Calculation of LCA characterization factors for terrestrial eutrophication at regional scale

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OUTLINE OF THE PRESENTATION

1) Introduction

2) Terrestrial Eutrophication

3) Development of regional characterization factors

4) Conclusions

Introduction

Quality of the data

- Absence of reliable or relevant data or in the adequate unit

Diversity of methodologies

- Different types of impact categories
- Different types of models, specially for toxicity
- Lack of trackability

Scarce uncertainty analysis

- Uncertainty in the parameters, scenarios and models

Need of higher development of the characterization factors

- Spatial, temporal and causality chain definition

Spatial definition

Site-independent impact categories

- Produced by contaminants [illegible] allo[illegible]o distribute globally and therefore, their effect is independent of the [illegible] example: [illegible] o [illegible]

Characterization factors

Global

Regional

Site-dependent impact categories

- Produced by emissions of substances [illegible] sh[illegible] which are transported hundreds or thosusands of kil[illegible] example: Terrestrial eutrophication or acidification

Local

Terrestrial Eutrophication

TERRESTRIAL EUTROPHICATION

Effects

Deposition of aerial nitrogen compounds (NO_x and NH_x)

Growth and competitiveness of vegetation in natural ecosystems controlled by the limited availability of N

Decrease in biodiversity due to competitive substitution

Sensitivity of vegetation to disease, drought, frost and herbivores increases

Terrestrial Eutrophication in Galicia

Terrestrial eutrophication is a main threat in Galicia (Cuesta *et al.*, 2008; Rodríguez y Macías 2006):

- Deposition >15 kg N/ha in 69% of the Galician forest
- Critical loads exceeded in 40% of forests
- Atlantic heathlands (protected natural areas) and macrofauna associated are very vulnerable

Terrestrial eutrophication in LCA

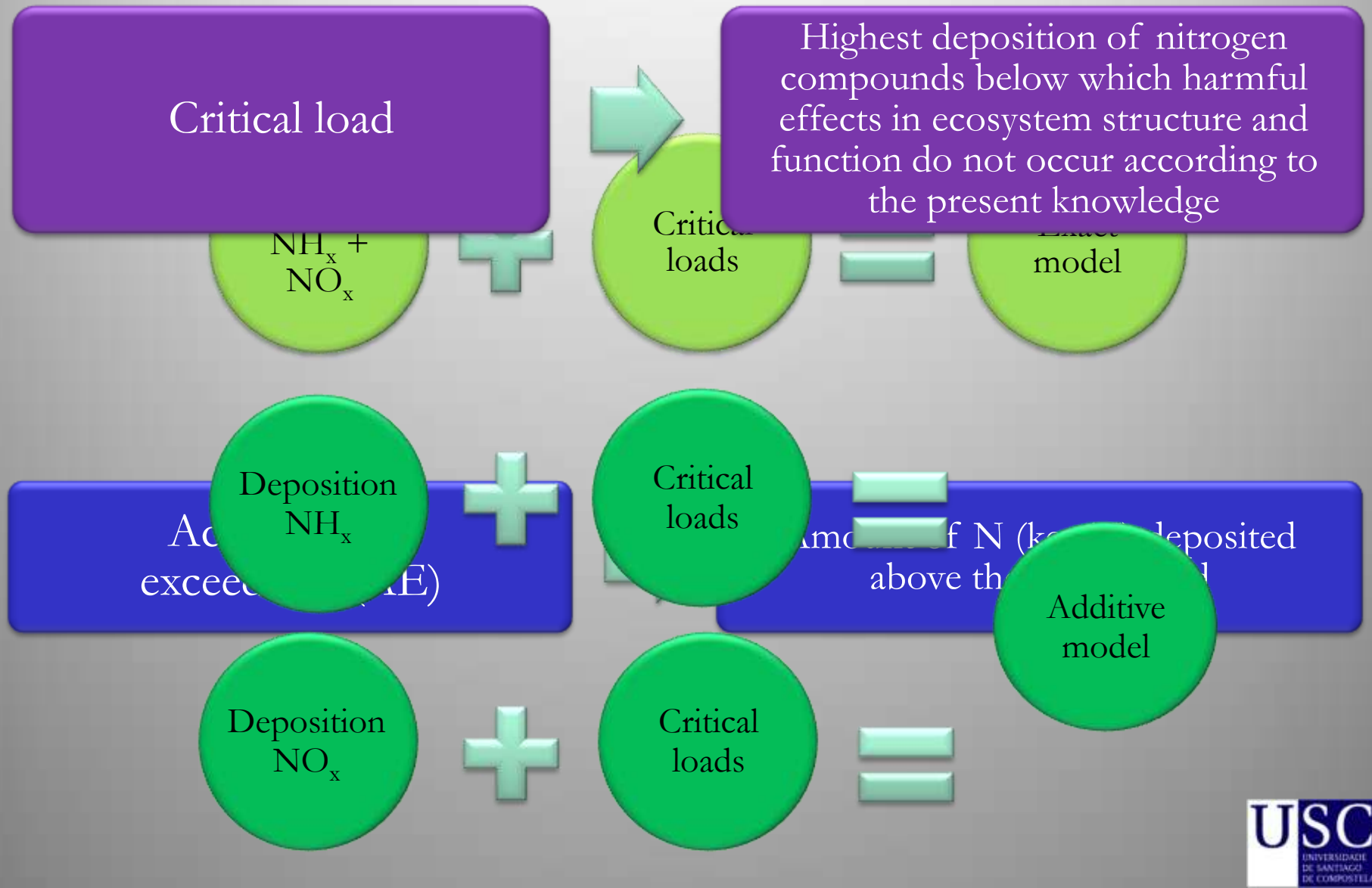
EMEP, RAINS, EcoSense models relate emissions and critical loads

Spatial differenciation: Country in Europe

Characterization factors at lower scale

Regional factors for terrestrial eutrophication

American Center for Life Cycle Assessment IX Conference 'toward the global life cycle economy"
Boston, 28th September -2ndOctober 2009


Critical load
Highest deposition of nitrogen compounds below which harmful effects in ecosystem structure and function do not occur according to the present knowledge
NH_x + NO_x
Critical loads
model
Deposition NH_x
Critical loads
Additive model
Deposition NO_x
Critical loads

Methodology from Seppälä *et al.* (2006)

Calculation of regional characterization factors (CAE) for contaminants B (NO_x or NH_x):

$$CAE_B = \frac{\Delta AE^{X\_B}}{\Delta E_{X\_B}} = \frac{AE - AE^{X\_B}}{E_B - E_{X\_B}}$$

AE= Total accumulated exceedance per year (keq/yr)

AE^{X_B}= Total accumulated exceedance after a certain X amount of annual variation of the emissions of pollutant B (keq/año)

E_B= Annual emissions of pollutant B (t/yr)

E_{X_B}= Emissions of B after the variation X (t/yr)

Characterization error

$$Err_{ab} = AE - AE^{X\_NO_x, X\_NH_x} - CAE_{NO_x} \cdot \Delta E_{NO_x} - CAE_{NH_x} \cdot \Delta E_{NH_x}$$

AE = Total accumulated exceedance per year [keq/yr]

$AE^{X\_NOx,\ X\_NHx}$ = Total accumulated exceedance in the region of interest after X emission variation of NO_x and NH_x (keq/yr)

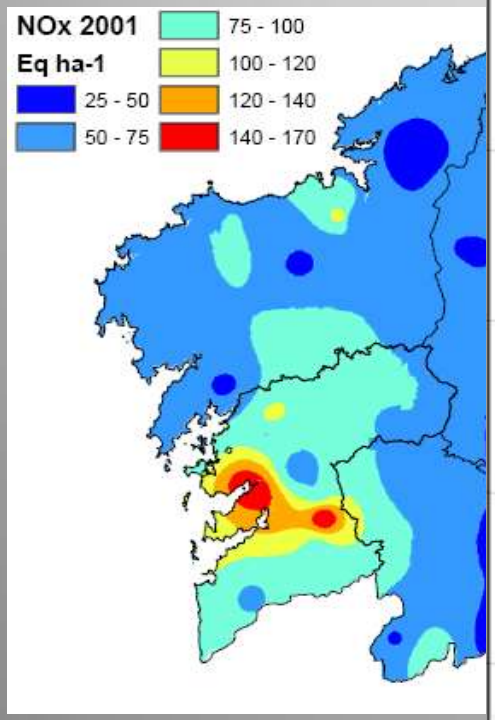
$CEA_{NOx,NHx}$ = Characterization factors for NO_x y NH_x (keq/t/yr)

Results of the exact model

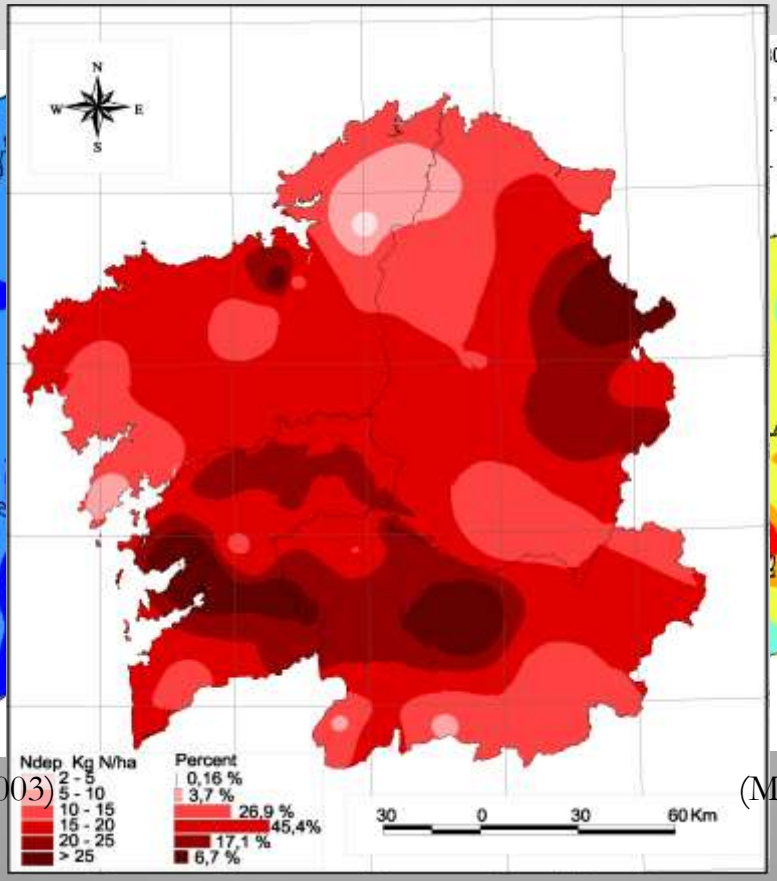
Results of the additive model

$\Delta E_{NOx,NHx}$ = Variation X of emissions (t)

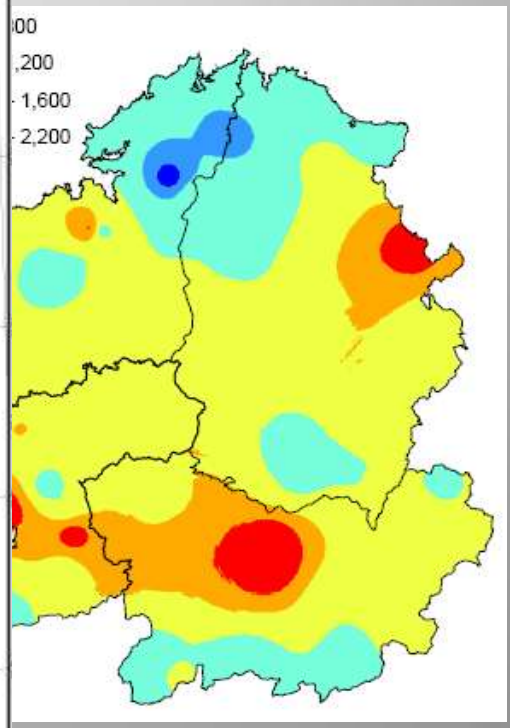
Deposition of nitrogen compounds



(Macías et al., 2003)



(Rodríguez and Macías, 2006)



(Macías et al., 2003)

Calculation of critical loads (Posch et al. 1995)

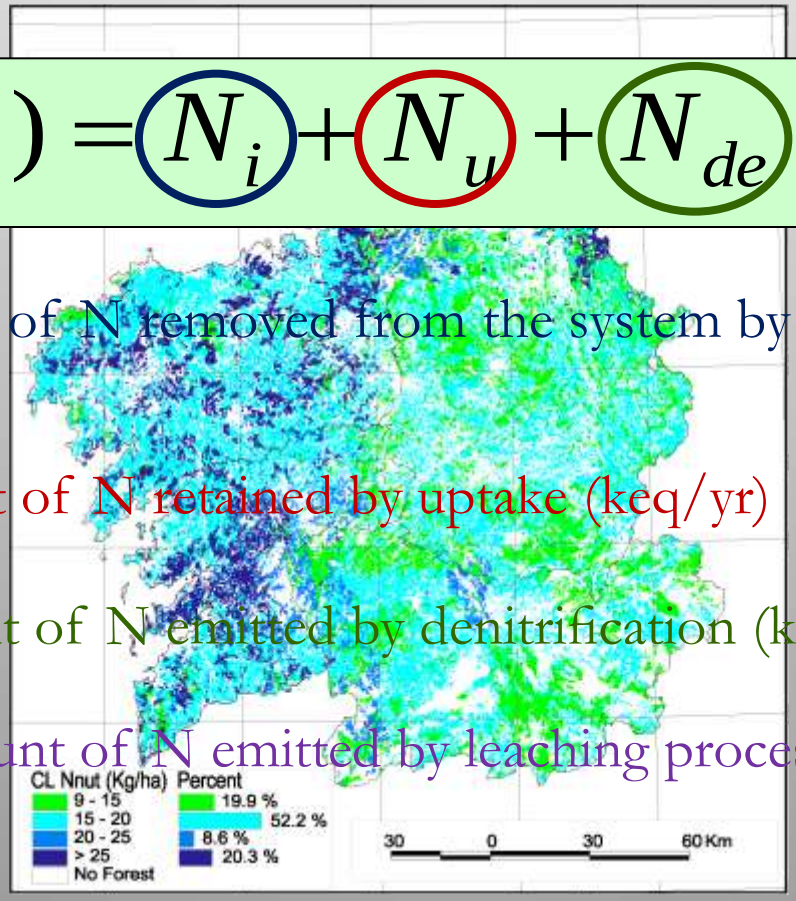
$$CL(N_{nut}) = N_i + N_u + N_{de} + N_{le(crit)}$$

N_i = Amount of N removed from the system by immobilization (keq/yr)

N_u = Amount of N retained by uptake (keq/yr)

N_{de} = Amount of N emitted by denitrification (keq/yr)

$N_{le(crit)}$ = Amount of N emitted by leaching processes (keq/yr)



(Rodríguez and Macías, 2006)

REGIONAL FACTORS FOR TERRESTRIAL EUTROPHICATION

Calculation of characterization factors

NH_x (as NH_3)		NO_x (as NO_2)		Characterization error (%)
ΔE_{X_NHx} (t)	CAE_{NHx} (keq/t)	ΔE_{X_NOx} (t)	CAE_{NOx} (keq/t)	
1	1,96	1	0,074	-0,05
100	1,96	100	0,074	-0,09
175	1,95	318	0,074	-0,10
351	1,94	636	0,074	-0,17
351	1,93	954	0,074	-0,25
701	1,92	1.273	0,074	-0,33
1402	1,87	2.545	0,074	-0,69
2.103	1,82	3.818	0,073	-1,05
2.804	1,78	5.090	0,073	-1,38
3.505	1,74	6.363	0,073	-1,75
4.206	1,69	7.636	0,073	-2,14
4.907	1,65	8.908	0,073	-2,54
5.608	1,61	10.181	0,073	-2,88
6.309	1,57	11.453	0,072	-3,23
7.010	1,53	12.726	0,072	-3,57
14.020	1,17	25.452	0,071	-7,63
21.031	0,91	38.178	0,069	-11,92
28.041	0,72	50.904	0,068	-17,13
35.051	0,57	63.630	0,066	-21,00

Comparison of characterization factors			
	Seppäla et al. (2006) (Spain)		Gallego (2008) (Galicia)
	Characterization NO_x (keq/t)	**Characterization NH_x (keq/t)**	**Characterization error (%)**
Galicia	**0,074**	**1,96**	**-0,09**
España	**0,877**	**3,43**	**-0,01**
Area of interest	Europe		Galicia
Year	2002		2001

Conclusions

The Galician characterization values obtained are different than those obtained for a higher scale (Spain), but a more detailed comparison of both studies is required in order to calculate the exact value of the uncertainties associated with each characterization factor.

Accumulated exceedance is a good category indicator because it allows to obtain stable characterization factors and appropriate characterization errors **with low variations in emissions** (<100 t) which is typical for LCA applications.

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