

Operational readiness of rural fire fighters during bushfire suppression

Smoke impacts at the rural urban interface

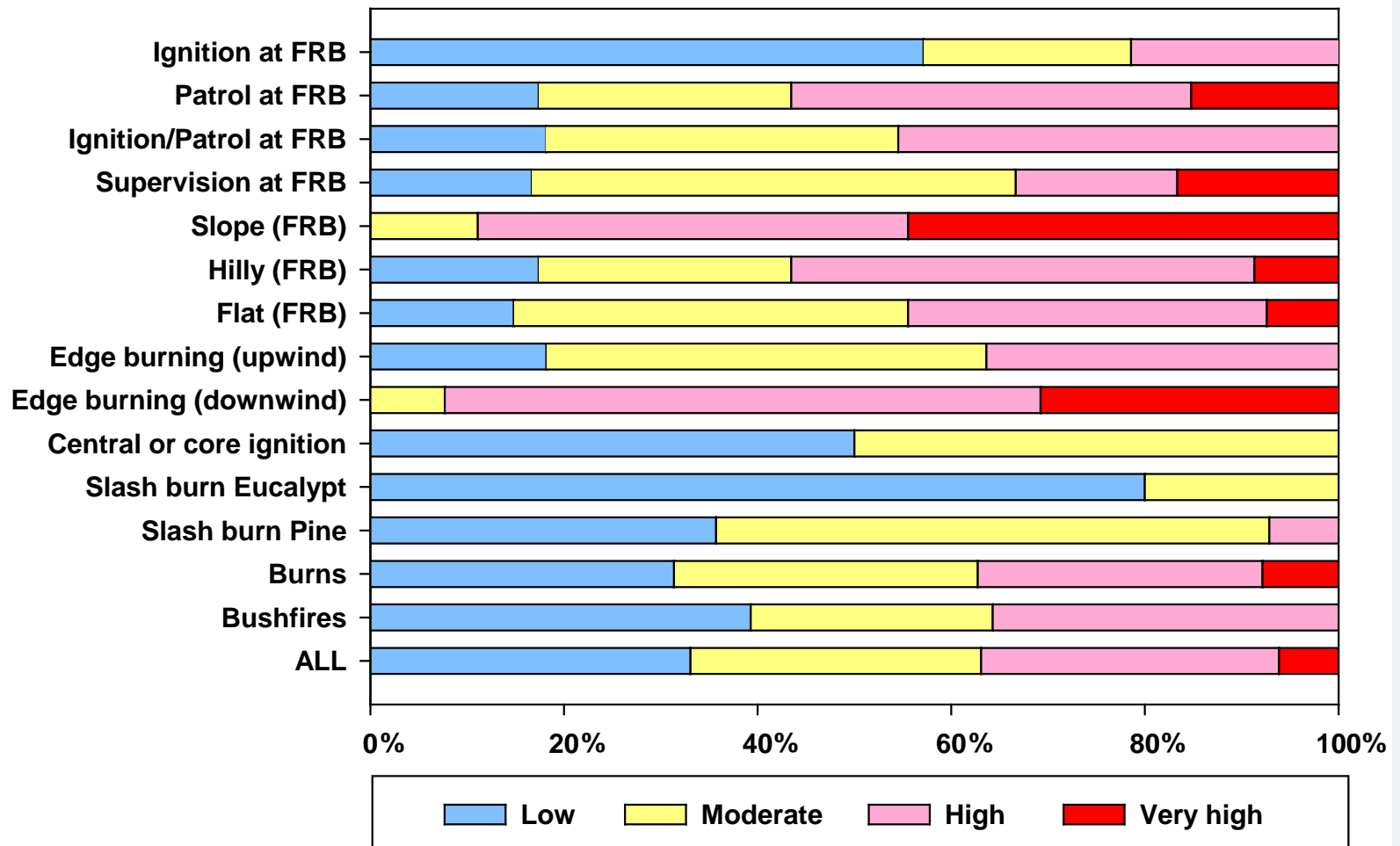
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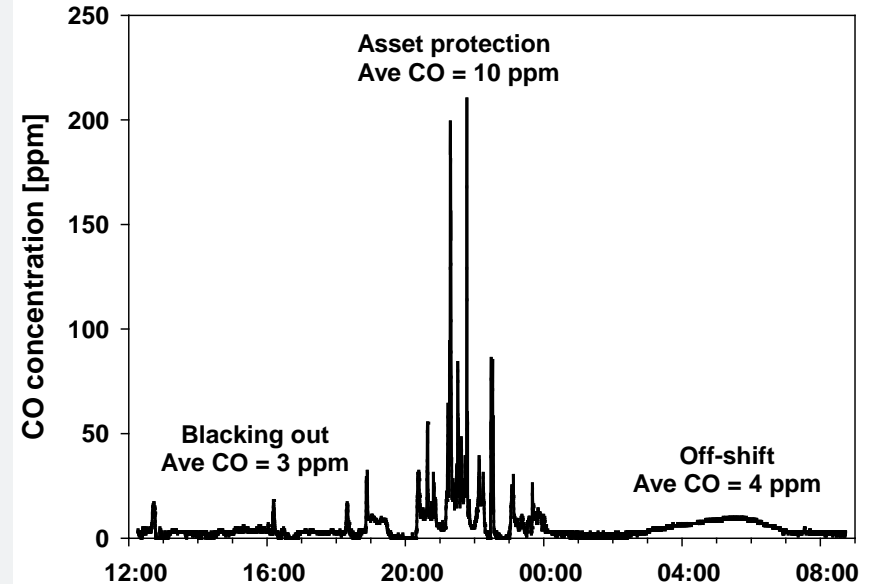
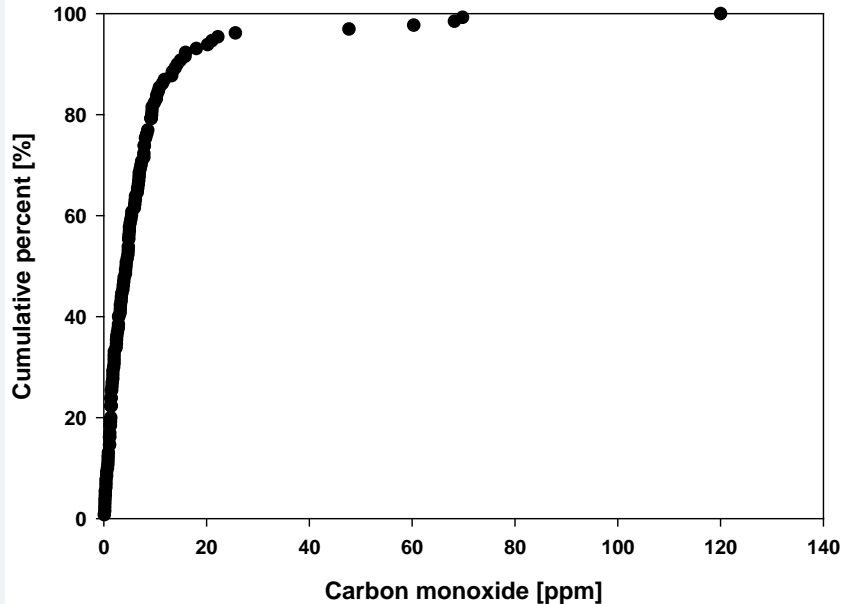
THE “S” IN THE ASH PROJECT



EXPOSURE RISKS

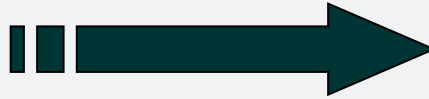


CARBON MONOXIDE EXPOSURE



COHb [%]	SYMPTOMS, EFFECTS
5%	Potential for adverse cardiovascular effects
5-10%	Effects on performance of tasks requiring vigilance and on reaction time, potential headaches, dizziness, reduced work capacity
10-20%	Slight headaches, dizziness, slight breathlessness on exertion
20-30%	Slight to moderate headaches, nausea
30-40%	Severe headaches, vertigo, nausea

RURAL-URBAN INTERFACE



- Identify and characterise potential hazards due to exposure to air toxics while fighting bushfires that extend into the RUI
- Assess whether concentrations of air toxics in the smoke and in the ash residue could potentially impact firefighter's health or safety

RESEARCH APPROACH



OUTCOME



1. Identification of air toxics

Inventory of major materials in building and furnishing components commonly used in houses in regions impacted by fires;

Detailed laboratory testing aiming at characterising and quantifying emission rates, chemical composition of combustion products and toxic residues in ash and dust

2. Determination of exposures

Incorporation of emissions data into adapted fine scale hazardous plume models to estimate exposures

THE RURAL-URBAN INTERFACE: FUEL



Complex mix of vegetation and other fuels

- House structure
- House contents
- Surrounding elements
- Vehicles
- Sheds



1. Wood & wood-based products
 - Building material
 - Decking, fencing, flooring
 - Furniture
2. Polymeric products (PS, PE, PP, PVC, PUR, PIR, ABS, PC)
 - Upholstery, furniture
 - Thermal and cable insulation
 - Flooring
 - Roofing membranes
 - Appliances, electronic equipment cases
 - Window frames
3. Textile
4. Paper
5. Liquid HC and other organic chemicals, paint



- Composition and yields of combustion products
- Ash residue
- Potential health impact

AIR TOXICS – HEALTH EFFECTS

Air toxic	TWA (mg/m ³)	Health effect
CO ₂	9000	Changes to respiratory patterns
CO	34	Asphyxiant
HCN	11 (peak)	Asphyxiant
NH ₃	17	Respiratory irritant
NO	31	Hypoxia at high concentrations
NO ₂	5.6	Respiratory irritant
HCl	7.5 (peak)	Severe irritant
SO ₂	5.2	Irritant
Hydrocarbons	3.2 (benzene)	Irritant; asphyxiant; carcinogen
VOCs	1.2 (formaldehyde)	Irritant; probable carcinogens
PAHs	52 (naphthalene)	Irritant; probable carcinogens

FACTORS DRIVING EMISSION COMPOSITION

Type of material	Combustion Product
Wood, PE, PP, PS	CO, CO ₂ , aliphatic, aromatic and oxygenated hydrocarbons (HC), PAHs
Nitrogen-containing material e.g., nylon, PUR, ABS, melamine, urea-formaldehyde	HCN, NO _x (NO, NO ₂), NH ₃ , nitriles, amines, isocyanates, organic nitro-compounds
Halogen-containing material, e.g. PVC, FP	Halides (HCl, HF), Dioxins, chlorinated PAHs or hydrocarbons
Sulphur-containing material, e.g. rubber, wool	SO ₂ , H ₂ S, organic sulphur compounds

Yield ↗ with ventilation	Yield ↘ with ventilation	Yield independent of ventilation
CO ₂ , NO, NO ₂ , SO ₂	CO, HCN, NH ₃ , H ₂ S, HC, VOCs, PAHs	HCl, HF, HBr

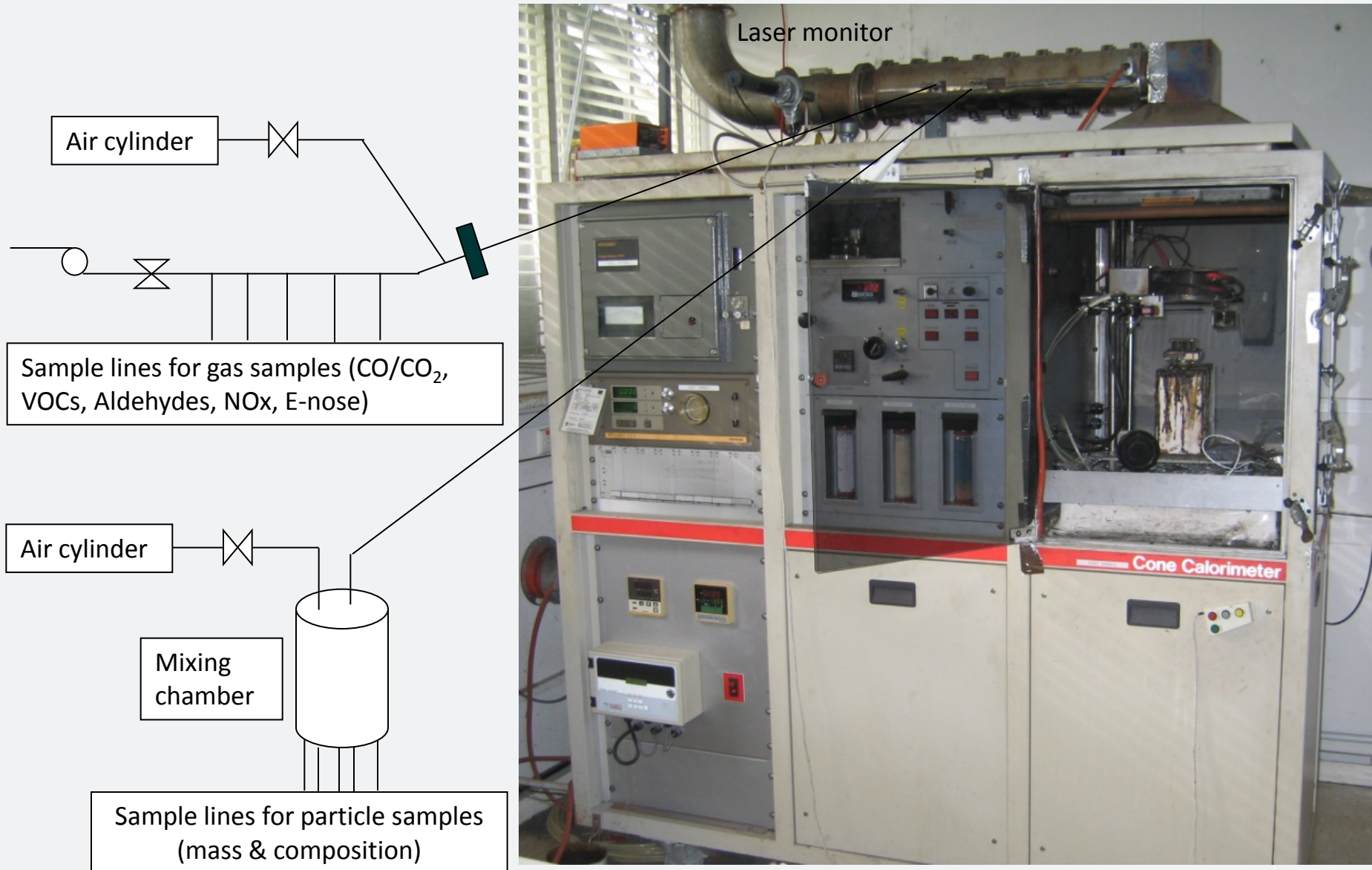
- Review of existing literature data
- Identify gaps for setting up experimental burns

Small bench-scale experimental burns under controlled conditions for pure materials

- Emission factors of gaseous or particle species for combustible materials that serve as input into dispersion model
- Validation and potential use of e-nose technology
- Collection and analysis of ash residue



EXPERIMENTAL BURNS - DESIGN

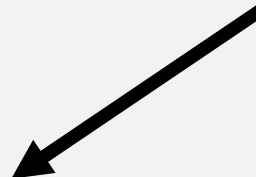
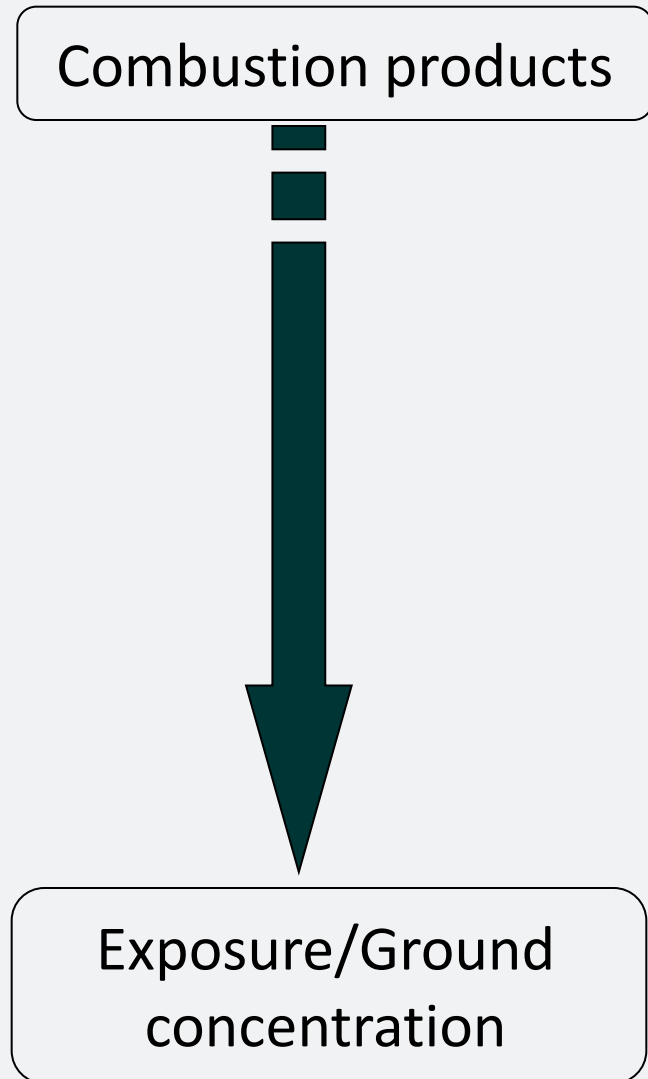


Materials tested

- Wood (Pine) as reference material
- Treated pine
- Paint
- Medium-density fibreboard
- Particle board with and without melamine
- Plasterboard
- Polyurethane foam
- Wool carpet
- Polystyrene
- Polyester

Analysis

- CO, CO₂ (continuous)
- NO_x (continuous)
- PM mass
- PM (continuous)
- PAHs
- Speciated VOCs
- Aldehydes
- E-nose
- Ash residue



Scales of interest

1. within the urban fringe canopy (the Rural Urban Interface), e.g. in and around the actual buildings near the surface of the earth
2. in the urban regional context, i.e. the transport from the burnt or burning fringe across the broader city-scape or from city to city or city to rural.

Appropriate urban canopy parameterisation

how the local wind flows and turbulence depend on (burnt) building and vegetation type, terrain surface heat fluxes and emission source locations

SMOKE DISPERSION MODELS

Model	Use
TAPM (CSIRO)	not designed or optimised for fine scale applications
AUSPLUME (Vic EPA)/ CALPUFF (US EPA)	Gaussian plume or puff model; in principle adapted for near field analysis; reduced utility for using real time assimilation
HYSPLIT (NOAA)	Longer range transport model, not optimal for near surface emitters and receptors
ARGOS	Uses real time weather and tabulated sources for emergency response prediction
RIMPUFF (Denmark)	plume model that underpins ARGOS; emphasis on surface-layer mixing
CCAM	a user derived meteorological prediction system for input into RUI surface properties (wind prediction tool)
Research models	Extensions of RIMPUFF spreading models; can produce time series of fluctuating concentrations

RURAL URBAN INTERFACE AIR TOXICS

Toxic Dispersion from Smouldering Buildings

ARGOS Model:

- distributed by ARPANSA to Government Agencies in Australia
<http://www.arpansa.gov.au/>
CSIRO will acquire in late Nov 2010
- licensed from the ARGOS Consortium, based in Denmark
<http://www.pdc.dk/Argos/decision.asp>
- RimPuff Dispersion model (*Riso National Labs, Tech. Uni. Denmark*)
 - Adapted to use ACCESS forecast input in Australia
 - Can use local meteorological input (incl. met. masts)
 - ARGOS has urban canopy dispersion
 - Has models for burning building emissions and chemical fires
 - CSIRO will embed Matlab modules from its odour work for fine scale modelling for e-nose sensor integration and possible odour signals from toxic emissions

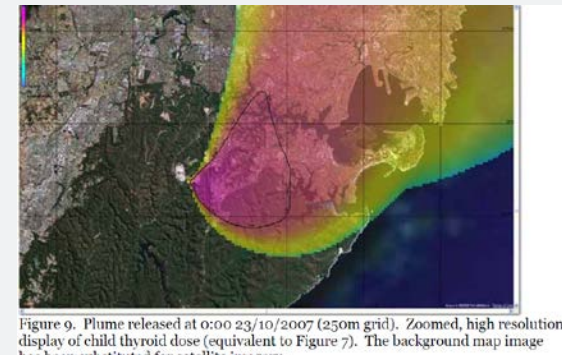
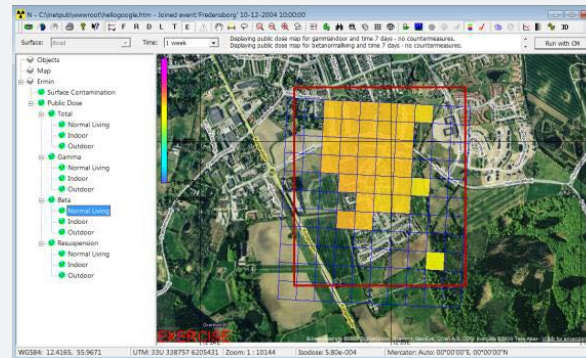
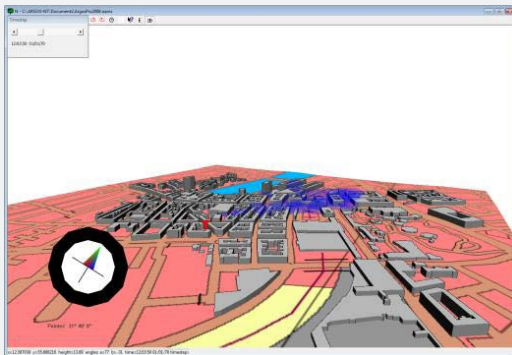
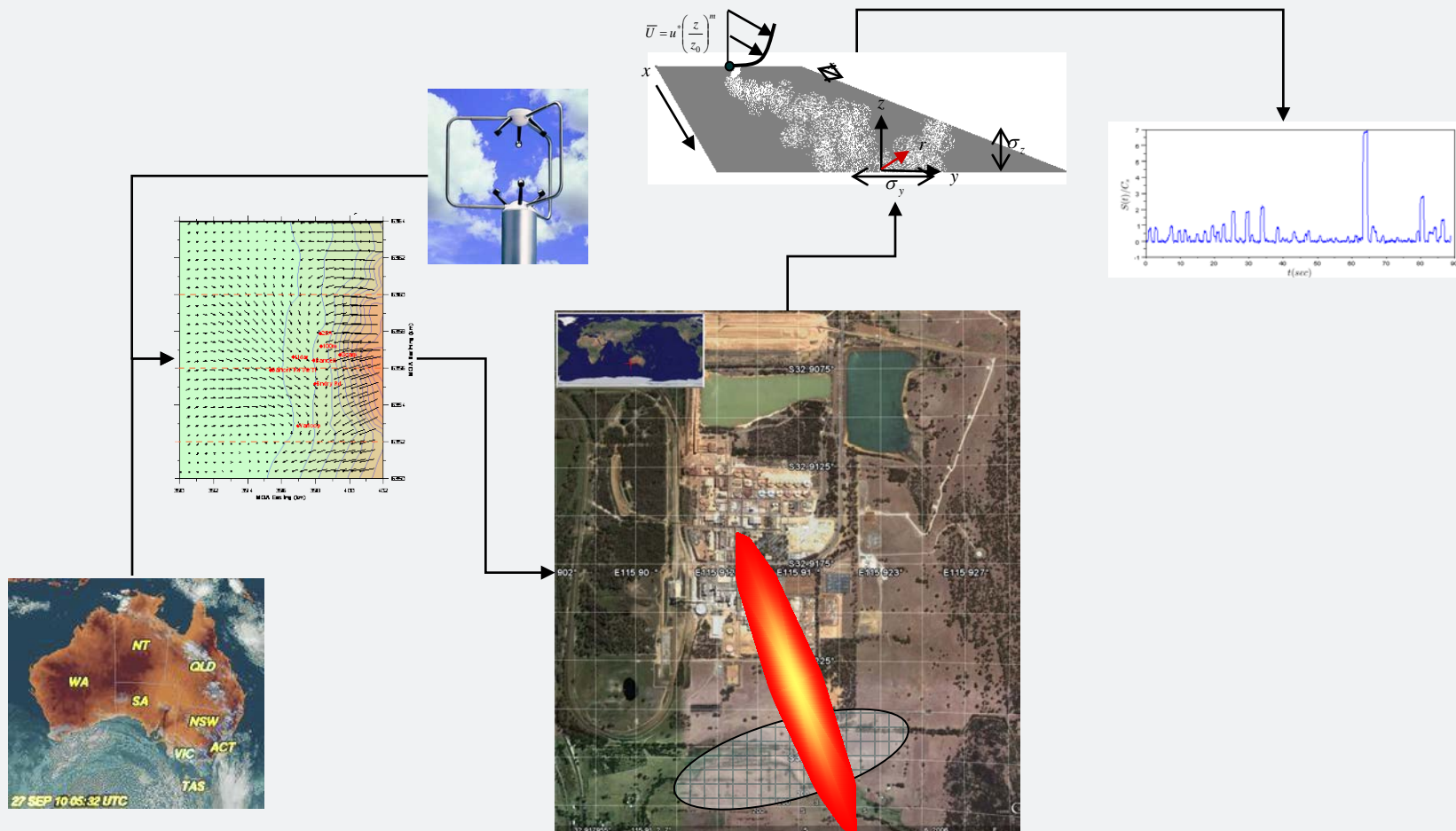


Figure 9. Plume released at 0:00 23/10/2007 (250m grid). Zoomed, high resolution display of child thyroid dose (equivalent to Figure 7). The background map image has been substituted for satellite imagery.

RURAL URBAN INTERFACE AIR TOXICS

Information flows for chemical plumes in the field



CSIRO Light Metals Flagship: Alumina Air Quality

Posters

- AFAC/BFCRC conference 2010: Smoke impacts at the rural-urban interface
- AFAC/BFCRC conference 2011: Emissions from fires at the rural-urban interface

Fire note

- Identifying smoke impacts from bushfires extending into the rural-urban interface

Reports

- Inventory of major materials present in and around houses and their combustion emission products
- Design of experimental burns
- Models for dispersion and exposure prediction of combustion emission products
- Toxic emissions from fires at the rural urban interface - Desktop study

- Data from experimental burns
- Integration of emissions data into dispersion model
- Exposure assessment
- Integration of new exposure information into ASH project