# Effects of climate change on atmospheric nitrogen deposition to the Baltic Sea

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## **Acknowledgements**:


- Nordic Council of Ministers project EnsClim
- EU ECLAIRE project
- EMEP under UN-ECE
- HELCOM

# **Content**:

- EMEP contribution to HELCOM
- Calculation of nitrogen deposition to the Baltic Sea
- EnsClim Project
- Application of EnsClim results to the Baltic Sea
- Effects of climate change on nitrogen deposition
- Conclusions

# EMEP contribution to HELCOM

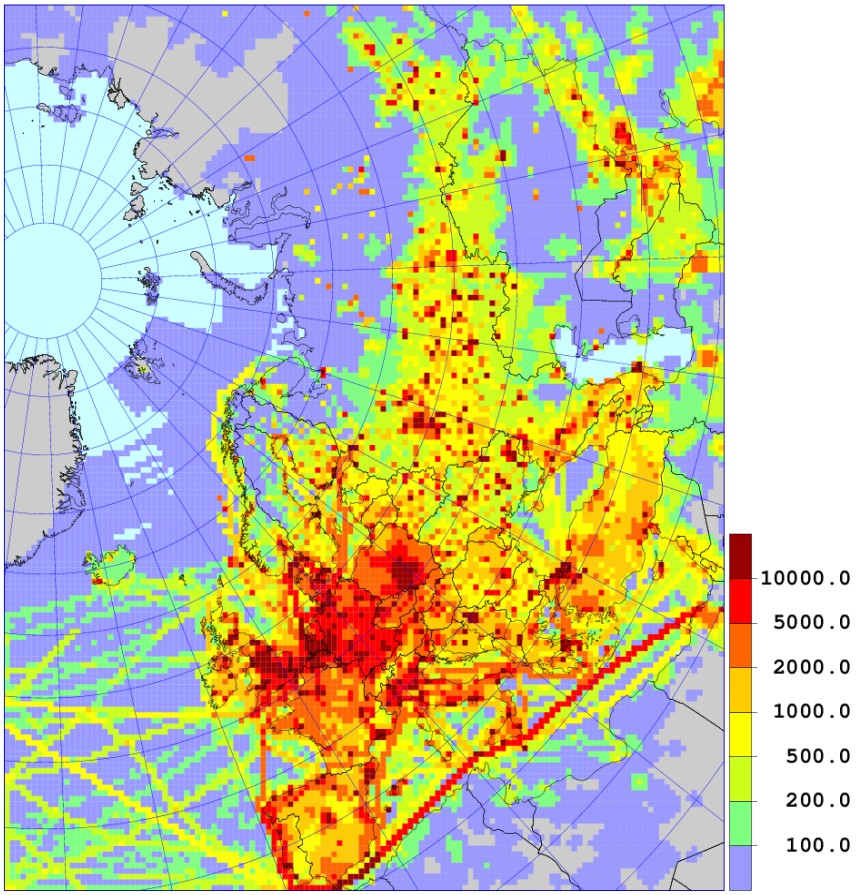
- Long term cooperation starting from 1997 and agreed until 2018 (Bartnicki et al., 2011, ACPD)
- Annual contribution from three EMEP Centres: MSC-W, MSC-E and CCC
- Annual deposition of N, HM and POP
- Annual source-allocation budgets
- Comparison of model results and measurements at HELCOM stations
- Joint annual report
- Indicator fact Sheets (on HELCOM web)

# Why atmospheric N deposition important?

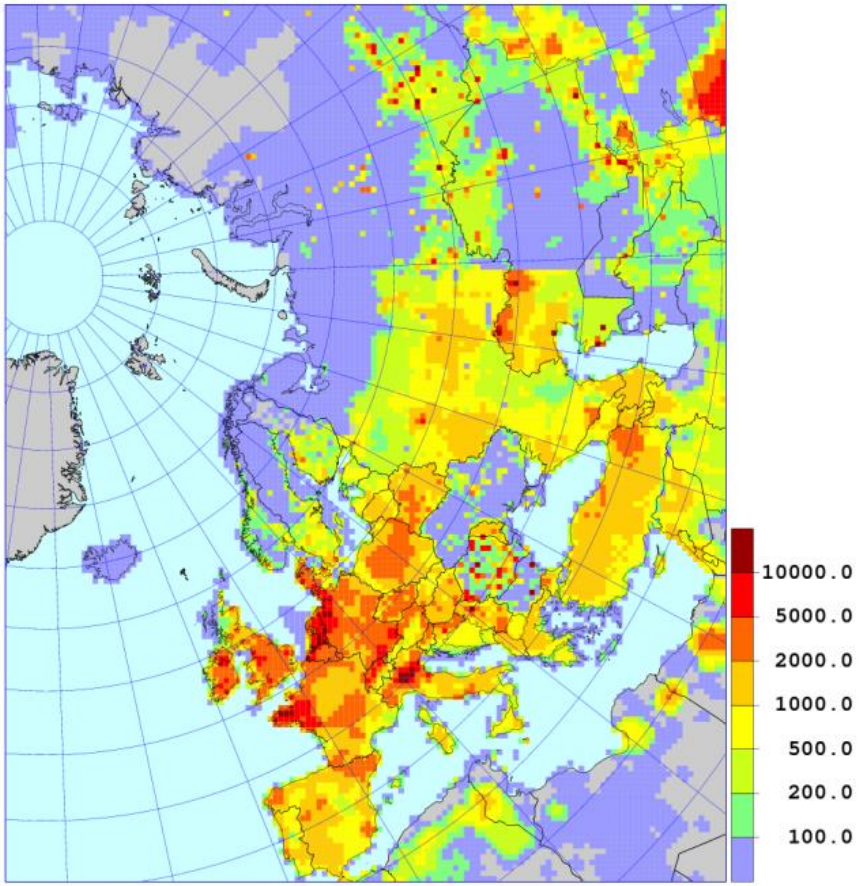
- Eutrophicatian – major problem for the Baltic Sea
- Caused mainly by excessive input of N and P
- Mostly waterborne input for P
- 25-30% of N coming from atmospheric deposition
- Reduction of atmospheric N deposition included in BSAP (Baltic Sea Action Plan)
- What will be the effects of the climate change?

# Calculation of nitrogen deposition - emissions

NOx - 2011

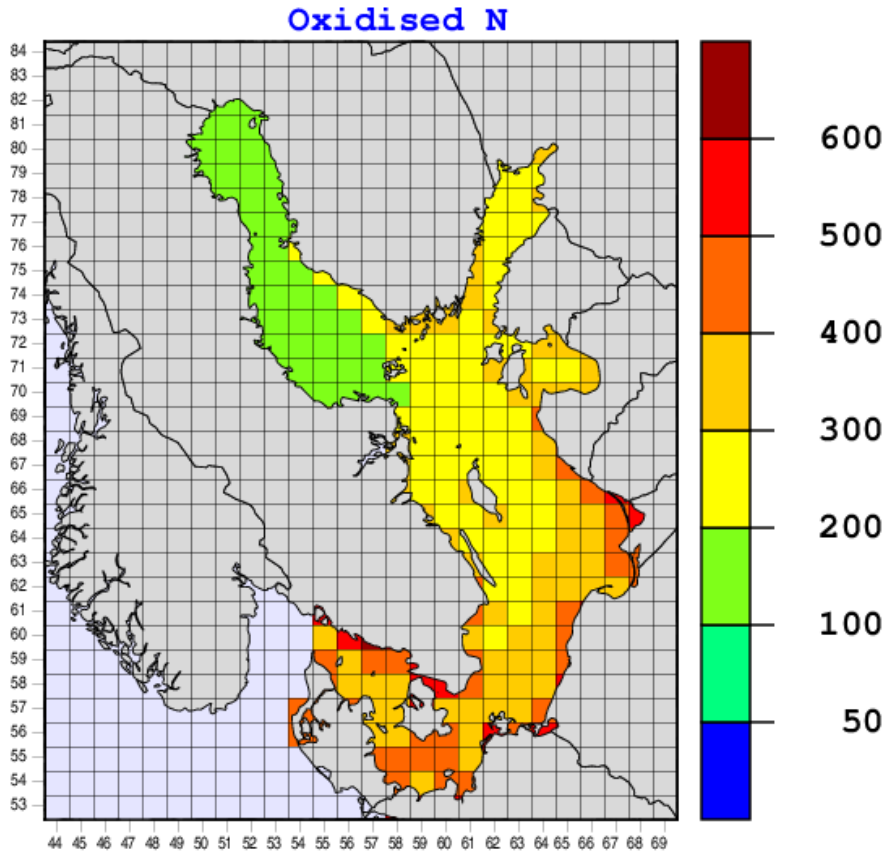



NH3 - 2011

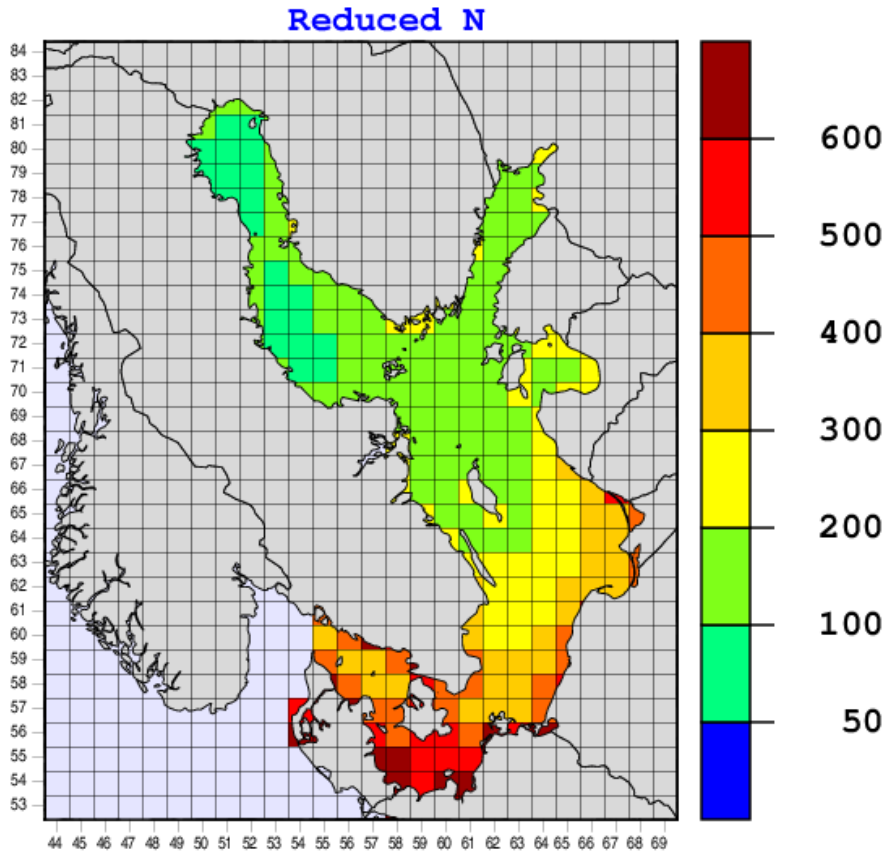


# Calculation of nitrogen deposition Baltic region

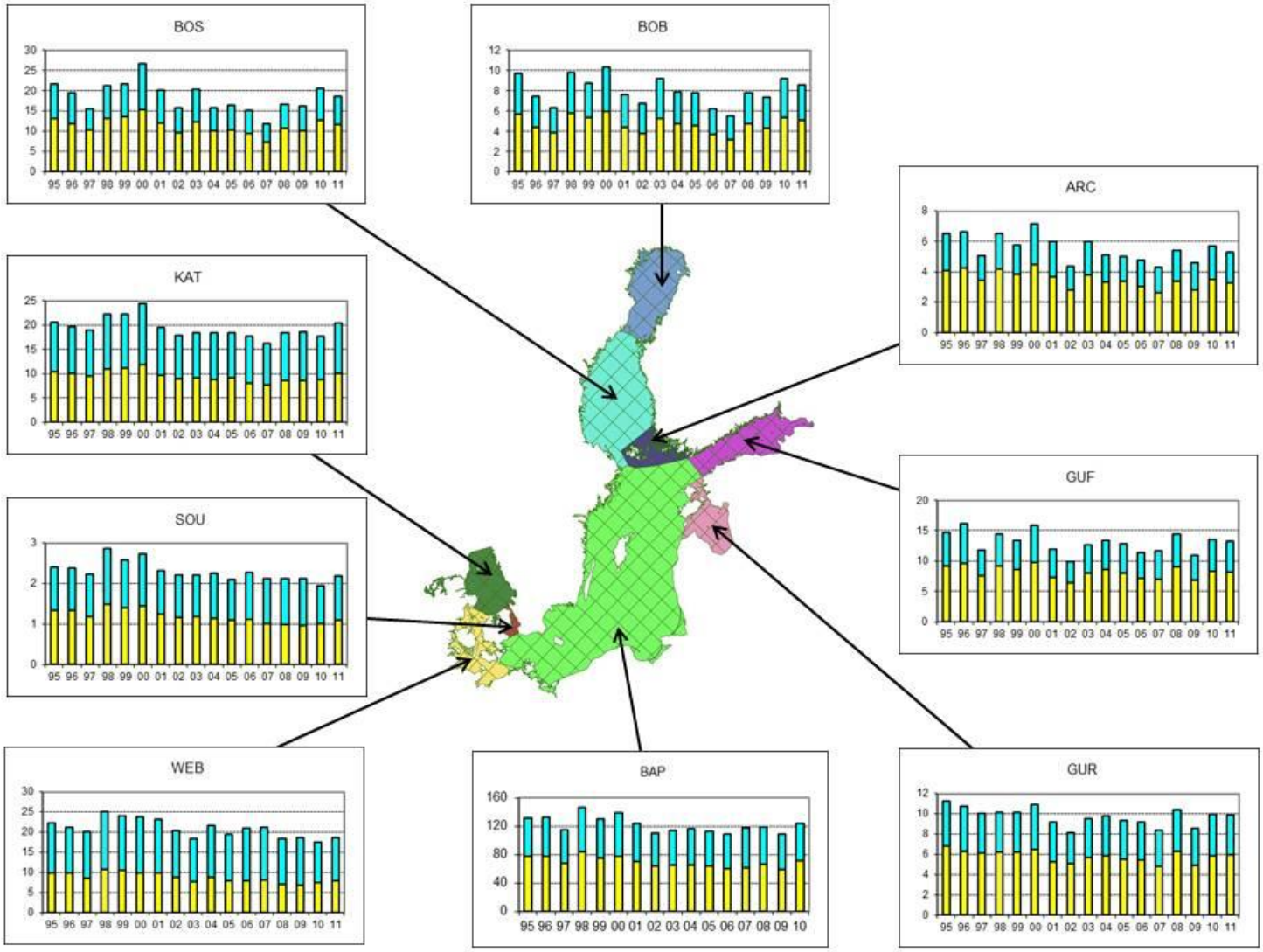
Oxidised - 2011



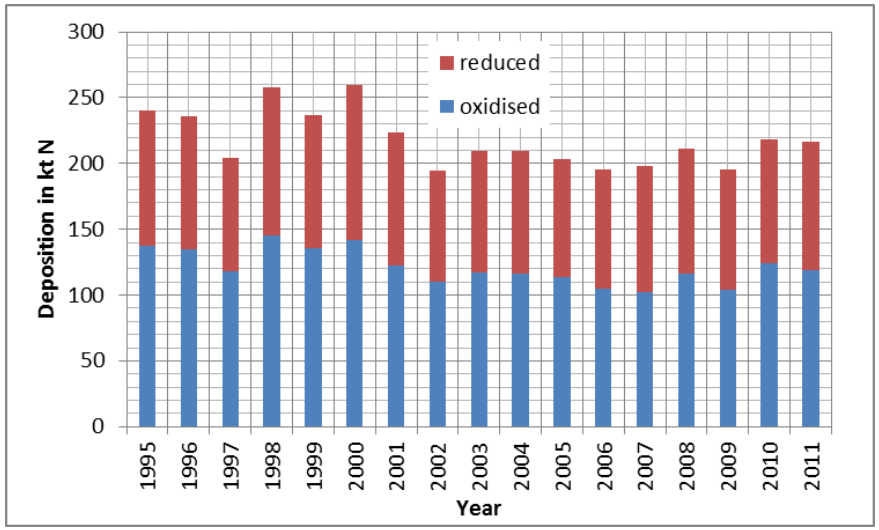

Reduced - 2011

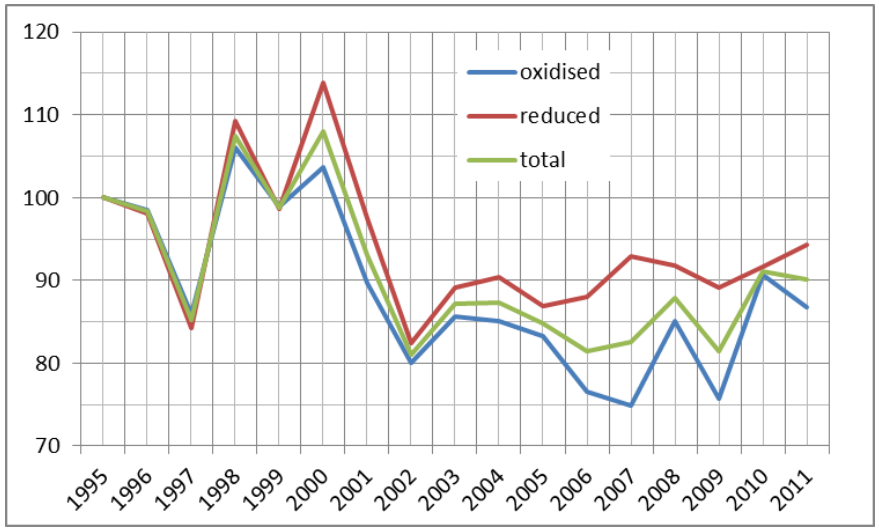


# Calculation of nitrogen deposition Sub-basins

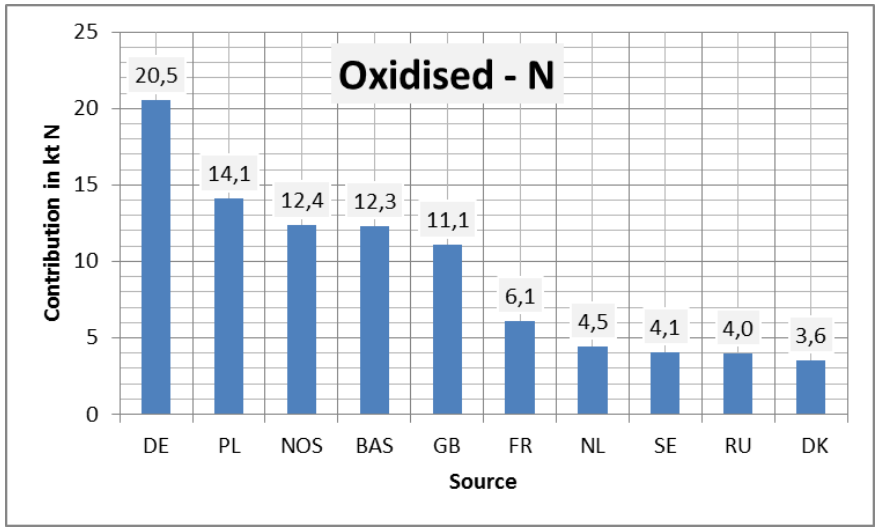


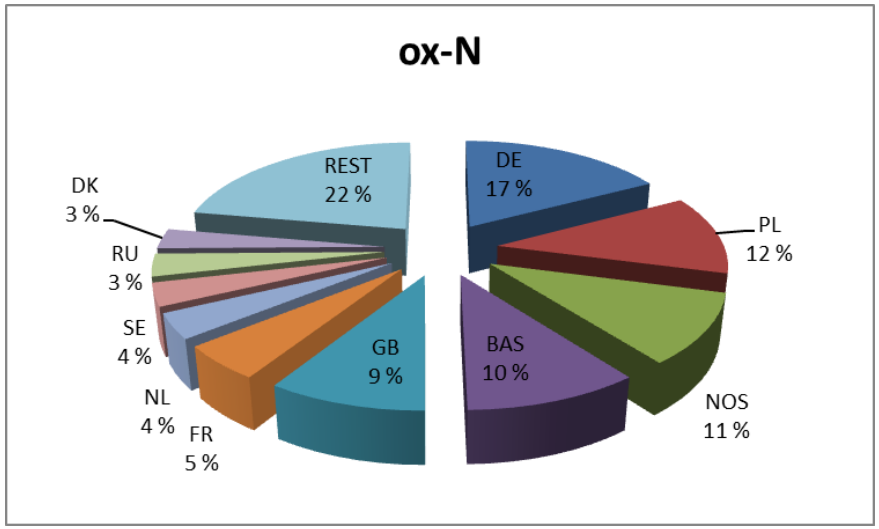
# Calculation of nitrogen deposition Baltic Sea Basin 1995-2011



# Source allocation budget 2011
# Oxidised N



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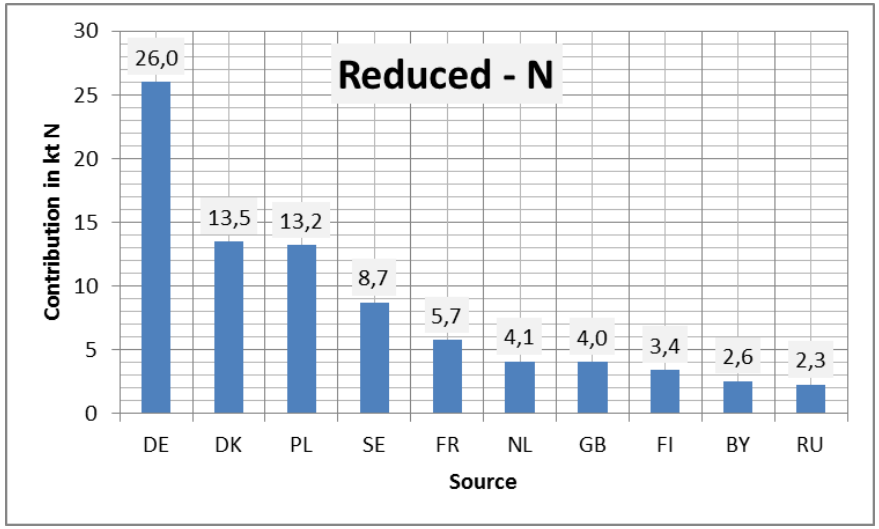
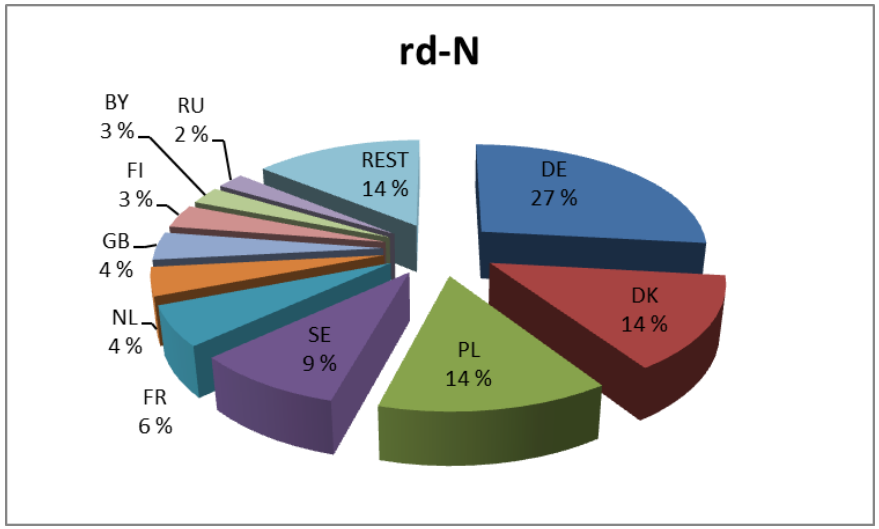
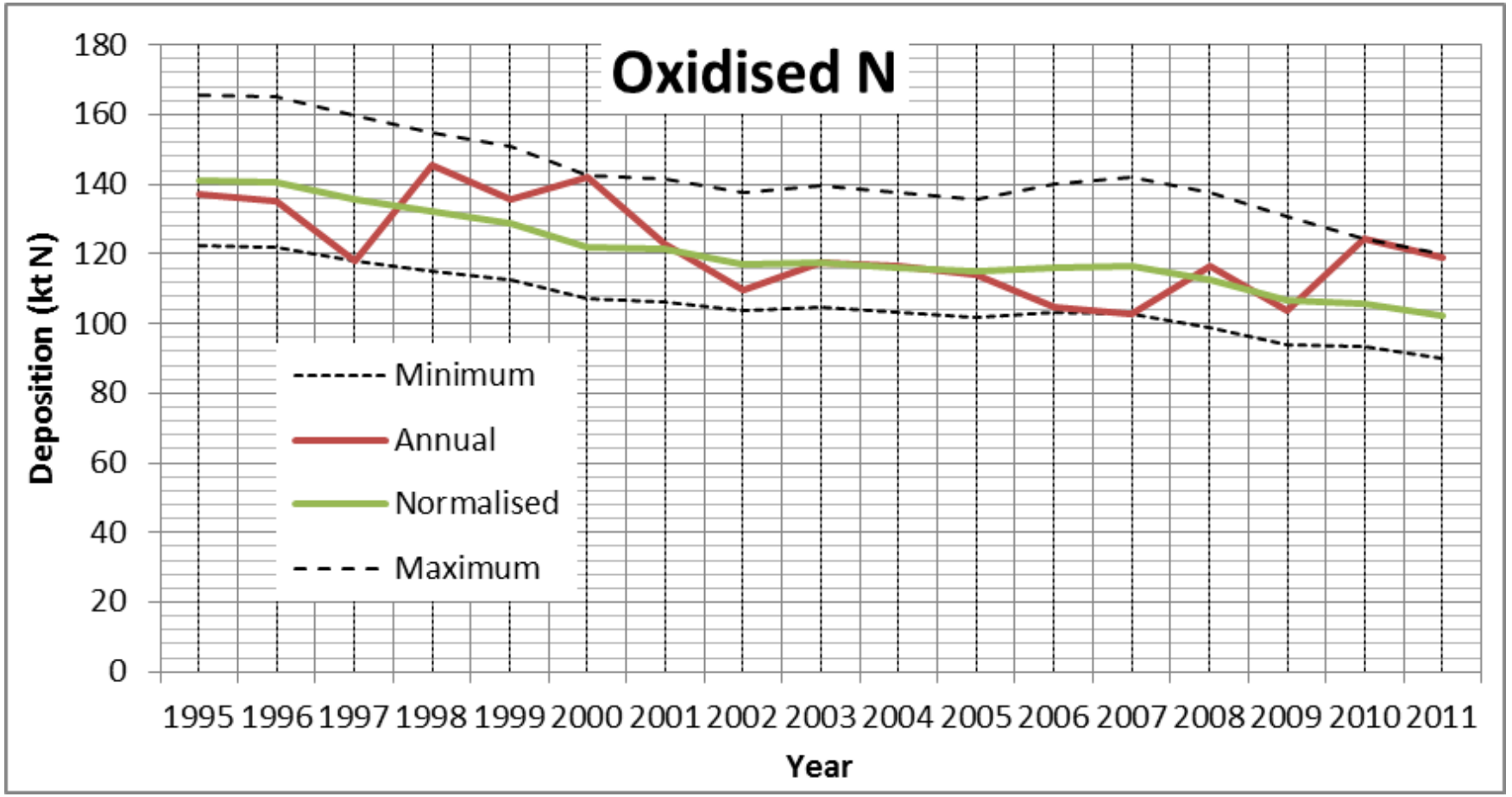


# Normalised depositions



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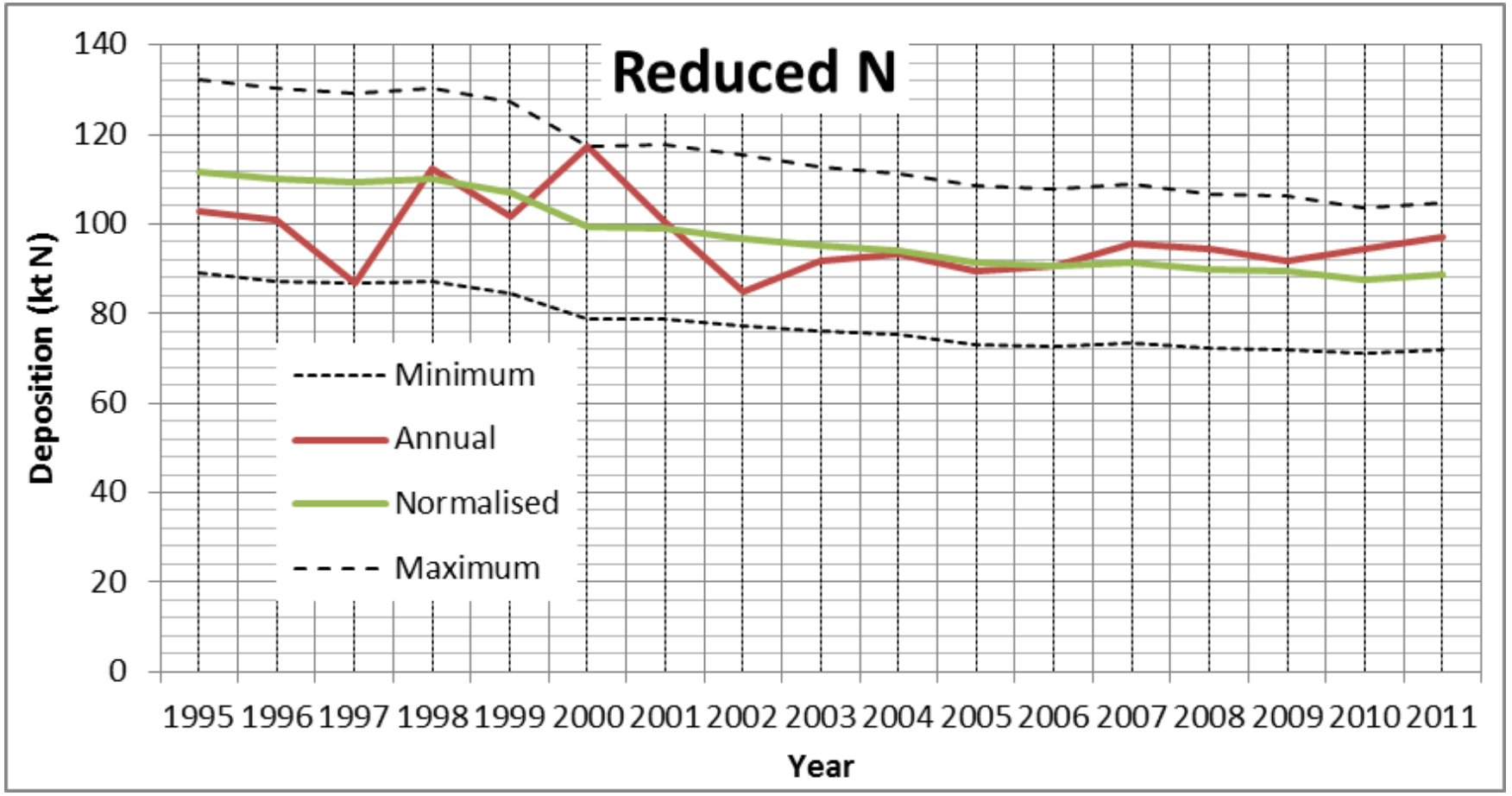

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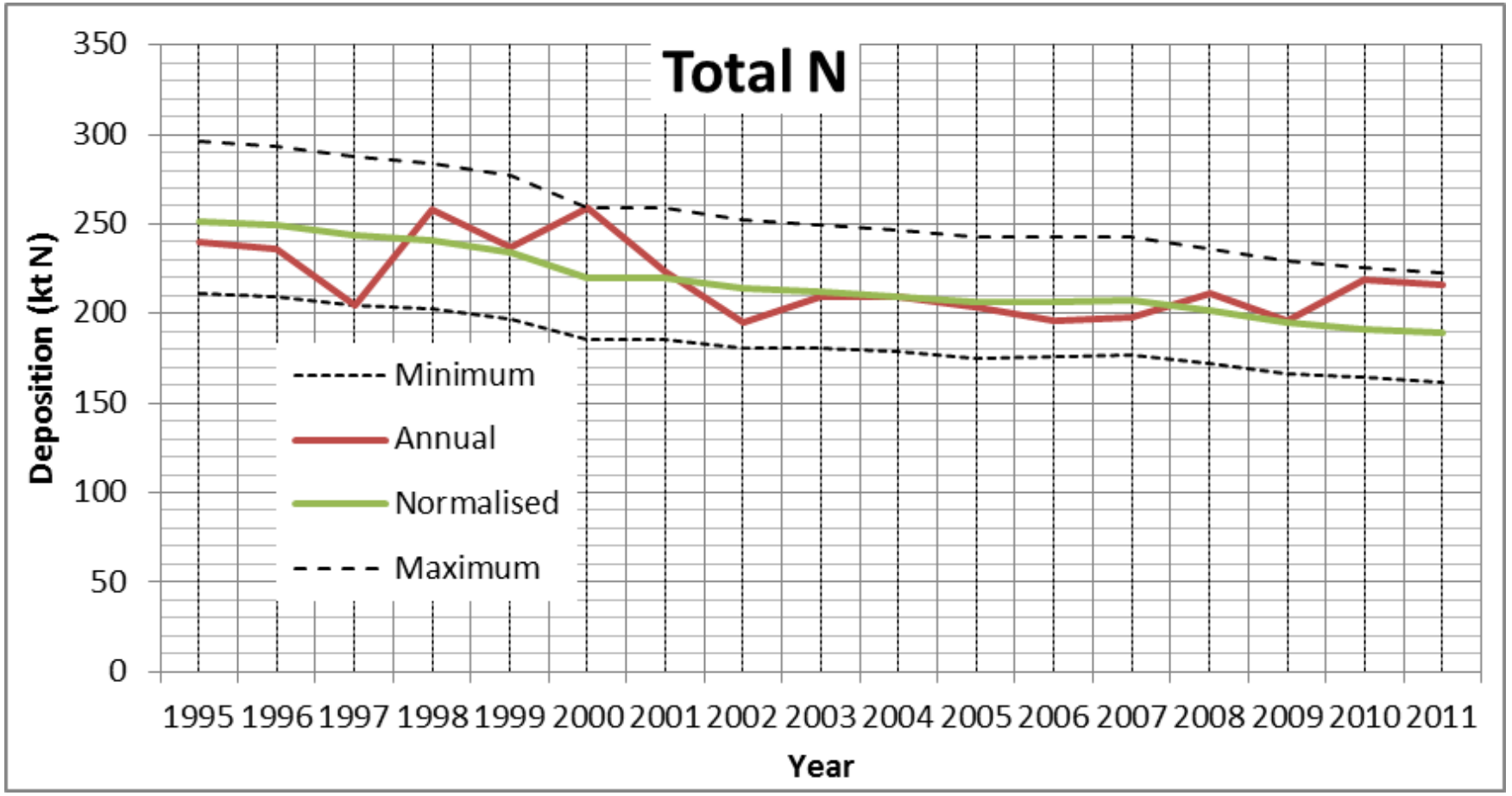
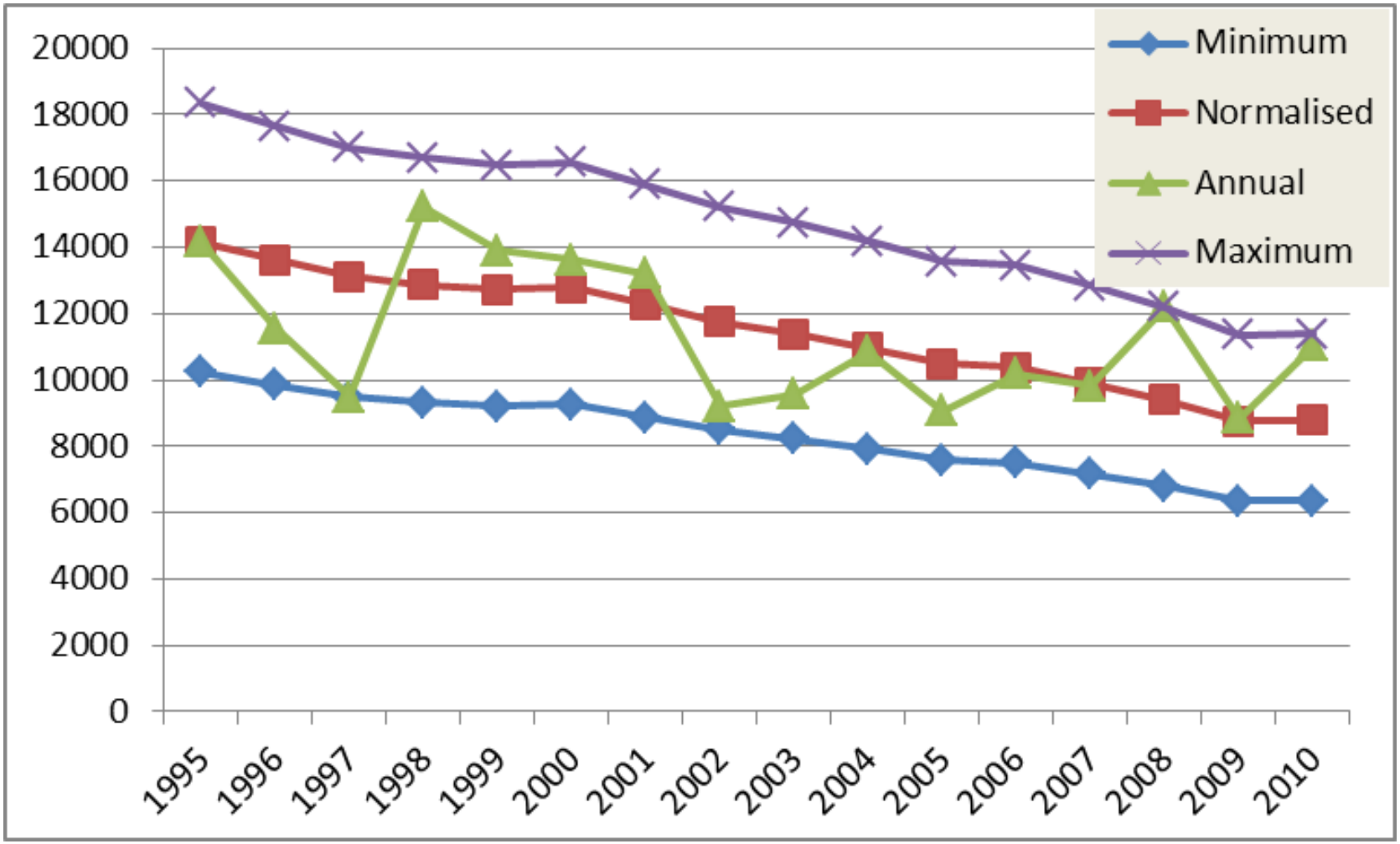


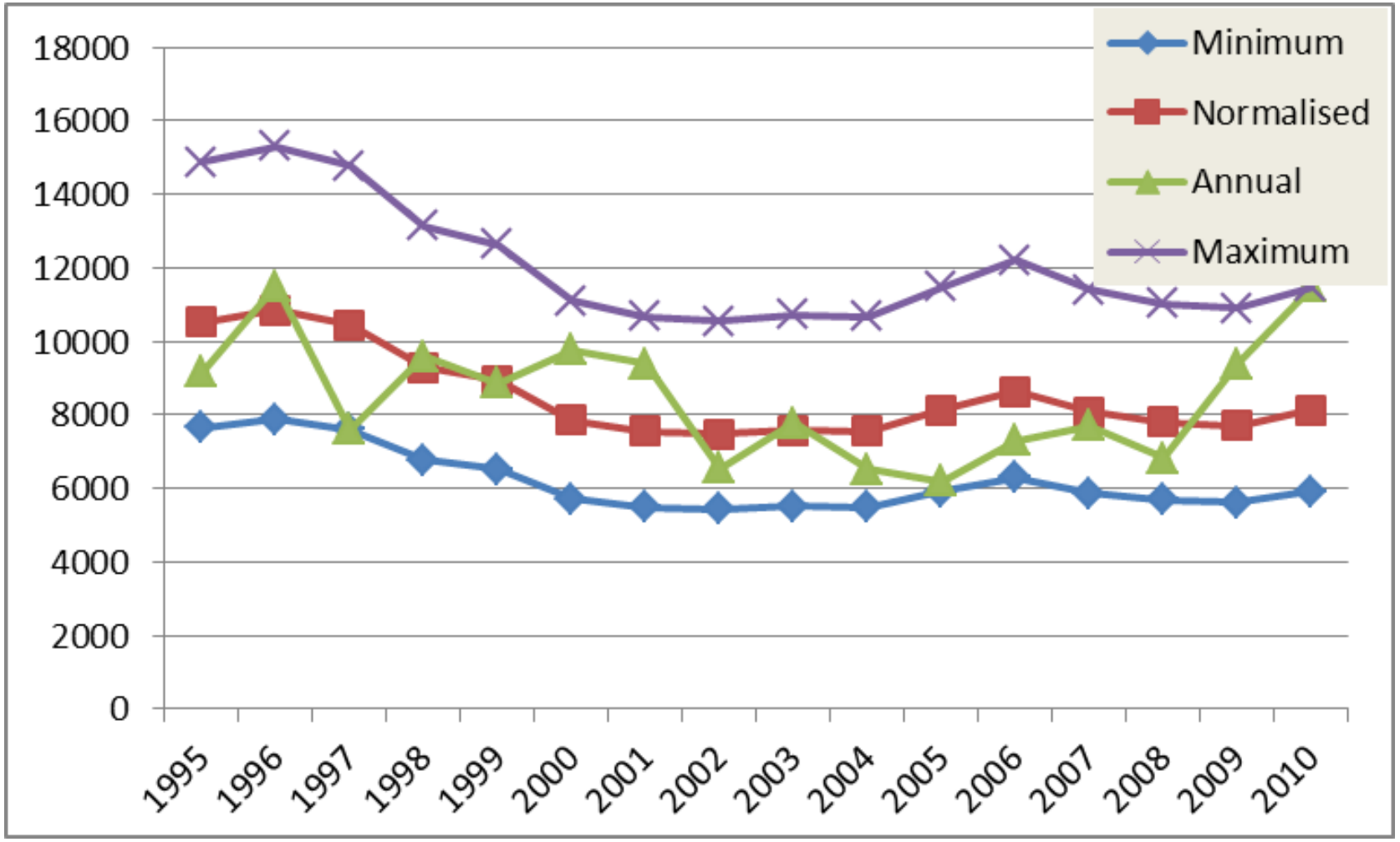
# Example of normalised contributions

Oxidised N (Mg N/year), BAP, Germany



# Example of normalised contributions

Oxidised N (Mg N/year), BAP, Poland



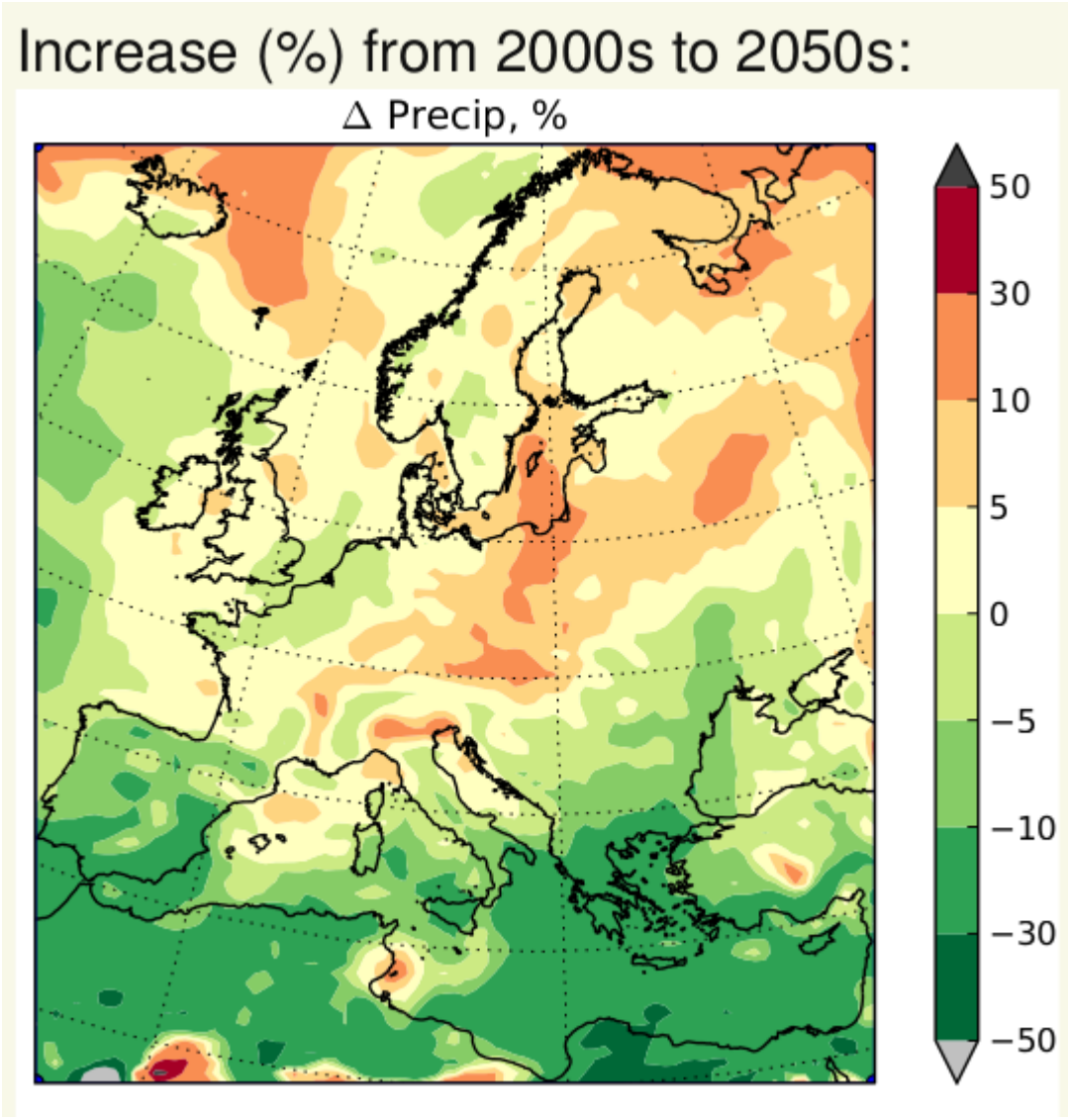
# EnsClim project

- Goal: Estimation of the impact of climate and emissions changes on the deposition of reactive nitrogen (Nr) over Europe in the period 2000 – 2050 (Simpson et al., 2014, ACPD)
- Four CTM models used: regional - EMEP MSC-W, MATCH and SILAM, and hemispheric DEHM
- Climate in 2000 based on meteorology between 1990–2009 and climate in 2050 based on meteorology between 1940–2059. Both from global-scale ECHAM5-A1B general circulation model (GCM) (Roeckner et al., 2006, J. Climate)

# EnsClim project

- Horizontal ECHAM resolution: ca. 140 km × 210 km
- Temporal resolution: 6 hours
- Downscaling over Europe with the Rossby Centre Regional Climate model (RCM), version 3 (RCA3)
- Horizontal resolution of RCA3: 0.44° × 0.44° (ca. 50 km × 50 km) for the transport models
- Boundary conditions for regional models from hemispheric DEHM model

# EnsClim project



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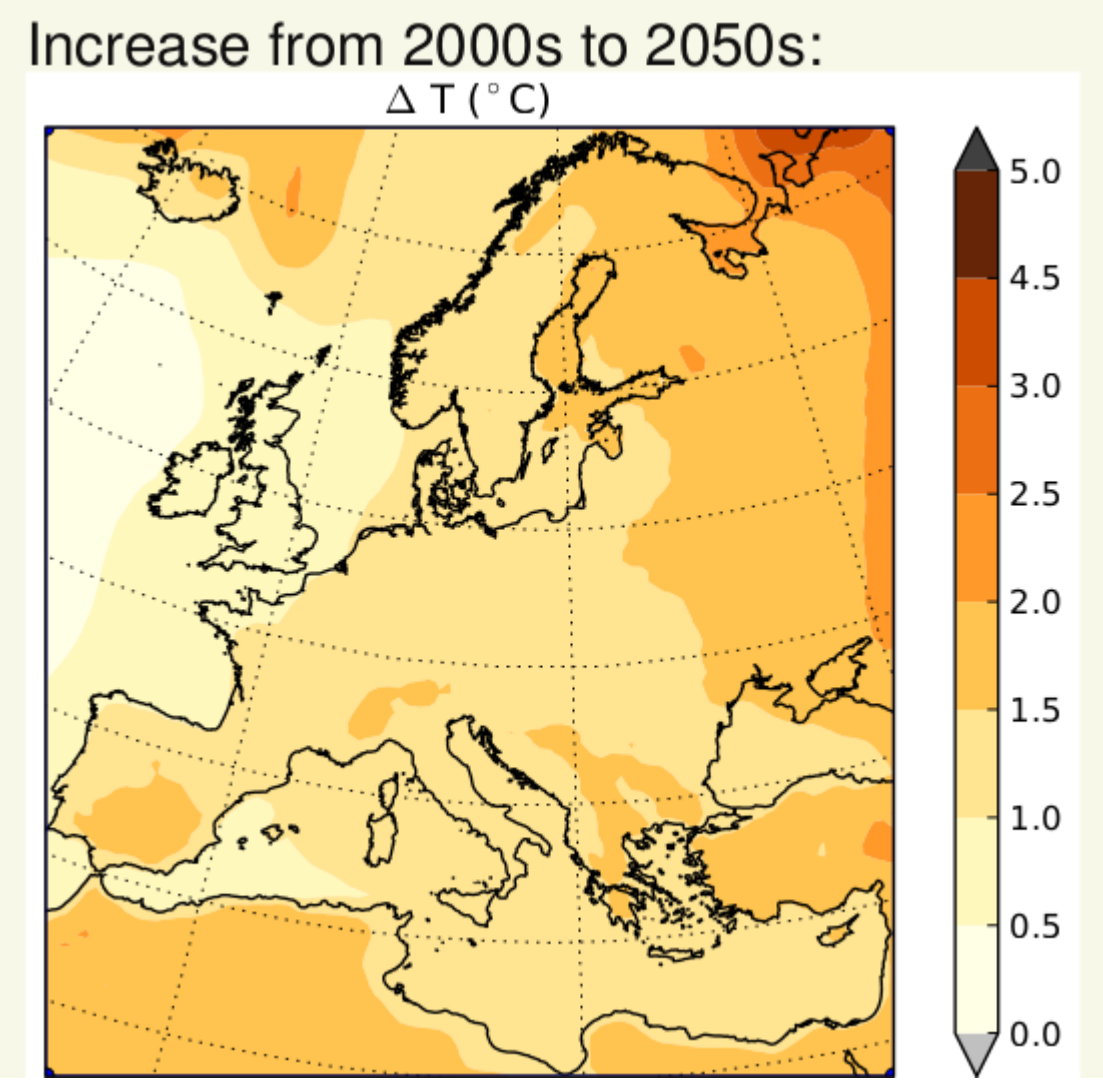
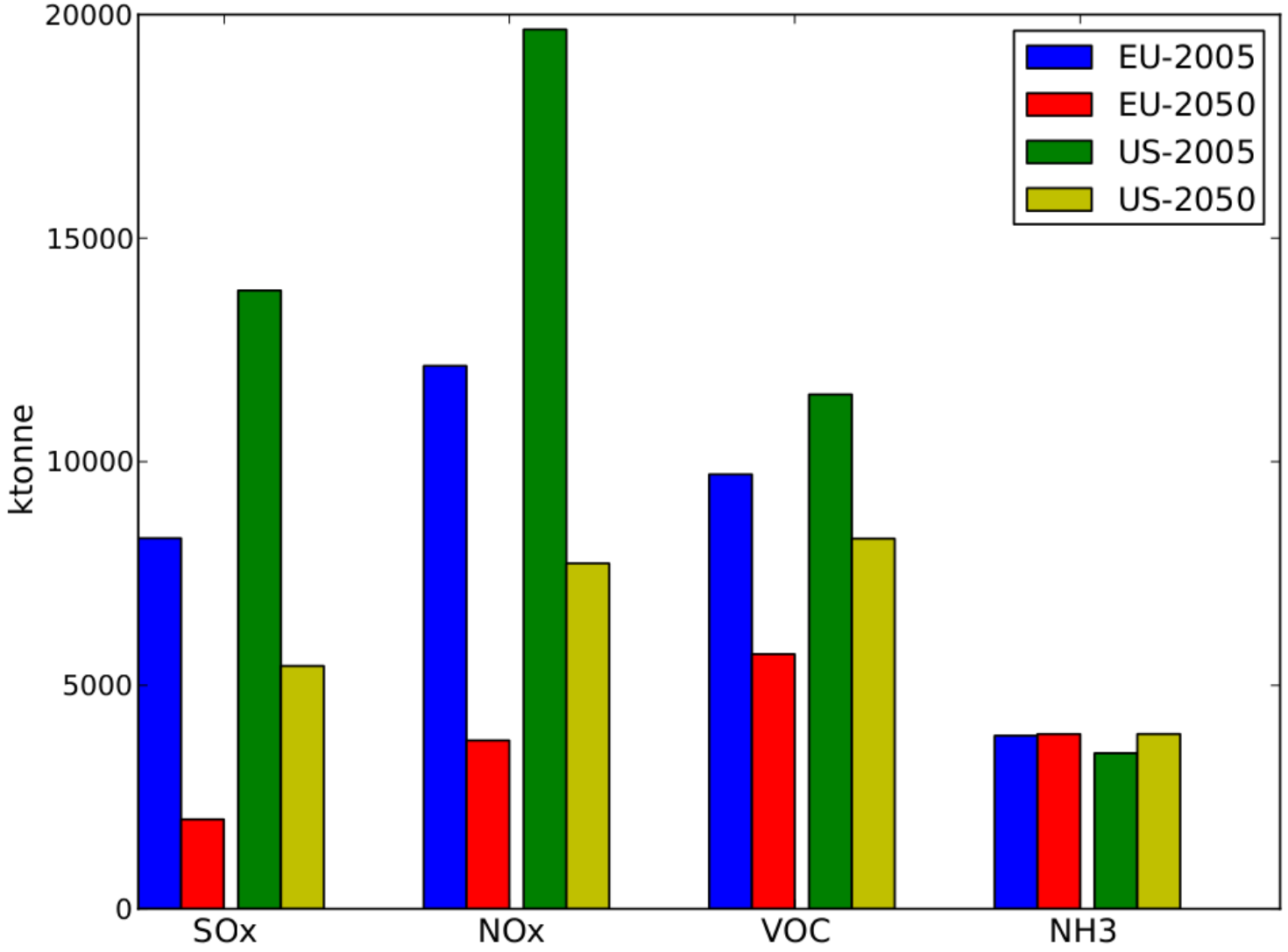


# EnsClim project

- Common emissions data-base developed at IIASA and updated in February 2012 for the ECLAIRE project were used by all models (Amann et al., 2013, Annu. Rev. Env. Resour.)
- Components: sulphur and nitrogen oxides ($SO_x$, $NO_x$), NH3 , non-methane volatile organic compounds (NMVOC), CO, and for DEHM $CH_4$
- Annual emissions for the years 2005 and 2050
- Changes in NOx emissions between 2005 and 2050 are dramatic across almost the whole EU area, but changes in ammonia emissions small

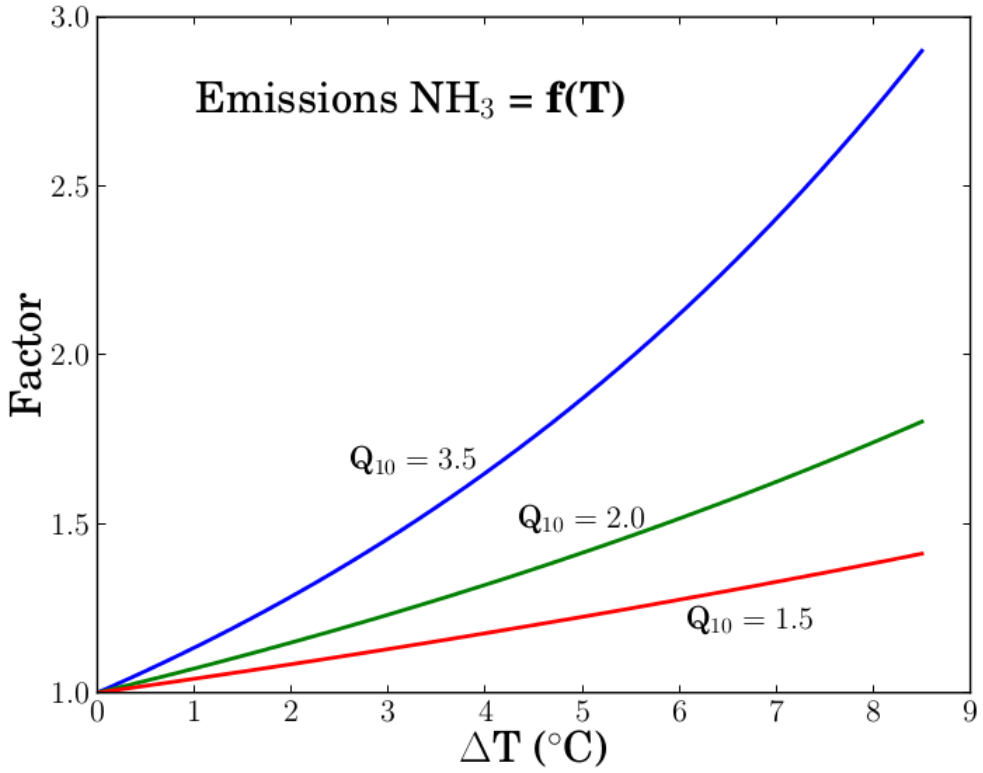
# EnsClim project



# EnsClim project

- Ammonia emissions for 2050 can be underestimated
- They are based on 2000 temperature
- NH3 evaporates easily and evaporation increases with rising temperature
- NH3 emissions in 2050 should be higher!

# EnsClim project

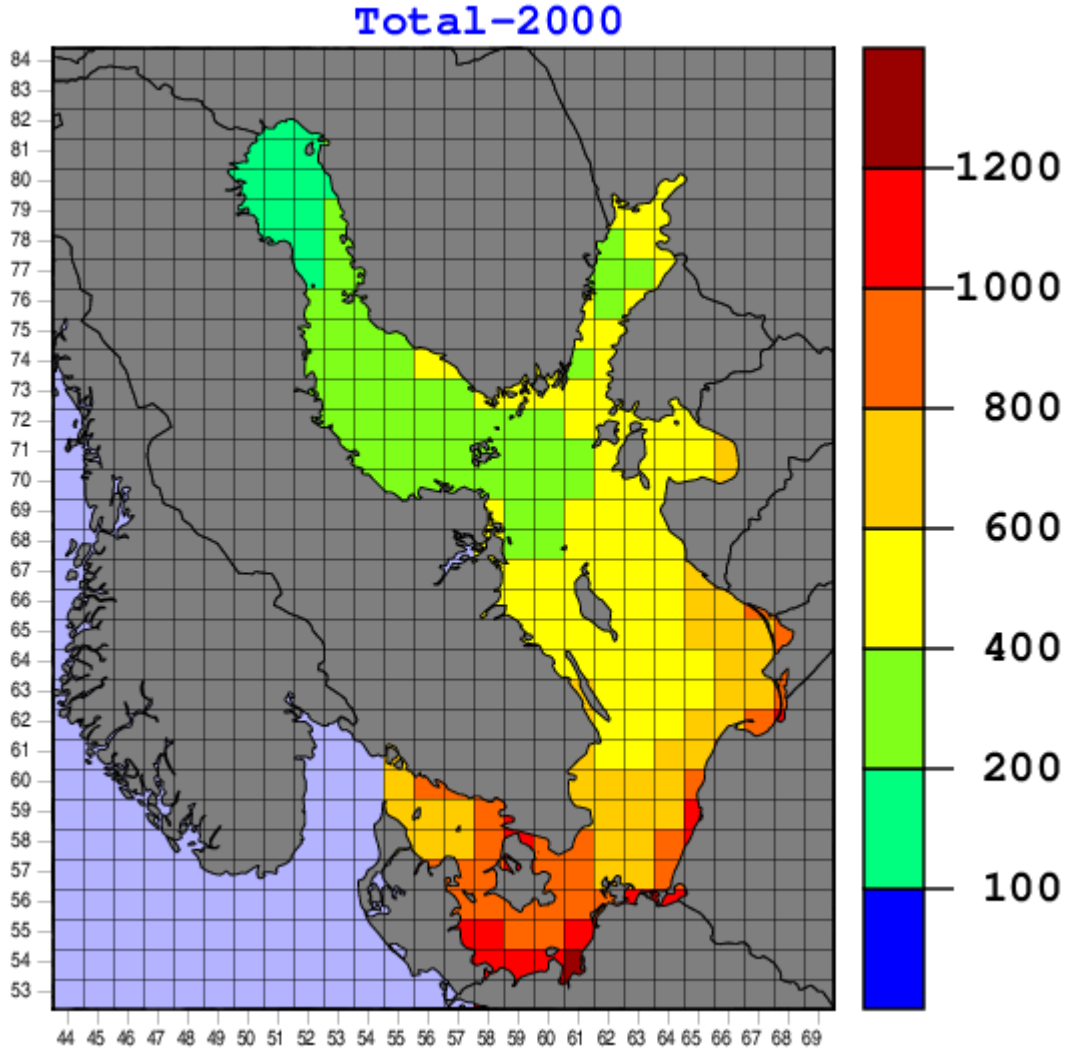



Emissions in a future world might be 20-50% higher than previously accounted for. (Sutton et al, Proc. Roy. Soc., 2013)

# Effects of the climate change

- Focus on the climate change only!
- The same 2005 EnsClim emissions were used for 2000 and 2050
- Focus on nitrogen deposition to the Baltic Sea basin
- Only results for the EMEP MSC-W model (Simpson et al., 2012, ACPD) presented here
- Interpolation from RCA3 to EMEP grid creates some smoothing effects

# Total N deposition in 2000



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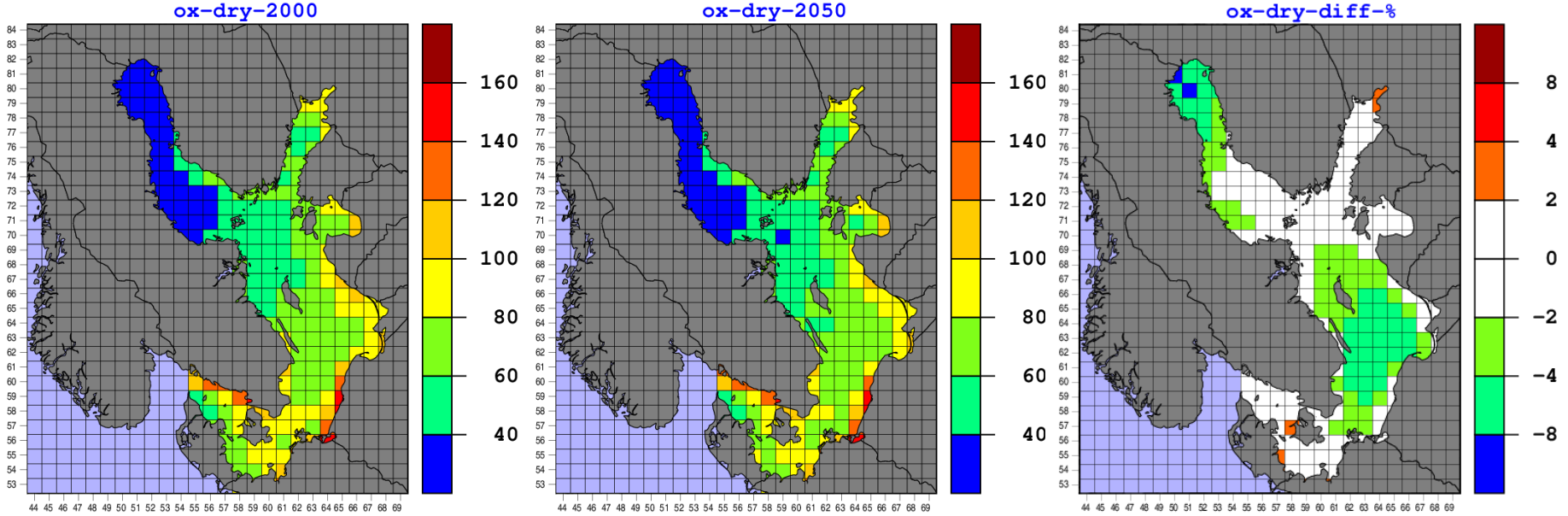


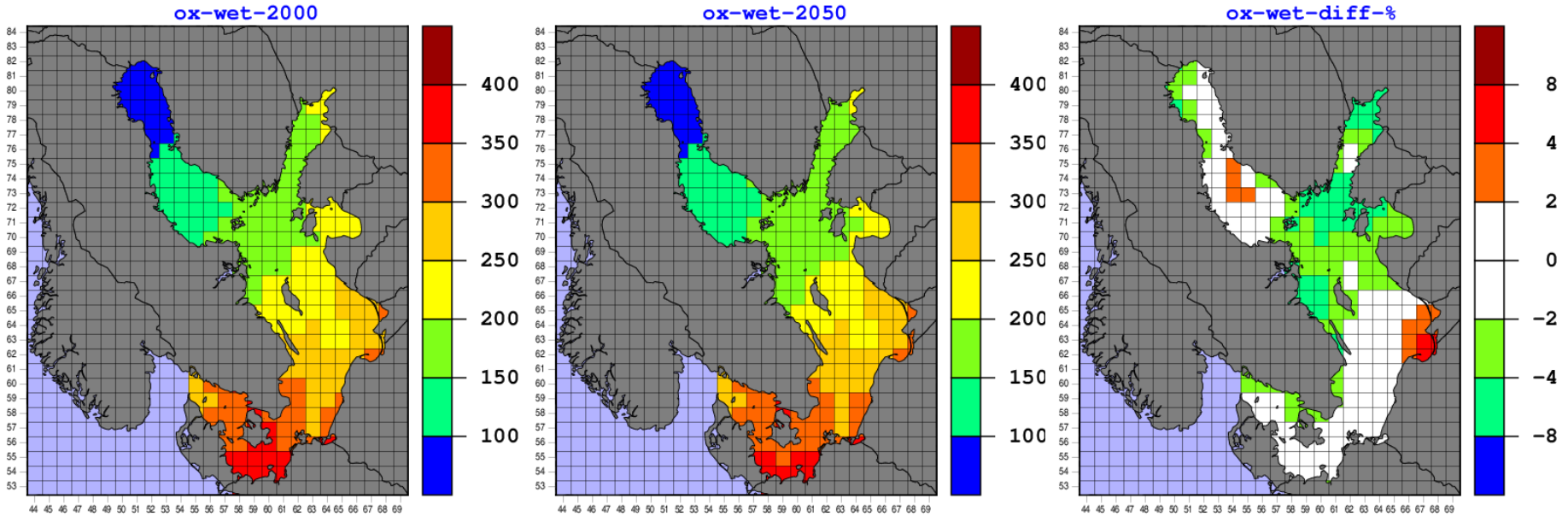

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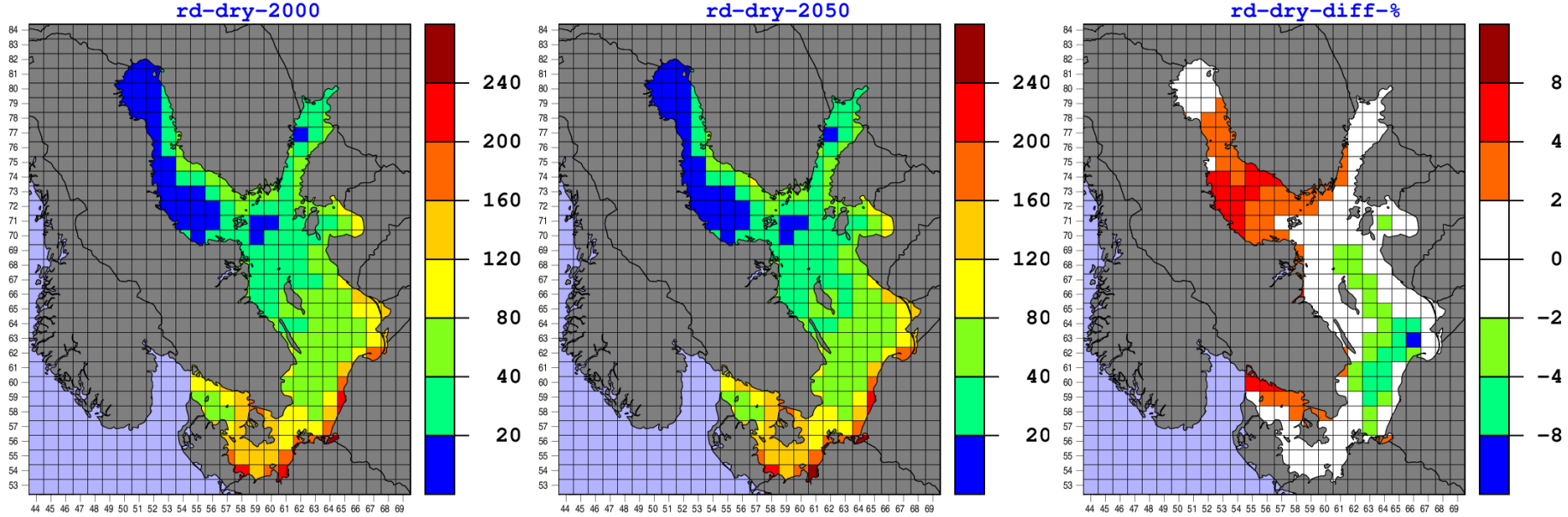


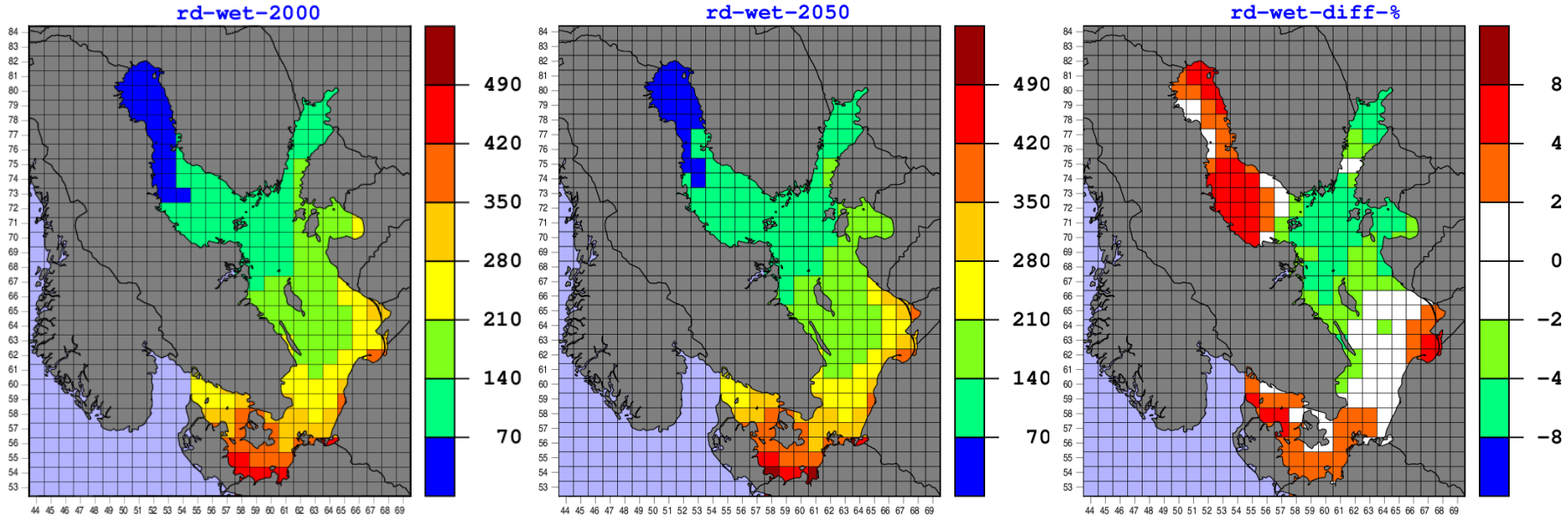

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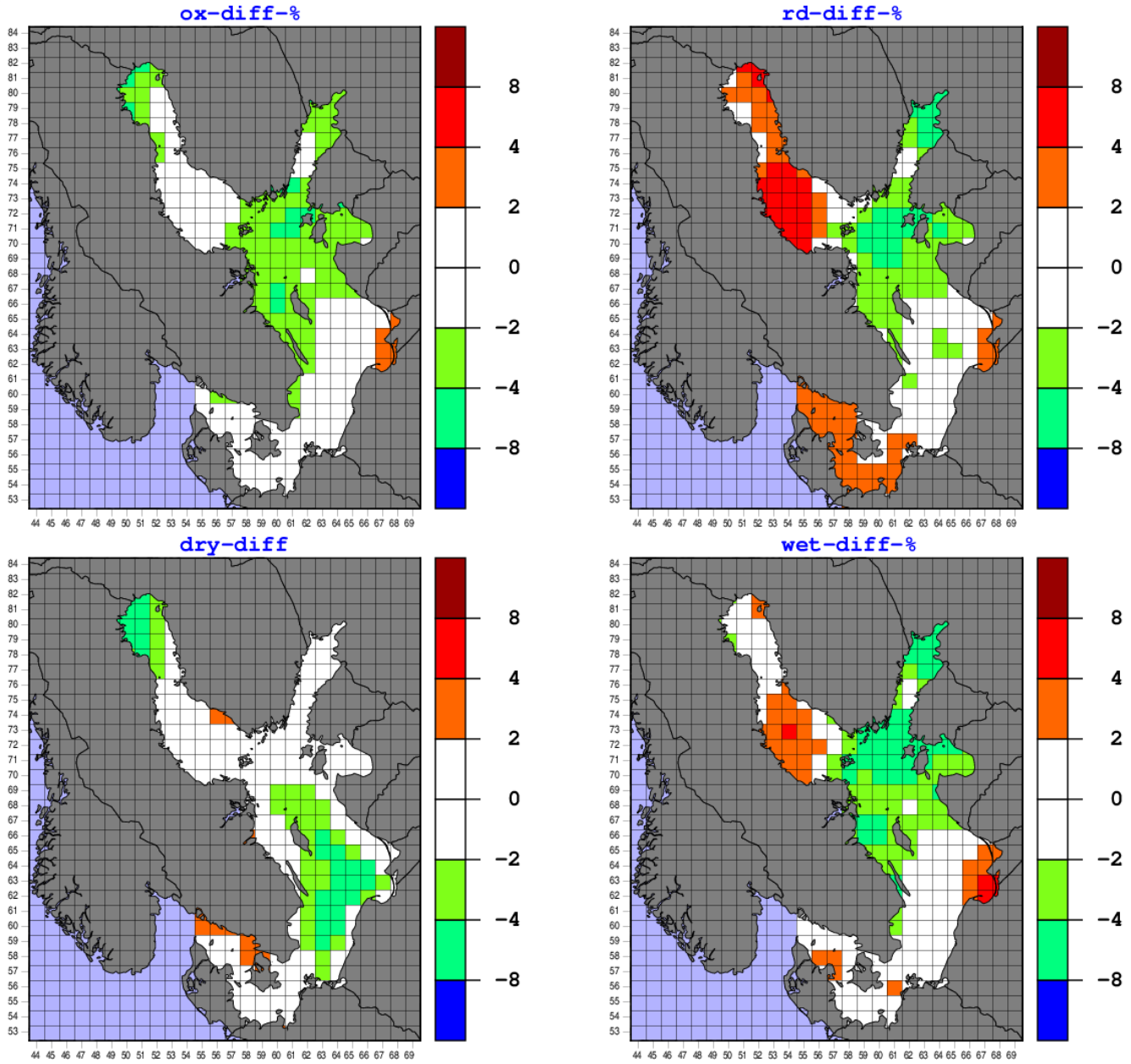

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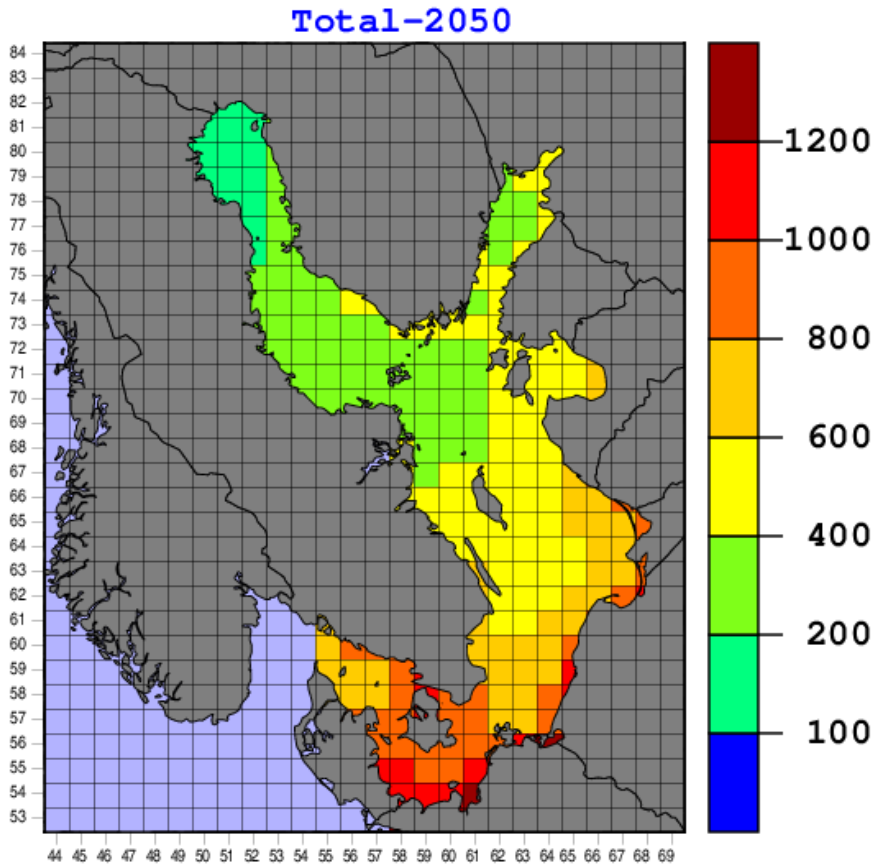


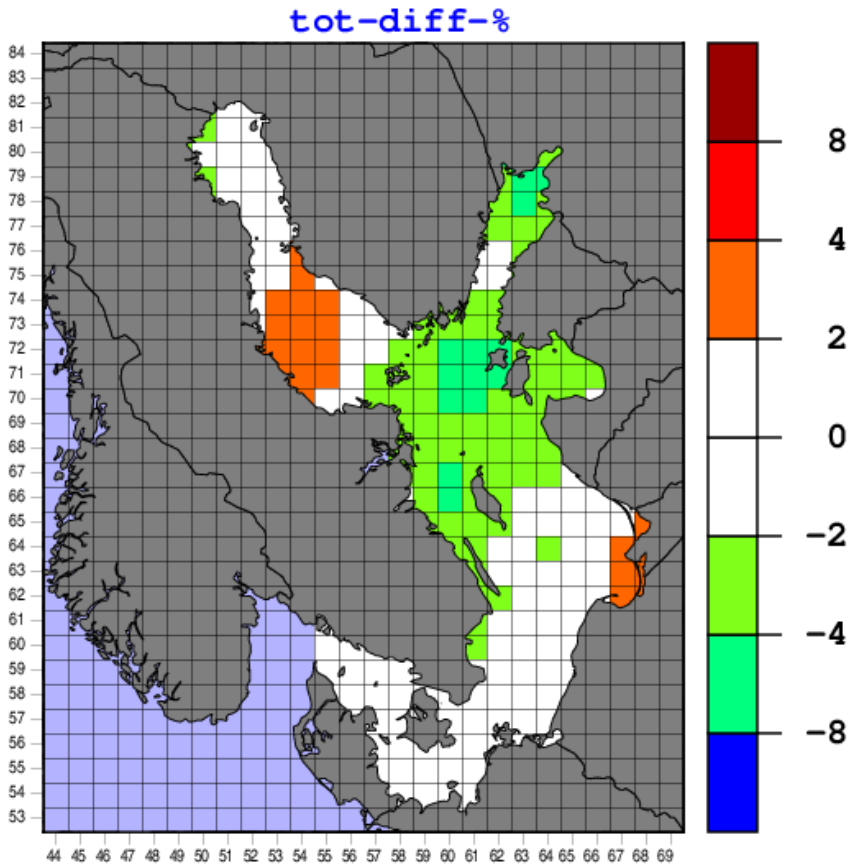

# Conclusions

- The effects of climate change alone practically do not change the annual amount of reactive nitrogen deposited to the Baltic Sea basin, at least with prescribed emissions
- These effects are much lower than the effects of other factors responsible for changes in future reactive nitrogen deposition e. g. inter-annual variation of meteorological conditions and especially nitrogen emission changes
- The effect of climate changes presented here can slightly underestimate the real effects because of current parameterisation of ammonia emissions
- The parameterisation of ammonia emissions should be improved taking into account the effects of rising temperature