COMPUTING AERIAL SUPRESSION EFFECTIVENESS BY IR MONITORING

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bushfire CRC

CSIRO

OUTLINE

1. **Introduction**

2. **Material and methods**
   - ✓ Experimental site
   - ✓ Experimental design
   - ✓ Performance of the experiments

3. **Methodoloy to analyse the IR images**

4. **Preliminary results**

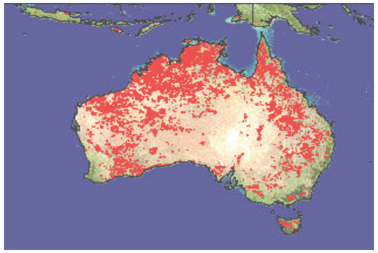
5. **Conclusions**

1. INTRODUCTION

The protection of fire prone ecosystems is a challenge for the scientific community

- A sound understanding of both fire behaviour and suppression difficulty is required.
- Experimental programs are needed to obtain good fire data.

The project FuSE (Bushfire CRC, Australia)



- Milestones
  - Fire behaviour model
  - Prescribed burning guide

- Experimental program
  - Fuel dynamics and fire wheather
  - Fire behaviour
  - **Fire suppression**

1. INTRODUCTION

Aerial suppression effectiveness

How can we define it?

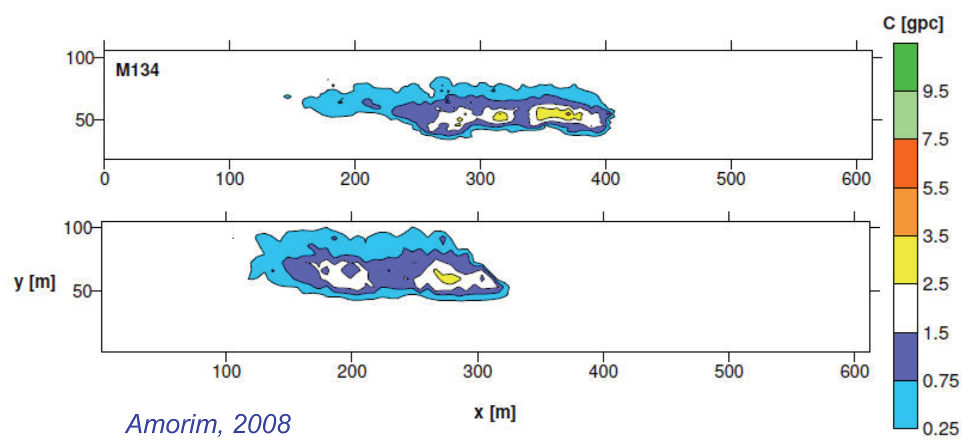
- ✓Productivity
- ✓Placement
- ✓Coverage
- ✓Effect on fire behaviour

Drop effectiveness

1. INTRODUCTION

Aerial suppression drop effectiveness

Drop pattern and chemical properties



Amorim, 2008

1. INTRODUCTION

Aerial suppression drop effectiveness

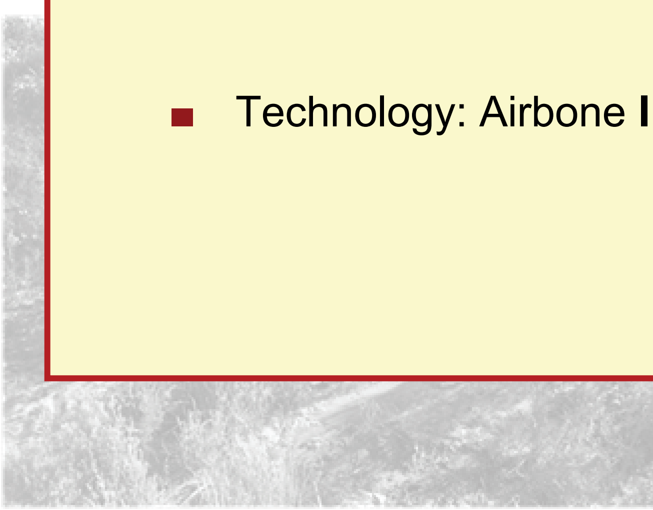
Strategy

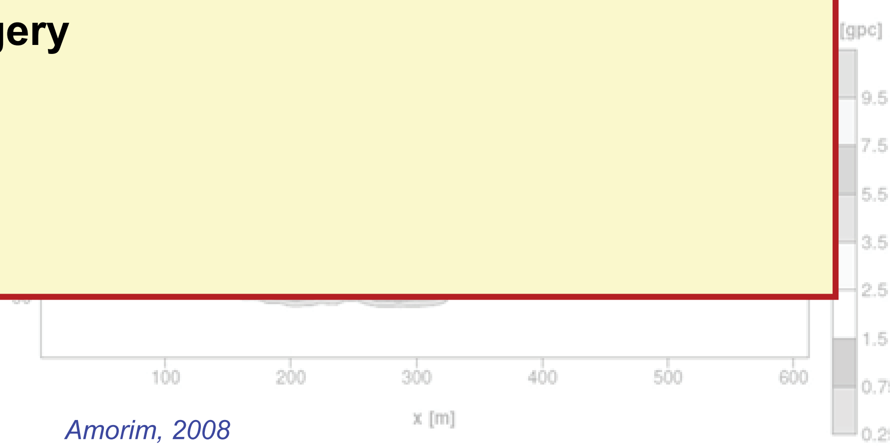
Canopy interception

Main objectives of the study

- Analyse and quantify the **effectiveness** of a “real” fire attack performed by fixed wing aircrafts delivering **chemical suppressant drops,** in a controlled experimental fire scenario.

- Technology: Airbone **IR imagery**





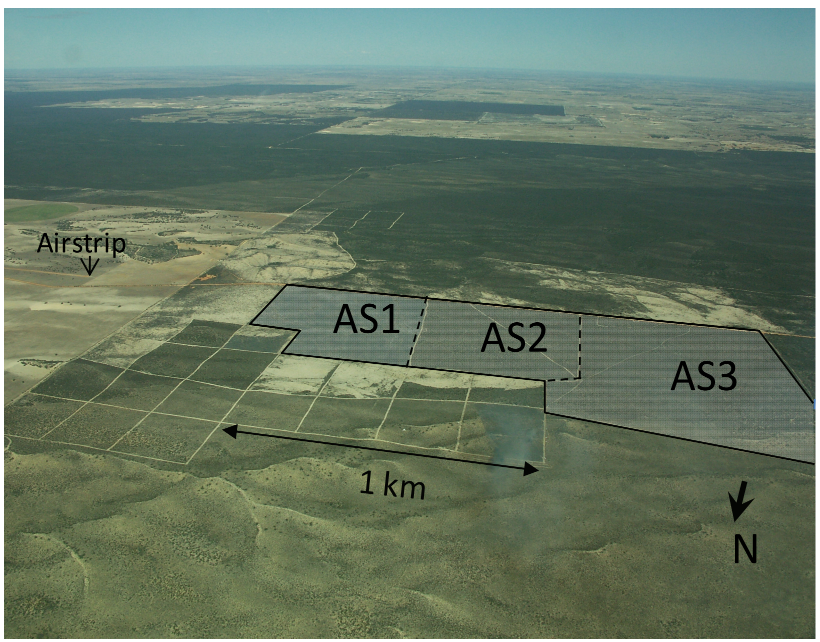
Amorim, 2008

2. MATERIAL AND METHODS

The experimental site

- <u>Location</u>: Ngarkat Conservation Park (eastern South Australia)
- <u>Fuel</u>: 20 year old mallee (woodland dominated by multistemmed eucalypts)
- <u>Experimental area</u>: Composed by 3 large plots and an airbase

AS1 and AS2 (700 m x 750 m) and AS3 (900 m x 1000 m)



2. MATERIAL AND METHODS

The experimental design and equipment

- 3 Types of suppressants: water enhancer, foam and LT retardant
- Data collection roles:
  - Ground investigation
  - Aerial monitoring
    - TIR camera (7.5-13 μm) operated by a laptop computer
      - ✓ IR images (240 x 320 pixels) at 5 fps
    - Video camera
    - Beacons (contained bonfires) as geo-references for image analysis

2. MATERIAL AND METHODS

Performance of the aerial suppression experiments

	03/03/2008:AS1 (Gel)	04/03/2008:AS3 (Retardant)	05/03/2008:AS2 (Foam)
Max Temp , ºC	35	32	37
Min RH , %	8	23	13
Uw (Gust), km/h	16(35)	19(33)	19(33)

- Fires ignited with 200 m drip torch lines perpendicular to the predominant wind
- Aerial fire attack performed by 2 bombers (airtractors 802F)
  - Direct attack at the fire edge for gel and foam; indirect for LT retardant
  - Short turnaround times for multiple loads
- Helicopter hovering (500-800 m) along the plot edge parallel to the fire spread, advancing following the head of the fire.

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2. MATERIAL AND METHODS

Performance of the aerial suppression experiments

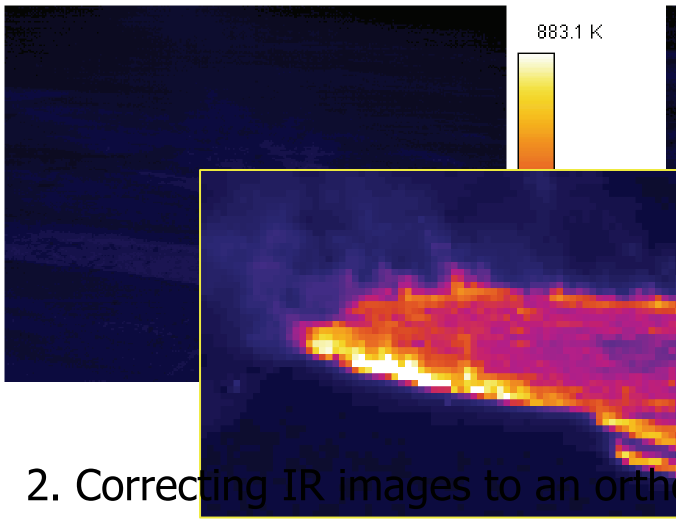
ROS~2.5 km/h
Lf ~ 15 m

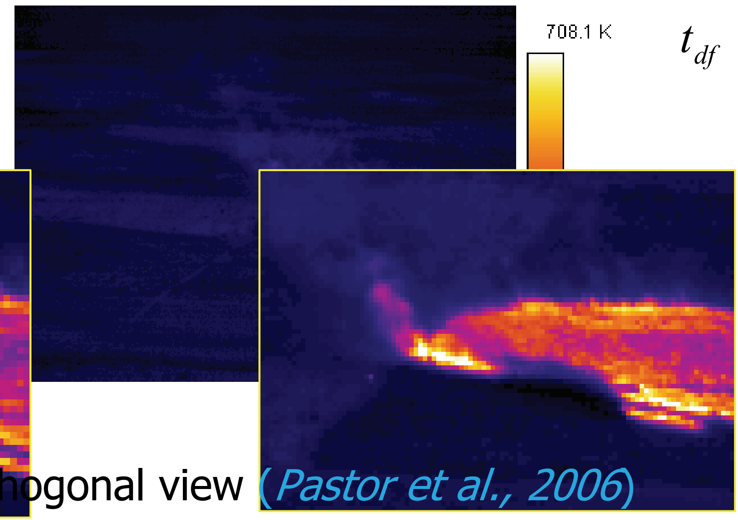
3. METHODOLOGY TO ANALYSE THE IR IMAGES

Part 1: Location of the "drop zone"

- 1. Identifying characteristic drop times

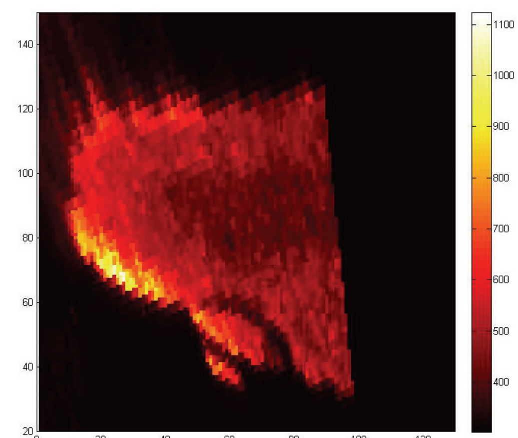
t_{di}





t_{df}

- 2. Correcting IR images to an orthogonal view *(Pastor et al., 2006)*
  - Homography matrix (4 geo-referenced points needed)

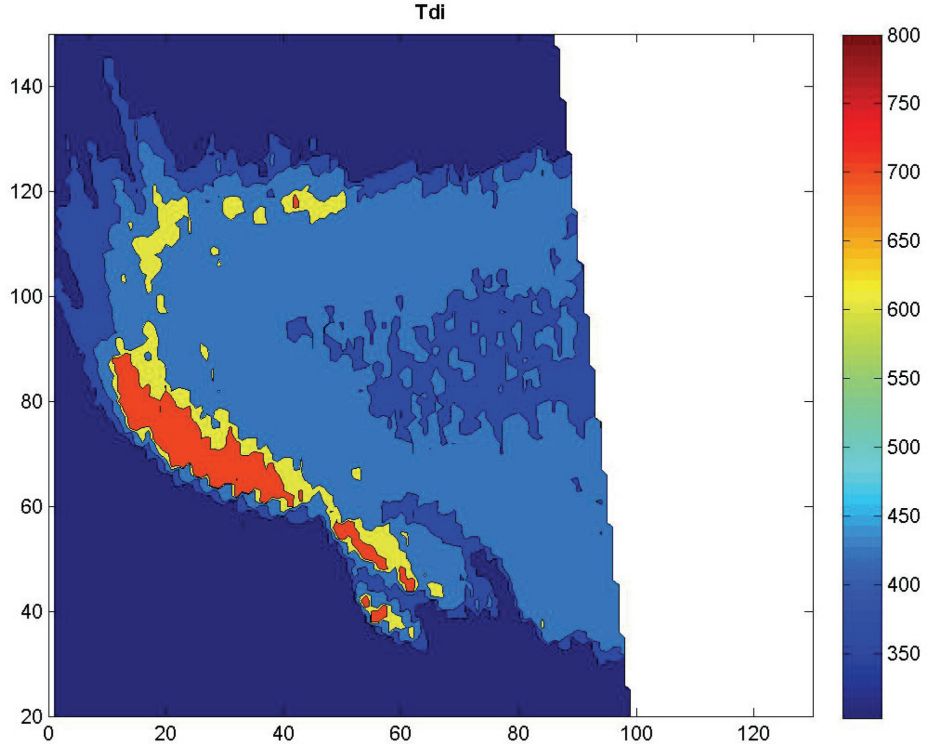


3. METHODOLOGY TO ANALYSE THE IR IMAGES

Part 1: Location of the "drop zone"

- 3. Segmenting the IR images

Characteristic zone	IR temperature value (K)
Flaming	>700
Glowing	600-700
Residual / Preheating	425-600
Burned	360-425
Unburned / cooled	<360

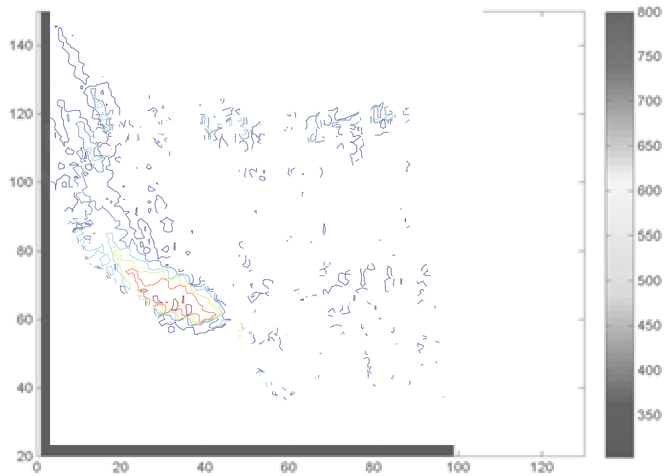


3. METHODOLOGY TO ANALYSE THE IR IMAGES

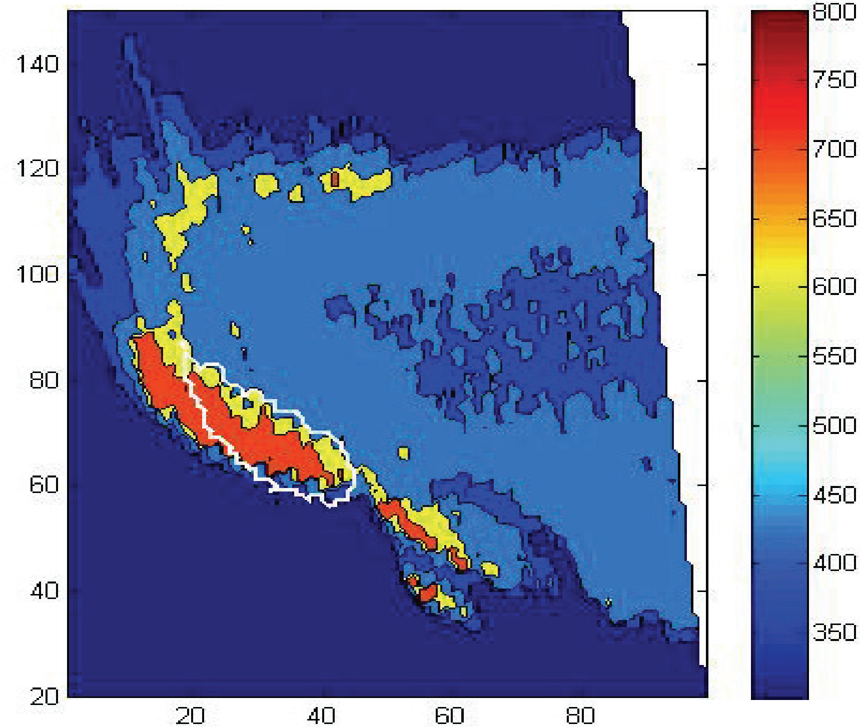
Part 1: Location of the "drop zone"

- 4. Identifying the drop on the ground surface
  - Calculating the temperature gradients

$$\nabla T_{drop} = \frac{T(t_{di}) - T(t_{df})}{T(t_{di})}$$



Characteristic zone	Gradient
Flaming	25%
Glowing	25%
Residual / Preheating	15%
Burned	10%
Unburned / cooled	10%



3. METHODOLOGY TO ANALYSE THE IR IMAGES

Part 2: Characteristic parameters of the drop and evolution over time

- Geometric parameters
  - Area covered by the drop
  - Maximum length and width
  - Drop zone areas covering different predefined sectors
- Apparent temperatures
  - Minimum, maximum and mean temperatures for the whole drop and the different sectors
- Drop interaction with the fire perimeter evolution

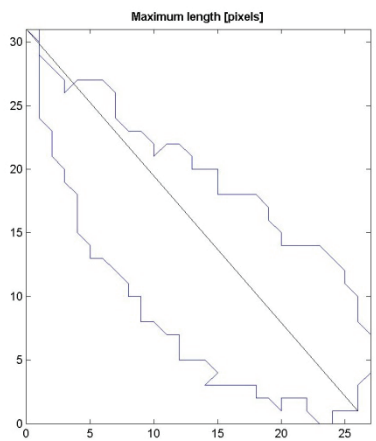
Suppression effectiveness indicators of…

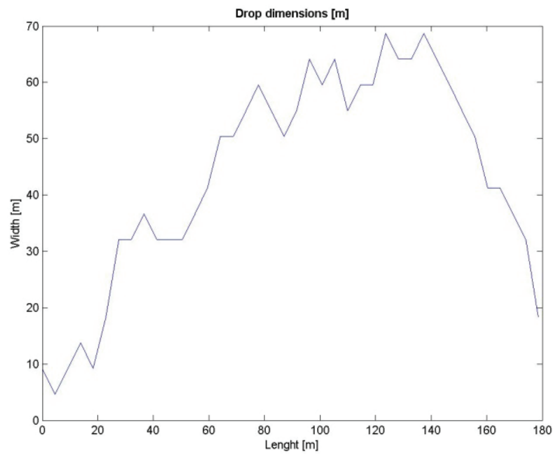
- Placement (strategy of the aerial attack)
- Coverage
- Effects on fire behavior (performance of the chemical suppressant)

4. PRELIMINARY RESULTS (drop 2)

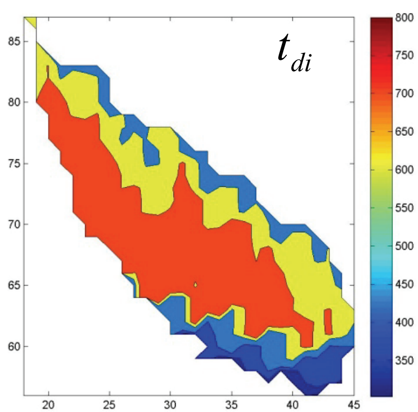
Geometric parameters

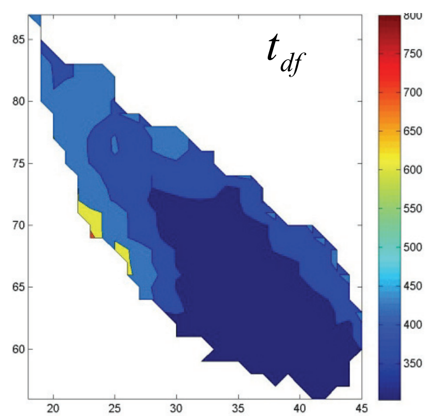
- Characteristic dimensions

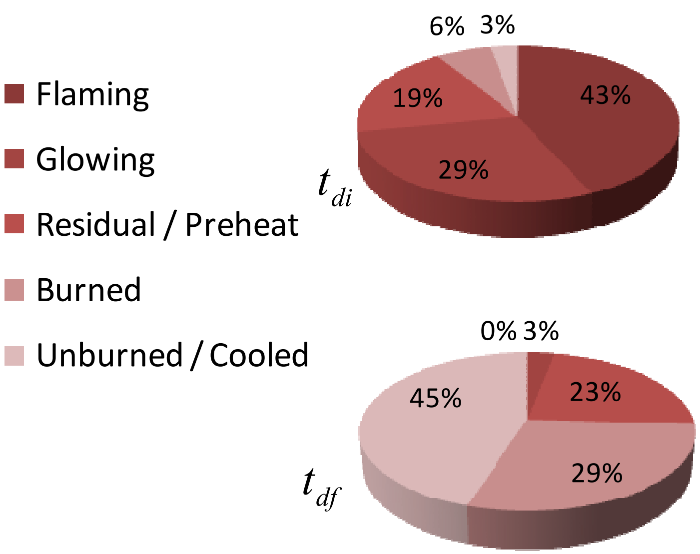




- Area covered: 3393 m^2
- Max length: 180 m
- Max width: 68 m

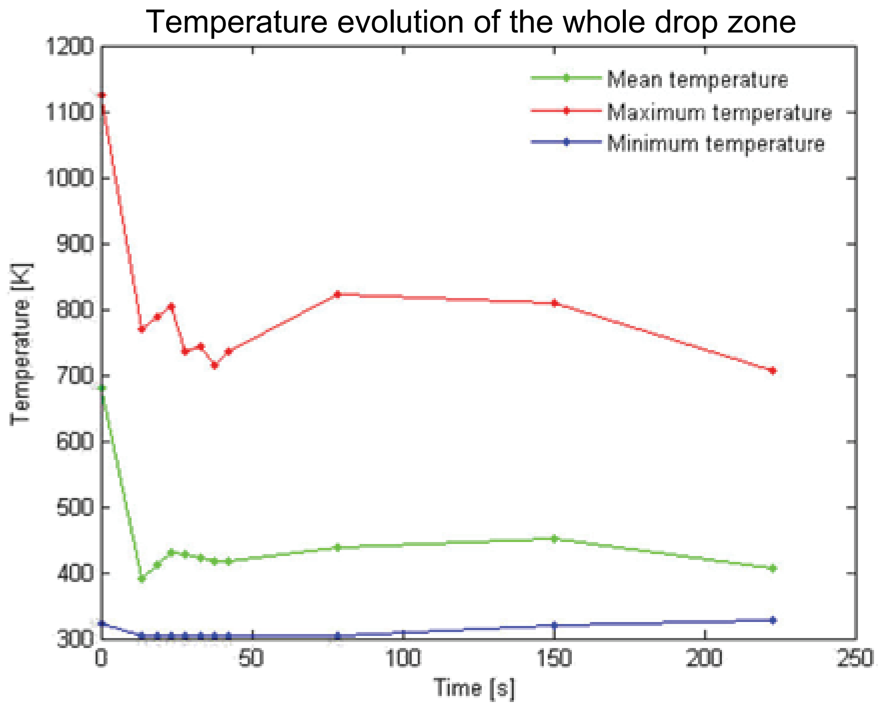




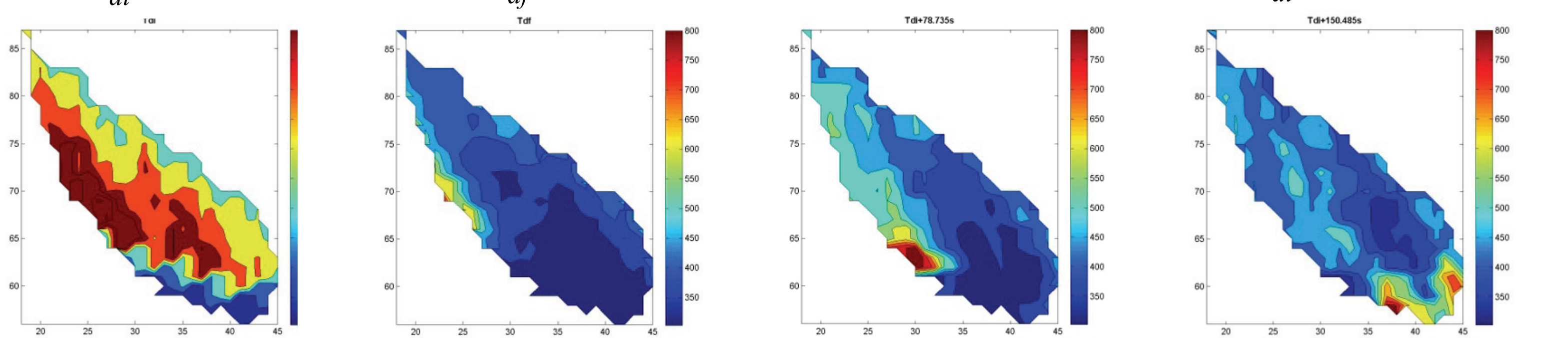


4. PRELIMINARY RESULTS (drop 2)

Aparent temperatures



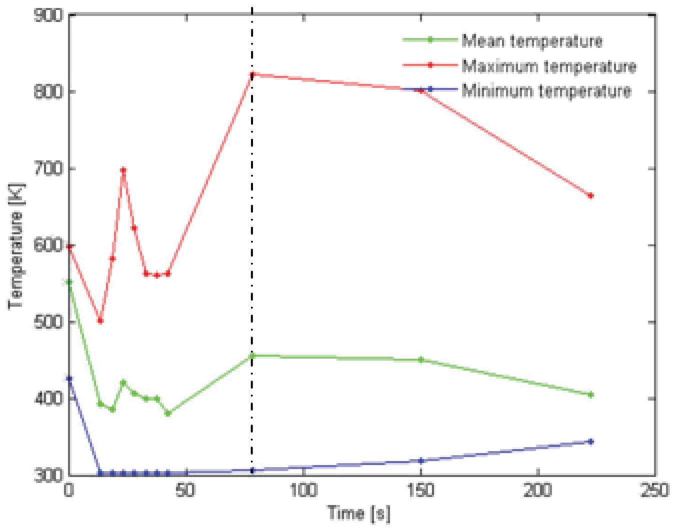
$t_{di} = 0$ t_{df} $t_{di} + 78s$ $t_{di} + 150s$



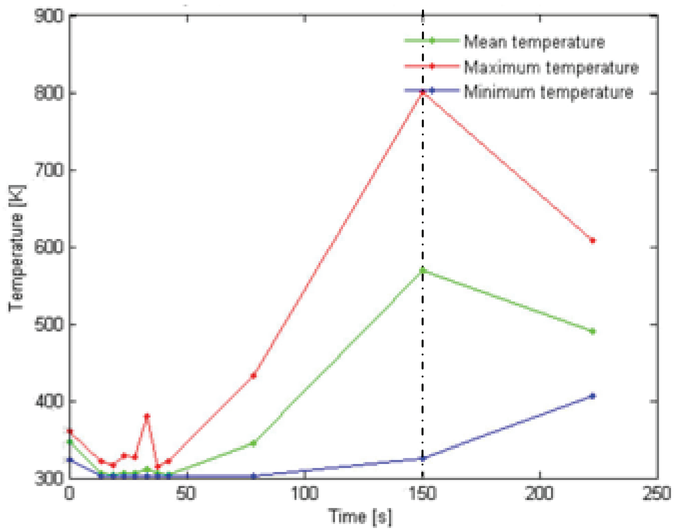
4. PRELIMINARY RESULTS (drop 2)

Aparent temperatures

Temperature evolution of the preheating area

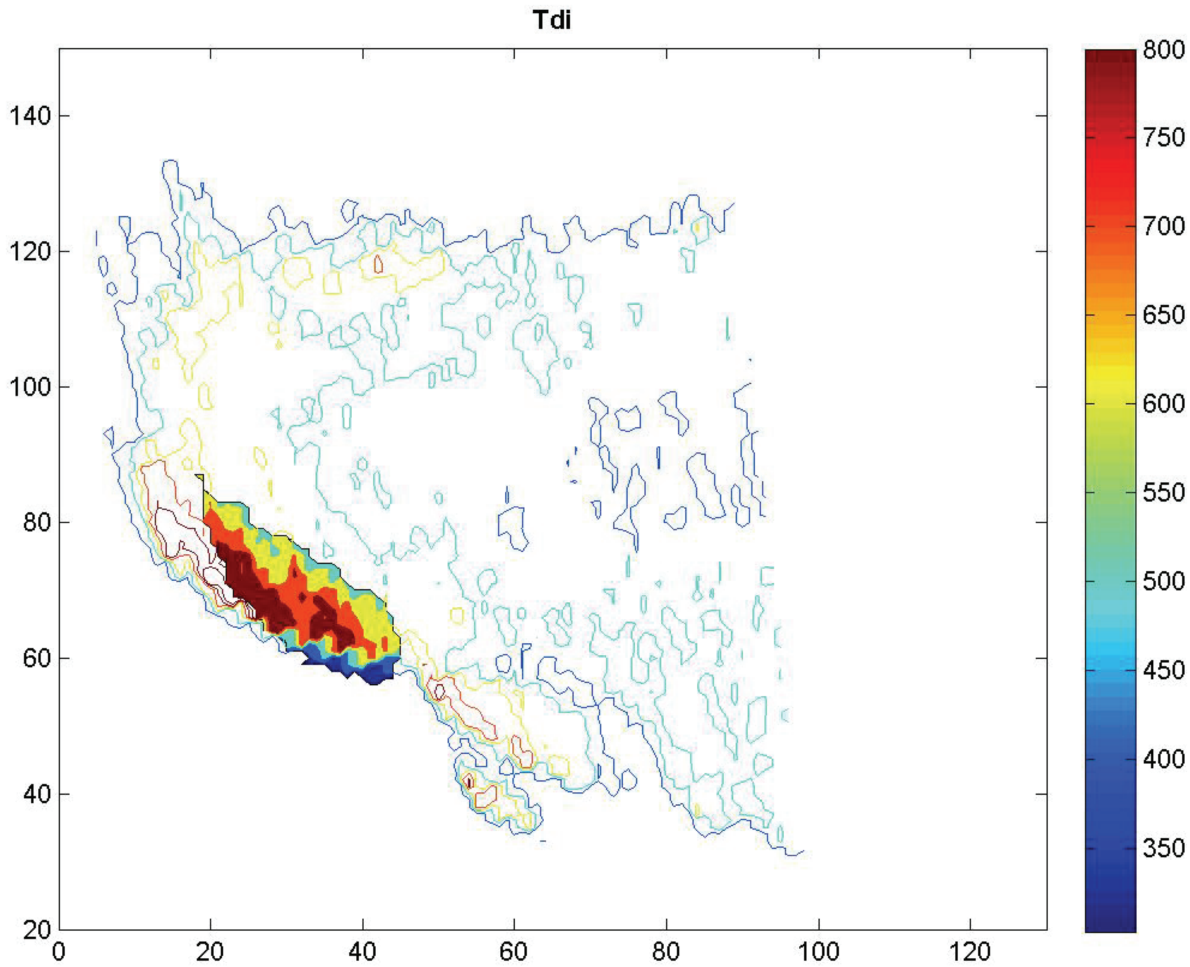


Temperature evolution of the unburned area



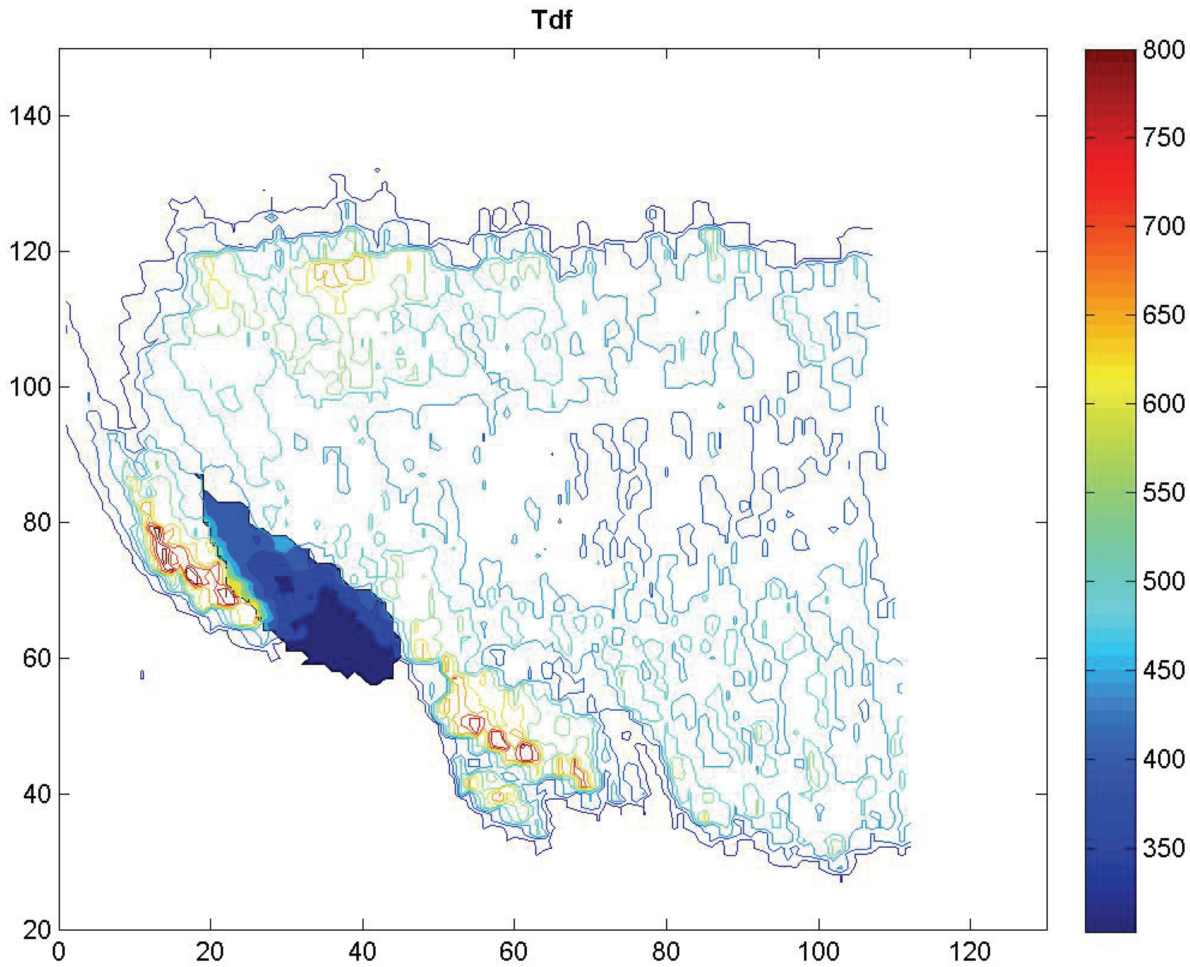
4. PRELIMINARY RESULTS (drop 2)

Fire evolution – drop interaction



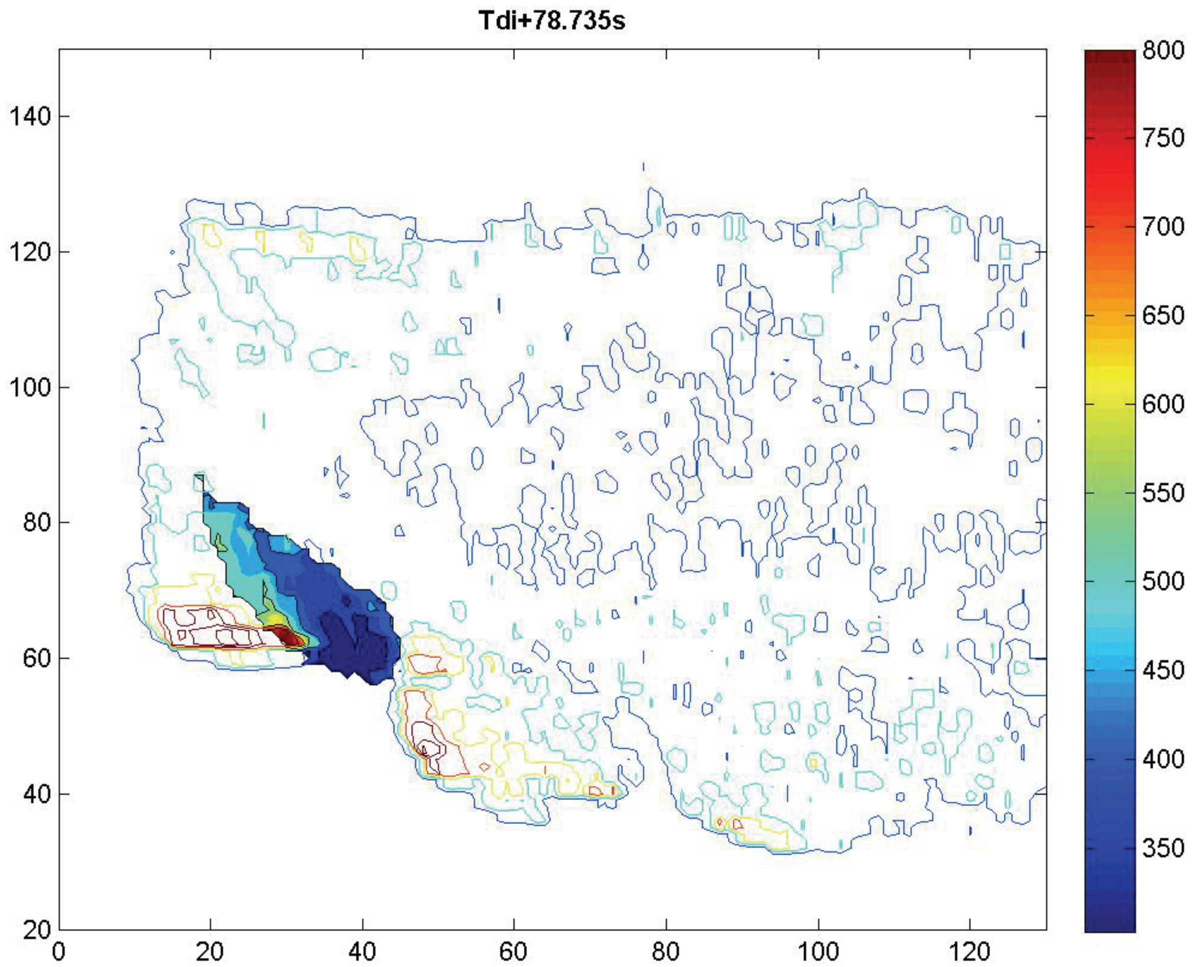
4. PRELIMINARY RESULTS (drop 2)

Fire evolution – drop interaction



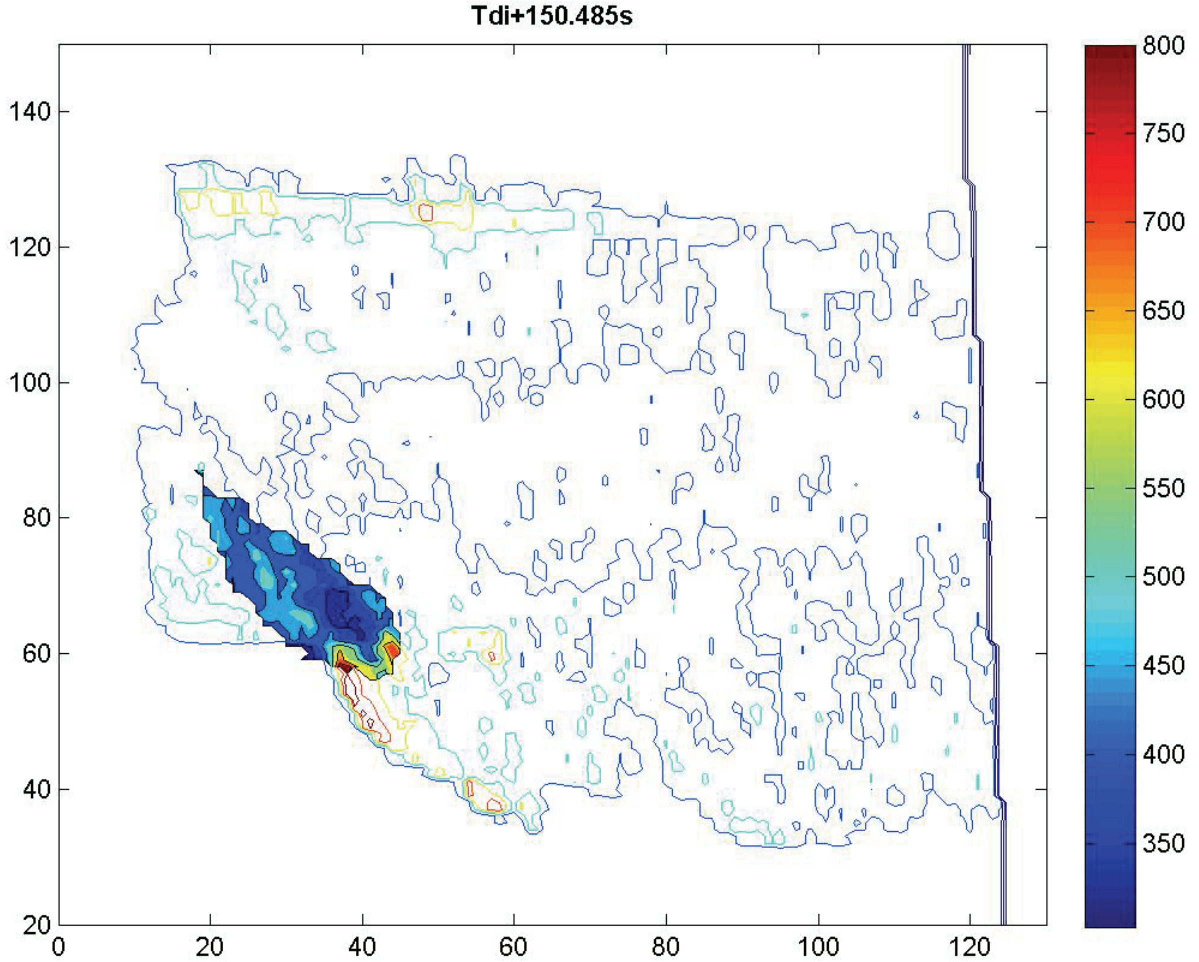
4. PRELIMINARY RESULTS (drop 2)

Fire evolution – drop interaction



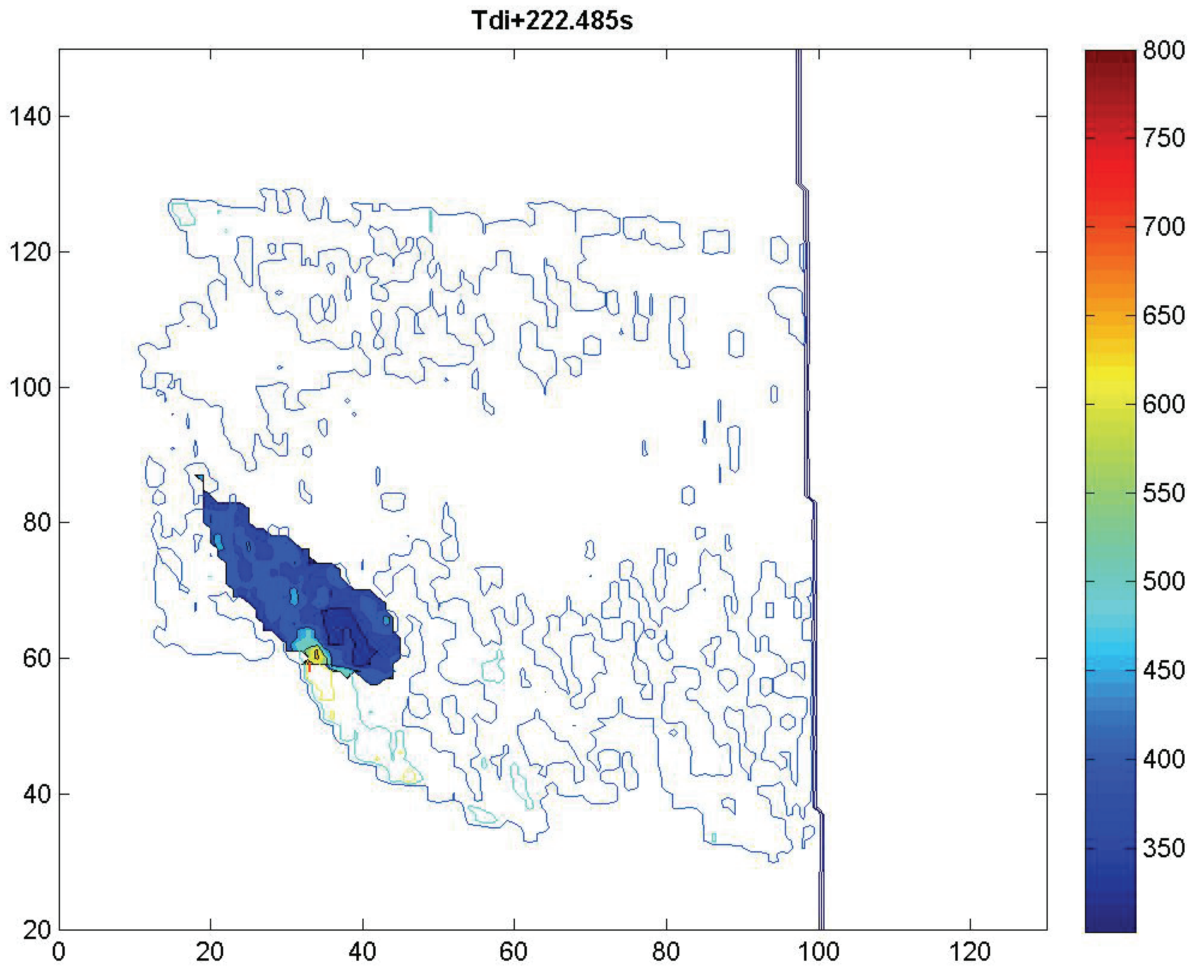
4. PRELIMINARY RESULTS (drop 2)

Fire evolution – drop interaction



4. PRELIMINARY RESULTS (drop 2)

Fire evolution – drop interaction



5. CONCLUSIONS

- A methodology to quantify aerial suppression effectiveness at fine scale by means of airborne IR images has been developed.
- This methodology has shown to be reliable and powerful in the analysis of large fire scenarios

Suppression effectiveness indicators of...

- Placement (tactics and strategy)
- Coverage
- Effects on fire behaviour (performance of the chemical suppressant)

Placement of the drop:

✓ Was this the intended target?
✓ Has the drop been anchored and linked well?
✓ Was this the most appropriate target?

Coverage:

✓ Did the drop land in the fire edge?
✓ Already burned areas?
✓ Unburned fuel?

Effects on fire behaviour:

✓ Did the fire burn around the drop? Burn through?
✓ Did the drop holding time last enough?

Further work:
Indexes of Drop Effectiveness