



Appendix D. List of Model Variables and Their Definitions

Table D.1. Global Time-Dependent Prognostic Variables

Code Name	Description	Symbol	Note
<i>u</i>	Total u-velocity	<i>u</i>	
<i>v</i>	Total v-velocity	<i>v</i>	
<i>w</i>	Total w-velocity	<i>w</i>	
<i>ptprt</i>	Perturbation potential temperature	θ'	
<i>pprt</i>	Perturbation pressure	p'	
<i>qv</i>	Water vapor mixing ratio	q_v	
<i>qc</i>	Cloud water mixing ratio	q_c	
<i>qr</i>	Rain water mixing ratio	q_r	
<i>qi</i>	Cloud ice mixing ratio	q_i	
<i>qs</i>	Snow mixing ratio	q_s	
<i>qh</i>	Hail mixing ratio	q_h	
<i>tke</i>	Turbulent kinetic energy	E	
<i>qvsfc</i>	Effective surface mixing ratio	q_{vs}	
<i>tsfc</i>	Ground surface temperature at surface	T_s	
<i>tsoil</i>	Deep soil temperature	T_2	
<i>wetsfc</i>	Surface soil moisture	W_g	$0 \leq W_g \leq 1$
<i>wetdp</i>	Deep soil moisture	W_2	$0 \leq W_2 \leq 1$
<i>wetcanp</i>	Canopy water amount	W_r	$0 \leq W_r \leq 1$

**Table D.2. Time-Dependent Diagnostic Variables Local
to Each Time Step**

Code Name	Description	Symbol	Note
<i>wcont</i>	Contravariant vertical velocity	W^c	$\frac{wJ_1 + vJ_2 + w}{\sqrt{G}}$
<i>km</i>	Turbulent mixing coefficient for momentum	K_m	
<i>kh</i>	Turbulent mixing coefficient for heat and moisture	K_h	
<i>lendel</i>	Turbulent length scale normalized by $(\Delta x \Delta y \Delta z)^{1/3}$	$l / (\Delta x \Delta y \Delta z)^{1/3}$	

Table D.3. Time-Dependent Diagnostic Variables Not Local to a Single Time Step

Code Name	Description	Symbol	Note
<i>udteb</i>	Time tendency of u at east boundary	$\left(\frac{\partial u}{\partial t}\right)_{nx\ j\ k}^n$	
<i>udtwb</i>	Time tendency of u at west boundary	$\left(\frac{\partial u}{\partial t}\right)_{1\ j\ k}^n$	
<i>udtnb</i>	Time tendency of u at north boundary	$\left(\frac{\partial u}{\partial t}\right)_{i\ ny-1\ k}^n$	
<i>udtsb</i>	Time tendency of u at south boundary	$\left(\frac{\partial u}{\partial t}\right)_{i\ 1\ k}^n$	
<i>vdteb</i>	Time tendency of v at east boundary	$\left(\frac{\partial v}{\partial t}\right)_{nx-1\ j\ k}^n$	
<i>vdtwb</i>	Time tendency of v at west boundary	$\left(\frac{\partial v}{\partial t}\right)_{1\ j\ k}^n$	
<i>vdtnb</i>	Time tendency of v at north boundary	$\left(\frac{\partial v}{\partial t}\right)_{i\ ny\ k}^n$	
<i>vdtsb</i>	Time tendency of v at south boundary	$\left(\frac{\partial v}{\partial t}\right)_{i\ 1\ k}^n$	
<i>wdteb</i>	Time tendency of w at east boundary	$\left(\frac{\partial w}{\partial t}\right)_{nx-1\ j\ k}^n$	
<i>wdtwb</i>	Time tendency of w at west boundary	$\left(\frac{\partial w}{\partial t}\right)_{1\ j\ k}^n$	
<i>wdtnb</i>	Time tendency of w at north boundary	$\left(\frac{\partial w}{\partial t}\right)_{i\ ny-1\ k}^n$	
<i>wdtsb</i>	Time tendency of w at south boundary	$\left(\frac{\partial w}{\partial t}\right)_{i\ 1\ k}^n$	
<i>pdteb</i>	Time tendency of $pprt$ at east boundary	$\left(\frac{\partial p'}{\partial t}\right)_{nx-1\ j\ k}^n$	
<i>pdtwb</i>	Time tendency of $pprt$ at west boundary	$\left(\frac{\partial p'}{\partial t}\right)_{1\ j\ k}^n$	
<i>pdtnb</i>	Time tendency of $pprt$ at north boundary	$\left(\frac{\partial p'}{\partial t}\right)_{i\ ny-1\ k}^n$	
<i>pdtsb</i>	Time tendency of $pprt$ at south boundary	$\left(\frac{\partial p'}{\partial t}\right)_{i\ 1\ k}^n$	

Table D.4. Time-Independent Variables

Code Name	Description	Symbol	Note
<i>ubar</i>	Base-state u-velocity	\bar{u}	
<i>vbar</i>	Base state v-velocity	\bar{v}	
<i>ptbar</i>	Base state potential temperature	$\bar{\theta}$	
<i>pbar</i>	Base state pressure	\bar{p}	
<i>rhobar</i>	Base state density	$\bar{\rho}$	
<i>rhostr</i>	Base state density rhobar times <i>j3</i>	ρ^*	$\rho^* = \bar{\rho} \sqrt{G}$
<i>qvbar</i>	Base state water vapor mixing ratio	\bar{q}_v	
<i>piibar</i>	Base state Exner function	$\bar{\pi} = \left(\frac{\bar{p}}{p_o}\right)^{R/c_p}$	
<i>x</i>	Cartesian coordinate in E-W direction	x, ξ	
<i>y</i>	Cartesian coordinate in N-S direction	y, η	
<i>z</i>	Height in a computational coordinate	ζ	
<i>zp</i>	Height in a Cartesian coordinate	z	
<i>j1</i>	Coordinate transformation Jacobian	$J_1 = \frac{\partial z}{\partial \xi}$	
<i>j2</i>	Coordinate transformation Jacobian	$J_2 = \frac{\partial z}{\partial \eta}$	
<i>j3</i>	Coordinate transformation Jacobian	$J_3 = -\frac{\partial z}{\partial \zeta}$	
<i>csndsqr</i>	Sound wave speed squared	C_s^2	
<i>hterain</i>	Height of the terrain	h_m	
<i>soiltyp</i>	Soil type		
<i>vegtyp</i>	Vegetation type		
<i>lai</i>	Leaf area index	LAI	
<i>roufns</i>	Surface roughness	z_o	

Table D.5. Time-Independent Parameters

Code Name	Description	Symbol	Note
<i>dx</i>	Grid spacing in x-direction in computational as well as physical space	$\Delta x = \Delta \xi$	
<i>dy</i>	Grid spacing in y-direction in computational as well as physical space	$\Delta y = \Delta \eta$	
<i>dz</i>	Averaged grid spacing in vertical direction in transformed computational space	$\Delta \zeta$	
<i>dzmin</i>	Minimum grid spacing in vertical in physical space	Δz_{min}	(Fig. 7.3)
<i>zrefsfc</i>	Reference height of the surface	z_0	(Fig 7.3)
<i>dlayer1</i>	Depth of the lower layer with uniform ($dz-dzmin$) vertical spacing	D_1 ,	(Fig. 7.3)
<i>dlayer2</i>	Depth of the middle layer with stretched vertical spacing	D_2 ,	(Fig. 7.3)
<i>zflat</i>	Height at which the grid levels become flat in the terrain-following coordinate transformation	Z_{flat}	(Eq. 7.3.2)
<i>longitud</i>	Model reference (typically center) longitude		
<i>latitud</i>	Model reference (typically center) latitude		
<i>scfct</i>	Map scale factor(1 for ARPS generally)		
<i>dtbig</i>	Model integration time step	Δt	
<i>tstart</i>	Model start-up time		
<i>tstop</i>	Time when the integration is to be stopped		
<i>csopt</i>	Option for sound wave speed used in p equation		
<i>csfactr</i>	A multiplication factor for the sound speed for $csopt=2$		
<i>csound</i>	User specified constant sound speed		
<i>vimplct</i>	Vertical implicit option for the w and p equations		
<i>ptsm1stp</i>	Option for integrating potential temperature equation		
<i>tacofef</i>	Time average weighting coefficient used in the velocity implicit solver	β	
<i>dtm1</i>	Small time integration step size for acoustic wave modes	$\Delta \tau$	
<i>c_phase</i>	Fixed phase speed in radiation lateral boundary condition	C	$\frac{\partial u}{\partial t} + (u + C) \frac{\partial u}{\partial x} = 0$
<i>rlx1bc</i>	Relaxation coefficient used by radiation boundary condition option (RBCopt = 1, 2 only)	γ	
<i>cdm1nd</i>	Surface momentum drag coefficient over land	C_{d_m}	$-\rho C_{d_m} \sqrt{u^2 + v^2} u$
<i>cdmwtr</i>	Surface momentum drag coefficient over water	C_{d_m}	$-\rho C_{d_m} \sqrt{u^2 + v^2} u$

Table D.5. Time-Independent Parameters (continued ...)

Code Name	Description	Symbol	Note
<i>cdhlnd</i>	Surface drag coefficient for heat fluxes over land	C_{d_h}	$-\bar{p} C_{d_h} \sqrt{u^2 + v^2} (\theta - \theta_0)$
<i>cdhwtr</i>	Surface drag coefficient for heat fluxes over water	C_{d_h}	$-\bar{p} C_{d_h} \sqrt{u^2 + v^2} (\theta - \theta_0)$
<i>cdqlnd</i>	Surface drag coefficient for moisture fluxes over land	C_{d_q}	$-\bar{p} C_{d_q} \sqrt{u^2 + v^2} (q_v - q_{v0})$
<i>cdqwtr</i>	Surface drag coefficient for moisture fluxes over water	C_{d_q}	$-\bar{p} C_{d_q} \sqrt{u^2 + v^2} (q_v - q_{v0})$
<i>dt_sfc</i>	Time step size for surface (soil) model time integration	Δt_{sfc}	
<i>tmixcst</i>	Value of the constant mixing coefficient		
<i>tmixcst1</i>	Constant used by <i>tmixopt=4</i>	c_m	
<i>tmixcst2</i>	Constant used by <i>tmixopt=4</i>	c_ϵ	
<i>prantl</i>	Turbulent Prandtl number	Pr	$Pr = K_m / K_h = 1 / (1 + 2l)$
<i>cfcm2h</i>	2nd order horizontal computational mixing coefficient scaled by horizontal grid spacing	K_{m_h}	
<i>cfcm2v</i>	2nd order vertical computational mixing coefficient scaled by vertical grid spacing	K_{m_v}	
<i>cfcm4h</i>	4th order horizontal computational mixing coefficient scaled by horizontal grid spacing	K_{m_h}	
<i>cfcm4v</i>	4th order vertical computational mixing coefficient scaled by vertical grid spacing	K_{m_v}	
<i>cdvdmp</i>	Divergence damping coefficient	α	
<i>divdmpnd</i>	Non-dimensional divergence damping coefficient		
<i>cfrdmp</i>	Rayleigh damping coefficient	R_D	
<i>fltps</i>	Robert-Asselin time filter coefficient	ϵ	

Table D.6. Parameters that May Change with Time

Code Name	Description	Symbol	Note
<i>umove</i>	Model domain movement speed relative to the Earth in x-direction		
<i>vmove</i>	Model domain movement speed relative to the Earth in y-direction		