

PERUN: THE SYSTEM FOR SEASONAL CROP YIELD FORECASTING BASED ON THE CROP MODEL AND WEATHER GENERATOR

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www.ufa.cas.cz/dub/crop/crop.htm

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Previous research (since 1995):

experimental crop sites: three locations in the Czech Republic
[Žabčice, Domanínek, Kroměříž]

~ source of data for crop model validation

crop models: MACROS, WOFOST, CERES (Maize, Wheat, Barley),
SHOOTGRO

weather generator: Met&Roll (PREC, SRAD, TMAX, TMIN, wind,
humidity)

climate change impact studies:

- **climate change scenarios** = incremental scenarios, GCM-based scenarios, climate sensitivity scenarios)
- **method** = direct modification approach; weather generator approach

[see www.ufa.cas.cz/dub/dub.htm for the references]

PERUN

(development of the software started last year)

PERUN: system for crop model simulations under various meteorological conditions

tasks to be solved by PERUN/:

- crop yield forecasting
- climate change/sensitivity impact analysis

requirements:

- runs under Windows
- user friendly & robust
- comprises all parts of the process:
 - preparing input parameters for the crop model simulation (with a stress on the weather data representing various climate conditions or a short/long range weather forecast)
 - launching the crop model simulation
 - statistical and graphical analysis of the crop model output

components:

1) WOFOST crop model (v. 7.1.1.; provided by Alterra Wageningen)

new: Makkink formula for evapotranspiration was implemented

2) Met&Roll weather generator (Dubrovský, 1997)

new: - wind and humidity generated by nearest neighb. resampling
- synthetic series follows with the observed series at any date

3) user interface

- **input for WOFOST** (crop, soil and water, start/end of simulation, production levels, fertilisers, ...)
- **launching the simulation** [construction of the batch file (GO.BAT) and starting it,]
- **statistical and graphical processing** of the simulation output

PERUN
 File Simulate Data Analysis Graphs Settings Help Exit

Crop
 Spring barley AKCENT, NAZV-PROJECT, Czech. [new]

Soil and Water
 NAZV_BARLEY_DOM [new]
 groundwater
 initial gw table (cm) [44.3] init. avail. soil w. (cm) [19.6] max. init. moist. in RD [0]
 init. surf. stor. [0] drainage depth [11] non-infiltration fraction [0.05] or
 max. surf. stor. [0] max. rooting depth [130]
 Evapotranspiration Penman Makkink fixed function of storm size

Weather
 input daily data
 observed
 generated RS = [0] specify
 from: [1994] of years [1] re-runs: [1] day0 [1]
 Forecast present climate FORECAST. [edit]
 Scenario file: [E-A2-HI.SCE] step-wise no change
 factor [1] Srch. coef. [1] Add to list

Start of simulation
 fixed emergence date [124] [id]
 fixed sowing date [888] [id]
 variable sowing date from [222] [id] to [333] [id]

End of simulation
 fixed end date [365]
 maturity (<=max duration) [310]
 earliest of both dates

Fertilizer
 amount (0-100 kg/ha) N [90] P [90] K [90]
 apparent recovery fraction (0-1) [0.35] [0.1] [0.5]

Output
 interval (days) [1] output file [abc]

General
 number of production levels
 potential yields
 + water-limited growth
 + nutrient-limited growth
 summary seasonal soil water balance
 no summary
 whole system (1-D column)
 root zone
 whole system and root zone
 type of water limited crop growth
 effect of drought only
 effects of drought and O3 shortage
 start day water balance [1]
 Wofost v.6 v.7

Česky English SaveAs open Start save End

assumptions:

- crop model is validated
- weather generator is validated

climate change impact analysis

general scheme:

1. crop model run with weather series representing *present climate*
2. crop model run with weather series representing *changed climate*
3. comparison of the outputs from the two simulations

weather / climate options:

- type of the weather series (2 approaches):

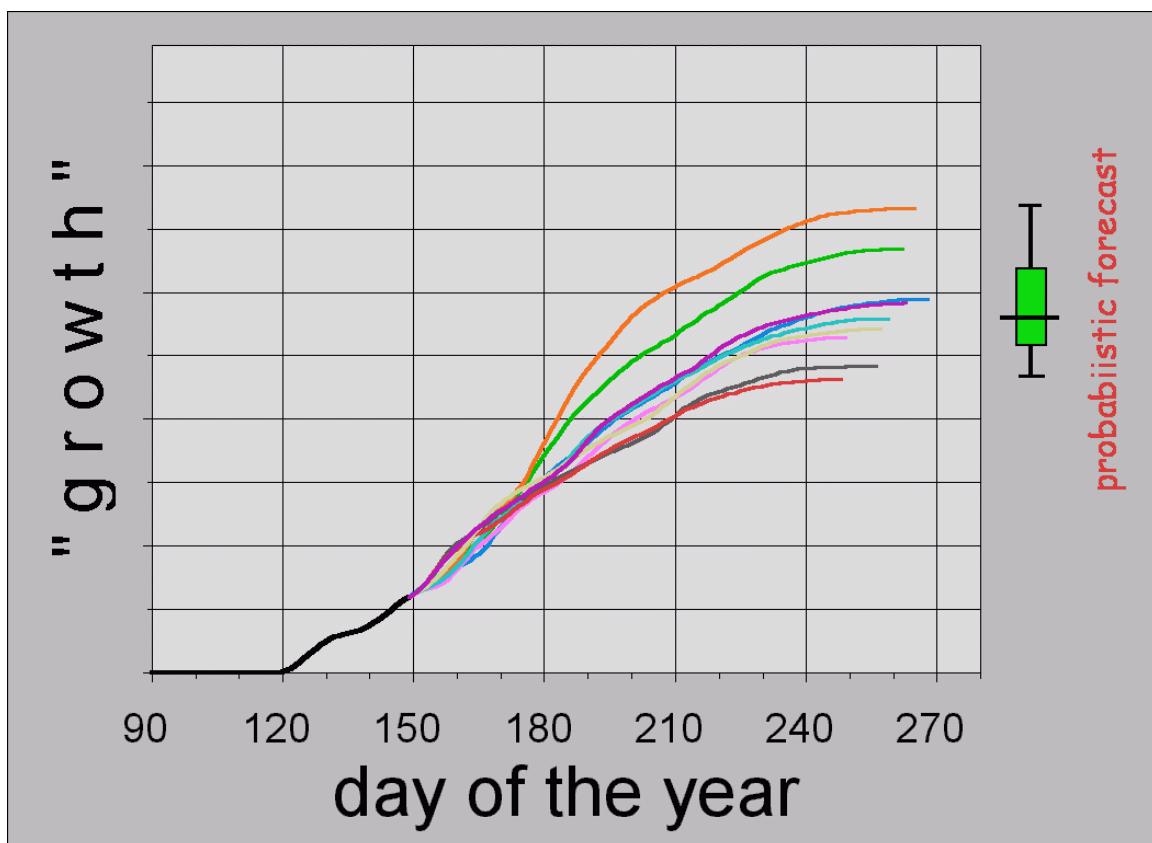
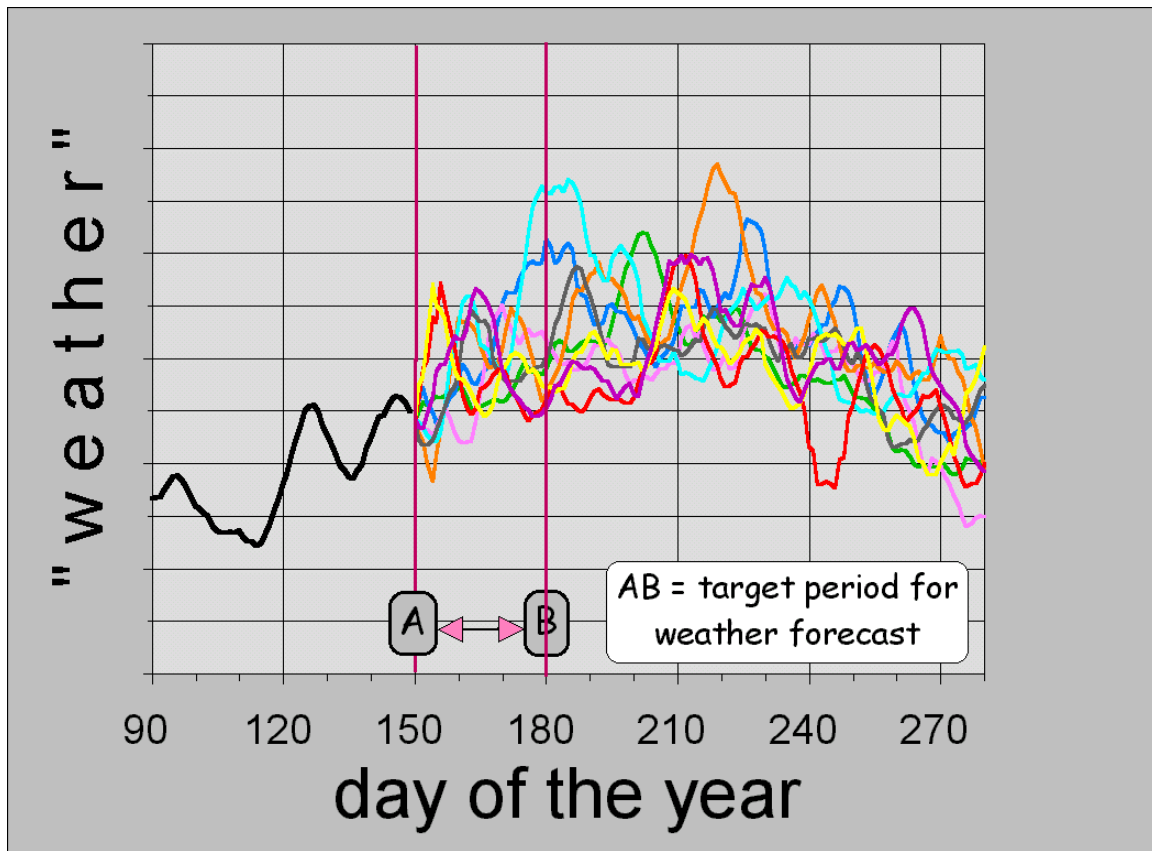
- a) *direct modification approach (DM)*: observed series for present climate, directly modified weather series for changed climate (according to the climate change scenario)
- b) *weather generator approach (WG)*: synthetic series for both climates (parameters of WG are derived from the observed series and modified according to the climate change scenario)
 - in case the Penman formula is used, the wind and humidity is generated using nearest neighbours resampling
 - selected parameters of the generator may be set (order of the Markov chain, effectiveness of the resampling procedure, ...)

- climate change scenario (may include changes in variabilities and in other WG parameters in the case of WG approach)

- length of the weather series:

- a) less than the length of the observed series (DM approach)
- b) arbitrary length (WG approach)

seasonal crop yield forecasting



[PROG_G.GIF + PROG_W.GIF ∈ DEMO.WB2]

seasonal crop yield forecasting

input data to crop model

- a) **non-weather data:** info about crop, soil and hydrology, water regime; start/end of simulation, nutrients, ... (as in WCC)
- b) **weather data:**
- station
 - day D_0 (observed data till $D_0 - 1$, synthetic since D_0 ;
 - **weather forecast table** (weather series are postprocessed to fit the weather forecast table forecast)
 - observed or synthetic series (obs. series is used for validation)
 - formula for evapotranspiration: Makkink or Penman
- c) **N = number of re-runs** (new weather data are generated for each simulation; other input data are always the same)

weather forecast table (3 methods)

- 1) absolute values of the n -days averages [n is optional]

* weather forecast		random component					
METHOD = 1		...averages...			..std. deviation..		
@JD-from	JD-to	TMAX	TMIN	PREC	TMAX	TMIN	PREC
99121	99130	17	6	30	2	2	10
99131	99140	14	4	60	3	3	20
99141	99150	21	10	10	4	4	10
@							

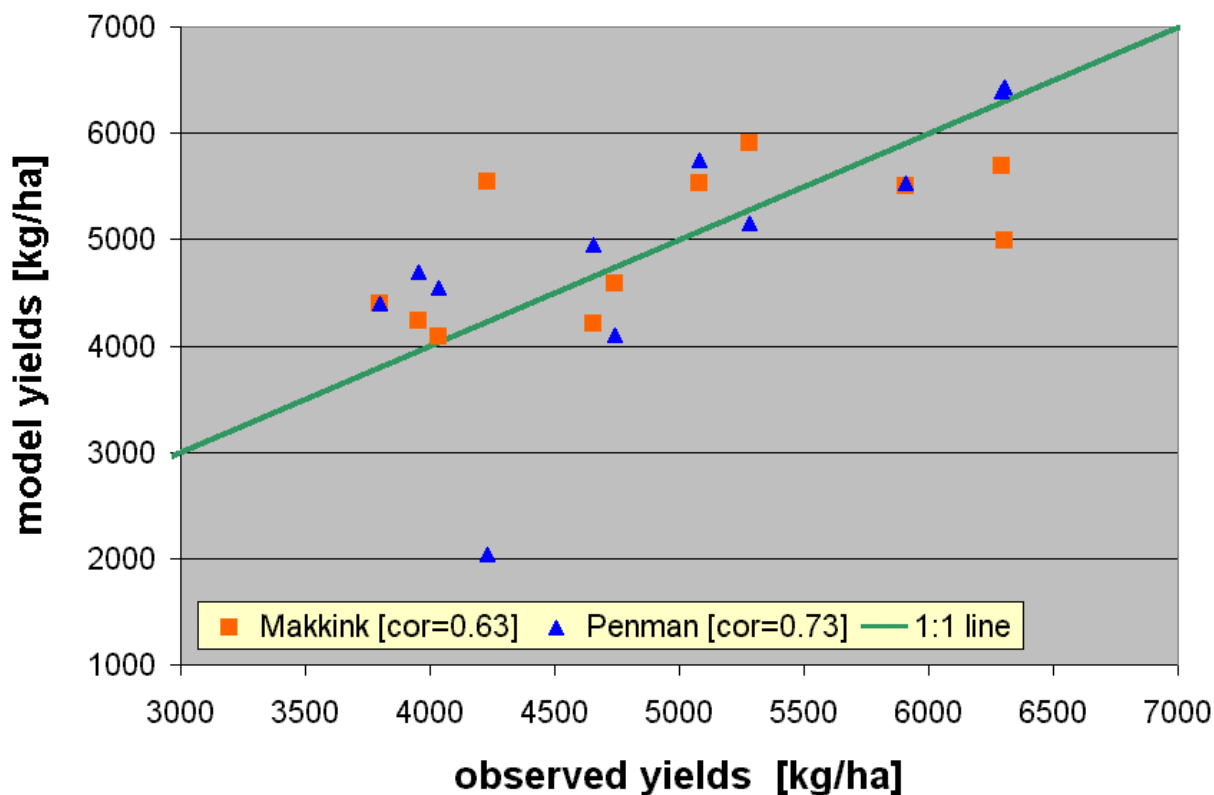
- 2) increments to existing series

- 3) increments with respect to the long-term means

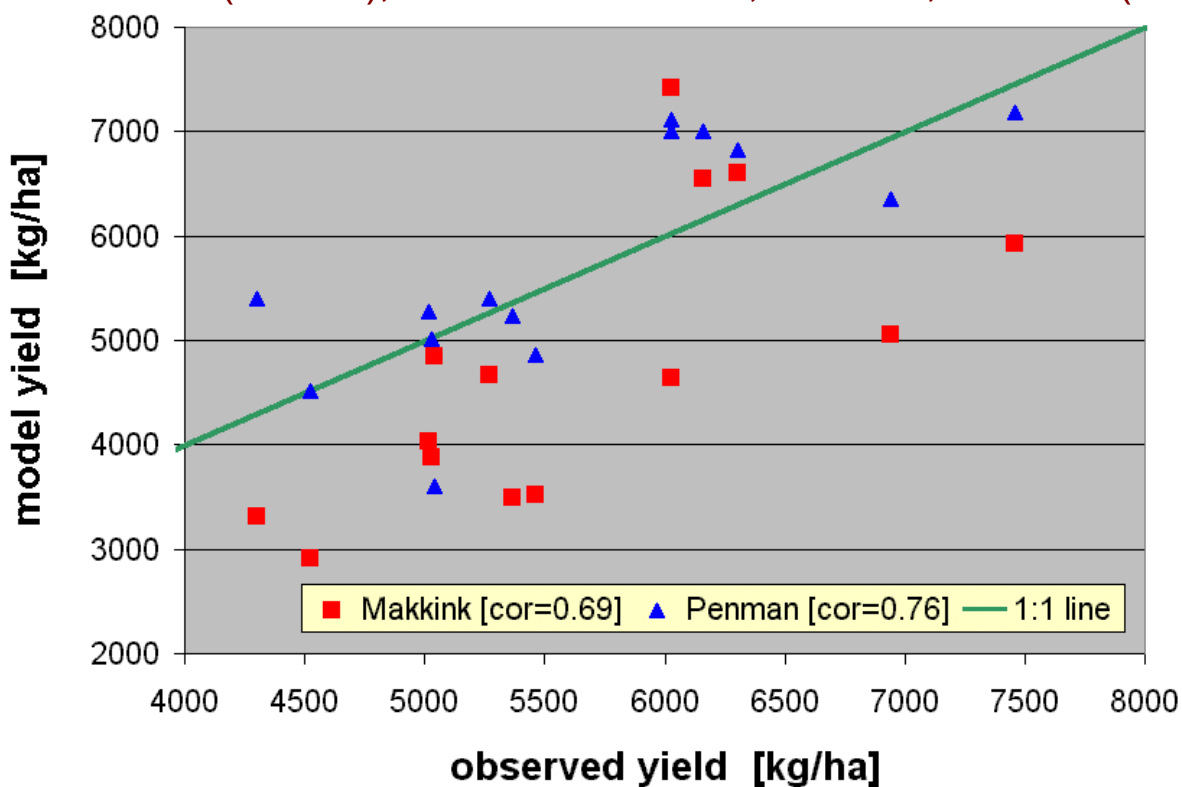
* weather forecast		random component					
METHOD = 3		...averages...			..std. deviation..		
CLIMATE = DOMA.DAY		TMAX	TMIN	PREC	TMAX	TMIN	PREC
@JD-from	JD-to	TMAX	TMIN	PREC	TMAX	TMIN	PREC
99121	99130	-1	-1	1	0	0	0
99131	99140	-1	-1	1	0	0	0
99141	99150	-1	-1	1	0	0	0
@							

validation of WOFOST

a) spring barley - Hana; site = Domanínek, Czechia; 1990-2000 (11 y)



b) winter wheat (Akcent); site = Domanínek, Czechia; 1985-97 (14 y)

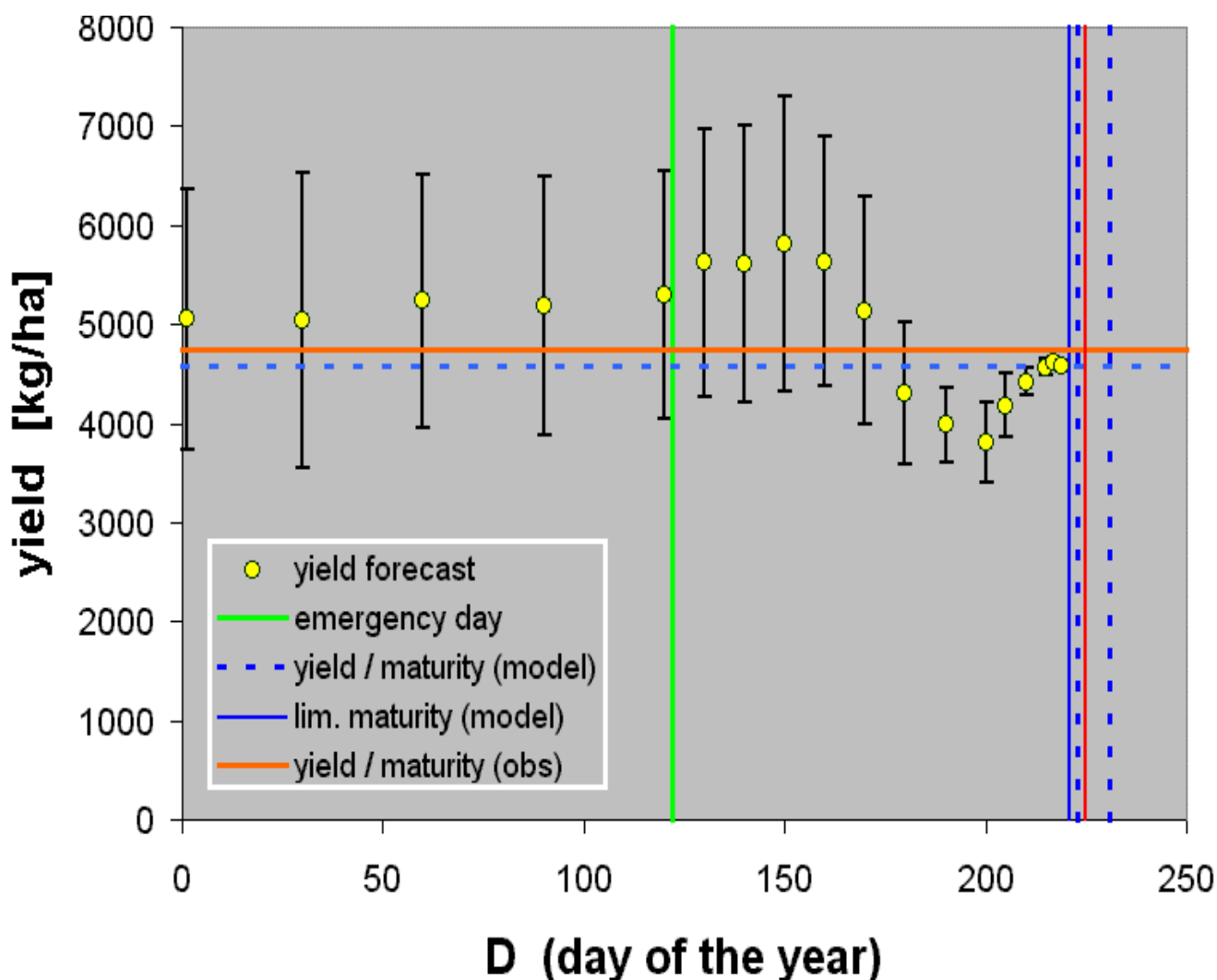


Crop yield forecasting at various days of the year

- ◆ forecast $\langle \text{avg} \pm \text{std} \rangle$ is based on 30 simulations
- ◆ input weather data for each simulation =
[obs. weather till D-1] + [synt. weather since D; without forecast!]

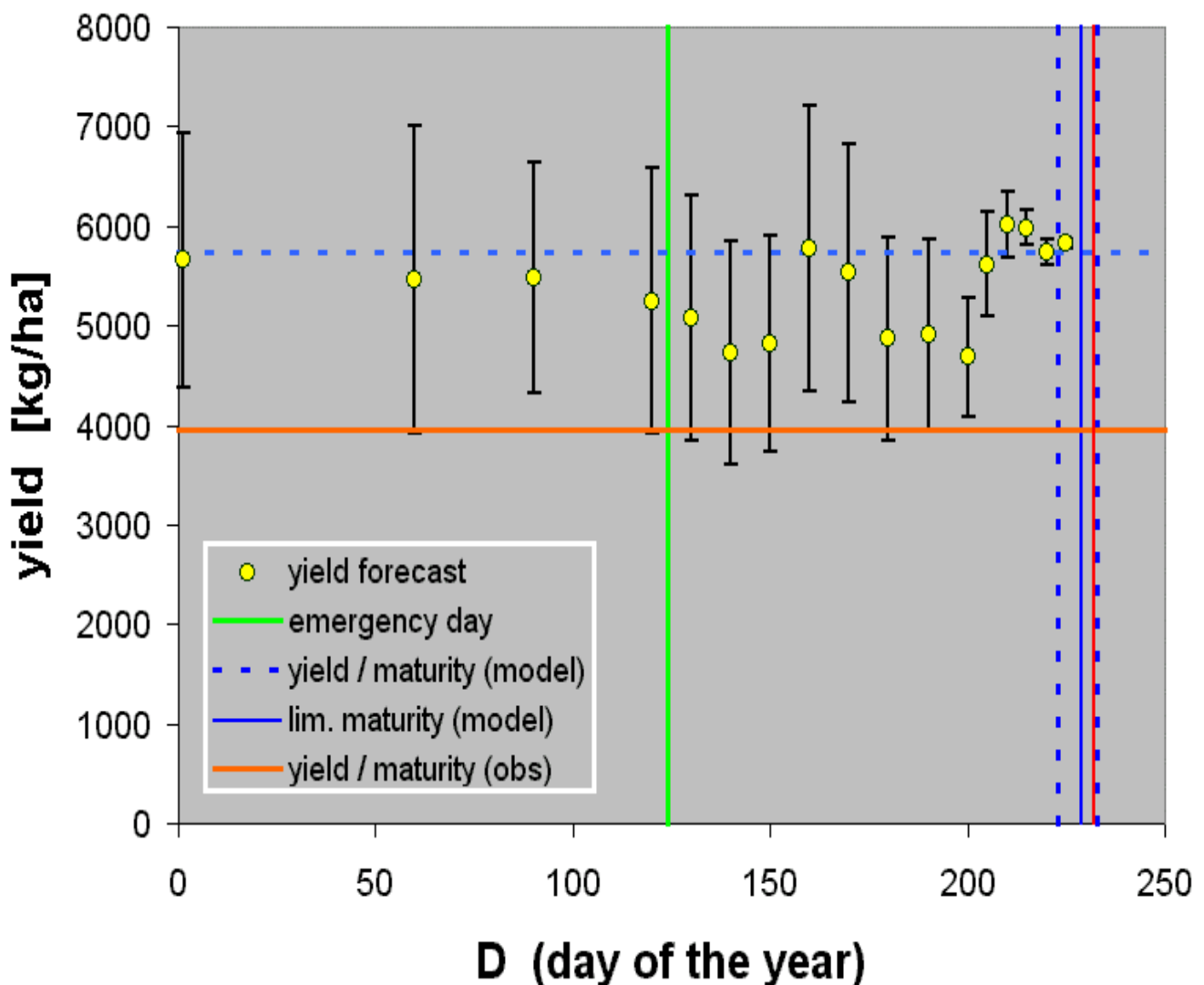
a) the good fit between model and observation

site	= Domanínek, Czech Republic
crop	= spring barley
year	= 1999
emergency day	= 122
maturity day	= 225
observed yield	= 4739 kg/ha
model yield	= 4580 kg/ha (simulated with obs. weather series)



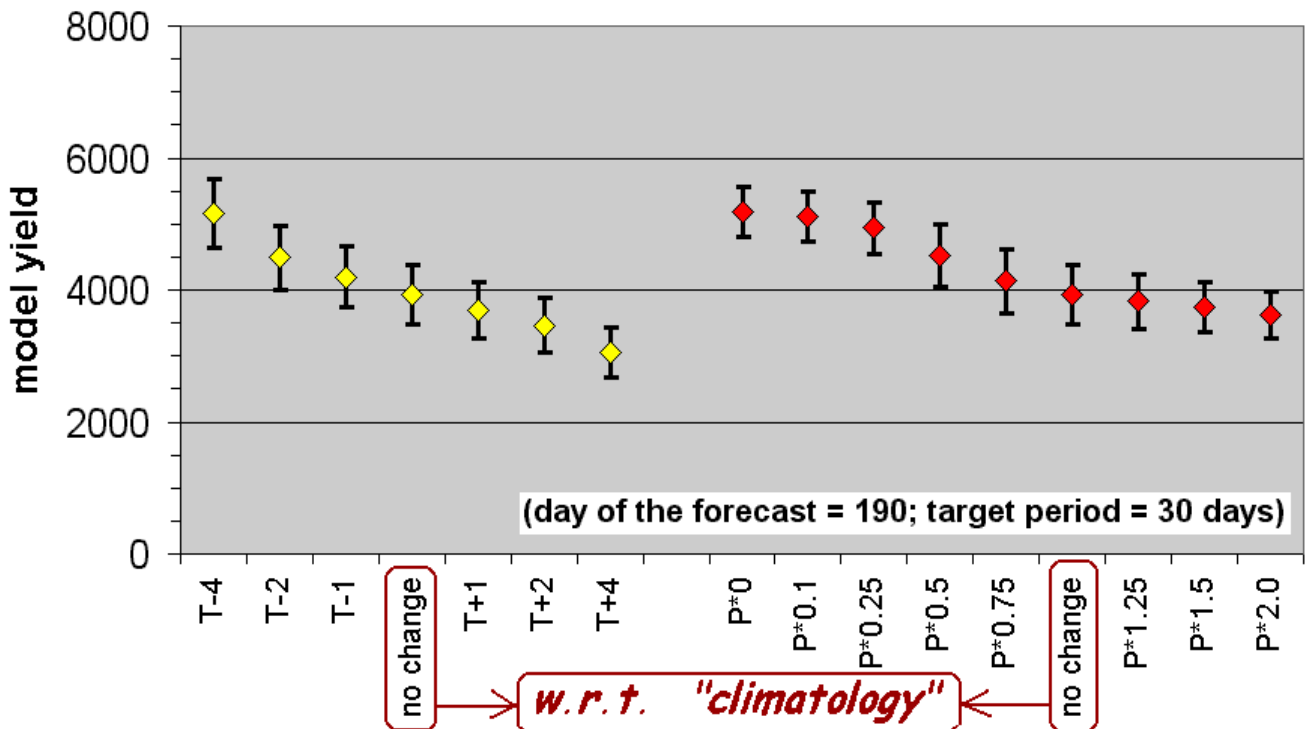
b) the poor fit between model and observation

site	=	Domanínek, Czech Republic
crop	=	spring barley
year	=	1996
emergency day	=	124
maturity day	=	232
observed yield	=	3956 kg/ha
model yield	=	5739 kg/ha (simulated with obs. weather series)

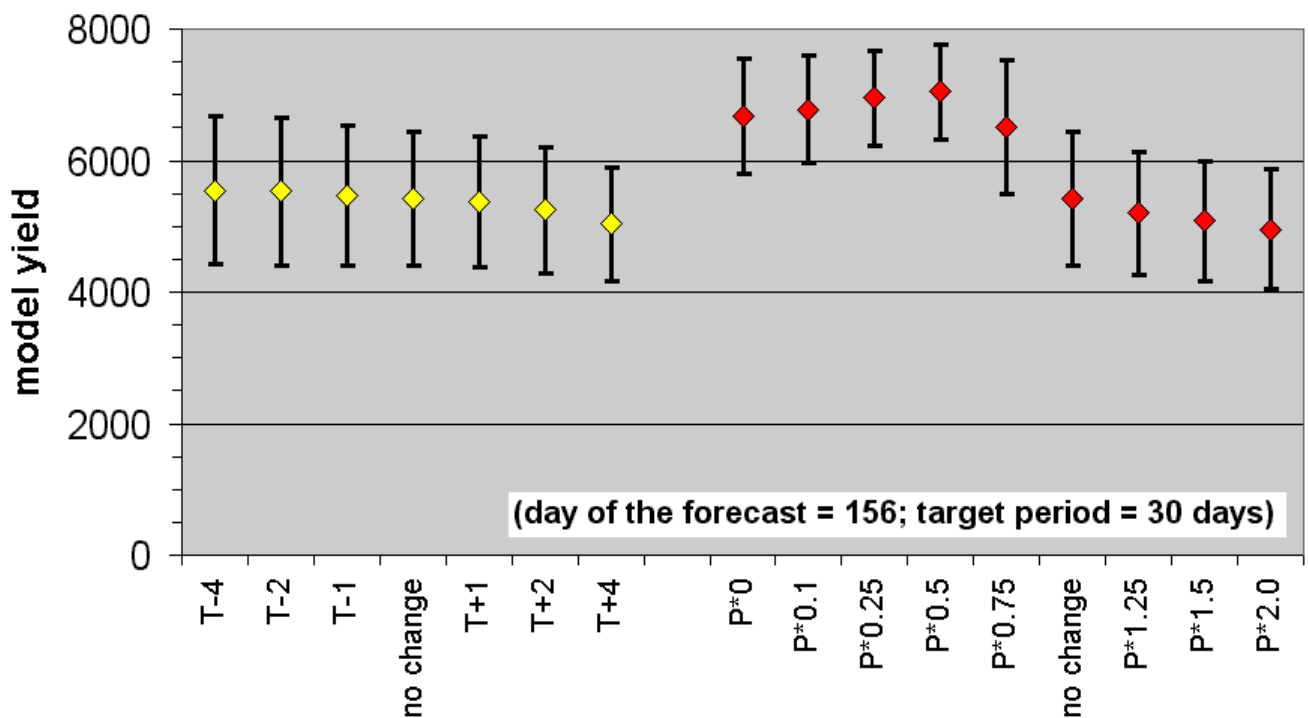


task for future research: to find *indicators* of the crop growth/development (measurable during the growing period) which could be used **to correct the simulated characteristics**, thereby allowing more precise crop yield forecast

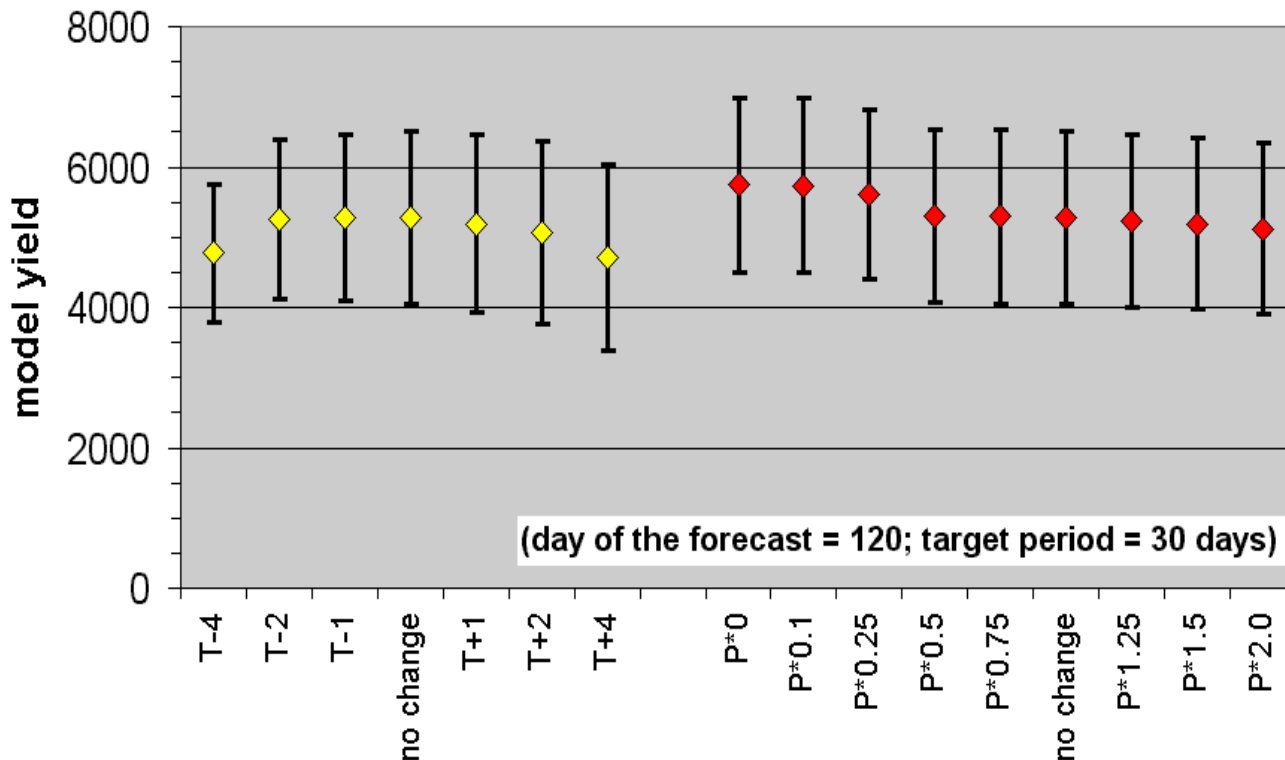
sensitivity of prognosed yields to temperature and precipitation (for various days of the year)



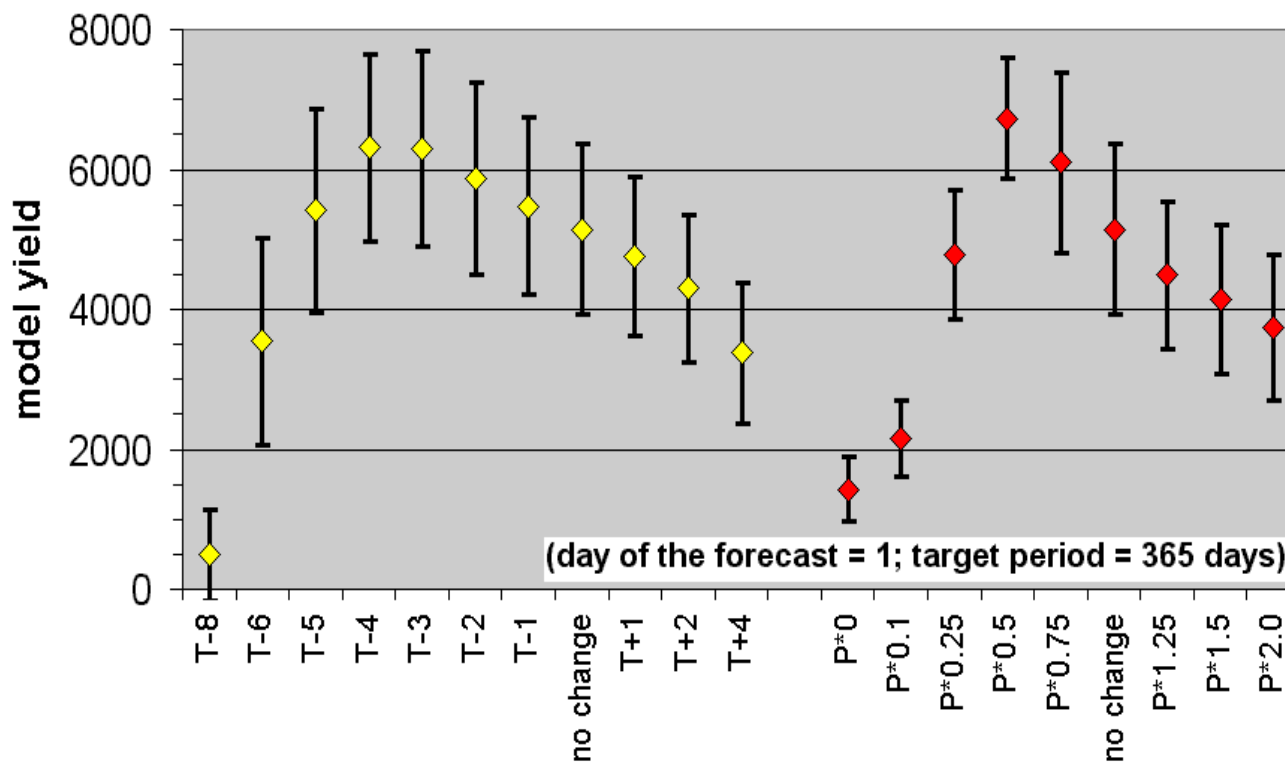
input weather data: [observed data till day 189] + [synthetic since 190]
target weather forecast period = day 190 - maturity



input weather data: [observed data till day 155] + [synthetic since 156]
target weather forecast period = day 156 - 185



input weather data: [observed data till day 119] + [synthetic since 120];
 target weather forecast period = day 120 - 149



input weather data: synthetic weather series for the whole year
 target weather forecast period = day 1 - 365

Conclusions

PERUN = system for

- probabilistic crop yield forecasting
- climate change/sensitivity analysis

validation of crop model WOFOST:

- **not good** (*higher correlation between observed and model yields is required to make reliable crop yield forecast*)
- **not bad** (*input data for crop model were not perfect*)

Penman formula performs slightly better than the Makkink's

future research:

to find **indicators** of the crop growth/development (measurable during the growing period) which could be used **to correct the simulated characteristics**, thereby allowing more precise crop yield forecast:

