Forecasting wheat rust dispersal across South Asia: challenges and approaches

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ARRCC project details

- Phase I: 12 month pilot
  - Initial proof-of-concept
  - Predictive modelling and pilot early warning system for:
    - Wheat stripe rust in Nepal
    - Wheat stem rust in Bangladesh and Nepal
    - Wheat blast in Bangladesh
- Phase II: Test, refine, expand, scale-up

Government of Nepal
Department of Hydrology and Meteorology

ARRCC
Asia Regional Resilience to a Changing Climate

UKaid from the British people

Foreign, Commonwealth & Development Office

Background

<u>Wheat rust:</u>

- Reduces yield
- Crop failure
- Threat to livelihoods
- Threat to national and global wheat production

Bangladesh	Nepal
Wheat: 2nd most consumed crop	Wheat 3rd most consumed crop
Production: +10 % pa	Production +11.5 % pa
Imports 88%	Imports 34%

Source: FAO GIEWS country briefs

Background

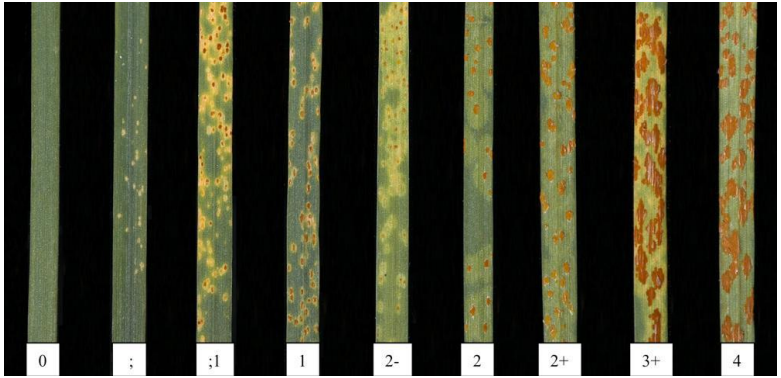
Options for control

Resistant varieties of wheat

+ Long-term resistance to rust strain
- Needs years to research, develop and adopt

Fungicide control

+ Immediate response to outbreak
- Arguably less sustainable
- Cost and access in LMICs



Different reaction types to stem rust. 0: resistant.
Image: www.ars.usda.gov/

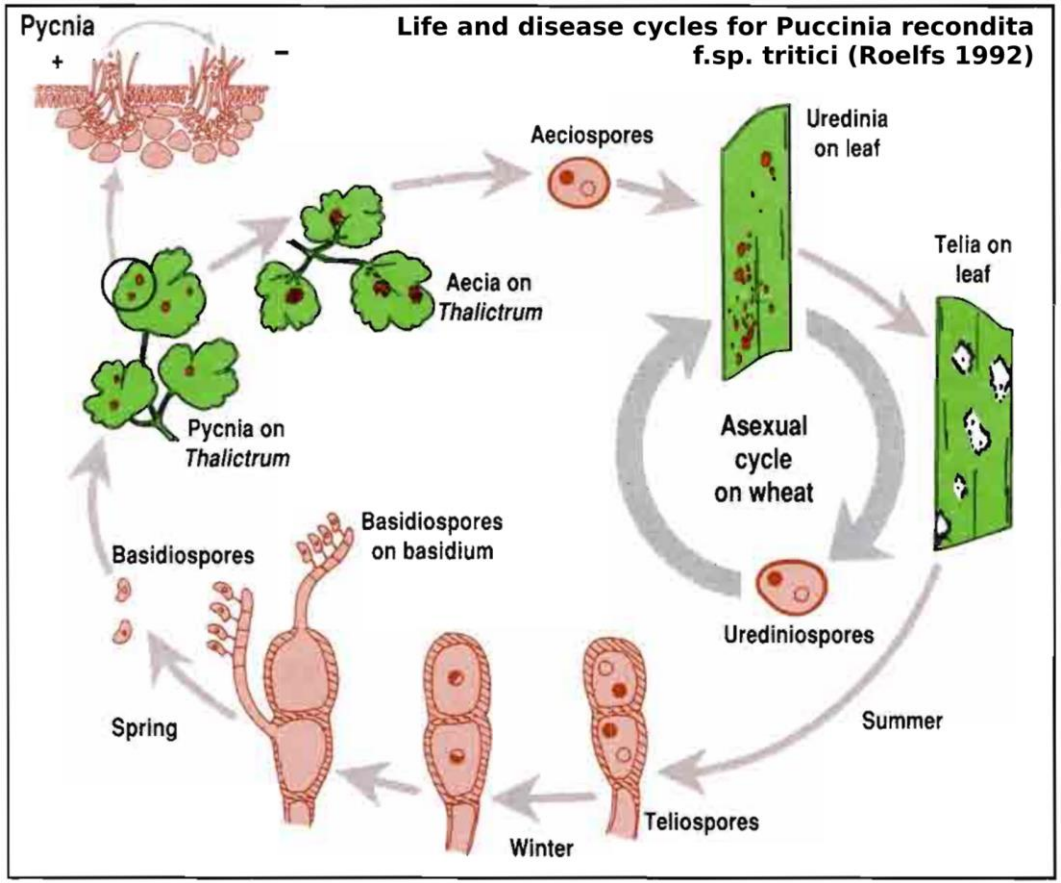
Resistant variety (left) is less infected.
Photo: Joshua Masinde, CIMMYT

Background

Wheat rust

- Outbreaks via aerially-dispersed spores

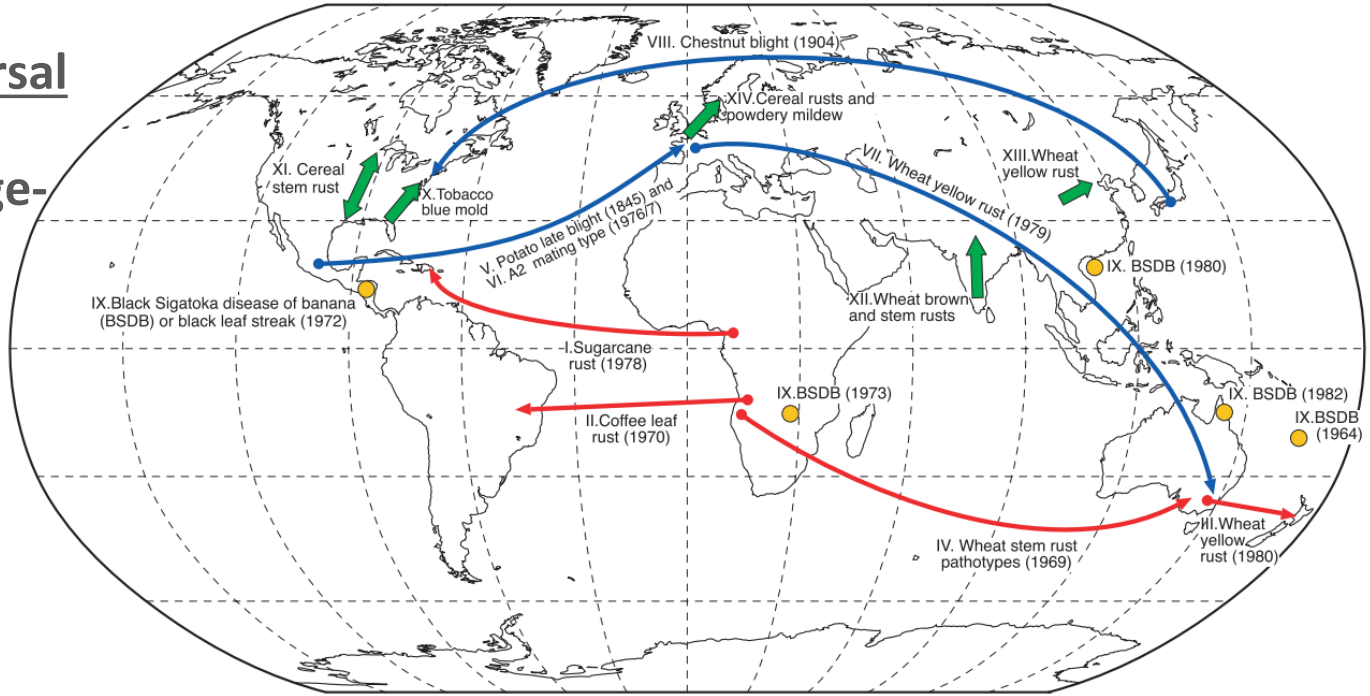
- Persistent infection across seasons via:
  - Overlapping wheat cropping seasons
  - Wild grass hosts
  - Alternate host cycle on barbery



Background

Long-distance dispersal

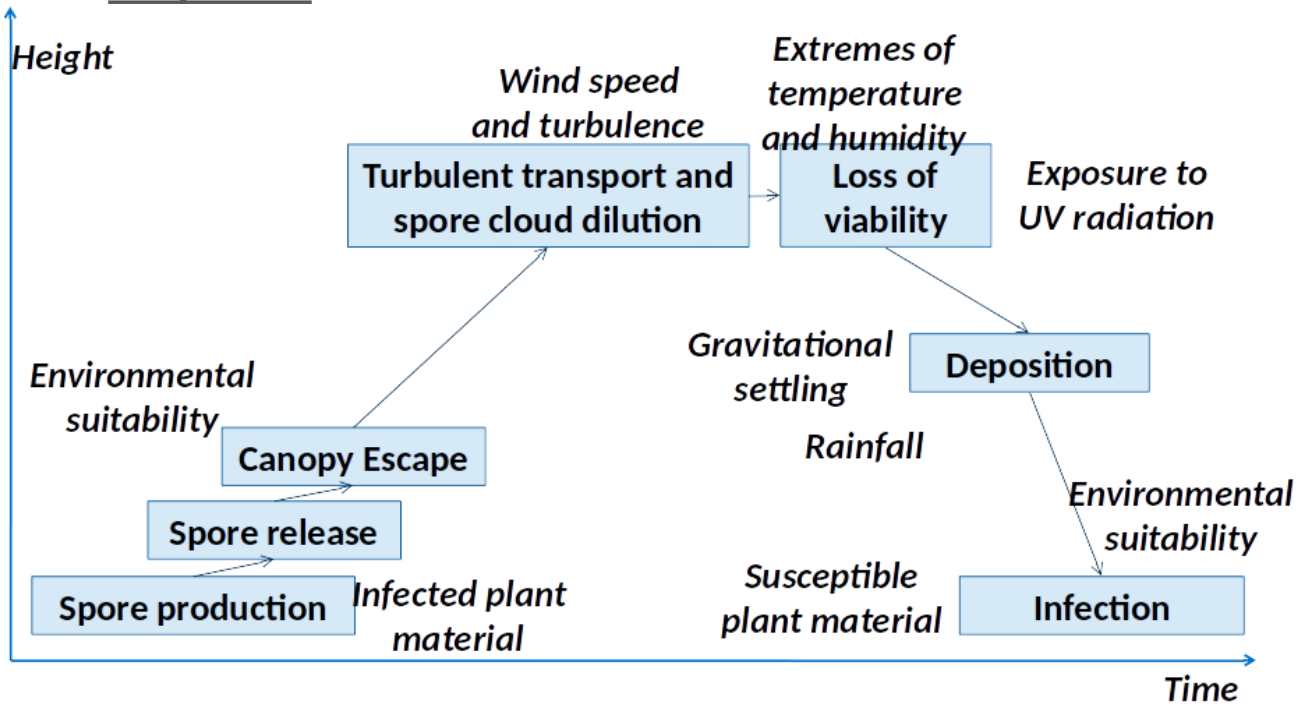
- implicated in large-scale spread



Brown, J. K. M., & Hovmøller, M. S. (2002). Aerial dispersal of pathogens on the global and continental scales and its impact on plant disease. *Science*, *297*(5581), 537–541. https://doi.org/10.1126/science.1072678

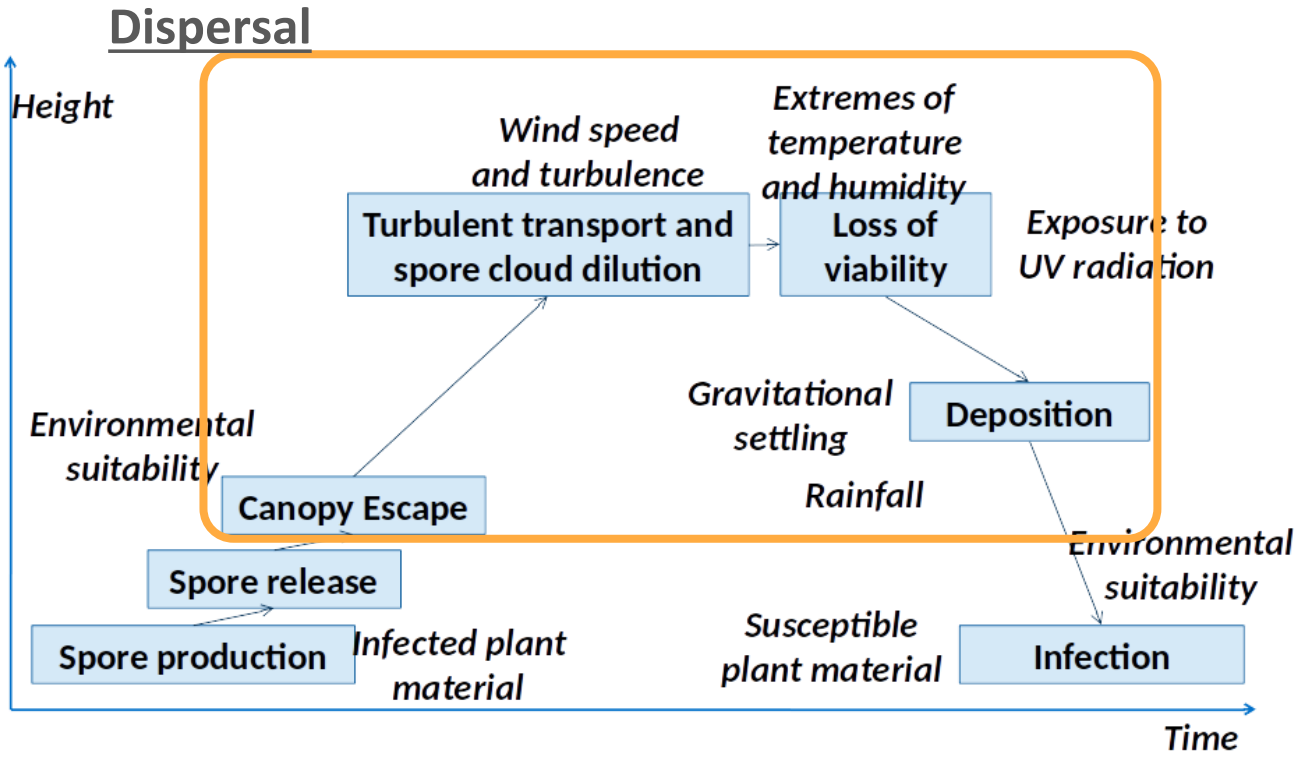
Background

Dispersal



After Aylor (1986)

Background



NAME particle dispersal model adapted to simulate the biophysical characteristics of wheat rust urediniospores.

After Aylor (1986)

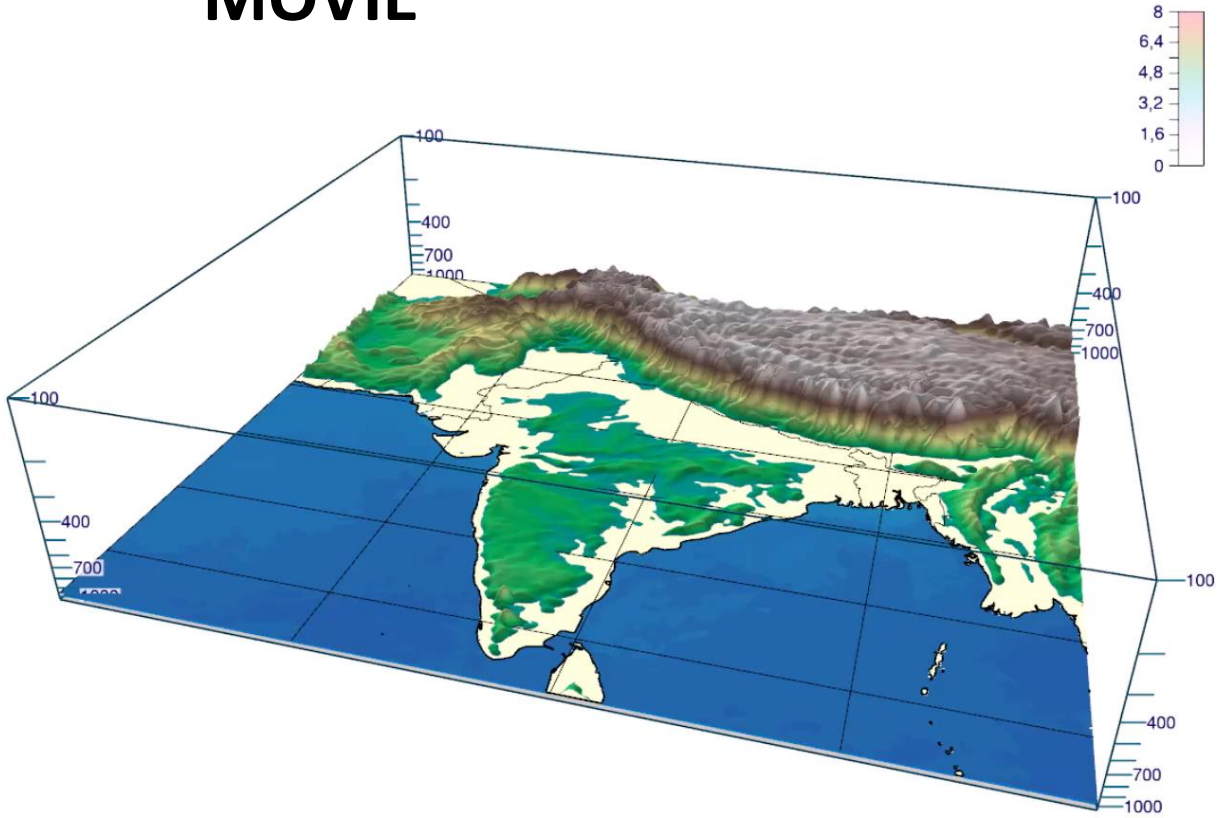
Case study

Stem rust surveys in South Pakistan

17th - 26th March 2018

Valid: Sa. 2018-03-17 00:00 UTC (step 0 hrs from Sa. 2018-03-17 00:00 UTC)

MOVIE



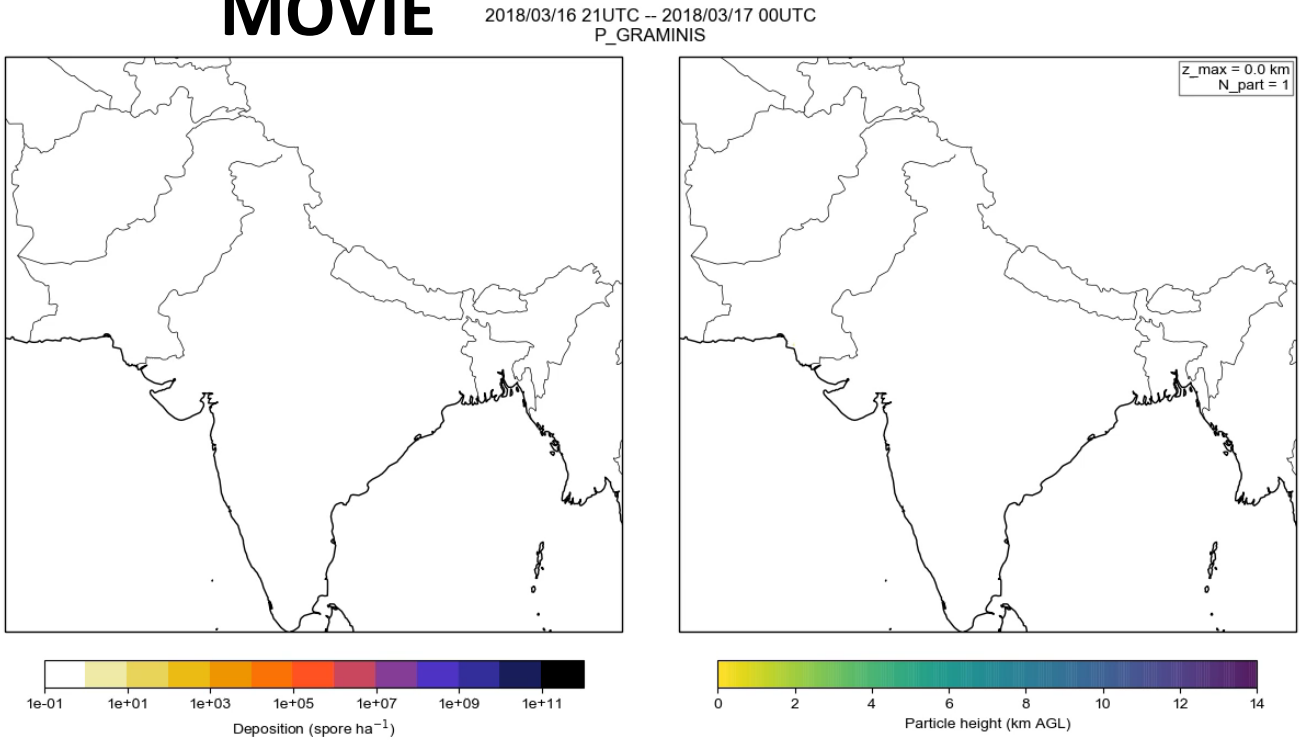
Visualisation by Marcel Meyer using met3d.wavestoweather.de

Case study

Stem rust surveys in South Pakistan

17th - 26th March 2018

MOVIE



Visualisation by Will Thurston
using scitools.org.uk/iris

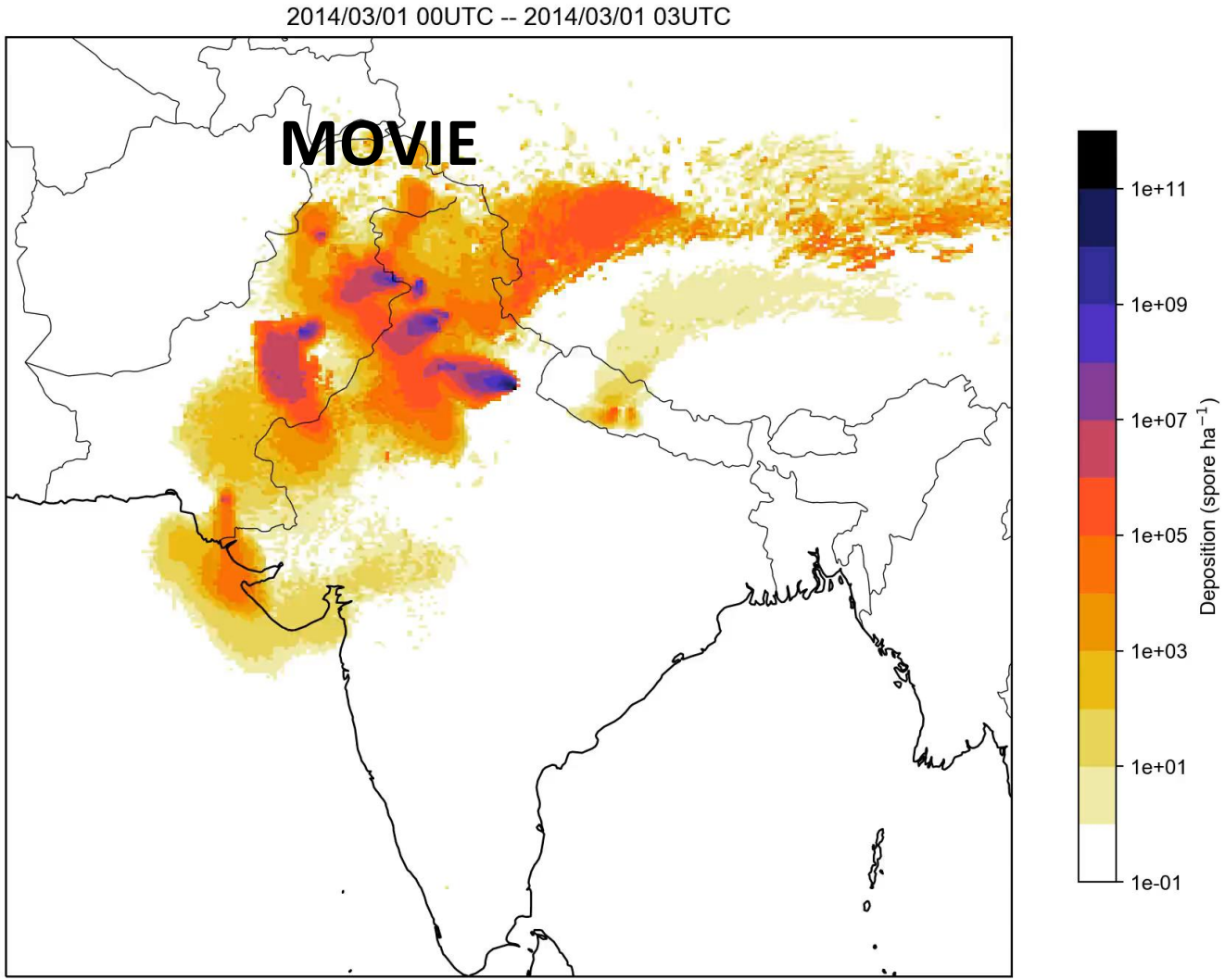
Met Office

Iris

Case study

Stripe rust surveys across South Asia

March 2014



Visualisation by Will Thurston using scitools.org.uk/iris

Met Office

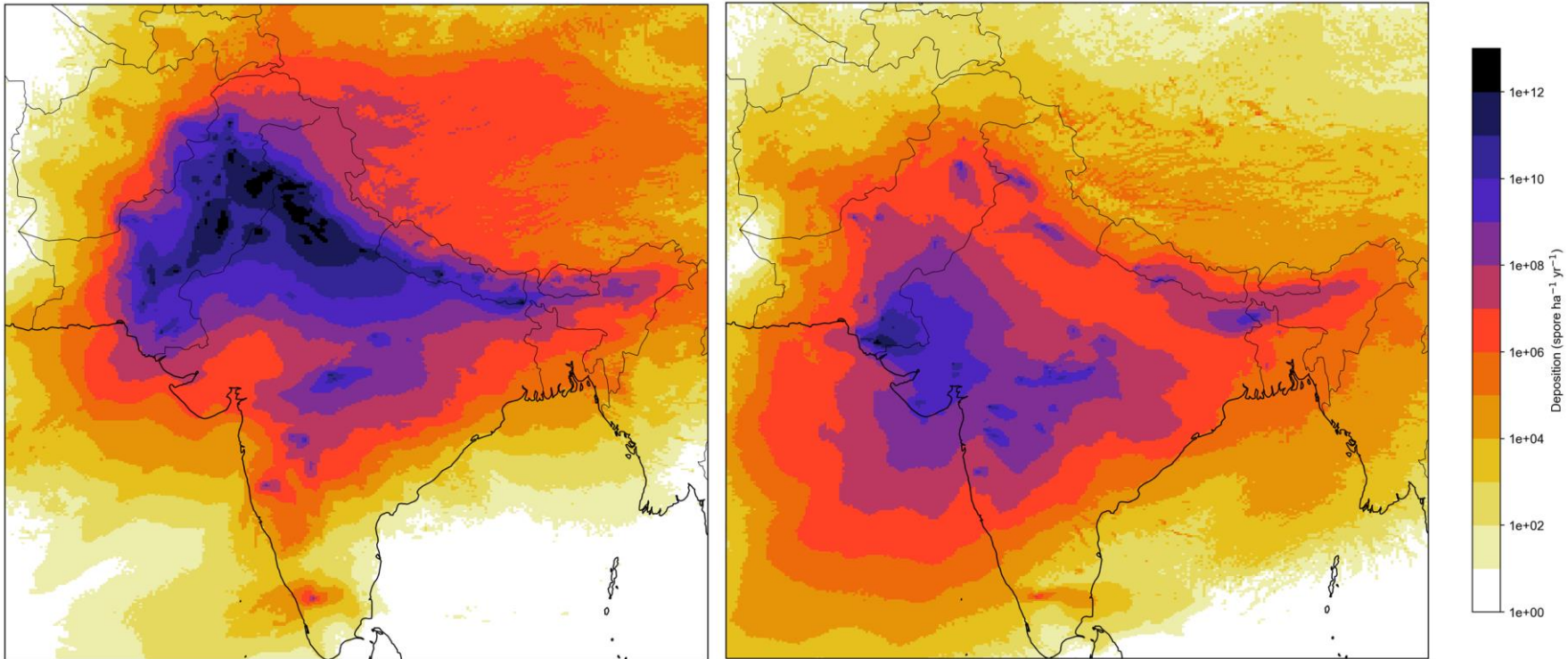
Iris

Historical analysis

Annual cumulative spore deposition from all CIMMYT surveys (2011-2018 average)

Stripe rust | Stem rust

Generated by Will Thurston

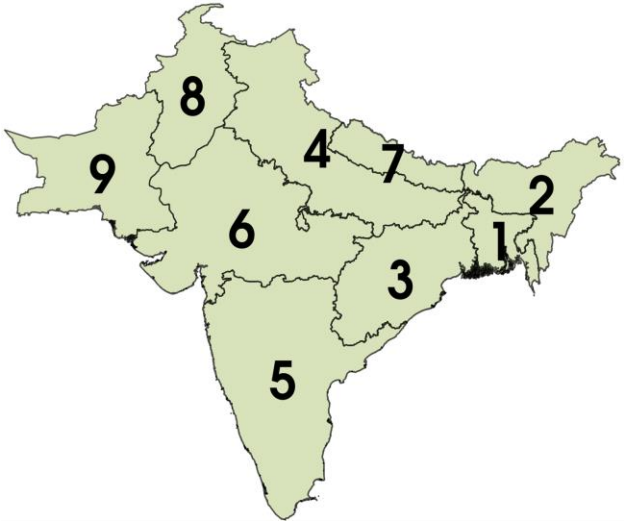


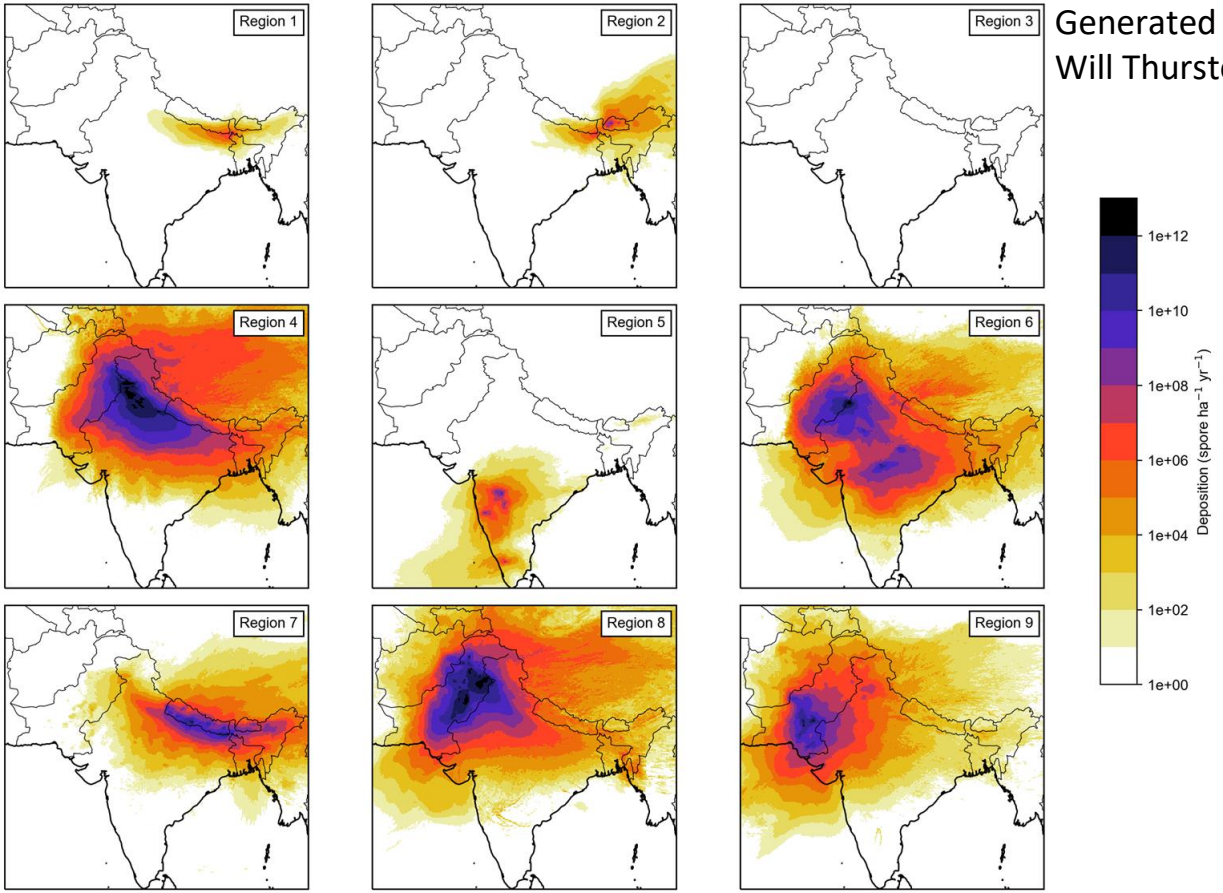
Historical analysis

Annual cumulative spore deposition by source region stripe rust (2011-2018 average)

Generated by Will Thurston

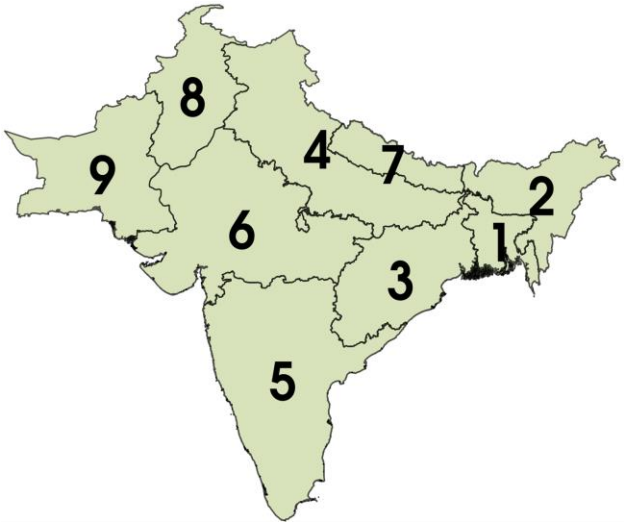
Inter-regional dependence across South Asia



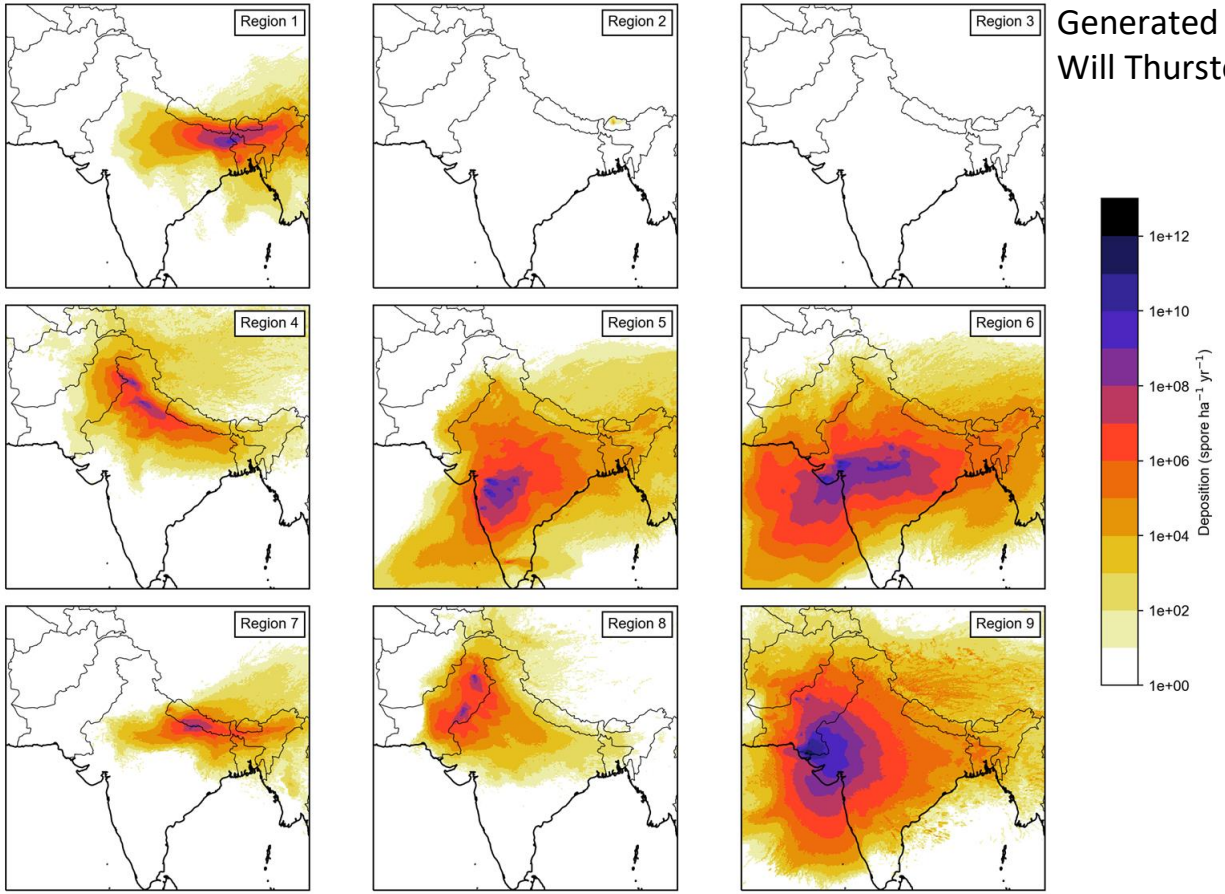


Historical analysis

Inter-regional dependence across South Asia

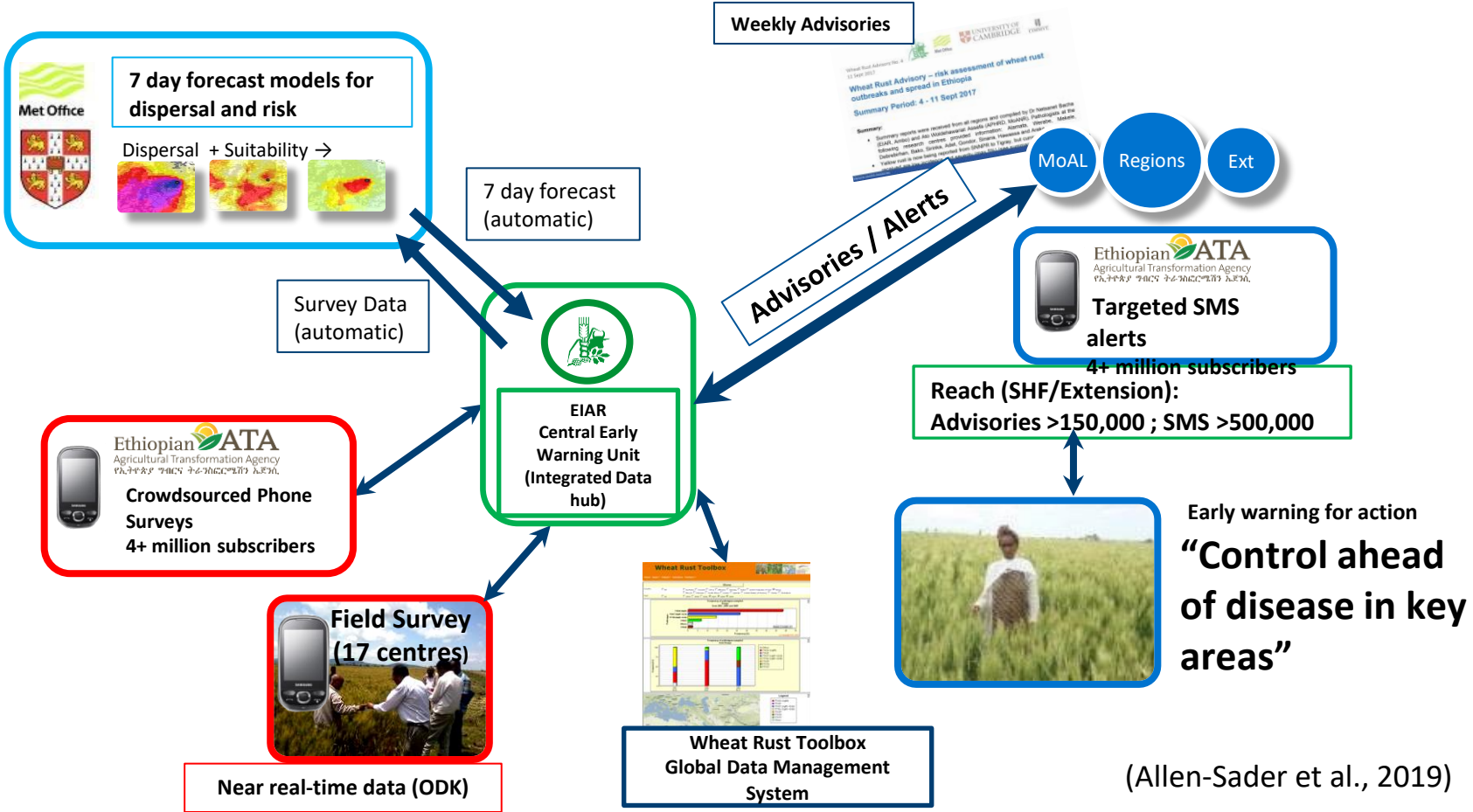


Annual cumulative spore deposition by source region stem rust (2011-2018 average)



Generated by Will Thurston

Early Warning System functioning in Ethiopia



(Allen-Sader et al., 2019)

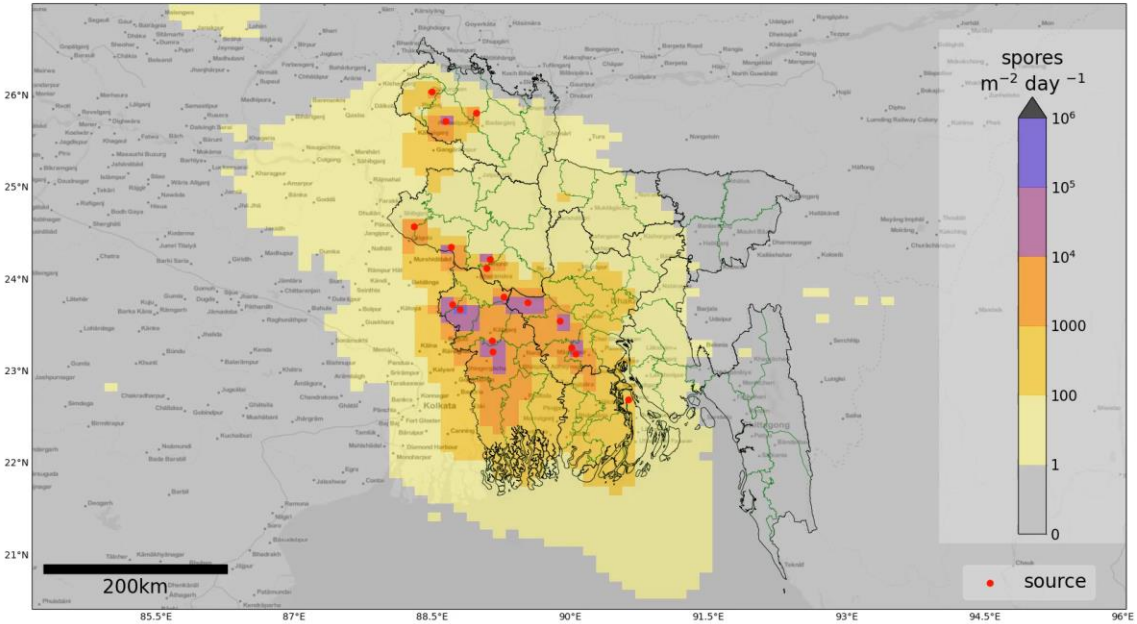
Forecasting wheat rust dispersal in Bangladesh and Nepal

MOVIE

Daily 7-day forecast for:

- **Stem, stripe and leaf rusts**
- **Spore deposition**
- **Environmental suitability for spore infection**
- **Integrated risk of infection**
- **Revised visualisation**

NAME dispersion forecast for the proportion of Wheat **Leaf** rust spores
2020-02-27-00:00 - 2020-02-28-00:00 (UTC)



Issued 27 Feb 2020 with Met Office Unified Model meterological input data

UNIVERSITY OF CAMBRIDGE CIMMYT Met Office

Forecasting wheat rust dispersal in Bangladesh and Nepal

MOVIE

Daily 7-day forecast for:

- **Stem, stripe and leaf rusts**
- **Spore deposition**
- **Environmental suitability for spore infection**
- **Integrated risk of infection**
- **Revised visualisation**

NAME dispersion forecast for the proportion of Wheat **Stripe** rust spores
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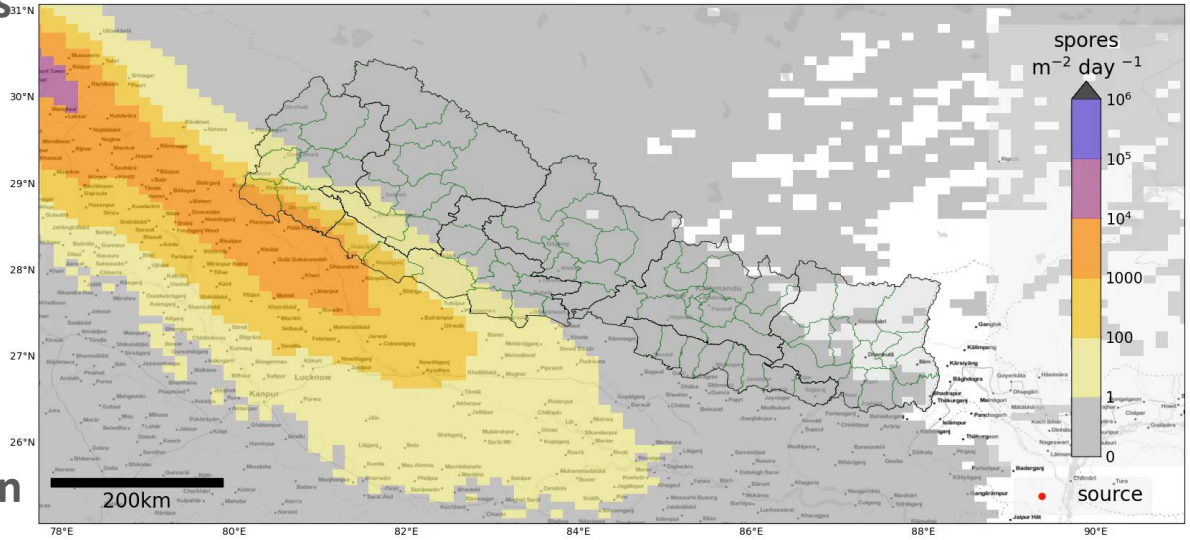
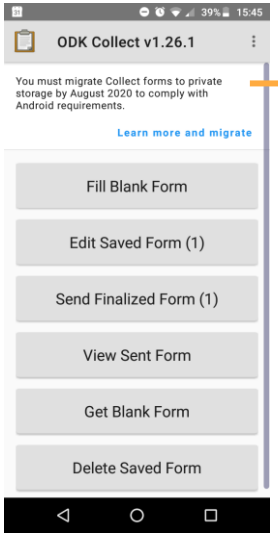


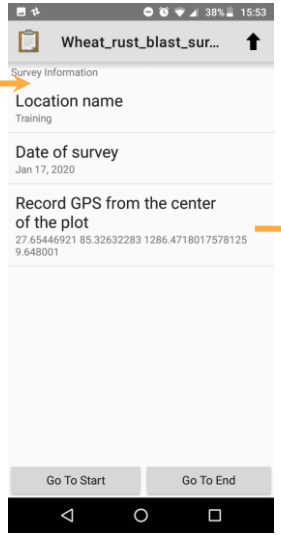
Issued 06 Feb 2020 with Met Office Unified Model meterological input data

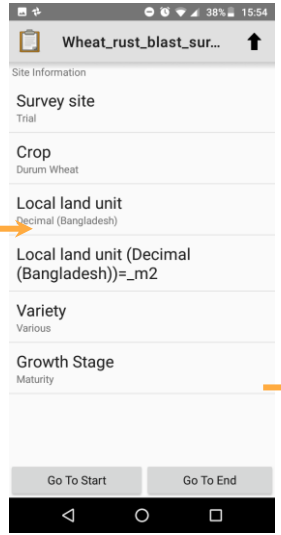
Challenge: Consistent and prompt survey reporting Approach: ODK app

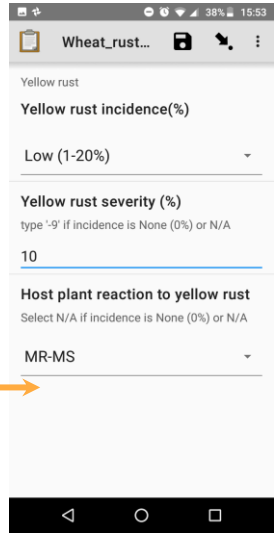
CIMMYT set up consistent international surveillance strategy

Use of OpenDataKit (ODK) by surveyors in Bangladesh and Nepal allows near real-time upload and automatic intake to model forecasting.



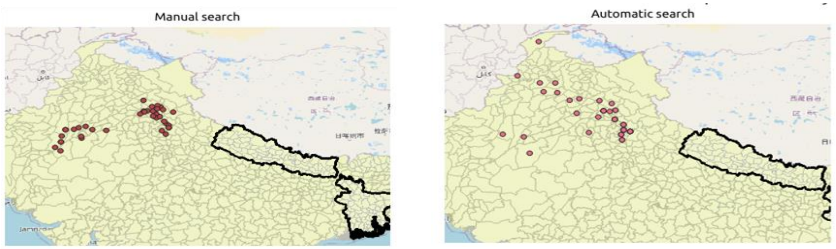






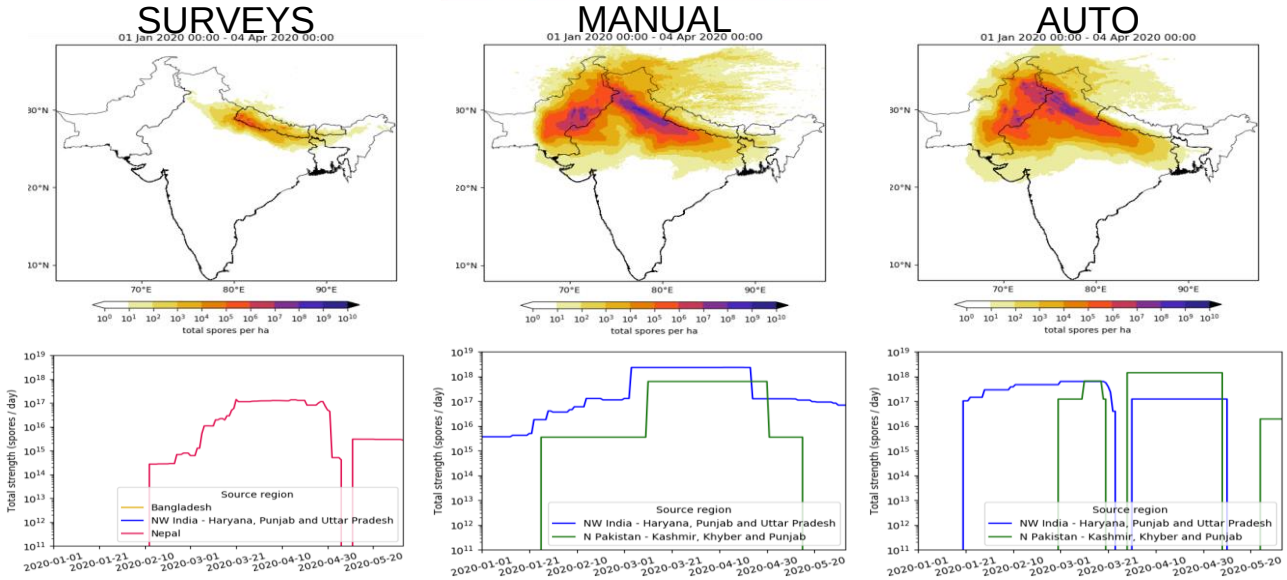
Challenge: International coverage of unsurveyed areas
Automated media scraping

2020, Stripe rust outbreak in N Pakistan and NW India affected spore deposition in SW Nepal.



Impact to Nepal relative to SURVEYS:

MANUAL: +200%
AUTO: +15%



Challenge: Prompt processing across multiple sites
Collaborative effort

Wheat rust surveillance	News media search	Meteorological forecast	Wheat rust dispersal and suitability forecasts	Delivery to small-holder farmers
Thousands of in-season field surveys with ODK	International search	Forecast for the next 7 days	~1 million particles	Concept-phase investigations underway
International coordination		>1 million observations assimilated each day	~27GB of input meteorological data	National extension agents
Accessible server		3.4 million model gridpoints	Output 3 hourly on 10km x 10km grid	Proven communication methods
		8 thousand CPU hours		Aiming to reach >0.5million farmers

Summary

Challenges in forecasting wheat rust infection	Approaches
Consistent and prompt survey reporting	Standardised CIMMYT format and ODK adoption
international coverage of unsurveyed areas	Automated media scraping
Prompt processing at multiple sites	Collaborative effort
Forecasting leaf rust and wheat blast dispersal	Empirical data sources and sensitivity studies
Impact of more accurate host map	Exploring remote-sensing datasets
Validation	Exploring statistical methods