HMCR model description

1. Ensemble version		
Ensemble identifier code	**RUMS**	**RUMS**
Short Description	Global ensemble system that simulates initial uncertainties using breeding method. **It is based on 41 members, run weekly (Wednesday at 00Z) up to day 46.**	Global ensemble system that simulates initial uncertainties using breeding method. It is based on 20 members, run weekly (Wednesday at 00Z) up to day 61.
Research or operational	Operational	Operational
Data time of first forecast run	**15/09/2022**	**07/01/2015**
2. Configuration of the EPS		
Is the model coupled to an ocean model ?	No	No
If yes, please describe ocean model briefly including frequency of coupling and any ensemble perturbation applied		
If no, please describe the sea surface temperature boundary conditions (climatology, reanalysis ...)		
Is the model coupled to a sea Ice model?	No - Sea ice initial conditions are relaxed to climatology using individual coefficients for 0.75x0.75 degree cells.	No - Sea ice initial conditions are persisted up to day 15 and then relaxed to climatology up to day 45.
If yes, please describe sea-ice model briefly including any ensemble perturbation applied		
Is the model coupled to a wave model?	No	No

If yes, please describe wave model briefly including any ensemble perturbation applied		
Ocean model		
Horizontal resolution of the atmospheric model	**0.9 x 0.72 degrees lat-lon**	1.125 x 1.40625 degrees lat-lon
Number of model levels	**96**	28
Top of model	0.04 hPa	5 hPa
Type of model levels	**hybrid**	sigma
Forecast length	**46 days (1104 hours)**	61 days (1464 hours)
Run Frequency	weekly (**Thursdays**)	weekly (Wednesday 00Z up to May 2017, Thursdays 00Z since June 2017)
Is there an unperturbed control forecast included?	Yes	Yes
Number of perturbed ensemble members	40	19
Integration time step	**24 minutes**	36 minutes
3. Initial conditions and perturbations		
Data assimilation method for control analysis	**3D-Var analysis for upper-air fields; OI analysis for screen-level temperature and humidity; simplified extended Kalman filter for soil moisture**	3D Var
Resolution of model used to generate Control Analysis	**0.5 degrees for upper air; 0.72x0.9 degrees lat-lon for screen-level and soil variables**	0.5 degrees
Ensemble initial perturbation strategy	Breeding perturbations added to control analysis	Breeding perturbations added to control analysis
Horizontal and vertical resolution of perturbations	**0.72 x 0.9 degrees lat-lon**	1.125 x 1.40625 degrees lat-lon.
Perturbations in +/- pairs	No	No
4. Model uncertainties perturbations		

Is model physics perturbed?	**Yes**	No
Do all ensemble members use exactly the same model version?	Yes	Yes
Is model dynamics perturbed?	No	No
Are the above model perturbations applied to the control forecast?	No	No
5. Surface boundary perturbations		
Perturbations to sea surface temperature?	No	No
Perturbation to soil moisture?	No	No
Perturbation to surface stress or roughness?	No	No
Any other surface perturbation?	No	No
Are the above surface perturbations applied to the Control forecast?	No	No
Additional comments -		
6. Other details of the models		
Description of model grid	**Regular lat-lon grid, hybrid pressure based coordinate in vertical.**	Regular lat-lon grid, sigma-coordinate in vertical.
List of model levels in appropriate coordinates	**see the section 9 below**	.0001, .0092, .01935, .03234, .04904, .06975, .09376, .12045, .15003, .1837, .2231, .2692, .3204, .3751, .4321, .4905, .5503, .6101, .6692, .72532, .77773, .82527, .86642, .90135, .93054, .95459, .97418, .99, 1.0
What kind of large scale dynamics is used?	Finite-difference semi-implicit semi-Lagrangian, vorticity-divergence formulation **(Tolstykh et al, GMD 2017)**	Finite-difference semi-implicit semi-Lagrangian, vorticity-divergence formulation (Tolstykh, JCP 2002; section 2 in Shashkin, Tolstykh, GMD 2014)
What kind of boundary layer parameterization is used?	**Bastak-Duran et al (JAS 2014)**	pTKE scheme (Geleyn, J.-F., et al 2006) with shallow convection included
What kind of convective parameterization is used?	Bougeault (MWR 85), Ducrocq and Bougeault (95), Gerard and Geleyn (QJ 2005) **with our modification of momentum transport**	Bougeault (MWR 85), Ducrocq and Bougeault (95), Gerard and Geleyn (QJ 2005)

What kind of large-scale precipitation scheme is used?	**Gerard et al 2009**	Geleyn et al 1994
What cloud scheme is used?	Xu-Randall (JAS 96), diagnostic	Xu-Randall (JAS 96), diagnostic
What kind of land-surface scheme is used?	**INM RAS – MSU**	ISBA
How is radiation parametrized?	**CLIRAD SW (Tarasova, Fomin 2005), RRTMG LW (Mlawer et al 1997)**	Ritter, Geleyn (1992), Geleyn et al (2005)
Other relevant details?		
7. Re-forecast Configuration		
Number of years covered	**25**	26
Produced on the fly or fix re-forecasts?	On the fly	On the fly
Frequency	Produced on the fly once a week to calibrate the **Thursday** 00 Z real-time forecasts. The re-forecasts consist of a 11-member ensemble starting the same day and month as **Thursday** real-time forecasts for the years **1991-2015**.	Produced on the fly once a week to calibrate the **Thursday** 00Z real-time forecasts. The re-forecasts consist of a 11-member ensemble starting the same day and month as **Thursday** real-time forecasts for the years **1991-2015**.
Ensemble size	**11 members**	10 members
Initial conditions	quasiassimilation with **ERA5 data for upper air, SEKF for soil moisture, OI for soil temperature**	quasiassimilation with ERA Interim data
Is the model physics and resolution the same as for the real-time forecasts	Yes	Yes
If not, what are the differences	N/A	N/A
Is the ensemble generation the same as for real-time forecasts?	Yes	Yes
If not, what are the differences	N/A	N/A
Other relevant information	HMCR re-forecasts are produced on the fly. Every week a new set of re-forecasts is produced to calibrate the real-time ensemble forecast of the given day. **The ensemble re-forecasts consist of a 11-member ensemble starting the same day and month as a Thursday real-time forecast, but covering 1991-2015 years.** The re-forecast dataset is therefore updated every week in the S2S archive.	HMCR re-forecasts are produced on the fly. Every week a new set of re-forecasts is produced to calibrate the real-time ensemble forecast of the given day. The ensemble re-forecasts consist of a 10-member ensemble starting the same day and month as a Wednesday real-time forecast, but covering 1985-2010 years. The re-forecast dataset is therefore updated every week in the S2S archive.

8. References

Dynamics

Tolstykh M., Shashkin V., Fadeev R., Goyman G. Vorticity-divergence semi-Lagrangian global atmospheric model SL-AV20: dynamical core, Geosci. Model Dev., 2017, V. 10, P. 1961-1983.

Turbulence

Bašták urán, I., Geleyn J.-F., and Váa F. A Compact Model for the Stability Dependency of TKE Production–Destruction–Conversion Terms Valid for the Whole Range of Richardson Numbers, J. Atmos. Sci., 2014, V. 71, P. 3004–3026.

SW radiation

Chou, M.-D., Suarez M. J. A solar radiation parameterization (CLIRAD-SW) for atmospheric studies – 1999. NASA Tech. Memo. 10460, V. 15, NASA Goddard Space Flight Center, Greenbelt, MD, 48 pp.

Tarasova T., Fomin B. The Use of New Parameterizations for Gaseous Absorption in the CLIRAD-SW Solar Radiation Code for Models, J. Atmos. and Oceanic Technology. 2007. V. 24, I. 6, P. 1157–1162.

LW radiation

Mlawer E.J., Taubman S.J., Brown P.D., Iacono M.J. and Clough S.A.: RRTM, a validated correlated-k model for the longwave, J. Geophys. Res. 1997, V. 102, P. 16663-16682.

Deep convection

Gerard L., Geleyn J.-F. Evolution of a subgrid deep convection parametrization in a limitedarea model with increasing resolution. Quart. J. Roy. Meteor. Soc. 2006, V. 131. P. 2293 - 2312. (and references herein)

Large scale precipitation and microphysics

Gerard L., Piriou J.-M., Brozkova R., et al. Cloud and Precipitation Parameterization in a Meso-Gamma-Scale Operational Weather Prediction Model. — Mon. Wea. Rev., 2009, V. 137, P. 3960—3977.

Orographic gravity wave drag

Catry B., Geleyn J.-F., Bouyssel F., Cedilnik J., Brožková R.,Derková M., and Mladek R.: A new sub-grid scale lift formulation in a mountain drag parameterisation scheme, Meteorol. Z., 2008, V. 17, P. 193–208.

Non-orographic gravity wave drag

Hines C.O. Doppler-spread parameterization of gravity-wave momentum deposition in the middle atmosphere. Part 1: Basic formulation, J. Atm. & Solar-Terrestrial Phys. 1997. V. 59, I. 4, P. 371-386.

Multilayer soil

Volodin E. M. and Lykosov V. N., Parameterization of Heat and Moisture Processes in Soil–Vegetation System. Part 1. Description and Calculations Using Local Observational Data, Izv., Atmos. Oceanic Phys., No. 4, V. 34 (1998).

9. List of model levels in appropriate coordinates

(RUMS 15/09/2022)

N	A	B
1	2.6858925E-5	0
2	6.521674E-5	0
3	9.5737065E-5	0
4	1.3942415E-4	0
5	2.011347E-4	0
6	2.870224 E-4	0
7	4.046345E-4	0
8	5.6289845E-4	0
9	7.7195615E-4	0
10	1.0428361E-3	0
11	1.387315E-3	0
12	1.818298E-3	0
13	2.3497605E-3	0
14	2.993734E-3	0
15	3.7552525E-3	0
16	4.62815E-3	0

17	5.5946875E-3	0
18	6.633841E-3	0
19	7.7301835E-3	0
20	8.8752315E-3	0
21	1.0066637E-2	0
22	1.1306625E-2	0
23	1.2599275E-2	0
24	1.3949105E-2	0
25	1.536087E-2	0
26	1.6839435E-2	0
27	1.838968E-2	0
28	2.001639E-2	0
29	2.1724365E-2	0
30	2.351879E-2	0
31	2.351879E-2	0
32	2.739097E-2	0
33	2.948251E-2	0
34	3.168817E-2	0
35	3.401692E-2	0
36	3.647871E-2	0
37	3.908456E-2	0
38	4.1846685E-2	0
39	4.4778645E-2	0
40	4.789549E-2	0
41	5.1213915E-2	0
42	5.475246E-2	0
43	5.8531705E-2	0
44	6.257452E-2	0
45	6.690632E-2	0
46	7.155365E-2	1.711604E-6
47	7.6541645E-2	1.1460423E-5
48	8.1897783E-2	3.6816742E-5
49	8.7654268E-2	8.4632497E-5
50	9.3845508E-2	1.6405206E-4
51	0.10050788	2.8738153E-4
52	0.10768070	4.7119814E-4
53	0.11540868	7.3797217E-4
54	0.12374385	1.1184485E-3
55	0.13274668	1.6551708E-3
56	0.14248693	2.4078173E-3
57	0.15304148	3.4611242E-3

58	0.16447771	4.9349952E-3
59	0.17682732	6.9968291E-3
60	0.19005918	0.20404697
61	0.20404697	1.3880277E-2
62	0.21853412	1.9403728E-2
63	0.23311013	2.6931367E-2
64	0.24723154	3.7048655E-2
65	0.26025510	5.0472252E-2
66	0.27143429	6.8094264E-2
67	0.27988784	9.1050159E-2
68	0.28453942	0.12079088
69	0.28413173	0.15857732
70	0.27779435	0.20402365
71	0.26598128	0.25427937
72	0.25031986	0.30581109
73	0.23247062	0.35649843
74	0.21349702	0.40570793
75	0.19400596	0.45341879
76	0.17442633	0.49961317
77	0.15510822	0.54420098
78	0.13635191	0.58704339
79	0.11841143	0.62799050
80	0.10149555	0.66690305
81	8.5771185E-2	0.70365821
82	7.1364710E-2	0.73815564
83	5.8362444E-2	0.77032265
84	4.6811675E-2	0.80011772
85	3.6722423E-2	0.82753238
86	2.8070594E-2	0.85259051
87	2.0801944E-2	0.87534661
88	1.4836649E-2	0.89588350
89	1.0074879E-2	0.91430797
90	6.40262E-3	0.93074583
91	3.697367E-3	0.94533689
92	1.83359E-3	0.95822921
93	6.8736347E-4	0.969574337
94	1.40194E-4	0.9795227
95	1.003E-6	0.988301
96	0.	0.9962179