School of Earth and Environments
FACULTY OF ENVIRONMENT

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Observed and modelled influences of synoptic meteorology on UK air quality

Richard Pope (PhD)

Supervisors: Prof Martyn Chipperfield and Dr Nick Savage

Contents:

- Understanding links between synoptic weather and satellite observations of tropospheric column NO_2.
- Evaluate regional model representation of air quality under different synoptic weather regimes.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Met Office

Motivation:

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Poor UK air quality results in:

- An average premature loss of 7-8 months off life expectancy.
- Approximately 50,000 premature deaths per year.
- An annual cost of £8-20 billion to the British health service.

Hazardous atmospheric chemical species include:

- Ozone (O_3)
- Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Particulate Matter (PM 2.5 & 10)

Human health effects include:

- Asthma
- Reduced lung function and disease
- Eye irritation

Satellite Datasets:

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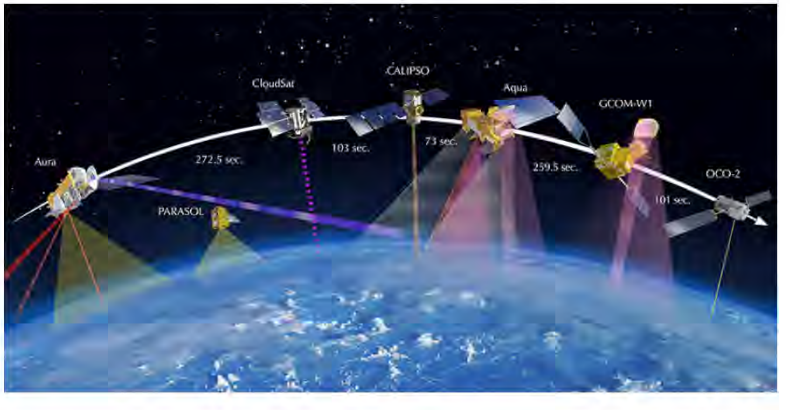
- Satellite datasets provide a useful tool to evaluate AQ models, despite high retrieval error and uncertainty.
- We use LWTs to bin the OMI NO_2 data in different meteorological regimes.
- These synoptic climatologies can be used to validate models once mission comes to the end of its life.
- Do not always need day by day comparisons with larger variability; instead can use these generic climatologies.



Ozone Monitoring Instrument:

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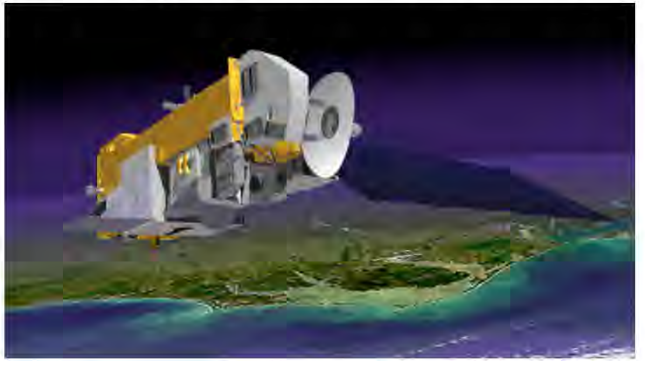
- On-board NASA Aura satellite.
- Nadir viewing with footprint size of 312 km^2.
- UV-VIS range of 270-500 nm.
- OMI data from 2004 – present. We look at 2006-2010.
- Tropospheric Column NO_2 data (DOMINO vn 2.0) from Tropospheric Emissions Monitoring Internet Service, available at http://www.temis.nl/airpollution/no2.html
- Approximate UK overpass time of 13.00 local time.



Lamb Weather Types:

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LWTs characterise the synoptic weather over the UK, based on an objective scheme using daily midday grid point mean sea level pressure from NCEP reanalysis data, in the form of the 27 codes below.

Lamb Weather Types – Number Coding			This Study
-1 Unclassified		-9 non-existent day	
0 A		20 C	
1 ANE	11 NE	21 CNE	**North-Easterly**
2 AE	12 E	22 CE	**Easterly**
3 ASE	13 SE	23 CSE	**South-Easterly**
4 AS	14 S	24 CS	**Southerly**
5 ASW	15 SW	25 CSW	**South-Westerly**
6 AW	16 W	26 CW	**Westerly**
7 ANW	17 NW	27 CNW	**North-Westerly**
8 AN	18 N	28 CN	**Northerly**
Anticyclonic	**Neutral**	**Cyclonic**	**11 Classifications**

OMI NO_2 Synoptic Composites:

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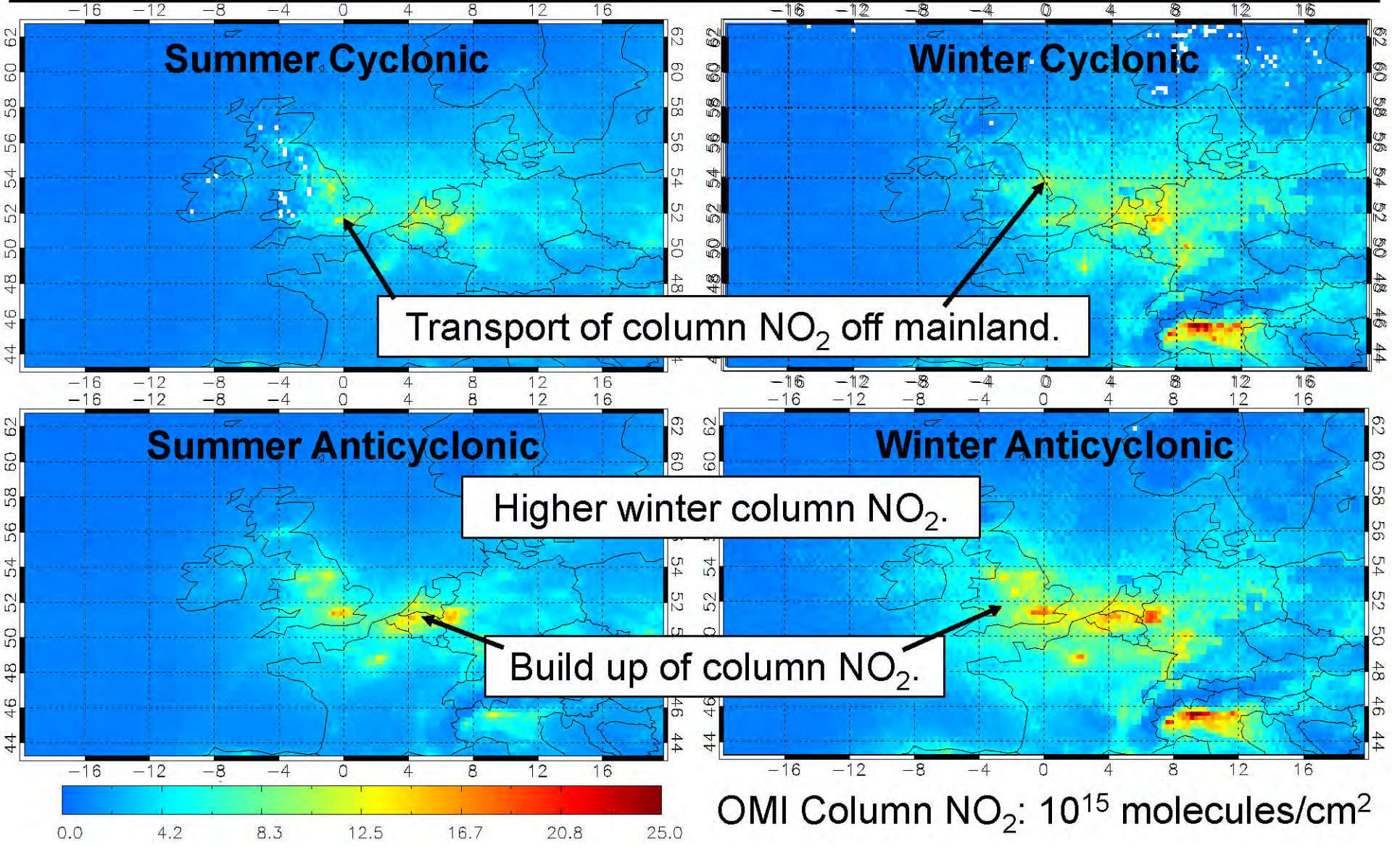

OMI Column NO_2: 10^{15} molecules/cm^2

OMI NO_2 Synoptic Composite Anomalies:

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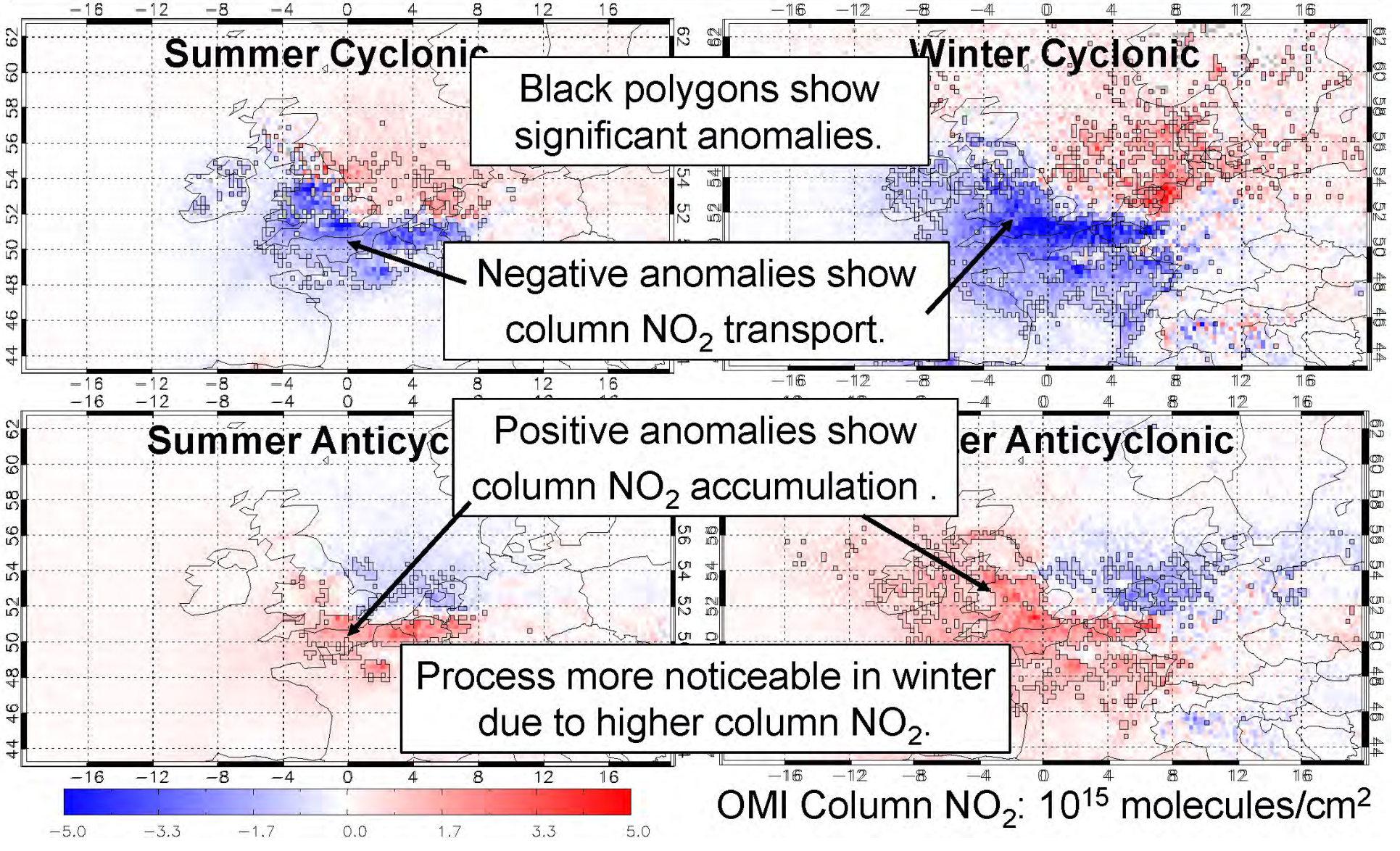

OMI NO_2 Wind Flow Composites:

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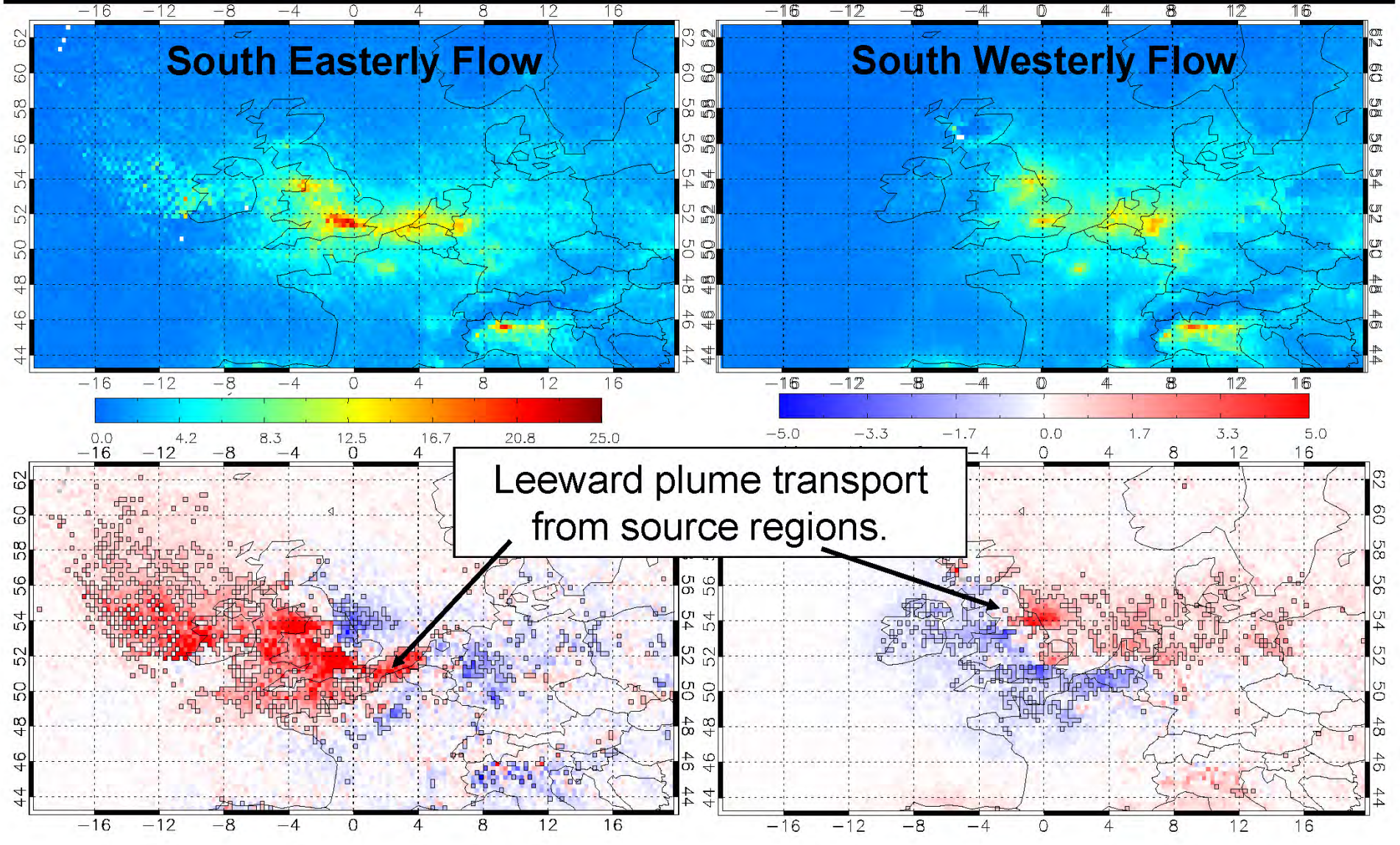

AQUM Configuration:

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Initial and Boundary Conditions:

Meteorology - Global UM

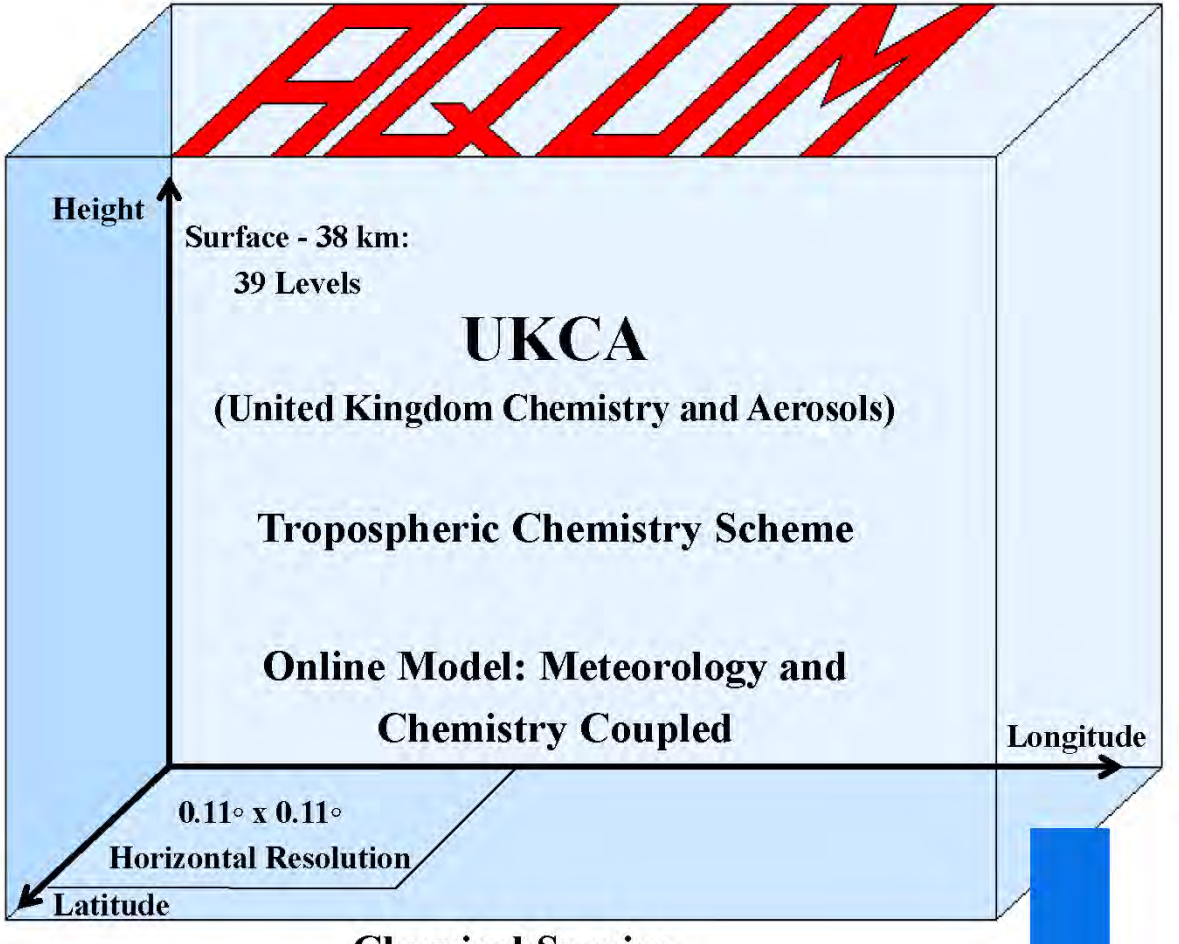
Chemistry - MACC Forecasts & GEMS reanalyses

Emissions Datasets:

UK - NAEI - 1km x 1km

Europe - EMEP - 50km x 50km

Shipping - ENTEC - 5km x 5km



Chemical Species:

O3, NO2, NO, CO, PAN, HCHO, OH, PM 2.5 & 10

AQUM NO_2 Synoptic Composites:

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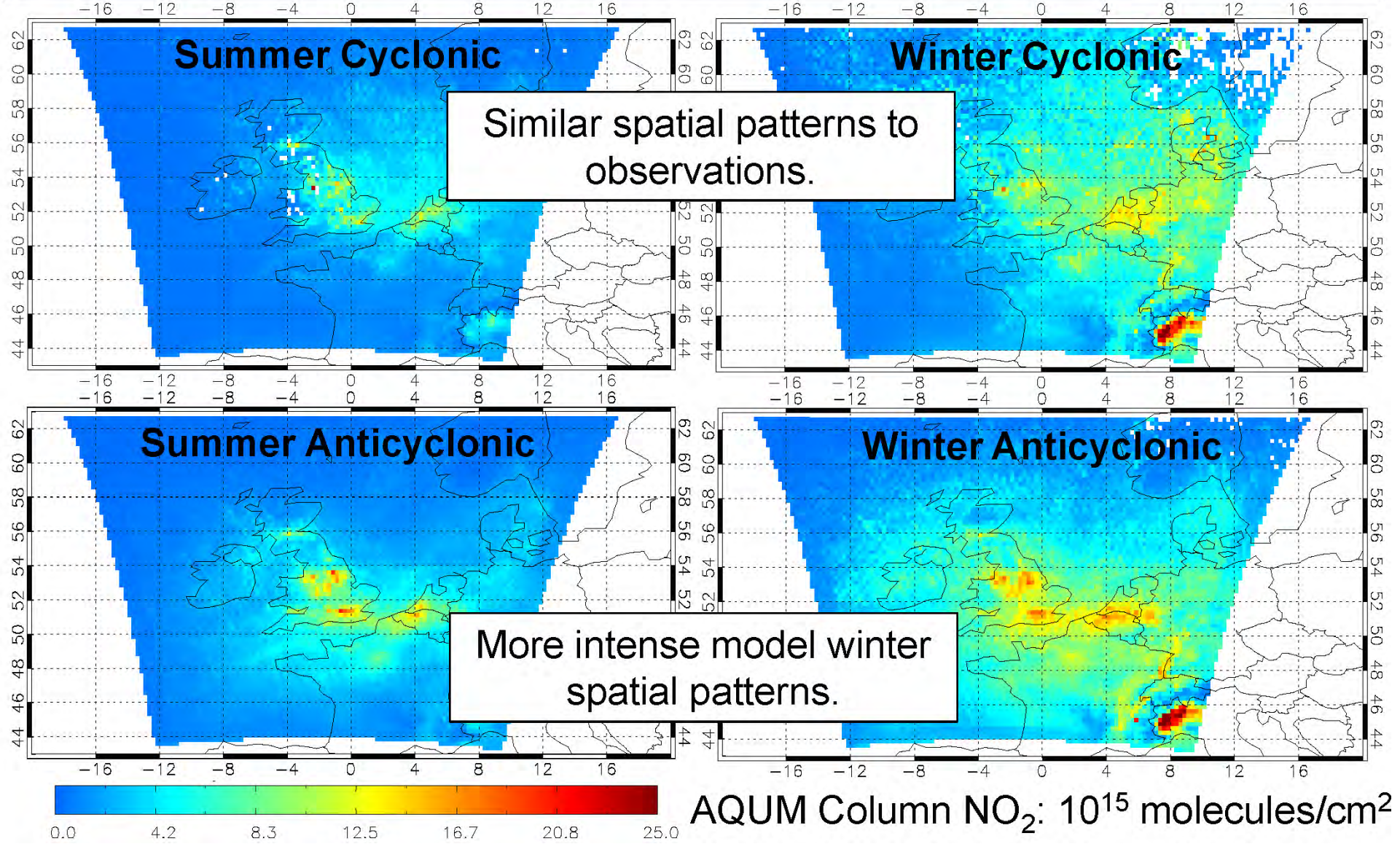

AQUM NO_2 Synoptic Composite Anomalies:

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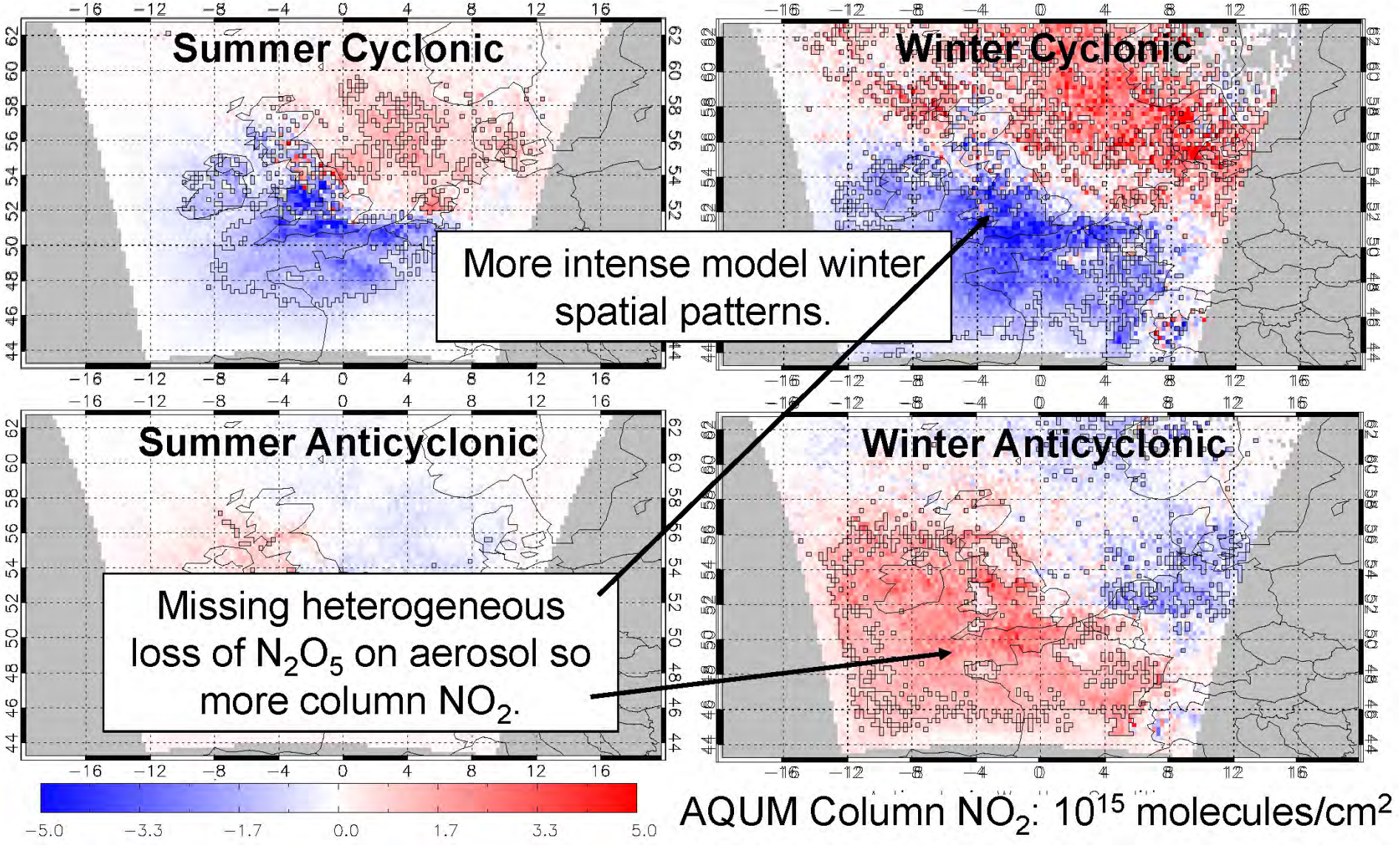

AQUM Tracer Synoptic Composites:

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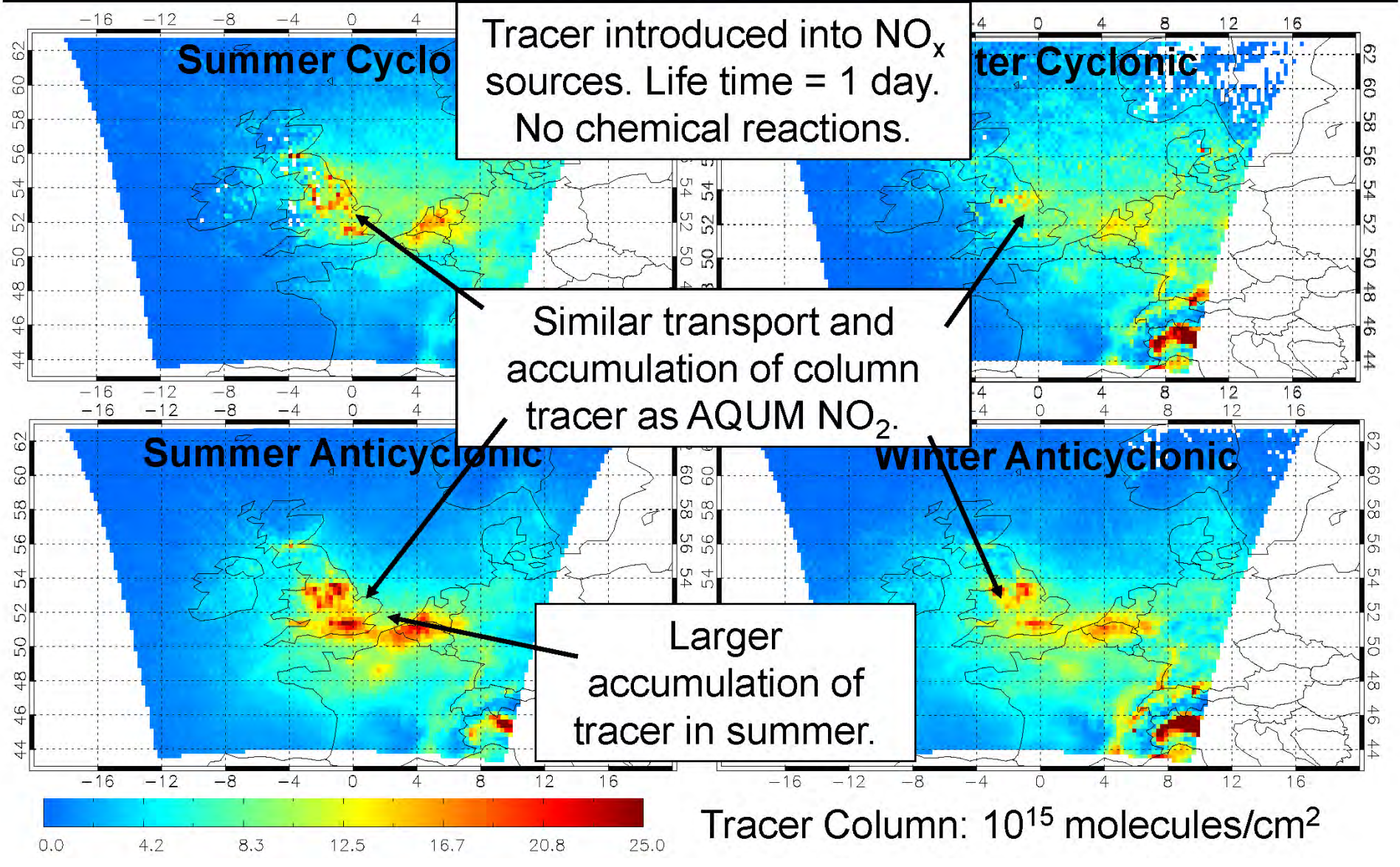

Tracer introduced into NO_x sources. Life time = 1 day. No chemical reactions.

Similar transport and accumulation of column tracer as AQUM NO_2.

Larger accumulation of tracer in summer.

Tracer Column: 10^{15} molecules/cm^2

AQUM Tracer Synoptic Composites Anomalies:

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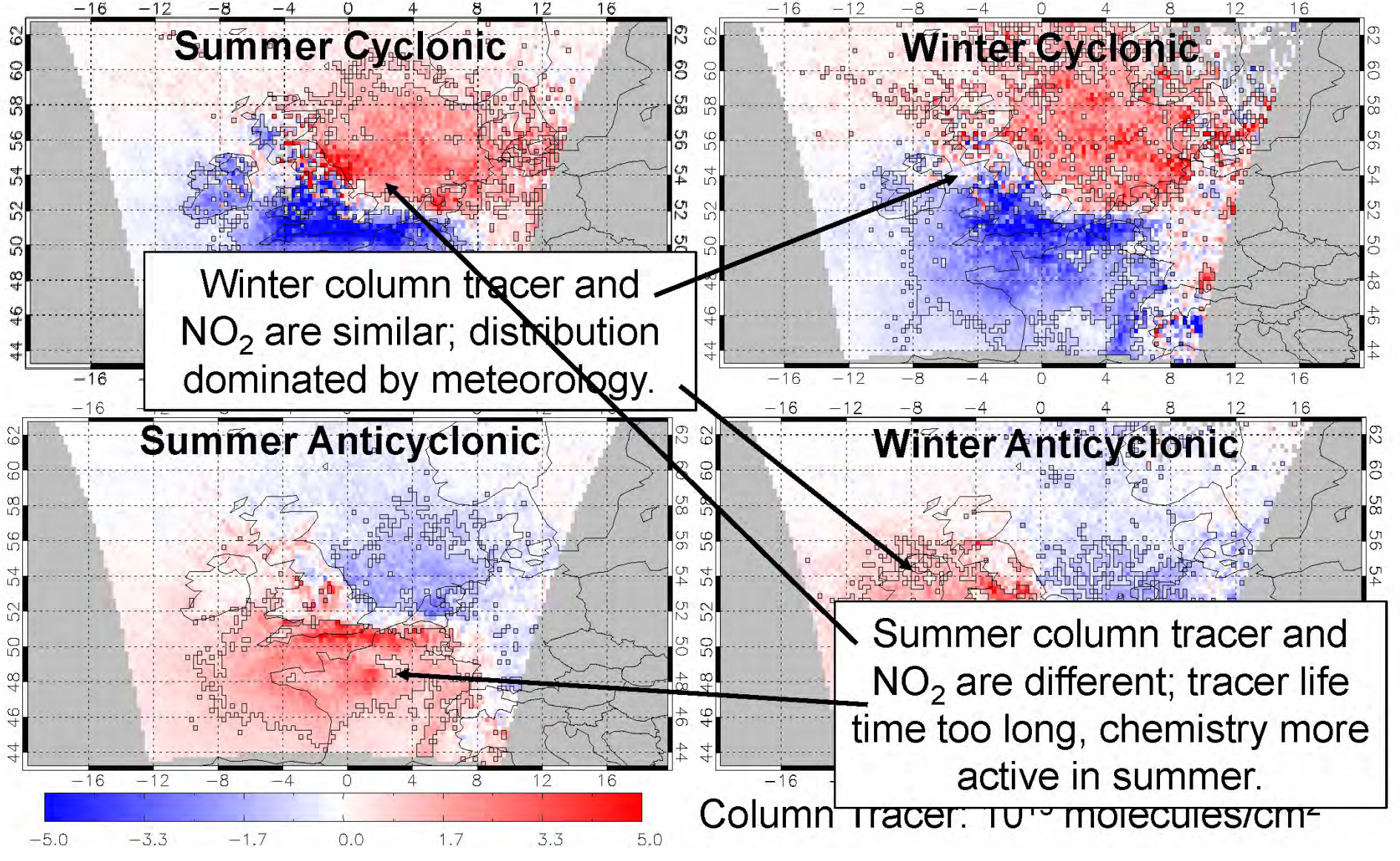

Winter column tracer and NO_2 are similar; distribution dominated by meteorology.

Summer column tracer and NO_2 are different; tracer life time too long, chemistry more active in summer.

Column Tracer: 10^{19} molecules/cm^2

Summary:

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- We successfully used LWT and OMI data to find climatological composites of air quality under different synoptic regimes.

  Pope RJ, Savage NH, Chipperfield MP, Arnold SR and Osborn TJ. (2014). The influence of synoptic weather regimes on UK air quality: analysis of satellite column NO_2. *Atmospheric Science Letters,* DOI: 10.1002/asl2.492
- The AQUM reproduces the air quality – synoptic weather patterns seen in the observations. However, it overestimates the relationships in winter as it is missing a NO_2 sink of N_2O_5 hydrolisis on aerosol.
- We use a idealised tracer to show in winter synoptic weather is the primary driver of UK/northern Europe NO_2 pollution spatially. However in summer, chemical processes are increasingly important.