Deposition of nitrogen in Mediterranean forests of *Quercus ilex*: Significance of dry deposition

Héctor García Gómez *, Sheila Izquieta-Rojano,
Laura Aguillaume, Ignacio González-Fernández,
Fernando Valiño, Jesús M. Santamaría, David Elustondo,
Anna Àvila, Isaura Rábago,
Rocío Alonso, Victoria Bermejo-Bermejo

* hector.garcia@ciemat.es

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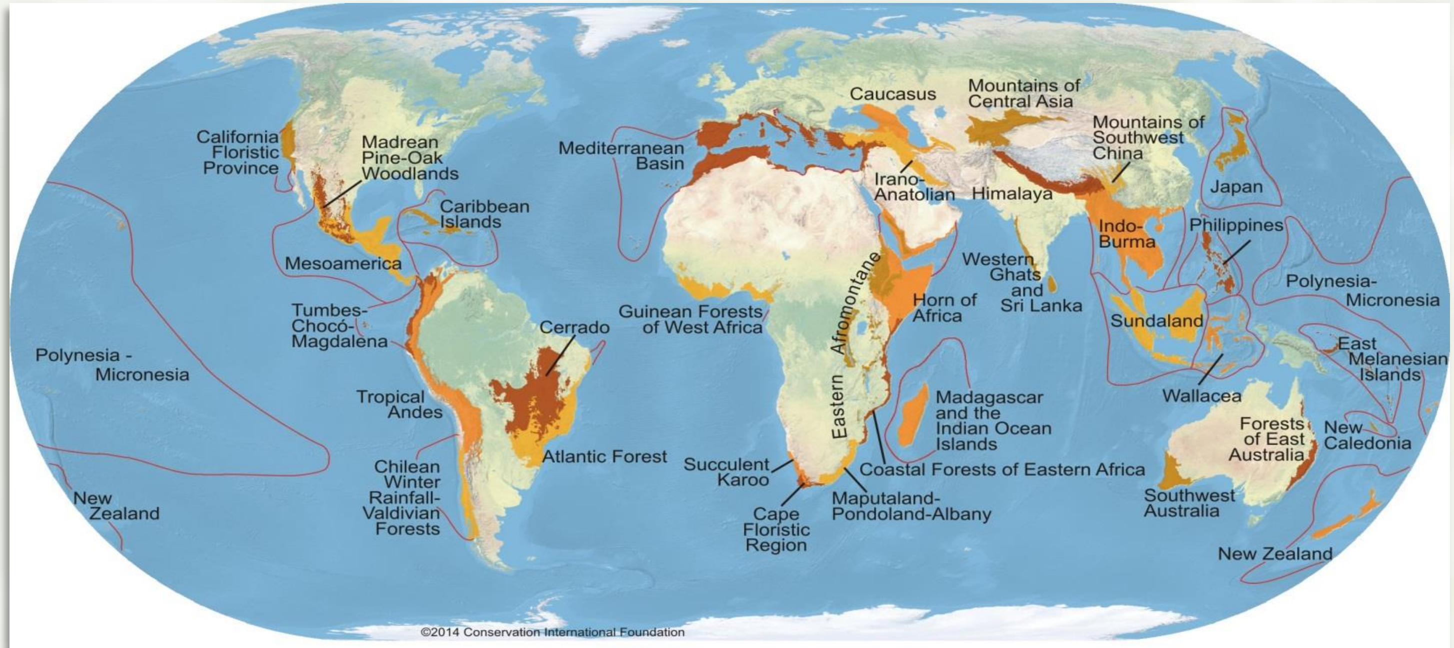
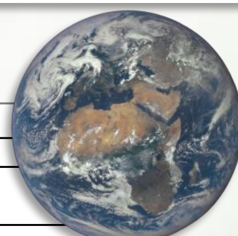
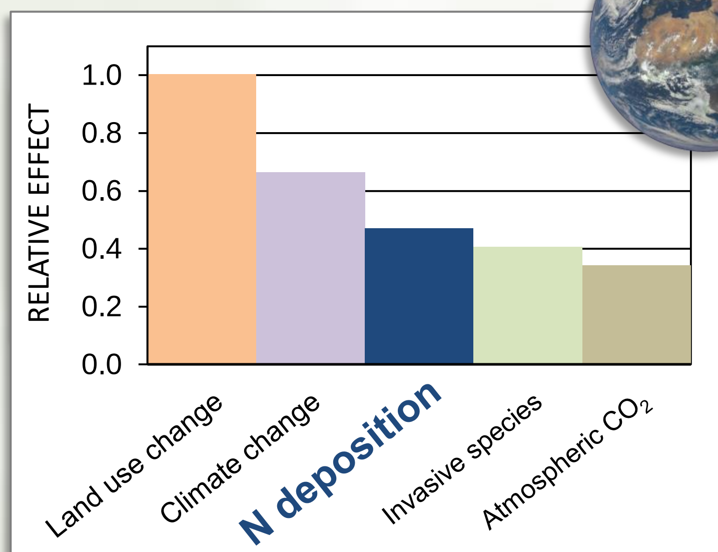


Global biodiversity hotspots

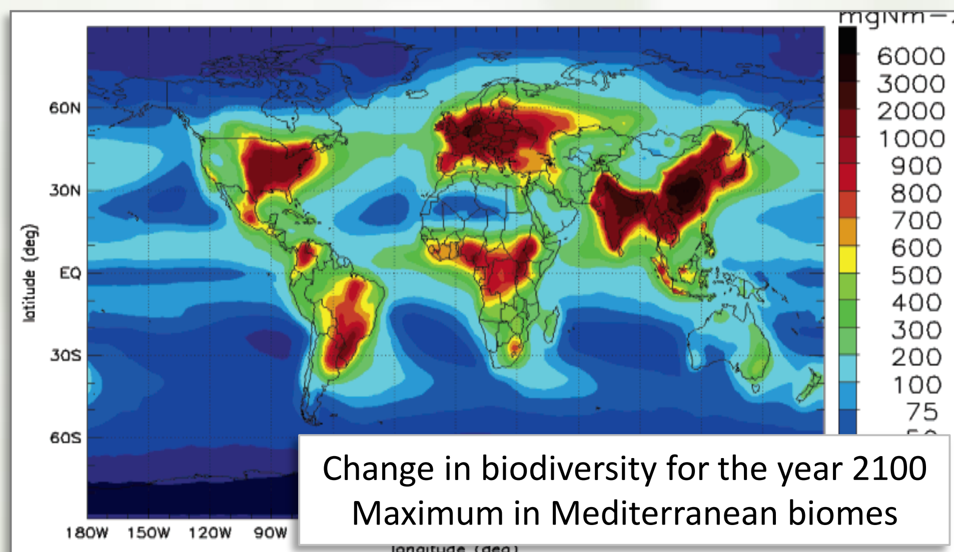
Myers et al. 2000, *Nature*

Artwork: http://atlas-for-the-end-of-the-world.com





Sala et al., 2000, *Science*



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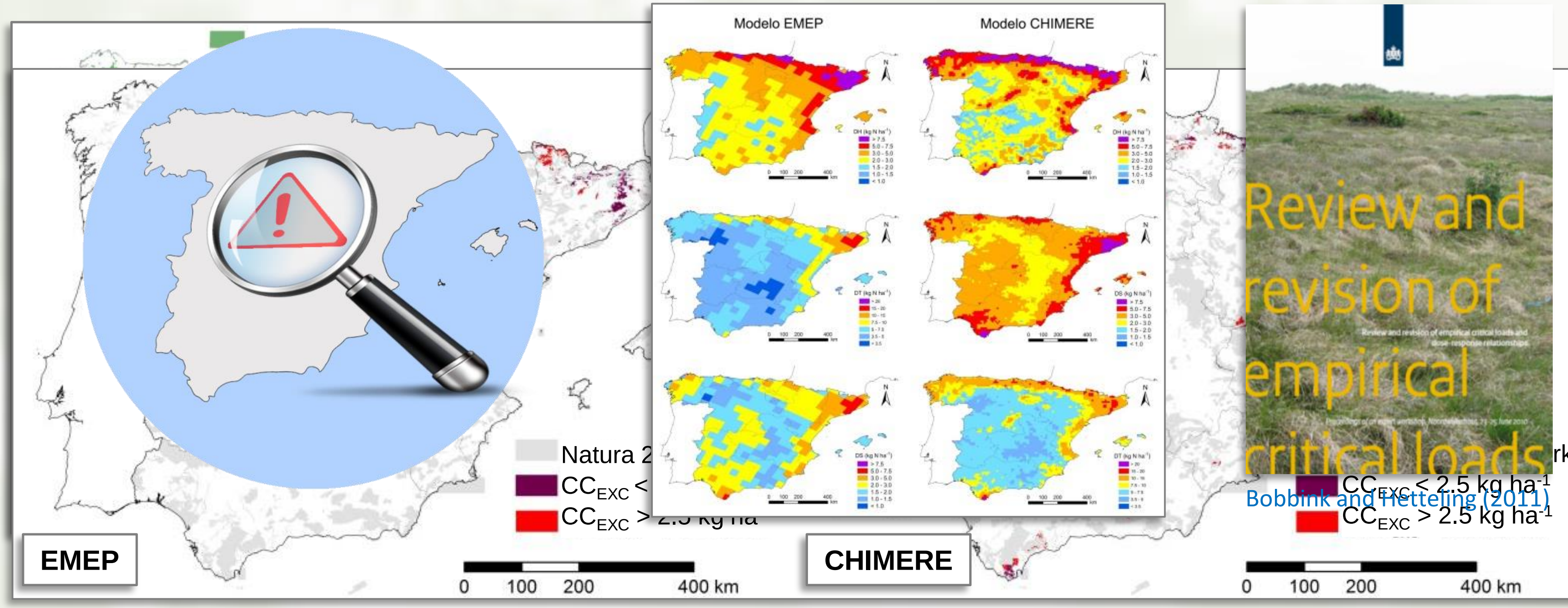


Bobbink and Hettelingh (2011)

García-Gómez et al., 2014 (with data for 2008)

RESULTS FOR FOREST HABITATS

Threatened forest habitats (according to CHIMERE model)

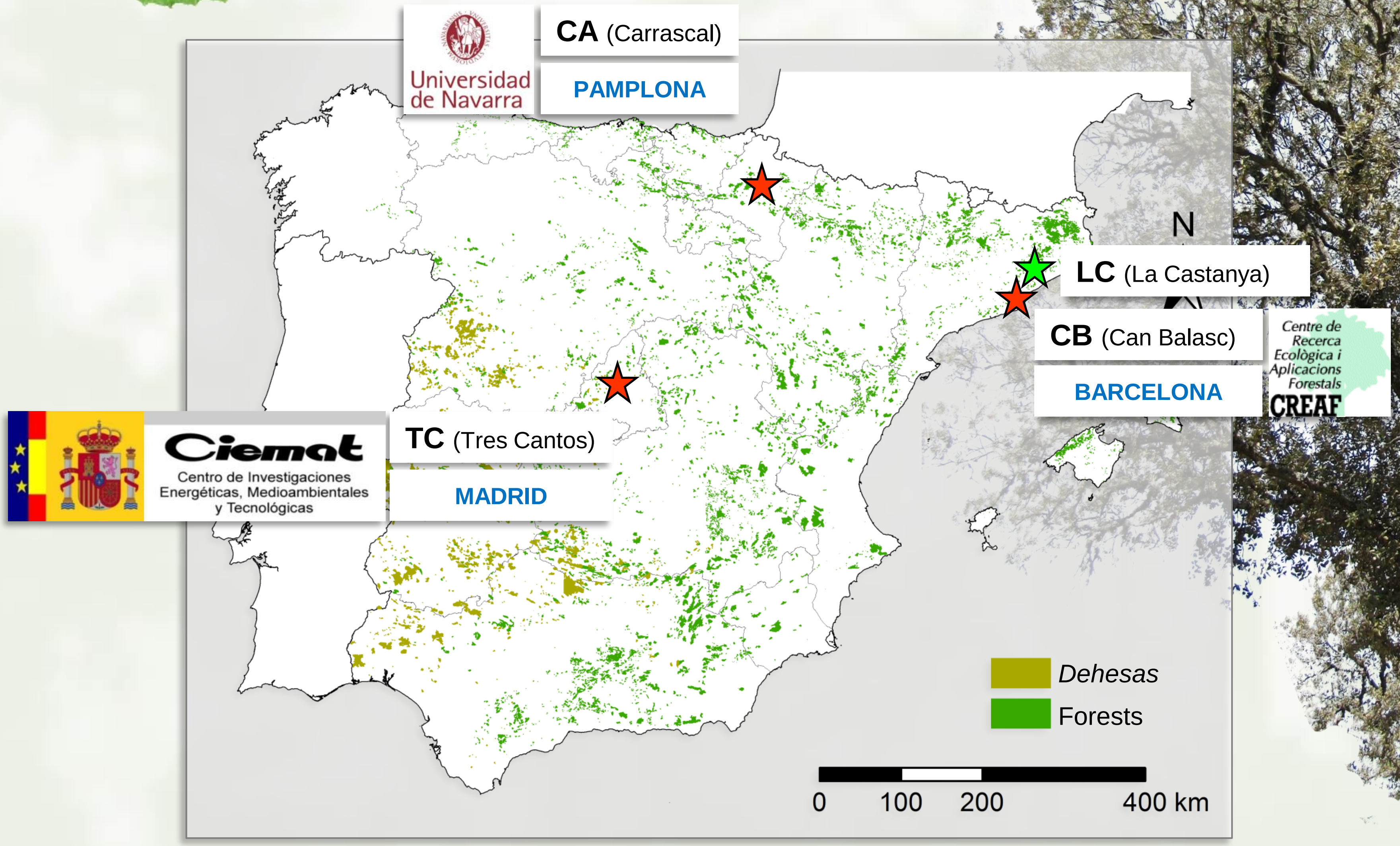
- Subalpine and montane *Pinus uncinata* forests (86%)
- Mediterranean pine forests with endemic Mesogean pines (71%) *(Pinus halepensis, P. pinaster, P. pinea)*
- Luzulo-Fagetum beech forests (71%)
- *Abies pinsapo* forests (57%)

UNDERESTIMATION OF DRY DEPOSITION IN MEDIT. FORESTS

RELIABLE DRY DEPOSITION DATA AR[illegible]D FOR IMPROVING RISK ASSESSMENT

RESULTS FROM EDEN PROJECT

DRY DEPOSITION



EMPIRICAL INFERENTIAL METHOD

Branch washing

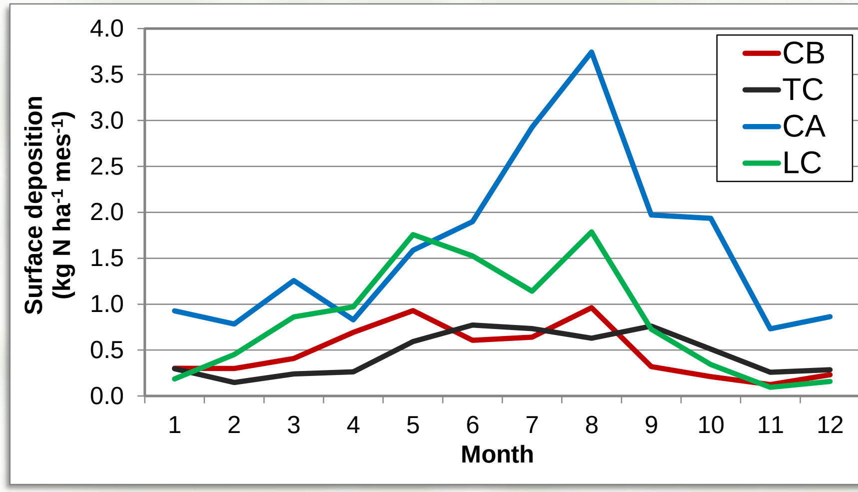
Passive sampling

SURFACE CONDUCTANCE

$$K_N = {F_N}/{C_N}$$

SURFACE DEPOSITION

$$DD_{surface} = K_N \times C_N \times LAI$$



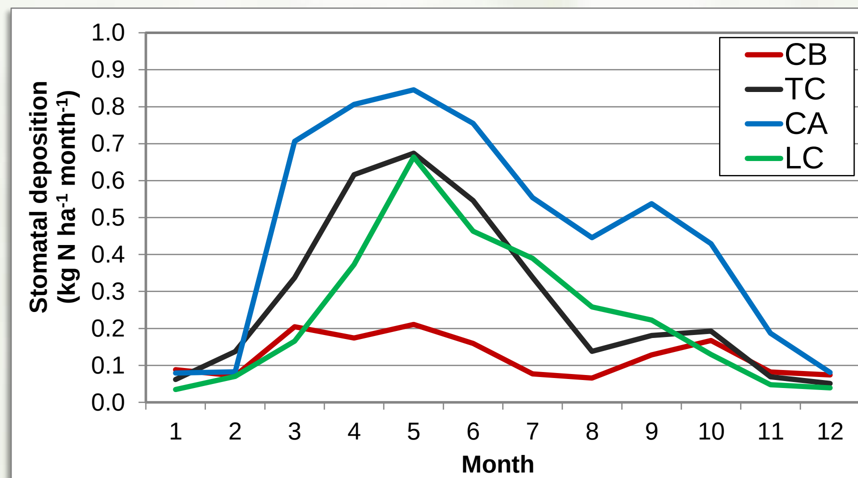
STOMATAL UPTAKE MODELLING

Model DO_3SE (*Deposition of Ozone and Stomatal Exchange*)

Jarvis, 1976 - Emberson et al., 2000 - Alonso et al., 2007, 2008

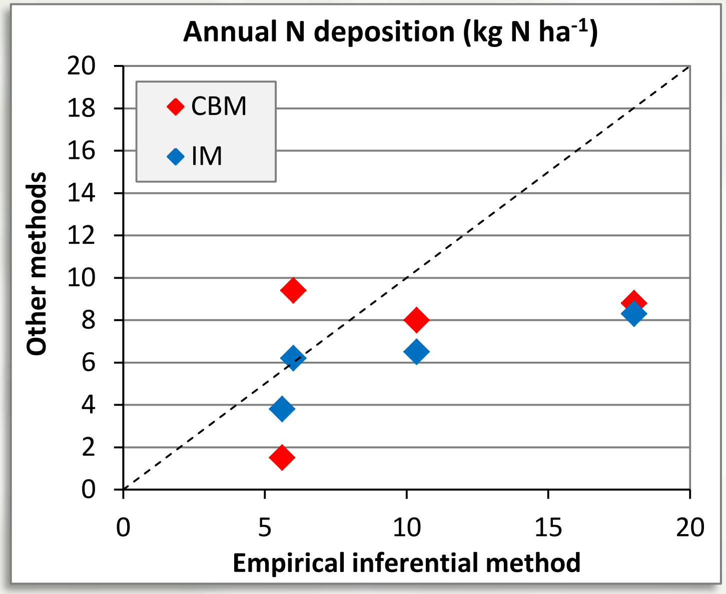
$$g_s = g_{max} \times f_{light} \times \max \{ f_{min}, (f_{temp} \times f_{VPD} \times f_{SWP} \times f_{phen}) \}$$

$$DD_{stomatal} = C_N \times g_s \times LAI$$

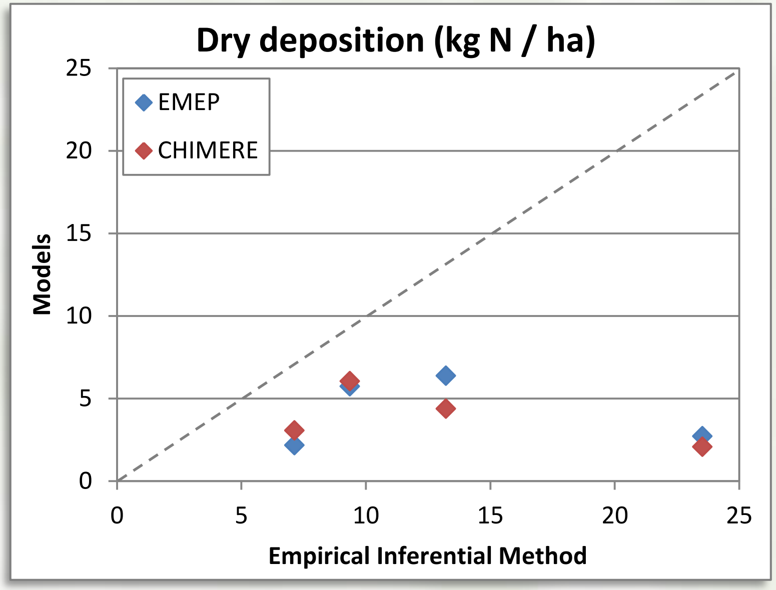


EMPIRICAL INFERENTIAL METHOD

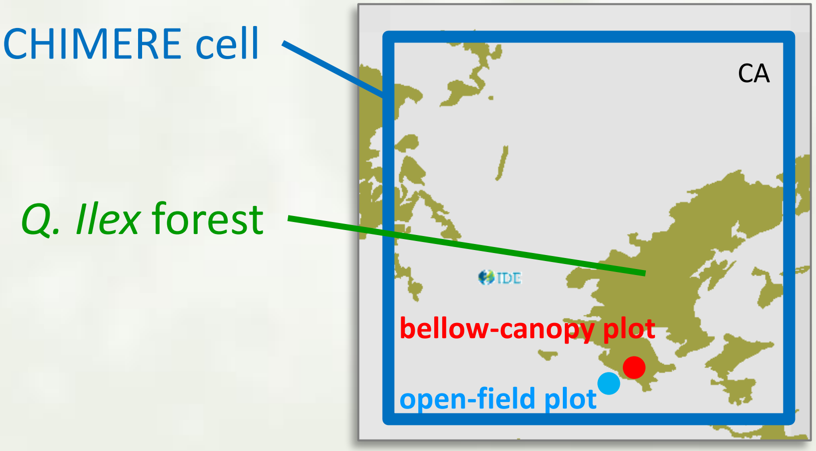
Comparison with other methods



Comparison with models



Models' output are commonly cell- (and habitat-) averaged values



EMPIRICAL INFERENTIAL METHOD

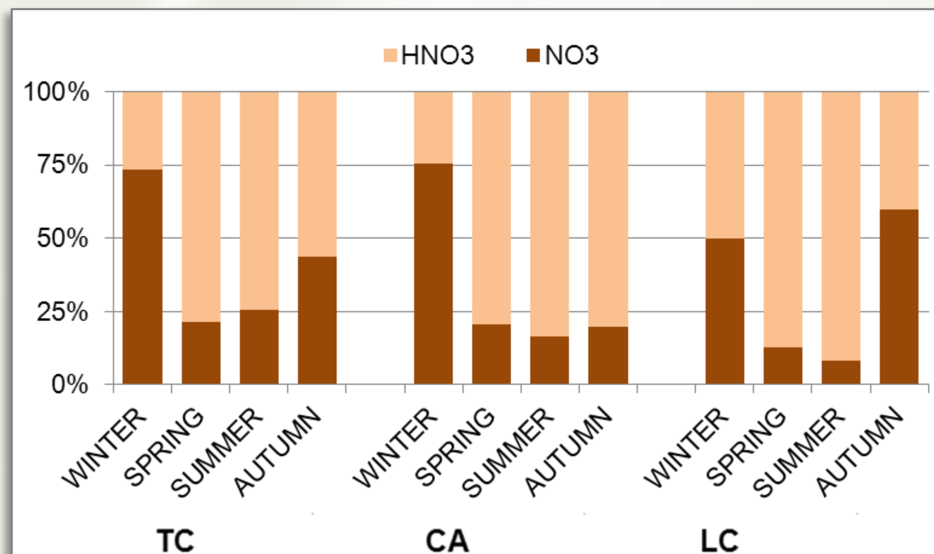
Easy-to-apply, not expensive.
Site-specific results

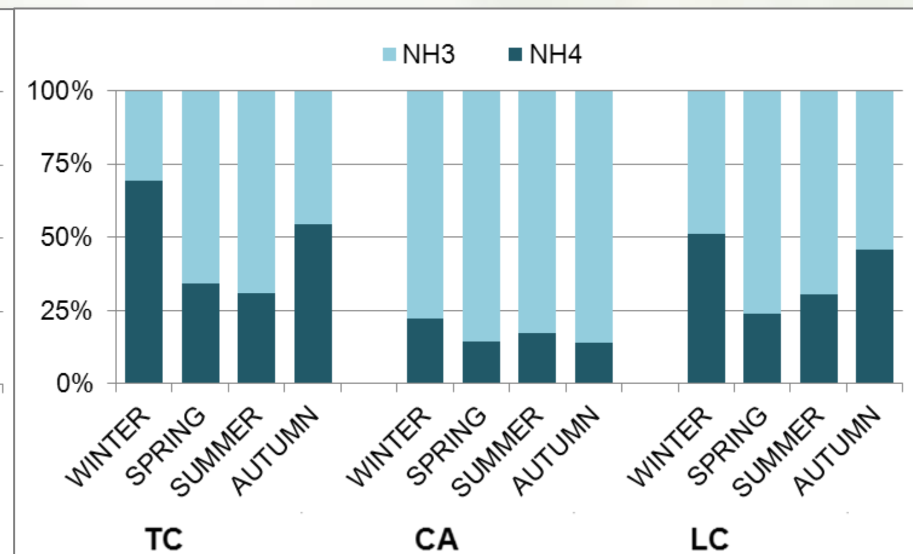
Sources of uncertainty:

Representativeness of selected trees

EIM does not include particulate N in the estimation

RATIO GAS / PM

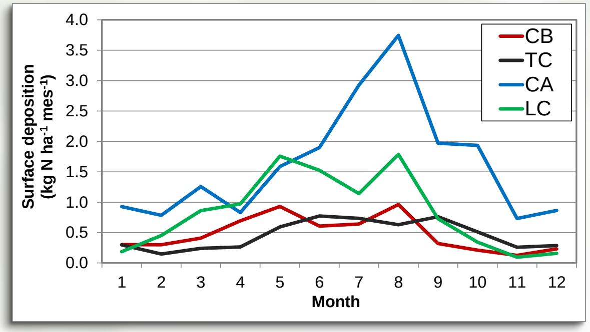




García-Gómez et al., 2016, Environ. Sci. Poll. Res.

TOTAL DEPOSITION AND RISK ASSESSMENT

Surface deposition estimation



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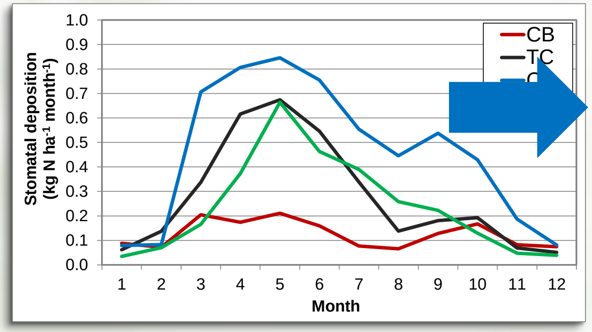
Stomatal uptake modelization



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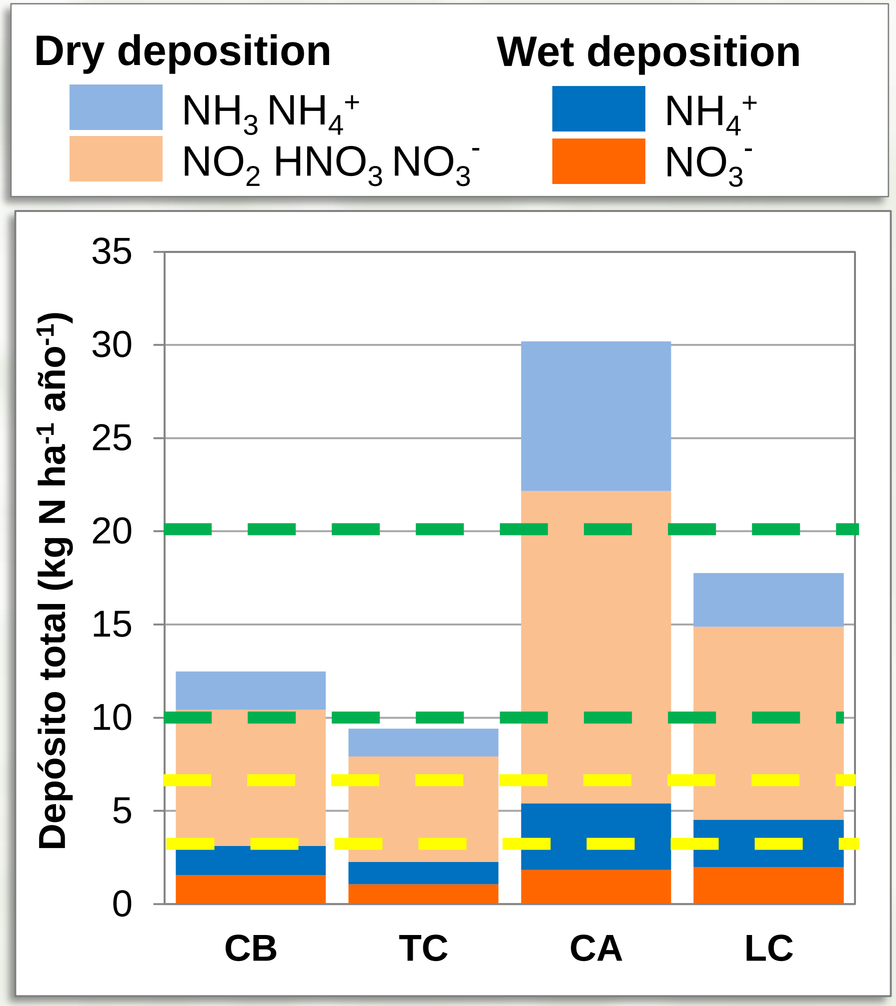
Wet depostition measurements



García-Gómez et al. In prep. (2011-2013 data)

Empirical CL (mostly based on lichens)

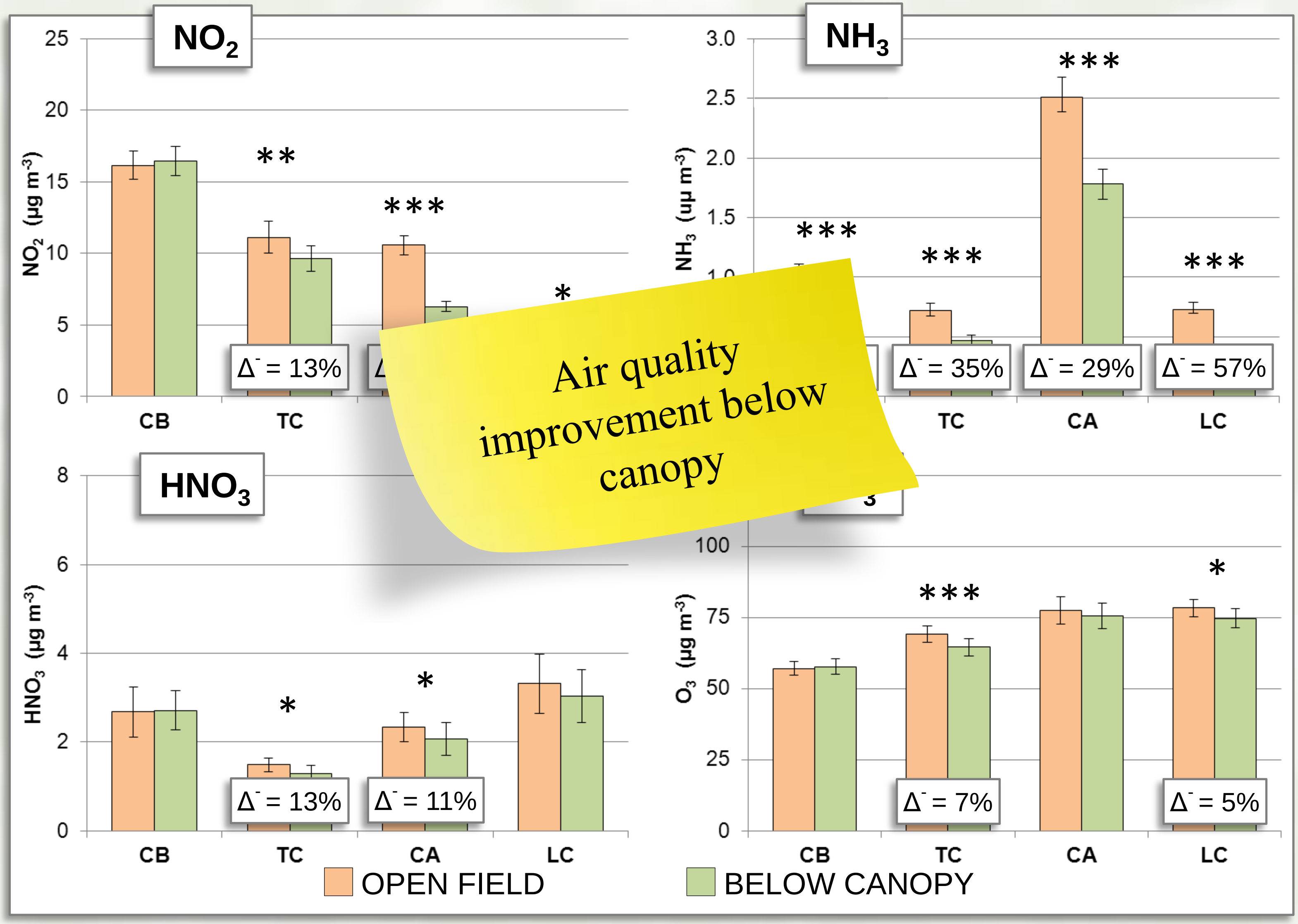
Bobbink et al. 2011

Pardo et al. 2011

... but, apart from assessing risk of eutrophication, why dry deposition matters?

CONCENTRATION OF GASEOUS N: BELOW CANOPY *vs.* OPEN FIELD

BELOW-CANOPY REDUCTION OF GASEOUS POLLUTANTS



Wilcoxon (for matched pairs) *: $p < 0.05$; **: $p < 0.10$; ***: $p < 0.01$

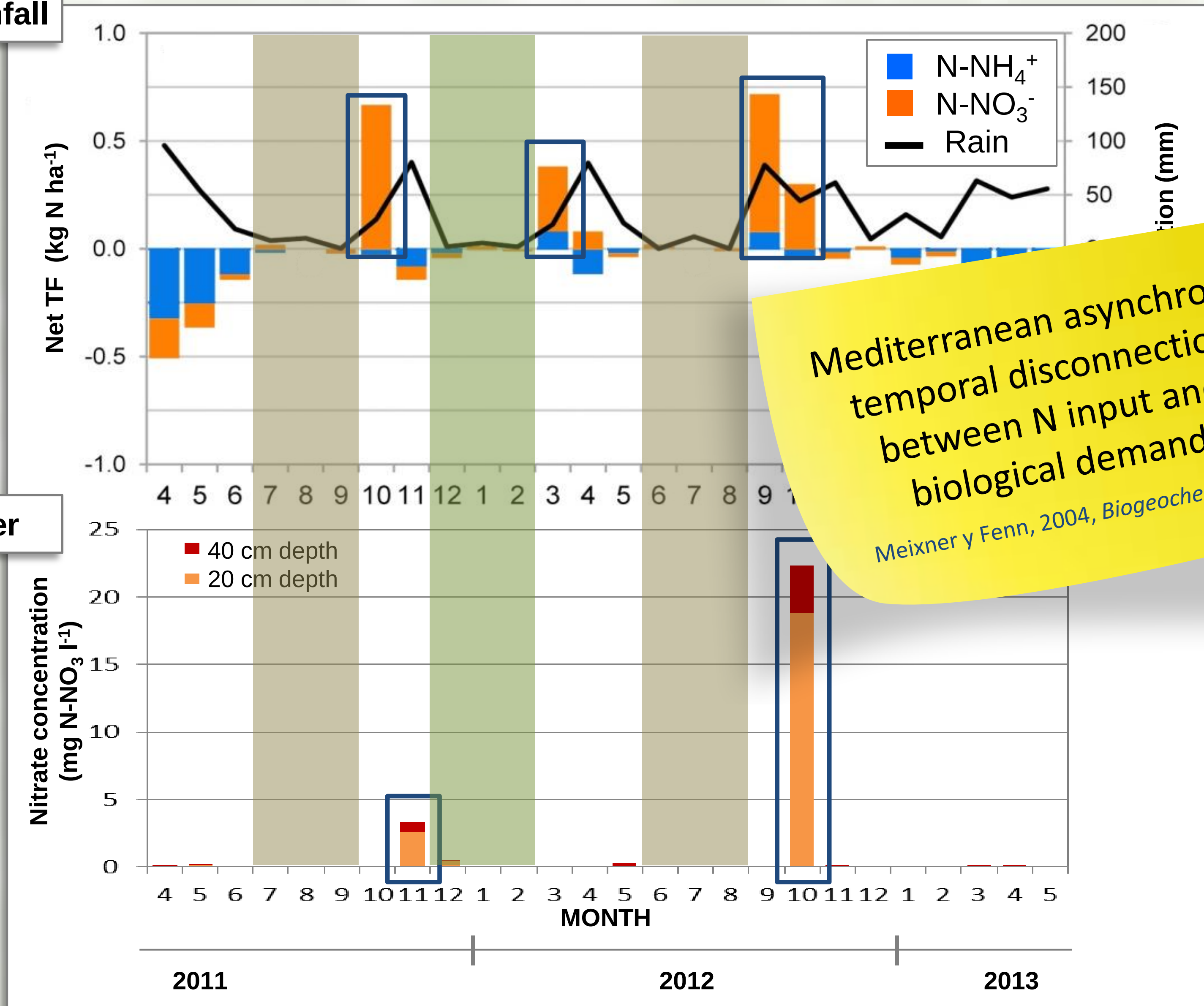
García-Gómez et al. 2016, *Environ. Sci. Poll. Research*

SEASONALTY OF N INPUTS

SEASONALITY OF NUTRIENT INPUTS

Net throughfall

Soil water



Mediterranean asynchrony: temporal disconnection between N input and biological demand

Meixner y Fenn, 2004, *Biogeochemistry*

García-Gómez et al. 2016, *Environ. Poll.*

Dry deposition significance

- ✓ Atmospheric **models** are useful tools for risk assessment but further developments are still needed for **dry deposition** measurements and modelling
- ✓ Deposition of **atmospheric N** might be an important added stress to some **forest** habitats in Spain and other Mediterranena areas
- ✓ **EIM** is an easy-to-apply method for estimating dry deposition and originates site-specific results
- ✓ According to the EIM, dry deposition represented **77%** of the total N input to *Q. ilex* forests, dominated by the oxidized N

  → further efforts in **HNO_3** measurements
- ✓ Meteorology and N deposition show important seasonal and inter-annual **variations in Mediterranean** region

  → implications for effects and CL estimation


Gracias
Thank you
Paldies
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AGRISOST, Com. Madrid
CONcumbres- Fundación Biodiversidad

ESTIMATING ATMOSPHERIC DRY DEPOSITION

METHODOLOGY: EMPIRICAL INFERENTIAL METHOD

(Bytnerowicz et al., 2015, *EP*)

Branch washing

$$K_{NH_4^+} = F_{NH_3+NH_4^+} / C_{NH_3}$$

$$K_{NO_3^-} = F_{HNO_3+NO_3^-} / C_{HNO_3}$$

Passive sampling

LAI

Natural branches

Lyophilized branches

C: Pollutant concentratoin in air

K: Surface conductance

LAI: Leaf area index

$\boldsymbol{F_{surface}}$: Flux of N onto the leaf surface (surface dry deposition)

$\boldsymbol{F_{stomatal}}$: Flux of N into the stomata (stomatal dry deposition)

$\boldsymbol{c_s}$: Stomatal conductance

$$\boldsymbol{F_{surface} = C \times K \times LAI}$$

≀≀

$$\boldsymbol{F_{stomatal} = C \times c_s \times LAI}$$

DRY DEPOSITION

SURFACE DEPOSITION

STOMATAL DEPOSITION

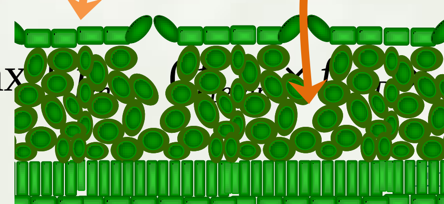
$$c_s = g_s \times D_u$$

Bytnerowicz et al., 2015
Massman, 1998

Model DO$_3$SE (*Deposition of Ozone and Stomatal Exchange*)

CLRTAP, 2004

$$g_s = g_{max} \times f_{light} \times \max \ldots f_{SWP} \times f_{phen}) \}$$



Jarvis, 1976
...berson et al., 2000
...lonso et al., 2007, 2008

UNITED NATIONS

LRTAP
Long-range Transboundary Air Pollution

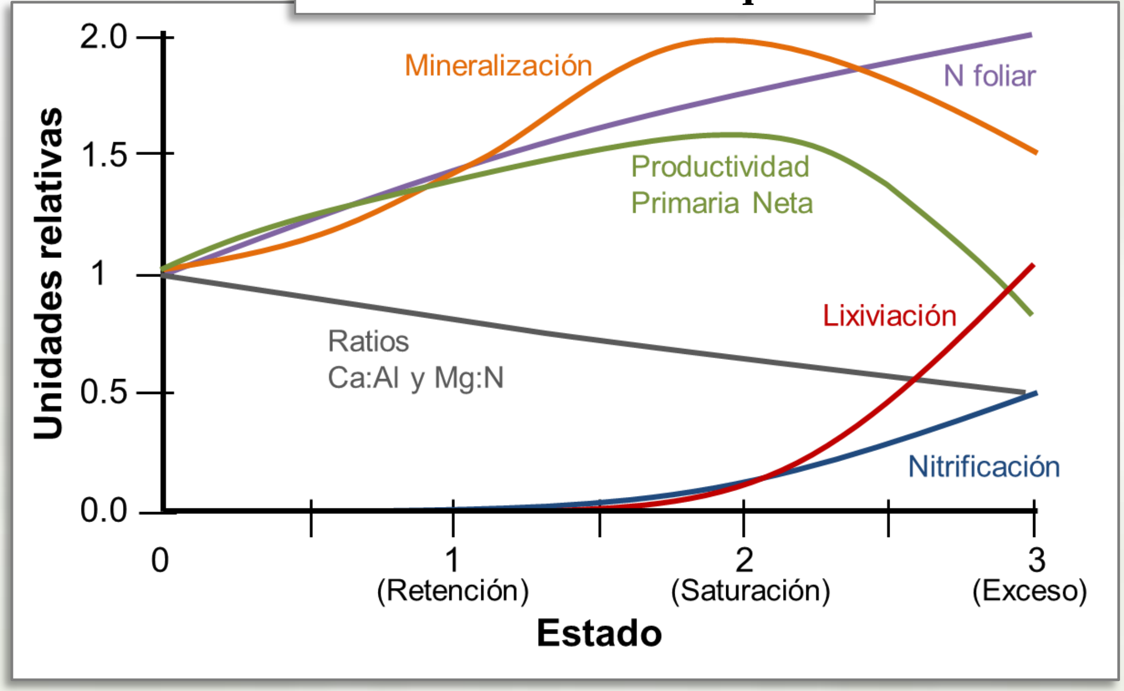
DEPÓSITO ATMOSFÉRICO DE NITRÓGENO

EFECTOS DEL DEPÓSITO DE NITRÓGENO

Ecosistemas terrestres:

- Toxicidad directa
- Acidificación de los suelos
- Mayor susceptibilidad a otros factores de estrés
- Eutrofización de ecosistemas

Eutrofización en bosques



Saturación por N: Cambio de un ecosistema limitado por el N a uno enriquecido en N

Aber et al., 1998, *BioScience*
Emmett, 2007, *WASP*

ESTIMATING ATMOSPHERIC DRY DEPOSITION

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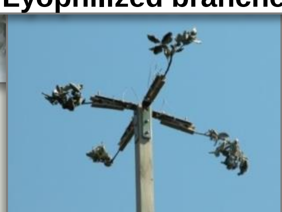
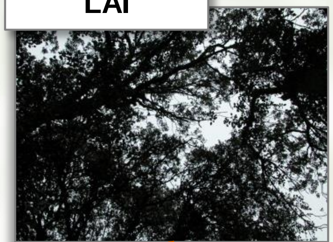
Natural branches

Lyophilized branches



Passive sampling

LAI



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≀≀

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DRY DEPOSITION

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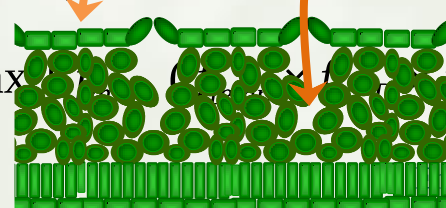

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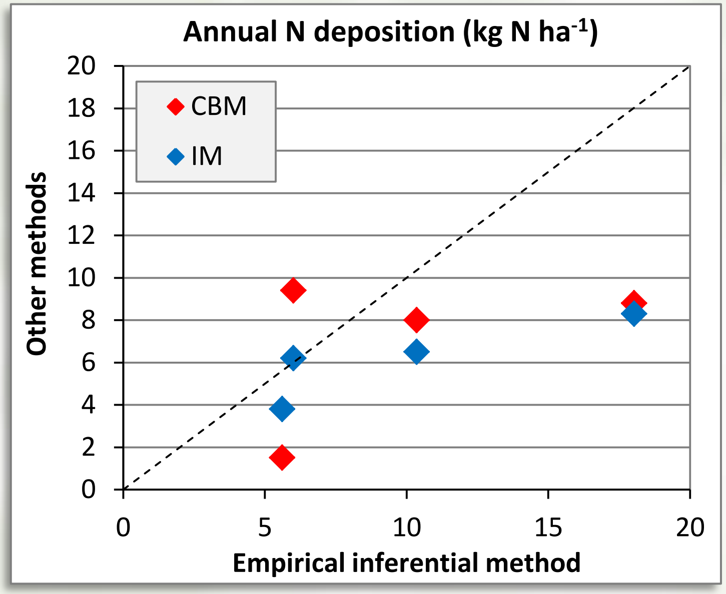
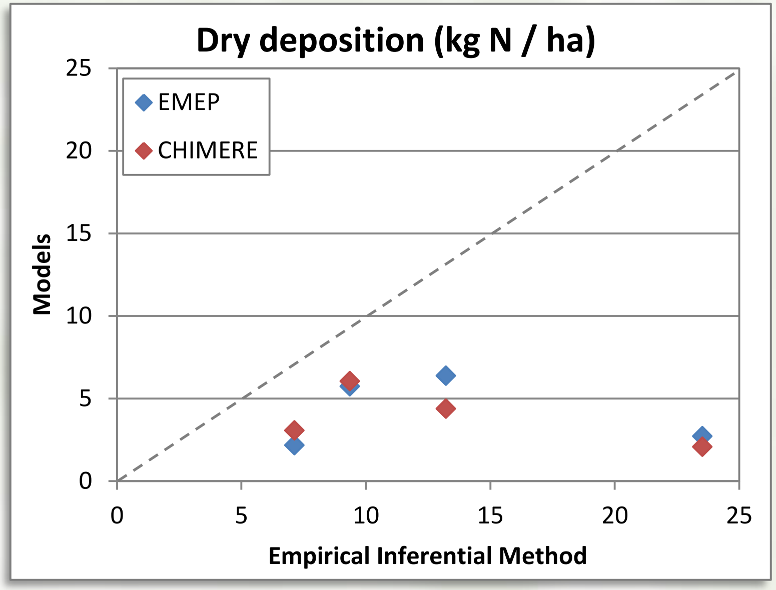
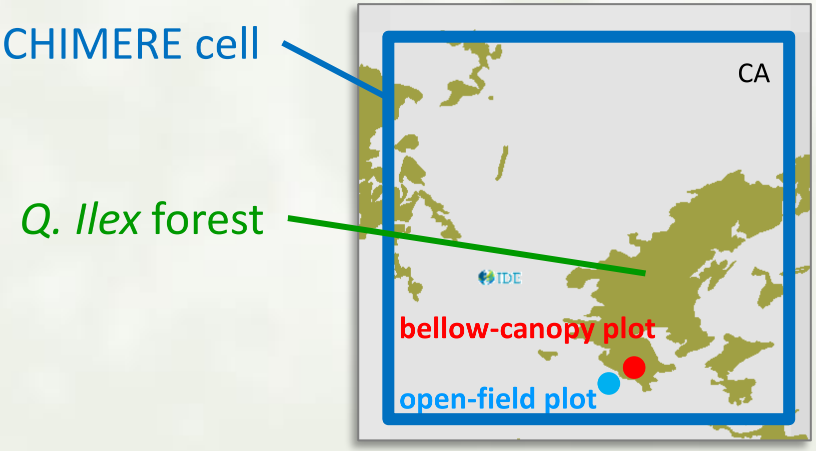


Comparison with models



Models' output are commonly cell- (and habitat-) averaged values



ESTIMATING ATMOSPHERIC DRY DEPOSITION

METHODOLOGY

Branch washing: alive branches (NB) and lyophilized branches (LB)

NB

LB

Seasonal Same sampling day for LB and NB

Exposure period = number of days from last rain

Exposure period = 7 – 14 days

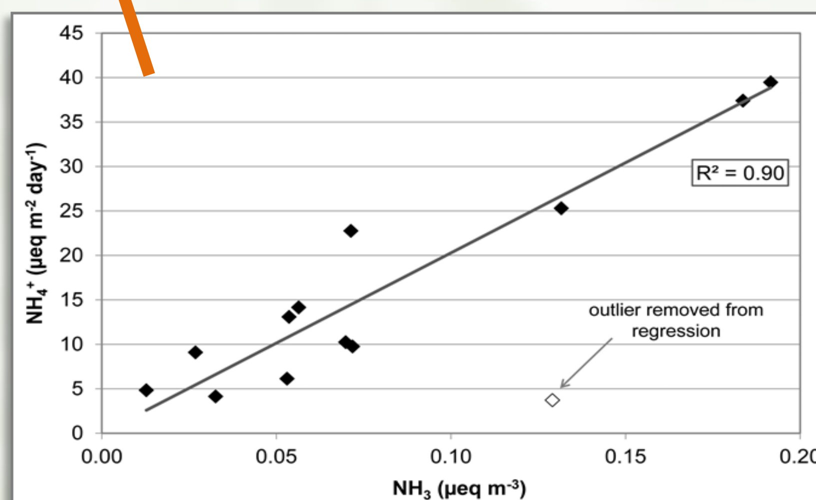
ESTIMATING ATMOSPHERIC DRY DEPOSITION

RESULTS: SURFACE CONDUCTANCE (K_{sup})

Study of NB washing experiment

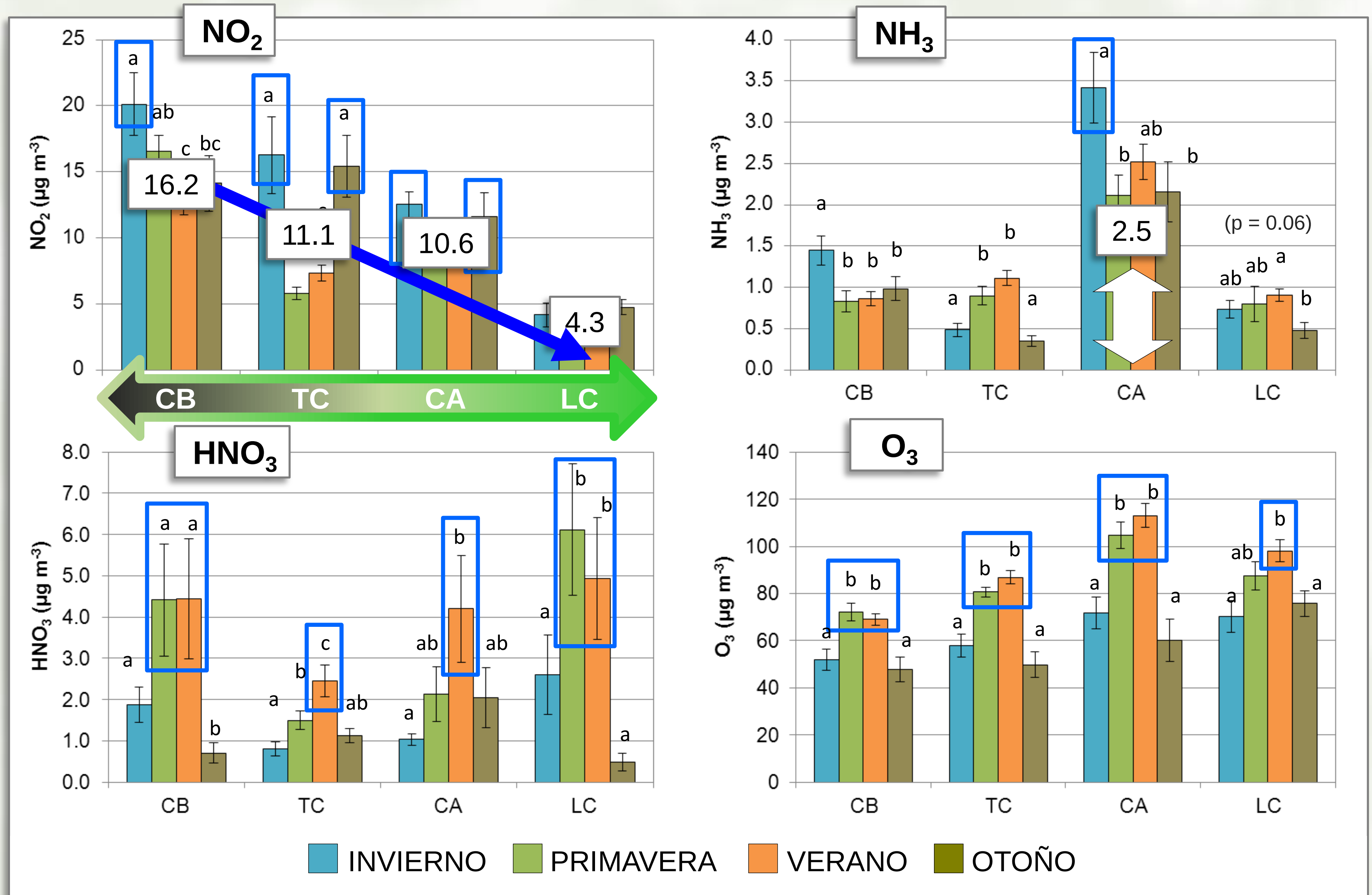
Region	Sites	N	$K_{NH_4^+}$ (cm s^{-1})		$K_{NO_3^-}$ (cm s^{-1})	
			Avg.	Std. error	Avg.	Std. error
CENTRAL	TC	5	**0.258**	0.065	**1.405**	0.478
NORTH-EAST	CB, LC	4	**0.272**	0.046	**0.491**	0.168
NORTH	CA	4	***0.232***	0.052	**1.826**	0.775
Average		3	0.238	0.028	1.241	0.394
Regression		12	**0.235**	0.013	n.s.	

K was consistent for reduced N, but it varied largely among regions for oxidized N



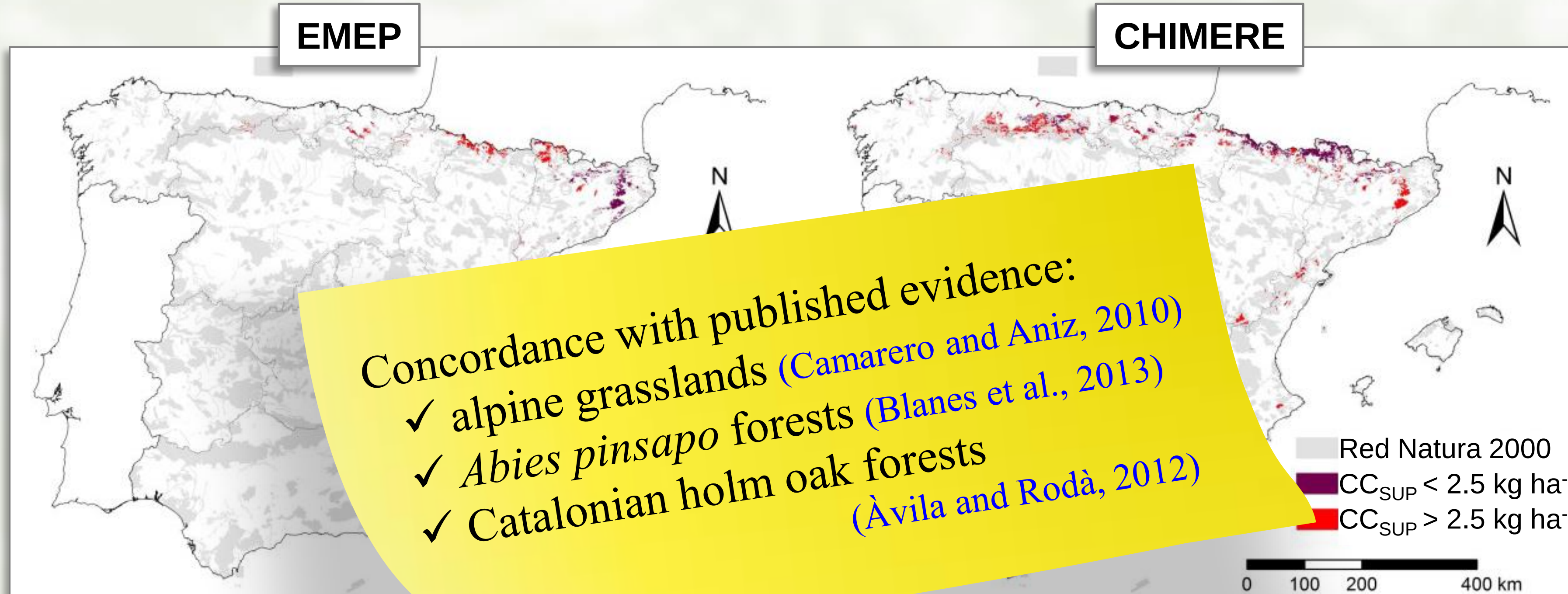
CONCENTRACIÓN ATMOSFÉRICA DE CONTAMINANTES

VARIABILIDAD ESPACIAL Y TEMPORAL



RISK ASSESSMENT OF N_r DEPOSITION

MAIN RESULTS



Concordance with published evidence:

- ✓ alpine grasslands (Camarero and Aniz, 2010)
- ✓ *Abies pinsapo* forests (Blanes et al., 2013)
- ✓ Catalonian holm oak forests (Àvila and Rodà, 2012)

Assessed: 52 183 km^2 **2.8 – 7.3% threatened** **Avg. CL_{EXC}: 2.7 – 3.0 kg N ha^{-1}**

Higher risk using CHIMERE model

Threatened habitats:

- Mainly in areas with high deposition and for habitats with CL ≤ 10 kg ha^{-1}
- Most threatened habitat: natural grasslands, according to both models (30 – 60%)
- Other mountainous habitats

RISK ASSESSMENT OF N_r DEPOSITION

RESULTS FOR FOREST HABITATS

Threatened species:

- Relictic temperate and temperate-like mountainous forest: *Pinus uncinata* and *Abies Pinsapo*
- Mediterranean esclerophyllous evergreen forest: *Quercus ilex* (in NE Spain)
- Endemic coastal pines: *Pinus halepensis*, *P. pinaster*, *P. pinea* (according to CHIMERE model)

Dry deposition:

- Comparison of modeled dry deposition values with estimations obtained by other authors (Rodá et al., 2002; Sanz et al., 2002; Aguillaume et al., 2017) showed that the modelled dry deposition could be underestimated for Spanish Mediterranean forests.
- Mediterranean forests (and other forests) in Spain could be withstanding a higher risk derived from N deposition than the one resulting from this first approach

The most endangered tree species were either relictic, endemic or representative of the Mediterranean region

The assessment might be improved by using dry deposition values estimated for each particular habitat type

$$F_{surface} = C_{GAS} \times K_{GAS}$$

$$F_{N_{GAS}+N_{PM}} = C_{GAS} \times K_{GAS} + C_{PM} \times K_{PM}$$

$$\frac{F_{N_{GAS}+N_{PM}}}{C_{GAS}} = K_{GAS} + K_{PM} \times \frac{C_{PM}}{C_{GAS}}$$