Atmospheric deposition of total nitrogen and sulfur to the Norwegian Forests - assessment of uncertainties in the current estimates

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Background

- Atmospheric deposition is usually the main source of nitrogen and sulphur to the Norwegian forest.
- Nitrogen input important factor for forest management
- Exceedences of nutrient input in14 % of Norwegian areas (south west Norway). Nitrogen deficiency in some areas.
- Large uncertainties in the estimates of nutrient load, depending on approach.

→ Quantify the uncertainty in deposition estimates

Necessary to understand the atmospheric processes better to improve model parameterization

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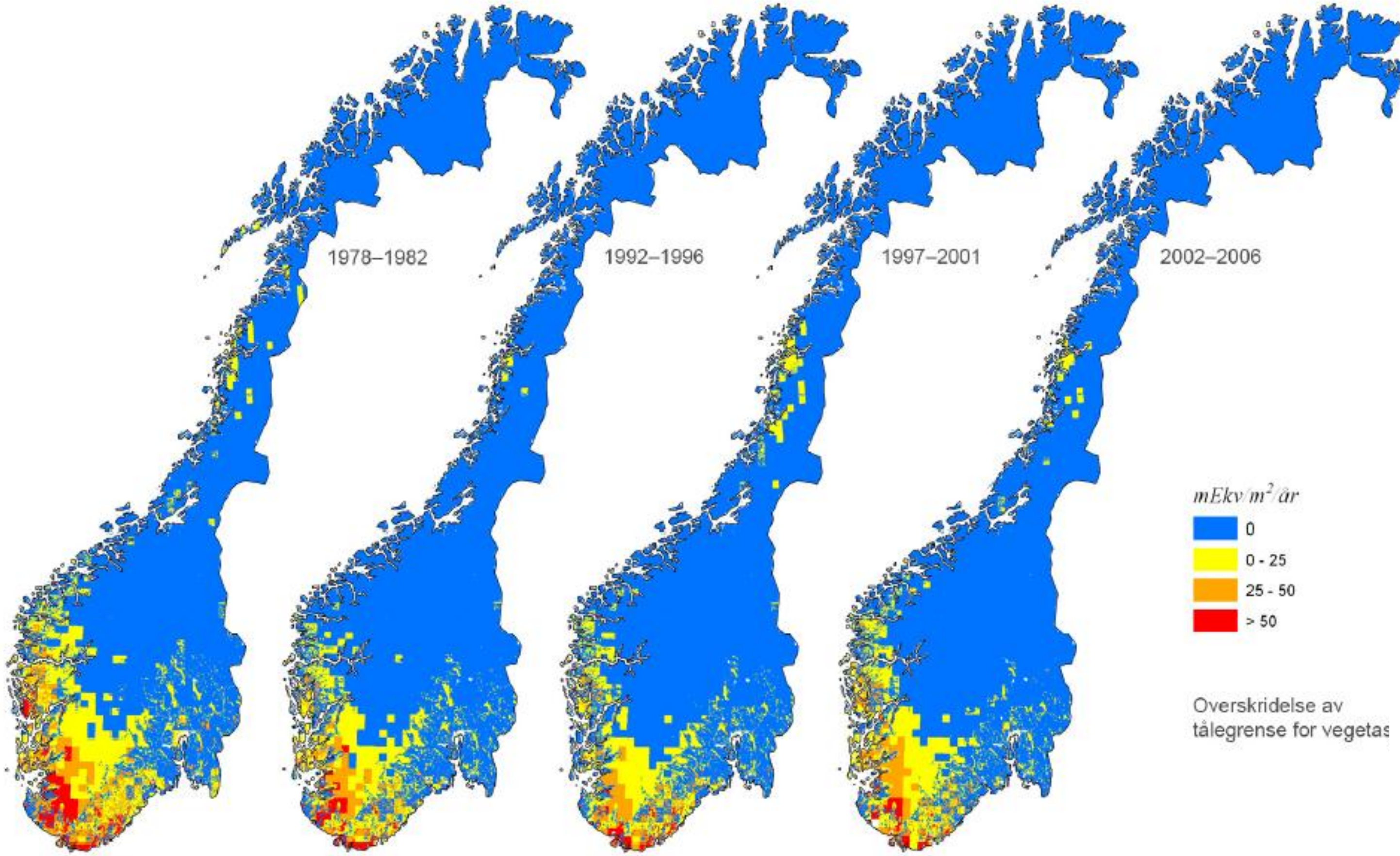
Exceedence of critical load for vegetation

Periode	km^2	% av Norges areal
1978–1982	63 314	20
1992–1996	42 449	13
1997–2001	40 927	13
2002–2006	44 234	14



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Quantifying atmospheric deposition

- Measured atmospheric concentration in air and precipitation
  1. Average for 5 years interval and statistical kriging for 50x50km
     - Dry deposition calculated using estimated deposition velocity from literature
  2. Site specific measurements particulate and gaseous component combined with Inferential modelling (using local meteorology and leaf area index (LAI).
  - ➢ **Main uncertainly**: ⇨ quantification of dry deposition velocity

- Throughfall measurements
  - Using throughfall data as an estimate of total deposition
  - Utilizing a canopy budget model (CBM)
  - ➢ **Main uncertainty**: ⇨ quantification of canopy exchange

- Chemical transport model
  - EMEP model. Deposition on a 50x50 km grid (finer scale will be available)
  - ➢ **Main uncertainty**: ⇨ emissions and representation of hydrological cycle

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Canopy budget model (CBM)

(excluding stem flow fluxes)

Ref: Draaijers GPJ. (2010) Canopy budget models applicable for use within the intensive monitoring programme. ICP Forests manual,

Net throughfall (NTF) = TF – PD = DD+CE

PD (precip deposition; DD= dry depostion); CE = Canopy exchange)

$$DD_x = \frac{(TF - PD)_{Na}}{PD_{Na}} \times PD_x \quad where\, X = Ca, Mg, K$$

Na as tracer ion for calculation the dry deposition factor of the base cations

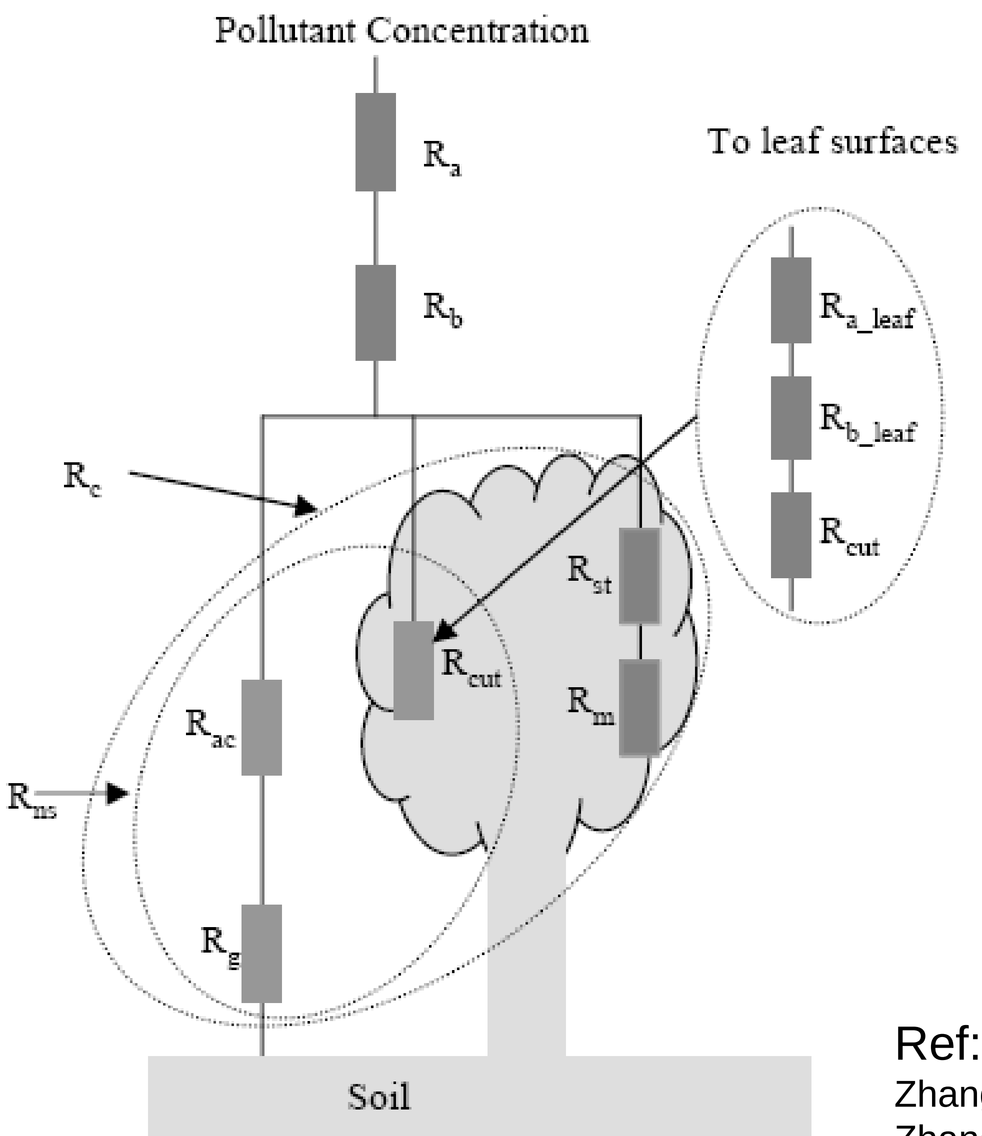
Assume uptake of NH4 and H+ is equal leaching of base cations:

$$CU_{NH4} = \frac{TF_{NH4}}{TF_{NH4} + xH(TF_H)} \times CL_{BC\,(=sum\,of\,x)} \qquad (CL_x = NTF_x - DD_x)$$

Alternative 2 includes CU also for NO_3

$$CU_{(NO3+NH4)} = \frac{xNH4 \times TF_{NH4} + TF_{NO3}}{xNH4 \times TF_{NH4}} \times CU_{NH4} \qquad x = 6$$

Inferential Modeling



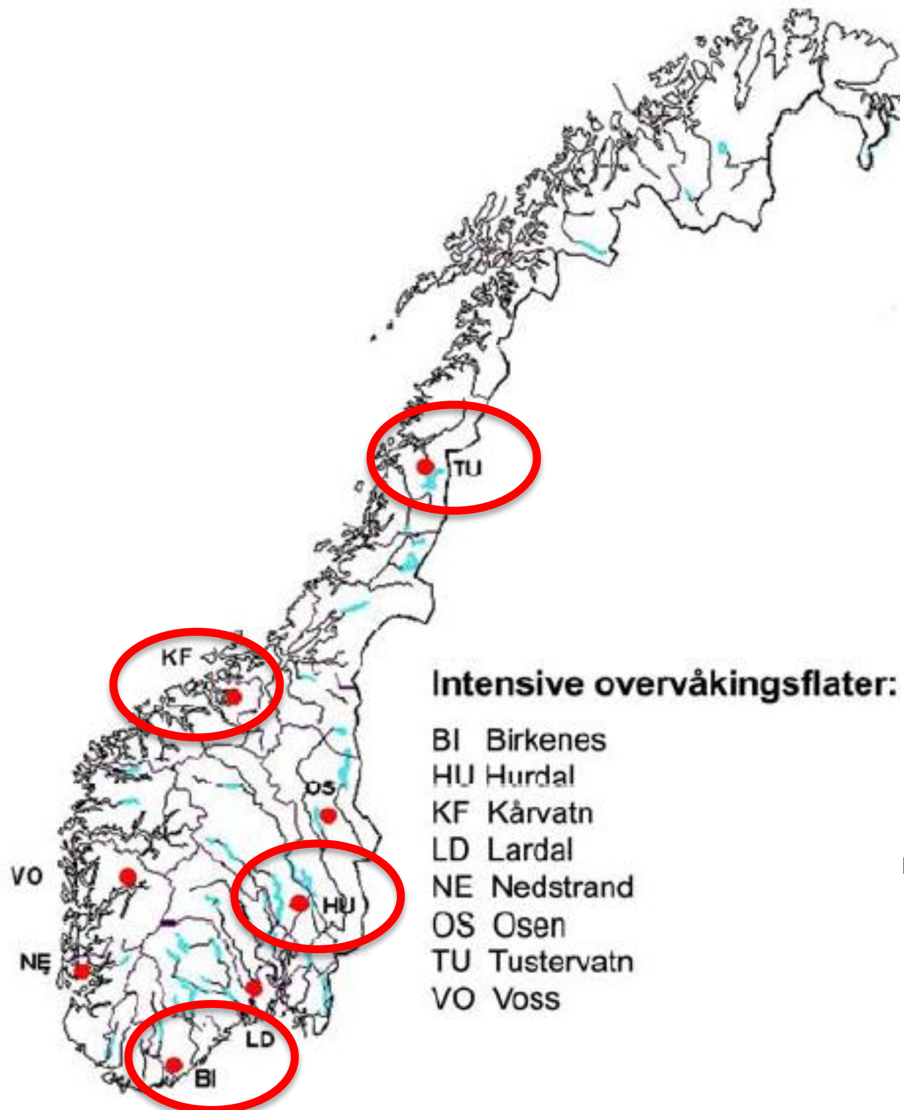
Dry deposition velocities (Vd) were calculated using the CAPMoN big-leaf dry deposition models and meteorological input from the on-site measurements

Ref:

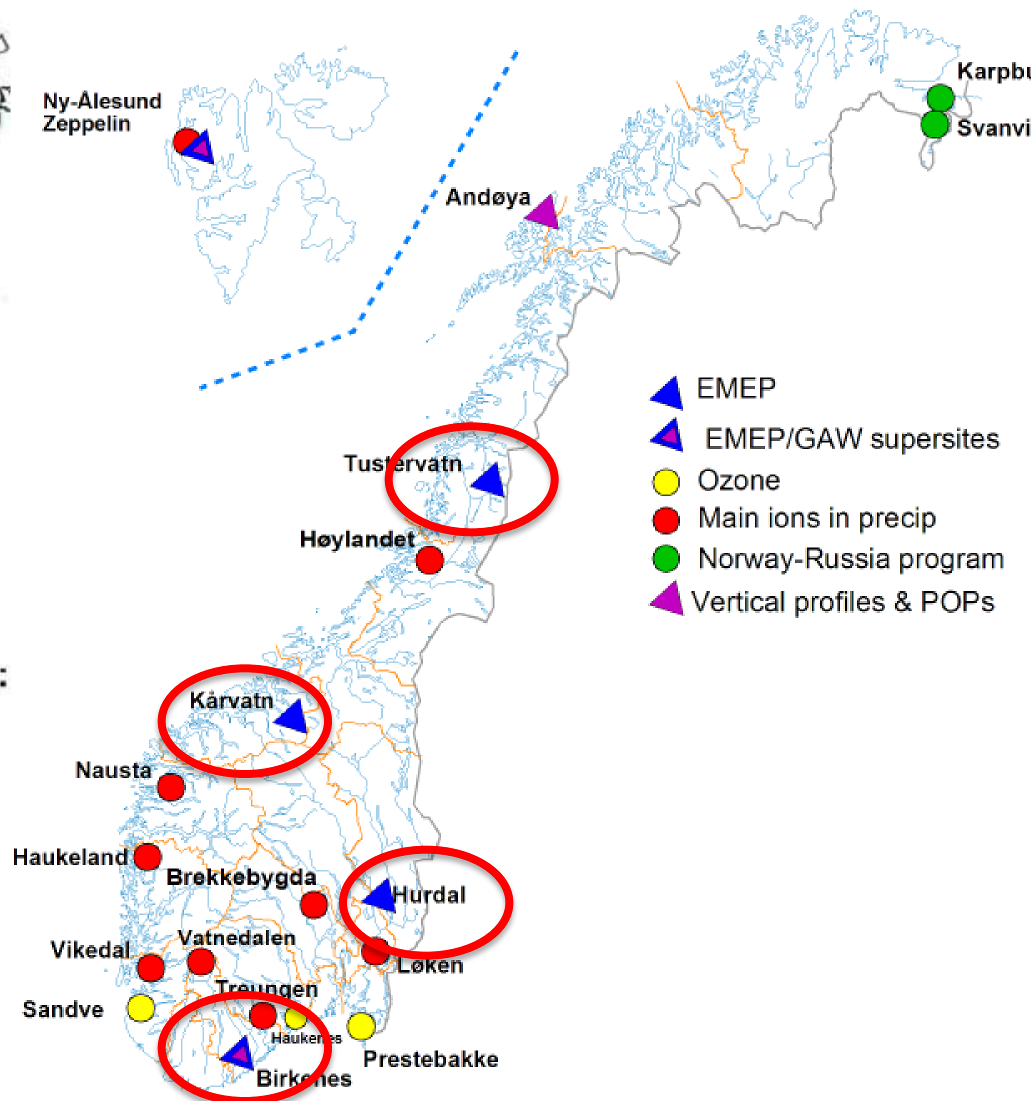
Zhang et al 2003. Atmos. Chem. Phys., 3, 2067–2082
Zhang et al 2001 Atmos Environ, 549-560

Monitoring networks

Forest (ICP Forest level II)

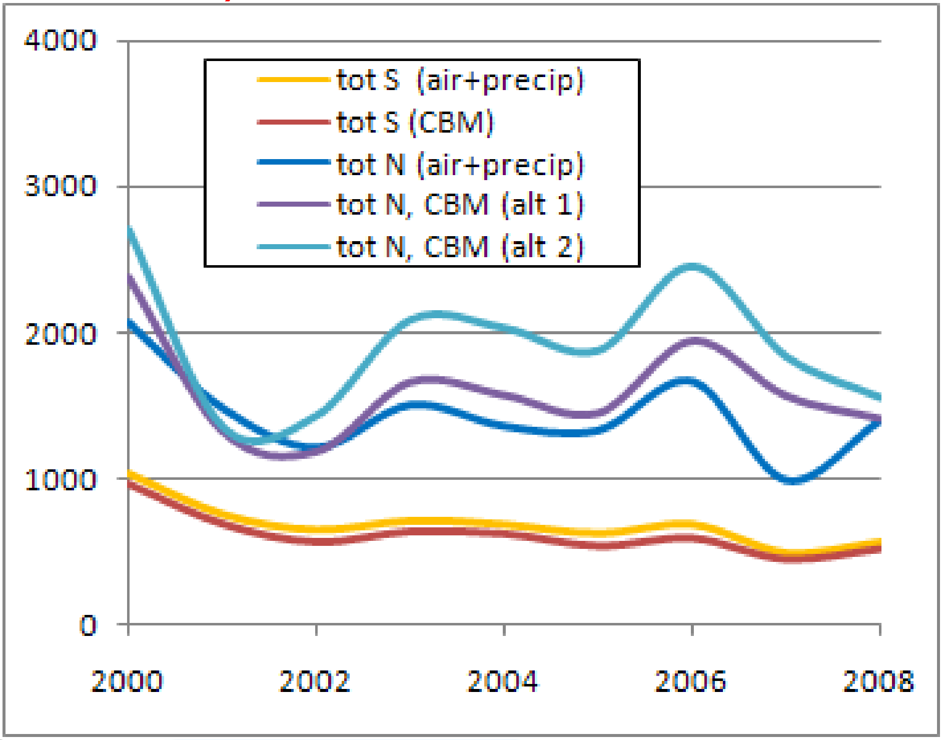


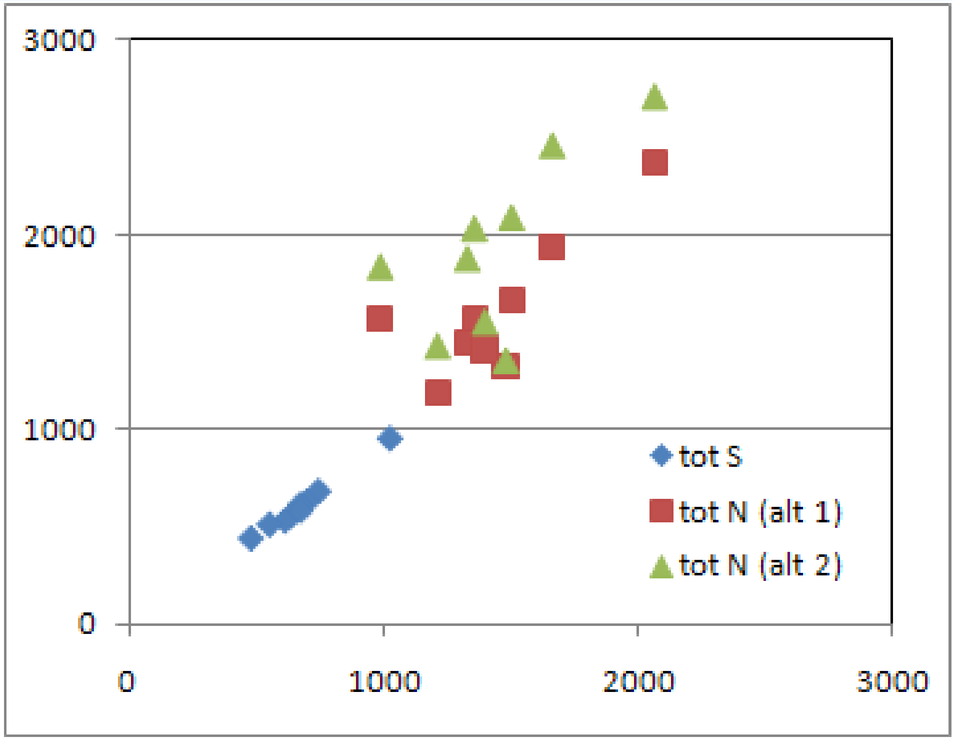
Atmospheric deposition



Measured dep (air + precip) vs Canopy BM

Birkenes, 2000-2008





	Avg		Sd	SD %
tot S	647	±	51	8 %
tot N (alt 1)	1528	±	182	12 %
tot N (alt 2)	1689	±	404	24 %

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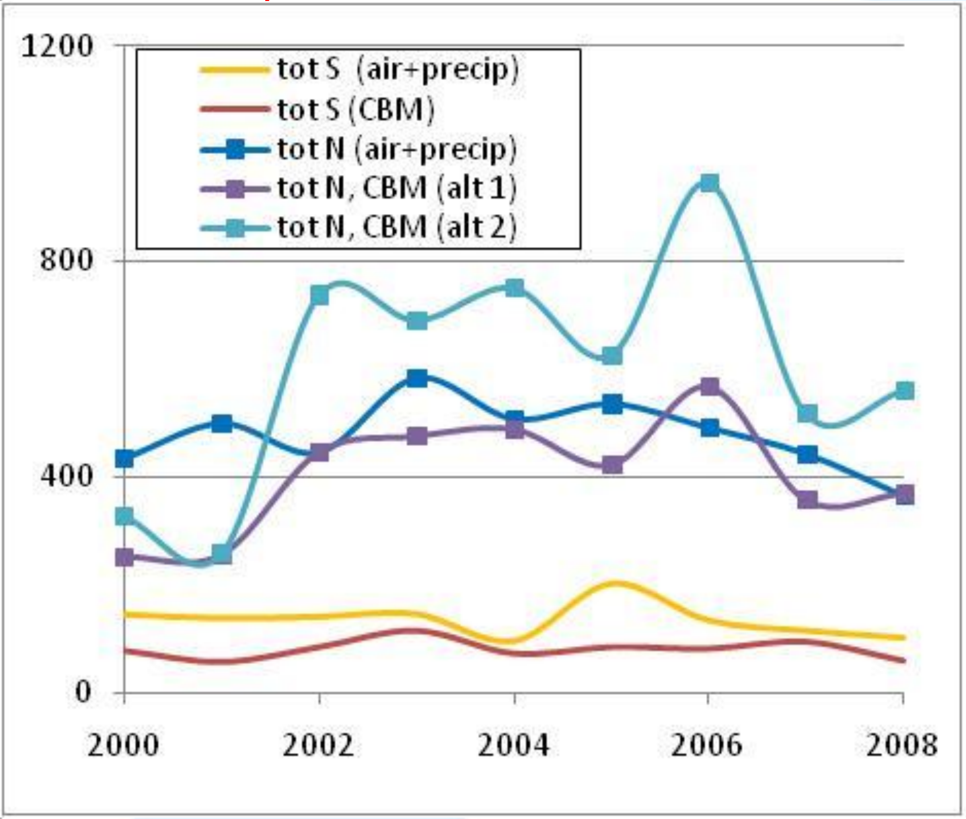
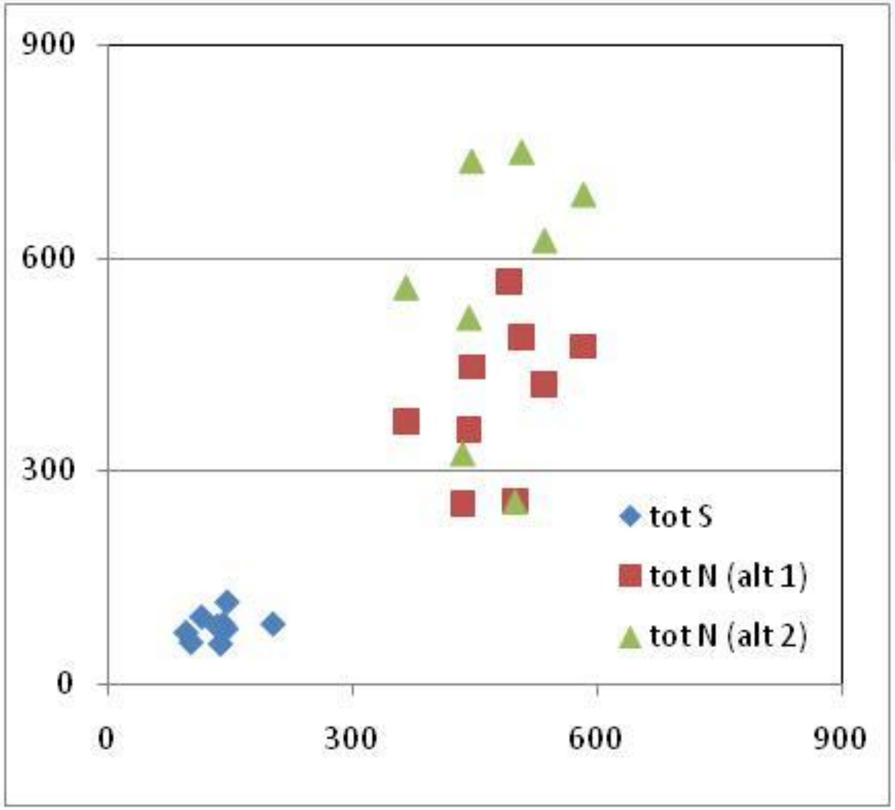
Measured dep (air + precip) vs Canopy BM

Tustervatn, 2000-2008





	Avg		Sd	SD %
tot S	108	±	44	41 %
tot N (alt 1)	441	±	85	19 %
tot N (alt 2)	539	±	164	30 %

Statistic, 8 years and 4-5 sites

	Avg		Sd	SD %
tot S	282	±	45	16 %
tot N (alt 1)	725	±	132	18 %
tot N (alt 2)	803	±	239	30 %

•Seems like traditional CBM where only canopy uptake of NH4 should be used

Expanded uncertainty: S dep= 32%
N dep= 36%

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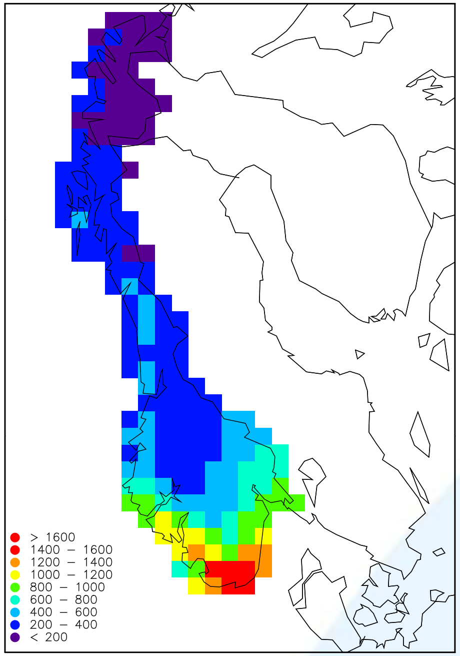
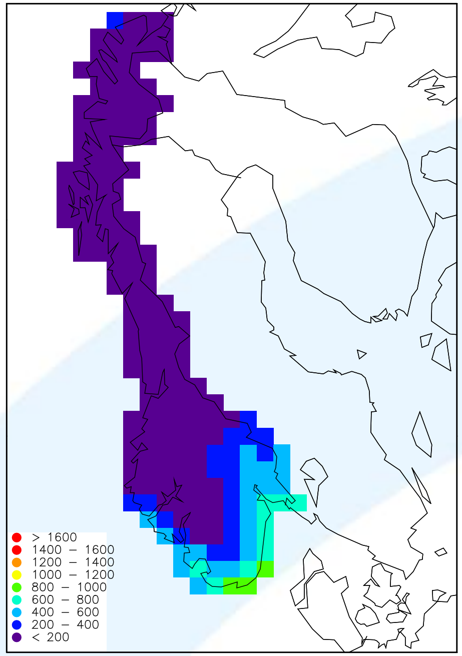
EMEP vs NILU gridded averages (N dep)

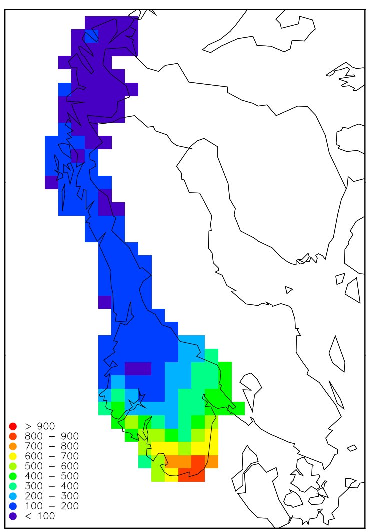
Tot N (mgN/m²) 2002-2006
NILU calculations



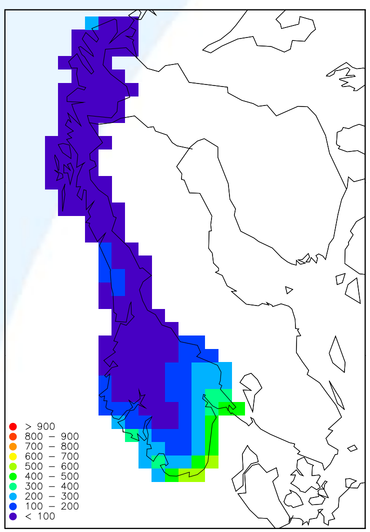
Tot N (mgN/m²) 2004
EMEP model, version 2010



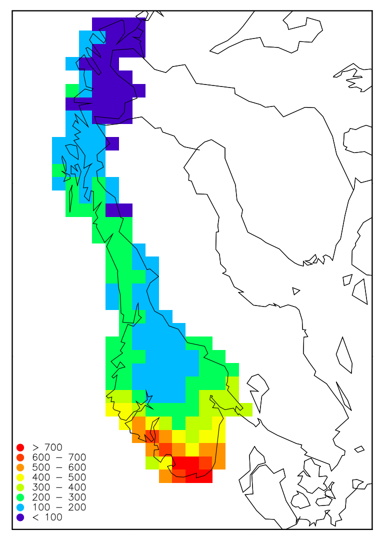
Tot Nox -NILU



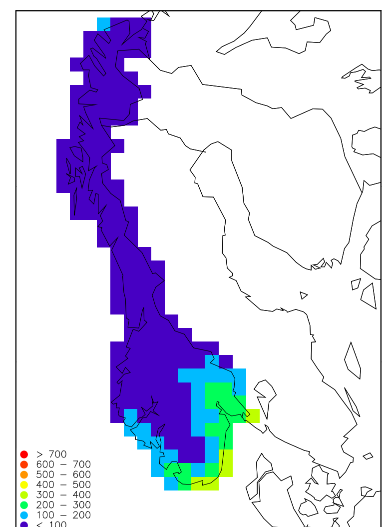
Tot Nox EMEP



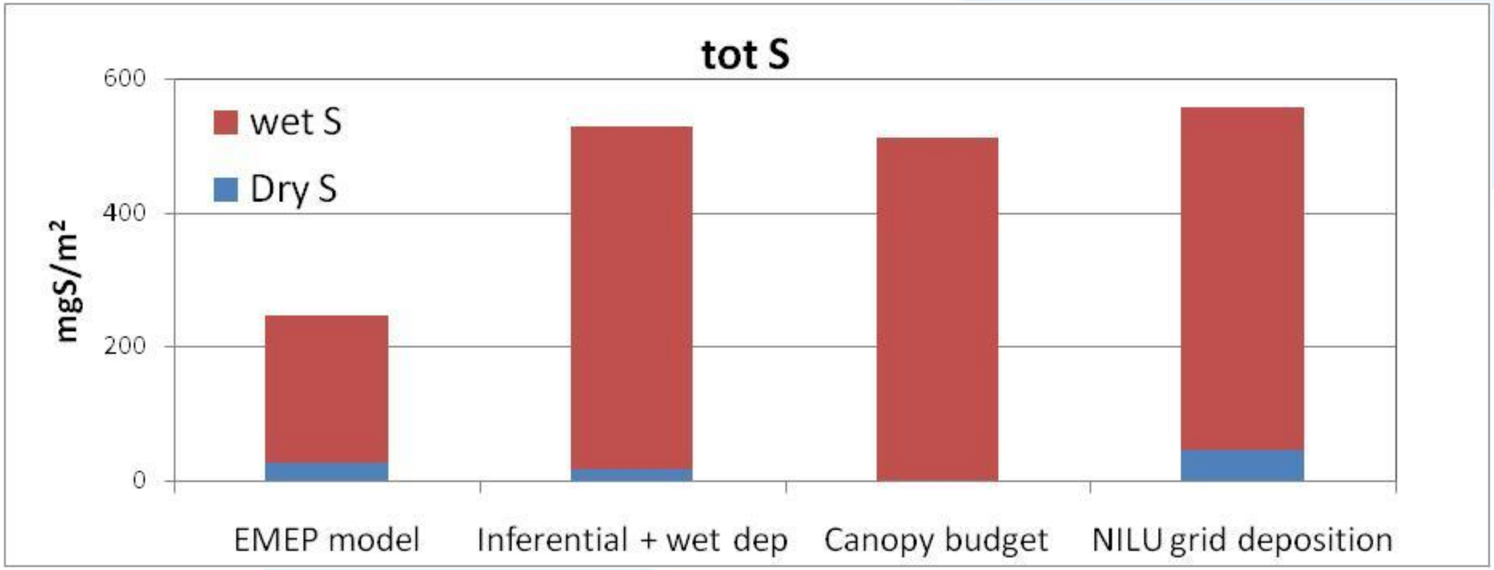
Tot Nred -NILU



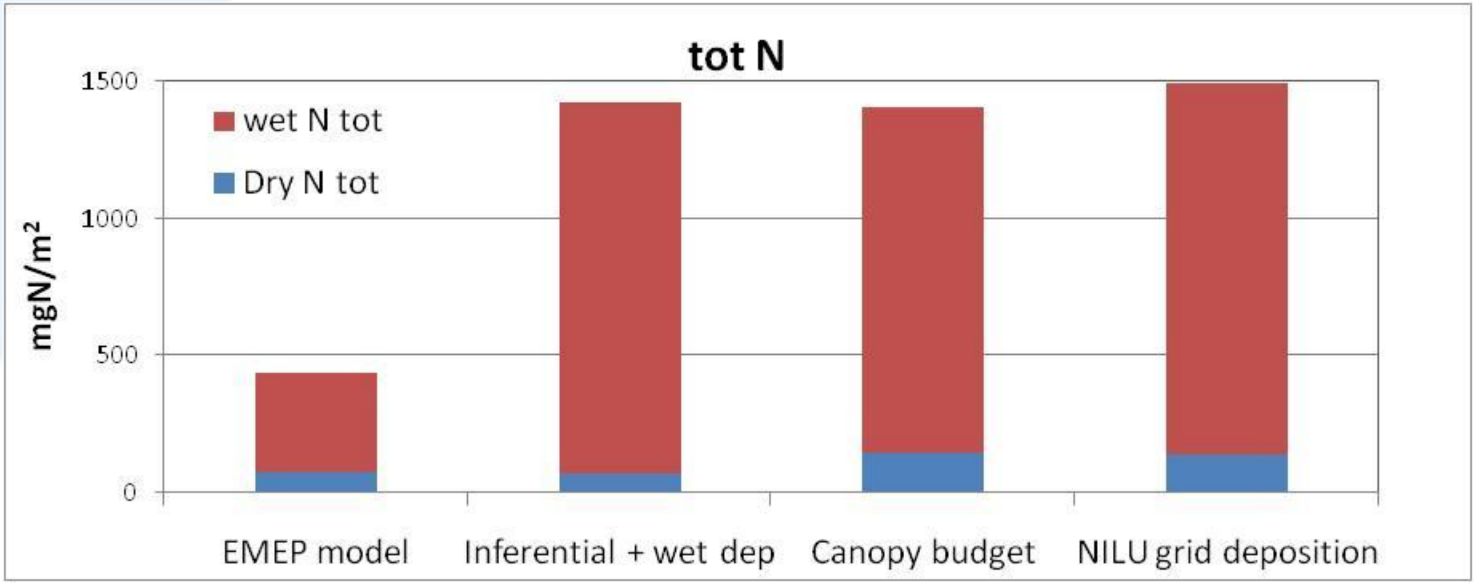
Tot Nred -EMEP



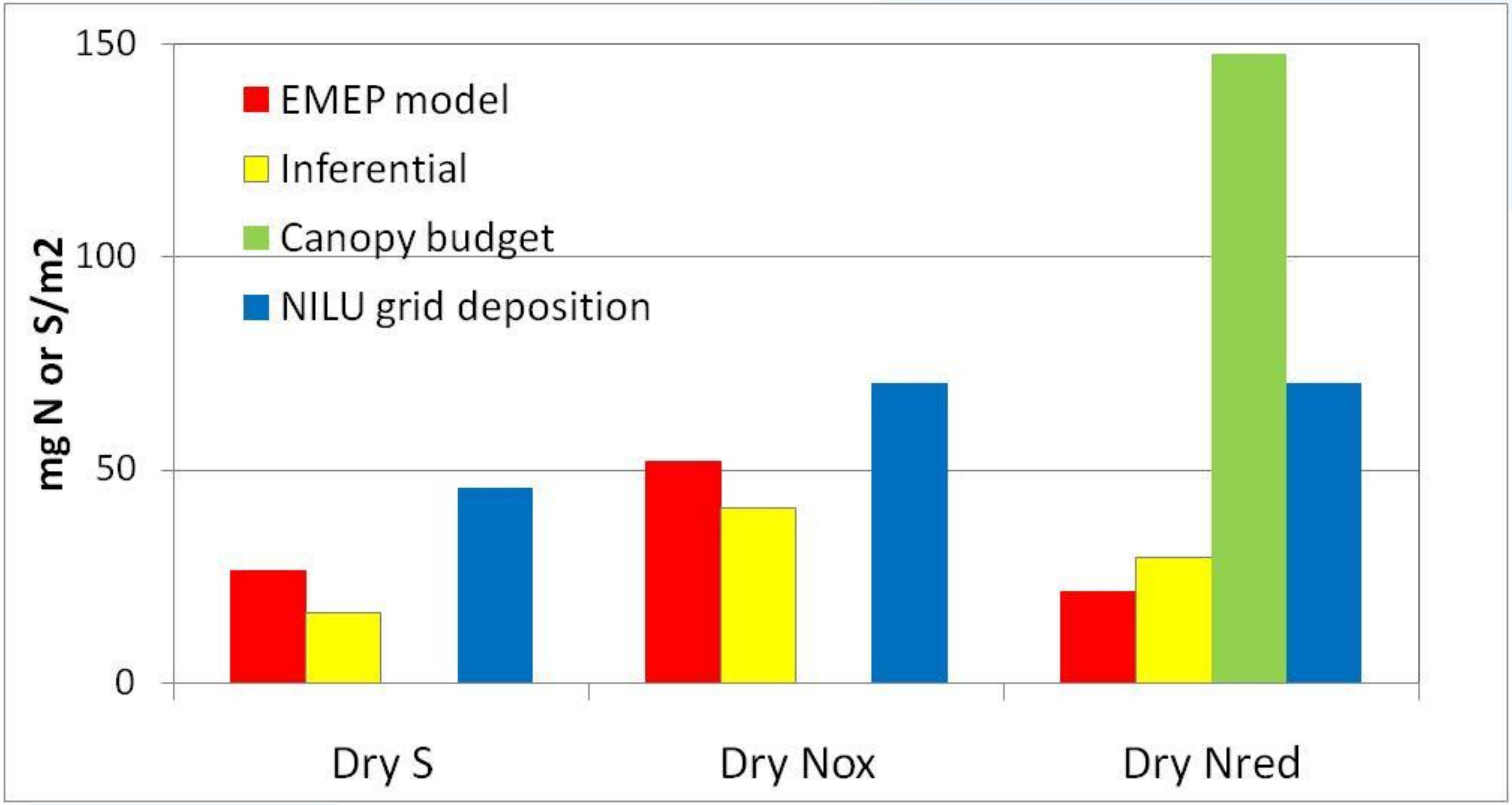
Comparing inferential model with the other methods, at one site (Birkenes) in 2008



Wet deposition is dominating (10% dry dep)



Dry deposition at Birkenes, 2008



- EMEP CTM and CAPMoN inferential model very similar
- The crude estimates in the NILU grid may have too high V_d
- Throughfall data are very uncertain for dry dep. estimates

Summary

- Large variations in deposition depending on approach
- A factor 20-50% difference in measured and modeled deposition in Norway, though a standard deviation of 50-115%
- Throughfall CBM are quite comparable to estimated deposition using air and precipitation data, expanded uncertainty of about 35%.
- Inferential modeling show comparable results of dry deposition as the EMEP model
  - Too high dry deposition values in previous estimates used in the evaluation of critical loads??

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