ILCYM's Index Interpolator for regional pest risk assessments in mountainous regions

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Introduction

The International Potato Center developed the Insect Life Cycle Modeling (ILCYM) software, which supports the development of process based temperature driven and age-stage structured insect phenology models and applies obtained models for species distribution and risk mapping in a geographic information system (GIS) environment using different climate data scenarios (Sporleder et al. 2013, Kroschel et al. 2013). However, the use of global coarse and monthly sources of climate surfaces (Hijmans, 2004) is a limiting factor in the precision of predictions of the potential distribution and abundance of insects especially in mountainous regions. To improve the software capacity to capture the small-scale distribution of pests in those regions, a new tool for the interpolation of locally collected climate data was developed and integrated into ILCYM for analyzing and mapping pest risk indices at finer spatial and temporal resolution.

Objective

Development of the ILCYM's Index Interpolator tool (II-tool) to allow the assessment for pest risks in mountainous regions at higher spatial and temporal resolution using locally collected climate data.

Methods

The II-tool constructs surfaces through the fitting of thin plate spline functions of geographical position (longitude and latitude) and elevation estimated from means of climate variables. The analysis consists of developing a statistical model of spatial variation of observed climate variable means considering noisy estimates of standard period means. The II-tool uses the thin-plate smoothing spline algorithm (Hutchinson 1995, Hutchinson 2004).

Daily temperature data from 23 weather stations homogenously distributed across the Mantaro valley in the central highlands of Peru at altitudes ranging from 3,300 to 4,200 masl were applied for testing the tool. The tool was adapted to first calculate the three temperature-dependent risk indices (establishment index, ERI; generation index, GI; and activity index, AI) location by location and then conduct the interpolation of the calculated values (Fig. 1). The algorithm was successfully implemented in ILCYM.

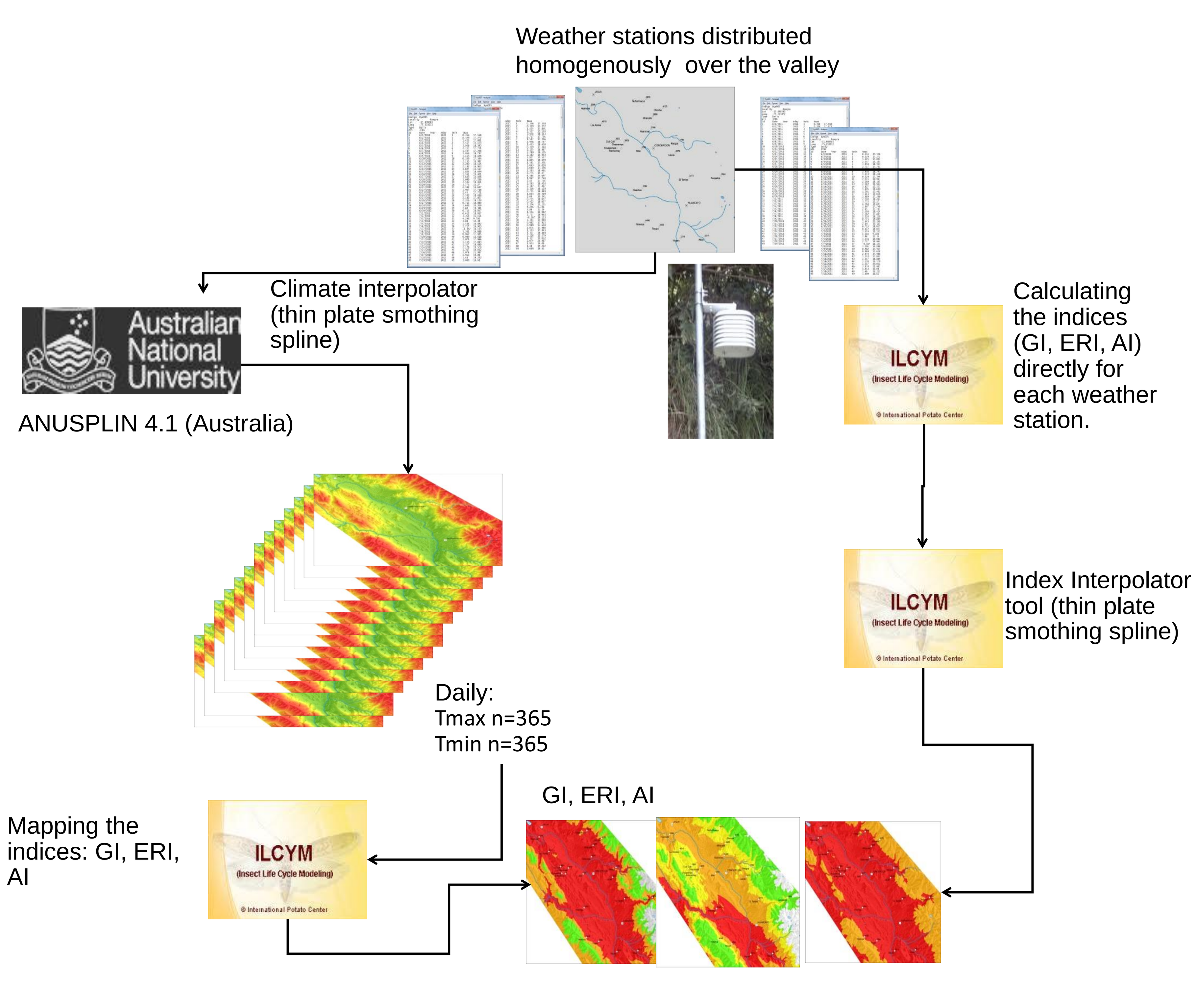

Fig. 1. Flow diagram to develop ILCYM's risk maps through the interpolation of climate input data (min. and max. temperature) in a first step cell by cell and then calculating the risk indices or by directly calculating the risk indices for each weather station and applying the Index interpolator tool.

Results

The II-tool inputs daily min. and max. temperature data and simultaneously calculates the three risk indices location by location. The II-tool applies the thin-plate smoothing spline algorithm to interpolate and constructs the surfaces. With this approach, the time for data processing could be considerably reduced yielding satisfactory results.

Based on locally collected climatic data, the II-tool simulates with high precision the potential establishment (ERI) and abundance (GI) of pests and provides detailed index variability that can be partly lost at lower resolutions; i.e. the II-tool can reach high spatial resolution (90 x 90 m) which is particularly useful in mountainous areas (Fig. 2, A1, A2). Additionally, the II-tool can predict the risk indices with hypothetically induced climate change scenarios by increasing the temperature stepwise (+1, +2°C) in the input data (Fig. 2, B1, B2). This innovative methodology overcomes the limitations of pest risk modeling and mapping in mountainous regions where temperature varies due to small changes in distance and altitude gradients.

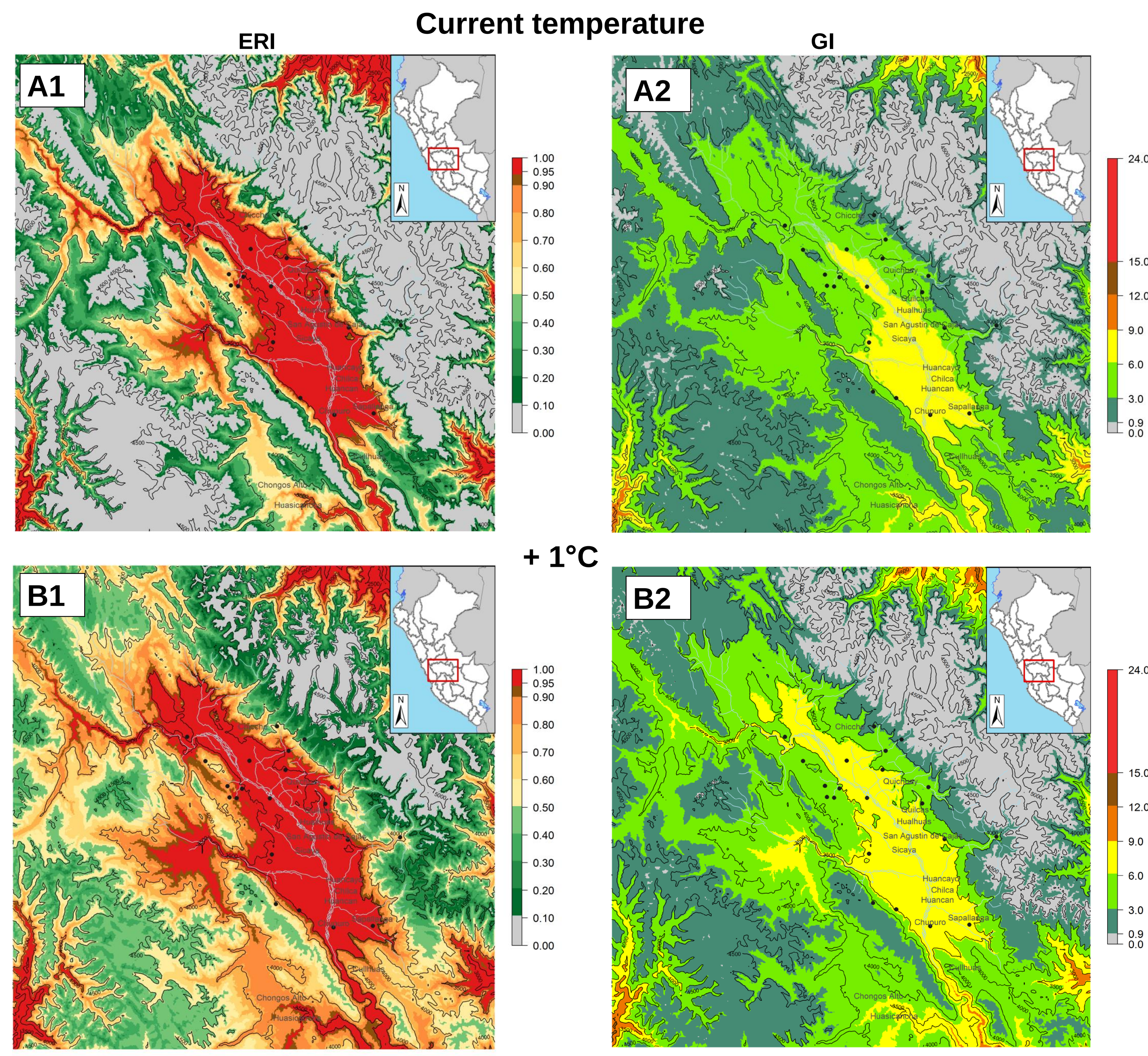

Fig. 2. Potential establishment (ERI) and abundance (GI) of the leafminer fly, *Liriomyza huidobrensis*, in the Mantaro valley, Peru, under current (A1, A2) and induced (+1°C, B1, B2) temperature conditions to simulate impacts of climate change.

Conclusions

- Spatial and temporal resolution are limiting factors in the accuracy of pest risk assessment. The Index Interpolator tool expands the usability of ILCYM to achieve higher temporal and spatial resolutions by using locally collected climatic data.

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