

RUSSIAN FEDERATION
FEDERAL SERVICE FOR HYDROMETEOROLOGY
AND ENVIRONMENTAL MONITORING OF THE RUSSIAN FEDERATION
(ROSHYDROMET)

**TECHNICAL DOCUMENTATION OF THE GLOBAL DATA PROCESSING AND
FORECASTING SYSTEM (GDPFS) AND RELATED NUMERICAL WEATHER
PREDICTION RESEARCH ACTIVITIES FOR JANUARY 2018**

Country: Russian Federation

Centre: RSMC Khabarovsk

1. Summary of main highlights

Adopted to operational schedule:

- Automatical forecasting technology to predict the position and evolution of tropical cyclones (TC) on the territory of North-West part of the Pacific Ocean based on numerical regional model HWRf (calculations are held in FERHRI, Vladivostok).
- Numerical sea level forecasting model for the seashores and areas of the Sea of Okhotsk and North part of the Sea of Japan with considering sea ice.
- Calculations of specialized forecasts for the aviation meteorological service on the territories of East Siberia and Far East of Russia based on output production of operational regional WRF-ARW model with grid spacing of 15 km.

Adopted to experimental schedule:

- Forecasting of low-level turbulence on the territories of East Siberia and Far East of Russia based on output production of WRF-ARW model with grid spacing of 15 km.

2. Equipment in Use

- Computational complex based on supercomputer G-ScaleS4700 with productivity of 0.6 TFlops (104 processing cores 1.66 GHz each) includes additionally front-end server, two servers of the task queue system, two servers of the data management system, two servers of the operational information processing and other subsidiary servers on the bases of Intel Itanium2, Intel Xeon processors. Computational complex includes disk unit SGIS4000F with 13.5 TB memory and tape data storage system Quantum Scalari500 with the memory volume of 32 TB.
- Storage system 'Synology' (the memory volume of 15 TB).
- Two Xeon double-processors (3.2 GHz each).
- Server for data accumulation and storage of all incoming information (observations and processed data) and production of computational centre of RSMC Khabarovsk.
- Server for data processing and distribution via the ESIMO – AQUARIUS system with a 4-core Intel Xeon E5506 processor, 2.13 GHz, 6 GB operative memory, and two hard disks drives of 300 GB each.

- Server for the CLIWARE meteorological information management system with a 2-core Intel Core 2 Duo E4500 processor, 2.2 GHz, 3 GB operative memory, and two hard disk drives of 300 GB each.
- Computational complex based on supercomputer ALTIX UV-100 with productivity of 1 TFlops (112 processing cores 1.66 GHz each) includes additionally six supporting servers and SGI storage system (the memory volume of 10 TB). Complex is placed in FERHRI, Vladivostok.

3 UsedDataandProductsComingfromGST

Total amount of received data comprises 255 MB/day, transmitted data – 520 MB/day (without transit).

Average number of telegrams per day:

Codeform	Number of telegrams	
	Received	Used
SATEM	26300	26300
TEMP	63000	63000
SYNOP+SHIP	78000	78000
KN15	250	250
PILOT	6600	6600
SATOB	4500	4500
AIREP	1300	1300
AMDAR	55900	55900
BUOY	43600	43600
BUFR-SYNOP	40000	40000
BATHY	5000	5000
GRIB (Exeter)	2500	2500
GRIB (Reading)	74	74
GRIB (Moscow)	386	386
GRIB (Tokyo)	2420	2420
Facsimile (Tokyo)	312	312

Productions of satellite observations are received and used with total daily amount of 1 GB.

3.1 Used Data and Products Available via INTERNET

Operational products of numerical weather prediction system ‘Global Forecasting System’ (NCEP, USA) in GRIB2 format are downloaded four times a day via FTP (daily volume of downloaded data is 6 GB).

4. Forecasting System:

4.1. Time Schedule and Forecasting Period

Main initial hours of the forecasting system operation are 00^h и 12^h UTC (regional and quasigeostrophic synoptic-scale models MLp 11-100/50, MLs 22-50, and regional non-hydrostatic model WRF-ARW).

A) Regional model (50×50 km), versions MLp 11-100/50 and MLs 22-50: for Yakut, Transbaikal Territories, North-eastern part of the Far East of Russia (Kamchatka and Chukotka peninsulas, Kolyma region), South-Eastern part of the Far East of Russia (including Khabarovsk and Primorskiy Territories and Sakhalin and Amurskiy districts) using the initial data of 00^h and 12^h UTC – up to 48 hours (readiness time 3.00 and 15.00 UTC). Visualization information presents the weather fields with 1-hour time step and information at upper levels with 3-hour time step.

B) Regional model WRF-ARW:

- Version based on 15×15 km grid – for Eastern Siberia and Far East region (initial data of 00^h and 12^h UTC). Maximum lead time is 72 hours, readiness time 7.30 and 19.30 UTC, output information is produced with 1- and/or 3-hour time step (according to production types).

- Version based on 30×30 km grid – for Transbaikal Territory (initial data of 00^h UTC). Maximum lead time is 72 hours, readiness time is 12.00 UTC, output information is produced with 3-hour time step.

- Version based on 25×25 km grid – for Yakut Territory (initial data of 00^h UTC). Maximum lead time is 72 hours, readiness time is 11.00 UTC, output information is produced with 3-hour time step.

- Version based on 3×3 km grid for Transbaikal Territory (initial data of 12^h UTC). Maximum lead time is 24 hours, readiness time is 18.00 UTC, output information is produced with 1-hour time step.

4.2 System for the medium range forecasting (4-10 days)

4.2.1 Data assimilation, objective analysis and initialization - None

4.2.2 Global Models - None

4.2.3 Operationally available medium-range Numerical Weather Prediction (NWP) Products

The output of the models of Hydrometcentre of Russia, ECMWF, NMC Exeter received via GTS is used.

4.2.4 Applied operational techniques of NWP products (MOS, PPM, KF, Expert Systems etc.), medium range forecast (72 – 240 h)

4.2.4.1 In operation:

A statistical interpretation system of the ECMWF forecasts received via GTS is used for 48 points of the Russian Far East to determine extreme and daily averaged surface air temperature, 12-hour accumulated precipitation, surface wind speed and direction is used for 5 days forecasts.

4.2.5 Ensemble Prediction System - None

4.3 Short-range forecasting system (0-72 hours)

4.3.1 Data assimilation, objective analysis and initialization

4.3.1.1 In operation

The objective analysis for the integration area of the regional model using as the first approximation fields the results of RSMC Exeter forecasts with resolution $2.5 \times 2.5^\circ$ - twice a day for 00^h and 12^h UTC. Method of analysis is bilinear interpolation for single surface characteristics and 3-dimensional optimal interpolation for heopotential fields and wind.

The analyzed parameters include heopotential, temperature and wind speed components at 12 standard isobaric surfaces (1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, and 50 hPa) and fields of dew point temperature at 1000 hPa and deficit of dew point at 5 levels (925, 850, 700, 500, and 400 hPa).

In the MLs 11-100/50 model initialization of the heopotential fields and the fields of wind speed components using the 4 vertical modes decomposition is conducted.

4.3.1.2 Research performed in this field- None

4.3.2 Models for short-range numerical forecasting

4.3.2.1. In operation

A) Regional model of the Hydrometeorological Centre of Russia

Regional quasi-geostrophical model of the Hydrometeorological Centre of Russia adopted for the Russian Far East in horizontal Cartesian coordinate system is operating in two versions: p- and σ -vertical systems.

MLs 22-50 in σ -coordinate system with horizontal resolution 50 km at 22 vertical levels;

MLp 11-100/50 in p-coordinate system is integrated with horizontal resolutions of 100 and 50 km at 11 standard isobaric surfaces.

These versions are used as a back-up operational numerical forecasting system.

Model configuration

Three versions of the regional MLs 22-50 model (121×151 grid points) are used operatively:

- 1) $110^\circ - 170^\circ$ E, $30^\circ - 65^\circ$ N (Russian Far East);
- 2) $90^\circ - 160^\circ$ E, $40^\circ - 75^\circ$ N (Yakutia);
- 3) 120° E – 170° W centered at 160° E, 54° N (Kamchatka peninsula, Kolyma and Chukotka).

B) WRF-ARW model

Model configuration

Currently three versions of the model are used operationally:

Title	Version	Horizontal resolution (km)	Number of points, centered at	Area of integration	Time step	Lead time (hours)
Khab-15	3.4.1	15	501×401 ; Khabarovsk	$20^\circ - 70^\circ$ N; $100^\circ - 180^\circ$ E	60	72
Yak-25	3.4.1	25	251×201 ; 62° N, 129° E	$45^\circ - 80^\circ$ N, $95^\circ - 160^\circ$ E Yakutia	150	72
Zab-30	3.4.1	30	251×201 ; 54° N, 110° E	$40^\circ - 75^\circ$ N, $75^\circ - 140^\circ$ E	150	72

				Transbaikal		
Zab-9	3.1.1	9 / 3	333 × 251 / 619 × 340; 54°N, 110°E	35°-60° N; 90°-120° E Transbaikal.	30 / 10	24

The following parameterizations are used:

Title	Convection	Boundary and surface layers	Microphysics	Soil processes	Radiation (long-, and short wave)
Khab-15	Kain-Fritsch	MM5 similarity and Yonsei University scheme	WRF Single-Moment 6-class	NoahLand Surface Model	Rapid Radiative Transfer Model, Dudhia scheme
Yak-25	Kain-Fritsch	MM5 similarity and Yonsei University scheme	WRF Single-Moment 6-class	NoahLand Surface Model	Rapid Radiative Transfer Model, Dudhia scheme
Zab-30	Betts-Miller-Janjic	Eta similarity and Mellor-Yamada-Janjic scheme	WRF Single-Moment 6-class	NoahLand Surface Model	Rapid Radiative Transfer Model, Dudhia scheme
Zab-9	Betts-Miller-Janjic / none	Eta similarity and Mellor-Yamada-Janjic scheme	Thompson	NoahLand Surface Model	Rapid Radiative Transfer Model, Dudhia scheme

‘Khab-15’ model is executed twice a day starting from 00 and 12 UTC; ‘Zab-30’ model is executed once a day starting from 00 UTC; ‘Yak-25’ model is executed once a day starting from 00 UTC; ‘Zab-9’ model is executed once a day starting from 12 UTC. ‘Zab-9’ is used for forecasting of the convective hazardous weather phenomena (strong showers, squalls and squall winds) for Transbaikal region of Russia only in the period from May to October.

4.3.2.2 Research performed in this field

- Development of methods and schemes for the aviation meteorological service based on output production of ‘Khab-15’ model.
- Study to define possibilities to forecast active convection zones and associated with them weather hazardous phenomena by various indices of atmospheric state which are calculated on output production of operational WRF-ARW models.
- Development of methods and schemes for air turbulence prediction based on output production of ‘Khab-15’ model.

4.3.3 Available operational products of numerical weather forecasts (modeling for bounded territories)

4.3.3.1 Output of the different versions of regional models MLs 22-50 and MLp 11-100/50 (100×100 and 50×50 km)

Yakut district, Transbaikal district, Kamchatka, Chukchi peninsula, Sakhalin island, Priamurskiy, Khabarovsk and Primorsky districts, and adjacent areas of East Siberia, Mongolia, North-West China, Korea, Japan, and Japan sea and Sea of Okhotsk.

Types of products (forecasts)

- PMSL and 1 hour precipitation intensity (detailed once an hour);
- Geopotential fields, wind components at 11 standard isobaric surfaces (1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100 hPa) detailed each 3 hours;

- Fields of temperature and relative humidity at 9 standard isobaric surfaces (925, 850, 700, 500, 400, 300, 250, 200, 150 hPa) detailed each 3 hours;

Information is provided to users via e-mail, ftp protocol, and is presented at khabmeteo.ru (PMSL, T2, and 1-hour accumulated precipitation).

4.3.3.2 Output of the regional mesoscale non-hydrostatic model WRF-ARW (15×15 km) for the Far East regions

Forecasts are provided for the territory of the Russian Far East and East Siberia and adjacent territories of Mongolia, North-West of China, Korea, Japan, and Sea of Japan and Sea of Okhotsk.

Types of products (forecasts)

- PMSL, T2, 10 m wind speed and direction (with emphasized zones of strong winds), 3-hour accumulated precipitation detailed each 3 hours;
- PMSL and accumulated amount of precipitation detailed each 3 hours;
- Cloud distribution and precipitation detailed each 3 hours;
- Heopotential fields, temperature, wind speed and direction at standard isobaric surfaces (1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100 hPa) detailed each 3 hours.
- QNH, possible icing zones, active convection index detailed each 3 hours.
- Total precipitation forecasts for partial basins of the Amur River (tables).
- Meteograms for 83 points of Eastern Siberia and Far East includes hourly forecasts of PSFC, T2, Td2, RH2, 3-h forecasts of meteorological distance of visibility, vertical shift of horizontal wind vector, top and bottom cloud heights, cloud cover, 3-h precipitation amount and distribution of temperature, wind, relative humidity in layer of surface – 10 hPa with lead time of 72 hours.

1) For forecaster centers of Far-East Roshydromet Territorial administration:

Information is presented on the server of common use in the graphic files (maps) and text files (tables) reflecting the forecasts of weather characteristics at 333 points of the East Siberia and Far East region.

2) For forecaster centers of Sakhalin, Kolyma and Kamchatka Roshydromet Territorial administrations: For Sakhalin—set of products (text files, meteograms and maps) is transferred to ftp server. For Kolyma and Kamchatka UGMS –set of products (text files, meteograms and maps) is transferred by e-mail and available on khabmeteo.ru.

3) Operational production of ‘Khab-15’ model in lat-lon grid with spacing of 0.5° (GRIB1) is available in GTS of Roshydromet.

4.3.3.3 Output of the regional mesoscale non-hydrostatic model WRF-ARW (25x25 km) for the territory of Yakutia

Types of products (forecasts)

- Fields of heopotencial, temperature, wind speed and direction on 500, 700, 850, 925 hPa detailed each 3 hours;

- PMSL, 10 m wind speed and direction, 3-h amount of precipitation and T850 detailed each 3 hours;
- Text files (tables) include forecasts of T2, 10 m wind speed and direction, 6-h amount of precipitation for 33 points of Yakutia;
- Meteograms includes hourly forecasts of PSFC, T2, Td2, RH2, 3-h forecasts of, cloud cover, 3-h precipitation amount and distribution of temperature, wind, relative humidity in layer of surface – 800 hPa with lead time of 72 hours.

Production (maps, meteograms and text files) is transferred to Yakutia UGMS by e-mail.

4.3.3.4 Output of the regional mesoscale non-hydrostatic model WRF-ARW (30×30 km) for the Transbaikal area

Transbaikal district including Bouriatie and Irkutsk area.

Types of products (forecasts)

- PMSL, T2, 10m wind speed and direction (with emphasized zones of strong winds), 3-h amount of precipitation detailed each 3 hours;
- Fields of heopotencial, temperature, wind speed and direction on 500 hPa detailed each 3 hours;

Information is presented as the slide-maps, tables of precipitation and squall forecasts in the settlements is transmitted to Transbaikal UGMS by e-mail.

4.3.3.5 Output of the regional mesoscale non-hydrostatic model WRF-ARW (3×3 km) for the Transbaikal area

Transbaikal district including Bouriatie.

Types of products (forecasts)

- PMSL, T2, index of squall wind, 10m wind speed and direction (with emphasized zones of strong winds), 3-h amount of precipitation detailed each hour;

Production (maps, meteograms and text files) is transferred to Transbaikalia UGMS by e-mail.

Operational forecasts of regional WRF-ARW model are presented at the sites of khabmeteo.ru, ferhri.org, meteo-dv.ru.

4.3.4 Operational techniques for application of NWP products MOS, PPM, KF, Expert Systems etc.), short range forecasts (0 – 72 h)

4.3.4.1 In operation

Forecasts of 12-hour accumulated precipitation at 333points of the Far East and East Siberia using the hydrodynamic model data in the closest forecasting grid pointwith consideration of the maximum value from the four nearest grid points are produced.

Forecasts of sea-level pressure and surface air temperature at 333points of the Far East and East Siberia are produced using bilinear interpolation of the model data from 4 grid points nearest to the forecasting point.

Forecasts of the land and seasurface wind is produced using the special interpolation method of the wind components from 4 nearest forecast grid points to the point of forecast.

Additionally forecasts in points are calculated to meteogram producing:

- Forecasts of vertical shift of horizontal wind vector in surface – 500 m AGL layer.
- Total cloud cover, top and bottom cloud heights, active convection index and meteorological distance of visibility.
- Vertical distribution of temperature, wind and relative humidity.
- Zones of possible icing.

4.3.4.2 Research performed in this field

The research aimed to develop and improve the physical-statistical forecasting methods for prediction of hazardous weather phenomena, including phenomena of convective nature for Far East and Eastern Siberia (abrupt wind speed intensification, squalls, intensive showers, very intensive precipitation).

Studies aimed to produce specialized forecasts (especially for meteorological aviation service).

4.3.5 Ensemble Prediction System (EPS) - None

4.4 Nowcasting and Very Short-range Forecasting Systems (0-12 hrs)

4.4.1 Nowcasting system

None

4.4.2 Very short-range modeling

The information is presented in 4.3

4.5 Specialized numerical predictions (sea waves, storm surge, sea ice, marine pollution transport and weathering, tropical cyclones, air pollution transport and dispersion of pollutants, solar ultraviolet (UV) radiation, air quality forecasting, smoke, sand and dust, etc.)

- Sea level forecasting model for the coastal line and offshore of the Sea of Okhotsk and the North part of the Sea of Japan.
- Forecasting of position and evolution of tropical cyclones by regional HWRF model for the Northwest part of the Pacific Ocean (helded in FERHRI, Vladivostok);
- Forecasting of wind sea waves (helded in FERHRI, Vladivostok).

4.5.1. Assimilation of specific data, analysis and initialization (where applicable)

The forecasting products of the hydrodynamic model MLs 22-50 and operative information from the observational network (flow rate, intensity of ice phenomena in the mouth of the Amur River) from the code forms Hydro and Sea are operatively assimilated.

The forecasting products of the 'Khab-15', operative information from the observational network (flow rate, intensity of ice phenomena in the mouth of the Amur River) from the code forms Hydro and Sea and operational satellite information of sea cover by JMA (Japan) are operatively assimilated.

4.5.1.2 Research performed in this field. – None

4.5.2 Specialized models

A) A non-linear non-stationary numerical hydrodynamic model for prediction sea level variations for the coastal line and offshore of the Sea of Okhotsk and North part of the Sea of Japan with assessment probability of exceeding of the critical marks in the coastal points is used with grid spacing of 7.5 km (nested domains of 2.5km grid spacing).

B) Forecasting of position and evolution of tropical cyclones by regional HWRF model for the North-west part of the Pacific Ocean by HWRF R27r9L43 model with grid spacing of 27 km (typhoon grid spacing of 9 km).

C) Forecasting of wind sea waves (heights of significant waves; average propagation direction, average length, mean period, height and direction of propagation of wind waves, height and direction of propagation of swell waves of three systems) by discrete spectral Wave Watch III (v. 4.06) model.

4.5.2.1 In operation

A) Sea level forecasts (up to 72 h) are reproduced to predict the hazardous marine phenomena for the coastal line and offshore of the Sea of Okhotsk and North part of the Sea of Japan with grid spacing of 7.5 km (nested domains of 2.5km grid spacing). Forecasts of hazardous weather phenomena (storm surge, sea swell, ice breaking, water entering solid mass of ice) for mouth of the Amur River are additionally produced. Calculations perform twice a day (00 and 12 UTC). Readiness time is 10 and 22 UTC.

B) Forecasting of position and evolution of tropical cyclones on the territories of North-west part of the Pacific Ocean and South-east part of Russian Far East by HWRF-R27r9L43 model with grid spacing of 27 km (typhoon grid spacing of 9 km). Calculations perform twice a day (00 and 12 UTC). Readiness time is 7 and 19 UTC.

Title	Version	Horizontal resolution (km)	Number of points, centered at	Area of integration	Time step	Lead time (hours)
HWRF-FERHRI-R27r9L43	WRF-NMM 3.3.1	27/9	216 x 216; Philippine Sea	10° S-60° N; 100°-180° E	54	72

The following parameterizations are used:

Title	Convection	Boundary and surface layers	Microphysics	Soil processes	Radiation (long-, and short wave)
HWRF-FERHRI-R27r9L43	Arakawa - Schubert scheme	Modified GFDL surface layer and a GFS PBL schemes	Ferrier-Aligoscheme	GFDL SLAB	GFDL longwave and shortwave scheme

Model 'HWRF- FERHRI- R27r9L43' uses information of GFS with grid spacing of 0.5° (NCEP, USA) and specialized text messages 'TCVITAL' (JTWC, Japan).

C) Forecasting of wind sea waves by Wave Watch III v. 4.06 model performs twice a day (00 and 12 UTC) with leading time of 5 days for the Pacific Ocean (grid spacing of 0.5°), Bering Sea (0.17°), Sea of Okhotsk and Sea of Japan (0.07°). Model used information about sea surface wind on 10 m from GFS with grid spacing of 0.5° (NCEP, USA).

4.5.2.2 Research performed in this field

A) Study to expand forecasting area of sea level model.

B) Study to improve quality of forecasting TC position and evolution.

C) Study to use spherical multiple-cell grid in a wind wave model.

4.5.3 Operational products of specialized prediction

A) Text messages with hourly information about sea level and its tidal and run-up components for seashore points of the Russian Far East and text messages about possibility of hazardous weather phenomena are available by e-mail (Primorsky, Kolyma, Kamchatka and Sakhalin UGMS) and via data exchange server (Far Eastern UGMS).

B) Forecasting production of 'HWRP-FERHRI-R27r9L43' includes maps, meteograms and text messages:

- PMSL and accumulated amount of precipitation detailed each 3 hours;
- Cloud distribution and precipitation detailed each 3 hours;
- Geopotential fields, temperature, wind speed and direction at standard isobaric surfaces (1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100 hPa) detailed each 3 hours.
- Total precipitation forecasts for partial basins of Amur River (tables).
- Meteograms includes hourly forecasts of PSFC, wind maximum, average and maximum precipitation amount, wind speed and its direction in the location of TC with leading time of 72 hours.
- Text messages about position and intensity of TC in Northwest part of the Pacific Ocean each 3 hours.

Production is available on ferhri.org and via data exchange server (Primorsky UGMS).

C) Forecasting of wind sea waves model (heights and propagation direction of significant waves) with time step of 6 hours are available on ferhri.org.

4.6. Extended range forecasts (10 to 30 days)

4.6.1 In operation

The forecasting of the weather parameters (surface air temperature, wind speed, precipitation occurrence and amount) with one month lead time are produced for the points of Primorskiy and Khabarovsk territories with one-day detailed elaboration. The forecasts are produced on the basis of the analogous year.

4.6.2 Research performed in this field–None

4.6.3 Operationally available ensemble prediction systems products (10-30 days)

Forecasts in the points of the Russian Far East.

4.7 Long-range forecasts (30 days - 2 years) (Models, Ensembles, Methodology)

The forecasts with the 6-month lead time are produced based on the analogous year conditions and forecasts received from the Far East Research Hydrometeorological Institute. Monthly average surface air temperature, temperature anomalies and monthly average accumulated precipitation are predicted.

5. Verification of prognostic products

5.1 Review of mean annual results

Assessment of forecasts of air temperature at 2 m and wind at 10 m produced in 2017 against observations							
<i>MLs 22-50 model</i>							
Lead time (hours)	Temperature at 2 m			Wind at 10 m			
	PH	ME	ABS	ME_V	MSE_V	ABS	ME
12	56	1,1	3,3	12,0	15,4	6,4	3,4
24	50	-0,1	3,4	11,5	12,3	6,3	4,3
36	53	1,2	3,4	12,4	15,5	6,8	5,7
48	50	0,4	3,3	11,1	12,1	6,2	5,8
<i>WRF-ARW model, version 'Khab-15'</i>							
Lead time (hours)	Temperature at 2 m			Wind at 10 m			
	PH	ME	ABS	ME_V	MSE_V	ABS	ME
12	64	-1,1	3,0	2,7	3,7	1,9	1,1
24	63	-0,1	3,2	3,0	4,0	2,0	1,3
36	59	-1,3	3,4	3,0	4,0	2,1	1,4
48	58	-0,4	3,5	3,2	4,3	2,2	1,4
60	54	-1,5	3,8	4,3	4,2	2,2	1,4
72	55	-0,6	3,8	3,5	4,6	2,3	1,5

Abbreviations:

PH – forecast accuracy (as per RosHydromet guidelines) (%),

ME – mean error (degrees for temperature, m/s for wind),

ABS – absolute error (degrees for temperature, m/s for wind).

ME_V – absolute error of wind vector forecast (m/s),

MSE_V – wind vector root-mean-square error (m/s).

5.2 Research performed in this field - None

6. Plans for the future (2018– 2020)

6.1. Development of the GDPFS

6.1.1. *Major changes in the operational DPFS expected in 2018*

- Operational trials of the forecasts (with a lead time of 9-30 hours) of surface wind on 10 m for metrological aviation service on the airports of Eastern Siberia and Russian Far East under the guidance of Federal Aviation Rules No. 60 based on output production of regional WRF-ARW model with grid spacing of 15 km.

6.1.2. *Major changes in the operational DPFS expected in 2018-2020*

- Short-term numerical prediction system for aviation meteorological service based on WRF model.
- Operational short-term numerical prediction system with grid spacing of 3-5 km.

- Data assimilation technology (surface observation of radiation fluxes, temperature, humidity) for WRF model to improve quality of surface temperature forecasting.

6.2. Planned Research Activities in NWP, Nowcasting and Long-range Forecasting and Specialized Numerical Prediction

6.2.1. Planned Research Activities in NWP

- Development of the model WRF-ARW configuration for detailed numerical weather forecasts and hazardous weather phenomena for the Russian Far East and Eastern Siberia.
- Development of methods and technology of meteorological elements and weather phenomena forecasting, as well as other numerical characteristics of atmospheric conditions within the regional hydrodynamic model framework.
- Refinement of coastal line and surface properties (surface temperature and albedo) for the territory of Eastern Siberia and Far East is planned to improve quality of short-time numerical weather prediction of WRF-ARW model.

6.2.2 Planned Research Activities in Nowcasting – not planned.

6.2.3 Planned Research Activities in Long-range Forecasting

Modernization and development of physical-statistical and analogous methods of long-range (from 1 month to 2 years) forecasting of the monthly average values of meteorological parameters and their anomalies.

6.2.4 Planned Research Activities in Specialized Forecasting

- Development and improvement of the numerical hydrodynamic model of the tropical cyclone evolution.
- Development and improvement of the forecasting model to predict sea level at the coastal line and offshore of Far Eastern seas.
- Development and improvement of technology for aviation meteorological service.

7. References

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