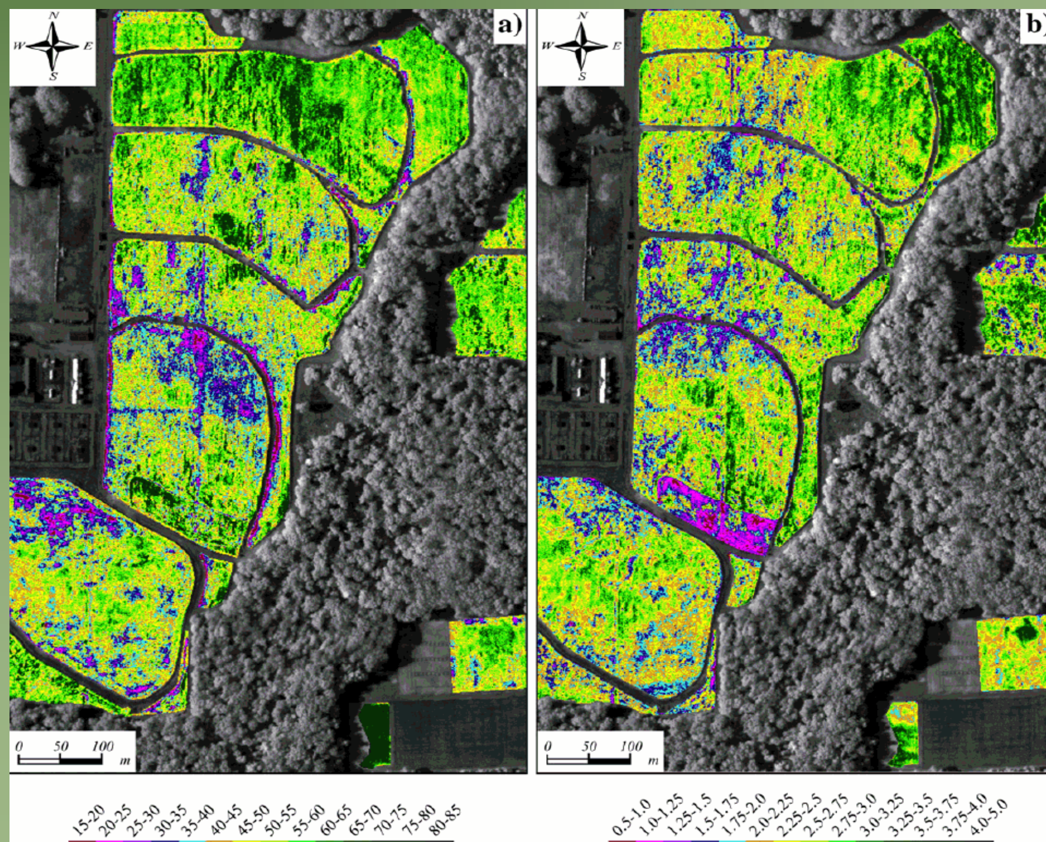
Crescimento das plantas

MT RADIAÇÂO: INTERCEPTAÇÃO-USO-RELAÇÕES BIOFÍSICAS

MTR - Aplicações do problema direto – Modelagem física

Correção dos valores de albedo
Correção do coeficiente de extinção
Indicação de favorabilidade

MTR - Aplicações do problema inverso – Inversão Numérica RNs ou LUTs



Clorofila µg cm^{-3} *IAF m2m-2*