Fire danger

The skill provided by ECMWF ensemble prediction system

Link to slides: https://goo.gl/QM15fK

Francesca Di Giuseppe and Claudia Vitolo
Forecast Department, ECMWF

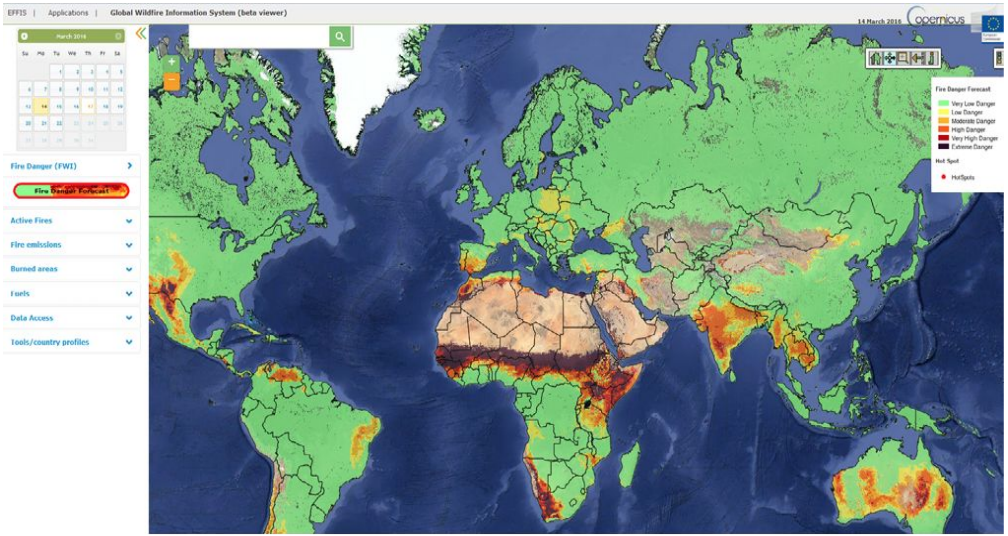
ECMWF

Fire forecast @ECMWF

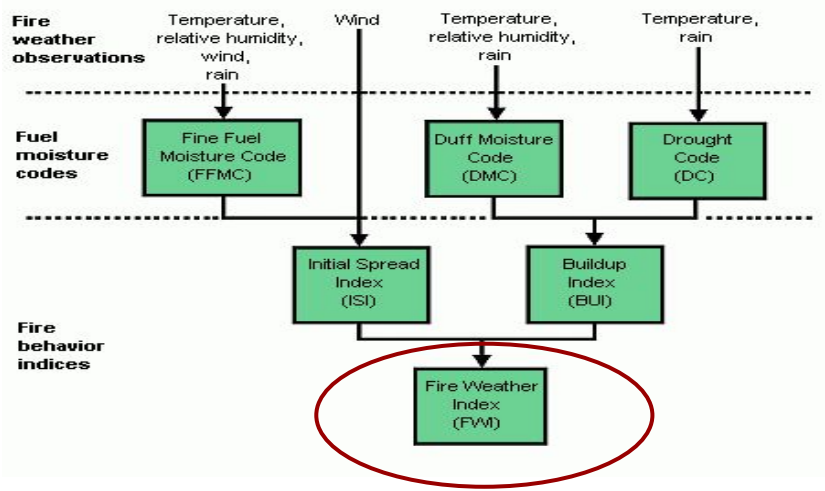
The European Forest Fire Information System (EFFIS) is one of the products in support of natural disaster management provided by the Copernicus Emergency Management Service

Traditional approach -> use of weather stations to assess fire danger conditions.

EFFIS approach -> relies on weather forecast to expand the early warnings



How do we forecast fire danger? Here an example using the FWI

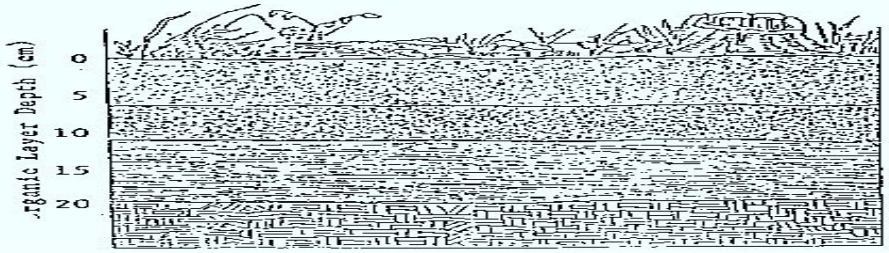


Three non interactive fuel layers

Drying depends on long and short term temperature, humidity and precipitation conditions

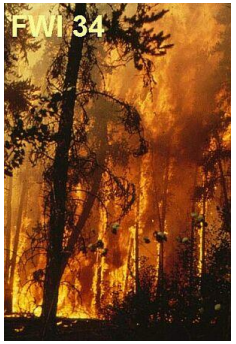
Wind mostly controls inflammability

Combinations of dryness and inflammability produces a general index of fire danger called Fire Weather Index



	Weight	Fuel Moisture Code
Duff Layer	5 t/ha	FFMC
Upper Middle	50 t/ha	DMC
Lower	440 t/ha	DC
Mineral Soil		

Example of Fire danger index “meaning” (FWI)



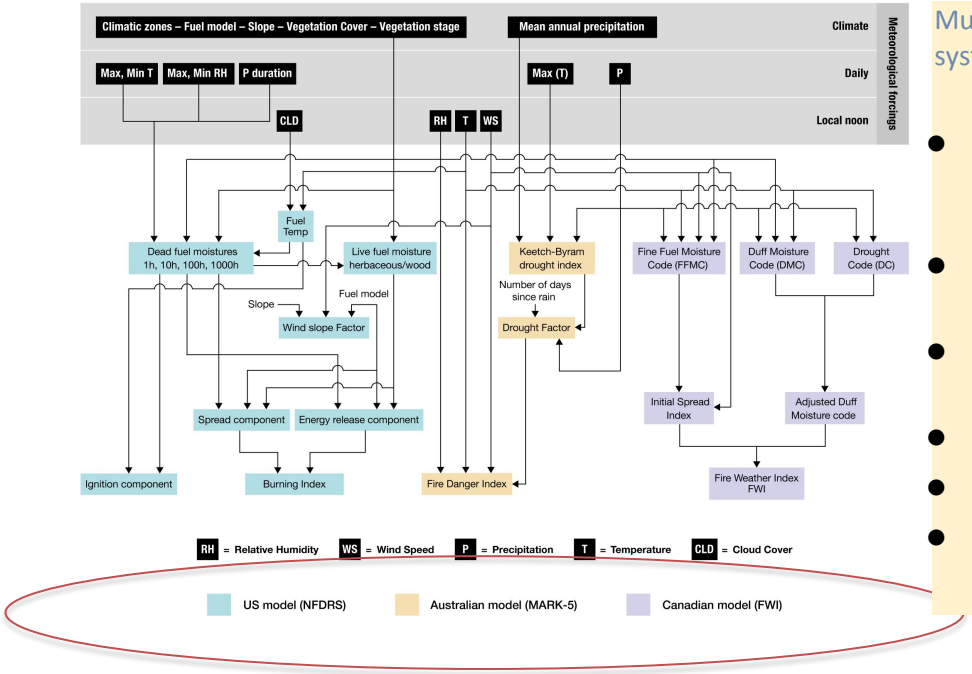
Fire Danger Ratings give you an indication of the consequences of a fire, if one was to start. The higher the fire danger, the more dangerous the conditions.

Fire Danger Ratings should be used as a trigger to take action to prevent or control a possible fire

Alexander, M.E.; De Groot, W.J. 1988. Fire behavior in jack pine stands as related to the Canadian Forest Fire Weather Index System. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Poster with text.

Quintilio, D.; Fahnestock, G.R.; Dubé, D.E. 1977. Fire behavior in upland jack pine: the Darwin Lake Project. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Information Report NOR-X-174.

The ECMWF Fire Forecast system



Multi-model ensemble prediction system for fire danger forecast:

- 3 fire rating models: NFDRS (US),MARK-5 (Australia), FWI (Canada)
- 51 ensemble members at 18 km resolution
- 1 high resolution run at 9km resolution
- 10 days lead time
- Daily updates
- Uses the most recent ECMWF model cycle

Reanalysis from ERA-Interim 1980-2017

Extended rage [46 days]

Di Giuseppe, Francesca, et al. "The potential predictability of fire danger provided by numerical weather prediction." Journal of Applied Meteorology and Climatology 55.11 (2016): 2469-2491.

Forecast or observations ?

Extension of early warnings

Availability of an ensemble prediction system to estimate the range of possible scenarios

Availability of a prediction where observations are not available

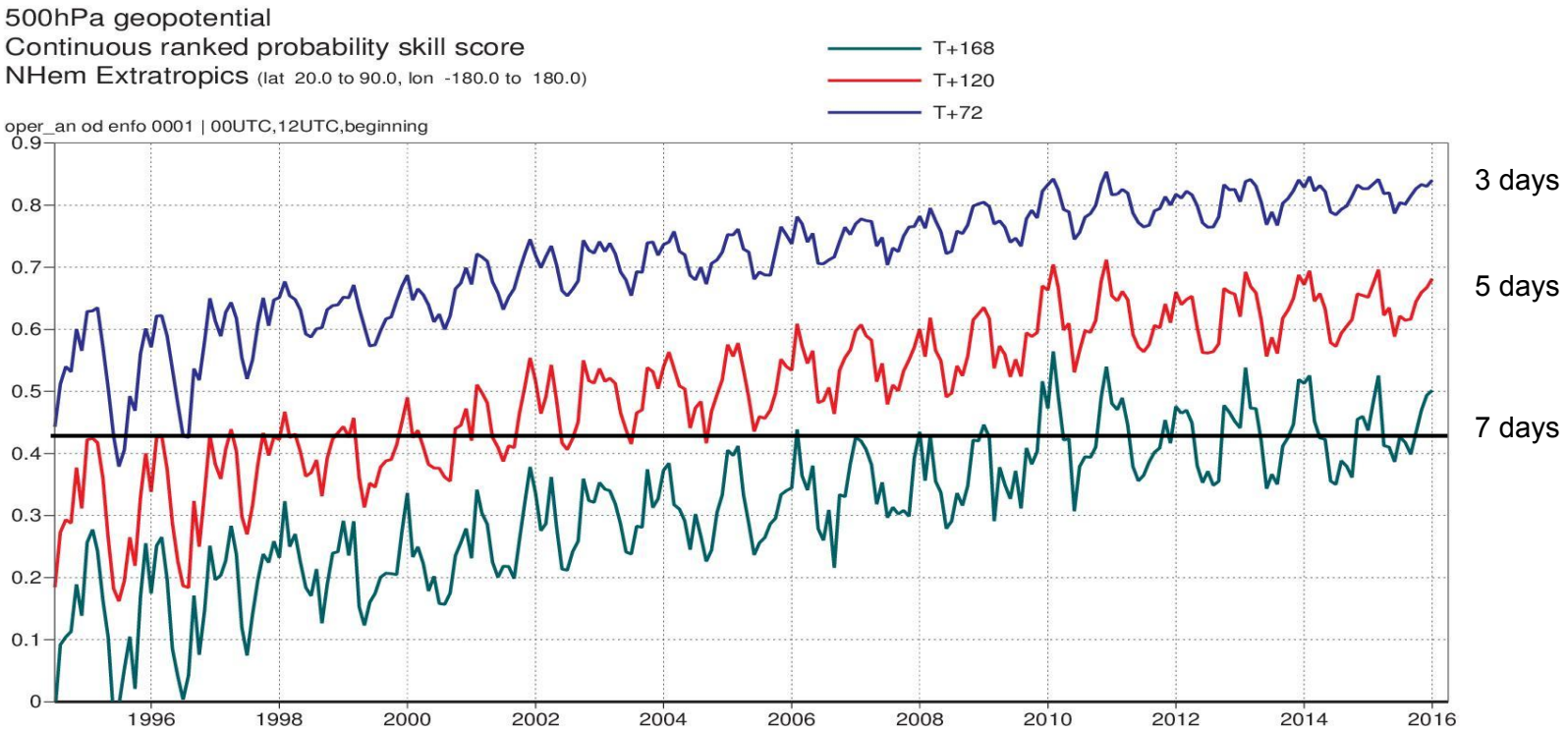
More accurate calculations of fire danger indices

Better temporal resolution can allow for a better diurnal cycle characterization

Better representation of local ecosystem

Increase in forecast skills in the last 20 years

CRPSS is a measure of skill. Today, +7d fcs are as good as +3d fcs 20y ago!

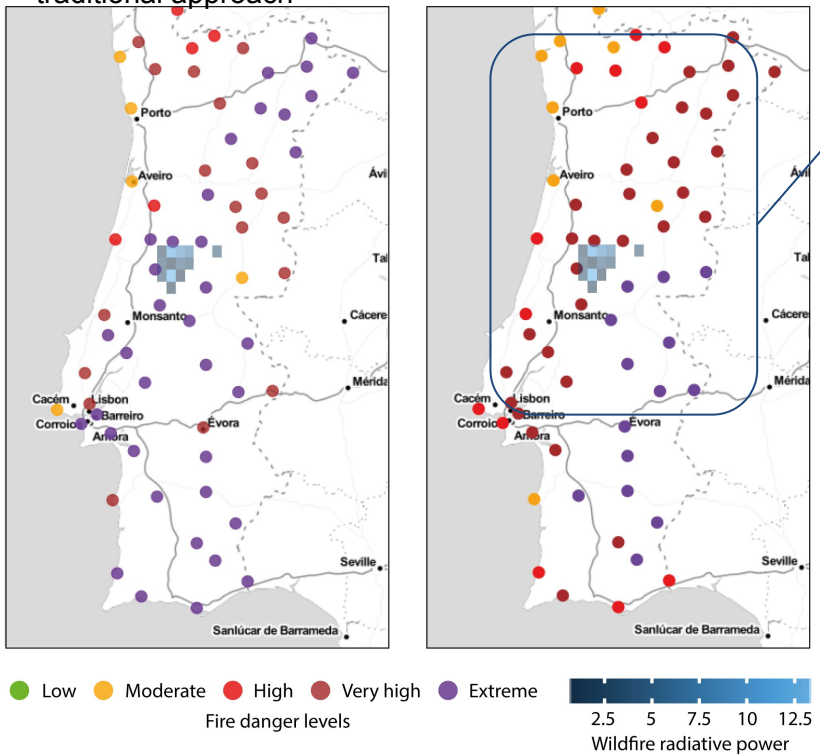


ECMWF

Increasing use of weather forecast to assess fire danger conditions

FWI using station data
"traditional approach"

FWI using ECMWF FC 10 days



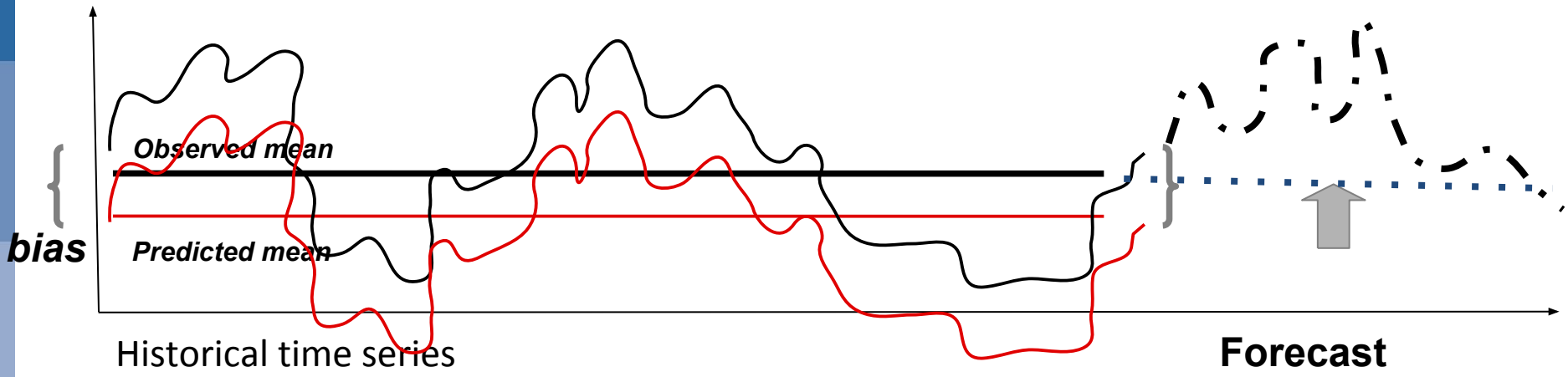
Under estimation of fire danger ???

The increase in forecast skills means a growing opportunity to use weather forecast in fire prediction and extend the early warning of environmental modelling

Use of ECMWF medium range forecast in recent Portuguese fire

10 days forecast for FWI on weather station for the 18 June 2017

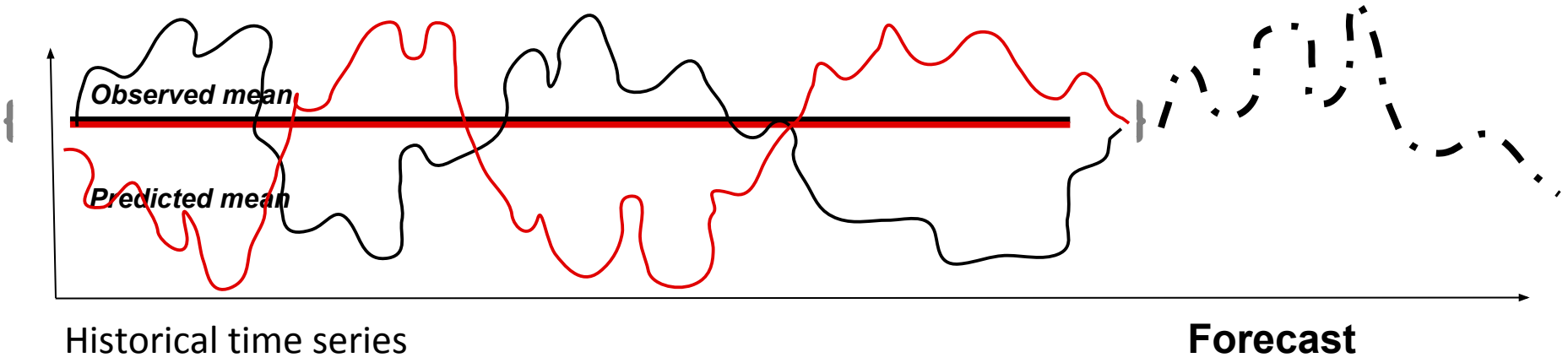
Desirable situation



The 'climate' of the model is offset BUT the temporal variability is good (this means good model skills)

- the predicted anomalies are good even if forecast fields are biased
- a simple bias correction [i.e adding the mean bias] can improve the forecast fields

Not so desirable situation

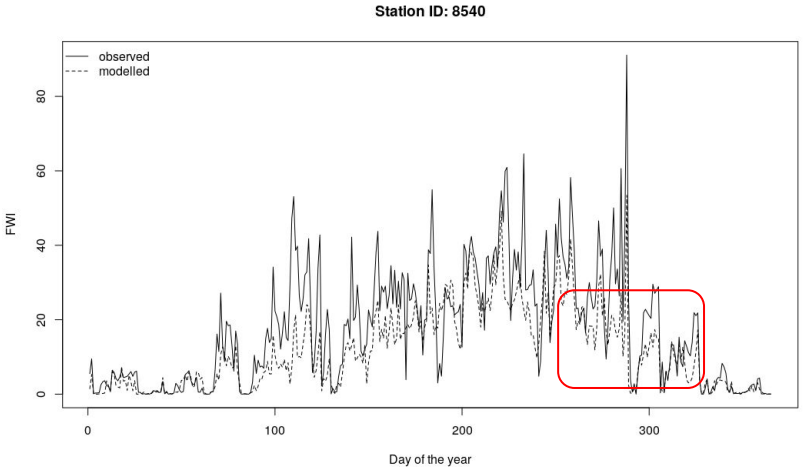


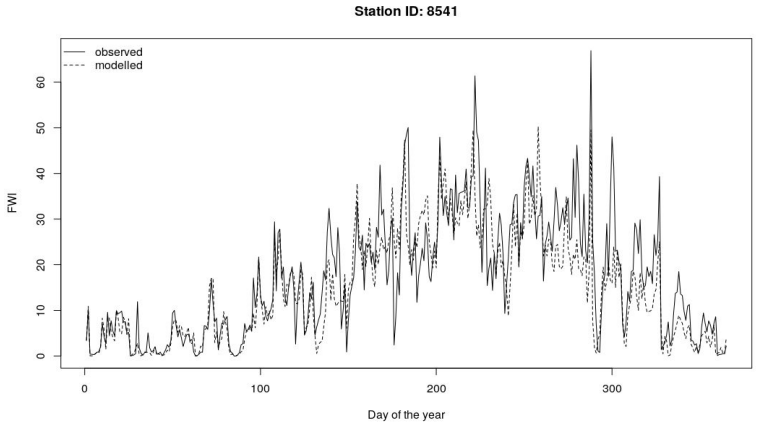
The 'climate' of the model is very good BUT the temporal variability is in anti-phase with the observations (bad model prediction skills)

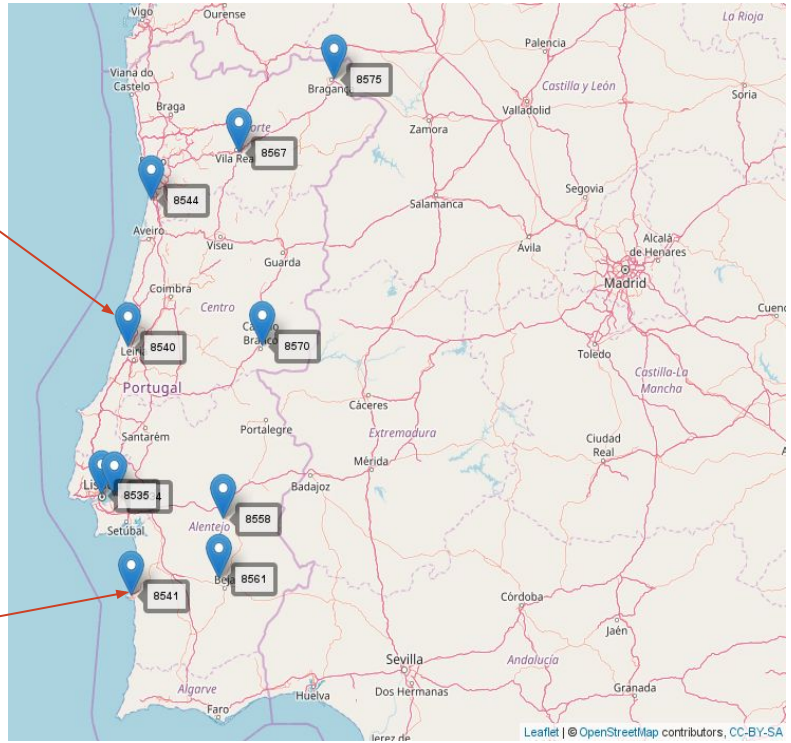
→ the predicted anomaly are reversed respect to the observations!!

→ a simple (i.e. statistical) bias correction could NOT help to provide a good forecast

FWI comparison between ERA-I and weather stations data (2017-Portugal)



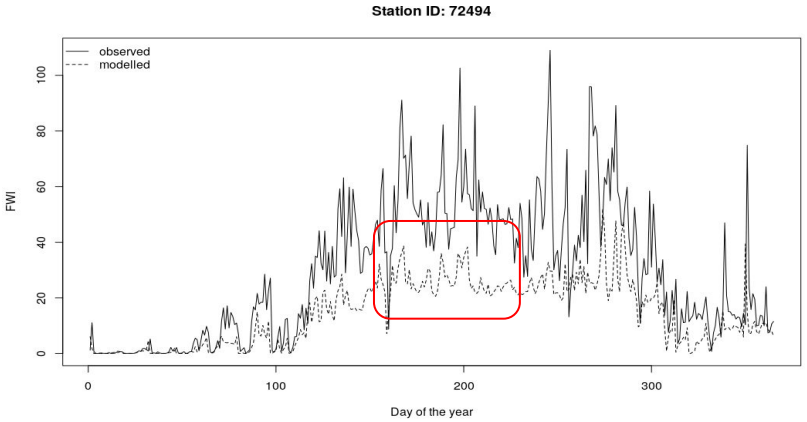


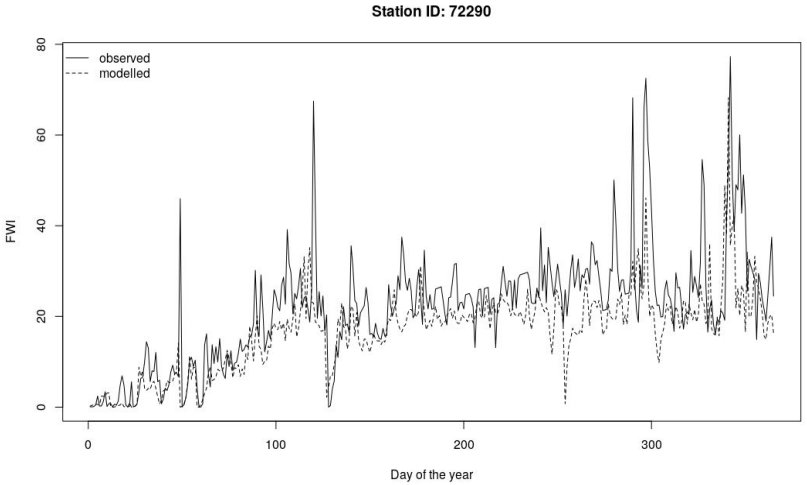


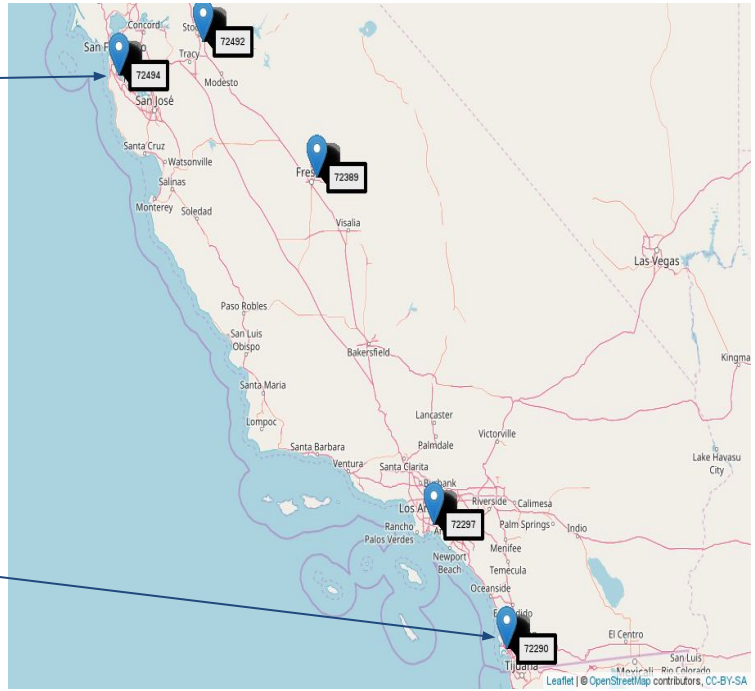
WEATHER FORECASTS

ACC >0.85 in most stations

FWI comparison between ERA-I and weather stations data (2017-California)







ACC >0.85 in all stations

The problem of defining early warning levels at the global scale : the Calive-R package

Same FWI value can correspond to different warning levels in different location

Need for a “calibration” to translate fire danger rating into warning levels

PDF of FWI values

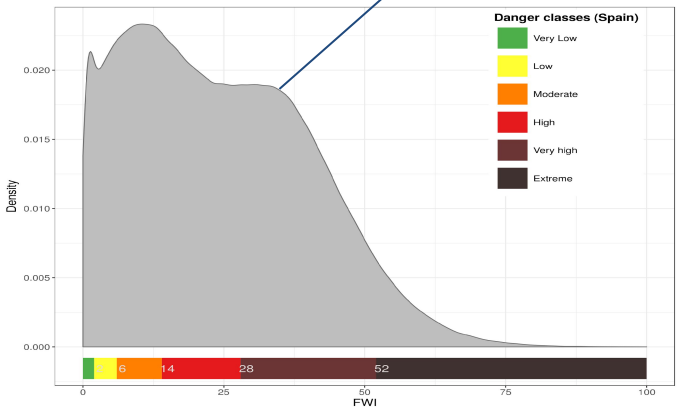


Table 7. Fire danger levels for selected areas.

Area of interest	Very low	Low	Moderate	High	Very high	Extreme
Europe	<= 2	3 – 4	5 – 9	10 – 16	17 – 28	> 28
United Kingdom	<= 1	2 – 3	4 – 6	7 – 11	12 – 18	> 18
Spain	<= 2	3 – 6	7 – 14	15 – 28	29 – 52	> 52
Italy	<= 2	3 – 5	6 – 11	12 – 21	22 – 38	> 38
Calabria Region (IT)	<= 2	3 – 5	6 – 12	13 – 22	23 – 40	> 40
Sicily (IT)	<= 2	3 – 6	7 – 13	14 – 26	27 – 48	> 48
Liguria Region (IT)	<= 1	2 – 4	5 – 8	9 – 15	16 – 25	> 25
Province of Genoa, part of Liguria Region	<= 2	3 – 4	5 – 9	10 – 16	17 – 27	> 27

Practical on how to generate warning levels from fire forecast

15:45-17:00
Discover ECMWF: ecCharts, Data Services, Software, Services

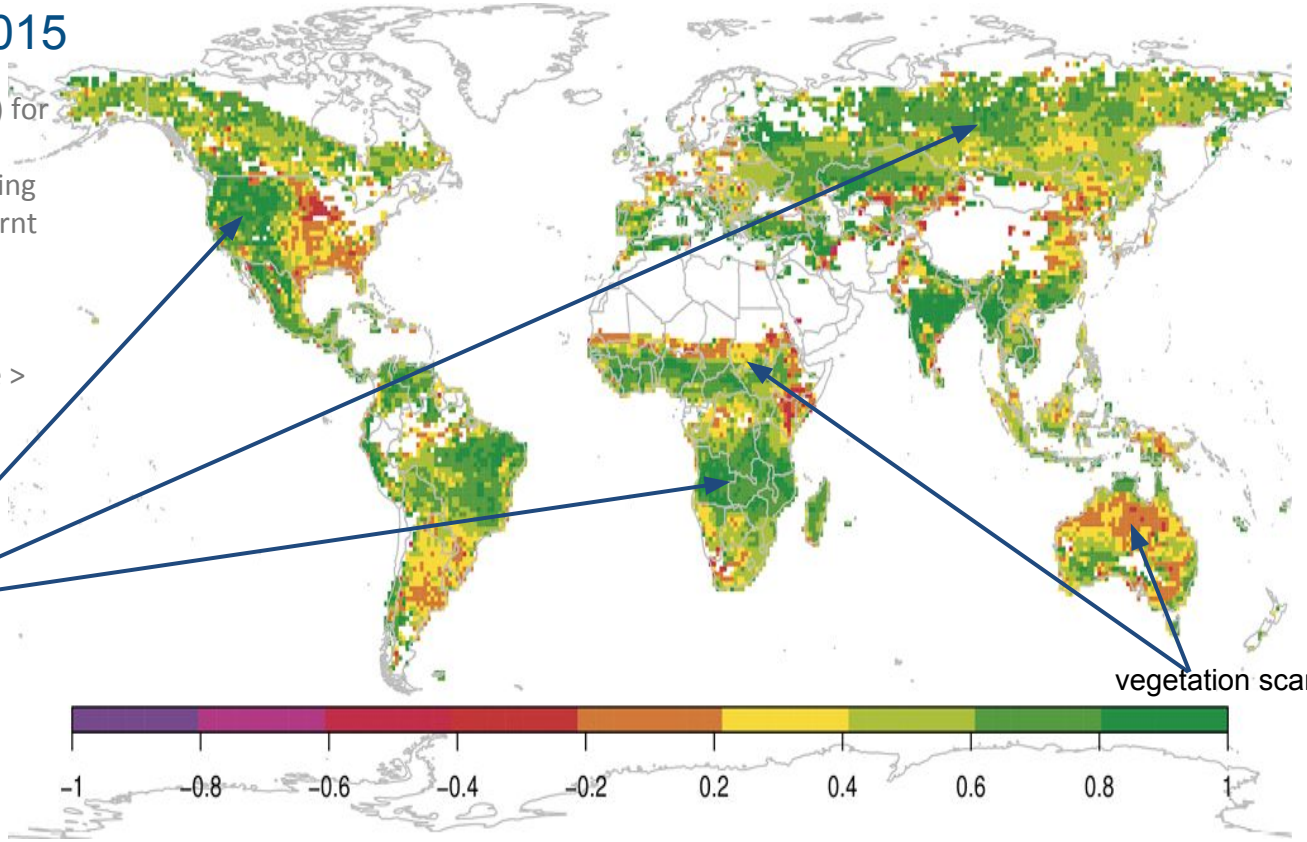
Claudia

Where FWI approach is likely to be more accurate to detect fire danger: reanalysis 2000-2015

Extremal Dependence Index (EDI) for the Fire Weather Index (FWI).
The EDI skill score is calculated using the fire mask derived from the burnt areas of the GFED4 dataset.

A fire is considered to have been forecasted when the FWI is above > 75% of its distribution.

EDI =1 perfect forecasts
EDI =0 random forecasts.

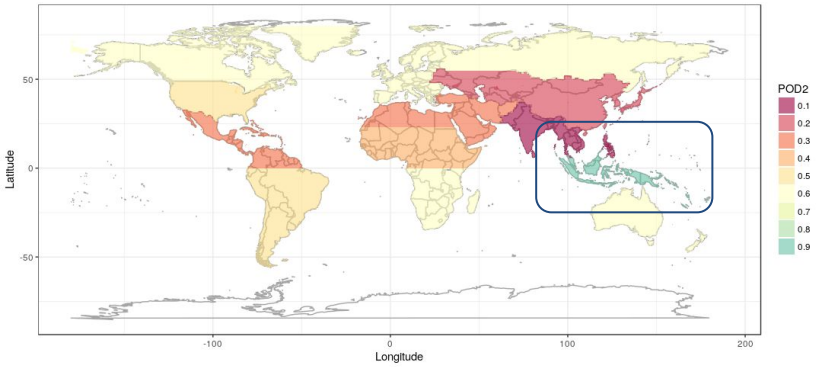


ECMWF EUROPEA

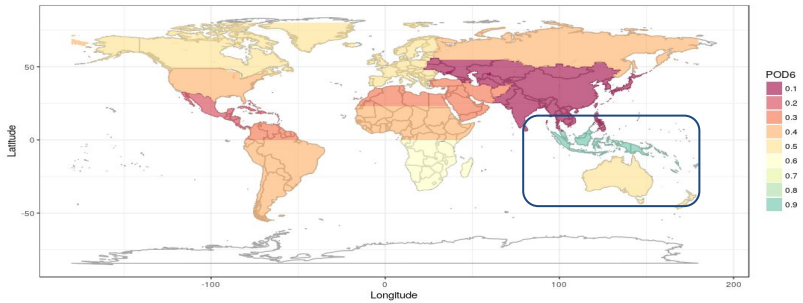
Di Giuseppe, F et al. "The potential predictability of fire danger provided by numerical weather prediction." Journal of Applied Meteorology and Climatology 55.11 (2016): 2469-2491.

Probability of detection 2 -6 days forecast in 2017

DAY-2

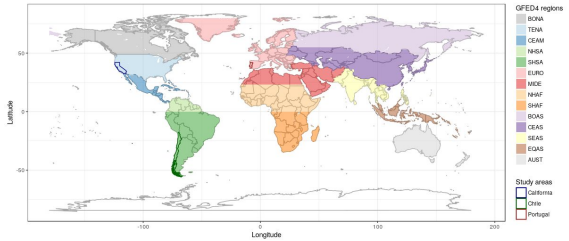


DAY-6



POD =hits/ (hits+misses)

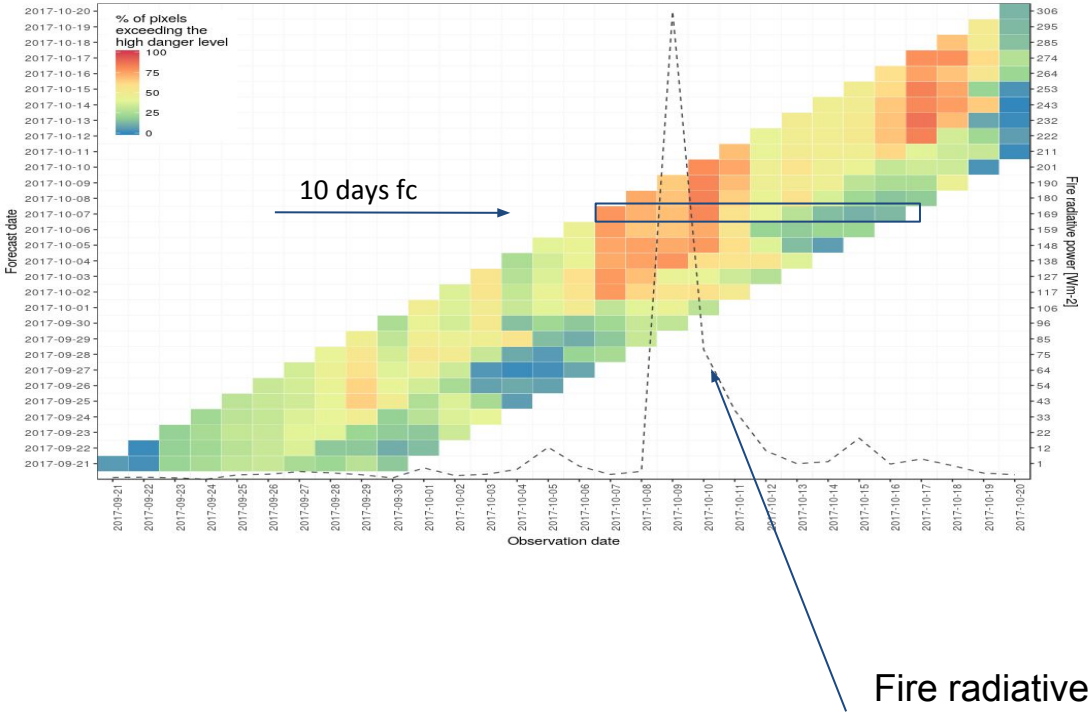
Very rough overview of potential usability of weather forecast for fire danger detection

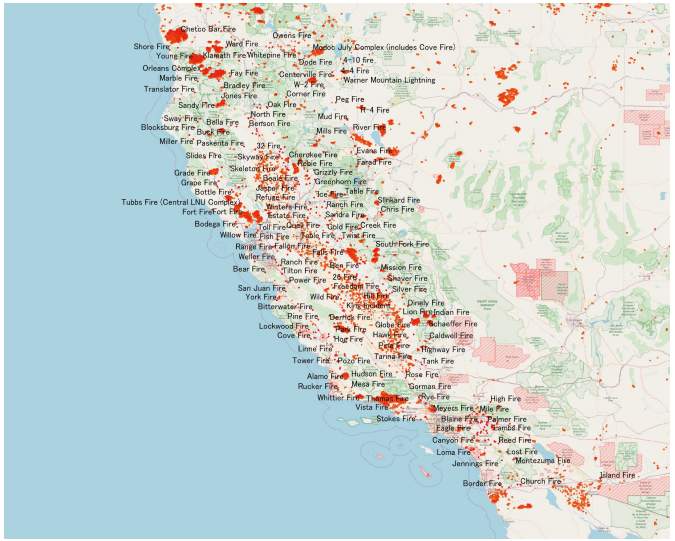


GFED4 Regions for averaging

Di Giuseppe, F et al. "Fire Danger: the skill provided by ECMWF ensemble prediction system." Journal of Applied Meteorology and Climatology (2018);to be submitted

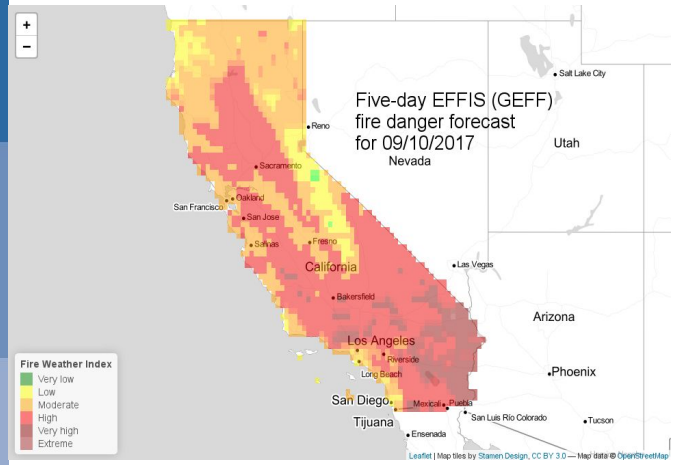
Looking into the fire forecasting system - California Fire 2017





By Phoenix7777Own work [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0

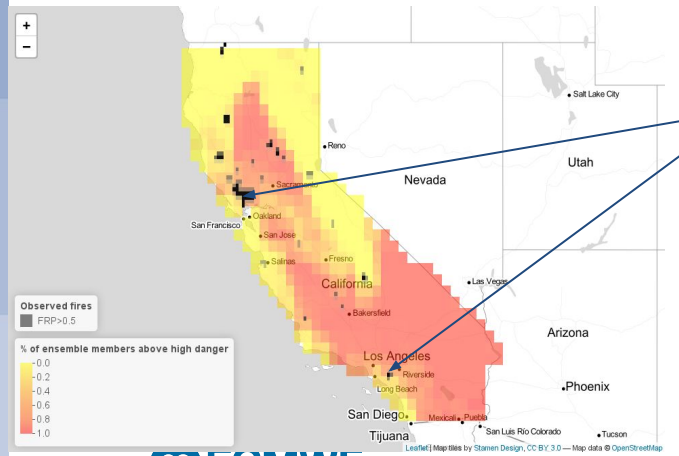
Exploiting the ensemble prediction informations



California fire (8-11 October 2017)

The **2017 California wildfire season** was the most destructive wildfire season on record,which saw multiple wildfires burning across California. A total of 9,133 fires burned 1,381,405 acres (5,590.35 km^2), according to the California Department of Forestry and Fire Protection, including five of the 20 most destructive wildland-urban interface fires in the state's history.

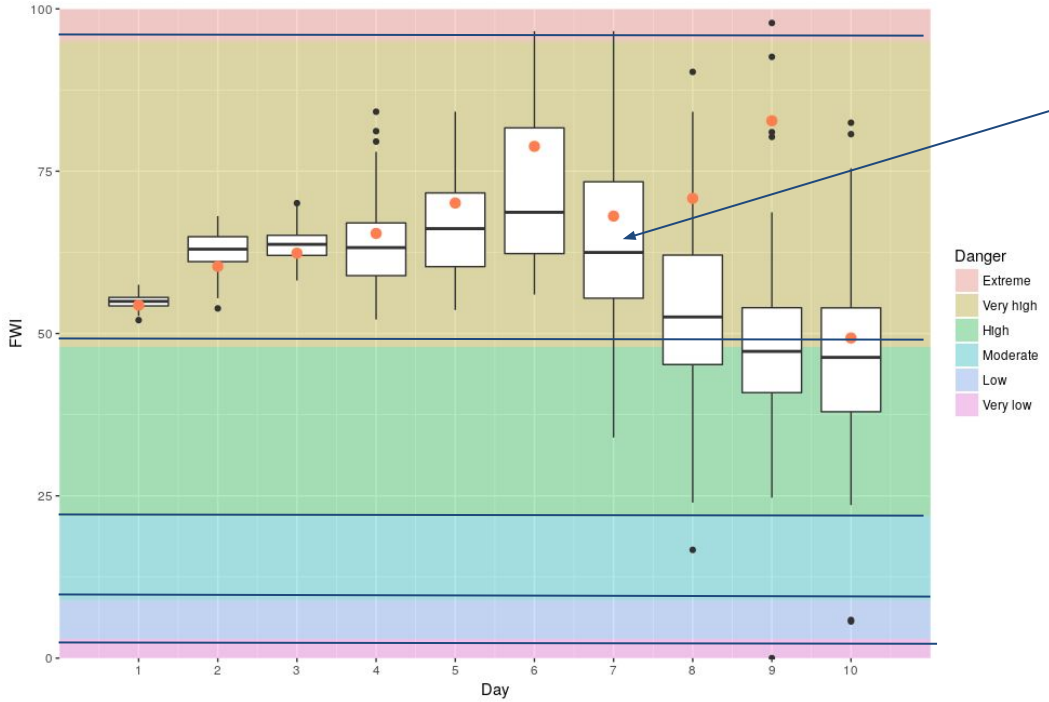
State data showed that the large wildfires killed 43 people – 41 civilians and 2 firefighters - higher than the previous 10 years combined



Observed fires

Probabilistic information provided by the fire forecast Ensemble prediction system

“ Fire -gram”



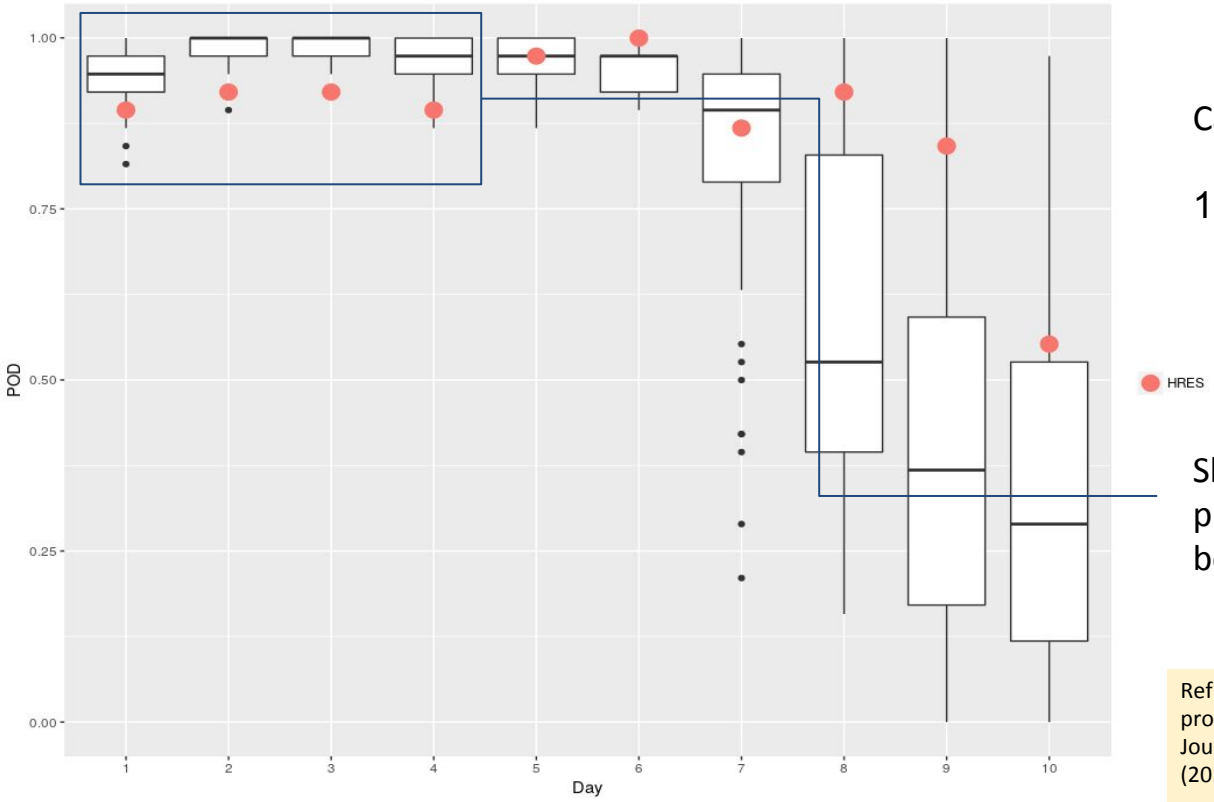
The higher resolution did not captured the “Extreme conditions”

Fire Weather Index distribution at one location where fire raged out of control the 8th of October. California Fire 8 October 2017

1 Location @ [38 34'N; 122 34' W]

Di Giuseppe, F et al. "Fire Danger: the skill provided by ECMWF ensemble prediction system." Journal of Applied Meteorology and Climatology (2018);to be submitted

The added skill provided by the ensemble prediction



California Fire 8 October 2017

1 Location @ [38 34'N; 122 34' W]

Skills from the distribution of the ENS prediction system is, in this case, better than the HRES

Ref: Di Giuseppe, F et al. "Fire Danger: the skill provided by ECMWF ensemble prediction system." Journal of Applied Meteorology and Climatology (2018);to be submitted

Conclusions

Fire danger prediction to really be helpful should be accurate at least 3 days ahead (says to us the "Portugues met-service").

With today weather forecast accuracy this might be in reach of this goal, especially if information is complemented:

- Model derived warning levels
- "confidence" levels (-> ensemble prediction)
- Range of possible scenarios (-> ensemble prediction)

Thank you!

Questions?

ECMWF