ADA Symposium
Deutsch-Wagram, 4th November 2015

Drought Monitoring System for Agriculture in Austria

Project “AgroDroughtAustria-ADA”

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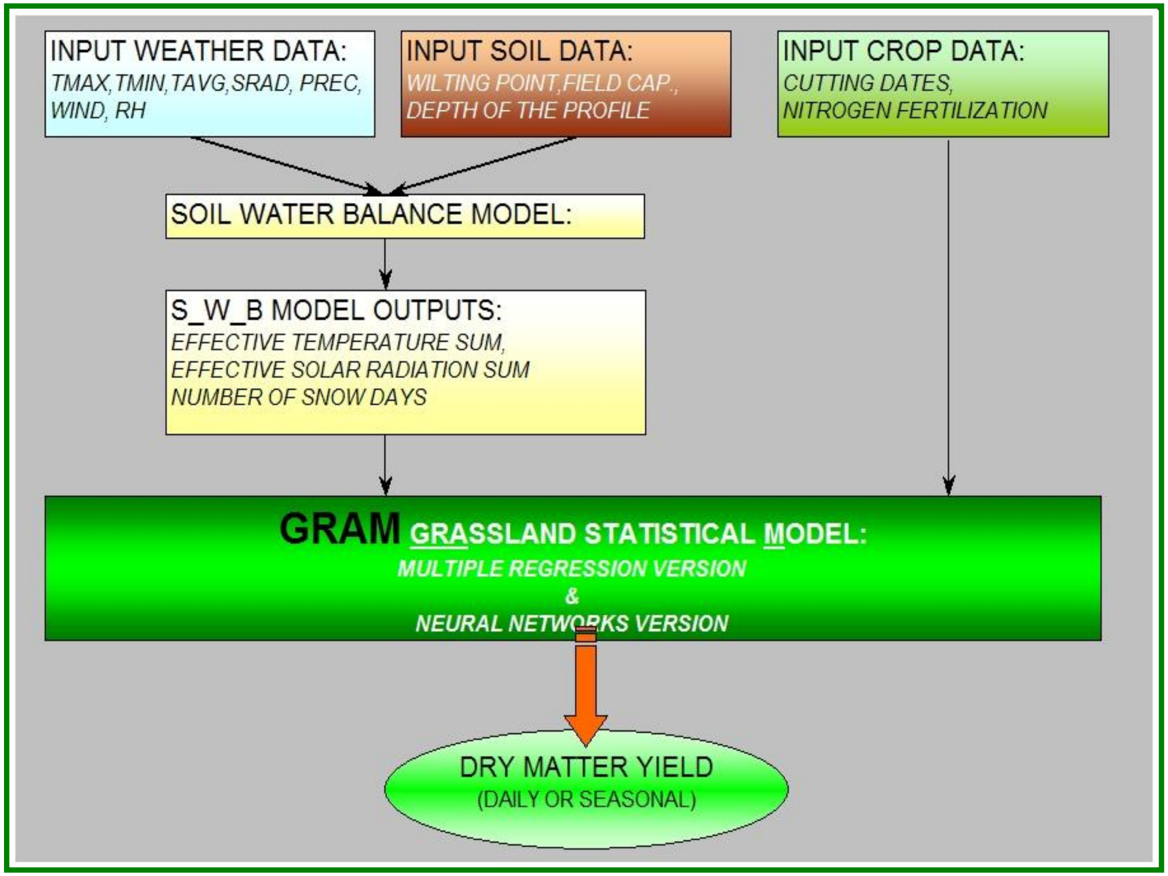
Pre – projects

GRAM: GIS-based Grassland simulation

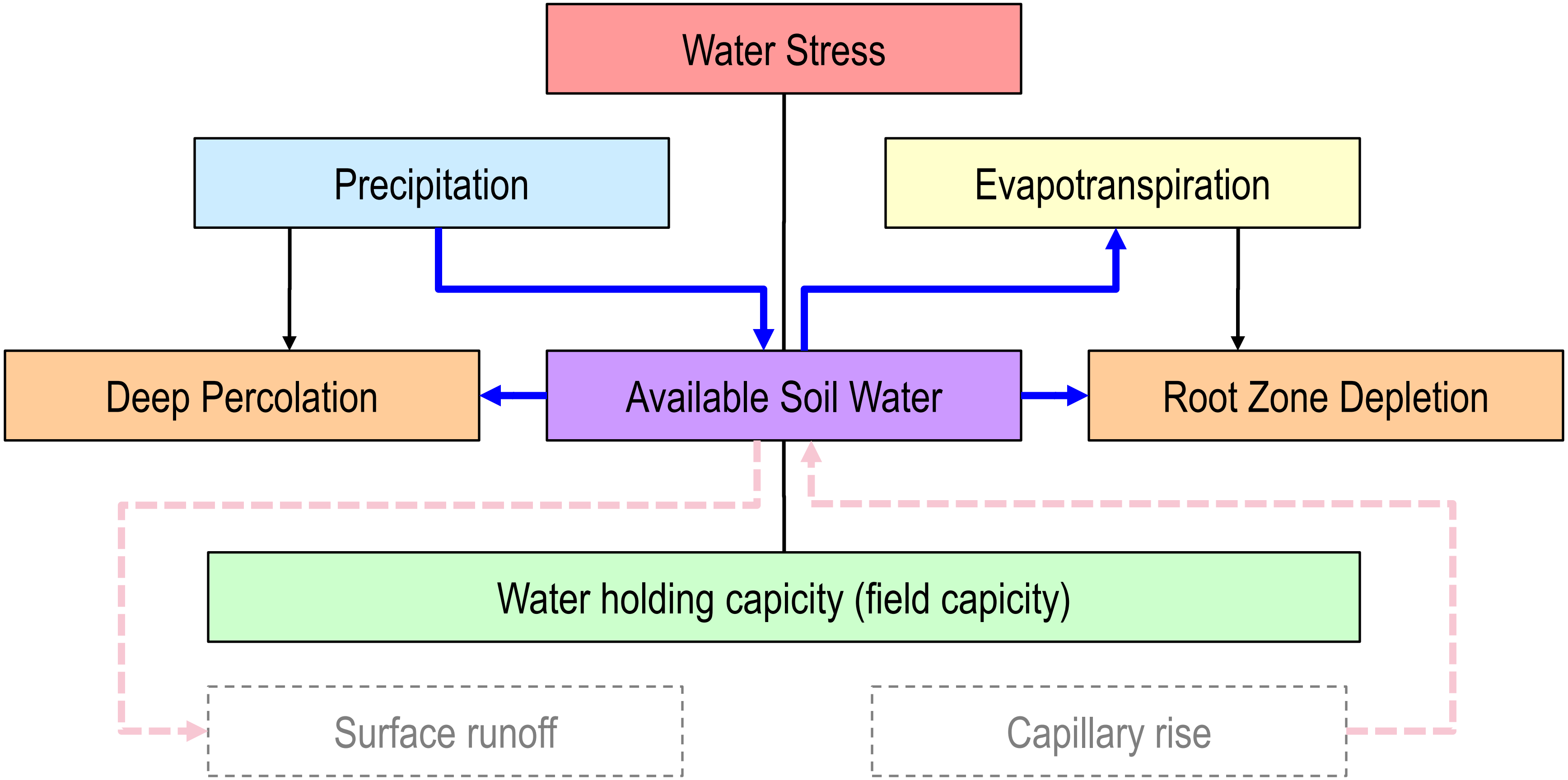
CLIMSOIL: GIS-based soil temperature model

Original model concept (grassland)

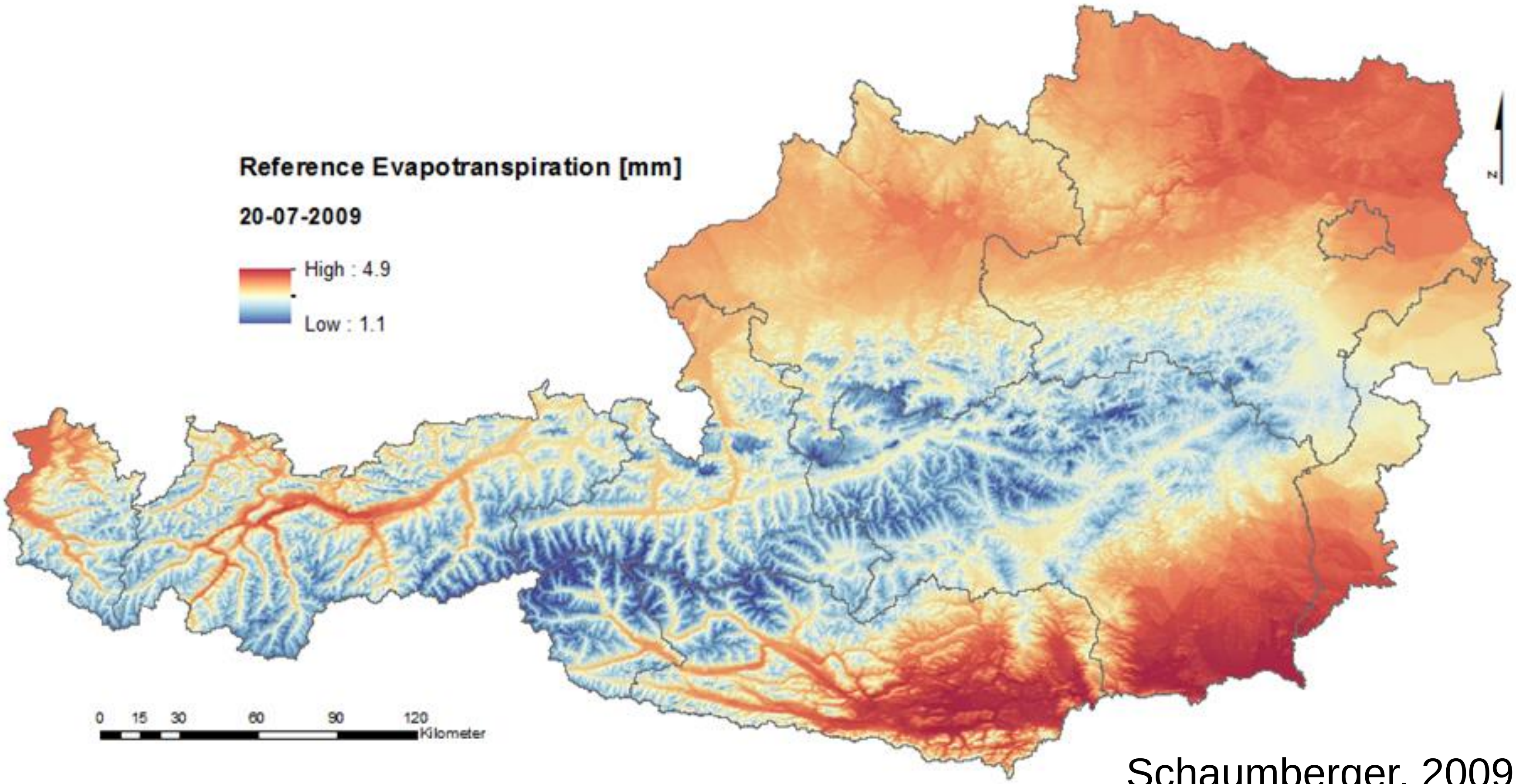
M. Trnka, J. Eitzinger, Schaumberger, A. (2009)



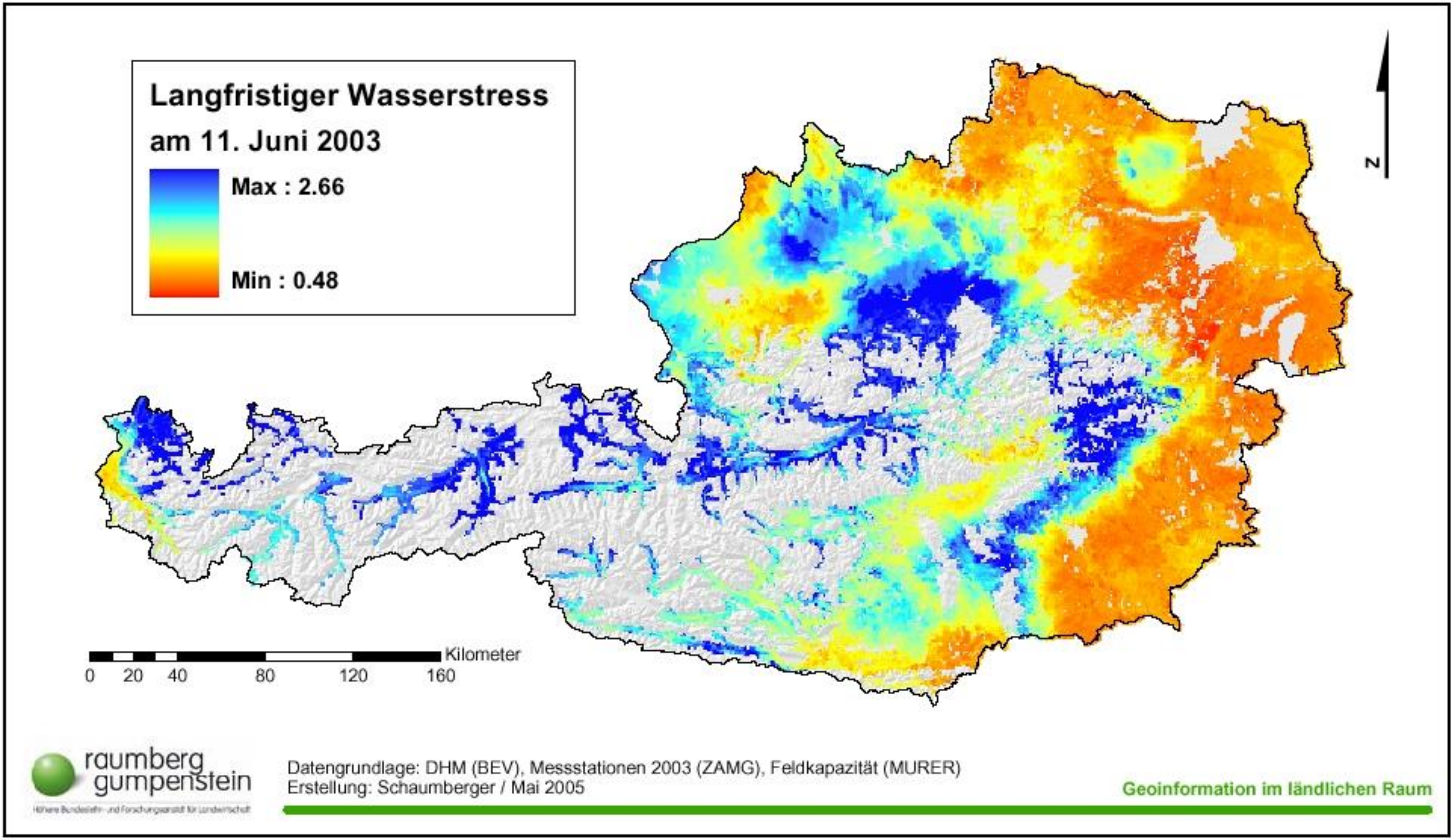
Water Balance Model according to FAO Paper No. 56



Simulated actual evapotranspiration of grassland on July 20th 2009 in 1x1 km spatial resolution.

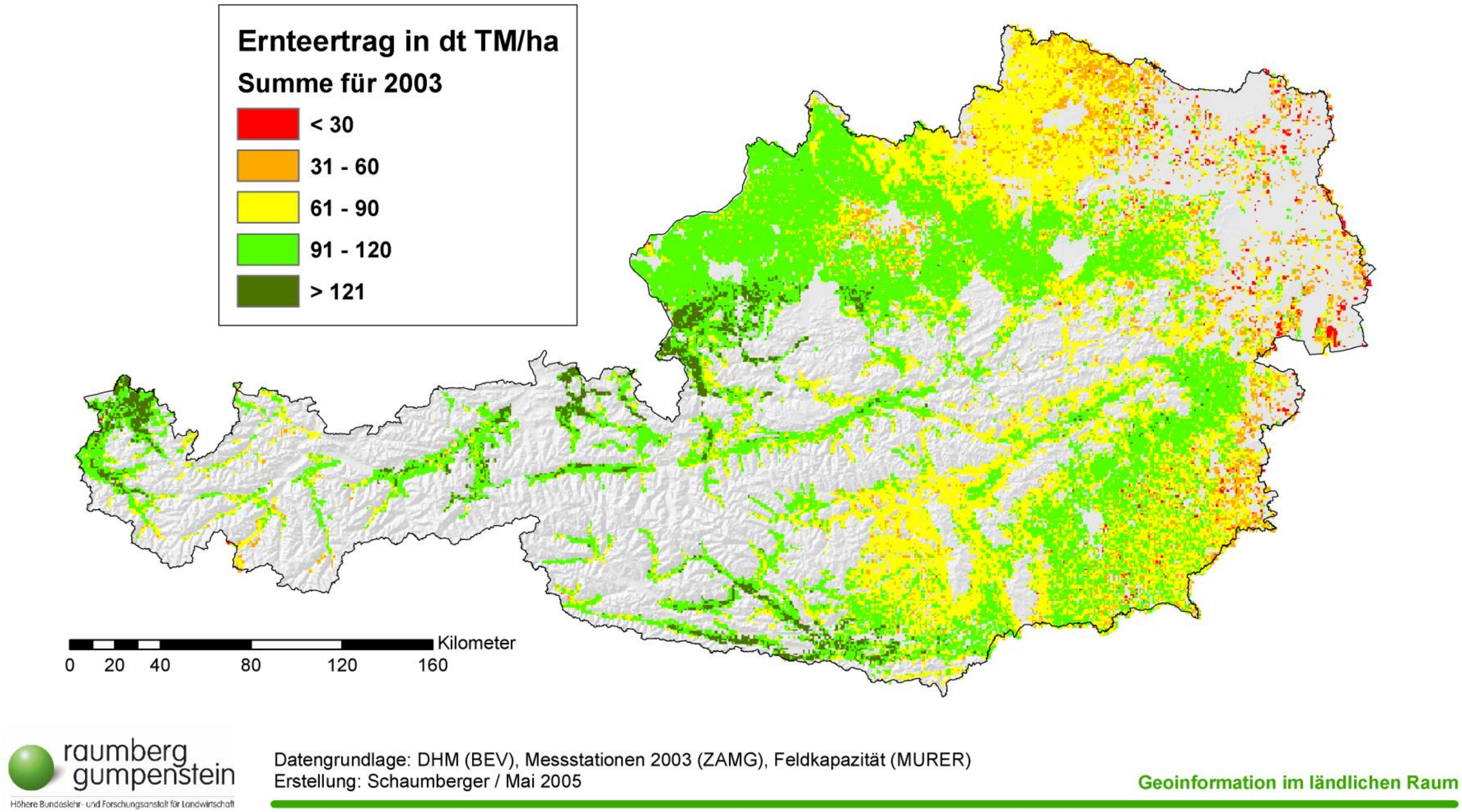


Schaumberger, 2009



Spatial water balance parameters of grassland:
Long term water stress factor of grassland June 11 2003

Simulated grassland biomass yields in 2003



Soil Temperature Model Scheme for GIS application

Input of spatial data (1x1 km) from GIS

Variable Parameters (daily):

Air Temperatures : Mean, Maximum, Minimum
Global Radiation
Snow Cover
Soil cover - biomass
Albedo
Actual evapotranspiration
Soil water content (layer)
Soil pore volume (layer)

Constant Parameters:

Soil layer thickness (per layer)
Soil - fraction of sand
Soil - fraction of clay
Annual mean temperature

Output parameters (1x1 km) from GIS

Variable Parameters (per predefined soil layers, daily basis):

Soil surface temperature (Max, Min)
Mean, maximum and minimum temperatures
Fraction of soil ice content

Soil temperature sum (per soil layer)

Pest models, C/N balance model, ...

Soil temperature model calculation steps:

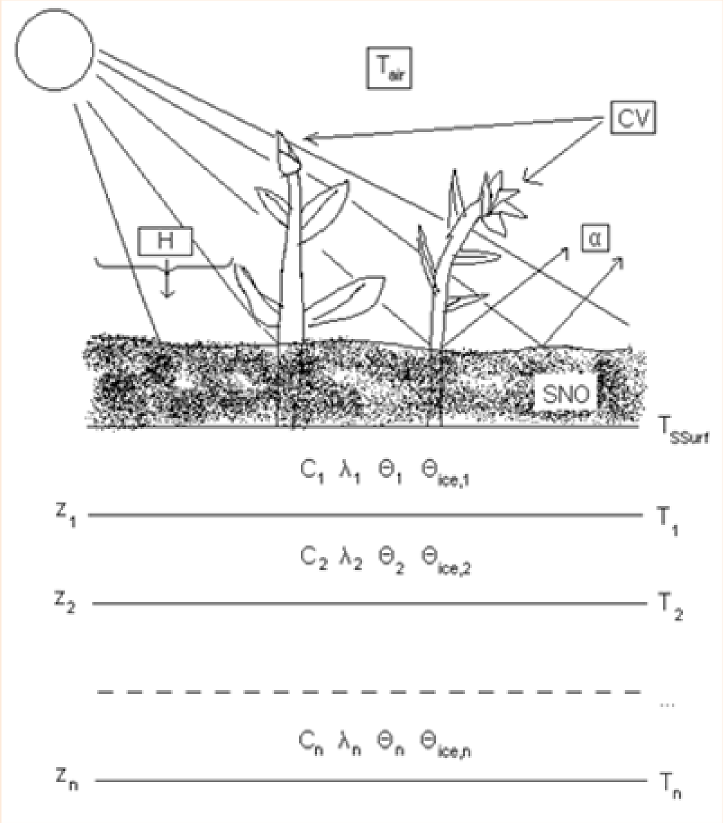
1) Estimation of soil surface temperature

2) Estimation of soil heat conductivity and capacity per sopil layer

3) Estimation of heat flux through soil layers (reduced number of steps, heat flux equation)

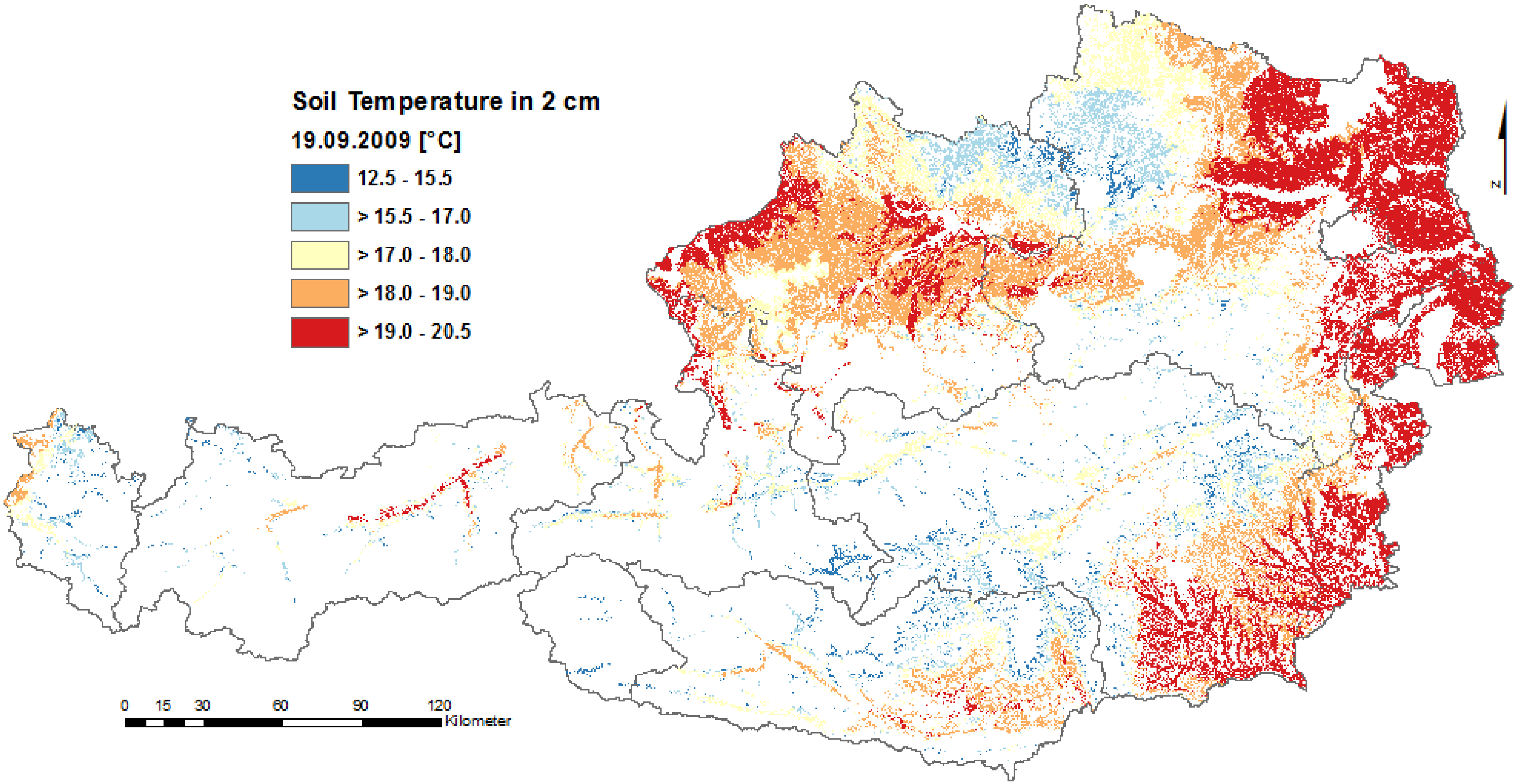
4) Consideration of soil water freecing/thawing

5) Estimation of daily temperature amplitude per soil layer



Met

Project CLIMSOIL: Soil Temperature Model in GIS



Data: ZAMG - MGI Austria Lambert
Layout: Andreas Schaumberger / Mai 2012

The aim of the ADA project (2013-2016) is to develop and test a crop specific drought monitoring and forecasting system for agriculture in Austria.

Objectives:

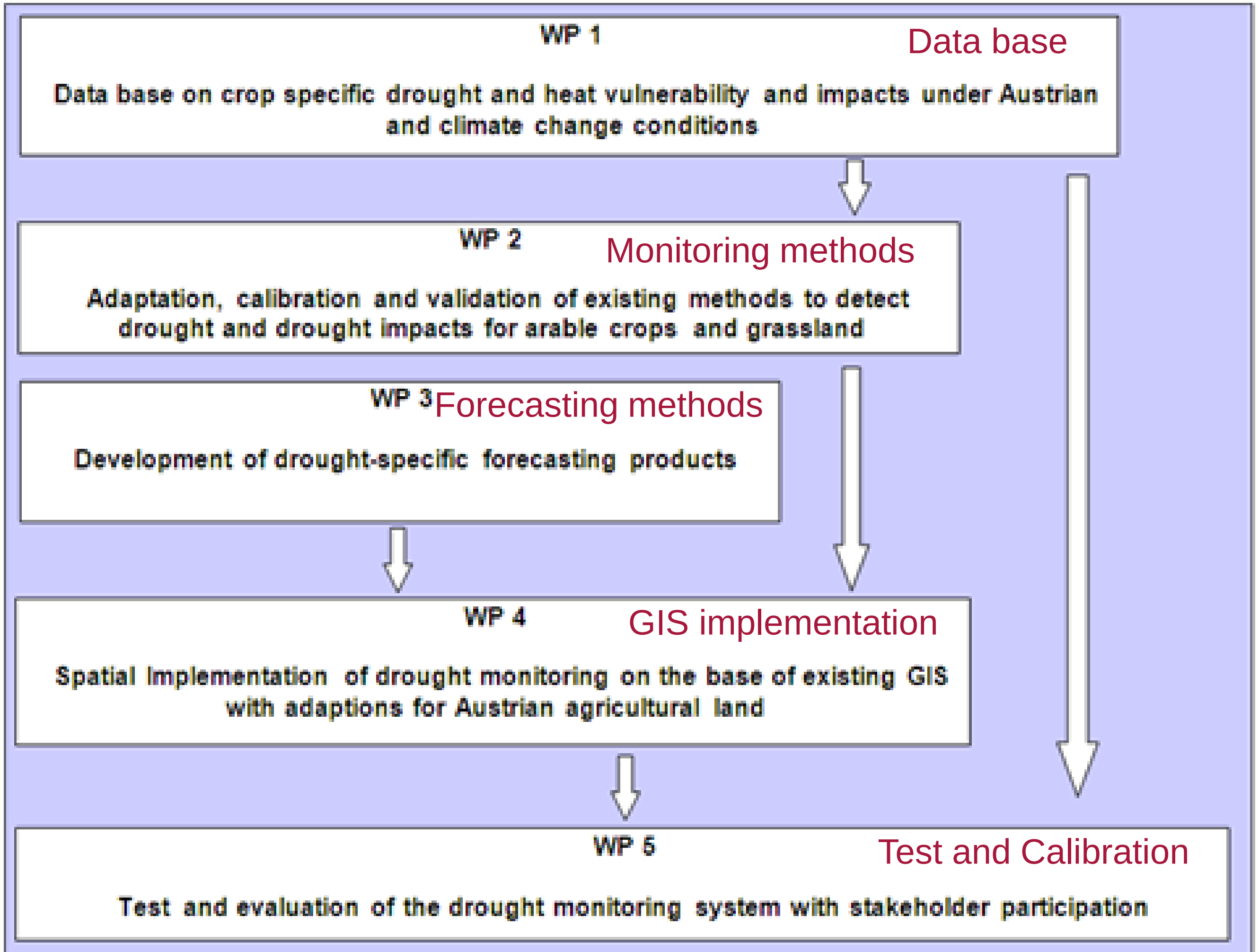
1)Establish a data base and develop methods for crop drought and heat stress and yield impact detection

2)Establish a forecasting approach modelling drought occurrence (10 days and seasonal) and GIS implementation

3)Adapt and validate soil water content calculation methods (SOILCLIM Model) and GIS implementation

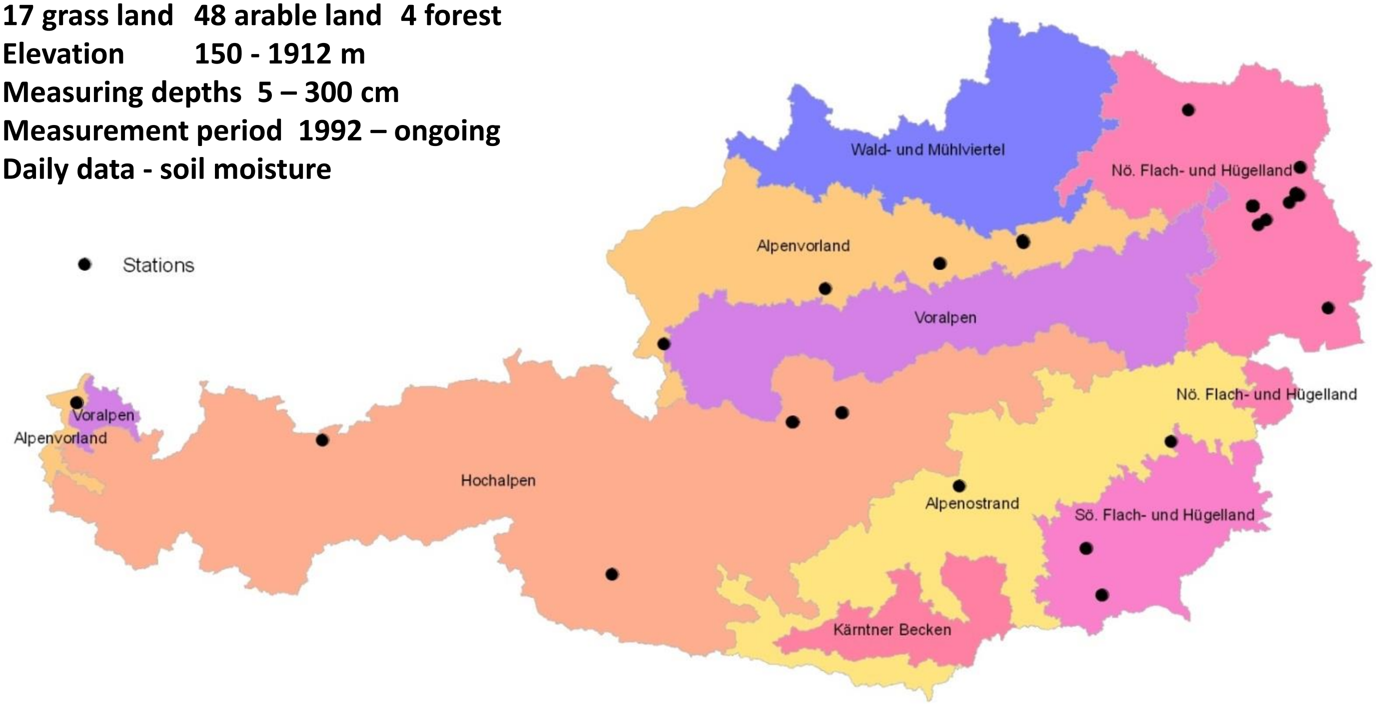
4)Test the crop specific drought monitoring system for operational use

ADA – Work packages



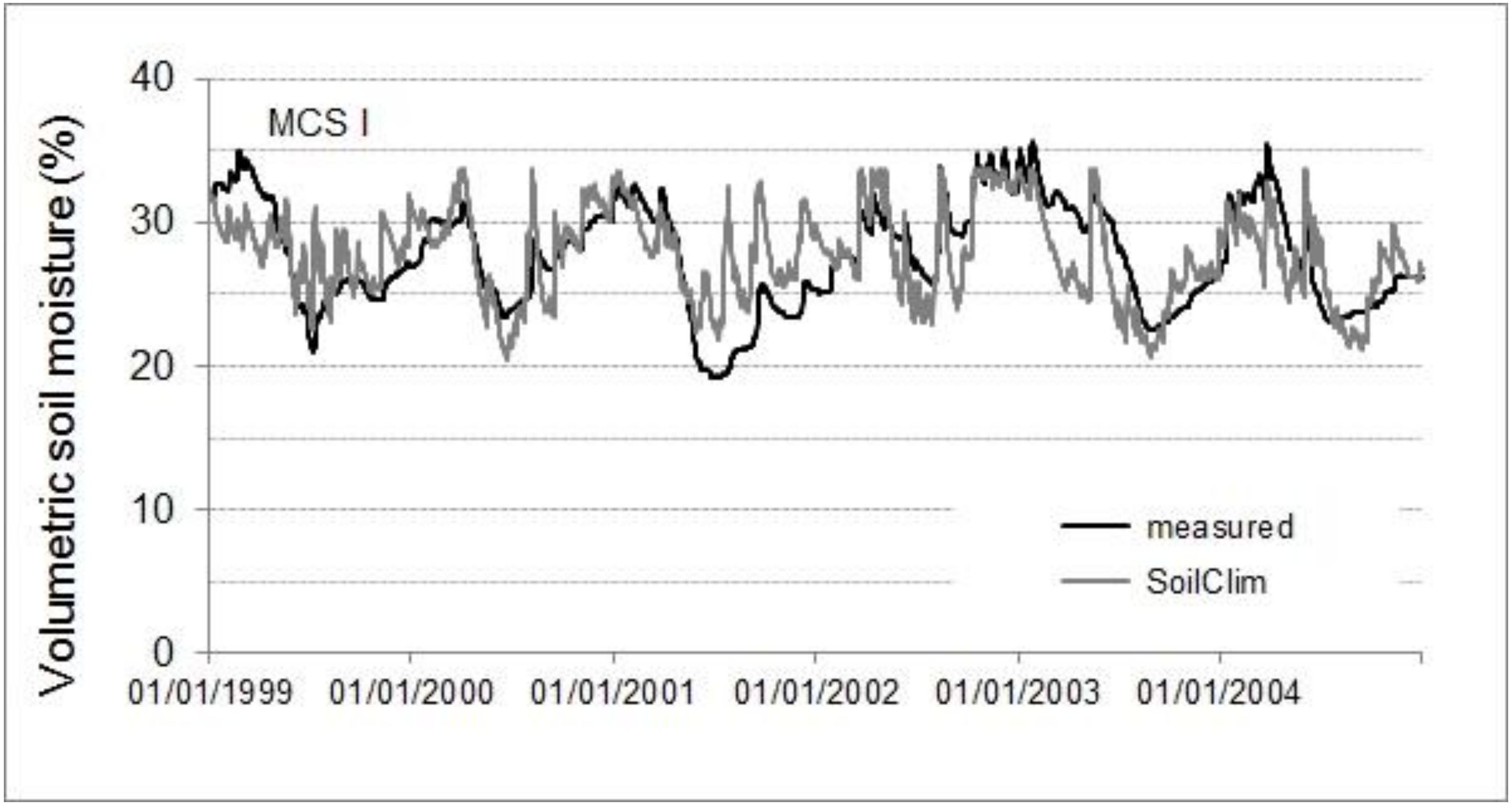
Validation data base for simulated soil moisture – Available Soil Water Stations & Main Production Areas

21 Locations 69 plots
17 grass land 48 arable land 4 forest
Elevation 150 - 1912 m
Measuring depths 5 – 300 cm
Measurement period 1992 – ongoing
Daily data - soil moisture



Krammer, 2013

Soil water balance model (SOILCLIM) - evaluation



Example of the SoilClim model evaluation at the Hirschstetten site (top layer 0-40 cm).

Estimating drought impacts on crops

1) **Development/implementation of crop phenology model (Kc model)**

Methods: Crop model application under Austrian conditions

2) **Development and test of drought and heat impacts on yield risk (indicator) and yield level (potential yield depletion)**

Methods: Statistical analysis of crop yield data

Crops specific responses to drought/heat

1) Drought impacts:

Dominating effects on biomass accumulation (Photosynthesis rate depression), biomass partitioning and yield forming processes (i.e. corn filling)
(crop yields determined by vegetative development only:
i.e. grassland, sugar beet, biomass crops)

2) Heat impacts:
(further forced by water stress conditions)

Dominating effects on phenology, corn filling and fertility (flowering period!)
(especially crop yields determined by generative development:
Grain maize, cereals, ..)

Crop Coefficient Model for ADA (Kc Factor)

Reference Evapotranspiration (ET0) for December, January and February is a constant value of **0.2 mm.**

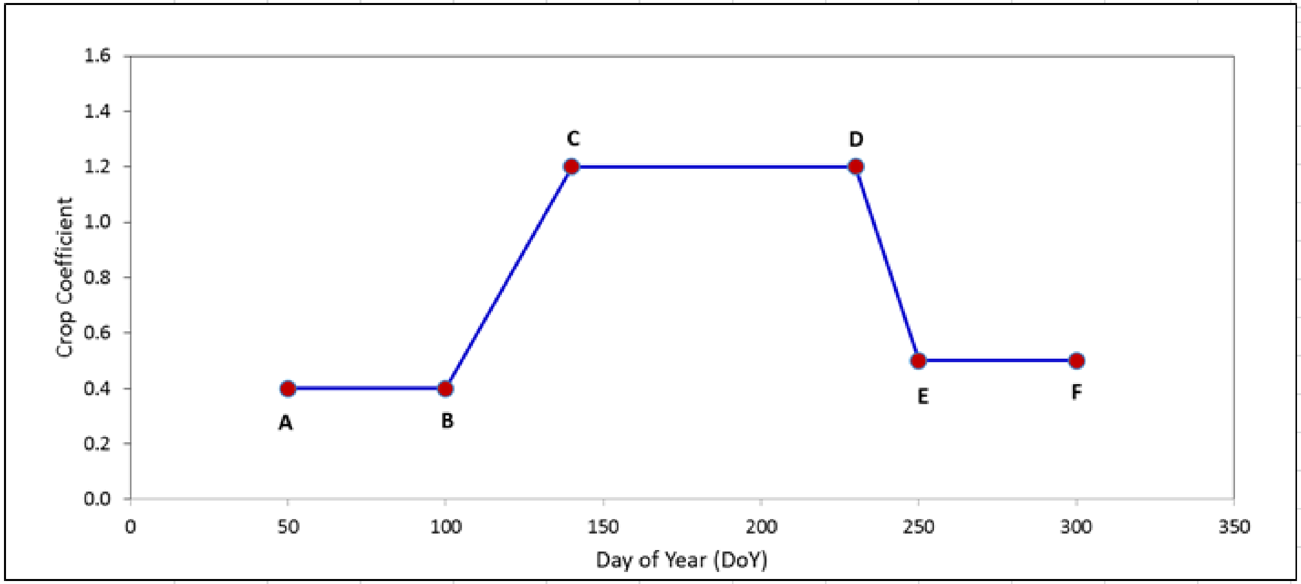
Start of Growing Season (SGS): **First day of 5 consecutive days with daily mean temperatures above 5°C**

Start of Growing Season for Maize (SGS-M): **First day of 5 consecutive days with daily mean temperatures above 10°C**

Base temperature for calculation of degree day temperature sum (BT): **5 °C**

Base temperature for calculation of degree day temperature sum for Maize (BT-M): **8 °C**

Culture	Initial (Evaporation)			Crop Development	Mid-Season		Late Season		End of Growing			
	Entry of A		Entry of B		Entry of C		Entry of D		Entry of E		Entry of F	
	Kc	Time	Kc	Time (GDD)	Kc	Time (GDD)	Kc	Time (GDD)	Kc	Time	Kc	Time
Grassland (3-cut)	Will be done by LFZ Raumberg-Gumpenstein (according to Schaumberger, 2011)											
Winter Wheat	0.4	01.03.	0.4	SGS	1.2	592	1.2	953	0.5	+14 days	0.5	30.11.
Spring Barley	0.4	01.03.	0.4	SGS	1.2	816	1.2	767	0.5	+14 days	0.5	30.11.
Spring Maize	0.4	01.04.	0.4	SGS-M	1.2	572	1.2	2063	0.5	+14 days	0.5	30.11.
Sugar Beet	0.4	01.04.	0.4	300	1.2	2100	1.2	100	0.2	20.0	0.2	30.11.



Phenological model

(to be used for evapotranspiration calculation and stress indicators)

Stress indicators

Impact of drought and heat on crop stress (risk indicators) and yield level (potential yield depletion)

A. Risk approaches (without crop specific vulnerability calibration)

1. **a) General drought indicator** (Soil water content in regard to the normal)
and b) crop specific water stress factor (actual and accumulated)
(linear increasing stress beyond 30% AWC depletion)

2. Heat stress factor (actual and accumulated)
- number of days above 32°C
-Duration above critical T:
Accumulated hourly indicator for day N: (Sum(T_hourly-31.9)^2)

3. Heat stress x crop specific water stress factor
(way of combination of ad 1+2; i.e. reduction of heat stress impact above 70% AWC)

B. Crop vulnerability approaches

1. **Crop specific heat and drought stress risk at different phenological states**
2. **potential yield depletion**

(implementation of relative sensitivities in combination with crop phenology)
Calibration/validation with crop yield data

Central European **drought impacts** on Maize and Wheat (exp. yield statistics > 15years)

Table 8. Correlation coefficients and p values (in brackets, underlined values are significant) between AMI describing number of dry days and observed MZ yield. No effect: *11 of 22*; with effect: **7** of **22**.

Location	Dstart		Dintensive			Dextreme			Dvextreme		
	AMJ	JJA	MAM	AMJ	JJA	MAM	AMJ	JJA	MAM	AMJ	JJA
Ziharec	**0.59**	*0.10*	**0.65**	**0.59**	*0.13*	**0.52**	**0.50**	*0.08*	*0.08*	**0.63**	*−0.12*
	(0.05)	*(0.76)*	**(0.03)**	**(0.05)**	*(0.70)*	**(0.10)**	**(0.11)**	*(0.81)*	*(0.81)*	**(0.03)**	*(0.72)*
Podhajska	*0.19*	−0.42	*0.26*	*0.23*	**−0.51**	0.49	*0.10*	−0.32	0.40	*0.12*	*−0.15*
	(0.57)	(0.19)	*(0.44)*	*(0.49)*	**(0.10)**	(0.12)	*(0.76)*	(0.33)	(0.22)	*(0.72)*	*(0.65)*

Maize: June-August

Table 9. Correlation coefficients and p values (in brackets, underlined values are significant) between AMI describing number of dry days and observed WW yield. No effect: *27 of 49*; with effect: **3** of **49**.

Location	Dstart	Dintensive		Dextreme		Dvextreme	
	AMJ	MAM	AMJ	MAM	AMJ	MAM	AMJ
Gross-Enz.	−0.49	−0.41	**−0.52**	*−0.16*	−0.39	*0.10*	*−0.16*
	(0.04)	(0.10)	**(0.03)**	*(0.53)*	(0.12)	*(0.70)*	*(0.53)*
RimskiSancevi	*−0.22*	*−0.13*	−0.32	−0.41	*−0.30*	−0.48	−0.34
	(0.30)	*(0.54)*	(0.12)	(0.04)	*(0.15)*	(0.01)	(0.10)
Ziharec	−0.37	*−0.26*	−0.31	*−0.28*	−0.43	**−0.61**	−0.39
	(0.213)	*(0.39)*	(0.30)	*(0.35)*	(0.14)	**(0.02)**	(0.18)
Podhajska	−0.34	−0.38	−0.31	*−0.17*	**−0.51**	−0.42	−0.41
	(0.21)	(0.16)	(0.26)	*(0.54)*	**(0.05)**	(0.11)	(0.12)
Belusa	*−0.24*	*0.00*	−0.38	*−0.27*	*−0.27*	*−0.18*	*−0.15*
	(0.37)	*(1.00)*	(0.14)	*(0.31)*	*(0.31)*	*(0.50)*	*(0.57)*

WW: yes (March-June)

Lalic et al., 2014

Central European **heat impacts** on Maize and Wheat (exp. yield statistics > 15years)

Table 6. Correlation coefficients and *p* values (in brackets, underlined values are significant) between AMI describing number of days with extreme temperatures and observed MZ yield. No effect: *17 of 30*; with effect: **6** of **30**.

Location	April		May		June		July		August	
	SumD	FrostD	TropD	SumD	TropD	SumD	TropD	SumD	TropD	SumD
DubrovčakLijevi	*0.03*	−0.43	−0.31	−0.34	*−0.07*	−0.37	*0.15*	*−0.05*	**−0.64**	−0.42
	(0.93)	(0.18)	(0.35)	(0.30)	*(0.83)*	(0.26)	*(0.65)*	*(0.88)*	**(0.03)**	(0.19)
Ziharec	*0.09*	*0.24*	**0.51**	0.38	*−0.01*	*−0.01*	**−0.58**	**−0.72**	*−0.25*	*−0.25*
	(0.79)	*(0.47)*	**(0.10)**	(0.24)	*(0.97)*	*(0.97)*	**(0.06)**	**(0.01)**	*(0.45)*	*(0.45)*
Podhajska	−0.47	*0.08*	*0.00*	*−0.20*	*−0.19*	*−0.11*	*0.08*	*0.06*	**−0.56**	**−0.56**
	(0.14)	*(0.81)*	*(1.00)*	*(0.55)*	*(0.57)*	*(0.74)*	*(0.81)*	*(0.86)*	**(0.07)**	**(0.07)**

Maize: yes (July-August)

Table 7. Correlation coefficients and p values (in brackets, underlined values are significant) between AMI describing number of days with extreme temperatures and observed WW yield. No effect: *41 of 63*; with effect: **2** of **63**.

Location	January		February		March	April	May	June	
	FrostD	FreezD	FrostD	FreezD	FrostD	FrostD	SumD	TropD	SumD
Gross-Enz.	*−0.14*	*−0.14*	−0.43	−0.43	*−0.27*	*0.14*	−0.32	*0.04*	*−0.24*
	(0.59)	*(0.59)*	(0.08)	(0.08)	*(0.29)*	*(0.59)*	(0.21)	*(0.87)*	*(0.35)*
RimskiSancevi	*−0.27*	*−0.10*	−0.42	−0.44	*−0.03*	*−0.22*	*−0.02*	*−0.24*	*−0.30*
	(0.20)	*(0.64)*	(0.04)	(0.03)	*(0.88)*	*(0.30)*	*(0.92)*	*(0.25)*	*(0.15)*
Ziharec	−0.37	−0.44	*−0.12*	−0.34	−0.33	*−0.06*	*−0.22*	−0.33	*0.07*
	(0.21)	(0.13)	*(0.69)*	(0.25)	(0.27)	*(0.84)*	*(0.47)*	(0.27)	*(0.82)*
Podhajska	*−0.23*	−0.32	*−0.15*	*0.08*	*−0.02*	*−0.23*	**−0.64**	**−0.58**	*−0.29*
	(0.40)	(0.24)	*(0.59)*	*(0.77)*	*(0.94)*	*(0.40)*	**(0.01)**	**(0.02)**	*(0.28)*
Belusa	*0.11*	*−0.23*	*−0.30*	*−0.28*	*−0.21*	*−0.03*	*−0.20*	−0.32	*−0.17*
	(0.68)	*(0.39)*	*(0.25)*	*(0.29)*	*(0.43)*	*(0.91)*	*(0.45)*	(0.22)	*(0.52)*

WW: yes (May-June)

Lalic et al., 2014

Results (see next presentations for more details)

-Simple crop-soil water balance approach satisfactory validated

-Significant relationships of drought/heat events for selected main crops

-Crops differ on heat and drought responses under conditions in Austria

-Combination of drought/heat indices is the best approach to adress crop specific responses

-General and crop specific drought/heat monitoring and forecast implemented in GIS

-Operational setup of the system demonstrated

Potentials

1. The GIS model enables near time monitoring and forecast of crop growing conditions and risks (water balance, biomass development, drought and heat stress and yield depletion) for agricutural land in Austria in a high spatial resolution (0.5 x 0.5km) and daily time step.

2. High application potential for spatial mapping/forecast of additional weather related indicators (water footprint, other crop risks from adverse weather conditions).

3. Extended application potentials by including remote sensing products.

4. Potential of an operational multiple agricultural risk monitoring and forecasting tool.

5. International cooperation for drought/heat monitoring system increases efficiency and robustness of system performance

Problems and challenges

1. Operational implementation requests permanent scientific and technical maintainance (financing problem) and institutional cooperation and agreements (weather and forecast data, feedback system - validation etc.)

2. Extended and better data base (soil characteristics, crop risks, damage, yields etc.) for further calibration and validation are needed to improve performance and identify / reduce regional biases and uncertainties.

3. Organizing permanent stakeholder/user feedbacks to increase user acceptance and fitting to user needs

ADA webpage: ada.boku.ac.at

Thank you for your attention !