AgMIP The Agricultural Model Intercomparison and Improvement Project

Advancing Pest and Disease Modeling

Day 2, Introduction:

Building on what we have learned from past experiences for advancing capabilities

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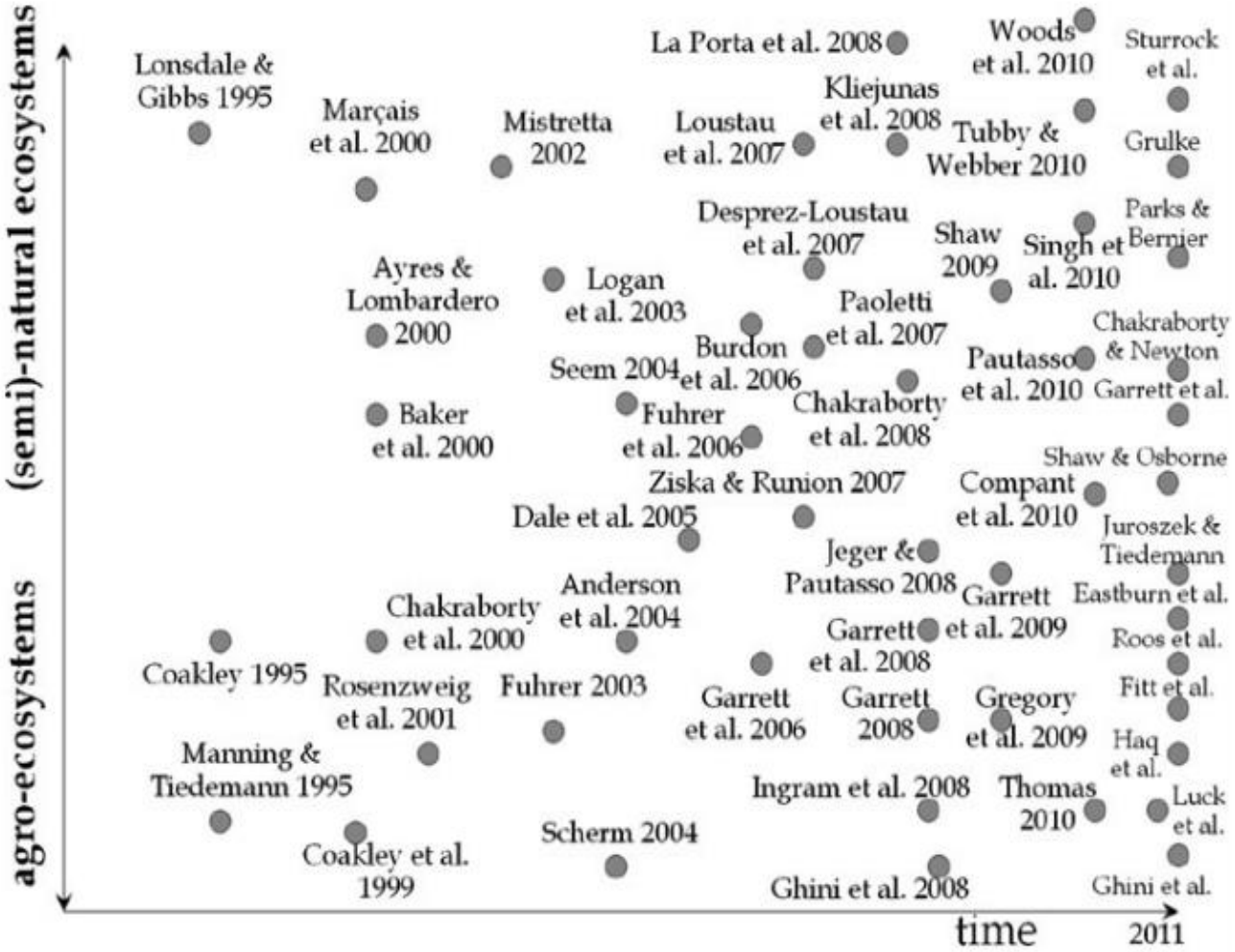
What target

- Articulated knowledge is available for modelling both biotic stressors and crops/cropping systems, even if there are areas which still require research.
- Coupling the knowledge on biotic stressors simulation to crop simulation is a big challenge when our target is operational; there is a need to make choices and concretely develop tools.
- Our interest is within climate change scenarios; we need to be fully aware that the environmental conditions are critical because «different» in a partially unknown way, and this diversity impacts on the modelling approaches we can select.
- We cannot expect to provide stable solutions, instead we need to design and develop a system to update knowledge and modelling tools.

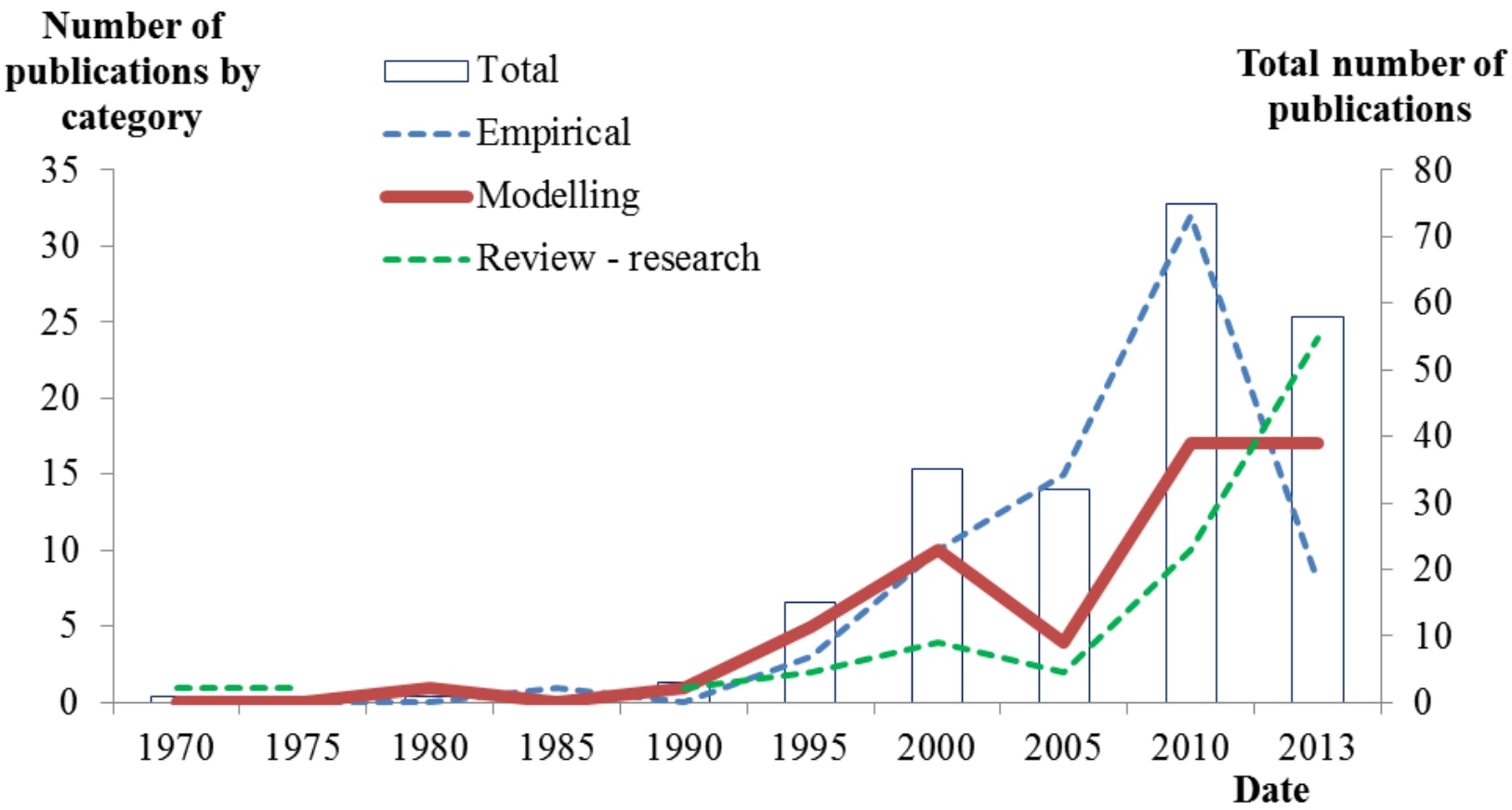
Climate change and plant diseases

- The analysis of the impacts of climate change on plant diseases started in the 90' (Pautasso et al., 2012)
- Many authors state that the assessment of host-pathogen interactions requires a case by case evaluation (Coakley et al., 1995).



Pautasso et al., 2012

Content of papers



Re-elaborated from Chakraborty (2013)

Main open issues from literature

"Findings on climate change influence on plant pathogens are often inconsistent and context dependent. Knowledge of pathogens affecting agricultural crops and natural plant communities remains fragmented along disciplinary lines."
Chakraborty, Global Change Biology (2013) 19, 1985–2000

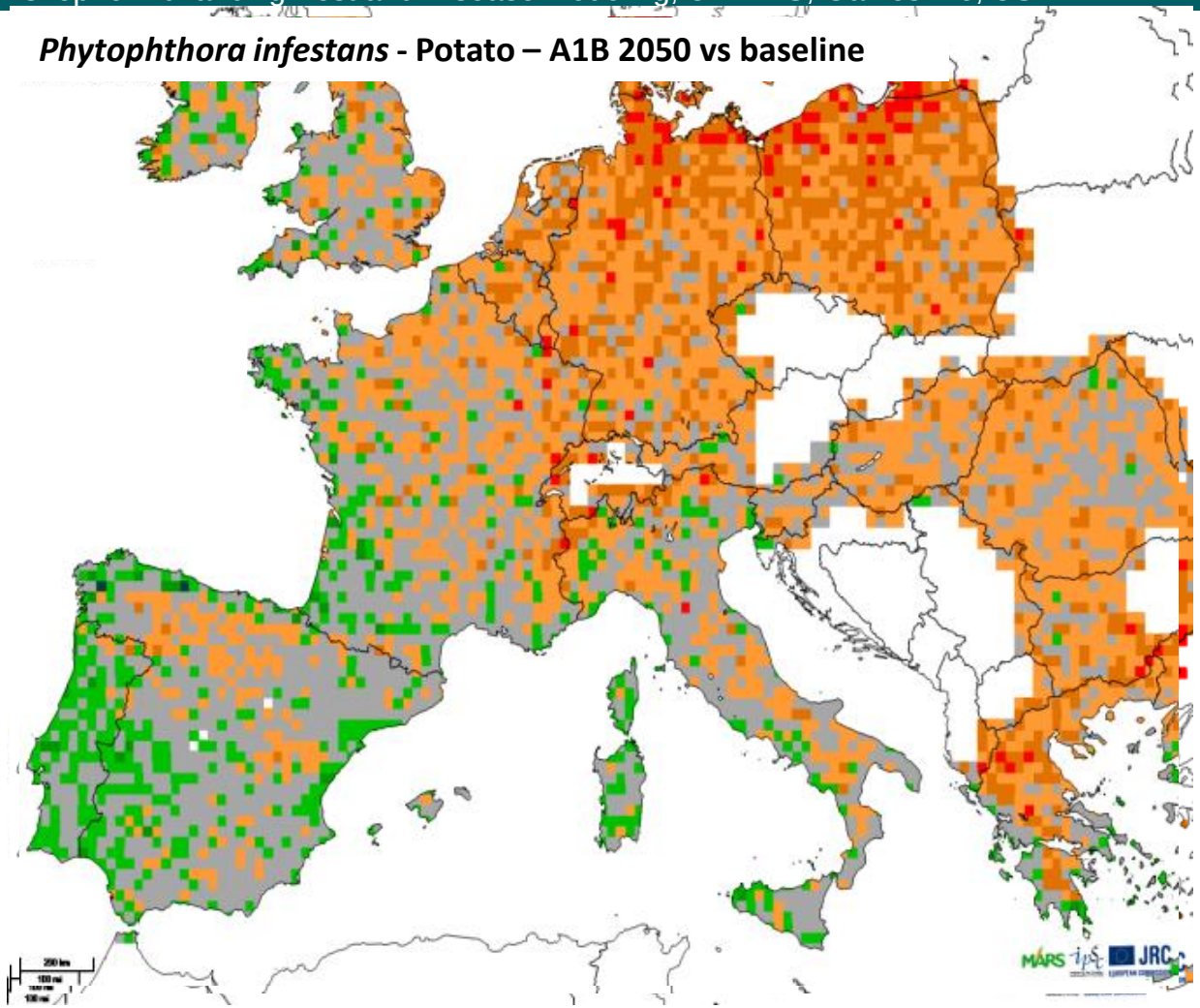
	Climate signature	Phatogen biology, ecology & epidemiology
Relevance	• Reduce uncertainty • Improve models • Justify research investments	• Management to target pathogen vulnerability • Maintain food security
Limitation	• Very few studies • Data sources from long-term experiments are ignored • No use of historical data to predict future trends	• No multifactorial study • No data of extreme weather impact • Knowledge of biology and life cycle is fragmented

A diversified future…

"The effect of changin
individual pathosyster
Garrett et al., Annu. R

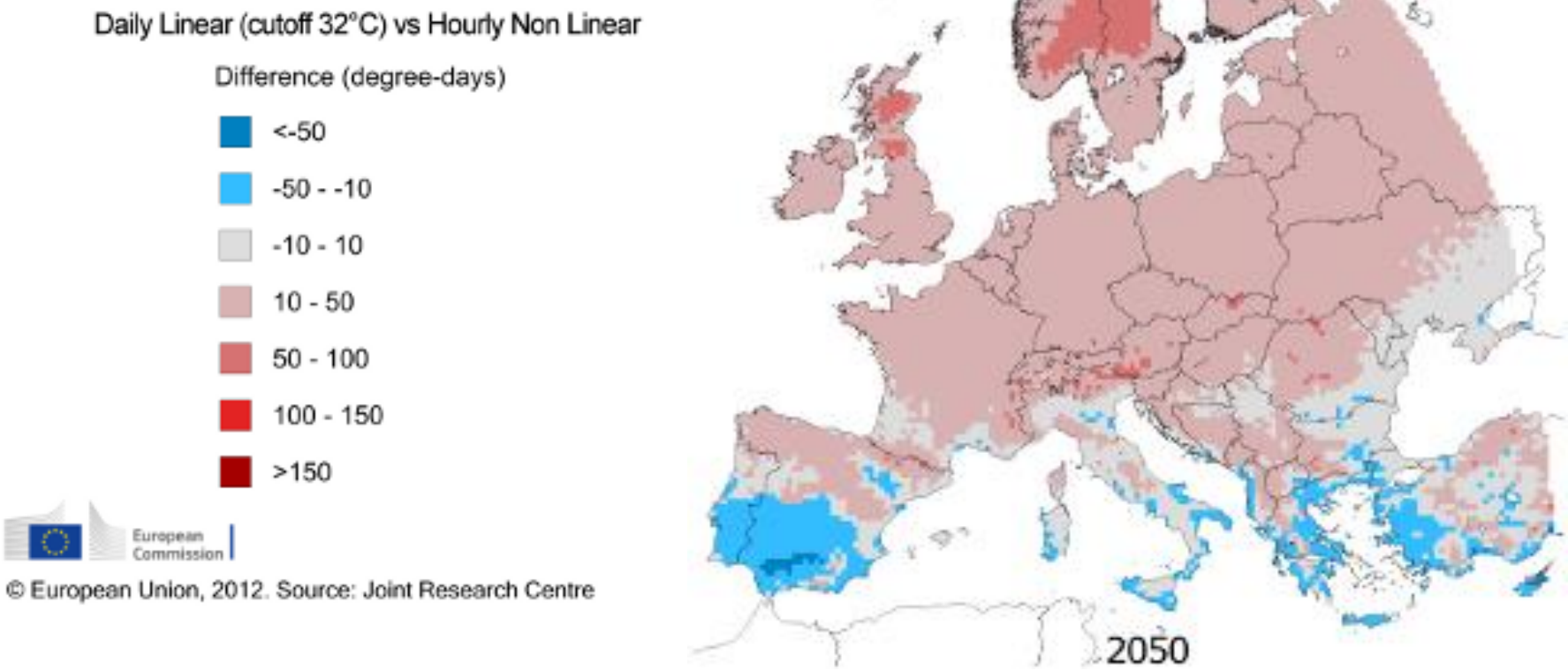
- **- infection events**
- **no variations**
- **+ infection events**

Magarey et al.' model of potential infection, 2005



Temperature responses

Comparing a curvilinear response phenology model to a broken linear with cutoff



An integrated (integrable) system

In practice, it may be necessary to expand models to include more components, identify those components that are the most important, and synthesize such models to include the optimal level of complexity for research prioritization.
Garrett et al., Plant Pathology (2011) 60, 15–30

…linking of pathogen dynamics, crop growth and climate models is essential in predicting disease risks under climate change.
Pangga et al., Plant Pathology (2011) 60, 70–81

- The target is set as using a modelling framework (e.g. the APS GENECROP and GENEPEST), possibly further stressing on:
  - Extensibility
  - Reusability of modules
  - Libraries of known crop/diseases approaches
  - Transparency
- Building a framework matching those requirements (and others) has been technologically at reach since many years!

Right answers for wrong reasons

- Even considering crop models only, data for thorough model testing have always been a limiting factor.
- For applications which do not allow using statistical models, we use process-based models which require for testing reference dataset rich of detail and cases, to avoid merely fitting data, i.e. setting parameter values which provide an acceptable matching to reference data, but which are almost meaningless for process based models.
- Including in the picture disease models and their interaction with crop models increases the requirements for dataset to be used for model evaluation, hence making the problem even bigger.
- Collecting data to develop models for generic reuse – which is not equivalent to collect data for context specific applications, remains a limit difficult to overcome but a prerequisite for improving crop+disease model predictive capabilities via testing.

Linking stress models to a crop

- Impact models can be linked to different states or rates of crop models with different implications

Type of impact model	Implementation	Evaluation
Modelling a crop efficiency factor (e.g. RUE)	Adjusting at run time the crop parameter value	Easiest implementation, difficult to get a reusable calibration
Modelling impacts on plant organs using an additive model of impacts	Integrate the relevant state variables independently and in sequence	Easy implementation, it may causes an overestimate of impact (“hidden” via calibration)
Modelling impacts using either a multiplicative or a *MaxValueEstimated* type function	Replacing the crop model process implementation and including an input from the stress models	Slightly more complicated implementation, max robustness of estimates, requires detail knowledge of interactions