Met Office Science Plan

Strategic Priorities Fund Wave 1

Clean Air: Analysis and Solutions Programme

Purpose

This document articulates the vision for research managed by the Met Office in Wave 1 SPF Clean Air: Analysis and Solutions (Work packages 2b and 4, Figure 1).

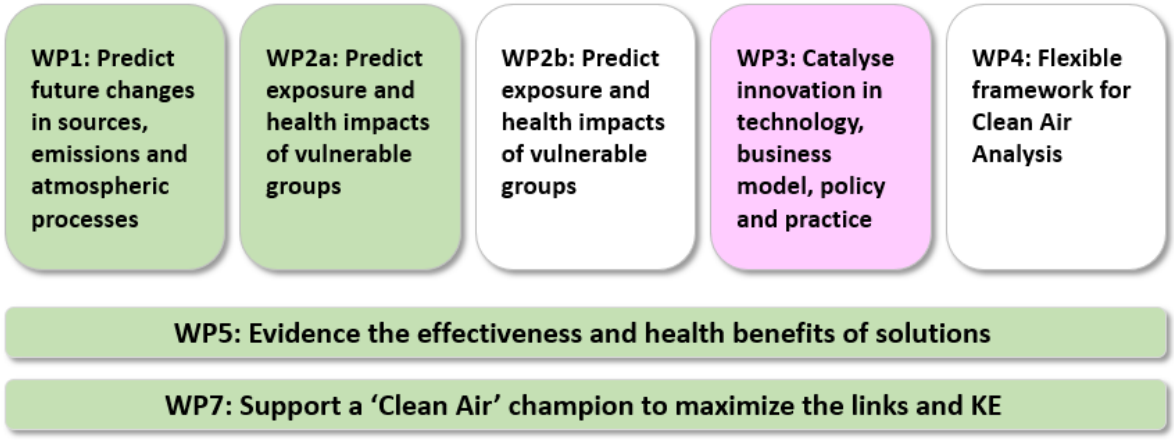

Figure 1: SPF Clean Air: Analysis and Solutions Work Packages. White = Met Office leadership, green = NERC leadership, pink = IUK leadership.

Introduction

Clean Air Analysis and Solutions is a joint UKRI and Met Office programme with the objectives of:

- *Driving forward new multidisciplinary research and innovation;*
- *Leveraging existing UK investments and enabling a challenge-focussed multidisciplinary community to work together for the first time;*
- *Informing implementation of the Clean Air Strategy; and*
- *Developing new solutions to reduce emissions and protect public health, whilst avoiding perverse consequences.*

The programme will support multidisciplinary research and innovation to stimulate solutions for clean air through predictive understanding of future air quality challenges, a systems approach to analysis, new abatement technologies and innovative policy and practice interventions to benefit vulnerable groups, improve public health and increase productivity.

Text from Clean Air Proposal

This science plan has been informed by the scope of the Clean Air Analysis and Solutions proposal and through consultation with air quality experts from the UKRI research communities and Met Office research communities; UK policy stake holders such as DEFRA; published UK government policy such as the Clean Air Strategy; engagement with expert groups and their associated publications (e.g. AQEG report) and by the outputs from the Met Office Clean Air Workshop held in Exeter over 3 days in February 2019.

Met Office Clean Air Activities

The air quality challenge is multi-disciplinary, and as such the SPF Clean Air programme is a joint and combined project where considerable interaction and synergies are expected across the Met Office and UKRI activities.

Air quality presents a multi-disciplinary, cross-community and multi-organisational challenge. The activities and scientific challenges are inter-linked, spanning emissions, meteorology, atmospheric physical and chemical processes, pollution impacts and policy actions (Figure 2).

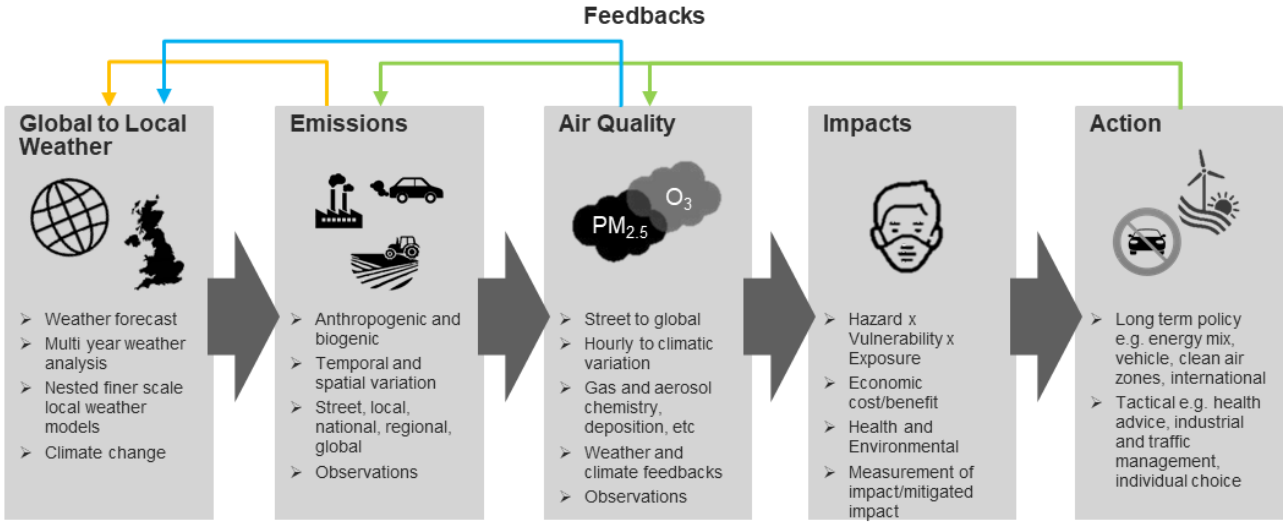

Figure 2. Schematic representation of Clean Air components.

Consideration of the breadth and interdependencies of the research activities required to stimulate solutions for poor air quality suggests that, while ongoing work is required within individual research areas, considerable effort is also required to link these together. For example, in order to reliably predict the future health impacts resulting from policy changes an analysis framework is needed to link together all parts of the chain: emissions, atmospheric transport, chemistry, deposition, and ultimately effects on health through human exposure and vulnerability. This type of systems based approach is currently lacking and provides a barrier to progress. Linking these parts of the air pollution chain together in a systematic way will enable researchers to investigate sensitivities in the “Clean Air System”, to target research where the sensitivities are greatest and ultimately provide traceable scientific advice to support policy decisions.

The Met Office-led Clean Air work packages are WP2b and WP4 (Figure 1) and are described in the SPF Clean Air proposal as:

WP2b: Predict exposure and health impacts of vulnerable groups

Children, elderly and those with underlying health conditions are particularly vulnerable to air pollution. Our lack of understanding of susceptibilities and exposure routes limits our ability to protect them. The aim is to develop innovative techniques to predict exposure of vulnerable groups and determine mechanistic pathways by which air pollution leads to health impacts, examining the actions of different groups to understand how best to mitigate, manage and treat.

SPF Wave 1 will:

- ***Catalyse early research to decode molecular effects of life-long exposures on health*** *through identifying biomarkers of exposure and effect from established cohorts used to study impacts of air pollution exposure.*
- ***Develop pilot informatics approaches*** *that exploit very large public sector data holdings related to emissions, air quality and health, to identify trends, regional variations and impacts for example, attribution of trends to specific factors or identifying associations between lifelong or childhood exposure and health.*
- ***Address the critical need for more accurate and reliable low-cost pollution sensors****, through interrogating the latest commercially-available sensors in well-characterised field-based sensor-test beds to understand interferences and their reliability.*
- ***Address need for high-resolution prediction capabilities to support personal exposure for health impacts,*** *through national and local model resolution and capability developments****.***

Text from Clean Air Proposal

The Met Office-led WP 2b, compliments the UKRI WP 2a, (both of which share the above objectives) and is focused on improving the quantification of outdoor human exposure for health impacts from atmospheric pollutants.

WP4: Systems framework for clean air analysis

There is an inter-linked chain connecting emissions, atmospheric processes, air quality, its impacts and policy action (figure 1). The links and feedbacks are multidisciplinary and highly inter-dependent. A systems analysis framework is required to connect the data and modelling elements in the chain into a coherent national capability for clean air analysis. This scientific analysis framework will enable research and ensure it is balanced across the chain, while enhancing traceability, scientific and economic analysis and pull-through into policy.

SPF Wave 1 will:

- ***Support a virtual community hub*** that networks multidisciplinary communities.
- ***Develop and initiate the systems analysis framework*** by establishing requirements, software architecture and implementation plan.
- **Deliver key components of the framework** in the areas of meteorology, air quality modelling, open data standards and sharing protocols.

Text from Clean Air Proposal

This Met Office-led WP 4 encompasses all areas defined in the proposal and includes both the community networking and software architecture to support the development of the systems analysis framework, as well as creation of and improved access to data sets and models to be used within the framework.

Research Plan

The Met Office-led aspects of SPF Clean Air support the strategic goals of SPF, fit within the scope of the SPF Clean Air proposal and compliment the activities planned by UKRI. The objectives of Met Office-led WP2b and WP4 activities are:

- Design and initiate a community network and software framework within which researchers can work more effectively. The Clean Air Framework will link together models and data (referred to as “components”) to facilitate traceable end-to-end analysis by the air-quality research community and greater pull-through of science into policy and community action.
- Development of individual components for use within the Clean Air Framework, including (i) a new community-enabled emissions analysis system to represent pollution sources at the temporal and spatial scales required by air quality models; (ii) models and 4-D observations of key air pollutants to help provide information at scales and locations important for human exposure and health impacts.
- Improving the modelling of acute and chronic outdoor exposure to air pollution and its impact on health.

To meet these objectives the research is broken down into four themes that span the two Work Packages. These are:

Theme	Work Package
1. Clean Air Framework	4
2. Emissions Modelling System	4
3. Modelling for Exposure - bridging the scales between atmospheric prediction/monitoring and human exposure	2b & 4
4. Community Engagement	2b & 4

Table 1. Research themes.

The Clean Air Framework is a central and integrating capability within the broader UKRI/Met Office Clean Air programme.

1. The Clean-Air Framework

Figure 3 illustrates some of the components required for an air-quality study, along with the links between them.

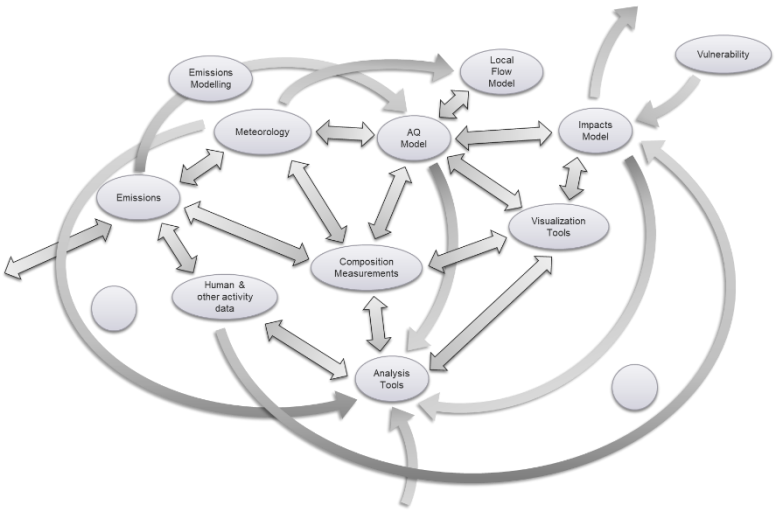

Figure 3. An illustration of some of the components and links required for Clean Air Analysis.

Air quality can be described using a risk-based approach whereby the risk is derived from combining the hazard (the pollutant), vulnerability (how human health is affected) and exposure (where people are). This risk-based approach (Figure 4a) is likely to be fundamental to the design of the Framework. It is also helpful to re-map Figure 3 into a linear chain, categorising the components by hazard, exposure and vulnerability (Figure 4b).

The Clean Air Framework will be designed to provide a scientific and technical framework, based on the above concepts.

Guiding design principles of the Framework are that it will:

1. Support research and policy relevant work;
2. Aid discoverability, and ease the use, of data, tools and models;
3. Be an open structure that improves transparency and traceability;
4. Be scalable, flexible and portable;

Support understanding of uncertainties and testing and evaluation.

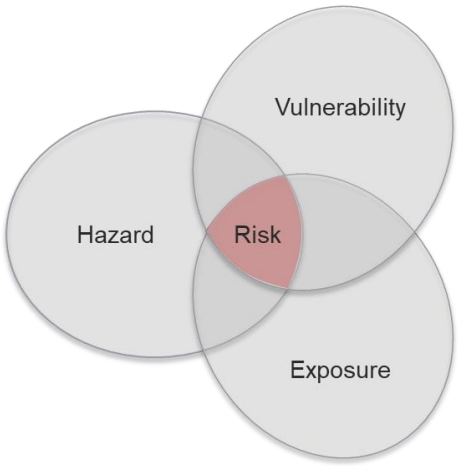

Figure 4(a): Air quality risk, depicted as the combination of hazard, exposure and vulnerability.

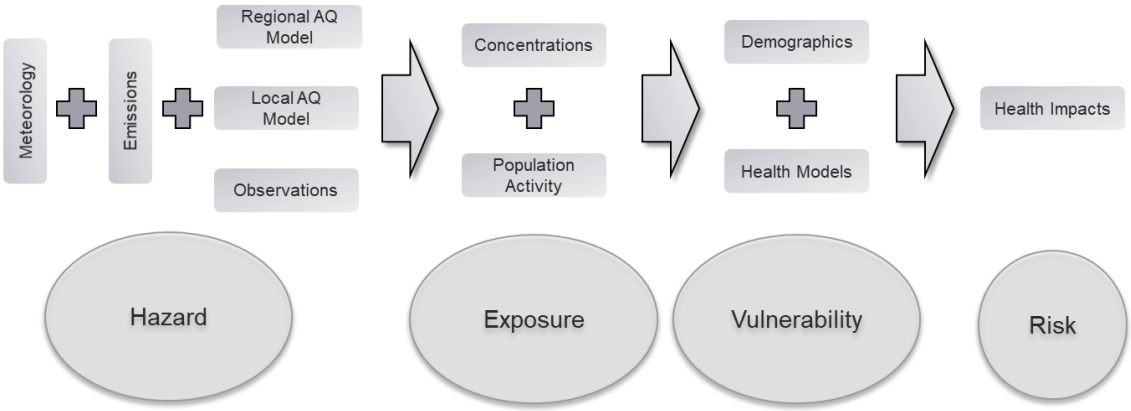

Figure 4(b): Scientific components required for Clean Air Analysis, described as a process chain, categorized according to hazard, exposure and vulnerability.

The Framework is a research and development activity in its own right that requires significant effort. Activities will include:

- Development of the Framework concept and design;
- Integrate existing monitoring/measurement and modelling data, tools and models into the Framework;
- Exploitation of the Framework;
- Development of visualisation and analysis tools to support data exploration;
- Development of modelling evaluation methods.

2. Emissions Modelling System

The UK has a world leading emissions data set in the form of the UK National Atmospheric Emissions Inventory (NAEI), which is updated annually. However, for some applications the NAEI requires further development. For example, modelling that requires detailed temporal and spatial information requires further processing of the inventory data or merging together other sources of emissions and data with the NAEI, which can lead to significant uncertainty. Current and future air quality challenges require greater spatial and temporal resolution to be able to answer research and policy questions.

As part of Wave 1 of the SPF a new emissions modelling system (EMS) will be produced. This EMS will be for use by and sustainable development across the community and will:

- Build on existing inventory work (e.g. NAEI), expose more fundamental information such as activity data and allow new sources of data to be incorporated;
- Provide outputs at temporal and spatial scales to meet national to local scale needs;
- Be transparent, scalable and flexible;
- Include both anthropogenic and biogenic emissions modelling.

3. Modelling for Exposure - bridging the scales between atmospheric prediction/monitoring and human exposure to health impacts

Understanding exposure requires analyses and measured and modelled data that cover a wide range of scales and environments. A key goal is to use these analyses and data in order to gain understanding of the role of physical, chemical, biological and social science processes contributions to exposure. Analysis across these scales is a major scientific challenge.

Activities will include:

- Improvement of atmospheric and air quality models and exploring approaches to bridge the scales from typical atmospheric modelling, through to city scales, and to individual exposure, including:
  - Improving national to local scale air quality modelling;
  - Developing aspects of urban meteorology important for air quality in cities;
  - Developing novel approaches to downscale predictions to the human scale.
- New four-dimensional measurements of chemical composition in the lower atmosphere in order to complement surface measurements
- Improved understanding, traceability and recording of uncertainty in air quality measurements.
- Development of approaches to bring together improved estimates of dynamic population data/population behaviour with air pollution data to better calculate exposure and enable flexible air quality risk-based analysis and health impact assessments.

4. Community Engagement

Clean Air will help develop multi-disciplinary knowledge by fostering cross-disciplinary links and expanding these across a broad community. This will be achieved by:

- Engaging with the Clean Air Champion and Clean Air Steering Committee.
- Hosting a series of workshops bringing together air quality researchers, health experts, practitioners and stakeholders from the full spectrum of air quality research and policy practise.
- Holding events to facilitate and promote access to the Clean Air Framework and related tools and datasets.