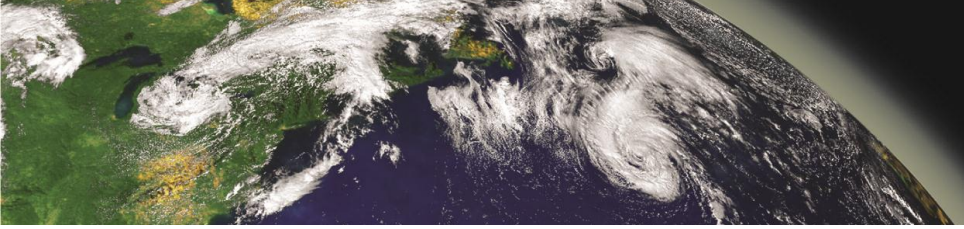


Institute for Sustainability, Health and Environment

healthy people + healthy planet

A STUDY OF OZONE CONCENTRATIONS AND TRENDS ACROSS EUROPE: 1996-2010

*T. Chatterton (1), E. Hayes (1), **J. Barnes** (1), J. Longhurst (1), D. Laxen (1), J. Irwin (1), H. Bach (2), J. Brandt (2), J.H. Christensen (2), T. Ellermann (2), C. Geels (2), O. Hertel (2), A. Massling (2), H.Ø. Nielsen (2), O.K. Nielsen (2), C. Nordstrøm (2), J.K. Nøjgaard (2), H. Skov (2), F. Pelsy (3) and T. Zamparutti (3)*

(1) Air Quality Management Resource Centre, University of the West of England, Bristol, BS16 1QY, UK;

(2) DCE - Danish Centre for Environment and Energy, Aarhus University, Denmark;

(3) Milieu, 15 rue Blanche, Brussels 1050, Belgium

Presenting author email: jo.barnes@uwe.ac.uk

2014 Annual UK Review Meeting on Outdoor and Indoor Air Pollution Research, Solihull

3-4 June 2014

University of the West of England, BRISTOL

bettertogether

Overview

- Summary/Background
- Methodology
- Data selection
- Data analysis
- Results summary
- Conclusions
- Acknowledgement/References

Summary

- This study reviews ozone concentrations from rural monitoring stations across Europe between 1996 and 2010 across a range of statistics with regard to the various objectives, target values and thresholds established by the 2008 Ambient Air Quality Directive 2008/50/EC.

- The findings reveal that there have been complex and varied changes in patterns of ozone concentrations during the last 15 years, which have equally complex implications for policy to manage ozone.

Background

- “Services to assess the reasons for non-compliance of ozone target value set by Directive 2008/50/EC and potential for air quality improvements in relation to ozone pollution”
- Project funded until May 2013
- Commissioned by the General Directorate (DG) Environment of the European Commission http://ec.europa.eu/environment/air/pdf/review/Final_ozone_report.pdf
- Support the review of the implementation of the Directive 2008/50/EC, focusing specifically on ozone
- Project consortium:

Risø DTU DTU | MWH. BUILDING A BETTER WORLD | ECORYS | milieu ENVIRONMENTAL LAW & POLICY | EUROPEAN COMMISSION environment

AARHUS UNIVERSITY DCE - DANISH CENTRE FOR ENVIRONMENT AND ENERGY | UWE BRISTOL University of the West of England

- Task 1 on ‘Assessment of current air quality situation in the Member States and Croatia for ozone’

Methodology

- The methodology is based around two significant earlier reviews of ozone data:
  - EEA (2009) **Assessment of ground-level ozone in EEA member countries, with a focus on long-term trends**
  - Wilson, *et al.* (2012) **Have primary emission reduction measures reduced ozone across Europe? An analysis of European rural background ozone trends 1996–2005**

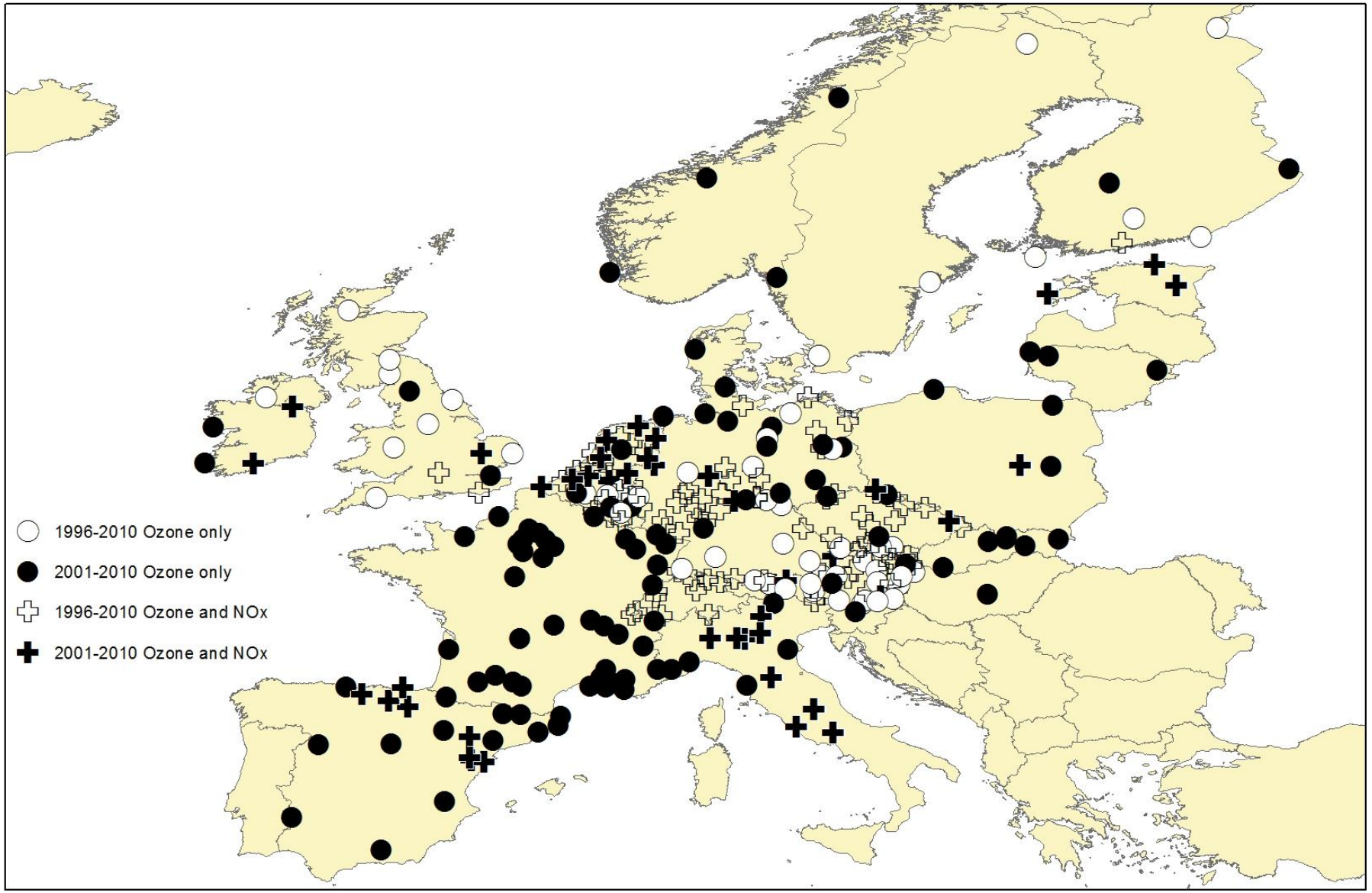
- Briefly, these reviews concluded:
  - AirBase data quality is uncertain
  - The majority of stations had insufficient monitoring history for long-term trend analysis (i.e. >10 years)
  - Network of long-term AirBase sites (1996 to 2005) was unevenly spread, few monitoring sites in France, Spain, Italy and Greece
  - Large variations in year to year concentrations e.g. high in 2003, low in 1998
  - No clear overall spatial or temporal patterns to the trends
  - "O_3 trends related to anthropogenic NO_x and VOC reductions are being masked as a result of a number of factors including meteorological variability, changes in background ozone and shifts in source patterns" (Wilson, *et al.* 2012)

Data selection – ozone and NOx

- Only AirBase v6, Feb 2012, sites to ensure reproducibility, and uniformity of data quality checks
- Only 'rural background' sites to reduce influence from local conditions and local emissions of NOx leading to depletion of ozone concentrations and to trends related directly to local changes in NOx
- Continuous measurement record from 1st January 2001, minimum 10-year period for assessing trends
- Measurements continued up to the end of 2010
- Maximum one year <75% data capture 1996-2010

- 138 stations with a suitable 15 year dataset (1996-2010) – O_3 only
- 286 stations with a suitable 10-year dataset (2001-2010) – O_3 only
- 127 sites with suitable 10 year data records (2001-2010) – NOx & O_3

Location of All 286 Rural Background Stations in Study



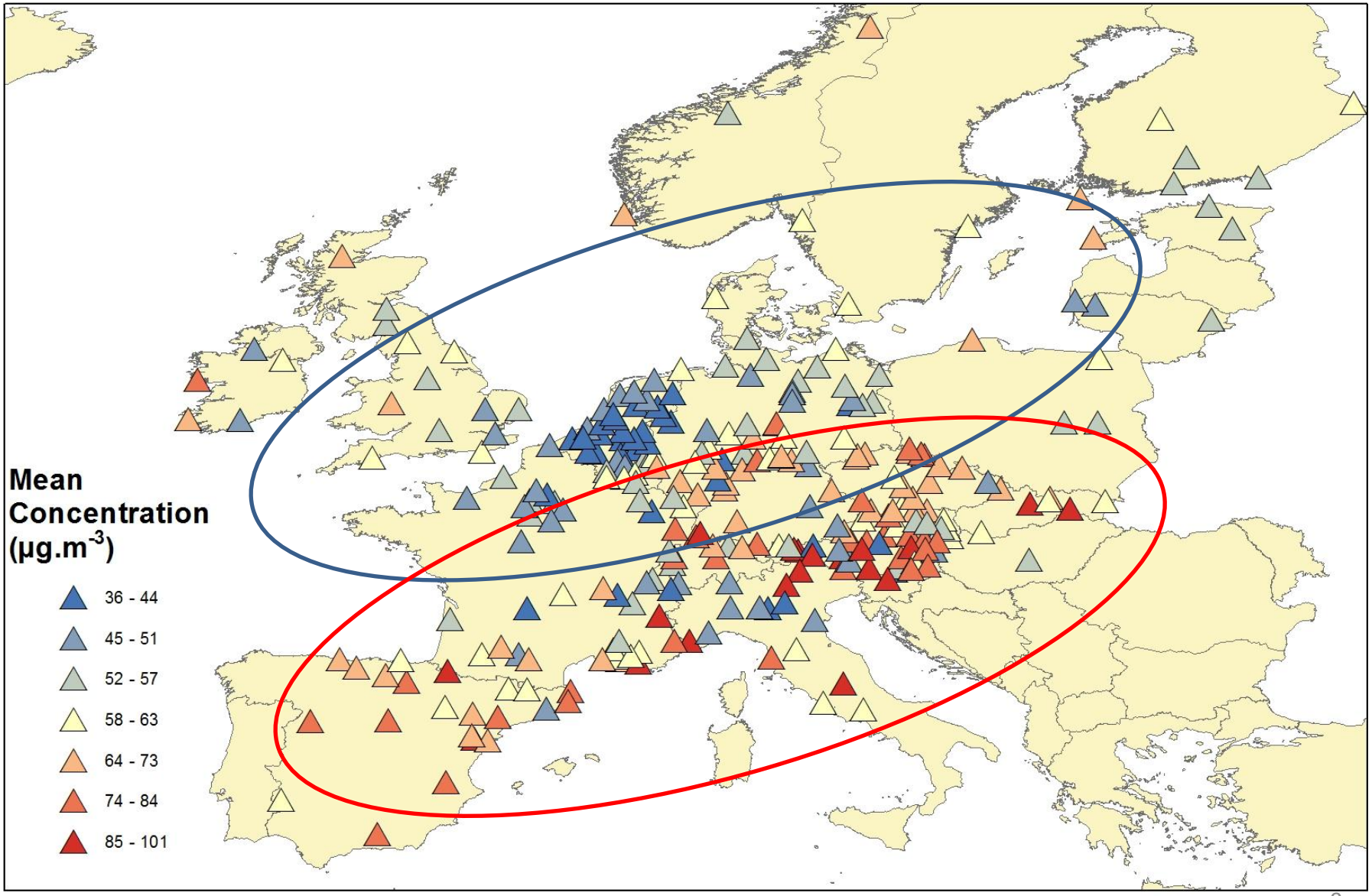
- N.B. No suitable monitoring sites were identified in Albania, Andorra, Bosnia, Bulgaria, Croatia, Cyprus, Denmark, Greece, Iceland, Liechtenstein, Luxembourg, Macedonia, Moldova, Monaco, Montenegro, Portugal, Romania, Serbia, Slovakia or Slovenia.

Data analysis

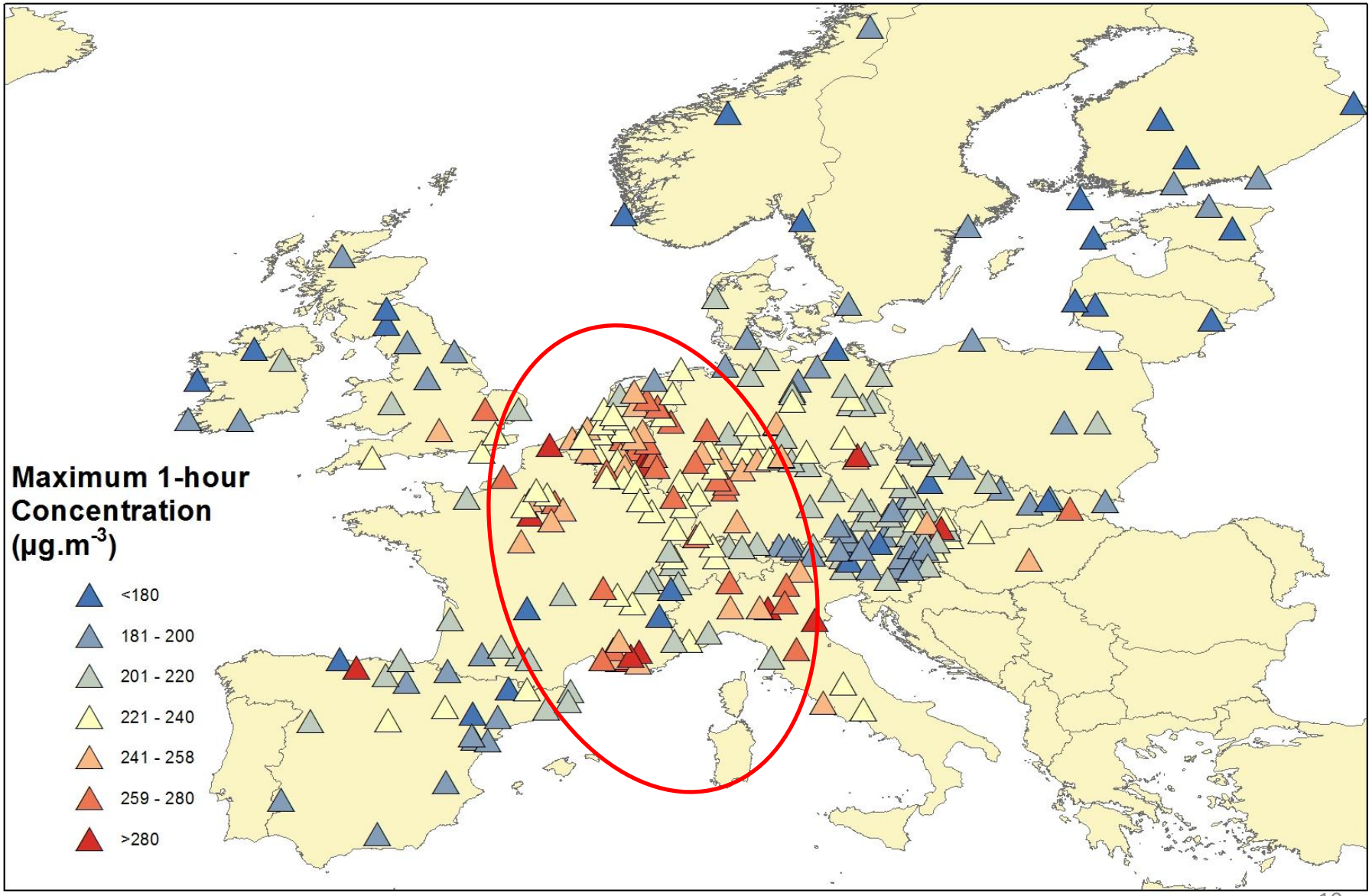
- Using *Openair*[1] four main analyses were carried out:
  - Trends in concentrations of ozone from **1996-2010** at the **138 sites** that have 15 years or more of data;
  - Trends in ozone from **2001 to 2010** at the **286 sites** in order to establish a broad spatial picture of decadal trends;
  - A comparison of decadal trends between **1996-2005 and 2001-2010** for the **138 sites** with full 15 year records in order to calculate differences in trends over two periods;
  - Comparisons between decadal trends from **2001 to 2010** in nitrogen oxides and ozone at **127 monitoring sites** with **collocated NOx and O_3** monitoring
- Trend analyses for mean, peak (95th percentile) and 'background' (5th percentile) concentrations (following Wilson *et al.*)
- Significance values $p<0.1$ for trends at individual monitoring stations
- Mean trends across all monitoring stations within each of the countries have also been calculated.

[1] http://www.openair-project.org/

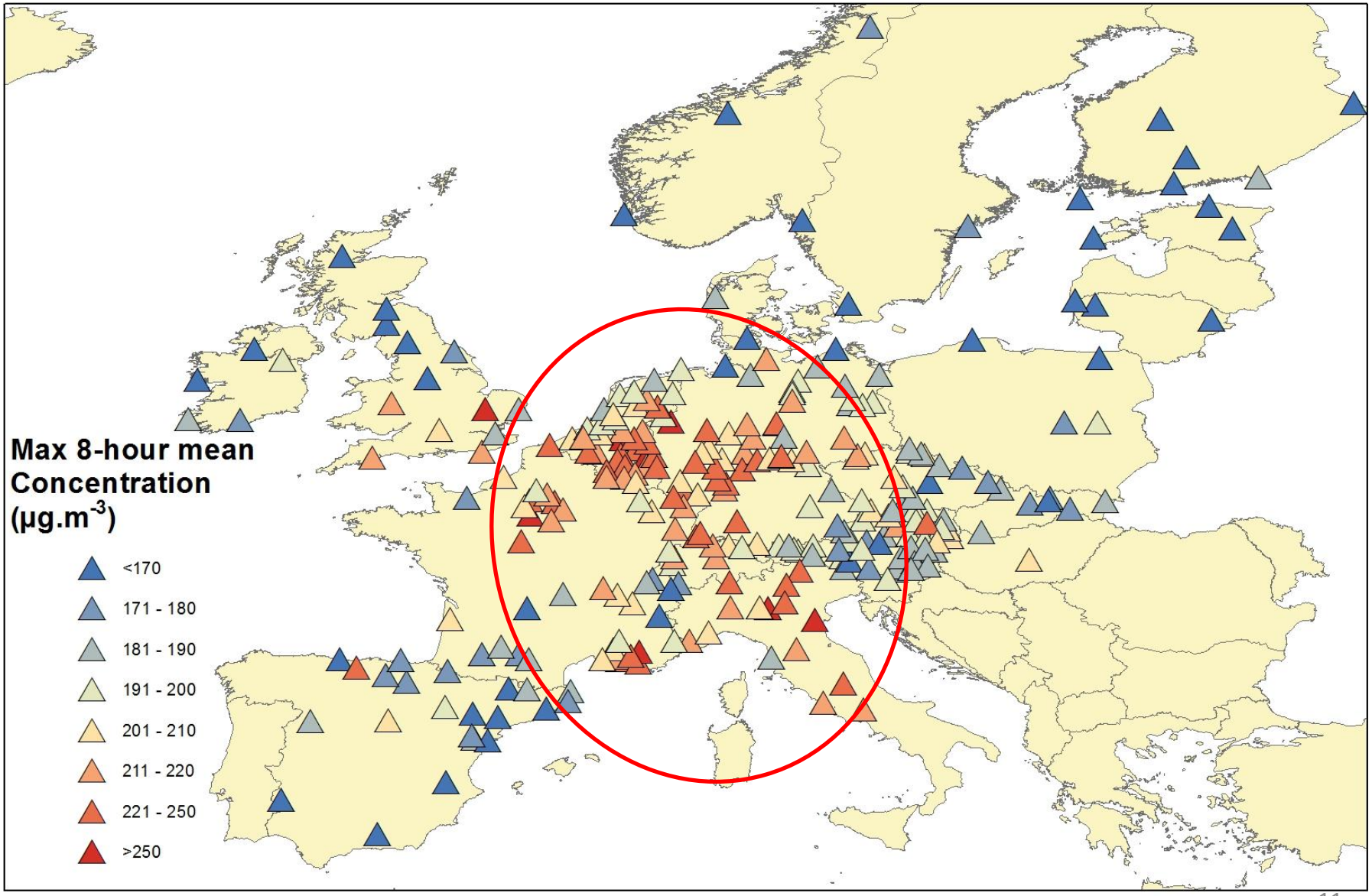
Mean Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010



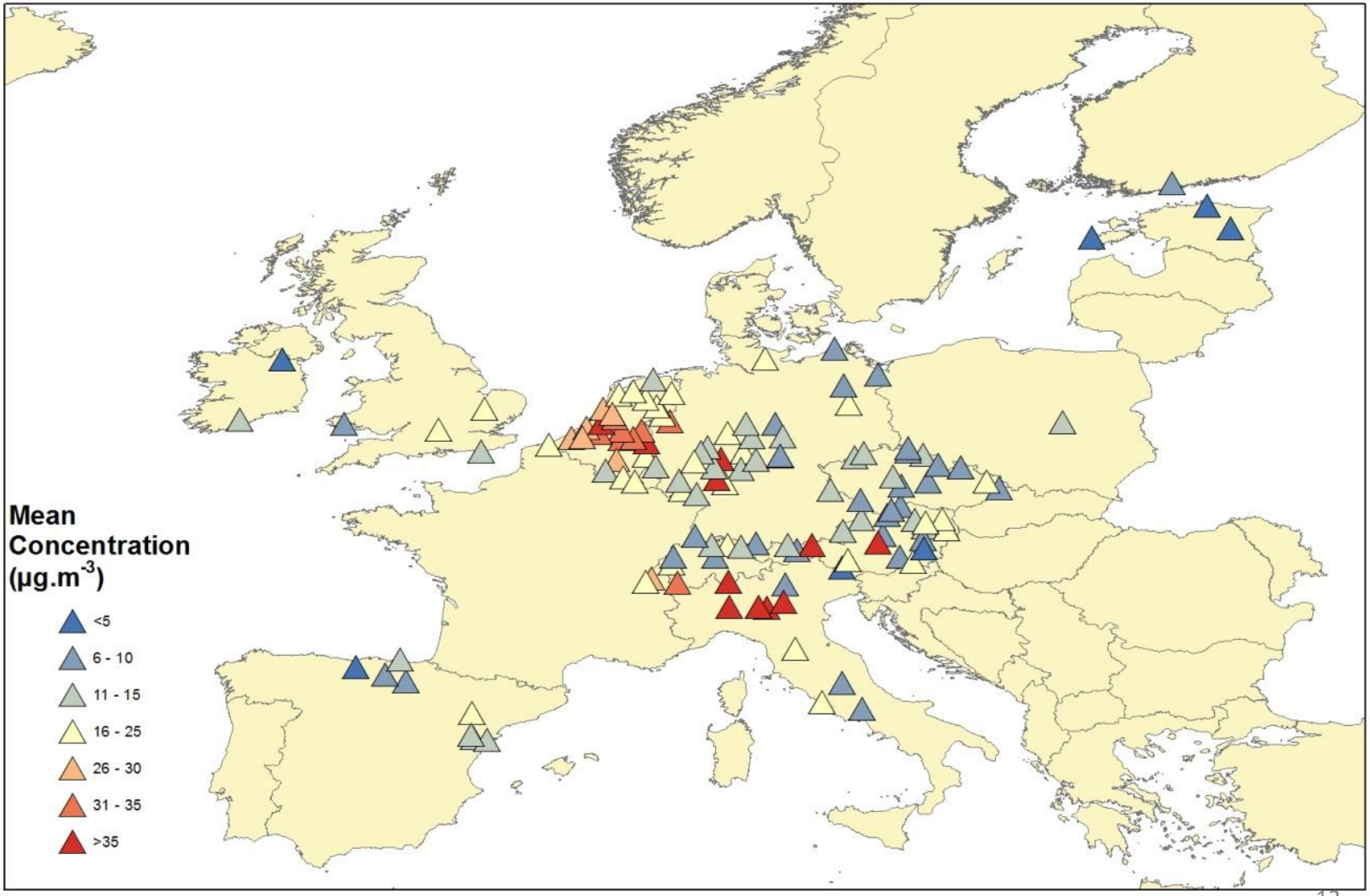
Maximum Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010



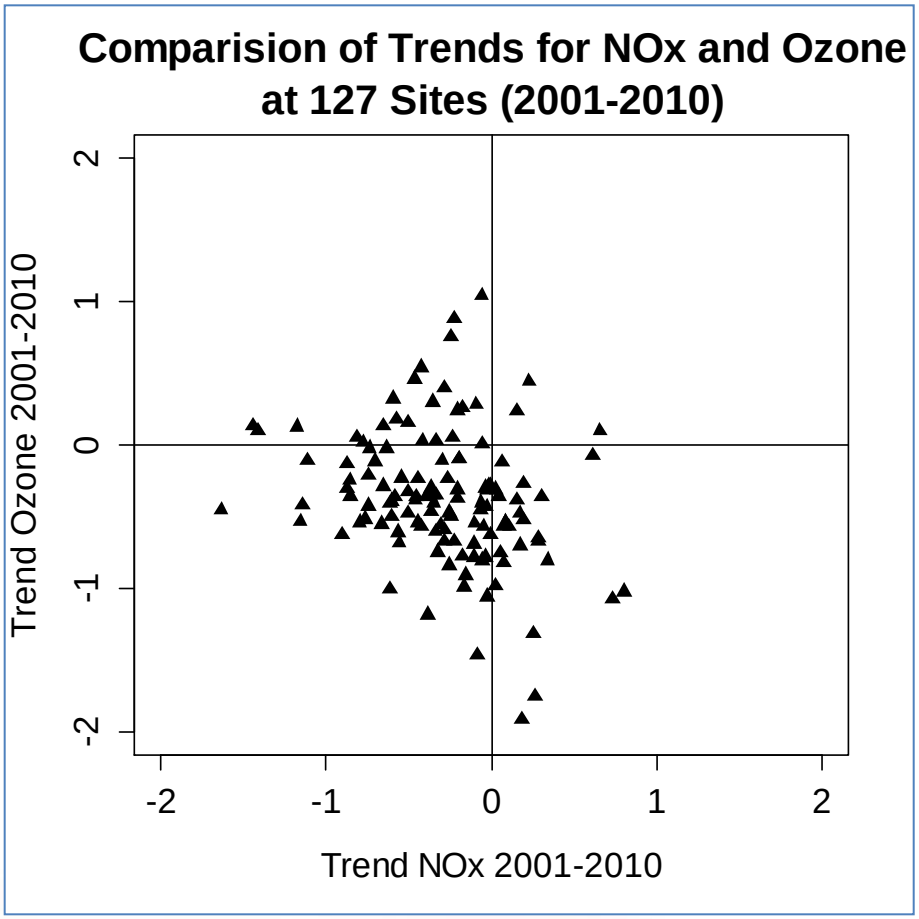
Maximum 8-hour Mean Ozone at 286 Rural Background Monitoring Stations 2001-2010



Mean Nitrogen Oxides at 127 Rural Background Monitoring Stations 2001-2010

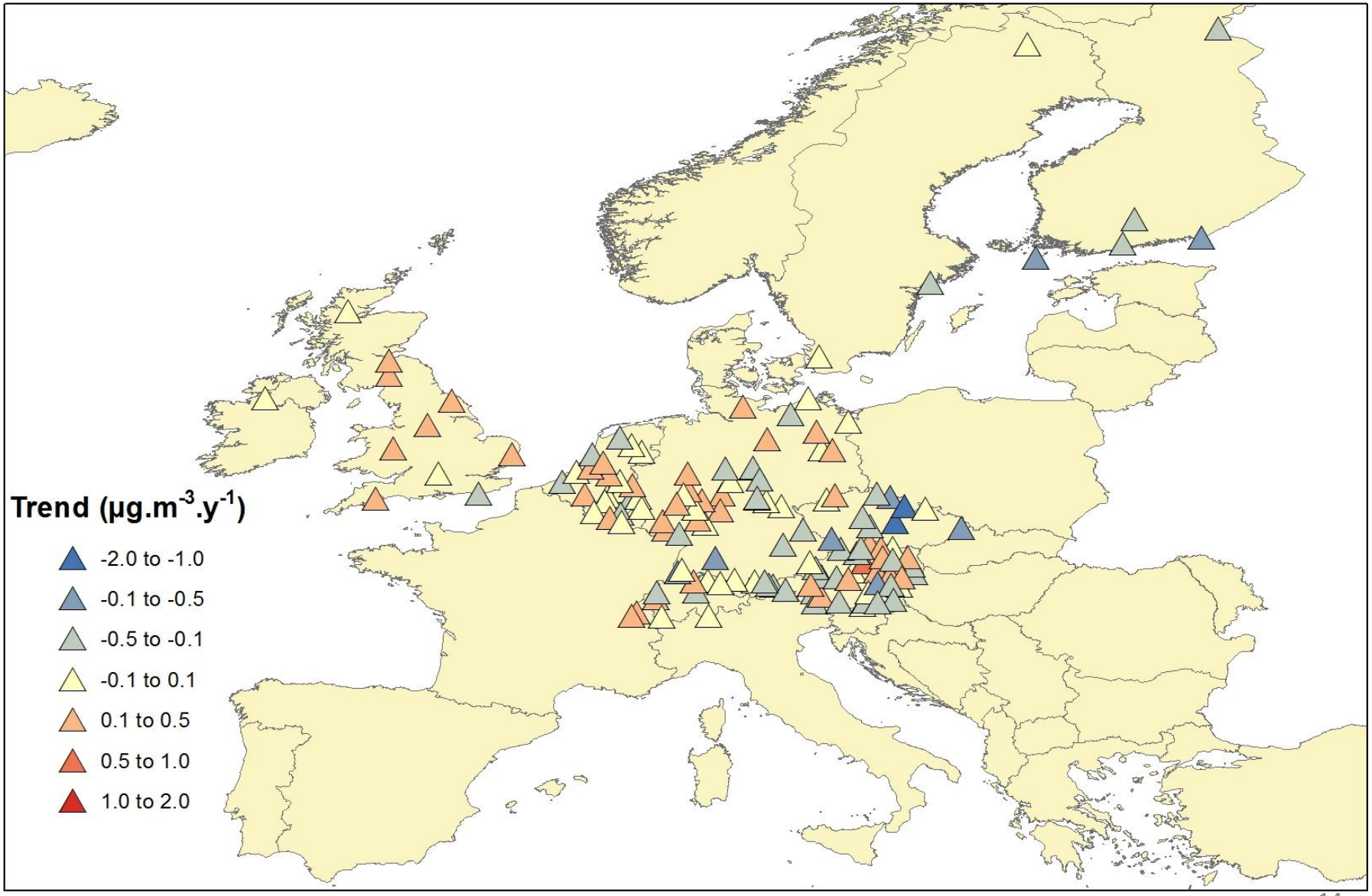


Comparison of trends in O_3 and NOx 2001-2010

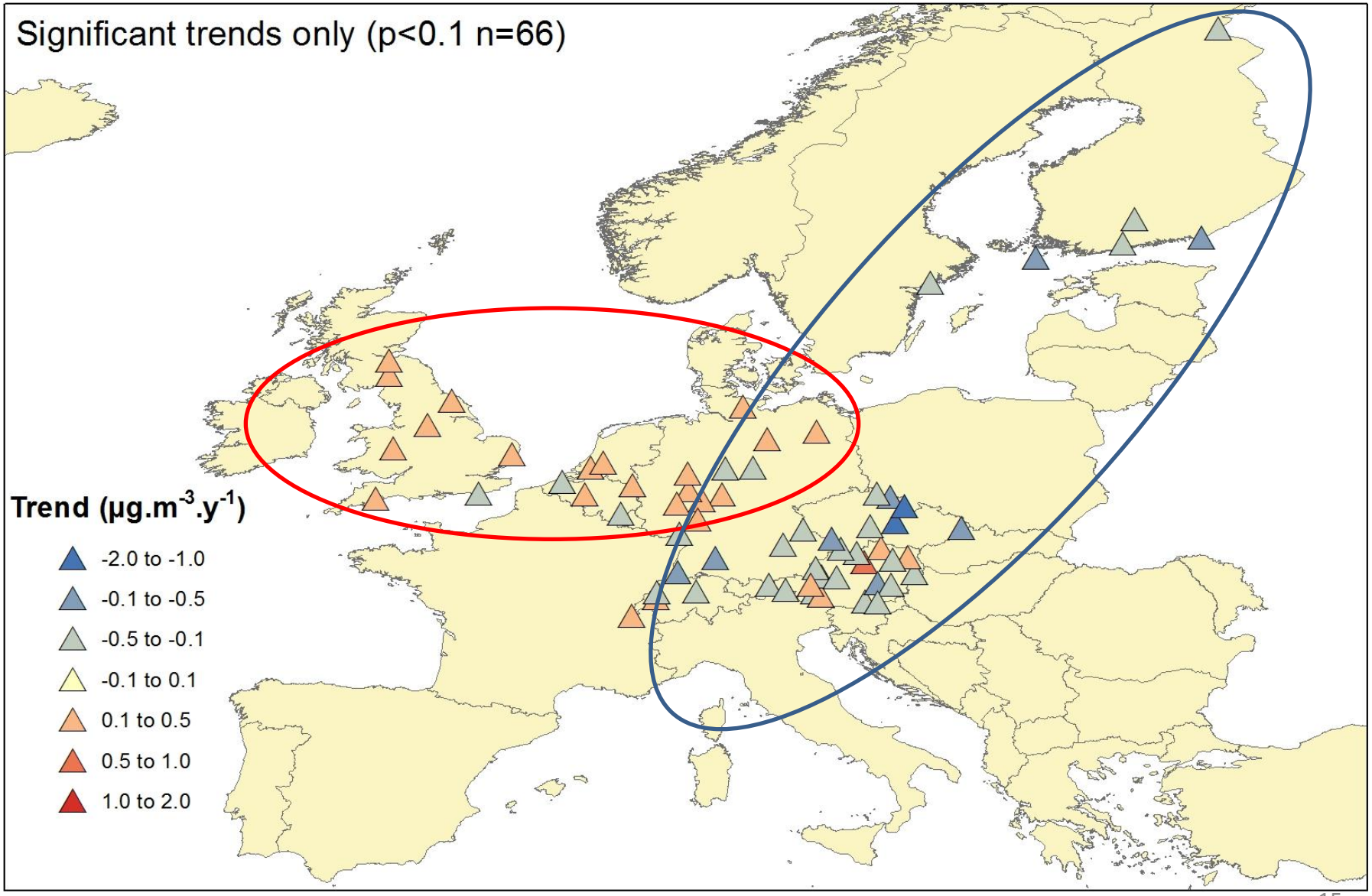


- Most sites showed negative trends in both pollutants.
- Any overall reductions in background ozone over the last decade are therefore unlikely to have been due to increases in NOx.

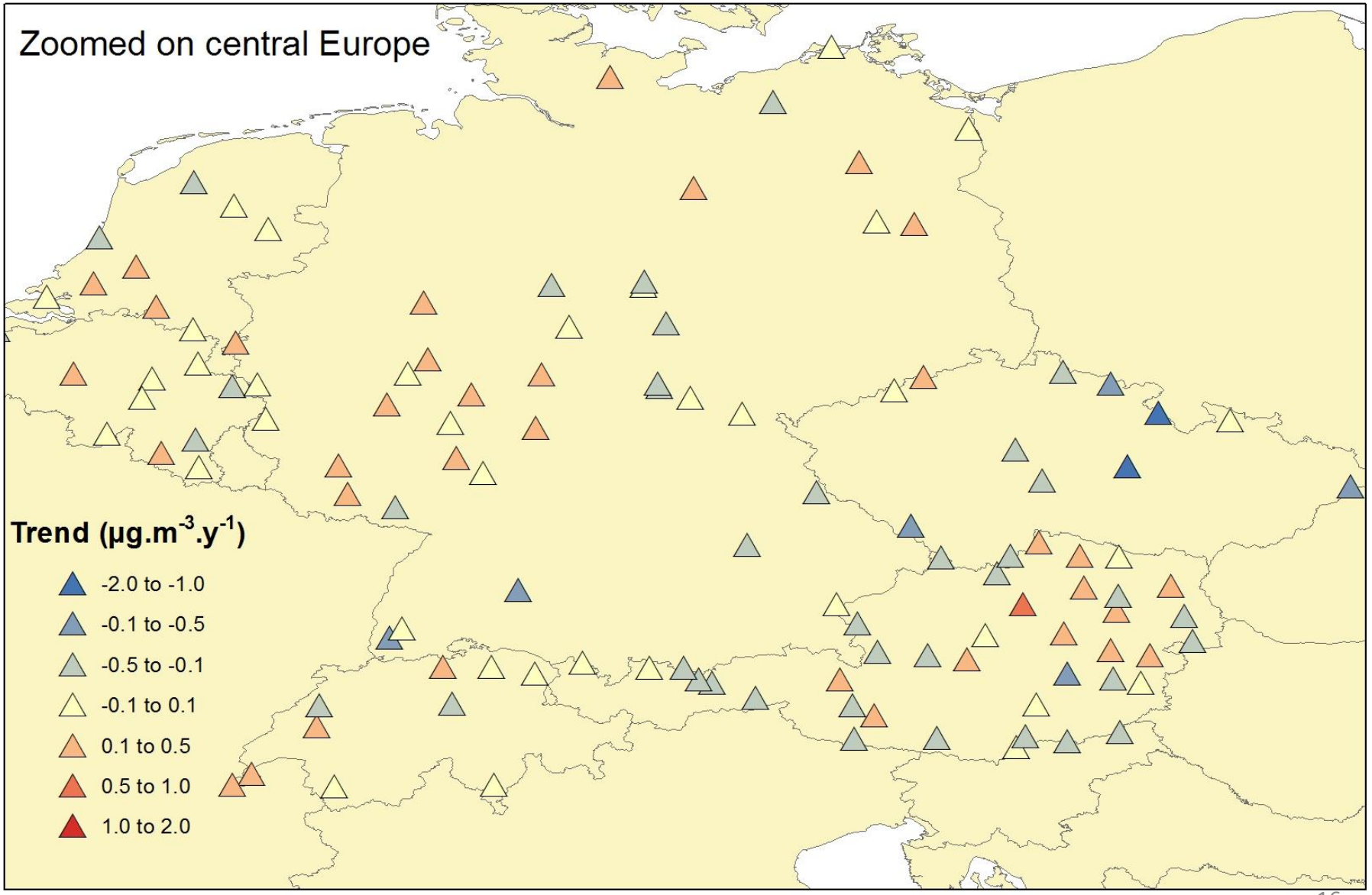
Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations 1996-2010



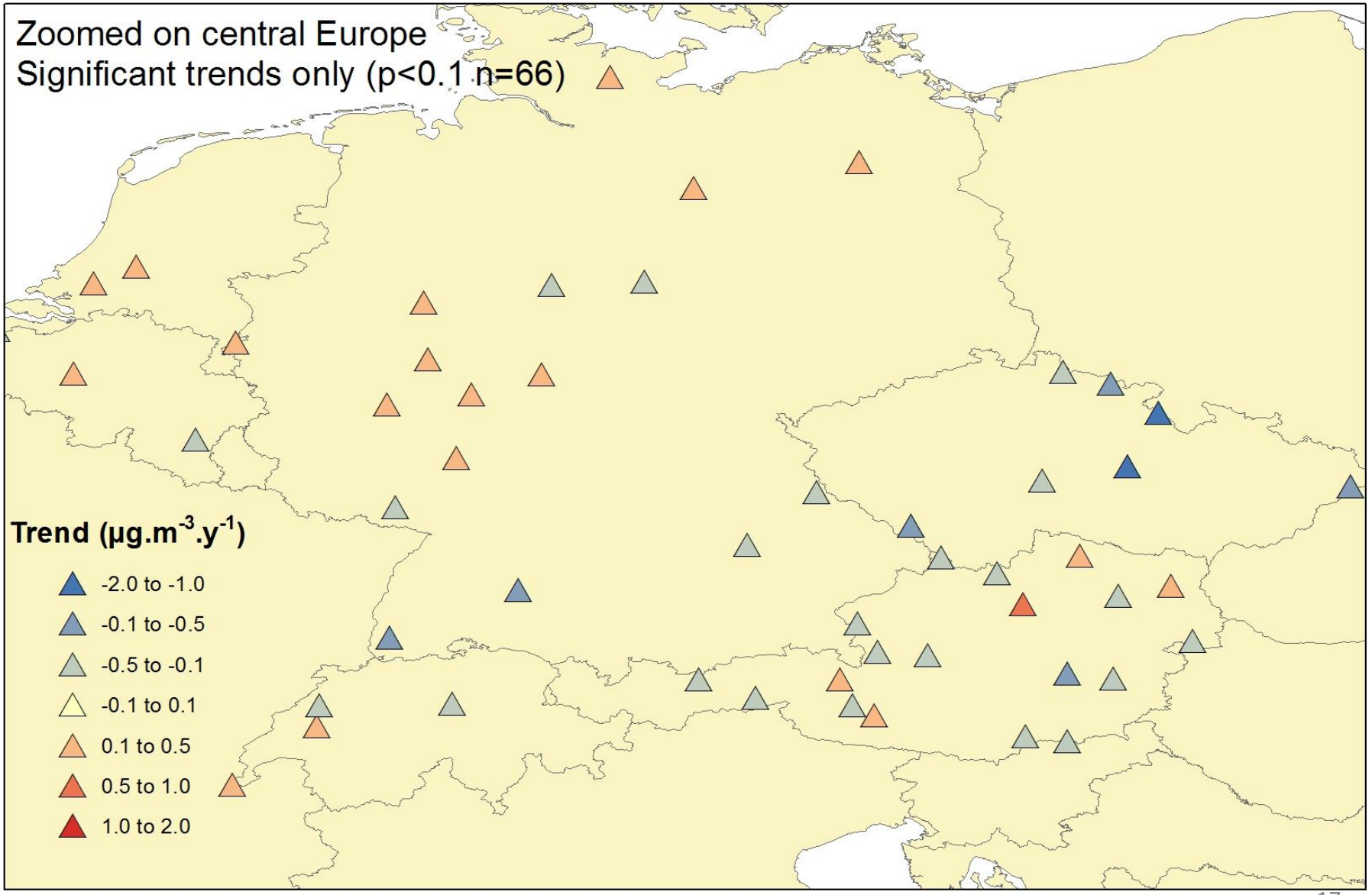
Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations 1996-2010



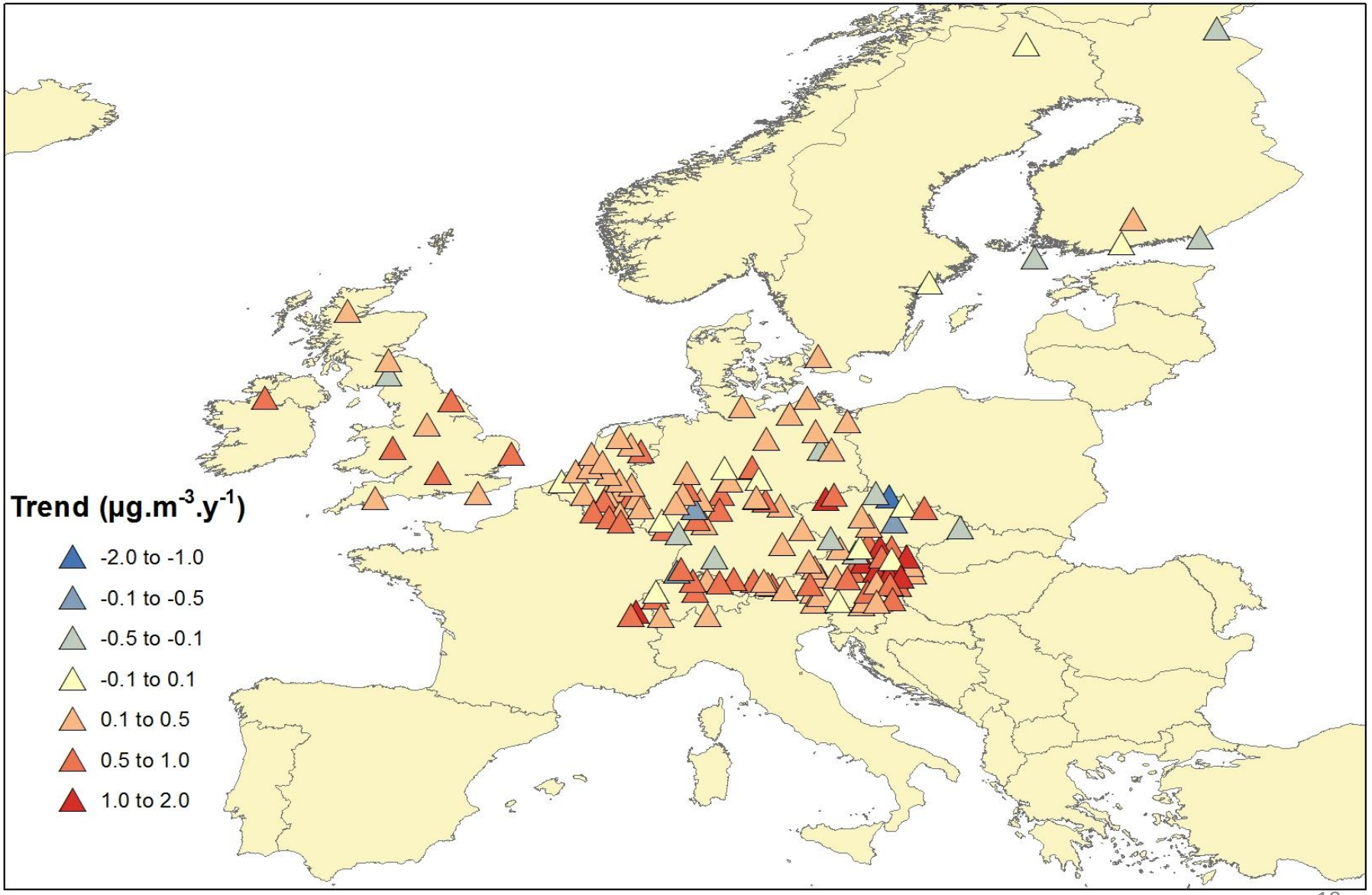
Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations 1996-2010



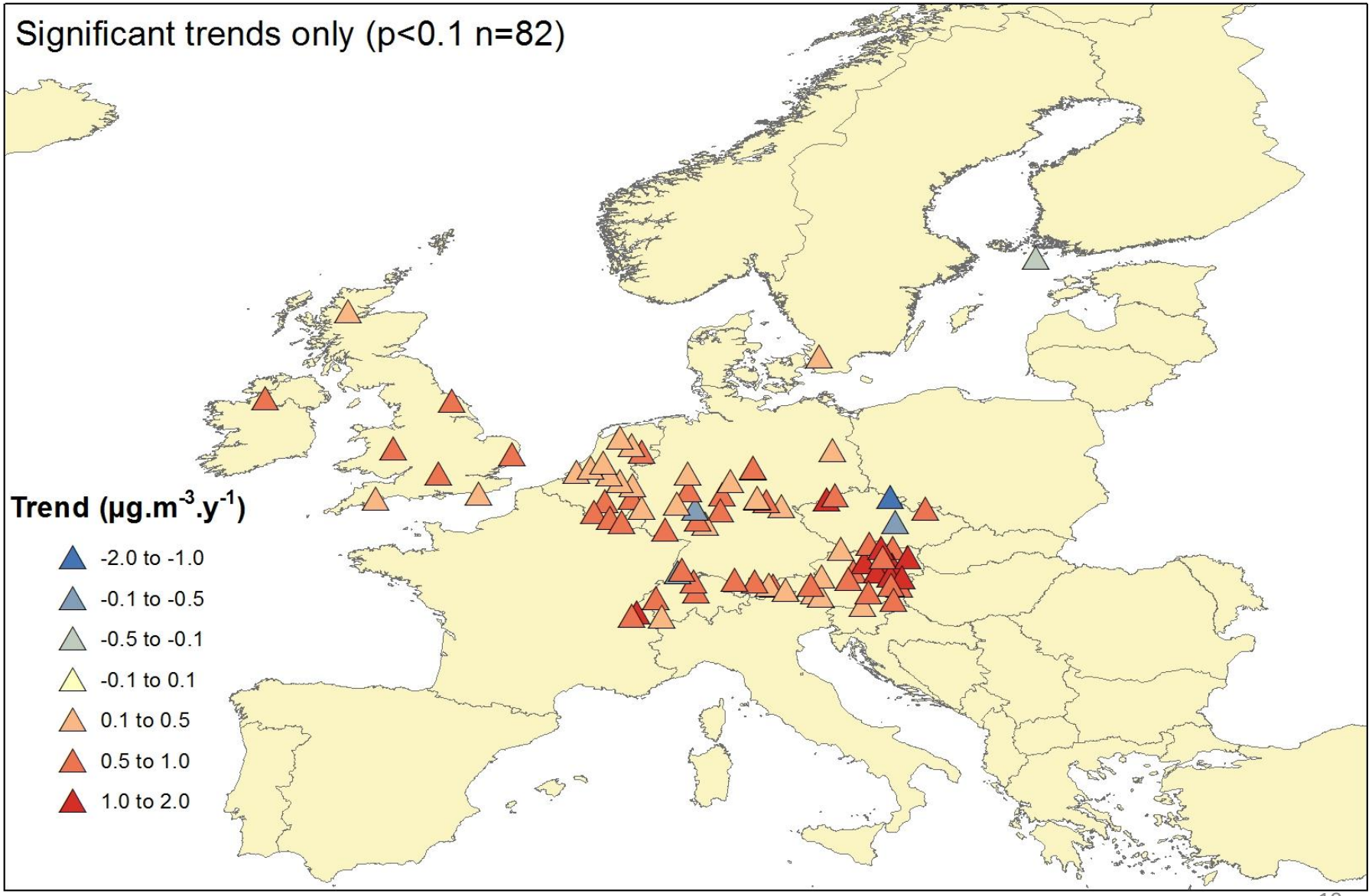
Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations 1996-2010



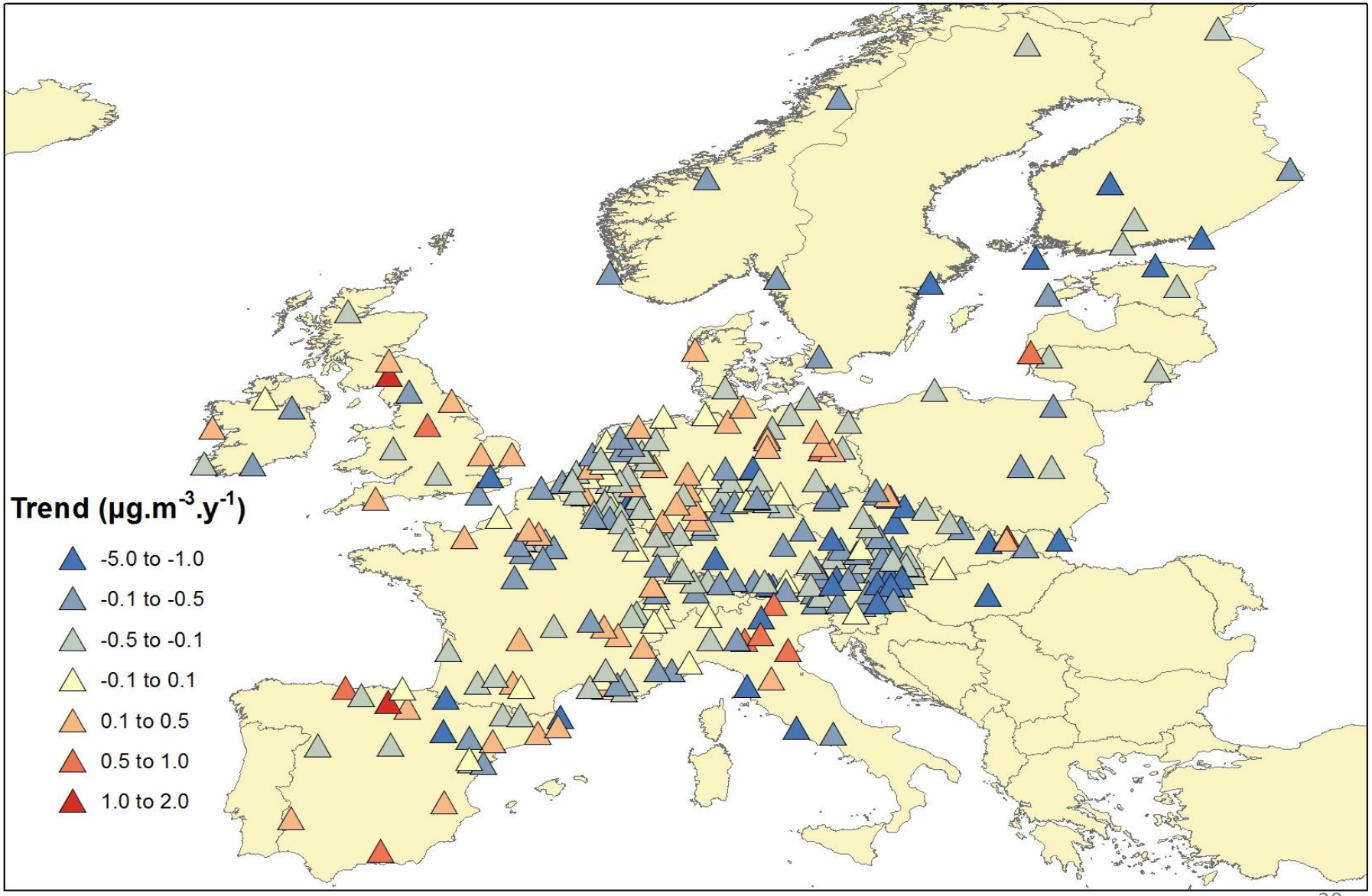
Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations 1996-2005



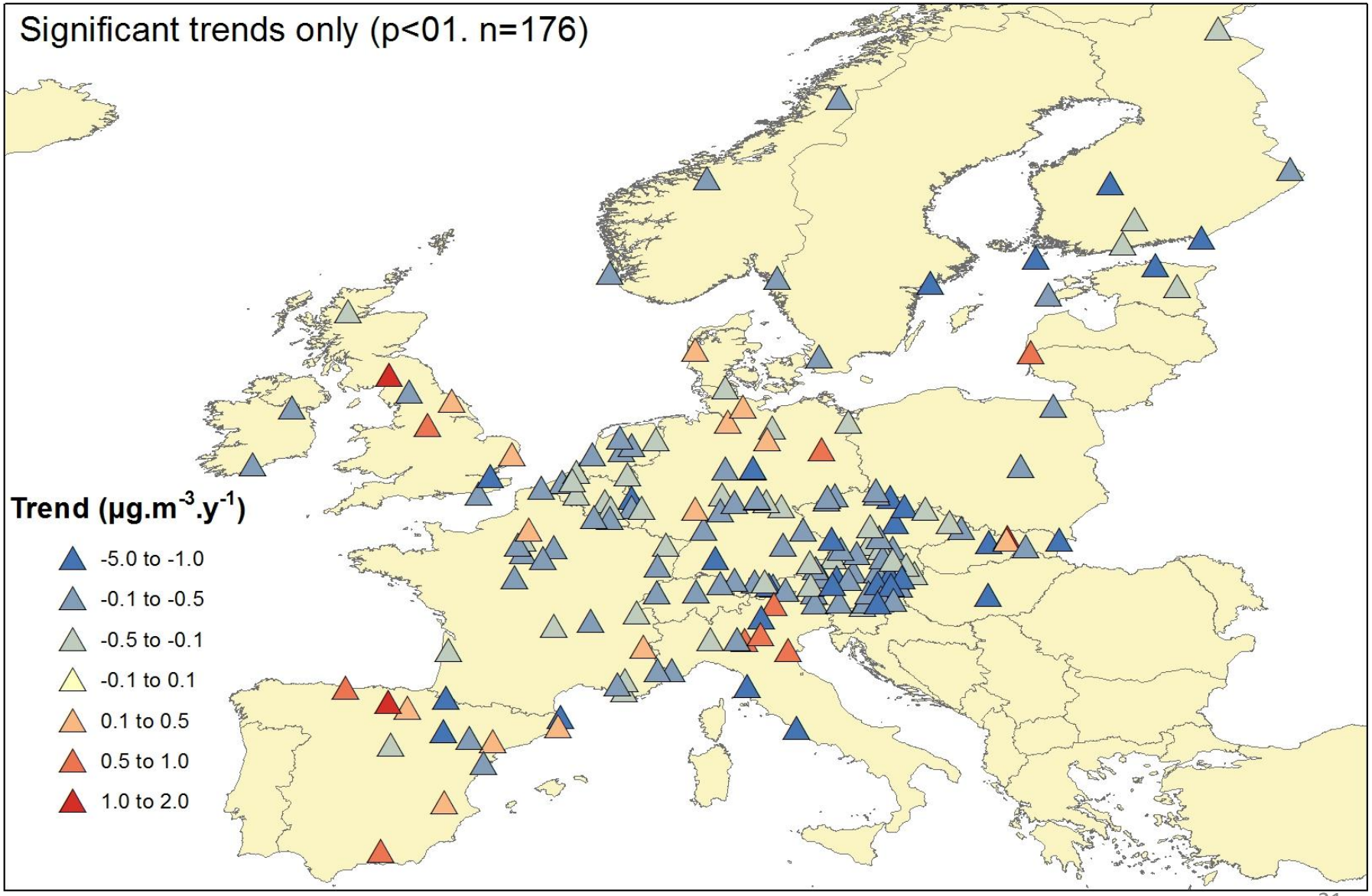
Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations 1996-2005



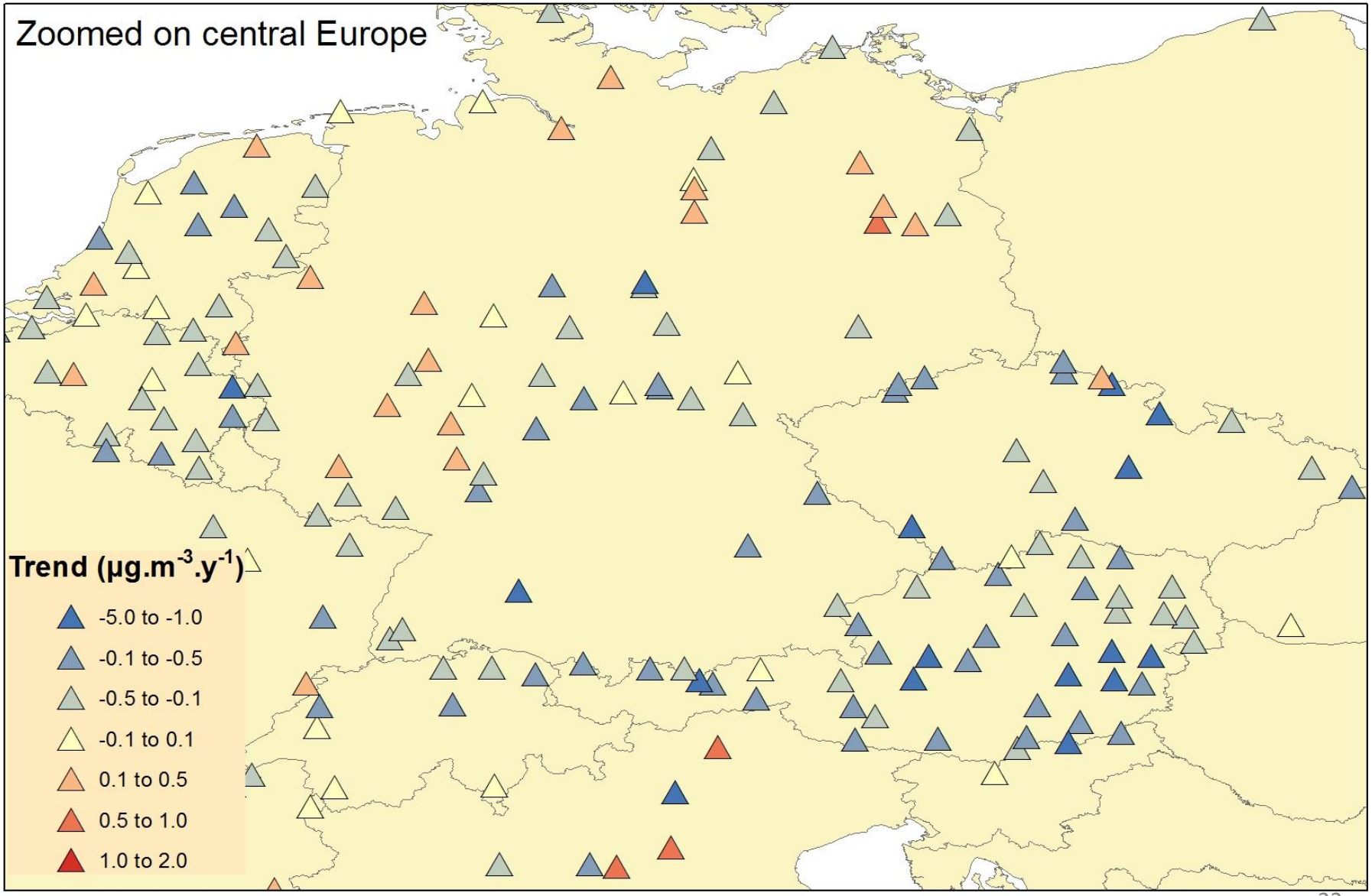
Trend in Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010



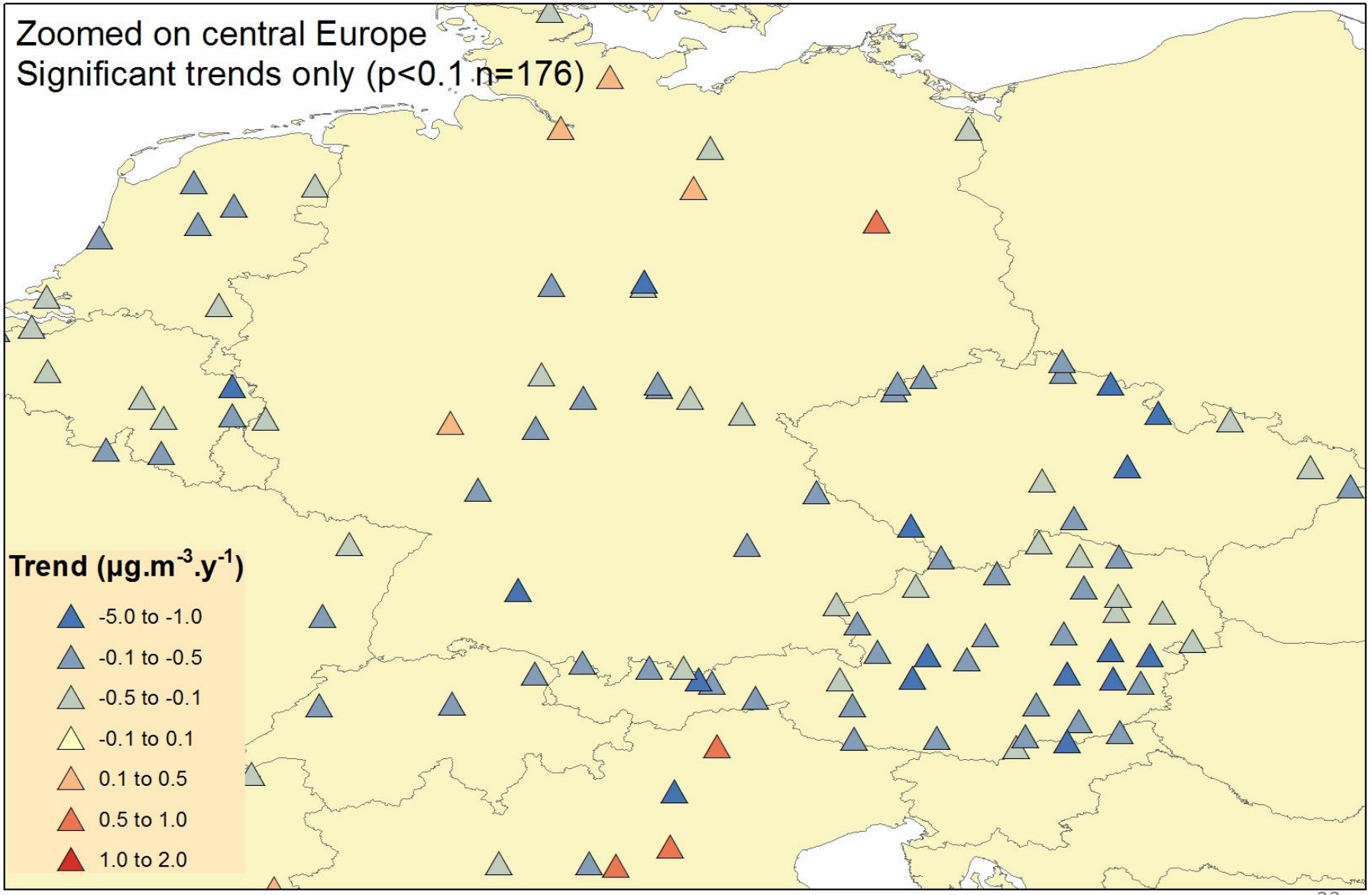
Trend in Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010



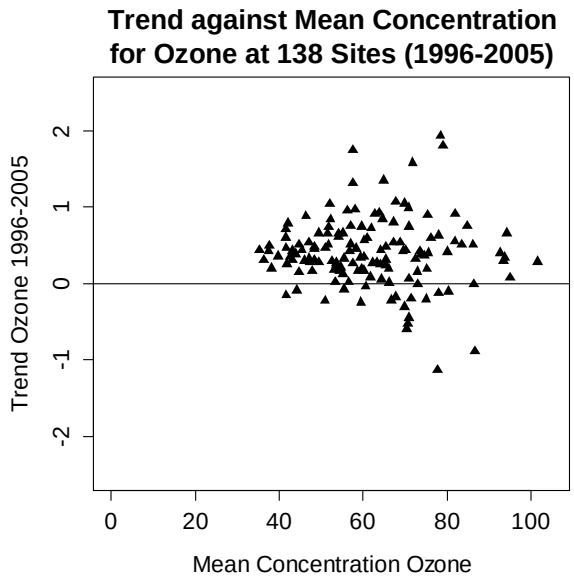
Trend in Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010

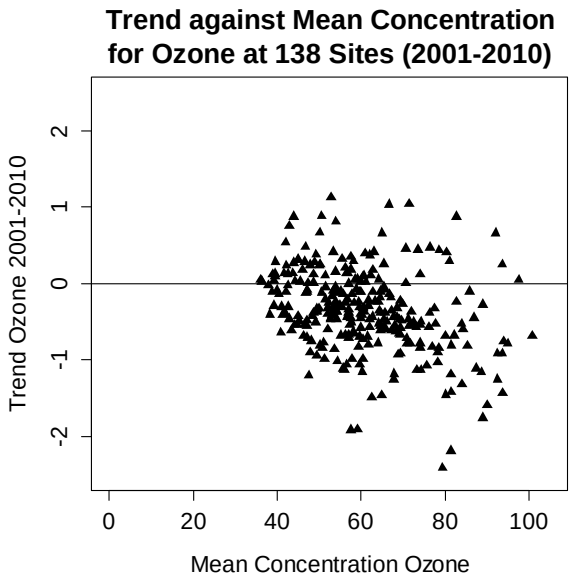


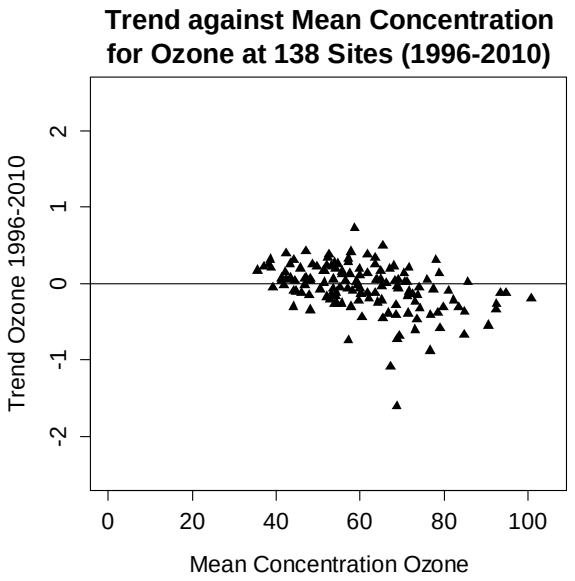
Trend in Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010



Trend in O_3 concentrations against mean concentration (1996-2010, 1996-2005 & 2001-2010)

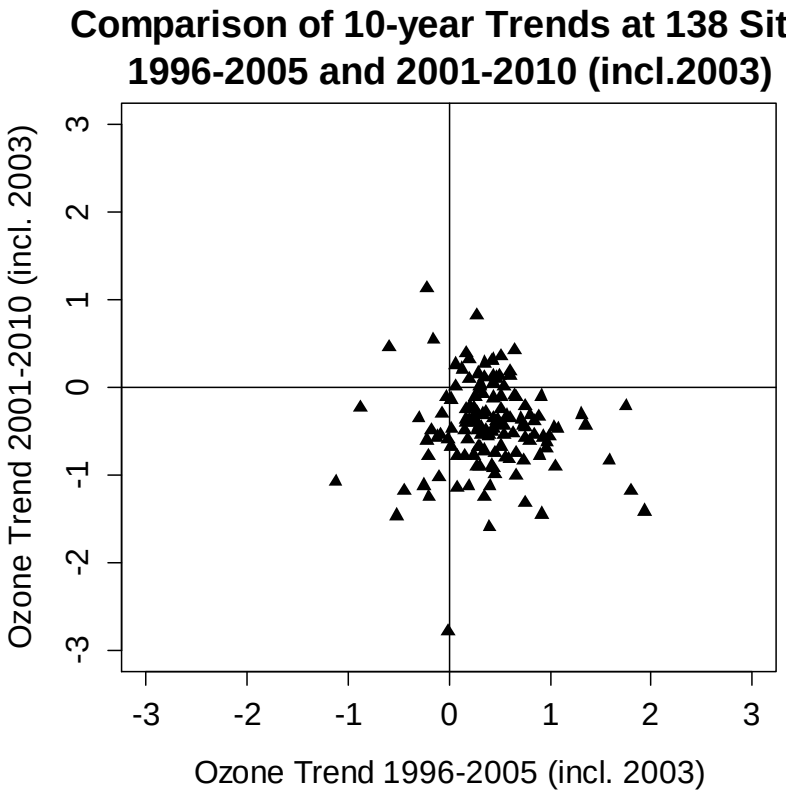


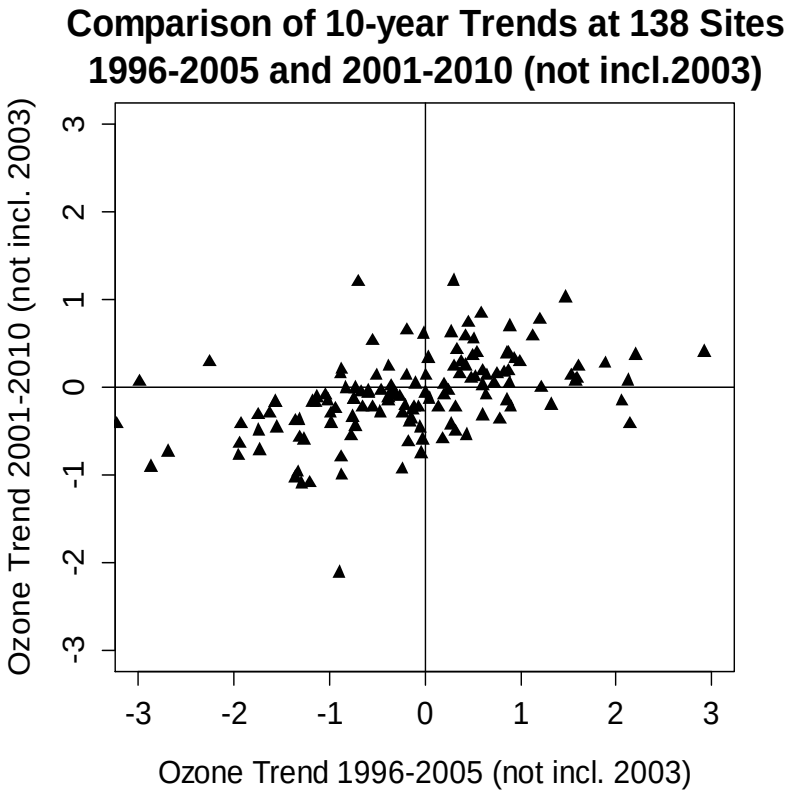




- Over the entire 15 year period (RH plot), sites with higher mean concentrations tended to show a reduction in concentration.
- In the first decadal period (1996 - 2005) sites tended to have an increasing trend, irrespective of overall mean concentration.
- In the second decadal period (2001-2010), most sites saw a reduction in concentrations, with the greatest reduction occurring at the sites with highest mean concentrations. Where there were increasing trends in this period, there was no clear relationship to mean concentrations.

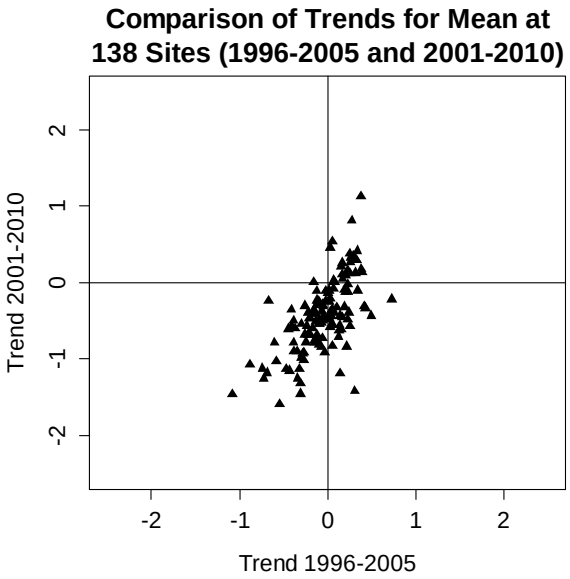
Scatter plots showing influence of 2003 on long-term trends

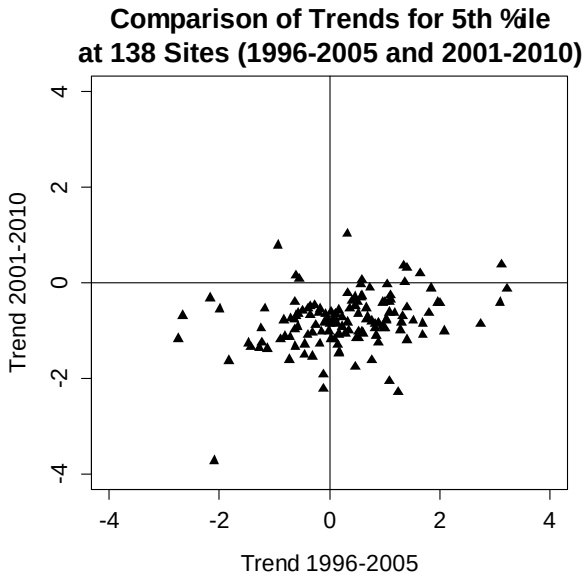


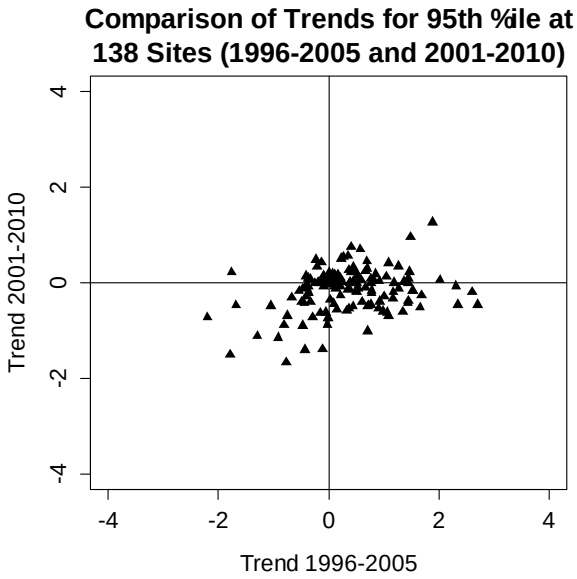


- 2003 had a substantial effect leading to increasing trends in the first decadal period (1996-2005), but less impact on trends in the second period (2001-2010).
- The RH plot reflects the finding elsewhere that sites that showed a downward trend in the first period, also showed a downward trend in the second, and vice versa.

Comparison of trends in mean, 5th and 95th percentiles between 1996-2005 and 2005-2010







- Trends for each site in the monthly mean and 5th %ile concentrations in the first decadal period were often reproduced in the second.
- Where trends differed (e.g. 5th %ile comparison), these tended to show an increasing trend 1996-2005 & a decreasing trend 2001-2010.
- Trends in 95th %ile reflected the same pattern but with a lower increasing trend in the second decadal period.
- Across all measurements, there were virtually no sites with decreasing trends in the first period and increasing in the second.

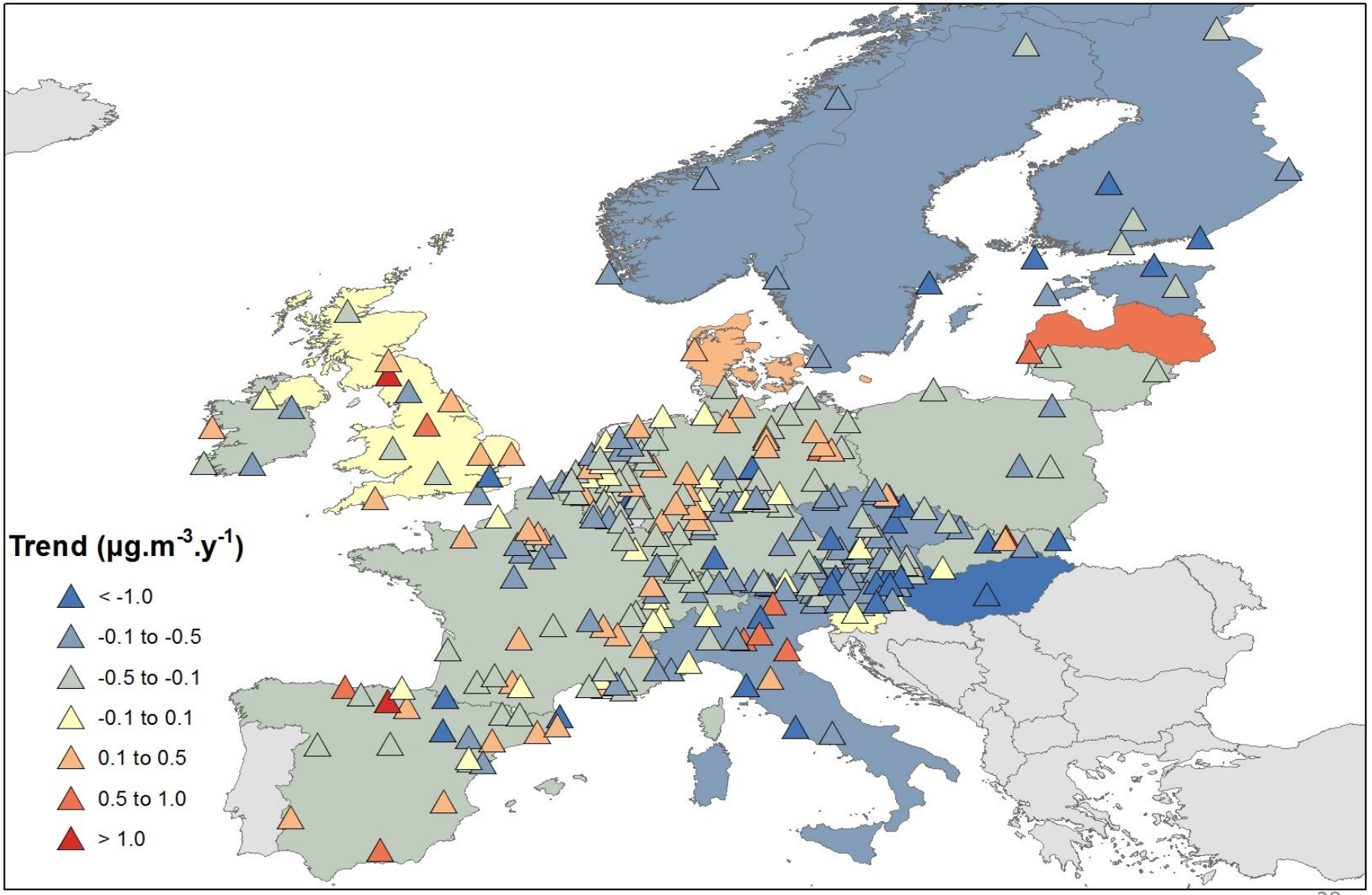
Average trend by country (138 sites 1996-2010, 1996-2005, 2001-2010)

	Ozone Trend 1996-2010			Ozone Trend 1996-2005			Ozone Trend 2001-2010		
Country	Mean	5th %ile	95th %ile	Mean	5th %ile	95th %ile	Mean	5th %ile	95th %ile
Austria	-0.20	-0.16	0.04	0.67	-0.12	0.48	-0.72	-0.96	-0.47
Belgium	-0.02	-0.46	0.08	0.45	0.63	0.18	-0.34	-0.91	-0.01
Switzerland	0.03	-0.39	0.25	0.52	-0.31	0.31	-0.32	-0.75	0.03
Czech Republic	-0.52	-0.70	-0.37	0.01	-0.01	0.64	-0.88	-1.17	-0.57
Germany	-0.01	-0.23	0.14	0.29	0.41	0.26	-0.26	-0.67	0.03
Finland	-0.44	-0.58	-0.26	-0.14	0.15	0.25	-0.73	-0.82	-0.46
United Kingdom	0.15	-0.10	0.36	0.41	1.29	0.73	0.11	-0.27	0.36
Netherlands	0.06	-0.27	0.11	0.42	0.29	-0.05	-0.28	-0.83	0.10
Sweden	-0.16	-0.31	-0.11	0.15	-1.05	-0.56	-0.67	-0.91	-0.47

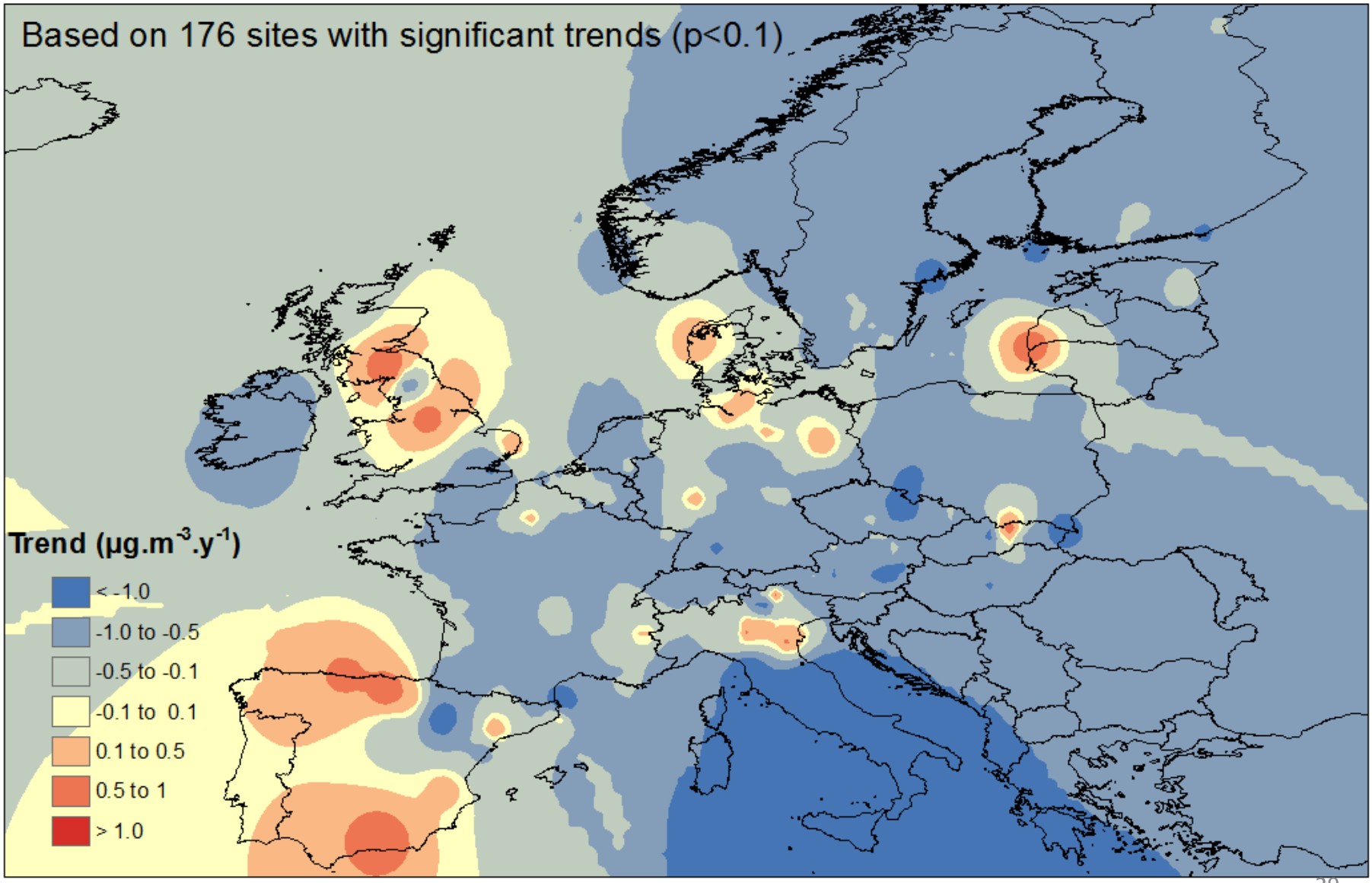
Red indicates trend > 0.5 $\mu g.m^{-3}.y^{-1}$, Blue indicates trend < -0.5 $\mu g.m^{-3}.y^{-1}$

- General tendency for trends to be upwards in the first period and downward in the second for the mean concentrations and for the 5th percentile.
- 95th percentile tended to increase across both decadal periods.

Trend in Ozone Concentrations at 138 Rural Background Monitoring Stations and Country Averages1996-2010



IDW Interpolation of 10-Year Trend in Ozone Concentrations at 286 Rural Background Monitoring Stations 2001-2010



Results

- Highest mean concentrations tend to be in S and E Europe. Highest maximum 1-hour and 8-hour concentrations show a different pattern. Generally mean and max. concentrations tend to be inversely related.
- Mean concentrations in NW Europe (UK, Germany, Netherlands) tended to increase, whilst mean concentrations in E. Europe and Scandinavia (Czech Republic, Sweden, Finland) decreased.
- Trends not consistent over Europe, and there is a tendency for trends to have increased in the areas of lowest mean concentration (NW Europe), and to have decreased in the areas of highest mean concentration (SE Europe). There are notable exceptions to the general downward trend from 2001 to 2010 which include Spain, the UK, northern Germany and northern Italy.
- Clear difference in decadal trends:1996-2005 tendency for mean concentrations to increase, whilst 2001-2010 tendency for mean concentrations to decrease. Largely influenced by 2003 concentrations.

Conclusions

- EU monitoring network is only now coming to the stage where widespread spatial trends can be evaluated
- Patterns of ozone pollution over Europe are highly complex
- Unlikely that a ‘one size fits all’ policy will be suitable for all Member States
- Better information on the nature of any region’s problem will be vital for effective management strategies

Acknowledgement

- This work was undertaken as part of a service contract for DG ENV, European Commission.
- Published as supporting documents in the review of air quality policy http://ec.europa.eu/environment/air/review_air_policy.htm
- However, this presentation does not necessarily reflect the opinion or position of the Commission or of its services.

References

- EEA, (2009) Assessment of ground-level ozone in EEA member countries, with a focus on long-term trends, Technical report No 7/2009 http://www.eea.europa.eu/publications/assessment-of-ground-level-ozone-in-eea-member-countries-with-a-focus-on-long-term-trends

- Wilson, R. C., Fleming, Z. L., Monks, P. S., Clain, G., Henne, S., Konovalov, I. B., Szopa, S., and Menut, L.: Have primary emission reduction measures reduced ozone across Europe? An analysis of European rural background ozone trends 1996–2005, Atmos. Chem. Phys., 12, 437-454, doi:10.5194/acp-12-437-2012, 2012 http://www.atmos-chem-phys.net/12/437/2012/acp-12-437-2012.html

Institute for Sustainability, Health and Environment

healthy people + healthy planet

Thank you for your attention.

Any questions?

Email: jo.barnes@uwe.ac.uk

LinkedIn: http://www.linkedin.com/pub/jo-barnes/a/299/561

Twitter: https://twitter.com/jobarnes_uwe

Skype: jo5.barnes

Website: http://www1.uwe.ac.uk/et/research/aqmrc

Bristol City Council
European Green Capital
Air Quality Masterclass
October 2014

- European event to be held in Bristol, UK
- 28-29 October 2014
- Showcase air quality management successes in European cities
- Interactive workshop to discuss and develop solutions
- You're all invited!
- FREE OF CHARGE!!
- To find out more, please email me: jo.barnes@uwe.ac.uk