Evaluation of climate change impact on soil and snow processes in small watersheds of European part of Russia using various scenarios of climate

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Key objective

Necessity of understanding the effect of climate change in the hydrological processes

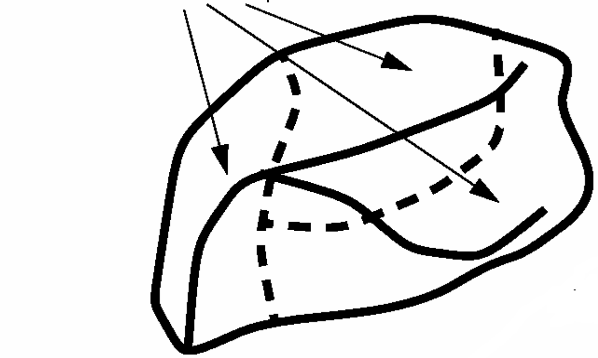
requires

The appropriate instrument for its quantitative estimation

Tasks

- Application and testing of the Deterministic-Stochastic Modelling system
- Assessment the possible change in soil and snow processes according to IPCC climate change scenarios

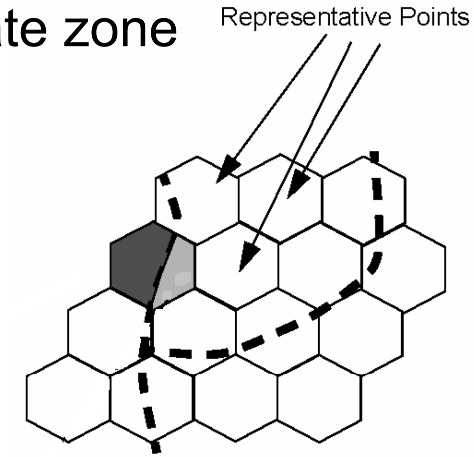
Deterministic hydrological model “Hydrograph”



a) Watershed and runoff formation complexes

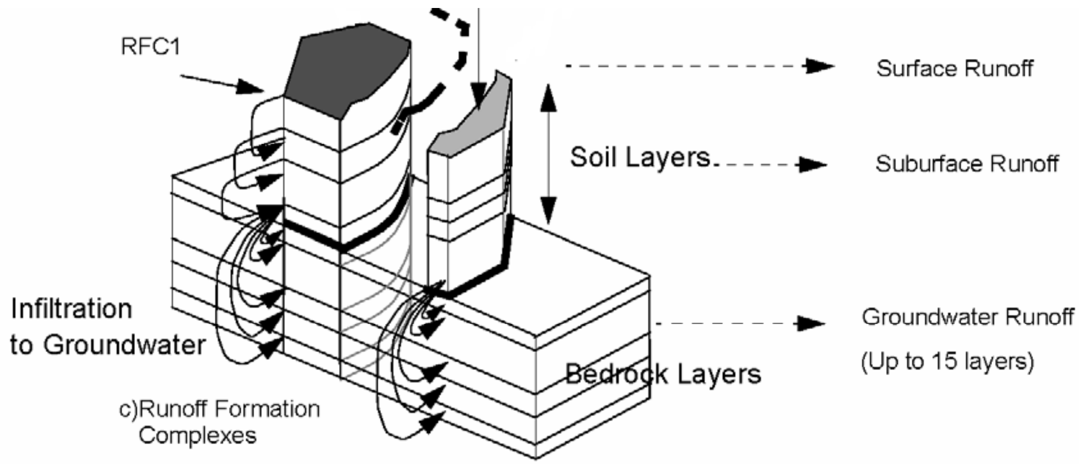
- Can be applied in any landscape and climate zone
- Basins of any size
- Distributed

parameters



b) Watershed schematization

- Model input – air temperature, relative humidity, precipitation
- Time step – day
- Model output – water balance elements, runoff hydrograph, state variables



c)Runoff Formation Complexes

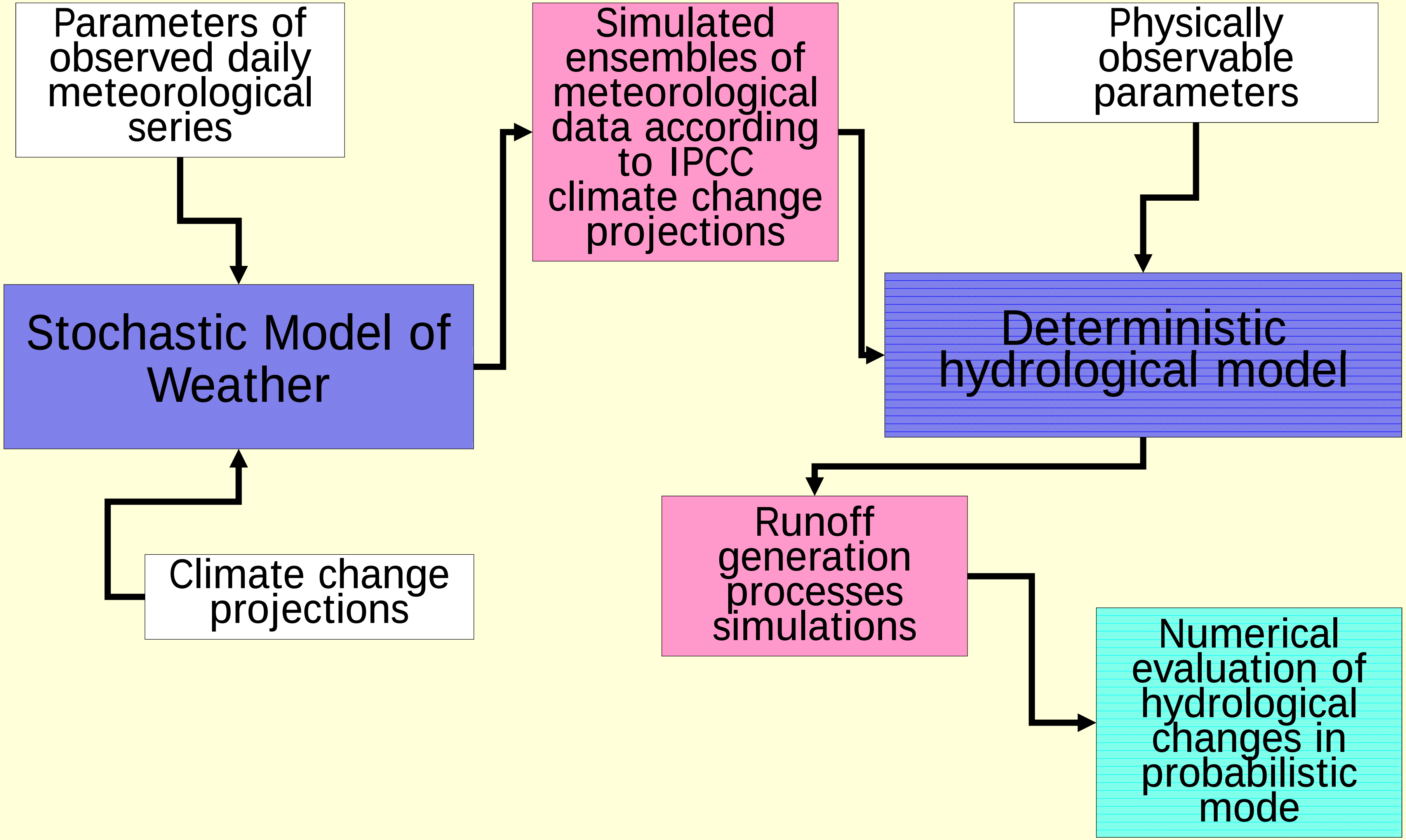
Stochastic Model "Weather"

- Simulation of daily precipitation, temperature and relative humidity
- Simulation of annual and intra-seasonal variations
- Simulation for hexagonal system of representative points
- Spatial and temporal correlation of meteorological elements

Parameters are estimated from observed series of meteorological data

Parameters <u>may be modified</u> according to climate change projections

Research strategy



Objects of research

1. Nizhnedevickaya station

- Don river tributary – river Devica
- 550 mm per year
- Forest-steppe

2. Podmoskovnaya station

- Volga middle course
- 650 mm per year
- Mixed forest

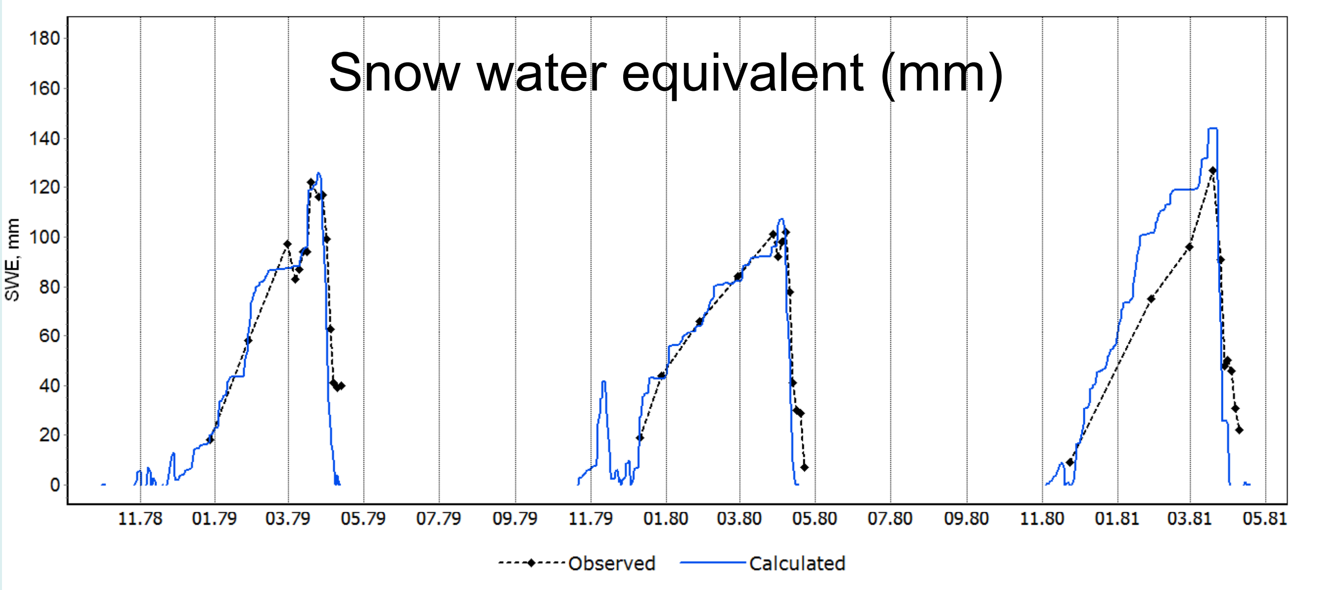
3. Valday station

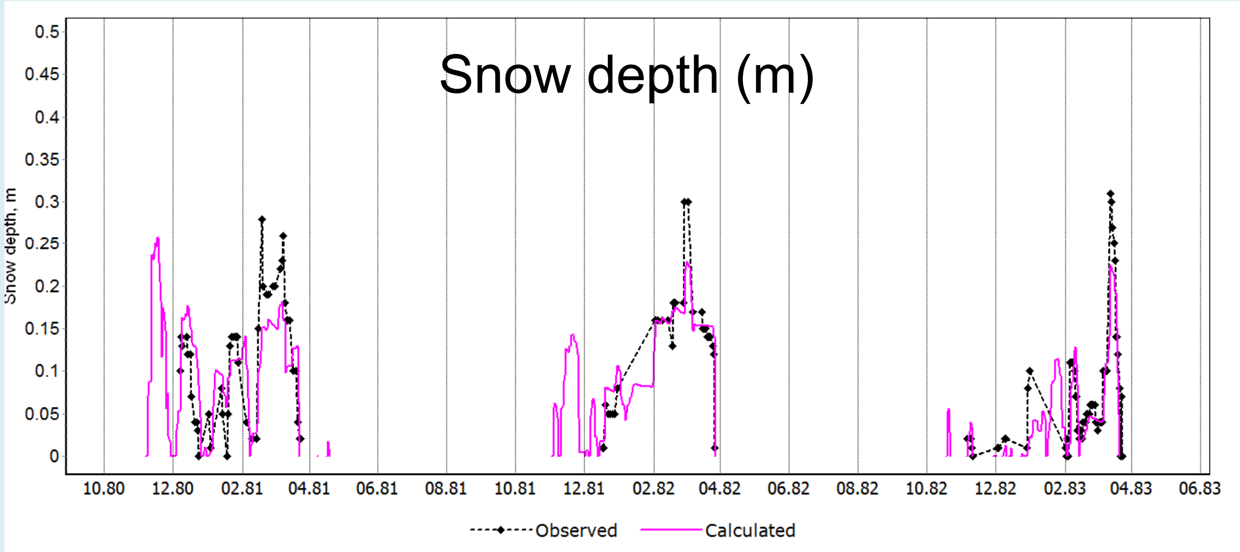
- Upper Volga
- 820 mm per year
- Taiga

Modelling results: snow

using historical meteorological data

Podmoskovnaya station, 1979–1981

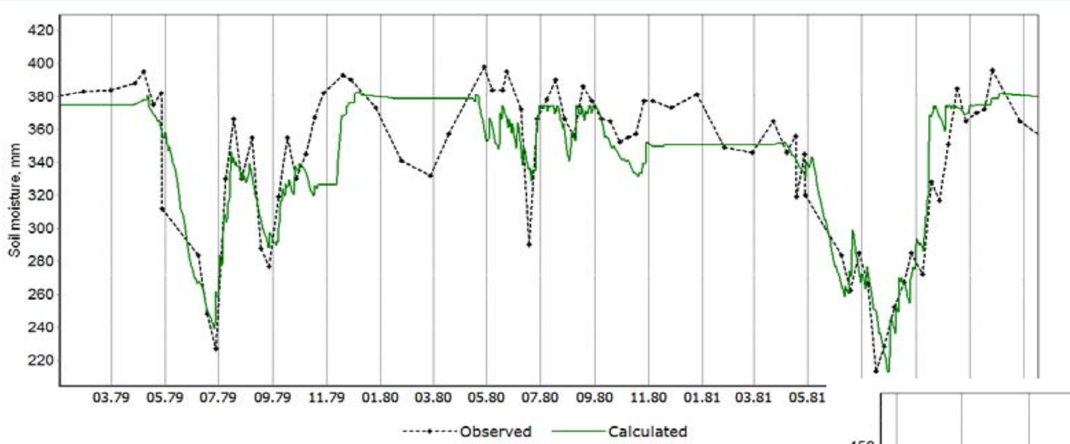




Niznedevickaya station, 1980–1983

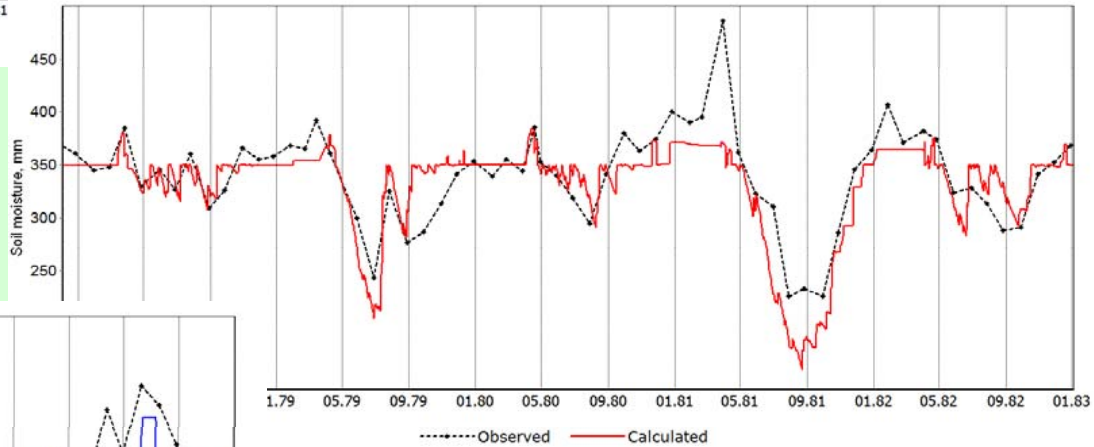
Modelling results: soil moisture in 1 m layer

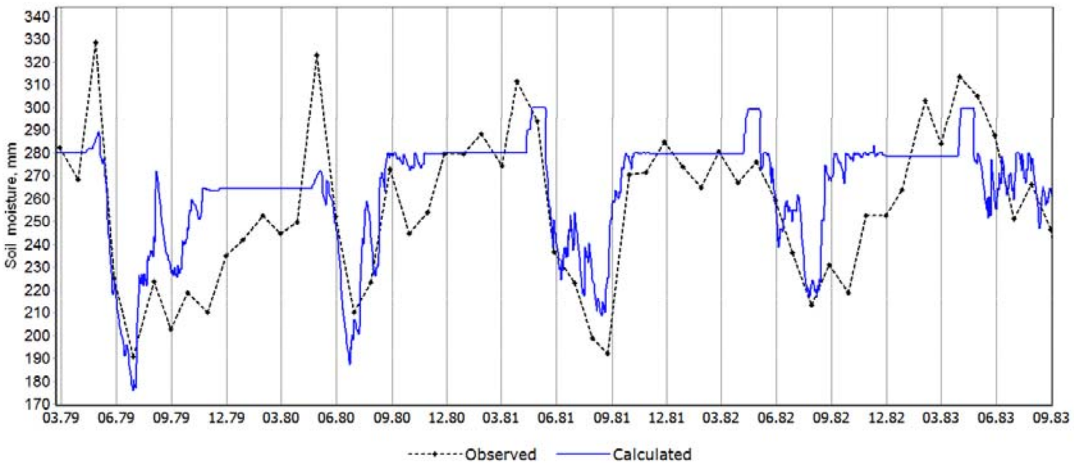
using historical meteorological data



Podmoskovnaya station, 1979–1981

Nizhnedevickaya station, 1979–1983

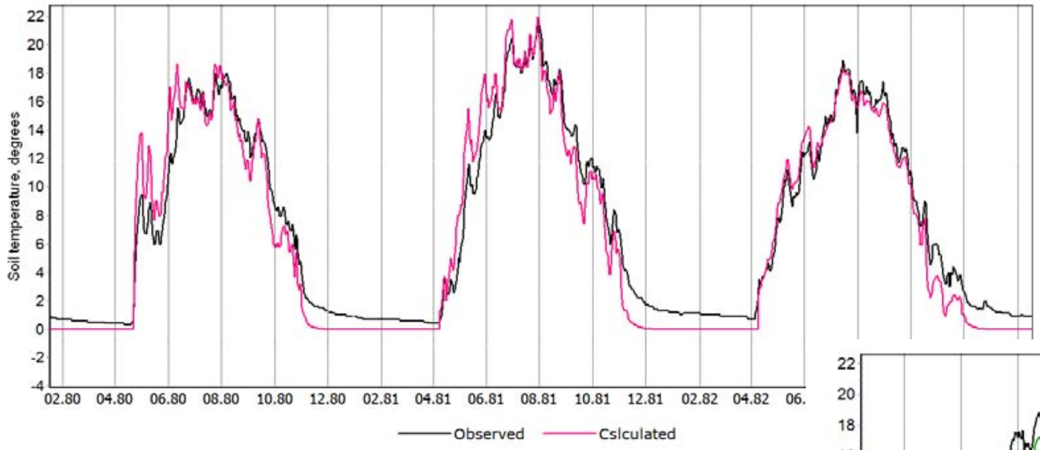




Valday station, 1978–1983

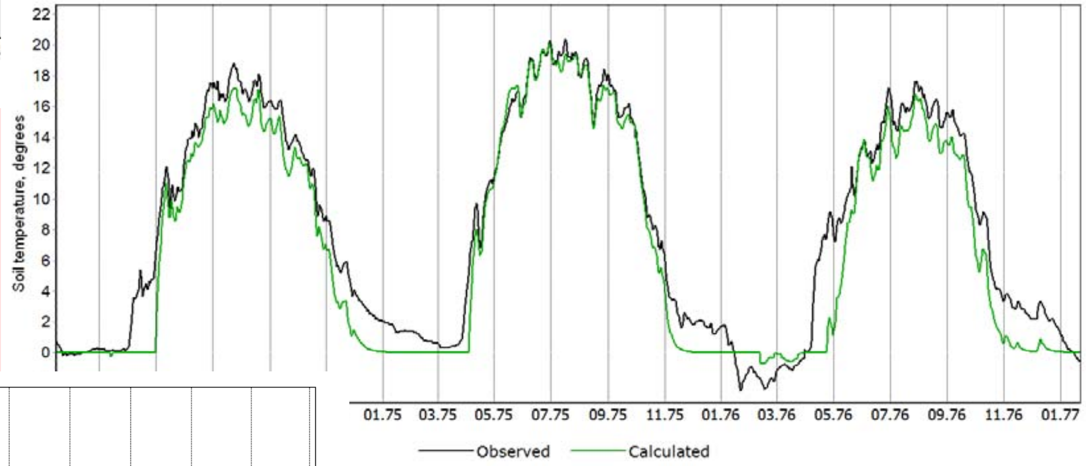
Modelling results: soil temperature at 0,4 m depth

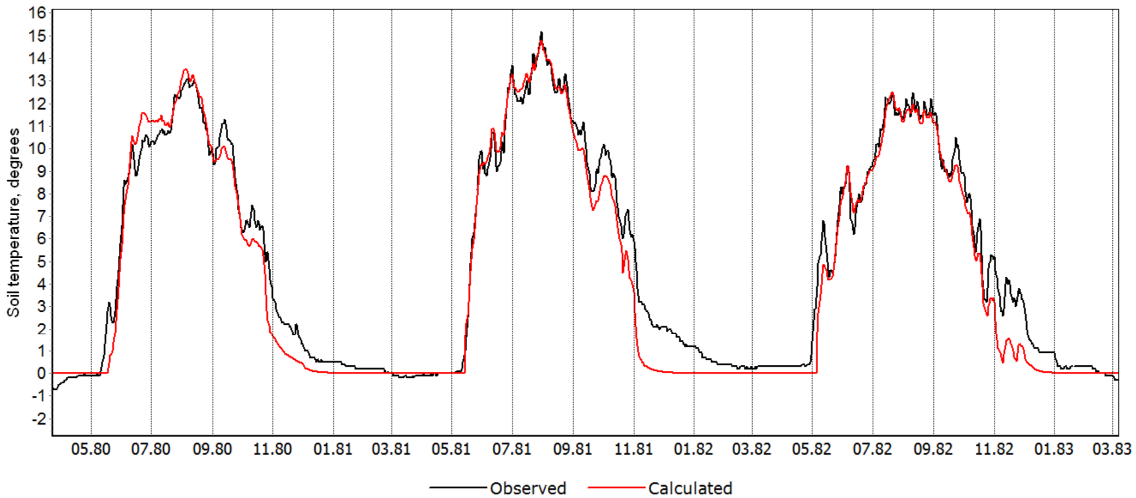
using historical meteorological data



Podmoskovnaya station,
1980–1983

Nizhnedevickaya station,
1974–1977





Valday station,
1980–1983

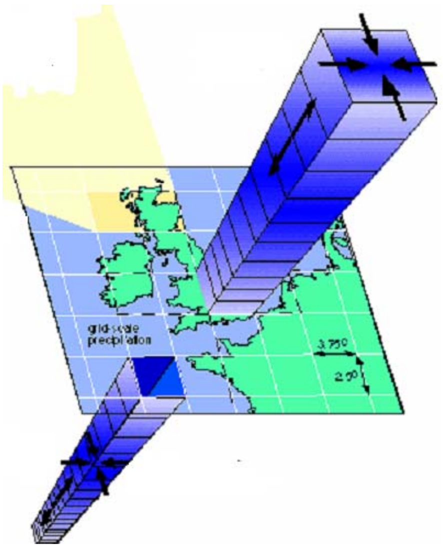
IPCC emission scenarios

Implications of emission scenarios for global T° by 2100 relative to 1990

(chosen scenarios and the model marked as **red**)

Scenario	Global ΔT(⁰C)
A1F1	**4.5**
A1B	2.9
A1T	2.5
A2	**3.8**
B1	**2.0**
B2	**2.7**

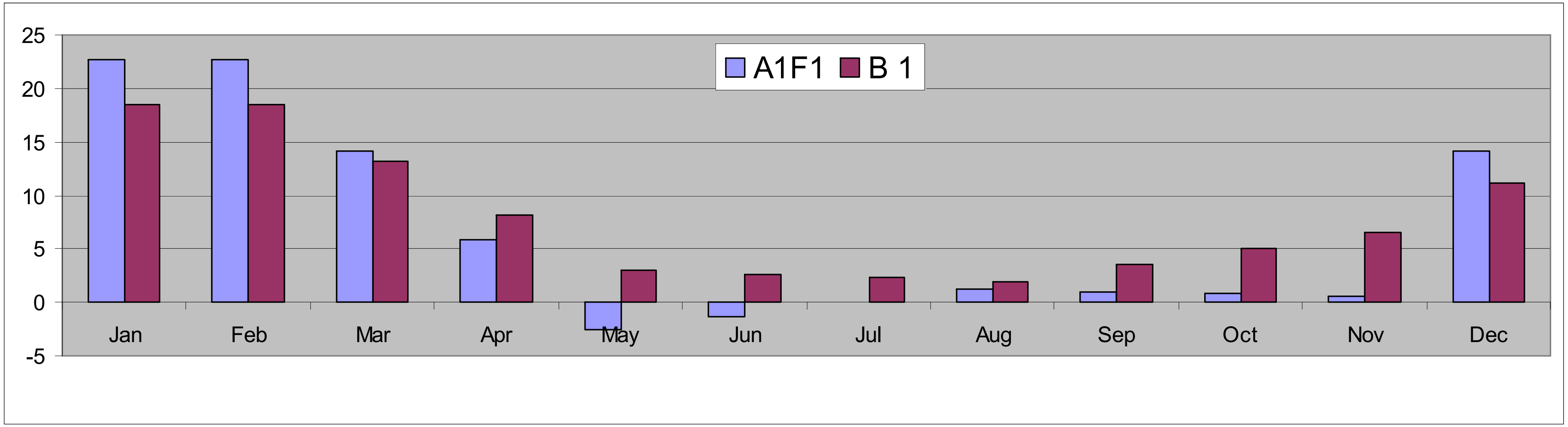
Atmospheric-Ocean General Circulation Models



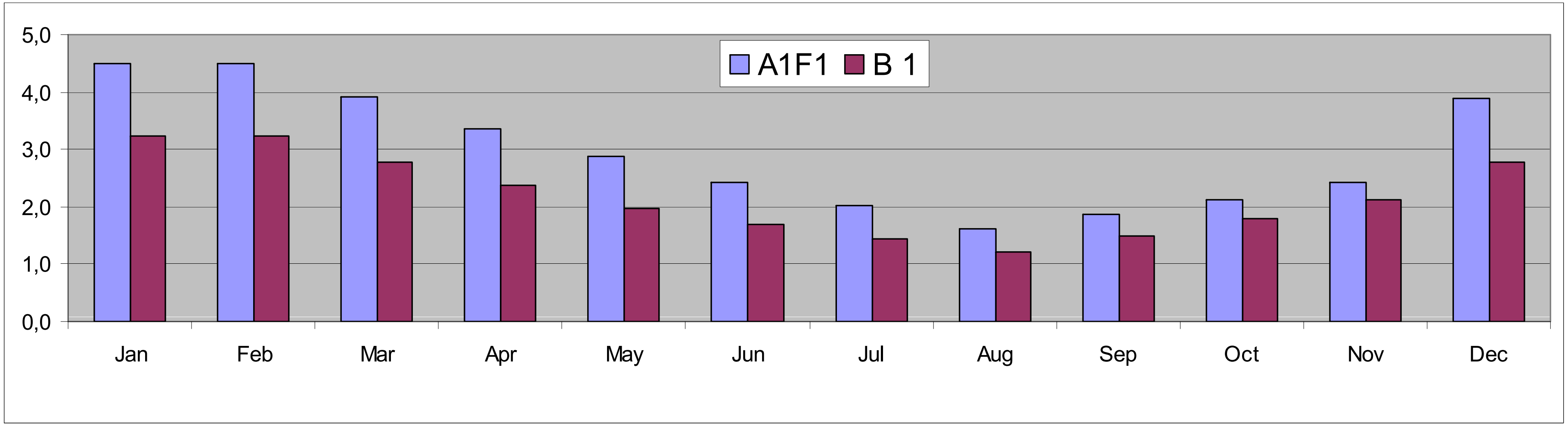
Model	Country	ΔT_{glob}
CCSR/NIES	Japan	4.4
CGCM2	Canada	3.5
CSIRO Mk2	Australia	3.4
ECHAM4/OPYC3	**Germany**	**3.3**
GFDL R30	U.S.A.	3.1
HadCM3	United Kingdom	3.2
NCAR DOE PCM	U.S.A.	2.4

ECHAM4/OPYC3 model projection according to A1F1 and B1 scenarios for 2010-2039

Precipitation change (%)



Temperature change (degree C)

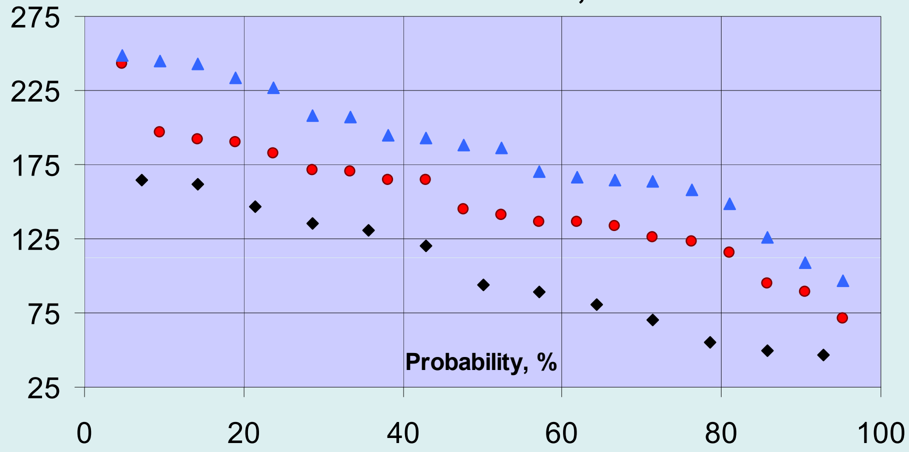


Modelling results: snow (by 2039)

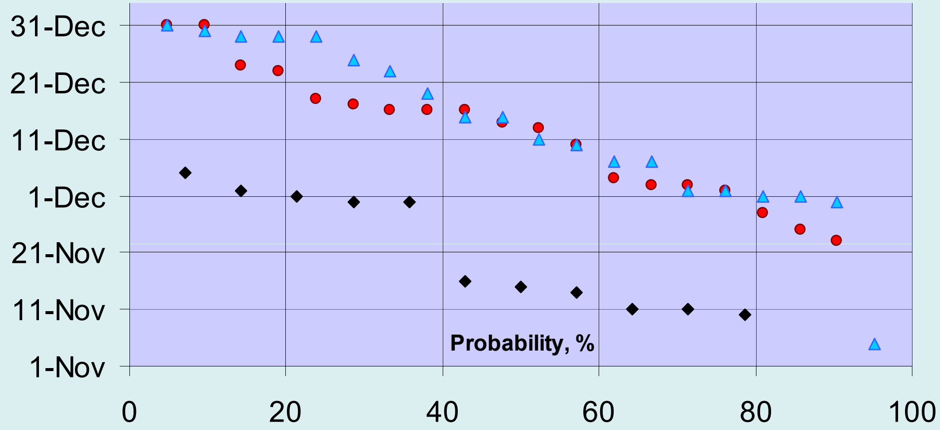
using generated ensembles of meteorological input

Podmoskovnaya station

Maximum SWE, mm

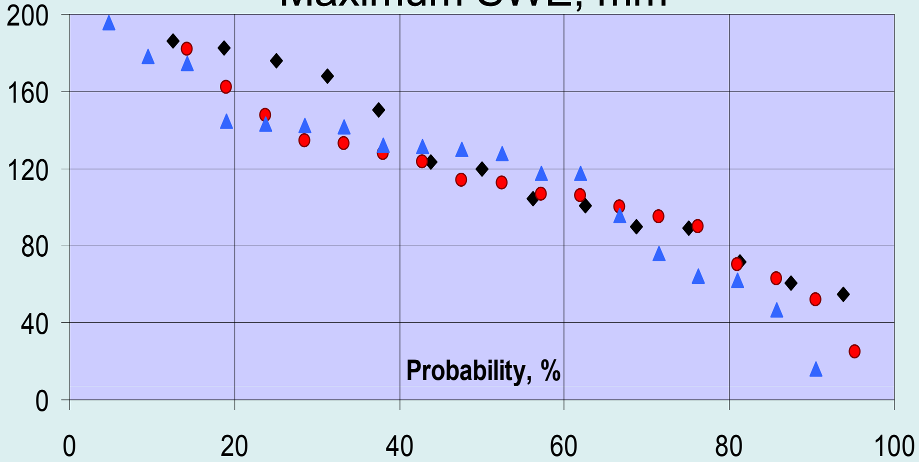


Date of snow establishment

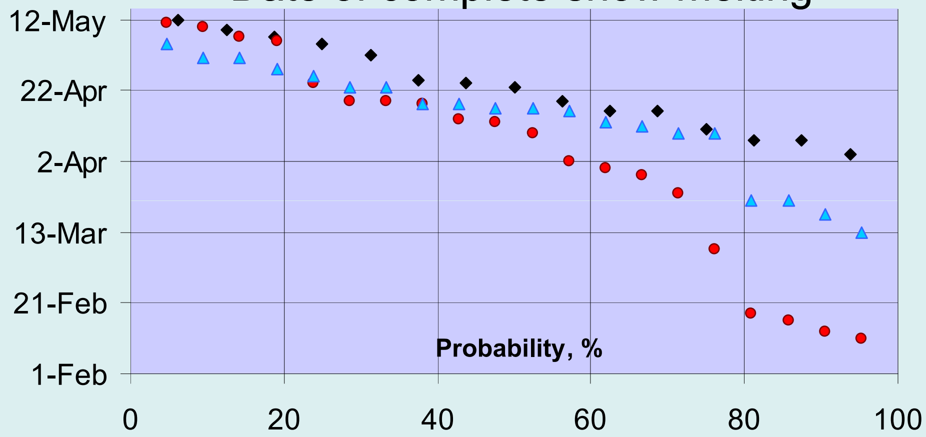


Nizhnedevickaya station

Maximum SWE, mm



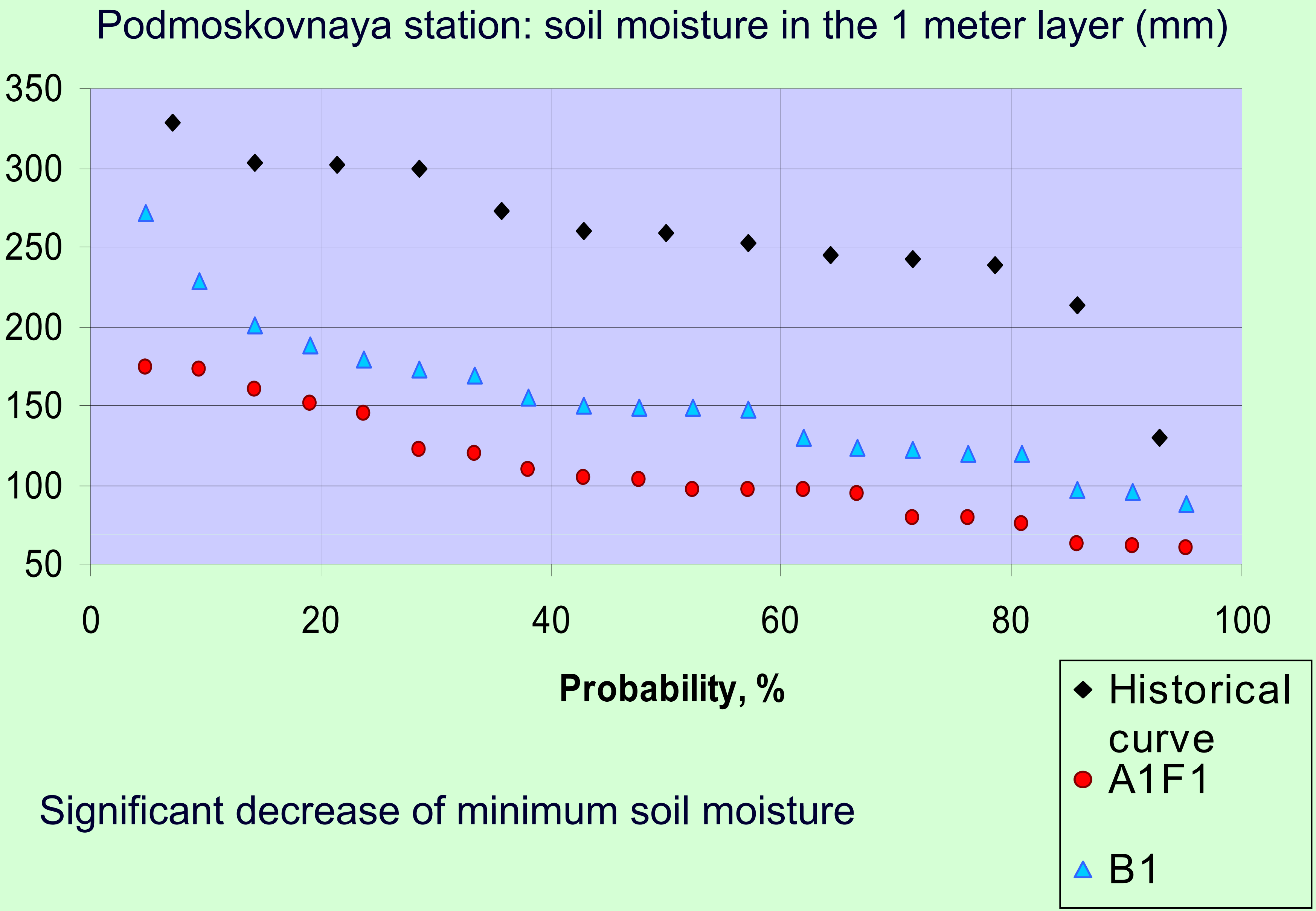
Date of complete snow melting



◆ historical curve ● A1F1 ▲ B1

Modelling results: minimum soil moisture (by 2039)

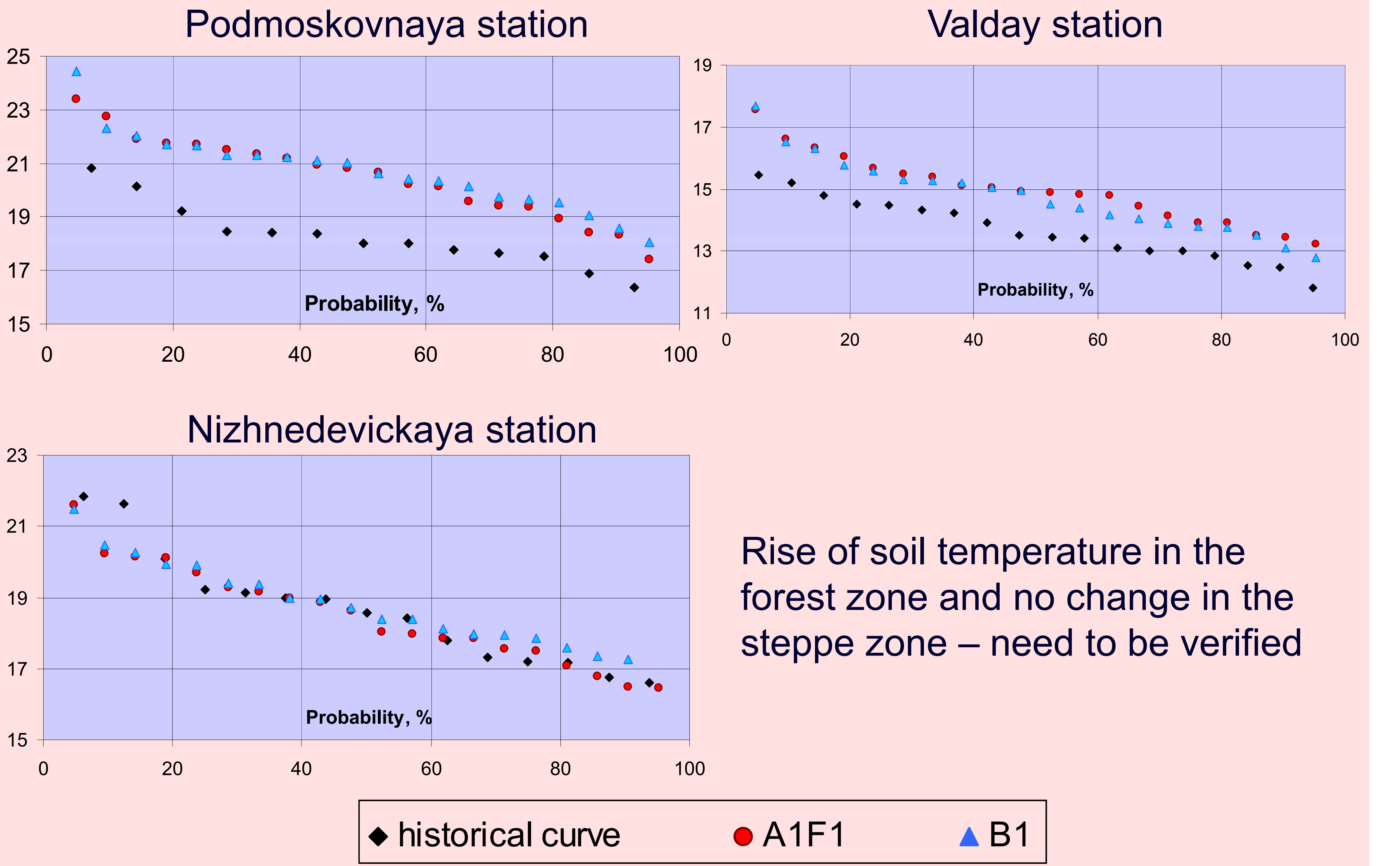
using generated ensembles of meteorological input



Significant decrease of minimum soil moisture

Modelling results: maximum soil temperature at 0,4 m depth (by 2039)

using generated meteorological input according to chosen scenarios



Rise of soil temperature in the forest zone and no change in the steppe zone – need to be verified

Conclusions

- The deterministic hydrological model Hydrograph simulates the processes in snow and soil well for the European zone of Russia using the historical data

- The stochastic model takes into account annual, seasonal and daily variation of meteorological elements and their spatial and temporal correlation

- Deterministic-Stochastic Modelling System can be used for the assessment of possible changes in soil and snow processes

- Verification of the modelling results based of their analysis is required

Next step would be…

Probabilistic estimates of annual, seasonal and daily extreme runoff variables for small watersheds

Thank you for attention!

Acknowledgements

1) The support **granted by the ERB conveners is highly appreciated**

2) The research was conducted with partial support by the German-Russian Otto-Schmidt laboratory