THMB: um modelo do hidrologia global

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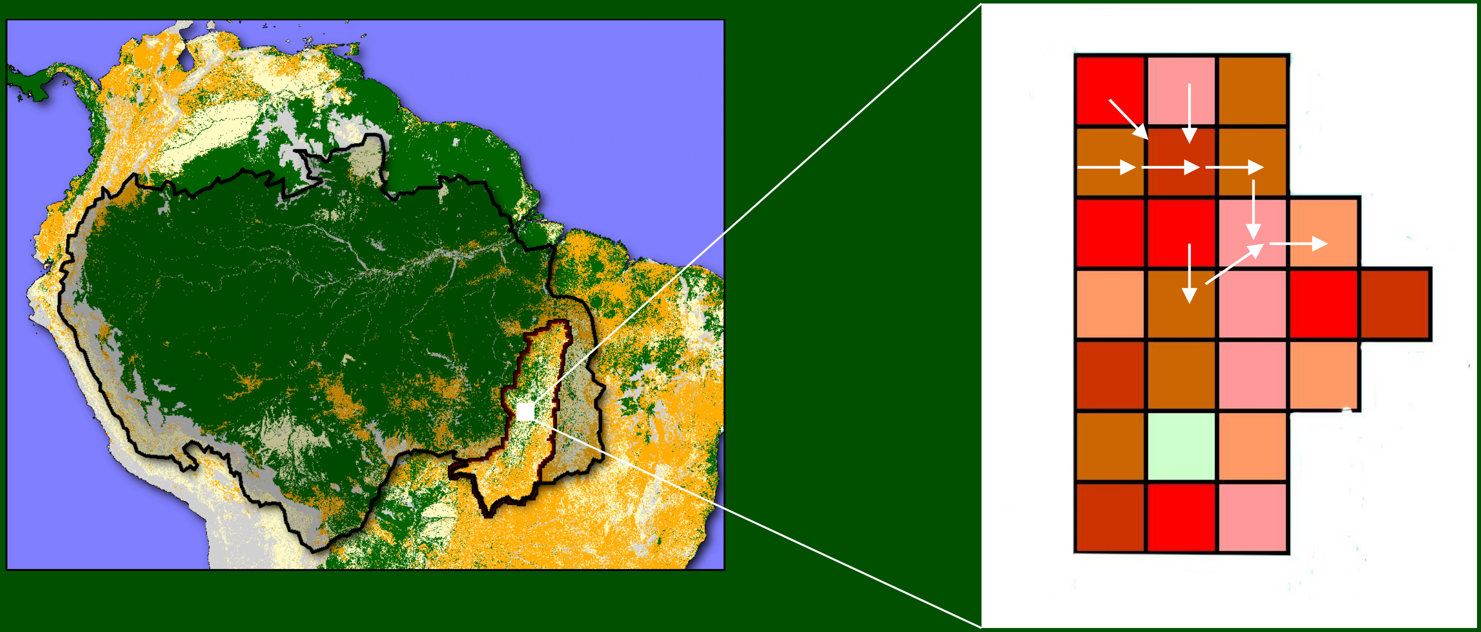
The Woods Hole Research Center

THMB: um modelo mecanistico para simular a hidrologia global

- Suficiente simples para usar com modelos global
- Suficiente complexo para representar os processos fisicos e para ser sensível a mudanças (usas da terra, mudanças climáticas)
- Capacidade de funcionar em resolução baixa e alta
- Capaz de expandir para modelar bioquímica, temperatura, oxigenio dissolvido, sedimento

A paisagem como um grid



Cada caixinha contem caracteristicas medias da paisagem

- morfologia
- clima
- manejo

Cada caixinha são ligado do grid com caminhos de fluxo dos rios.

THMB combina:

- Dados climáticos (escoamento superfiçial e sub-superficial e perda de nitrato do IBIS)
- Morfologia superficial do modelo digital de elevação SRTM

Para calcular:

- Transporte fluvial traversando as superficies terrestres até chegar aos oçeanos e bacias de drenagem continentais.
- Abasteçimento de água em lagos, áreas inundadas, e reservatórios.
- Transporte de solutos em sistemas fluviais (nitrogênio actualmente, carbono no futoro).

THMB

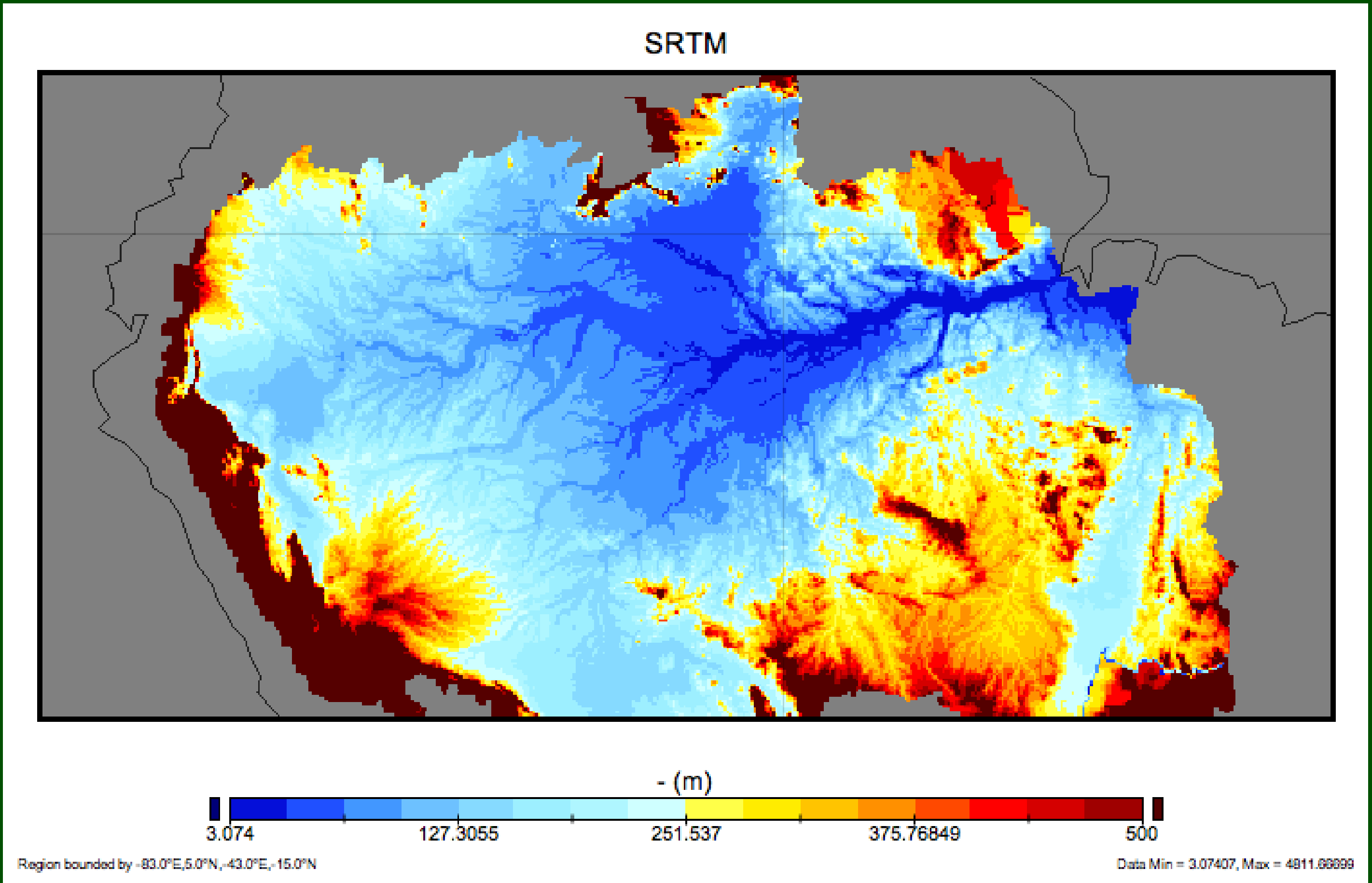
O volume da água em cada caixa é representada por equações simples

$$dV/dt = R(1-A_w) + (P-E)A_w + (\Sigma F_{in} - F_{out})$$

A_w = área da água no rio e inundação previsto para modelo
$R = R_{surface} + R_{sub\text{-}surface}$ (escoamento local)
E = evaporação da água
$\Sigma F_{in} = \Sigma F_{out}$ (input montante)
$F_{out} = V(u/d)$ (descarga jusante)

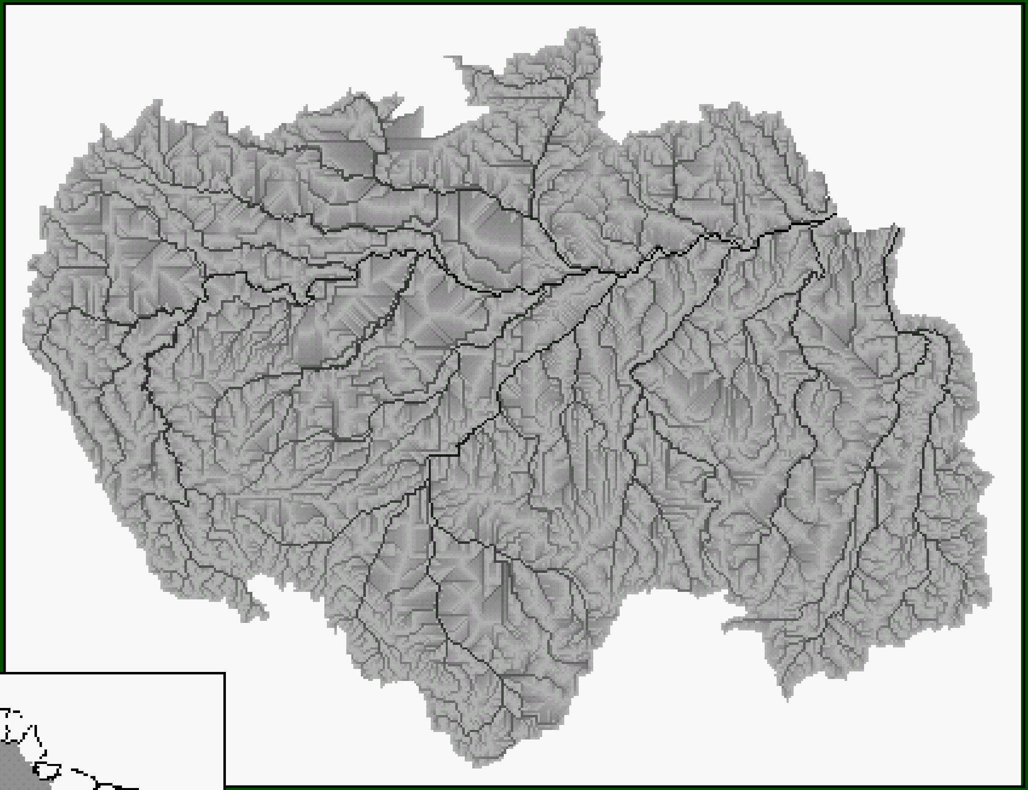
A massa é conservada -- toda a água que entra no rio é descargada pelo oceano ou é evaporada.

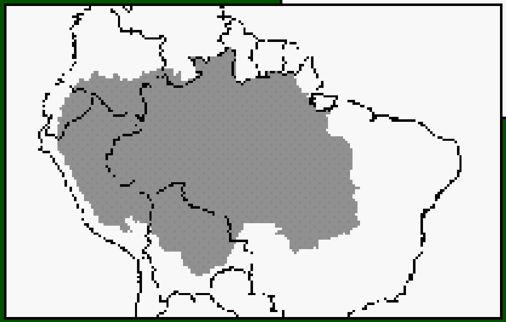
Área de inundação



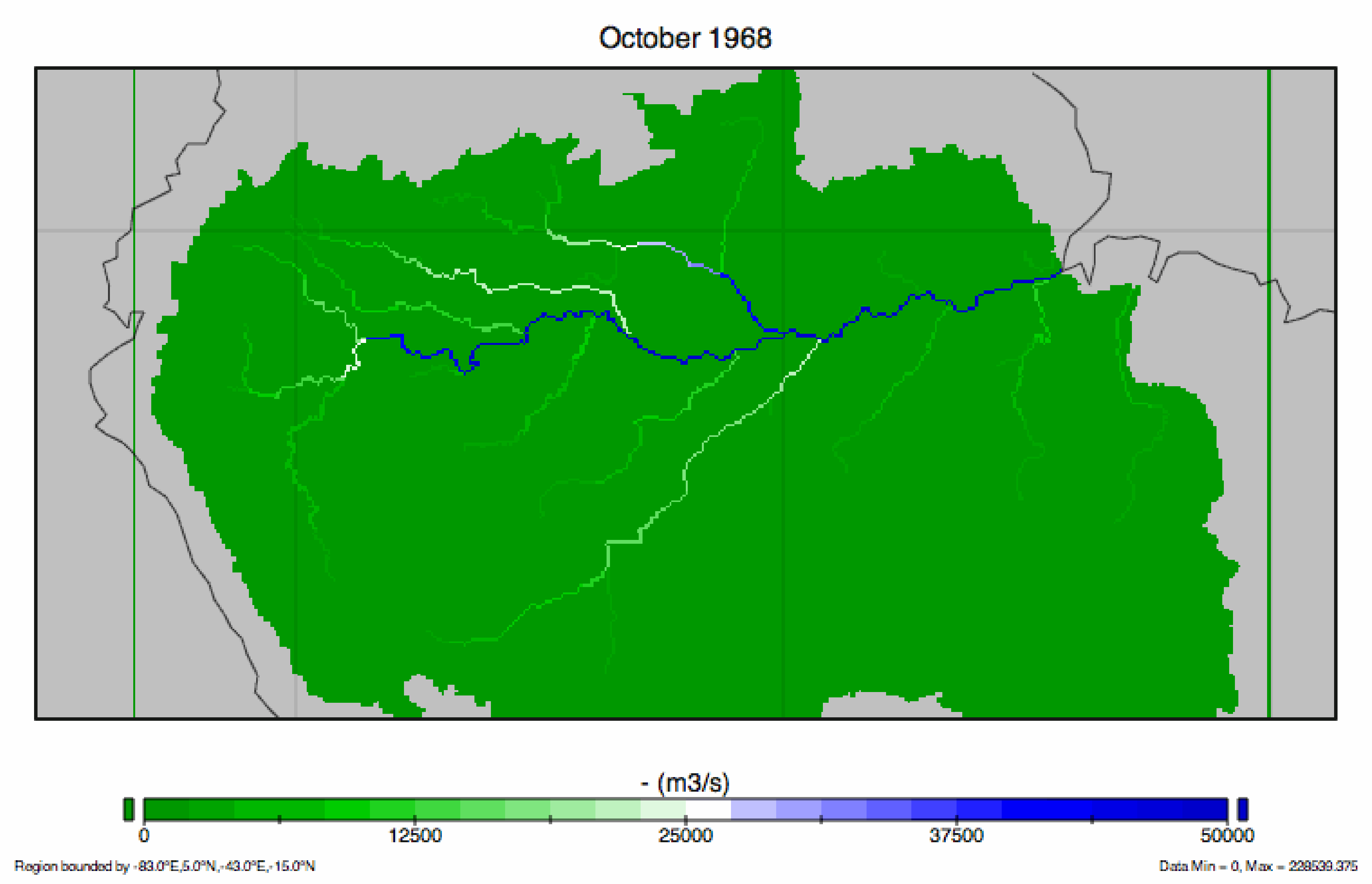
Define a planície de inundação com modelo digital de elevação SRTM

Aplicações 2-D no Amazônia



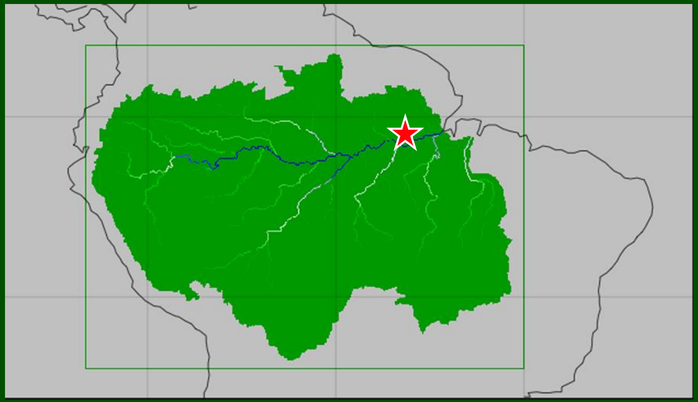


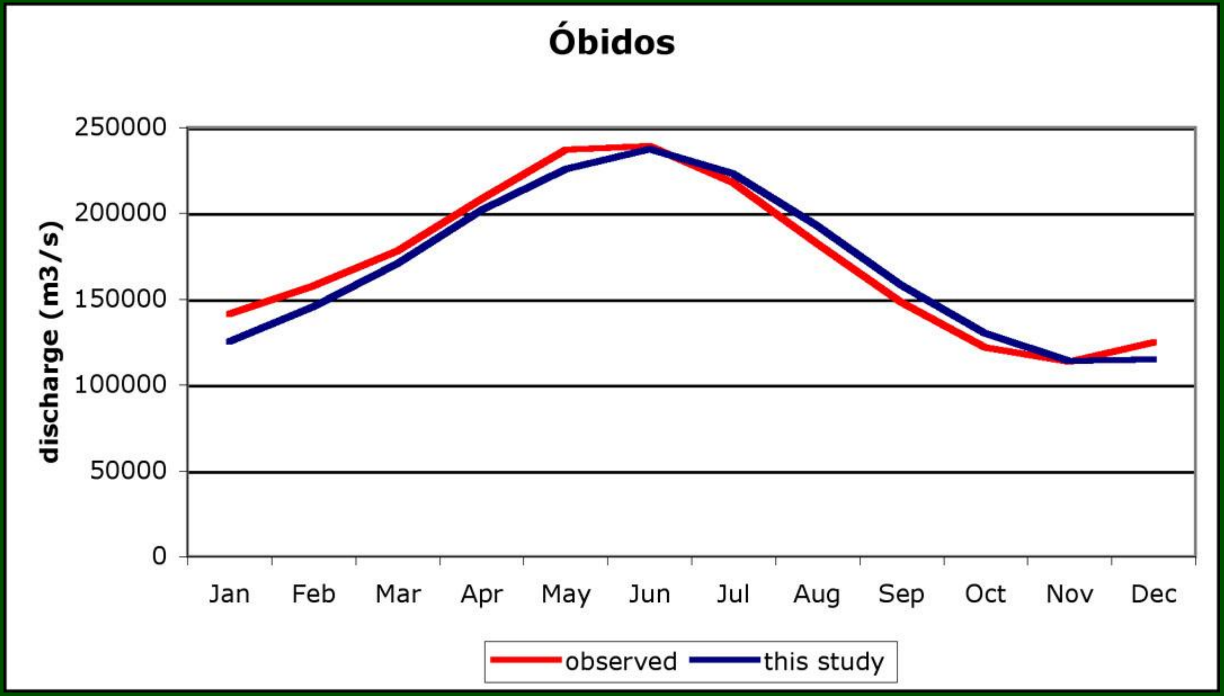
Descarga



October 1968
- (m3/s)
0
12500
25000
37500
50000
Region bounded by -83.0°E,5.0°N,-43.0°E,-15.0°N
Data Min = 0, Max = 228539.375

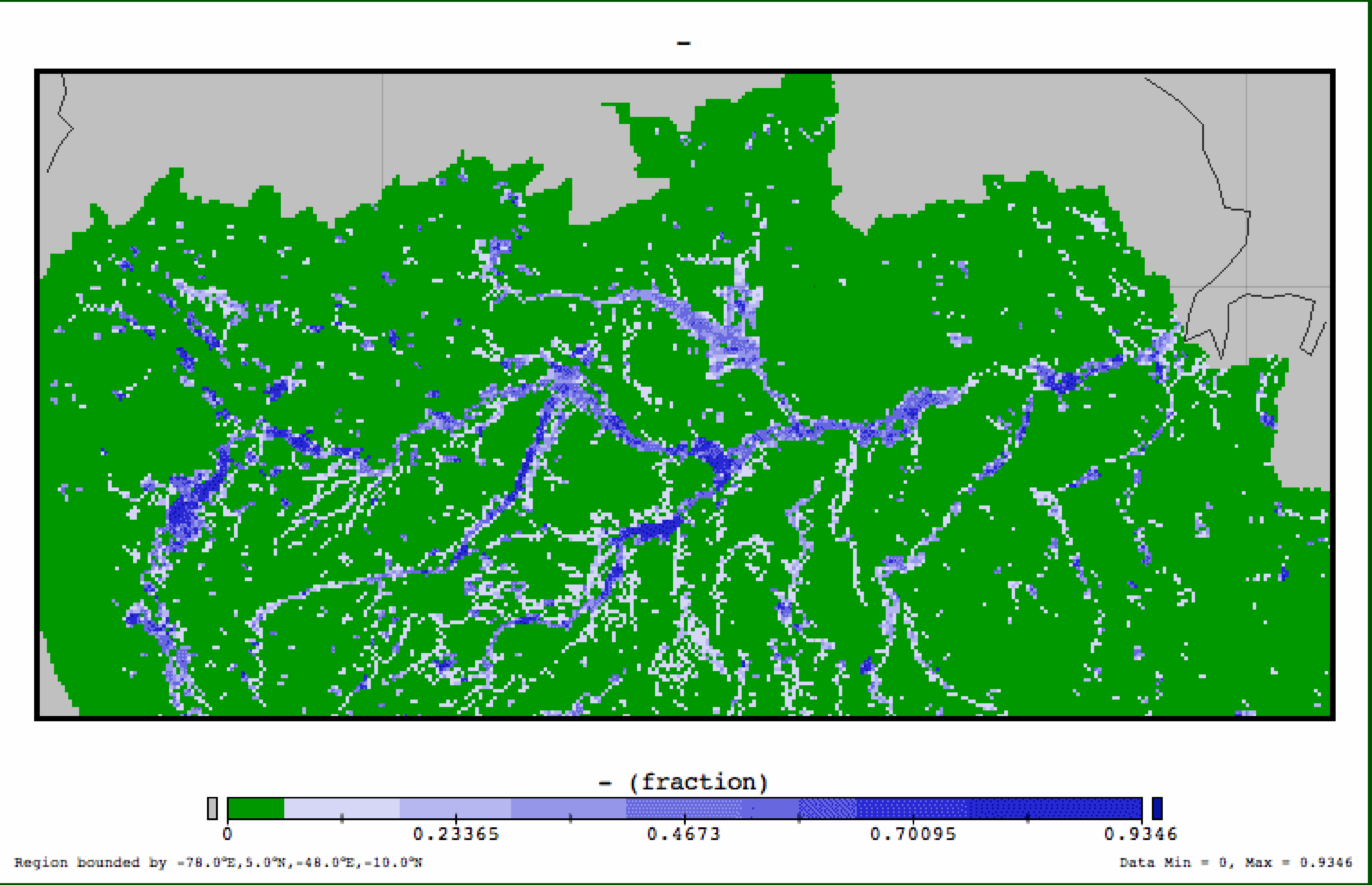
Descarga



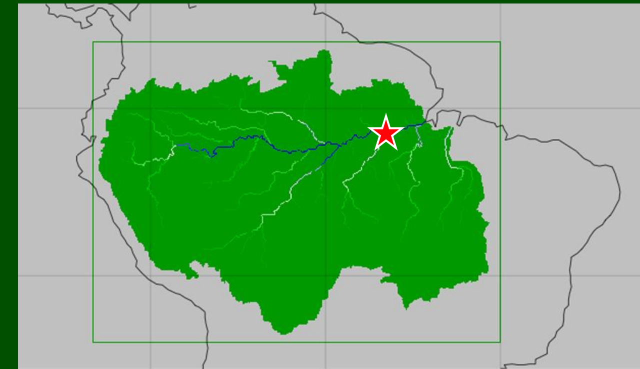


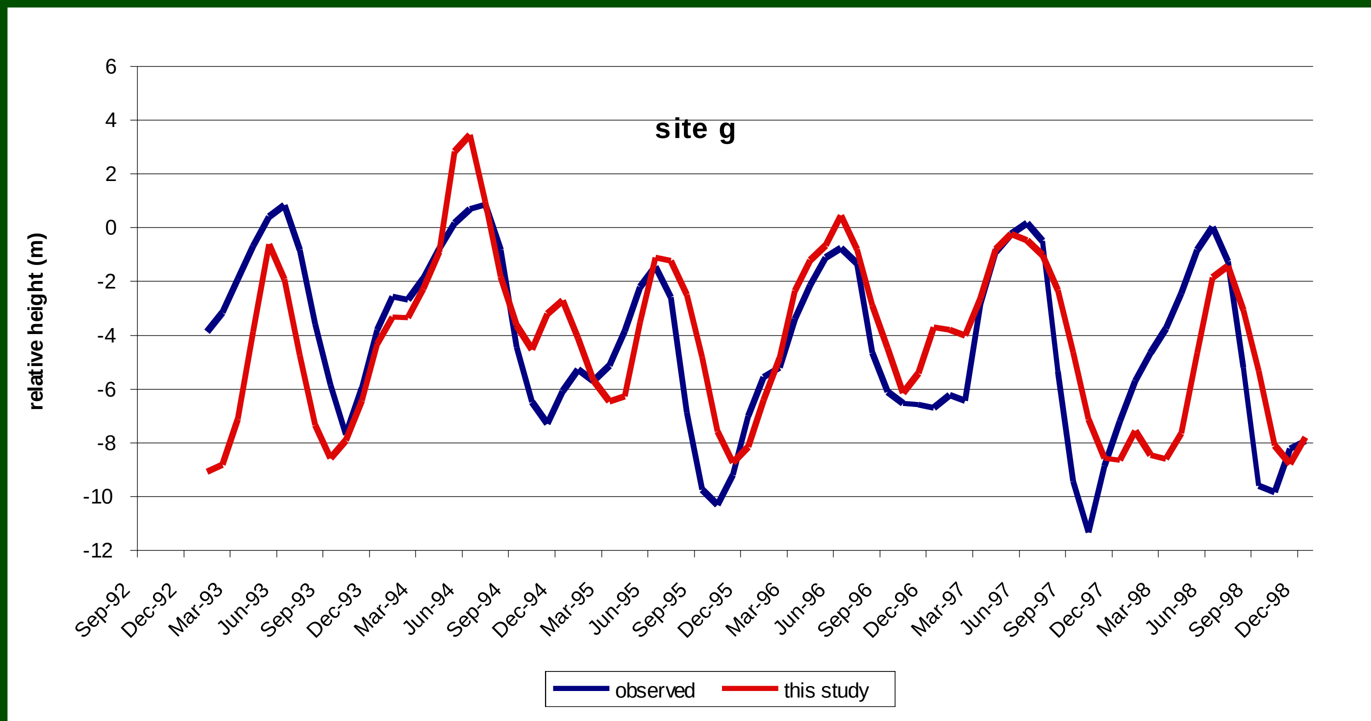
Óbidos
250000
200000
150000
100000
50000
0
discharge (m3/s)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
observed
this study

☐Área de inundação



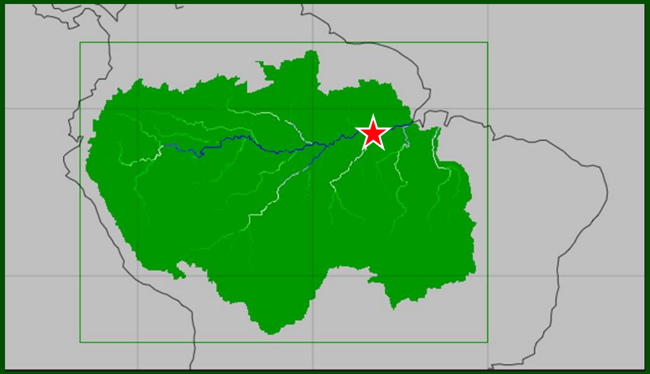
Altura da □água

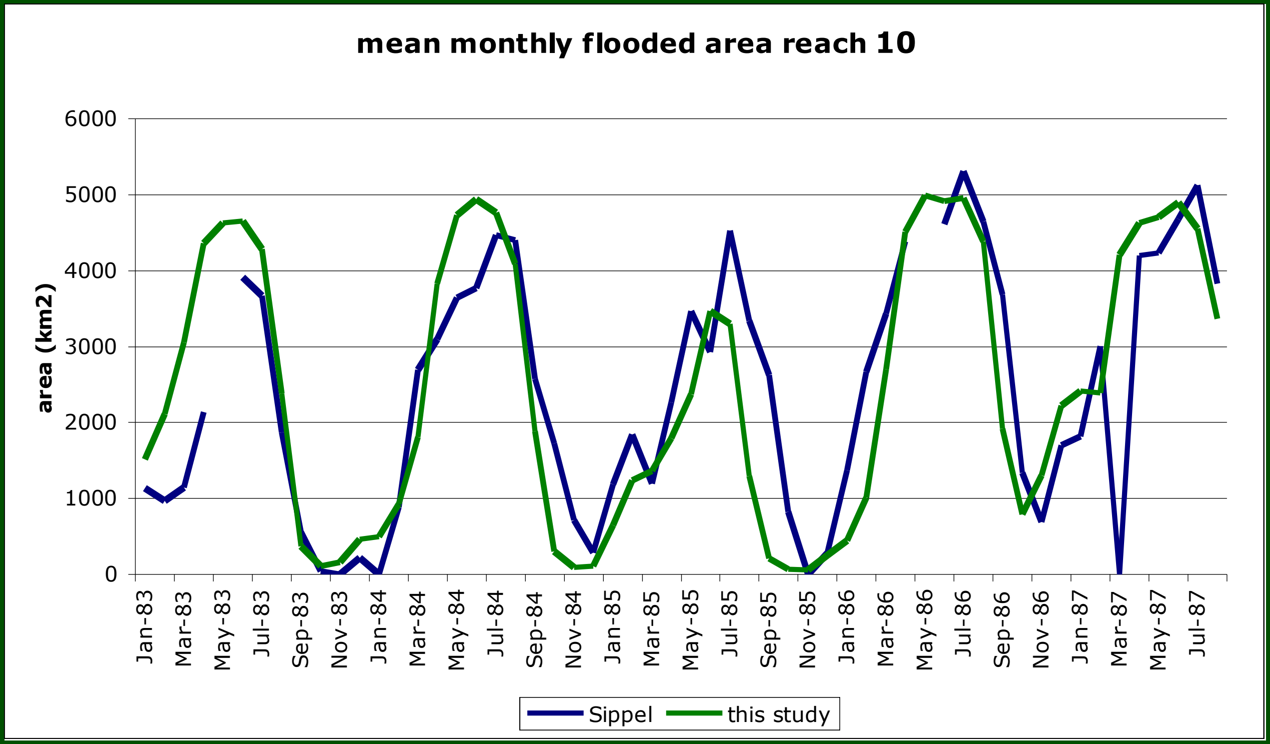




Comparação de altura da água relativa, medida por altimetro radar TOPEX/Poseidon e simulado pelo modelo. $r^2 = 0.66$

Área de inundação





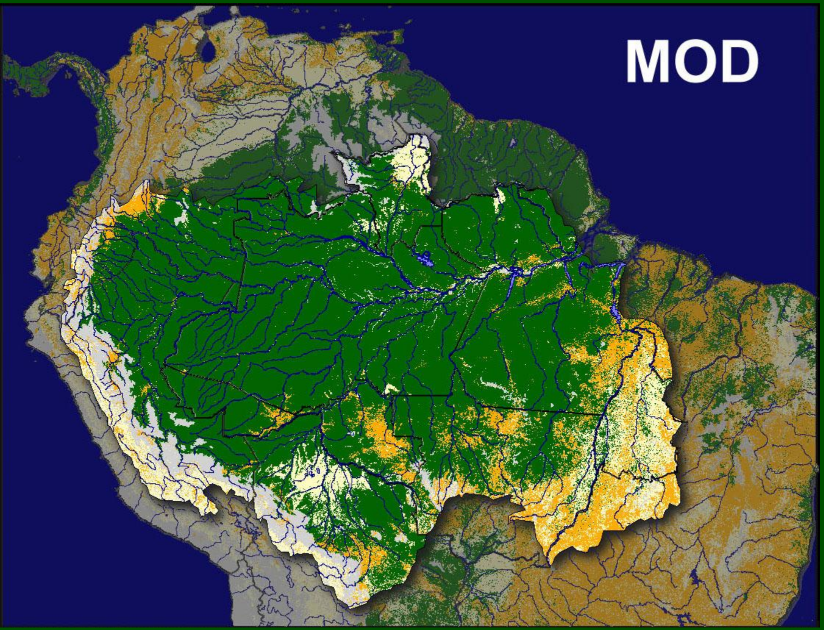
Observaçoes de Sippel et al., 1998

Desmatamento

Local impacts:
• Decreased ET, increased T, increased runoff

Continental scale impacts:
• Climate feedbacks, decreased rainfall and runoff at least regionally

Combined impacts:
• Greater extremes and potentially further reduction in forest area

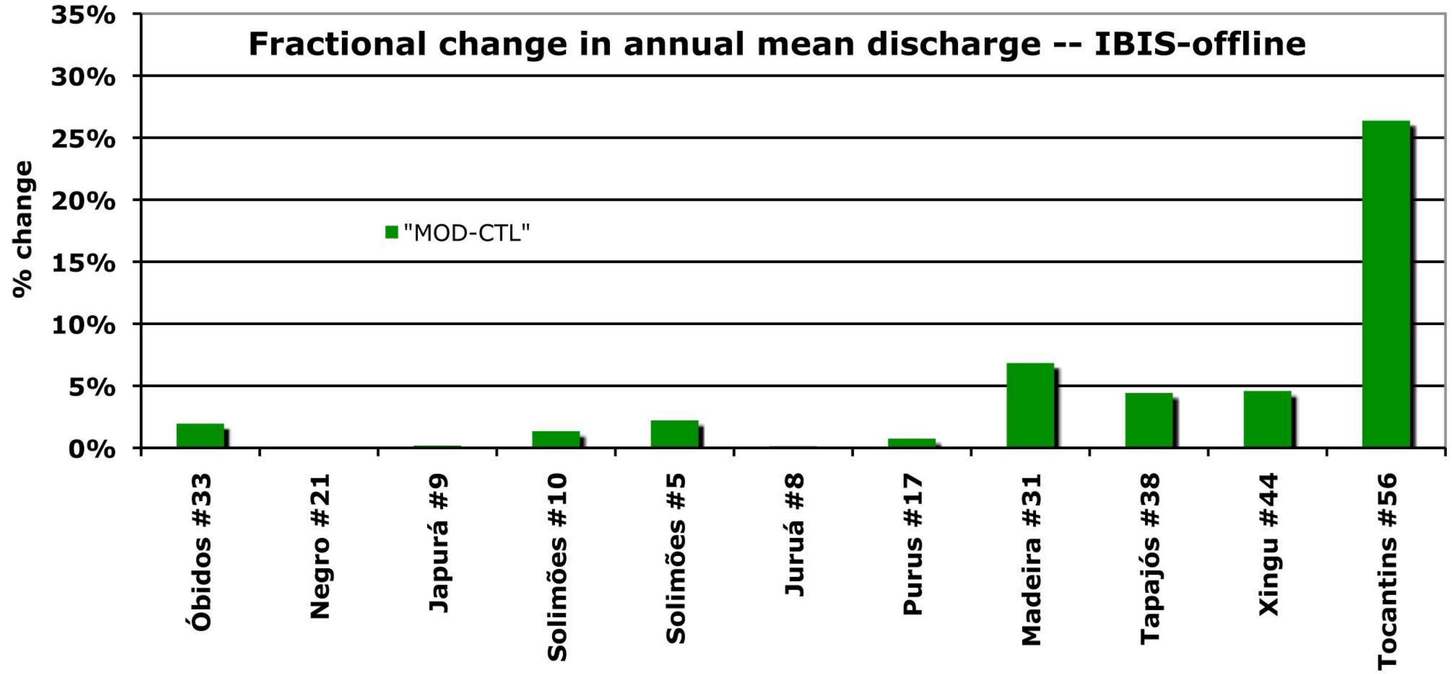


1. Has land cover change affected streams already via decreased evapotranspiration?

Two simulations with IBIS & THMB alone with identical climate (1939-2000), but agriculture, represented by grass, replacing forest in the modern simulation

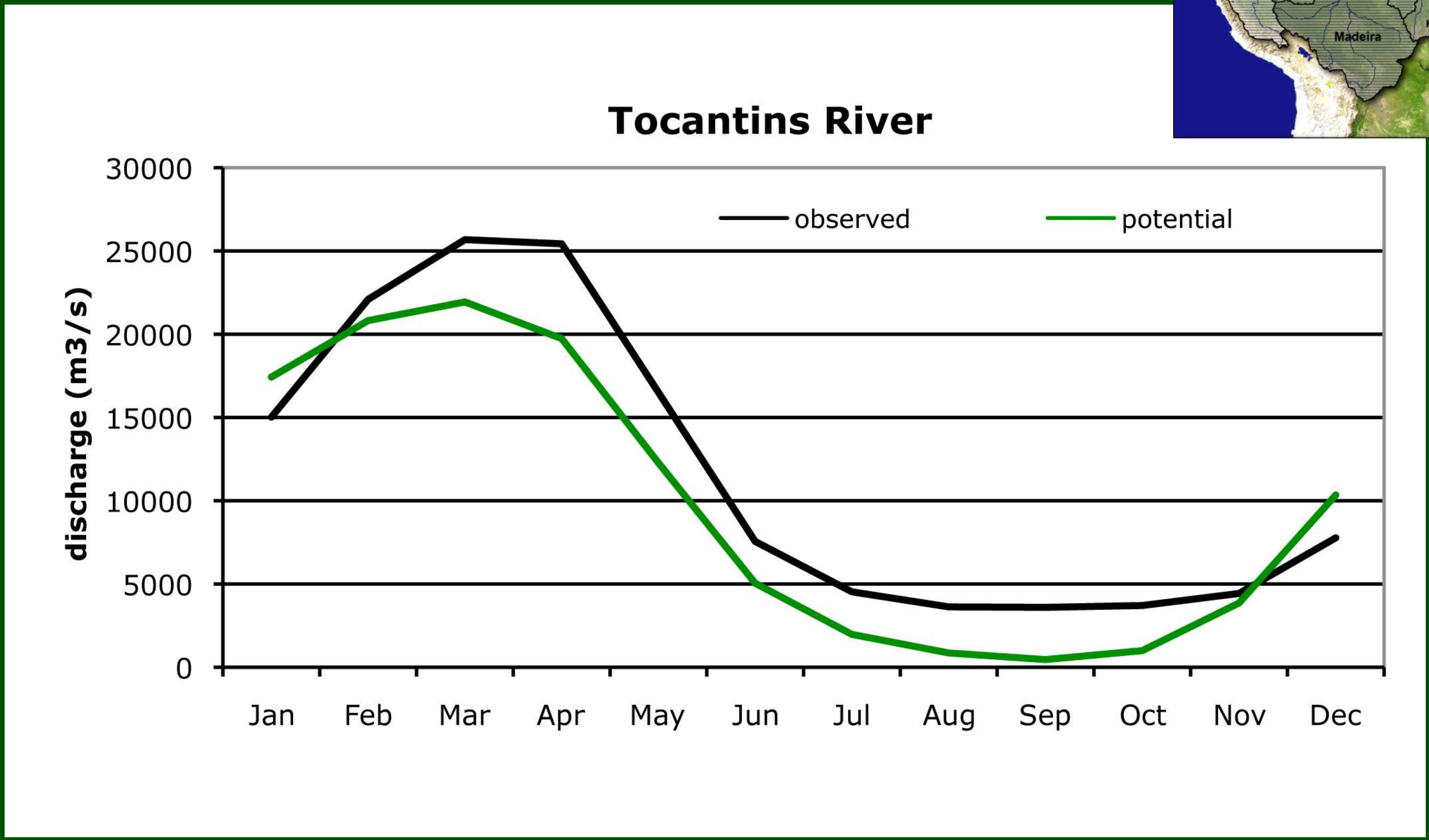
Any difference in simulated evapotranspiration and discharge is a function of land cover change alone

Moderno menos o potencial



O aumento da descarga é proporcional à desmatamento

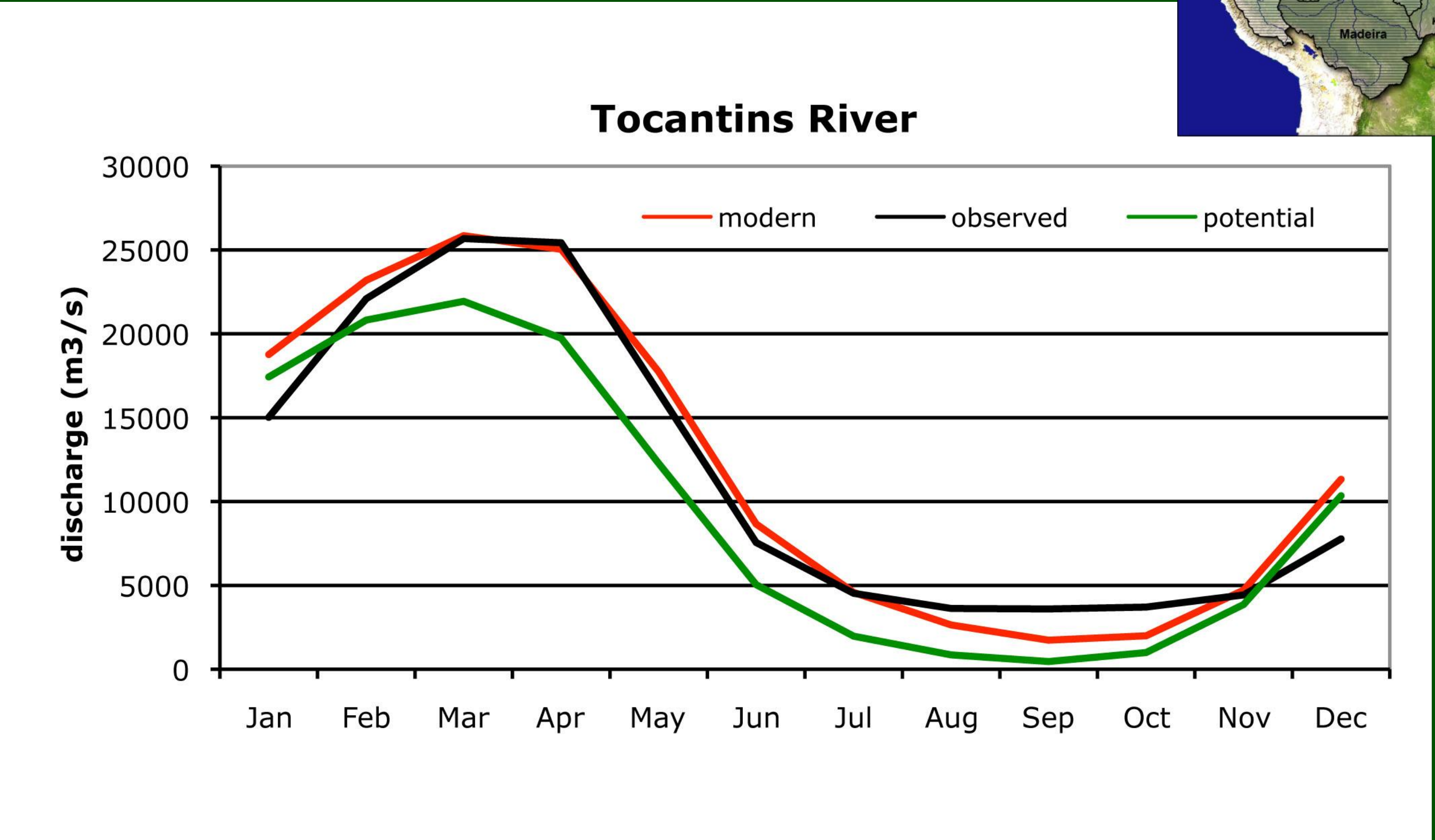
Tocantins River – 1990s



Descarga observada, preto

Descarga simulada sim desmatamento, verde

Tocantins River – 1990s



Descarga observada, preto

Descarga simulada sim desmatamento, verde

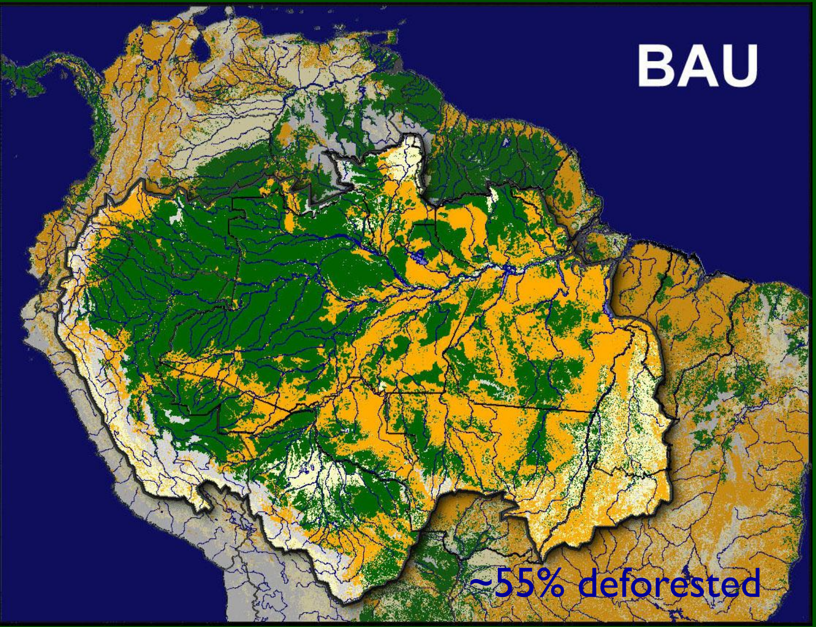
Descarga simulada com desmatamento, vermelho

Original Question

1. Has land cover change affected streams already?

Yes, in SE Amazonia simulated discharge agrees with observations in the 1990s only if land cover change is included

Strongly suggests that observed change in discharge over the last few decades is largely a result of deforestation



Future Land Cover Scenarios

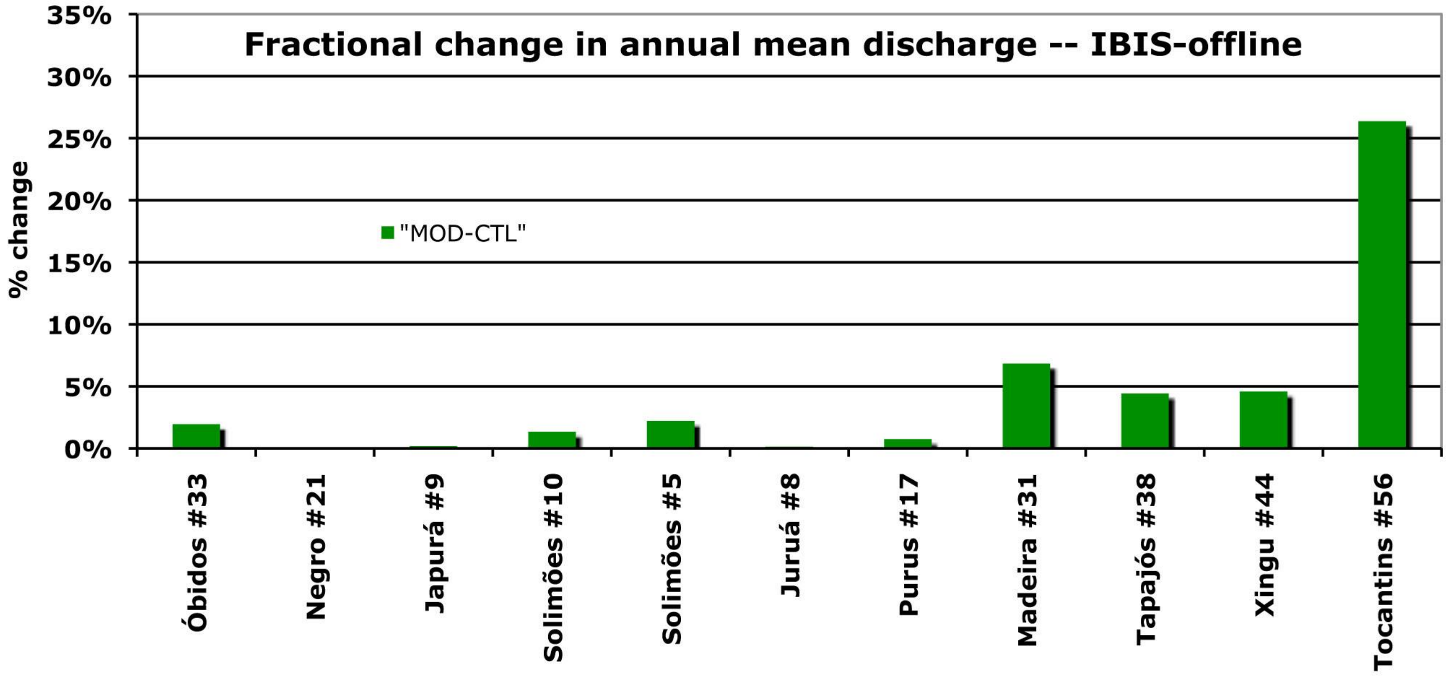
2. Are future atmospheric feedbacks to rainfall of potentially important scale?
3. Are there important differences in future scenarios for the Amazon River?

Two sets of simulations:

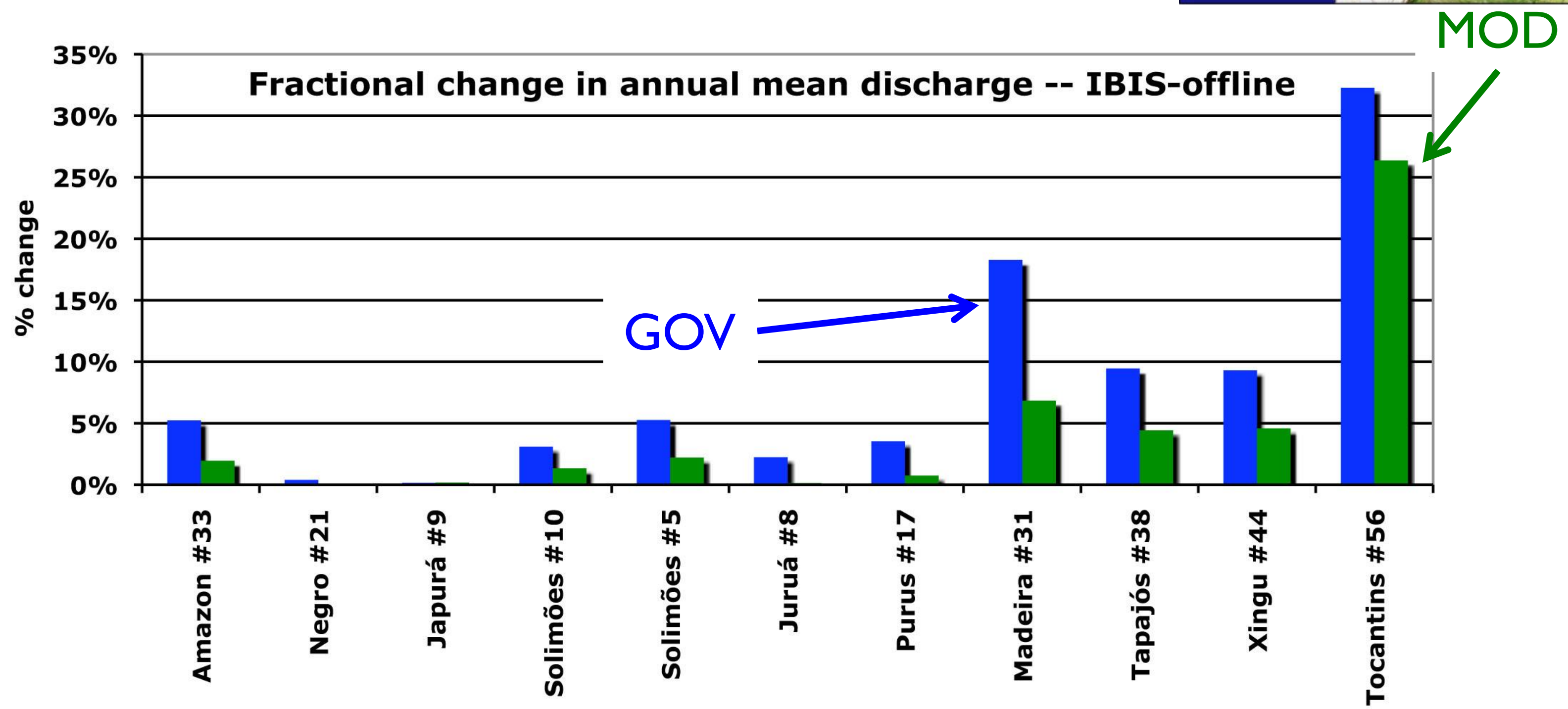
IBIS/THMB alone with prescribed historical climate 1939-2000 and different land cover scenarios – the effect of future land cover change alone

CCM3/IBIS/THMB coupled with dynamic climate and different land cover scenarios – the effect of future land cover change and climate feedbacks

IBIS/THMB Modern Deforestation and Prescribed Climate

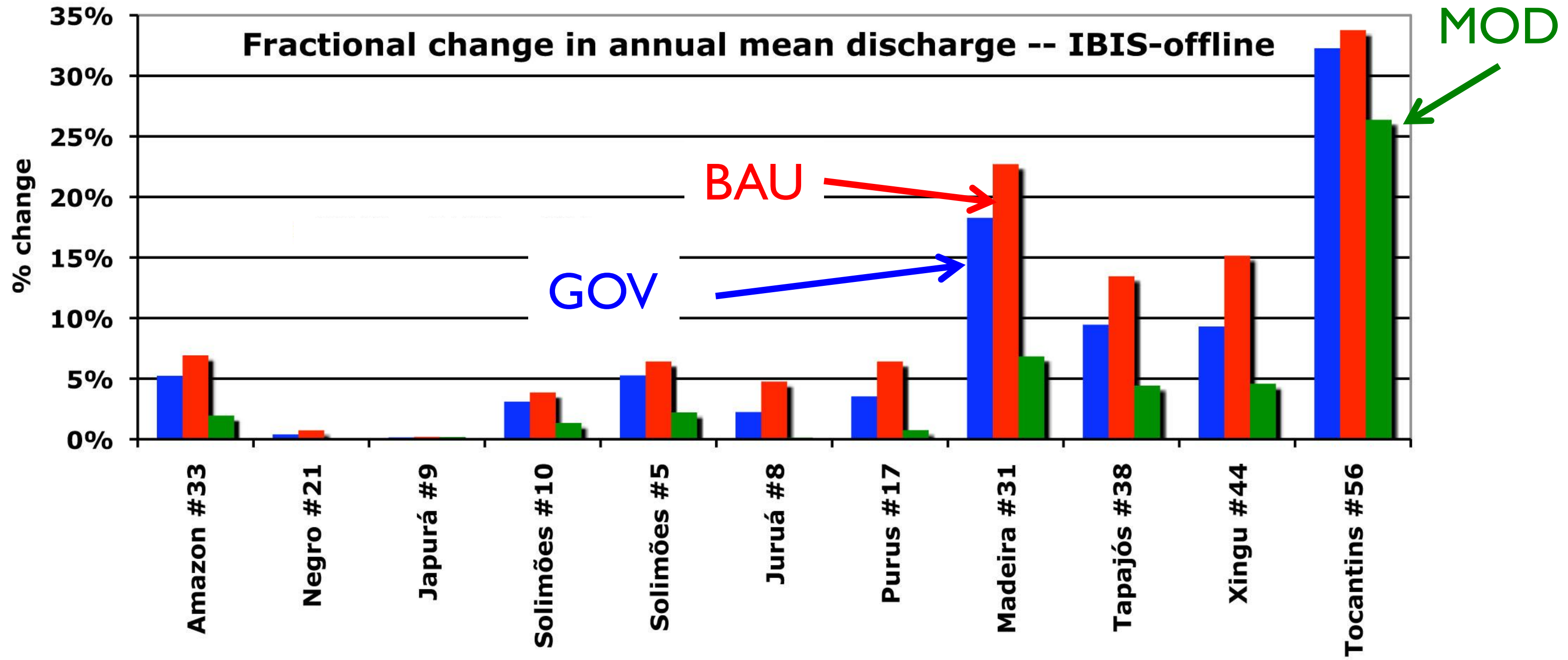


IBIS/THMB – Future Deforestation Scenarios and Prescribed Climate



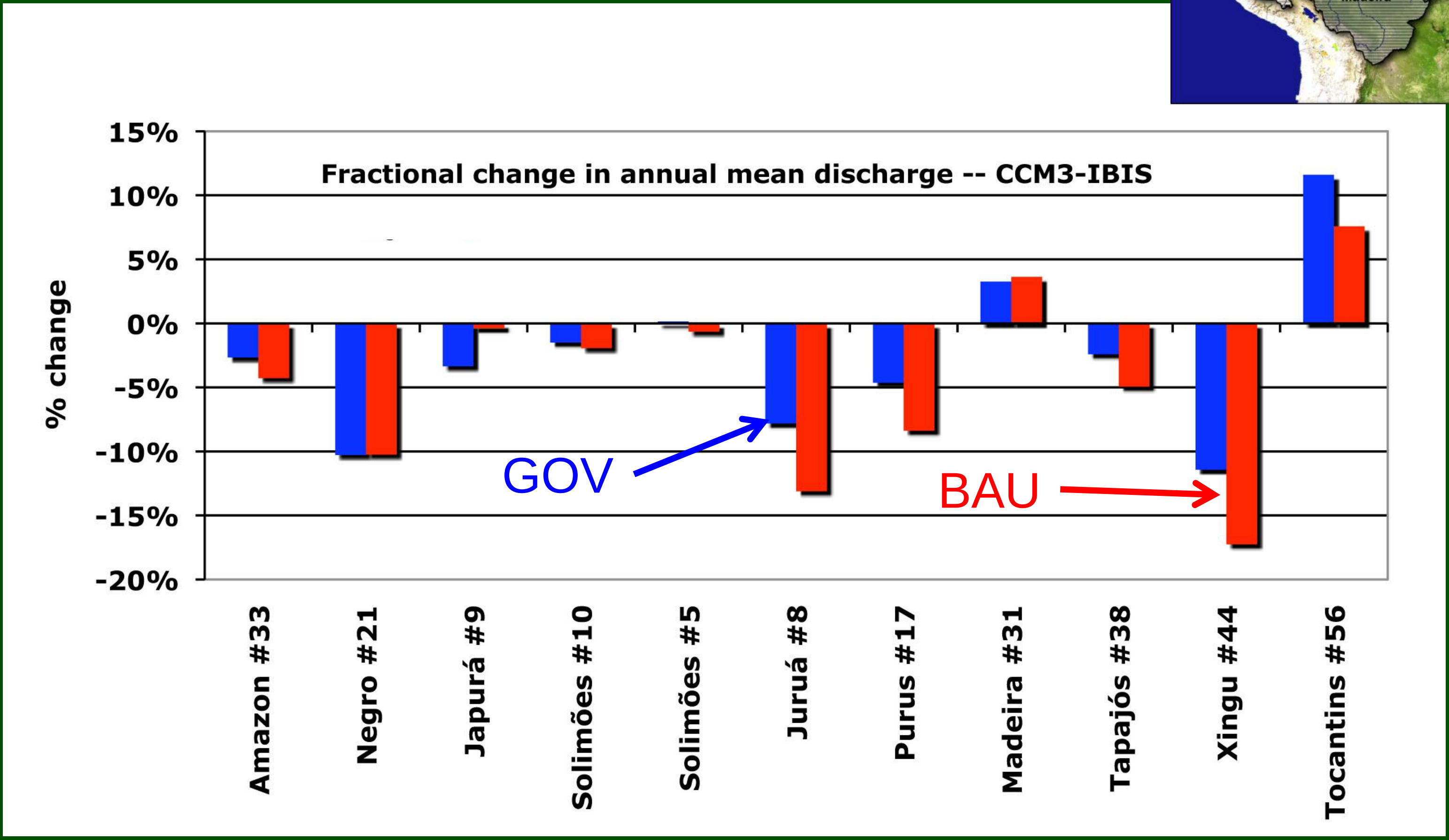
In absence of atmospheric feedback predicted change is large in SE Amazonia

IBIS/THMB – Future Deforestation Scenarios and Prescribed Climate



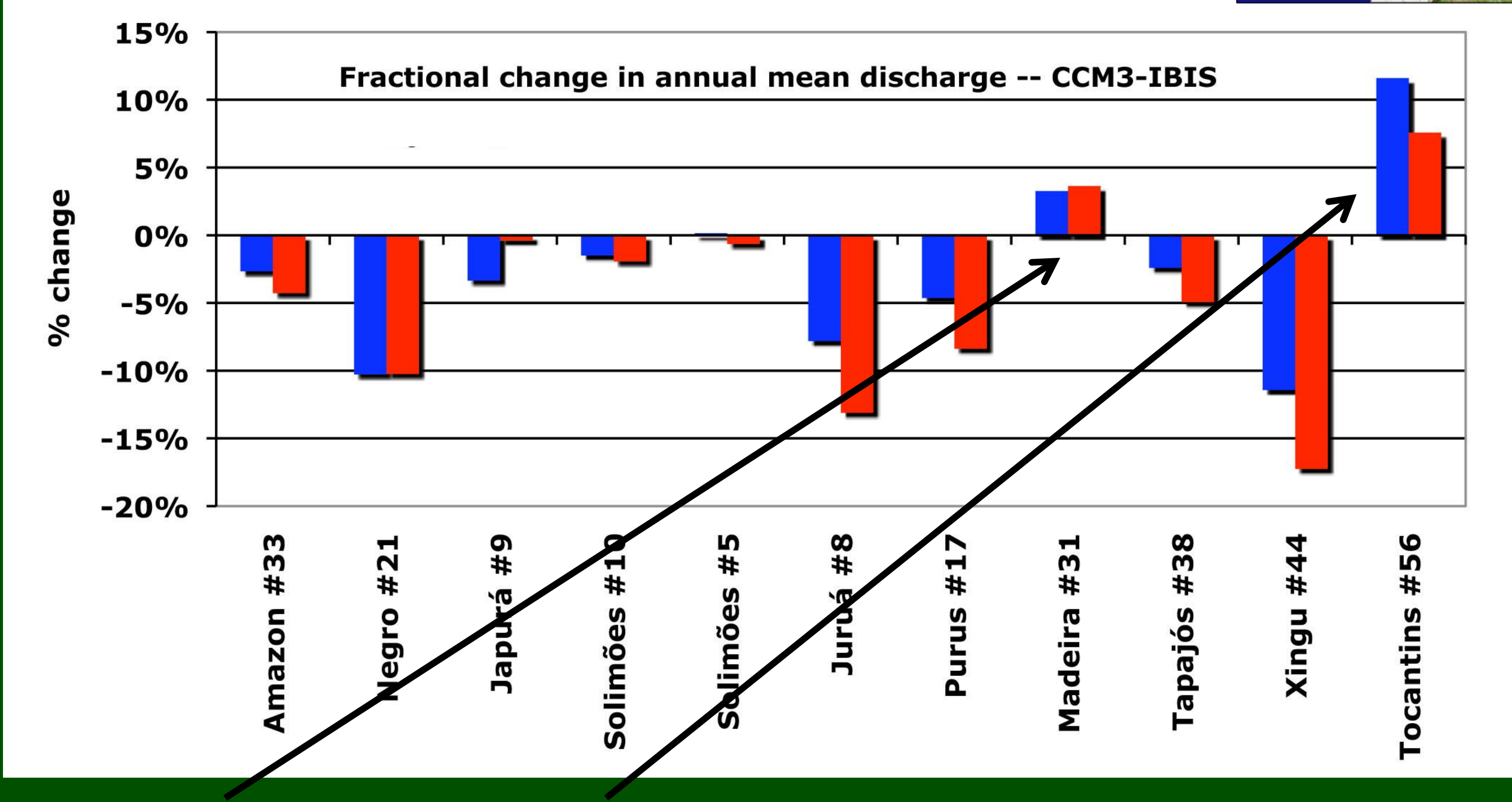
In absence of atmospheric feedback predicted change is large in SE Amazonia

CCM3/IBIS/THMB Coupled - Future Deforestation Scenarios and Dynamic Climate



Precipitation decrease in ALL basins (5-20%)
Discharge decrease in most basins
Significant difference between GOV and BAU

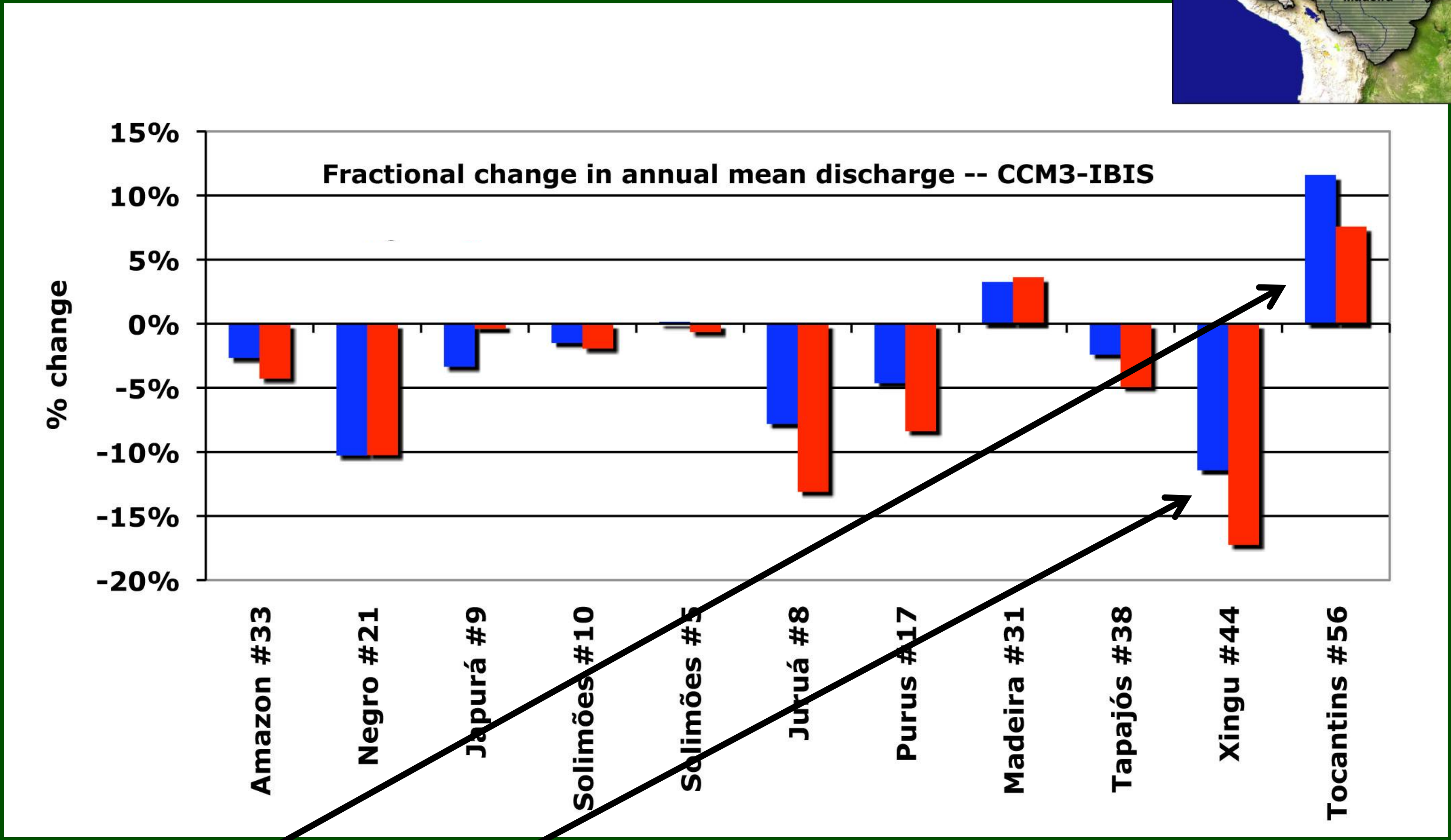
CCM3/IBIS/THMB Coupled - Future Deforestation Scenarios and Dynamic Climate



Madeira and Tocantins have largest deforested areas (GOV = 41%, 80%)

Net positive change because the local ET decrease is large

CCM3/IBIS/THMB Coupled - Future Deforestation Scenarios and Dynamic Climate

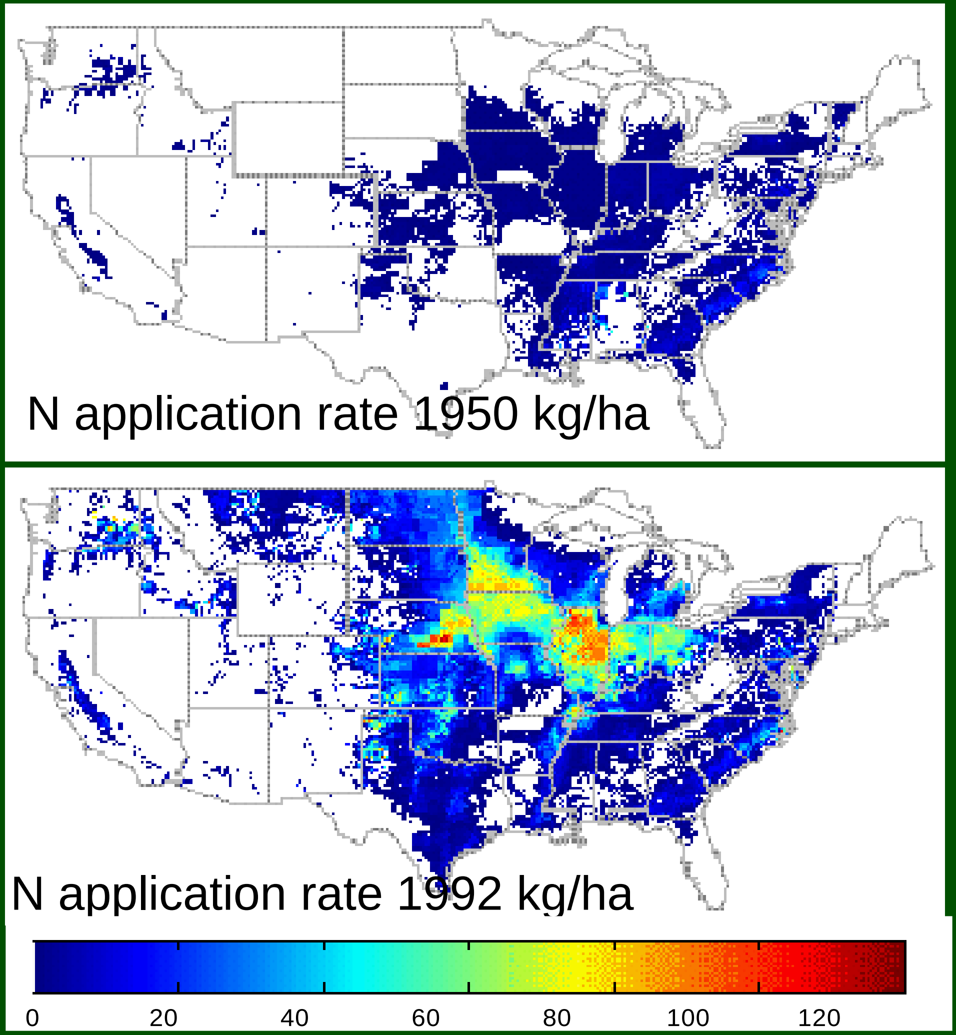


Tocantins and Xingu have similar precipitation decrease (GOV = -15%)

Xingu is less deforested (25% vs 80%) and ET decrease is less

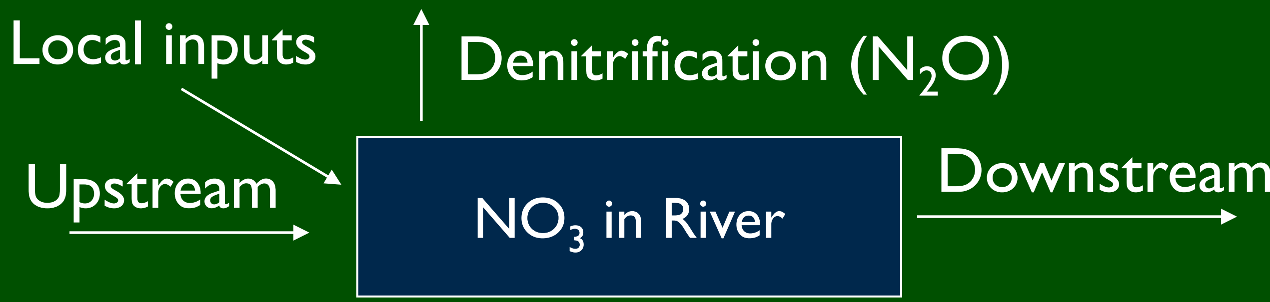
Nitrôgenio

Os fluxos do nitrôgenio aumentaram muito e afetam os rios e oceanos



Donner et al., 2002; Donner and Kucharik, 2003

Nitrôgenio

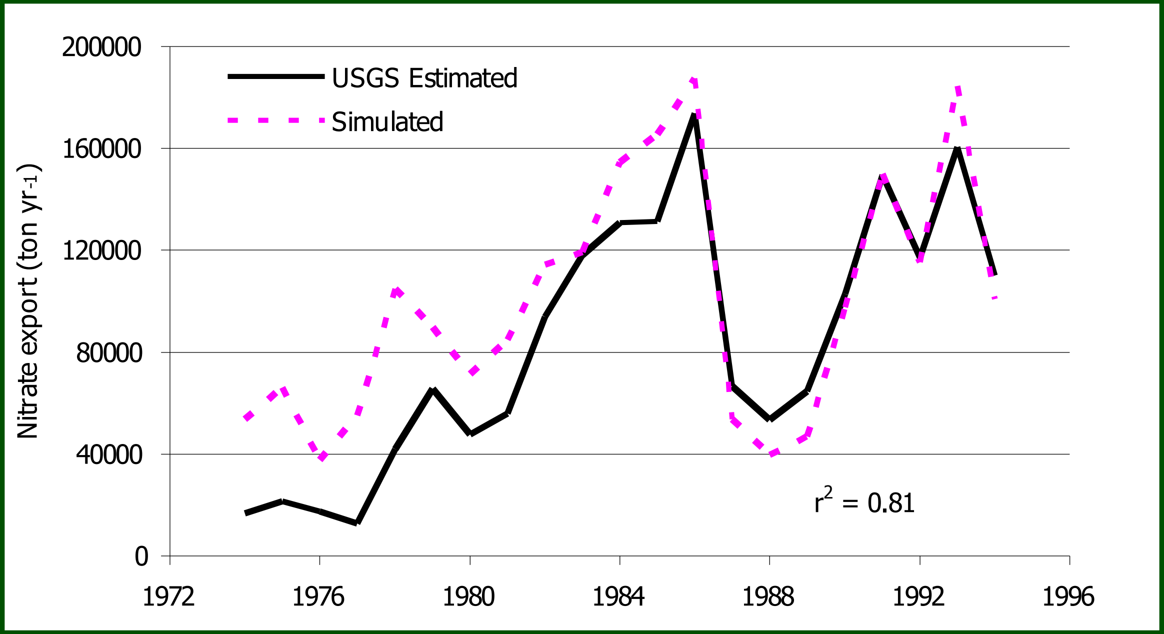


$$dN/dt = N_l(1 - A_w) + (\Sigma N_{in} - N_{out}) + P - dC - L$$

$N_l = N_{surface} + N_{sub\text{-}surface}$	(N local, IBIS)
$\Sigma N_{in} = \Sigma N_{out}$	(N input montante)
$N_{out} = N(u/d)$	(N jusante)
$P = 0$	(N de ponto)
$dC = 0$	(transformaçoes)
$L = f(T)$	(processos do córrego)

Nitrogênio no rio

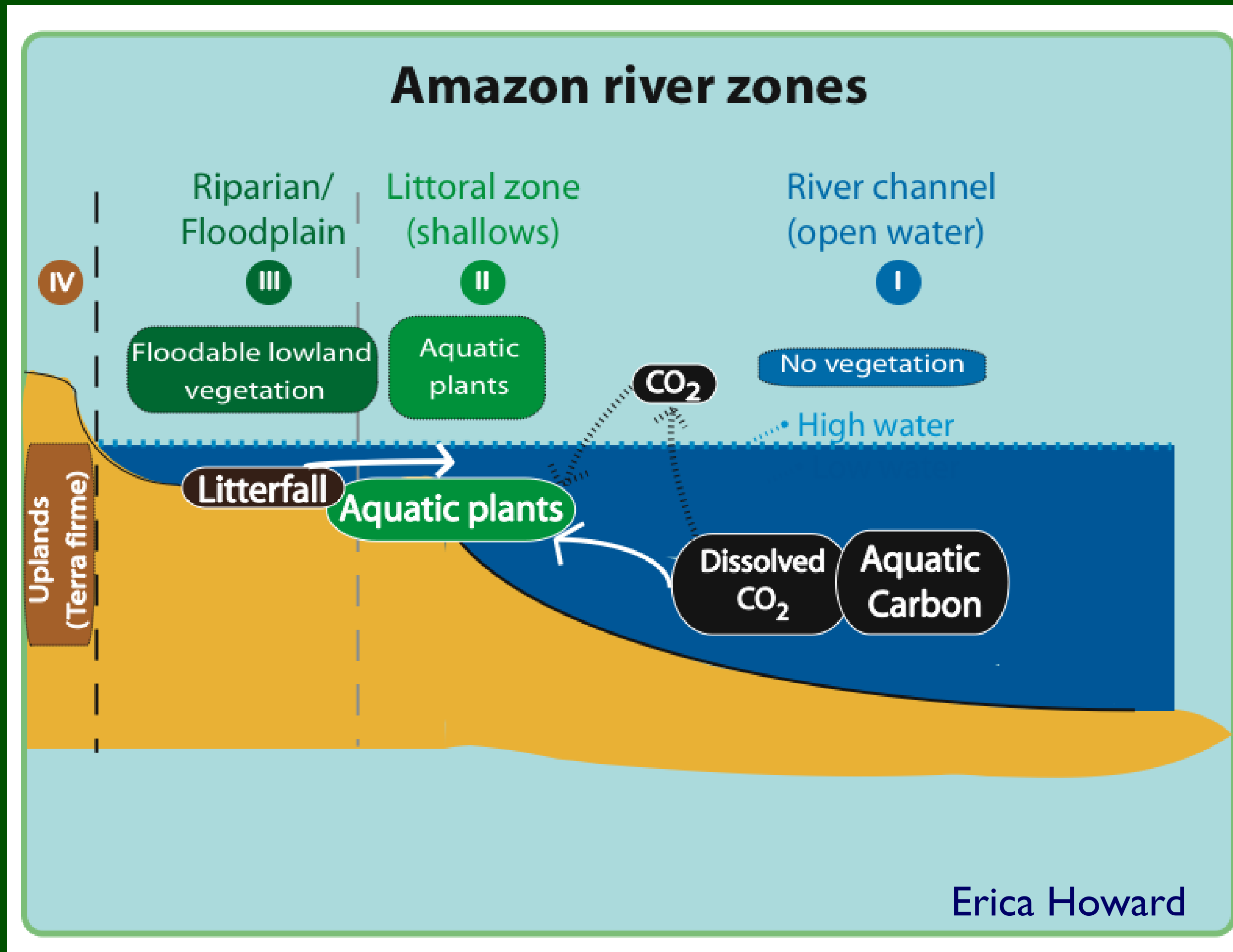
Nitrate export: Mississippi River at Clinton, IA



- O fluxo simulado do nitrato compara bem com as observações do USGS
- O fluxo é concentrado nas regiões onde o milho é crescido
- 75% da mudança no fluxo é devido ao uso aumentado do fertilizante

Donner et al., 2002; Donner and Kucharik, 2003

Carbono



No futuro: combina o modelo do rio e planície do inundação com o modelo do ciclo de carbono

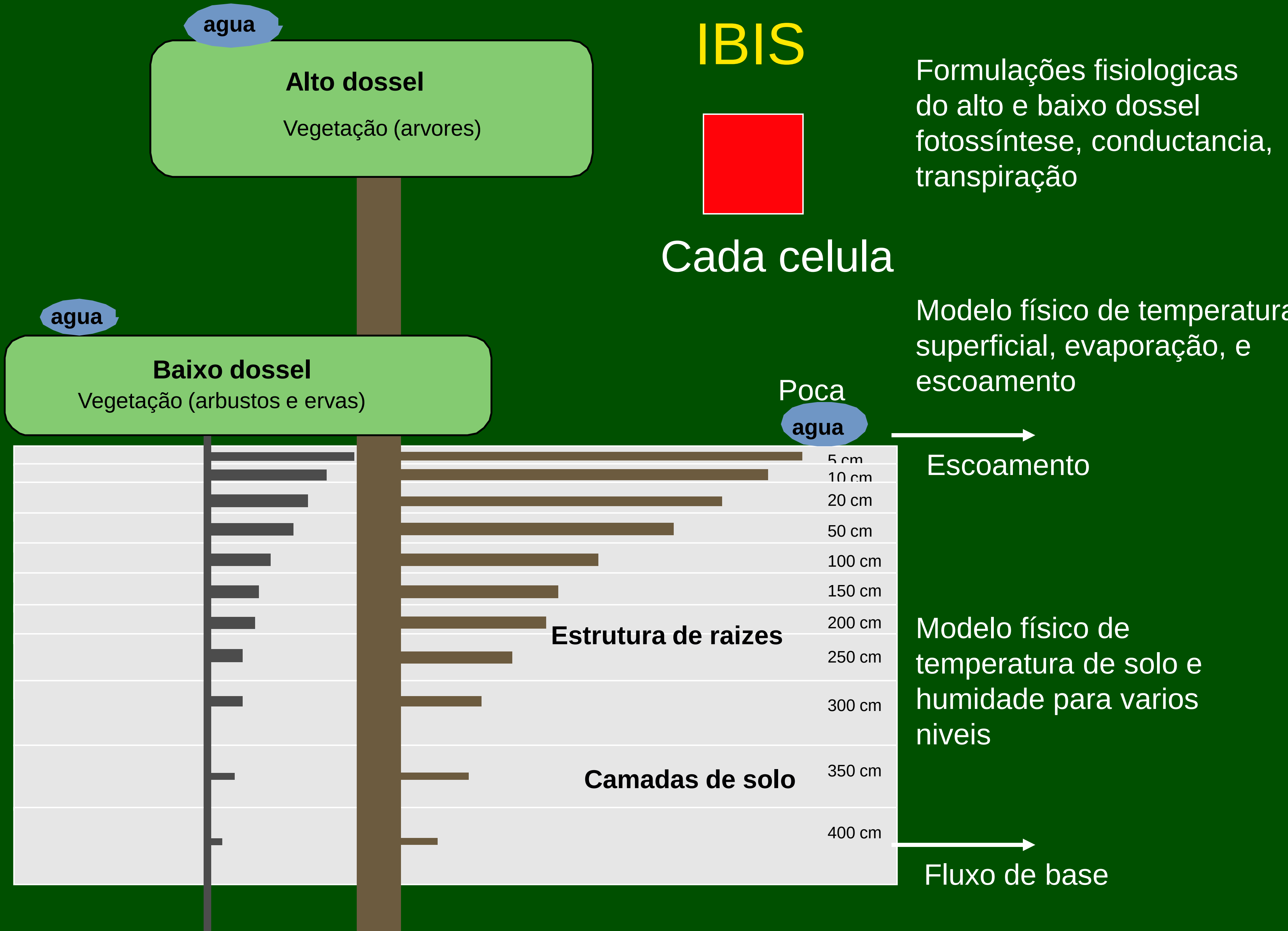

Obrigado

IBIS combina:

- Dados climaticos (precipitação, velocidade de vento, humidade, nuvens)
- Representações fisicas de vegetação, terra e dinamicos de solo

Para simular:

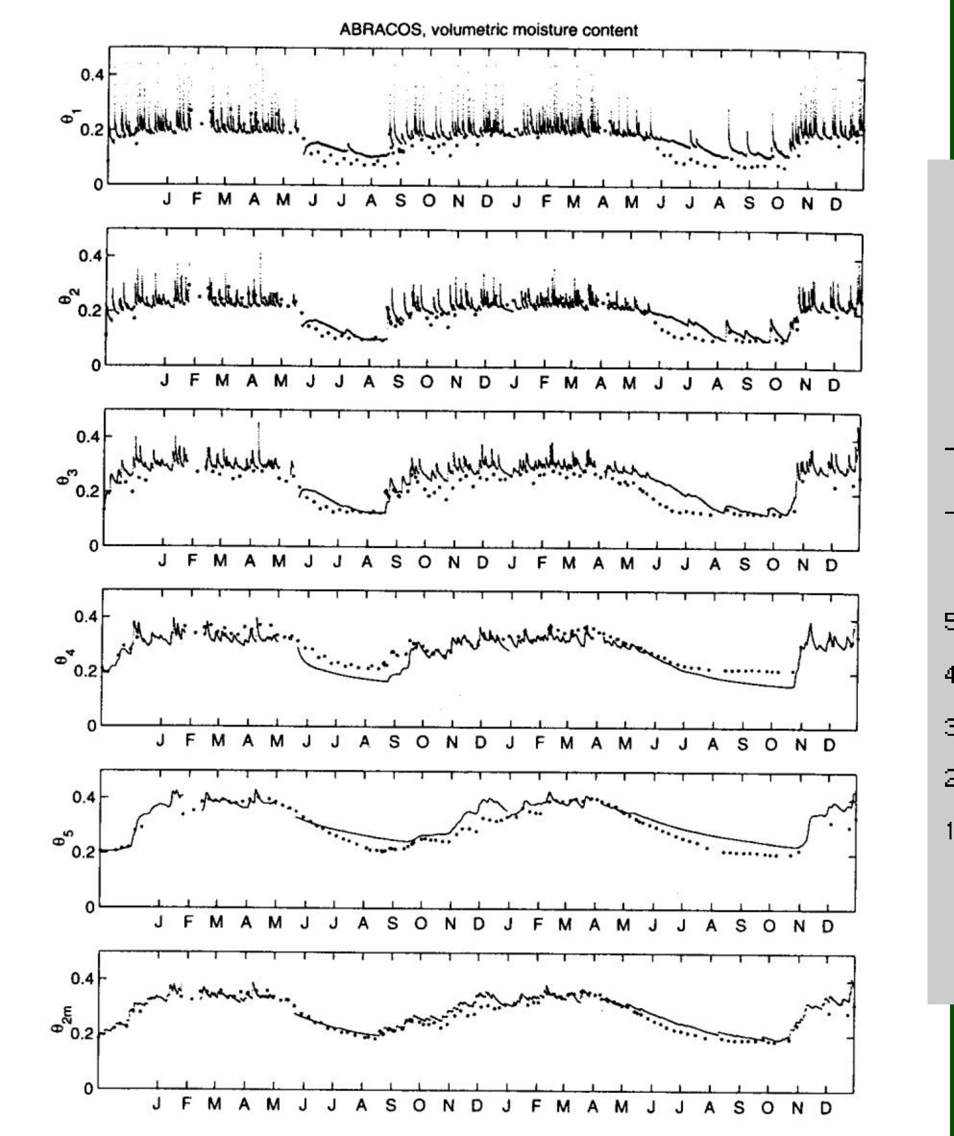
- Ciclagems de agua, carbono, nitrogênio entre vegetação, atmosfera e solo
- Movimento vertical de agua na coluna de solo
- Evaporação como uma função de humidade de solo, demandas stomatais, e estrutura de vegetação e raizes
- Fluxo de base e escoamento superficial como residuo de precipitação entrando e evapotranspiração saindo



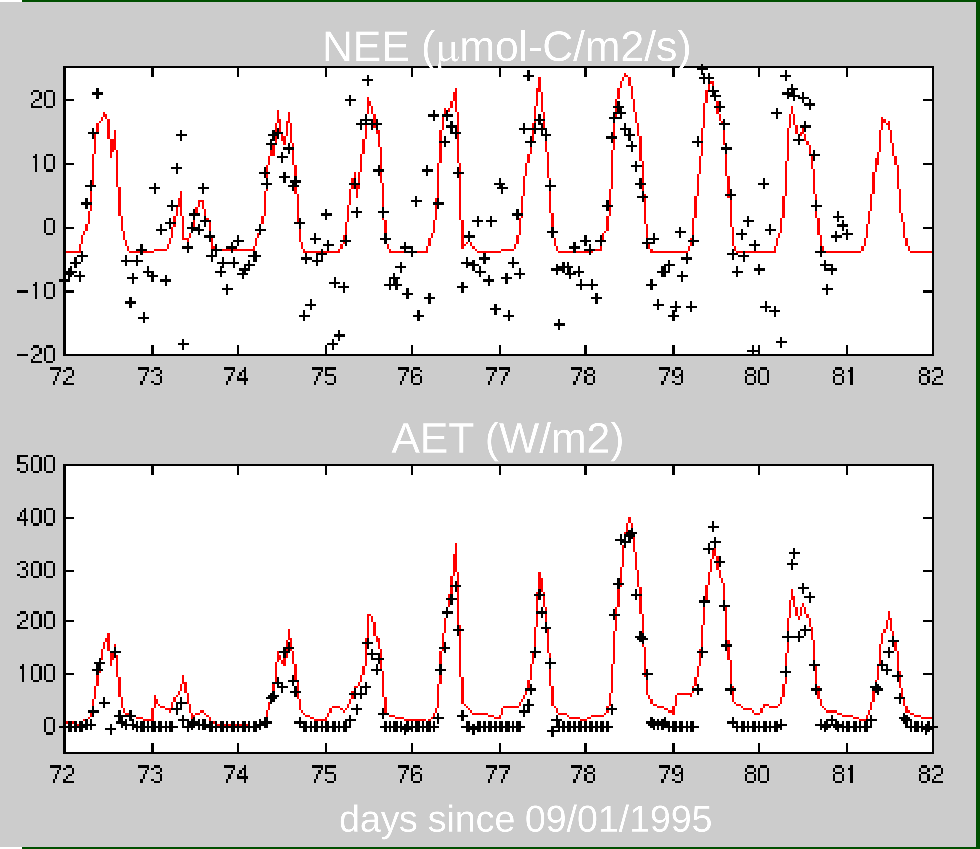
Integrated BIoshpere Simulator (IBIS), grafico adaptado de Kucharik (2000)

Avaliação do IBIS ao nivel local: medidas de torres de fluxo

Aplicação 1-D



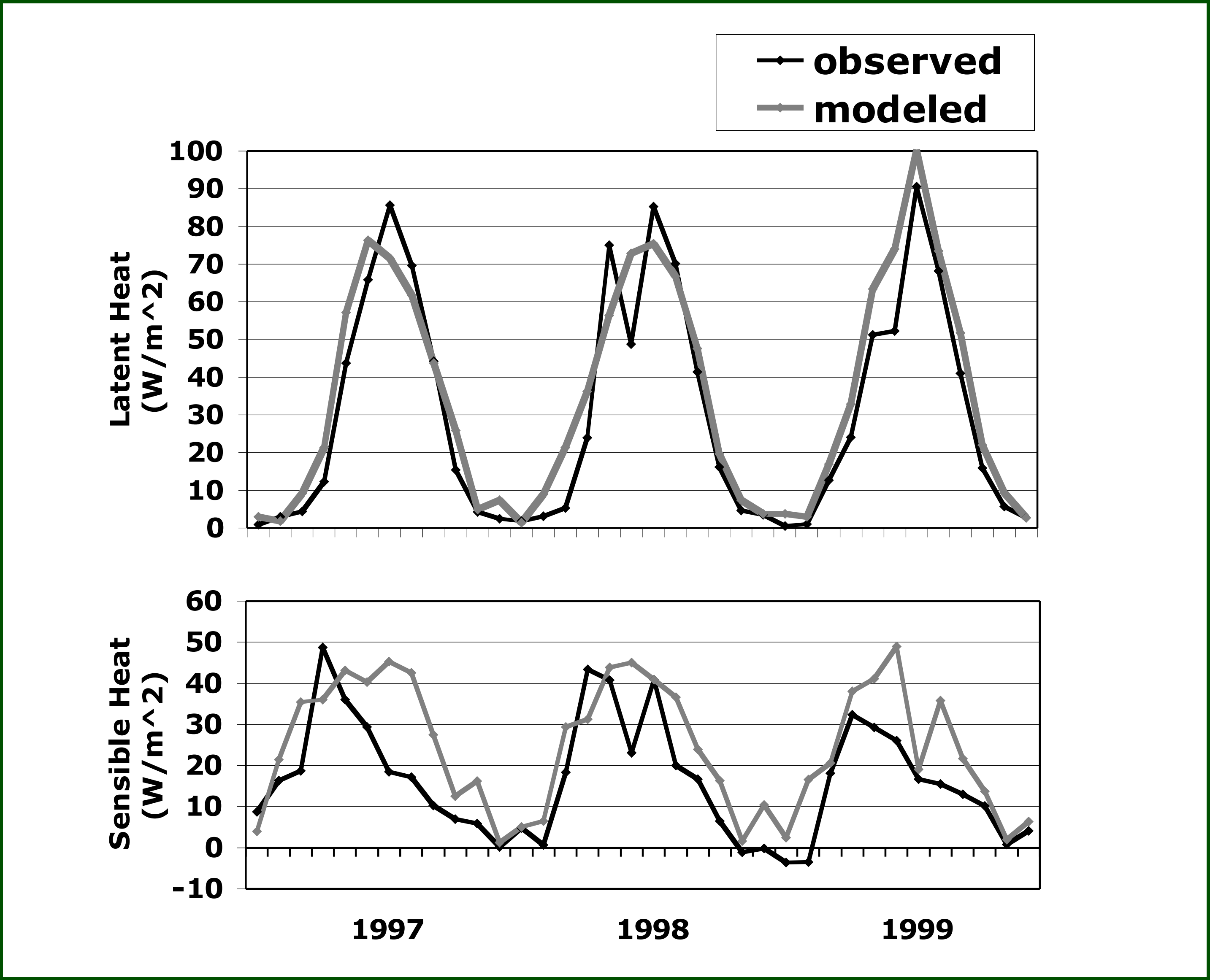
Jaru (Delire *et al.* 1999)



Cuieiras (observed data from Mali *et al.*, 1998)

Caxiuana (Sílvia de N. Monteiro dos Santos and Marcos Costa work)

Validação -- Balanço de Energia



Fluxos de calor latente e sensivel medidos na Torre de Fluxo WLEF (Parkfalls, Wisconsin) e comparados com resultados de modelos do IBIS. Vano et al.

Large-scale 2-D application

Data needs - Gridded input data for region of interest

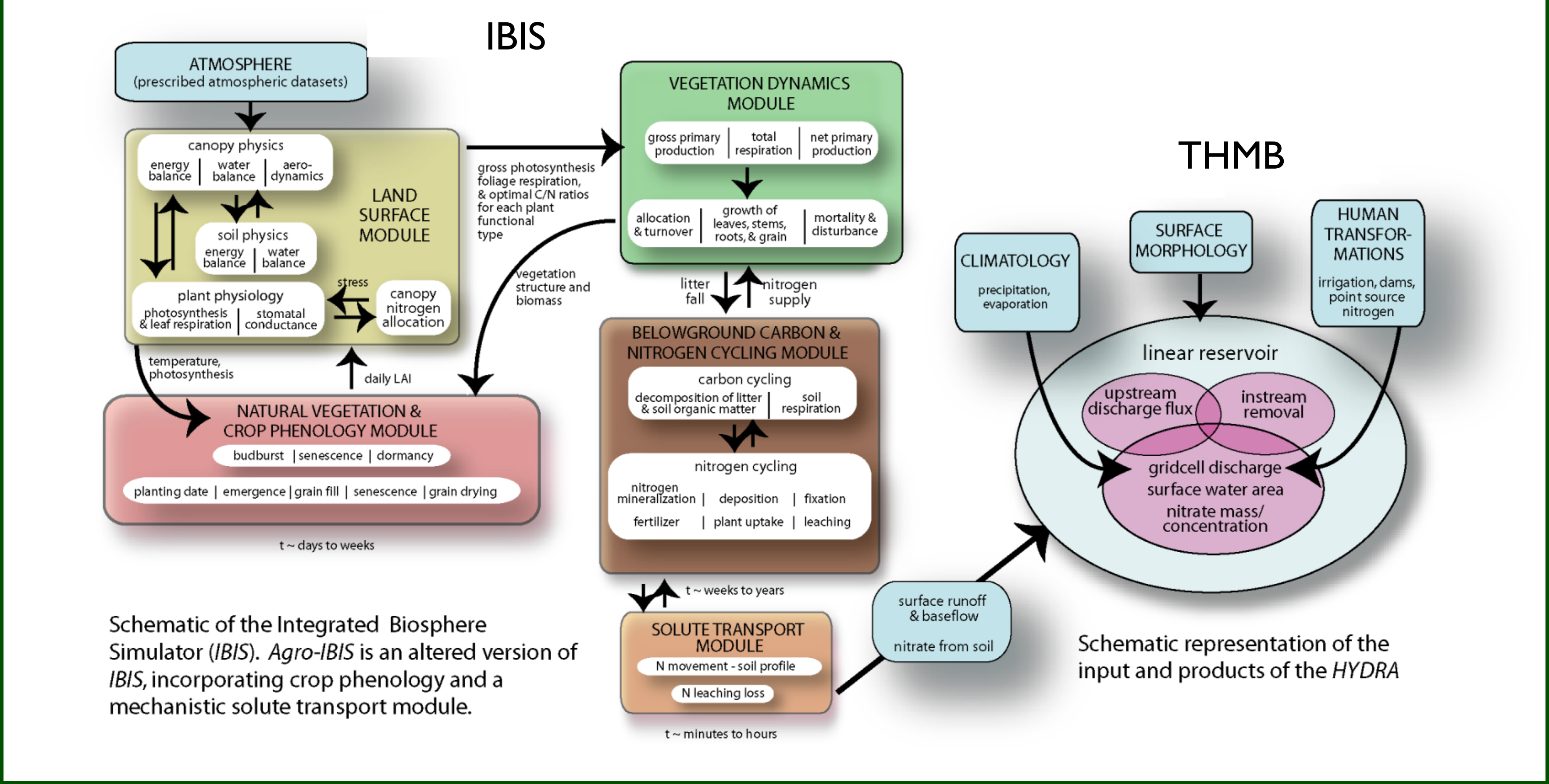
Climate:

- precipitation
- temperature
- humidity
- wind speed
- cloudiness (% sunshine)

Land:

- soil (texture, depth)
- biome classification (savannah, tropical evergreen forest, etc)
    - % vegetation cover of trees, grasses, and shrubs
    - Structural qualities (canopy height, LAI, root depth and density, etc)

Modelos IBIS-THMB



- Modelos mecanisticos de função de plantas e solo
- Divide precipitação e radiação
- Transporte escoamento e solutos na paisagem para simular rios, lagos e areas pantanosas

Kucharik et al., 2000; Coe et al., 2007