Impact of climate change on Latvian water environment

WP1: Impact of the climate change on runoff, nutrient fluxes and regime of Gulf of Riga

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WP1. GOAL

Modelling of several scenarious of the change of water environment using the existing climate change sceanrious for Baltic Sea region

WP1. TASKS

WP1a. Evaluate and adapt the results from the regional climate models, and design the series of data which form the state of the water objects.
SCENARIOUS = MODEL DATA = FORCING CONDITIONS

WP1b. Investigate and forecast the impact of the climate change on the river runoff and its seasonal variability. **MODELLING OF DRAINAGE BASIN**

WP1c. Adapt 3D sea state models to produce the data series for the forecast of biogeochemical processes and sea ecosystem evolution.
OCEANOGRAPHIC MODELLING

WP1d. Provide modelling and data analysis support for other WPs. **SUPPORT**

	TIME TABLES OF TASKS	2006				2007				2008				2009			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
	1a SCENARIO							1 A	OK								
	1b DRAINAGE BASIN MODELLING										1 B ?						
	1c SEA STATE MODELLING												1 C				
	1d SUPPORT																1 D

ROADMAP

1. SCENARIOUS

- Investigate access to RCM numerical results
- Method for RCM comparison NEW!
- Select best RCM
- RCM data quality control via runoff modelling NEW!
- Systematic non-compliance of observed and modelled climate found for reference period
- Method for RCM correction NEW!
- Scenarious prepared (T, p for Latvia) NEW!
- Features of future T & p expectations analysed ppt

ROADMAP (continued)
2. RIVER MODELLING

- **Geospatial information organised**
- **Model (FiBasin) developed/tested in pilot basin – Aiviekste**

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- **MIKE SHE tested (Bērze)**
- **MIKE BASIN tested (Bērze)**
- **Extension of FiBasin calibration tested (Aiviekste vs. Abava)**
- **2nd order non-compliance of observed and modelled climate found via runoff modelling NEW!**
- **Runoff scenarious**
- **Nutrient load scenarious**

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ROADMAP (continued)

3. SEA STATE MODELLING

- Modelling area selected
- Model (SwEvolver 3D, used in operational modelling) adapted and tested

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- Reengineering of numerical engine of SwEvolver 3D to ensure 30+ year stable run
- Access to climatic “virtual ocean” for Baltic sea via BOOS cooperation
- Sea state scenarious

Possible continuations of presentation:

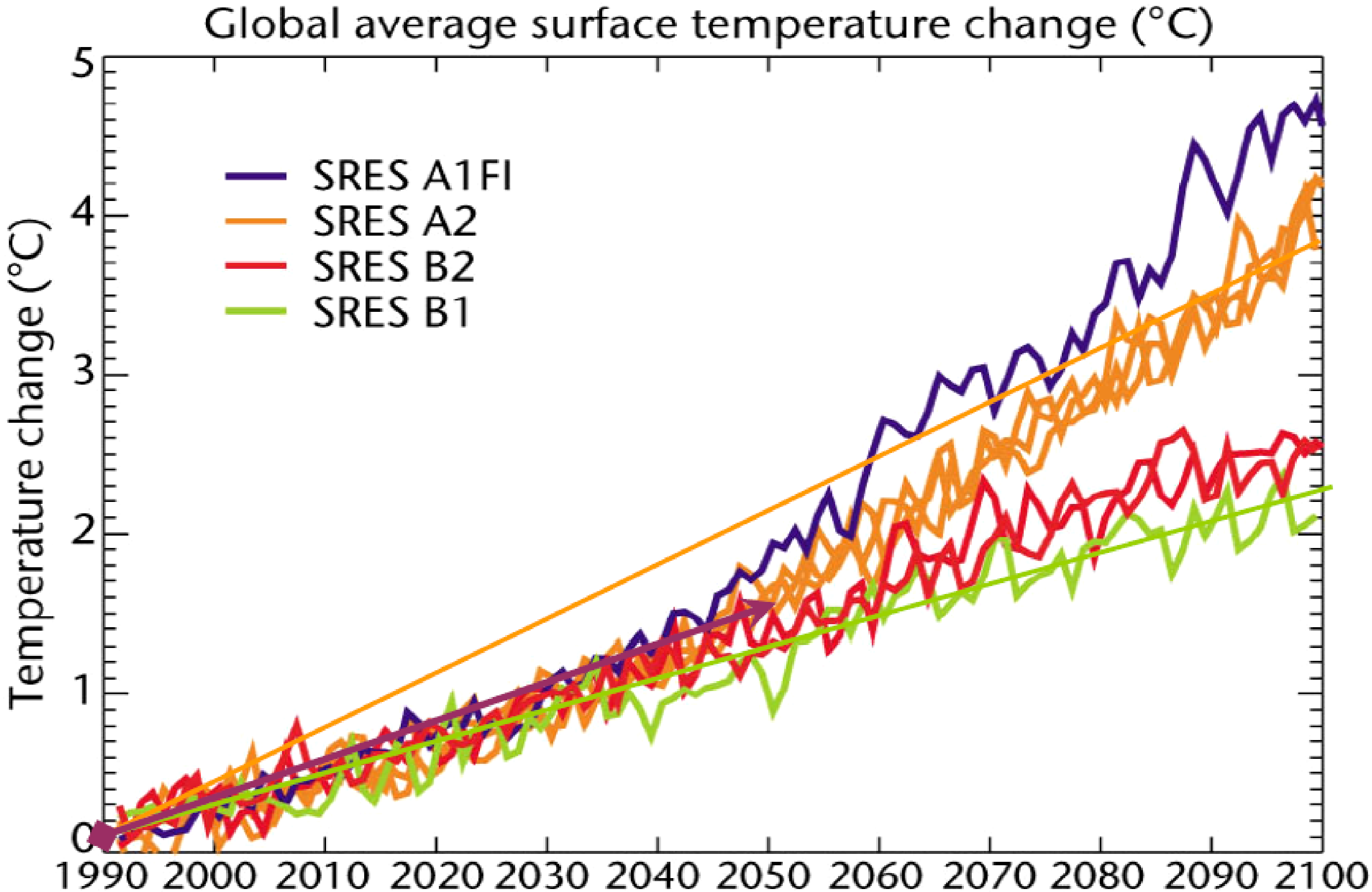
-> RCM comparison/selection/usage in runoff modelling/correction (now + general discussion)

-> Principal features of future T/p in Latvia (skip)

-> Current work on river modelling (general discussion)

GLOBAL SCENARIOS

Intergovernmental Panel on Climate Change (IPCC) by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)

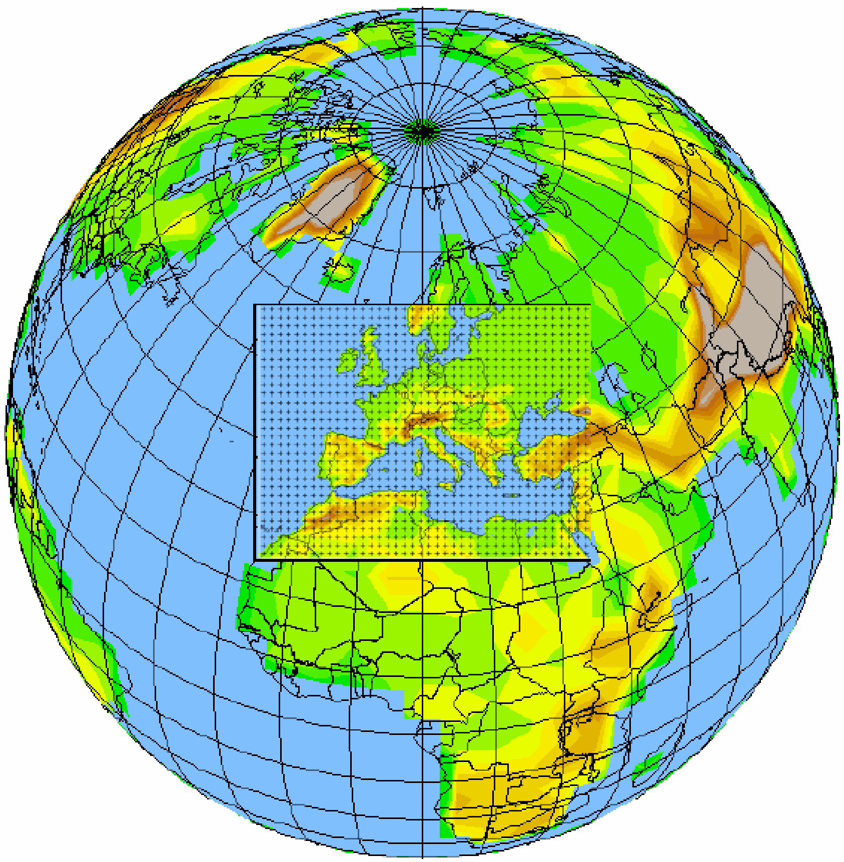


Choice of RCM

Global climate change scenario

Global climate model

Regional climate model (RCM)



PRUDENCE is a European FP5 scientific project to quantify confidence and the uncertainties in predictions of future climate and its impacts, using an array of climate models.

PRUDENCE will provide a series of high-resolution climate change scenarios for 2071-2100 for Europe

Choice of RCM / approach

- 21 model is considered for control period 1961-1990.
- 14 observations locations are considered for time period 1961-1990 (observations by USSR Hydrometeorological Agency)
- Monthly average precipitation, monthly average temperature, standard deviation of monthly precipitation and standard deviation of monthly temperature is calculated for each observation location from the 1 observation data series and 21 model data series (4 parameters x 12 months x 14 locations x (1 obs + 21 mod))
- 672 deviations between the model results and observations are calculated for each of 21 models
- Model data is interpolated to observation location from each model's grid
- Deviations are normalised for each of 4 parameters
- Penalty function is constructed from normalised deviations to quantify the difference between the model climate and the observed climate

14 observation station

SMHI_HCCTL grid

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Algorythm for RCM comparison

For each model ***i*** and observations

Foreach station ***s***

Sort data series (reference period 1961-1990) by month

For each month ***m*** in [1..12]

Calculate average values $\overline{x}_{i,s,m}$ $\overline{x}^{*}_{s,m}$

Calculate dispersion of values $D_{i,s,m}$ $D^{*}_{s,m}$

For each model ***i***

For each station ***s***

For each month ***m*** in [1..12]

$\left(\overline{X}_{i,s,m} - \overline{X}^{*}_{s,m}\right)^2$ Calculate square difference of average values (model-observations)

$\left(D\left(X_{i,s,m}\right) - D\left(X^{*}_{s,m}\right)\right)^2$ Calculate square difference of dispersion values (model-observations)

Find maximum square deviation $X_{\max}$ $D_{X\max}$

Foreach model ***i***

Calculate weighted sum of differences

K_i ΔX_i $\left(\Delta D_X\right)_i$

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Construction of penalty function

i – model
m – month
s - station

$$D(x) = \sqrt{\overline{(x-\overline{x})^2}}$$

$$T_{\max} = \max_{i,s,m}\left(\left(\overline{T}_{i,s,m} - \overline{T}^*_{s,m}\right)^2\right)$$

$$P_{\max} = \max_{i,s,m}\left(\left(\overline{P}_{i,s,m} - \overline{P}^*_{s,m}\right)^2\right)$$

$$D_{T\max} = \max_{i,s,m}\left(\left(D\left(T_{i,s,m}\right) - D\left(T^*_{s,m}\right)\right)^2\right)$$

$$D_{P\max} = \max_{i,s,m}\left(\left(D\left(P_{i,s,m}\right) - D\left(P^*_{s,m}\right)\right)^2\right)$$

$$\Delta T_i = \sum_{s,m} \frac{\left(\overline{T}_{i,s,m} - \overline{T}^*_{s,m}\right)^2}{T_{\max}}$$

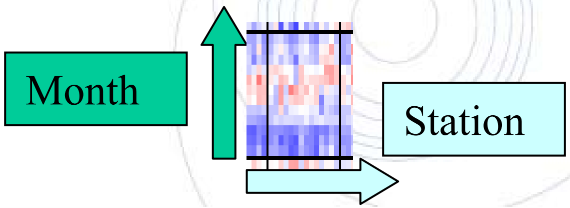
$$\Delta P_i = \sum_{s,m} \frac{\left(\overline{P}_{i,s,m} - \overline{P}^*_{s,m}\right)^2}{P_{\max}}$$

$$\left(\Delta D_T\right)_i = \sum_{s,m} \frac{\left(D\left(T_{i,s,m}\right) - D\left(T^*_{s,m}\right)\right)^2}{D_{T\max}}$$

$$\left(\Delta D_P\right)_i = \sum_{s,m} \frac{\left(D\left(P_{i,s,m}\right) - D\left(P^*_{s,m}\right)\right)^2}{D_{P\max}}$$

$$K_i = \Delta T_i + \Delta P_i + \left(\Delta D_T\right)_i + \left(\Delta D_P\right)_i$$

Plot of difference between model and observations
for each model, month and station

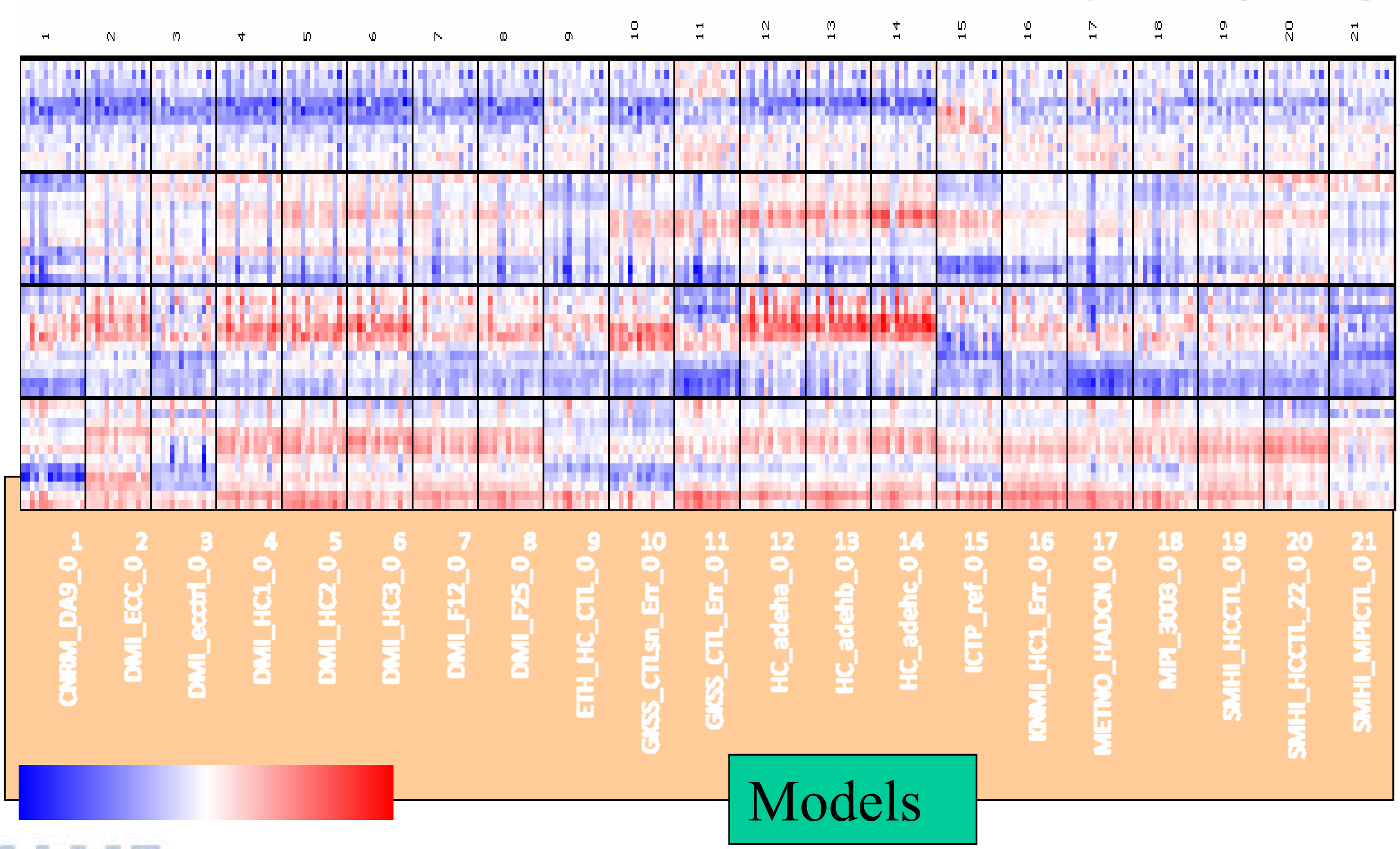


$$\frac{D(P_{i,s,m})-D(P^{*}_{s,m})}{D_{P\max}}$$

$$\frac{D(T_{i,s,m})-D(T^{*}_{s,m})}{D_{T\max}}$$

$$\frac{\overline{P}^{*}_{s,m}-\overline{P}_{i,s,m}}{P_{\max}}$$

$$\frac{\overline{T}_{i,s,m}-\overline{T}^{*}_{s,m}}{T_{\max}}$$



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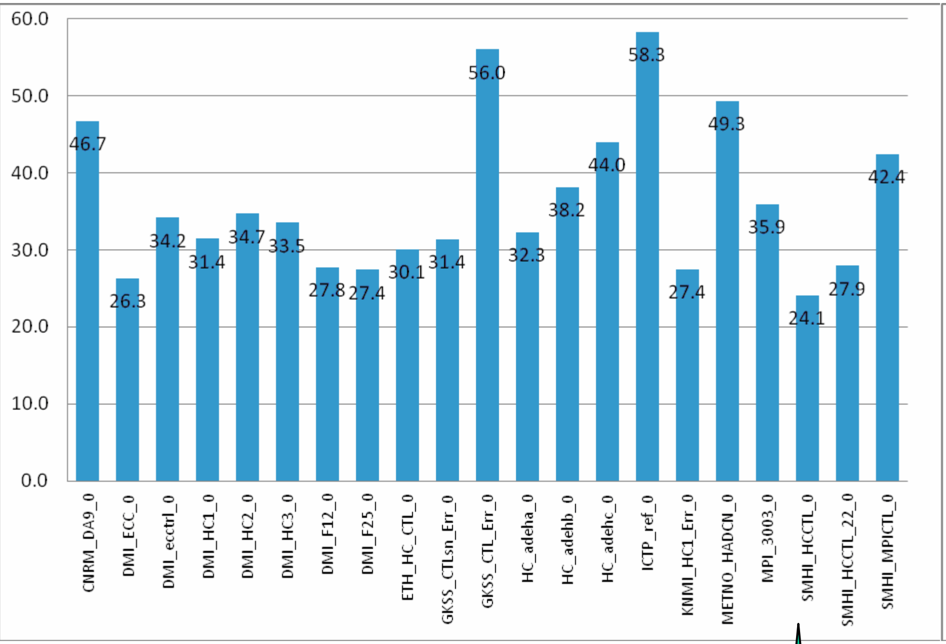
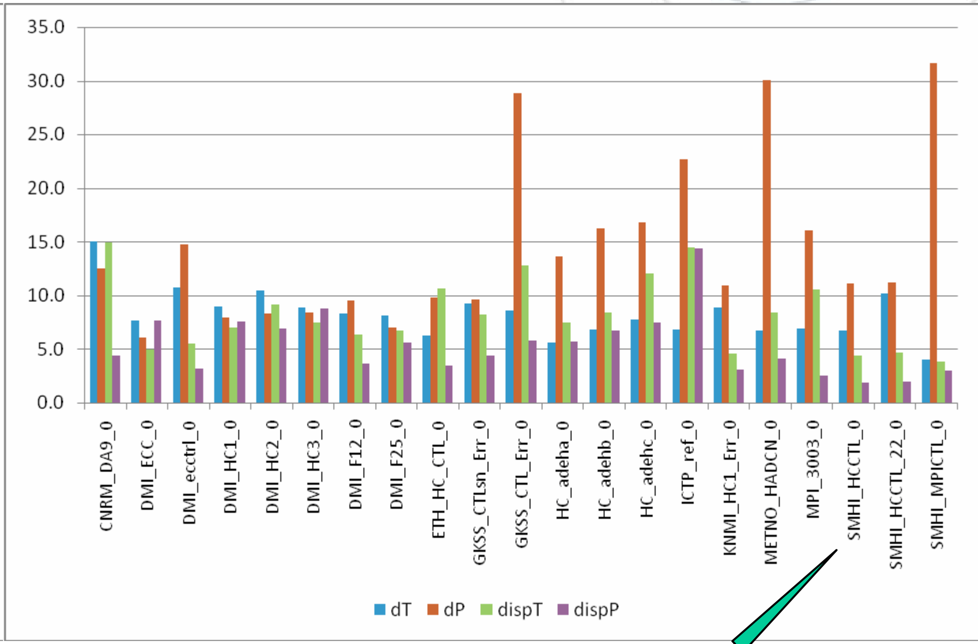
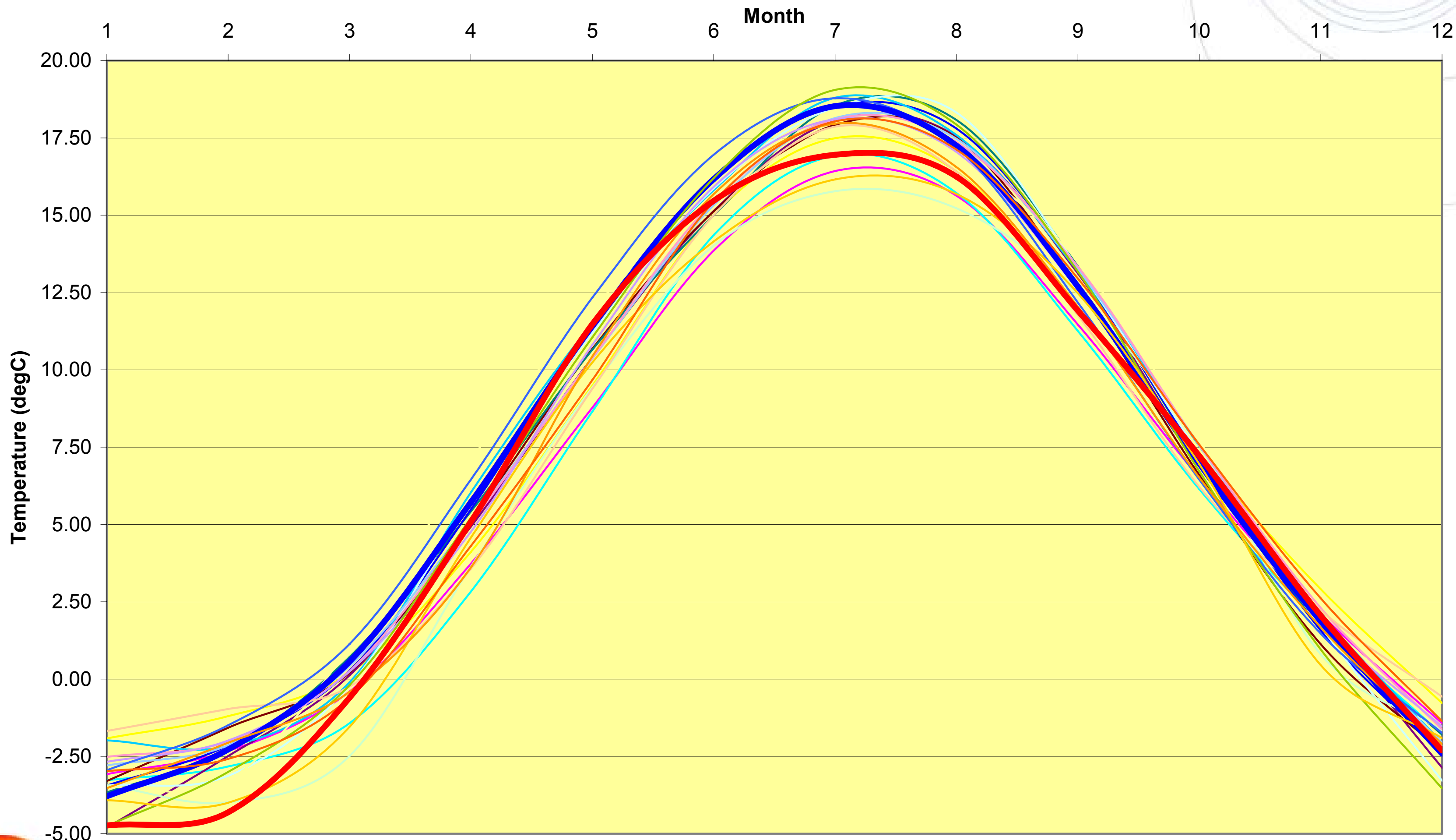
Model selection





Minimal K is for SMHI_HCCTL
Next DMI_ECC

Monthly temperature, red- observations, blue – selected RCM



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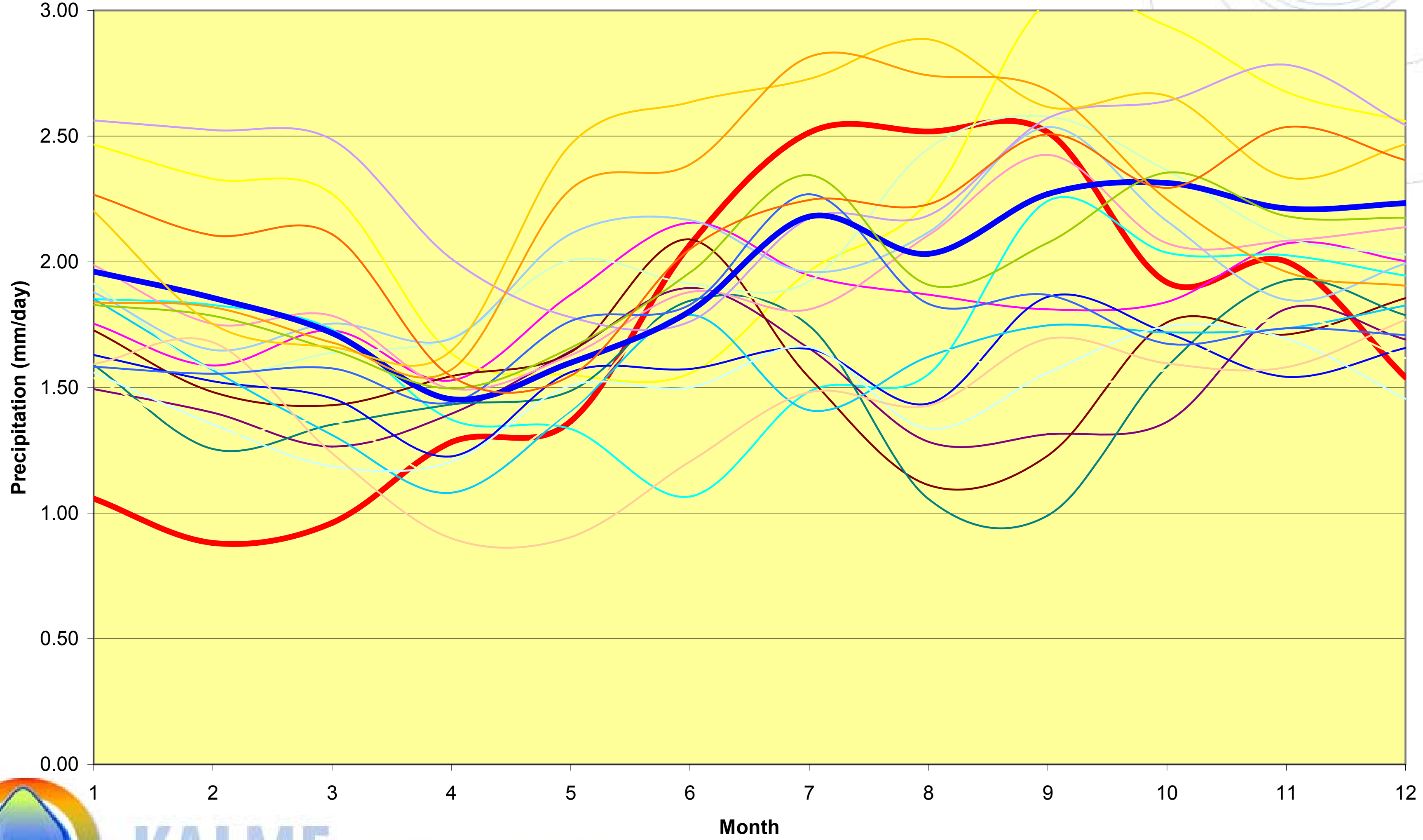
Monthly precipitation, red- observations, blue – selected RCM



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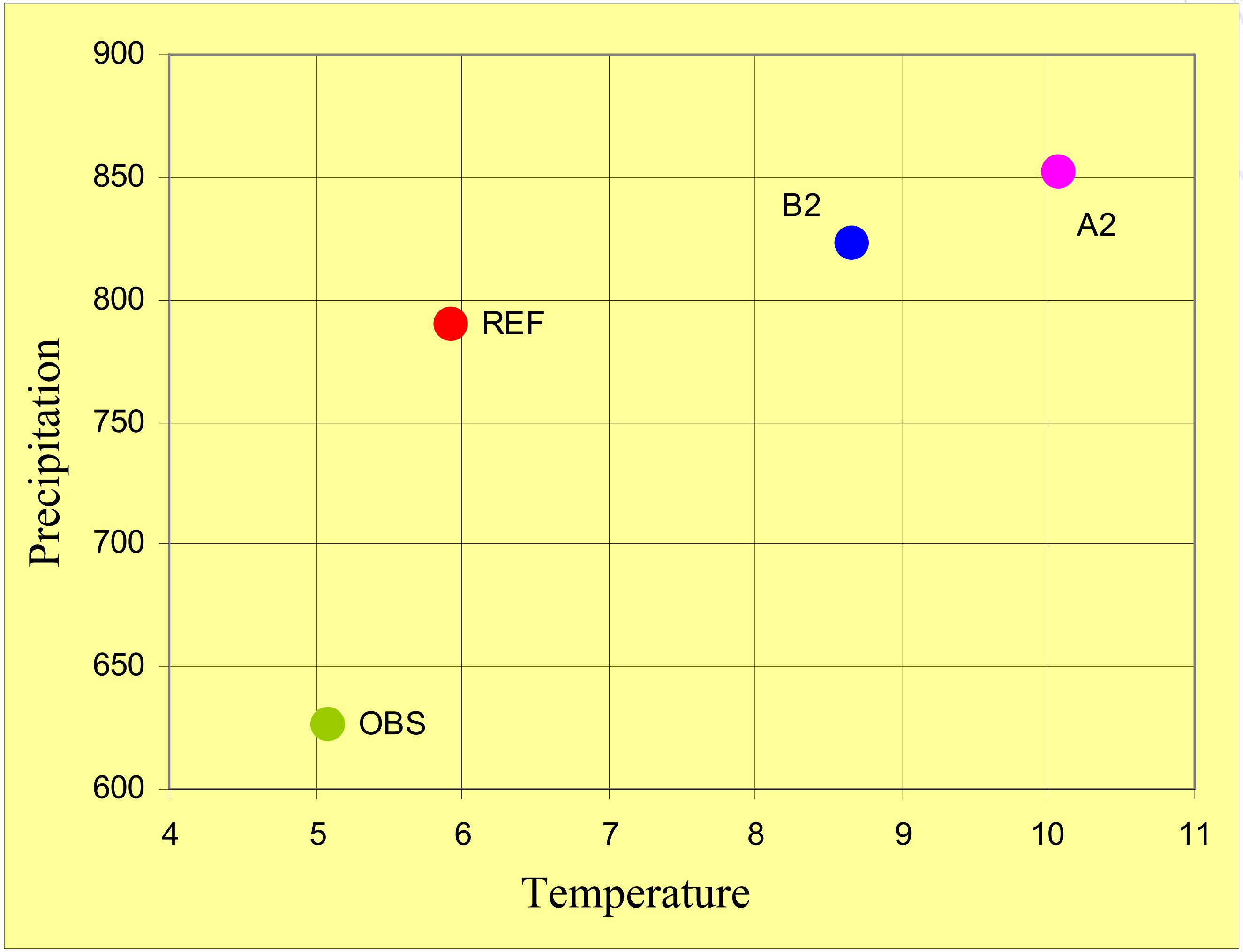
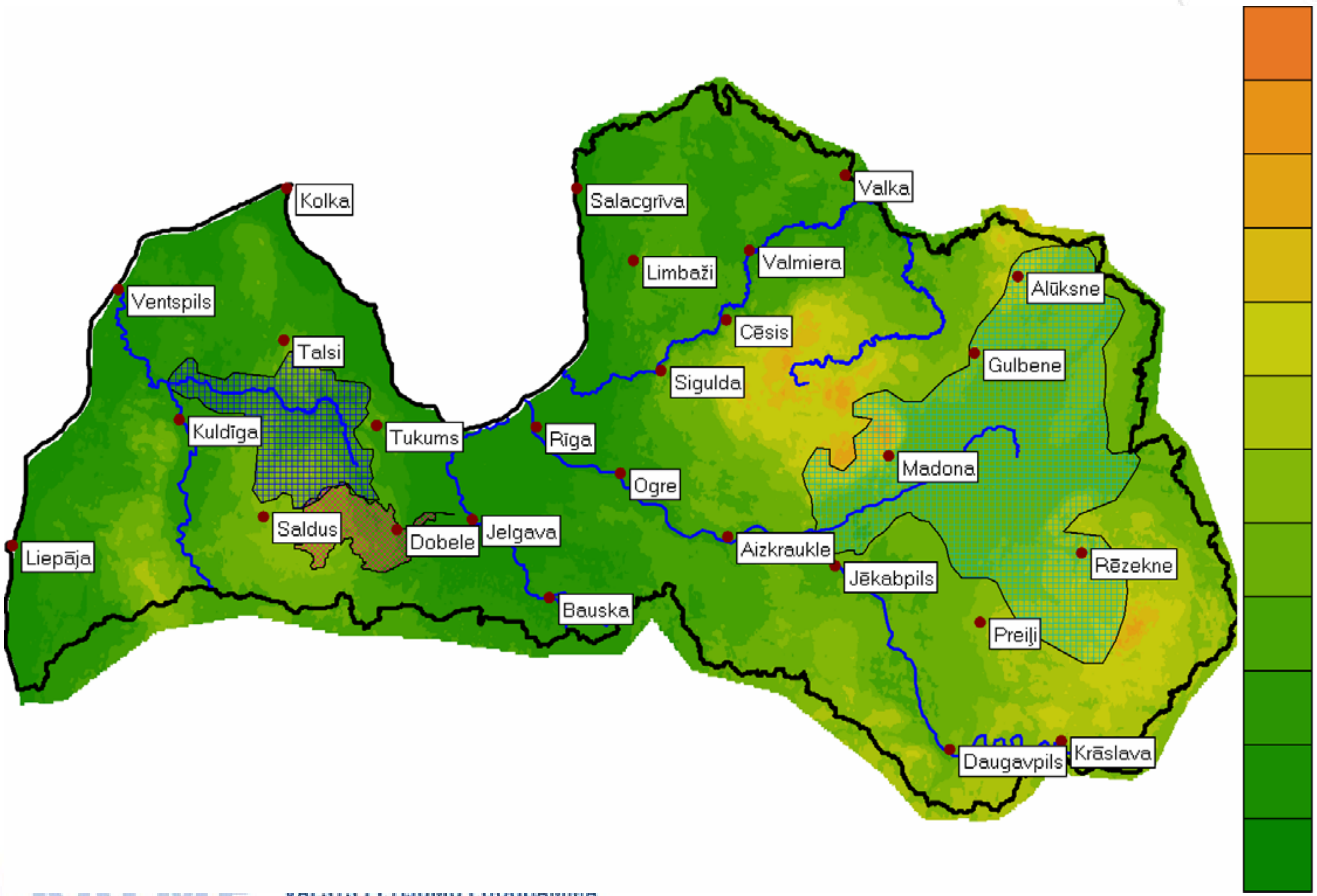
Choice of RCM.

Yearly average temperature (degC) and precipitation sum (mm)



Runoff modelling as quality control: model & domain

In-house model of hydrological processes FiBasin.
Aiviekste basin in Latvia. Calibration for 1976-1979.



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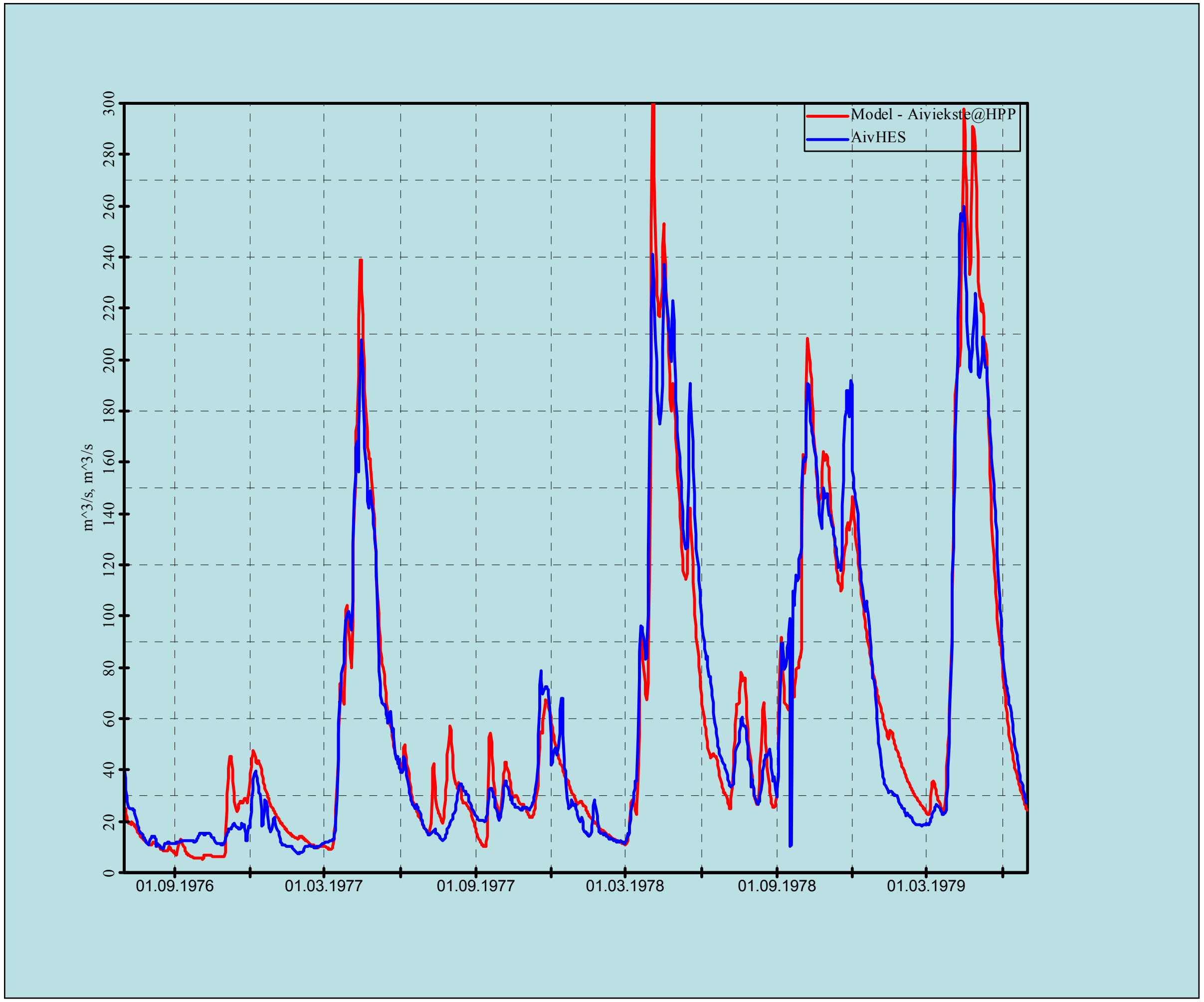
Hydrological modelling: calibration



Comparison of observed Q / modelled Q (forcing by observed T, p)

3 years, starting in June, time step one day

Average runoff
OBS 61.6 m^3/s
MOD 62.5 m^3/s

$R2=0.922$

Approach to hydrological model

Physically-based spatially and temporally distributed dynamic modelling

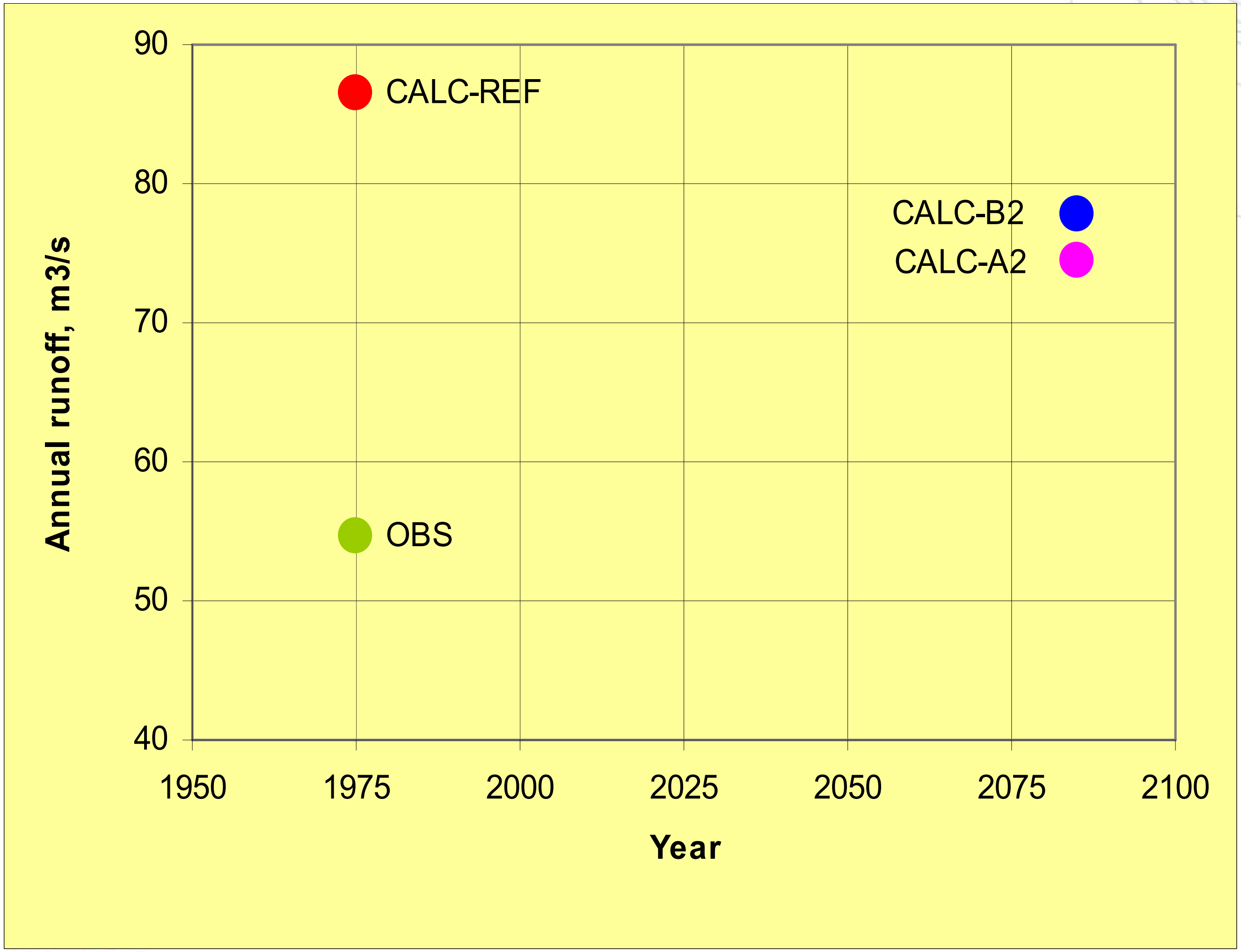
The catchment is divided into hierarchical subbasins downscalable up to the finite element level. The hydrological cycle is resolved for the lowest hierarchical level, the hydrological cycle modelling is coupled with the dynamic routing of the water flow through the network of streams.

Principal components of model

- Surface water model – solves for surface water content (intercepted+ponded).
- Groundwater model – solves for groundwater level
- Flow routing model
- Lake model – solves for waterlevel of lake

Yearly average discharge of river Aiviekste

OBS – observed; CALC-REF – model, RCM T and P for reference period
CALC-B2, CALC-A2 - scenarios



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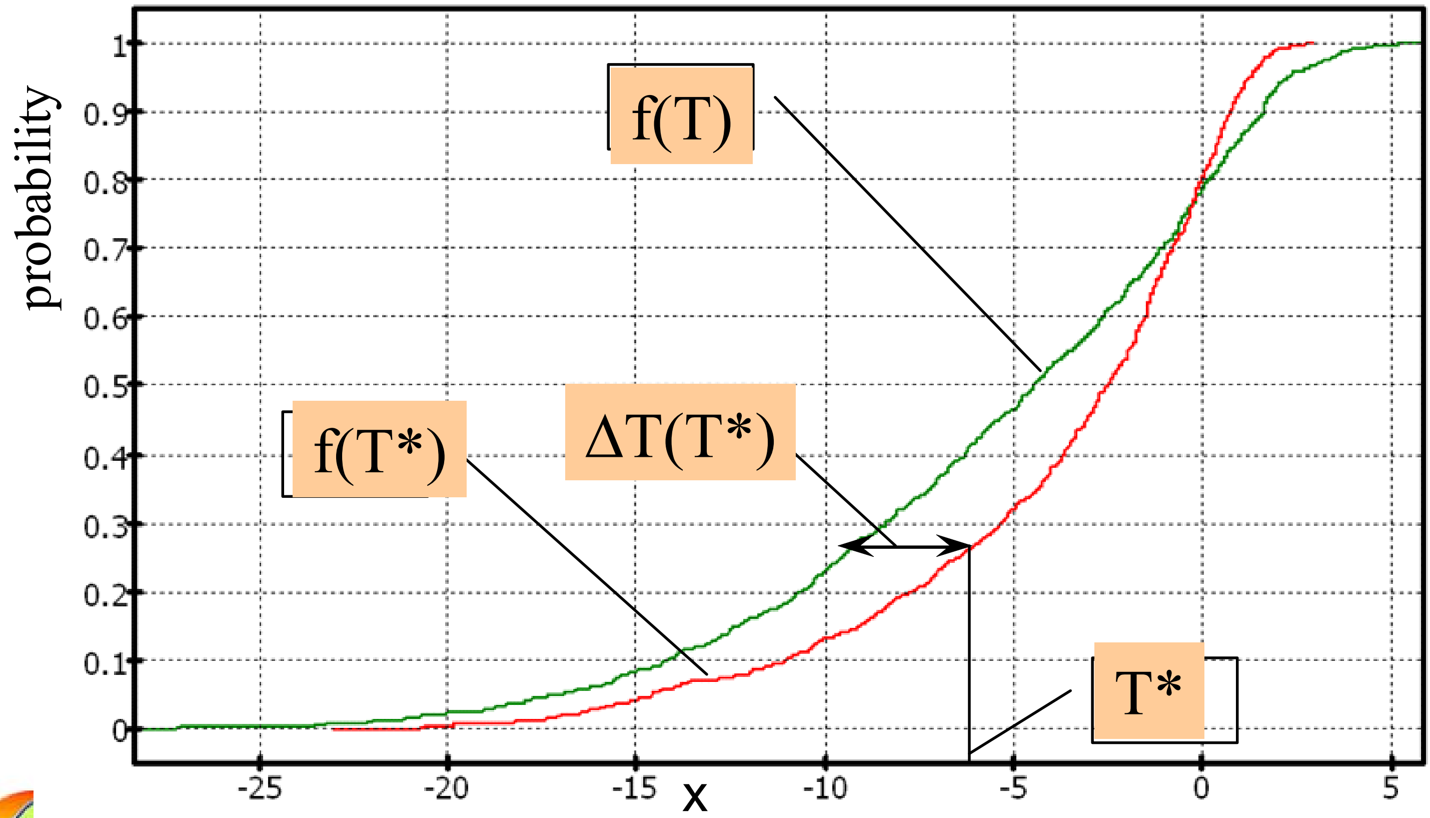
RCM data modification

T – observed temperature, T* - modeled temperature

$$T^*_{\text{mod}}(T^*) = T\Big|_{f(T)=f(T^*)} \Rightarrow \Delta T(T^*)$$



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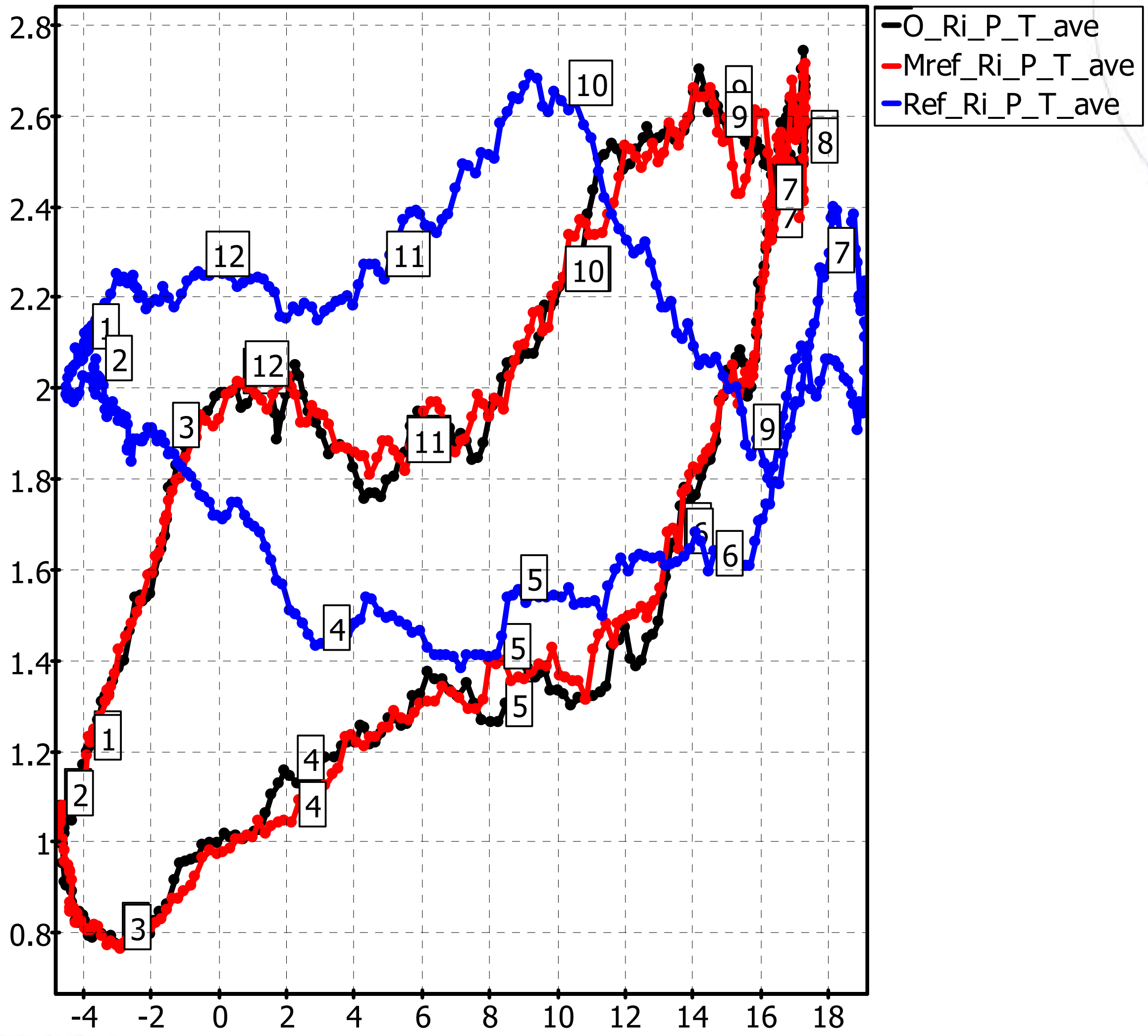
Result of RCM data modification for Riga



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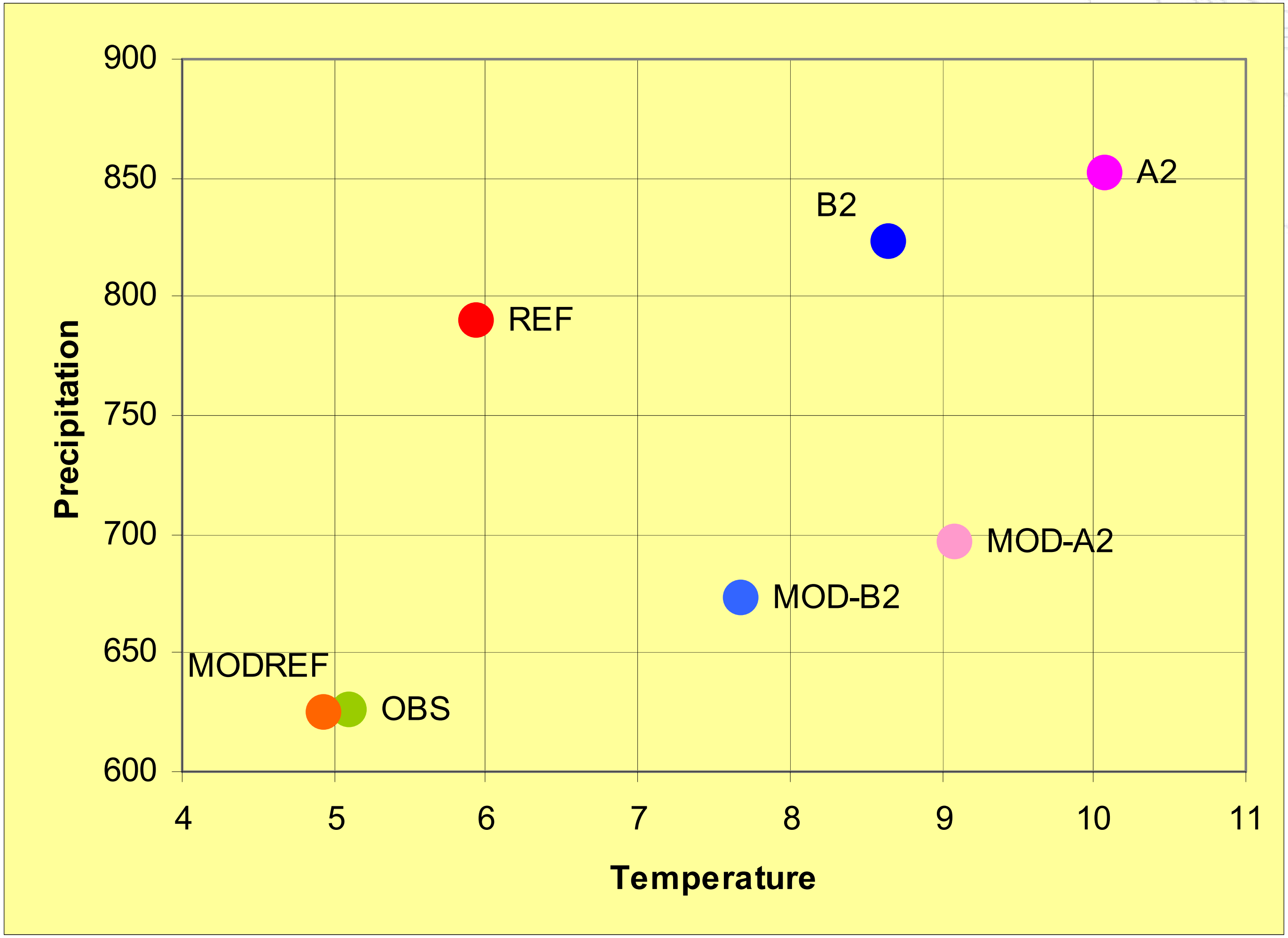
MODIFIED RCM DATA



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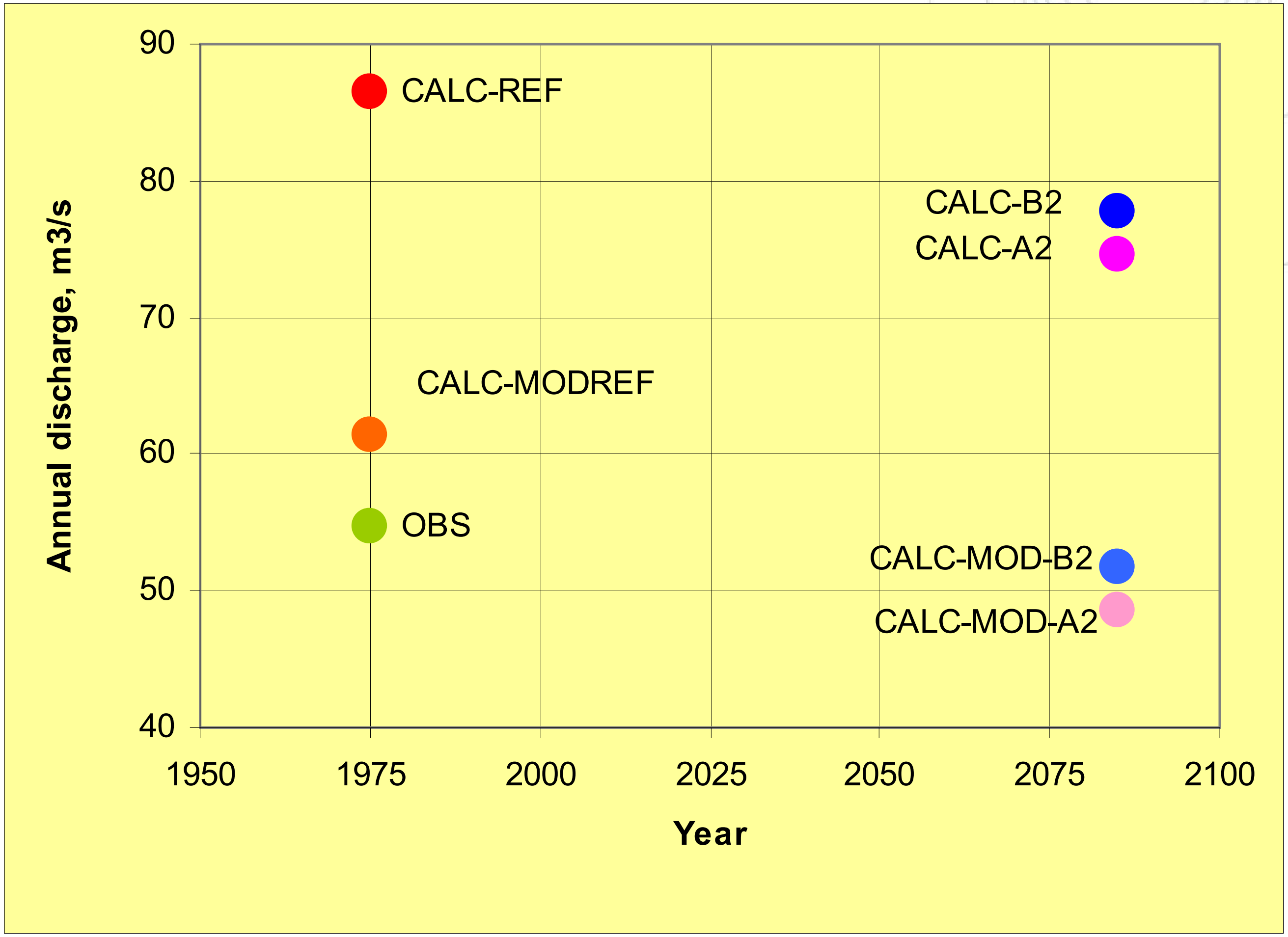
Yearly average discharge of river Aiviekste

- OBS –observed
- CALC-REF – model, RCM T and P for reference period
- CALC-B2, CALC-A2 – scenarios
- CALC-MODEF – model, RCM modified T and P for reference period
- CALC-MODB2, CALC-MODA2 – scenarios with modified data



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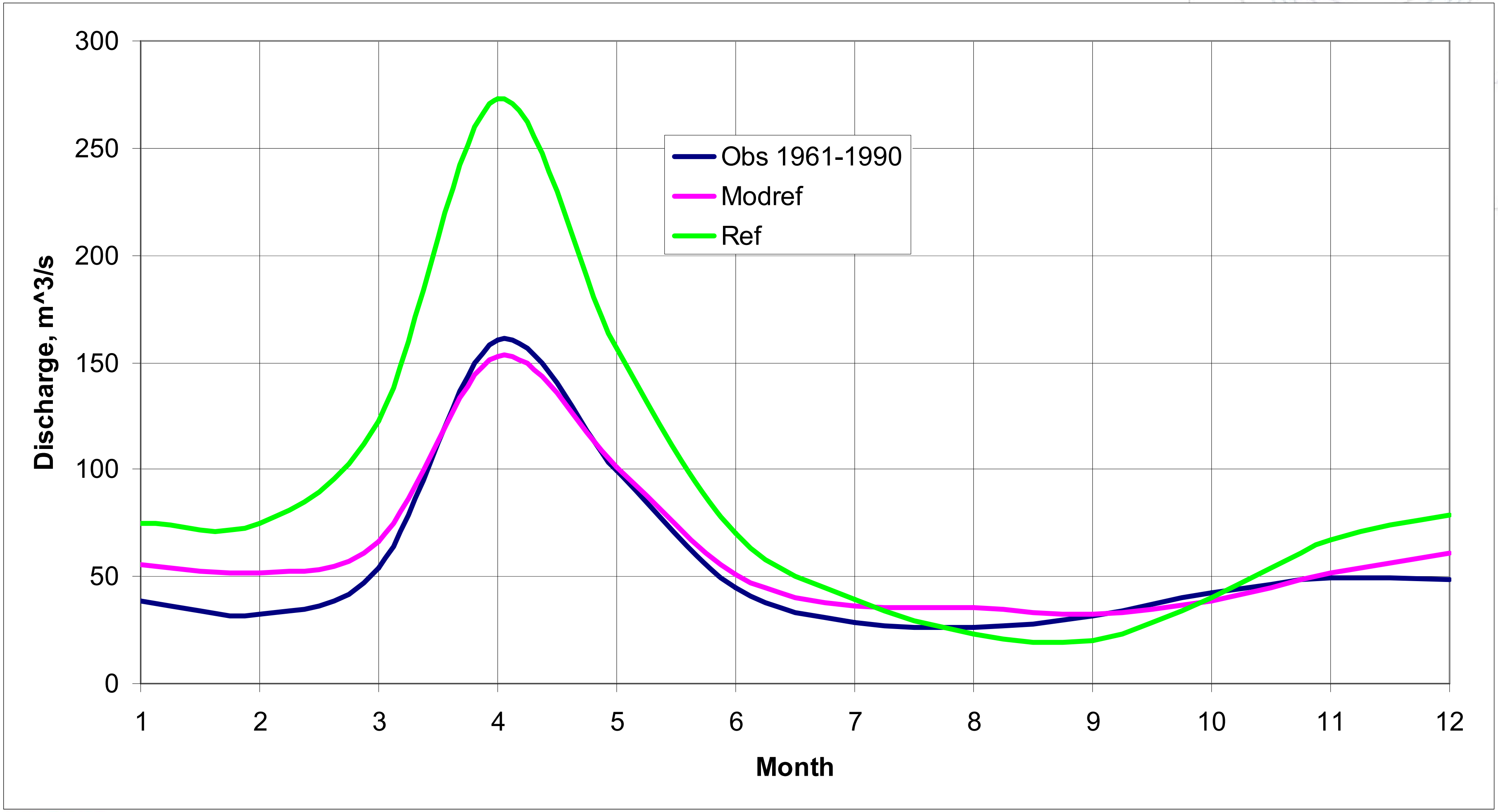
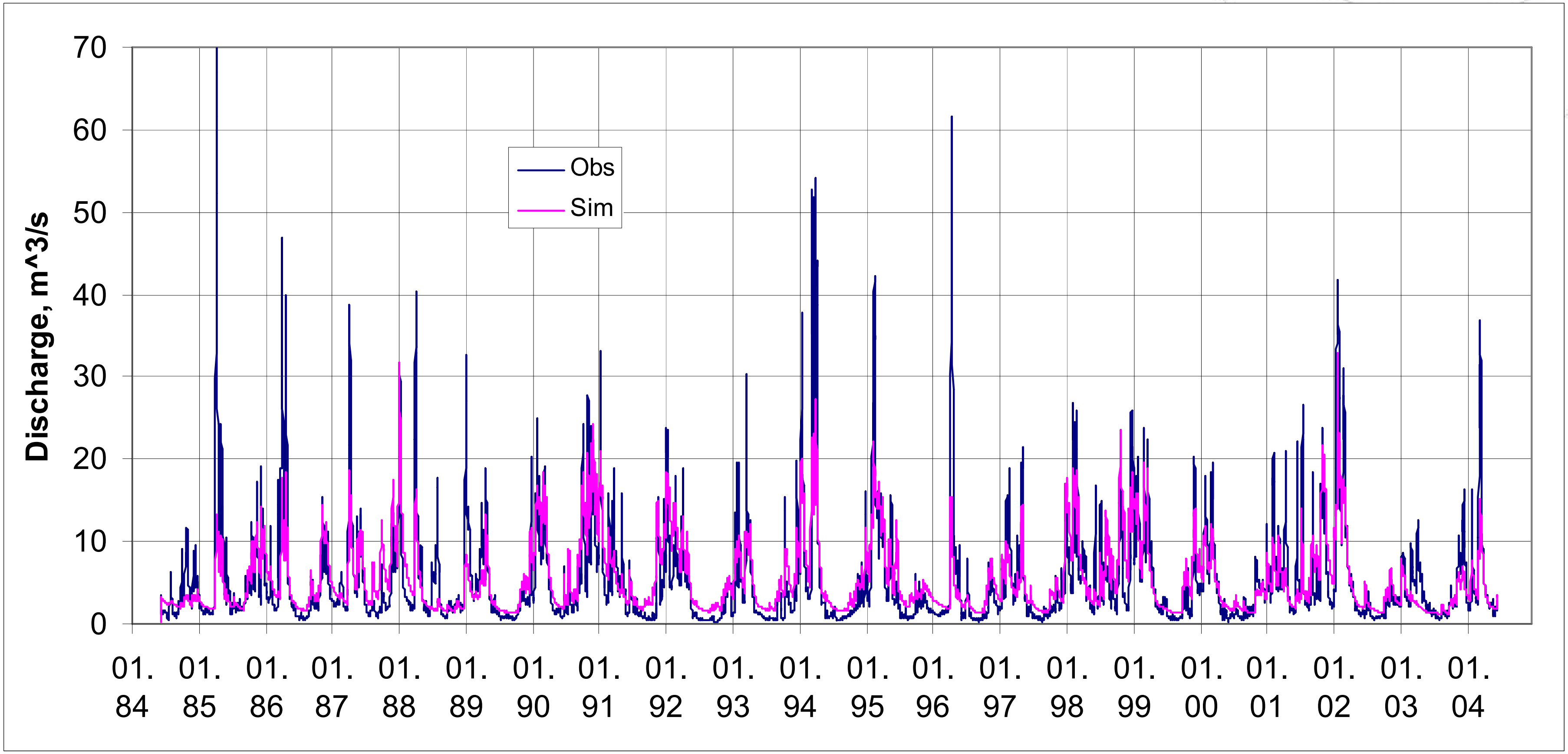
Monthly average discharge of river Aiviekste



MIKE SHE

Bērze basin (~1000 km², 1984-2004, R2=0.565)



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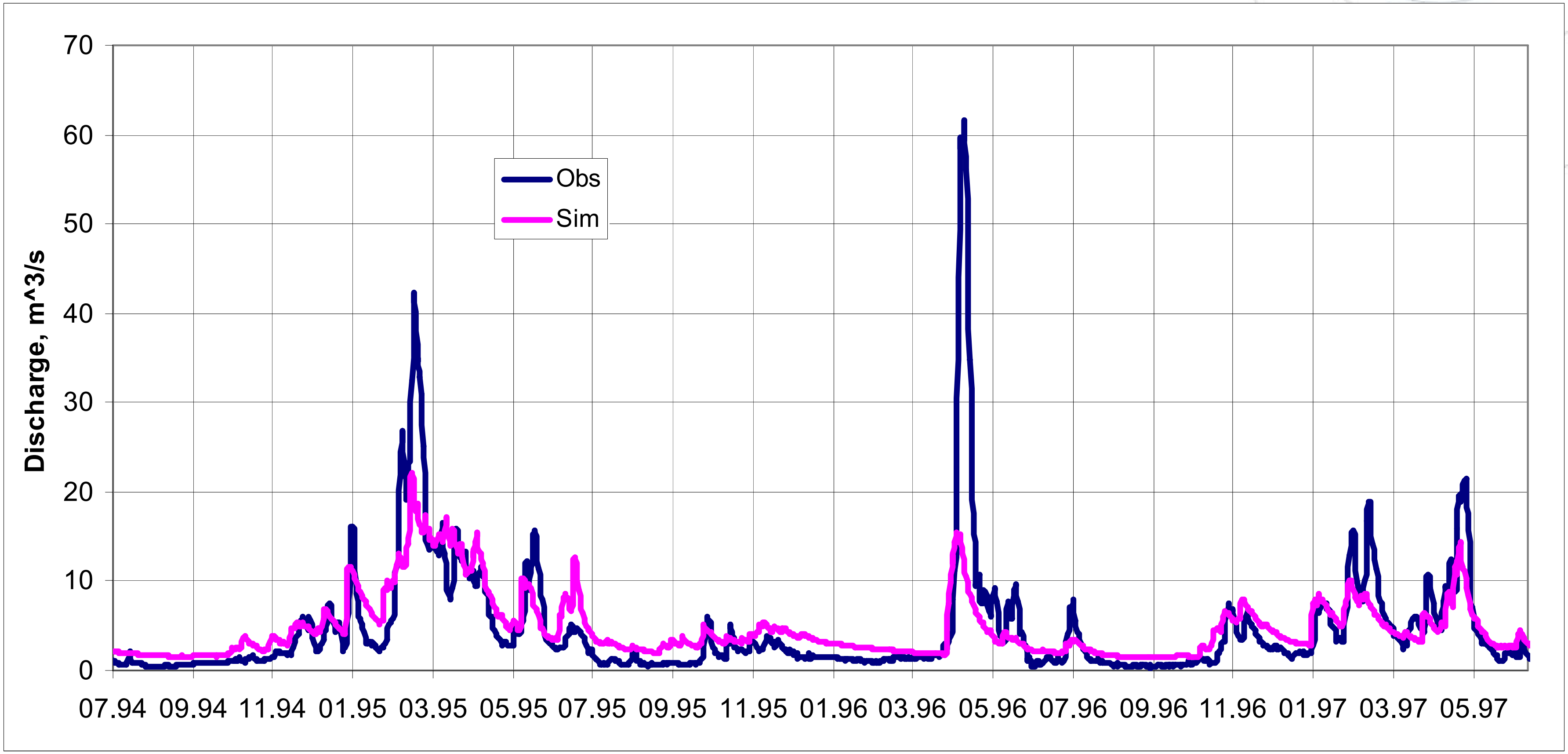
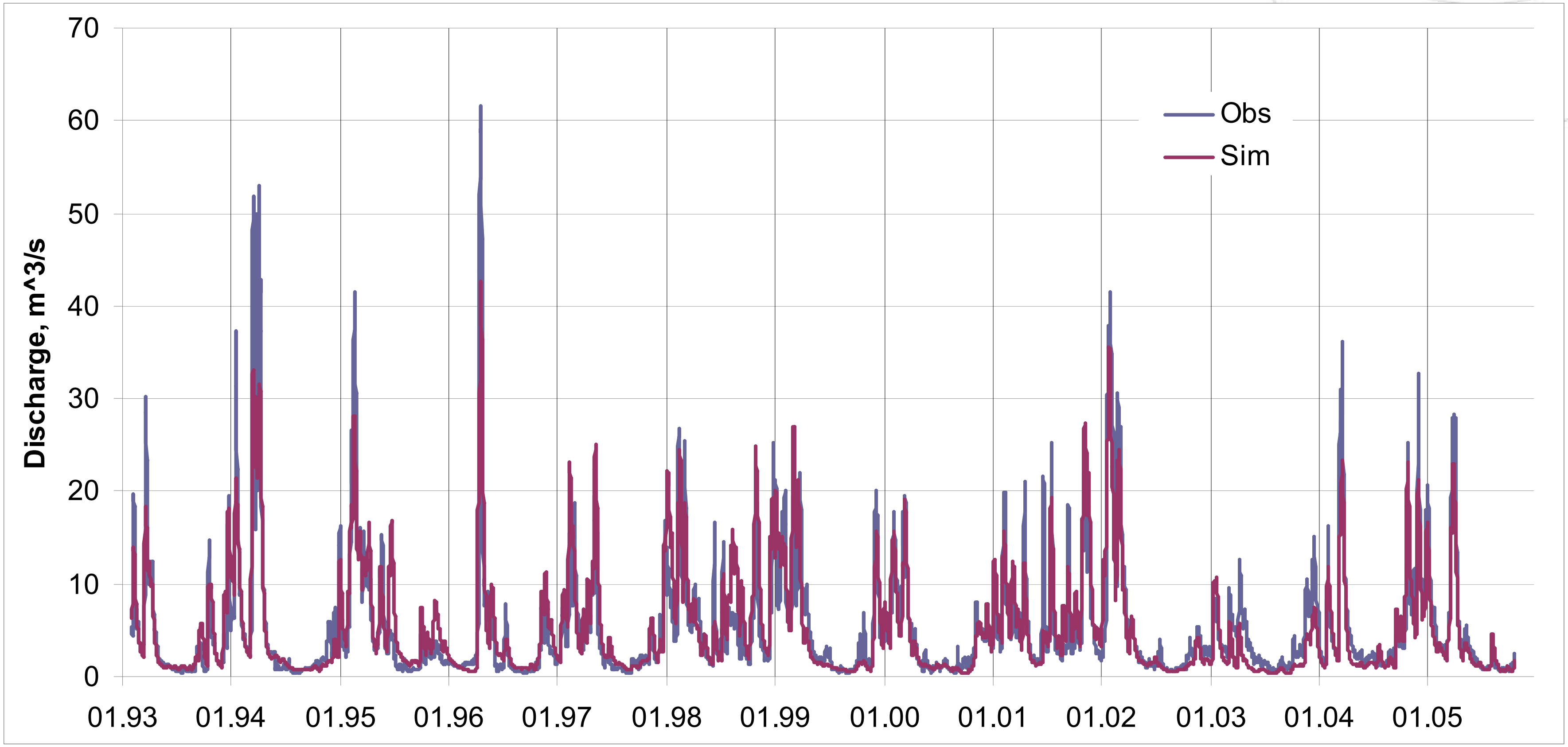
MIKE SHE

Spring flood underestimated – model limitation



MIKE BASIN

Bērze basin (~1000 km^2, 1993-2005, R2=0.794 !)



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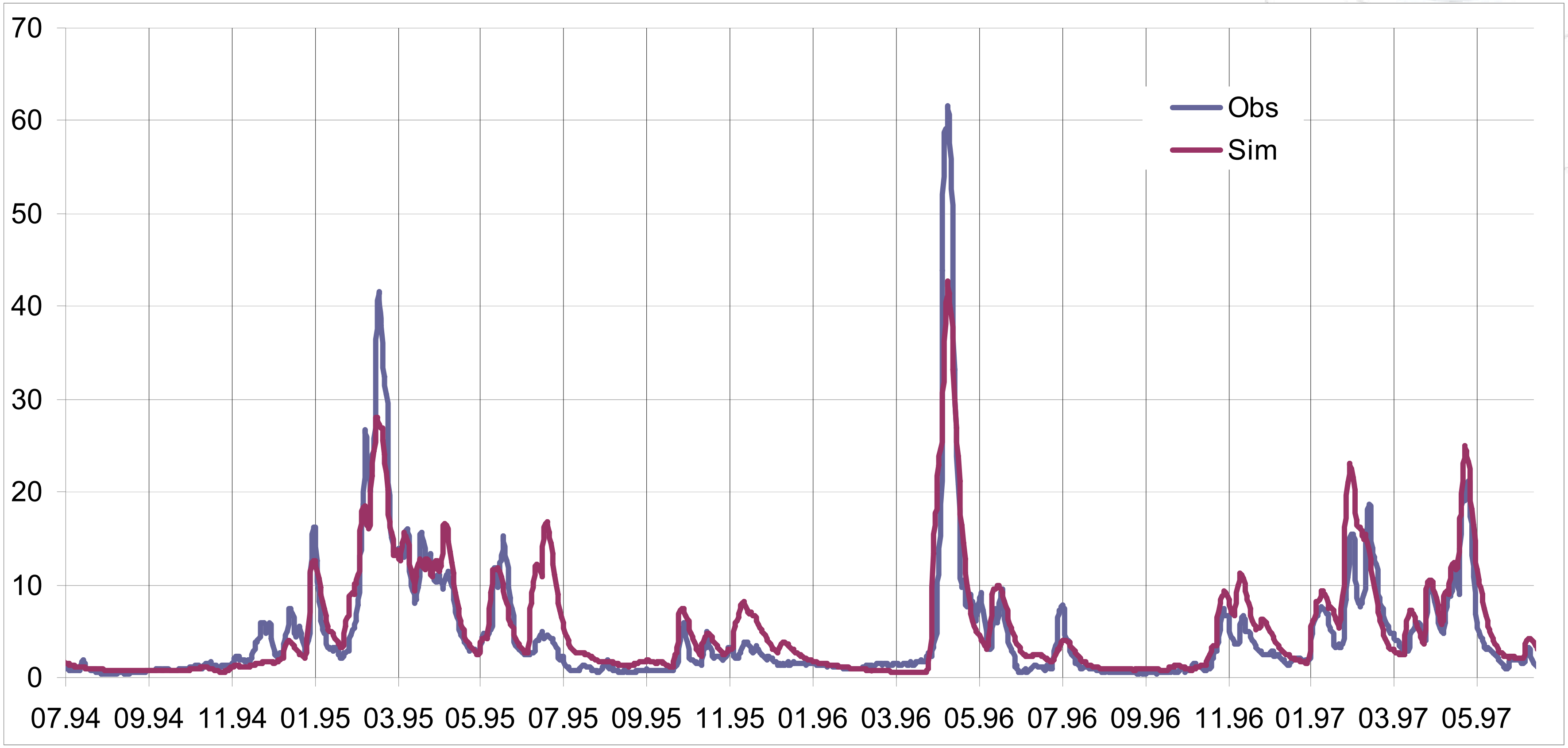
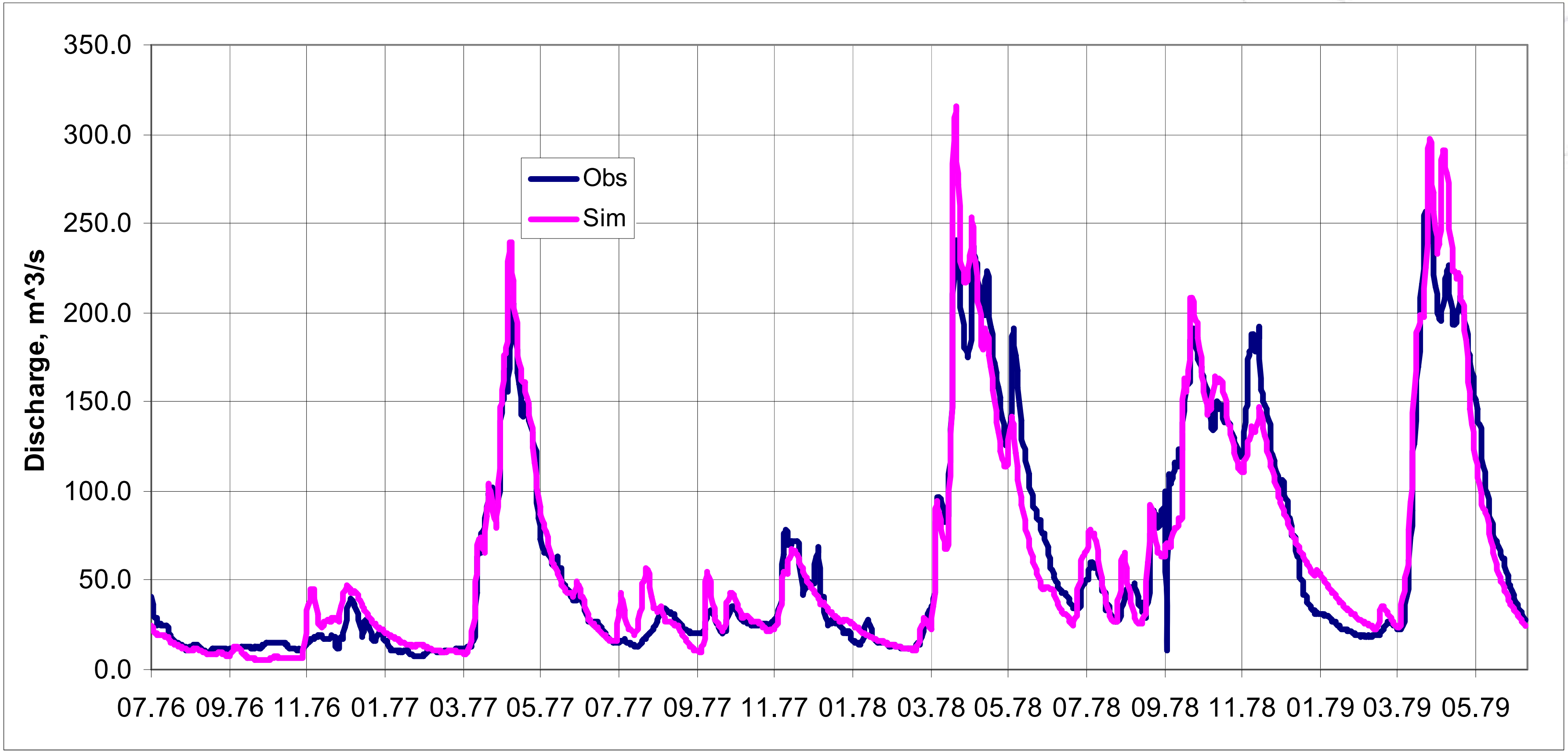
MIKE BASIN



70
60
50
40
30
20
10
0
Obs
Sim
07.94 09.94 11.94 01.95 03.95 05.95 07.95 09.95 11.95 01.96 03.96 05.96 07.96 09.96 11.96 01.97 03.97 05.97

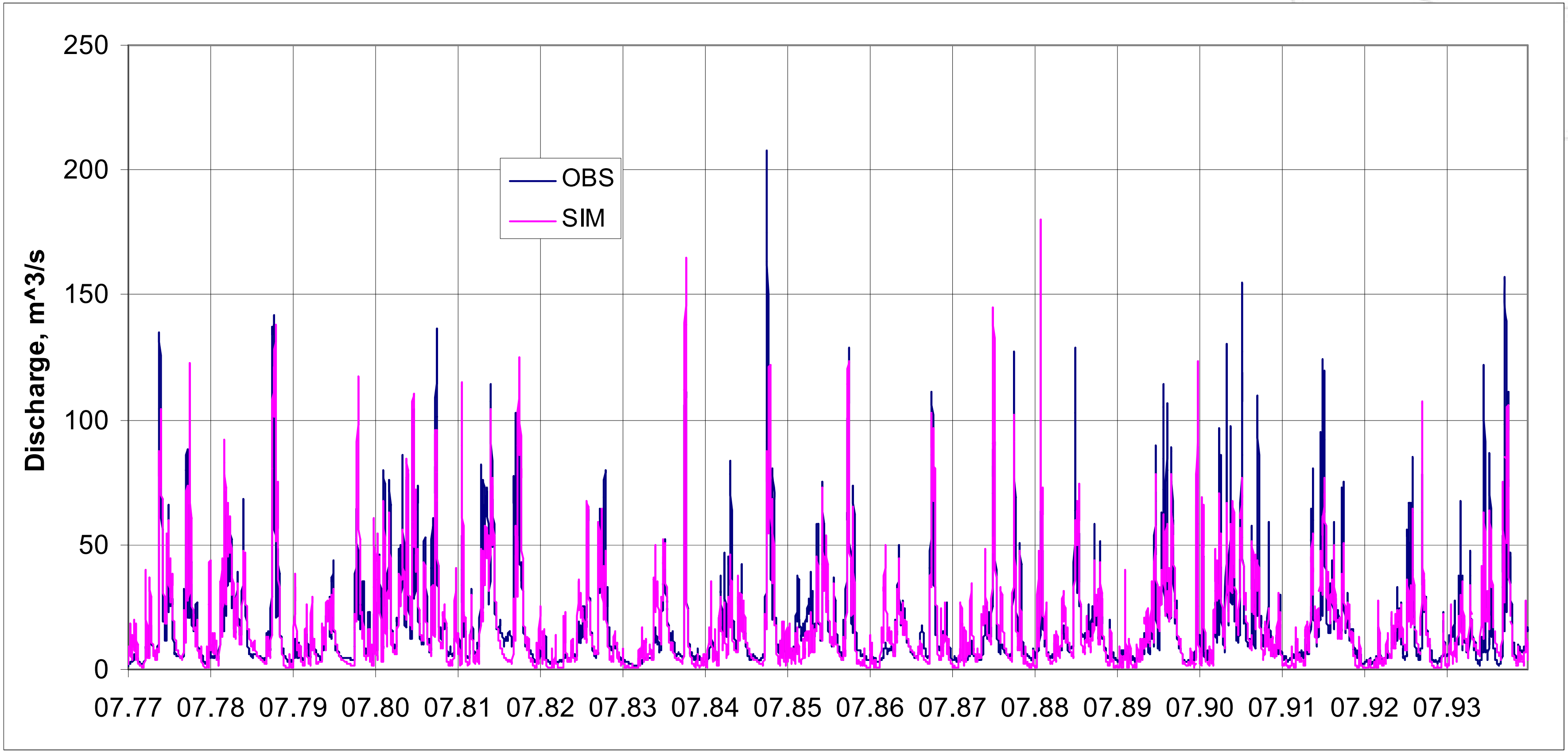
FIBASIN

Aiviekste basin (~10000 km^2, 1976-1979, R2=0.922)



FIBASIN

Abava basin (~2000 km^2, 1977-1994)



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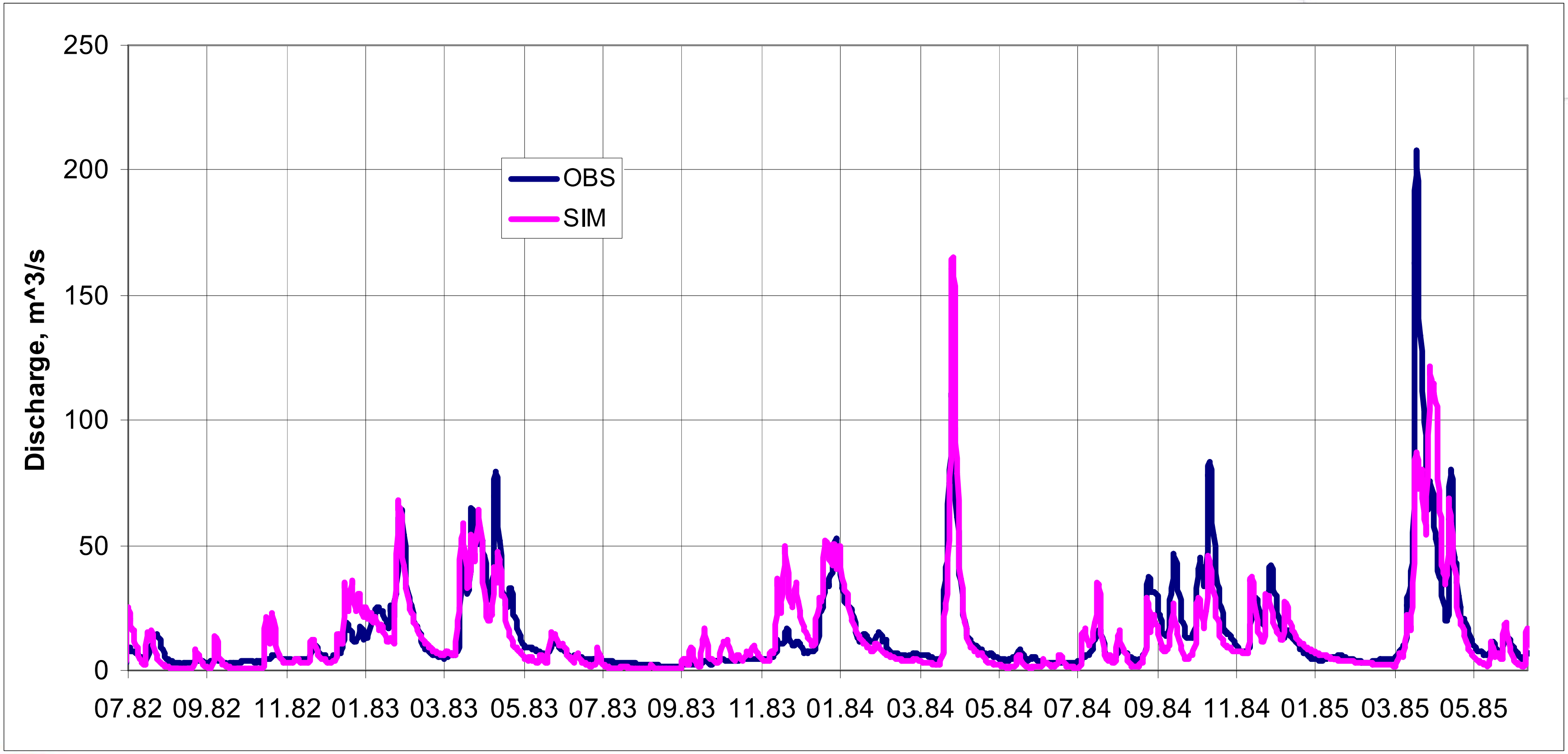
FIBASIN Abava basin, R2=0.675 achieved using calibration parameters of Aiviekste basin!

We may expect the same parameter set for whole Latvia



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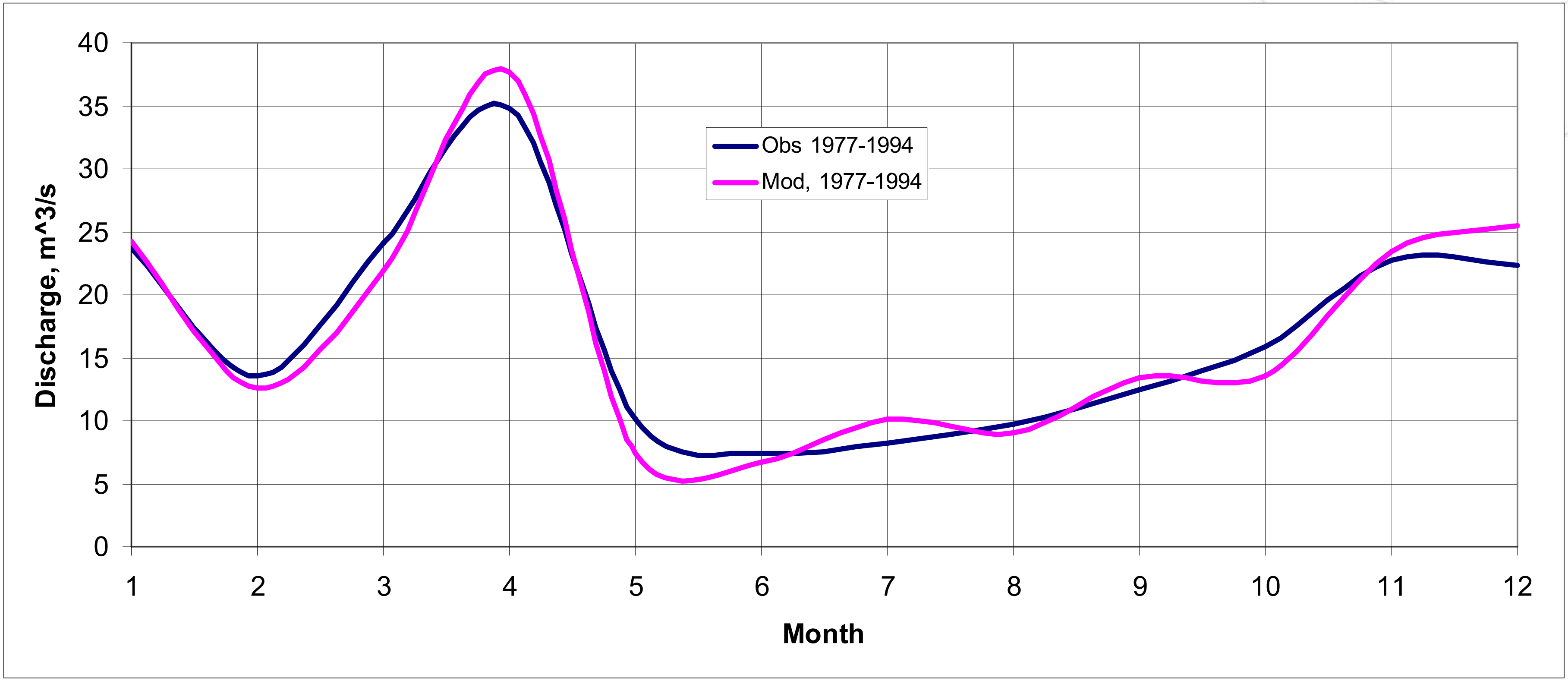
FIBASIN Abava basin Monthly data:

Model vs observed discharge



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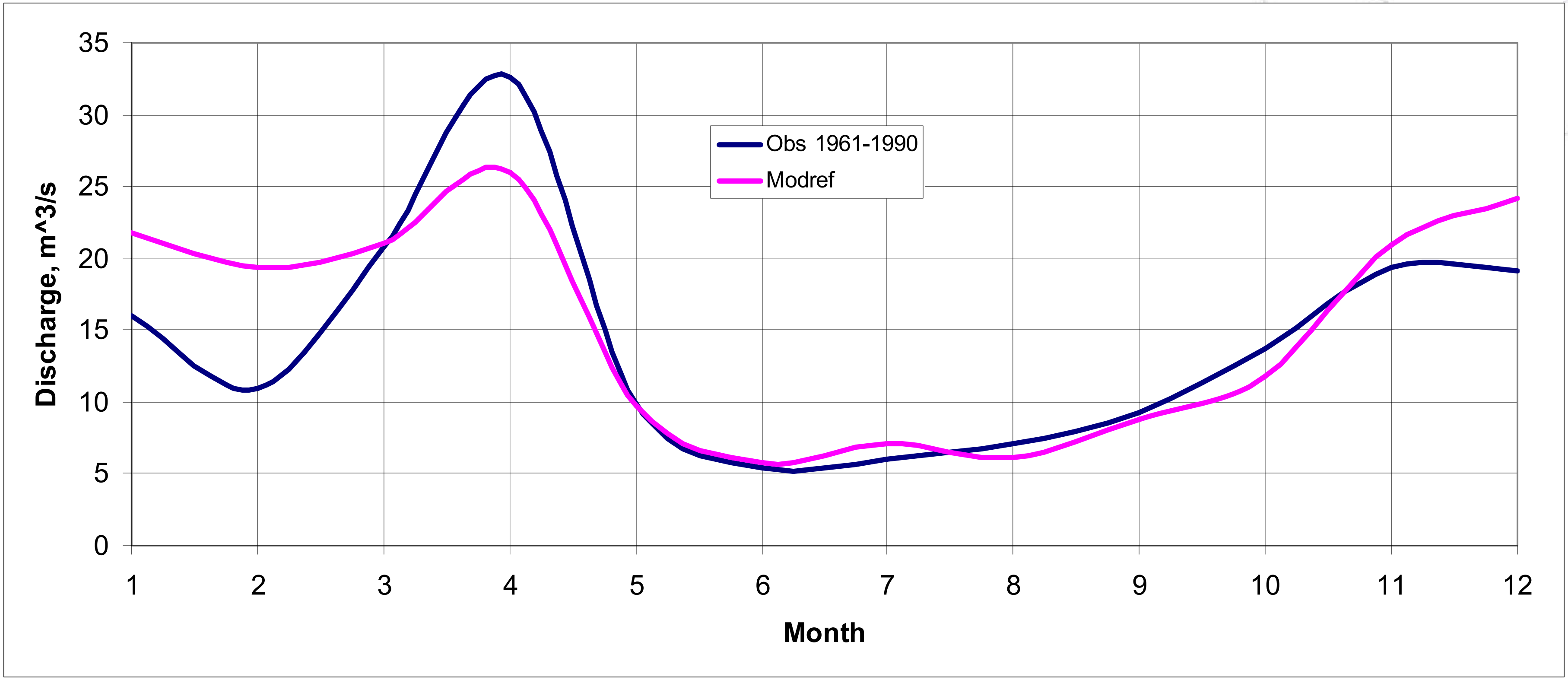
FIBASIN Abava basin monthly data

Observed vs. Modelled discharge using modified RCM input



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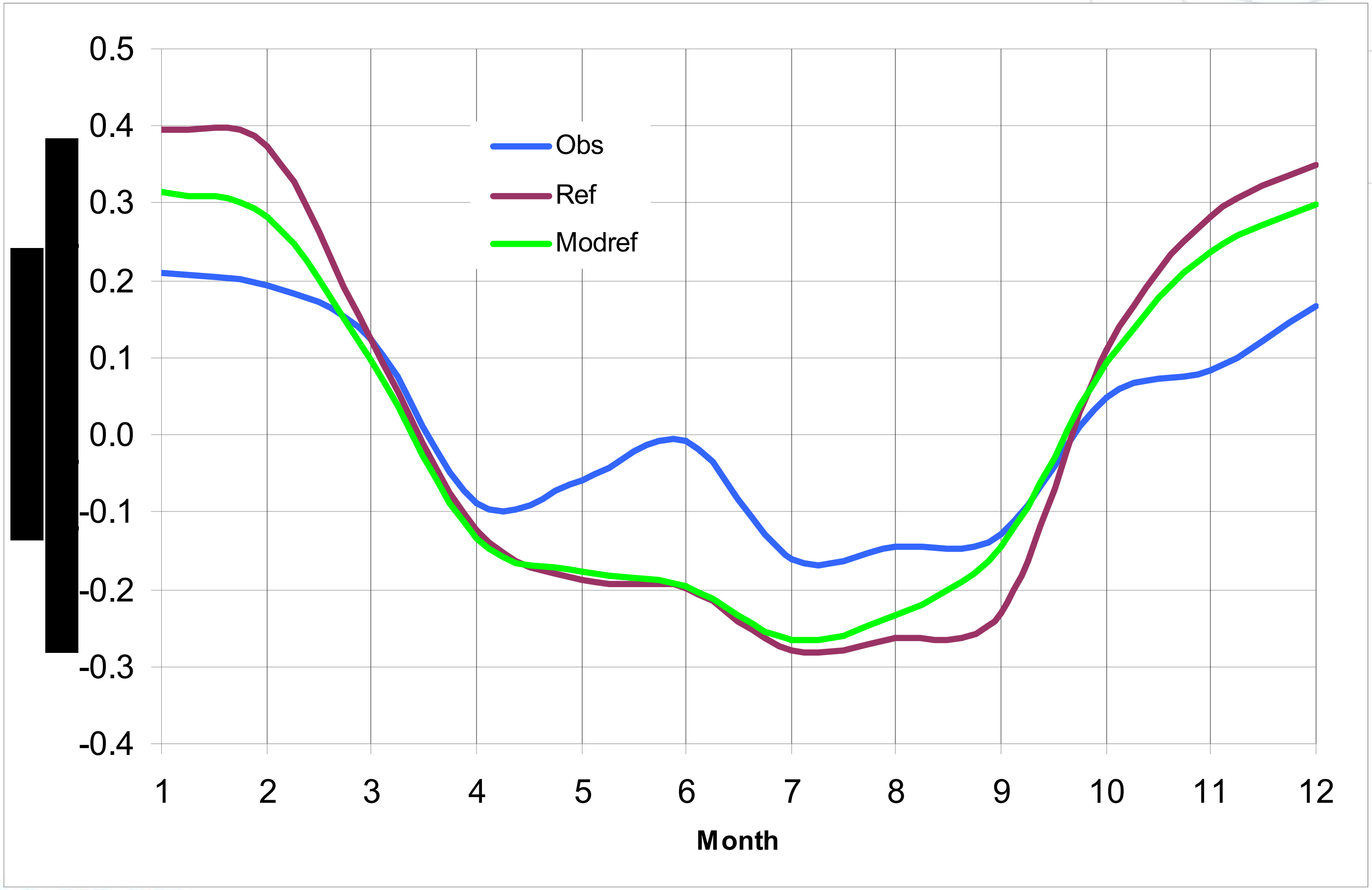
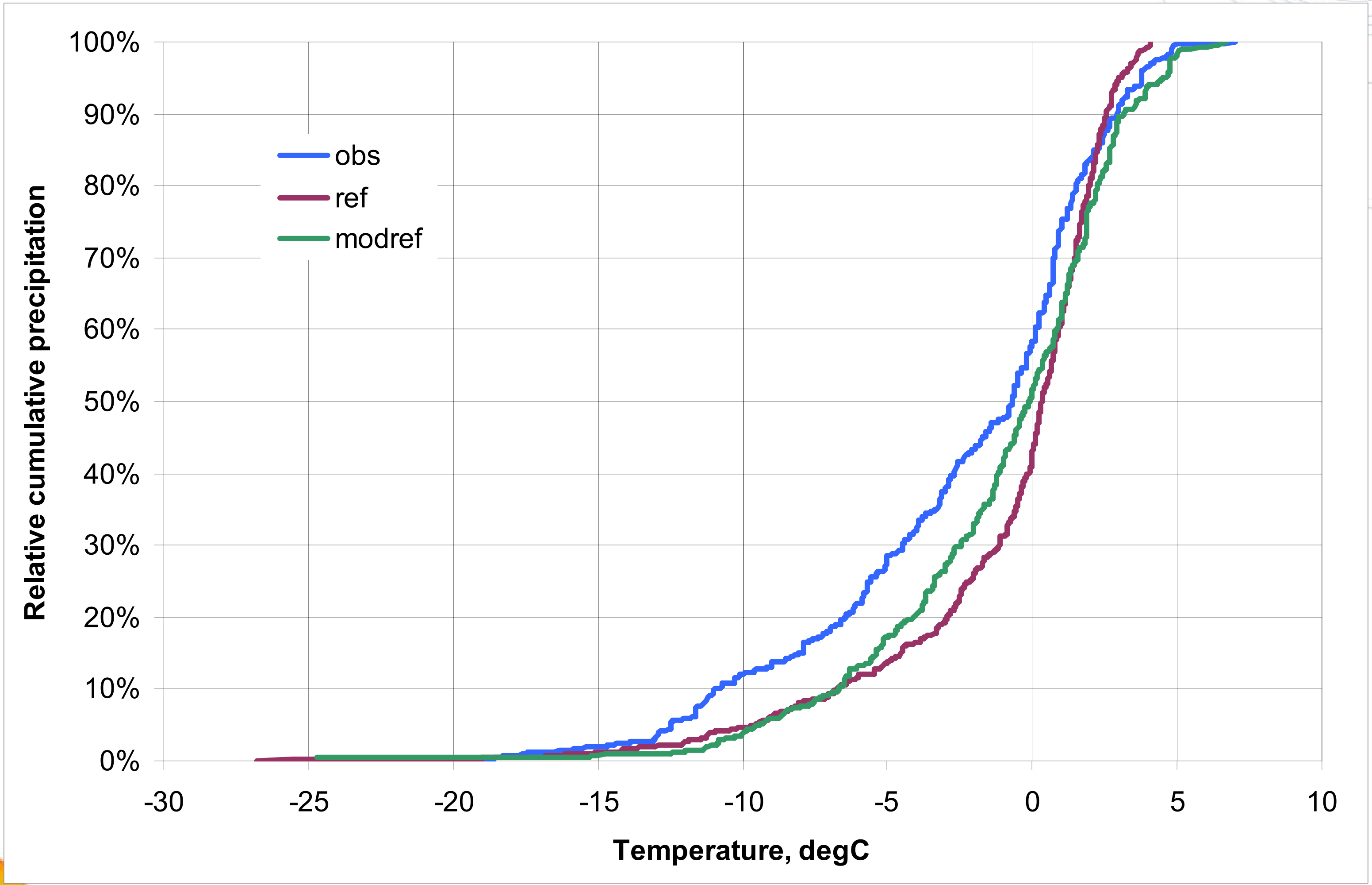
2nd order non-compliance found in RCM data

RCM overrestimates correlation between T and p



2nd order non-compliance found in RCM data

For January we are missing.... 16% of snow. NO SOLUTION YET



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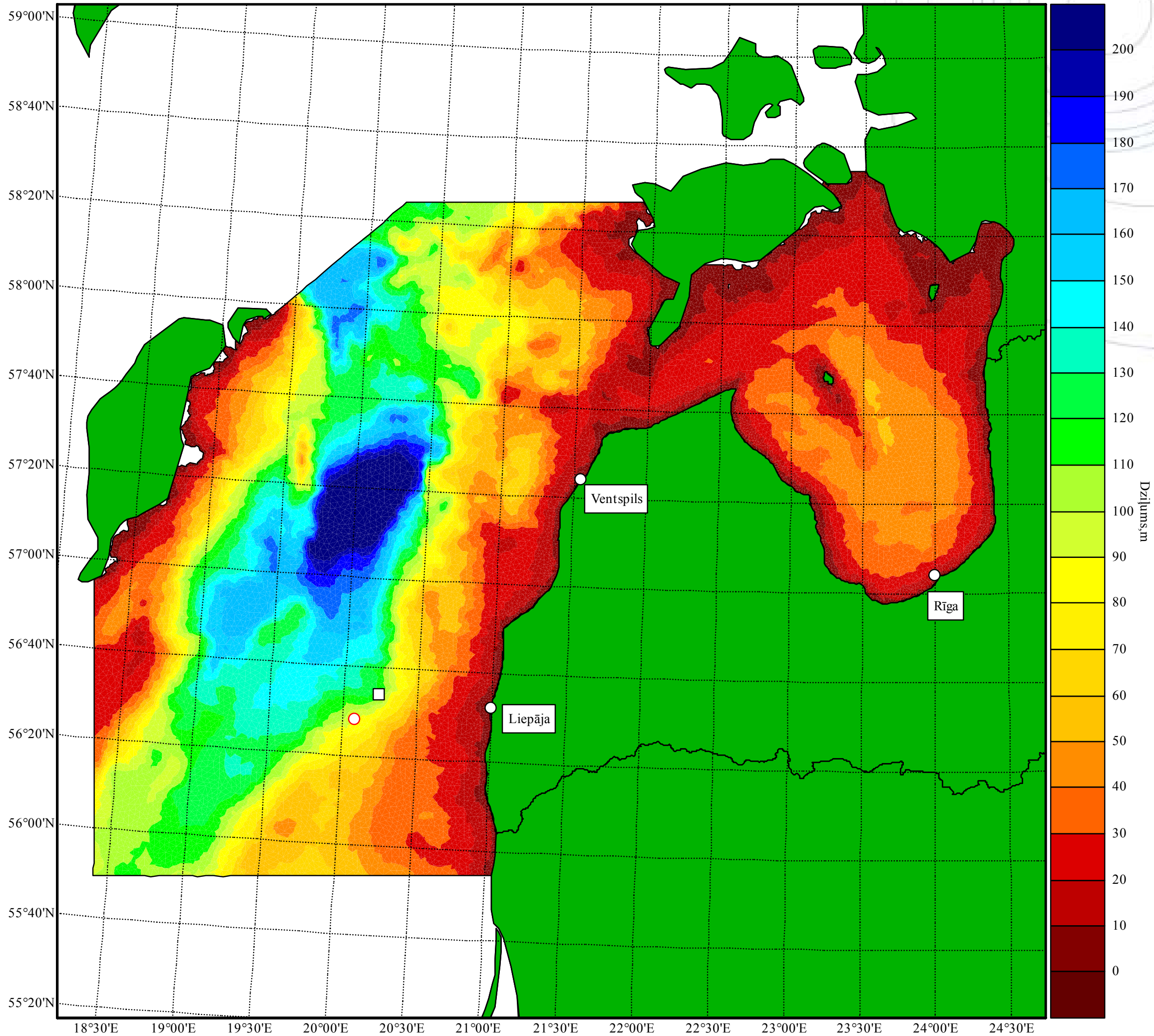
SEA State model: domain



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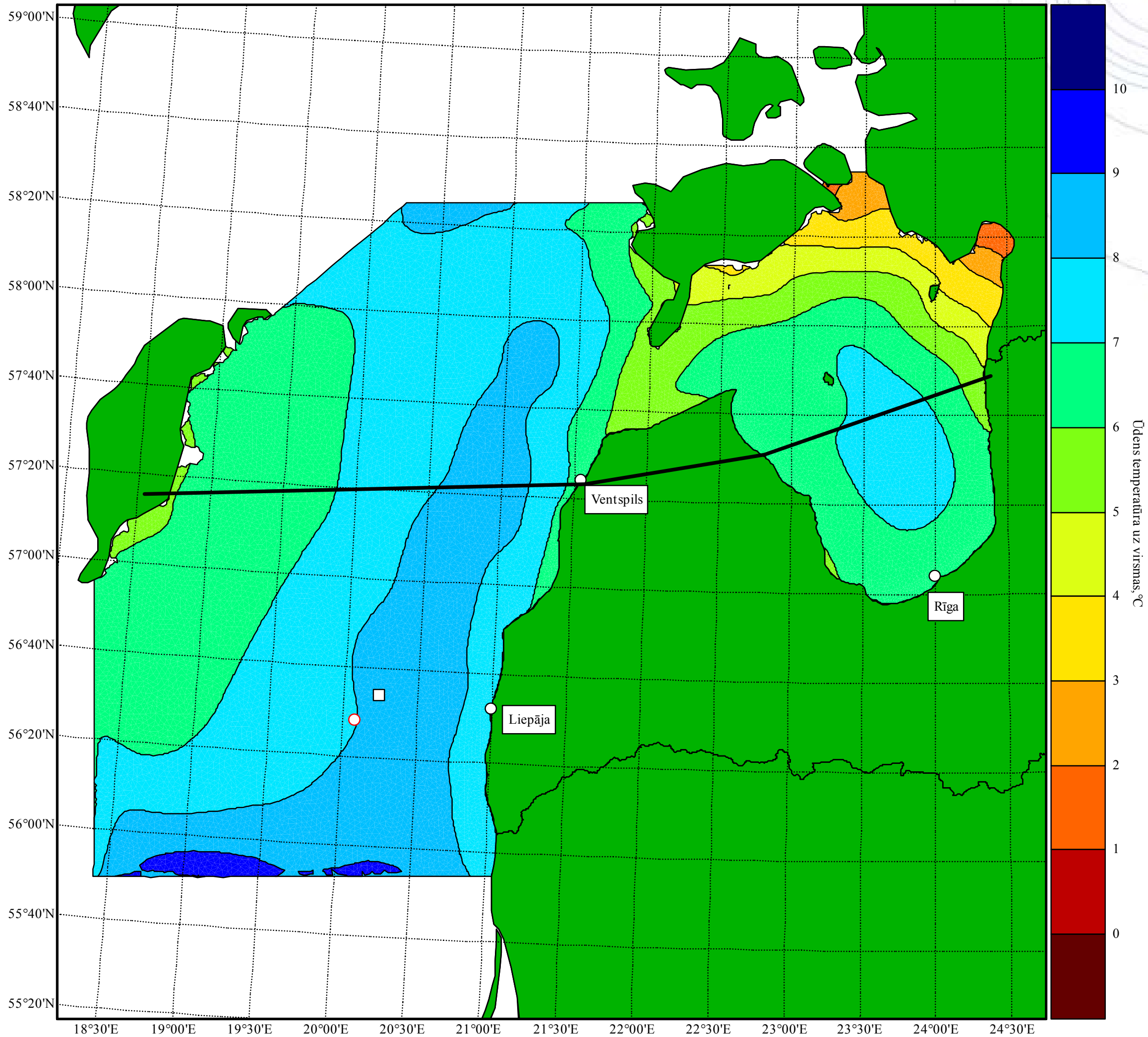
Water temperature Oct07



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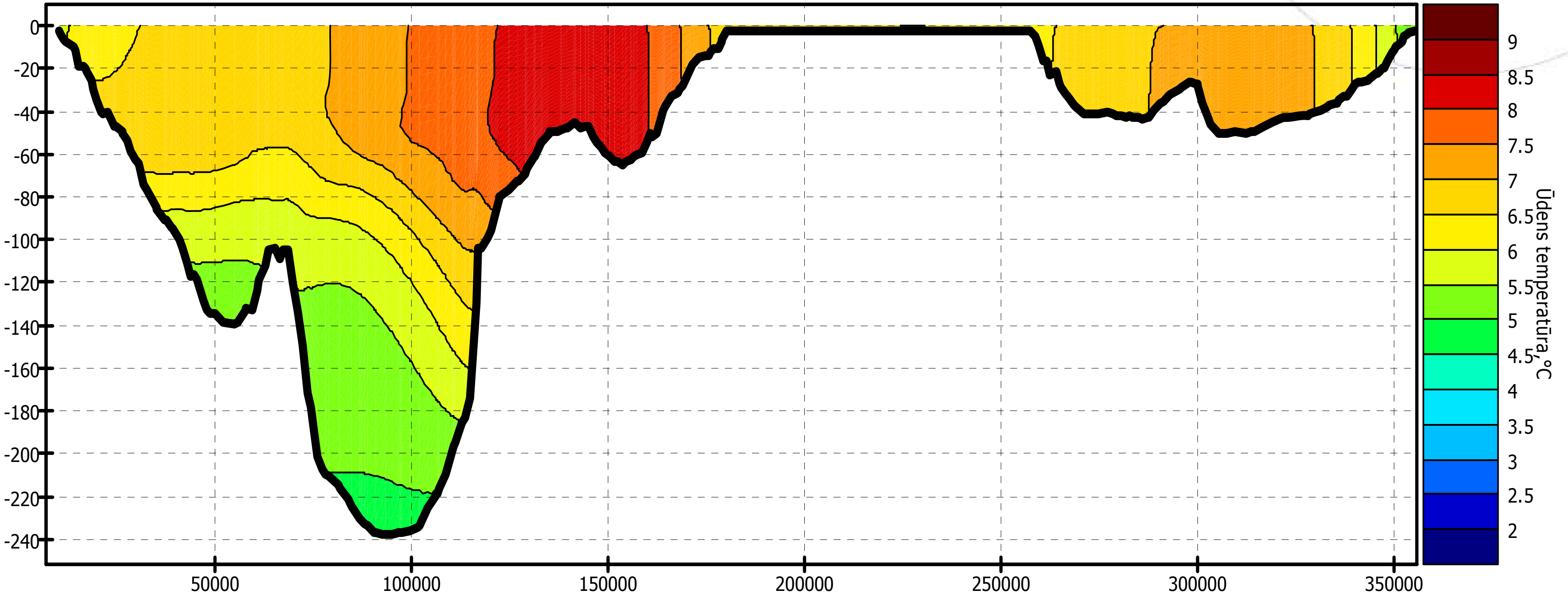
Water temperature / Oct07



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- Aigars Valainis, modeler
- [Jūlija Gaidelene, data business, quit in 2007]
- Maksims Igoņins, modeler [started in 2008]