A Summary of the UCAR google.org Weather and Meningitis Project

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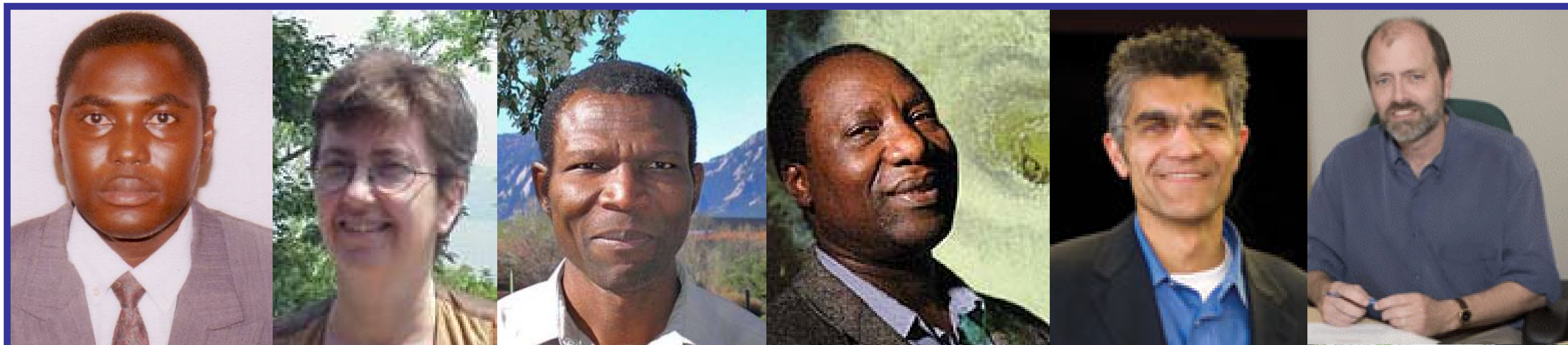
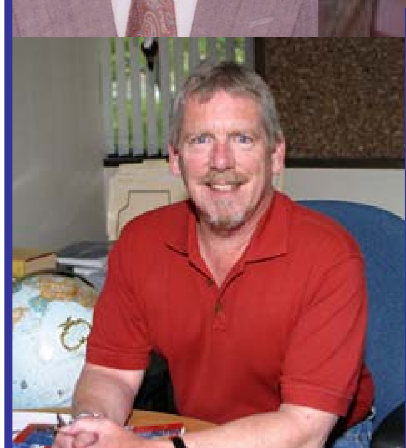
Delivered by: Raj Pandya, 8 December 2008





Participants, Clockwise from top left:

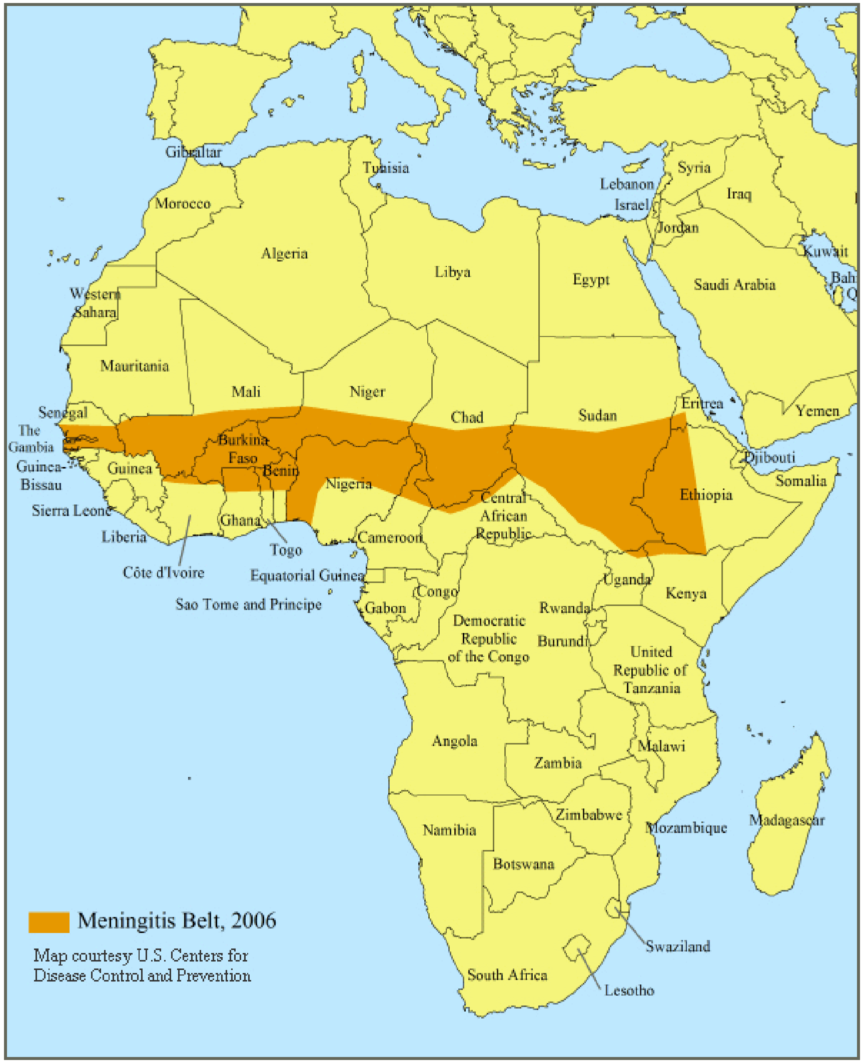
Abudulai Adams-Forgor, Madeline Thomson, Benjamin Lamptey, Fred Semazzi, Raj Pandya, Jeff Lazo, Mary Hayden, Thomas Hopson, Abraham Hodgson(tentative), Jennie Rice, Tom Yoksas, Sylwia Trzaska, Tom Warner

Outline

- Project Goal
  - to use meteorological forecasts to help those who are managing Meningitis in the face of limited vaccine availability
- Context
  - An overview of Meningitis
  - Reactive and proactive vaccination strategies
- Problem
  - How to identify areas at risk for an epidemic
  - Short term: How to allocate scarce vaccines
- Method
  - Comprehensive analysis of meningitis risk factors
  - First step: Using meteorological data to target reactive vaccination

Context: Meningococcal Meningitis

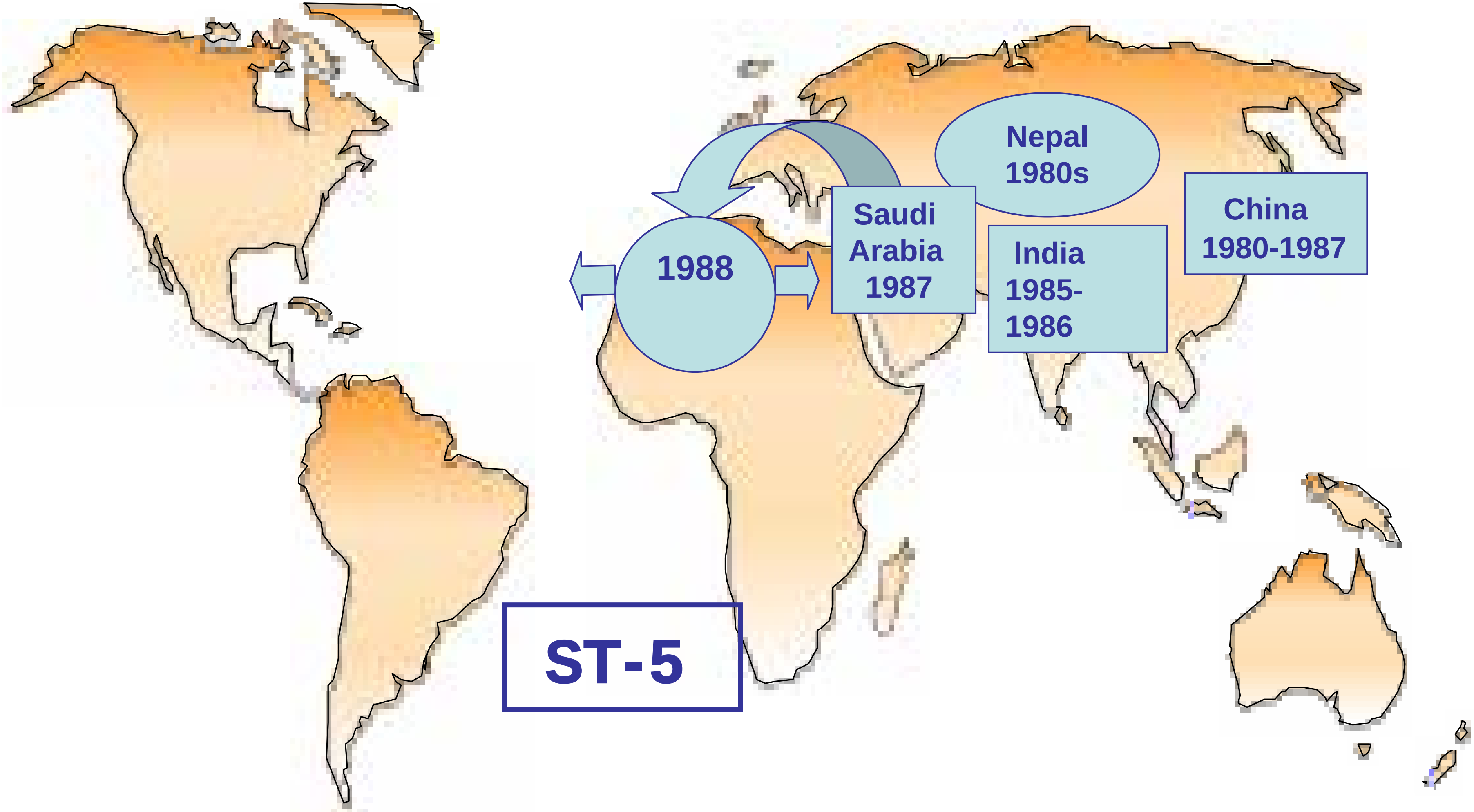
- Endemic in Africa
- Sporadic epidemics (e.g., 1996-1997: 250,000 cases)
  - 5-10% fatality rate
  - 10-20% of survivors have permanent impacts, e.g., hearing loss, brain damage, leaning disabilities
- Not a current epidemic threat in US, Europe



Managing Meningococcal Meningitis Worldwide

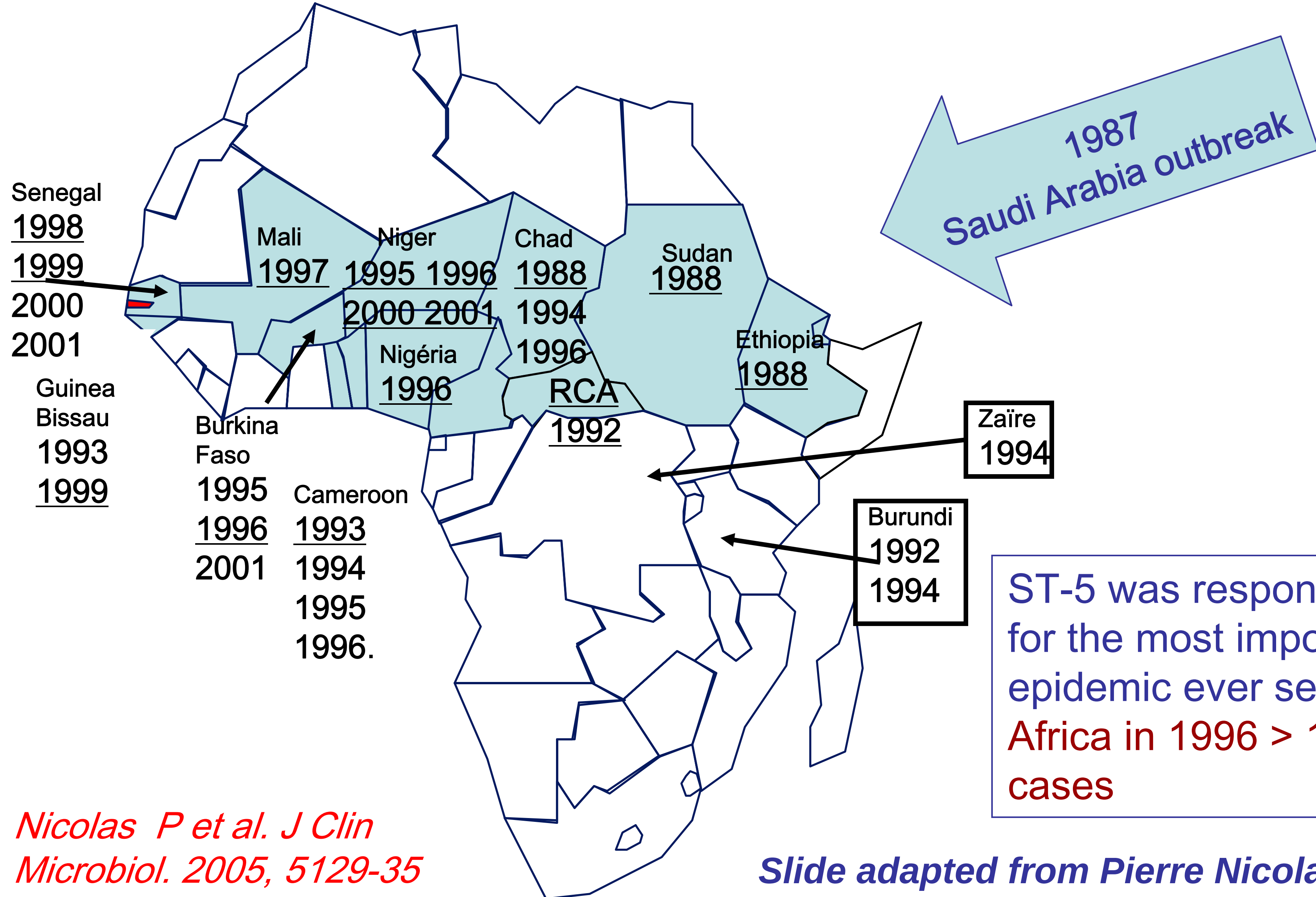
- Neisseria meningitidis (Nm), is responsible for meningococcal disease that occurs worldwide
- In the meningitis belt epidemics are usually due to serogroup A meningococcus
  - The currently-available vaccine for serogroup A is scarce and has limited efficacy
  - An improved vaccine is being piloted next year: mass vaccinations throughout the meningitis belt over the next 10 years may eliminate the disease
- In the developed world, the disease is uncommon. Most cases are due to serogroup C meningococcus, for which there are good vaccines
- In the last decade, we have seen the emergence of serogroups X and W135, internationally
  - Serogroup X has no vaccine; a limited efficacy vaccine for W exists

Global expansion of serogroup A meningococcus ST-5 complex



Slide adapted from Pierre Nicolas, WHO

Serogroup A ST-5 expansion in Africa: 1988 - 2001

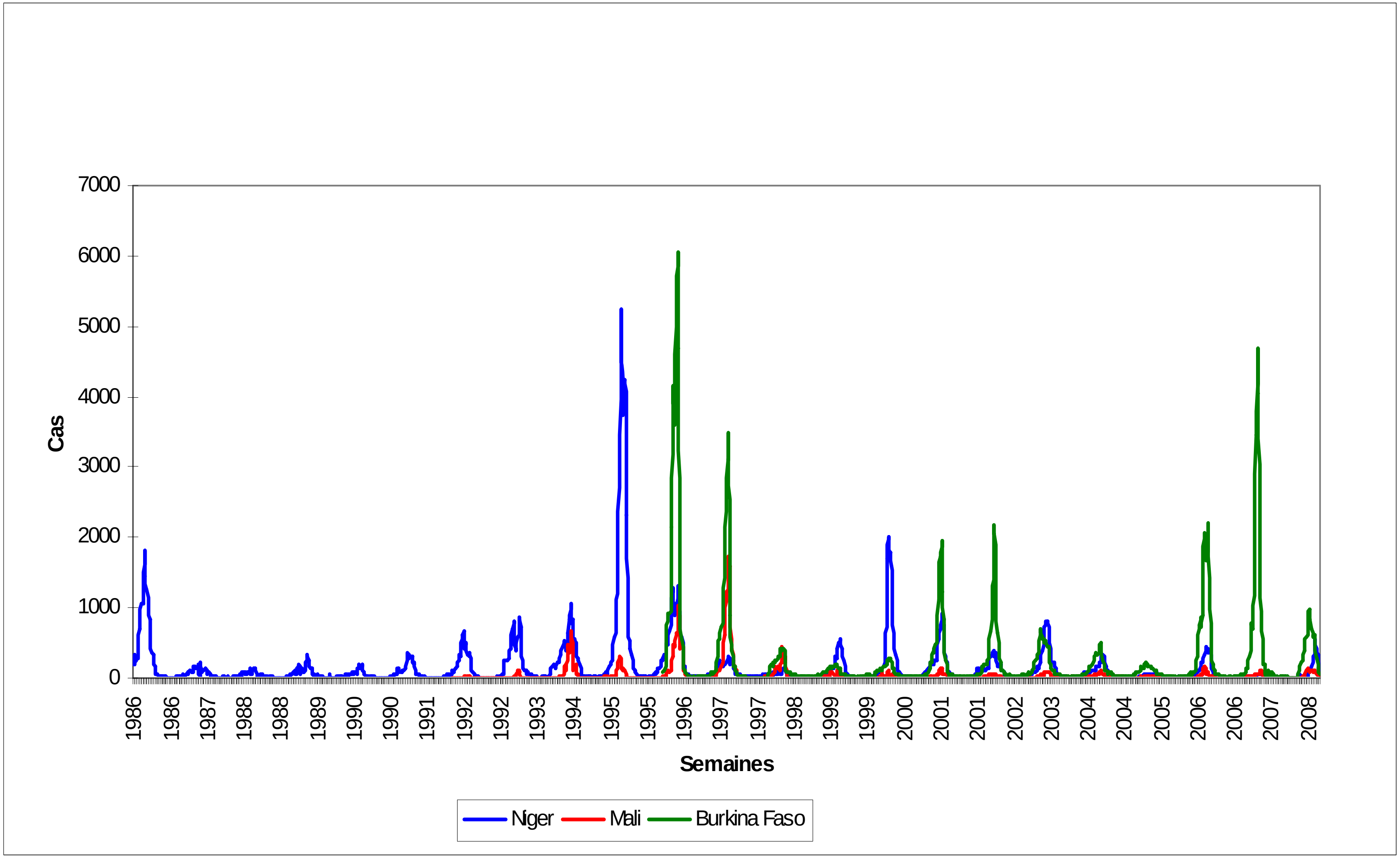


ST-5 was responsible for the most important epidemic ever seen in Africa in 1996 > 150,000 cases

Nicolas P et al. J Clin Microbiol. 2005, 5129-35

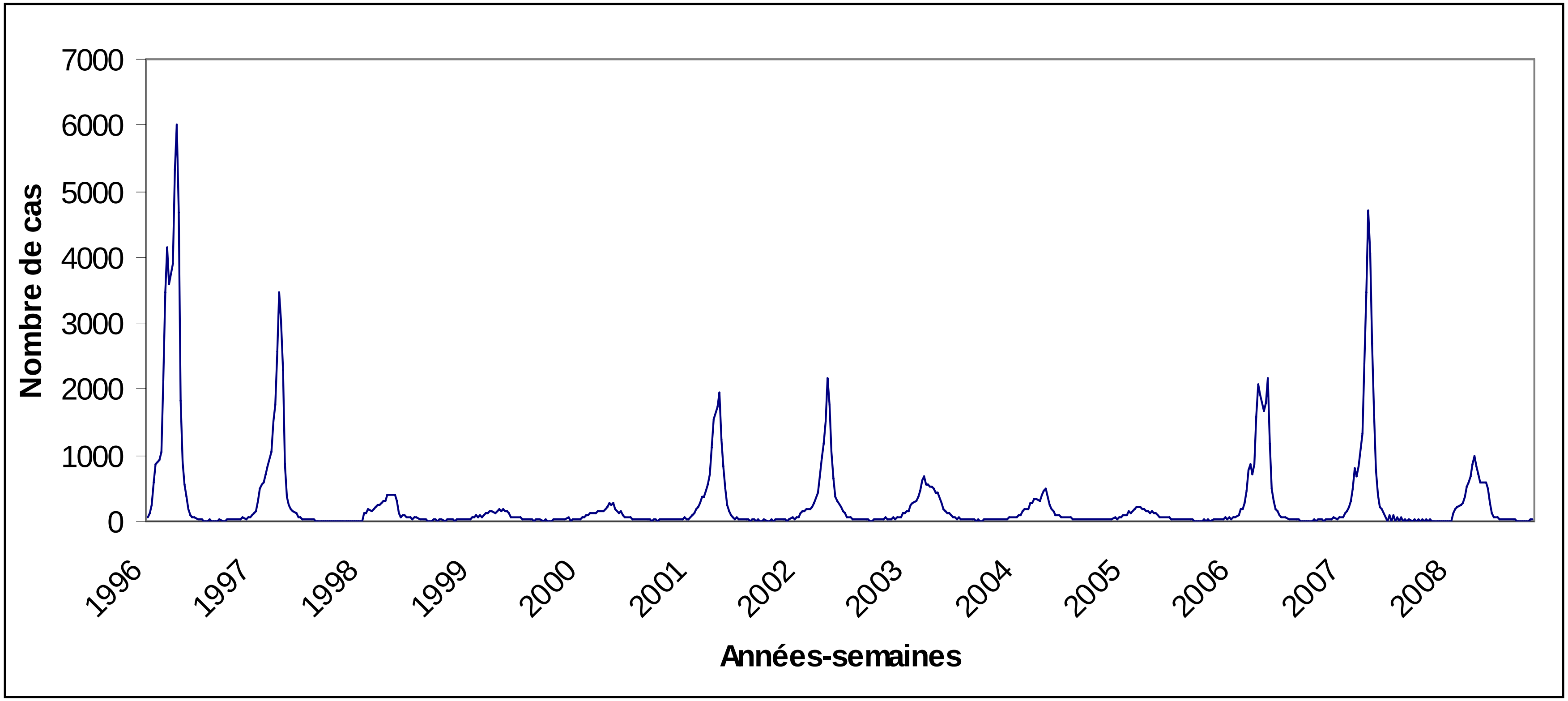
Slide adapted from Pierre Nicolas, WHO

Suspect meningitis cases/week, /year Burkina Faso, Mali, Niger: 1996 - week 21, 2008



Slide Adapted from Stéphane Hugonnet, WHO

Cas suspects de méningite
Burkina Faso: 1996-2008



Slide Adapted from Stéphane Hugonnet, WHO

Cost of 2007 Epidemic in Burkina Faso

Health System US$ 7.103 M US$ 0.52 / inhab 2% of National Health Expenditure	Meningo Case US$ 2.325 M US$ 0.17 /inhab US$ 90 / case
Reactive Immunization campaign 85%; US$ 0.44/inhab; US$1.45/vaccinated	Indirect costs 54.7%; US$49.2/case
Case management 9.6%; US$0.05/inhab; US$26.4 / case	Direct Medical Cost 28.2%; US$25.3/case
Other SR 4,8%, US$ 0.02/inhab; US$13.3 /case	Direct Non Medical Cost 17.2%; US$15.5/case

Slide from A. Colombini, F. Bationo; Agence de Médecine Préventive

Reactive Vaccination

- The currently available vaccine for Serogroup A (Polysaccharide)
  - Scarce
  - Only provides immunity to the person vaccinated, but still allows them to transmit the disease to others (carriage)
  - Only lasts 1-2 years
  - Doesn’t produce an immune response in kids under two

- The currently available vaccine is used reactively to manage the epidemics, once they start.

16 Countries implementing enhanced meningitis surveillance, 2008

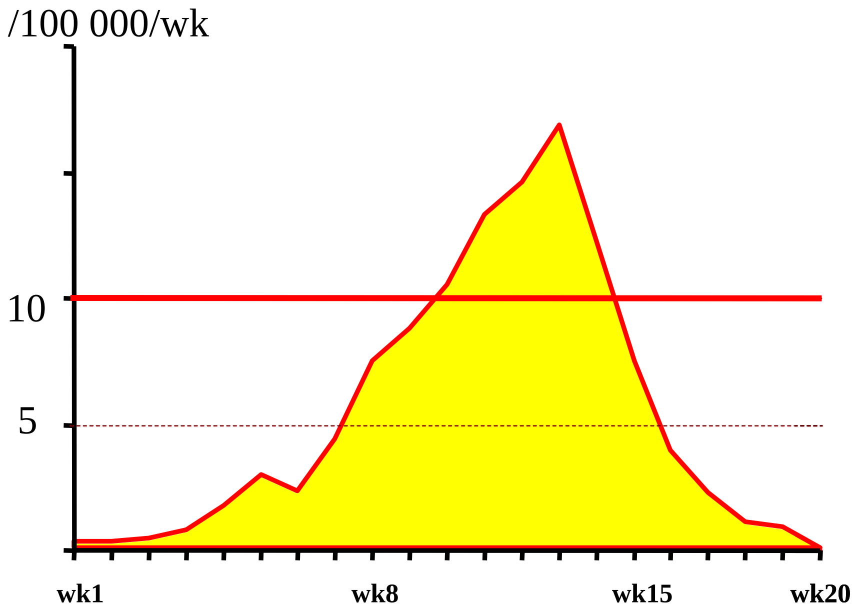
Slide Adapted from Stéphane Hugonnet, WHO

The principle of thresholds

Alert threshold

5/100 000/week

Clinical samples + lab confirmation



Epidemic threshold

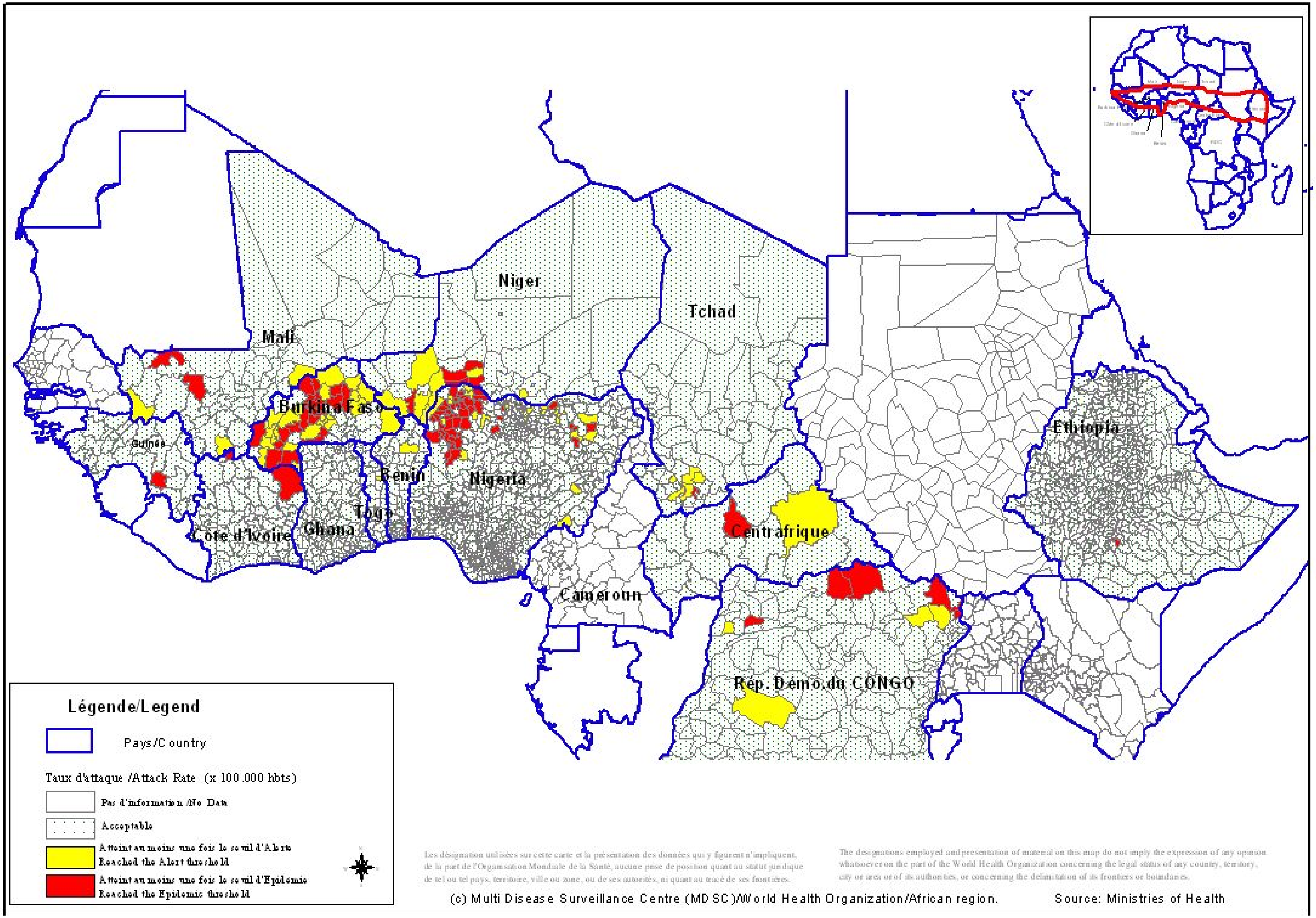
10/100 000/week

Immediately conduct district mass vaccination
Strengthen case management

Note that in the developed world epidemic threshold is 1 per 100k per year!!

Slide Adapted from Stéphane Hugonnet, WHO

Alert and epidemic districts in African meningitis belt: Weeks 1-26, 2008



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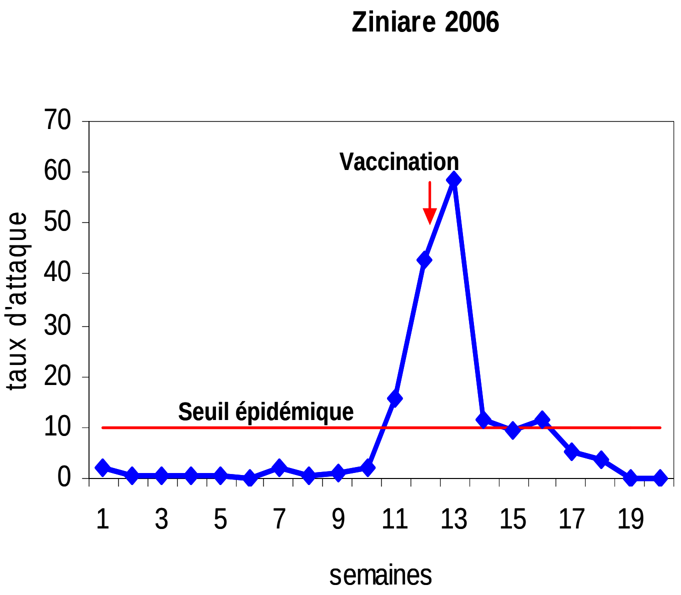
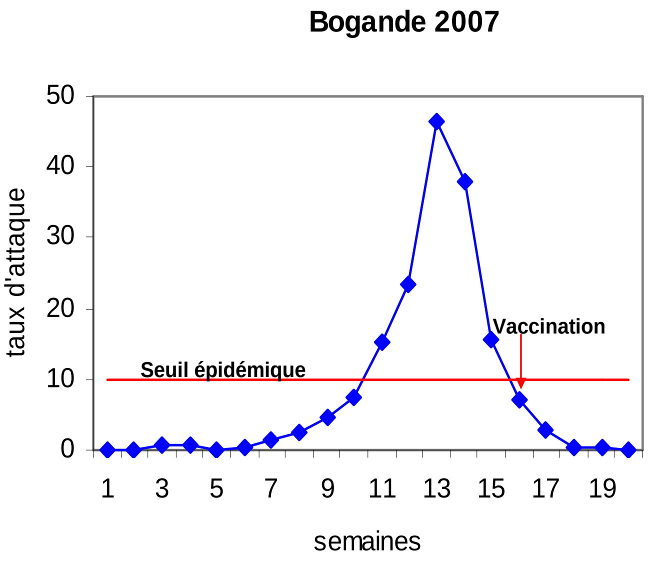
From the reaction to the prevention..

Reactive Vaccination: A frustrating strategy





Slide Adapted from Stéphane Hugonnet, WHO

The new vaccine - Conjugate A

- Promising features
  - May provide immunity for up to 10 years
  - Once vaccinated, a person can’t transmit the disease (no carriage)
  - Immunogenic in children under two
  - ***All this implies that the new vaccine (conjugate) can be used proactively***
- Caveats..
  - The vaccine hasn’t yet been evaluated in real-world settigns
  - Manufacturing constraints mean that it may require ten years to vaccinate everyone in the meningitis belt
    - Implies the need to continue reactive strategies in response to epidemics
  - Doesn’t protect against X or W serogroup
    - W was a problem among Hajj pilgrims, and responsible for 12,617 cases and 1,447 deaths in Burkina in 2002 (but has been much less visible lately)
  - ***All this suggests the reactive use of the currently-available vaccine (the polysaccharide) will continue***

Managing and Forecasting Meningitis Epidemics

- Meningococcal meningitis epidemics require three factors…
  - A population susceptible to the emerging serogroup
  - An hyper-invasive/hyper-virulent strain
  - ***Risk factors – including environmental factors, social factors, …***

Why do we think Weather is a Risk Factor for Meningitis?

- Meningitis in Africa is largely, though not entirely, confined to regions with a defined dry season
  - Meningitis epidemics always occur in the dry season

- Meningitis is culturally associated with dust, which is seasonal (in fact, in many languages the name for meningitis is “sand disease”)

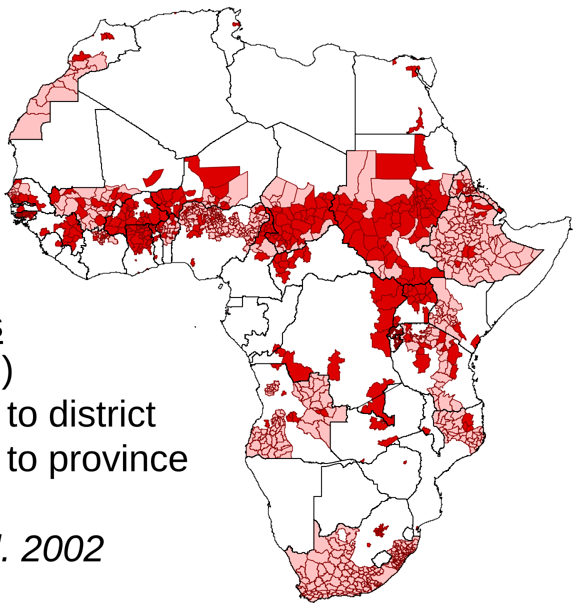
- Meningitis epidemics end abruptly with the start of the rainy season

Two questions:

- Can what is known about climate and weather risk factors be used to better help manage scarce vaccines in the current reactive strategy

- What kind of research can improve future management, including the proactive application of the new Conjugate A vaccine.

Comparison of observed epidemic areas and areas predicted from environmental variables

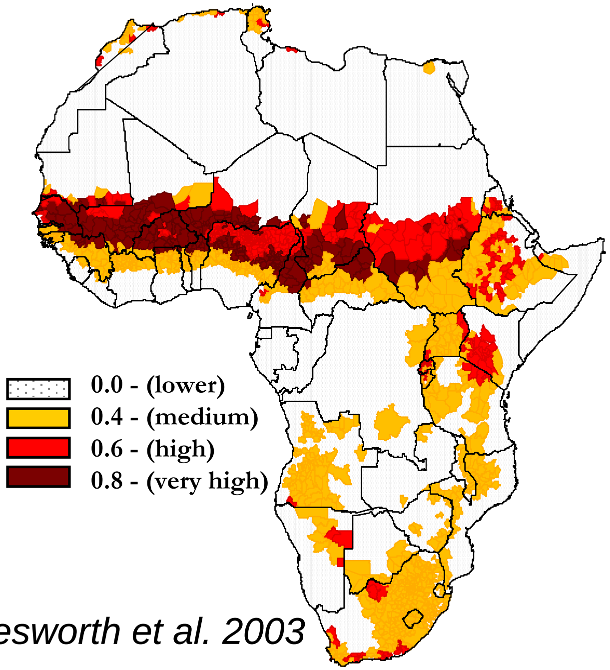


Affected districts
(n = 1232 / 3281)
Reported to district
Reported to province

Molesworth et al. 2002

- **Risk mapping based on env. factors**
- Land cover type
- Seasonal absolute humidity profile

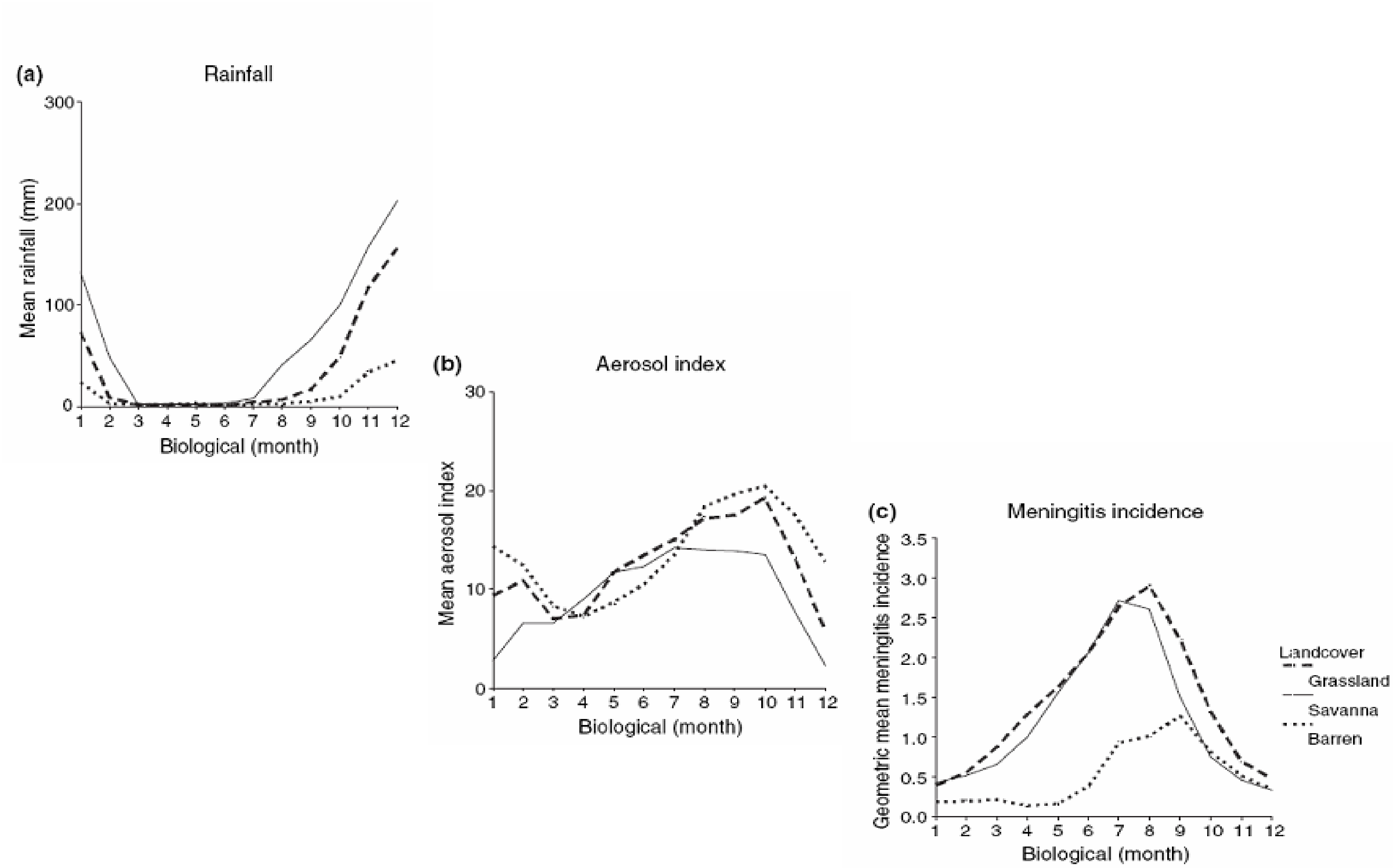
NB. Significant but not included in final model
Seasonal dust profile, Population density, Soil type



Molesworth et al. 2003

Slide from Sylwia Trzaska, IRI

Seasonality of meningococcal disease



Slide from Sylwia Trzaska, IRI

Thomson et al., 2006

Seasonal onset of cases may be triggered by climate

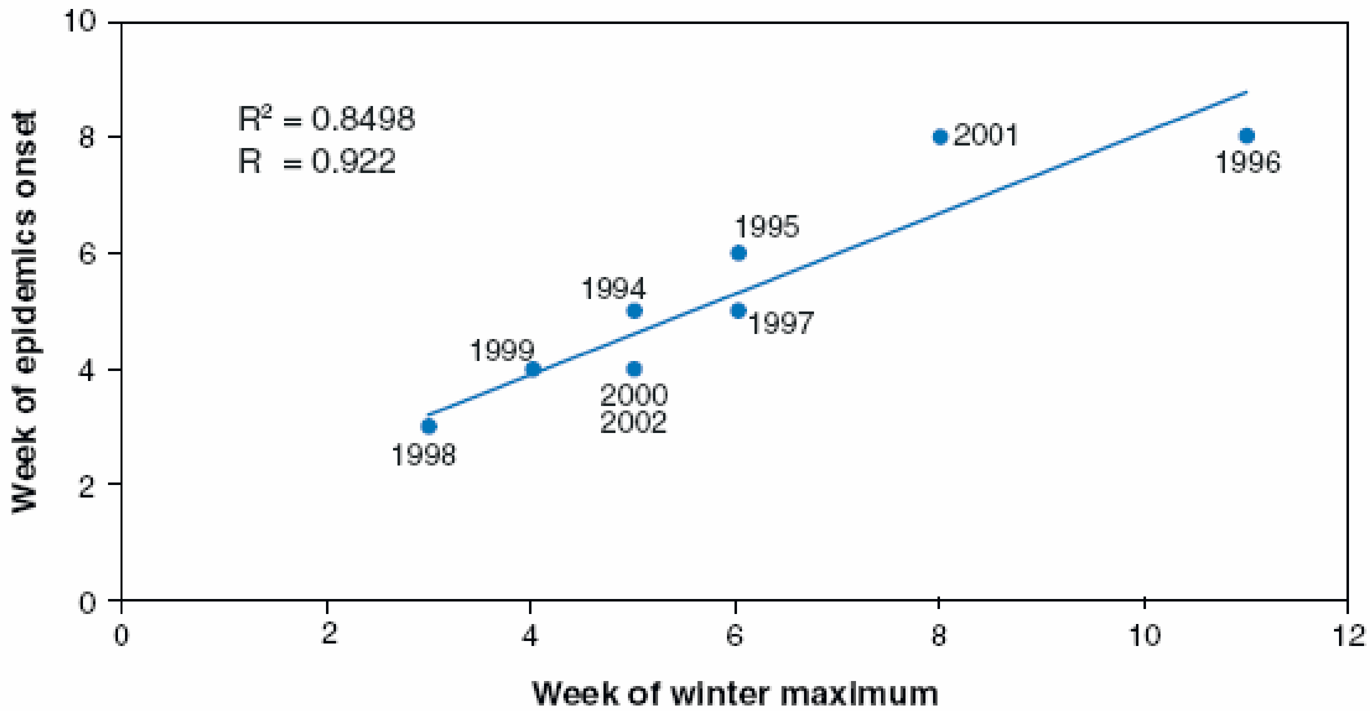


Figure 10

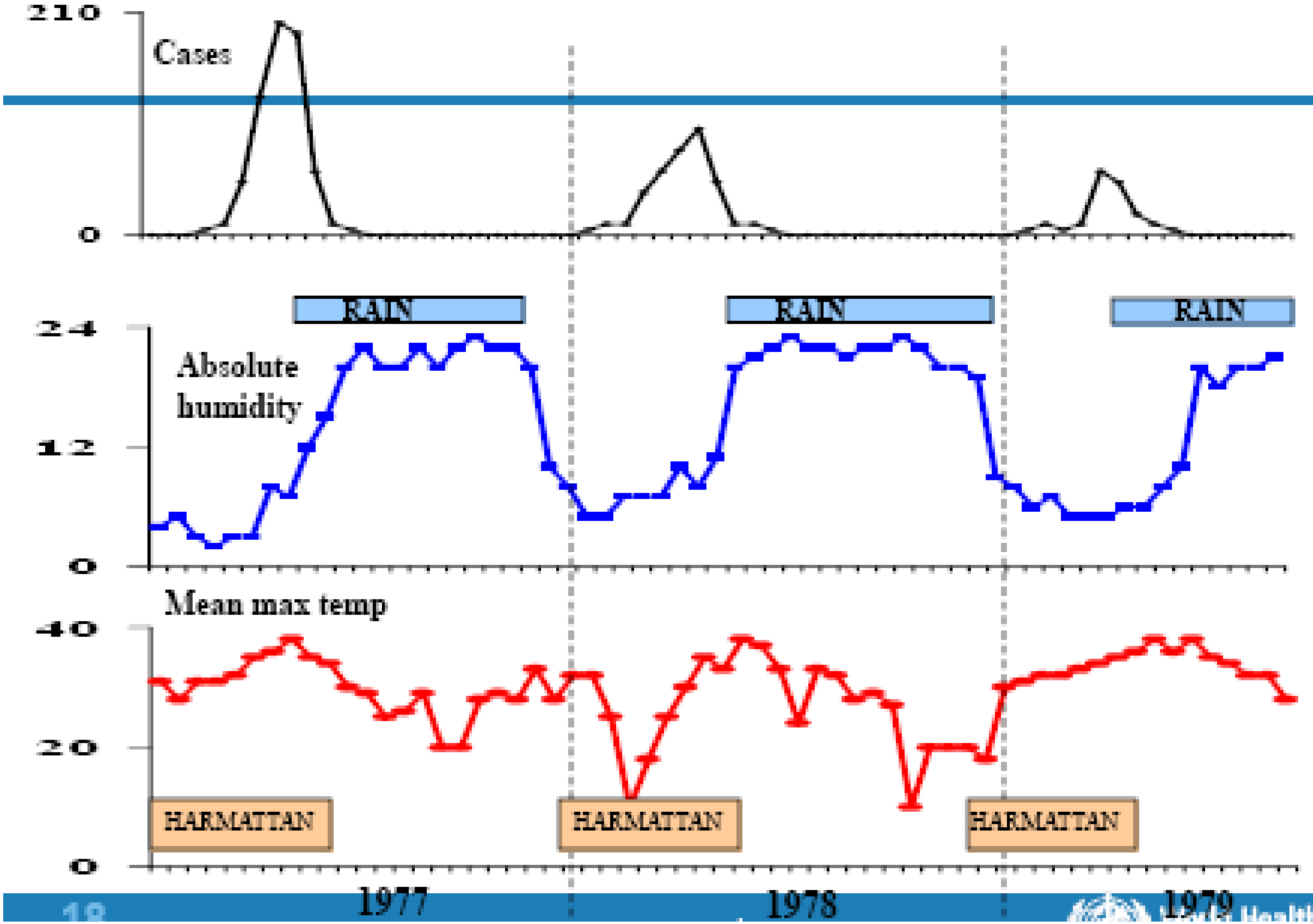
Sultan and colleagues demonstrated that the week of onset of epidemic meningococcal disease in Mali shows a linear relationship with the timing of maximum Harmattan winds. Reproduced from *Public Library of Science Medicine* (76) under terms of the Creative Commons Attribution License.

Slide from Sylwia Trzaska, IRI

Sultan et al. 2006

Season and Meningococcal Epidemics

(Greenwood et al. Lancet 1979; 73:557-62)



Our Google Project Components

0. Overall focus on Ghana, especially Navrongo

Activity 1. Systematic investigation of the factors (not just environmental) that will impact the epidemics

- The role of dust?
- Cultural Practices, Population, etc..

Activity 2. Better forecasts of the end of the dry season

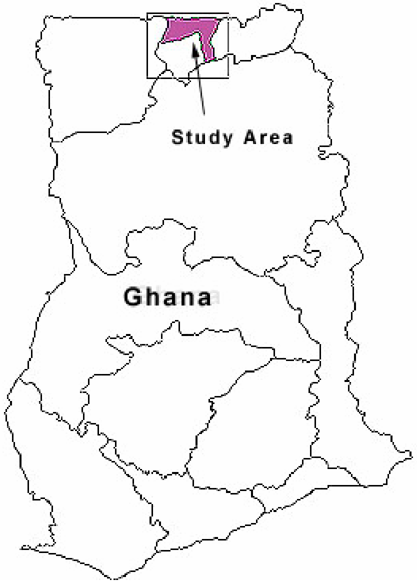
- Preliminary conversations suggest more precise information would help; decision makers are already informally trying to account for this
- Focus on implementation of current understanding in a decision process while doing research

Activity 3. Preliminary economic assessment of the impact of vaccine intervention – including impact of new weather information

- Includes a survey of households to identify other factors that may be managed as well

Ghana Focus

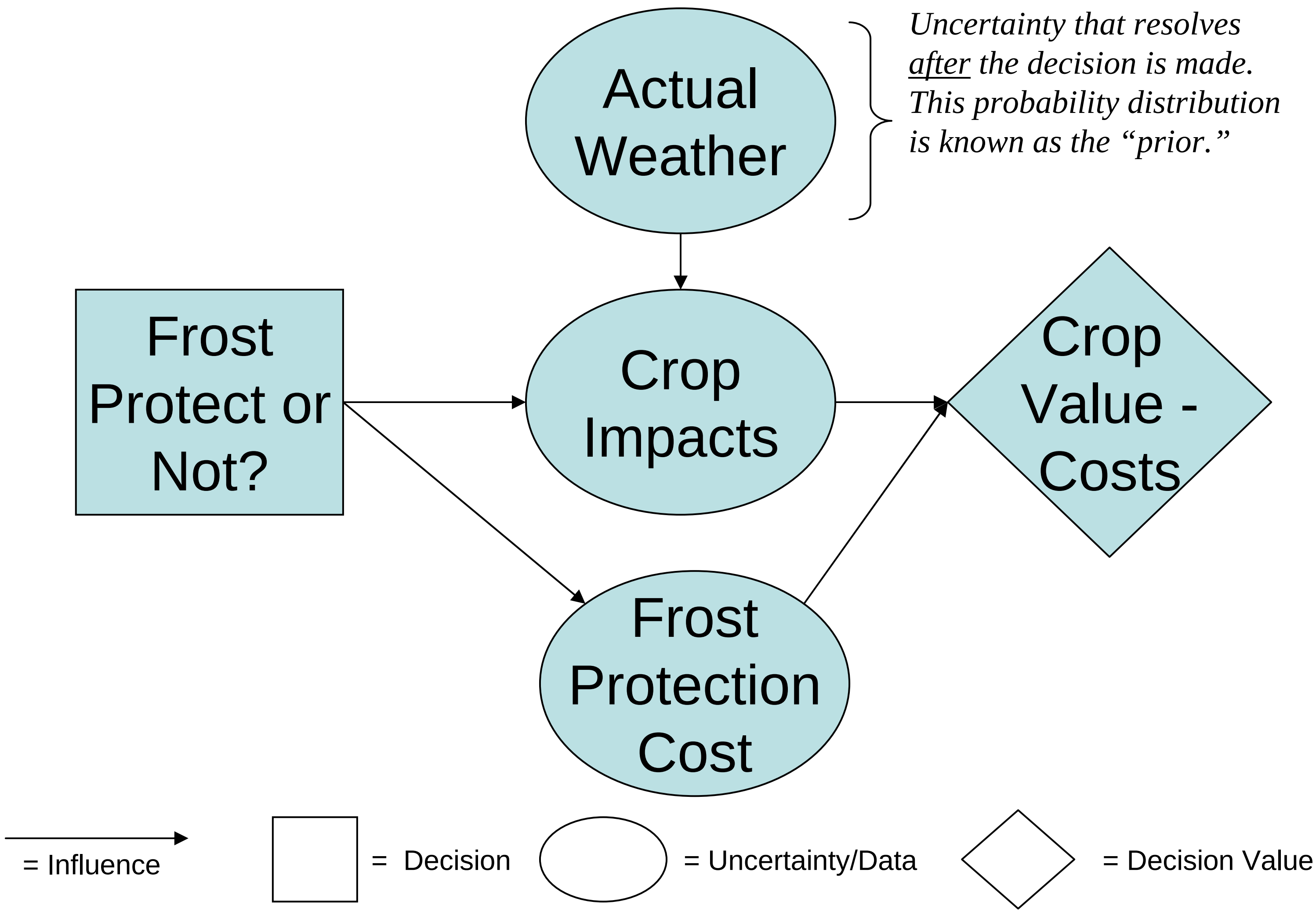
- Navrongo, in northern Ghana, has excellent epidemiological surveillance data going back 10 years
- Their staff includes necessary expertise, including Abudulai Adams-Forgor and Abraham Hodgson (the director) who are publishing a paper on weather-meningitis links in Ghana
- Former UCAR post-doc, Benjamin Lamptey provides ties to the operational community in Ghana; which will help with data access and sustainability (ultimately, weather service will provide forecasts)



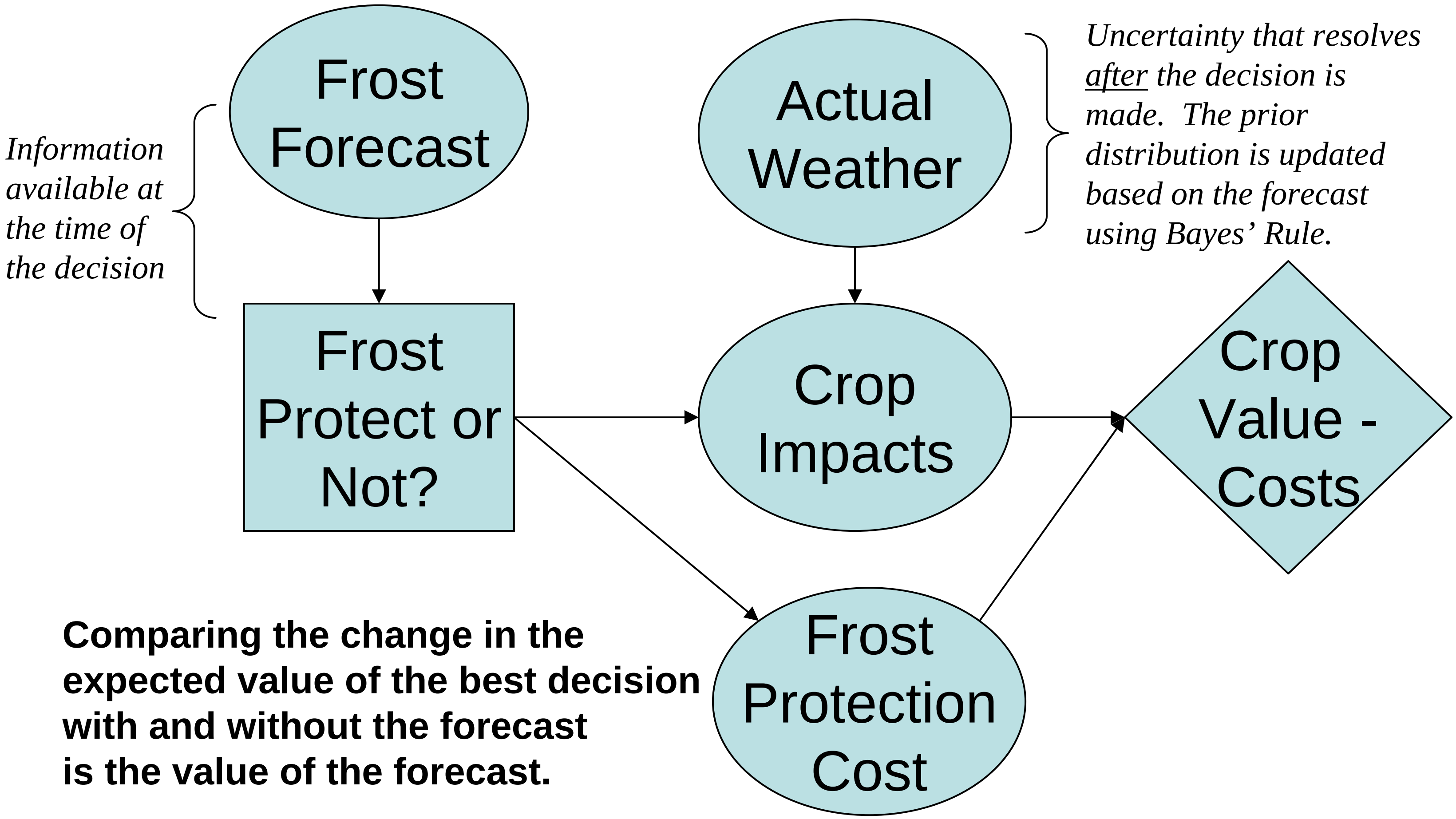
Influence Diagrams: A tool for organizing and activating the projects activities

- Compact, graphical way to communicate complex relationships between:
  - Decisions
  - Uncertainties, data, research results
  - Outcomes and objectives
- Corresponds to a mathematical model (Bayesian network)
  - Incorporates probability distributions
  - Optimizes the decision
  - Determines the value of new information, research

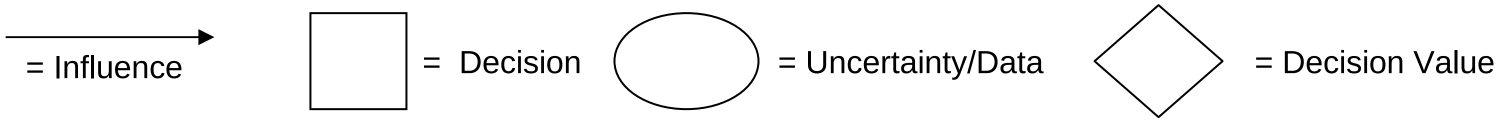
Example: Orange Grower Decision



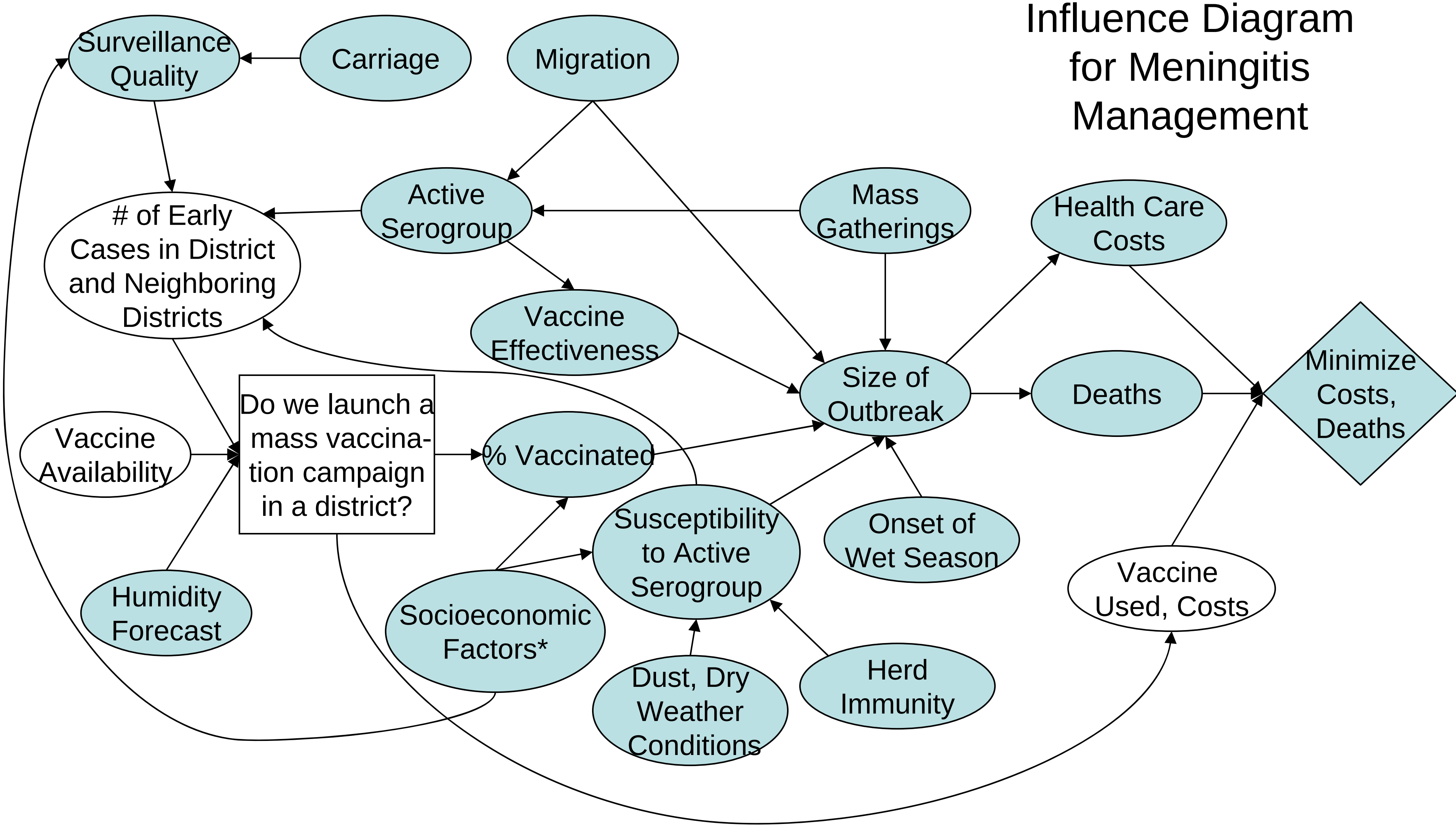
Orange Grower Decision with a Forecast



Comparing the change in the expected value of the best decision with and without the forecast is the value of the forecast.



Influence Diagram for Meningitis Management



*Includes: cultural practices (e.g., use of traditional medicine, head scarves, cooking practices, etc.), demographics (e.g., age, gender), income, presence of other diseases, awareness, and so on.

Activity 1: Identify socioeconomic factors that influence epidemic and provide baseline data for economic evaluation

- Survey designed to be administered in conjunction with twice-per-year carriage visits in Navrongo District
- Survey will characterize:
  - Economic impact of disease on households
  - Attitudes and beliefs about the disease
  - Socio-economic conditions that may impact risk of disease
  - Cultural knowledge and practices that may influence disease risk (e.g., practice of breathing through a scarf, food practices, use of traditional medicine)
- Could allow an opportunity to expand the decision support system

Activity 2a: Identify weather variables linked to end of epidemic

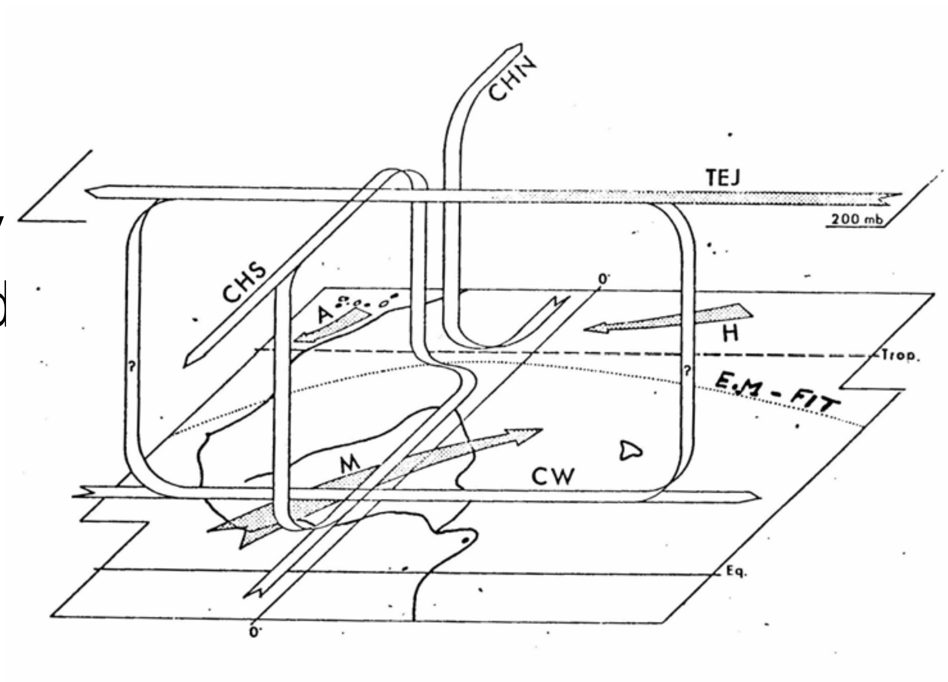
- Collect Epidemiological Data
  - Archive Navrongo district epidemiological records
  - Locate and archive less valuable but still good data from neighboring districts
- Collect Weather Data
  - Locate and archive in-situ weather data for Navrongo and surroundings
  - Prepare additional meteorological data from other sources- NCEP reanalysis, COSMIC soundings, etc.
- Compare the two data sets, and identify variables strongly correlated with the end of the epidemic (e.g., sustained absolute humidity)

Activity 2b: Predict the end of the dry season

- Use TIGGE (WMO **T**HORPEX **I**nteractive **G**rand **G**lobal **E**nsemble) ensemble model output and other tools to predict weather in Northern Ghana 2-14 days in advance

- Optimize this prediction for the variables associated with meningitis.

- Since this signal is primarily the interplay of synoptic and global scale circulations, we believe we can forecast this



OUTPUT: A Decision Support System

- Meet with local, regional and international decision makers to design data delivery systems that support their needs:
  - Vaccination deployment decisions are made by WHO, Médecines sans Frontières, UNICEF and Red Cross/Red Crescent
  - They do try to prioritize areas where rains are farther away in time for vaccination campaigns
  - Seasonal forecasts are not yet actionable
- If we can build a decision support system, we can use the influence diagram to do a very preliminary evaluation the impact of the decision (Activity 3)

Some final thoughts…lessons I think I've learned so far (and the rest of team already knew…)

- ***Listen*** - to decision-makers and in-the-field workers to ensure the decision process is based on real data, meets decision-makers needs, and results in action.
    - E.g.: we've learned that seasonal forecasts are (currently) more difficult to use than short-term forecasts, because decision makers we are working with can't influence the amount of vaccine available.
- ***Be Humble*** - Meteorology isn't the only factor that influences the disease spread, so it needs to be considered in that context; multiple expertise is needed to even figure out how meteorology can contribute
- ***Involve the Community*** - Work in Africa (or any community) needs to occur at the invitation of the community, with the community, and address the needs of the community. "No drive-by science"