

Index

- absorptance, 35, 104, 223
- acetaldehyde emissions, leaf, 403
- adaptive tradeoffs, 177, 178, 216
- adiabatic
 - ascent, 289
 - buoyant expansion, 288
 - dew point, 232
 - evaporation, 231, 241
 - general, 28, 231
 - lapse rate, 28, 290
 - potential temperature, 288
 - thermodynamics, 28
 - work, 28, 289
- advection
 - general, 228
 - katabatic flow, 322
 - mesoscale fluxes, 345
 - molecular, 121
 - stable drainage flow, 322
- aerenchyma, 388
- aerodynamic resistance, 315
- aerodynamic roughness length, 305
- aerosols
 - BVOC oxidation, 411
 - cloud formation, 286
 - forest production, 226
 - global budget, 411
 - primary, 408
 - secondary, 408
- albedo, 9, 223, 226
- ammonia emissions, leaf, 403
- amphistomatous, 152, 194
- apoplast, 191, 210
- aquaporin, 23, 190, 191, 211, 218
- Arrhenius equation, 43, 60, 100, 105
- Asrar, Ghassem, 256
- Atacama Desert, 221
- atmosphere
 - adiabatic lapse rate, 290
 - capping inversion, 282
 - convective mixed layer, 284
 - Coriolis force, 282
 - entrainment zone, 282, 283, 285
 - free troposphere, 281
 - hydrostatic equilibrium, 288
 - inertial sublayer, 284
 - neutral stability, 290
 - nocturnal stable layer, 283
 - Obukhov length, 292
 - planetary boundary layer, 282
 - potential temperature, 287
 - residual layer, 283
 - roughness sublayer, 284
 - stability, 290
 - structure, 281
 - subsidence, 228
 - surface layer, 282
 - unstable, 292
 - virtual potential temperature, 287
 - wind, 297
- ATP, adenosine triphosphate
 - C₄ photosynthesis, 87
 - endergonic metabolism, 46
 - guard cells, 147, 162
 - isoprene, 401
 - photorespiration, 81
 - redox reactions, 48
 - respiration, 84
 - RPP pathway, 69
 - RuBP regeneration, 93
 - thermodynamics, 70
 - triose phosphate utilization, photosynthesis, 95
- AVHRR, Advanced Very High Resolution Radiometer, 273
- Ball–Berry model, 159
- Beer–Lambert Law, 35, 259
- Berry, Joseph, 89
- bidirectional reflectance distribution function (BRDF), 274
- bifacial leaves
 - light traps, 188
 - morphology, 175
- big-leaf modeling, 353
- biogeochemical cycles, 1, 2, 17
- Birch effect, 384
- Björkman, Olle, 177
- black-body, 31
- boundary layer
 - conductance, 357
 - diffusivity, 144
 - friction, 139

- boundary layer (cont.)
 - general, 138, 139
 - isotope fractionation, leaf, 421
 - Kelvin–Helmholtz instabilities, 139
 - leaf conductance, 143
 - nocturnal, atmosphere, 287
 - no-slip assumption, 139
 - planetary, 225, 282
 - shear stress, 139
 - thickness, leaf, 142, 236, 237
- Bradley, Frank, 368
- Brooks and Corey equation, 208
- Brown, Robert, 111
- Buckingham Pi theorem, 314
- bundle sheath extensions, 192
- Bunsen coefficient, 201
- buoyancy
 - adiabatic ascent, 288
 - convective mixed layer, 283
 - deep convection, 308
 - free convection, 228
 - hydrostatic disequilibrium, 288
 - instability, atmosphere, 290
 - Obukhov length, 292
 - potential temperature, 287
 - solar energy, 281
 - turbulence kinetic energy, 308
 - vertical gradient, 288
 - z/L , 293
- BVOC, biogenic volatile organic compounds
 - acetaldehyde, 398
 - acetone, 397
 - dimethyl sulfide, DMS, 399
 - general, 396
 - global aerosol production, 411
 - Henry's Law, 406
 - isoprene, 397, 399
 - lifetime, 398
 - mechanisms of oxidation, 396
 - methanol, 397
 - methylbutenol, 397
 - monoterpenes, 397
 - oxidation, polluted, 413
 - oxidation, unpolluted, 412
 - oxygenated, 397
 - ozone formation, 414
 - pollution, 406
 - secondary organic aerosols, 397
 - sesquiterpenes, 397
 - stomatal control, 404
- C_3 photosynthetic pathway, 70
- C_4 photosynthetic pathway, 85, 87, 422
- canopy
 - albedo, 270
 - Beer–Lambert Law, 259
 - BVOC oxidation, 409
 - evapotranspiration, 356
 - flux models, 266
 - gap fraction, 249, 257, 260, 267
 - geometric-optic models, 267
 - leaf area distribution function, 261
 - leaf clumping, 252, 263
 - leaf orientation, 259, 261
 - lidar, 275, 276
 - MODIS, 274
 - multiple-layer model, 358
 - N distribution, 354, 358
 - NDVI, 273
 - non-Gaussian PPFD distribution, 265
 - penumbra, 251
 - PPFD gradient, 357
 - shear stress, 331
 - skewness, turbulence, 367
 - spectral shortcut, turbulence, 336
 - sun/shade big-leaf model, 266, 358
 - sunlit fraction, 278, 357
 - sweep and ejection, turbulence, 333
 - turbid medium, photons, 245, 265
 - von Karman streets, turbulence, 336
 - wake, turbulence, 337
 - waves, wind, 319
- capping inversion, 282
- carbon dioxide, i, 1
- carbonic anhydrase, 73, 422
- carboxylation efficiency, 103
- Casparian strips, 211
- Chandrasekhar, Subrahmanyan, 255
- chemical potential, 20, 27, 133
- chemical reaction
 - catalyst, 41, 50
 - displaced from equilibrium, 49
 - endergonic, 44
 - energy of activation, 41, 43
 - equilibrium, 40, 46
 - exergonic, 44, 46
 - kinetics, 39
 - law of mass action, 39
 - order of reaction, 39
 - oxidation reaction, 47
 - Q_{10} , 44, 60
 - rate constants, 39
 - rate law, 39
 - redox reactions, 49
 - reduction reactions, 47
 - standard free energy, 45
 - standard reduction potential, 48
 - steady state, 40
 - stoichiometry, 39
 - temperature, 43, 44, 60
 - thermodynamics, 46
 - transition state, 41, 58
- chloroplast
 - CO_2 concentration, 73, 90

- CO₂ concentration, Rubisco, 167
- diffusive resistance, 167
- electron transport, 70
- isoprene, 401
- migration in cell, 187
- phosphate balance, 79, 95
- photon harvesting, 69
- photorespiration, 95
- photosynthetic components, 69
- redox reactions, 70
- RPP pathway, 70
- Rubisco protein concentration, 74, 92
- stroma, 73
- chronosequence, 248, 378
- Clausius–Clapeyron equation, 230, 237, 239
- climate warming, 226
- CLM, Community Land Model, 362
- cloud condensation nuclei, 286
- CO₂ compensation point, 101, 122
- CO₂ concentration, 90
- collimated light, 187
- combination equation, 233, 239
- conditional analysis, 333
- conductance
 - aerodynamic, canopy, 315
 - Ball–Woodrow–Berry, stomatal, 159
 - boundary layer, leaf, 138
 - Knudsen diffusion, 123
 - leaf, 146, 190
 - Ohm’s Law, 119
 - Penman–Monteith model, 234
 - pore end effect, 131
 - pore perimeter effect, 129
 - Stefan–Maxwell model, 120
 - stomatal, 144, 162
 - ternary, 169
 - thermal, 24
 - thermal, leaf boundary layer, 142
 - thermodynamic derivation, 169
 - viscous flow, 128
- constant flux layer, 284
- continuity
 - control volume, 133
 - diffusion, 119
 - Fick’s Second Law, 119, 133
 - flux divergence, 133
 - general, 4, 30, 112, 133, 349
 - Richards equation, 206
- control volume, 133, 206, 239, 349, 362, 425
- convection
 - deep convection cells, 308
 - free, 228
 - general, 228
- convective mixed layer, 282
- convergent evolution, 178
- Coriolis force, 282
- cost-benefit
 - leaf, 173, 178, 179, 196
 - xylem construction, 216
- counter-gradient transport, 340, 371
- Craig–Gordon model, 421
 - derivation, 432
- Cram, Donald, 64
- Criegie Intermediate, 408
- Crutzen, Paul, 1
- cumulus clouds, 286
- cyanide-resistant respiration, 97, 98
- Dalton, John, 233
- Darcy’s Law, 125, 205, 206
- decomposition
 - climate control, 385
 - constraint by NPP, 384
 - exoenzymes, 375, 394
 - general, 374
 - kinetic models, 392
 - lignin, 375, 377
 - microbial guilds, 394
 - mineralization, 374
 - photodegradation, 376
 - priming, 375
- denitrification
 - general, 391
 - hole-in-pipe model, 392
 - N₂ production, 391
 - NO and NO₂ production, 391
 - redox reactions, 391
- Denmead, Thomas, 368
- adiabatic
 - dew point, 231
 - evaporation, 28, 241
 - general, 28
 - latent heat exchange, 242
 - Penman–Monteith model, 236
- diffuse-porous wood, 214
- diffusion
 - binary, 111, 113, 118, 126, 146, 422
 - boundary layer resistance, 138
 - BVOCs, 405
 - CO₂, within leaf, 190, 199
 - conductance, 119
 - diffusivity, 114
 - driving force, 112, 134
 - eddy diffusion, 117
 - Einstein–Stokes equation, 117
 - evolutionary constraint, leaf, 168
 - Fick’s First Law, 118
 - Fick’s Second Law, 119
 - isotope fractionation, 417
 - Knudsen diffusion, 121, 123
 - leaf resistance, 138
 - length scale, 117

- diffusion (cont.)
 - mass fractionation, 128
 - mean free path, 114
 - molecular, 13, 111, 112, 114, 117, 118, 121, 122, 126, 340
 - molecular fractionation, 116
 - nonequimolar flux, 114
 - non-segregative, 113, 121, 123
 - Ohm's Law, 119
 - paradox of pores, 128
 - pore effective length, 131
 - pore end correction, 130
 - pore perimeter effect, 129
 - porous media, 121, 204
 - pressure effect, 135
 - resistance, 112, 123, 134
 - retroflux, isotope fractionation, 422
 - segregative, 113, 121, 123
 - slip flux, 114, 122
 - Stefan–Maxwell equation, 120, 147
 - stomata, 128, 138
 - ternary, 101, 122, 130
 - thermodynamic context, 118
 - thermodynamics, 133
 - transition, Knudsen-to-ordinary, 125
 - viscous flux, 121, 124, 170
- diffusivity
 - boundary layer, leaf, 144
 - CO₂, 114, 117, 144
 - eddy, 328
 - Fick's First Law, 118
 - general, 114
 - heat, 140
 - helox, 152
 - Knudsen, 126, 127
 - K*-theory, canopy, 348
 - leaf, 145
 - molecular fractionation, 116
 - molecular mass, 116
 - pressure effect, 114, 115
 - Stefan–Maxwell model, 120
 - temperature effect, 114
 - ternary, 146
 - water vapor, 144
- dimensionless number
 - Buckingham Pi theorem, 314
 - drag coefficient, 314
 - general, 314
 - Reynolds number, 314
- dipole moment, 36
- DMS, dimethyl sulfide, 399
- Dokuchayev, Vasily, 373
- drag
 - aerodynamic roughness length, 315
 - drag coefficient, 315
 - friction, 297
 - general, 30, 139, 283
 - leaf surface, 139
 - relation to shear, 30
- dynamic xylem stress, 212
- ecosystem, definition, 2
- eddies
 - conditional analysis, 333
 - Eulerian scales, 318
 - general, 298
 - gustiness, 296
 - horizontally advected, 299
 - inertial subrange, 312
 - Kelvin–Helmholtz instabilities, 139
 - mixing length, 329
 - phase frequency data, 310
 - plane mixing layers, 332
 - Rayleigh–Taylor instabilities, 284
 - roll and braid structure, 333
 - spectral analysis, 310
 - spectral shortcut, 336
 - sweep-ejection, 333
 - Taylor's frozen turbulence, 299
 - TKE, turbulence kinetic energy, 307
 - viscosity, 297
- eddy covariance, 301, 328, 343
- eddy diffusivity, 328
- eddy flux
 - air density effects, 341
 - canopy CO₂ storage term, 339
 - co-spectral analysis, 339
 - covariance, 301
 - derived from continuity, 349
 - energy budget closure, 340
 - Eulerian, 316
 - Gaussian closure, 367
 - K*-theory, 329, 340
 - measurement, 339
 - relation to diffusive flux, 338
 - relation to NPP, 339
 - Webb–Pearman–Leuning correction, 343
- Einstein, Albert, 31, 111
- Einstein–Smoluchowski relation, 134, 169
- electrochemical potential, 49
- electromagnetic radiation, 31, 34
- electronegative, 47
- emittance, 32
- Encelia farinosa*, 185
- endergonic process, 20, 44, 52
- endodermis, 209
- energy
 - conservation, 30
 - electromagnetic radiation, 31
 - free, 18, 20, 44, 205
 - general, 17
 - internal, 16, 26, 237
 - joule, 17
 - kinetic, 17, 42, 111, 229, 282, 308

- latent heat exchange, 23
- potential, 15, 17, 29, 47
- radiant, 31, 35, 36
- solar, 17, 32, 223
- thermal, 18, 111, 224
- turbulence kinetic, 307
- energy of activation, 41, 58, 382
 - chemical reactions, 41
 - enzyme catalysis, 51
 - isotope discrimination, 416
 - Maxwell–Boltzmann distribution, 43
 - transition state, 41
- ensemble average, 323
- enthalpy, 18, 105
- entrainment flux, 362
- entropy, 19, 45, 105, 134, 229, 238
- enzyme
 - active site, 51
 - allosteric sites, 55
 - elasticity coefficient, 68
 - general, 50
 - induced fit, active site, 51
 - isotope discrimination, 416
 - kinetics, 62
 - K_m , 52
 - mathematical model, activity, 52
 - metabolic control, 65
 - Michaelis–Menten model, 52
 - pH dependence, 55
 - rapid equilibrium kinetics, 52
 - stable isotopes, 58
 - strain hypothesis, active site, 51
 - substrate affinity, 54
 - substrate cooperativity, 55
 - temperature dependence, 54
 - turnover number, 53
 - V_{max} , 52
- equation of state, 26, 28
- equifinality, 362
- erectophile leaf, 261
- ergodic condition, 319
- Eulerian
 - autocorrelation, 317
 - canopy flux model, 365
 - eddy flux, 365, 367
 - ergodic condition, 319
 - general, 316
 - length scale, 317, 332
 - stationarity, 319
 - Taylor’s frozen turbulence, 299
 - time scale, 317
- evaporation
 - adiabatic, 231, 241
 - Clausius–Clapeyron relation, 230
 - diabatic, 28, 241
 - general, 22, 23, 128, 233
 - isotopic fractionation, 59
 - solar energy, 230, 233, 236
 - thermodynamics, 229, 238
- evapotranspiration
 - big-leaf model, 356
 - control by entrainment, PBL, 363
 - Dalton model, 233
 - diffusive component, 233
 - equilibrium, 356
 - general, 9, 28, 229, 233
 - imposed, 356
 - net radiation component, 233
 - Penman–Monteith model, 233
 - Priestly–Taylor coefficient, 357
 - radiative coupling, 242
 - surface temperature feedback, 233, 240, 242
- EVI, Enhanced Vegetation Index, 274
- exergonic process, 20, 44
- Eyring equation, 61, 105
- Eyring, Henry, 61
- far infrared radiation
 - leaf, 185
 - solar spectrum, 32
- Farquhar, Graham, 89
- fast Fourier transform, 310
- feedback
 - canopy evapotranspiration, 9
 - climate feedback, DMS, 399
 - gene expression, 109
 - general, 8
 - leaf temperature, transpiration, 151
 - metabolic, 66, 79
 - negative, 7
 - Penman–Monteith, radiative coupling, 242
 - photosynthesis, phosphate, 80
 - positive, 7, 218, 242
 - stomatal conductance, humidity, 149
- Fick, Adolf, 118
- Fick’s First Law of Diffusion, 118, 133
- Fick’s Second Law of Diffusion, 119, 131
- flux
 - canopy, 337
 - control coefficient, metabolism, 66
 - co-spectrum, 311, 338
 - covariance, 301
 - density, 3
 - divergence, 30, 206
 - driving variables, 4
 - eddy, 339
 - mesoscale, 343
 - non-linear averaging, 193
 - open system, 16
 - sink, 3
 - source, 3
 - thermodynamic context, 17
- flux-gradient relation
 - counter-gradient transport, 340

- flux-radiant relation (cont.)
 - eddy diffusivity, 328
 - eddy flux, 340
 - general, 330
 - K*-theory, 340
 - tall canopies, 340
- force
 - body force, 30
 - buoyancy, 288
 - Coriolis, 282
 - diffusive, 111
 - driving force, transport, 15
 - general, 17
 - gravitational, 21, 22
 - Newton, 17
 - pressure, 17, 30
- forests
 - albedo, 226, 270, 271
 - ammonia emissions, 403
 - BVOC oxidation, 409
 - displacement height, 306
 - effect on climate change, 226
 - gap fraction, 249, 260
 - hydroxyl radical formation, 409
 - influence on surface energy budget, 226
 - leaf area index, 248, 261
 - leaf clumping, 252, 263
 - nitric oxide exchange, 404
 - soil organic matter, 383
 - SOM, turnover time, 429
 - turbulence, 333
- formaldehyde, 413
- forward modeling, 12
- Fourier's law, 24, 140, 228
- free troposphere, 281
- friction
 - drag, 297
 - drag coefficient, 315
 - general, 30
 - wind, 297
- friction velocity
 - aerodynamic resistance, 316
 - general, 305
 - measurement, 306
 - vertical wind speed profile, 305
- fugacity, 27
- Gaia, 1
- gap fraction, 267
- Gates, David, 222
- GDM, Guild Decomposition Model, soil, 393
- geometric-optic models, 267
- geostrophic flow, 281
- G-function, 260, 279
- Gibbs free energy, 20, 45, 238
- Gibbs, Josiah Willard, 15, 20
- girdling, trees, 379
- global carbon budget, 4, 181, 226, 384, 395
- global warming, 35, 108, 388
- global water cycle, 23, 203
- Graham, Thomas, 111, 118
- Graham's Law, 117, 389
- greenhouse gases, 35, 37
- gross CO₂ assimilation rate, 100
- gross primary productivity
 - global, 4
 - MODIS, 274
- Hagen–Poiseuille Law, 124
- heat
 - dew, 224
 - adiabatic exchange, 28
 - diffusivity, 140
 - Fourier's Law, 24
 - general, 23
 - latent, 34, 203, 223, 224, 229, 233
 - molecular motion, 111
 - partitioning between sensible and latent, 224
 - sensible, 24, 34, 223, 227
 - soil heat flux plates, 25
 - stored radiant energy, 223
 - thermal conductivity, 142
 - thermal updrafts, 285
 - transfer coefficient, 140
- helox, 151
- Henry's Law, 72, 201, 402
- heterobaric leaves, 194
- higher-order model closure, 367
- homobaric leaves, 194
- humidity
 - mole fraction, 27
 - relative, 231
 - temperature dependence, 230
 - wet-bulb temperature, 231
- humus, 378
- hydraulic conductance
 - aquaporins, leaves, 218
 - catastrophic failure, 216
 - embolism, 216, 218
 - evolution, 214
 - measurement, 217
 - models, 220
 - pressure head, 207
 - Richards equation, 205
 - tracheids vs. vessels, 214
- hydraulic lift, 221
- hydraulic vulnerability curve, 217
- hydrostatic equilibrium, 288
- hydroxyl radical
 - abstraction reaction, 414
 - addition reaction, 414
 - formation, 406, 412
 - regeneration above forests, 409
- hypertonic, 23

- hypostomatous, 194
- hypotonic, 23
- ideal gas law, 26, 28
- immobilization, soil nutrient, 374
- inertial cascade, 298
- internal energy, 15, 16, 17, 18, 19, 20, 26, 28
- inverse modeling, 12
- inviscid flow, 139
- isoprene, 414
 - aerosol production, 411
 - basal emission rate, 400
 - chloroplast, 399
 - CO₂ dependence, 400
 - emission models, 400
 - general, 397
 - global emissions, 397
 - isoprene synthase, 401
 - leaf N dependence, 271
 - photosynthetic electron transport, 399
 - PPFD dependence, 400
 - stomatal control, 404
 - temperature dependence, 400
- isothermal Penman–Monteith equation, 242
- isotope effects
 - chemical reactions, 58
 - dependence on leakage, 60
 - diffusion, 58
 - discrimination, 57
 - dissolution of CO₂ in H₂O, 59
 - evaporation, 420
 - fractionation, 59
 - general, 57
 - kinetic, 59
 - Rubisco, 416
 - thermodynamic, 59, 421
- isotopic disequilibrium, 426
- Jarvis, Paul, 12, 136, 168
- Jensen's inequality, 193
- Joule, James, 28
- Kaimal, J.C., 327
- katabatic flow, 322
- Keeling, Charles, 415
- Keeling plot, 423
- Kelvin–Helmholtz instabilities, 139, 283
- Knudsen number, 123
- Kolmogorov microscale, 310
- Krebs cycle, 82
- K-theory, 329, 348
- Lagrangian
 - canopy flux models, 368
 - dispersion, 369
 - dispersion matrix, model, 370
 - far-field, 369
 - general, 317
 - Langevin equation, 371
 - near-field, 369
 - time scale, 318
 - transition probability, 368
- Lambertian assumption, 186
- laminar flow, 139
- land breeze, 343
- land-use, climate change, 226
- large eddy simulation, 367
- latent heat
 - Clausius–Clapeyron relation, 230
 - equilibrium transpiration, 236
 - exchange, 7, 136, 143, 150, 175, 204, 224, 233
 - general, 229
 - partitioning, 224, 236
 - Penman–Monteith, 239
 - vaporization, 224, 238
- leaf area density, 245
- leaf area index
 - chronosequence, 248
 - climate influences, 247
 - crops, 249
 - displacement height, 307
 - effective LAI, 258
 - forest succession, 249
 - general, 245
 - G-function, 259, 279
 - maximum limit, 247, 261
 - measurement, 264
 - MODIS, 274
 - NDVI, 273
 - probability, photon transfer, 257, 277, 278
 - projected leaf area, 261
 - representative ecosystems, 246, 248
 - scaling, 247
 - sunlit fraction, 263
- leaf CO₂ transport path, 190, 200
- leaf conductance, 146
- leaf diffusion
 - ¹³CO₂ fractionation, 418
 - boundary layer, 143
 - CO₂, 190, 200
 - general, 138
 - Graham's Law, 117
 - H₂O, 191
 - helox, 152
 - methane, 389
 - ordinary diffusion vs. viscous flow, 128
 - resistances, in series, 138
 - stomata, 144
- leaf energy budget, 174, 175, 185, 222
- leaf H₂O transport path, 191, 218
- leaf hairs, 184
- leaf internal resistance
 - general, 167, 190, 200
 - measurement, 167

- leaf life span, 177, 178, 180
- leaf light traps, 188
- leaf photon absorption, 181, 198
- leaf scattering phase function, 186
- leaf-to-air vapor pressure difference, 146
- lidar, 275, 276
- lifting condensation level, 286
- lignin, 377
- local lapse rate, 291
- longwave radiation, 32, 35, 223, 242
- Lovelock, James, 1
- Margulis, Lynn, 1
- Markov model, 265, 278
- mass balance, 132
- mass density, 26, 119, 343
- Maxwell–Boltzmann energy distribution, 42
- McCree–Thornley model, 96
- mesophyll area ratio, 191, 201
- mesophyll resistance, 166
- mesoscale flux, 343
- metabolic control analysis, 65
- metabolism
 - connectivity theorem, 68
 - dynamic stability, 66
 - elasticity coefficient, 67
 - endergonic process, 46
 - exergonic process, 46
 - feedback, 64, 65
 - flux control coefficient, 66
 - general, 64
 - isotope effects, 57
 - pacemaker enzymes, 68
 - pathways, 65
 - redox reactions, 46
 - shared control, 68
 - stable isotopes, 58
 - structural stability, 66
 - summation theorem, 67
- methane, 37, 50, 414
 - aerenchyma, 388
 - climate warming, 388
 - diffusion, transport, 388
 - ebullition, transport, 388
 - free energy, methanogenesis, 386
 - general, 386
 - global, 386
 - Knudsen flow, transport, 389
 - methanogenesis, 374, 386
 - methanotrophic bacteria, 386
 - oxidation, 412
 - stable isotope fractionation, 390
 - Venturi transport, 390
 - viscous flux, transport, 388
 - wetland transport, 390
- methanogenesis, 374
- methanogenic archaea, 386
- methanol emissions, leaf
 - general, 397
 - pectin demethylation, 402
 - stomatal control, 404
- methanotrophic bacteria, 386
- Michaelis–Menten equation, 52, 62, 63, 91, 93, 94, 393
- mineralization
 - general, 374
 - priming, 375
- mixing length, 325, 329
- mixing ratio, 26, 27, 343
- models
 - analytical, 89
 - big-leaf, 353, 356
 - bottom-up, 11
 - box, 362
 - closure, leaf flux, 166
 - closure, turbulence, 367
 - empirically-based, 11
 - entrainment flux, 363
 - equifinality, 362
 - Eulerian, 365
 - forward modeling, 11, 12, 353
 - inverse modeling, 11, 12, 274, 353
 - large eddy simulation, 367
 - multiple-layer, 358
 - numerical, 89
 - photosynthesis, 89
 - soil decomposition, 392
 - top-down, 11
- MODIS, Moderate Resolution Imaging Spectrophotometer, 274
- molar density, 26
- mole fraction, 26, 119
- Molina, Mario, 1
- momentum
 - conservation, 30
 - deformation transfer, 305
 - flux, 284, 308, 325
 - friction velocity, 305
 - general, 26, 30
 - leaf boundary layer, 139, 142
 - plane mixing layers, 332
 - production, 308
 - rigid rotation transfer, 305
 - shear stress, 139, 303
 - TKE budget, 308
 - transfer, 301, 303, 304, 316, 327
 - translation transfer, 305
 - viscosity, 297
 - wake motions, canopy, 336
- Monin, Andrei, 327
- Monin–Obukhov similarity theory, 328, 347
- monoterpenes, 397
- Mooney, Harold, 221
- Myneni, Ranga, 256

- NADPH
 - electron transport, 104
 - isoprene, 401
 - photorespiration, 81
 - RPP pathway, 69
 - RuBP regeneration, 93
- Navier–Stokes equations, 29, 30, 301
- NDVI, normalized difference vegetation
 - index, 273
- near-infrared radiation, 32, 269
 - leaf, 181
- Nernst equation, 49
- net CO₂ assimilation
 - canopy, 361, 362
 - compensation point, 101, 122
 - definition, 101
 - Farquhar model, 105
 - isotope fractionation, 419
 - isotopic, retroflux, 422
 - leaf structure, model, 200
 - vertical profile, canopy, 353, 361
 - vertical profile, leaf, 198
 - volumetric, mesophyll, 200
- net primary production
 - definition, 181, 274
 - soil organic matter, 384
 - soil respiration, 381
- net radiation, 34, 223, 225, 226, 242
- neutral stability, atmosphere, 290
- Newton's Second Law of Motion, 30, 297
- nitrate radicals, 408
- nitric oxide, 398, 414
- nitric oxide emissions, leaf, 403
- nitrification
 - general, 390
- Nitrobacter*, 390
- Nitrosomonas*, 390
- nitrous oxide, 50, 390
- Nobel, Park, 191
- nocturnal jet, 320
- non-linear averaging errors, 193
- non-linear relations, 5, 7
- no-slip assumption, 139
- NO_x
 - conceptual model, soil emissions, 392
 - ozone, 390
 - redox reactions, 391
- numbra, 250
- Nusselt number, 141
- O·(¹D), 406
- O¹⁸/O¹⁶ ratio, 420
- Obukhov, Alexander, 327
- Obukhov length, 292
- Ohm's Law, 119
- osmosis, 23
- O_x-HO_x-NO_x chemistry, 412
- oxidation reactions, 46
- oxidation state, 46, 47
- oxygen, source in atmosphere, 50
- ozone
 - global warming, 36
 - NO-NO₂ cycle, 413
 - O·(³P), formation, 413
 - photolysis, 412
- ozonolysis, 408
- pacemaker enzymes, 65
- palisade mesophyll, 175, 194
- partial pressure, 27
- pedotransfer function, 208, 219
- Penman, H.L., 232, 233
- Penman–Monteith equation, 233, 234, 239, 355, 356
- penumbra
 - general, 251
 - half-width, 252
 - light-use efficiency, 252
 - Monte Carlo model, 252, 268
- peroxy radicals, 407
- PGA, 3-phosphoglyceric acid, 70, 93, 95
- Philip, John R., 203
- phloem, 175, 209
- phosphoglycolate, 80
- photocompensation point, 101
- photodegradation, 375, 376
- photon, 31
 - absorption, 274
 - albedo, 223
 - binomial transfer function, 275
 - downwelling stream, 271
 - epidermal focusing, 187
 - integro-differential transport equation, 255
 - leaf internal scattering, 181, 198
 - leaf reflectance, 181, 185
 - Poisson probability, photon transfer, 277
 - probability, photon transfer, 275
 - scattering, 255, 266
 - transmittance, 278
 - upwelling stream, 271
- photophosphorylation, 95
- photorespiration
 - CO₂ compensation point, 101
 - general, 80
 - photocompensation point, 101
 - stoichiometry, 81, 93, 95
 - temperature dependence, 82
- photosynthesis
 - albedo/N relation, 271
 - atmospheric CO₂, 107, 108
 - biochemical conductance, 168
 - C₄, 54, 85
 - canopy modeling, 353
 - carbonic anhydrase, 73

- photosynthesis (cont.)
 carboxylation efficiency, 103
 CO₂ compensation point, 102, 122
 CO₂ dependence, 26, 73, 90, 101, 103, 106, 164, 190
 CO₂ solubility, 73
 electron transport, 69, 93, 104, 105
 entropy, 20
 evolution, 168, 191
 fluorescence, 47
 gross, 82, 101, 115
 high elevation, 115
 inorganic phosphate, 71
 internal resistance, 167
 isoprene, 399
 leaf internal conductance, 166, 190
 light-use efficiency, 188, 197, 274
 mesophyll thickness, 199
 MODIS, 274
 multiple-layer model, canopy, 358
 NDVI, 273
 net, 101, 105, 178, 271
 nitrogen-use efficiency, 87, 354
 non-linear averaging, 193
 penumbra, 252
 photon harvesting, chloroplast, 47, 69, 93
 photon harvesting, leaf, 188, 273
 potential energy, 20
 PPFD dependence, 90, 101, 102, 104, 106, 188, 189, 193, 196
 redox reactions, 47
 reductive pentose phosphate pathway, 70
 remote sensing, 273
 Rubisco-limited state, 90, 91, 103, 110
 RuBP-limited state, 77, 90, 93, 95, 104, 110
 scaling, 101, 106, 110, 199
 shade leaf, 178
 stable isotope fractionation, 58, 128
 stomatal control, 149, 152, 153, 156, 163
 supply-demand, CO₂, 191
 temperature dependence, 105, 175
 triose phosphate utilization limitation, 79, 109
 water-use efficiency, 82, 87, 152, 174
 photosynthetically-active radiation, 32
 phytometrics, 244
 plagiophile leaf, 261
 Planck, Max, 31
 Planck's radiation distribution law, 31
 plane mixing layers, 332
 planophile leaf, 261
 plant functional type, 177, 179
 plasmodesmata, 211
 Poisson model, 277
 potential temperature, 285, 287, 288
 PPFD
 diffuse, 250, 255, 265, 269, 358
 direct, 250, 265, 358
 general, 32
 G-function, 260
 numbra, 250
 penumbra, 251
 sunlit fraction, canopy, 260
 umbra, 251
 PPFD gradient
 canopy, 355
 leaf, 189, 196, 199
 Prandtl's mixing layer theory, 325
 pressure, 28, 115, 294, 309
 gradient, 113, 114, 123, 125, 126, 136, 169, 288, 297, 298, 303, 319
 kinetic energy, 26
 pressure head, soil, 206
 Priestley–Taylor coefficient, 357
 psychrometer constant, 232

 Q₁₀ model, 44, 62, 100

 radiant energy, 31, 223, 242
 radiative transfer
 Beer–Lambert Law, 259
 canopy flux models, 266
 canopy, models, 267
 discrete ordinate method, 256
 integro-differential transport equation, 255
 leaf area distribution function, 261
 Markov model, 265, 278
 models, 35
 Monte Carlo model, 268, 269
 Poisson model, 277
 probability, photon transfer, 257, 275, 278
 theory, 255
 two-stream model, 271
 Raschke, Klaus, 144, 222
 Rasmussen, Rei, 395
 rate-limiting enzymes, 65
 Raupach, Michael, 368
 Reagan, Ronald, 406
 recollision probability, 269
 redox reactions, 2, 46, 47, 49, 50
 reduction potential, redox, 48
 reductive pentose phosphate pathway
 atmospheric CO₂, 108
 general, 70
 metabolic control, 95
 Rubisco, 73, 108
 stoichiometry, 71, 94, 102
 relative humidity, 230, 231, 421
 remote sensing
 AVHRR, 274
 bidirectional reflectance distribution function, 274
 Enhanced Vegetation Index, EVI, 274
 general, 273
 gross primary productivity, global, 274

- lidar, 275
- MODIS, 274
- NDVI, 273
- resistance
 - aerodynamic, 315
 - boundary layer, leaf, 138, 139, 235
 - Fick's First Law, 119
 - friction, drag, 30
 - internal (mesophyll), leaf, 138, 166
 - Knudsen diffusion, 123
 - leaf boundary layer, 142
 - Ohm's Law, 119
 - pore end effect, 131
 - Stefan–Maxwell model, 120
 - stomatal, 144
- respiration, 48
 - decomposition, 380
 - ecosystem, 423
 - electron transport, 48
 - enthalpy-balance model, 98
 - general, 82, 96
 - global, 4
 - growth, 83
 - growth efficiency, 97
 - isotope fractionation, 417
 - Keeling plot, 423
 - leaf N concentration, 98
 - maintenance, 83, 96, 98
 - microbial, 50, 97
 - photodegradation, 375
 - Q_{10} , 100
 - redox reactions, 48
 - rhizospheric, 379
 - scaling, 85, 96, 98
 - temperature, 99, 105
 - thermodynamics, 96, 97, 100
- retroflux, isotope, 422
- Reynolds averaging, 300, 301, 304, 323, 337
- Reynolds number, 141, 314
- Reynolds shear stress, 304, 324, 332
- rhizodeposition, 375
- ribulose 5-phosphate (Ru5P) kinase, 78
- Richards equation, 205, 206
- Richards, Lorenzo, 206
- Richardson number, 291
- ring-porous wood, 214
- root
 - apoplastic flow, 210
 - cortex, 209
 - endodermis, 209
 - H₂O transport path, 209
 - positive pressure, 216
 - stele, 209
 - symplastic flow, 211
 - water viscosity, 211
- Ross, Juhan, 244, 256
- roughness sublayer, 283, 284
- Rowland, Sherwood, 1
- Rubisco activase, 74
- Rubisco, ribulose 1,5-bisphosphate carboxylase/
 - oxygenase
 - ¹³C discrimination, 416
 - activation, 74
 - C₄ photosynthesis, 85
 - canopy vertical gradient, 362
 - catalytic mechanism, 74
 - CO₂ dependence, 27, 54, 72, 73, 90, 91, 102
 - evolution, 74
 - general, 64, 73
 - isotope discrimination, 59
 - isotope effect, 416
 - K_c , 75, 91, 106
 - leaf vertical gradient, 190, 197
 - metabolic control, 76, 79
 - oxygenase, 75, 80, 91, 93
 - photosynthetic constraint, 168
 - relation to leaf albedo, 273
 - relative specificity factor, 75
 - RPP pathway, 70, 73
 - RuBP dependence, 90
 - temperature dependence, 75
 - V_{cmax} , 75, 91, 103, 106
- Rubisco-limited photosynthesis, 90
- RuBP enediolate, 74
- RuBP regeneration, 40, 71, 93
- RuBP-limited photosynthesis, 90, 93
- Sahel Africa, 343
- saturation vapor deficit, 231, 233
- scalar, 3
- scaling, hierarchical modeling, 12
- sea breeze, 343
- sedoheptulose 1,7-bisphosphatase, 78
- sensible heat
 - adiabatic ascent, 288
 - convection, 228
 - flux, leaf, 223
 - Fourier's Law, 24
 - general, 24
 - leaf boundary layer flux, 141, 142
 - partitioning, 224
 - surface roughness, 226
 - temperature gradient, 229
- sequoia, 212
- sesquiterpenes, 397
- Shannon, Claude, 19
- shared metabolic control, 65
- shear
 - aerodynamic roughness length, 305, 315
 - displacement height, 305
 - general, 301
 - mechanical stress, 139

- shear (cont.)
 - momentum transfer, 297
 - Obukhov length, 292
 - plane mixing layers, 332
 - Reynolds shear stress, 324
 - turbulence kinetic energy, 282
 - viscosity, 303
- shortwave radiation, 32, 34, 223
- singlet oxygen
 - excited, 406
 - ground state, 406
- sink, flux, 3
- skylight, 250
- soil
 - capillaries, 208
 - exoenzymes, 375, 394
 - fulvic acids, 378
 - horizons, 374
 - humus, 378
 - porosity, 204
 - pressure head, 206
 - priming, 375
 - rhizodeposition, 375
 - soil organic matter, 374
 - SOM age, 375
 - SOM priming, 375
 - tortuosity, 204
 - water potential, 204
 - water retention curve, 208
 - water viscosity, 209
- soil heat flux, 25
- soil organic matter
 - ^{14}C , 428
 - active pool, 380
 - hydrophobicity, 384
 - isotopic disequilibrium, 426
 - oxidation, 49, 406
 - passive pool, 381
 - residence time, global average, 427
 - slow pool, 381
 - Suess effect, 427
 - temperature sensitivity, decomposition, 382
 - turnover kinetic models, 393
- soil respiration, 50, 373, 379
 - Birch effect, 384
 - latitudinal gradient, 382
 - lignin, 380
 - microbial guilds, 381
 - moisture dependence, 383
 - pressure pulses, 384
 - Q_{10} , 381
 - redox reactions, 49
 - Suess effect, 427
 - temperature dependence, 381
- soil-plant-atmosphere continuum, 22, 203, 220
- source, flux, 3
- specific heat
 - air, constant pressure, 289
 - air, constant volume, 289
 - general, 228
- specific leaf area, 177
- specular reflectance, 181
 - leaf, 183, 186
 - polarized, 184
- spongy mesophyll, 175, 183
- stable isotopes
 - abundance ratio, 57
 - atmosphere, 58
 - atmospheric disequilibrium, 426
 - bicarbonate, 59
 - carbonic anhydrase, 422
 - c_i/c_a , fractionation, 418
 - delta notation, 57, 58
 - discrimination, 57
 - disequilibrium flux, 427
 - evaporative fractionation, 59
 - Farquhar model, 429
 - fractionation, 57
 - general, 55, 56
 - H_2O fractionation, 420
 - isotope effects, 57, 59
 - Keeling plot, 423
 - kinetic, 59
 - leaf discrimination, 417
 - leaf fractionation, 429
 - leakage, 60
 - respiration, fractionation, 418
 - retroflux, 422
 - Rubisco discrimination, 59
 - Suess effect, 427
 - water-use efficiency, 419
- state variable
 - conjugates, 17
 - general, 4
 - thermodynamic system, 16
- static stability, 290
 - atmosphere, 291
- Stefan–Boltzmann Law, 32, 242
- Stefan–Maxwell equation, 120, 121
- stele, 209
- stoichiometry, 39, 102
- stomata
 - ATP, 147, 162
 - blue light sensor, 149
 - evolution, 155, 156
 - guard cell mechanisms, 147, 158, 162
 - leaf alveolus, 194
 - optimal function, 155
 - patchy, 195
 - PPFD sensors, 149
 - red light sensor, 149
 - turgor, 144, 147

- stomatal conductance
 - abscisic acid, 157
 - Ball–Berry model, 159, 171
 - CO₂, 146
 - CO₂ dependence, 152, 153
 - control by photosynthesis rate, 158
 - control by xylem water potential, 192
 - Fick’s First Law, 145
 - general, 144, 146
 - humidity response, theories, 153
 - isoprene, 404
 - leaf N concentration, 159
 - leaf-to-air vapor concentration difference, 146, 149, 153
 - Leuning model, 161, 171
 - methanol, 404
 - Monteith model, 161, 171
 - optimality, 156, 191
 - patchy stomatal behavior, 195
 - PPFD dependence, 149, 153
 - relative humidity, 153
 - soil water potential, 157
 - temperature dependence, 151, 153
 - ternary interactions, 147, 169
 - transpiration dependence, 151
 - viscous flow, 128
 - xylem constraint, 217
- strong nuclear force, 56
- suberin, 211
- Suess effect, 427
- Sullivan, Louis Henri, 173
- summation theorem, metabolic control, 67
- sunfleck, 250, 254, 278
- surface energy budget
 - albedo, 9
 - ecosystem, 225
 - general, 18, 34
 - leaf, 174, 185
 - surface roughness, 226
 - turbulence, 283
- surface layer, atmosphere
 - constant flux layer, 284
 - general, 283
- symplast, 192
- systems biology, 64
- Taylor’s frozen turbulence hypothesis, 299
- TCA, tricarboxylic acid pathway, 82
- Teisserenc de Bort, Leon Philippe, 280
- temperature, 28
 - adiabatic processes, 28
 - dew point, 230
 - equilibrium, 18
 - general, 24
 - intensive property, 24
 - leaf, 142, 143, 151, 175, 223, 224
 - leaf, Δc_w , 150
 - potential, 287
 - scale, 25
 - state variable, 24
 - temperature vs. heat, 23
 - virtual potential, 287
 - wet-bulb, 230
 - Zeroth Law, 18
- temperature acclimation, 100
- ternary diffusion, 122
- thermal conductivity, 24, 25, 142, 224
- thermal equilibrium, 18
- thermodynamics
 - biogeochemistry, 16, 17
 - chemical equilibrium, 38
 - chemical potential, 20, 133
 - closed system, 16
 - diffusion, 118
 - disequilibrium, 15, 17
 - endergonic processes, 20
 - enthalpy, 18, 105
 - entropy, 19, 105, 224
 - equation of state, 26
 - equilibrium, 16
 - exergonic processes, 20, 28
 - First Law, 18
 - force, 17
 - general, 17
 - heat, 23
 - internal energy, 26
 - irreversible processes, 19
 - isolated system, 16
 - open system, 16
 - potential energy, 15
 - potential temperature, 294
 - Second Law, 19
 - spontaneous processes, 19
 - temperature, 24
 - water potential, 21, 205
 - work, 15, 17, 20
 - Zeroth Law, 18, 24
- trace gases, 50
- tracheid, 213
- transpiration
 - big-leaf model, 356
 - control by roots, 209
 - equilibrium, 236
 - imposed, 236
 - isotope fractionation, 421
 - leaf diffusion, 146
 - leaf energy budget, 175
 - meteorological control, 236
 - physiological control, 236
 - rate equation, 146
 - stomatal control, 149
 - ternary conductance, 146

- transpiration (cont.)
 - thermodynamics, 191, 203
 - xylem cavitation, 216
- triose phosphate utilization limitation, 90, 95
- triose-phosphate sugar, 70
- troposphere
 - capping inversion, 282
 - convective mixed layer, 282
 - entrainment flux, 362
 - historical description, 280
 - residual layer, 283
 - roughness sublayer, 344
 - stable nocturnal layer, 283
 - structure, 281
 - surface layer, 282
- turbulence
 - atmospheric instability, 292
 - boundary layer, leaf, 139
 - buoyancy, 228, 283
 - canopy wakes and waves, 336
 - conditional analysis, 333
 - convection, free, 228
 - convective mixed layer, 284
 - eddies, 139, 281
 - Eulerian perspective, 316
 - frequency density, 310
 - friction velocity, 305
 - general, 139, 281
 - inertial cascade, 298
 - isotropic, 312
 - Kelvin–Helmholtz instabilities, 139
 - kinetic energy, 307
 - kurtosis, spectral distribution, 367
 - Lagrangian perspective, 317
 - mixing length, 325, 329
 - neutral atmosphere, 290
 - Obukhov length, 292
 - plane mixing layers, 332
 - Rayleigh–Taylor instabilities, 284
 - Reynolds averaging, 300
 - Reynolds number, 142, 315
 - Richardson number, 291
 - roll and braid structure, 333
 - shear, 330
 - skewed frequency distribution, 367
 - spatial persistence, Lagrangian, 368
 - spectral analysis, 310, 313
 - spectral shortcut, 336
 - sweep and ejection, canopy, 333
 - Taylor’s hypothesis, 299
 - turbulence intensity, 300
 - turbulence kinetic energy
 - budget, 308
 - buoyancy, 308
 - deep convection, 308
 - dissipation, 310
 - general, 282, 307
 - Kolmogorov microscale, 310
 - pressure fluctuations, 309
 - production, 308
 - spectral analysis, 311
 - turbulence transport, 309
 - viscosity, 310
- umbra, 251
- van Genuchten equation, 209
- van’t Hoff, Jacobus, 38, 44, 60
- vector, 3
- Vernadsky, Vladimir, 373
- virtual potential temperature, 288
- viscosity
 - drag, 297
 - dynamic, 30, 303
 - general, 139
 - hydraulic conductance, 211
 - kinematic, 142, 303
 - shear, 303
 - water, 192
- viscous flux, 124, 127, 228
- von Caemmerer, Susanne, 89
- von Humboldt, Alexander, 173
- von Karman streets, 336
- von Kármán, Theodore, 296
- von Newman, John, 19
- water potential
 - atmosphere, 191
 - general, 21, 22, 191
 - gravitational, 22, 207
 - humidity, 229
 - matric, 22, 204, 207, 220
 - osmotic, 22, 23, 204, 216
 - pressure, 22, 205, 207, 220
 - soil, 204, 221
 - thermodynamics, 211
 - volumetric, 205
 - xylem, 211
- water retention curve, 208
- water vapor
 - chemical potential, 229
 - concentration, 7, 160, 236
 - dew point, 230
 - mole fraction, 27
 - psychrometer constant, 232
 - saturation vapor deficit, 230
 - temperature dependence, 230, 232, 237
 - wet-bulb temperature, 230
- water-use efficiency
 - adaptive trait, 174
 - c_i/c_a dependence, 419
 - soil moisture control, 157

- stable isotope, 419
- stomata, CO₂ dependence, 152
- Webb–Pearman–Leuning correction, 343
- Went, Fritz, 395
- wet-bulb temperature, 231
- Wien’s displacement law, 32
- wind
 - advection, 298
 - aerodynamic resistance, 315
 - Cartesian coordinates, 298, 323
 - frictional force, 297
 - general, 297
 - inertial cascade, 298
 - katabatic flow, 322
 - logarithmic profile, 325
 - mean wind, 298
 - Navier–Stokes equations, 301
 - Newton’s Laws, 297
 - nocturnal jet, 320
 - pressure force, 297
 - spectral analysis, 313
 - variance, turbulent, 300
 - waves, 298, 319
- work, 17, 18, 20
 - adiabatic, 289, 294
 - cellular, 21
 - electrical, 48
 - internal energy, 20
 - potential energy, 17
 - wind, 297
- Wright, Frank Lloyd, 173
- Wyngaard, John, 327, 342
- xylem
 - adaptive tradeoffs, 216
 - air seeding, 216
 - catastrophic failure, 216
 - cavitation, 216, 218
 - dynamic stress, 212
 - embolism, 214, 216, 217, 219
 - general, 175, 209
 - hydraulic safety margin, 216
 - packing limit, 214
 - static stress, 211
 - tension, 203, 211, 218
 - tracheids, 213
 - vessels, 213
 - water potential, 22
 - water potential gradients, 212
 - water retention curve, 219
 - water viscosity, 217
- zero-plane displacement height, 305