

# C and N trace gas emissions from tropical forest ecosystems: measurements, driving forces and upscaling

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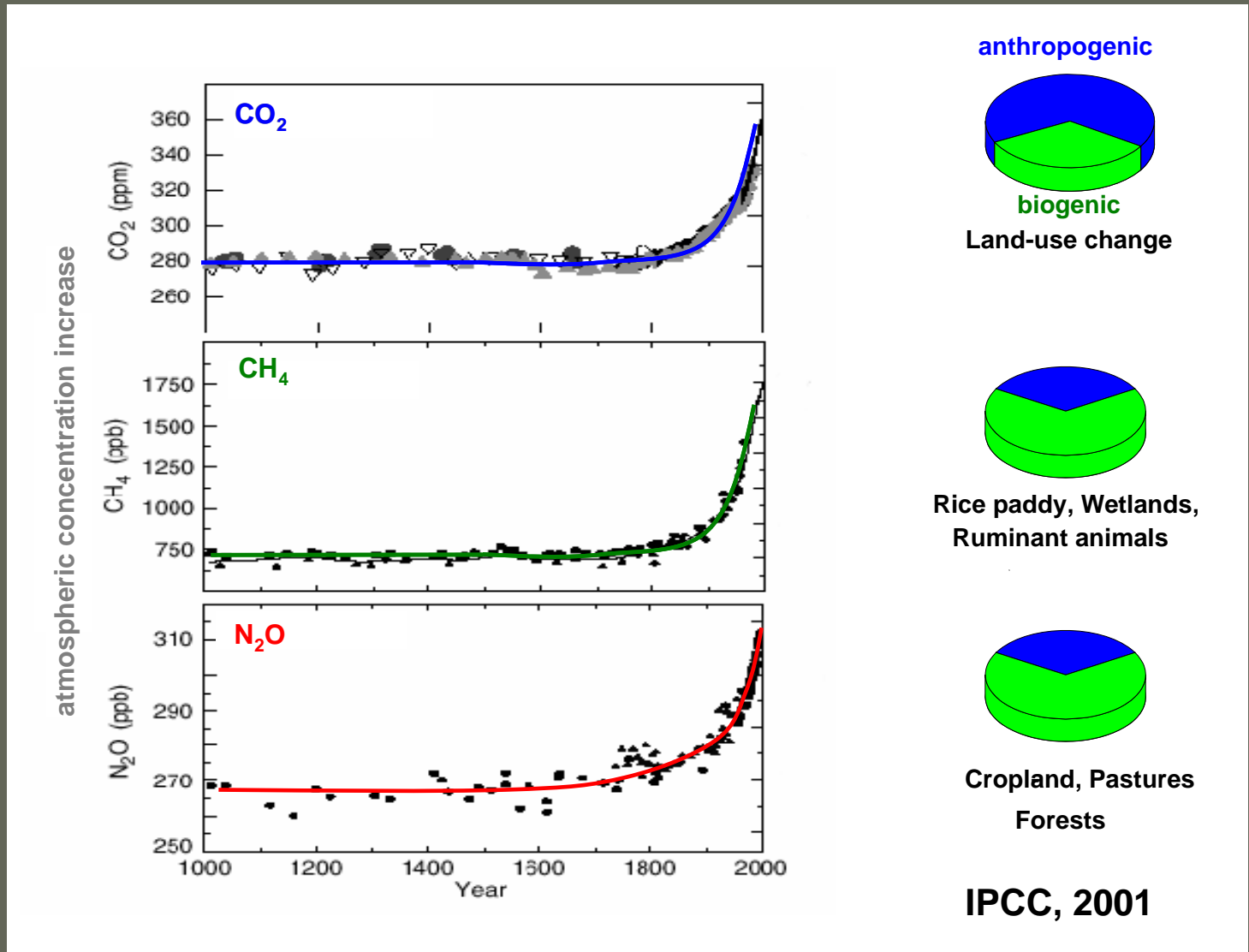
Institute for Meteorology and Climate Research  
Atmospheric Environmental Research (IMK-IFU)  
Karlsruhe Research Center  
Germany

Workshop "Adaptation of Kilimanjaro ecosystems to climate and land use change", 26.02.2008, Moshi, Tanzania)





## Motivation





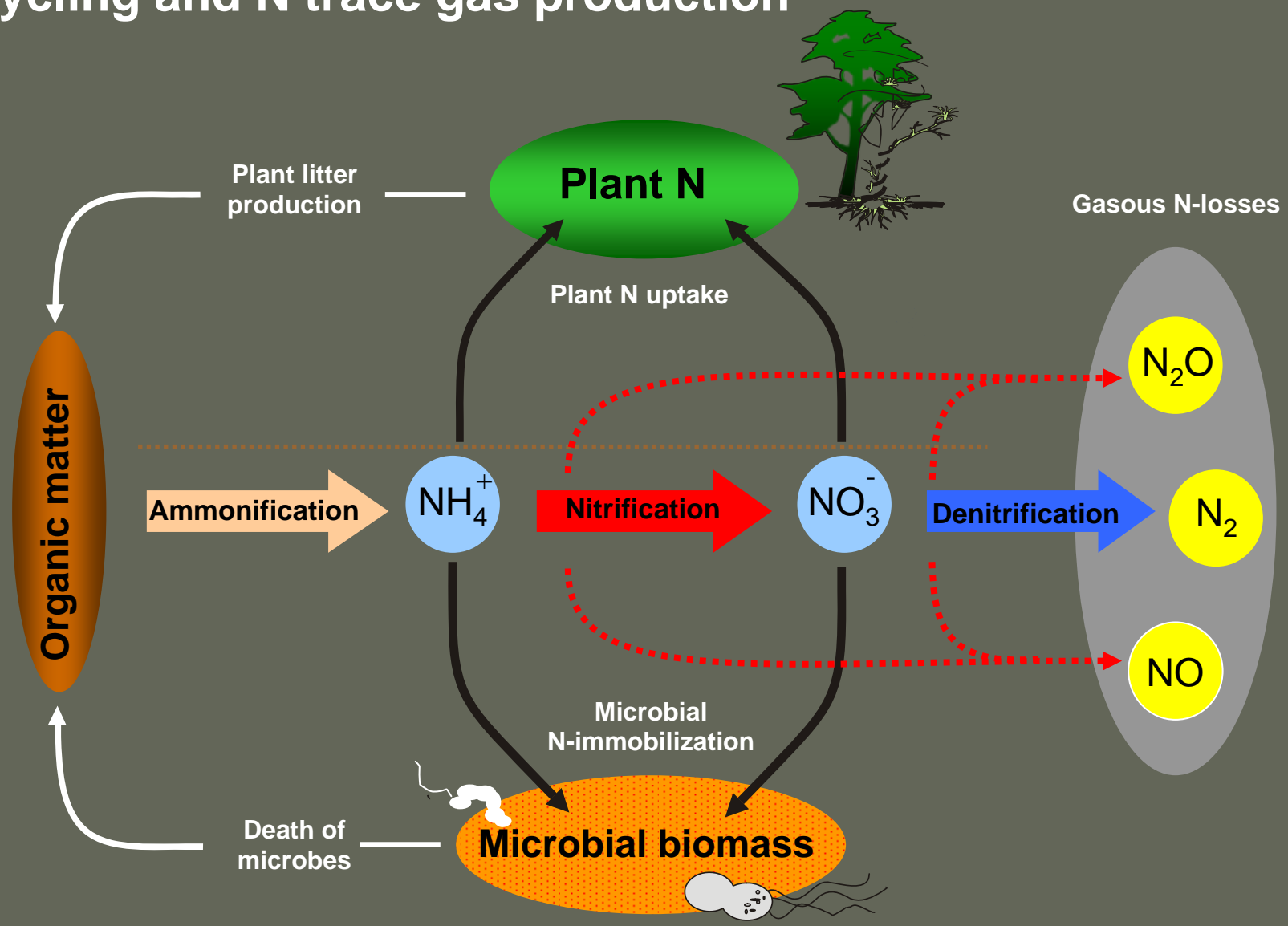
## Global N<sub>2</sub>O budget

N <sub>2</sub> O-sources	Relative contribution to all identified sources [%]	Tg (10 <sup>12</sup> g) N <sub>2</sub> O-N a <sup>-1</sup>	
<b>Natural N<sub>2</sub>O sources</b>			
Ocean	18.5	3.0	(1.0-5.0)
<b>Tropical soils</b>			
<b>Wet forests</b>	<b>18.5</b>	<b>3.0</b>	<b>(2.2-3.7)</b>
Dry savannas	6.2	1.0	(0.5-2.0)
Temperate soils			
Forests	6.2	1.0	(0.1-2.0)
Grasslands	6.2	1.0	(0.5-2.0)
<b>Anthropogenic N<sub>2</sub>O sources</b>			
<b>Agricultural soils</b>	<b>20.4</b>	<b>3.3</b>	<b>(0.6-14.8)</b>
Biomass burning	3.1	0.5	(0.2-1.0)
Industrial sources	8.0	1.3	(0.7-1.8)
Cattle and feedlots	13.0	2.1	(0.6-3.1)
<b>Total N<sub>2</sub>O sources</b>		<b>16.2</b>	<b>(6.4-34.4)</b>
<b>N<sub>2</sub>O sinks and atmospheric increase</b>			
Stratospheric destruction		12.3	(9.0-16.0)
Removal by soil microbes		?	(?)
<b>Atmospheric increase</b>		<b>3.9</b>	<b>(3.1-4.7)</b>

IPPC, 2001



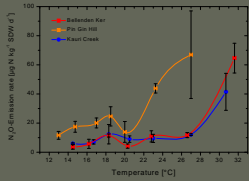
# N cycling and N trace gas production





## Integrated interdisciplinary research concept

### process scale



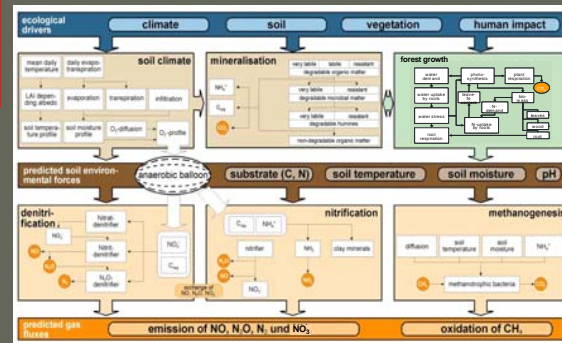
$$\text{fact\_moist}[i] = 1 - \frac{1}{1 + e^{-\frac{\text{water}[i] - W\_CRIT}{W\_DELTA}}}}$$

$$\text{fact\_temp}[i] = \left( \frac{T\_MAX - \text{temp}[i]}{T\_MAX - T\_OPT} \right)^{T\_A} * e^{-\frac{\text{temp}[i] - T\_OPT}{T\_MAX - T\_OPT}}$$

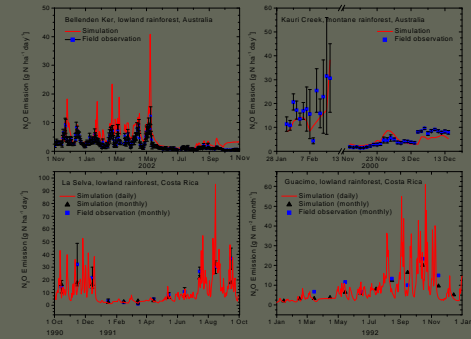
$$\frac{d \text{nitr\_akt}[i]}{dt} = \text{MUEMAX} * \left( \frac{\text{temp\_moist\_fact}}{\text{DOC}[i] + \text{KM\_DOC}[i] + \text{KM\_N}[i] + \text{n}[i]} \right) - \text{nitr\_akt}[i]$$

parameterisation

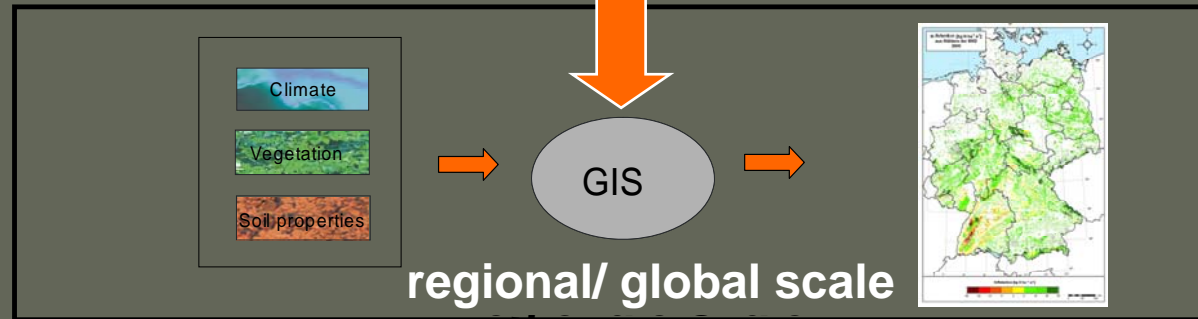
### mechanistic model



### plot scale



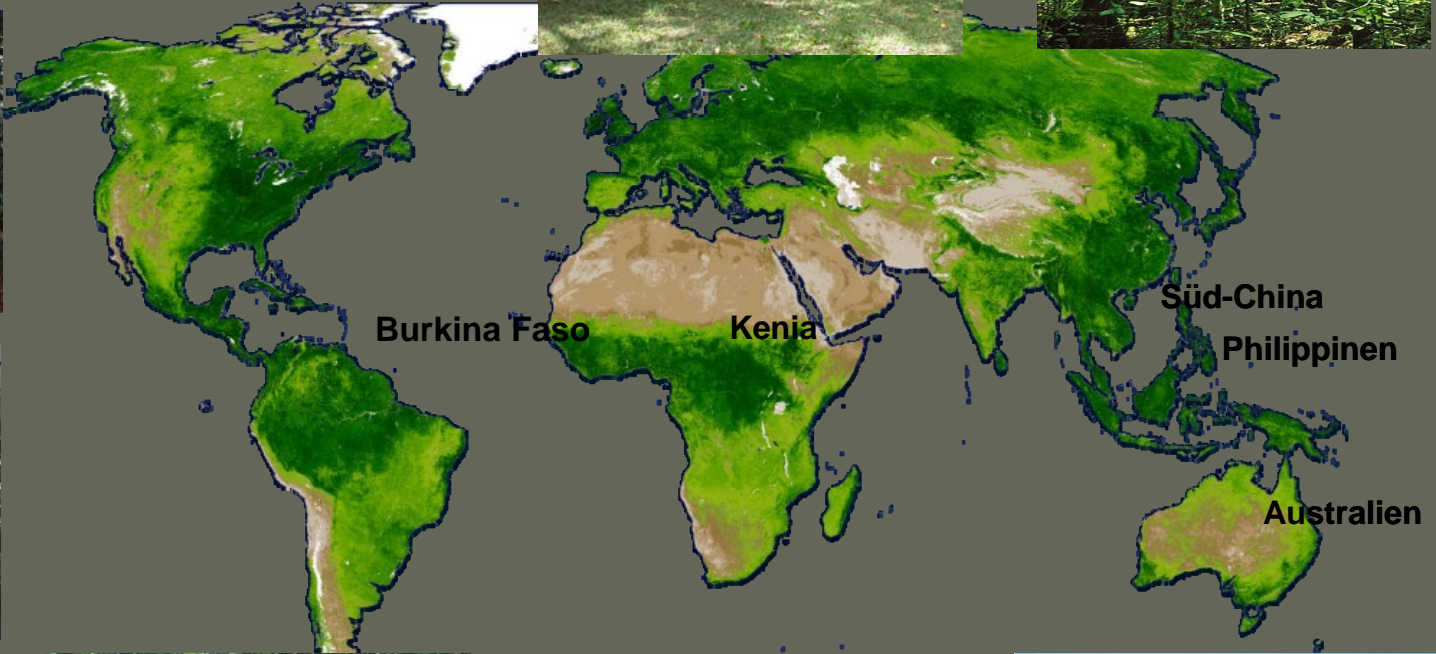
calibration/ testing



regional/ global scale

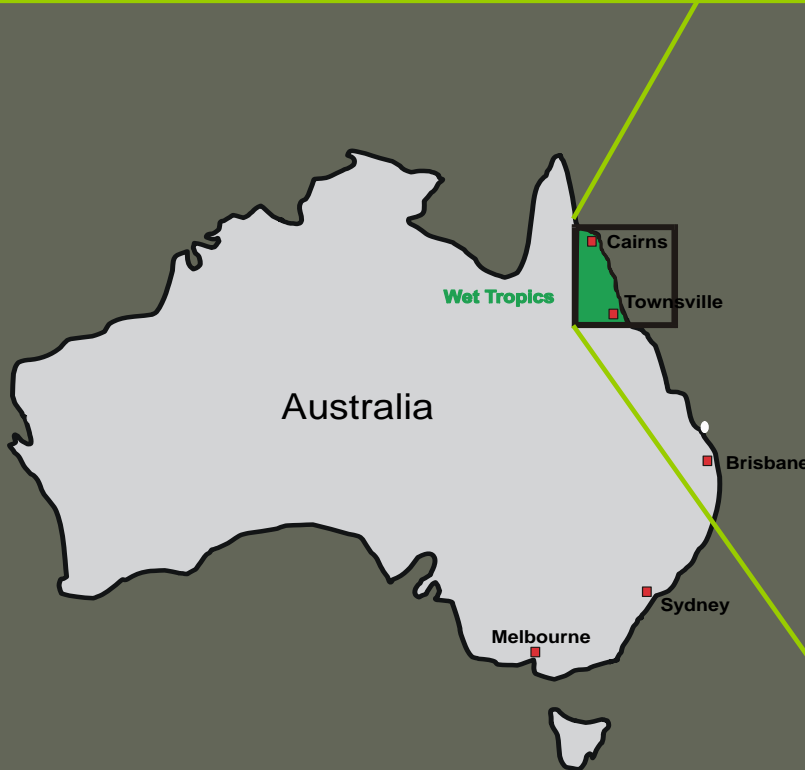
# C and N trace gas emissions from tropical forests

## IMK-IFU measuring sites in the tropics



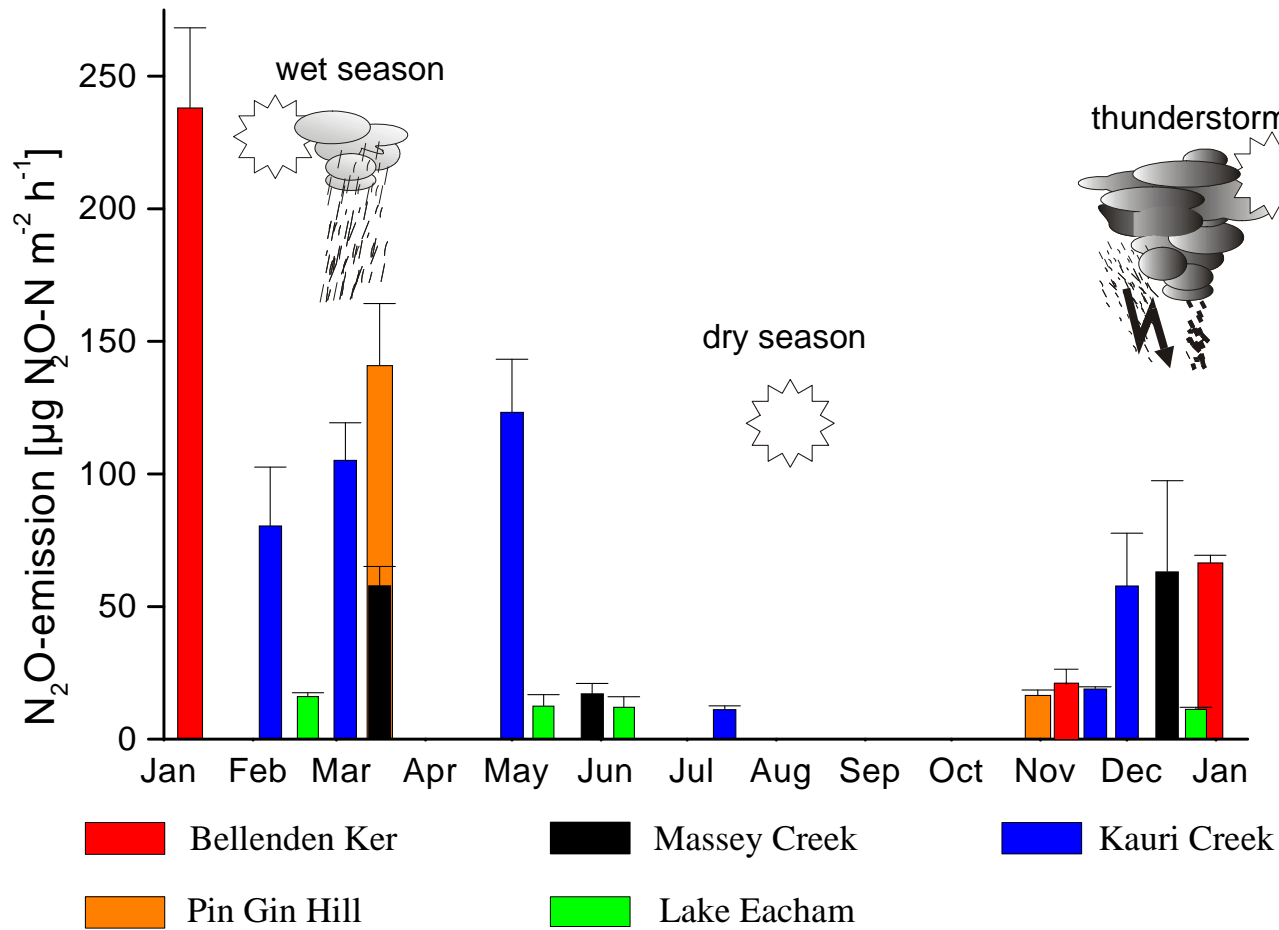


# Case study "Wet Tropics Australia"





## Field campaigns

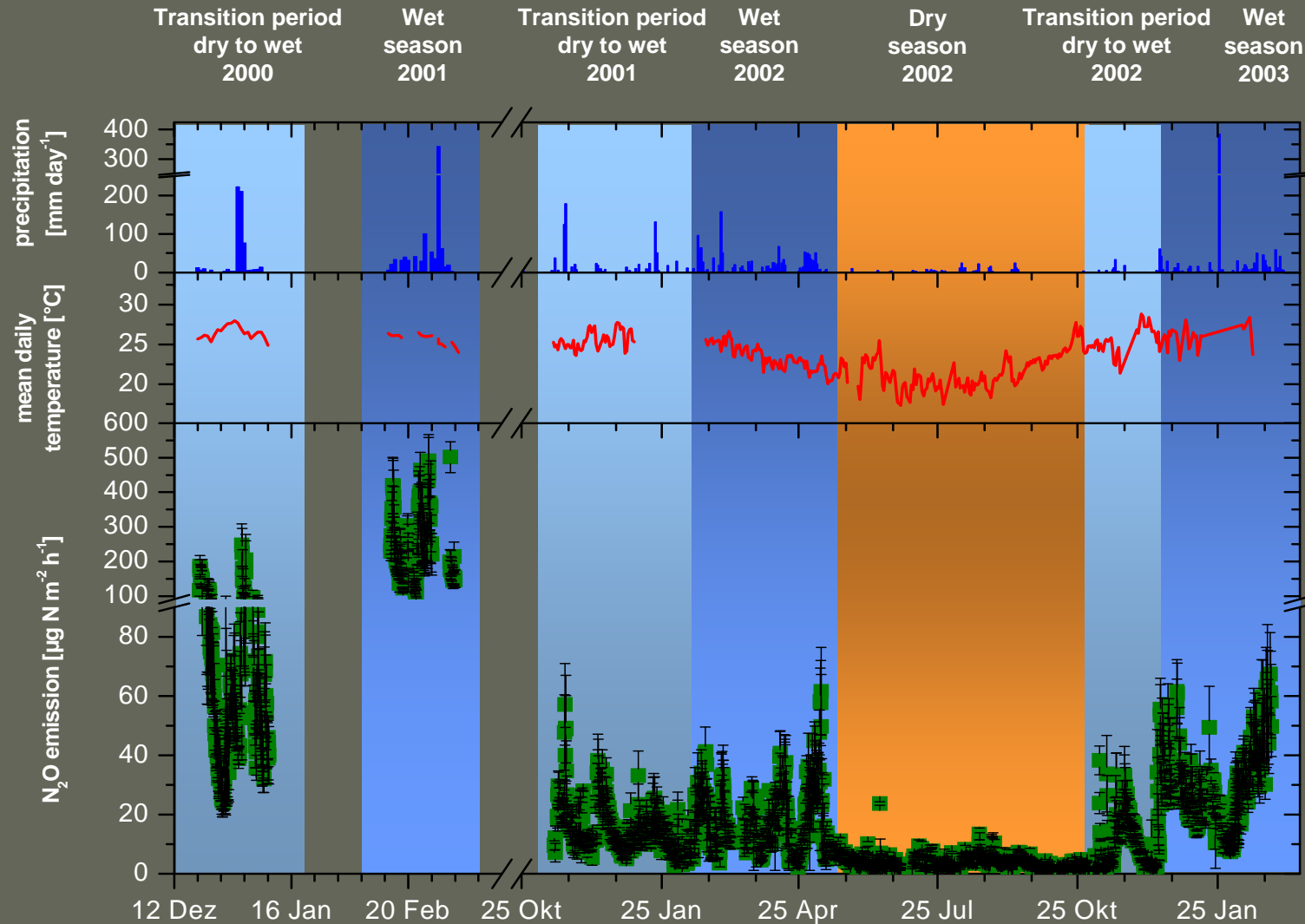


Kiese & Butterbach-Bahl, 2002, Soil Biol.Biochem. 34, 975-987





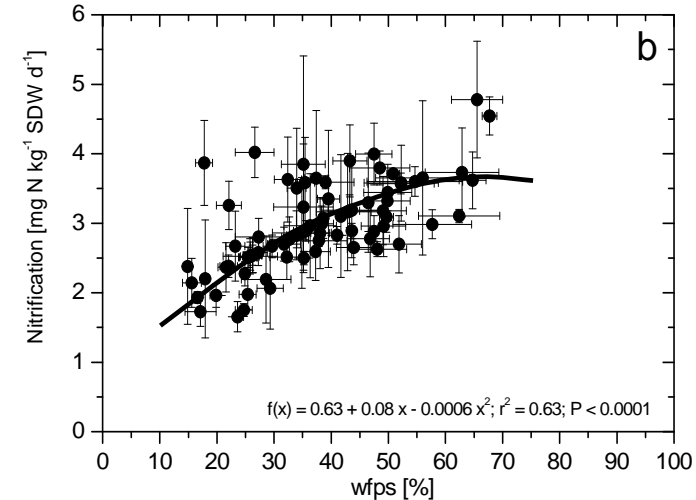
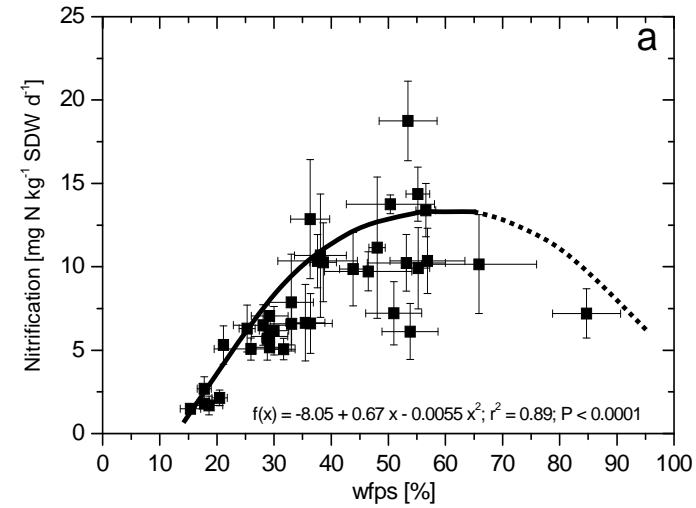
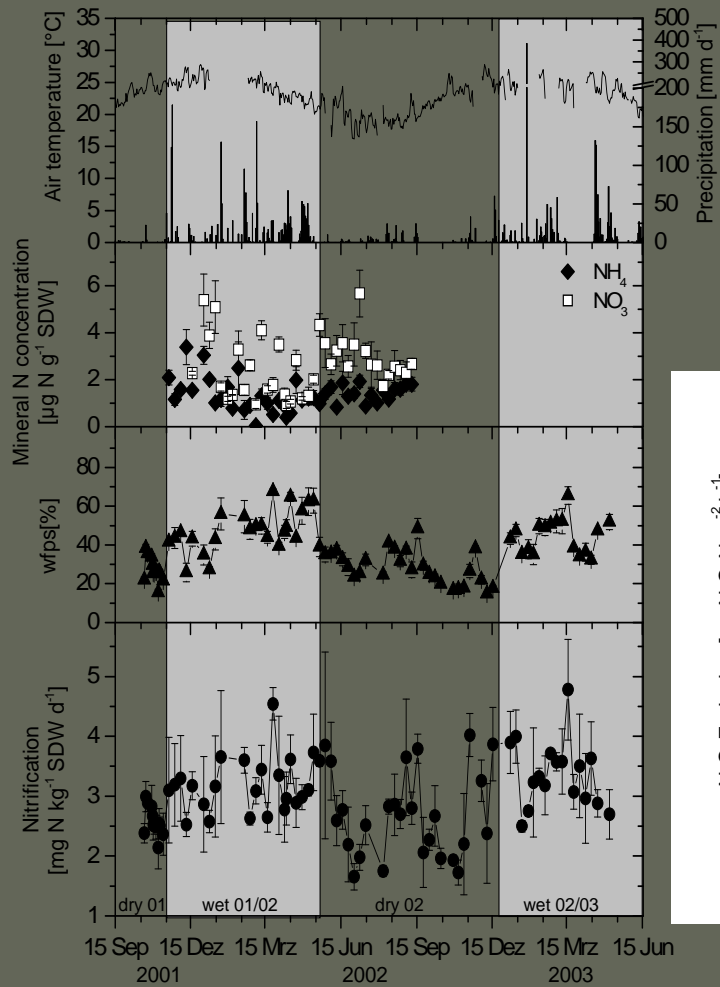
## More field campaigns



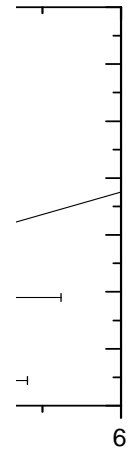
Kiese & Butterbach-Bahl, 2002, Soil Biol. Biochem.; Kiese et al., 2003: Global Biogeochem. Cycl.; Butterbach-Bahl et al., 2004, Global Biogeochem. Cycles.



# Process studies – Nitrification and N<sub>2</sub>O emissions



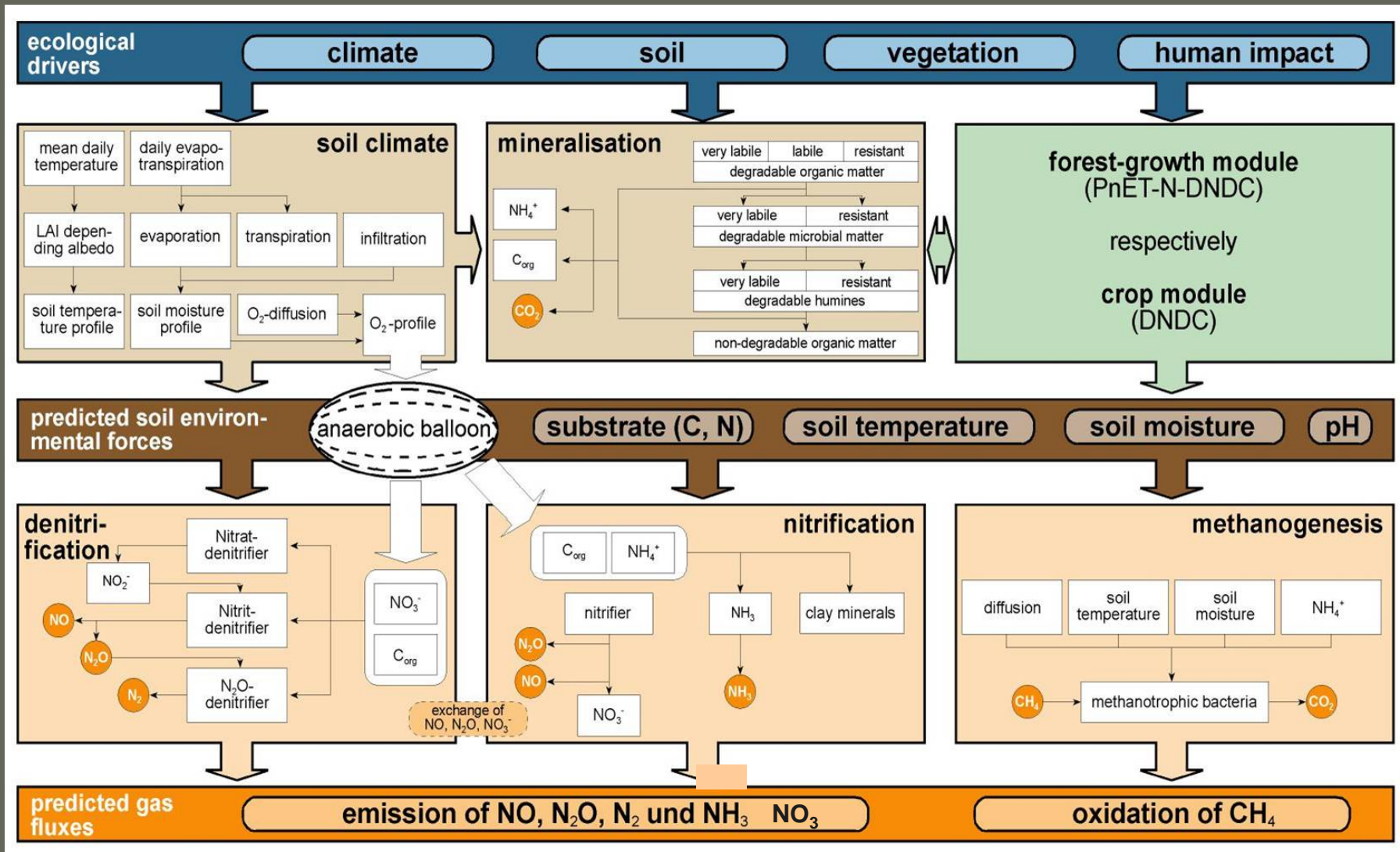
N<sub>2</sub>O-Emission [µg N<sub>2</sub>O-N m<sup>-2</sup> h<sup>-1</sup>]



Kiese et al., Plant and Soil 2008

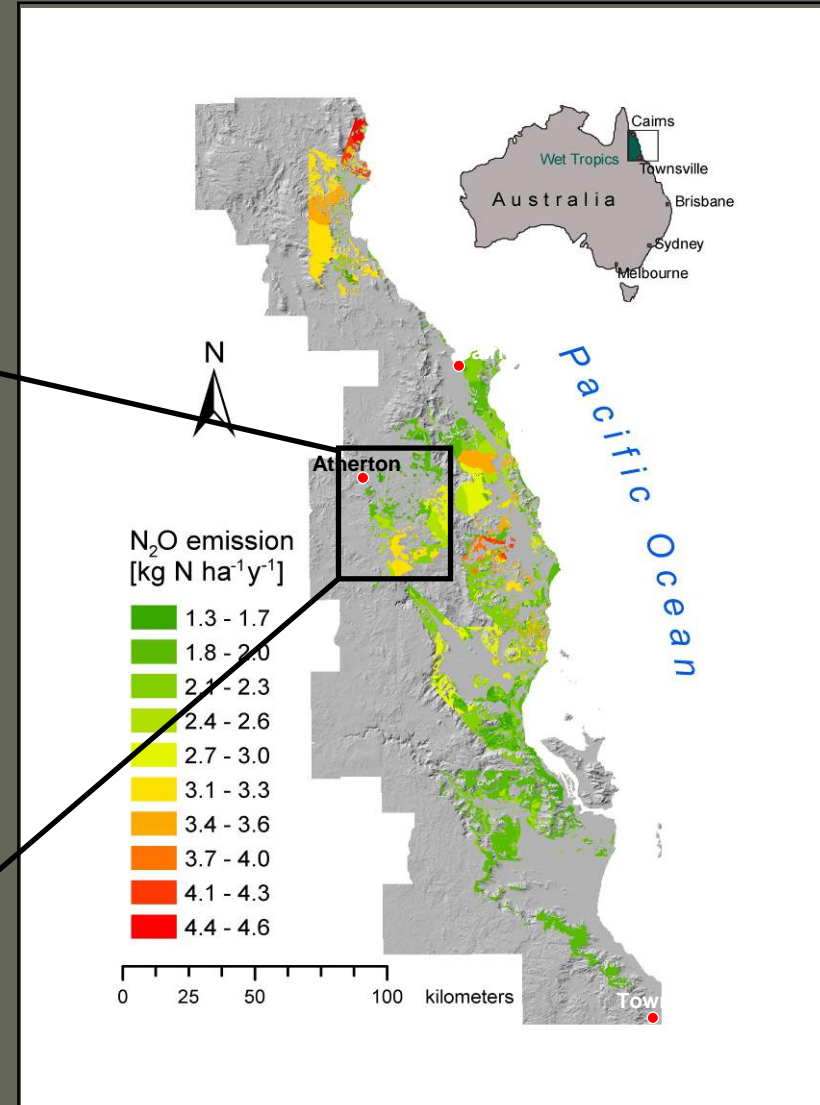
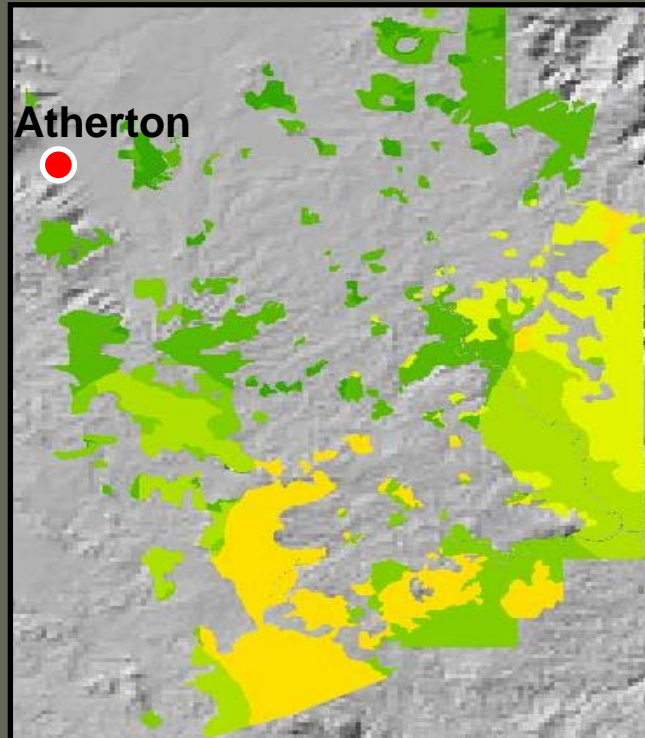
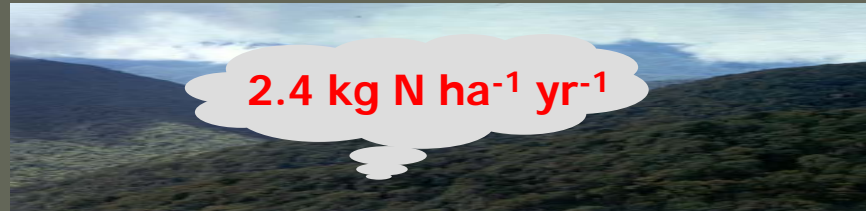


# DNDC model applications on site and regional scale





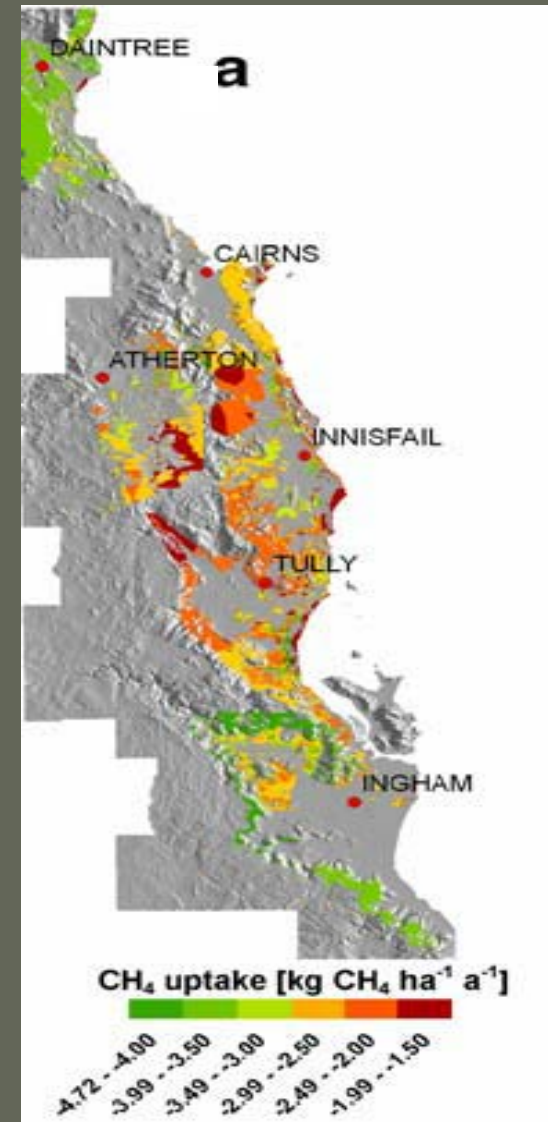
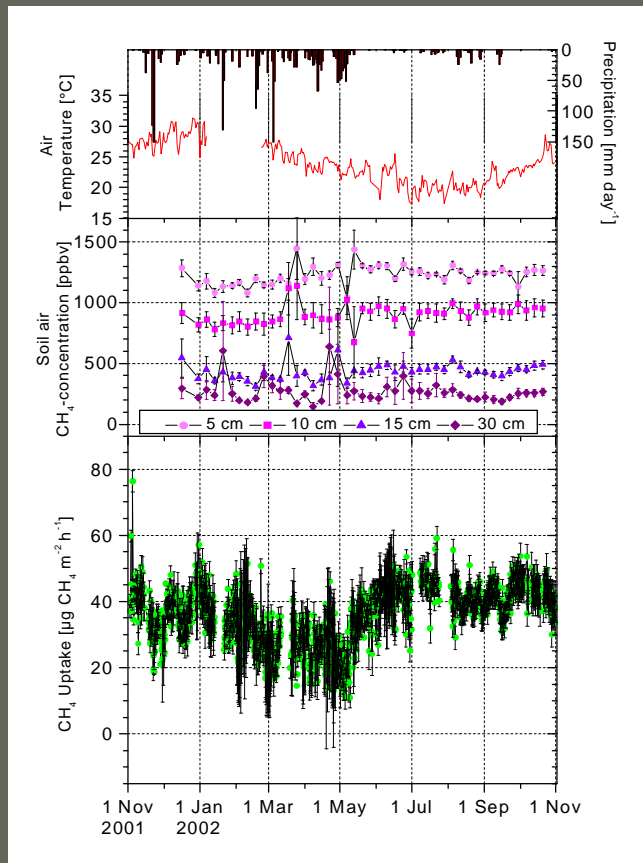
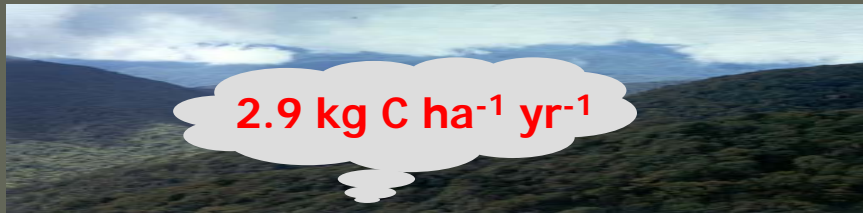
# Upscaling of N<sub>2</sub>O emissions – model GIS approach



Kiese et al., 2005, Global Change Biology 11, 128-144

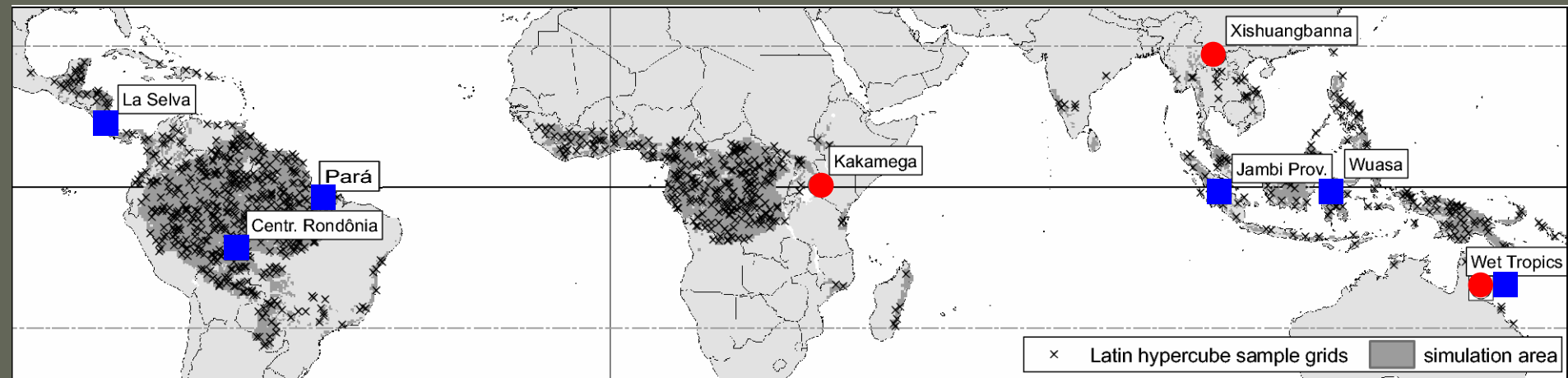


## Upscaling of CH<sub>4</sub> emissions – model GIS approach



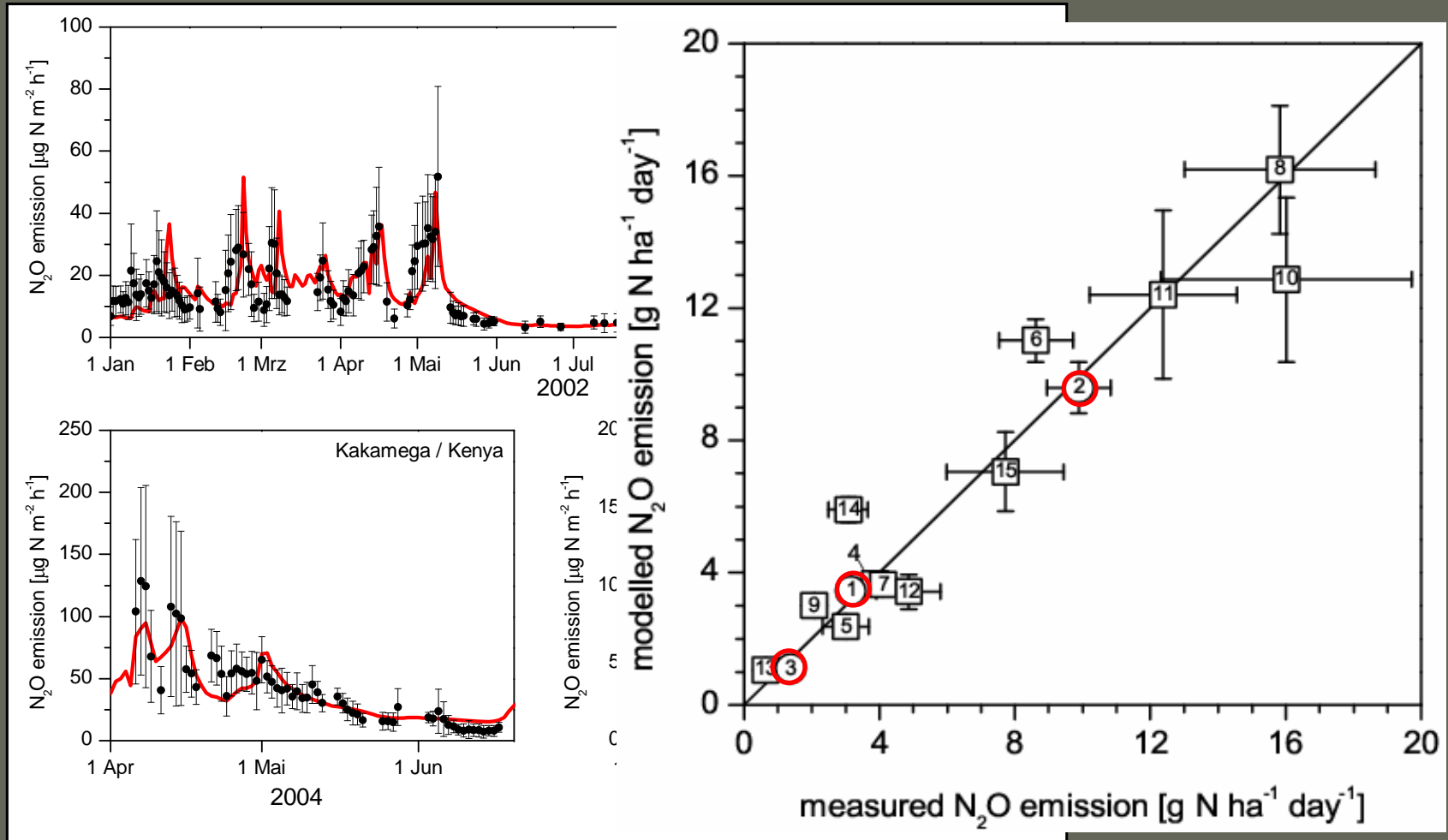


## More measuring sites for model application on global scale





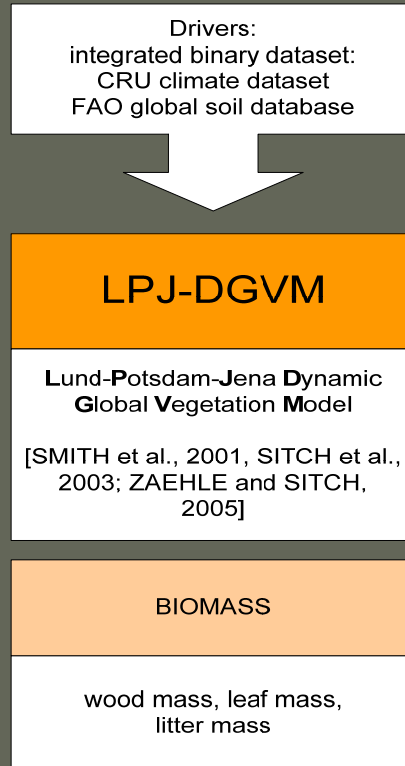
## Add. measuring sites for model testing and application on global scale



Werner et al., 2007, Global biogeochem Cycl; Werner et al., 2007 J Geophys Res; Werner et al., 2007 Plant and Soil



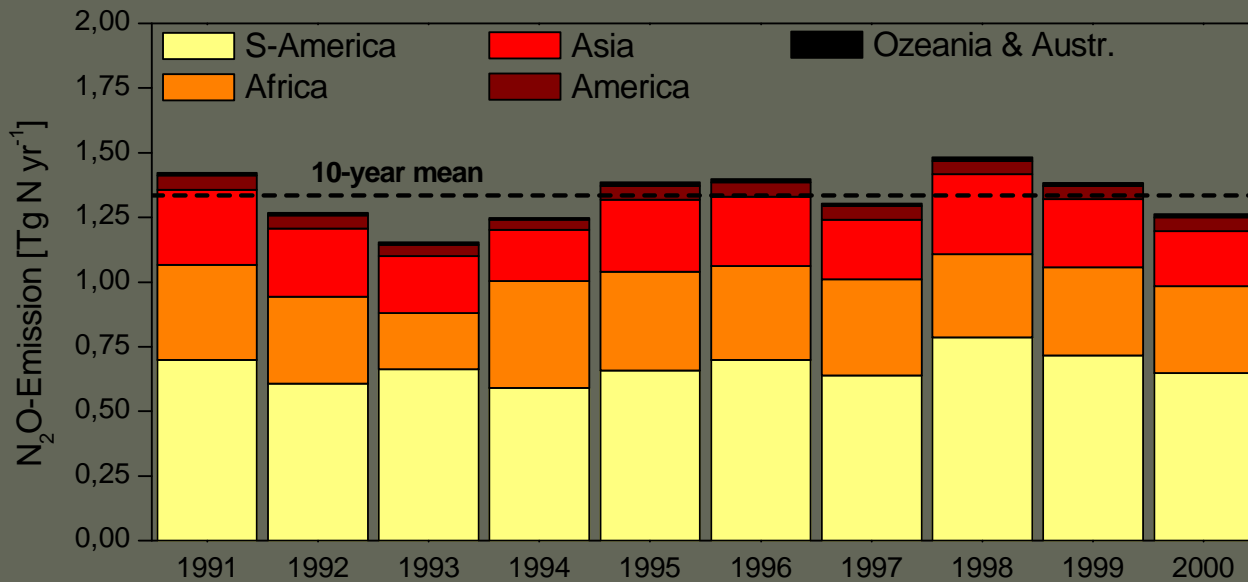
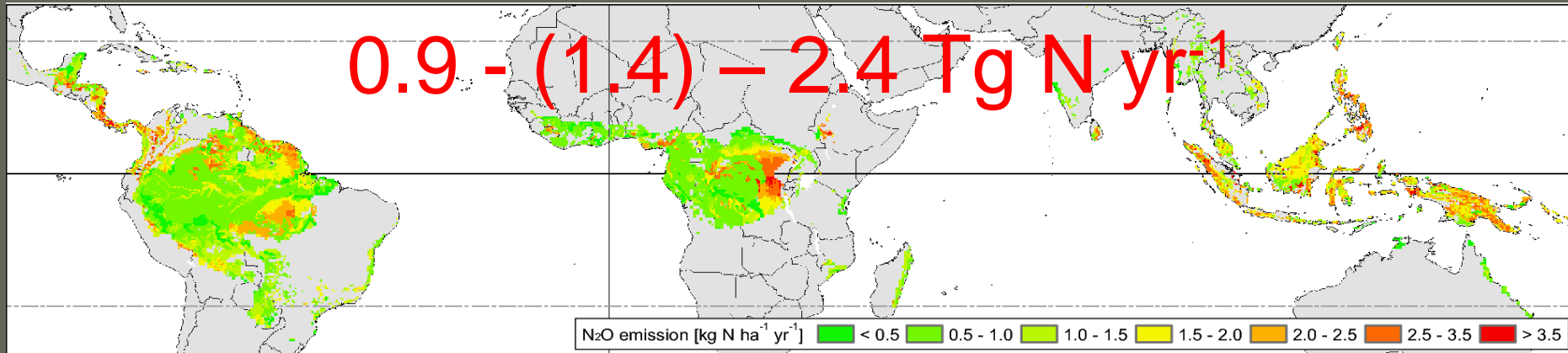
## Coupled model - GIS approach







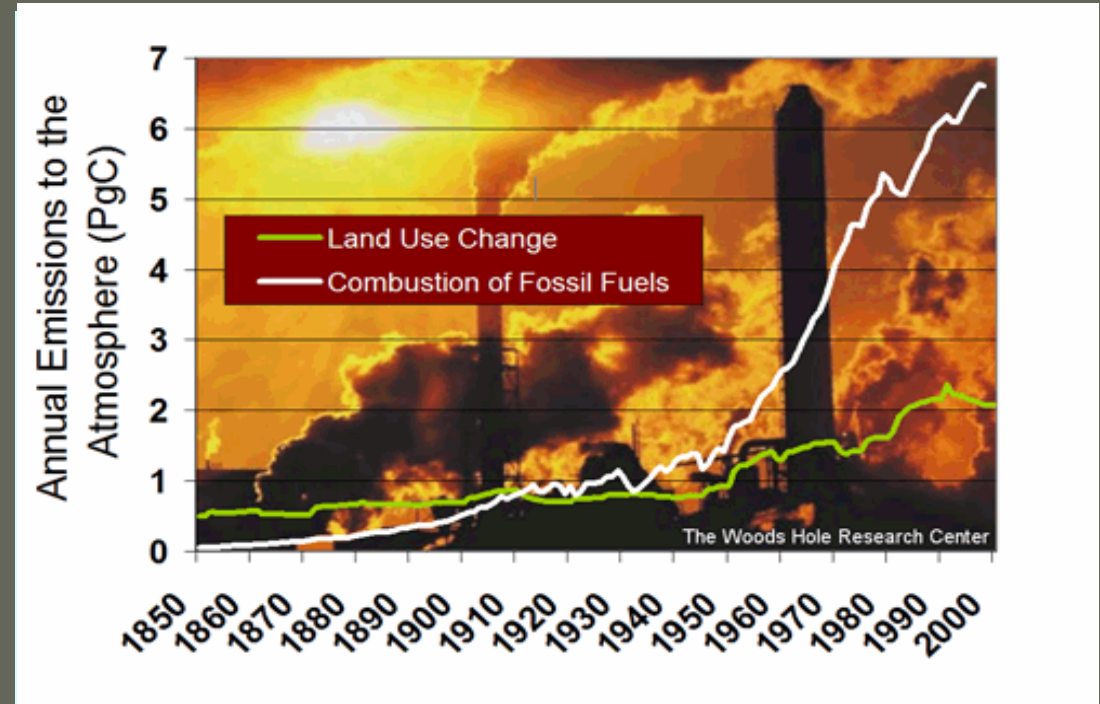
## Global N<sub>2</sub>O emission inventory (1991-2000)



Werner et al., 2007, Global biogeochem Cycl

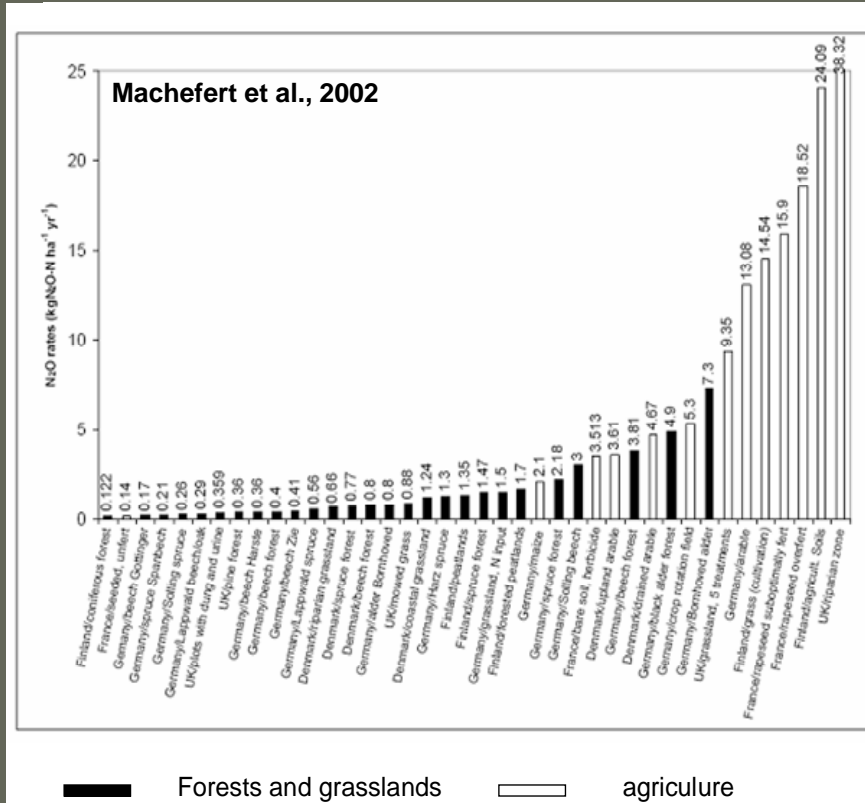


## Land use change and C and N trace gas emissions





## Land use change and C and N trace gas emissions

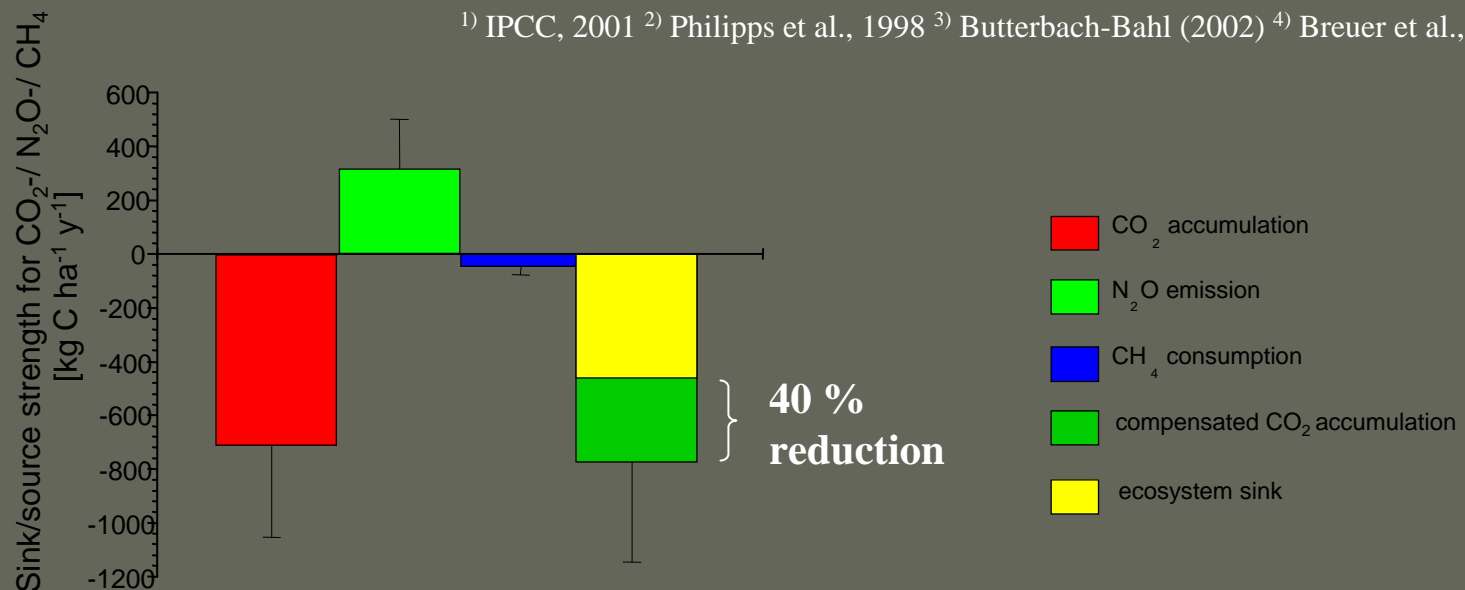




# Full ecosystem GHG balance e.g. tropical forest Australia

Greenhouse gas balance (CO <sub>2</sub> -/ CH <sub>4</sub> -/ N <sub>2</sub> O) of tropical rain forests		Global warming potential <sup>1)</sup>	Greenhouse gas balance of tropical rain forests expressed in CO <sub>2</sub> -C-equivalents	
CO <sub>2</sub> -accumulation	710 ± 340 <sup>2)</sup> kg CO <sub>2</sub> -C ha <sup>-1</sup> y <sup>-1</sup>		1	710 ± 340 kg CO <sub>2</sub> -C ha <sup>-1</sup> y <sup>-1</sup>
CH <sub>4</sub> -consumption	4 ± 1.8 <sup>3)</sup> kg CH <sub>4</sub> -C ha <sup>-1</sup> y <sup>-1</sup>	23 (17.2)	69 ± 31 kg CO <sub>2</sub> -C ha <sup>-1</sup> y <sup>-1</sup>	Source <b>+304.6</b>
N <sub>2</sub> O-emission	2.4 ± 1.4 <sup>4)</sup> kg N <sub>2</sub> O-N ha <sup>-1</sup> y <sup>-1</sup>	296 (126.9)	304.6 ± 177.7 kg CO <sub>2</sub> -C ha <sup>-1</sup> y <sup>-1</sup>	Ecosys. sink <b>-474.4</b>

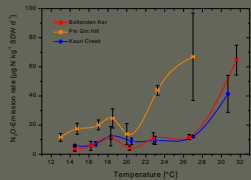
<sup>1)</sup> IPCC, 2001 <sup>2)</sup> Philipps et al., 1998 <sup>3)</sup> Butterbach-Bahl (2002) <sup>4)</sup> Breuer et al., 2000





## Climate and land use change at Mt. Kilimanjaro

### process scale



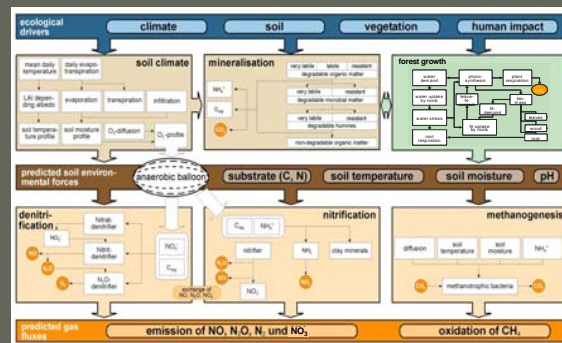
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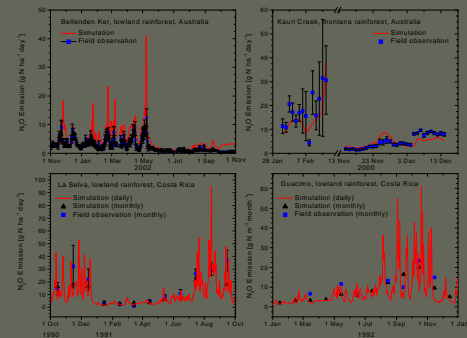
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parameterisation

### mechanistic model

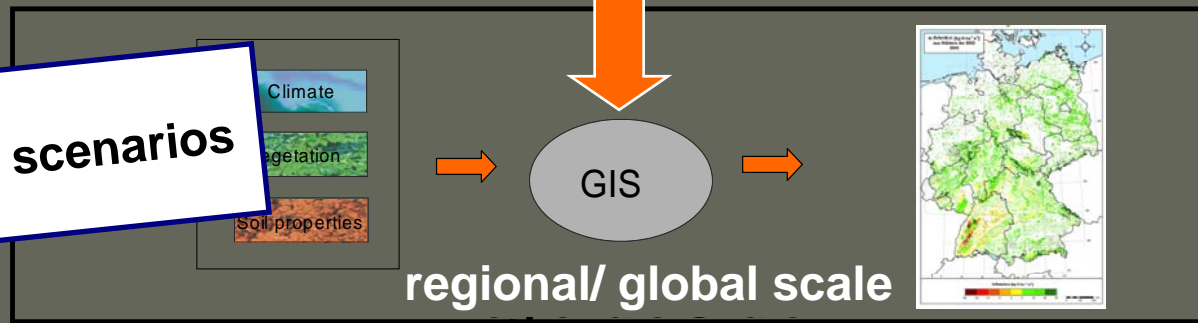


### plot scale



calibration/ testing

global change scenarios



regional/ global scale



**THANK YOU**

