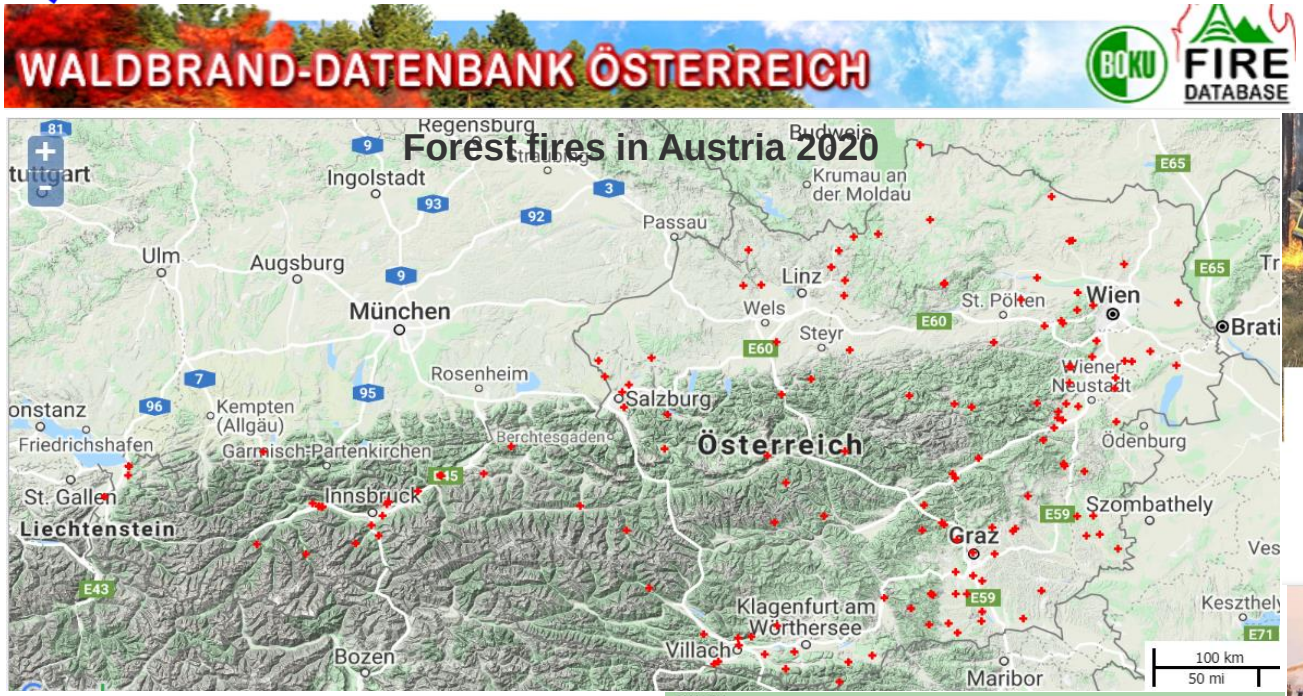
CONFIRM: Copernicus Data for Novel High-Resolution Wildfire Danger Services in Mountain Regions

Ruxandra-Maria Zotta[1], Clement Atzberger[2], Jörg Degenhart[3], Markus Hollaus[1], Markus Immitzer[2], Haimo Krajnz[4], Heinz Lick[5], Mortimer M. Müller[6], Harald Oblasser[7], Andreas Schaffhauser[8], Stefan Schlaffer[1], Harald Vacik[6], and Wouter Dorigo[1]

[1]Vienna University of Technology (TU Wien), Department of Geodesy and Geoinformation, Vienna, Austria
[2]University of Natural Resources and Life Sciences (BOKU), Institute of Geomatics, Vienna, Austria
[3]Landesfeuerwehrverband Tirol, Telfs, Austria
[4]Berufsfeuerwehr Graz, Graz, Austria
[5]Landesforstdirektion Steiermark, Graz, Austria
[6]University of Natural Resources and Life Sciences (BOKU), Institute of Silviculture, Vienna, Austria
[7]Amt der Tiroler Landesregierung, Abteilung Waldschutz, Innsbruck, Austria
[8]Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Vienna, Austria

Contact: https://project-confirm.geo.tuwien.ac.at/

FIRE in Austria



CHRONIK

Großeinsatz für Feuerwehr bei Waldbrand

Bei Saubersdorf (Bezirk Neunkirchen) ist Dienstagnachmittag ein Waldbrand ausgebrochen. Mehr als 300 Einsatzkräfte von 50 Feuerwehren kämpften gegen die Flammen. Betroffen waren laut Landesfeuerwehrkommando 30 Hektar Wald.

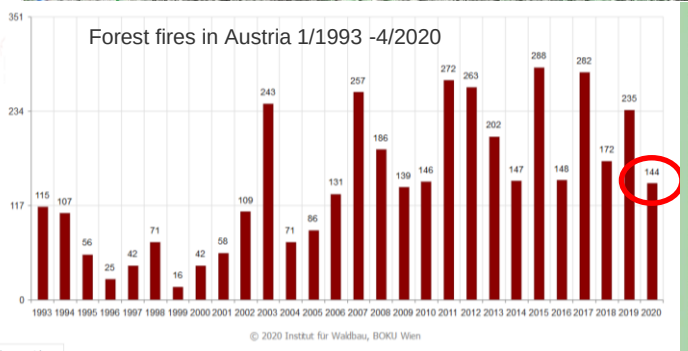
7. April 2020, 16.13 Uhr (Update: 7. April 2020, 17.27 Uhr)

CHRONIK

Brände sorgen für Großeinsätze

Ein Böschungsbrand hat Dienstagnachmittag zu einem Großeinsatz der Feuerwehr an der Brennerautobahn bei Patsch geführt. In Kirchdorf (Bezirk Kitzbühel) geriet ein gelegtes Feuer außer Kontrolle.

7. April 2020, 18.37 Uhr (Update: 8. April 2020, 8.56 Uhr)



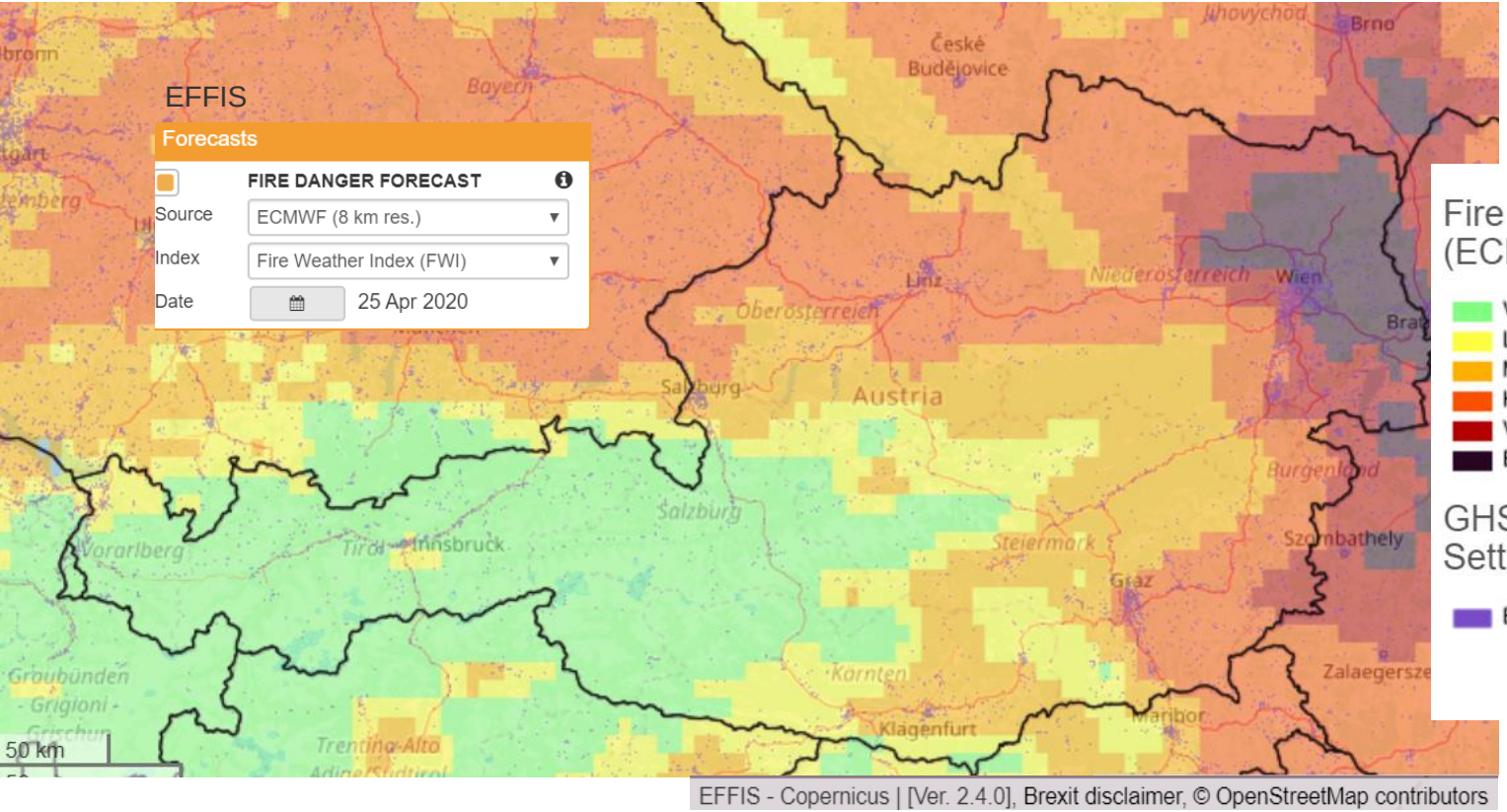
HALLTAL

Waldbrand löste Großeinsatz der Feuerwehr in Tirol aus

137 Mitglieder der Feuerwehren Absam, Hall, Mils und Thaur mussten in der Nacht ausrücken

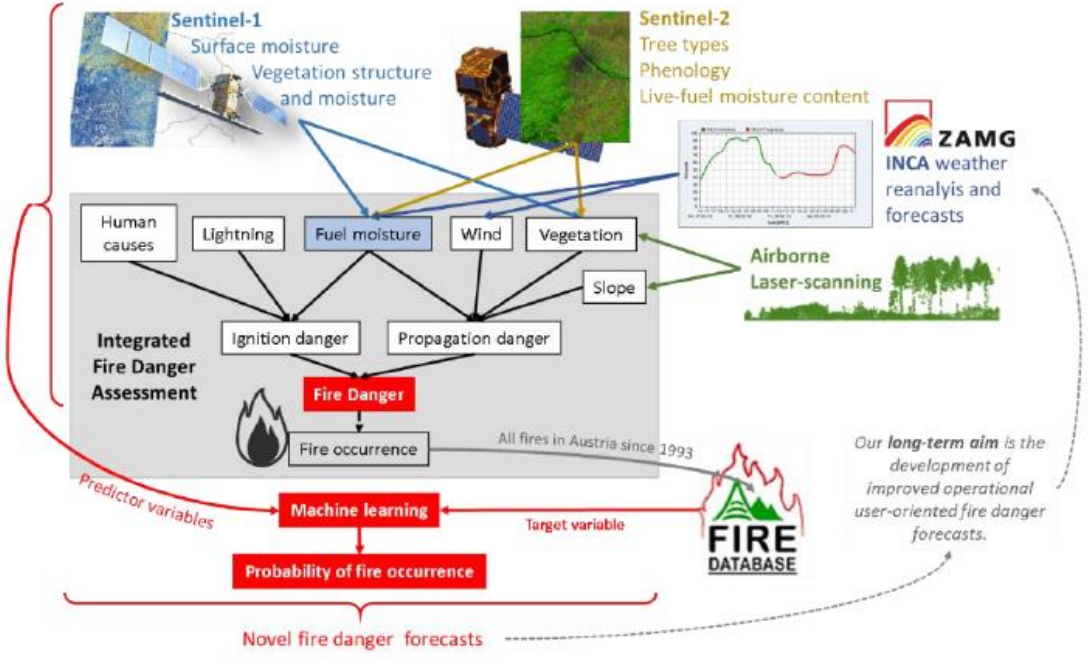
9. April 2020, 09:11 12 Postings

FIRE in Austria



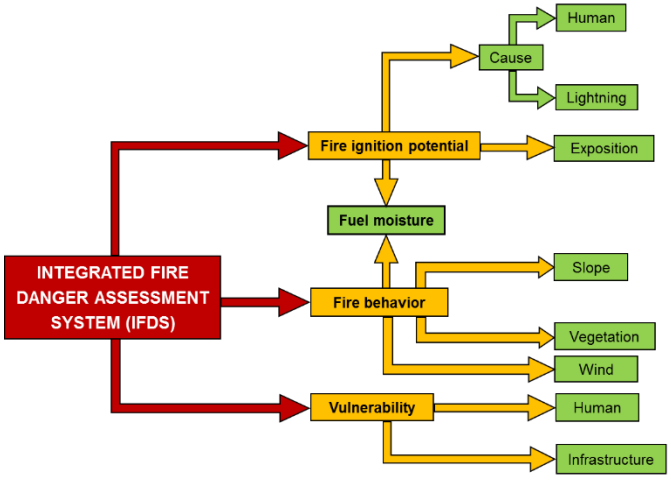
Overview

- **Fire Danger Forecast** based on
  - Expert knowledge
    - Stakeholder involvement (fire departments, forest managers, weather services, infrastructure providers)
  - Machine Learning to estimate
    - Fuel moisture and structure
    - Forest fire danger
  - 3-day weather forecast
- Demonstration during fire season 2021
- Target spatial resolution: 100m

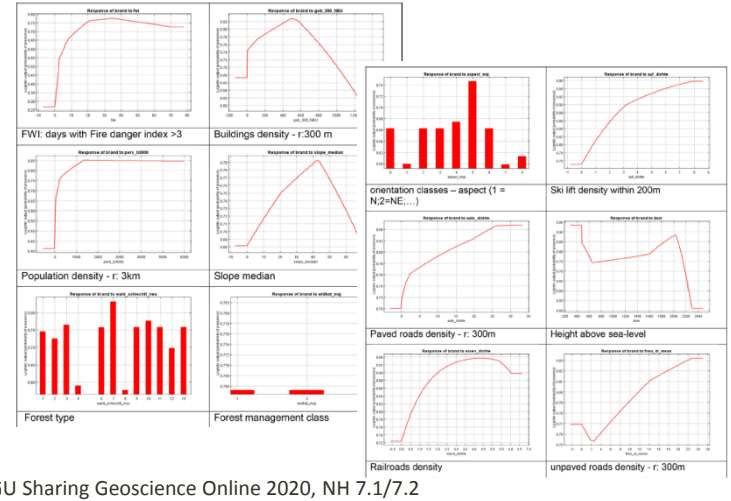


Concept development

- **Expert-based** approach
  - Individual factors are combined by weights
  - Definition of **thresholds for fire danger rating** (1 – 5)
  - Different weighting scenarios are tested against fire occurrences
- **Quantitative modelling** approach
  - Feed the input data into the **machine learning** algorithm
  - Compare different approaches SOFIA (Forkel et al. 2017), Random Forest, MaxEnt (Arpaci et al. 2014)



(Müller et al, 2020)



(Arpaci et al., 2014)

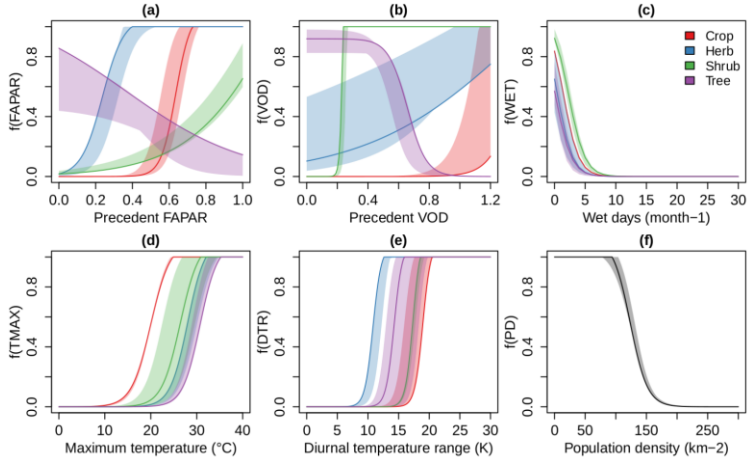
Stakeholder Involvement

- Development workshops:
  - Stakeholders will actively participate in concept development and refinement

- User evaluation
  - Potential users will test prototype IFDS during demonstration phase (April 2021 - February 2022)
  - Empirical evidences will be compared with various predictions of IFDS
    - expert knowledge based on interpretation of real situations in the field
    - Interpretation of satellite-derived moisture- and vegetation-related products and interpretation of fire weather indices (FWI based on INCA weather forecasts)

Quantitative Modelling

SOFIA model (Forkel et al. 2017)



- Burned area equals vegetated area *A* * environmental controls *f*:

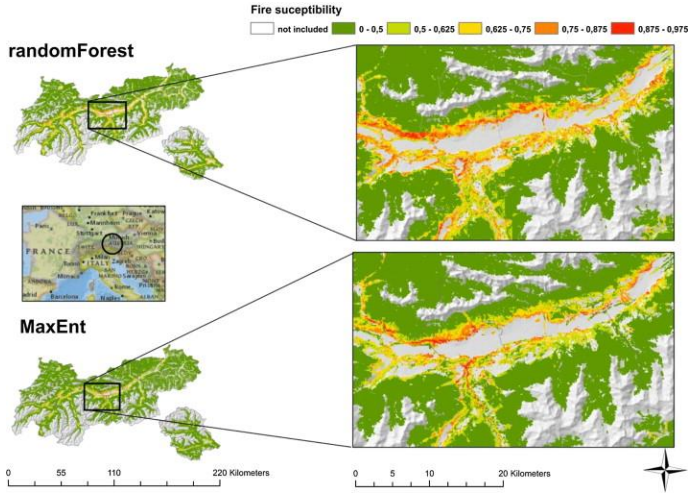
$$\mathrm{BA}_t = \sum_{g=1}^{g=N} A_g \cdot f_{g,t}$$

- Environmental controls: product of several logistic/exponential functions based on climate, vegetation or socioeconomic variables *x*:

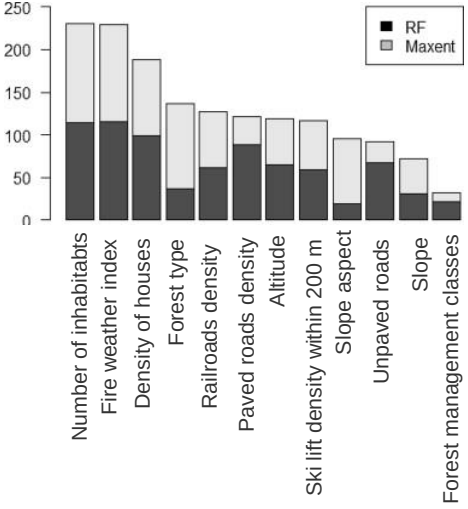
$$f_g = \prod_{i=1}^{i=N} f\left(x_{i,g}\right),$$

$$f(x_{i,g}) = \min\left[1, \frac{\max_{g,i}}{1 + e^{\left(-\mathrm{sl}_{i,g} \times (x - x0_{i,g})\right)}}\right]$$

Random Forest, MaxEnt (Arpaci et al. 2014)

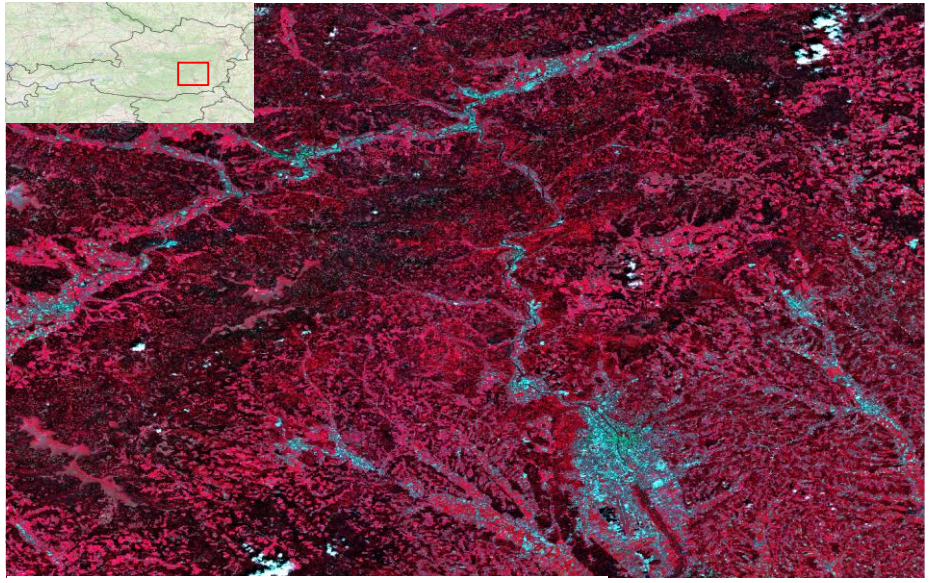


Sum of relative importance of rankings of variables in RF and Max Ent based on 10 runs. Each run gives 12 points at maximum, so the highest possible score is 120.



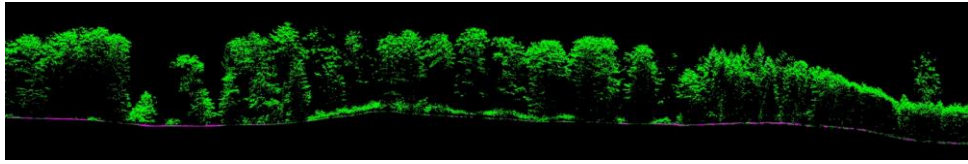
Data

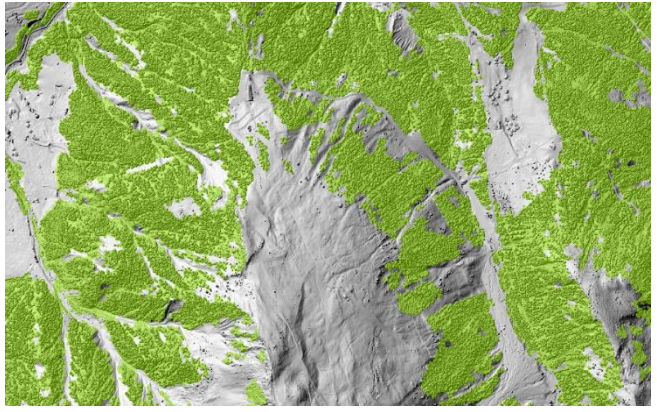
Satellite data



Sentinel-2
Forest type/tree species
Vegetation state

LiDAR





Forest structure
Topography

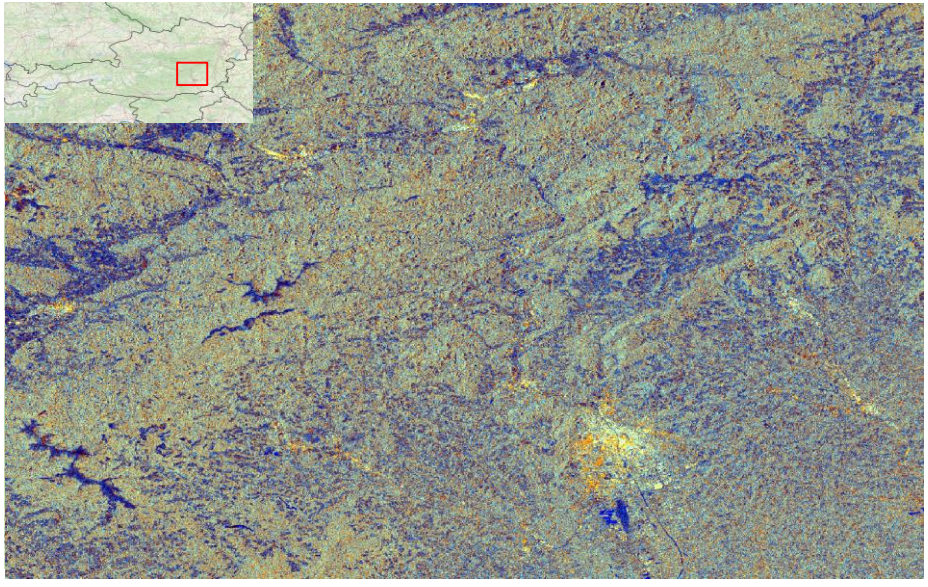
+ Weather data

+ Infrastructure data

+ Fire occurence data

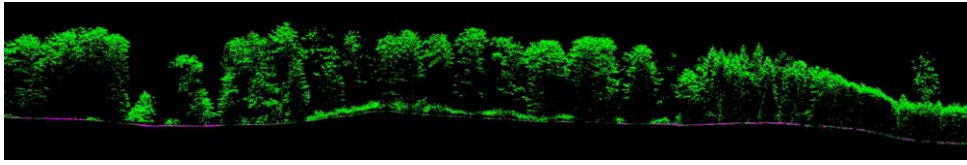
Data

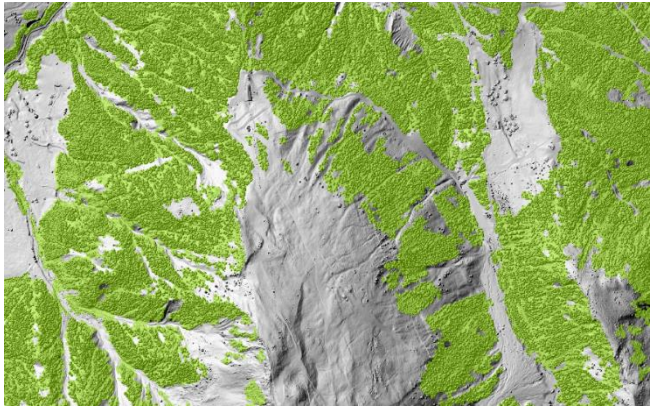
Satellite data



Sentinel-1
Soil and vegetation water content

LiDAR





Forest structure
Topography

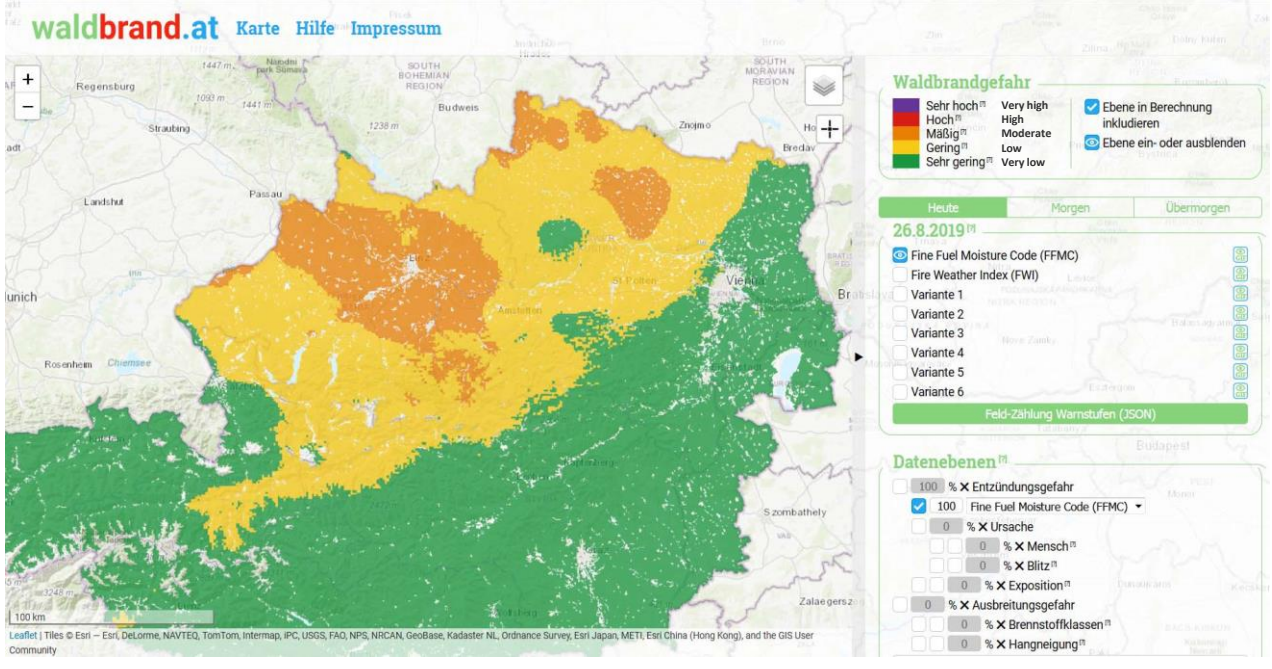
+ Weather data

+ Infrastructure data

+ Fire occurence data

Visualisation tool

- prototype http://www.waldbrand.at combines datasets on topography, vegetation, human impact, lightning, meteorology, fuel classes, fuel moisture content
- supports the definition of weighting scenarios by experts
- documentation and retrieval of fire danger on fire / non fire days



With contributions from:

Arpaci et al., 2011
Arpaci et al., 2013
Arndt et al., 2013
Grima, 2011
Albers, Jasper, 2012
Müller et al., 2013
Müller et al., 2020
Vacik et al., 2011

References

- Albers, Jasper (2012): Comparative Analysis of the Forest Fire Situation in Central-Eastern Europe. Diplomarbeit / Masterarbeit - Institut für Waldbau, BOKU-Universität für Bodenkultur, pp 81.
- Arndt, Natalie, et al. "Modeling human-caused forest fire ignition for assessing forest fire danger in Austria." *iForest-Biogeosciences and Forestry* 6.6 (2013): 315.
- Arpaci, Alexander, et al. "Using multi variate data mining techniques for estimating fire susceptibility of Tyrolean forests." *Applied Geography* 53 (2014): 258-270.
- Arpaci, Alexander, Chris S. Eastaugh, and Harald Vacik. "Selecting the best performing fire weather indices for Austrian ecoregions." *Theoretical and applied climatology* 114.3-4 (2013): 393-406.
- Forkel, Matthias, et al. "A data-driven approach to identify controls on global fire activity from satellite and climate observations (SOFIA V1)." Geoscientific Model Development 10 (2017): 4443-4476.
- Forkel, Matthias, et al. "Emergent relationships with respect to burned area in global satellite observations and fire-enabled vegetation models." (2019).
- Grima, N. Forest fire hazard mapping in Carinthia (Southern Austria). Diss. M. Sc. Thesis, University of Natural Resources and Applied Life Sciences (BOKU), Vienna. Available at http://bit. ly/2EwTETb [Verified March 2020], 2011.
- Müller, Mortimer M., et al. "Analysis of lightning-induced forest fires in Austria." *Theoretical and Applied Climatology* 111.1-2 (2013): 183-193.
- Müller, M., Vacik, H., Valese, E., 2015. Anomalies of the Austrian Forest Fire Regime in Comparison with Other Alpine Countries: A Research Note. Forests 6, 903–913. https://doi.org/10.3390/f6040903.
- Müller, MM; Vilà-Vilardell, L; Vacik, H (2020): Forest fires in the Alps – State of knowledge, future challenges and options for an integrated fire management. EUSALP Action Group 8, 83; https://www.alpine-region.eu/results/forest-fires-alps-state-knowledge-and-further-challenges
- Vacik, H., Arndt, N., Arpaci, A., Koch, V., Müller, M., Gossow, H., 2011. Characterisation of forest fires in Austria. Austrian Journal of Forest Science 128, 1–32.

Contact: https://project-confirm.geo.tuwien.ac.at/