Assessment of Possible Relation Between Trends in Agroclimatic Indices and Crop Model Outputs

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How to improve crop model outputs using agrometeorological indices describing extreme weather conditions?

Q1: Why?

In order to predict future behavior of crop models in extreme weather conditions

Releted to extreme weather conditions

Crop model outputs deviate from observations

- **Q2:** *Which outputs?*
- **Q3:** *Why it happens?*
- **Q4:** *Why/How to use indices?*

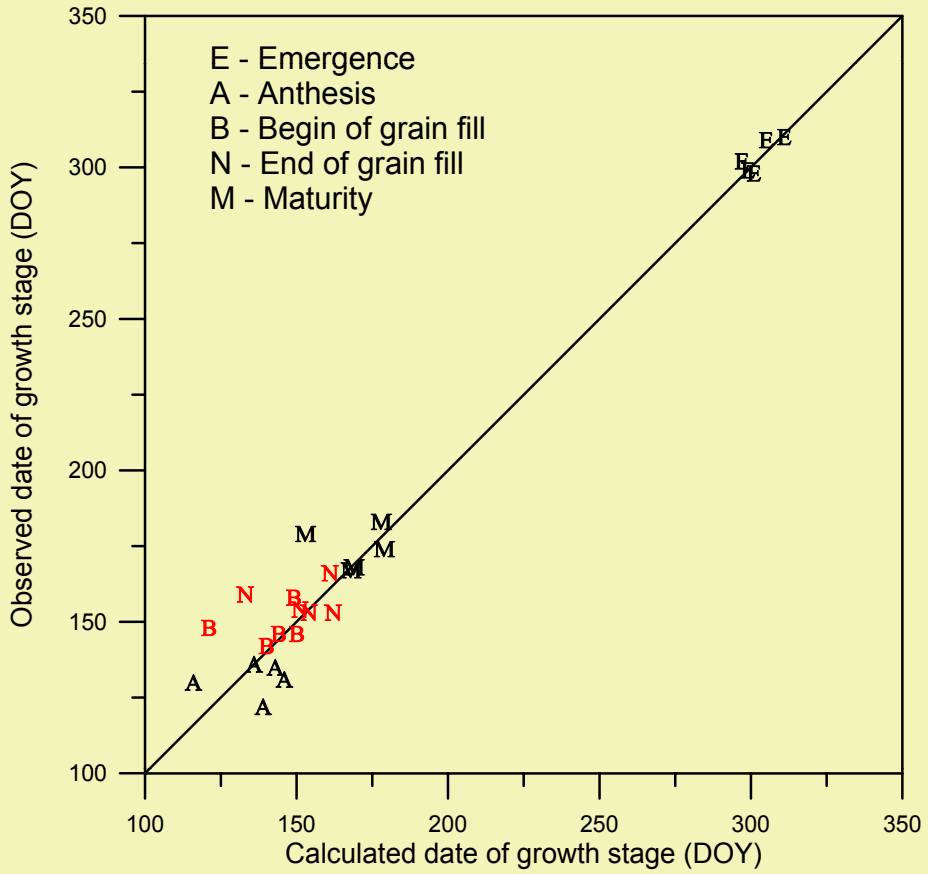
What was done?

- *SIRIUS and DSSAT crop models were run for 1986-2007 period. Comparison with observations was made.*
- *Identified cause of* **variation** *(not deviation)*
- *Calculated deviations are correlated with different agrometeorological indices describing extreme weather conditions*
- *Statistical significance of obtained correlation was calculated*

Q2: Which outputs?

- *Yield*
- *Phenology**
- *Water balance components ….*

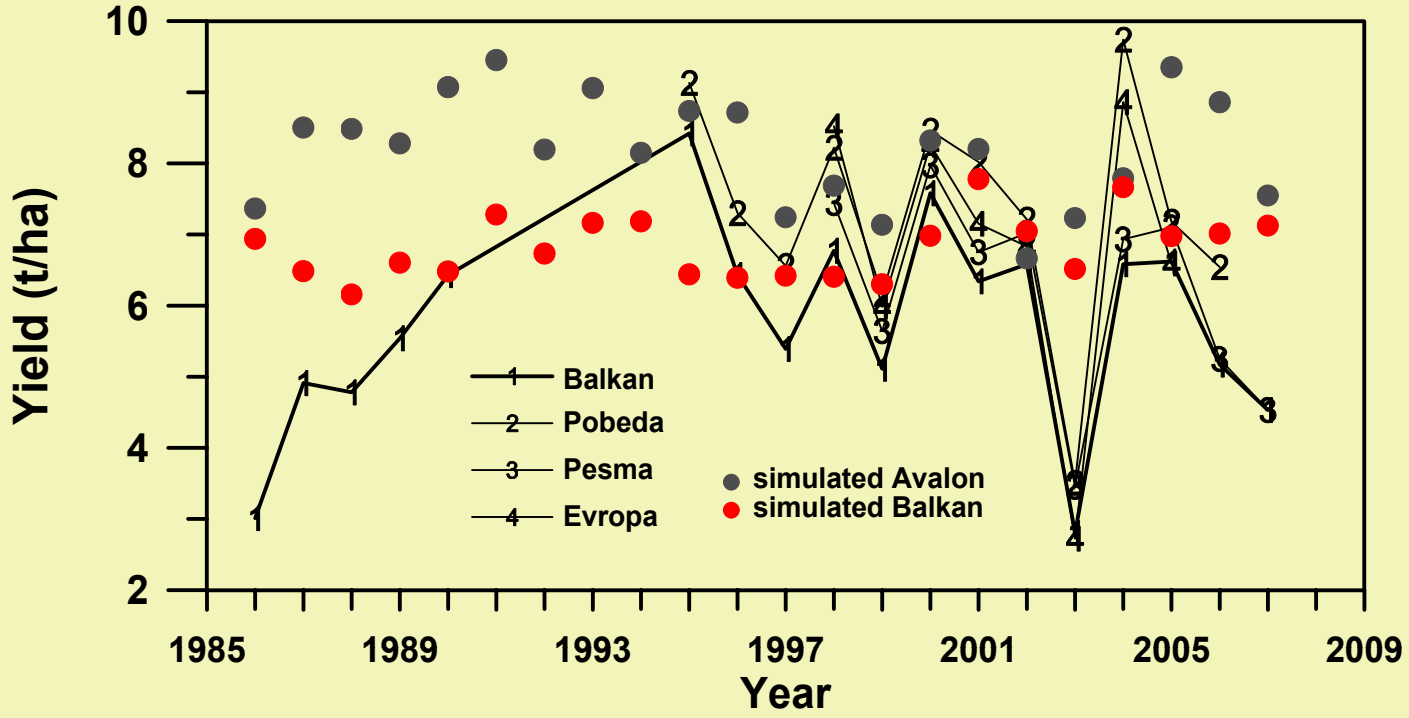
We have no problem with phenology



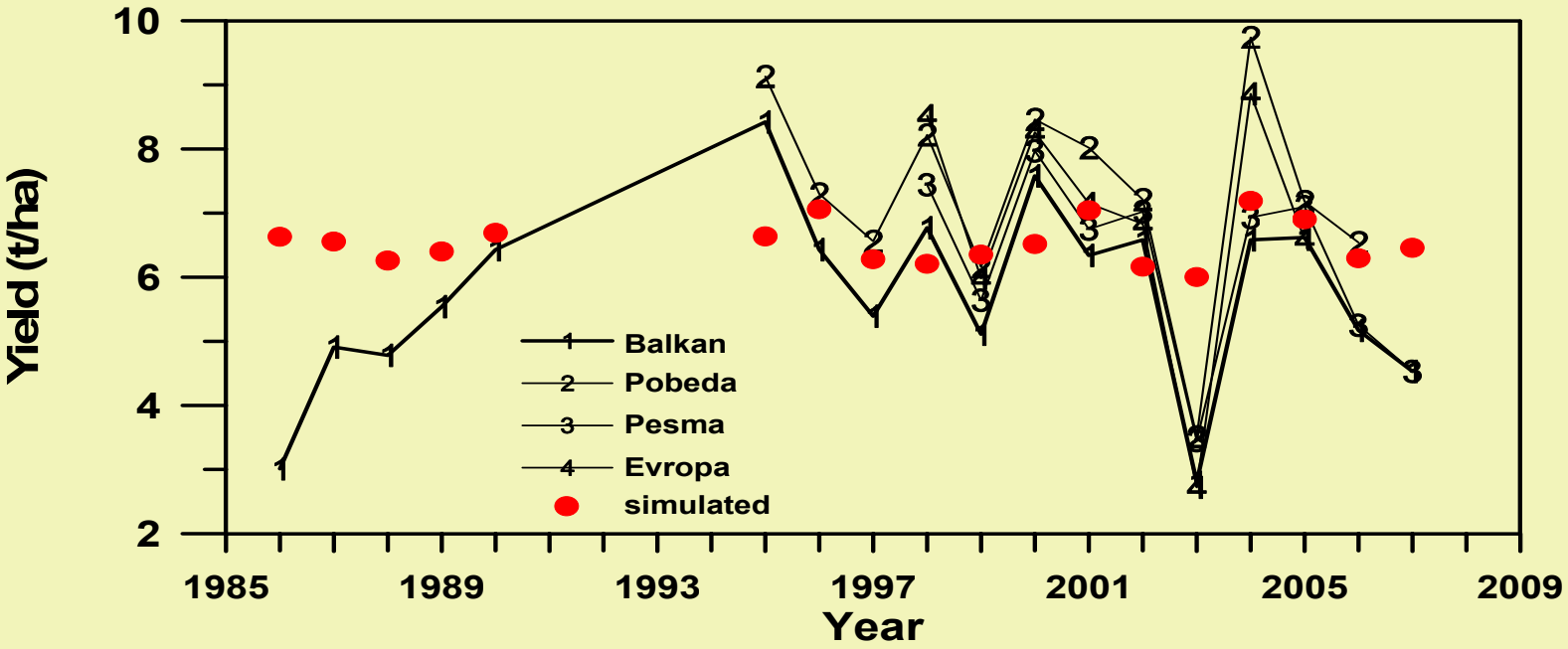
Q3: Why it happens?

- *Input data problem?*
- *Observed (output) data problem?(!)*
- *Is it common behavior of models?*
- *Model-related problem?*

- Soil?
  Chernozem
- Variety?

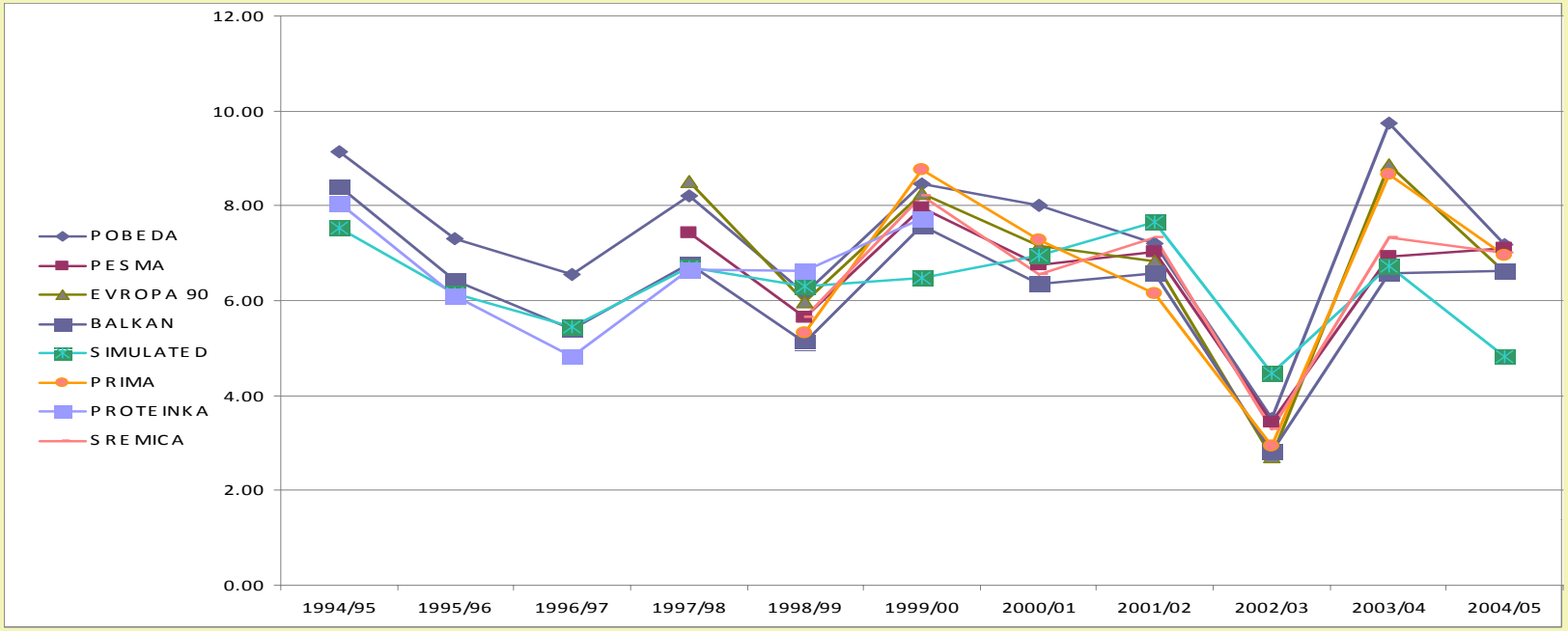


Is it common behavior of crop models?



SIRIUS

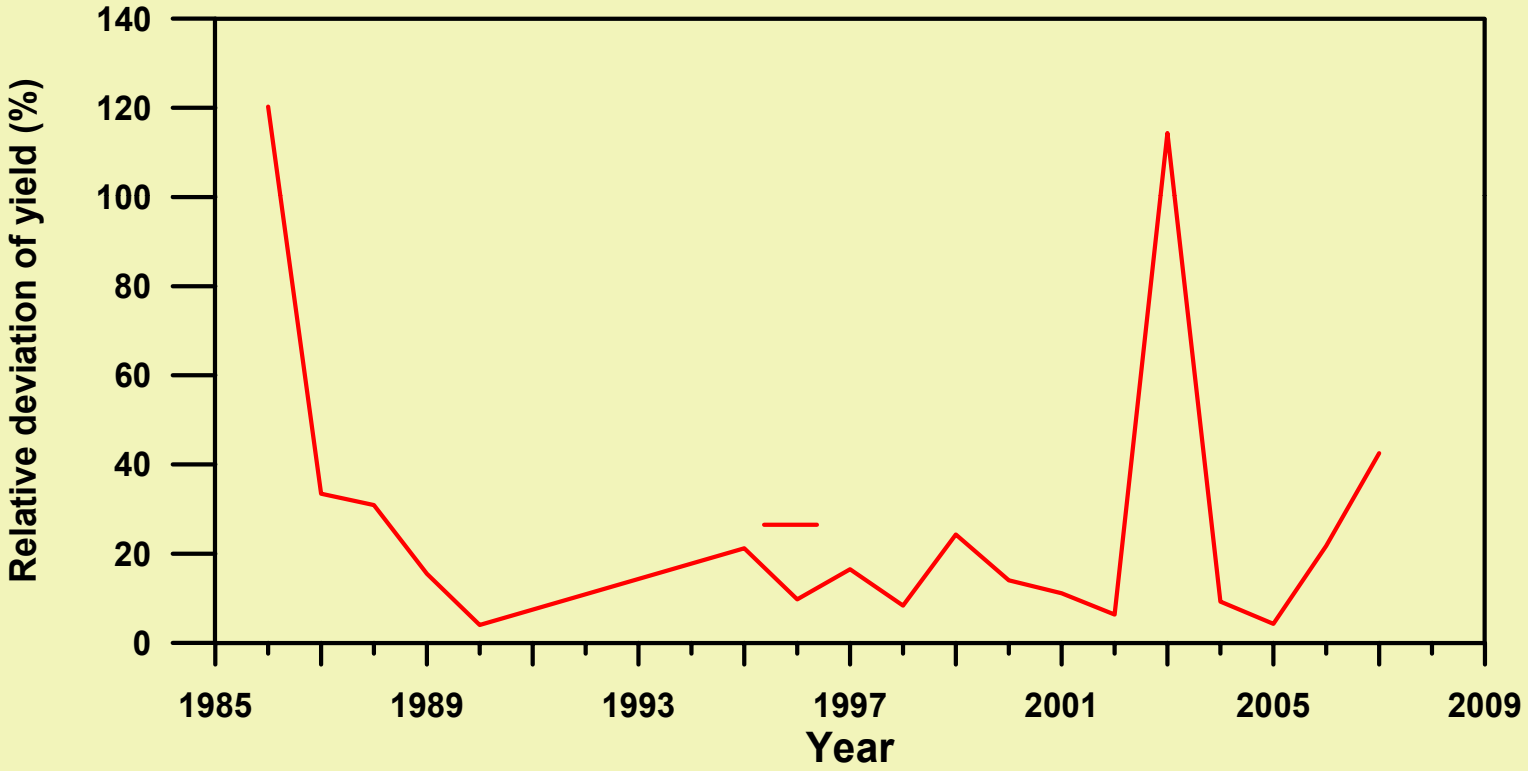
DSSAT



Model-related problem. Statistical (black box) approach or

Q4: Why/How to use indices?

- *Yield variation. Model deviation. Agm extreme weather index*



Cause of yield variation - Amount and distribution of spring precipitation

Q4: Why/How to use indices?

Correlation with ....

- *Indices during vegetation period (1)*

1986	**3,01**	**6,63**	**3,62**	**120,23**		**3358**	**694**	**0**	**280**	**165**	**176**	**35390**	**2448**	**-414**
1987	4,91	6,55	1,64	33,46		3330	680	52	406	163	170	34905	2416	-274
1988	4,78	6,26	1,48	30,90		3327	668	0	240	167	176	35076	2417	-428
1989	5,54	6,40	0,86	15,51		3311	619	0	354	161	175	34577	2396	-265
1990	6,43	6,69	0,26	4,03		3249	679	0	219	170	176	33940	2335	-460
1995	8,42	6,63	1,79	21,21		3268	673	0	467	154	168	34383	2361	-207
1996	6,43	7,06	0,63	9,77		3181	663	0	513	158	170	33125	2269	-150
1997	5,39	6,28	0,89	16,51		3151	675	28	440	159	168	32905	2257	-235
1998	6,77	6,21	0,56	8,33		3378	693	8	490	157	169	35772	2463	-203
1999	5,11	6,35	1,24	24,27		3444	683	55	544	152	164	36488	2529	-139
2000	7,58	6,52	1,06	14,04		3709	790	0	148	174	179	40573	2794	-642
2001	6,34	7,04	0,70	11,09		3298	682	10	742	145	155	34636	2384	60
2002	6,58	6,16	0,42	6,34		3521	718	0	282	169	173	38001	2607	-436
2003	**2,8**	**6,00**	**3,20**	**114,32**		**3659**	**762**	**0**	**237**	**169**	**175**	**40148**	**2757**	**-525**
2004	6,58	7,19	0,61	9,24		3273	682	0	458	154	166	34212	2358	-223
2005	6,62	6,90	0,28	4,24		3281	684	34	530	151	166	34268	2366	-153
2006	5,17	6,29	1,12	21,70		3386	691	0	420	154	168	35790	2471	-271
2007	**4,53**	**6,46**	**1,93**	**42,54**		**3518**	**756**	**13**	**368**	**163**	**171**	**37916**	**2603**	**-388**
	observed	simulated	deviation	r (%)		St > 0 oC	wto	sws	rain	c1	c2	ptu	tu	h-wto

Correlation with ....

- *Indices during vegetation period (2)*

DP – duration of dry period
H – amount of precipitation
EO – number of rainy episodes
RD – number of rainy days
I – intensity of precipitation
H5 – number of days with 0<H<5

1986	***120***	***14***	**38**	**4**	**12**	**3**	**9**	**57**	**3**	**13**	**4**	**9**	**51**	**7**	**9**	**6**	**7**	**50**	**5**	**11**	**5**	**5**
1987	33	9	63	8	17	4	11	81	5	13	6	9	176	5	12	15	6	62	5	12	5	8
1988	31	16	94	6	18	5	12	57	7	15	4	11	26	8	10	3	8	65	7	12	5	7
1989	16	11	35	6	11	3	10	82	7	15	5	11	66	6	15	4	11	93	6	17	5	11
1990	4	15	33	4	6	6	5	34	5	15	2	14	18	6	8	2	7	70	5	15	5	11
1995	21	12	43	7	11	4	7	54	6	14	4	10	60	8	13	5	8	109	6	17	6	10
1996	10	14	30	7	9	3	7	25	6	10	3	8	90	7	16	6	12	79	4	8	10	4
1997	17	12	32	3	5	6	3	75	7	17	4	14	17	7	14	1	14	62	6	12	5	8
1998	8	27	23	4	6	4	4	40	6	12	3	9	64	5	13	5	9	104	4	8	13	4
1999	**24**	**10**	**11**	**5**	**11**	**1**	**11**	**61**	**7**	**14**	**4**	**9**	**76**	**7**	**15**	**5**	**10**	**91**	**7**	**14**	**7**	**8**
2000	14	22	32	6	14	2	12	25	6	7	4	3	40	7	11	4	8	32	3	4	8	3
2001	11	11	76	6	12	6	8	156	5	11	14	3	79	6	11	7	5	237	6	18	13	8
2002	6	17	10	3	7	1	7	30	8	11	3	10	85	5	11	8	7	28	4	5	6	2
2003	**114**	**20**	**9**	**4**	**6**	**1**	**6**	**9**	**8**	**11**	**1**	**11**	**22**	**5**	**7**	**3**	**5**	**31**	**4**	**6**	**5**	**4**
2004	9	16	18	6	9	2	8	119	6	16	7	8	88	6	18	5	13	97	7	13	7	6
2005	4	17	40	6	11	4	8	33	4	13	3	12	38	5	14	3	10	136	3	9	15	5
2006	22	9	73	6	13	6	9	66	6	13	5	9	70	7	12	6	6	104	6	13	8	5
2007	**43**	**40**	**79**	**3**	**10**	**8**	**5**	**0**	**0**	**0**	**0**	**0**	**99**	**6**	**15**	**7**	**12**	**71**	**6**	**14**	**5**	**10**
					march					april					may					jun		
	r (%)	DP	H	EO	RD	I	H5	H	EO	RD	I	H5	H	EO	RD	I	H5	H	EO	RD	I	H5

P	t
0.5	0.689
0.1	1.74
0.05	2.11
0.02	2.57
0.01	2.9

Correlation is ...

Indices	correlation	T parameter
summ t > 0 (oC)	0.37	1.61
Wto (mm)	0.33	1.41
sws (mm)	-0.11	0.46
Rain (mm)	-0.36	1.54
c1 (day)	0.32	1.37
c2 (day)	0.34	1.46
ptu (oC hour)	0.38	1.65
tu (oC)	0.39	1.68
h-wto (mm)	-0.39	1.71
longest dry period	0.11	0.43
March: precipitation	-0.05	0.21
March: episodes	-0.25	1.04
March: rainy days	0.04	0.15
March: intensity	-0.17	0.68
March: 0 < H < 5	0.04	0.16
April: precipitation	-0.23	0.96
April: episodes	-0.16	0.64
April: rainy days	-0.14	0.55
April: intensity	-0.23	0.94
April: 0 < H < 5	-0.01	0.06
May: precipitation	-0.13	0.54
May: episodes	0.01	0.02
May: rainy days	-0.51	2.37
May: intensity	0.03	0.12
May: 0 < H < 5	-0.34	1.45
June: precipitation	-0.37	1.59
June: episodes	-0.04	0.16
June: rainy days	-0.16	0.67
June: intensity	-0.42	1.84
June: 0 < H < 5	-0.15	0.59

Model-related problem. Dinamical approach

- *Reanalisys of parameterisations and paramaters used in the model*

$$P = \frac{C_a - C_c}{r_c} \qquad P = \frac{(C_a + K + r_c P_M) - \left[(C_a + K + r_c P_M)^2 - 4 C_a r_c P_M\right]^{1/2}}{2 r_c}$$

$$P(C_a, L, T) = \frac{\left[C_a + K + r_c\left(\frac{P_{MLT} G(T)}{1 + \frac{K_L}{L}}\right)\right] - \left\{\left[C_a + K + r_c\left(\frac{P_{MLT} G(T)}{1 + \frac{K_L}{L}}\right)\right]^2 - 4 C_a r_c \left(\frac{P_{MLT} G(T)}{1 + \frac{K_L}{L}}\right)\right\}^{1/2}}{2 r_c}$$

P_{MLT} – photosinthetic capacity under maximum CO2 concentration, maximum PAR intensity and optimum temperature

Reanalisys of parameterisations and paramaters used in the model

$$\frac{\partial MSC}{\partial T} = TCC(t)$$

$$TCC(t) = EC(t)(FC(t) - M \cdot MSC(t))$$

$$FC(t) = F_{MAX} \cdot LAI(t) \cdot FL \cdot F$$

MSC - dry matter mass
TCC - growth intensity
EC - photosynthesis efficiency
FC - net photosynthetic intensity
M - emphirical parameter
Fmax - potential photosynthetic intensity
FL - daylight/night length duration
F - Fmax adjucement to environmental conditions

Instead of conclusion…

Q4: Why/How to use indices?

- *In our agrometeorological conditions it is very hard to improve yield forcasting in extreme weather conditions using indices*

Q3: Why it happens?

- *Input data problem? NO (or not importante)*
- *Observed (output) data problem?(!) NO (or not importante)*
- *Is it common behavior of models? NO*
- *Model-related problem? - YES*

Q1: Why?

In order to predict future behavior of crop models in extreme weather conditions BUT ONLY FOR (MAXIMUM) 10 DAYS IN ADVANCE