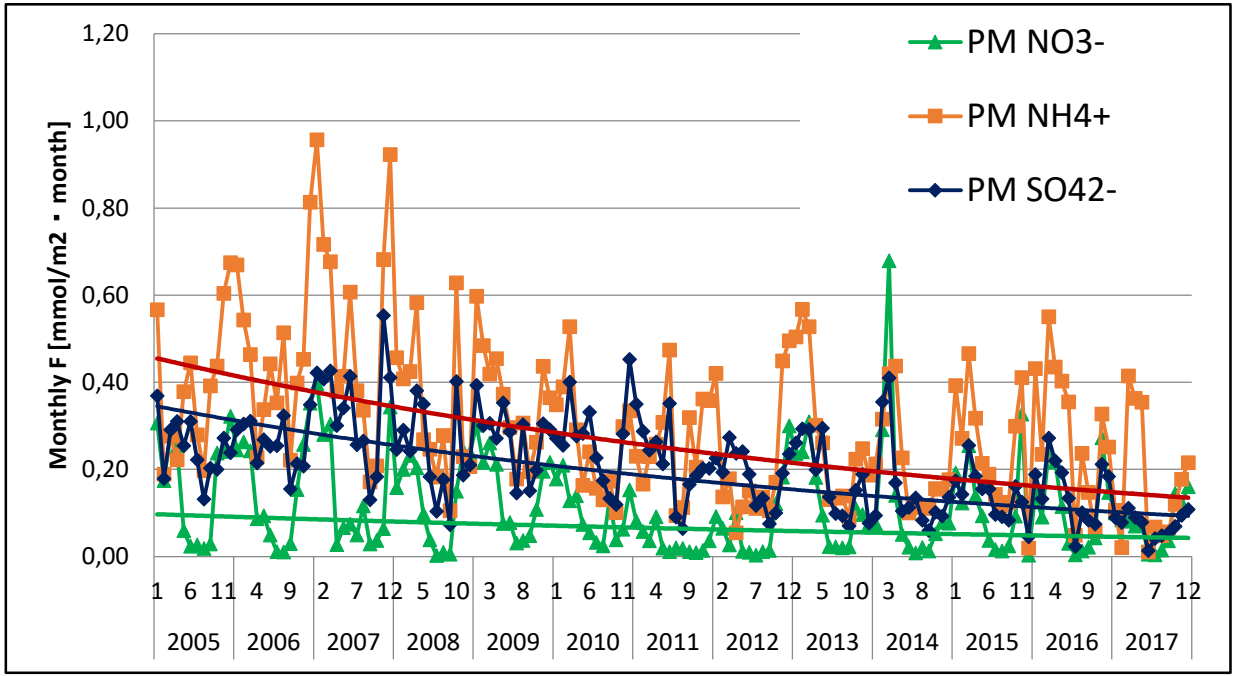
Multiyear annual and seasonal variation of Dry Deposition Fluxes of airborne sulphur and nitrogen compounds and their contribution into the total atmospheric deposition at natural forest catchment based on long term experimental observations

Ekaterina S. Zhigacheva (1,2), Sergey A. Gromov (1,3), Hiroyuki Sase (4), Masaaki Takahashi (4), Tsuyoshi Ohizumi (4,5)

(1) Yu.A.Izrael' Institute of Global Climate and Ecology (IGCE), Environmental pollution monitoring division, Moscow, Russian Federation (kosjatko@gmail.com), (2) Russian State Social University, Moscow, Russian Federation, (3) Institute of Geography RAS, Moscow, Russian Federation, (4) Asia Center for Air Pollution Research (ACAP), Niigata, Japan, (5) Niigata prefectural institute of public health and environmental sciences, Niigata, Japan



Monthly values of dry deposition flux of PM NO_3^-, NH_4^+, SO_4^{2-}

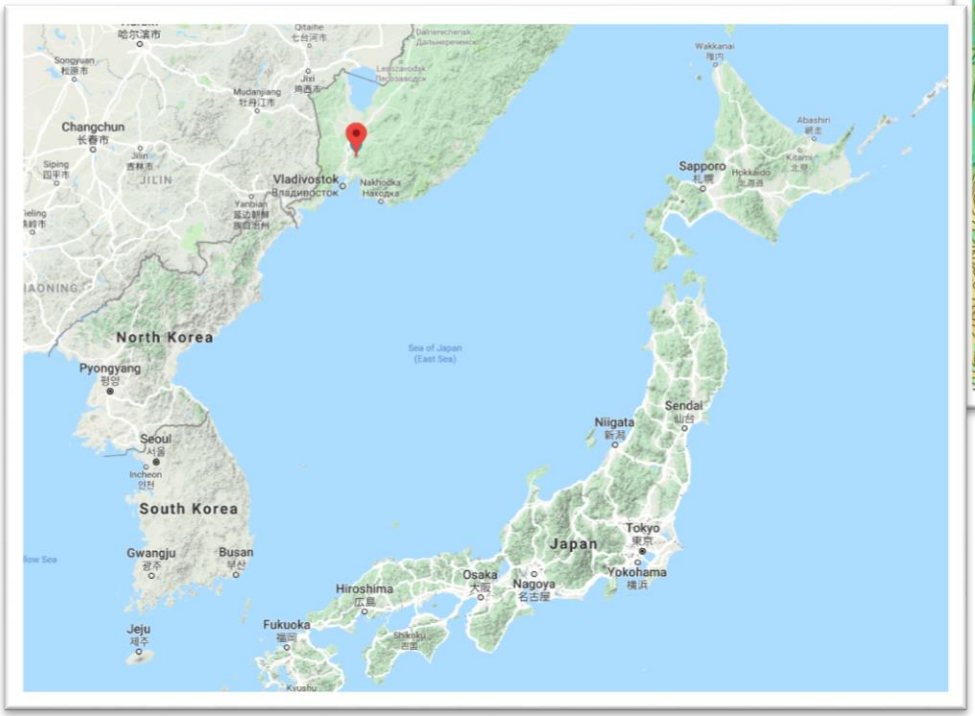
$$F_i = Vd_i \times C_i$$

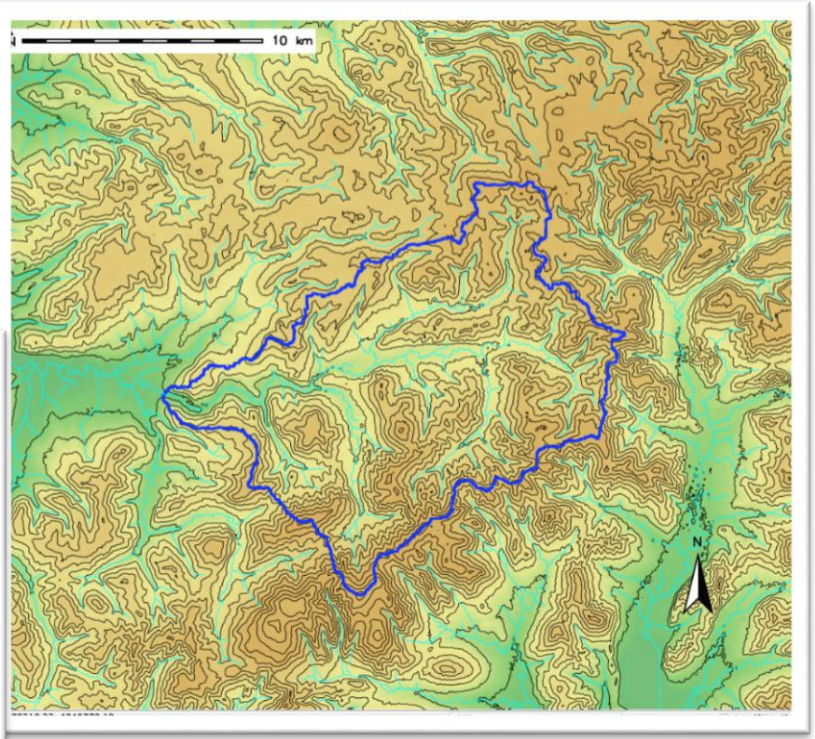
F_i - flux of *i* species
Vd - deposition velocity of *i* species
C_i -concentration of *i* species.

Estimation were made based on **Technical Manual for Dry Deposition Flux Estimation in East Asia - EANET**. 2010

Study area

Komarovka river catchment
(Russia Far East)
EANET site Primorskaya





Assumed to be 100% covered by forests

Komarovka river

Meteorological station

Temperate deciduous forest

Data & Methods

Deposition velocities were calculated for the period from **2005 to 2017** using inferential method been realized in Microsoft Excel macros file by EANET Network Center (ACAP).

Meteorological data and data on air chemistry were obtained from station Primorskaya.

Meteorological data

Daily: Temperature [^{o}C], Relative Humidity [%], Wind Speed [m/s], Cloud Coverage [1-10]

Hourly: Solar Radiation [MJ/m^{2}],

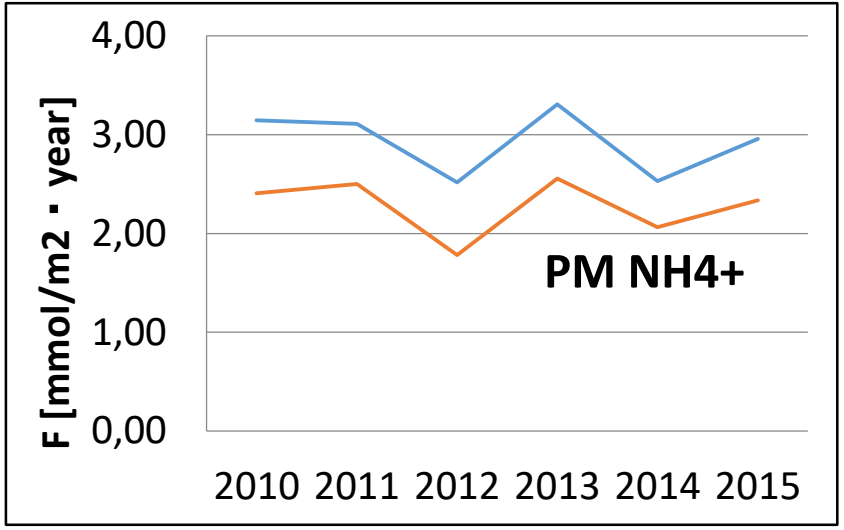
Air samples are taken twice a month (filter packs)

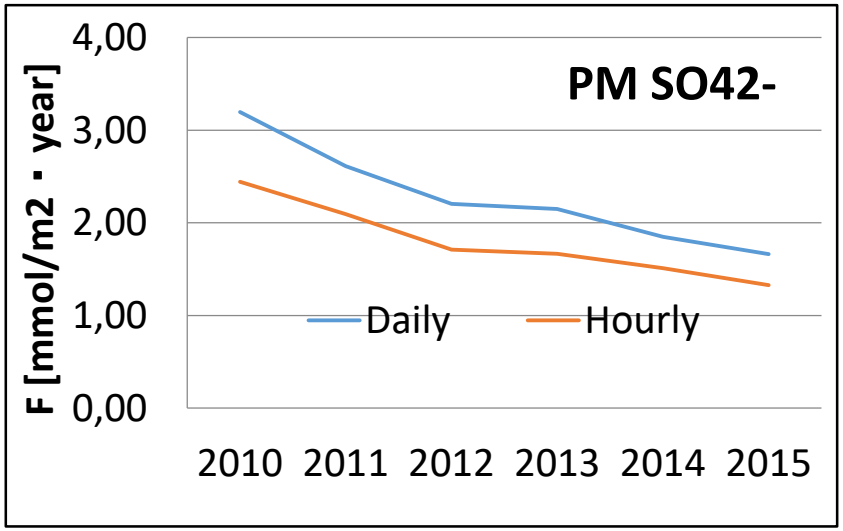
Vegetation data from EANET Data Report 2006

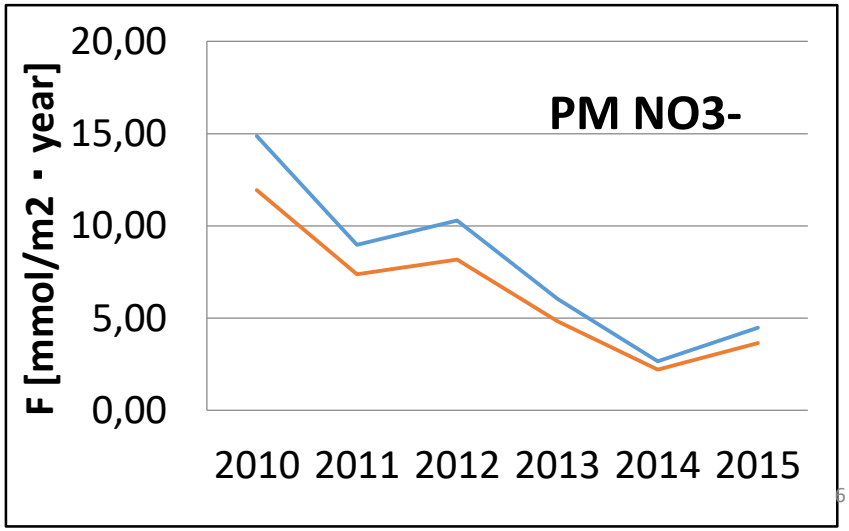
Input data comparison
Daily vs Hourly calculations

SO_4^{2-}	21%
NO^{3-}	22%
NH_4^{+}	22%

Exceeding rate while using hourly data



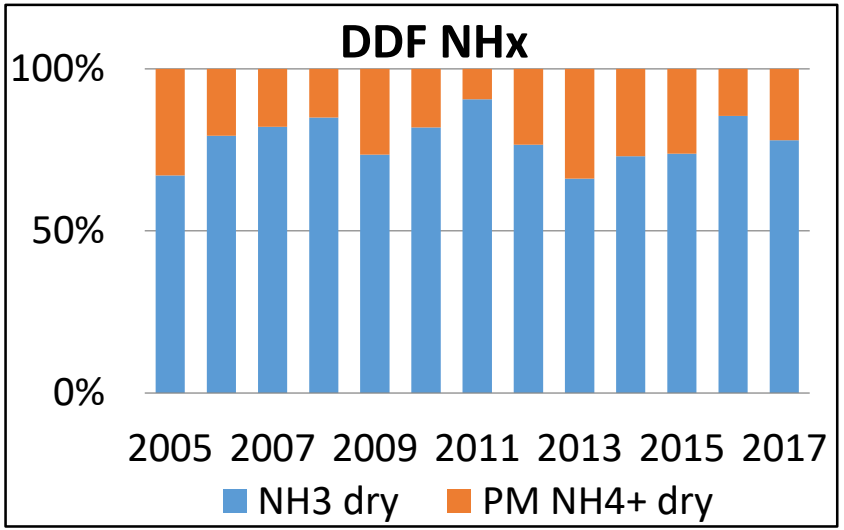


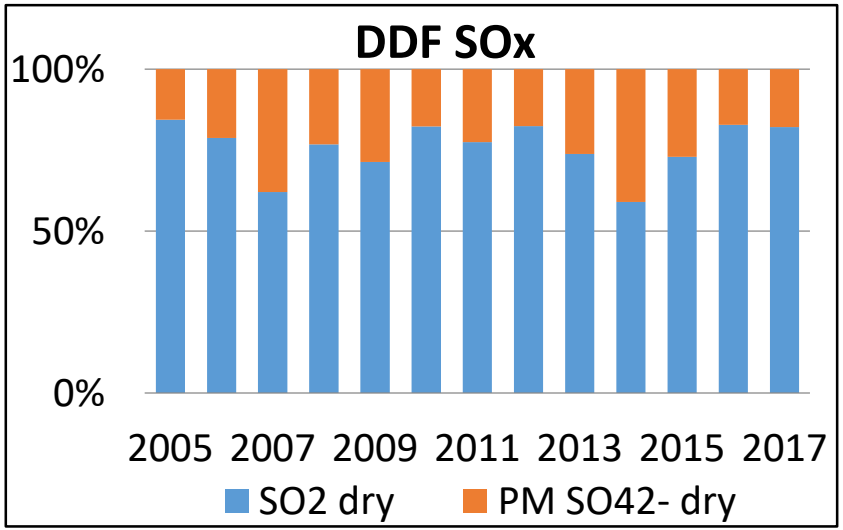


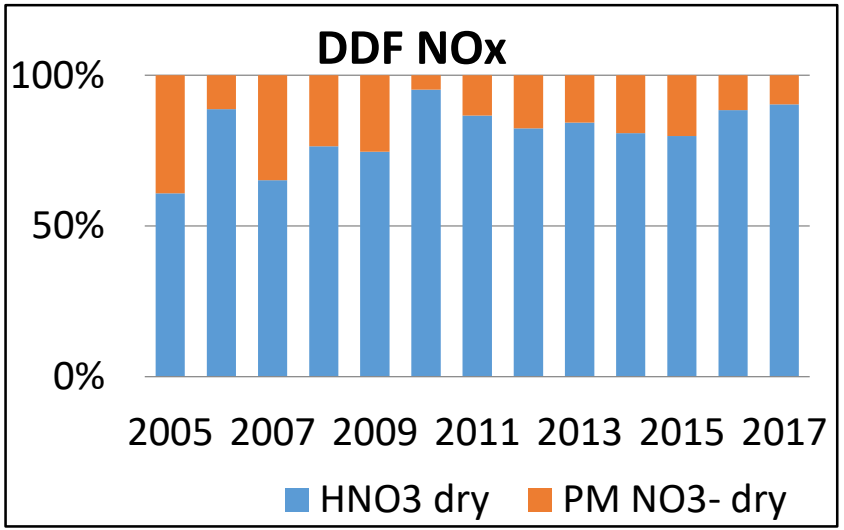
Gaseous and PM contribution

SO_2	76%
HNO_3	81%
NH_3	78%

Percent of gaseous particles contribution into the total DDF of sulphur and nitrogen compounds







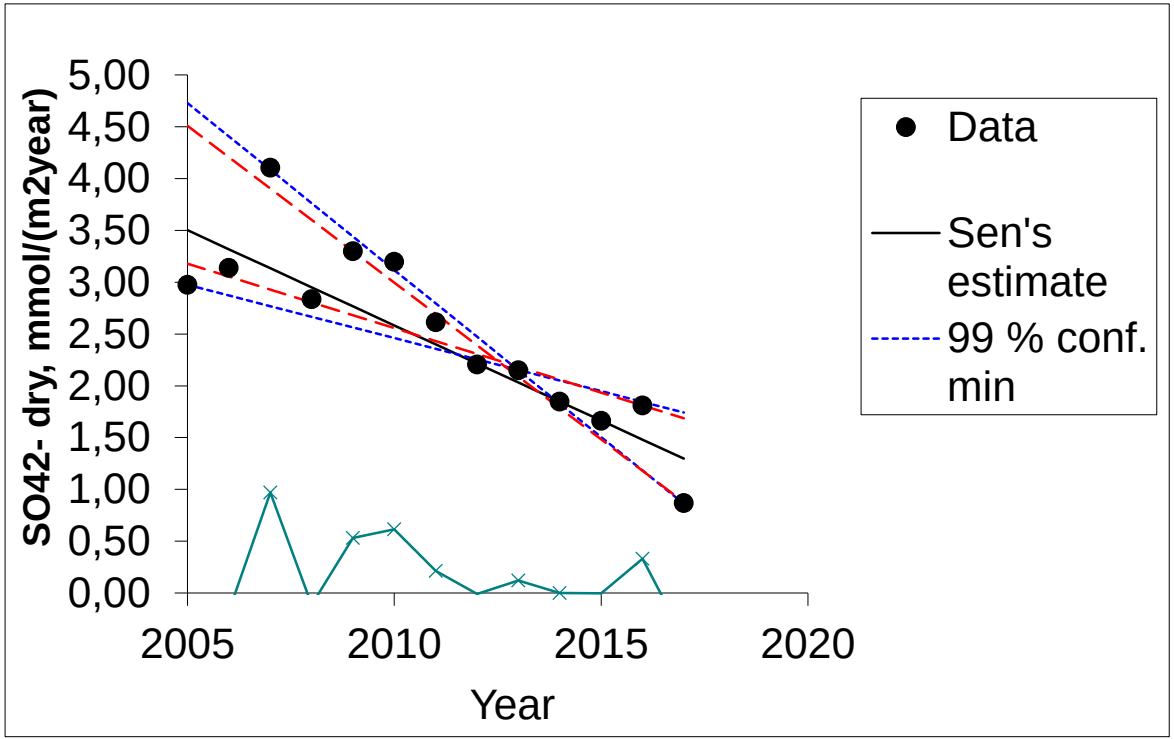
Mann-Kendall Test

TREND STATISTICS

Time series	n	Test Z	Signific.	Q
SO2 dry	13	-2,38	*	-0,680
HNO3 dry	13	1,28		0,319
NH3 dry	13	-1,40		-0,880
SO42- dry	13	-3,48	***	-0,184
NO3- dry	13	-2,62	**	-0,059
NH4+ dry	13	-2,75	**	-0,235
SOx dry	11	-2,18	*	-0,956
NOx dry	11	0,47		0,146
NHx dry	11	-1,71	+	-1,672
Cl dry	11	1,09		0,285

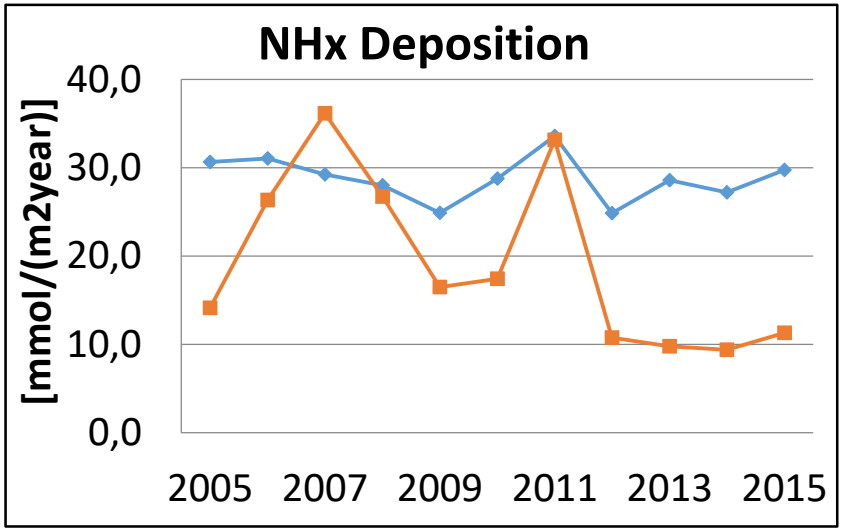
level of significance	
***	$\alpha = 0.001$
**	$\alpha = 0.01$
*	$\alpha = 0.05$
+	$\alpha = 0.1$

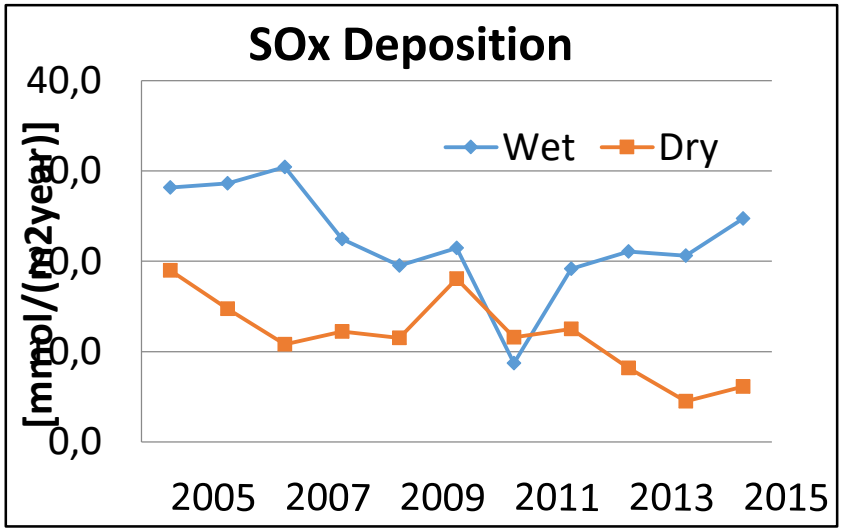
TsNumber	4
Name	SO42- dry
Years	2005 - 2017
n	13
Test S	
Test Z	-3,48
Signific.	***
Q	-1,84E-01
Qmin99	-3,22E-01
Qmax99	-1,03E-01
Qmin95	-3,03E-01
Qmax95	-1,24E-01
B	3,50E+00
Bmin99	4,73E+00
Bmax99	2,97E+00
Bmin95	4,51E+00
Bmax95	3,18E+00

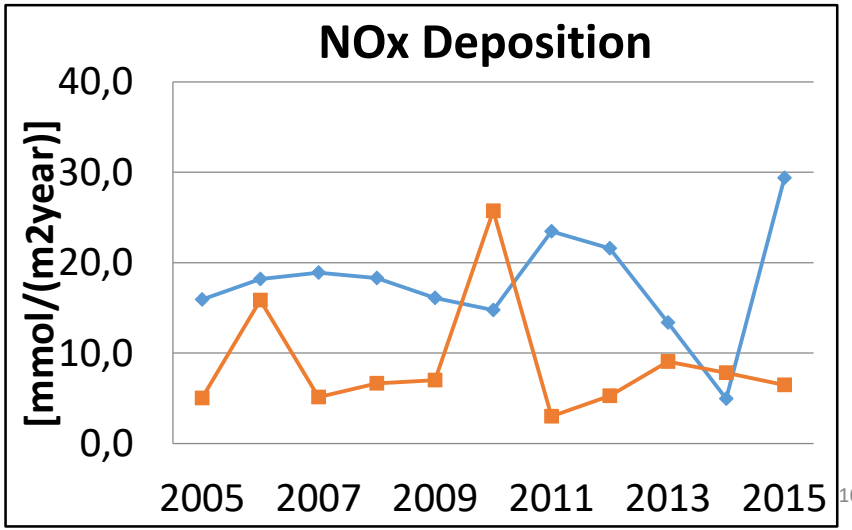


MAKESENS-application for trend calculation
by Finnish Meteorological Institute
https://en.ilmatieteenlaitos.fi/makesens

Wet And Dry Deposition







Conclusions

- The values for "daily" calculations exceeded "hourly" while maintaining a high correlation. On average, the overestimation was about 22%.
- Gaseous compounds make the major contribution into the DDF for sulfur and nitrogen: about 75% for SO_2, 78% for NH_3 and 82% for HNO_3 .
- Visible declining trends can be distinguished for some compounds by Mann-Kendall test.

  Although testing the air concentrations the trend can be found for sulfates only ($\alpha = 0.05$).
- Comparison of contributions to the total deposition fluxes of S and N compounds shows that wet deposition exceeds dry one for the most of years.