
THE KIND OF THING THAT HAPPENS WHEN THINGS ARE RUNNING TOO SMOOTHLY AND THERE ARE NO FIRES TO PUT OUT
I'M THINKING OF COMBINING WEDNESDAYS AND FRIDAYS AND ELIMINATING THURSDAYS ALTOGETHER!
JOE MARTIN
5-17-05
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RISK ANALYSIS FOR MARKED POINT PROCESS DATA

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$2\pi \neq 1$

$2\pi \neq 1$

$2\pi \neq 1$

Layout

RUINS OF THE CATHEDRAL—LISBON.

RUINS OF THE CHURCH OF ST. PAUL—LISBON.

RUINS OF THE OPERA-HOUSE—LISBON.

RUINS OF THE CHURCH OF ST. NICOLAS—LISBON.


nisee

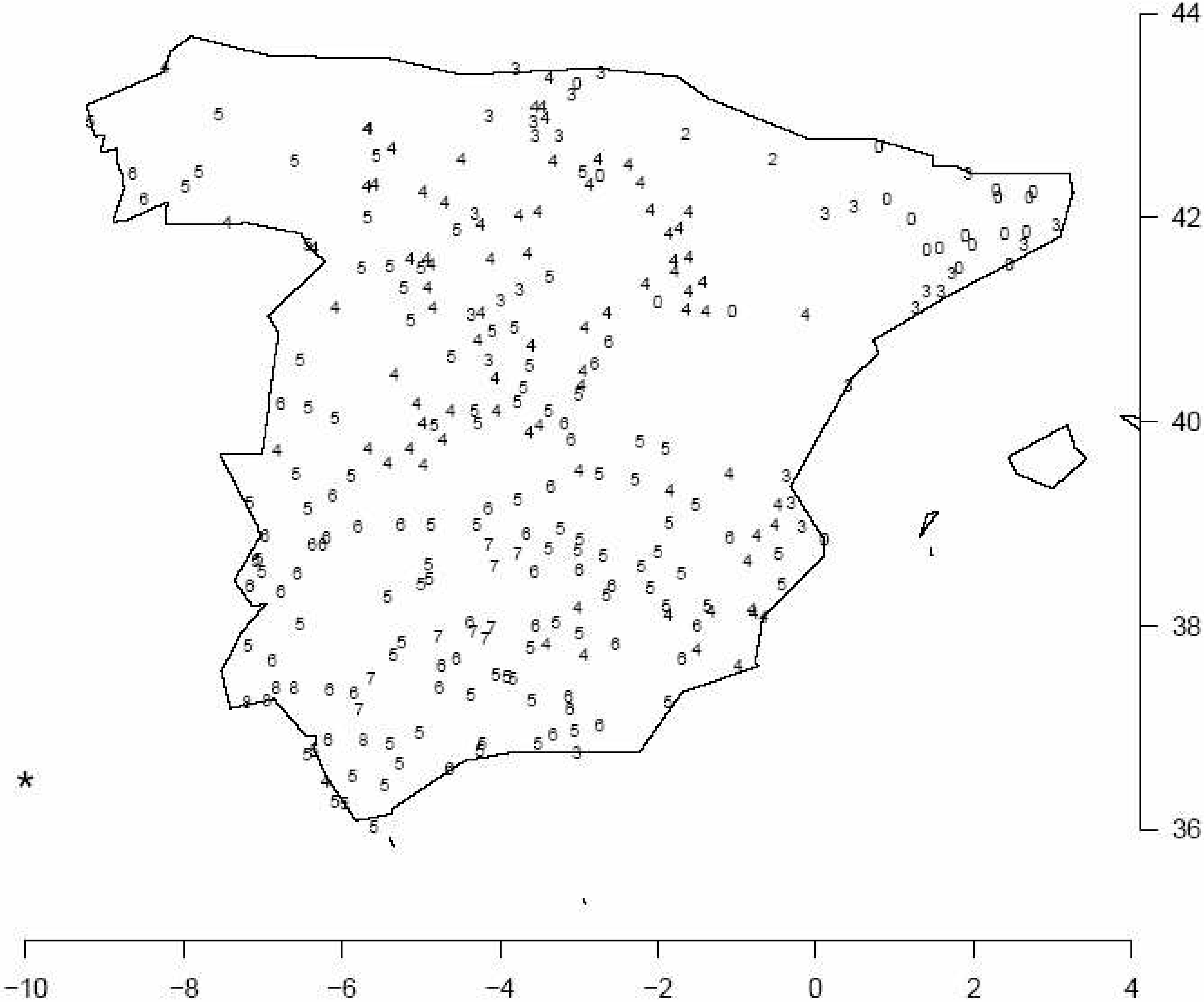
2. Introduction.

Risk analyses and (marked) point processes abound

Concern here is with:

earthquakes
wildfires
insurance issues

One specific topic is ordinal-valued marks



44
42
40
38
36
−10
−8
−6
−4
−2
0
2
4

A SYNOPSIS OF THE EUROPEAN MACROSEISMIC SCALE (EMS 98)

EMS	DEFINITION	DESCRIPTION
1	Not felt	Not felt, even under the most favourable circumstances.
2	Scarcely felt	Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.
3	Weak	The vibration is weak and is felt indoors by a few people. People at rest feel a swaying or light trembling.
4	Largely observed	The earthquake is felt indoors by many people, outdoors by very few. A few people are awakened. The level of vibration is not frightening. Windows, doors and dishes rattle. Hanging objects swing.
5	Strong	The earthquake is felt indoors by most, outdoors by few. Many sleeping people awake. A few run outdoors. Buildings tremble throughout. Hanging objects swing considerably. China and glasses clatter together. The vibration is strong. Top heavy objects topple over. Doors and windows swing open or shut.

6	Slightly damaging	Felt by most indoors and by many outdoors. Many people in buildings are frightened and run outdoors. Small objects fall. Slight damage to many ordinary buildings e.g.; fine cracks in plaster and small pieces of plaster fall.
7	Damaging	Most people are frightened and run outdoors. Furniture is shifted and objects fall from shelves in large numbers. Many ordinary buildings suffer moderate damage: small cracks in walls; partial collapse of chimneys.
8	Heavily damaging	Furniture may be overturned. Many ordinary buildings suffer damage: chimneys fall; large cracks appear in walls and a few buildings may partially collapse.
9	Destructive	Monuments and columns fall or are twisted. Many ordinary buildings partially collapse and a few collapse completely.
10	Very destructive	Many ordinary buildings collapse.
11	Devastating	Most ordinary buildings collapse.
12	Completely devastating	Practically all structures above and below ground are heavily damaged or destroyed.

3. Some statistical background.

Planar point process.

locations in the plane of points (x_j, y_j) for $j = 1,2,3,\ldots$

$$Y(x,y) = \sum_j \delta(x-x_j, y-y_j)$$

Marked point process.

sequence (x_j, y_j, M_j) for $j = 1,2,3,\ldots$

Marks may be real, e.g. fire size , seismic damage cost

$$Y(x,y) = \sum_j M_j \; \delta(x-x_j, y-y_j)$$

Stochastic case - marks assigned randomly to points?

Spatial-temporal point process.

David Vere-Jones (2005). Some models and procedures for space-time point processes. *Fields Institute Workshop on Forest Fires and Point Processes*

Models for marks. Categories, label j

i). interval scale: $j \; \varepsilon \; R$

ii). ordinal scale: qualitative order
spacing does not matter
can merge adjacent

iii). nominal categories: exchangeable

$$i) > ii) > iii)$$

Goals: few parameters, sensitivity, interpretability

Grouped continuous model. Conceptual approach

Latent random variable ζ

$$Y = j \quad \text{if} \quad \theta_{j-1} < \zeta \leq \theta_j$$

Multinomial, mle via

$$Prob\{Y = j\} =$$

$$Prob\{Y \neq 1\} Prob\{Y \neq 2 \mid Y \neq 1\} \ldots Prob\{Y = j \mid Y \neq 1, \ldots, j-1\}$$

Model $Prob\{Y = j \mid Y \geq j\}$

Explanatory $\mathbf{X}$: $\zeta = -\beta^{\tau}\mathbf{X} + \varepsilon$

Cloglog. Extreme value

$$F(\varepsilon) = 1 - \exp\{-e^{\varepsilon}\}$$

$$Prob\{Y=j \mid Y \geq j, \mathbf{X}\} = 1 - \exp\{-e^{\phi_j - \beta^{\tau}\mathbf{X}}\}$$

$$Prob\{Y \leq j \mid \mathbf{X}\} = 1 - \exp\{-e^{\theta_j - \beta^{\tau}\mathbf{X}}\}$$

$$Prob\{Y=j \mid \mathbf{X}\} = \exp\{-e^{\theta_{j-1} - \beta^{\tau}\mathbf{X}}\} - \exp\{-e^{\theta_j - \beta^{\tau}\mathbf{X}}\}$$

$$e^{\theta_j} = e^{\phi_j} + \ldots + e^{\phi_2} + e^{\phi_1}$$

$j = 1, \ldots, J-1$

Chosen $\mathbf{X}$

Estimate of linear predictor

$$\zeta = -\hat{\beta}^{\tau}\mathbf{X} + \gamma, \qquad \gamma = .57721566...$$

Which cell $(\hat{\theta}_{j-1}, \hat{\theta}_j)$ does ζ fall into?

Inference.

mle

glm

gam

Besag models

Baddeley-Turner's spatstat

Assessment of fit

4. The seismic case.

Intensity data and maps.

Historically very important

The data are ordinal

How to smooth/display?

Have been used numerically. OK?

Attenuation laws

Lisbon 1755.

1 November 1755 - All Saints Day

Magnitude 8.3 to 9.0, several minutes duration

50-70 thousand deaths

Epicentre in Atlantic

Tsunami, fires

Voltaire, *Poème sur le désastre de Lisbonne*

Week after event, Royal enquiry by Spain

Model.

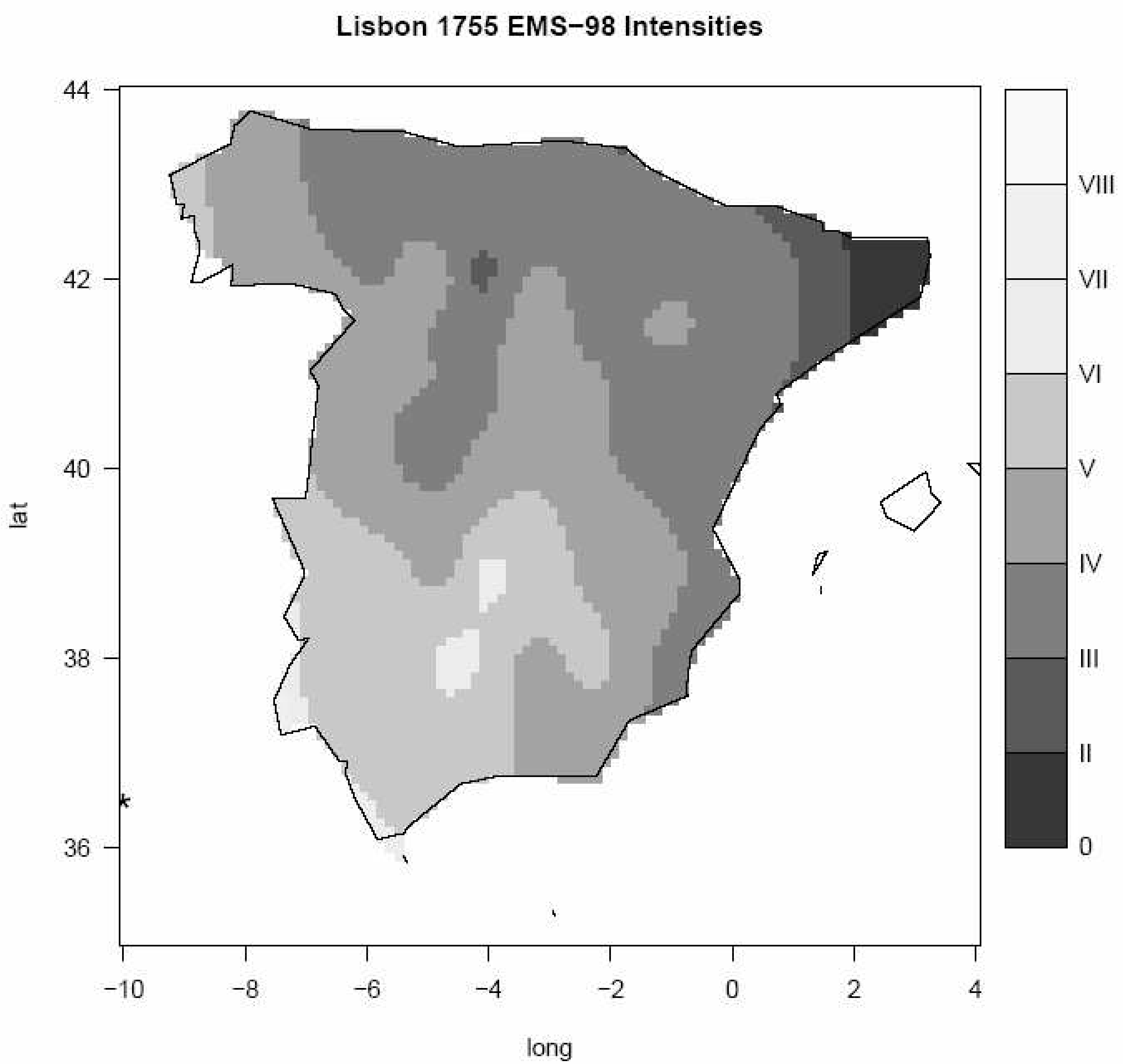
Y: intensity (mark)

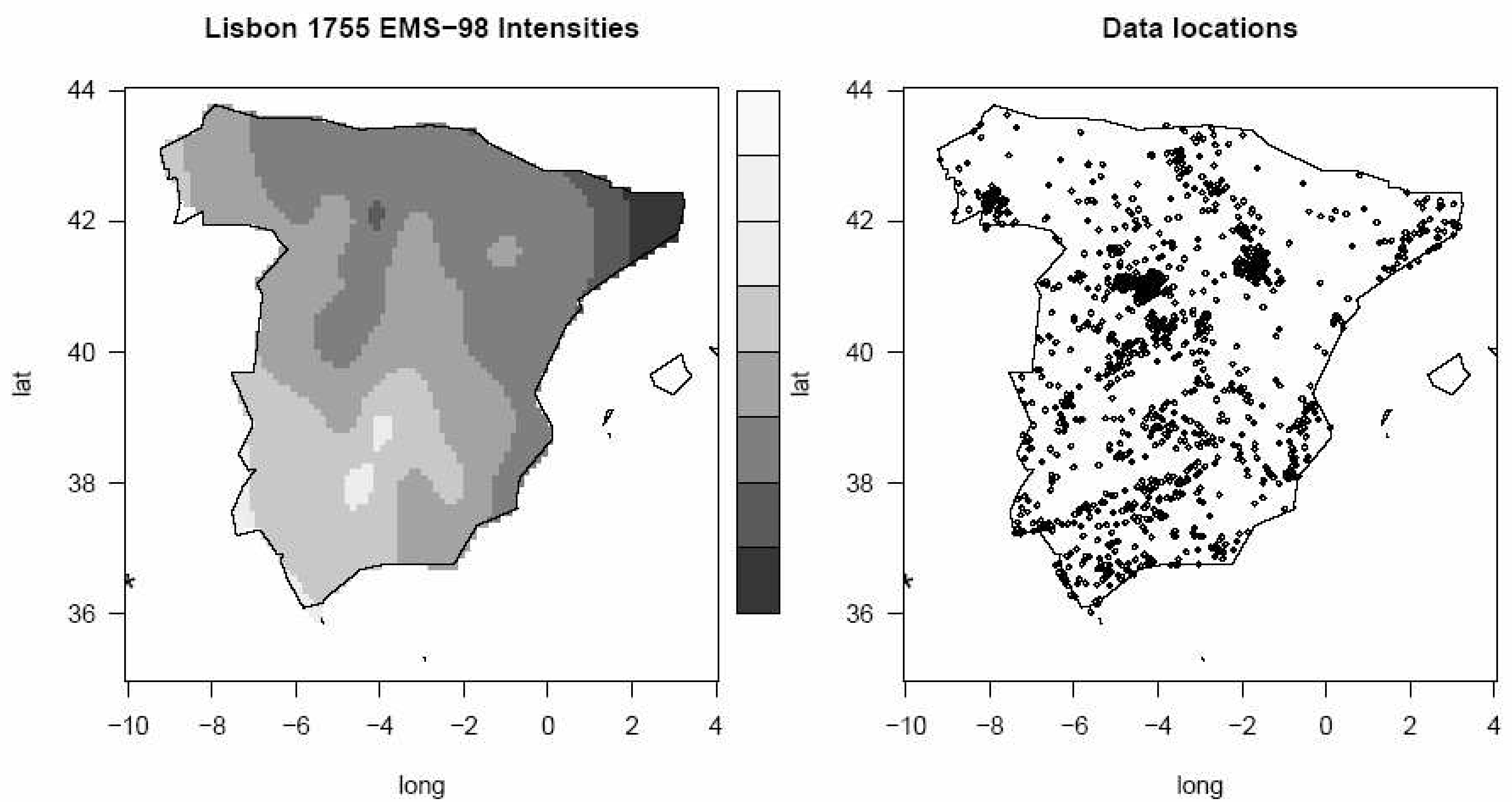
(x, y): location

$$Prob\{Y \leq j \mid (x,y)\} = 1 - \exp\{-e^{\theta_j - g(x,y)}\}$$

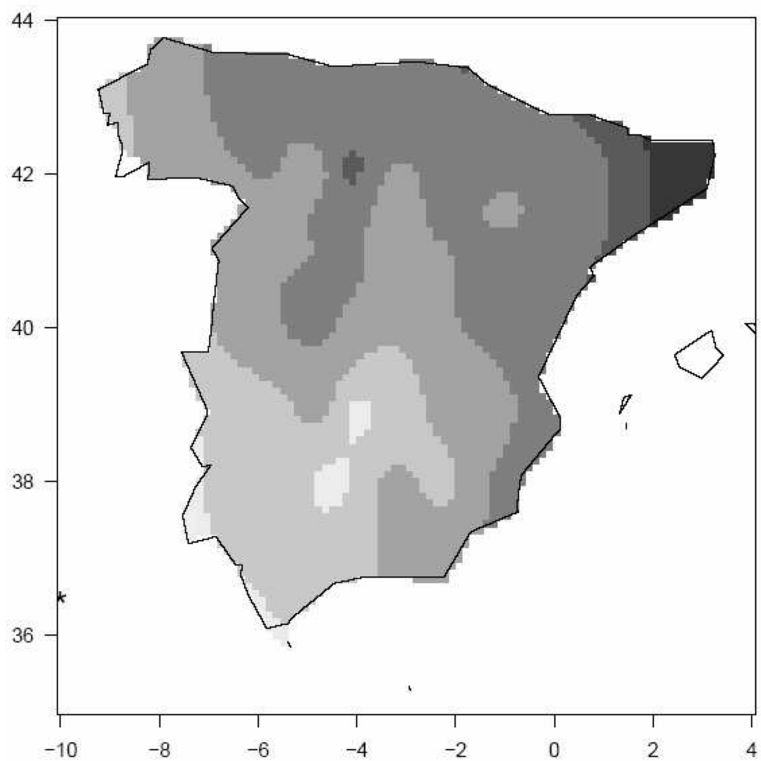
$\{\theta_j\}$: cutpoints

$g(x,y)$: smooth


Lisbon 1755 EMS−98 Intensities
lat
long
44
42
40
38
36
−10
−8
−6
−4
−2
0
2
4
VIII
VII
VI
V
IV
III
II
0



Lisbon 1755 EMS−98 Intensities
Data locations
lat
long
44
42
40
38
36
−10
−8
−6
−4
−2
0
2
4



44
42
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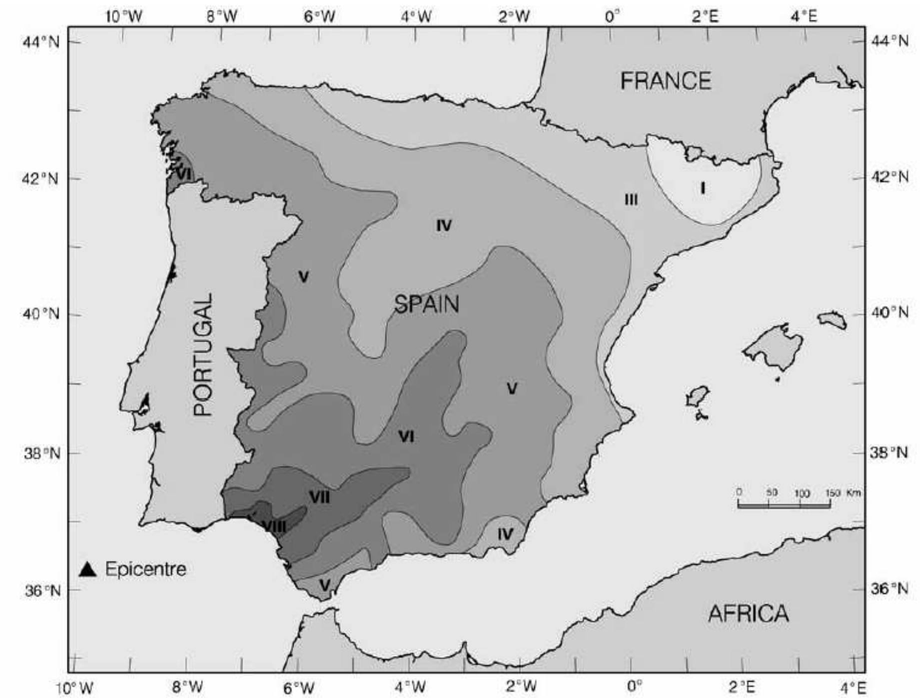
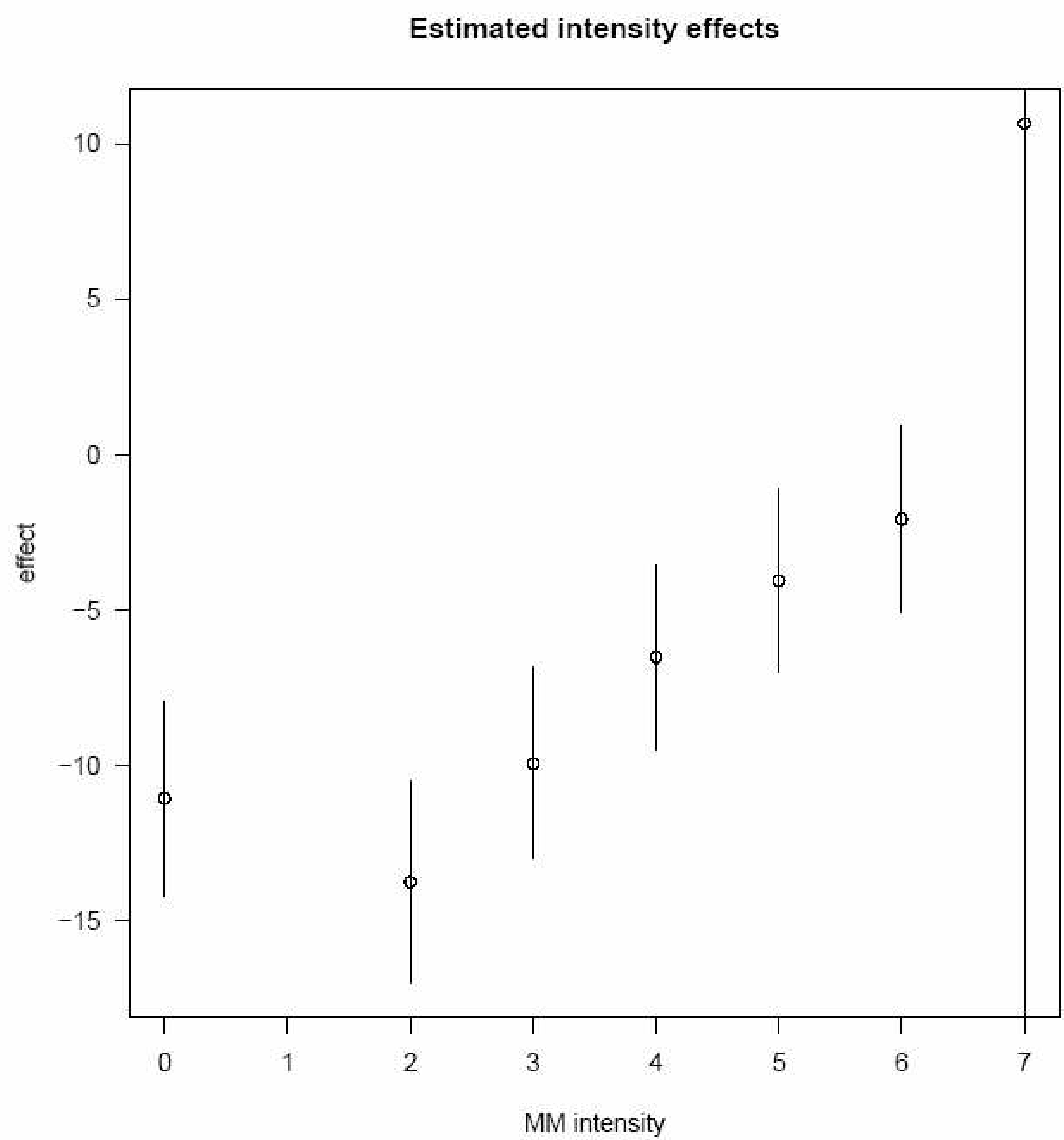
−4
−2
0
2
4



10°W
8°W
6°W
4°W
2°W
0°
2°E
4°E
44°N
42°N
40°N
38°N
36°N
FRANCE
PORTUGAL
SPAIN
AFRICA
I
III
IV
V
VI
VII
VIII
0 50 100 150 Km
▲ Epicentre

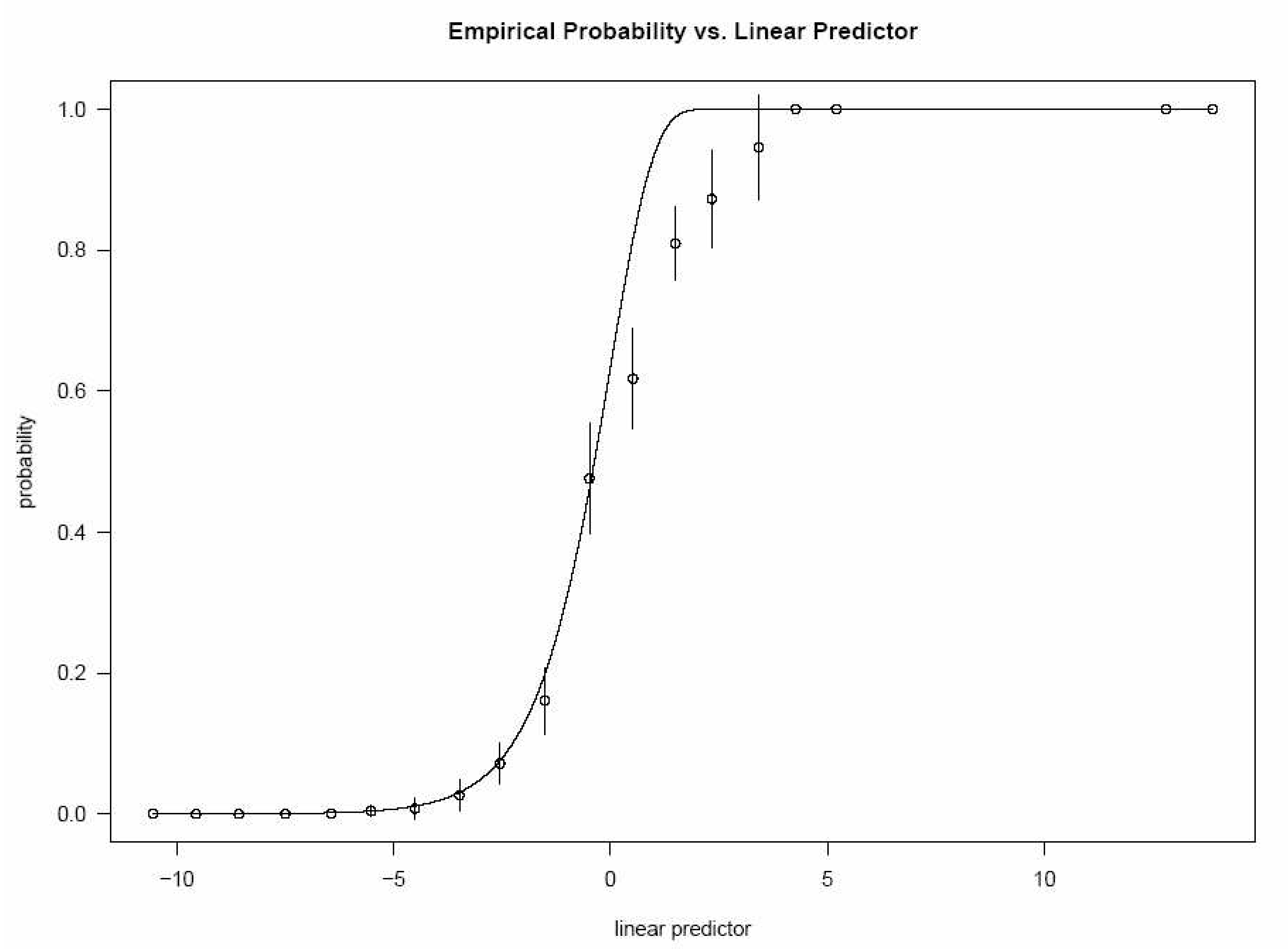

Estimated intensity effects
effect
MM intensity
10
5
0
−5
−10
−15
0
1
2
3
4
5
6
7

Assessment of fit.

$$Prob\{Y = j \mid Y \geq j, (x, y)\} = 1 - \exp\{-e^{\phi_j - g(x,y)}\}$$

$\phi_j - g(x,y)$: linear predictor

$g(x,y)$: smooth



Empirical Probability vs. Linear Predictor
1.0
0.8
0.6
0.4
0.2
0.0
probability
−10
−5
0
5
10
linear predictor

$$Prob\{Y = j \mid Y \geq j, (x,y)\} = 1 - \exp\{-e^{\phi_j - g(x,y)}\}$$

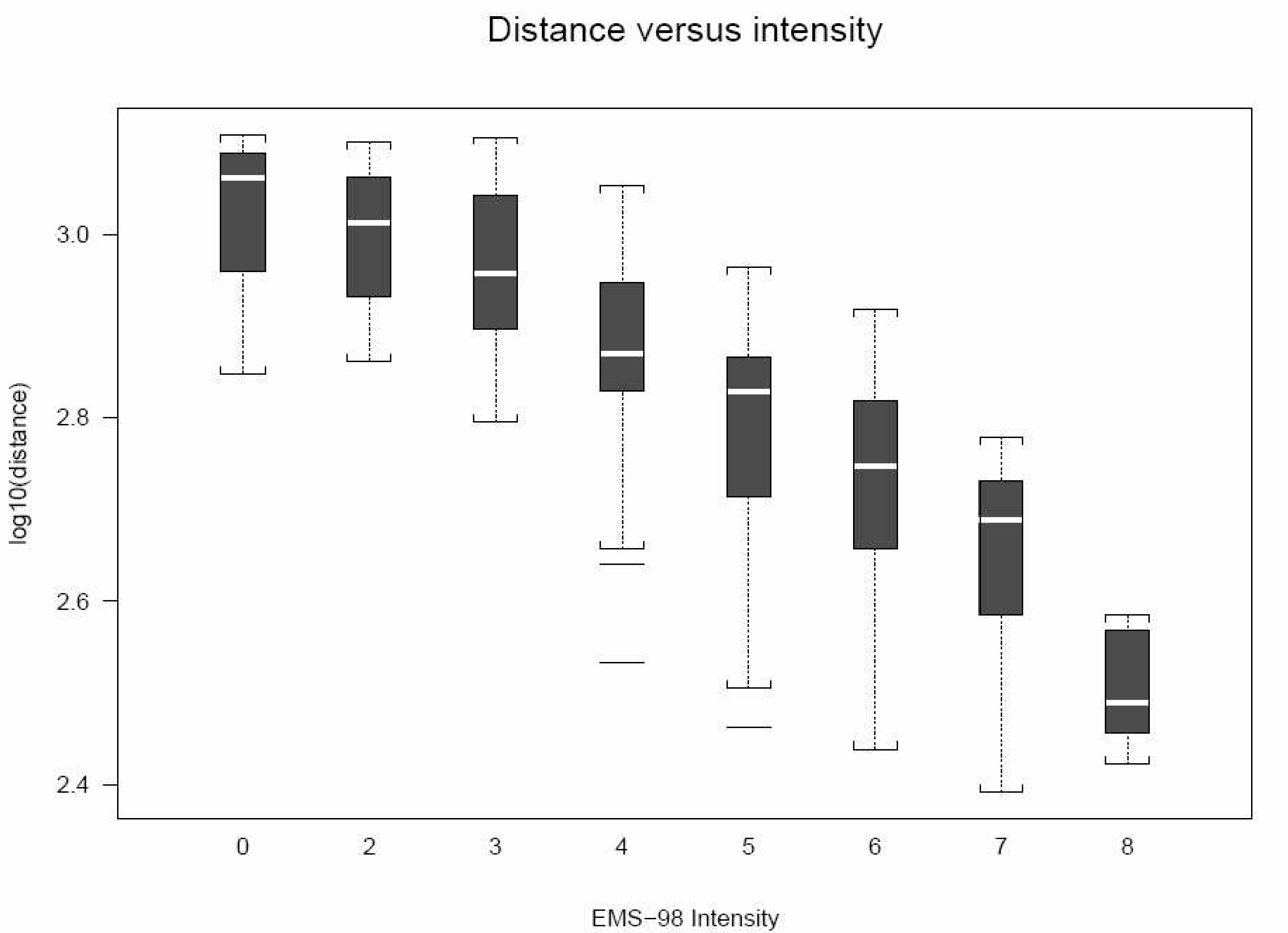
$\phi_j - g(x,y)$: linear predictor

$g(x,y)$: smooth

Parameter estimate uncertainty

Omitted variables, e.g. geology

$$\int [1 - \exp\{-e^{\phi_j - g(x,y) + \sigma z}\}] \phi(z) dz$$

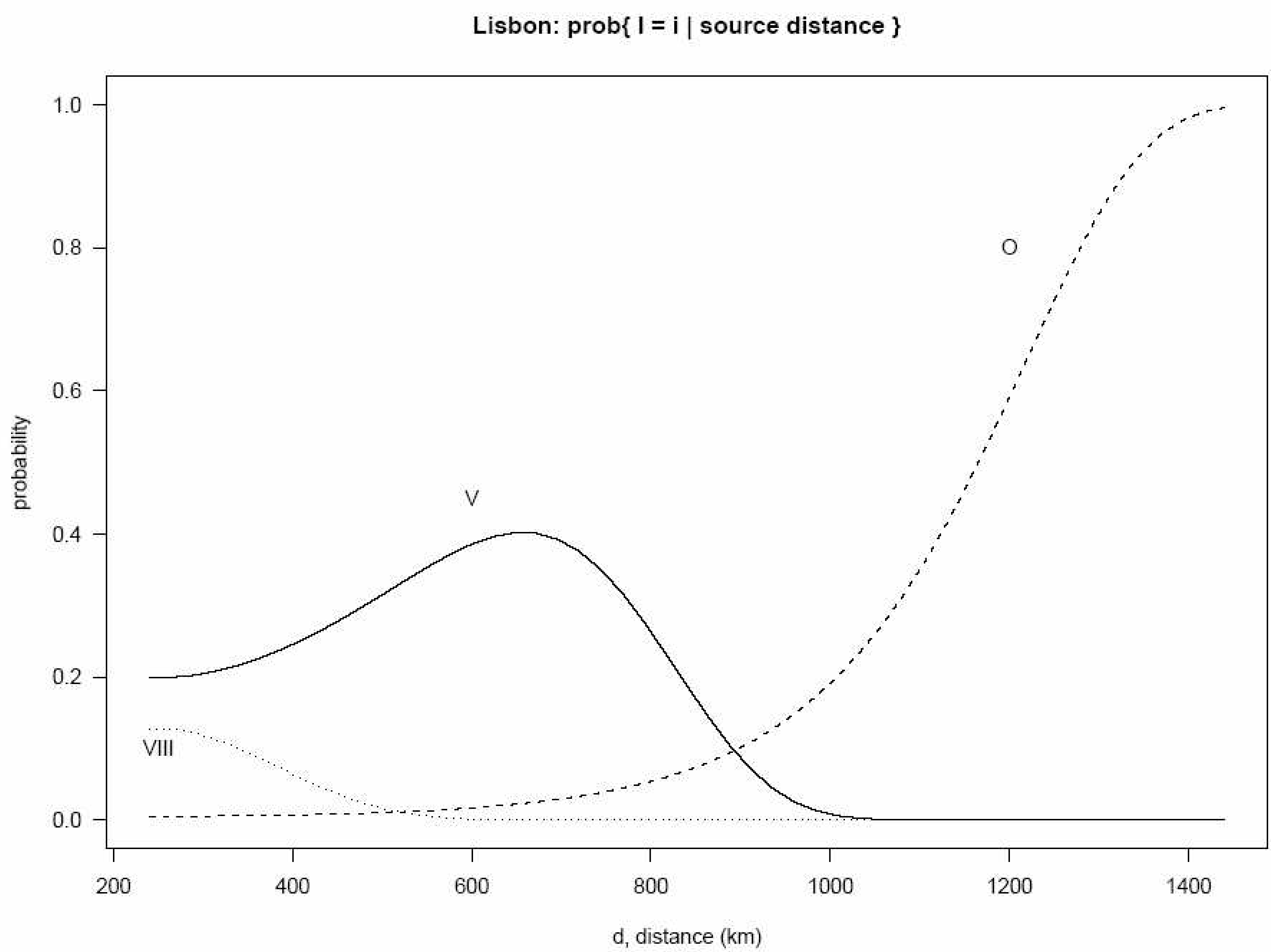

Distance versus intensity
log10(distance)
3.0
2.8
2.6
2.4
0
2
3
4
5
6
7
8
EMS−98 Intensity

Attenuation.

$$log(-log(1 - Prob\{Y=j\})) = \alpha_j + \beta d + \gamma log(d)$$

d: distance

Needed for building codes



Lisbon: prob{ I = i | source distance }
probability
1.0
0.8
0.6
0.4
0.2
0.0
O
V
VIII
200
400
600
800
1000
1200
1400
d, distance (km)

Damageability matrix.

Two building types

Masonry - traditional houses at the times of the shock

Monumental - castles, churches, ...

Proportions damaged

Risk type vs. EMS-98	V	VI	VII	VIII
masonry	.01	.25	.61	.92
monumental	.04	.25	.52	.60

Martinez Solares & Lopez Arroyo (2004)

5. Wildfires.

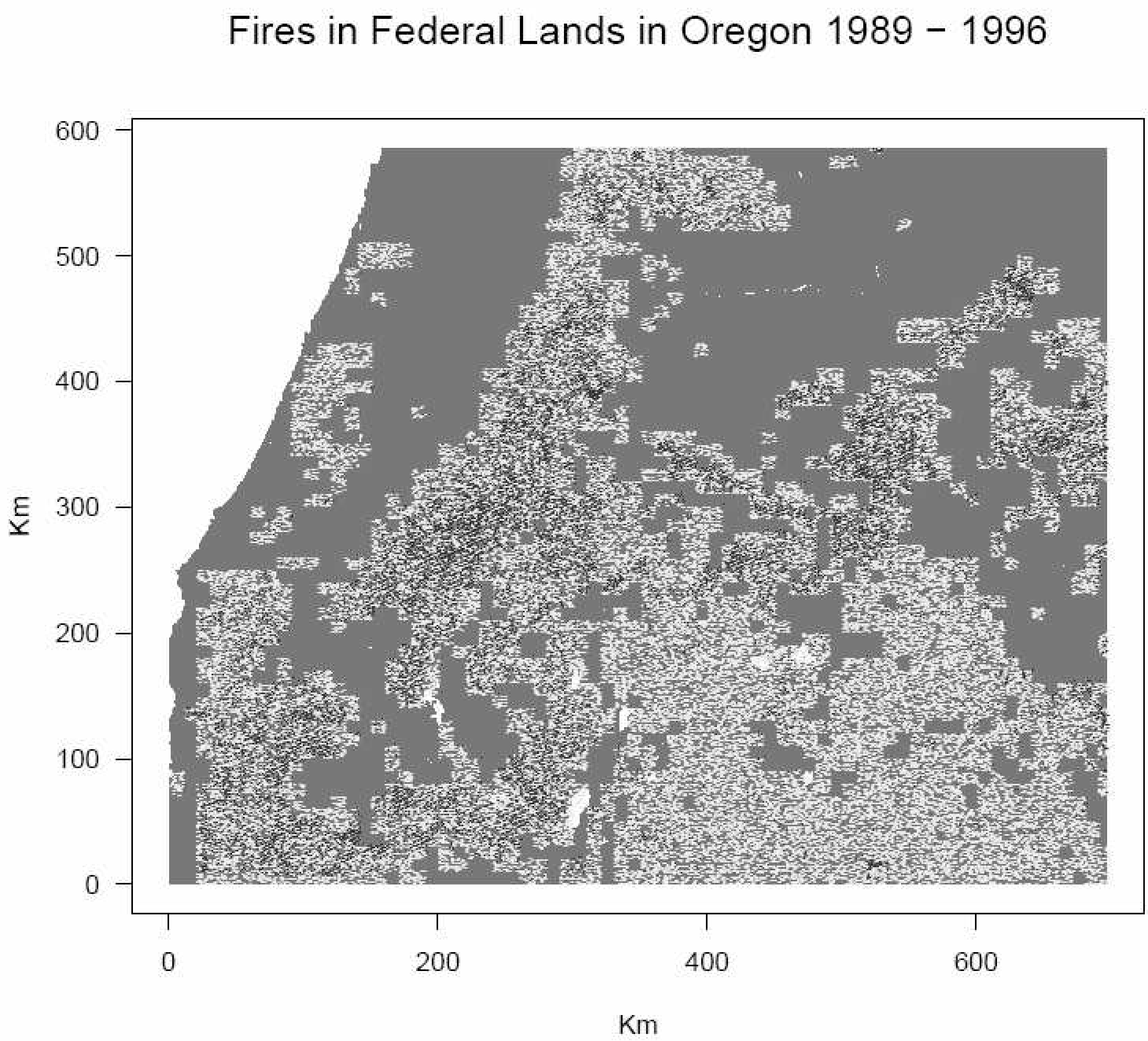
Tens of thousands/year in North America

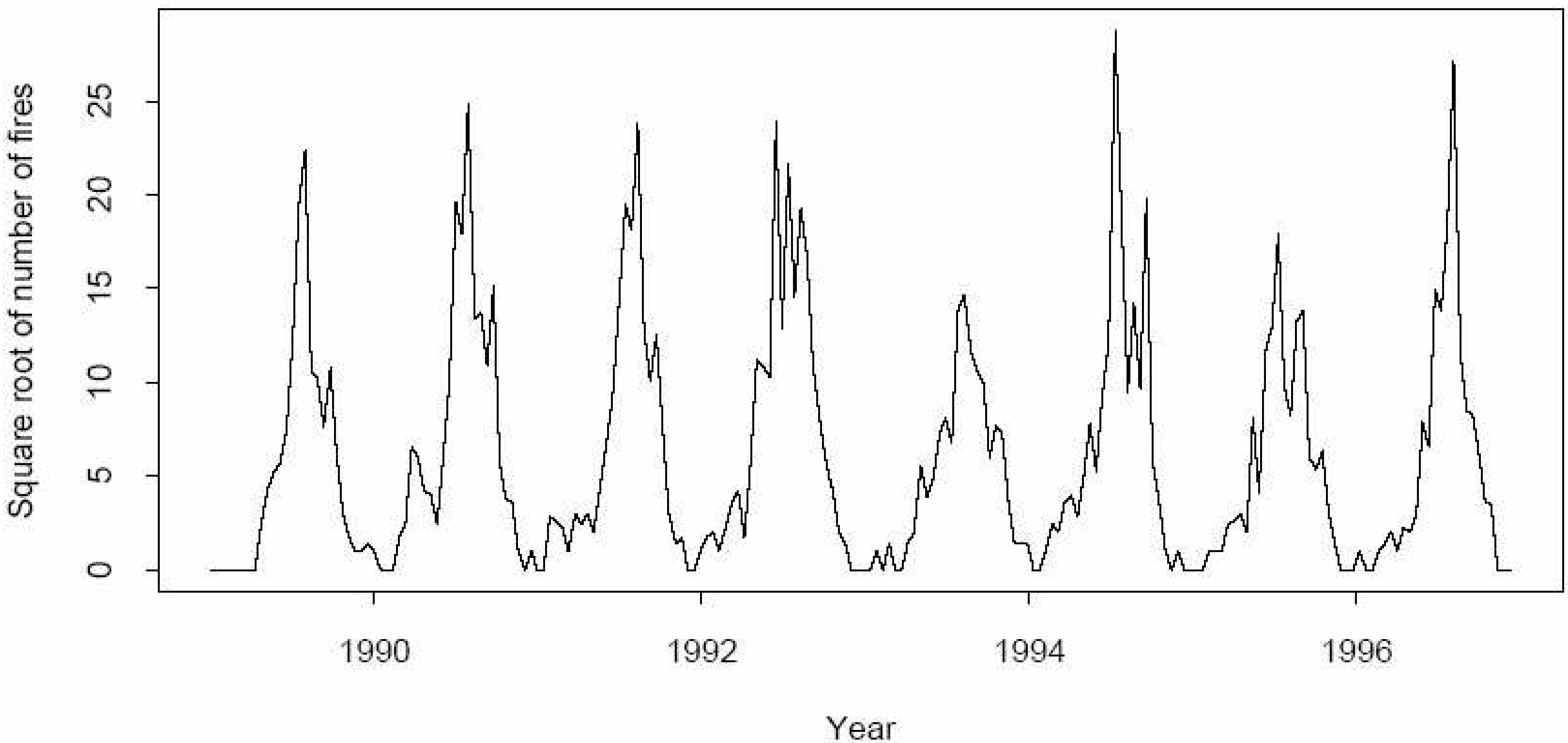
Millions of acres

Hundreds millions of dollars spent on suppression

1989 - 1996 date, size, location in Oregon

$n = 15{,}786$


Fires in Federal Lands in Oregon 1989 − 1996
Km
600
500
400
300
200
100
0
0
200
400
600
Km



Square root of number of fires
0
5
10
15
20
25
1990
1992
1994
1996
Year

Model.

Many voxels, (dx, dy, dt). All "fires", sample of "no-fire" cases (with prob $\pi = .00012$).

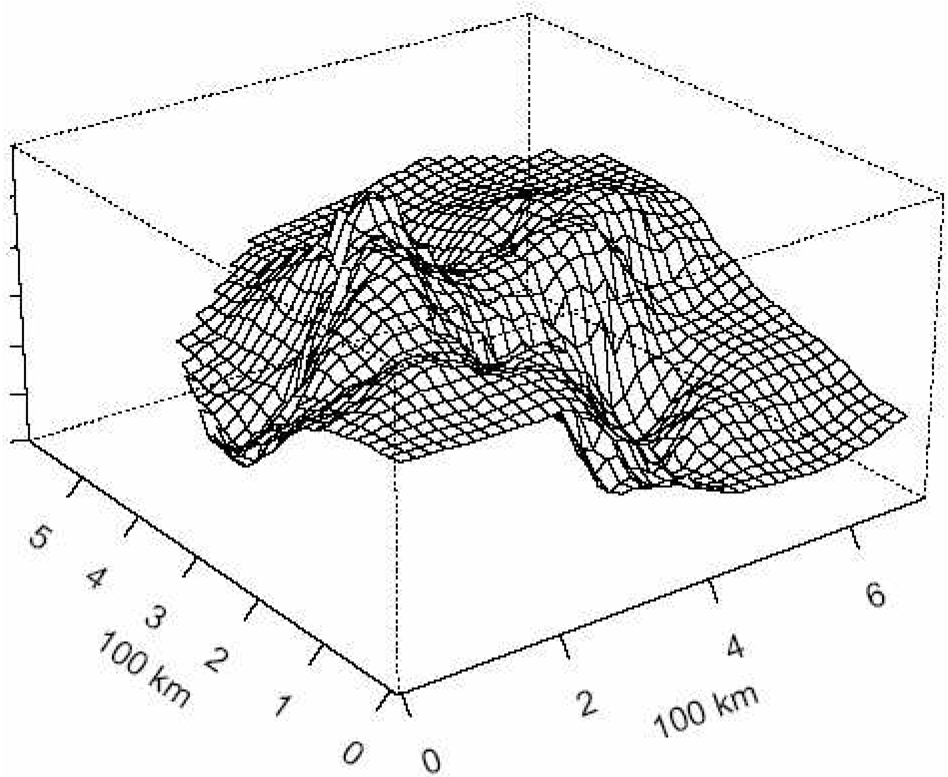
$$logit\ risk = g_1(x,y) + g_2(d) + \zeta$$

(x,y) - location

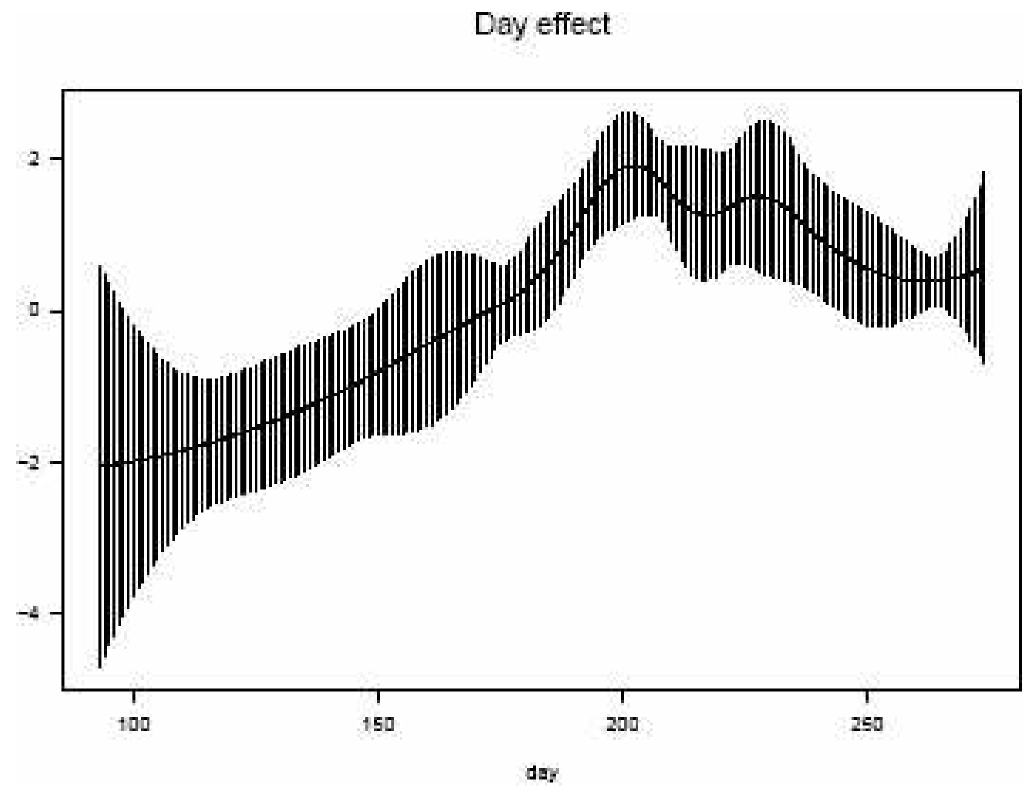
d - day of the year

ζ - year effect: $IN(0,\tau^2)$

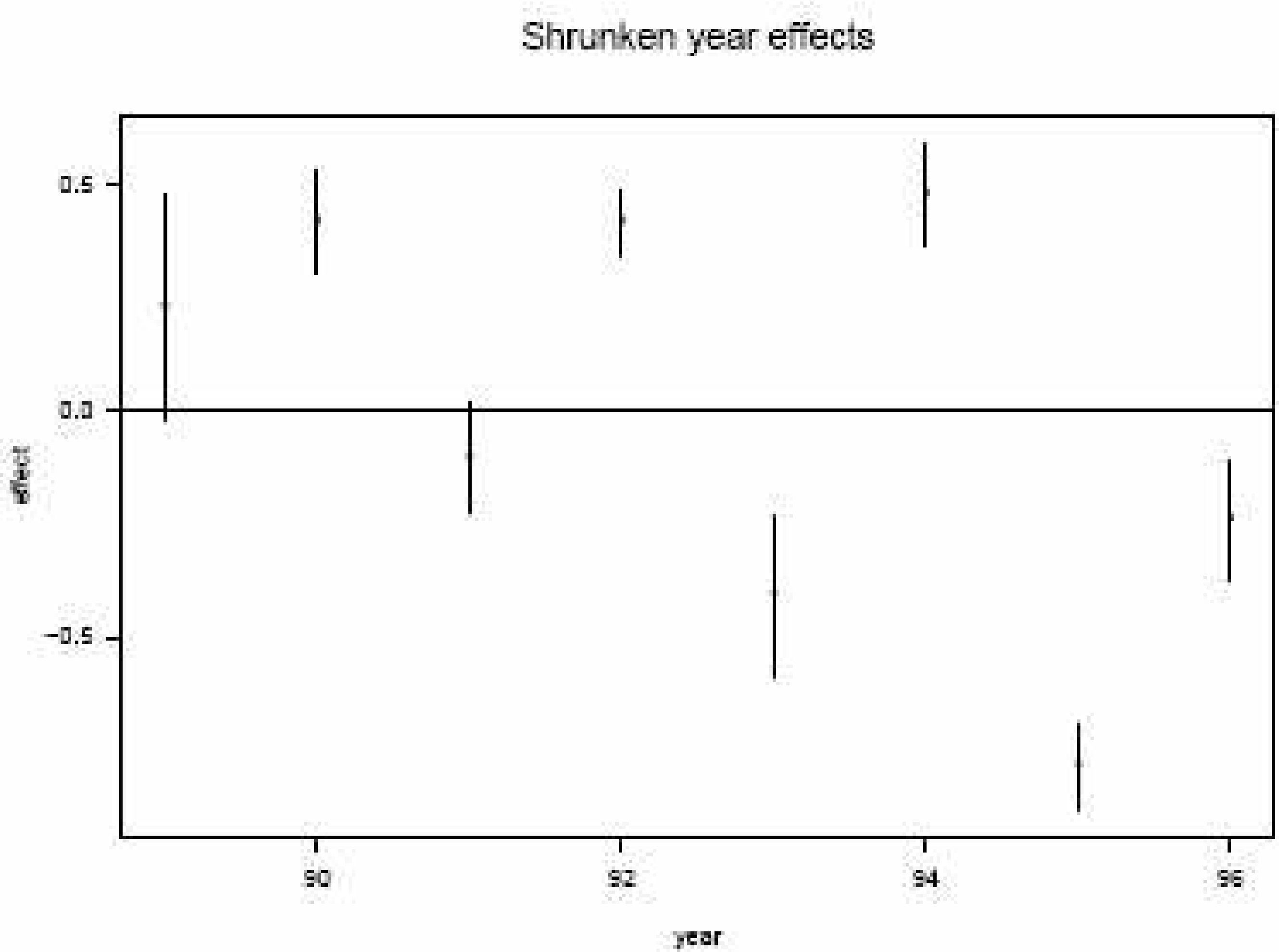
log $1/\pi$ as offset, $logit\ p = log(p/(1-p))$



5
4
3
2
1
0
100 km
0
2
4
6
100 km



Day effect
2
0
-2
-4
100
150
200
250
day



Shrunken year effects
0.5
0.0
-0.5
effect
90
92
94
96
year

Expected number of fires for some region and future occasion

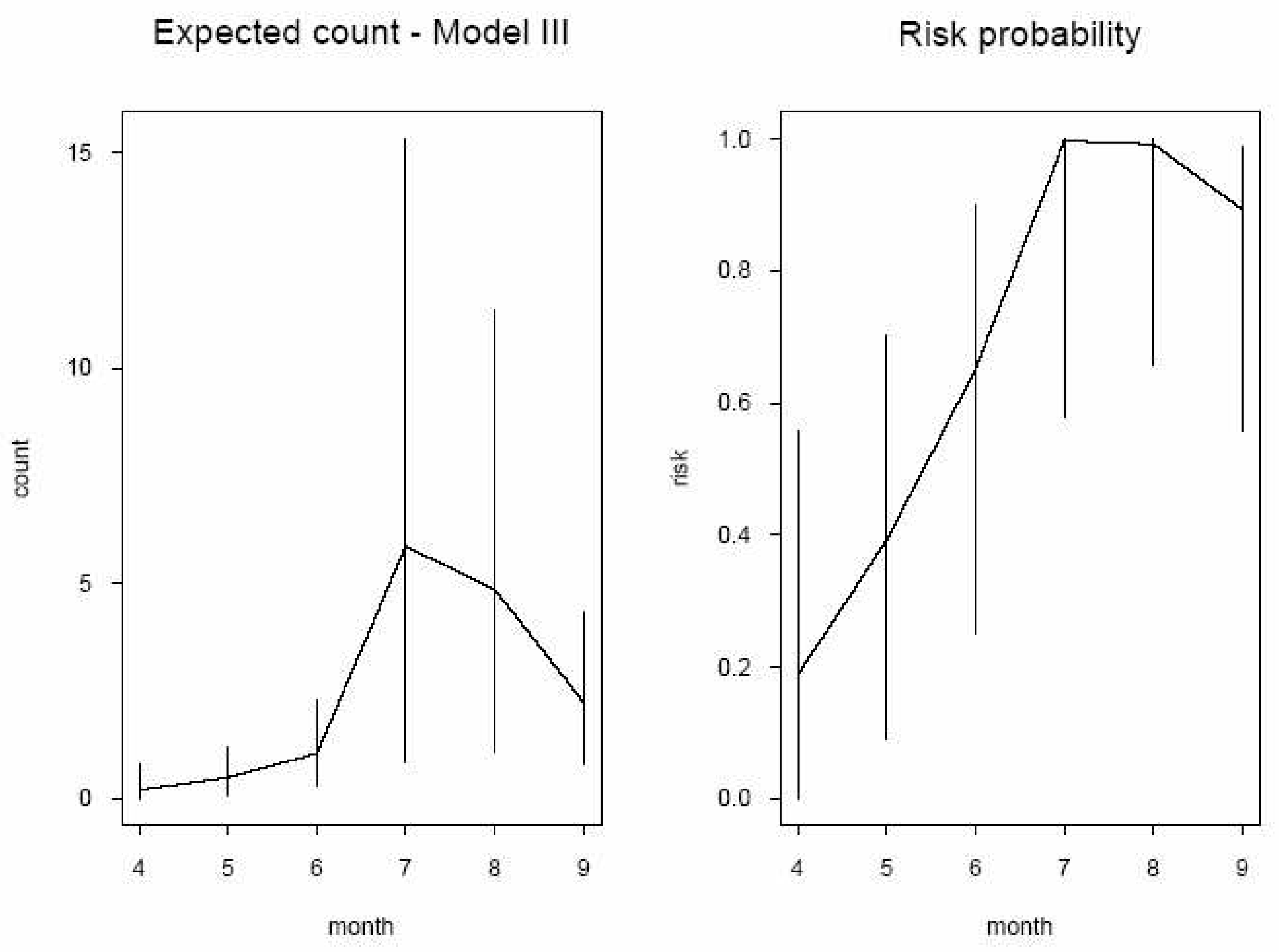
$$\hat{=} \sum_i \int \exp\{\hat{\eta}_i + \hat{\tau} z\} / (1 + \exp\{\hat{\eta}_i + \hat{\tau} z\}) \phi(z) dz \qquad (*)$$

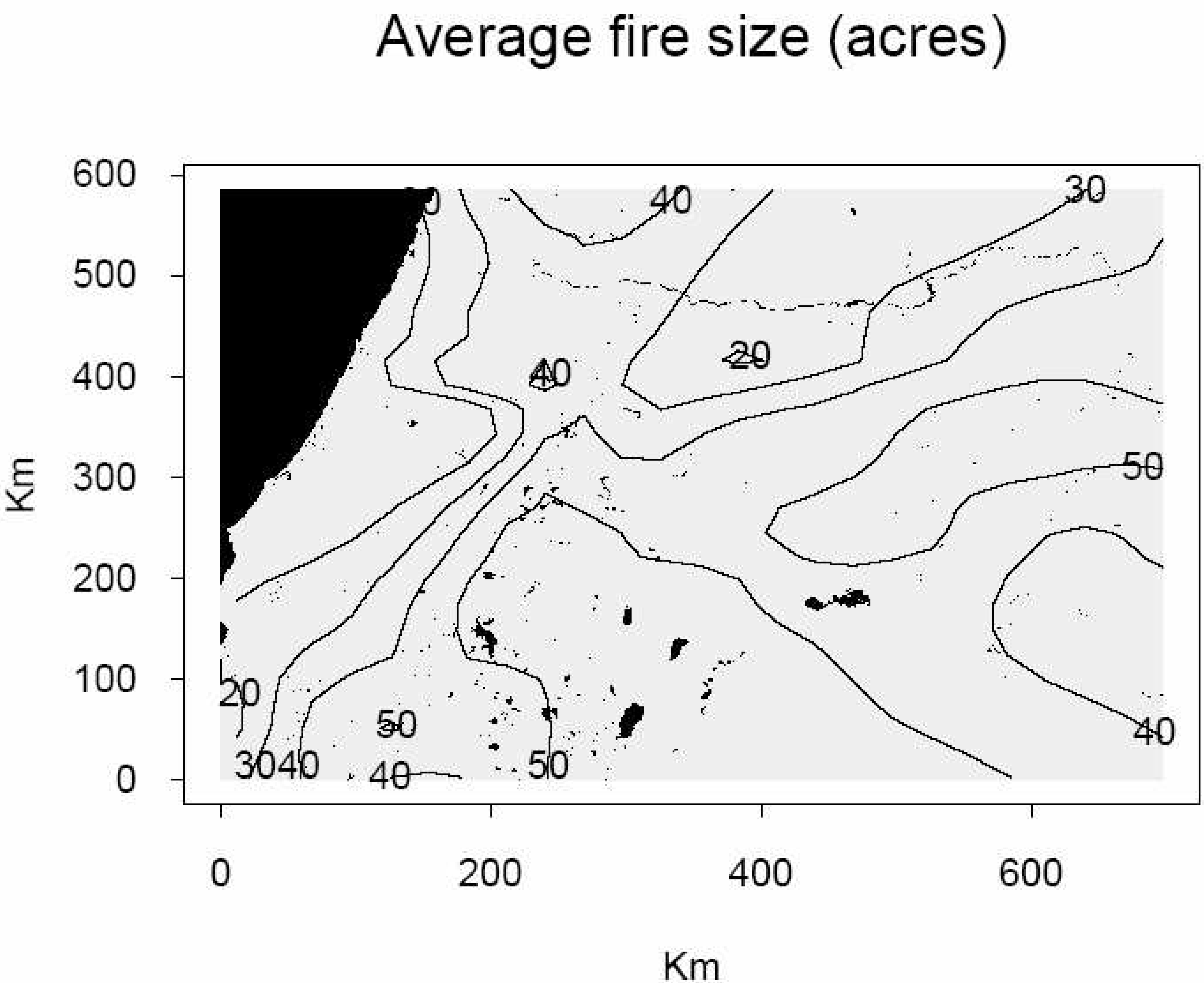
with i labelling pixels and days of the month and $\hat{\eta}_i = \hat{g}_1(x_i, y_i) + \hat{g}_2(d_i)$.

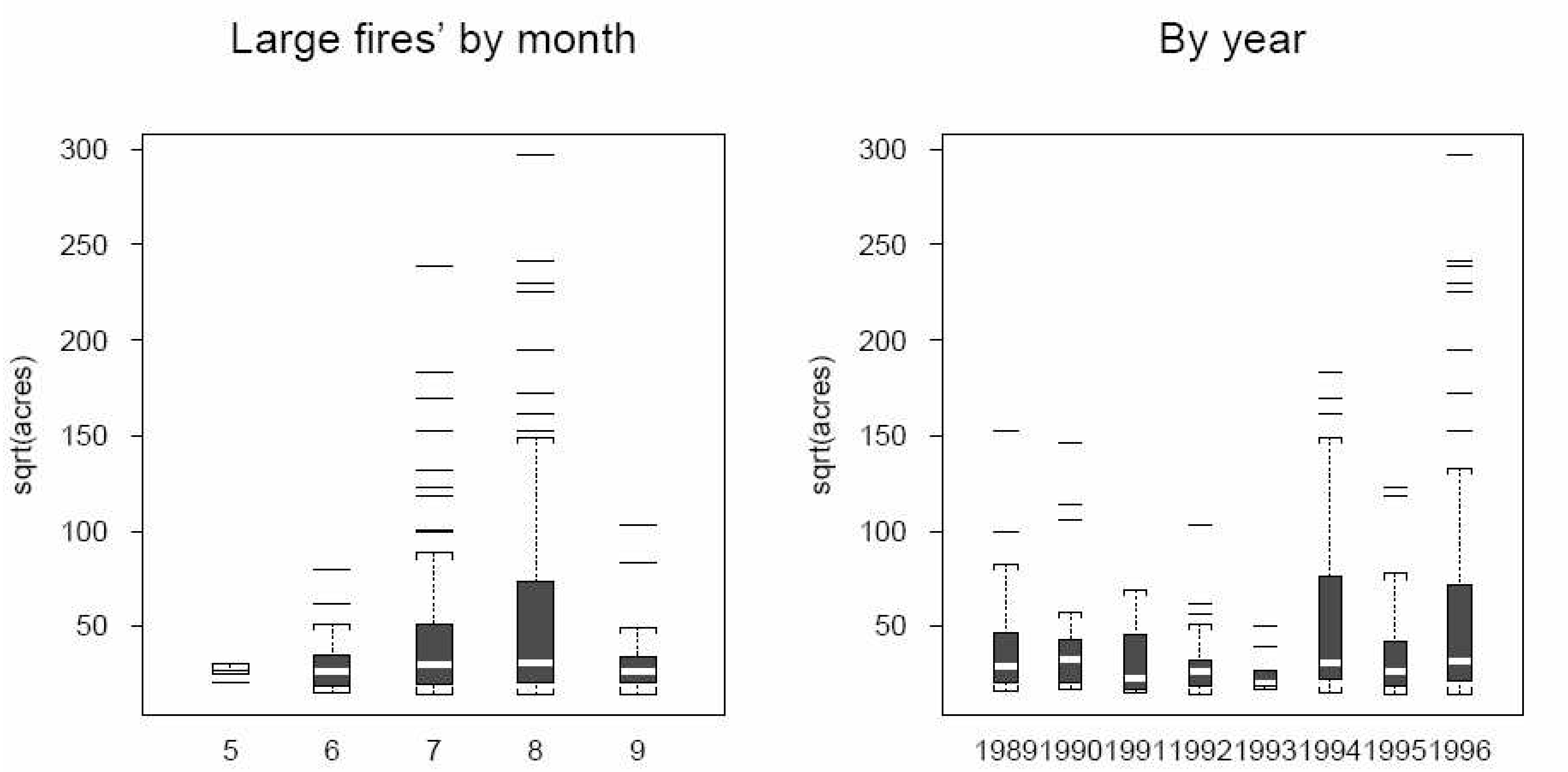
If after

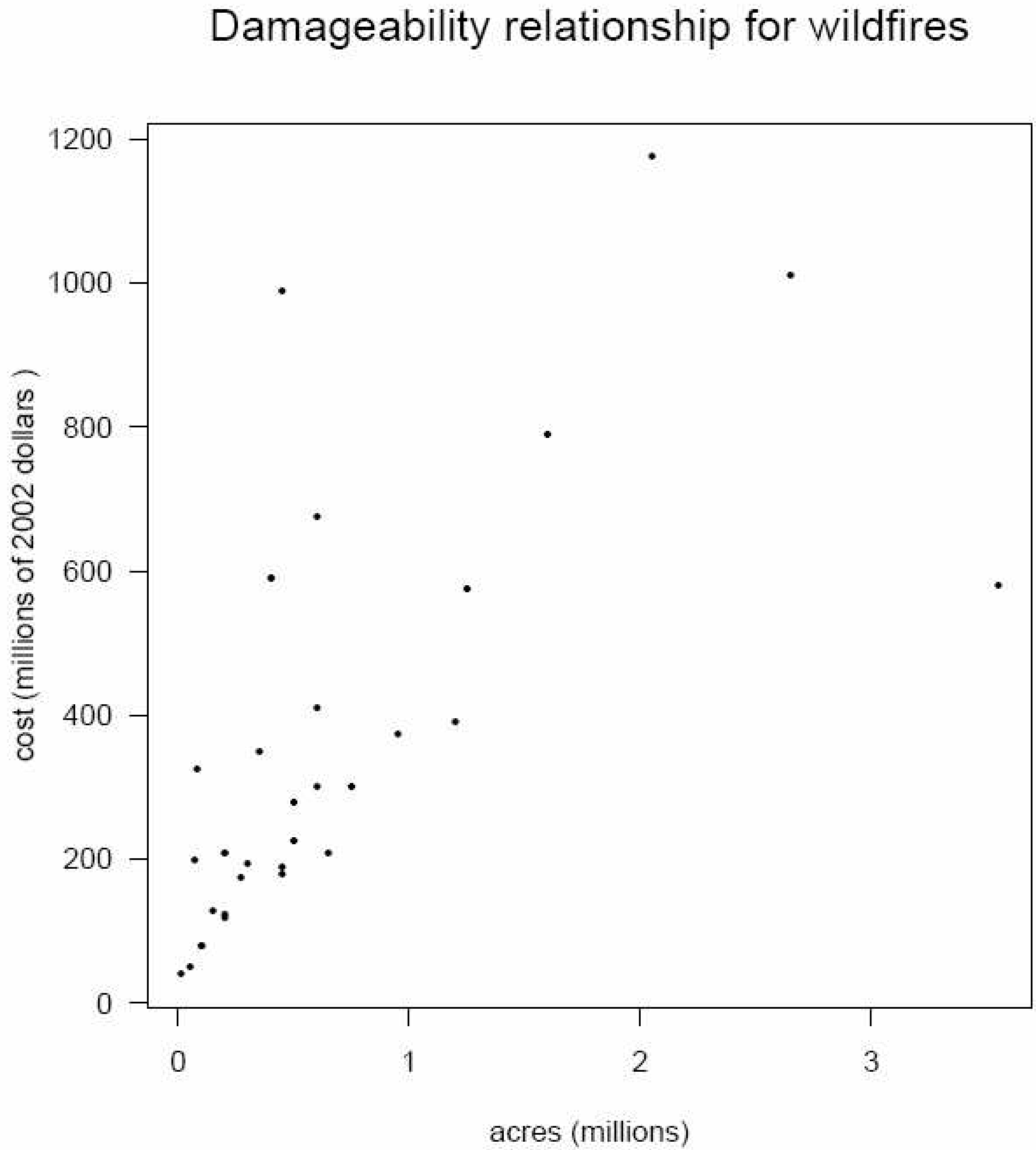
$$Prob\{at\ at\ least\ one\ fire\ in\ M\}$$

can integrate/sum (*) over M.


Expected count - Model III
count
month
Risk probability
risk
month


Average fire size (acres)
600
500
400
300
200
100
0
Km
0
200
400
600
Km
40
30
20
40
50
40
20
50
3040
40
50
40


Large fires' by month
By year
sqrt(acres)
300
250
200
150
100
50
5
6
7
8
9
1989
1990
1991
1992
1993
1994
1995
1996


Damageability relationship for wildfires
1200
1000
800
600
400
200
0
cost (millions of 2002 dollars)
0
1
2
3
acres (millions)

6. Insurance considerations.

L: accumulated claims over a year

Pure risk premium.

$$P = E\{L\} = \mu_L$$

Loaded premium. safety premium

$$P = (1+\lambda)\mu_L + \beta\sigma_L + \gamma\sigma_L^2$$

Loading should be larger the greater the uncertainty involved

Damageability matrix/relationship. Provides potential losses from given "intensity"

Discussion.

Considering the insurance problem provides focus

Can treat intensities as approximately numerical

Acknowledgements.

The organizers.

John Braun

David Martell

Rick Schoenberg

B. Bolt, J. M. Martinez Solares, J. Benoit, H. Preisler

NSF Grant DMS-02-03921

US Forest Service Contract 02-JV-11272165-02

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