**ENSO Prediction and Policy**

Making the world a better place with science

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**Millennium Villages Program**

- Columbia University Program
- Goal: End extreme poverty in our lifetime
- African focus: highest risk
- 14 villages

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**Global ENSO Impacts**
Normal Conditions in the tropical Pacific

El Niño Conditions

La Niña Conditions

Patterns:
- STRONG East-west SST
- STRONG upwelling
- STEEP Thermocline slope
- STEEP Sea surface slope
- POSITIVE SOI
- STRONG trade winds
- MORE rainfall SE Asia
How to predict?

Historical Sea Surface Temperature Index

Forecasts courtesy of IRI (Lamont-Doherty)

Global SST anomalies - last week

http://iridl.ldeo.columbia.edu

What can we do with this information? Not much

Dry    normal    Wet
Unusual climate in the news last week

Indonesia Flooding  Hawaii Drought

Predictions and Policy
Snapshots of current conditions are not very useful.
People need advance warning, and for their region.

Today:
1) how predictions are made
2) what we can do with them

ENSO Prediction Methods
• Skillful 6-9 months into the future
• This ability has saved many millions of lives
• Two methods: Dynamical vs. Statistical
How to predict?

Historical Sea Surface Temperature Index

Correlation

Dynamical Climate Modeling

Physically-based models, grid-calculations based on conservation of mass, energy, momentum
Surface layer $\tau$
Deep ocean; $u=v=w=0$
Active layer
50 m
150 m
Simplified Ocean and Atmosphere Models
Simplified form of equations for conservation of mass, momentum, energy

Lots of open ocean observations (now)

TOGA-TAO Buoys
Buoys measure winds, SST, SLP...
Physical equations are initialized with real observations

DEA LEVEL-ANOMALY (m, m) and OCEAN-TEMPERATURE-ANOMALY (m, m, K)
Here are images from the tropical Pacific, simulated through DEA model
The surface shows sea-level anomalies and the surface is colored according to the SST anomalies associated with each event.
What sort of computing power do you need?

Earth Simulator 130 TeraFLOPS
IBM Roadrunner still 8x faster

What a Model El Niño event looks like

Pacific simulation - SST anomalies

Wind anomalies

Model forecasts this winter

Lots of models!
Each predicts 5 months ahead, each month
Result is a "plume" of predictions
Modeling gives you skill at forecasting:
Better skill after 3-4 months than “persistence”
Skilful up to 9 months into future

Revised NINO3 forecasts initialized each month

There is a prediction “barrier” in Spring
Other “models” can be built using a probabilistic approach: “Statistical”

The Forecast

“La Niña” for another 6 months at least

What do we do with this information?

The same models that predict ENSO state can be used to predict climate changes, globally. Some regions warm/cold, some wet/dry. Critical is being able to say “how unusual” climate will be.
Precipitation forecasts


How to use / disseminate these results

• Communicate broadly, for free
• Train how to use the predictions
• Each country has unique “problems”, ENSO vulnerabilities.
• Key is to understand:
  a) identifying their culture/problem
  b) your ability to provide actionable information
  c) how to implement change.

Index Insurance for Drought in Africa

Science in the service of humanity

Dan Osgood & Eric Holthaus
International Research Institute for Climate and Society
Outline

- Problem: ENSO impacts rainfall and agriculture - Food Security
- Solution: Farmer Index insurance to buffer impacts
- Results from Ethiopia Millennium Villages Project (MVP)
- 13 other MVPs with very different problems and solutions

Drought and Development: The Problem

- Climate shocks increase vulnerability (in already vulnerable places)
  - Survey: 10 of 12 list drought as #1 livelihood risk (source: MVP)
- Climate Risk Management = Risk Reduction (terracing, rainwater harvesting, improved seeds and fertilizer)
  + Risk Transfer (division of labor, insurance, other financial mechanism)
  + Risk Taking (prudent loans to increase productivity in good years)

IRI: Helping developing countries to manage climate risk.

Case Study: Ethiopia

- 85% of population practices subsistence rainfed agriculture
- History of drought leading to civil unrest (1984)
- Famine response usually slow
- Risk management strategies have slow uptake due to poverty traps

Ethiopia statistics:
- Population = 80M
- 2X size of Texas
- Diverse topography and climate
- ~160 rain gauges w/ 30 years history
- GDP per capita: $700/yr
Science Strategy: Index development

- Goal: identify a shared climate risk and insure the community as a whole.
- Define shared risk (drought vs flood, etc)
- Quantify risk (through historical weather information - weather modelling)
- Create index (match climate and climate outcomes - agricultural modelling)
- Create insurance product (frequency of payouts, magnitude of payouts, premium price)
- Target insurance product (keep stakeholders in mind - happens throughout the entire process!)

Index focuses on late season rainfall, when crop harvest is most vulnerable

Ground-based:
- Local Rainfall

Climate data is hard to get for rural populations

Satellite:
- Regional NDVI

Ground-based:
- Local Rainfall
Index insurance data

- Rainfall data is short, with gaps
- Limited spatial coverage
- How far is too far from station?
- Common to many applications
  - Need technique for new stations
  - Most places do not have long met station history
  - Must address for scale-up

Science Strategy: Remote Sensing

- Goal: examine potential to scale up availability of climate/environmental data in data poor regions.
- Satellite rainfall estimates give complete spatial coverage - but short histories and competing methods
- Satellite vegetation can give direct measure of crop health - but also includes surrounding native veg. (also short history)
- Working with NMA(Ethiopia) & Reading U. to develop 30-year satellite rainfall climatology for Ethiopia.
- Working with NASA to "upscale" higher resolution Quickbird and Landsat to MODIS

Seasonal rainfall total is not the best indicator for crop yield

Alternative is to use a simple crop model, e.g.:
Water Requirement Satisfaction Index (WRSI)

Water requirement varies through crop growth cycle

Eg for 180-day maize (as used for Sauri)
Index Insurance

Problems with traditional insurance have kept it from being available to most of the world

- TraditionalCrop Insurance
  - Undermined by adverse selection problems
  - Almost always subsidized (subsidies can cause problems)

- Recent innovation
  - Insure weather index (eg seasonal rainfall, not crop)
  - Only partial protection (basis risk), should not oversell
  - Cheap, easy to implement, fast payout, good incentives
  - Only partial protection (basis risk)
  - Field implementations only a couple of years old
  - Exploding popularity--dangerous if misused
  - Structure to target each particular goal

Design complex

- Only a naive partner would reveal all their cards
- All partners must play active role in collaborative design
- Client must know what is not covered
- How do we build a tool to address climate risk in development?
- How do we design index insurance?

Probabilities of climate events key

- Money in = average(Pay) + cost of holding risk
- Money out = 0.06 (99th percentile - average(Pay))

Micro Example

Malawi Groundnut

- Farmer gets loan (~4500 Malawi Kwacha or ~$35)
  - Groundnut seed cost (~$25, ICRISAT bred, delivered by farm association)
  - Interest (~$7), premium (~$2), tax (~$0.50)
  - Prices vary by site

- Farmer holds insurance contract, max pay is loansize
  - Insurance payouts on rainfall index formula
  - Joint liability to farm "Clubs" of ~10 farmers
  - Farmers in 20km radius around met station

- At end of season
  - Farmer provides yields to farm association
  - Proceeds (and insurance) pay off loan
  - Remainder retained by farmer

- Farmers pay full financial cost of program (with tax)
  - Only subsidy is data and contract design assistance
  - Farmers told us:
    - Insurance package is how they adapt to climate change
  - Malawi Project Partners: Farmers, NASFAM, OIBM—MIA, MRFC, ICRISAT, Malawi Insurance Association, the World Bank, CRMG, Malawi Met Service, CUCRED, IIASA
Macro Example

• Early warning vs early action?

• IRI projects:
  – Index product for Earth Institute MVP
  – Index to ensure development goals of MVP for each village cluster
    • If MVP lifts people out of poverty traps
    • Prevent climate from them falling back in
  – Also exploring: Locust, fire, malaria, livestock disease and international trade, forage, water management...

Multiple poverty challenges, multiple index strategies

Insurance is not for its own sake—it is to reduce poverty, improve food security, and encourage development

Implementation strategy driven by context, type of risk
A. Damage dropping people into poverty traps
B. Risk preventing people from moving forward
C. Immediate damage