Ruisdael observatory

ROTTERDAM

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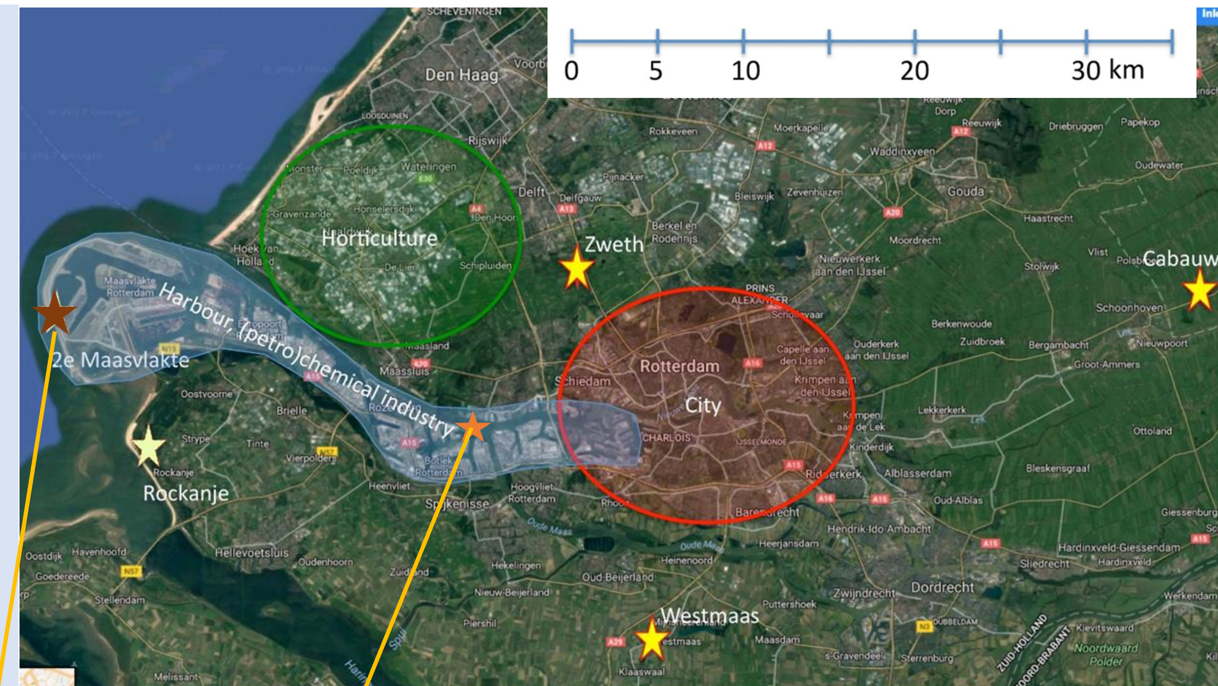
The greater Rotterdam area ("Rijnmond") is the ideal test bed for innovative methods to observe and quantify anthropogenic impact on atmospheric composition in a highly industrialized and urbanized environment. Three distinctly different source areas and activities are present: the port with petrochemical industry, power plants and shipping activities, the city area with intense traffic, and the horticulture area Westland, with large natural gas combustion emissions. Three permanent stations are foreseen (yellow stars), while Cabauw functions as a 4th Eastern background site. Ruisdael partners will construct an extremely valuable dataset for innovative science. Several ongoing developments are shown. Ruisdael is a national observatory; Groups interested in measurement campaigns or modelling are welcome to join.



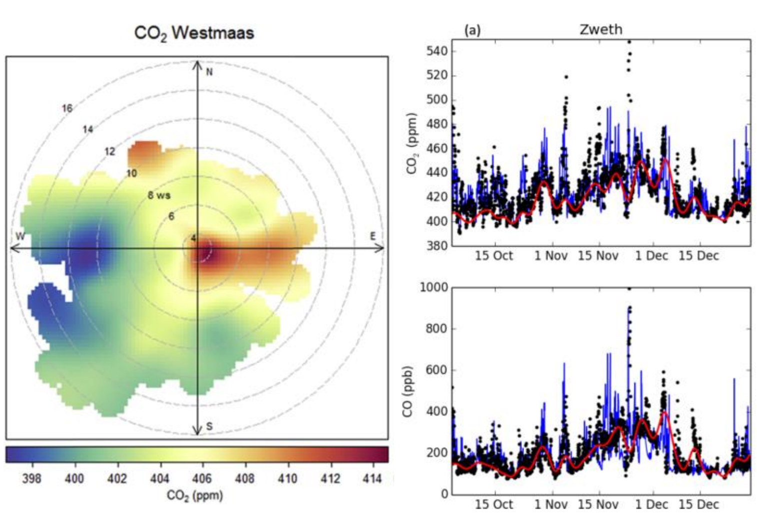


Figure 1. Continuous monitoring of CO_2, CO and CH_4 is done by TNO and RUG at three sites. The median CO_2 mole fraction observed at Westmaas (South of Rotterdam) as a function of wind direction (left panel) shows that air masses from the east are enriched in CO_2 but also from North East (city and port). Right panels show time series of modelled (WRF-Chem) and observed CO_2 and CO mixing ratios at Zweth station for 2014.

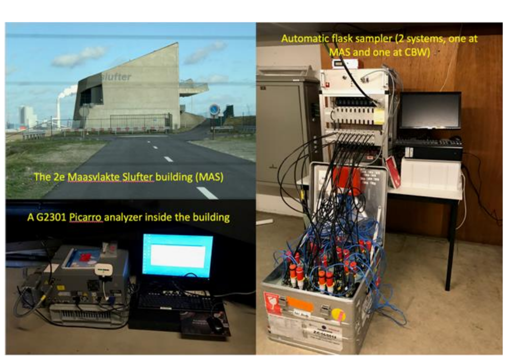


Figure 2. RUG installed equipment to measure radiocarbon (14C) on the 2e Maasvlakte site (MAS; brown star). Samples are also taken at Cabauw (CBW). Radiocarbon (14C) is an important tracer for quantifying fossil fuel CO2 emissions (FFCO2). Therefore, by analyzing air samples before and after they pass through a city area (here Rotterdam between MAS and CBW), the observed differences in 14C levels can be used to calculate the amount of FFCO2 from that city.

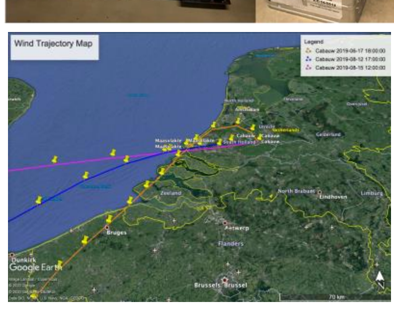


Figure 3. Trajectory map of three official events collected in summer 2019 (June-August) at MAS and CBW; colours of trajectory correspond to Table 1.

Sample name		Date	Time	CO_2 (ppm)	$\Delta^{14}C$ (permil)	$ffCO_2$ (ppm)
RINGO 1	MAS 1	17 Jun	14:00	413.6 ± 0.08	-6.4 ± 4.4	-0.3 ± 2.1
	CBW 1	17 Jun	18:00	409.3 ± 0.04	-5.6 ± 2.4	
RINGO 2	MAS 2	12 Aug	14:00	400.6 ± 0.02	-9.4 ± 2.2	-3.0 ± 1.4
	CBW 2	12 Aug	17:00	409.5 ± 0.18	-2.2 ± 2.5	
RINGO 3	MAS 3	15 Aug	10:00	402.9 ± 0.05	5.6 ± 2.8	2.0 ± 1.4
	CBW 3	15 Aug	12:00	406.6 ± 0.74	0.5 ± 1.9	

Table 1 Measurement results from the flasks collected during the summer events. In event 1, a lower total CO_2 value from the target station could be attributed to the higher vegetation uptake in the summer. In event 2, it is unclear why the fossil fuel value is negative. Event 3 was the most expected, as total CO_2 at the target station was higher, and there was also a positive $ffCO_2$ value.

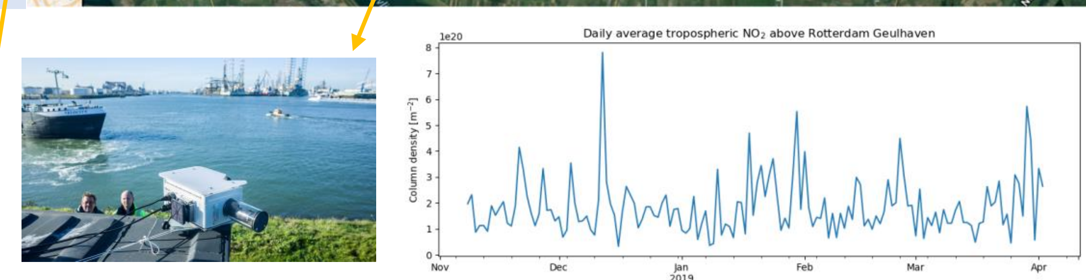


Figure 4. Since Nov 2018, KNMI measures tropospheric NO2 with a MAXDOAS instrument in Rotterdam, at DCMR station Geulhaven. The measurements are performed every 5-15 minutes during daytime. They serve as a validation source for satellite measurements (e.g. TROPOMI), and regional air-quality models (e.g. CAMS, LOTOS-EUROS).

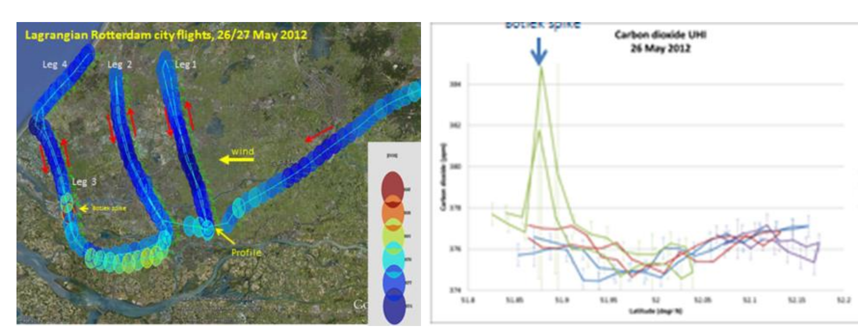


Figure 5. Observations by WUR aircraft were made over Rotterdam. (Note the Botlek CO_2 – spike, see graph). New flights under Ruisdael will be discussed to complement the observations at Ruisdael stations.

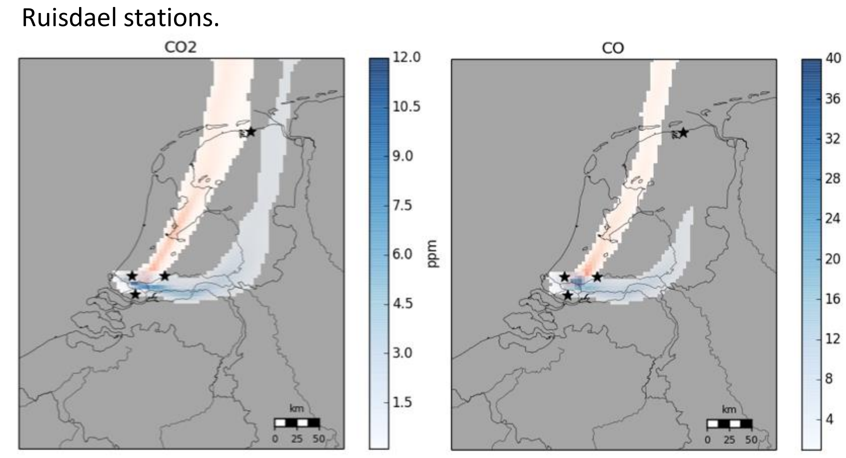


Figure 6. Together with high resolution simulations of transport in the atmosphere, 'inverse modeling' allows us to find the combination of sources, sinks, and emission ratios that optimally reproduces observed CO, CO_2, Δ14C , and NOx. Model teams at WUR, TNO and others aim to separate the impact of different sectors (such as traffic, power production, or ship transport) on the regional budget of greenhouse gases and air pollution. The figure shows the dispersion of a plume from the Rijnmond on Oct 21, 2014 at 12pm (red) and two hours later (blue) as calculated with the WRF-CHEM transport model at a highest resolution of 1x1 km. Stars indicate the Ruisdael "Rotterdam" measurement sites and the Ruisdael background monitoring sites (Cabauw, Lutjewad).

Outlook: To characterize urban pollution we will also monitor NO_2 and Black carbon next to CO_2, CO, CH_4. Additional data will be available from the DCMR and RIVM air quality monitoring stations. One station will be extended with an Aerosol Chemical Speciation Monitor (ACSM) by UU to measure the composition of local PM2.5 pollution. At one location RUG & WUR will perform Atmospheric O_2 measurements which will allow to attribute the emissions to specific fossil fuel source categories. TUD will operate high resolution weather radar, surface rainfall equipment, and eddy covariance observations to better understand the water balance in urban areas. Stations are expected to be fully operational in 2020 and additional efforts will be made to integrate the workflows, data handling and sharing.

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