STOCHASTIC WEATHER GENERATORS

Gen-CFox

a stochastic weather generator for daily temperatures and precipitations : usability for climate change adaptation in agriculture

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Vannes – Centre Henri Lebesgue - 17/20th May 2016

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Adaptation to climate change : issue in the network of french Chambers of Agriculture

- What kind of climate projections could be relevant for operationnal adaptation toward the near future (2015-2040)?

- GCM results are strongly incompatible with observed climate change (1980-2015) over France
- Classical definition of climate is outdated

→ Let's conceive and use a specific SWG, adapted to our agronomical purpose !

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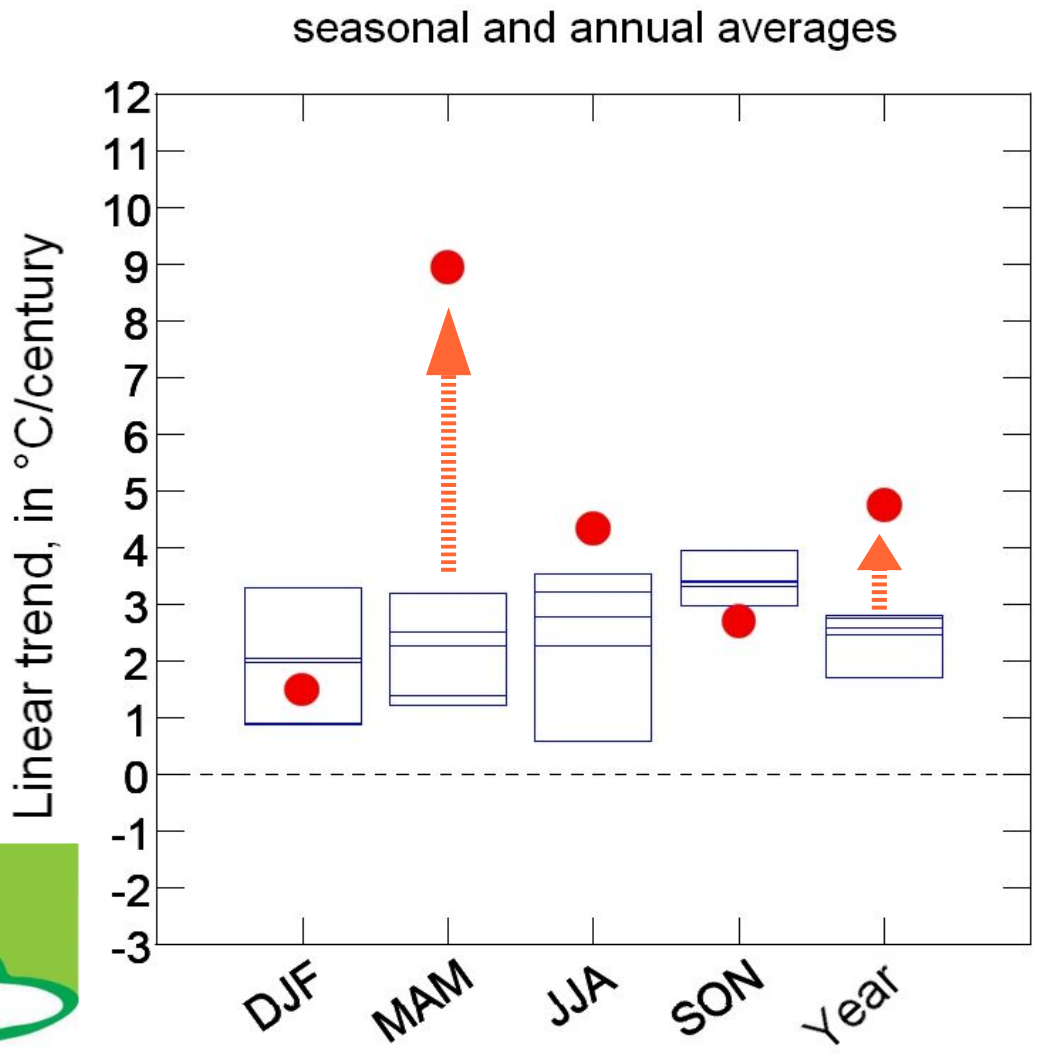
Observed VS simulated C.C.

La Courtine (Creuse,France) max. daily temperature



Observation (1980-2015)

Trends by difference of 30-year averages (2021-2050)-(1976-2005)
5 models extracted from www.drias-climat.fr :

- CNRM RCP2.6
- CNRM RCP4.5
- CNRM RCP8.5
- IPSL RCP4.5
- IPSL RCP8.5

"corrected" model outputs

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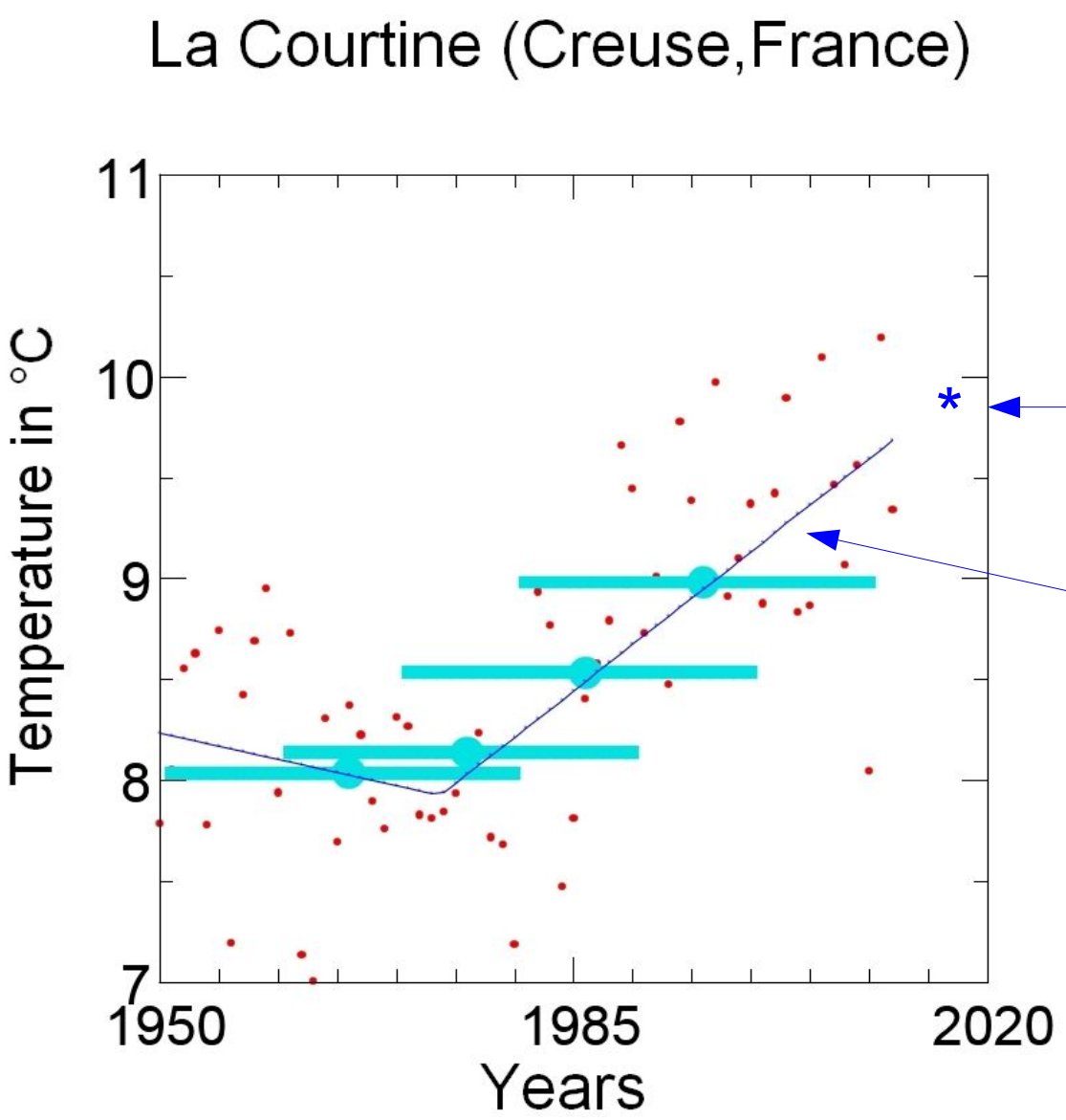
An outdated climate definition :

the 30-year average



2016 expectation

First idea of new definition

Homogenized mean annual temperature and 30-year average with center point.
Datas from Météo-France and Chambre Agriculture Creuse

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Redefining the climate :
the "climate expectancy"

Classical WMO definition (Technical Regulations, Basic documents n°2, vol.1, General Meteorological Standards and Recommended Practices, 2011 edition updated 2012. http://library.wmo.int/pmb_ged/wmo_49-V1-2012_en.pdf)

- Observation = 30-year average + Anomaly

The 30-year average is the „normality“

Proposed V. Cailliez definition („Prud'homme“ prize 1992, SMF)

- Homogenized serial of observations = combination of organizations + random part

Re-exposed : Climate and impacts workshop, IPSL (11/2014)
and International climate conference, UNESCO (07/2015)

Let's name the combination of organizations (or complementary part of randomness) the **„climate expectancy“** in replacement of the 30-year average.

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Gen-CFox in general :

Let's put the new climate definition into equations

- Take Par(t), a serials of daily temperatures (Tn,Tx) or precipitations (RR) during 1980-2015

  - Homogenize the serials
  - Progressively extract organizations
    - Long-term (trend, cycles...)
    - Short-term (persistence...)
  - Study the residual
    - Randomness
    - Descriptive distribution

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Gen-CFox :

Removing the long-term organization

Par(t) = a*t+b (if linear...) | Trend

$+A_1 * \sin(2\Pi t/P_1+\varphi_1)$ | Cycles

+ … |

$+A_k * \sin(2\Pi t/P_k+\varphi_k)$ |

+ParWLTO(t) | Residual

t : time in days, months, years...
Par : climatic Parameter (temperature, precipitations...)
WLTO : Without Long Term Organization

Notice : - A_i and φ_i can be organized themselves

- Only statistically significant coefficients are kept

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Gen-CFox :

Removing the short-term organization

ParWLTO(t) = α_1*ParWLTO(t-1) | Autoregression
+α_2*ParWLTO(t-2) | ''
+ … | ''
+α_n*ParWLTO(t-n) | ''
+**ParWSTO(t)** | Residual

WSTO : Without long term and Short Term Organization

Notice : - a_i can be organized themselves
- Tn,Tx are linked through the autoregressive process -->multi-variation of the SWG
- n goes from 3 to 7

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Gen-CFox :

Studying the residual

- Randomness
  - Runs tests → O.K.

- Idealized distribution
  - via intensive parameters (not quantiles)
    - Average → *0 (must be!)*
    - Standard deviation → *function of time, organized in trend and cycles*
    - Skewness (G1) and Kurtosis (G2) → *very weakly organized, considered as constants*

Notice : Climate expectancy alone doesn't need an SWG !

ClimExpect(t)= Par(t) - ParWSTO(t)

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Gen-CFox :

Generating climate to the present

- Re-generation of the residual :
  - Use of a random number generator, calibrated on idealized ParWSTO(t)
  - 10 000 iterations of daily 1980-2015 serials for each observation serials (10000*13149 datas)

- Rebuilding of autoregressive process, day by day

- Addition of the long-term organization

- You get 10 000 complete serials. You have to check the relevancy in distribution and organization with the observed one.

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Gen-CFox :

Comparating SWG simulations VS observations

- Verification of total distribution Par(t)
  - Quantile-Quantile correction needed !

- Verification of chronological organizations
  - Average(Sim.coeff)=Obs.coeff
  - Std Dev(Sim.coeff)=Std Err(Obs.coeff)

- Accuracy of classical climate indexes
  - Tx>30°C „very hot days“
  - Tx>25°C „hot days“
  - Tn<0°C „freezing days“
  - Tx<0°C „non-defreezing days“
  - Tn<-5°C „severely freezing days“

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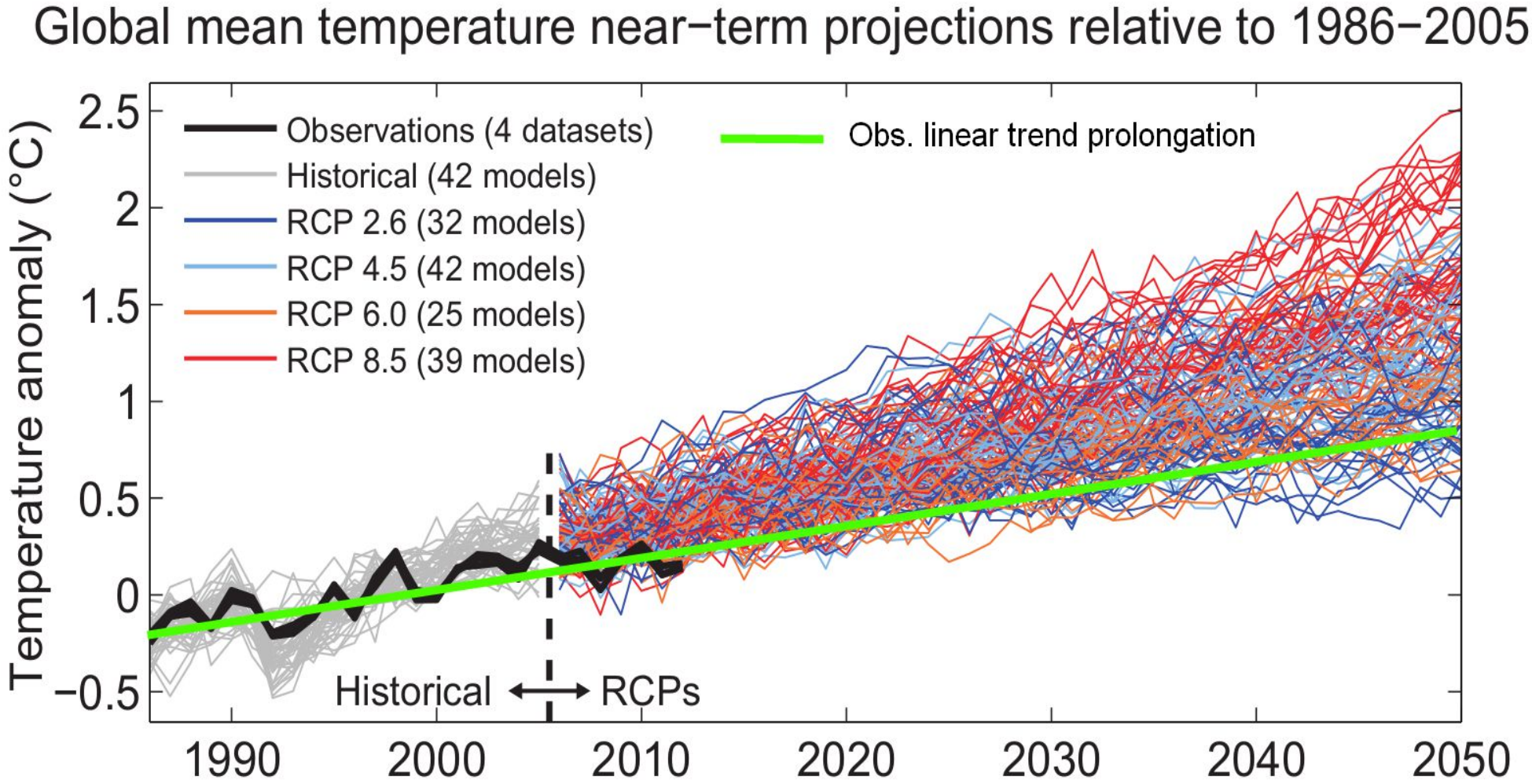
Gen-CFox :

What about the future ?



IPCC AR5, Tech. Summary, p87, figure TS.14 and adaptation

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Gen-CFox :

What about the future ?

- Prolongation of chronological organization
  - toward the near future (2015-2040)
  - without any acceleration
    - very moderate hypothesis!

- Ensemble statistics on many agro-climatic indexes
  - grass
  - wheat
  - corn
  - fruits
  - ...

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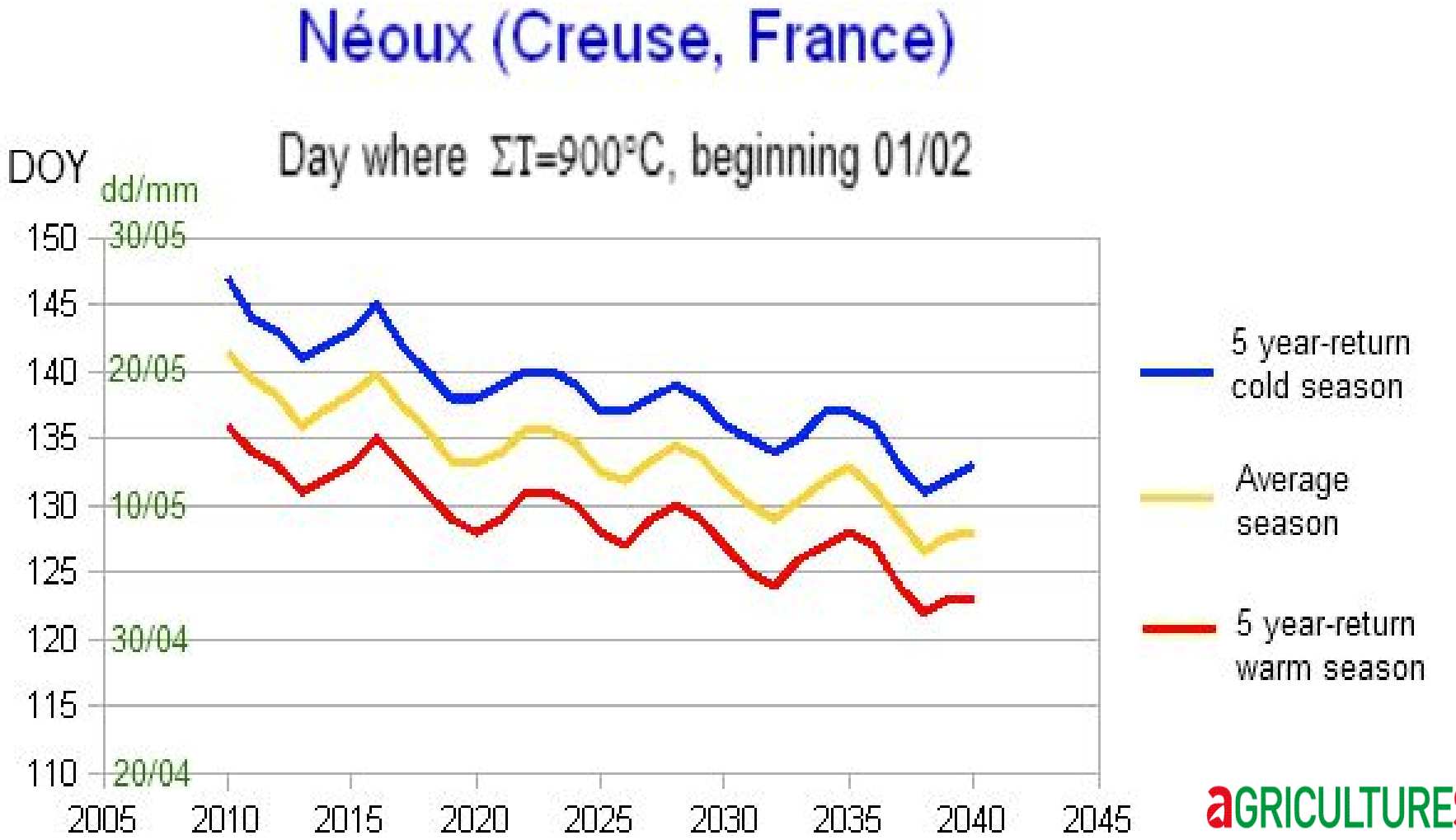
Examples of use :

Time to mow the hay (1st)



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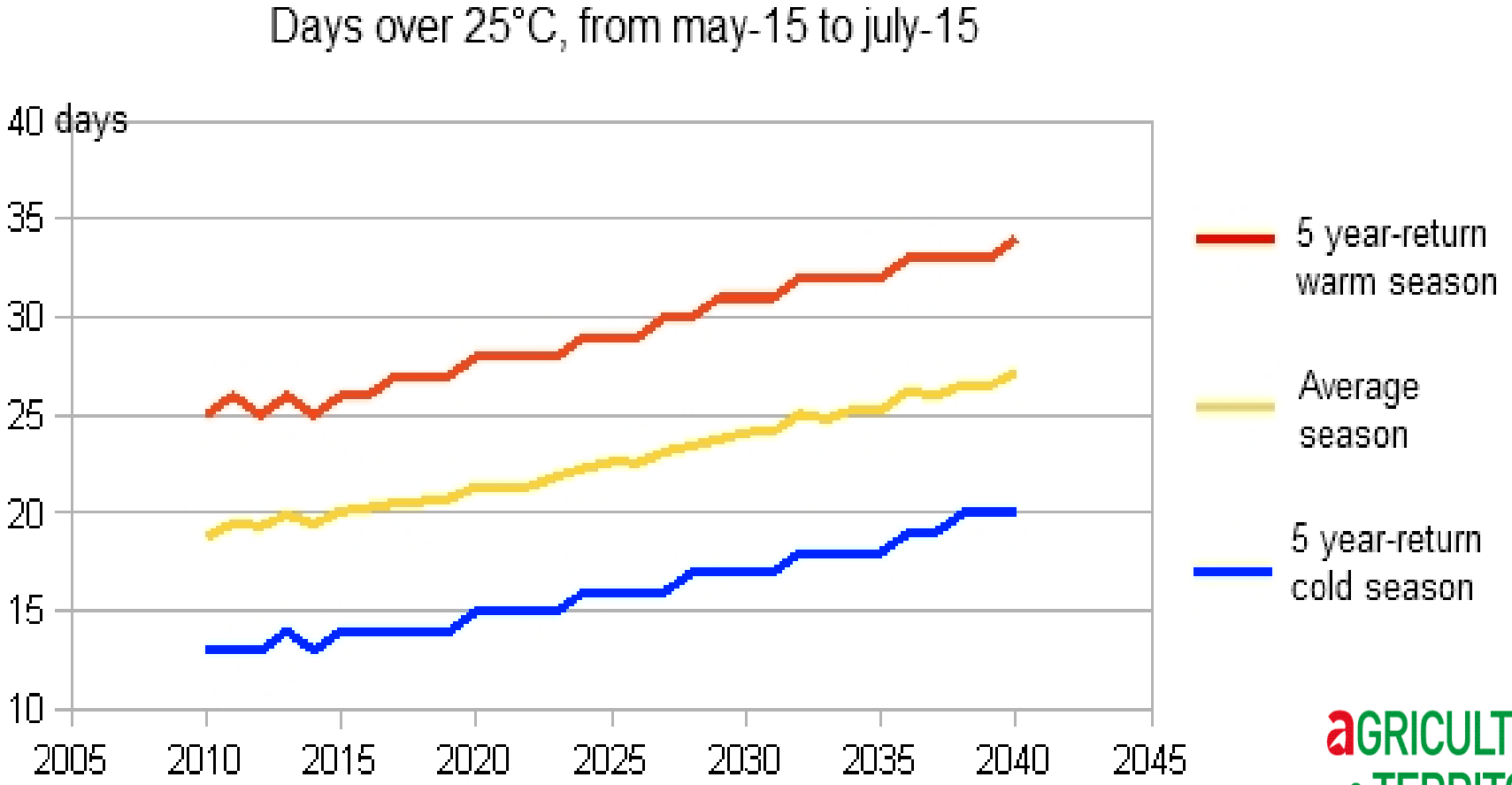
Examples of use :

Wheat over-heating days

Ahun (Creuse, France)



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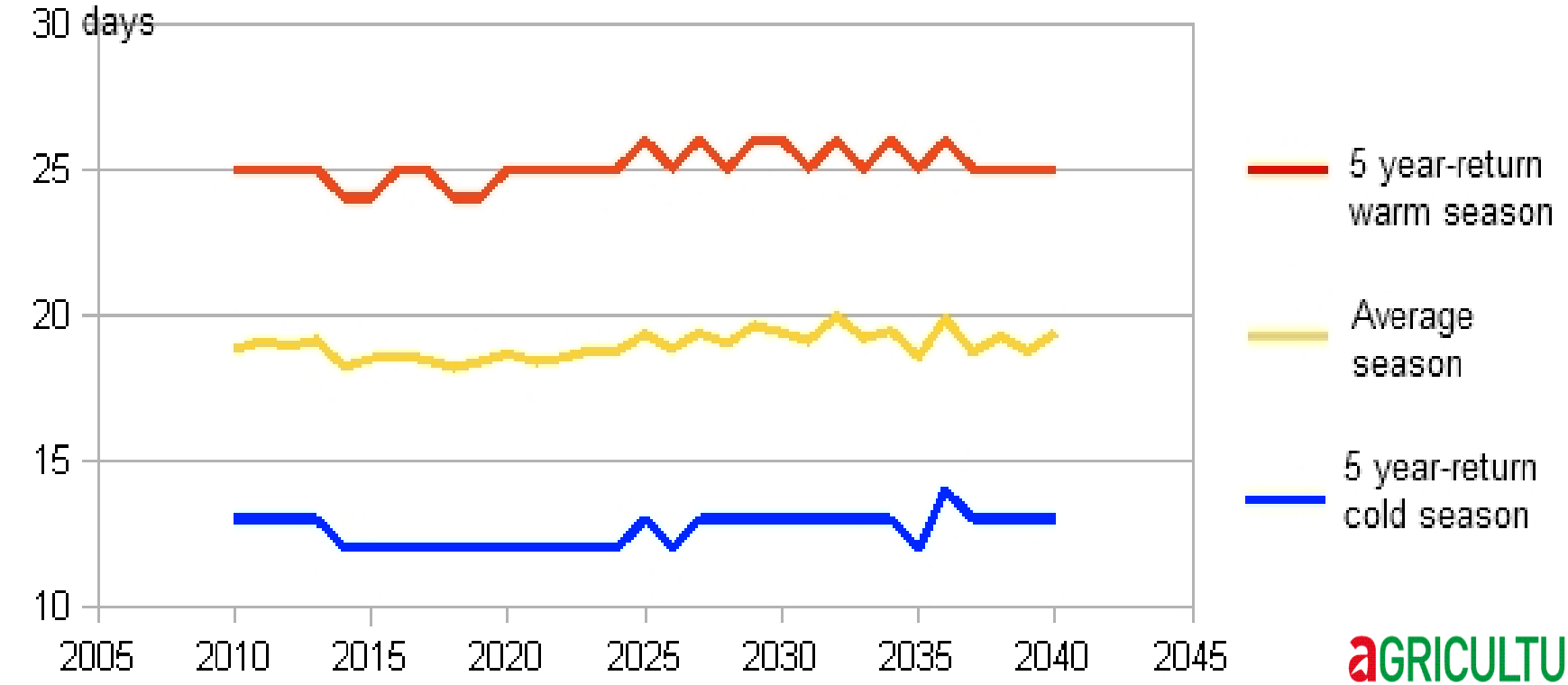
Examples of use :

Wheat over-heating days

Ahun (Creuse, France)

Days over 25°C, from may-15 to july-15 (2010), shifting 7days/10 years



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Examples of use :
Climate extremes

- Heat Wave of August 2003, in France

  - Indicator : summer (JJA) mean of max daily temperature

Calculation type	Return period
Original calculation (Météo-France, „La Météorologie“,n°46, aug. 2004)	**140 yrs**
Climate expectancy 2003	**35 yrs**
Climate expectancy 2015	**18 yrs**
Climate expectancy 2040	**5 yrs**

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Extensions

- After a beginning in the Limousin region (2012-2015), the method is now in use in 2 agro-climate projects (2015-2019) concerning ~½ of France :
    - AP3C (Massif Central)
    - Agri-Accept (Western France)

- Refinements:
    - Fully multi-variate approach (Tn,Tx,RR,P.E.T.)
    - Dynamical adjustment of G1,G2 on residual

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Complementary informations

- Climate expectancy developments in :
  - the acts of „Atelier Climat et Impacts“ IPSL, 2014
  - the book of abstracts of the 2015 UNESCO climate conference, p105-106 :
http://pool7.kermeet.com/C/ewe/ewex/unesco/DOCS/CFCC_abstractBook.pdf

- Popularization work in the prospective magazine „Futuribles“, n°407, july 2015 :
https://www.futuribles.com/

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Thanks for your attention !