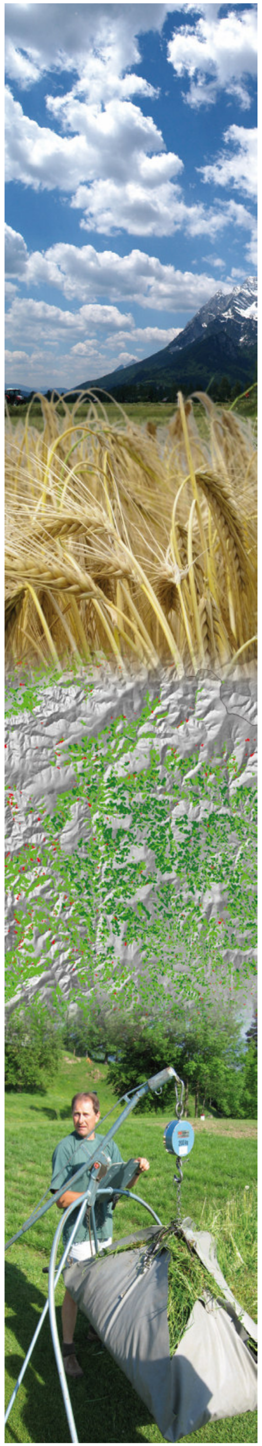

Symposium: 04.11.2015, Betriebsgesellschaft Marchfeldkanal

Spatial Drought Monitoring and Forecast Application for Crops and the ADA-WEB-Portal

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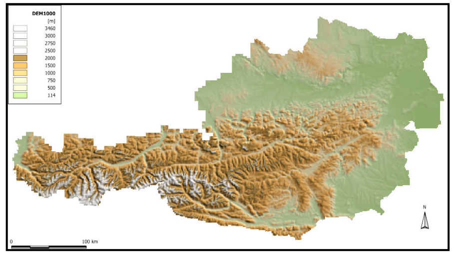
ADA objectives of the workpackage - overview

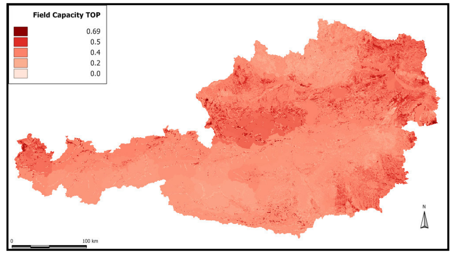
- Spatial interpolation of weather data for the period before INCA* data is available (1981 – 2002).
- Development of a platform independent software that integrates existing models (SpatialGRAM, SoilClim) to monitor and forecast soil water balance and crop drought for the Austrian territory.
- Implementation of extensions on the base of new models (drought stress indicators) provided by the project partners.
- Web interface to publish the results.

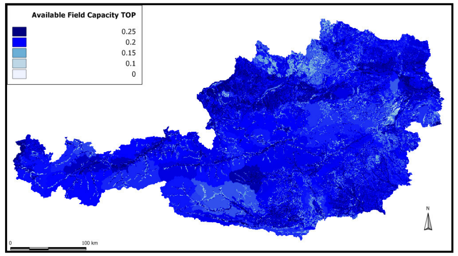
* Integrated Nowcasting through Comprehensive Analysis

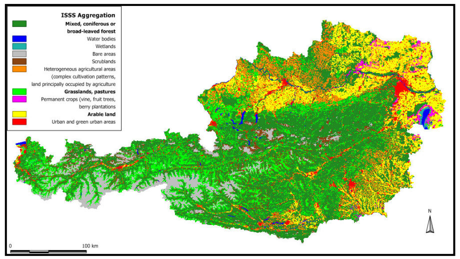
ADA input data – general statements

- All input/output data using the **netCDF** file format
  - Data format for reading/writing large scientific data files developed by American company Unidata
  - Self describing (reducing the incidence of errors)
  - High-performance data format
  - Single and multidimensional grids (continuous surfaces)
- **Spatial resolution:**
  - DEM, Meteorological input data: 1000 m
  - Soil and landuse input data: 500 m
  - Output data (ET0: 1000 m, all other data: 500 m)
  - Resolution is increased using simple split algorithm
- **File Coverage:**
  - Complete territory of Austria







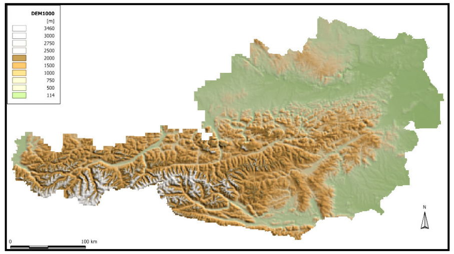


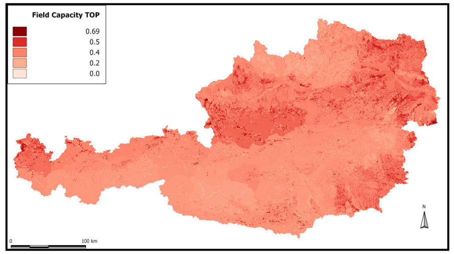
ADA input data –DEM, soil and landuse data, meteorological data

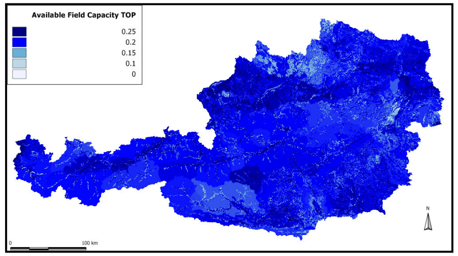
Which data is used?

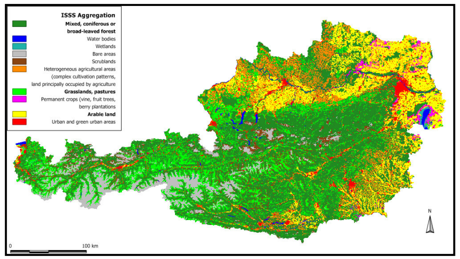
- Digital elevation model [m]: 1 layer
- Field capacity [Vol%]: 1 top layer (0,4 m)
  1 sub layer (0,6 m)
- Available field cap. [Vol%]: 1 top layer (0,4 m)
  1 sub layer (0,6 m)
- Landuse: 1 layer (grass, winter wheat, spring barley, spring maize, sugar beet, coniferous forest, broad-leaved forest)
- Met data: Relative humidity [%], Wind [m/s], Temperature [°C], Precipitation [mm], Radiation [MJ/m² day] *

* **1981 - 2002:** Spatial interpolation of weather data for the period before INCA data is available
2003 – now (+ 10 days forecast): INCA weather data interpolated by ZAMG









ADA input data – landuse data and it‘s implemetation

CLC2006 -> ISSS* -> ADA classification schemes

- Aggregation of 44 Corine Land Cover classes to 13 ISSS* classes
- Then partial aggregation of 13 ISSS classes and selection of 7 ADA classes (grass, winter wheat, spring barley, spring maize, sugar beet, coniferous forest, broad-leaved forest)

Problem:

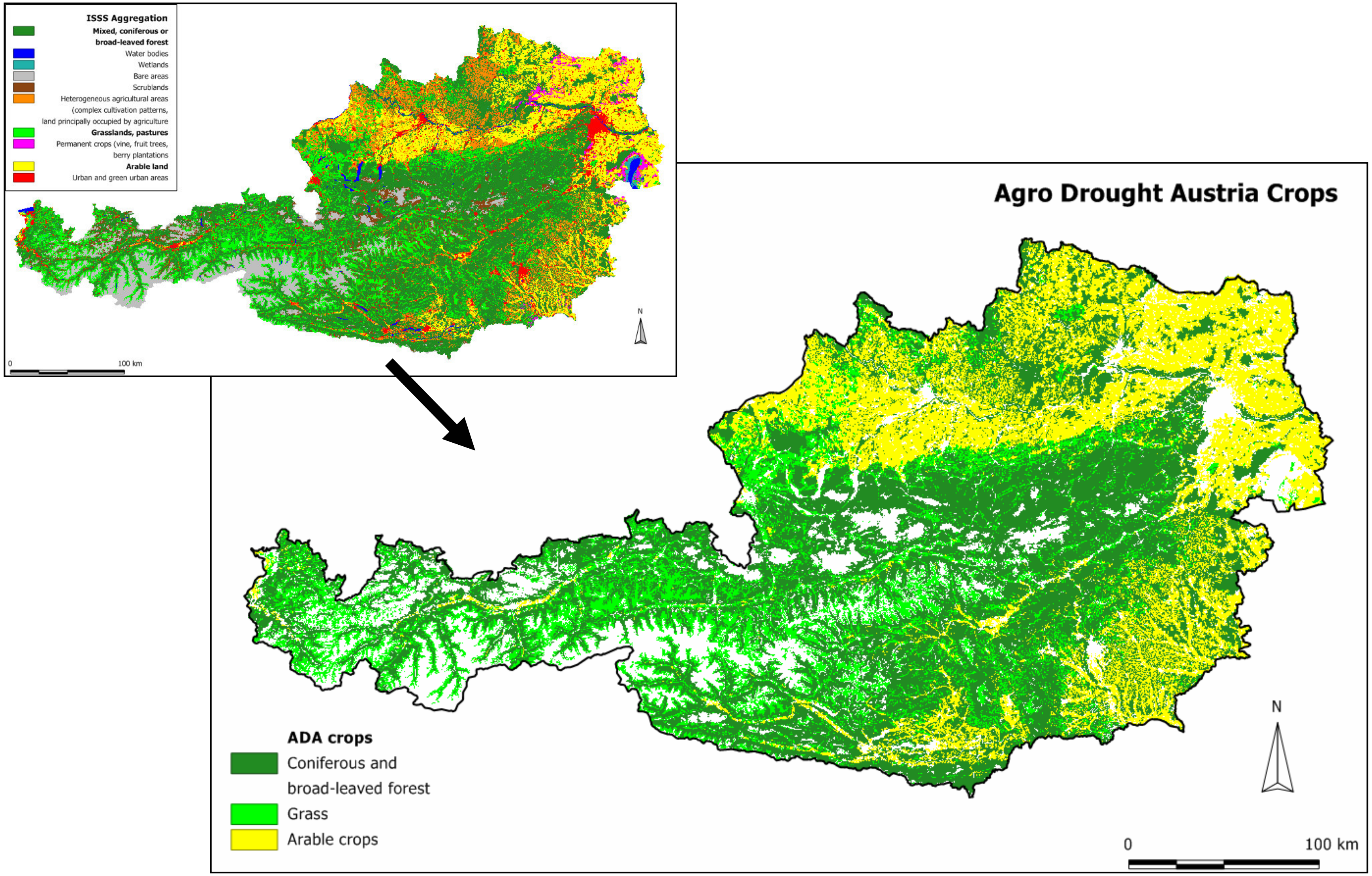
- CLC2006 does not distinguish between the ADA arable crop types winter wheat, spring barley, spring maize, sugar beet => no separate data information available for the ADA computations

Solution:

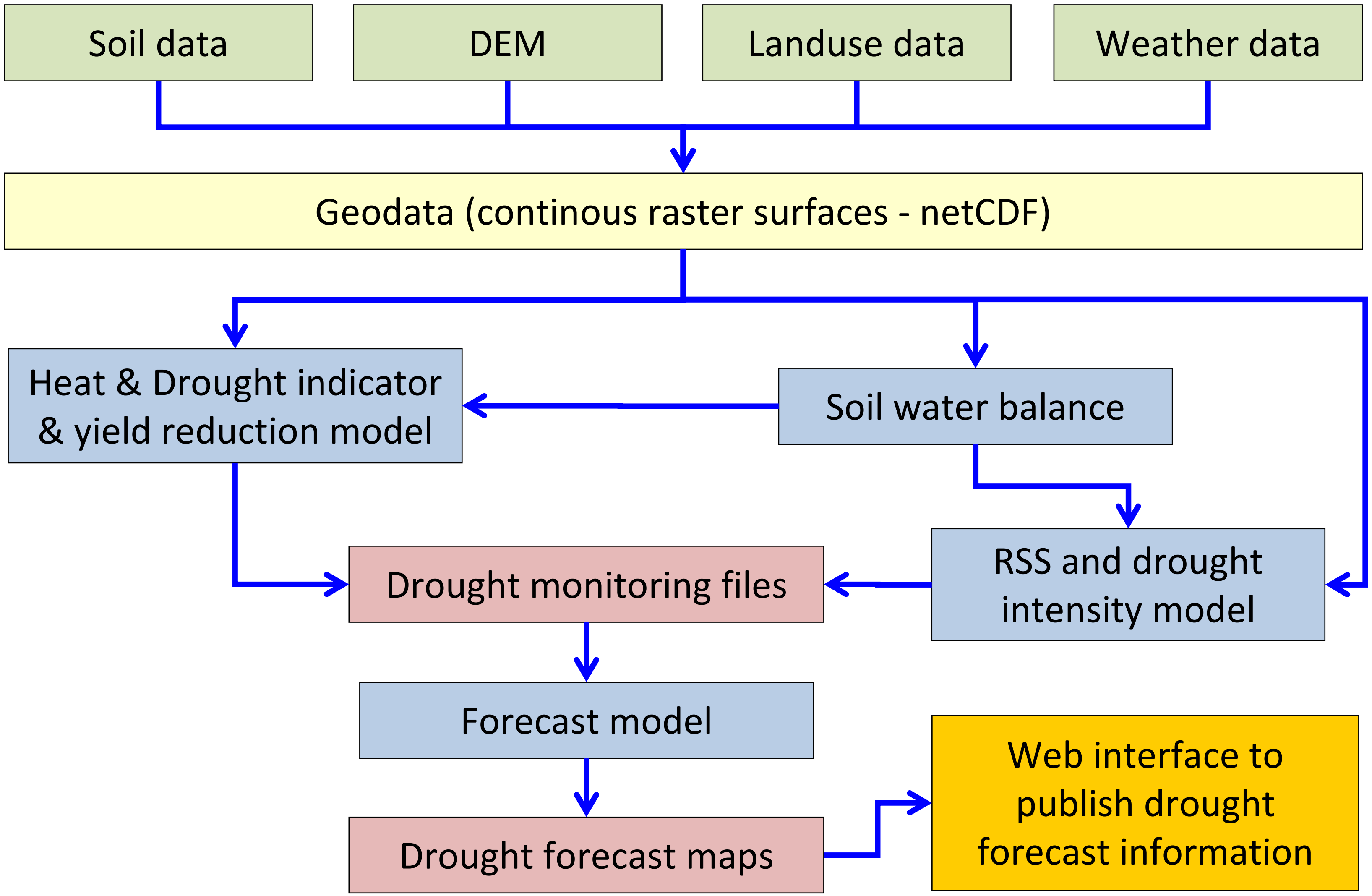
- Computation of 4 scenarios for arable land with 4 different ADA arable crop types (i.e. assume that the complete area of arable land in Austria is cultivated with one of the 4 ADA arable crops) and additionally 1 scenario with average values. Although not a real picture of the arable crop distribution, it enables the the computation of results for each of the 4 ADA arable crop types.

* ISSS landuse classification scheme from MENDELU University (Brno)

ADA input data – landuse data and it's implemetation

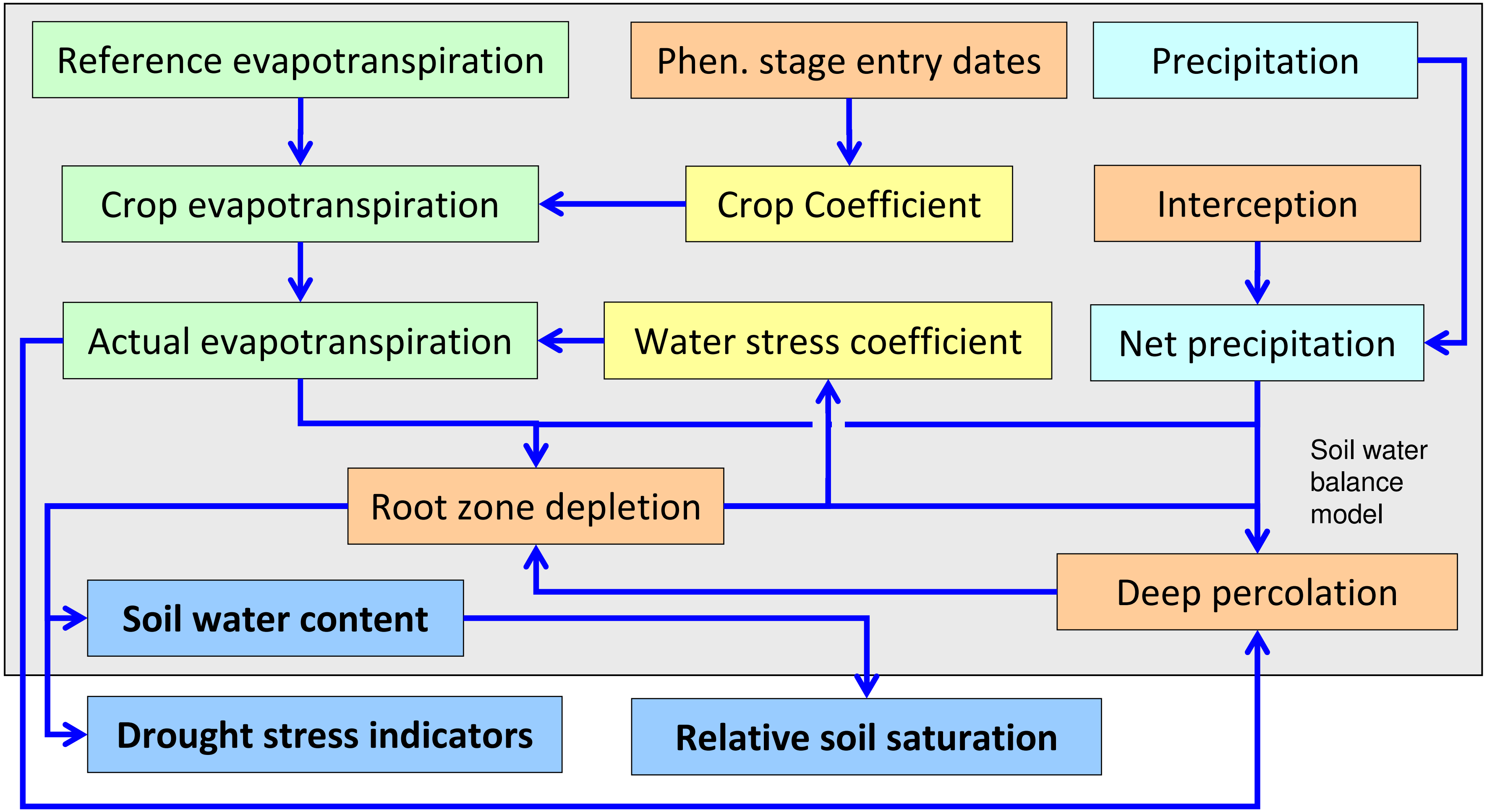


ADA: from data to spatialized drought information



ADA soil water balance & drought stress indicator model

Soil water balance model according to ALLEN et al. (1998): Crop evapotranspiration, FAO paper No 56



ADA soil water balance model – side notes

- Soil depth considered for the soil water balance computations:
  - grass: top layer 0-20 cm, sub layer 20-40 cm
  - arable crops: top layer 0-40 cm, sub layer 40-100 cm
  - Forest: top layer 0-40 cm, sub layer 40-100 cm
- Weighting factor for the two soil layers: 60% (top), 40% (sub). I.e. The top layer is responsible for 60% of the total evapotranspiration value and the sub layer for 40%.
- Full water saturation at the beginning of each computation year (optional: continuous water saturation computation without reset)
- Computation of all phenological stage entry dates of a year (historical as well as monitoring/forecast year) at the beginning of the year

ADA soil water balance model – reference evapotranspiration

- Reference evapotranspiration: the evapotranspiration from the reference surface (ET0). The reference surface is a hypothetical grass reference crop surface with an assumed crop height of 0.12 m, a fixed surface resistance and albedo value. The reference surface closely resembles an extensive surface of green, well-watered grass of uniform height, actively growing and completely shading the ground.

- The FAO Penman-Monteith method is now recommended as the sole standard method for the definition and computation of the reference evapotranspiration.

- ET0 can be computed solely from meteorological data. The FAO Penman-Monteith method requires radiation, air temperature, air humidity and wind speed data.

- ET0 is constant (0,2 mm) for the months Dec, Jan and Feb.
  Reason: the Penman-Monteith method produces wrong ET0 results during the winter months, especially if the existence of snow cover is disregarded. ADA does not consider snow cover due to the lack of data.

ADA soil water balance model – crop coefficients

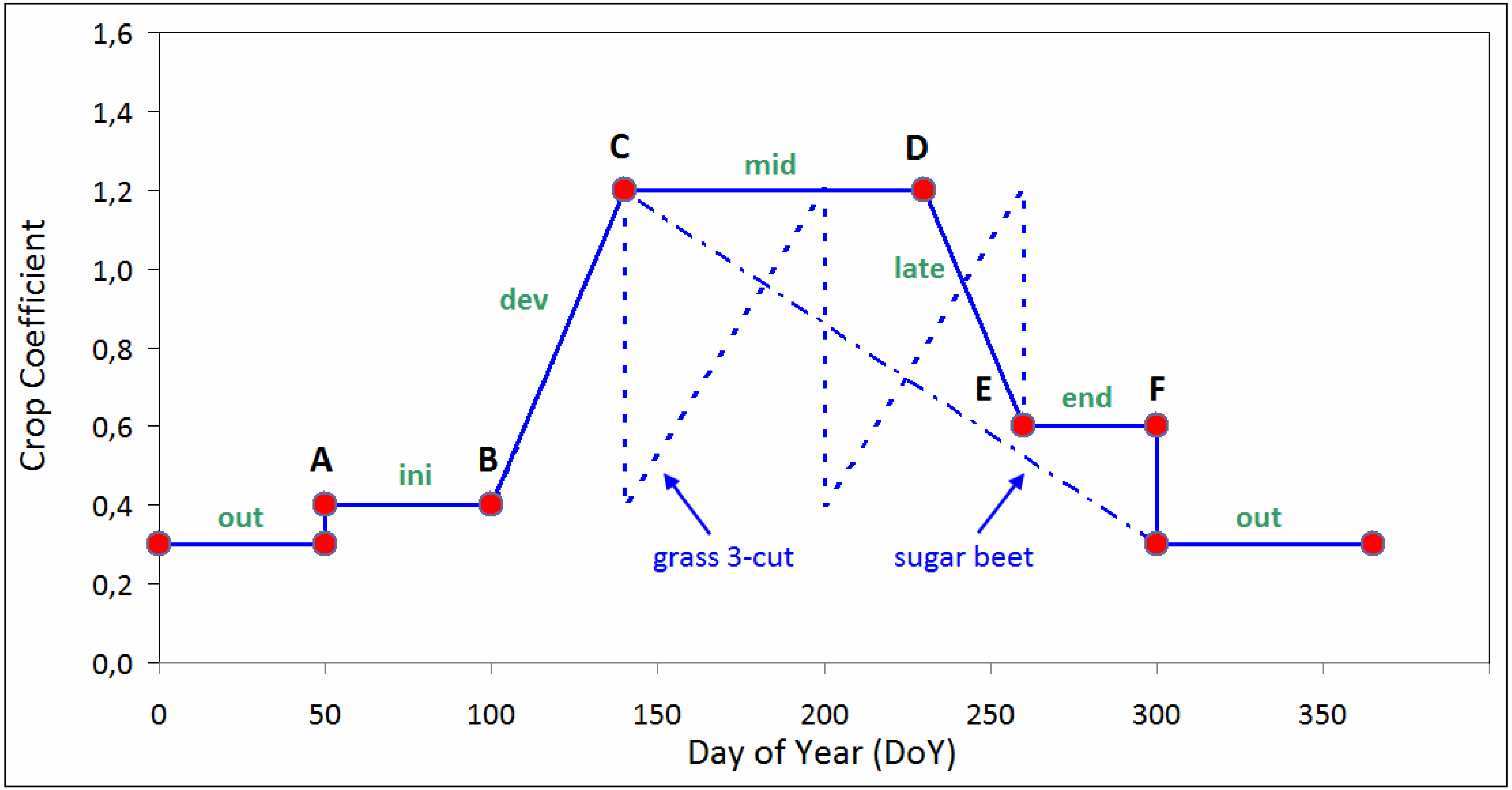
Crop coefficient determination for the ADA crops:

- Using an (almost) standardized pheonological stage entry dates scheme to determine the crop coefficient values for each crop (needed to compute the crop evapotranspiration).

- Crop specific pheonological stage entry dates are dependent on temperature sum computations, pre-defined dates or „start of growing season‟ events (SGS = First day of 5 consecutive days with daily mean temperatures above 5°C, SGS-M = First day of 5 consecutive days with daily mean temperatures above 10°C).

- Phenological stage entry dates for grass (2 cut, 3 cut, 4 cut) are furthermore determined using a statistical approach comparing actual temperature sums with long-term observations (i.e. compare the actual temperature sum at a statistically determined harvesting day with it‘s statistically determined temperature sum and compute a shortening or lengthening growth duration based on the discrepancy).

ADA soil water balance model – crop evapotranspiration



ADA soil water content and relative soil saturation model

Soil water content [mm] - swc: result of the water balance computations

- Soil water content is an expression of the mass or volume of water in the soil. The maximum soil water content equals the soil water content at field capacity **swc_fc**. With no rain, day for day the swc is reduced due to the water use of the plants till it reaches the water content at permanent wilting point **wilt**. From that point on no more water can be extracted by the plants and the water content at permanent wilting point is kept in the soil for extended periods.

- swc, swc_fc and wilt enable the computation of the relative soil saturation

Relative soil saturation [%] - rss: probably the most appropriate measure of plant water status in terms of the physiological consequence of cellular water deficit.

- rss = (swc - wilt) / (swc_fc - wilt)*

* **Barrs HD, Weatherley PE**. 1962. A re-examination of the relative turgidity technique for estimating water deficits in leaves. Australian Journal of Biological Sciences 15, 413-458. **Weatherley PE**. 1950. Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytologist 49, 81-97.

Relative soil saturation classification

Relative soil saturation - rss

0% = no available soil water (wilting point)

50% = soil water access limited

100% = soil water at field capacity

Relative soil saturation classification

- Rss classification in accordance with CzechGlobe/MENDELU University (Brno)

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

ADA drought intensity model

Drought intensity

- ADA uses the soil water content as crop specific drought indicator to quantify the so called drought intensity.
- ADA 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.
- ADA 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.*

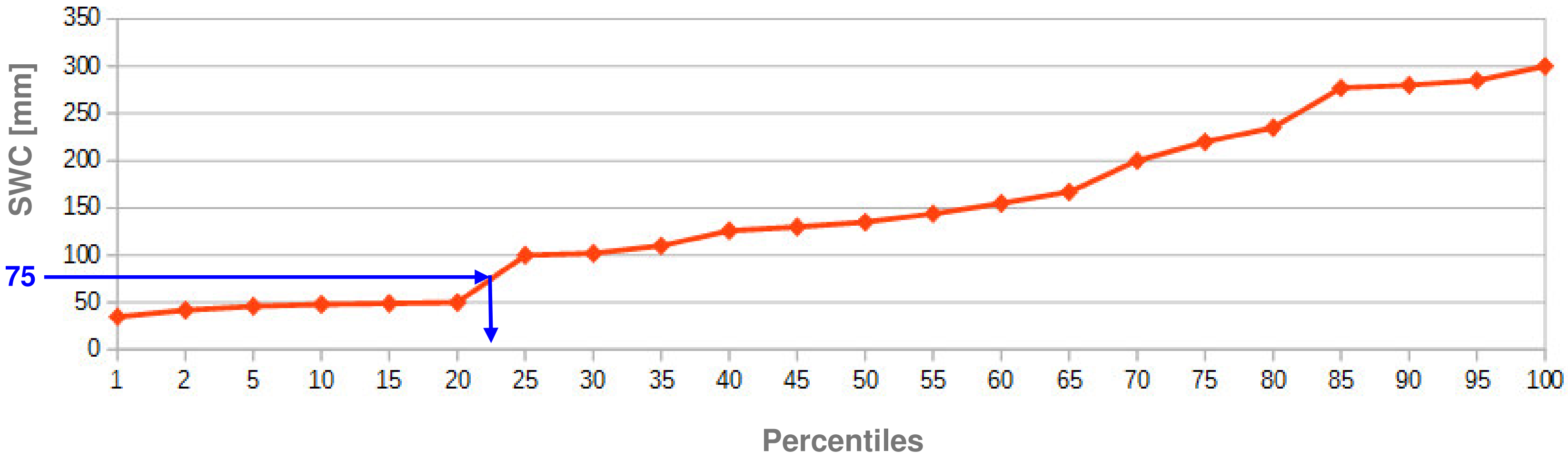
* Wikipedia - https://en.wikipedia.org/wiki/Percentile

ADA drought intensity model

Drought intensity calculation example

Observation list: 21 days (10 days before and 10 days after the current computation day) for each historical year (1981 – 2014) = 714 SWC values

ADA uses the percentile classes 1, 2, 5, 10, 20 and 30
Percentile 20: 20% of the observation values are <= 50 mm
SWC = 75 mm => starting drought



- percentile 30 = decreased soil moisture content
- percentile 20 = starting drought
- percentile 10 = moderate drought
- percentile 2 = exceptional drought
- percentile 5 = significant drought
- percentile 1 = extreme drought

Heat and drought indicators & yield reduction model

Heat and drought indicators

- High temperatures and drought conditions take their toll on the corn and grass crops. The amount of yield loss due to these stresses depends on growth stage, severity of the stress, and the number of days the crop is stressed.

- A set of calibrated indicators and methods on crop specific drought and heat vulnerability and impacts based on field experiment data and crop model application have been developed by ADA project patners and are implemented in the ADA software as follows:

  1. **Drought indicator** option as a function of the soil water content at available field capacity (0-20 cm) and the root zone depletion.

  2. **Heat indicator** option as a function of the maximum daily temperature and a temperature threshold value.

  3. **Combined indicator** option as a function of the water stress indicator and the maximum daily temperature.

Heat and drought stress indicators & yield reduction model

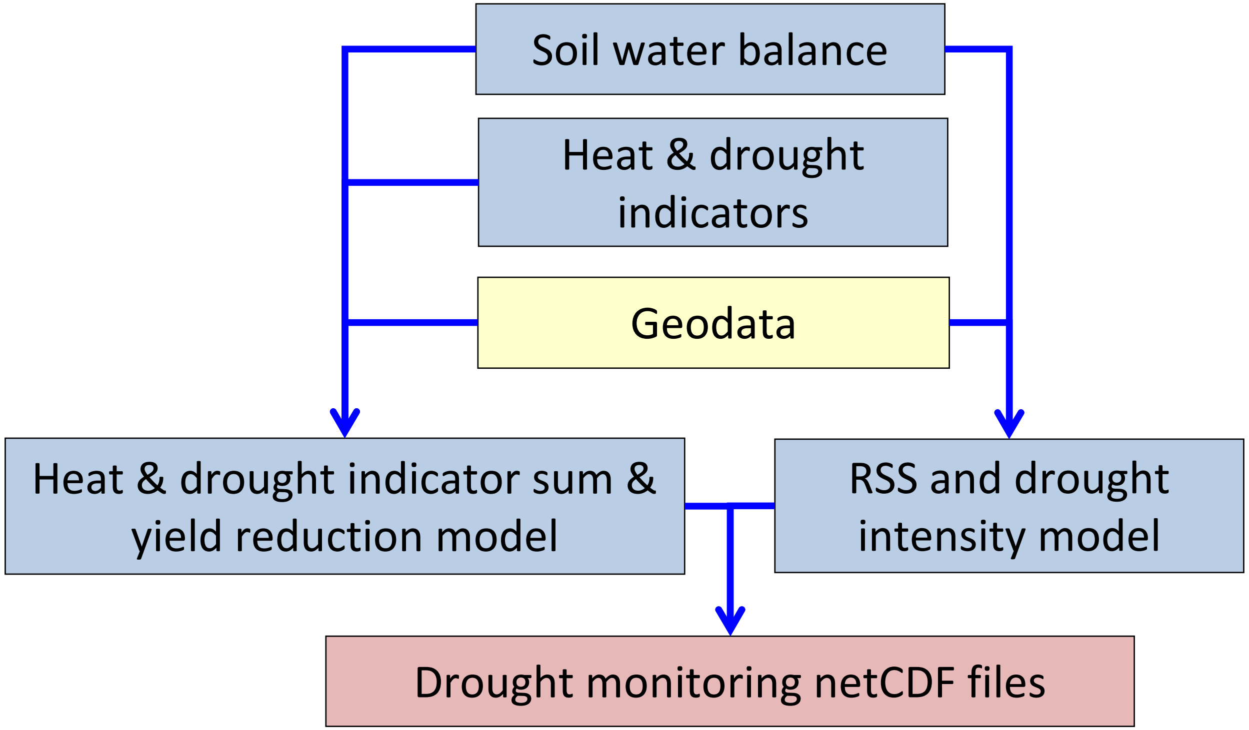
Heat and drought stress indicators and sums

- Heat and drought stress indicators are calculated each day of the year within the water balance computation module of the ADA software.
- Drought and stress indicator sums are calculated from crop specific start days till the end of the crop's phenological „late" phase (grass: till the second cut of a 3 cut regime).

The yield reduction model

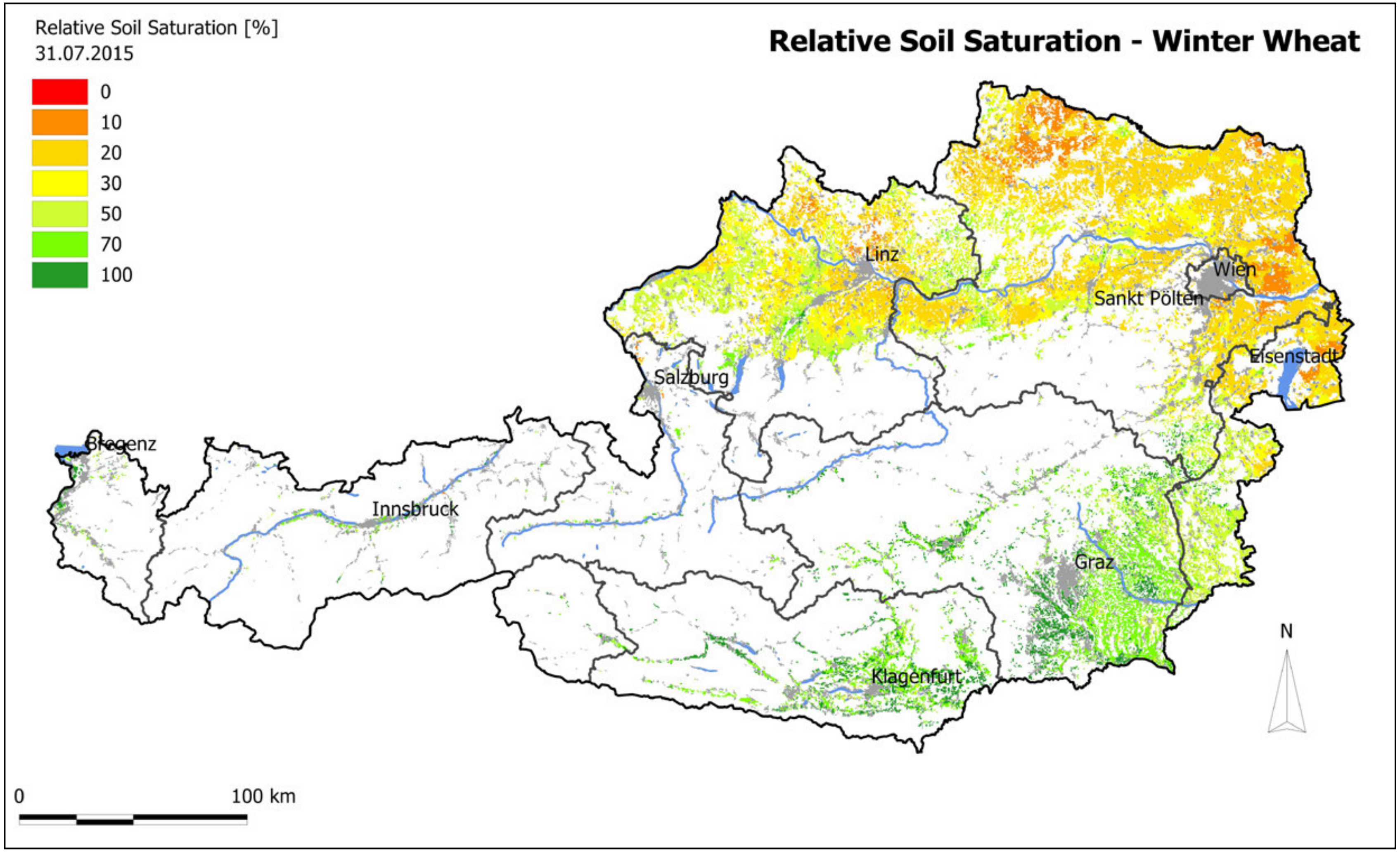
- Yield reduction formulas have been developed by the project partners and have been incorporated into the ADA software.
- The yield reduction formulas are linear functions with crop specific equation coefficients A and B as well as the drought stress indicator sum as the independent variable x: $y = B*x + A$
- Computation Results: relative yield reduction as percentage of maximum yield
- Yield reduction classification: 0-5% 5-30% 30-60% >60%

ADA monitoring results: RSS, DI & yield reduction export

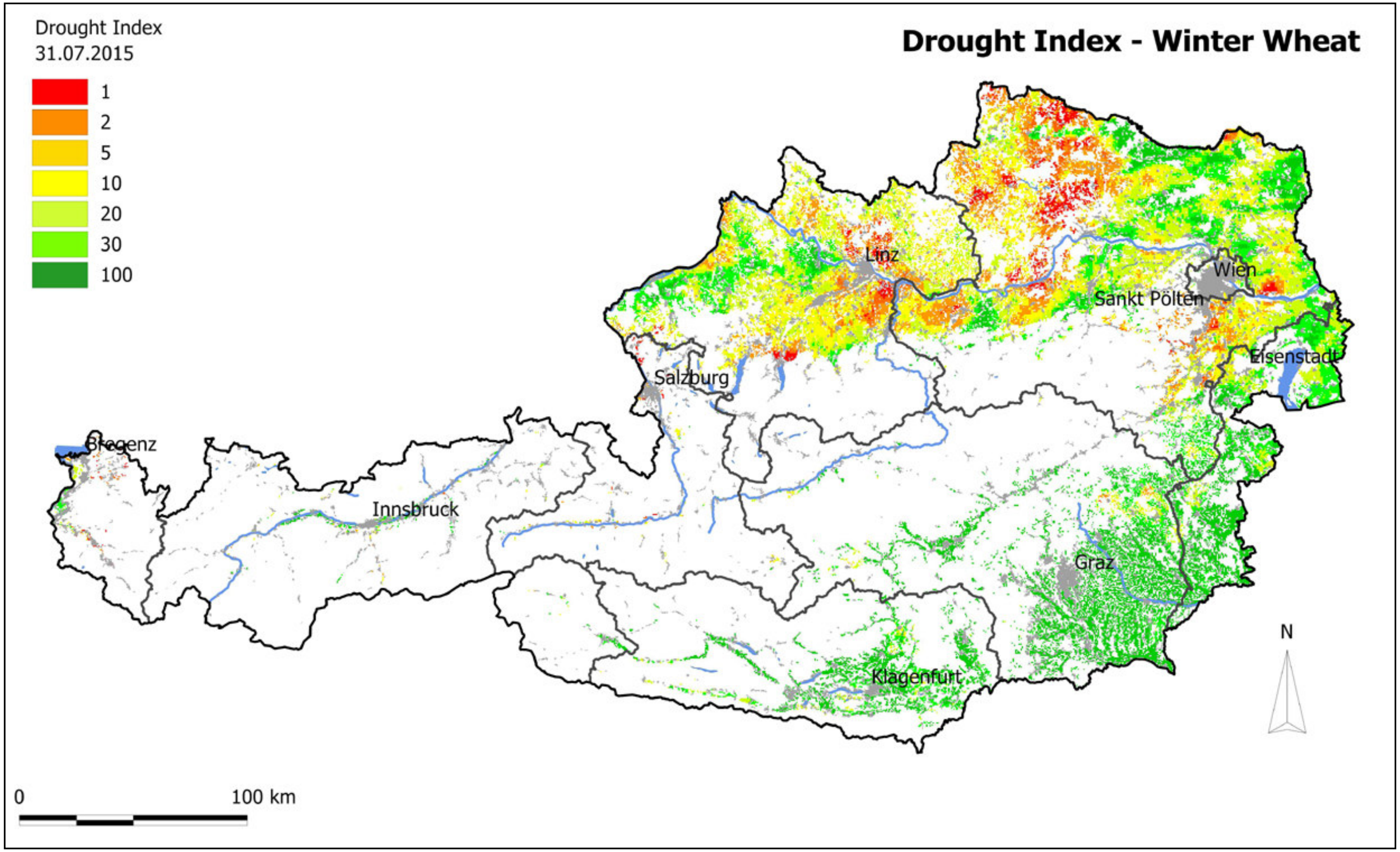


- Drought monitoring result files are export for each day of each historical year.
- Export of Phenological entry day files, RSS, DI and yield reduction files. Optional: export of ET0, KC, ETC, INTERC and ETA files.

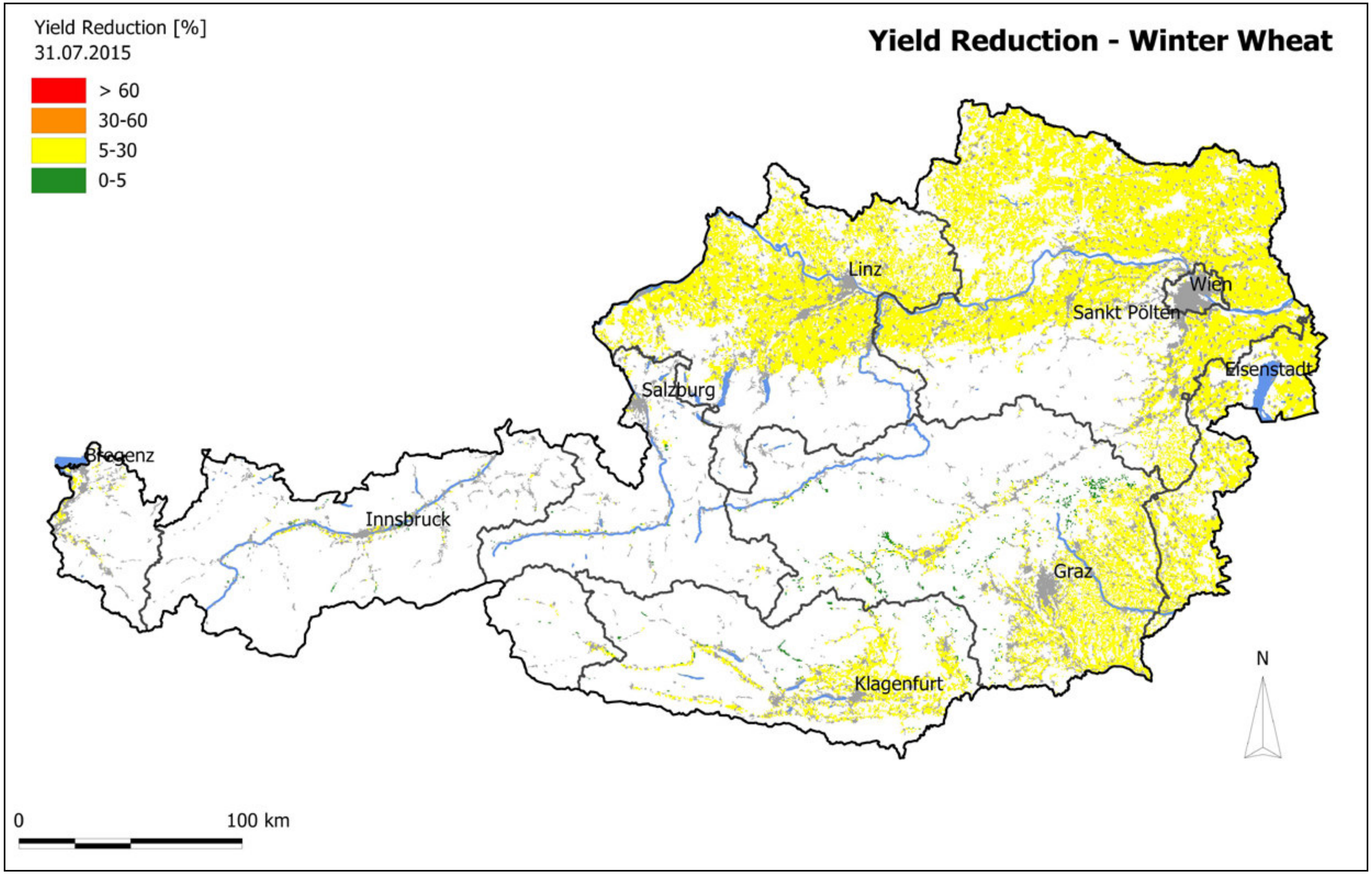
ADA monitoring results: RSS, DI & YIELD reduction classes



ADA monitoring results: RSS, DI & YIELD reduction classes



ADA monitoring results: RSS, DI & YIELD reduction classes



ADA forecast data & facts

- ADA forecast computations are based on meteorological forecast data (short term forecast of 10 days) and averaged meteorological data of historical years (medium/long term forecast of any number of days).
- Meteorological forecast data is delivered by ZAMG (Zentralanstalt für Meteorologie und Geodynamik, Wien). Historical meteorological data is available from the ADA database.
- The extended ADA computation time (presently up to 2 days) allows forecast updates every three days.
- All ADA forecast drought computations (phenological entry das, RSS, DI, yield reduction, etc.) are run in analogy to the computations of historical years – the only difference is the manipulated meteorological input data.

ADA forecast methodology

- The forecast process:

    1. For short term calculations use a combination of meteorological forcast data and historical meteorological data: apply a weighting algorithm that emphsizes the forecast data at the beginning of the short term forecast period and the historical data at the end of the short term period.

    2. For medium/long term calculations use solely the historical meteorological data.

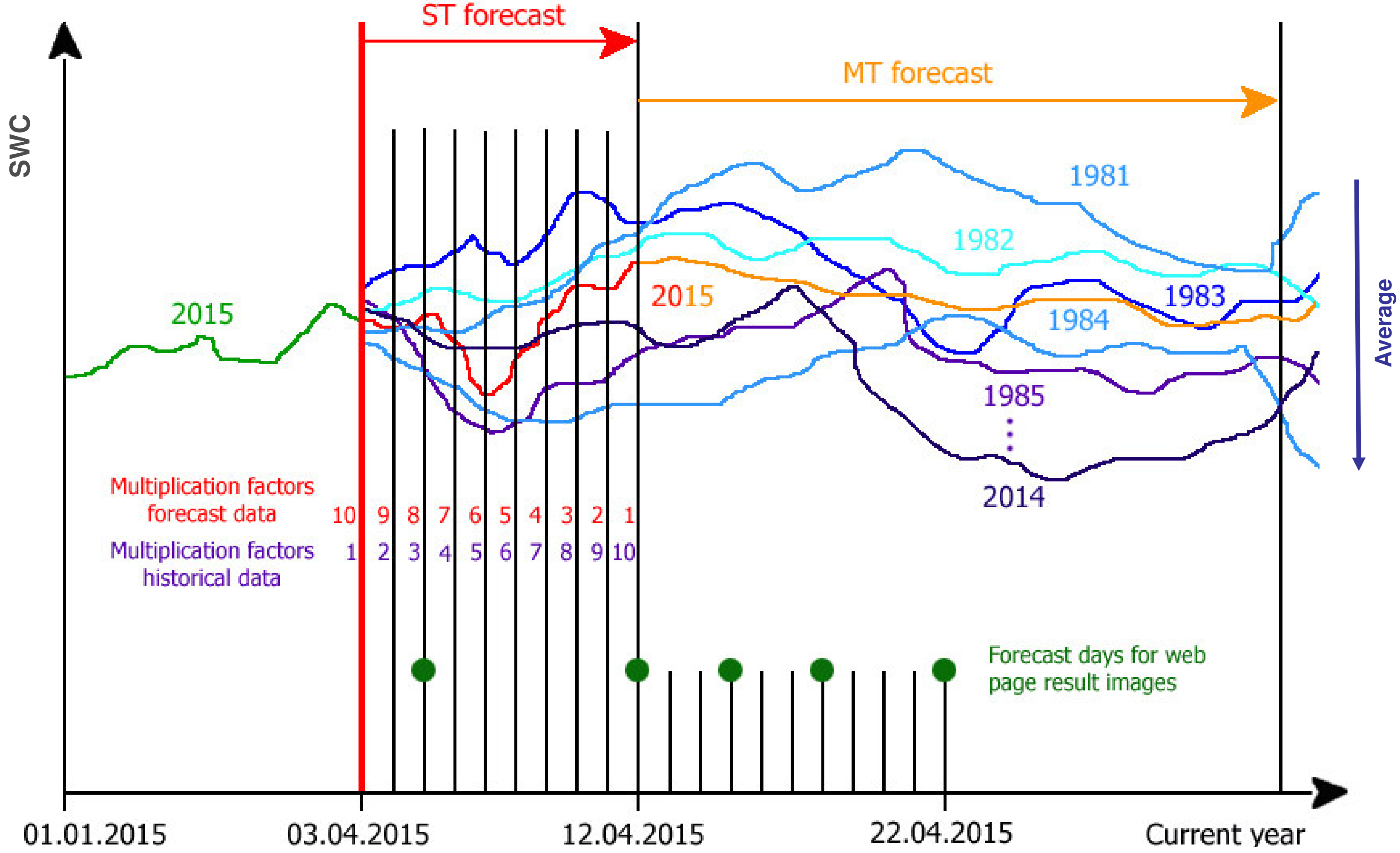
    3. Compute the soil water content for each day of each historical year using the meteorological data described above getting an individual soil water trend for each historical year.

    4. Average all soil water trends.

    5. Define any desired forecast date for publication and extract the soil water content values from the averaged soil water trends.

ADA forecast methodology

- Forecast using weighted and averaged meteorological data



ADA forecast computation times

ADA computation time depends on CPU speed and available RAM memory. Insufficient RAM memory forces to split up the region of interest (the Austrian territory) into several fractions resulting in an increase of computation time.

The lack of adequate landuse data (arable crops) substantially increases the computation time!

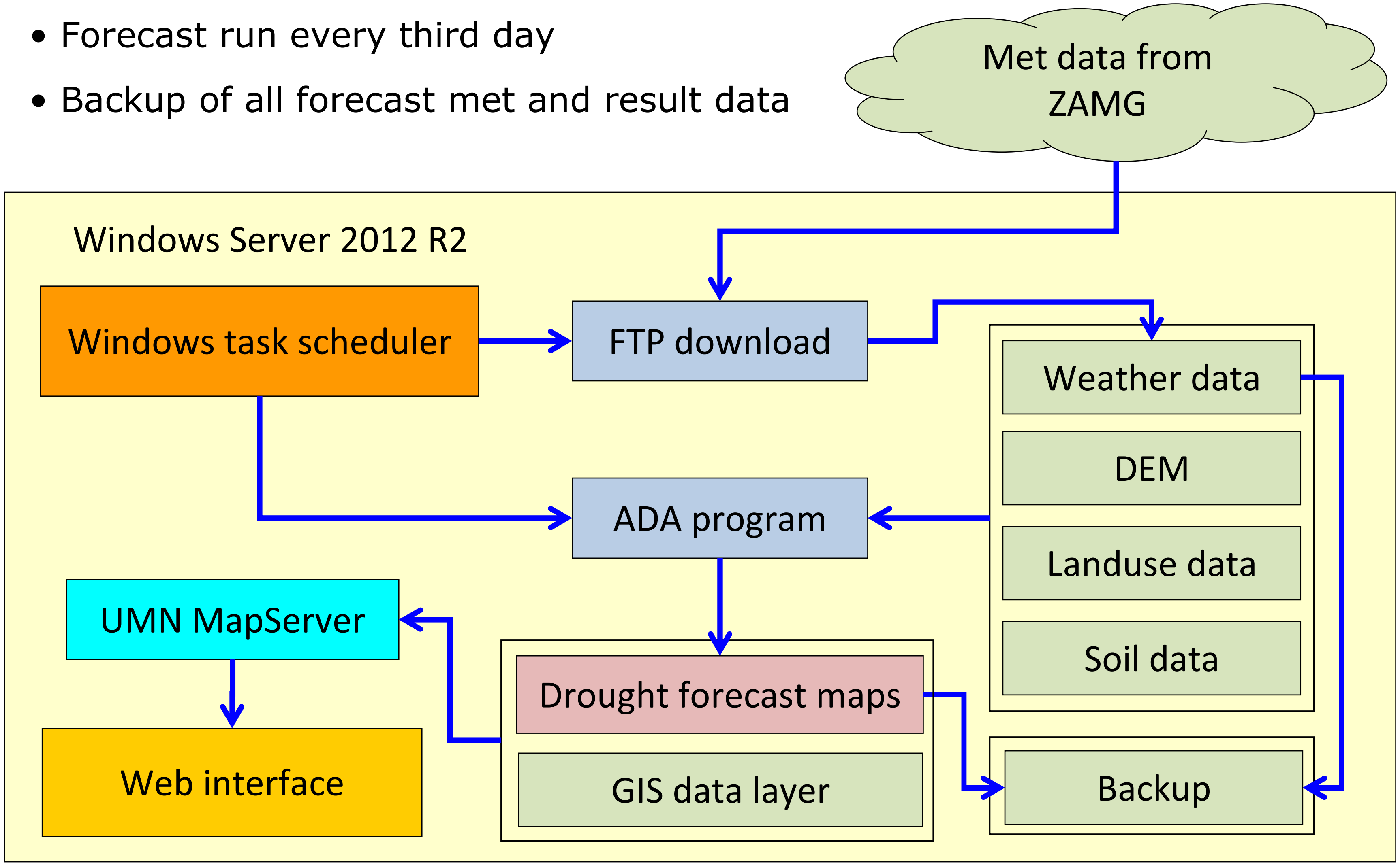
The later the computation year, the more data have to be crunched. The more historical years are used, the more data have to be crunched.

Present forecast computation times:

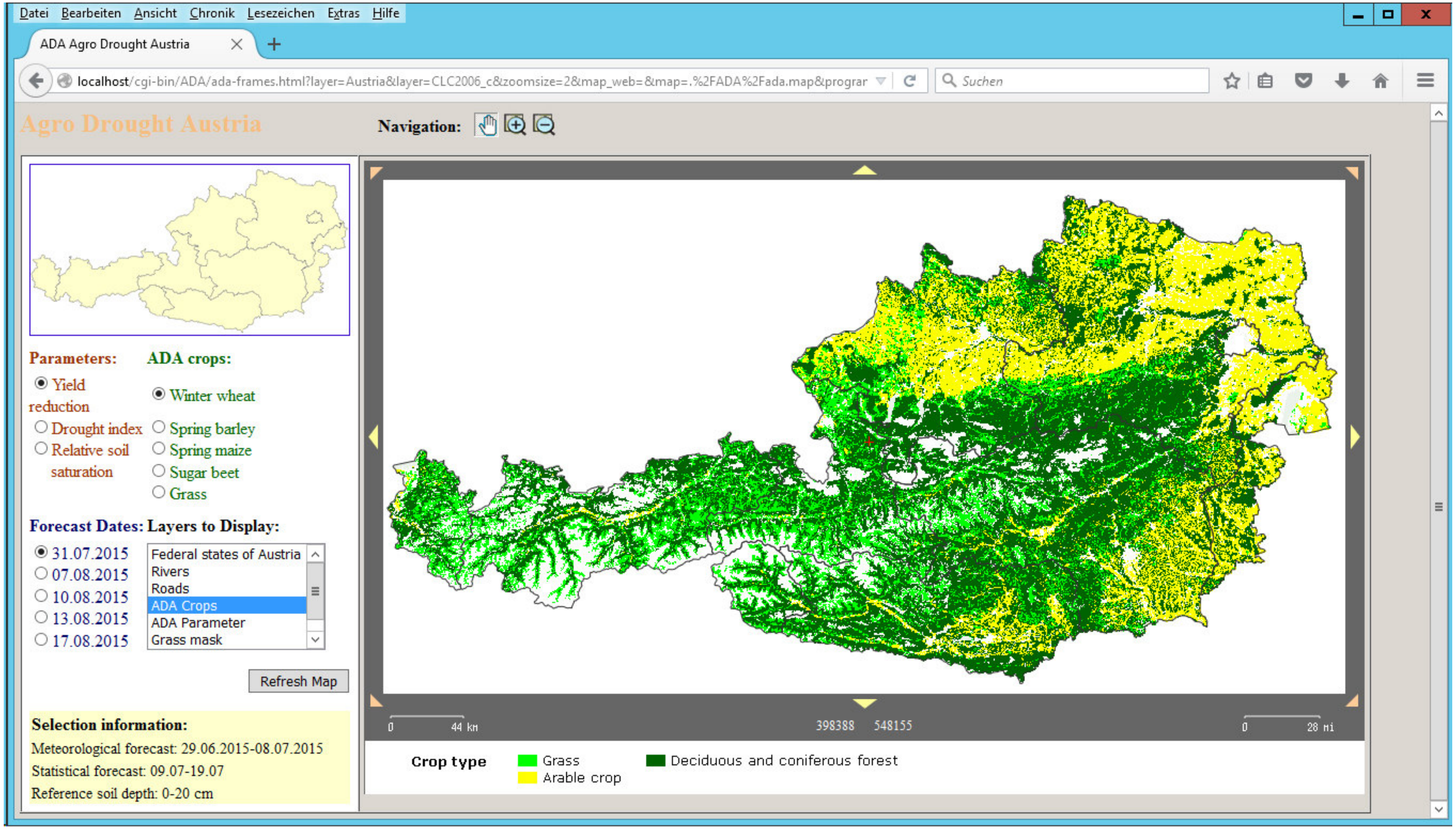
- Soil water balance & RSS (complete Austrian territory): approx. 24h
- Drought index, Heat & drought indicators (Austrian territory split up into 4 fractions): approx. 11h

ADA web architecture

- Forecast run every third day
- Backup of all forecast met and result data



ADA web interface



ADA

Thank you for your attention ...