

Index

- Ablation in melt ponds, 243
- Accumulation Area Ratio (AAR), 95–96
- Active layer, 173
 - survey methods, 174
 - thickness, 174–76
- Active layer thickness
 - northern Alaska, 175–76
 - projected changes, 328
 - Qinghai-Tibet, 186
- Active microwave
 - to map snow cover, 43–44
- Advanced Microwave Scanning Radiometer-EOS (AMSR-E), 37
- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), 7
- Advanced Synthetic Aperture Radar (ASAR), 142
- Advanced Very High Resolution Radiometer (AVHRR), 225
- aerial reconnaissance flights
 - Canadian Arctic, 225
 - Eurasian Arctic seas, 225
- Agassiz, L., 85, 300
- Ahlmann, H-W., 86
- Air drag law, 294
- Airborne electromagnetic (EM) ice thickness in the Arctic, 274
- Airborne electromagnetic-inductive (EM) measurements
 - sea ice thickness, 274
- Alases, 185
- Alaskan glaciers
 - sea-level contribution, 137
- albedo
 - in the Antarctic, 245
 - melt ponds, 243
 - of Arctic Basin surface, 244
 - sea ice, 244
 - snow, 16
- albedo – temperature positive feedback, 16
- Aletsch Glacier, 89
- Allegheny River, 206
- Alpine glaciation
 - earliest, 307
- Alpine permafrost
 - projected changes, 329
- Alps
 - projected glacier changes, 122
- Altimetry
 - of ice sheets, 284
 - of ice shelves, 284
- AMSR-E, 242
- Amundsen, R., 140
- Anchor ice, 190, 203
- Andes
 - projected glacier changes, 327
- Andrews Glacier, 90
- angle of repose, 74
- Antarctic
 - exploration, 140–41
 - ice shelves, 278
 - megadunes, 157
 - surface microrelief, 157
- Antarctic – Northern Hemisphere glacial fluctuations, 311–12
- Antarctic Circumpolar Current, 253, 303
- Antarctic Cold Reversal, 313
- Antarctic Divergence, 253
- Antarctic Ice Sheet, 152–59
 - contribution to sea-level rise, 345
 - sea level equivalent, 152
- Antarctic Isotopic Maxima, 312
- Antarctic Peninsula,
 - ice shelves, 279–82
 - permafrost, 169
- Antarctic Peninsula Ice Sheet, 311
- Antarctic sea ice, 238
 - changes, 274–75
 - mass balance, 248
 - projected changes, 331
 - thickness, 264
- Antarctic Sea Ice Processes and Climate (ASPeCt) program, 232, 264
- Antarctic sea ice production, 238
- Antarctica
 - coastal polynyas, 262
 - glacial onset, 303
 - GRACE measurements, 164
 - interferometric SAR data, 163
 - surface snow melt, 157
- Applications of snow and ice research, 333–38
- Aral Sea
 - sea ice, 224
- Arctic atmospheric dipole anomaly (DA), 268

- Arctic ice area 2007
 loss in 272
- Arctic Ice Dynamics Joint Experiment (AIDJEX), 222
- Arctic melt onset and freeze-up
 trends, 272
- Arctic Observing Network (AON) program, 223
- Arctic Ocean
 ice balance, 247
 ice extent minima, 268
 ice volume change, 247
 ice-free season, 268
 projected ice-free state, 332
 sea ice ages, 269
 sea ice drift speeds, 248
 sea ice extent, 267
 sea ice thickness, 264
- Arctic Ocean ice
 thickness changes, 273
- Arctic Ocean Model Intercomparison Project (AOMIP), 257
- Arctic Oscillation (AO), 251
- Arctic Research Laboratory Ice Station (ARLIS), 296
- Arctic sea ice
 age trends, 268
 annual growth and melt, 256
 melt onset dates, 231
 projected changes in September, 331
 recent decrease, 321
 seasonal cycle in extent, 225
 thickness (modeled), 257
- Arctic warming
 projected, 324
- Arctic glaciers
 projected changes, 327
- Area-Altitude Balance Ratios (AABRs), 96
- Atlantic meridional overturning circulation, 312
- Atlantic water, 251
- Atlas Antarktiki, 275
- Atmospheric Model Intercomparison Project (AMIP), 22
- Avalanche
 characteristics, 73–79
 control methods, 339
 danger scale, 338
 occurrence in western United States, 78
 risk assessment, 338
 runout, 80
 size classification, 75
 size range, 73
 warning services, 337–38
- Avalanche bulletins
 verification, 83
- Avalanche zones, 337
- Avalanches, 72–76
 changes in 21st century, 325
 climax, 80
 hazards, 337–39
 loose snow, 73
 statistical prediction, 82–83
 trends, 83–76
 yield, 78
- AVHRR data
 on Canadian lake ice, 199
- AVHRR Polar Pathfinder, 143
- AVHRR snow maps, 63
- Axial tilt of the Earth, 300, 306
- Backscatter signatures from different ice types, 231
- Baffin Bay
 icebergs, 289
- Balance velocities, 160
- Baltic rivers
 break up, 212
- Baltic Sea
 landfast ice, 240
- bare ice zone, 146
- Barents Sea, 251
 icebergs, 290
 sea ice extent, 266
- Barents Sea Ice Sheet, 308, 309
- Barnes ice cap, 159
- Barrow, Alaska
 active layer, 174
- Basal sliding, 104, 105, 159
- Baydyarakhs, 185
- Beaufort Gyre, 246
- Beaufort Sea
 ice severity index, 344
 landfast ice, 240
- Beaufort Sea coast
 erosion, 349
- Benson, C., 145
- Bergeron–Findeisen process, 14
- Bergy bit, 291
- Bering Glacier system, 92
- Bering Strait
 heat transport, 271
- Black ice (glaze), 336
- Black lake-water ice, 191
- Blizzard, 336
- blowing snow, 23–24
 Antarctica, 157
 models, 45
- Bohai Bay
 sea ice, 224
- Bölling–Allerød warm interval, 312
- Bootstrap algorithm, 228
- Borchgrevink, C., 140
- Bowen ratio, 117
- Bridging, 203
- Brine drainage, 245
- Brine pockets, 236
- Brine rejection, 238

- Brine solution, 234
 British Arctic Air Route Expedition, 138
 British Arctic Expedition, 1875–76, 277
 British Isles
 Quaternary history, 309
 British North Greenland Expedition, 138
 British trans-Arctic Expedition, 222, 246
 Buggy, 216
 Byrd Station, 139
 Byrd, R., 140
- Calving mechanisms, 286
 Calving rate
 water depth relationship, 288
 Calving rates
 on lacustrine glaciers, 288
 Calving, 286
 Camp Century, 139
 Canadian Arctic
 sea ice, 267
 Canadian Arctic Archipelago
 sea ice thickness, 241
 Canadian Arctic Archipelago sea ice
 projected changes, 331
 Canadian Arctic ice caps, 124
 Canadian High Arctic, 107
 Canadian Ice Patrol, 225
 Canadian Ice Service (CIS), 347
 Canadian Lake Ice Model (CLIMo), 198
 Canadian rivers
 ice cover duration, 209
 Candelaria Cave, 181
 Candelaria Ice Cave, 180
 Carbon content of permafrost soils, 188
 Carbon dioxide, 319
 concentration, 319
 in glacial intervals, 306
 in interglacials, 307
 Pliocene-Quaternary levels, 305
 Carbon dioxide release, 188–89
 Caspian Sea
 sea ice, 224
 Cenozoic glaciations, 303–05
 Central Yakutia
 icing growth, 215
 icings, 214
 Changes
 in permafrost and soil freezing, 185–68
 lake ice cover, 199
 Charts of sea ice conditions, 232
 Circumpolar Active Layer Monitoring (CALM)
 observational network, 173
 Cirque glaciers, 90
 Climate and Cryosphere (CLIC) Project, 6
 Climate change
 impact on permafrost, 187
 Climate Model Intercomparison Project (CMIP), 183
- Climate projections
 for 21st century, 321–24
 Climate warming, 319
 Coastline erosion, 348–49
 Cold and Arid Regions Environmental and
 Engineering Research Institute (CAREERI), 166
 Cold content, 50, 52
 Cold Land Processes Experiment (CLPX), 11, 24
 Columbia Glacier, 95, 288
 Colville River, 214
 Congelation ice, 235
 Coordinated Eastern Arctic Experiment (CEAREX),
 222
 Cordillera Blanca, Peru, 128
 Cordillera Real, Bolivia, 128
 Cordilleran ice, 310
 Coupled Model Intercomparison Project (CMIP), 257
 Creep, 21
 Cretaceous period, 302
 Crevasses, 102
 CROCUS
 model, 49
 Cross-polarized gradient ratio (XPGR), 144
 Cryofacies, 181
 Cryopeg, 170
 Cryosat-2, 231
 Cryosphere, 1
 future, 318–23
 in the past, 299–301
 Cryosphere role in climate, 4–5
 Cryospheric changes
 recent, 321
 Cryoturbation, 184–85
- ¹⁸O isotopic record, 139
 Dalton's law, 27
 Danish Meteorological Institute, 221
 Dansgaard–Oeschger (D–O) oscillations, 313
 Dansgaard–Oeschger event, 312
 Daugava River
 break up, 212
 de Saussure, H.B., 85
 Deformation of a floating ice field, 206
 Degree-day factor (DDF), 118
 Degree-day method
 snowmelt-runoff modeling, 46–47
 Densification
 snow, 87
 Depth-hoar, 14, 39, 74
 Deuterium excess, 139
 Devensian
 in British Isles, 309
 Devon Island Ice Cap, 111
 Devonian glaciation, 302
 Diamond dust, 14
 Dimensions
 Cryosphere, 1

- Dimictic lakes, 193
 Discharge
 of ice from calving glaciers, 288
 of icebergs into Southern Ocean, 289
 Division of Building Research (DBR),
 National Research Council, Canada,
 166
 Dry snow zone, 145
 Drygalski Ice Tongue, 154
 Ductile / brittle fracture, 77
 Dundas Island polynya, 261
- Earth Remote Sensing (ERS)-1 and -2 Active
 Microwave Instrument, 229
 East Antarctic Ice Sheet
 during Last Glacial Maximum, 311
 East Antarctic ice sheet (EAIS), 152
 East Asia
 sea ice extent, 224
 East Greenland
 icebergs, 293, 295
 East Greenland Current, 246
 East Greenland sea ice, 265
 Eastern Alps
 lake ice, 202
 Eccentricity of the Earth's orbit, 300, 306
 "Egg" code, 248
 Eidgenössische Instituts für Schnee- und
 Lawinenforschungs (EISLF), 72
 Eisriesenwelt, 181
 Ekman effect, 248
 Elastic-plastic rheology, 253
 Electrical resistivity, 178
 Electrically-Scanning Microwave Radiometer
 (ESMR), 7, 226
 Electricity, generated from hydropower, 341
 Electromagnetic induction, 178
 Elephant seals
 temperature/salinity profiles from, 239
 Ellesmere Island Ice Shelf, 278, 282–83
 Energy balance
 at ice/water interface, 196
 Energy balance method
 one-dimensional for snowmelt modeling, 49–57
 snowmelt modeling, 47–49
 two-dimensional for snowmelt modeling, 57–60
 Englacial drainage systems, 114
 Eocene/Oligocene boundary, 303
 Epilimnion, 193
 Epishelf lake, 194
 Equal-Area Scalable-Earth (EASE) grid, 226
 Equilibrium Area Altitude Ratio (AAR), 137
 Equilibrium line altitude (ELA), 90
 mean, 97
 Eurasian Arctic
 sea ice trends, 272
 Eurasian Arctic ice caps, 125
- European Ice Sheet Modelling Initiative (EISMINT),
 162
 European Project for Ice Coring in Antarctica
 (EPICA), 140, 306
 European Remote Sensing (ERS) satellites, 142
 Expedition Glaciologique Internationale au Groenland
 (EGIG), 138
- Feedback loops, 254
 Fenno-Scandinavian Ice Sheet
 disappearance, 314
 Field techniques for sea ice research, 232
 Filchner–Ronne Ice Shelf, 278, 283
 iceberg, 291
 Finsterwalder, S., 85
 Firn, 87
 First-year ice, 237
 First-year sea ice
 production in the Arctic, 238
 salinity, 234
 Fletcher's ice island T-3, 222, 296
 Flexural-gravity waves, 285
 Forest Service National Avalanche Center, 338
 Fracture mechanics, 77
Fram, 221, 248
 Fram Strait
 ice export, 247, 251, 271
 Frazil, 235
 Frazil ice, 191, 202
 Frazil slush, 203
 Freeze up
 in rivers, 202–05
 Freezing (thawing) degree-day, 172
 Freezing nuclei, 12
 Freezing precipitation, 336–37
 Freezing-degree days, 191
 Freshwater ice, 190–92
 applications, 342
 projected changes, 329–30
 Frobisher, M., 165, 276
 Frost flowers, 236
 Frost heave, 184, 349
 Frost index method, 182
 Frost mound, 183–84, 216
 Frost Number method, 172
 Frozen ground, 165
 definitions, 167
 distribution map, 168
 seasonal, 167
 thermal relationships, 169–72
- Gamma radiation, 12, 36
 Gauss, 293
 GCM simulations
 permafrost, 182–83
 Geomorphological features associated with permafrost,
 183–85

- Geoscience Laser Altimeter System (GLAS), 7, 141, 229
 ice freeboard, 274
 precision, 284
 Geothermal heat flux, 105
 Geothermal temperature gradient, 173
 Glacial ice
 blue color, 90
 Glacial lake, 116
 Glacial Lake Agassiz, 312, 314
 Glacial Lake Outburst Floods (GLOFs), 345
 Glacial lakes
 in Nepal and Bhutan, 345
 Glaciation
 concept, 299
 Glaciation level (GL), 97
 Glaciations
 in Antarctica, 310
 in North America, 307, 309
 in northern Europe, 307
 in Tibet, 310
 Northern Hemisphere, 304
 Glacier
 annual mass-balance measurements, 122
 changes, 121
 characteristics, 88–90
 definitions, 87–88
 energy budget values, 118
 flow, 102–06
 flow mechanisms, 104
 hydrology, 114–21
 hypsometry, 106
 limits, 97
 modeling, 109–10
 response time, 106–07
 runoff, 119–21
 tourism, 346
 transection, 94
 types, 92–94
 volume response time (VRT), 107
 Glacier “surges”, 345
 Glacier change index, 135
 Glacier changes
 Alaska, 126
 Alps, 122
 Andes, 128–30
 Antarctic Peninsula, 127
 Antarctica, 128
 Arctic, 123
 British Columbia, 126–27
 Central Asia, 131
 China, 132
 equatorial, 130–31
 Himalaya, 129–30
 New Zealand, 128
 Glacier Elevation Indices, 96
 Glacier mapping
 Landsat TM, 99
 Glacier melt index, 96
 Glacier monitoring, 86
 Glacier motion
 basal heat generation, 105
 Glacier National Park, 326
 glacier shrinkage, 346
 Glacier surges, 145
 Glacier variations
 in the southern and northern hemispheres, 316
 Glacier velocity
 remote sensing, 100
 Glacierized area
 Himalayan catchments, 120
 Glacier-lake outburst floods (GLOFs), 345
 Glaciers, 85–89
 accurate definition, 92
 applications, 345–47
 areal extent, 89
 cirque, 92
 energy balance, 117–18
 hanging, 93
 Himalaya, 92
 number, 88
 on low latitude mountains, 89
 polar, 92
 polythermal, 92
 “reference”, 122
 retreat in western North America, 121
 scaling, 108–09
 surging, 107–08
 temperate, 92
 temperature index method, 118–19
 tidewater, 94–95
 valley, 93
 Glaciology, 1
 Glen, J., 86
 GLIMMER ice sheet model, 304
 Global Climate Observing System (GCOS), 5
 Global Cryosphere Watch (GCW), 6
 Global Lake and River Ice Phenology Database, 195
 Global Land Ice Measurement from Space (GLIMS), 7, 88, 89
 Global Positioning System (GPS), 147
 Global Terrestrial Network for Permafrost (GTN-P), 170
 Global Terrestrial Networks (GTN), 6
 Global warming, 318, 319
 GOES-VISSR
 mapping lake ice break-up, 199
 Gradient ratio, 228
 Gran Campo Nevado Ice Cap, 112
 Grand Banks, 289
 Gravity Recovery and Climate Experiment (GRACE), 7, 141, 149
 Grease ice, 235

- Great Bear Lake
 ice conditions, 199
- Great Lakes
 ice cover, 201, 342
 shipping, 342
- Great Slave Lake, 198
 ice conditions, 199
- Great Slave Lake ice cover
 projected changes, 330
- Greenhouse gases, 318, 319
- Greenland
 icebergs, 289, 295
 interferometric studies, 163
 precipitation, 147–48
 snow melt, 62–63
- Greenland glaciers
 submarine melt rates, 152
- Greenland Ice Core Project (GRIP), 139
- Greenland Ice Sheet, 145–52
 at Last Glacial Maximum, 308
 contribution to sea level rise, 345
 equilibrium line altitude, 149
 iceberg calving, 151
 in last interglacial, 307
 mass balance, 149–50
 mass balance over time, 150
 projected changes, 327
 snow melt extent, 148–49
 summer meltwater, 144
- Greenland Ice Sheet Project (GISP)-II, 139
- Ground ice, 167, 178
- Ground icing
 conceptual model, 216
- Ground icings, 214
- Ground surface temperature
 mean annual, 170
- Ground temperature
 at Yakutsk, 186
- Grounding line, 162, 163, 277, 286
 retreat, 163
- Ground-penetrating radar, 178
- Growler, 291
- Gulf of St. Lawrence
 sea ice, 266
- Guliya ice cap, 113, 310
- Halocline
 in the Arctic Ocean, 238
- Hamburg Ship Testing Ice Basin, 223
- Hanging dam, 203
- Heinrich events, 313
- Helsinki University of Technology, 223
- Hibernia platform, 347
- Himalaya
 glacial meltwater, 345
 projected glacier changes, 326
- Hintereisferner, 98
- Historical Soviet Daily Snow Depth, 33
- History
 avalanches, 72–73
 freshwater ice, 190–91
 glacier research, 85
 ice sheet exploration, 138
 ice shelves, 276
 icebergs, 276
 sea ice, 221–23
 snowfall and snow cover, 11–12
- Holocene, 314–17
- Holocene thermal maximum, 314
- Home Bay, 259
- Huronian/Makganyene glaciations, 299
- Hydraulic thickening, 203
- Hydropower, 340–41
- Hypolimnion, 193
- IAHR Working Group on River Ice Hydraulics,
 205
- Ice, 4, 8
 compressive strength, 104, 164
 density, 88
 electrical conductivity, 101
 in lava tubes and ice caves, 180–81
 tensile strength, 104, 164
- Ice Ages, 299
- Ice area in Arctic
 local temporal minimum, 246
- Ice avalanches, 339
- Ice break-up observations
 in Finland, 190
- Ice caps, 111–13
- Ice caves, 180–81
- Ice content, 179
- Ice cores, 139–40
- Ice crystal
 shapes, 12
- Ice floes
 river, 203
 size classes, 238
- Ice flow
 theory, 104
- Ice houses, 342
- Ice islands, 296
- Ice jam, 203, 205–07
 database, 207
 flood damage, 342
 floods, 343
 photograph, 205
 roughness, 206
 thickness, 206
- Ice jam release wave (“jave”), 208
- Ice mass balance (IMB) buoys, 274
- Ice mélange, 284
- Ice motion
 ice sheets, 144

- Ice pump, 284
- Ice roads, 343–44
- Ice sheet
 - basal motion, 144
 - change mechanisms, 144–45
 - changes, 159
 - diagnostic models, 161
 - mass balance, 141–44
 - prognostic models, 160
 - surface profile, 160
- Ice sheet–ice shelf interactions, 162–63
- Ice sheet mass balance
 - component approach, 141
 - integrated approach, 141
- Ice sheet changes
- Ice sheet model
 - GLIMMER, 161
 - Parallel Ice Sheet Model (PISM), 162
- Ice sheet models
 - coupled ice sheet–climate models, 162
- Ice sheets, 3, 138–40
- Ice shelf
 - buttressing, 286
- Ice shelves, 145, 276–86
 - conditions below, 284–85
- Ice storms, 336
- Ice streams, 283
 - in Antarctica, 155
- Ice thickness
 - estimate from freezing-degree days, 191
 - maximum on rivers, 204
 - south-north differences, 210
- Ice velocities
 - Antarctica, 154
- Ice velocity, 103
- Ice wedge
 - oldest, 185
 - photograph, 179
- Ice wedges, 178
- Ice, Cloud, and Land Elevation Satellite (ICESat), 231
- Iceberg, 286–96
 - applications, 347
 - density, 293
 - deterioration, 293–94
 - drift speed, 295
 - motion, 294–96
 - physical characteristics, 291–94
 - size distribution, 291
 - volumes, 292
- Iceberg calving, 286–88
- Iceberg data, 289
- Icebreakers, 344
- Iceland, 108
 - projected ice cap changes, 327
 - sea ice index, 265
- Icelandic coasts
 - sea ice, 265
- Ice-rafted detritus
 - ice-rafted debris, 313
 - in the Arctic Ocean, 304
- ICESat, 143
 - sea ice measurements, 264
- Greenland, 145
- Icing
 - photograph, 213
- Icing formation
 - formula, 216
- Icings, 191, 213–16
 - area and type in northern Russia, 214
- Imja Lake, 116
- Impulse radars, 102
- Indigenous knowledge of sea ice, 232
- Infragravity waves, 285
- Inuitian Ice Sheet, 308
- Institute of Snow and Ice Studies (IANIGLA), 129
- Integrated Global Observing System (IGOS), 6
- Interferometric SAR (INSAR), 143
- Internal ice stress, 253
- Internal refraction horizons, 102
- International Arctic Buoy Program (IABP), 222, 250
- International Association of Cryospheric Sciences (IACS), 6
- International Commission on Snow and Ice (ICSI), 86
- International Conference on Permafrost, 166
- International Geophysical Year, 86, 139, 140, 153, 222
- International Glaciological Society (IGS), 6
- International Ice Patrol, 276, 347
- International Iceberg Patrol, 289
- International Permafrost Association, 166
- International Polar Year (IPY), 1, 223, 226, 239
- International Programme for Antarctic Buoys (IPAB), 252
- Intrusive ice, 178
- IPCC Fourth Assessment Report
 - sea ice in GCMs, 257
- IPCC scenarios, 321–22
- Irian Jaya
 - glacier changes, 130
 - glaciers, 109
- ISNOBAL
 - energy and mass balance snow model, 24
- Jakobshavn Glacier, 295
- Jakobshavn Isbræ, 150, 151
- Jökulhlaup, 116
- Juneau Icefield, 113
- Kamb Ice Stream, 283
- Kara Sea Ice Sheet, 308

- Karakorum glaciers, 130
 Keels, 263, 293
 Koch index, 265
 Koch, L., 221, 265
 Kolka Glacier, 339
 Kudryatsev equation
 for active layer thickness, 175
- Labrador Shelf
 icebergs, 289
- Lake
 freeze-up algorithm, 197
- Lake Baikal
 ice cover, 202
- Lake Balaton, 190
- Lake break-up
 advance, 199
- Lake Constance
 ice conditions, 202
- Lake Erie
 ice cover, 200
- Lake freeze up
 delay, 199
- Lake freeze-up and break-up dates
 variability, 195
- Lake freeze-up and weather, 196
- Lake ice, 191–202
 correlations with climate, 195
 energy balance model, 196
- Lake ice break-up and climate, 196
- Lake ice condition dates, 195
- Lake ice cover in Russia
 projected changes, 330
- Lake ice freeze-up and break-up monitoring
 in Canada, 190
- Lake Ice Model Numerical Operational Simulator
 (LIMNOS), 197
- Lake ice models
 comparison of PROBE and LIMNOS, 198
- Lake ice phenology
 simulation, 198
- Lake ice thickness
 maximum, 192
- Lake Kallavesi
 ice cover, 202
- Lake Ladoga
 ice roads, 344
- Lake Mendota, 198
- Lake Näsijärvi
 ice cover, 202
- Lake Pääjärvi, 198
- Lake Superior
 ice cover, 200
- Lake Suwa
 ice cover, 202
- Lake Vostok, 156
- Lakes, 193
- perennially ice covered, 193
 thermal regime, 193
- Lambert Glacier, 154
- Land Data Assimilation Systems (LDAS), 62
- Land ice
 changes in 21st century, 326–28
- Landfast ice, 240–41
 anchoring strength, 248
 trends in Alaska, 273
 thickness, 241
- Landsat, 7
- Landsat Image Mosaic of Antarctica (LIMA), 144
- Landsat Thematic Mapper
 Snow cover, 36
- Lanzhou Institute of Glaciology and Cryopedology,
 73
- Lanzhou Institute of Glaciology and Geocryology
 (LIGG), 166
- Laptev Sea, 251
 landfast ice, 240
 permafrost, 167
 polynyas, 262
- Laptev Sea shelf
 methane source, 188
- Larsen B Ice Shelf
 disintegration mechanism, 294
- Larsen Ice Shelf, 286
 breakup, 279
- Last Glacial Maximum, 162
 permafrost, 186
 temperatures, 308
- Latent heat
 at snow surface, 51
- Latent heat of fusion, 170
- Latent heat of fusion of pure ice, 30
- Latent heat polynya, 261
- Laurentide Ice Sheet, 308, 310
 disappearance, 314
- Lead density in the Arctic, 259
- Lead geometry, 259
- LEADEX, 258
- Leads, 258–59
- Lej da San
 lake ice break up, 202
- Lemon Creek Glacier, 113
- Lena River
 freeze up and break up, 209
- Lidar altimeters, 229
- Liquid water content, 53
- Little Ice Age, 125, 132, 265, 315
 in South America, 316
 in tropical Andes, 316
 Lake Constance ice, 202
 sea ice, 317
- Lliboutry, L., 80
- Lomonosov Ridge
 iceberg scouring, 293

- MacAyeal Ice Stream, 283
- Mackenzie delta
 break up and ice jams, 211
 ground temperature, 187
 hydroclimatic controls of break up, 211
 pingos, 184
- Mackenzie River
 ice break-up, 207
 spring break up, 208, 343
- Malaspina Glacier, 94
- Malmgren, F., 221
- Manning coefficient, 217
- Manning roughness coefficient, 206
- Marginal Ice Zone Experiment (MIZEX), 222
- Marginal Ice Zones (MIZs), 236
- Marine cryosphere, 219
- Marine ice
 beneath ice shelf, 284, 285
- Marine ice sheet instability hypothesis, 162
- Marine Isotope Stages (MIS), 307
- Mass balance
 annual, 97
 Antarctic sea ice, 239
 direct glaciological method, 97
 glaciers, 97–99
 global, 137
 hydrological, 99
 indirect (geodetic) method, 98
 net, 98
 remote sensing, 100
 sea ice, 246–48
 sensitivity, 99
- Mass balance sensitivity, 136
- Massive ground ice, 178, 186
- Matanuska Glacier, 116
- Maud Rise polynya, 261
- McCall Glacier, 124
- McMurdo Dry Valleys, 193
- Medieval Warm Period, 316, 317
- Melt onset dates
 for Arctic sea ice, 231
- Melt ponds, 242
 role in sea ice albedo, 244
- Mercer, J., 163
- Meridional overturning circulation, 313
- Mesozoic era, 302
- Methane, 319
 concentration, 319
- Methane release, 188–89
- Mid-winter break up events, 213
- Milankovitch cycles, 299
- Milankovitch, M., 300
- Miocene
 Antarctic ice sheets, 303
- Model
 wind-driven polynya, 261
- Models
 avalanche, 79
 ice sheets, 159–62
 lake ice, 196–98
 permafrost, 182–83
 river ice, 209–11
 sea ice, 254–58
 treating frozen ground, 183
- Moderate Resolution Imaging Spectroradiometer (MODIS), 7
- MODIS Mosaic of Antarctica (MOA), 144
- Mohr–Coulomb material, 206, 216–17
- Moma River, 214
- Mongolian rivers
 freeze up, 212
- Monomictic lakes, 193
- Moulin, 114
- Mountain glaciers
 during last glacial cycle, 311
- Mountain permafrost, 172
- Mt. Kenya, 130
- Mt. Kilimanjaro, 130
- Muir Glacier, 95
- Muller, S., 166
- Multi-angle Imaging SpectroRadiometer (MISR), 144
- Multiyear ice (MYI), 238, 245–46
 thickness in Canadian Arctic, 246
- Multiyear sea ice
 in the Northwest Passage, 272
- Murtel-Corvatsch, 187
- Naled, 213
 altitudinal distribution in eastern Siberia, 215
 maximum volume, 216
- Nansen, F., 138, 221
- Nares Strait
 ice export, 251, 271
- Narrow-channel ice jams, 205
- Naryn, 213
- NASA Team algorithm, 228
- National Ice Center, USA, 347
- National Ice Core Laboratory (NICL), 139
- National Operational Hydrologic Remote Sensing Center (NOHRSC), 12, 340, 342
- National Resource Conservation Service (NRCS), 340
- National Snow and Ice Data Center (NSIDC), 5
- National Weather Service River Forecast System, 46
- Natural variability
 of climate, 320
- NCAR Community Climate System Model (CCSM), 328
- Near-surface freeze/thaw
 from passive microwave data, 176
 from SAR data, 176
- Needle ice, 184
- Neoglaciations, 315

- Neoproterozoic era, 300
 Neoproterozoic glaciations, 299
 Nepal glaciers, 120
 Nepal Himalaya, 116
 New England
 lake ice, 201
 New England rivers
 ice, 212
 New Hampshire
 ice jams, 206
 New ice, 237
 Newfoundland
 icebergs, 295
 n-factor, 169
 Nieves penitentes, 91
 Nilas, 235
 Nipher shield, 32
 Nitrous oxide, 319
 Nordenskjold, A.E., 138
 Nordic Seas
 ice edge, 266
 sea ice extent, 266
 Normalized Season Severity Index (NSSI) for
 icebergs, 289
 North Atlantic
 extreme iceberg sightings, 276
 North Atlantic Oscillation (NAO), 251
 North Patagonia Icefield, 129
 North Pole
 ice thickness, 274
 North Pole Drifting Stations, 221, 222, 241, 296
 North Slope of Alaska
 icings, 214
 North Water, 261, 262
 Northeast Snowfall Impact Scale, 335
 Northeastern Siberia
 icings, 214
 Northern Sea Route, 269, 344
 NorthGRIP ice core, 314
 Northwest Passage, 269, 272, 316
 Norwegian Coastal Current, 251
 Norwegian–U.S. International Polar Year traverse,
 153
 Norwegian-British-Swedish expedition to the
 Antarctic, 140
 Novaya Zemlya, 108
 ice cover, 125
 Nye, J.F., 86, 109
- Obliquity cycles, 303
 Ocean circulation
 beneath the Ross Ice Shelf, 285
 Ocean infragravity waves, 264
 Ocean thermal expansion, 346
 Ocean waves
 role in iceberg break-up, 294
 Oerlemans, J., 110
- Ogives, 102
 Ordovician glaciation, 302
- Pacific Decadal Oscillation (PDO), 68
 Pacific North American (PNA) index, 68
 Paddle River Basin, Alberta, 47, 50, 55
 Paleocrystic ice, 312
 Palsa, 183
 Pálsson, S., 85
 Panama seaway closure, 305
 Pan-Arctic Snowfall Reconstruction, 32
 Pancake ice, 236
 Pancake ice floes
 photograph, 203
 Pancakes, 203
 Passive microwave
 snow mapping, 36
 Passive microwave algorithms for sea ice, 228
 recent, 229
 Patterned ground, 185
 Peary, R., 145
 Pechora River basin
 ground temperature trends, 186
 relict permafrost, 186
 Penck-Bruckner scheme of glacial episodes, 307
 Percolation zone, 90, 145
 Periglacial terrain, 349
 Permafrost, 3, 165–68
 applications, 347–49
 continuous, 167
 development time, 173
 disappearance, 186
 discontinuous, 167
 during the Last Glacial Maximum, 309
 extent, 167–69
 ground thermal regime, 171
 mountain, 169
 projected changes, 328–29
 Southern Hemisphere, 169
 sporadic, 167
 subsea, 167
 thawing, 329, 347
 thickness, 172–73
 vertical characteristics, 172–74
 Permafrost and Climate in Europe (PACE) program,
 187
 Permafrost Research Institute, Yakutsk, 166
 Permafrost temperatures
 in Alaska, 186
 Swiss alpine sites, 187
 Permafrost thaw lakes, 195
 Permafrost thawing
 in Sweden, 187
 Permanent Service on Fluctuations of Glaciers
 (PSFG), 86
 Permo-Carboniferous glaciation, 302
 Petermann Gletscher, 151

- Phanerozoic glaciations, 302
 Photoclinometry, 142
 Piedmont lobes, 94
 Pine Island Glacier, 154, 163
 Pingo, 183
 Pipeline Right-of-Way (ROW), 348
 Piscataquis River
 ice thickness, 212
 Plastic deformation of glacier ice, 105
 Pleistocene glaciations, 306
 Polarization ratio, 226, 228
Polarstern, 223, 239
 Polygonal ground, 183
 Polynya
 photograph, 259
 Polynyas, 258, 259–63
 marine ecosystem, 262
 Pore ice, 178
 Practical salinity units (PSU), 232
 Precession of the Earth's axis of rotation, 300
 Precipitation Temperature Area-Altitude (PTAA)
 model, 110
 Presidents' Day storm, 335
 Pressure melting point (PMP) of ice, 105
 Pressure ridge
 photograph, 237
 Pressure ridges, 258, 263
 thickness, 263
 Pressure ridging, 257
 Prince of Wales Icefield, 124
 Projection Pursuit Regression (PPR), 40
 Prokletije Mountains, Albania, 90
- Qinghai Plateau
 lower limit of permafrost, 186
 Qinghai–Tibet railroad, 166
 Quaternary Environments of the Eurasian North
 (QUEEN) program, 308
 Quaternary period, 306–14
 Quelccaya ice cap, 113
 QuikSCAT, 143, 148, 229, 268
- Radar altimeters, 229
 radar altimetry, 7
 precision, 284
 Radar backscatter signatures, 232
 RADARSAT, 7, 143, 240, 276
 RADARSAT-1, 231
 RADARSAT-1 Antarctic Mapping Project (RAMP), 153
 radio-echo sounding (RES), 142
 glaciers, 101–02
 Recovery Glacier, 153
 Red River
 flood, 341
 Regelation., 105
 Regelation-slip, 105
 Remote sensing
 cryosphere, 33–44
 frozen ground, 169, 176–78
 glaciers, 99–102
 ground based for frozen ground
 studies, 177
 ice sheets, 142–44
 lake ice, 199
 of snow, 33–44
 of SWE, 36
 sea ice, 225–32
 snow cover, 11
 Retrogressive thaw slump, 178
 Reynold's number for iceberg, 295
 Rheology of sea ice, 253
 Rhône drainage basin
 runoff changes, 119
 Rhône glacier, 86
 River 1-D hydrodynamic model, 209
 River 2-D hydrodynamic model, 209
 River Danube, 190
 River ice, 202–13
 break-up, 207–09
 development, 206
 dynamic breakup front, 207
 projected changes, 329
 rate of thinning, 207
 thickness equation, 207
 volume at ice clearance, 211
 River icings, 213
 RMS *Titanic*, 276
 Robert Peary, 138
 Rock glaciers, 184
 Rocky Mountain National Park, 90
 Rogers Pass, British Columbia, 83
 Ronne–Filchner Ice Shelf, 152
 Ross Ice Shelf, 152, 154, 276, 277, 278, 283
 record iceberg, 291
 Royal Geographical Society, 165
 Runoff changes
 due to glacier recession, 120
 Runoff due to glacier retreat, 120–21
 Runoff in the Ötztal, 121
 Runout distance
 statistical model, 81
 Russia
 river ice cover, 342
 Russian Arctic
 active layer, 175
 sea ice charts, 221
 Russian Arctic seas
 icebergs, 290
 Russian Geographical Society, 166
 Russian Great Northern Expedition, 165
 Russian rivers
 changes in ice cover, 211–12
 ice cover duration, 208
 spring break up, 208

- Rutschblock score, 78
 Ruwenzori, 131
- Saalian glaciation, 293
 Sagamartha National Park, Nepal, 130
 Saltation, 21
 Satellite Image Atlas of Glaciers of the World, 88, 100
 Satellite sensors
 for sea ice research, 230
 Scandinavian Ice Sheet, 309
 Scanning Multichannel Microwave Radiometer (SMMR), 7, 37, 226
 Scatterometers, 229
 Scatterometry, 229
 Schellenberger ice cave, 180
 Scoresby, W., 221
 Scotian Shelf
 sea ice, 266
 Scott, R.F., 140
 Sea ice, 221–75
 albedo, 244
 applications, 344
 area trend in Arctic and Antarctic, 267–68
 characteristics, 223–24
 charts, 248
 compressive strength, 253
 concentration, 226
 decay, 242–45
 draft, 263
 drift, 248–53
 drift (modeled), 257
 dynamics – stresses, 253
 dynamics and thickness, 256–57
 engineering properties, 253
 extent, 223
 farthest south in Northern Hemisphere, 224
 growth, 232–39
 Holocene history, 316
 phases, 234
 projected changes, 331–32
 shear strength, 253
 symbology, 248
 tensile strength, 253
 thickness, 263–65
 thickness distribution, 257
 trends in extent and thickness, 265–27
 Sea ice concentration anomalies, 231
 Sea-ice extent, 3
 Sea Ice Index (NSIDC), 228
 Sea Ice Mass Balance (SIMBA), 239
 Sea ice model
 equations, 256
 Sea Ice Physics and Ecosystem eXperiment (SIPEX), 239
 Sea-ice thermodynamics model, 254
 Sea ice thickness
 East Antarctica, 239
 frequency distribution, 263
 probability density function, 264
- Sea level
 during Eemian interglacial, 307
 history, 302
 postglacial, 317
 projected rise, 327
 rise, 321
- Sea-level rise
 glacier and ice sheet contributions, 345–46
 glacier contribution, 135–37
 ice sheet contribution, 163–64
 twenty-first century, 164
- Sea of Okhotsk
 polynyas, 261
 sea ice, 224
- Seasonal ground freezing
 applications, 349
- Seasonal Ice Zone Observing Network (SIZONet), 243
- Seasonally frozen ground, 4
 Northern Hemisphere distribution map, 177
- Second-year ice, 238
- Sediment-laden ice, 245
- Seepage taliks, 215
- Segregated ice, 178
- Seismic (echo sounding)
 first glacier measurements, 85
- Sensible heat
 at snow surface, 51
- Sensible heat polynya, 261
- SEVER program, 222
- Severnaya Zemlya, 111
- Shackleton ice shelf, 194
- Shallow-ice approximation, 159
- Shergin, F., 165
- Shishmaref, 348
- Shuga, 238
- Side-Looking Airborne Radar (SLAR), 276
 mapping sea ice, 225
- Sintering, 88
- Ski resort, 339
- Slab avalanches, 74
- Slab fracture, 75
- Sliding velocity of ice, 105
- Slope instability, 77
- Snow
 albedo, 50
 artificial, 339
 density, 28
 depth, 32
 formation, 12–14
 hardness, 28
 in situ measurement, 30–36
 liquid water content, 30
 metamorphism, 28–30

- Snow accumulation/ablation
 integrated approach to modeling, 61–62
- Snow course, 11
 networks, 19
- Snow cover, 3, 14–21
 density, 29
 duration, 20
 extent, 17, 30
 extent changes, 63–64
 frequency from AVHRR, 35
 in Land Surface Models, 22–23
 interannual fluctuations, 19
 last-observed in spring, 20
 MODIS product, 36
 projected Northern Hemisphere changes,
 324–25
 recent observed changes, 62–63
 seasonal changes, 19
- Snow covered area (SCA), 29, 33
- Snow depth, 12, 23
 Canada, 33
 Former Soviet Union, 33
 on Arctic sea ice, 241–42
- Snow depth on sea ice
 algorithm for mapping, 242
- Snow facies
 Antarctica, 156–57
 Greenland, 145–47
- Snow fences, 336
- Snow gauges, 32
- Snow grains, 28
- Snow ice, 204
- Snow interception
 by canopy, 24–26
- Snow line
 depression, 311
- Snow melt
 floods, 341–42
- Snow melt in Antarctica, 158
- Snow micro-penetrator (SMP), 78
- Snow Model Intercomparison Project (SnowMIP),
 22
- Snow Runoff Model (SRM), 118
- Snow surface
 temperature, 59
- Snow surveys, 11
- Snow Telemetry (SNOTEL) network., 11
- Snow water, 17
- Snow water equivalent (SWE), 11, 32
 adjustment factor, 33
 changes for SRES scenarios, 325
 estimation by Artificial Neural Networks, 41–47
 recent changes, 64–71
 remote sensing, 36
- Snow, Ice and Permafrost Research Establishment
 (SIPRE), 139
- Snowball Earth, 299, 300
- Snowfall, 11–13
 applications, 335–36
- Snowfall/precipitation ratios
 in western USA, 340
- Snowflakes, 11, 13
- Snow-ice, 239
- Snowmelt modeling, 45
- Snowmelt models
 intercomparison, 60–62
- Snowmelt Runoff Model, 46
 empirical, 45
- SnowMIP2 project, 60
- Snowpack
 meltwater, 54
 water balance, 53–57
- SNOWPACK model, 49, 81–82
- SNOWpack TELEmetry (SNOTEL), 19
- SNTHERM model, 38, 47–8
- Soil freezing days
 in Canada, 188
- Soil temperature measurements
 Qinghai–Tibet highway, 186
- Soil temperature trends
 midwestern United States, 188
- South Atlantic
 iceberg sightings, 276
- South Cascade Glacier, 98
- South Pole
 temperature, 153
- South Pole – Queen Maud Land traverses, 153
- South Pole station, 153
- Southern Ocean, 140
 ice motion, 252
- Southern Patagonia Icefield, 112, 129
- Southwest Pacific.
 iceberg sightings, 276
- Special Report on Emission Scenarios (SRES), 321
- Special Sensor Microwave Imager (SSM/I), 7, 37,
 226
- Spring icings, 214
- St. Lawrence River
 ice bridges, 212
- St. Lawrence Seaway
 shipping, 343
- Station Alpha, 222
- Stefan equation, 204, 254
- Stefan's equation
 for active layer thickness, 175
- Storis drift, 266
- Storm of the century, 336
- Sturtian glaciation, 300
- Subglacial lakes in Antarctica, 156
- Sublimation, 23, 26–28
 of blowing snow, 27
- Submarine sonar
 Arctic ice thickness changes, 273
- Submarines

- Arctic ice measurements, 264
- Subsidence
 - due to permafrost thaw, 185
- Sumgin, M.I., 166
- Summit station, Greenland, 138
- Sun cups, 91–92
- Supercooled water, 191
- Superimposed ice, 90
- Supra-glacial channels, 144
- Supra-glacial lake, 147
- Surface air temperature anomaly
 - trends, 70
- Surface Heat Budget of the Arctic Ocean (SHEBA)
 - experiment, 223
- Surface heat flux from water, 204
- Surface melt processes, 117–19
- Surface temperature
 - from MODIS, 177
- Surface Vegetation Atmosphere Transfer Schemes (SVATS), 62
- Svalbard Archipelago, 126
- Swiss Plateau
 - lake ice, 202
- SNTHERM
 - model, 47–48
- Synthetic aperture radar (SAR), 7, 240
 - for sea ice mapping, 225
- Synthetic Aperture Radar (SAR)/Interferometric Radar Altimeter (SIRAL), 231
- Tabular icebergs, 291
 - break-up, 294
- Taku Glacier, 113
- Talik, 176, 185
- Tanana River
 - break-up, 212
- Taylor Glacier, 94
- Teleconnections, 318
- Temperature
 - at base of winter snow cover, 172
 - at top of permafrost, 182
 - effects of increases on water availability, 341
 - mean annual air (MAAT), 167
 - of an iceberg, 293
 - of maximum density, 234
 - planetary over last 500 million years, 301
- Temperature gradient (TG) metamorphism, 74
- Temperature Index method
 - snowmelt-runoff modeling, 46–47
- Temperatures
 - projected for AD 2100, 322
- Termination of glacial cycles, 314
- Terra Nova Bay polynya, 262
- Terrestrial cryosphere, 9
- Thaw tubes, 174
- Theory of sliding (Weertman), 105
- Thermal offset, 170
- Thermal state of permafrost, 170
- Thermodynamic ice growth, 254
- Thermokarst, 185
- Tibet glacier change, 132
- Tibetan Plateau
 - permafrost, 169
- Tibetan Plateau railway, 348
- Tie points, 226, 228
- Tien Shan, 132
 - permafrost temperatures, 186
- Tornio River
 - break up, 212
- TransAlaska Pipeline, 348
- Transpolar Drift Stream, 250
- Transportation disruption, by snowfall, 335
- Trends in river ice cover, 211–13
- Turbulent suspension, 21
- Tyndall Glacier, 90
- US Army Cold Regions Research and Engineering Laboratory (CRREL), 223
- US National Technical Means program for sea ice, 225
- Ulakhan taryn, 214
- Upper Danube drainage system, 120
- Upward looking sonar (ULS), 264
- US Army Cold Regions Research and Engineering Laboratory (CRREL), 222
- US Navy Oceanographic Atlas of the Polar Seas, 275
- USS Nautilus*, 264
- USS Queenfish*, 264
- Vatnajökull ice cap, 113, 116
- Vein ice, 178
- VELMAP project, 143
- Vernagtferner glacier, 85
- Very High Resolution Radiometer (VHRR), 7, 11, 225
- Victor, P-E., 138
- Viscous-plastic model of sea ice, 253, 256
- Voikov, A., 165
- Voellmy avalanche model, 80–81
- von Baer, K., 165
- von Drygalski, E., 140
- Vostok ice core, 140
- Vostok station, 153
- Waiting time for climatic shifts, 311
- Ward Hunt Ice Shelf, 282
- Washburn, A.L., 166
- Water drag
 - for icebergs, 295
- Water level
 - associated with ice jams, 206
 - due to river ice, 204
- Water resources, 340
- Water-ice heat transfer beneath an ice cover, 207

- Weather filters for PMR data, 229
- Weddell Sea, 264
 ice, 275
 ice floe drift, 223
 sea ice, 239
- Wegener, A.
 Greenland Expedition, 138
- Weissflujoch Research Station, 72
- West Antarctic Ice Sheet, 145
 during Last Glacial Maximum, 311
 ice volume, 163
- West Antarctic Ice Sheet (WAIS), 152, 162
- West Greenland
 icebergs, 292
- West Greenland Current, 295
- Western Austria glaciers, 120
- Western China
 glacial meltwater, 121
- Wet snow (isothermal) avalanche, 75
- Wet snow zone, 90, 146
- Whaling ship ice data, 275
- Whillans Ice Stream, 283
- White Sea Lake, 308
- White snow-ice, 191
- Wide-channel ice jams, 205
- Wild, H., 165
- Wilkins Ice Shelf, 280, 285
- Wind stress, 253
- Winter sports industry, 339–40
- Wisconsinan glaciations, 310
- World Climate Research Programme, 6
- World Data Center-A for Glaciology, 5
- World Data Centers (WDCs) for
 Glaciology, 86
- World Glacier Inventory (WGI), 86, 88
- World Glacier Monitoring Service (WGMS), 86
- World Meteorological Organization-Double Fence
 Inter-Comparison Reference, 32
- Yachevskiy, L.A., 165
- Yedoma, 178, 188
 photograph, 179
- Yellow River
 break-up, 212
- Yellowknife
 ice roads, 343
- Yershov, E.D., 166
- Yield stress of ice sheet, 164
- Young ice, 237
- Younger Dryas, 312–13
- Yukon River
 break-up, 212
- Zero annual amplitude, 173
- Zero curtain, 170
- Zubov, N., 223