Remote Sensing of Global Environmental Change

VOD2LFMC model evaluation

with soil moisture and precipitation anomalies

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OBJECTIVES

1. To quantify the performance of the VOD2LFMC dataset in reproducing field observations of LFMC under drought conditions.

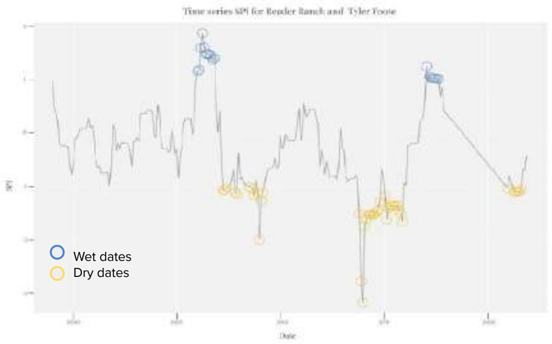
2. To analyse the correlation of VOD2LFMC with precipitation anomalies and soil moisture.

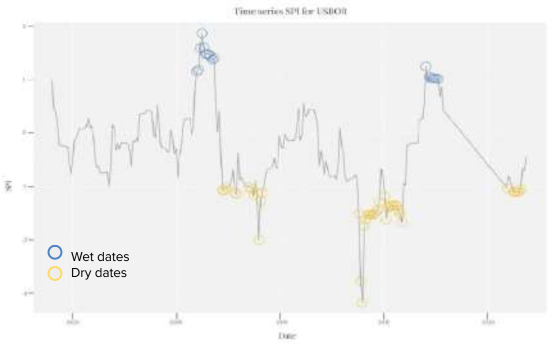
1.

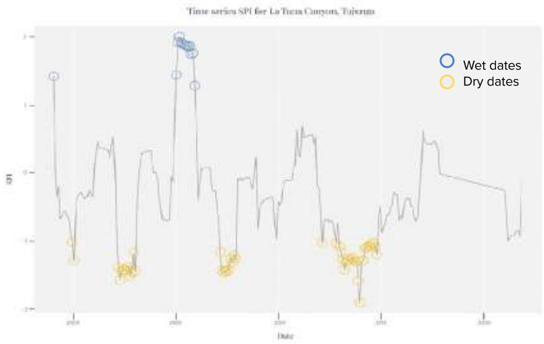
How well VOD2LFMC represent field measurements of LFMC, especially under drought?

How did we define the wet and dry conditions?

Datasets: SPI dataset using sites from GLOBE LFMC

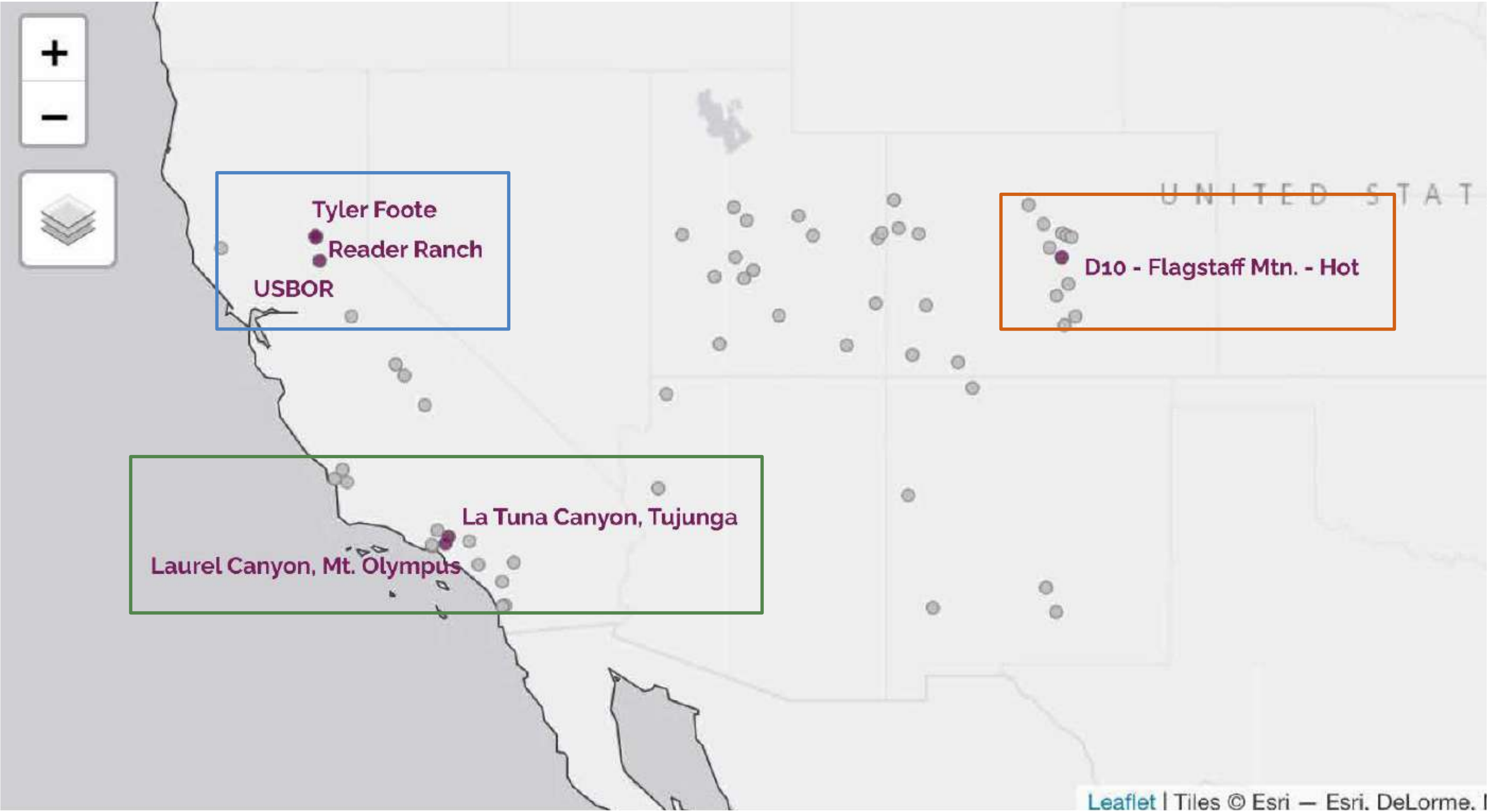




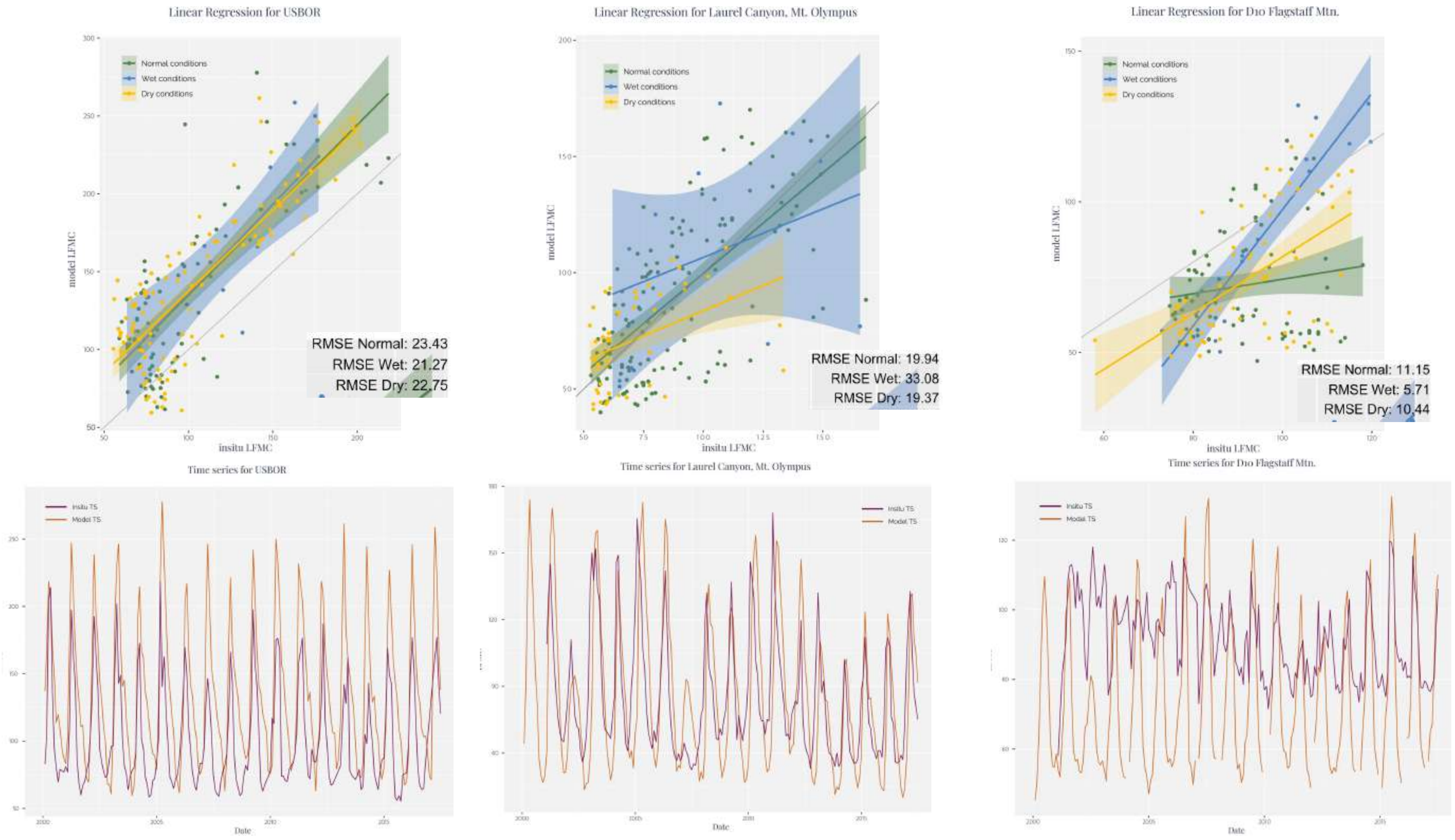


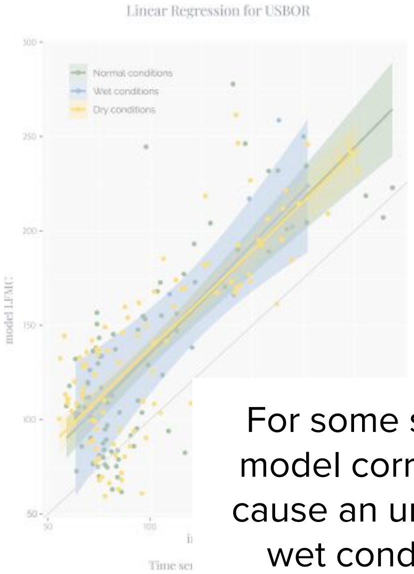
Dry and wet season identification

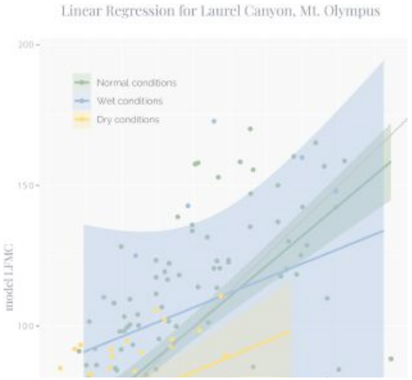
Dry dates with SPI (< -1)
Wet dates with SPI (> 1)

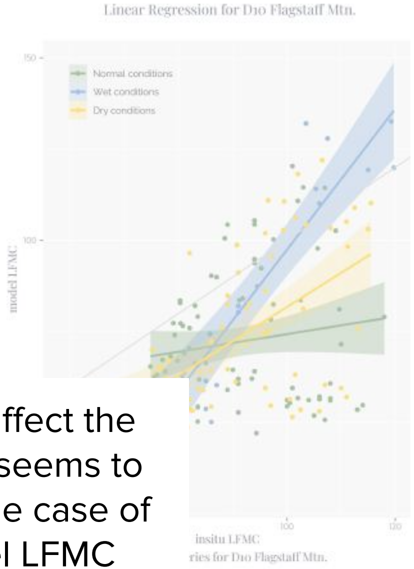


+
−
UNITED STAT
Tyler Foote
Reader Ranch
USBOR
D10 - Flagstaff Mtn. - Hot
La Tuna Canyon, Tujunga
Laurel Canyon, Mt. Olympus
Leaflet | Tiles © Esri — Esri, DeLorme, I

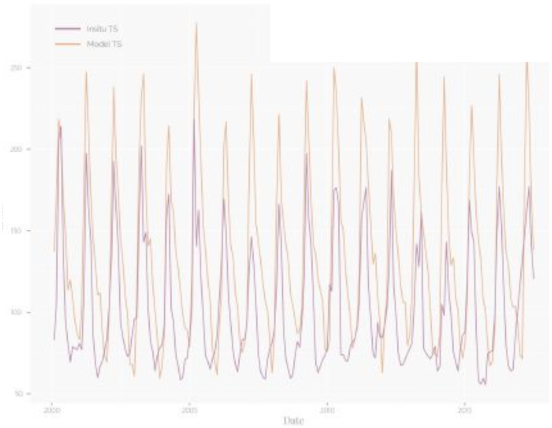

Linear Regression for USBOR
Normal conditions
Wet conditions
Dry conditions
RMSE Normal: 23.43
RMSE Wet: 21.27
RMSE Dry: 22.75
model LFMC
insitu LFMC
Linear Regression for Laurel Canyon, Mt. Olympus
Normal conditions
Wet conditions
Dry conditions
RMSE Normal: 19.94
RMSE Wet: 33.08
RMSE Dry: 19.37
model LFMC
insitu LFMC
Linear Regression for D10 Flagstaff Mtn.
Normal conditions
Wet conditions
Dry conditions
RMSE Normal: 11.15
RMSE Wet: 5.71
RMSE Dry: 10.44
model LFMC
insitu LFMC
Time series for USBOR
Insitu TS
Model TS
Date
Time series for Laurel Canyon, Mt. Olympus
Insitu TS
Model TS
Date
Time series for D10 Flagstaff Mtn.
Insitu TS
Model TS
Date

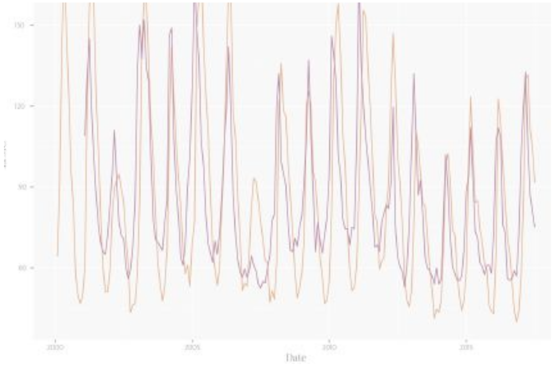


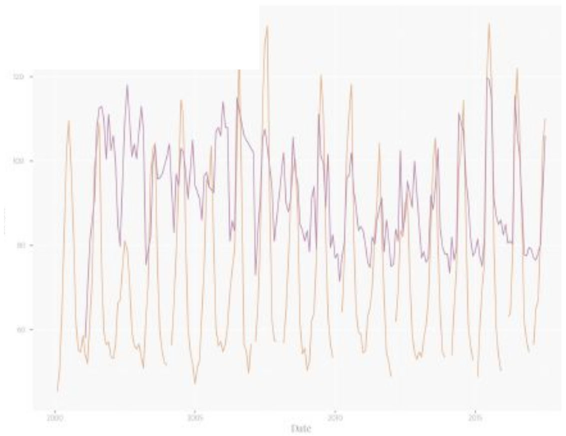


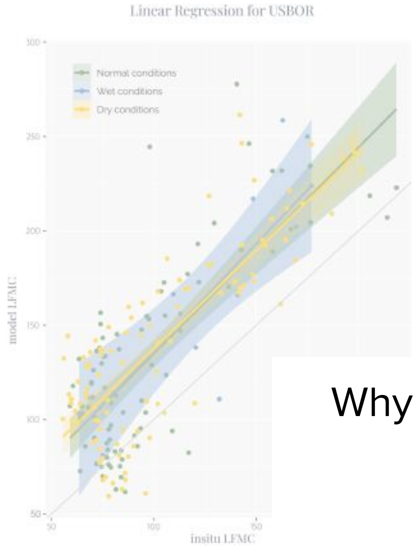


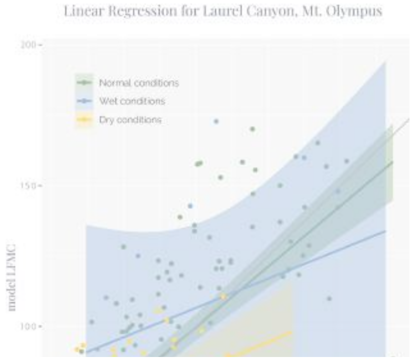
For some sites the SPI (dry and wet conditions) does not affect the model correlation (USBOR). For others, the dry conditions seems to cause an underestimation of Model LFMC values. And in the case of wet conditions, it also affects the correlation of the Model LFMC values.

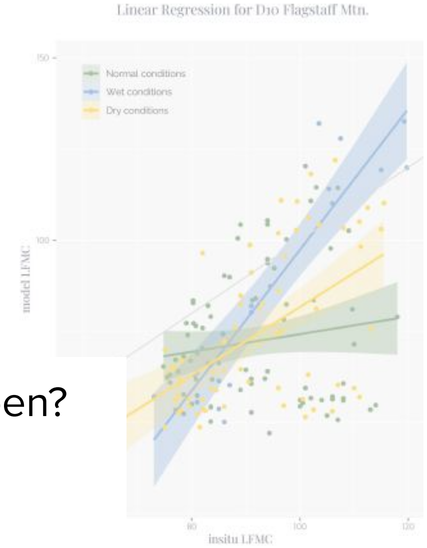






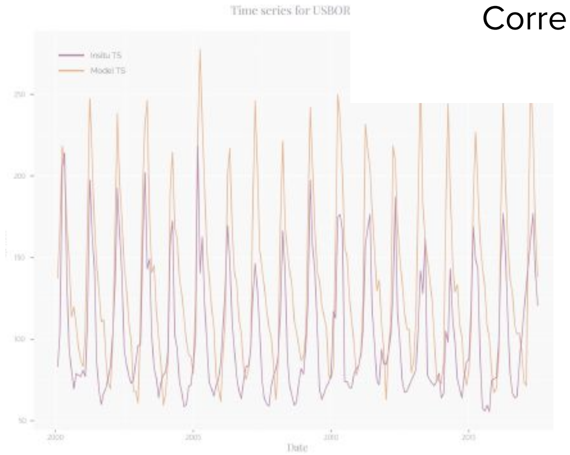


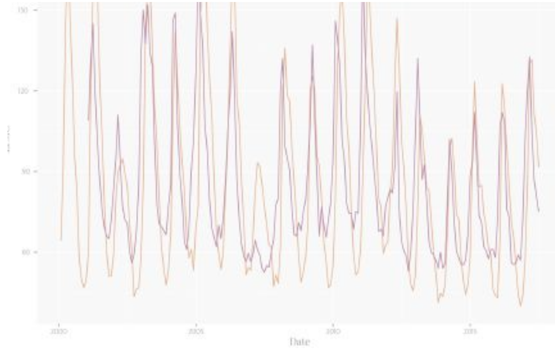


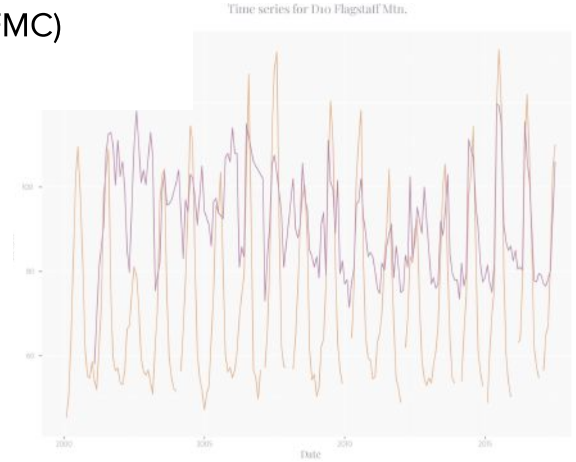


Why could this difference between sites happen?

Land cover, plant species, land cover difference
Terrain, altitude
Correlation between parameters (SPI - SWI - LFMC)
Mismatching Resolution







Land cover and plant species

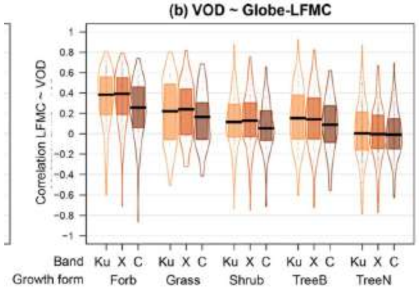
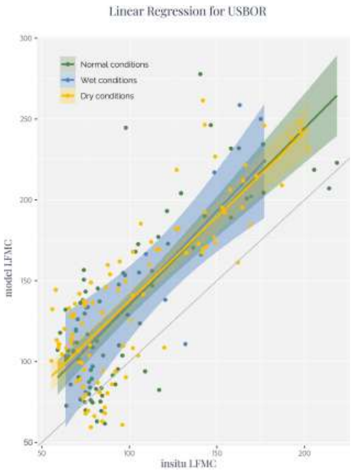
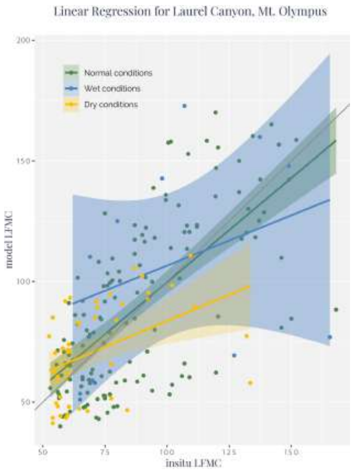


Fig. 1: M. Forkel et al.(2023)



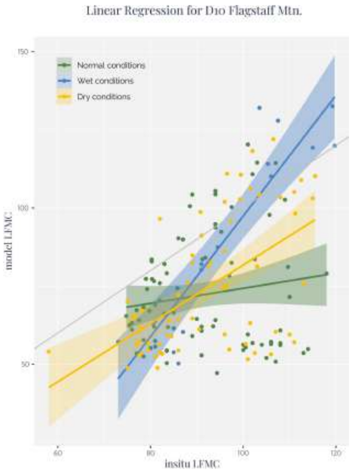
Tree cover, needleleaved, evergreen, closed to open (>15%)

Adenostoma fasciculatum



Mosaic tree and shrub (>50%) herbaceous cover (<50%)

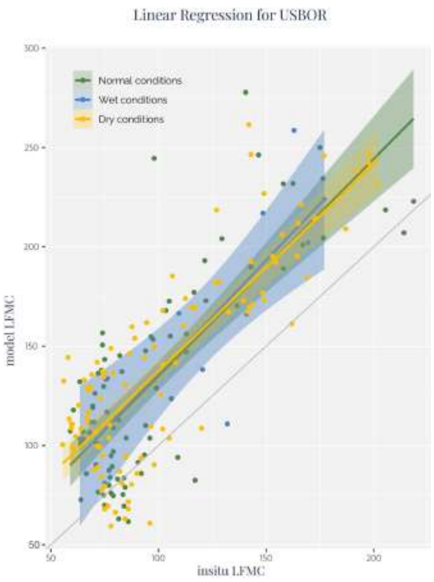
Adenostoma fasciculatum

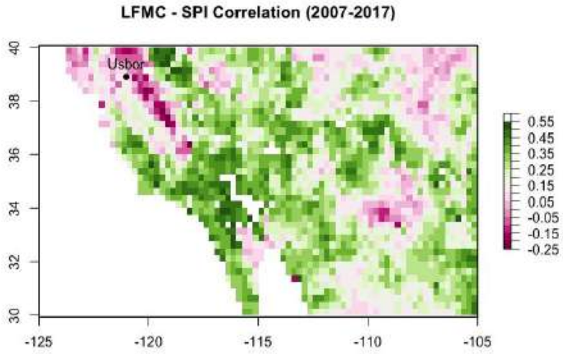


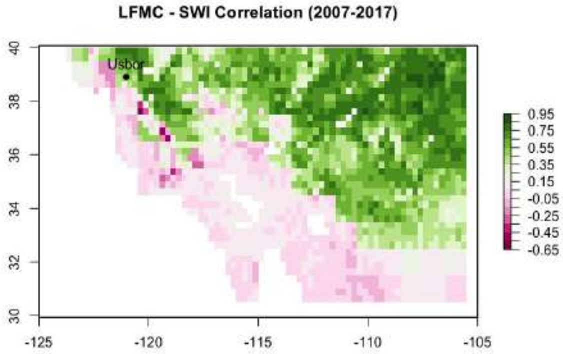
Shrubland

Cercocarpus montanus, Pinus ponderosa

Correlation between parameters (SPI - LFMC)







FUTURE IMPROVEMENTS

To consider not only sites with high number of measurements but also those that have a low land cover difference.

To do histogram to have a full overview of the behaviour of the model influenced by the wet and dry conditions.

RMSD to compare the error of the model with other estimates as the ideal regression line.

2.

What is the relationship of LFMC with soil moisture and precipitation anomalies (SPI-12)?

Identify dry and wet months

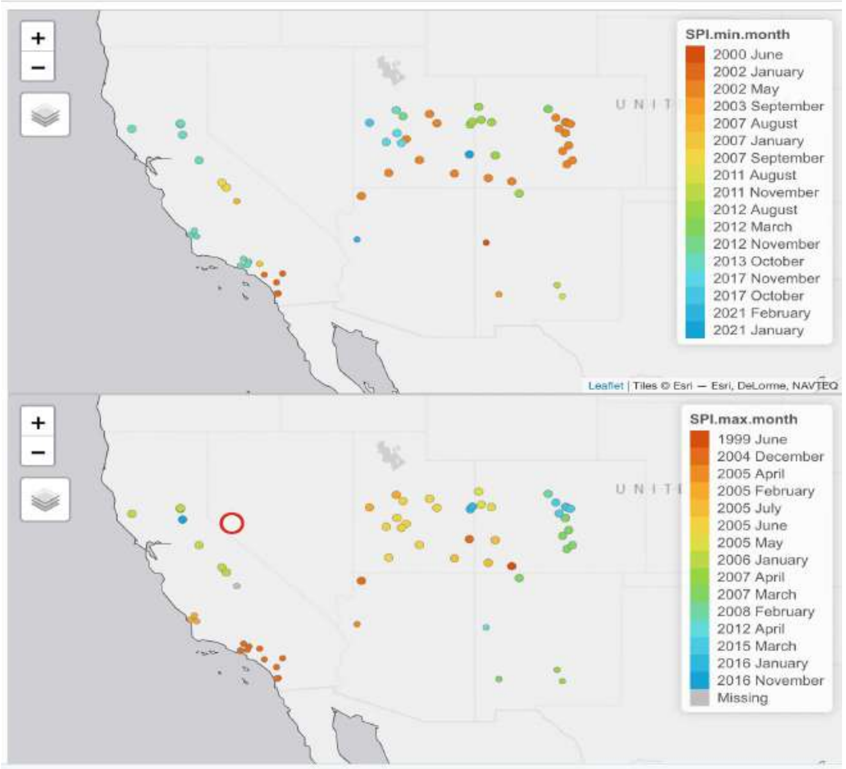
Datasets: SPI dataset using sites from GLOBE LFMC

Find mean SPI for each month within all the sites

Choose the driest and wettest month

August 2002 – Dry
March 2005 - Wet

	site	lat	lon	1999-01-01	1999-02-01	1999-03-01	1999-04-01
46	RGFO - Copper Gulch	38.34556	-105.4519	-0.5020000	-0.63900000	-0.9360000	0.11300000
47	RGFO - Four Mile	38.54056	-105.2039	-0.5020000	-0.63900000	-0.9360000	0.11300000
48	San Jacinto	33.79389	-116.9261	0.8290000	-0.33100000	-0.7770000	-0.70999998
49	Sanborn	38.18722	-108.2131	-0.0780000	-0.13800000	-0.7650000	-0.11700000
50	Sauls Creek	37.23583	-107.5361	-0.1070000	-0.24200000	-0.7500000	-0.08300000
51	Schueren Road, Malibu	34.07889	-118.6447	1.4320000	0.01600000	-0.3350000	-0.19300000
52	Sevier Reservoir	39.58333	-112.0000	1.0010000	0.43500000	0.0770000	0.67600000
53	Signal Peak	38.63194	-112.0611	1.1180000	0.57499999	0.2090000	0.74800003
54	Sonora	38.00333	-120.3517	1.1690000	0.88599998	0.7380000	0.63999999
55	Spear Hunter	39.36444	-108.3658	-0.1490000	-0.30700001	-0.7570000	-0.13300000
56	Stinking Springs	37.35833	-108.4994	-0.1770000	-0.42300001	-0.9330000	-0.48699999
57	Stunt Road, Calabasas	34.10111	-118.6550	1.4320000	0.01600000	-0.3350000	-0.19300000
58	Temecula	33.45750	-117.1711	1.4410000	-0.25000000	-0.6830000	-0.50400001
59	Tule Valley	39.35000	-113.3667	1.7210000	1.13000000	0.6770000	0.82700002
60	Tyler Foote	39.33056	-121.1122	0.9950000	0.47499999	0.3980000	0.21799999
61	USBOR	38.92333	-121.0253	1.1270000	0.34099999	0.2550000	0.10300000
62	ZUA Repeater	34.96556	-108.5867	1.0970000	0.61500001	-0.0960000	-0.09400000
63	NA	NA	NA	0.6574355	0.06583871	-0.2689032	0.09645161



Identify dry and wet months from 2007 to 2017

Datasets: SPI dataset

Clip data for each consecutive year

Plot Summary SPI of all months

Note down lowest and highest mean SPI

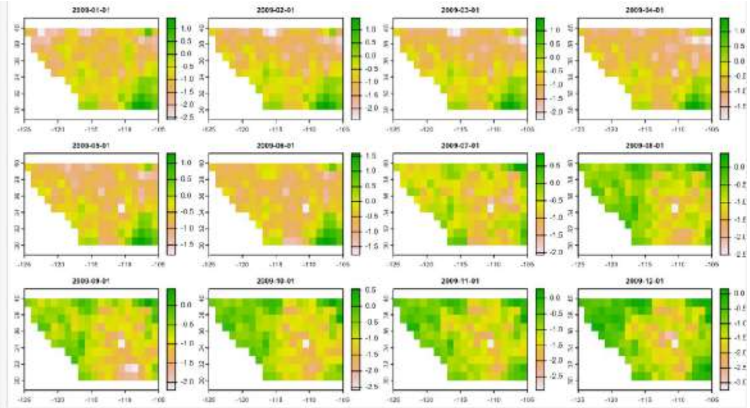
April 2013 – Dry
July 2017 - Wet

```
> summary(spi.rsub)
   SPI12_121          SPI12_122          SPI12_123          SPI12_124          SPI12_125
 Min.   :-2.5840   Min.   :-2.4220   Min.   :-2.2690   Min.   :-1.9280   Min.   :-1.8100
 1st Qu.:-1.2050   1st Qu.:-1.2040   1st Qu.:-1.0655   1st Qu.:-0.9360   1st Qu.:-0.8472
 Median :-0.8500   Median :-0.8350   Median :-0.7670   Median :-0.6710   Median :-0.5955
 Mean   :-0.8476   Mean   :-0.7816   Mean   :-0.7080   Mean   :-0.6079   Mean   :-0.5440
 3rd Qu.:-0.4908   3rd Qu.:-0.4437   3rd Qu.:-0.3945   3rd Qu.:-0.3580   3rd Qu.:-0.3260
 Max.   : 1.4290   Max.   : 1.4450   Max.   : 1.4590   Max.   : 1.4450   Max.   : 1.3040
 NA's   :40        NA's   :40        NA's   :40        NA's   :40        NA's   :40
   SPI12_126          SPI12_127          SPI12_128          SPI12_129          SPI12_130
 Min.   :-1.7700   Min.   :-2.0660   Min.   :-2.5020   Min.   :-2.2070   Min.   :-2.5970
 1st Qu.:-0.6810   1st Qu.:-0.8120   1st Qu.:-1.0517   1st Qu.:-1.0345   1st Qu.:-1.0970
 Median :-0.4930   Median :-0.5850   Median :-0.7765   Median :-0.7810   Median :-0.8210
 Mean   :-0.3931   Mean   :-0.5949   Mean   :-0.8069   Mean   :-0.8095   Mean   :-0.7886
 3rd Qu.:-0.1870   3rd Qu.:-0.3653   3rd Qu.:-0.5407   3rd Qu.:-0.5258   3rd Qu.:-0.3792
 Max.   : 1.5960   Max.   : 0.8640   Max.   : 0.4040   Max.   : 0.4420   Max.   : 0.5460
 NA's   :40        NA's   :40        NA's   :40        NA's   :40        NA's   :40
   SPI12_131          SPI12_132
 Min.   :-2.9360   Min.   :-3.2570
 1st Qu.:-1.2975   1st Qu.:-1.5417
 Median :-1.0070   Median :-1.1780
 Mean   :-0.9826   Mean   :-1.0935
 3rd Qu.:-0.6065   3rd Qu.:-0.5308
 Max.   : 0.3090   Max.   : 0.1830
 NA's   :40        NA's   :40
> plot(spi.rsub)
```

```
spi <- rast("us49_southwest_reg_spg12_m_wld_19990101_20211201_m.nc")
date.prep <- time(spi)

start.prep <- grep(as.Date("2009-01-01"), date.prep)
end.prep <- grep(as.Date("2009-12-01"), date.prep)
spi.rsub <- subset(spi, start.prep:end.prep)

summary(spi.rsub)
plot(spi.rsub)
```



```
2007
SPI12_106 october   Mean:-0.8811
SPI12_98 feb Mean   : 0.07168

2008
SPI12_120 december  Mean   :-0.4203
SPI12_110 feb Mean   :-0.1056

2009
SPI12_131 november Mean   :-0.9826
SPI12_126 june Mean   :-0.3931

2010
SPI12_133 January Mean   :-0.5291
SPI12_144 December Mean   : 0.3245 #wet2

plot(spi$SPI12_144)

2011
SPI12_156 December Mean   :-0.9072
SPI12_149 May Mean   :-0.2990

2012
SPI12_166 Octobober Mean   :-1.275 #dry2
SPI12_157 January Mean   :-0.833

2013
SPI12_172 april Mean   :-1.419 ##dry1
SPI12_179 november Mean   :-0.5990

2014
SPI12_181 january Mean   :-1.0247
SPI12_186 June Mean   :-0.6646

2015
SPI12_193 january Mean   :-0.5187
SPI12_203 november Mean   : 0.04919

2016
SPI12_215 nov Mean   :-0.5813
SPI12_208 april Mean   : 0.1234

2017
SPI12_228 dec Mean   :-0.4822
SPI12_223 july Mean   : 0.2566 #wet1
```

Analyse correlation of VOD2LFMC with precipitation anomalies and soil moisture

Plot Maps of VOD2LFMC, SWI SPI-12 during Dry and Wet months

High LFMC appear in same areas
Might depend on altitude, terrain

Low SPI (-2) in dry month corresponds to **Low LFMC**
High SPI (2) in wet month corresponds to **High LFMC**

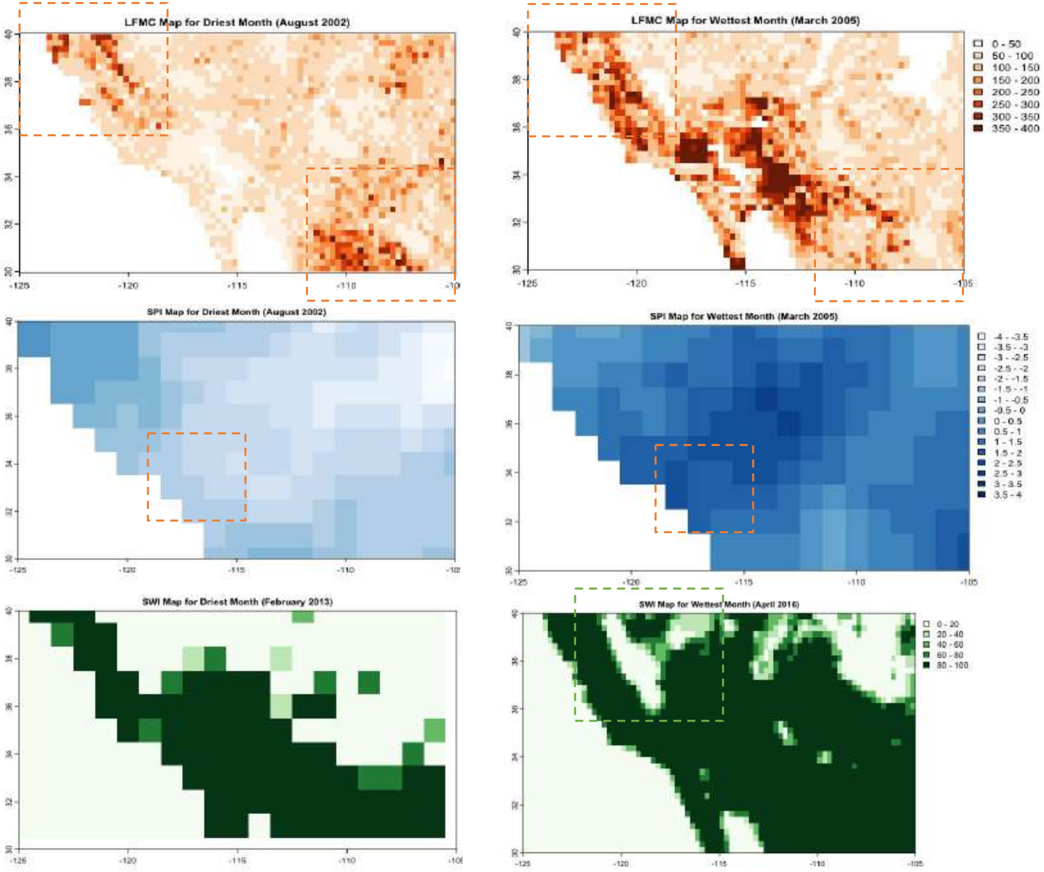
Satellite Image (Fig. 1) shows dry region.

Dry regions with **High SPI** lead to **high LFMC** with *increased fire risk*

Fig. 1: Google maps

Spatially, the central part is experiencing dry and wet conditions (satellite image shows desert like region)

In top left mountain range where **SWI is 0** LFMC is in high range despite changes in SPI



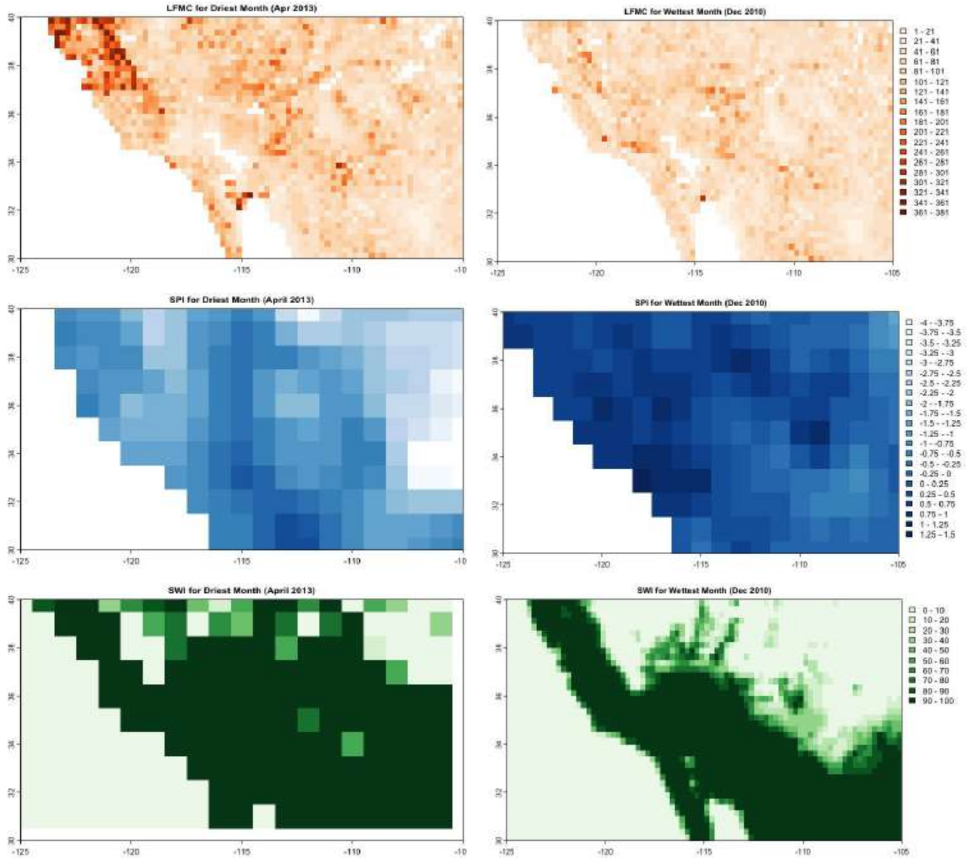
SPI 0.5
LFMC 0.25
SWI 0.125

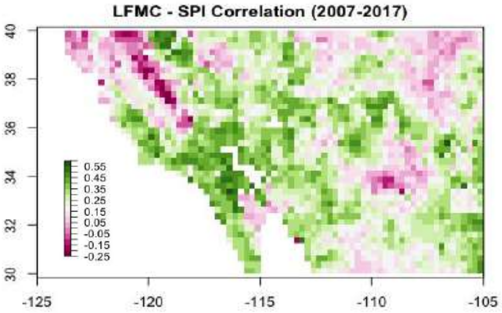
```
>                spi.wet.re
class       : SpatRaster
dimensions  : 40, 80, 1  (nrow, ncol, nlyr)
resolution  : 0.25, 0.25  (x, y)
extent      : -125, -105, 30, 40  (xmin, xmax, ymin, ymax)
coord. ref. : lon/lat WGS 84
source(s)   : memory
name        : SPI12_223
min value   : -1.213547
max value   :  1.806250
time        : 2017-07-01 UTC
```

```
>                 swi.dry.re
class       : SpatRaster
dimensions  : 40, 80, 1  (nrow, ncol, nlyr)
resolution  : 0.25, 0.25  (x, y)
extent      : -125, -105, 30, 40  (xmin, xmax, ymin, ymax)
coord. ref. : lon/lat WGS 84 (EPSG:4326)
source(s)   : memory
name        : VOBS_010_226
min value   :            0
max value   :          100
time (days) : 2013-04-01
```

Analyse correlation of VOD2LFMC with precipitation anomalies and soil moisture

Pixel wise Co-relation Maps for LFMC x SPI and LFMC x SWI

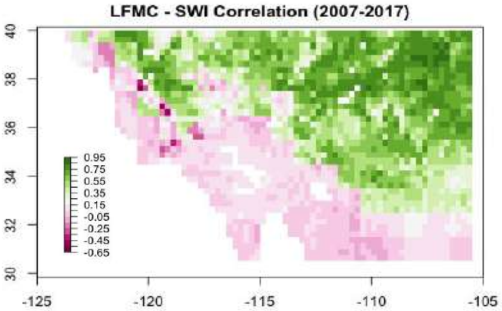




At mounatin and plateau there is negative co-relation

High SPI --> Low LFMC

In the desert like regions we have positive co-relation

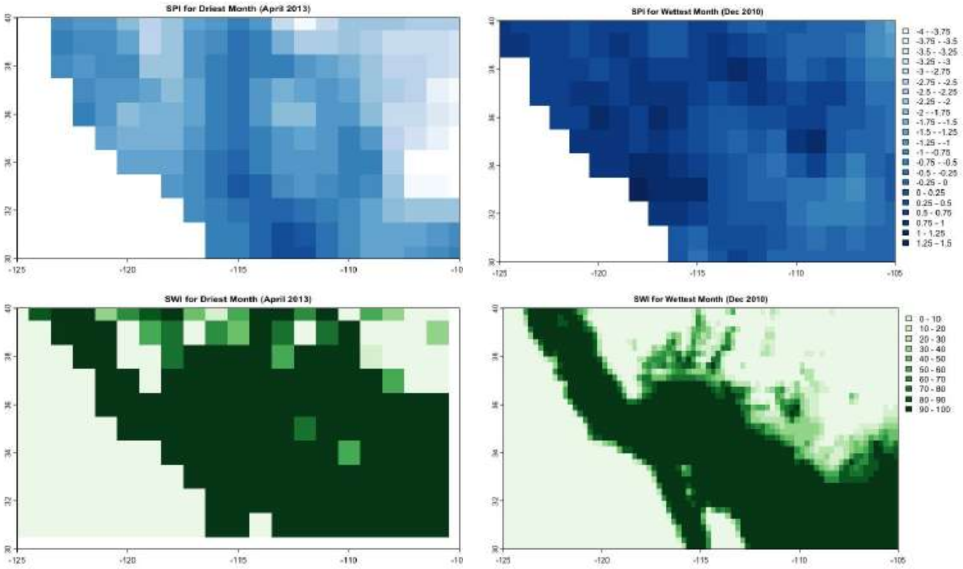


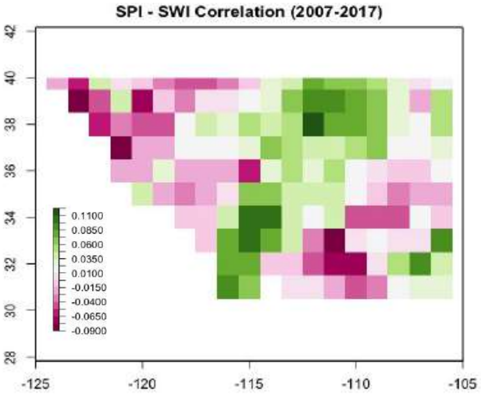
At mounatin slope we have neagtive co-relation

In wet months we have low LFMC which co-relate to low SWI and neagtively im parts of high SWI

Analyse correlation of VOD2LFMC with precipitation anomalies and soil moisture

Pixel wise Co-relation Maps for SPI and SWI

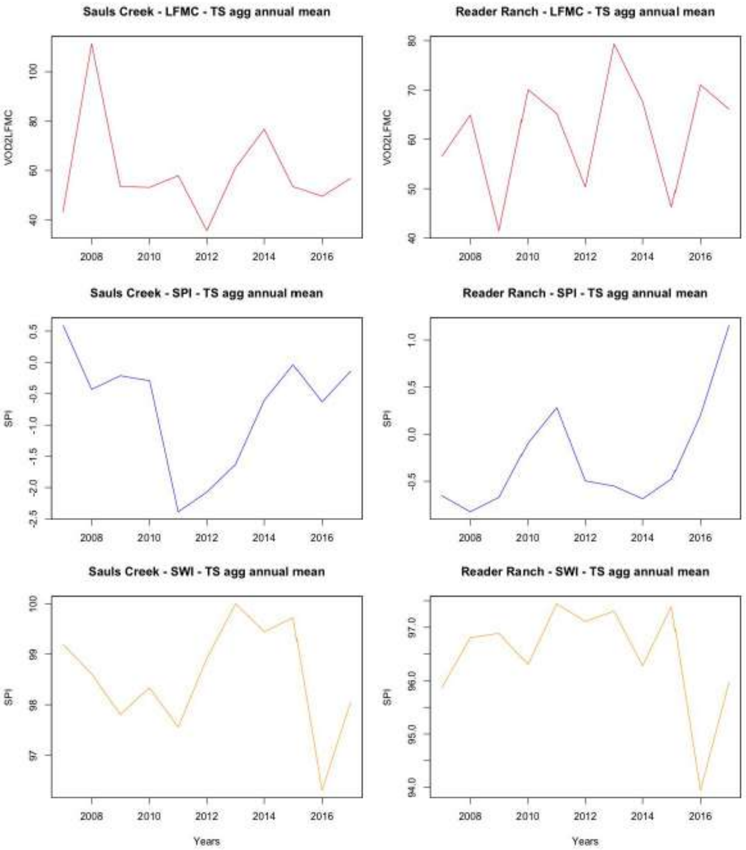


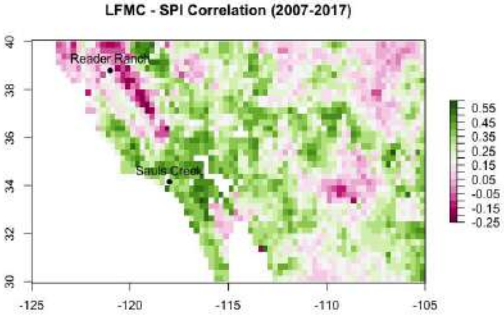


At mounatins there is negative co-relation - even is SPI is high the SWI low – probably because of rocky landcover

Analyse correlation of VOD2LFMC with precipitation anomalies and soil moisture

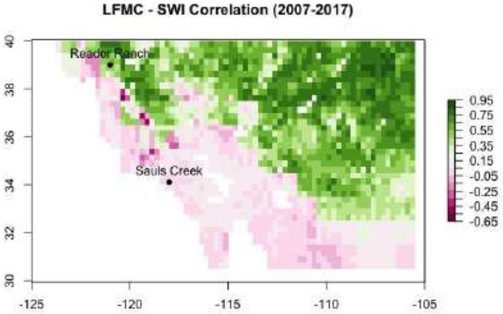
Time series of VOD2LFMC + SPI-12 + SWI for selected pixels





Sauls creek
positive LFMC x SPI correlation – trends follow same pattern

Reader Ranch
negative LFMC x SPI correlation – trends do not follow



Sauls creek
negative LFMC x SWI correlation –
swi drops and lfmc rises

Reader Ranch
positive LFMC x SWI correlation – trends follow

FUTURE IMPROVEMENTS

To better define dry and wet conditions by taking the SPI raster dataset.

To compare maps with satellite images and/or land cover for further insight.
This will help to verify the results of the model for broad leaf, needle leaf and tall/short vegetation in the given area.

To do a comparison between mean of all dry/wet months between 2007– 2017 with the correlation maps for the same period.