International Conference on current knowledge of Climate Change Impacts on Agriculture and Forestry in Europe
3-6 May 2011, Topolcianky, Slovakia

Sensitivities of crop models to extreme weather events - a case study for maize and winter wheat in Austria

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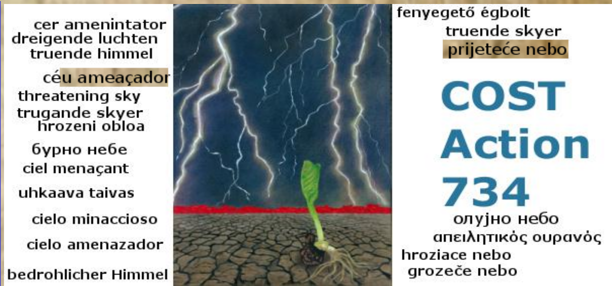
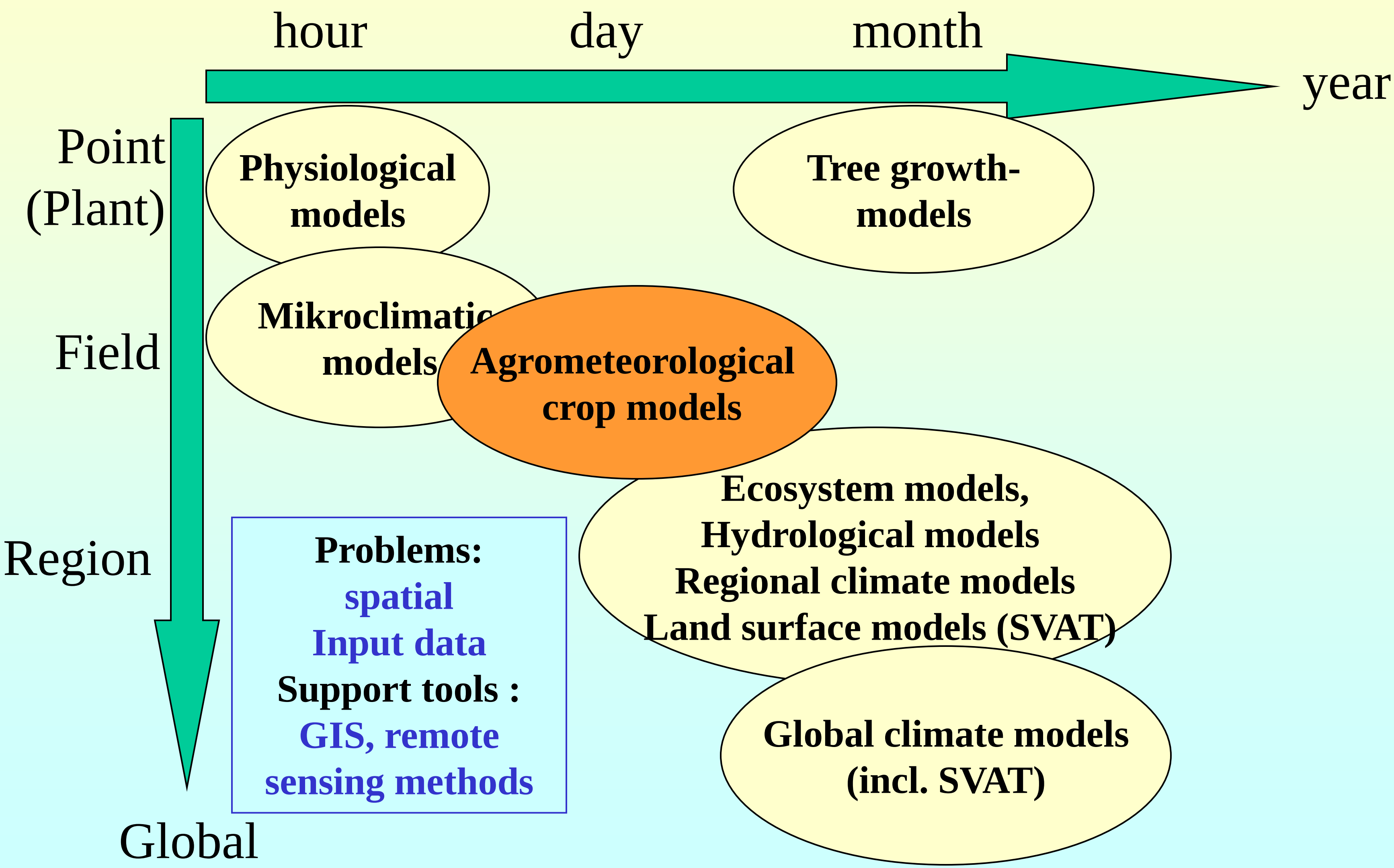
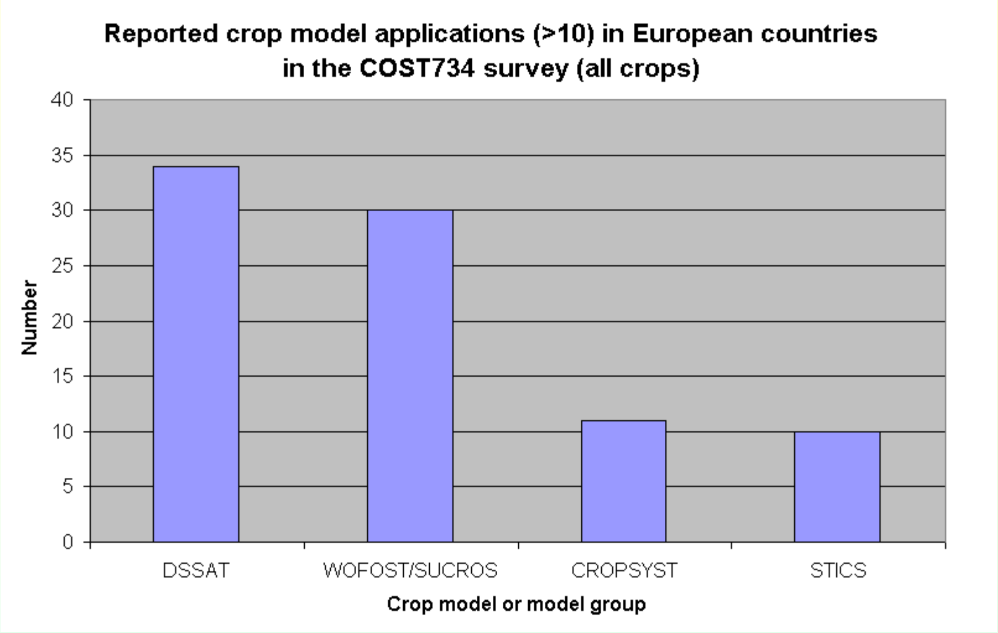


Application of process oriented models in Europe

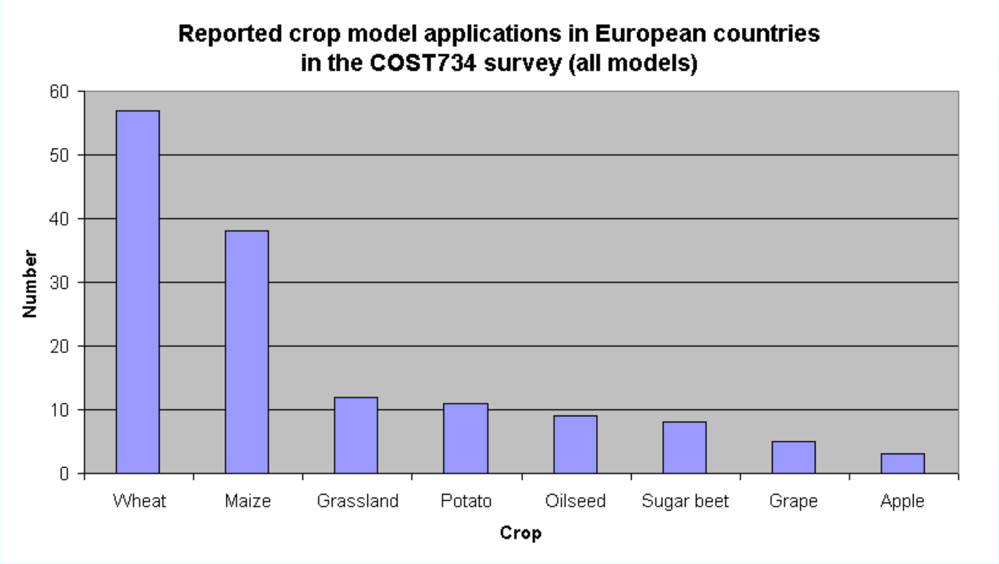
Models and their related spatial and time scale



Use of process oriented crop models in European countries



Models



Crops

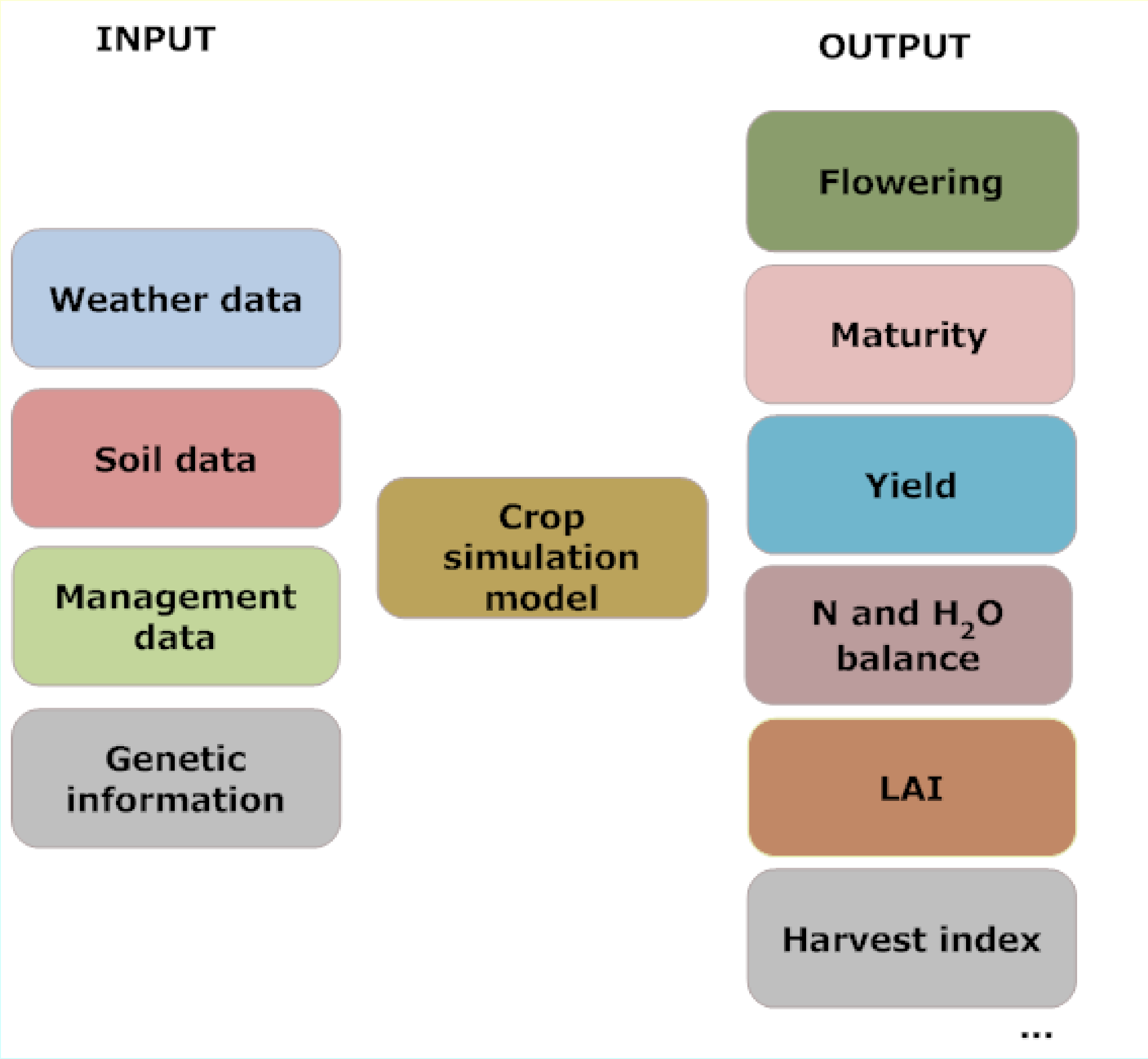
Reported research applications of crop models

	Wheat	Maize	Grassland	Oilseed (Rape)	Potatoes	Sugar beet	Apple	Grape	Other
Austria	CERES-Wheat, SIMWASER, WOFOST, PERUN, EPIC	CERES-Maize, WOFOST, SIMWASER	FAO-GRAM	no	No	no	no	no	Soybean, barley: CERES, EPIC, SIMWASER
Bulgaria	CERES, Weather-Yield, Roimpel, WOFOST	CERES-Maize, WOFOST Weather-Yield, Roimpel, Statistical models	no	no	No	no	no	no	CERES/WOF, Barley, sunflower : ROIMPEL
Croatia	No	CERES-Maize	no	no	No	no	no	no	no
Czech Republic	CERES-Wheat, WOFOST, STICS, SHOOTGROW	CERES-Maize, PERUN, WOFOST	STICS	no	No	no	no	no	CERES-Barley
Denmark	CLIMCROP, DAISY	no	CLIMCROP	DAISY	CLIMCROP	no	no	no	Barley : CLIMCROP, DAISY
Finland	CERES-Wheat, AFRC-Wheat, CropWatN	CERES-Maize	no	no	POTATOS	no	no	no	no
France	STICS, CropSyst, SUCROS	STICS	STICS	STICS	No	SUCROS	no	STICS	no
Germany	AGROSIM, APSIM, DAYCENT, FASSET, HERMES, SWIM(EPIC), N-EXPERT	HERMES, SWIM (EPIC), DAYCENT, N-EXPERT	DAYCENT	DAYCENT		AGROSIM, DAYCENT, HERMES	no	N-VINO	no
Greece	WOFOST, CERES-wheat	WOFOST, CERES-maize	no	no	No	no	no	no	WOFOST-cotton, BEAVER-sorgum
Hungary	CERES-Wheat, 4M	CERES-Maize, 4M	no	no	No	no	no	no	no
Ireland	No	CERES-Maize	JTC grass model Dairy-sim	no	SUBSTOR	no	no	no	CERES-Barley CROPGRO (soy bean)
Italy	WOFOST, CROPSYST, CERES-Wheat, CRITERIA	CROPSYST, CERES-Maize	no	no	No	no	no	no	no
Netherland	WOFOST, SUCROS	WOFOST, SUCROS		WOFOST, SUCROS	WOFOST, SUCROS				WOFOST, SUCROS, LINTUS, SWACROP2, SWAP
Norway	WOFOST, KONOR	no	ENGNOR	no	No	no	no	no	no
Poland	WOFOST	no	no	no	WOFOST	no	no	no	IPO
Portugal		CERES-Maize							
Romania	CERES-Wheat, ROIMPEL	CERES-Maize, ROIMPEL, CROPWAT	ROIMPEL	ROIMPEL	ROIMPEL	ROIMPEL	no	no	no
Serbia	SIRIUS, PERUN, CROPSYST	no	no	no	BAHUS	no	BAHUS	no	no
Slovakia	GLOBAL, WOFOST, DAISSY, CERES-Wheat	GLOBAL, WOFOST, DAISSY, CERES-Maize	no	no	No	no	no	no	no
Slovenia	IRRFIB	IRRFIB	no	no	No	IRRFIB	IRRFIB	no	no
Spain	CERES-Wheat, SWAP	CERES-Maize	no	no	No	no	no	OLIWIN, SWAP	SWAP
Switzerland	CROPSYST	CROPSYST	PaSim	no	CROPSYST	no	no	no	no
United Kingdom	SIRIUS, CERES-Wheat, SUCROS, PALM (CENTURY; DSSAT), LADSS (CROPSYST)	PALM (CENTURY; DSSAT), LADSS (CROPSYST)	PALM (CENTURY; DSSAT), LADSS (CROPSYST)	PALM (CENTURY; DSSAT), LADSS (CROPSYST)	PALM (CENTURY; DSSAT), LADSS (CROPSYST)	PALM (CENTURY; DSSAT), LADSS (CROPSYST)			PARCH – tropical crops

Problems and uncertainties in crop model applications:

A) Caused by crop model inputs

Crop model inputs /outputs



Problems of input data quality
(Soil, weather data, plant data)

Quality of weather input data :

- Homogeinity of time series (climate data!)

- Accuracity of measured data (technical)

- Representativity of measured data

Factors :

Soil characteristics

Topography (!)

Soil surface

...

Model results are as accurate as their input data !!

Reported limitations of crop model applications in European countries

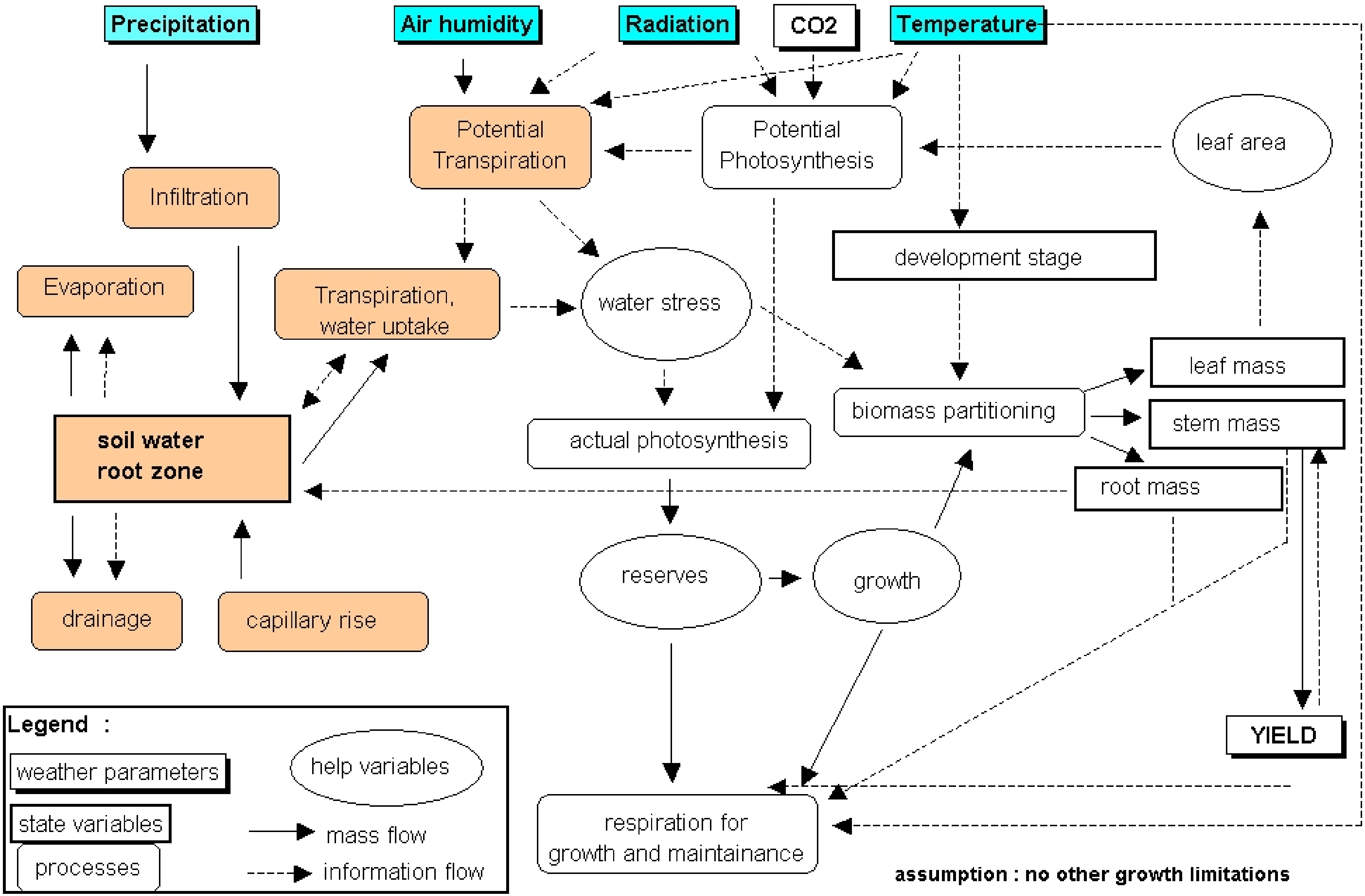
Type of limitation	Number
Lack of availability of biological and crop data for validation of models (long term yield of specific varieties etc.)	12
Low quality of soil data like parameter value describing texture, organic content, soil physical indicators (too low spatial resolution for field applications etc.)	11
Daily weather data not available in time	5
Quality of (historical) weather data	1

Problems and uncertainties in crop model applications:

B) Caused by the representation of the simulated processes

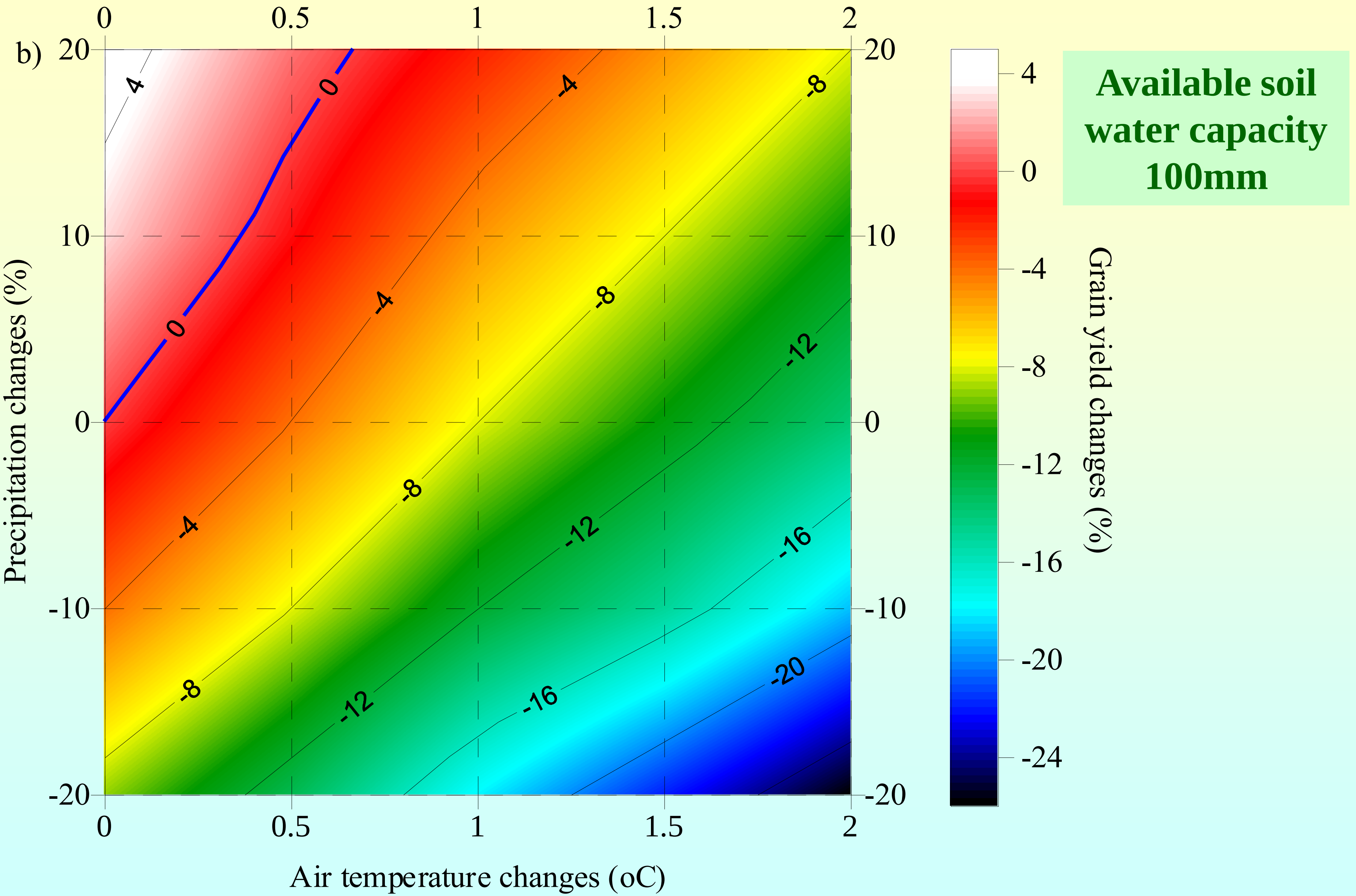
LEVEL 2

Flow diagram of growth model MACROS (Penning de Vries, 1989)



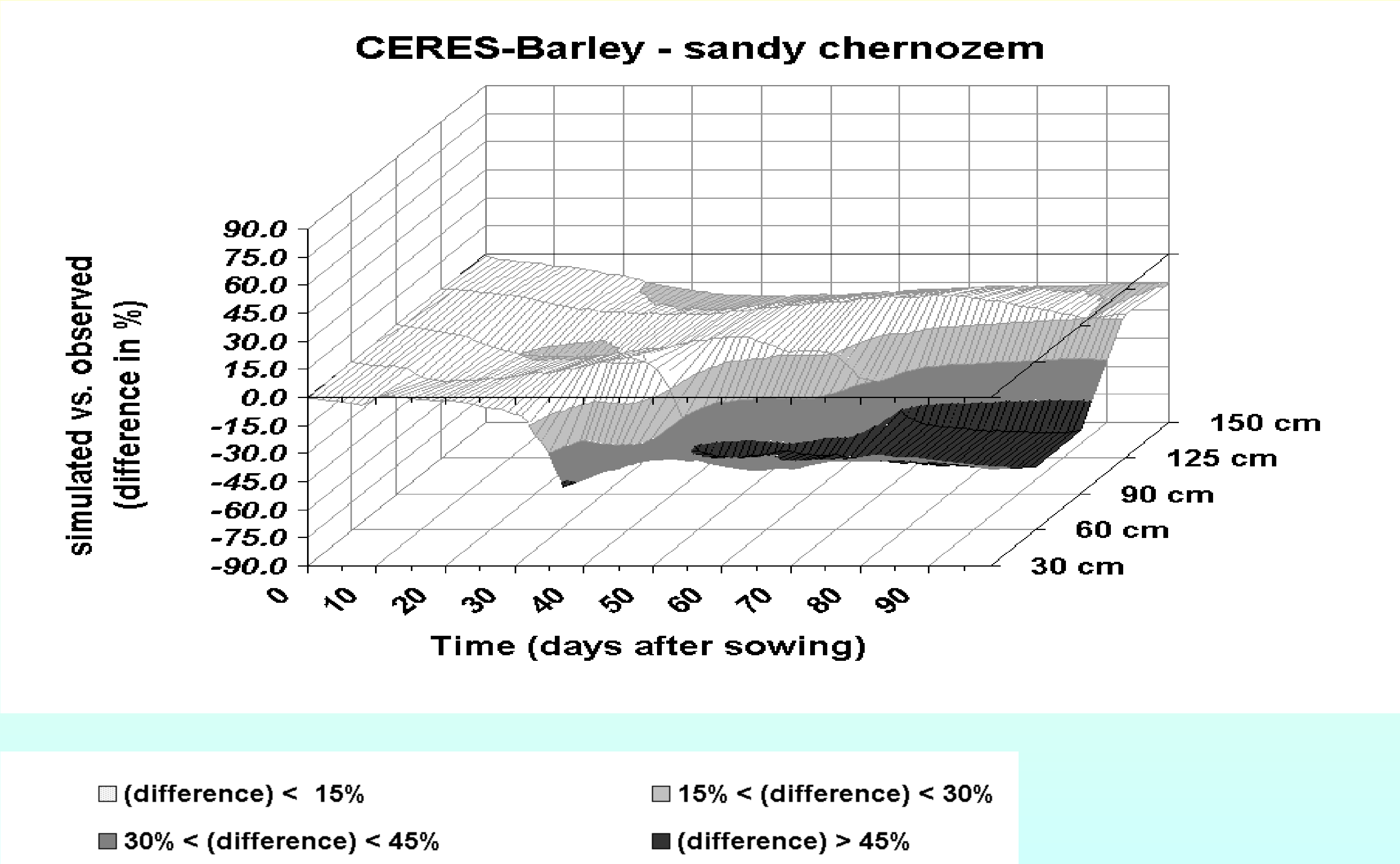
Testing and comparing crop models:

Checking the sensitivity of simulated processes and related outputs on input parameters

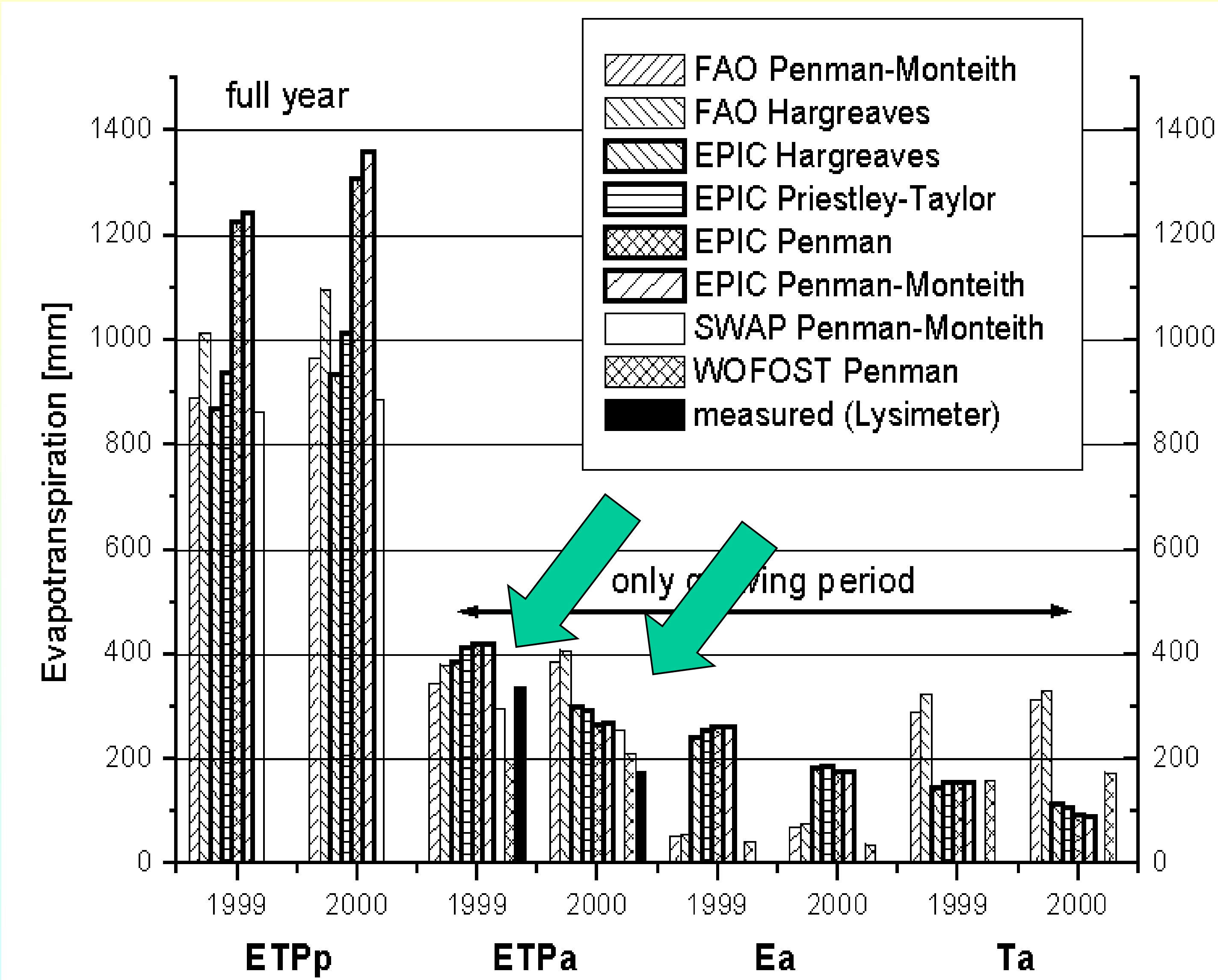


Sensitivity of winter wheat yield to temperature and precipitation in Austria – CERES-Wheat model (Alexandrov et al., 2002)

Deviations in simulated soil water contents



Simulated and measured soil water in lysimeter (Eitzinger, Trnka, Zalud et al., 2003)



Measured (Lysimeter) and simulated ETP

COST 734 case study

Crop model comparison

(7 models:
DSSAT, EPIC, WOFOST, AQUACROP,
FASSET, HERMES, CROPSYST)

on drought and heat stress effects
on winter wheat and maize yields

Study contributers (modellers)

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Erwin Schmid(*2)*, Franziska Strauss(*2)*…….*EPIC*
Roberto Ferrise(3), Marco Moriondo(3), Marco Bindi(4)…….CROPSYST
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Study design:
2 years, 2 crops, 2 locations, 2 soil cultivation types

Years : 2003 (dry) and 2004 (wet)

Crops: Maize and Winter Wheat

Locations: Marchfeld (semi-arid, sandy loam),
Styria (humid, loam)

Soil cultivation: Plough and minimum cultivation (harrow)

Baseline conditions during flowering periods in 2003 and 2004 (real weather conditions)

Crop season	Crop	Weather scenario period (Flowering date + 14 days)		T_{max} (mean) (ºC)		T_{min} (mean) (ºC)		Precipitation (sum) (mm)	
		A	B	A	B	A	B	A	B
2003	WW	June 1-15	June 3-17	29.0	29.6	17.5	16.5	16	22
2003	M	July 13-27	July 12-26	29.3	29.4	15.5	15.3	49	98
2004	WW	June 6-20	June 10-24	23.1	23.3	13.2	12.9	6	116
2004	M	July 29 - Aug 12	Aug 1-15	27.8	26.7	14.4	15.1	7	35

T_{max}: Maximum air temperature;

T_{min}: Minimum air temperature;

M: Maize; WW: Winter wheat;

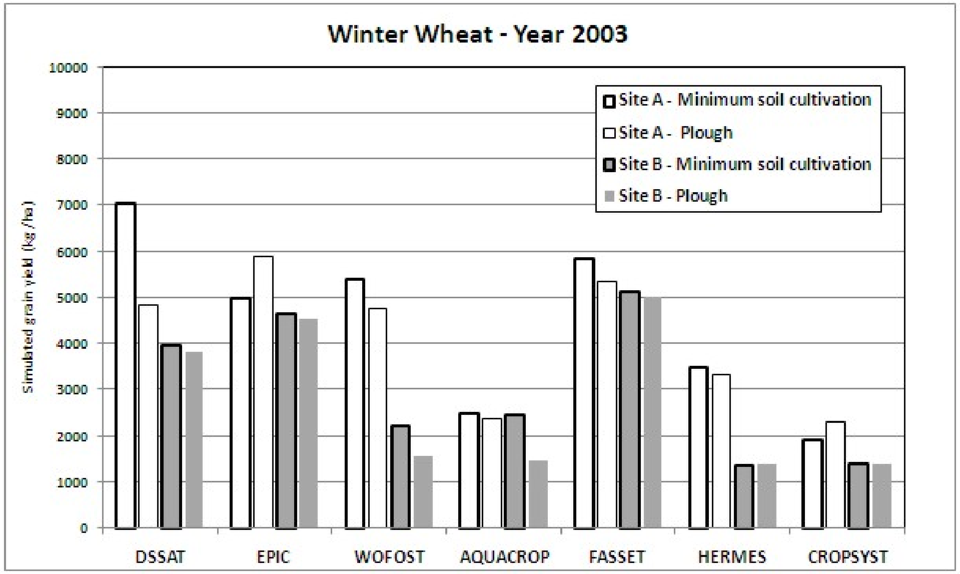
A: Location Raasdorf (Lower Austria);

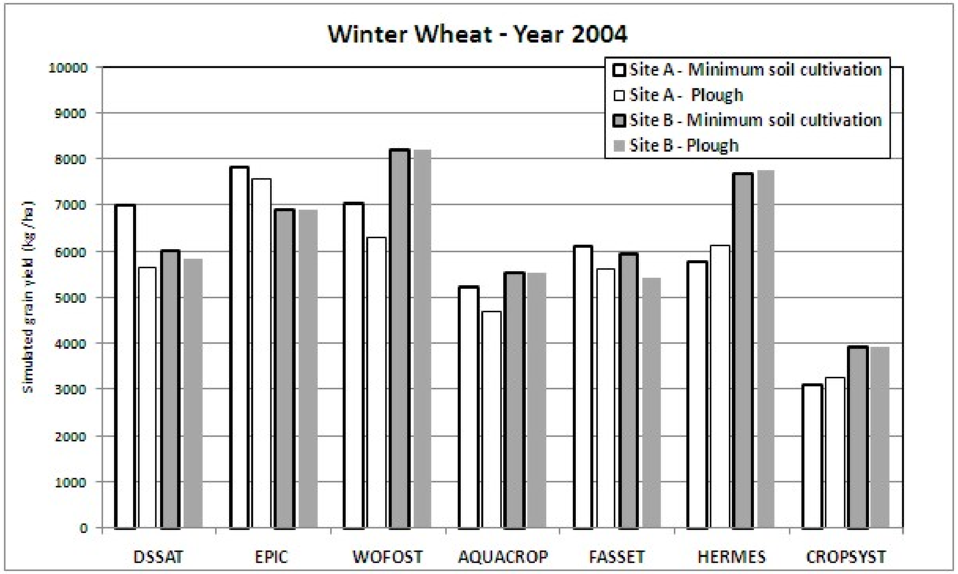
B: Location Paurach (Styria).

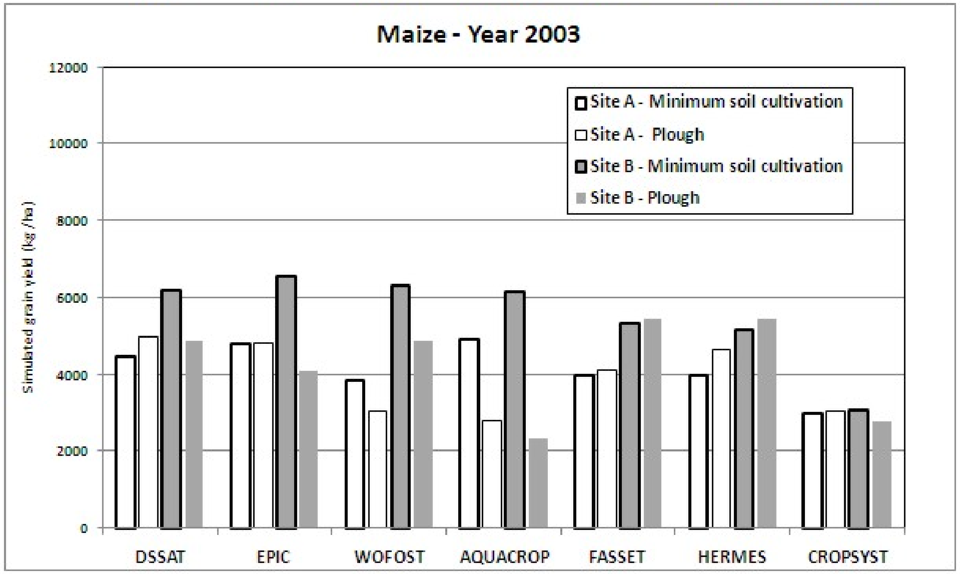
Weather scenarios applied on baseline (change of a 14-day period during flowering of maize and winter wheat)

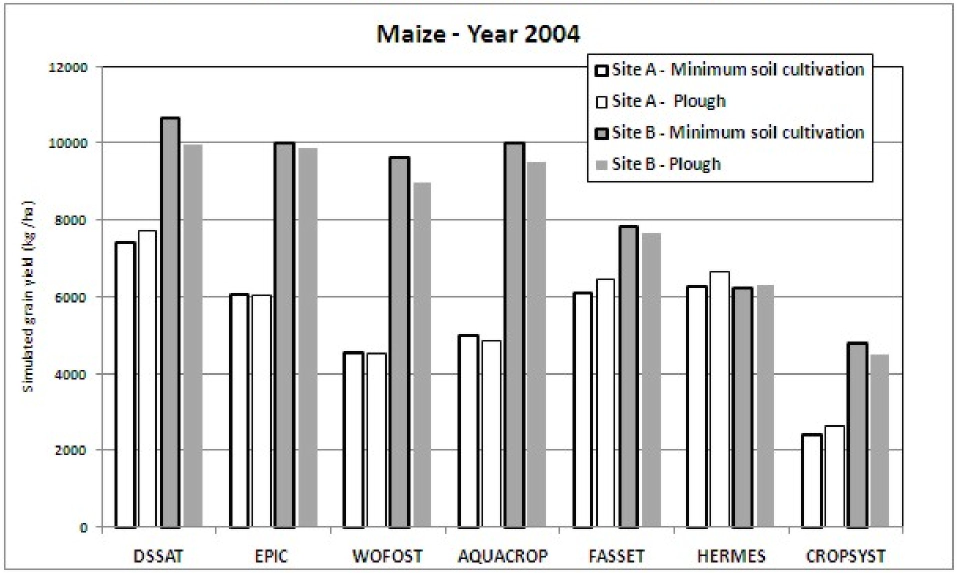
Scenario No.	Δ Tmax °C	Δ Tmin °C	∑ Precipitation mm
1 (T4)	+ 4	x	X
2 (t4)	x	+ 4	X
3 (Tt2)	+ 2	+ 2	X
4 (Tt4)	+ 4	+ 4	X
5 (T4P)	+ 4	x	0
6 (t4P)	x	+ 4	0
7 (Tt2P)	+ 2	+ 2	0
8 (Tt4P)	+ 4	+ 4	0
9 (P)	x	x	0
x = Unchanged baseline value (see Table 3a)			

Simulated yields for the baseline (real weather conditions)









MAIZE – Minimum Soil Cultivation

	Site A - 2003										Site A - 2004								
	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P		T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-15.4	-10.5	-13.9	-15.8	-34.3	-32.2	-32	-37.6	-29.6		-24.9	-22.1	-23.9	-28.3	-25	-22.3	-23.7	-28.4	-19
EPIC	-8.5	4	-2.7	-5.4	-45.9	-44.3	-45.1	-47	-43.5		-6.2	4.6	-1.1	-2.1	-12.7	-3.1	-8.3	-9	-7.3
WOFOST	-15.3	-6.9	-11.1	-23.5	-66.7	-62.2	-64.8	-72.8	-55.3		-10.5	-5.2	-8.3	-16.9	-16.1	-11.1	-14	-22.4	-6
AQUACROP	-4.1	-3.7	-4.5	-5.6	-86.7	-86	-86.3	-86.8	-85.8		0.6	-1.9	-2.4	-2.8	-13.5	-11.8	-12.5	-13.3	-12.1
FASSET	-2	-2	-2	-5.1	-22.2	-22.2	-22.2	-24.4	-22.2		-4.8	-4.8	-4.8	-7.8	-5.8	-5.8	-5.8	-9.2	-0.6
HERMES	2	2	2	1.3	-26.2	-26.2	-26.2	-39.6	-35.1		3.9	3.9	3.9	-2.8	-3.7	-3.7	-3.7	-23.4	1.1
CROPSYST	-5.6	3.5	-1.7	-5.1	-11.1	-5.1	-8.6	-10.2	-7.4		-6.5	2.8	-1.2	-3.7	-15.5	-11.4	-13.6	-14.6	-13
mean	***-7***	***-1.9***	***-4.8***	***-8.5***	***-41.9***	***-39.7***	***-40.7***	***-45.5***	***-39.8***		***-6.9***	***-3.2***	***-5.4***	***-9.2***	***-13.2***	***-9.9***	***-11.7***	***-17.2***	***-8.1***

	Site B - 2003										Site B - 2004								
DSSAT	-3.5	-0.7	-2.9	-7.7	-54.3	-54.2	-54.8	-58.8	-50.9		-0.6	-0.6	-0.1	0	-15.8	-13	-14.4	-15.2	-14.2
EPIC	-8	-1.1	-4.6	-9.9	-66.9	-66.1	-66.5	-69.5	-63.2		-6	1.6	-2.5	-6	-16.5	-10.8	-14.1	-17.6	-11.1
WOFOST	-92.9	-8.1	-9.5	-13.6	-99.5	-99.3	-99.5	-99.9	-11.7		-18.8	-2.1	-2.7	-6.7	-22.1	-20.5	-20.7	-23.6	-4.8
AQUACROP	-4	-6.3	-7.8	-10.1	-77.1	-76	-76.5	-77.2	-75.8		-0.7	0.2	-0.3	-0.9	-43	-40.8	-41.8	-40.5	-40
FASSET	-2.9	-2.9	-2.9	-4.6	-26.1	-26.1	-26.1	-25.3	-23.9		-1.5	-1.5	-1.5	-1.1	-0.6	-0.6	-0.6	-0.4	1
HERMES	-6.3	-6.3	-6.3	-8.1	-69.3	-69.3	-69.3	-69.2	-69.8		6.3	6.3	6.3	7.2	13.2	13.2	13.2	14.4	6.5
CROPSYST	-7.4	-0.6	-5.2	-7.1	-11.6	-7.3	-10.1	-10.2	-9.4		-11.6	3.7	-4.4	-9	-27.8	-23.1	-25.8	-26.6	-24.9
mean	***-17.8***	***-2.7***	***-4.5***	***-7.8***	***-59.3***	***-58.2***	***-58.8***	***-60***	***-44.9***		***-4.6***	***1.2***	***-0.6***	***-2.2***	***-10.7***	***-8.4***	***-9.5***	***-10.5***	***-7.5***

MAIZE – Plough

Site A - 2003

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-17.3	-11.2	-14	-15.7	-36.5	-35.5	-35.6	-37.8	-36.3
EPIC	-8.3	4.2	-2.5	-5	-45.1	-43.6	-44.4	-46	-42.9
WOFOST	-18	-8.3	-13.3	-28.1	-71.2	-67.9	-70	-78.7	-61.1
AQUACROP	-5.5	-3.4	-4.1	-5.7	-90.6	-90	-90.3	-92.8	-89.9
FASSET	-2.1	-2.1	-2.1	-4.7	-25.1	-25.1	-25.1	-26.3	-24.3
HERMES	-0.4	-0.4	-0.4	-7.6	-43.7	-43.7	-43.7	-62.5	-33
CROPSYST	-7.7	1.5	-3.9	-10	-28.8	-26.2	-27.6	-28.6	-27.3
mean	***-8.5***	***-2.8***	***-5.8***	***-11***	***-48.7***	***-47.4***	***-48.1***	***-53.2***	***-45***

Site A - 2004

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-22.3	-20.7	-21.6	-24.7	-22.1	-19.5	-21.8	-24.9	-20
EPIC	-5.5	1.6	-2.3	-4.2	-12.2	-7.8	-10.2	-11.9	-8.2
WOFOST	-12.4	-6.9	-9.9	-21.1	-19.6	-14.4	-17.2	-11.8	-8.1
AQUACROP	-4.1	-0.6	-2	-4.6	-35.8	-33.9	-34.7	-35.9	-33.5
FASSET	-0.7	-0.7	-0.7	-3.2	-2.5	-2.5	-2.5	-5	-2.1
HERMES	-7.3	-7.3	-7.3	-23.4	-21.2	-21.2	-21.2	-37.1	-0.4
CROPSYST	-3.9	0.5	-2	-2.7	-4.1	-0.1	-2.3	-3	-0.6
mean	***-8***	***-4.9***	***-6.5***	***-12***	***-16.8***	***-14.2***	***-15.7***	***-18.5***	***-10.4***

Site B - 2003

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-5.5	-2.1	-4.7	-8	-56.2	-56.3	-56.8	-60.2	-53.3
EPIC	-8	-1.3	-4.8	-10.2	-66.8	-66	-66.4	-69.5	-62.8
WOFOST	-94.4	-6.9	-8.2	-11.9	-99.8	-99.7	-99.7	-100	-10.3
AQUACROP	-4.1	-7.7	-9.2	-11.5	-79.4	-78.5	-78.8	-79.5	-78.5
FASSET	0.3	0.3	0.3	-1.7	-23.4	-23.4	-23.4	-23.8	-24.5
HERMES	-16.7	-16.7	-16.7	-16.4	-69.5	-69.5	-69.5	-69.2	-69.8
CROPSYST	-5.3	1.6	-3.3	-3.7	-5.3	-0.5	-4	-3.7	-4.2
mean	***-19.2***	***-3.7***	***-5.9***	***-8.1***	***-58.7***	***-57.6***	***-58.5***	***-59.4***	***-44.7***

Site B - 2004

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-0.7	-0.7	0.2	-0.2	-14.8	-12.2	-13.4	-14.7	-12.1
EPIC	-6	1.4	-2.5	-6.2	-16.9	-12.2	-14.7	-18.4	-11.9
WOFOST	-20.2	-2.4	-2.9	-6.9	-23.3	-21.9	-22.1	-24.6	-4.7
AQUACROP	-5.5	-1.4	-3.3	-6.5	-58.4	-56.7	-57.4	-58.8	-56
FASSET	-0.2	-0.2	-0.2	-1.3	1.7	1.7	1.7	0.5	1.6
HERMES	3.5	3.5	3.5	6.8	9	9	9	11.6	6.2
CROPSYST	-12.4	3.6	-7.9	-9	-22.6	-14	-19.1	-20	-13.2
mean	***-5.2***	***0.8***	***-1.4***	***-2.4***	***-10.7***	***-8.1***	***-9.4***	***-10.5***	***-5.9***

WINTER WHEAT – Minimum Soil Cultivation

Site A - 2003

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-1.9	-2.7	-2.2	-8.5	-6.9	-7.7	-7.3	-10.9	-3.5
EPIC	-14.4	0.2	0	0	9.4	10.2	9.9	-0.1	-14.4
WOFOST	-29.4	-13.3	-20	-40.1	-36	-20.1	-26.7	-46	-7.3
AQUACROP	-4.3	-0.4	-3.6	-7.2	-14.2	-10.8	-11	-14.3	-7.8
FASSET	3	3	3	2.3	0.6	0.6	0.6	0	1.3
HERMES	-6.1	-6.1	-6.1	-19.4	-24.6	-24.6	-24.6	-27.5	-21
CROPSYST	-9.8	9.4	-3	-4.9	-9.8	9.4	-3	-4.9	0
mean	***-9.1***	***-1.9***	***-4.7***	***-11.3***	***-11.7***	***-6.5***	***-9.3***	***-15.8***	***-7.8***

Site A - 2004

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-14.4	-12.9	-13.3	-15	-17.5	-16.5	-17	-16.4	-15.5
EPIC	-4.6	-4	-4.2	-9.4	-5.3	-4	-4.3	-9.6	-0.1
WOFOST	-13.3	-7.8	-10	-21.4	-20.3	-14.8	-16.8	-28.1	-7
AQUACROP	-6	-0.6	-5.2	-6.2	-21.6	-18.5	-19	-21.7	-16
FASSET	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0	0.3
HERMES	-5.1	-5.1	-5.1	-18.5	-22.9	-22.9	-22.9	-40.6	-13.4
CROPSYST	-15.7	8.1	-6.6	-11.8	-18.3	2.7	-10.3	-14.2	-5.6
mean	***-7.8***	***-3.1***	***-5.7***	***-11.1***	***-12.7***	***-8.4***	***-10.7***	***-16.3***	***-6.3***

Site B - 2003

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-1.9	-0.7	-1.4	-3.6	-11.9	-11.4	-11.7	-14.4	-10.2
EPIC	-4.9	-1	-3.5	-6.9	-14.2	-9.6	-12.1	-13.1	-10.5
WOFOST	-35.3	-15.1	-24.6	-43.8	-61.9	-44.6	-53.2	-68.3	-32.3
AQUACROP	-5.6	-7.8	-5.4	-8.4	-34.2	-36.3	-34.2	-36.7	-33.7
FASSET	5.3	5.3	5.3	4.5	2.4	2.4	2.4	1.6	3
HERMES	-0.7	-0.7	-0.7	-1.6	-2.5	-2.5	-2.5	-3.4	-1.8
CROPSYST	-4.5	2.6	-1.7	-2.9	-4.5	2.6	-1.7	-2.9	0
mean	***-6.2***	***-2.6***	***-4.7***	***-9.1***	***-16.7***	***-12.7***	***-14.3***	***-18.1***	***-10***

Site B - 2004

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-3.4	-5	-4.9	-8.6	-4.9	-5	-3.5	-8	-0.3
EPIC	-4.7	-4.2	-4.4	-9.7	-5	-4.3	-4.6	-9.8	-0.1
WOFOST	-6.9	-6.2	-6.5	-13.5	-8.8	-7.1	-7.8	-15.5	-0.8
AQUACROP	0.1	0	0	0.1	0.2	0.3	0.2	0.2	0.2
FASSET	0	0	-0.1	-0.4	-0.4	-0.4	-0.4	-0.7	-0.3
HERMES	-4.5	-4.5	-4.5	-8.7	-4.6	-4.6	-4.6	-8.8	-0.1
CROPSYST	-7.3	4.2	-3	-5.7	-9.5	4.2	-3.5	-6.9	-0.2
mean	***-3.8***	***-2.2***	***-3.3***	***-6.6***	***-4.7***	***-2.4***	***-3.5***	***-7.1***	***-0.2***

WINTER WHEAT – Plough

	Site A - 2003										Site A - 2004								
	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P		T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-0.3	-1	-0.6	-5.7	-4.2	-4.9	-4.5	-8.5	-1.3		-5.8	-3.7	-5.5	-4.1	-9.6	-8.7	-9.1	-7.8	-8.5
EPIC	-22.5	-6.9	-7.9	-15.6	-11.4	-8	-10	-16.2	-18.3		-7.6	-1.8	-4.4	-9.5	-10.7	-4.1	-7.2	-12.2	-3.2
WOFOST	-32.2	-14.5	-21.6	-42.9	-40.9	-23.8	-30.8	-50.9	-9.9		-15.1	-8.9	-11.3	-23.7	-23.9	-18	-20.2	-32	-9.3
AQUACROP	-1.1	-0.3	-0.7	-1.4	-1.3	-0.6	-0.9	-3.5	-0.4		-16.5	-0.5	-1.1	-16.7	-29	-24.2	-28.5	-31.1	-23.9
FASSET	8.5	8.5	8.5	7.8	6.7	6.7	6.7	6.1	7.4		2.2	2.2	2.2	0.2	1.2	1.2	1.2	-0.4	0.8
HERMES	-9.6	-9.6	-9.6	-19.8	-22.6	-22.6	-22.6	-25.7	-16.9		-9.2	-9.2	-9.2	-27.7	-28.1	-28.1	-28.1	-48.6	-12.6
CROPSYST	-10.7	11.9	-2.9	-5.7	-10.7	11.9	-2.9	-5.7	0		-16.5	7.2	-6.4	-12.1	-20.1	2.4	-11.1	-15.4	-5.6
mean	***-10.2***	***-2.2***	***-5.5***	***-12.4***	***-13.4***	***-7.2***	***-10.6***	***-16***	***-6.5***		***-7.7***	***-2.1***	***-5.1***	***-11.3***	***-14.5***	***-8.9***	***-12***	***-18.1***	***-6.4***

	Site B - 2003										Site B - 2004								
DSSAT	-1.4	-0.8	-1	-3.3	-13.7	-13.1	-13.4	-16.7	-12		-4.8	-5	-4.9	-8.6	-4.9	-5.1	-5	-8.6	-0.3
EPIC	-5.6	-0.9	-3.3	-6.4	-16	-10.3	-13.3	-13.8	-11.8		-4.7	-4.2	-4.4	-9.7	-5	-4.3	-4.6	-9.8	-0.1
WOFOST	-34.3	-15.5	-24.2	-41.3	-64.6	-52.6	-59.3	-67.1	-41		-6.9	-6.2	-6.5	-13.6	-11.3	-8.6	-9.4	-18.3	-1.7
AQUACROP	-7.9	-10.7	-7.5	-11.6	-28.3	-34.2	-31.2	-34.7	-27.6		0	0	0	0	0.2	0.3	0.2	0.2	0.2
FASSET	5.3	5.3	5.3	4.3	2.4	2.4	2.4	2	3.1		-0.9	-0.9	-0.9	-1.3	0	0	0	0.9	0.3
HERMES	-6.4	-6.4	-6.4	-7.2	-9.1	-9.1	-9.1	-9.1	-7.4		-4.4	-4.4	-4.4	-8.6	-4.5	-4.5	-4.5	-8.7	0
CROPSYST	-4.7	3.1	-1.7	-3	-4.7	3.1	-1.7	-3	0		-7.3	4.2	-3	-5.7	-10.9	3.8	-4.7	-8.1	-1.1
mean	***-7.2***	***-3.4***	***-4.9***	***-9.4***	***-17.9***	***-15.2***	***-16.6***	***-19.3***	***-12.6***		***-4.1***	***-2.4***	***-3.4***	***-6.8***	***-5.2***	***-2.6***	***-4***	***-7.5***	***-0.4***

Potential reasons for deviations between the models

- Differences in simulated basic water balance parameters (Eto, interception, etc.)
- Differences in simulated root growth and water uptake
- Differences in simulated N-balance (if simulated)
- Differences in simulated biomass accumulation and LAI
- Differences on model parameterization of cultivar temperature response and water stress impacts.
- Differences in yield estimation details (Final harvest index vs. Biomass distribution processes etc.)
- more

(General) CONCLUSIONS

- **The crop models agree with few exceptions in general yield trends in the baseline scenarios (in respect of the influence to the year and location).**
- **All models show for winter wheat higher relative yield response to temperature increase than for maize.**
- **All models show for maize higher (negative) yield response to skipped precipitation (water stress) than for winter wheat.**
- **The models show mixed yield reponse to increased temperatures for both crops (positive and negative ones).**
- **Under water stress the models show mixed yield reponse for winter wheat (positive and negative ones) and mostly significant negative yield response for maize.**
- **All models respond to soil cultivation, but in different way and range.**
- **Huge differences occurred between the relative yield responses to water stress between the models.**

Thank you for your attention !