# Water and Land

## 1. Land Use Planning, Forest Cover and Afforestation

# ST.1.2 Effects of Amazonian deforestation on the rainfall and evapotranspiration regimes

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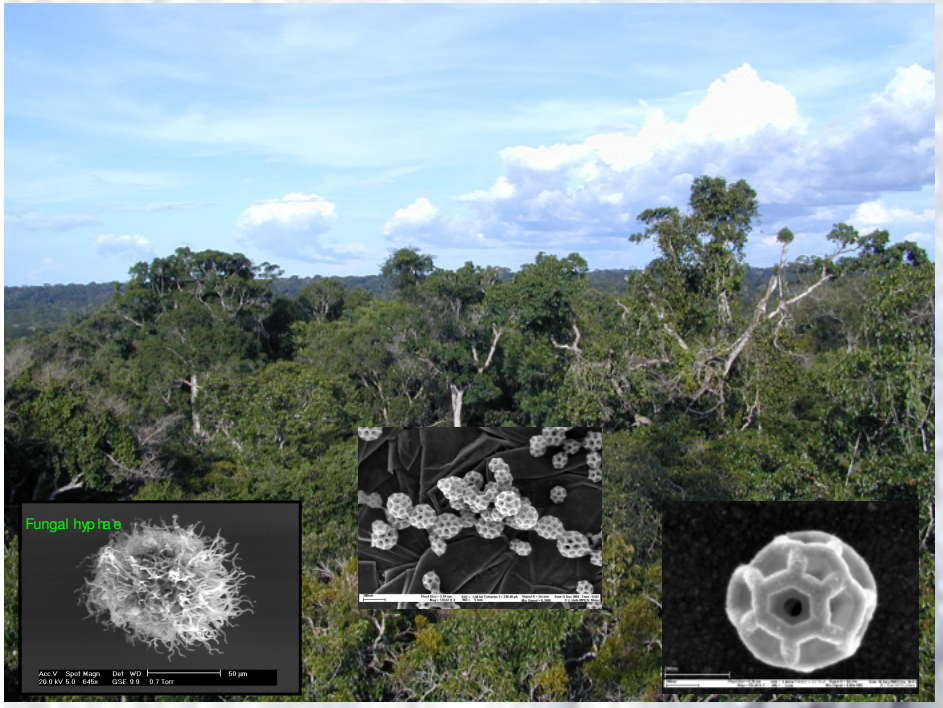
*Zaragoza, June 16, 2008*

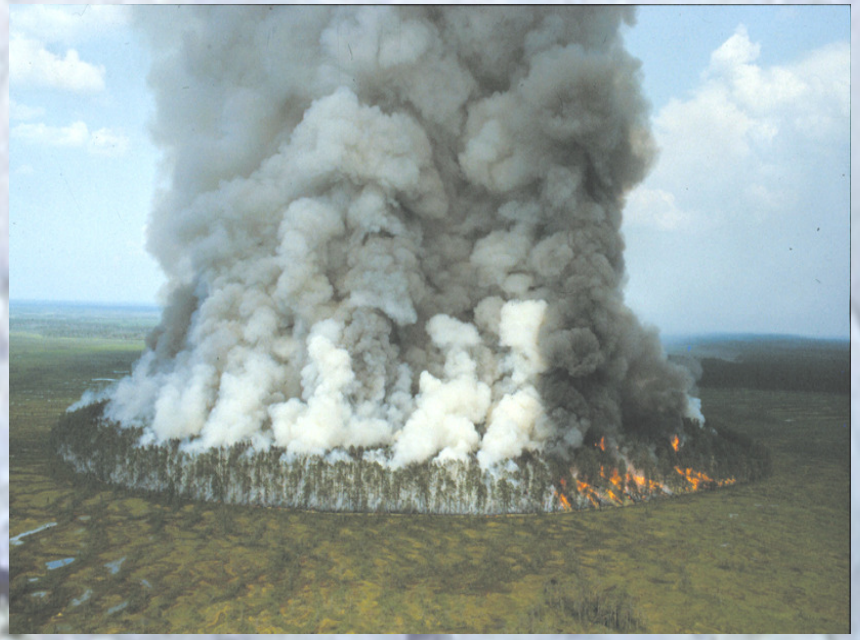
**Effects of Amazon forest on global climate?**
**Still much to learn next years on that, ... but some contributions already done...!**

The natural system: coupling forest to water cycle

Vegetation controlling:
atmospheric composition
- concentration of gases
- aerosol and CCN particles
- part of the radiation balance
- fluxes of water vapour



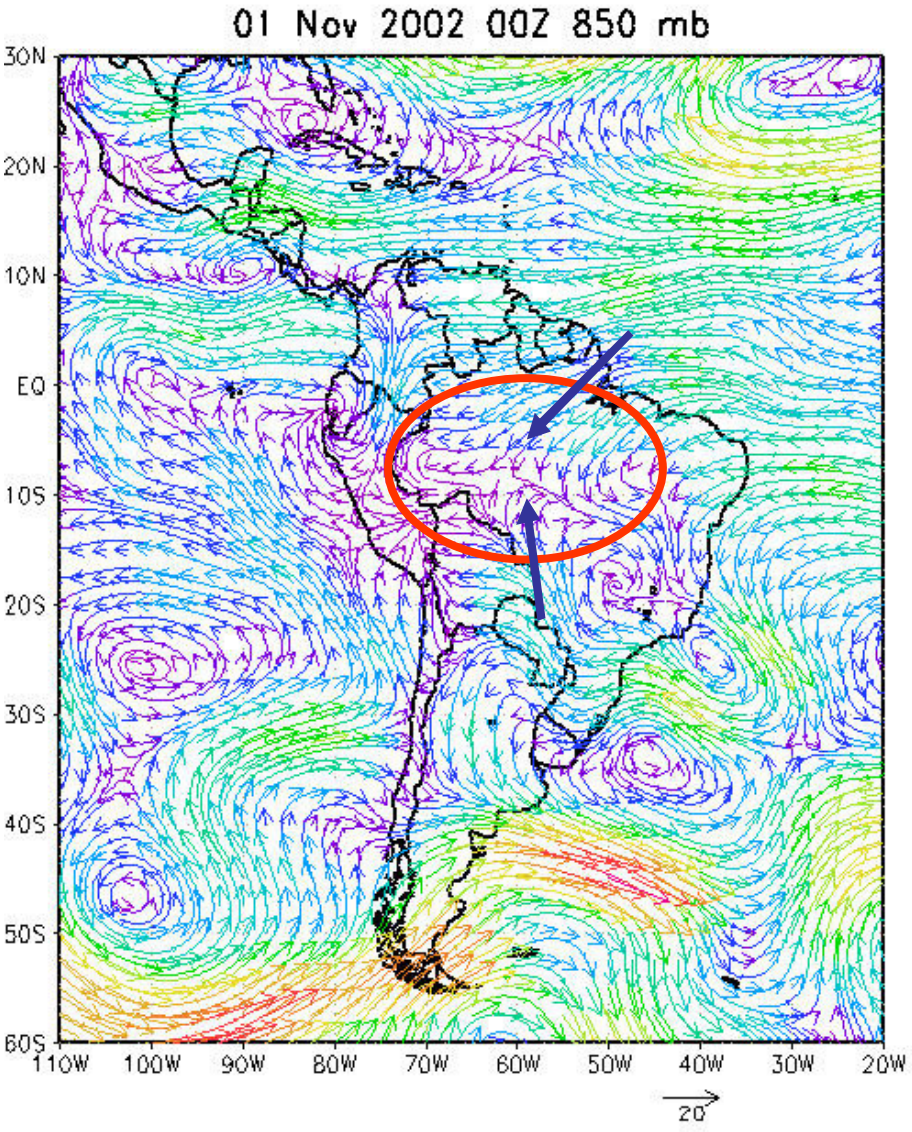

**Amazon "Green Ocean": natural clouds with oceanic characteristics**

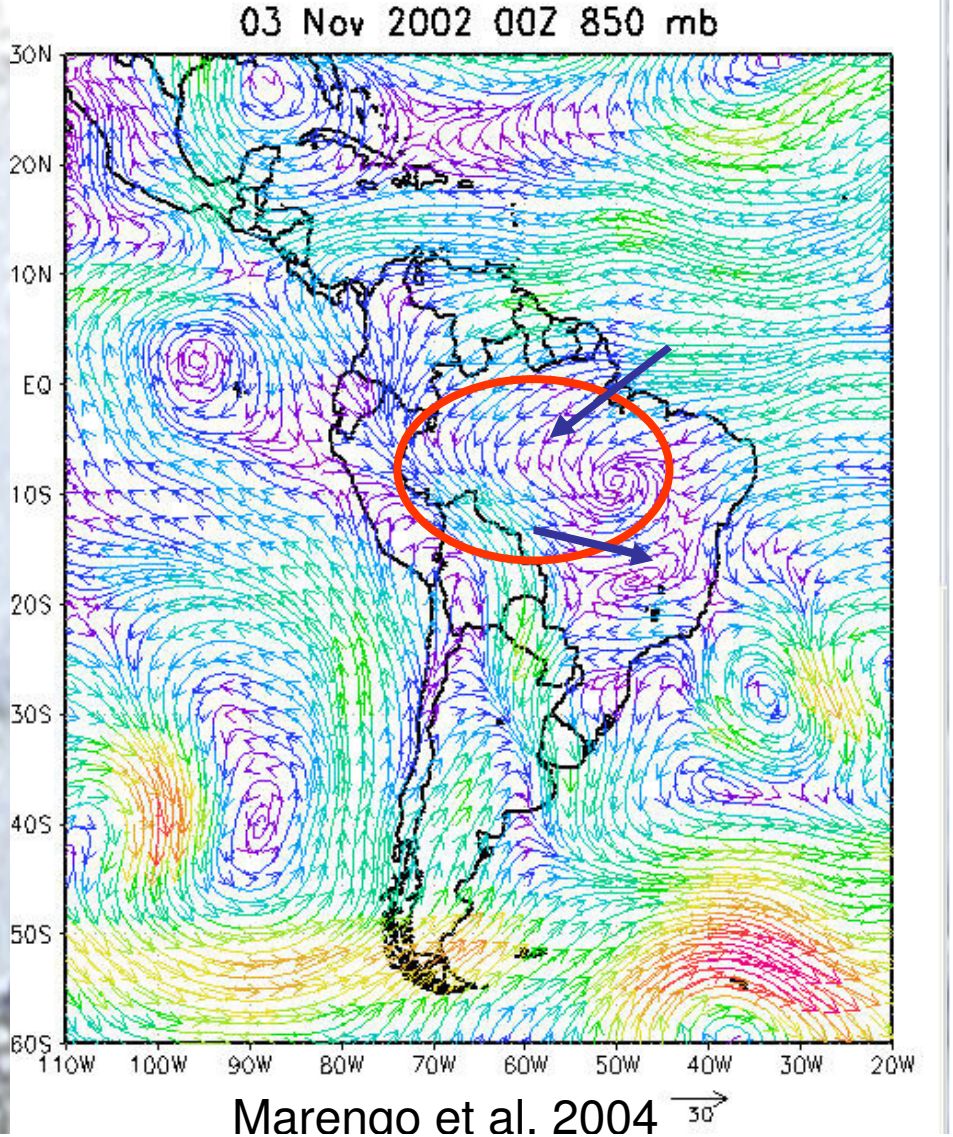


...all disturbed by deforestation & LUC

# Low-jet air entering into Amazon Basin

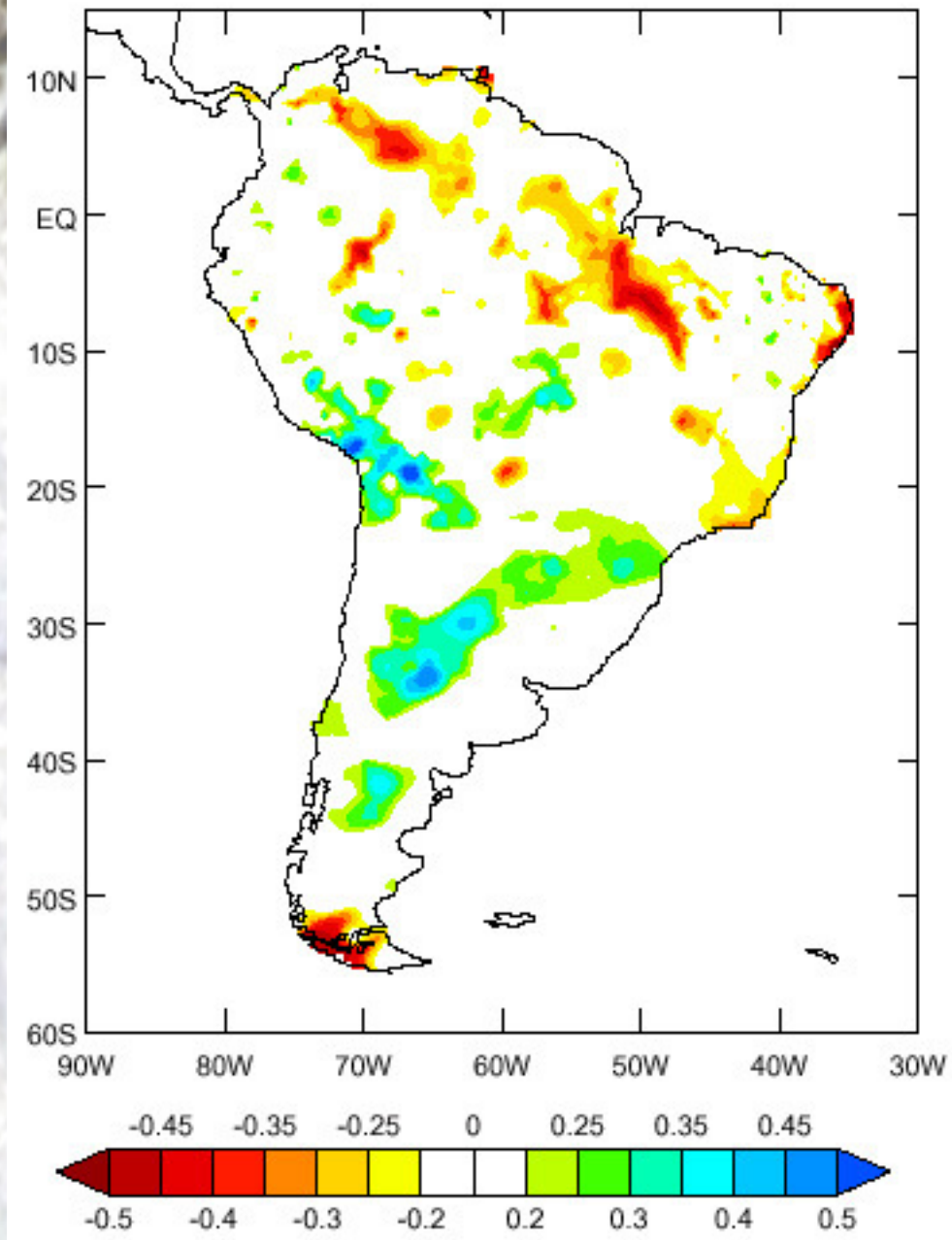
## - when leaving the basin, brings moisture to central and southern SA (connections to La Plata Basin)




Marengo et al. 2004

# Correlation between South America rainfall and Scandinavia index for boreal autumn



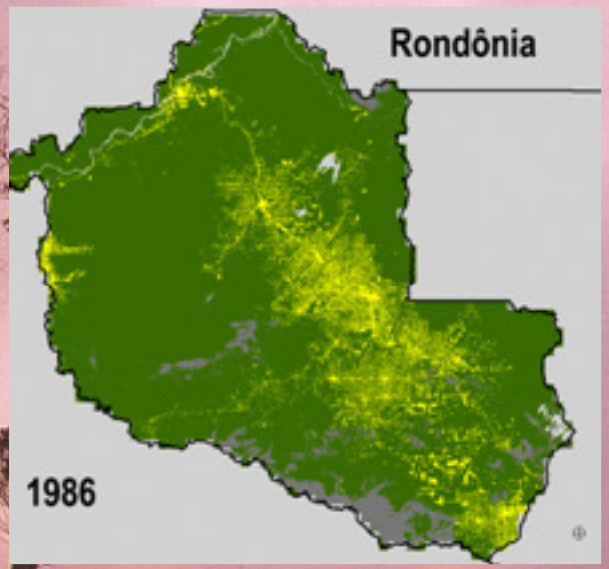

SON, 1960-1990

Correlations between South American precipitation and the Scandinavia index for boreal Autumn (SON), 1960-1990.

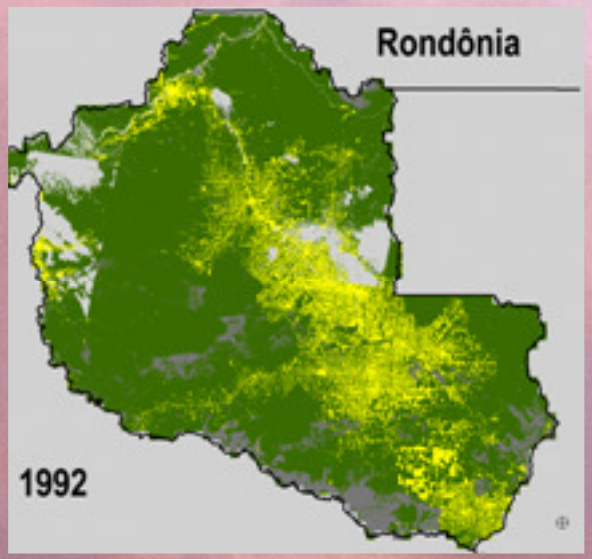
A coherent pattern of negative correlations occurs north of 10°S, coincident with the upper tropospheric convergence anomalies observed during Autumn 2000

(Blackburn and Hoskins, 2001)

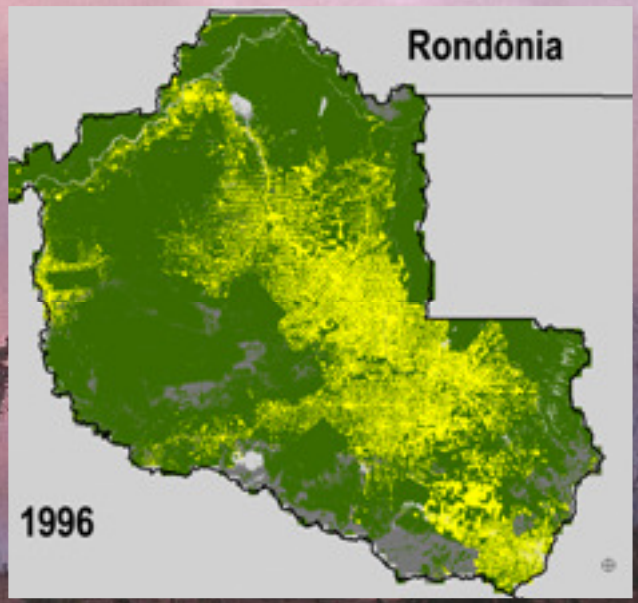
# Land use and land cover change in Amazonia




1986



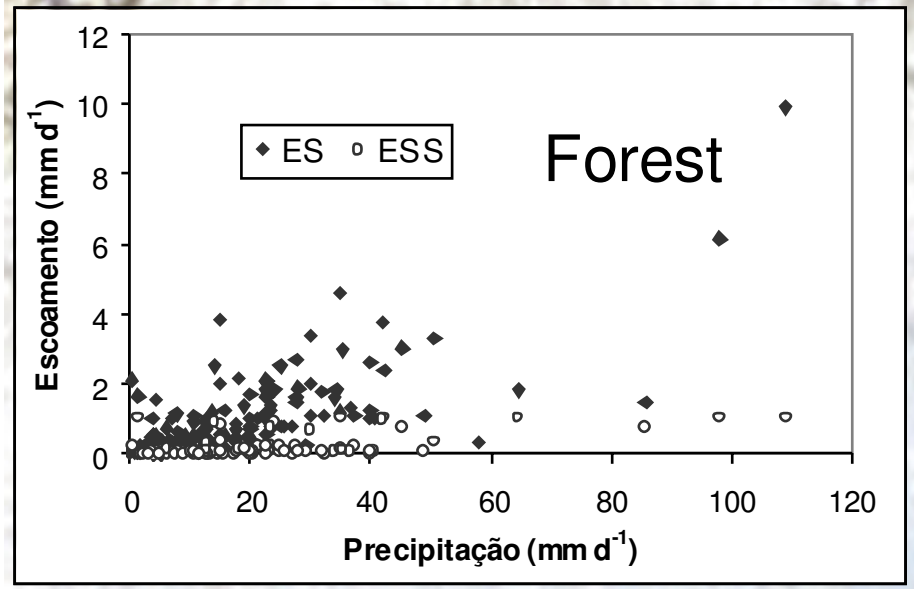

1992

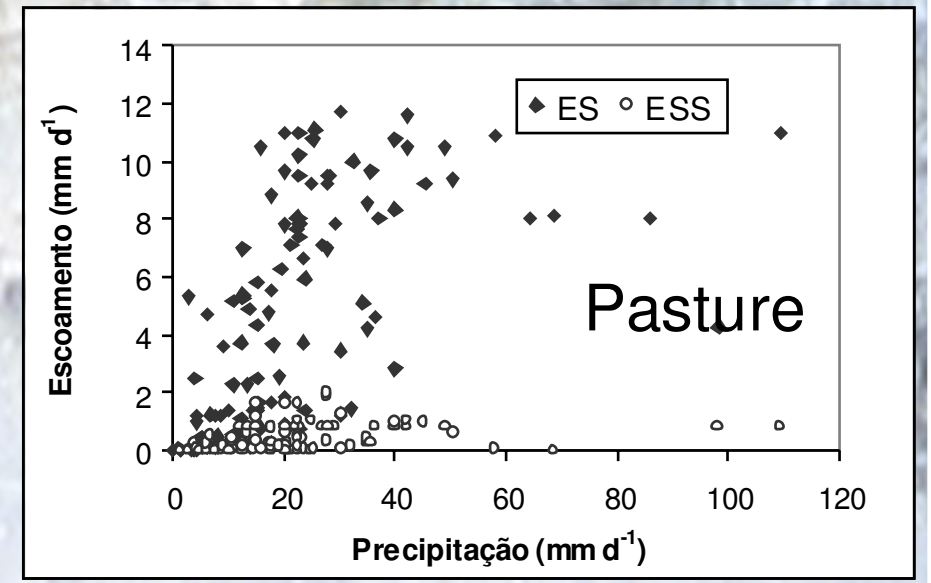



1996

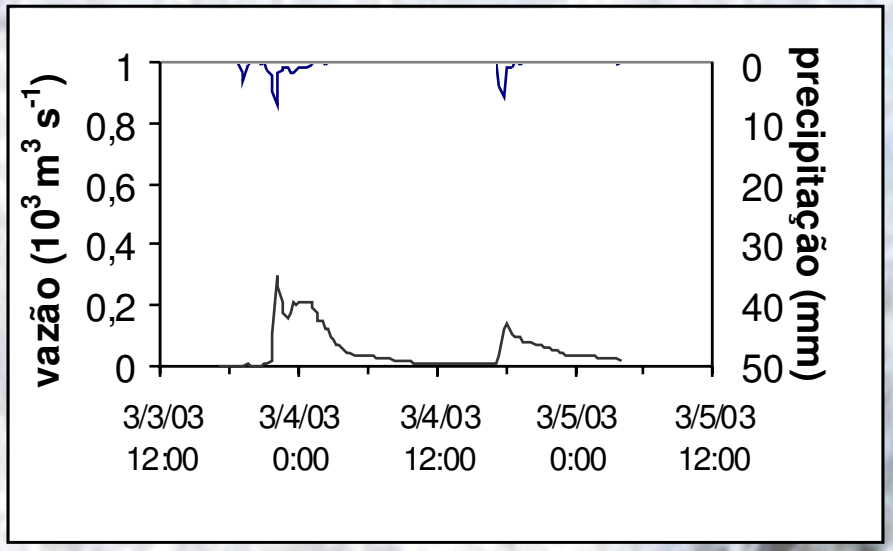
*Source: IPAM & INPE*

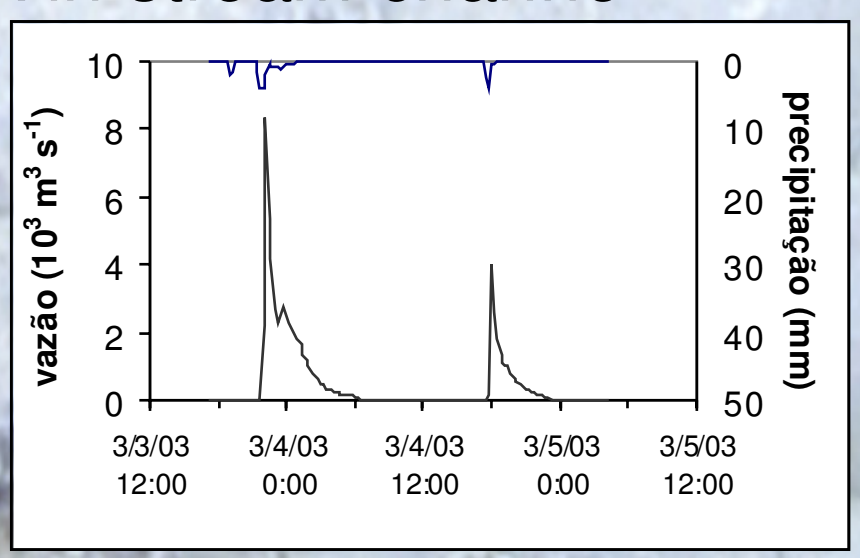
# Surface and sub-surface runoff




# Rainfall vs. Water flux in stream channel

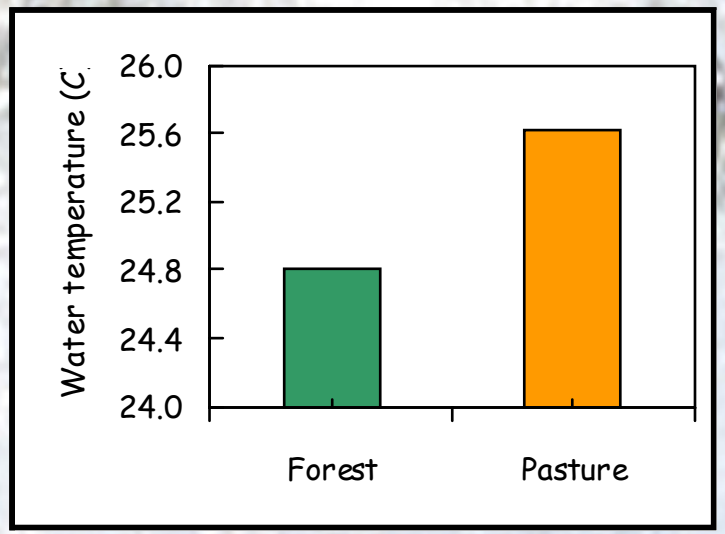


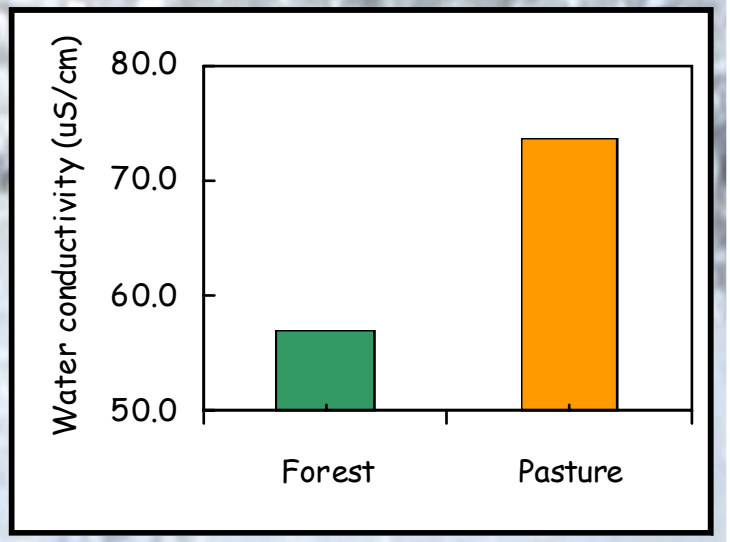




(Schuler, 2004)

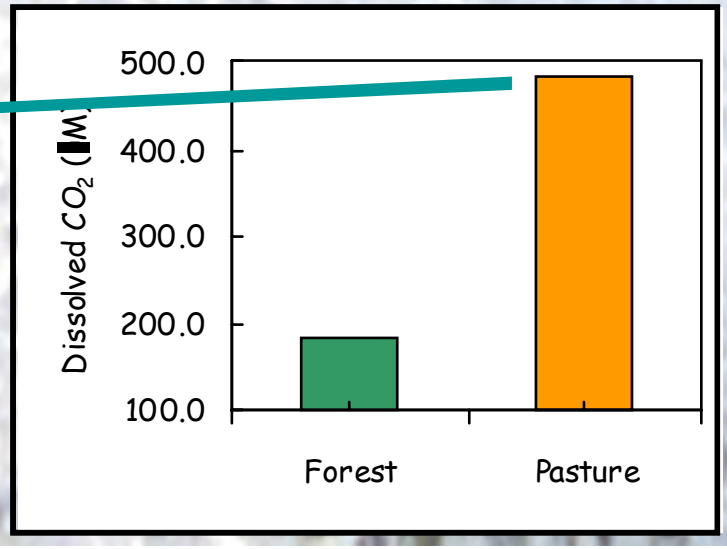
# Direct effects on water bodies

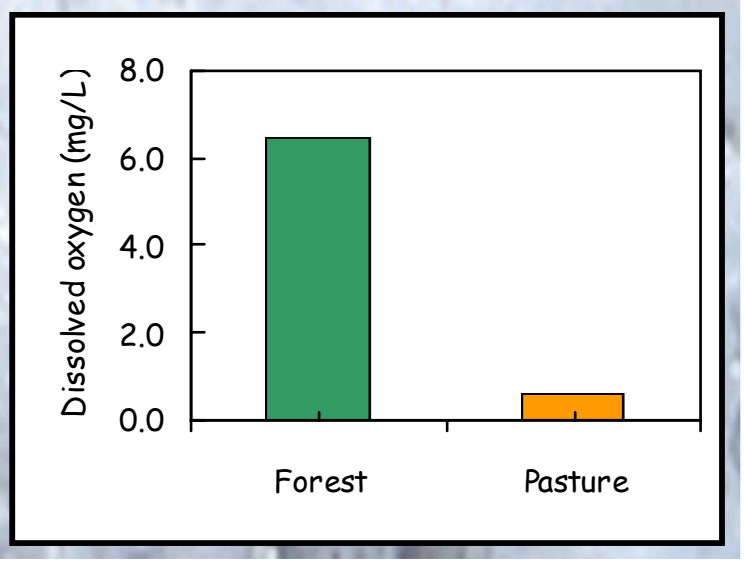
## Forest X Pasture




Higher $CO_2$ losses



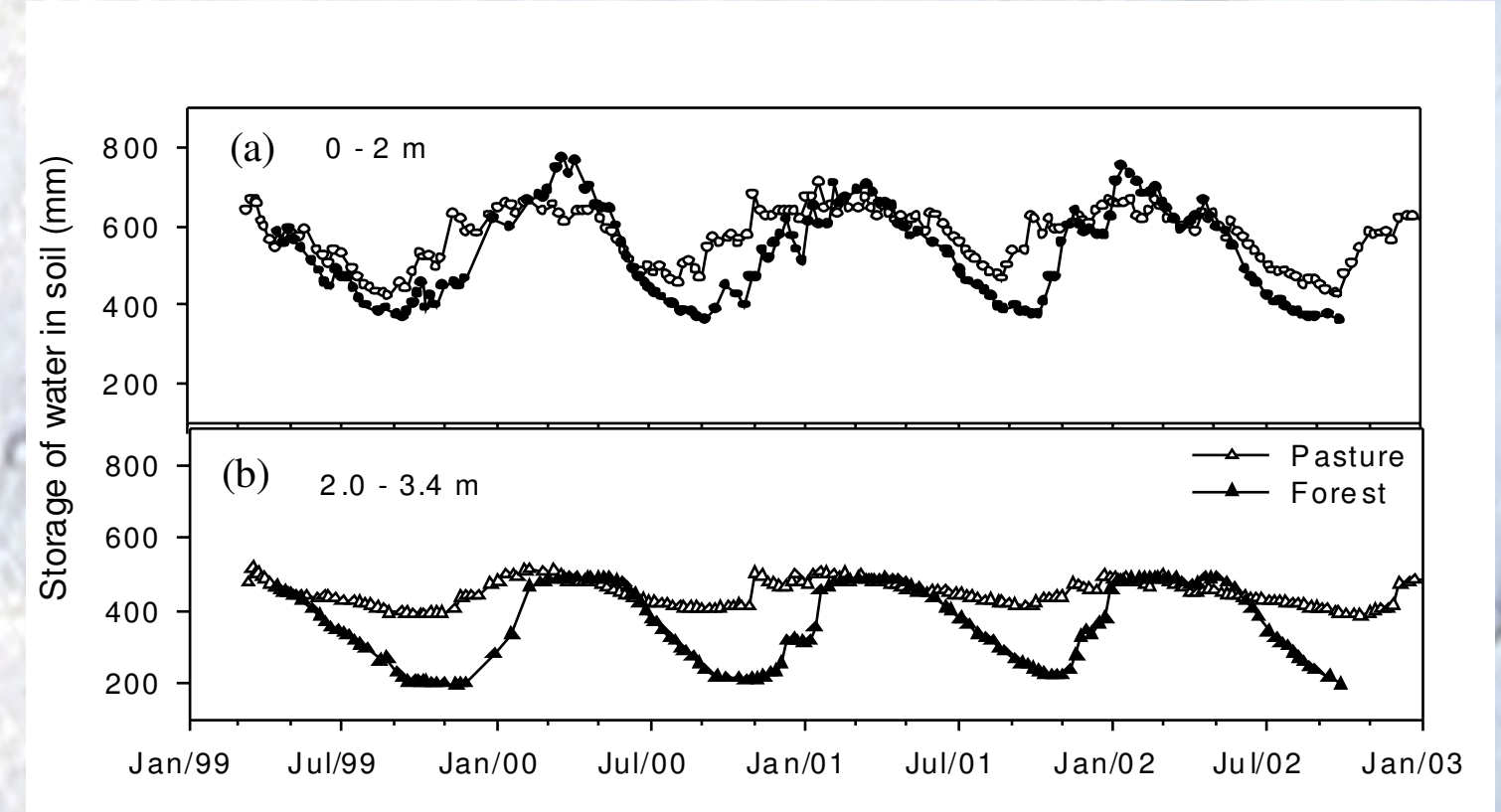
# Evapotranspiration: $E = E_g + E_{TR} + E_{INT}$

$E_g$ = Direct soil evaporation

$E_{TR}$ = Transpiration

$E_{INT}$ = Evaporation of water intercepted by the vegetation

Storage of water in the soil at forest and pasture sites in Rondonia



Thus, LCLUC induce changes in several parameters linked to the water cycle:

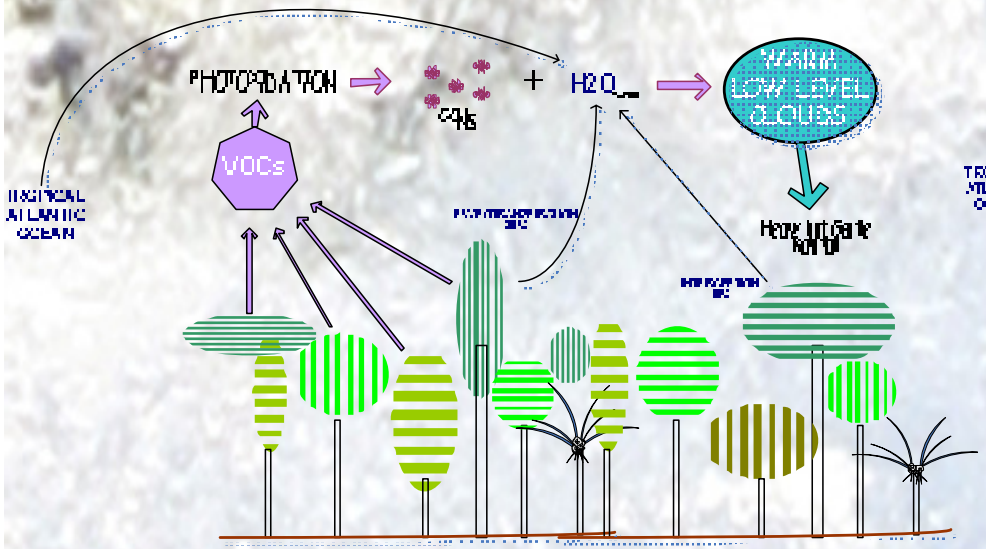
-Water bodies exposed to direct sun light and heath, and to changed water fluxes
-Soil water stored nearer to the surface and in lower amounts in soil profile
-Evaporation increased due to higher temperatures
-Others

But, rainfall regimes are also affected or changed by other forcing factors

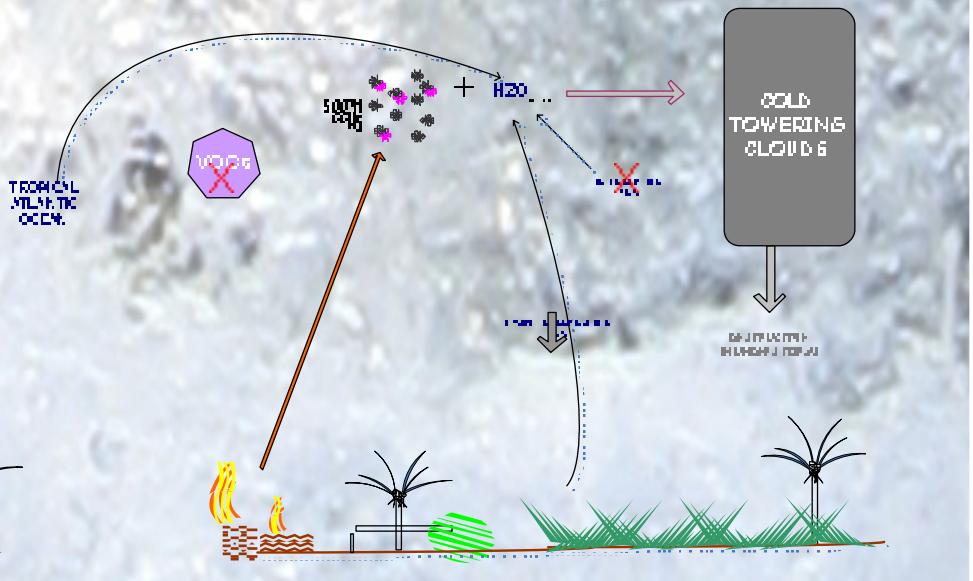
Possible rainfall decrease due to the aerosol effects

# DISTINCT MECHANISMS OF RAIN FORMATION IN AMAZONIA

## CLEAN ATMOSPHERE




## POLUTTED ATMOSPHERE



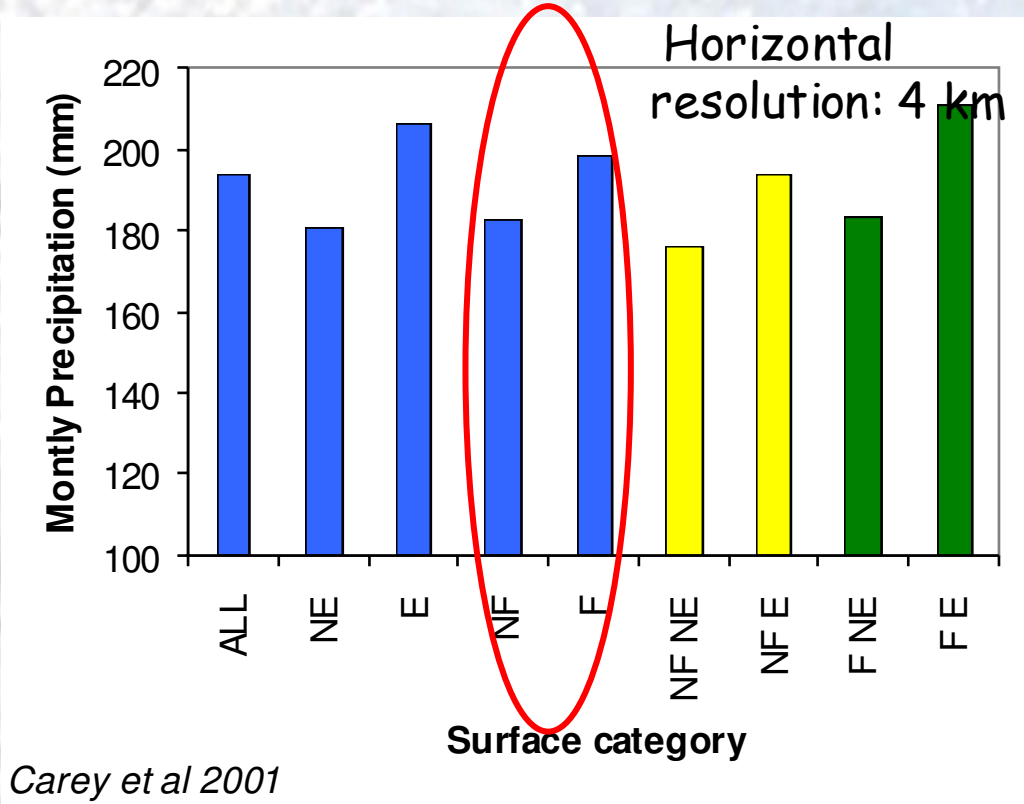

# ? Evidences of changes in rainfall caused by deforestation

Measured values in Rondonia

Rain season 1999 - radar
Total monthly rainfall

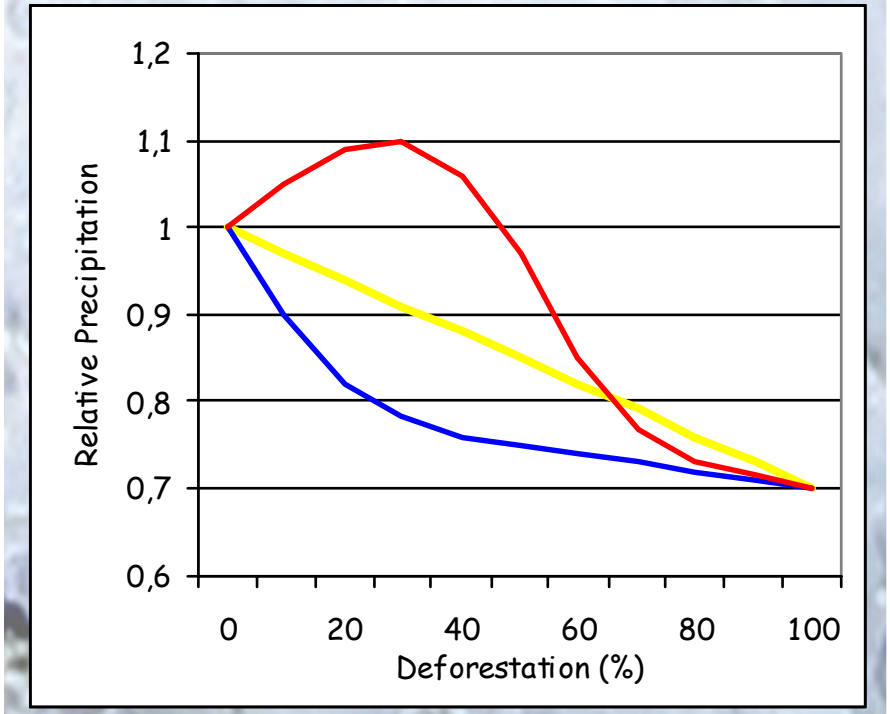
F - Forest; NF – Non forest

E - Elevation; NE- Non elevated

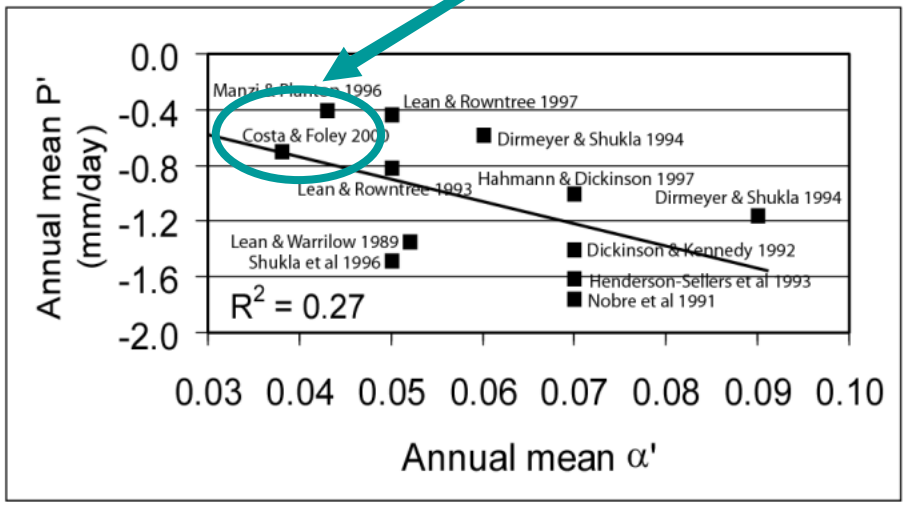



*Carey et al 2001*

***Conceptual models of deforestation impact on precipitation - Avissar et al., 2002***



ABRACOS effect



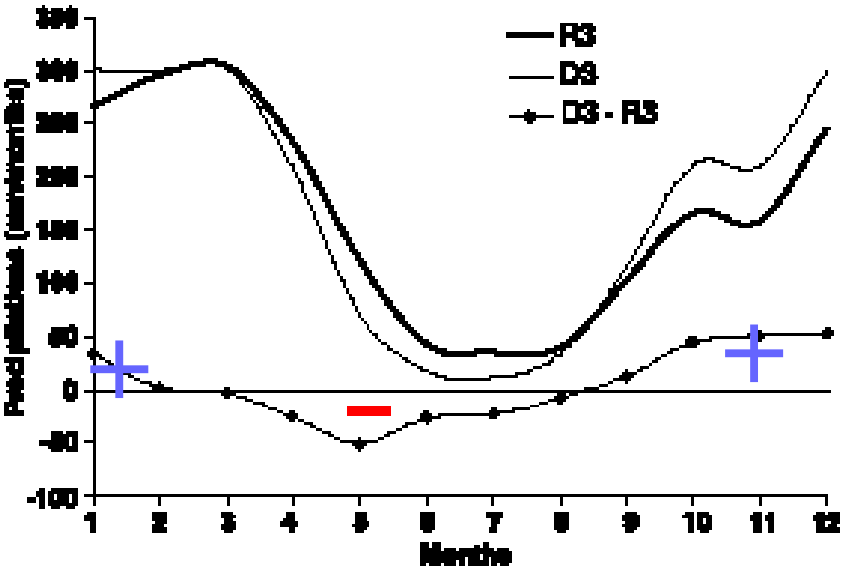




Fig. 6. Mean monthly precipitation for $R_3$ and $D_3$ and difference $D_3 - R_3$.

## Amazonian deforestation x Rainfall modeling

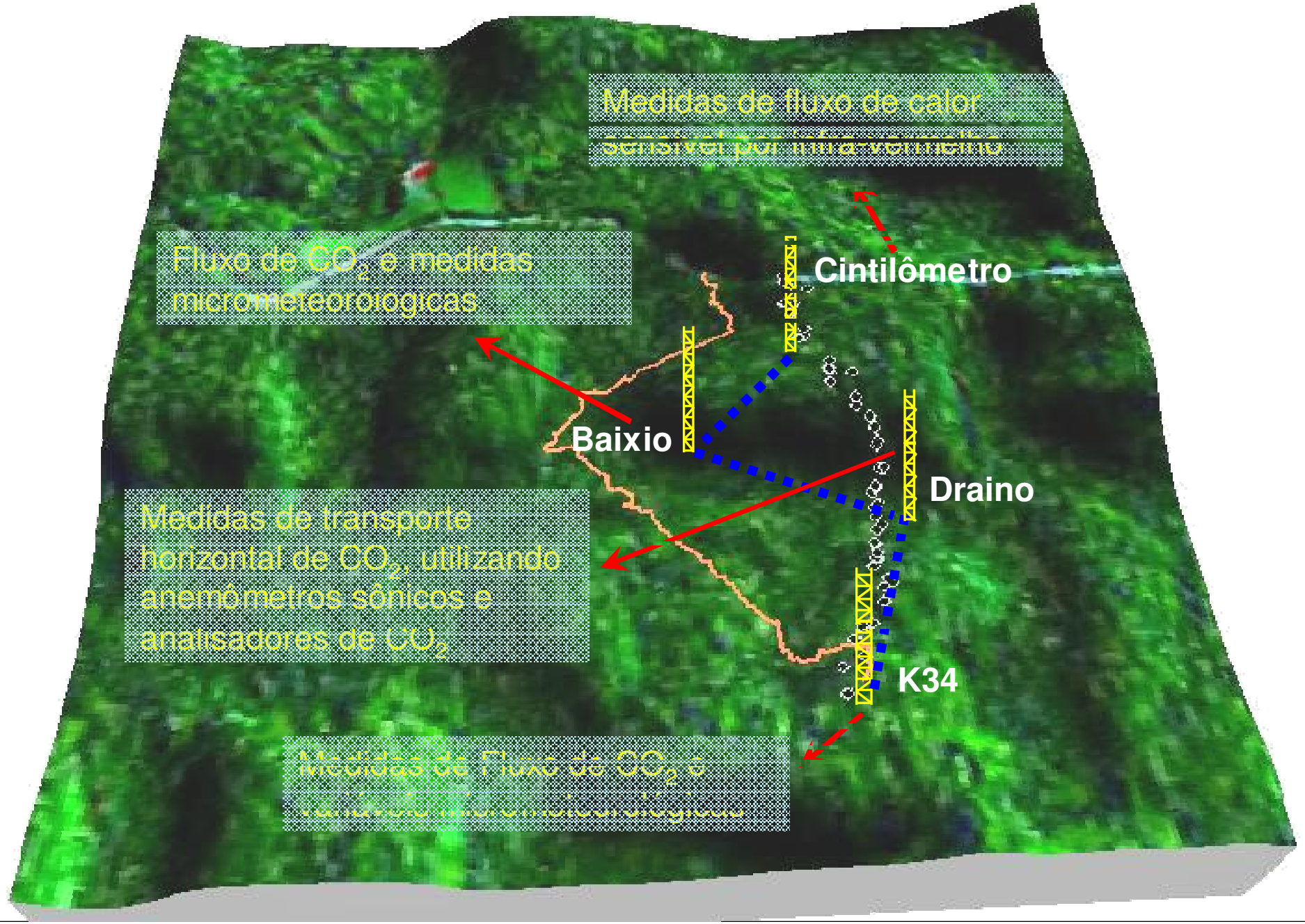
**Numeric simulations**

1 - 2.5 C increase in air temperature
15 – 30 % reduction in evapotranspiration
5 – 20 % decrease in rainfall

"Higher rainfall over deforested areas during rainy season, and lower rainfall during dry seasons : "increase in seasonality possibly caused by a shift of the equatorial-tropical transition zone (*Durieux et al, 2003*)

*Forest replaced by other kind of vegetation in Amazonia?*

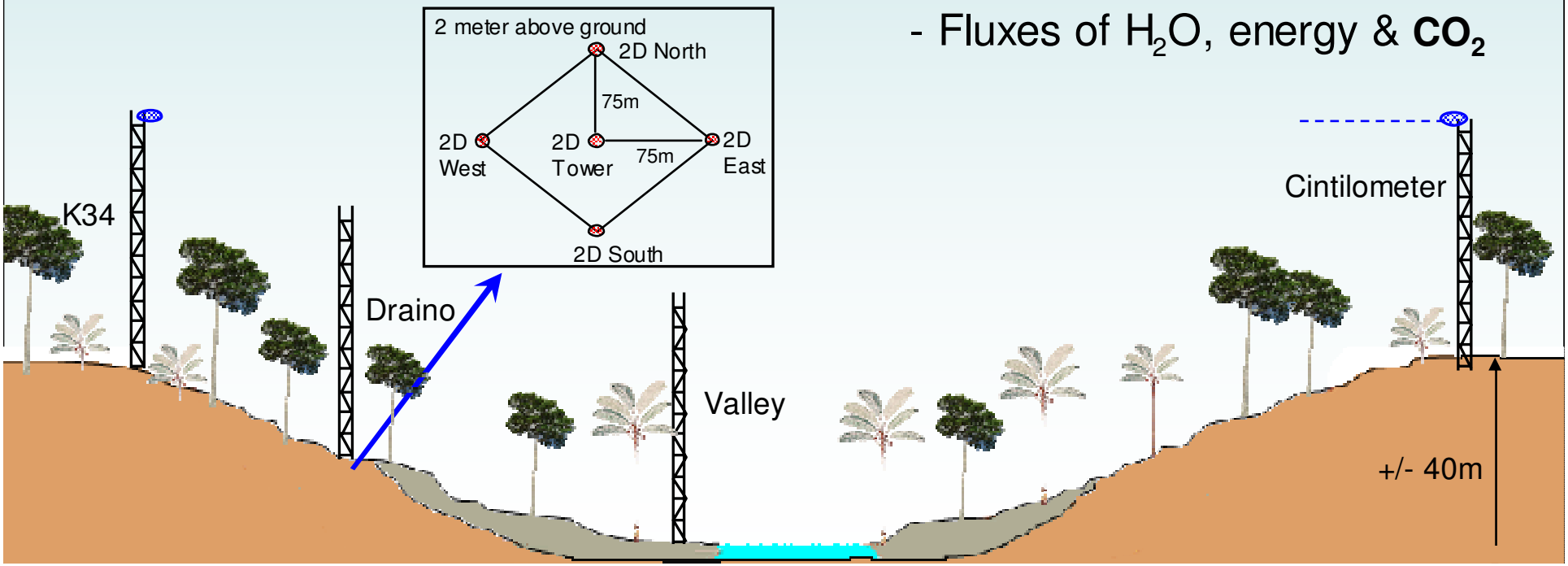
# Distribution of experiments at footprints of K34 tower - Manaus



# Studies at the Plateau-Slope-Valley continuum (nearby K34 tower, in Manaus)

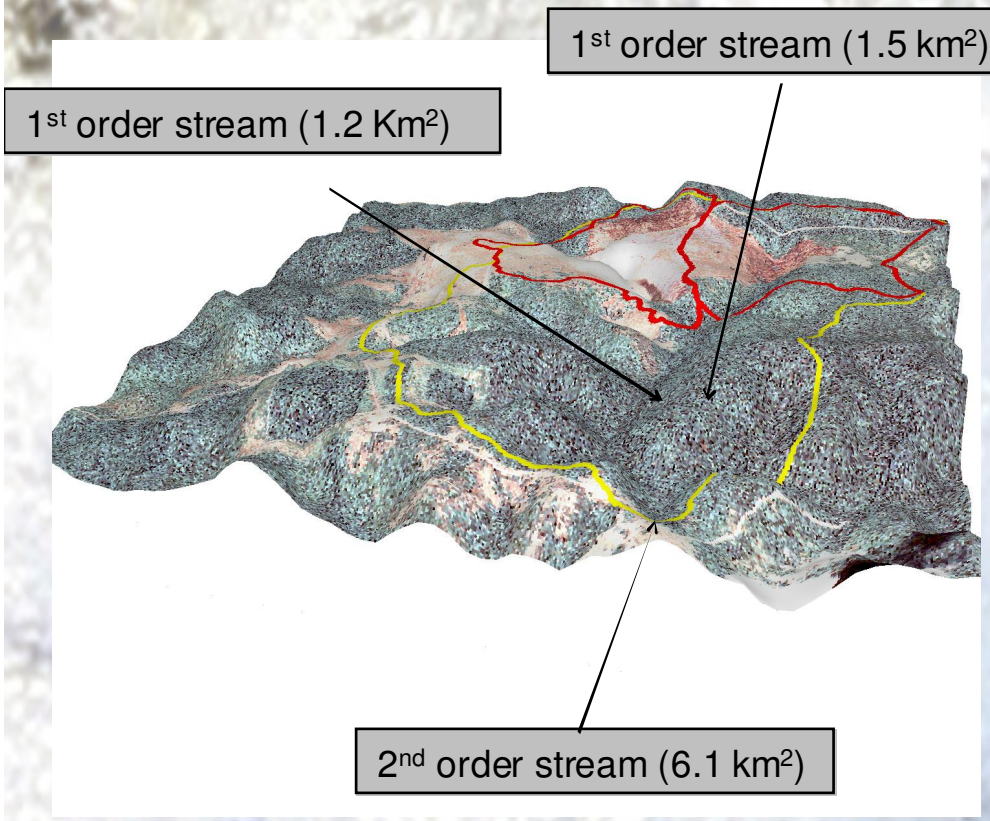
- Hydrology
- Hydrochemistry
- Soils
- Litter (stocks & quality)
- Valley groundwater drainage

- Physiology
- Botany
- Forest biomass
- Soil $CO_2$ fluxes
- Micrometeorology
- Fluxes of $H_2O$, energy & **$CO_2$**



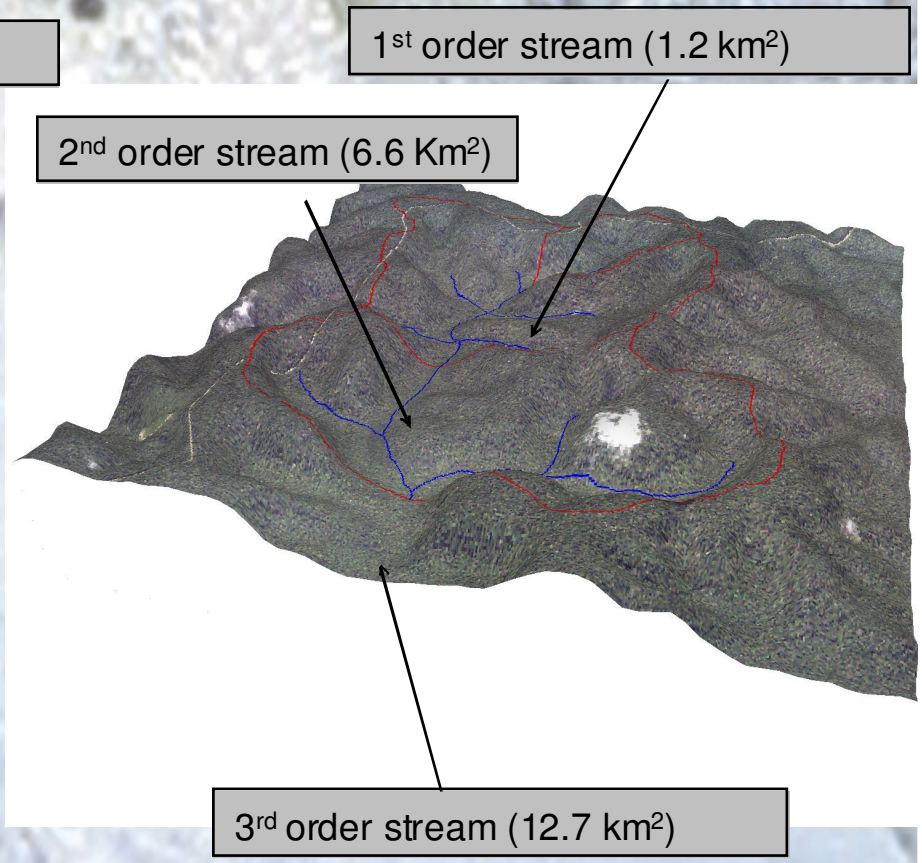
## Site with pastures and second growth

(N of Manaus, ZF 3 road – BDFFP)




## Site with intact forest

(N of Manaus, ZF 2 road LBA Project)




**Main research subjects:**

**- Climatology, hydrology and fluxes of gases (low tower in pasture)**

**- Increases in carbon and nutrient concentrations of stream water after deforestation = losses of C and nutrients from terrestrial system;**

**- Rehabilitation of soil, aquatic fauna and environmental services (including carbon & nutrient cycling, and water quality)**

# MICRO-SCALE HYDROLOGICAL MODELING

A parametric distributed model, physically based allow a dynamic and integrated representation of basin processes at the espatial scale described by the digital elevation model (DEM).

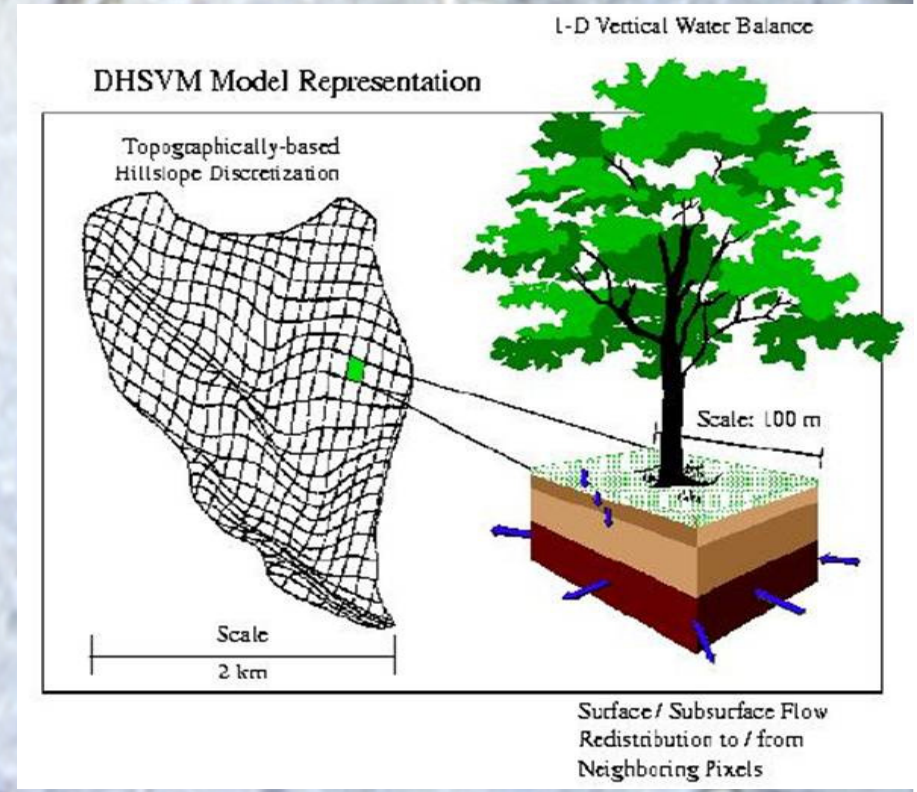
Espatial Resolution :

- 5 - 10 m → basins up to 100 km$^2$
- 100 m → basins up to 100 – 10$^4$ km$^2$

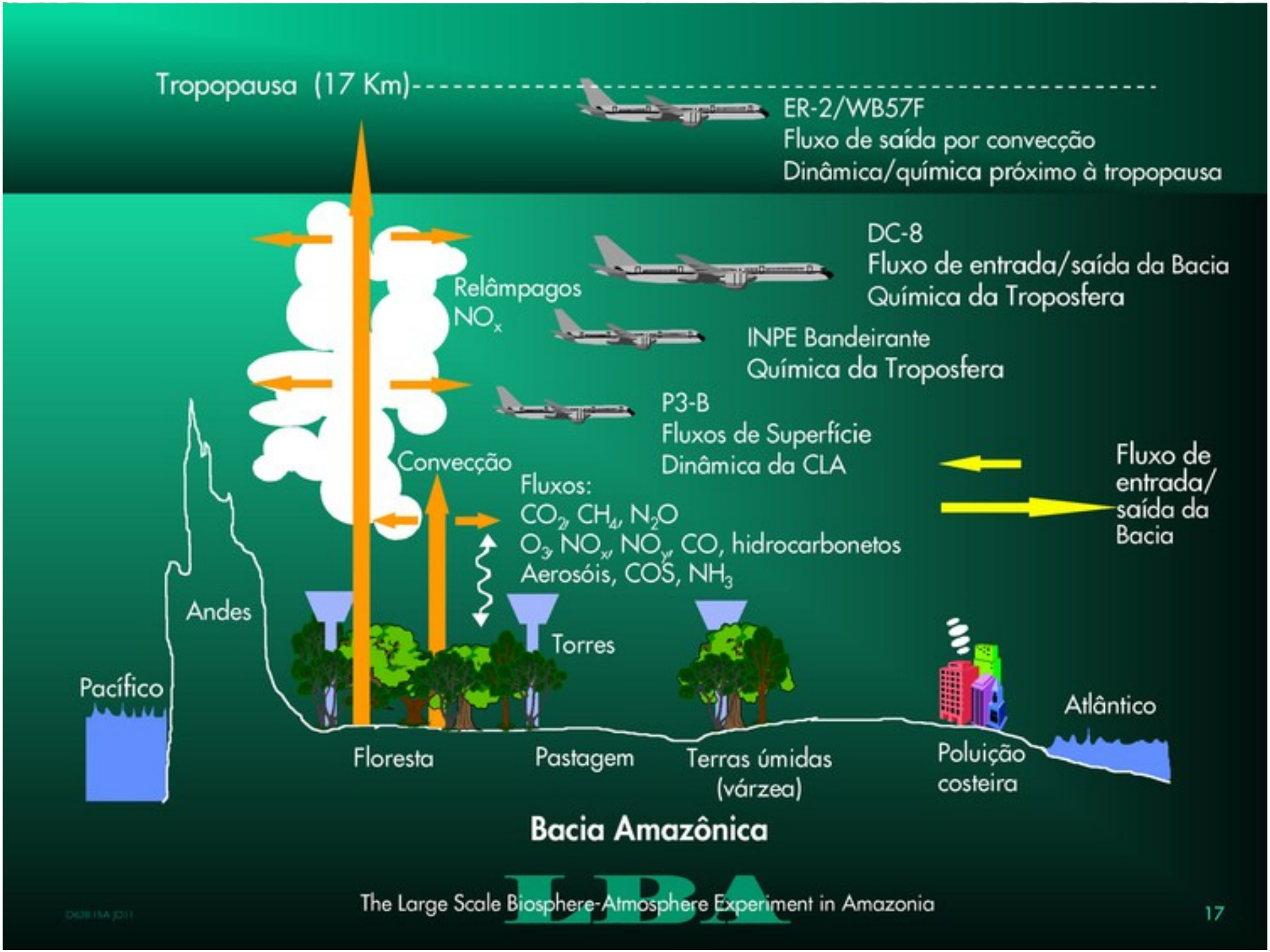
Temporal Resolution:

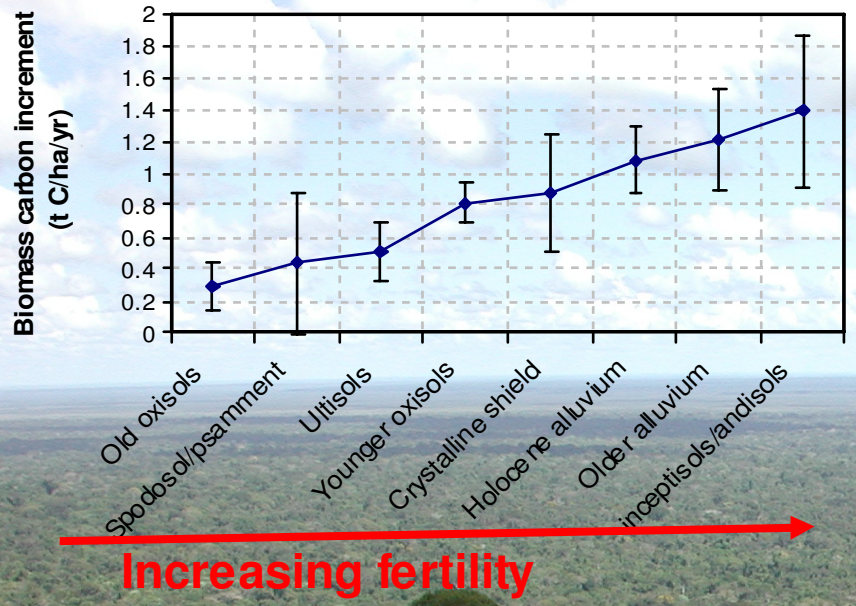
From a single event to a multi-annual scale, using daily or sub-daily paces.

Produce simultaneous solutions for the balance equations of water and energy for each cell in basin grid (Wigmosta et al., 1994; Wigmosta et al., 2002).




**DHSVM (Distributed Hydrology Soil Vegetation Model)**


Tropopausa (17 Km)
ER-2/WB57F
Fluxo de saída por convecção
Dinâmica/química próximo à tropopausa
DC-8
Fluxo de entrada/saída da Bacia
Química da Troposfera
Relâmpagos
$NO_x$
INPE Bandeirante
Química da Troposfera
P3-B
Fluxos de Superfície
Dinâmica da CLA
Convecção
Fluxos:
$CO_2$, $CH_4$, $N_2O$
$O_3$, $NO_x$, $NO_y$, CO, hidrocarbonetos
Aerosóis, COS, $NH_3$
Fluxo de entrada/ saída da Bacia
Andes
Torres
Pacífico
Atlântico
Floresta
Pastagem
Terras úmidas (várzea)
Poluição costeira
Bacia Amazônica
LBA
The Large Scale Biosphere-Atmosphere Experiment in Amazonia

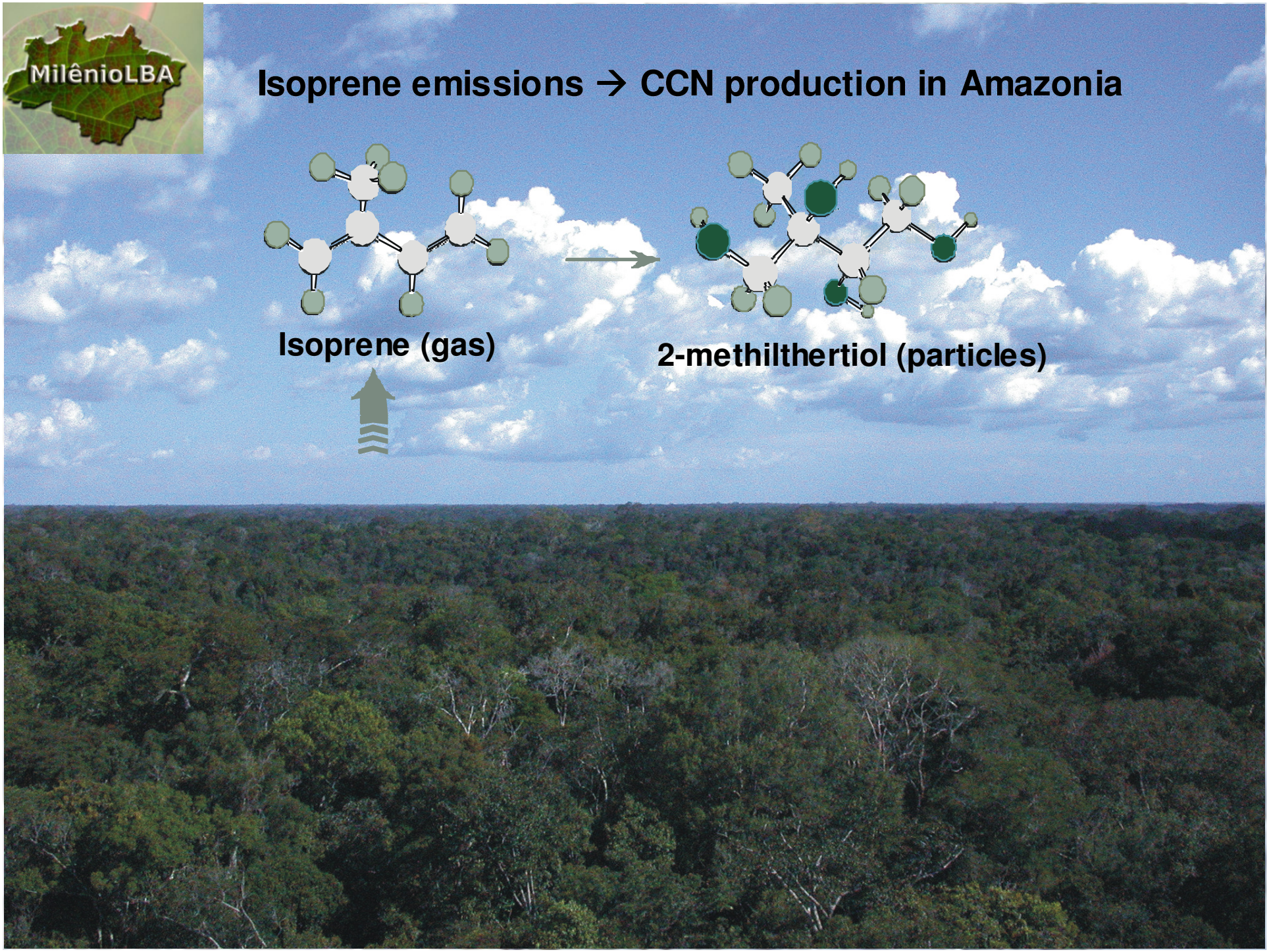



# Forests in western Amazonia are much more productive in wood than forests in the east

**Climax hypothesis revisited: climate and composition of the atmosphere are changing!**

- Amazonia functions as a modest sink of carbon (in the range of 0.5-1.0 Mg C ha/yr)

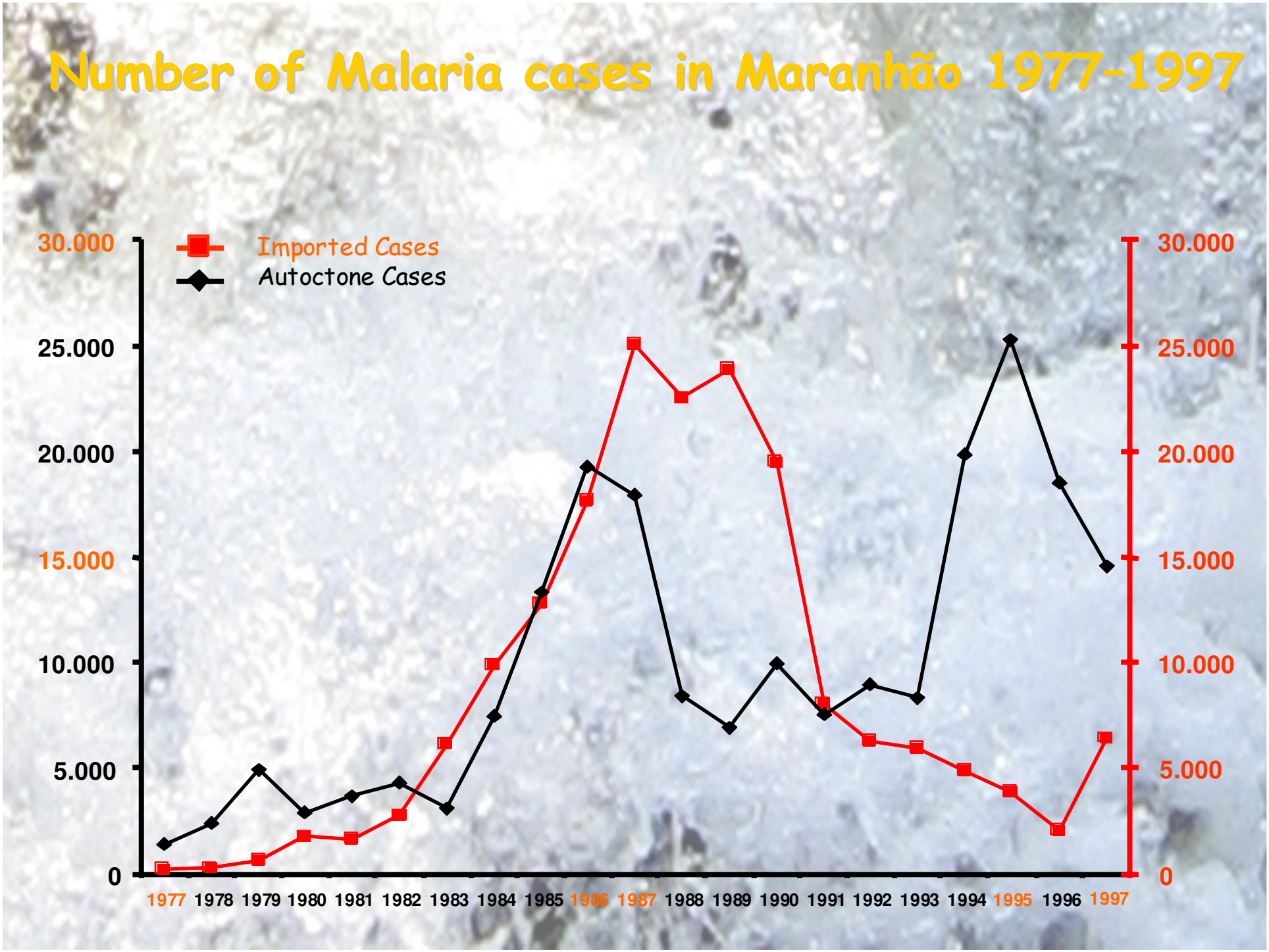
Huanchaca, Bolivia


MilênioLBA
Isoprene emissions → CCN production in Amazonia
Isoprene (gas)
2-methilthertiol (particles)

# Land use change X Health in Brazilian Amazonia

| | | |
|---|---|---|
| URBANIZATION | → | Malaria e leishmaniase em Manaus |
| HE dams | → | Mudanças nas populações de mosquitos |
| SELECTIVE LOGGING | → | Arbovirus e infecçõs leishmania |
| MINING | → | Morcegos |
| ROAD BUILDING/PAVING | → | Síndrome hemorragica de Altamira; arbovirus |
| "SAVANNIZATION" (?) | → | Kala-azar |
| EXTRATIVISM | → | Pararamose |

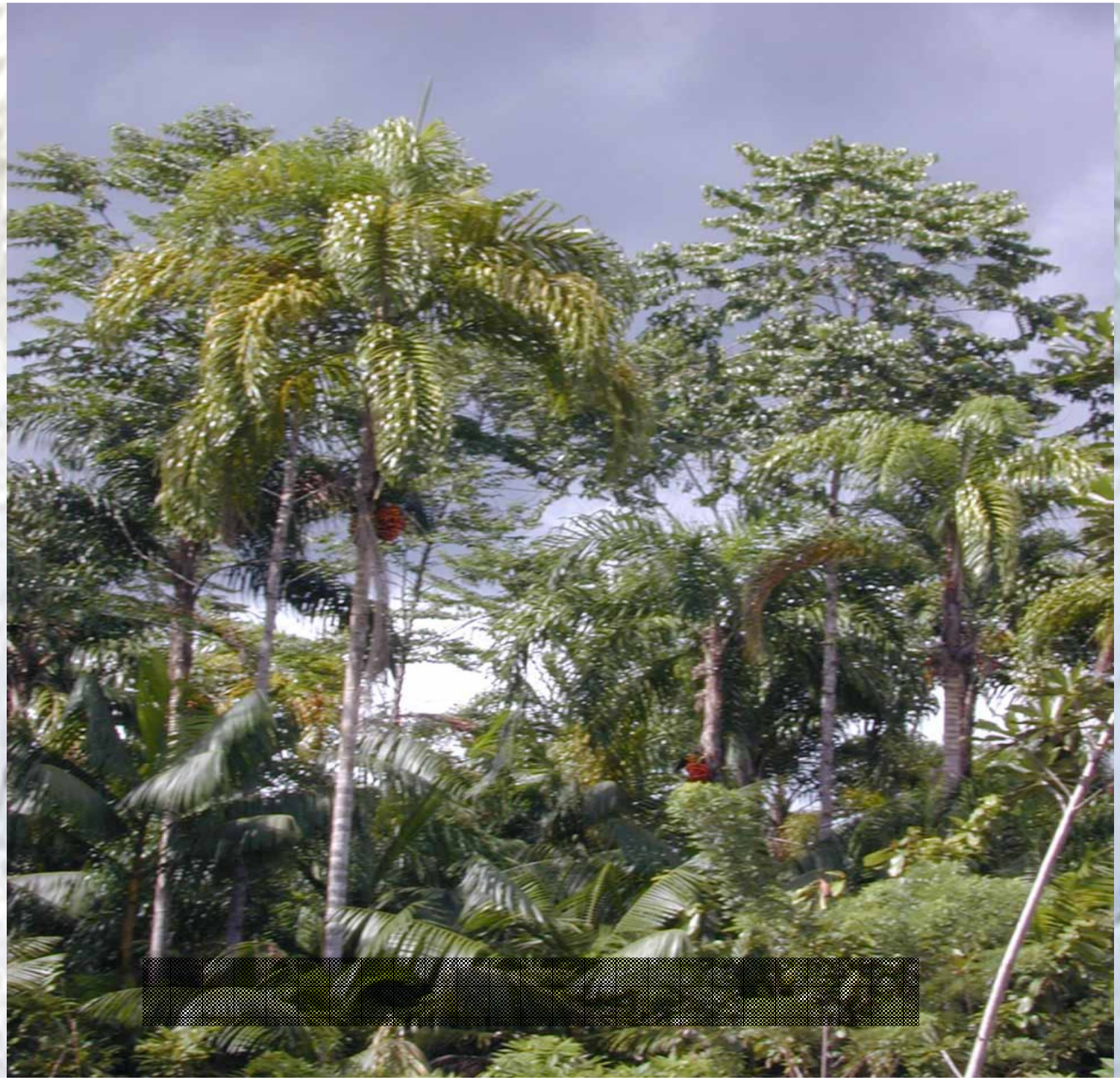
# Number of Malaria cases in Maranhão 1977-1997



# Supression/reduction of fire to land preparation

Land prepared without use of fire

➔ biomass cut-choping



Multi-strata AFS (several fruit trees + valuable timber species (including Mahogany planted in1991)

Recovering ecosystem services:
-Carbon sequestration
-Nutrient recycling
-Local water circulation