New Loobos ecosystem site turning into an attractive research infrastructure

1 Introduction

In March 2021, a new 38 m tall tower was built in Loobos (Veluwe, near Kootwijk, view on map, photo 1). The tower turns out to be stable and easily accessible via stairways. Along with the 6 m sea container, the site is becoming an attractive research infrastructure. Researchers from Wageningen University, Utrecht University and TU Delft have installed various sensors to measure meteorology and air quality components. Here, I'd like to tell a bit about the current status, the observations being done and the future prospects.

2 Ruisdael & ICOS

One of the biggest challenges is obtaining the ICOS label as Ecosystem site (class 2). For this purpose, the following components need to be installed and their data automatically transmitted to the ICOS carbon portal:

1. Eddy covariance measurements (u,v,w, T, CO_2, H_2O at the top of the tower to measure momentum flux, sensible and latent heat flux and net CO_2 flux, photo 2)
2. Meteorological measurements at the top of the tower (air temperature, humidity, pressure, incoming and outgoing shortwave and longwave radiation, photosynthetically active radiation, 20 seconds repeat time)
3. Profile of temperature, wind speed, wind direction (5 levels between tower top and forest floor, 20 seconds repeat time)
4. Profile of CO_2 and H_2O concentrations (11 levels + 2 calibration gases, 1 second repeat time, 30 seconds per level, 5m30s regular cycle, 2 calibrations per day)
5. Soil measurements (4 locations, ~30 m from the tower in each direction; soil temperature, soil moisture, soil heat flux, water table depth; 2 locations with profile down to 100 cm, 2 locations with sensors at 5 cm, photo 3)
6. Precipitation (Weighing rain gauge, heated, at canopy level + regular tipping bucket at top of the tower)
7. Backup meteorology (incoming shortwave radiation, air temperature, humidity and precipitation)
8. Vegetation and soil sampling.

The instruments for steps 1 to 3 have been installed and are fully operational. The instruments for steps 4 to 5 have been installed (except calibration gases and water table depth). The CO_2 and H_2O profile suffered from fluffiness of the water vapour and condensation in the tubes. This is being solved by replacing the tubes by teflon tubes, installing pressure reducers at the intake points (to reduce the vapour pressure below the saturation vapour pressure) and by installing tube heating for the lowest levels, which are led below (sometimes cold) ground. The instruments for steps 6 and 7 are present in the old tower and/or have been ordered and will be installed in the next months. Step 8 still needs to be initiated.

2.1 Data availability

You can visually inspect all available measurements via https://met.wur.nl/loobos/graphs/cur/. Additionally, the step 1-3 raw and processed data can be accessed via https://www.icos-cp.eu (Go to 'Data Portal', Station of origin = NL-Loo and 'Data Level' = empty) with a Creative Commons Attribution 4.0 Internation licence (CC BY 4.0). The step 4 to 7 data will be added in the next months.

The aim is to obtain the ICOS Ecosystem station label in May 2023. The majority of this work has been done by Henk Snellen and Michiel van der Molen.

3 Air quality components

In a parallel track, Utrecht University (Rupert Holzinger) and Wageningen University (Julie Fry) have installed several air quality sensors to try and characterize VOC and NO_x chemistry. The Volatile Organic Compounds (VOC's) are being sampled by a PTMRS (Proton Transfer Reaction Mass Spectrometer) system, which measures hundreds of VOC signatures along a full spectrum every second. The samples are taken at the top of the tower, next to the EC system and led to the container, where the instrument is based. The instrument was installed some time ago and after obtaining the first positive concentration results, Rupert is now testing if fluxes can be calculated using the anemometer's wind data.

Recently (Dec 2022), Julie Fry has installed a NO-NO_2-NO_x sensor to measure concentrations and possibly fluxes too.

In the meantime, RIVM (Ewout Melman) is considering methods to measure ammonia fluxes and profiles in the tower. There are plans to use at least the HealthyPhoton flux instrument and COTAG's for profile measurements. These plans are being made concrete and hopefully the first measurements can be collected around summer 2023.

WU has plans to install an ozone eddy covariance flux sensor at the tower too, possibly along with a profile system to better understand the production and deposition dynamics. This will be made concrete in the coming months.

These are important steps towards measuring the N balance and dynamics of the forest, which is arguably one of the important drivers of forest growth on the poor sandy soils. On top, it helps understanding NO_x-O_3-VOC photochemistry at the site.

4 DTS measurements

TU Delft (Miriam Coenders, Luuk van der Valk) installed a Distributed Temperature Sensing (DTS) system in Loobos. Two fibre lines are installed top to bottom along the tower to measure dry and wet bulb temperature. MSc student Annika Vroom has installed an experimental 2D net (width-height) to test if up and downward eddies can be tracked when the move through the below canopy layer in the forest. The first results are expected soon.

5 Ruisdael CO_2 and isotopes campaign – spring 2022

In May 2022 an spontaneous measurement campaign was held, led by Getachew Adnew (UU). In this campaign, many individual components of the carbon cycle were measured at different scales, ranging from leaf level via ecosystem level to boundary layer level. It involved taking measurements of d18O isotopes in CO2, light response curves and GPP measurements at different levels in the canopy, ecosystem eddy covariance measurements and ultimately concentration and flux measurements in the boundary layer using the PH-WUR aircraft.

6 Concluding remarks

I am surprised by the long list of meteorological, CO_2 and air quality measurements and activities based at the new tower, so short after the formal opening celebration in November 2021 (Photo 4). It proves that Loobos is a viable and attractive research site. Besides, it is used frequently as a training site for MSc students (course based and thesis based) too. We hosted an excursion during the ICOS Science Conference in Utrecht 2022 (see figure).

In the future we hope to attract and host many more activities. There are already projects we look forward to. For one, we will host Ingrid Luijkx (WU), who obtained a VIDI project to study O_2/CO_2

exchange rates. Additionally, the WU Remote Sensing department is using the Loobos forest to do and test Lidar imaging of the forest to quantify growth and mortality of above ground biomass.

If you are interested in a field visit, collaboration, data sharing, please contact me at Michiel.vanderMolen@wur.nl.

Photo 1: The new Loobos tower, 38 m tall, rising up far above the 22 m trees.

Photo 2: The eddy covariance system for fluxes of momentum, sensible and latent heat and CO_2 and VOC fluxes.

Photo 3: Soil pit for (left) soil temperature, soil water content profile, (middle) soil heat flux and (right) 2 more soil temperature sensors. This is one of the two extended locations. The other two locations do not have the deeper sensors.

Photo 4: Loobos opening celebration (12 November 2021).