Regional differences in nitrogen deposition trends

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Introduction

Future climate change with more precipitation and higher air temperatures in Norway will affect the nitrogen cycle. The REGCLIM project (*regclim.met.no*) has recently published scenarios for the period 2071-2100 suggesting that the annual precipitation in Southern Norway can increase with between 0.2 and 19.6% while the winter precipitation can increase with 2.0 to 35.6% compared to the present situation.

The CLUE project was established to better understand climate change effects on the N cycle in Norway in a combination of field experiments and model studies including coupling to regional climate models (*www.umb.no/ipm/forskning/clue*).

According to Hanssen-Bauer (2005) the annual precipitation in Norway has increased in 9 of 13 regions with a 15-20% increase in north-western regions. The same study shows that there is a correlation between the North Atlantic Oscillation index (NAOI) and winter air temperature in all regions and a correlation between NAOI and winter precipitation in the western regions. However, this correlation varies with time. One explanation may be that the atmospheric circulation over Norway is not only dependent on NAOI but also the position of the Icelandic low.

Regional N deposition gradients are partly caused by large differences in annual precipitation (a factor of 10). South-West Norway has the highest precipitation and consequently the highest deposition, while dry deposition dominates in the north and along the Swedish border.

Precipitation data from seven monitoring stations were tested with the nonparametric Mann-Kendall as a two-tailed test (*Gilbert, 1987*). Secondly the estimate for the slope of a linear trend was calculated with the nonparametric Sen's method (*Sen, 1968*).

Acknowledgements

The Software used for trend analysis was kindly provided by Anders Grimvall and Claudia Libiseller, Linköping University, Sweden.

This work has been supported by the Norwegian Research Council through project grant 155826/720.

Figures

All figures: Triangles are winter month data (December, January and February) and dots are summer month data (June, July and August). Blue lines are winter trends and red lines are summer trends. Significant trends (p<0.1) are shown for 1980-2005 and 1990-2005.

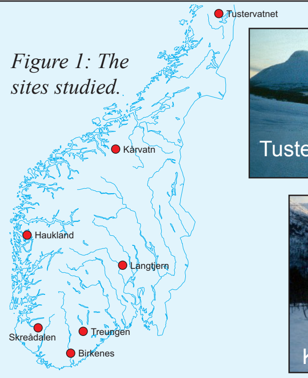
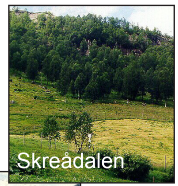


Figure 1: The sites studied.



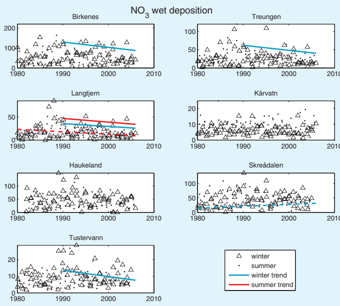


Figure 2: Monthly average NO_3 wet deposition (mg/m^2). Dashed line: 1980-2005 trend. Solid line 1990-2005 trend.

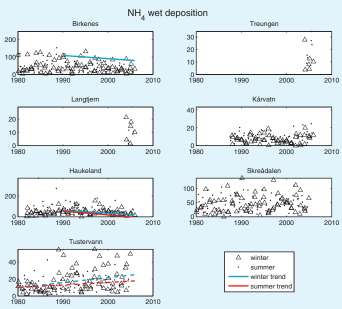


Figure 3: Monthly average NO_3 wet deposition (mg/m^2). Dashed line: 1980-2005 trend. Solid line 1990-2005 trend.

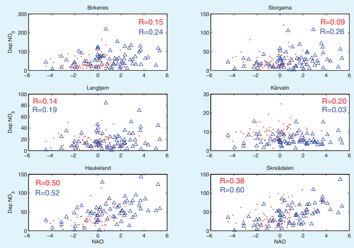


Figure 4: Monthly average NO_3 wet deposition (mg/m^2) vs monthly NAO index.

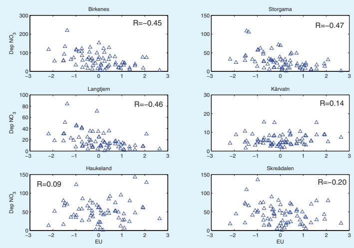


Figure 5: Monthly average NO_3 winter wet deposition (mg/m^2) vs monthly European blocking index.

Table 1: Average summer and winter monthly characteristics 1980-2005 of the sites studied. Precipitation is measured at the sites, while air temperature is taken from the nearest climatological station (provided by met.no).

Station name		Precipitation [mm]	NO_3 concentration [mg l^{-1}]	NO_3 wet deposition [mg m^{-2}]	NH_4 concentration [mg l^{-1}]	NH_4 wet deposition [mg m^{-2}]	Air temperature [°C]
Birkenes	Winter	125	0.51	59.8	0.42	48.5	1.5
	Summer	107	0.41	40.7	0.45	42.0	13.9
Treungen	Winter	74	0.39	26.6	0.21	11.2	0.7
	Summer	88	0.30	26.0	0.21	20.5	13.5
Langtjern	Winter	44	0.45	18.1	0.62	11.7	-1.5
	Summer	82	0.20	16.3	0.13	10.9	13.3
Kårvatn	Winter	141	0.06	6.0	0.05	7.1	-0.4
	Summer	116	0.10	9.8	0.09	11.3	10.0
Haukeland	Winter	398	0.15	48.5	0.14	45.7	0.8
	Summer	190	0.20	33.4	0.40	64.7	11.3
Skreådalen	Winter	242	0.22	43.0	0.22	45.1	1.1
	Summer	129	0.33	40.3	0.41	48.1	13.8
Tustervatn	Winter	147	0.09	9.8	0.13	17.6	
	Summer	87	0.10	7.5	0.18	14.3	

Table 2: Significant trends in monthly values 1980-2005. See Figs 1-3.

Station name		Monthly Precipitation [mm]	NO_3 wet deposition [mg m^{-2}]	NH_4 wet deposition [mg m^{-2}]
Birkenes	Winter			
	Summer			
Treungen	Winter			NA
	Summer			NA
Langtjern	Winter			NA
	Summer	1.3	-0.5	NA
Kårvatn	Winter	3.0		
	Summer			
Haukeland	Winter			
	Summer	3.2		
Skreådalen	Winter		0.7	
	Summer			
Tustervatn	Winter			0.6
	Summer			0.3

Table 3: Significant trends in monthly values 1990-2005. See Figs 1-3. NA=Not Available.

Station name		Monthly Precipitation [mm]	NO_3 wet deposition [mg m^{-2}]	NH_4 wet deposition [mg m^{-2}]
Birkenes	Winter		-2.7	-1.8
	Summer			
Treungen	Winter		-1.4	NA
	Summer			NA
Langtjern	Winter		-0.6	NA
	Summer		-0.8	NA
Kårvatn	Winter	6.7		
	Summer			
Haukeland	Winter			-2.3
	Summer			-3.5
Skreådalen	Winter			
	Summer			
Tustervatn	Winter		-0.3	
	Summer			

Results

- There is a significant increase in both summer and winter precipitation at some stations. No stations show a significant decrease
- Because 1990 was the warmest (and consequently one of the wettest) year on record in Norway, there are few significant trends in precipitation in 1990-2003.
- There are significant reductions in nitrate concentration in precipitation at several stations, particularly at the driest station (Langtjern).
- For reduce nitrogen there are negative trends at the wettest station (Haukeland). The positive trend at Tustervann could be explained by changes in local farming activities.
- NAOI is best correlated with nitrate deposition at the coastal stations (Haukeland and Skreådalen). This is particularly true in winter.
- The European blocking index is strongest (and negatively) correlated with winter nitrate deposition at the drier sites.
- Increasing precipitation seems to compensate for decreasing nitrate concentrations at several sites in the south (Birkenes, Storgama and Langtjern).
- More detailed statistical analysis is in progress as part of the CLUE project. (*www.umb.no/ipm/forskning/clue*).

References

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NILU PP 19/2006