Using Swarms of Drones for Wildfire Management

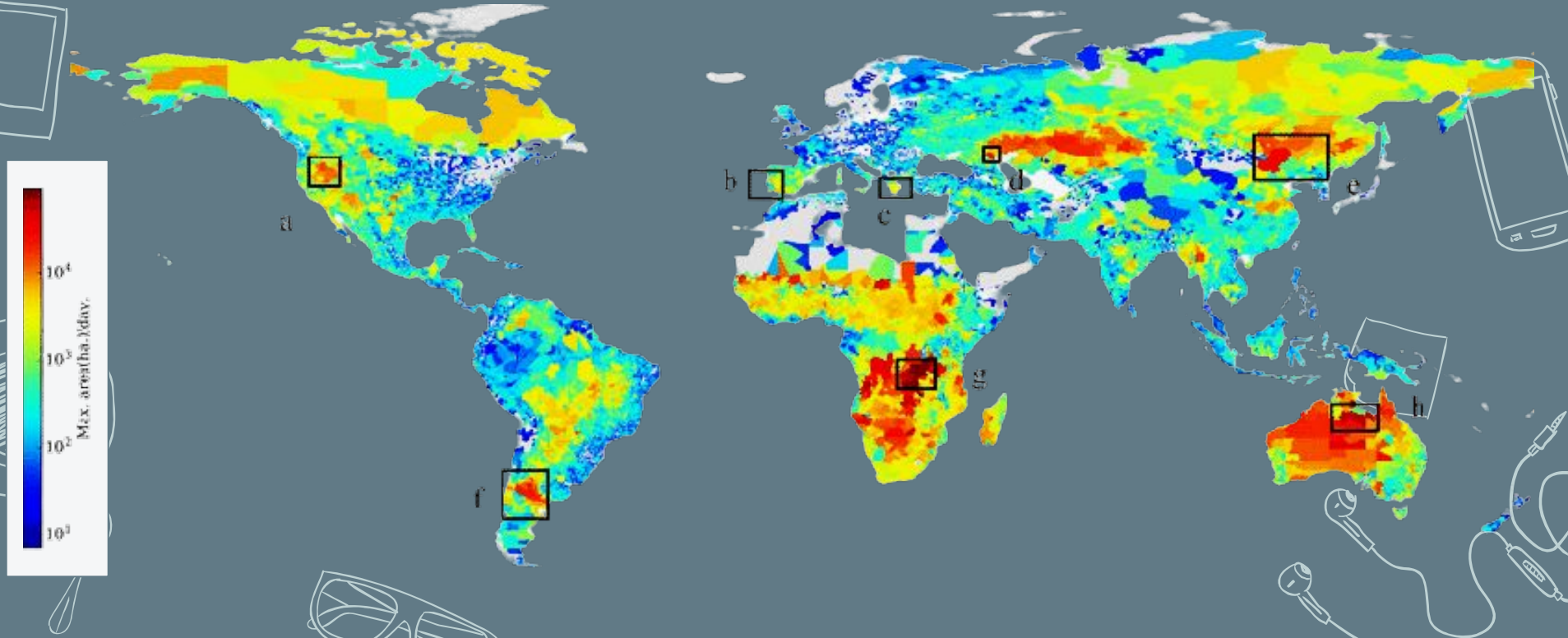
Motivation

- Since 1983 - 70,000 fires per year (Climate Change Indicators: Wildfires | US EPA)
- This century - 5 million acres burn area per year - increasing trend
- Largest burn acreage in a year coincide with warmest years
- Increasing temperature -> Increasing wildfire burn area
- Since 1910 to 2015 - over 10 firefighters per year - increasing
- Hostile, unpredictable environment, difficult to access extent and rate of spread (Applied Sciences | Free Full-Text | A Survey on Robotic Technologies for Forest Firefighting: Applying Drone Swarms to Improve Firefighters' Efficiency and Safety | HTML (mdpi.com))
- Autonomous systems can be explored for assisting in fire management

INTRODUCTION

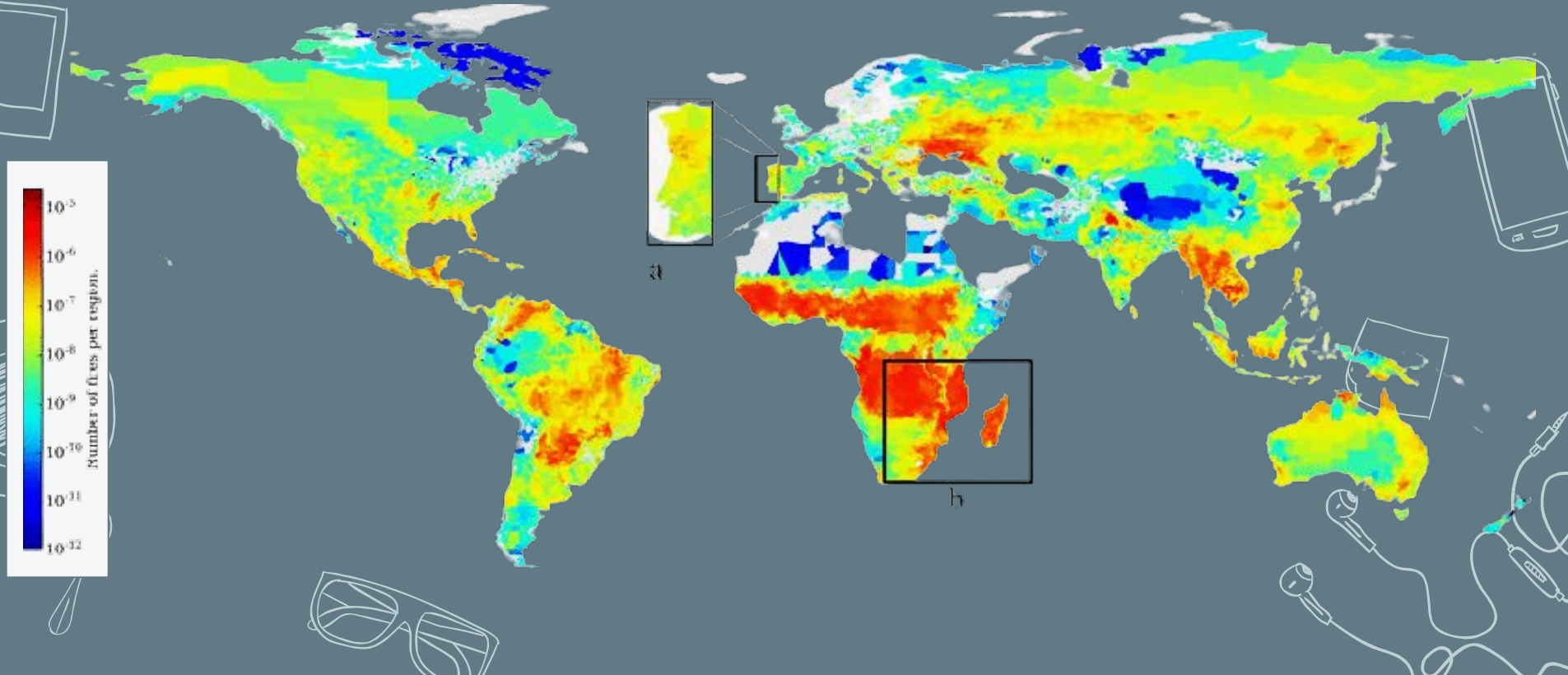
- Difference between multi-drone and swarm of drones - with definition of swarm of drones
- How swarms of drones have been used till now for wildfire management activities? - include prevent, detect & extinguish
- In addition to helping with tasks like forest surveillance, creating fire risk maps, spotting and monitoring wildfires, gathering information for a human decision-maker, supporting search and rescue operations, and situational awareness, UAVs have been used to set up reliable communications networks for emergency response.
- Swarms of drones provide a system with distributed decision-making that is strong and resilient and can handle uncertainty, mistakes, and the failure or loss of a few non-essential units without endangering the mission as a whole.

Average Fire Spread per region



REF: A global wildfire dataset for the analysis of fire regimes and fire behaviour

Wildfire distribution



Largest fires of the 21st century

Rank	Name	Country	Area burned (km^2)	Deaths
1	2019–2020 Australian bushfire season	Australia	338,000	34+
2	2021 Russia wildfires[3][4]	Russia	200,000	0
3	2019 Siberia wildfires	Russia	43,000	0
4	2014 Northwest Territories fires	Canada	34,000	0
5	2009 Black Saturday bushfires	Australia	21,000	173
6	2020 California wildfires	United States	18,000	31
7	2010 Bolivia forest fires	Bolivia	15,000	0

Rank	Name	Country	Area burned (km^2)	Deaths
8	2011–2012 Australian bushfire season	Australia	14,000	0
9	2006–2007 Australian bushfire season	Australia	13,000	5
10	2017 British Columbia wildfires	Canada	12,000	0
11	2015 Russian wildfires	Russia	11,000	33
12	2012–2013 Australian bushfire season	Australia	9,000	4
13	2019 Amazon rainforest wildfires	Brazil, Bolivia, Paraguay, Peru	9,000	2

Swarm Algorithm

- Use of Particle Swarm Optimization
- Algorithm accommodated for dynamic search space
  - Erase memory
  - Randomly re-initialise memory

Wildlife casualties

- Bushfires rage across Australia from June 2019 to February 2020. New WWF research reveals that the toll on wildlife was around three times higher than an earlier study estimated.
- In total, 143 million mammals, 2.46 billion reptiles, 180 million birds, and 51 million frogs were harmed.

Prevent

- The acoustic sensors can also be used to prevent the wildfires
- Prevention interventions, aiming at reducing the potential causes of fire ignition, may consist of fire treatment: preventive silviculture techniques, prescribed fire, interventions on firebreaks, and access roads to the forest
- Sensing capacity based on weather sensors data (temperature, humidity, CO, or CO2) are used to feed certain prediction model which in turn is processed, proving alerts for early detection or for analyzing the fire front evolution.

Detection/Surveillance

- Search hotspot using temperature sensor
- Use of acoustic sensors - a technique for continuously localising a moving acoustic source based on energy measurements for the purpose of detecting wildfires.
- Computer vision

Extinguish

- Drones equipped with water refilling capability
- Use of fire extinguishing balls by the swarm
  - Light weight, environment friendly

Future

- Self-organising swarms of autonomous UAVs - notably unexplored
  - Further research and real time experiments needed
- Incorporate collisions avoidance algorithms
- Live demonstration

Conclusion

- Wildfire incidents and firemen casualties may increase as per trend
- Swarm of drones are potential autonomous firefighters
- Can assist in all aspects of fire management
  - Prevent
  - Detect / surveillance
  - Extinguish

Thanks