WP3: Identifying and mapping of cropping risks by GIS-implemented indicator models under current and climate change conditions – work status

Vojko Daneu

BOKU, Department of Water, Atmosphere and Environment, Institute of Meteorology

Department Geoinformation
Agricultural Research and Education Centre Raumberg-Gumpenstein

University of Natural Resources and Life Sciences, Vienna

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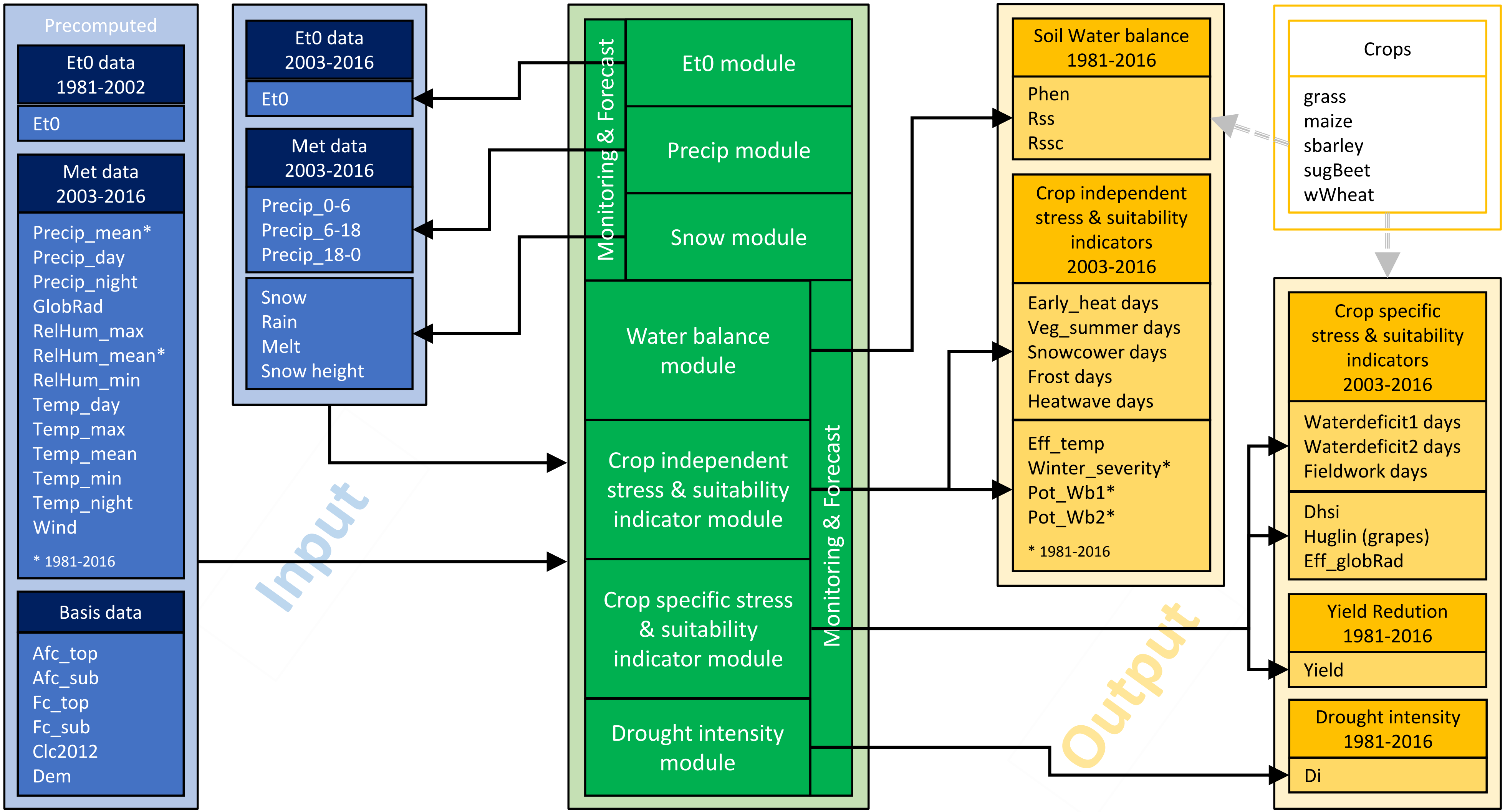
ARIS – System Overview



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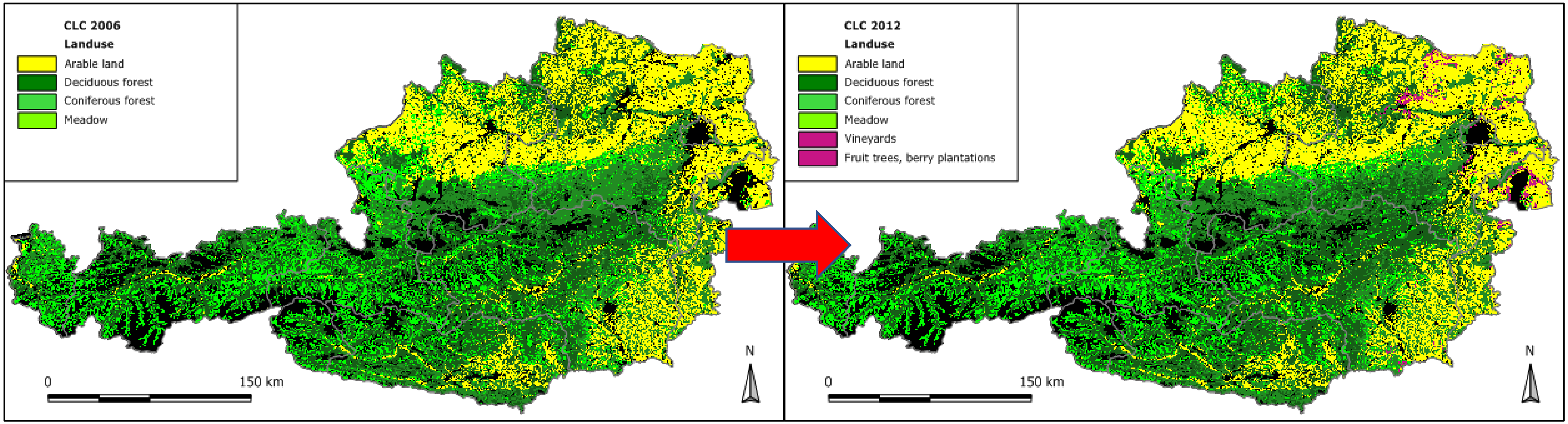
<u>Update of the landuse database</u>

- Update: Corine Landcover 2006 -> Corine Landcover 2012
- New landuse class: Vineyards + fruit trees + berry plantations



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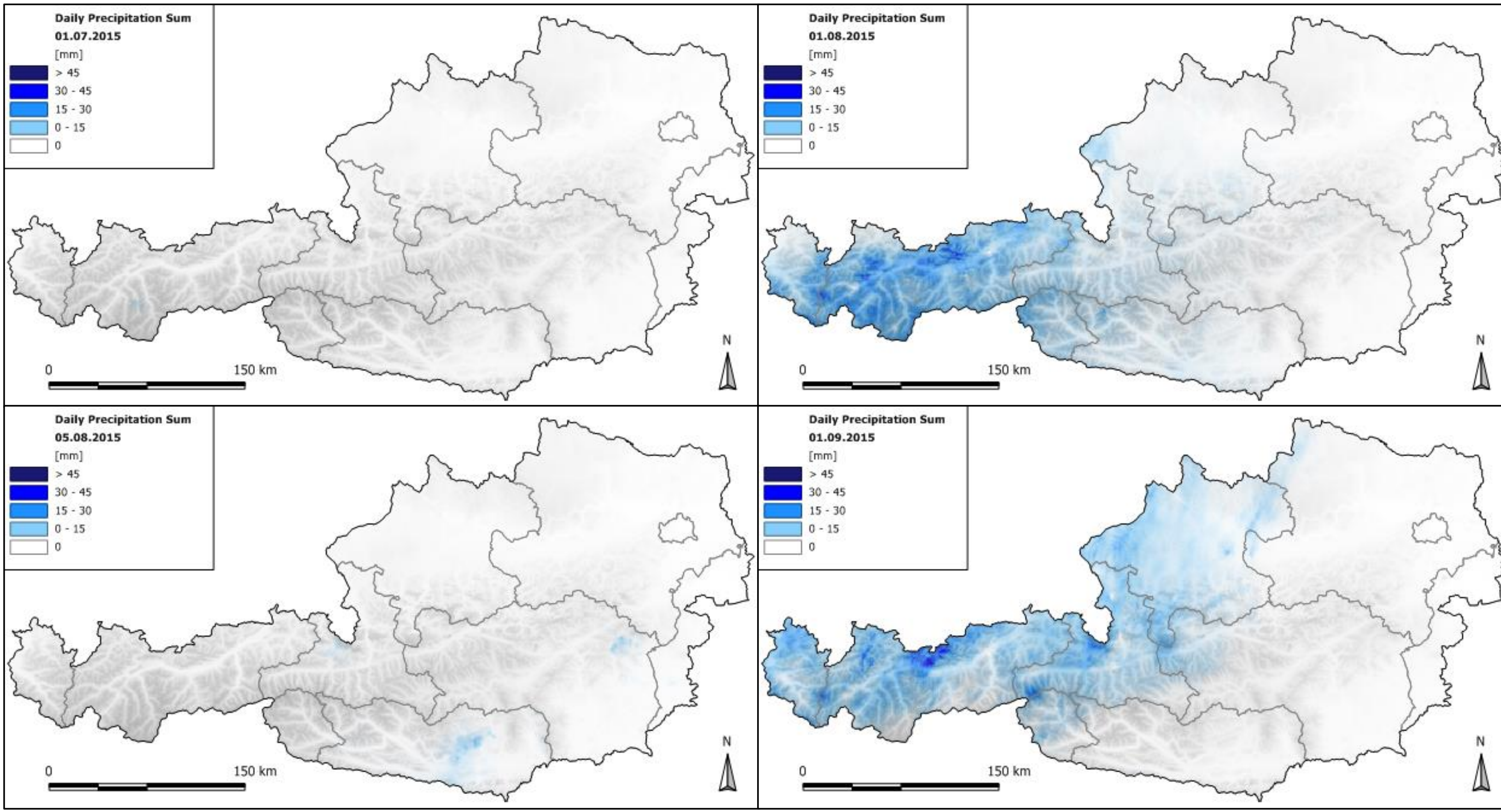
ARIS Data Input Example – Precipitation



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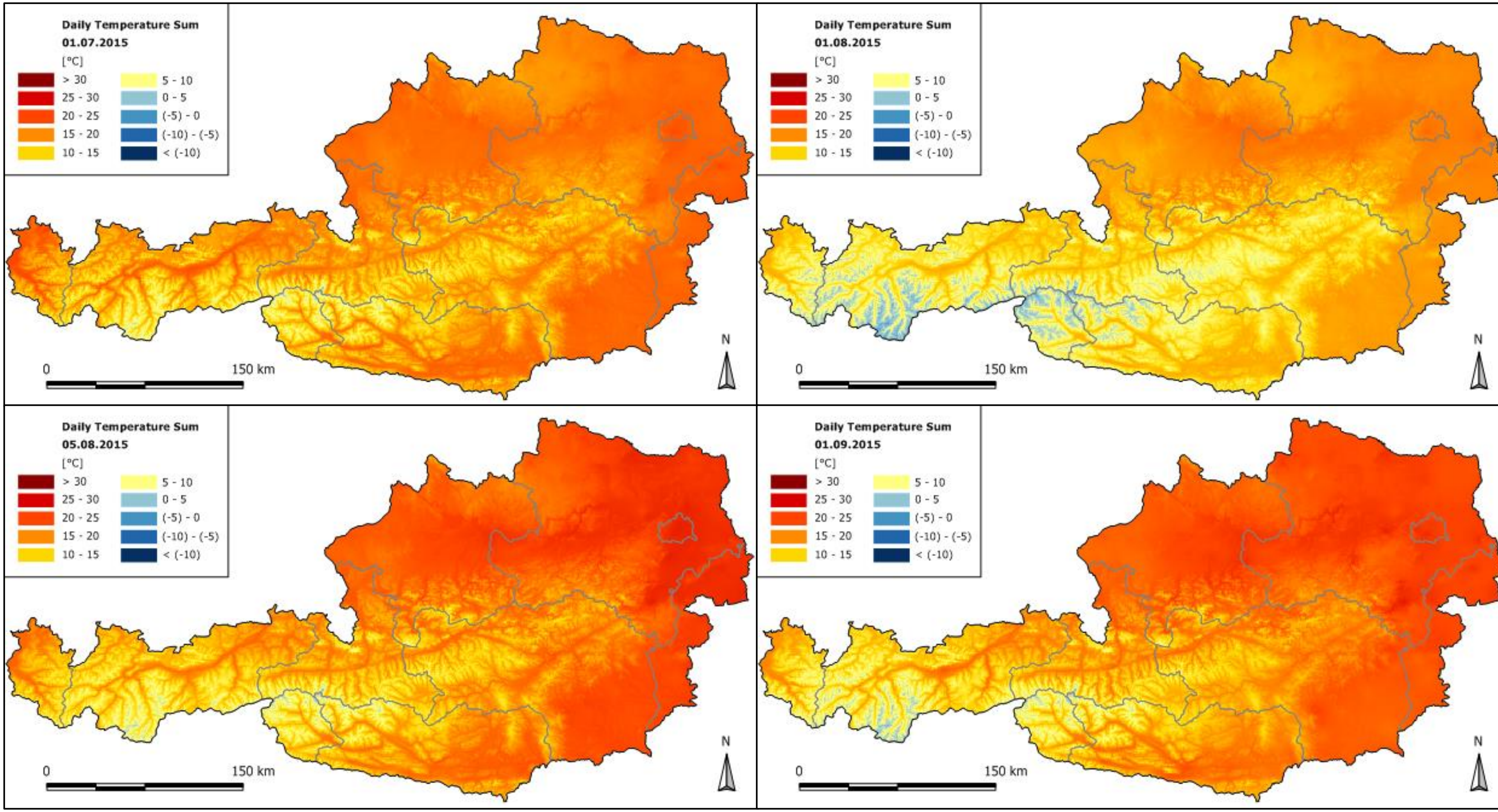
ARIS Data Input Example – Temperature



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FAO Penman-Monteith Evapotranspiration* [mm]

$$et0 = f(t_{min}, t_{mean}, t_{max}, rh, wind, rad, elev, lat_{mean}, alb, h, d, lat, lon)$$

$$et0 = 0{,}2 \text{ mm (December, January, February)}$$

t_{min}	daily minimum temperature [°C]
t_{mean}	daily average temperature [°C]
t_{max}	daily maximum temperature [°C]
rh	daily average of relative humidity [%]
wind	wind velocity [m/s]
rad	daily sum of radiation [MJ/m^2 d]
elev	elevation (altitude) at location [m]
lat_{mean}	average latitude of the region of interest [°]
alb	reflection coefficient of the surface
h	wind measurement height [m]
d	calculation day
lat	latitude of the location [°]
lon	longitude of the location [°]

* 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.

ARIS Data Input Example – Reference Evapotranspiration

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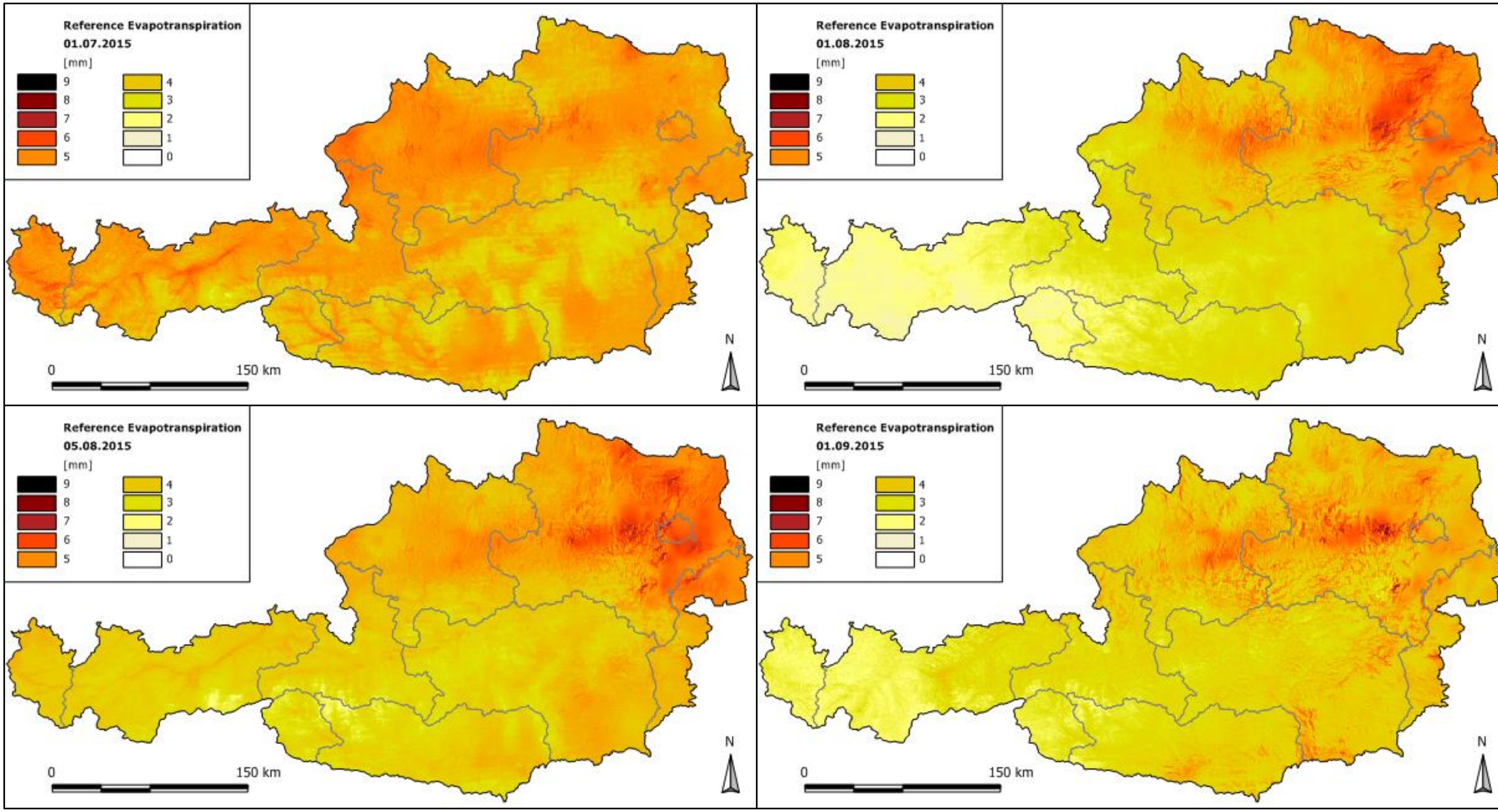

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Accumulated Early Heat Stress Days

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]

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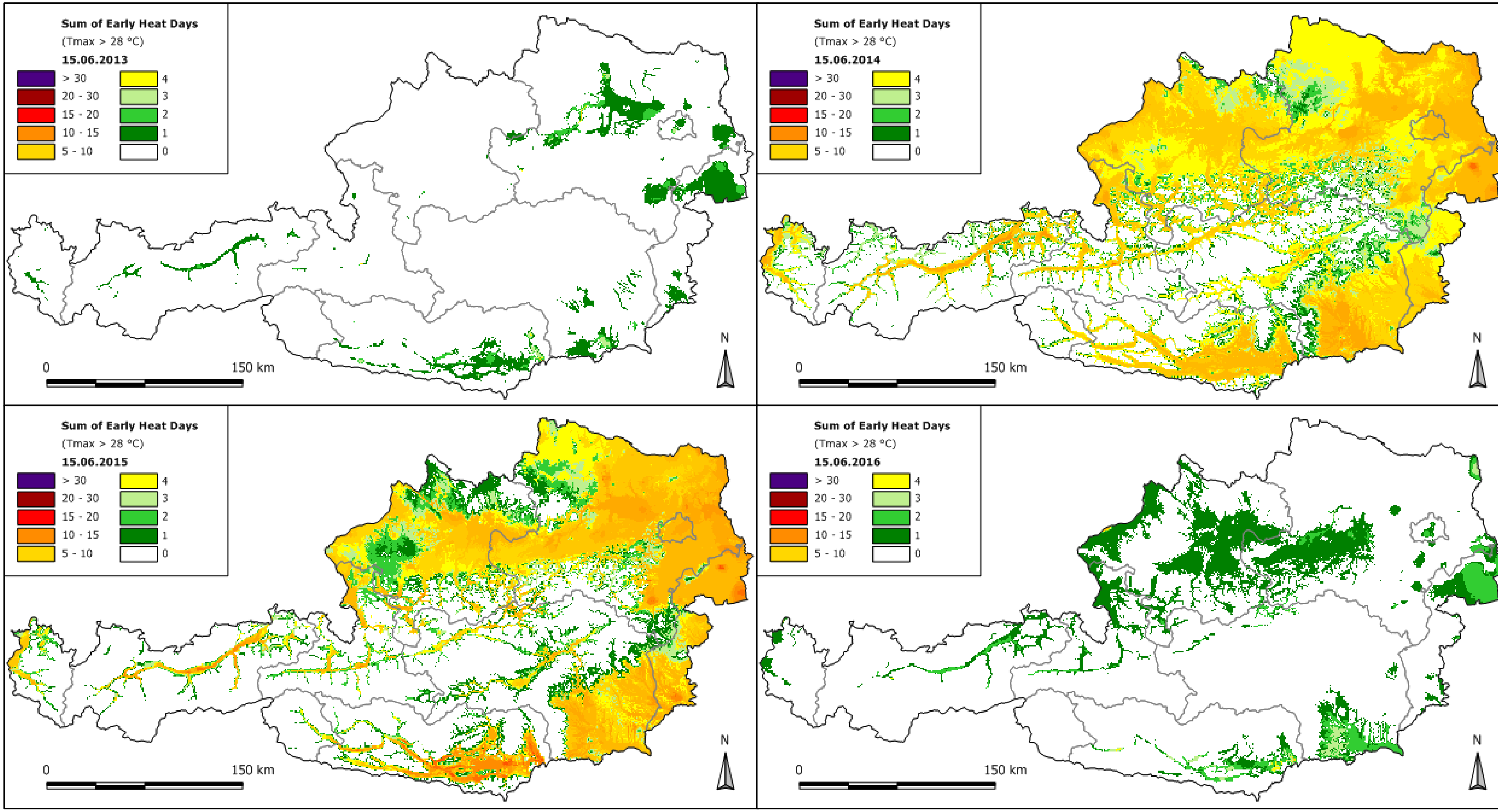
ARIS Data Input Example – Early Heat Stress Days



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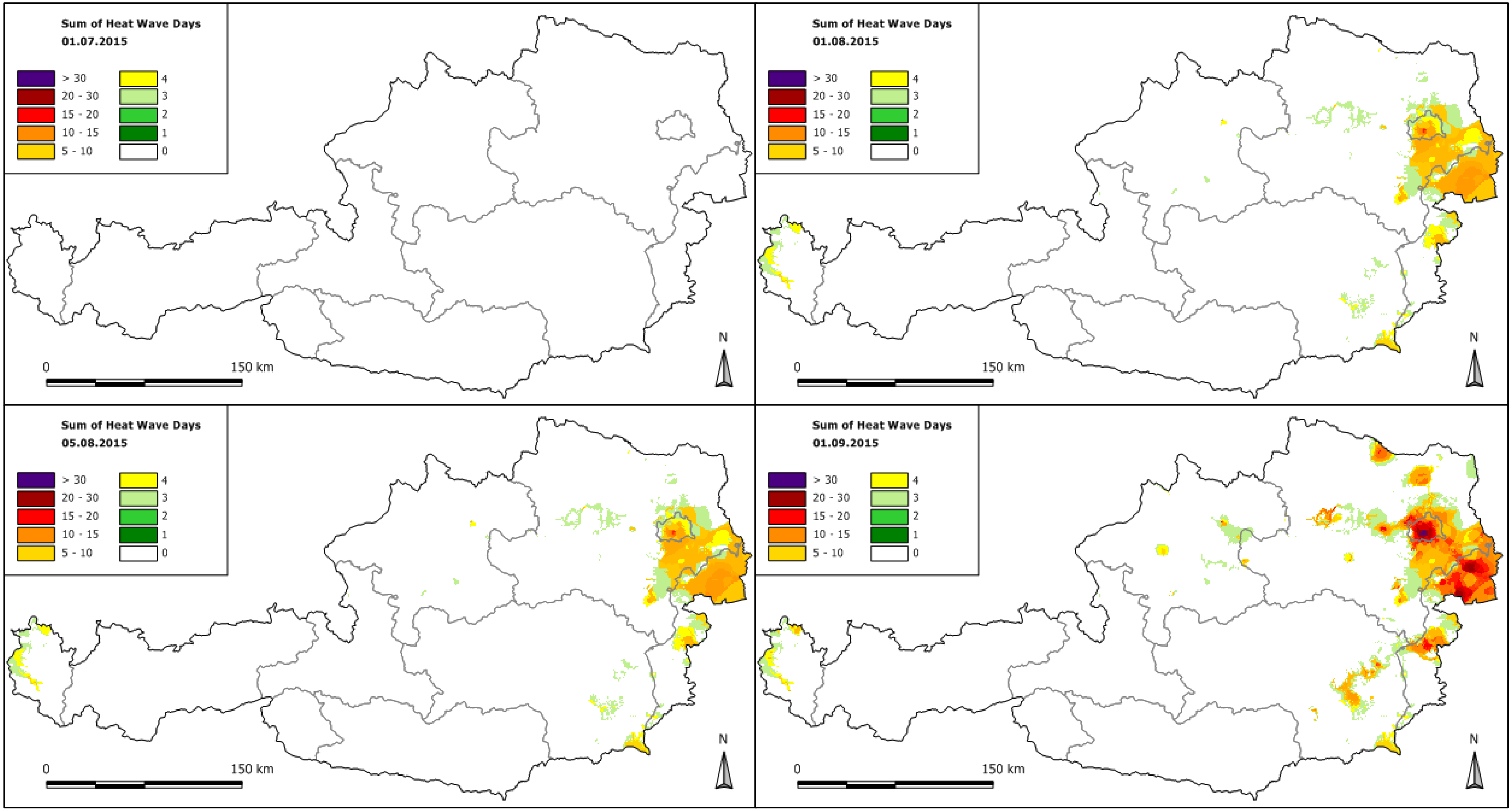
ARIS Data Input Example – Heat Wave Days



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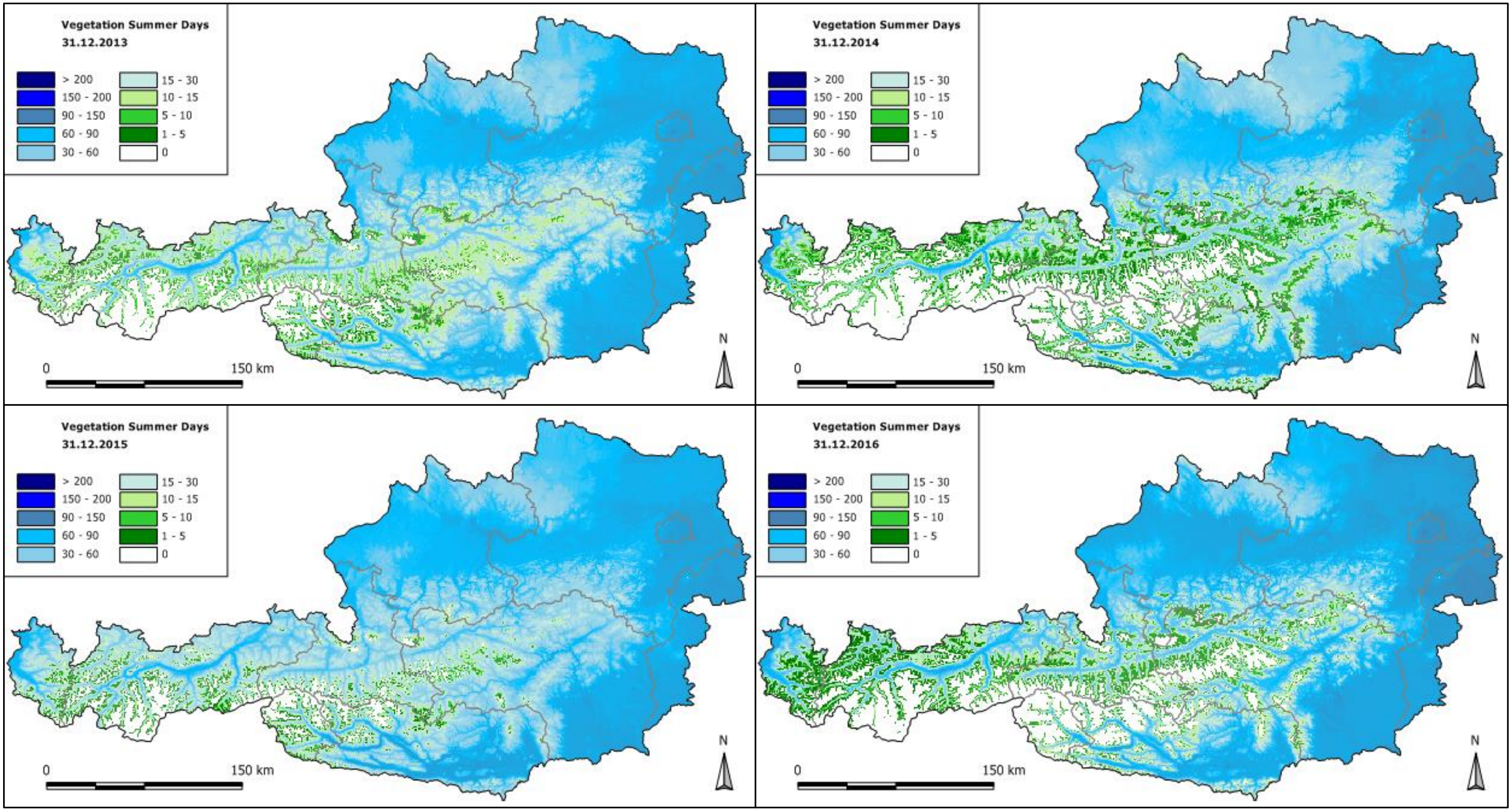
ARIS Data Input Example – Vegetation Summer Days



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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

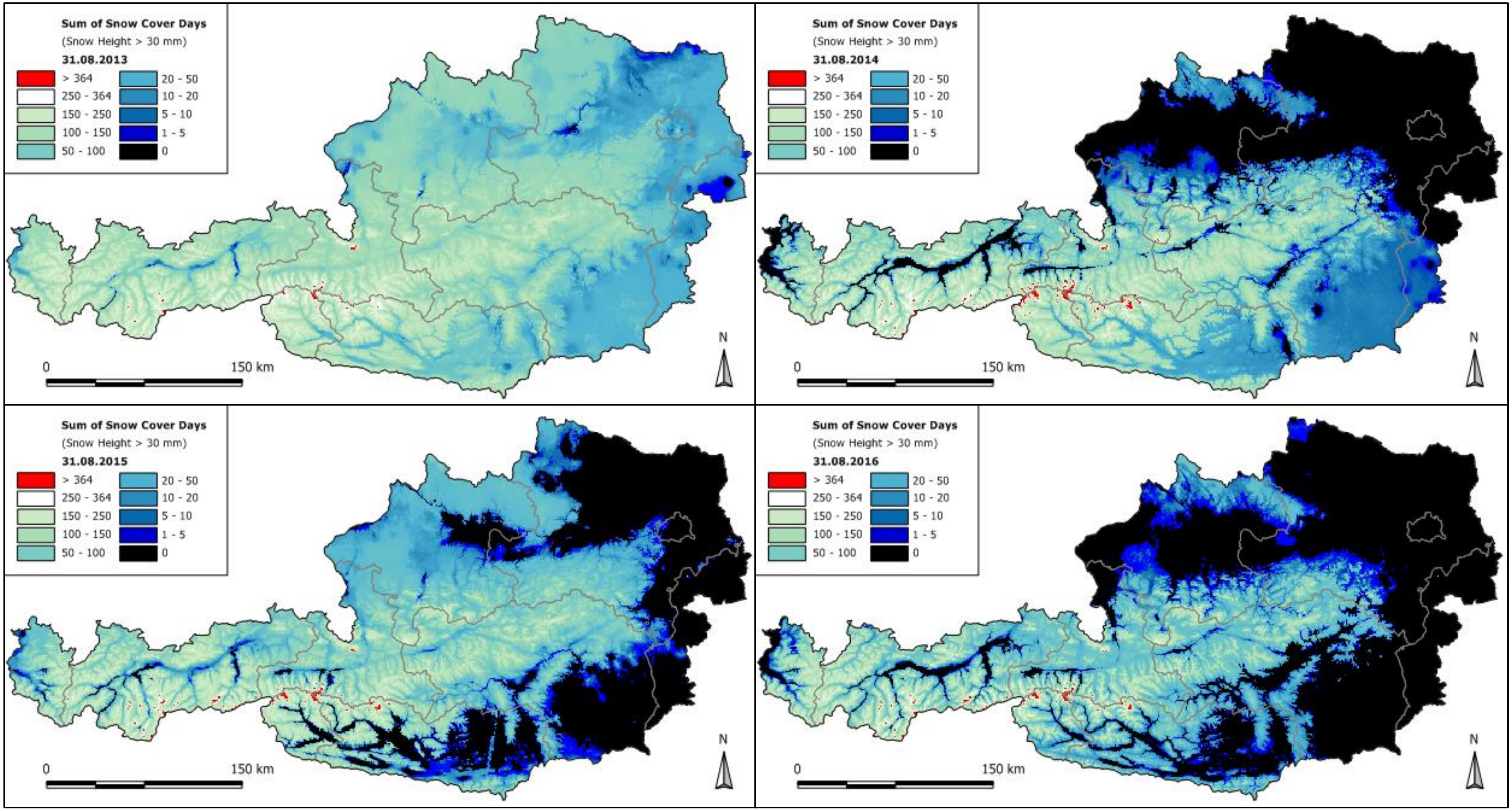
f = number of days with t_{min} < -10°C and no continuous snow cover from September 1st to August 31st

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 Input Example – Snow Cover Days



ARIS Data Input Example – Frost Days

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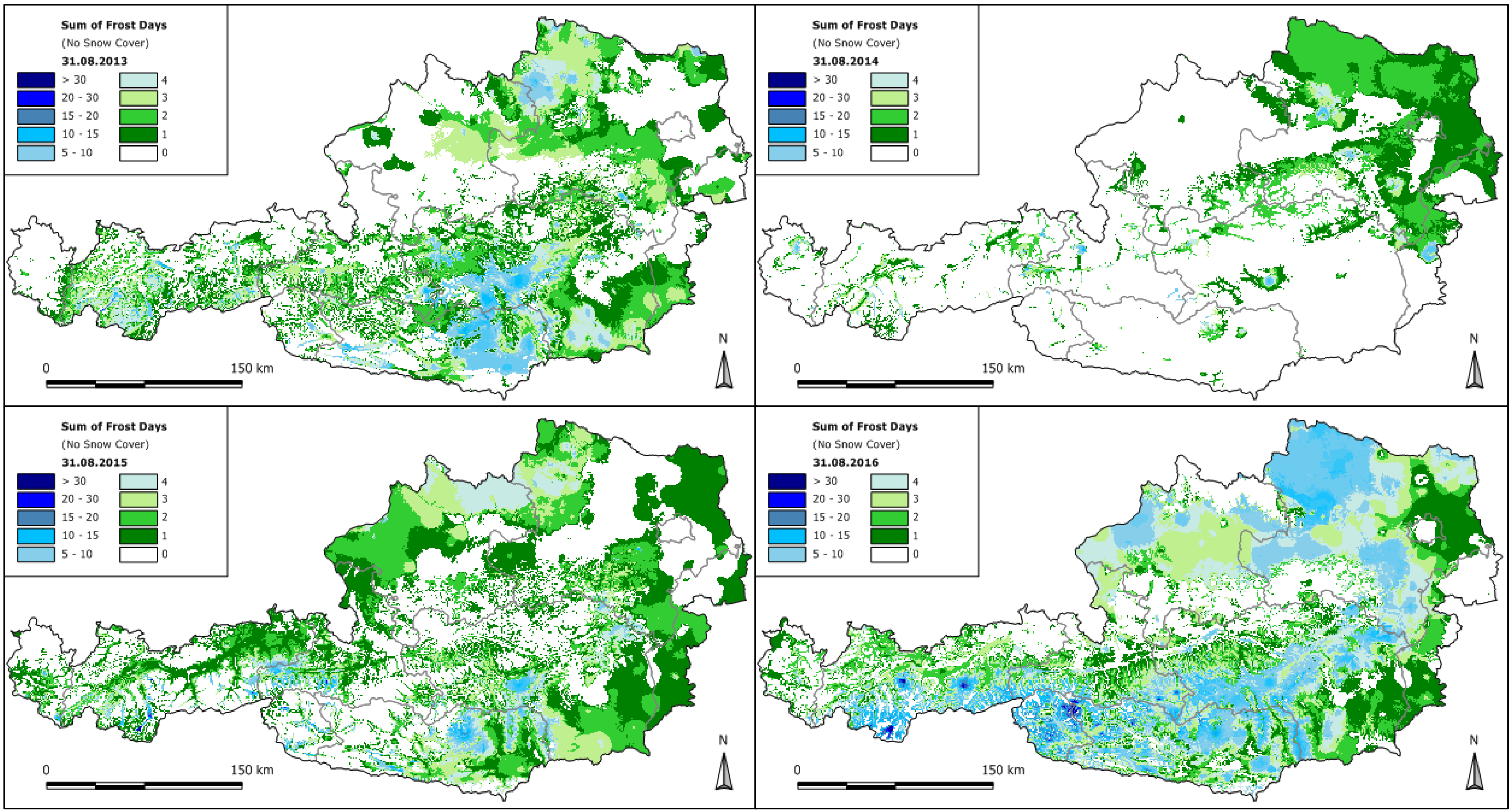

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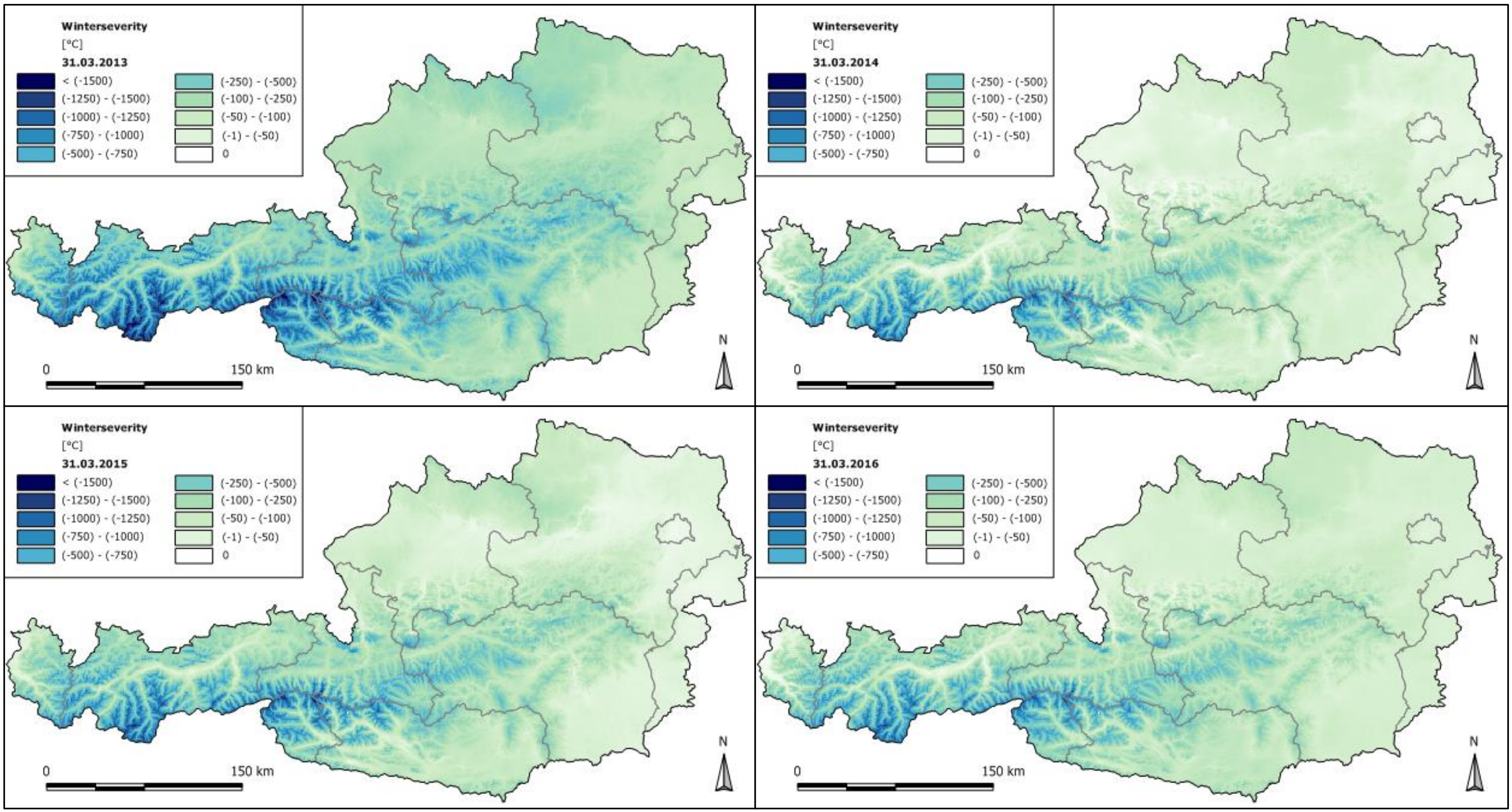
ARIS Data Input Example – Winter Severity



ARIS Methodology – Crop Independent Stress and Suitability Indicators

Accumulated Effective Temperatures [°C]

effft = 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]

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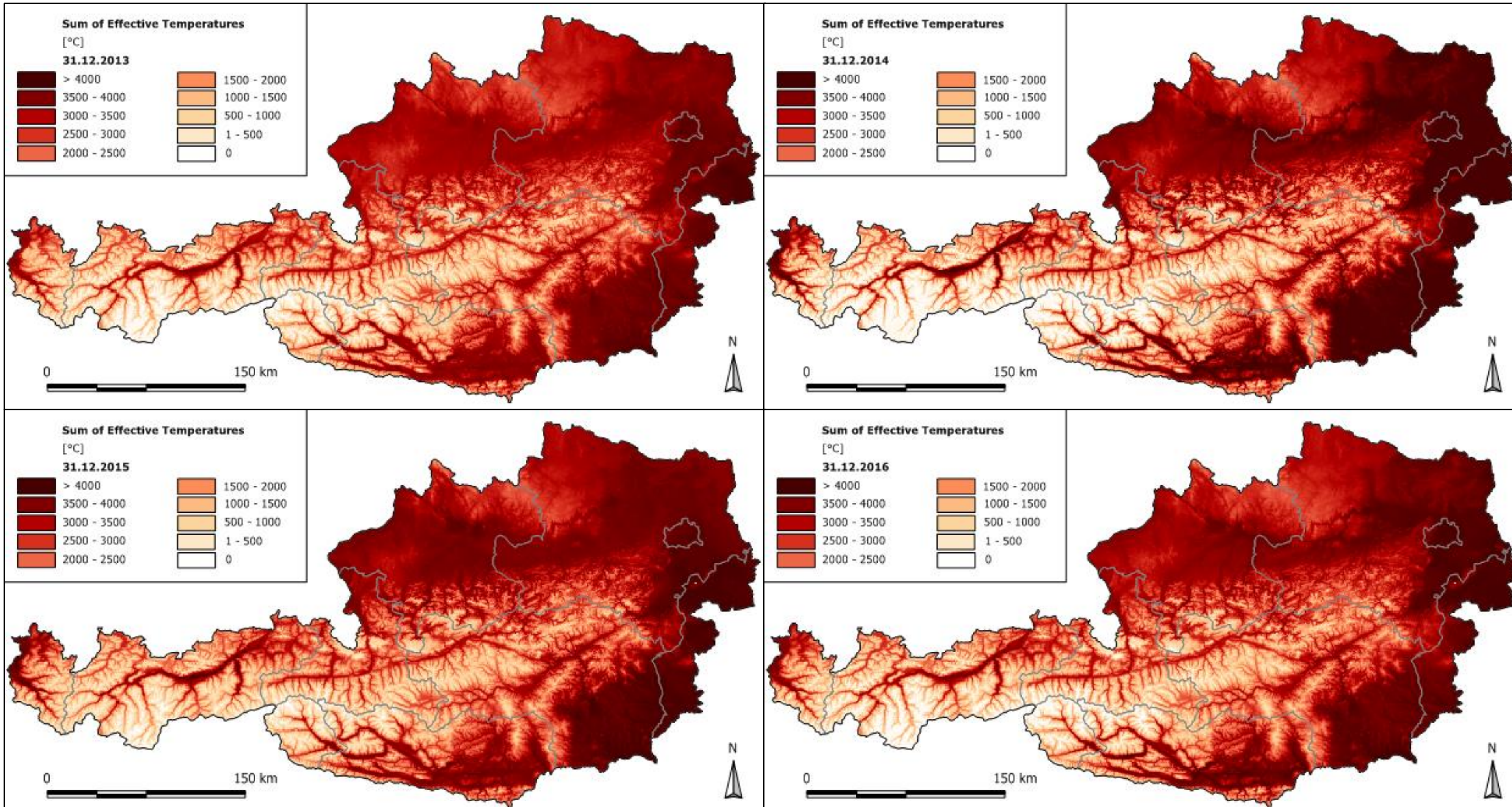
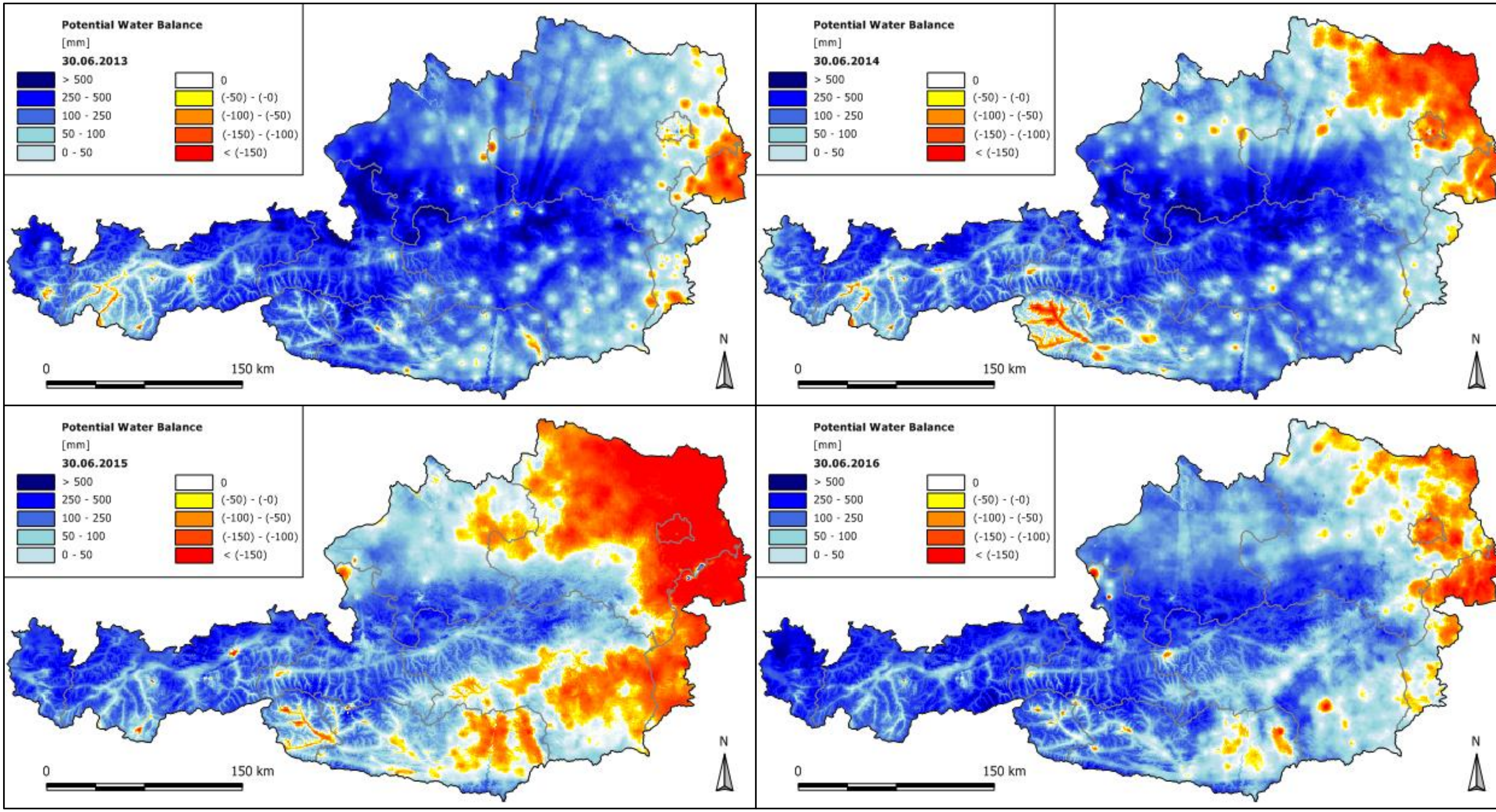
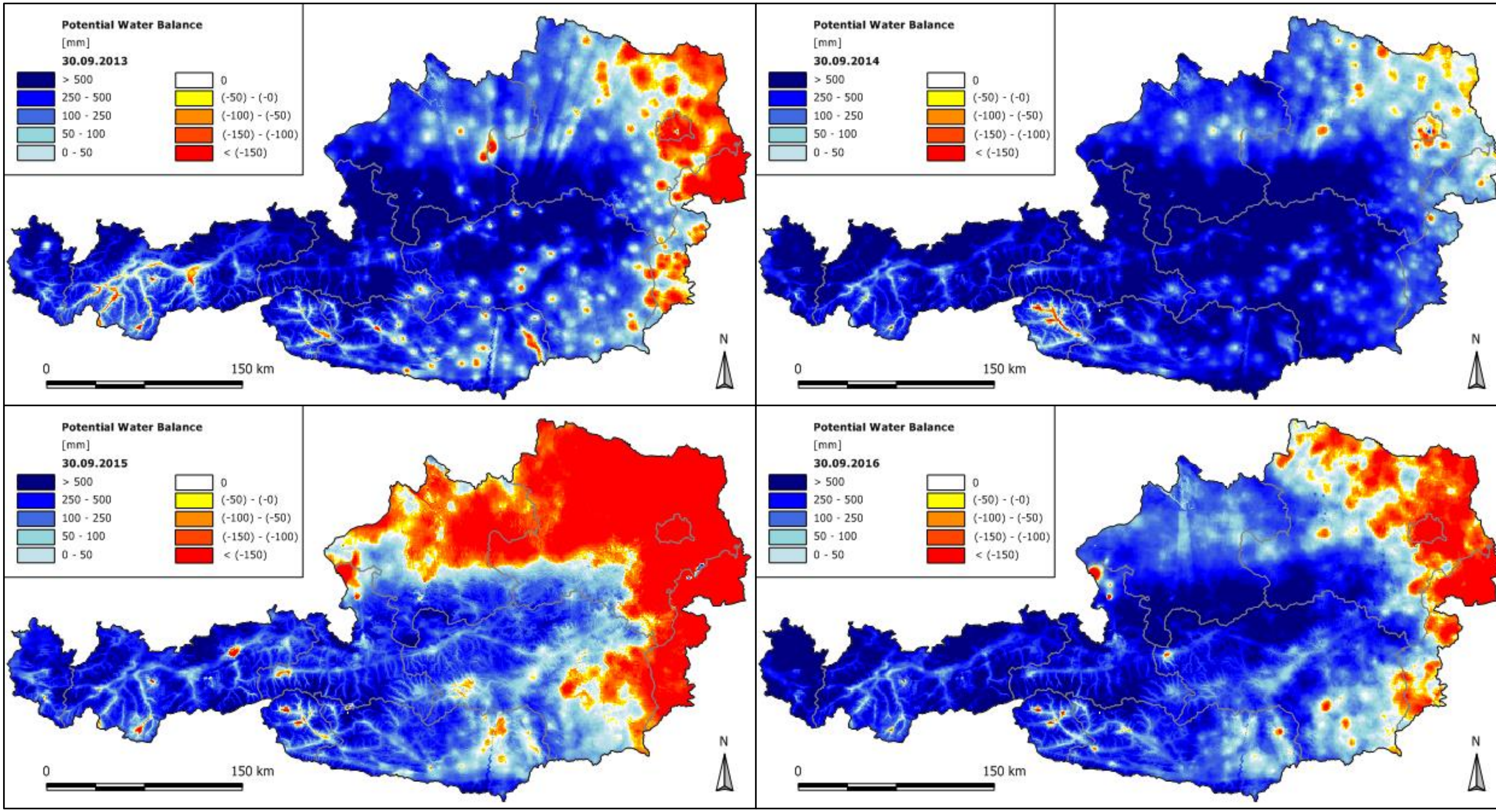
ARIS Data Input Example – Effective Temperatures



ARIS Data Input Example – Potential Water Balance 1



ARIS Data Input Example – Potential Water Balance 2



ARIS Methodology – Water Balance

Soil Water Content [mm/m]*

swc needs the values/computation of: *et0*, *taw*, *phen*, *snow*, *kc*, etc, *raw*, *ks,* eta, *interc*, *netRain*, *waterInput*, *dr*, *dp*

et0	reference evapotranspiration [mm]
taw	total available water [mm]
phen	phenological stage entry days (-> kc)
snow	snow cover (if the snow layer is equal or higher than 3 mm) [mm]
kc	crop coefficient with correction of climatic effect (kc = 0 when snow cover)
etc	crop evapotranspiration [mm]
raw	readily available water [mm]
ks	water stress coefficient [0 - 1]
eta	actual evapotranspiration [mm]
interc	interception [mm]
netRain	net precipitation (as a function of precipitation, interception and et0) [mm]
waterInput	water input into the soil (as a function of net rain and melt) [mm]
dr	root zone depleetion [mm]
dp	deep percolation [mm]

* Schaumberger, A. (2011). Räumliche Modelle zur Vegetations- und Ertragsdynamik im Wirtschaftsgrünland. Dissertation. Lehr- und Forschungszentrum für Landwirtschaft Raumberg-Gumpenstein, A-8952 Irdning des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft.

ARIS Methodology – Relative Soil Saturation

Relative Soil Saturation*

$$rss = (swc - wilt) / (swc\_fc - wilt)$$

swc	actual soil water content [mm/m]
wilt	wilting point [mm/m]
swc_fc	soil water content at field capacity [mm/m]

Relative Soil Saturation Classification [%]

0	no available soil water (wilting point)
>0 - 10	
10 - 20	
20 - 30	
30 - 50	soil water access limited
50 - 70	
70 - 100	soil water at field capacity

* Trnka M.; Hlavinka P.; Semerádová D.; Balek J.; Možný M.; Štěpánek P.; Zahradníček P.; Hayes M.; Eitzinger J. and Žalud Z. (2014): Drought monitor for the Czech Republic - www.intersucho.cz. Rožnovský, J., Litschmann, T., (eds): Mendel a bioklimatologie. Brno, 3.–5.9.2014, ISBN978-80-210-69831.

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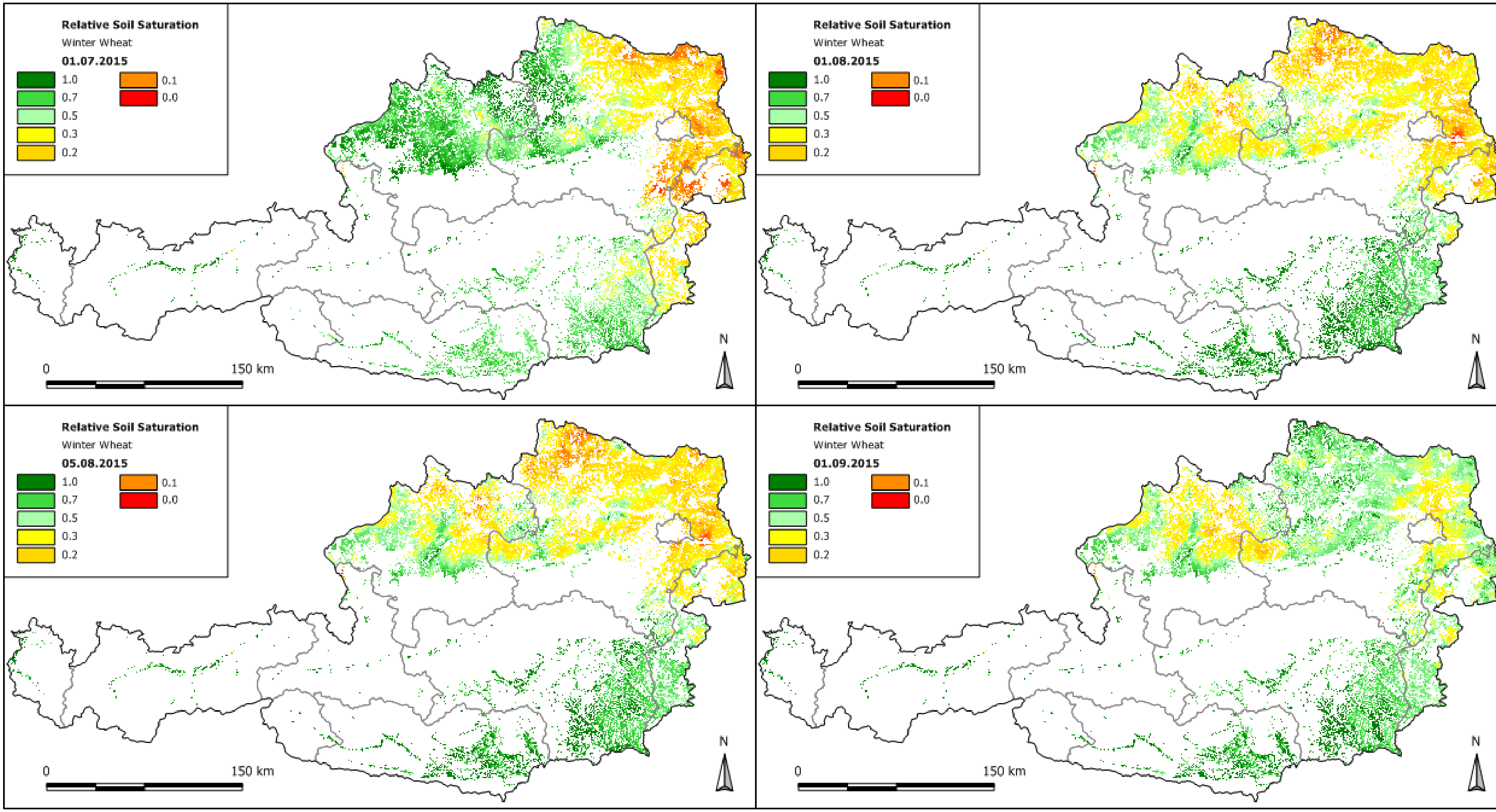
ARIS Data Input Example – Relative Soil Saturation



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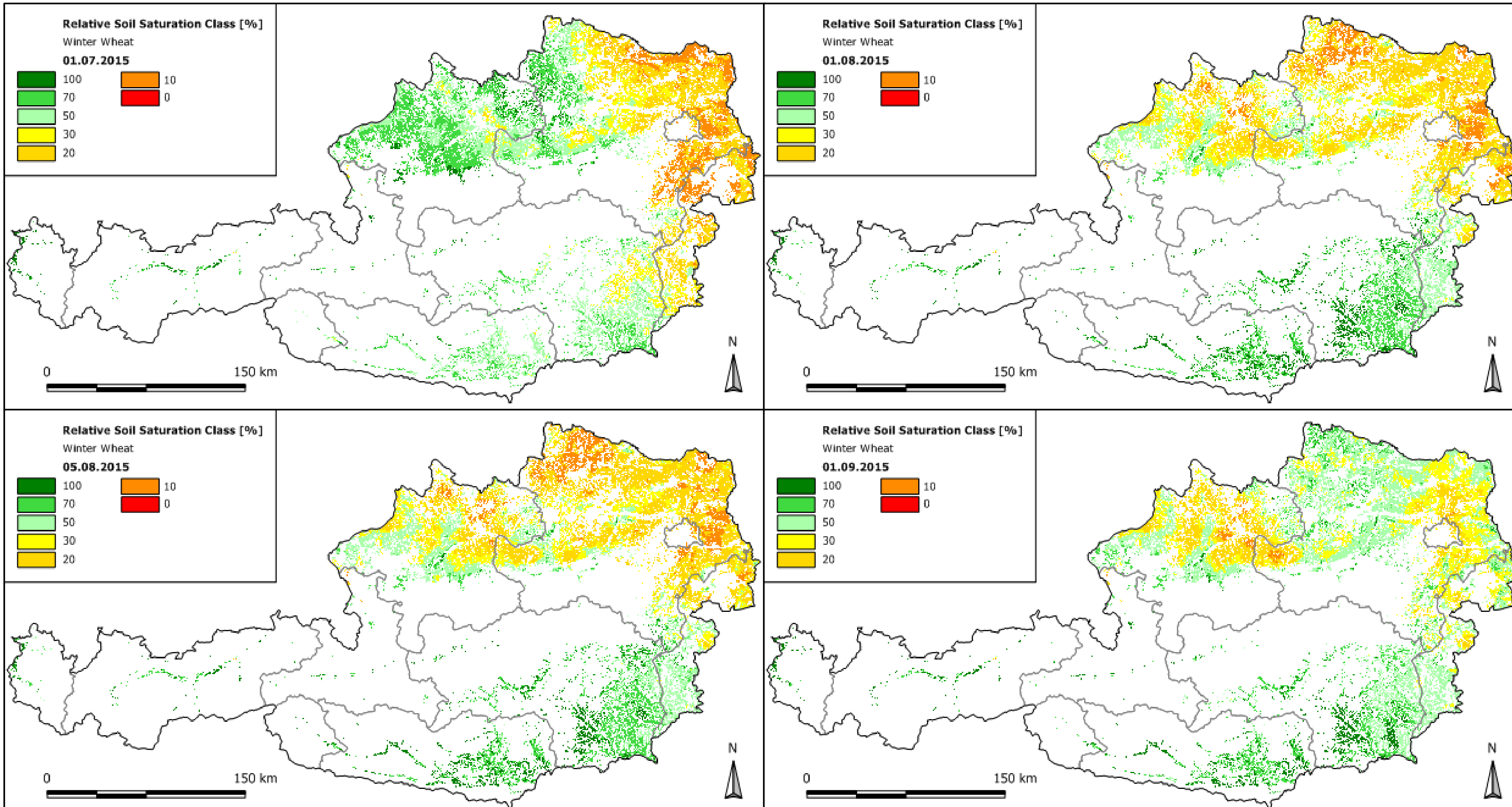
ARIS Data Input Example – Classified Relative Soil Saturation



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Drought Intensity and Classification

- ARIS uses the relative soil saturation as crop specific drought indicator to quantify the so called drought intensity.
- ARIS drought intensity is a measure of deviation from the statistically derived „normal“ state. I.e. a high drought intensity at an arbitrary day of the computation year means that the soil water content is significantly lower than the soil water content at the same day of the other historical years.
- ARIS soil water content deviations are statistically calculated using the „Microsoft Excel“ percentile method*.
- A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall. For example, the 20th percentile is the value (or score) below which 20 percent of the observations may be found.*

Drought Intensity Classification

(p . . . percentile)

- No drought (p100)
- decreased soil moisture content (p30)
- starting drought (p20)
- moderate drought (p10)
- significant drought (p5)
- exceptional drought (p2)
- extreme drought (p1)

* Wikipedia - https://en.wikipedia.org/wiki/Percentile

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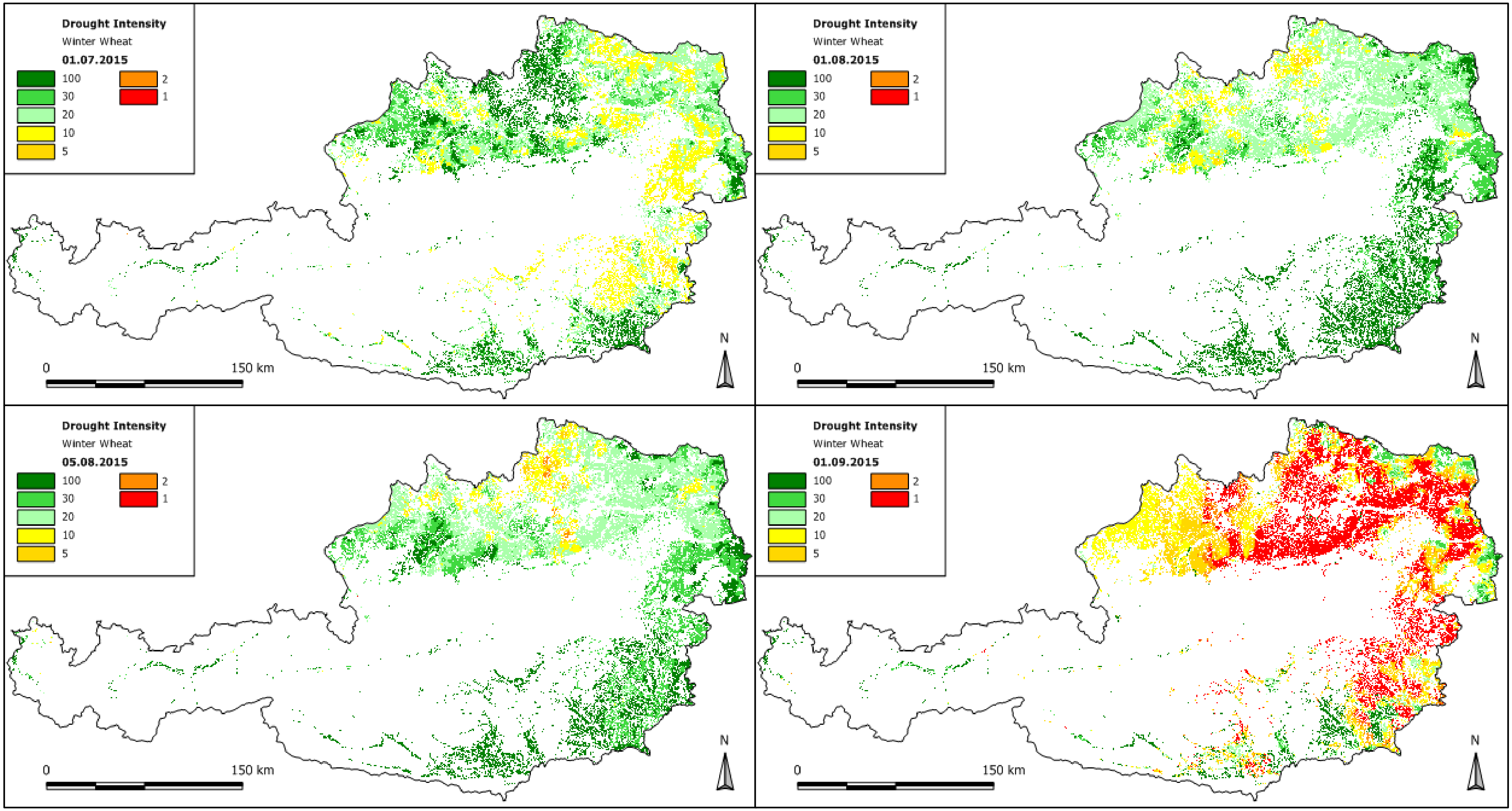
ARIS Data Input Example – Drought Intensity



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ARIS Methodology – Heat & Drought Indicators

Heat & Drought Indicators

Yield Reduction

Huglin Suitability Indicator

Water Deficit Indicator

Effective Global Radiation Indicator

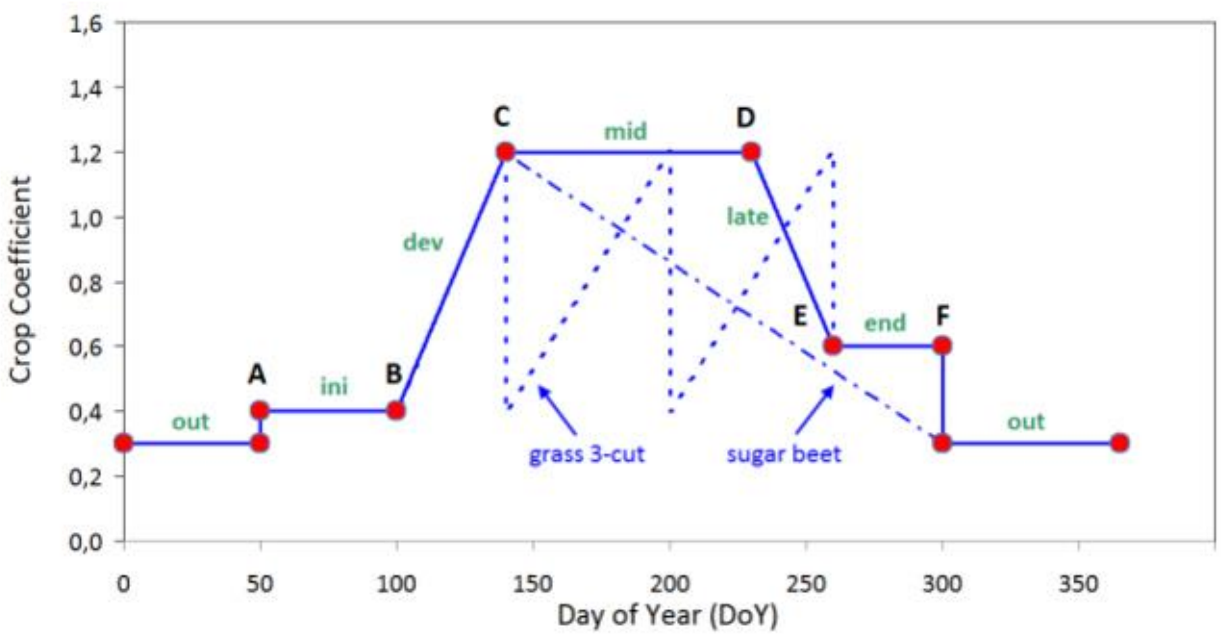
Field Working Days Indicator

ARIS Methodology – KC Reminder

Soil water balance model requires the computation of ETc:

ETc = Kc * ET0

Model with 6 phenological stage entry events:



Stage out: stage with no plant growth during the winter season

Stage ini: stage that starts with the sowing event and lasts till plant emergence

Stage dev: plant development stage till achievement of maximum plant size with linear Kc value increase

Stage mid: stage till achievement of plant maturity

Stage late: stage between plant maturity and harvest with linear Kc value decrease

Stage end: stage of soil tillage after harvest

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ARIS Methodology – KC Reminder

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	Kc	Time	Kc	Time	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	350	1,2	692	0,5	+14 days	0,5	30.11.
Spring Barley	0,4	01.03.	0,4	SGS	1,2	502	1,2	568	0,5	+14 days	0,5	30.11.
Spring Maize	0,4	01.04.	0,4	SGS-M	1,2	249	1,2	1238	0,5	+14 days	0,5	30.11.
Sugar Beet	0,4	01.03.	0,4	300	1,2	2400					1,1	31.12.

- ✓ Winter wheat, spring barley, maize, sugar beet
- ✓ Coniferous forest, deciduous forest
- ✓ Meadow (grassland)
- ⚠ Potatoes
- ⚠ Grapes
- ⚠ Apple (phenological model exists, but no Kc values