



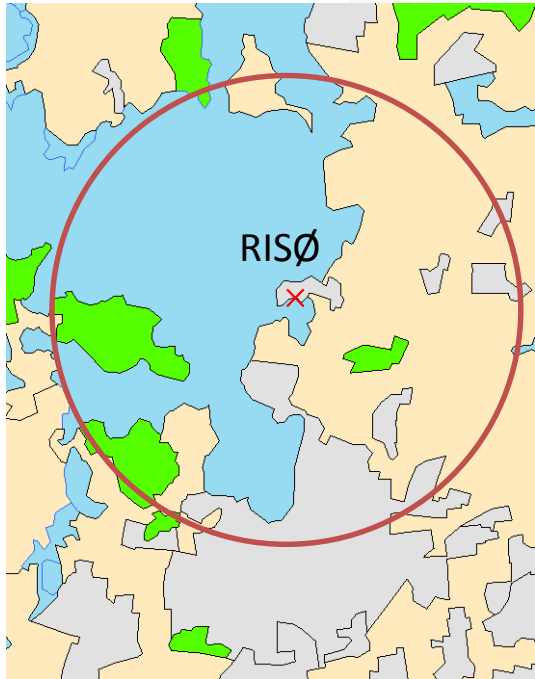
Comparing bottom-up and top-down approaches at the landscape scale, including agricultural activities and water systems, at the Roskilde Fjord, Denmark

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Context and objectives of the study

The Roskilde region: an interfacial study site



Study site:

- tall tower at the DTU Risø Campus (sensor at 96 m high)
- 5 km around the tall tower (80 km²)

Features included here:

- large **agriculture** area (crops: 18 km²)
- inner **Roskilde fjord** (36 km²)
- urban area (Roskilde and other smaller cities nearby)
- woody areas

→ Opportunity to study:

- **direct** emissions: crop fields & N fertilisers + microbial reactions
- **indirect** emissions: from NO₃⁻ leaching to freshwater bodies & estuaries + microbial reactions → **26-37%** of direct emissions: importance & uncertainty (Reay et al., 2012)

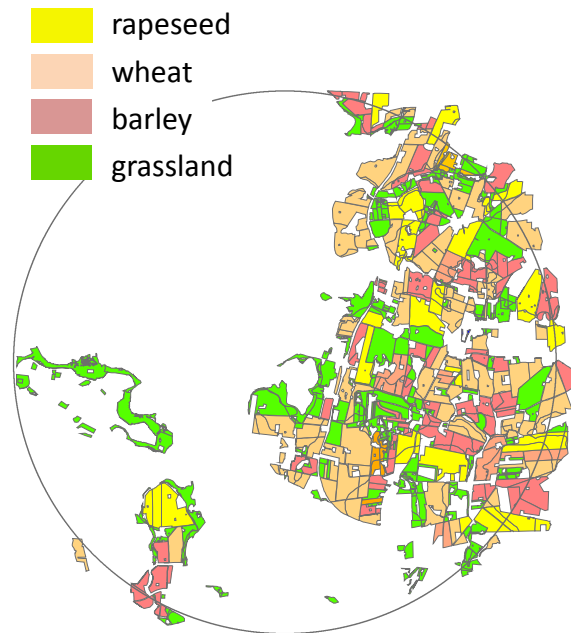
Objectives of the study

- Compare the results of the **bottom-up** and **top-down** approaches both for the agricultural and the fjord areas
- Estimate the **distribution** between direct N₂O emissions and indirect emissions

Material and methods

❖ Bottom-up approach (terrestrial part)

- Distribution of crop fields and grasslands in the study site
- Use of two ecosystem models: Ceres-EGC and Pasim for crop fields and grasslands
- General functioning of the two models

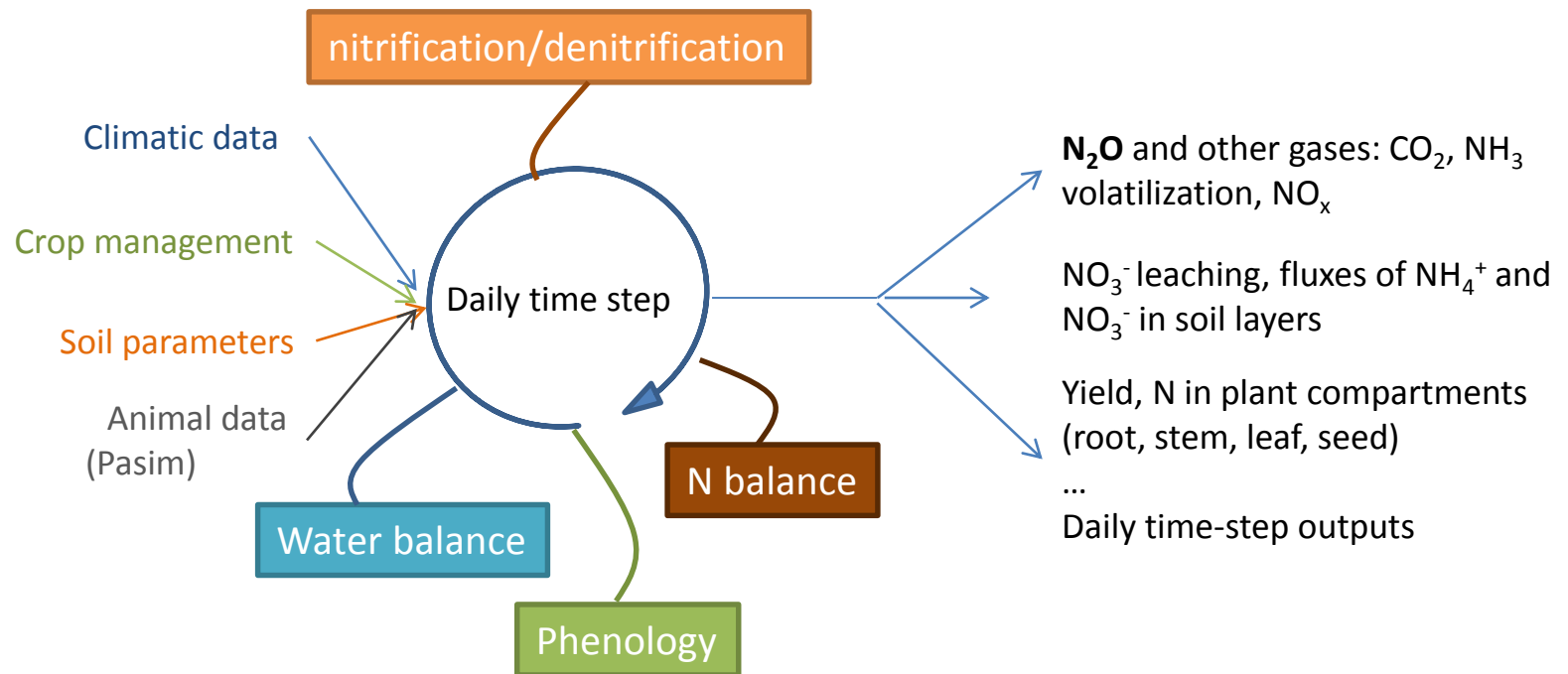


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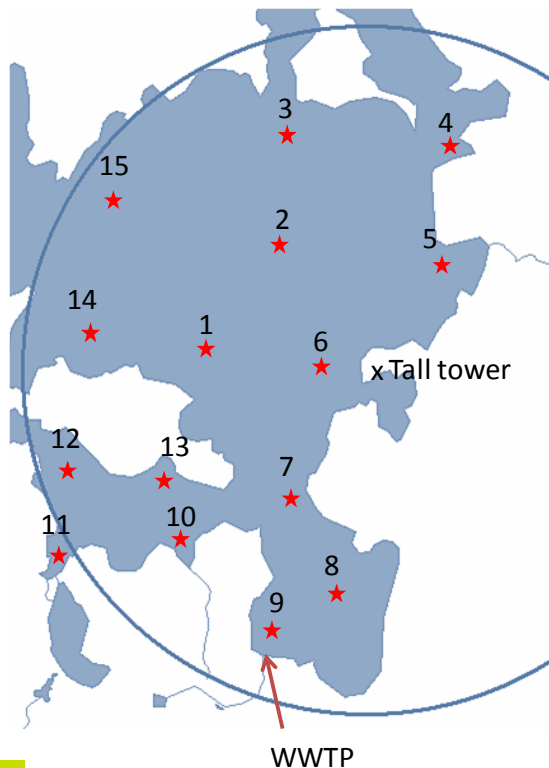
From Ceres-Maize (Jones and Kiniry, 1986; Gabrielle et al., 2006)
Pasim (Calanca et al. 2007)



Material and methods

❖ Bottom-up approach (aquatic part)

- Roskilde fjord: mildly salty (10-15), shallow (3m) and recovering from eutrophication
- Measurements of N₂O concentrations in 15 points distributed in the Roskilde fjord
- Empirical equations to obtain the N₂O fluxes (transfer water → atmosphere function of wind speed, and [N₂O]_{eq} depending on salinity and temperature



$$FN_2O = k_w * (C_w - C_e)$$

K_w ($m s^{-1}$): gas transfer coefficient, $f(u, 10m)$

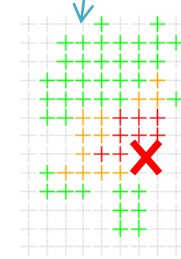
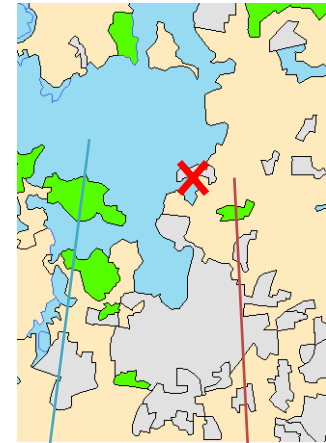
C_a ($g N_2O-N L^{-1}$): equilibrium N₂O concentration in seawater, $f(T, salinity, [N_2O]_{atm})$

Bange et al. (2001), Weiss and Price (1980)

Material and methods

❖ Top-down methodology: measurements and comparison to the bottom-up results

- tall tower equipped with inlet and anemometer at 96m high, tube-connected to a N_2O sensor (cf Ibrom et al. in this session)
- GIS: rasters of the agricultural area and the Roskilde fjord for which bottom-up results are available
- Source attribution within the rasters calculated according to Neftel et al. (2008) based on the model footprint of Kormann and Meixner (2001)
- Comparison: daily averages within the pixels of the rasters for the modelled and measured fluxes, compared at daily scale for the whole area and within each pixel of the raster.



*Raster of
the Roskilde
fjord*

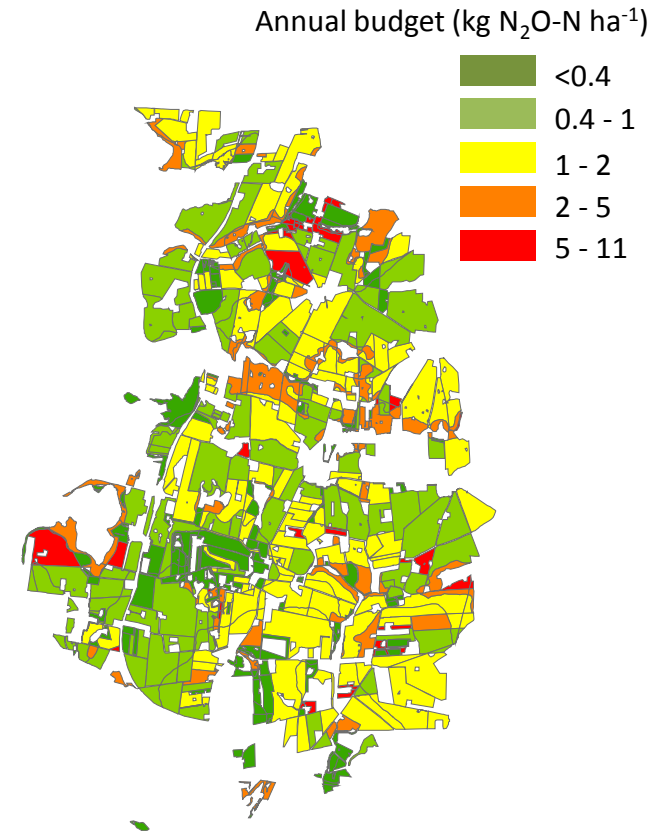


*Raster of
the
agricultural
area*

Results – terrestrial part

❖ Bottom-up results: CERES and PASIM simulations

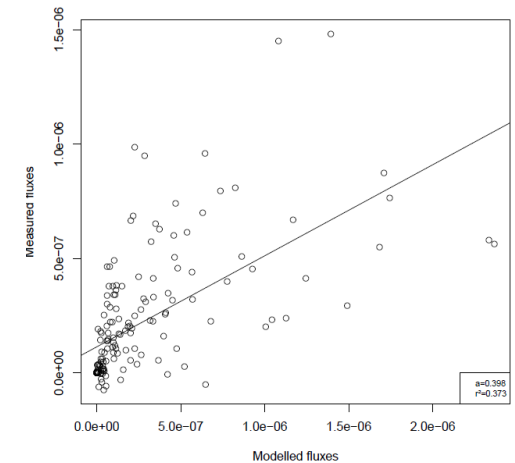
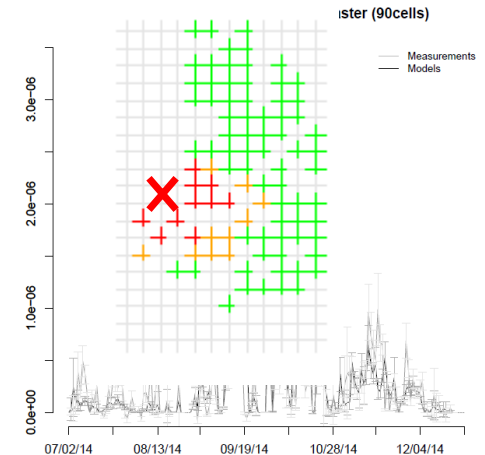
- Very different annual fluxes from a plot to another
 - <1 to $10 \text{ kg N}_2\text{O-N ha}^{-1} \text{ year}^{-1}$
 - Due to the different level of fertilizers used in the plots (from unfertilized to $>300 \text{ kgN ha}^{-1} \text{ yr}^{-1}$)
- Differences within the year between CERES and PASIM
 - Dates of fertilization
 - Dates of harvest / cutting
- Quite heterogeneous emissions both at spatial and temporal scales



Results – terrestrial part

❖ Comparison with flux tower measurements

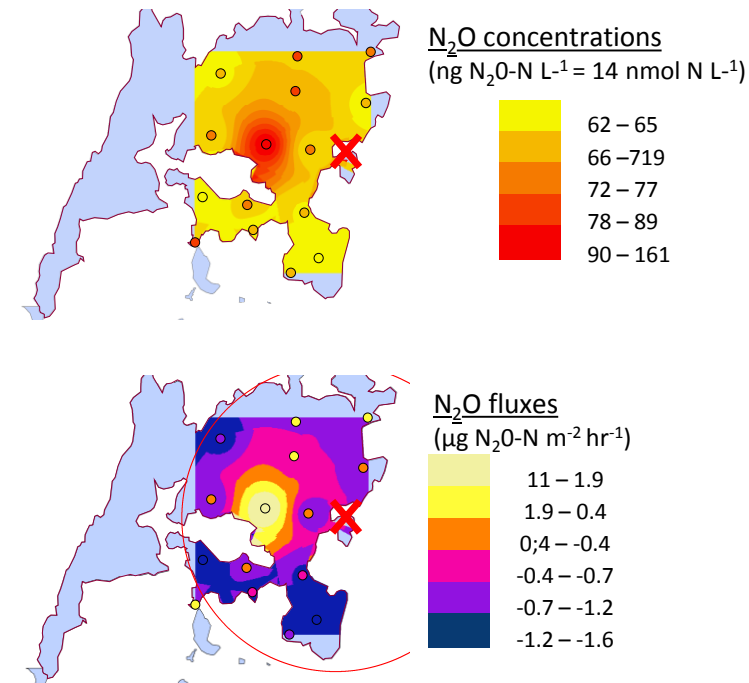
- Source attribution over the raster: max range=0-11%, median=3% of the total flux by pixel
- Comparison at daily scale
 - ✓ Expected values of the models vs. overall measurements of the tower
 - ✓ Linear regression: **slope=0.4, R²=0.37**
→ Not that bad, esp. for N₂O and suggests the tower underestimates the fluxes at landscape scale
- Comparison between the pixels of the raster
 - Good agreement as well
 - **Slope of 0.7** between tower/models at the pixel scale (**R²=0.65**)
 - Very encouraging fit that suggest towers are able to detect “hotspots” in a heterogeneous terrestrial system (pixel size: 500x500m)



Results – aquatic part

❖ Bottom-up results: N₂O fluxes from water sampling

- Measurements once in May and July: very low concentrations of N₂O (<0.2 µg N₂O-N/L)
- Estimated fluxes can be positive or negative
- Area includes potentially high fluxes
 - Theoretically as high as those from agricultural area (10 µg N₂O-N m⁻² hour⁻¹)
 - Fluxes in July are lesser than those in May and mainly negative



Results – aquatic part

❖ Comparison with top-down approach

- Most of source attribution in the southwestern part of the tower (higher source attribution than the agricultural part: max range=0-20%, median=7%)
- Negative fluxes in both approaches, magnitude seems similar for the values in early July
- Waiting for coming data to complete this comparison from July to September

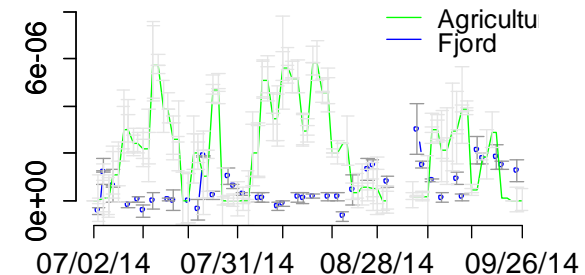
❖ Comparison with agricultural fluxes:

- Per m², the Roskilde fjord emitted ~3-time less N₂O than the agricultural area
- Negative correlation between fluxes from water and agricultural areas (-0.5)

→ Ratio of the agricultural and fjord emissions (daily averages): 77/23% to be confirmed by the bottom-up approach



N₂O fluxes (g/m²/day)



Limits of the study

❖ Terrestrial part:

- Only the Jul-Dec part of 2014 so we missed the large flux induced by fertilizers
- Homogeneous input files may not depict thoroughly the real management in the agricultural plots
- Ceres-EGC is not suitable for other crops present in the study site (oat, potatoes...)

❖ Aquatic part:

- Still waiting for data to complete our database from May to Sept. 2014 and obtain a large overlap with the tall tower measurements
- No use of intermediary measurements (floating chamber, small tower...) at the Roskilde fjord as the equations are subject of large uncertainty

Conclusions and perspectives

❖ Good agreements:

- Fit between daily measurements and model outputs at daily scale over the whole agricultural area and in most of the pixels of the raster made from the agricultural area → 1D models without lateral transfers can predict good emissions with a good spatial accuracy at the landscape scale
- Encouraging results for the aquatic part: similar magnitudes, positive (emission) and negative (absorption) fluxes over the 15 points of the Roskilde fjord/raster

❖ Bottom-up and top-down approaches produce very similar trends and budgets at least for the study period at the landscape scale: here we show that the ratio between direct/indirect emissions (as defined in introduction) was ~77/23%, but we need to pursue the study to obtain one-year of tower measurements

❖ Next steps?

- Use of dedicated landscape model to compare with tower fluxes? Landscape-DNDC or integrative NitroScape (coming soon)
- Include other land uses such as urban systems, forests and so on
- Test this methods at the landscape scale for other tall towers in Europe?
- Possibility to feed the IPCC database with local/landscape emission factors



Thank you for your attention!

View of the agricultural area and the Roskilde fjord from the tall tower



Courteously from Ebba Dellwik, DTU