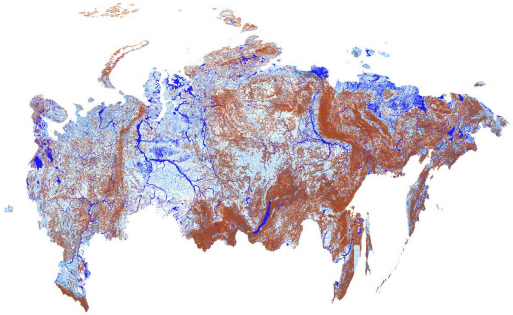
Melentiev Energy Systems Institute, SB RAS

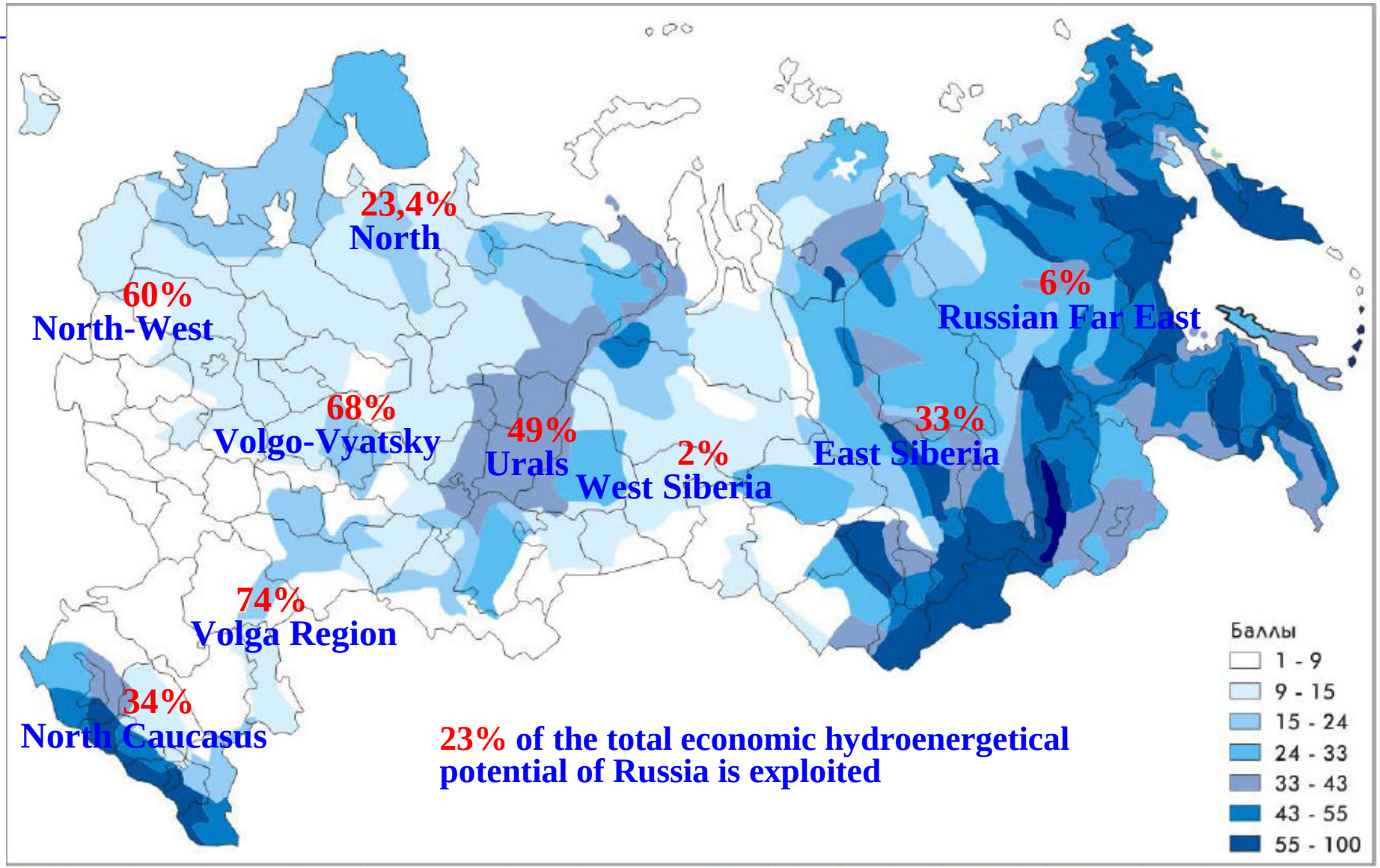


GeoGIPSAR – A SYSTEM INTENDED FOR LONG-TERM FORECASTING AND ANALYSIS OF NATURAL-CLIMATIC FACTORS IN ENERGETICS

N.V. Abasov

Enviromis-2012

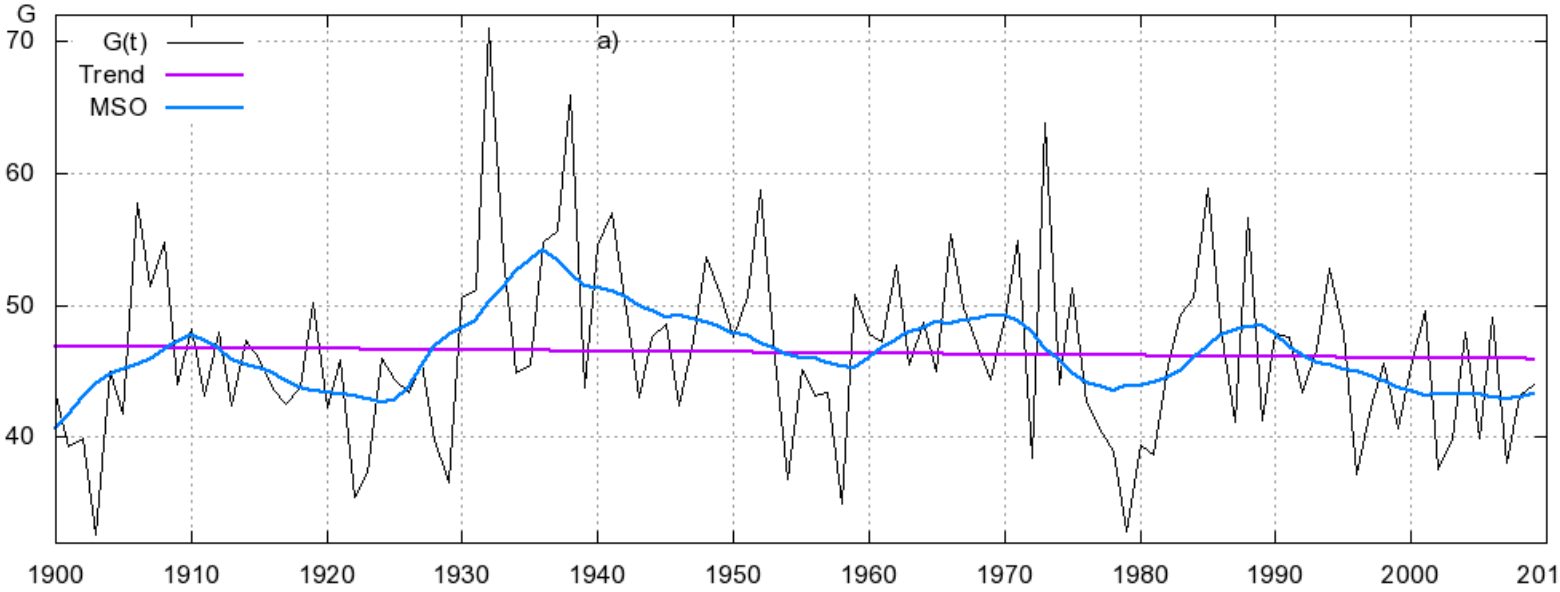
Hydro-energetic resources of Russia.
The level of the hydroenergetic potential exploited

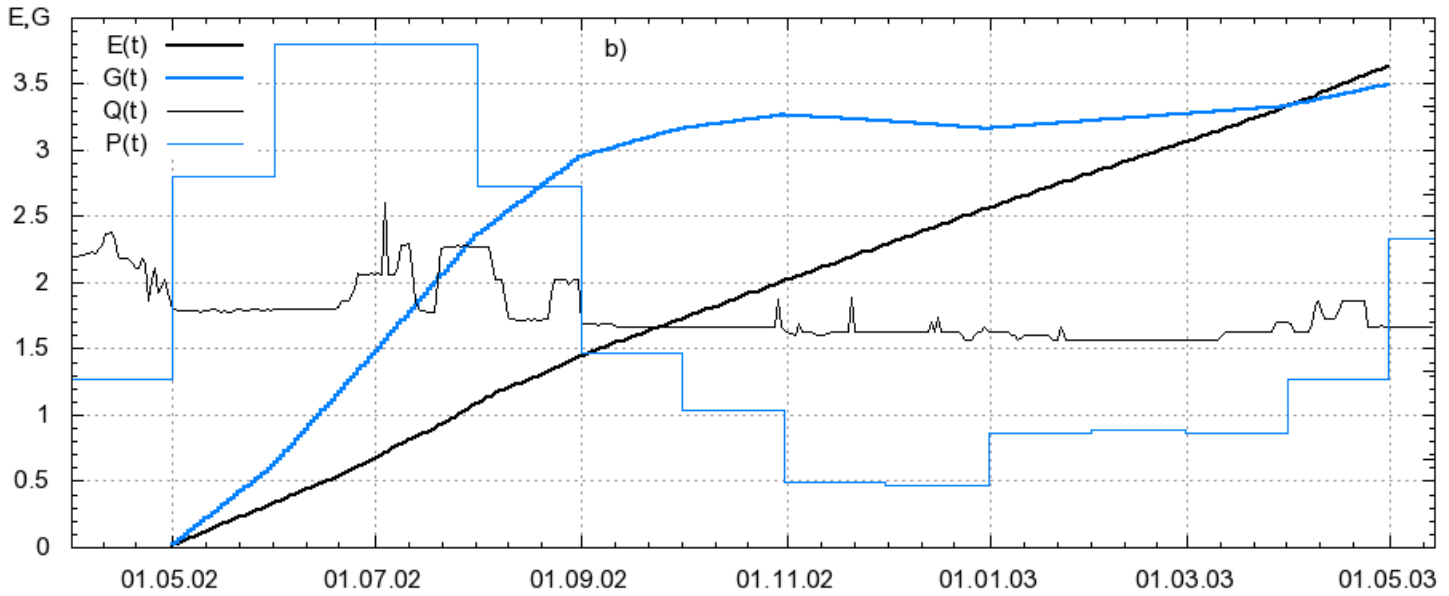


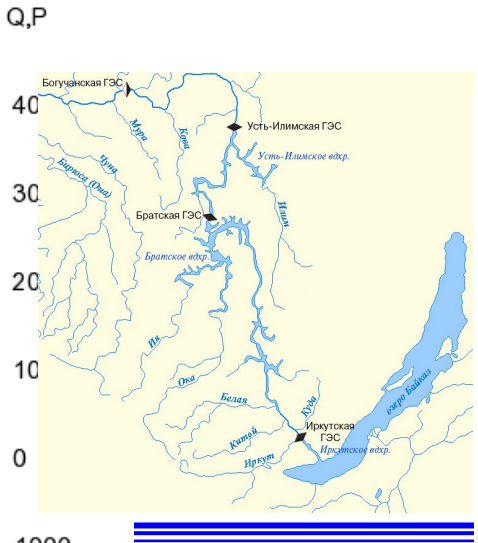
1-9 баллов – территории с наименьшими гидроэнергетическими ресурсами; 55-100 баллов – территории с наибольшими ресурсами.

IEA-2004.

Hydro-energetic potential of the Anagara cascade HPPs (annual and monthly variability)







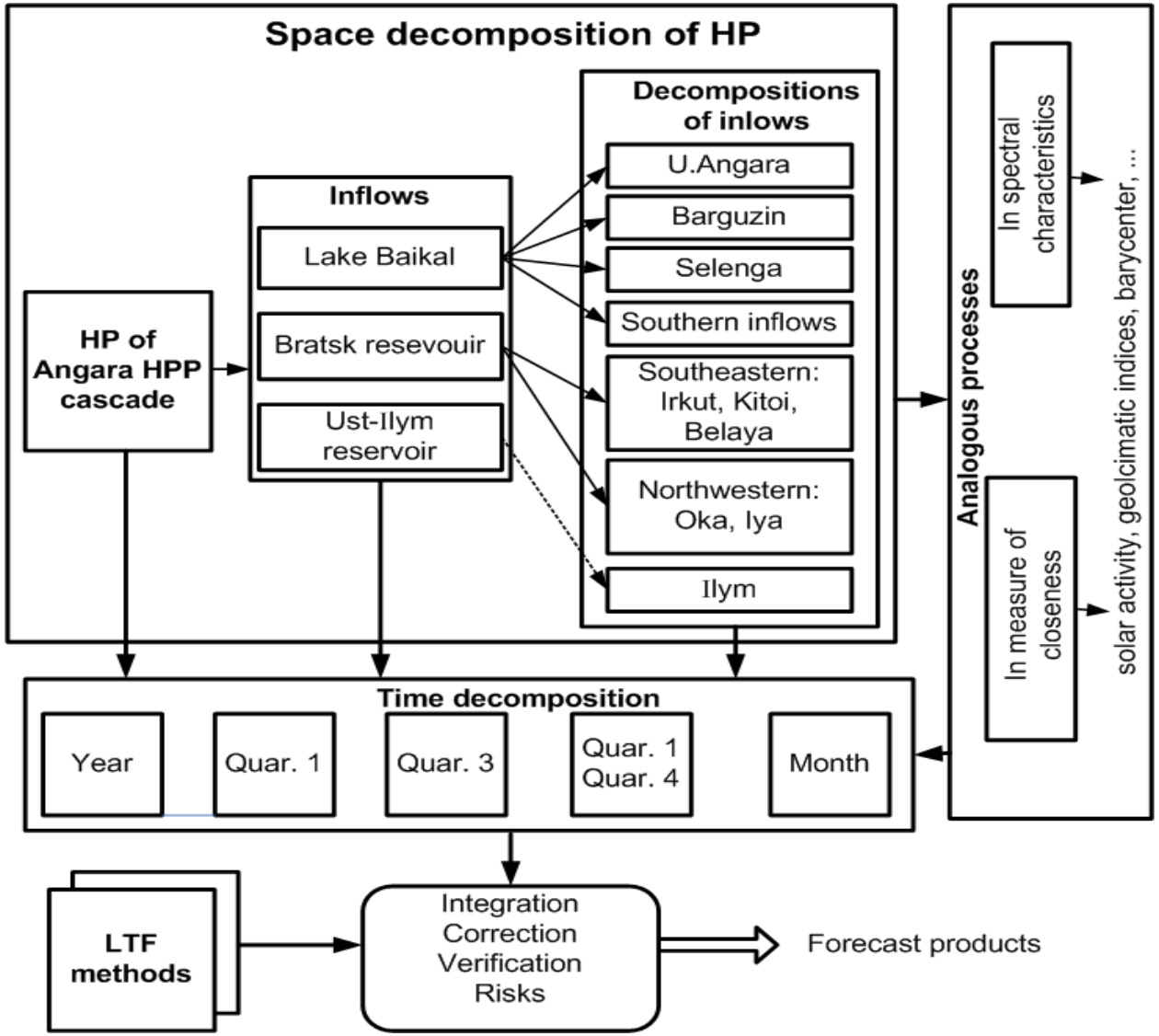
Stages in development of the technology of long-term forecasting in Melentiev Energy Systems Institute, SB of RAS (generations)

- **Generation one** (1960–1994)
  Technique of Forecastiong (***I.P.Druzhynin***, A.*P. Reznikov, T.V.Berejnykh*) space-time regularities + approximation (neural network) techniques.
  (Programming technology → *Fortran)*.

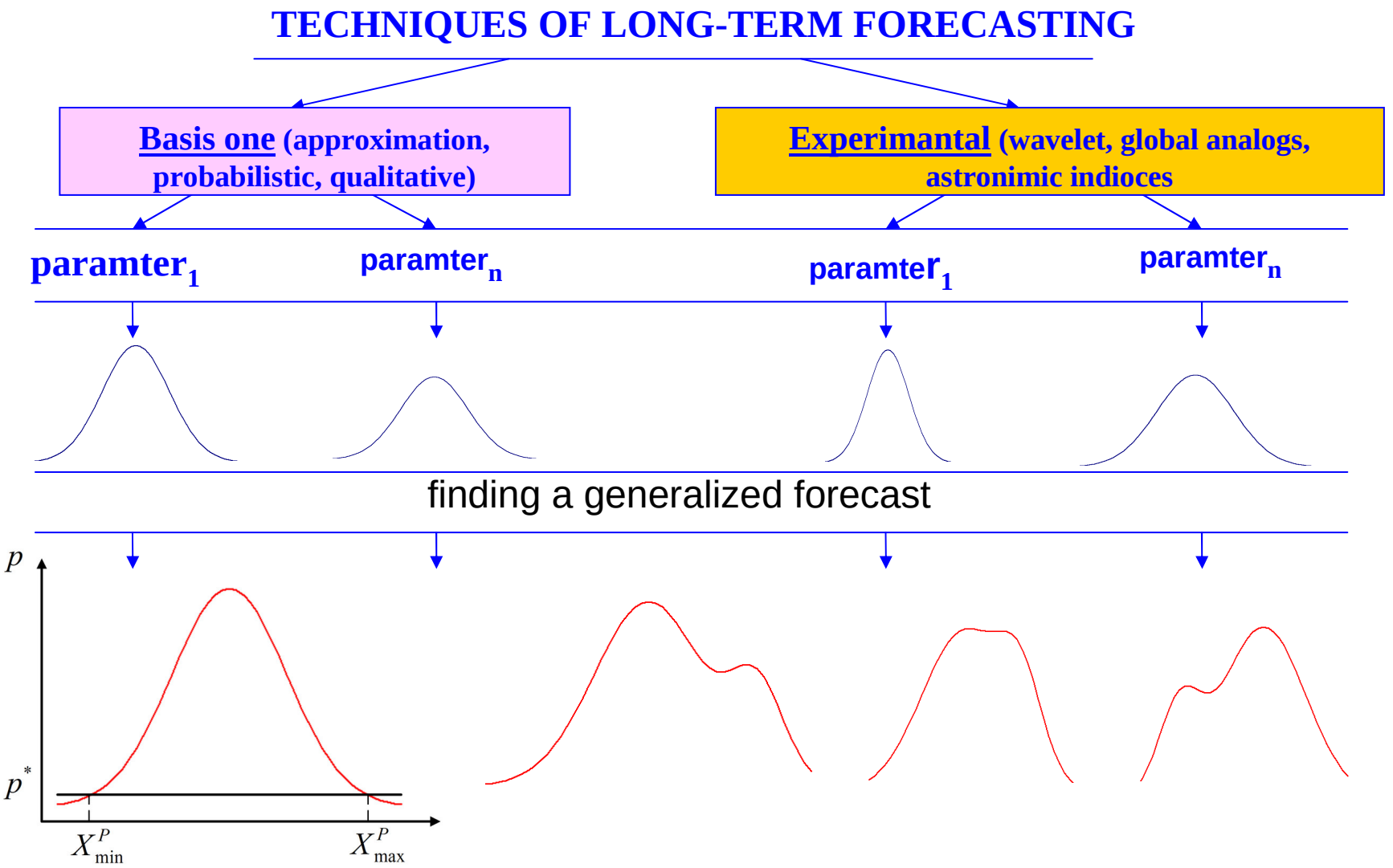
- **Generation two** (1995–2004) – an information-forecasting system GIPSAR → complex automation of the process of forecasting: *data preparation*; *choosing the forecasting technique; verifications; finding a generalized forecast; analysis (**A.P. Reznikov**, T.V.Berejnykh*).
  Programming technology → a universal programming environment *ZIRUS(N.Abasov)*.

- **Generation three** (2005-2012) → a sharp increase of the volume of the information component employed in forecasting, which is gained at the expense of:
  satellite monitoring;
  global climate change*;*
  application of geoinformation technologies (GeoGIPSAR)
  (***T.V. Berejnykh**, E. Osipchuk, O. Marchenko*)

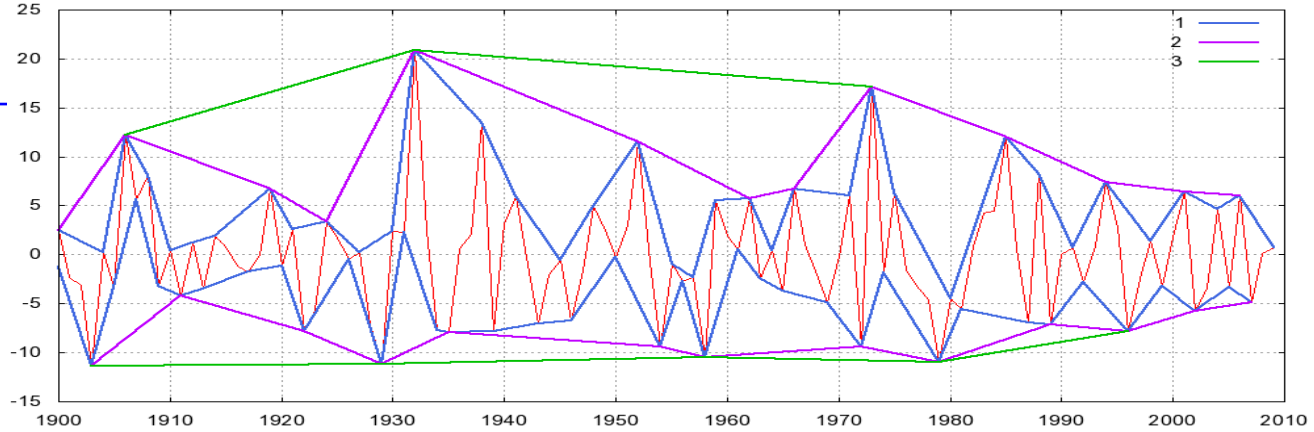
Space-time decomposition of the hydropower potential model (Angara cascade of HPPs)

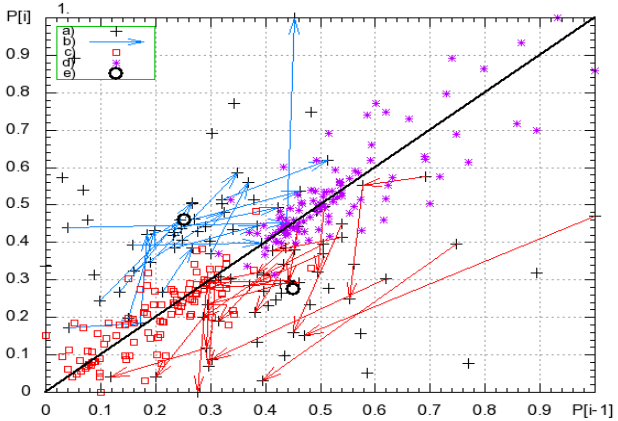


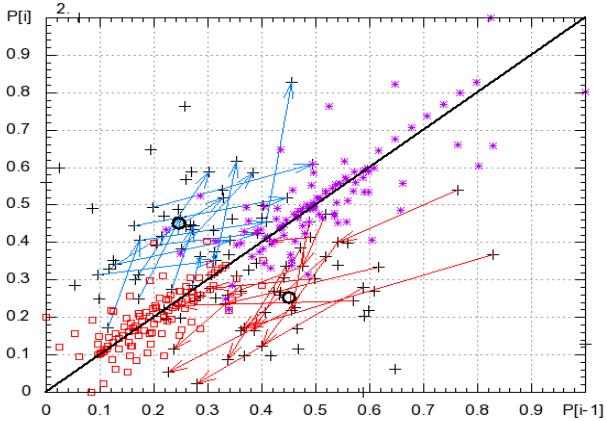
Output data of the information-forecasting system GIPSAR

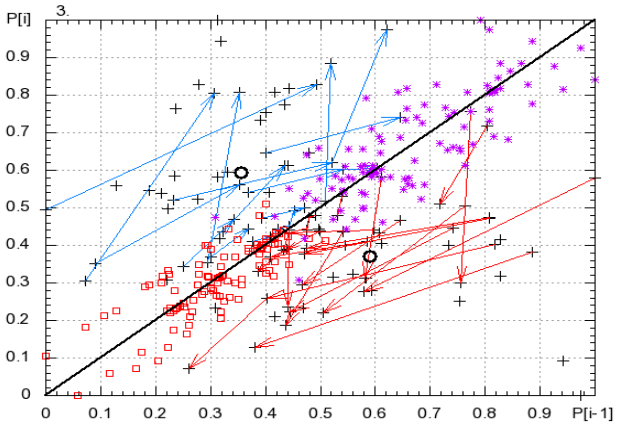


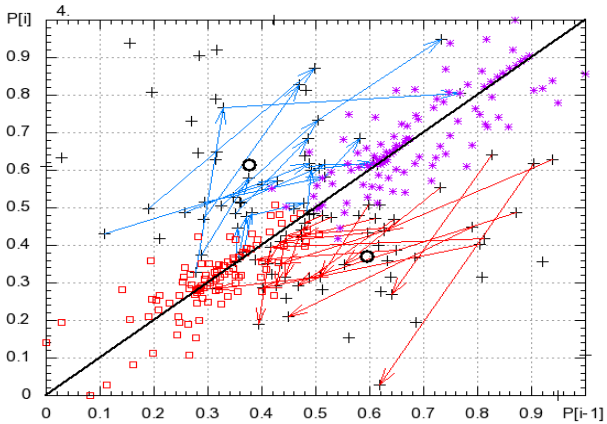
Local extremes and Investigation of the attractors





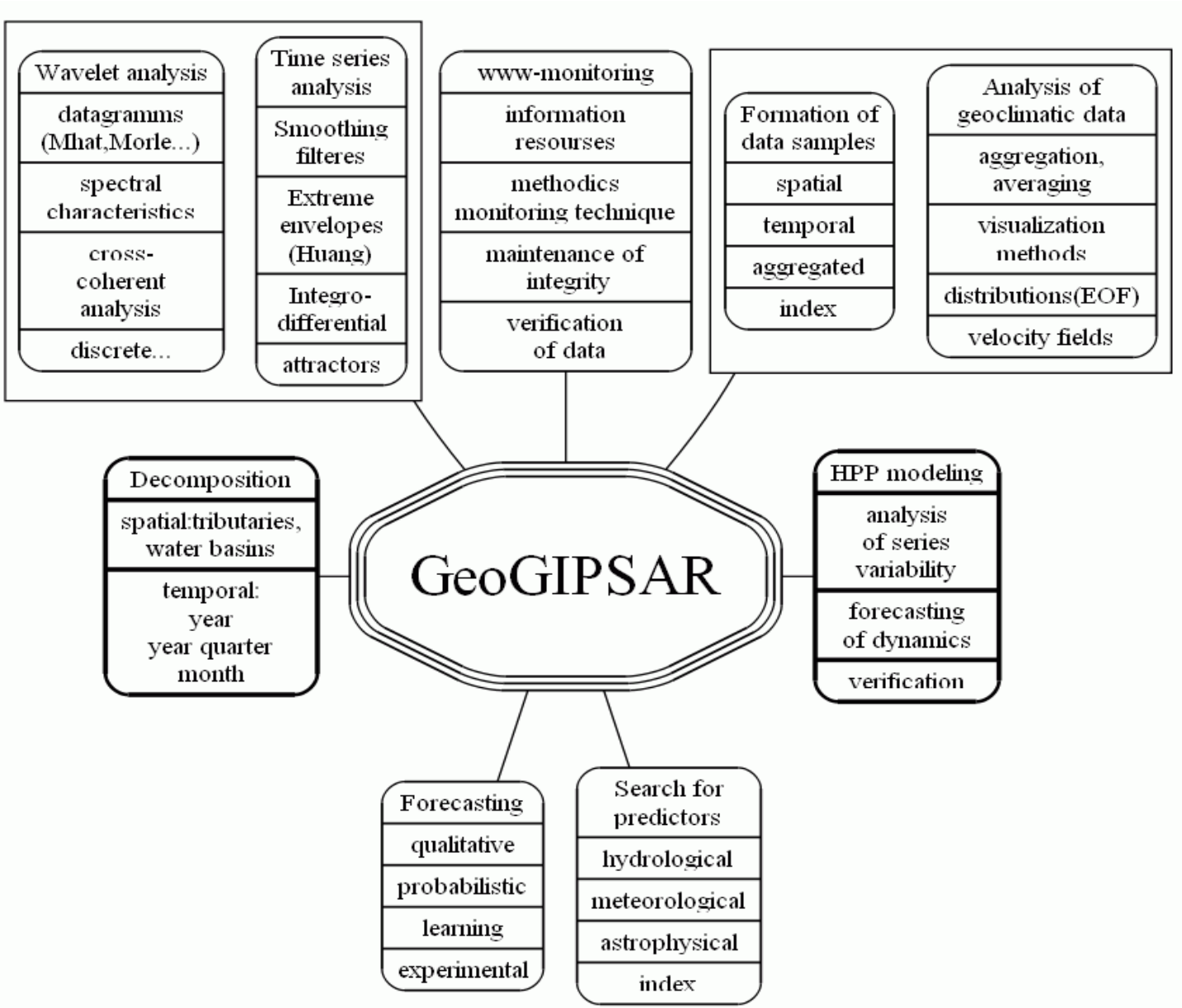




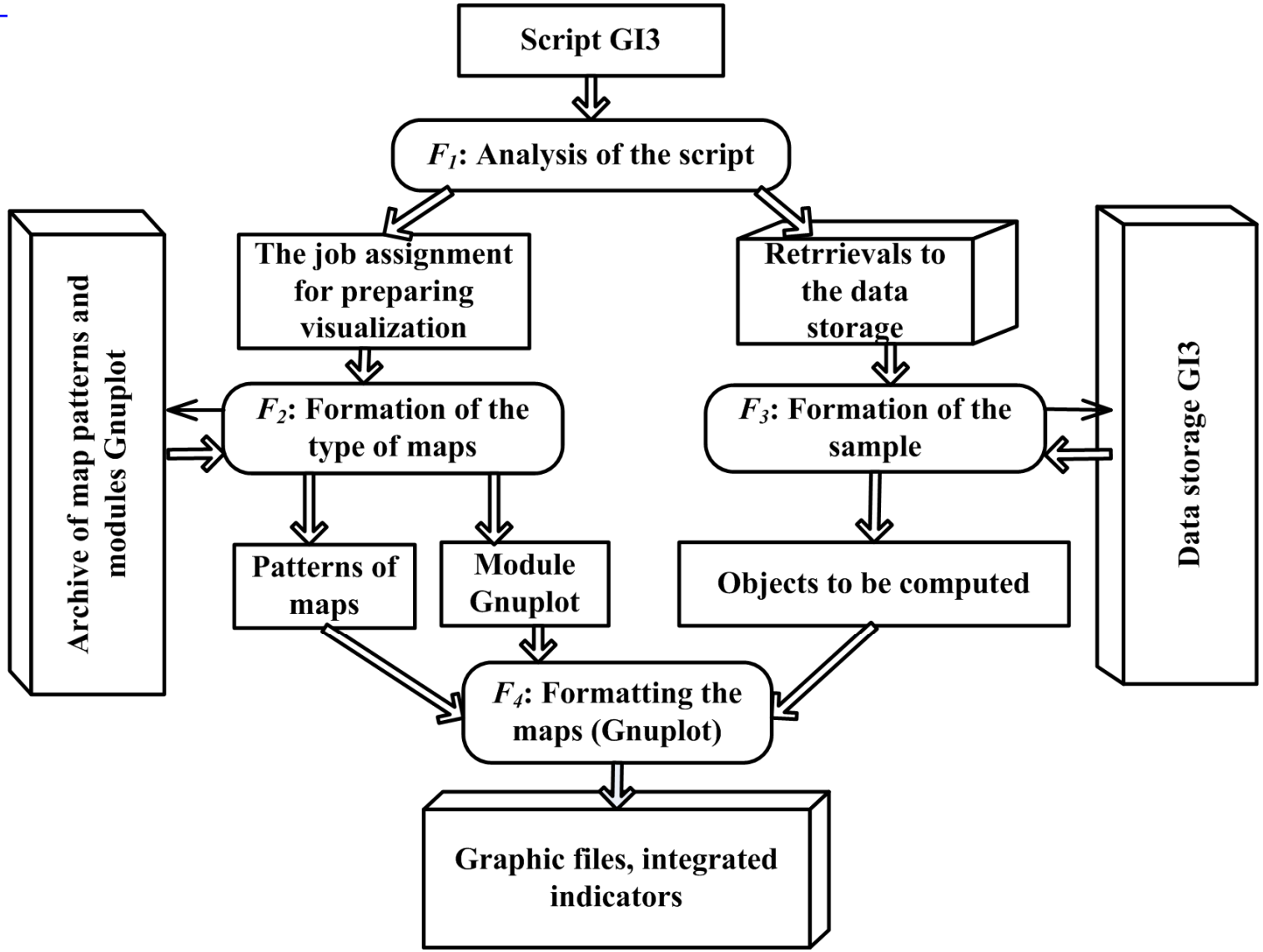


Attractors of (a) inflows (annual and 3rd quarter, resp.) for Lake Baikal (1,2) and Bratsk reservoir (3,4). Indicated are many-year series (b), envelopes of the maxima (d) and minima (c) of inflows and the centers of these attractors (e).

Basic functions of the system GeoGIPSAR



The technology for processing geoclimatic data



Wavelet analysis

Интегральное вейвлет-преобразование

$$W(s,\tau)=\frac{1}{\sqrt{s}}\int_{-\infty}^{\infty} f(t)\cdot\psi^{*}\left(\frac{t-\tau}{s}\right)dt$$

Обратное интегральное вейвлет-преобразование

$$f(t)=C_{\psi}^{-1}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} W(s,\tau)\psi\left(\frac{t-\tau}{s}\right)\frac{1}{\sqrt{s}}\frac{ds\,d\tau}{s^{2}}$$

s – масштаб

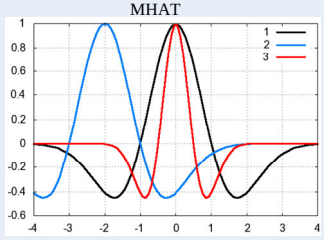
τ – временной сдвиг

$s,\tau\in R,\ \tau>0,\ s>0$

$1: s=0,\ \tau=0;\ 2: s=0,\ \tau=2;$

$3: s=2,\ \tau=0$

MHAT



Ограничения (условия):

$\psi(t)$ – *базисный вейвлет*

1. $\psi(t)\in L^{2}(R):\ \int_{-\infty}^{\infty}|\psi(t)|^{2}dt<\infty$

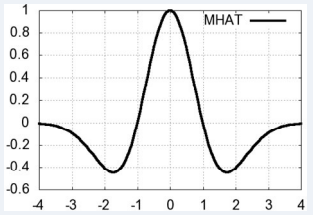
2. $\int_{-\infty}^{\infty}\psi(t)dt=0$

3. *Доп. условие*: $\int_{-\infty}^{\infty}\psi(t)t^{m}dt=0$

Примеры базисных вейвлет-функций

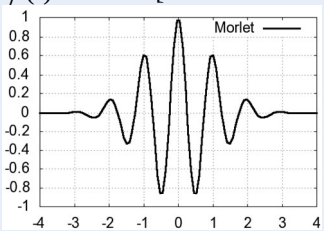
MHAT

$$\psi(t)=\frac{d^{2}}{dt^{2}}e^{-t^{1}/2}=(1-t^{2})e^{-t^{2}/2}$$



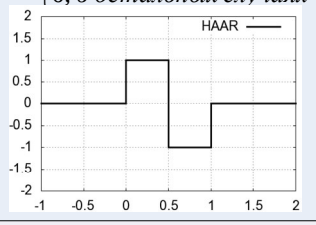
Morlet

$$\psi(t)=e^{-t^{2}/\alpha^{2}}[e^{ik_{0}t}-e^{-k_{0}^{2}\alpha^{2}/4}]$$



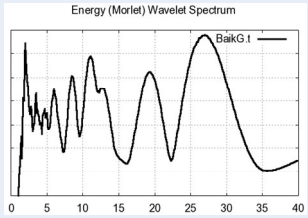
HAAR

$$\psi(t)=\begin{cases}1, \text{ для } 0\le t<1/2\\ -1, \text{ для } 1/2\le t<1\\ 0, \text{ в остальных случаях}\end{cases}$$

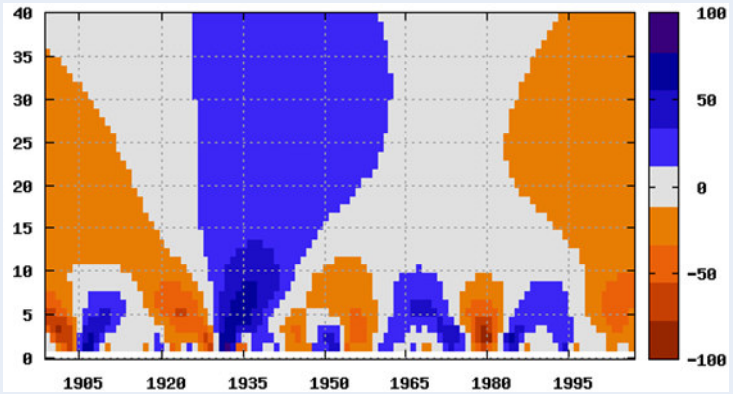


Глобальный вейвлет-спектр

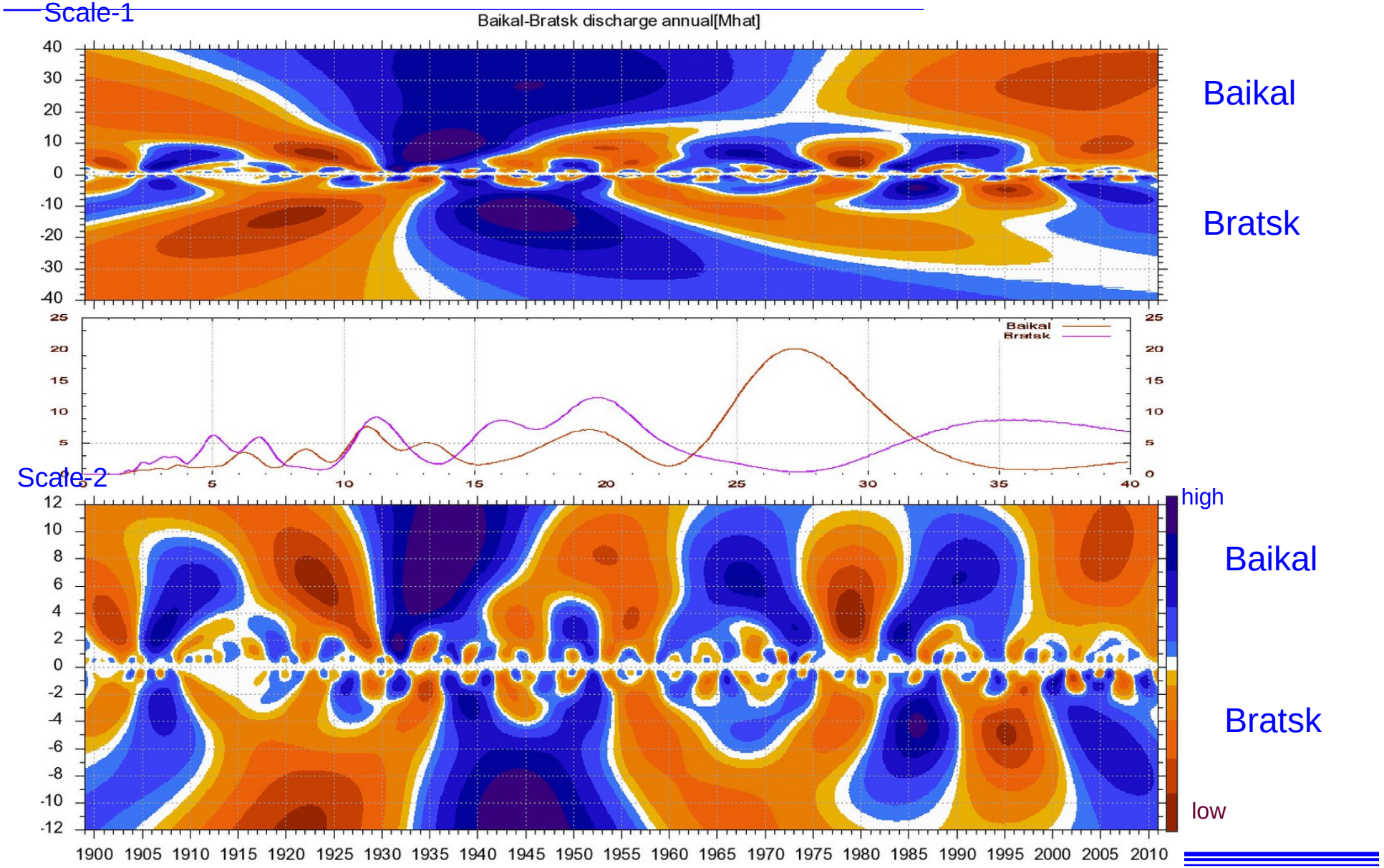
$$E_{w}(s)=\int W^{2}(s,\tau)d\tau$$



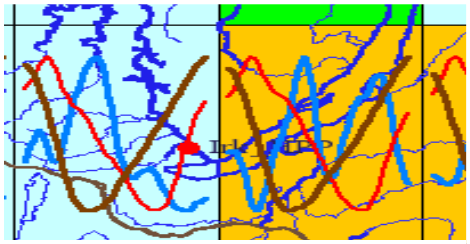
Вейвлетограмма

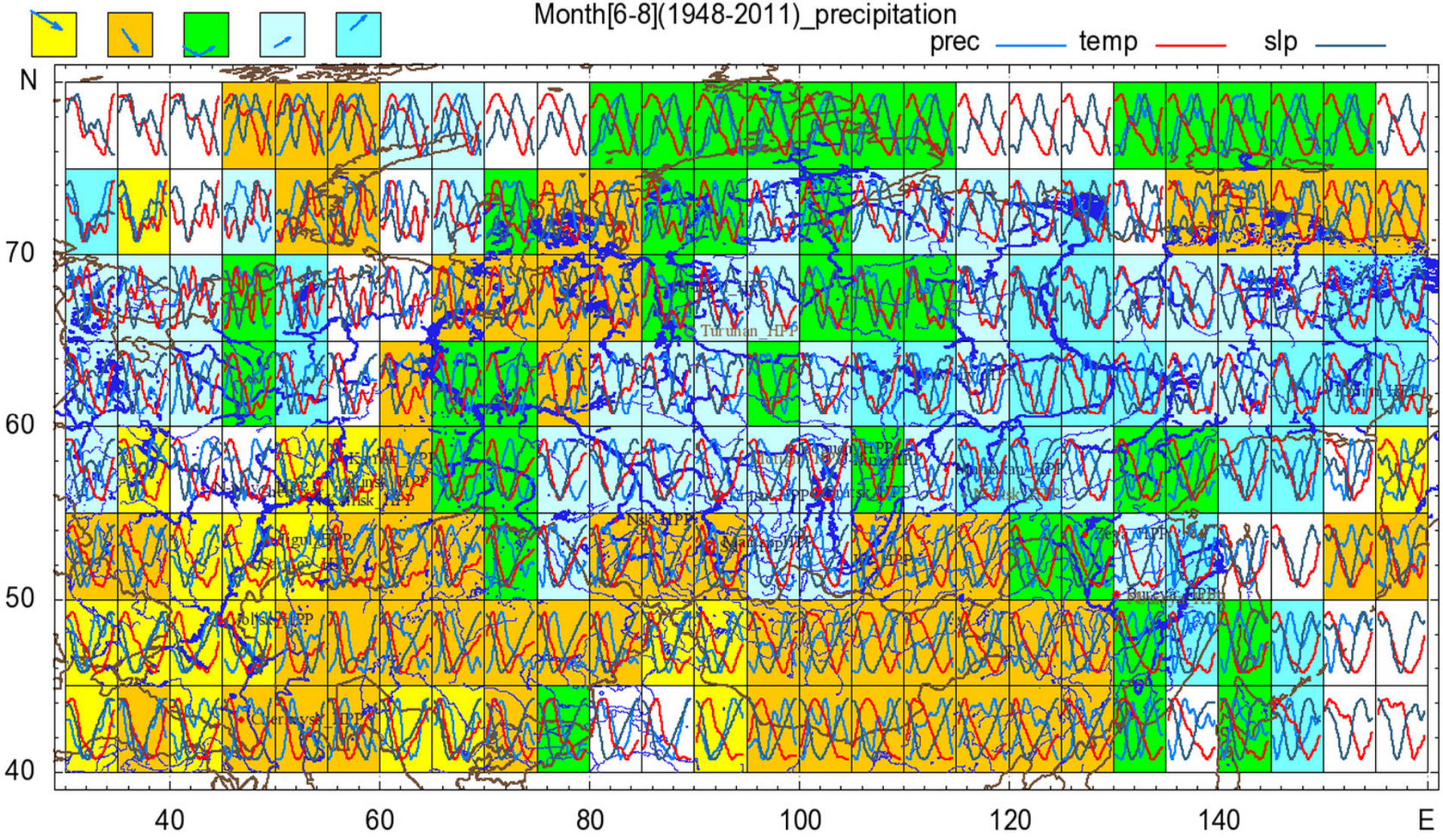


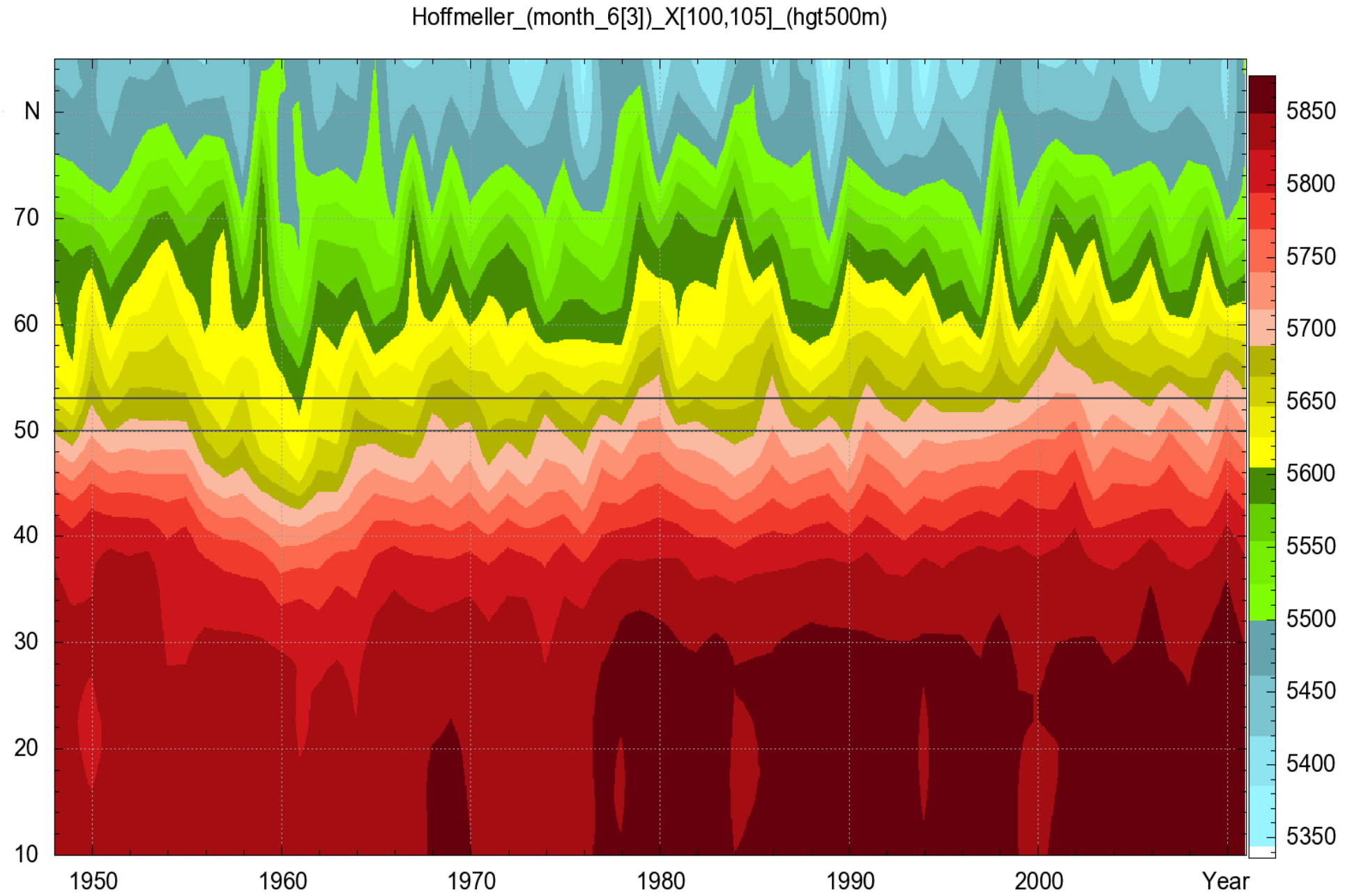
Wavelet analysis of inflows for the Lake Baikal and Bratsk reservoir + (spectral characteristics)

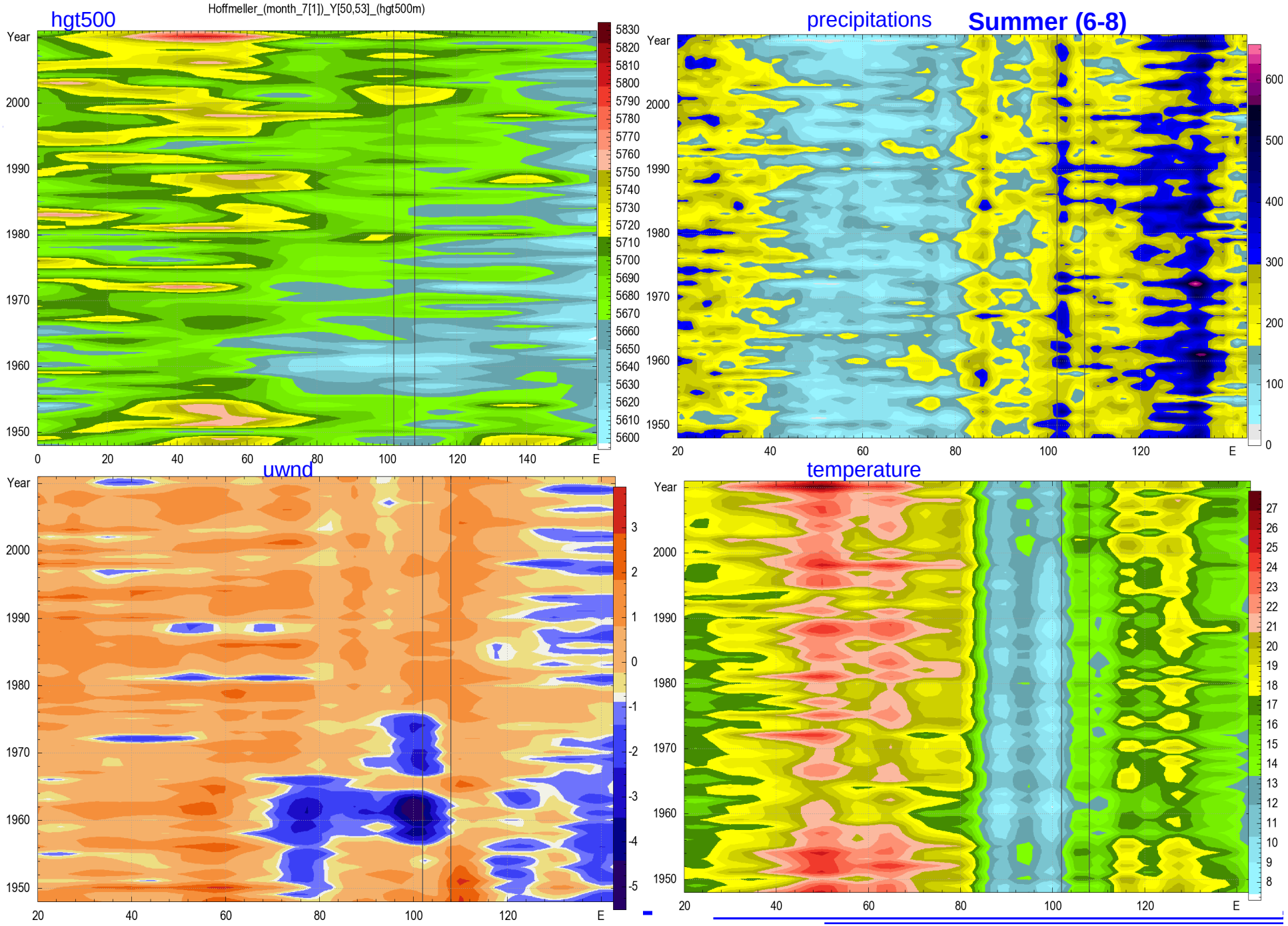


Classification and Clastering of spatial cells of intergral-difference curves representing summer precipitation, temperature and pressure data

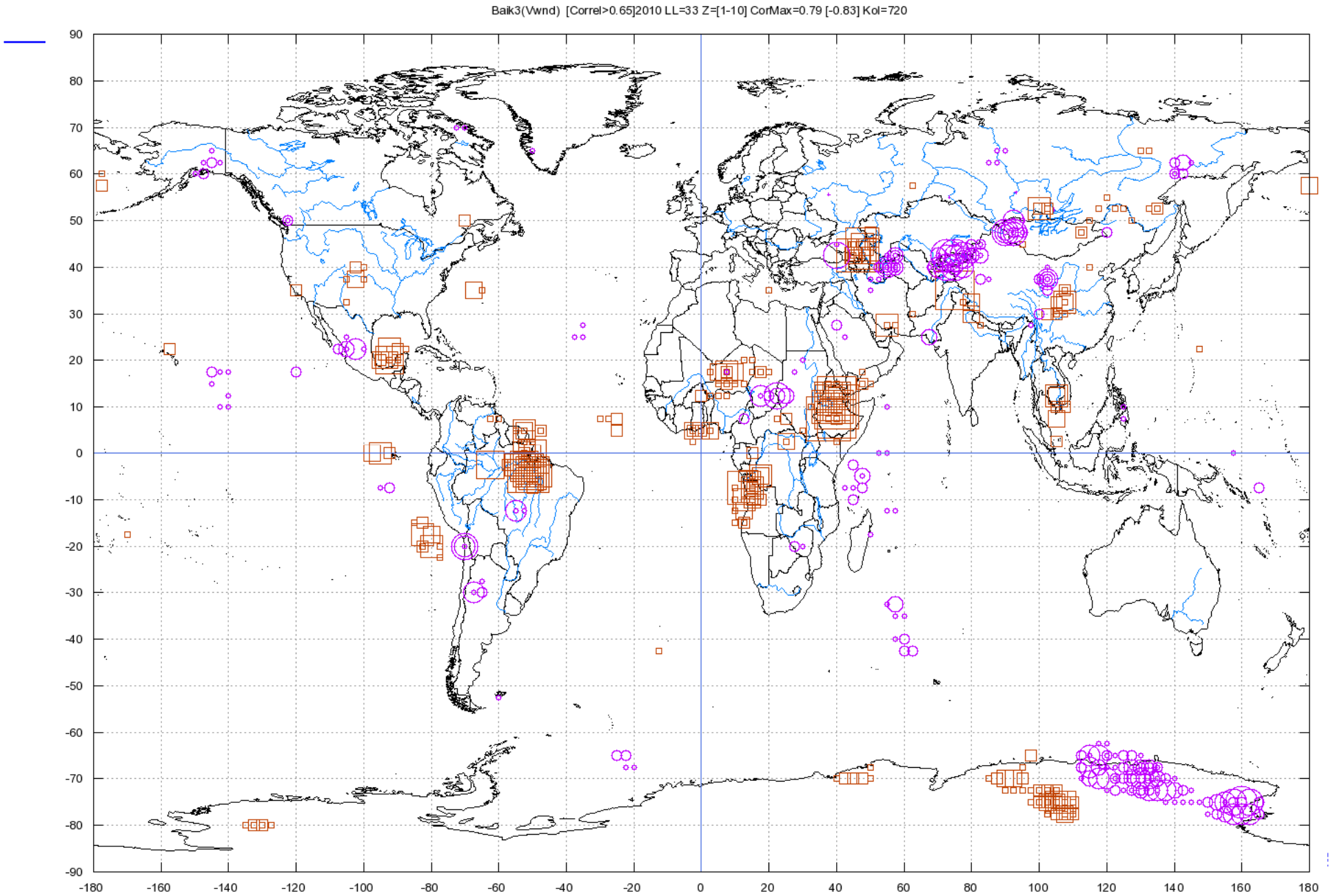




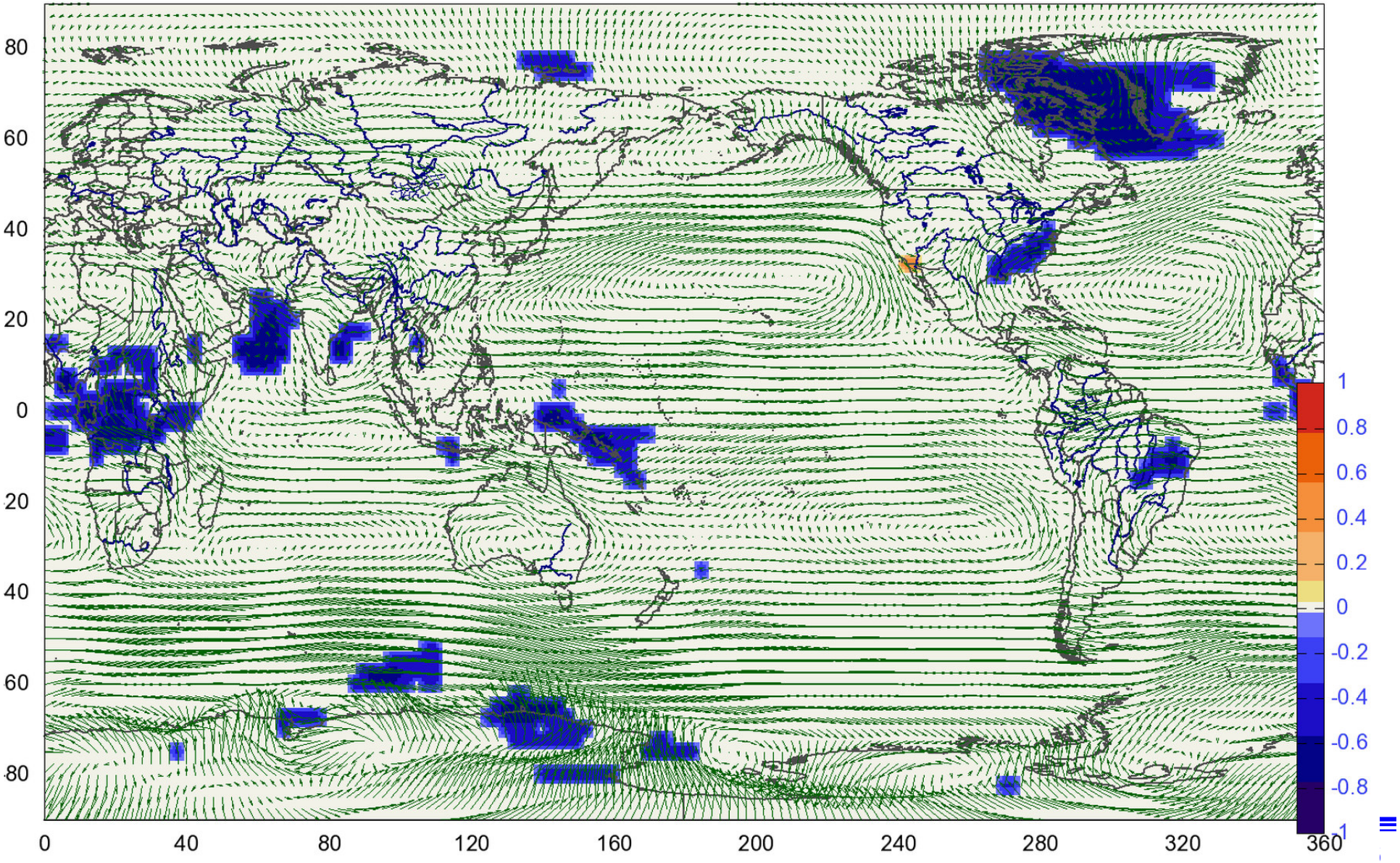

Hoffmeller_(month_6[3])_X[100,105]_(hgt500m)
N
70
60
50
40
30
20
10
1950
1960
1970
1980
1990
2000
Year
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
5350


hgt500
Hoffmeller_(month_7[1])_Y[50,53]_(hgt500m)
precipitations
Summer (6-8)
uwnd
temperature
Year
E

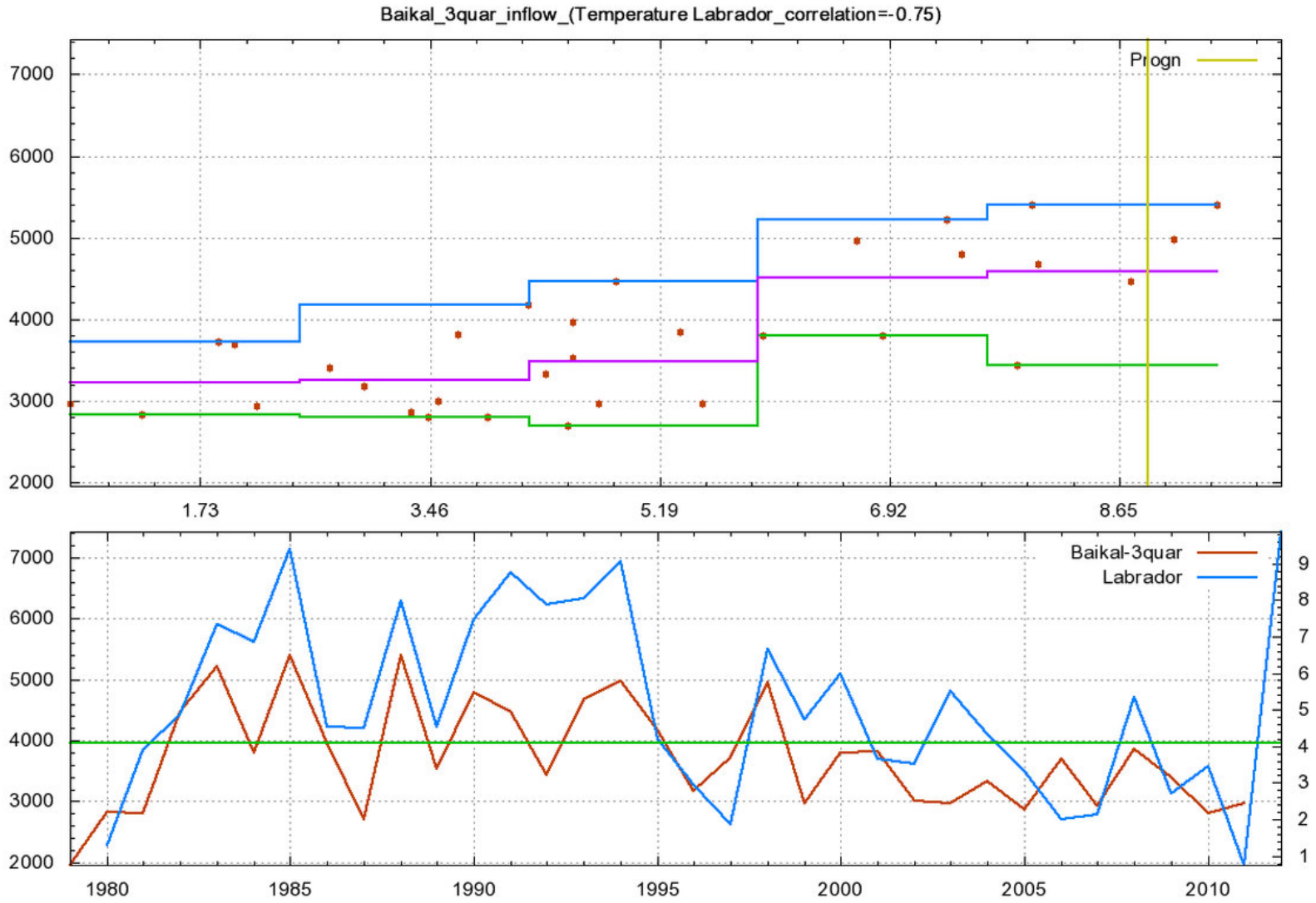
Analogs with respect to geoclimatic indices



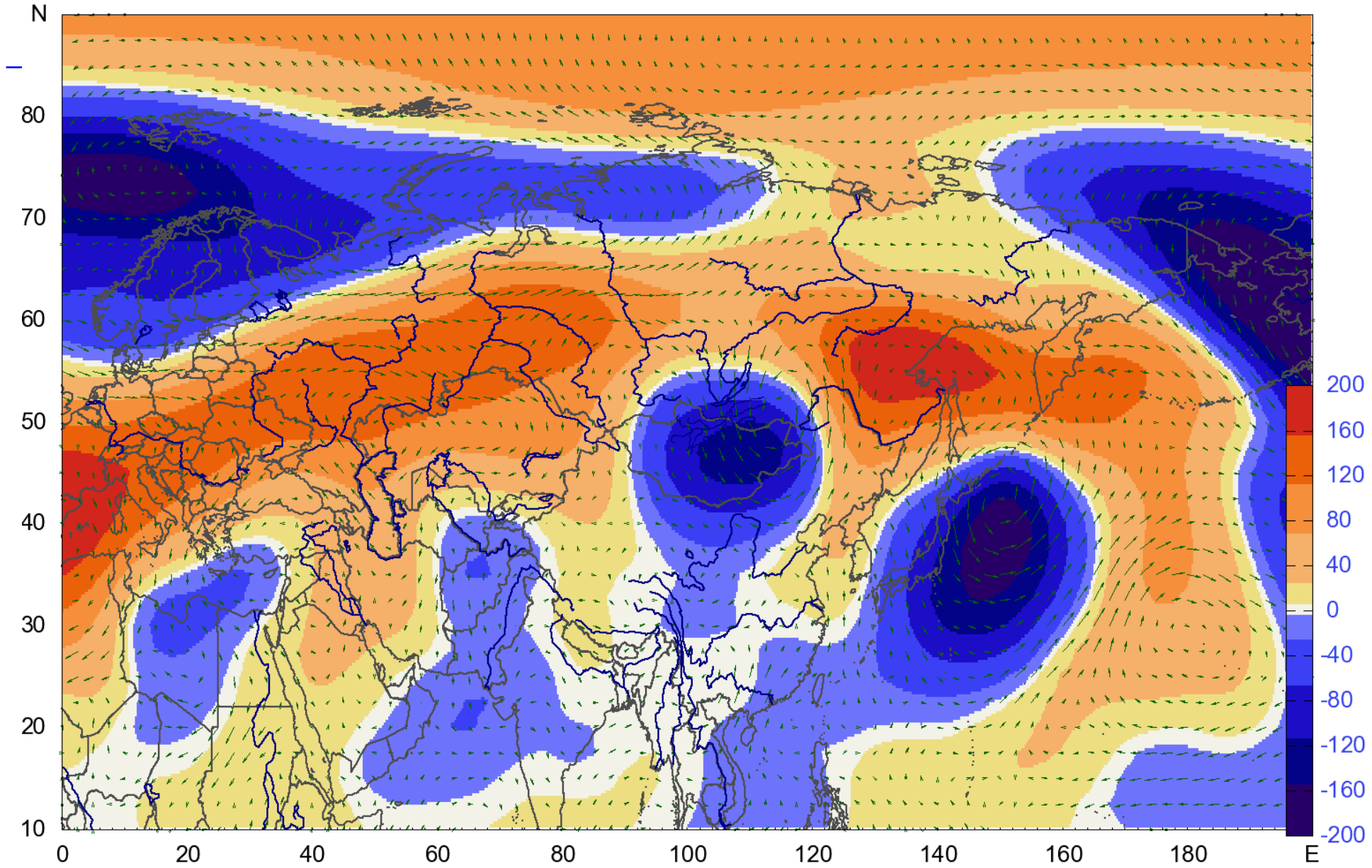
Correlations between the inflow into Lake Baikal (3rd quarter (4-5 months)) and the surface temperatures (advance time being 1 year)



Correlations between the inflow into Lake Baikal (3rd quarter [4-5 months]) and the surface temperatures (advance time being 1 year)

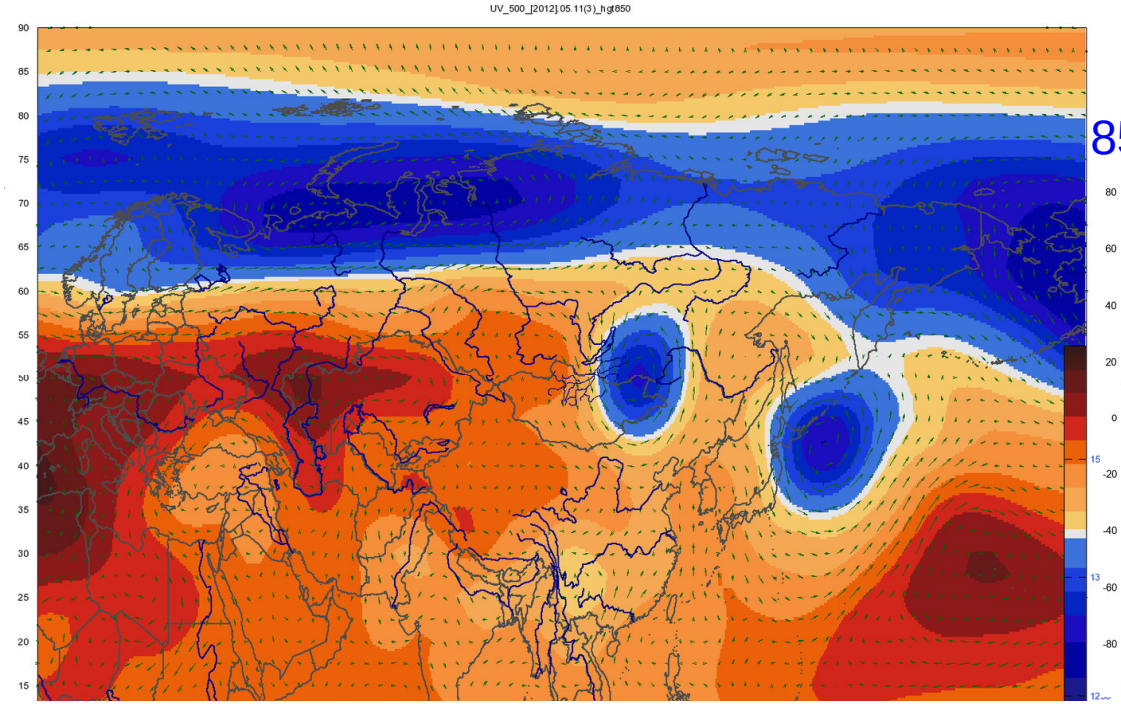


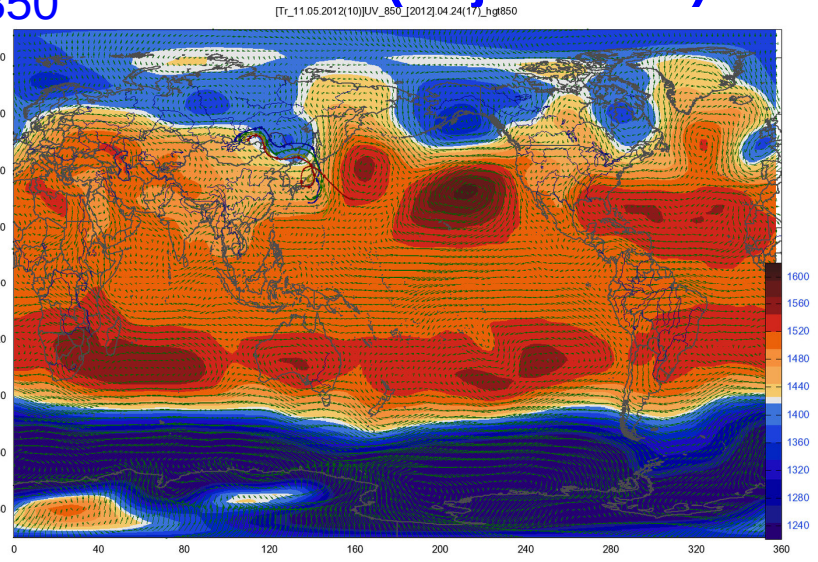
11-13.05.2012 HGT-500 (anomaly) UV-850



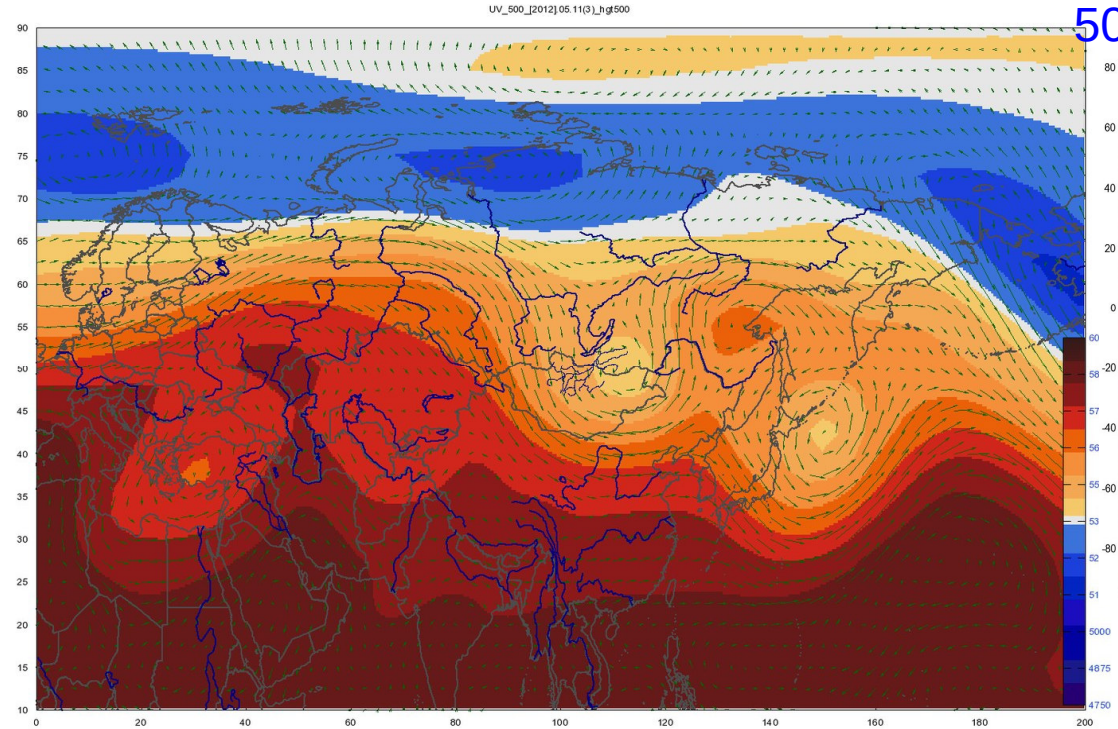
11-13.05.2012 HGT-850-500 (trajectories)

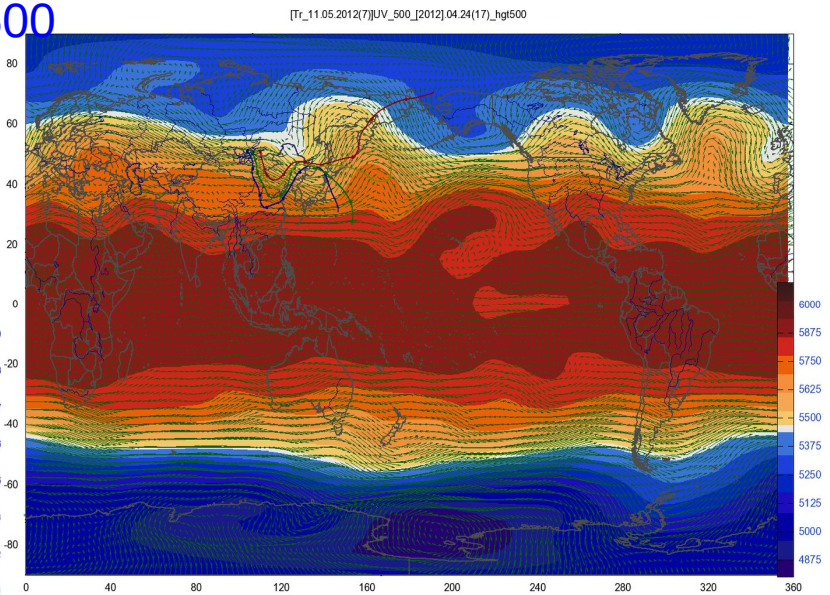
850





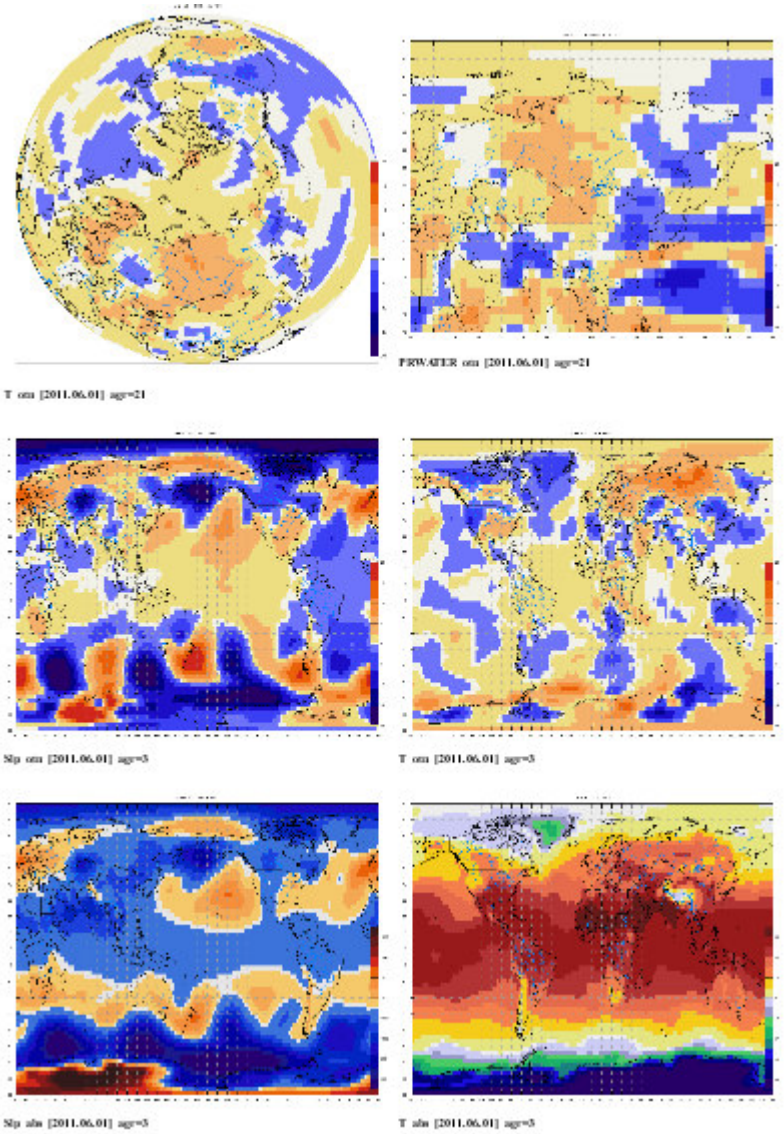
500



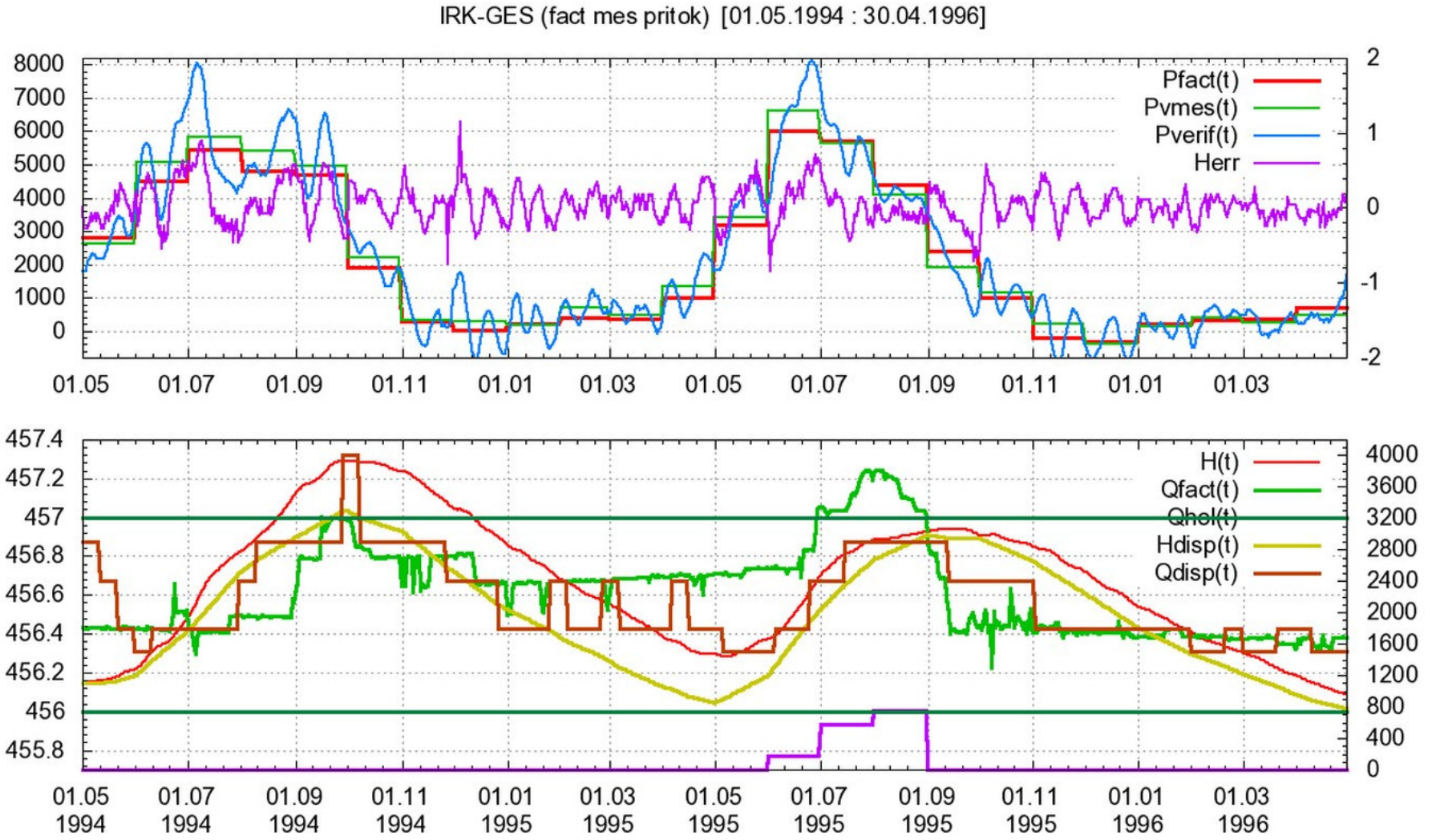


The process of constructing HTML-files in course of analysis of geoclimatic data, a special language of retrievals being employed

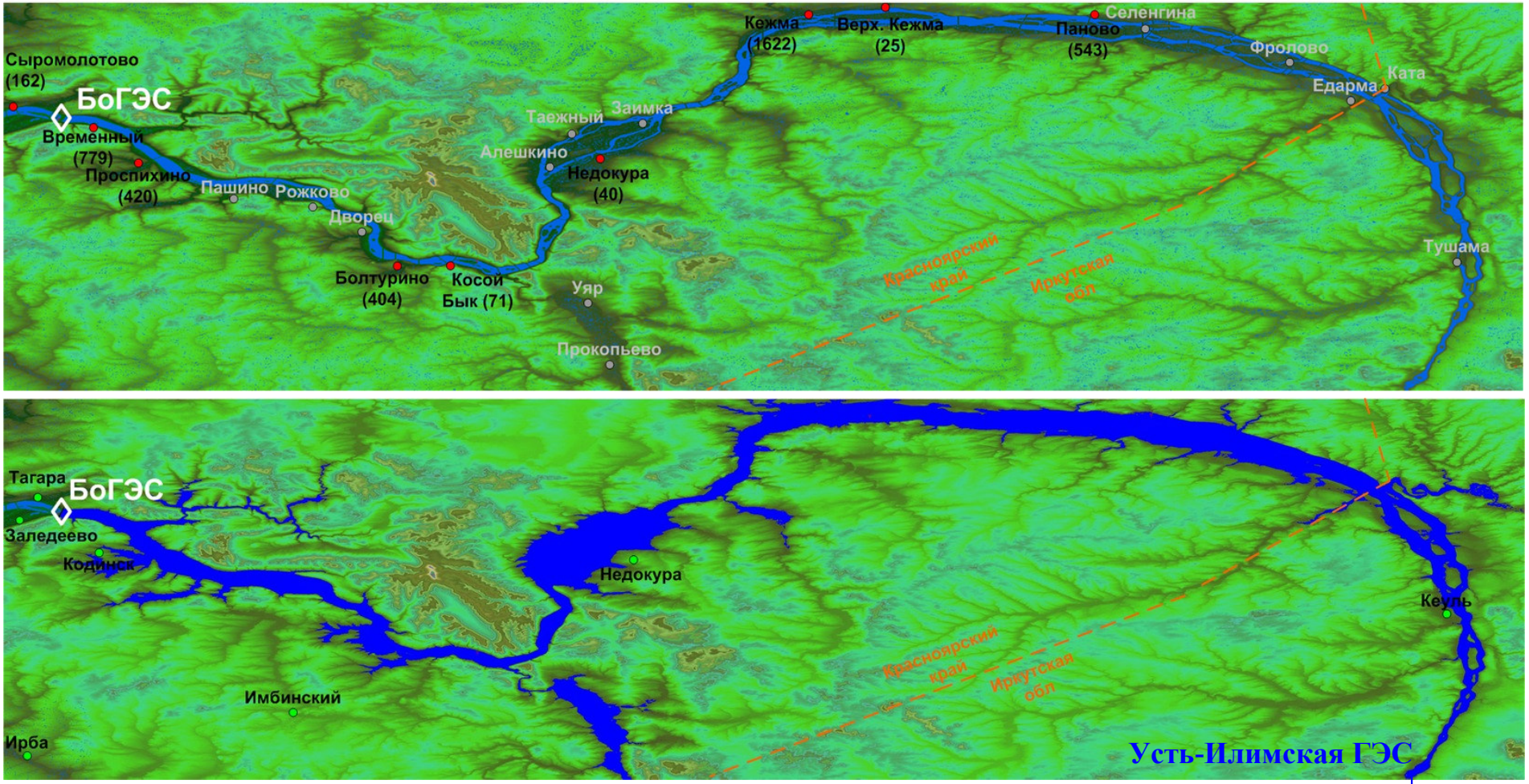
```
DIR=d:\gi3\gi3n
EKRAN=1680,1050
TAB_HTM=2
-------------------------------------------
map=0

#           --LEVEL={1000, 925, 850, 700, 600, 500, 400
grange=[-20:20]
-------------------------------
$P1=temperature
$P2=slp
$P3=PRWATER

$MAP1=3
$MAP2=2
$MAP3=1
$MAP4=0


$DAT1=01.06.2011
$DAT2=01.06.2011
$AGR1=21  --30
$AGR2=3   --30

-------------------------------
gi3=slp
agr=1

-------------

dat=$DAT1       AGR=$AGR1   MAP=$MAP1 GI3=$P1
dat=$DAT1       AGR=$AGR1   MAP=$MAP2 GI3=$P3

dat=$DAT2       AGR=$AGR2   MAP=$MAP3 GI3=$P2
dat=$DAT2       AGR=$AGR2   MAP=$MAP4 GI3=$P1

dat=$DAT2       AGR=$AGR2   MAP=$MAP3 GI3=$P2 tip=ABS
dat=$DAT2       AGR=$AGR2   MAP=$MAP4 GI3=$P1 tip=ABS

?
```



Modeling water regimes of the Irkutsk HPP

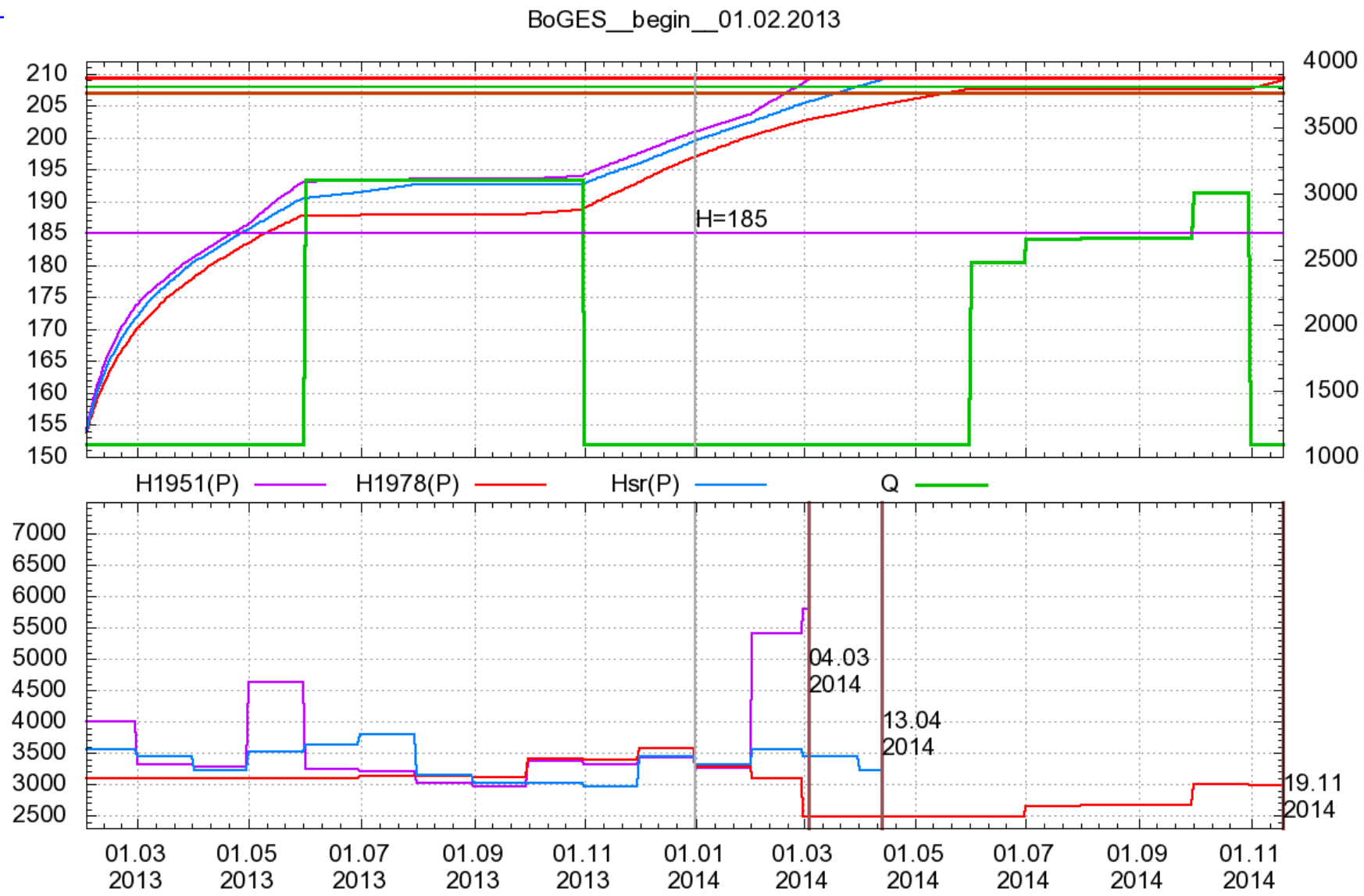


Modeling of the volume and the surface of the Boguchany water reservoir

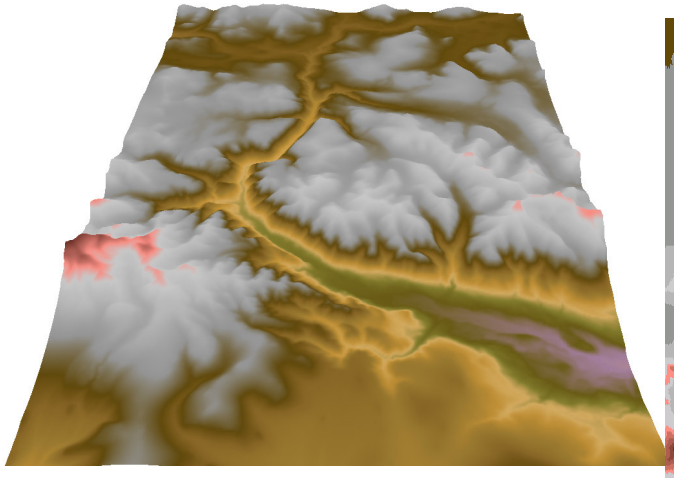


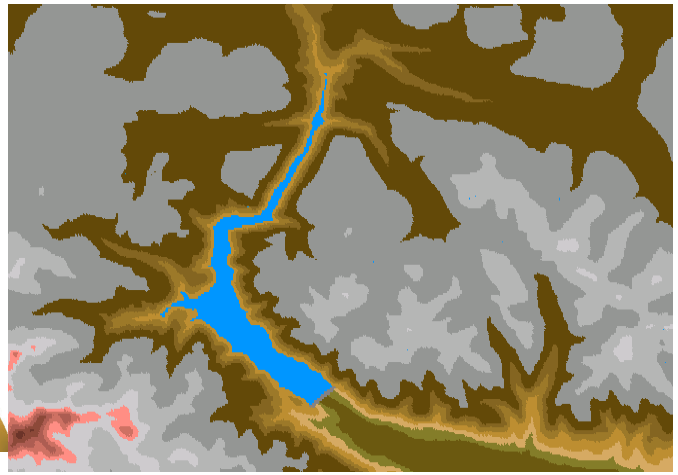
$V=63км^3$ $V^{полезн}=2.3км^3$ $Н^{УМО}=207м$ $\mathbf{Н^{НПУ}=208м}$ $Н^{ФПУ}=209.5м$

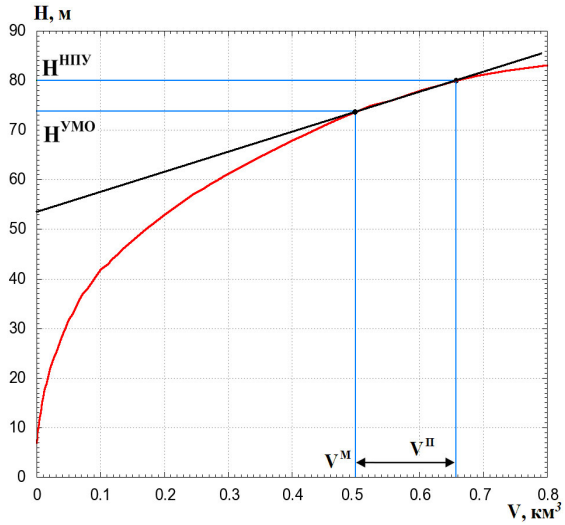
Various terms of filling in the Boguchany HPP

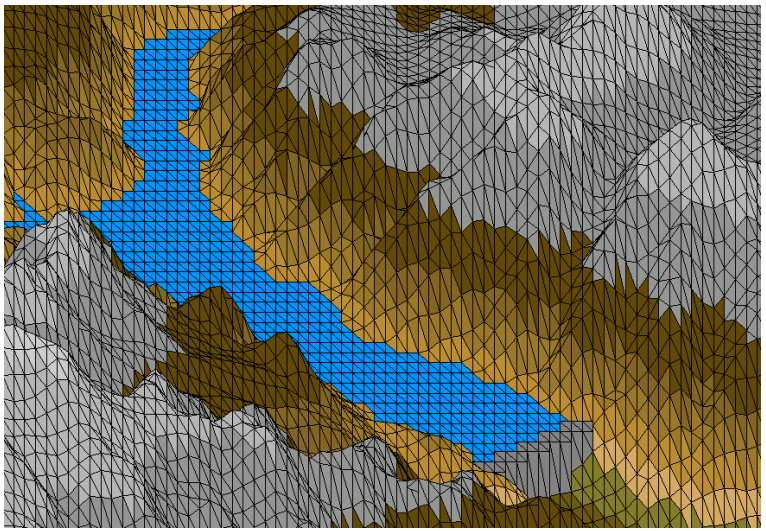


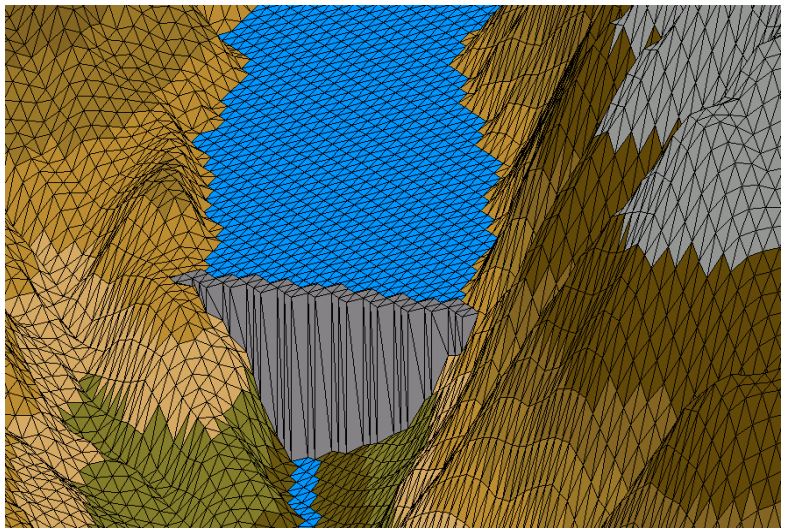
Modeling of potential HPPs on the river Irkut.
(Mondy Reservoir)











Conclusion

1. An easy-to-learn portable technology intended for processing geoclimatic data has been developed.
   2 Gb – monthly data (NCEP reanalysis, GPCC-precipitations)
   5Mb – basic system software (extended version of Lua with ZIRUS, Gnuplot, SciTE -editor)
   50 Mb – gis data

2. 50 Gb daily data (NCEP reanalysis)

3. This technology is extensively employed in energetics for the purpose of emproving reliability of forecasting of hydroenergetic potential under the conditions of global and regional climate changes.

This tecnology is simple and portable for different kind of users.

Thanks for Your kind attention