Health risks from bushfire smoke

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Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

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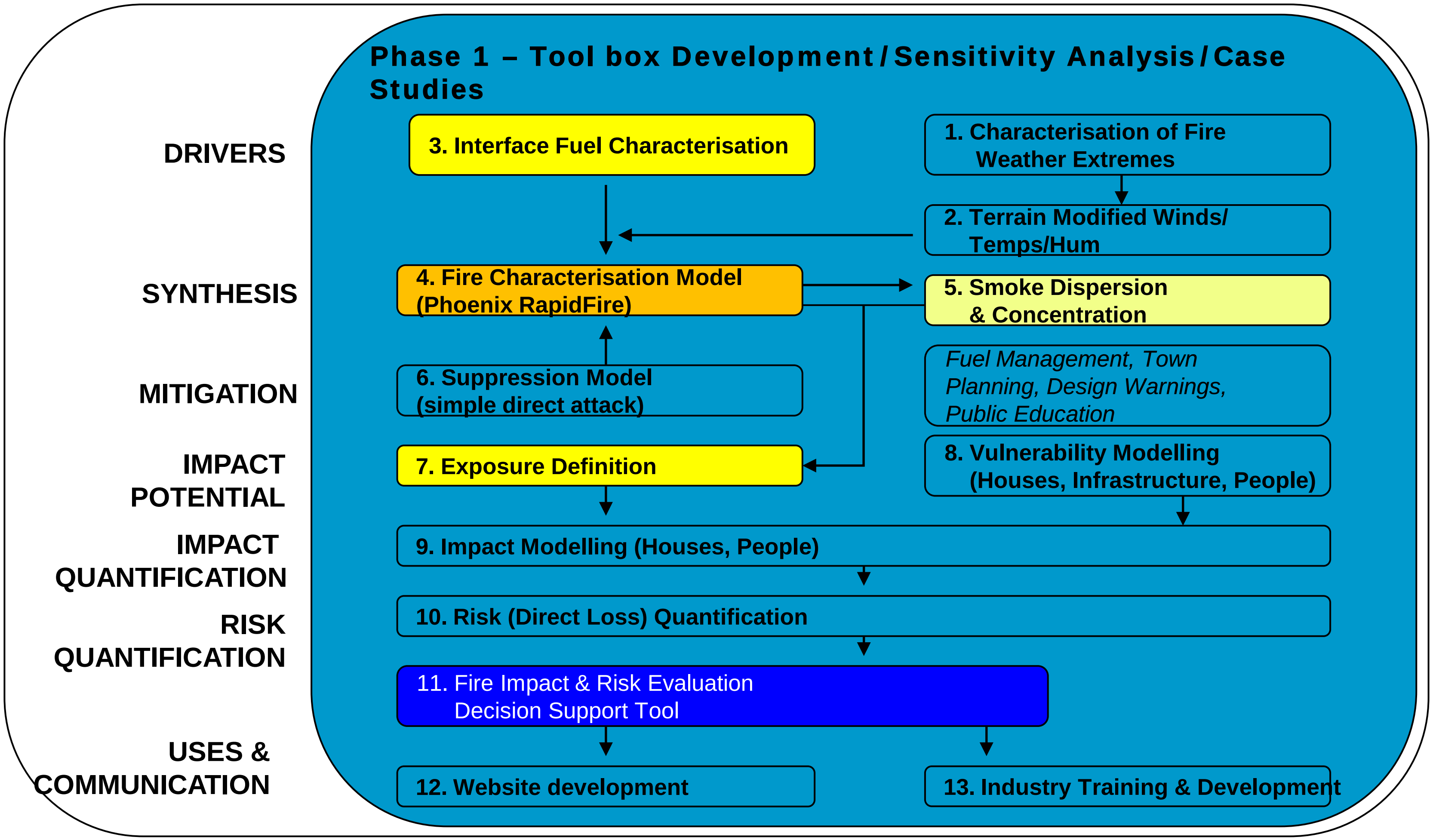
FIRE- DST



Phase 1 – Tool box Development / Sensitivity Analysis / Case Studies
DRIVERS
SYNTHESIS
MITIGATION
IMPACT POTENTIAL
IMPACT QUANTIFICATION
RISK QUANTIFICATION
USES & COMMUNICATION
3. Interface Fuel Characterisation
1. Characterisation of Fire Weather Extremes
2. Terrain Modified Winds/ Temps/Hum
4. Fire Characterisation Model (Phoenix RapidFire)
5. Smoke Dispersion & Concentration
6. Suppression Model (simple direct attack)
Fuel Management, Town Planning, Design Warnings, Public Education
7. Exposure Definition
8. Vulnerability Modelling (Houses, Infrastructure, People)
9. Impact Modelling (Houses, People)
10. Risk (Direct Loss) Quantification
11. Fire Impact & Risk Evaluation Decision Support Tool
12. Website development
13. Industry Training & Development

The Risks

- Risk to health
  - Diffuse impacts

  e.g. For every 10 µg m^{-3} increase in PM10 the death rate increases by 1%

  Acute, non lethal health issues – asthma, COPD, etc

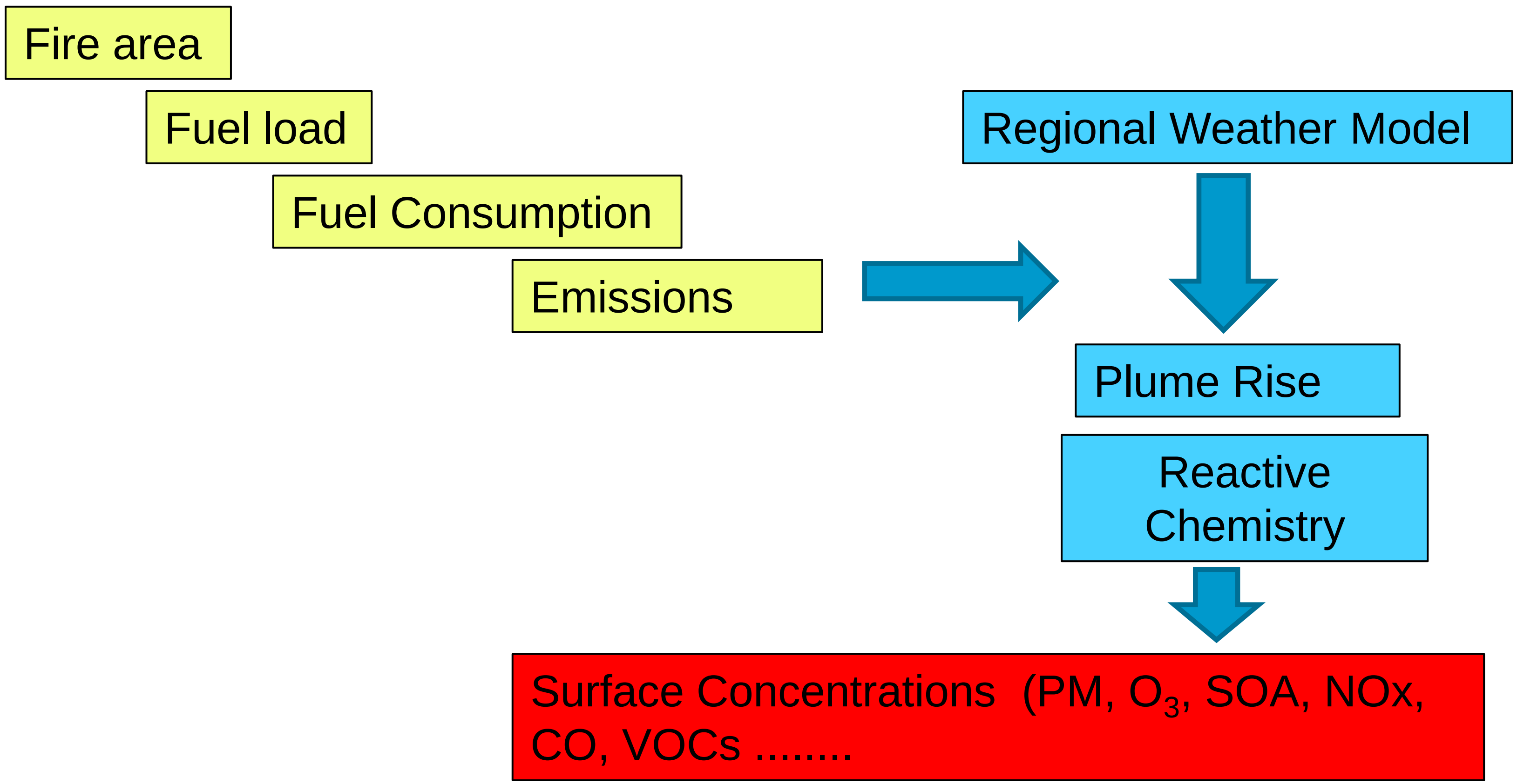
  Other toxics and irritants and pollutants (sVOCs (PAH etc), VOCs(HCHO, BTEX)

  - Direct impacts
    - Visibility
- Risks to livelihood
  - Wine taint

Risks for fire managers

- Balancing competing impacts
  - e.g. impacts from prescribed burning vs impacts from wildfires
- Balancing forest/land management demands with risks to industries
  - e.g. Forest regeneration burns in Tasmania

Modelling Frameworks used for this problems



Framework Implementations

- USA: BLUESKY
- Canada: Canada Fire
- Europe- Various
- Australia:
  - National spatial emissions grid/TAPM (Meyer et al, 2008)
  - Australian Air Quality Forecasting System (AAQFS)
  - HISPLIT smoke Trajectories (Alan Wain, BoM – Not CAWCR)

BlueSky

- Fire Area: Geostationary satellite, agency data
- Fuel Loads; FCCS, NFDFS, Hardy (strata: veg class, fuel size,..)
- Fuel Consumed: CONSUME, FEPS, BURNUP, EPM
- Time course: FEPS, BURNUP,EPM
- Emissions: FEPS, BURNUP, EPM
- Weather: CALMET, MCIP, WRF
- Dispersion: HYSPLIT, CALPUFF, SMOKE, CMAQ

US Standard data sets
A limited range of fire spread/ combustion models

The model applies to Australia, but the data sets must be local.

The objective

- Implement
- Test
- Compare

these systems in Southern Australian Forests

Our Options

- Emissions parameterisations:
  - Fuel loads:
    - measured fuels (state vegetation/fuels data bases) e.g. Phoenix
    - Modelled- CASA/CABLE, VAST, NCAS
  - Consumption
    - MacArthur fire spread (Meyer et al.,2008)
    - Phoenix
  - Emissions
    - Country specific emission factors (NAILSMA, etc)
- Dispersion/Transport
  - CCAM + CTM
  - TAPM
  - HYSPLIT
  - WRF, WRF-Fire

The objectives

- System verification
  1. Comparing prediction against observations
  2. Synthesis Inversions
  3. Constraints using Satellite sensed data

The key objective is surface concentrations: not just the hourly spatial emissions of combustion products, but the fraction of this that remains within the boundary layer

The key outputs:

tools for managers to access/operate models for management planning and risk assessment.

The tasks

- Validation of a range of case studies
  - Wildfires:
  - Prescribed burns/regen burns
- Outputs;
  - Input data sets for the models
  - Methodologies for configuring current models
  - Characterisation of dispersion properties of major events

Our tools

- Observational data with detailed air quality parameters of fire events
  - 2006/7 NE Vic fires
    - Vic EPA network/ CSIRO Aspendale data, CSIRO Cape Grim
    - CARP Ovens data set
  - Black Saturday
    - Vic EPA Network
  - Fuel Reduction burns
    - Ovens 2006-2008
    - Manjimup 2006- 2008
    - Huon Valley 2009-201
- Satellite observations
  - CALIPSO- Space borne Lidar
  - Sciamachy- Space borne UV DOAS
  - MODIS, ATSR Aerosol Optical Depth (AOD)
- Emission factors for trace combustion products

Progress and Plans

- Model implementation
  - First stages are complete
    - Add/test plume rise parameterisations
    - Develop emission model based on Phoenix
- Analysis of 2006/7 fire event
  - In progress/ almost complete
- Analysis of plume transport in the Huon Valley
- Emission factors
  - Complete analysis of PM/ Carbonyl EFs from Savanna woodlands
  - EF measurement campaign in Vic forests (with Chris Weston & Luba Volkova March/April 2012
  - Characterise N_2O & NOx emission processes and CH4 & PM aerosol chemistry and EFs in the Pyrotron (with Andrew Sullivan Feb/March 2012
- PhD Studentship to address health impacts
  - Student appointed

Project outputs to End Users

- Tools exist but
  - What is needed is the means for agency staff to apply them
  - Specification of optimal configuration
  - Tools/specifications for compiling the emission fields
  - Advice on comparative accuracy of alternative models and frameworks

We need you input here.

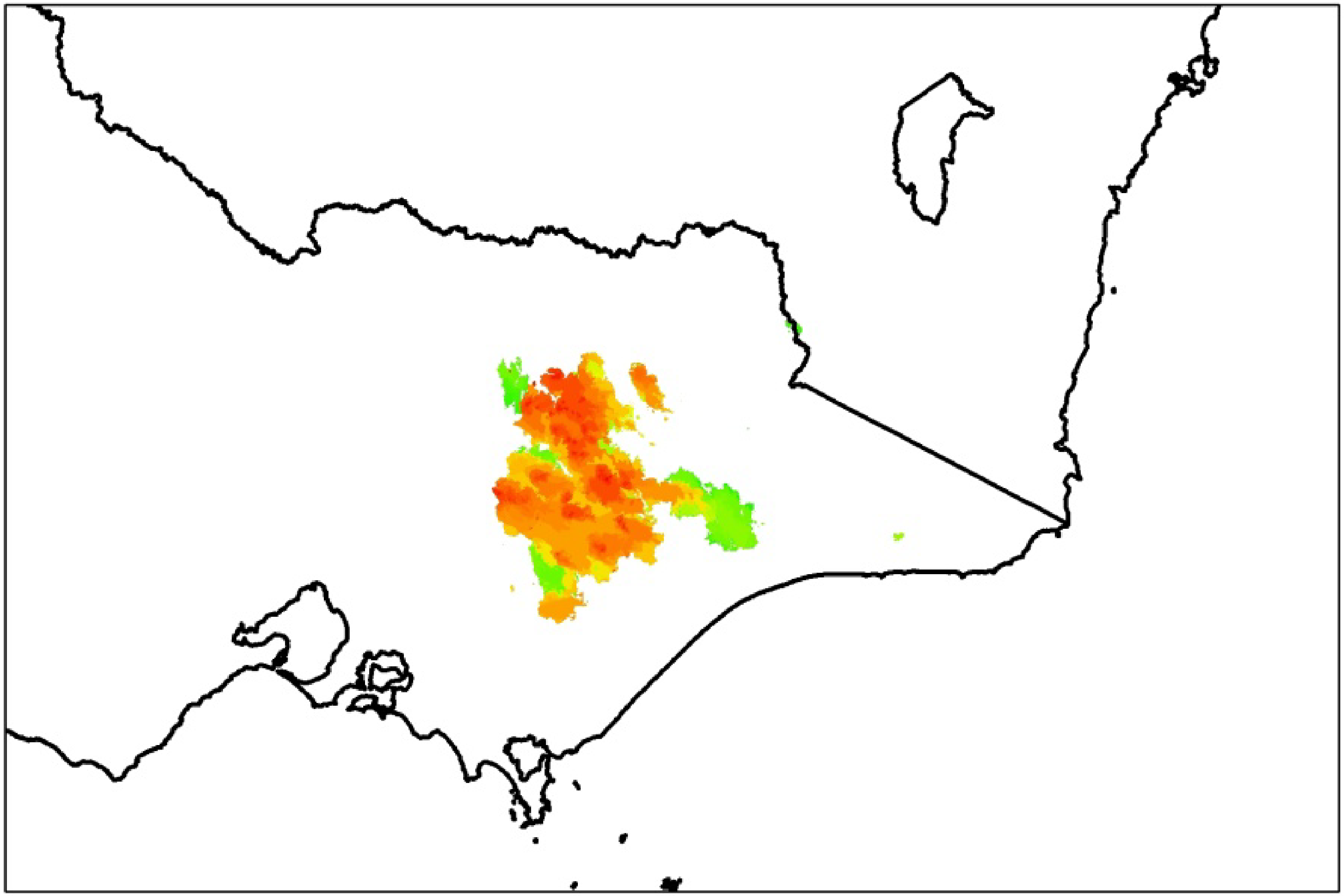
Staff

- PhD studentship
  - Anjali Haikerwal.   Monash Epidemiology (Martine Dennekamp, Malcolm Sim, Michael Abramson)

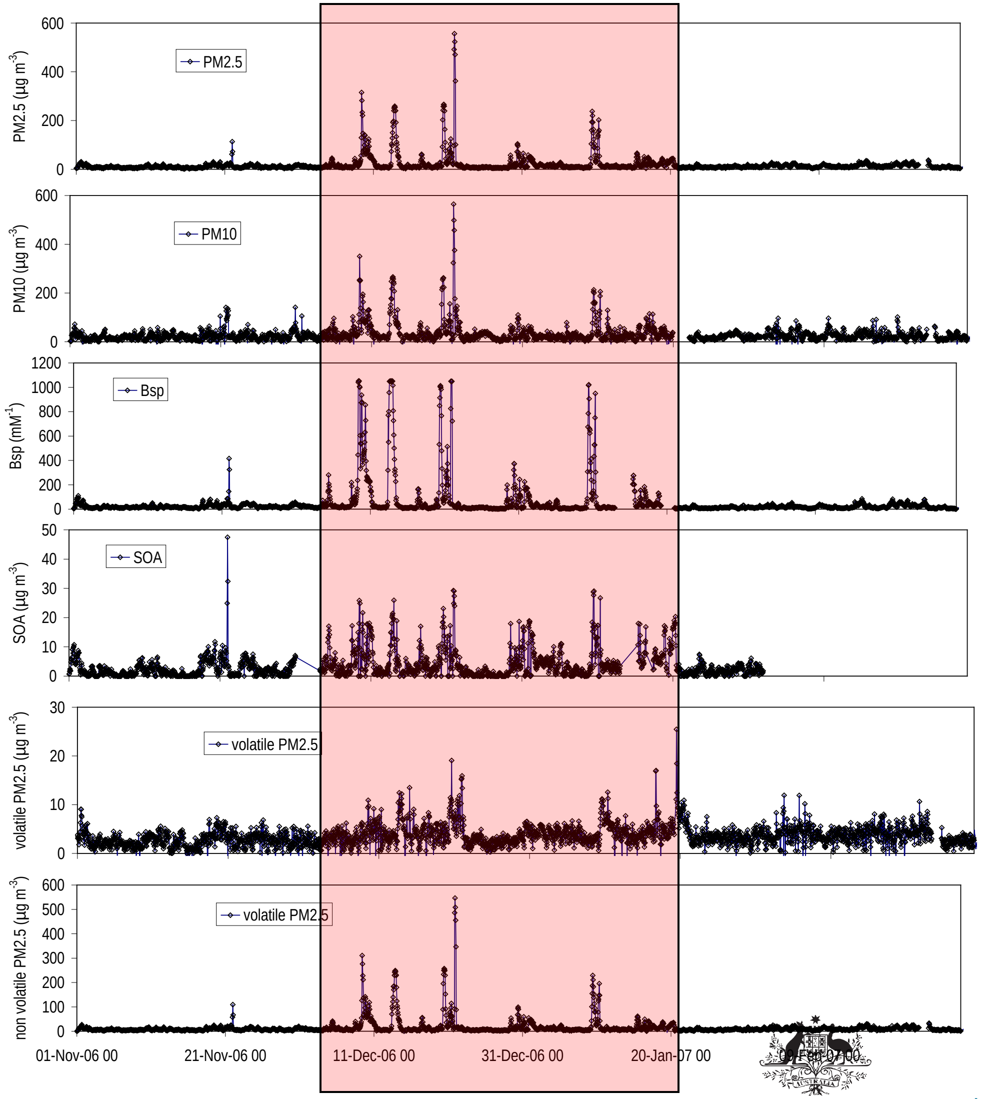
  Regional health impacts

- CSIRO staff
  - Martin Cope, Sunhee Lee, Stuart Young, Kathryn Emerson, Russell Howden.
  - Fab (when not otherwise occupied on BF CRC work)

Progress: 2006/7 Smoke events.



Particle metrics Nov 06 to Feb 07



Time series of hourly concentrations of PM2.5, PM10, Bsp, SOA, volatile PM2.5 and non-volatile PM2.5.

Peaks:

PM2.5:	**550 µg m^{-3}**
SOA	**30 µg m^{-3}**
NO_2	**55 ppb**
O_3	**140 ppb**

Averages for fire and non-fire periods (tables)

Particle composition

Metric	M2.5 ($\mu g\ m^{-3}$)		PM10 ($\mu g\ m^{-3}$)		Bsp (Mm^{-1})		volatile PM2.5 ($\mu g\ m^{-3}$)		non volatile PM2.5 ($\mu g\ m^{-3}$)		SOA ($\mu g\ m^{-3}$)	
	Fires	non-fire	Fires	non-fires	Fires	non-fires	Fire	non-fire	Fire	non-fire	Fire	non-fire
average	106	12	109	22	443	23	7	3	99	9	10	3

Particle size distribution

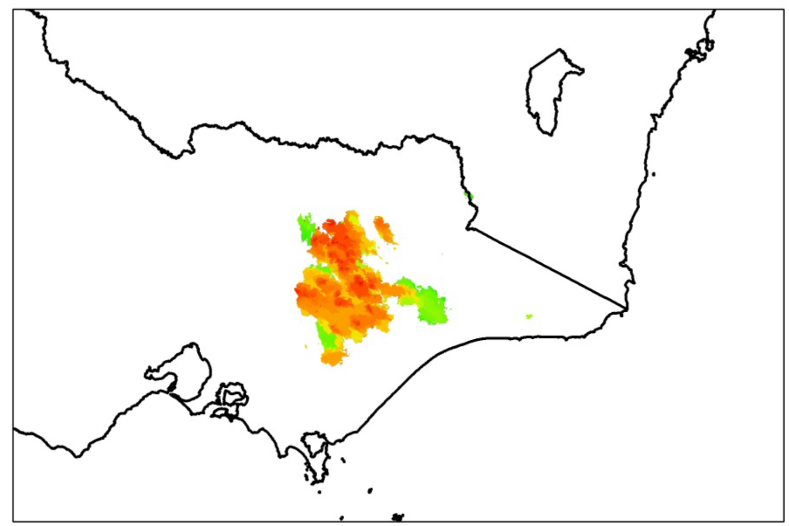
Metric	UCN (particles cm^{-3})		less than 20 nm diameter (particles cm^{-3})		20 to 100 nm diameter (particles cm^{-3})		greater than 100 nm (particles cm^{-3})		diameter of mode (nm)	
	Fires	non-fires	Fires	non-fires	Fires	non-fires	Fires	non-fires	Fires	non-fires
average	13322	12055	215	169	7730	7254	31018	3591	169	74

Criteria pollutant gases

Metric	CO (ppm)		O3 (ppb)		NO2 (ppb)		NO (ppb)		SO2 (ppb)	
	Fires	non-fires	Fires	non-fires	Fires	non-fires	Fires	non-fires	Fires	non-fires
average	815	115	38	19	16	7	6	4	1.12	0.65

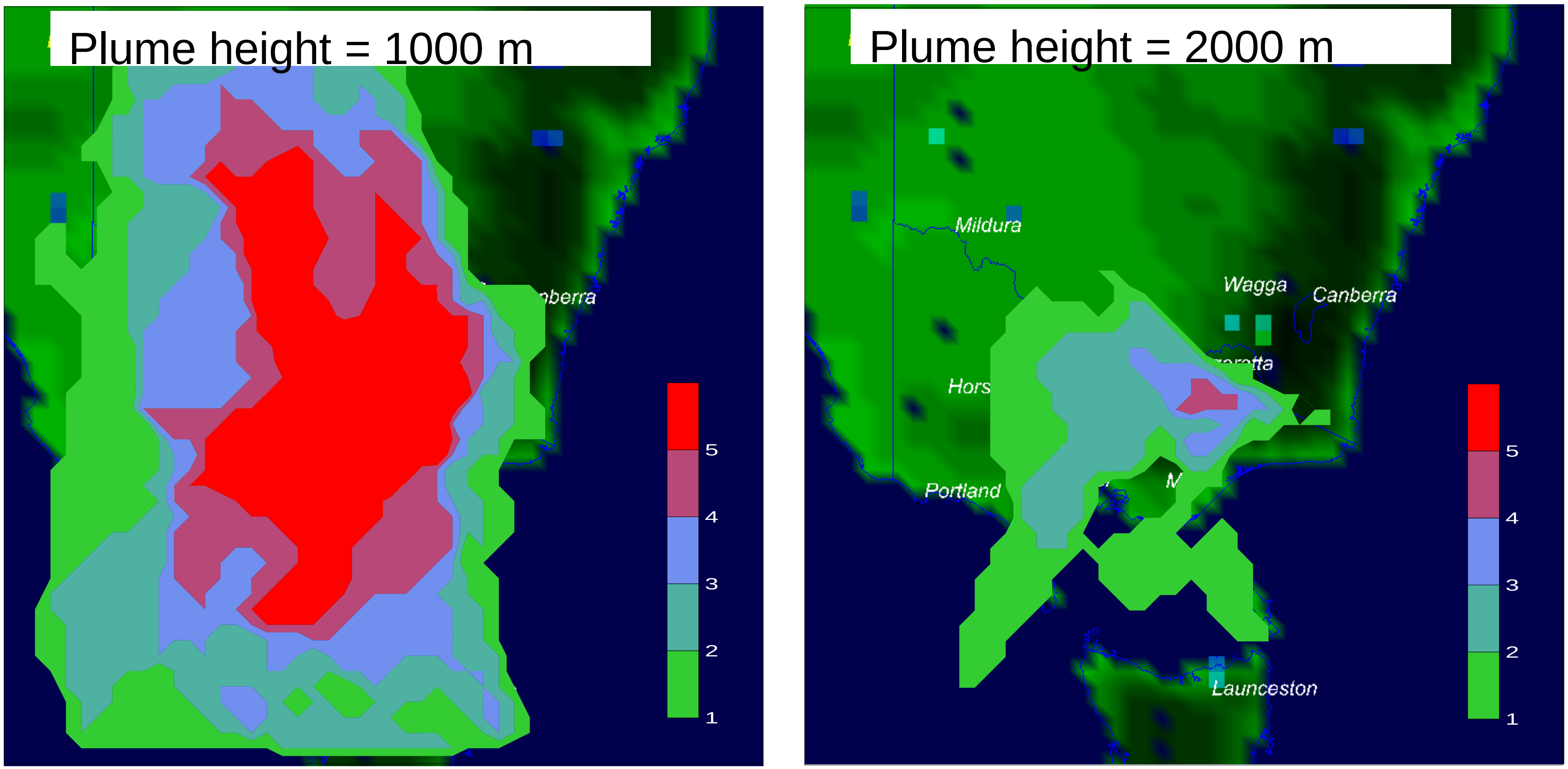
Model PM10 transport

- Model 2006/7 fire smoke transport using
  - 1km fire grid derived from AVHRR scars using Meyer e al., 2008
  - fuel loads modelled from VAST 1.5 (Barrett, 2010)
  - uniform convection column
- Next step
  - 100m daily grid
  - Phoenix fuel loads
  - CCAM plume rise parameterization active

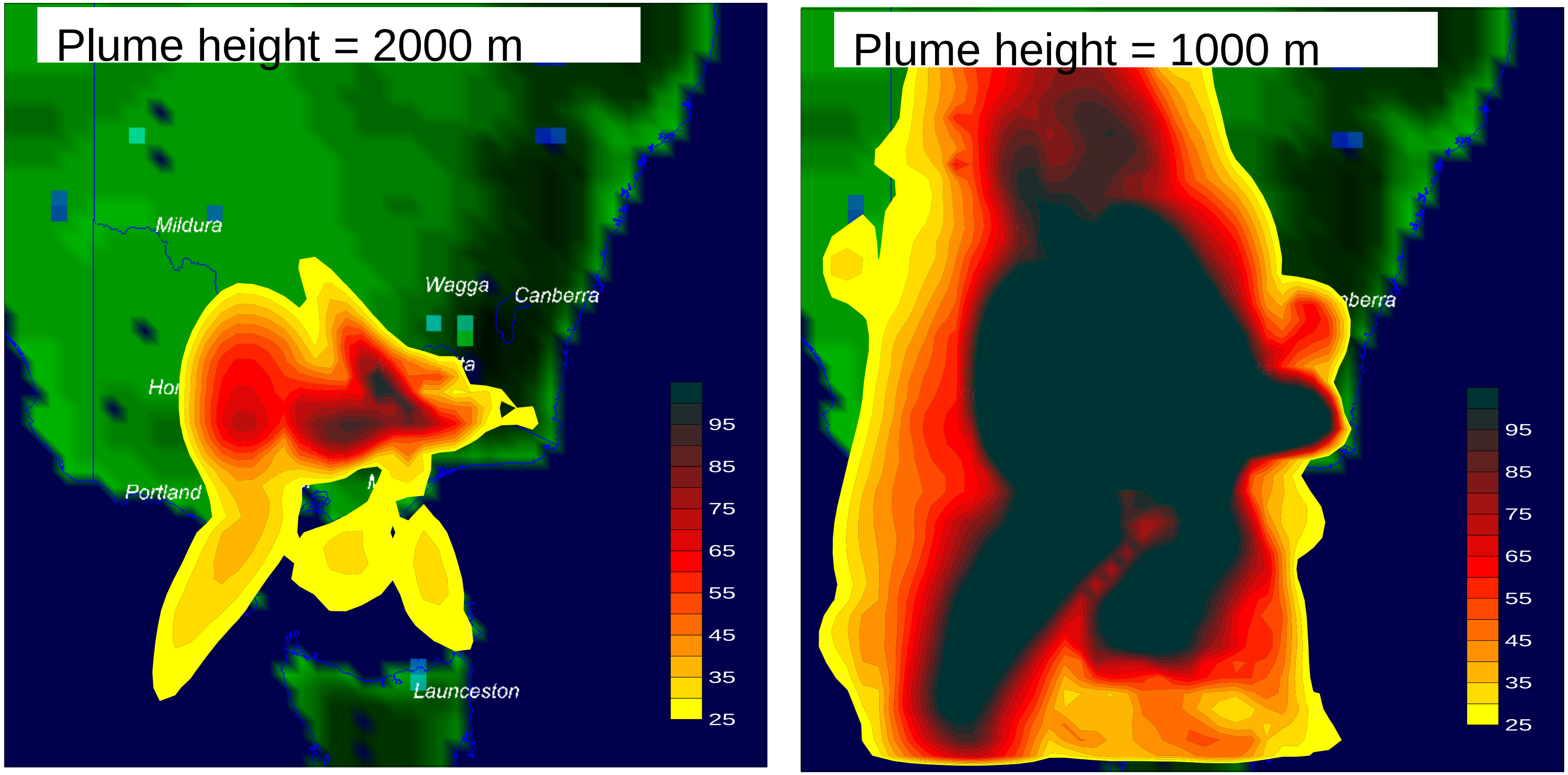


Sensitivity of $PM_{2.5}$ exceedence frequency to plume rise- 1000 m vs. 2000 m. Dec 2006

- (frequency of days when 24-h $PM_{2.5}$ > 25 $\mu g\ m^{-3}$)



Sensitivity of peak 24-h $PM_{2.5}$ concentration to plume rise- 1000 m vs 2000 m. Dec 2006



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Emission Factors

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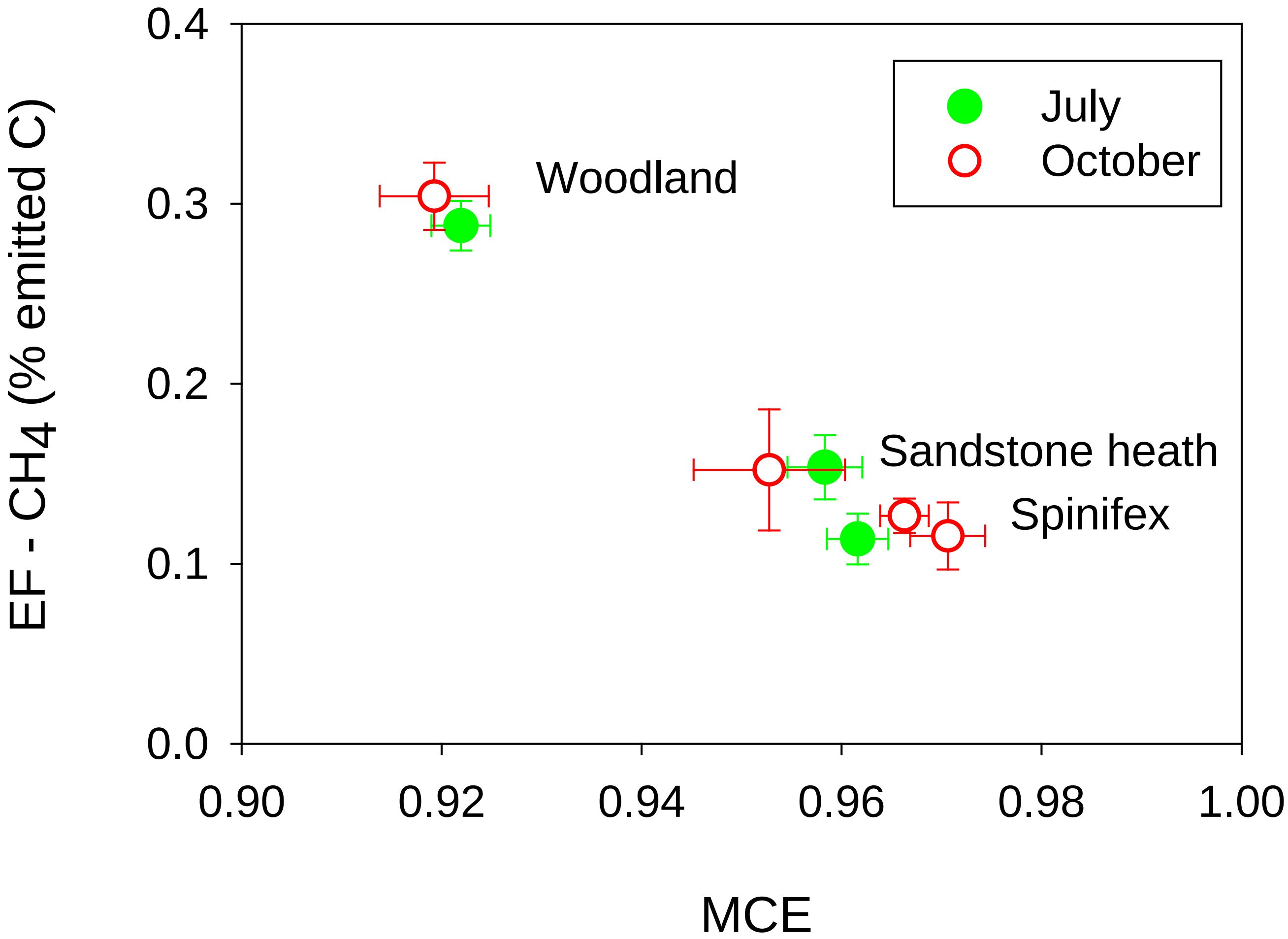
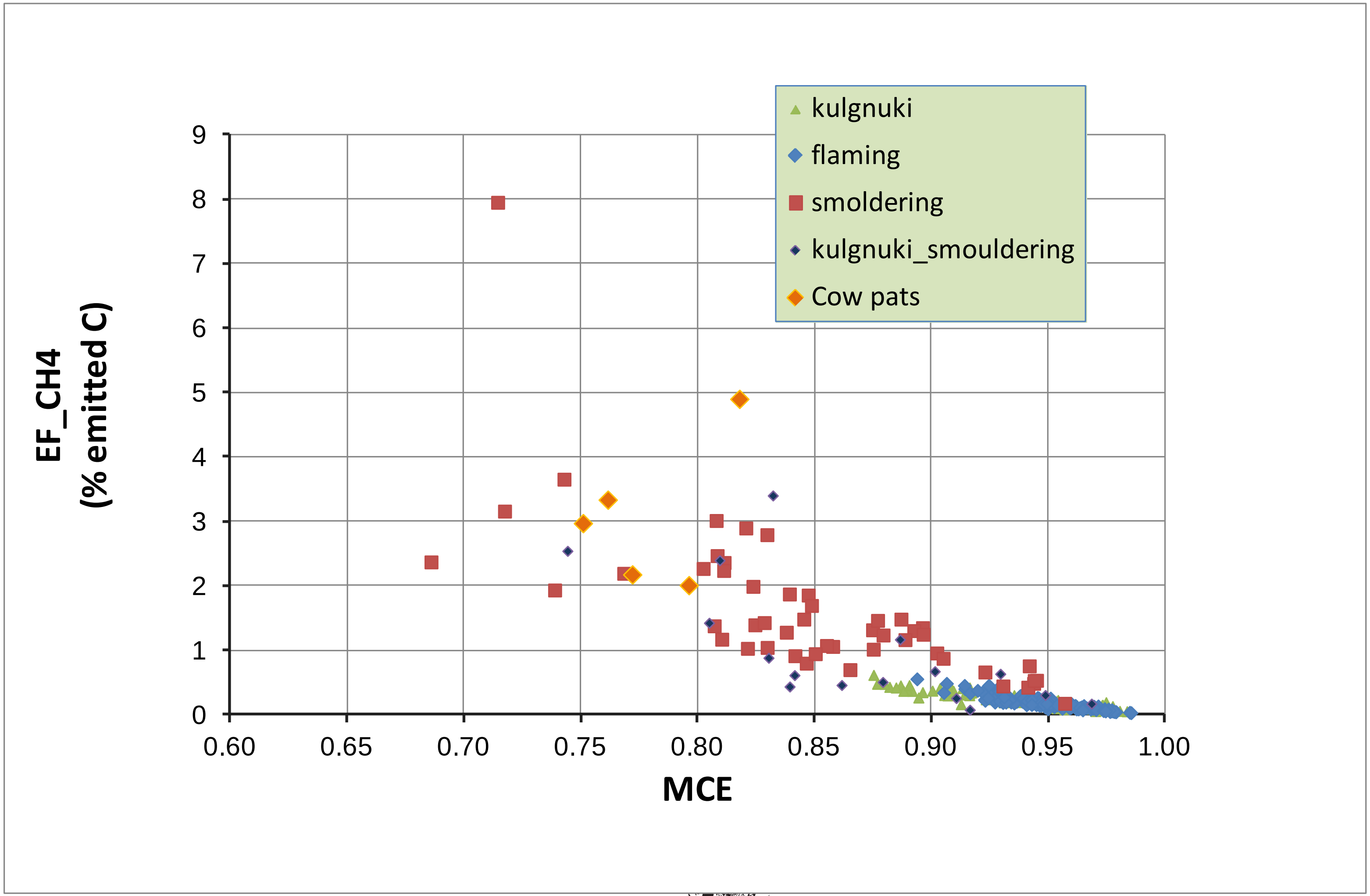
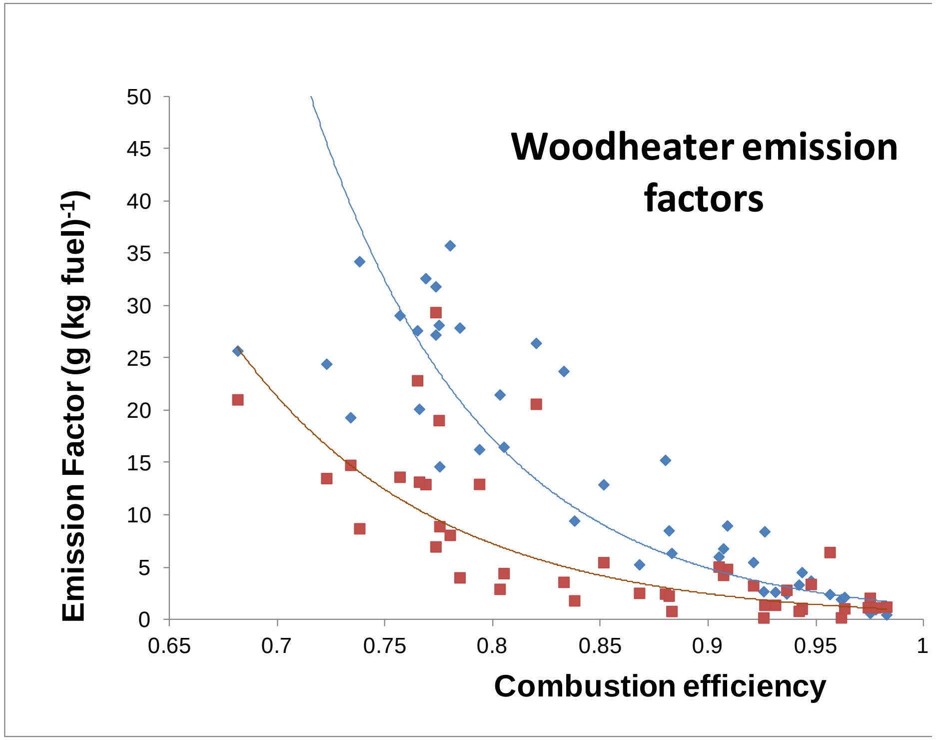
Emission factors : CH_4



Emission factors : CH_4

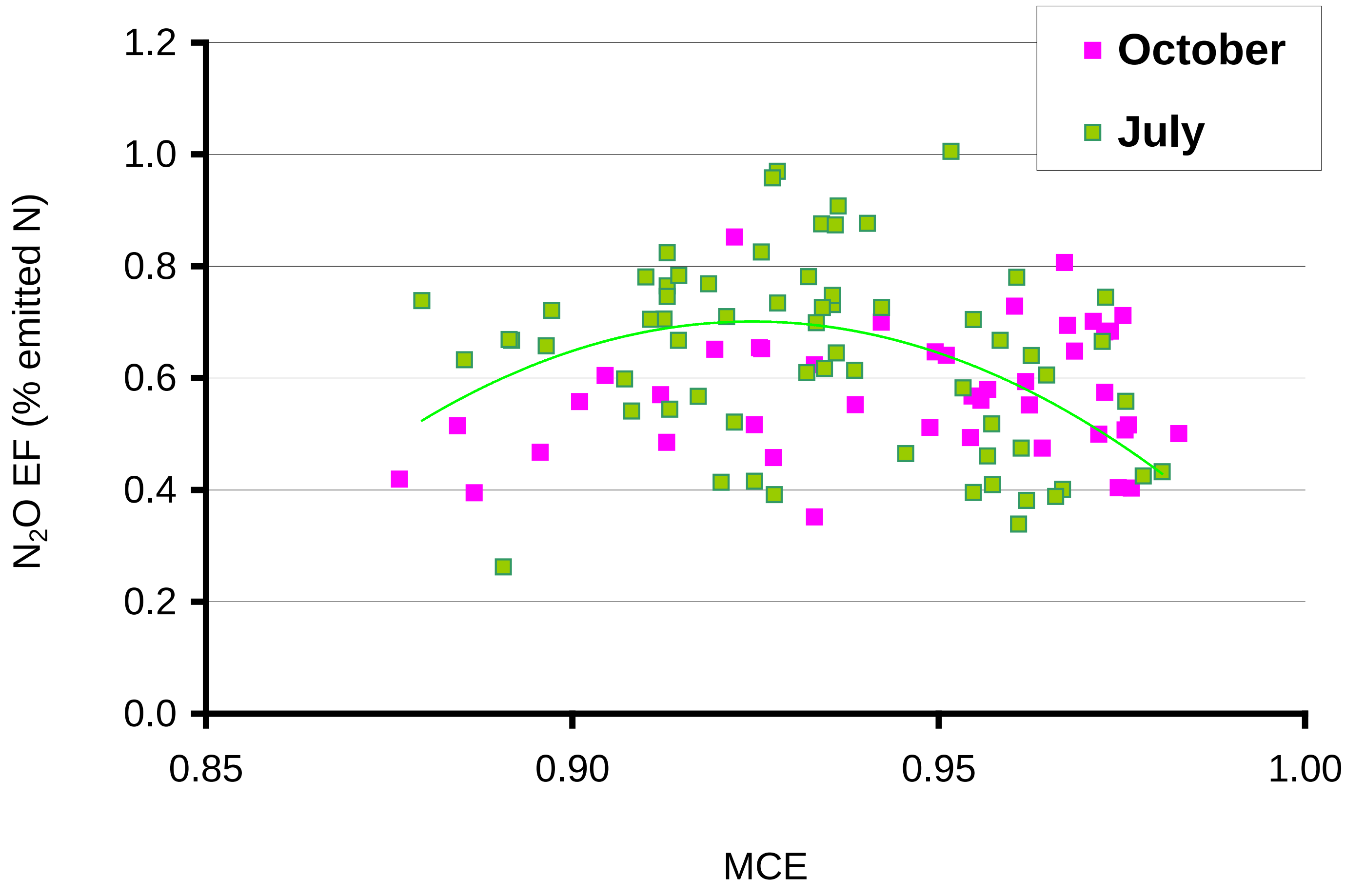


PM emission factors



Paper 2: analysis of PM and VOC emission factors from grass, fine and heavy fuels in Northern Australia

Nitrous oxide: not easily predictable from MCE



Regen Burns in the Huon Valley

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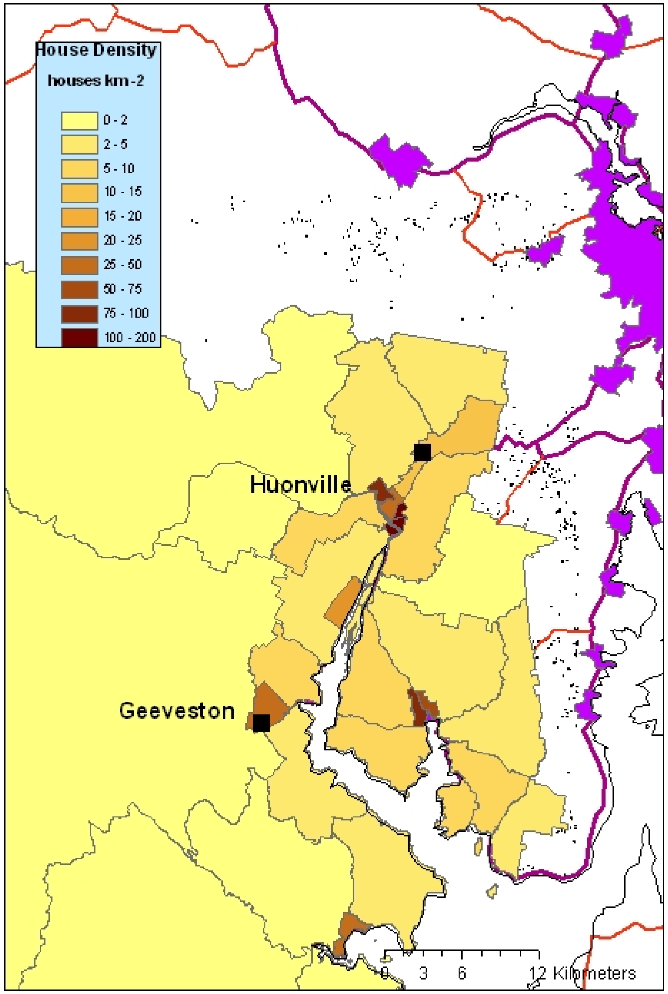

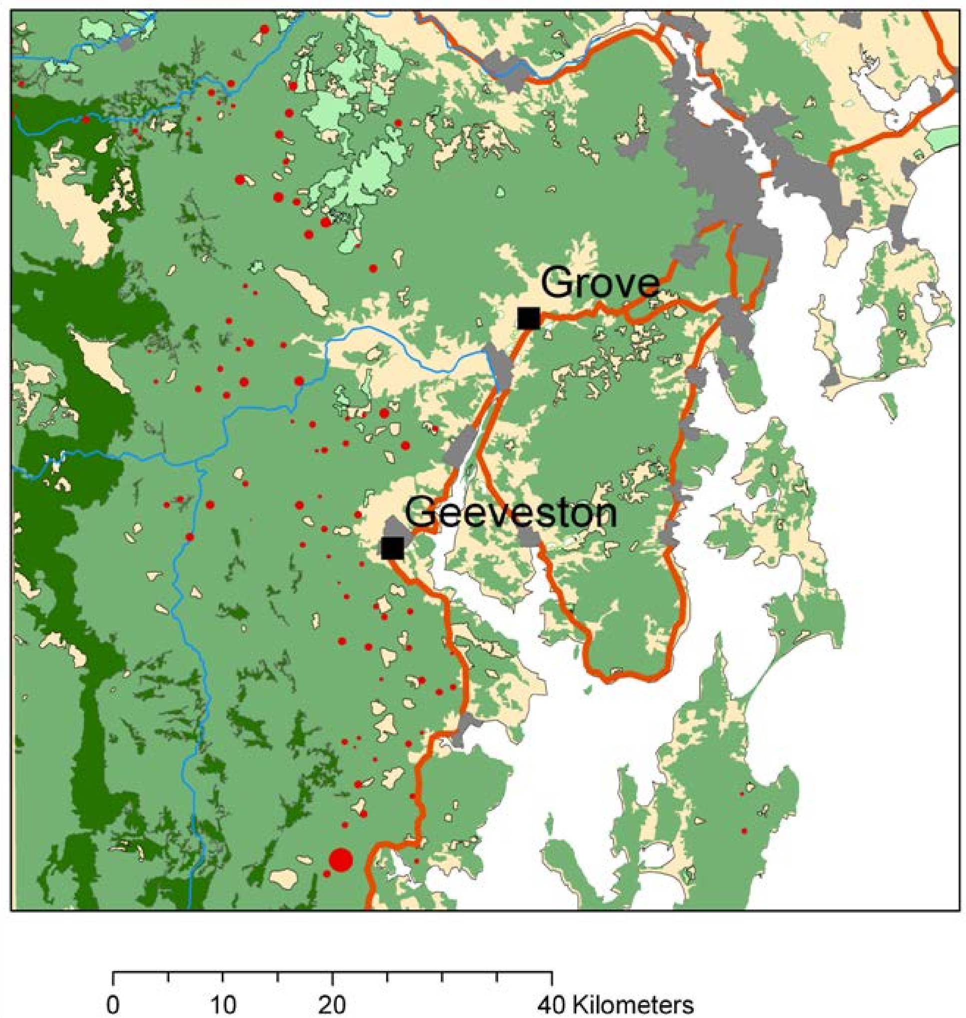

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PM emissions

Source	NPI
Forest Fires	20 (8%)
Domestic Solid Fuel	148 (59%)
Wind-blown Dust	60 (24%)
Fossil Fuel Combustion	20 (8%)
Industry	2 (1%)
Waste	3 (1%)

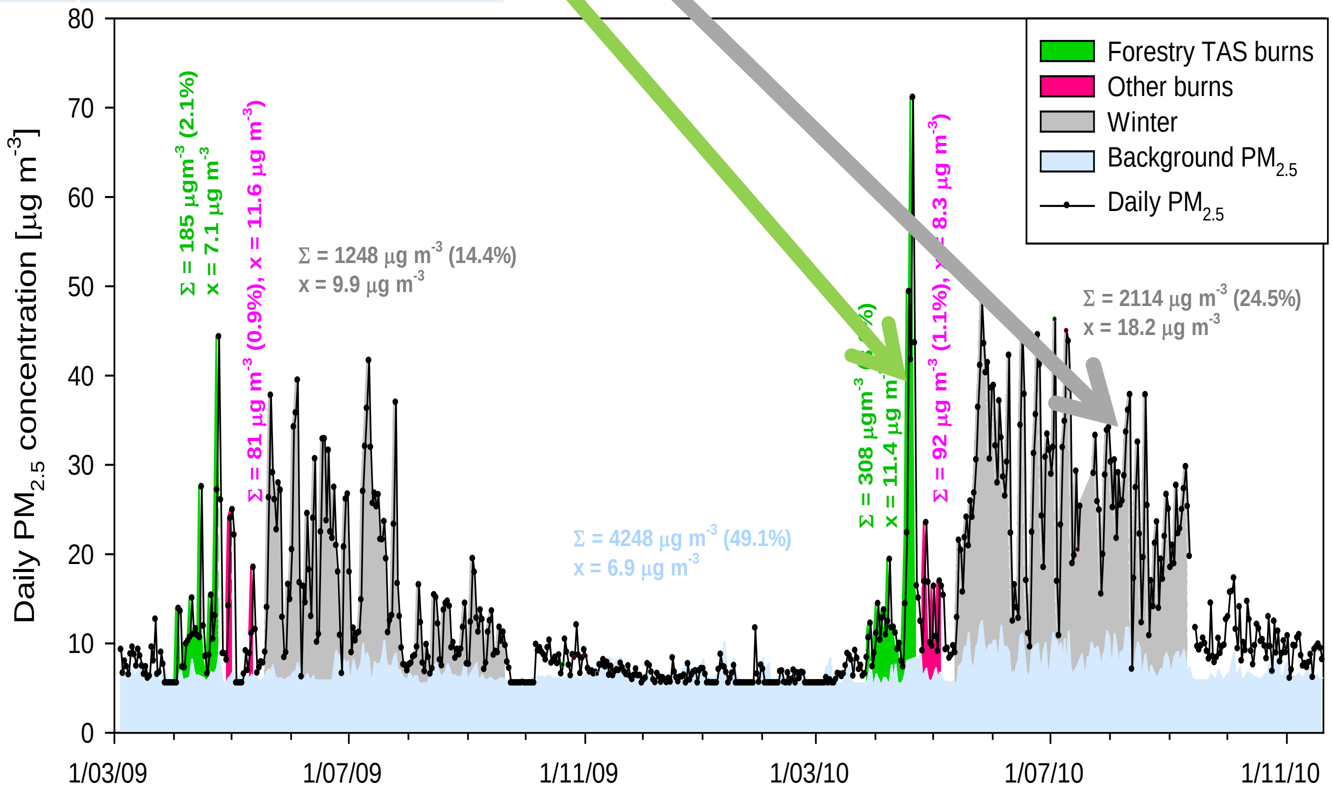
→ ~250 t PM_{10}/yr

But NPI fuel loads are for forest fires (~50 t/ha) not regeneration fires (>200 t/ha)

Source	NPI
Forest Fires	8500 (99%)
Domestic Solid Fuel	121 (<1%)

→ ~8700 t PM_{10}/yr

Source	% Impact on surface concentration
Woodheaters	77
Prescribed burns	11
Private property	4
Other	8



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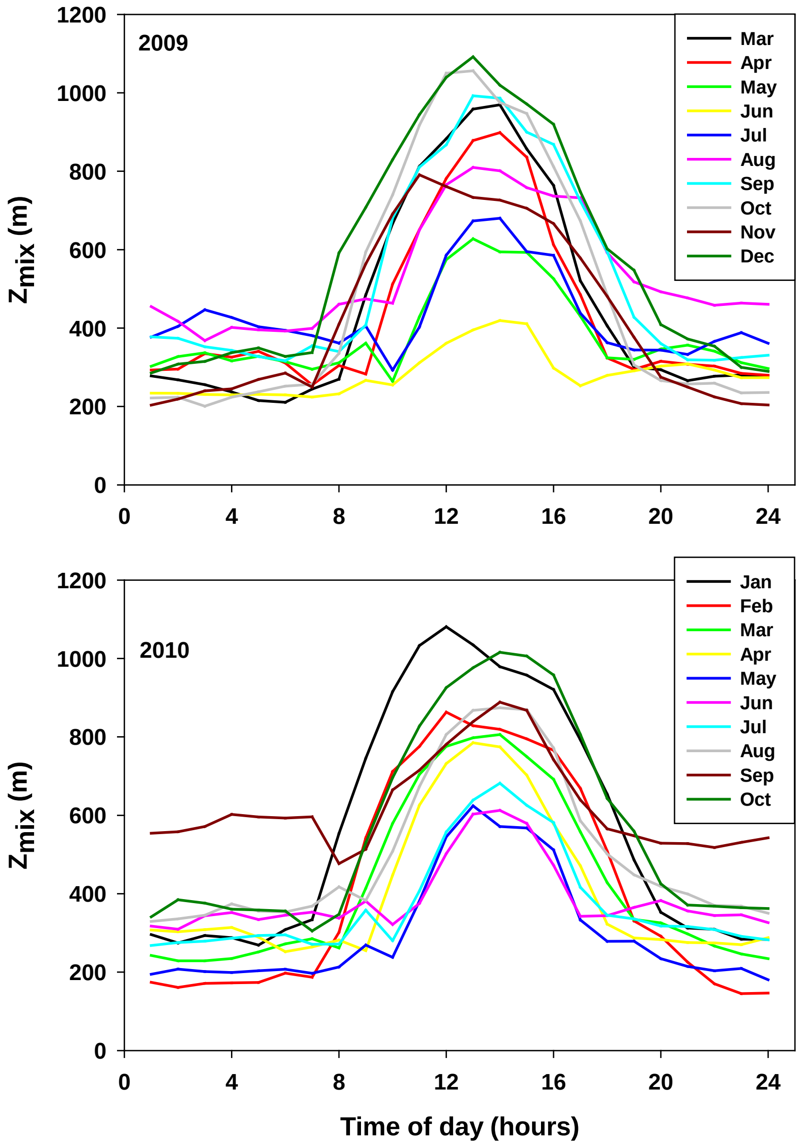
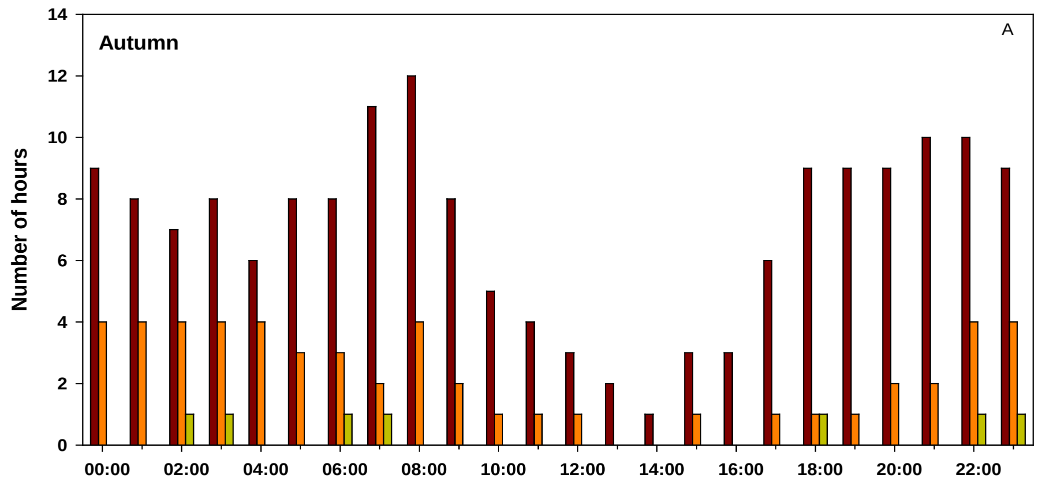
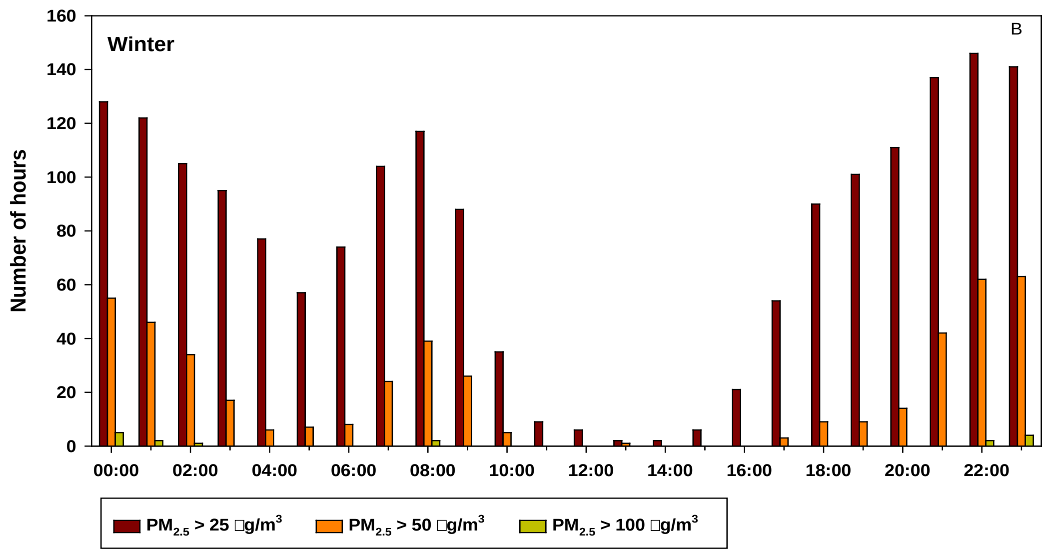
Mixing Depth



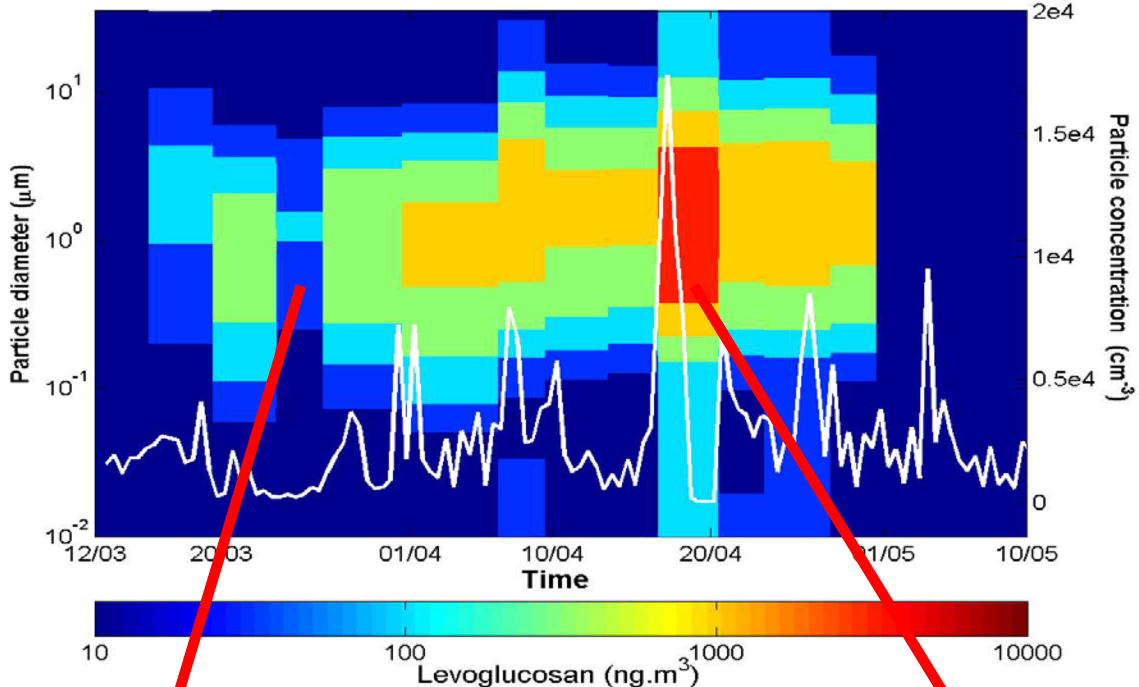
Diurnal distribution of hourly mean smoke concentration



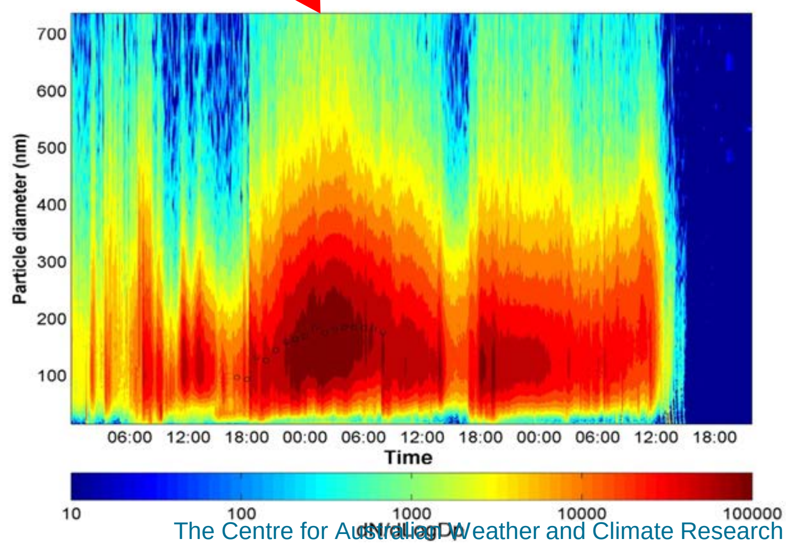
REGEN burns



Woodheaters



Particle diameter (μm)
Particle concentration (cm-3)
2e4
1.5e4
1e4
0.5e4
0
12/03
20/03
01/04
10/04
20/04
01/05
10/05
Time
10
100
1000
10000
Levoglucosan (ng.m3)



Particle diameter (nm)
700
600
500
400
300
200
100
06:00
12:00
18:00
00:00
06:00
12:00
18:00
00:00
06:00
12:00
18:00
Time
10
100
1000
10000
100000
dN/dlogDp