



## Nitrogen Emission and Deposition Budget in Africa

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7th INI international conference, Melbourne 4-8 December 2016



## OUTLINE

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Objective: To give an overview of the N activities in Africa in atmospheric chemistry

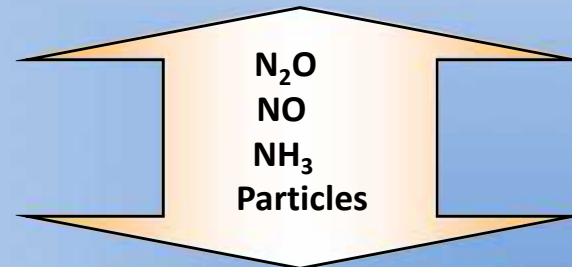
- Presentation of the INDAAF programme  
*Long term deposition monitoring network since the 2000's*
- A Global Assessment of Precipitation Chemistry and Deposition (2010-2014)  
*A project of the WMO's GAW SAG for TAD*  
*Focus on important N-related results of the Global Assessment: Africa*
- N Emission-Deposition budget in Africa: ecosystemic transect  
*INDAAF DEBITS long term programme*  
*N budget dry savanna-wet savanna-forest*  
*N budget in the sahelian ecosystem of Dahra in Senegal*

# Why Study Atmospheric Chemistry in the tropics ?

## Tropical atmospheric Chemistry includes:

- high UV flux, high T, high water vapour content promote intense photochemistry
- urbanization, industrialization, land use change, agriculture and biomass burning are increasing rapidly producing large emissions of gases and particles
- deep convection provides rapid vertical transport into the upper tropo and stratosphere and strong deposition

70% african savannas burned each year  
NOx soils main contribution to O<sub>3</sub> in West Africa  
NOx from soils affect also O<sub>3</sub> upper troposphere



Vegetation



Biomass Burning



Agriculture Pasture Soils





# Future challenges/ New approaches



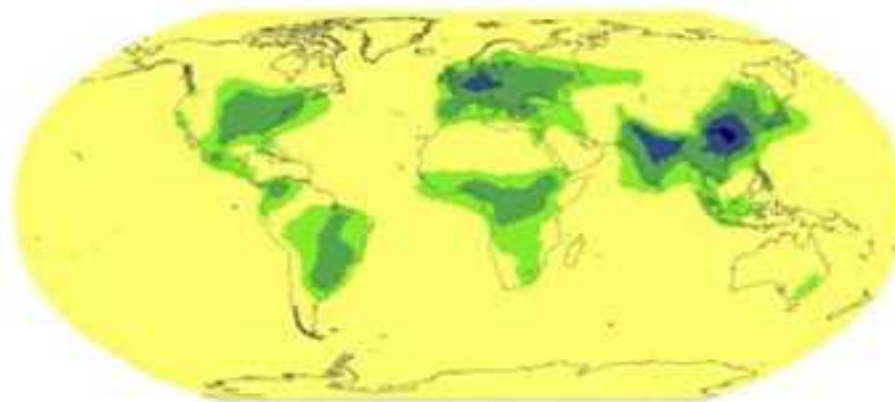
In the future, South Asia, Africa and South America will be key regions to study.

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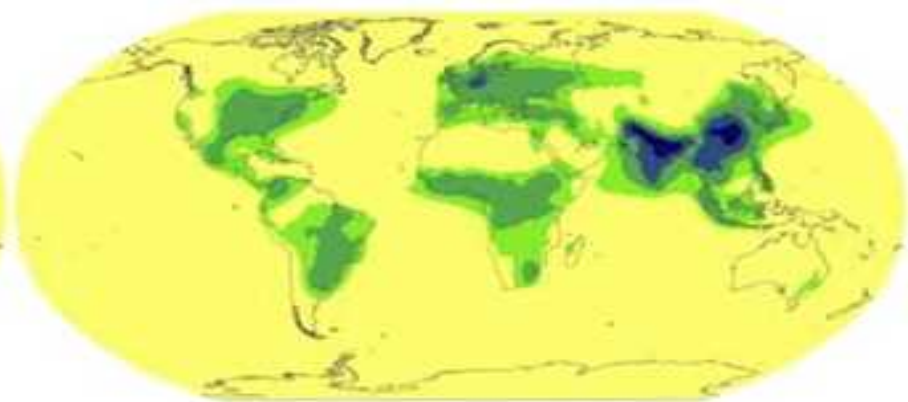
2000

A. Bleeker et al. / Environmental Pollution 159 (2011) 2280–2288

2030



Total nitrogen deposition (kg N/ha/yr)



Total nitrogen deposition (kg N/ha/yr)



Fig. 1. Spatial distribution of total nitrogen deposition (in kg N/ha/yr) for 2000 (left) and 2030 (right) (after Dentener et al., 2006).

Dentener et al. 2006



INDAAF  
IGAC/DEBITS/Africa

# THE INDAAF PROGRAMME

International Network to study Deposition and Atmospheric chemistry in Africa

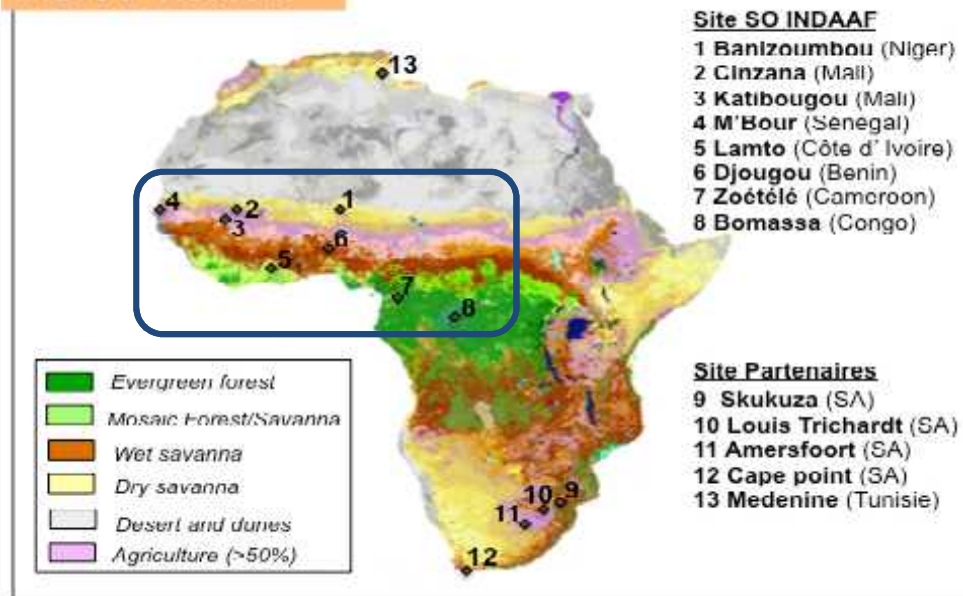
## The SNO

National programme Label INSU/CNRS and label IRD (2016-2020)

International programme WMO/GAW contributing network , IGAC-DEBITS

Web site and database <http://idaf.sedoo.fr>

### INDAAF Network



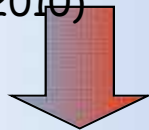
## Missions

- ✓ Long term monitoring of the chemical composition of the atmosphere and of deposition fluxes.
- ✓ Production of a unique dataset for the african continent using international standards of quality.

## Measurements and methodology



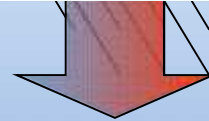
Dry deposition  $\text{NO}_2$  -  $\text{HNO}_3$  -  $\text{NH}_3$   
(Adon et al. 2010)



$\text{NH}_3$  Volatilization,  
(Schlecht et al., 1997,  
Mosier et al., 1998, FAO)

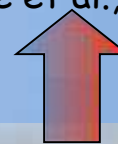


Biogenic  $\text{NO}$   
emission from soils  
(Delon et al., 2007)



Wet deposition  
 $\text{NH}_4^+$ ,  $\text{NO}_3^-$  (Laouali  
et al., 2012)

$\text{NO}_x$ ,  $\text{NH}_3$   
Biomass burning  
(Liousse et al., 2010)



$\text{NO}_x$ ,  $\text{NH}_3$  Domestic  
fires (Assamoi  
& Liousse, 2009)



## *A Global Assessment of Precipitation Chemistry and Deposition of Sulfur, Nitrogen, Sea Salt, Base Cations, Organic Acids, Acidity and pH, and Phosphorus*

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- World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) Scientific Advisory Group for Total Atmospheric Deposition (SAG-TAD)
- **Data period: 2000 – 2007**
- Measurement and modelling results

R. Vet, R. Artz, S. Carou, M. Shaw, C.-U. Ro, W. Aas, A. Baker, V. Bowersox, F. Dentener, C. Galy-Lacaux, A. Hou, J. Pienaar, R. Gillett, M. C. Forti, S. Gromov, H. Hara, T. Khodzher, N. Mahowald, S. Nickovic, P. Rao, N. Reid

**Source:** Vet et al. (2014). *Atmospheric Environment*, Volume 93, 1-116.  
<http://www.sciencedirect.com/science/journal/13522310/93/supp/C>

# Global Assessment of Precipitation Chemistry and Deposition Approach

## Integration of Data from the Major Wet Deposition Monitoring Networks

### **Temporal Period**

2000 to 2007

Two 3-year averaging periods:

**2000-2002** and **2005-2007**

### **Spatial Scales**

Global

Regional: *Africa, Asia, Oceania, Europe, North America, South America, Oceans*

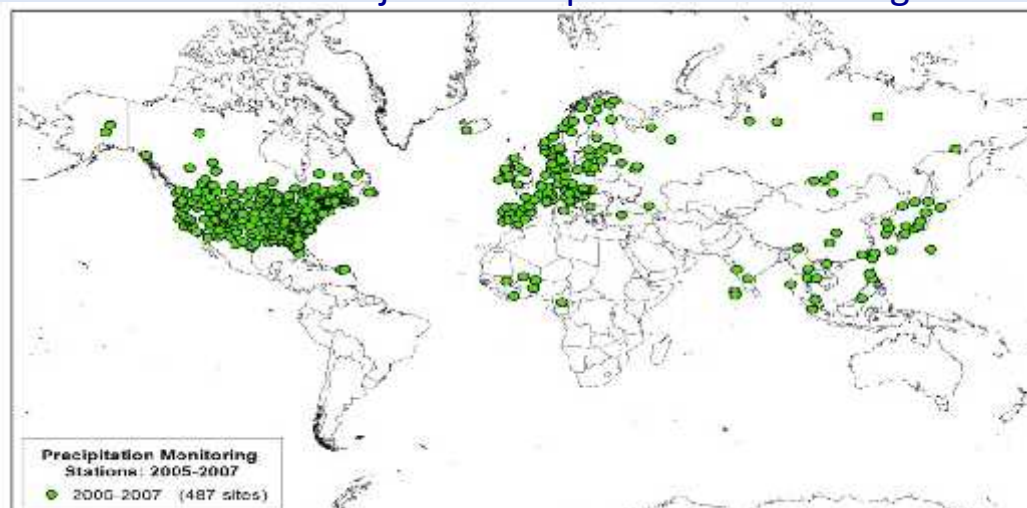
### **Method:**

**Combination of measurement and modelling results**

*Coordinated Model Studies Activities of the Task Force on Hemispheric Transport Of Air Pollution (TF HTAP): Ensemble mean 21 model results*

### **Data:**

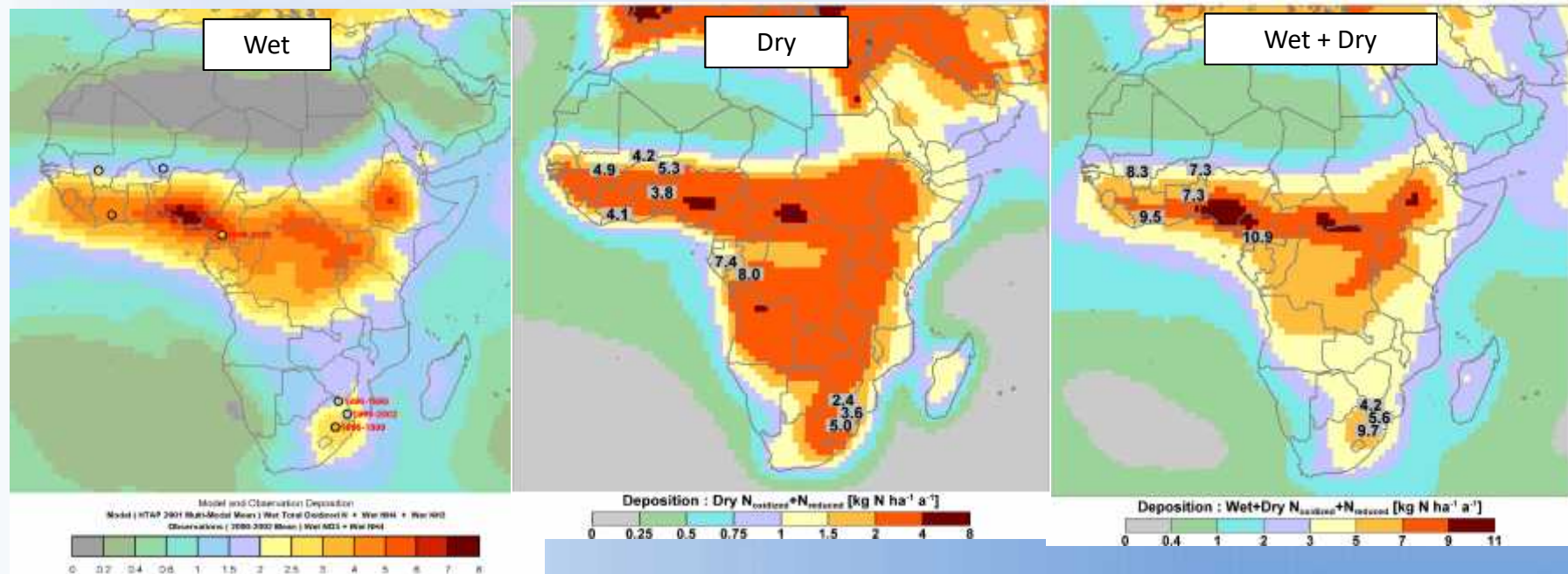
Regionally-representative non-urban sites (470 sites)



- **Africa and South America:** Deposition of Biogeochemically Trace Species
- **Canada :** Canadian Air and Precipitation Monitoring Network (CAPMoN)
- **East Asia :** East Asia Network (EANET)
- **Europe :** European Monitoring and Evaluation Program (EMEP)
- **Global :** World Meteorological Organization's Global Atmosphere Watch Programme (WMO/GAW)
- **United States :** National Atmospheric Deposition Program (NADP)
- **Other national networks :** India, Russia

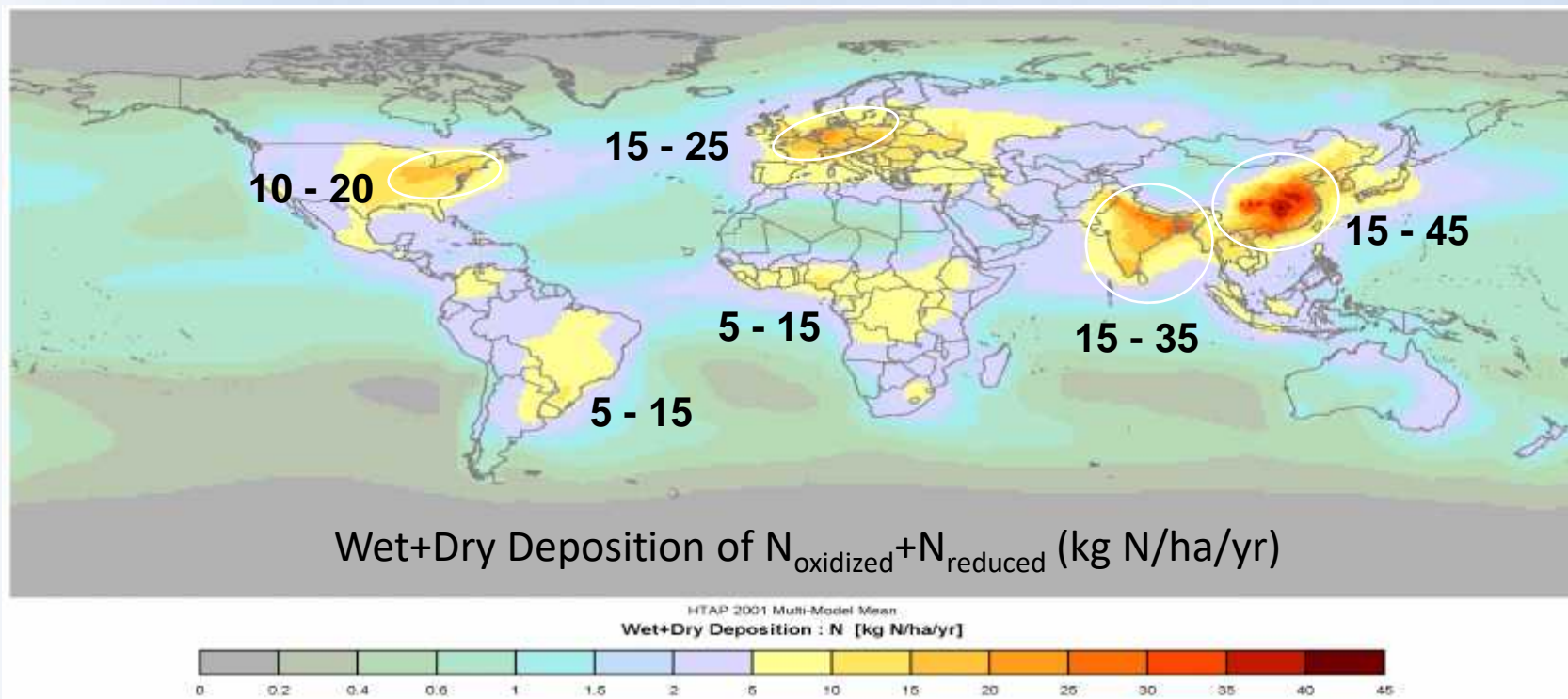


## Africa: Wet, Dry and Wet+Dry Deposition of N (NO<sub>2</sub> and NH<sub>3</sub> included in measured dry and total deposition)



- *N wet deposition 1.0 to 5.3 kg N/ha/a. Dry sav 1.7 to 3.4, wet savannas and forests: 3.6 to 5.3*  
- *N wet deposition in West Central Africa dominated by N in the form of NH<sub>4</sub><sup>+</sup>: 63 to 70%*
- *N Dry deposition dominates N wet deposition for all african ecosystems (2-8 kgN/ha/a)*
- *Total N deposition is ranged from 7-8 dry savanna-8-9 wet savanna- 11kgN/ha/a forest*

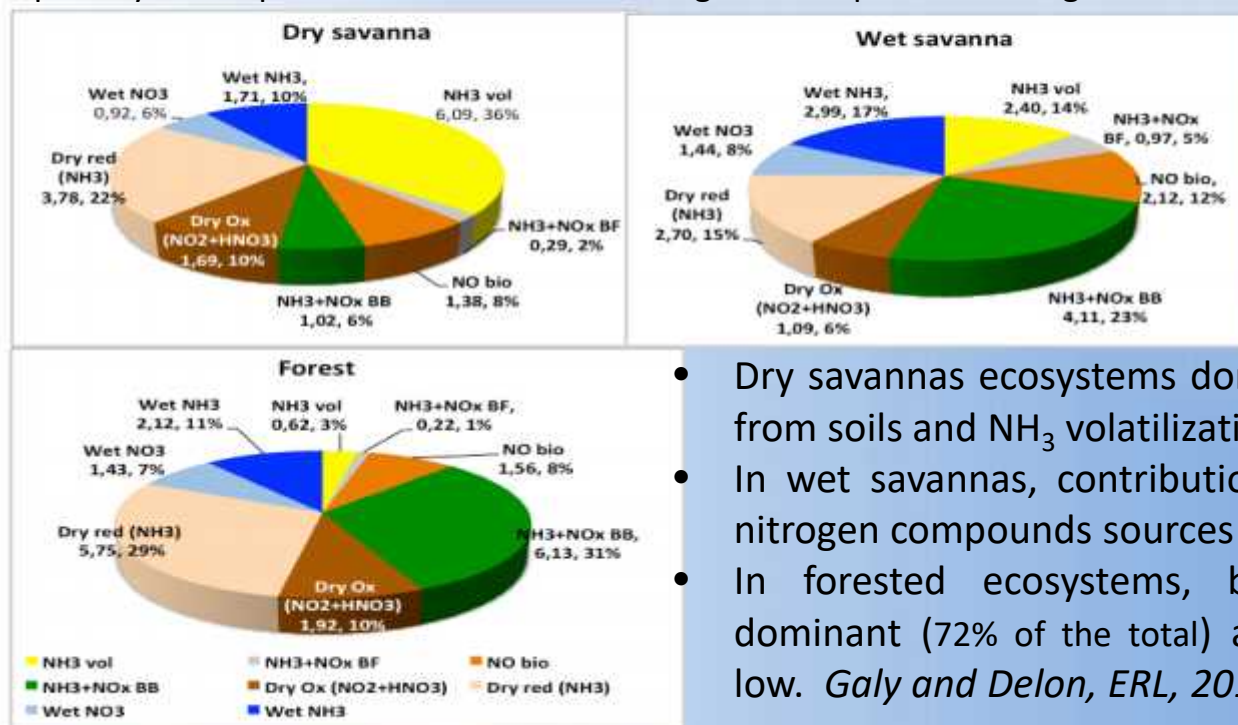
# Comparison of deposition studies and modelling



**HTAP simulation Hemispheric Transport Air Pollution**

N emission and deposition budget for the major ecosystems in West and Central Africa.

The approach combines both unique experimental data based on the program (associated projects) and modeling studies, especially developed for SSA to estimate nitrogen atmospheric exchanges.



Wet: wet deposition

Dry: dry deposition

bio: biogenic emissions

BB: biomass burning emissions

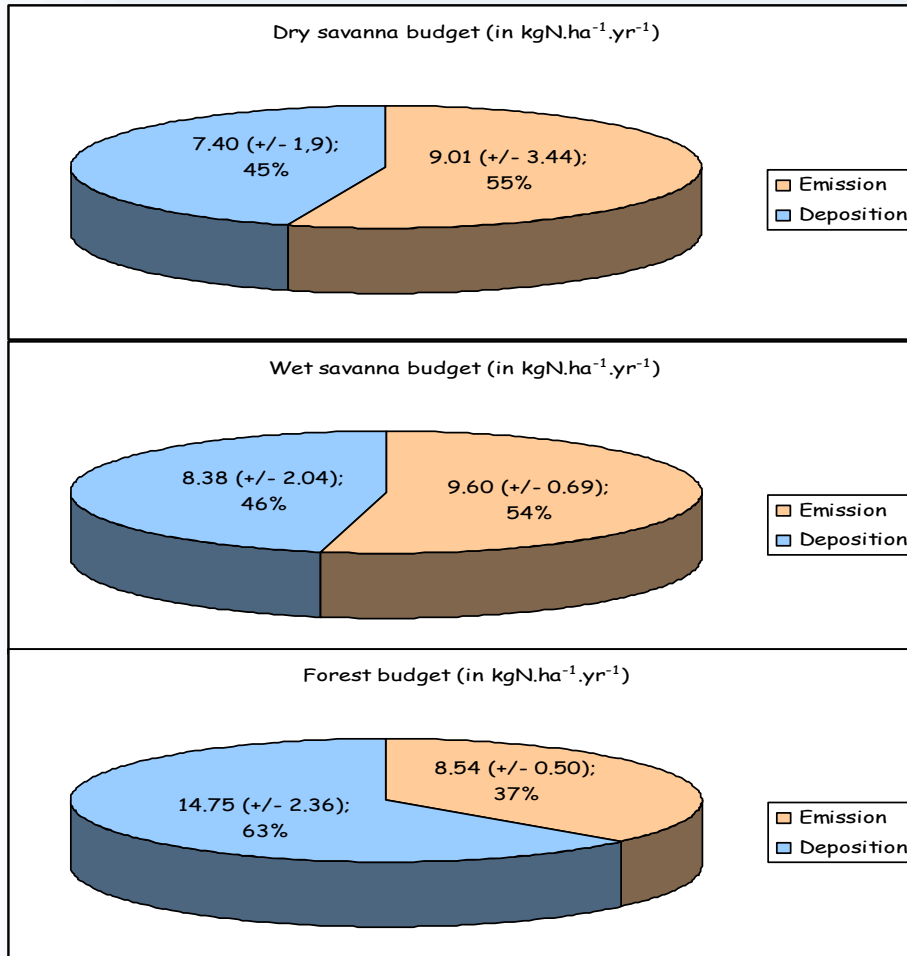
BF: biofuel emissions,

vol: volatilization.

- Dry savannas ecosystems dominated by natural emissions of NO<sub>x</sub> from soils and NH<sub>3</sub> volatilization from animal excreta.
- In wet savannas, contributions of natural and biomass burning nitrogen compounds sources are equivalent.
- In forested ecosystems, biomass burning sources become dominant (72% of the total) and NH<sub>3</sub> from volatilization remains low. *Galy and Delon, ERL, 2014*

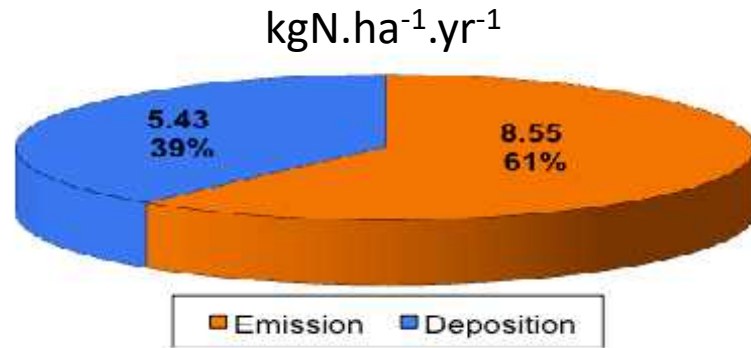
Biomass burning emissions of NH<sub>3</sub> and NO<sub>x</sub> increase along the transect dry savanna/wet savanna/forest.

## N Deposition – Emission budget



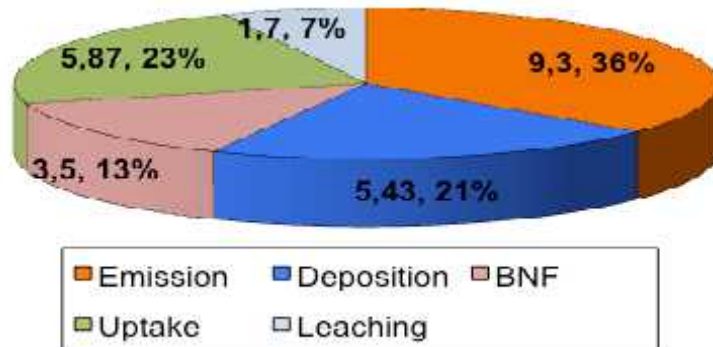
- Emission sources of nitrogen compounds in equilibrium with deposition fluxes in dry and wet savannas
- In forested ecosystems, the nitrogen budget is dominated by wet + dry deposition processes, influenced by biomass burning emissions coming from the two hemispheres and transported over the Central African forest.
- This work brings a new insight in deposition and emission regional budgets in remote areas in Africa.
- Atmospheric N deposition fluxes represent a significant nutrients input (from 8 to 14 kg.ha<sup>-1</sup>.yr<sup>-1</sup>).
- Uncertainties: importance of organic compounds in wet deposition

# Sahelian emission-deposition budget: Dahra site (Senegal)



N Deposition = wet+dry  
 N Emission = Biogenic NO  
 NH<sub>3</sub> volatilization  
 Domestic fires  
 Biomass burning

## A first estimate of critical load using a stationary model



N input: Deposition + BNF= 8.9  
 N output: 16,9  
 Budget: - 8 kgN.ha<sup>-1</sup>.yr<sup>-1</sup>

Calculation of N critical load  
 Using critical N Conc for temperate grassland  
 Critical load Dahra estimated to 20 kgN.ha<sup>-1</sup>.yr<sup>-1</sup>

**No excess of N in this sahelian savanna**

## Conclusion – Key messages and Perspectives



**INDAAF** International **N**etwork to study **D**eposition and **A**tmospheric chemistry in **AF**rica  
Web site and database <http://idaf.sedoo.fr>  
15 years of data



**EADN** : a GEF UNEP project «Equatorial Africa Deposition Network » 12 sites around lake victoria



### WMO GAW

A global Assesment of precipitation and deposition Vet et al, 2014. Overview paper 100pages, vol 93, Atmospheric Environment Data: <http://ebas.nilu.no> , <http://wdcpc.org/>

MMF TAD concept: an upcoming workshop (February 2017, Geneva)  
fusion data – models outputs for deposition maps products



**INMS** Global Project for improving understanding of the global nitrogen towards the establishment of an international managment system.

**Five demonstrations areas in the project Towards INMS: East Africa: lake victoria**

**THANKS FOR YOUR ATTENTION**

