# Appendix B

## Acronyms, Symbols, and Constant Values

Purpose: Defines acronyms and symbols used throughout the book. Where relevant, the value of the constant is provided

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>available potential energy</td>
</tr>
<tr>
<td>A_{bd}</td>
<td>planetary albedo</td>
</tr>
<tr>
<td>A_{bd,c}</td>
<td>planetary albedo (cloudy)</td>
</tr>
<tr>
<td>A_{bd,nc}</td>
<td>planetary albedo (clear, no cloud)</td>
</tr>
<tr>
<td>AEF</td>
<td>atmospheric total energy flux</td>
</tr>
<tr>
<td>AMIP</td>
<td>Atmospheric model intercomparison project</td>
</tr>
<tr>
<td>ASHF</td>
<td>atmospheric sensible heat flux</td>
</tr>
<tr>
<td>amc</td>
<td>angular momentum conserving</td>
</tr>
<tr>
<td>a_{\Lambda}</td>
<td>absorptivity at electromagnetic wavelength ( \Lambda )</td>
</tr>
<tr>
<td>a_{SA}</td>
<td>shortwave absorptivity of ‘glass’ atmosphere</td>
</tr>
<tr>
<td>a_{SG}</td>
<td>shortwave absorptivity of ground</td>
</tr>
<tr>
<td>a_{LA}</td>
<td>longwave absorptivity of ‘glass’ atmosphere</td>
</tr>
<tr>
<td>a_{LG}</td>
<td>longwave absorptivity of ground</td>
</tr>
<tr>
<td>BEBVE</td>
<td>baroclinic equivalent barotropic vorticity equation</td>
</tr>
<tr>
<td>C_{E}</td>
<td>bulk transfer coefficient for evaporation (similar magnitude as C_{H_{i}} )</td>
</tr>
<tr>
<td>C_{H_{i}}</td>
<td>bulk transfer coefficient for heat (1x10^{-3} to 5x10^{-3}, unitless)</td>
</tr>
<tr>
<td>C_{p}</td>
<td>specific heat of dry air at constant pressure, ( \approx 1004 \text{ J}} \text{ K}^{-1} \text{ kg}^{-1}</td>
</tr>
<tr>
<td>C_{d}</td>
<td>specific heat estimate for dry soil, ( \approx 800 \text{ J}} \text{ K}^{-1} \text{ kg}^{-1}</td>
</tr>
<tr>
<td>C_{wv}</td>
<td>specific heat estimate for wet soil, ( \approx 1500 \text{ J/(kgK)}</td>
</tr>
<tr>
<td>C_{v}</td>
<td>specific heat of dry air at constant volume, ( \approx 717 \text{ J}} \text{ K}^{-1} \text{ kg}^{-1}</td>
</tr>
<tr>
<td>C_{w}</td>
<td>specific heat for water, ( \approx 4200 \text{ J}} \text{ K}^{-1} \text{ kg}^{-1} ) varies with temperature. This value for ( T \approx 280 \text{ K}</td>
</tr>
<tr>
<td>CTW</td>
<td>cloud-track winds</td>
</tr>
<tr>
<td>c</td>
<td>speed of light (3 \times 10^8 \text{ m/s})</td>
</tr>
<tr>
<td>c_{B}</td>
<td>Boltzmann constant (1.38 \times 10^{-23} \text{ J/K})</td>
</tr>
<tr>
<td>c_{d}</td>
<td>drag coefficient (3x10^{-3} over land, 10^{-3} over ocean; see surface stress, ( \tau ))</td>
</tr>
<tr>
<td>c_{\lambda}</td>
<td>Planck constant (6.625 \times 10^{-34} \text{ Js})</td>
</tr>
<tr>
<td>D</td>
<td>divergence</td>
</tr>
<tr>
<td>D_{T}</td>
<td>total diabatic heating rate per unit mass, ( = D_{i} / C_{p} ) (units K/s)</td>
</tr>
<tr>
<td>D_{i}</td>
<td>total diabatic heating rate in units J s^{-1} kg^{-1} (see C.3)</td>
</tr>
<tr>
<td>D_{SM}</td>
<td>diabatic heating rate from processes other than net changes of water state (K/s units)</td>
</tr>
<tr>
<td>DOE</td>
<td>(U.S.) Department of Energy</td>
</tr>
<tr>
<td>DSE</td>
<td>dry static energy (per unit mass), ( = C_{p} T + \Phi )</td>
</tr>
</tbody>
</table>

Commented [01]: Missing the many acronyms from the reanalysis data sources. See those tables in chapter 2. Such as AIREP, ACARS, AMDAR, ASDAR, TAO, TRITON, PAOBs, beta, cap U, k_{sub}, beta, GPS/MET, LIMS, TCPW, RMS. See website list at bottom of table 2.1, WMO, more in Table 2.3 and 2.4

Commented [RG2]: Consider using D instead of Q
dX distance (path length) increment
do solid angle increment

ECMWF European Centre for Medium-range Weather Forecasts
ERA-40 ECMWF 40 year reanalysis datasets
ERA-Interim ECMWF reanalysis dataset successor to ERA-40

E_v evaporation of liquid water
\( E \) radiance
\( E_o \) diffuse radiance emitted by a layer, also \( E_d \)
\( E_i \) incident irradiance
\( \bar{E}_i \) average intensity that reaches an atmospheric layer
\( E_i \) radiance from layer \( i \)
\( E_A \) radiance (at wavelength \( \Lambda \))

ENSO el Niño – Southern Oscillation

e vapor pressure
e_s saturation vapor pressure

F friction
\( F_{cd} \) fraction of sky covered by cloud
\( F_r \) Froude number, = \((U, \text{typical value})/(gH)\)
\( f \) Coriolis parameter, = \(2\Omega \sin \phi \)
\( f_0 \) constant value of Coriolis parameter at latitude \( \phi_0 \), = \(2\Omega \sin \phi_0 \)
\( g \) acceleration of gravity, = 9.81 m s\(^{-2}\)
\( h \) elevation, Montgomery Stream function, geopotential (See appendix C)
\( H \) scale height, = \(RT/g\) where \( T \) has usually been averaged in some way

HCBE hypothetical boundary between atmospheric regions where Hadley Cells dominate versus baroclinic eddies.

\( H_L \) Sunrise or sunset (in radians) relative to local noon, such that \(2H_L = \) the length of daylight (in radians)

i square root of -1
\( \hat{i} \) (bold) unit vector pointing eastwards
\( \hat{\imath} \) (bold) unit vector pointing northwards

\( J \) irradiance (over all wavelengths)
\( I_A \) irradiance from atmosphere in glass slab model
\( I_F \) net vertical flux of radiant energy
\( I_g \) irradiance from ground in radiative models
\( I_i \) irradiance from layer \( i \)
\( I_{in} \) irradiance input into glass slab model
\( I_o \) incident solar radiation at the TOA
\( I_a \) annual and global average solar radiation spread over the Earth (=\(I_{sol}/4\))
\( I_{sol} \) solar constant (1356-1370 Wm\(^{-2}\), 1365 generally used here)
\( I_{sol}\_1 \) solar radiation at the TOA incident upon a latitude averaged over a day
\( I_{sol}\_2 \) irradiance (at wavelength \( \Lambda \))

ISCCP International Satellite Cloud Climatology Project
ICZ intertropical convergence zone

K kinetic energy
\( j \) layer index
\( \hat{j} \) (bold) unit vector pointing northwards
\( \hat{k} \) (bold) unit vector pointing locally outwards (i.e. 'upwards')
k_a  mass extinction coefficient for absorber a
k_{Hh}  horizontal viscosity coefficient for second order friction
k_r  viscosity coefficient for Rayleigh friction
k_z  vertical viscosity coefficient for second order friction
k_0  transitional wavenumber for jets versus eddies
L  latent heat of vaporization, = 2.5 \times 10^6 \text{J kg}^{-1} \text{at } 0\text{C.}
LE  latent heat energy
LH  latent heating (from any phase change of water)
LHF  latent heat flux
LHS  left hand side (of an equation)
lw  longwave (radiation) (~5 to 200 \text{µm wavelength})
lw_{-1}  total longwave radiation from the Earth (atmosphere + surface contributions)
M  angular momentum per unit mass, = R_c (R_c \Omega + u)
M  angular momentum, = \rho R_c (R_c \Omega + u)
MMC  zonal and time mean meridional cell(s)
MSE  moist static energy (per unit mass), = C_p \Theta + \Phi + Lq
N  north
N^2  Brunt-Väisälä frequency (squared), = \frac{g}{\rho} \left( \frac{\partial \Theta}{\partial z} \right) \text{in height coordinates for an ideal gas}
NCEP  (U.S.) National Centers for Environmental Prediction
NDRA2  NCEP-DOE (AMIP-II) reanalysis datasets
NHem  Northern Hemisphere
NRC  Net radiative cooling
nr_{-1}  TOA net radiation (sw_{-1} – lw_{-1})
O_a  optical depth of absorber a
O_{ab}  optical depth of absorber a through whole depth of the atmosphere
OHF  oceanic heat flux
\rho  pressure
\rho_0  reference pressure, typically set to 10^5 \text{Pa}
PDO  Pacific Decadal Oscillation
PGF  pressure gradient force
\rho_{sfc}  surface pressure
P_{sw}  precipitation of any solid or liquid form of water
Q_v  potential vorticity in isentropic coordinates (see C.49)
Q_{QG}  quasi-geostrophic potential vorticity (see C.47)
Q_{QGy}  meridional gradient of quasi-geostrophic potential vorticity
Q_{SWE}  shallow water equations potential vorticity, = \frac{\zeta + f}{h}
QG  quasi-geostrophic
Q_{sol}  daily total solar insolation
q  specific humidity
q_{sat(TG)}  saturation specific humidity for temperature T_G
q_{sfc}  specific humidity measured at surface instrument height
R  gas constant for dry air, = 287 \text{J K}^{-1} \text{kg}^{-1}
R_v  gas constant for water vapor, = 461 \text{J K}^{-1} \text{kg}^{-1}
R_e  r \cos(\phi)
Rossby number, $= \frac{U}{L_s}$, where $U$ and $L_s$ are speed and horizontal length scales.

$r$ mean radius of the solid earth, 6370 km

RCE radiative convective equilibrium

RHS right hand side (of an equation)

RMS root mean square

S south

$S_e$ enthalpy, $= C_p T$

$S_o$ entropy, $dS_o = C_p d\ln(\theta)$

$S_R$ Rossby wave source

SH heating by sensible heat flux

SHem Southern Hemisphere

SHF sensible heat flux

SLHF surface latent heat flux

SLP sea level pressure

SPCZ South Pacific convergence zone

SSHF surface sensible heat flux

SWE shallow water equations

T temperature

$\bar{T}_A$ atmospheric temperature

$\bar{T}_G$ surface temperature

$\bar{T}_{wa}$ skin temperature of atmosphere (radiative models)

$\bar{T}_{sc}$ ‘surface’ air temperature (at surface instrument height of 2m or 10m)

TE total energy (per unit mass) = MSE+$K$

TH thickness (between two isobaric surfaces)

THC global, oceanic thermohaline circulation

TOA top of atmosphere

t time

$U_{amc}$ a zonal wind component conserving angular momentum

$U_s$ wind speed

u zonal component of the wind

$u_{ag}$ zonal component of the ageostrophic wind, $= u - u_g$

$u_g$ zonal component of the geostrophic wind, $= \frac{1}{f} \frac{\partial Z}{\partial \bar{x}}$ in pressure coordinates

V vector wind, 3 dimensional unless otherwise stated

$V_g$ geostrophic wind vector, 2 dimensional

$V_{gm}$ vertical (pressure) average geostrophic wind vector, 2 dimensional

v meridional component of the wind

$\nu_{ag}$ meridional component of the ageostrophic wind, $= v - \nu_g$

$\nu_g$ meridional component of the geostrophic wind, $= \frac{1}{f} \frac{\partial Z}{\partial \bar{x}}$ in pressure coordinates

[\nuR] meridional component of the zonal average residual circulation

w vertical velocity in height coordinates
\( w_c, w_s \) vertical velocity in cloudy, sinking regions (of tropics)

\( w_d \) mixing ratio, equivalent to saturation mixing ratio at dewpoint temperature

WBC western boundary current

\( x \) distance

\( x \) longitudinal distance (depends on coordinate system)

\( Z \) geopotential height

\( z \) elevation independent variable

\( z_a \) length

\( \mu \) specific volume, \( = 1/\rho \)

\( \alpha_v \) specific volume for water vapor, \( = 1/e \)

\( \beta \) meridional derivative of the Coriolis parameter

\( \Gamma \) lapse rate \( (= -\partial T/\partial z) \)

\( \Gamma_d \) dry adiabatic lapse rate \( (= g/C_p) \)

\( \Gamma_m \) moist (or saturation) adiabatic lapse rate

\( \delta \) solar declination angle (Chap 3 homework)

\( \lambda \) wavelength of electromagnetic radiation

\( \lambda \) longitude or azimuth based on context

\( \mu = \sin(\phi) \)

\( \rho \) density

\( \rho_a \) density of absorber

\( \rho_w \) density of fresh water, \( = 10^3 \text{ kg/m}^3 \)

\( \sigma \) Stefan-Boltzmann constant, \( = (2\pi^4 c_s^4)/(15c^2 e_s^3) = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4} \)

\( \tau \) surface stress by wind

\( \tau_{\text{zonal}} \) surface stress in zonal direction \( (= \rho \ c_d |V| u) \)

\( \nu_{\text{e}} \) electromagnetic frequency at wavelength \( \lambda \)

\( \Omega \) angular rotation rate of the earth, \( 7.292 \times 10^{-5} \text{ rad/sec} \)

\( \Omega, \Omega \) (bold or with arrow) angular rotation vector for the earth, \( = (0 \ i, \ \Omega \ \cos(\phi) \ j, \ \Omega \ \sin(\phi) \ k) \)

\( \omega \) (vertical) pressure velocity. \( \omega = dP/dt \)

\( \omega_{\text{dp}} \) diabatic pressure velocity from vertical advection balancing diabatic processes

\( \omega_{\text{circ}} \) (vertical) pressure component of the zonal average residual circulation

\( \Phi \) geopotential, \( \Phi = g \ dz = -RTdp/p \) (for hydrostatic balance)

\( \phi \) latitude or zenith angle based on context

\( \chi \) velocity potential (in two dimensions)

\( \Psi \) or \( \nu \) stream function (in two dimensions)