Ozone trends across Europe

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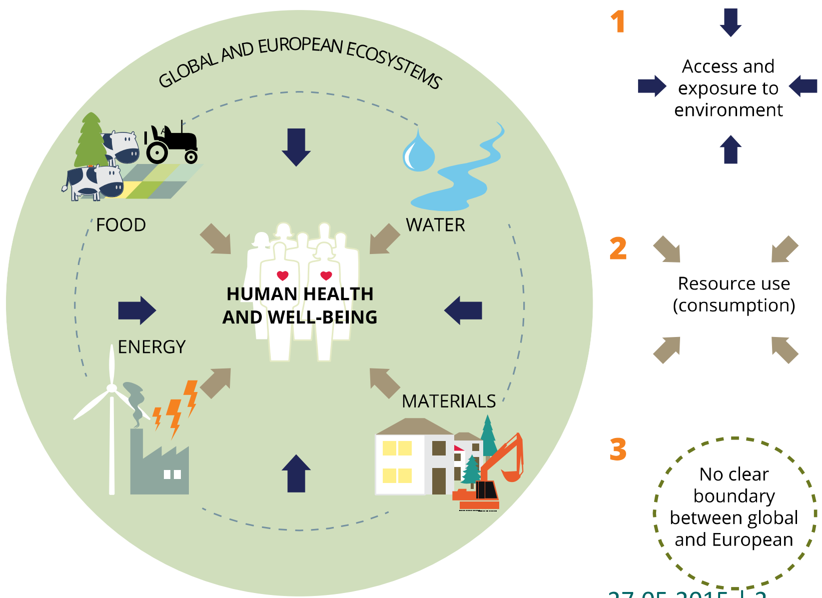
Introduction

- **During last century, background O_3 has considerably increased and reached phytotoxic doses for vegetation.**
  (Staehlin et al. 1994; Matyssek et al. 2007)

- **Most vegetation and agricultural crops are exposed to levels above the target; in 2011, 80% of Europe's agricultural area.**
  (EEA, 2013)

- **PM, O_3 (100 $\mu g/m^3$ 8-hour mean) and NO_2 remain of particular health concern.** *(WHO, 2006)*

- **O_3 precursor emissions have declined but not so O_3 at most monitoring stations**
  -> long-range transport / MEGATRENDS *vs.* regional trends.
  (EEA, 2014)



Objective & Methods

- Temporal and spatial trends for ozone concentrations (ppb) and exposures (AOT40) for the 2000-2013 period on Level II sites across Europe (***WGE Trend Report 2015***)
- ICPF DB downloads from 23 Feb 2015
- For Trend analyses, Sen's slope (1968), R-zyp approach
- From 21 countries

Austria (AUT)	UK (GBR)	Luxembourg (LUX)
Belgium (BEL)	Greece (GRC)	Poland (POL)
Cyprus (CYP)	Hungary (HUN)	Romania (ROU)
Czech Republic (CZE)	Ireland (IRL)	Slovakia (SVK)
Estonia (EST)	Italy (ITA)	Slovenia (SVN)
France (FRA)	Lithuania (LTU)	Spain (ESP)
Germany (DEU)	Latvia (LVA)	Switzerland (CHE)

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QA criteria

ICPF Manual on Ambient Air Quality XV

1) Season: 1 April - 30 September

2) Concentration range: 5 - 140 ppb [O_3]

3) Mean values were weighted according to exposure time

4) Data coverage:

   for seasonal means, only plots with 120-183 days

   for trend analyses, only plots with ≥ 4 years

5) AOT40 according to Ferretti *et al*. (2012);

$$\mathbf{AOT40_{season}=\Sigma AOT40_{weekly}=\Sigma(75.848 * [O_{3\_passive\_weekly}]- 2462.9)}$$

Layer 1 data (aggregated)

Table 1. Remaining number (and %) of measurement values, plots, site years, partners and countries after applying QA criteria.

QA criteria	No of values	No of plots	No of site years	No of countries
Raw data (Layer 0)	38'635	240	1'458	21
Filter NA and values before 2000	37'215 (100%)	240 (100%)	1'379 (100%)	21
***ug*/m3 or ppb and min 5 ppb, max 140 ppb**	**35'043**	**222**	**1'285**	**21**
Only 1 April-30 Sept	31'005	221	1'256	21
120-184 days exposures period (Layer 1)	**29'356 (79%)**	**203 (85%)**	**1'040 (75%)**	**20**

O_3 concentrations

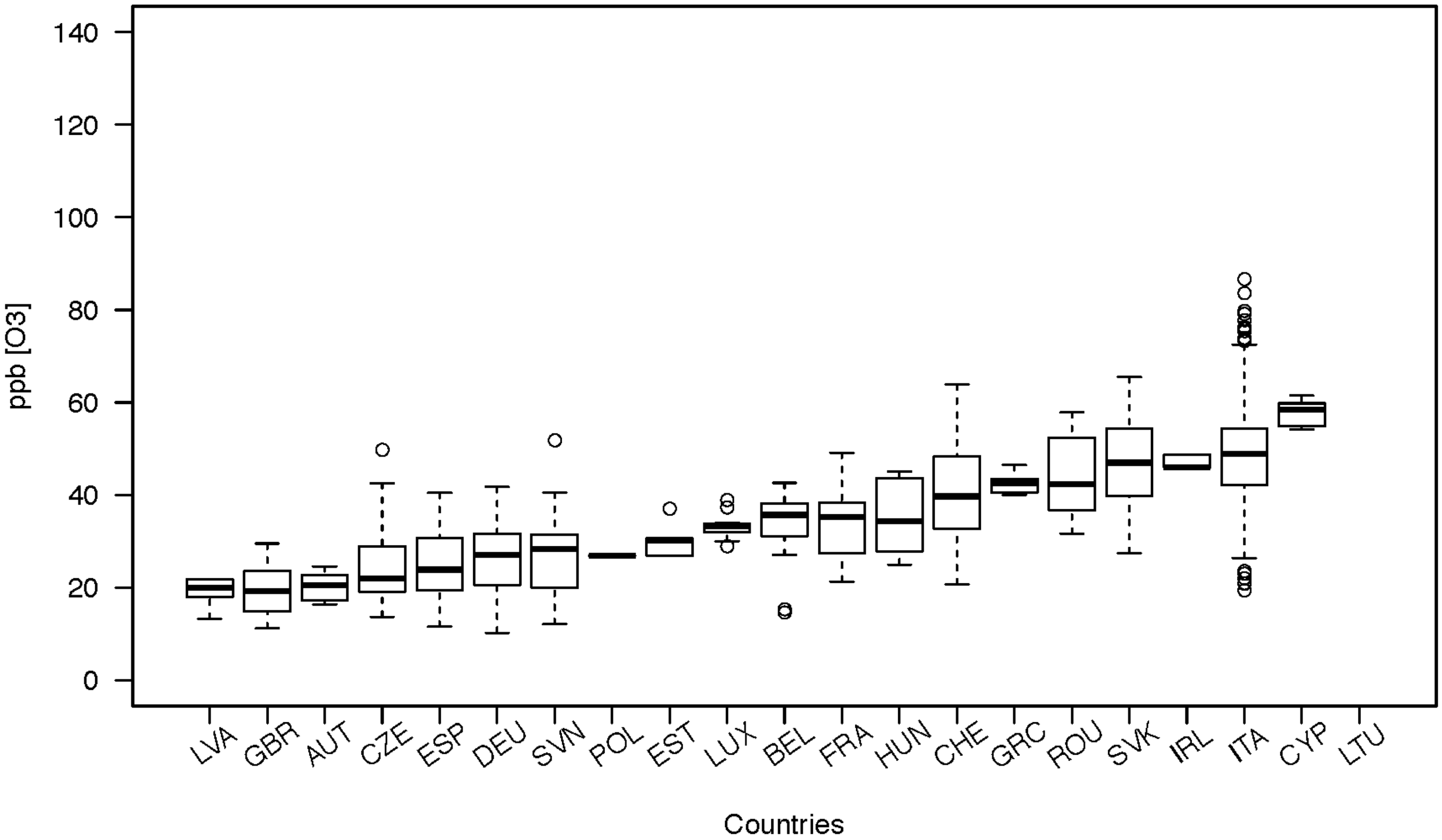

Figure 1. Box plots of ozone concentration values from passive samplers processed data in 20 countries from 2000-2013 (n= 29’356).

Spatial distribution of O_3 concentrations

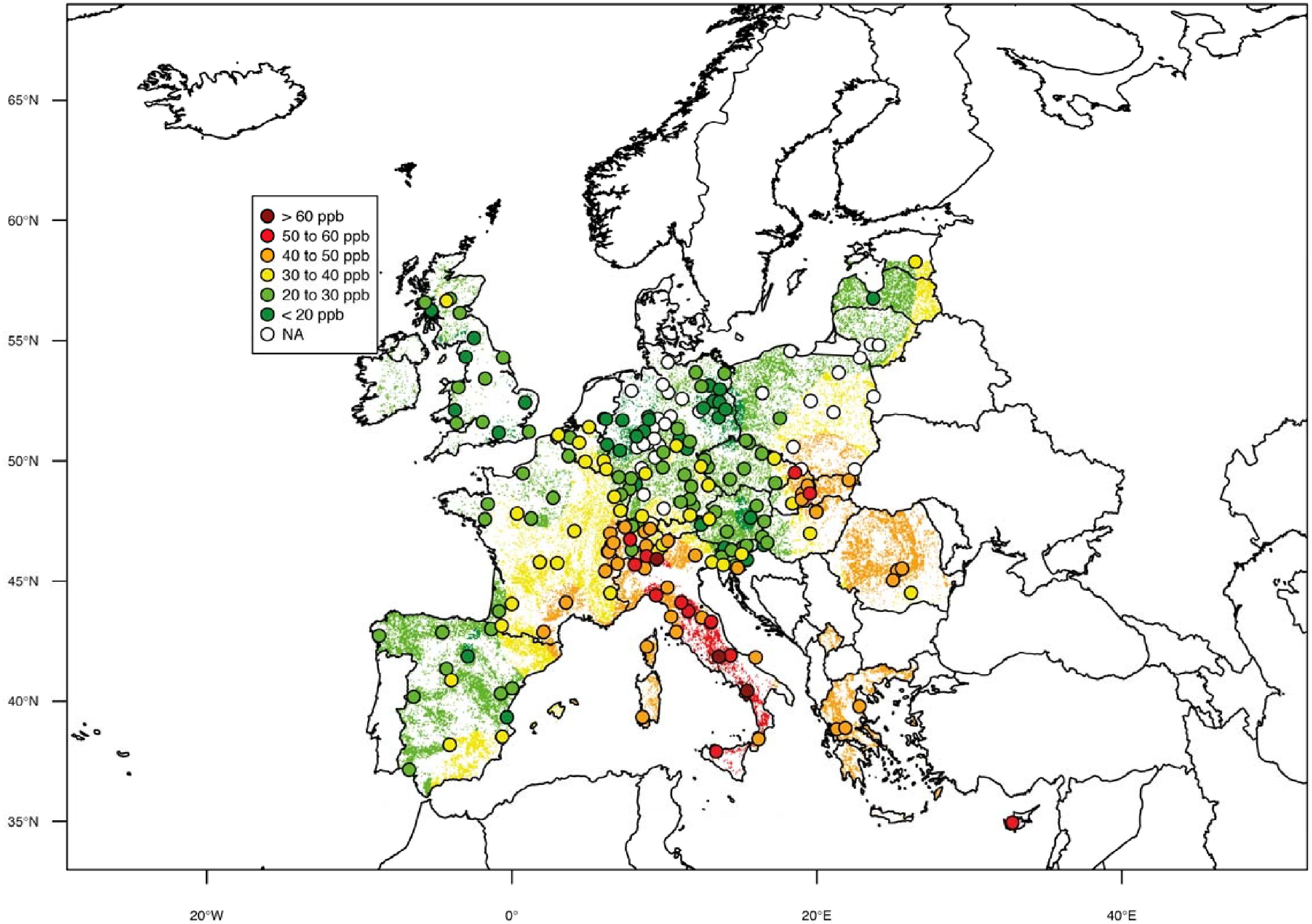

Figure 2. Spatial distribution of mean ozone concentrations (ppb) from passive samplers on 203 plots and 20 countries during 2000-2013.

AOT40

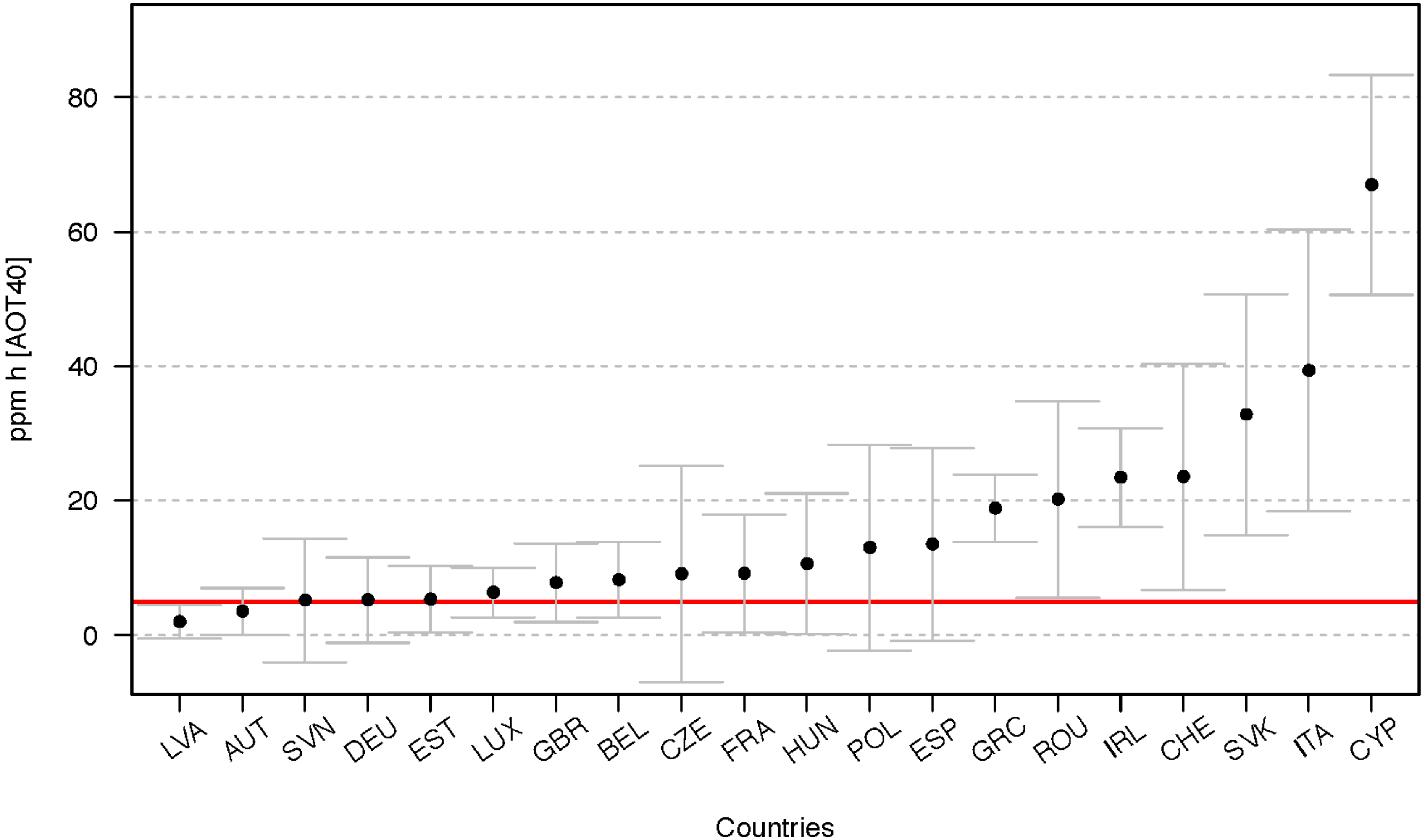

Figure 3. Mean AOT40 for 20 countries based on Ferretti et al. (2012) and 2000-2013 data from 20 countries.

Over all trend

Slope: −0.5729 ppb/year, Intercept: 43.9260

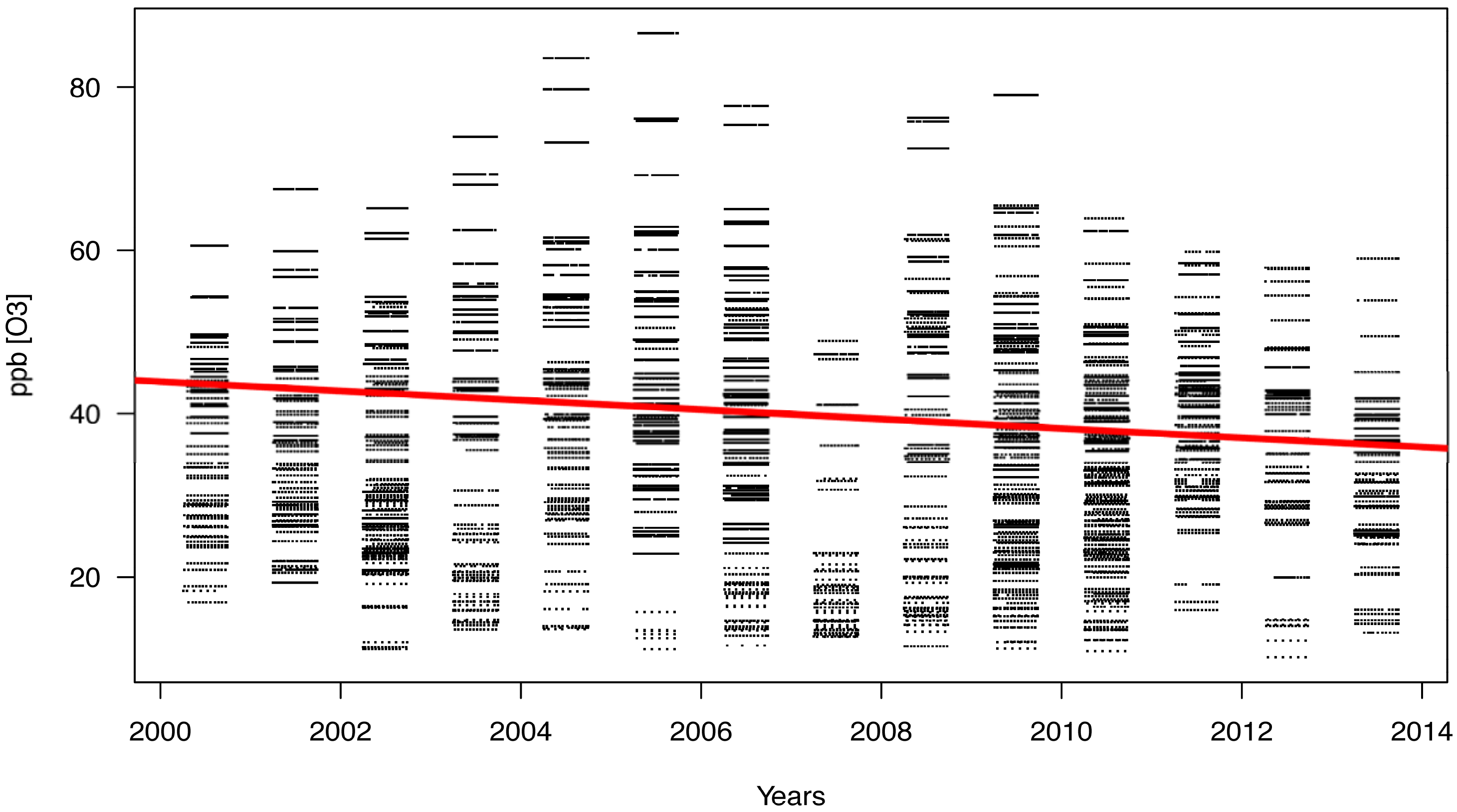

Figure 4. Scatter plot of ozone concentration values (ppb) from passive samplers exposed in 20 countries from 2000 until 2013 with a significant decrease of 0.6 ppb/year (n=29’356; p=0.000).

Plot-specific trend

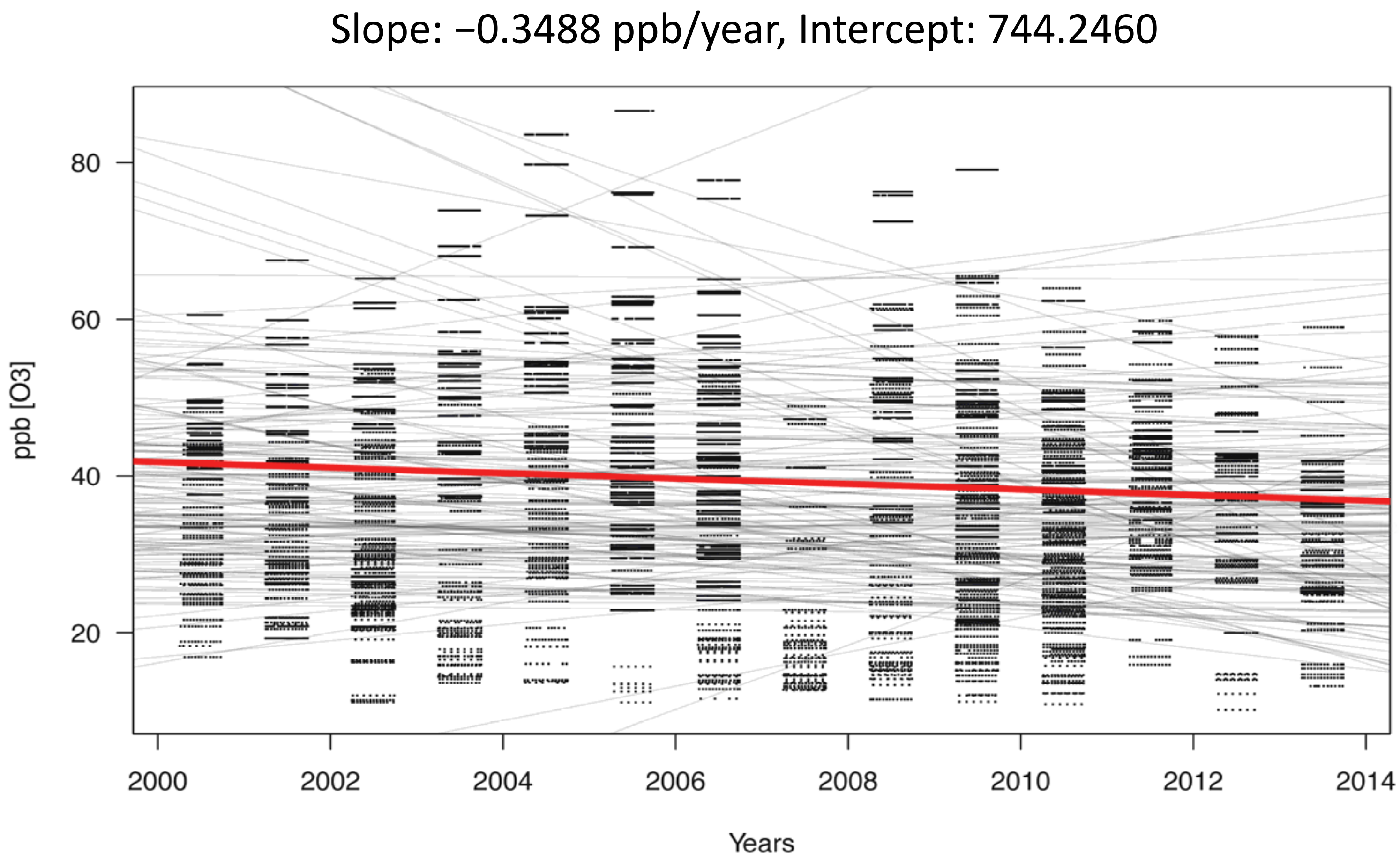

Figure 5. Scatter plot of ozone concentration values (ppb) from passive samplers exposed in 20 countries from 2000 until 2013 with a significant decrease of 0.4 ppb/year (n=29'356; p=0.000).

Plot-wise trend analyses

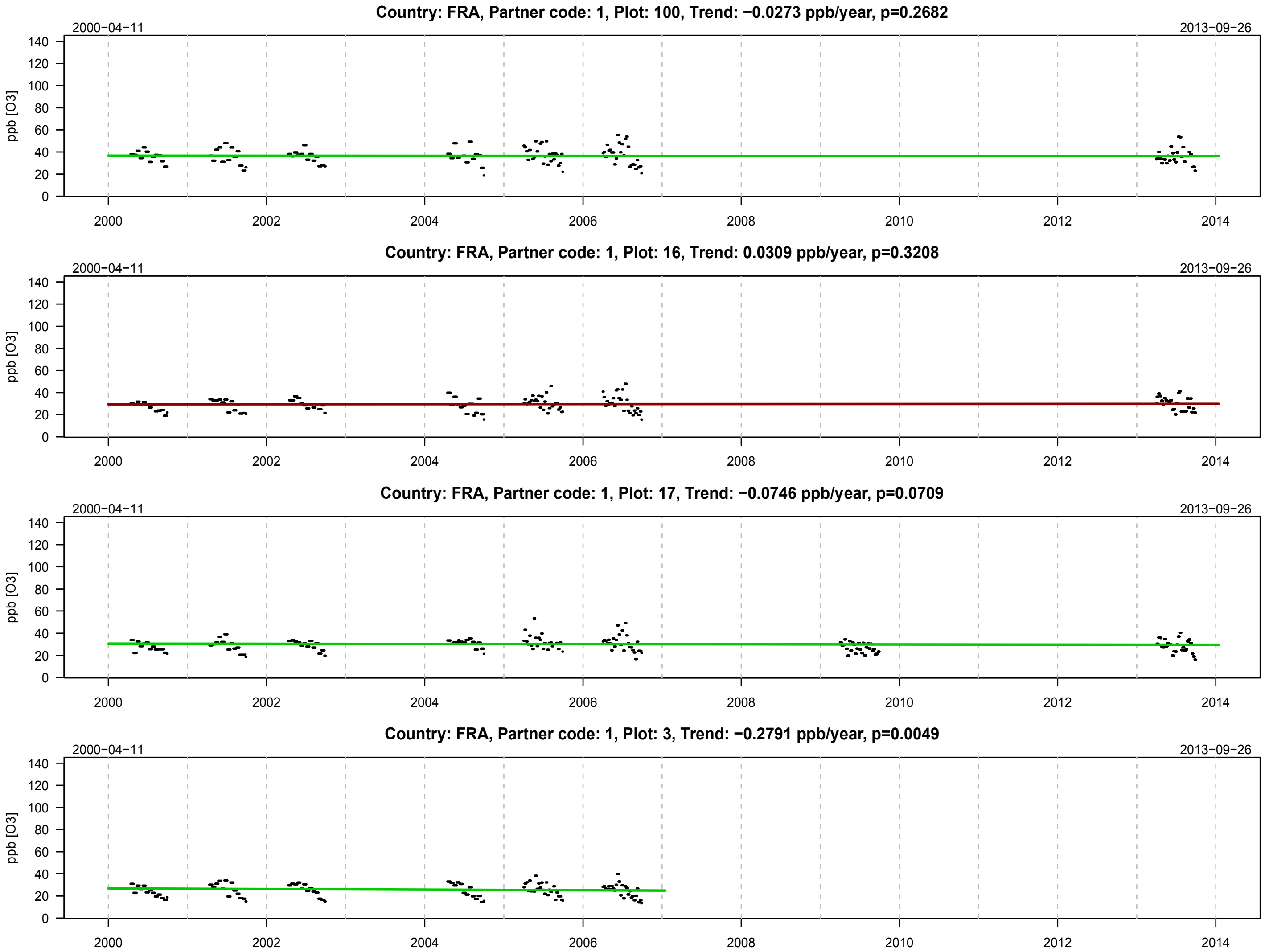

Figure 6. Partner code plots for each plot and country, showing data coverage and trends from 2000-2013.

Spatial trend analyses

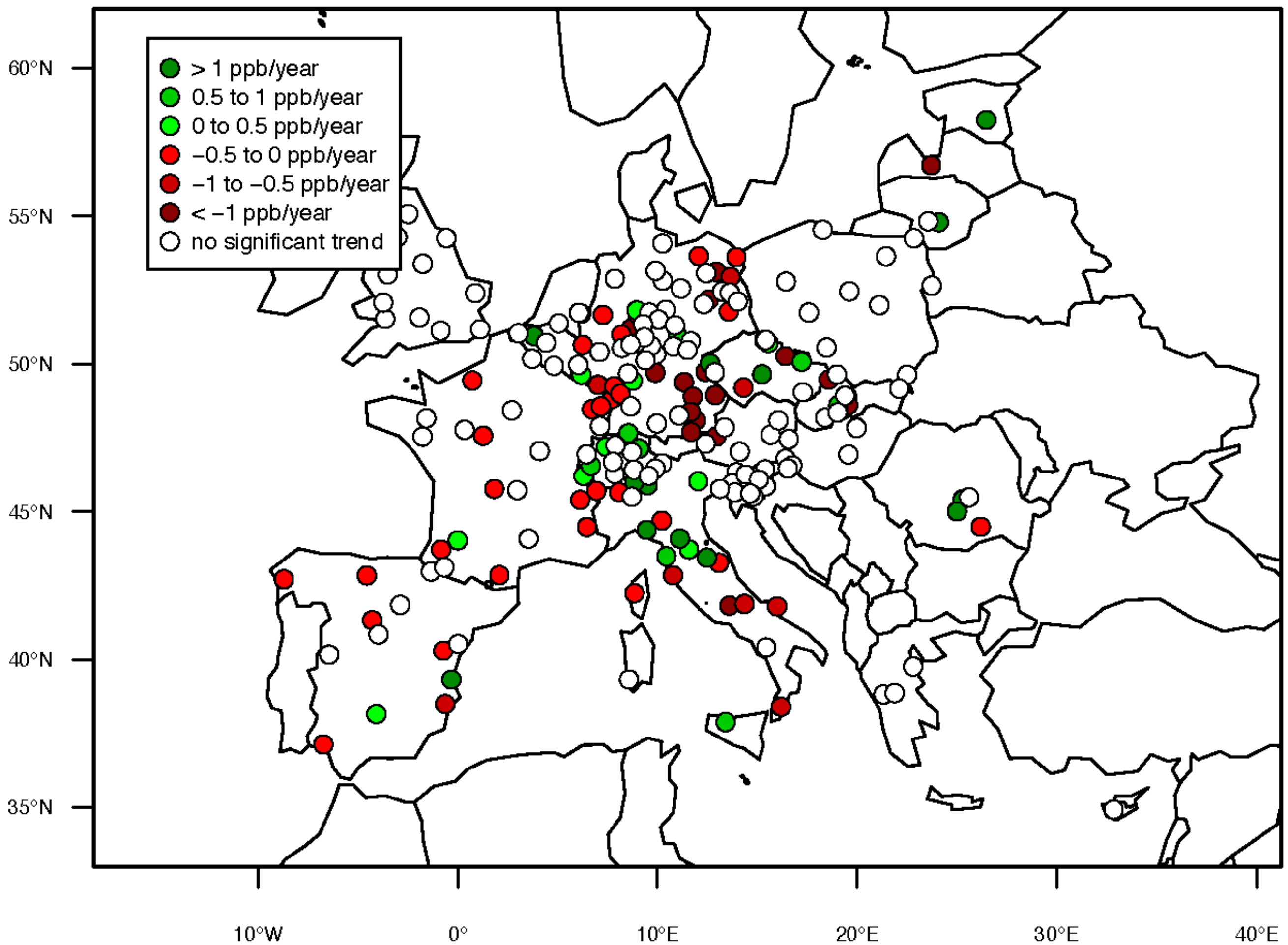

Figure 7. Spatial distribution of significant trends for weighted mean ozone concentrations on 203 sites with at least 4 years (ADDITIONAL!) and 120 days per season of data coverage from 2000-2013.

Spatial trend analyses

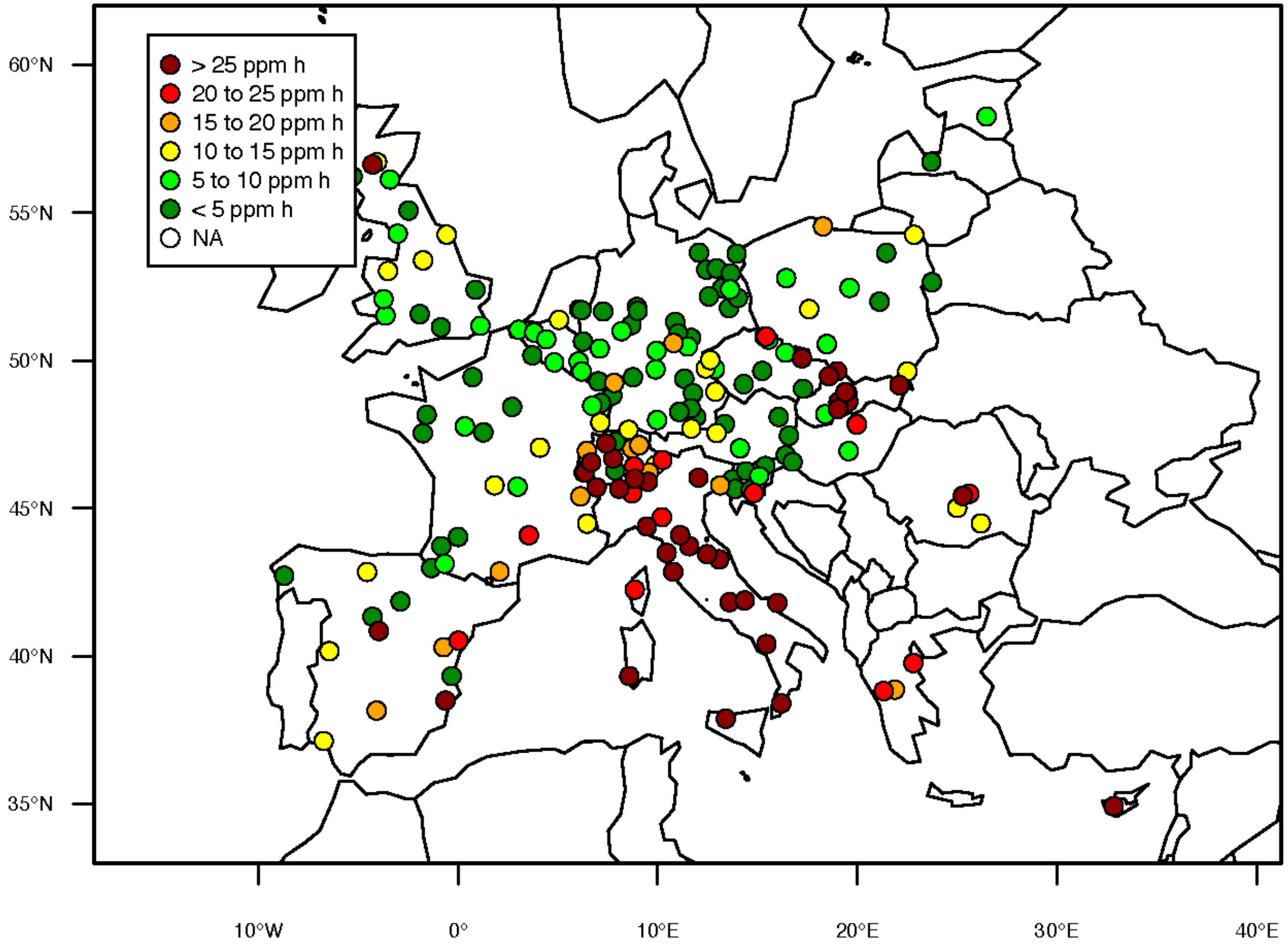

Figure 8. Spatial distribution of mean AOT40 for 2000-2013.

Conclusions

1) 2000-2013 decreasing trend of 0.4-0.6 ppb O_3/year matches EMEP (2014) where 6-months modeled max. values decreased by 0.1 - 0.5 ppb/year for the April-Sept period in most of Europe during 2000-2012.

2) Logan et al. (2012), Parrish et al. (2012), Tørset et al. (2012), Derwent et al. (2013), Simpson et al. (2014) show flattening or even reduction in the ozone levels.

3) EEA (2014) reports marginal reduction or even increase (due to long-distance transport from outside of Europe)

4) The differing outputs from various trend reports demonstrate the difficulty of modeling ozone concentration trends

-> which underlines the great value of long-term air pollution measurements at the very forest sites.

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Take home message

5) EEA (2014): up to 2009, approx 250 sites, 10 countries with continuous ozone monitoring data for the past 11 years.

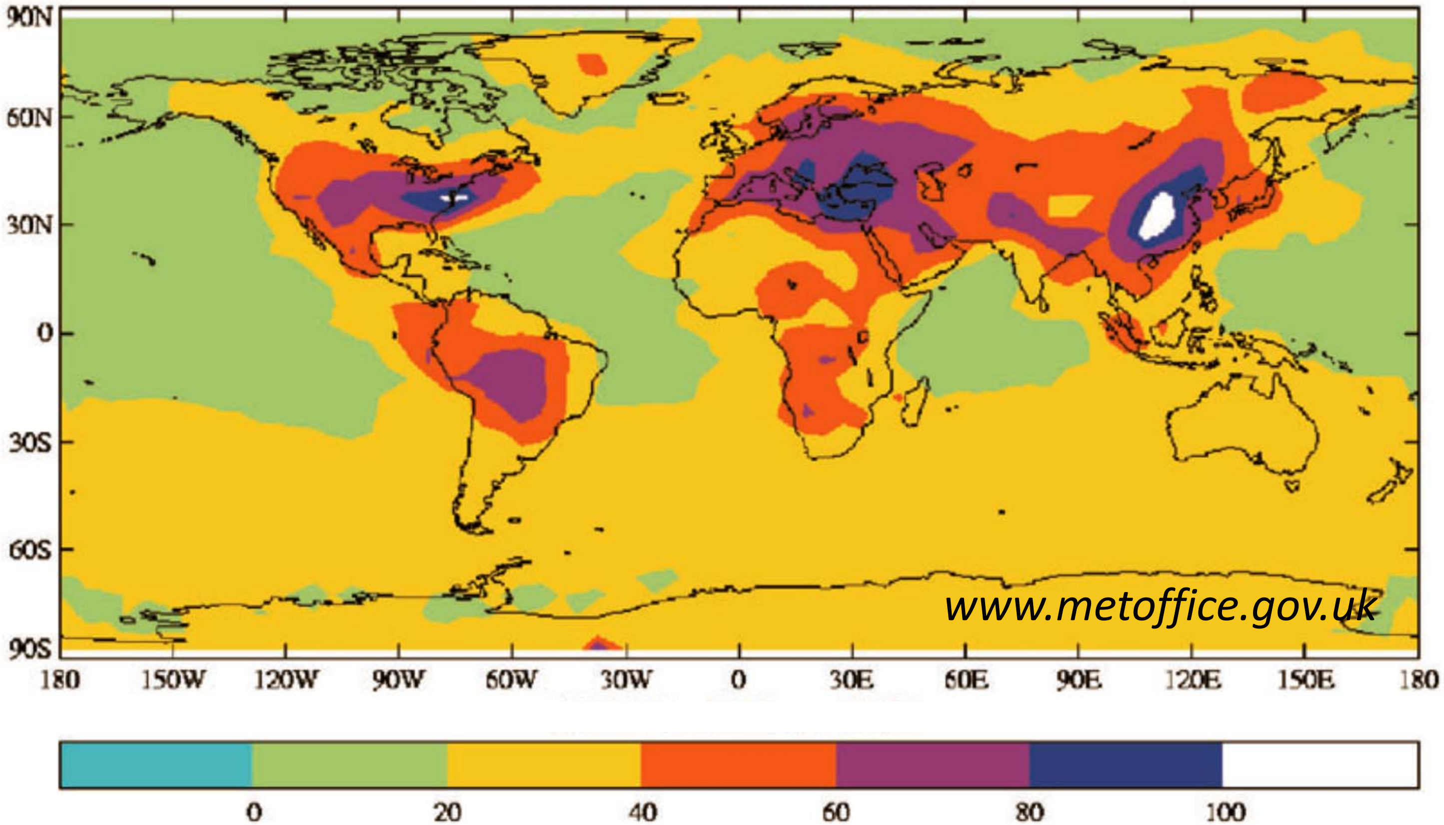
6) ICPF (2015): up to 2013, approx 240 sites, 21 countries with passive ozone data for the past 13 years.

7) 37 ICPF sites with data coverage < 4 years.

-> It is therefore crucial to extend the data series of ozone concentrations on the already established sites!

The future looks “bright” ...

July 2050



O_3 level (ppb)

xyz

Upcoming meetings

- **Tropospheric Ozone Assessment Report TOAR**

  Madrid, 28-30 April 2015 (Owen Cooper, NOAA Earth System Research Laboratory, USA

- **4th ICP Forests Scientific Conference**

  Ljubljana, 19-21 May 2015

- **IUFRO „Global Challenges of Air Pollution and Climate Change to Forests“**

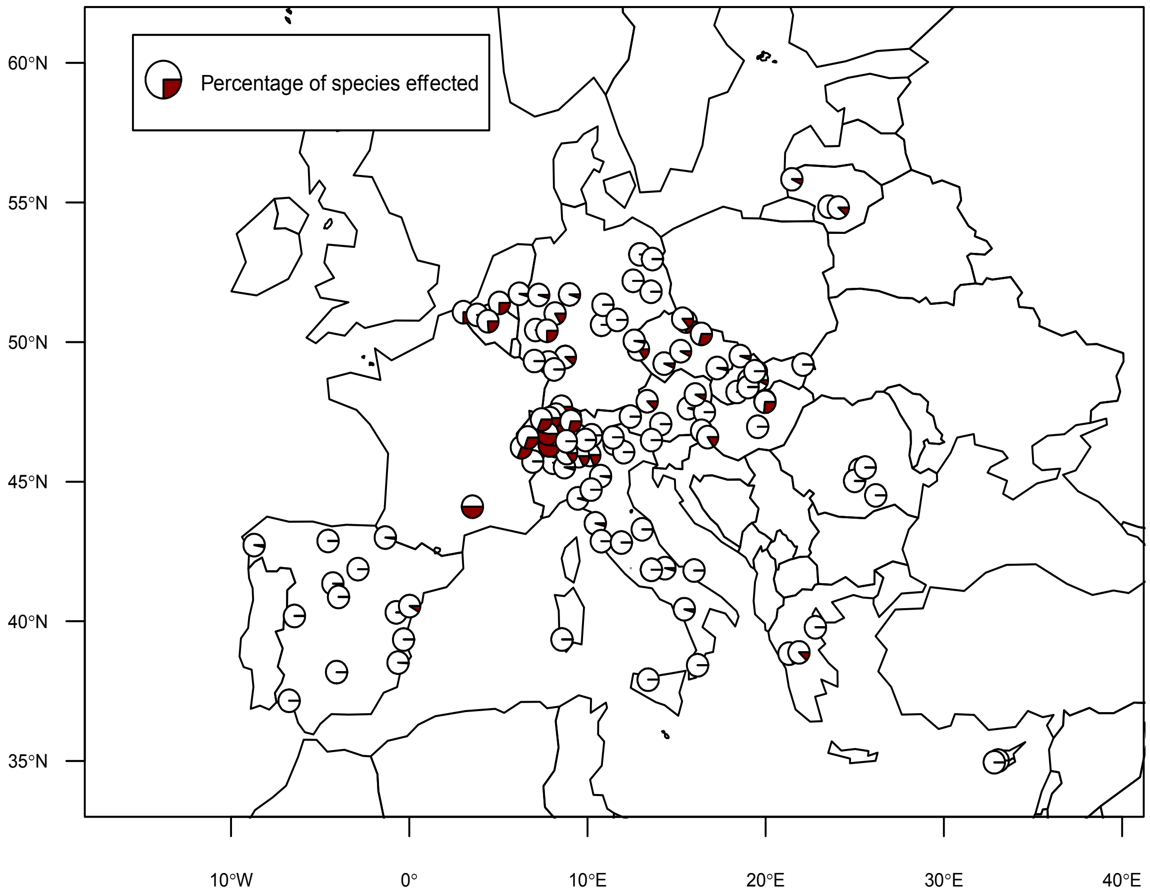
  Nice, 1-5 June 2015

- **1st Asian Air Pollution Workshop**

  Tokyo, 30 Oct-4 Nov 2015

Status – ozone symptom data

- The ICPF DB <fmd_oz_lss.csv> for symptoms contains ... (Vicent)
- No correlation between O3 concentrations, O3 exposures and symptom occurrence found
- **Issues**
- Long/Lat in **<fmd_aq_aqp.csv>** and **<fmd_aq_aqa.csv>** match plots in **<fmd_aq_lss.csv>**

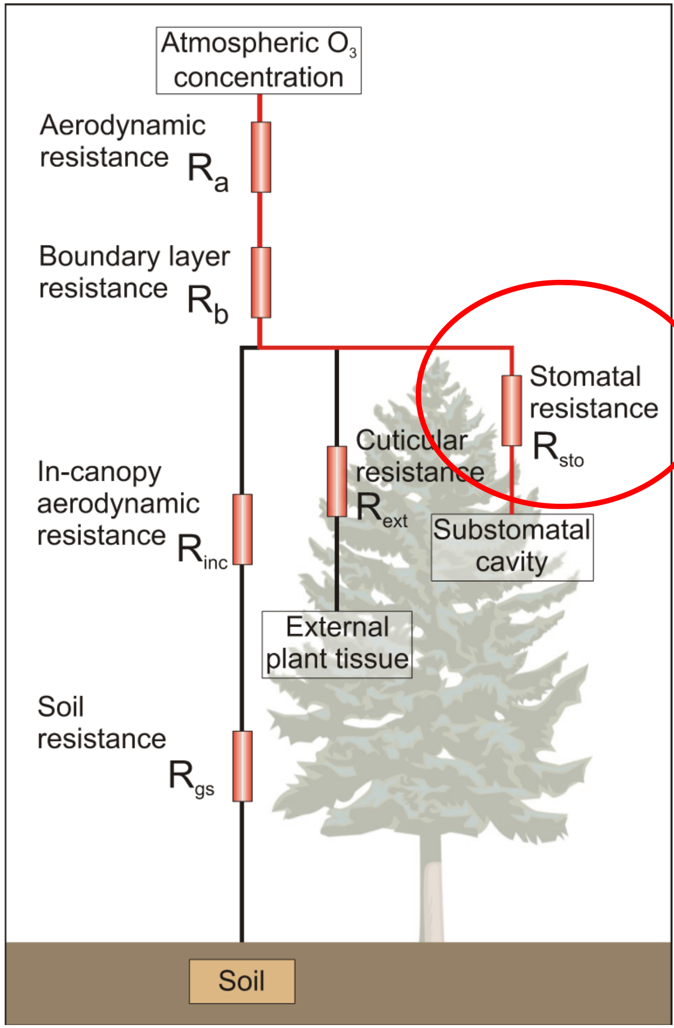


DO$_3$SE - model

$$g_{sto} = g_{max} f_{phen} f_{light} \max\{f_{min}, f_T f_D f_{SW}\}$$

Standard micrometeorological methods

Constant R values



Species / cover type characteristics
g_{max}

Phenology
Timing + length of GS
Leaf/Needle age

Canopy characteristics
SAI + LAI; height

Environmental variables:
Irradiance
Temperature
VPD
SWP

(e.g. Büker et al. 2007, 2011)