The Role of Satellite Data in GEO-FCT

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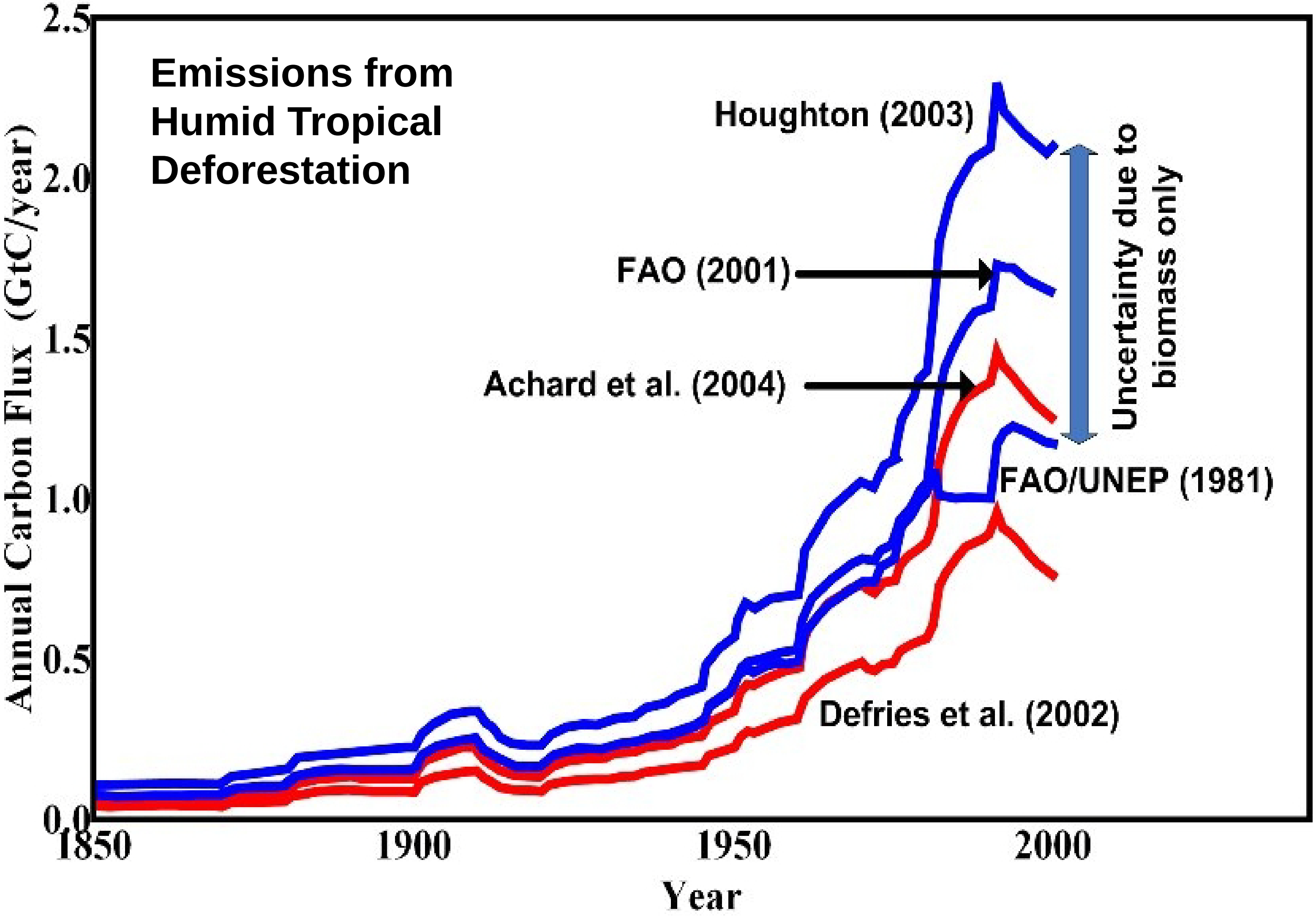
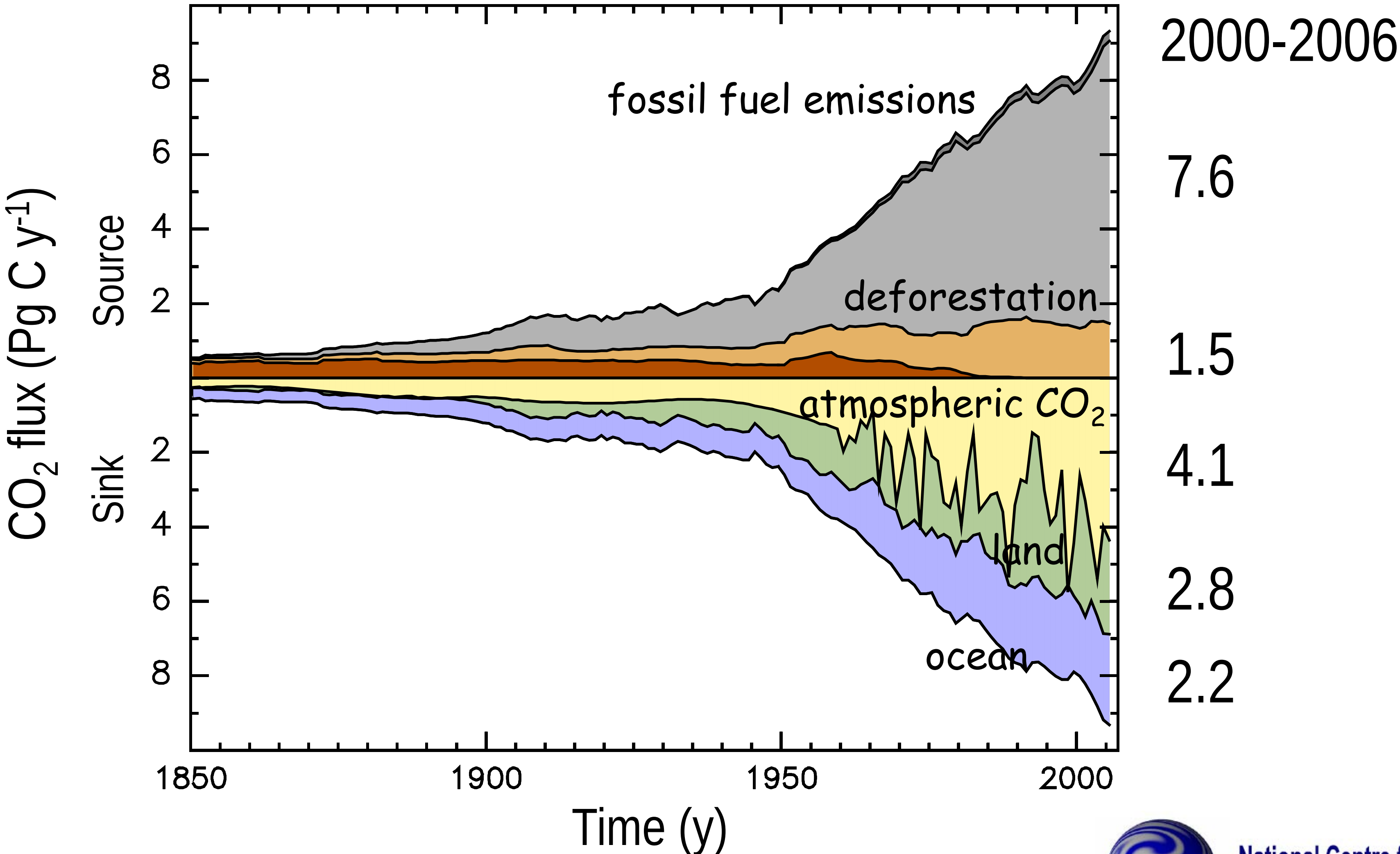
Uncertainty in emissions from humid tropics



Perturbation of Global Carbon Budget (1850-2006)



Le Quéré et al. 2009

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GEO-FCT: The Path to Implementation

The GEO FTC initiative will pave the way for countries to establish national MRV systems as part of a global network via eight main actions:

1. A commitment by CEOS members to provide satellite data, tools and training for national wall-to-wall forest carbon tracking.
2. Guide countries on methods and standards for data processing to produce forest information products.

The Path to Implementation

3. Guidance on linking ground measured forest inventories, remote-sensing data and carbon models.
4. Develop validation and accuracy assessment procedures for forested area and carbon stocks.
5. Grow the network of 'National Demonstrator' countries: Southeast Asia, Africa and South America.

Principles of FCT

The main goal of GEO-FCT is to support the establishment of national Monitoring, Reporting and Verification (MRV) systems, complying with IPCC guidelines.

To do this, signatory countries require:

(a) access to regular, secure and low cost satellite data to supplement available in-country ground data;

(b) methods to extract forest quantities from these data that can be applied within country;

(c) methods to exploit these data within country in GHG calculations (source & sink) through some form of model;

(d) methods to calibrate and verify these models.

A model = a machine turning DATA into a C flux ESTIMATE.

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Zeroth order model for carbon emissions from deforestation (Tier 1)

$CE = \Delta A \times B \times EF$

- CE = C emissions over a given time period
- ΔA = reduction in forest area caused by deforestation
- B = average above-ground biomass in C units (~ biomass x 0.5)
- EF = *emissions factor* giving the proportion of the available C that is converted to emissions; default value = 1.

Therefore

$$\frac{\Delta CE}{CE} = \frac{\Delta A}{A} + \frac{\Delta B}{B} + \frac{\Delta E}{E} + (\text{2nd order terms})$$

Other error sources, e.g., bias if deforestation selectively removes high biomass forests.

Adding more knowledge

When there are *n* types of forest ***and we have relevant data*** this can be expanded to:

$$\mathrm{CE} = \sum_{1}^{n} \Delta \mathrm{A}_i \times \mathrm{B}_i \times \mathrm{EF}_i$$

Degradation also needs to be accounted for:

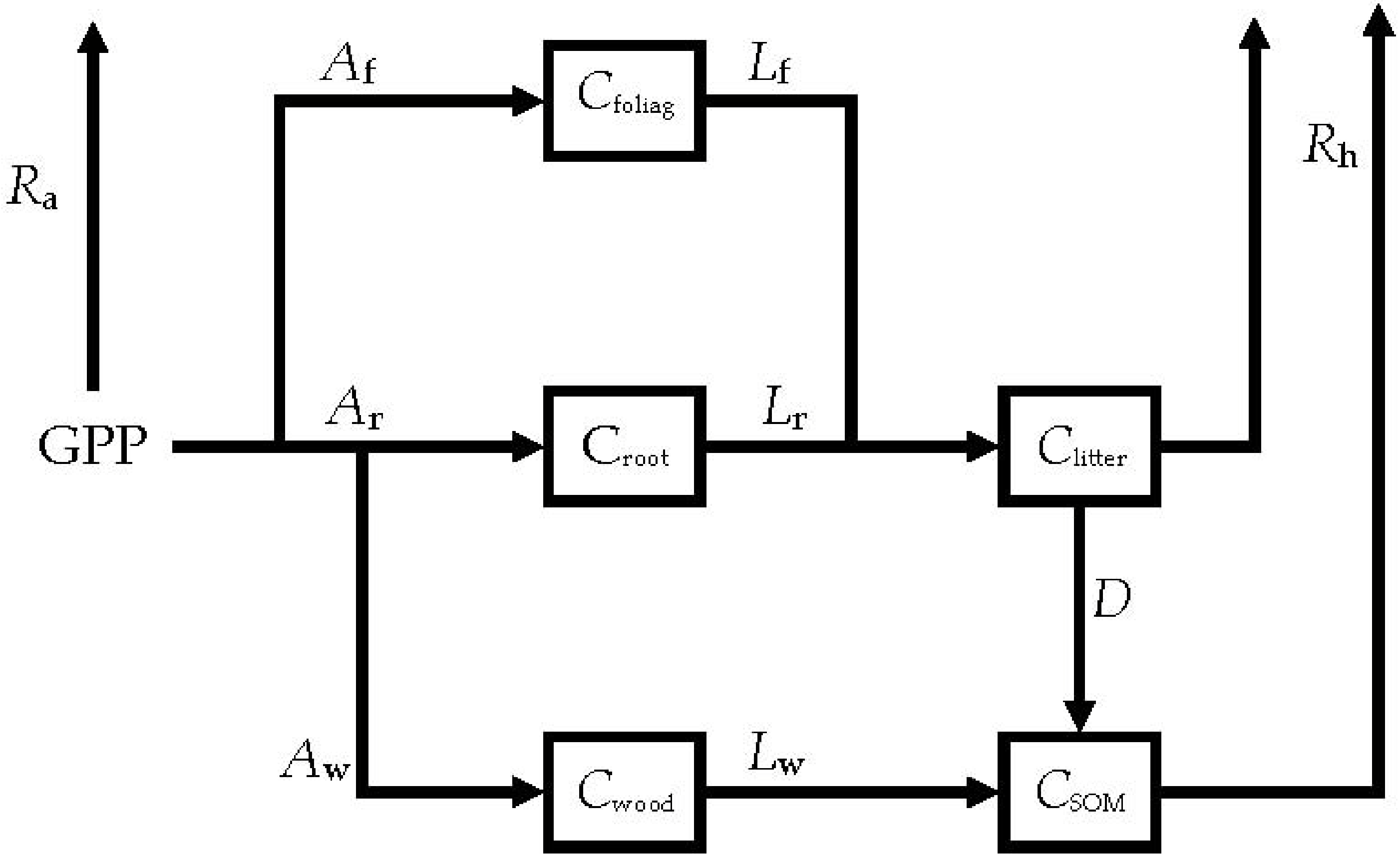
$$\mathrm{CE} = \sum_{1}^{n} \Delta \mathrm{A}_i \times \mathrm{B}_i \times \mathrm{EF}_i + \sum_{1}^{m} \mathrm{DA}_j \times \mathrm{B}_j \times \mathrm{DEF}_j$$

Regrowth (C uptake) can be accounted for in the same way:

$$\mathrm{CU} = \sum_{1}^{p} \mathrm{AR}_k \times \Delta \mathrm{B}_k$$

AR = area of regrowth; ΔB = biomass increment

Carbon flow through an ecosystem



Disturbance: drastic modification of states

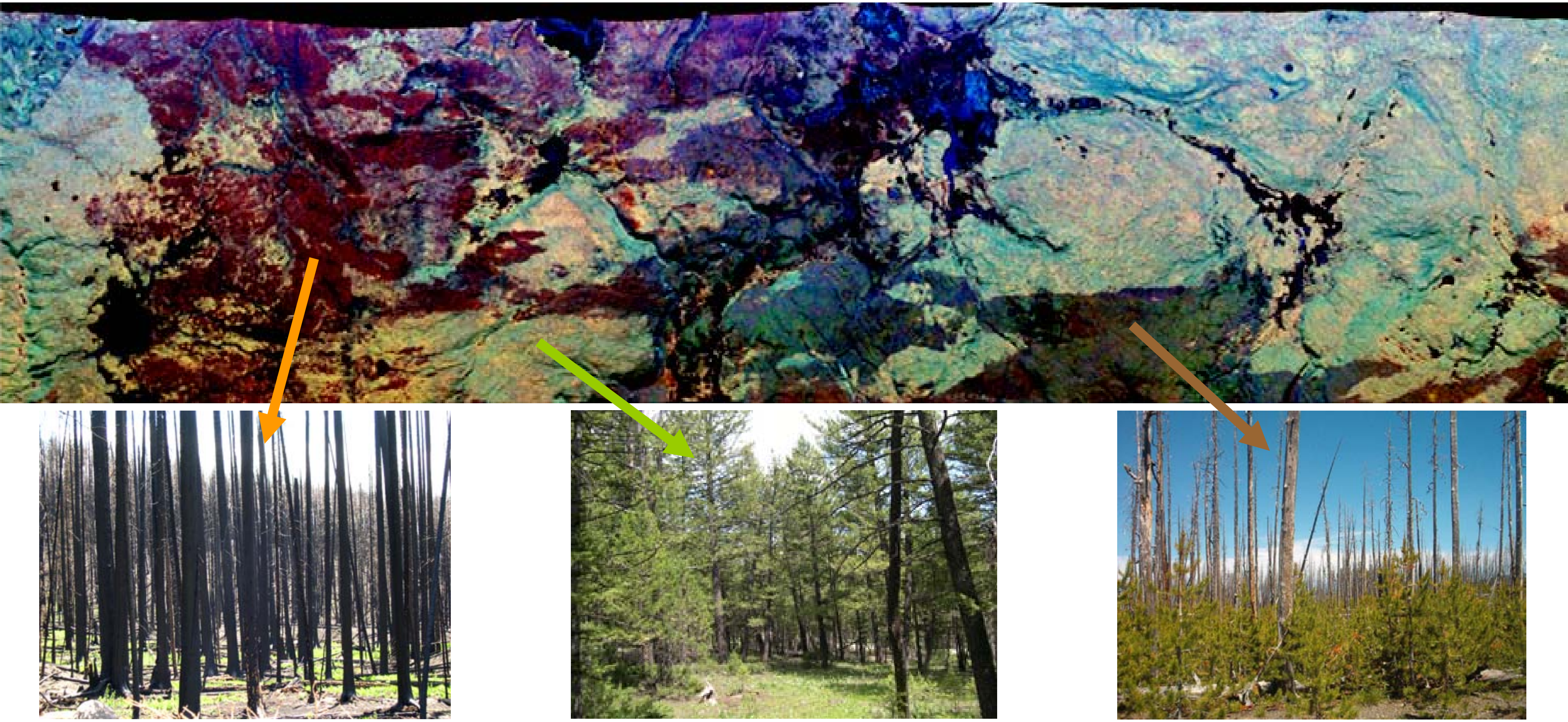
$$\mathbf{S}_1(\mathbf{x},t) \longrightarrow \Big|\Big| \longrightarrow \boldsymbol{S}_2(\boldsymbol{x},t+1)$$

Two timescales:

1. **Instantaneous effects**: fluxes and changes in the carbon pools directly caused by the disturbance
2. **Longer term effects**: the evolution of the carbon pools under the new conditions.

A dynamic landscape of disturbance and regrowth

Polarimetric P-band SAR image of Yellowstone Park (2003)

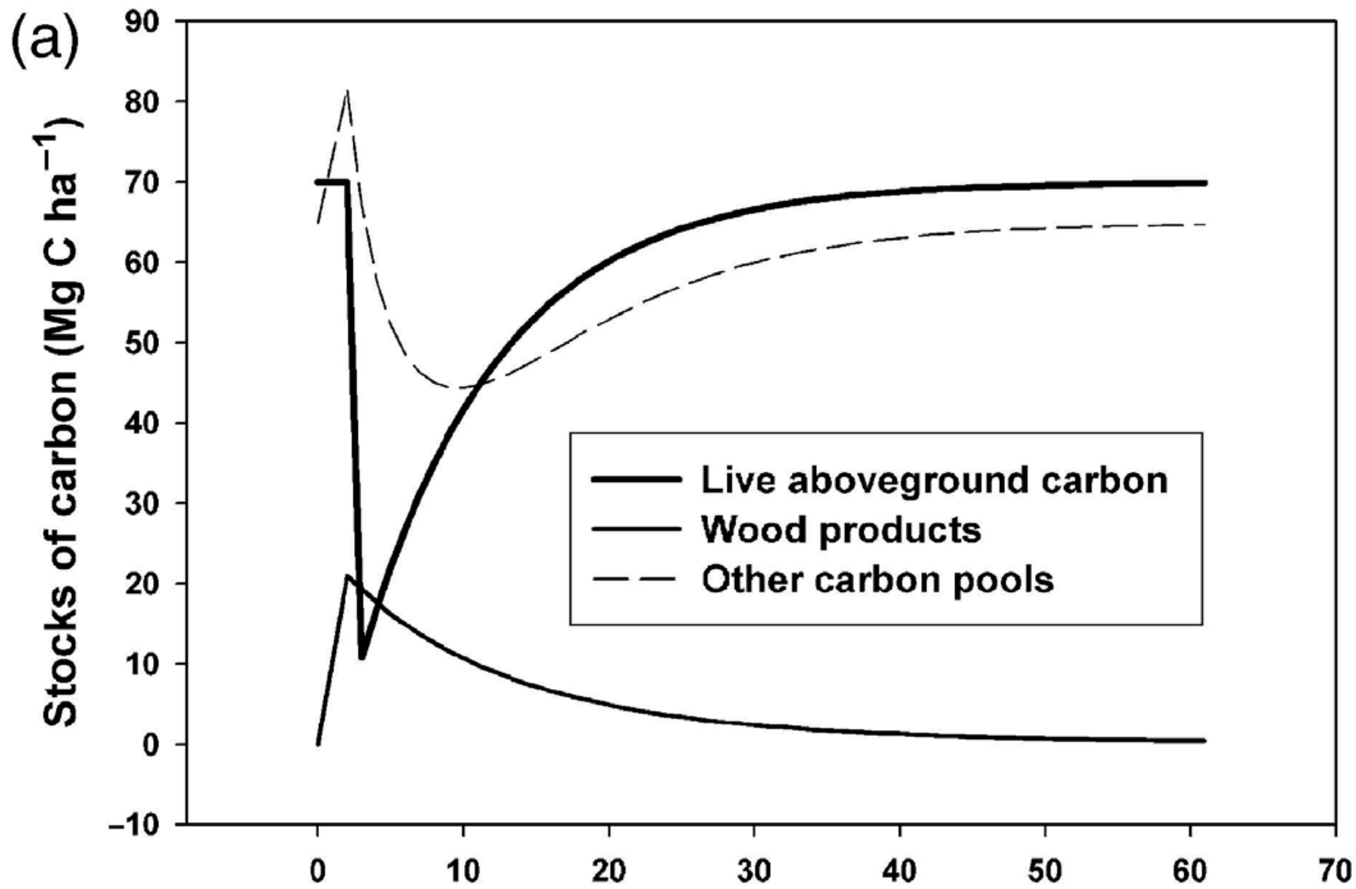


A week after burn
P-HV = - 27 dB

60-80 years after burn
P-HV = - 12 dB

15 years after burn
P-HV = - 19 dB

A landscape full of “events”



Time (years)

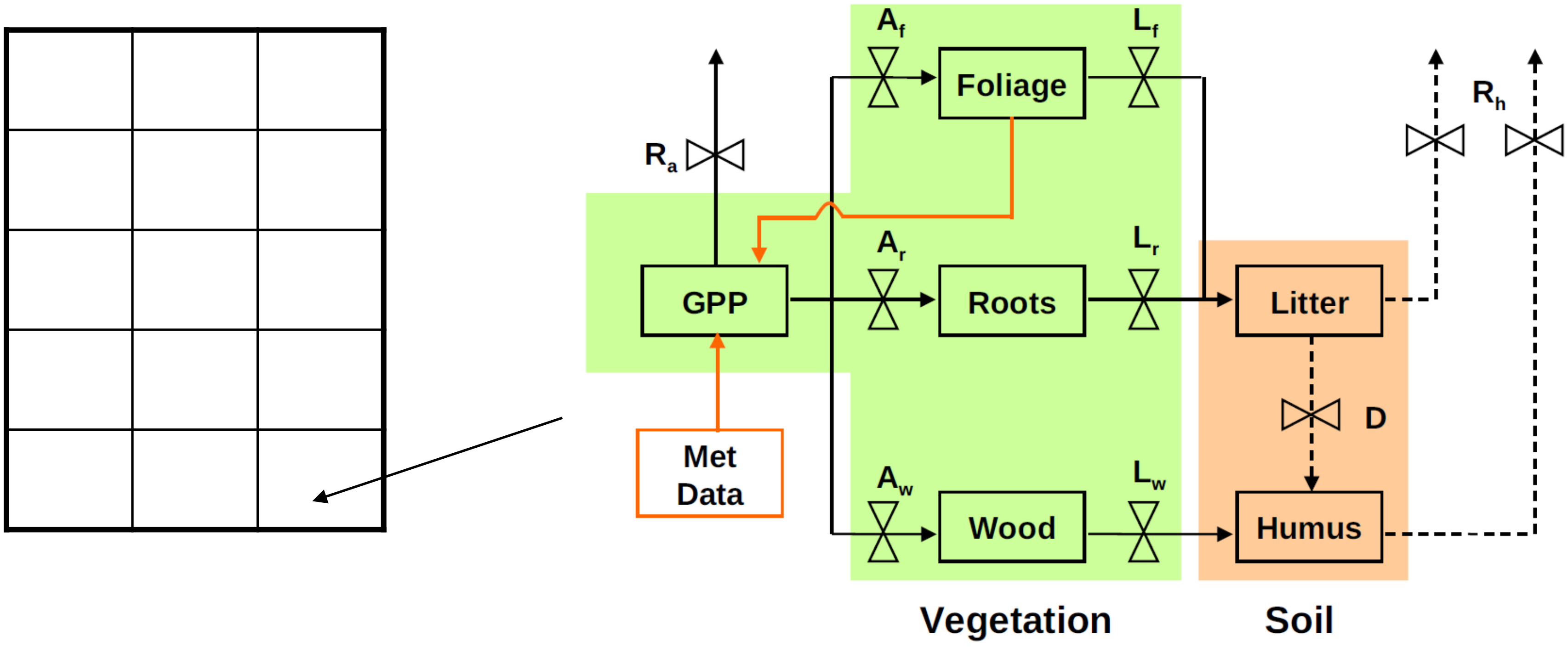
Forest transitions

	Mode of change	**Destination**
Forest loss	Logging	Cropland
Degradation	Fire	Pasture
		Plantation
Forest gain	Regrowth	“Natural” forest
	Afforestation	Forest type?

Data requirements

- Maps of disturbance through time
- Type of change in land use
- Carbon export
- Response curves for the carbon pools

GIS + transition mode + embedded ecosystem model



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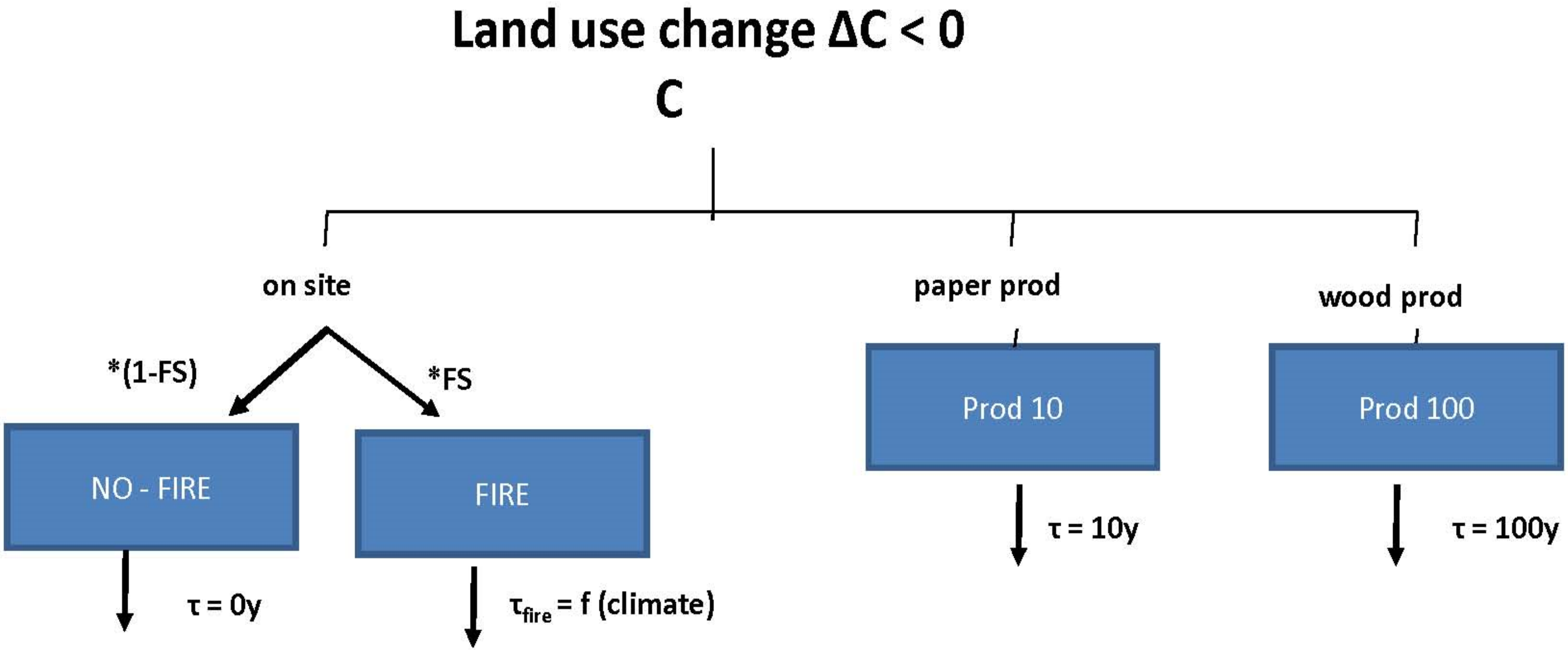
Representing C fluxes from disturbance



Current FCT efforts on satellite data

- Almost all effort devoted to detecting deforestation and, to some extent, forest degradation; almost nothing on land use transitions and C processes.
- Strong claims being made about measuring biomass from space, but poorly supported by evidence
- For good reasons, significant effort on use of ALOS-PALSAR (24 cm wavelength radar) but:
  - PALSAR failed in July 2011 (but PALSAR-2 still planned)
  - Possible cost issues for PALSAR-2 data

Issues for satellite data

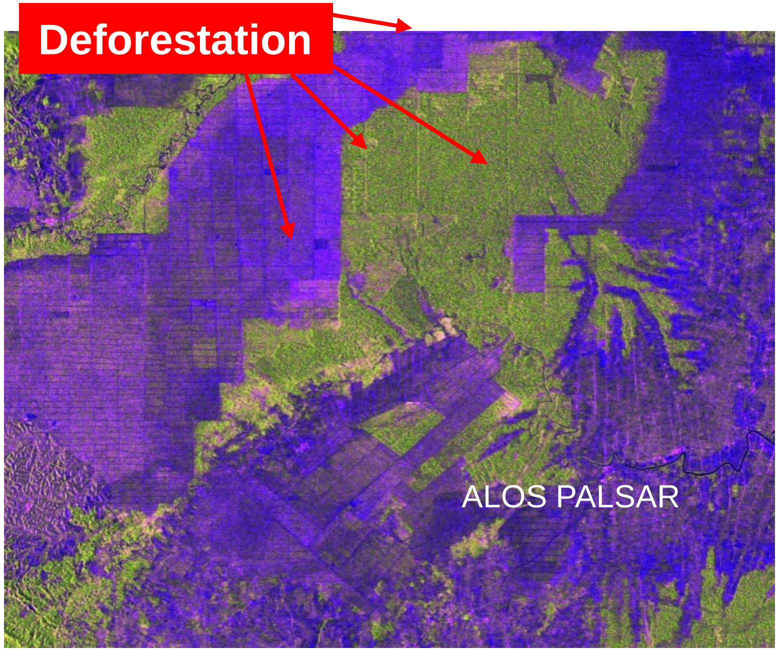
- Appropriateness (fit for purpose and cost)
- Optimised methods of information extraction from the data
- Errors and validation

Optical vs SAR

Landsat

This Landsat image was the best available from the same time (03/09/2006) and emphasises the difficulty of using optical Imagery to develop accurate databases.

PALSAR



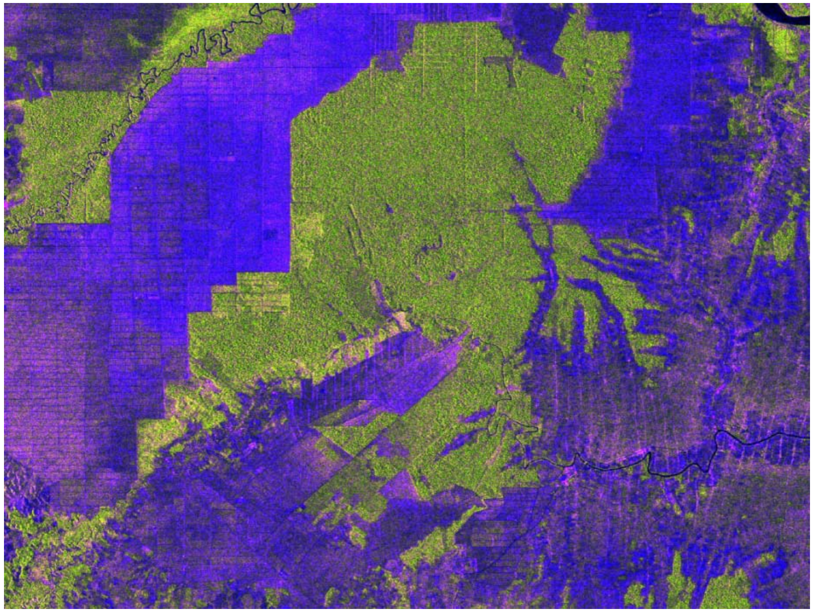
HH

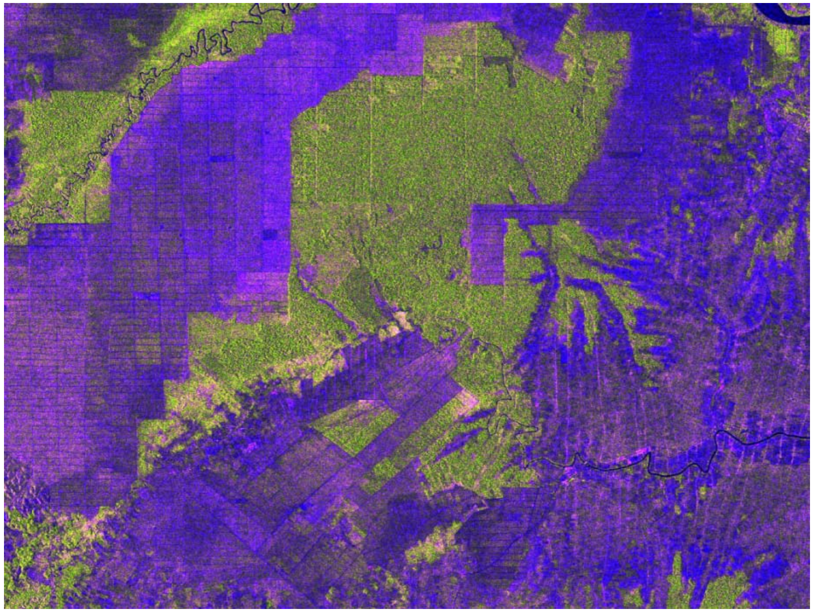
HV

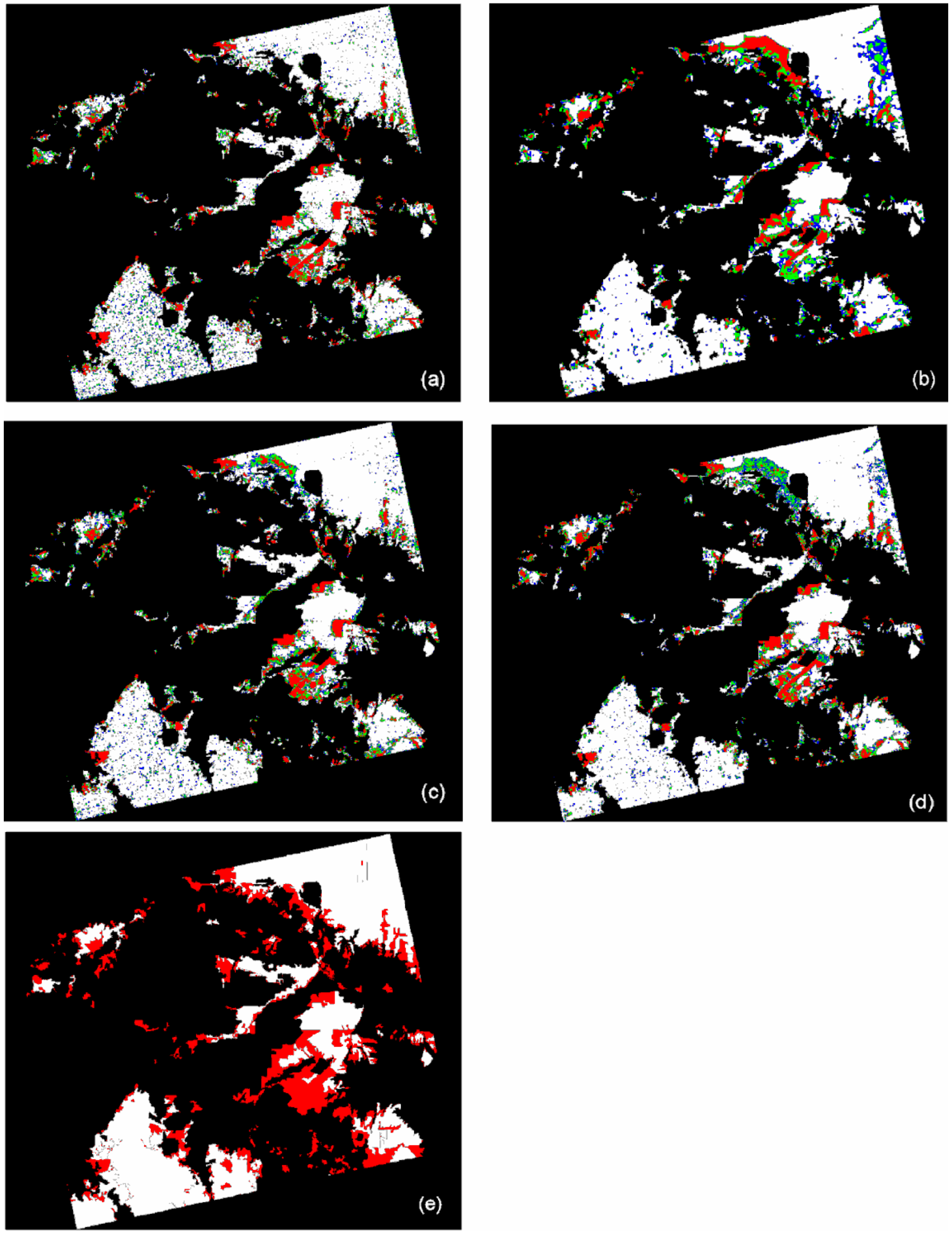
HH/HV

SAR does not suffer from cloud problems

How do we recognise forest change?







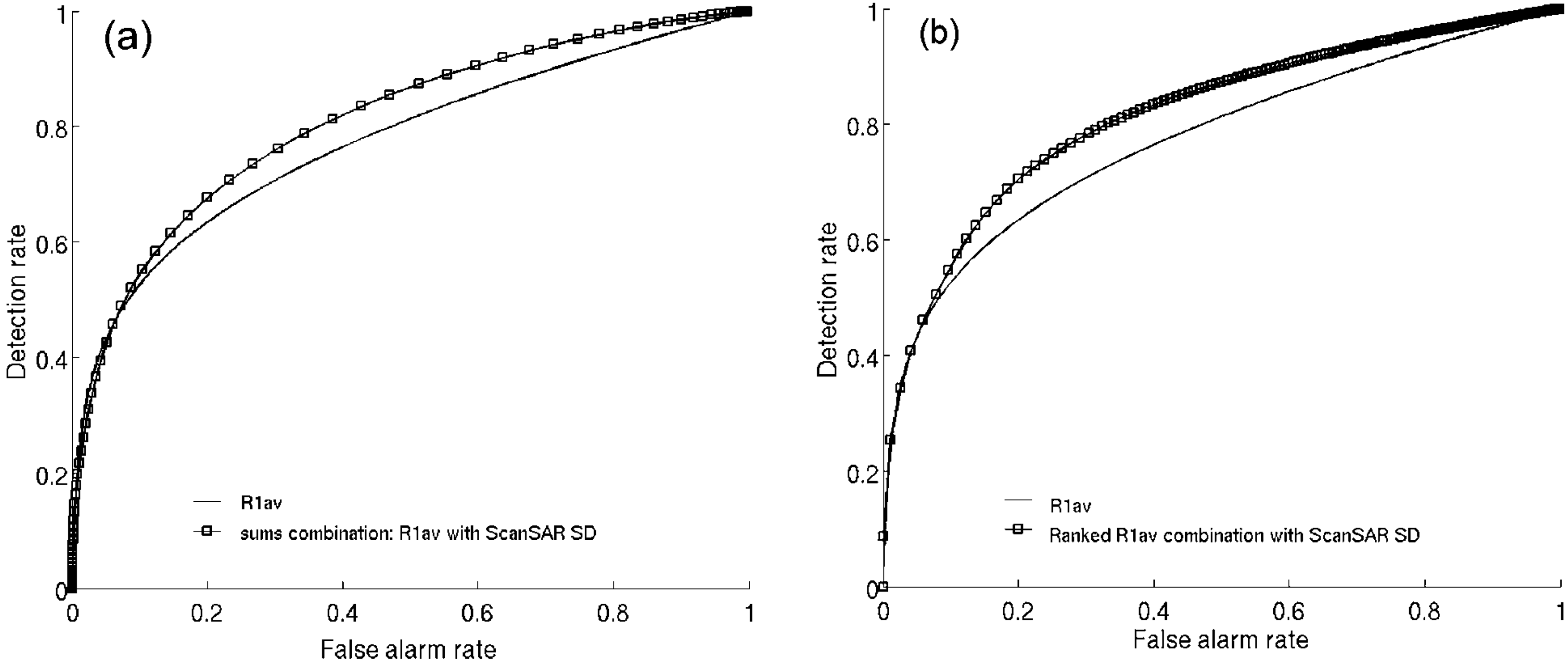
Optimisation

Riau region, Sumatra.

PALSAR data.

Attempts to optimise performance by combining polarisations and ScanSAR

Performance



Deforestation is a rare event: detection theory is the right tool for assessing performance. Validation is difficult.

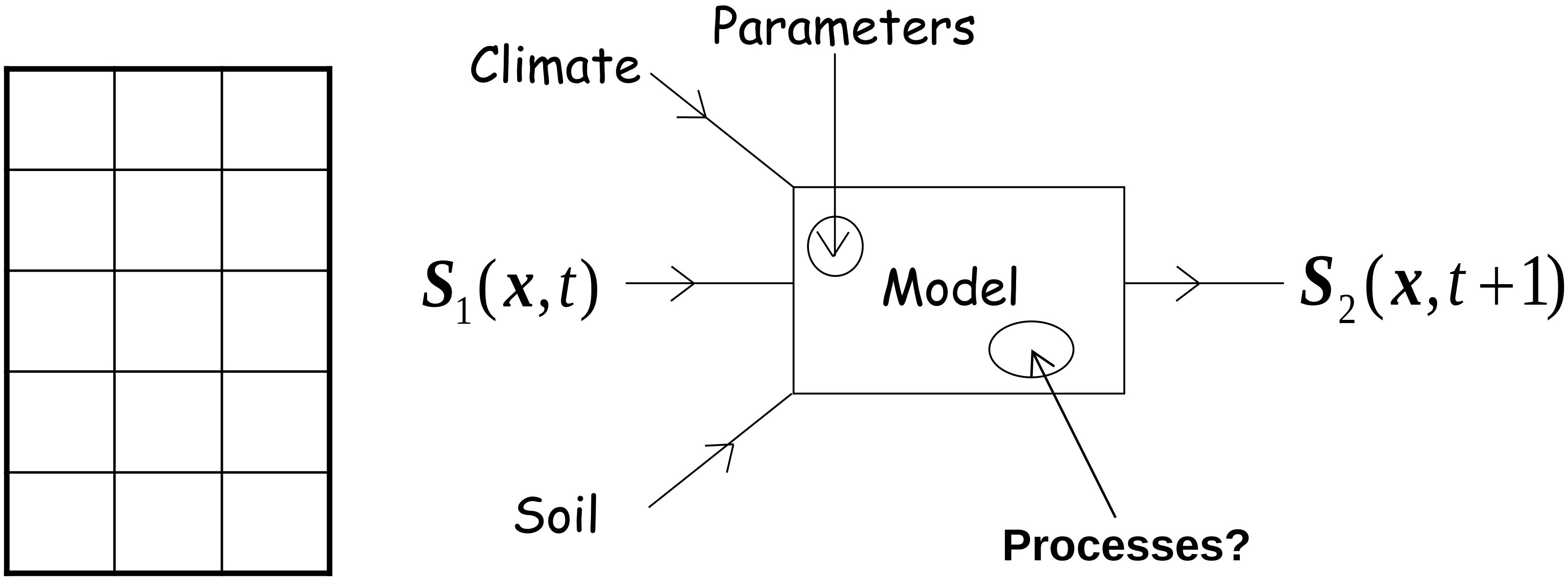
The FCT process - issues

- National demonstrators involve different data streams & different groups involved in methodology development
  - Widely different expertise
  - Little attempt to consolidate data or methods
  - Competition rather than collaboration
- Proper peer review is lacking
- The need for national implementation is not being addressed seriously enough

Summary remarks

- The current strong emphasis in GEO-FCT on gaining commitments from agencies to acquire substantial time series of data is probably appropriate, but the link to national emissions calculations – the real goal of FCT – needs to clarified & strengthened.
- The current National Demonstrator structure is not conducive to developing best practice unless there is stronger emphasis on "picking the best". There is no real forum for method comparison.
- The approaches needed to pick the best have intrinsic difficulties because deforestation is a rare event.
- There needs to be more clarity on the process whereby countries embed FCT tools and concepts within their national systems.

Ecosystem Models: Evolving States



S(x,t) is the state vector describing the vegetation-soil system at position **x** (or area A) and time t

Principles of FCT

The IPCC GPG identifies three **Tiers** distinguished by the level of detail and accuracy needed convert forest changes to country level estimates of GHG fluxes:

- **Tier 1** is simple and uses global defaults for emissions factors.
- **Tier 2** requires some country-specific information for areas of land affected, and associated GHG fluxes.
- **Tier 3** uses complex, locally-calibrated modelling approaches and usually remotely-sensed data to provide spatially explicit estimates.

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