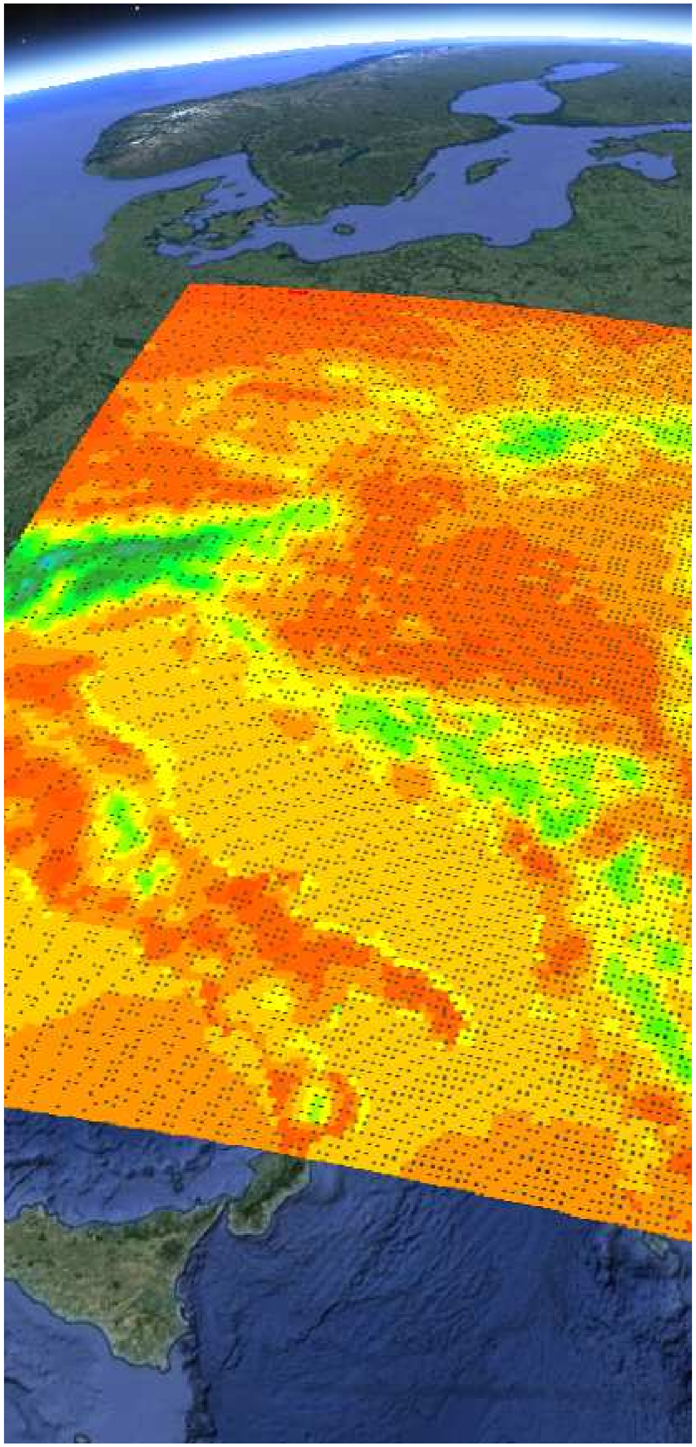

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H2020-TWINN-2015
AgMet+

Application of different NWP products in agricultural production: Limits and efficacy

Ana Firanj Sremac & Branislava Lalic
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NWP products

1	**Nowcasts**	Descriptions of current weather parameters and descriptions of forecast weather parameters over the next 0-2-hours.
2	**Very short-range**	Descriptions of weather parameters over up to 12 hours into the future.
3	**Short-range**	Descriptions of weather parameters beyond 12 hours and up to 72 hours into the future.
4	**Medium-range**	Descriptions of weather parameters beyond 72 hours and up to 240 hours into the future.
5	**Extended-range**	Descriptions of weather parameters beyond 10 days and up to 30 days into the future. Typically averaged and expressed as departures from the climatological values for that period.
6	**Long-range forecasts**	From 30 days up to two years into the future.
6.1	**Monthly outlooks**	Descriptions of average weather parameters. Expressed as departures (deviations, variations, or anomalies) from the climatological values for that month (not necessarily the coming month).
6.2	**Three-month or 90 day**	Descriptions of the average values of weather parameters. Expressed as departures from the climatological values for that 90-day period (not necessarily the coming 90-day period).
6.3	**Seasonal outlooks**	Descriptions of the average values of weather parameters. Expressed as departures from the climatological values for that season.
7	**Climate forecasts**	Beyond two years.
7.1	**Climate variability predictions**	Descriptions of the expected values of climate parameters associated with the variations in inter-annual, decadal and multi-decadal climate anomalies.
7.2	**Climate predictions**	Descriptions of expected future climate conditions, including the effects of both natural and human driving factors.

Time and spatial scale

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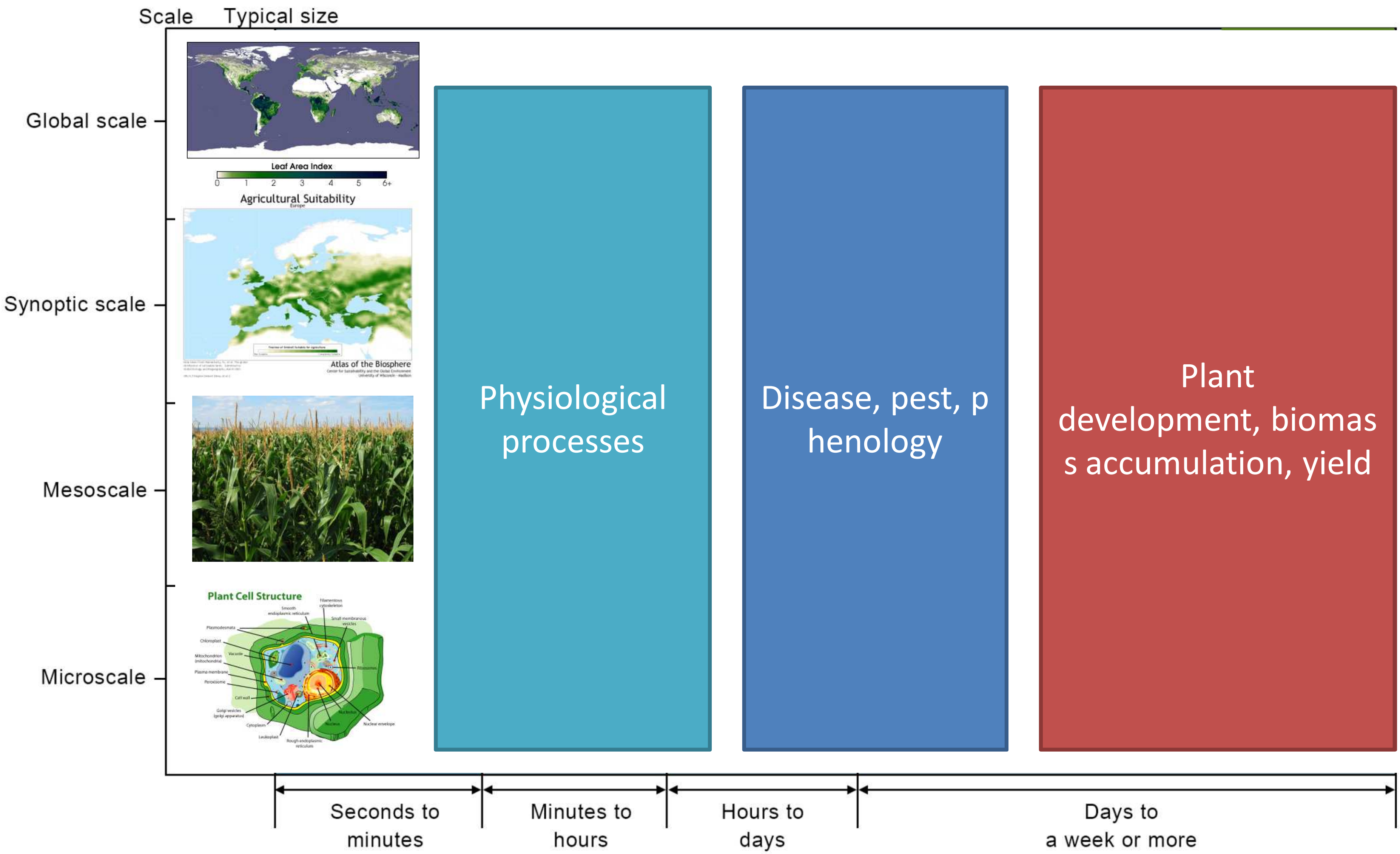
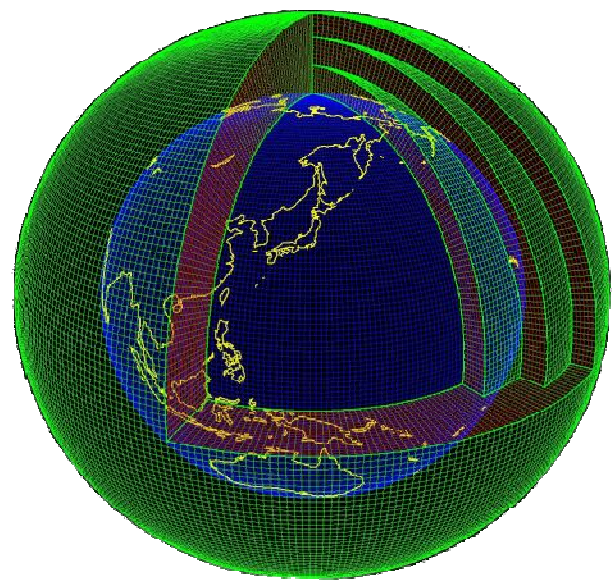
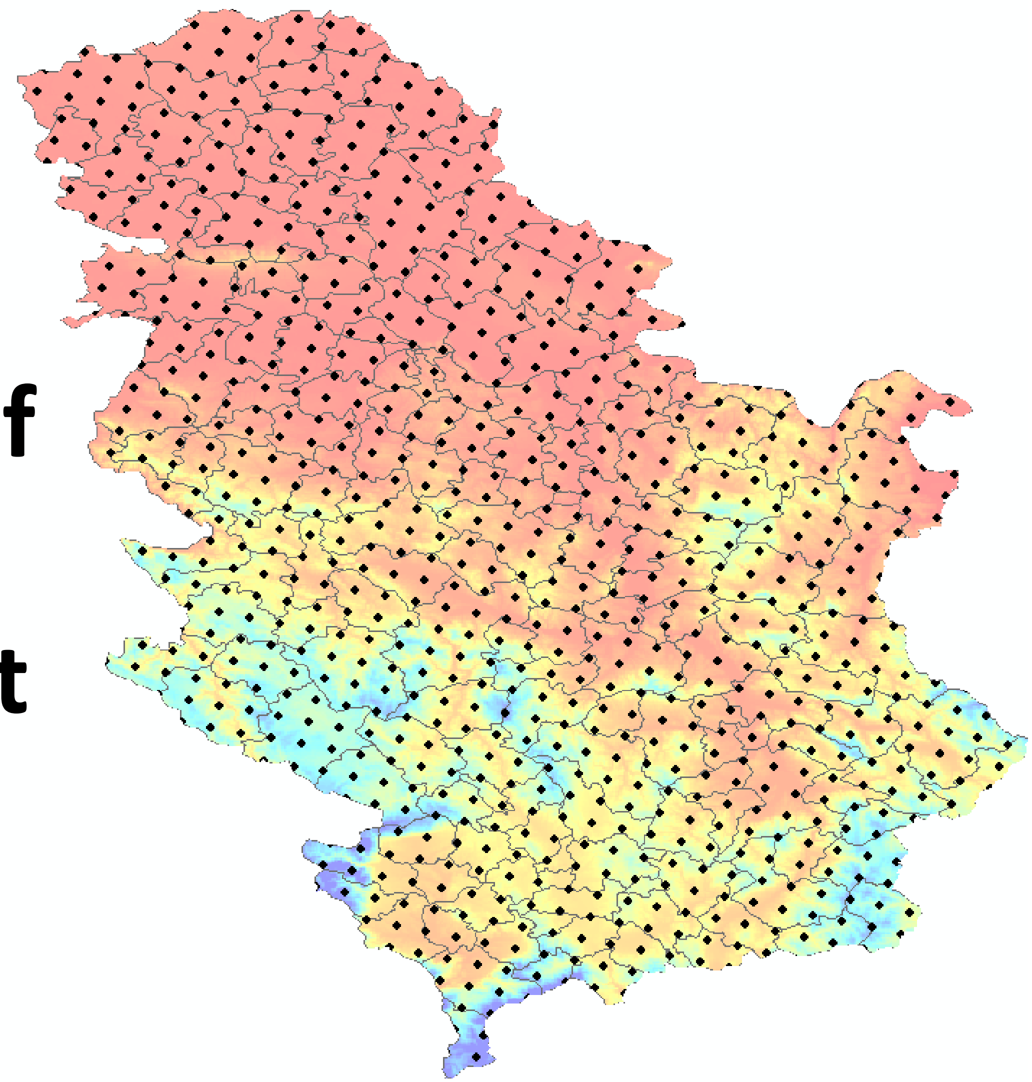


Used NWP products

- Short-range
  - Source NWP models: WorkEta, WRF-ARW
- Long-range forecasts (monthly, seasonal)
  - Source: ECMWF



An application of short-range weather forecast

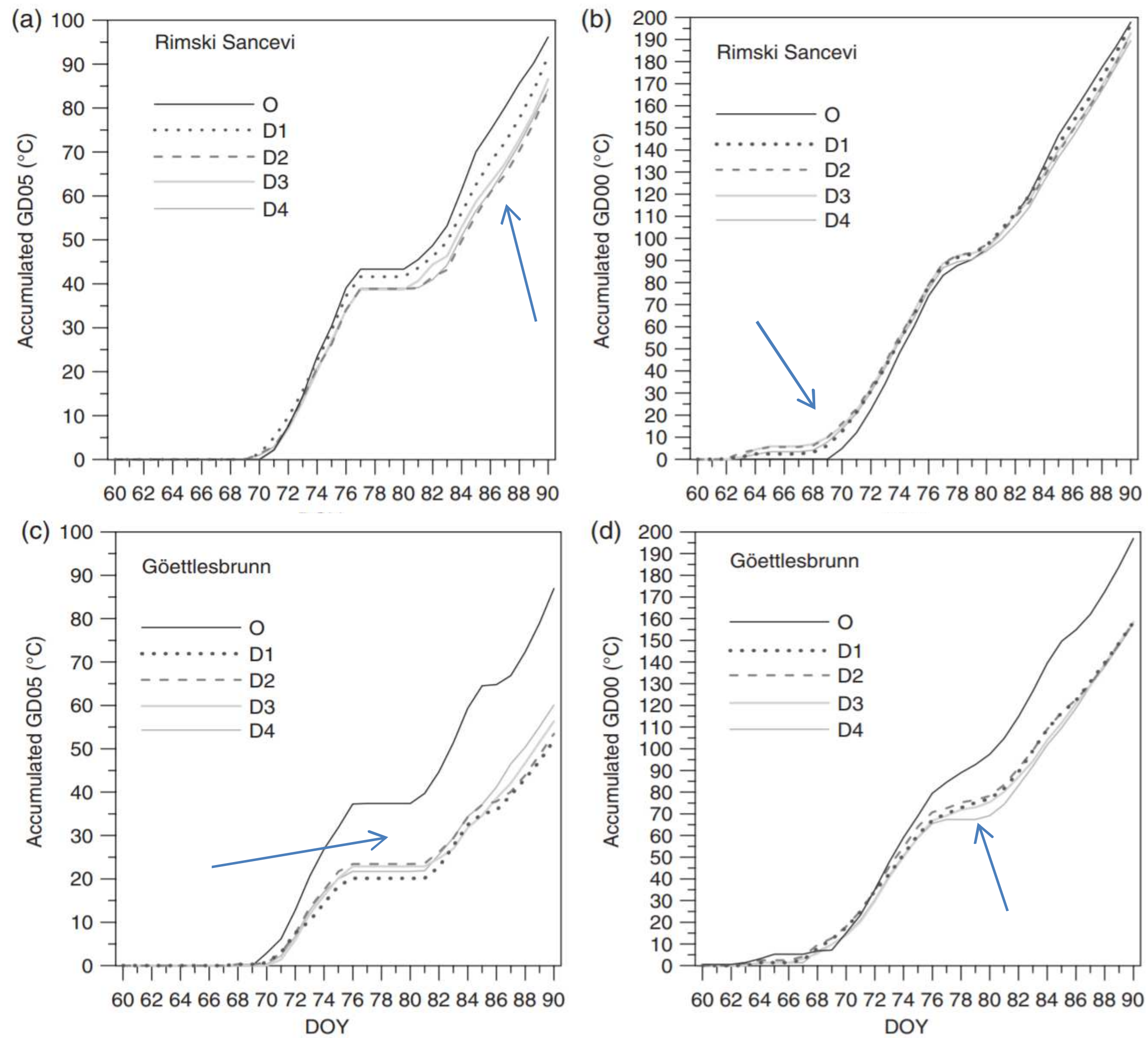


- Select phenomena with adequate time step
  - plant dieses and pest appearance, phenology, frost
- Select adequate numerical tool
  - Disease and pest models, phenological models

An application of short-range weather forecast

- **Lalic et al. (2016)** Effectiveness of short-term numerical weather prediction in predicting **growing degree days** and meteorological conditions for **apple scab appearance**. *Meteorol. Appl. 23: 50–56.*
- NWP used: TheWorkEta model, 4 day, 10 km resolution
- Growing dynamics, Disease model: BAHUS
  - ***Limit** – computational time*
  - ***Efficiency** – small difference between 1,2,3,4 day forecast*

Accumulated growing degree days



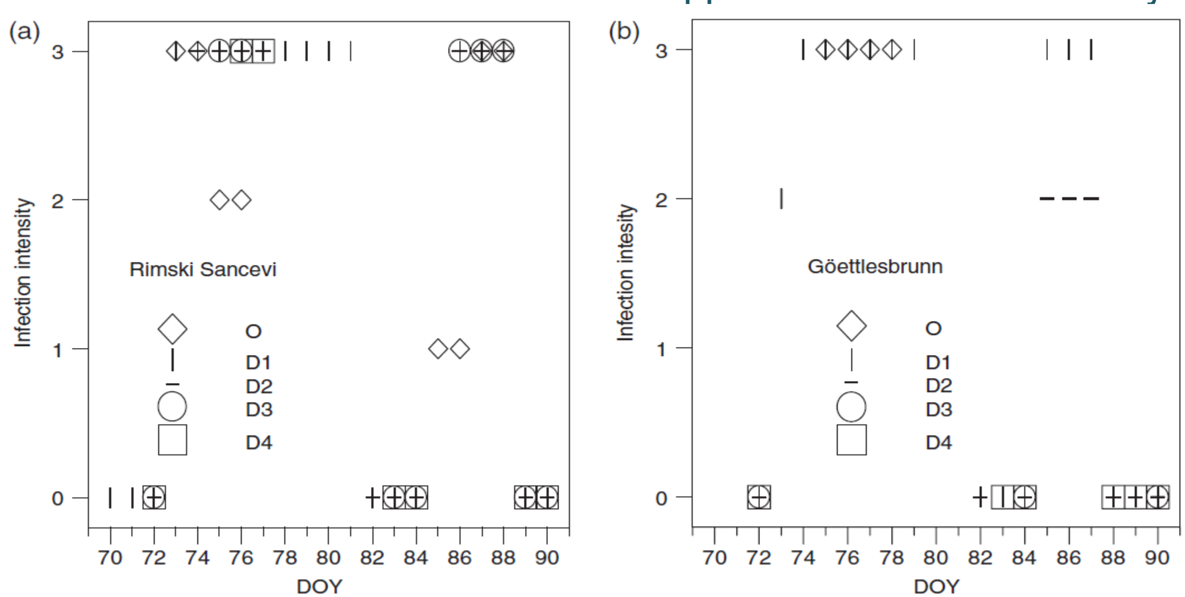
An application of short-range weather forecast

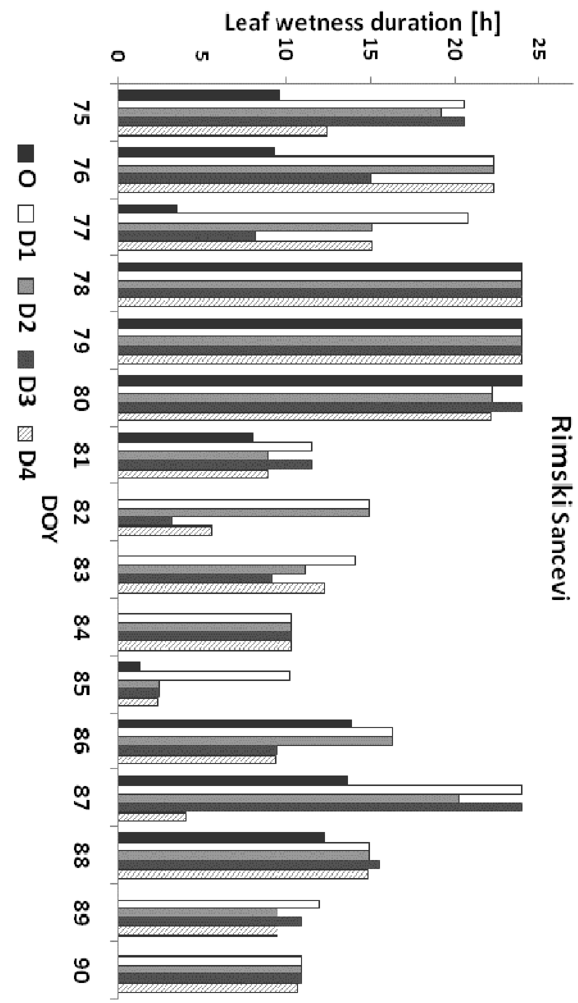
- **Lalic et al. (2016)** Effectiveness of short-term numerical weather prediction in predicting **growing degree days** and meteorological conditions for **apple scab appearance**. Meteorol. Appl. 23: 50–56.
- NWP used: TheWorkEta model, 4 day, 10 km resolutior
- Growing dynamics, Disease model: BAHUS

  Limit *– computational time, orrography*

  Efficiency *– small difference between 1,2,3,4 day forecast*

Apple scab infection intensity





An application of short-range weather forecast

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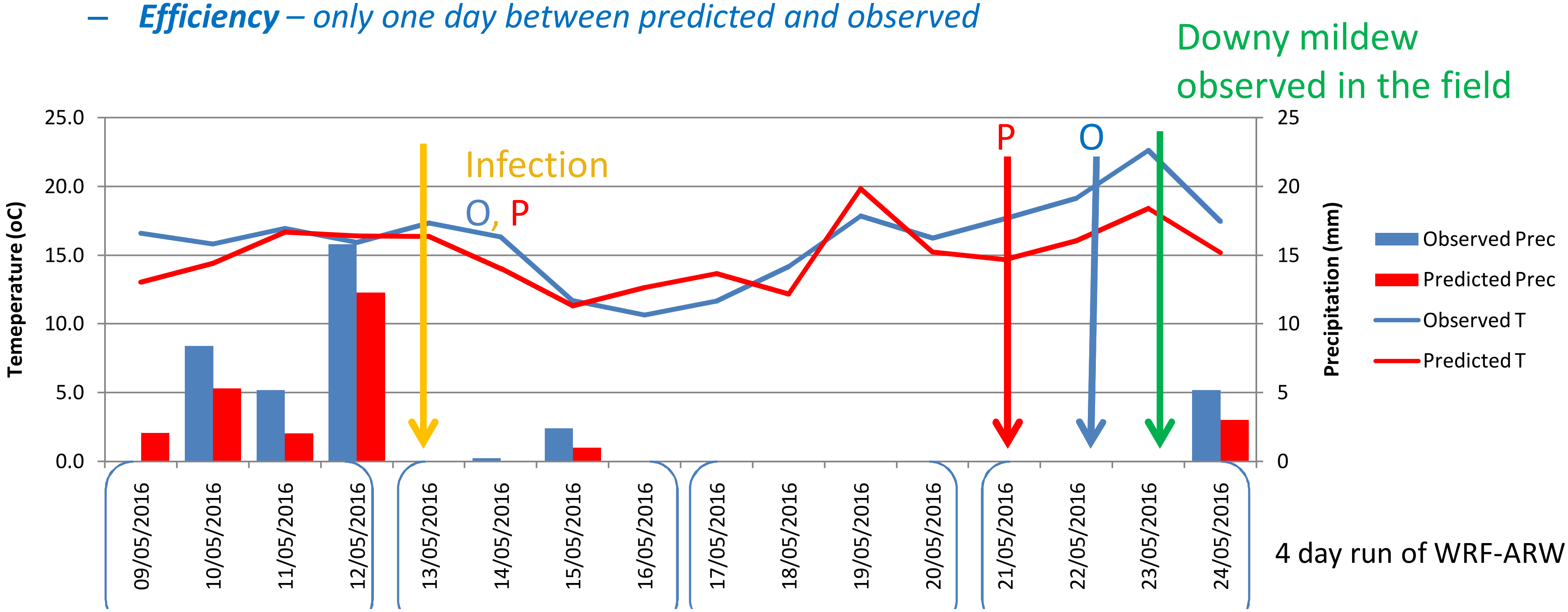
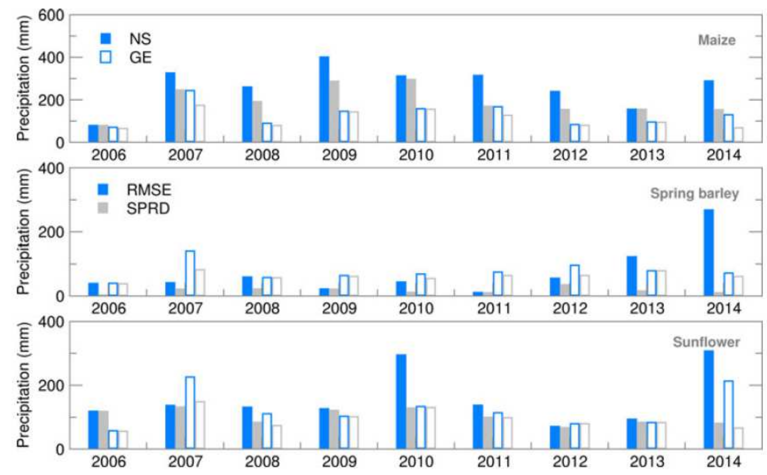
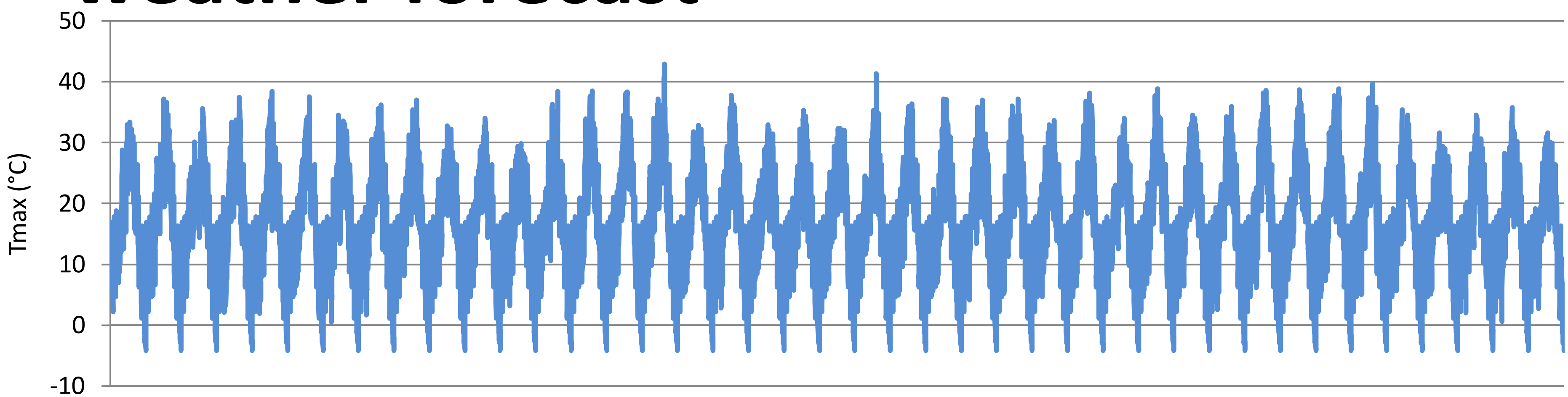
- **Firanj Sremac et al. (2016)** The WRF-ARW application in predicting meteorological conditions for **Downy mildew** (Plasmopara viticola) appearance of wine grape. Abstract EMS, Trieste, Italy, 12-16 September 2016
- NWP used: WRF-ARW model, 4 day, 10 km
- Disease model: BAHUS (**Müller's method**)
  - ***Limit*** *– computational time, errors in precipitation*
  - ***Efficiency*** *– only one day between predicted and observed*



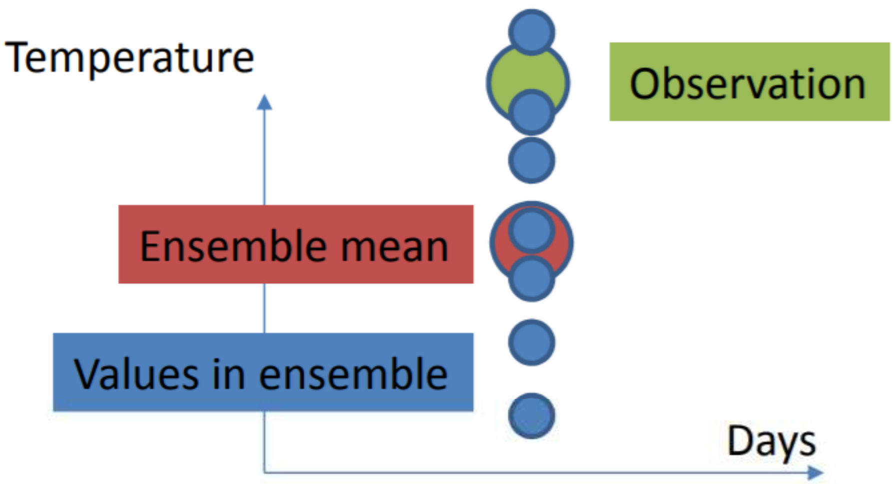


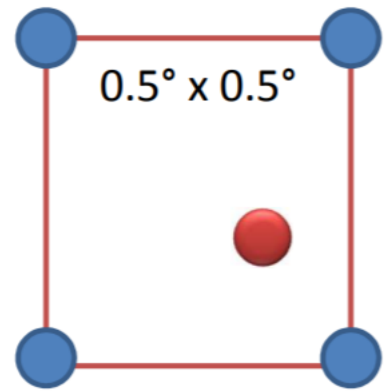
An application of monthly and seasonal weather forecast



- Select phenomena with adequate time step
  - Plant phenology (monthly), vegetation dynamics, biomass, yield
- Select adequate numerical tool
  - Crop model
- Ensemble forecast -> ensemble of phenology/ crop model outputs

Data sets – ensemble forecast





Observed average temperature for March 2017: 10.5 °C

Forecasted – control run temperature for March 2017: 10.8 °C

Forecasted – ensemble for March 2017, averaged by ensemble:

1. 10.1
2. 11
3. 10.4
4. 10.9
5. 10.
6. 12.1
7. 10.5
8. 10.6
9. 10.2
10. 11.1
11. 10.5
12. 10.1

Ensemble mean = 10.6 °C

An application of monthly and seasonal weather forecasting

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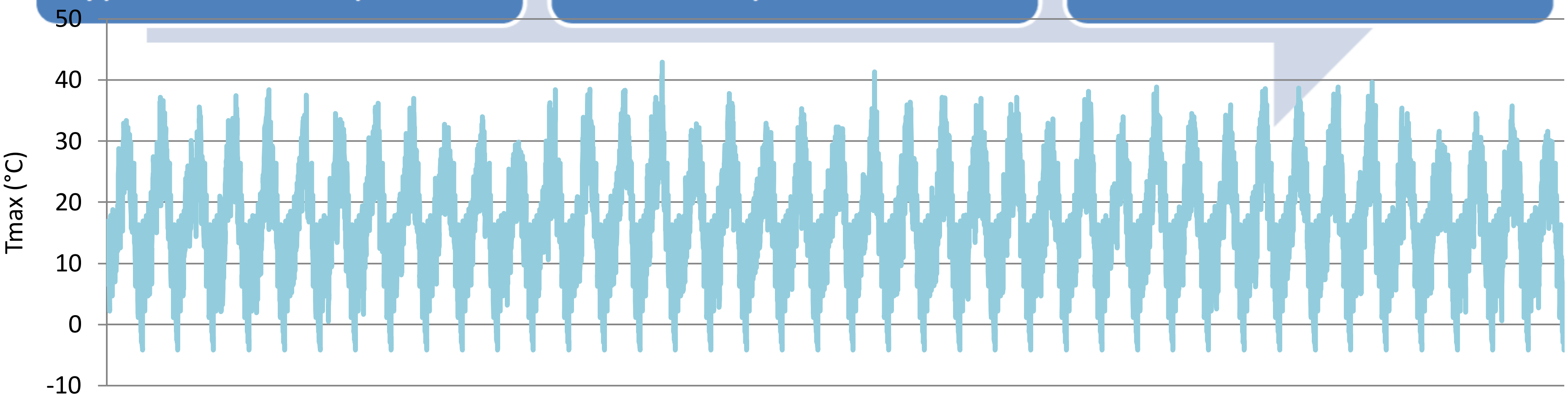
First run – observed meteorology

Observed meteorology: Typical set for crop model → Calibrated and validated crop model → Crop model outputs: yield, biomass

One run per one ensemble member

Forecasted meteorology: Typical set of crop model → Calibrated and validated crop model → Ensemble of crop model estimates



VERIFICATION STATISTICS

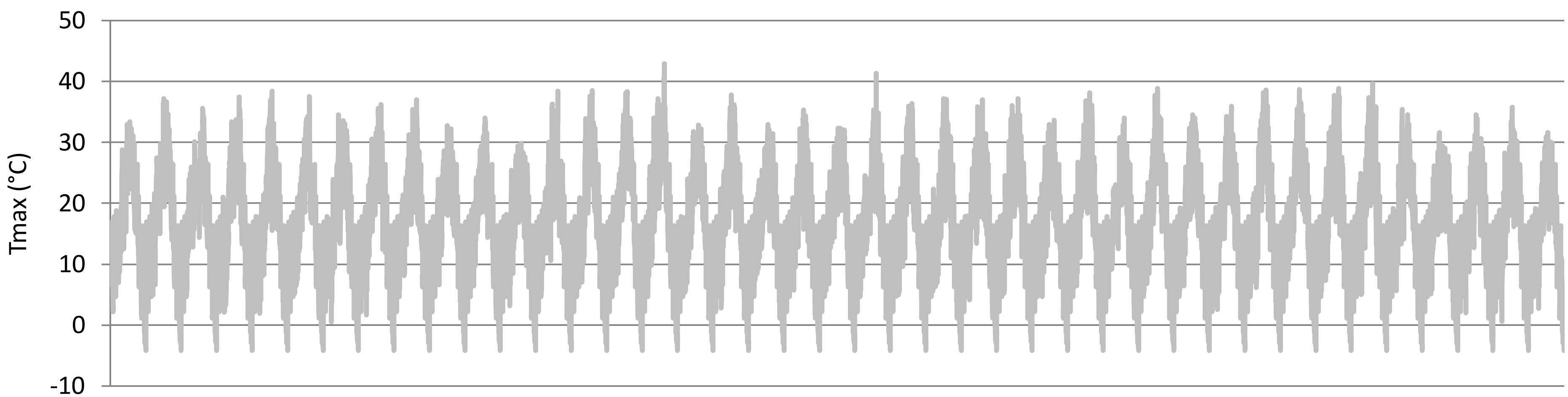
$$RMSE = \frac{1}{N}\sqrt{\sum_{i=1}^{N}\left(\overline{A} - A_{OBS}\right)^2}$$

$$SPREAD = \sqrt{\frac{1}{n-1}\sum_{i=1}^{N}\left(\overline{A} - A(i)\right)^2}$$

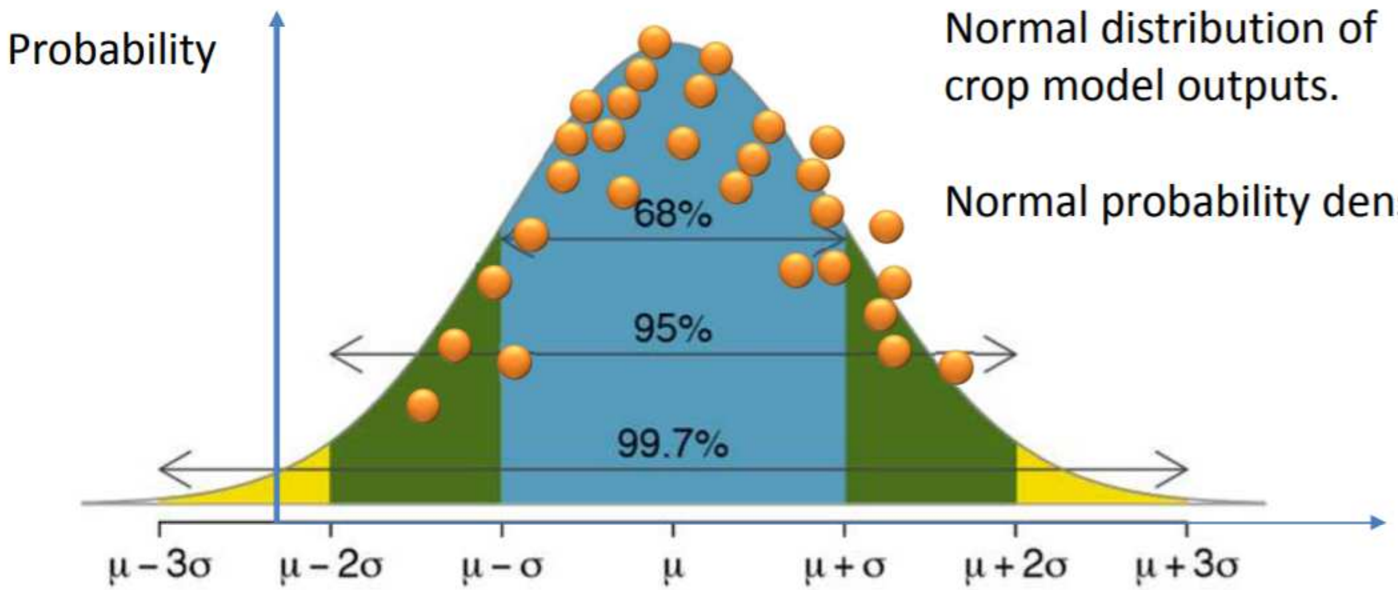
Ensemble statistics

$$RLD = \frac{\left|A_{CR} - A_{OBS}\right|}{A_{OBS}} \cdot 100\%$$

Control run statistics



IGNORANCE SCORE



Normal distribution of crop model outputs.

Normal probability density function.

$$I\left(p(y), Y\right) = -\log_2\left(p(Y)\right)$$

$p(Y)$ is a unitless probability density function of CMO

After calculating Ignorance for different crop model outputs, we can compare them.

Ignorance is < 2.04, the model is very good, and if it is > 7.81, the model is not adequate.

An application of monthly weather forecasting

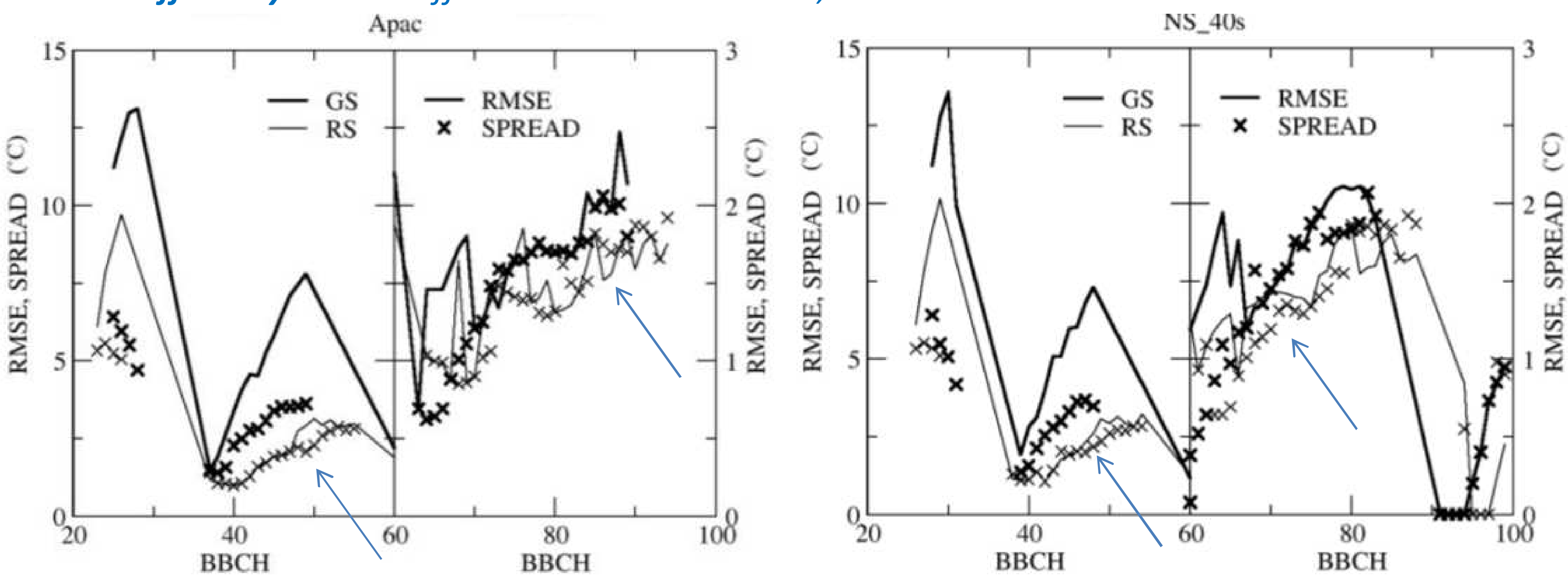
- Lalic et al. (2017a) Testing **efficacy of monthly forecast** application in agrometeorology: Winter wheat **phenology dynamic**. *IOP Conf. Ser.: Earth Environ. Sci.* 57 012002
- ECMWF – monthly forecast, MARCH-JUNE, 51 ensemble, 35 km resolution
- Crop model SIRIUS
  - ***Limit*** *– dependant on the position of the grid points*
  - ***Efficiency*** *– small difference RMSE and SPRED for Tmin, Tmax, Yield, RS*

Setting	RMSE (°C)				SPREAD (°C)			
	M	A	M	J	M	A	M	J
	T_{min}							
Groß-Enzersdorf	2.9	1.6	1.0	0.8	1.2	1.1	0.9	0.7
Rimski Sancevi	1.3	1.2	1.0	1.6	1.2	1.2	0.9	0.7
	T_{max}							
Groß-Enzersdorf	5.1	4.0	2.4	2.8	1.5	1.4	1.3	1.3
Rimski Sancevi	3.0	1.9	1.7	1.5	1.7	1.4	1.4	1.5

	ET (mm)	Max def. (mm)	Anthesis day	Maturity day	Biomass (t/ha)	Yield (t/ha)
Grossensdorf obs	395	187	**149**	190	14.859	6.989
Grossensdorf month	355	145	**149**	187	13.899	5.940
Novi Sad obs	425	136	**139**	**181**	**14.473**	**6.006**
Novi Sad month	379	143	**139**	**179**	**14.478**	**5.920**

An application of monthly weather forecasting

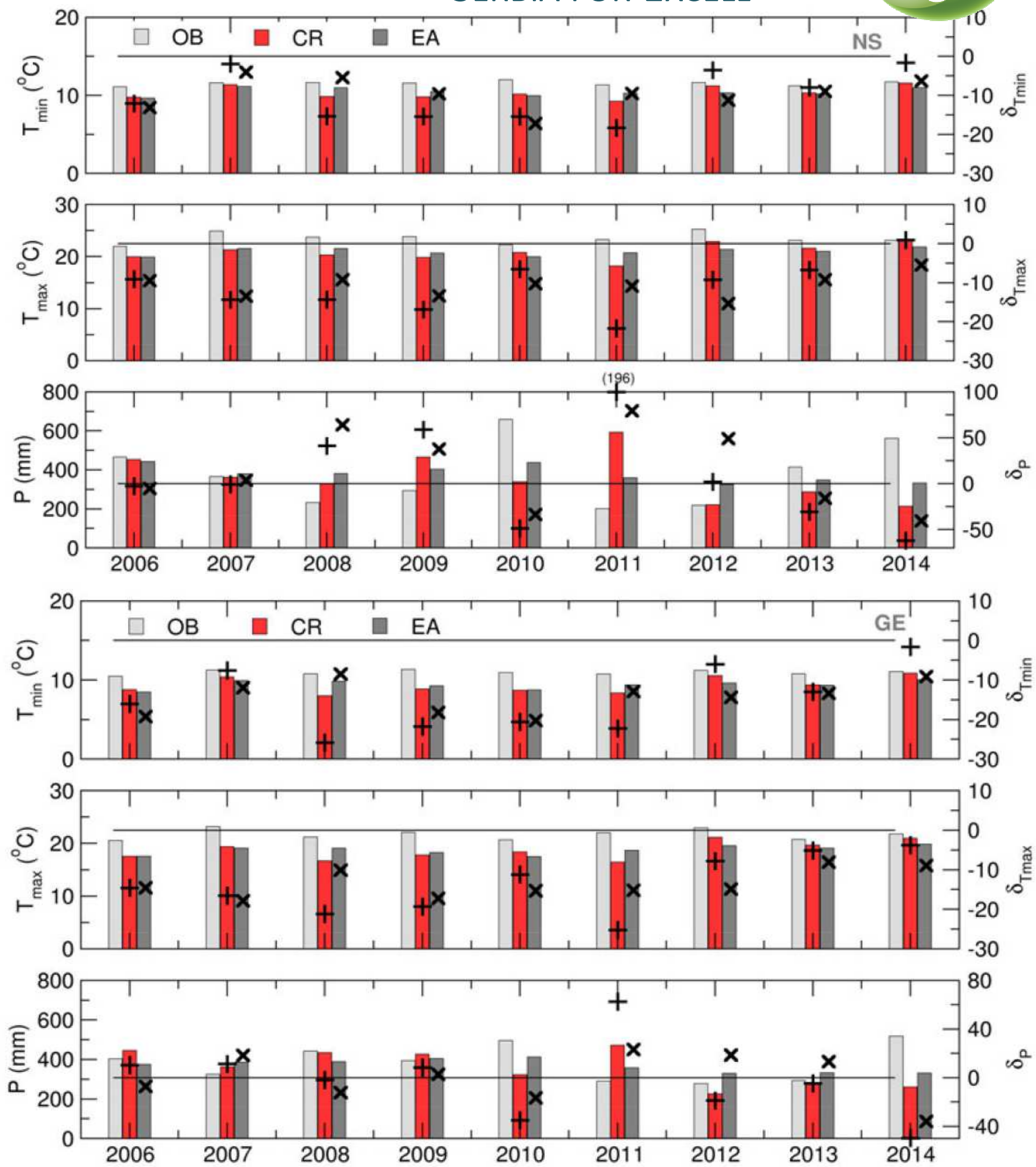
- Lalic et al. (2017a) Testing **efficacy of monthly forecast** application in agrometeorology: Winter wheat **phenology dynamic**. *IOP Conf. Ser.: Earth Environ. Sci.* 57 012002
- ECMWF – monthly forecast, MARCH-JUNE, 51 ensemble, 36 km resolution
- Crop model SIRIUS
  - ***Limit** – dependant on the position of the grid points*
  - ***Efficiency** – small difference RMSE and SPRED, RS*



An application of seasonal weather forecasting

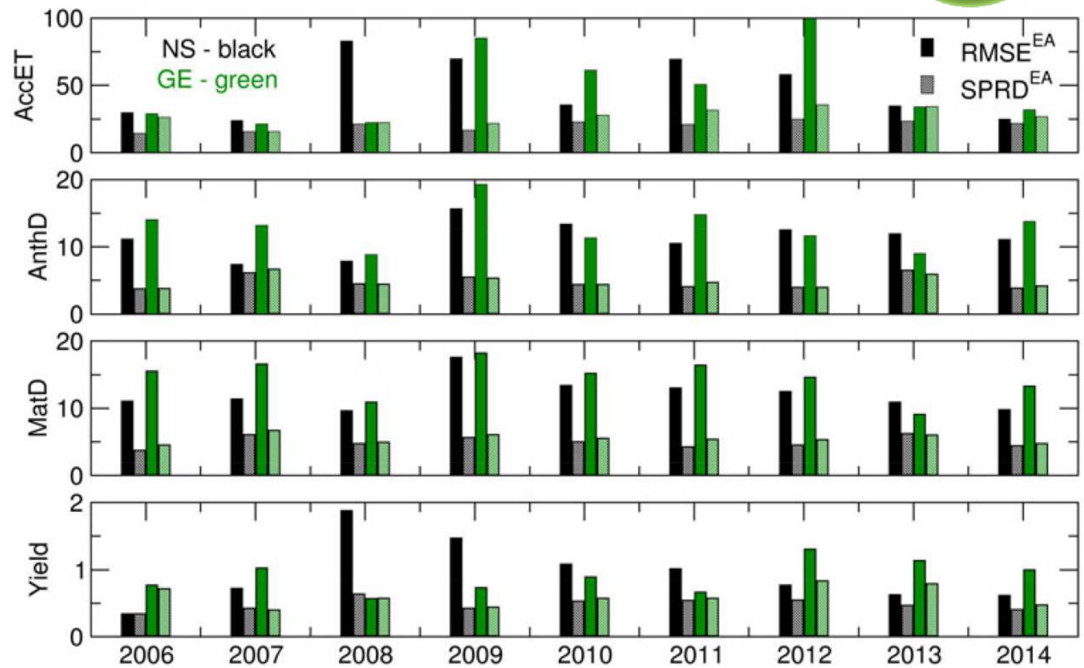
Serbia for Excell

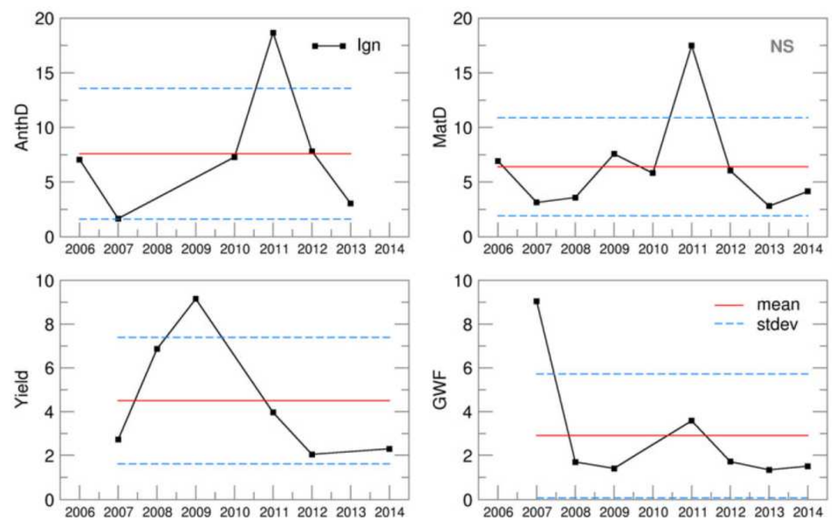
- Lalic et al. (2017b) Seasonal forecasting of **green water components** and **crop yields of winter wheat** in Serbia and Austria. *Journal of Agricultural Science*, 1-17
- ECMWF – seasonal forecast, MARCH-OCTOBER, 10-50 ensemble (depending on the year), 0.5° × 0.5° resolution
- Crop model: SIRIUS
  - ***Limit*** *– dependant on the position of the grid points, OB is larger than EA, CR*
  - ***Efficiency*** *– small difference RMSE and SPRED*



An application of seasonal weather forecasting

- Lalic et al. (2017b) Seasonal forecasting of **green water components** and **crop yields of winter wheat** in Serbia and Austria. *J. Agric.Sci*, 1-17
- ECMWF – seasonal forecast, MARCH-OCTOBER, 10-50 ensemble (depending on the year), 0.5° × 0.5° resolution
- Crop model: SIRIUS
  - ***Limit*** *– dependant on the position of the grid points*
  - ***Efficiency*** *– small difference RMSE and SPRED for Yield*





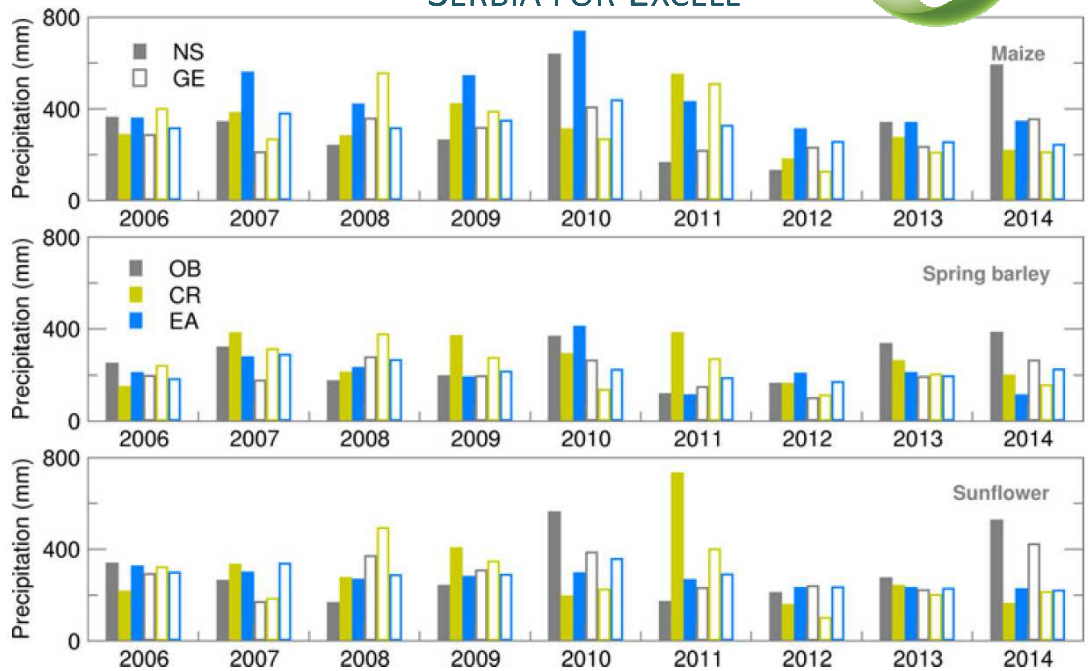
Ignorance is < 2.04, the model is very good, and if it is > 7.81, the model is not adequate.

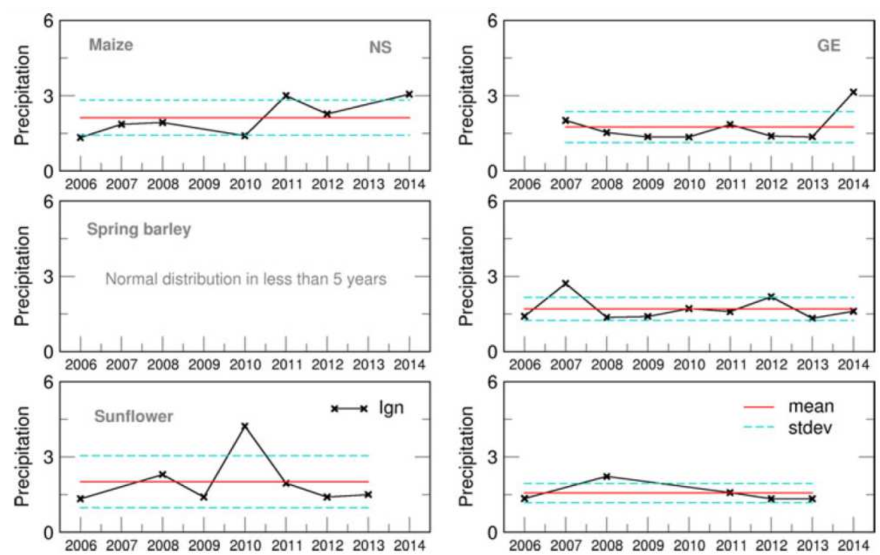
An application of seasonal weather forecasting

SERBIA FOR EXCELL

- Lalic et al. (2018) Seasonal forecasting of **green water components** and crop yield of summer crops in Serbia and Austria. *J. Agric.Sci*, 1-15
- ECMWF – seasonal forecast, MARCH-OCTOBER, 10-50 ensemble (depending on the year), 0.5° × 0.5° resolution
- Crop model: AquaCrop
  - ***Limit*** *– dependant on the position of the grid points, but in years with extremes EA closer to OB*
  - ***Efficiency*** *– average Ignorance less then 3.*

Ignorance is < 2.04, the model is very good, and if it is > 7.81, the model is not adequate.

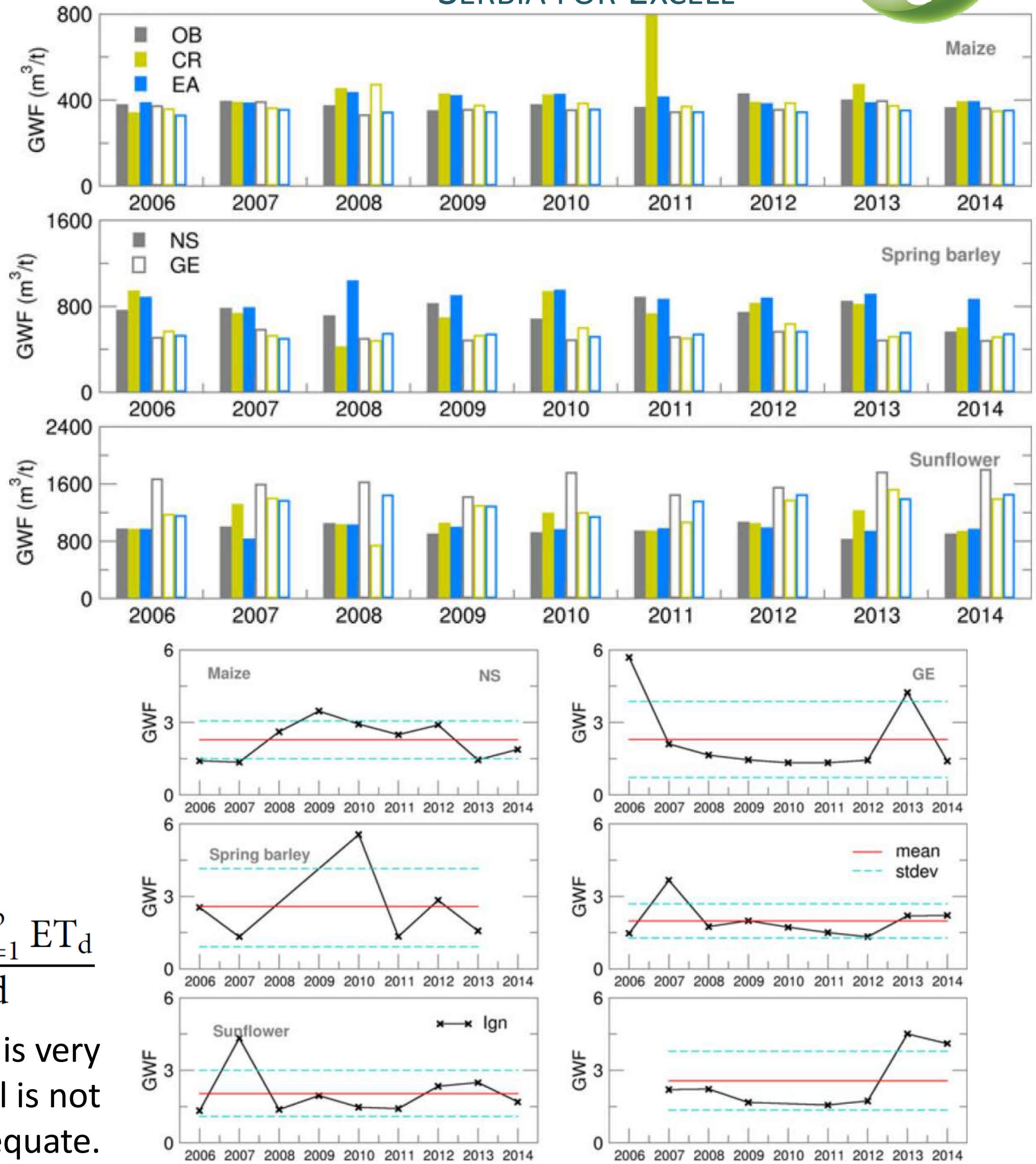




An application of seasonal weather forecasting

SERBIA FOR EXCELL

- Lalic et al. (2018) Seasonal forecasting of **green water components** and **crop yield** of summer crops in Serbia and Austria. *J. Agric.Sci*, 1-15
- ECMWF – seasonal forecast, MARCH-OCTOBER, 10-50 ensemble (depending on the year), 0.5° × 0.5° resolution
- Crop model: AquaCrop
  - ***Limit*** *– dependant on the position of the grid points, and cultivar*
  - ***Efficiency*** *– apart from some years in average Ign less than 3*



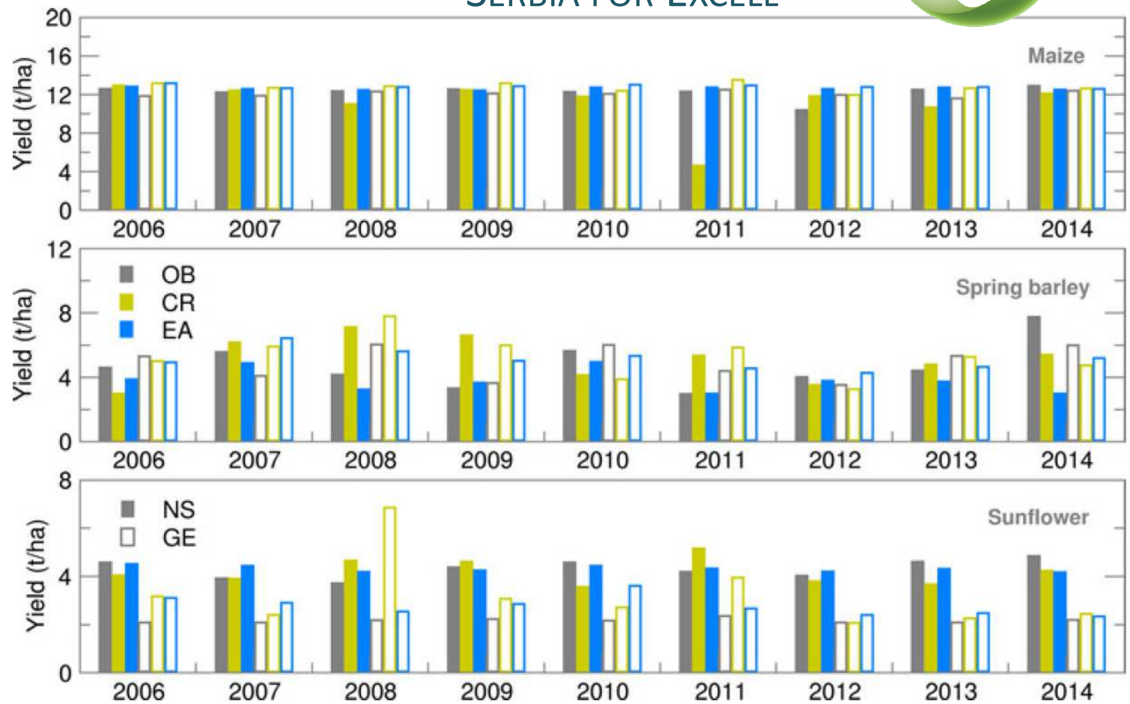
$$\mathrm{GWF} = \frac{10 \times \sum_{d=1}^{lgp} \mathrm{ET_d}}{\mathrm{Yield}}$$

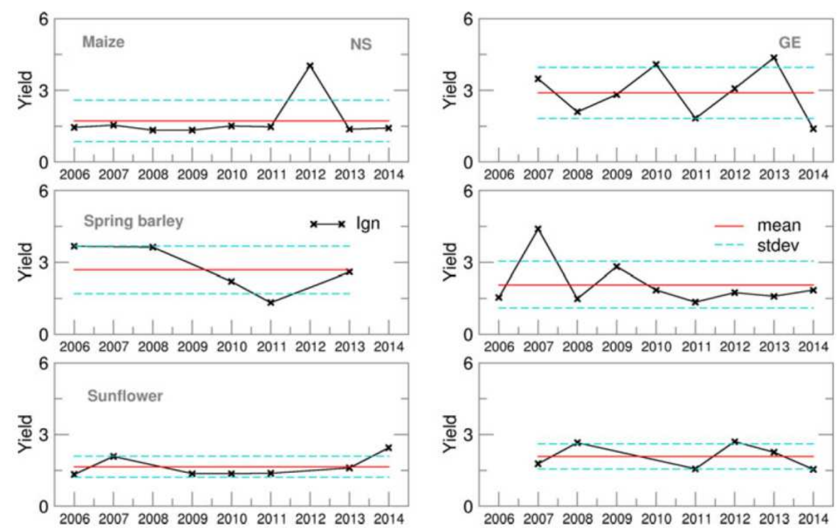
Ignorance is < 2.04, the model is very good, and if it is > 7.81, the model is not adequate.

An application of seasonal weather forecasting

SERBIA FOR EXCELL

- Lalic et al. (2018) Seasonal forecasting of green water components and **crop yield** of summer crops in Serbia and Austria. *J. Agric.Sci*, 1-15
- ECMWF – seasonal forecast, MARCH-OCTOBER, 10-50 ensemble (depending on the year), 0.5° × 0.5° resolution
- Crop model: AquaCrop
  - ***Limit*** *– dependant on the position of the grid points, and cultivar*
  - ***Efficiency*** *– average Ignorance less than 3 for all*





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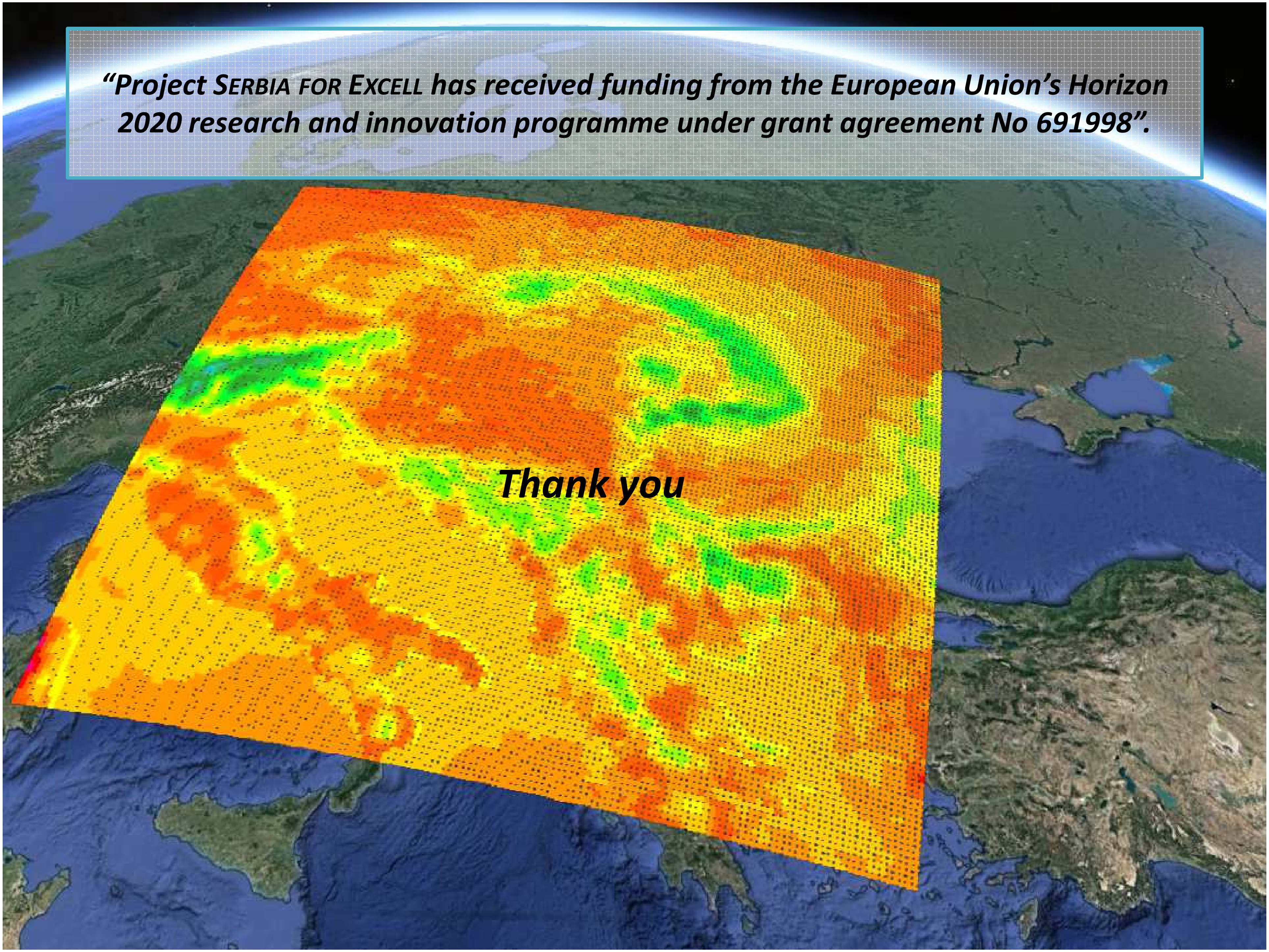

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Thank you