Department
for Environment
Food & Rural Affairs

Exploiting the high resolution JRC-MARS European climatic dataset for pest risk mapping

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Summary of the presentation

1. Climatic data for pest risk mapping: ideal versus reality

2. The JRC-MARS European climatic dataset is summarised

3. Three case studies are presented where JRC-MARS data have been used for UK pest risk mapping
   - *Thaumetopoea pityocampa* (pine processionary moth)
   - *Popillia japonica* (Japanse beetle)
   - *Hyphantria cunea* (fall webworm)

4. Advantages and disadvantages of JRC-MARS dataset

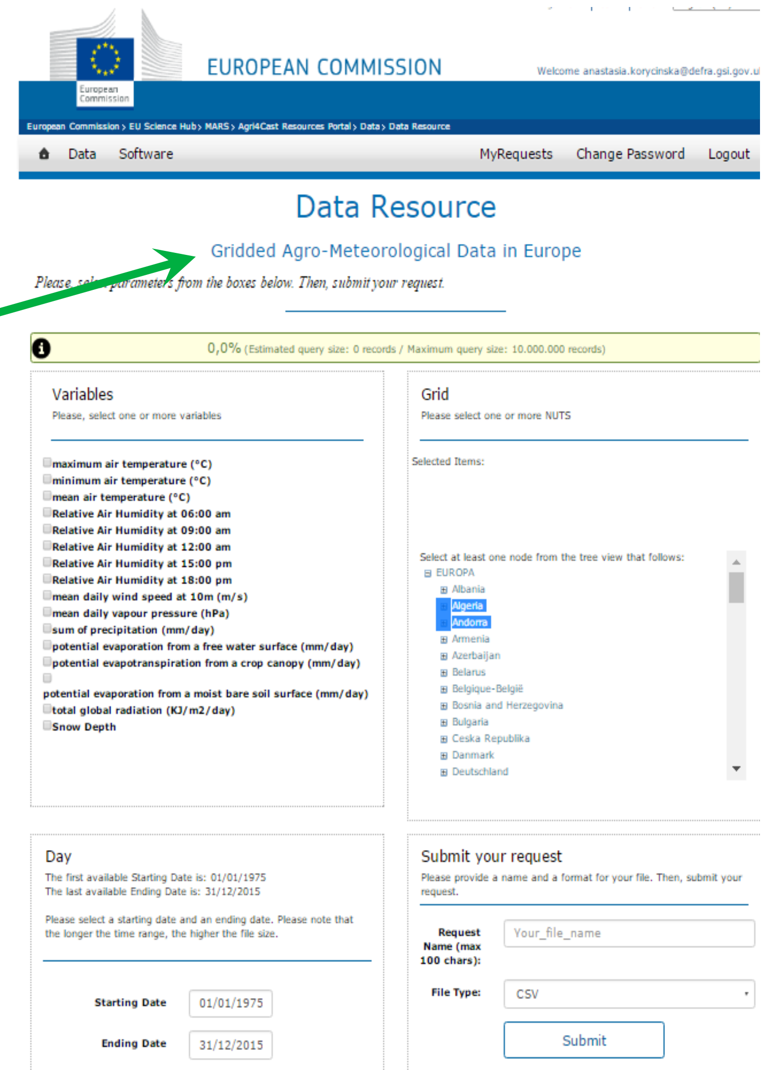
5. Future work using JRC-MARS data

Climatic data for pest risk mapping: ideal versus reality

To ensure that climatic data driving the models and underlying pest risk maps are as relevant as possible and help to inform surveillance/ control and management measures, the data need to:

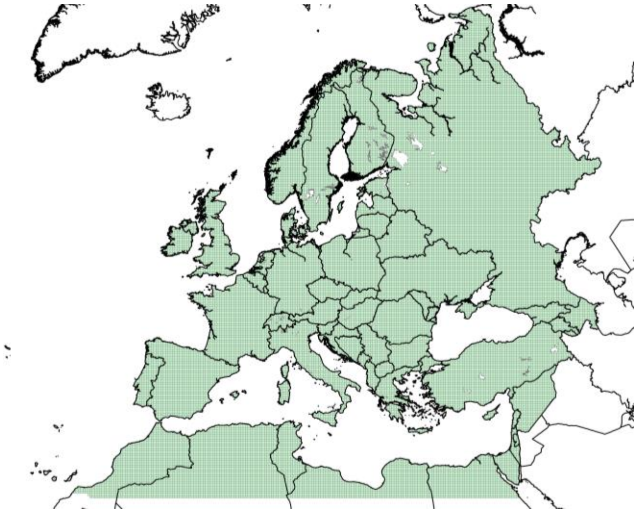
- Reflect current climates
  - Many key datasets are out of date, e.g. 1961-90
- Be interpolated to a spatial resolution relevant to the crops threatened
  - Most respected global datasets are at 0.5° or 0.1° latitude/longitude
- Be at a temporal resolution related to the life cycle of the pest
  - Many datasets provide only monthly, 30 year summaries
- Include all key climatic parameters needed for pest risk modelling
  - Many datasets only provide temperature
- Cover both the area of concern and neighbouring areas consistently
  - Datasets tend either to be based on one country or the world
- Ideally be freely available
  - And in an easily accessible format for analysis

The EU JRC-MARS Dataset
http://agri4cast.jrc.ec.europa.eu/DataPortal/



JRC-MARS dataset: details

- Open-access since 2011
- Resolution 25 km x 25 km
- 41 year time series available:
  - From 1 January 1975, to the December of the previous year
  - Currently 31 December 2015
- Interpolated to mean agricultural altitude
- Geographical coverage (green):



  - Data can be downloaded by single country
  - Also smaller regions (e.g. NUTS)

- Daily data available for the following climatic parameters:
  - Maximum air temperature (°C)
  - Minimum air temperature (°C)
  - Mean air temperature (°C)
  - Relative Air Humidity at 06:00 am
  - Relative Air Humidity at 09:00 am
  - Relative Air Humidity at 12:00 am
  - Relative Air Humidity at 15:00 pm
  - Relative Air Humidity at 18:00 pm
  - Mean daily wind speed at 10m (m/s)
  - Mean daily vapour pressure (hPa)
  - Sum of precipitation (mm/day)
  - Potential evaporation from a free water surface (mm/day)
  - Potential evapotranspiration from a crop canopy (mm/day)
  - Potential evaporation from a moist bare soil surface (mm/day)
  - Total global radiation (KJ/m^2/day)
  - Snow Depth

Comparing the JRC-MARS dataset with others

Dataset	Geographical coverage	Spatial resolution	Time period	Temporal resolution
Climatic Research Unit, University of East Anglia	World (land)	30’	1961-1990	Monthly
CliMond	World (land)	10’ or 30’	1961-1990	Monthly
WorldClim	World (land)	30’’ to 10’	1960-1990	Monthly
E-OBS	Europe +	15’ to 30’	1950 - part 2016 (currently)	Daily
JRC-MARS	**Europe +**	**25 km**	**1975 - 2015 (currently)**	**Daily**
National meteorological services	National	Dependent on individual datasets Usually high spatial and temporal resolutions		

Analysing JRC-MARS data

Using Microsoft Excel®

- Daily data for multiple grid squares = many rows of data
- Excel 2010 allows just over 1 million rows (2^{20} = 1,048,576)
- This limits the analyses possible in one spreadsheet, for example:
  - 1 year of data for France
- Multiple source spreadsheets can be used
  - Summary data extracted and combined in new file
  - Risk of copy errors

Using R

- JRC-MARS has a limit of 10,000,000 records
- Individual downloads can be combined in R
- R can deal with much larger amounts of data at once, e.g.:
  - 30 years from France
- Defra has R scripts for JRC-MARS data
  - These scripts can be run for both new or existing data
  - Annual accumulated degree days for a given threshold
  - Julian day reached for a given threshold

Popillia japonica: multi-year generations

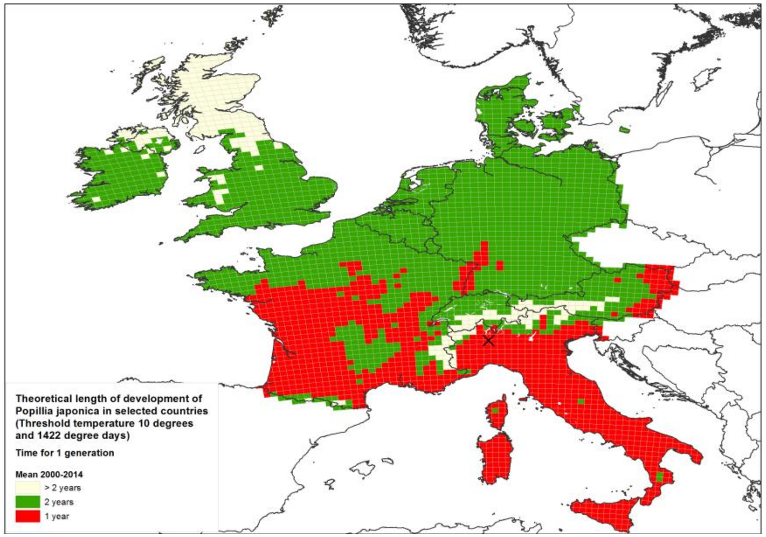
Background

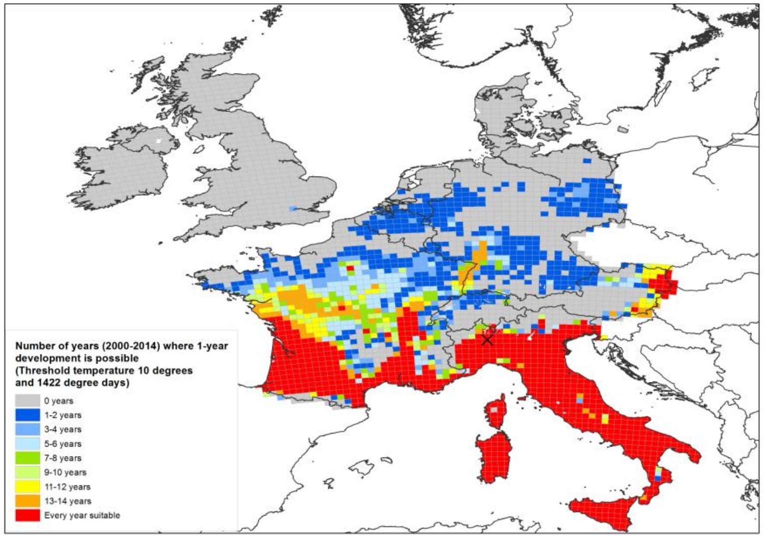
- Japanese beetle
- Larvae live in soil
  - Lifecycle can be 1 or 2 years long
- Native to Japan
  - North America since the 1910s
  - Azores 1970s
  - Mainland Europe: Italy 2014
- A number of previous studies on climatic requirements of this pest
  - Most are from the USA
  - Several very dated
- Soil moisture not considered for UK
  - May be important elsewhere in Europe
- 5 countries initially modelled, later increased to 11

Adult *Popillia japonica* on *Malus* leaf
(Image from Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org)

Displaying data with a temporal component

1. Average over a long time period
   - E.g., data from 2000-2014 = 1 map depicting average of 15 years for each grid square
     - Example – *Popillia japonica*
     - Red = 1 year lifecycle (average)
2. Analyse annual variation
   - E.g., number of years suitable for each grid square
     - Example – *Popillia japonica* 1- year lifecycle
     - Red = 15/15 years suitable
     - Dark blue = 1-2 years/15 suitable
3. Explore uncertainty
   - Example presented later, *Hyphantria cunea*, illustrates uncertainty based on different temperature thresholds





Thaumetopoea pityocampa: winter feeding

Background

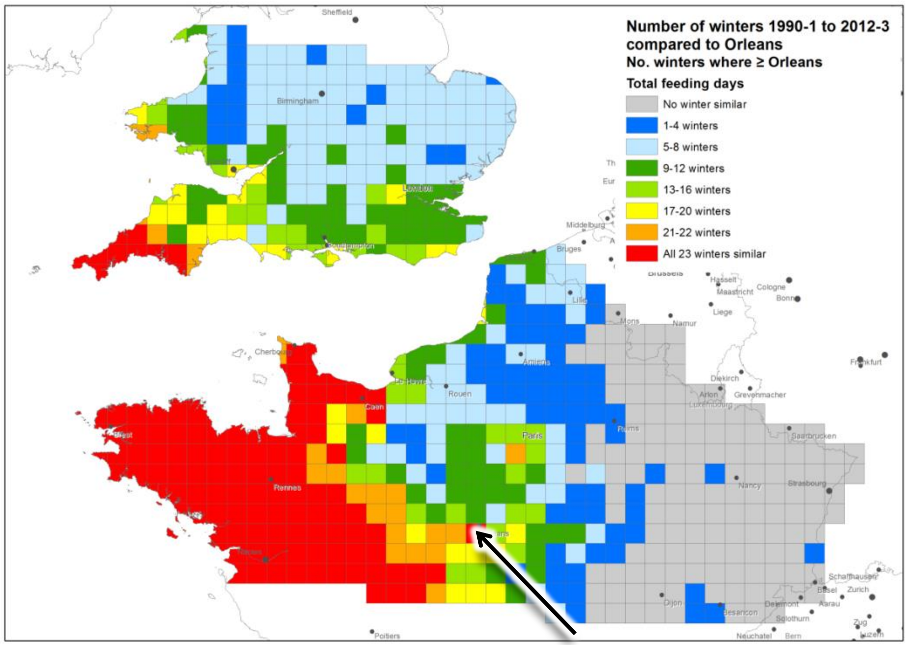
- Pine processionary moth
- Unusual life cycle:
  - Larvae actively feed over winter in silk nests
  - Sunlight raises nest temperature
- Spreading north in France, from Orleans into the Paris Basin

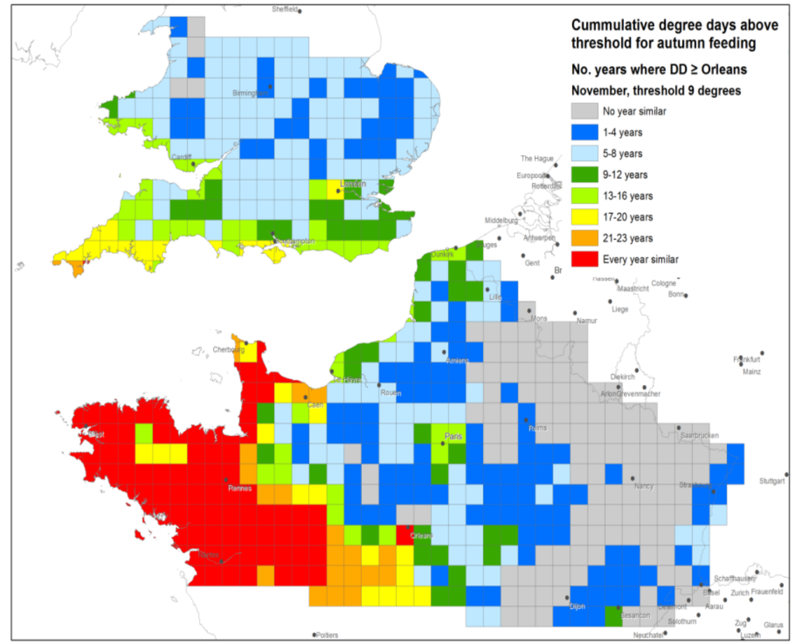
Thaumetopoea pityocampa larva.
Image courtesy of Fera.

- Several different models available, using temperature and sunshine
- Orleans was suitable for the pest from early 1990s onwards
  - In the absence of thresholds, values for every grid square compared with the Orleans grid square
  - Values ≥ Orleans value for the equivalent time period were judged to be suitable for the pest.
    - 1990 compared with 1990; 1991 compared with 1991; etc.

T. pityocampa: winter feeding

Comparing winter parameters with the Orleans grid square





Total winter feeding days

Number of winters 1990-2013 where a grid square was ≥ Orleans value (Orleans square marked with arrow)

Accumulated day degrees in November (threshold 9°C)

Number of years 1990-2013 where a grid square was ≥ Orleans value

<u>Conclusion</u>: Some parts of SW England are at risk from *T. pityocampa*

Hyphantria cunea: displaying uncertainty

Background

Adult *Hyphantria cunea* © Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

- Fall webworm, American white moth…
- Polyphagous leaf-feeding larvae
- Native to North America
    - Europe, first recorded 1940 in Hungary
    - Asia, first recorded 1945 in Japan
    - Spreading in Europe and Asia since
- Uni to multi-voltine lifecycles
    - Overwinters as diapausing pupa
- 12 different combinations of thermal thresholds found in the literature
    - Subset of 3 models used
    - Reasons for rejecting other models detailed in PRA
- Diapause not explicitly considered in this rapid modelling
    - Increased accumulation of day degrees required for diapause

Hyphantria cunea in Europe: uncertainty

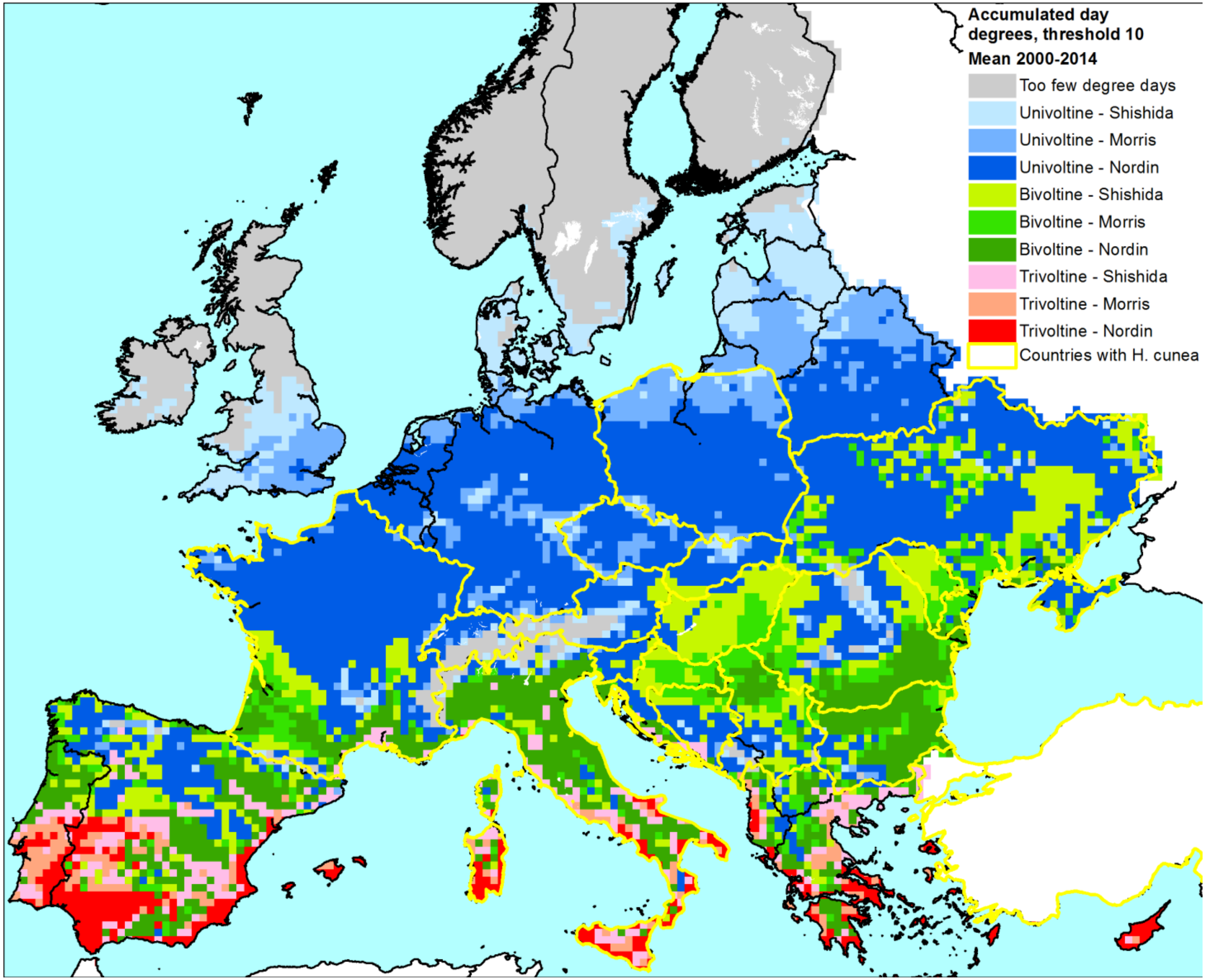
The darker the colours, the greater the number of sources agree the area is suitable

Grey = unsuitable

Blue = univoltine

Green = bivoltine

Red = trivoltine



Conclusion: Depending on the source model, parts of the UK may be suitable for univoltine populations

Conclusions (1): Advantages of the JRC-MARS dataset

Pest risk mapping and modelling in European areas has an excellent climatic data resource in the JRC-MARS dataset:

- High spatial resolution (25 km grid)
- Large area of geographical coverage (all of Europe, including European Russia, plus Mediterranean regions)
- High temporal resolution (daily data)
- Long and regularly updated time series (1975 – currently 2015)
- Wide range of climatic parameters included
- Freely available
- Data in an easily manipulated format (.csv files)

The UK will continue to use the existing R code on JRC-MARS data for general or preliminary analyses of selected pests

Conclusions (2): Limitations of the JRC-MARS dataset

- JRC-MARS data are interpolated to the mean agricultural altitude
  - This can lead to problems comparing this dataset with others
- When applying disease models, JRC-MARS does not contain all the necessary variables at the correct resolution
  - E.g. some models on *Guinardia citricarpa* require hourly leaf wetness
- The JRC-MARS data are at a 25 km resolution
  - This gives a general indication of each square's suitability
  - However, some areas of a given square are likely to be more suitable than others, e.g. south-facing slopes
  - Microclimate is also important
    - E.g., species which live inside tree trunks will be buffered
    - And isolated trees on the south edge of a wood are likely to be warmer than crowded trees in the northern part

Future Work

- The practicalities of importing JRC-MARS data into CLIMEX for more detailed analyses are currently being explored

- Not only establishment but endangered area must be considered

- Comparison of JRC-MARS and E-OBS datasets

- Investigating and representing climate change?

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