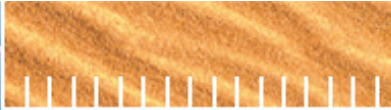




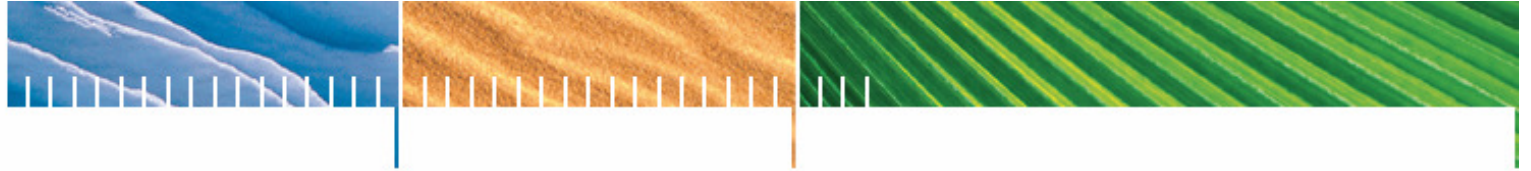
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Malaria Epidemiology Modeling Using Volunteer Computing

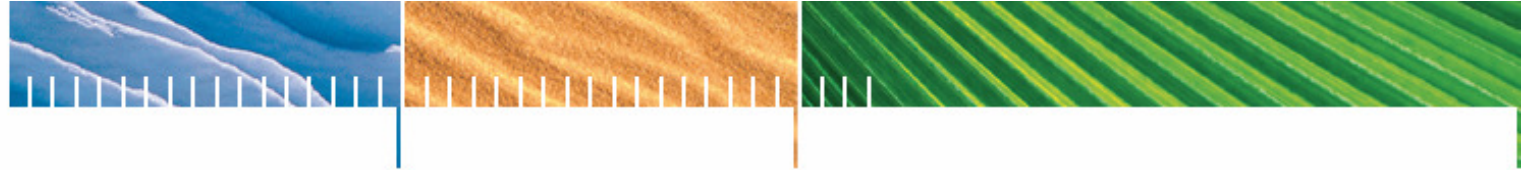
Nicolas Maire
Swiss Tropical Institute
ISGC 09





Malaria and malaria models

- Malaria: a mosquito-borne disease caused by a parasite
- One to three million deaths per year
- Hundreds of millions of illness episodes per year, up to 40% of health expenditure
- Indirect cost through lost productivity
- Mathematical models have been a valuable decision making tool in public health, especially planning vaccination strategies
- Increasing demand for rational setting of priorities

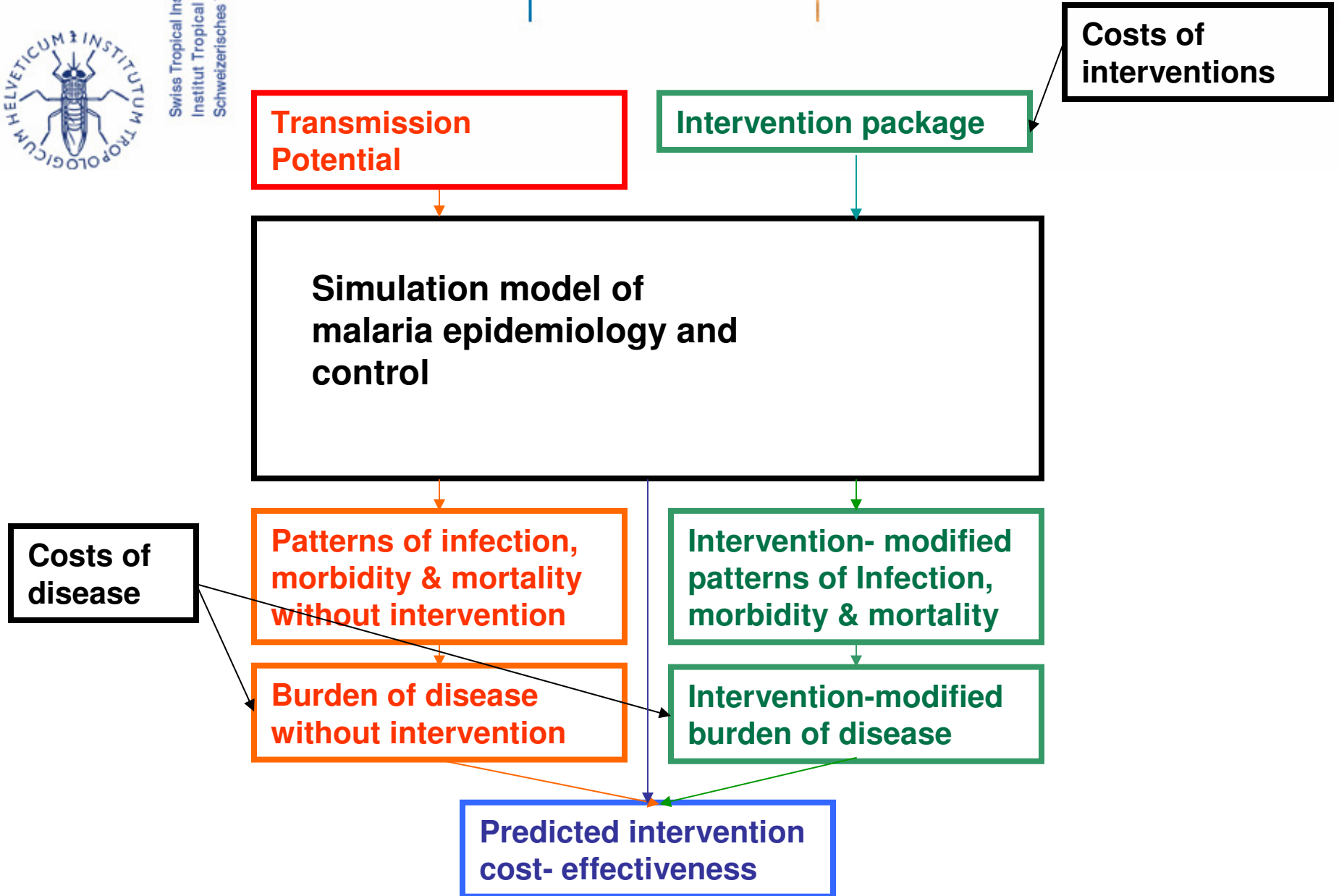
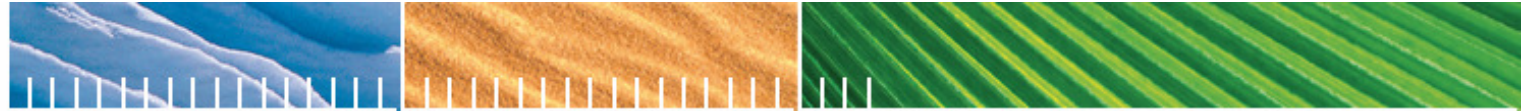


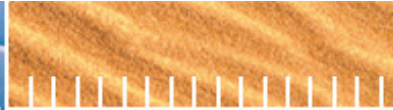
Simulation models of malaria transmission and control

- July 2003: Mathematical modeling of the impact of malaria vaccines on the clinical epidemiology and natural history of Plasmodium falciparum malaria
 - Funded by MVI/GSK
 - Effectively 2 year project
- June 2006: Simulation modeling of the epidemiological impact and cost-effectiveness of malaria interventions
 - Funded by BMGF
 - 3 year project
- March 2009: A stochastic simulation platform for predicting the effects of different malaria intervention strategies
 - Funded by BMGF
 - 2 year project



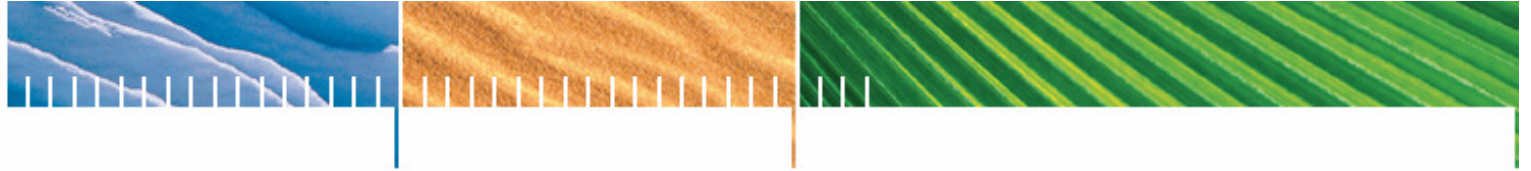
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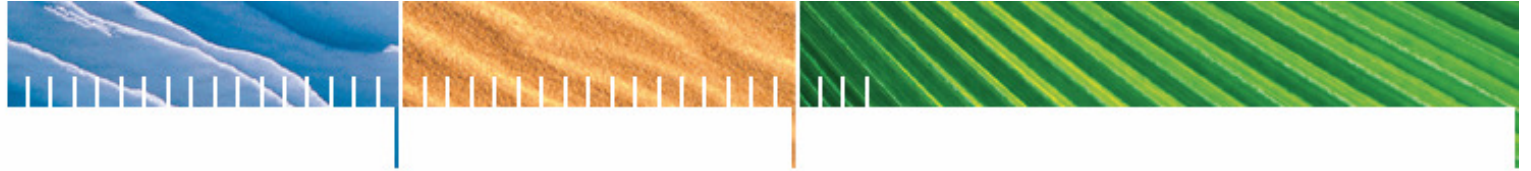
Modeling approach

- Discrete time stochastic individual-based simulations
 - Human hosts are characterized by a set of state variables (age, parasite densities, immune status variables, infectiousness)
- Models for the effect of acquired immunity on parasite densities, for transmission to the vector, for morbidity, and for mortality, as functions of parasite density
- Fit model to data from field studies
- Predict impact of control strategies by comparing simulated interventions with baseline scenarios

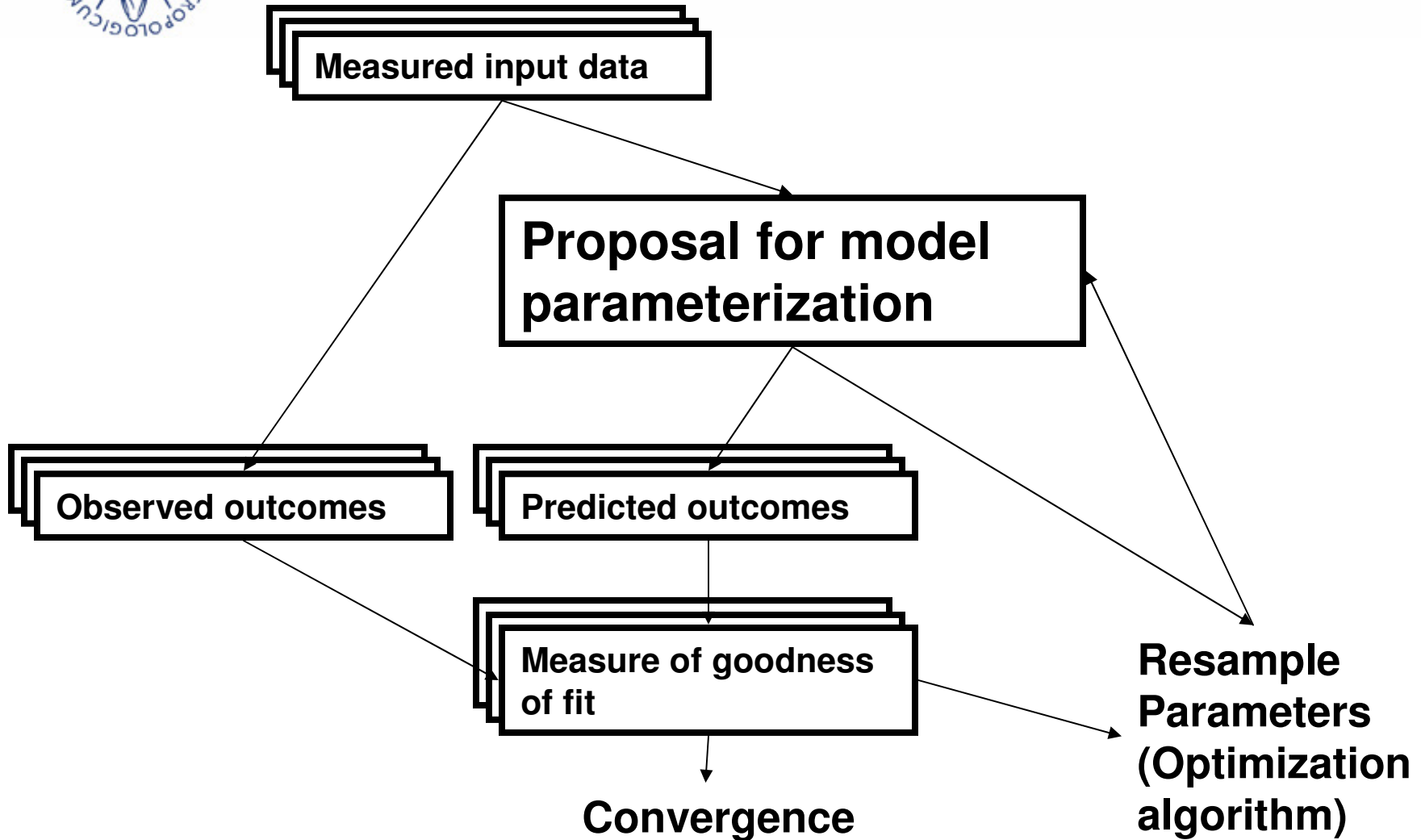


Simulation objectives

- Fitting of model parameters to field data
- Prediction for a range of scenarios
- Sensitivity analysis
- Expected value of perfect information



Estimating model parameters from field data

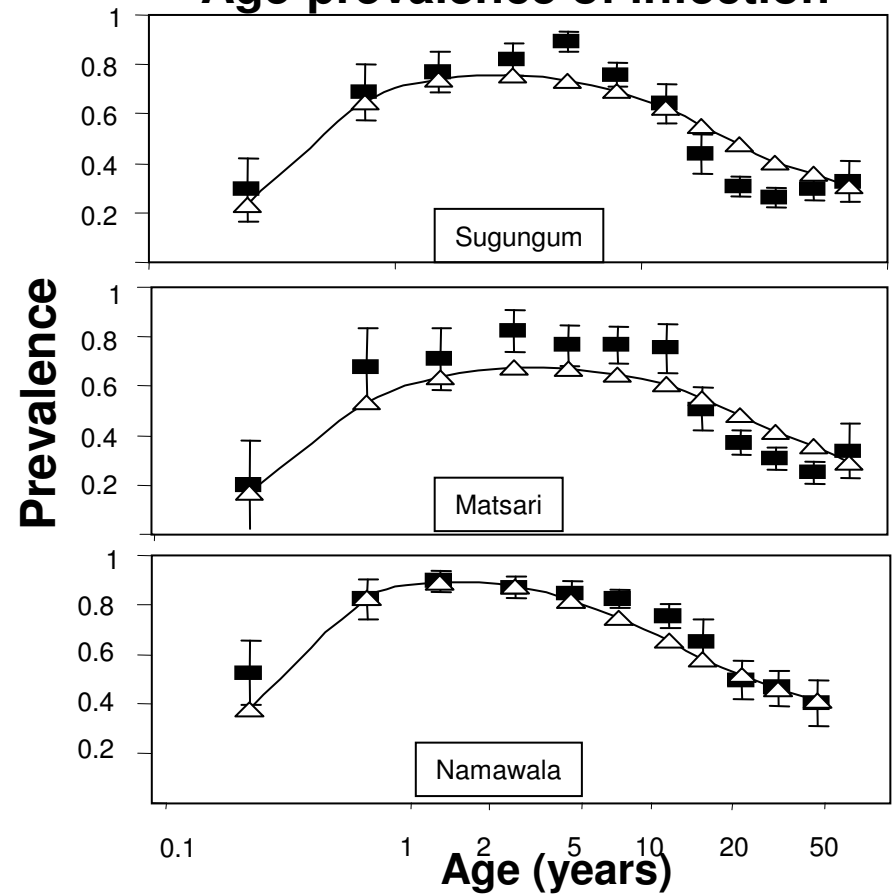




Calibration

- 61 datasets from field studies, different objectives*
 - Incidence of infection
 - Age-prevalence of parasitemia
 - Seasonality of parasitemia
 - Age-density of parasites
 - Age-incidence of clinical disease, hospitalisation and mortality

Age-prevalence of infection



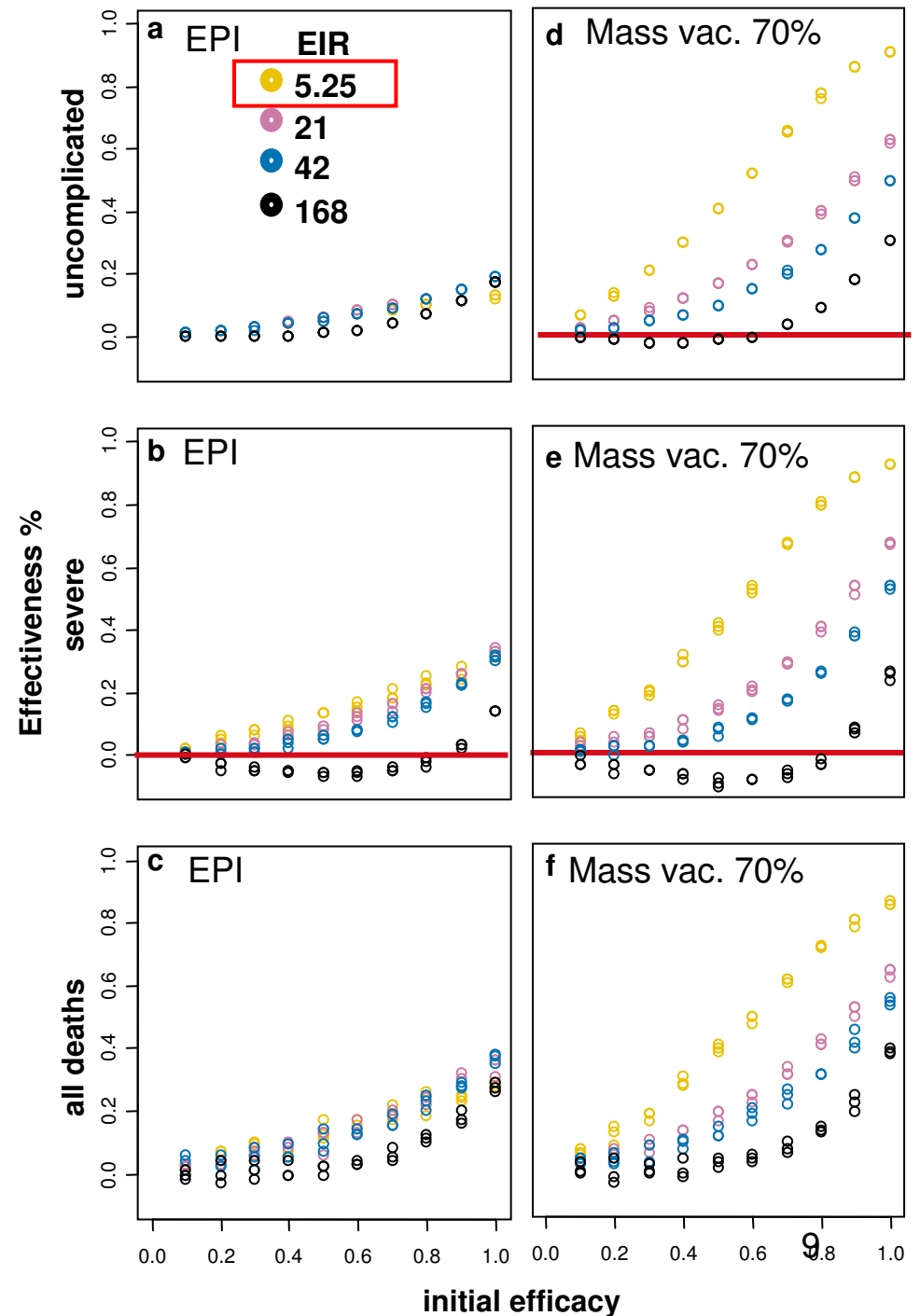
■ Field data (CI) △—△ Model

*all related to seasonal patterns of transmission

PE-Vaccine – key results

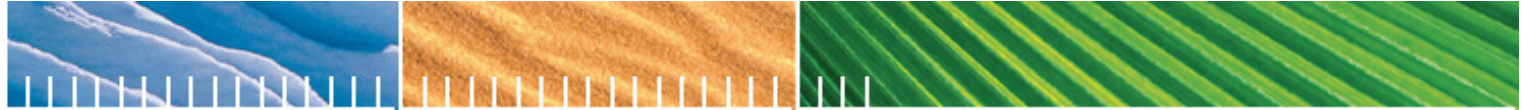
- Most effective : low transmission
- Can achieve local elimination in low transmission settings
- At high transmission with mass vaccination observe negative efficacy (delay of events in whole population)
- (Penny et al, 2008)

23.04.2009

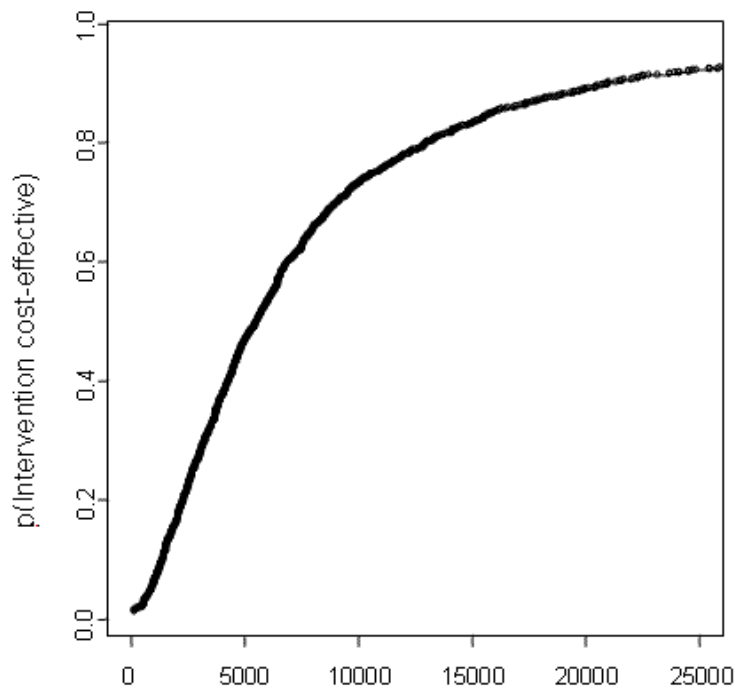




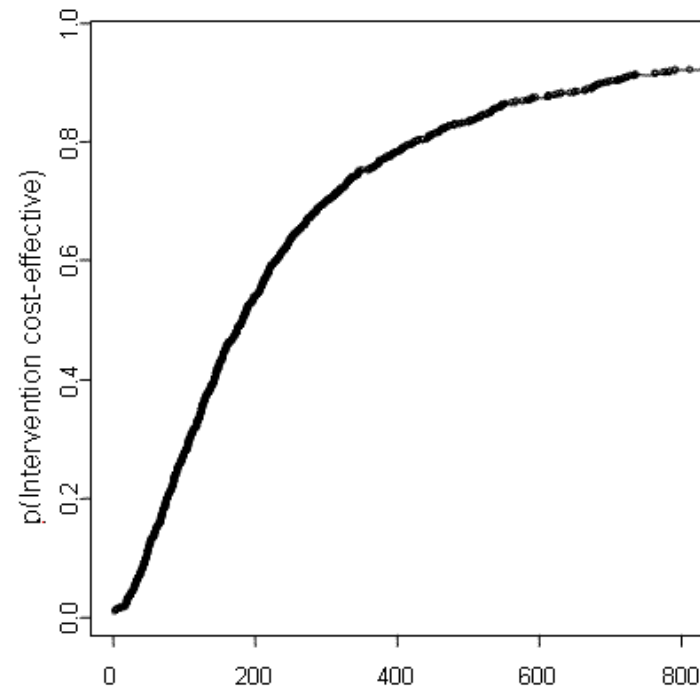
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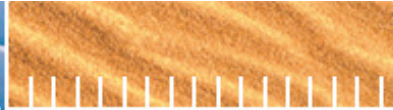
Probabilistic sensitivity analysis: Cost-Effectiveness acceptability curves



Willingness to pay (US\$ per Death averted)



Willingness to pay (US\$ per DALY averted)



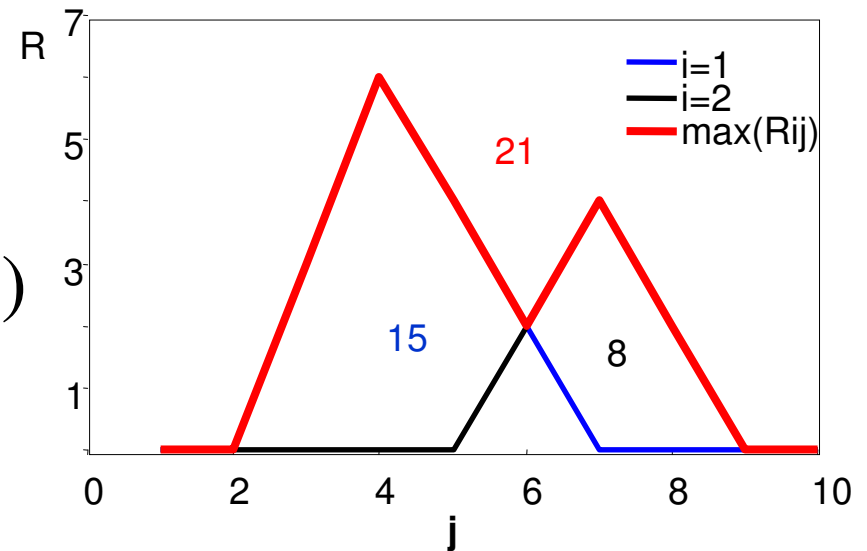
Expected value of perfect information (EVPI)

- EVPI = payoff with perfect information – payoff with current information
- How much is it worth to know more about a parameter?
 - payoff can be seen as expected net benefit (ENB)

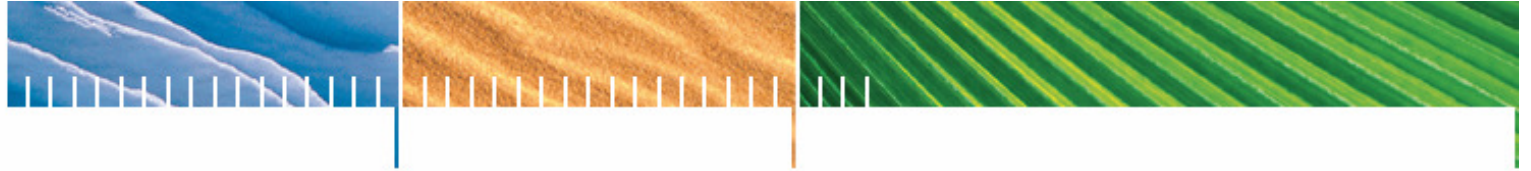
$$ENB = \max_i \sum_j p_j R_{ij}$$

$$ENB | PI = \sum_j p_j (\max_i R_{ij})$$

j: parameter
i: intervention
p_j: probability (param=j)
R_{ij}: payoff matrix

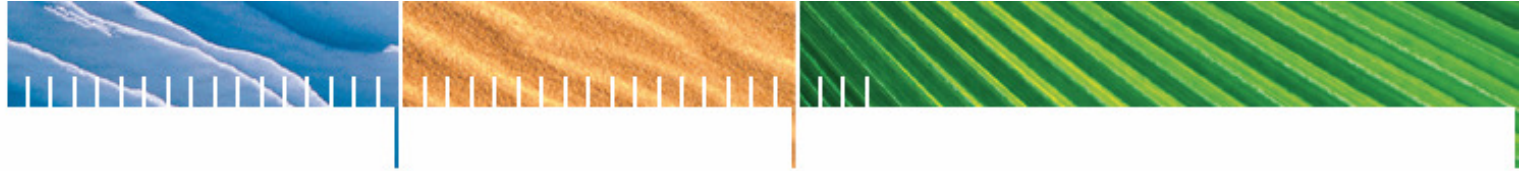


$$EVPI = 21 - 15 = 6$$



Computation needs

- Several hours to run a single simulation
- Large number of simulation runs
 - 1'000s of iterations necessary to fit parameters to field data
 - 10'000s to 100'000s of simulations for predictive runs and sensitivity analysis
- **Need for HPC**

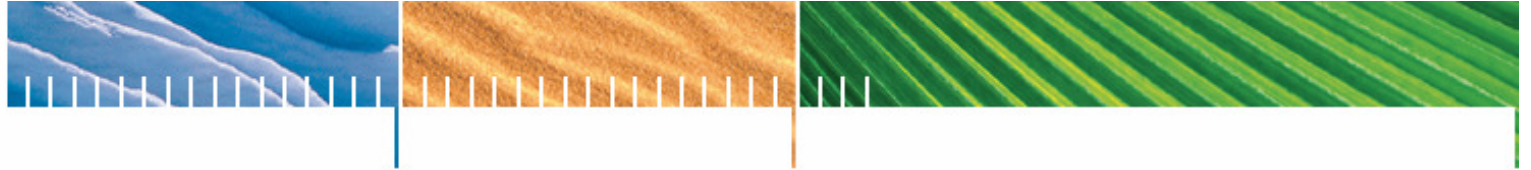


Suitability for Volunteer computing

- Independent parallelism
 - Divisible into parallel parts with few or no data dependencies
- Low data/compute ratio
- Public appeal

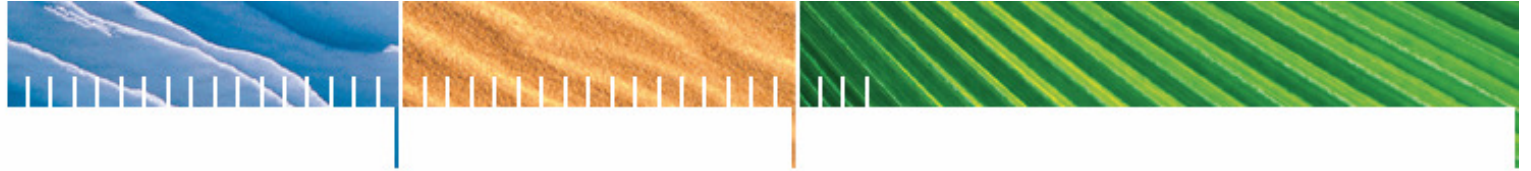


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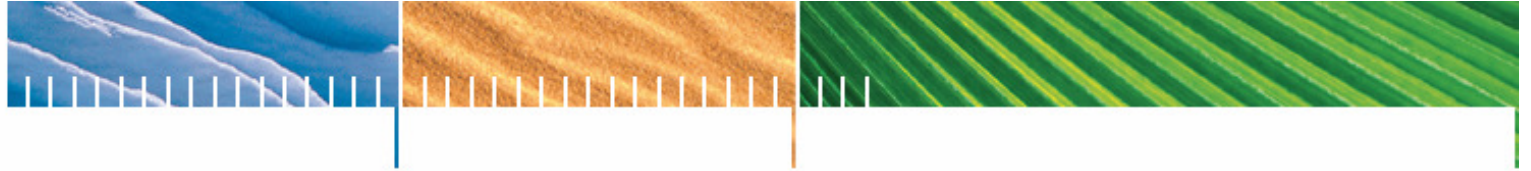
BOINC, a software platform for Volunteer computing

- Berkeley Open Infrastructure for Network Computing
- NSF supported (2002-present)
- Open source (LGPL)
- <http://boinc.berkeley.edu>
- Volunteers support projects by attaching their internet-connecte PCs



Port of existing application to BOINC

- Science application/Client
 - Reimplementation of some components (Java, commercial libraries)
 - Communication with core client (BOINC-API)
 - Implementation of checkpointing
- Project Server setup
 - Hardware provided by CERN/CUI Geneva
 - Hosting provided by CUI
 - Development of project specific server components

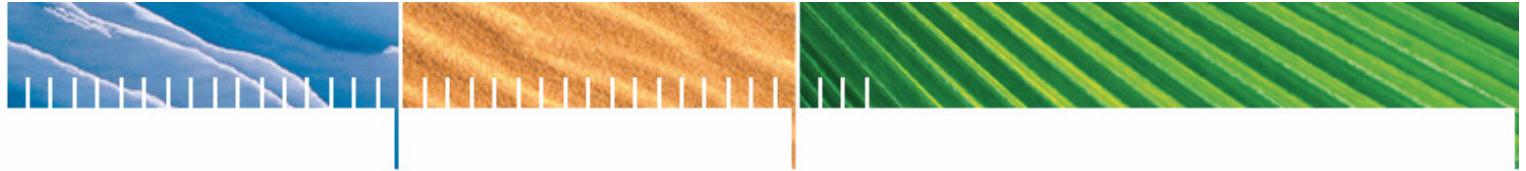


Project specific server components

- Assimilator
 - Processes validated results
 - Compares the predictions with the corresponding field data
 - Computes a measure of fit
- Work generator
 - Creates new work if necessary
 - Based on the completed parameterizations



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malariacontrol.net



malariacontrol.net

What is malariacontrol.net?

The malariacontrol.net project is an application that makes use of network computing for stochastic modelling of the clinical epidemiology and natural history of *Plasmodium falciparum* malaria. Click [here](#) for more information.

Join malariacontrol.net

1. [Read our rules and policies](#)
2. [Download BOINC](#)
3. When prompted, enter <http://www.malariacontrol.net/>

Returning participants

- [Your account](#) - view stats, modify preferences
- [Teams](#) - create or join a team
- [Applications](#)
- [BOINCWiki](#) - BOINC documentation
- [Server status](#)

Community

- [Participant profiles](#)
- [Message boards](#)
- [Questions and answers](#)

Project totals and leader boards

- [Top participants](#)
- [Top computers](#)
- [Top teams](#)
- [Other statistics](#)



User of the day



Pentti Kiesi

Hi. I am 54 years old electronic engineer. I like computers which are not Tamagotchies.

My other hobbies are technical sciences,...

News

2008-12-04

Project out of work intermittently. Please read [this thread](#) for more information.

2008-11-03

The database problem is fixed. However, we expect that workunits will be available only intermittently for the next few hours.

2008-11-03

We're currently experiencing problems with our database. We're working on a solution. Sorry for the inconvenience.

2008-09-12

The optimizer application will leave testing status during next week, from monday 15.Sept. 08 [More info](#)

2008-07-25

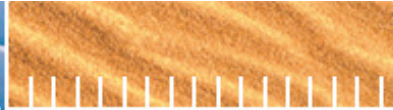
The project server may be intermittently unavailable later today while we're testing a new backup process.

[...more](#)

News is available as an [RSS feed XML](#).



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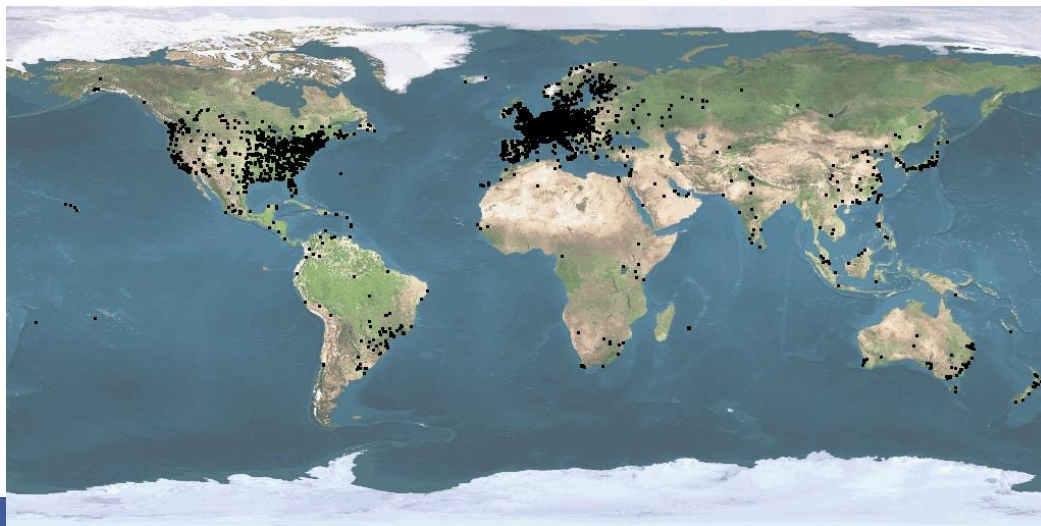
malariacontrol.net statistics

Volunteers: 25'000 total, 10'000 active

- Sign up rate: up to 400 new users per day
- Currently no new users

Host PCs: 15,000 active,

- 85% Windows, 15% Linux, Mac



CPU power:10(5)

TeraFLOPS

- delivered to date 10,000 CPU years (Oct 08)

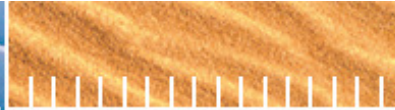
Simulations per day:

75,000

...+ huge public/press interest (Economist, Nature news, National Geographic, New Scientist, BBC, ...)



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Current Research Team

Applied Mathematics

Melissa Penny
Nakul Chitnis (MACEPA)

Epidem./Public Health

Allan Schapira
Blaise Genton
Christian Lengeler
Don de Savigny
Marcel Tanner
Rick Steketee (MACEPA)

Quantitative biology

Ian Hastings (Liverpool)
Michael Bretscher

Statistics

Amanda Ross
Penelope Vounatsou
Tom Smith

Computer Science

Diggory Hardy
Nicolas Maire
Tiago Antão (Liverpool)

Health Economics

Fabrizio Tediosi
Josh Yukich
Lesong Conteh
Valerie Crowell

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