Norwegian experience on deposition monitoring and assessment in Norway and Europe

Wenche Aas

NILU
Norsk institutt for luftforskning
Norwegian Institute for Air Research

Air pollution and impacts

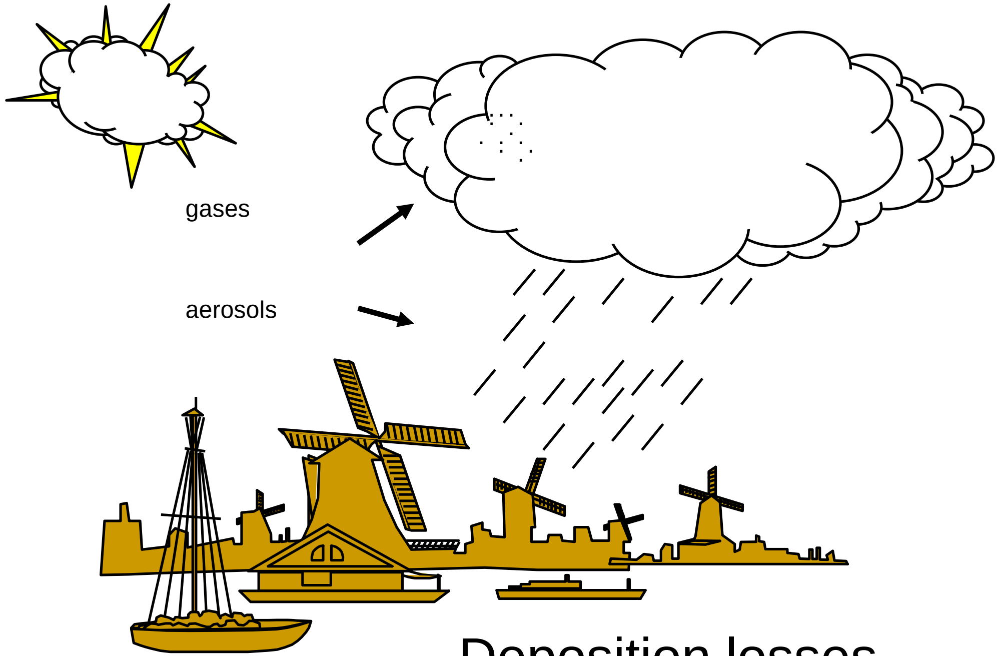






Mobile, industrial
and non-point sources

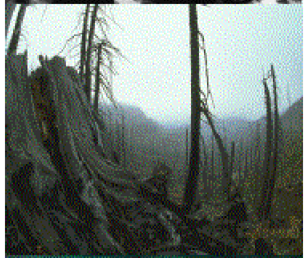
Atmospheric transport
and chemistry



Deposition losses

Receptors

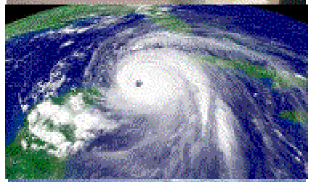
Cultural heritage



Ecosystems

Crops

Humans/animals

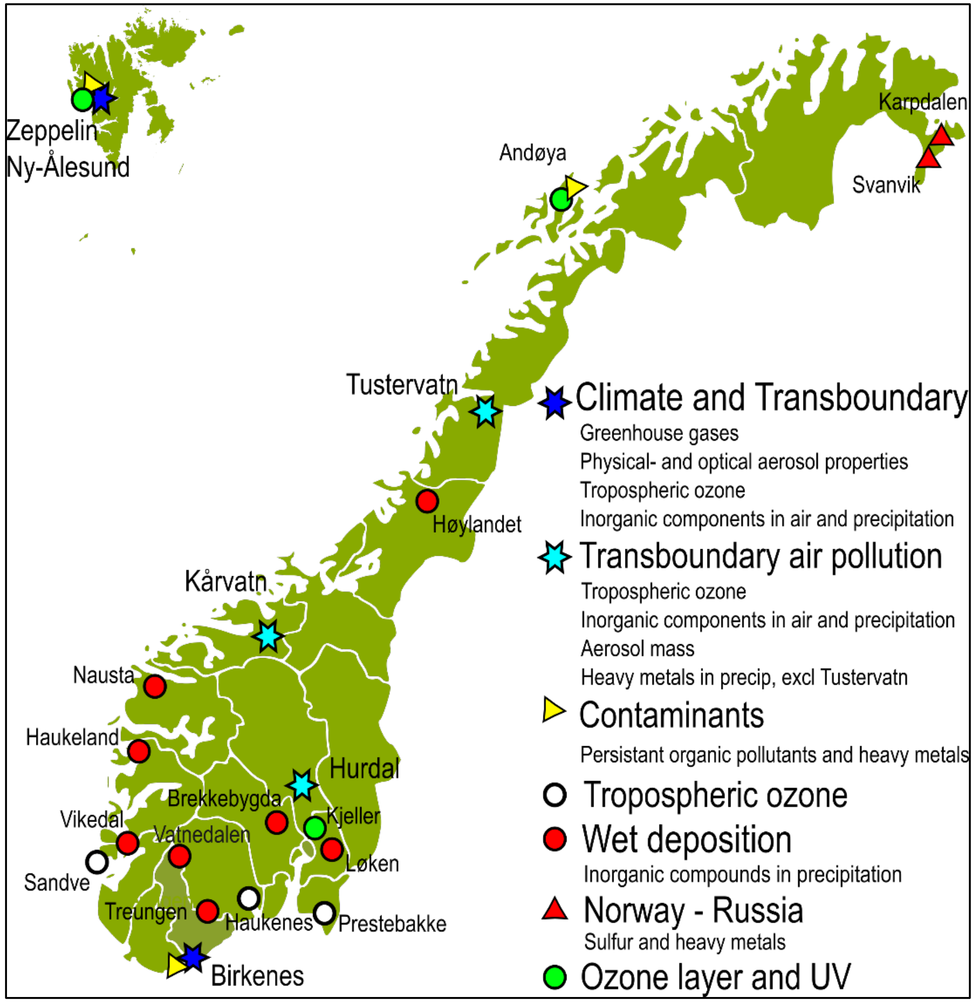


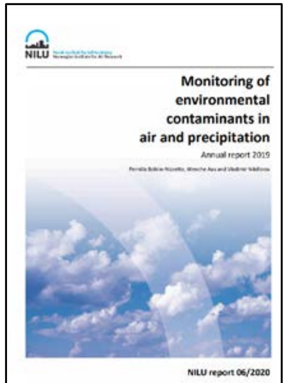
Climate

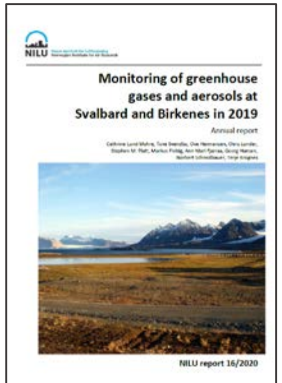
Estuaries

The Norwegian national monitoring programme

- Fulfill several purposes
  - Transboundary fluxes
  - Contaminates (including new compounds of emerging concern)
  - Climate change and ozone layer
  - Provide data for effect studies (i.e. LRTAP ICPs) and research on atmospheric processes
  - Trends (compliance monitoring)
- Sites of different complexities
  - From very advanced/research oriented to only include a few compounds
- Long term (financial) commitment

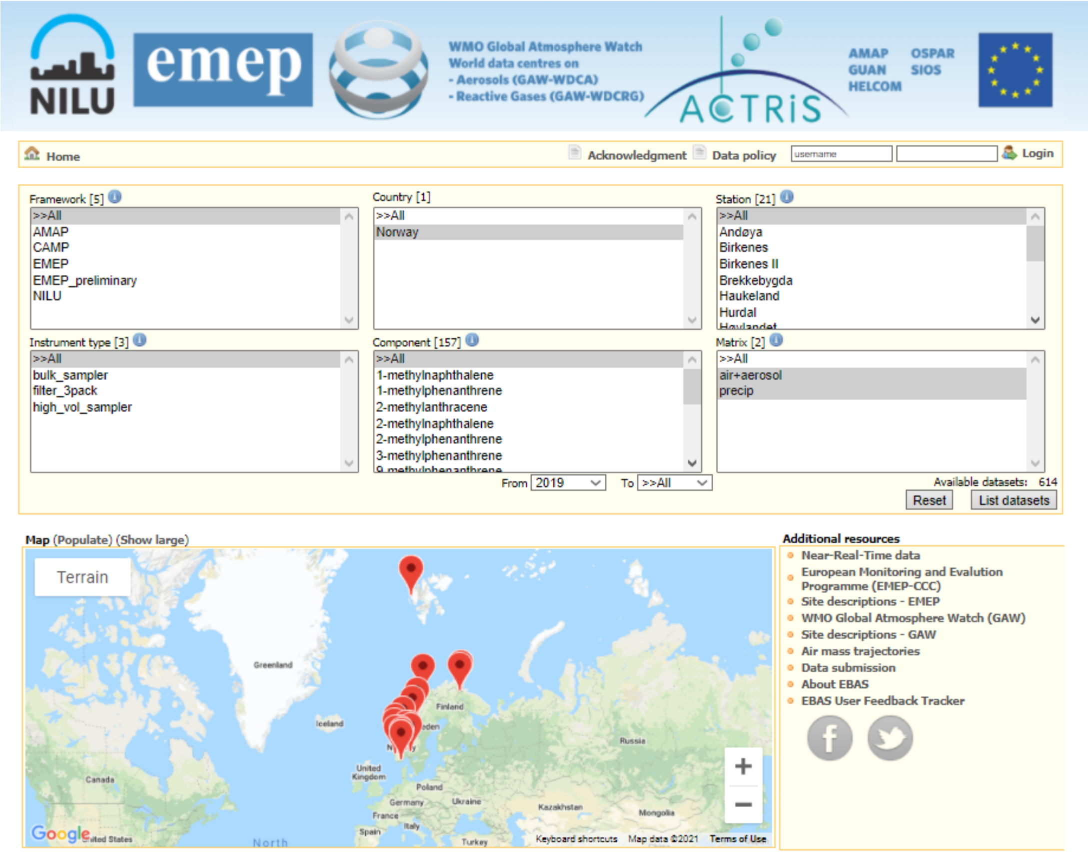






Norwegian Environment Agency

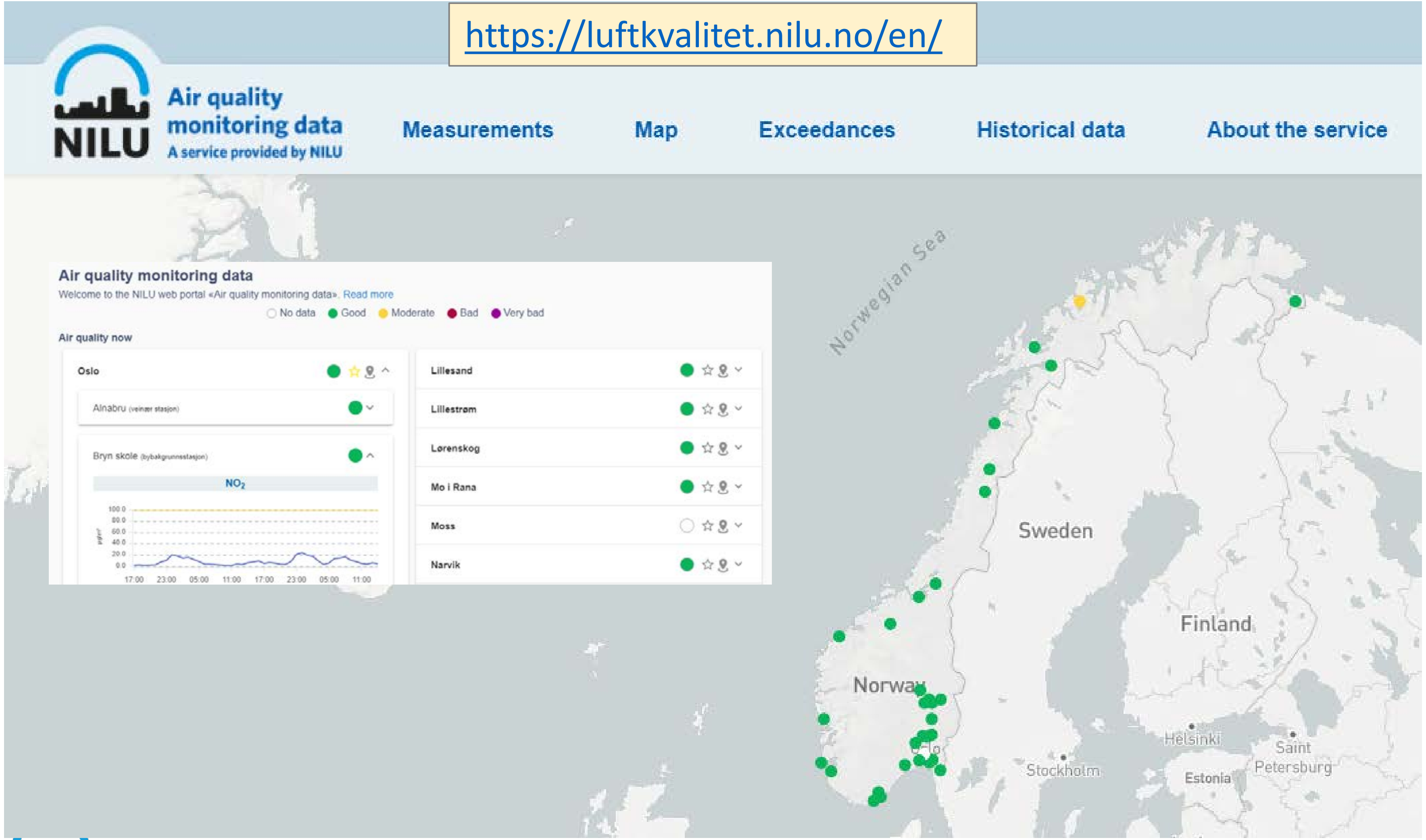
All the data are openly available



http://ebas.nilu.no/

Database infrastructure for several networks: EMEP, ACTRIS, WMO GAW, AMAP, HELCOM, OSPAR and more

Urban montoring



- Municipalities /city authorities with the monitoring responsibilities
- Transferred data to different online data portal
- Reference laboratory at NILU
- Simple programme (mainly PM, NO2)
- More advanced observations in Oslo

The observational system needs to fulfill several criteria

- **Long term commitments**. Takes long time to obtain a useful time series -at least ten year
  - Shorter periods for screening and research
- Adequate **spatial resolution**
  - Enough stations to observe regional differences, especially important in regions with strong meteorological variations
- Adequate **temporal resolution**
  - Hours or days necessary to study sources and transport.

Adequate **data quality**

- Harmonized methods with international/national standards and use of reference methods and standard operational procedures
- Regularly checked

- **Co-located** measurements
  - Many different components at the same sites. Cost efficient and better understanding of atmospheric processes and sources

Monitoring and **research** in close cooperation

- Use of same infrastructure (sites, lab, database)
- Dependent on each other

International commitments

- Program

  Protocols and conventions
- Quality

  standards, procedures and QA/QC assessments

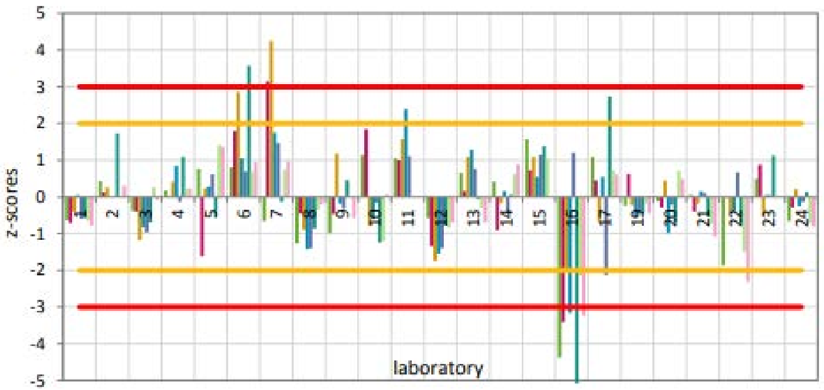
Developing procesudurs, document tracebility and quality assessessmens of observations

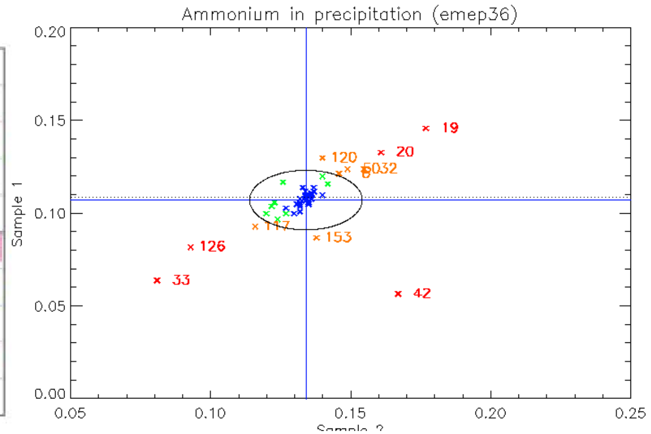
In close cooperation with international monitoring frameworks and research infrastructures I.E EMEP, CEN, ACTRIS, ICOS, WMO-GAW

GAW Guidelines for Precipitation Chemistry Measurements – Appendix A (Updated – 10 July 2020; Previous Versions - 30 June 2018, and Original Version – November 2004)

TABLE A.1. DATA QUALITY OBJECTIVES (DQOS) FOR GAW PRECIPITATION CHEMISTRY MEASUREMENTS (effective 1 January 2018)

Measurement Parameter	Detection Limits	Precision		Inter-Network Bias		Calibration Levels	Data Completeness (See footnotes for PCL & TP)
		Overall	Laboratory	Overall	Laboratory		
pH (pH units)	Not Applicable	pH > 5: ± 0.1 pH < 5: ± 0.03	pH > 5: ± 0.04 pH < 5: ± 0.02	pH > 5: ± 0.24 pH < 5: ± 0.12	pH < 4: ±0.05 pH 4.00–4.99: ±0.07 pH $\geq$ 5.00: ±0.10	4.0 & 7.0 low ionic strength reference solution	90% PCL 70% TP
Conductivity ($\mu S\ cm^{-1}$)	± 2	Not Available	Not Available	Not Available	± 7%	Between 2nd & 98th percentile concentrations	90% PCL 70% TP
Acidity/Alkalinity ($\mu mole\ L^{-1}$)	Not Applicable	Not Available	Not Available	Not Available	± 25%	Between 2nd & 98th percentile concentrations	90% PCL 70% TP
SO_4^{2-} ($mg\ L^{-1}$)	0.06	0.06	0.03	± 0.42	± 5%	Between 2nd & 98th percentile concentrations	90% PCL 70% TP
NO_3^- ($mg\ L^{-1}$)	0.09	0.06	0.03	± 0.36	± 5%	Between 2nd & 98th percentile concentrations	90% PCL 70% TP
Cl^-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Between 2nd & 98th	90% PCL





Norwegian monitoring programme, regional background
(excl. climate gases or ozone depletion substances)

	Air							Precipitation			
	Hourly		Daily		Weekly		2d per week	Daily	Weekly		monthly
Stasjon	Metr.	Ozone	main	NO_2	$PM_{2,5}$, PM_{10} + EC/OC	HM.	POPs	main	main	HM	POPs
Birkenes	X	X	X	X	X	X[b]	X[d]	X		X[b]	X[e]
Vatnedalen									X		
Treungen									X		
Haukenes		X									
Prestebakke		X									
Løken									X		
Hurdal	X	X	X	X	X			X		X[a]	
Brekkebygda									X		
Vikedal									X		
Sandve		X									
Nausta									X		
Kårvatn		X	X	X	X			X		X[a]	
Høylandet									X		
Tustervatn		X	X	X				X			
Andøya	X					X[b]	X[g]				
Karpbukt									X		
Zeppelin, Ny-Ålesund	X	X	X			X[c]	X[g]		X		
Total number	4	7+1	5	4	3	3	3	4	9	4	1

EMEP Monitoring strategy:
https://unece.org/fileadmin/DAM/env/documents/2019/AIR/EB_Decisions/Decision_2019_1.pdf

Monitoring requirements for the various levels specified by the monitoring strategy

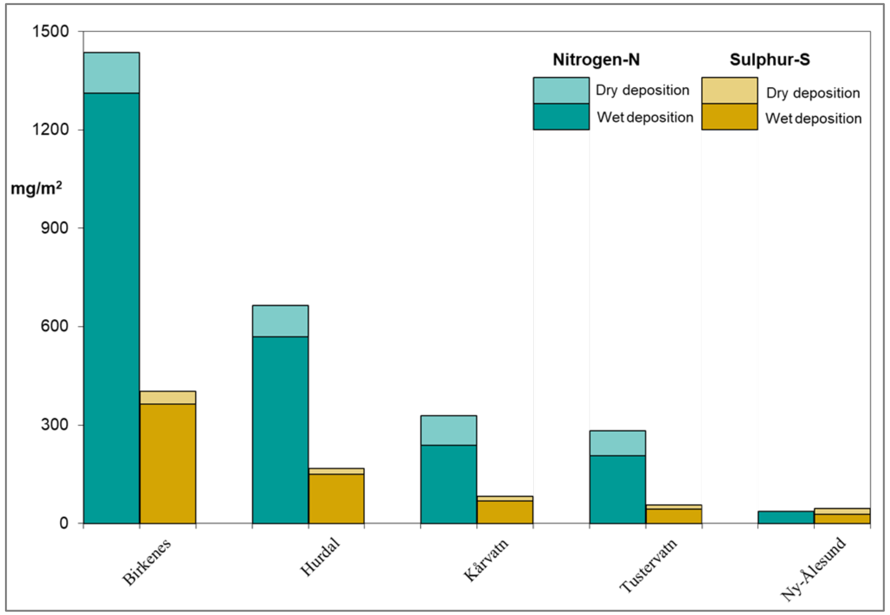
Levels 1 and 2 are mandatory. Information on reference methods is provided in the EMEP Manual for Sampling and Chemical Analysis and in the Quality assurance/Quality control section available on the EMEP Chemical Coordinating Centre website: www.emep.int; https://projects.nilu.no//ccc/index.html.

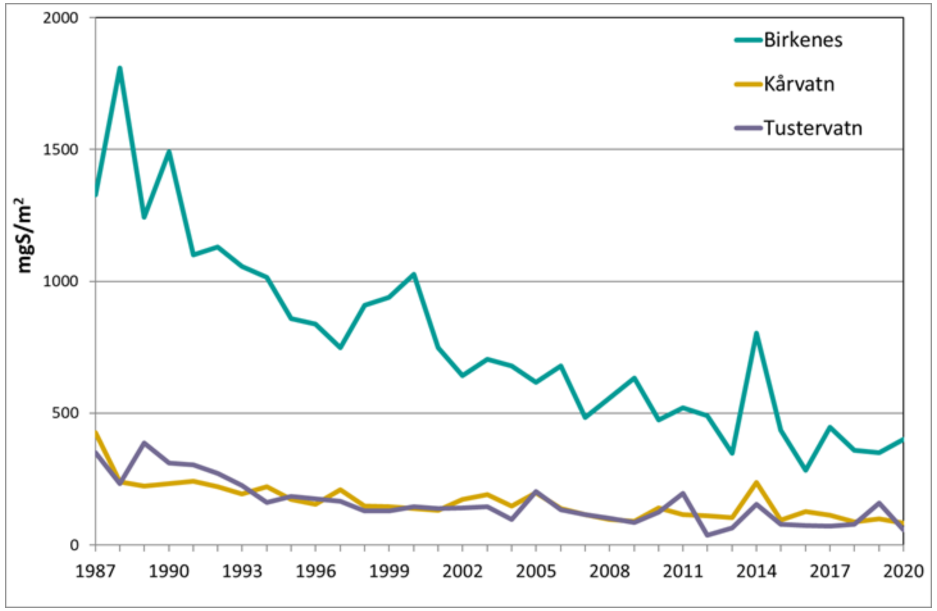
Level 1 - "variables to be measured at all basic EMEP sites"		*Recommended temporal resolution*
Inorganic compounds in precipitation	SO_4^{2-}, NO_3^-, NH_4^+, H^+ (pH), Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, precipitation amount	24 hours
Inorganic compounds in air	SO_2, SO_4^{2-}, NO_3^-, HNO_3, NH_4^+, NH_3, (sNO_3, sNH_4), HCl, Na^+, K^+, Ca_2^+, Mg_2+	24 hours
Elemental and Organic Carbon	EC and OC in $PM_{2.5}$	24 hours /7 days
Nitrogen dioxide	NO_2	1 hour/24 hours
Ozone	O_3	1 hour
PM mass concentration	$PM_{2.5}$, PM_{10}	24 hours
Heavy metals in precipitation	Cd, Pb (1st priority), Cu, Zn, As, Cr, Ni (2nd priority)	7 days
Meteorology	Precipitation amount (RR), temperature (T), wind direction (dd), wind speed (ff), relative humidity (rh), atmospheric pressure (pr)	24 hours (RR), others 1 hour

Level 2 - "additional variables to be measured at a subset of sites - EMEP level 2 sites"		*Recommended temporal resolution*
Oxidant precursors and gaseous short-lived climate pollutants		
Nitrogen oxide	NO	1 hour
Light hydrocarbons	C_2–C_5, BTEX (Benzene, Toluene, Ethylbenzene and Xylene)	1 hour/grab sample once or twice per week
OVOCs	Aldehydes and ketones	Absorbing Solution tube, once or twice per week
Hydrocarbons	C_6–C_{12}	1 hour/ABS tube, once or twice per week
Methane	CH_4	1 hour
Carbon Monoxide	CO	1 hour
Particulate matter (PM) observations contribute to the assessment of particulate matter and its source apportionment		
PM mass	PM_1	1 hour

Total (wet + dry) deposition of S and N

- Simple estimates every year at the 4-5 sites with concentrations in both air and precipitation
- Using dry deposition rates from literature
- 10-35% dry deposition. Highest for nitrogen, and higher in summer than winter





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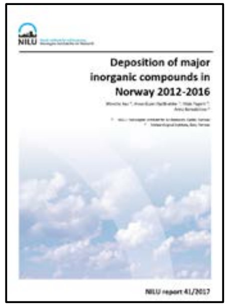
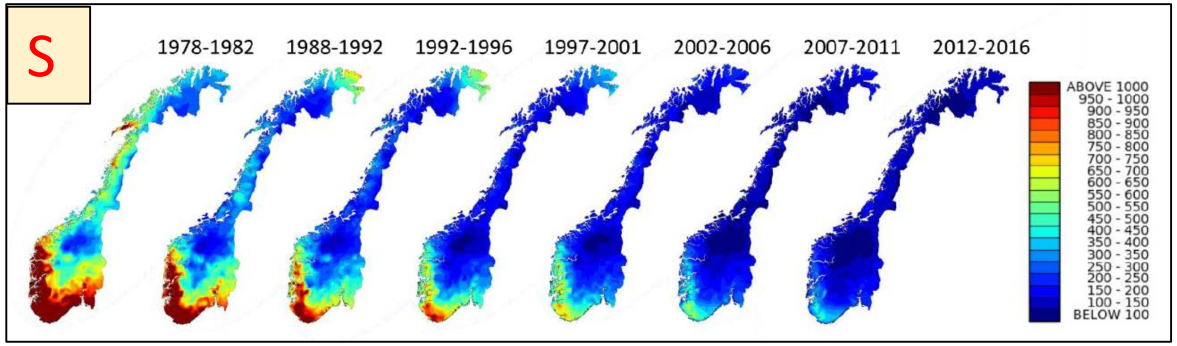
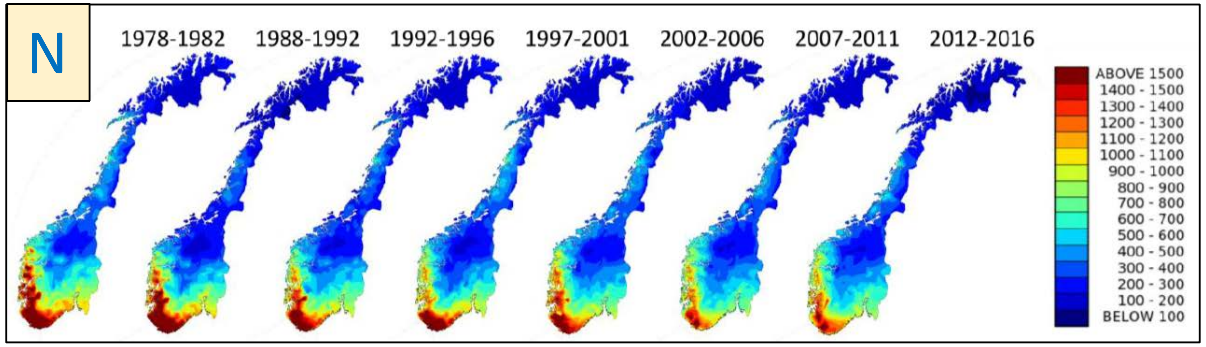
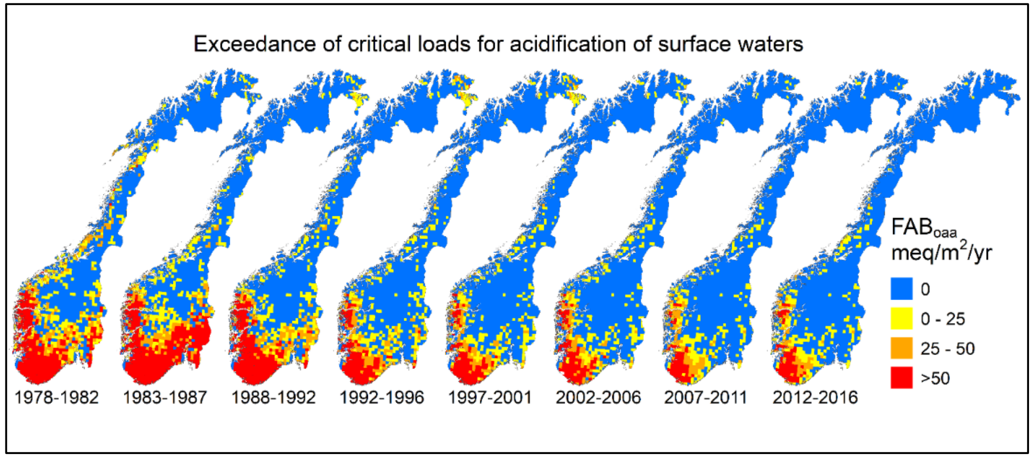
Atmospheric deposition of sulfur and nitrogen -for critical load assessments

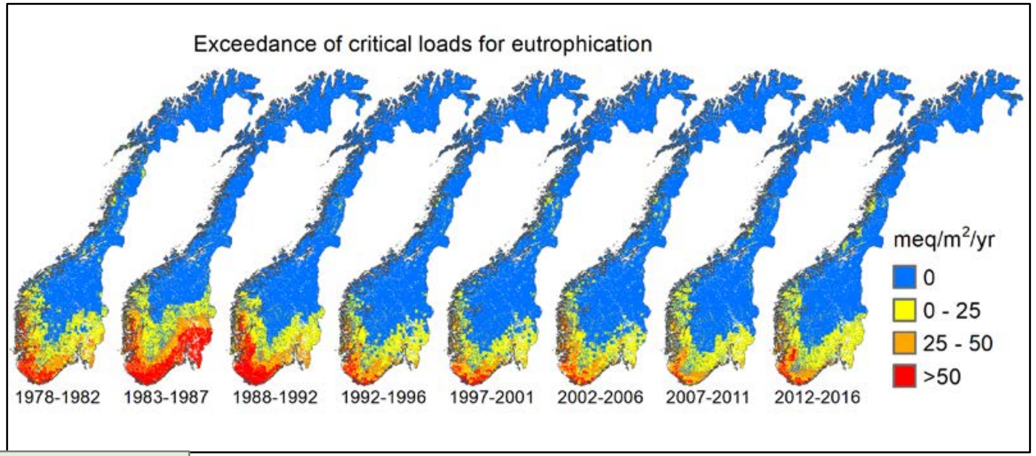


Trends in atmospheric deposition









Trends in exceedances

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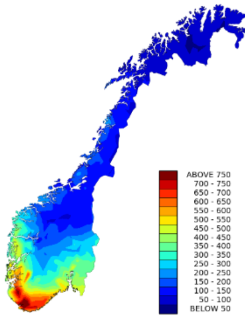
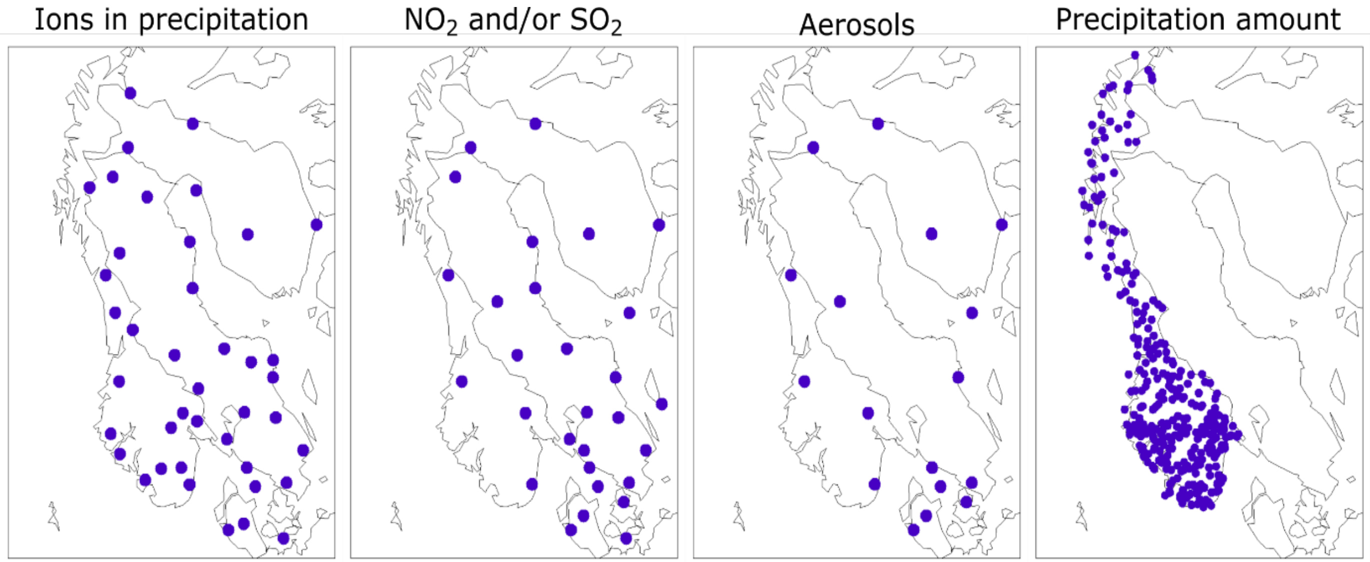
Data used for total depositum assessment



Site coverage



- Some regions with too few sites
- Some sites maybe not regionally representative (special problem for Nred)
- Dry deposition 10-30 % of total deposition
- Large differences in precipitation amounts in Norway

Extrapolating concentration fields:

- Statistical kriging techniques

Or:

- EMEP model (simple data assimilation)

Calculate dry deposition rates:

- Data from literature

Or

- Fluxes from EMEP model

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Using atmospheric models in combination with observations

✓Improve the spatial distribution.

- Especially in regions where sites are missing.
- Bias in kriging approach when spatial representativity's of the sites are not homogeneous
- Spatial resolution of many models have improved the latter years

✓Improve dry deposition calculations.

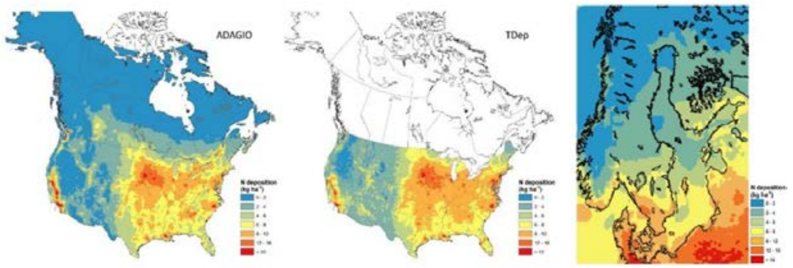
- Data from literature is too crude and are not changing

✓ However, model output is dependent on good emission data

Data model fusion become more common, i.e.:

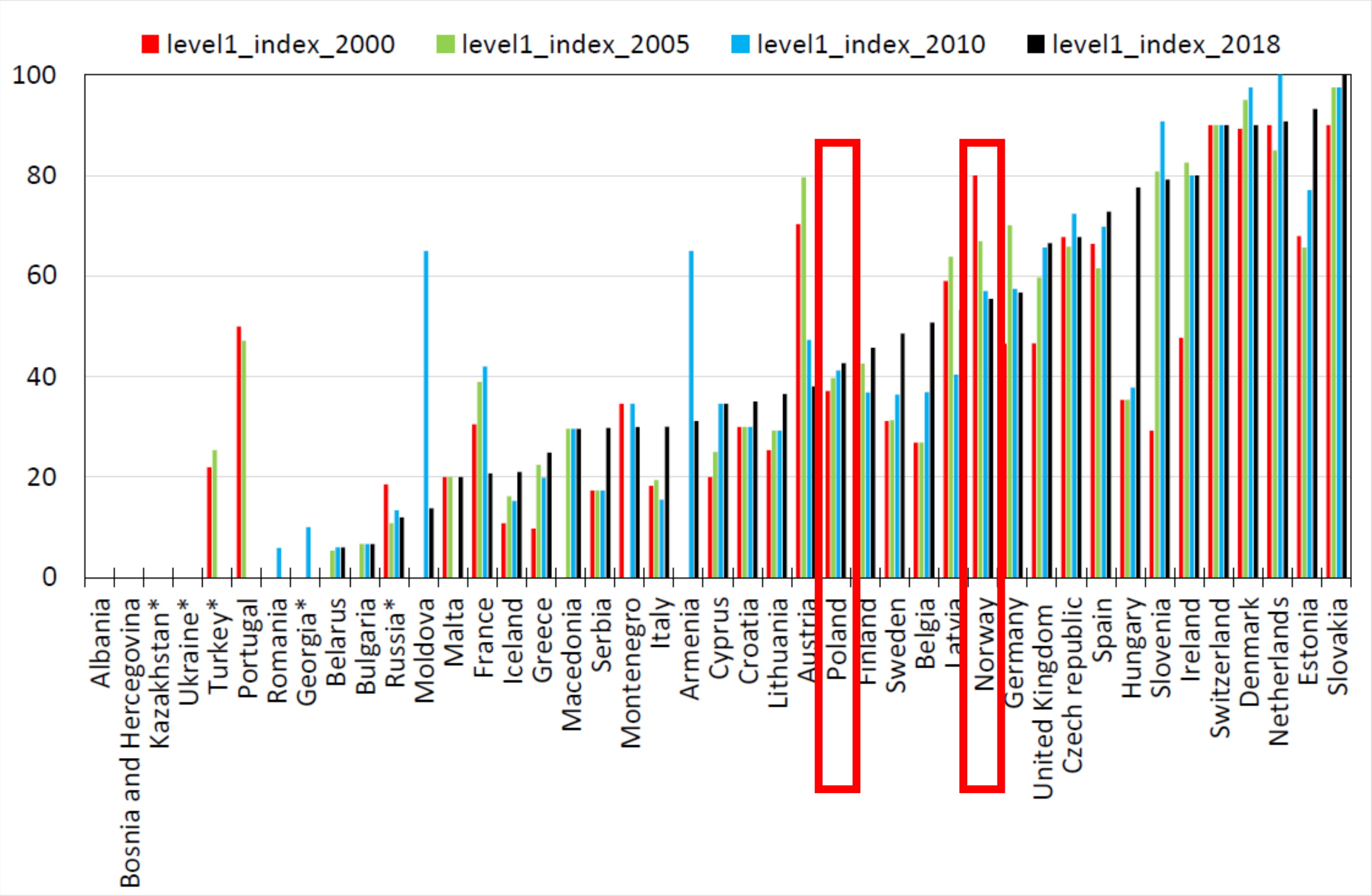
- Copernicus Atmosphere Monitoring Service (not dep yet)
- WMO – GAW MMF GTAD

Combine the best of two worlds



Spatial coverage

Implementation of the EMEP basic monitoring programme



- ✓ Dependent on what to study
  - Catchment or ecosystem (or health, climate)
  - Local, national or regional focus
- ✓ International requirements
  - EMEP (Monitoring strategy)
  - EU AQD

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Site representativity

✓ Dependent on component

✓ Dependent on orography and meteorology

✓ A site representativity can change with time

- In nearby sources: Farming, traffic, dust, heating
- Vegetation changes
- New buildings/obstacles

- Site representativity needs to be documented
    - Pictures
    - Campaigns studied (i.e. passive sampling)
    - Modelling (i.e. compare models with observations and inverse modelling)

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Final remarks of the Norwegian programme

- Internationally, Norway has some of longest time series of **high quality** atmospheric observations
- **Fulfill** to a large extent our international obligations
- Some gaps in spatial coverage
- Good and important link with **research** communities
- Relatively stable national funding
- **Still knowledge gaps** on sources, transport pattern and atmospheric processes and deposition

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