UNIFIED MODEL DOCUMENTATION PAPER 5

NOTATION LIST FOR METEOROLOGICAL ROUTINES, VALUES OF PHYSICAL CONSTANTS, UNITS AND VARIABLE NAMES FOR GENERAL USE IN THE UNIFIED FORECAST/CLIMATE MODEL

by

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1. NOTATION AND VARIABLE NAMES FOR METEOROLOGICAL ROUTINES

This notation is based on that in Meteorological Office Scientific paper no. 41. The names in the code will be augmented by an initial letter followed by an underscore if a naming convention is in force. Most of the notation in the dynamical equations is covered, but only those physical quantities needed for exchange between sections of the model are included. Internal notation conventions for individual physics routines are included with the technical documentation of these routines.

Values are given for physical constants which will appear in the main COMDECKs for broadcast across the model. The values are taken from the WMO Meteorological Tables (WMO ##188) where possible. The COMDECKs are as follows:

a	*COMDECK C_A	A	Mean radius of earth 6371229m
g	*COMDECK C_G	G	Mean acceleration due to gravity at earth's surface 9.80665 m s^{-2}
L_C	*COMDECK C_LHEAT	LC	Latent heat of condensation of water at 0 deg 2.501x10^6 Kkg^{-1}
L_F		LF	Latent heat of fusion 0.334x10^6 J kg^{-1} at 0°C
R	*COMDECK C_R_CP	R	Gas constant for dry air 287.05 J kg^{-1} K^{-1}
c_P		CP	specific heat of dry air at constant pressure 1005 J $Kg^{-1}K^{-1}$
κ		KAPPA	R/c_P, power used in Exner function - dimensionless
		PREF	100000
k	*COMDECK C_VKMAN	VKMAN	Von Karman's constant 0.4 (dimensionless)
ε		EPSILON	ratio of molecular weights of water and dry air 0.62198 (dimensionless)
$\varepsilon^{-1}-1$		C_VIRTUAL	(dimensionless)
Ω	*COMDECK C_OMEGA	OMEGA	Magnitude of earth's angular velocity 7.292116x10^{-5} radians s^{-1}
$0^O C$		ZERODEGC	Conversion from Kelvin to Celsius 273.15K
T_{FS}		TFS	temperature at which sea water freezes 271.35K
π	*COMDECK C_PI	PI	3.1415926535879323846
$\pi/180$		PI_OVER_180	Conversion factor degrees to radians = $\pi/180$.
$180/\pi$		RECIP_PI_OVER_180	Conversion factor radians to degrees = $180/\pi$
	*COMDECK C_KT_FT	KT2MS	knots to m/s conversion 1852/3600 m s^{-1} $knots^{-1}$
		FT2M	feet to metres conversion 0.3048 m $feet^{-1}$

	*COMDECK SWSC	SC	Solar constant 1365.
	*COMDECK C_SOILH	RHO_SNOW	250.0 Density of lying snow 250.0 kg m^{-3}
		RHO_WATER	Density of fresh water 1000.0 kg m^{-3}
		SNOW_HCON	Thermal conductivity of lying snow 0.265 W m^{-1} K^{-1}
	*COMDECK C_DENSITY	RHO_SEA	density of sea water 1000.0 kg m^{-3}
		RHO_WATER	density of pure water 1000.0 kg m^{-3}
	*COMDECK C_RHOWAT	RHO_WATER	density of water 1000.0 kg m^{-3}
	*COMDECK TICE	TICE	Temperature in kelvin at which liquid water turns to ice in the convection scheme 263.15K
R_V	*COMDECK RV	RV	Gas constant for water vapour 461.1J $kg^{-1}K^{-1}$

Symbol	Name in code	Definition, Value, Units
a		suffix for analysed value
A_k	AK	coefficients defining hybrid vertical Pa coordinate values of A_k, B_k – no units
$A_{k+1/2}$	AKH	Coefficient at half levels
$B_{k+1/2}$	BKH	Coefficient at half levels
ΔA_K	DELTA_AK	$A_{k+\frac{1}{2}} - A_{k-\frac{1}{2}}$
ΔB_K	DELTA_BK	$B_{k+\frac{1}{2}} - B_{k-\frac{1}{2}}$
b		suffix for background value
c_D, c_H, c_E	CD,CH,CE	bulk transfer coefficients for momentum (c_D), heat (c_H) and moisture (c_E) – dimensionless
c_L, c_M, c_H	LOW_CLOUD, MED_CLOUD, HIGH_CLOUD	Low, medium and high cloud amounts diagnosed from output – dimensionless
C_T	TCA	total cloud amount pure fraction (0–1) dimensionless
C_{BASE}, C_{TOP}	CCB,CCT	convective cloud base and top – dimensionless
C_C	CCA	convective cloud amount (0–1) dimensionless
CWP_C	CCLWP	Convective condensed water path (kgm^{-2})
D	D	divergence
$\mathbb{D}$	D	diffusion operator
E_*	E	surface moisture flux – kg m^{-2} s^{-1}

E		root mean square error (SI units)
e	E	water vapour partial pressure – Pa
f	ICE_FRACTION	fraction of the grid-box covered by sea-ice – dimensionless
τ_x, τ_y	TAUX,TAUY	Turbulent stress N m^{-2}
F_T	FT	vertical turbulent fluxes of heat – kg K m^{-2} s^{-1}
F_q	FQ	vertical turbulent fluxes of moisture – kg m^{-2} s^{-1}
f_1, f_2, f_3	F1,F2,F3	Components of Coriolis parameter $2\Omega\sin\phi$
$f\chi$		stability function used in definition of vertical diffusion coefficients for variable X – dimensionless
$\mathbb{F}u, \mathbb{F}v, \mathbb{F}_\theta, \mathbb{F}q$		sources and sinks of momentum, heat and moisture
g as a subscript		suffix for gridpoint value
σ_H	SD_OROG	sub-grid-scale standard deviation of orography – m
H_*	HSTAR	surface sensible heat flux – W m^{-2}
i as a subscript	I	suffix for horizontal grid-point or observation point index
	IMDI	Integer missing data Indicator –32768
j as a subscript		suffix for horizontal gridpoint or observation point index
$K\chi_c$		diffusion coefficient for variable χ (m^2 s^{-1})
K_1, K_2	K1,K2	diffusion coefficients
k	K	vertical grid-point index (k=1 denotes lowest level)
K_{gwd}	KAY	Gravity wave stress constant 2.5×10^{-5} m^{-1}
L	LHEAT	latent heat (either L_C or ($L_C + L_F$))
LE_*	LHFLUX	latent heat flux due to surface evaporation – W m^{-2}
m	SMC	soil moisture content – kg m^{-2}
$m(suffix)$		model level
N		time period
n		suffix for time level
o		suffix for observed value
P_k	PK	rate of precipitation at level k (kg m^{-2} s^{-1})
p	P	pressure = $A(\eta)+B(\eta)p_*$ (Pa)
P_{ref}	PREF	Reference surface pressure of 101325 Pa
p	PSTAR	pressure at earth's surface as represented by model orography – Pa
q	Q	specific humidity – $kgkg^{-1}$
q_{Cl}	QCL	specific cloud water content – $kgkg^{-1}$

q_{Cf}	QCF	specific cloud ice content – $kgkg^{-1}$
q_{SAT}	QSAT	saturation specific humidity – $kgkg^{-1}$
q_T	QT	specific total water content, $q+q_{Cl}+q_{Cf}$ ($kgkg^{-1}$)
	RMDI	Real missing data Indicator –32768.0
Ri	RI	local Richardson number – dimensionless
Ri_B	RIB	bulk Richardson number– dimensionless
RH	RH	relative humidity – dimensionless
ROT	ROT	local angle of rotation between model and true spherical polar coordinates
r_S	R_S	distance from centre of earth at given pressure assuming UM standard atmosphere (see UMDP No 10) – m
R_*	RSTAR	surface net radiation – Wm^{-2}
S	SNODEP	snow mass (kgm^{-2}), m in ocean model
T	T	temperature $= \theta(p/100000)^{\kappa}$ (K)
T_L	TL	liquid water temperature $= T-(L_C/c_P)q_{CL}$ $-((L_C+L_S)x/c_P)q_{CF}$
T_S	TS	temperature from UM standard atmosphere
T_V	TV	virtual temperature – K
T_*	TSTAR	surface temperature – K, ^{0} C in ocean model
T_{*ICE}	TSTAR_ICE	surface temperature of the sea-ice fraction of a grid-box – K
t	TIME	time – s
u	U	zonal wind component relative to model spherical polar coordinates – m s^{-1}
u_A	UA	zonal wind component relative to spherical polar coordinates based on Earth's axis of rotation – ms^{-1}
u'		wind component along x axis using Cartesian coordinates – m s^{-1}
v		vector wind – m s^{-1}
v	V	meridional wind component relative to model spherical polar coordinates – m s^{-1}
v	VA	meridional wind component relative to spherical polar coordinates based on Earth's axis of rotation – m s^{-1}
v'		wind component along y axis using Cartesian coordinates – m s^{-1}
w	W	vertical velocity in physical height coordinate m s^{-1}
X		vector of model variables

x^n		generalised variable u,v,q or p_* at time level n
x		suffix for local Cartesian coordinate
Y		generalised variable
y		suffix for local Cartesian coordinate
z	Z	height – m
z_0	Z0	surface roughness length. – m
z_h	ZH	boundary layer depth. – m
α_{CS}	CSSA	clear–sky ("true") surface albedo – pure fraction
α_{ij}		angle between r_{ij} and latitude at point i
γ_g		scaling factor for geostrophic wind increments
γ_h		scaling factor for hydrostatic temperature increments
γ		safety factor used to scale the amplification factor in linear stability analysis.
ε^x		difference from truth for model variable X.
ζ	ZETA	vorticity
η	ETA	hybrid vertical coordinate $A+Bp_*$ (Pa)
$\dot{\eta}$	ETADOT	vertical velocity $d\eta/dt$. (s^{-1})
θ	THETA	potential temperature – K
θ_L	THETAL	liquid water potential temperature = T_L / Π (K)
θ_R	THETA_REF	basic state potential temperature
θ_S	THETAS	UM standard potential temperature – K
θ_V	THETAV	virtual potential temperature=$\theta(1+(\varepsilon^{-1}-1)q)$ (K)
λ	LONGITUDE	longitude
μ	MU	correction to gravity to allow for centrifugal effect
ν	NU	parameter defining relative weights in finite difference scheme between local fluxes and those a gridlength away – no units.
Π	P_EXNER	Exner function = $(p/100000)^{\kappa}$ (dimensionless)
ρ	RHO	density of air – kg m^{-3}
ρ_*	RHOSTAR	density of air at surface – kg m^{-3}
τ	TAU	gravity wave stress – N m^{-2}
τ_*	TAUSTAR	Surface turbulent stress flux N m^{-2}
ϕ	LATITUDE	latitude – radians
ξ	XI	Courant number $u\Delta t/\Delta x$ (no units)
ϕ	PHI	geopotential=gz (m^2 s^{-2})

ϕ_*	PHISTAR	geopotential at surface of earth - $m^2\ s^{-2}$
$\overline{\omega}$	WP	vertical velocity relative to pressure coordinates
$\overline{A}^X$		$\{A(x+\Delta x/2) + A(x-\Delta x/2)\}/2$
δ_X^A		$\{A(x - \Delta x/2) - A(x-\Delta x/2)\}/\Delta x$
Δx		increment in x
ΔX		calculated corrections to vector of model fields
$\Delta A_{k+1/2}$		$A_{k+1} - A_k$
$\partial/\partial x$		partial derivative with respect to x
∇		lateral gradient operator