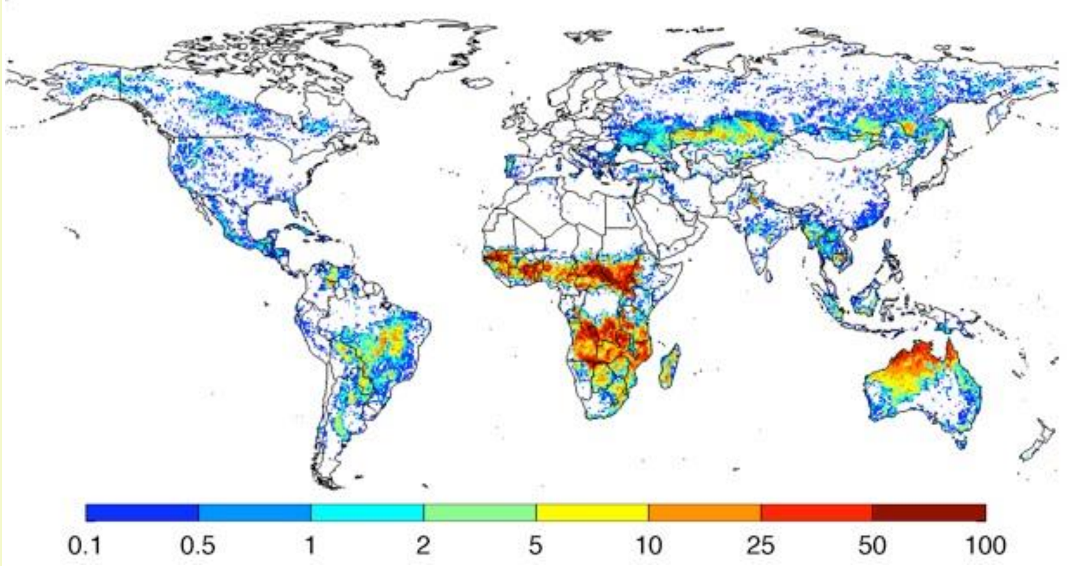
Swiss Re

Deep Learning of Remote Sensing Images to Predict Wildfires

presented by Christian D. Klose

Wildfires are a global issue showing a strong increase in the amount of burnt area – Hot spots are distributed all over the world

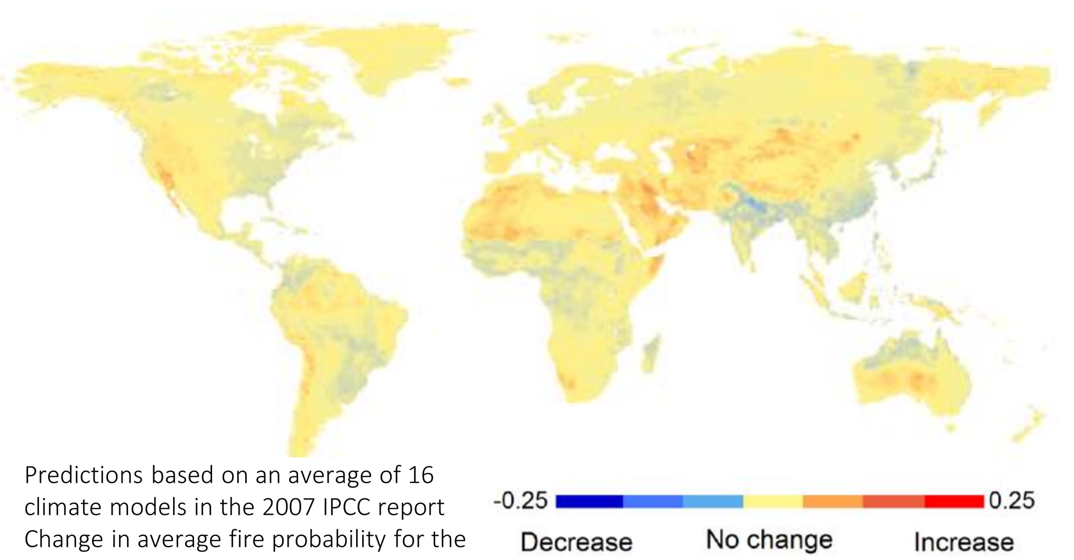
Average annual fraction of burnt area (1997 - 2009)



Figures mostly based on MODIS data

Currently the most severe fires happen in the tropics as well as in Central Asia and Siberia. Areas that typically lead to insurance loss from wildfires are relatively less affected. But the situation is expected to significantly shift over the next years due to climate change.

Wildfires are expected to increase with climate change



Predictions based on an average of 16 climate models in the 2007 IPCC report
Change in average fire probability for the period 2010 - 2039

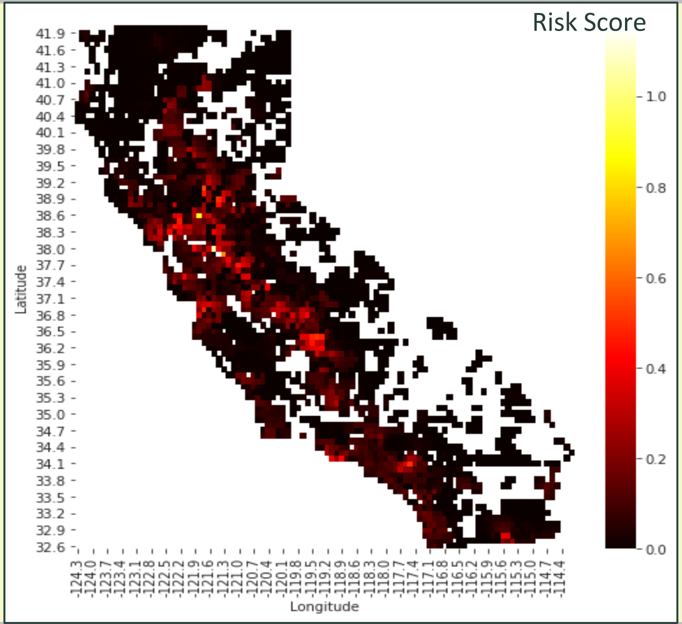
The likelihood to experience large fires is increasing globally in the subtropics and temperate zones while decreasing in the tropics.
This means that the number of people and property value at risk from wildfire will significantly increase over the next decades.

Source: ONAL/NASA, Moritz *et al.* (2012), Ecosphere

Swiss Re identified wildfires as a peril gaining more and more relevance – Therefore we are looking more deeply into this topic from a hazard modelling perspective

Swiss Re's current wildfire layer has global coverage …

… but a more sophisticated forecast model is in development



- Swiss Re developed in the past a wildfire hazard layer looking at the count of 600MW+ fires between 2000 and 2011.
- The data was mostly based on remote sensing data.

- Swiss Re's wildfire hazard model is able to forecast wildfire hazard in space several month in advance.
- It takes into account climatic and non-climatic characteristics in space and time on a 10x10km resolution.

Source: Swiss Re CatNet®, DigitalGlobe Imagery via Google Maps

Challenges

Data Imbalance
Fires represent 0.1 % of our training data, hence we have an imbalanced problem

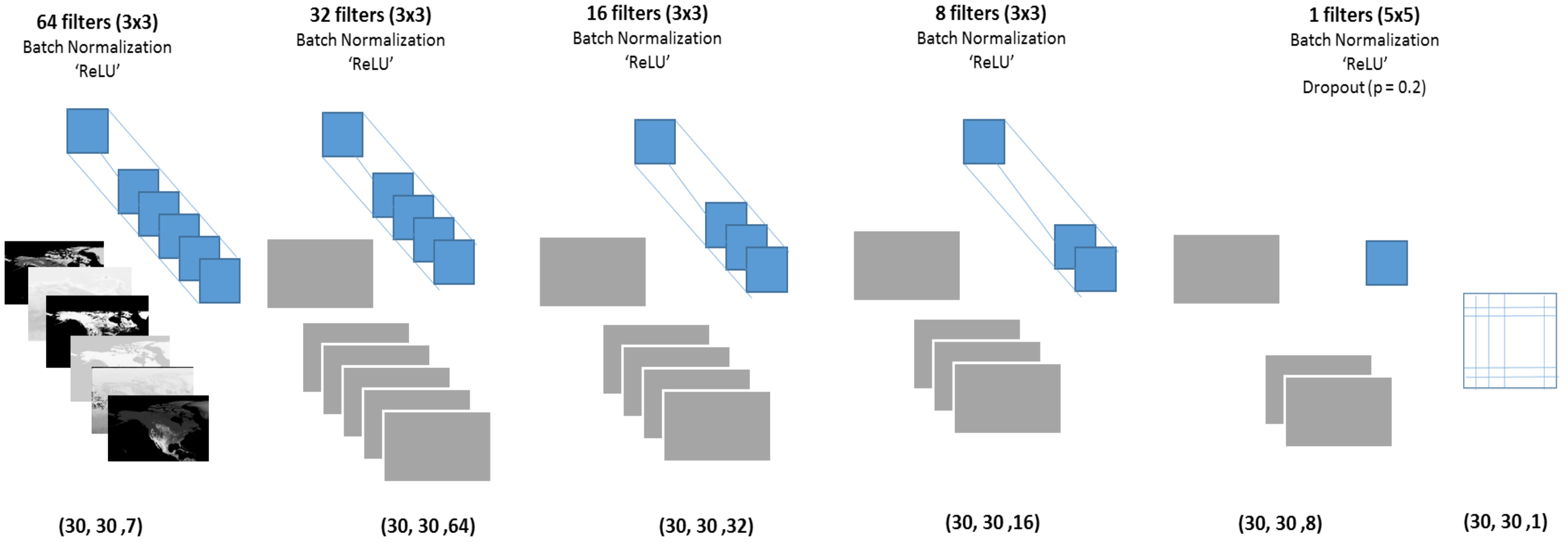
Fire Distribution
Distribution of fires is highly skewed towards small fires

Fires’ Low Predictability
Fires can be hard to predict. We need to use different proxies to increase our prediction power

Deep Learning: Classic CNN - Set-Up

Motivation
- Account for spatial correlation
- Give the model more complexity and scalability

Data
- Grayscale images of North America (7 channels)
- Size =30, overlap = 50%
- Training data: 80923 images with at least one fire in them *(out of 332310)*



Results: Best Occurrence/Severity Model and Features

Features Selected

Climatic	Geographical	Sources Of Ignition	Historical
Climatic conditions	**Vegetation index**	**Lightning**	**Number of past fires**
Climatic conditions year before	**Snow cover**	**Roadmap**	Number of past fires in neighbors
Climatic conditions evolution	**Vegetation type**	**Closest roadmap**	Months since last fire
Climatic conditions of neighbors	**Elevation**	Population	Months since last fire in neighbors
Climate indices	**Fuel / WUI**	**Closest population**	

Sampling Selected

Location-Based Sampling	Ensemble Method	Filtering	Imbalance	**Classical Sampling**	Regional Model

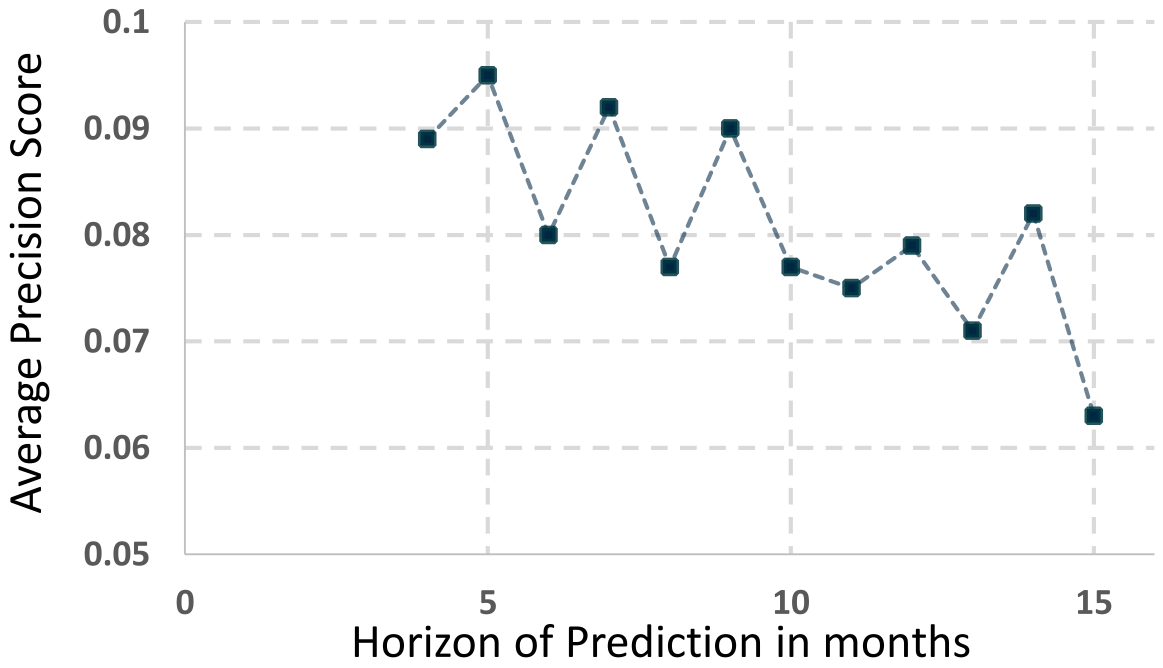
Method Selected

Logistic Regression	CART	**Random Forest**
Boosted Trees	Neural Networks	Optimal Trees

Results: Best Occurrence/Severity Model and Features

	Accuracy	Precision	Recall	**Average Precision**
Baseline	99%	8%	37%	3%
Best Model	90%	2%	88%	10%

Evolution of Average Precision Score with increasing prediction horizon for Best Model



Severity Model Output

Fire Size Actual/Predictions:

	Small	Medium	Large
Small	869360	12602	140
Medium	423	311	2
Large	53	87	30

precision

Small: 0.99
Medium: 0.02
Large: 0.17
Overall : 0.40

recall

Small: 0.99
Medium: 0.42
Large: 0.18
Overall: 0.53

Greater than threshold (0.04):

	Small	Medium	Large
Small	1138	49	0
Medium	126	94	2
Large	24	28	10

precision

Small: 0.88
Medium: 0.55
Large: 0.83
Overall : 0.76

recall

Small: 0.96
Medium: 0.42
Large: 0.16
Overall: 0.51

Historical Fire Pixels:

	Small	Medium	Large
Small	3292	182	0
Medium	423	311	2
Large	53	87	30

precision

Small: 0.87
Medium: 0.54
Large: 0.94
Overall : 0.78

recall

Small: 0.95
Medium: 0.42
Large: 0.18
Overall: 0.52

Model Benchmarking (Prediction done in Sept of the previous year)

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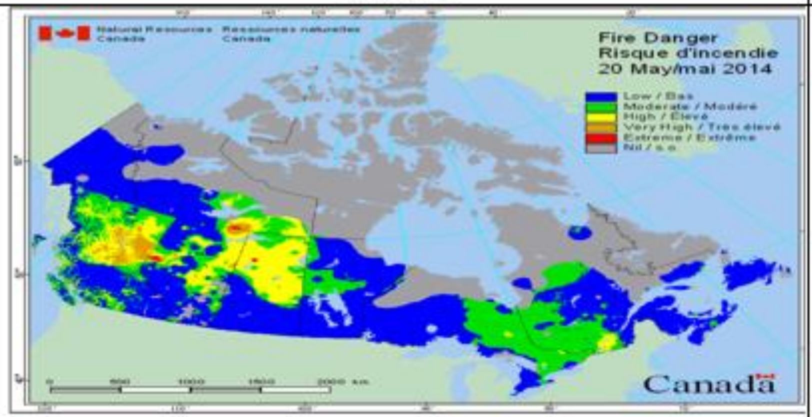
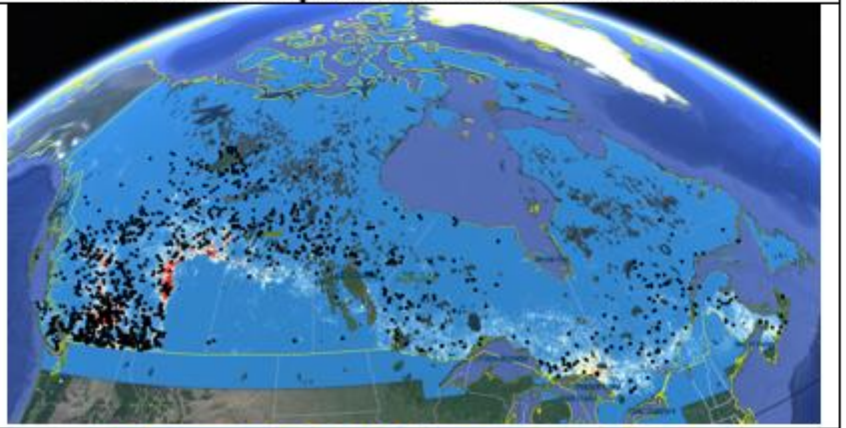
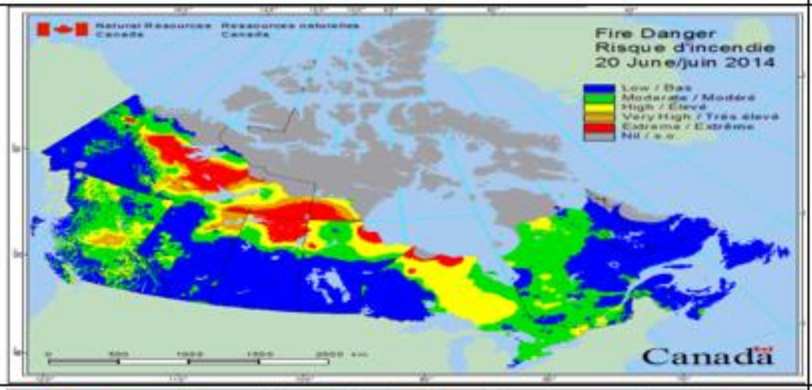
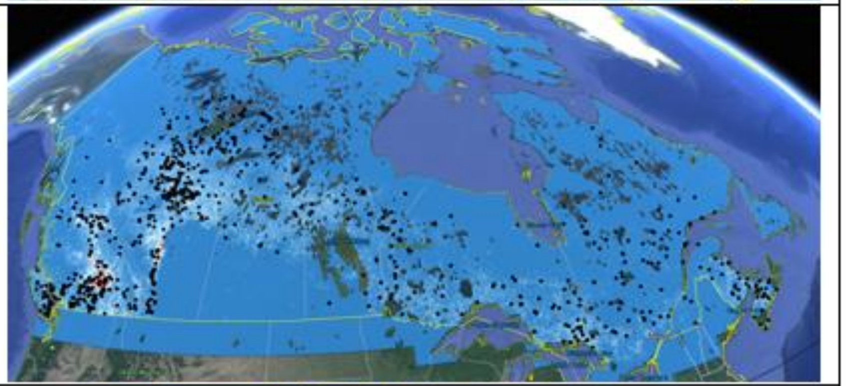
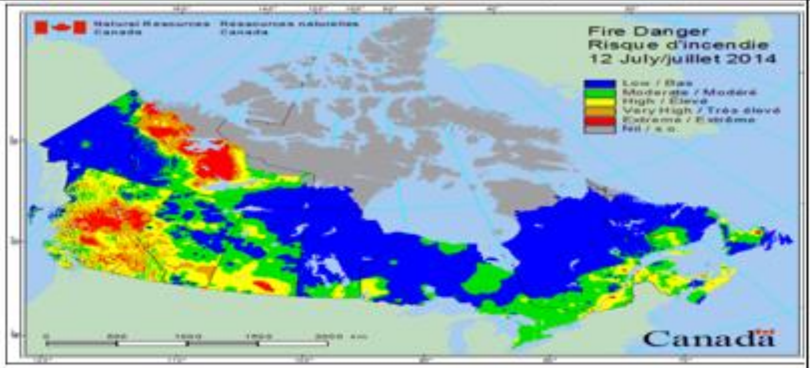
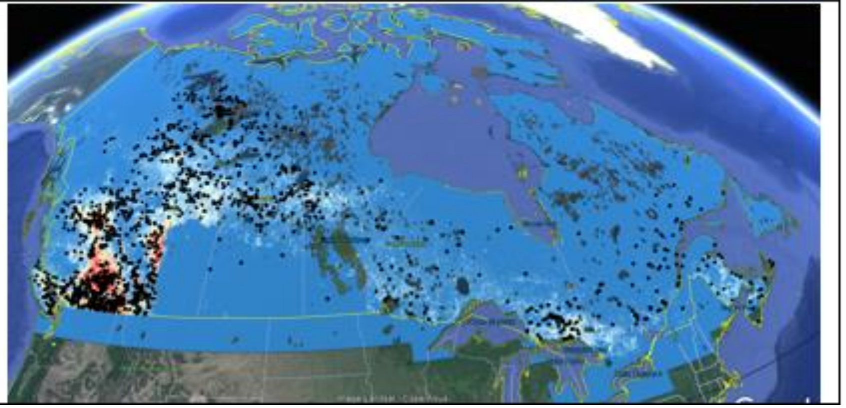
<tr><td>May</td><td>
</td><td></td></tr>
<tr><td>June</td><td>
</td><td></td></tr>
<tr><td>July</td><td>
</td><td></td></tr>
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Output of the Forecasts

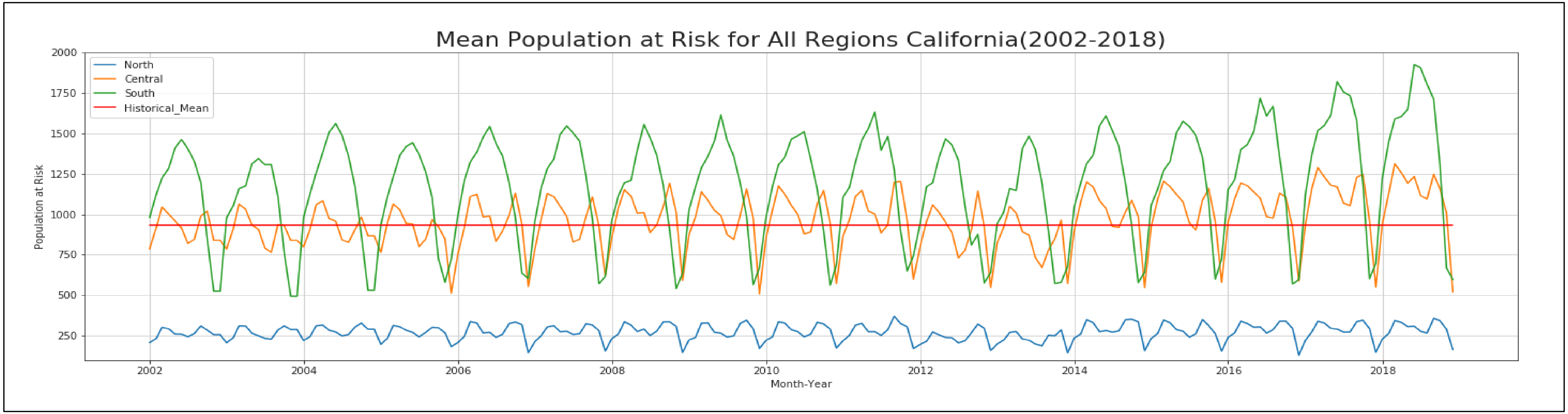


Fig 5: The chart illuminates the wildfire hazard annual changes in North, Central and South California since 2002 with seasonal changes.

An AI View on California's Wildfire Risk since 2002

This presentation summarizes a very simple risk analysis on wildfire in CA by including population growth as proxy for exposure and wildfire hazards model that takes atmospheric into account and that utilized AI to learn from historic observations.

Forecast Precision of Large Fires

83%

Wildfire risk tends to increase within CA due to population increase particularly in Wildland Urban Interfaces. Large Fires (>100 km2) can be seen with 83% confidence.

Overall the modelled expected wildfire risk may not explain all major losses of 2017 and 2018. However, it shows that California's population is continuously exposed to a minimum wildfire hazard, due to increasing exposure in WUIs but more importantly due to conditions in the atmosphere and biosphere, including net radiation, water vapor or wind speed.

16% of Fires Seen

Only every 5th large fire can be detected by the model yet.

15% Wind Speed Increase

The speed of peak winds has been continuously increasing since 2013.

5% Drop in Water Vapor

Throughout CA, the cooling water vapor has been dropping since 2013.

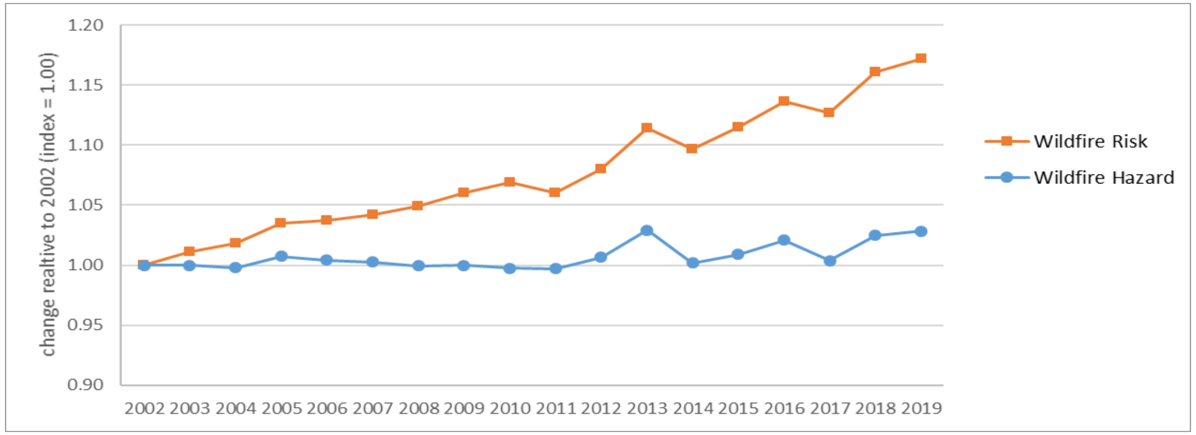


Fig 1a: The chart illuminates the wildfire hazard/risk annual changes in California since 2002.

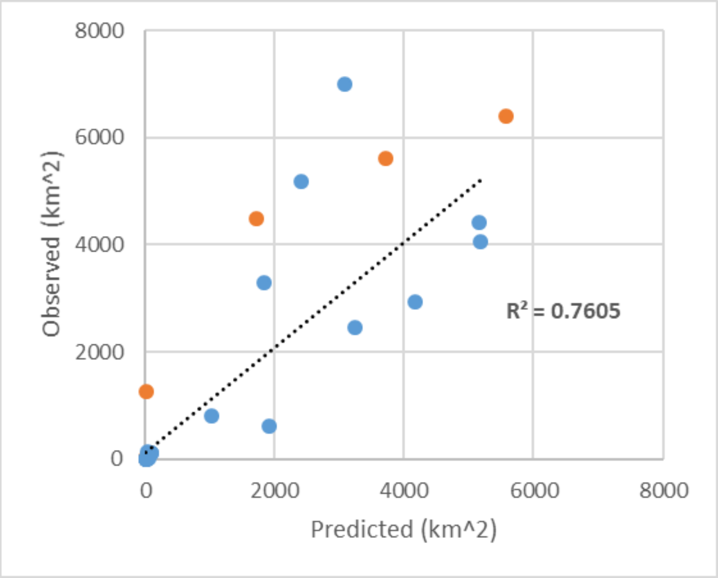


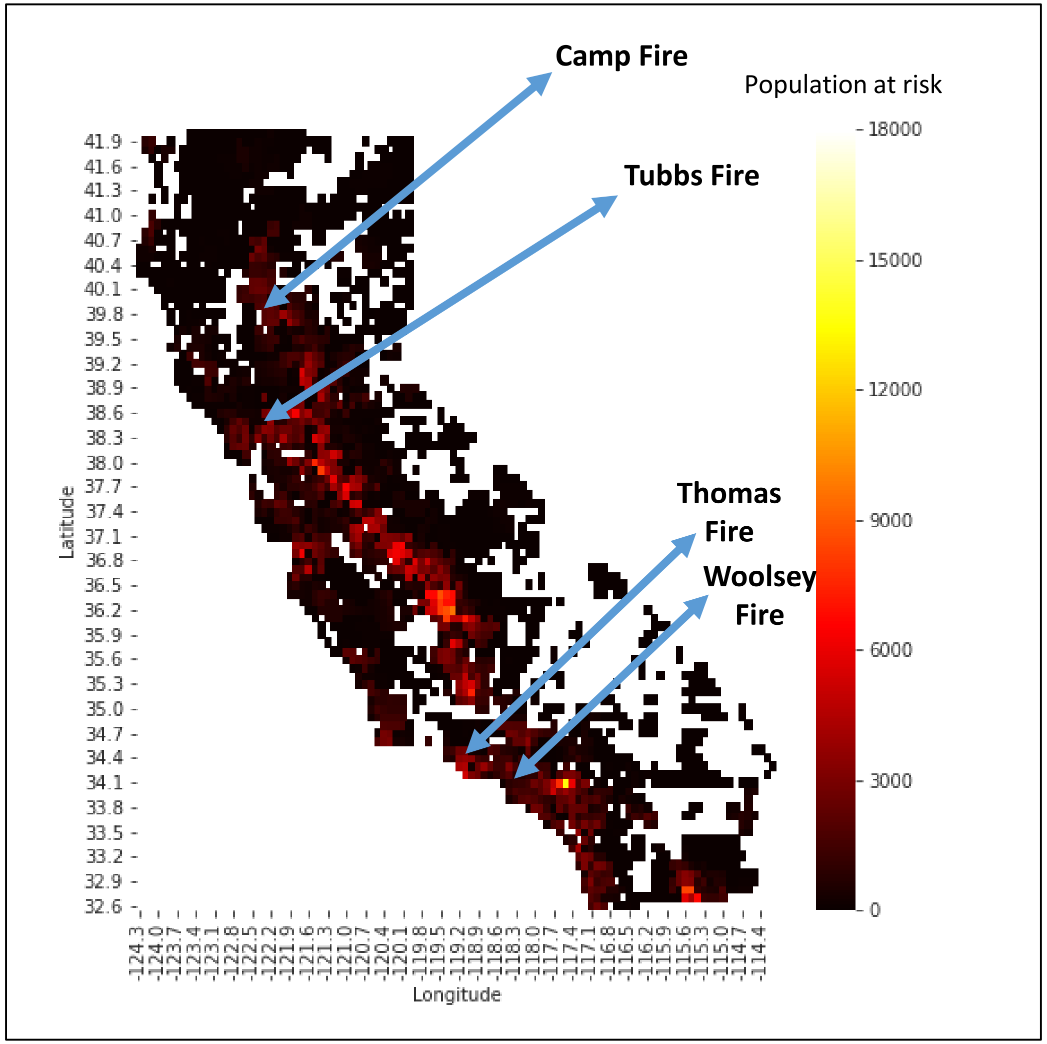
Fig 1b: Correlation of the observed and predicated total burned areas (seasonal view).

Wildfire Risk – 2019 CA

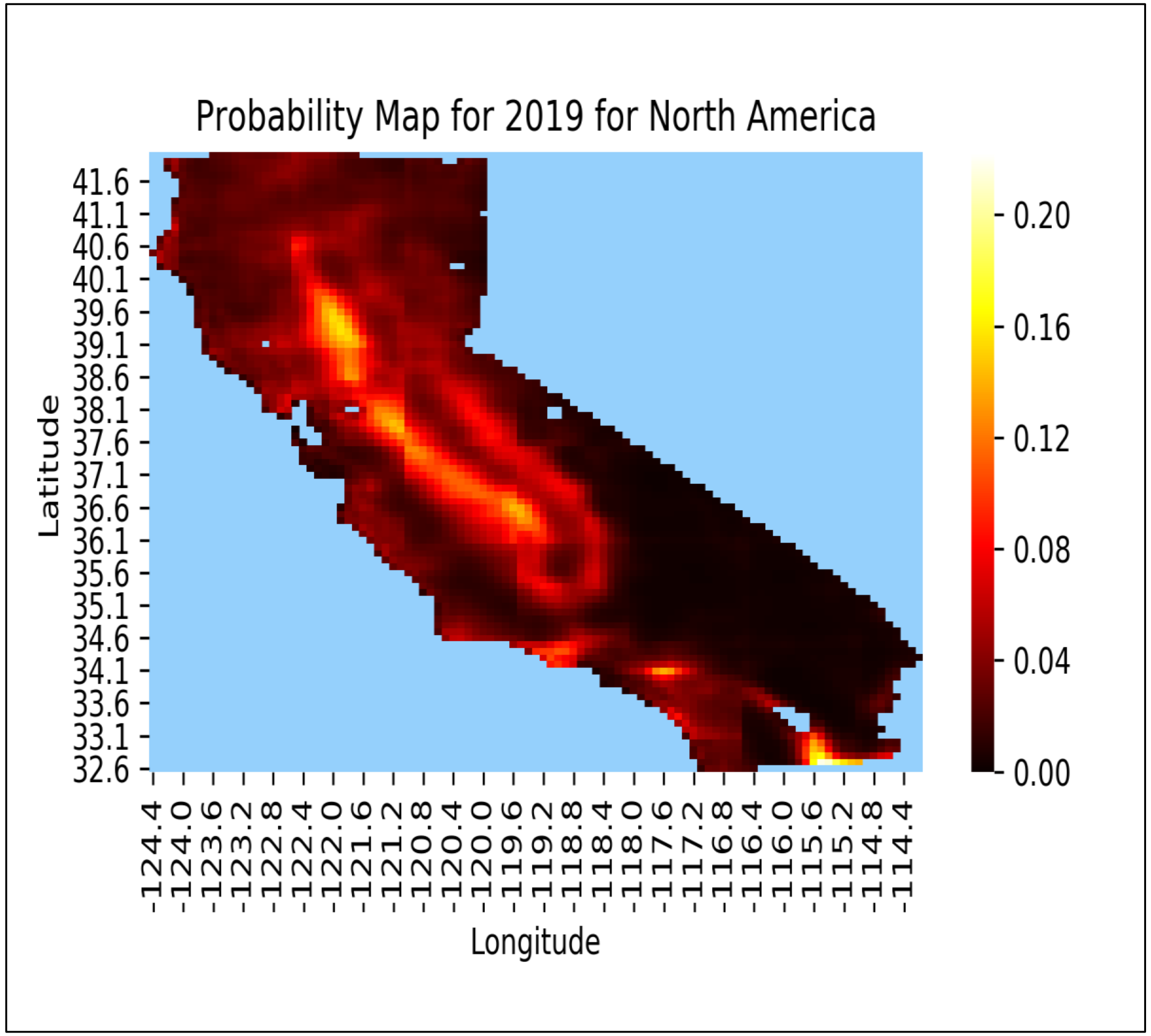
North CA

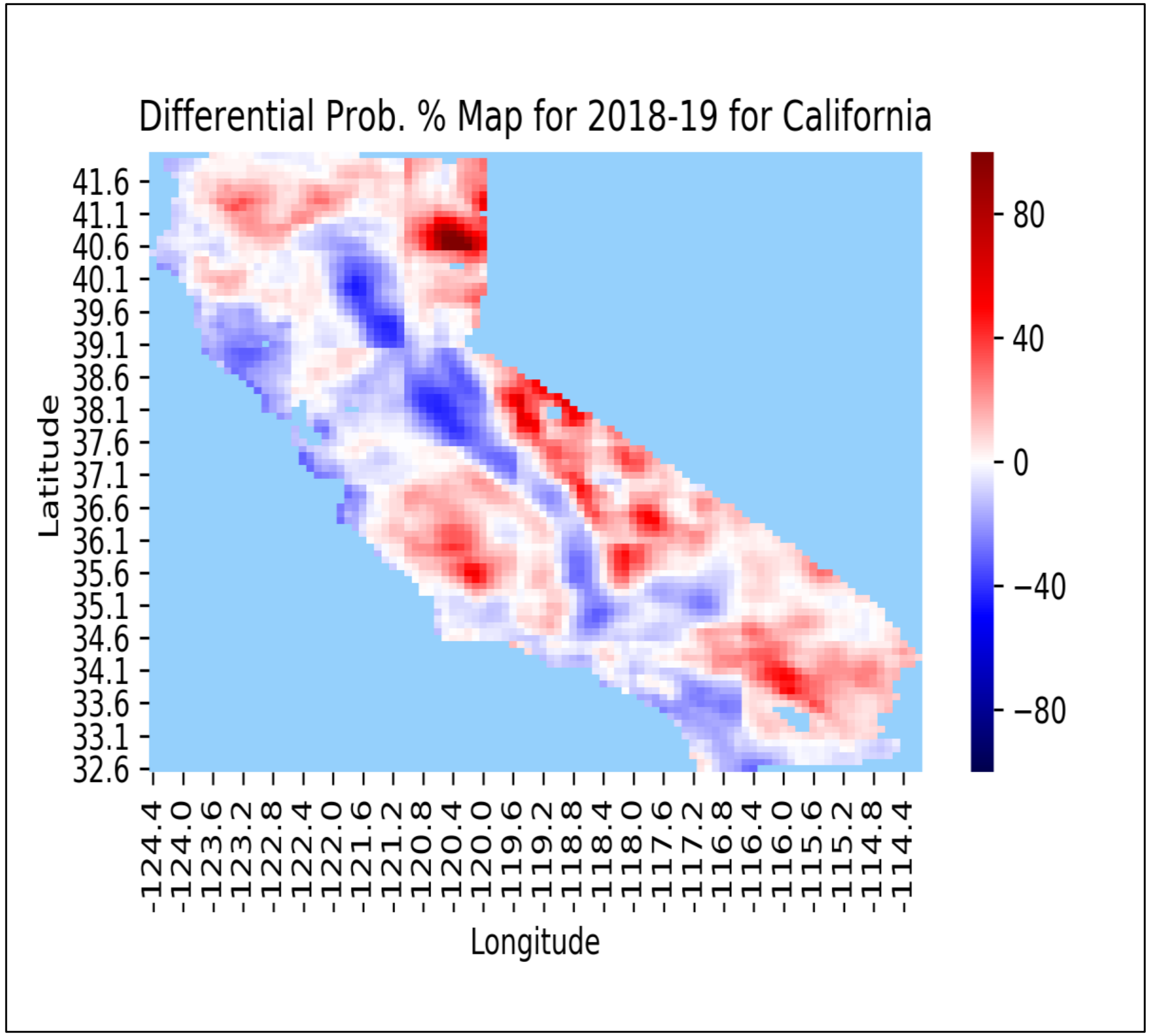
Central CA

South CA



Wildfire Hazard – 2018 and 2019 CA





Thank You

Any questions?