School of Earth and Environment
INSTITUTE FOR CLIMATE & ATMOSPHERIC SCIENCE
UNIVERSITY OF LEEDS

Widespread changes in UK air quality observed from space

Richard Pope

SEE-Chem Seminar - Thursday 26th October

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL
National Centre for Atmospheric Science
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Motivation – Air Quality

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Degradation in UK air quality results in:

- Approximat
- Reduces life
- C).

Legis
from

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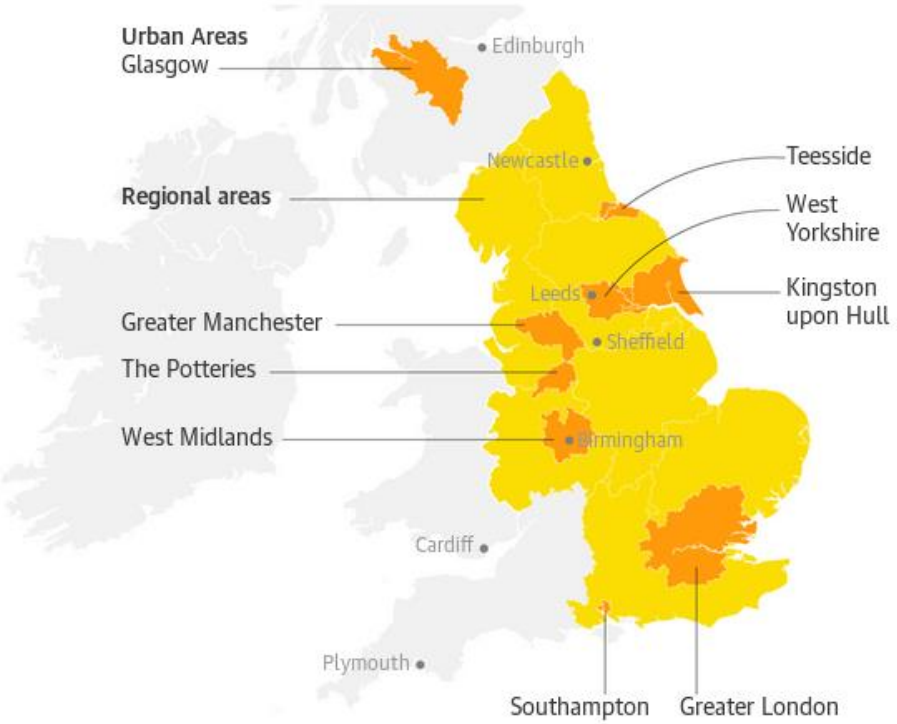
The European commission has sent a 'final warning' to the UK for failing to address repeated breaches of legal air pollution limits in 16 areas



European Commission

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breaches

pollution

Brussels, 15 Februa

The European Commission sends final warnings to Germany, France, Spain, Italy and the United Kingdom for failing to address repeated breaches of air pollution limits for nitrogen dioxide (NO2). NO2 pollution is a serious health risk. Most emissions result from road traffic.

Satellite Data

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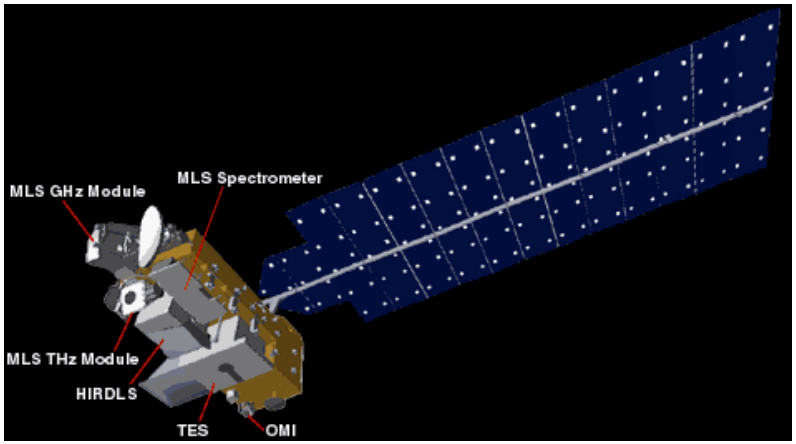
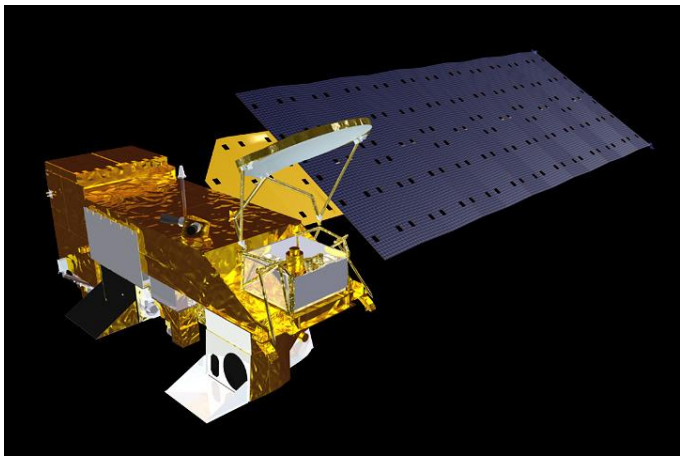
Ozone Monitoring Instrument (OMI)



- On-board NASA Aura satellite.
- Nadir viewing.
- UV-VIS range of 270-500 nm.
- OMI data from 2004 – present.
- Overpass time of 13.45 LT.

Moderate Resolution Imaging Spectroradiometer (MODIS)



- On-board NASA's AQUA satellite.
- Nadir viewing.
- Vis-IR range of 620- 876 nm.
- MODIS data from 2002–present.
- Overpass time of 13.30 LT.

High Resolution Satellite Data

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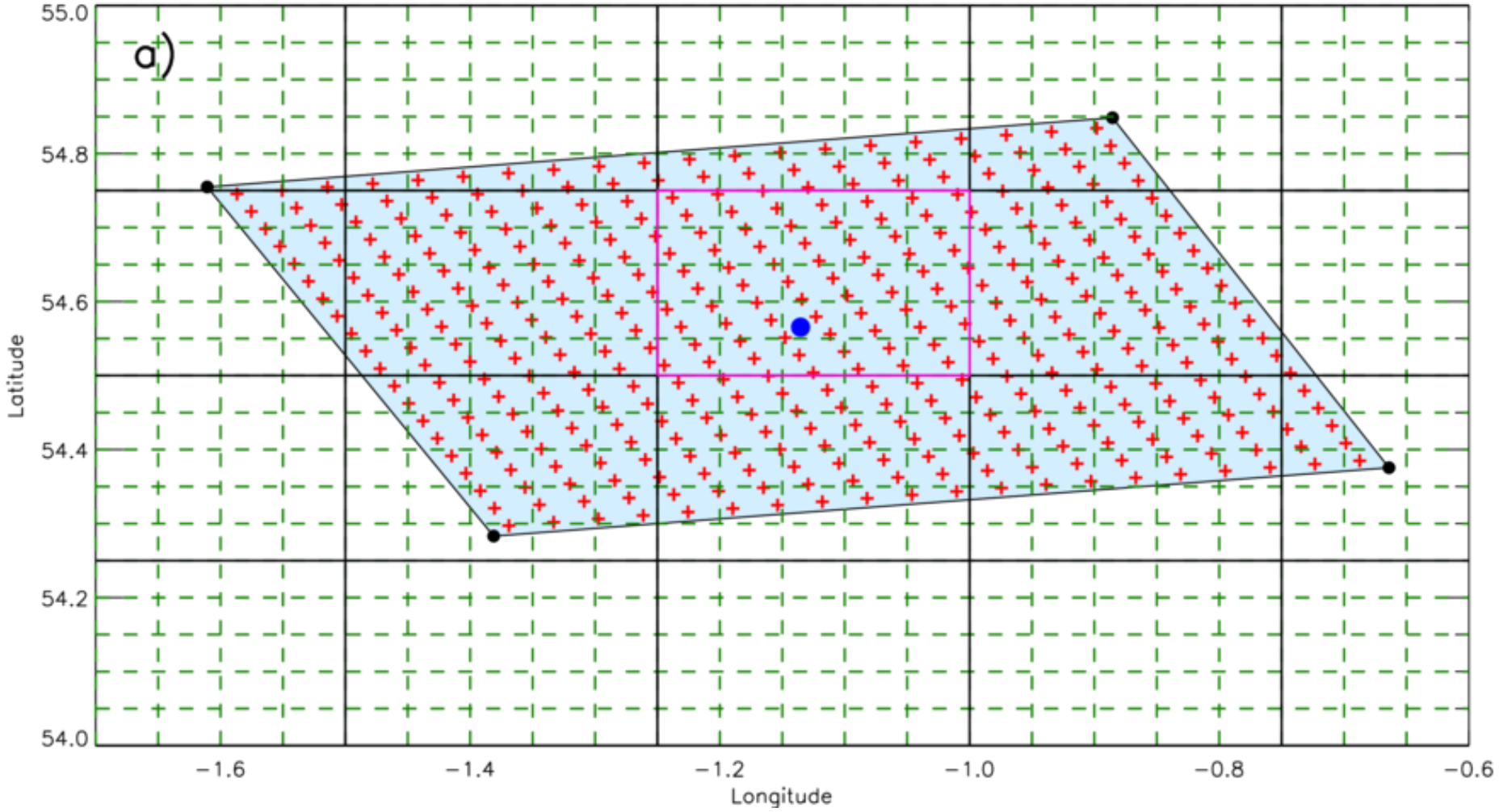

Pope et al., (submitted), ASL

High Resolution Data (2005-2006)

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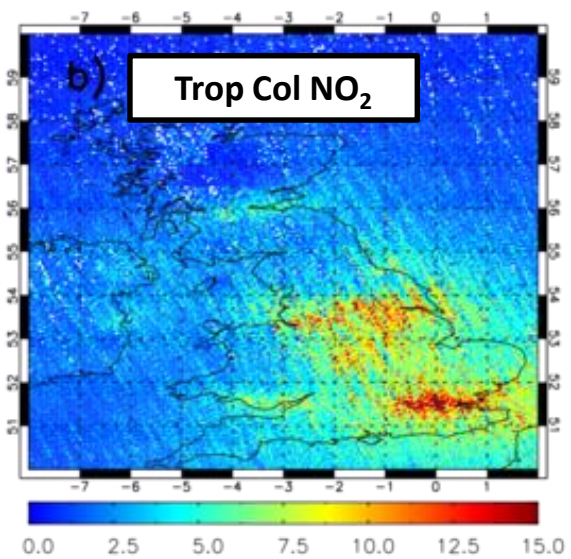

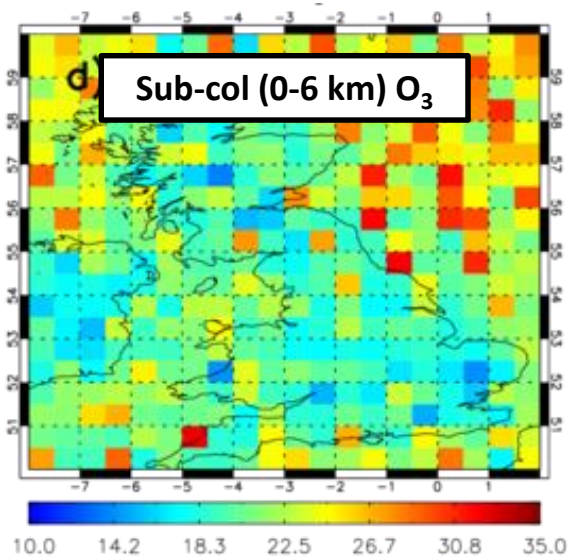

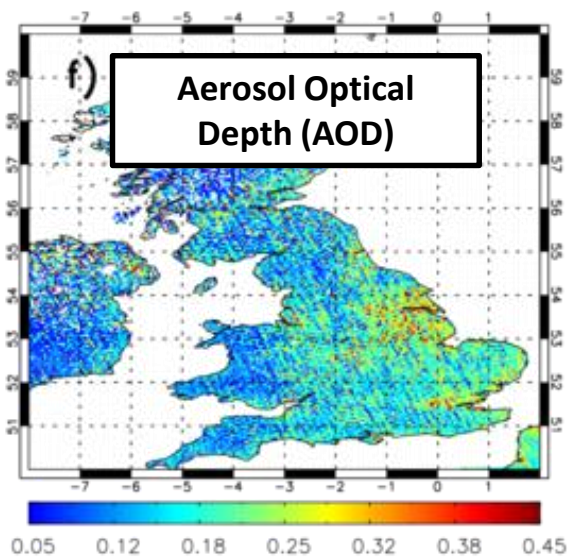

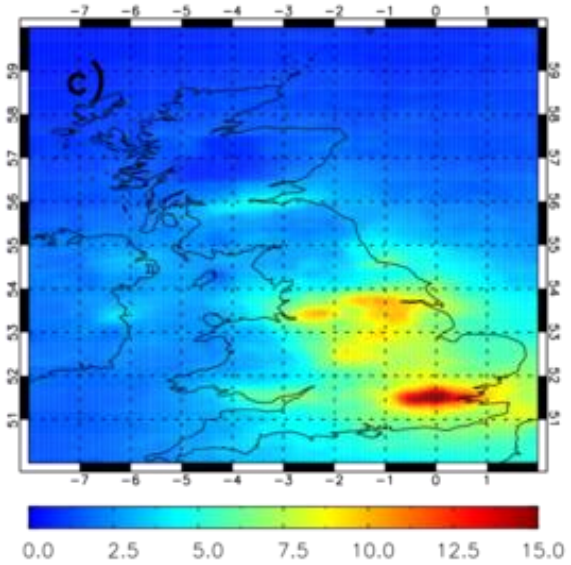

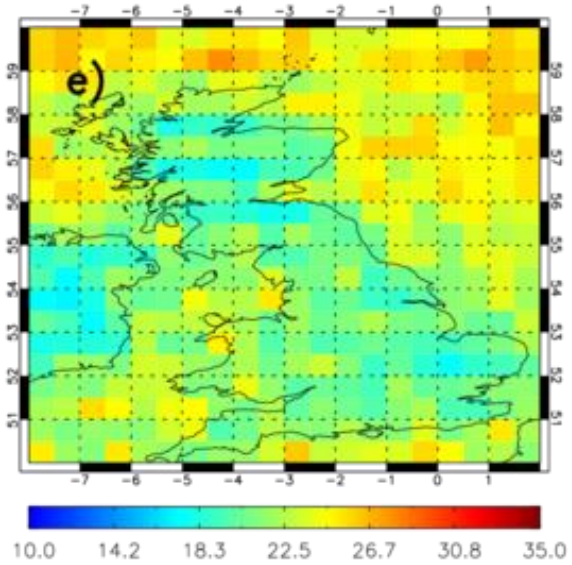

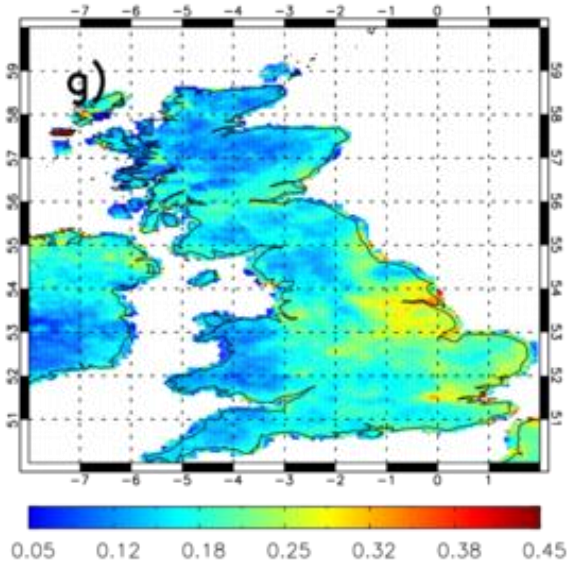

x10^{15} molecules/cm^2

Dobson Units - DU

Dimensionless

Trend Methodology:

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Non-linear Least Squares Regression – Fit Parameters

$$Y_t = C + BX_t + A\sin(\omega X_t + \phi) + N_t$$

ω=π/6

- Y_t: Monthly Trop Col NO_2 Time-series
- C: Trop Col NO_2 Jan 2005
- BX_t: Annual Linear Trend
- $A\sin(\omega X_t + \phi)$: Seasonal Model
- N_t: Residuals

$$|B/\sigma_B| > 2.0$$

Significant Trend at 95% Confidence Level

$$\sigma_B \approx [(\sigma_N / n^{3/2}) \sqrt{(1+\alpha)/(1-\alpha)}]$$

- σ_B: Trend Uncertainty
- σ_N: Residual Uncertainty
- α: Time-series Autocorrelation

Van der A et al., (2006 & 8)
Weatherhead et al., (1998)

NO_2 & AOD Trends (2005-2015)

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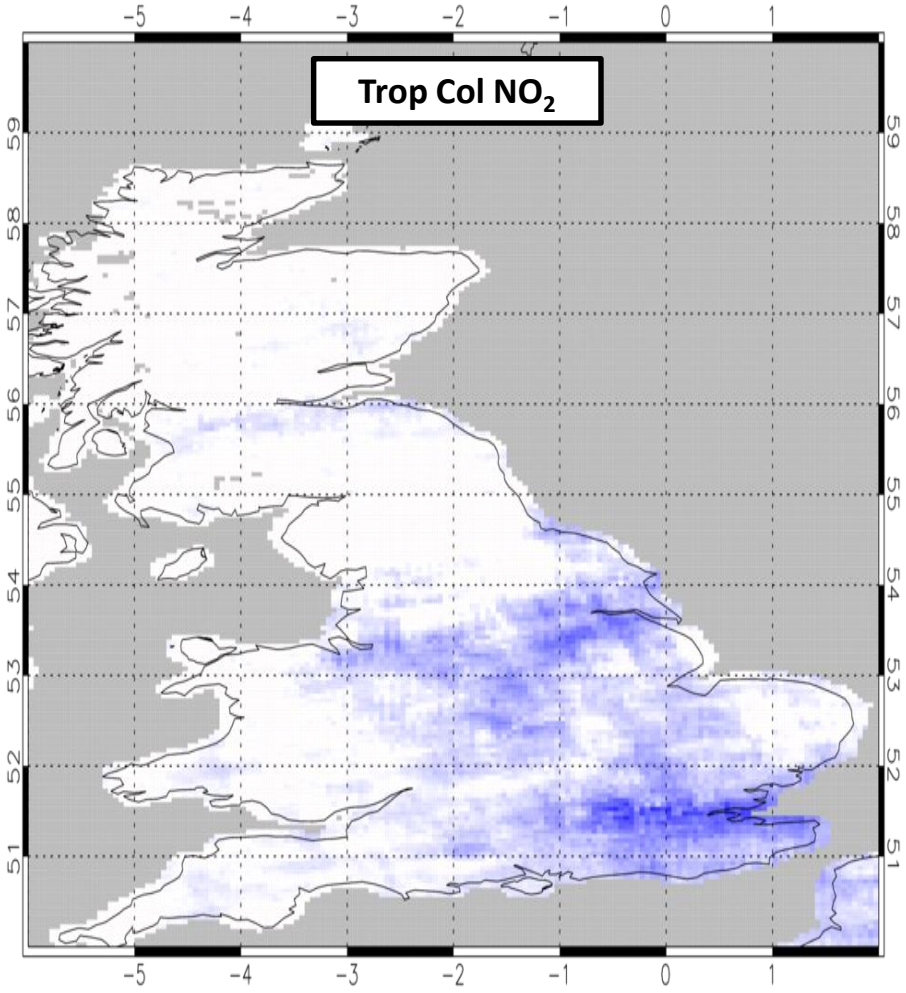

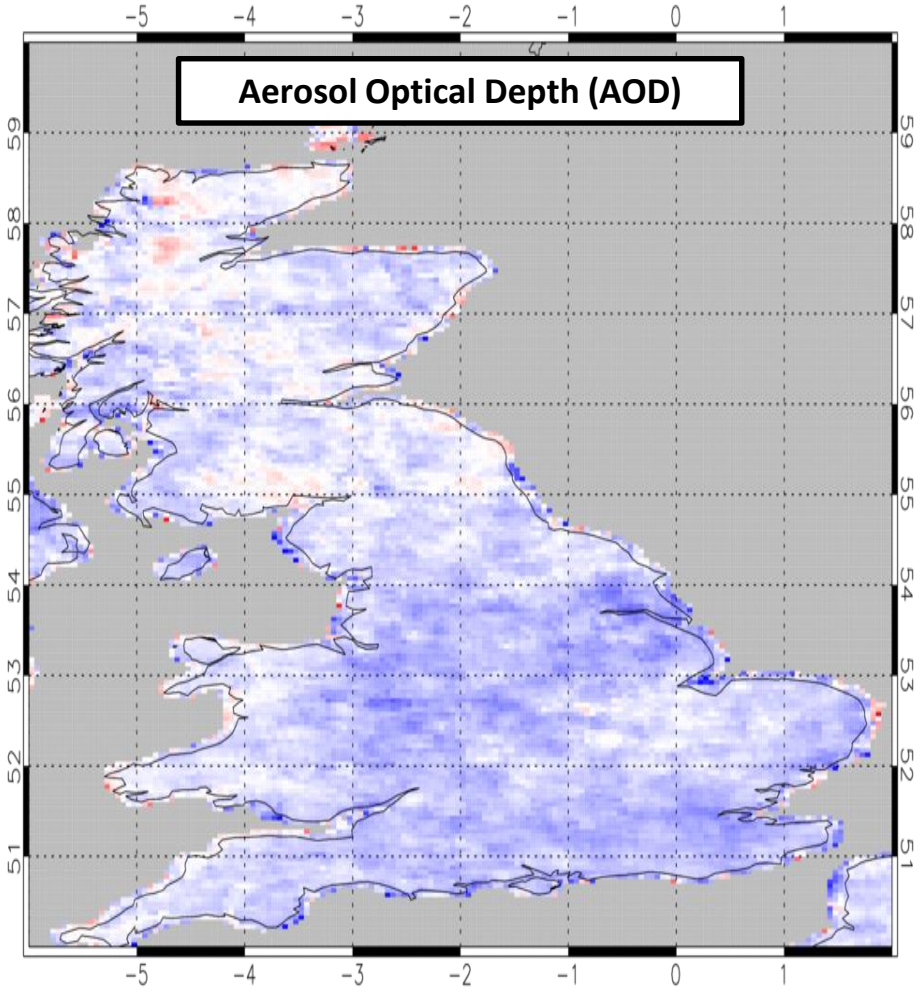

NO_2 Significant Trends (2005-2015)

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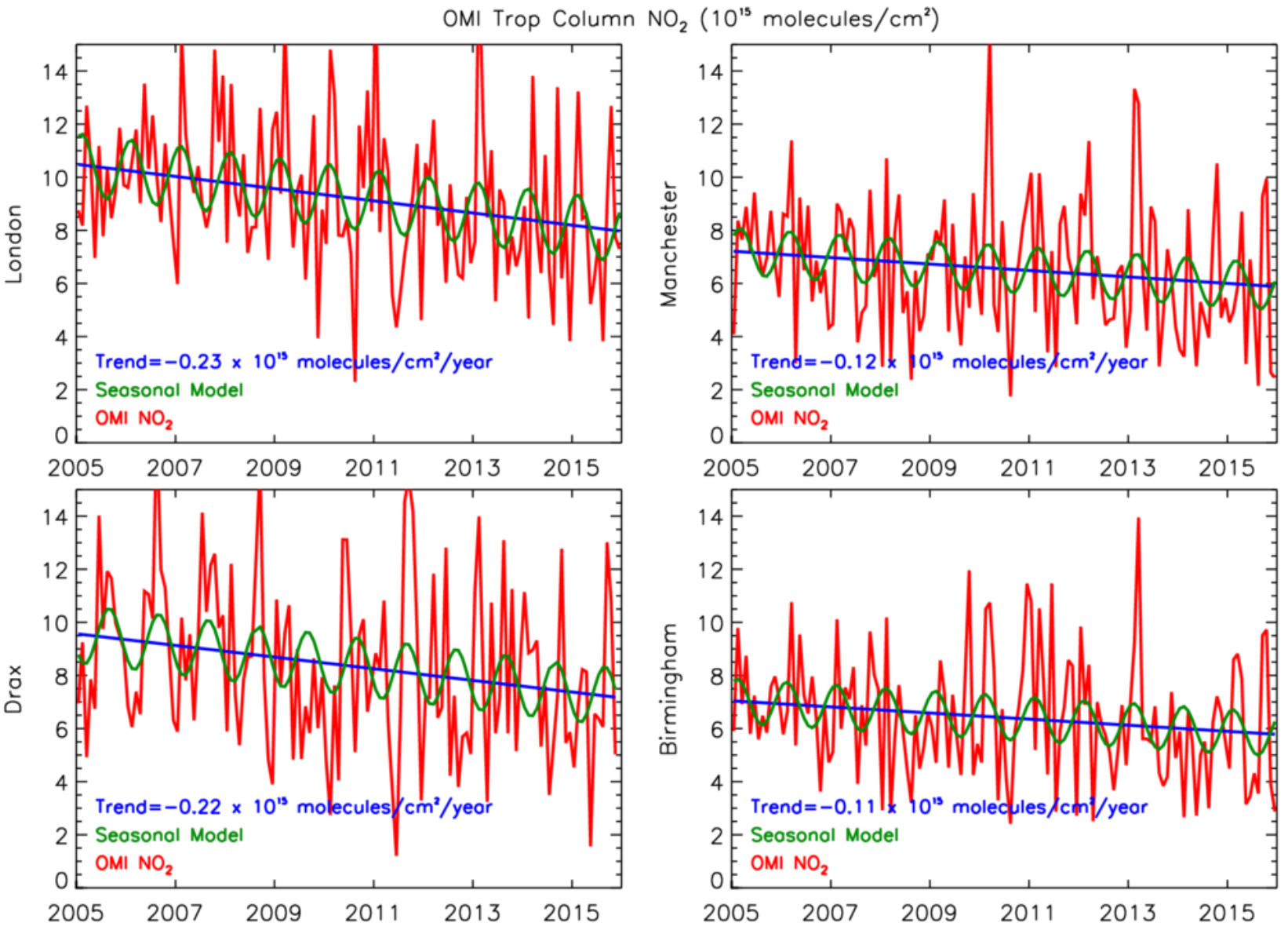

AOD Significant Trends (2005-2015)

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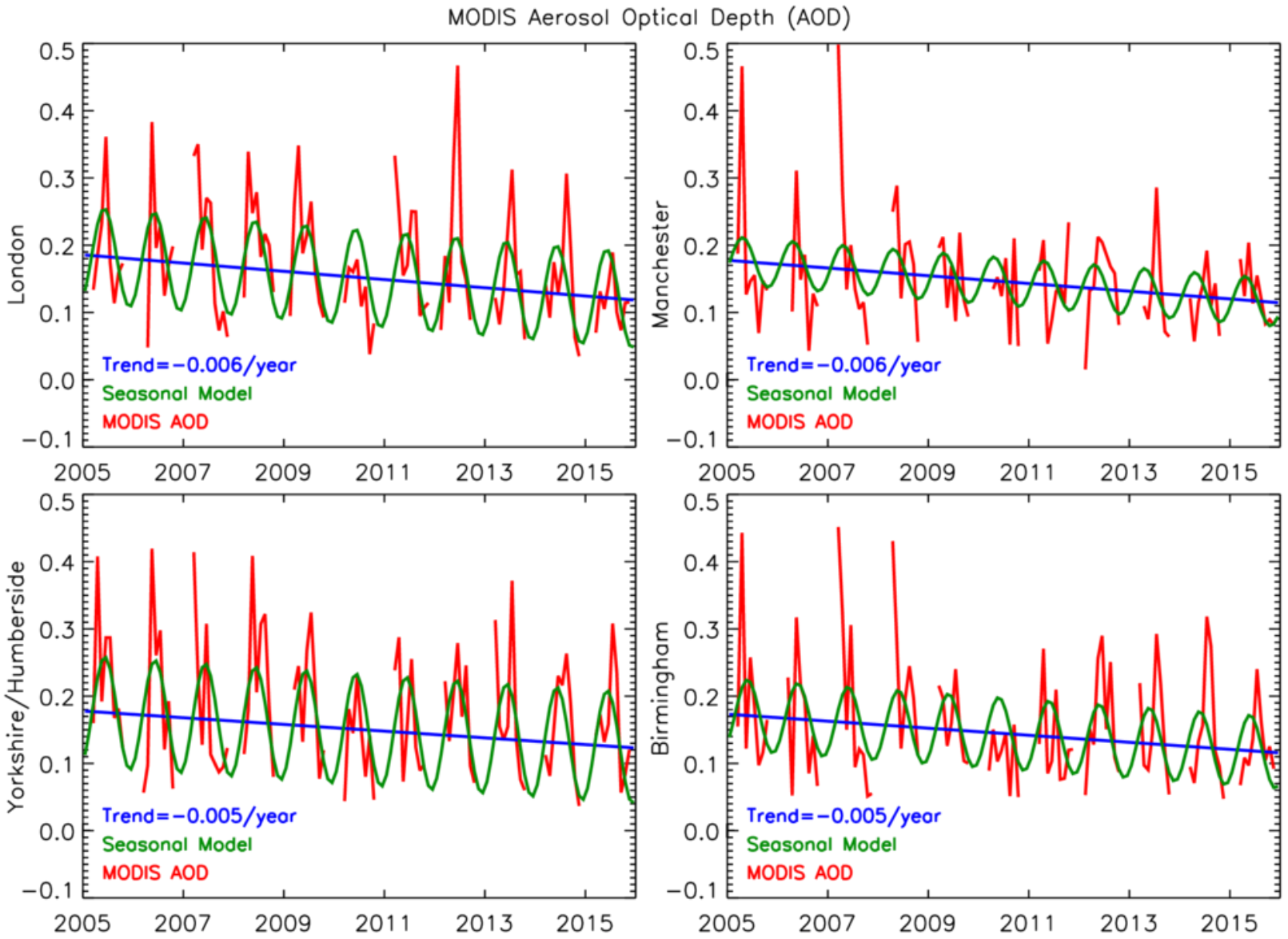

Trends Weighted by Population

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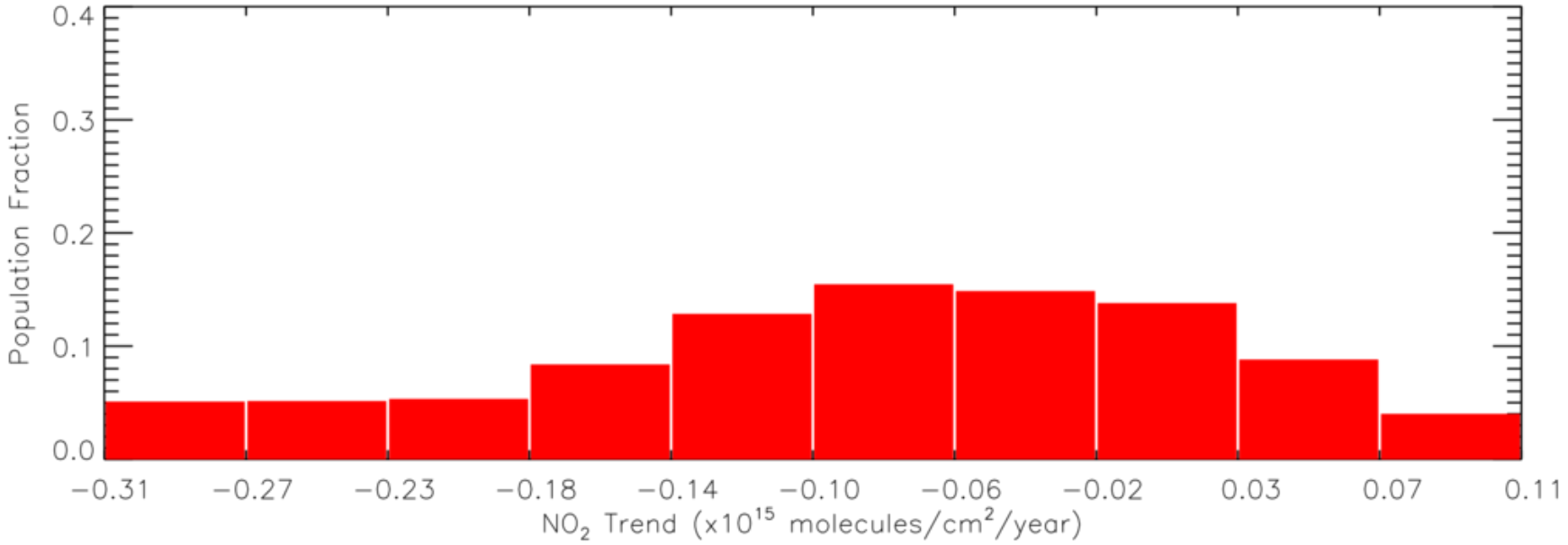

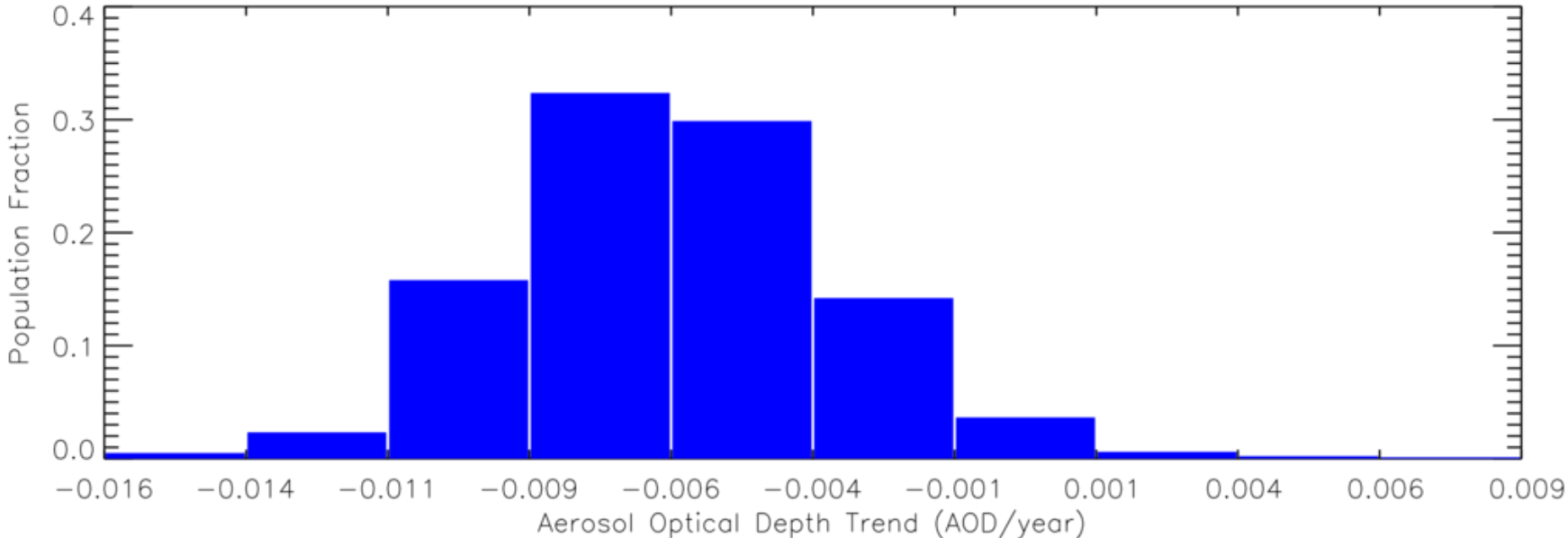

O_3 Trends (2005-2015)

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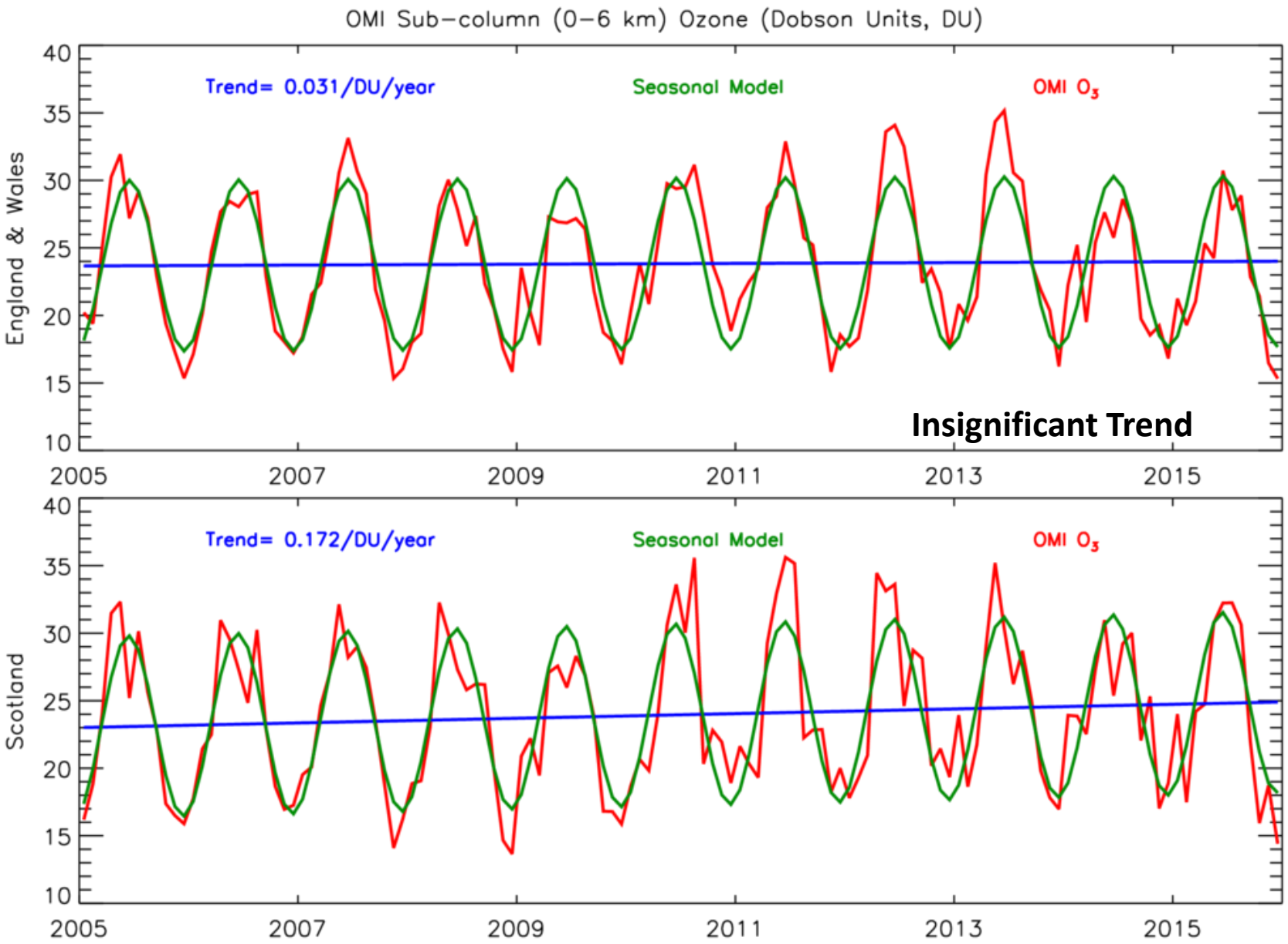

North Atlantic Oscillation (NAO)

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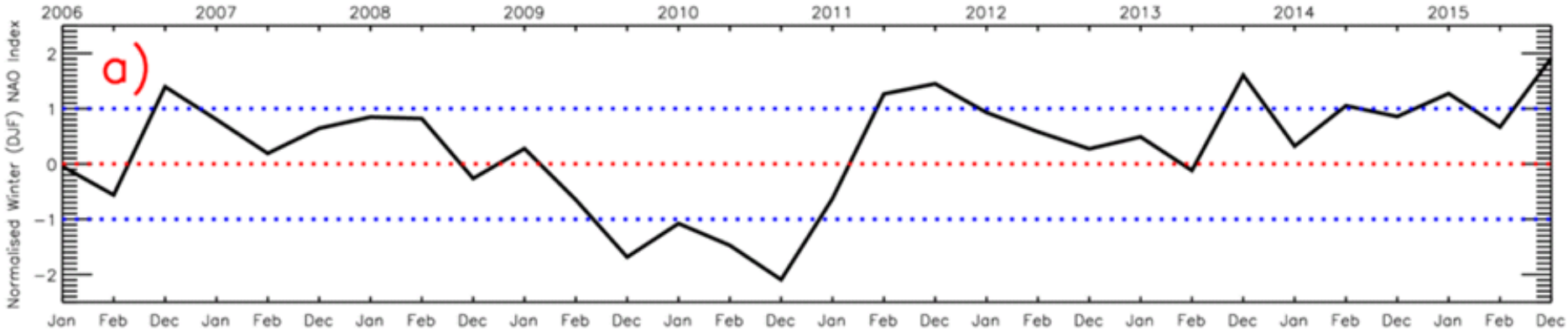
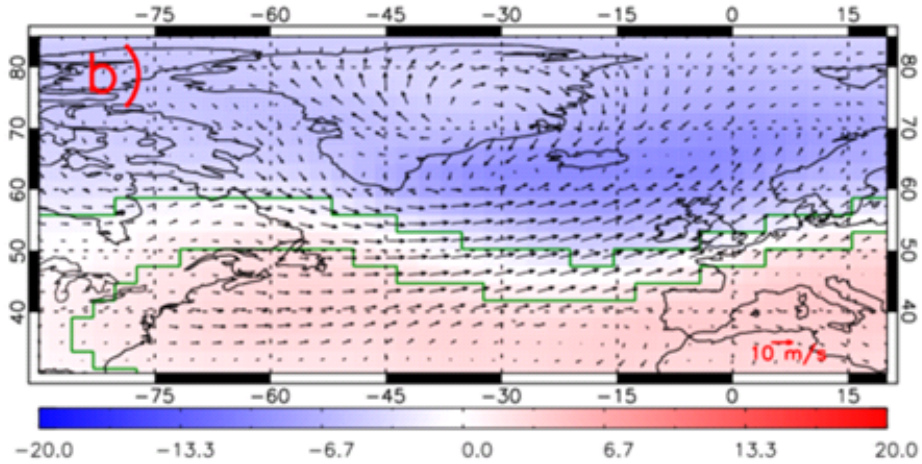
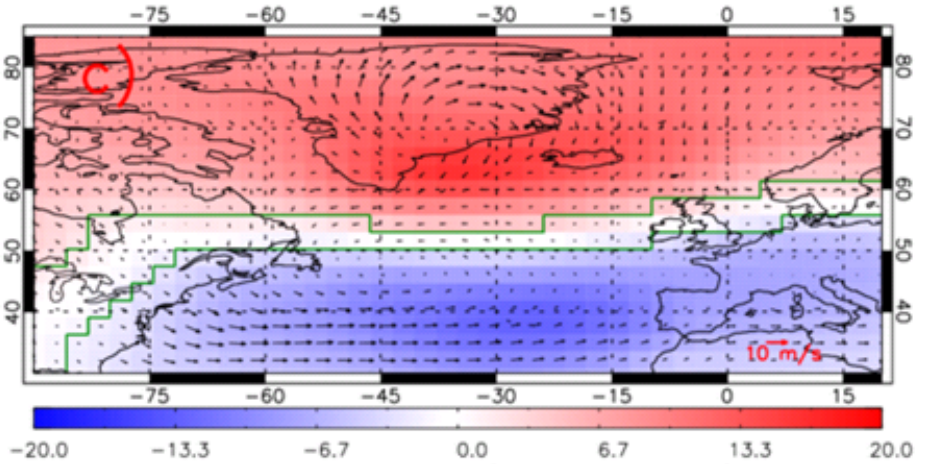
- NAO Index – University of East Anglia
- Meteorological Data – ECMWF ERA-Interim





NAO+



NAO-

Pope et al., (in prep), ACP

OMI Trop Col NO_2

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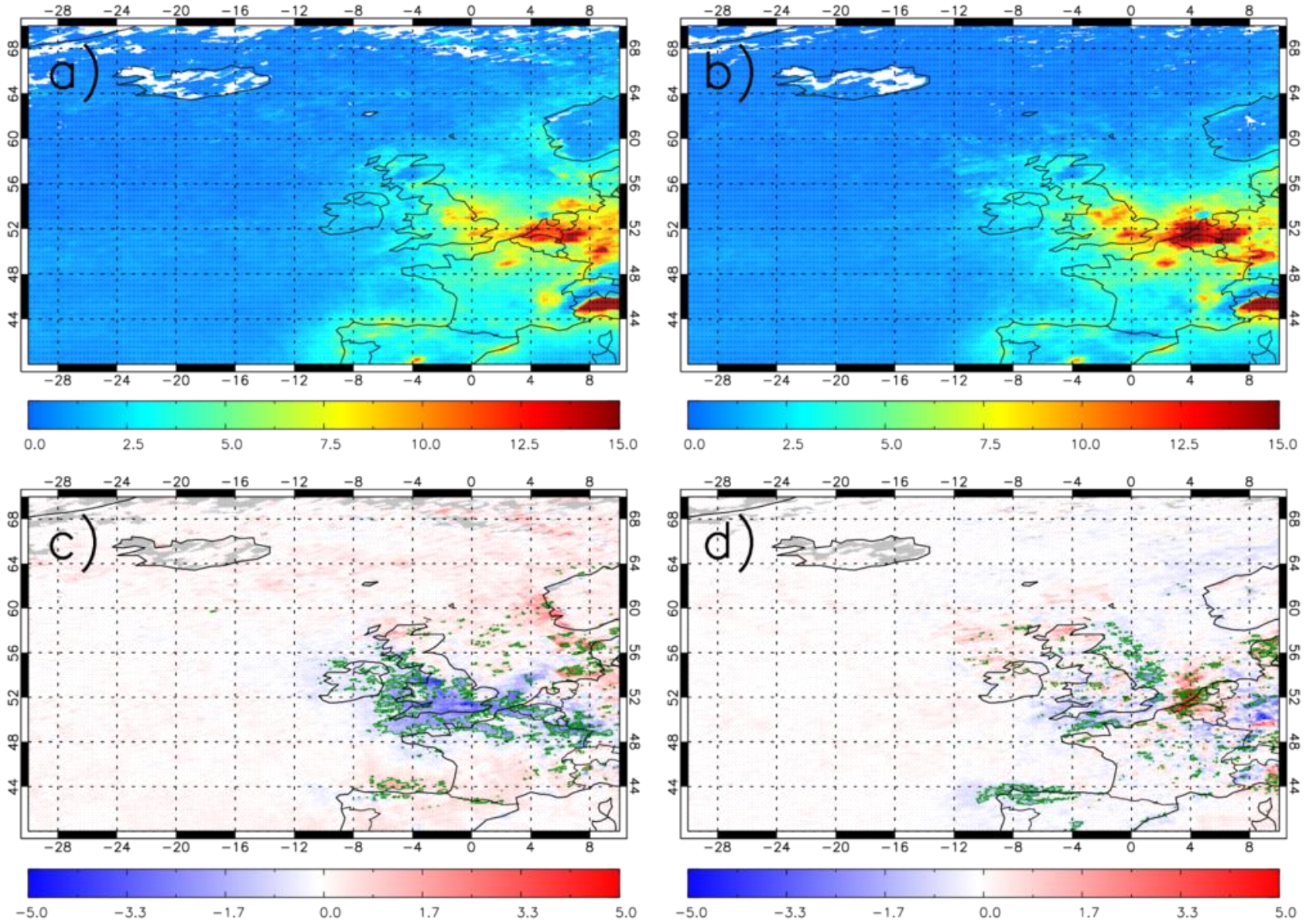

$x10^{15}$ molecules/cm^2

TES Vertical Profiles – O_3

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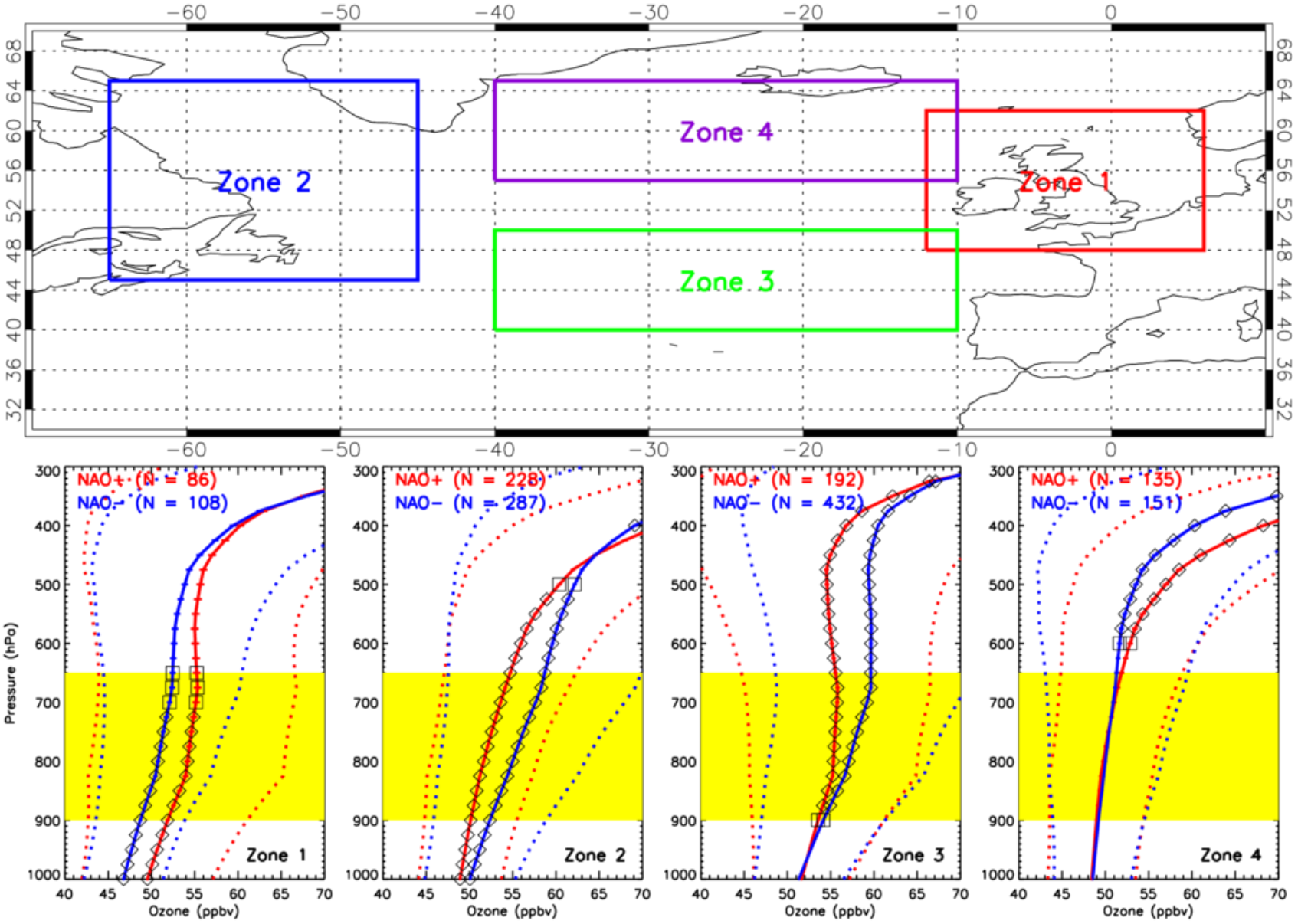

Surface O_3 and NO_2

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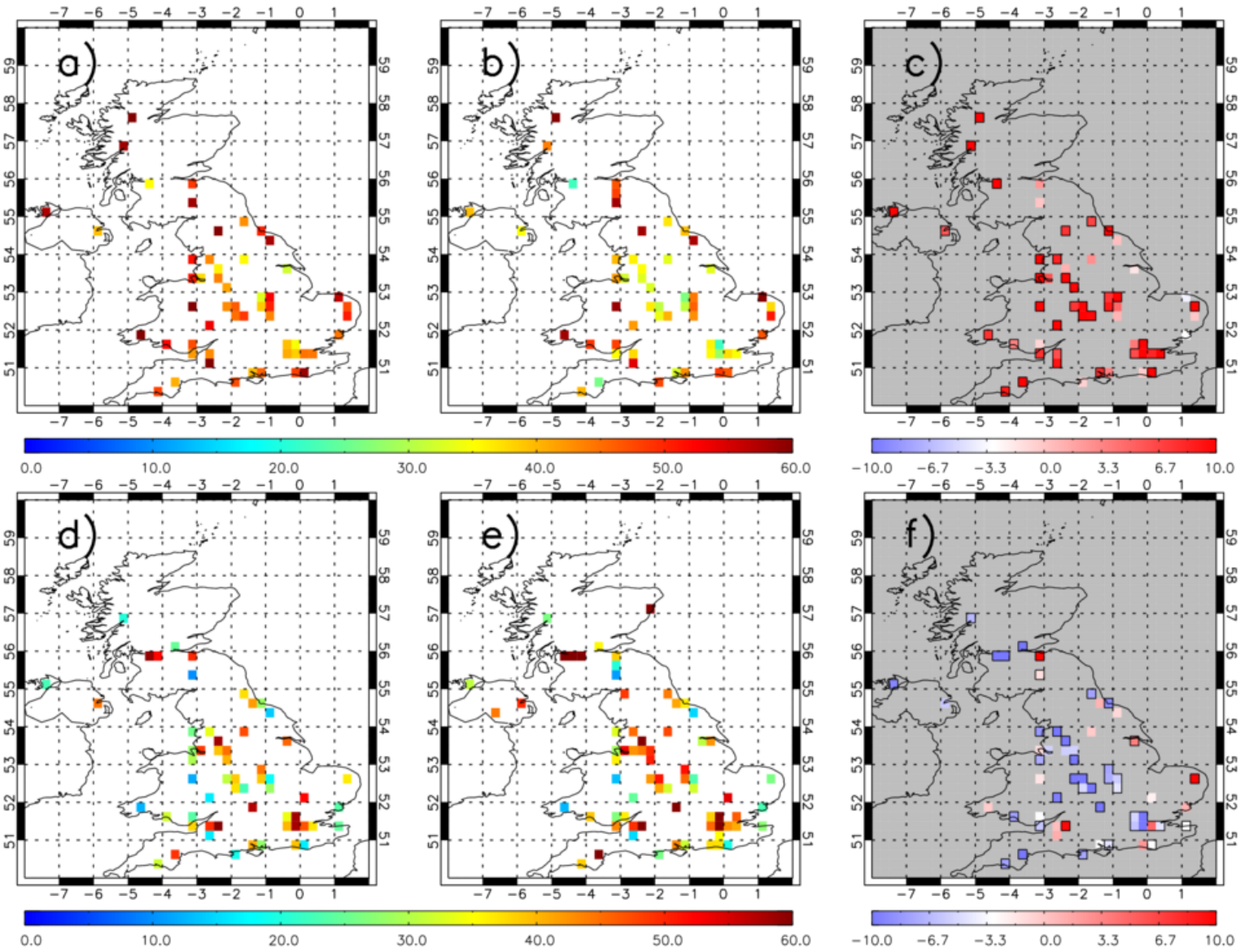
O_3

NO_2



NAO+ NAO- Difference

µg/m³

TOMCAT – Global CTM

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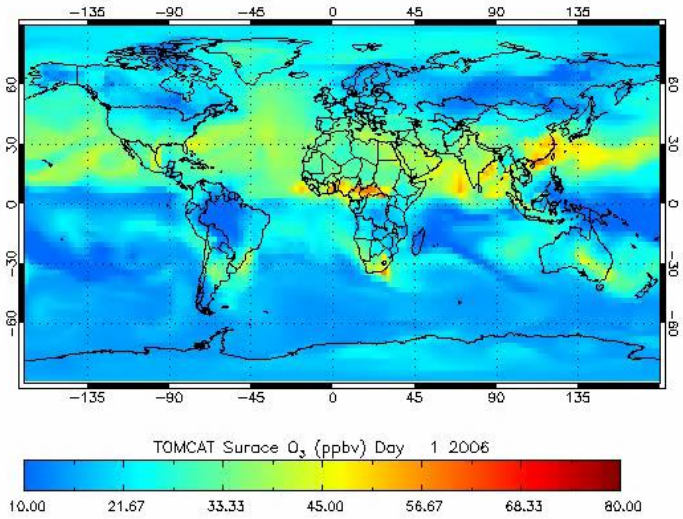
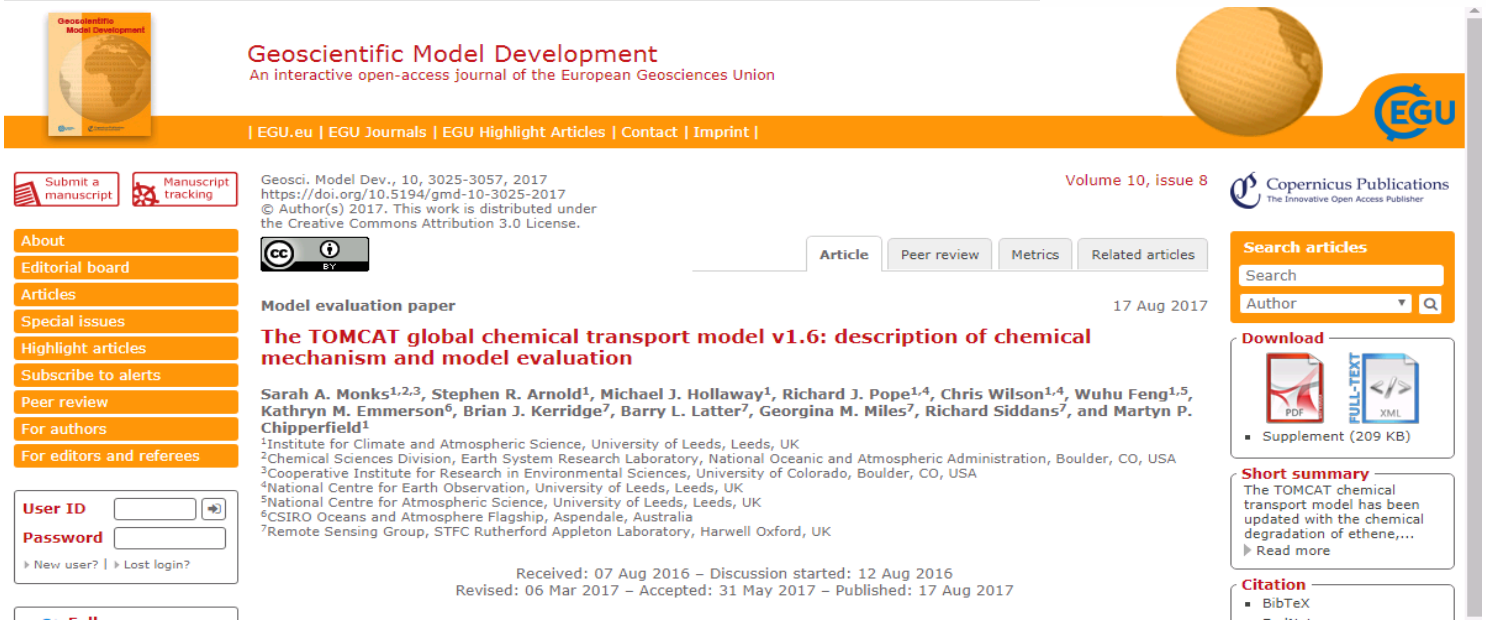
- Global off-line chemistry transport model (CTM).
- Forced by ECMWF ERA-Interim meteorology.
- Horizontal Resolution: 2.8° lon x 2.8° lat.
- Vertical Resolution: 31 levels (surface – 10 hPa).
- 82 advected tracers & 229 gas-phase reactions.
- Simulation 1st Jan 2006 to 31st Dec 2015.





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Geosci. Model Dev., 10, 3025-3057, 2017
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Volume 10, issue 8

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Model evaluation paper

17 Aug 2017

The TOMCAT global chemical transport model v1.6: description of chemical mechanism and model evaluation

Sarah A. Monks[1,2,3], Stephen R. Arnold[1], Michael J. Hollaway[1], Richard J. Pope[1,4], Chris Wilson[1,4], Wuhu Feng[1,5], Kathryn M. Emmerson[6], Brian J. Kerridge[7], Barry L. Latter[7], Georgina M. Miles[7], Richard Siddans[7], and Martyn P. Chipperfield[1]

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[4]National Centre for Earth Observation, University of Leeds, Leeds, UK
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Received: 07 Aug 2016 – Discussion started: 12 Aug 2016
Revised: 06 Mar 2017 – Accepted: 31 May 2017 – Published: 17 Aug 2017

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Short summary
The TOMCAT chemical transport model has been updated with the chemical degradation of ethene,...
Read more

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TOMCAT Surface NO_2 - NAO

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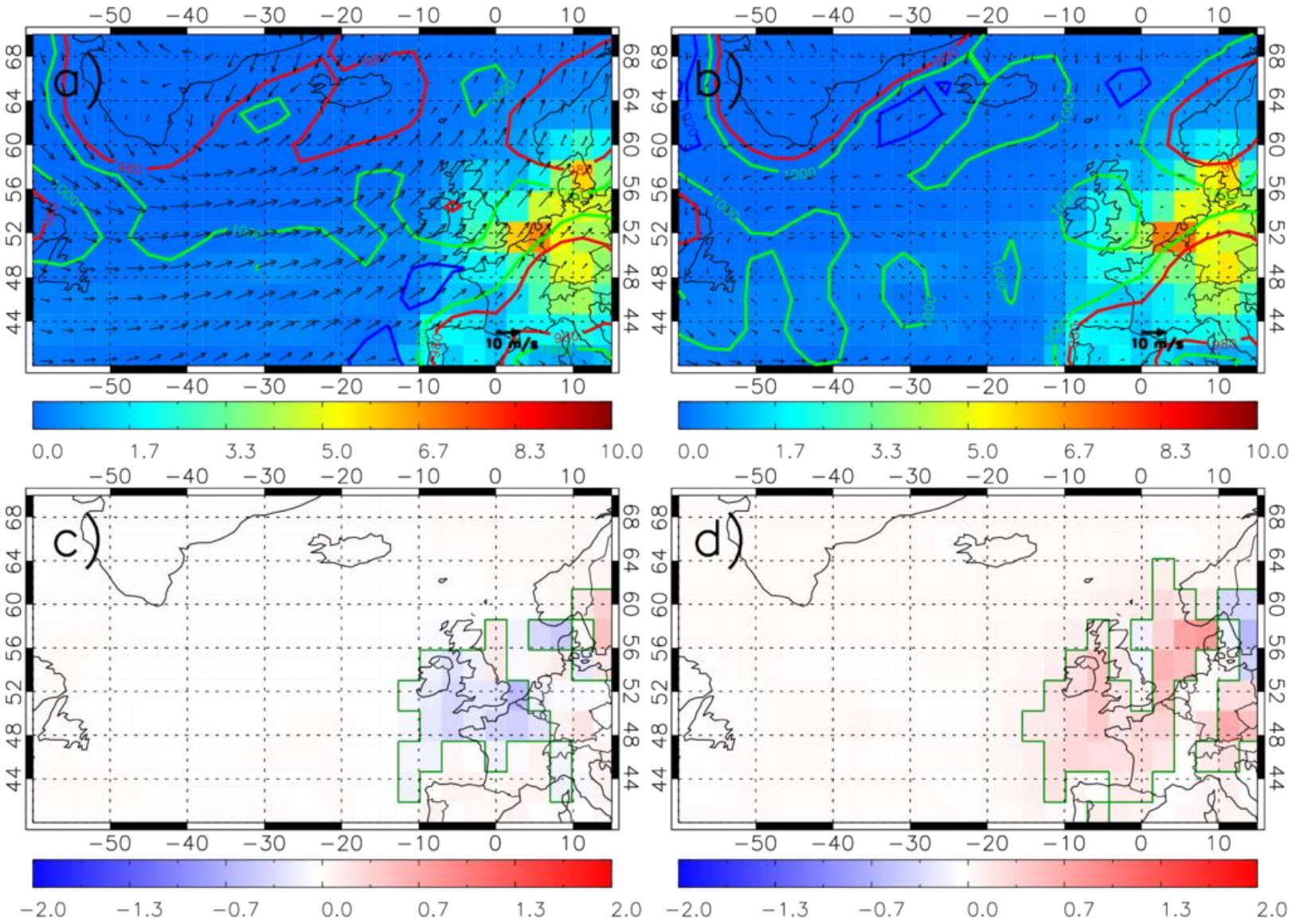

TOMCAT Surface O_3 - NAO

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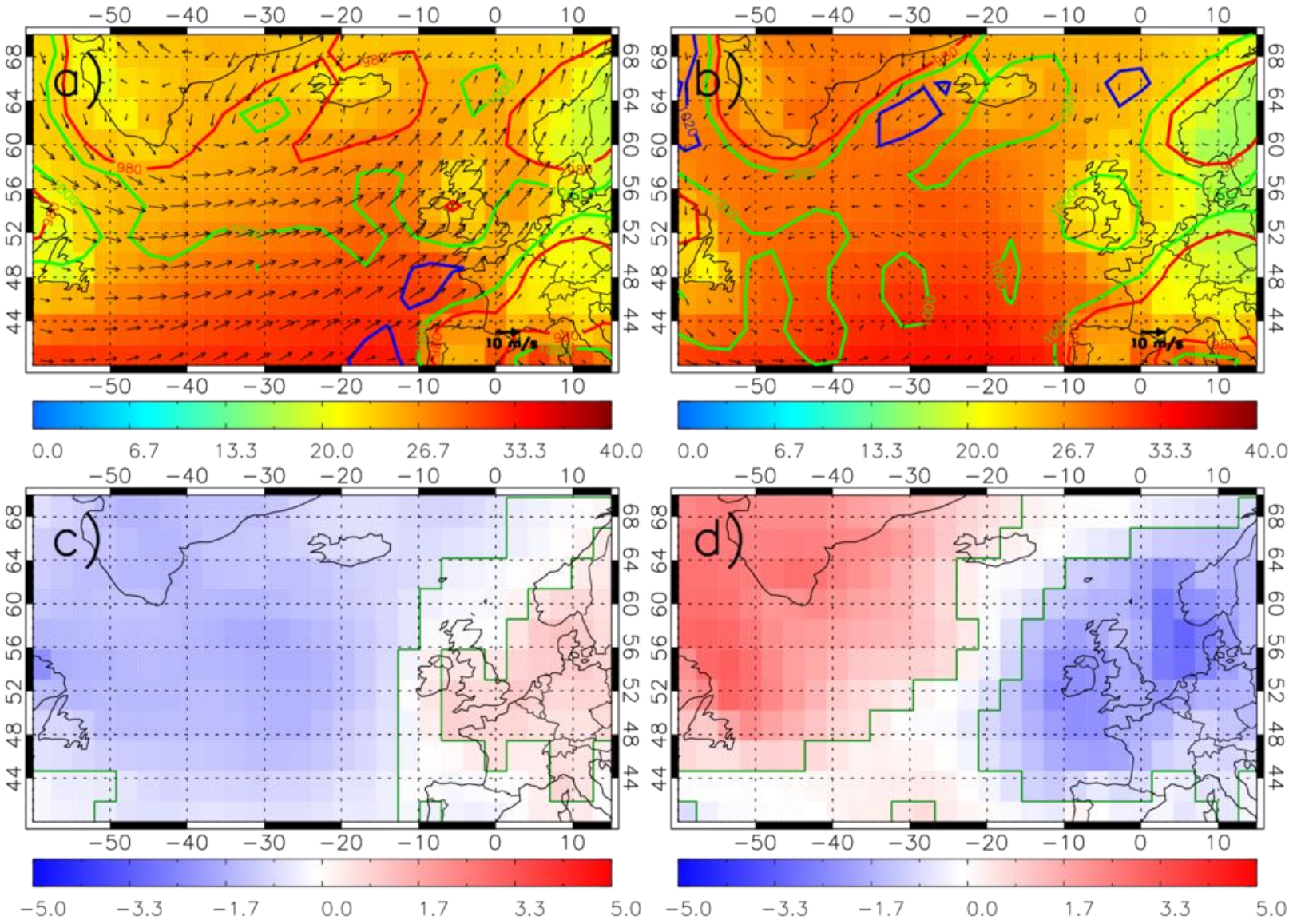

Summary

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UK Trends (2005-2015):

NO_2 ↓ O_3 ↑ AOD ↓

North Atlantic Oscillation (NAO): Western Europe

NAO+ NO_2 ↓ O_3 ↑

NAO- NO_2 ↑ O_3 ↓

Any Questions?

TOMCAT NO_2 vs. AURN NO_2

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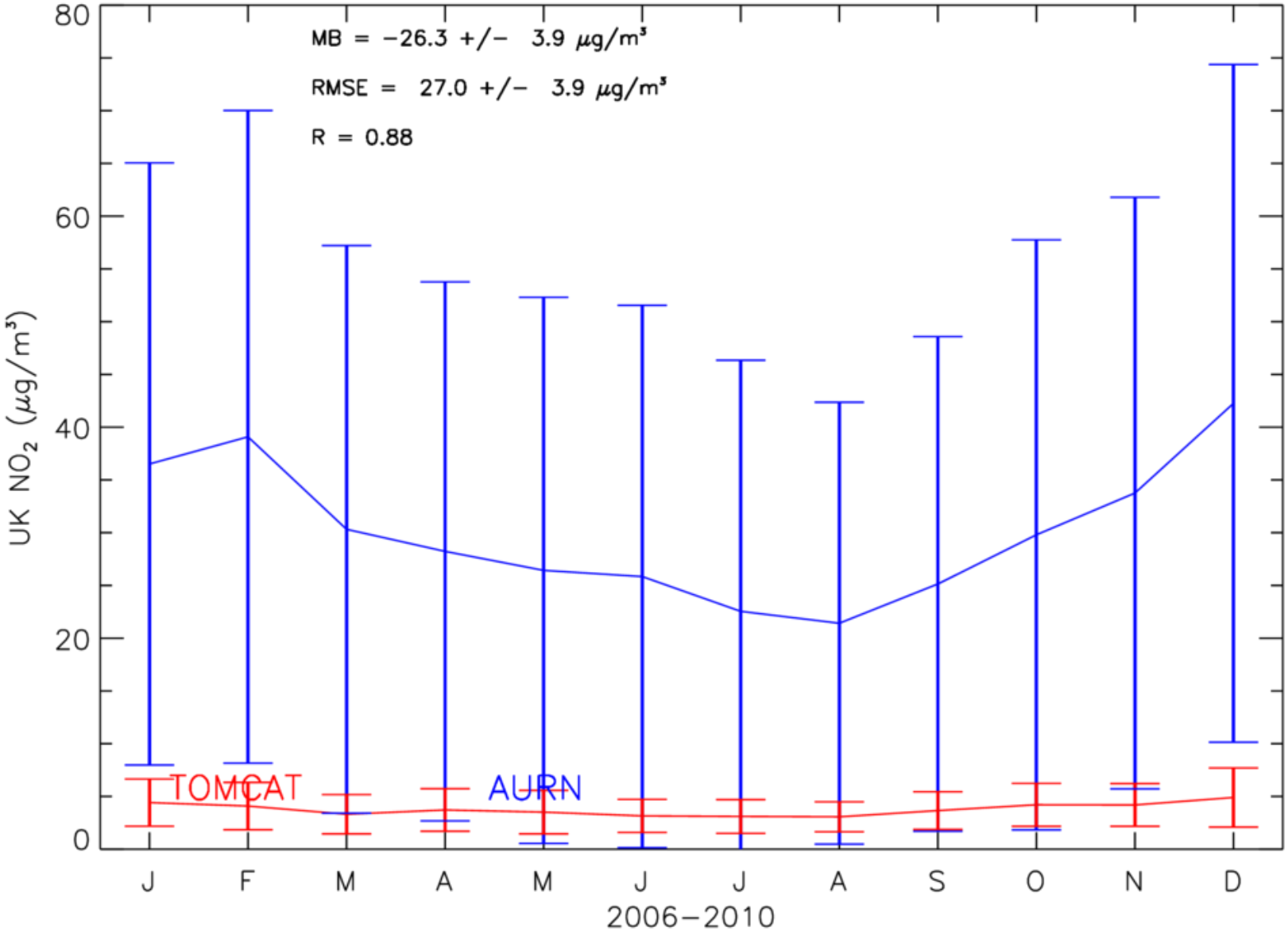

TOMCAT O_3 vs. AURN O_3

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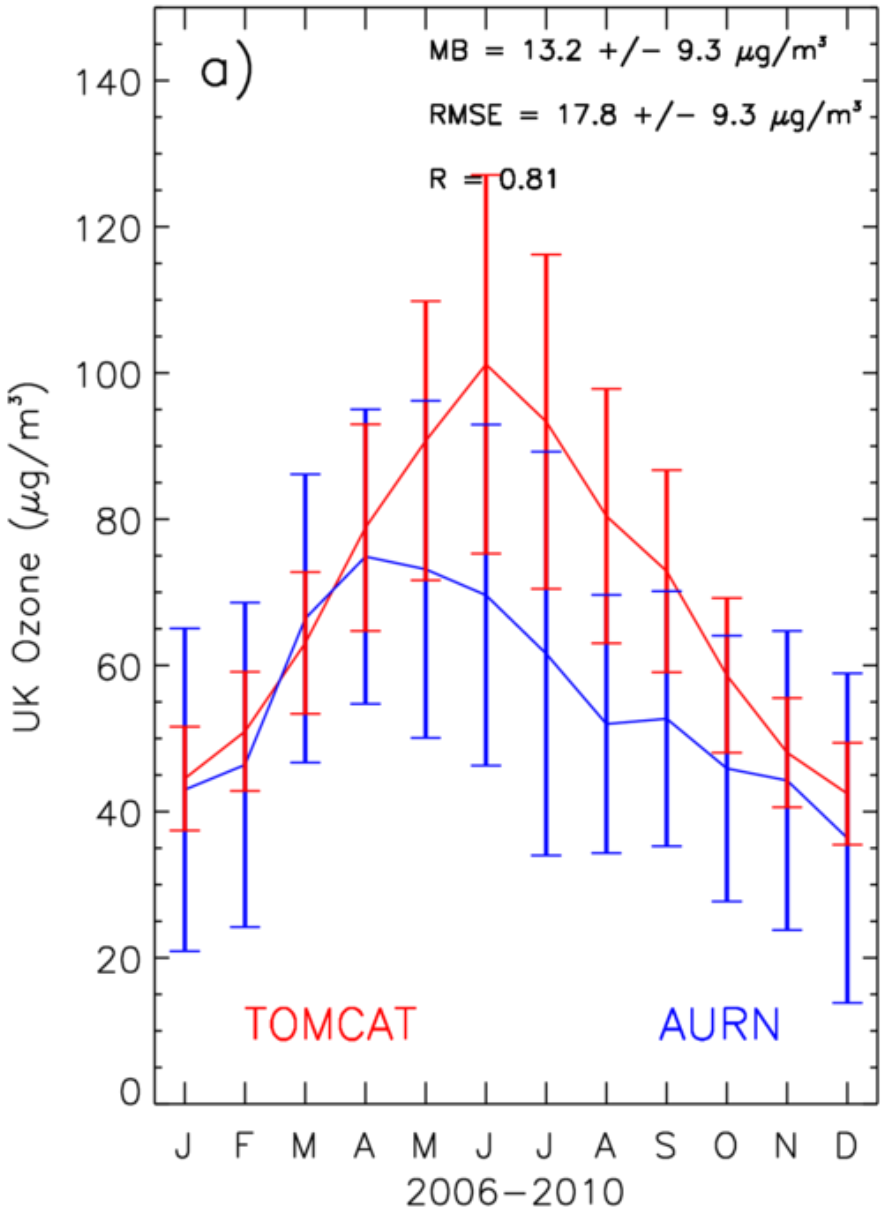

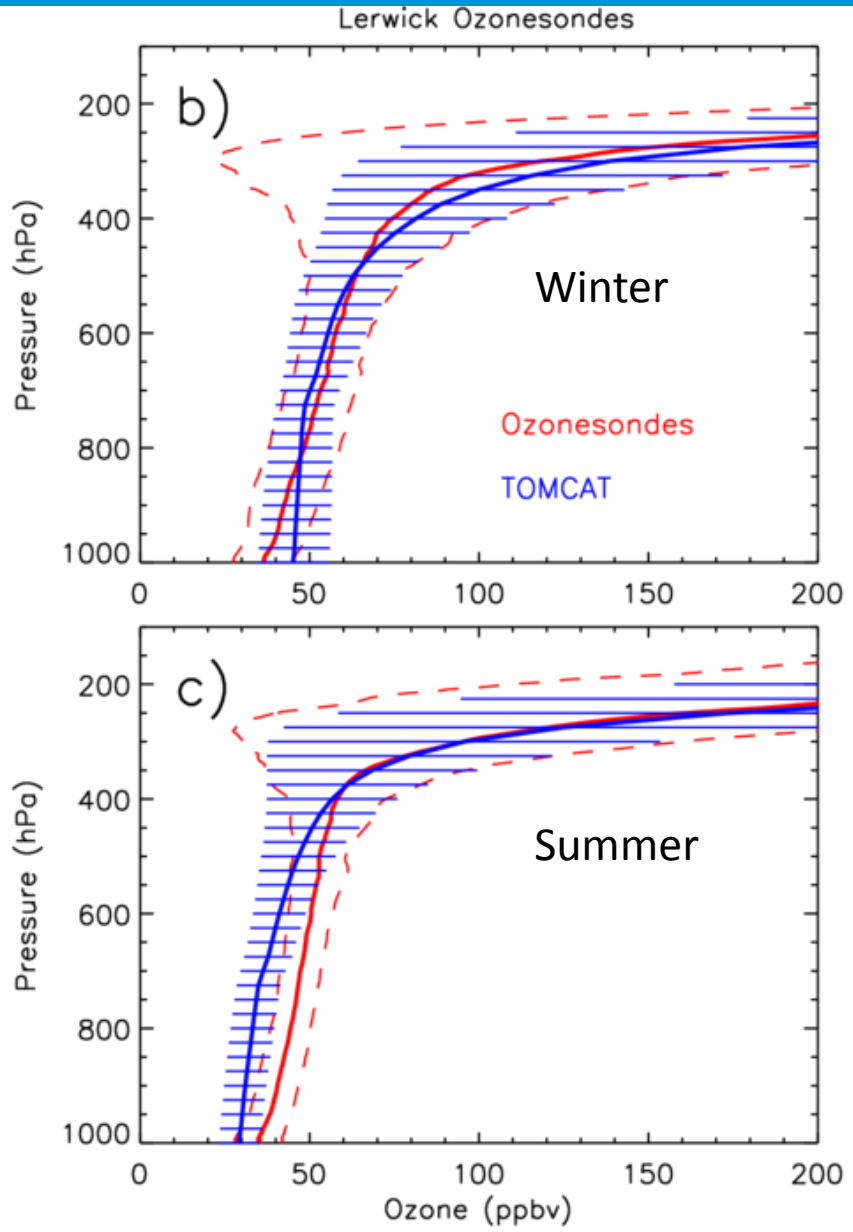

TOMCAT vs. Trop Col OMI NO_2

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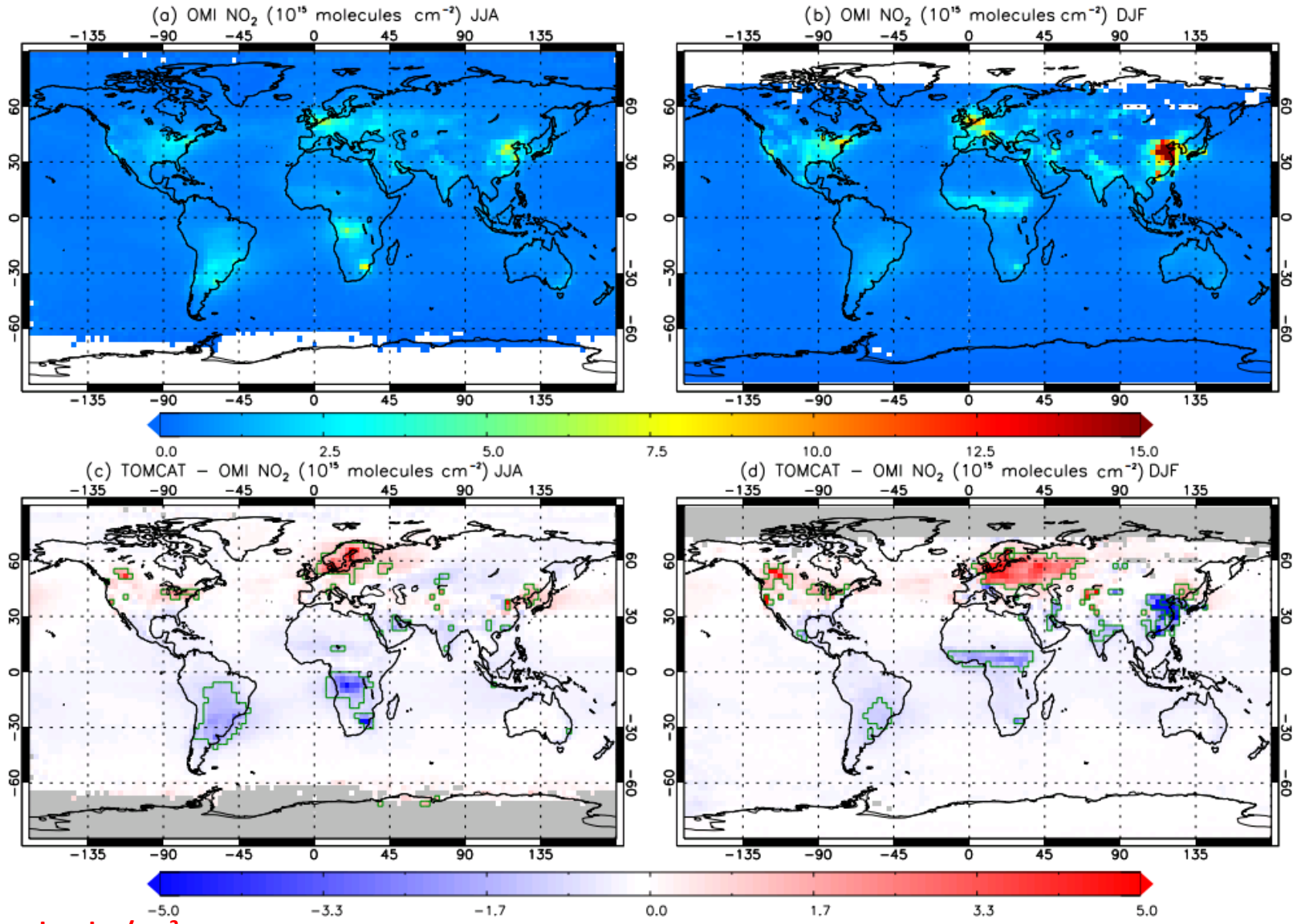

x10^{15} molecules/cm^2

TOMCAT vs. Sub-col (0-6 km) OMI O_3

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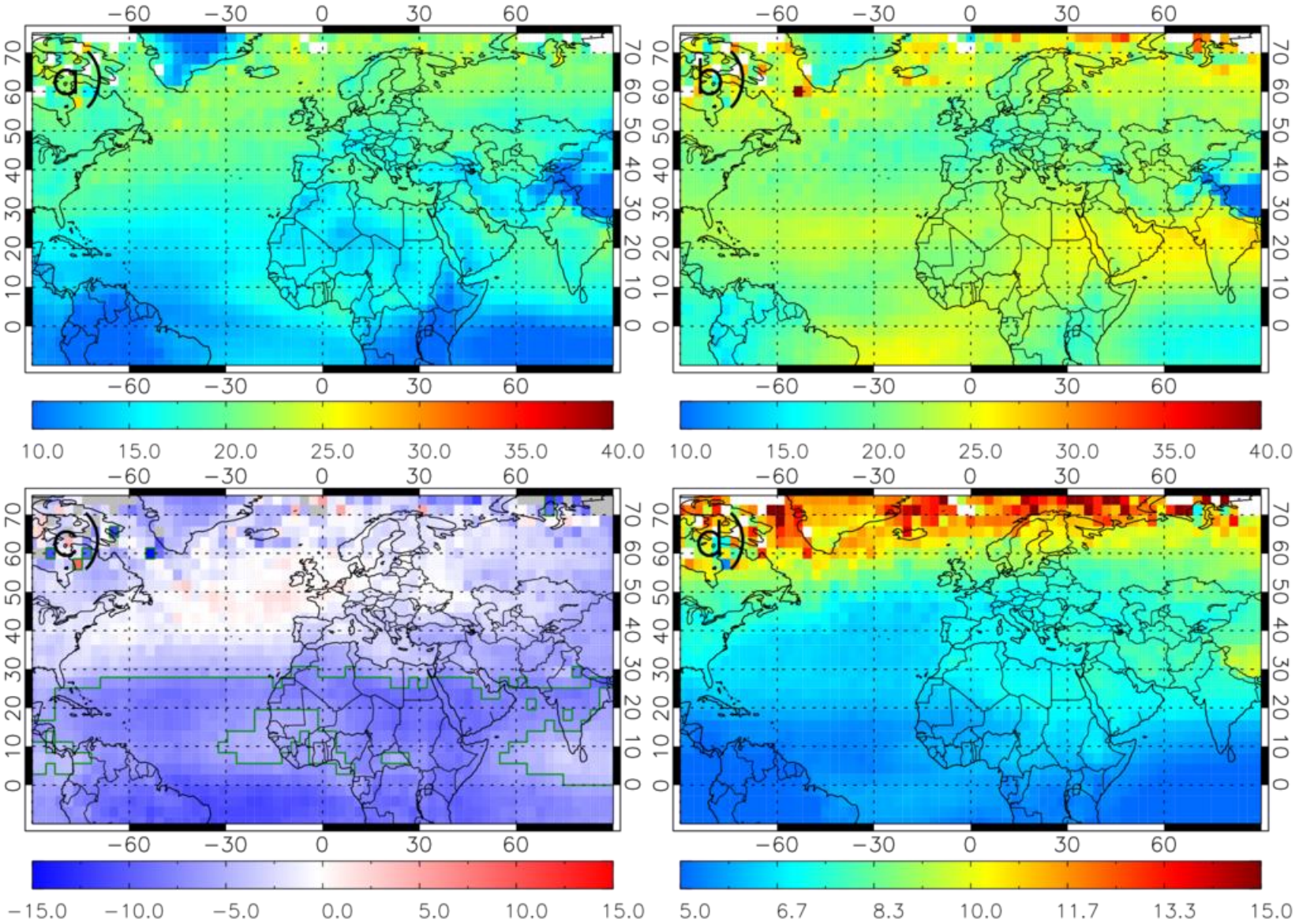

Dobson Units - DU