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Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

NH34C-07: Seasonal to decadal prediction of fire danger

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Climate Prediction Group

Earth Sciences Department

FWI - Introduction

The 2017 fire season in California WAS the costliest on record, with 18 Billion US$ in damages, and deadliest with 43 casualties on record.

2018 wildfire season was even worse...

REX/Shutterstock

Introduction

- The European countries most affected by wildfires are in the Mediterranean basin, with summer fires occurring during periods of drought.
- 2017 was a particularly extreme year for wildfires fire season with many deaths in Portugal and record-breaking wildfires in California.
- The 2018 wildfire season in California has been even worse, with many tragic deaths.
- In light of this, seasonal prediction of wildfire danger appears as a priority for health, safety and economic welfare.
- While several short-term (up to 10 days in advance) fire danger systems are in place, there is currently no operational seasonal wildfire forecasting system for Europe and only a few for other continents

Introduction

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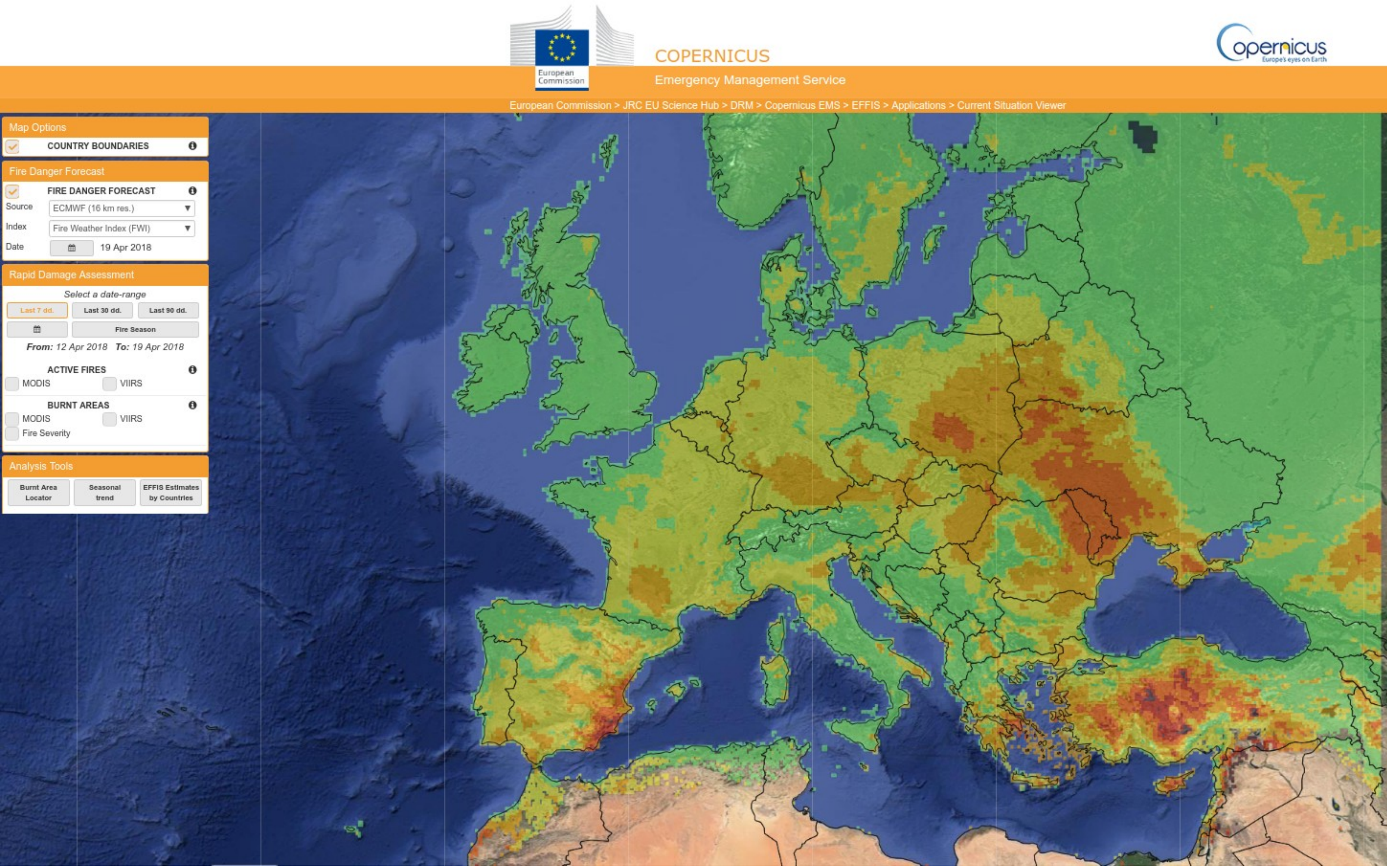
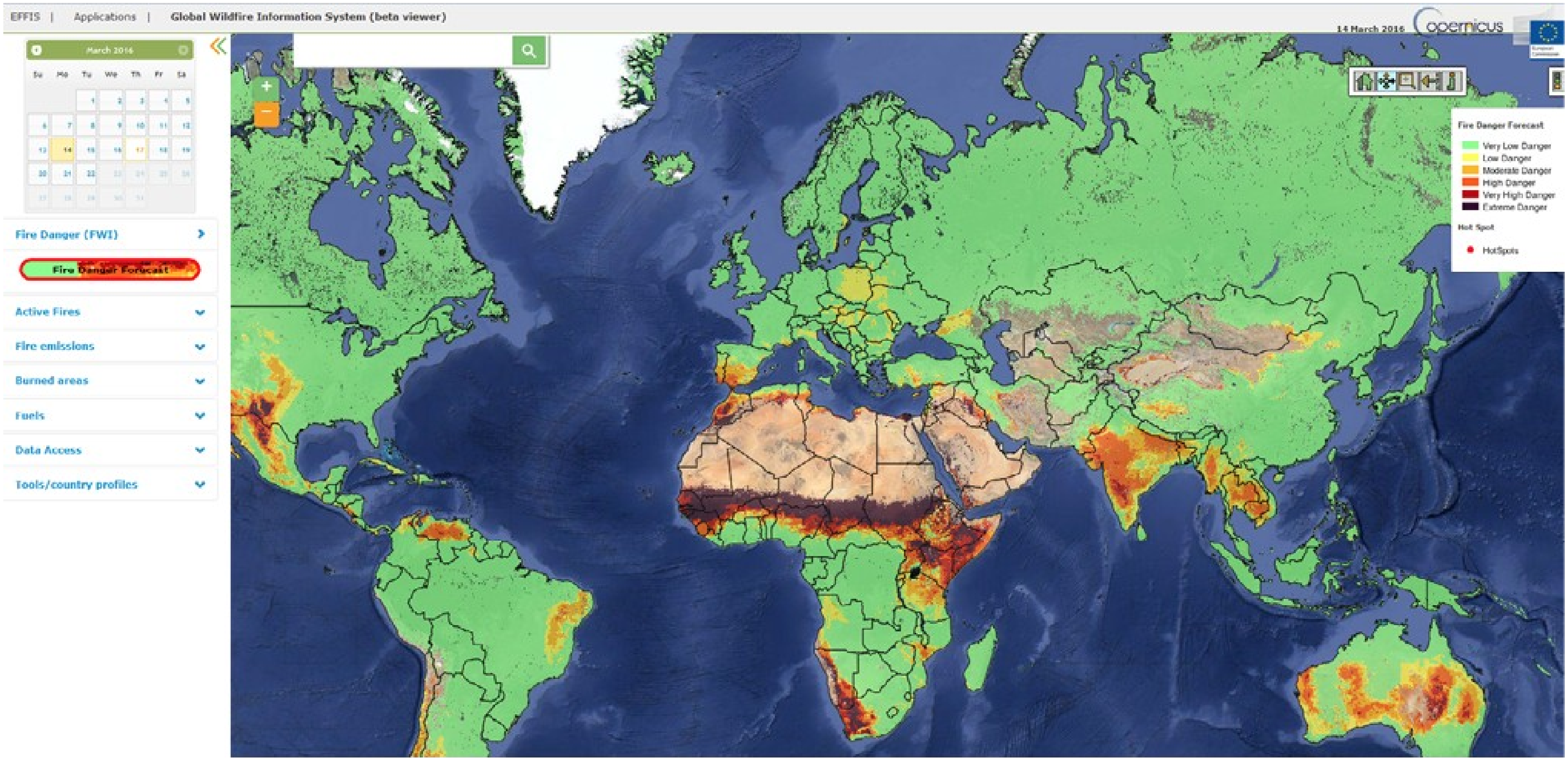
- Seasonal Prediction of Fire danger using Statistical and Dynamical models (SPFireSD) is a MSCA Individual Fellowship
- Other approaches not discussed here:
  - Statistical approach: fire danger predictions using linear regression models
  - Dynamical approach: ensemble dynamical predictions using Earth System Models
- **Fire danger indices approach**: simple fire danger indices computed from seasonal dynamical climate prediction systems
  - Adapt existing ECMWF infrastructure for operational short-term wildfire predictions (GEFF model), using FWI forecasts
  - ECMWF SEAS5 hindcasts (C3S 1degree grid) from 1981-2017 used as input for FWI computations, compared to FWI computed from ERA-Interim
  - FWI prediction requires daily predictions of precipitation, temperature, relative humidity and wind
- Decadal prediction of fire danger using SPI/SPEI – preliminary work

EFFIS 10-day FWI forecast



GWIS 10-day FWI forecast



Fire danger forecast

Very low danger
Low danger
Moderate danger
High danger
Very high danger
Extreme danger

Hotspot

EFFIS “seasonal prediction”

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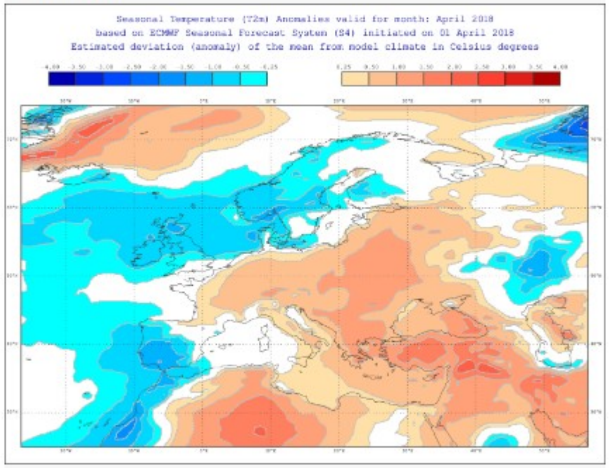
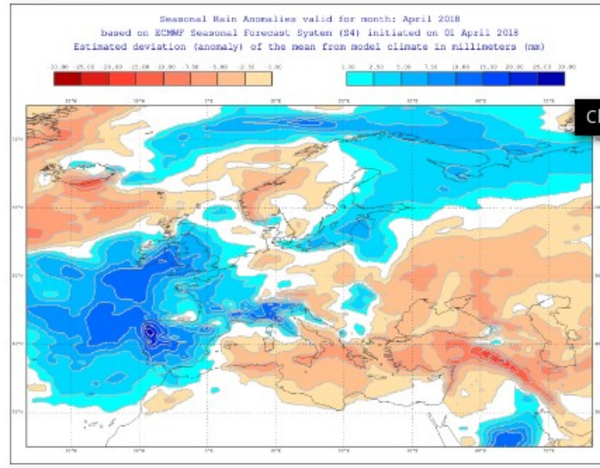
Temperature anomalies

APRIL 2018



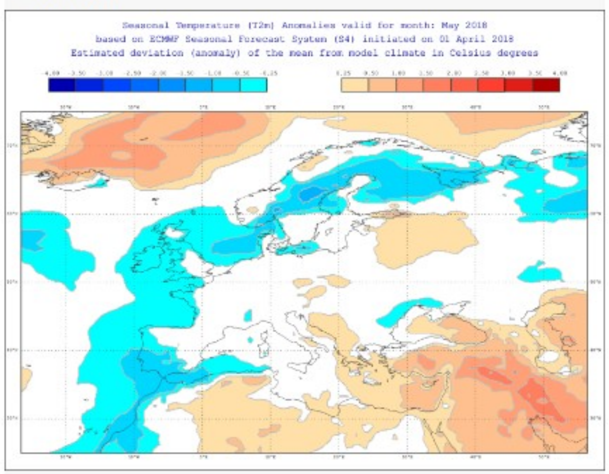
Rain anomalies

APRIL 2018



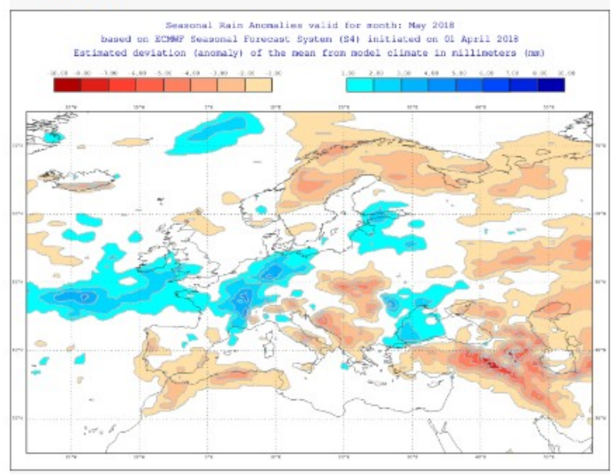
Temperature anomalies

MAY 2018



Rain anomalies

MAY 2018



California 2017 wildfires

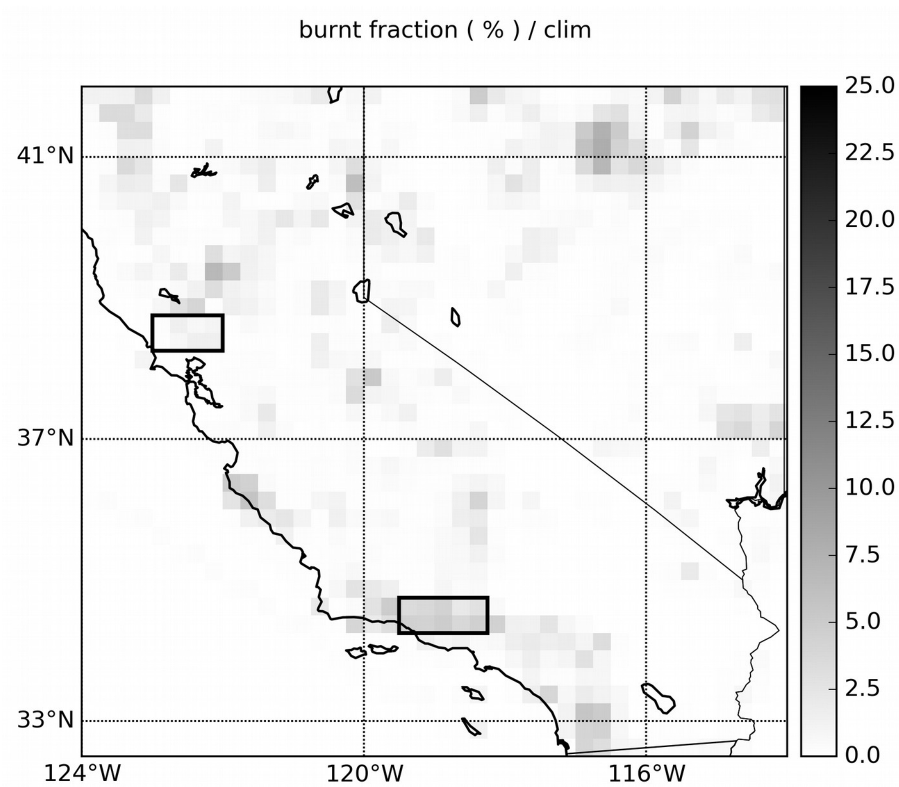
In October, around the Napa valley in Northern California, the Tubbs fire was the most destructive in US history. Warm temperatures and strong winds are thought to be responsible for the severity of these wildfires.

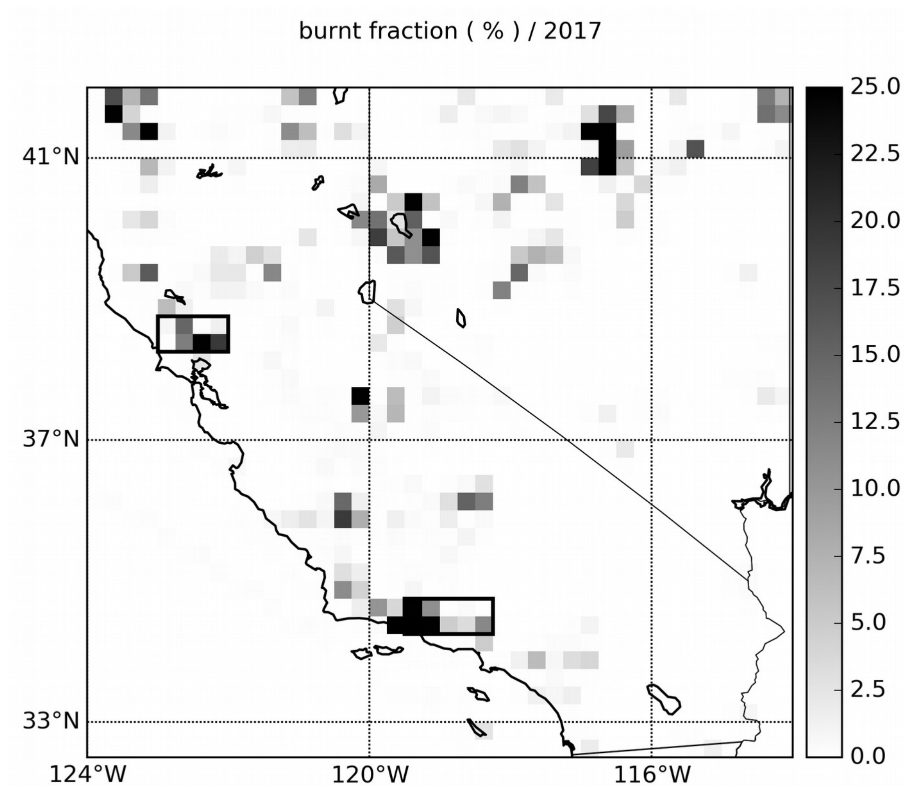
In December, Southern California was plagued by severe wildfires and the Thomas fire near Los Angeles became the largest in California history. It was thought to be fueled by sever Santa Ana winds and warmer than average temperatures.

was 2017 extreme?

Observed burned areas in 2017 were indeed much higher than climatological averages.

In fact many areas had not been previously burned in the entire MODIS observation period (2000-2017).





FWI in October-December 2017

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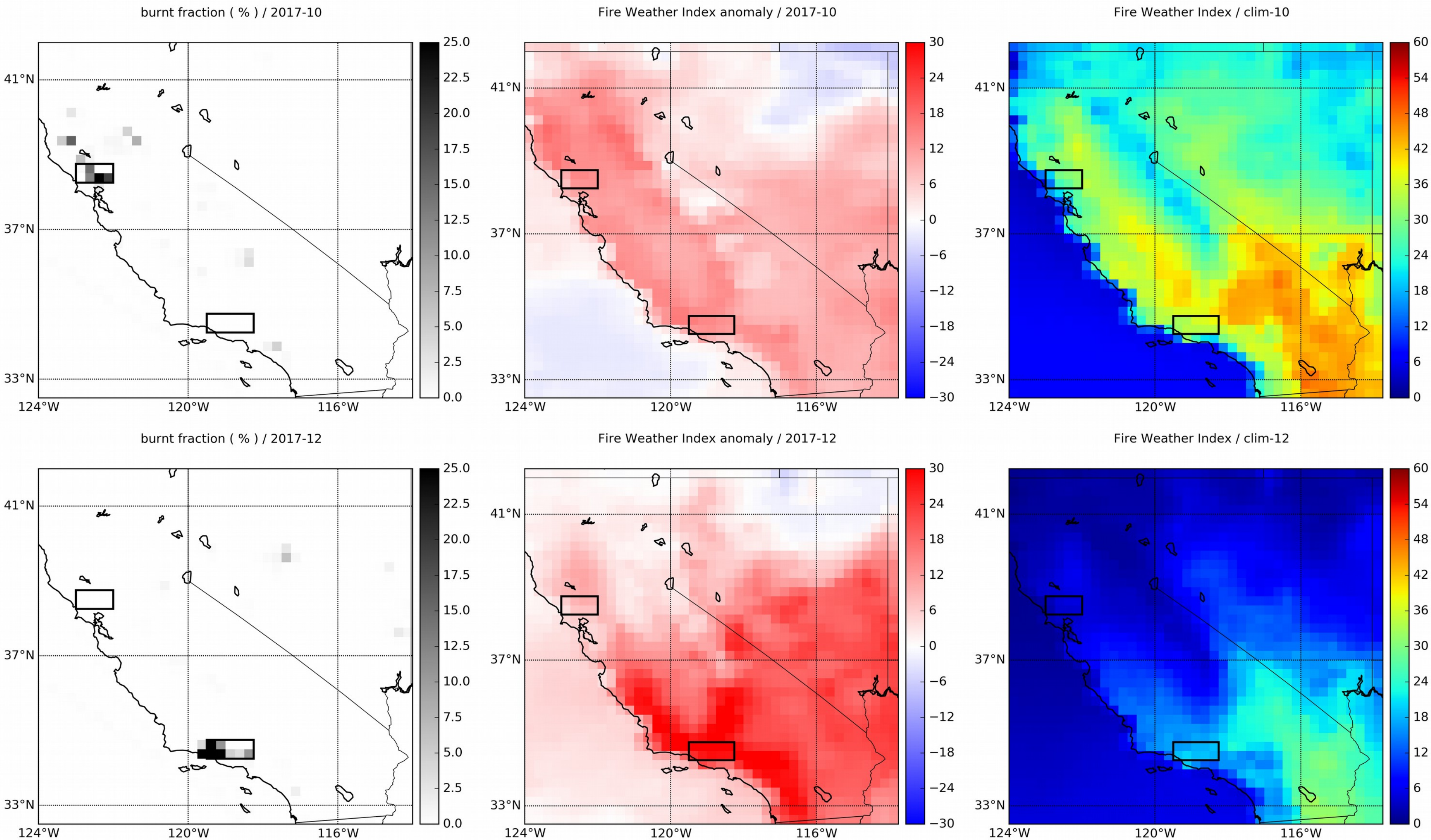
Widespread positive FWI anomalies in Oct and Dec created conditions which favoured the extreme wildfires in northern and southern California.

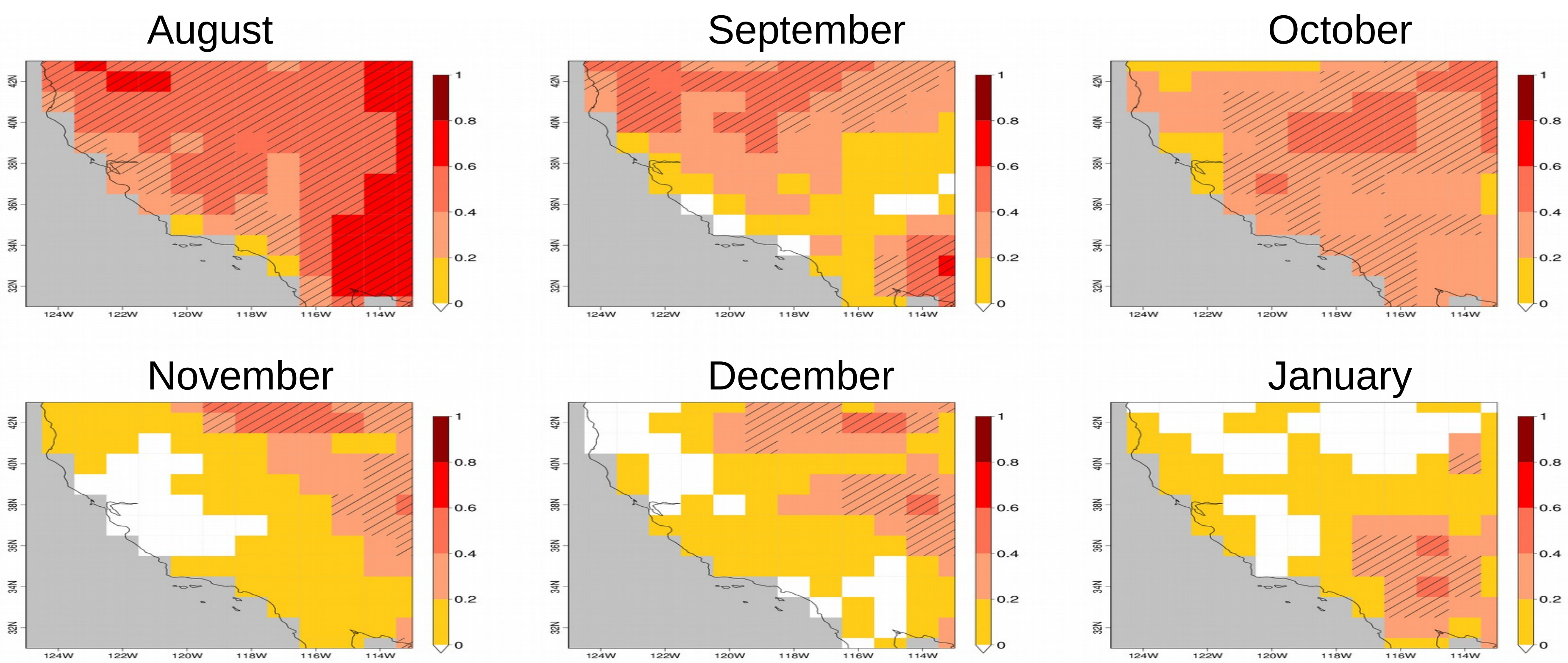


Seasonal prediction skill – August init

Anomaly Correlation Coefficient (ACC) of SEAS5 FWI predictions (monthly, ensemble means) vs. ERA-Interim over California, initialized in August.

Shows potential skill in Lead month 0 (August) and 2 (October), but not near the coast

After 3 months skill drops rapidly.



Seasonal prediction – August 2017

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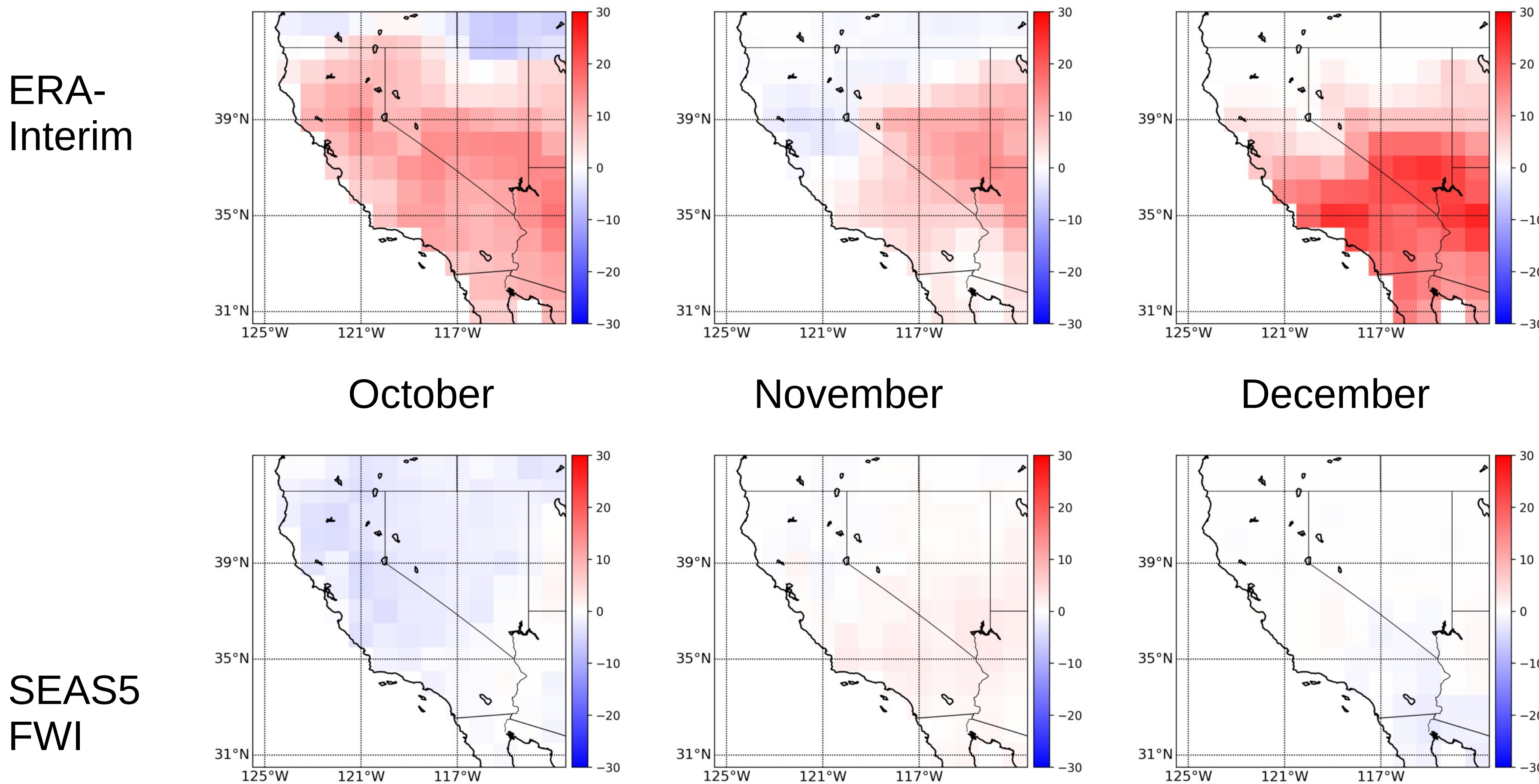
FWI computed from August predictions – results are quite dissapointing…

This is due to poor skill after 2+ months



Seasonal prediction – August 2017

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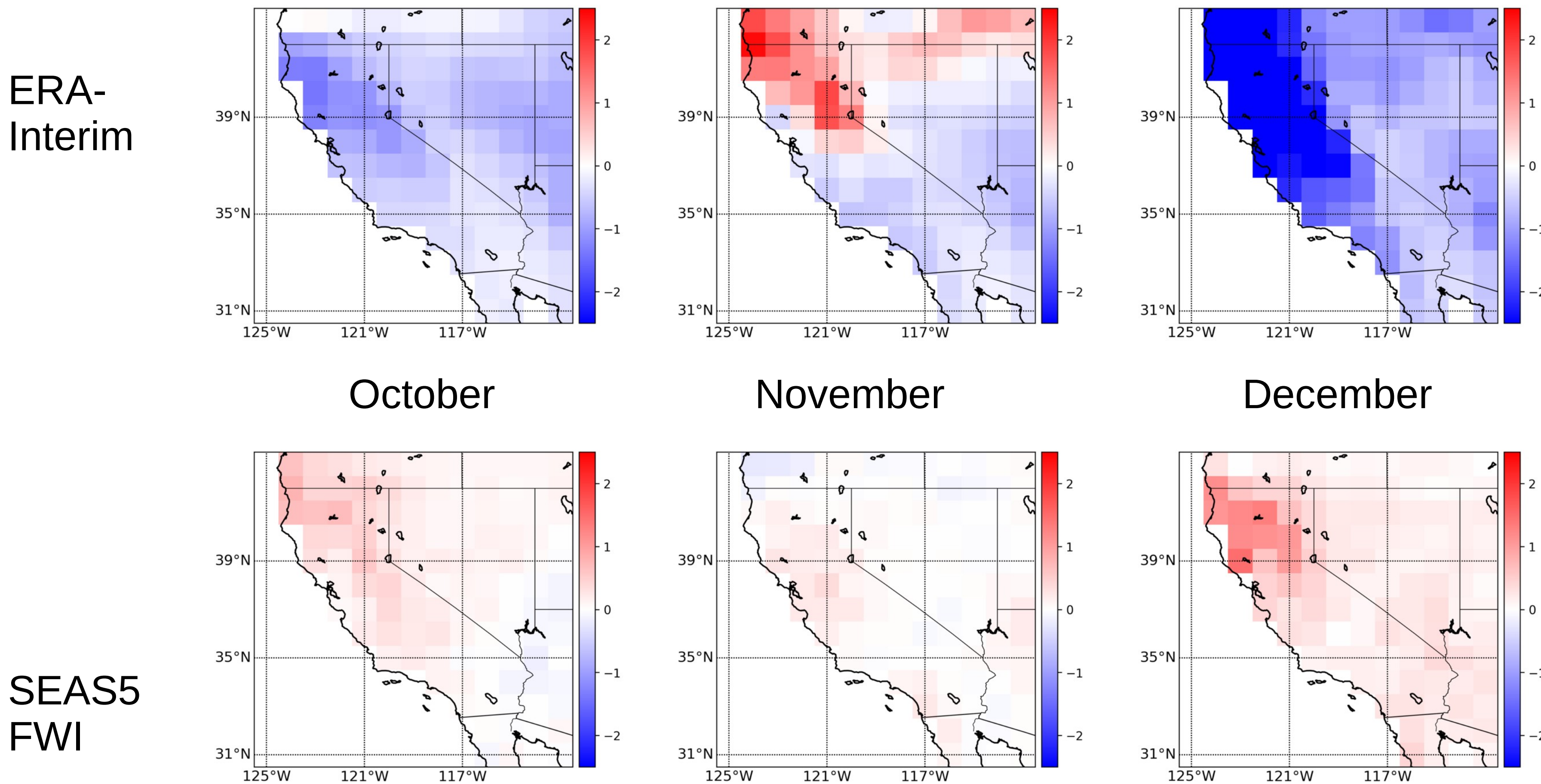
FWI computed from August predictions – results are quite dissapointing…

Precipitation is not well predicted 2+ months ahead!

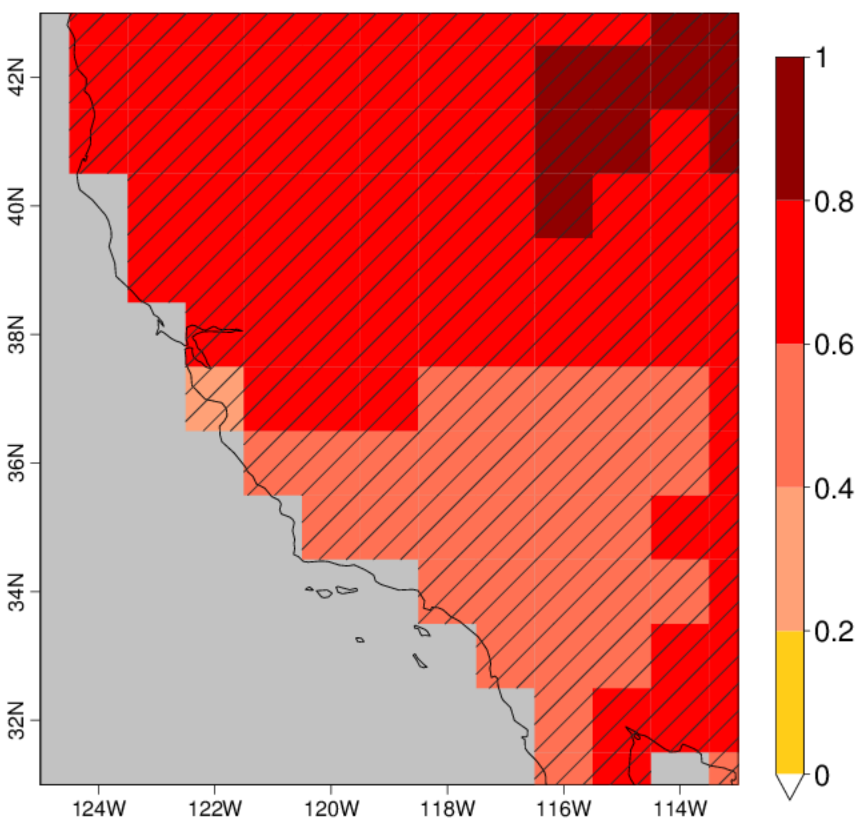
Must run hindcasts at later start dates



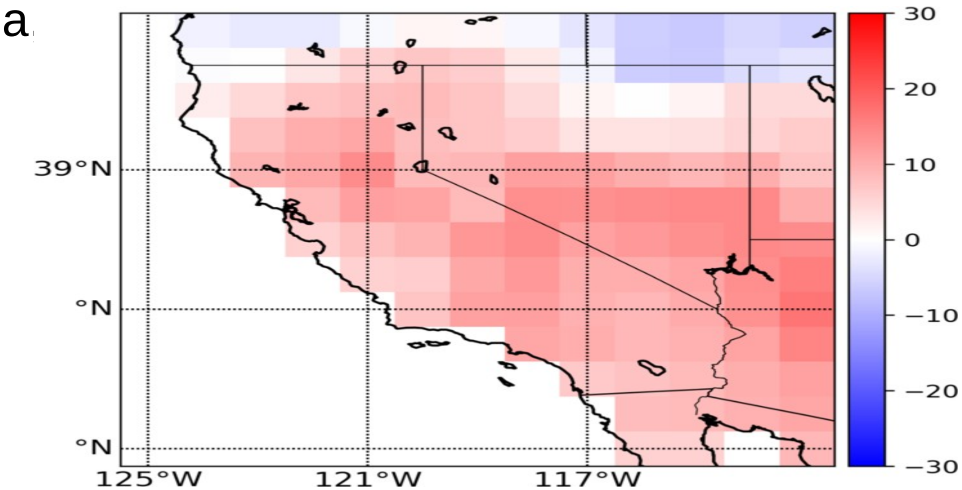
Seasonal prediction skill – Oct. init

Anomaly Correlation Coefficient (ACC)
of SEAS5 FWI predictions over California
initialized in October – much better!!!

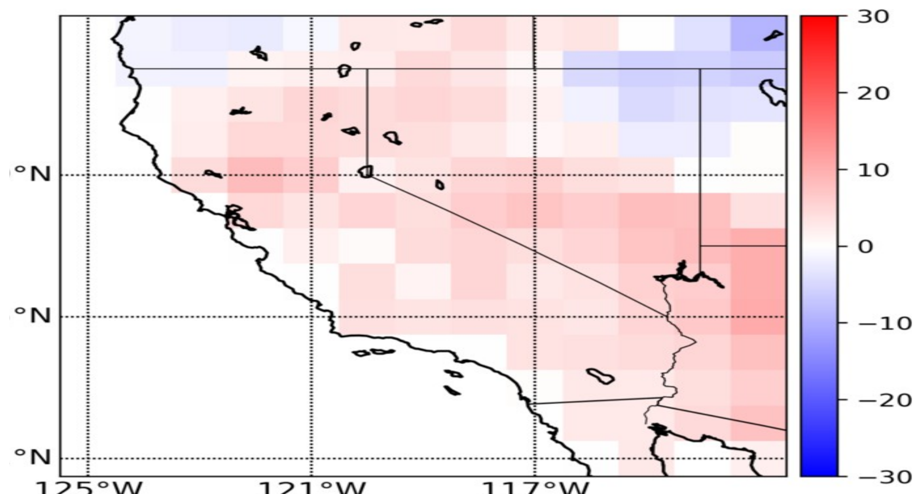
Ens-corr monthly fwi seas5-eraint Oct startdate-lead 0



ERA-Interim Oct. 2017 FWI anomaly



SEAS5 Oct. 2017 FWI anomaly



Seasonal prediction skill – Dec. init

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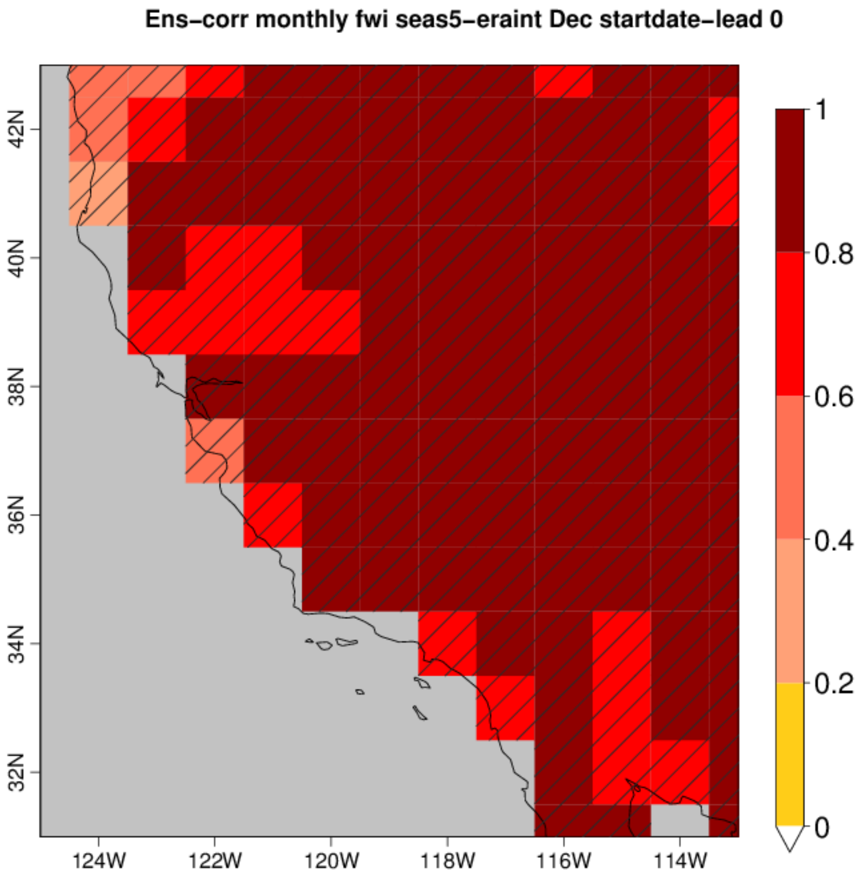
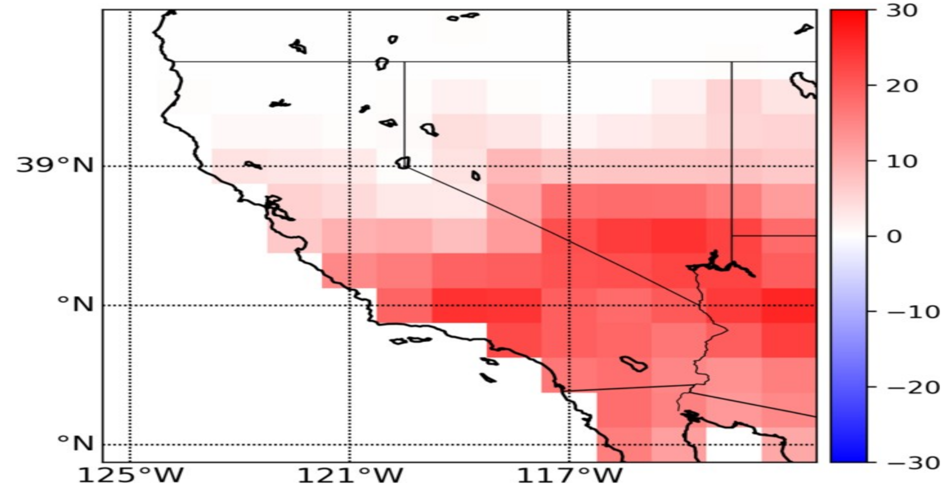
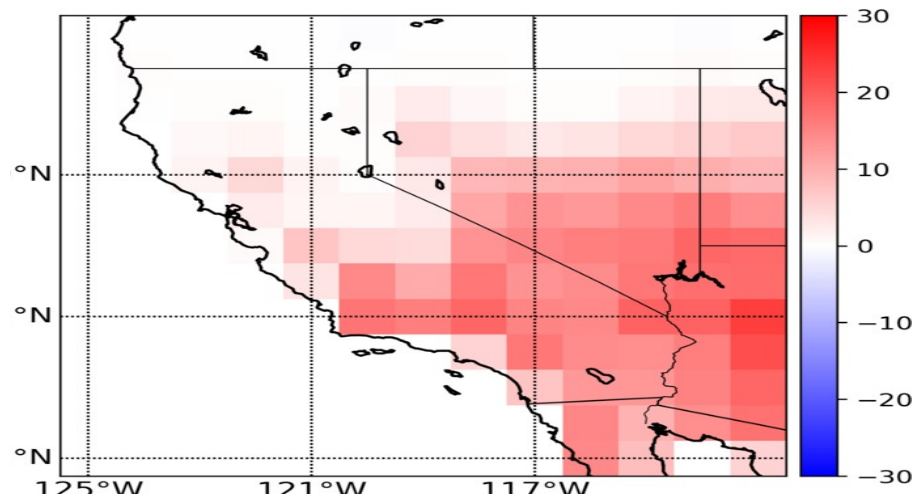
Anomaly Correlation Coefficient (ACC) of SEAS5 FWI predictions over Iberia, initialized in October – much better!!!



ERA-Interim Dec. 2017 FWI anomaly



SEAS5 Dec. 2017 FWI anomaly



Iberia 2017 wildfires

In June 2017, the infamous “Pedrogão Grande” wildfires (in central Portugal) killed 62 people trapped in their cars are they fled the intense wildfires.

https://www.cnn.com/2017/06/18/europe/portugal-fire/index.html

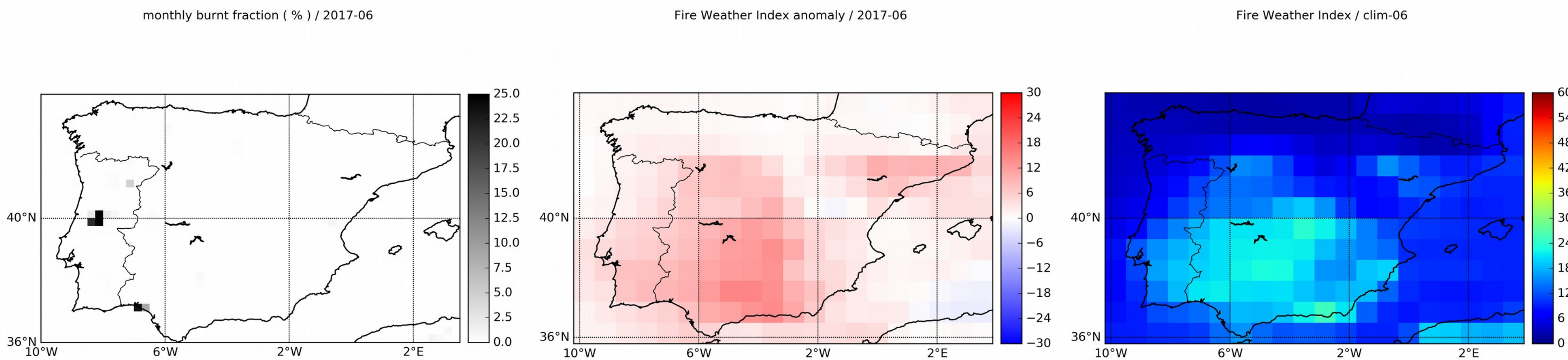
Iberia 2017 wildfires

In October 2017, wildfires raged across northern Portugal and Galicia (Spain). The wildfires were made possible due to an intense drought and fueled by intense winds from Hurricane Ophelia. Arson is believed to be responsible for igniting many fires.

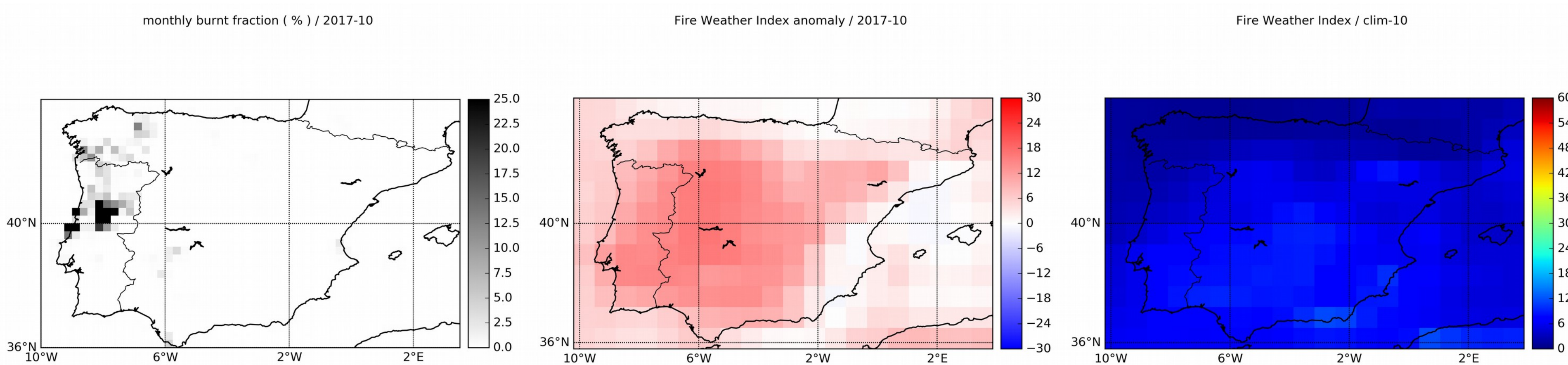
https://www.nytimes.com/2017/10/16/world/europe/portugal-spain-fires.html

Iberia 2017 wildfires

During the “Pedrogão Grande” wildfires in Portugal in June 2017, positive FWI anomalies were observed, but not so strong over the area of interest.



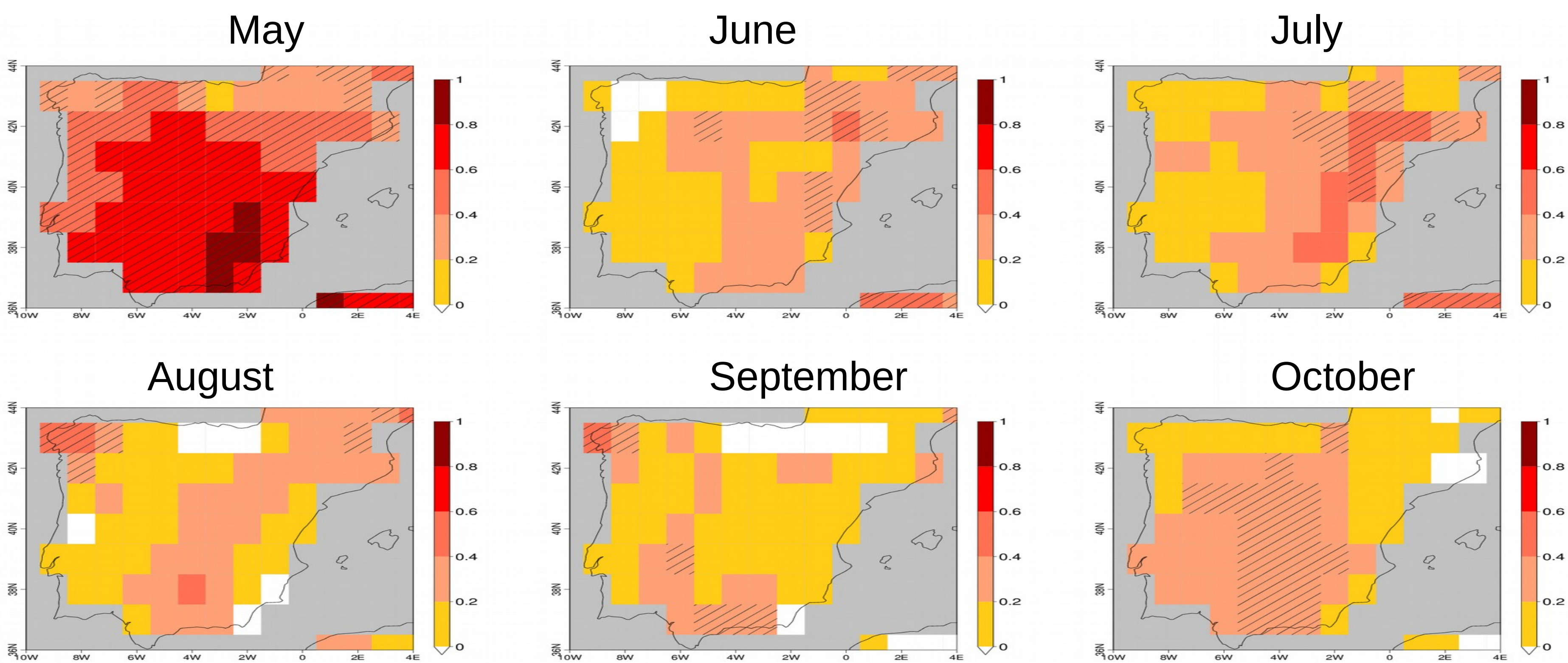
During the Galicia/Portugal wildfires in October 2017, widespread FWI anomalies were observed over most of the peninsula.



Seasonal prediction skill – May init

Anomaly Correlation Coefficient (ACC) of SEAS5 FWI predictions over Iberia, initialized in May.

Shows potential skill in Lead month 0 (May), patchy skill later.



Seasonal prediction – May 2017

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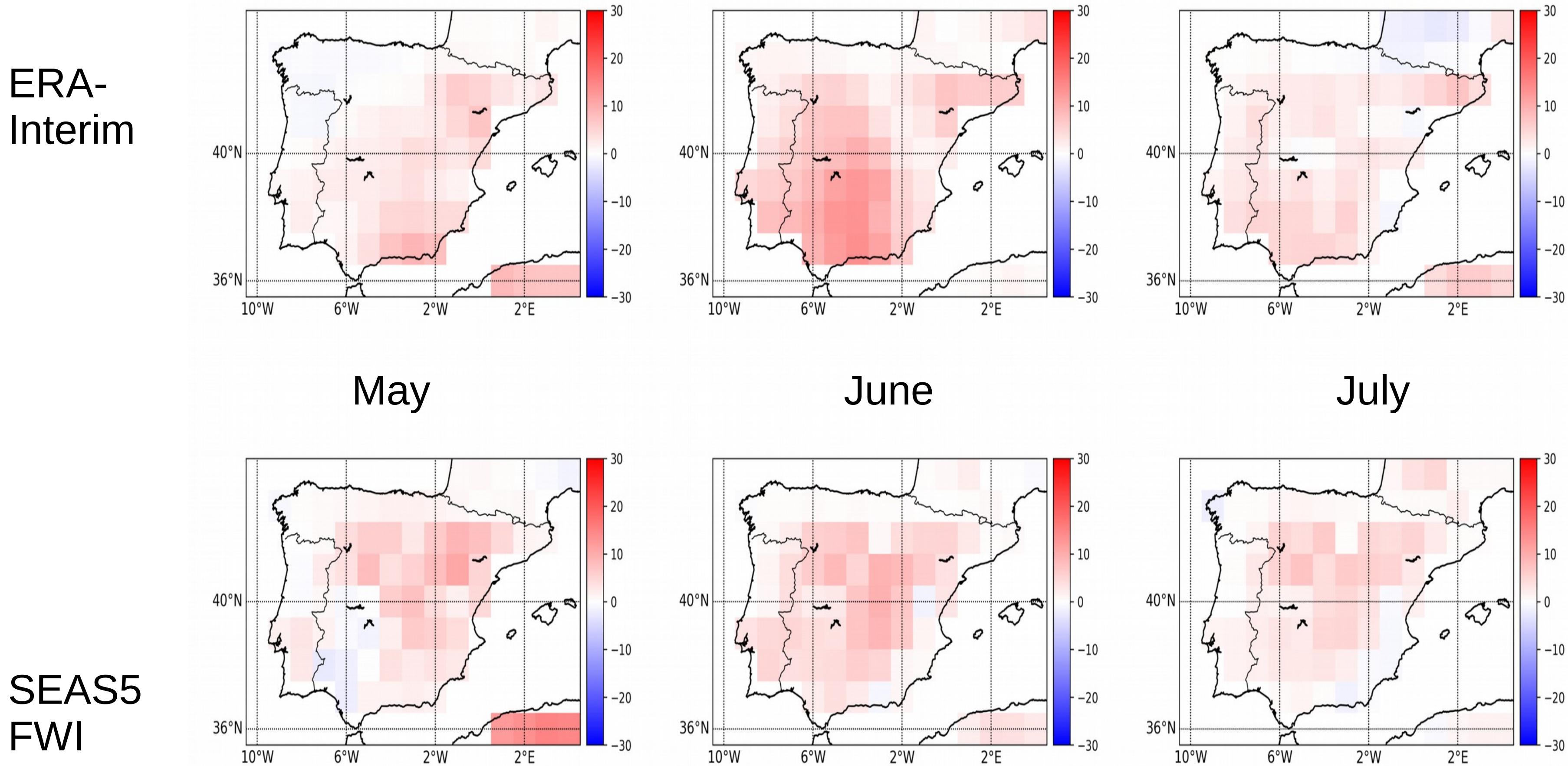
FWI computed from May predictions – results are not so bad!

Widespread positive FWI anomaly during the June wildfires.

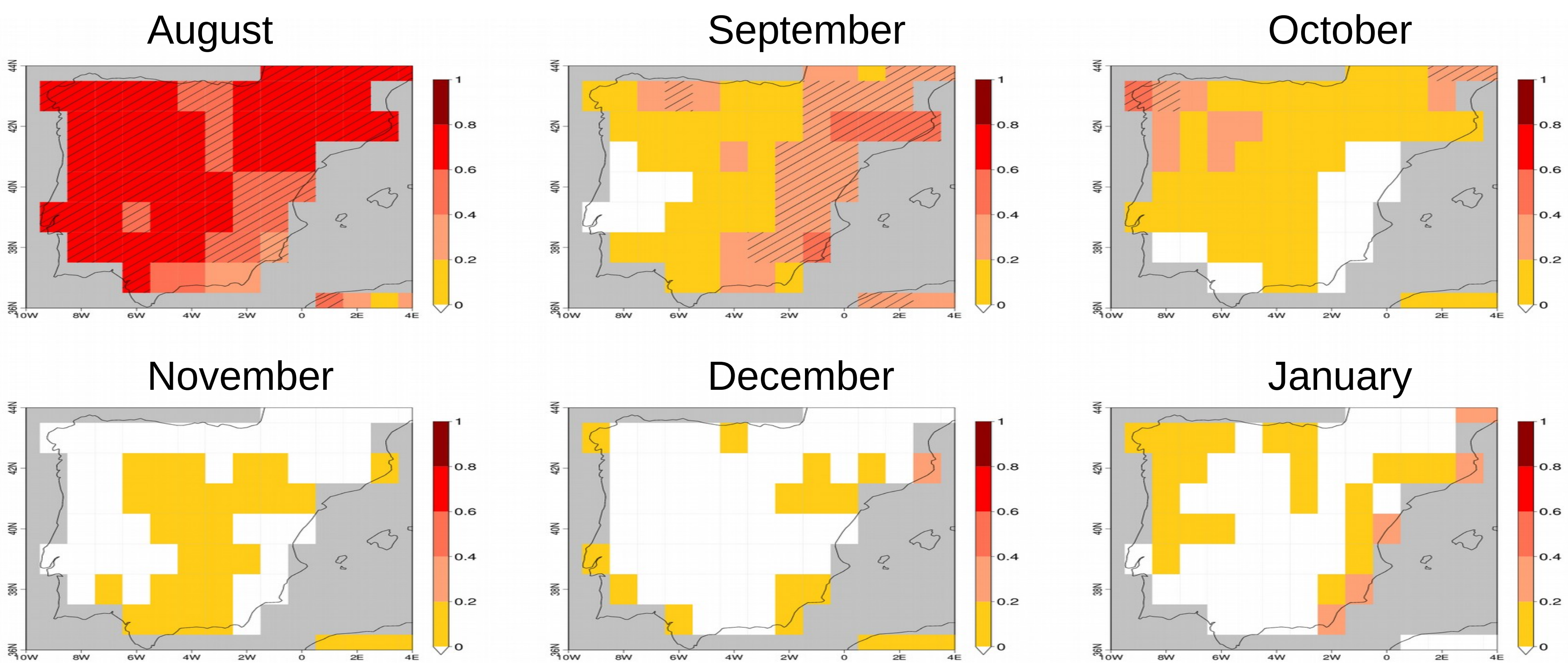


Seasonal prediction skill – August init

Anomaly Correlation Coefficient (ACC) of SEAS5 FWI predictions over Iberia, initialized in August.

Shows potential skill in Lead month 0 (August), limited skill in Lead Month 1 (Sept.), some skill in northwest area of the peninsula in October.

After 2 months skill drops rapidly.



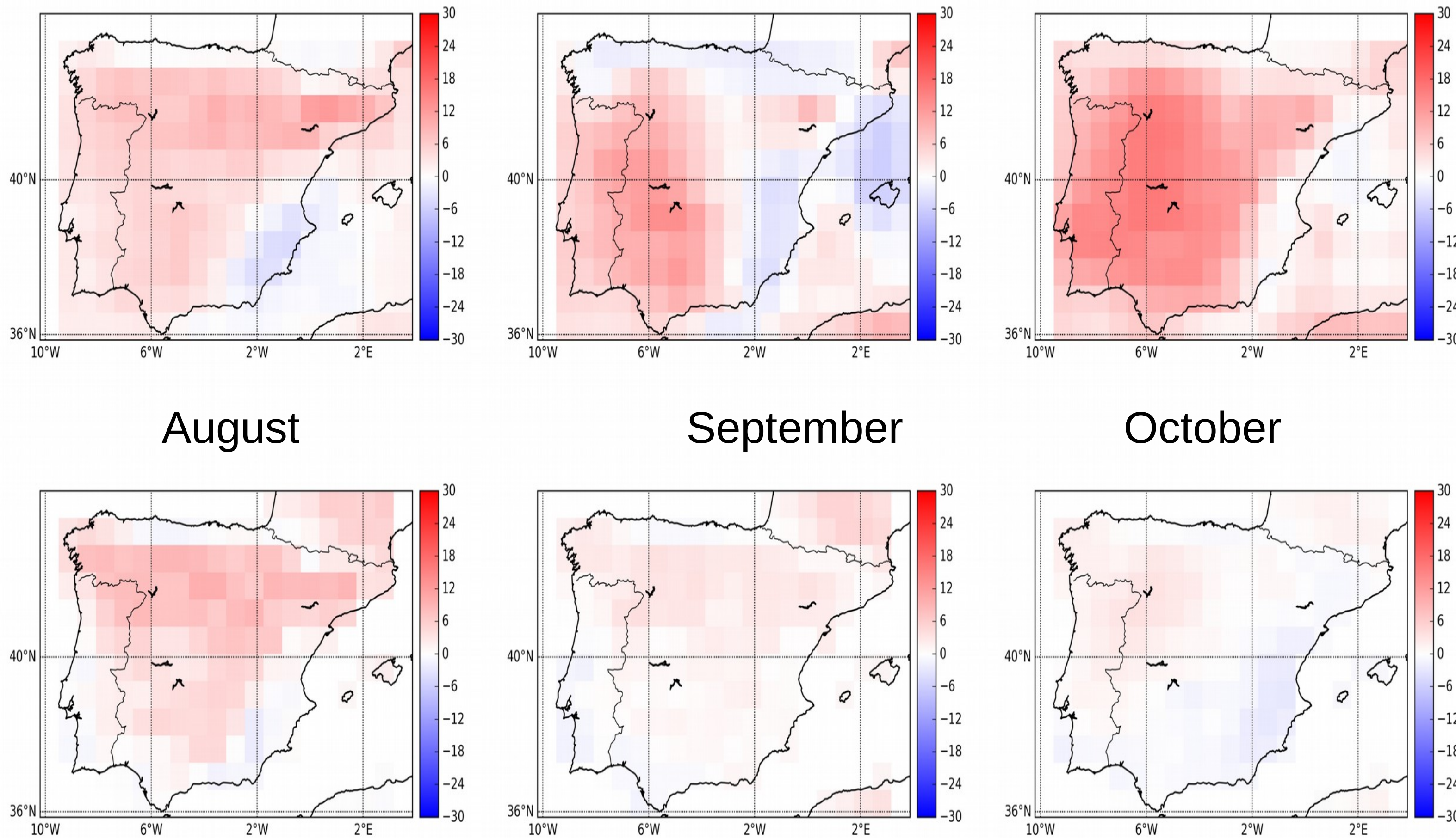
Seasonal prediction – August 2017

FWI computed from August predictions – results are mixed

Observed FWI anomaly during the October fires are stronger than predictions.

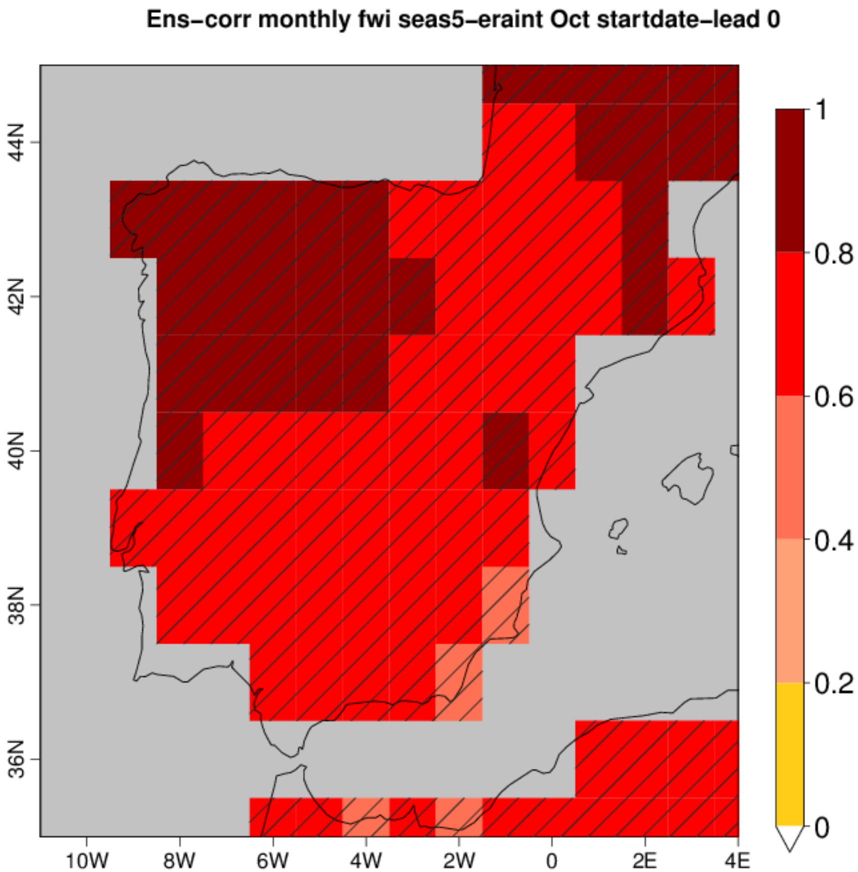
ERA-Interim

SEAS5 FWI

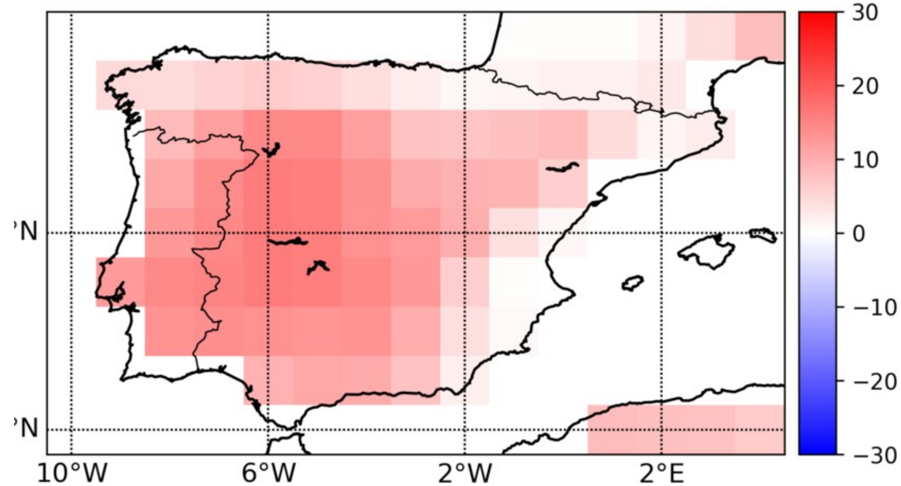


Seasonal prediction skill – Oct. init

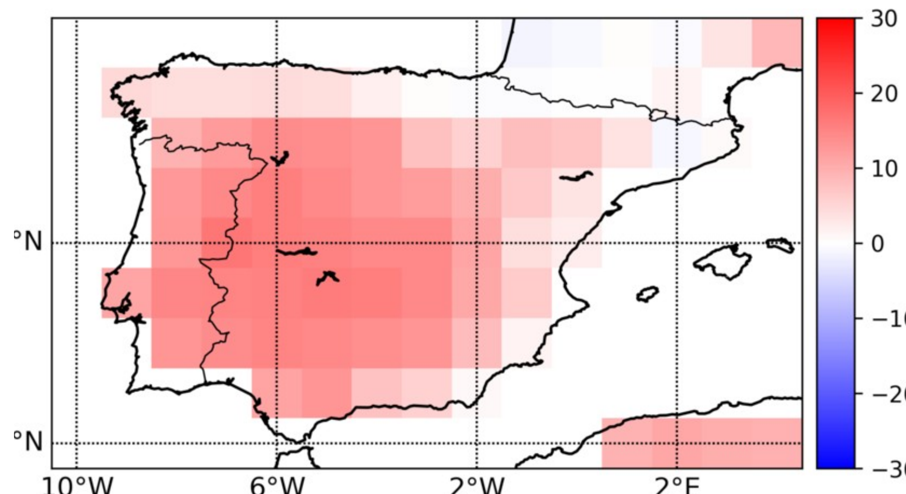
Anomaly Correlation Coefficient (ACC) of SEAS5 FWI predictions over Iberia, initialized in October – much better!!!



ERA-Interim October FWI anomaly



SEAS5 October FWI anomaly



Decadal prediction using SPI/SPEI

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Using SPI/SPEI indices (based on precipitation and temperature), multi-model ensembles of seasonal prediction systems can be used to predict Burned Area.

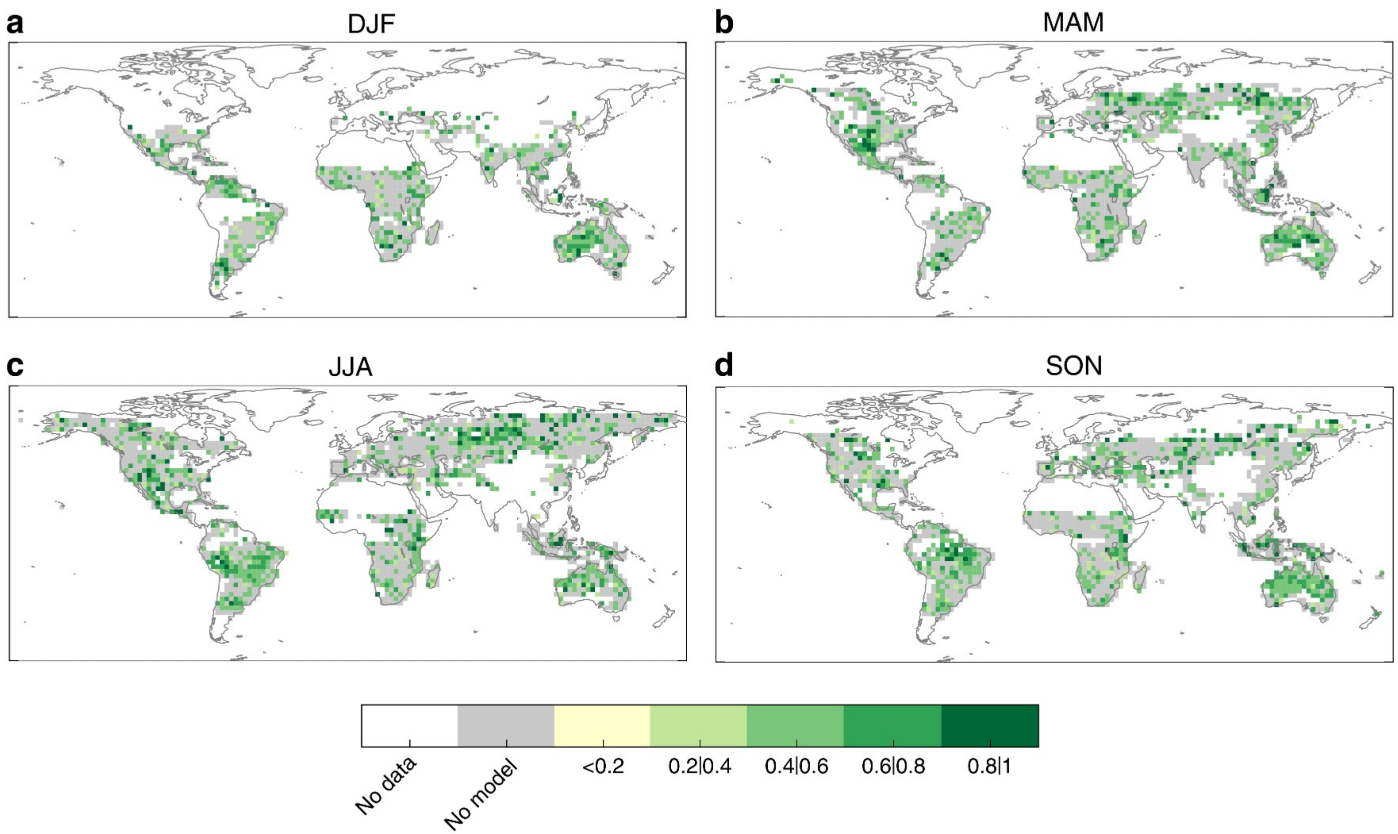

Fig. 5 Skill of burned area predictions obtained from the seasonal forecast ensemble BESTENS. Correlations of out-of-sample burned area (BA) predictions using the SPI-BA model fed with seasonal forecasts of SPI from the BESTENS for **a** December–January–February (DJF), **b** March–April–May (MAM), **c** June–July–August (JJA) and **d** September–October–November (SON). Only correlations that are significant (*p*-value < 0.05) are shown in green colours. Grey colour shadows the grid points with non-significant correlation values. White indicates areas where fires do not occur (e.g. sea) or have not been recorded

Turco et al. (2018), Nature Communications

Decadal prediction using SPI/SPEI

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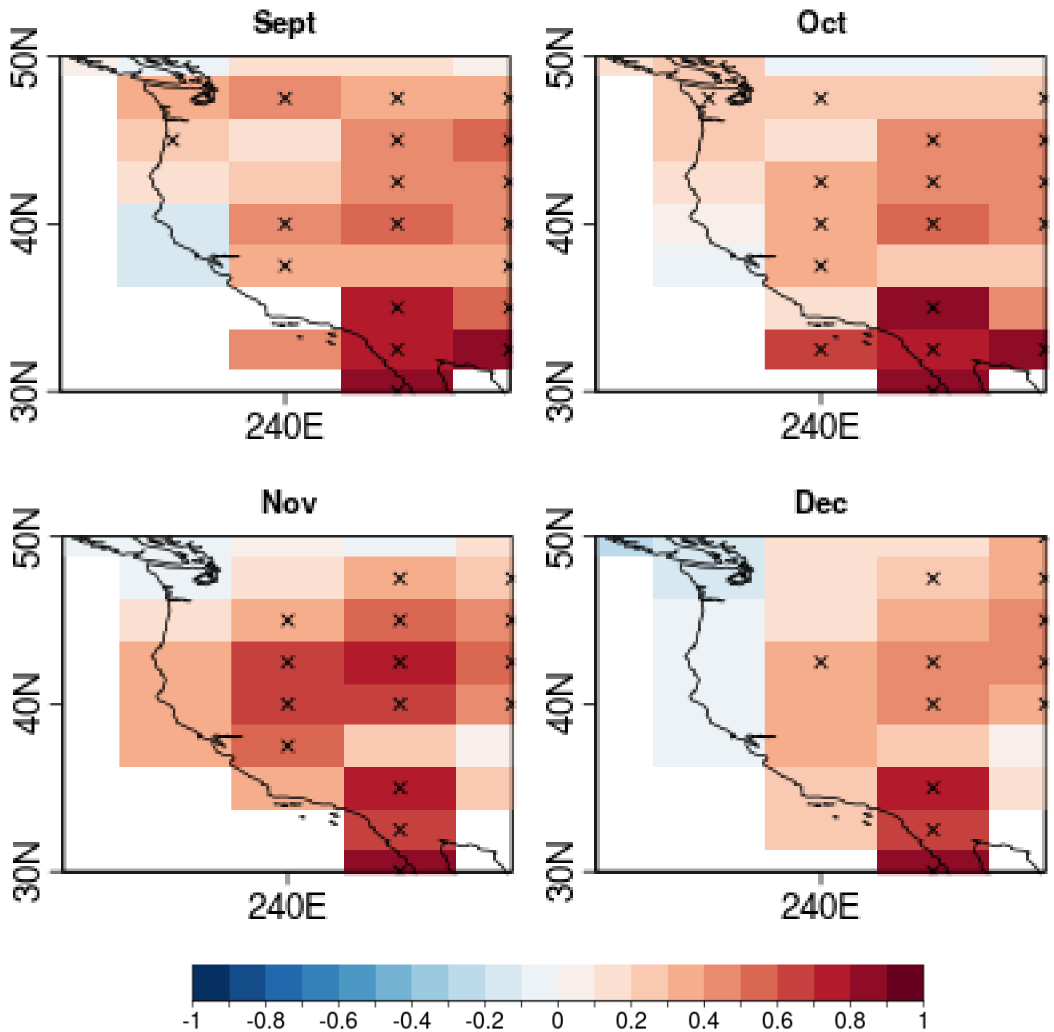
Long-term drought conditions can be estimated using the standardized precipitation evapotranspiration index over a 6 month temporal scale (SPEI6; Vicente-Serrano et al., 2010).

We show here the skill of a multi-model hindcast of drought conditions over the forecast years 2-5 over Western US.

Future work will evaulate the correspondance between Burned Area and SPEI6 and valuate the skill in predicting burned area from decadal forecasts.



Source: Balakrishnan Solaraju

Conclusions

A wildfire seasonal prediction system using ECMWF SEAS5 predictions and wildfire forecasting infrastructure has been tested.

- Preliminary results show some skill (1-2 months lead time) over California and Iberian peninsula
- However, FWI was not well predicted over California in 2017 with more than 2 months lead time, better result over the Iberian peninsula
- These results suggest that FWI is predictable at the sub-seasonal to seasonal timescale, not strictly seasonal timescale.
- Decadal prediction is a relatively new field in climate science, an interesting application is the prediction of fire danger and burned area by using simple drought indices.
- Future work:
  - Apply bias correction techniques (e.g. QQ mapping)
  - Use thresholds / quantiles for forecasting fire danger classes instead of absolute FWI values
  - Use other seasonal prediction systems to make a multi-model forecast
  - Decadal predictions using SPEI and Dynamic Vegetation Models!

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Thank you!

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SPFireSD

Seasonal Prediction of Fire danger using Statistical and Dynamical models

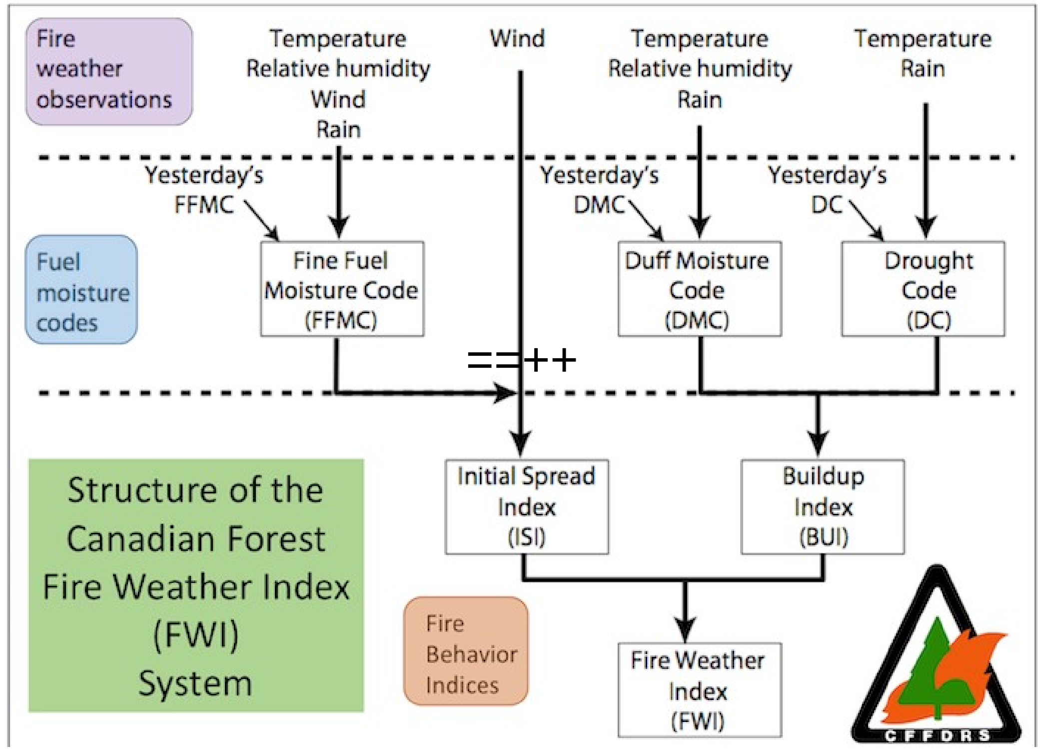
Canadian Fire Weather Index

The Canadian Fire Weather Index (FWI) is used operationally for short- and medium- term forecasting of fire danger in Canada.

It relies on daily observations of precipitation, temperature, wind and relative humidity at 12h local time.

It has been adopted by the (European Forest Fire Information System) EFFIS and Global Wildfire Information System (GWIS) for producing 10-day forecasts of fire danger in Europe.

However, these systems do not go beyond the 10-day short term forecast fimeframe.



(source: http://www.fbfrg.org/cffdrs/fire-weather-index-fwi-system)

Canadian Fire Weather Index

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

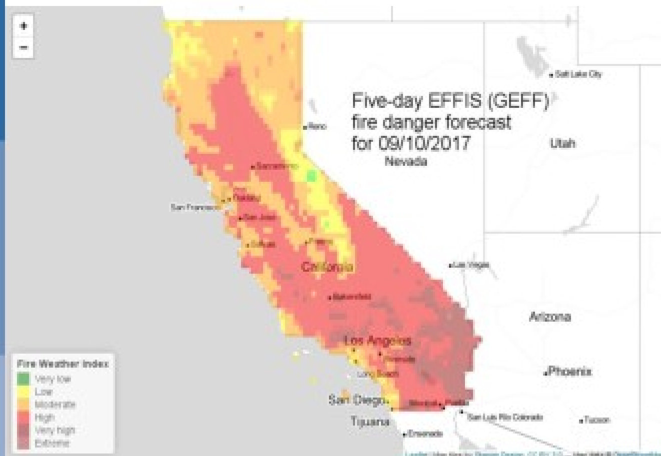
Alexander, M.E.; De Groot, W.J. 1988. Fire behavior in jack pine stands as related to the Canadian Forest Fire Weather Index System. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Poster with text.

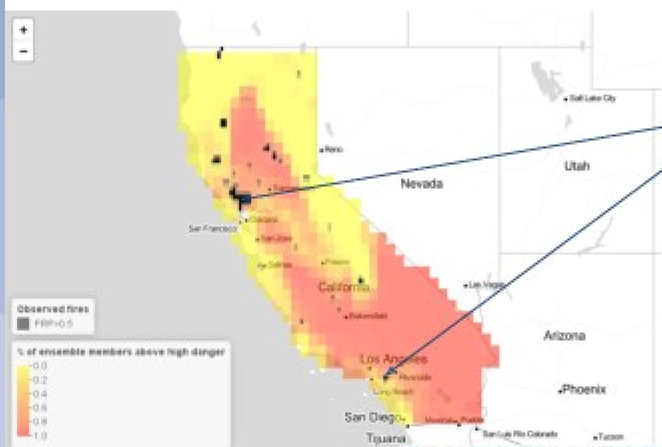
Quintilio, D.; Fahnestock, G.R.; Dubé, D.E. 1977. Fire behavior in upland jack pine: the Darwin Lake Project. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Information Report NOR-X-174.

Source : Francesca Di Giuseppe (ECMWF)
https://cpo.noaa.gov/Portals/0/Docs/MAPP/Pdfs/DiGiuseppe.pdf

EMCWF wildfire forecast using FWI

Another example: the California fire





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

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS 15

Source : Francesca Di Giuseppe (ECMWF)
https://cpo.noaa.gov/Portals/0/Docs/MAPP/Pdfs/DiGiuseppe.pdf

FWI in OCT-DEC 2017

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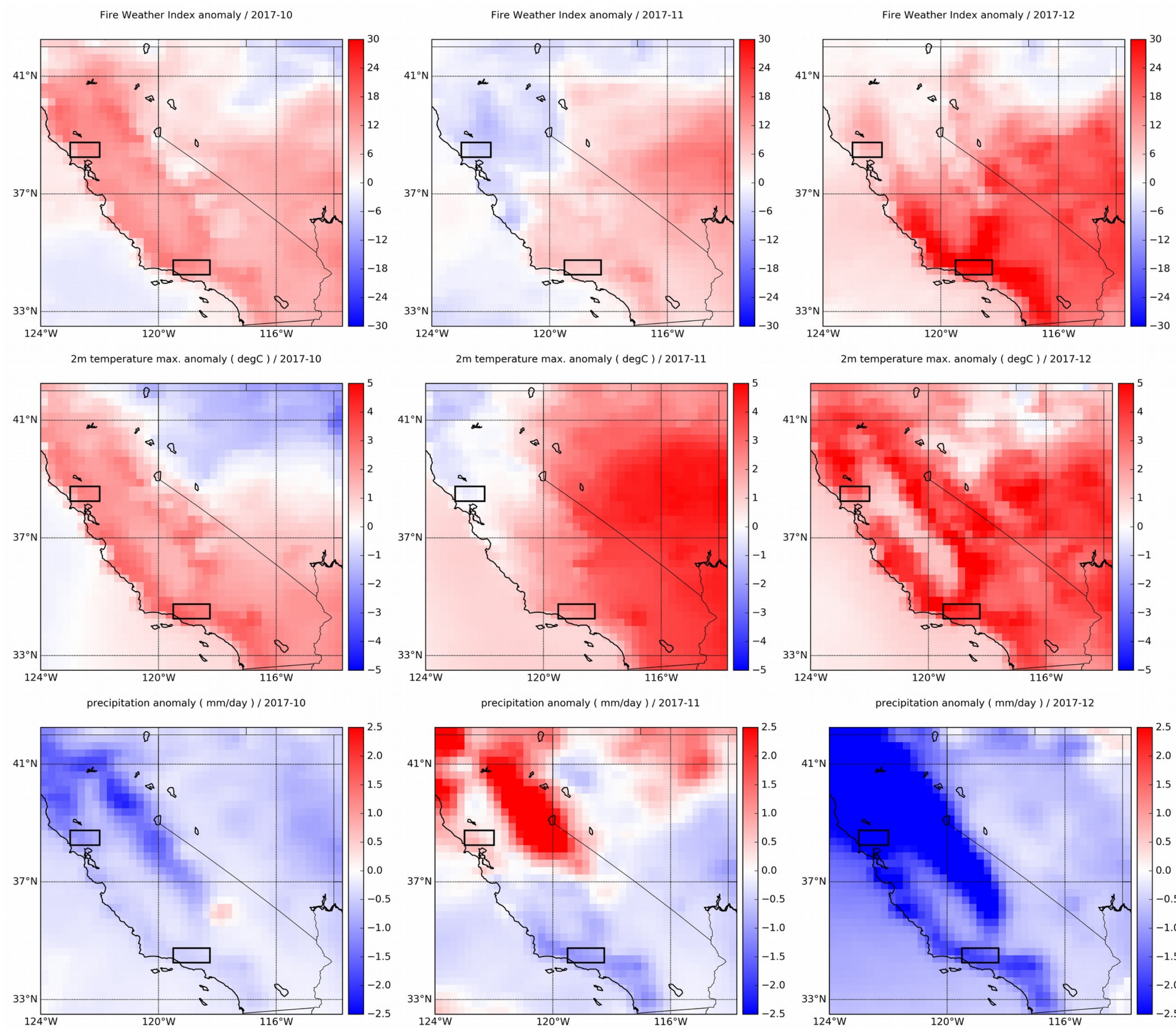
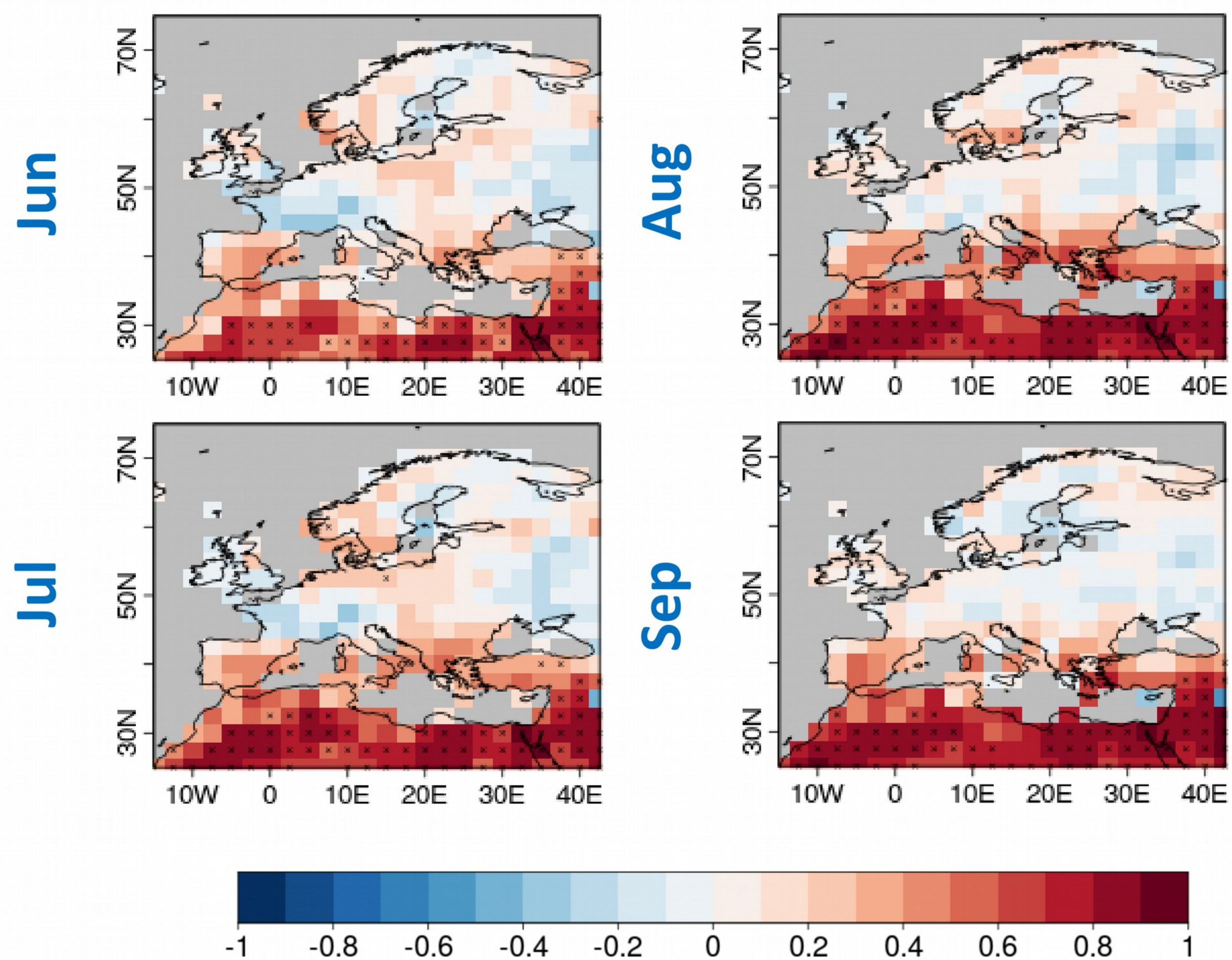
	October	November	December
FWI			
Temperature			
Precipitation			



Decadal prediction using SPI/SPEI

Long-term drought conditions can be estimated using the standardized precipitation evapotranspiration index over a 6 month temporal scale (SPEI6; Vicente-Serrano et al., 2010).

We show here the skill of the EC-Earth climate model at forecasting drougtht conditions over the forecast years 2-5 over Europe.



Source: Balakrishnan Solaraju