Application de modèles d'incendie / outils pour évaluer les impacts des changements climatiques sur les incendies

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ClimaSouth

Office National de la Météorologie

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« PREMIER ATELIER SUR LES INCENDIES DE FORET ET LE CHANGEMENT CLIMATIQUE »

11-12 Janvier 2016, Dar el Beida (Alger)

(…) Most Atmosphere-Ocean General Circulation Models project increased summer dryness and winter wetness in most parts of the northern middle and high latitudes. Summer dryness indicates a greater risk of drought. Along with the risk of drying, there is an increased chance of intense precipitation and flooding (...)

(…) In a warmer future climate, there will be an increased risk of more intense, more frequent and longer-lasting heat waves.
The European heat wave of 2003 is an example of the type of extreme heat event lasting from several days to over a week that is likely to become more common in a warmer future climate (…)

IPCC, 2007

FUTURE PROJECTIONS

The **Mediterranean Basin** is identified as one of the most affected areas of the world by future climate change:

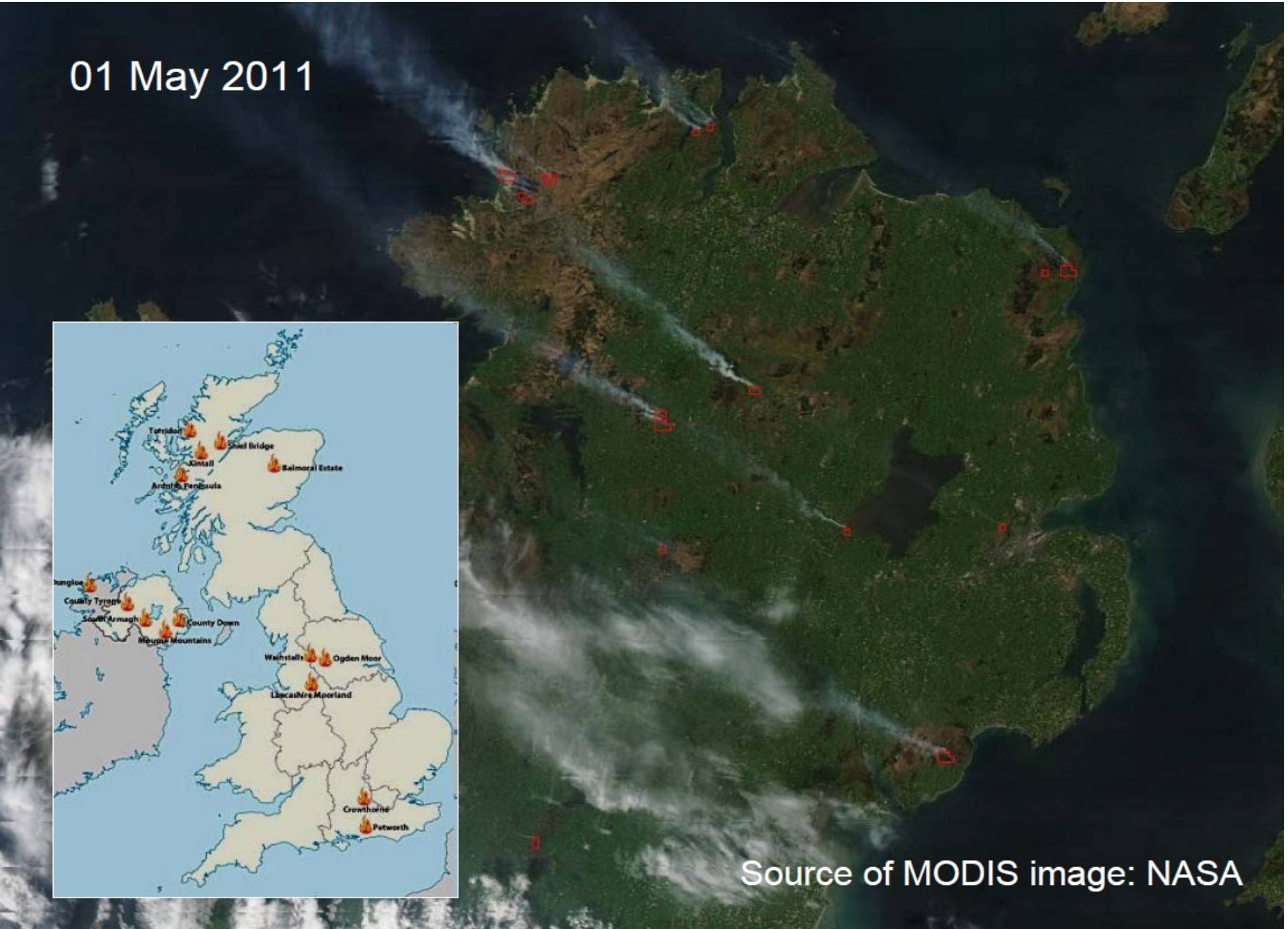
i) Increase in temperatures and extreme temperatures;
ii) More frequent and longer heat waves;
iii) Longer dry periods;
iv) Decrease in precipitation amounts and in the total rainy days
v) More frequent extreme events (extreme precipitation and flooding)

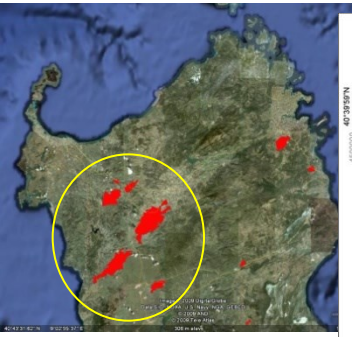
IPCC, 2014

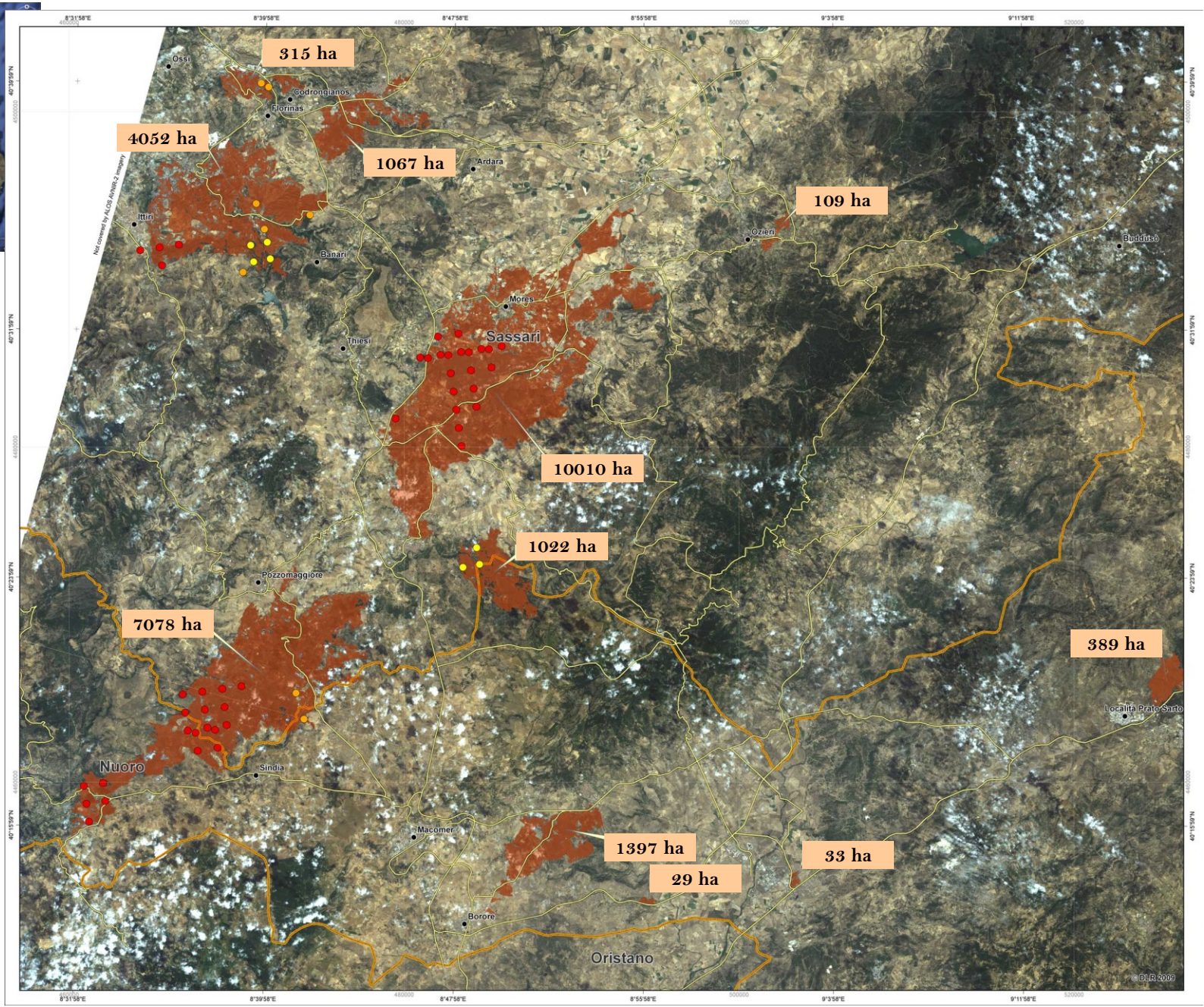
FUTURE PROJECTIONS – Impacts on Wildfires in Mediterranean areas

- Higher Wildfire Risk
- Increase in Wildfire Intensity and Frequency
- Increase in Fire Season Length
- Increase in the Occurrence of High Fire Danger Conditions
- Increase in the Area Burned (up to 300-500% with respect to the baseline)
- Increase of Wildfire GHG Emissions

IPCC, 2014


01 May 2011
Torridon
Sand Bridge
Kintail
Balmoral Estate
Ardnish Peninsula
County Tyrone
South Armagh
County Down
Mourne Mountains
Wainstalls
Ogden Moor
Lancashire Moorland
Crowthorne
Petworth
Source of MODIS image: NASA

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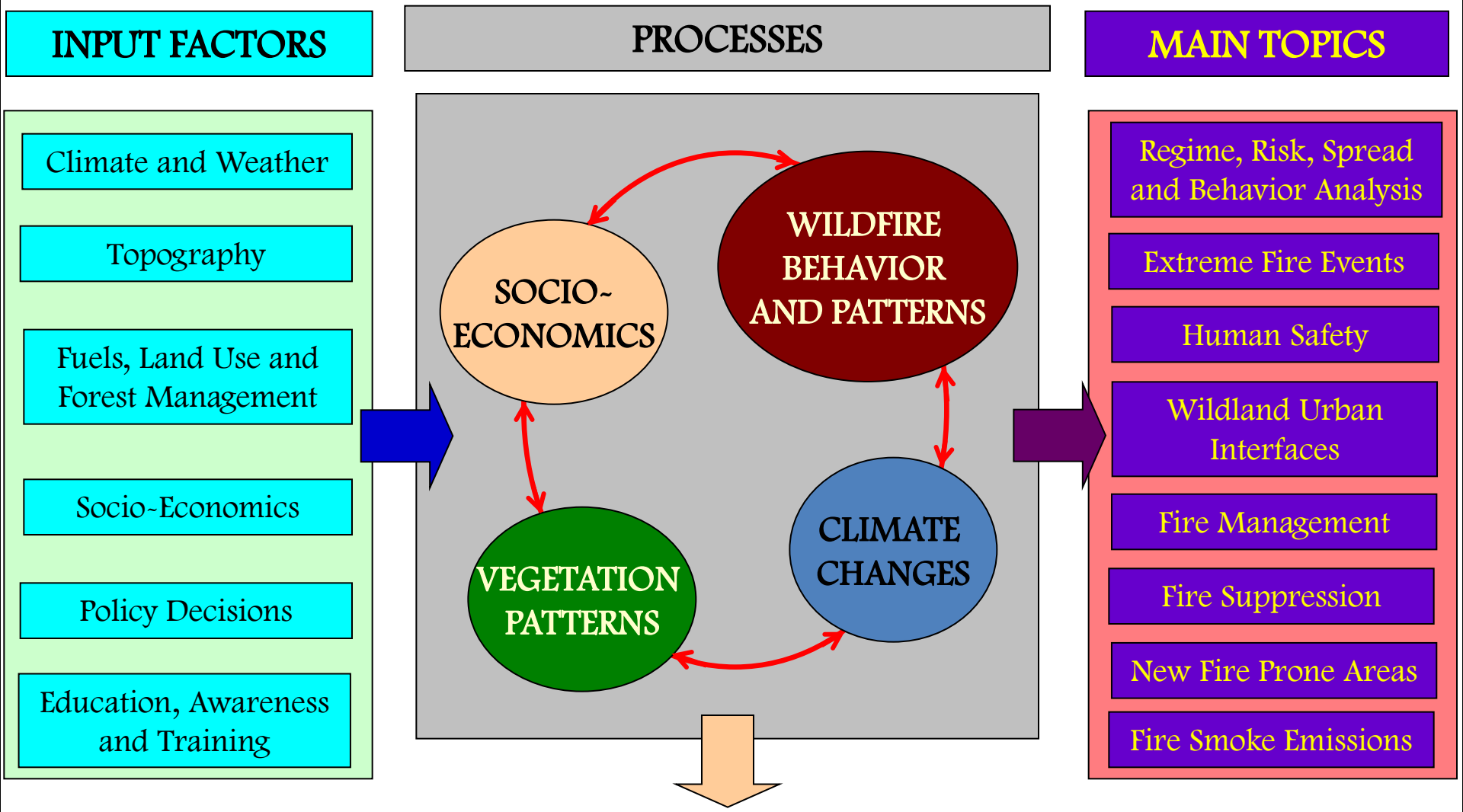
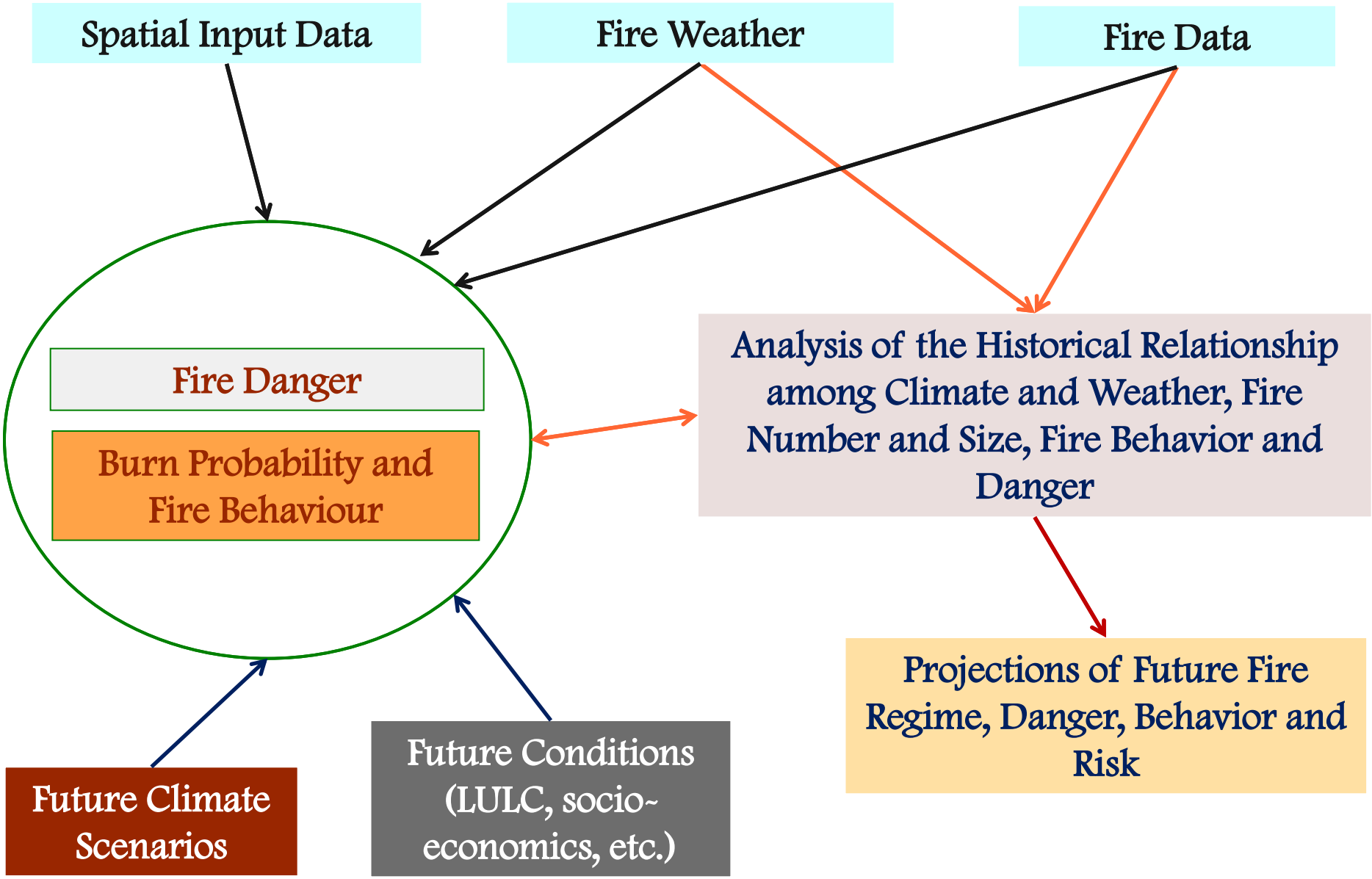
Florinas
Ardara
Ittiri
Banari
Ozieri
Budduso
Mores
Sassari
Thiesi
Pozzomaggiore
Nuoro
Sindia
Macomer
Borore
Oristano
Località Prato Sarto
Not covered by ALOS AVNIR-2 imagery
© DLR 2009

WILDLAND FIRE REGIME AND RISK (PAST, PRESENT AND FUTURE)

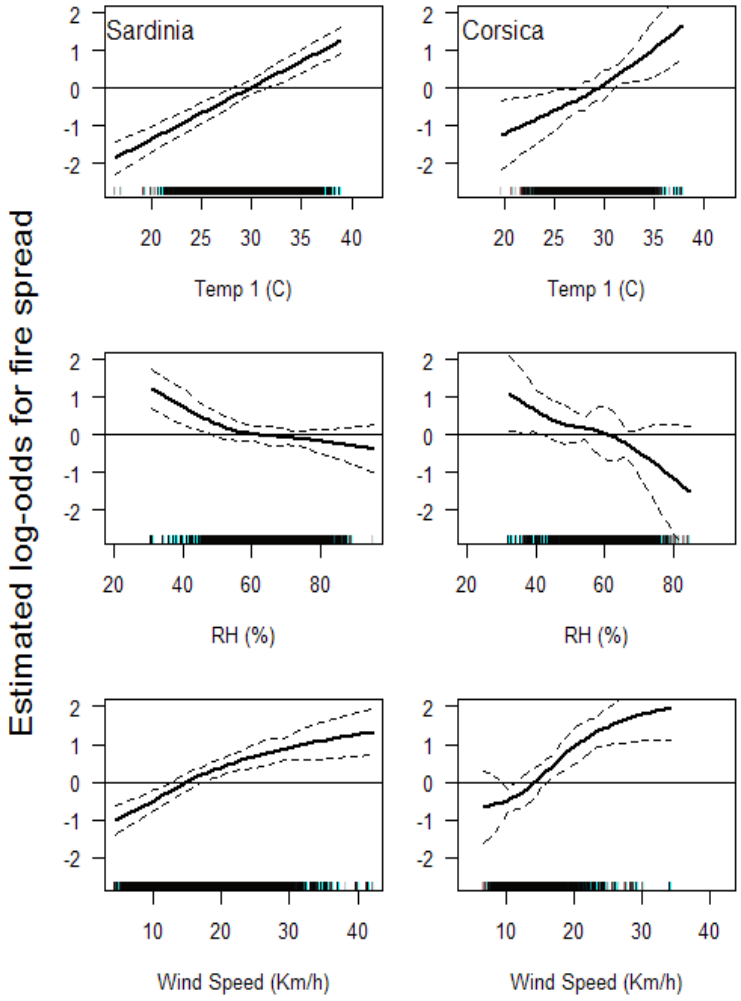


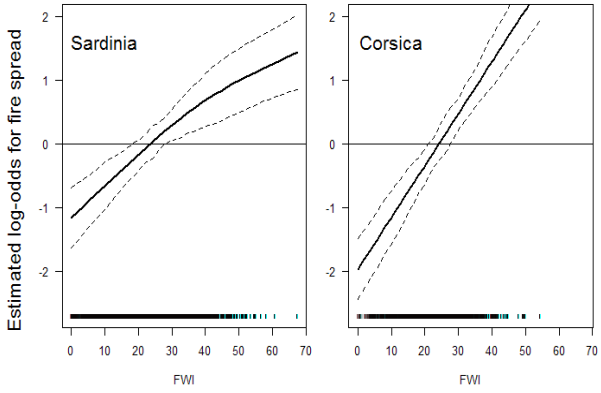
WILDLAND FIRES UNDER CHANGING ENVIRONMENTAL CONDITIONS


Spatial Input Data
Fire Weather
Fire Data
Fire Danger
Burn Probability and Fire Behaviour
Analysis of the Historical Relationship among Climate and Weather, Fire Number and Size, Fire Behavior and Danger
Projections of Future Fire Regime, Danger, Behavior and Risk
Future Climate Scenarios
Future Conditions (LULC, socio-economics, etc.)

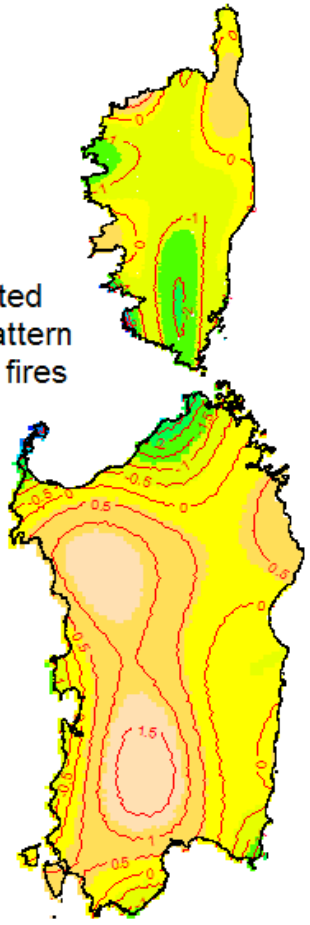
Case Study 1 ~ Assessment of historical relationship between fires, weather and FWI

Estimated partial effects of some weather variables and FWI on the log-odds of **fire spread** (JS, 1995-2009)



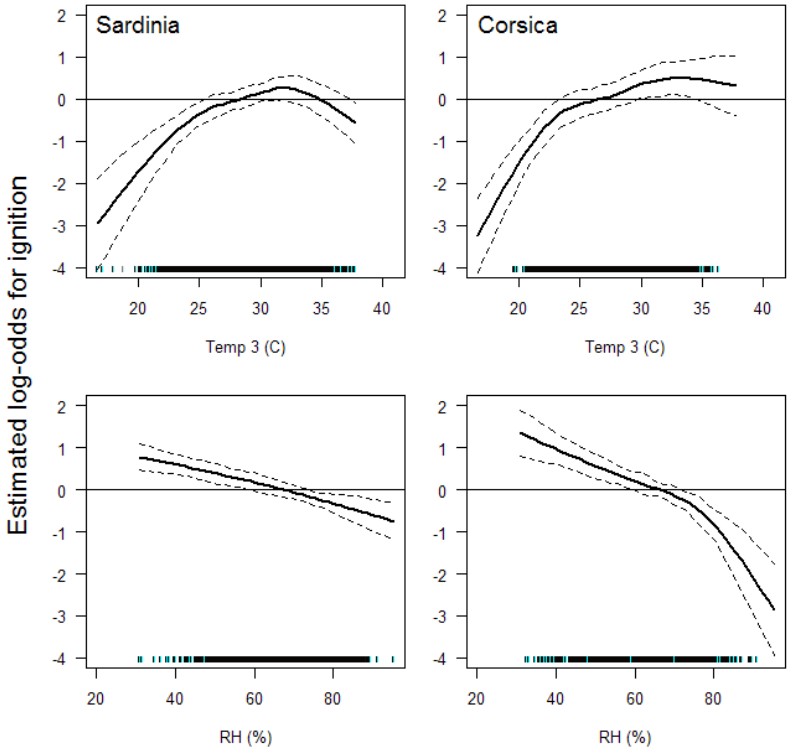


Estimated spatial pattern for large fires

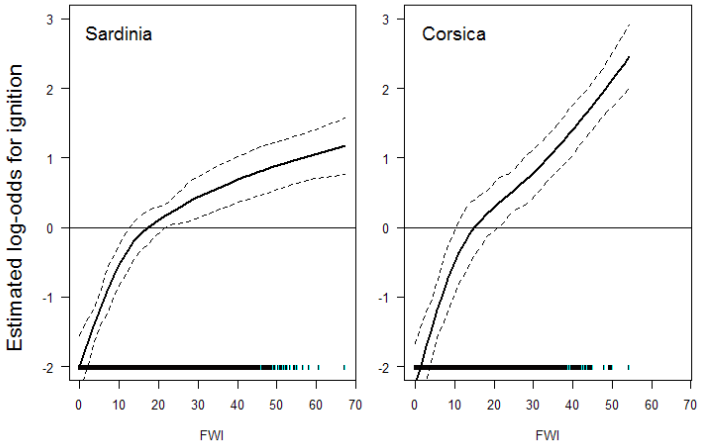


Source: Salis et al. 2011

Case Study 1 ~ Assessment of historical relationship between fires, weather and FWI



Estimated partial effects of some weather variables and FWI on the log-odds of **fire ignition** (JS, 1995-2009)



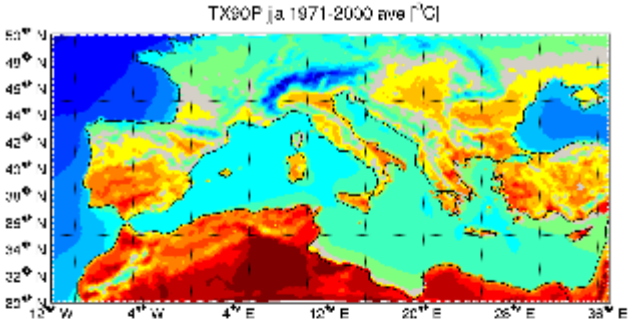
Source: Salis et al. 2011

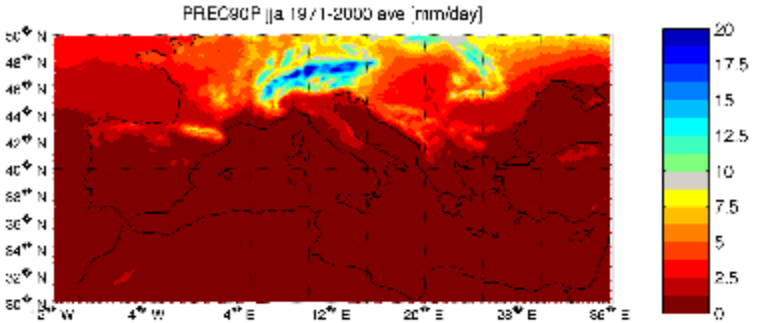
Case Study 2 – Projecting Future Fire Danger (FWI)

TEMPERATURE

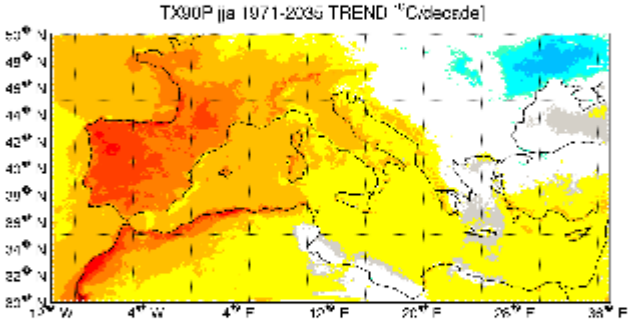
PRECIPITATION

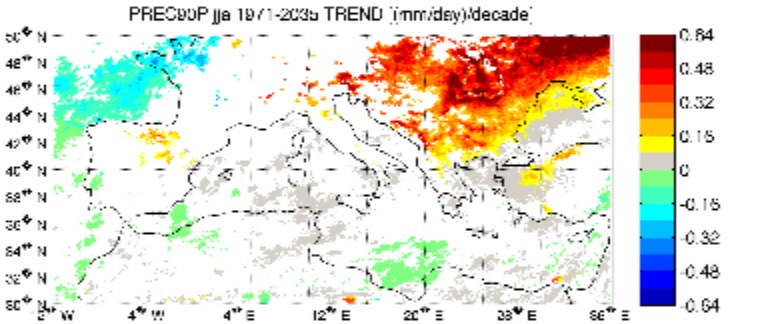
JJA



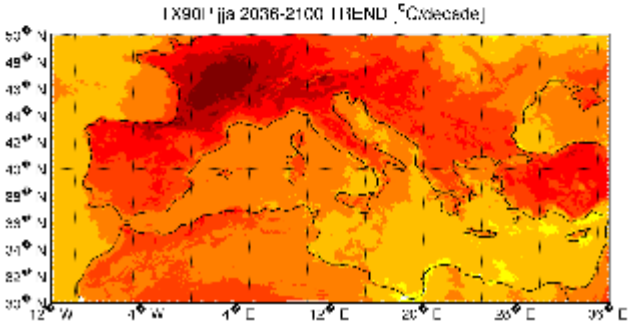


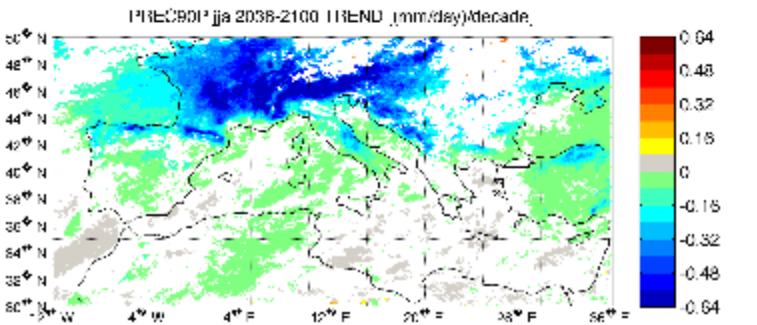
1971-2035 trend





2036-2100 trend

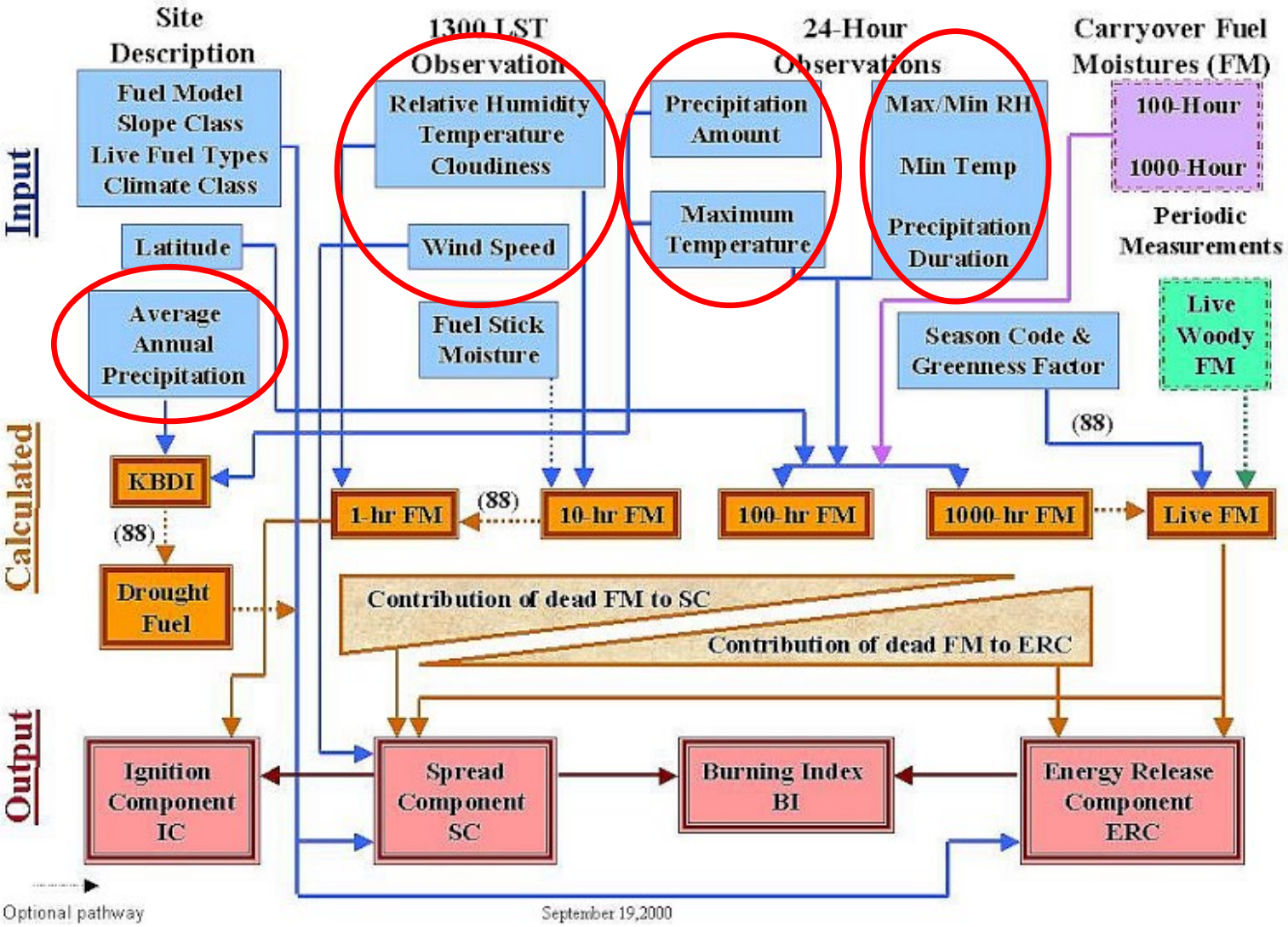




Sanna et al, 2012

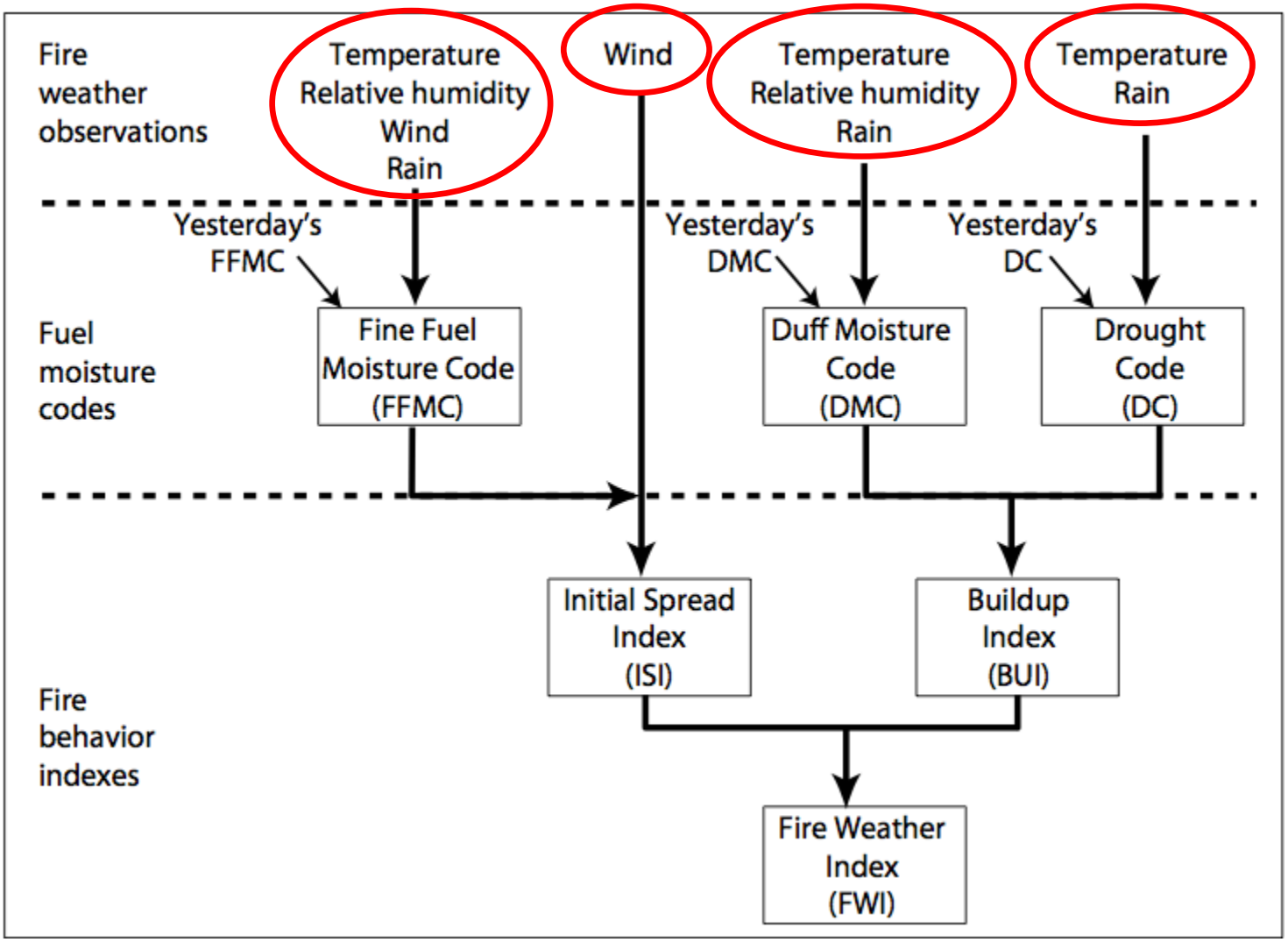
Case Study 2 – Projecting Future Fire Danger (FWI)

USA National Fire Danger Rating System

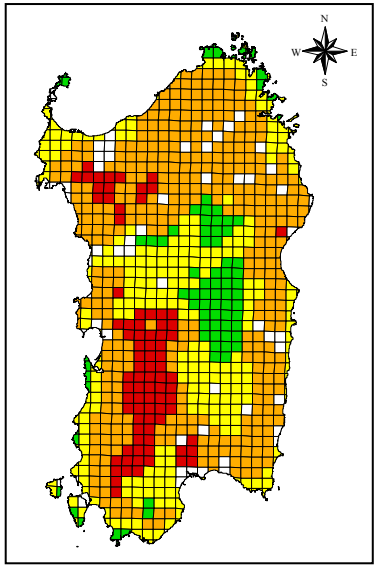


Case Study 2 – Projecting Future Fire Danger (FWI)

Canadian Fire Weather Index



Case Study 2 – Projecting Future Fire Danger (FWI)



Integrated Fire Danger Index (IFI)

INPUTS

SUB-CODES

- Temperature
- Solar radiation
- Rainfall
- Relative humidity
- Wind speed

Drought code

Meteo code

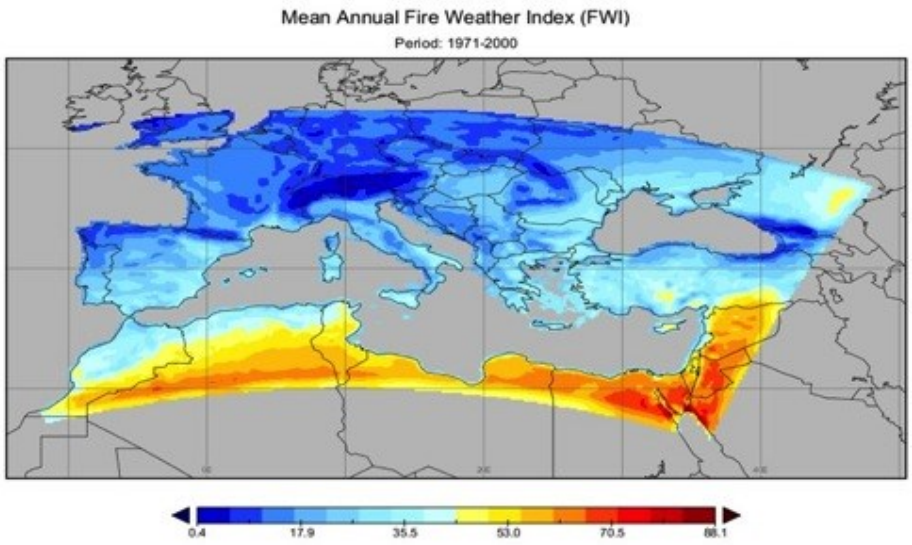
Fuel code

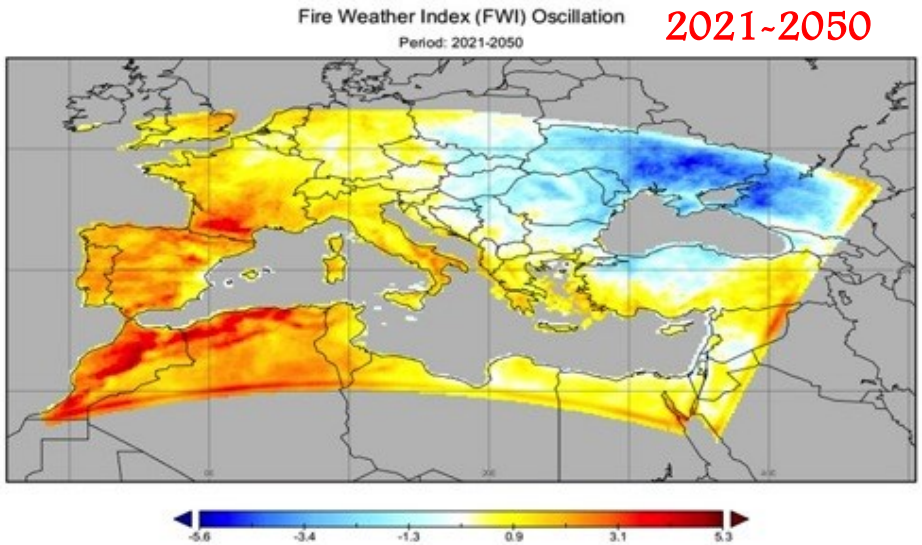
IFI

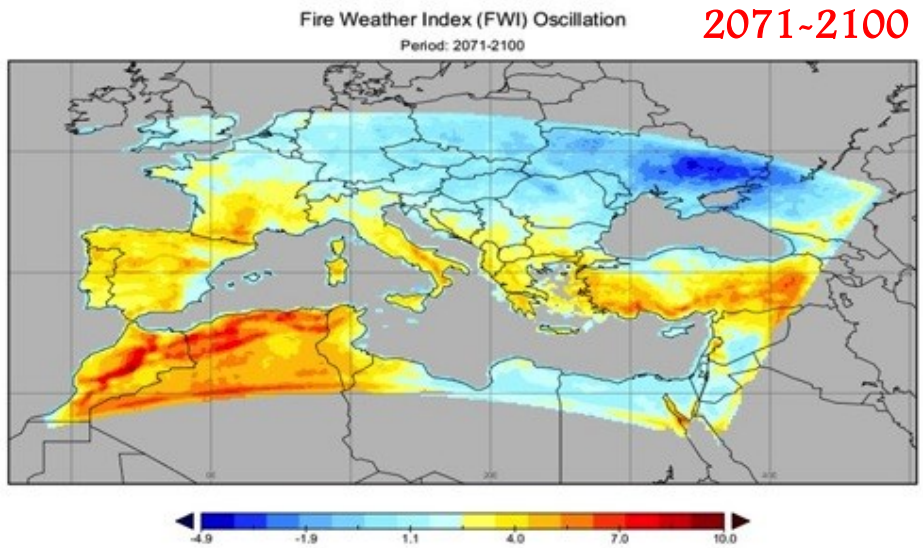
FIRE DANGER

Source: Sirca, 2014

Case Study 2 – Projecting Future Fire Danger (FWI)







Mean annual value & anomalies

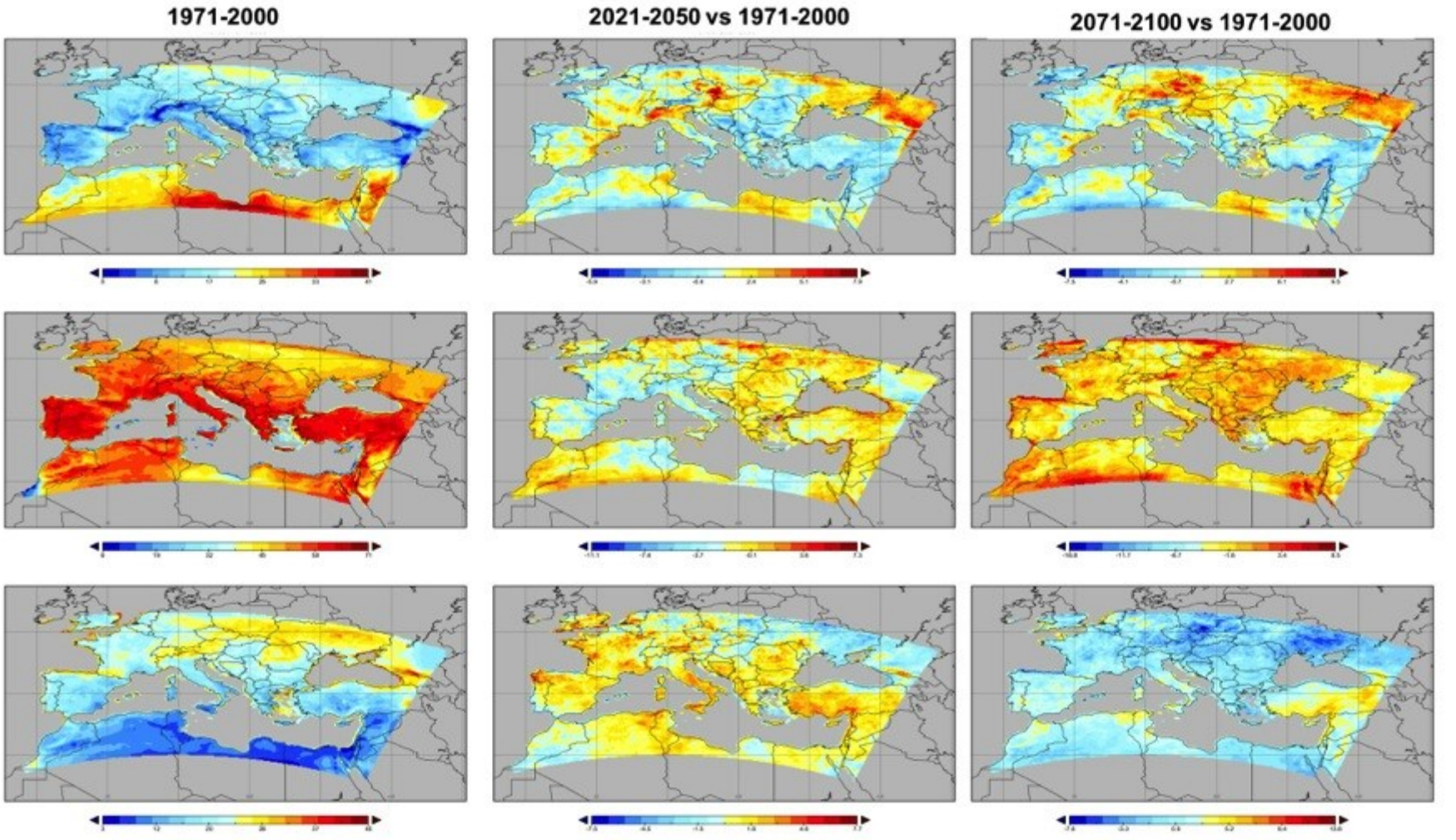
South-west Europe

North-east Europe

Source: Sirca et al, 2013

Case Study 2 – Projecting Future Fire Danger (FWI)

Sirca et al, 2013



FWI 75th percentile

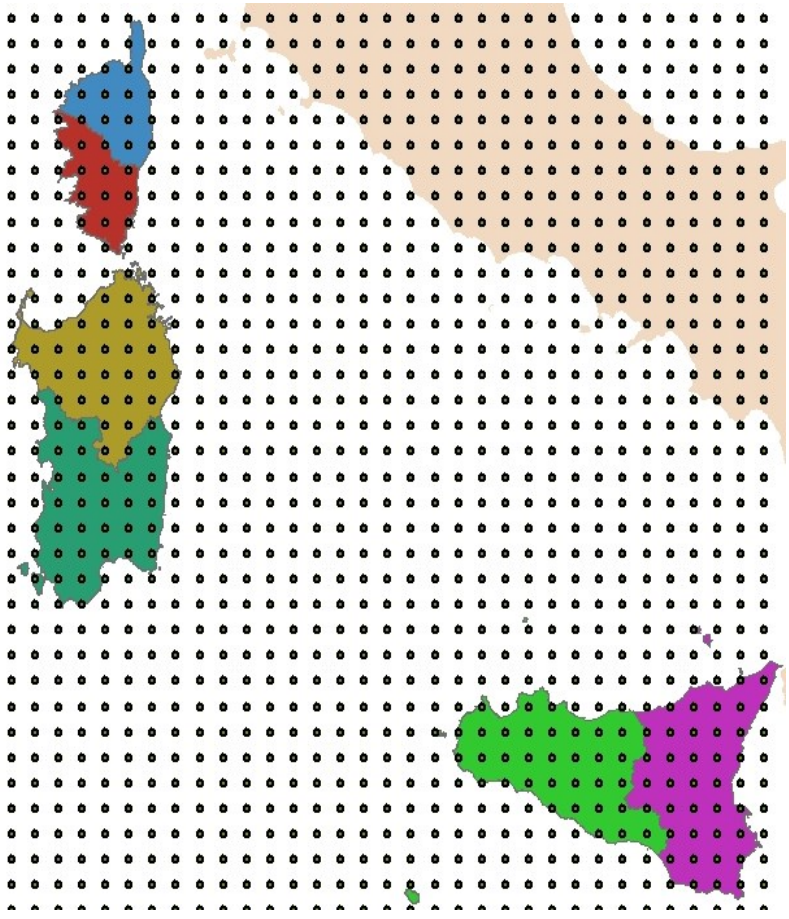
Increase of the 75th percentile value

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

COMPARISON BETWEEN REGIONAL CLIMATE MODEL A) BASELINE DATA (1961~1990) AND B) A1B SCENARIO (2071~2100)

Climatic data generated by the RCM developed by Belgrade University and CMCC, using 1961~1990 as baseline reference period, and a simulated climate for the period 2071~2100 (A1B SRES greenhouse gas scenario)

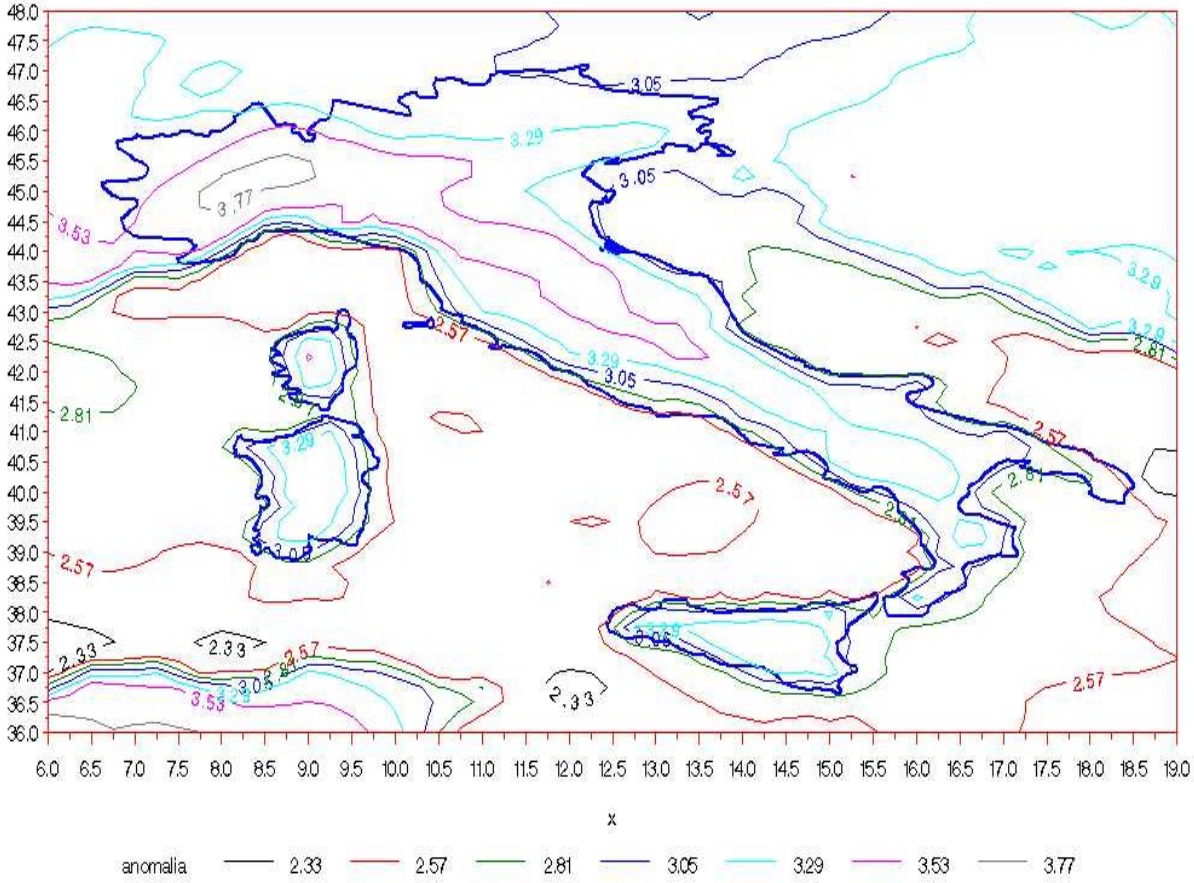
The RCM data used in this study were characterized by a 6 hours time step and a spatial resolution of 25 km.



Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

COMPARISON BETWEEN REGIONAL CLIMATE MODEL A) BASELINE DATA (1961~1990) AND B) A1B SCENARIO (2071~2100):

MEAN TEMPERATURE ANOMALIES (FROM MAY TO OCTOBER)

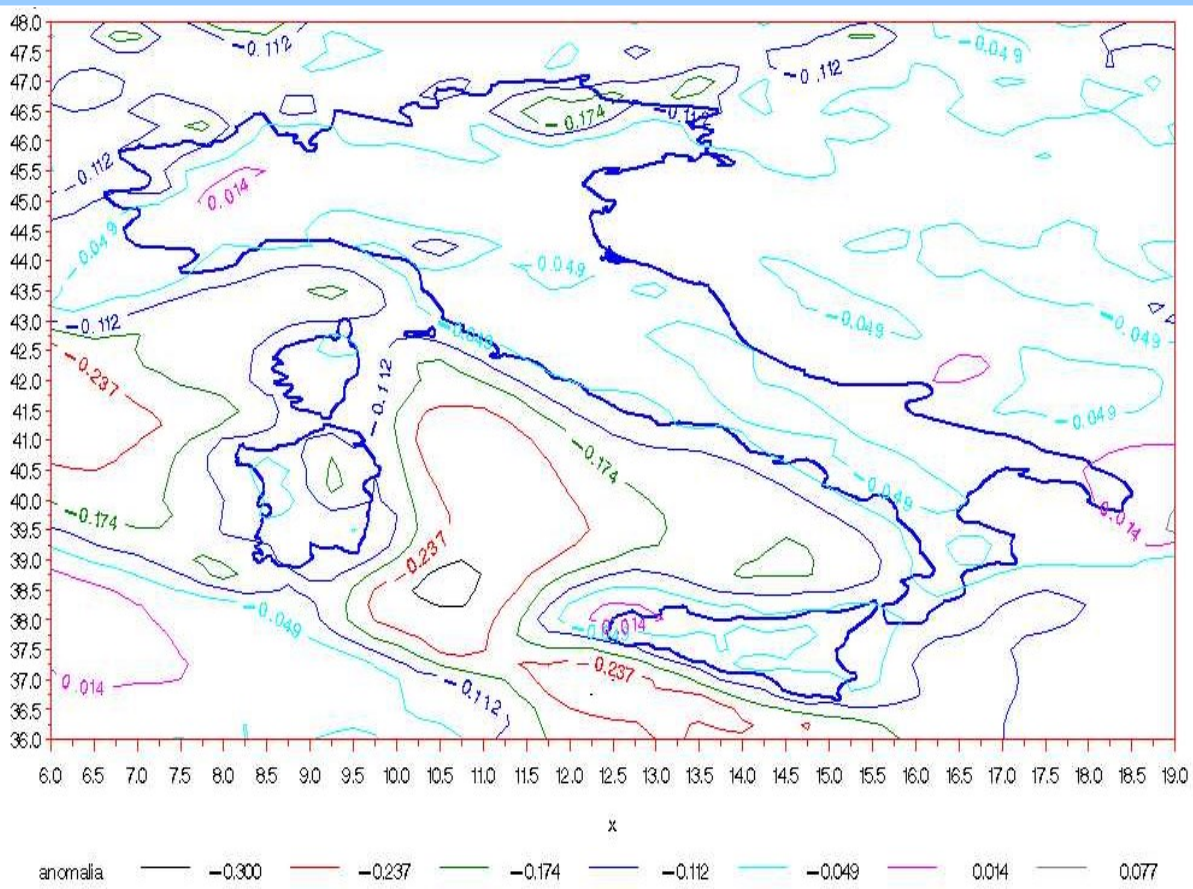


Arca et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

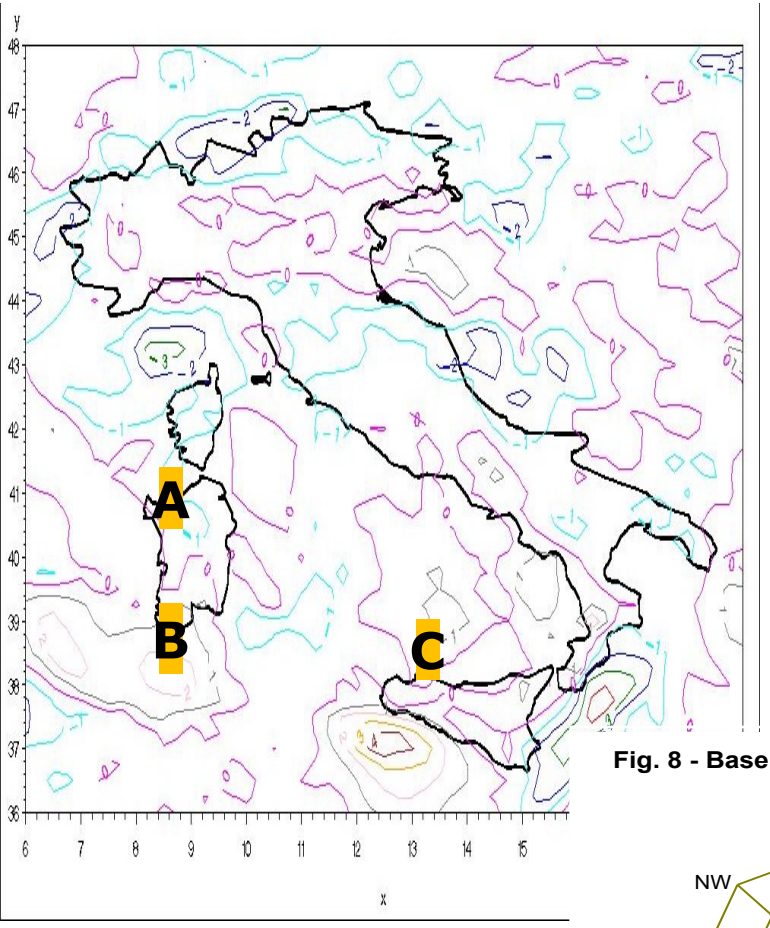
COMPARISON BETWEEN REGIONAL CLIMATE MODEL A) BASELINE DATA (1961~1990) AND B) A1B SCENARIO (2071~2100):

MEAN WIND SPEED ANOMALIES (FROM MAY TO OCTOBER)



Arca et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes



COMPARISON BETWEEN REGIONAL CLIMATE MODEL A) BASELINE DATA (1961-1990) AND B) A1B SCENARIO (2071-2100):

WIND DIRECTION ANOMALIES (FROM MAY TO OCTOBER)

Fig. 7 - Baseline vs A1B scenario (Point A)

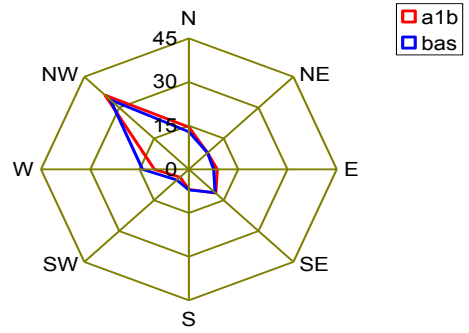


Fig. 8 - Baseline vs A1B scenario (Point B)

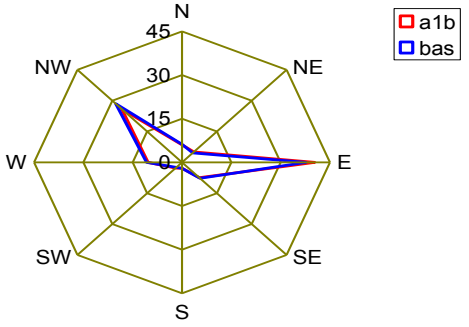
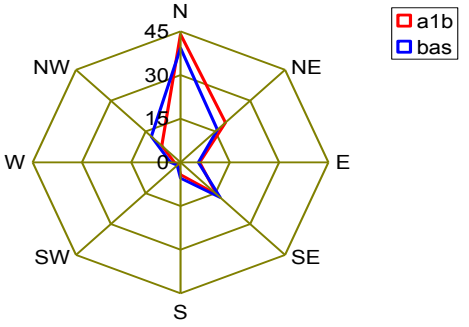


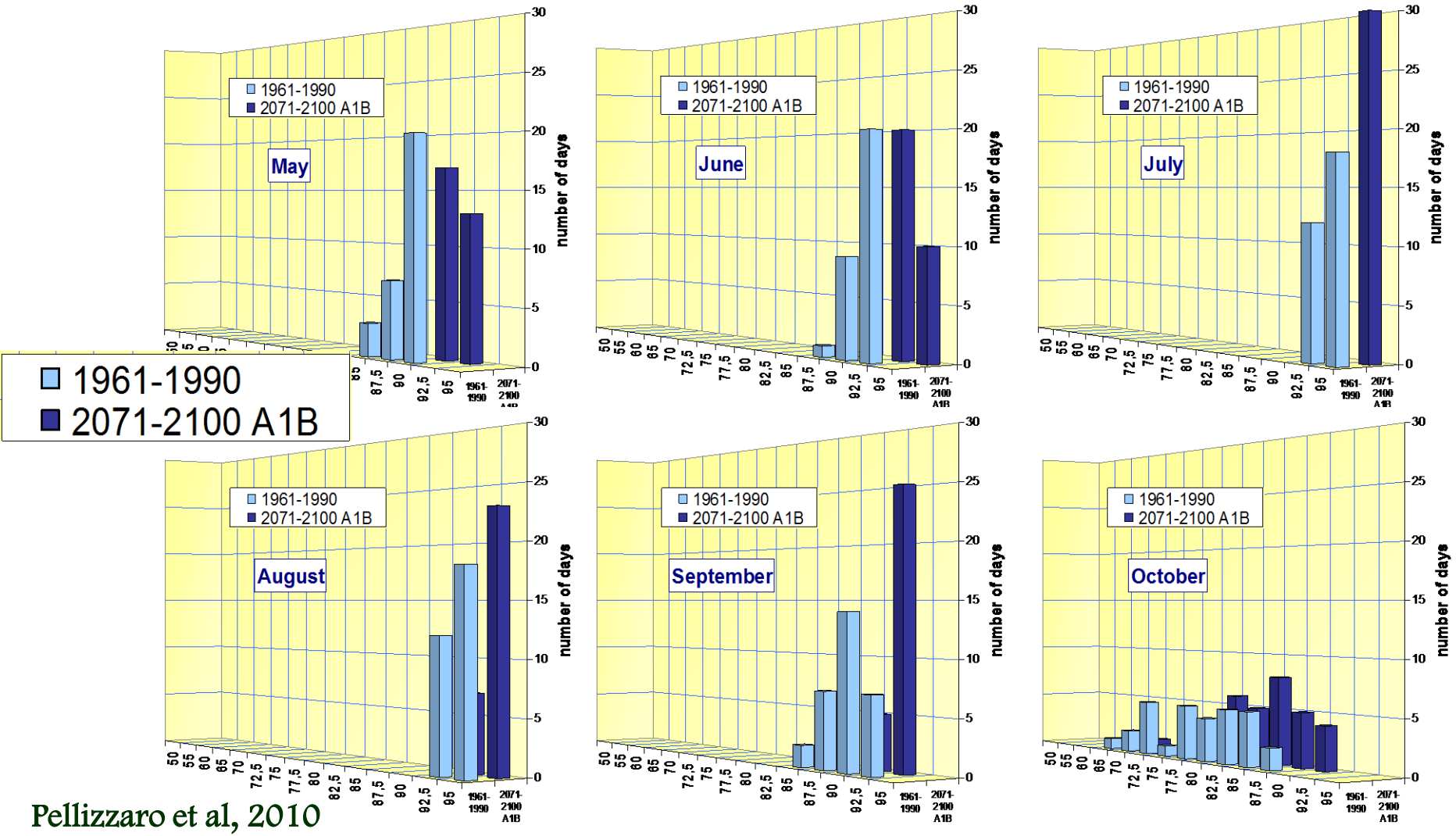
Fig. 9 - Baseline vs A1B scenario (Point C)



Arca et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

FINE FUEL MOISTURE CODE (FFMC)



Pellizzaro et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

Fire weather index (FWI) classes (Sardinia, Italy)

	Percentile	Historical FWI	Baseline FWI
Very low	25	12.0	3.4
Low	50	19.5	10.9
Moderate	75	25.6	21.6
High	90	31.5	36.6
Very high	95	35.5	44.8
Extreme	99	46.3	56.6

☑ 153 days, baseline

☑ 274 days, A1B scenario

Arca et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

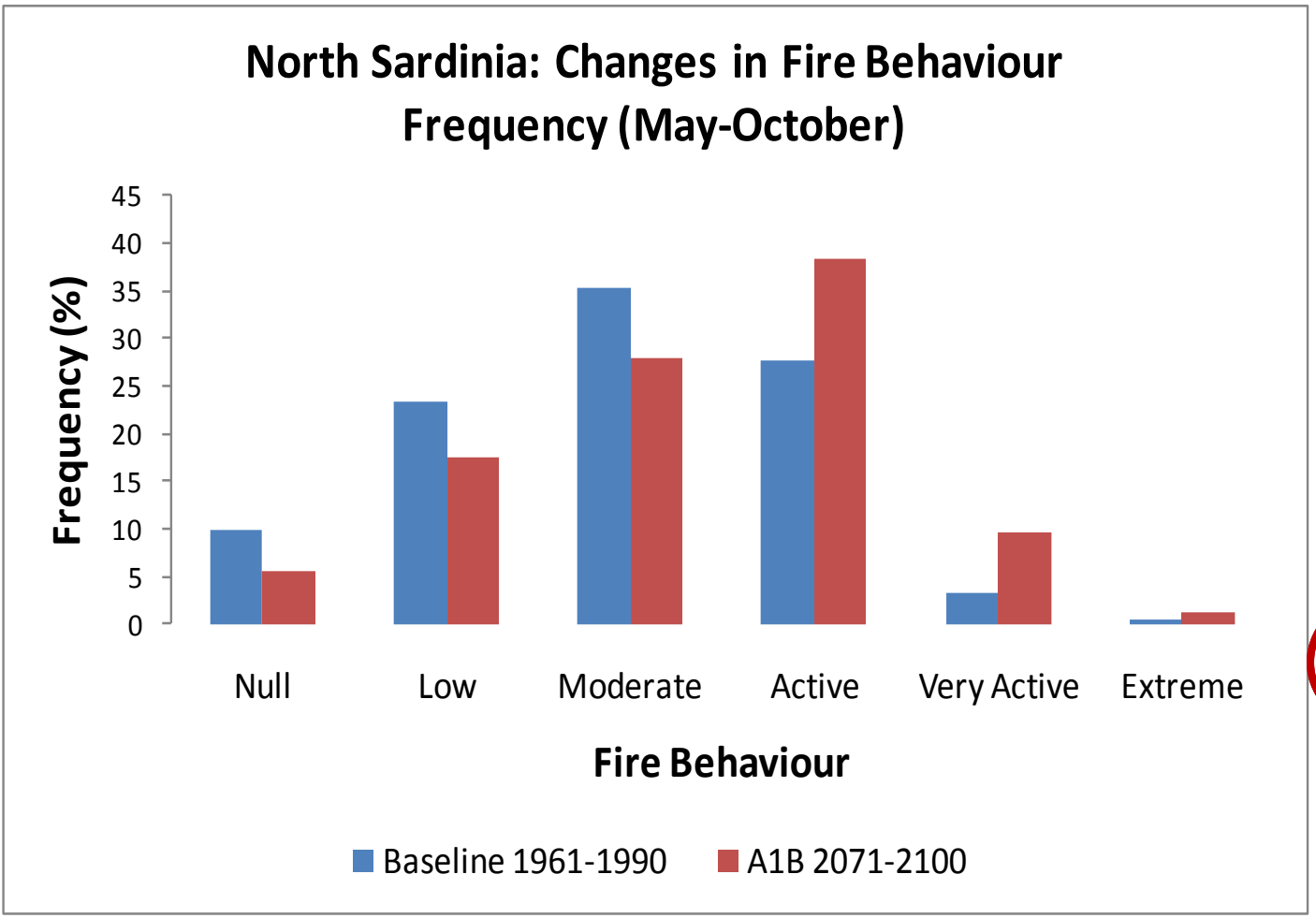
Differences in conditions for days above 99th perc. (Sardinia)

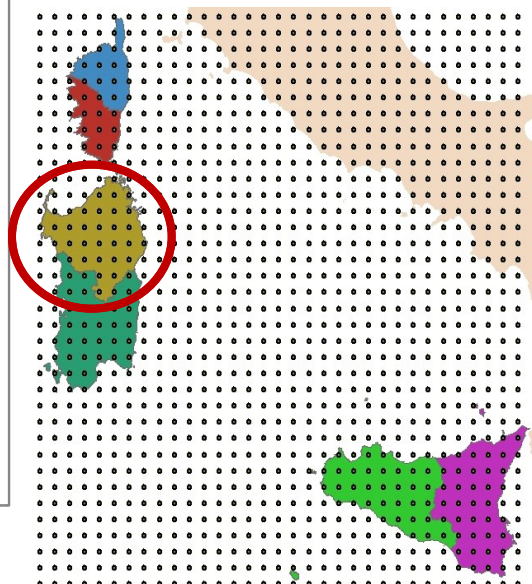
	Baseline (1961-90)	A1B Scenario (2071-00)
Temp (°C)	31.5	34.9
RH (%)	21.5	20.7
Wind speed (km h^{-1})	7.2	5.6
Prevailing wind directions	NW (35%) SE (21%)	NW (34%) SE (18%)
FWI	48.3	48.8
N° of days	153	274

Arca et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

FIRE BEHAVIOUR FREQUENCY (FROM MAY TO OCTOBER)

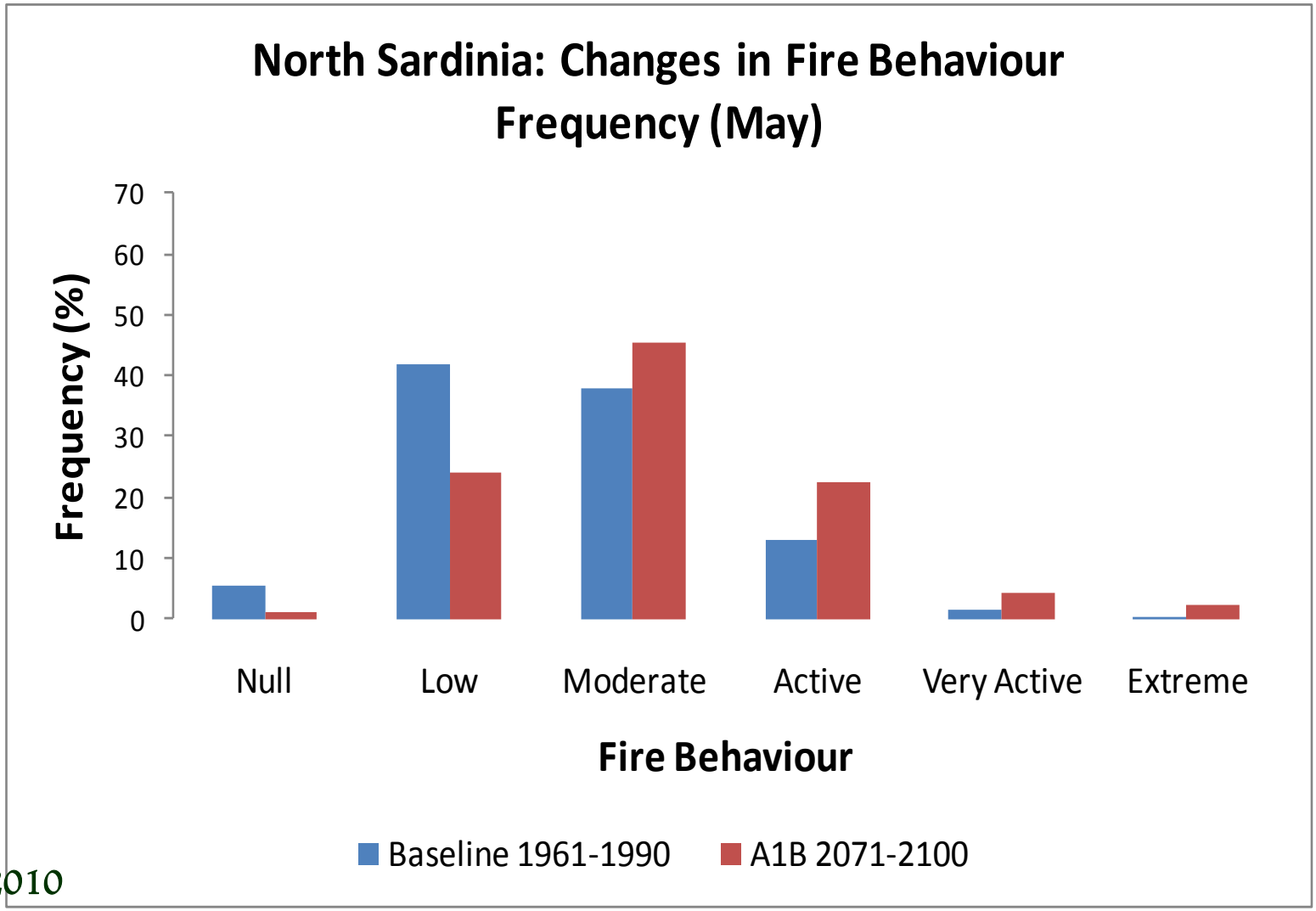




Salis et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

FIRE BEHAVIOUR FREQUENCY (FROM MAY TO OCTOBER)



Salis et al, 2010

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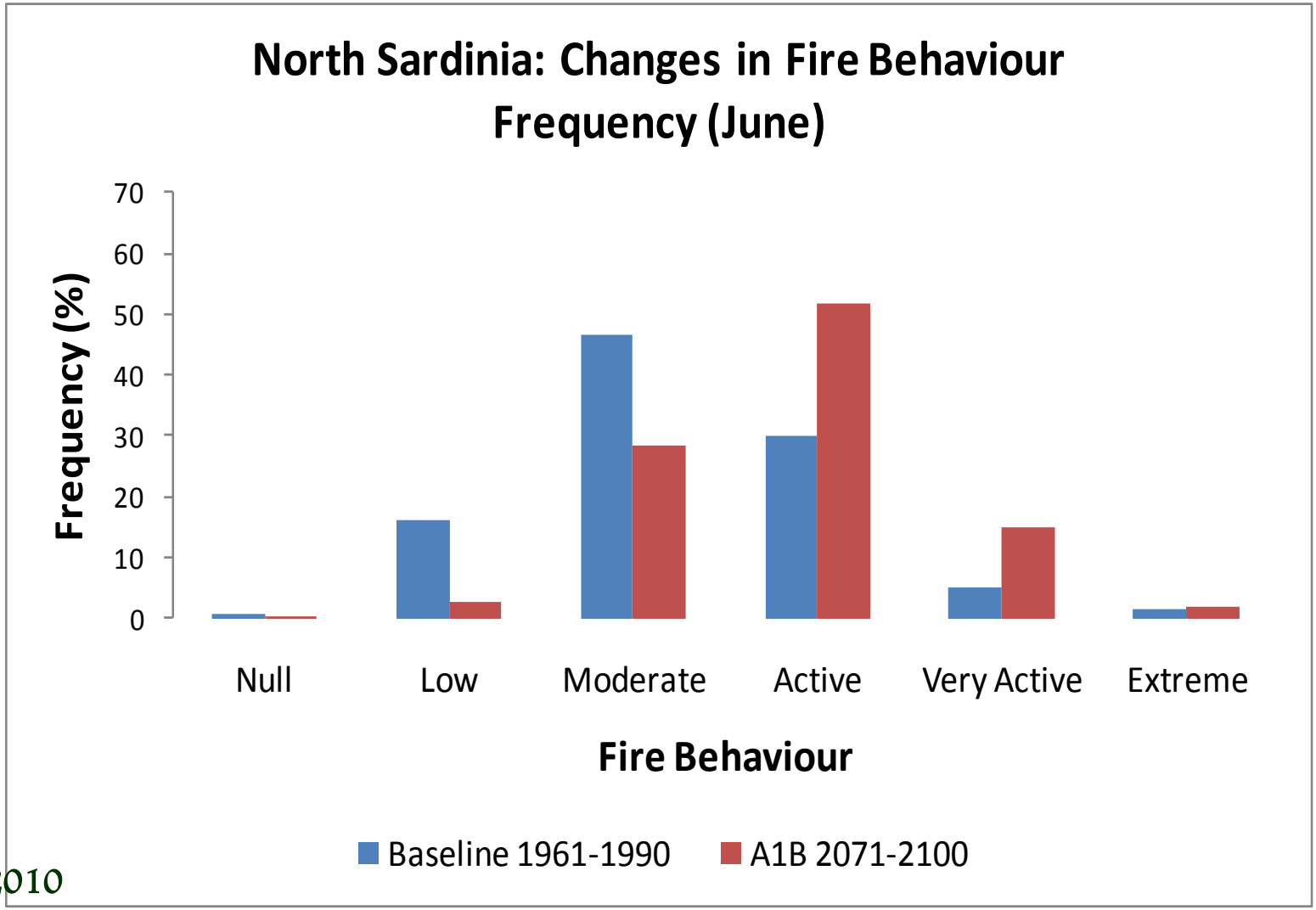
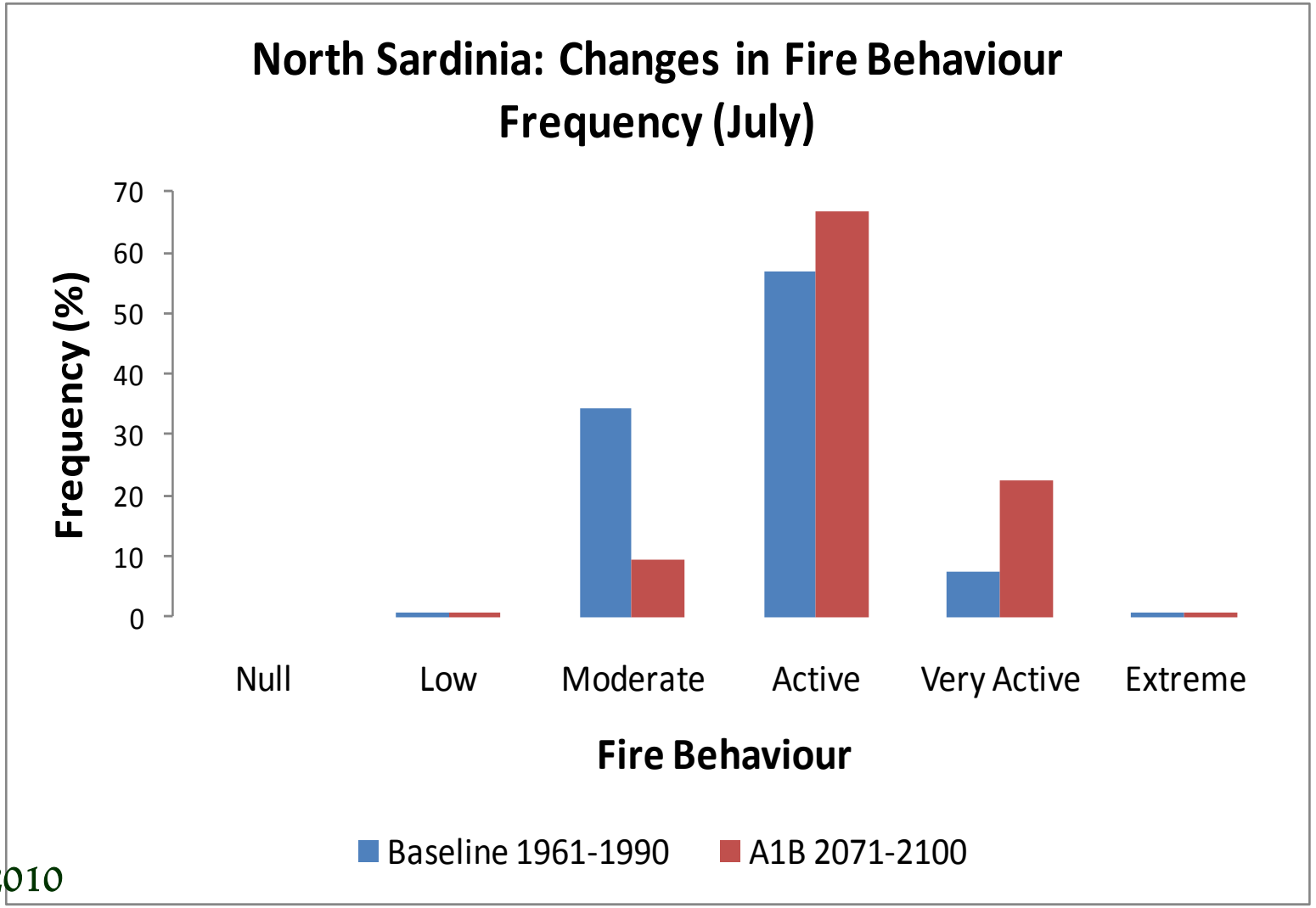


Salis et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

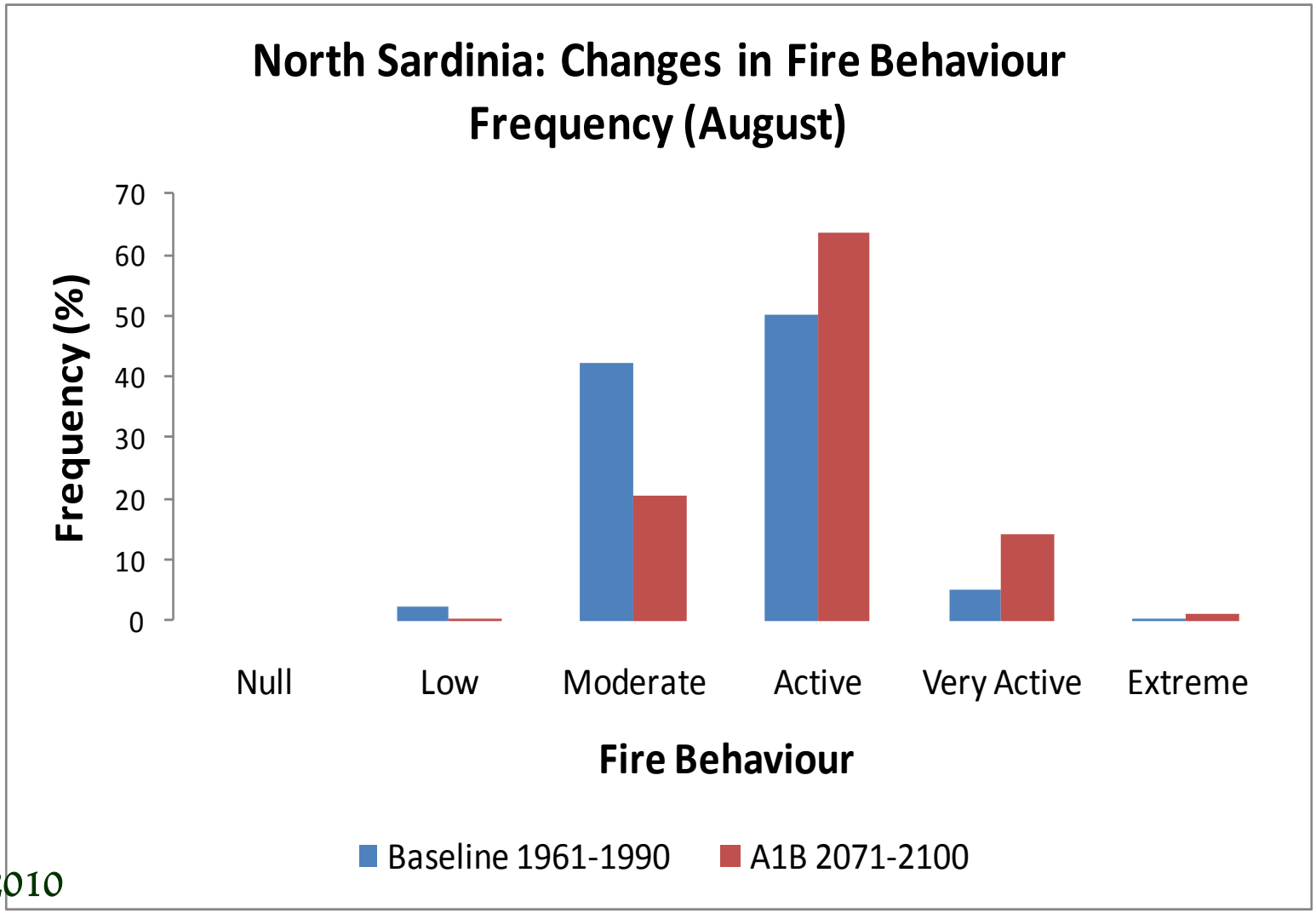
FIRE BEHAVIOUR FREQUENCY (FROM MAY TO OCTOBER)



Salis et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

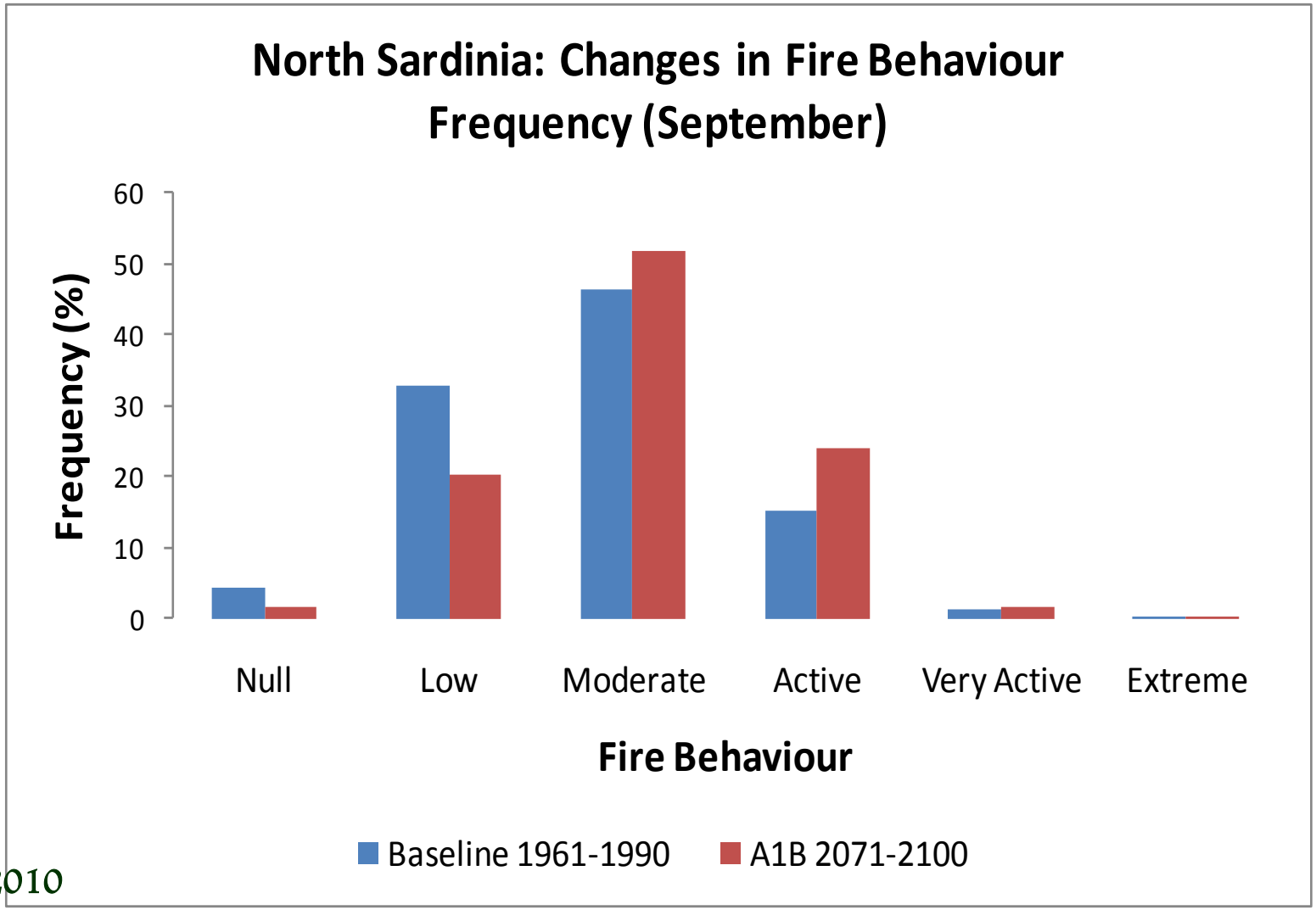
FIRE BEHAVIOUR FREQUENCY (FROM MAY TO OCTOBER)



Salis et al, 2010

Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

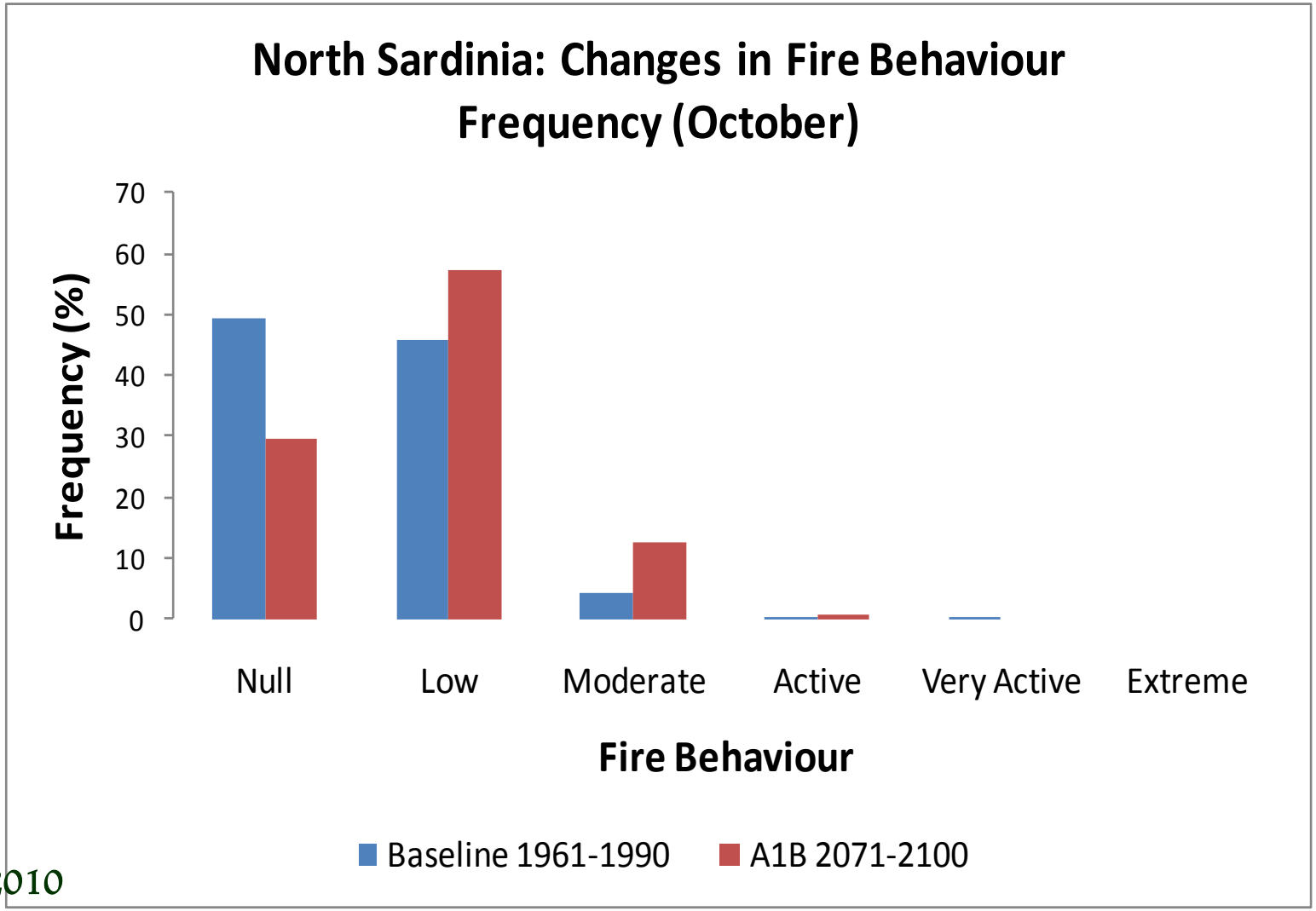
FIRE BEHAVIOUR FREQUENCY (FROM MAY TO OCTOBER)



Salis et al, 2010

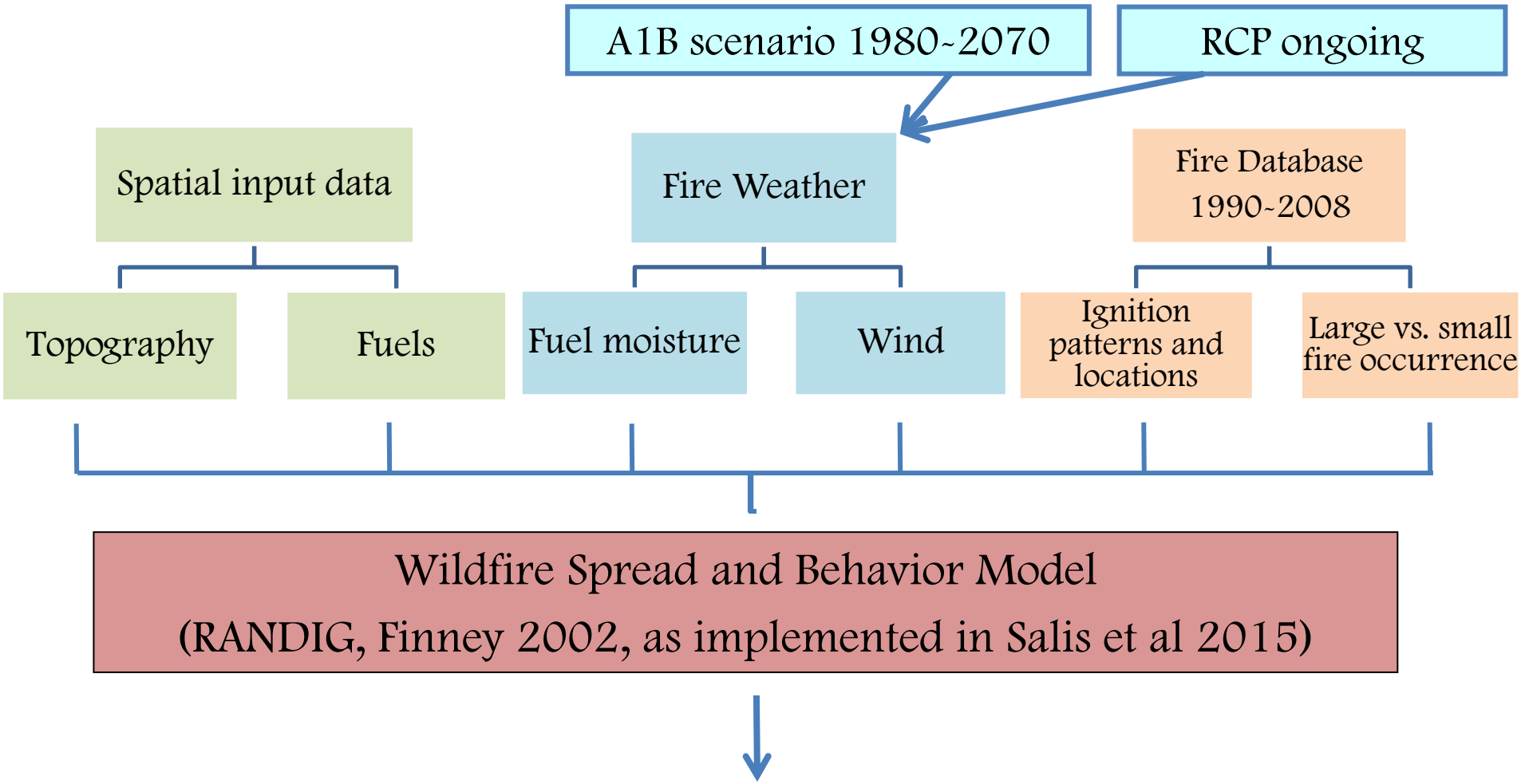
Case Study 3 – Projecting Future Fire Danger (FWI) and Behavior Classes

FIRE BEHAVIOUR FREQUENCY (FROM MAY TO OCTOBER)



Salis et al, 2010

Case Study 4 – Projecting Future Fire Exposure for Italy

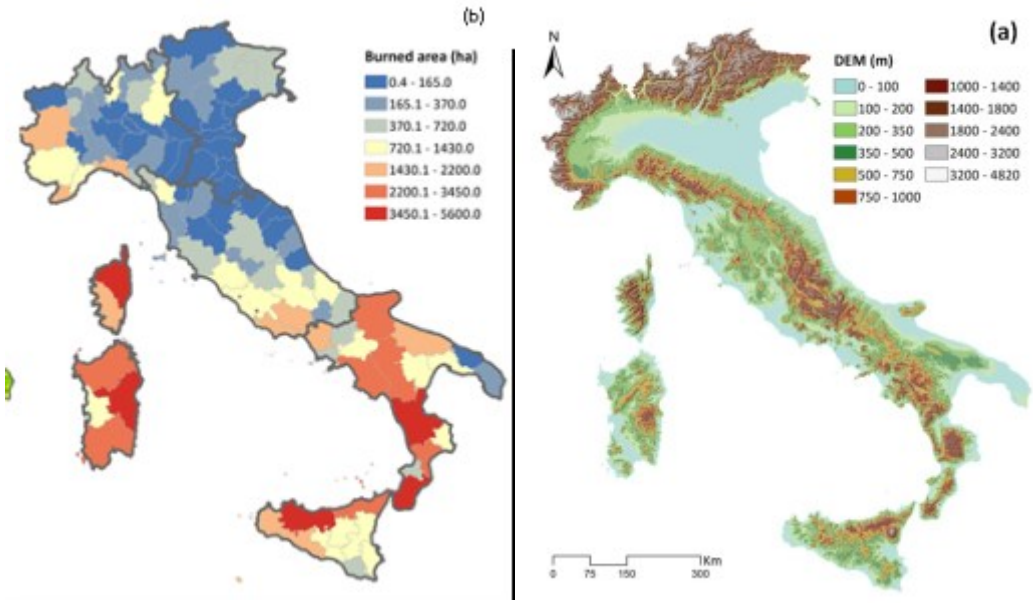


Burn probability (BP), Conditional flame length (CFL), Average fire size (FS), Fire potential index (FPI), etc.

Salis et al., 2013

Case Study 4 – Projecting Future Fire Exposure for Italy

- Italy was split in 6 macro-areas + Corsica
- Simulations and input data at 250 m of resolution
- 3 time-frames: 1981-2010; 2011-2040; 2041-2070
- About 350,000 wildfires simulated per each time-frame

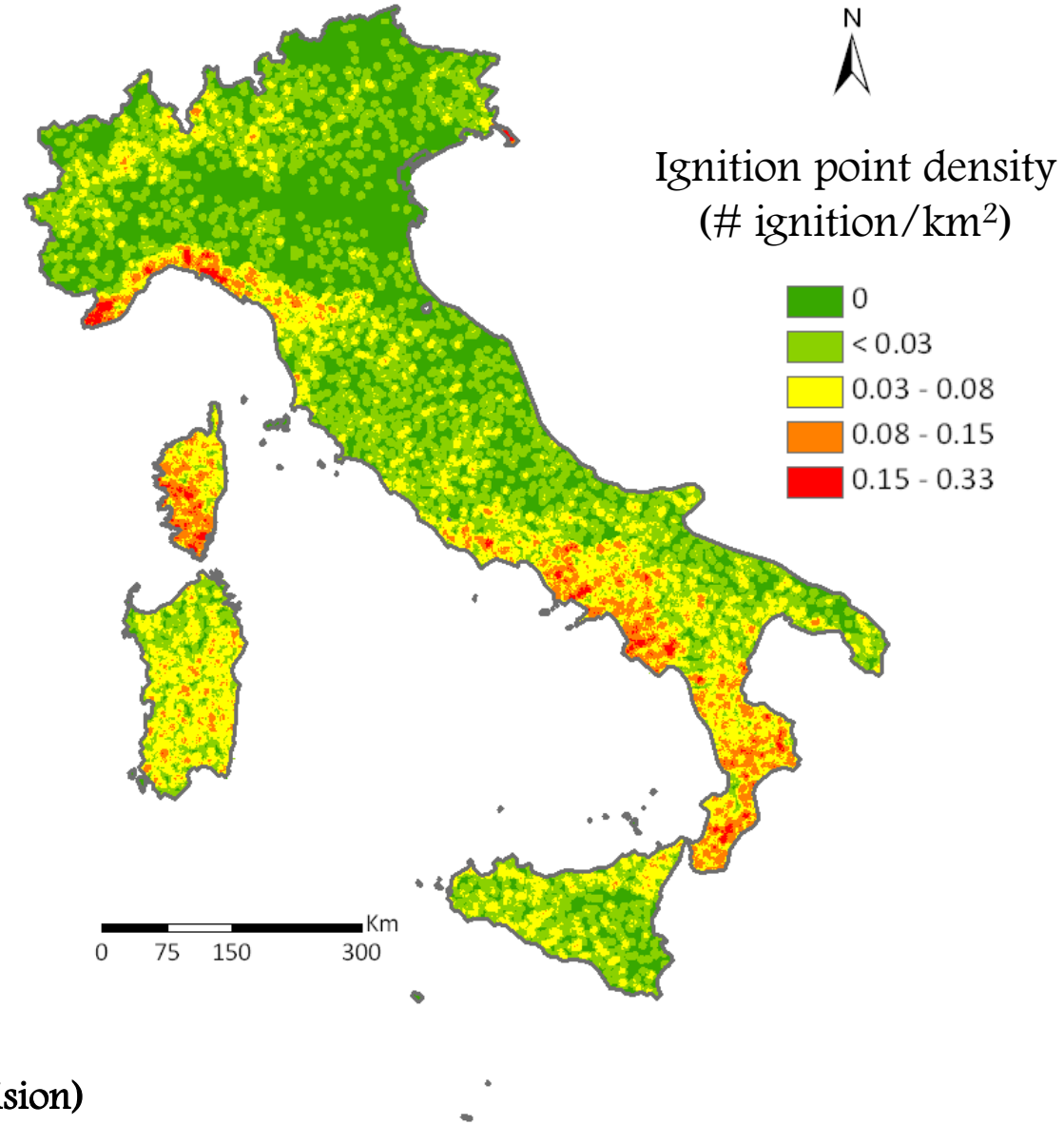


Lozano et al., 2015 (accepted, under revision)

Case Study 4 – Projecting Future Fire Exposure for Italy

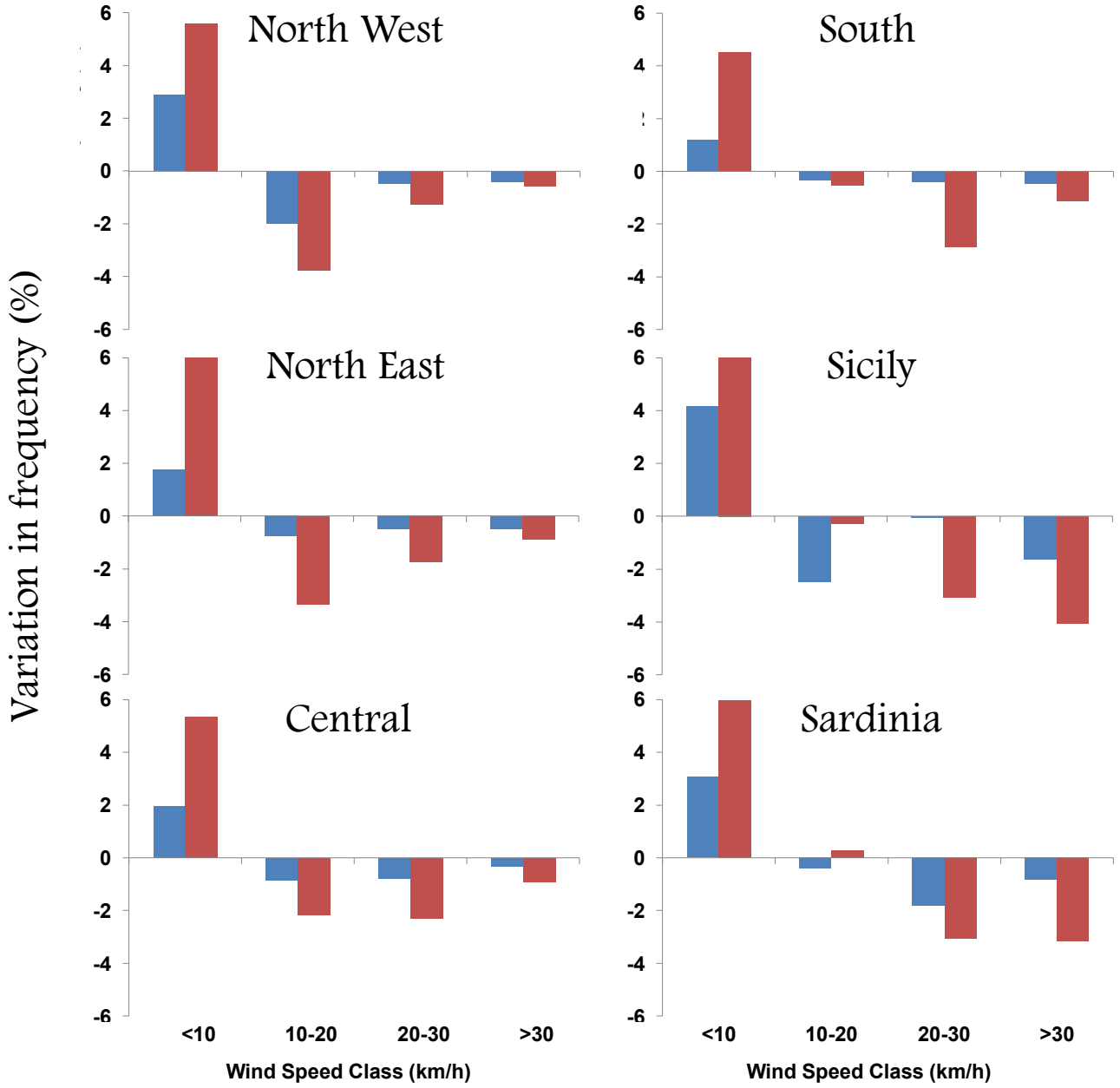
DRIVING FACTORS: FIRE IGNITION PATTERNS

JRC Average (1990-2008)



Lozano et al., 2015 (accepted, under revision)

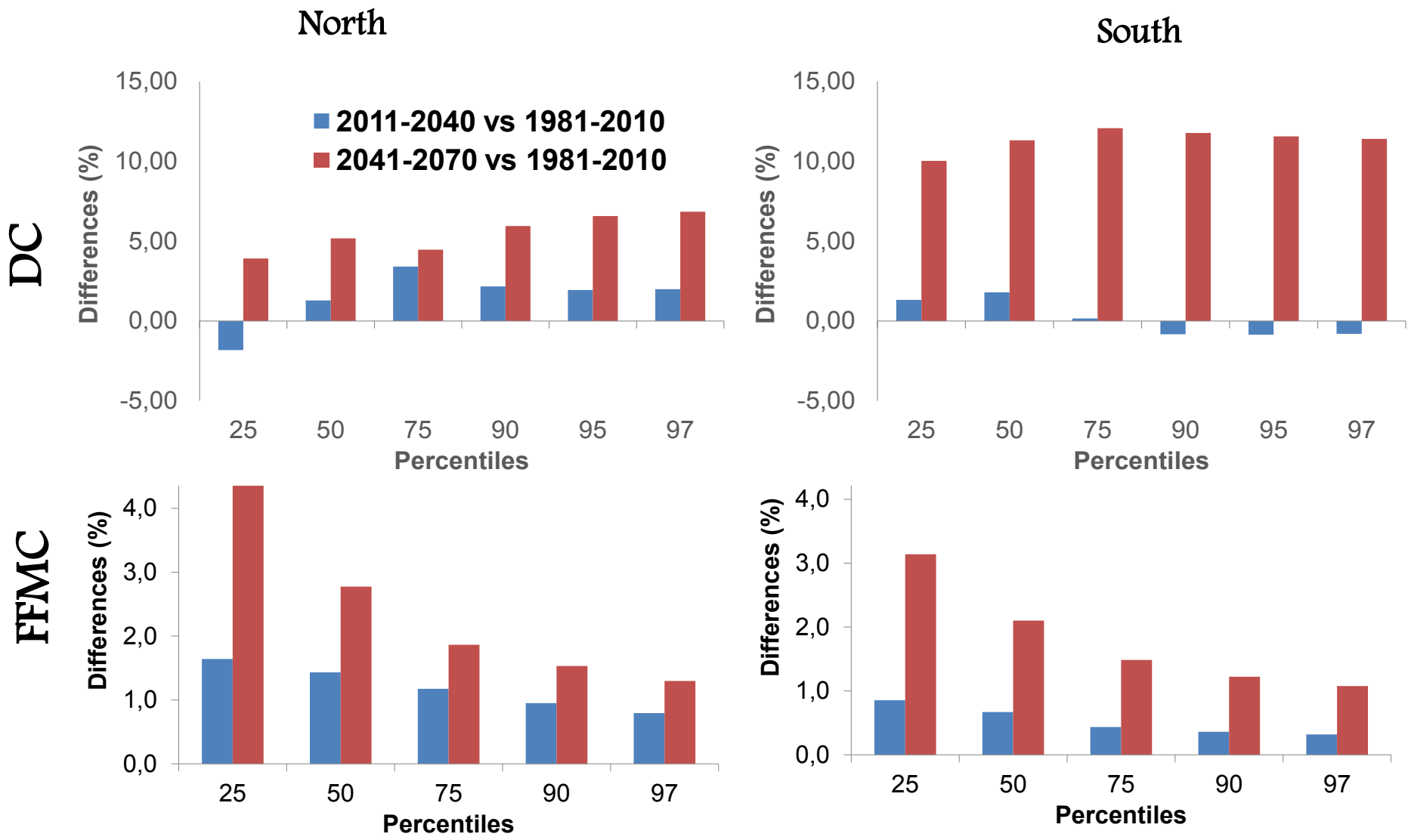
Case Study 4 – Projecting Future Fire Exposure for Italy



frequency of days with very strong wind (more than 30 km hr^{-1}) are going to decrease in all macroareas

DRIVING FACTORS: WIND SPEED

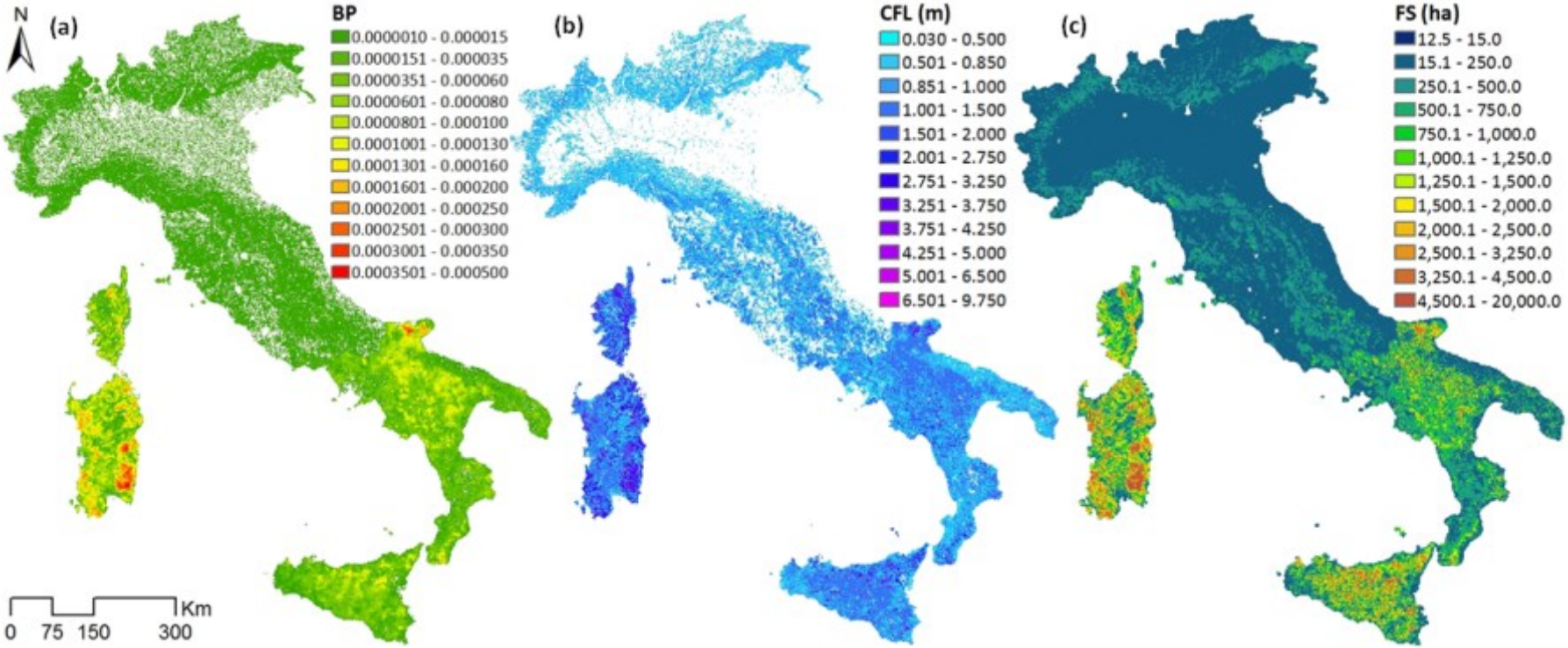
Case Study 4 – Projecting Future Fire Exposure for Italy



DRIVING FACTORS: DEAD & LIVE FUEL MOISTURE CONTENT

Higher Dryness

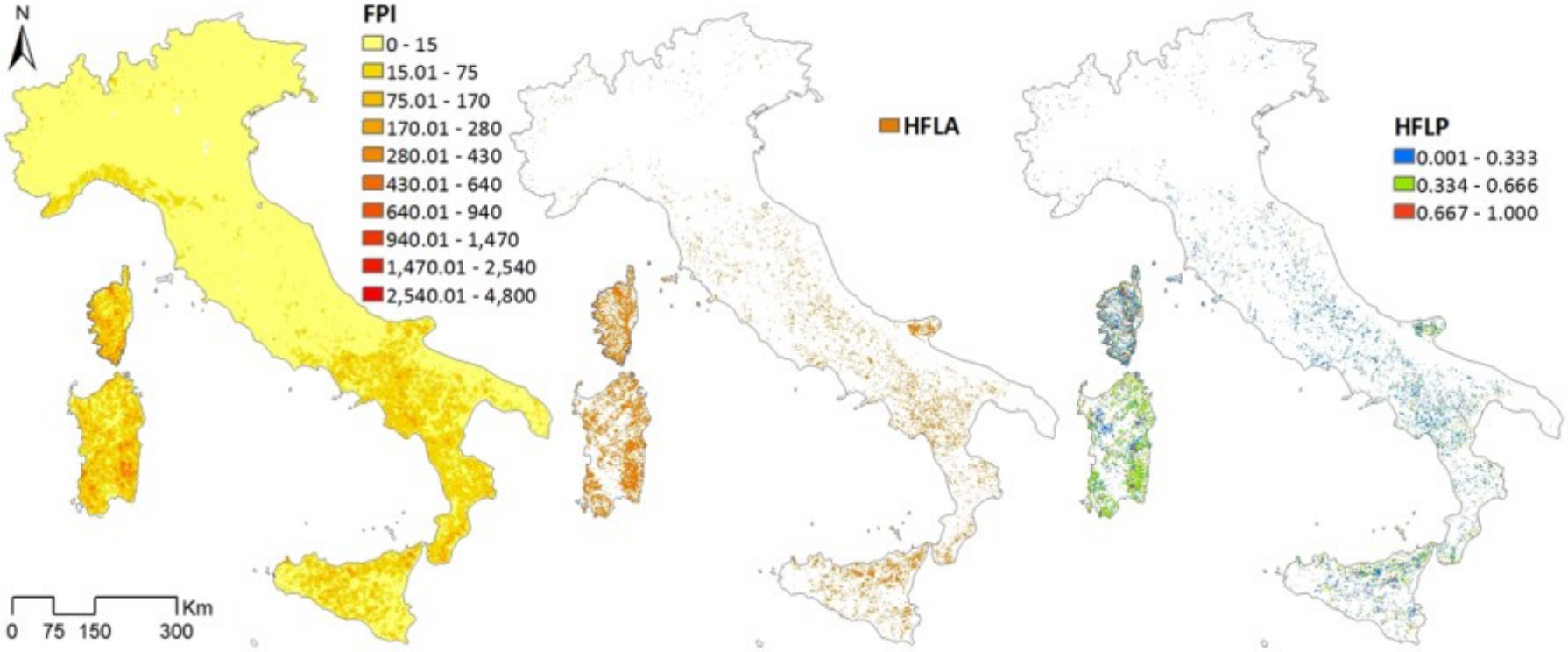
Case Study 4 – Projecting Future Fire Exposure for Italy



Maps of: Burn Probability (a); Conditional Flame Length (b); and Fire Size (c) for the baseline period (1981-2010)

Lozano et al., 2015 (accepted, under revision)

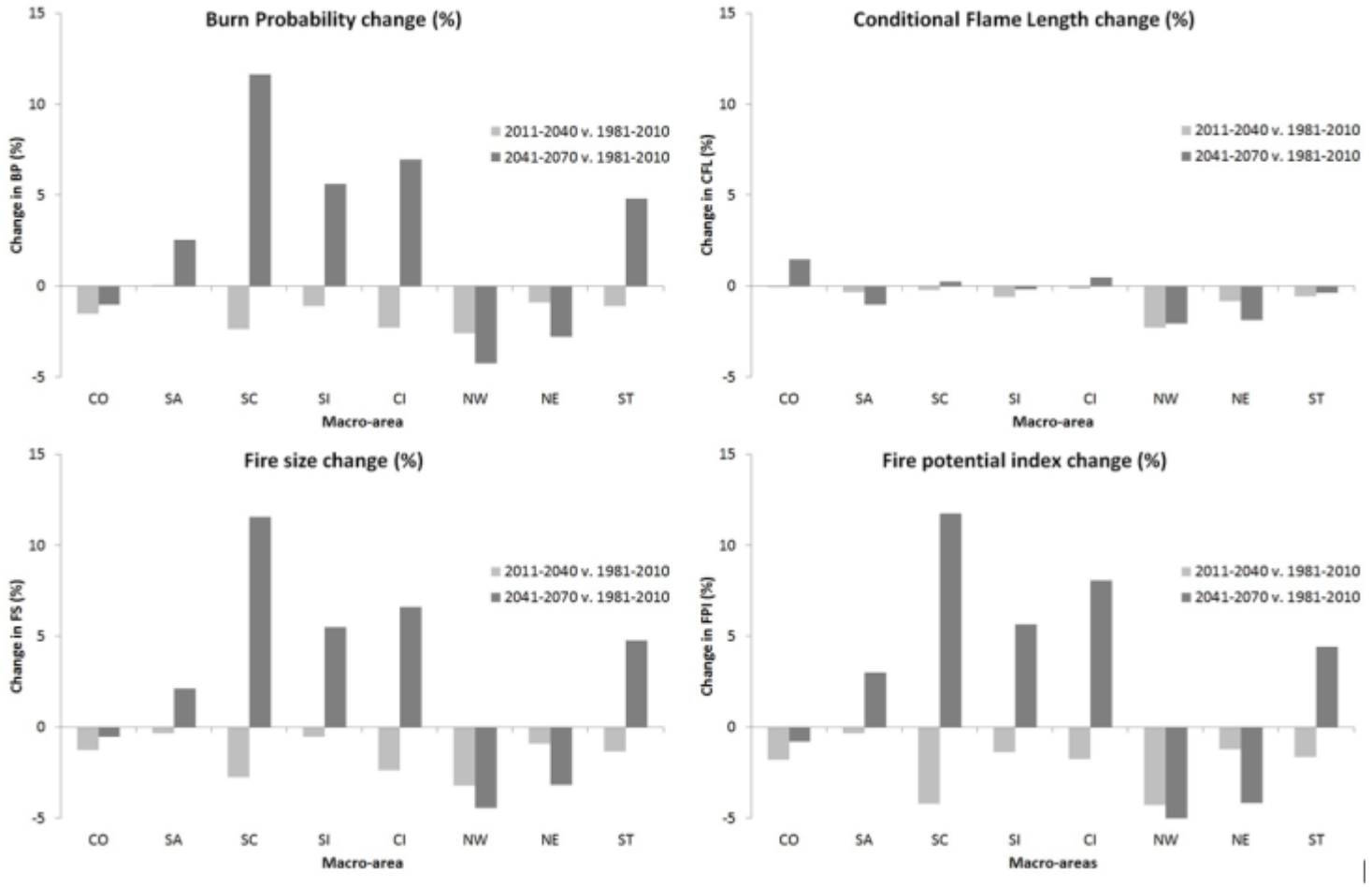
Case Study 4 – Projecting Future Fire Exposure for Italy



Maps of: Fire Potential Index (FPI, Fire Size x Ignitions) (a); High Flame Length Areas (HFLA, flame length >2.5m) (b); and High Flame Length Probability (HFLP, probability of burning with flame length >2.5m) (c). Baseline period (1981-2010)

Lozano et al., 2015 (accepted, under revision)

Case Study 4 – Projecting Future Fire Exposure for Italy

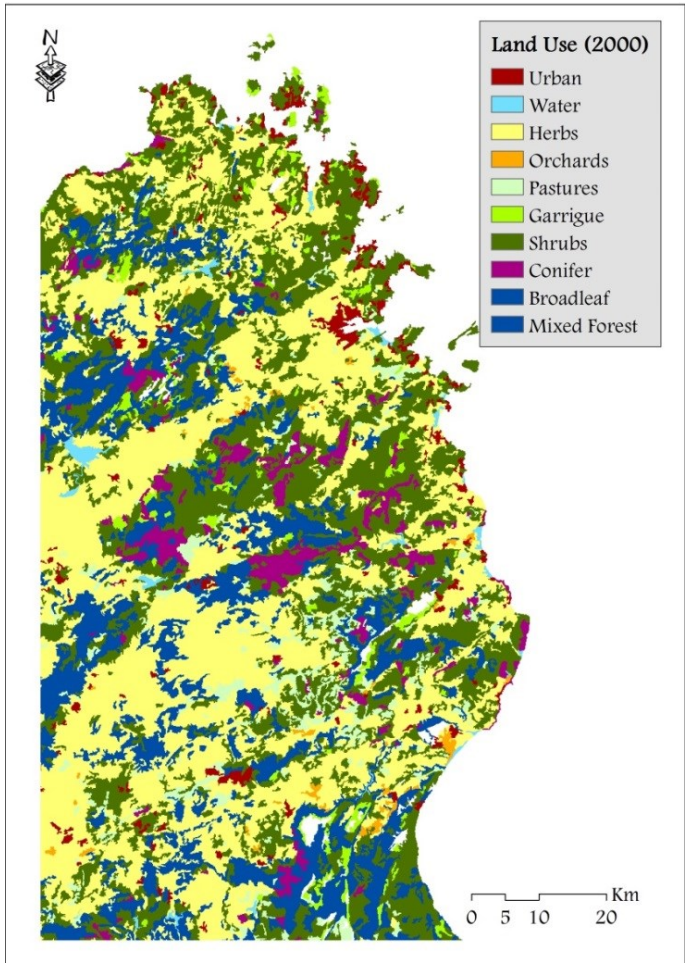


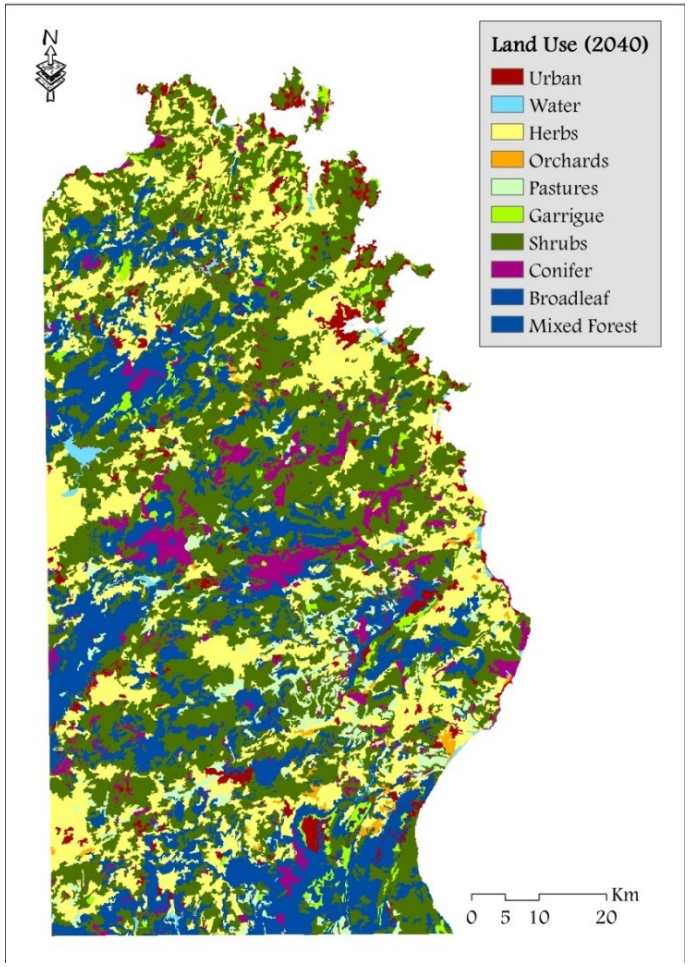
Variation in BP, CFL, FS and FPI from the baseline (1981-2010) to the second (2011-2040) and third (2041-2070) study periods respectively

Lozano et al., 2015 (accepted, under revision)

Case Study 5 – Projecting Future Land Use Changes for Sardinia

Land use changes (2000 vs 2040)



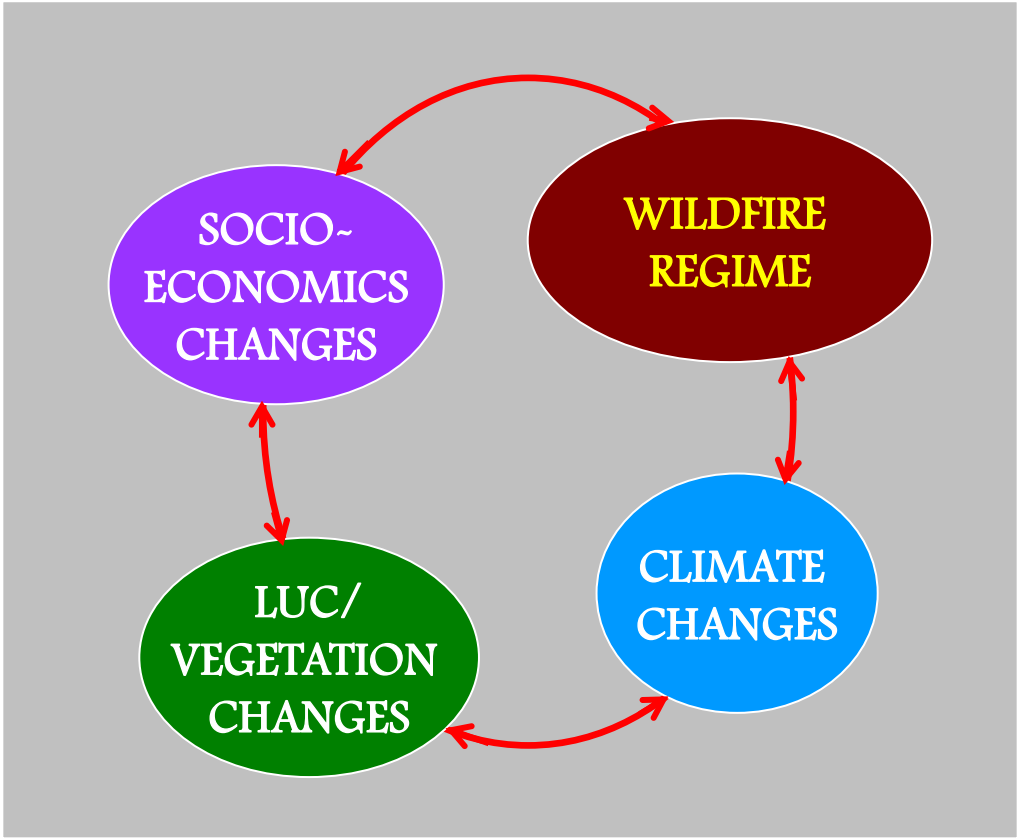


(A1B, FUME Project IAFENT-CMCC)

Future land use maps predict an increase in forest areas, shrublands and urban areas, along with a reduction of agricultural areas and pastures, for both Sardinia and Corsica

Challenges in Future Wildfire Risk Projections…

Fire Spread Modeling: Long Term



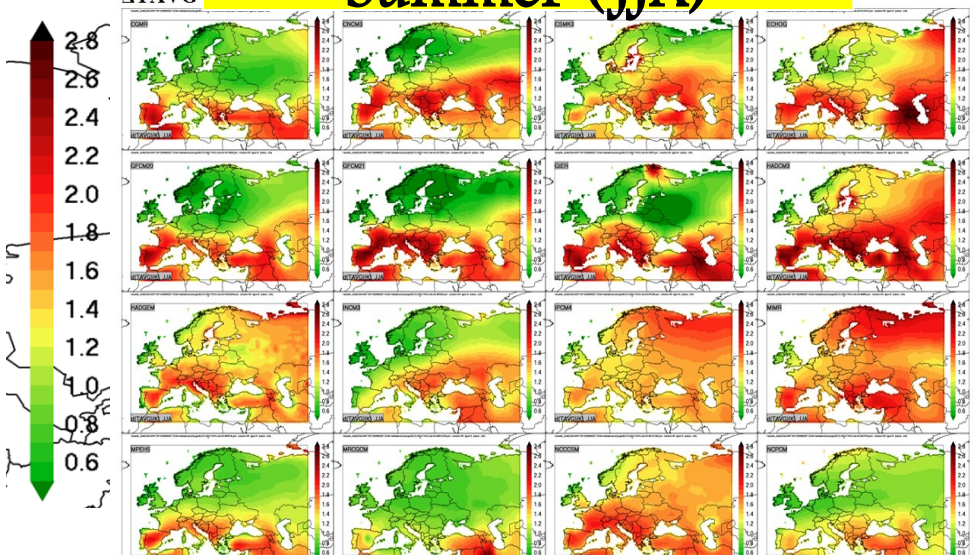
Complex interactions among climate changes, LUC and vegetation changes, socio-economic changes, fire regime

Challenges in Future Wildfire Risk Projections…

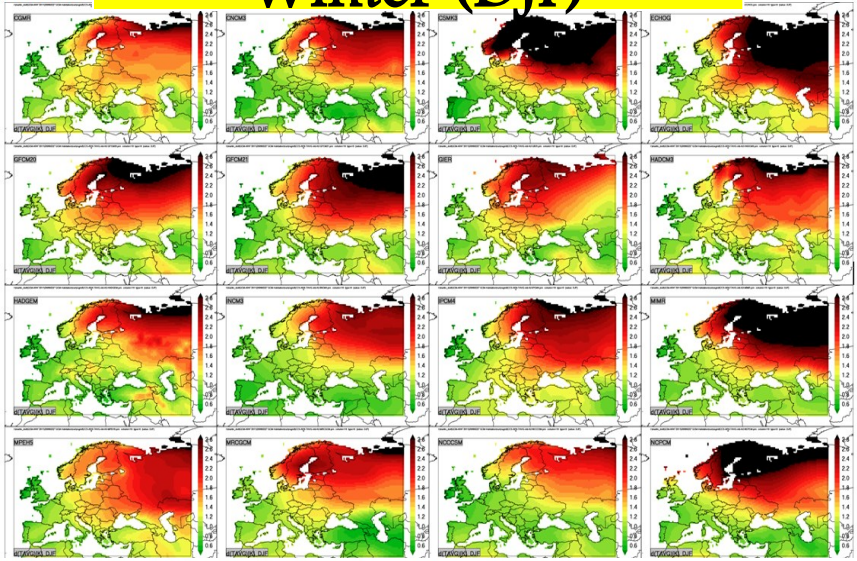
Dubrovsky, 2011

ΔTAVG

Summer (JJA)

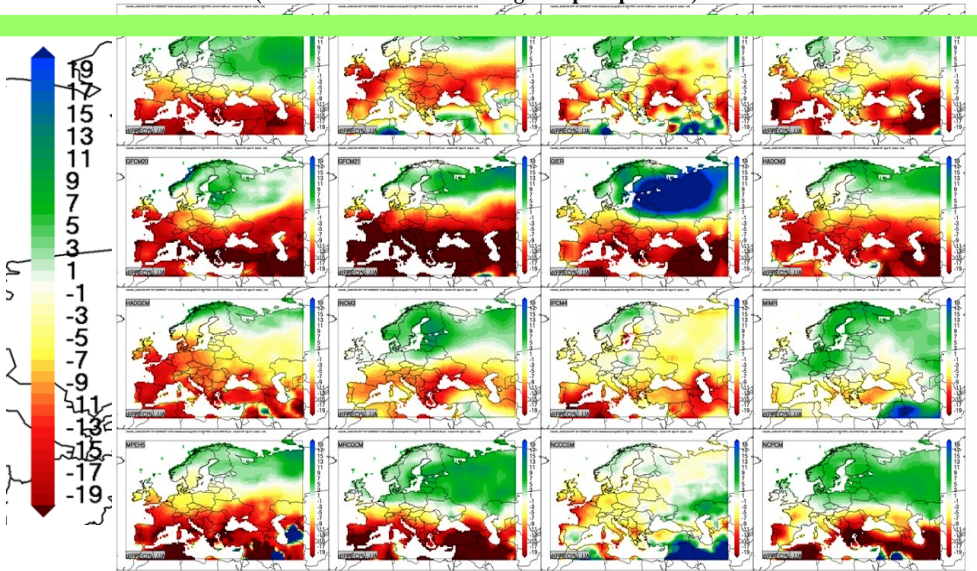


Winter (DJF)

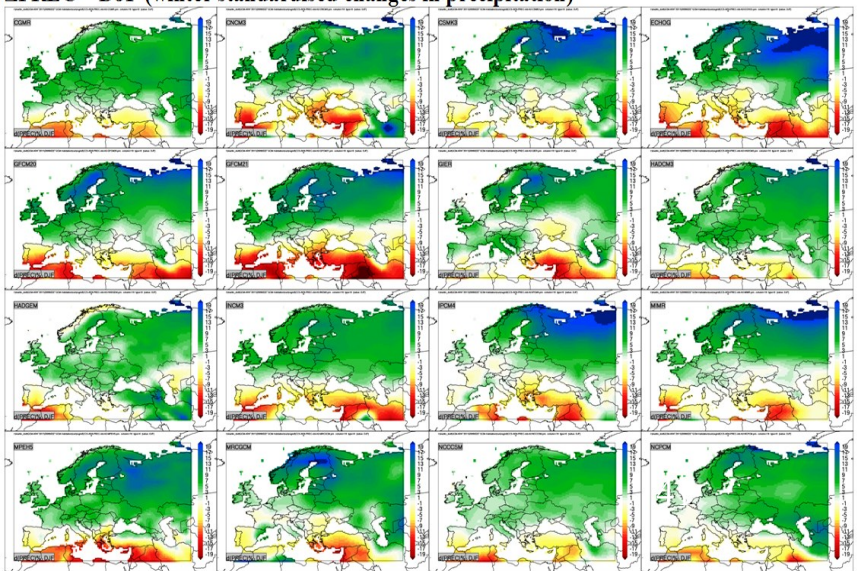


ΔPREC

ΔPREC – JJA (summer standardised changes in precipitation)



ΔPREC – DJF (winter standardised changes in precipitation)

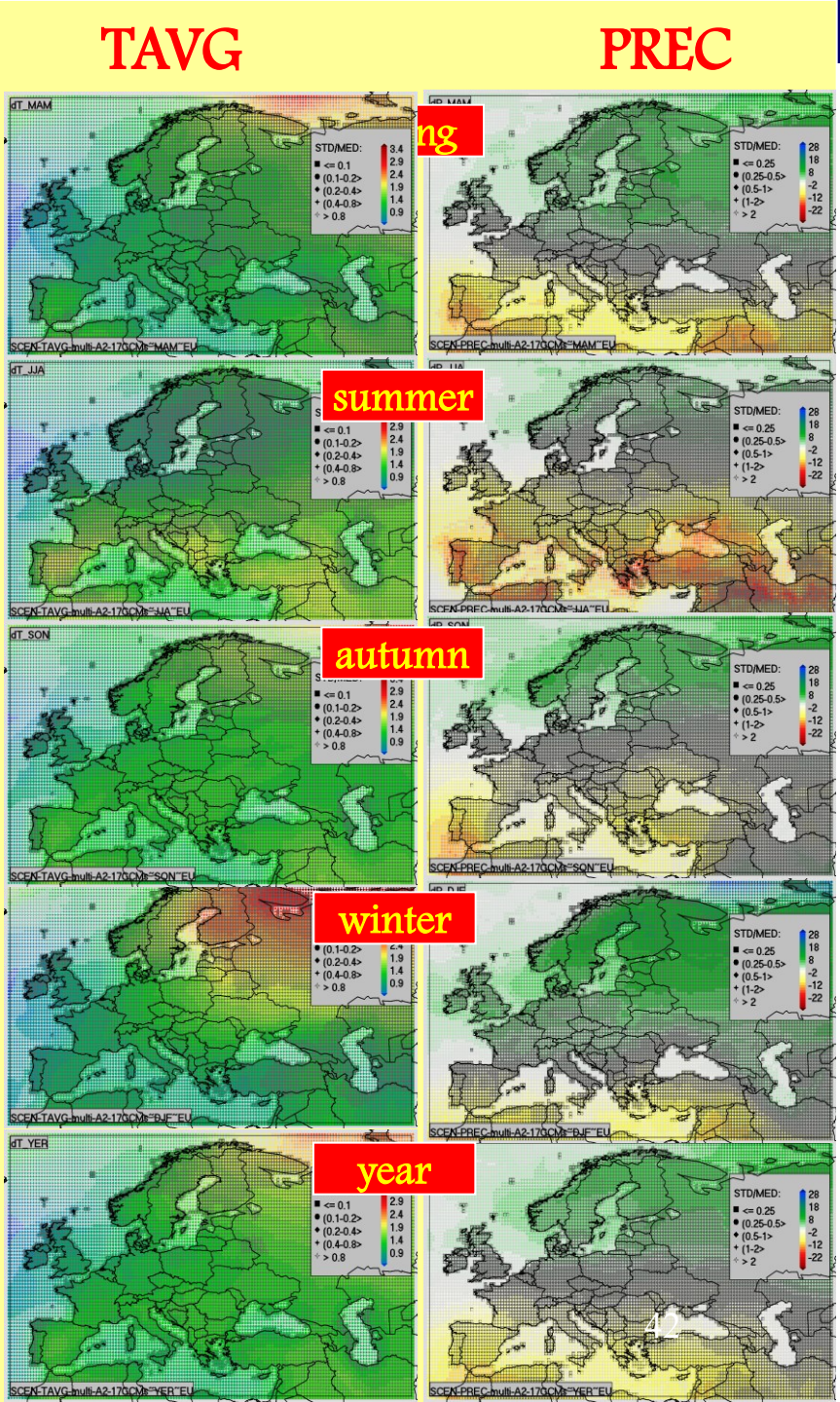


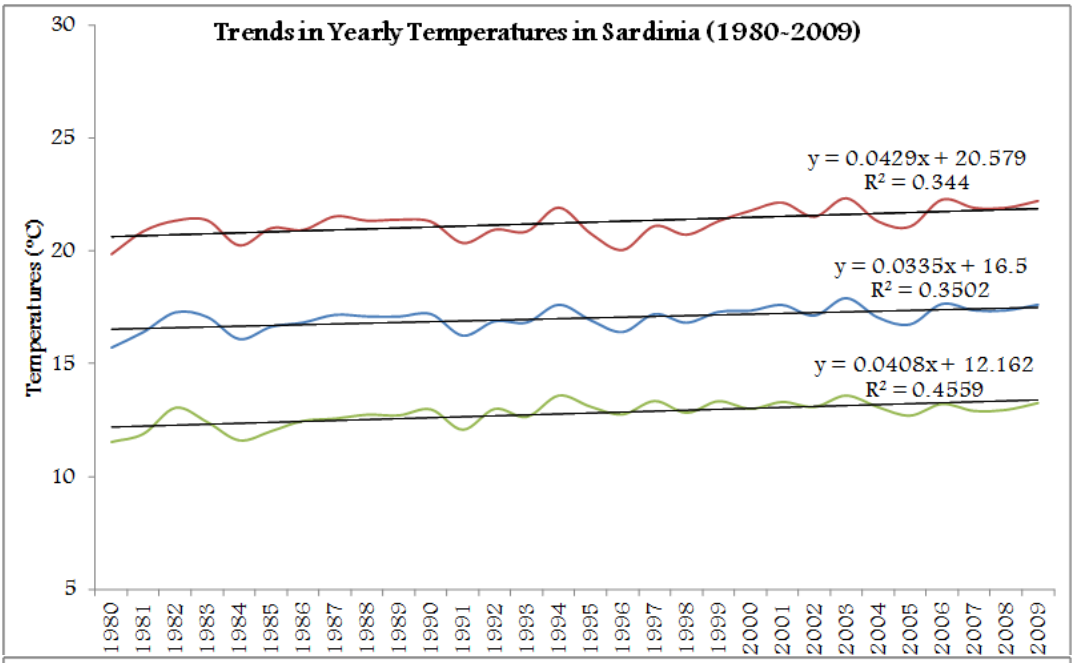
Challenges in Future Wildfire Risk Projections…

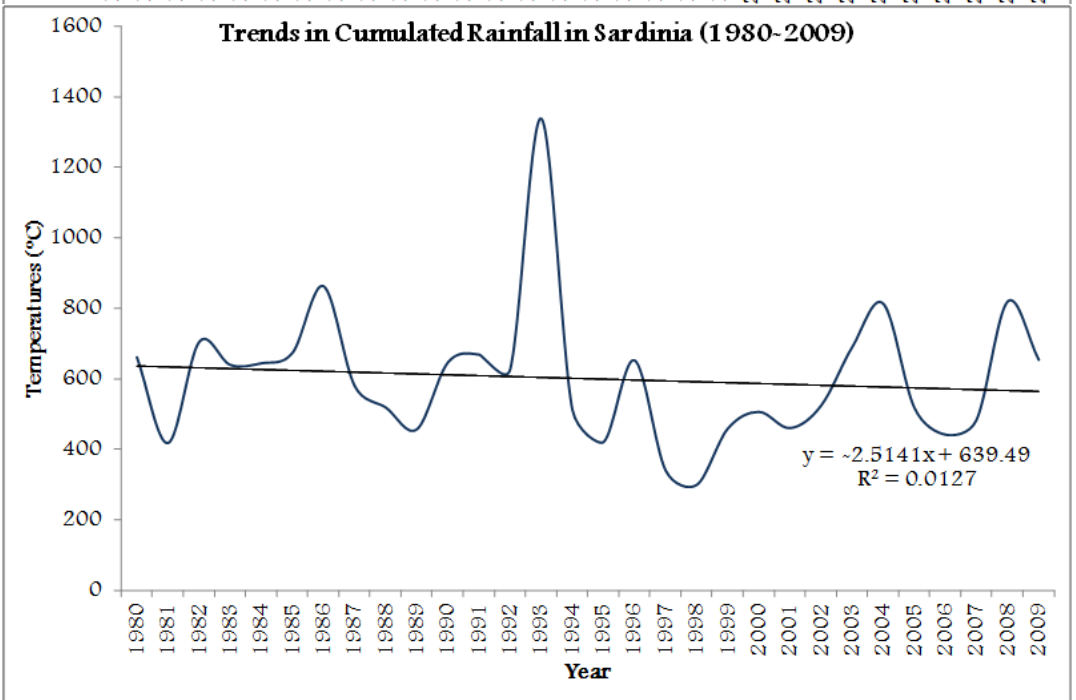
- **TAVG increases:** everywhere & all months
- **PREC:**
  Significant decrease in spring and summer
  Lowest change in winter
- **Mediterranean:**
  temperature increase:
  - highest : summer
  - lowest : winter

  precipitation decreases during most months of the year
  TEMP increase + significant PREC decrease ➔ drought risk will increase

Dubrovsky, 2011







Challenges in Future Wildfire Risk Projections…

Trends (1980-2009) in Yearly Temperatures and Cumulated Rainfall in Sardinia

Significant differences between 1980-1994 and 1995-2009:

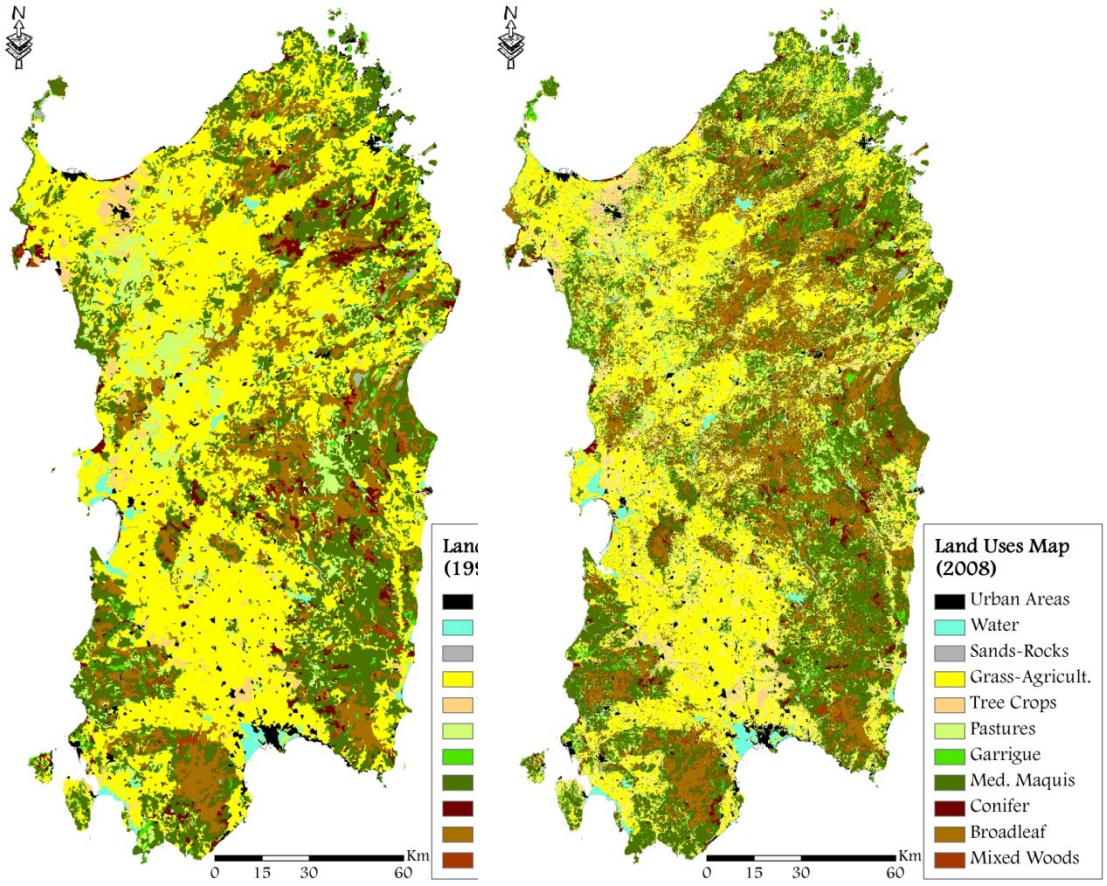
a) Increase of T, TM, Tm (April, May, June)
b) Reduction of PP in February

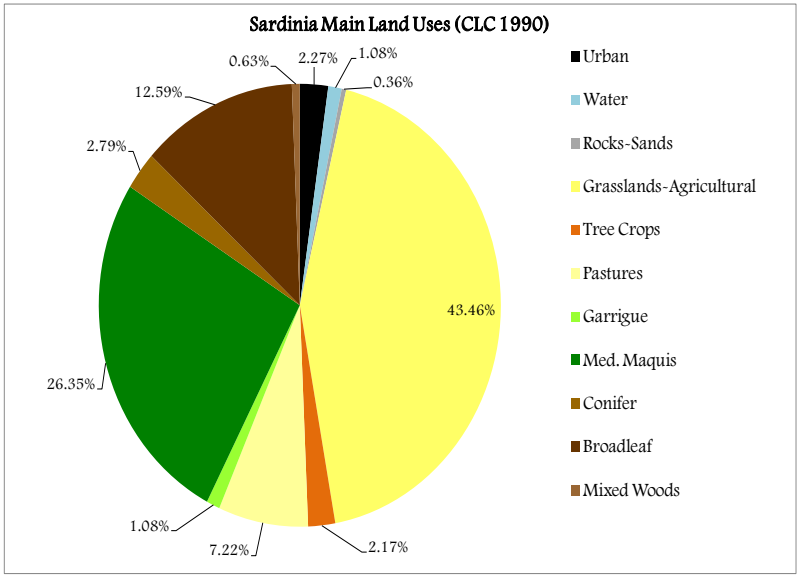
Salis et al, 2014

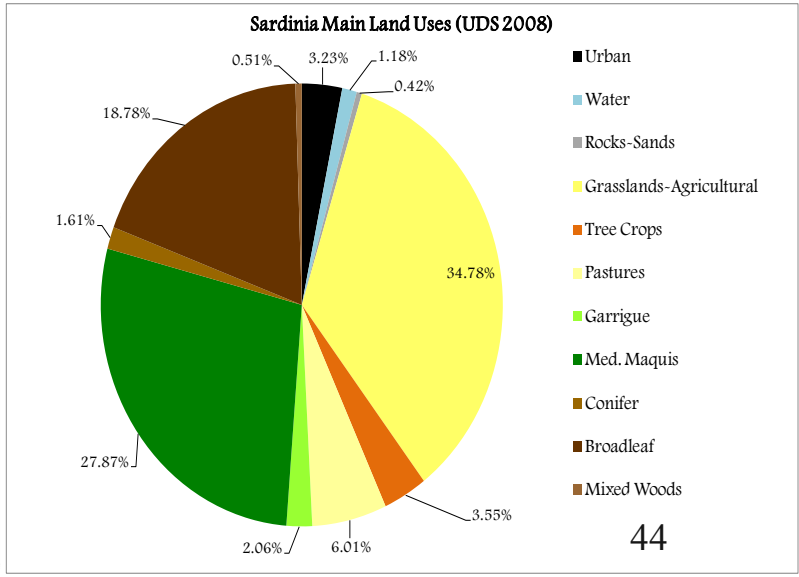
Challenges in Future Wildfire Risk Projections…

Land use changes

Salis et al, 2014

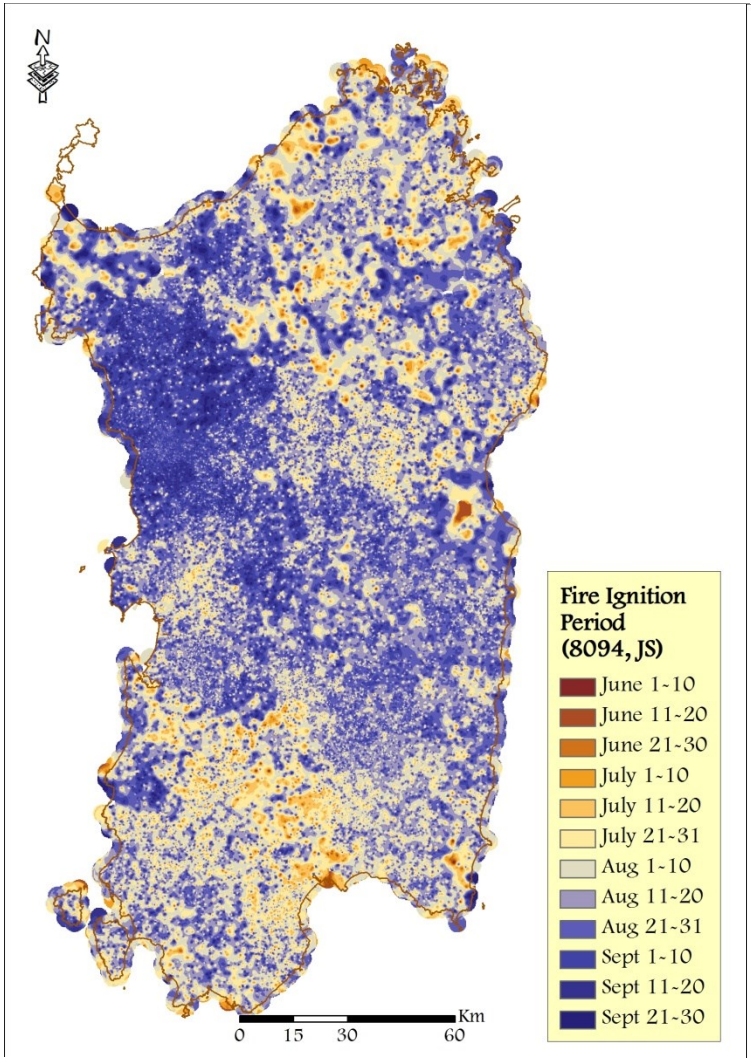


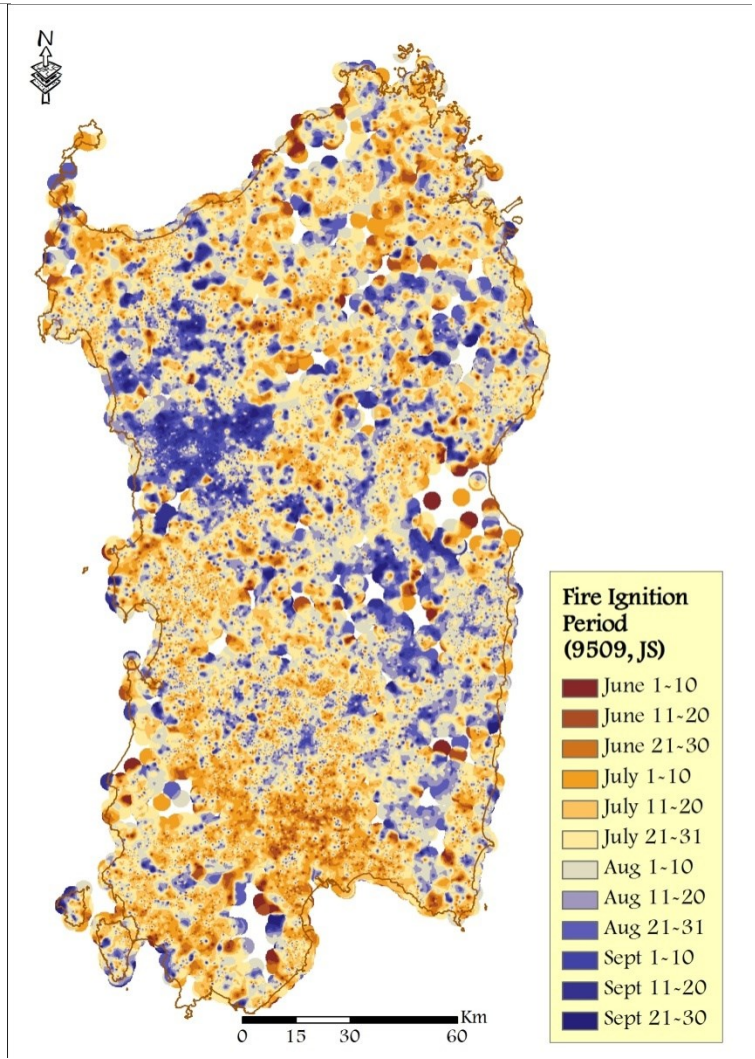




Challenges in Future Wildfire Risk Projections…

Temporal changes in fire ignitions



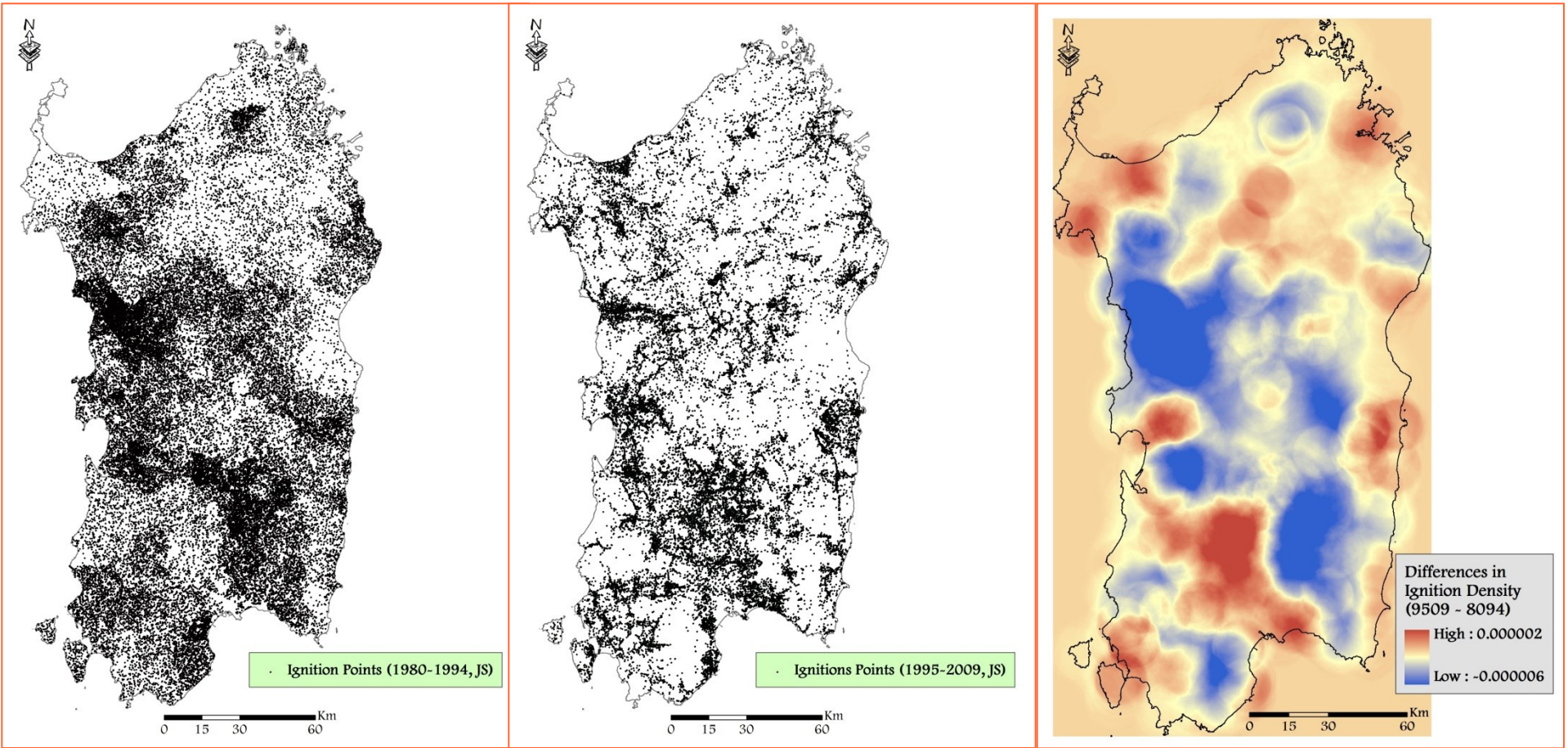


Salis et al, 2014

Challenges in Future Wildfire Risk Projections…

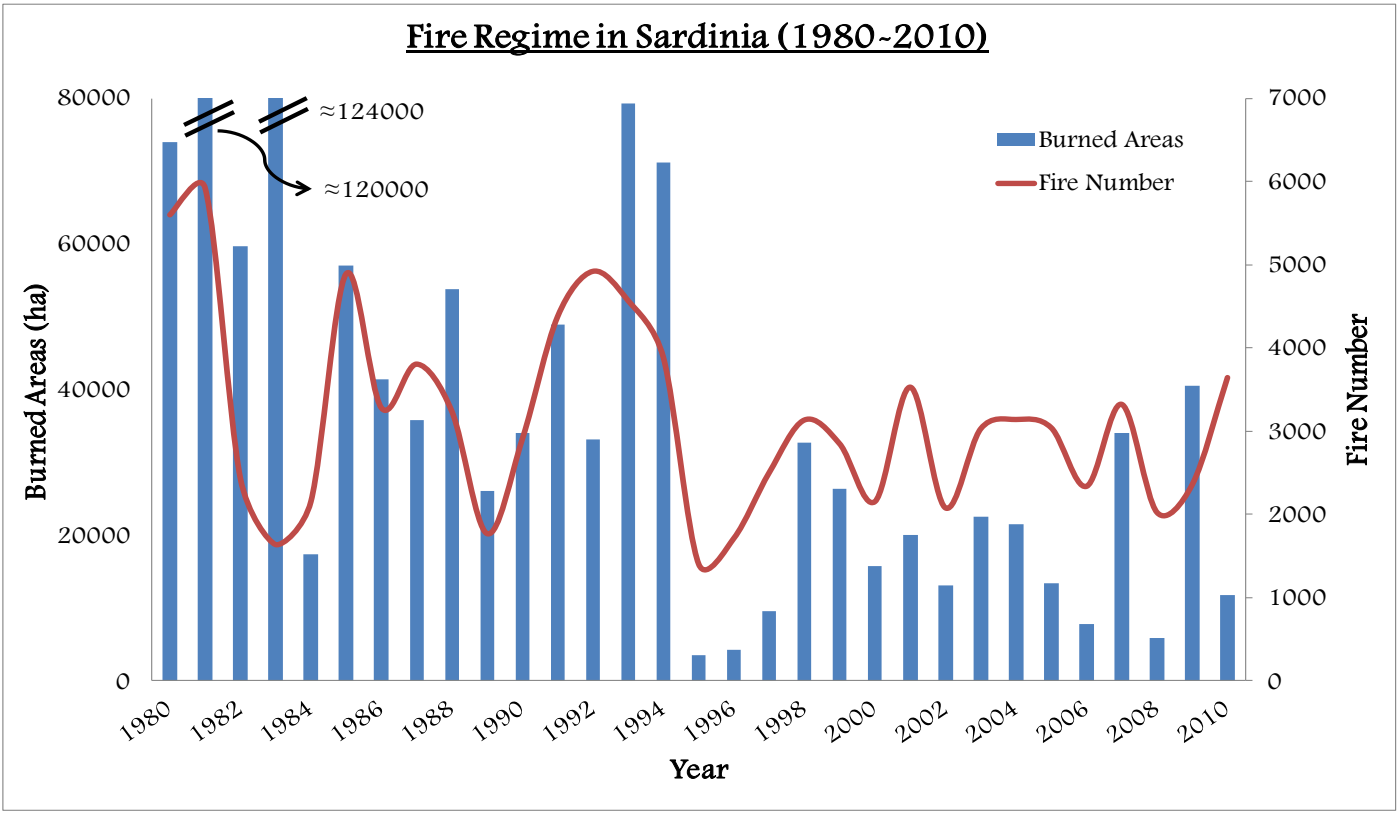
Spatial changes in fire ignition locations

Salis et al, 2014



Challenges in Future Wildfire Risk Projections…

Improvements in fire fight and management technology, strategies, and knowledge



Higher demand of education, training, tactical and planning support from Forest Services, Civil Protection, National, Regional and Local Institutions











Courtesy of CFVA


Thank you for your attention!
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