Supplementary material to: *"The Met Office Unified Model Global Atmosphere 7.0/7.1 and JULES Global Land 7.0 configurations"*, submitted to Geosci. Model Dev.

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1 Introduction

This supplementary material to the main paper is designed to help users of GA7.0/7.1 and GL7.0 in configuring their systems to correctly implement the new configurations.

2 GA7.0 settings that vary with global horizontal resolution

Table 1 lists the Unified Model (UM) settings (as set in the Rose suite applications - see the Rose documentation at http://metomi.github.io/rose/doc/rose.html) that should be changed when changing horizontal resolution. The settings listed here are valid for UM code base vn10.6. The resolutions supported span from N96 (≈ 135 km in the mid-latitudes) to N1280 (≈ 10 km in the mid-latitudes).

namelist entry	N96	N216	N320	N400	N512	N768	N1024	N1280
[namelist:nlsizes]								
global_row_length	192	432	640	800	1024	1536	2048	1560
global_rows	144	324	480	600	768	1152	1536	1280
[namelist:nlst_mpp]								
extended_halo_size_ew	4	4	4	4	5	5	5	5
extended_halo_size_ns	5	7	7	8	8	8	10	10
[namelist:nlstcgen]								
steps_per_periodim	72	96	120	120	144	192	288	360
[namelist:run_dust]								
us_am	1.45	1.40	1.40	1.40	1.40	1.40	1.40	1.40
[namelist:run_gwd]								
ussp_launch_factor	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Table 1: GA7.0 settings that vary with global horizontal resolution.

3 GA7.0 settings that vary with vertical resolution

3.1 UM settings to change with level set

Table 2 lists the UM settings (as set in the Rose suite applications) that should be changed when changing vertical resolution. The settings listed here are valid for UM code base vn10.6. Note that as discussed in the main paper, GA7.0 systems should only use either L85(50$_{\rm t}$,35$_{\rm s}$)$_{85}$, L70(50$_{\rm t}$,20$_{\rm s}$)$_{80}$, or L63(50$_{\rm t}$,13$_{\rm s}$)$_{40}$ level sets.

3.2 Details of vertical level sets

In the vertical, the UM uses the terrain-following height coordinate η, which is normalised to be $\eta = 0$ at the lower boundary, and $\eta = 1$ at a height z_T, the height of the fixed model lid. In between, the height above mean sea level at any given point, z, is defined by

$$z = \begin{cases} \eta z_T + h\left(1 - \frac{\eta}{\eta_I}\right)^2, & 0 \le \eta \le \eta_I; \\ \eta z_T, & \eta_I \le \eta \le z_T, \end{cases} \tag{1}$$

where h is the height of the model orography above the earth's mean radius and η_I is the level at and above which the levels are flat.

The namelists below detail the level sets used with GA7.0. In these namelists, the variable `z_top_of_model`$=z_T$ (in metres), `eta_theta` is the array of η values for the levels on which the prognostic potential temperature (θ) is held including the surface, `eta_rho` is the array of η values for the levels on which the prognostic density (ρ) is held, and `first_constant_r_rho_level` is the ρ-level at which $\eta = \eta_I$.

namelist entry	L85($50_{\rm t}$,$35_{\rm s}$)$_{85}$	L70($50_{\rm t}$,$20_{\rm s}$)$_{80}$	L63($50_{\rm t}$,$13_{\rm s}$)$_{40}$
[namelist:domain("All model level STASH domains")			
levt	85	70	63
[namelist:nlsizes]			
cloud_levels	85	70	63
model_levels	85	70	63
ozone_levels	85	70	63
[namelist:run_cloud]			
rhcrit(18:)	68*0.800	53*0.800	46*0.800
[namelist:run_dyn]			
eta_s	0.5	0.5	0.75

Table 2: GA7.0 settings that vary with atmospheric vertical resolution. Note that whilst the PC2 cloud scheme now uses a diagnostic formulation for rhcrit ($RH_{\rm crit}$) as described in section 3.4 of the main paper, a prescribed $RH_{\rm crit}$ profile is still in the microphysics scheme to determine the in-cloud relative humidity.

Level set L85($50_{\rm t}$,$35_{\rm s}$)$_{85}$

```
&VERTLEVS
 z_top_of_model =     85000.00,
 first_constant_r_rho_level=   51,
 eta_theta=
 0.0000000E+00,   0.2352941E-03,   0.6274510E-03,   0.1176471E-02,   0.1882353E-02,
 0.2745098E-02,   0.3764706E-02,   0.4941176E-02,   0.6274510E-02,   0.7764705E-02,
 0.9411764E-02,   0.1121569E-01,   0.1317647E-01,   0.1529412E-01,   0.1756863E-01,
 0.2000000E-01,   0.2258823E-01,   0.2533333E-01,   0.2823529E-01,   0.3129411E-01,
 0.3450980E-01,   0.3788235E-01,   0.4141176E-01,   0.4509804E-01,   0.4894118E-01,
 0.5294117E-01,   0.5709804E-01,   0.6141176E-01,   0.6588235E-01,   0.7050980E-01,
 0.7529411E-01,   0.8023529E-01,   0.8533333E-01,   0.9058823E-01,   0.9600001E-01,
 0.1015687E+00,   0.1072942E+00,   0.1131767E+00,   0.1192161E+00,   0.1254127E+00,
 0.1317666E+00,   0.1382781E+00,   0.1449476E+00,   0.1517757E+00,   0.1587633E+00,
 0.1659115E+00,   0.1732221E+00,   0.1806969E+00,   0.1883390E+00,   0.1961518E+00,
 0.2041400E+00,   0.2123093E+00,   0.2206671E+00,   0.2292222E+00,   0.2379856E+00,
 0.2469709E+00,   0.2561942E+00,   0.2656752E+00,   0.2754372E+00,   0.2855080E+00,
 0.2959203E+00,   0.3067128E+00,   0.3179307E+00,   0.3296266E+00,   0.3418615E+00,
 0.3547061E+00,   0.3682416E+00,   0.3825613E+00,   0.3977717E+00,   0.4139944E+00,
 0.4313675E+00,   0.4500474E+00,   0.4702109E+00,   0.4920571E+00,   0.5158098E+00,
 0.5417201E+00,   0.5700686E+00,   0.6011688E+00,   0.6353697E+00,   0.6730590E+00,
 0.7146671E+00,   0.7606701E+00,   0.8115944E+00,   0.8680208E+00,   0.9305884E+00,
 0.1000000E+01,
eta_rho=
 0.1176471E-03,   0.4313726E-03,   0.9019608E-03,   0.1529412E-02,   0.2313725E-02,
 0.3254902E-02,   0.4352941E-02,   0.5607843E-02,   0.7019607E-02,   0.8588235E-02,
 0.1031373E-01,   0.1219608E-01,   0.1423529E-01,   0.1643137E-01,   0.1878431E-01,
 0.2129412E-01,   0.2396078E-01,   0.2678431E-01,   0.2976470E-01,   0.3290196E-01,
 0.3619608E-01,   0.3964706E-01,   0.4325490E-01,   0.4701960E-01,   0.5094118E-01,
 0.5501961E-01,   0.5925490E-01,   0.6364705E-01,   0.6819607E-01,   0.7290196E-01,
 0.7776470E-01,   0.8278431E-01,   0.8796078E-01,   0.9329412E-01,   0.9878433E-01,
 0.1044314E+00,   0.1102354E+00,   0.1161964E+00,   0.1223144E+00,   0.1285897E+00,
 0.1350224E+00,   0.1416128E+00,   0.1483616E+00,   0.1552695E+00,   0.1623374E+00,
 0.1695668E+00,   0.1769595E+00,   0.1845180E+00,   0.1922454E+00,   0.2001459E+00,
 0.2082247E+00,   0.2164882E+00,   0.2249446E+00,   0.2336039E+00,   0.2424783E+00,
 0.2515826E+00,   0.2609347E+00,   0.2705562E+00,   0.2804726E+00,   0.2907141E+00,
 0.3013166E+00,   0.3123218E+00,   0.3237787E+00,   0.3357441E+00,   0.3482838E+00,
 0.3614739E+00,   0.3754014E+00,   0.3901665E+00,   0.4058831E+00,   0.4226810E+00,
 0.4407075E+00,   0.4601292E+00,   0.4811340E+00,   0.5039334E+00,   0.5287649E+00,
```

```
  0.5558944E+00,   0.5856187E+00,   0.6182693E+00,   0.6542144E+00,   0.6938630E+00,
  0.7376686E+00,   0.7861323E+00,   0.8398075E+00,   0.8993046E+00,   0.9652942E+00,
 /
```

Level set L70(50$_\mathrm{t}$,20$_\mathrm{s}$)$_{80}$

```
 &VERTLEVS
  z_top_of_model =  80000.0,
  first_constant_r_rho_level= 50,
  eta_theta=
  .0000000,  .0002500,  .0006667,  .0012500,  .0020000,
  .0029167,  .0040000,  .0052500,  .0066667,  .0082500,
  .0100000,  .0119167,  .0140000,  .0162500,  .0186667,
  .0212500,  .0240000,  .0269167,  .0300000,  .0332500,
  .0366667,  .0402500,  .0440000,  .0479167,  .0520000,
  .0562500,  .0606667,  .0652500,  .0700000,  .0749167,
  .0800000,  .0852500,  .0906668,  .0962505,  .1020017,
  .1079213,  .1140113,  .1202745,  .1267154,  .1333406,
  .1401592,  .1471838,  .1544313,  .1619238,  .1696895,
  .1777643,  .1861929,  .1950307,  .2043451,  .2142178,
  .2247466,  .2360480,  .2482597,  .2615432,  .2760868,
  .2921094,  .3098631,  .3296378,  .3517651,  .3766222,
  .4046373,  .4362943,  .4721379,  .5127798,  .5589045,
  .6112759,  .6707432,  .7382500,  .8148403,  .9016668,
  1.0000000,
  eta_rho=
  .0001250,  .0004583,  .0009583,  .0016250,  .0024583,
  .0034583,  .0046250,  .0059583,  .0074583,  .0091250,
  .0109583,  .0129583,  .0151250,  .0174583,  .0199583,
  .0226250,  .0254583,  .0284583,  .0316250,  .0349583,
  .0384583,  .0421250,  .0459583,  .0499583,  .0541250,
  .0584584,  .0629583,  .0676250,  .0724583,  .0774583,
  .0826250,  .0879584,  .0934586,  .0991261,  .1049615,
  .1109663,  .1171429,  .1234950,  .1300280,  .1367499,
  .1436715,  .1508076,  .1581776,  .1658067,  .1737269,
  .1819786,  .1906118,  .1996879,  .2092815,  .2194822,
  .2303973,  .2421538,  .2549014,  .2688150,  .2840981,
  .3009862,  .3197505,  .3407014,  .3641936,  .3906297,
  .4204658,  .4542161,  .4924589,  .5358422,  .5850902,
  .6410096,  .7044966,  .7765451,  .8582535,  .9508334,
 /
```

Level set L63(50$_\mathrm{t}$,13$_\mathrm{s}$)$_{40}$

```
 &VERTLEVS
  z_top_of_model =  41022.39,
  first_constant_r_rho_level= 50,
  eta_theta=
   0.0000000E+00,   4.8753872E-04,   1.3001683E-03,   2.4376935E-03,   3.9003098E-03,
   5.6880168E-03,   7.8006196E-03,   1.0238313E-02,   1.3001097E-02,   1.6088778E-02,
   1.9501548E-02,   2.3239411E-02,   2.7302168E-02,   3.1690016E-02,   3.6402956E-02,
   4.1440792E-02,   4.6803717E-02,   5.2491732E-02,   5.8504645E-02,   6.4842649E-02,
   7.1505740E-02,   7.8493737E-02,   8.5806817E-02,   9.3444988E-02,   1.0140806E-01,
   1.0969621E-01,   1.1830946E-01,   1.2724760E-01,   1.3651083E-01,   1.4609917E-01,
   1.5601239E-01,   1.6625071E-01,   1.7681430E-01,   1.8770337E-01,   1.9891910E-01,
   2.1046326E-01,   2.2233970E-01,   2.3455390E-01,   2.4711467E-01,   2.6003483E-01,
   2.7333215E-01,   2.8703120E-01,   3.0116495E-01,   3.1577647E-01,   3.3092082E-01,
   3.4666792E-01,   3.6310497E-01,   3.8034007E-01,   3.9850461E-01,   4.1775790E-01,
   4.3829069E-01,   4.6033016E-01,   4.8414484E-01,   5.1004976E-01,   5.3841203E-01,
   5.6965858E-01,   6.0428101E-01,   6.4284474E-01,   6.8599641E-01,   7.3447162E-01,
   7.8910542E-01,   8.5084140E-01,   9.2074203E-01,   1.0000000E+00,
  eta_rho=
   2.4376936E-04,   8.9375599E-04,   1.8688334E-03,   3.1690018E-03,   4.7940658E-03,
   6.7442209E-03,   9.0194661E-03,   1.1619608E-02,   1.4544840E-02,   1.7795164E-02,
```

```
2.1370383E−02,   2.5270693E−02,   2.9496092E−02,   3.4046389E−02,   3.8921777E−02,
4.4122253E−02,   4.9647629E−02,   5.5498090E−02,   6.1673649E−02,   6.8174094E−02,
7.4999638E−02,   8.2150280E−02,   8.9625798E−02,   9.7426422E−02,   1.0555213E−01,
1.1400293E−01,   1.2277844E−01,   1.3187923E−01,   1.4130490E−01,   1.5105568E−01,
1.6113155E−01,   1.7153251E−01,   1.8225874E−01,   1.9331124E−01,   2.0469119E−01,
2.1640146E−01,   2.2844680E−01,   2.4083437E−01,   2.5357473E−01,   2.6668346E−01,
2.8018168E−01,   2.9409820E−01,   3.0847082E−01,   3.2334876E−01,   3.3879438E−01,
3.5488644E−01,   3.7172252E−01,   3.8942233E−01,   4.0813133E−01,   4.2802429E−01,
4.4931039E−01,   4.7223738E−01,   4.9709725E−01,   5.2423090E−01,   5.5403531E−01,
5.8696973E−01,   6.2356299E−01,   6.6442049E−01,   7.1023387E−01,   7.6178843E−01,
8.1997347E−01,   8.8579178E−01,   9.6037108E−01,
/
```

4 Namelist differences between GA7.0 and GA7.1

Section 5 of the main paper describes the GA7.1 "branch" configuration that will be used in climate models submitted to CMIP6, which includes a number of scientific differences from the GA7.0 "trunk" configuration. Table 3 lists the UM settings (as set in the Rose suite applications) that should be changed when changing from GA7.0 to GA7.1. The settings listed here are valid for UM code base vn10.6.

namelist entry	GA7.0	GA7.1
[namelist:run_bl]		
l_conv_tke	.false.	.true.
[namelist:run_convection]		
cca_sh_knob	0.2	0.5
[namelist:run_precip]		
mp_dz_scal	1.0	2.0
[namelist:run_radiation]		
l_use_liu_spec	.false.	.true.
[namelist:run_ukca]		
l_ukca_scale_seadms_ems	.false.	.true.
seadms_ems_scaling	1.0	1.7
ukcaaclw	ga3-7/nml_ac_lw	ga7_1/nml_ac_lw
ukcaacsw	ga3-7/nml_ac_sw	ga7_1/nml_ac_sw
ukcaanlw	ga3-7/nml_an_lw	ga7_1/nml_an_lw
ukcaansw	ga3-7/nml_an_sw	ga7_1/nml_an_sw
ukcacrlw	ga3-7/nml_cr_lw	ga7_1/nml_cr_lw
ukcacrsw	ga3-7/nml_cr_sw	ga7_1/nml_cr_sw
ukcaprec	ga3-7/RADAER_pcalc.ukca	ga7_1/RADAER_pcalc.ukca

Table 3: UM settings that differ between GA7.0 and GA7.1. Note that where there are different ancillaries used, these are specified through an ancil_versions file, so require no specific changes to the UM Rose app.

5 Settings that may vary with system/application

As described in the main paper, GA7.0/GL7.0 (or GA7.1/GL7.0) defines the scientific configuration of the UM and JULES components used in various systems. In addition to the differences with horizontal and vertical resolution described above — and the scientific differences between GA7.0 and GA7.1 — there are some settings that may be seen as system dependent, which we illustrate in this section. In Table 4 we illustrate an example of the systems settings that vary between deterministic global NWP and climate research configurations of GA7.0/G7.0. Note that this is just a description of the scientific differences rather than a full list of technical options/namelist entries that would need to be changed to apply these changes.

Area of the model Scientific option	NWP	Climate
Time dependent options		
Calendar type	Gregorian	360 day*
Method for calculating global sums		
Summation type	Non-reproducible	Double-double precision
Definition of land/sea		
Use of "coastal tiling"	Off	On
Global conservation options		
Conservative moisture/tracer advection	Off	On
Enforced energy conservation	Off	On
Aerosol modelling		
Prognostic/climatological aerosol	Climatological**	Prognostic

Table 4: A descriptive example of GA7.0 settings that might vary with system/application. *Note that the 360 day calendar is not compulsory for GA7.0 climate jobs, but is still used in most standard jobs. ** As discussed in the main paper, the aerosol definition is dependent on the system. Most climate runs use full UKCA Glomap-mode prognostic aerosols with with prescribed gas phase precursors. Runs on Seasonal timescales or shorter use CLASSIC aerosol climatologies, although in time we would like to replace these with Glomap-mode climatologies. Finally, we now usually include prognostic mineral dust forecasting and assimilation on NWP timescales.