

Climate Change 2007

The Physical Science Basis

Edited by

Susan Solomon

Co-Chair,
IPCC Working Group I

Dahe Qin

Co-Chair,
IPCC Working Group I

Martin Manning

Head, Technical Support Unit
IPCC Working Group I

Melinda Marquis

Kristen Averyt

Melinda M.B. Tignor

Henry LeRoy Miller, Jr.

Technical Support Unit, IPCC Working Group I

Zhenlin Chen

China Meteorological Administration

Contribution of Working Group I
to the Fourth Assessment Report of the
Intergovernmental Panel on Climate Change

Published for the Intergovernmental Panel on Climate Change

Index

Note: * indicates the term also appears in the Glossary (Annex I). Page numbers in italics denote tables, figures and boxed material; page numbers for boxed material are followed by B. Page numbers in bold indicate page spans for entire chapters.

8.2 ka event*, 455, 456, 463-464

A

Abrupt climate change*, 57, 106-107, 435-436, 454-457, 463-464

defined, 775B, 818

modelling, 640-643

projections, 775-777B, 818-819

ACE index, 304, 305B, 312B

Advection*, 355, 356, 528

Aerosols, 29-30, 106, 131-132,

135-136, 153-180

aviation aerosols, 188, 561

climatic factors, 557-558

couplings and feedbacks, 78-

79, 504, 555-566

direct effect, 153, 154, 159-160,

168-171, 201, 203-204

direct radiative effect, 157-158

glaciation effect, 558, 559, 560-561

indirect effects*, 30, 153-154, 504, 558, 559-563, 565-566

modelling, 159-160, 562-563, 564, 565, 607

natural, 555-558, 559

precipitation effects, 254, 560, 563, 564

projections, 78-79, 755-757,

760, 796-797

radiative forcing, 29-30, 153-

180, 198-200, 559

satellite and surface-based

observations, 154-159

semi-direct effect, 154, 555,

558, 559, 565

thermodynamic effect, 558, 559

total aerosol optical depth, 29

total anthropogenic effect,

562-563, 564-565

volcanic aerosols, 193-195, 201, 478

See also specific aerosols

Afforestation*, 528

Africa. *See* Climate projections

Air quality, 28, 79, 502, 540B, 566-567

Aircraft/aviation, 30, 186-188

aviation aerosols, 188, 561

contrails/induced cloudiness, 30, 132,

186-188, 201, 203-205

Albedo*, 30, 110, 180-186, 508

cloud albedo effect, 30, 132,

153-154, 171-180, 201,

203-205, 558, 559-563

cryospheric-albedo feedback, 110

ice-albedo feedback, 97

snow, 30, 184-185, 205, 343

snow-albedo feedback, 343,

638-639, 640

surface albedo, 30, 132, 180-

186, 201, 203-205

surface albedo feedback, 593, 638-639

Albrecht effect. *See* Cloud lifetime

effect, under Clouds

Altimetry*, 49, 361, 408, 410, 411-412, 431

Ammonia (NH₃), 544-546

Annular modes*, 38-40, 64, 112, 238-239, 286-295, 287B, 620-621, 780-782

Antarctic Circumpolar Current

(ACC), 401-402, 765

Antarctic Circumpolar Wave

(ACW), 294-295

Antarctic Oscillation (AAO), 777B, 782

Antarctic region

climate projections, 904, 907-909

ice sheet (*see* Ice sheets)

oceans, 401-402, 420

sea ice, 342, 351, 352, 353, 355

Arctic Ocean, 398, 906

Arctic Oscillation (AO), 777B, 780

Arctic region

climate projections, 902-907

sea ice, 44, 45, 60, 317, 339, 342,

351-356, 716, 776B, 851

Asia. *See* Climate projections

Atlantic Multi-decadal Oscillation

(AMO)*, 245-246, 293-294

Atlantic Multi-decadal Variability, 623

Atlantic Ocean, 394-399

hurricanes, 306-312

past variability, 482

salinity, 387, 393, 394-399, 420

sea level change, 413

temperature, 237, 247, 387, 392,

395, 398-399, 420

Atmospheric climate change,

35-43, 82, **235-336**

circulation, 38, 280-295, 287B,

318, 709-712, 770

free atmosphere*, 265-280,

317, 699-701, 730

teleconnections, 38-40, 238, 286-295

temperature of upper air, 36, 37,

237, 265-271, 699-701

See also Surface climate change

Atmospheric constituents, 129-234

aerosols, 29-30, 131-132, 153-180

chemically and radiatively

important gases, 24-28,

131, 137-153, 539-555

contrails and aircraft-induced

cloudiness, 30, 132, 186-187,

186-188, 201, 203-205

couplings and feedbacks, 504, 539-555

modelling, 603

See also specific constituents

Atmospheric modelling, 597-599, 602-603, 608-613, 623, 646-647

Attribution of climate change. *See*

Detection and attribution

of climate change

Australia. *See* Climate projections

Aviation. *See* Aircraft/aviation

B

Bayesian methods*, 726, 744-745, 810

Biogeochemistry, 108-110

couplings and feedbacks (*see* Climate system couplings)

modelling, 642-643

oceanic, 48, 387, 389, 403-408

projections, 789-811

Biomass burning, 29, 132, 164,

165-167, 204, 501-502

Black carbon*, 30, 132, 163-165,

184-185, 205, 565, 566

aviation-associated, 561

projections, 760, 796

Blocking, 282, 285, 623

C

Carbon

dissolved inorganic carbon (DIC),

387, 403-405, 408,

514, 529-530, 532

global budget, 26, 516, 517-

526, 522-523, 525

isotopes, 139, 439, 446B, 452,

460, 476, 519

modelling, 618

oceanic, 387, 403-406, 420,

528-533, 529B

organic, fossil fuel, 29, 132,

161-163, 204-205

organic, natural, 556-557

See also Black carbon

Carbon cycle*, 26-27, 501, 511-539

biological pumps, 528-530

couplings and feedbacks, 77-80,

501, 511-539, 534, 566

interannual changes, 523-524, 525

marine, 403-406, 408, 437, 528-

533, 529B, 534, 793

modelling, 481, 533-539, 591,

604-605, 618

overview, 511-517

palaeoclimate, 437, 442, 443,

446B, 452, 460

projections, 750, 777B, 789-

793, 823-825

- regional fluxes, 521-523
sources and sinks, 513, 519-521, 527-531, 604-605, 777B
terrestrial processes and
 feedbacks, 526-528
top-down/bottom-up views, 521-522
- Carbon dioxide (CO₂)***, 24-27, 77-80, 115, 135, 137-140, 511-515
air-sea fluxes, 403, 404
atmospheric concentration, 24-27, 131, 137-140, 141, 146, 511, 515, 516, 517
buffering (Revelle factor), 531
in carbon cycle, 501, 511-517
couplings and feedbacks, 77-80, 501, 511-539
dissolved in oceans, 387, 402-406, 408
fertilization*, 185-186, 526-527, 605
global warming potential, 211, 212
growth rate, 26, 523-526, 790
increase in industrial era, 97, 100, 105-106, 512
palaeoclimate, 54-57, 435-437, 440-450, 446B, 452-453, 455-456, 459-460, 465, 481
projections, 77-80, 789-811, 822-828
radiative forcing, 25, 131, 136, 137-140, 141, 185-186, 205, 207, 212
- Carbon monoxide (CO)**, 205, 207, 214, 549, 793-794
- Carbon tetrachloride (CCl₄)**, 141, 145, 146, 212
- Carbonate (CO₃²⁻)**, 77, 387, 406, 421, 442, 443, 446B, 460, 530, 532
buffer system, 529B, 530
projections, 77, 793, 794
- Caribbean region**, 909-917
- Central and South America**. *See* Climate projections
- Chlorofluorocarbons (CFCs)**, 28, 100, 105-106, 141, 145, 146
CFC-11, 28, 100, 145, 420
industrial era increase, 512, 513
as oceanic tracers, 100, 404, 406, 420
radiative forcing, 131, 141, 207, 212
- Circulation**
atmospheric, 38, 64, 238-239, 280-295, 318, 565-566, 709-712, 731, 770
indices, 287B, 294-295
modelling, 615-616
oceanic, 48, 111-112, 387, 394-402, 417, 420
projections, 770, 777B, 780-782
- Climate***
defined, 104
factors determining, 96-97
human and natural drivers, summarized, 21-35, 81
weather and, 104-105
- Climate change***, 35-58, 663-746
atmospheric (*see* Atmospheric climate change)
- commitment (*see* Climate change commitment)
concept, 667-670, 678
consistency across observations, 51-54, 239, 317-318
cryospheric (*see* Snow, ice and frozen ground)
current, compared to palaeoclimate changes, 436-437, 465
defined, 667
detection and attribution (*see* Detection and attribution of climate change)
irreversible, 775-777B
last 1,000 years, 680-683
last 2,000 years, 436, 466-483, 468-469B
long-term, 822-831
mechanisms, 96, 449
observations, summarized, 35-58
oceanic (*see* Oceanic climate change)
relationship to weather, 104-105
robust findings and key uncertainties, 81-91
surface (*see* Surface climate change)
variability (*see* Climate variability)
See also Climate change science
- Climate change commitment***, 68-69, 68B, 78, 79-80, 749, 753, 761, 822-831
commitment to year 2300, 822-827
commitment to year 3000 and beyond, 823-827
constant composition commitment scenarios, 753, 822-823
constant emission commitment scenarios, 822
overshoot scenarios, 753, 827-828
sea level, 68, 80, 752, 822, 828-831
stabilisation scenarios, 753, 791-793
temperature, 79, 752, 822-828
zero emission commitment scenarios, 753, 822, 825
- Climate change science, 93-127**
IPCC history and assessments, 95, 118-121
nature of earth science, 95-99
progress in climate modelling, 112-118
progress in detection and attribution, 100-103
progress in understanding climate processes, 103-112
- Climate feedbacks***. *See* Feedbacks
- Climate forcing**. *See* Radiative forcing
- Climate models***, 589-662, 669-670
abrupt climate change, 640-643
advances in, 112-118, 591-593, 596-608
Atmosphere-Ocean General Circulation Models (AOGCMs), 59-60B, 66-67, 591-592, 596-608, 761, 797-831, 852-861, 918
Atmosphere-only GCMs (AGCMs), 918-919
C⁴MIP, 533-539, 618, 789-790
- changes in performance, 618-619
climate sensitivity and feedbacks, 592, 629-640
climate variability, 591, 592, 620-627
confidence in, 591, 600-601, 639-640, 668
construction of, 596
contemporary climate, 608-619
coupled models, 117-118, 481, 532-539, 607, 608-627
downscaling*, 74, 601, 865, 919-921, 925
Earth System Models of Intermediate Complexity (EMICs), 67, 77, 78, 591-592, 643-645, 646-647, 797, 801-802, 823-827, 828
evaluation, 87, 591, 594-596
evolution, 98, 99, 112-114
extremes, 627-629
flux adjustments*, 117, 591, 597-599, 607-608, 646-647
General Circulation Models (GCMs), 114-116, 208, 629-633, 925
hierarchies, 67, 112-114, 797-800
initialisation, 607-608
intercomparison, 510
large-scale variability, 591-592, 620-627
multi-model data set (MMD), 597-599, 753-754, 858-860B
nested regional climate models, 919
resolution, 113-114, 591, 797-800
shorter-term predictions, 626-627
simple climate models, 643-647, 797, 802-804, 844
thresholds, 640-643
See also specific topics and processes
- Climate predictions***, 626-627, 643
See also Climate projections
- Climate projections***, 66-80, 87-91, 747-940
about, 753-754, 852-865
Africa, 850, 854, 866-872
Asia, 850, 855, 879-887
Australia and New Zealand, 850, 856, 896-902, 916B
biogeochemical feedbacks, 77-79, 789-811
Central and South America, 850, 856, 892-896
change in the 21st century, 69-76, 764-766
emissions, concentrations and radiative forcing, 25, 755-760
ensemble projections*, 754, 755-760, 766-767, 805-811, 852-861
Europe and the Mediterranean, 850, 854, 872-879, 917B
extremes, 782-789, 854-857, 862-864, 916-917B
global projections, 69-74, 89, 747-845
greenhouse gases, 25, 755-760
hierarchy of models, 797-800
islands, small, 850, 857, 909-915

- long term change and commitment, 79-80, 749, 822-831
 methods, 844-845, 917-925
 North America, 850, 855-856, 887-892
 ocean acidification, 793, 794-795
 physical climate system, 760-789
 polar regions, 850, 857, 902-909
 probabilistic projections, 807-809, 810-811, 921-925
 quantifying, 797-811, 921-925
 range of projections, 797-811
 regional projections, 74-76, 91, **847-940**
 sea level, 68, 70-71, 73, 90, 774, 812-822, 823, 828-831, 844-845, 909, 914-915, 916-917B
 summary, 749-752, 849-851, 858-860B
 temperature, 69-72, 74-76, 762, 763, 764-766
 uncertainty, 797-800, 805-811
- Climate scenarios***, 753, 791-793, 802-804, 822-831
See also SRES scenarios
- Climate sensitivity***, 64-66, 88, 114-116, 754, 825-827
 climate models, 593, 629-640, 632B
 cumulative distributions, 65
 defined, 629-630
 equilibrium climate sensitivity (ECS), 64-65, 88, 718-727, 754, 798-799B, 825-827
 estimation methods, 718-719
 instrumental observations, 719-723
 key physical processes, 633-637
 observational constraints, 718-727, 807-808
 palaeoclimate data, 481, 724-725
 probability density functions (PDFs), 65, 719-721, 724-725, 798-799B, 808-809, 923-924
 transient climate response (TCR), 66, 88, 691, 718, 723, 724, 725, 754, 798B, 800-801, 807
- 'Climate surprises'**, 775-777B
- Climate system***, 96-97
- Climate system couplings**, 77-80, **499-587**, 789-811
 aerosols, 78-79, 502, 555-566
 atmosphere dynamics, 504, 555
 carbon cycle, 77, 501, 511-539, 566
 land climate system, 504-511, 505B
 land surface, 501
 modelling, 597-599, 629-640, 646-647, 754, 765
 projections, 77-80, 789-811
 reactive gases, 501-502, 539-555, 540B
 scales, 505-507, 566
- Climate variability***, 667, 668-669, 702-703, 864
 modelling, 591-592, 620-627, 686
 modes of*, 286-295, 287B, 463, 667-668, 778-782, 867B
 patterns of*, 38-40, 39B, 867B
- Clouds**, 40-41, 97, 238, 275-277
 aerosol effects, 30, 153-154, 558, 559-564, 565, 566, 676-677
 aviation-induced cloudiness, 30, 132, 186-188, 201, 203-205
 cloud albedo effect, 30, 153-154, 171-180, 201, 203-205, 558, 559-563
 cloud condensation nuclei (CCN)*, 154, 171, 504, 555, 559
 cloud lifetime effect, 153, 154, 171, 555, 558, 559-560, 563
 couplings and feedbacks, 502, 558, 559-563, 635-638, 640
 modelling, 114-116, 593, 635-638, 640
 projections, 766-768
 radiative forcing (CRF)*, 173-178, 180, 502, 635, 637-638, 767-768
- Coastal zone climate change**, 916-917B
- Cold Ocean-Warm Land (COWL) pattern**, 622-623
- Commitment**. *See* Climate change commitment
- Confidence***, 22-23B, 81-91, 120-121B
- Contrails**, 30, 132, 186-187, 201, 203-205
- Cosmic rays**, 31, 132, 202, 476
- Coupled models**, 117-118, 481, 532-539, 607, 608-627
- Couplings**. *See* Climate system couplings
- Cryosphere***, 43-46, 110, **337-383**, 716-717, 732
 area, volume, and sea level equivalents, 340, 342, 361, 374
 components, 341-343
 feedbacks, 110, 593, 638-639
 modelling, 111, 593, 606-607, 638-639
See also Snow, ice and frozen ground
- Cyclones**
 extratropical, 312-313, 316, 712, 788-789
 modelling, 591, 613, 628
 projections, 74, 751, 786-788, 864, 915
 tropical, 41-43, 239, 304-307, 305B, 314, 316, 711-712, 751, 786-788, 864, 915
- D**
- Dansgaard-Oeschger (DO) events***, 106-107, 111, 455, 456-457
- Deforestation***, 512, 517-518, 520-521, 527-528
- Detection and attribution of climate change***, 52, 58-66, 81-86, 135-136, **663-746**
 carbon cycle perturbations, 512-515
 greenhouse gas increase, 60, 501-502, 512-513
 industrial era, air temperature, 683-705, 727, 729-730
 industrial era, other variables, 705-718, 730-732
 introduction/concepts, 667-670
 observational constraints, 718-727
- observations, summarized, 35-58
 pre-industrial, 673, 679-683
 progress in, 100-103
 radiative forcing and climate response, 31, 131, 670-679
 robust findings and key uncertainties, 81-91
 statistical methods, 744-745
 variability, 667, 668-669, 702-703
See also Palaeoclimate
- Dimethyl sulphide (DMS)**, 78, 557
- Dimethylether (CH₃OCH₃)**, 213
- Dimming**. *See* 'Global dimming'
- Diurnal temperature range (DTR)**. *See* Temperature
- Downscaling***, 74, 601, 865, 919-921, 925
- Droughts***, 254, 260-265, 261B, 308, 310-311B, 315, 715-716
 defined, 314
 palaeoclimate, 435, 437, 482-483
 projections, 732, 750, 783, 859B, 863
 summary, 43, 54, 238, 317, 318, 435
- Dust**, 29, 78, 159, 502, 555-556, 797
 mineral dust aerosol, 29, 132, 167-168, 204-205
- E**
- El Niño**. *See* El Niño Southern Oscillation
- El Niño Southern Oscillation (ENSO)***, 111-112, 245-246, 287-288, 295, 709
 cyclones and, 305-306, 305B, 308
 modelling, 592, 601, 623-625
 monsoons and, 296-297, 305B, 780
 palaeoclimate, 437, 464, 481-482
 projections, 751, 779-780
 summary, 38, 39B, 238
- Emissions scenarios***. *See* SRES scenarios
- Energy balance***
 changes, 392-393, 727-728
 mean, 96-97
 modelling, 608
 radiation, 277-280
 surface energy and water balance, 35, 505B
 surface energy budget, 180-186
- Equilibrium climate sensitivity (ECS)**, 64-65, 88, 718-727, 754, 798-799B, 825-827
- Europe and the Mediterranean**. *See* Climate projections
- Evapotranspiration***, 238, 260, 261B, 279B, 507, 769
- Extreme events***, 299-316, 696
 extratropical storms, 312-313, 314-315, 316
 modelling, 300-303, 627-629
 precipitation, 41, 301-303, 308, 314-315, 316, 714, 782-784, 785
 projections, 52, 73, 750, 782-789, 849-851, 854-857, 862-864, 916-917B
 recent events, 310-311B

regional (see Climate projections)
 sea level, 51, 414, 916-917B
 severe local weather, 316
 summary, 40, 41, 51, 52, 53B, 237, 591
 temperature, 40, 237, 300-301,
 302, 308-309, 311-312B,
 314-315, 316, 698-699,
 750, 785-786, 787
 tropical storms, 304-312, 305B,
 314-315, 316

F

Faculae*, 107, 108, 188, 189, 190

FAQs

Arc extreme events, like heat waves, droughts or floods, expected to change as the Earth's climate changes?, 783
 Are the increases in atmospheric carbon dioxide and other greenhouse gases during the industrial era caused by human activities?, 512-513
 Can individual extreme events be explained by greenhouse warming?, 696
 Can the warming of the 20th century be explained by natural variability?, 702-703
 Do projected changes in climate vary from region to region?, 865
 Has there been a change in extreme events like heat waves, droughts, floods and hurricanes?, 308-309
 How are temperatures on Earth changing?, 252-253
 How do human activities contribute to climate change?, 135-136
 How is precipitation changing?, 262-263
 How likely are major or abrupt climate changes, such as loss of ice sheets or changes in global ocean circulation?, 818-819
 How reliable are the models used to make projections of future climate change?, 600-601
 If emissions of greenhouse gases are reduced, how quickly do their concentrations in the atmosphere decrease?, 824-825
 Is sea level rising?, 409
 Is the amount of snow and ice on the Earth decreasing?, 376-377
 Is the current climate change unusual compared to earlier changes in Earth's history?, 465
 What caused the ice ages and pre-industrial climate changes?, 449-450
 What factors determine Earth's climate?, 96-97

What is radiative forcing?, 136
 What is the greenhouse effect?, 115-116
 What is the relationship between climate change and weather?, 104-105

Feedbacks*, 77-80, 97, 499-587

carbon cycle, 501, 511-539, 534,
 566, 789-793, 823-825
 climate-vegetation, 452, 789-793
 cryospheric, 110, 593, 638-639
 modelling, 593, 605-606,
 629-640, 632B
 permafrost-climate, 110
 projections, 77-80, 789-811
 snow-albedo, 343, 593, 638-639, 640
 water vapour, 593, 630-633, 632B
 water vapour-lapse rate, 633-635, 640
 See also Climate system couplings

Fingerprints*, 100, 668

Fires, 501, 527

Floods, 311B, 783, 784

Fluorinated ethers (HFEs), 213

Forcing. See Radiative forcing

Forests*, 517-518, 520-521, 527-528

Fossil fuel emissions*, 25-29, 138-140, 145, 160-165, 204-205, 511-518, 546

Frequently Asked Questions. See FAQs

Frozen ground*, 43-44, 340, 341, 342-

343, 369-374, 375, 376, 772

G

General Circulation Models (GCMs).

See Climate models

Geopotential height, 280-281, 285

Glacial-interglacial cycles. See Palaeoclimate

Glacial isostatic adjustment (GIA)*,

408, 411, 417, 457

Glaciers*, 341, 342, 356-360, 368, 717

mass balance*, 357-359, 814-816, 844
 monitoring, 110
 palaeoclimate, 57, 436, 461B
 projections, 776B, 814-816, 844-845
 sea level rise and, 44, 358, 359, 375,
 418, 419, 814-816, 829
 summary, 44, 57, 339, 375, 376, 436

'Global dimming'*, 41, 238,

278-280, 279B, 317

Global temperature potential

(GTP), 215-216

Global warming potentials (GWPs)*,

31, 33-34, 137, 210-216

Greenhouse effect, 103-106, 115-116, 696

Greenhouse gases (GHGs)*, 23-35, 100,

131, 135-153, 200-206, 512-513
 couplings and feedbacks, 501-
 502, 539-555, 540B
 lifetimes, 212-213, 824-825
 long-lived (LLGHGs), 31-35, 133,
 137-153, 198, 201, 203-204
 palaeoclimate, 435, 436, 440-450,
 446B, 455, 459-460, 481
 projections, 753, 755-760,
 789-811, 822-828

radiative forcing, 31-35, 131, 135-136,
 153, 203-204, 212-213

See also specific gases

Greenland ice sheet. See Ice sheets

H

Hadley Circulation*, 295-296, 299, 318

Halocarbons*, 28, 100, 135, 141, 145, 205, 214-215, 512, 513

Halons, 100, 145, 207

Heat balance. See Energy balance

Heat waves, 40, 73, 308, 311-

312B, 314, 783

Heinrich events, 455, 456

Holocene. See Palaeoclimate

Human influence on climate. See Detection and attribution of climate change

Hurricanes, 239, 304, 305B, 306-

312, 312B, 314, 316

projections, 750, 864

See also Cyclones

Hydrochlorofluorocarbons (HCFCs), 28

industrial era increase, 512, 513

radiative forcing, 131, 141, 145,

146, 205, 207, 212

Hydrofluorocarbons (HFCs), 100,

141, 144-145, 146, 205

industrial era increase, 512, 513

summary, 28, 131, 212

Hydrogen (H₂), 215, 547, 548

Hydrology. See Water

Hydroxyl radical (OH), 131, 147-149, 205, 502, 550-553, 795, 796

I

Ice, 44-46, 339-343, 346-369, 374-377

flow, 44-45, 342, 367B, 368

land ice, 354, 418, 419

mass balance*, 357-359, 374-375

pack ice, 342, 353, 355, 356

river and lake ice, 44, 339, 341,

342, 346-349, 375

sea ice (see Sea ice)

See also Glaciers; Ice caps; Ice sheets;
 Ice shelves; Ice streams

Ice ages*, 56B, 449-450, 453, 641, 776B

Ice-albedo feedback, 97

Ice caps*, 44, 341, 356-360, 776B, 814-816

projection methods, 844-845

sea level change and, 342, 374, 829

summary, 339, 375-376

Ice cores*, 24, 54-57, 106, 439,

444, 446B, 476

Ice nuclei, 171, 188, 502, 555, 559

Ice sheets*, 341-342, 361-369, 717

Antarctic, 46, 341, 342, 361, 364-366,

374, 375, 376, 776-777B,

816-820, 821, 830-831

causes of changes, 366-369, 367B

dynamics and stability, 44B,

46, 367B, 845

- Greenland, 46, 70, 341, 342, 361, 363-364, 365-366, 374, 375, 376, 418, 419, 772, 776-777B, 816-820, 821, 829-830
- mass balance*, 80, 361-366, 772, 816-817, 845
- modelling, 592, 641-642, 646-647
- palaeoclimate, 367B, 456-457, 459
- projections, 70-71, 80, 772, 776-777B, 816-820, 821, 829-831, 845
- sea level equivalents, 342, 342, 361, 374
- sea level rise and, 46, 339, 361, 366, 367B, 375, 418, 419, 457, 459
- summary, 44-46, 339, 340, 374-375
- Ice shelves***, 341-342, 361-362, 366, 369, 717
- Larsen B Ice Shelf, 45, 317, 366, 374, 776B, 819
- projections, 776-777B, 819-820
- summary, 341-342, 374, 375
- Ice streams***, 361, 362, 366, 367B, 368, 374
- Indian Ocean**, 400-401
- Indian Ocean Dipole (IOD), 295
- projections, 910, 911, 914
- salinity, 393, 394
- temperature, 237, 246, 295, 400-401, 420
- Insolation***, 436, 445B, 453, 460, 462, 464, 673
- Inter-Tropical Convergence Zone (ITCZ)***, 295, 566, 624
- Iodine compounds**, 557
- Islands, small**. *See* Climate projections
- J**
- Jet streams**, 280-281, 285
- K**
- Kyoto Protocol gases**, 28, 131, 141, 143-145, 512
- L**
- La Niña**. *See* El Niño Southern Oscillation
- Labrador Sea**, 285, 393, 396, 397B, 416-417, 776B
- Lake ice**, 44, 339, 341, 342, 346-349, 375
- Land climate system**, 504-511, 505B
- modelling, 597-599, 617-618, 646-647
- Land ice**, 354, 418, 419
- Land surface air temperature***. *See* Temperature
- Land use change***, 180-184, 205, 243-245, 512, 513, 526-528, 897-898B
- carbon budget, 516, 517-518, 527-528
- climate projections, 792-793
- emissions from, 518
- land cover, 30, 136-137, 180-182, 183, 509, 682-683, 792-793, 897-898B
- land water storage, 126-127, 317, 413, 418-419
- urban effects, 30, 36, 243-245, 259, 506B
- Last Glacial Maximum (LGM)***, 58, 435, 447-451, 673, 679-680, 725, 798-799B
- Latent heat**, 97, 393, 399
- Likelihood***. *See* Uncertainties
- LOSU (level of scientific understanding)***, 22B, 201-202
- Low-pass filters**, 336
- M**
- Madden-Julian Oscillation (MJO)**, 592, 601, 625
- 'Medieval Warm Period'***, 466, 468-469B
- Mediterranean Sea**, 399
- Meridional heat transport (MHT)**, 394, 429-430
- Meridional Overturning Circulation (MOC)***, 48, 111, 395-397, 397B, 421, 514, 707
- modelling, 603-604, 615-616, 640-642
- projections, 72, 80, 752, 772-774, 775-776B, 801-802, 818, 823
- Methane (CH₄)**, 27, 77-78, 100, 135, 140-143, 513
- atmospheric concentration, 24-25, 27, 131, 140-143, 146, 501-502, 511-514
- atmospheric growth rate, 135, 142-143, 502
- couplings and feedbacks, 77-78, 539-544
- modelling, 642
- palaeoclimate, 435, 444, 447, 448, 455, 459-460
- permafrost, 642
- projections, 502, 793-795, 796
- radiative forcing, 25, 27, 131, 140-143, 205, 207, 212, 214
- Methane hydrate**, 642
- Methyl chloroform (CH₃CCl₃)**, 141, 145-146, 147-149, 212
- Methylene chloride (CH₂Cl₂)**, 141, 145, 213
- Microwave Sounding Unit**. *See* MSU (Microwave Sounding Unit)
- Mid-latitude circulation**, 780-782
- Mid-latitude storms**, 751
- See also* Cyclones, extratropical
- Milankovitch cycles**, 56B, 445B, 449
- Mineral dust aerosol**, 29, 132, 167-168, 204-205
- Mitigation**, 753, 827-828
- Models**. *See* Climate models
- Monsoons***, 295-299, 318, 711, 716
- modelling, 626
- palaeoclimate, 435, 462-463, 464, 482
- projections, 751, 778-779, 780
- Montreal Protocol gases**, 28, 131, 141, 145-146, 512
- Mountain regions**, 886B
- MSU (Microwave Sounding Unit)***, 36, 237, 266, 267-268
- Mt. Pinatubo**, 98, 109, 142, 193-194, 723
- Multi-model data set (MMD)**, 597-599, 753-754, 858-860B
- N**
- Natural climate forcing**. *See* Radiative forcing
- New Zealand**. *See* Climate projections
- Nitrate aerosol**, 132, 167, 204-205
- Nitric oxides (NO_x)**, 214, 215, 544-546, 793-795
- Nitrogen compounds**, 502, 544-546, 547
- Nitrous oxide (N₂O)**, 100, 105-106, 115, 135, 143-144, 513
- atmospheric concentration, 24-25, 27, 131, 141, 143-144, 146, 544
- couplings and feedbacks, 544-546, 547
- global budget, 544-546
- palaeoclimate, 444, 447, 448, 455, 460
- radiative forcing, 25, 27, 131, 141, 205, 212, 214
- Non-methane volatile organic compounds (NMVOCs)**, 214, 215, 549
- Nordic Seas**, 396-398
- North America**. *See* Climate projections
- North Atlantic Deep Water (NADW)**, 395, 396-398, 421, 437, 456, 642
- North Atlantic Ocean**, 394-399, 395, 397B, 402, 413, 482
- North Atlantic Oscillation (NAO)***, 290-292, 395-399, 402, 408
- changes, 238-239, 248, 290-292, 709-710
- modelling, 620
- past variability, 482
- projections, 777B, 780-781, 806
- summary, 38, 39B, 238-239
- teleconnections, 286, 290-292, 295
- North Pacific Index (NPI)**, 287B, 289, 290
- Northern Annular Mode (NAM)***, 248, 287B, 389, 397, 709-710
- modelling, 620-621
- projections, 780-782
- summary, 38, 39B, 238-239
- teleconnections, 290-292, 295
- O**
- Ocean-climate couplings**, 501, 503, 519, 521-523, 528-533, 529B
- Ocean precipitation**, 259-260
- Ocean processes, modelling**, 535-538, 597-599, 603-604, 613-616, 622-623, 646-647
- Oceanic climate change, 385-433**, 705-707, 731
- acidification*, 77, 387, 403, 405-406, 408, 529B, 531, 750, 793, 794-795
- air-sea fluxes, 283-285, 393-394, 403, 408
- biogeochemistry, 48, 387, 389, 403-408, 503

- biological activity (productivity), 408
carbon/carbon dioxide, 387, 403-406, 408, 420, 793
circulation, 48, 111-112, 387, 394-402, 397B, 417, 420
coupled ocean-atmospheric dynamics, 111-112, 286-295, 318
decadal variability, 389, 412-413
density, 414-416, 812-814
heat content, 47-48, 387, 389, 390-393, 420, 705-706
heat transports, 393-394, 429-430
nutrients, 406-407
oxygen, 48, 403, 406, 407, 408, 430
projections, 750-751, 765, 793, 794-795, 801, 812-822, 822
salinity, 48, 49, 318, 387, 389-390, 393, 394-402
salinity measurement, 390, 420, 429
sea level, 48-50, 51B, 387, 408-421, 431, 432, 707-708, 750-751, 812-822
summary, 47-51, 84, 387-388, 420-421
techniques, error estimation and measurement systems, 429-432
temperature, 61, 62, 387, 389-393, 394-402, 420
temperature measurement, 389-390, 429, 430
thermal expansion*, 387, 408, 412-413, 414-417, 419-420, 801, 812, 820-821
water masses, 387, 394-402, 417-419, 706-707
See also specific oceans
- OH.** *See* Hydroxyl radical (OH)
- Optimal fingerprinting,** 744
- Orbital forcing,** 56B, 437, 445B, 453, 462-463
- Oxygen (O₂)**
atmospheric, 139
dissolved in oceans, 48, 403, 406, 407, 408, 430
- Ozone***, 115, 135, 149-152, 540B, 547-550
global budgets, 547-549
precursors, 547-550, 795
projections, 554, 759-760, 793-796
radiative forcing, 28, 132, 149-152, 203-204, 759
stratospheric, 28, 73, 149-150, 198, 201, 203-205, 553-555
tropospheric, 28, 108-110, 150-152, 201, 203-205, 513, 547-550
- P**
- Pacific Decadal Oscillation (PDO),** 246, 289-290, 295, 389, 408, 709
index, 287B
modelling, 621
summary, 38, 39B, 238
- Pacific Decadal Variability***, 289-290, 621
- Pacific-North American (PNA) pattern***, 286, 286, 287B, 288-289, 295
modelling, 622
summary, 38-40, 39B
- Pacific Ocean,** 399-400
cyclones, 306, 307
projections, 399-400, 910-911, 915
salinity, 387, 394-395, 399-400, 402, 420
sea level change, 413-414, 420
temperature, 237, 247, 399-400, 402, 420
- Pacific-South American (PSA) pattern,** 288-289, 295
- Palaeoclimate***, 54-58, 85, 106-107, 433-497, 679-683
attribution studies, 64, 446B, 460
current interglacial (Holocene), 57, 435-436, 453-454, 459-464, 461B, 679-680
glacial-interglacial variability, 435, 444-459
ice sheets, 367B, 456-457, 459
last 2,000 years, 436, 466-483, 468-469B
Last Glacial Maximum (LGM)*, 58, 435, 447-451, 673, 679-680, 725, 798-799B
Last Interglaciation (LIG), 453, 454, 458-459
'Medieval Warm Period*', 466, 468-469B
methods, 438-440
modelling, 435, 436-437, 439-440, 476-481
orbital forcing, 437, 445B, 453, 462-463
pre-Quaternary climates, 440-444, 441
sea level, 58, 435, 457-459
uncertainties, 483
- Perfluorocarbons (PFCs),** 28, 100, 131, 141, 144, 145, 207, 212-213
- Permafrost***, 341, 342-343, 369-372, 373, 376
permafrost-climate feedback, 110
projections, 772
summary, 43-44, 317, 339, 375
- pH* of oceans,** 77, 387, 403, 405-406, 408, 529B, 531
projections, 750, 793, 794-795
- Photosynthesis***, 186, 514, 527
- Plankton***, 439, 504, 514, 529B, 567
- Plant physiology,** 185-186
- Pleistocene***, 447, 457
- PNA.** *See* Pacific-North American (PNA) pattern
- Polar regions.** *See* Climate projections
- Pollen analysis***, 439, 455, 471
- Pre-Quaternary climates***, 440-444, 441
- Precipitation,** 254-265, 712-716, 731-732
aerosol effects, 254, 502, 560, 563, 564
couplings and feedbacks, 507, 508, 509-510
extreme events, 41, 301-303, 308, 314-315, 316, 714, 750, 782-784, 785, 863
modelling, 611-612, 628
monsoons (*see* Monsoons)
projections, 74, 75-77, 750, 762-763, 768-770, 782-784, 785, 806, 849-851, 854-857, 859B, 863
regional (*see* Climate projections)
summary, 41-43, 53-54, 238, 317-318
- Predictions.** *See* Climate predictions
- Pressure.** *See* Sea level pressure
- Probability density functions (PDFs)*,** 65, 719-721, 724-725, 798-799B, 808-809, 923-924
- Projections.** *See* Climate projections
- Proxy methods***, 438-439, 466-475, 481
- PRUDENCE project,** 873B, 925
- Q**
- Quasi-Biennial Oscillation (QBO),** 266, 283, 625-626
- R**
- Radiation,** 277-280, 279B, 317
couplings and feedbacks, 502, 505B, 508, 563-564, 565, 631
modelling, 610-611, 631
- Radiative forcing (RF)*,** 108-110, 129-234
aerosols, 29-30, 131-132, 153-180, 559
calculation methodologies, 134, 196-197, 199
chemically and radiatively important gases, 24-28, 131, 137-153
climate response, 64-66, 670-679
concept, 133-137, 136-137B, 826
contrails and aircraft-induced cloudiness, 132, 186-188
defined, 133
efficacies*, 197-199, 212-213
external*, 96, 133-134, 152, 667
future impact of current emissions, 77, 206-207
global mean, 31-35, 132, 200-206
global warming potentials and emission metrics, 31, 33-34, 137, 210-216
modelling, 173-180, 594-596, 607-608, 629-633, 643, 671-673
natural forcings, 96, 137, 188-195, 445B, 666
orbital forcing, 56B, 437, 445B, 453, 462-463
palaeoclimate, 438-439, 444-454, 445B, 476-481
projections, 752, 755-760, 795, 797
spatial and temporal patterns, 35, 132, 196, 209-210, 674-678
summary, 24-35, 131-132, 199-210
surface albedo and surface energy budget, 132, 180-186, 201, 203-205
surface forcing, 35, 133, 153, 170, 196, 208-210
time evolution, 208-209

- uncertainties, 199-200, 201-202
 utility of, 195-199
 vertical forcing, 196
See also specific gases and components
- Radiosondes**, 36, 82, 265-267, 719
- Rapid climate change.** *See* Abrupt climate change
- Regional changes**
 ocean circulation and water masses, 394-402
 projections (*see* Climate projections)
 sea level, 413-414
- Revelle factor**, 531
- River and lake ice**, 44, 339, 341, 342, 346-349, 375
- River flow (streamflow)**, 261-264
- River ice**, 44, 339, 341, 342, 346-349, 375
- S**
- Salinity (of oceans)**, 48, 49, 318, 387, 393, 394-402, 420, 421
 measurement, 390, 420, 429
 modelling, 613-615
 sea level/ocean mass and, 416-417, 417-418
- Satellite methods**
 altimetry, 49, 408, 410, 411-412, 411, 431
 Microwave Sounding Unit (MSU), 36, 237, 266, 267-268
- Scenarios.** *See* Climate scenarios; SRES scenarios
- Science, climate.** *See* Climate change science
- Scientific method**, 95
- Scientific understanding.** *See* LOSU (level of scientific understanding)
- Sea ice***, 341, 342, 350-356, 376, 716
 Antarctic, 342, 351, 352, 353, 355
 Arctic, 44, 45, 60, 317, 339, 342, 351-356, 716, 776B, 851
 feedbacks, 639
 modelling, 592, 597-599, 606-607, 616-617, 639, 646-647
 projections, 770, 771, 776B
 summary, 317, 339, 374, 375
- Sea level**, 48-50, 51B, 408-421
 attribution for changes, 60-61
 budget (global mean sea level change), 48-50, 419-420, 457
 change in 20th century (rise), 317, 389, 410-414, 415, 418-419, 420, 707-708
 change in previous millenia, 58, 409, 435, 457-459
 changes projected (*see* projections, below)
 commitment, 68, 80, 752, 822, 828-831
 contributions to, 44-46, 50, 60-61, 366, 374, 375, 408, 413, 414-420, 751, 812-822
 estimation/measurement techniques, 408, 410-412, 431, 432
 extremes, 50, 414, 916-917B
 interannual/decadal variability, 410, 412-414, 707-708
 long-term changes, 412-413
 methods of projections, 844-845
 palaeoclimate, 58, 409, 435, 457-459
 projections, 68, 70-71, 73, 90, 409, 750-751, 812-822, 823, 909, 914-915, 916-917B
 relative (RSL)*, 413, 457-458
 sea level equivalents (SLEs)*, 340, 342, 361, 374
 summary, 48-50, 51B, 52-53, 84, 90, 374-375, 387, 420-421
- Sea level pressure (SLP)**, 63, 280, 711
 projections, 73, 751, 770, 780-781
- Sea salt**, 556
- Sea surface temperature (SST)***, 101, 102, 245-247, 312B, 391
 palaeoclimate, 451, 460
 projections, 73, 786-788, 861
 rates of warming, 318
 summary, 51, 64, 237, 318
 tropical cyclones and, 239
- Severe weather.** *See* Extreme events
- Snow, ice and frozen ground**, 337-383, 716-717
 area, volume, and sea level equivalents, 342, 374
 frozen ground, 340, 341, 342-343, 369-374, 376
 glaciers and ice caps, 339, 341, 342, 356-360, 374, 375, 376, 717
 ice sheets and ice shelves, 339-341, 342, 361-369, 367B, 374-375, 376, 717
 modelling, 592, 593, 599-601, 606-607, 616-617, 617
 projections, 70-71, 73, 80, 750, 770-772, 776B, 814-816, 859B, 861
 regional projections (*see* Climate projections)
 river and lake ice, 339, 341, 342, 346-349, 375
 sea ice, 341, 342, 350-356, 374, 375, 376, 716
 snow albedo, 30, 132, 184-185, 205, 343, 638-639, 640
 snow cover, 317, 341, 342, 343-346, 375, 376-377, 593, 716-717
 snowfall, 258-259
 summary, 43-46, 83, 339-340, 374-375
- Soil moisture***, 260-265, 509, 510, 605-606, 769, 770
- Solar forcing**, 30-31, 476-478, 479
- Solar irradiance**, 30-31, 681-682
 'global dimming*', 238, 278-280, 317
 palaeoclimate, 476-478, 479
 total (TSI), 30, 107-108, 132, 188-189, 190, 198, 201, 203-205
- Solar variability**, 107-108, 188-193
- Soot***, 30, 172-173, 184, 559
See also Black carbon
- South Atlantic Convergence Zone (SACZ)**, 295
- South Pacific Convergence Zone (SPCZ)**, 295
- Southern Annular Mode (SAM)***, 287B, 292-293, 295, 389, 710-711
 modelling, 620-621
 projections, 782
 summary, 38, 39B, 238-239
- Southern Ocean**, 387, 401-402, 420
 modelling, 591, 592, 616
- Southern Oscillation.** *See* El Niño Southern Oscillation
- Southern Oscillation Index (SOI)**, 287B
- SRES scenarios***, 24-31, 761, 802, 806, 822-827, 852-861, 858-860B
 sea level rise, 68, 70-71, 409, 419, 750-751, 820-822
 subset for projections, 753, 761
 surface warming, 68-73, 74-77, 79
- Storm tracks***, 281-282, 285, 305B, 318
- Stratosphere***, 265-266, 283
 aerosols, 132
 ozone, 28, 73, 149-150, 198, 201, 203-205, 553-555
 stratosphere-troposphere exchange (STE), 795-796
 stratospheric-tropospheric relations, 284B, 795-796
 temperature, 36, 62, 237-238, 265-271, 285
 water vapour, 274-275
- Streamflow.** *See* River flow
- Sulphate aerosols**, 160-161, 193, 194
 couplings and feedbacks, 78-79, 502, 566-567
 palaeoclimate, 436, 478, 480
 radiative forcing, 31, 108-110, 160-161, 162, 204-205
 summary, 31, 132
- Sulphur hexafluoride (SF₆)**, 141, 144, 145, 146, 207
 summary, 28, 131, 212
- Sunspots***, 107, 108, 189, 191, 476
- Surface climate change**, 82, 235-336
 extreme events, 237, 299-316
 modelling, 604-606, 646-647
 precipitation, drought and surface hydrology, 238, 254-265, 301-303, 308, 317, 318
 surface fluxes, 283-285, 393-394, 403, 408
 temperature, 237, 239, 241-253, 300-301, 308-309, 317, 318
 tropics, subtropics, and monsoons, 295-299, 304-315
See also Atmospheric climate change
- Surface/surface air temperature*.**
See Temperature

- T**
- Teleconnections***, 38-40, 238, 281, 286-295, 287B
- Temperature**, 100-102, 241-253, 683-705
- attribution of changes, 58-63
 - continental temperature change, 61, 62-63, 74-76, 693-698, 852-862
 - diurnal temperature range (DTR)*, 36, 237, 243-244, 251, 766-768, 786
 - extremes, 40, 237, 300-301, 302, 308-309, 311-312B, 314-315, 627-628, 698-699, 750, 785-786, 787, 862
 - free atmosphere, 699-701
 - global ground surface temperature (GST), 474
 - global mean surface temperature, 36, 37, 62, 237, 247-248, 249, 252-253, 318, 683-693, 703, 749
 - global temperature potential, 215-216
 - global warming potentials, 31, 33-34, 137, 210-216
 - industrial era change, 683-705, 727, 729-730
 - last 2,000 years, 435-436, 466-483, 468-469B
 - measurement, 100-102, 102, 389-390, 429, 430
 - modelling, 600, 608-610, 613-615, 627-628
 - nighttime marine air temperature (NMAT), 243
 - oceans, 60, 61, 387, 389-393, 394-402, 420
 - palaeoclimate, 435-436, 440-457, 449-450B, 460-476, 462, 467-470, 475, 477, 478-481
 - projections, 69-72, 74-76, 762, 763, 764-766
 - relationship with precipitation, 264-265
 - sea surface temperature (SST), 42, 51, 64, 73, 101, 102, 237, 245-247, 312B, 318, 391
 - spatial distribution of changes, 37-40, 62-63, 250-251
 - spatial trend patterns, 250-251
 - summary, 36-40, 51-52, 60-61, 237, 239, 317-318
 - surface*, 61, 62-63, 100-102, 237, 239, 241-253, 317, 318, 683-693
 - surface air temperature (SAT), 51-52, 339, 474, 749, 845
 - upper air, 237, 265-271
- See also* Temperature projections
- Temperature projections**, 762, 763, 764-766, 785-786, 787, 806, 807-811
- commitment, climate change, 79, 752, 822-828
 - extremes, 862
 - global temperature at year 2100, 809-810, 858B
 - long-term projections, 822-828
 - regional projections, summarized, 21-23, 854-857, 858-859B
 - summary, 66, 69-72, 74-75, 749-750
- See also* Climate projections
- Terrestrial biosphere***, 504-505, 527-528, 606, 646-647
- Terrestrial ecosystems**, 503, 520
- Terrestrial processes, modelling**, 604-606
- Thermal expansion***, 387, 408, 412-413, 414-417, 419-420
- projections, 801, 812, 820-821, 823, 828-829
- Thermohaline Circulation (THC)***, 246-247
- See also* Meridional Overturning Circulation
- Thresholds**, 640-643
- Tide gauges***, 48-49, 408, 410, 411-412, 431, 432
- Tipping point**, 775B
- Top-of-atmosphere (TOA) radiation**, 277-278, 317
- Total solar irradiance (TSI)***, 107-108, 188-189, 190, 198, 202-205
- summary, 30, 132
- Transient climate response (TCR)**, 691, 718, 723, 724, 725, 754, 798B, 800-801, 807
- summary, 66, 88
- Tree rings***, 438, 439, 459, 471, 472-473, 475, 476
- Tropics**, 295-299
- climate projections, 751, 779, 786-788, 864, 915
 - tropical cyclones, 41-43, 239, 304-307, 305B, 314, 316, 711-712, 751, 786-788, 864, 915
 - tropical storms, 239, 304-312, 314-315, 316
- Tropopause***, 266, 270, 699-700
- Troposphere***, 265-267, 266, 730
- nitrous oxide (N₂O), 545, 547
 - ozone, 28, 108-110, 150-152, 201, 203-205, 513, 547-550
 - stratospheric-tropospheric relations, 284B, 795-796
 - temperature, 36, 37, 62, 237, 253, 265-271, 268-269
 - water vapour, 40, 238, 272-274, 318, 632B
- Twomey effect**. *See* Cloud albedo effect, under Clouds
- Typhoons**. *See* Cyclones, tropical
- U**
- Uncertainties***, 22-23B, 81-91, 119-121, 669
- quantification, 921-925
- Urban effects on climate**, 30, 36, 243-245, 259, 506B
- See also* Land use change
- Urban heat islands***, 102, 185, 237, 243-245
- Urban precipitation patterns**, 259
- V**
- Vegetation**, 505B, 507, 508-510, 566
- modelling, 509-510
 - projections, 777B, 789-793
- Volatile organic compounds (VOCs)**, 78, 150, 206, 207, 214, 547-549, 556-557, 796
- Volcanic eruptions**, 31, 96-97, 137, 193-195, 201, 681-682
- modelling, 641, 723
 - Mt. Pinatubo, 98, 109, 142, 193-194, 723
 - projections, 797
 - volcanic forcing, 459, 477, 478, 479, 673, 678, 731
- W**
- Walker Circulation***, 112, 295-296, 299, 318
- Warming**. *See* Temperature
- Water**, 40-43
- land water storage, 318, 418-419
 - projections, 768-770, 860-861
 - surface hydrology, 35, 64, 254, 260-265, 261B, 618, 768-770; 886B
 - surface water balance, 505B
- Water vapour**, 115, 135, 152, 185, 271-275, 712
- feedback, 593, 630-633, 632B
 - modelling, 593, 630-633
 - projections, 796, 860-861
 - radiative forcing, 28, 131, 152, 185, 201-204
 - stratospheric, 274-275
 - summary, 28, 40, 53-54, 131, 135, 238, 318
 - surface, 238, 272-274, 318
 - tropospheric, 40, 238, 272-274, 318
 - water vapour-lapse rate feedback, 633-635, 640
- Waves, ocean**, 283-285, 799, 806
- Winds**, 38, 159, 280-281, 283-285, 864, 877-878, 902
- mid-latitude westerlies, 238-239, 280, 283, 290
- See also* Cyclones
- Y**
- Younger Dryas***, 455, 456