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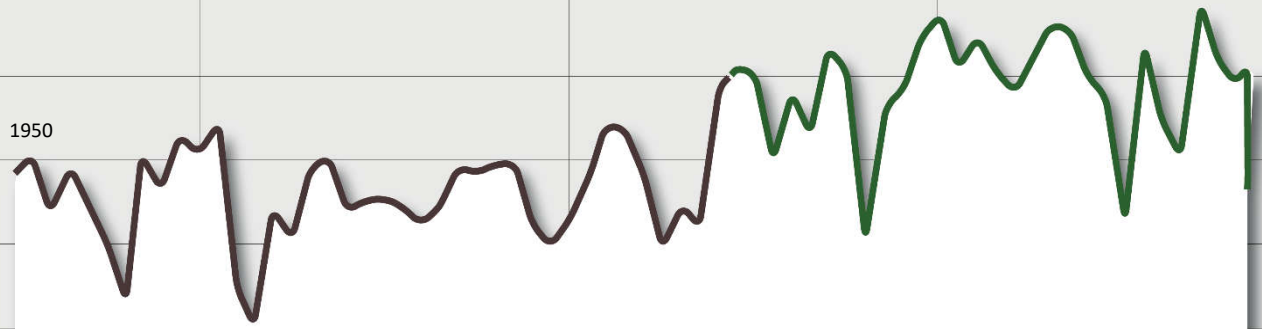
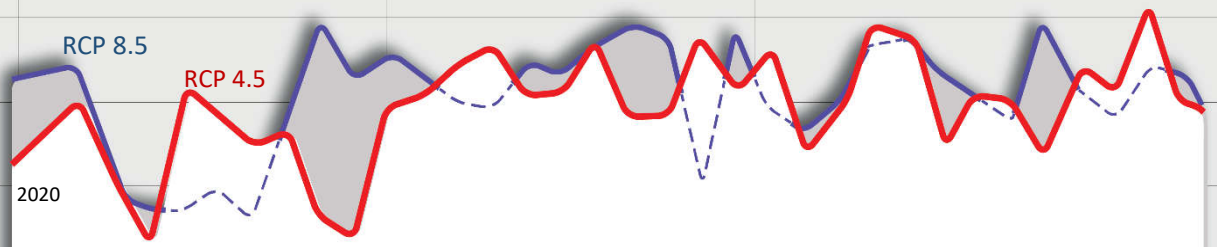
(2) Flemish Institute for Technological Research (VITO), Mol, Belgium

(3) Proefcentrum fruitteelt vzw, Sint-Truiden (Kerkom), Belgium





Increasing temperatures and fruit phenology

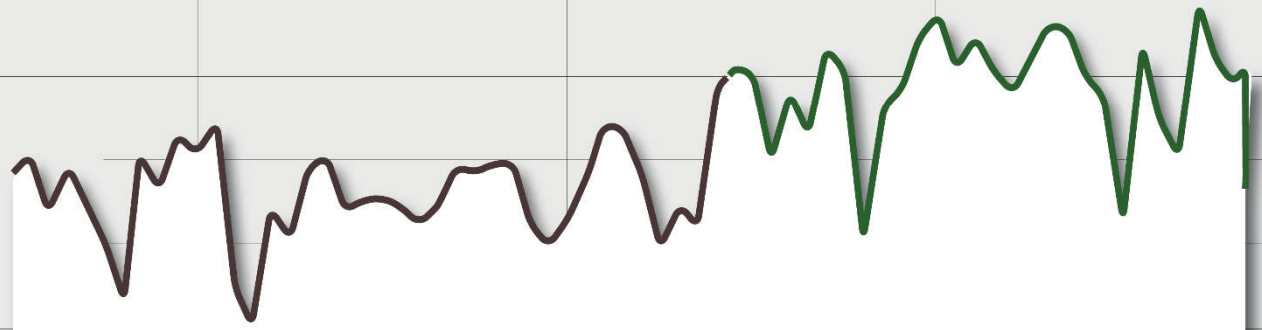
Bianca Drepper [1], Anne Gobin [1,2]

Comparing spatio-temporal trends for apple and pear in Belgium

Wim Verjans [3], Jos Van Orshoven [1]

KU LEUVEN

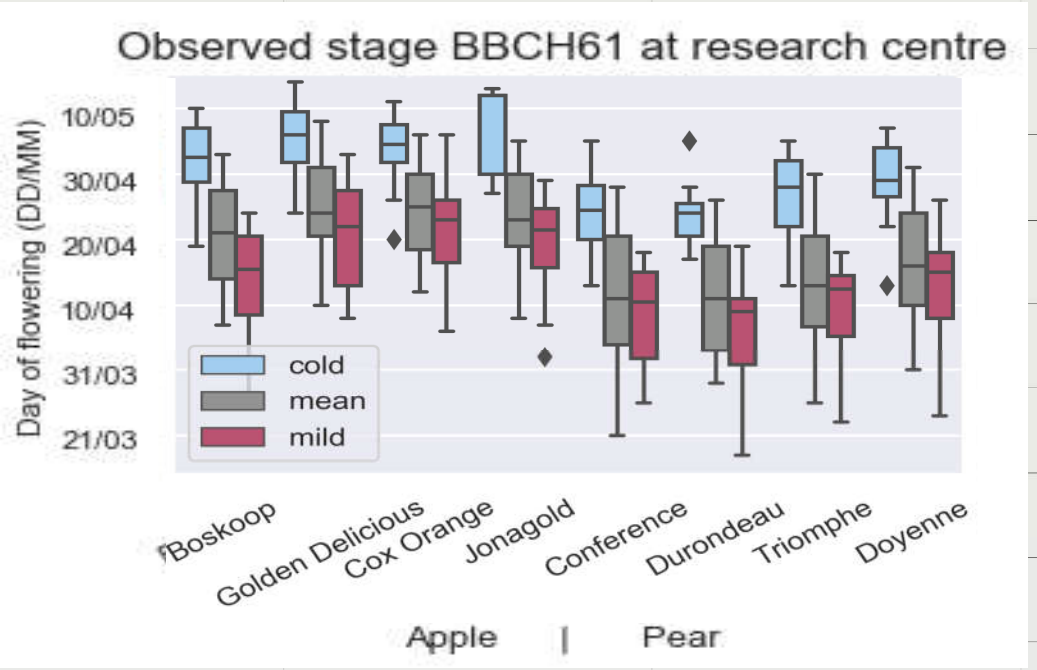
1) WHAT THE PAST 70 YEARS REVEAL *

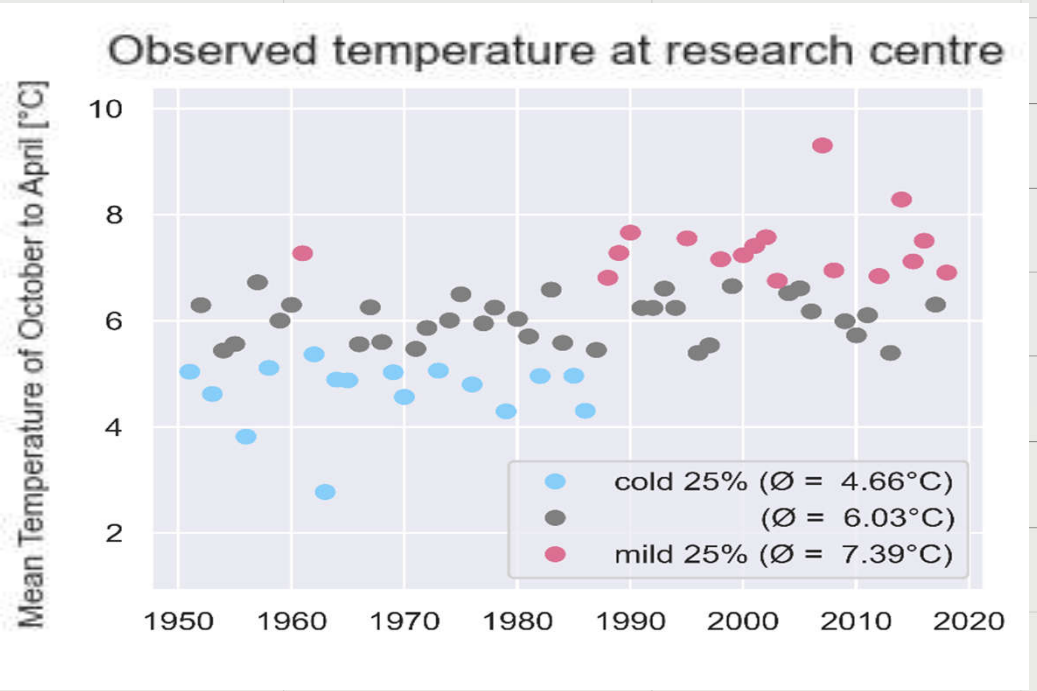


- **Pear trees flower 9 days earlier** than apple (median)
- Over time **pear flowering advances** 18% faster than apple flowering (9.8 days <> 8.3 days, Ø1990-2020 - Ø1950-1970)
- Mean winter **temperatures** ranked and grouped in 3 quantiles -> **Constant increase** (+1.36°C)
- **Begin of bloom** (BBCH61) grouped by the same quantiles -> **No constant decrease**
- **2017** frost hit the sector hard

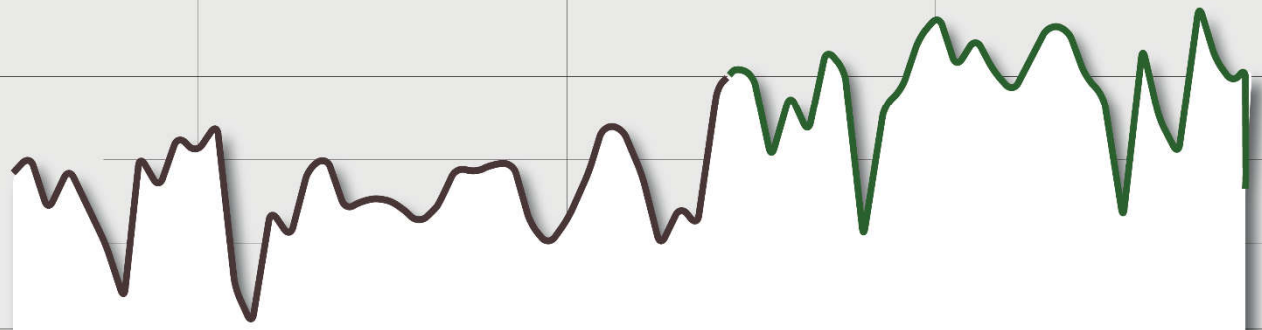
Drepper, B., Gobin, A., Remy, S., Van Orshoven J. "Comparing Apple and Pear Phenology and Model Performance: What Seven Decades of Observations Reveal." *Agronomy* 10, no. 1 (January 4, 2020): 73. https://doi.org/10.3390/agronomy10010073.

* Based on observations at the research centre for fruit pcfruit at the heart of the fruit growing region

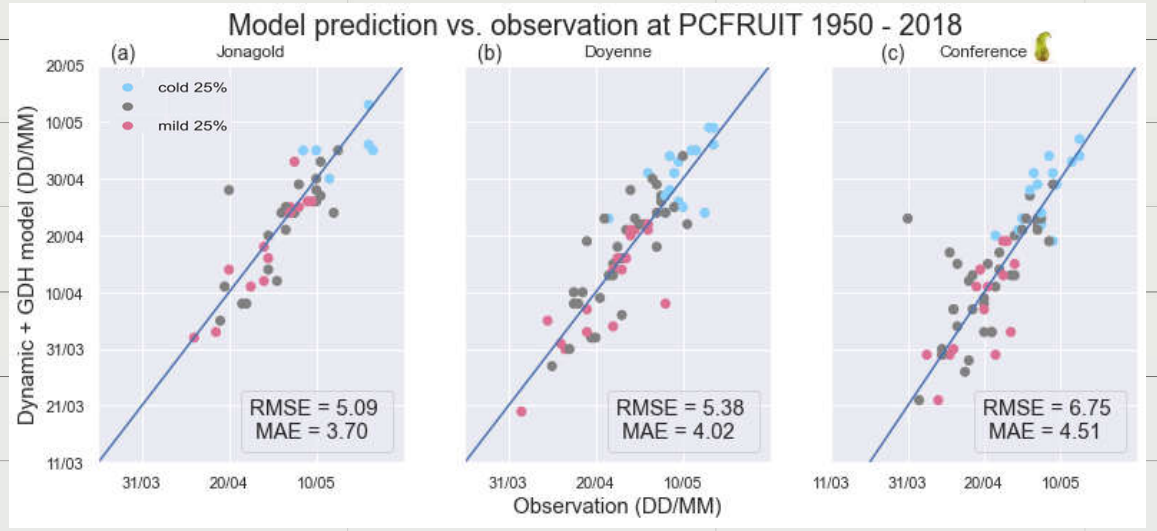


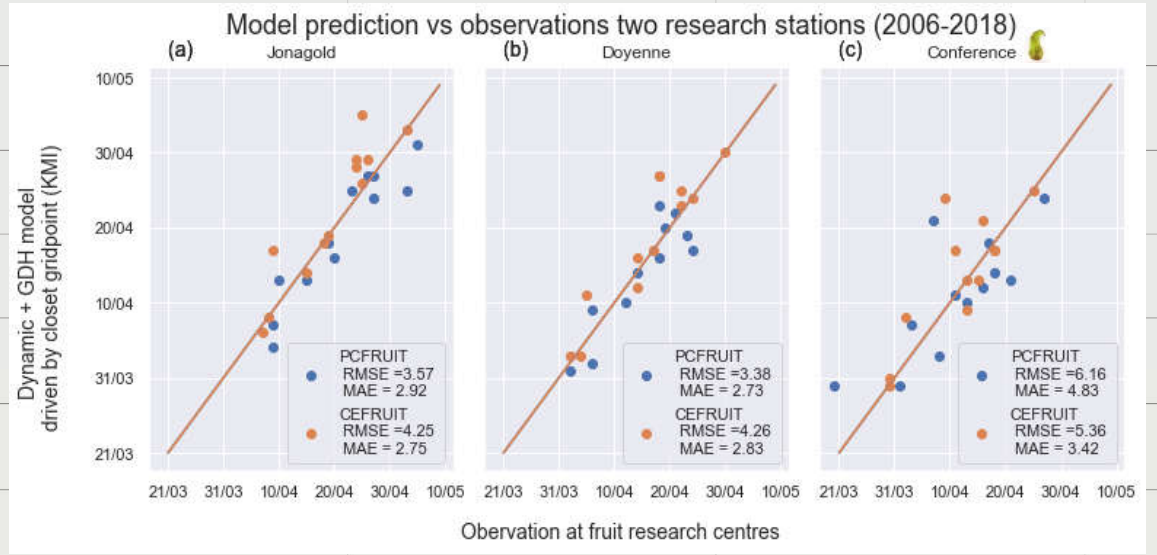


2) PHENOLOGICAL MODEL



- Built on observations based on Flemish station (pcfruit,1950-2018) :
  - **The dynamic model + GDH** (Erez, Fishman 1989, R package ChillR, Luedeling 2019) **performed best** (compared to 'Sequential model, M2' in Chmielewski et al., 2011)
- Testing against independent observations (driven by gridded meteo product)
  - Phenological observations from Wallonian research station (cefruit, 2006-2018): model performs well
  - 'Citizen science' observations season 2020: ongoing http://umap.openstreetmap.fr/nl/map/appel-en-peer-bloei-2020_427705





Drepper, B., Gobin, A., Remy, S., Van Orshoven J. "Comparing Apple and Pear Phenology and Model Performance: What Seven Decades of Observations Reveal." *Agronomy* 10, no. 1 (January 4, 2020): 73. https://doi.org/10.3390/agronomy10010073.

Chmielewski, F.M., Blümel, K., Henniges, Y., Blanke,M., Weber; R.W. S., Zoth, M. "Phenological Models for the Beginning of Apple Blossom in Germany." Meteorologische Zeitschrift 20, no. 5 (October 1, 2011): 487–96. https://doi.org/10.1127/0941-2948/2011/0258.

Fishman, S., Erez A., Couvillon G.A. "The Temperature Dependence of Dormancy Breaking in Plants: Computer Simulation of Processes Studied under Controlled Temperatures." Journal of Theoretical Biology 126, no. 3 (June 7, 1987): 309–21. https://doi.org/10.1016/S0022-5193(87)80237-0.

3) BIAS CORRECTION OF CORDEX MODELS

CORDEX Ensemble:

- 9 selected members from 3 Regional Circulation Models driven by 5 Global Circulation Models **~12.5 km²** resolution (see subplot titels)

Ground 'Truth'/Observation:

- **Daily min, max, mean temperature interpolated** on 5km² grid by the national met. Institute (KMI), 1970-2019**, regridded to match CORDEX**

Quantile mapping :

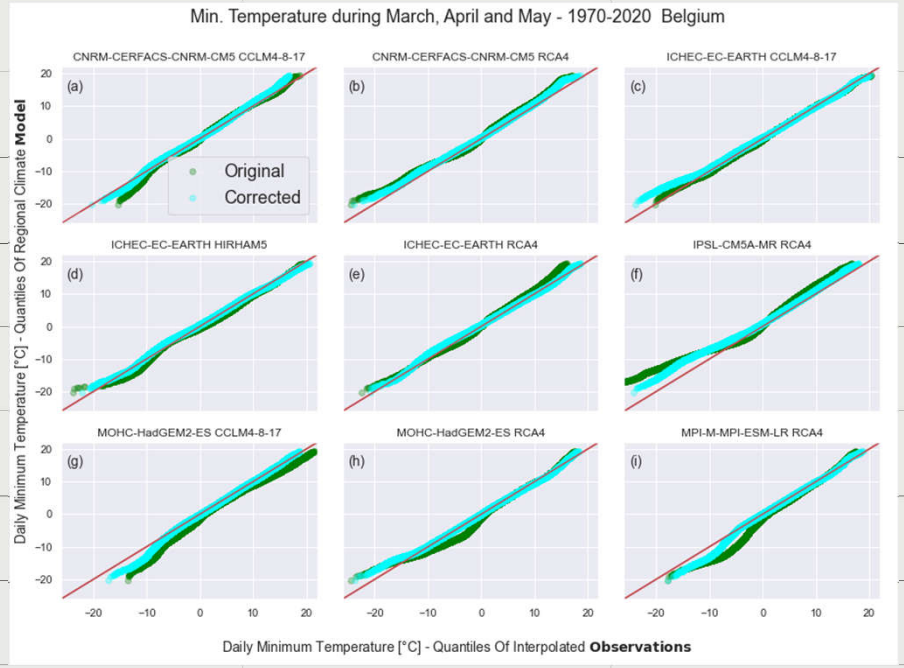
- N-dimensional probability density function transform **accounting for correlation between variables**
- R package MBC (MBC-n function, Mehrothra 2018, based on Cannon 2018)

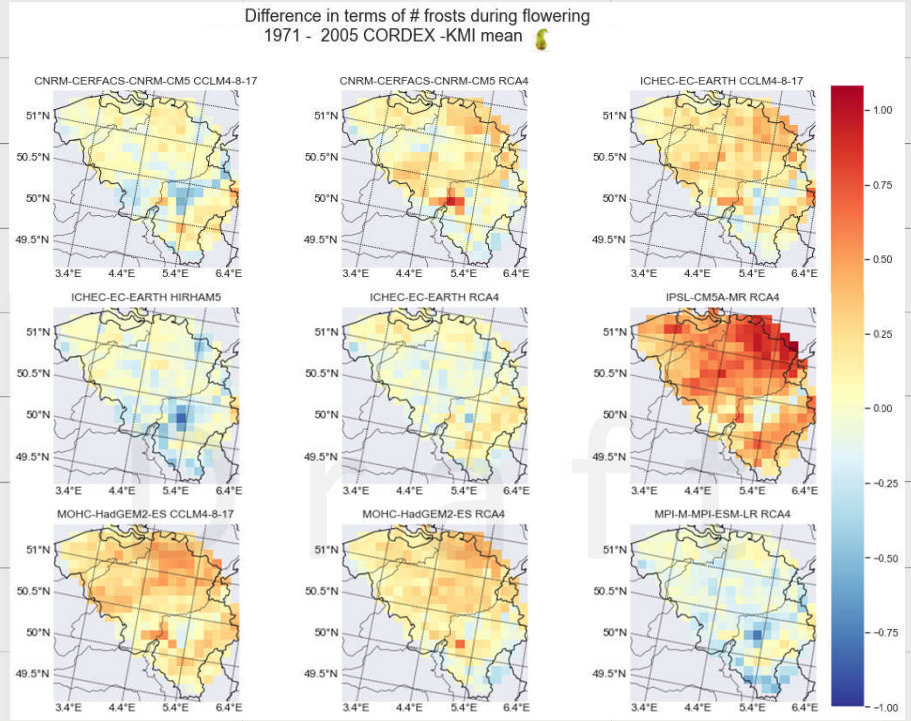
Performance:

- Quantiles over whole timeseries align neatly to observations
- Selection **spring : only small bias** remaining for min. temperature
- Count of **days < -2°C during flowering**: good, depends on topography
- Mean **flowering date: highly accurate** (see also slide 7)

Cannon, A. J. "Multivariate Quantile Mapping Bias Correction: An N-Dimensional Probability Density Function Transform for Climate Model Simulations of Multiple Variables." *Climate Dynamics* 50, no. 1 (January 1, 2018): 31–49. https://doi.org/10.1007/s00382-017-3580-6.

Mehrotra, R., F. Johnson, and A. Sharma. "A Software Toolkit for Correcting Systematic Biases in Climate Model Simulations." Environmental Modelling & Software 104 (June 1, 2018): 130–52 https://doi.org/10.1016/j.envsoft.2018.02.010.





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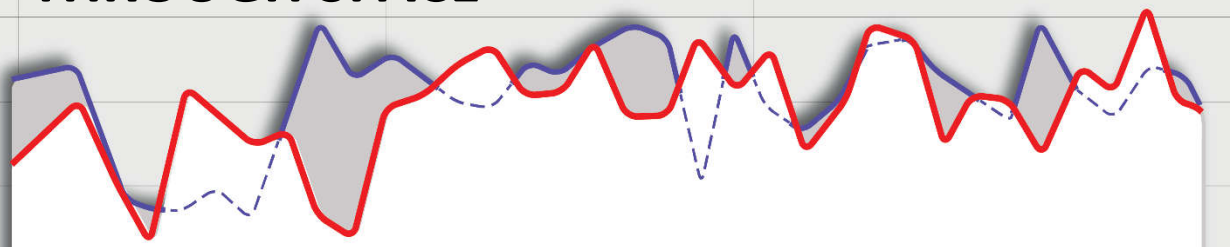
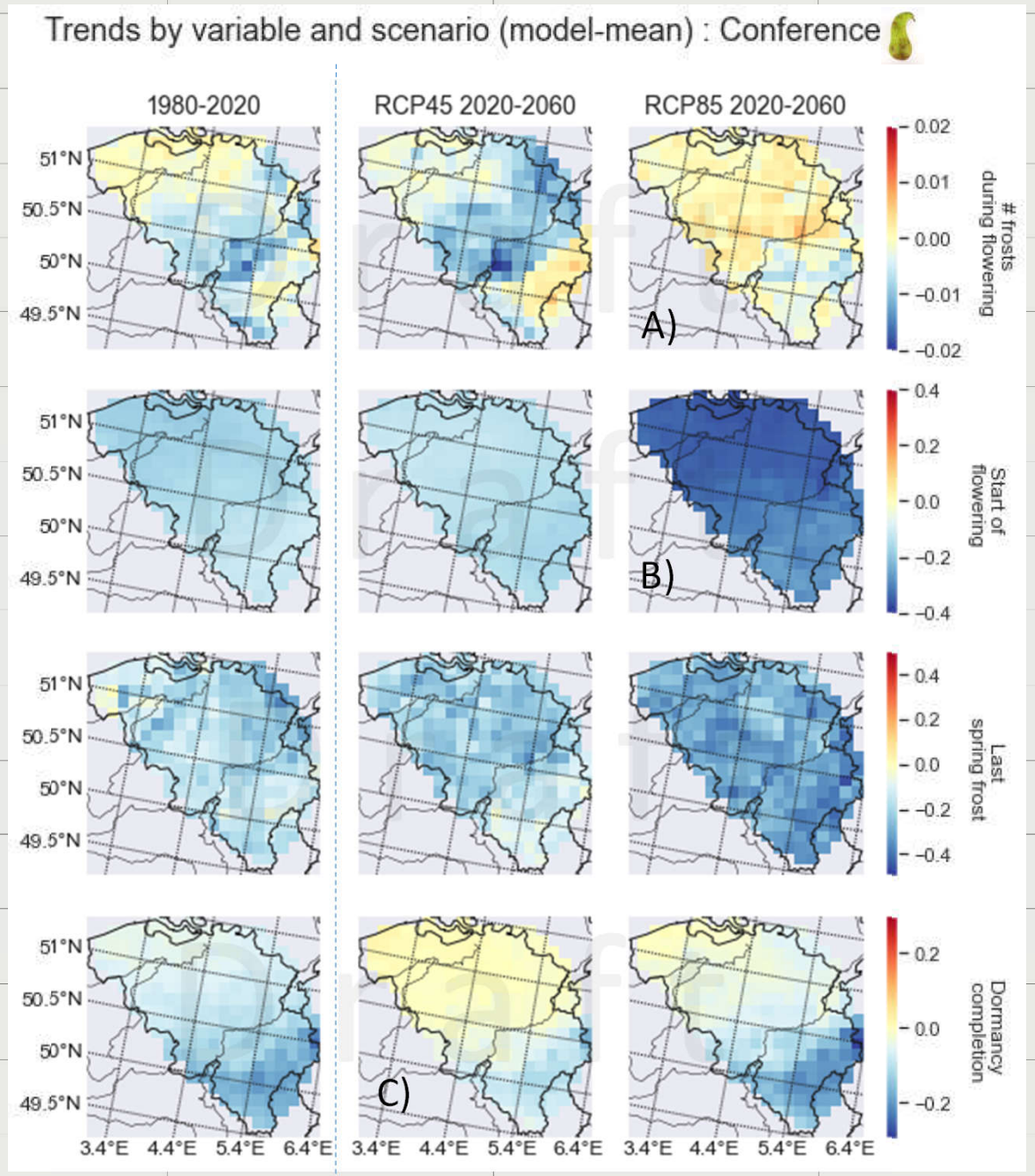
4) TRENDS OF PHENOLOGY AND FROST THROUGH SPACE





'Flowering' = frost **sensitive time defined as** modelled start of flowering -7 days and + 14 days

Trends = Slope coefficient over 40 years

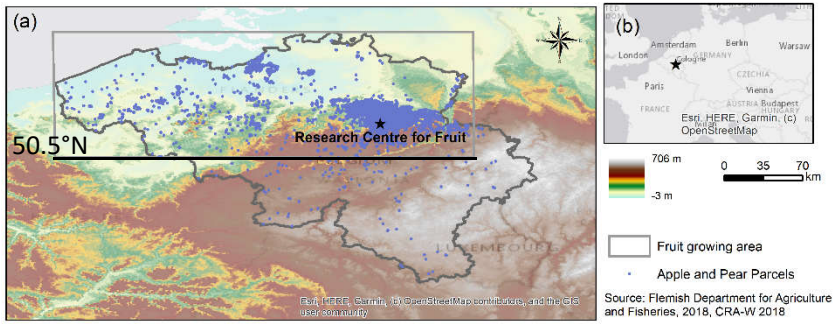
- red= later / more /higher
- blue = earlier / less /lower

-> On Climate-model-average for Conference

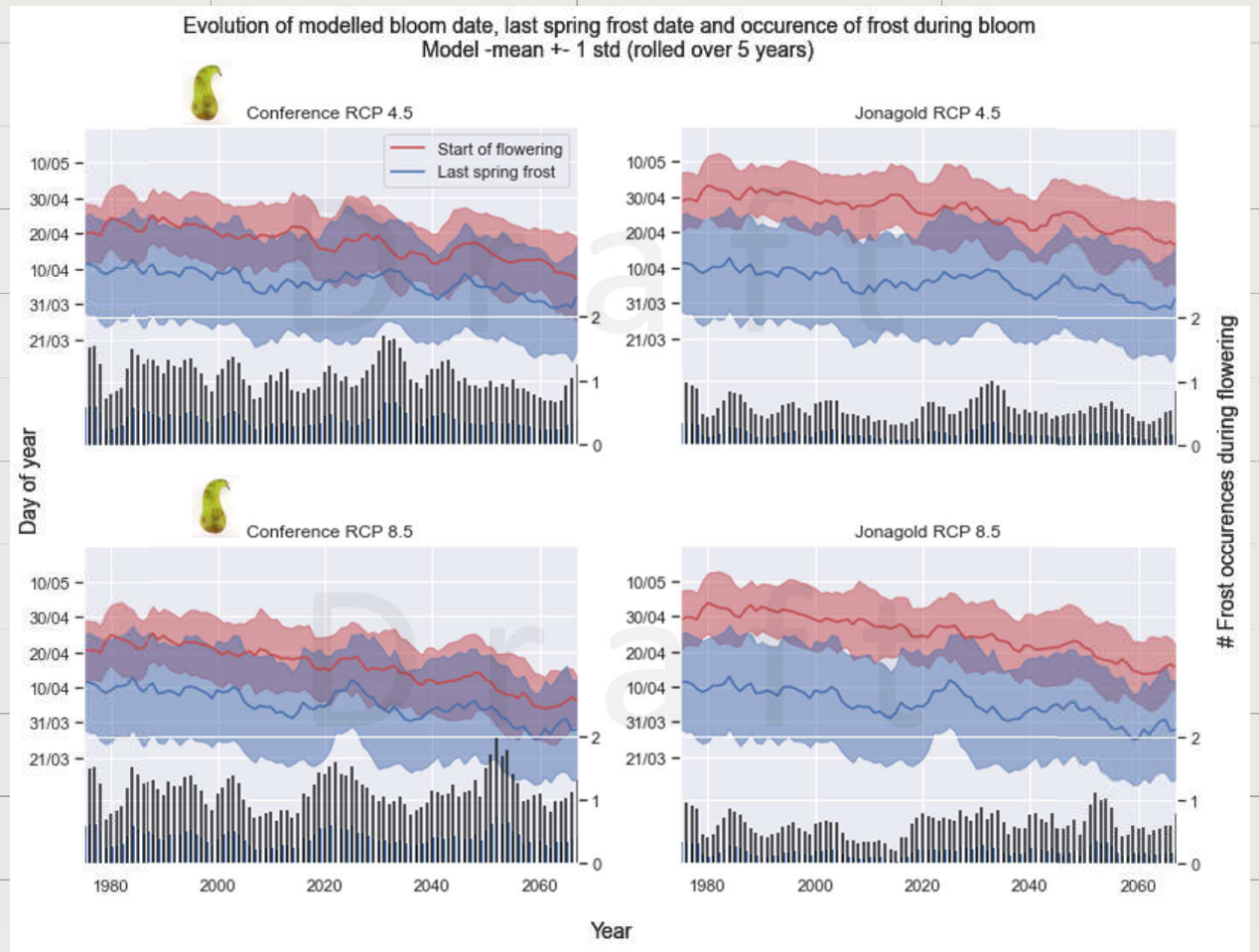
A) In the fruit growing region (> 50°N): **under RCP 8.5 more frequent frost during flowering**

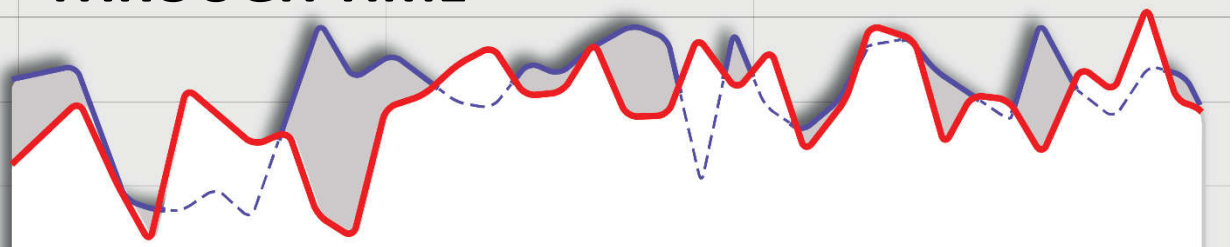
B) $Trend_{Flowering\ date}$ > $Trend_{Last\ frost}$

C) $Trend_{Dormancy\ fulfillment}$ changes direction in flat areas >< 'mountains'



5) TRENDS OF PHENOLOGY AND FROST THROUGH TIME





On average over Belgium for the two most common pear and apple cultivars:

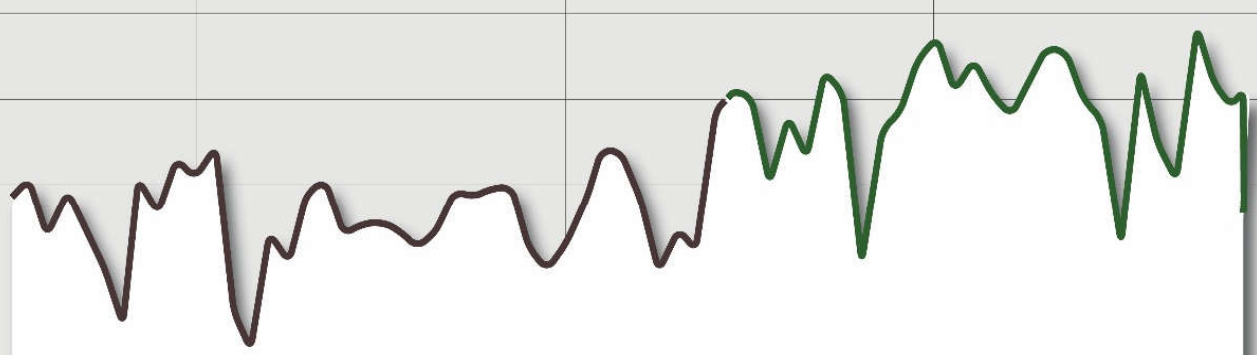
- The modelled **begin of flowering and is over time ~12 days earlier** under RCP4.5 and ~14 days earlier under RCP 8.5
- **The last day of frost** (Tmin < -2°C) **also occurs earlier** but at slightly lower pace

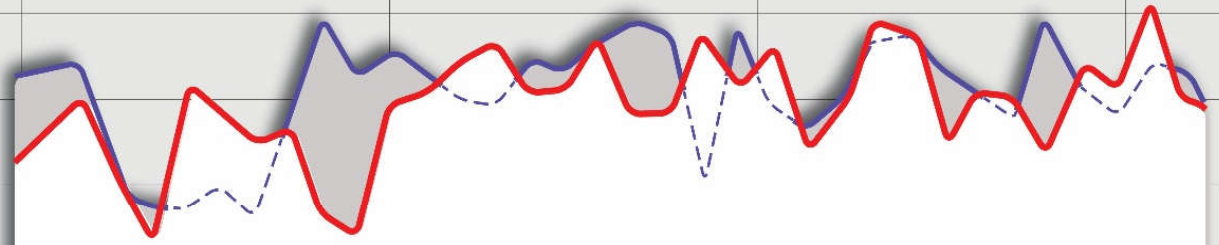
-> Occurences of frost during bloom period **increase**

- For 'Conference' more than for Jonagold
- More for 'business as usual scenario' (RCP8.5)
- High standard error in the count

6) CONCLUSION & OUTLOOK

Questions and suggestions are also welcome via bianca.drepper[at]kuleuven.be





- **Occurences of frost during bloom increases** over the coming decades
- Emission scenarios: **Worse perspective under 'business as usual'**

- Suitability of CORDEX is variable: **-> Multi Criteria Decision Analysis for robustness for phenological applications** is ongoing
- Currently increasing culture of **Conference cultivar is potentially problematic** -> better increase diversity

Absolute difference between CORDEX and the ground truth, KMI, (mean over 1971-2005): range over Belgium