# HAQT deliverable 6-2: Identification and suggestion of validation of AQ networks in China and India

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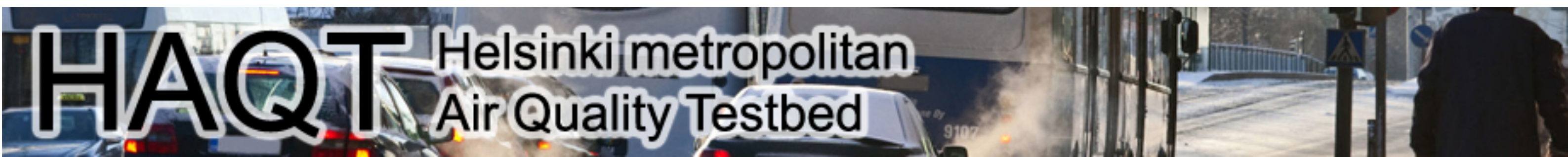

# Table of Contents

## 1. Introduction

Air quality is one of the grand challenges that the society faces at the moment (Gimeno, 2013, Lappalainen et al. 2014, Kulmala et al. 2016, Arnold et al. 2016). The problem arises from a suite of anthropogenic activities including industrial and emissions of pollution gases and particulate matter and associated land use changes (e.g. Foley et al. 2005, Baklanov et al. 2016). Particularly for the developing countries, the air quality problems typically follow from increased economical development (e.g. Ebernstein et al. 2015), but political and governmental control mechanisms and policies together with utilization of state-of-the-art equipment can mitigate the harmful side effects of economic development (e.g. van der A et al. 2017, Zeng et al. 2019).

The emerging economies can utilize the best practices and lessons learned via an open collaboration between already developed countries. Helsinki Air Quality Testbed (HAQT) integrates air quality observations from two supersites – one representing urban background and the other an urban street canyon – and an authority network are extended with supplementary observations with Vaisala AQT420 sensors. The observations are integrated with a fusion modeling framework (FMI-ENFUSER) to provide spatially representative air pollution fields that take into account in-situ observations, spatiotemporal variability of pollution sources (e.g. traffic, industry) and meteorological situation. This provides a good backbone for expertise to be utilized in the developing world. In this report we identify the potential of HAQT in China and India and introduce on-going and planned activities in the developing world stemming from the expertise from HAQT.

## 2. Case China

A platform to develop a Nanjing test bed in air quality is a Joint International Research Laboratory of Atmospheric and Earth System Sciences (JirLATEST, Ding and Petäjä, 2018) between University of Helsinki and Nanjing University. The aim is to lead the development of comprehensive observation network for atmosphere–land surface interactions in Eastern China, supported by full integration of observation and modeling platforms, which is required to advance the science-based synthesis to tackle global grand challenges and to reach sustainable development goals of the society.

The key joint activity is establishment of a comprehensive air quality – aerosol observation infrastructure Station for Observing Regional Processes of the Earth System (SORPES, Ding et al. 2013, Ding et al. 2016, Figure 1), which provides data on the temporal variation of in-situ trace gas and aerosol concentrations, as well as aerosol vertical variability with ground based active remote sensing using Lidar instruments to understand the interactions of different regional processes of the Earth System in the East China, a region strongly influenced by monsoon weather and by intensive human activities.

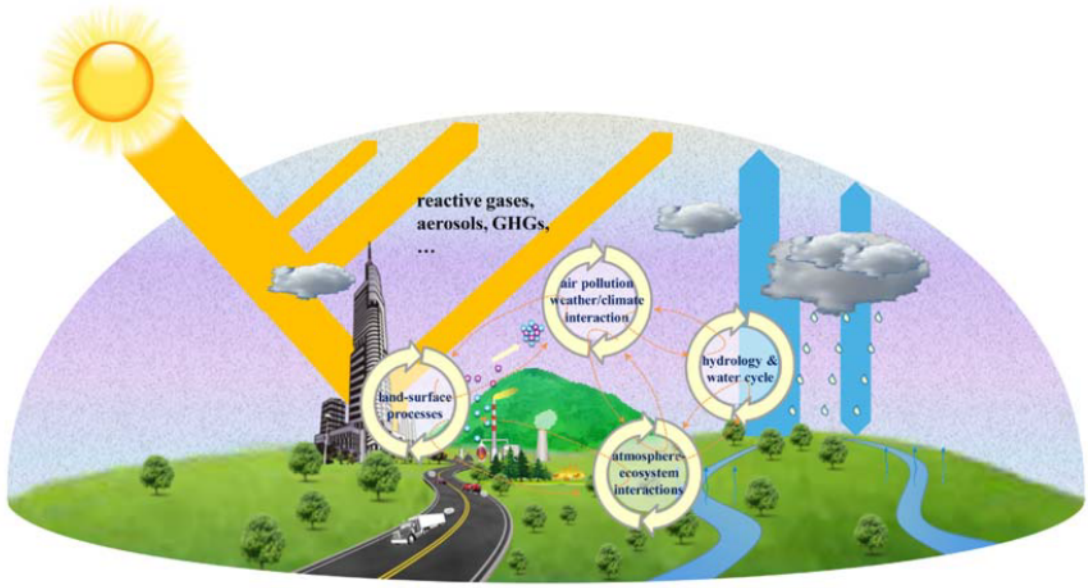


**Figure 1.** The concept and key scientific themes for the SORPES station indicating air pollution and weather-climate interactions as one of the main environmental problems tacked with the comprehensive data. The yellow and blue arrows show the radiative transfer of shortwave and long-wave radiation in the atmosphere, respectively (from Ding et al. 2016).

The SORPES station is a cross-disciplinary research and experiment platform. It was designed to be developed into a SMEAR (Station for Measuring Ecosystem-Atmosphere Relations) type “flagship” station. Compared to the boreal forest SMEAR II station in Finland (Hari et al. 2016), the SORPES station focuses more on the impact of human activities on the environmental and climate system in the rapidly urbanized and industrialized eastern China region under the influence of monsoon climate. The main scientific themes of the SORPES include land surface-atmosphere interactions, air pollution-weather/climate interactions, ecosystem-atmosphere interactions and hydrological cycle, as well as linkages between these associated processes (Figure 1, Ding et al. 2016). SORPES is also a part of the PEEX (Pan–Eurasian Experiment) infrastructure. In a global context, hierarchical and global observation network is required to tackle the grand challenges (Kulmala, 2018) as the availability of high quality data is indicated as one of the key requirements (McNeill, 2019) to tackle air quality.

To expand the expertise from HAQT, we initialized Business Finland and Jiangsu province funded Nanjing Air Quality Testbed (NAQT) project to take the advantage of the combination of high-quality atmospheric observations in Nanjing within the SORPES station together with a network of Vaisala AQT sensor network and integrated this with ENFUSER modeling framework (Johansson et al. 2015) to provide novel spatially resolved air quality data in Nanjing. This is a very practical expansion of HAQT, which facilitates export of Finnish air quality expertise in the Chinese market.

Following the example of HAQT, The ENFUSER modeling framework was utilized in optimization of placement of cost-effective air quality network consisting of Vaisala AQT 420 sensors in Nanjing. This was done in a nested manner, where first the spatial coverage of existing air quality network stations were taken into account, followed by considering the population density. This facilitates maximal emphasis on the foreseen human exposure analysis of air quality. In the final step, local features and specific pollution sources were weighed in into the selection, which facilitates more dynamic data describing the spatio-temporal variability stemming e.g. from local traffic and industrial activities. The final outcome of the optimization is presented in Figure 2.

In addition of being a good opportunity for commerce, the NAQT project expands the air quality analysis to ground-based lidar systems providing aerosol concentration aloft within the megacity of Nanjing. This will facilitate novel understanding on the air quality – boundary layer interactions (Petäjä et al. 2016, Ding et al. 2016) as well as pollution dispersion within the city. As a practical outcome, the comprehensive data can be utilized by private partners of the project (Climblue, Vaisala) in the development of new air quality applications for the citizens.

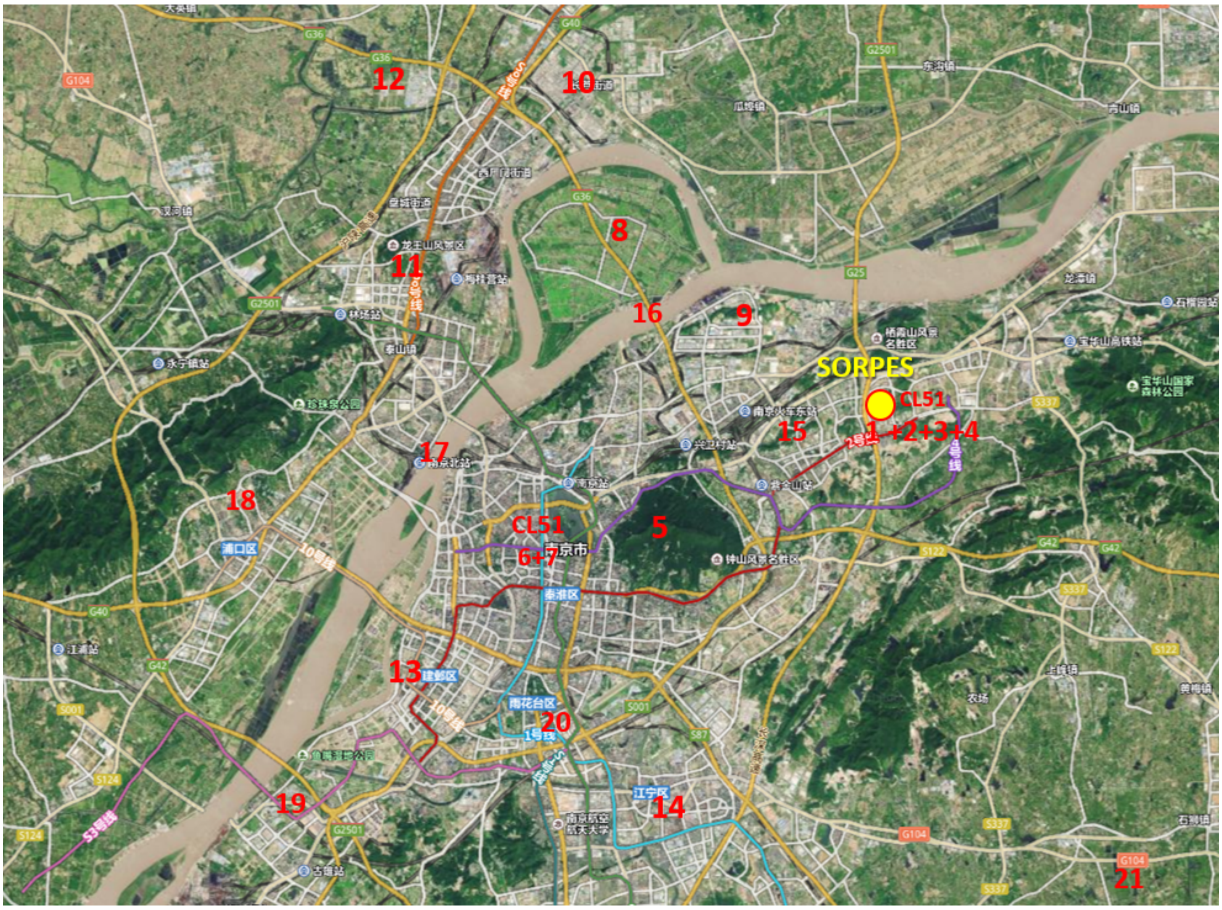


**Figure 2.** The locations of cost-effective, supplementary air quality observation sites (numbers) in Nanjing. The lidar observations on the vertical extent of air pollution was performed at the comprehensive SORPES station and in the city center indicated with text "CL51". The local air quality parameters in the city center is already covered by regional air quality authority.

Recently we established Aerosol and Haze Laboratory in Beijing University of Chemical Technology (BUCT). The aim in this collaboration was to understand processes leading to air quality problems in the megacity of Beijing. A particular focus was placed on formation haze and episodic extremely poor air quality situations. The supersite at BUCT was established following the concept of Station for Measuring Ecosystem and Atmospheric Relations (SMEAR, Hari and Kulmala, 2005, Hari et al. 2016). The site is located on the fifth floor in the BUCT Campus representing a typical area in urban Beijing subject to pollution sources, such as traffic, cooking and long-range transport of pollution. The comprehensive observations are performed since January 2018. The first results are presented in Zhou et al. (2019). Also in Beijing we have deployed cost-effective air quality sensors (Vaisala AQT420) and new sensors developed within the University of Helsinki. The expertise and knowledge from Helsinki Air Quality Testbed has been very valuable in the development of Beijing activities.

## 3. Case India

FMI-ENFUSER air quality modelling system was installed locally at Indian Meteorological Department (IMD) with offline modelling capabilities for 2013 in Delhi. IMD provided annual measurement time series for 8 sites in Delhi for PM2.5, PM10, $O_3$, NO, $NO_2$ and CO. Also meteorological measurements in these sites were provided. Based on this data, the model was localized and calibrated for Delhi.

The emission sources in Delhi region had distinct unique features. Due to this several new emission source categories and modelling mechanics (e.g., point sources with customizable temporal profiles) were introduced during the project. Information on local emission sources were provided by IMD and additional information was used based on existing emission inventories (and published papers of this topic) for Delhi.

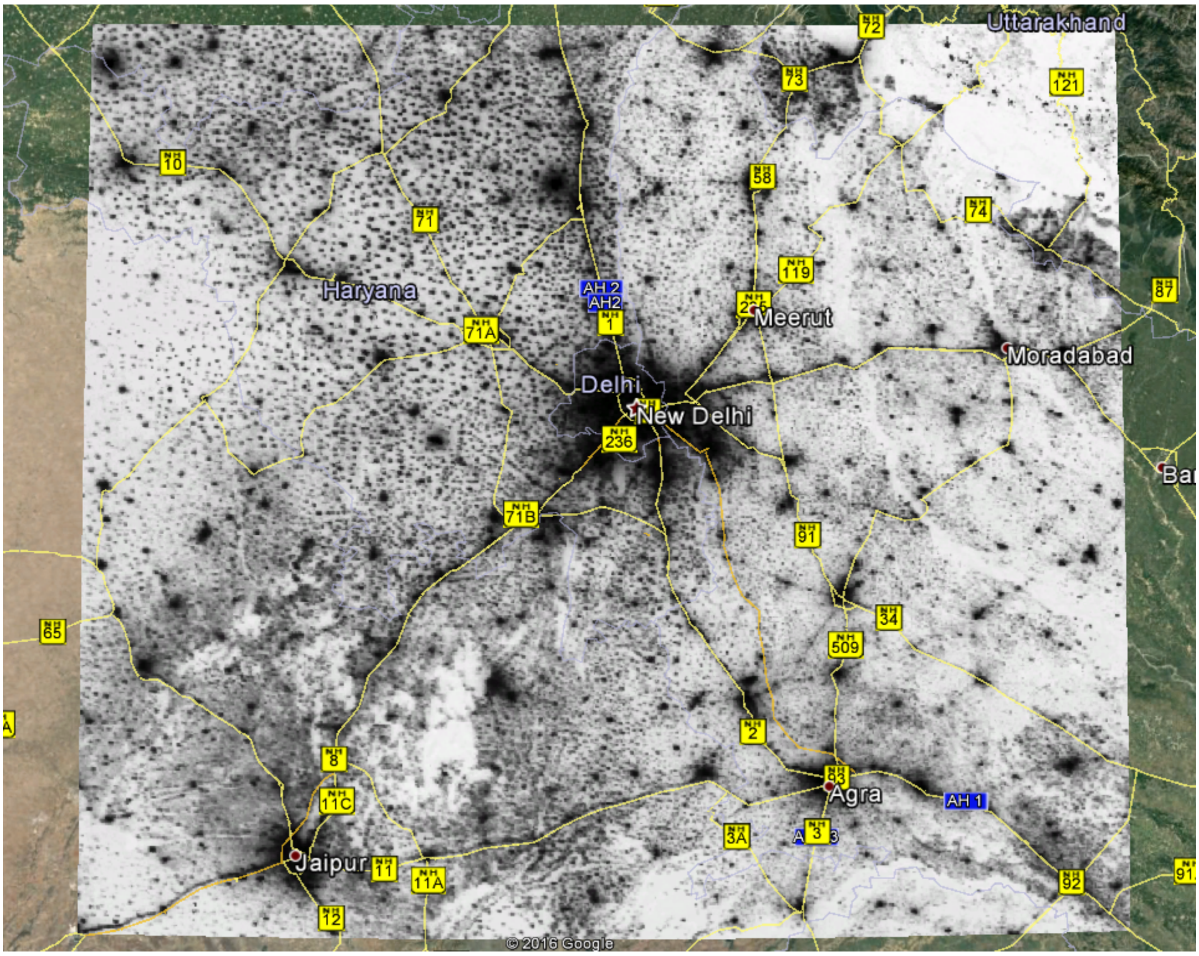


**Figure 3.** Population density data for Delhi area based on NASA EOSDIS luminosity data. The original luminosity mapping has been converted into BW-colors and processed into geo-referenced dataset using WGS84 coordinate system. made on the linearity of population density with respect luminosity and also the total population count on the area should be known).

As usually with ENFUSER testbeds in Asia, high resolution Geographical Information Systems (GIS)-data was difficult to come by for Delhi. Ultimately, a satisfactory set of GIS-information was utilized. Main information sources (for land use properties was OpenStreetMap, NASA EOSDIS and satellite imagery (Figure 3). The use of the model was tutored to IMD-personnel While the users of the ENFUSER model can affect several modelling parameters (e.g., changing variable attributes in text-form properties files) FMI will support the use and introduce further development by distributing new modelling software installer packages with improved features. As an outcome of the work, Figure 4 shows an example of the modelled hourly concentrations (PM2.5) in Delhi.

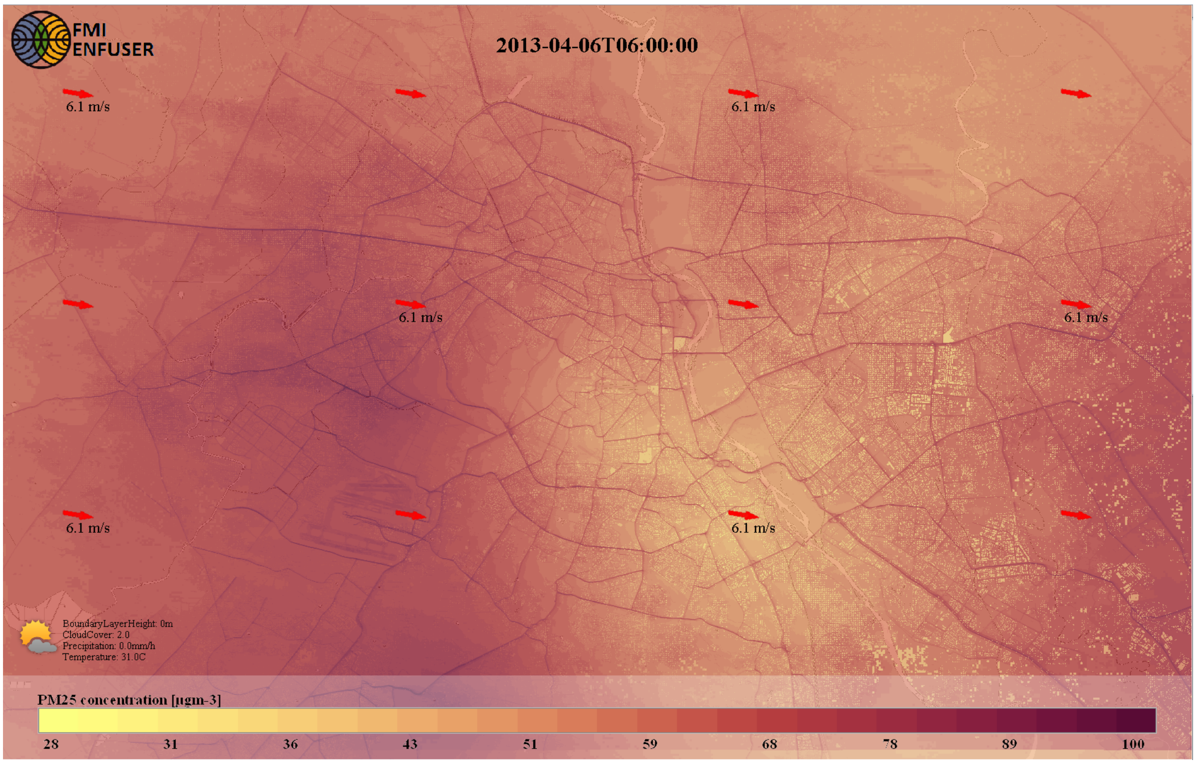


**Figure 4.** Modelled (EnFuser) hourly PM2.5 concentrations in Delhi in 2013-04-06T06:00 (UTC).

During 2019-2020 ENFUSER model will be installed for Delhi (IMD) for operative use. Ongoing work towards this goal is concentrating in Near Real Time (NRT) access of meteorological data and System for Integrated modeLling of Atmospheric composition (SILAM, Sofiev et al. 2006) regional air quality data . The EnFuser work will be conducted in parallel with regional scale modelling work, which includes the installation of SILAM-FMI for operative use at IMD, 2019-2020. Information on both local and regional emission sources will also be refined in co-operation with IMD.

## 4. Summary

The aim of this report was to underline the activities expanding the Helsinki Air Quality Testbed into a wider context by identifying success stories and provide suggestions for air quality observation network validation in the developing world.

As a summary, HAQT concept was identified as an excellent platform that has been and will be developed further by the project partners in the future. The combination of state-of-the-art supersite that is adapted to the local environment and tackling the pertinent regional environmental questions forms the backbone of the activity. For the maximal benefit, the supersite should be operated in concert with regulatory air quality network. The cost-effective air quality observation network, such as AQT 420 network from Vaisala provides additional spatial coverage. The HAQT-like collaboration provides also tools to develop proxy variables that can provide novel insights into regional air quality problems specific for the area of interest. The ENFUSER model can be used as a tool to optimize the sensor network and as a final integrator of the comprehensive data sets, which should be openly available for the local and regional partners for further analysis and synthesis.

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