

# Index

- Acoustic emission (AE), 11–29, 47–61, 63–78  
advantages and disadvantages, 11  
case histories, 56–59  
crustal stress, fractal analysis, and 47–61, 63–78  
energy release rate, granitic rocks, 11–29  
Greece, 63–78  
Italy, 47–61  
techniques, 71–76
- Active faults, *b*-value and fractal dimension, 26, 133–140
- AE. *See* acoustic emission
- Agia Efimia area, Kefallinia, Greece, 70
- Ainos block, Greece, 64–66
- Apennines, Italy, 50–51, 55, 113, 115, 133–136, 139  
grabens features of Miocene Early Pleistocene age, 50  
historical earthquakes, 137  
map of active faults, 136
- Argostoli block, Greece, 64
- Asteroid impacts, 1
- b*-value. *See also* earthquakes, Gutenberg–Richter, seismicity  
estimating, 15  
fractal dimension, 1–2, 25–26, 133–140  
granitic rocks pre-failure damage experiments and, 14–15  
Italy, 134  
recurrence time, 15–16  
southern California, USA, 2  
stress in rocks, 11–29  
variations and significance, 24
- Bed thickness, fracture spacing and, 126–127
- Biodiversity, and intermediate disturbance hypothesis, 156
- CA. *See* cellular-automata
- Cascade of clusters, 1–9
- Cellular automata (CA) models, 4–5  
avalanche behaviour, 4–5  
forest-fire model, 1, 5–8, 155, 157–159, 161–162  
frequency-size statistics, 1, 4–8  
inverse-cascade model, 5–8  
metastable regions, 1, 5–6, 8  
power-law frequency–area statistics, 1, 4–8  
sandpile model, 1, 4–5, 157  
slider-block model, 5
- Charles's power law, 19–20
- Cheat River, West Virginia, USA, flood analysis, 143, 147
- Chow's theory of multiplicative processes, 141
- Clusters  
cascade of clusters, small to large, 1–9  
crustal stress and seismicity, Greece, 67, 71  
faults, fractures, joints, 33–34, 37, 96, 116–118, 121, 124, 129  
growth, in forest-fire model, 1–9, 161  
percolation, 157
- Colfiorito seismogenic zone, Italy, 48, 56, 135, 137,
- Complexity theory in nature, and power-law relation, 96, 139, 141–142, 165
- Connectivity, multiscale fracture networks and, 31–45, 113, 115, 121, 126–128
- Correlation length, 34, 39, 161
- Correlogram, 81, 84, 90–91
- Cracks in rocks, 11–29, 31–45, 53, 80, 85, 119.  
*See also* microcracking
- Critical. *See also* self-organized criticality  
critical path and bond, in flow, 39  
critical phenomena, 4, 7, 12, 80, 86, 90–91, 133, 155, 157, 163, 165  
path analysis, 39  
subcritical crack growth, 11–12, 14, 18–23, 27
- Crustal stress  
AE techniques, 71–76  
crises, 47–61, 63–77  
DEM techniques, 70–71  
DInSAR techniques, 66–70  
GPS techniques, 64–66  
Ionian archipelago, Greece, 63–77  
Italian peninsula, 47–61  
soil exhalation, 71–76  
world stress map, 53–54
- Damage localization  
Charles's power law, 19  
failure nucleation, 24–25  
pre-failure damage, granitic rocks, 11–29
- DATAPLORE Software, rock slope displacement, 85
- DEM. *See* digital elevation model
- Detrended fluctuation analysis (DFA), 85–86, 89, 96–97, 99, 100
- DFFN. *See* discrete fault and fracture model
- DGPS. *See* Differential Global Position System
- Differential Global Position System (DGPS), 63–64, 66, 71
- Differential Interferometric Synthetic Aperture Radar (DInSAR), 64, 66
- Digaleto area, Kefallinia, Greece, 70
- Digital Elevation Model (DEM), techniques, 70–71
- Dilatometric measurements of cracks, 80, 85–90
- DInSAR. *See* Differential Interferometric Synthetic Aperture Radar
- Discrete fault and fracture model (DFFN), 113, 115, 128–129
- Disturbance regimes, wildfires, 155–156, 159, 165
- Dual porosity model, fractures, 128
- Dynamical systems theory, 79–81, 157–158
- Earthquakes. *See also* acoustic emission, *b*-value, crustal stress crises, faults, Gutenberg–Richter, seismic, slider-block model  
body-wave magnitude, 14  
fault zones and fractal dimension, 25, 133–139  
foreshocks, 24  
frequency-size statistics, 1–2  
geolectrical time series analysis of, 95–103  
Greece, 63–78  
Italy, 47–61, 95–103, 133–140  
landslides triggered by, 3, 105–106  
Omori law, 24

- Earthquakes (*Continued*)  
 prediction of via *b*-value, 26  
 USA, 2, 106
- Ecology and ecosystems, succession–disturbance theory, and wildfires 156–157
- Elasticity, concept of, 51–52
- Emergent simple scaling, flooding analysis, 142–144, 151
- Energy release rate and AE magnitude, 14–17, 21–23, 26–27
- Erissos peninsula, Greece, 64
- Failure nucleation, damage localization and, 24–25
- Faults. *See also* acoustic emissions, damage localization, earthquakes, fractures  
 bioclastic limestone, 116–117  
 Apennines fault system, Italy, 133–140  
 Caramanico fault system, Italy 115–116  
 earthquake magnitude and fractal dimension, 133–139  
 fault seal analysis, 113  
 Kefallinia transform fault, Greece, 66, 72  
 Majella Mountains, Italy, 113–131  
 microcracking phases, 11  
 Nojima fault zone, Japan, 13, 25  
 Anatolian fault zone, Italy, 51, 65  
 porous grainstones, 116  
 San Andreas fault system, USA, 33  
 spacing, 117–118  
 spatial pattern as predictor of earthquake size, 133–139
- FFA. *See* flood frequency analysis
- Firing frequency, forest fire model, 5, 7, 158–159
- Flood frequency analysis (FFA), 1, 141–153  
 Log-Pearson III (LP3), 142, 147–149  
 magnitude/frequency curves, 143–144  
 Mississippi River study, 143  
 peak annual discharge data, 144  
 power-law (PL) model, 142–143  
 rainfall data, 143, 148–149, 151  
 strengths and weaknesses, 141–142  
 US catchment study, PL vs. LP3 models, 148
- Flow models, for multiscale networks, 31–45
- Fluid transfer, in fractured rock, modelling of, 31
- Forecasting, probabilistic hazard  
 damage model, granite, and fractures, 11–29  
 earthquakes and acoustic emission, 47–61, 63–78,  
 earthquakes and spatial fault patterns, 133–140  
 floods, 141–153  
 rock slopes and rock falls, 79–93, 107–108  
 wildfires, 163–165
- Forest fires. *See* wildfires
- Forest-fire model, 1, 5–8, 155, 157–159, 161–162
- Fractal. *See also* heavy-tail, Mandelbrot, multifractal, nonlinear, power-law  
 acoustic emission data, 13, 16–19, 24–27, 47–61, 63–78  
 band-limited, 24  
 bed thicknesses, 127  
 box counting method, 59–60  
*b*-value, relationship to fractal dimension, 1–2, 25–26, 133–140  
 clusters, spatially, 1, 6–8, 36–37  
 construction, 7–8  
 crack populations, 11–12  
 fault zones, 25, 133–139  
 floods, 1, 141–153  
 fracture networks, 31–45, 113–131  
 geoelectrical data, multifractal variability, 95–103  
 landslide events, 105–111  
 natural hazards, in general, 1–4  
 rock slopes and rock falls, 79–93, 107–108  
 seismogenic faults, 133–140  
 self-affine, 31, 91  
 self-similar, 1, 33, 59, 141–143, 151, 157, 163  
 soil exhalation, 47–61, 71–76  
 wildfires, 8, 155–167
- Fractures. *See also* faults  
 aperture distributions, 31  
 bed thickness and, 127  
 clustering, fractal networks and, 36–37  
 connectivity and, 35–36  
 damage phase, 22–24  
 DFFN model, 128, 129  
 dual porosity model, 128  
 dynamics, study techniques, 11  
 Hornelen basin, 33  
 hydrothermal fluid migration, 31  
 length distributions, 31, 39  
 length, three-dimensional rules, 35  
 Majella Mountains, Italy, 113–131  
 mechanism, 22–24  
 network connectivity, 33–34  
 percolation theory, permeability, 33–34  
 permeability as constant, 39–40  
 scale invariance of, 32  
 transmissivity, 37–38
- Fragmentation, rockfalls and, 108
- Frequency–area statistics. *See* frequency–size statistics
- Frequency–size statistics. *See also* Charles's law, Gutenberg–Richter, heavy-tail, inverse-gamma, power-law, self-similar  
 asteroid impacts, 1  
 bed thickness, 127  
 cellular-automata models, 4–5, 157–159  
 crack populations, 11–12  
 earthquakes, 1–2, 26  
 floods, 1, 141–153  
 fractures, 32–34, 117–118, 120–122  
 inverse cascade, and, 1–9  
 landslides, 3, 105–111  
 rockfalls, 107–108  
 volcanic eruptions, 1  
 wildfires, 3–4, 155–167
- Geoelectrical data, Giuliano, Italy, 95–103  
 Giuliano, Italy data, 48, 55–56, 96–99  
 Granite, experiments on, 11–27  
 Graphical tools, phase space portraits and correlograms, 81–86  
 Greece, crustal stress and seismicity, 63–77  
 Ground deformation. *See* Differential Interferometric Synthetic Aperture Radar  
 Gutenberg–Richter frequency–magnitude relation, 1, 2, 15–16, 26, 105, 108

- Heavy-tail frequency–size statistics. *See also* frequency–size statistics, power-law rainfall, 148  
wildfires, 155, 157, 159, 161, 162, 165
- Hellenic arc, trench system, 64–65
- Hidden information, nonlinear science issues and rock slopes, 80–86
- Highly Optimized Tolerance (HOT), 162
- Histograms. *See* frequency–size distributions
- Hölder exponent, 95, 100–102
- HOT. *See* Highly Optimized Tolerance
- Hurst exponent, 95, 98–100, 102
- Hydraulic models, general, 38
- Intermediate disturbance hypothesis, 156
- Inverse-cascade model, 1–9
- Inverse-gamma distribution, landslides, 3, 105–109
- Italy  
crustal stress crises and seismic activity in, 47–61  
fracture systems, Majella mountain region, 113–131  
landslides, Todi and Umbria, 3, 105–111  
multifractal variability in self-potential signals, 95–103  
seismogenic faults, central Apennines, 133–140  
tectonic framework, 47–51  
wildfires, 160
- Kefallinia, Greece, 58, 63–77
- Lacunarity, definition of, 37
- Landslides. *See also* rockfalls  
area, average in triggered events, 108  
frequency–size distributions, 1, 3, 105–108  
'general' probability distribution, 3, 105–111  
Guatemala, 3, 106, 108  
historical/incomplete landslide inventories, 109  
inverse-gamma distribution, 3, 106–107  
Italy, 3, 105–111  
magnitude scale, 108–109  
power-law frequency–area statistics, 3, 107  
triggers of, 3, 105  
USA, 3, 105–106, 108
- Lattice-based models. *See* cellular-automata (CA) models
- Lefkada earthquake, 64, 66–67, 76
- Limestone, 116–117, 122
- Log-Pearson III (LP3), 141–143, 145–146, 151
- LP3. *See* Log-Pearson III
- Magnitude–frequency curves. *See* frequency–size statistics
- Majella Mountains, Italy, fracture study, 113–131
- Mandelbrot, vii (preface), 32, 137, 142
- Mediterranean ecoregion, USA, wildfire statistics, 4, 8, 159, 161, 163
- Metastable region, 5–6, 8
- Microcracking, 11, 13–14, 16–17, 22–23, 25, 27
- Molise earthquake, Italy, 48, 55–58
- Multifractals  
Detrended Fluctuation Analysis (DFA), 97  
floods, power-laws, and, 142–143  
pre-failure damage, and, 16, 25  
self-potential signals, 95–103
- Multiscale fractal fracture networks, 31–45
- Natural hazards. *See* asteroid impacts, earthquakes, floods, landslides, rockfalls, volcanoes, wildfires
- Non-fractal networks, 34–36
- Nonlinearity. *See also* fractal, multifractal, self-organized criticality  
acoustic emissions, granitic rocks, and, 14, 21, 23  
definition of, 80  
*sensu stricto*, definition of, 80  
unstable rock slopes, 79–93
- Nonstationary, 95, 97
- Nucleation phase, 11, 16–27
- Orchi, Italy, acoustic emissions, 57
- Peaks-over-threshold, floods, 143, 150
- Percolation, 33–39, 43, 157
- Permeability, flow in fracture networks, 31–45
- Phase portrait, rock slope displacement analysis, 81, 83, 91
- Phase transition, floods, 143–144, 150
- PL. *See* power-law.
- Power-law frequency–size distribution. *See also* fractal, frequency–size distributions, Gutenberg–Richter, heavy-tail, self-similar  
asteroid impacts, 1  
bed thicknesses, 127  
cellular-automata models, 1, 4–5, 157–159  
Charles's power law, 19–20  
crack populations, 11–12  
earthquakes, 1–2, 26  
floods, 1, 141–153  
fractures, 32–34, 117–118, 120–122  
Highly Optimized Tolerance (HOT), 162  
inverse cascade, and, 1–9  
landslides, 3, 105–111  
mechanisms of, 163  
rockfalls, 107–108  
volcanic eruptions, 1  
vs. log-Pearson III distribution, flood frequency analysis, 147–149  
wildfires, 3–4, 155–167
- Prediction. *See* forecasting
- Probabilistic hazard assessment. *See* forecasting
- Rainfall  
floods, relation to, 141–143, 148, 151  
landslides, trigger for, 3, 105–109
- Raponi, Italy, acoustic emissions, 56–57
- Recurrence time. *See also* forecasting  
*b*-value, relation to, 15  
granitic rocks pre-failure damage experiments, 15–16  
wildfires, 162–164
- Rockfalls, 107–108. *See also* rocks
- Rocks  
cracks, 11–29, 31–45, 53, 80, 85, 119  
failure, predictability of, 26–27  
fracturing, 14, 16–19, 22–23, 25–26  
near to stability plots, of rock slope displacement, 82  
rock slope displacement analysis, 79–91

- Sandpile model, 1, 4–5
- Scaling. *See* fractal, self-similar, power-law
- Seismic activity. *See* earthquakes
- Self-affine distribution, 31, 91
- Self-organized criticality (SOC) 4, 7, 113, 133, 155, 157–159, 162–163, 165
- Self-potential signals, seismic areas, 95–103
- Self-similar
- cascade of clusters from small to large, 1–9
  - distribution, identification, 59, 143–144
- Singularity spectra, Giuliano, Italy series, 100–102
- Slider-block model, 1, 5
- Slope failures, 79–93
- SOC. *See* self-organized criticality
- Software
- Bernes GPS software, 65
  - Dataplore software, 85
  - static kinematic software, 64
  - WINFAP, flood software, 145
- Soil exhalation
- Italy study, fractal analysis of, 47–60
  - Kefallinia, Greece study, 63–78
- Sparking frequency, forest fire model, 5, 7, 158–159
- Spectral analysis, in self-potential dynamics, 96
- Static Kinematic Software, 64
- Stress crises. *See* crustal stress, crises
- Subtropical ecoregion, wildfire power-law statistics, 4, 8, 159, 161
- Succession, in ecology, definition of, 156
- Tensile stress, mechanisms for, 23
- Todi, Italy, landslides, 107–109
- Tyrrenian seafloor, 48–52
- USA
- earthquakes, 2–3, 105–106, 108
  - flood catchment study, 141–153
  - landslides, 3, 105–106, 108
  - wildfires, 3–4, 8, 155–167
- Volcanoes, 1, 53, 58, 65, 108
- Wildfires. *See also* forest-fire model
- Australia, 4, 160
  - Canada, 160–161
  - China, 160
  - Europe (France, Greece, Italy, Spain, Sweden), 160
  - disturbance regimes, 155–156, 159, 165
  - forecasting, power-law analysis for, 165–166
  - frequency–area distributions, 156–160
  - heavy-tailed wildfire frequency–area distributions, 159, 161–162
  - Mediterranean ecoregion, 4, 8, 159, 161, 163
  - meteorological conditions and, 4
  - power-law scaling in, 3–4, 159
  - recurrence intervals map, USA, 164
  - self-organized criticality (SOC), 162–163
  - subtropical ecoregion, 4, 8, 159, 161
  - succession-disturbance theory, 156–157
  - Russia, 160
  - USA, 3–4, 8, 155–167
- World Stress Map, 53–54