Identification of relevant in-situ and satellite data for proxy development

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WP 4: Integrating in-situ and satellite components

Task 4.1 Novel quality assurance methods, proxies and observables related to aerosols, mixing layer and biosphere parameters, Milestone M4.1.1

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In iCUPE Task 4.1 we aim to produce novel proxy variables for Polar areas, which integrate in-situ and satellite remote sensing data. We are working on producing proxies for planetary mixing layer height, vapour condensation sink, and gross primary production, which stands for ecosystem scale uptake of CO_2 in photosynthesis. Below we present the variables we have so far identified as relevant for developing these proxies. Since the methodology we apply (see e.g. Kontkanen et al., 2016) allows for testing the suitability of other variables during the progress, it is possible that the final proxies contain also other variables than those described below.

In all proxies we start with the comprehensive in-situ data recorded at SMEAR II station (Hari and Kulmala, 2005). If the variables applied for the proxies are available also at SMEAR I (Hari, 1994) or other sites at which the iCUPE consortium or partners conduct measurements, we test if the proxies can reproduce the observed variables there. Next, we convert the in-situ proxies to satellite based proxies by applying those variables for which the satellite retrievals can be obtained. At this stage we reassess the parameterisations derived from in-situ data. We identify the variables, which would be crucial for the proxies but are not possible to obtain from satellite data. Finally, we compare the satellite-based proxies with the available observations provided by the iCUPE consortium or partners.

Planetary mixing layer height -proxy

The driving force for the planetary mixing layer development is the convection of air masses next to the Earth surface that are heated by solar radiation absorbed at the surface. The key variable for the proxy is thus the solar radiation level. The boundary layer height at certain solar radiation level can also be expected to depend on the surface albedo (or better, absorptivity towards solar radiation), surface temperature, time derivative of the solar radiation, time of day and time of year. These variables should all be available from satellite observations. For in-situ proxies, other measured variables describing directly the air mass convection (e.g. friction velocity) might be investigated.

Condensation sink -proxy

Condensation sink can be calculated from the particle number size distribution, if the size range extends from ten or twenty to several hundreds of nanometers (Kulmala et al., 2013). There are several ways of doing in-situ proxies for condensation sink. One is to utilize measured particle mass and number concentrations, if such are measured. Other is to use black carbon concentration as an indicator of anthropogenic particle population (Kulmala et al., 2016) and temperature as an indicator of biogenic aerosol formation (Paasonen et al., 2013). For satellite-based proxies these parameters are more complicated. Applying the aerosol optical depth (AOD) is not useful for Polar areas since the aerosol concentrations are typically too low for determining AOD from satellites. Furthermore, the intended use of retrieval for aerosol index (cross-product of Ångström exponent and AOD) is not suitable, due to the problems indicated by Sundström et al. (2015). There is also no applicable retrieval for black carbon concentration. Thus, we are planning to try a satellite-based proxy relying simply on the temperature and CO concentration, which can be used as an indicator for combustion sources.

Gross primary production -proxy

The gross primary production (GPP) i.e. the photosynthetic CO_2 uptake by the plants depends on the level photosynthetically active radiation (PAR), which is in practise the spectral range of solar radiation roughly between 400 and 700 nm (McCree, 1981). In addition, GPP depends on the capability of the plants to uptake the radiation. This light use efficiency is closely related to photochemical reflectance index (PRI) (Nichol et al., 2000), which can be observed in-situ with optical sensors as well as with satellite remote sensing. We are deriving first an in-situ proxy for GPP with observed PAR and PRI. We will inspect if applying also the normalized difference vegetation index (NDVI) can be applied as the third parameter for the proxy. Also NDVI is obtained both from in-situ and satellite observations.

The initial idea of the GPP proxy was to use satellite-based fluorescence data for the proxy. However, it seems that the basic understanding of the quantitative relations between GPP and fluorescence are still not clear enough for deriving a proxy (Porcar-Castell et al., 2014).

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