Analysis of Fire Index Data

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Topics that will be considered:

- Index
  - recorded over time at one location
  - used to make decisions about risk

- Compare to environmental monitoring

- For one series: separation of smooth and rough components to provide a measure of uncertainty

Decision aspect

Criterion value to compare with index

- Use index as part of decision making process
- Fire manager will know how to interpret index for region

Incorporate error in a model

Sources of variability in the data

- Infer from emphasis on obtaining properly standardized and careful weather measurements
- Measurements at fixed times in changing weather systems

Thus, both measurement error and distribution of the weather variable

y_t value of index at time t

Treat as data. Calculations complex.

I_t true index value at time t

$y_t = I_t + z_t$

z_t since variability in measurements

measurement error

inherent variability (weather variable distribution)

C criterion value

$I_t > C$ à high risk

Index value is obtained from:

- Set of deterministic equations, coefficients externally calculated

- Random input of weather variables (also known as weather elements)

- Generation process for the series

  $y_t = f(\mathbf{x}_t, t) + z_t$ ie. $I_t = f(\mathbf{x}_t, t)$

- Have only (y_t, t)

- Address questions such as:

  1) is $I_t > C$?

  2) is $I_{t,\ location1} = I_{t,\ location\ 2}$?

Obtain $\hat{I}_t$, associated standard error or limits

Comparison with:

- Environmental monitoring

  eg. True concentration at site exceeds criterion level ➔ action

- Industrial process control

  eg. Mean of n_s observations exceeds control limit ➔ action

Difference here: temporal patterns in the index being monitored

Environmental monitoring (eg. ground water monitoring)

One scenario:

– ask if true concentration of the contaminant exceeds the criterion level
– if so, some remedial measure is taken

Calculate one of

- upper confidence limit
- upper prediction limit
- confidence limit for percentile (tolerance limit)

Also might follow over time

Model y_t vs t with a “smooth” component and a “rough” (error) component

- Being explicit about assumptions
- Particularly, trade-off between error term and terms of lower frequency

Two approaches

1. Generalized least squares

   sin, cos terms for cycling

   include serial correlation

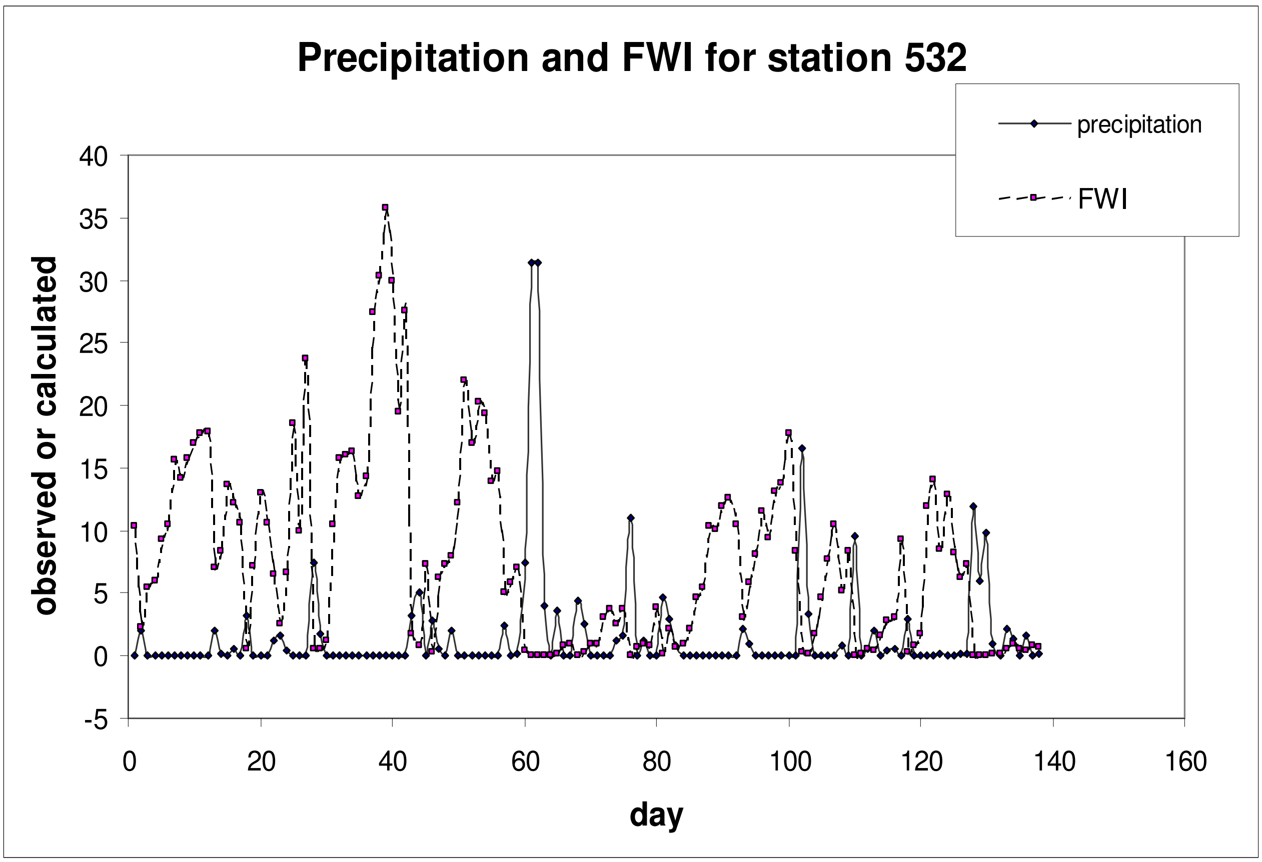
   heteroscedasticity

   Allows testing

2. Smoothing method (spline or loess)

Example of set of data: May 1 to September 15, 2003 Smithers

(data courtesy of Bradley Martin, Fire Protection, BC Ministry of Forests and Range, plots produced by Shazaib Barlas, McMaster University)



Precipitation, mm
138 days of observations
FWI fire weather index

Generalized least squares

- Terms to account for the peaks and troughs that result from precipitation
- Accounted for serial correlation
- Adjusted for heteroscedasticity

$$\mathrm{y}_{\mathrm{t}} = \beta_0 + \sum_{k=1}^{s}\left[\beta_{1k}\sin\frac{2kt}{T} + \beta_{2k}\sin\frac{2kt}{T}\right] + z_t$$

where s=2,3,4,5; t=1,2,…,T and T=138

Model would allow the calculation of eg. an upper prediction limit

On basis of series, state level of confidence and upper limit for the value of the FWI at time t

Plot of model and data, followed by plot of residuals

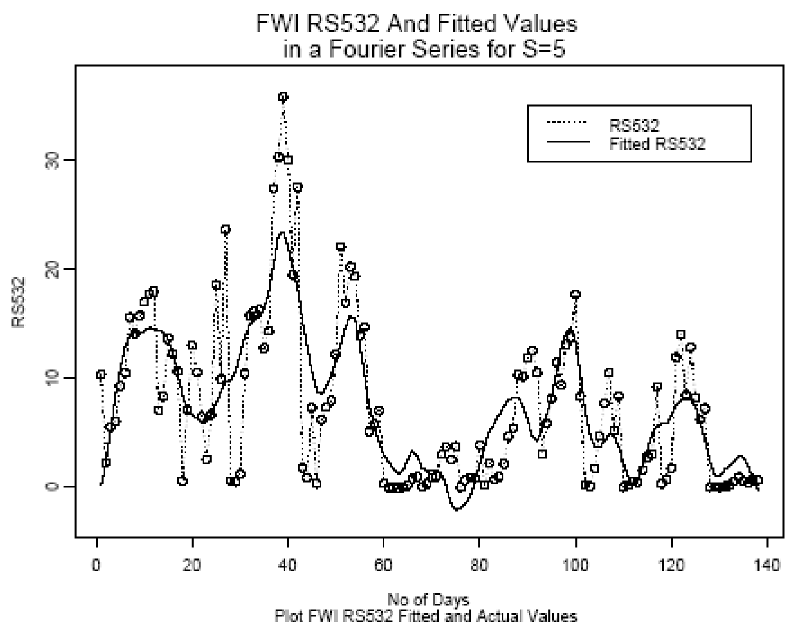
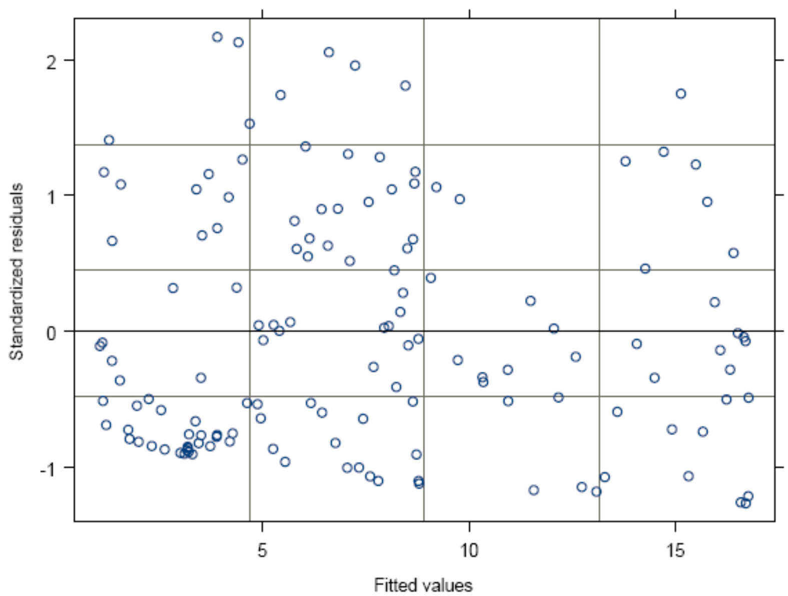
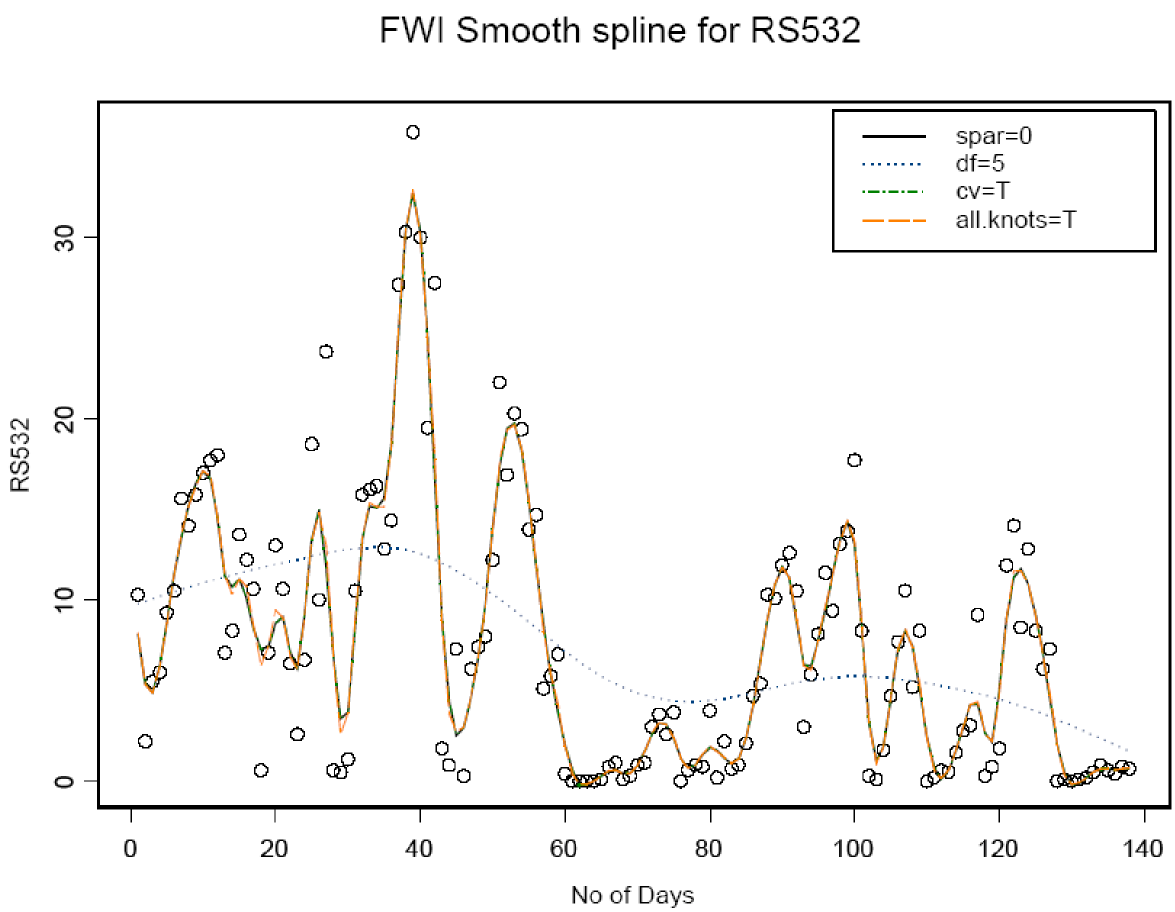


Figure 4: FWI RS532 fitted and Scatter plot together when S=5



Not best form for capturing rapid changes in index

Use spline to obtain the smooth, better able to capture peaks. Could also plot residuals.



Calculations:

Add standard error and/or

bootstrap confidence limit

An interpretation is:

Smooth to the level that is interpretable as predicted observation and thus obtain upper prediction limit

Comparable to GLS where we could test for model adequacy

More satisfactorily follows rapid changes in index

How do we decide what is smooth enough?

Need to relate this back to the size of differences that correspond to recognizable differences in fire behavior

A general approach that will allow us to:

- evaluate effects of changing weather elements (for example) acknowledging that there is variability in these measured quantities

- Make comparisons from location to location over a monitored period