Modelling Land-Climate Interactions in Amazônia under Uncertainty

Nathan Moore[1], Robert Walker[1], Eustaquio Reis[2], Eugenio Arima[3], Renato Ramos da Silva[4], Alex Pfaff[5], Marcellus Caldas[1], Stephen Perz[6], Jiaguo Qi[1], Claudio Bohrer[7], Juan Robalino[8]

[1]Michigan State University [2] IPEA
[3] Hobart & William Smith Colleges/IMAZON [4]UFPA
[5]Duke University [6] University of Florida [7]University Federal Fluminense
[8]Columbia University

NASA

INPA
INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA

Presentation of work from recent publication—

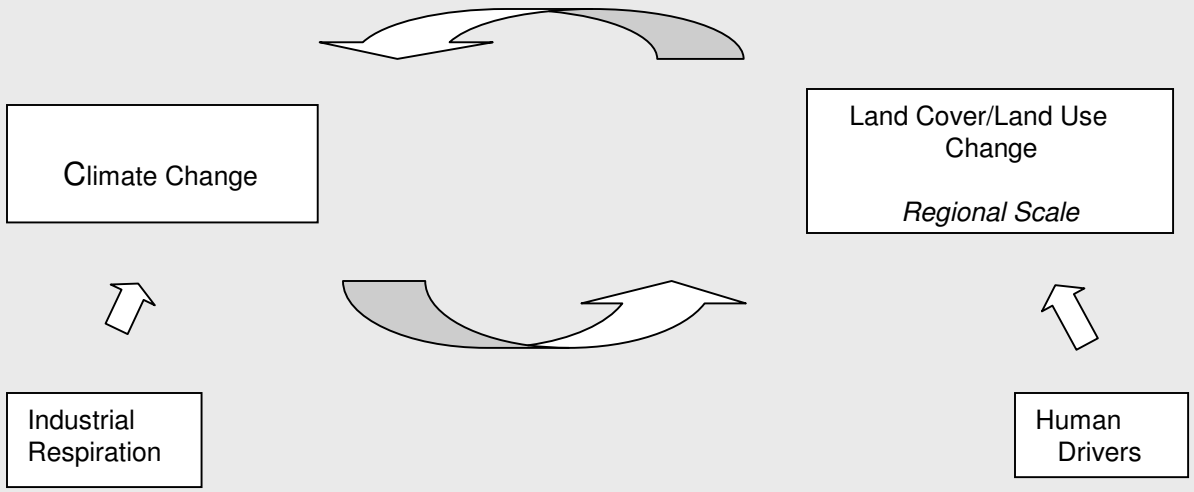
Moore, N., E. Arima, R. Walker, and R. Ramos da Silva (**2007**), **Uncertainty and the changing hydroclimatology of the Amazon**, *Geophys. Res. Lett.,* 34, L14707, doi:10.1029/2007GL030157.

Questions:

1) What is the “Future of the Amazon”?

2) How is uncertainty represented in predicted Amazonian climate outcomes?

Land-Climate System



Method

No one has future observations— so we must model the future

→

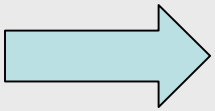
Represent the Uncertainty of these predictions

Assume two fundamental sources of uncertainty:

1. actual landscapes (stochastic)
2. external forcings in general climate

Land-Climate Modeling

Econometric (probit model)



Regional Climate Model (RCM)

Method

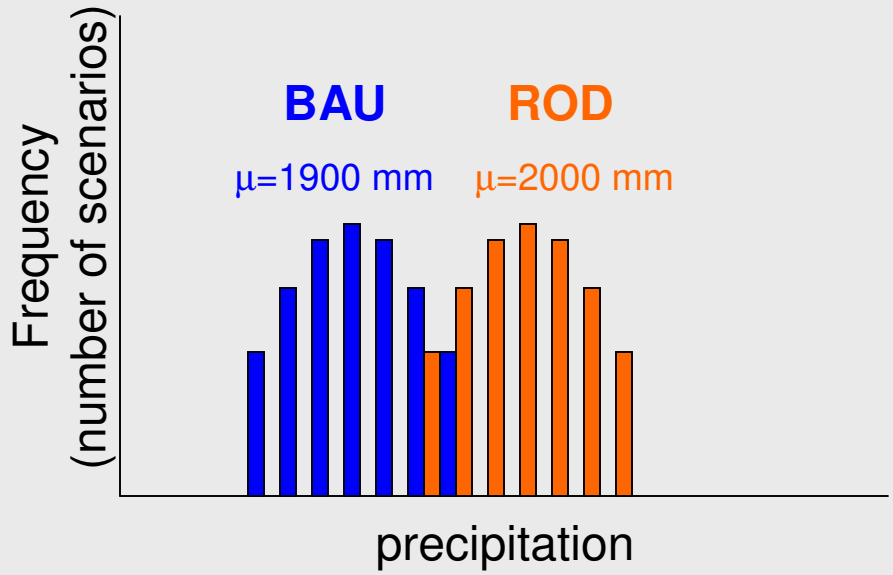
How we deal with these uncertainties:

1. use econometric model for landscapes
   A Spatially Explicit Model of Pixels
   Bernoulli trials, as inputs to RCM

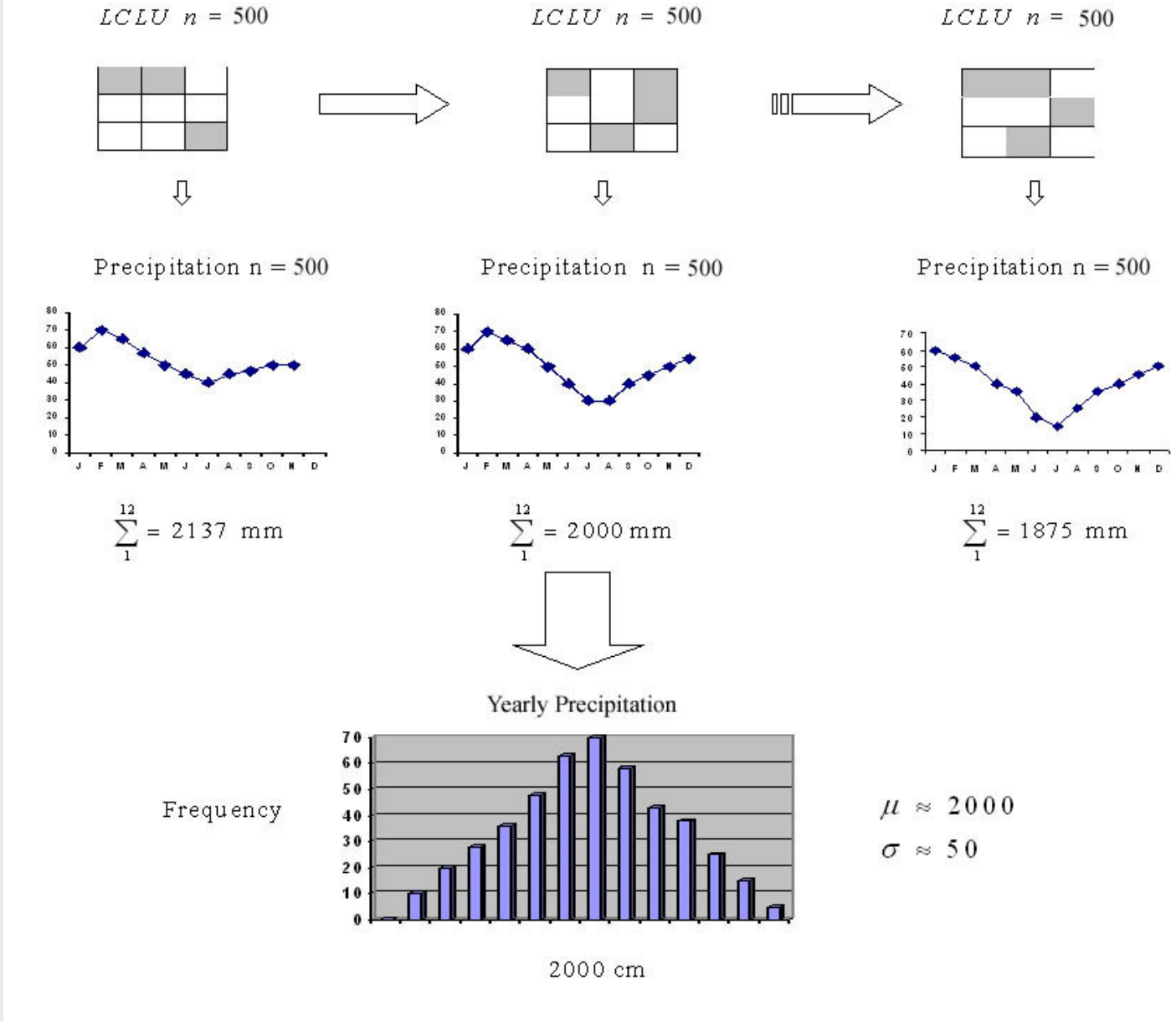
2. Run the RCM, using a range of general atmospheric conditions, across the spectrum, wet/normal/dry

Modeling Objective

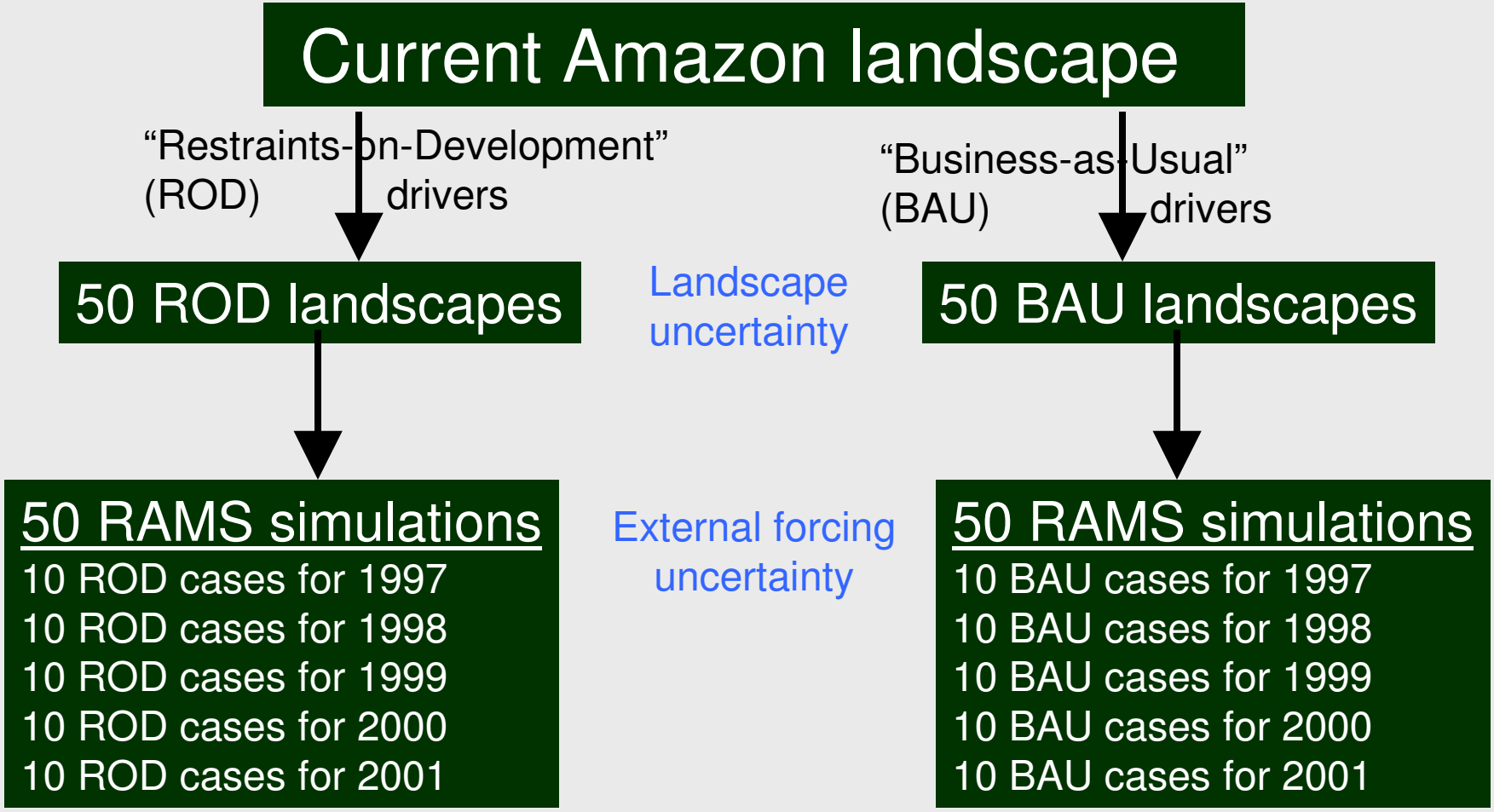
- to produce ***actual estimates of uncertainty*** based on probability distributions.
- **<u>Hypothesis:</u>**



•Ultimately, feedback climate changes to landscape


LCLU n = 500
LCLU n = 500
LCLU n = 500
Precipitation n = 500
Precipitation n = 500
Precipitation n = 500
J F M A M J J A S O N D
$\sum_{1}^{12}$ = 2137 mm
$\sum_{1}^{12}$ = 2000 mm
$\sum_{1}^{12}$ = 1875 mm
Yearly Precipitation
Frequency
2000 cm
$\mu \approx 2000$
$\sigma \approx 50$

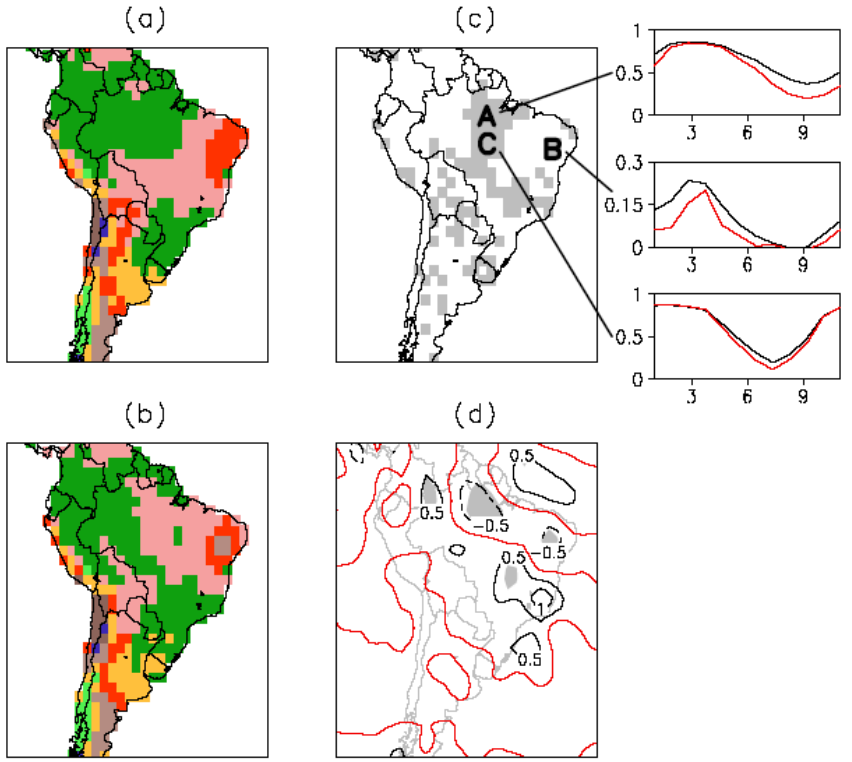
Method


Current Amazon landscape
"Restraints-on-Development" (ROD) drivers
"Business-as-Usual" (BAU) drivers
50 ROD landscapes
Landscape uncertainty
50 BAU landscapes
50 RAMS simulations
10 ROD cases for 1997
10 ROD cases for 1998
10 ROD cases for 1999
10 ROD cases for 2000
10 ROD cases for 2001
External forcing uncertainty
50 RAMS simulations
10 BAU cases for 1997
10 BAU cases for 1998
10 BAU cases for 1999
10 BAU cases for 2000
10 BAU cases for 2001

1.Motivation

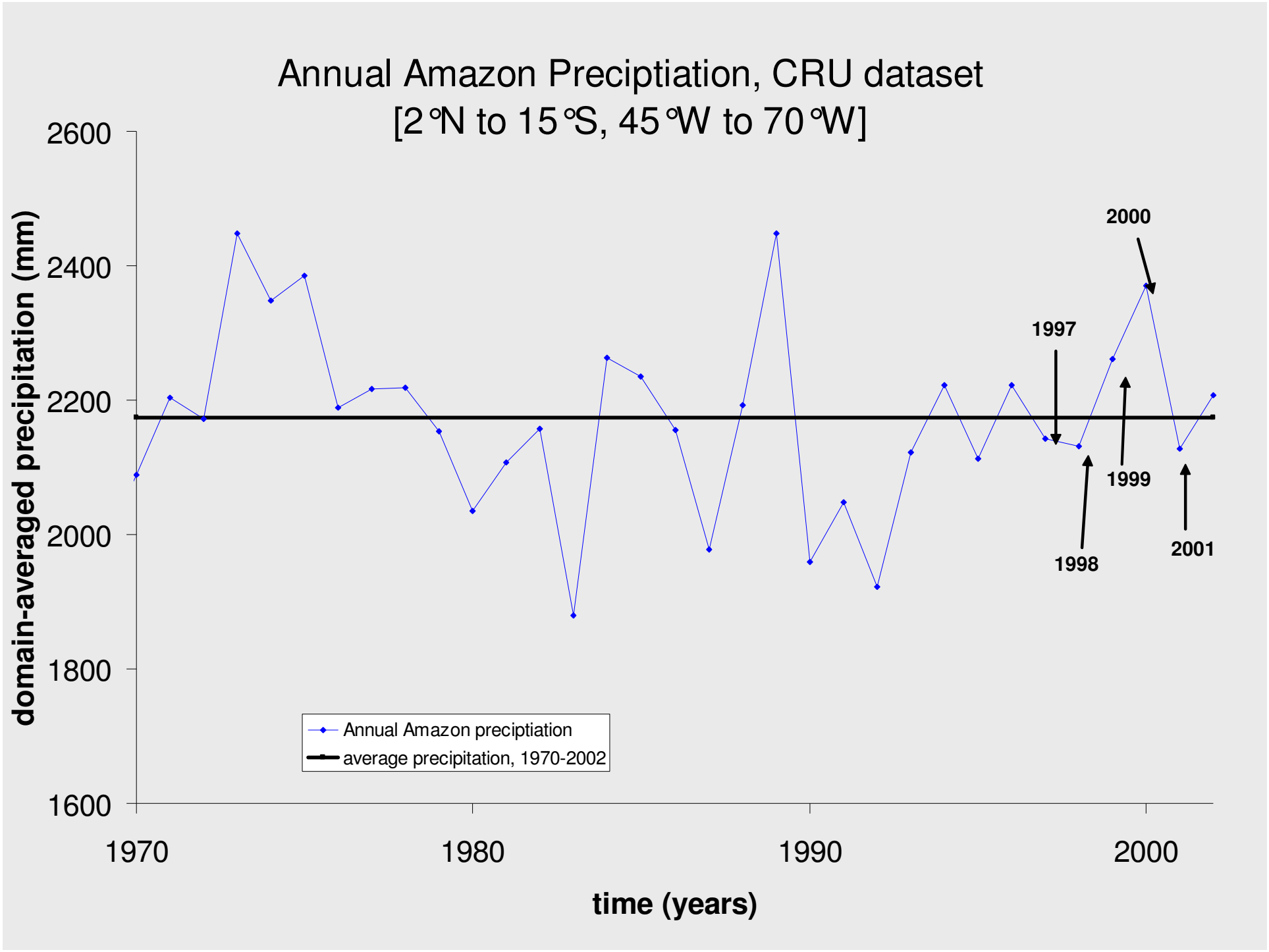
- Oyama & Nobre coupled modeling: (CPTEC/COLA AGCM)

2 potential equilibria



From Oyama & Nobre 2003 *doi:10.1029/2003GL018600*

"If sustainable development and conservation policies are not able to halt this increasing environmental degradation, then land use changes could, *per se*, tip the biome-climate system towards a ***new alternative drier stable equilibrium state*** with savannization of parts of Amazonia and desertification of the driest area of Northeast Brazil."


Annual Amazon Preciptiation, CRU dataset
[2°N to 15°S, 45°W to 70°W]
domain-averaged precipitation (mm)
2600
2400
2200
2000
1800
1600
1970
1980
1990
2000
time (years)
Annual Amazon preciptiation
average precipitation, 1970-2002
1997
1998
1999
2000
2001

Technical Considerations

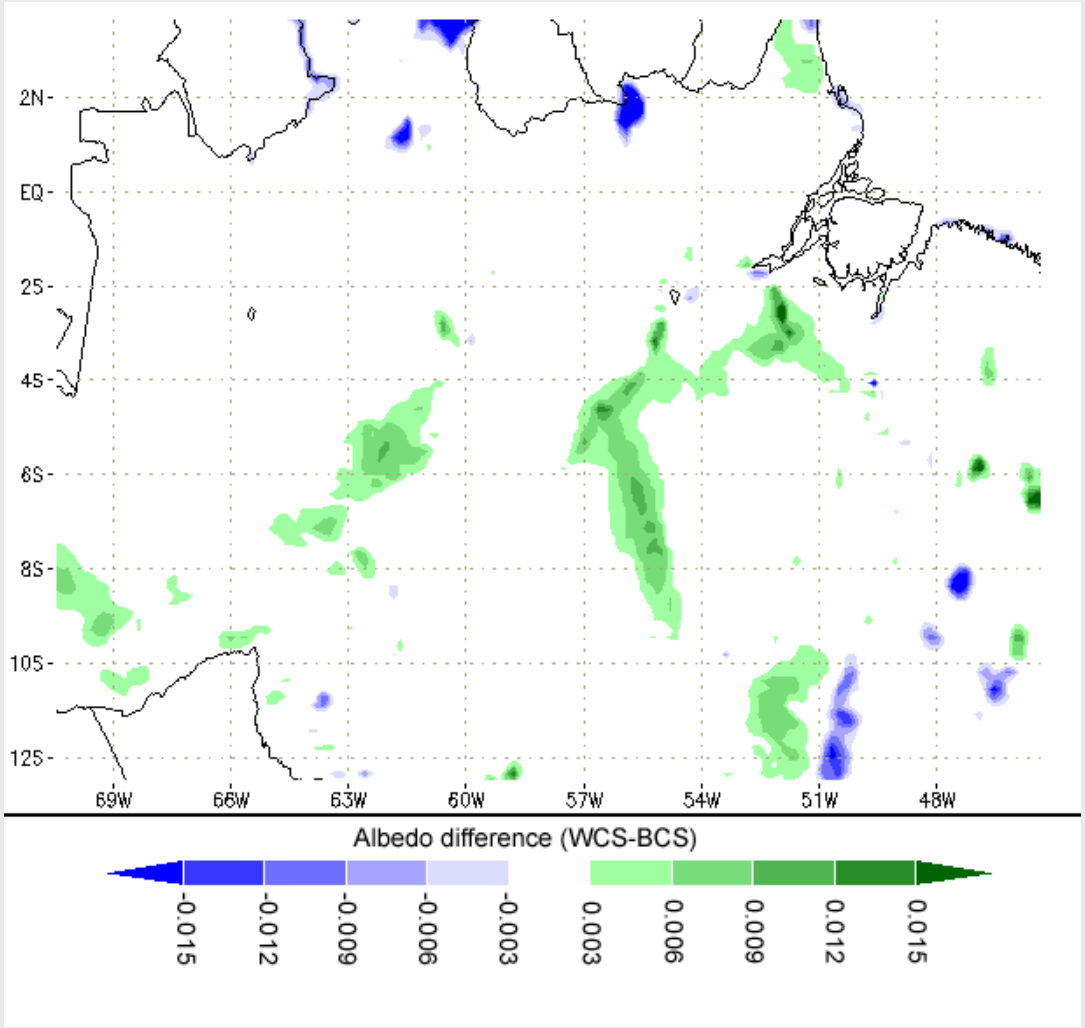
- 4.1 T of data (and counting…)
- 100 year-long simulations (50 ROD, 50 BAU)
- 1 sim month : 6 real days

Postprocessing:

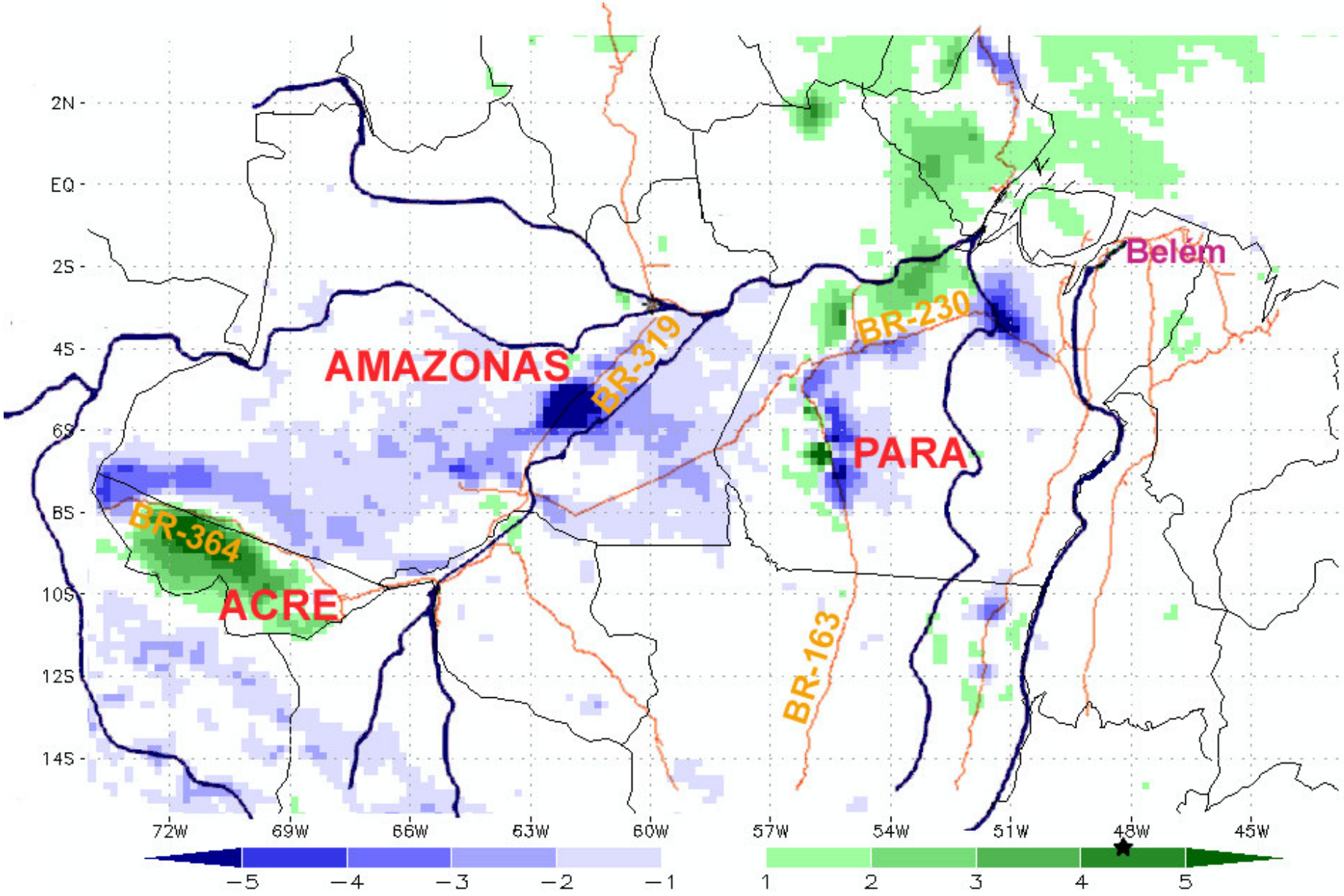
  - Only retained a subset of variables
  - LBA data,TRMM, MODIS LST available for validation

5. Results

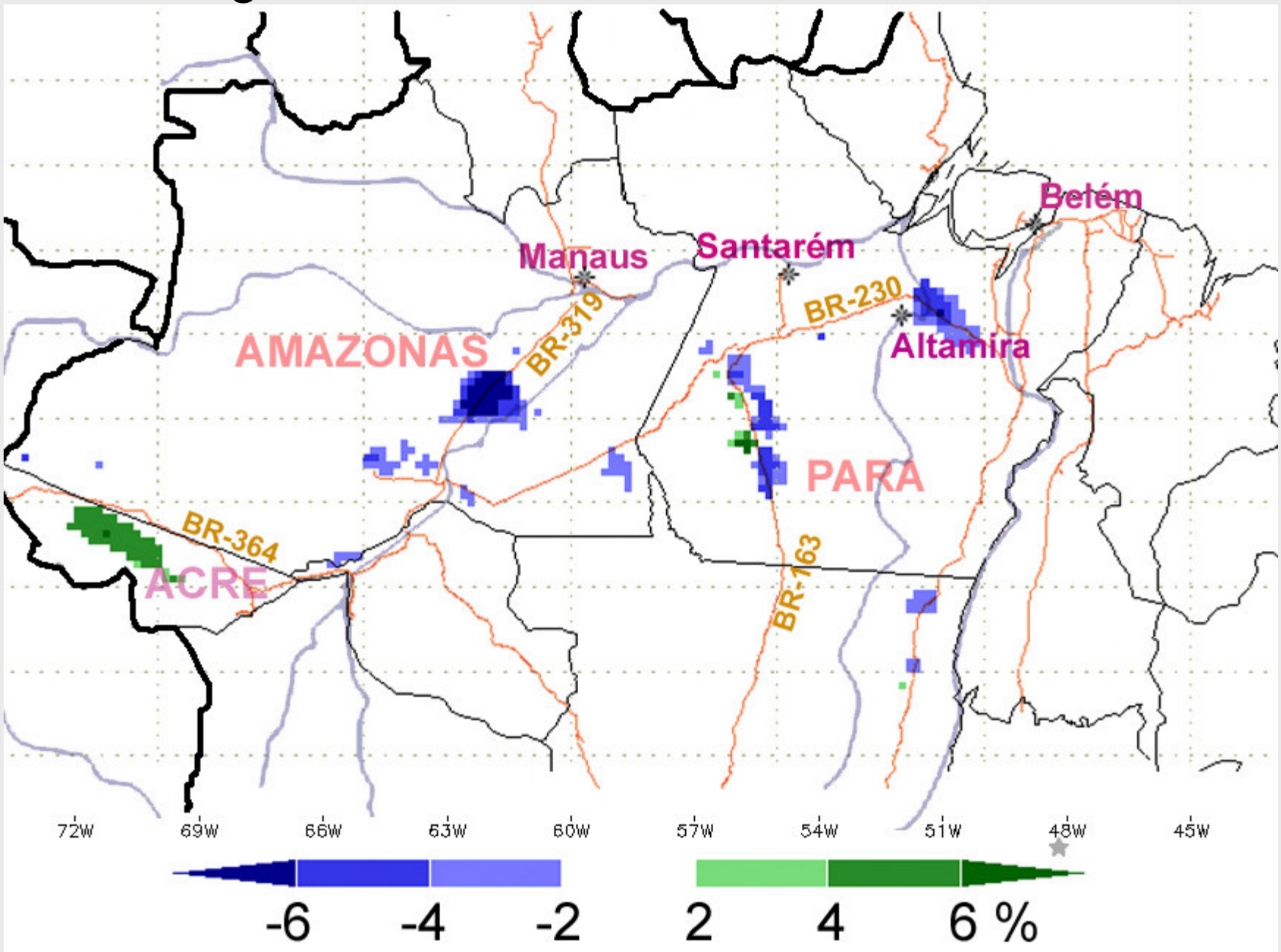
Brighter albedo



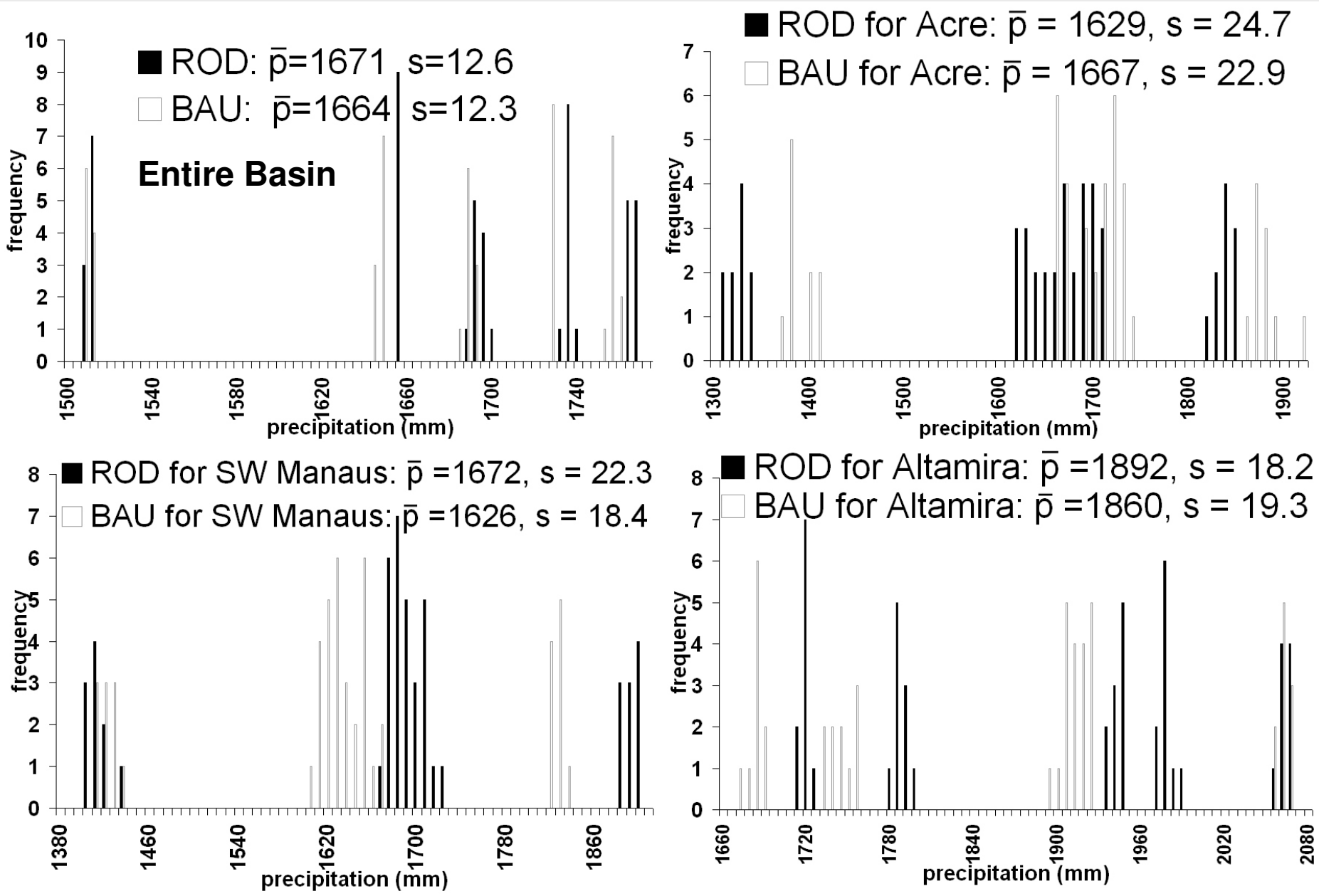
Precipitation difference (ROD – BAU), %



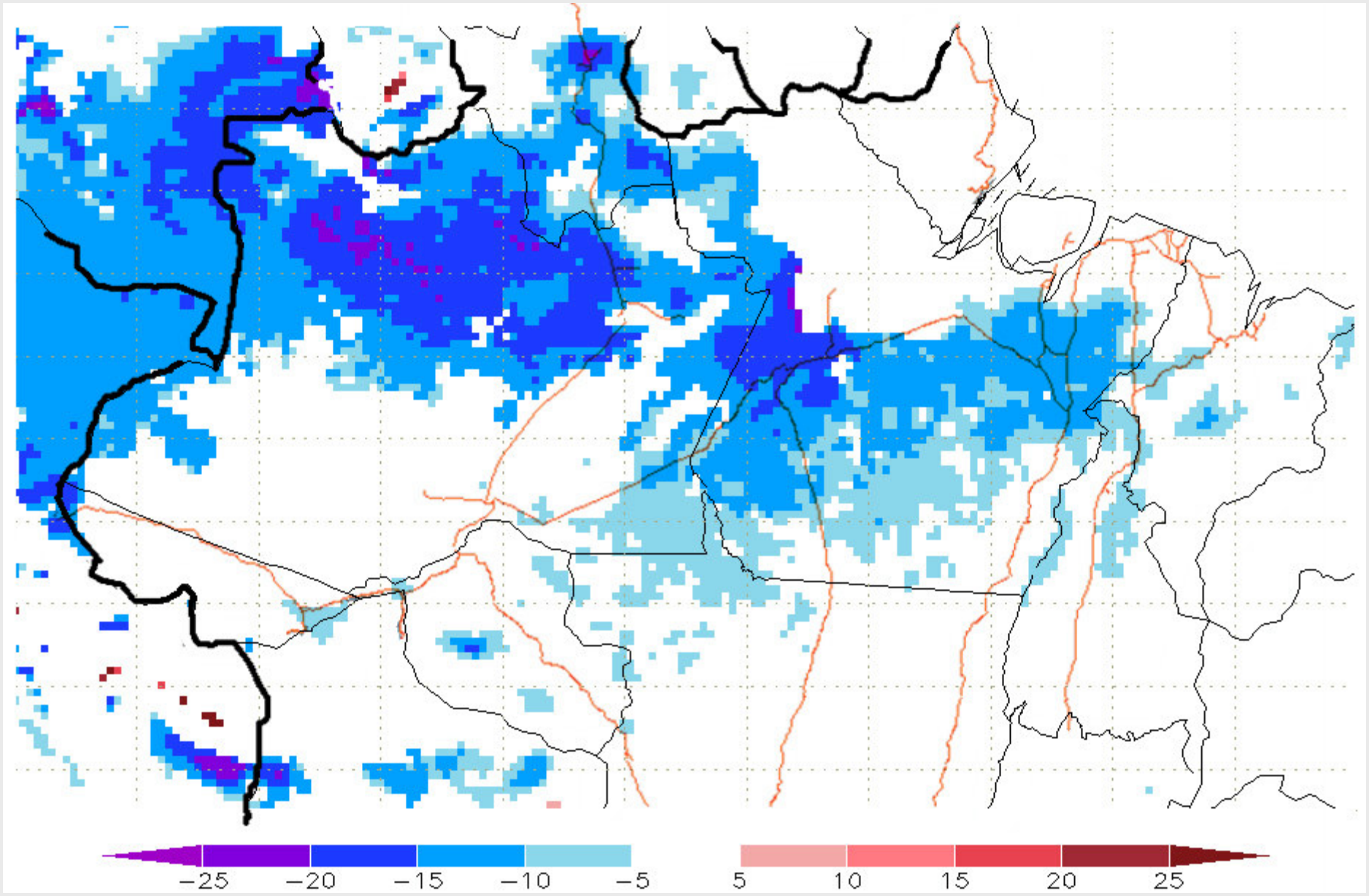
Significant at 95% confidence interval:



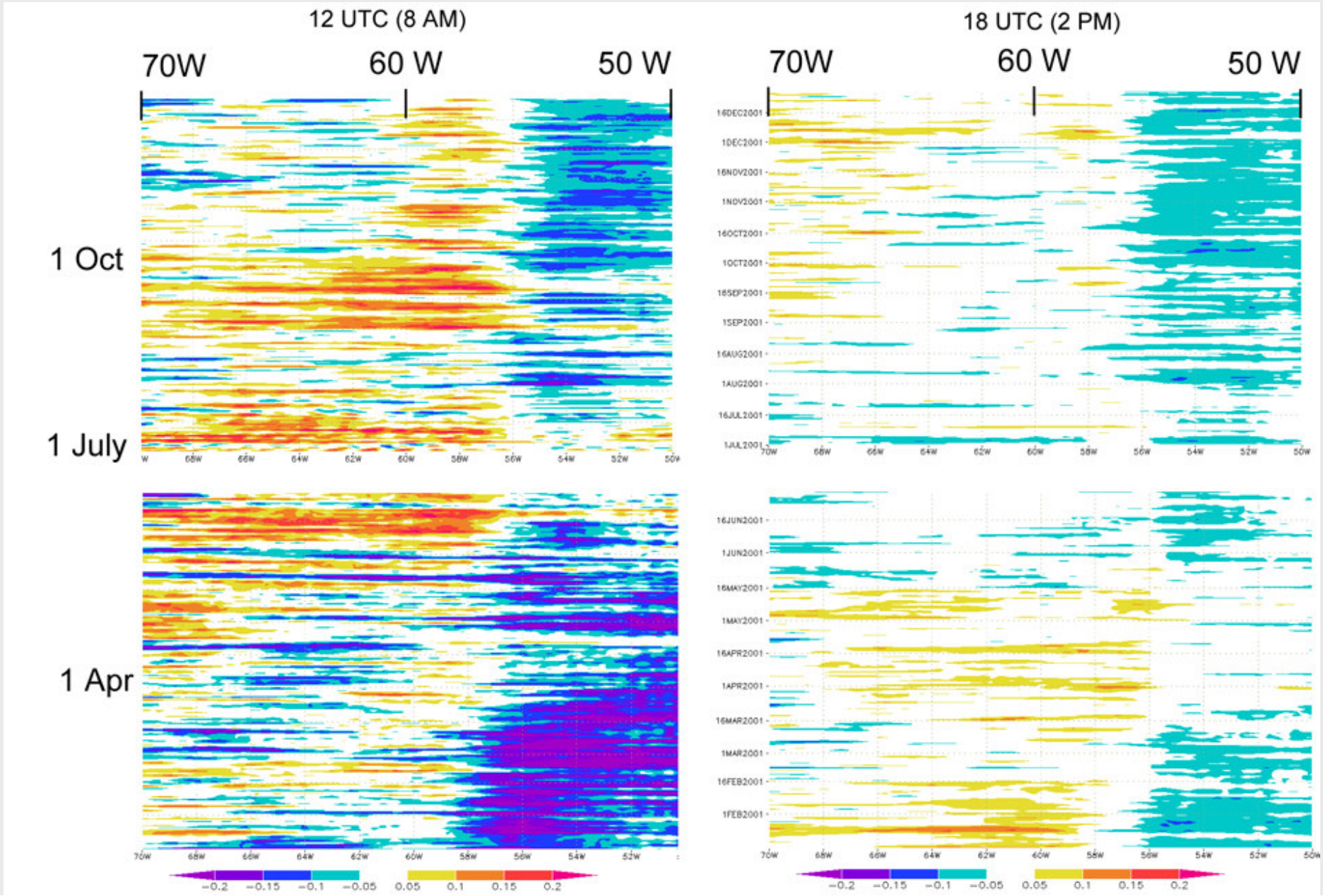
Domain-Averaged rainfall histograms



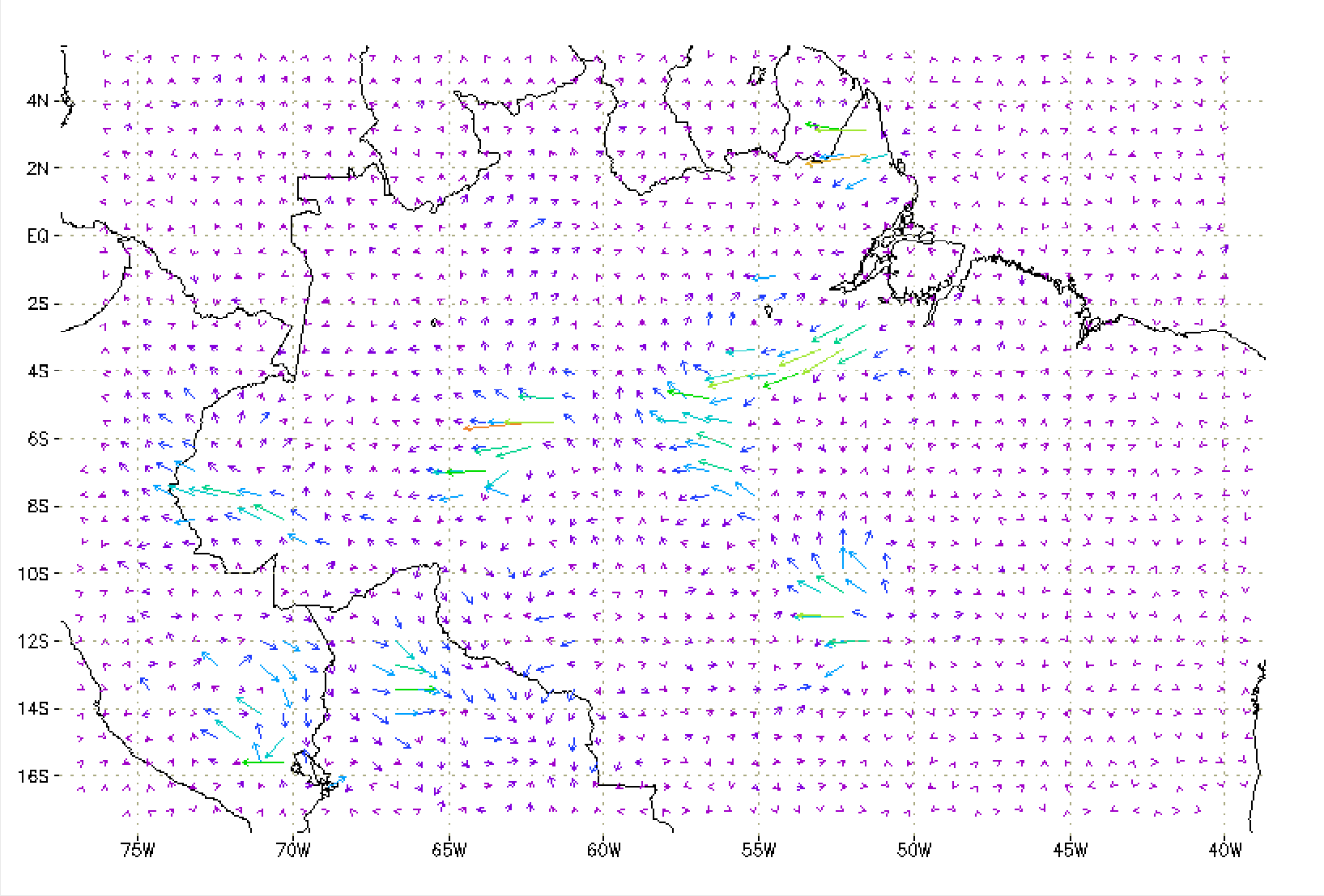
Total Deforestation?



Total Deforestation?



Average difference in wind direction

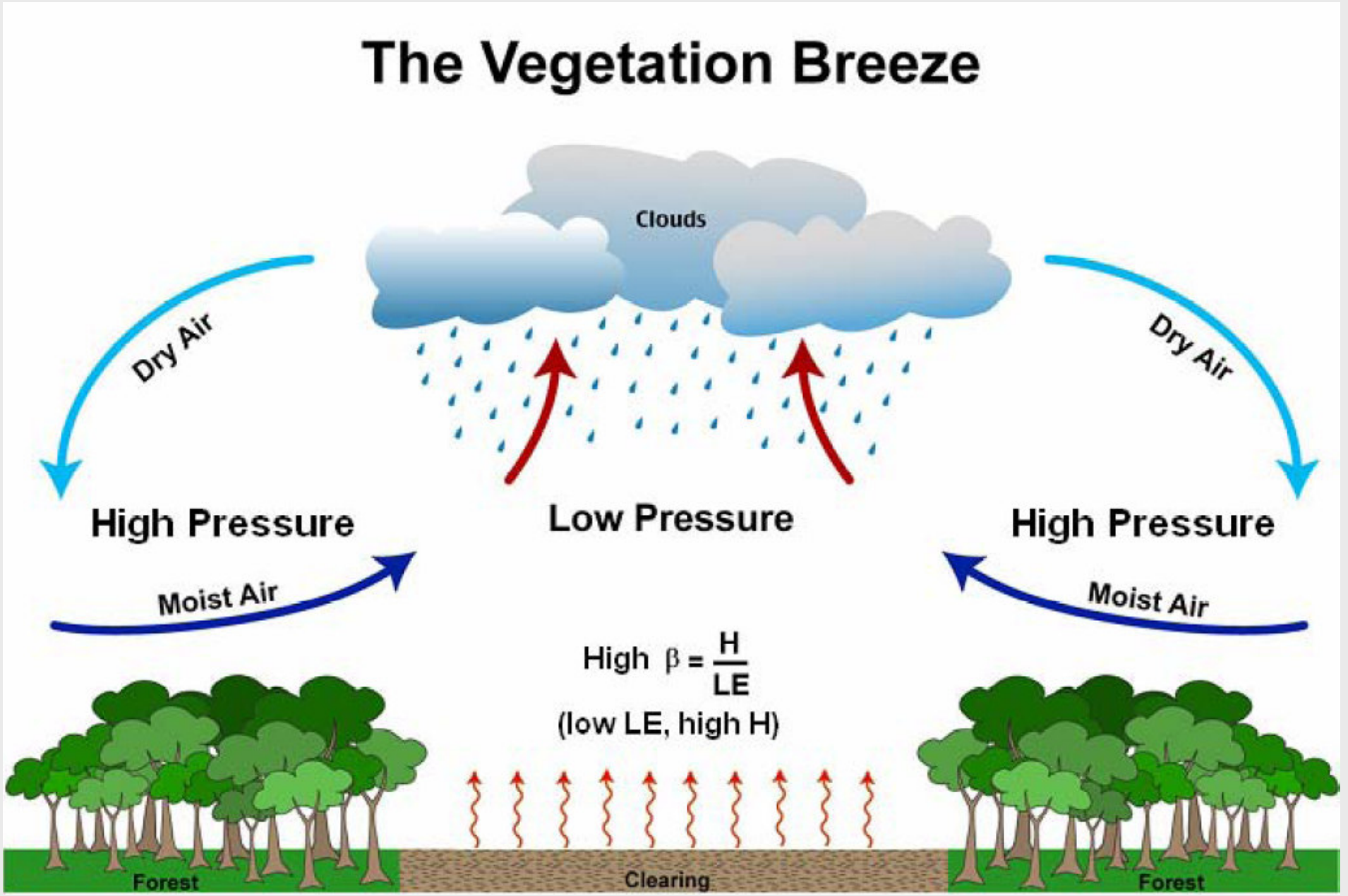


z = 1483 m

Major Advancements

- Treatment of uncertainty
- Spatial representation of threatened areas
- Span over wet-dry transition

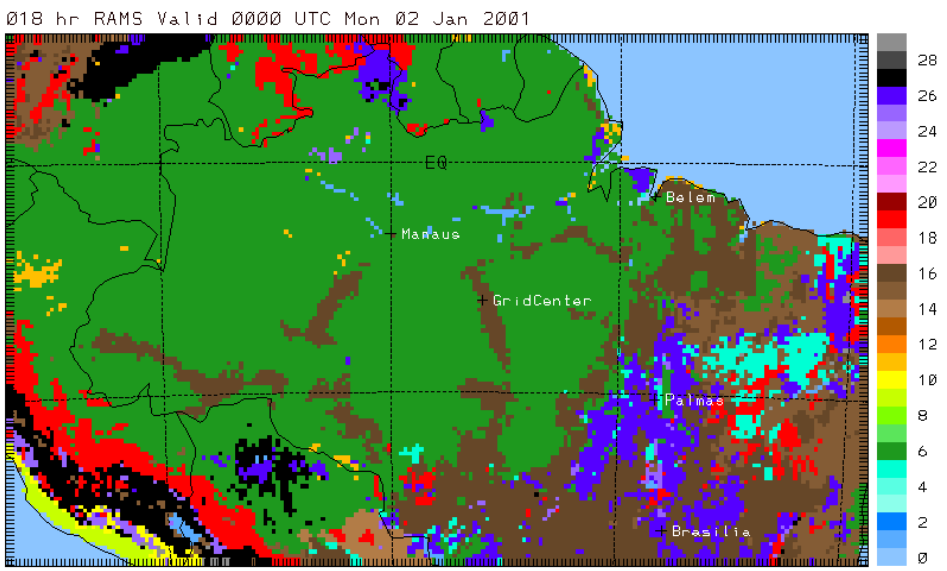
Extras

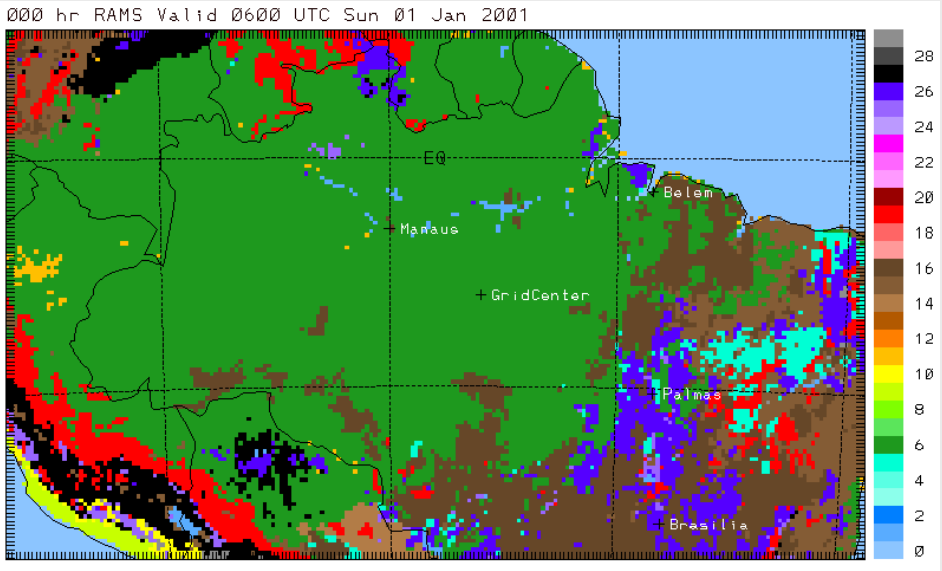

The Vegetation Breeze
Clouds
Dry Air
Dry Air
High Pressure
Low Pressure
High Pressure
Moist Air
Moist Air
High β = H/LE
(low LE, high H)
Forest
Clearing
Forest

2) Represent these maps in the RAMS Climate Model

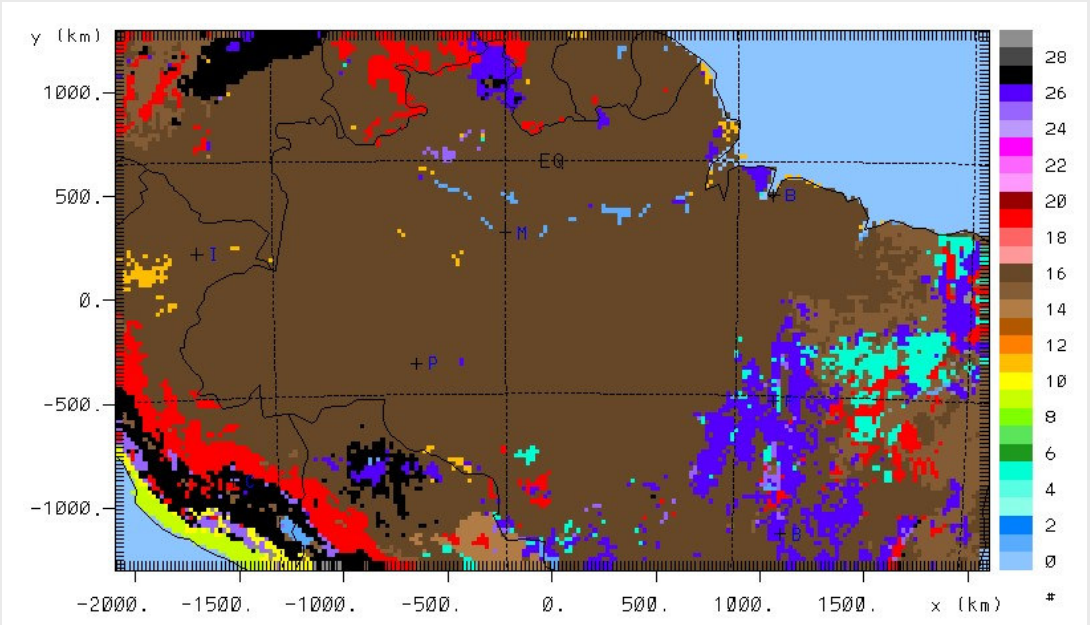
Aggregated to 20 km

Classes from GLC2000





WCS in RAMS



BCS in RAMS

Total Deforestation

4. Aspects of Model Configuration

- 20 km grid spacing (c.f. Ramos da Silva & Avissar 2006)
- 30 vertical levels
- Kain-Frisch convective parameterization
- LEAF-2 (Walko et al. 2000) biophysical characteristics
- Chen radiation scheme
- Mellor-Yamada diffusion
- Soil levels = -4.0, -2.0, -1.0, -.8, -.6, -.4, -.2, -.1, meters