# On track of $NH_3$: cross-validation of satellite and ground-level measurements

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# Improving Satellite Observations of Ammonia by Integrating Chemical Transport Modelling

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## RATIONALE

**Ammonia ($NH_3$)** is the most abundant alkaline gas in the atmosphere and has **major impacts on air, soil, and water quality**. It is responsible for the **formation ammonium ($NH_4^+$) particles** in the atmosphere which have a significant impact on human health (e.g. cardiovascular and respiratory diseases). In the UK, **agriculture** represents **88% of atmospheric $NH_3$ emissions**. The UK government aims to reduce emissions by 16% in 2030 compared to 2005 levels. The Code of Agricultural Practice (COGAP) for Reducing Ammonia Emissions was published in 2018 and is a guidance document that explains practical steps to minimize $NH_3$ emissions.

## SCOPING STUDY AIMS

1. To **cross-validate $NH_3$ column-integrated satellite** measurements **with $NH_3$ ground-level** measurements at **NUTS level**
2. To **evaluate temporal trends of $NH_3$**

## DATA

**Ground-level data** as measured monthly at the UKEAP network (*N* = 42 for Jul 07 – Nov 18)

**Monthly RAL-IASI data**: 0.025º x 0.025º; daily pass: 9:30 LT; Jul 07 – Nov 18

**Monthly RAL-CrIS data**: 0.025º x 0.025º; daily pass: 1:30 LT; Nov 15 – Nov 18

## RESULTS

**Clear seasonality in $NH_3$** concentrations as observed from grond-level and from the space. Some difference were observed across the country (Fig. 1).

**Mix response** when **comparing ground-level data and satellite** data at NUTS1 level. Some areas showed no correlation (i.e. East of England for CrIS data); other showed moderate correlation (East Midlands) (Fig. 2).

Based on **ground-level** data, **two areas in the UK** observed **significant upward trends** for the period **2007 – 2018 (south-west England & Wales).** Other **two** observed **signficant downward trends (West & East Midlands)**.

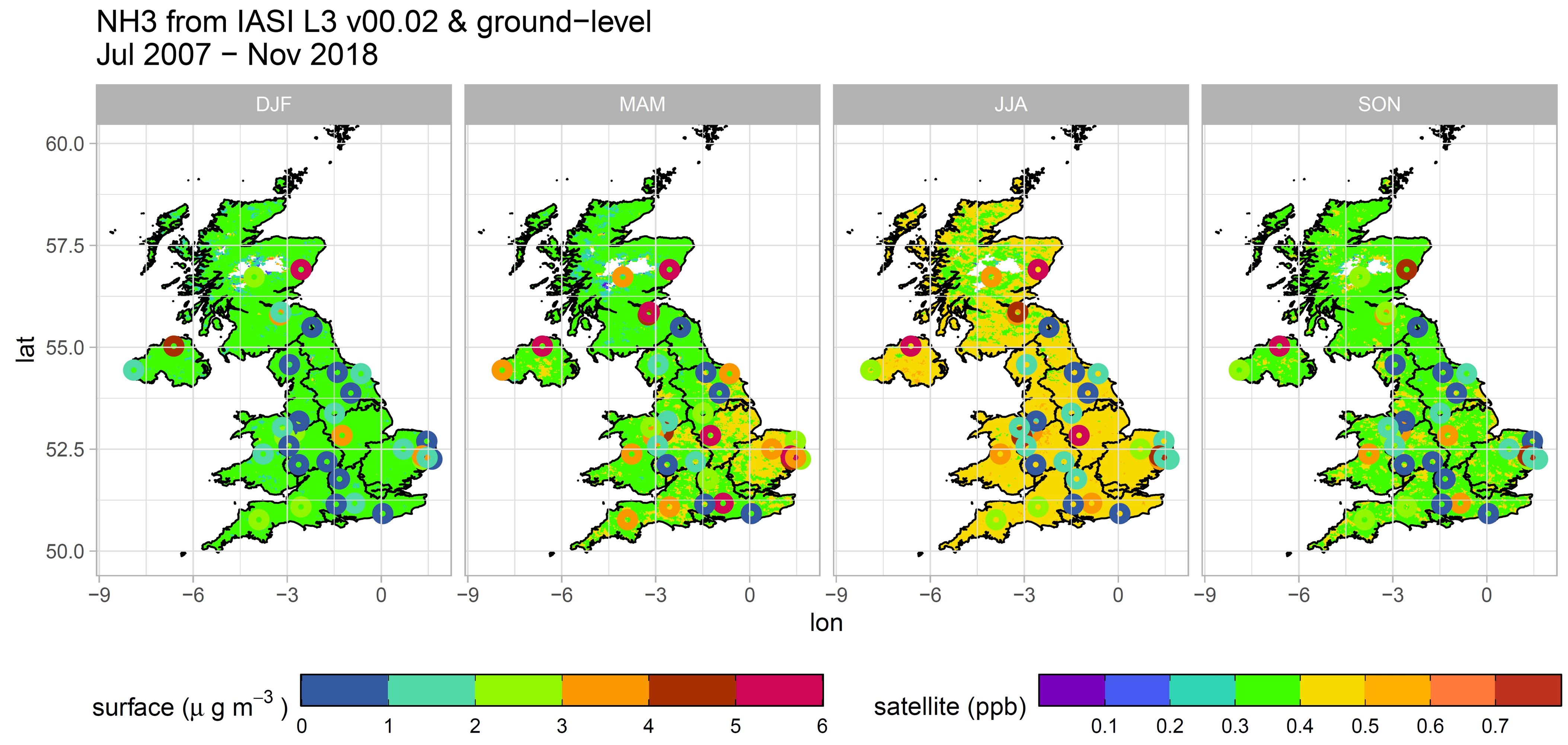


*Figure 1. Seasonal means from satellite (background colour) and grould-level (circles) for $NH_3$ in the UK for July 2017 – November 2018. Black lines represents NUTS1 area.*

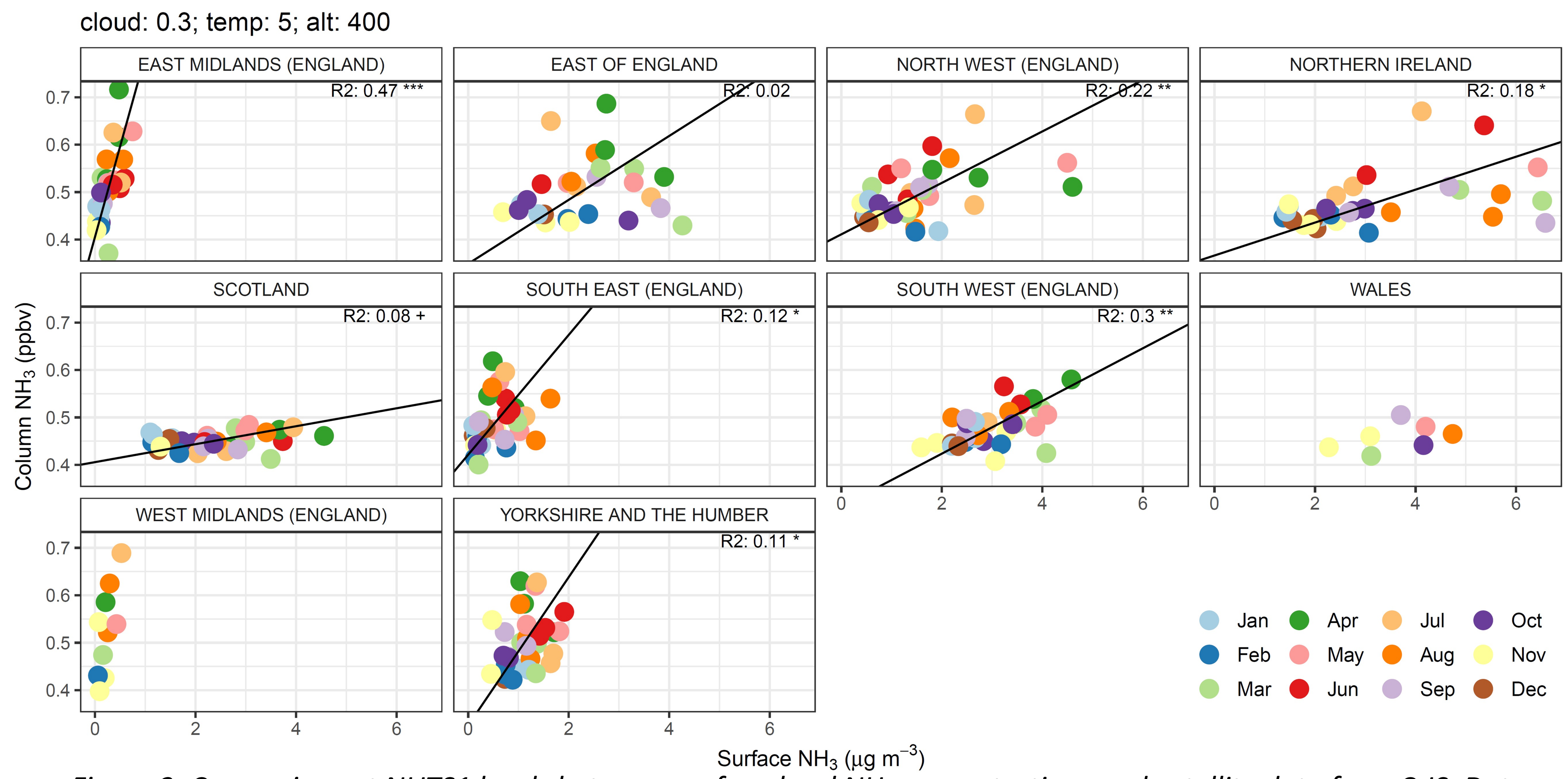


*Figure 2. Comparison at NUTS1 levels between surface-level $NH_3$ concentrations and satellite data from CrIS. Data from Nov 2015 to Nov 2018 considered. Correlation betweem the two indicated by the correlation coeficient ($R^2$). Only satellite data with a cloud cover < 0.3 and a contrast temperature between Surface and at 1 km >5 considered. Only data at altitudes < 400 m were compared.*

## PROOF OF CONCEPT AIMS

1. Establish the current level of **agreement between satellite-derived NH3 estimates** with state-of-the-art **regional chemical transport model** (CMAQ).
2. **Develop satellite NH3 estimates at improved spatial and temporal scales** through the Integration of modelled vertical profiles.
3. **Improve the agreement between satellite observations and ground-level measurements** for individual episodes and longer timescales with a focus on intensive agricultural activity.

## DATA

**Satellite data:** CrIS Level-2 satellite soundings, averaging kernels and filters for 2018-2020.

**Model data:** Hourly CMAQ modelled $NH_3$ vertical profiles at 2km spatial resolution for 2018-2020. Figure 3 shows an example of CMAQ 4D data.

**High-time resolution ground-based data:** Hourly data from EMEP and NERC supersites available from 2018.

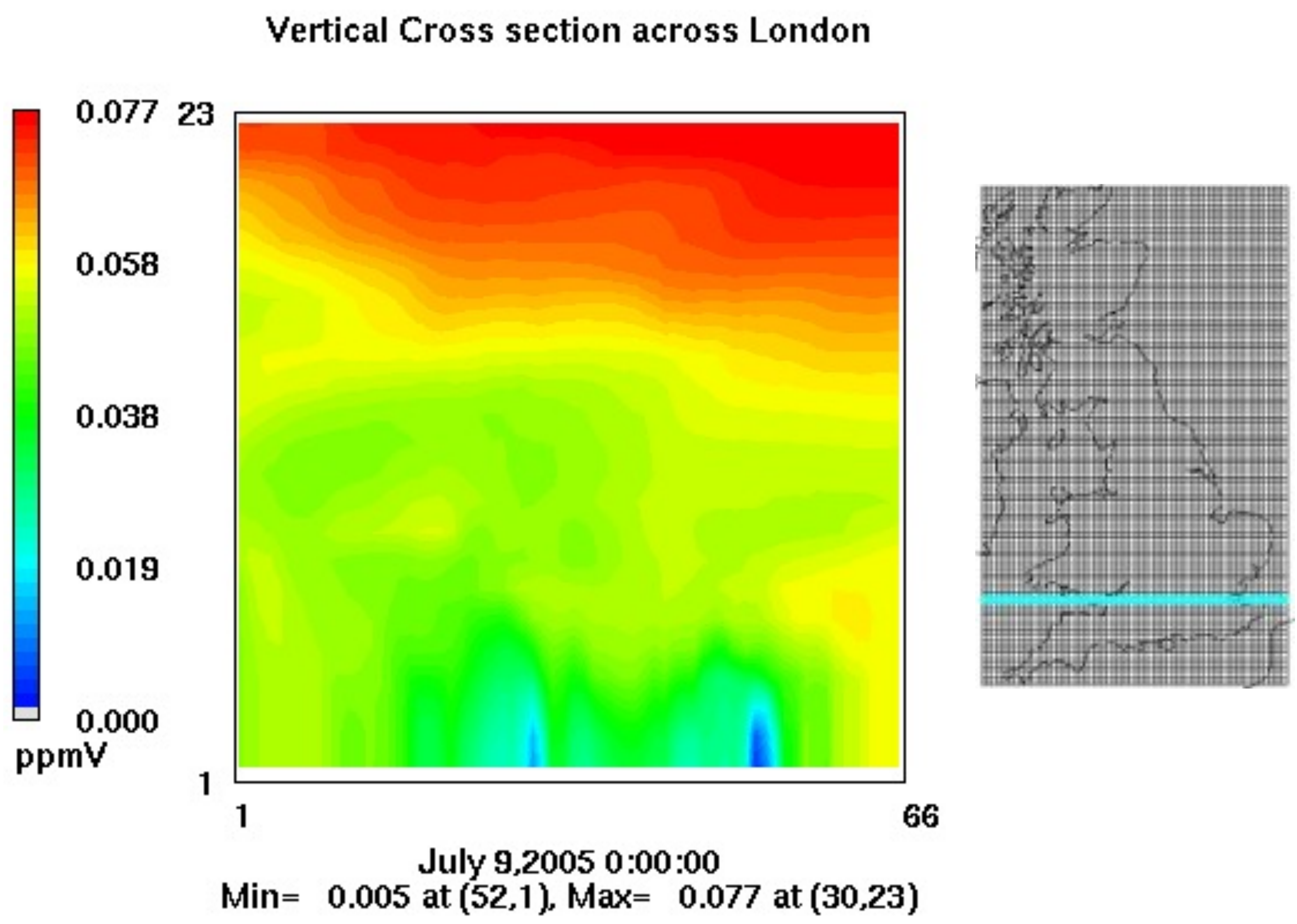


*Figure 3. Example of the 4D data output from CMAQ (image is of ozone for representation purposes)*

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