Determining which areas in Europe will experience the most significant shifts in pest persistence under climate change

Eva SVOBODOVÁ[1, 2], Miroslav TRNKA[1, 2], Martin DUBROVSKÝ[2, 3], Daniela SEMERÁDOVÁ[1], Josef EITZINGER[2, 4], Petr ŠTĚPÁNEK[2], Zdeněk ŽALUD[1, 2]

[1] Institute of Agrosystems and Bioclimatology, Mendel University in Brno, Czech Republic
[2] CzechGlobe - Global Change Research Centre ASCR, v.v.i., Academy of Sciences of the Czech Republic, Brno, Czech Republic
[3] Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic
[4] Institute of Meteorology, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

MOTIVE AND AIM OF THE STUDY

- Climate change is likely to be a dominant factor affecting the lifecycle and overall occurrence of pest's species whose development is directly linked with climate conditions. Warmer conditions may be expected to promote the range shift of most of multivoltine species.
- **The main aim:** investigate the occurrence of selected species from the family Tortricidae (*Cydia pomonella, Lobesia botrana)* and the family Pyralidae (*Ostrinia nubilalis*), Chrysomelidae beetles (*Leptinotarsa decemlineata, Oulema melanopus*) and species from the family Aphididae (*Ropalosiphum padi, Sitobion avenae*) in changing climate in European domain.
- **Climate change**: global circulation models MPEH5, CSMK3, IPCM4, GFCM21 and HADGEM SRES-A2 in 2055.

METHODS AND DATA

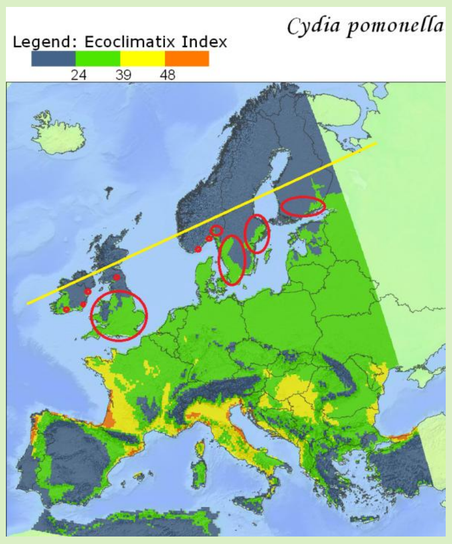
dynamical model CLIMEX

Input data: a) monthly long-term average TMIN, TMAX, RAIN, RH (9 a.m., 3 p.m.),
b) parameters characterising pests' development related to climate conditions – developmental thresholds

Output: *Ecoclimatic Index* EI - overall climate favourableness of the location for the pest occurrence. EI is the connection of the growth and stress indices and is scaled from 0 to 100. EI > 20 identifies locations very favourable for population growth and persistence.

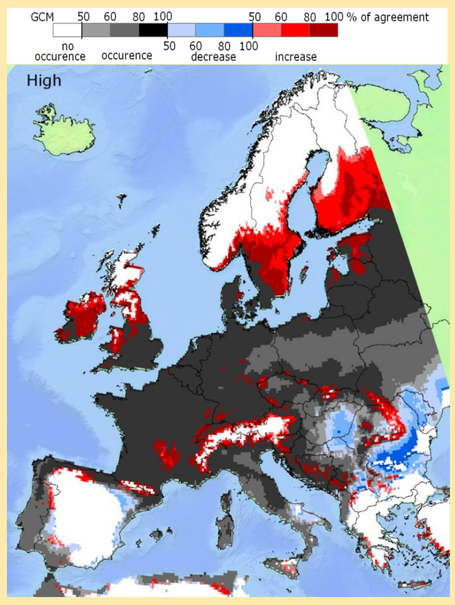
Validation: the comparison of the simulated potential pests' distribution to the field observations in the current climate conditions.

CURRENT CLIMATE – model validation



CLIMEX simulation: *C. pomonella*, visualisation of EI representing climate conditions favourable for the establishment of one (green), two (yellow) and three (orange) generations of the pest. Red circles mark observed occurrences of the pest. Yellow line constitutes potential northern range as was estimated based on the CLIMEX results.

EXPECTED CLIMATE



The most endangered areas in terms of increase or decrease in climate suitability ($\Delta EI_{scenario\text{-}present}$) for pests occurrence (*C. pomonella*, *L. botrana*, *O. nubilalis*, *L. decemlineata*, *O. melanopus*, *R. padi* and *S. avenae*). Determination of these areas was based on:

- all pest–scenario combination,
- agreement levels among scenarios.

Legend:

- red - increase in climate suitability,
- blue - decrease in climate suitability for pest development in terms of the decrease in generation number,
- grey - areas where the species is present under current climate conditions and climate suitability is expected to be maintained or to slightly increase without generation growth,
- transparency of the colours indicates the level of agreement among all pest-scenario combinations.

EXPECTED CLIMATE

Main consequences of increasing temperatures:

1. *Altitudal shift* = newly development of one or more generations in areas where the number of degree-days does not allow the completion of one generation under the current climate; mean shift of the species range to higher altitudes of about 400–1000 m.
2. *Shift of northern range* = the first generation newly in currently non-established northern areas, 100 – 750 km northward shift corresponding to a 1 ºC increase
3. *Generation growth* in currently established areas
4. *Shift of southern range* = retreat of species from the part of Mediterranean region, Spain, Portugal, Hungary and Black sea coast due to the limitations of high temperature and dry conditions.

IDENTIFYING AT-RISK AREAS

Increases in climate suitability for all species:

i) the southern coasts of Norway, Sweden, Finland and Denmark; most of the UK (northern regions located north of 55 ºN);
ii) higher altitudes of Europe (Alps, Carpathians, Massif Central, Pyrenees, Czech and Slovak mountains and Dinaric Alps)

Decreases in climate suitability: Hungary and the Black Sea coast

CONCLUSION Simulations using the climate change scenarios had signified the obvious trend in climate suitability shift for studied organisms. The results showed a shift in the developmental limitations of pest species, a subsequent widening of their areas of occurrence, and range shifts to higher altitudes and latitudes coupled with the production of more generations. The area of agricultural land that was predicted to be newly affected by pests when considering all of the modelled species was 16.28 million ha (2.70 million ha were located north of 55 ºN).

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