The Technology of long-term Forecasting of Water Inflow into Reservoirs using a Multi-parameter Neural Network

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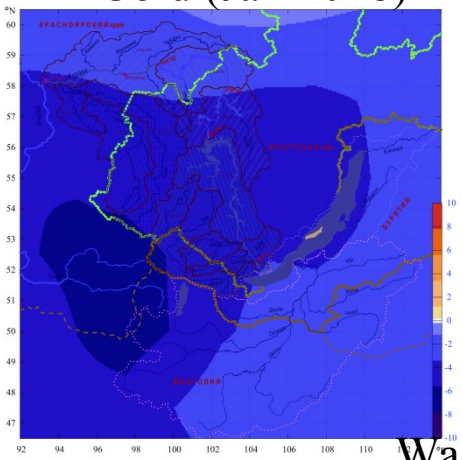
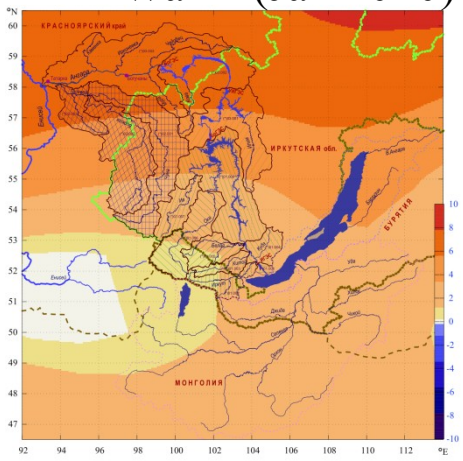
The importance of water and temperature regimes for the efficient functioning of the energy sector

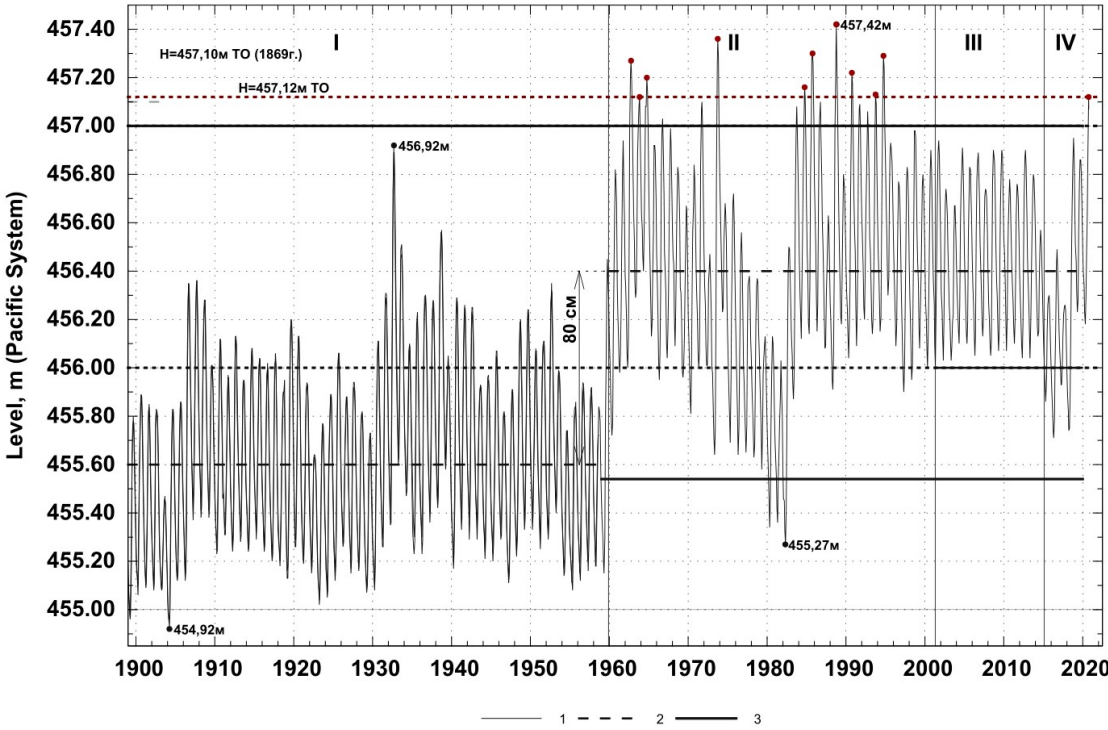
Anomaly of winter temperatures

Cold (Jan 2018)



Warm (Jan 2020)





Baikal: Low and High water inflow

Methodology and information support of researches

Evolutionary Development of Research (1960-2020)

I. Drujinin

-spatio-temporal patterns

- Integral-difference curves

- probabilistic methods

-cosmic factors

A.Reznikov

-approximate learning methods

-machine learning

GIPSAR -predictive system

GeoGIPSAR.Hybrid information-analytical system, including databases and knowledge bases for the research into the reservoir regulation conditions of HPP and HPP cascades (collection, analysis, monitoring and systematization of data of **hydro-meteorological observations** of the main river basins, lateral inflows to the reservoirs, **data of global climatic models**, requirements of water users, consumers and other data).

Information-analytical system for analysis, modeling and forecasting, GeoGIPSAR

Вейвлет-анализ
- вейвлетограммы (Mhat,Morle…)
- спектральные характеристики
- кросс-когерентный анализ
- дискретный

Анализ временных рядов
- Сглаживающие фильтры
- Экстремальные огибающие (Huang)
- Интегрально-разностные
- аттракторы

Интернет-мониторинг
- информационные ресурсы
- методика мониторинга
- поддержка целостности
- верификация данных

Формирование выборок данных
- пространственные
- временные
- агрегирование
- индексы

Анализ геоклиматических данных
- агрегирование, осреднение
- методы визуализации
- распределения показателей(EOF)
- поля скоростей

Декомпозиция
- пространственная: притоки, бассейны
- временная: год квартал месяц

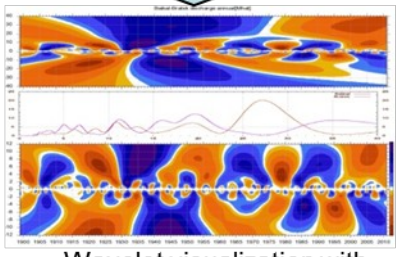
Расчет гидро-энергетического потенциала
- анализ динамики
- прогноз динамики
- верификация

GeoGIPSAR

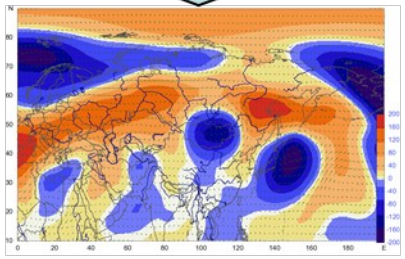
ГеоГИПСАР

Прогнозирование
- качественные
- вероятностные
- обучающиеся
- экспериментальные

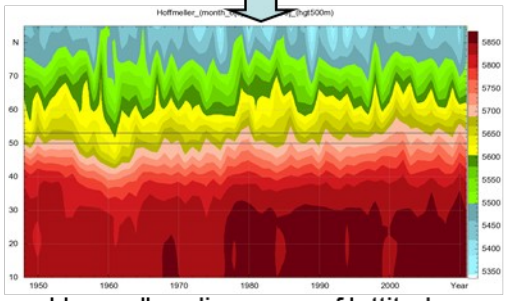
Поиск предикторов
- гидрологические
- метеорологические
- астрофизические
- индексы



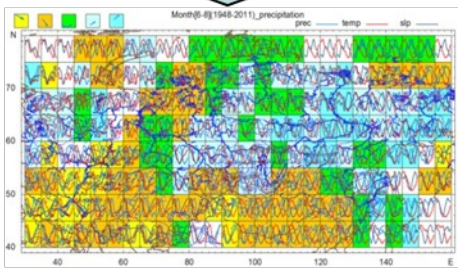
Wavelet visualization with spectral characteristics of annual inflows to Lake Baikal and Bratsk reservoir



Extreme anomalies of pressure and fields of velocities in the Lake Baikal basin (may 2012)

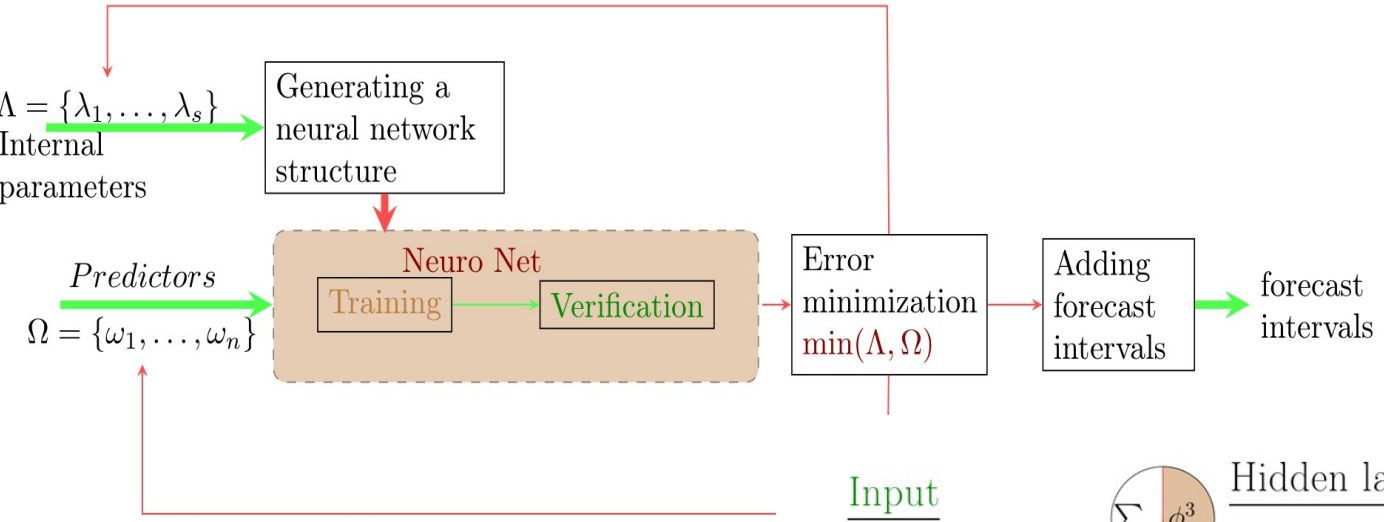


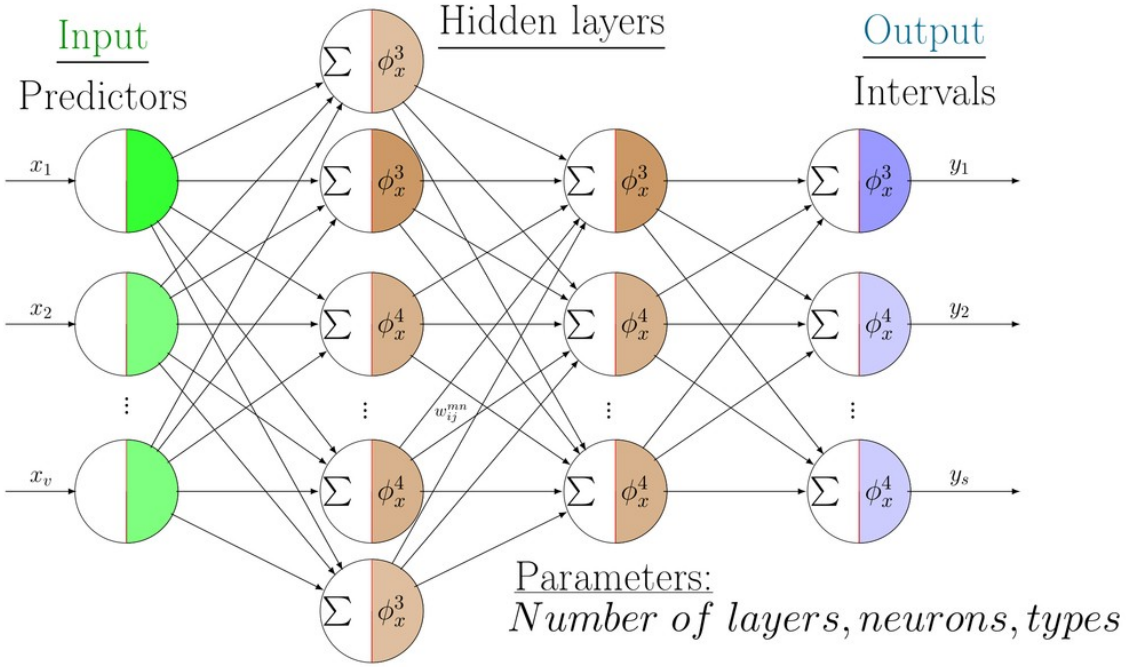
Hovmoller diagrams of lattitude - temporal section of geopotential (500 Gpa) for longitudes (100-105°)



Integral-difference curves for the analysis of spatial-temporal regularities

Basics of the Multi-parameter Neural Network (MNN)

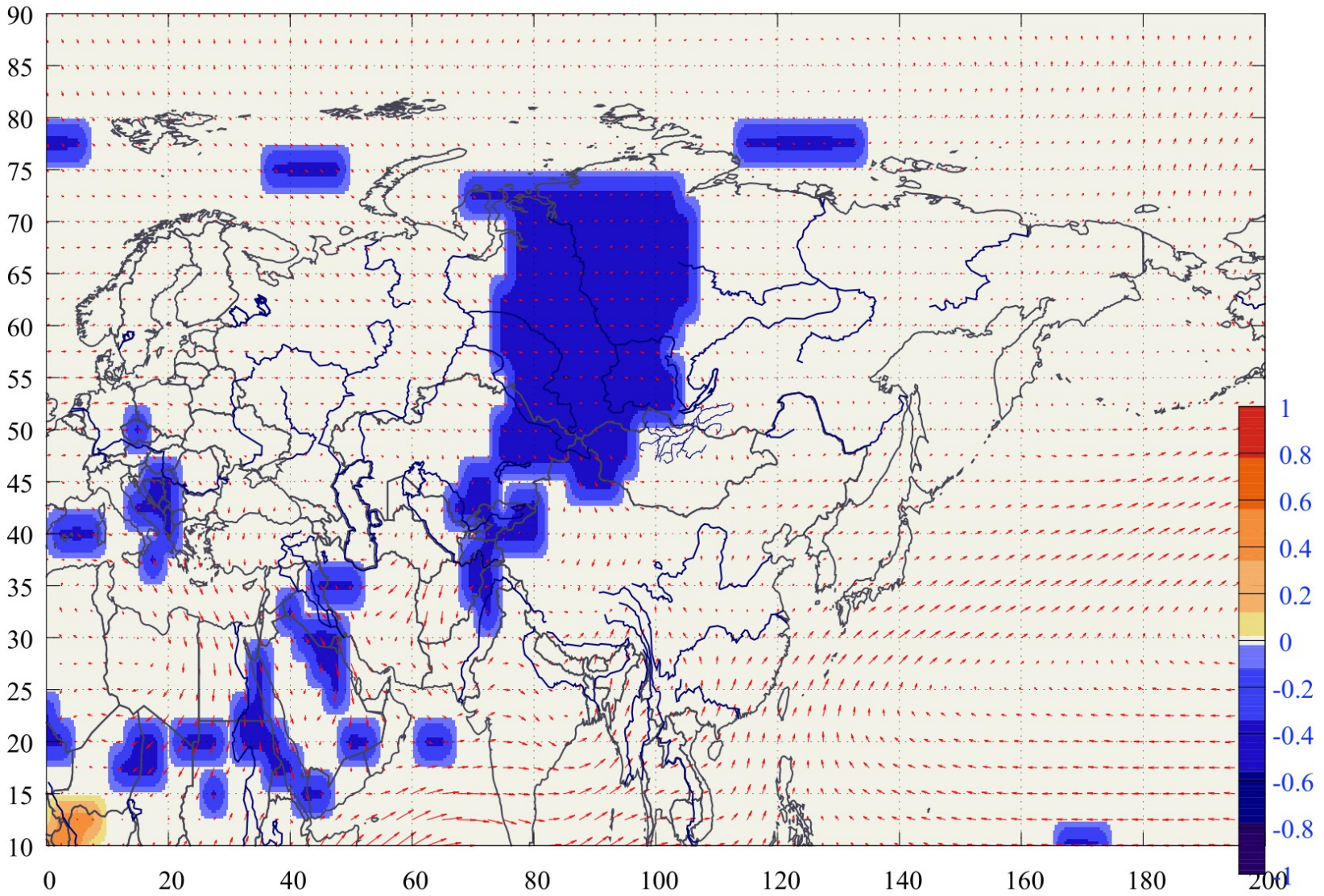




Methods of Forecasting

1. Prepare a temporary Set of the Inflow
2. Replace numeric Numbers to intervals Numbers
3. Create a Set of potential Predictors
4. Develop the Structure of the Neural Network
5. Set Training and Verification Data Samples
6. Complete the model setting
7. To train
8. To verify
9. Prediction for one interval (year, month)
10. Formation of the model forecasting report

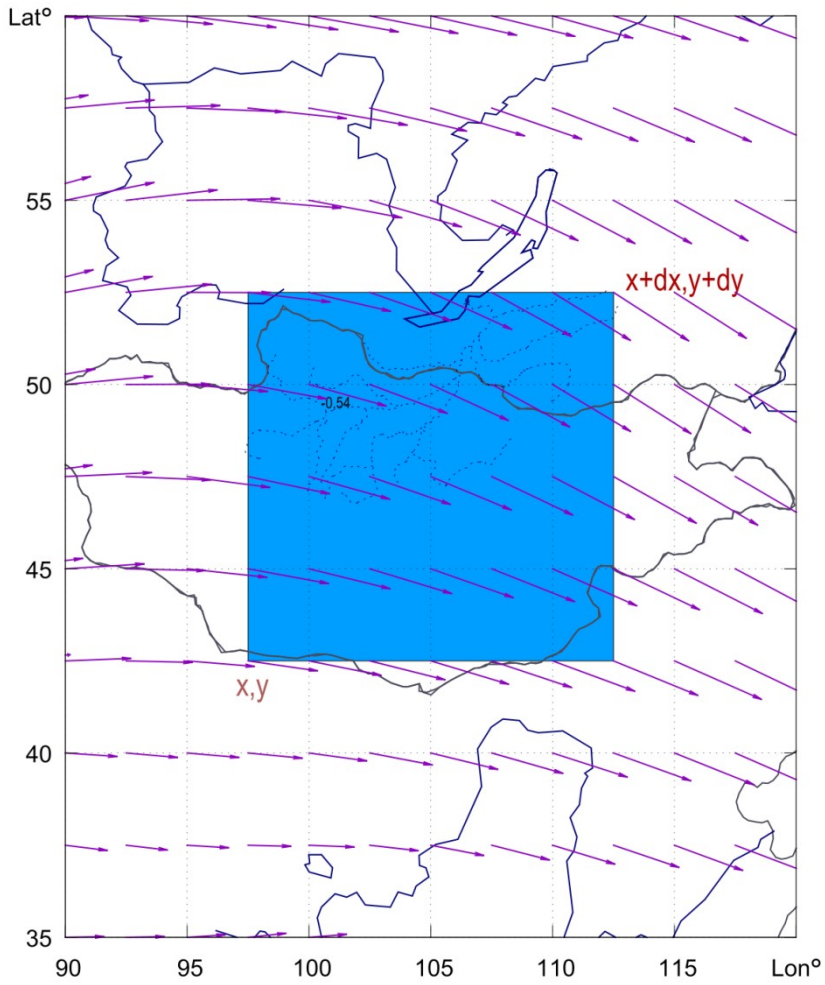
An example of correlation between the inflow of water and temperature fields with a delay 1 quarter



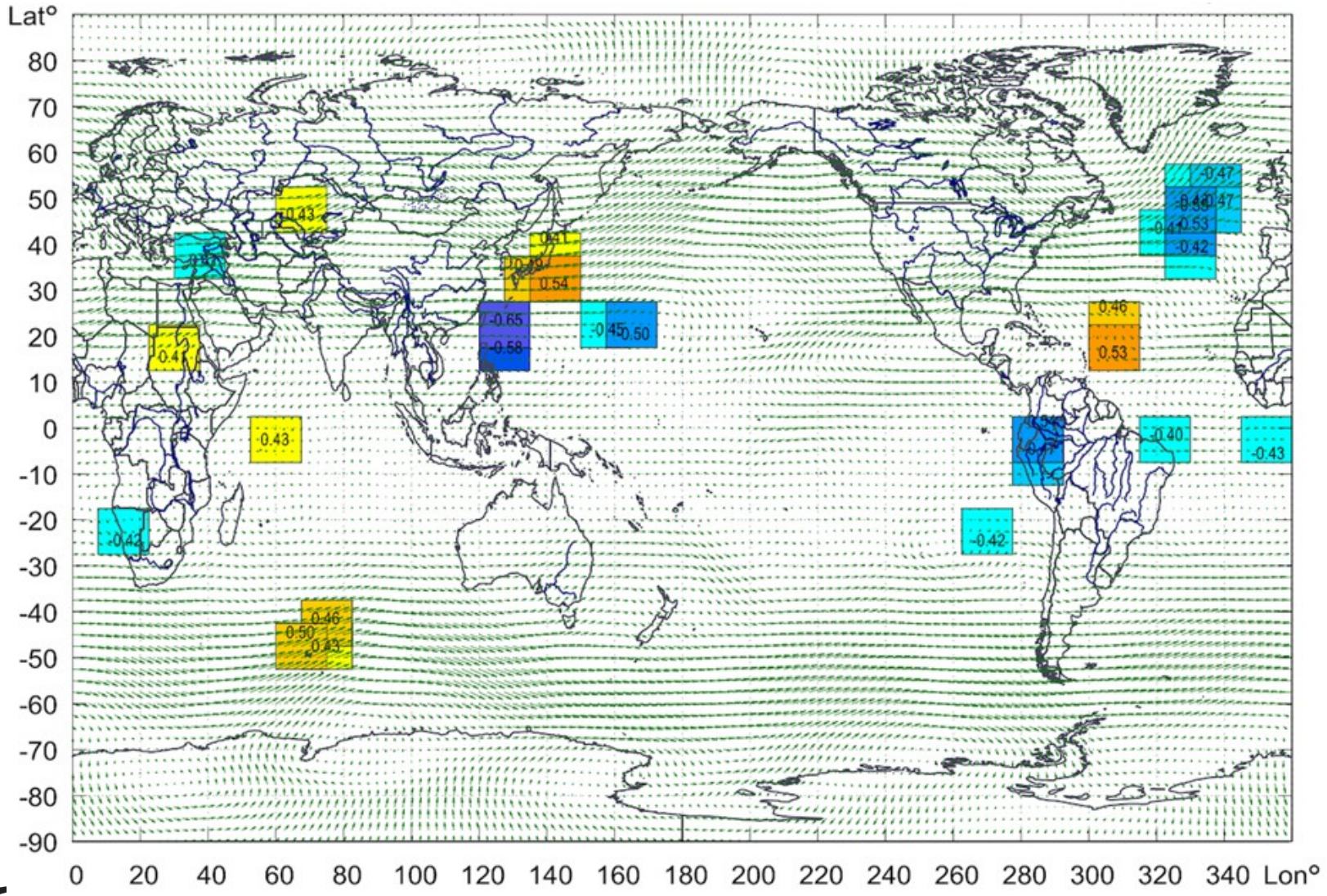
The Vertex Area Index

$$\lambda(B,t,\tau,x\ ,y\ ,dx,dy)=\frac{1}{N}\sum_{(i,j)}\left(\frac{\partial V}{\partial x}-\frac{\partial U}{\partial y}\right)_{ij},\quad i=\overline{x\ ,x\ +dx},\ j=\overline{y\ ,y\ +dy},$$

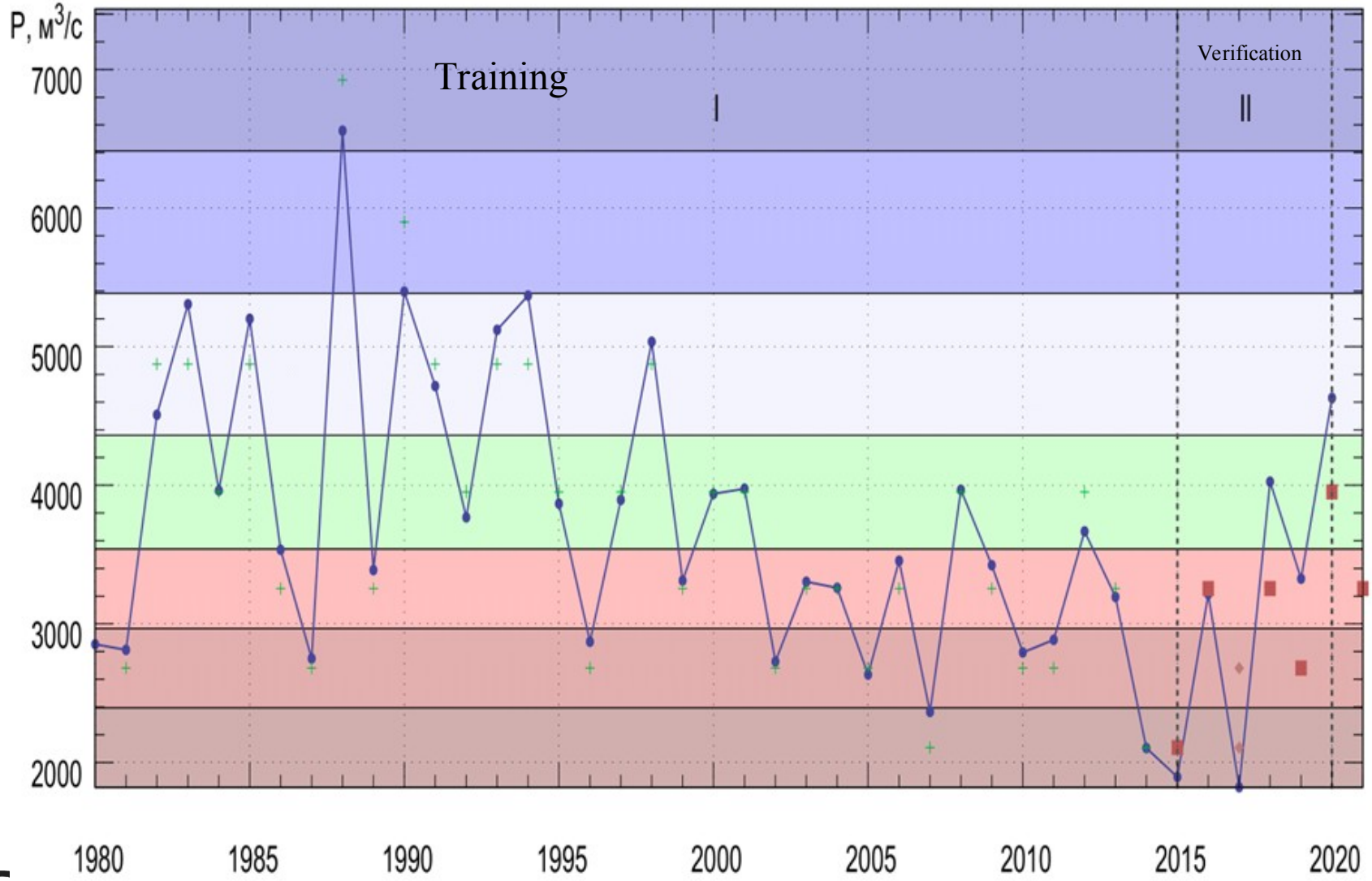
U,V - speed components
of the atmospheric flow
N – number of cells



The Vertex Area Index(example)



Graphical Interface (Water inflow in Lake Baikal for the third quarter)



Software (portable)

1 Basic API functions (C/C++)

- neuro.init() – MNS - initialization

- neuro.train() – MNS - training

- neuro.verif() - verification

- neuro.forecast()

2 LuaMESI (Lua + MESI libraries)

- Control scripts

- Graphical interface

- Portable software (<1Mb)

- data analysis

- modeling

3 Technologies for the creation and development of software systems

THANK YOU FOR YOUR ATTENTION