High-resolution maps of ammonia concentration and nitrogen deposition for Baden-Württemberg

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1. Objectives

- Maps of wet and dry deposition of reactive nitrogen (N_r) compounds are generated on a hectare raster for Baden-Württemberg (BW), Germany.
- An integrative modelling approach is applied, combining interpolation methods for wet deposition, emission maps and statistical dispersion models for ammonia as well as results from atmospheric transport models.
- The results are useful input for tasks such as evaluating threads to terrestrial ecosystems by excess atmospheric N concentration (critical level exceedance), N deposition (critical load exceedance), or establishing N balances for valuating excess nutrient loads on agricultural land (critical surplus exceedance).

2. Project outline

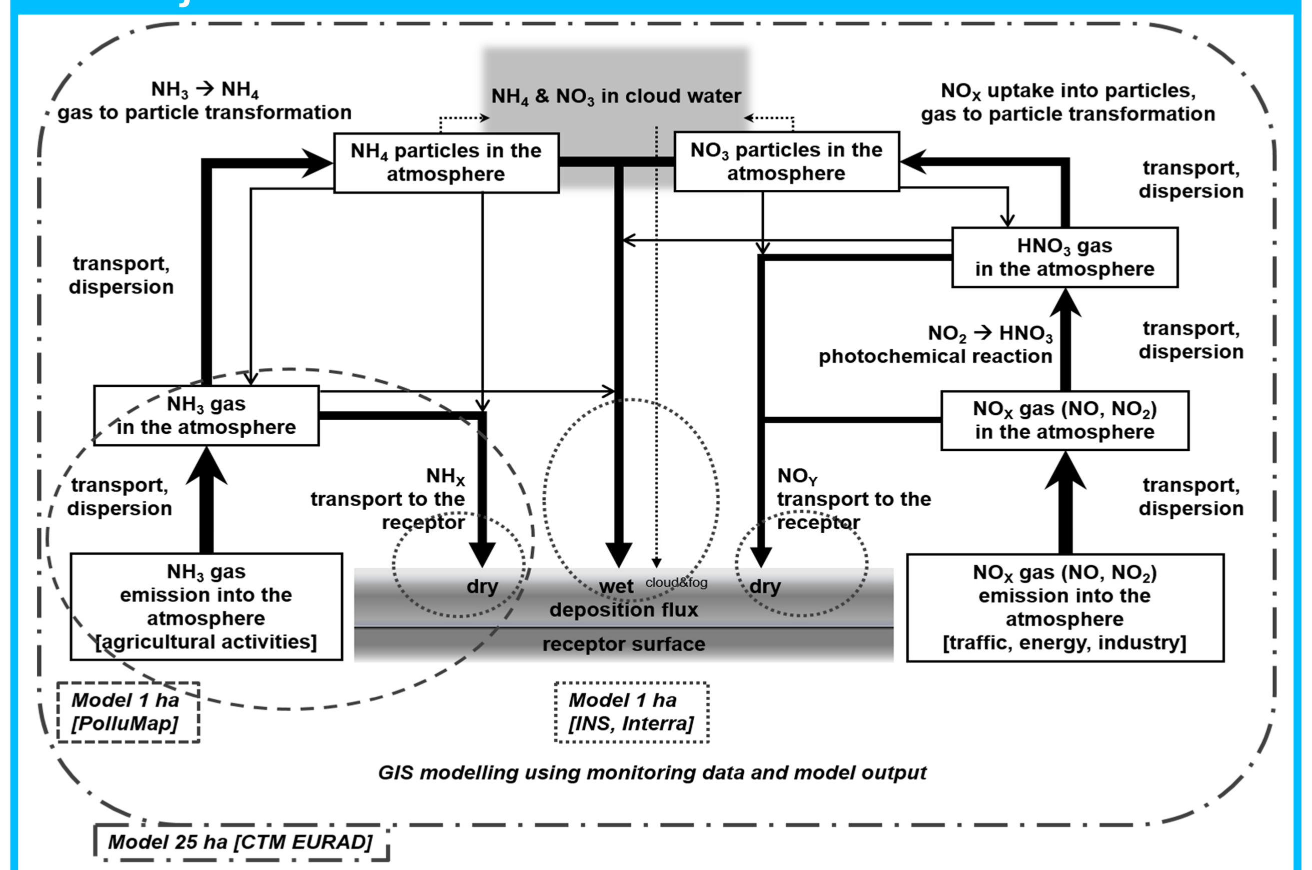

Fig. 1: Outline of the integrated modelling approach [adopted from Hertel (2009); modified]

Air concentration and deposition fluxes of reactive nitrogen (N_r) in Baden-Württemberg is modelled using the chemical transport model (CTM) EURAD providing a 25 ha raster resolution output, the inferential model PolluMap, GIS based geostatistical modelling, and GIS based regression modelling, respectively.

Different modelling approaches are combined in order to derive 1 ha raster maps of air concentration and atmospheric deposition of N_r species. The outline of the model combination is presented in Figure 1.

- All atmospheric pathways of oxidised and reduced N_r from emission over transport, in-air physico-chemical reaction, production of secondary N_r species, air concentration and wet and dry deposition fluxes are modelled in hourly time steps for the year 2014 using the CTM EURAD.
- The ecosystem level model output resolution (1 ha) for concentration and deposition fluxes of N_r species is achieved by GIS implemented modelling. Wherever applicable measurement data are integrated into the modelling approach, minimizing deviations between reliable monitoring data and modelling results.
- PolluMap (Meteotest) is used for modelling ammonia concentration and dry deposition using 1 ha local emissions and land use data along with regional CTM EURAD output data including monitoring data of ammonia on an annual base.

2. Project outline *(continued)*

- Wet deposition, and dry deposition into forests (including organic N) is calculated using GIS procedures (geostatisical modelling) carried out by INS based on annual forest monitoring data (open field, throughfall, canopy budget model data) and 1 ha precipitation fields, and land cover data.
- GIS based regression modelling is applied in order to derive high resolution precipitation data, and N_r wet and dry deposition estimates from monitoring results for forest areas (Interra).

3. Main modelling and mapping results

Main model outcome of the project are 5-year average air concentration and deposition maps (Figures 2 to 5). Since the model combination applied where ever possible is based on measured data, or at least includes a fitting to data derived from annual measurements, the result compares quite well with ground truth monitoring (graphs in Figure 2 and 5).

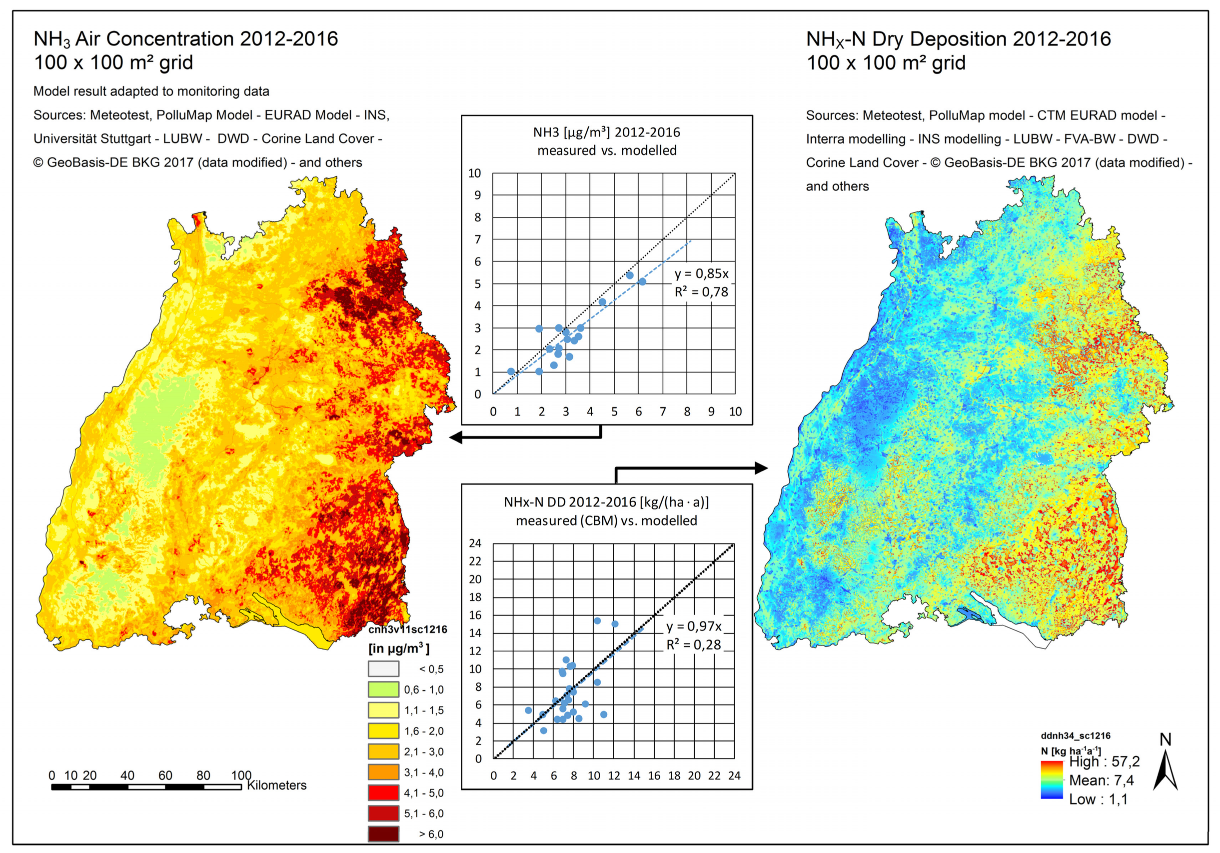

Fig. 2: Air concentration of ammonia (NH_3) adjusted to measurements (left) and dry deposition of reduced nitrogen (NH_X-N) (right) averaged for 2012-2016 (1ha raster); gaphs: comparison with monitoring data

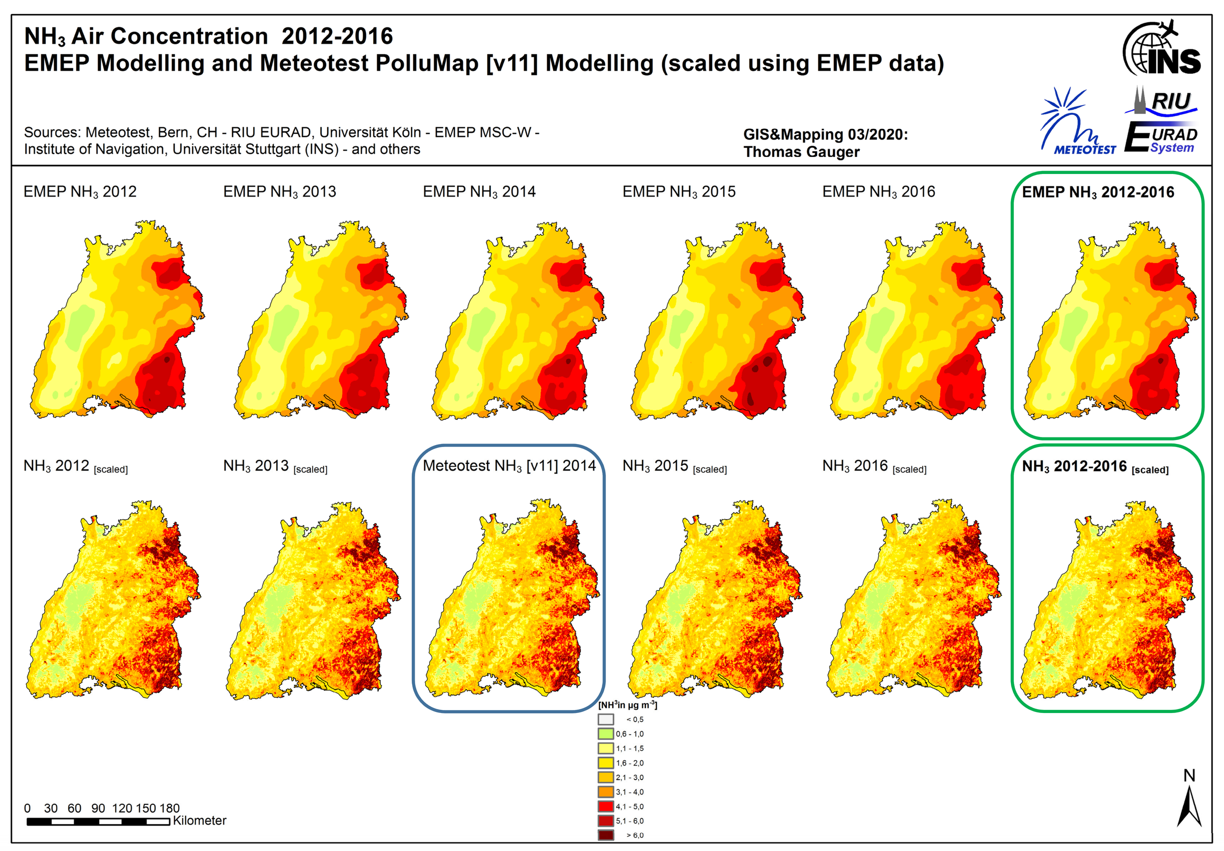

Fig. 3: Scaling of 2014 NH_3 air concentration over time (blue frame, lower row) using EMEP model results (upper row), and averaging for the years 2012-2016 (green frames)

3. Main modelling and mapping results *(contd)*

Wet (WD) and dry deposition fluxes (DD) of all relevant N_r species, i.e. inorganic Nitrogen *(NH_X-N = NH_3-N + NH_4-N; NO_Y-N = NO-N + NO_2-N+ HNO_3-N+ NO_3-N)*, and organic Nitrogen *(N_{org})*, are modelled separately and successively aggregated to total deposition (TD) of total reactive Nitrogen N_r (Maps in Figure 4).

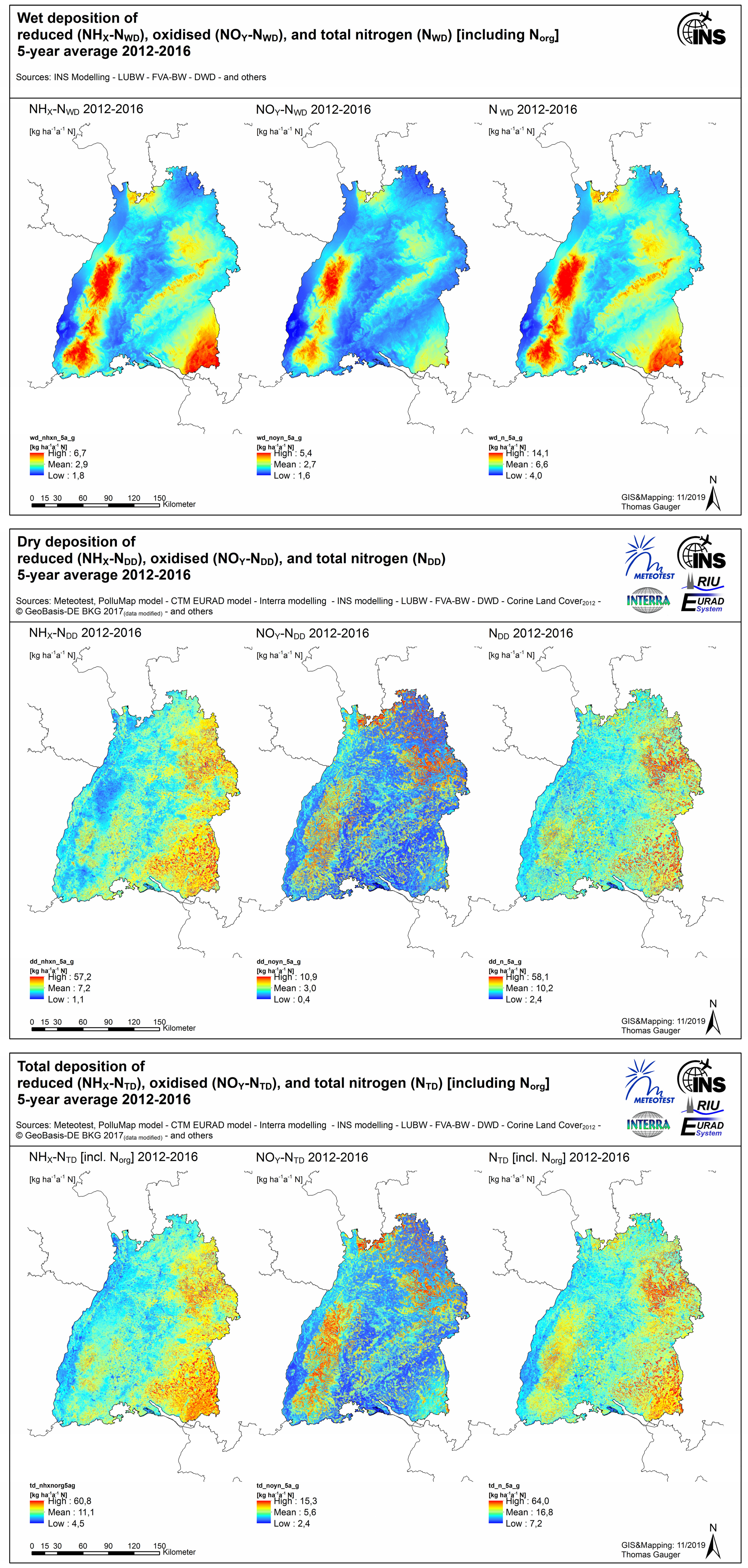

Fig. 4: Maps of wet (WD), dry (DD) and total deposition (TD) of total reactive nitrogen (N_r) in Baden-Württemberg averaged for the years 2012-2016

3. Main modelling and mapping results *(contd)*

A scaling procedure is applied in order to derive a five year time series and 5-year average air concentration and deposition maps using relative differences between annual EMEP modelling results (illustrated in Figure 3).

Figure 5 shows results of the deposition modelling and mapping of the wet, dry, and total deposition flux of high resolution total reactive nitrogen *(N_r)* separately. The comparison with corresponding monitoring data is visualised in scatter diagrams below the maps, showing reasonable correlation.

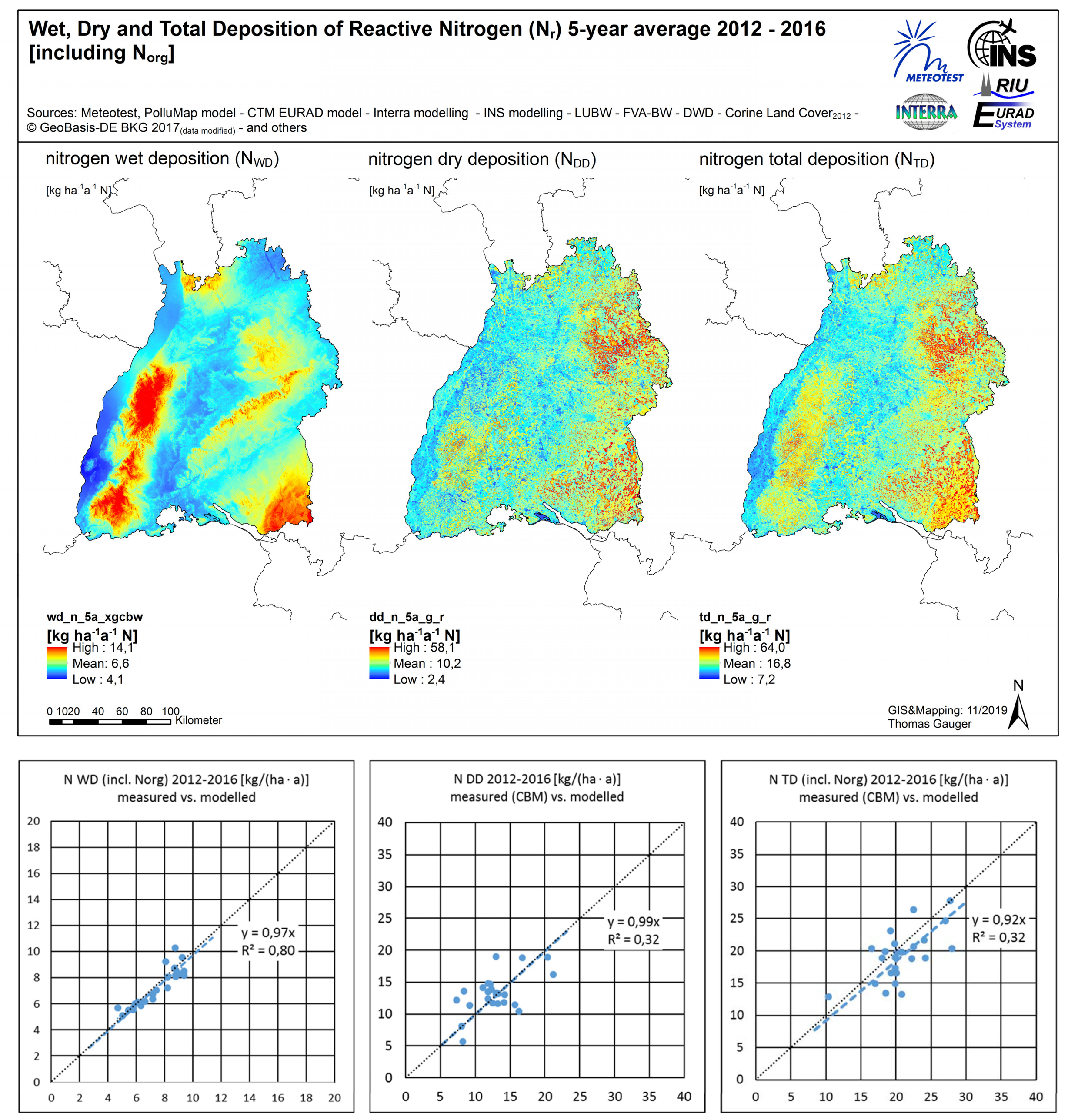

Fig. 5: Maps of wet, dry and total deposition of total reactive nitrogen (N_r) in Baden-Württemberg averaged for the years 2012-2016 – graphs: comparison with monitoring data

4. Conclusions and outlook

The concept and main results of ecosystem specific high resolution modelling and mapping air concentration and deposition fluxes of reactive Nitrogen *(N_r)* is presented.

Comparison with ground truth data confirm, that at ecosystem level exposure to N_r is met more properly than by chemical transport models. Next, refinement of the emission database, more measurement data, and data on ecosystem effects are expected, which enhance robustness of the modelling and mapping result and its application for mitigation of N_r.

5. Acknowledgements

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Further Information at StickstoffBW