
# Planning observations of a fleet of UAVs to monitor wildfires

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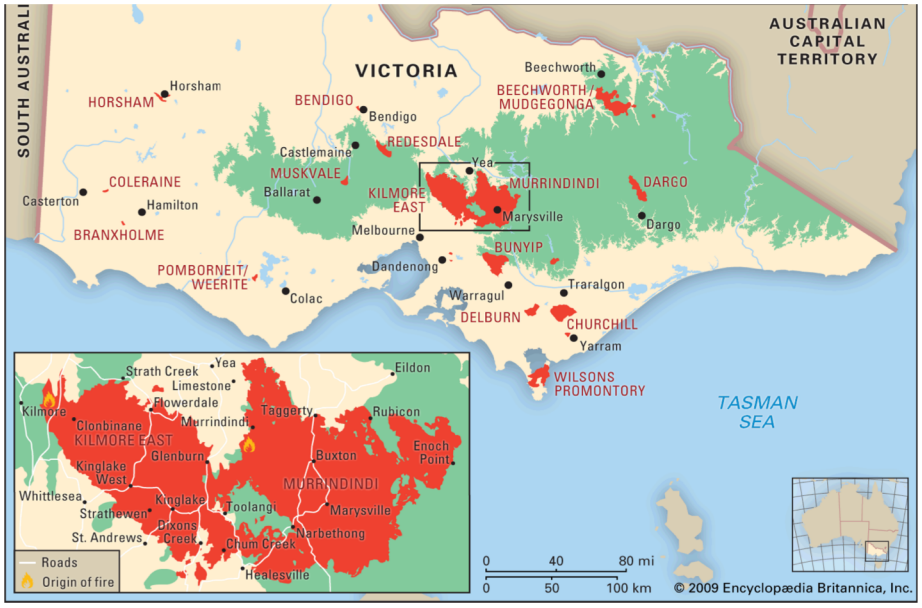
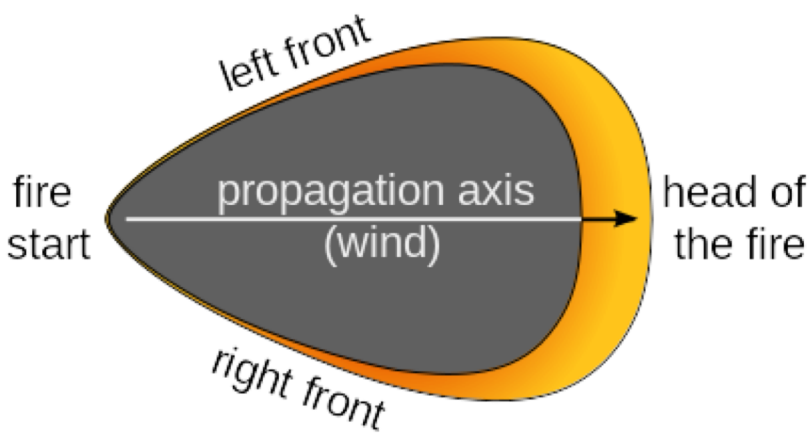
# A very brief introduction to wildfires

- **Wildland areas**
- **Propagation speed from 1 km/h to 10 km/h… or even faster**
- **Can last days or weeks**
- **They cause massive damage to people, property and the environment**



# Wildfire propagation

- **Wildfire physics → Complex interactions**
  - Thermodynamics, fluid mechanics, combustion…
- **Mainly:**
  - Slope
  - Wind speed
  - Vegetation types
  - Weather




- **Wildfire spread can be predicted from accurate data**

# Wildfire monitoring

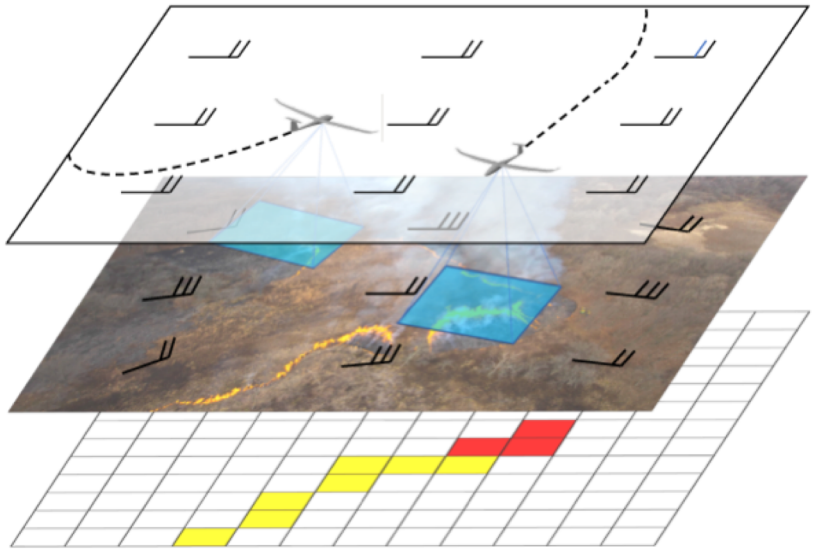
- **Fire fighters need to be well informed to make good decisions**
- **Information must be:**
  - Accurate
  - Up-to-date
  - Comprehensive/Complete
- **Multiple approaches:**
  - Watch towers, satellite imagery, helicopters...

# Using fleets of UAVs for wildfire monitoring

- Unmanned aerial vehicles equipped with IR cameras
- Explore large areas for long periods of time
- Real time footage of the fire + automated wildfire mapping
- Reduced risk

# Challenges of observing wildfires with UAVs

- Wildfire propagation is uncertain
- They are only observable at the fire front
- Observations have to be scheduled
- Fixed-wing UAV motion constraints



# FireRS SAOP: Automated wildfire monitoring software

***Provide firefighters with better information so they can make better decisions***

## 1.Prediction :

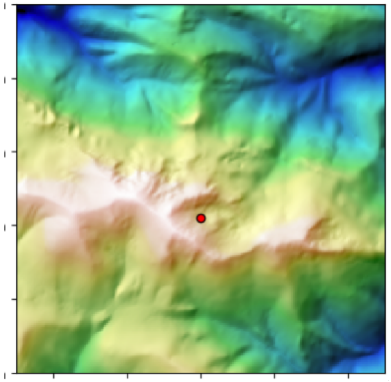
- Estimation of the current state of the fire from observations
- Realistic wildfire perimeter forecast

## 2.Observation Planning :

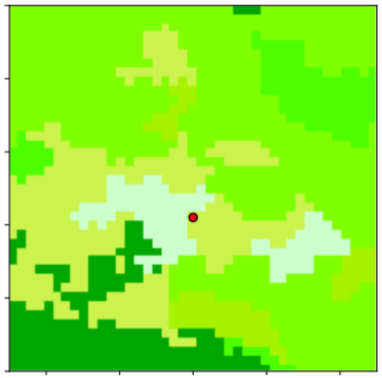
- Optimal path planning for fleets of UAVs

## 3.Fire Observation

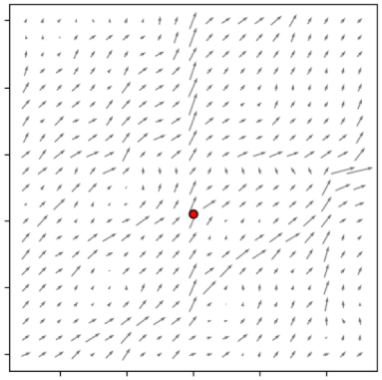
# Realistic wildfire perimeter forecast



Elevation

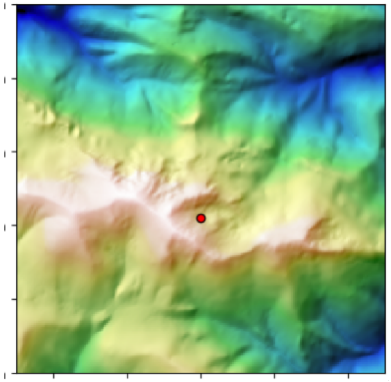


Fuel



Local wind

# Realistic wildfire perimeter forecast



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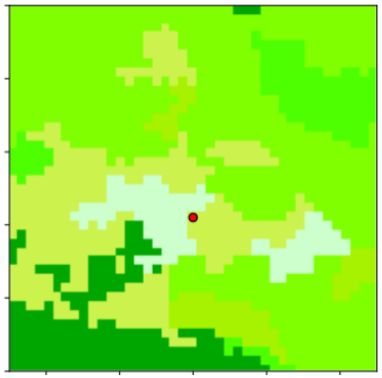

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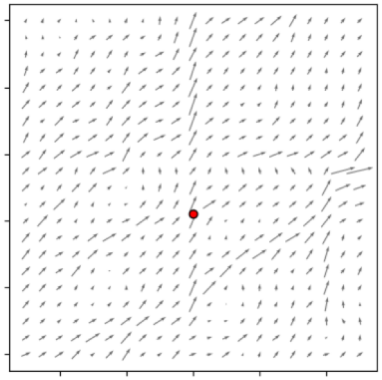
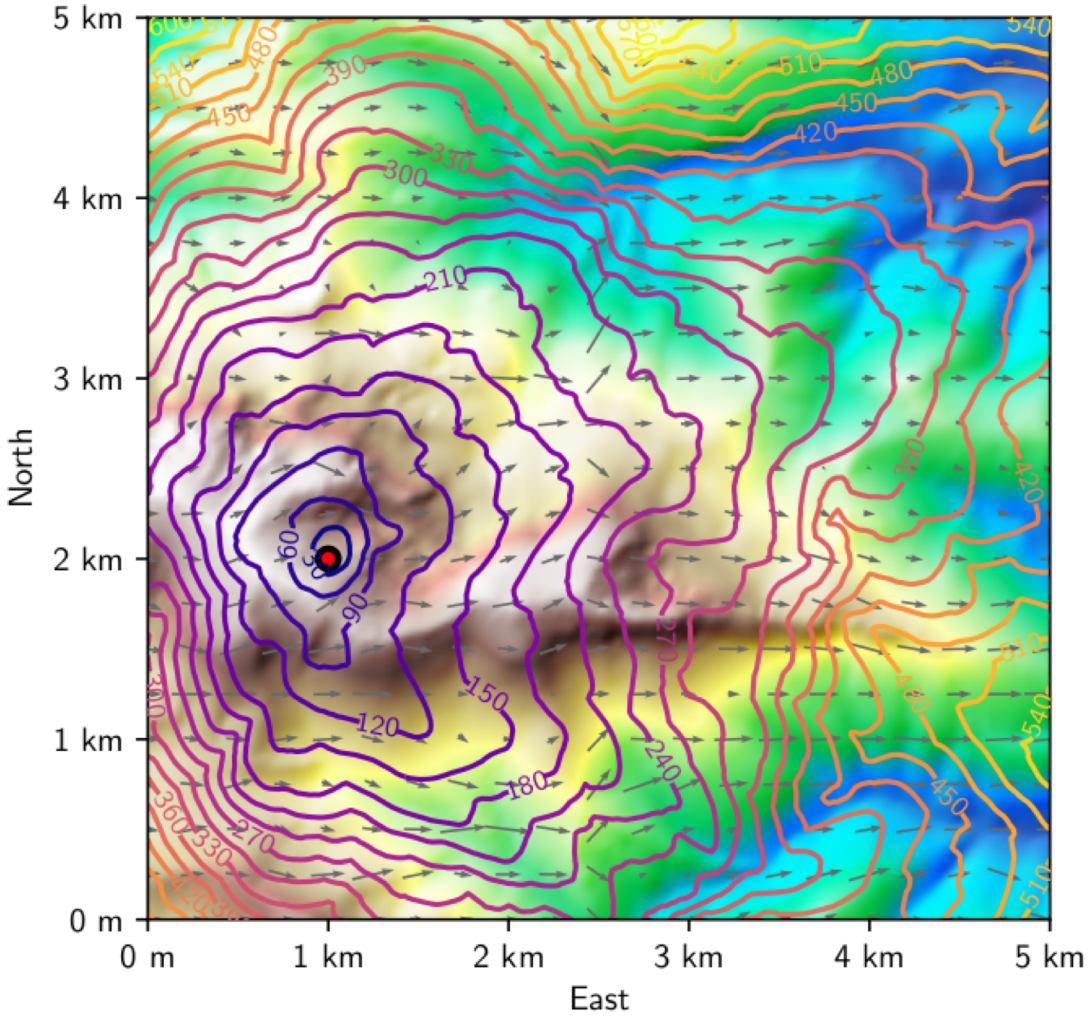


Local wind

# Fire prediction



# Observation Planning

- **Path planning algorithm**
  - Determine which places to visit,
  - and in which order,
  - so that the information gain is maximal
  - without exceeding UAV motion constraints

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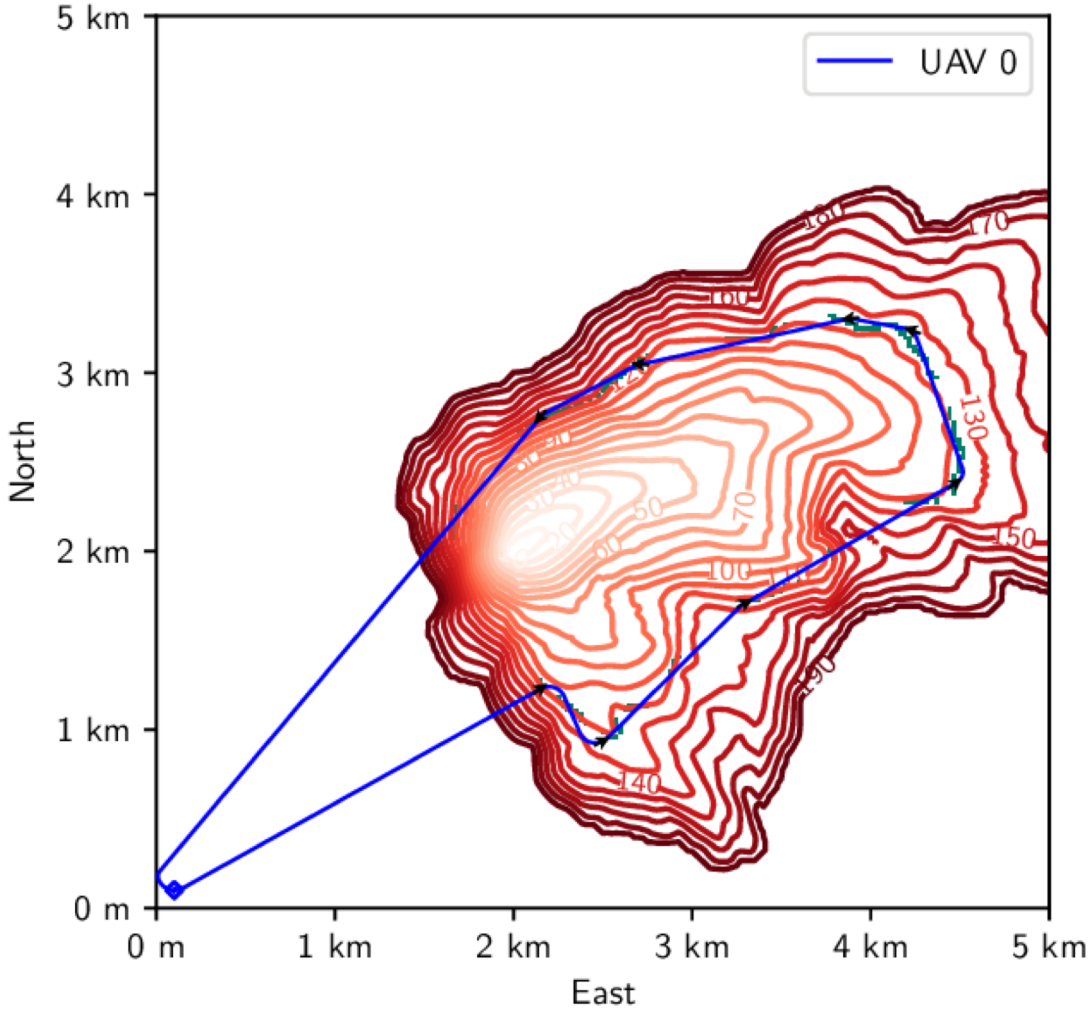
# Some observation Plans



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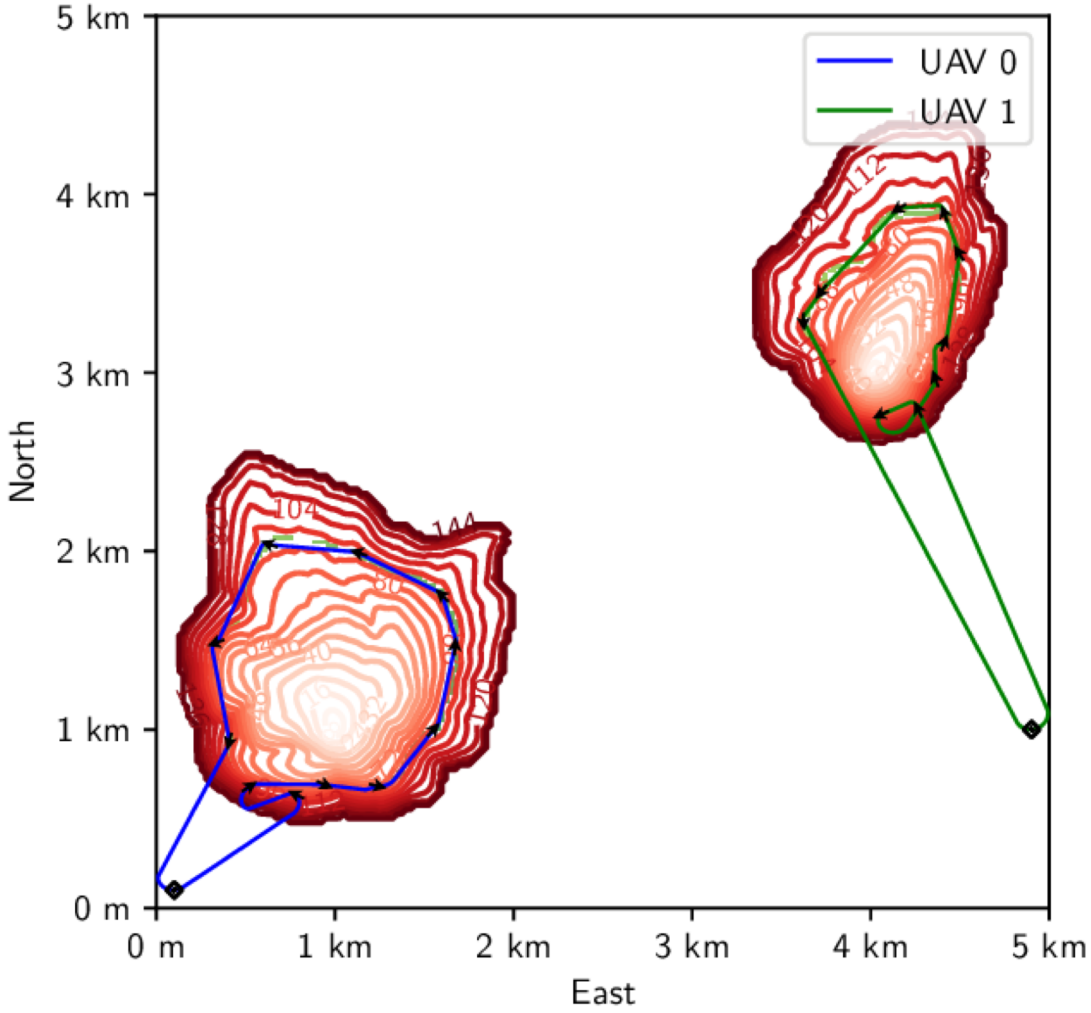

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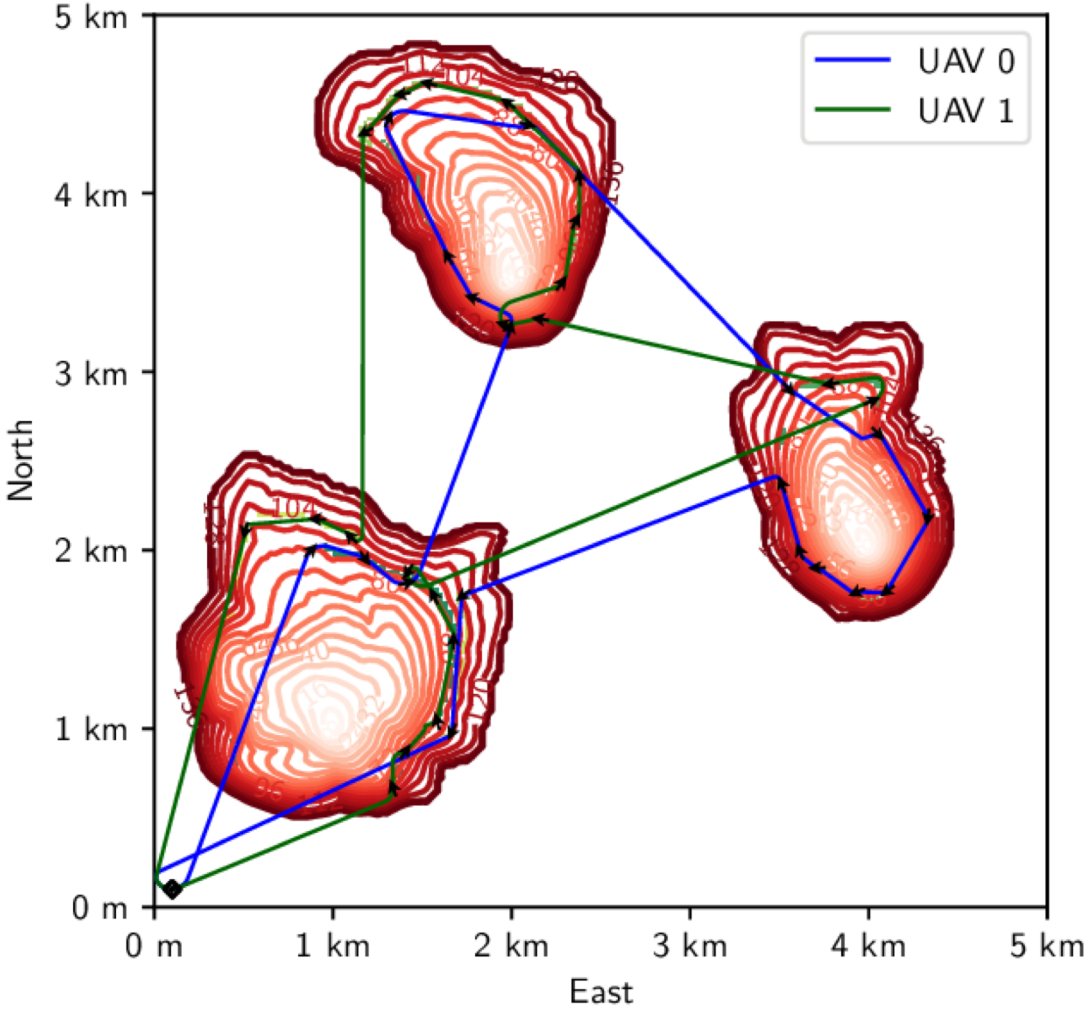
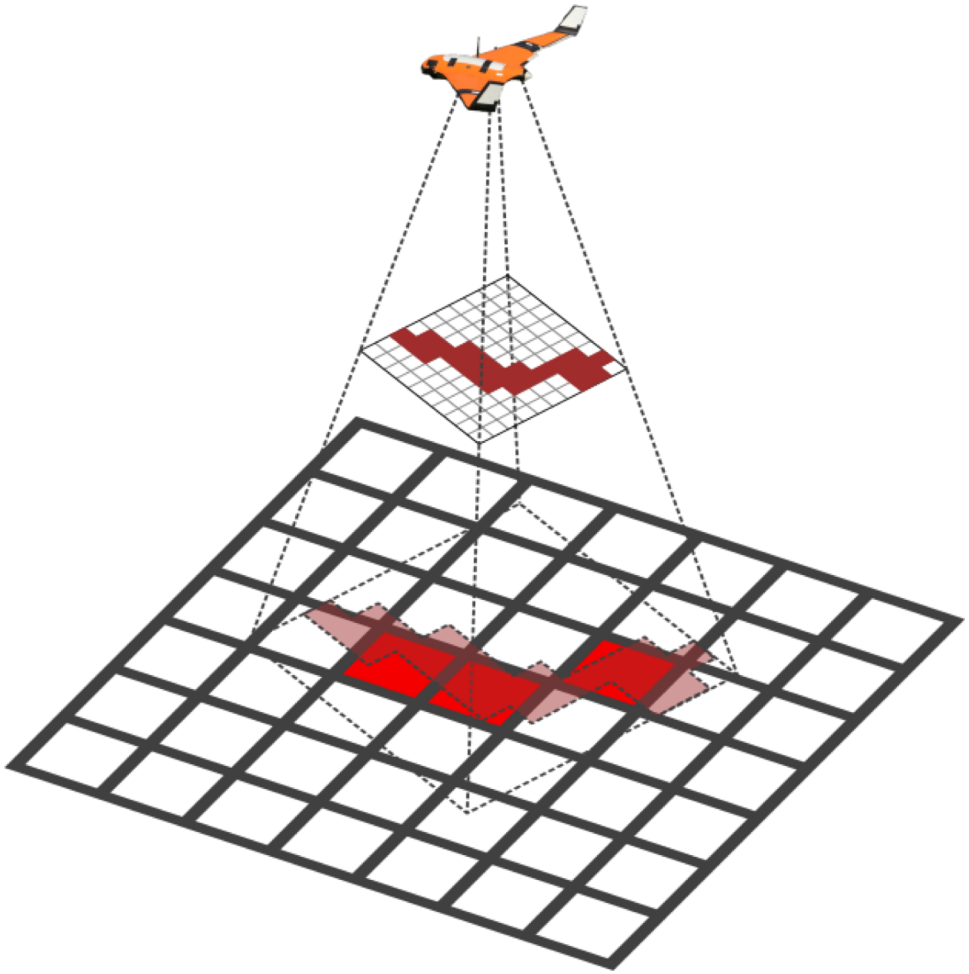


# Fire Mapping

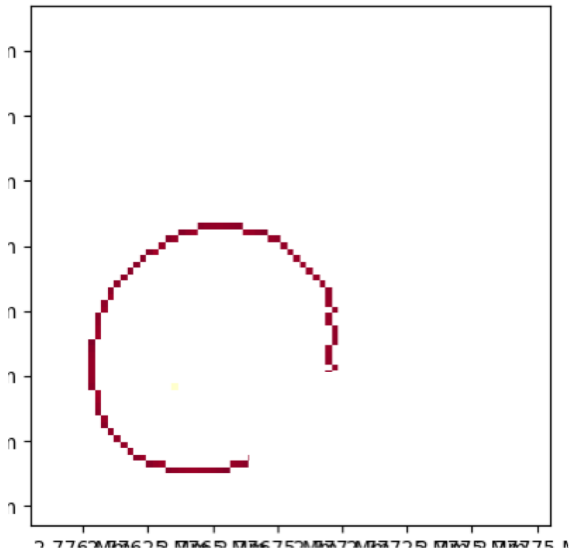
- Execution of the observation plan
- On board generation of local wildfire maps
- Possible real-time video broadcast: real-time monitoring by the firefighters



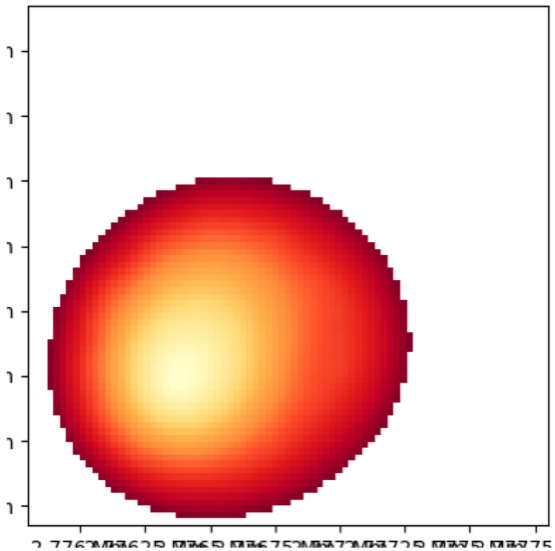
# Estimation of the wildfire current state

- Observations of the wildfire may be partial
- Reconstruction of the perimeter

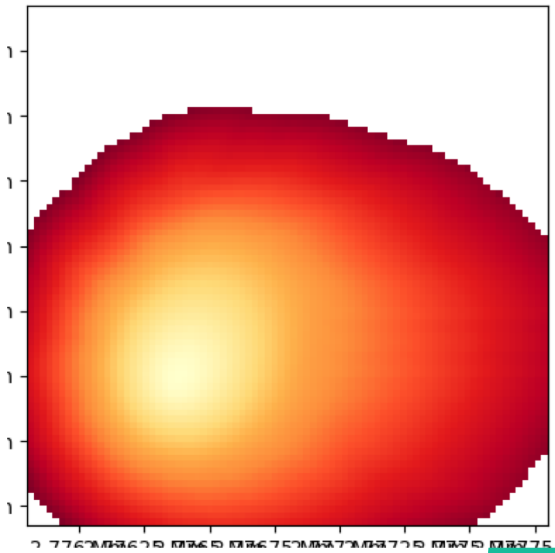
## Observed fire



## Current assessment



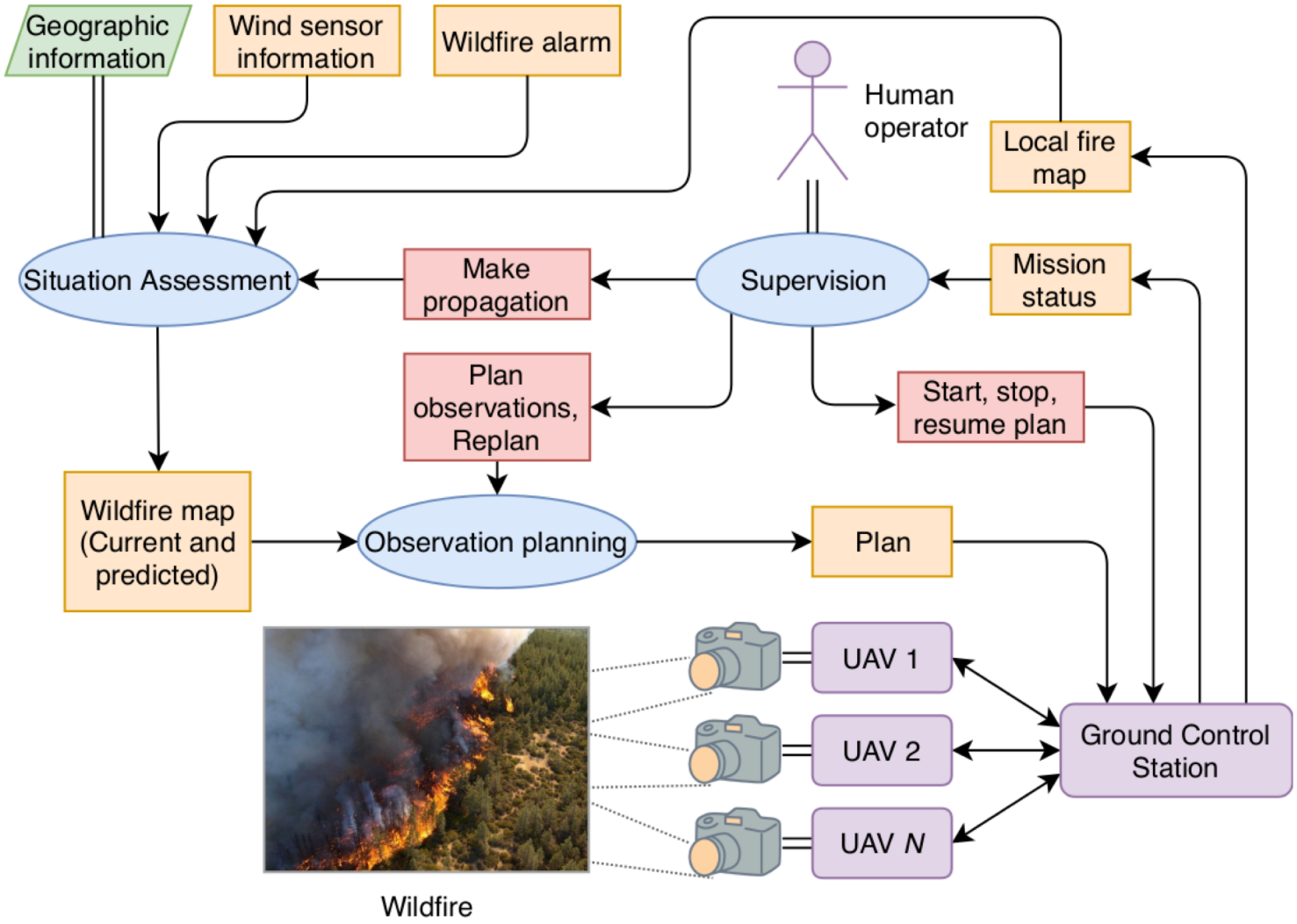
## Future assessment



# FireRS SAOP operation

- **Software architecture:**
  - Orchestrate the Prediction, Planning and Observation operations
  - Monitor the fleet of UAVs
  - Manage data flow: fire maps, alarms…
- **User interaction:**
  - High level commands

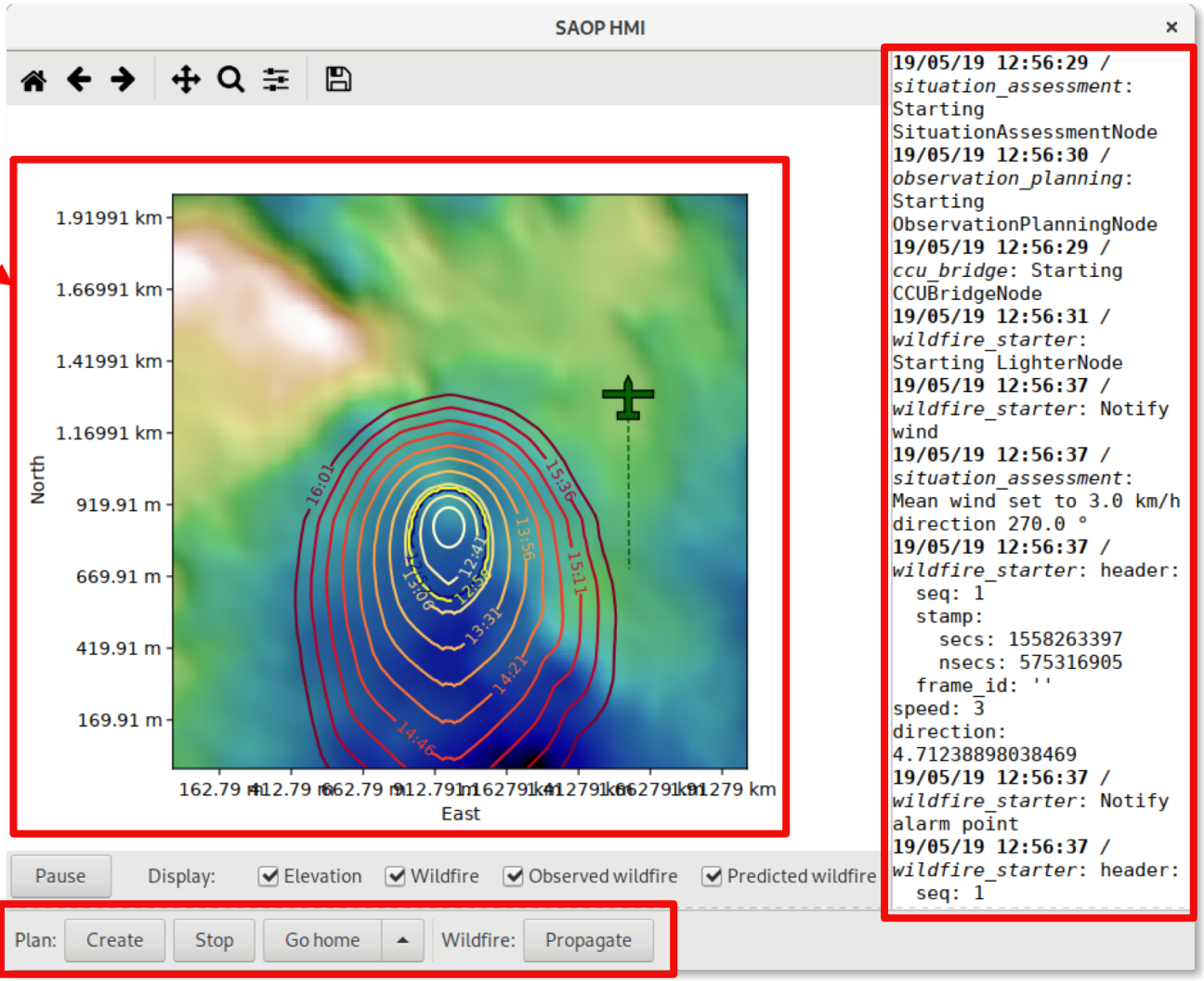
# FireRS SAOP architecture



# Fire RS SAOP operation interface

Integrated wildfire situation view

Simple user commands



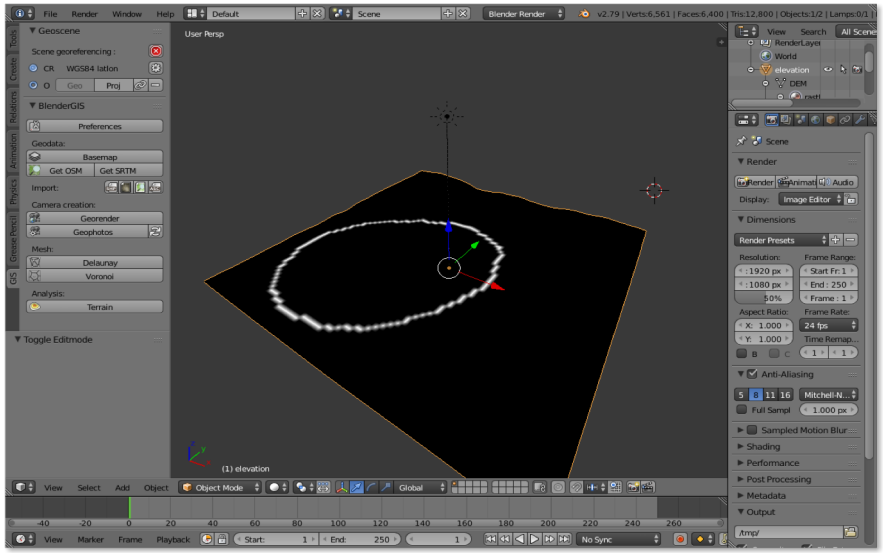

Advanced SAOP operation log

# Testing FireRS SAOP

- **In the lab:**
  - No UAVs, no wildfires
- **At the field:**
  - Real UAVs, no wildfires
- **Real life:**
  - UAVs and wildfires!

- Deal with different levels of realism
  - Simulated UAVs
  - Synthetic wildfires
  - Simulated image acquisition
- **Keep the same algorithms**

# Hybrid real/synthetic wildfire mapping

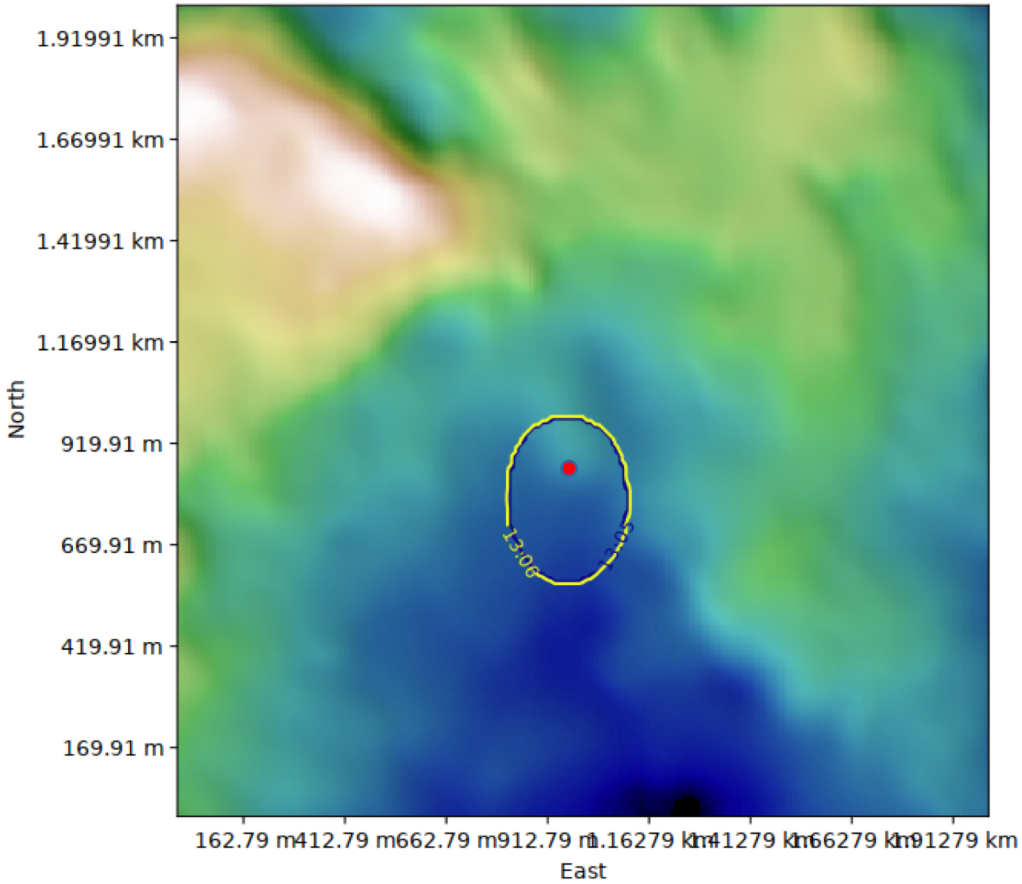


# FireRS demo

- **Alarm confirmation**

# FireRS demo

- **Mapping the perimeter of an ongoing wildfire**

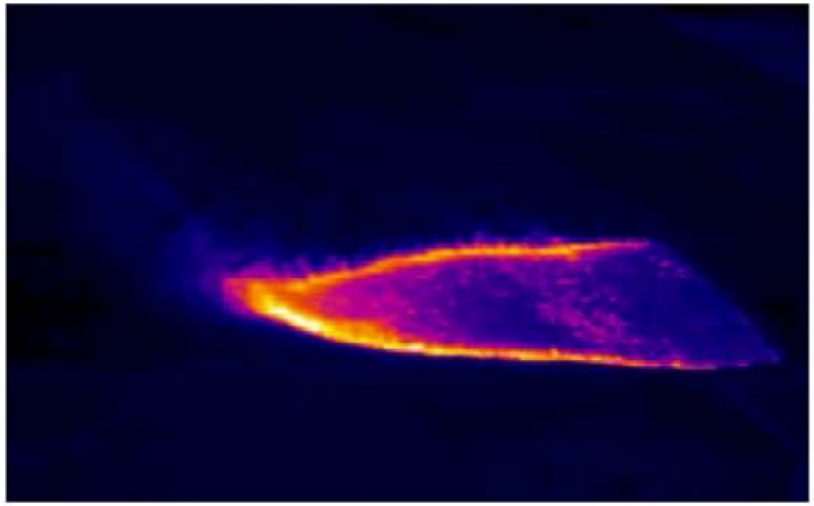


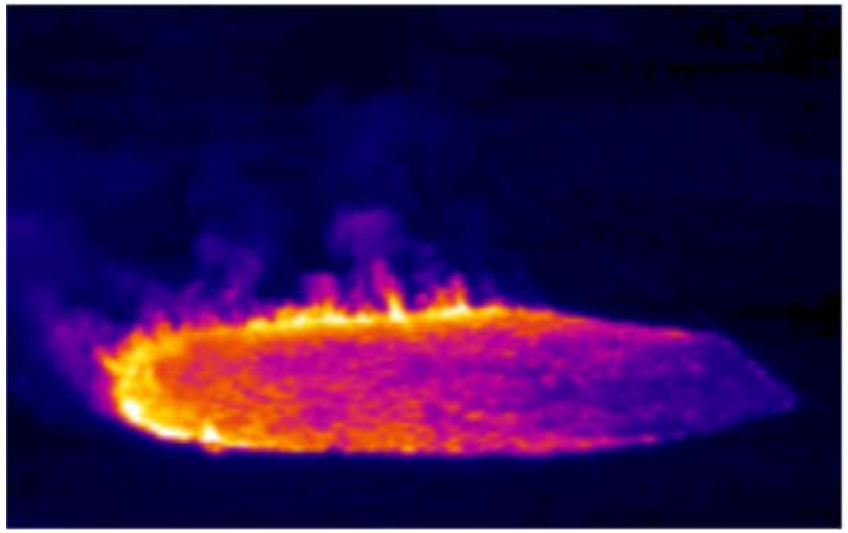
# FireRS demo

- (video)

# In summary…

- Fixed-wing UAVs are a promising tool for wildfire monitoring
- Automated situation assessment can help response teams make better decisions against fire





# Future

- Gather feedback from final users
- Improve fleet management
- Improve prediction models  from observations
- Operation in a real wildfire