



# AUSTRAL

Australia's Urban Supersite neTwork for Research on Air quaLity

Real time, high temporal and spatial observations of Australia's urban air quality for environmental and health research

# Overview

Air quality in Australia is among the best globally and yet it still poses significant risk to our urban populations. Over 3000 premature deaths a year are attributed to exposure to poor air pollution. Australia's urban air quality is under increasing pressure due to rapidly growing populations placing higher demand on energy and transport infrastructure. The threat of more frequent and severe fire activity and changing pollen seasons due to global warming also place urban air quality at risk. Currently, Australia has no nationally consistent measurement sites providing high quality, real-time information (via in-situ measurements or satellite products) for air quality essential to the health of our urban populations.

AUSTRAL wants to provide high quality, high resolution air quality measurements of international standard to Australia's capital cities. This data will provide the means to validate satellite air quality products for Australia's cities. Having high resolution in-situ observations and remote sensing products will be of large benefit to Australia's urban health. It will allow Australia's urban populations to be more aware of their everyday risk to poor air quality. It will enable health and emergency agencies to act quickly when large pollution events occur. It will provide the necessary information to improve Australia's capacity to predict air pollution occurrence and transport.

Whilst Australia currently has significant expertise in air quality modelling, we are unable to provide the necessary observations to achieve these outcomes. AUSTRAL wishes to collaborate with organisations and universities across the country to change this.

We can live three weeks  
without food, three  
days without water  
but only three minutes  
without air

We are now living in the  
anthropocene, bringing  
challenges to Australia's  
air quality including  
growing populations  
and the effects of a  
warming climate

Australia has the  
expertise but not the  
national infrastructure  
to provide air quality  
measurements that can  
protect human health

## AUSTRAL's key aims are to:

1. Provide real time, high resolution, traceable and publicly accessible urban air quality measurements at international standards relevant to human health
2. Provide the observations necessary to link urban air quality to satellite remote sensing products for validation
3. Provide a framework of collaboration between organisations, universities and agencies interested in urban air quality measurements, modelling and impacts
4. Provide a test bed for validating and calibrating innovative atmospheric composition technologies, both through education and industry



# Why?

## Sources of urban air pollution in Australia

Major sources of air pollution in Australian cities are diesel transport emissions, wood-fire heating, prescribed and natural fires, dust, pollen, industry, and fossil fuel energy generation. These contribute to particulate matter and toxic gas concentrations in the atmosphere.

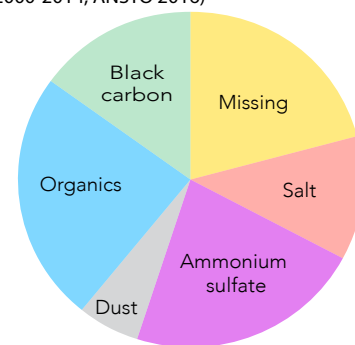
## Urban air quality and health

Australian air quality is among the cleanest globally, yet still contributes to over 3000 premature deaths annually. No level of air pollution is known to be safe for human health, and poor air quality has significant health and economic costs. Even low levels of pollution can have severe impacts on respiratory, cardiovascular, mental and reproductive health. Vulnerable populations such as children, the elderly and those with chronic respiratory disease are especially impacted. The total burden of disease from air pollution in Australia is 0.6%. This is comparable to that of sun exposure (0.8%) yet receives far less attention. Australia is one of the least regulated countries of the developed world for air quality, causing an unnecessary and preventable health burden on society.

## Increased fire and dust activity in the anthropocene

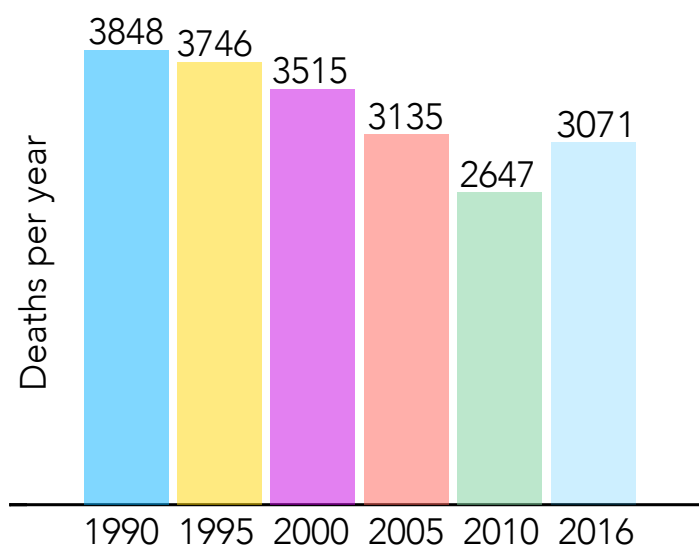
A major source of air pollution in our cities are prescribed or natural fires and wind blown dust. Both of these sources are predicted to increase under a warming climate. Whilst much effort can be made to limit the use of combustion fuels in our cities, reducing the impact of smoke and dust pollution is difficult. For this reason, real time monitoring, both from in-situ instrumentation and satellite products, is essential to help inform our urban populations of the personal risk to their health when these events occur.

**Sydney source apportionment**  
(2000-2014, ANSTO 2016)



**In 2016, 3071 premature deaths were attributed to poor air quality, costing Australia \$17.8 billion**

**Premature deaths per year in Australia** (State of Global Air, 2018)



**No level of air pollution is known to be safe to human health**



## Changing pollen seasons

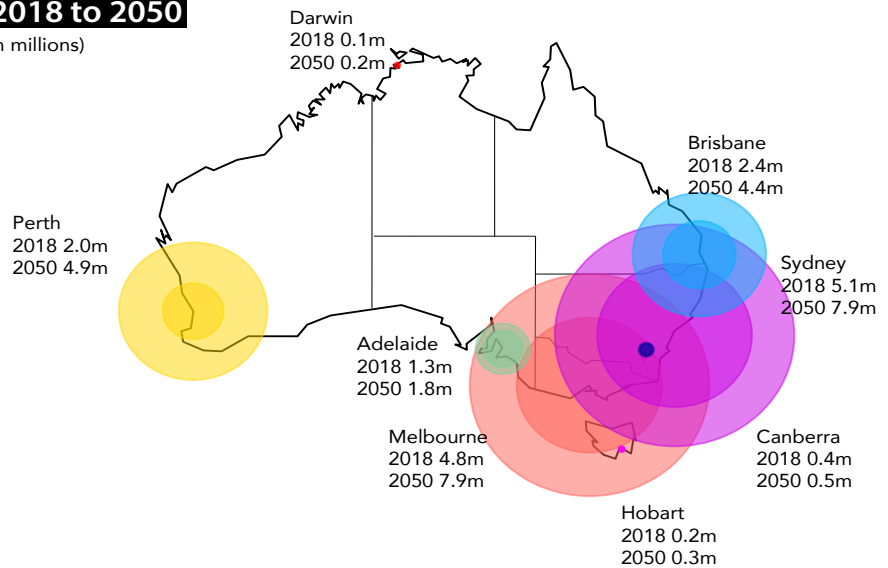
As our climate continues to warm, scientists predict that pollen seasons will become more severe for three reasons. The earlier onset of spring is lengthening the pollen season, pollen producing species are migrating into new regions and the amount of allergens in pollen is increasing. The increasing pollen burden and extended season will have serious consequences for Australia's populations, especially those with respiratory problems such as asthma. Real-time monitoring is essential to provide adequate warning to vulnerable people.

**Warming temperatures and a drying landscape will cause more frequent fires and dust storms, as well as increase the severity of the pollen season**

## Growing demands on energy and transport as populations rise

Up to 90% of Australia's population live in urban environments. By 2050, Australia's population is expected to exceed 35 million, with the majority of this growth in capital cities. The growing population will place increased stress on the energy and transport sectors. Of particular concern is the ongoing use and growth in uptake of diesel vehicles. Diesel emissions are highly toxic (a type I carcinogen), and produce ultra fine particles. These emissions cause significant harm, in particular to children's health. Without detailed and regular source apportionment of pollution, Australian cities have no way to monitor, attribute, regulate and reduce the emissions from individual anthropogenic sectors.

**Australian capital city populations:  
2018 to 2050**  
(in millions)



**Australia risks being left behind as the rest of the world take serious action to clean up the air we breathe**

## Global action

Around the world, governments and research organisations are taking serious action to tackle air pollution. Whilst Australia has good air quality currently, we risk being left behind as nations around the world clean up their act. Such action includes measures to reduce air pollution, for example transitioning away from combustion fuels for electricity, heating and transport, as well as significant investment in infrastructure to monitor and predict air quality.

**Without detailed source apportionment of pollution, Australian cities have no way to monitor, attribute, regulate and reduce anthropogenic emissions**

# Local knowledge

## Australia's air quality expertise

Australia's has extensive experience and knowledge in atmospheric composition and air quality measurements. Our capabilities lie within a range of institutions and government agencies. Many of these institutions are involved in national and international collaborations to improve air quality science. Additionally, Australia hosts several world-class atmospheric composition facilities.

Whilst we have the expertise, we currently do not have the national infrastructure to provide standardised measurements to the local and international community.

Whilst we have significant expertise, Australia has no national infrastructure to provide urban air quality observations

### Australian air quality expertise

#### EPAs

Regulation driven  
State standards  
Long term measurements  
Deployable, short term measurements

#### Universities

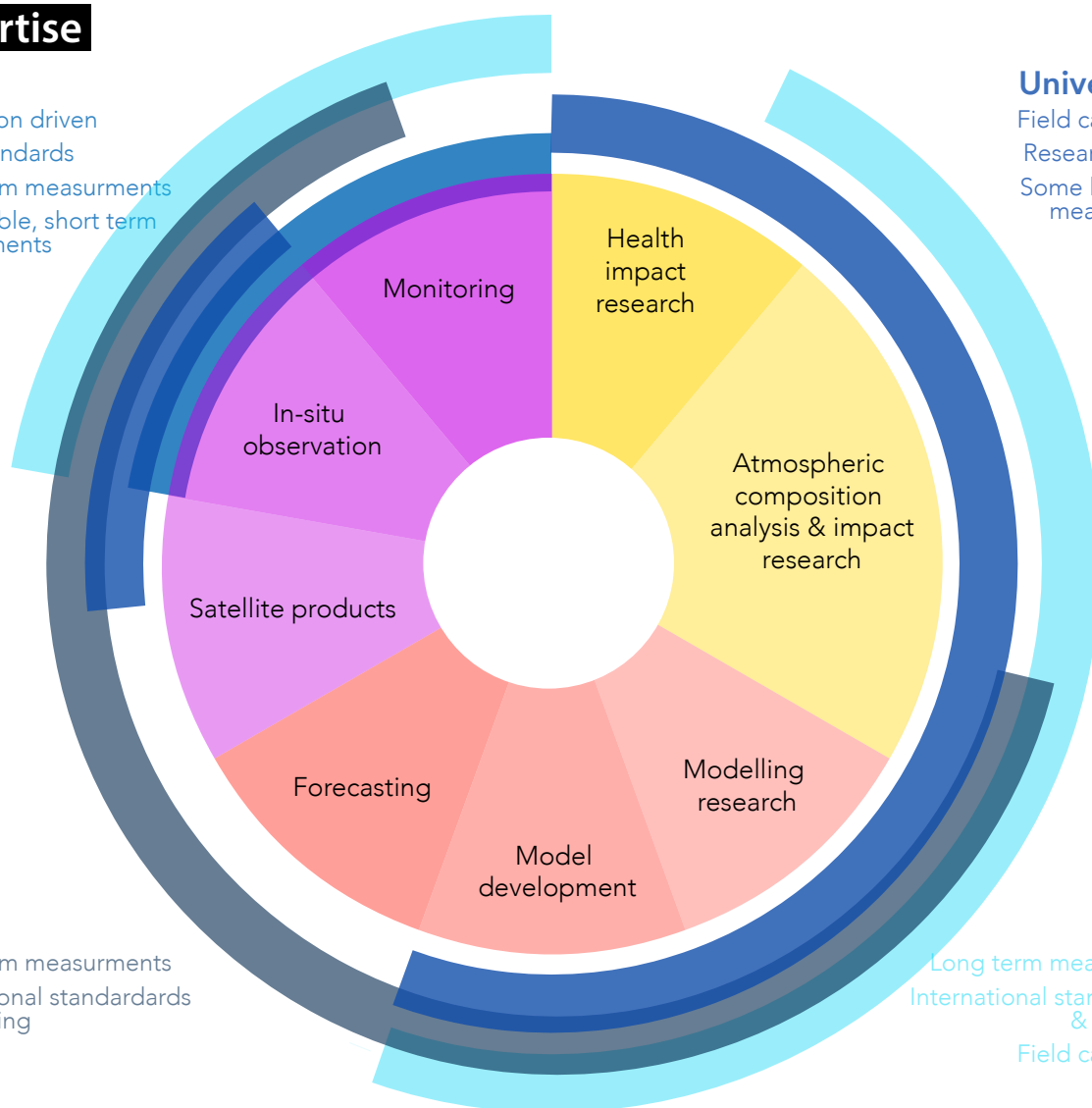
Field campaigns  
Research driven  
Some long term measurements

#### BoM

Long term measurements  
International standards & reporting

#### CSIRO

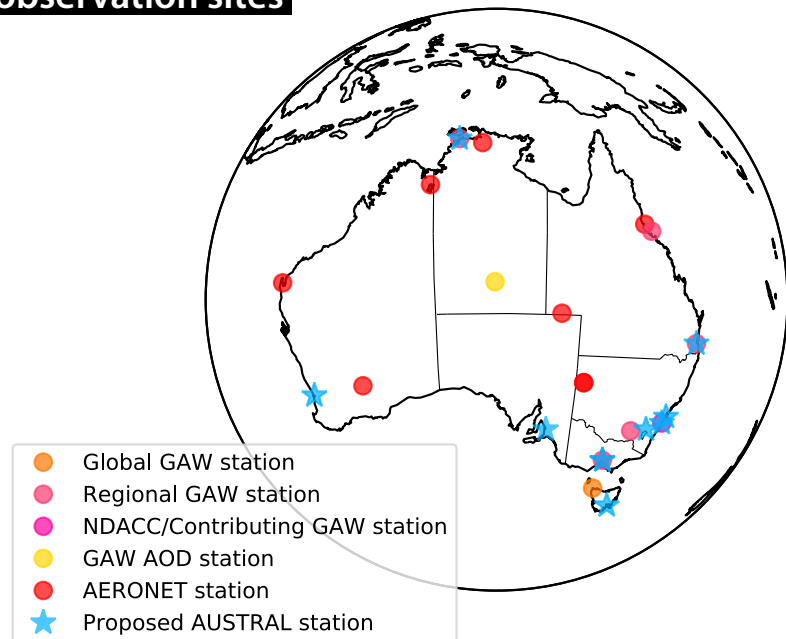
Long term measurements  
International standards & reporting  
Field campaigns



## International facilities

Australia's only World Meteorological Organisation (WMO) Global Atmospheric Watch (GAW) global station, located at Cape Grim, Tasmania, is maintained by the CSIRO. This world class facility provides baseline atmospheric composition data to the international community. The CSIRO also host several regional and contributing GAW stations, as well as one mobile station, the RV Investigator. Similarly, Australia's only Network for the Detection of Atmospheric Composition Change (NDACC) site is located at the University of Wollongong, as part of the infrared working group, while the Queensland University of Technology hosts a WMO International Laboratory for Air Quality and Health. Additionally, Australia hosts six AERONET sites. AERONET, lead by NASA, provide global observation of aerosol optical depth.

### Australia's international atmospheric composition observation sites



Australia hosts many world class atmospheric composition measurement sites. However, few of them are in our capital cities

## Successful collaborations

In response to the devastating thunderstorm asthma event of 2016, a collaboration between the Australian Bureau of Meteorology (BoM), the University of Melbourne, the Victorian Environmental Protection Authority (EPA) and emergency services has developed warning systems for elevated pollen concentrations. This will potentially save lives during future pollen seasons.

Australia's premium campaign facility for atmospheric composition observations, AIRBOX, is operated jointly by the University of Melbourne, the Queensland University of Technology, the University of Wollongong, Macquarie University, the University of Tasmania, Monash University, CSIRO and ANSTO. AIRBOX hosts instrumentation to measure atmospheric aerosol and chemical concentration and composition as well as meteorological and cloud properties. Three successful field campaigns have been undertaken, ranging from the Great Barrier Reef to Antarctica.

The universities and organisations across Australia are engaged in highly successful collaborations both nationally and internationally

 @airboxaus

# What we need

## Australia's need for national investment

Currently, Australia does not provide real time, nationally standardised observations of air quality in our urban areas. Without this information, the health of Australia's growing urban population remains at significant risk to exposure of poor air quality from both anthropogenic and natural sources.

## Infrastructure road map

Australia's current infrastructure roadmap does not consider investment in atmospheric composition studies. Whilst focus is placed on integrating observations into modelling and forecasting, these capabilities must be founded on robust observations with measures of reliability. The roadmap identifies several areas of need, each of which AUSTRAL will be able to address. These are listed below:

- *Enhancing integration of existing data and mathematical modelling across large geographic areas, including remote and urban regions for prediction of change over time to enable effective adaptation, planning and business development.*
- *Further develop remotely sensed data analysis given our unique geographic, economic and technical capabilities.*
- *Enhancing domestic instrument and sensor development, sensor networks and integration of new technology.*
- *Establishing the ACCESS modelling system as national infrastructure to align and deliver the next generation of products to business, government and for environmental management with greater certainty."*

2016 NATIONAL RESEARCH INFRASTRUCTURE ROADMAP



- Real time, high resolution observations
- A national network
  - International standards
- Observations able to be used for remote sensing
- Publicly accessible
- Sensor test beds
  - Domestic and international collaboration
- A place for education and knowledge



# AUSTRAL's vision

AUSTRAL will deliver accessible, high resolution, real-time observations of urban air and aerosol composition to the public by bringing together experts across universities and government agencies. This data will aid health and emergency agencies, as well as regulatory bodies to provide air quality information and action plans to save lives.

AUSTRAL will provide Australia's major urban environments with nationally consistent, high temporal and spatial, real-time air quality observations. Partnering Australian universities, the BoM, CSIRO and state EPAs, AUSTRAL will comprise air quality supersites in each capital city. Each supersite will host a range of intentionally standardised instrumentation, augmenting state EPA infrastructure and acting as a sensor test bed for smart city air quality networks. These supersites will provide aerosol composition for real-time source apportionment and ground-truthing for satellite air quality products. These new observations will provide essential, timely information for local agencies and residents to make informed decisions to limit personal exposure to air pollution.

## A national network of infrastructure and support

AUSTRAL will include nine standardised supersites in each capital city (and Wollongong), providing real-time, high-quality atmospheric urban meteorological and composition observations. Each supersite will host a base range of internationally standardised instruments, hosted by universities and research organisations in each capital.

In addition, AUSTRAL aims to create a virtual research network to share and integrate quality controlled urban air quality data. The virtual platform will facilitate research and data delivery across multiple national infrastructure programs through the National Collaborative Research Infrastructure Strategy such as AuScope, TERN, AURIN, NCI and Population Health Research Network as well as Earth Observation Australia. This platform will allow the data to be available in a timely manner and a user-friendly format, ensuring its ability to inform real-time decision making and operational science.

Provide real time, high resolution, traceable and publicly accessible urban air quality measurements at international standards relevant to human health

Provide the observations necessary to link urban air quality to satellite remote sensing products for validation

Provide a framework of collaboration between organisations, universities and agencies interested in urban air quality measurements, modelling and impacts studies

Provide a test bed for validating and calibrating innovative atmospheric composition technologies, both through education and industry

# Deliverables

## Real time observations

AUSTRAL will be able to provide high resolution, nationally standard observational in real time. This will open up a huge range of possibilities for air quality science and health.

AUSTRAL's high quality,  
high resolution, real  
time atmospheric  
composition  
measurements

## Improved urban source apportionment

The comprehensive suite of instruments proposed for AUSTRAL sites will allow regular, detailed source apportionment and attribution of air pollutants. This information can aid regulatory bodies to monitor and reduce air pollution at specific sources in Australian cities.

AUSTRAL's  
measurements will  
be compliant with  
international standards  
and of use for satellite  
validation

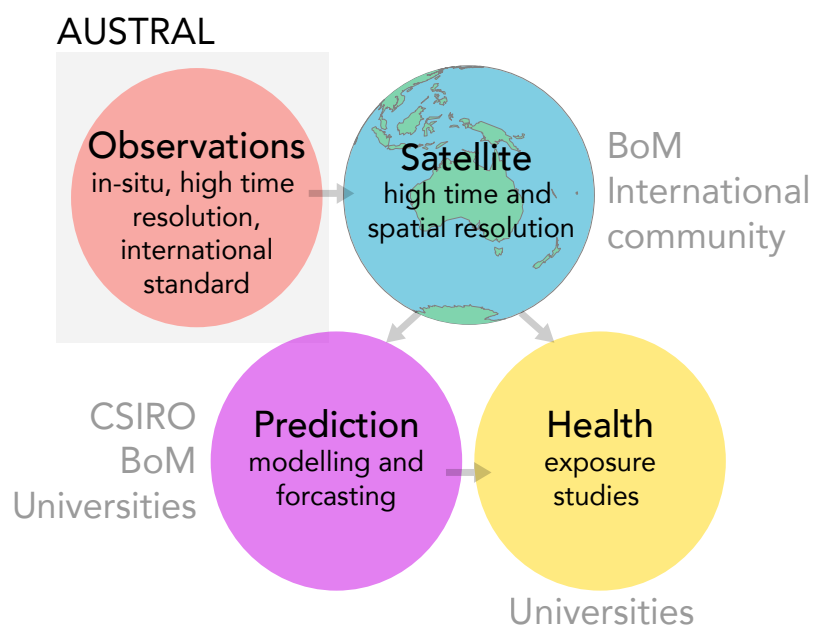
## Internationally recognised measurements

The AUSTRAL supersites will work with the international atmospheric composition, meteorological and satellite communities to contribute data to the World Meteorology Organisation's Global Atmospheric Watch (GAW) Urban program and NASA's AERONET observation network. AUSTRAL will validate new geostationary satellite remote sensing products of aerosol optical depth and  $PM_{2.5}$ , enabling personal exposure health studies on fine urban to regional spatial scales ( $>1.5km$ ), and short time scales (10 minutes).

## International satellite validation

Satellite products of atmospheric composition over Australia are currently not of sufficient standard to be used for air quality and health research and decision making. This can in part be attributed to the lack of recognised satellite validation sites in Australia. The AUSTRAL supersites will endeavour to contribute to the international AERONET aerosol optical depth observation network and the SPARTAN global particulate matter network to enhance satellite estimates of aerosol optical depth and  $PM_{2.5}$ . Additionally, the AUSTRAL network can help Australia improve its own remote sensing products with high time and

**Provide the observations to develop  
satellite products**

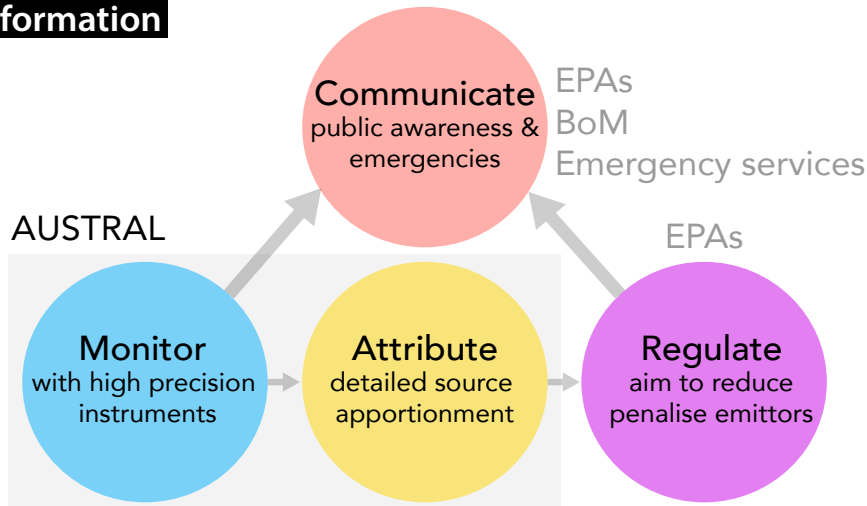


spatial resolution geostationary satellites such as the Himawari 8 and 9.

## Informed decision making

AUSTRAL will provide the data to allow health and emergency agencies, and regulatory bodies to make informed decisions about risks from air pollution exposure. This enhanced capability will ultimately improve the health and save the lives of Australia's urban populations.

### **Delivery of air quality information**



Measurements that will help inform the public of risk to air pollution exposure

A multi sector approach to deliver better air outcomes for urban populations

We envision AUSTRAL to have many applications across multiple disciplines. If you think AUSTRAL data could benefit your field, get in touch

## An innovation test bed

Integrating industry, regulators and tertiary education, these supersites will stimulate and encourage innovation and collaboration. These supersites will act as calibration and validation sites for emerging air quality technology for both the university and private sectors. Small, deployable sensors are an affordable and deployable solution to air quality monitoring. Provision of a traceable standards for these low-cost sensors will allow them to be thoroughly tested and validated to a national standard.

## Further applications of AUSTRAL

Whilst AUSTRAL's priority is to provide real-time, health relevant air quality data, the observations we are proposing have numerous applications to a wide range of industry and research:

- Visibility (aviation)
- Urban meteorology (engineering)
- Urban planning (design)
- Agriculture (crop impacts)
- Energy (solar efficiencies)

# Budget

## Supersite infrastructure and management

Each AUSTRAL supersite will be embedded within a university or scientific organisation with existing atmospheric composition capabilities. These sites will ideally be within the inner suburbs of each capital city and with a clear view in all directions. Every supersite will have a base set of instruments, calibrated to the same international standard. These instruments are listed on the next page and have been carefully selected to comply with Global Atmospheric Watch atmospheric composition measurement recommendations.

To maintain the supersite, AUSTRAL will include funding for one technician per site for its duration. The technician will be responsible for day to day maintenance, annual instrument calibration, and data management. In addition, each instrument will have an assigned expert champion, who is able to provide advice on instrument troubleshooting, data quality assurance, delivery and analysis.

AUSTRAL supersites will not be limited to the base instrumentation suggested here. We envision each university or organisation will have additional instruments to run alongside or test in the AUSTRAL sites for their own research purposes. Furthermore, AUSTRAL supersites will be accessible to researchers across Australia for instrument testing, calibration and validation, in addition to quality controlled data being publicly available via a virtual research platform.

## Budget

AUSTRAL has a proposed budget of \$AUD??? per site for initial set up, plus \$AUD??? for maintenance, staff, data management and storage and other ongoing overheads annually.

The funding for ongoing costs and initial set up are listed on the next page,

AUSTRAL will provide funding for the long-term operation of each supersite

All AUSTRAL data will be available to the public via a virtual research platform

## Annual costs

Item	Cost
Instrument maintenance, calibration and replacement	
Technical staff	
Data management and storage	
Facility maintenance and overheads	
Governance (project leader costs)	
<b>Total</b>	

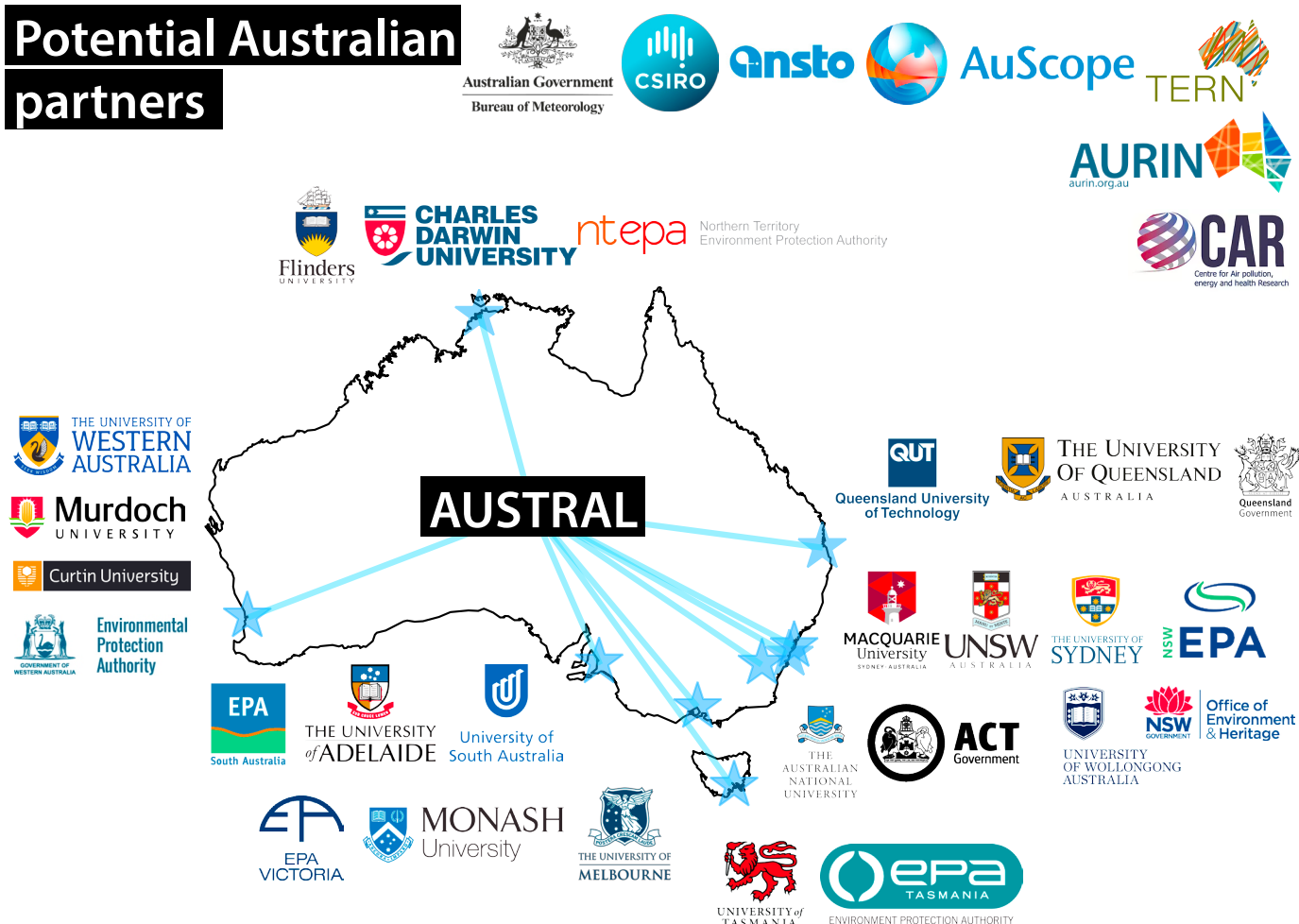
## Instrumentation

Instrument	Capability	Time	Quote
Aerosol Chemical Speciation Monitor	NO <sub>3</sub> , SO <sub>4</sub> , NH <sub>4</sub> , Cl and organic mass loadings, PM <sub>2.5</sub>	<30min	\$300k
Particle Into Liquid Sampler	PM <sub>2.5</sub> , SO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , Cl, NH <sub>4</sub> , K, Na, Ca, Mg, acetate, formate, oxalate organic acids, water soluble organic carbon	<30min	\$
Sun photometer	Aerosol optical depth	<5min	\$55k
Filter sampler	Aerosol scattering properties	Daily	\$34k
Nephelometer	Aerosol composition	<5min	\$45k
Proton Transfer Reaction - Mass Spectrometry	Volatile organic compounds	<30min	\$200k
Condensation Particle Counter	Condensation nuclei	<30min	\$50k
Scanning mobility particle sizer	Size distributions, aerosol composition	<30min	\$100k
Ceilometer	Aerosol optical depth, cloud properties, boundary layer high	<30min	\$47k
Lidar	3D aerosol optical depth, cloud properties, boundary layer height, vertical wind fields	<5min	\$500k
MAX-DOAS	Boundary layer profiles of NO <sub>2</sub> , O <sub>3</sub> , SO <sub>2</sub> , and aerosols	<5min	\$50
NO <sub>x</sub> , SO <sub>x</sub> and O <sub>3</sub> samplers	NO <sub>x</sub> , SO <sub>x</sub> and O <sub>3</sub>	<5min	\$84k
LI-7500DS	CO <sub>2</sub> /H <sub>2</sub> O flux	<10htz	\$
Sonic anemometer	3D winds	<10htz	\$15k
Weather station	Temperature, wind, pressure, humidity, radiation, precipitation	<5min	\$3k
<b>Total</b>			<b>\$1.483m</b>



# Funding model

## Potential Australian partners



## Potential international partners



## Proposed funding model for AUSTRAL (per site)

Partner	Assets	Cost (one off)	Operational	Cost per year
University	Site (including initial refurbishment) SMPS	\$300k \$50k \$350	Site rental, security, network access and maintenance Operational support	\$20k \$ \$
BoM	Lidar	\$250k	Ongoing instrument costs, data quality control and analysis Operational support	\$ \$ \$
CSIRO	ACSM PRTMS	\$150k \$100k \$250	Ongoing instrument costs, data quality control and analysis, Operational support	\$ \$ \$
TERN	Sonic anemometer LI-7500DS	\$7.5k \$ \$	Ongoing instrument costs, data quality control and analysis	\$ \$ \$
AURIN	Data storage		Data delivery	\$
EPAs	NO <sub>x</sub> , SO <sub>x</sub> and O <sub>3</sub> samplers	\$42k	Ongoing instrument costs, data quality control and analysis, Operational support	\$ \$ \$
AERONET	Sun photometer	\$27.5k	Ongoing instrument costs, data quality control and analysis	\$
SPARTAN	Filter sampler Nephelometer	\$17k \$22.5k \$39.5k	Ongoing instrument costs, data quality control and analysis	\$
AUSCOPE	Remaining instrumentation costs	\$800k		\$



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