Long-term weather predictability: Ural case study

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The accuracy of the state-of-the-art long-term meteorological forecast (at the seasonal level) is still low. Here it is presented approach (RAMES method) realizing different forecasting methodology. It provides prediction horizon of up to 19-22 years under equal probabilities of determination of parameters in every analyzed period [1].

RAMES is a Russian abbreviation of Calculation of Meteorological Situations.

Key points

1. Significant extension of long-term prediction horizon could be obtained only by the **revealing** and using **a periodicity** of meteorological situations **at one point of observation**.

2. **Conventional calendar is unsuitable for** generalization of meteorological data and **revealing of cyclicity of meteorological processes**. RAMES method uses natural time intervals: one day, synodic month and one year. It was developed a set of special calendars using these natural periods and the Metonic cycle.

3. Long-term time series of meteorological data is **not a uniform universal set**, it is a sequence of 28 universal sets appropriately superseding each other in time. This is an integral picture of relatively similar, coherent but autonomous meteorological (natural) processes.

Method specifics:

1. Usage of the original research toolkit consisting of

- a set of calendars based on the Metonic cycle;
- a set of charts (coordinate systems) for the construction of sequence diagrams of

daily variability of a meteorological parameter during the analyzed year;

daily variability of a meteorological parameter using long-term dynamical time series of periods-analogues;

monthly and yearly variability of accumulated value of meteorological parameter.

Application of RAMES calendars allow to **split the long-term series of meteorological data** to **uniform** (according to the specific criteria) sample sets. Values of set parameters form the **dynamic series**. Comparing of dynamic series allow to reveal two their simple but very important features:

- Similarity between series. Let's note, that similarity isn't defined by the parameter values, but is defined by the gradients of series variability;

- Dynamic series have different series terms..

2. Identification and usage of new virtual meteorological objects having several degrees of generalization appropriately located in the used coordinate systems

It is used several "virtual" meteorological objects having different degree of generalization:

- Flow of periods of meteorological processes;

- Empirically revealed trajectory of period flow;

- Axes of extreme values of meteorological parameters;

- Integral meteorological process.

3.Investigation of non-ordinary meteorological objects by the casual methods:

– Revealing of dynamic series of calculation periods using the single decision rule;

– Revealing of variability of parameter value in the dynamic series of preceding periods using graphical or computational method followed by the calculation of expected parameter value in the analyzed time interval using extrapolation and interpolation.

Source data

- Mean daily temperature data of Chelyabinsk-City weather station for the timeframe longer than 110 years.
- Conventional meteorological parameters daily data of Chelyabinsk-City weather station for the timeframe longer than 40 years.
- Own meteorological observation data at the "Height-300" site for more than 8 years.

General results

For Ural region RAMES method allowed to reveal the periodicity of

– air temperature (min, max, daily mean, diurnal variation, last spring and first autumn freeze);

– atmospheric pressure;

– relative humidity;

– precipitation periods and amount of precipitations;

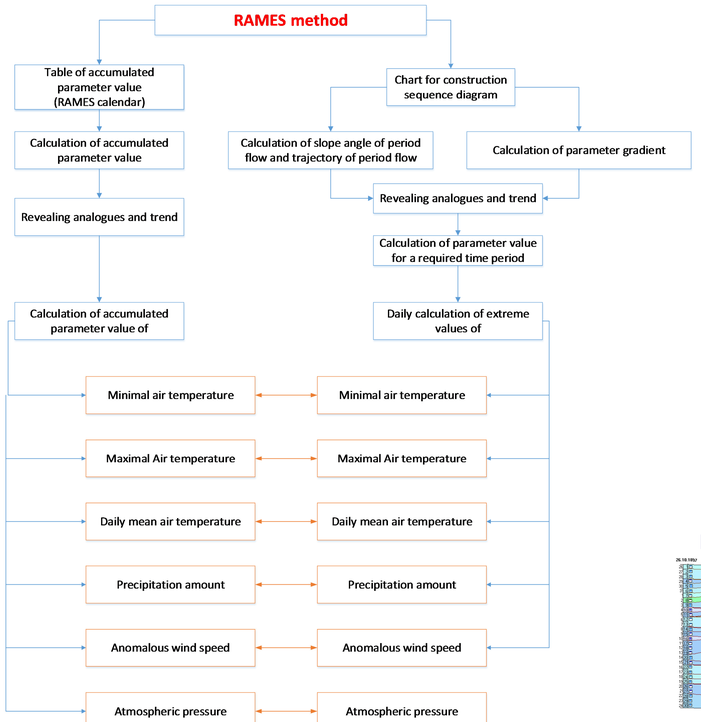
– periods of winds with speeds of >5m/s and the maximal expected wind speed.

Atmospheric events (thunderstorms, fog) and hydrometeors also occupy the appropriate positions at the sequence diagrams that provides a possibility of long-term forecasting also for these events.

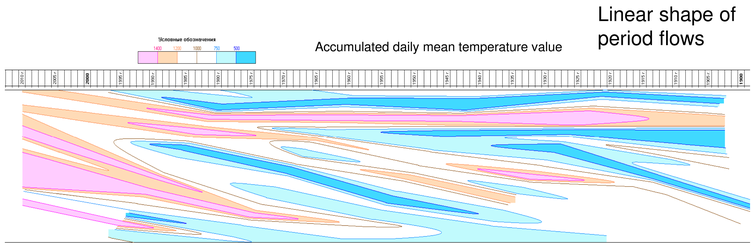
References

1. A.F. Kubyshen, "RAMES method: revealing the periodicity of meteorological processes and its usage for long-term forecast [Metodika «RAMES»: vyjavlenie periodichnosti meteorologicheskih processov i ee ispol'zovanie dlja dolgosrochnogo prognozirovanija]", in A.E. Fedorov (ed.), Sistema «Planeta Zemlja»: 200 let so dnja rozhdenija Izmaila Ivanovicha Sreznevskogo. 100 let so dnja izdanija ego slovarja drevnerusskogo jazyka LENAND. Moscow. pp. 305-311. (In Russian)

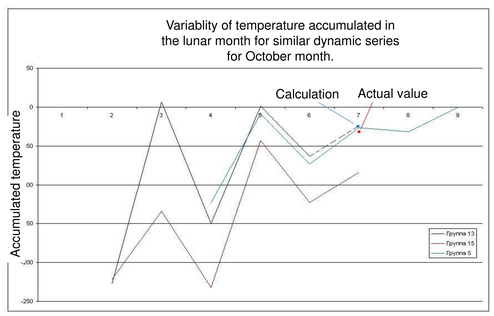
RAMES calculation scheme



Century-long sequence diagram of daily mean temperature



Calculation of monthly accumulated valued

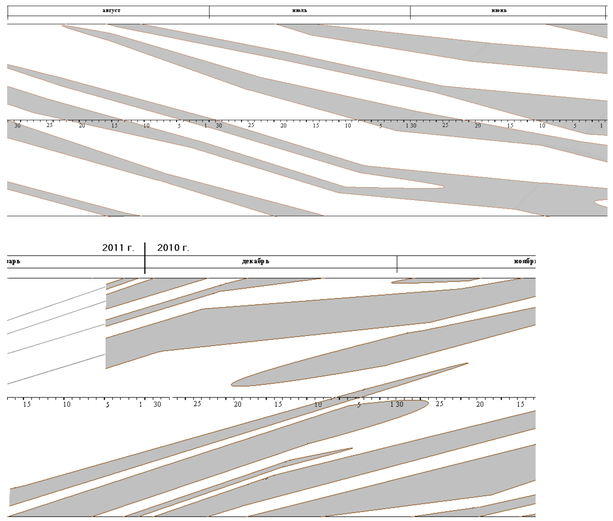


Dynamic series for each analyzed month are formed using RAMES calendar.

Each dynamic series parameter value is shown on graph. Analogues are revealed analyzing the shapes of dynamic series graphs.

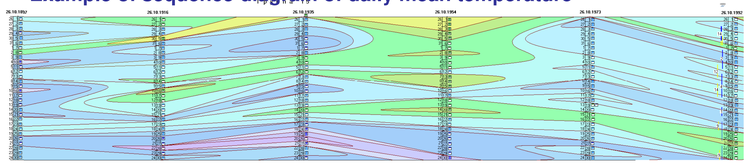
At graph above, there is a prediction for 2009 year, calculated using the data of up to 1990 – **19 years forestalling.**

Revealing monthly periodicity of meteorological processes

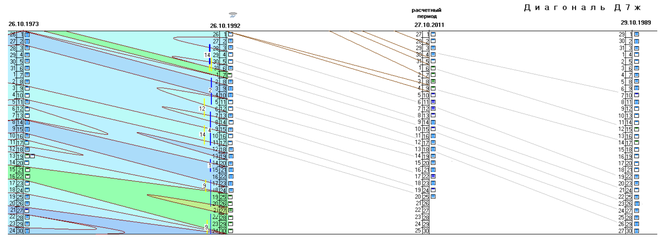


Wind speed (>5 m/s) sequence Gray areas are period flows that are grouping of time periods when meteorological parameter corresponds to the defined criteria.
It is possible to predict period flow using extrapolation for up to 70 days ahead.

Example of sequence diagram of daily mean temperature



Extrapolation of sequence diagram



Successful prediction examples:

- In 2012 winter, it was predicted than summer temperature will be significantly higher than the long-term average.

-In 2013 winter, heavy rains at the end of July-beginning if August were predicted. Heavy precipitation started on a day after the predicted date.

-- Prediction of thaw's in November of 2015 (which are very unusual for Ural region in that time) published in regional journal in September. At that, these thaws contradicted the Russian Meteorological Agency official prediction.

- Accuracy of predicted monthly mean temperature was verified during 2006-2009 years. The difference between the forecasted monthly mean temperature and actual values was <0.5ºC in 40.9% of cases, between 0.5ºC and 1ºC in 18.2% of cases, between 1ºC and 1.5ºC in 18.2% of cases, <2ºC in 86% of cases.

Conclusions

1. RAMES methods is an instrument for successful long-term weather prediction with forestalling of several years.

2. Predicted results for air temperature and precipitation for the timeframe of 2011-2030 years for Chelyabinsk region were calculated in 2010 year and they are presented at website http://rameslab.ru/

3. Prediction experience obtained at the South Ural can be extended to other regions of the world.

4. Modelling of global meteorological process for the years ahead under equal probability of parameters determination can be done using the "from the particular to the general approach" by the generalization of results from different observation sites.