Poljoprivredni Fakultet Univerzitet u Novom Sadu
PFNS
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Università degli Studi Firenze
DISPAA
Dipartimento di Scienze delle Produzioni Agroalimentari e dell'Ambiente

Universität für Bodenkultur Wien
BOKU
Department für Wasser-Atmosphäre-Umwelt

European Commission
Horizon 2020
European Union Funding for Research & Innovation

Workshop 2018

SERBIA FOR EXCELL, WORKSHOP, June 2018

COMBIRISK and POLICY-FIT

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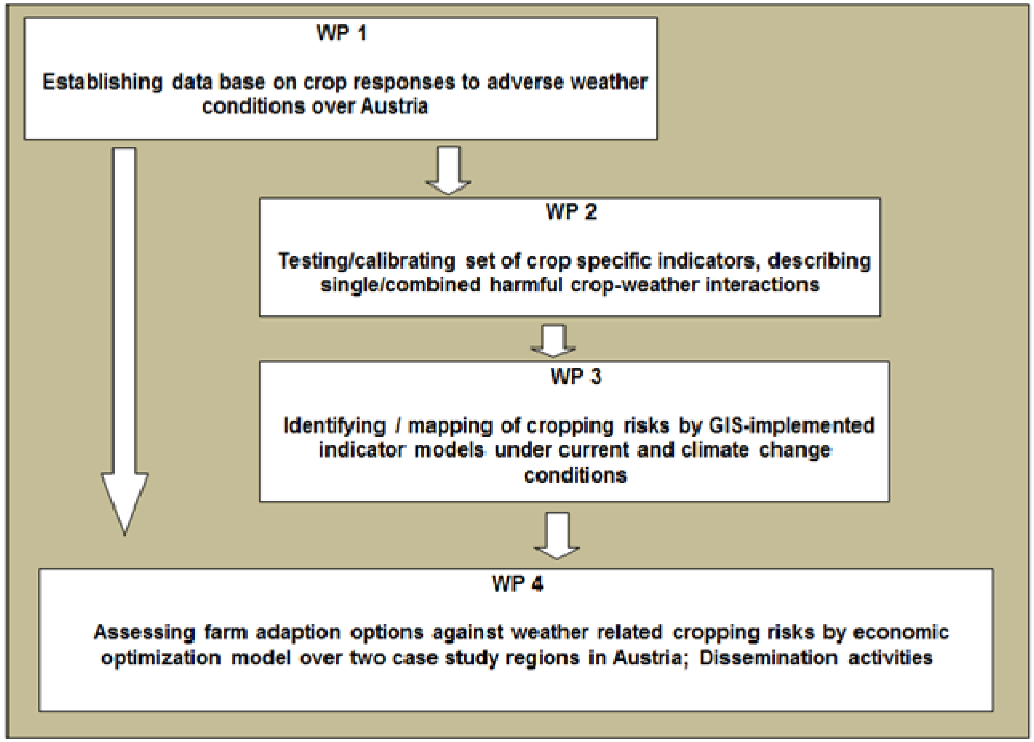
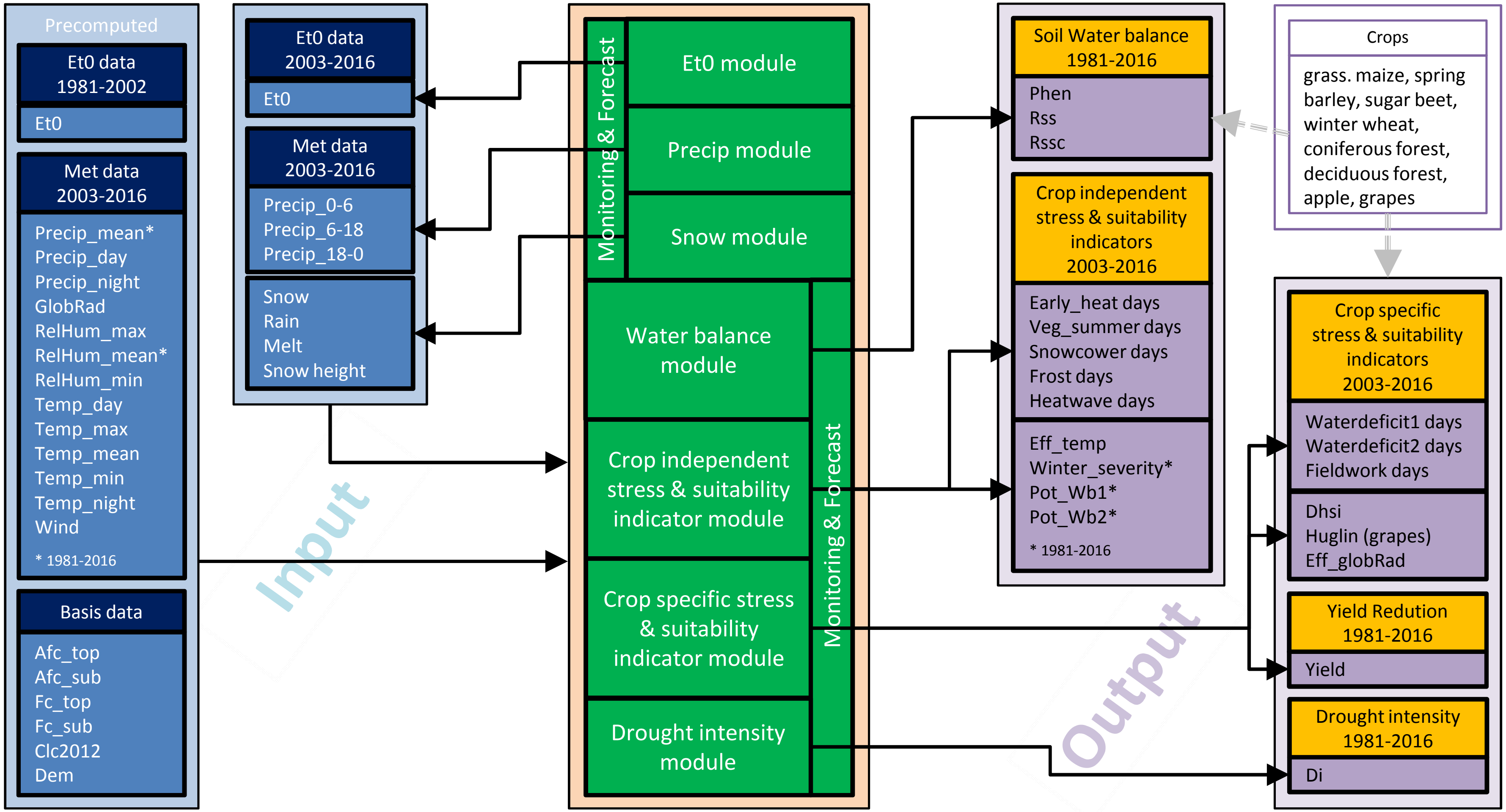
Project COMBIRISK

In this project, funded by (Austrian Climate research Fund) **indicator based models of combined abiotic and biotic weather related risks** are established and applied on current conditions over Austria and ensemble climate change scenarios in two main crop production regions in Austria. Further the method is implemented in an operational monitoring system (AgroDroughtAustria).



Abiotic Indicator(s) for	Applied for	Hot spots
Drought	All selected crops	All regions with less than 800mm annual precipitation and high temperatures and wind; relevant for crop stress and pest development.
Heat	Annual crops	Mainly lowland regions in central, eastern and southern Europe; heat stress and fertility impact on several crops; related increased ozone levels leading to yield losses.
Soil conditions for crop (root) growth	Annual crops	All regions with loamy-clay soils (critical temperatures and wetness) and sandy soils (drought).
Heavy precipitation	Field crops	Especially humid regions (mountainous regions); relevant for lodging and diseases as well as soil surface hardening.
Snow cover conditions	Annual winter crops	In all regions with extreme snow cover variation (too much, too long or too little).
Overwintering conditions	Selected crops	Frequency and duration of mild/cold fluctuations during winter; weakening frost hardiness, chilling conditions.
Humidity and leaf wetness	Selected crops	Humid crop growing regions; important conditions for many diseases.
Harvest conditions	Selected crops	Crop specific, include all weather parameters.
Soil workability	Arable crops	For soil cultivation and crop management; danger of soil compaction.
Suitable conditions for crop management measures	Selected crops	I.e., number and frequency of dry/calm days within certain periods, crop specific.
Drying conditions	Annual crops	Field drying conditions, relevant for yield quality and diseases (e.g. fusarium).
Frequency of rains	Selected crops	Relevant for diseases and pests; biomass accumulation (low radiation and cloudiness).
Frost damage	Many crops, but especially orchards	Combination of frost occurrence with crop vulnerability assessment (phenology model). Especially spring crops and orchards; huge damage potential for sensitive crops; great impact of orography.
Soil erosion	All cropping systems with periods of bare soils	Direct damage and long-term effects on soil fertility (and nutrient and water storage capacity); strong effect of soil cover and orography.
N-leaching	Annual crops	Cereals and high yielding crops such as maize; great impact of soil conditions and crop management, high spatial variability.

ARIS – System Overview



ARIS Methodology – Crop Independent Stress and Suitability Indicators

Accumulated Early Heat Stress Days

ehs = number of days with t_{max} > 28°C (32°C or 35°C) from January 1st to June 15th

Accumulated Heat Wave Days

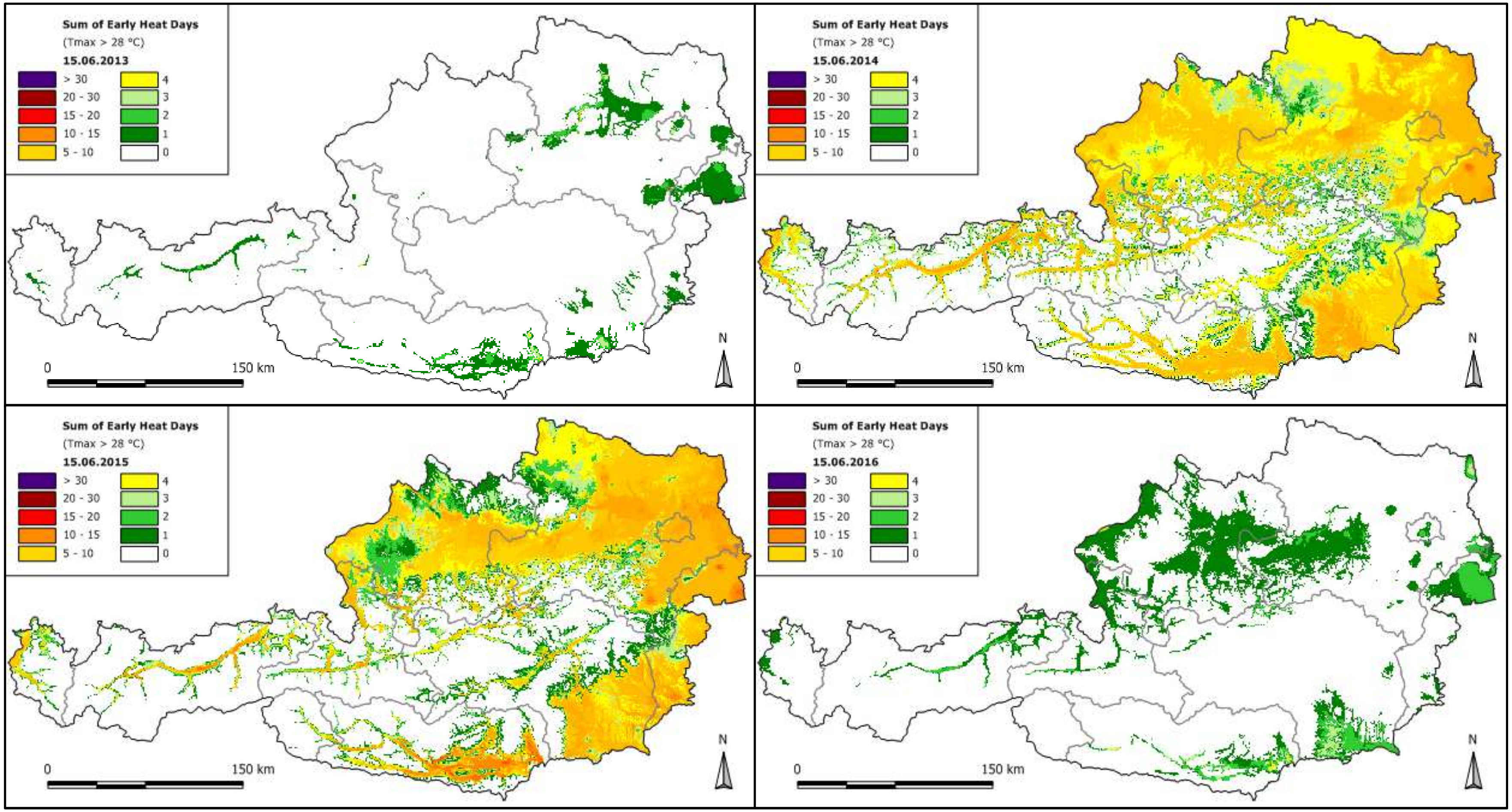
hw = total number of days within episodes when t_{max} is continuously > 30°C and t_{min} is continuously > 20°C for at least 3 days from January 1st to Dezember 31st

Accumulated Vegetation Summer Days

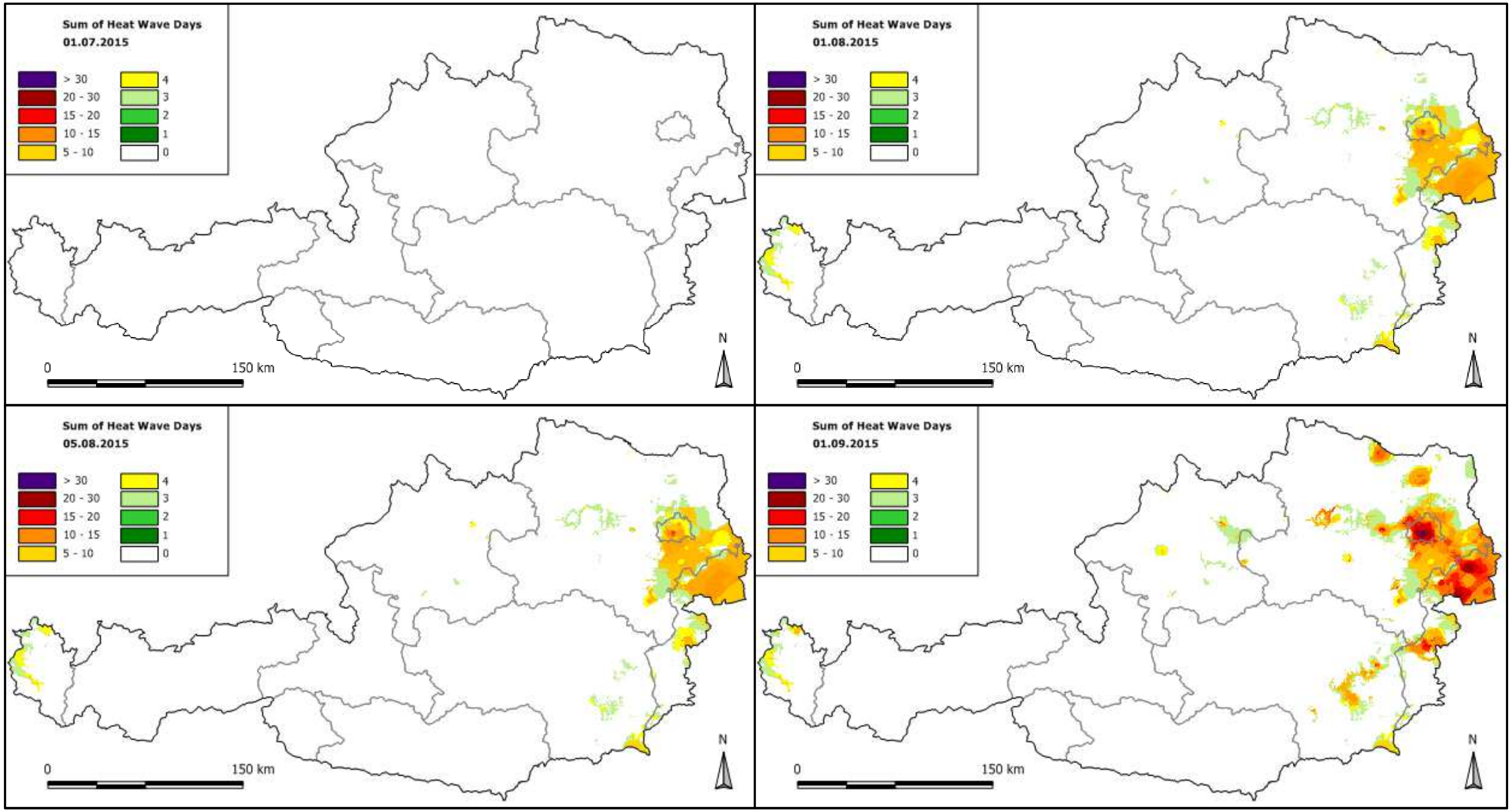
vs = number of days with t_{mean} continuously > 15°C and t_{min} continuously > 0°C for more than 3 days from January 1st to Dezember 31st

t_{max}	daily maximum temperature [°C]
t_{mean}	daily average temperature [°C]
t_{min}	daily minimum temperature [°C]

ARIS Data Output Example – Early Heat Stress Days



ARIS Data Output Example – Heat Wave Days



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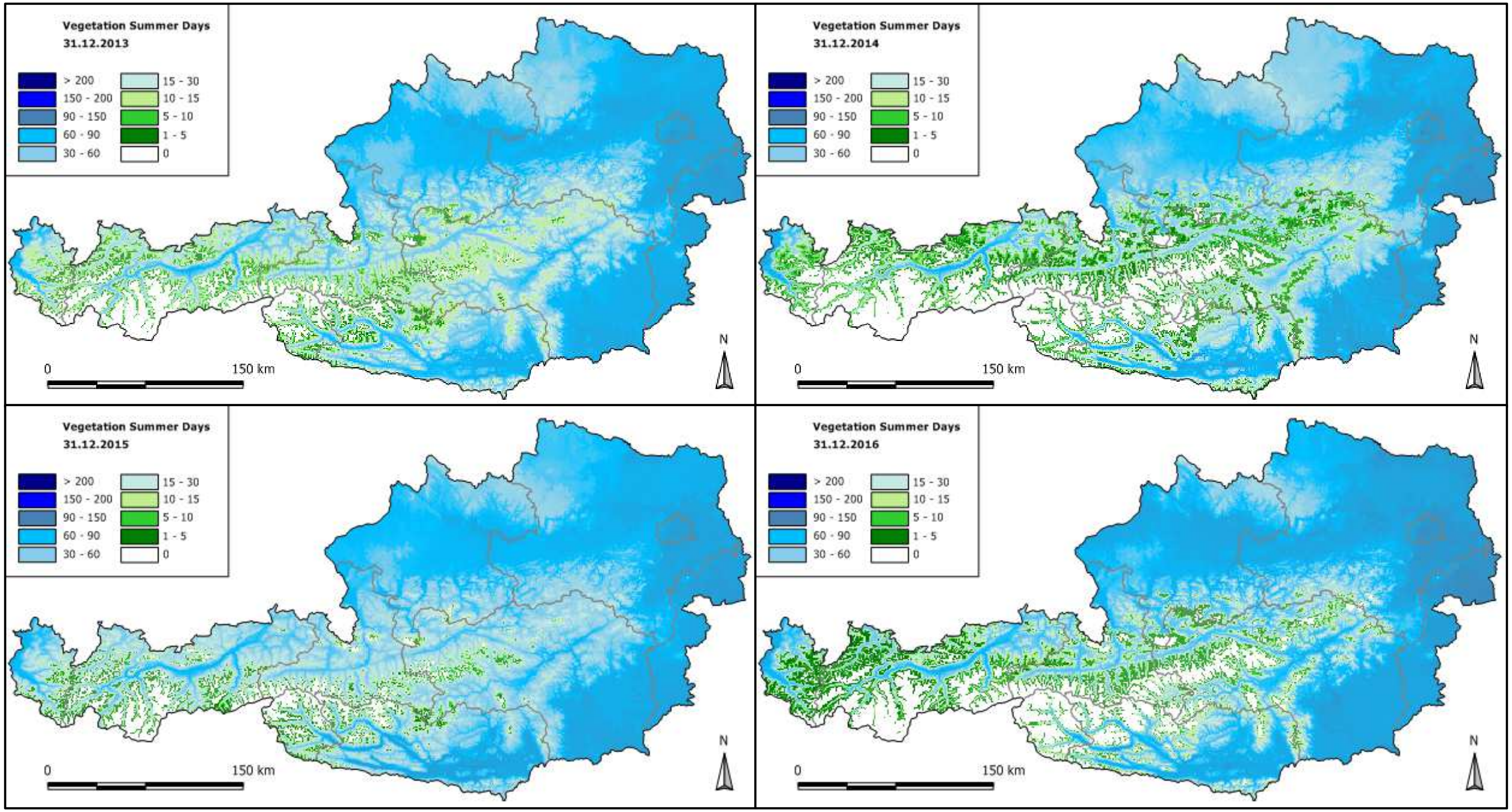
ARIS Data Output Example – Vegetation Summer Days



ARIS Methodology – Crop Independent Stress and Suitability Indicators

Accumulated Snow Cover Days

sc = number of days with snow cover (i.e. snow height > 30 mm) from September 1st to August 31st

Accumulated Frost Days

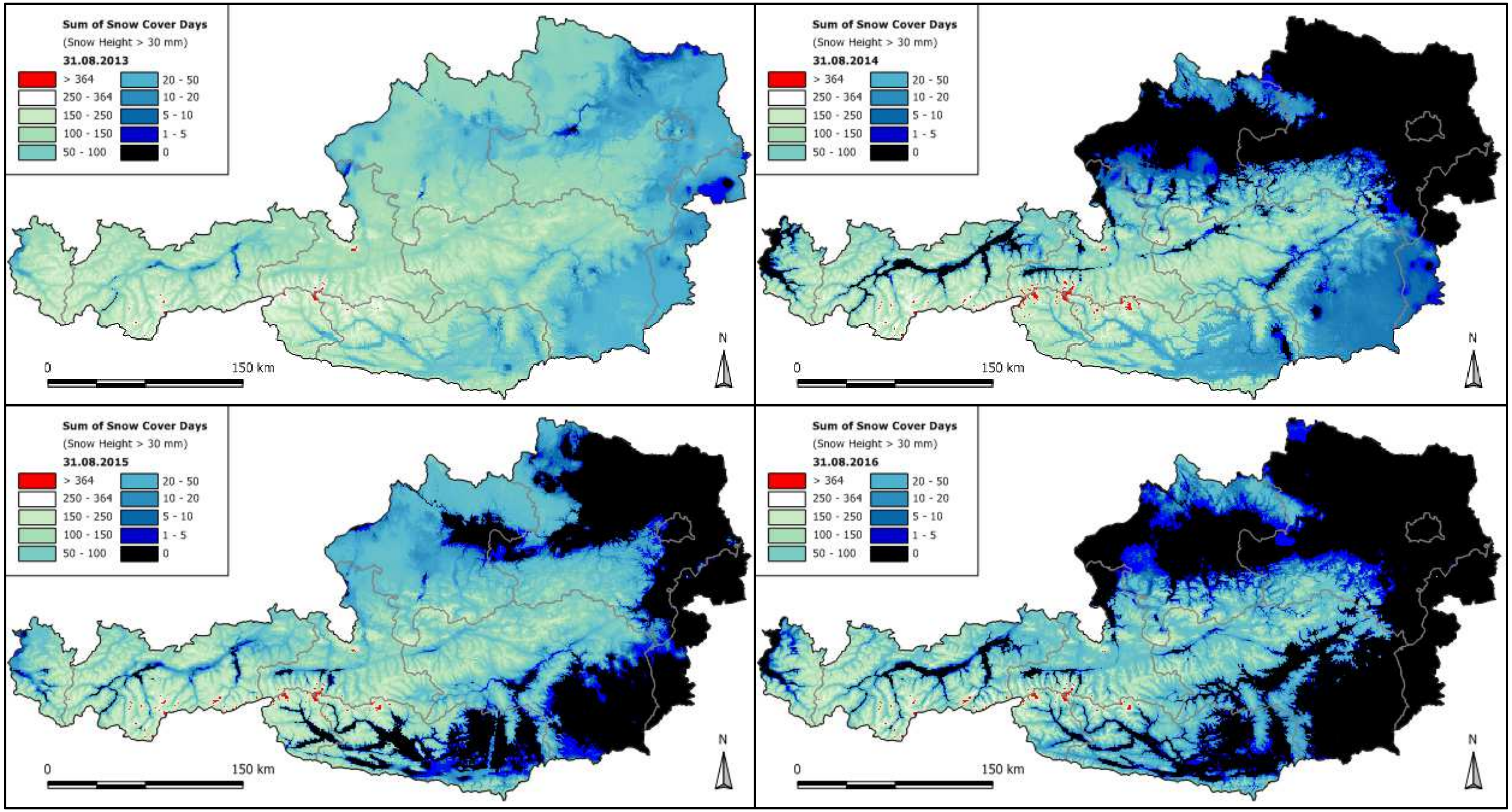
f = number of days with $t_{min} < -10°C$ and no continuous snow cover from September 1st to August 31st

Accumulated Winter Severity [°C]

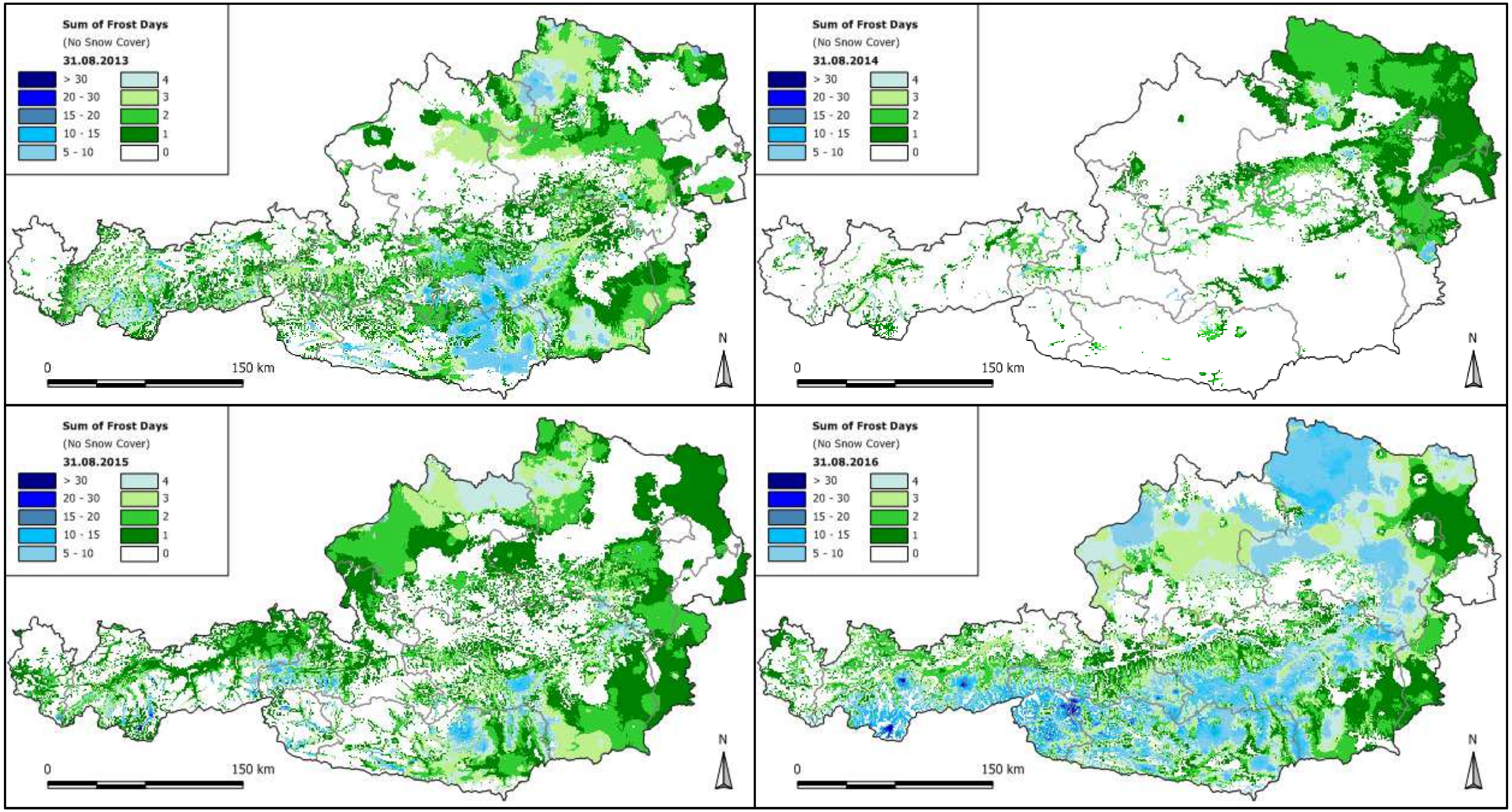
ws = sum of freezing temperatures ($t_{mean} < 0$ °C) from November 1st to March 31st

t_{mean} daily average temperature [°C]

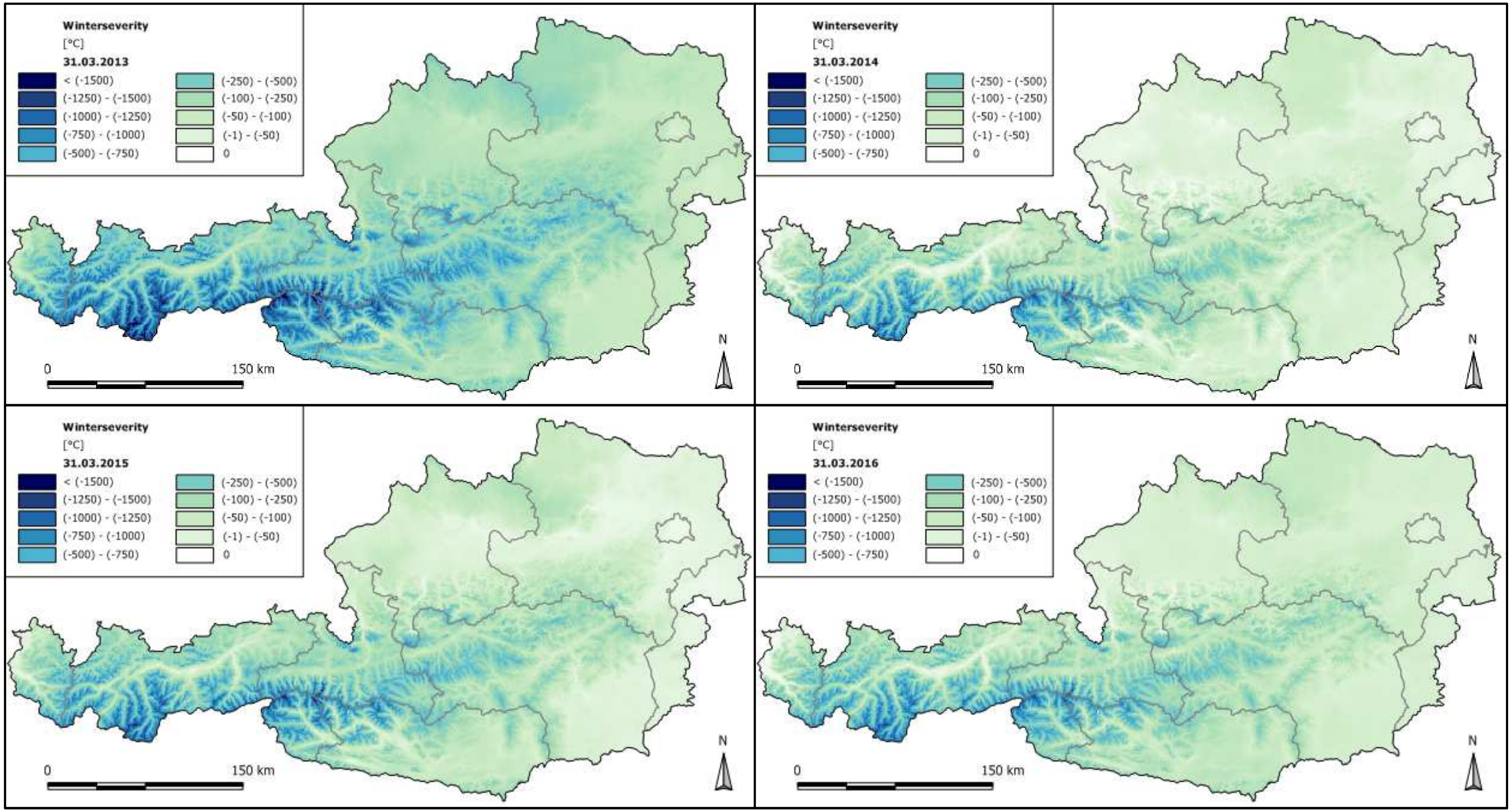
ARIS Data Output Example – Snow Cover Days



ARIS Data Output Example – Frost Days



ARIS Data Output Example – Winter Severity



ARIS Methodology – Crop Independent Stress and Suitability Indicators

Accumulated Effective Temperatures [°C]

efft = sum of effective temperatures for days with t_{mean} > 10°C, t_{min} >= 0°C and t_{max} <= 35°C

from January 1st to Dezember 31st ; effective temperature = $t_{max} - t_{base}$

Accumulated Potential Water Balance 1 [mm]

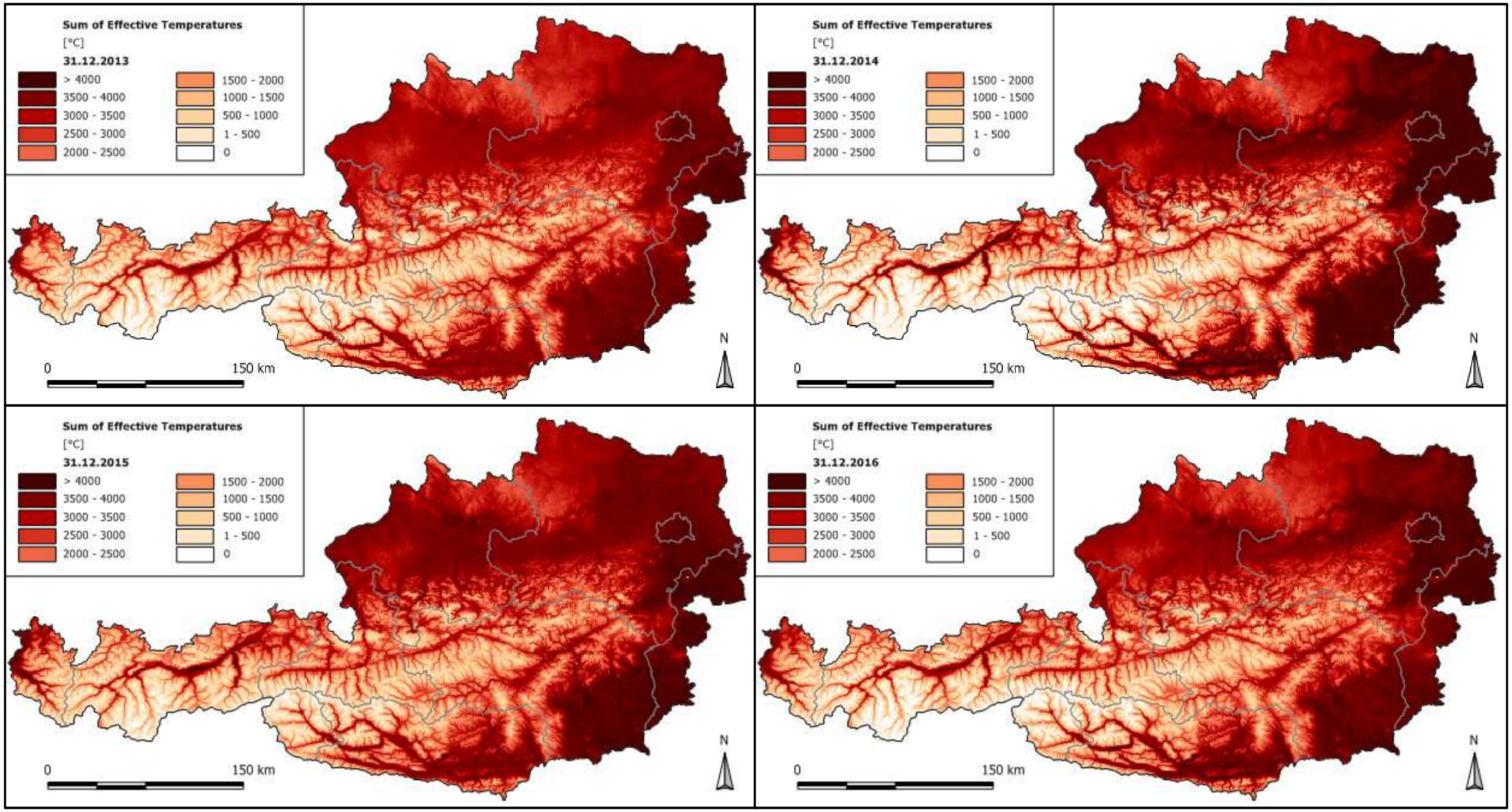
pWb1 = sum of ($precip_{mean}$ - et0) from April 1st to June 30th

Accumulated Potential Water Balance 2 [mm]

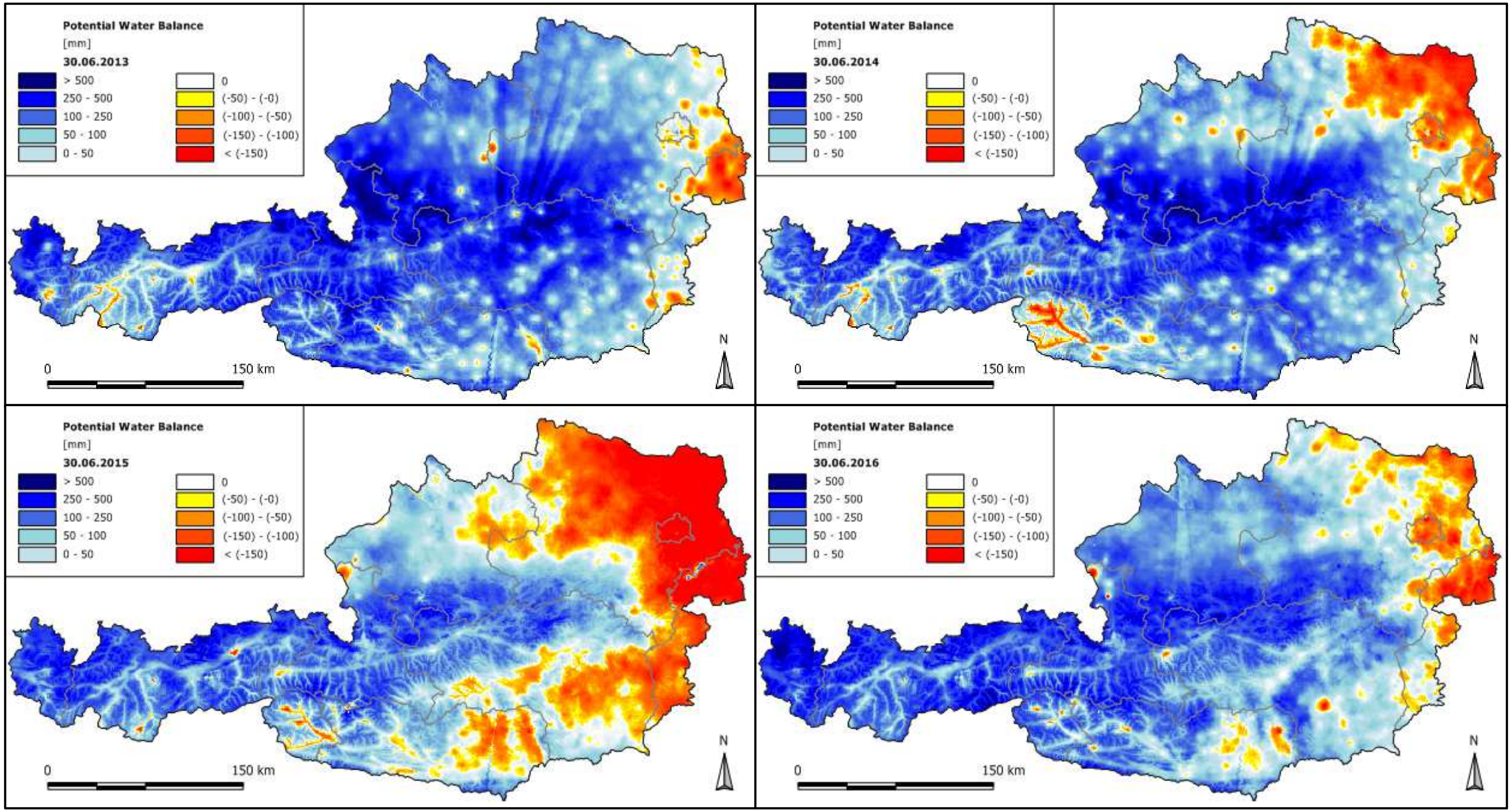
pWb2 = sum of ($precip_{mean}$ - et0) from April 1st to September 30th

t_{base}	base temperature [°C] = 0°C
t_{max}	daily maximum temperature [°C]
t_{mean}	daily average temperature [°C]
t_{min}	daily minimum temperature [°C]
$precip_{mean}$	daily average precipitation [mm]
et0	reference evapotranspiration [mm]

ARIS Data Output Example – Effective Temperatures



ARIS Data Output Example – Potential Water Balance 1



ARIS Methodology – Crop Dependent Stress and Suitability Indicators

Huglin Index - Huglin Indicator

The Huglin Index is a technique for classifying the climate of wine growing regions. It is an index specifically aimed at grape growth and is defined using daily averaged temperature and the daily maximum temperature for all days in the period 1 April to 30 September (Huglin, 1986):

$$HI = K \cdot \sum_{01.04.}^{30.09.} \left(\frac{T_{\text{med}} + T_{\text{max}}}{2} - 10 \right)$$

HI Huglin Index
K adjustment value for longer day lengths found at higher latitudes
t_{med} daily average temperature [°C]
t_{max} daily maximum temperature [°C]

The Huglin Index is a value describing the suitability of a particular region for the cultivation of specific grape types.

Huglin, P. (1986). Biologie et écologie de la vigne. Lavoisier (Edition Tec & Doc), Paris 1986, ISBN 2-60103-019-4. S. 292 (371 S.)

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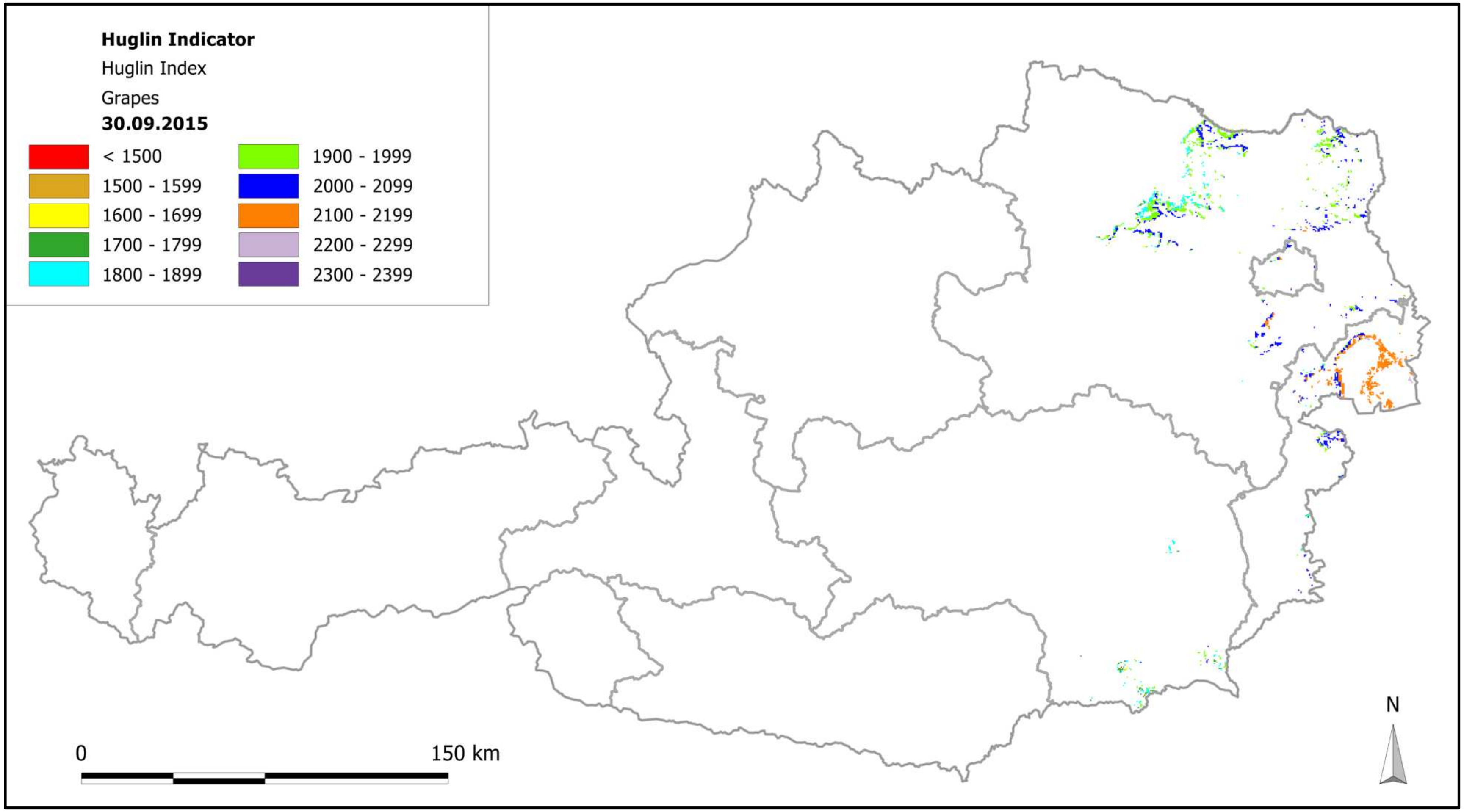
ARIS Data Output Example – Huglin Indicator



ARIS Methodology – Crop Dependent Stress and Suitability Indicators

Effective Global Radiation Indicator

Accumulation of global radiation values.

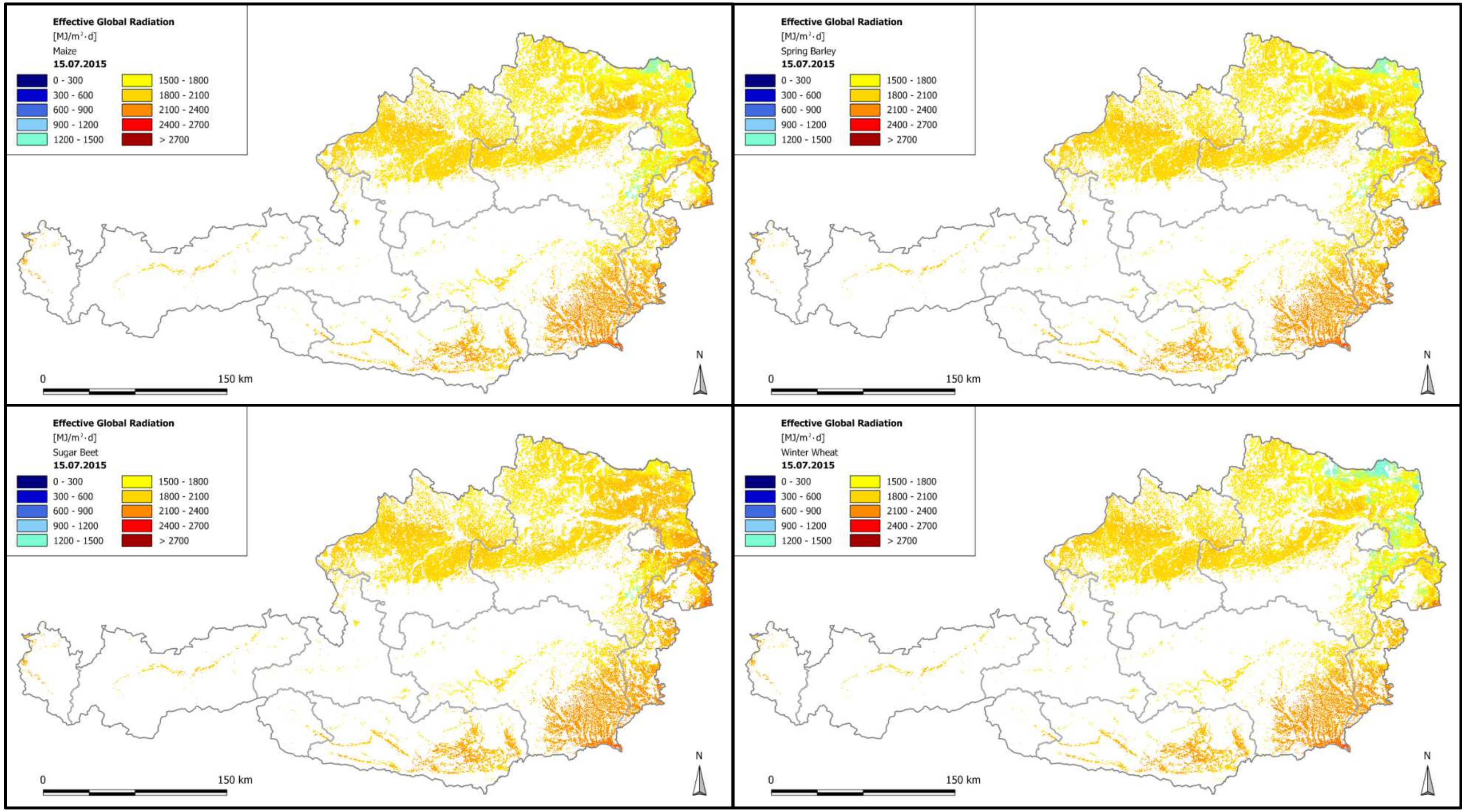
if ($t_{mean} > t_{thresh}$ & $ks > ks_{thresh}$): egr = rad
else: egr = 0

Accumulation from January 1st to December 31st

egr	effective global radiation [$MJ/m^2 \cdot d$]
rad	daily sum of radiation [$MJ/m^2 \cdot d$]
t_{mean}	daily average temperature [°C]
t_{thresh}	threshold value of the daily average temperature [°C]
ks	water stress coefficient [0 - 1]
ks_{thresh}	threshold value of the water stress coefficient [0 - 1]

Variable	Threshold value
t_{thresh}	5°C
ks_{thresh}	0,4

ARIS Data Output Example – Effective Global Radiation Indicator



ARIS Methodology – Crop Dependent Stress and Suitability Indicators

Intensive Water Deficit Indicator

Accumulation of days with intensive water deficit.

esf = eta / et0

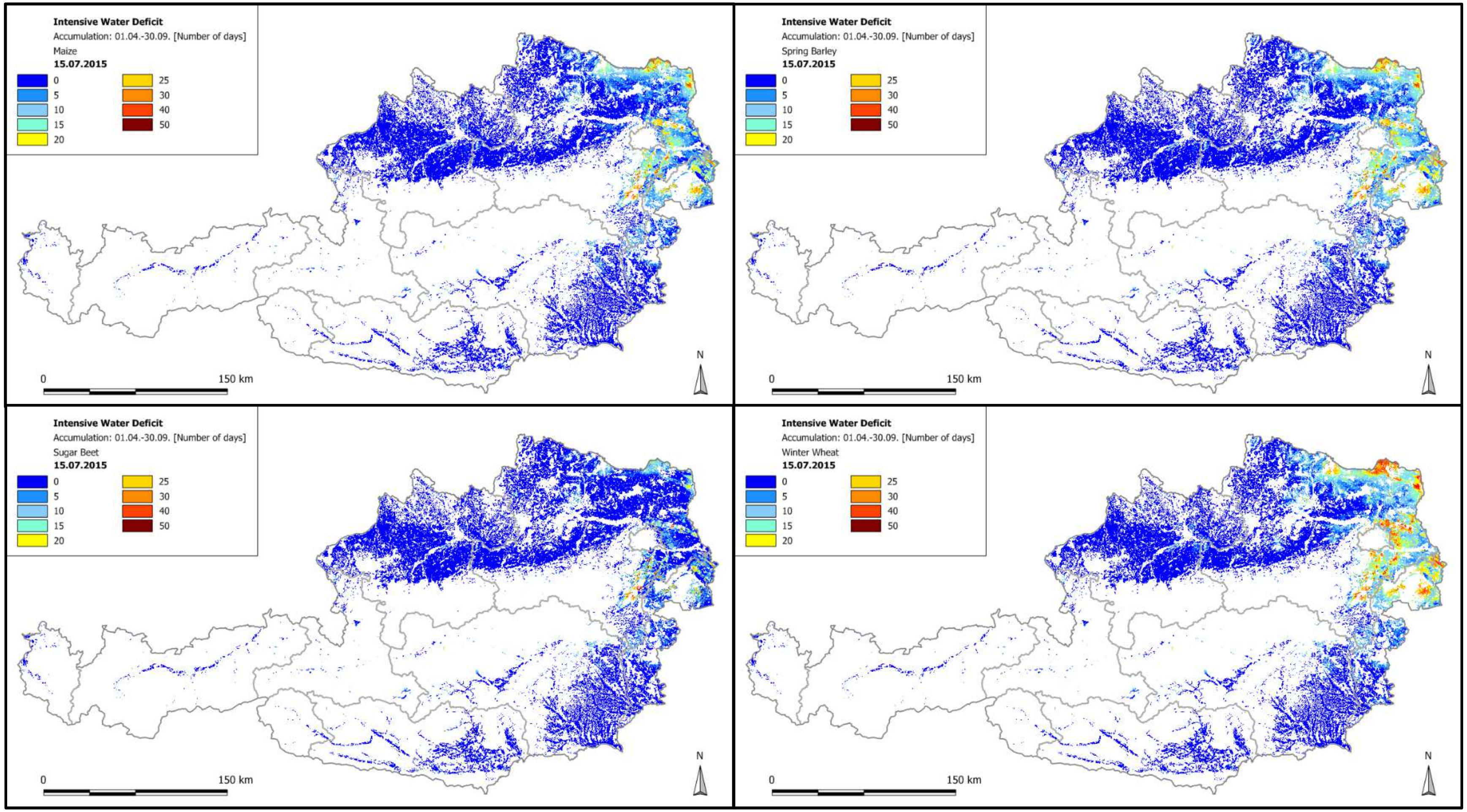
if (esf < esf_{thresh}): iwd = 1
else: iwd = 0

Version1 : accumulation of iwd from April 1st to June 30th
Version2 : accumulation of iwd from April 1st to September 30th

iwd	day with intensive water deficit [0,1]
esf	evapotranspiration stress factor
esf_{thresh}	threshold value of the evapotranspiration stress factor
eta	actual evapotranspiration [mm]
et0	reference evapotranspiration [mm]

Variable	Threshold value
esf_{thresh}	0,4

ARIS Data Output Example – Intensive Water Deficit Indicator



ARIS Methodology – Crop Dependent Stress and Suitability Indicators

Field Working Days Indicator

Accumulation of days with meteorological and soil conditions suitable for field work.

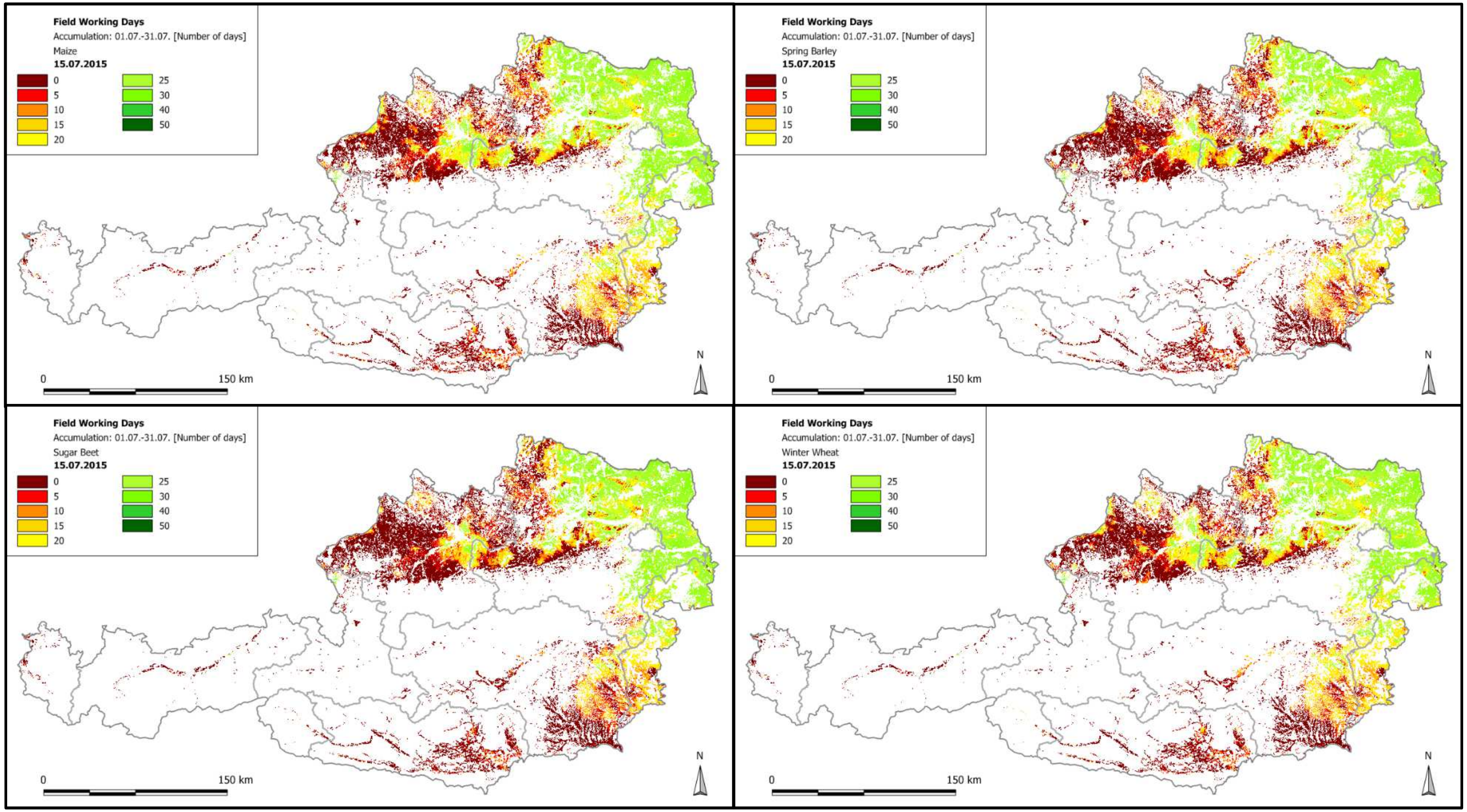
if ($p_{n-3} < p_{thresh3}$ & $p_{n-2} < p_{thresh2}$ & $p_{n-1} < p_{thresh1}$ & $p_n < p_{thresh}$ & $rss_n < rss_{thresh}$): $fwd_n = 1$
else:
$fwd_n = 0$

Version1 : accumulation of fwd from June 1st to June 30th
Version2 : accumulation of fwd from July 1st to July 31st

fwd_n	day n with meteorological and soil conditions suitable for field work [0,1]
p_n	sum of precipitation at day n [mm]
p_{thresh}	threshold value of the precipitation sum at day n [mm]
rss_n	relative soil saturation at day n [%]
rss_{thresh}	threshold value of the relative soil saturation [%]

Variable	Threshold value
rss_{thresh}	70 % of maximum soil water holding capacity
$p_{thresh3}$	20 mm
$p_{thresh2}$	10 mm
$p_{thresh1}$	5 mm
p_{thresh}	0.5 mm

ARIS Data Output Example – Field Working Days Indicator



ARIS Methodology – Apple Phenology

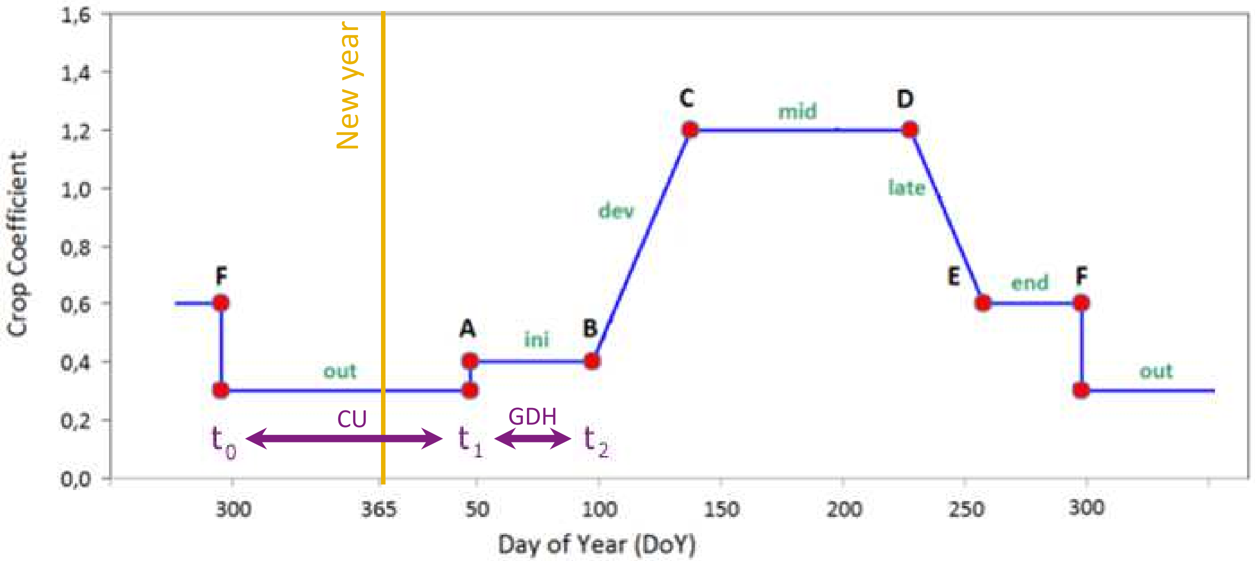
Apple Phenology Implemented in ARIS

- Apple trees show two distinct growth stages during their annual life cycle: rest period (BBCH0) and active growth period (BBCH1 to BBCH90) *
- Rest period: starts with leaf falling in autumn and ends with silver tip stage in spring after accumulation of enough winter chilling (chilling phenological model)
- Active growth period: starts with flower bud after accumulation of enough growing degree hours (forcing phenological model) and ends with leaf falling in autumn
- Chilling and forcing models need hourly temperature data

* BBCH - Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie
MEIER, U., H. GRAF, H. HACK, M. HESS, W. KENNEL, R. KLOSE, D. MAPPES, D. SEIPP, R. STAUSS, J. STREIF und T. VAN DEN BOOM (1994). Phänologische Entwicklungsstadien des Kernobstes (Malus domestica Borkh. und Pyrus communis L.), des Steinobstes (Prunus-Arten), der Johannisbeere (Ribes-Arten) und der Erdbeere (Fragaria x ananassa Duch.). Nachrichtenblatt Deutscher Pflanzenschutzdienst 46, 141-153.

ARIS Methodology – Apple Phenology

Phenological Stages of Apple



(1) ACRP8 – Combirisk: results for Hartberg Apple orchards
(2) Allen, R.G.; Pereira, L.S.; Raes, D.; Smith, M. (1998). Crop evapotranspiration-guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56, Rome.

Stage out: Rest period with no plant growth during the winter season. Accumulation of chilling temperatures. Starts with leaf falling (t_0) on September 1st (1)

Stage ini: Accumulation of growing degree hours. Starts after accumulation of 1.000 °C (1) chilling hours (t_1).

Stage dev: stage that starts with the flower bud after accumulation of 6.250 °C (1) growing degree hours (t_2).

Stage mid: stage starting 70 days (2) after the end of stage dev.

Stage late: stage starting 90 days (2) after the end of stage mid.

Stage end: stage starting 30 days (2) after the end of stage late.

ARIS Methodology – Apple Phenology

Computation of Hourly Temperature Data

Hourly temperature data can be estimated from daily minimum and maximum temperature values using the sine-log equations derived by Linvill*:

Day-time temperature cycle (sine curve from sunrise to sunset):

$$T(t) = (T_{max} - T_{min}) \times \sin [(\pi \times t)/(DL + 4)] + T_{min} \quad (1)$$

Night-time temperature cycle (logarithmic decline curve from sunset to sunrise):

$$T(t) = Ts - [(Ts - T_{min})/ \ln (24 - DL)] \times \ln(t) \quad (2)$$

$T(t)$	temperature at hour t [°C]	t	hour of the day
T_{max}	maximum daily temperature [°C]	DL	daylength [hour]
T_{min}	minimum daily temperature [°C]	T_s	sunset temperature from equation (1) [°C]

* Linvill DE. (1990). Calculating chilling hours and chill units from daily maximum and minimum temperature observations. HortScience. 25(1):14–16.

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ARIS Methodology – Apple Phenology

Computation of Chilling and Growing Degree Hours

Based on hourly temperature data a chilling hour unit (CU) model [1] and a Growing Degree Hour (GDH) model [2,3] can be implemented.

CU model:

Temperature [°C]	CU
T < 1,4	0
1,5 < T < 2,4	0,5
2,5 < T < 9,1	1
9,2 < T < 12,4	0,5
12,5 < T < 15,9	0
16,0 < T < 18,0	-0,5
T > 18,0	-1

GDH model:

$$GDH(k) = \sum_{i=1}^{i=24} \mathrm{Max}[0, (T(i) - 4.5)] \quad eq(4)$$

$$GDH(f) = \sum_{k=t1}^{k=t2} \sum_{i=1}^{24} GDH(i,k) \quad eq(5)$$

GDH sum of hourly temperatures [°C]
T temperature [°C]
i hour
k day number from t_1 to t_2

(1) Richardson, E.A., Seeley S.D., Walker D.R., 1974: A model for estimating the completion of rest for Redhaven and Elberta peach trees. HortScience, 9(4), 331-332.

(2) Anderson, J. L., Richardson, E. A. and Kesner C. D. (1986). Validation of chill unit and flower bud phenology models for 'Montmorency' sour cherry. Acta Hortic 184: 71-78.

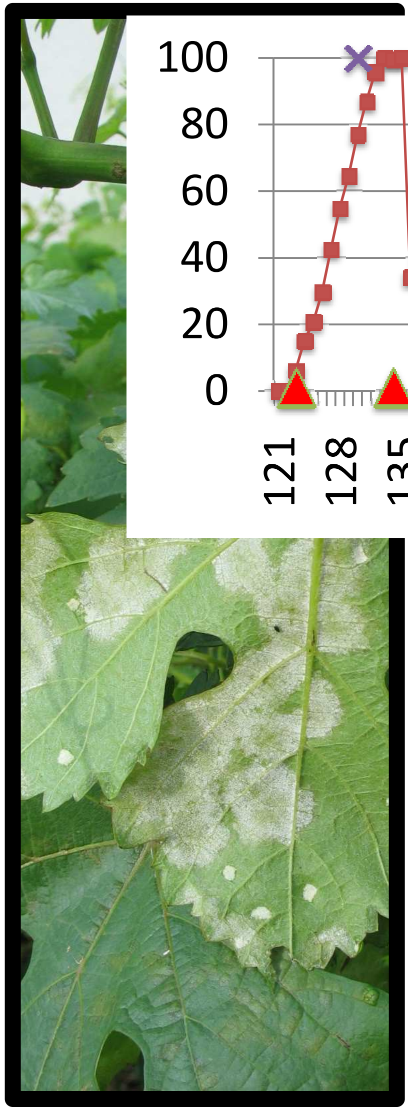
(3) Luedeling, E., Zhang, M., Luedeling, V. and Girvetz, H. (2009). Sensitivity of winter chill models for fruit and nut trees to climatic changes expected in California's Central Valley. Agric Ecosyst Environ 133: 23-31 CrossRf.

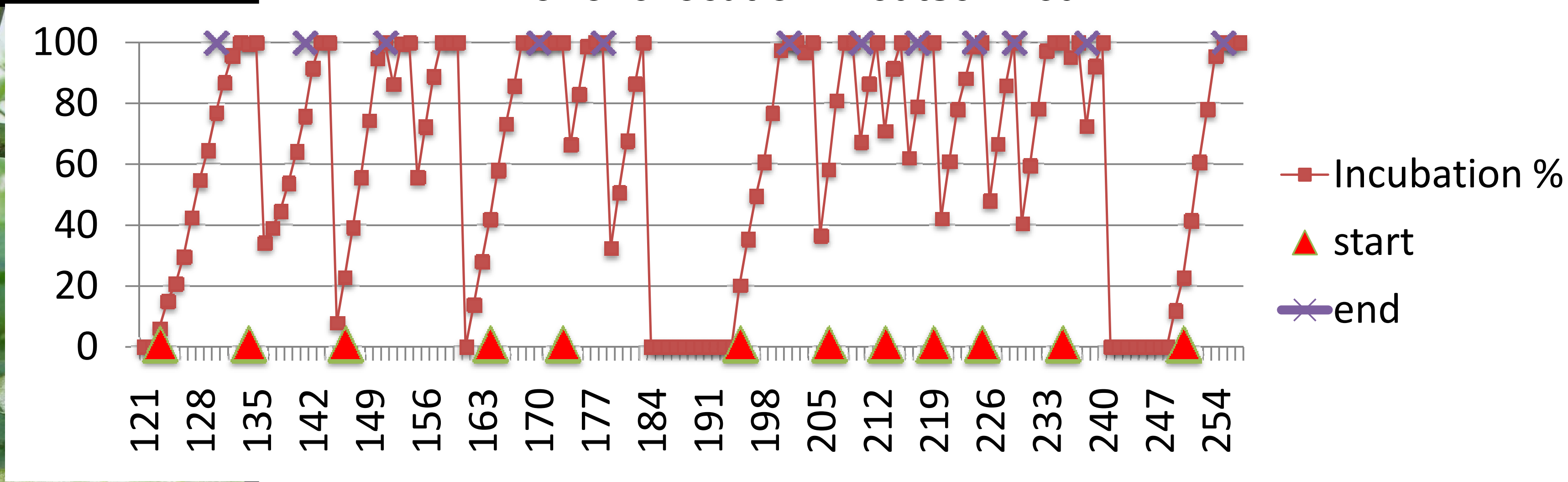
Examples for pest and disease algorithms in COMBIRISK

BAHUS model - *Grapevine downy mildew (Plasmopara viticola)*
UNSFA, Serbia

- Simple and widely known "3–10" empiric rule is included in Millers method:
- This rule is based on the simultaneous occurrence of the following conditions:
  - average daily air temperature equal to or greater than 10 °C;
  - vine shoots at least 10 cm in length;
  - a minimum of 10 mm of rainfall in 24–48 h (Baldacci, 1947).

Observed and calculated duration of incubation for one location: Deutschkreuz.





Observed is presented with the purple, Millers method starts with the red triangles and ends with black X marks.

Millers method is not calculating the Incubation in %, just start and the end.

- The results are showing good comparison with the reference simulations.
- Start of the primary and secondary infections are in very good comparison, which means that 3-10 rule is marching observations.
- The length of the incubation period is shorter when calculated with Millers method, by 3 to 4 days, but that time is long enough to protect the plant.

Pest model for WESTERN CORN ROOTWORM

with count data for Western Corn Rootworm (WCR),
to show the influence of climate and land use on the distributions and abundance of WCR on Austrian cropland

Method:

zero-inflated Poisson mixture model (ZIP)

this method is appropriate for count data with many zeros

2 regression parts:

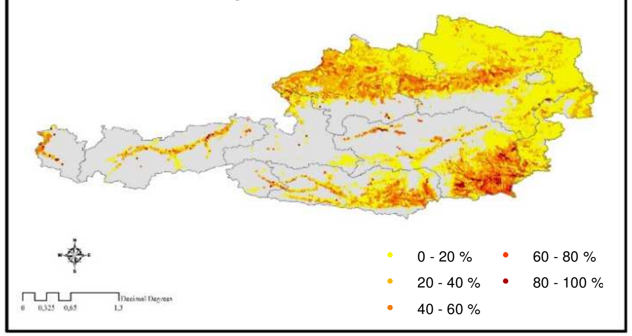
i. Bernoulli: probability of WCR occurrence
ii. Poisson: abundance of WCR (number of expected WCR)

the model was validated by running it separately for every year from 2005 – 2015, using climate data (INCA), land use data (GeDaBa, IACS) and WCR count data for these years

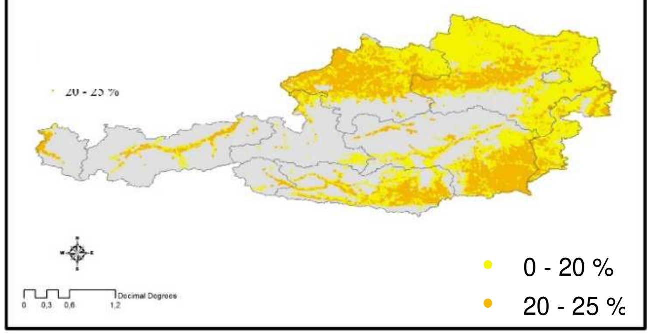
WCR - Results for crop rotation scenarios

- In crop rotation scenarios the maximum allowed maize share is
  - 25 % per pixel (M25)
  - 75 % per pixel (M75)

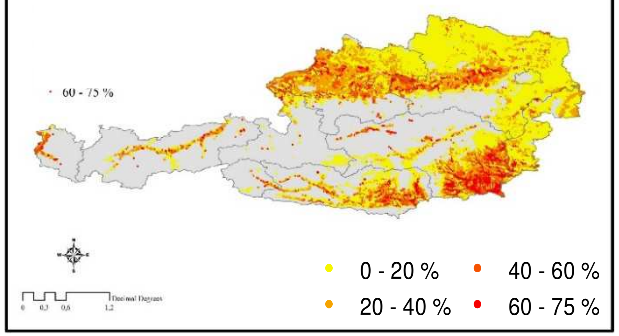
→ Especially in the Northern Alpine Foothills and Southern Styria the limitation of maize share in crop rotation makes big differences.



Real share of maize on cropland pixel averaged over 2013 - 2015



M25 Crop rotation restricted to 25 % maize



M75 Crop rotation restricted to 75 % maize

POLICY-FIT * - a follow-up H2020 Proposal

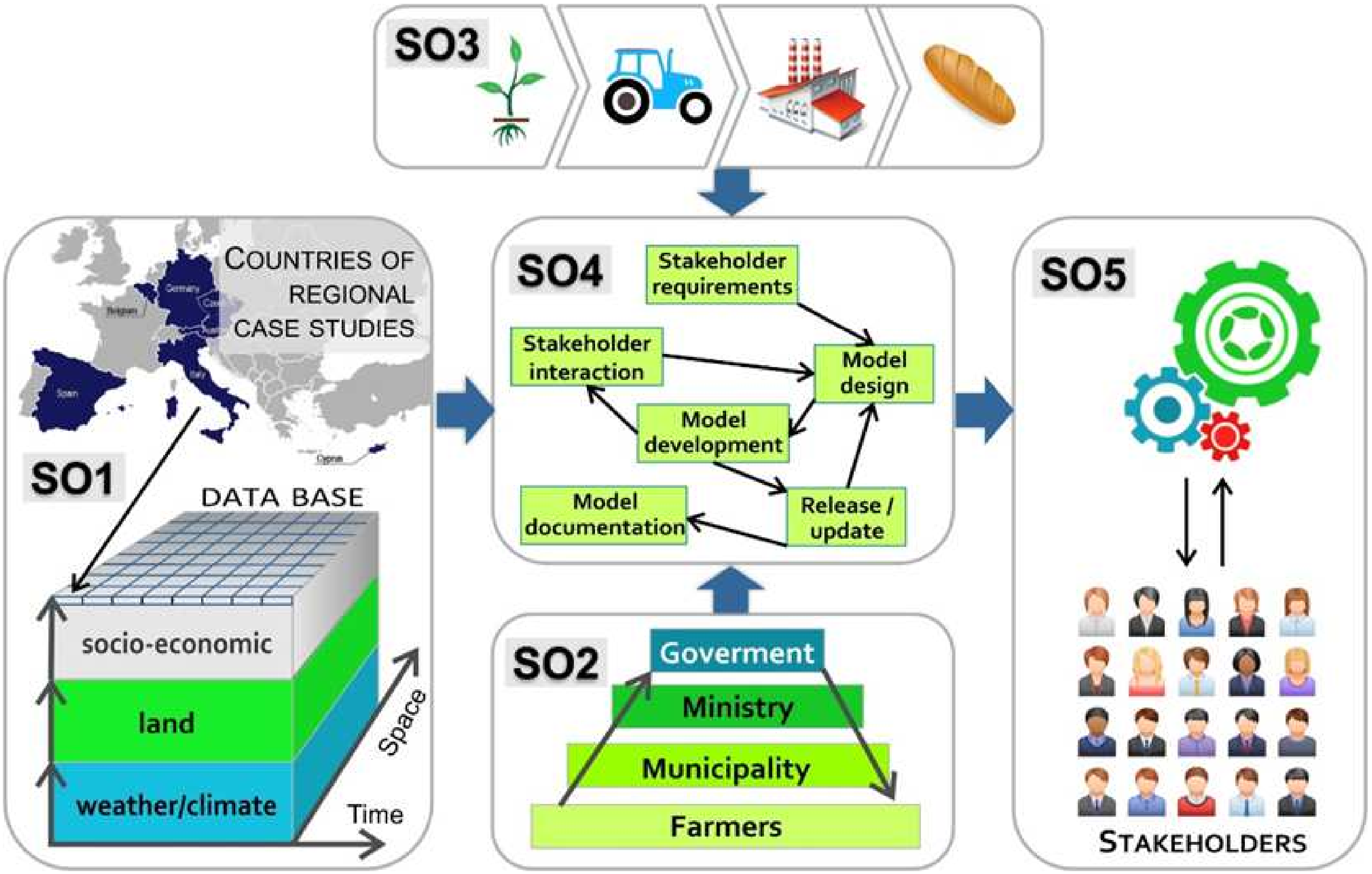
The overall objective of POLICY-FIT is

the development and demonstration of a flexible, modular and interactive decision-support system.

It aims to support evidence-based policy and decision making at different spatial and temporal scales in agriculture and related sustainable food production, natural and renewable resource management and ecosystem services.

*POLICY-FIT relates to RUR-04-2018-2019:
Analytical tools and models to support policies related to agriculture and food

POLICY-FIT - Outline



Хвала !

Vielen Dank !

Many Thanks !

Grazie !