JRA-55 Product Users Handbook

Model grid data

Climate Prediction Division
Global Environment and Marine Department
Japan Meteorological Agency
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Change record

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Contents

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1. Introduction

The Japan Meteorological Agency (JMA) has conducted the Japanese 55-year Reanalysis project (JRA-55) that covers the period from the year 1958 onward (Ebita et al. 2011). This document describes an overview of the JRA-55 products and changes from the JRA-25 products (Onogi et al. 2007).

2. File format

Both daily and monthly data are encoded in the Gridded binary (GRIB) Edition 1 (WMO 2011) (Note that daily data include 3-, 6-, and 24-hourly data, which vary with categories).

3. Filenames

Filenames of the JRA-55 products follow the naming convention in Table 3-1 for historical data and Table 3-2 for climatological normals.

Table 3-1 Naming convention for historical data.

Time range	Type	Filename
Daily	2D fields	<category>.<year><month><day><hour>
	3D fields	<category>_<parameter>.<year><month><day><hour>
Monthly_diurnal	2D fields, average	<category>.<year><month>_<hour>
	2D fields, variance	<category>_var.<year><month>_<hour>
	3D fields, average	<category>_<parameter>.<year><month>_<hour>
	3D fields, variance	<category>_<parameter>_var.<year><month>_<hour>
Monthly	2D fields, average	<category>.<year><month>
	2D fields, variance	<category>_var.<year><month>
	3D fields, average	<category>_<parameter>.<year><month>
	3D fields, variance	<category>_<parameter>_var.<year><month>

Table 3-2 Naming convention for climatological normals.

Time range	Type	Filename
Daily	2D fields	<category>.clim<period>.day<month><day>
	3D fields	<category>_<parameter>.clim<period>.day<month><day>
Monthly_diurnal Monthly	2D fields, average	<category>.clim<period>.mon<month>
	3D fields, average	<category>_<parameter>.clim<period>.mon<month>

4. Output parameters

4.1. Model grid data

4.1.1. Constant fields (TL319)

Table 4-1 shows parameters of the constant fields.

Table 4-1 Parameters of the constant fields (TL319).

Code figure	Field parameter	Unit
6	Geopotential	$m^2 s^{-2}$
81	Land cover (1=land, 0=sea)	Proportion
252	Type of vegetation	Code Table JMA-252

4.1.2. Total column analysis fields (anl_column)

The total column analysis fields (Table 4-2) are produced integrating the corresponding analysed fields vertically from the bottom to the top of atmosphere. These fields are output every 6 hours at 00, 06, 12 and 18UTC,

Table 4-2 Parameters of the total column analysis fields (anl_column).

Code figure	Field parameter	Unit
54	Precipitable water	$kg\ m^{-2}$
152	Meridional water vapour flux	$kg\ m^{-1}\ s^{-1}$
157	Zonal water vapour flux	$kg\ m^{-1}\ s^{-1}$
190	Zonal thermal energy flux[+]	$W\ m^{-1}$
191	Meridional thermal energy flux[+]	$W\ m^{-1}$

[+] See Section 12.3 “Addition and change of parameters”
NOTE: Precipitable water contains water vapour only.

4.1.3. Isentropic analysis fields (anl_isentrop)

Parameters in Table 4-3 are vertically interpolated to the isentropic surfaces listed in Section 7.2, except specific humidity, which are interpolated to 14 levels from 270 through 400K only. These fields are output every 6 hours at 00, 06, 12 and 18UTC.

Table 4-3 Parameters of the isentropic analysis fields (anl_isentrop).

Code figure	Field parameter	Unit	Filename
1	Pressure[+]	Pa	anl_isentrop_pres
4	Potential vorticity	K m^2 kg^{-1} s^{-1}	anl_isentrop_pvor
7	Geopotential height	gpm	anl_isentrop_hgt
33	u-component of wind	m s^{-1}	anl_isentrop_ugrd
34	v-component of wind	m s^{-1}	anl_isentrop_vgrd
37	Montgomery stream function	m^2 s^{-2}	anl_isentrop_mntsf
39	Vertical velocity	Pa s^{-1}	anl_isentrop_vvel
51	Specific humidity	kg kg^{-1}	anl_isentrop_spfh
132	Square of Brunt-Vaisala frequency	s^{-2}	anl_isentrop_bvf2

[+] See Section 12.3 “Addition and change of parameters”

4.1.4. Land surface analysis fields (anl_land)

Parameters in Table 4-4 are output from the land surface analysis every 6 hours at 00, 06, 12 and 18UTC.

Table 4-4 Parameters of the land surface analysis fields (anl_land).

Code figure	Field parameter	Unit	Level
65	Water equivalent of accumulated snow depth	kg m^{-2}	Ground surface
144	Canopy temperature	K	Ground surface
145	Ground temperature	K	Ground surface
85	Soil temperature	K	Entire soil (considered as a single layer)
225	Soil wetness	Proportion	Underground layers

4.1.5. Model level analysis fields (anl_mdl)

Parameters in Table 4-5 are output to the model levels listed in Section 7.1 every 6 hours at 00, 06, 12 and 18UTC.

Table 4-5 Parameters of the model level analysis fields (anl_mdl).

Code figure	Field parameter	Unit	Filename
7	Geopotential height	gpm	anl_mdl_hgt
11	Temperature	K	anl_mdl_tmp
33	u-component of wind	m s^{-1}	anl_mdl_ugrd
34	v-component of wind	m s^{-1}	anl_mdl_vgrd
39	Vertical velocity	Pa s^{-1}	anl_mdl_vvel
51	Specific humidity	kg kg^{-1}	anl_mdl_spfh

4.1.6. Snow depth analysis fields (anl_snow)

The parameter in Table 4-6 is output from the snow depth analysis at 18UTC every day.

Table 4-6 Parameter of the snow depth analysis fields (anl_snow).

Code figure	Field parameter	Unit	Level
66	Snow depth	m	Ground surface

4.1.7. Surface analysis fields (anl_surf)

The surface analysis fields (Table 4-7) are produced every 6 hours at 00, 06, 12, 18UTC.

Table 4-7 Parameters of the surface analysis fields (anl_surf).

Code figure	Field parameter	Unit	Level
1	Pressure	Pa	Ground or water surface
11	Temperature	K	2m
13	Potential temperature	K	Ground or water surface
51	Specific humidity	kg kg^{-1}	2m
52	Relative humidity	%	2m
33	u-component of wind	m s^{-1}	10m
34	v-component of wind	m s^{-1}	10m

NOTE: The order of the parameters in monthly statistics and climatological normal files is different from the one in daily files (Table 4-7); 1, 13, 11, 51, 52, 33 and 34.

4.1.8. Total column forecast fields (fcst_column)

The total column forecast fields (Table 4-8) are produced every 3 hours, integrating vertically from the bottom to the top of atmosphere the 3-hour forecast fields at 03, 09, 15 and 21UTC, and the 6-hour forecast fields at 00, 06, 12 and 18UTC.

Table 4-8 Parameters of the total column forecast fields (fcst_column).

Code figure	Field parameter	Unit
10	Total ozone	Dobson
54	Precipitable water	kg m^{-2}
58	Cloud ice^{+}	kg m^{-2}
152	Meridional water vapour flux*	kg m^{-1} s^{-1}
157	Zonal water vapour flux*	kg m^{-1} s^{-1}
190	Zonal thermal energy flux^{+}	W m^{-1}
191	Meridional thermal energy flux^{+}	W m^{-1}
227	Cloud liquid water^{+}	kg m^{-2}

[+, *] See Section 12.3 “Addition and change of parameters”
NOTE: Precipitable water contains water vapour only.

4.1.9. Land surface forecast fields (fcst_land)

The land surface forecast fields (Table 4-9) are produced every 3 hours at 00, 03, 06, 09, 12, 15, 18 and 21UTC.

Table 4-9 Parameters of the land surface forecast fields (fcst_land).

Code figure	Field parameter	Unit	Level
65	Water equivalent of accumulated snow depth[+]	kg m^{-2}	Ground surface
66	Snow depth[+]	m	Ground surface
144	Canopy temperature	K	Ground surface
145	Ground temperature	K	Ground surface
223	Moisture storage on canopy	m	Ground surface
224	Moisture storage on ground/cover	m	Ground surface
85	Soil temperature	K	Entire soil (considered as a single layer)
225	Soil wetness[+]	Proportion	Underground layers
226	Mass concentration of condensed water in soil[+]	kg m^{-3}	Underground layers

[+] See Section 12.3 “Addition and change of parameters”

4.1.10. Model level forecast fields (fcst_mdl)

Parameters in Table 4-10 are output to the model levels listed in Section 7.1 every 6 hours at 00, 06, 12 and 18UTC.

Table 4-10 Parameters of the model level forecast fields (fcst_mdl).

Code figure	Field parameter	Unit	Filename
7	Geopotential height	gpm	fcst_mdl_hgt
11	Temperature	K	fcst_mdl_tmp
33	u-component of wind	m s^{-1}	fcst_mdl_ugrd
34	v-component of wind	m s^{-1}	fcst_mdl_vgrd
39	Vertical velocity	Pa s^{-1}	fcst_mdl_vvel
51	Specific humidity	kg kg^{-1}	fcst_mdl_spfh
71	Total cloud cover[*]	%	fcst_mdl_tcdc
221	Cloud water	kg kg^{-1}	fcst_mdl_cwat
228	Cloud liquid water[+]	kg kg^{-1}	fcst_mdl_clwc
229	Cloud ice[+]	kg kg^{-1}	fcst_mdl_ciwc
230	Upward mass flux at cloud base	kg m^{-2} s^{-1}	fcst_mdl_mflxb
237	Ozone mixing ratio	mg kg^{-1}	fcst_mdl_ozone

[+, *] See Section 12.3 “Addition and change of parameters”

4.1.11. 2-dimensional average diagnostic fields (fcst_phy2m)

The 2-dimensional average diagnostic fields are produced every 3 hours. Parameters in Table 4-11 are averaged from the beginning of forecasts through 3 hours for 00-03, 06-09, 12-15 and 18-21UTC, and from 3 through 6 hours for 03-06, 09-12, 15-18 and 21-24UTC.

Dates in filenames indicate the beginning of the averaging period.

Table 4-11 Parameters of the 2-dimensional average diagnostic fields (fcst_phy2m).

Code figure	Field parameter	Unit	Level
1	Pressure	Pa	Ground or water surface
57	Evapolation+	mm day^{-1}	Ground or water surface
61	Total precipitation+	mm day^{-1}	Ground or water surface
62	Large scale precipitation	mm day^{-1}	Ground or water surface
63	Convective precipitation	mm day^{-1}	Ground or water surface
64	Snowfall rate water equivalent	mm day^{-1}	Ground or water surface
121	Latent heat flux	W m^{-2}	Ground or water surface
122	Sensible heat flux	W m^{-2}	Ground or water surface
124	Momentum flux, u component	N m^{-2}	Ground or water surface
125	Momentum flux, v component	N m^{-2}	Ground or water surface
147	Zonal momemtum flux by long gravity wave	N m^{-2}	Ground or water surface
148	Meridional momemtum flux by long gravity wave	N m^{-2}	Ground or water surface
154	Meridional momemtum flux by short gravity wave	N m^{-2}	Ground or water surface
159	Zonal momemtum flux by short gravity wave	N m^{-2}	Ground or water surface
160	Clear sky upward solar radiation flux	W m^{-2}	Ground or water surface
161	Clear sky downward solar radiation flux	W m^{-2}	Ground or water surface
163	Clear sky downward long wave radiation flux	W m^{-2}	Ground or water surface
170	Frequency of deep convection+	%	Ground or water surface
171	Frequency of shallow convection+	%	Ground or water surface
172	Frequency of stratocumulus parameterisation+	%	Ground or water surface
204	Downward solar radiation flux	W m^{-2}	Ground or water surface
205	Downward long wave radiation flux	W m^{-2}	Ground or water surface
211	Upward solar radiation flux	W m^{-2}	Ground or water surface
212	Upward long wave radiation flux	W m^{-2}	Ground or water surface
160	Clear sky upward solar radiation flux	W m^{-2}	Nominal top of atmosphere
162	Clear sky upward long wave radiation flux	W m^{-2}	Nominal top of atmosphere
204	Downward solar radiation flux	W m^{-2}	Nominal top of atmosphere
211	Upward solar radiation flux	W m^{-2}	Nominal top of atmosphere
212	Upward long wave radiation flux	W m^{-2}	Nominal top of atmosphere

+ See Section 12.3 “Addition and change of parameters”

4.1.12. Model level average diagnostic fields (fcst_phy3m)

The model level average diagnostic fields are produced every 6 hours. Parameters in Table 4-12 are averaged from the beginning of forecasts through 6 hours for 00-06, 06-12, 12-18 and 18-24UTC, and output to the model levels listed in Section 7.1.

Dates in filenames indicate the beginning of the averaging period.

Table 4-12 Parameters of the model level average diagnostic fields (fcst_phy3m).

Code figure	Field parameter	Unit	Filename
146	Cloud work function	J kg^{-1}	fcst_phy3m_cwork
151	Adiabatic zonal acceleration	m s^{-1} day^{-1}	fcst_phy3m_adua
165	Adiabatic meridional acceleration	m s^{-1} day^{-1}	fcst_phy3m_adva
173	Gravity wave zonal acceleration	m s^{-1} day^{-1}	fcst_phy3m_gwdua
174	Gravity wave meridional acceleration	m s^{-1} day^{-1}	fcst_phy3m_gwdva
222	Adiabatic heating rate	K day^{-1}	fcst_phy3m_adhr
230	Upward mass flux at cloud base	kg m^{-2} s^{-1}	fcst_phy3m_mflxb
231	Upward mass flux	kg m^{-2} s^{-1}	fcst_phy3m_mflux
236	Adiabatic moistening rate	kg kg^{-1} day^{-1}	fcst_phy3m_admr
239	Convective zonal acceleration	m s^{-1} day^{-1}	fcst_phy3m_cnvua
240	Convective meridional acceleration	m s^{-1} day^{-1}	fcst_phy3m_cnvva
241	Large scale condensation heating rate	K day^{-1}	fcst_phy3m_lrghr
242	Convective heating rate	K day^{-1}	fcst_phy3m_cnvhr
243	Convective moistening rate	kg kg^{-1} day^{-1}	fcst_phy3m_cnvmr
246	Vertical diffusion heating rate	K day^{-1}	fcst_phy3m_vdfhr
247	Vertical diffusion zonal acceleration	m s^{-1} day^{-1}	fcst_phy3m_vdfua
248	Vertical diffusion meridional acceleration	m s^{-1} day^{-1}	fcst_phy3m_vdfva
249	Vertical diffusion moistening rate	kg kg^{-1} day^{-1}	fcst_phy3m_vdfmr
250	Solar radiative heating rate	K day^{-1}	fcst_phy3m_swhr
251	Longwave radiative heating rate	K day^{-1}	fcst_phy3m_lwhr
253	Large scale moistening rate	kg kg^{-1} day^{-1}	fcst_phy3m_lrgmr

4.1.13. Land surface average diagnostic fields (fcst_phyland)

The land surface average diagnostic fields are produced every 3 hours. Parameters in Table 4-13 are averaged from the beginning of forecasts through 3 hours for 00-03, 06-09, 12-15 and 18-21UTC, and from 3 through 6 hours for 03-06, 09-12, 15-18 and 21-24UTC.

Dates in filenames indicate the beginning of the averaging period.

Table 4-13 Parameters of the land surface average diagnostic fields (fcst_phyland).

Code figure	Field parameter	Unit	Level
90	Water run-off	mm day^{-1}	Ground surface
155	Ground heat flux	W m^{-2}	Ground surface
202	Evapotranspiration	W m^{-2}	Ground surface
203	Interception loss	W m^{-2}	Ground surface
90	Water run-off^{+}	mm day^{-1}	The bottom of land surface model

$^{+}$ See Section 12.3 “Addition and change of parameters”

4.1.14. 2-dimensional instantaneous diagnostic fields (fcst_surf)

The 2-dimensional instantaneous diagnostic fields (Table 4-14) are produced every 3 hours at 00, 03, 06, 09, 12, 15, 18 and 21UTC.

Table 4-14 Parameters of the 2-dimensional instantaneous diagnostic field (fcst_surf).

Code figure	Field parameter	Unit	Level
1	Pressure	Pa	Ground or water surface
83	Surface roughness	m	Ground or water surface
118	Brightness temperature^{+}	K	Ground or water surface
71	Total cloud cover*	%	90 - 1100 hPa
75	High cloud cover*	%	90 - 500 hPa
74	Medium cloud cover*	%	500 - 850 hPa
73	Low cloud cover*	%	850 - 1100 hPa
2	Pressure reduced to MSL	Pa	Mean sea level
11	Temperature	K	2m
51	Specific humidity	kg kg^{-1}	2m
52	Relative humidity	%	2m
33	u-component of wind	m s^{-1}	10m
34	v-component of wind	m s^{-1}	10m

$^{+,*}$ See Section 12.3 “Addition and change of parameters”

4.1.15. Sea ice fields (ice)

The sea ice fields (Table 4-15) are output every 3 hours.

Table 4-15 Parameter of the sea ice fields (ice).

Code figure	Field parameter	Unit
91	Ice cover (1 = ice, 0 = no ice)	Proportion

4.1.16. 2-dimensional extreme fields (minmax_surf)

The 2-dimensional extreme fields (minmax_surf) are produced every 3 hours. Parameters in Table 4-16 are computed from the beginning of forecasts through 3 hours for 00-03, 06-09, 12-15 and 18-21UTC, and from 3 through 6 hours for 03-06, 09-12, 15-18 and 21-24UTC.

Dates in filenames indicate the end of the valid time.

The 2-dimensional extreme fields (minmax_surf) are produced for daily data only, not for monthly statistics.

Table 4-16 Parameters of the 2-dimensional extreme fields (minmax_surf).

Code figure	Field parameter	Unit	Level
15	Maximum temperature	K	2m
16	Minumum temperature	K	2m
219	Maximum wind speed	$m\ s^{-1}$	10m

5. Type of vegetation

Types of vegetation defined for JRA-55 are as follows;

Table 5-1 Types of vegetation (Code table JMA-252).

Code figure	Meaning
0	Sea or inland water
1	Broadleaf-evergreen trees
2	Broadleaf-deciduous trees
3	Broadleaf and needleleaf trees
4	Needleleaf-evergreen trees
5	Needleleaf-deciduous trees
6	Broadleaf trees with groundcover
7	Groundcover
8	Broadleaf shrubs with groundcover
9	Broadleaf shrubs with bare soil
10	Dwarf trees and shrubs with groundcover (tundra)
11	No vegetation: bare soil
12	Broadleaf-deciduous trees with winter wheat
13	Perennial land ice

6. Grid

6.1. Quasi-regular Gaussian latitude/longitude grid

Model grid data are output to the quasi-regular Gaussian latitude/longitude grid. The number of grid points along each parallel is as follows;

Table 6-1 The number of grid points along each parallel.

	1	2	3	4	5	6	7	8	9	10
0	48	64	80	80	96	112	112	128	128	144
10	144	160	160	192	192	192	192	224	224	224
20	224	240	240	256	256	288	288	288	288	288
30	320	320	320	320	320	336	336	384	384	384
40	384	384	384	384	384	400	400	400	432	432
50	432	432	432	432	448	448	448	480	480	480
60	480	480	480	512	512	512	512	512	512	512
70	560	560	560	560	560	560	560	560	560	560
80	560	576	576	576	576	576	640	640	640	640
90	640	640	640	640	640	640	640	640	640	640
100	640	640	640	640	640	640	640	640	640	640
110	640	640	640	640	640	640	640	640	640	640
120	640	640	640	640	640	640	640	640	640	640
130	640	640	640	640	640	640	640	640	640	640
140	640	640	640	640	640	640	640	640	640	640
150	640	640	640	640	640	640	640	640	640	640

NOTE: The 1st and 160th parallels correspond to the one nearest to the pole and the equator, respectively.

7. Vertical coordinates

7.1. Hybrid coordinates

Model level fields are produced for 60 hybrid levels. Each hybrid level is defined with half-levels $p_{k+\frac{1}{2}}$ as the boundary;

$$p_{k+\frac{1}{2}} = A_{k+\frac{1}{2}} + B_{k+\frac{1}{2}} p_s ,$$

where p_s is the surface pressure. Coefficients A and B are given in Table 7-1 and Table 7-2 for k = 0, 1, 2, …, 60. The following equation by Simmons and Burridge (1981) gives full-levels, i.e. the pressures that represent each hybrid level, except for the uppermost level (k = 60);

$$p_k = \exp\left[\frac{1}{\Delta p_k}\left(p_{k-\frac{1}{2}} \ln p_{k-\frac{1}{2}} - p_{k+\frac{1}{2}} \ln p_{k+\frac{1}{2}}\right) - C\right],$$

where $C = 1$ and $k = 1, 2, \ldots, 59$. The full-level pressure for the uppermost level ($k = 60$) is given by

$$p_{60} = \frac{1}{2} p_{59.5}\,.$$

Table 7-1 and Table 7-2 also give half-level and full-level pressures with a surface pressure of 1000 hPa.

Table 7-1 Model levels from 1 to 39.

Half level				Full level	
A (Pa)	B	P (Pa)	#	P (Pa)	#
0.000000000000	1.000000000000000000	100000	0.5	100000.0	Surface
0.000000000000	0.997000000000000000	99700	1.5	99850.0	1
0.000000000000	0.994000000000000000	99400	2.5	99550.0	2
0.000000000000	0.989000000000000000	98900	3.5	99149.9	3
0.000000000000	0.982000000000000000	98200	4.5	98549.8	4
0.000000000000	0.972000000000000000	97200	5.5	97699.6	5
0.000000000000	0.960000000000000000	96000	6.5	96599.4	6
0.000000000000	0.946000000000000000	94600	7.5	95299.1	7
133.051011276943	0.926669489887231000	92800	8.5	93698.6	8
364.904148871589	0.904350958511284000	90800	9.5	91798.2	9
634.602716447362	0.879653972835526000	88600	10.5	89697.8	10
959.797167291774	0.851402028327082000	86100	11.5	87347.0	11
1347.680041655150	0.819523199583449000	83300	12.5	84696.1	12
1790.907395951100	0.785090926040489000	80300	13.5	81795.4	13
2294.841689948500	0.748051583100515000	77100	14.5	78694.6	14
2847.484777711760	0.709525152222882000	73800	15.5	75444.0	15
3468.871488118640	0.668311285118814000	70300	16.5	72042.9	16
4162.956462969160	0.624370435370308000	66600	17.5	68441.7	17
4891.880832504910	0.580081191674951000	62900	18.5	64741.2	18
5671.824239804080	0.534281757601959000	59100	19.5	60990.1	19
6476.712996385320	0.488232870036147000	55300	20.5	57189.5	20
7297.469894720490	0.442025301052795000	51500	21.5	53388.7	21
8122.159791249150	0.395778402087509000	47700	22.5	49587.9	22
8914.082201062340	0.350859177989377000	44000	23.5	45837.6	23
9656.181910501640	0.307438180894984000	40400	24.5	42187.2	24
10329.436177774600	0.265705638222254000	36900	25.5	38636.8	25
10912.638444238700	0.225873615557613000	33500	26.5	35186.3	26
11369.647830843200	0.189303521691568000	30300	27.5	31886.6	27
11695.371597470000	0.155046284025300000	27200	28.5	28736.1	28
11861.253087394800	0.124387469126052000	24300	29.5	25736.4	29
11855.434316349300	0.096445656836507500	21500	30.5	22885.7	30
11663.355365580300	0.072366446344196600	18900	31.5	20186.0	31
11285.404064494200	0.052145959355057800	16500	32.5	17686.4	32
10729.949405567900	0.035700505944321400	14300	33.5	15386.9	33
10014.615053510700	0.022853849464893500	12300	34.5	13287.5	34
9167.247035833100	0.013327529641668900	10500	35.5	11388.1	35
8226.244907704420	0.006737550922955820	8900	36.5	9689.0	36
7201.568980298280	0.002484310197017220	7450	37.5	8164.3	37
6088.673008533920	0.000113269914660783	6100	38.5	6763.8	38
4950.000000000000	0.000000000000000000	4950	39.5	5515.0	39

Table 7-2 Model levels from 40 to 60.

Half level				Full level	
A (Pa)	B	P (Pa)	#	P (Pa)	#
4000.000000000000	0.000000000000000000	4000	40.5	4466.6	40
3230.000000000000	0.000000000000000000	3230	41.5	3608.1	41
2610.000000000000	0.000000000000000000	2610	42.5	2914.5	42
2105.000000000000	0.000000000000000000	2105	43.5	2353.0	43
1700.000000000000	0.000000000000000000	1700	44.5	1898.9	44
1370.000000000000	0.000000000000000000	1370	45.5	1532.0	45
1105.000000000000	0.000000000000000000	1105	46.5	1235.1	46
893.000000000000	0.000000000000000000	893	47.5	997.1	47
720.000000000000	0.000000000000000000	720	48.5	804.9	48
581.000000000000	0.000000000000000000	581	49.5	649.3	49
469.000000000000	0.000000000000000000	469	50.5	524.0	50
377.000000000000	0.000000000000000000	377	51.5	422.2	51
301.000000000000	0.000000000000000000	301	52.5	338.3	52
237.000000000000	0.000000000000000000	237	53.5	268.4	53
182.000000000000	0.000000000000000000	182	54.5	208.9	54
136.000000000000	0.000000000000000000	136	55.5	158.4	55
97.000000000000	0.000000000000000000	97	56.5	116.0	56
65.000000000000	0.000000000000000000	65	57.5	80.5	57
39.000000000000	0.000000000000000000	39	58.5	51.5	58
20.000000000000	0.000000000000000000	20	59.5	29.0	59
0.000000000000	0.000000000000000000	0	60.5	10.0	60

7.2. Isentropic coordinates

Isentropic fields are produced for the following 21 isentropic surfaces;

270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 425, 450, 475, 550, 650, 750, 850K

except specific humidity, which are produced for 14 levels from 270 through 400K only.

7.3. Soil layers of the land surface model

Porosities and thicknesses of soil layer of the land surface model are defined for each type of vegetation in Table 7-3 as follows;

Table 7-3 Soil layers of the land surface model.

Code figure	Porosity ($m^3\ m^{-3}$)	Thickness (m)		
		Top (#1)	Middle (#1)	Bottom (#1)
0	n/a	n/a	n/a	n/a
1	0.42	0.02	1.48	2
2	0.42	0.02	1.48	2
3	0.42	0.02	1.48	2
4	0.42	0.02	1.48	2
5	0.42	0.02	1.48	2
6	0.42	0.02	0.47	1
7	0.42	0.02	0.47	1
8	0.4352	0.02	0.47	1
9	0.4352	0.02	0.17	0.3
10	0.42	0.02	0.17	1
11	0.4352	0.02	0.17	0.3
12	0.4577	0.02	0.47	1
13	0.4352	1	1	1

8. Physical constants

Fundamental physical constants used in the forecast model are as follows;

Table 8-1 Physical constants.

Quantity	Value
Stefan-Boltzmann constant σ	5.67×10^{-8} W m^{-2} K^{-4}
Earth's radius	6.371×10^{6} m
Angular speed of Earth's rotation	7.29245×10^{-5} rad s^{-1}
Gravitational acceleration	9.80665 m s^{-2}
Gas constant for dry air	287.04 J K^{-1} kg^{-1}
Specific heat of dry air at constant pressure c_p	1004.6 J K^{-1} kg^{-1}
Latent heat of vaporization	2.507×10^{6} J kg^{-1}
Solar constant	1365 W m^{-2}

9. Monthly statistics

9.1. Monthly statistics for fixed hours (Monthly_diurnal)

Monthly averages and variances are produced for each of the output hours at 00, 06, 12 and 18UTC (and 03, 09, 15 and 21UTC when available), and referred to as monthly statistics for fixed hours (Monthly_diurnal).

Table 9-1 shows the meanings of time ranges indicator encoded in Octet 21 of Section 1.

9.2. Monthly statistics (Monthly)

Averages and variances for a whole month are also produced using 6 hourly data only for analysed and instantaneous forecast fields, and averages from the beginning of forecasts through 6 hours for average diagnostic fields. These statistics are referred to as monthly statistics (Monthly).

Table 9-1 shows the meanings of time ranges indicator encoded in Octet 21 of Section 1.

Table 9-1 Time range indicator for monthly statistics.

Code figure	Meaning
113	Average of N forecasts (or initialized analyses); each product has forecast period of P1 (P1 = 0 for initialized analyses); products have reference times at intervals of P2, beginning at the given reference time
123	Average of N uninitialized analyses, starting at the reference time, at intervals of P2
128	Average of N forecast products with a valid time ranging between reference time + P1 and reference time + P2; products have reference times at Intervals of 24 hours, beginning at the given reference time
129	Temporal variance of N forecasts; each product has valid time ranging between reference time + P1 and reference time + P2; products have reference times at intervals of 24 hours, beginning at the given reference time; unit of measurement is square of that in Code Table 2
130	Average of N forecast products; valid time of the first product ranges between R + P1 and R + P2, where R is reference time given in octets 13 to 17, then subsequent products have valid time range at interval of P2 – P1; thus all N products cover continuous time span; products have reference times at intervals of P2 - P1, beginning at the given reference time
131	Temporal variance of N forecasts; valid time of the first product ranges between R + P1 and R + P2, where R is reference time given in octets 13 to 17, then subsequent products have valid time range at interval of P2 – P1; thus all N products cover continuous time span; products have reference times at intervals of P2 - P1, beginning at the given reference time; unit of measurement is square of that in Code Table 2
132	Temporal variance of N uninitialized analyses (P1 = 0) or instantaneous forecasts (P1 > 0); each product has valid time at the reference time + P1; products have reference times at intervals of P2, beginning at the given reference time; unit of measurement is square of that in Code Table 2

10. Climatological normals

Climatological normals have been calculated for the period from 1981 to 2010 with the methods described below.

10.1. Daily mean smooth climatological normals

There are two steps for the calculation. In the first step, daily values are computed using 6-hourly values for analysis and instantaneous forecast fields and averages from

the beginning of forecasts through 6 hours for average diagnostic fields, and then simply averaged for the base period for each day of the year except the leap day. In the second step, Lanzcos low-pass filtering (Duchon, 1979) with 121-term weight factors by 60-day cutoff is applied to the time sequence of the daily values, since high-frequency variation remains in the daily values calculated in the first step. Climatological normals for the leap day are derived averaging the smooth climatological normals for 28th February and 1th March.

The concept of this method is quite simple. It should be noted that monthly mean calculated from daily mean does not coincide with that mentioned above due to the difference in treatment of the leap day and with or without the filtering.

10.2. Monthly mean climatological normals

Monthly mean climatological normals are calculated simply averaging historical monthly mean values.

11. Production streams

The JRA-55 production was organized into several streams shown in Table 11-1 in order to shorten the time required. Separate stream names are also assigned when data assimilation cycles were rerun or secondary products were recalculated. Those stream names are encoded in Octets 46-49 of Section 1.

There are three discontinuities among the streams in Table 11-1 at 00UTC on 1 July 1958 (A003/A002), 00UTC on 1 September 1980 (A004/B002) and 00UTC on 1 October 1992 (B003/B002), at which data were not succeeded to by the following streams. For the other stream changeovers, succeeding streams were initiated from the last data of the preceding streams.

Table 11-1 Production streams of JRA-55.

Stream	Period	Section 1 Octets 46-49	Note
A003	until 30 Jun 1958	AE03	fcst_column125 (thermal energy fluxes) fcst_p125 (cloud liquid water, cloud ice, ozone mixing ratio) fcst_phy3m125
		AR03	anl_isentrop125 fcst_column125 (other than thermal energy fluxes) fcst_phy2m125 fcst_surf125 (surface roughness, brightness temperature)
		A003	other parameters
A002	1 Jul 1958 to 30 Nov 1974	AE02	same as AE03
		AR02	same as AR03
		A002	same as A003
A004	1 Dec 1974 to 31 Aug 1980	AE04	same as AE03
		AR04	same as AR03
		A004	same as A003
B002	1 Sep 1980 to 31 May 1987	BE02	same as AE03
		BR02	same as AR03
		B002	same as A003
B003	1 Jun 1987 to 30 Sep 1992	BE03	same as AE03
		BR03	same as AR03
		B003	same as A003
B002	1 Oct 1992 to 31 Dec 2013	BE02	same as AE03, but until 31 Dec 2012
		BR02	same as AR03, but until 31 Dec 2012
		B002	other parameters
B004	from 1 Jan 2014 onward	B004	

12. Changes from the JRA-25 products

12.1. Parameter classification

In the JRA-25 products, there existed some categories in which 2- and 3-dimensional fields were put together. In the JRA-55 products, they are output into separate categories, and files of 3-dimensional fields are divided into each parameter, except land surface fields.

Table 12-1 Example of category change (in the case of anl_mdl).

JRA-25	JRA-55
anl_mdl	*Model level analysis fields*
	anl_mdl_hgt (geopotential height)
	anl_mdl_tmp (temperature)
	…
	Surface analysis fields
	anl_surf

While there existed some categories in which instantaneous, average and extreme fields were put together in the JRA-25 products, they are output into separate categories in the JRA-55 products.

Table 12-2 Example of category change (in the case of fcst_phy2m).

JRA-25	JRA-55
fcst_phy2m	*2-dimensional average diagnostic fields*
	fcst_phy2m
	2-dimensional instantaneous diagnostic fields
	fcst_surf
	2-dimensional extreme fields [1]
	minmax_surf

[1]extreme fields are produced for daily model grid data only, not for monthly statistics or latitude/longitude grid data.

12.2. Dates in Filenames

In the JRA-25 products, dates in filenames indicated valid times for instantaneous fields and the end of the averaging period for average diagnostic fields. In the JRA-55 products, there has been a change in average diagnostic fields for which dates in filenames indicate the beginning of the averaging period.

Table 12-3 Example of change of dates in filenames (in the case of fcst_phy2m.1981010100).

	Valid time
JRA-25	from 18UTC on 31 Dec 1980 to 00UTC 1 Jan 1981
JRA-55	from 00 to 03UTC on 1 Jan 1981

12.3. Addition and change of parameters

Parameters added to the JRA-55 products are indicated by a superscript+ in parameter tables shown in Chapter 4.

There are some parameters that have been switched from average forecast fields to instantaneous forecast fields in the JRA-55 products. Those parameters are indicated by a superscript*.

12.4. Discontinued parameters

Table 12-4 Discontinued parameter in the isentropic analysis fields (anl_isentrop).

Code figure	Field parameter	Unit
11	Temperature	K

Table 12-5 Discontinued parameter in the model level forecast fields (fcst_mdl).

Code figure	Field parameter	Unit
52	Relative humidity	Proportion

Table 12-6 Discontinued parameters in the 2-dimensional diagnostic fields (fcst_phy2m).

Code figure	Field parameter	Unit	Level
2	Pressure reduced to MSL (mean)	Pa	Mean sea level
136	u-component of wind (mean, surface)	m s^{-1}	10m
137	v-component of wind (mean, surface)	m s^{-1}	10m
138	Temperature (mean, surface)	K	2m
139	Specific humidity (mean, surface)	kg kg^{-1}	2m
80	Water temperature[#]	K	Water surface
218	Moist process heating rate	W m^{-2}	Entire atmosphere (considered as a single layer)
168	Frequency of precipitation	%	Ground or water surface
169	Frequency of cumulus precipitation	%	Ground or water surface
200	Zonal temperature flux	K Pa m s^{-1}	Entire atmosphere (considered as a single layer)
201	Meridional temperature flux	K Pa m s^{-1}	Entire atmosphere (considered as a single layer)
219	Maximum wind speed	m s^{-1}	Lowermost hyblid level
220	Maximum hourly precipitation	mm $hour^{-1}$	Ground or water surface
76	Cloud water	kg m^{-2}	Entire atmosphere (considered as a single layer)

[#] In the JRA-55 product, SST is output as brightness temperature in the 2-dimensional instantaneous diagnostic fields (fcst_surf).

Table 12-7 Discontinued parameters in the 3-dimensional diagnostic fields (fcst_phy3m).

Code figure	Field parameter	Unit
76	Cloud water	kg m^{-2}
175	Geopotential height (mean)	gpm
176	u-component of wind (mean)	m s^{-1}
177	v-component of wind (mean)	m s^{-1}
178	Vertical velocity (mean)	Pa s^{-1}
179	Temperature (mean)	K
180	Specific humidity (mean)	kg kg^{-1}

Table 12-8 Discontinued parameter in the land surface diagnostic fields (fcst_phyland).

Code figure	Field parameter	Unit	Level
86	Soil moisture content	Proportion	Underground layers

12.5. Output interval

Most of the JRA-25 products were output at 6 hourly intervals. In the JRA-55 products, land surface and 2-dimensional forecast fields are output at 3 hourly intervals.

12.6. Vertical coordinates

12.6.1. Hybrid coordinates

In the JRA-25 products, model level fields were produced for 40 hybrid levels. In the JRA-55 products, model level fields are produced for 60 hybrid levels listed in Section 7.1.

12.6.2. Isentropic coordinates

In the JRA-25 products, isentropic fields were produced for 20 isentropic surfaces at 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 425, 450, 475, 550, 650 and 750K. In the JRA-55 products, isentropic fields are produced for 21 isentropic surfaces listed in Section 7.2 (850K has been added).

12.7. Monthly statistics

While monthly statistics of the JRA-25 products were saved in the 4-byte big-endian floating point format, those of the JRA-55 products are saved in the GRIB Edition 1 (WMO 2011) in the same way as the daily data.

While only monthly averages were produced in the JRA-25 products, variances are also produced in the JRA-55 products except for the land surface and 2-dimensional average diagnostic fields. Variance files are indicated by "_var" at the end of filenames (Table 3-1).

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