Quantifying Weather and Climate Impacts on Health in Developing Countries (QWeCI)

Using the Liverpool Malaria Model to explore the uncertainty in the relationship between seasonal average climate and malaria
(+ make risk maps)

A Seventh Framework Programme Collaborative Project (SICA)

13 partners from 9 countries

www.liv.ac.uk/QWeCI

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SEVENTH FRAMEWORK PROGRAMME

Introduction

How does low-resolution climate information (e.g. Seasonal average temperature) relate to malaria outcomes?

This question is explored using the Liverpool Malaria Model & the 20th Century Reanalysis Dataset.

What are the uncertainties?

Methodology

- LMM: process-based SIR model of malaria, driven by daily temperature and rainfall

- 20th Century Renalysis Data: 6h, daily average and monthly values for 1871-2010 (140 years)
  - A quick & easy way to get multiple "realistic" daily time series
  - We don't think this is "what really happened" (issue with observations)

Methodology

- Malaria incidence lags precipitation peak.

- Regions selected where rainfall is roughly unimodal and running each point through the LMM, we define climate parameters & malaria average

Rain

Malaria incidence
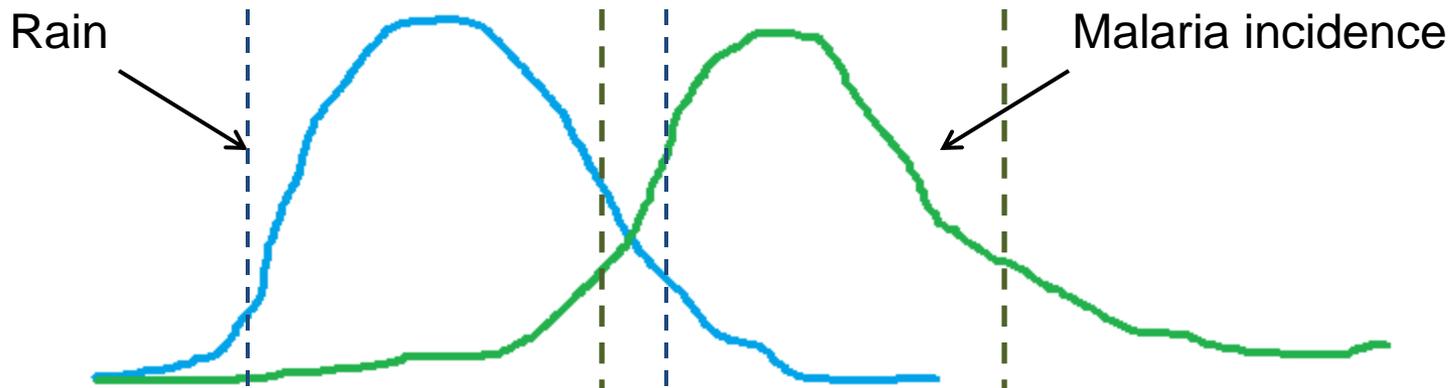
Methodology

- 3 separate latitude stripes of 10 gridpoints studied (based on the climate):
  - 2 in Sahel; **a -16.2N** and **b - 14.3N**, both from 1.9W to 15E
  - 1 below the equator; **c - 20S**, 15E-31.9E

- For each region: 10 gridpoints x 140 years = **1400 individual yearly timeseries**.

- LMM was run with climate for the region, followed each time with one of the 1400 timeseries – in each case defining a seasonal average T & P, associated with a seasonal average malaria incidence
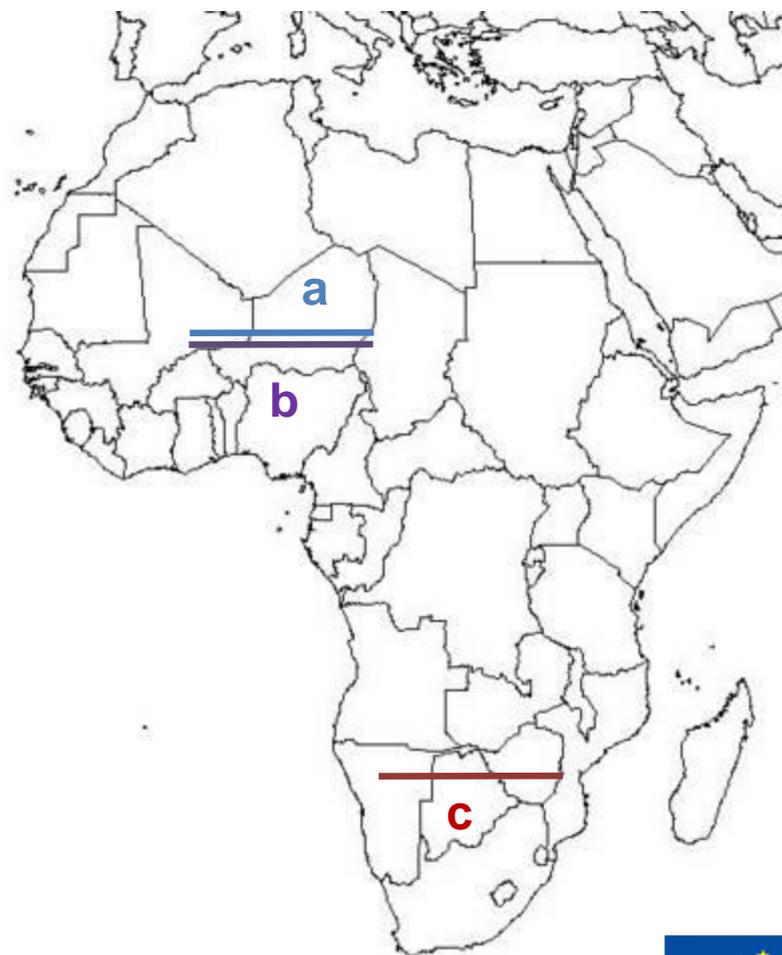
Regional climatologies
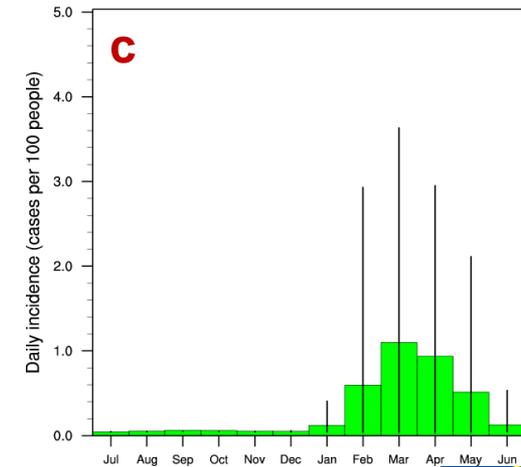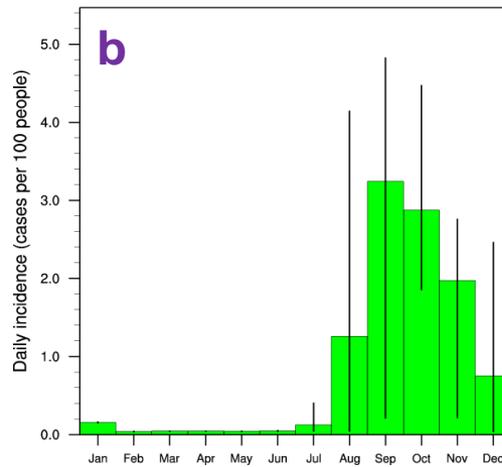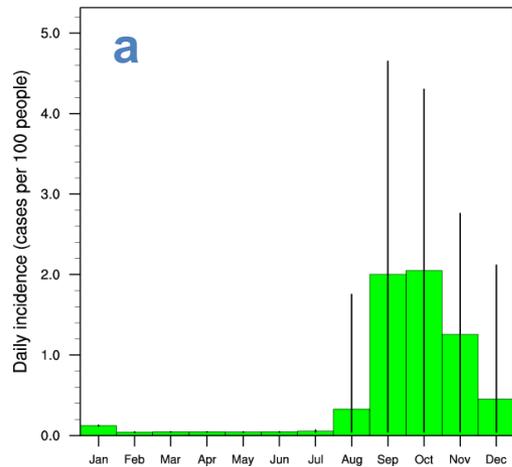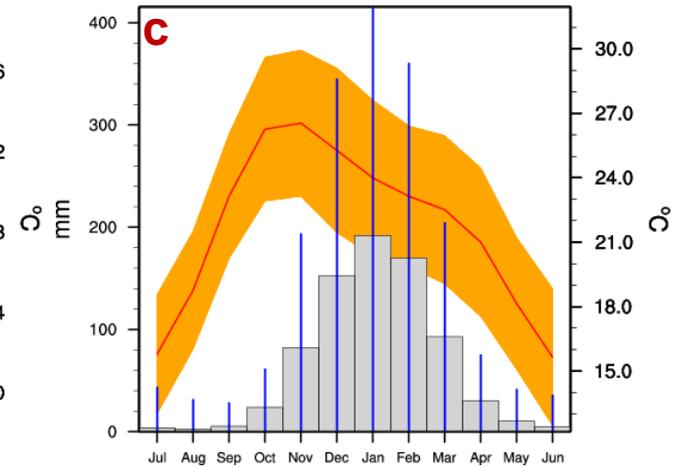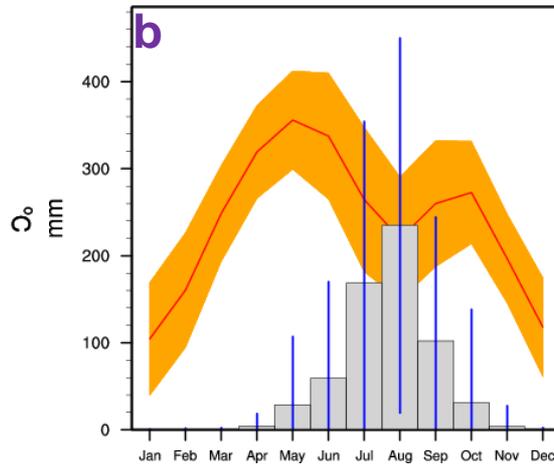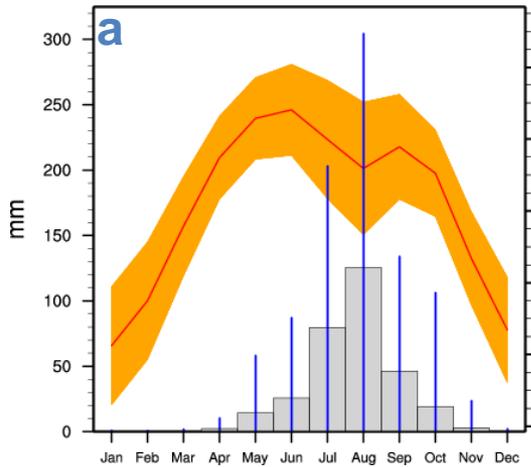
Climate parameters

- For each of the 1400 points various climate parameters are defined based on seasons identified on previous slide (e.g. JJA, JJAS, JAS for Sahel):
  - Average temperature
  - Total seasonal rainfall
  - Standard deviation of T / P
  - Max/min T
  - Degree days >18C
  - # rain days (> 1mm/day)
  - # heavy rain days (> 10mm/day)
  - # breaks in the season (defined as number of separate occasions rainfall is below 1mm/day for 3 or more days...) ???

- Malaria season defined as SOND for Sahelian regions and FMAM for Southern region

- **How do these parameters relate to malaria – and each other?**

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Climate parameters
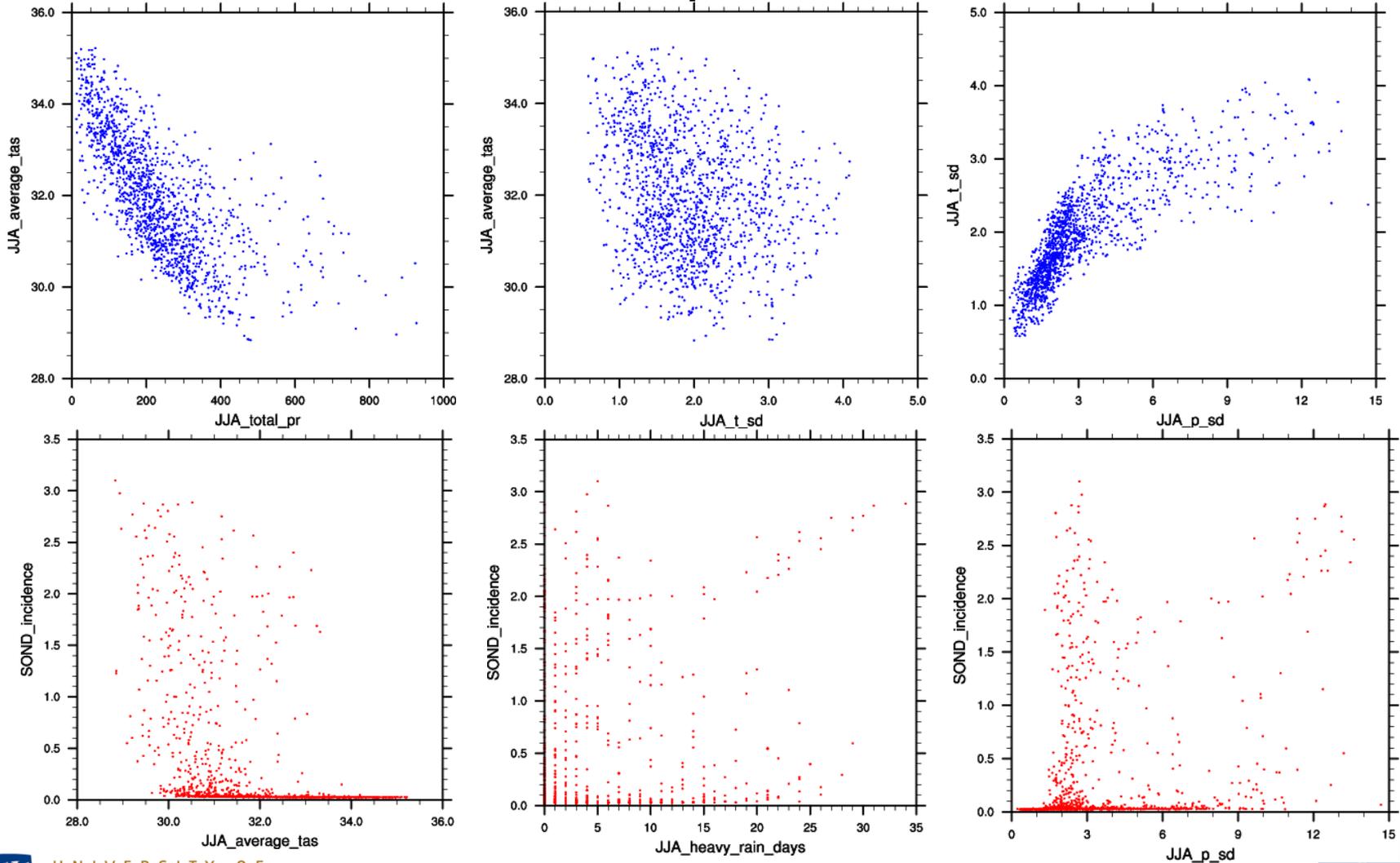
Risk map – region a

Region a; malaria tercile categories...

Risk maps, region a – 15.2N

Incidence : mean
(risk of high malaria)

Incidence: standard dev
(uncertainty)

N points

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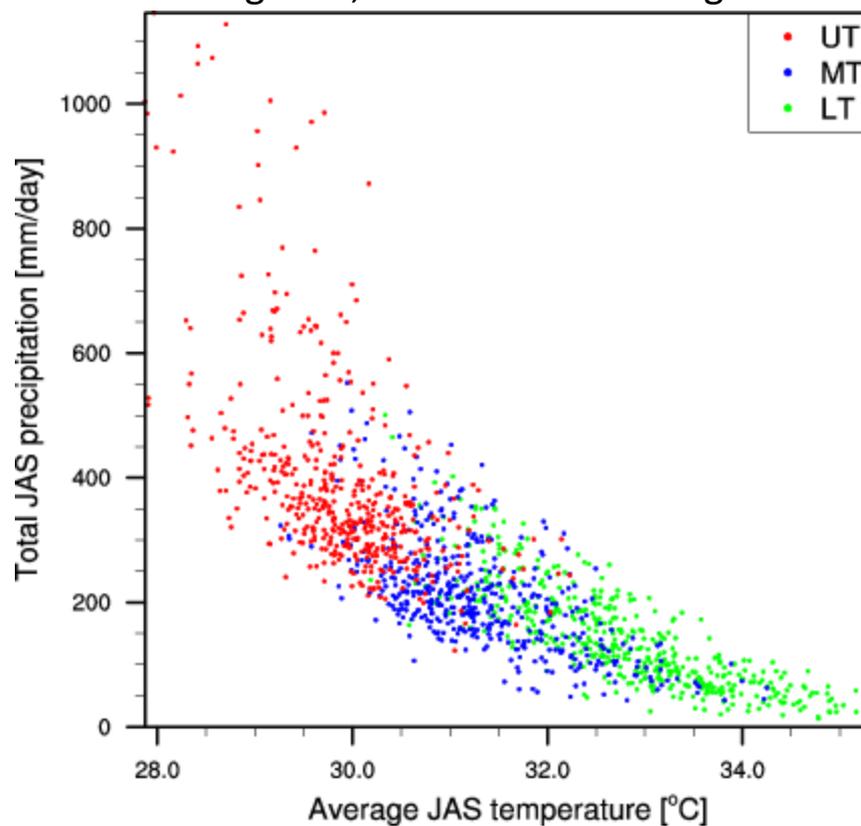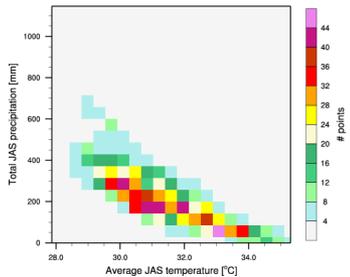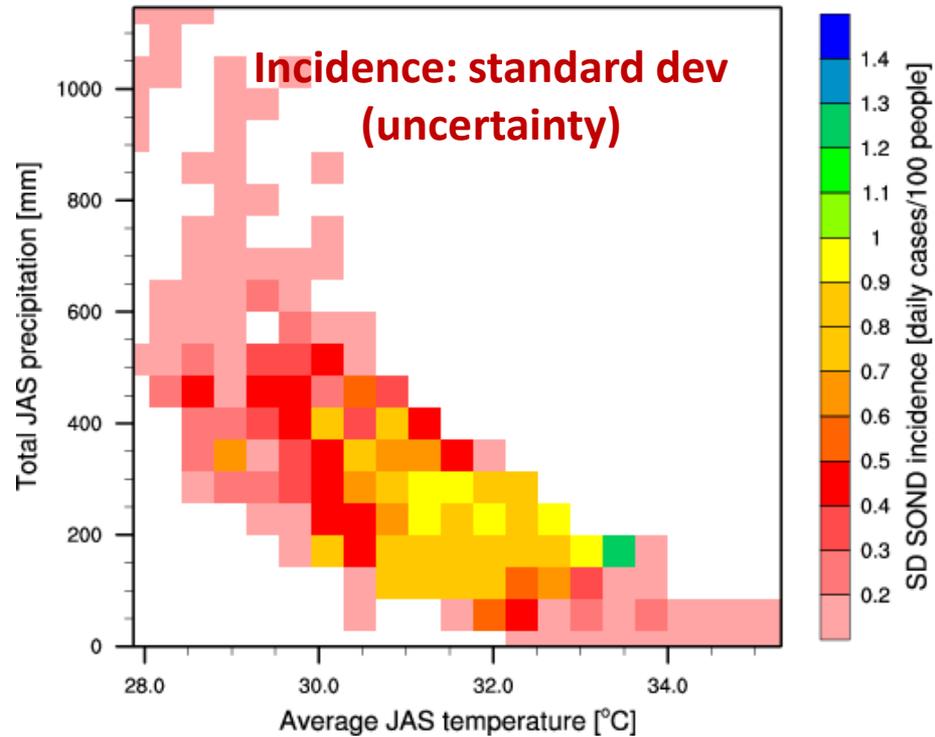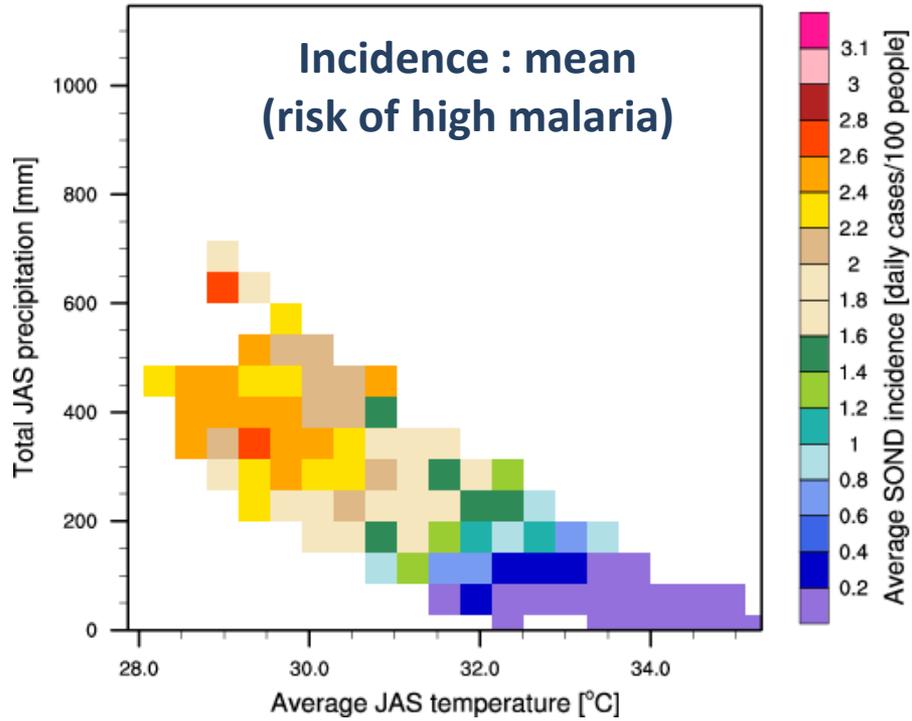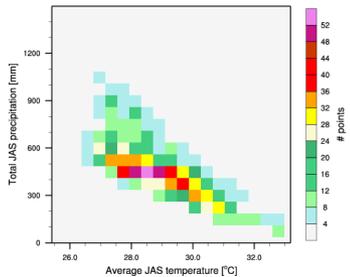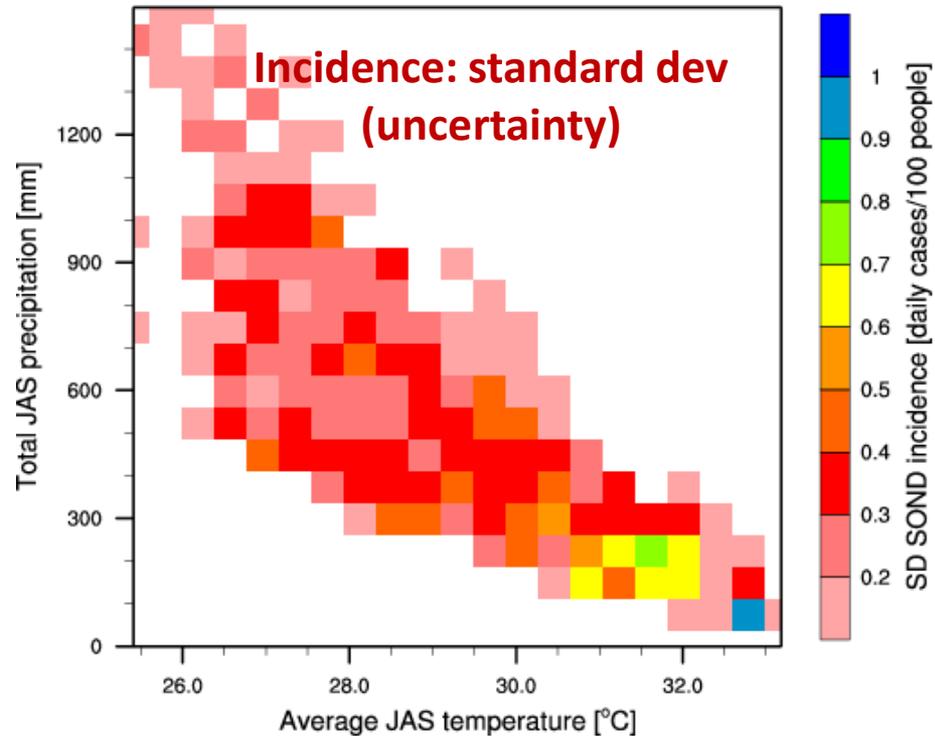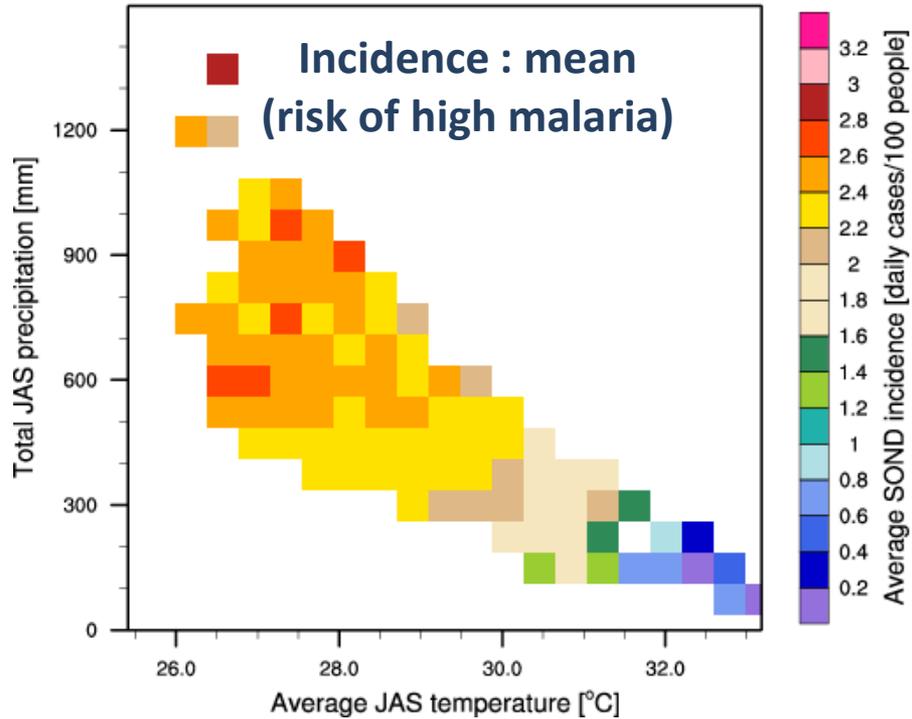
Risk maps, region b - 14.3N

Risk maps, region c – 20S
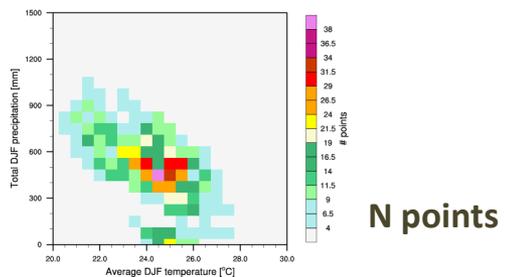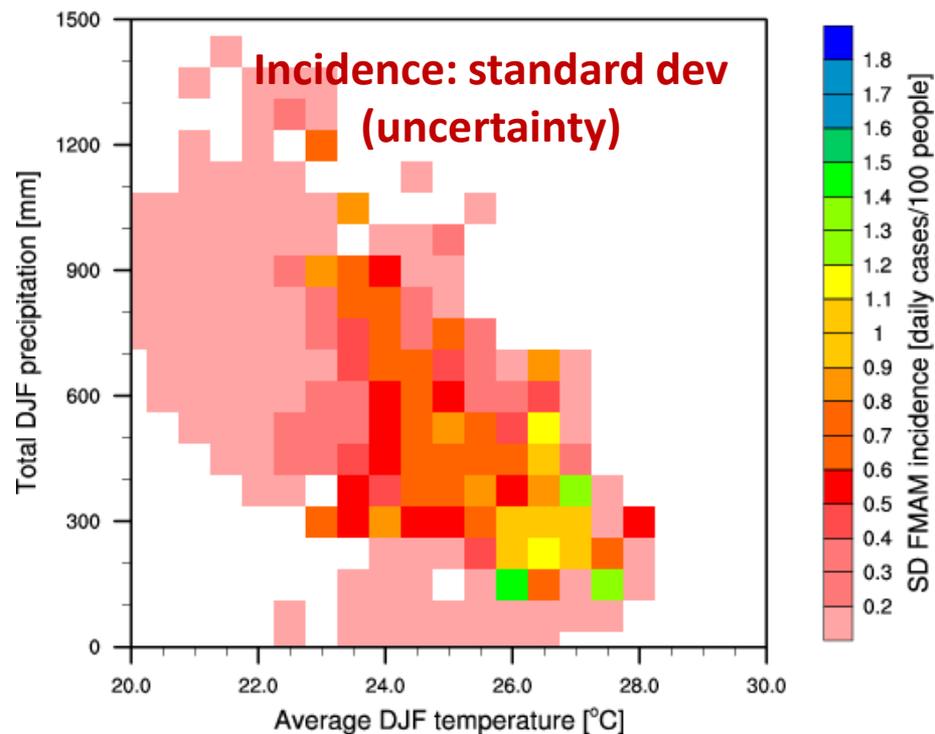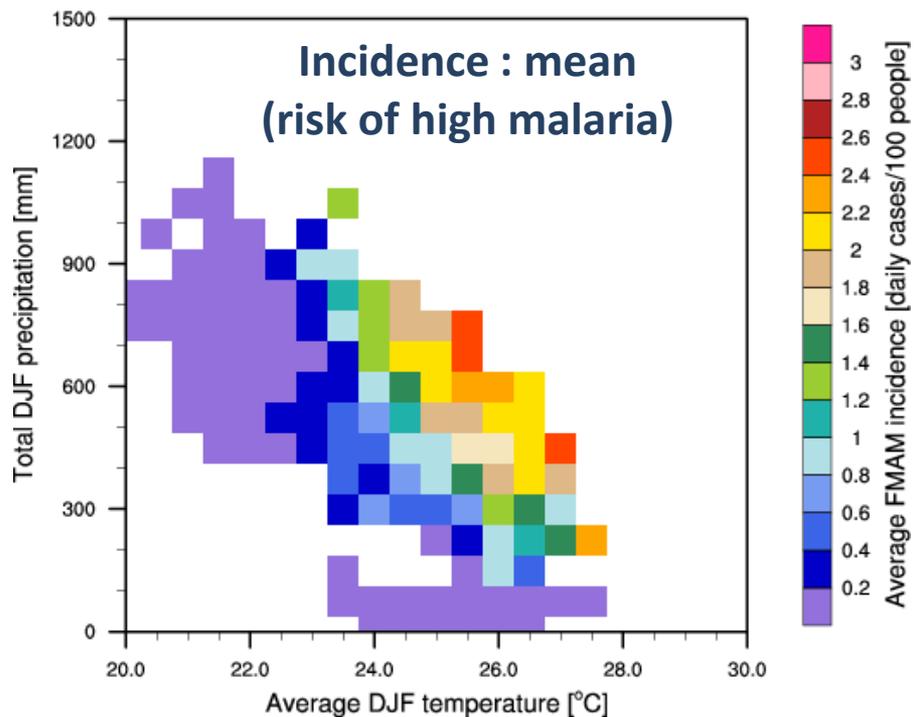
- Something approaching these risk maps could become part of a decision making tool

- Given a forecast of the season, we can place ourselves on the map – and have some idea of ~~real~~ LMM-world incidence in previous similar seasons (i.e. Analogue forecasting)

- (Even if climate is uncertain, we can draw a smudge)

- BUT!
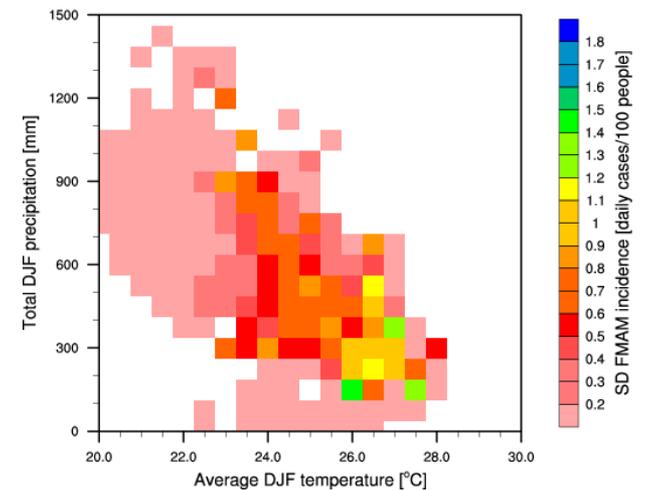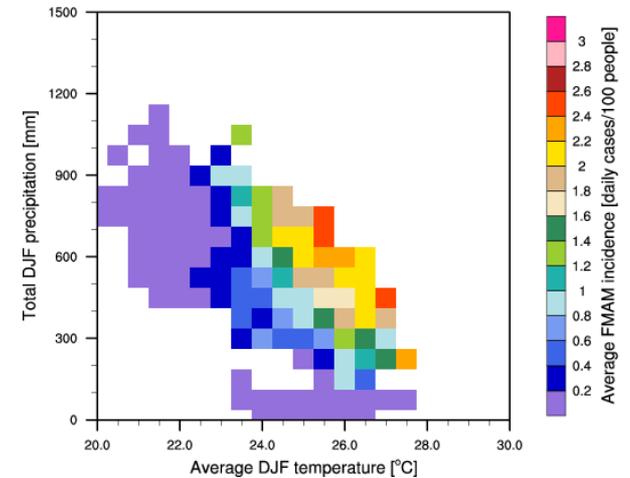
- There are uncertainties in the LMM
  - Uncertain parameters...structure...
  - One of the largest uncertainties is the choice of the survival scheme (Anne Jones, PhD thesis, personal communication)...

Mosquito mortality rate depends on temperature, according to one of three survival relationships for mosquito survival probability, P:

1 Martens (1995):
$P = -0.0016T^2 + 0.054T + 0.45$

2 Lindsay and Birley (1996):
Fixed per gonotrophic cycle

3 Craig (1999):
$P = \exp(-1/(-4.4+1.31T-0.03T^2))$

How does this affect the maps?

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Focusing on area c...
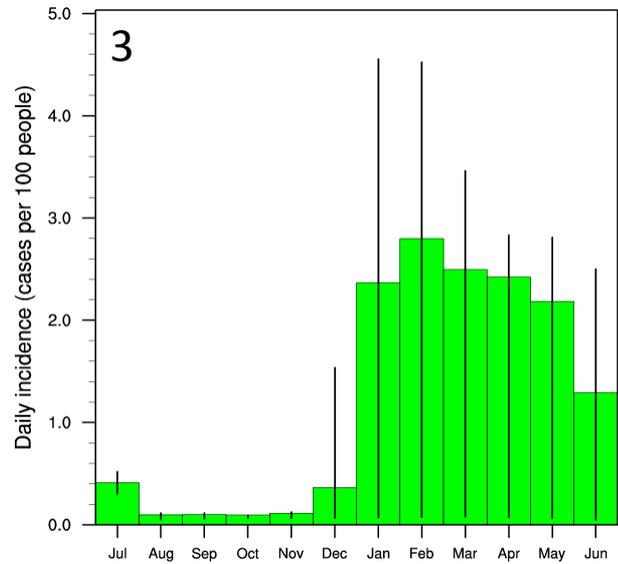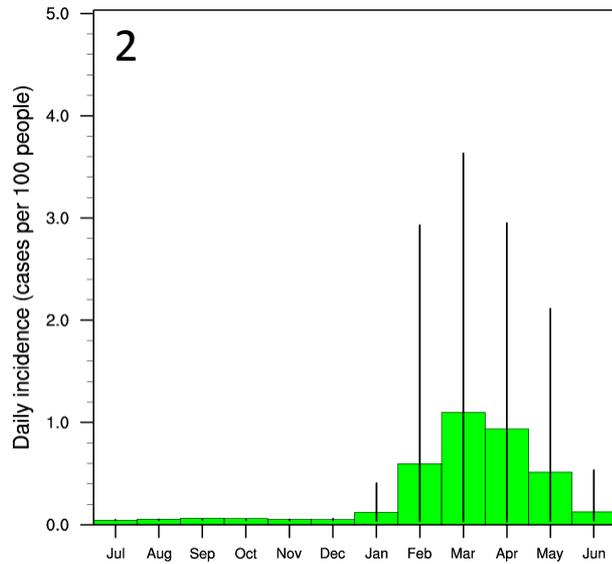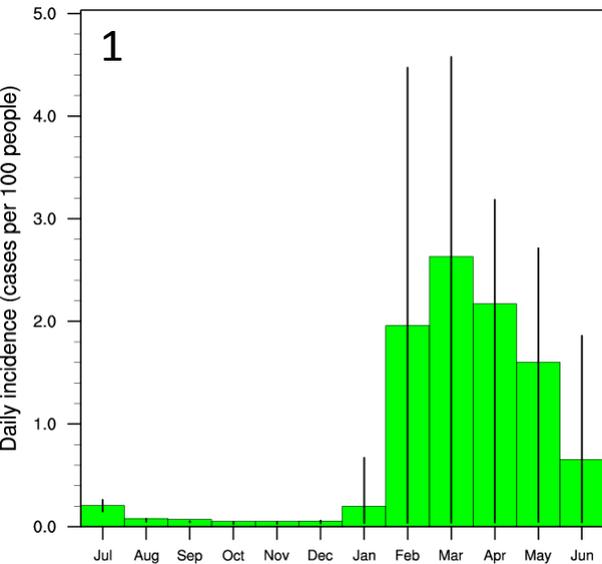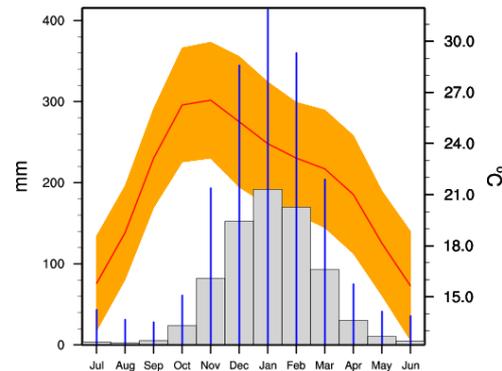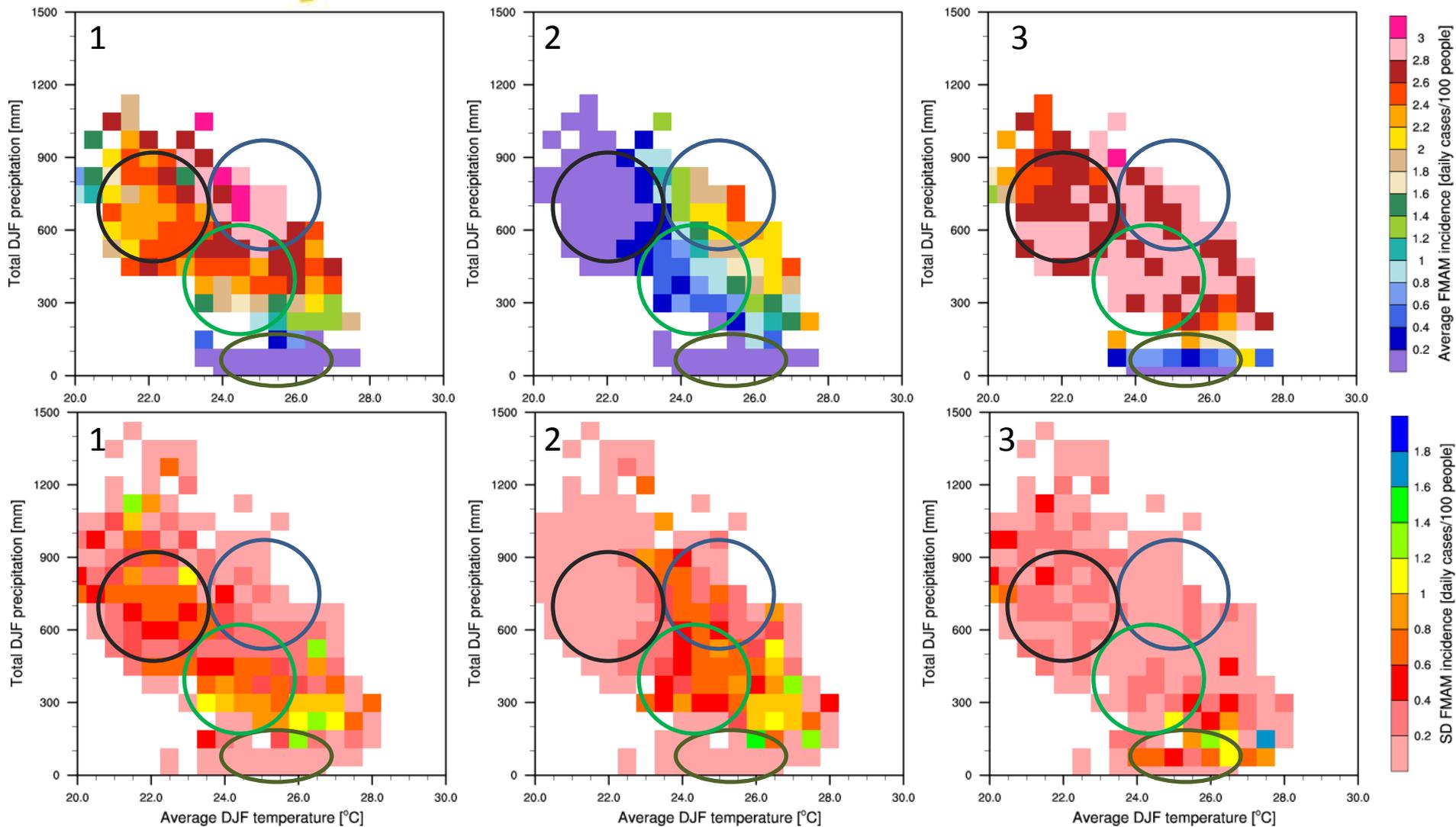
Region c

Summary & development

- Risk maps are a useful decision-making tool (intuitive, visual)
  - Defined for regions individually

- Allows exploration of uncertainty (in the LMM world)
  - Quantifying the relative uncertainty associated with different climate situations
  - Can it quantify absolute uncertainty? (what does that mean?)
  - Could be extended to include perturbations of other uncertain parameters, and other models (i.e. VECTRI, LMM_{2010}).

- Thanks for listening, any questions?

Supplementary slides

Results for area a (15.2N)
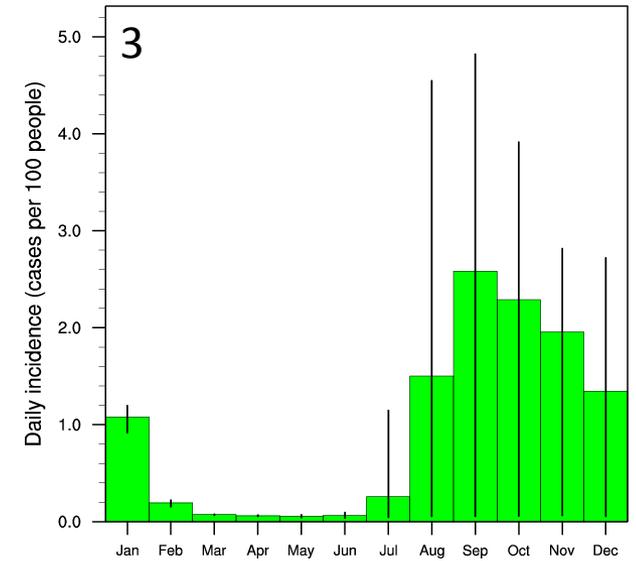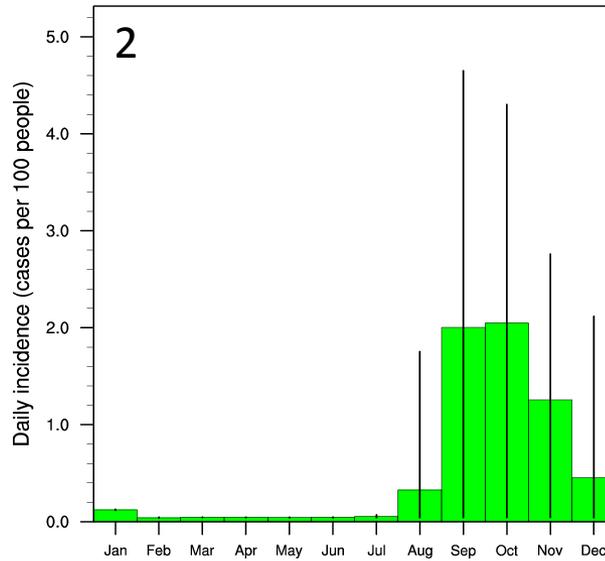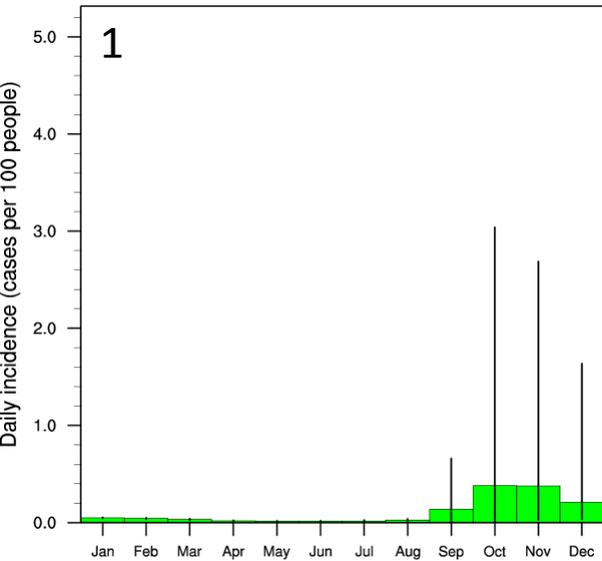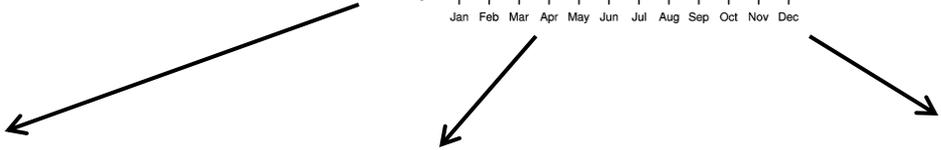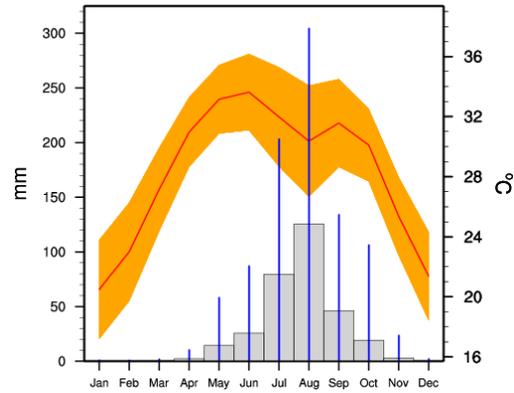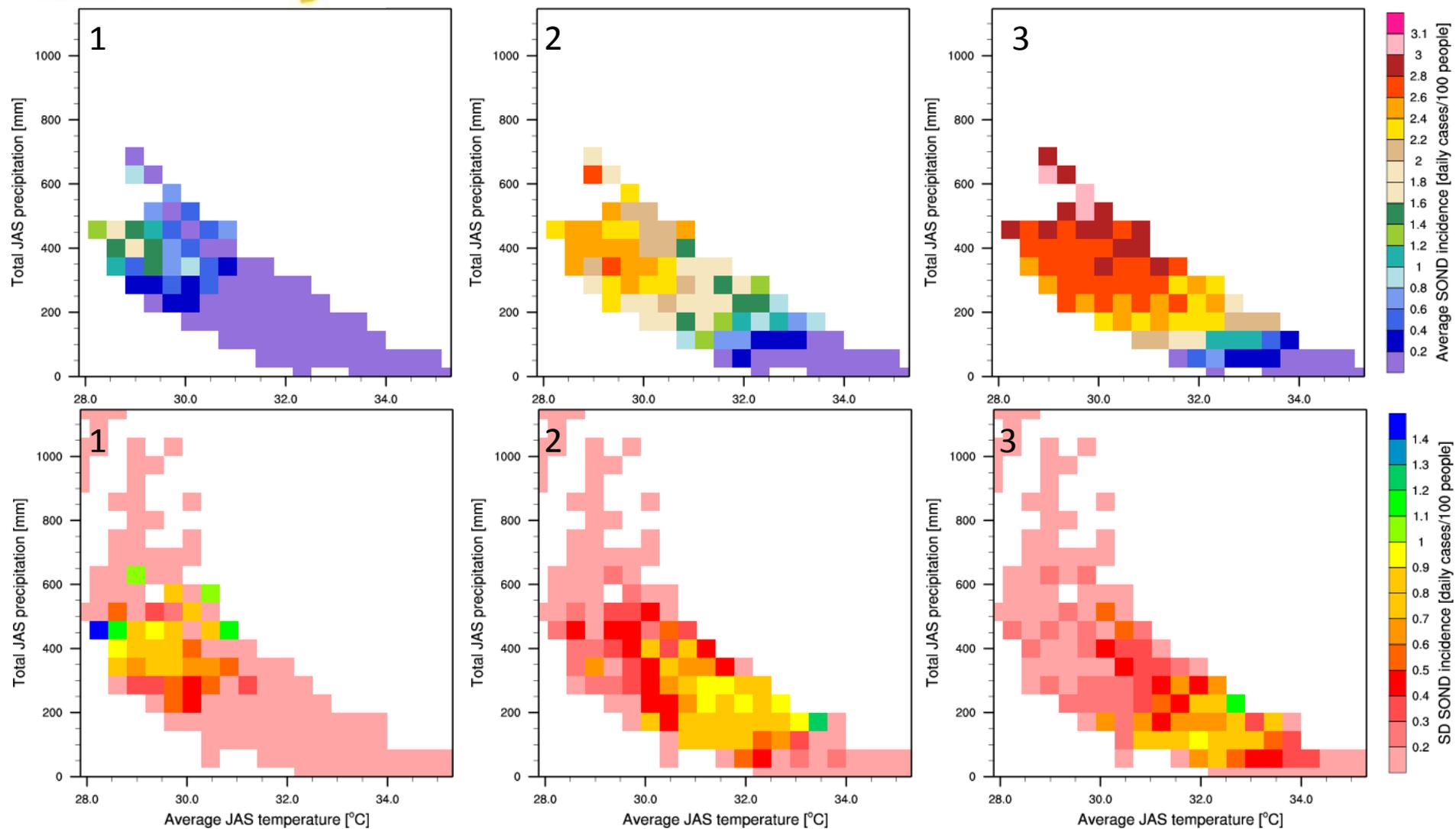
Region a

Results for area b (14.3N)

Region b