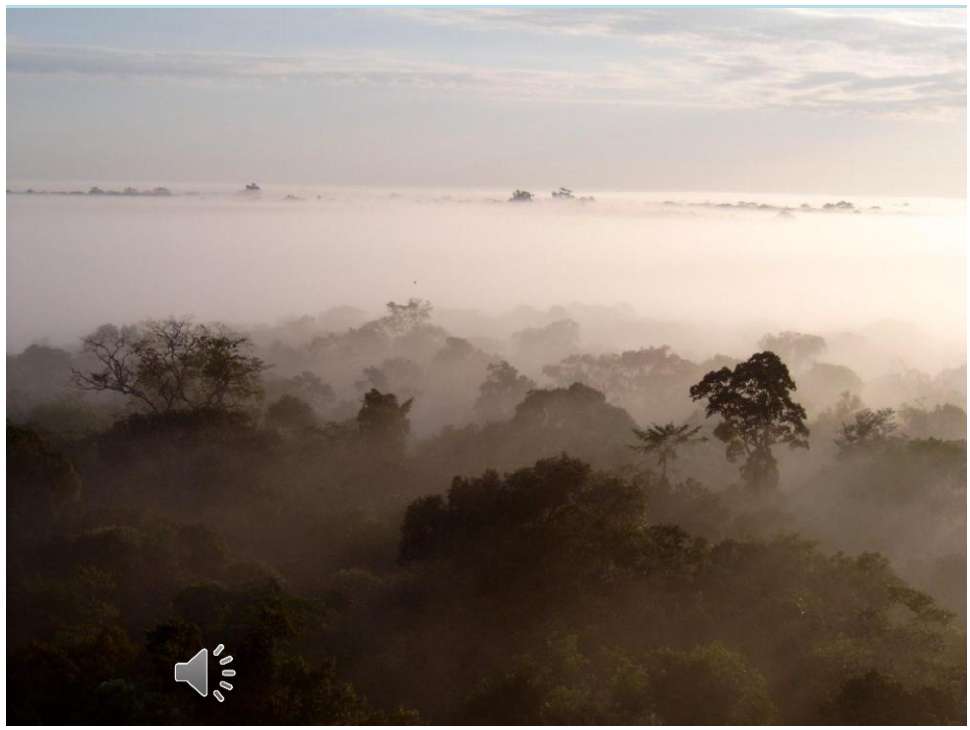

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WAGENINGEN UR

LBA

SEVENTH FRAMEWORK PROGRAMME

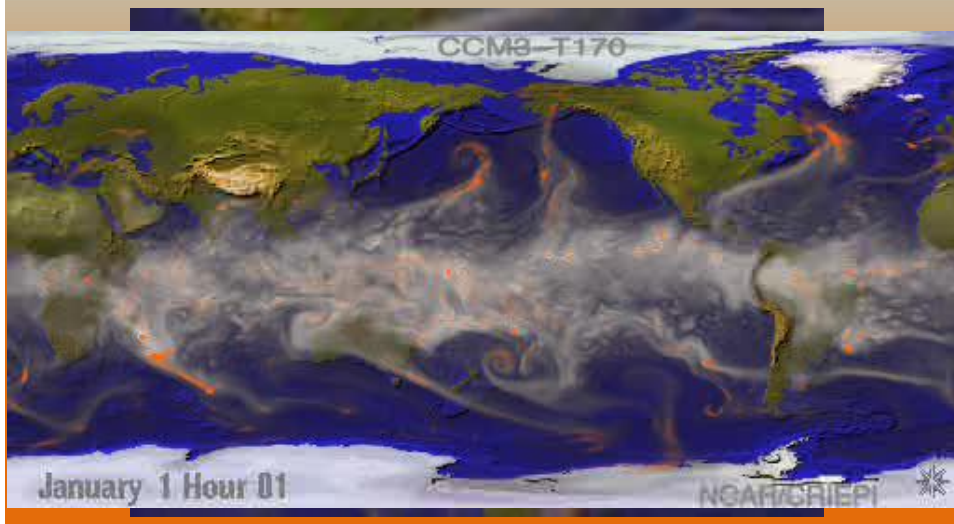
Coordinator: Bart Kruijt Co-coordinator: Carlos Nobre

‘Raising the alert on critical transitions in the Amazon’

Vulnerability of the Amazon ecosystem services to climate change and deforestation

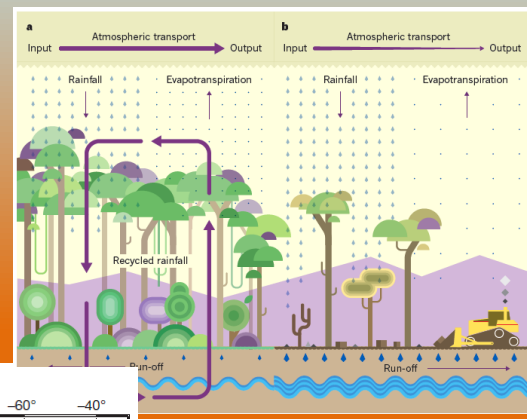
AMAZALERT consortium

Amazonia's role in global climate



Amazonia recycles water

Rainfall partly dependent on evaporation from forests



Aragao, 2012

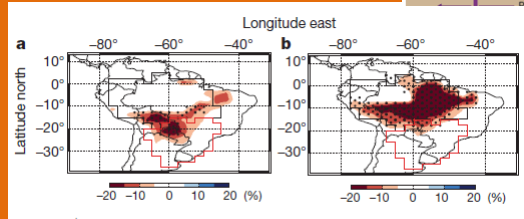
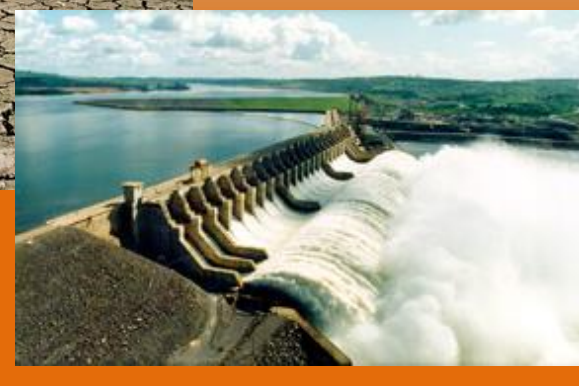


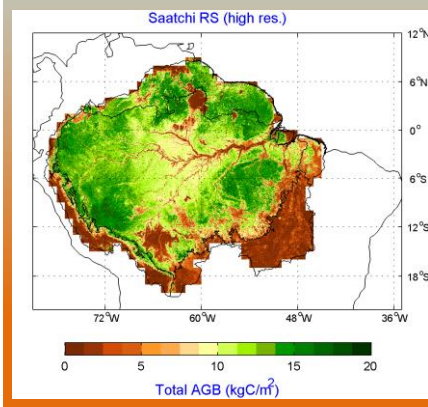
Figure 4 | Simulated percentage change in precipitation due to 2000–2050 business-as-usual deforestation of the Amazon basin. a, Wet season; b, dry

Spacklen et al., 2012

Amazonia maintains its own regional water cycle

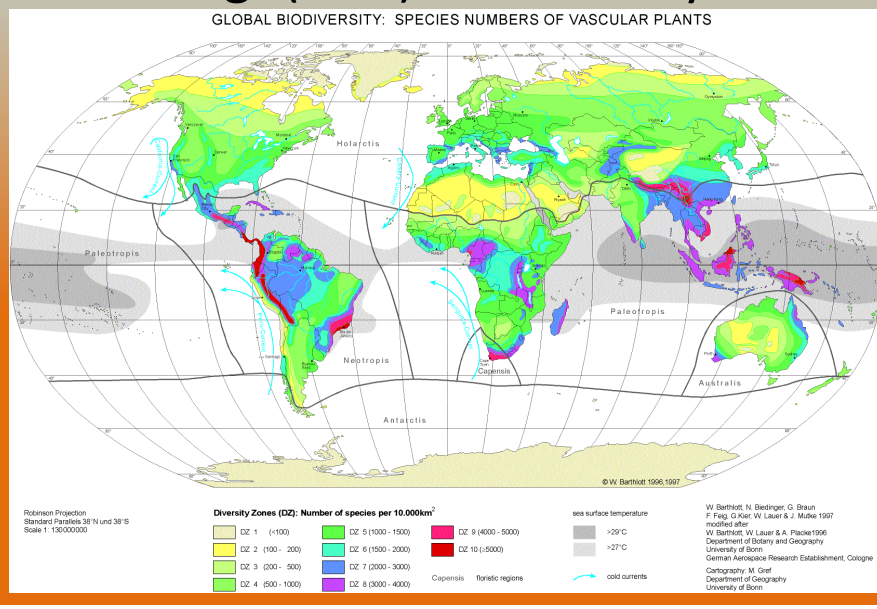


Amazonia stores CO_2 in biomass



On area basis not extremely high, but there is so much of it:
total 86 Pg C
Globally in atmosphere: 760 Pg

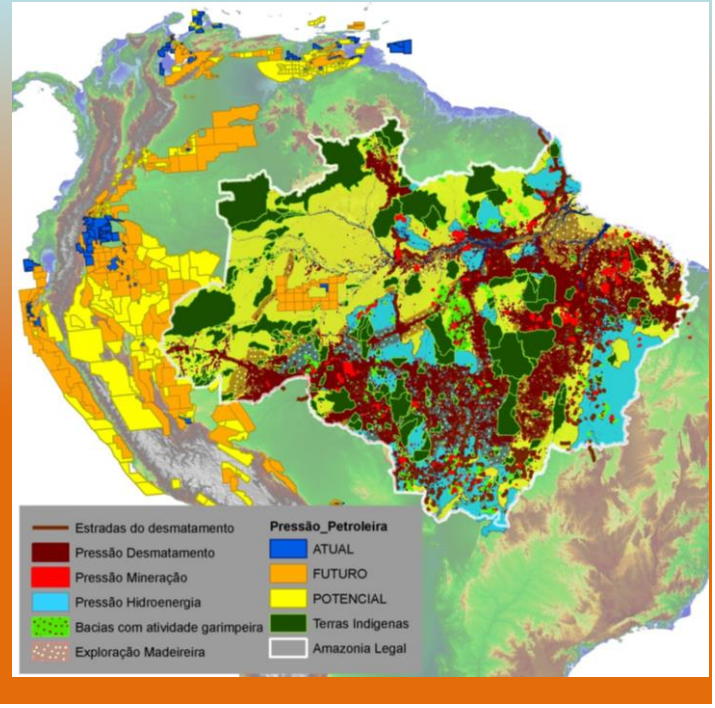
High(est?) Biodiversity



Threats to the Amazon

'Atlas of threats and pressures'

A. Carneiro
O. Braga



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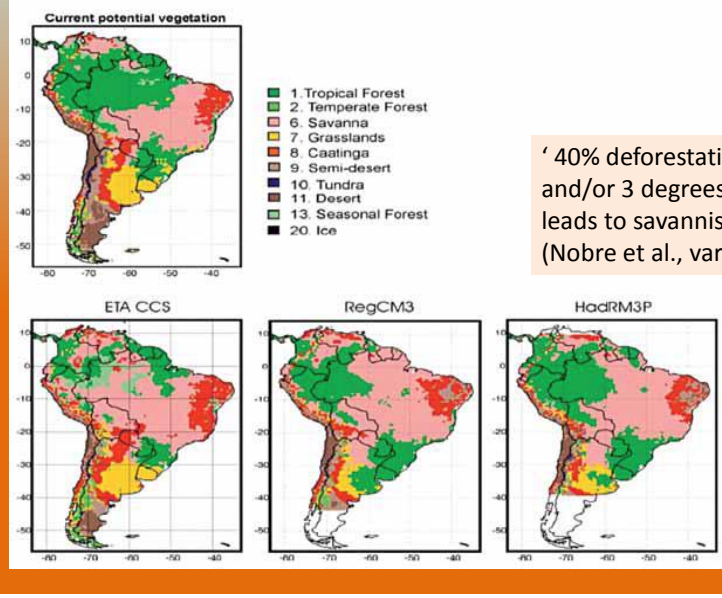
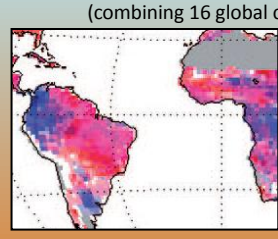
Forecast climate-induced changes to the Amazon till 2100

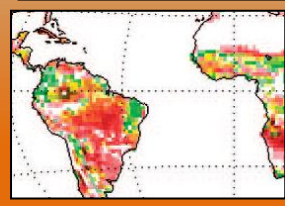


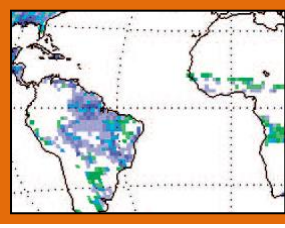
' 40% deforestation and/or 3 degrees warming leads to savannisation' (Nobre et al., various)

Consequences of climate change: 2080 compared with 1980

(combining 16 global climate models: temperature increase >3° C)







River runoff – water availability

- increase
- Mix of increase and decrease
- decrease

Fires

- increase
- Mix of increase and decrease
- decrease

Stable forests

- increase
- Mix of increase and decrease
- decrease

Nobre and Borma, 2009; Scholze et al, 2006

Coupled Atmosphere-Land surface

Analyse and new ESM results

Critical Ecosystem Services

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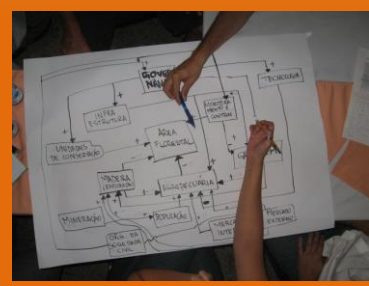
DGVMs
test
urgent issues
rivers
Coupled LUC

People
Scenario analysis
Policy analysis
Land-use change model

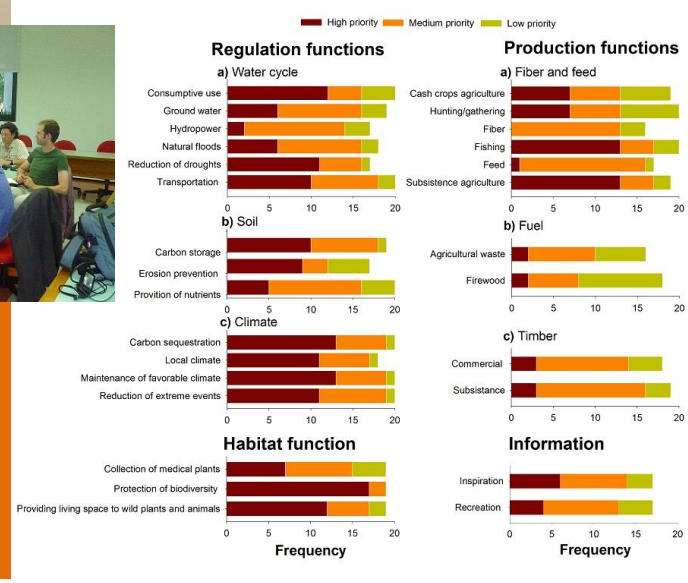
Blue-print
Early-Warning System

What is important in the Amazon?

- *Identify the ecosystem services most important to stakeholders in the Amazon Basin and beyond.*

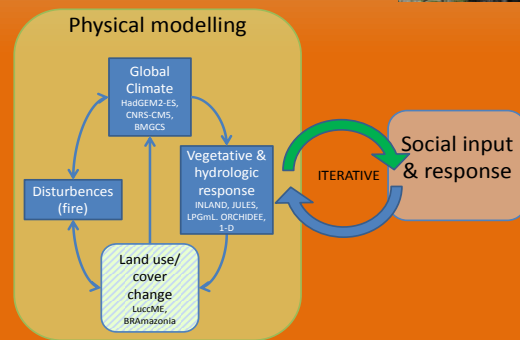


Inventory of ecosystem services

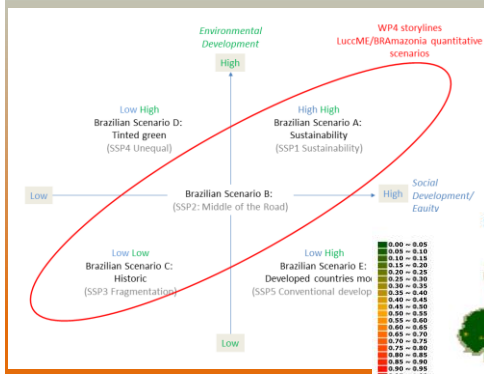


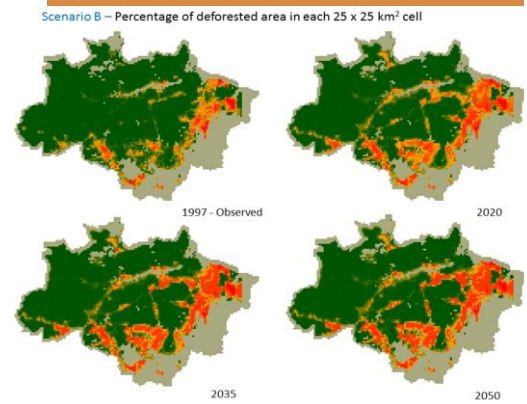
Model testing and improvement

- *Vegetation models*
- *Field data*
- *Land-use change models*
- *Climate-Earth System Models*



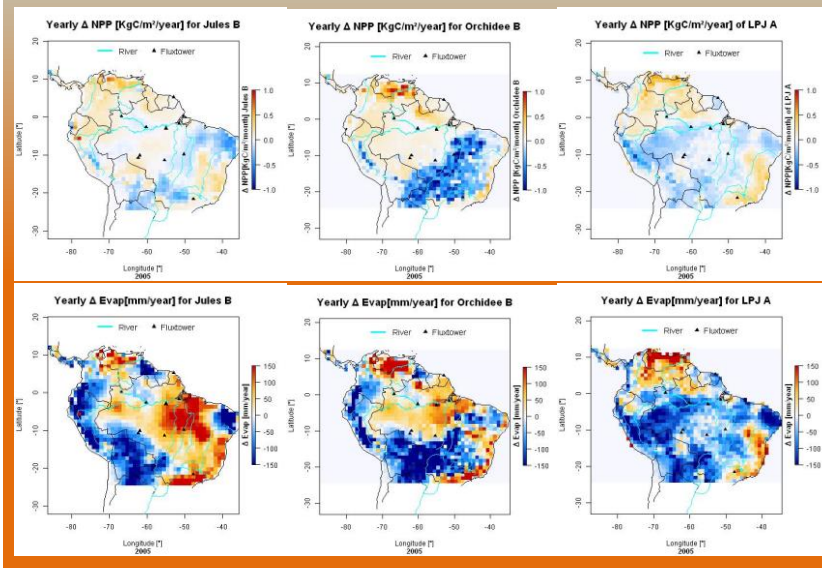
Initial scenarios and land-use change





Aguiar et al, subm

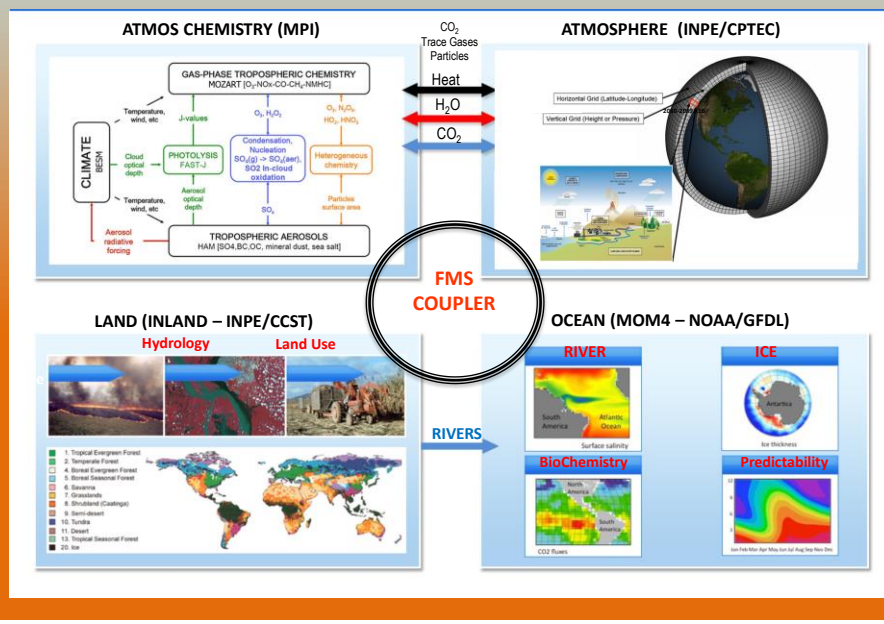
Three vegetation models, 2005 anomaly

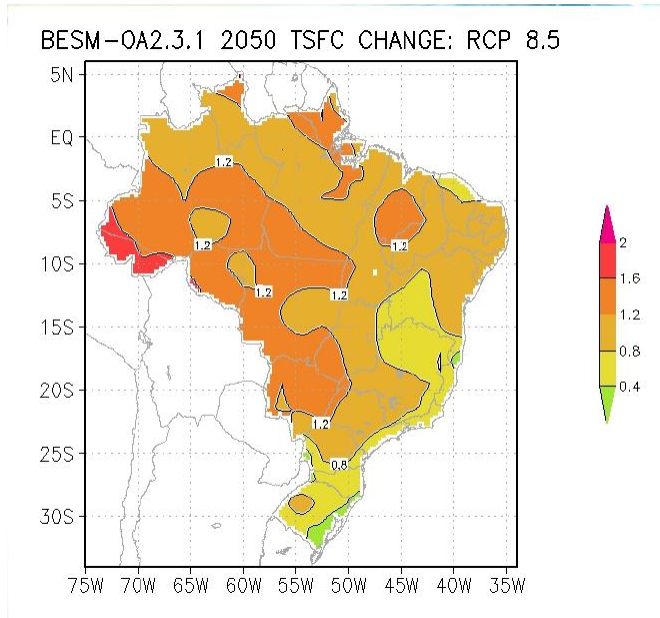


'Growth'

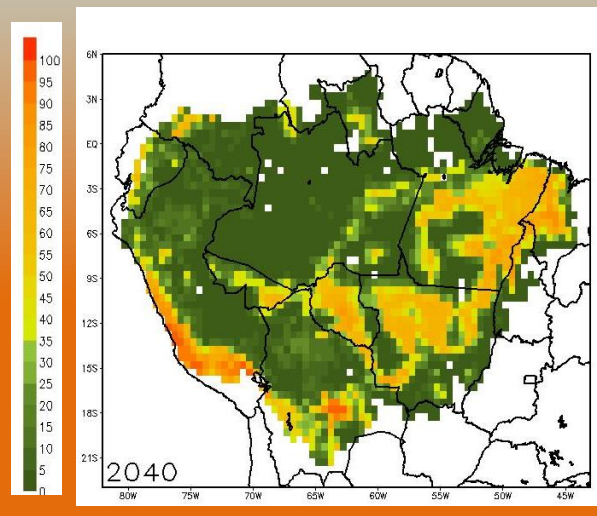
Evapo-ration

Brazilian Earth System Model - BESM





Deforestation Scenarios

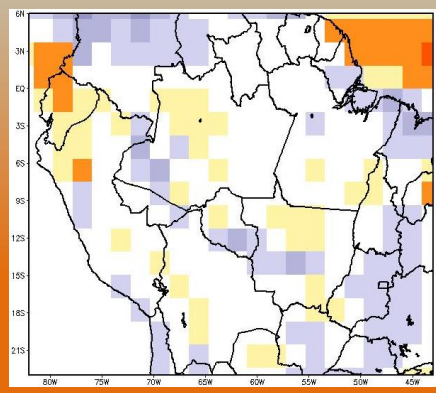


Aguiar et al. (2013, submitted)

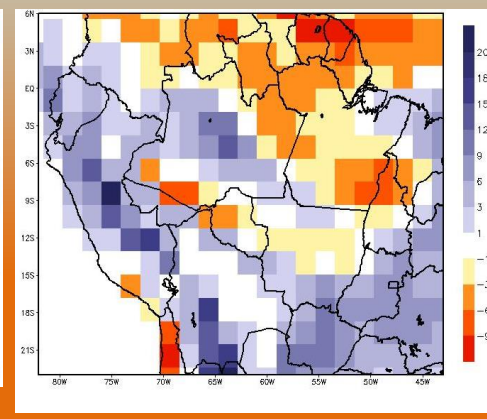
Precipitation change

RCP4.5 - 2050

No fire and no LU



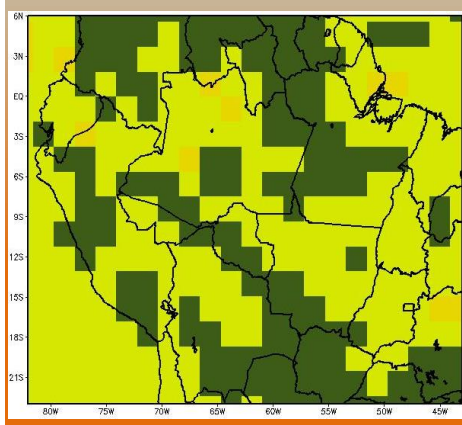
+ fire and LU



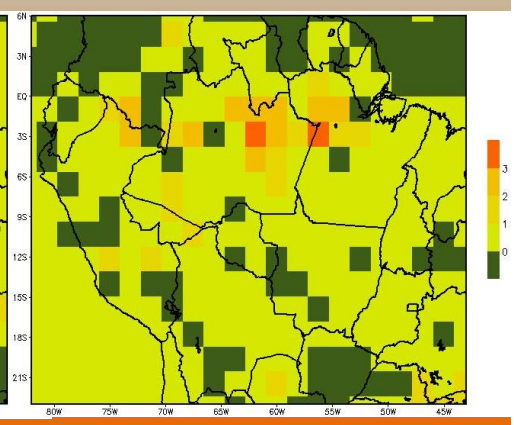
Dry season length

RCP4.5 - 2050

No fire and no LU



+ fire and LU

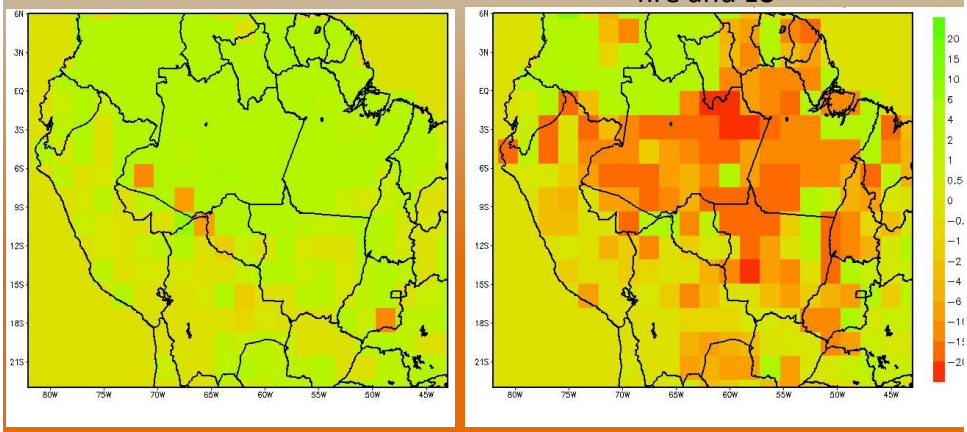


Biomass

RCP4.5 - 2050

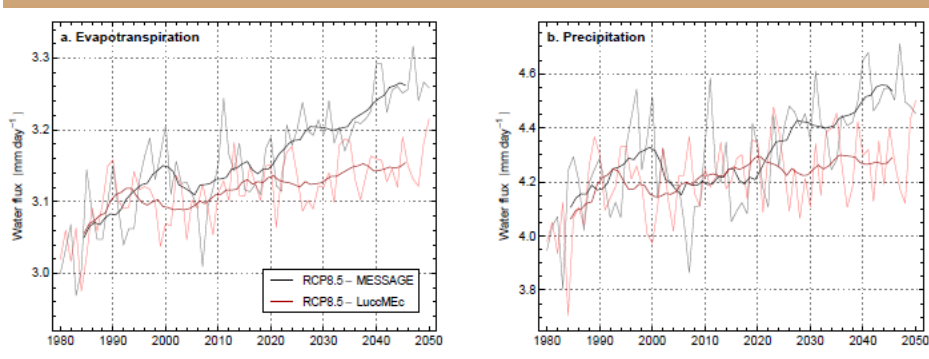
No fire and no LU

+ fire and LU



Sampaio et al, in prep

IPSL ES model forecasts overall rainfall increase



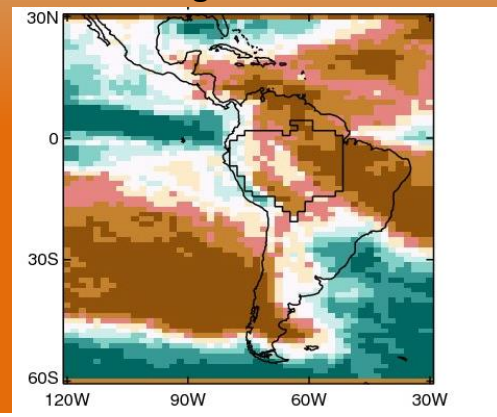
Boisier et al, in prep

CMIP5 Earth System models

Ensemble of models example for Sept-Nov.

Brown: agreement on drying

Blue: agreement on wetting



Kay et al, in prep.

Lower Madeira Basin – Mean discharges

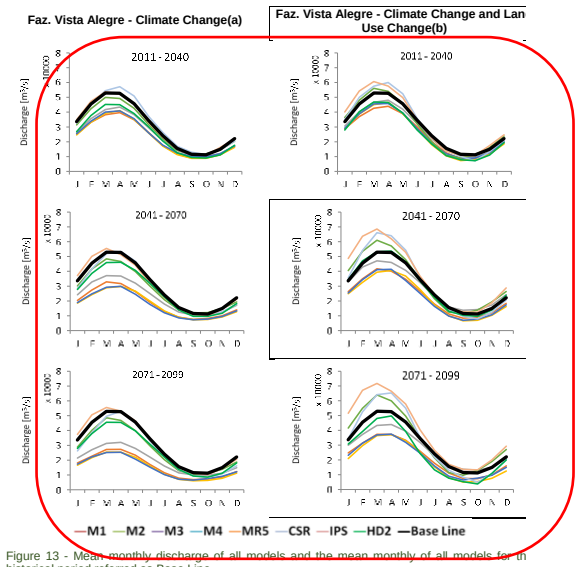


Figure 13 - Mean monthly discharge of all models and the mean monthly of all models for th historical period referred as Base Line.

In most projections, reductions in the discharges.

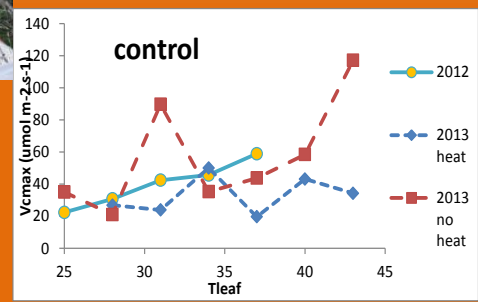
Deforestation increases the variability and further reduces the dry season discharges.

Tomassella et al, submitted

Data collection and analysis

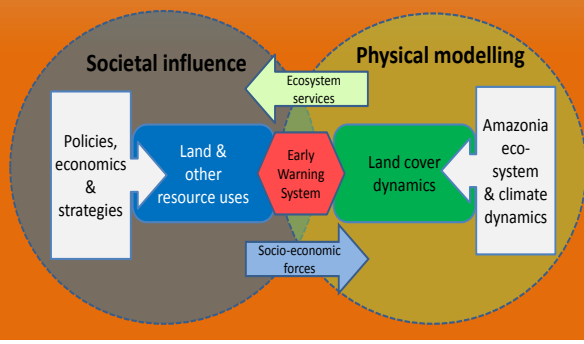
Temperature sensitivity of photosynthesis:

Little decline with temperature??



Construct an integrated view of the Amazon

- *Integrate policy and socio-economic factors into land use and climate models and use the results to inform decision making.*

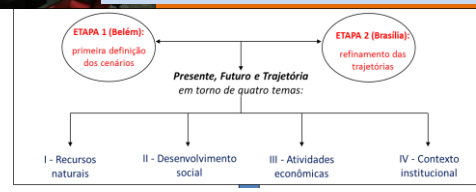


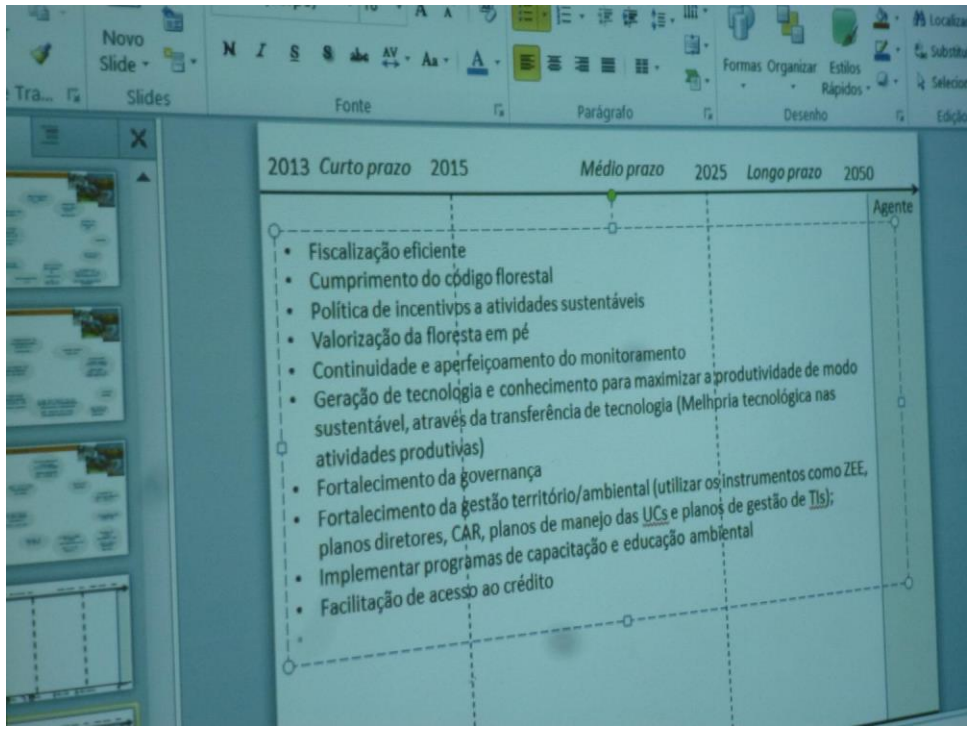
Socio-economic drivers

- *Evaluate policy*
  - First overview of Brazilian and international policies made
- *Improve scenarios (talk Kok):*

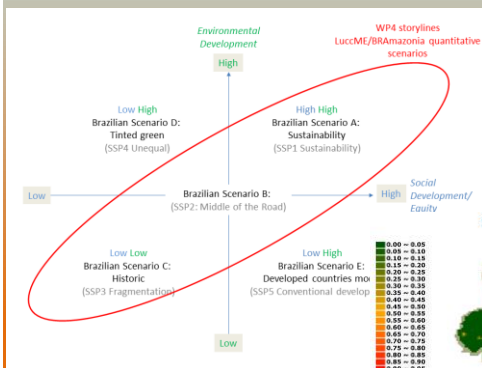
Workshop Brasilia, 25 November 2013

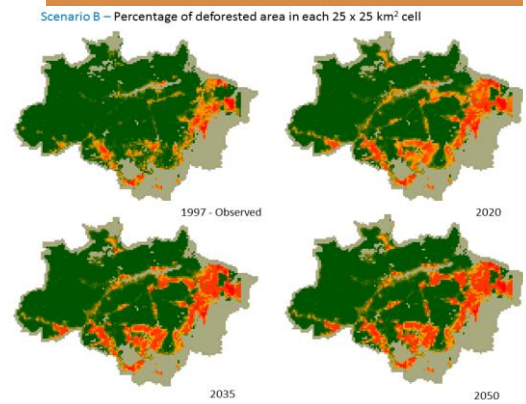
Workshop Brussels, December 2013





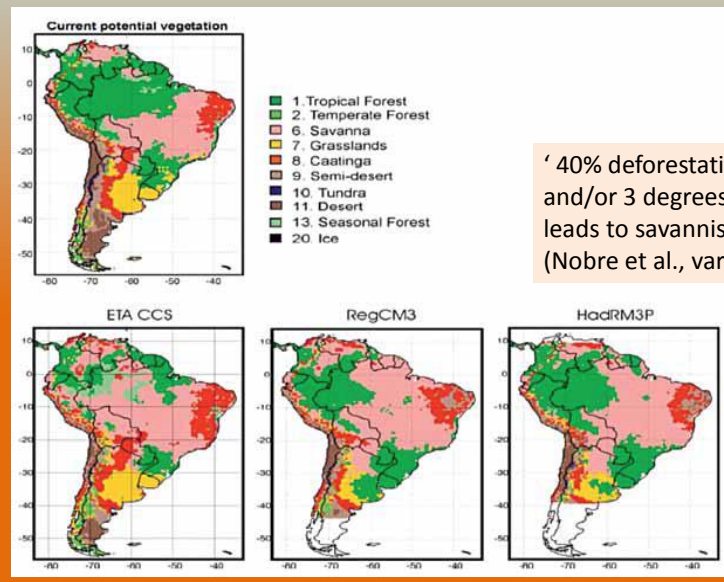
NEW scenarios and land-use change





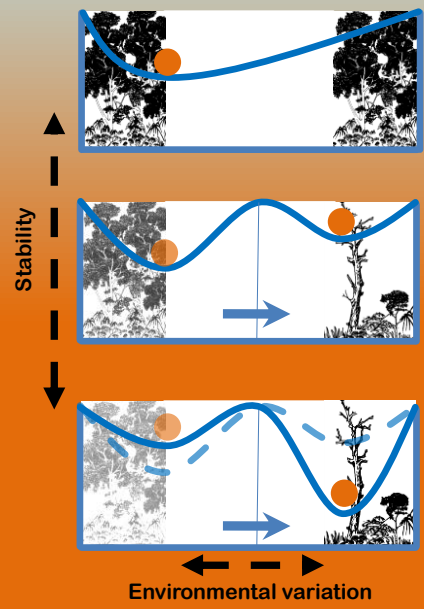
Iteration...

Forecast climate-induced changes to the Amazon till 2100



‘ 40% deforestation and/or 3 degrees warming leads to savannisation’ (Nobre et al., various)

Tipping points in Amazonia



Tropical forest

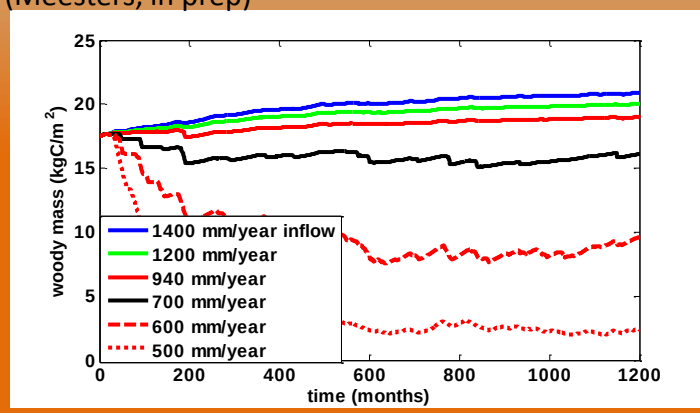
Savanna state triggered by climate change or deforestation

Stability of savanna enhanced by increased droughts and fires

Cardoso and Borma, 2010

Analysing tipping points with simple models

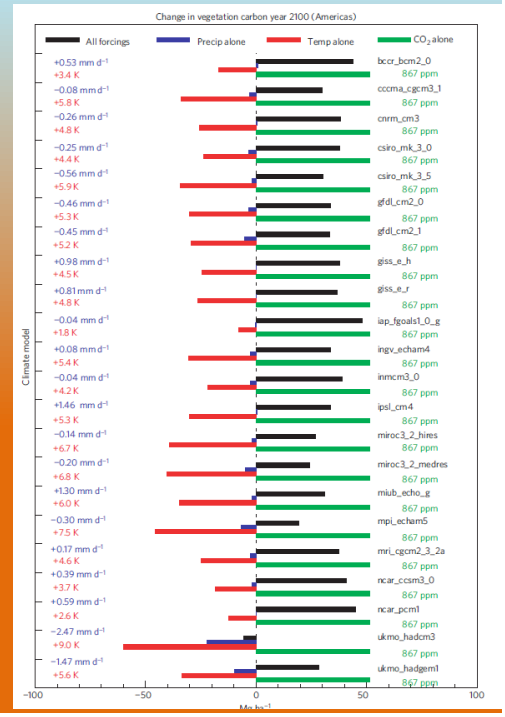
Example: Simple Amazon with variable climate circulation (Meesters, in prep)



What do complex, coupled models show?

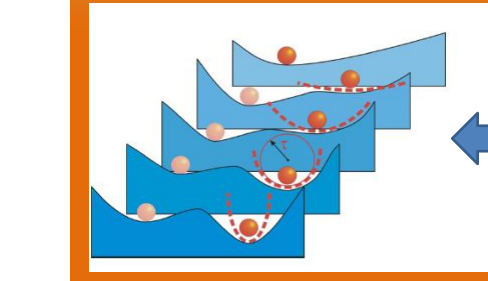
Results not yet available, tendency for little/no dieback under rising CO_2

Huntingford et al, 2013



Tools for policy

- Develop a proposal ('Blue-print') for an early warning system for imminent tipping points
- Policy analysis (National, International *(talk Frieden))*

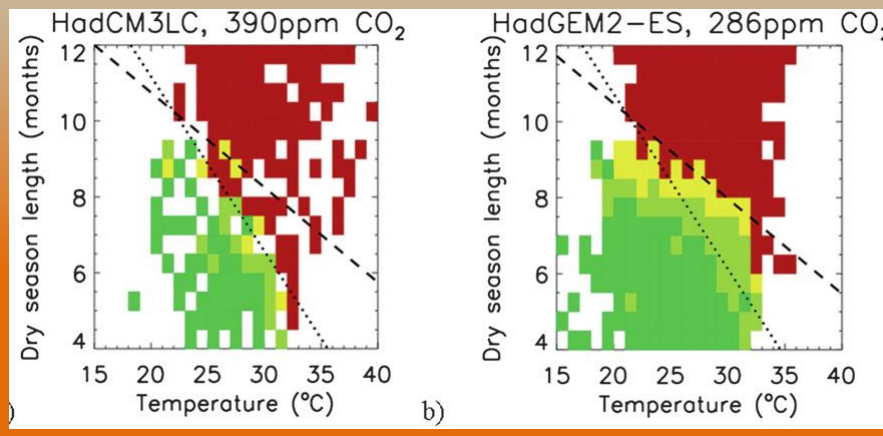


Early Warning System

What to warn about?

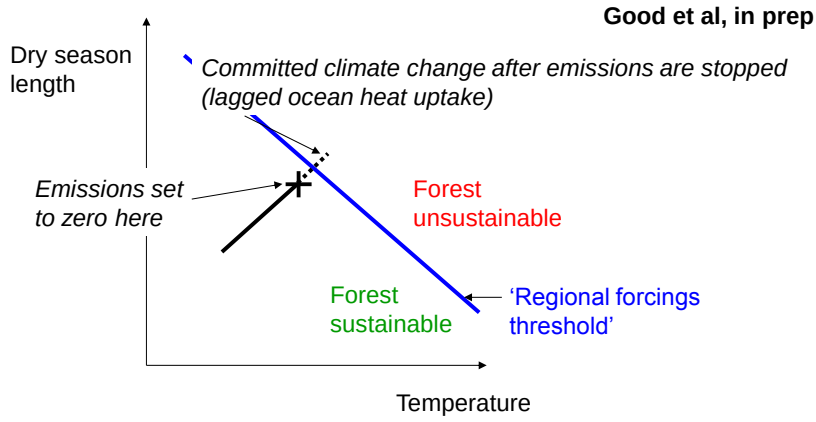
- Degradation of ecosystem services in what time scales (years – decades) ?
- Not only critical transitions, but also gradual change?
- Which changes are the biggest concerns of stakeholders?
- How do we translate large-scale change into local impact?
- Are there likely policy options in response?

How to define thresholds



Good et al, 2012

What kind of thresholds can we warn for?



- IMPACT threshold: Critical change occurs
- REGIONAL threshold: Critical change is unavoidable
- MITIGATION threshold: Existing policies are not sufficient any more to avoid critical change

Monitoring system

- WHICH properties of the Amazon would be important to monitor as indicators?
  - Existing monitoring
  - Invest in key new ones
- HOW would we detect imminent change from these?
  - Advanced statistical techniques looking at variability and 'slowing down'
  - Analyse model output as guidance

Critical indicators

- The basis of such a system is **long-term monitoring of critical indicators**
- These indicators should be quantities that are **relatively accessible**, and easy to monitor at high temporal and/or spatial resolution.
- should **represent the variability** of the Amazon ecosystem services and other important tipping phenomena

=> their behaviour near critical transitions should reliably **point to imminent change** in the state of that particular ecosystem service.

List of possible variables to monitor

- **Sea Surface Temperature (SST)** - indicator of global-scale change
- **Precipitation** (patterns, quantity, dry season length…) primary driver as well as an ecosystem service that can be affected
- **Climate modes** (ENSO, Atlantic Oscillations, etc) - often correlated indicators of high-impact changes or episodes in Amazonia
- **River flow and discharge**
- **Evapotranspiration** - prime driver of recycling

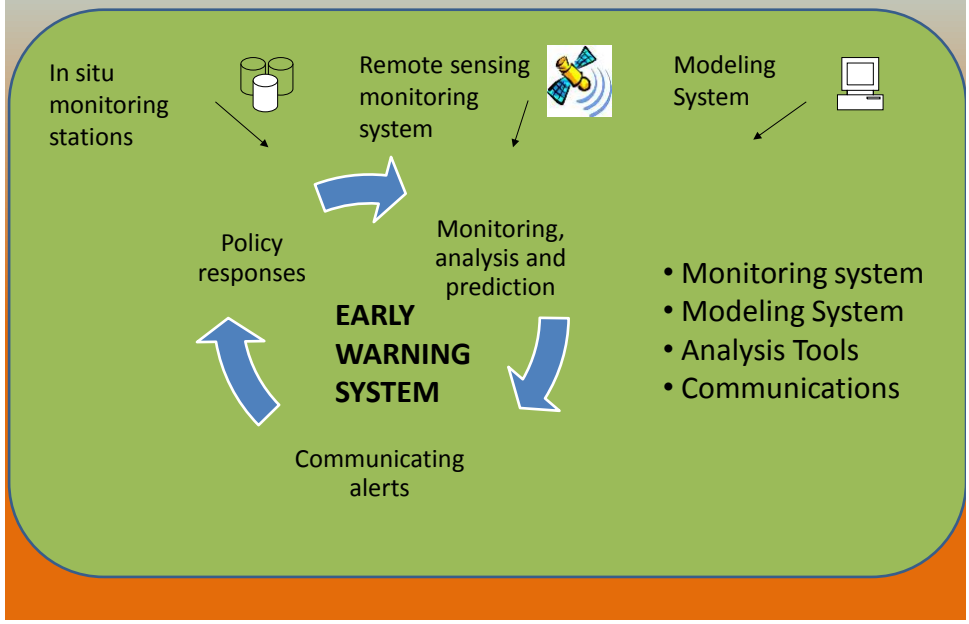
List of possible variables to monitor

- overall vegetation **productivity** changes – [CO2] over the tropical belt + anthropogenic emissions
- **Biomass** - remote sensing (eg S-band Radar) and well-referenced growth bands in forest plots across the basin
- **Water use efficiency** from tree-ring & gas exchange monitoring
- **Remote sensing indices** (NDVI , EVI)

List of possible variables to monitor

- **Fires** (remote sensing and in-situ observations) – not simply occurrence or area, but also fire effects (e.g. type of vegetation affected and recovery of previously burned areas
- **Economic indicators**, such as the GDP of the region, transport, trade and migration patterns
- **Exposure** and **Vulnerability** (?)

EWS framework



Which institution can do this?

- Aim:
  - Manage critical monitoring systems
  - Re-analyse and re-run coupled forecasts
  - issue regular 'state of the Amazon' reports
- CEMADEN – Brazil centre for monitoring and forecasting of natural disasters
  - Federal institute
  - Runs several intensive monitoring systems
  - Now short-term forecasting
  - Could add long-range forecasting branch
- An independent NGO?
  - More difficult to obtain information and run monitoring
  - Could more easily go against government policy

AMAZALERT final products

- More insight into the integral functioning of the Amazon
- Quantified uncertainty on the risk of dieback or other tipping points
- Point to way forward in further reducing uncertainty, in particular CO_2 effects

- A 'blue-print' for an Early Warning System
- Evaluation of national and international policies

Take-home messages

- AMAZALERT: work in progress
- Early model results and data suggest high uncertainty on Amazon drying, dieback or wetting and resilience
- Most important factors in uncertainty:
  - Global climate change
  - Deforestation rates
  - Temperature dependence
  - CO_2 dependence!
- Early warning specified and refined
- What about impact of European policies, trade and investments

Which is your road ahead?