modextreme

agriculture facing extreme climatic events

Assessment of modelling solutions in agricultural systems in Ukraine

Oleksii Kryvobok (UHMI)





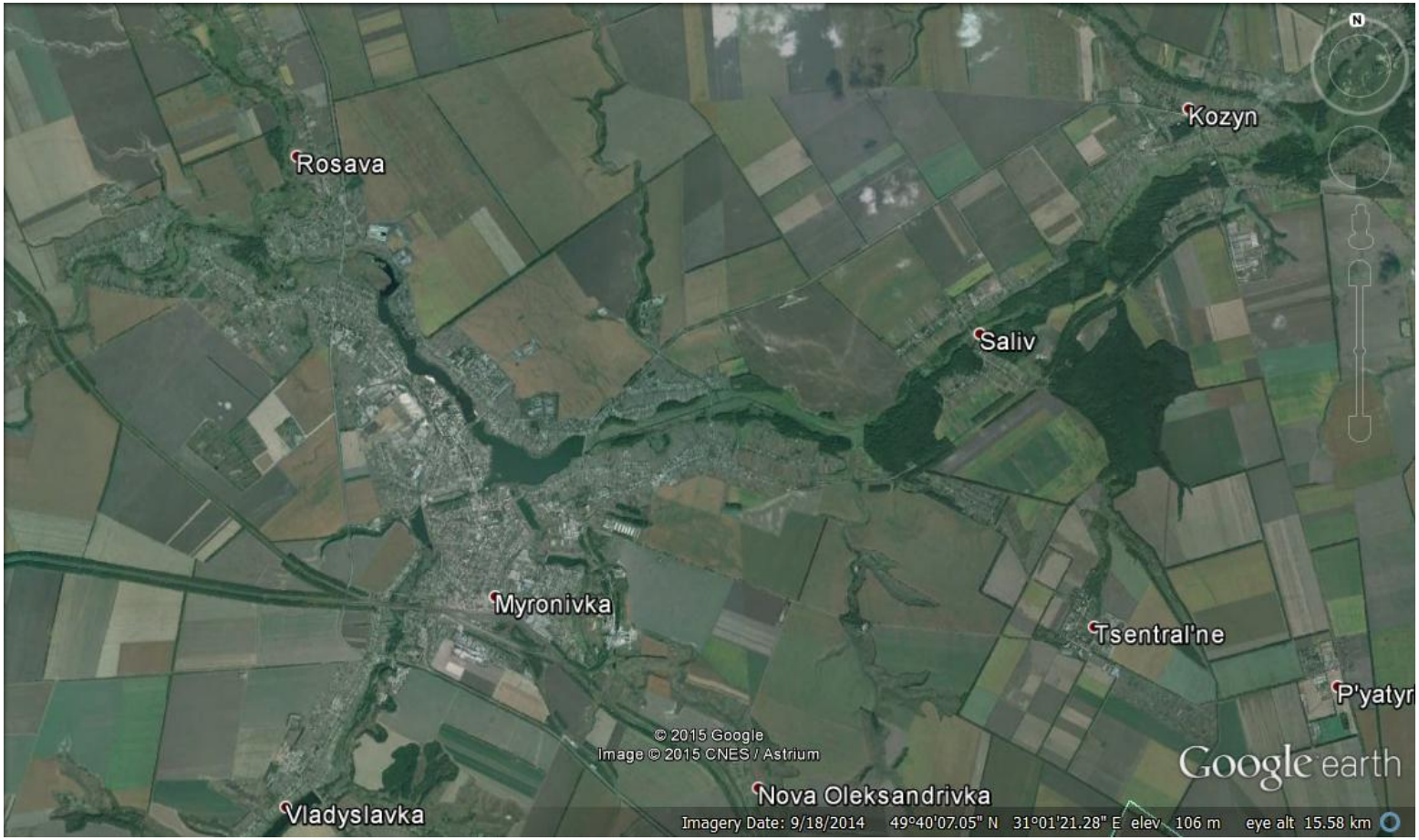

Objectives

- Evaluation model and experimental data equally representing standard and extreme weather. Weather anomalies used for targeted simulations, assessing the capability of new models to capture the anomalous response of plants.
- Calibration of WOFOST model, based on experimental data in Ukraine






Selected site



Collected data

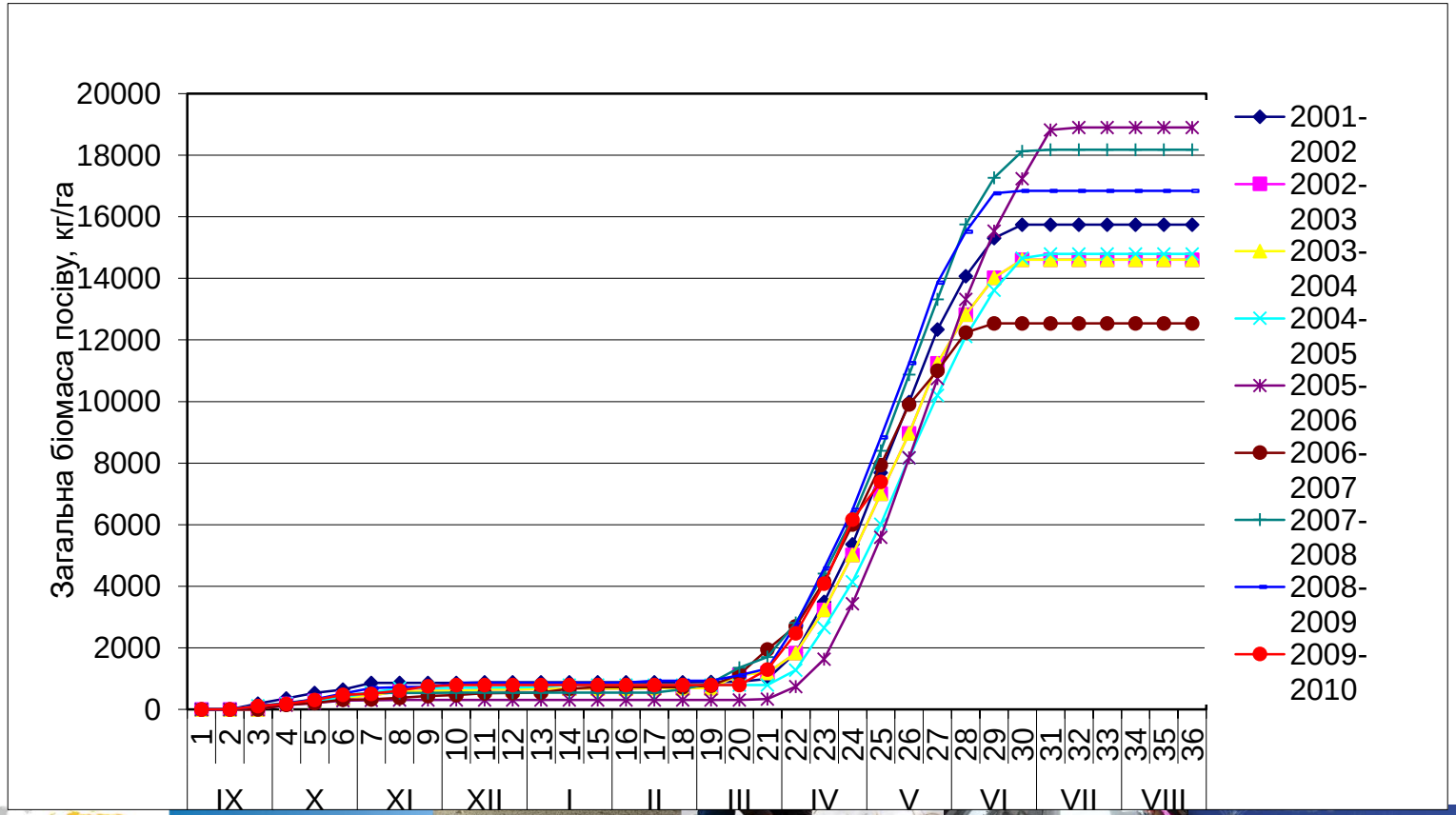
- Soil
- Agro management (fertilizer, tillage)
- Meteodata
- Phenology
- Biomass (weight of grains on m2 or 100m2)
- Statistical information (crop yield)

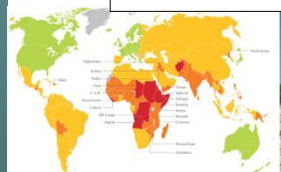




Run WOFOS model for a location with a continental climate

During the winter the mean daily temperature is below zero and WOFOST will not accumulate temperature. In other words: the phenological development is stopped and will continue when spring begins. This proofs that it could be possible to run WOFOST during winter time for climatic grid cells with a continental climate.





Input parameters to WOFOST model dependent on crop phenology.

TBASE	lower threshold temperature for ageing of leaves,°C
TBASEM	lower threshold temperature for emergence, °C
TEFFMX	max. effective temperature, °C
TSUM1	temperature sum from emergence to anthesis, °C
TSUM2	temperature sum from anthesis to maturity, °C
TSUMEM	temperature sum from sowing to emergence, °C
DD/MM/YYYY	sowing date/ emergence date
DD/MM/YYYY	Maturity date/harvest date






Crop model calibration. *Phenology data in Ukraine.*

For the estimation of **TSUMEM** we sum the effective daily temperature (T_{eff}) for crop development from date of sowing (BBCH00) to emergency (BBCH09) dates. The effective daily temperature is calculated as:

$T_{eff} = T - T_{basem}$,

where $T_{basem} = 0$℃ for winter wheat crop and $T_{basem} = 4$℃ for grain maize crop.

TSUM1 and **TSUM2** are calculated as a sum of T_{eff} from emergency (BBCH09) to anthesis (BBCH65) and anthesis to maturity (BBCH89), respectively.

TSUM$_s$ $= \sum_{i=1}^{d} T_{eff}$

$$T_{eff} = \begin{cases} 0\ , T < T_{base} \\ T - T_{base}\ , T_{base} \le T \le T_{effmx} \\ T_{effmx}, T > T_{effmx} \end{cases}$$

where T_{basem} the temperature threshold for crop development, for winter wheat $T_{base} = 0$℃, for grain maize $T_{base} = 10$℃;

T_{eff} effective temperature for crop development, for winter wheat and grain maize $T_{effmx} = 30$℃.






http:/modextreme.org/webxtreme

ARID=1 – T/ET0 (0 no water deficit, 1 most extreme aridity)

where T- transpiration, ET0 – reference evapotranspiration

- Heat shocks

  AIRTMAX > 30°C

- Cold shocks

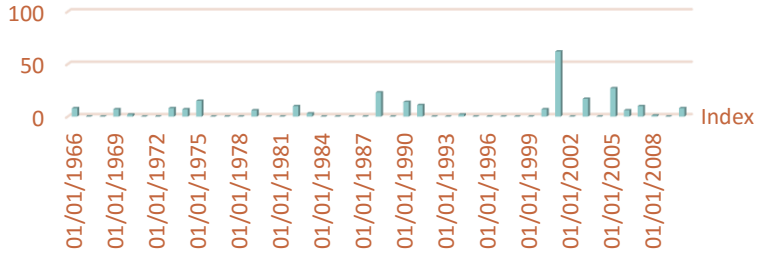
  AIRTMIN < -6°C



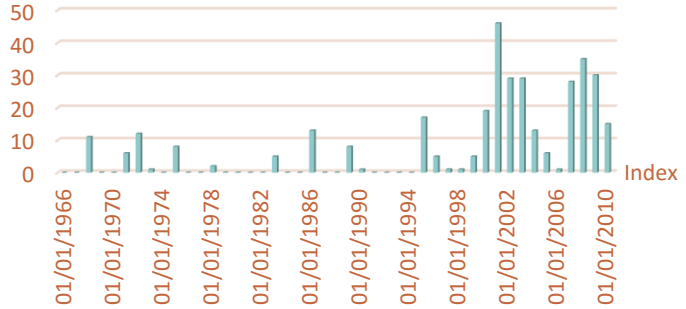



Winter wheat

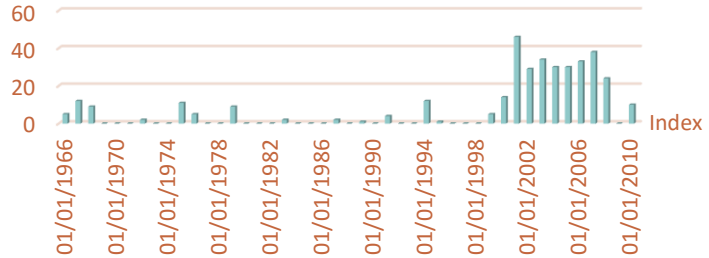
Aridity Index emergence Stop vegetation



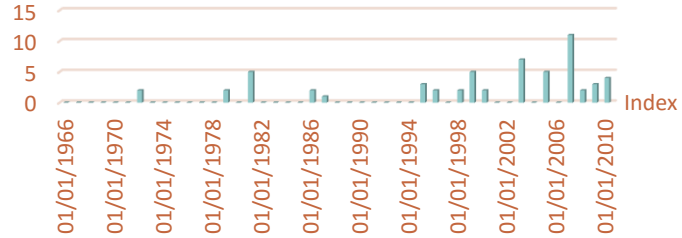
Aridity Index 01/04-flowering



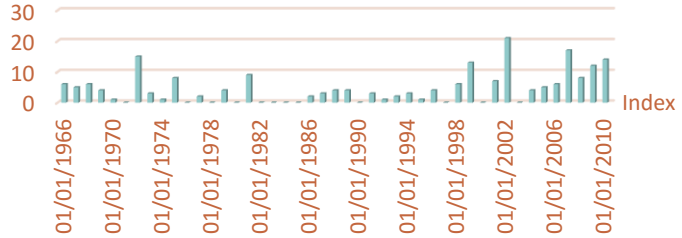
Aridity Index flowering - maturity



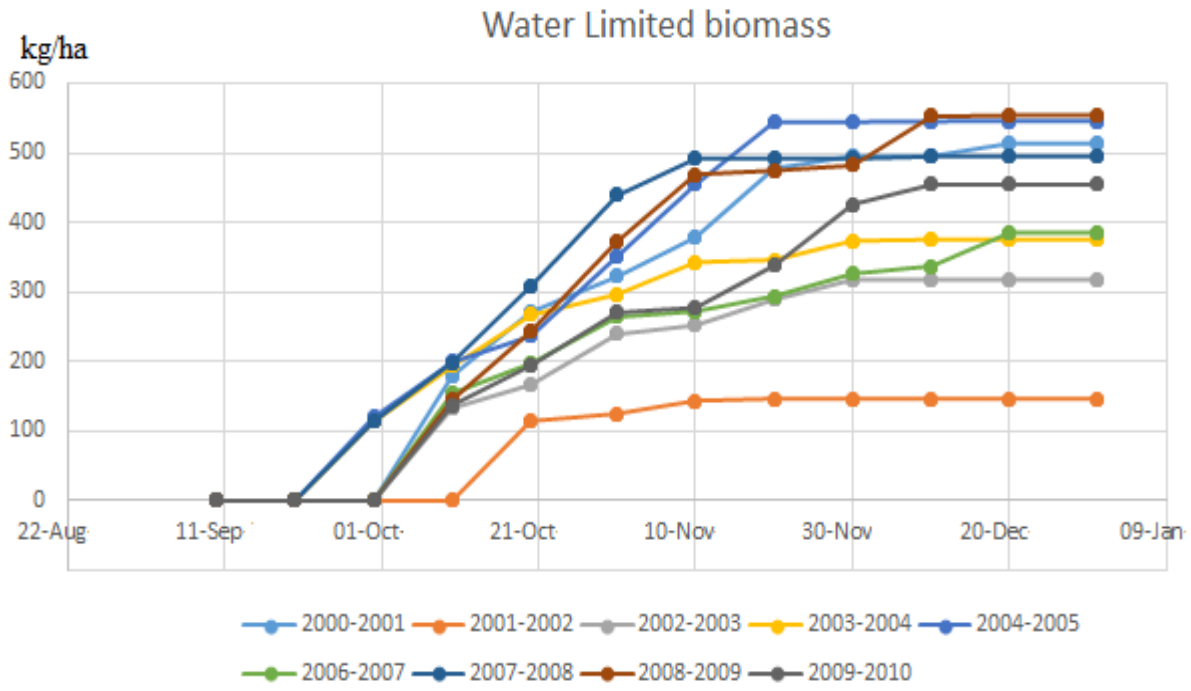
Heat Index 01/04-f



Heat Index flowering - maturity



Water limited biomass of winter wheat

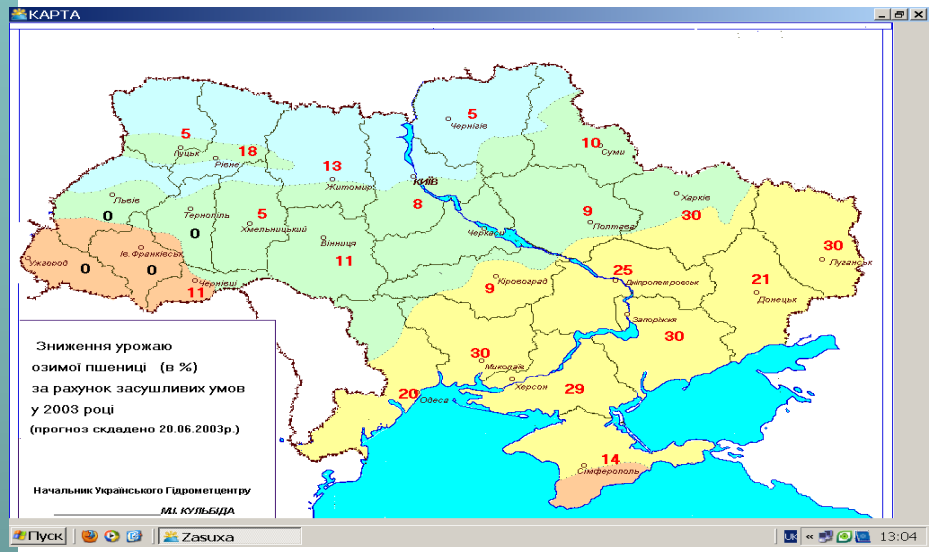






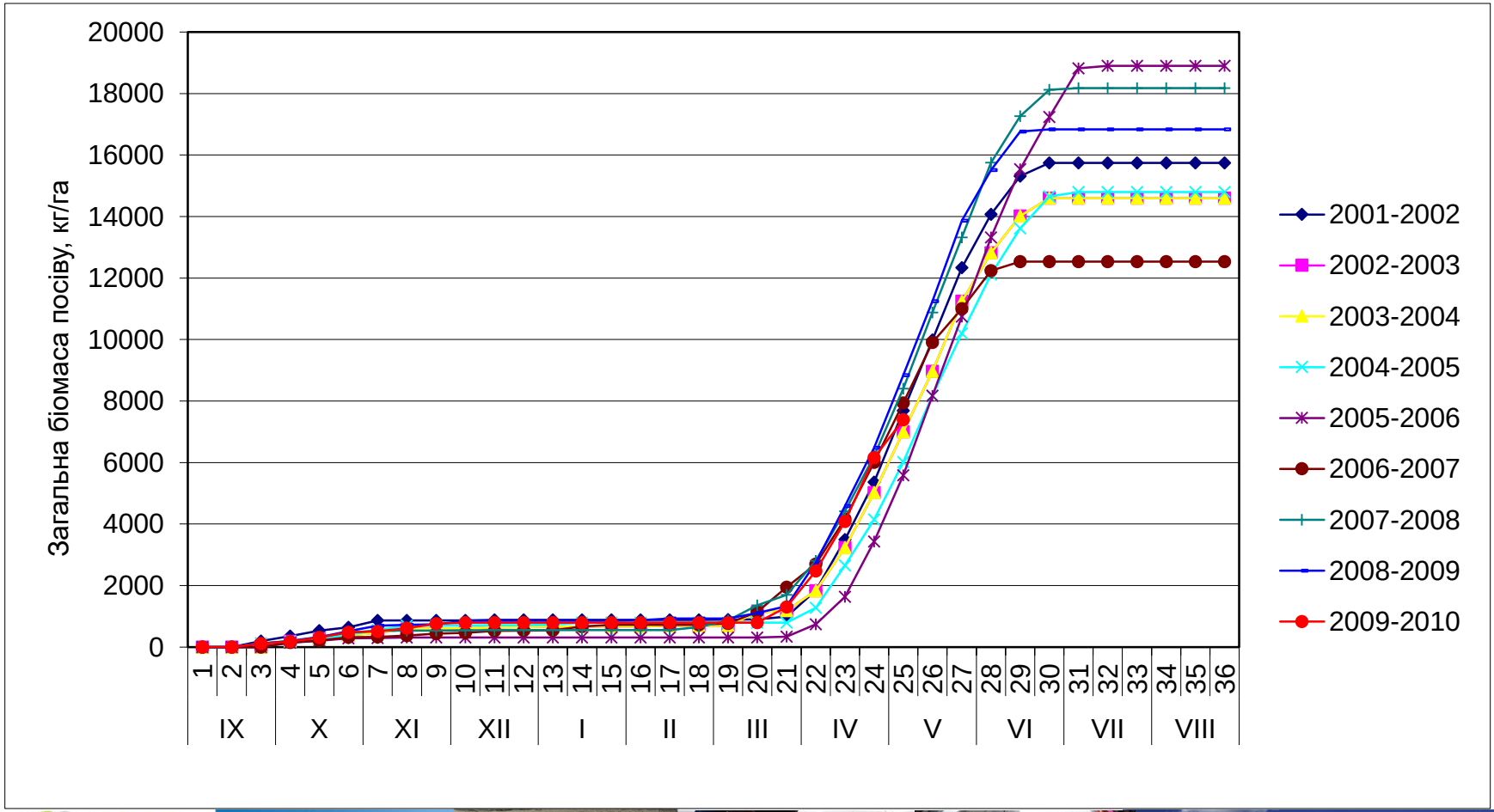

Extreme years

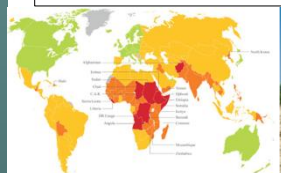
2003



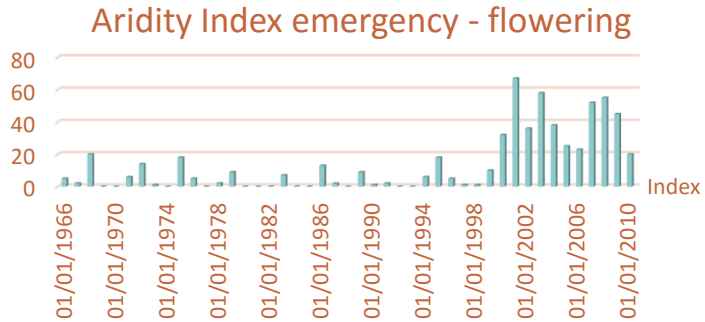
2007

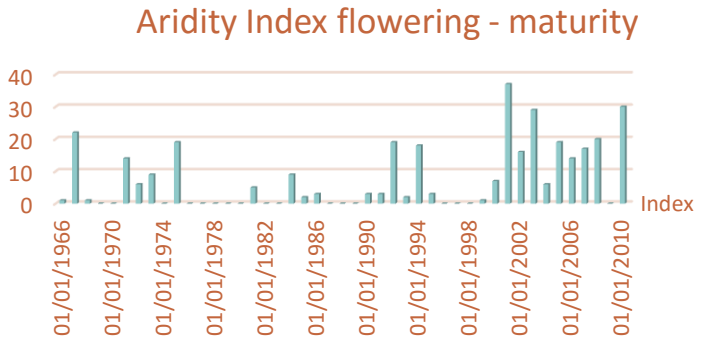
Water limited biomass of winter wheat

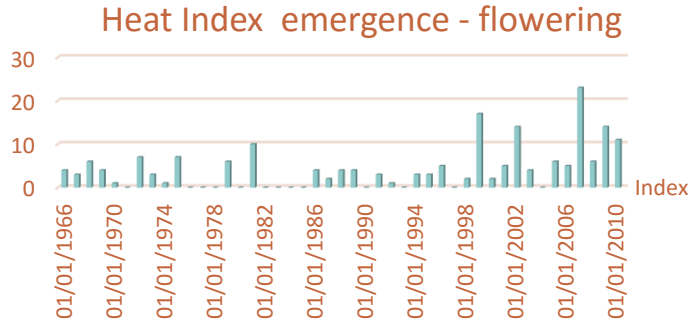


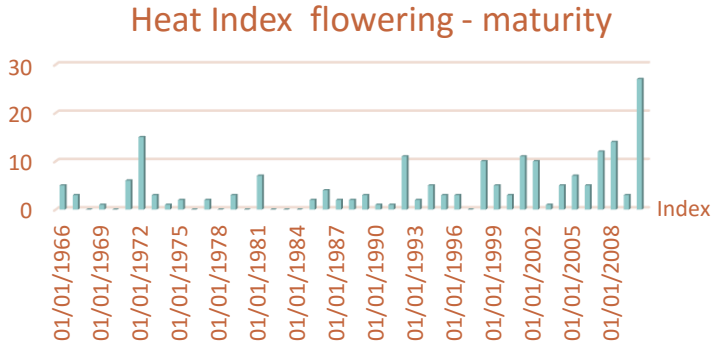


Maize


Aridity Index emergency - flowering
80
60
40
20
0
Index
01/01/1966
01/01/1970
01/01/1974
01/01/1978
01/01/1982
01/01/1986
01/01/1990
01/01/1994
01/01/1998
01/01/2002
01/01/2006
01/01/2010

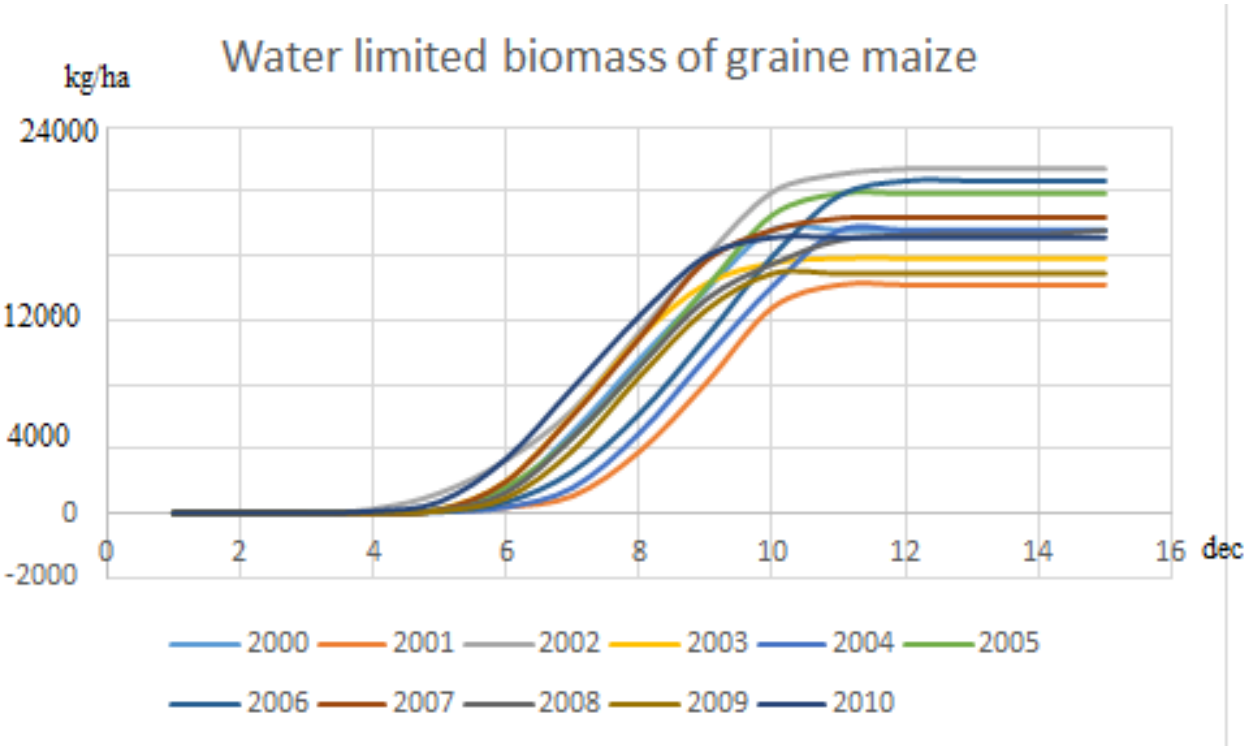

Aridity Index flowering - maturity
40
30
20
10
0
Index
01/01/1966
01/01/1970
01/01/1974
01/01/1978
01/01/1982
01/01/1986
01/01/1990
01/01/1994
01/01/1998
01/01/2002
01/01/2006
01/01/2010


Heat Index emergence - flowering
30
20
10
0
Index
01/01/1966
01/01/1970
01/01/1974
01/01/1978
01/01/1982
01/01/1986
01/01/1990
01/01/1994
01/01/1998
01/01/2002
01/01/2006
01/01/2010


Heat Index flowering - maturity
30
20
10
0
Index
01/01/1966
01/01/1969
01/01/1972
01/01/1975
01/01/1978
01/01/1981
01/01/1984
01/01/1987
01/01/1990
01/01/1993
01/01/1996
01/01/1999
01/01/2002
01/01/2005
01/01/2008


ModExtreme
2nd Annual Meeting
3-4 November, 2015

Water limited biomass of grain maize








Calibration of WOFOST model

Winter wheat

FRTB at emergence (DVS close to 0),
EFFTB for temperature around 10 °C,
FLTB at emergence (DVS ~ 0),
KDIFTB at emergence (DVS ~ 0),
FOTB around heading (DVS ranging from 0.7 to 1.0),
CVS,
CVR,
CVL,
AMAXTB at emergence (DVS close to 0),
Partitioning to leaves at tillering (DVS around 0.5),
Q10,
KDIFTB at anthesis (DVS around 1),
EFFTB for temperature around 40.

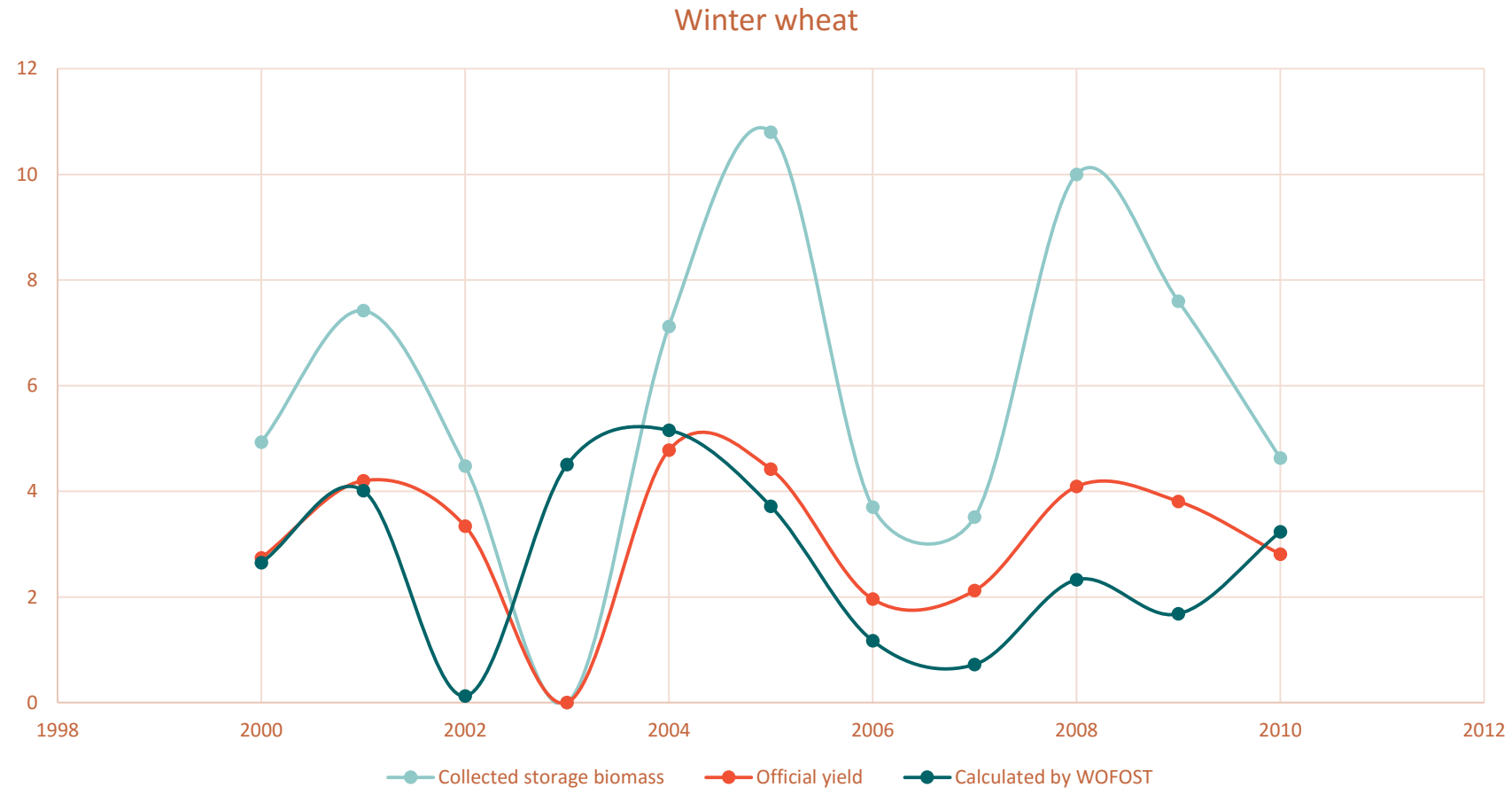
Grain maize

SLATB at emergence (DVS around 0),
EFFTB (regardless of temperature),
SLATB 0.5 (before stem elongation),
FLTB before anthesis (DVS from around 0.5 to around 0.88),
RMR,
KDIFTB at emergence (DVS close to 0),
FLTB at emergence (DVS close to 0),
CVO





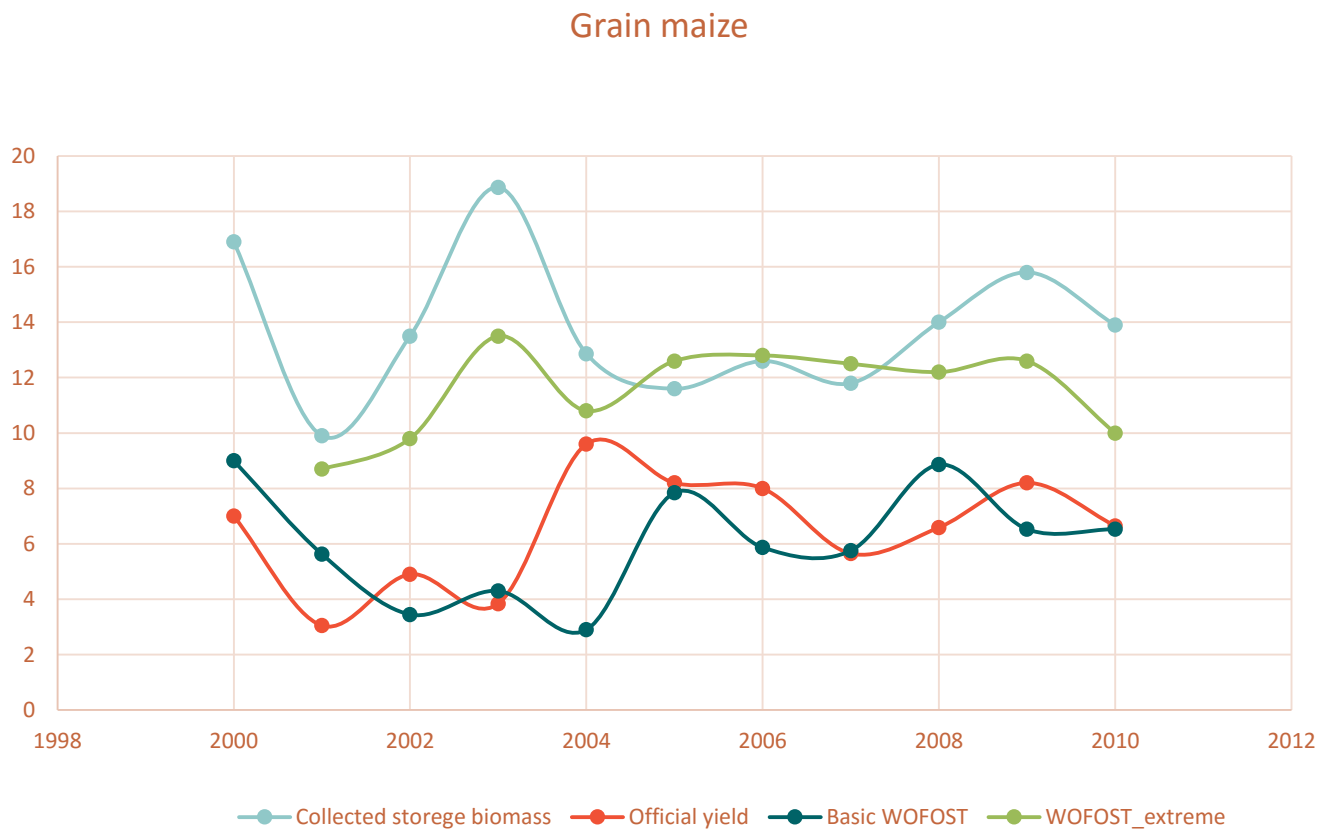

Comparison between storage biomass (crops yield) collected on the field and simulated by basic and improved WOFOST








Comparison between storage biomass (crops yield) collected on the field and simulated by basic and improved WOFOST



Conclusion

- Basic solution of WOFOST provides realistic values of potential and water limited biomass for Ukraine (winter wheat and grain maize).
- Extreme weather solution of WOFOST is still needed in improvement for winter wheat crops.
- Extreme weather solution of WOFOST for grain maize looks very realistic after calibration based on collected biomass






Acknowledgement

"The research leading to these results has received funding from the European Community's Seventh Framework Programme – FP7 (KBBE.2013.1.4-09) under Grant Agreement No. 613817, 2013-2016"