



Ecology and Evolution of Avian Influenza at the Ecosystem-Animal-Human Interface

Xiangming Xiao (肖向明)

Center for Spatial Analysis

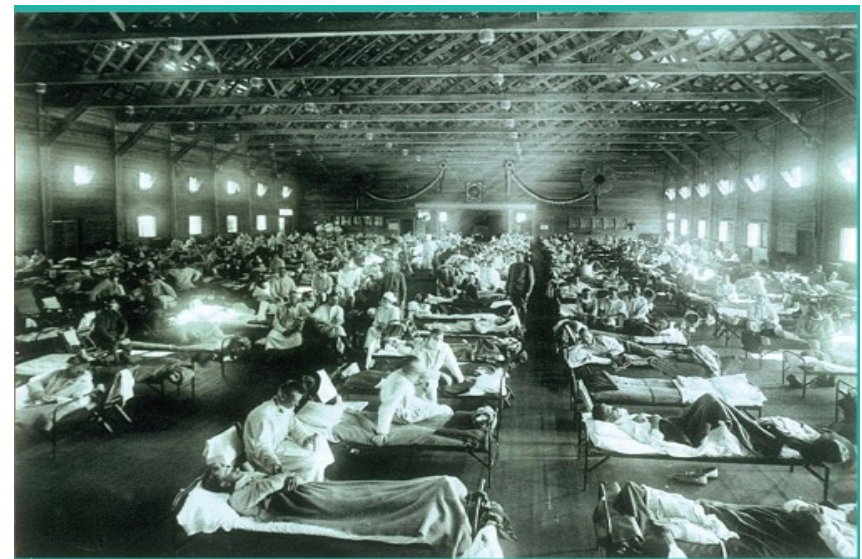
Earth Observation and Modeling Facility

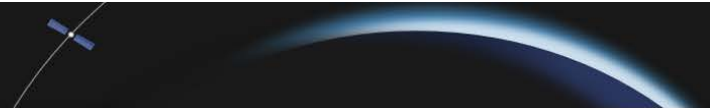
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Where is Oklahoma?

What are famous things in Oklahoma



The Broadway Musical Show



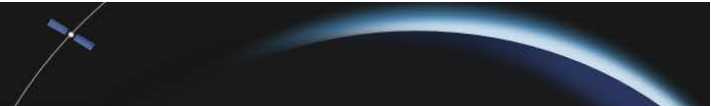
1943



The Dust Bowl in 1930s

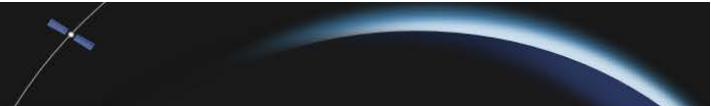


Tornado



University of Oklahoma, Norman, Oklahoma





Ongoing major projects with a contribution from EOMF (since 2007)

Agriculture and food security

1. NASA Agriculture dynamics and intensification in Asia (~\$3 million, 2007-2017)
2. USDA Resilience and vulnerability of beef cattle production in Southern Great Plains under changing climate, land use and markets (~\$10 million, 2013 -2018)

Climate change

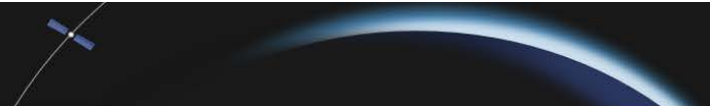
1. DOI South-Central Climate Science Center (~\$4 million, 2011 – 2016)
2. NSF Adapting social-ecological systems to increased climate variability (~\$20 million, 2013 – 2018)

Diseases

1. NIH, NASA, FAO, Ecology and evolution of avian influenza in China and Southeast Asia (~\$5 million, 2007 – 2012, 2013 - 2017)

Cyber-infrastructure for data and models

1. NSF CyberCommons for Ecological Forecasting (~\$6 million, 2009-2013)



Acknowledgement: Research Projects and Funding Agencies

➤ **FAO/UN Department of Animal Production and Health**

Application of satellite remote sensing for the study of ecology and risk factors of highly pathogenic avian influenza in Southeast Asia and China

Project Period: 2006 - 2007

➤ **NIH Fogarty International Center (FIC)**

1. Ecology-based risk assessment and early warning of highly pathogenic avian influenza H5N1 in Asia

R01, Project Period: 2007 – 2012

NSF/NIH Ecology and Evolution of Infectious Diseases (EEID) Program

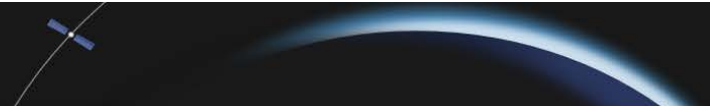
2. Dynamics of cross-species influenza transmission: an international collaboration

Project Period: 2009 – 2012

➤ **NIH National Institute of Allergy and Infectious Diseases (NIAID)**

Transmission dynamics and spillover risk of avian influenza under changing agricultural intensification and landscapes

R01, Project Period: 2013 – 2017



Acknowledgement: International Workshops and Funding Agencies

FAO/UN Department of Animal Production and Health

Workshop grants and in-kind support

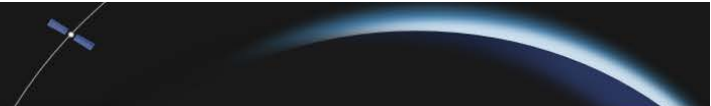
Project Period: 2006 - 2014

National Institutes of Health (NIH) Fogarty International Center (FIC)

International Workshops on Community-based Data Synthesis, Analysis and Modeling of Highly Pathogenic Avian Influenza (H5N1)

Project period: 2009 – 2013

Accomplishment: One international workshop per year during 2006 - 2014
China, Thailand, Vietnam, Italy, USA

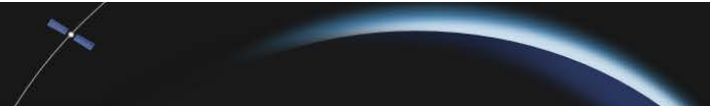


高致病性禽流感生态学和风险因素研讨会

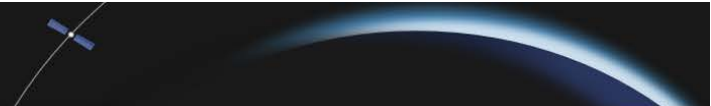
2006.11.28 中国·青岛



Ecology and Risk Factors of Highly Pathogenic Avian Influenza H5N1 in China
November 28-30, 2006, Qingdao, China

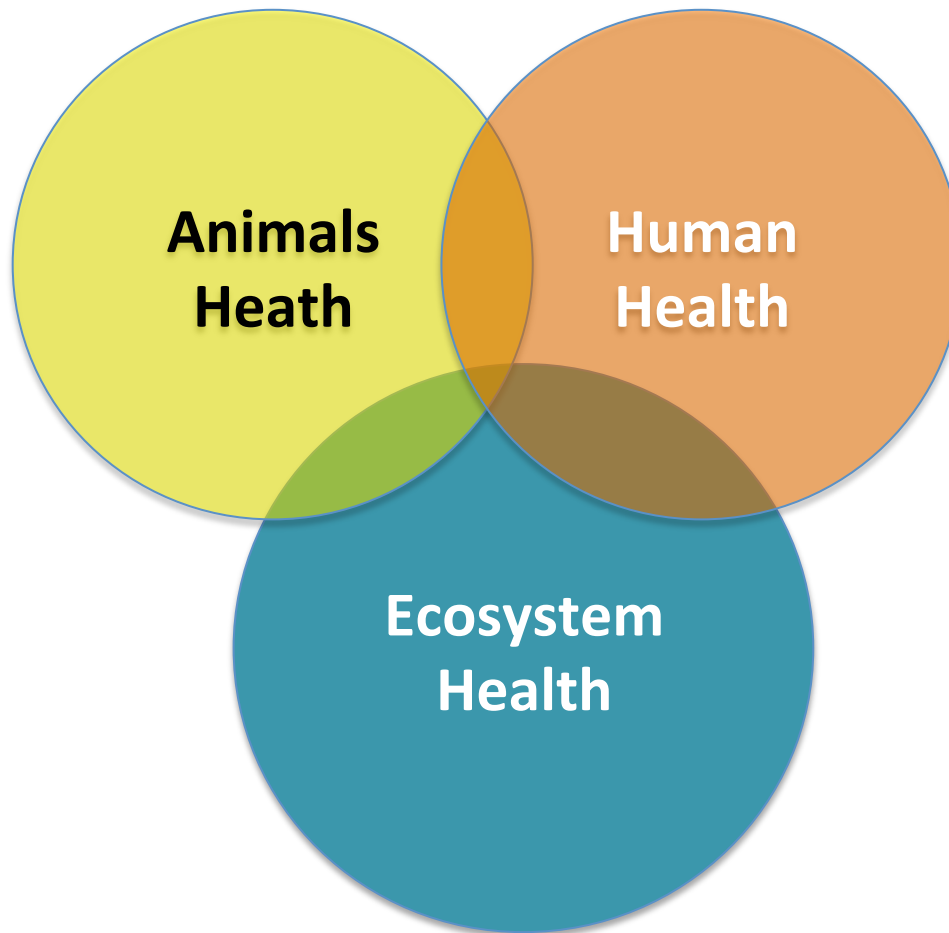


Wild Birds – Wetlands – Agriculture Complex System in Poyang Lake
December 2-4, 2006, Nanchang, Jiangxi, China

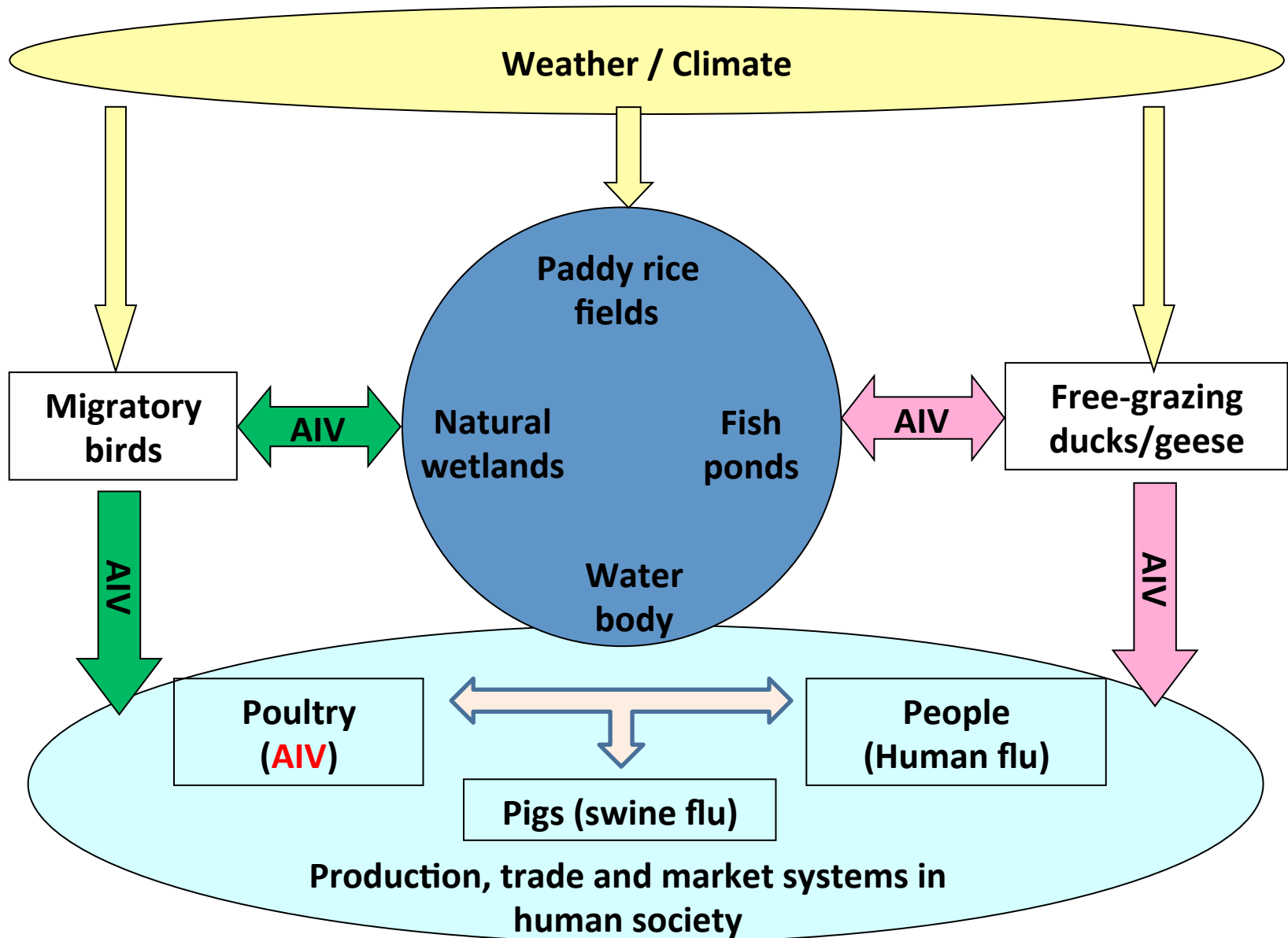


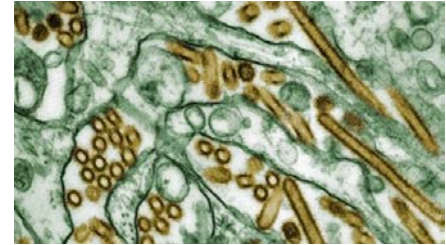
**The 6th International Workshop on Community-based Data Synthesis, Analysis
and Modeling of Highly Pathogenic Avian Influenza H5N1 in Asia
and
Europe-China Workshop on Transboundary Animal Diseases and Zoonoses
April 14-16, 2014, Shanghai, China**

One-Health Framework to study ecology and evolution of infectious diseases at the ecosystem-animal-human interface



Avian influenza virus (AIV) in coupled nature and human systems





Major topics of this presentation

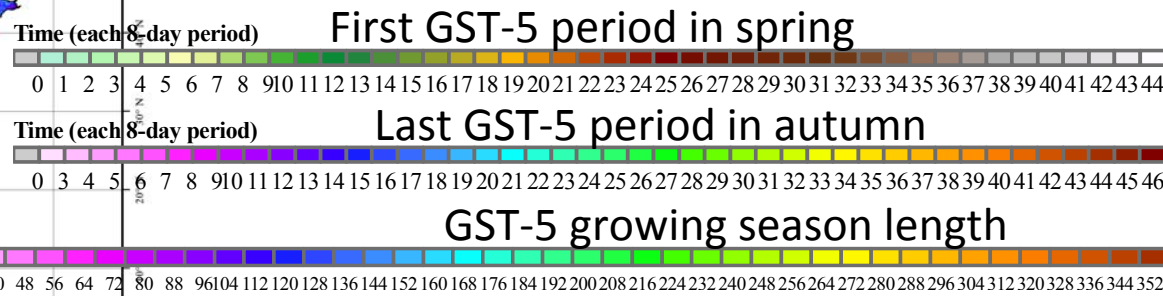
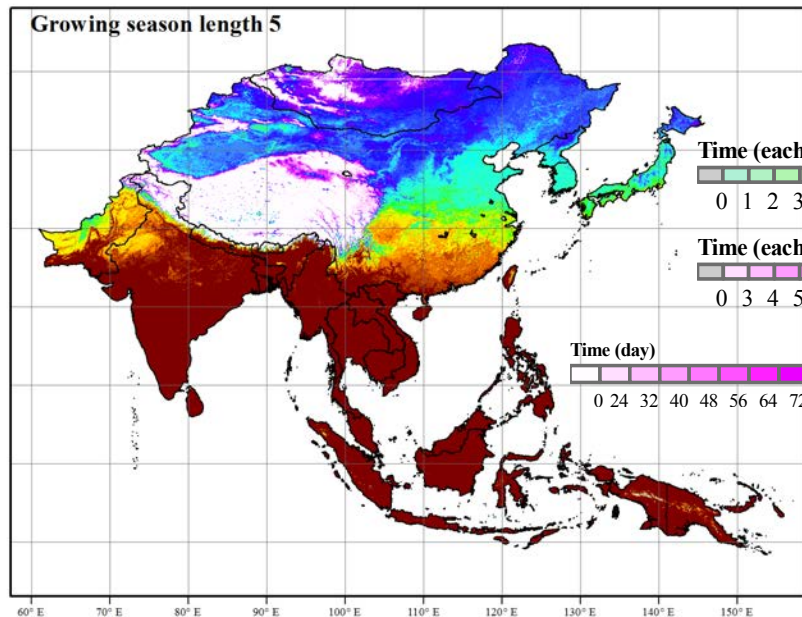
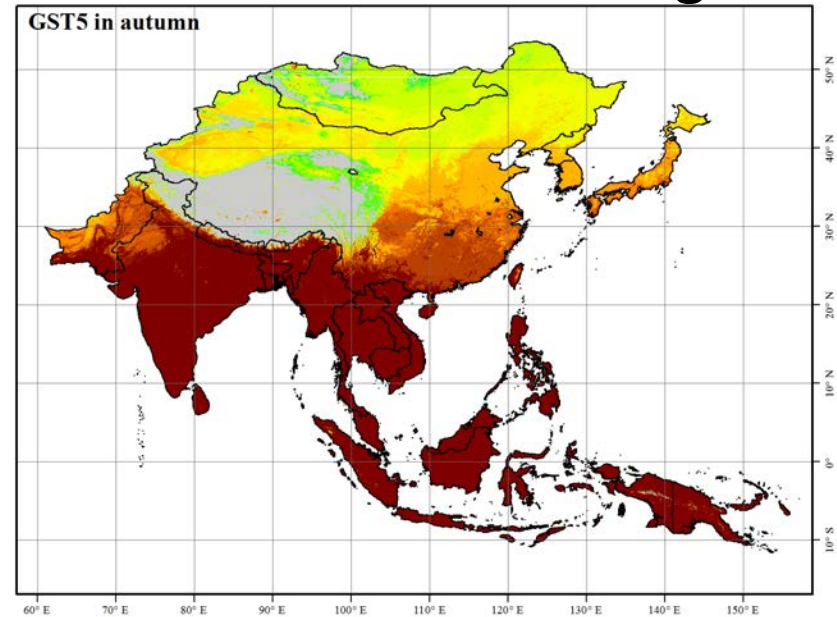
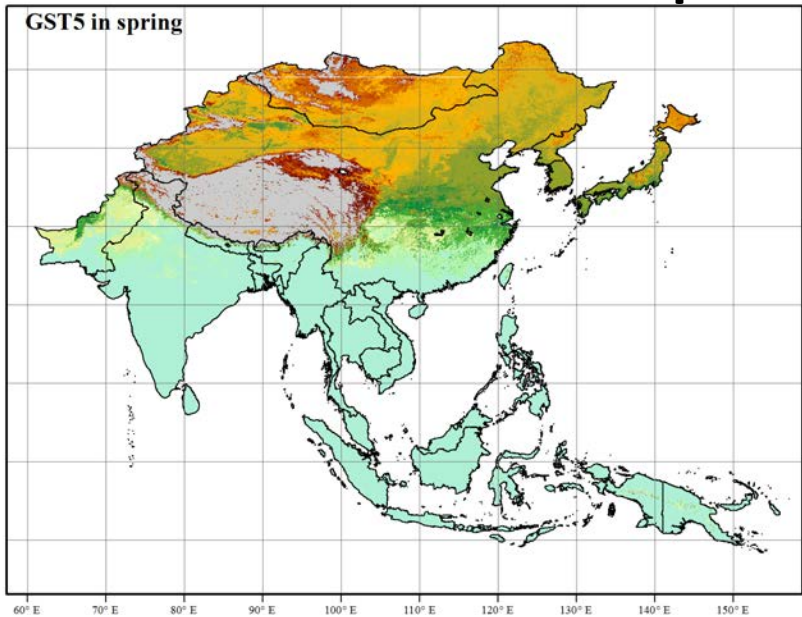
- 1. Model and predict hot-spots of transmission, spillover and re-assortment of avian influenza at country, continental and global scales**
- 2. Understand the ecological and evolutionary processes that contribute to emergence, transmission, and spillover of avian influenza at local scale**
 - Poyang Lake, Jiangxi Province, China**



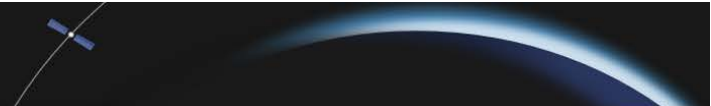
Model and predict hot-spots of transmission, spillover and re-assortment of avian influenza at country, continental and global scales

- **Assemble and develop geospatial datasets at country, continental and global scales**
- **Apply spatial statistical models**

Land Surface Temperature from MODIS thermal images

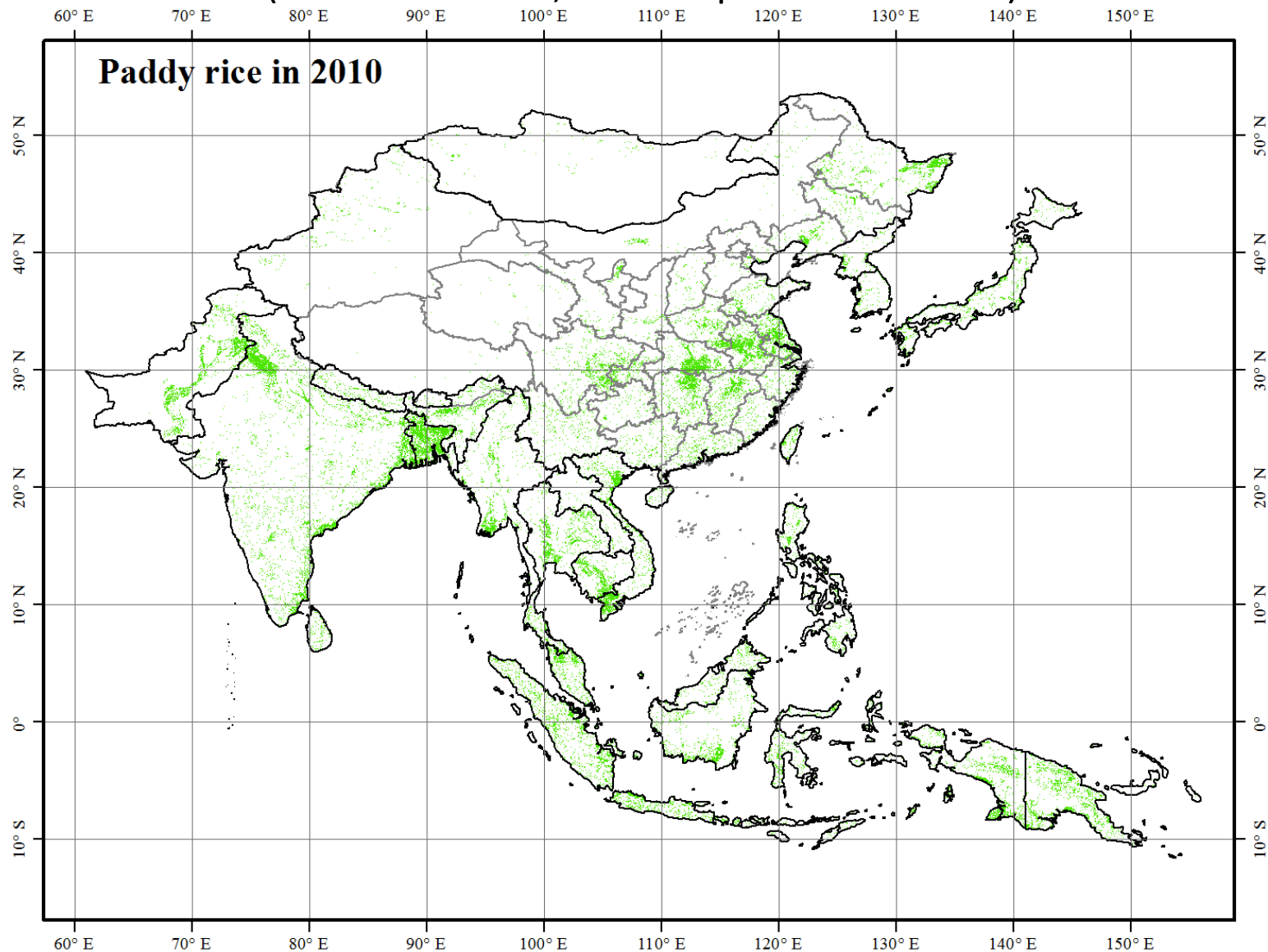


MODIS MYD11A2 Land Surface Temperature (LST, nighttime) in 2010
1-km spatial resolution

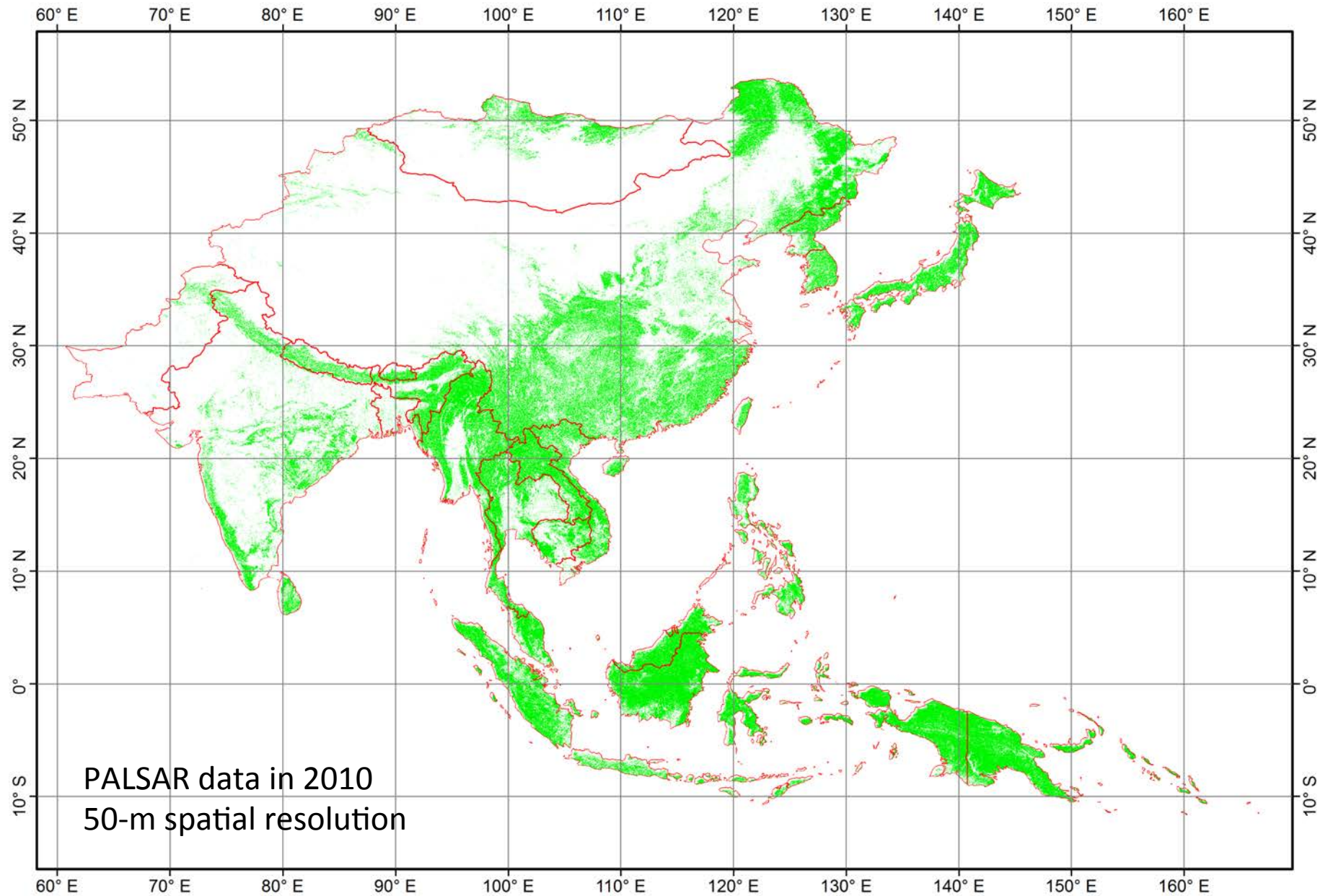


Map of paddy rice planting area in Monsoon Asia in 2010

(MOD09A1 data, 500-m spatial resolution)



Map of Forests in Monsoon Asia in 2010





Risk modeling and assessment at country and continental scales

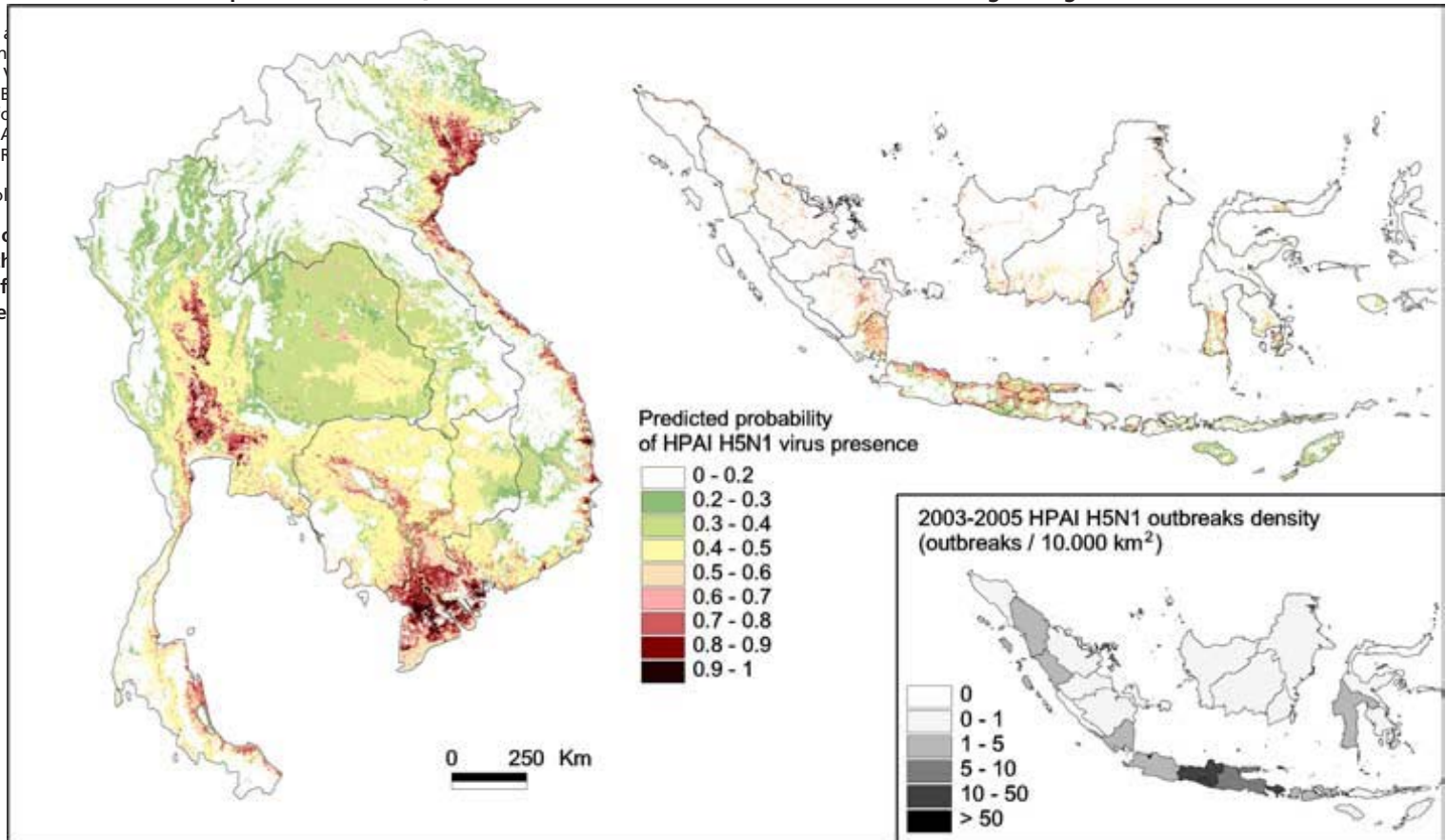
Mapping H5N1 highly pathogenic avian influenza risk in Southeast Asia

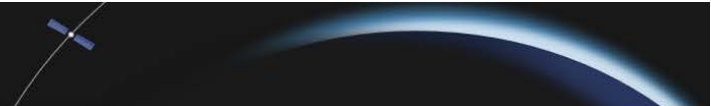
Marius Gilbert^{**†}, Xiangming Xiao[‡], Dirk U. Pfeiffer[§], M. Epprecht[¶], Stephen Boles[‡], Christina Czarnecki[‡], Prasit Chaitaweesub^{||}, Wantanee Kalpravidh^{**}, Phan Q. Minh^{††}, M. J. Otte^{**}, Vincent Martin^{**}, and Jan Slingenbergh^{**}

*Biological Control
of Earth, Oceans, and
Sciences, The Royal
North-South, 3012 B
**Regional Office for
Health, Ministry of A
di Caracalla, 00100 R

Edited by Rita R. Col

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Risk modeling and assessment at country and continental scales

OPEN ACCESS Freely available online

PLOS PATHOGENS

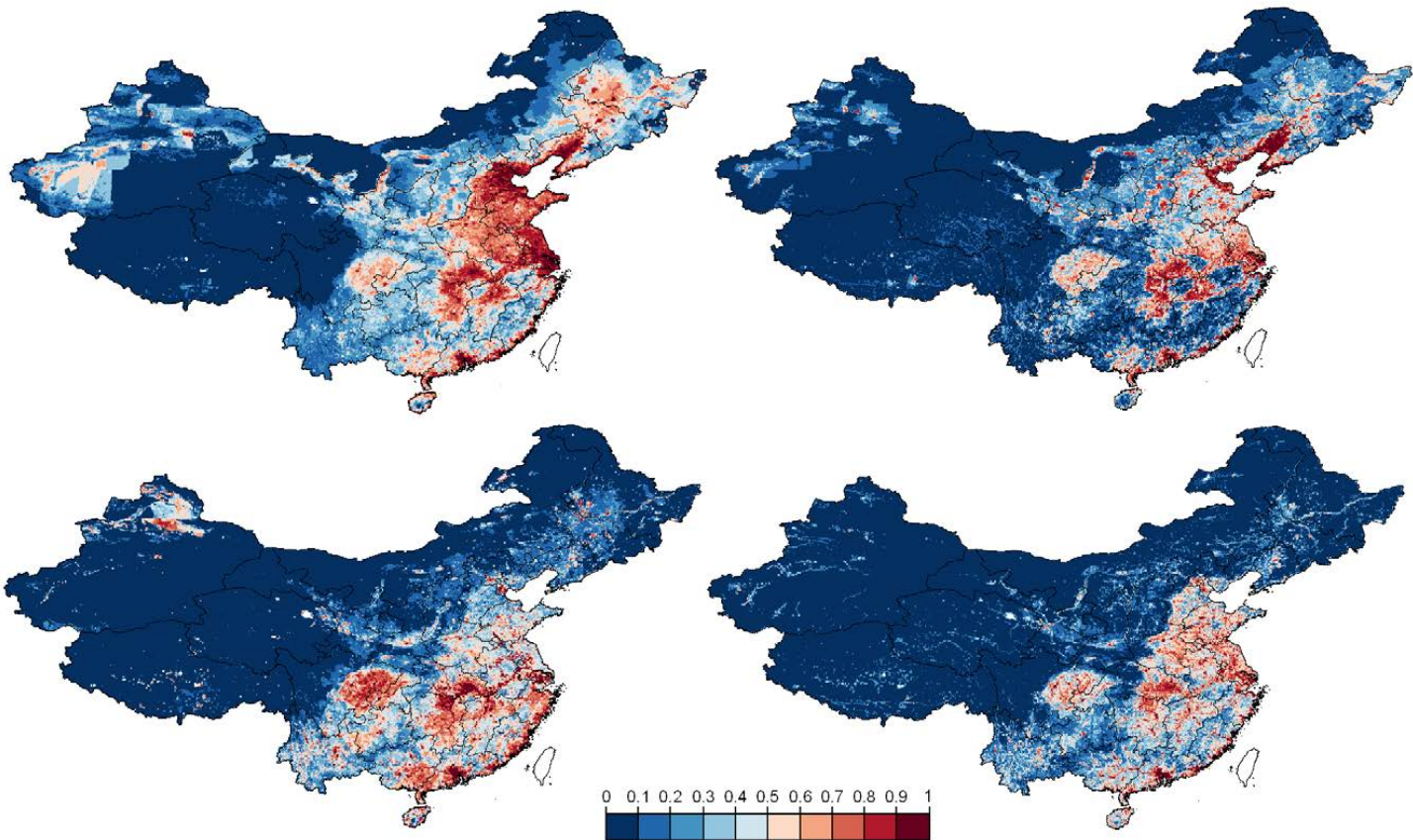
Spatial Distribution and Risk Factors of Highly Pathogenic Avian Influenza (HPAI) H5N1 in China

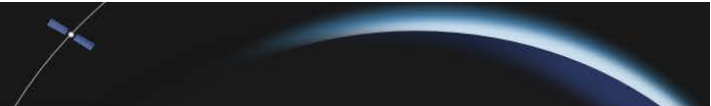
Vincent Martin¹, Dirk U. Pfeiffer², Xiaoyan Zhou¹, Xiangming Xiao³, Diann J. Prosser^{4,5}, Fusheng Guo¹, Marius Gilbert^{6,7*}

¹ Emergency Centre for the Control of Transboundary Zoonotic Infections, Department of Epidemiology & Public Health Group, Department of Botany and Microbiology, C Research Center, Beltsville, Maryland, United States, ² Department of Ecology, Université Libre de Bruxelles, Brussels, Belgium

Abstract

Highly pathogenic avian influenza (HPAI) H5N1 is spreading throughout Asia and H5N1 distribution has been studied in China. HPAI H5N1 surveillance sampling of domestic

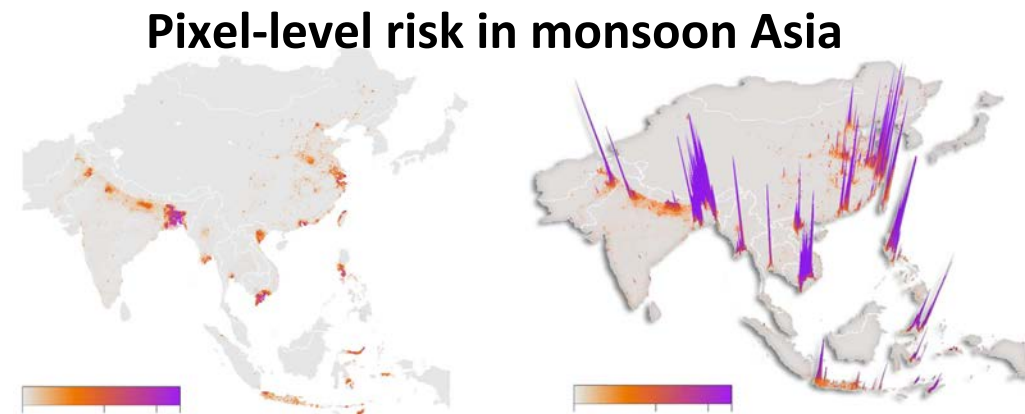
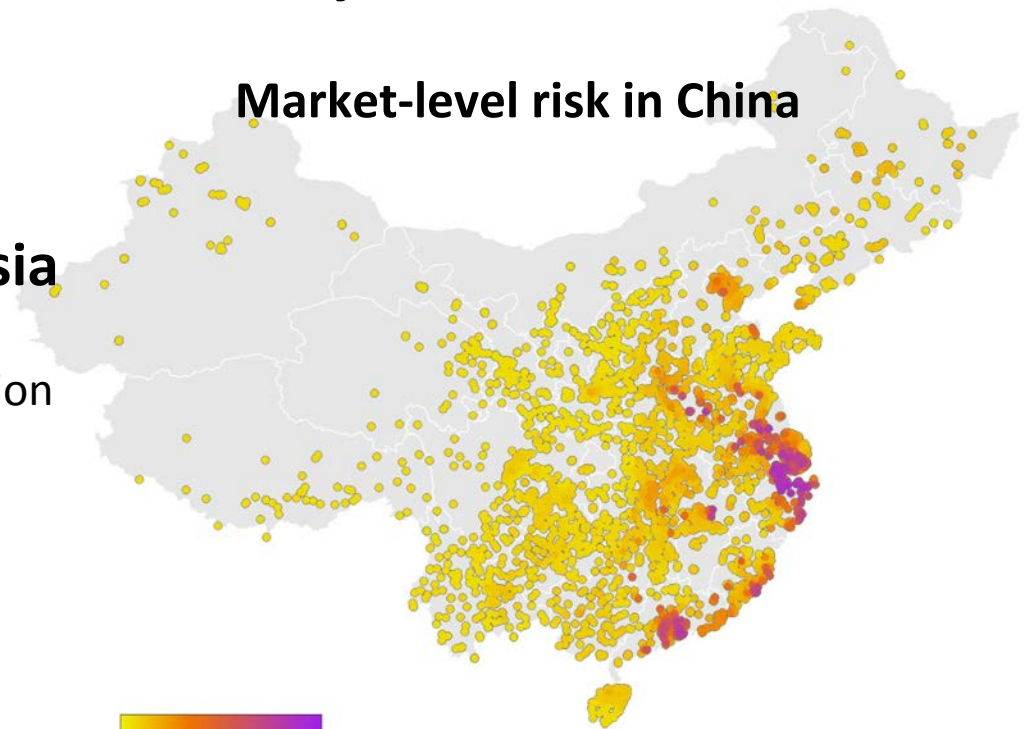




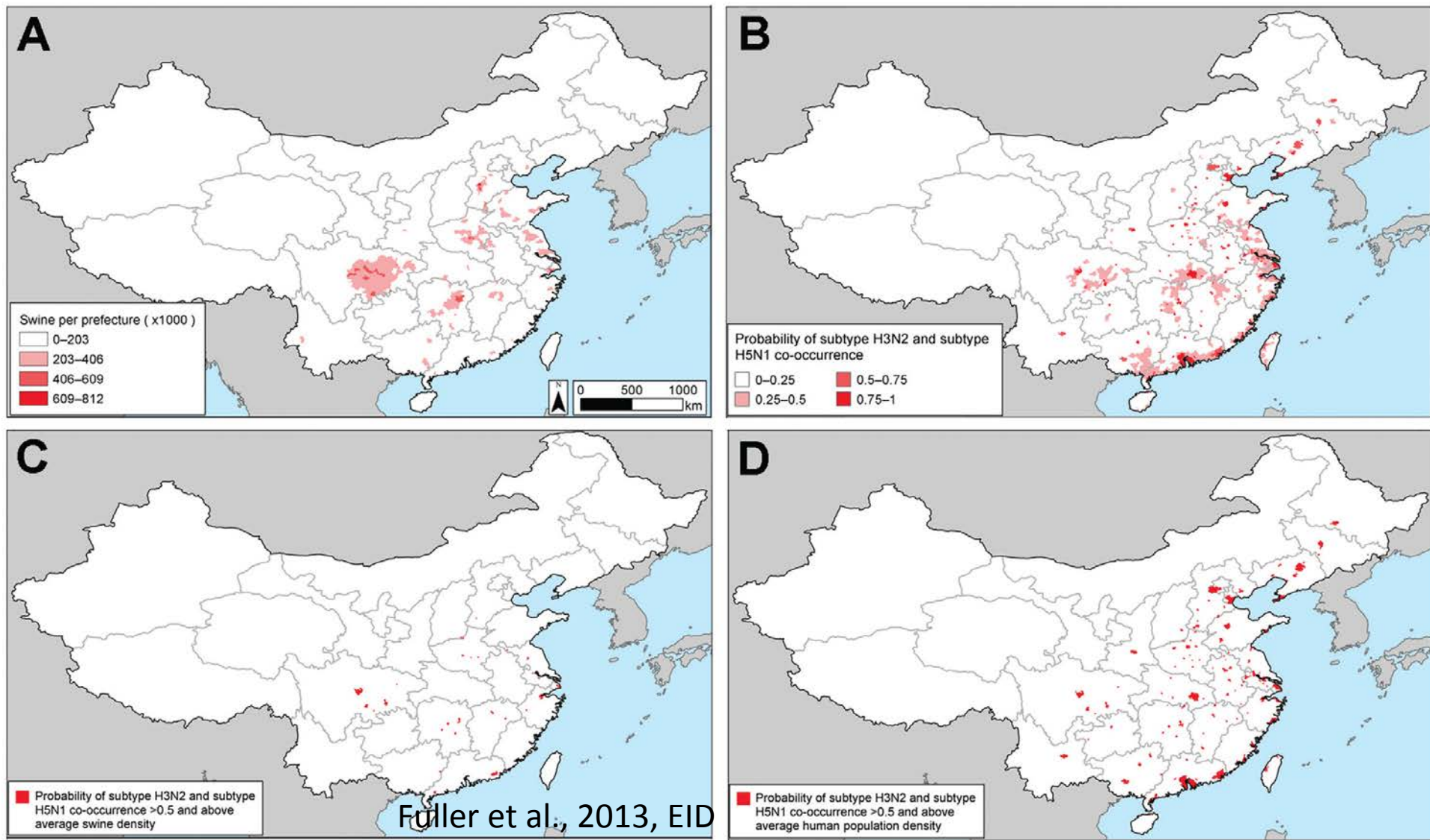
Risk modeling and assessment at country and continental scales

Predicting the risk of avian influenza A H7N9 infection in live-poultry markets across Asia

Gilbert et al., 2014, Nature Communication



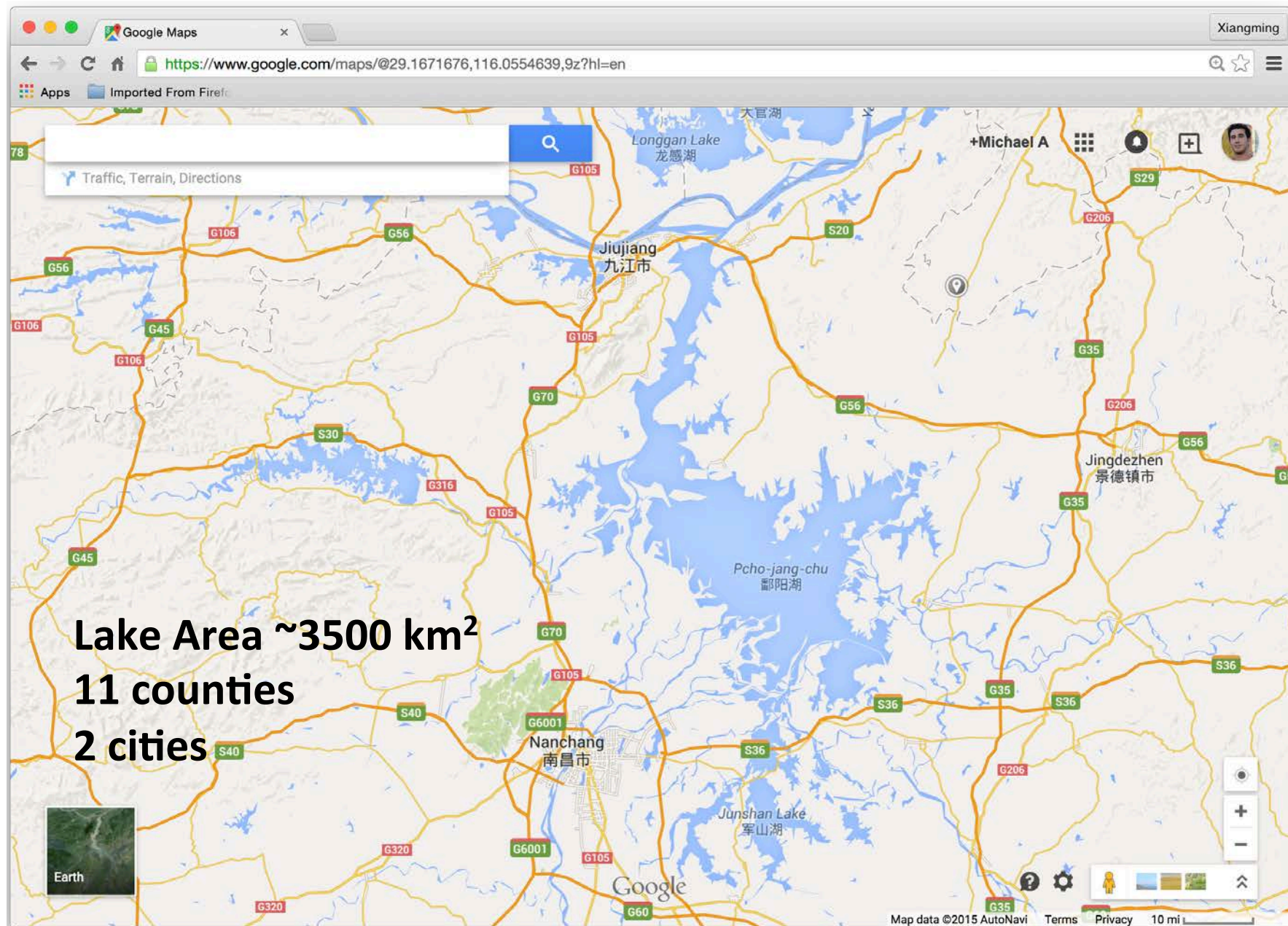
Re-assortment Risk between Human (Seasonal) Influenza and Highly Pathogenic Avian Influenza (H5N1)





Understand the ecological and evolutionary processes that contribute to emergence, transmission, and spillover of avian influenza at local scale

-- Poyang Lake, Jiangxi Province, China





Why did we choose Poyang Lake for process-based study sites?

- Largest freshwater lake and wetlands
- Tens of millions of poultry (ducks, chicken)
- ~1/2 million of wild birds wintering there
- Millions of people living there





Animal Health (domestic poultry and wild birds)

Wild waterbirds

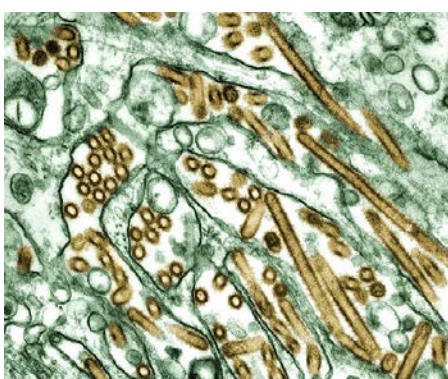
Scientific questions to be addressed

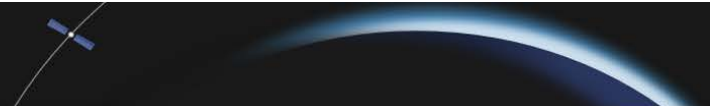
What are the local movement of wild birds and its interaction with poultry?

What are pathway and timing for seasonal and long-distance migration of wild birds? (spring migration and fall migration)

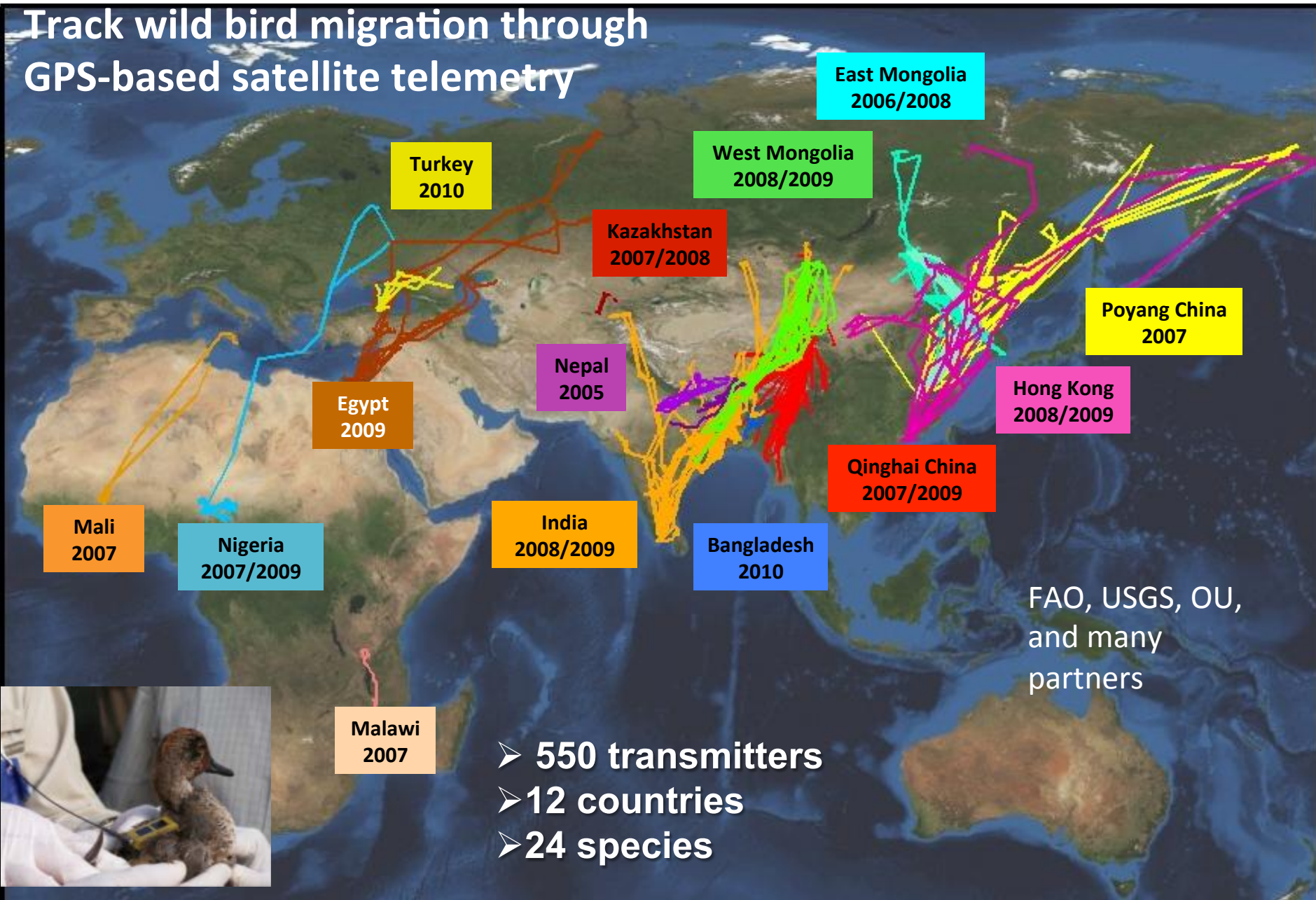
Geospatial datasets to be developed

GPS-based movement data (time, location, ...)





Track wild bird migration through GPS-based satellite telemetry



- 550 transmitters
- 12 countries
- 24 species





Track wild waterfowl movement and its role in HPAI H5N1 spread in China and Asia





Animal Health (domestic poultry and wild birds)

Poultry (domestic ducks and chicken)

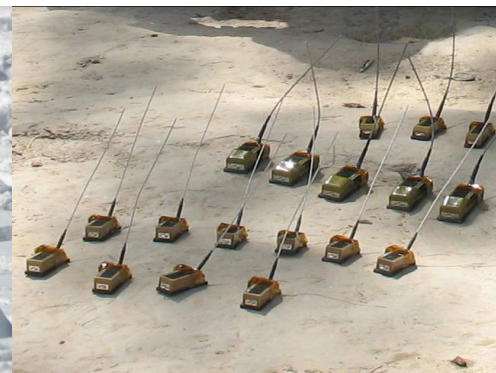
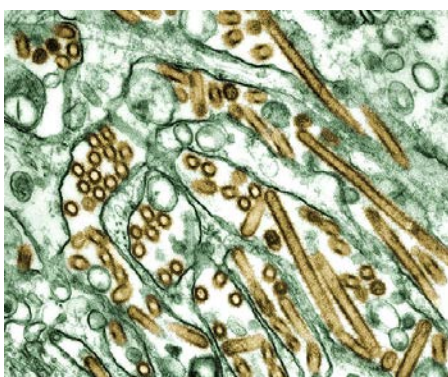
Scientific questions to be addressed

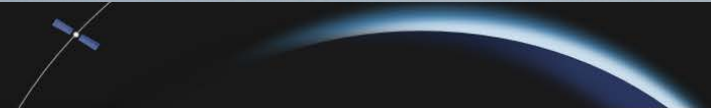
What are the local movement of free ranging ducks in poultry farms and how do they interact with wild birds?

What are the trade (market) chain from poultry production farms through live bird markets (wholesale and retail) to consumers?

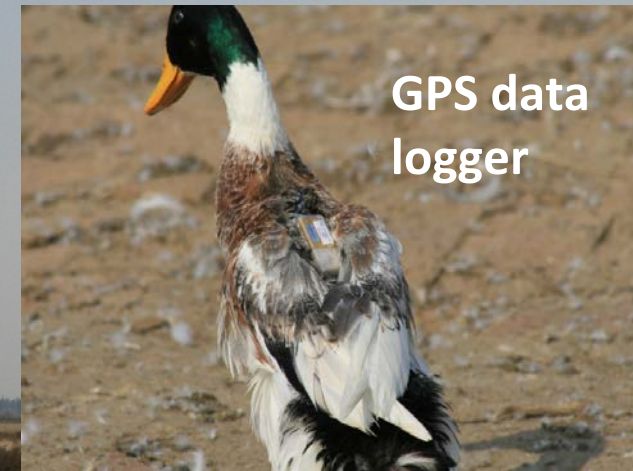
Geospatial datasets to be developed

GPS-based location data





Local movement of free-range ducks in rice paddy and wetlands



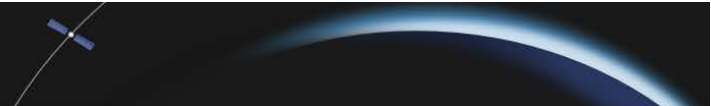
GPS data
logger



**There are lots of domestic free-range ducks
in post-harvested rice paddy fields.**

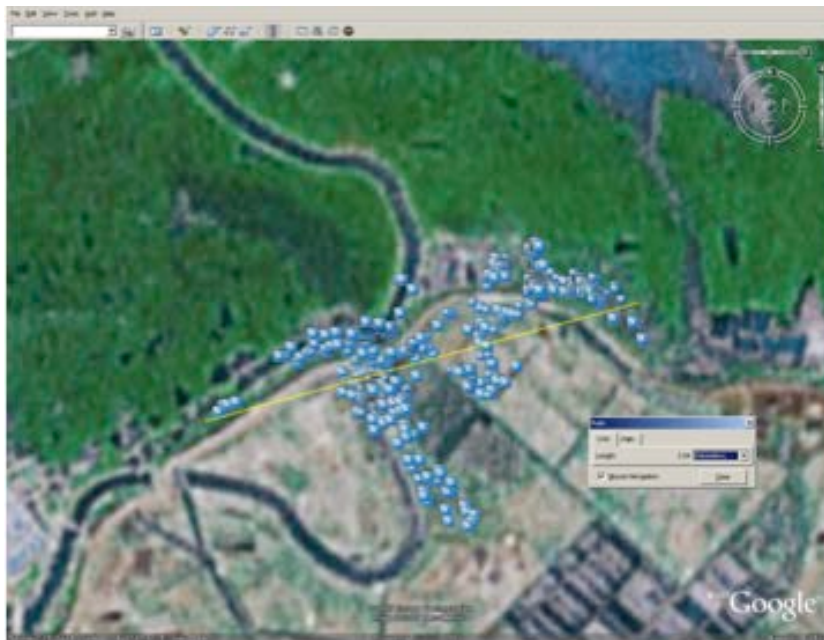
-- Healthy ducks may carry H5N1 virus



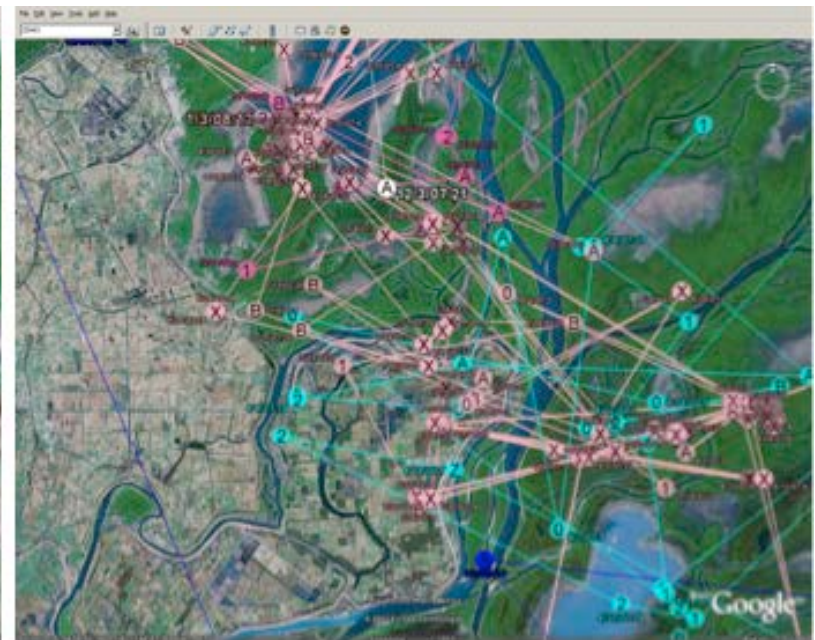


Interaction between domestic free grazing ducks and wild waterfowls at the rice paddy – wetland landscapes

There are extensive overlaps between free range domestic ducks and wild duck in Poyang Lake region, according to GPS data loggers on free-range ducks in rice fields and satellite transmitters on wild ducks



Free Range Domestic Ducks

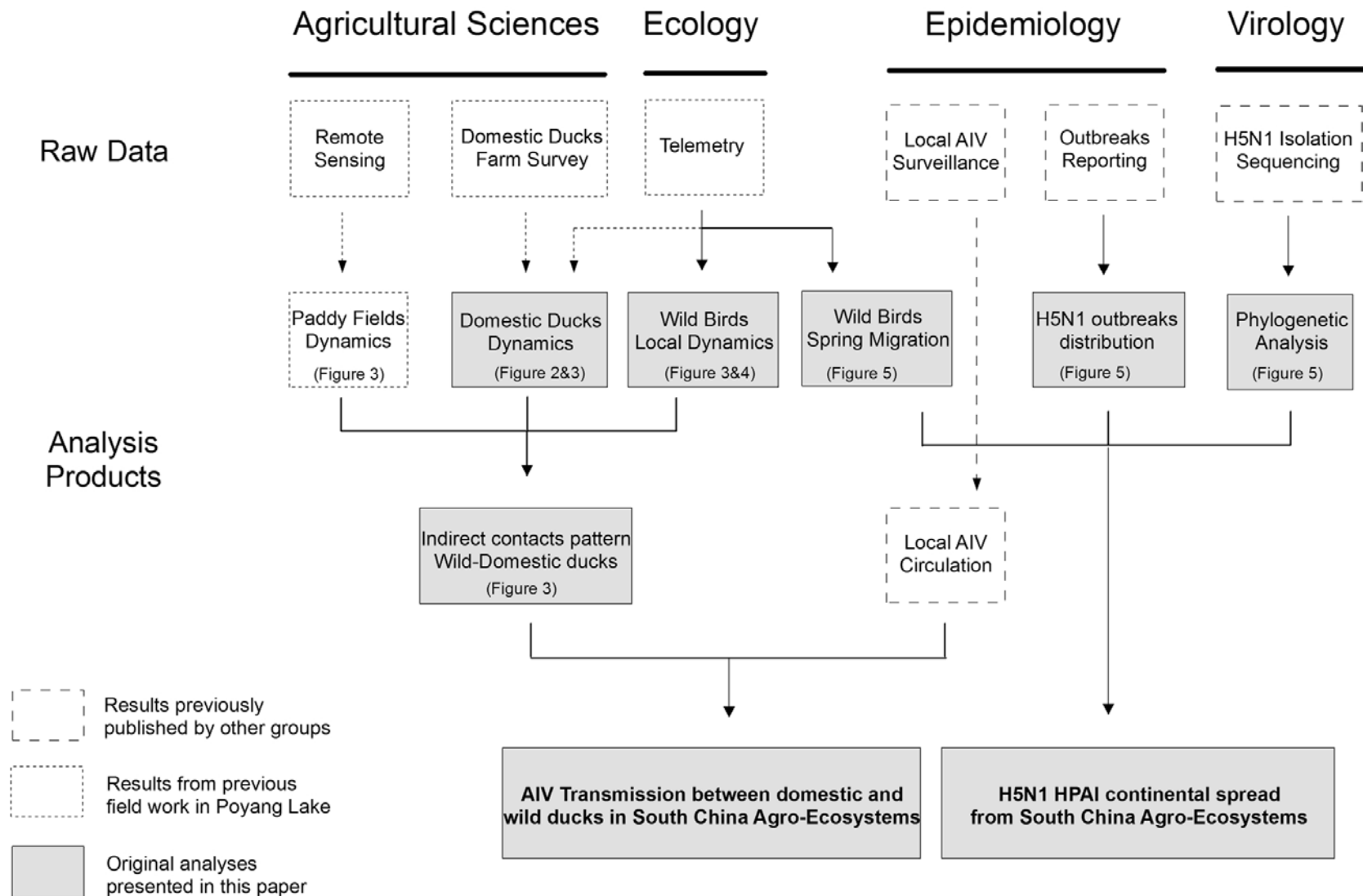


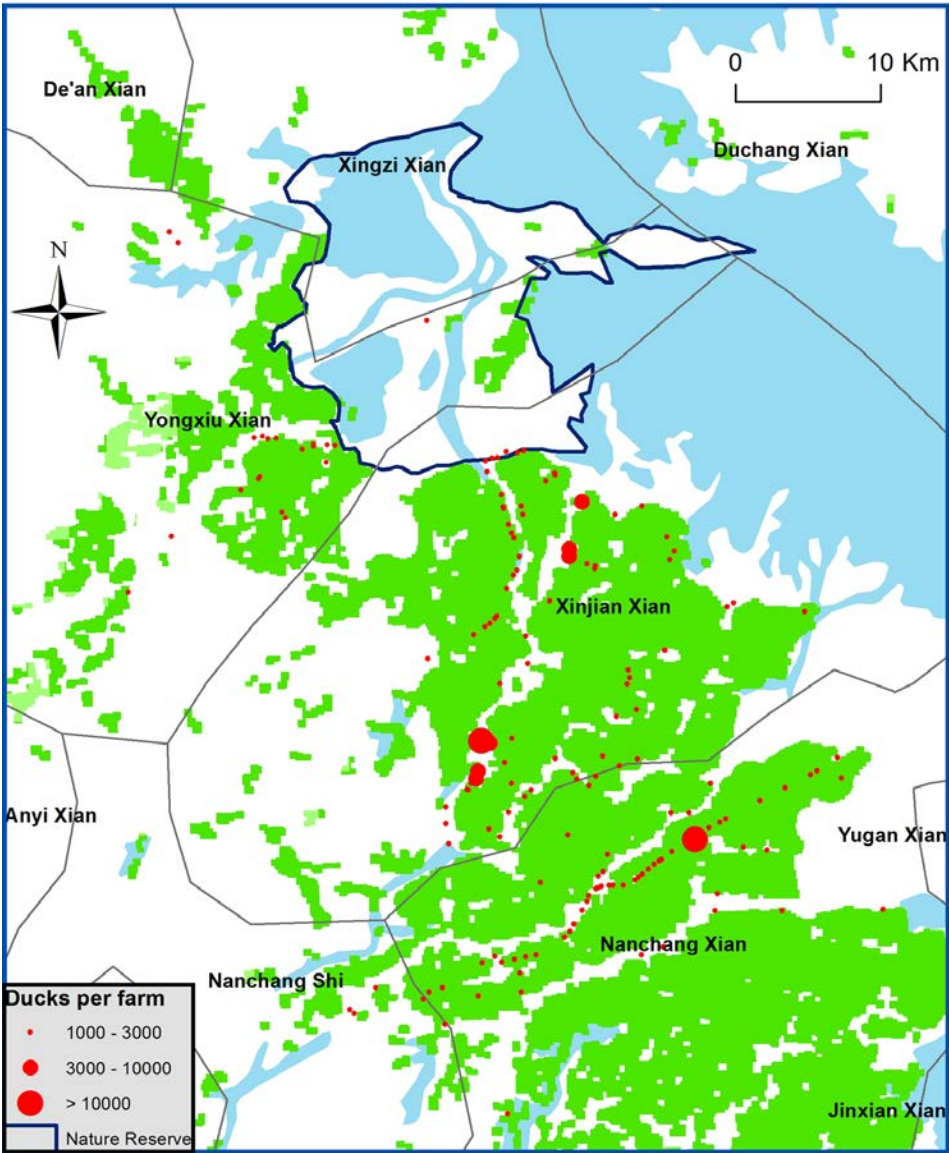
Wild Ducks

(see Cappelle et al., 2014, EcoHealth)

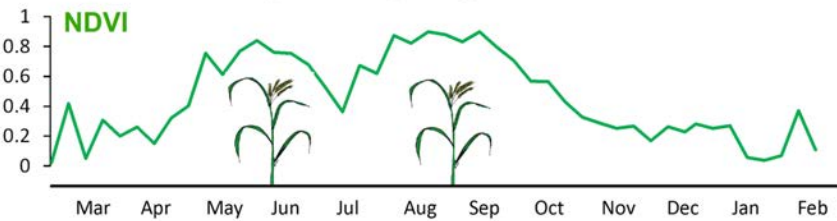


Cappelle, J., et al., 2014, Risks of avian influenza transmission in areas of intensive free-ranging duck production with wild waterfowl, *EcoHealth*

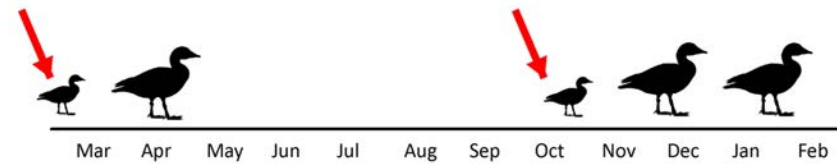




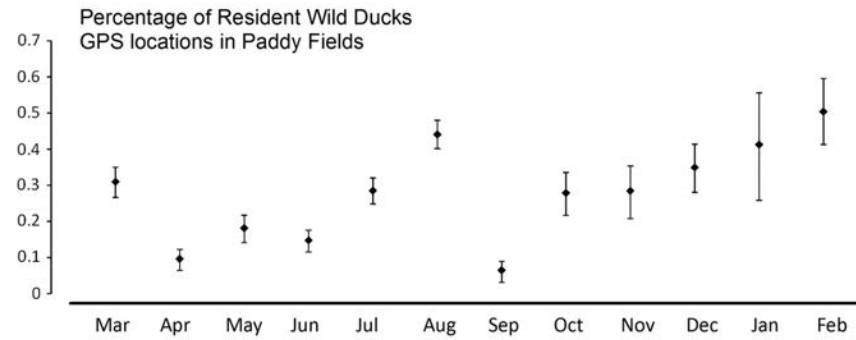
(a) Main production cycles of paddy rice



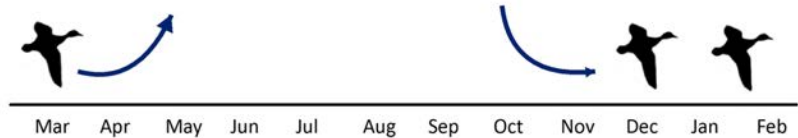
(b) Main production cycles of ducks in paddy fields



(c) Resident wild ducks presence in Paddy Fields

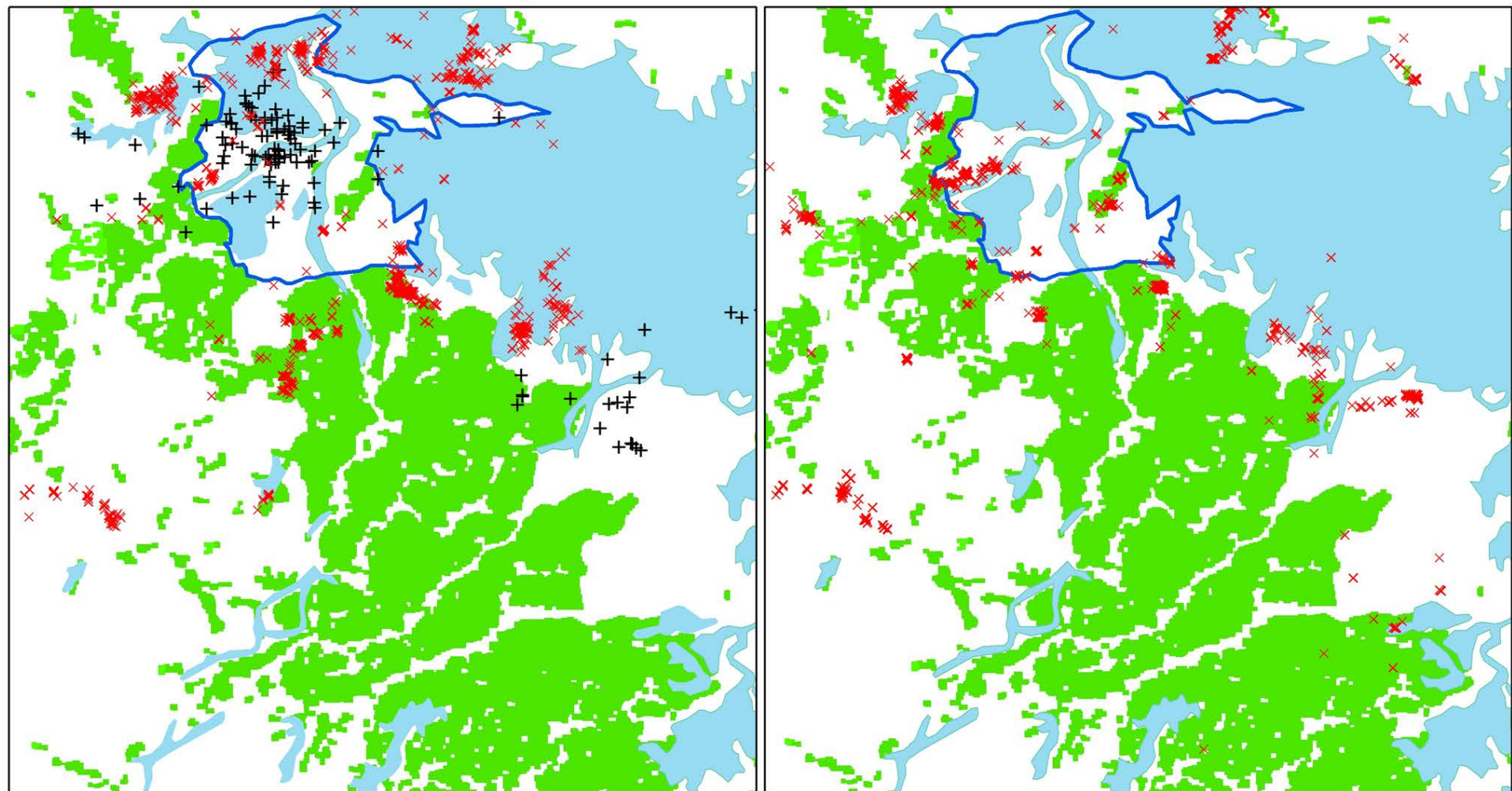


(d) Migratory wild ducks wintering period



December to May

June to November



 Paddy Fields

 Migratory Duck Argos Location

 Nature Reserve

 Resident Duck GPS Location

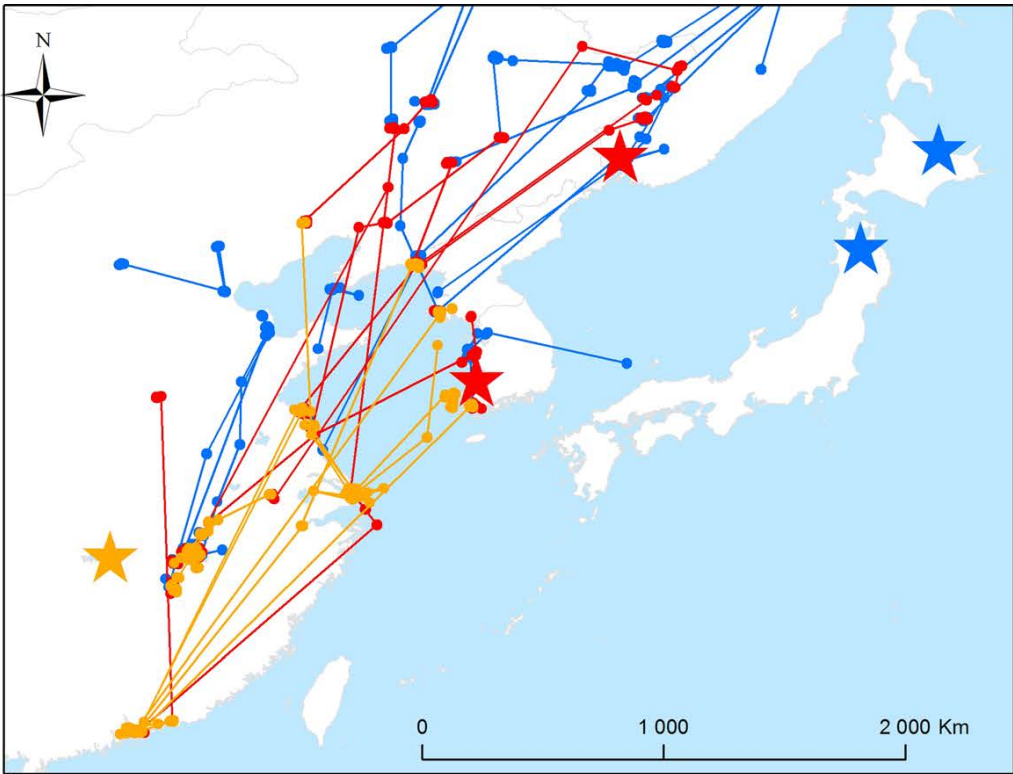
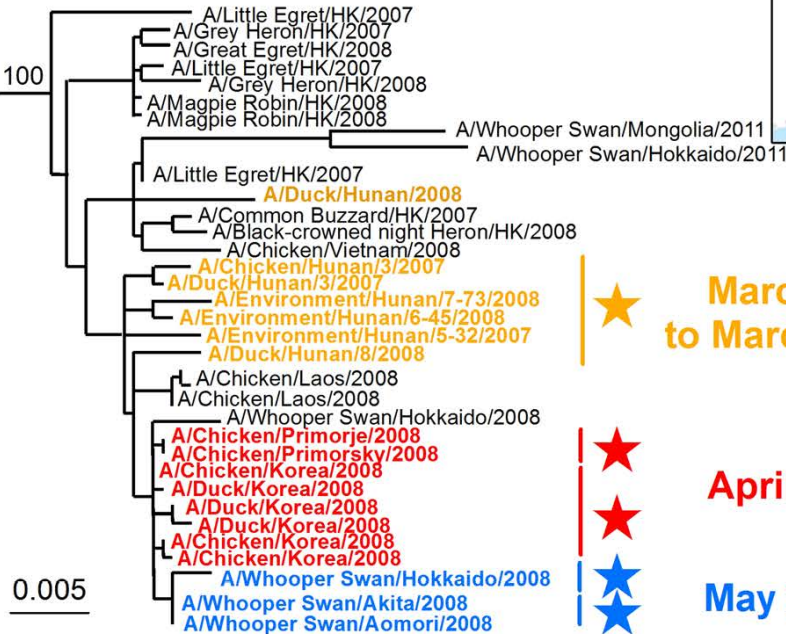
0 10 20 Kilometers



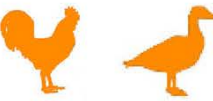

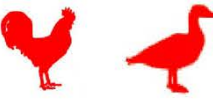


Locations and tracks of wild ducks in 2007, 2008 and 2009 transmitted during :

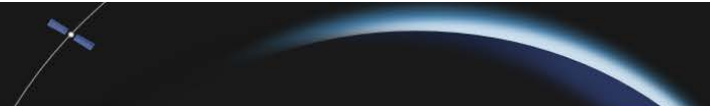
- — March
- — April
- — May

Phylogenetic relationships of 37 full-length (1,704 ntd) HA sequences from H5N1 HPAIV (Extracted from Supporting figure 3):



Origin of H5N1 HPAIV strains:

Domestic birds	Environment	Wild birds
		
		
		

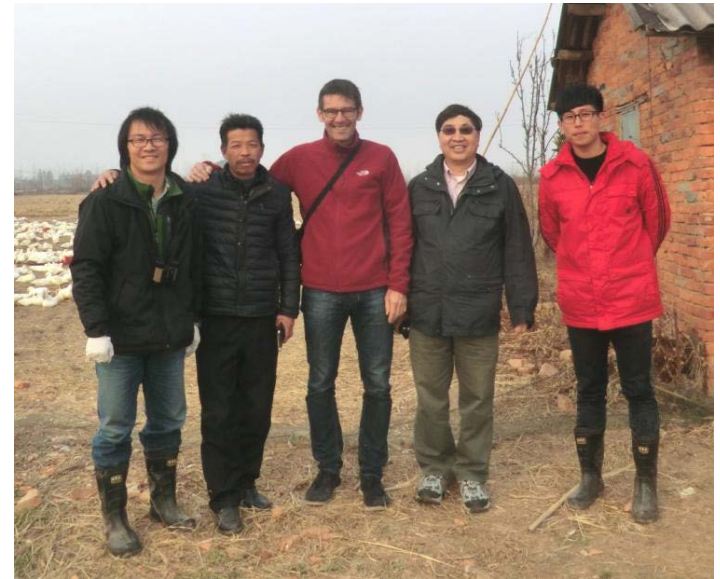


Movement of domestic ducks from poultry farm to live bird markets

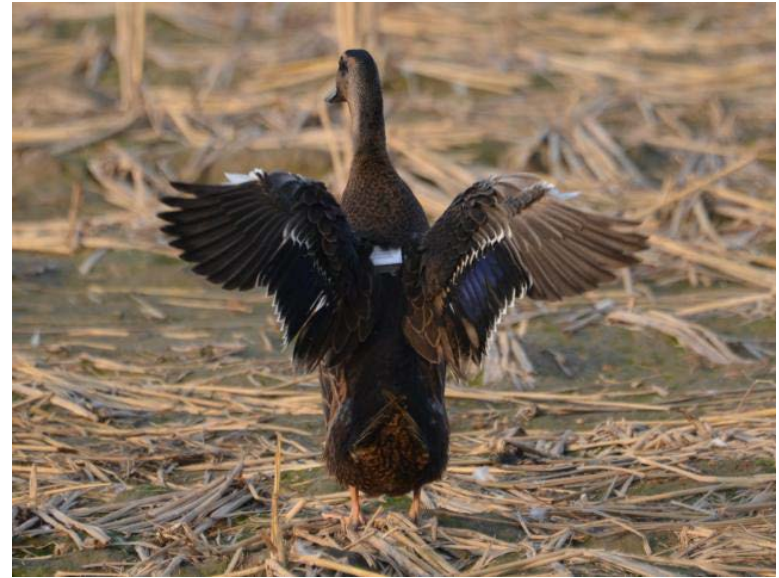
Market Chain Study

Technology Pilot Project - 1/2015

GSM-based data transmitters (40) were attached to meat and layer ducks to track poultry movement from farm through live bird market (wholesale and retail markets) to consumers

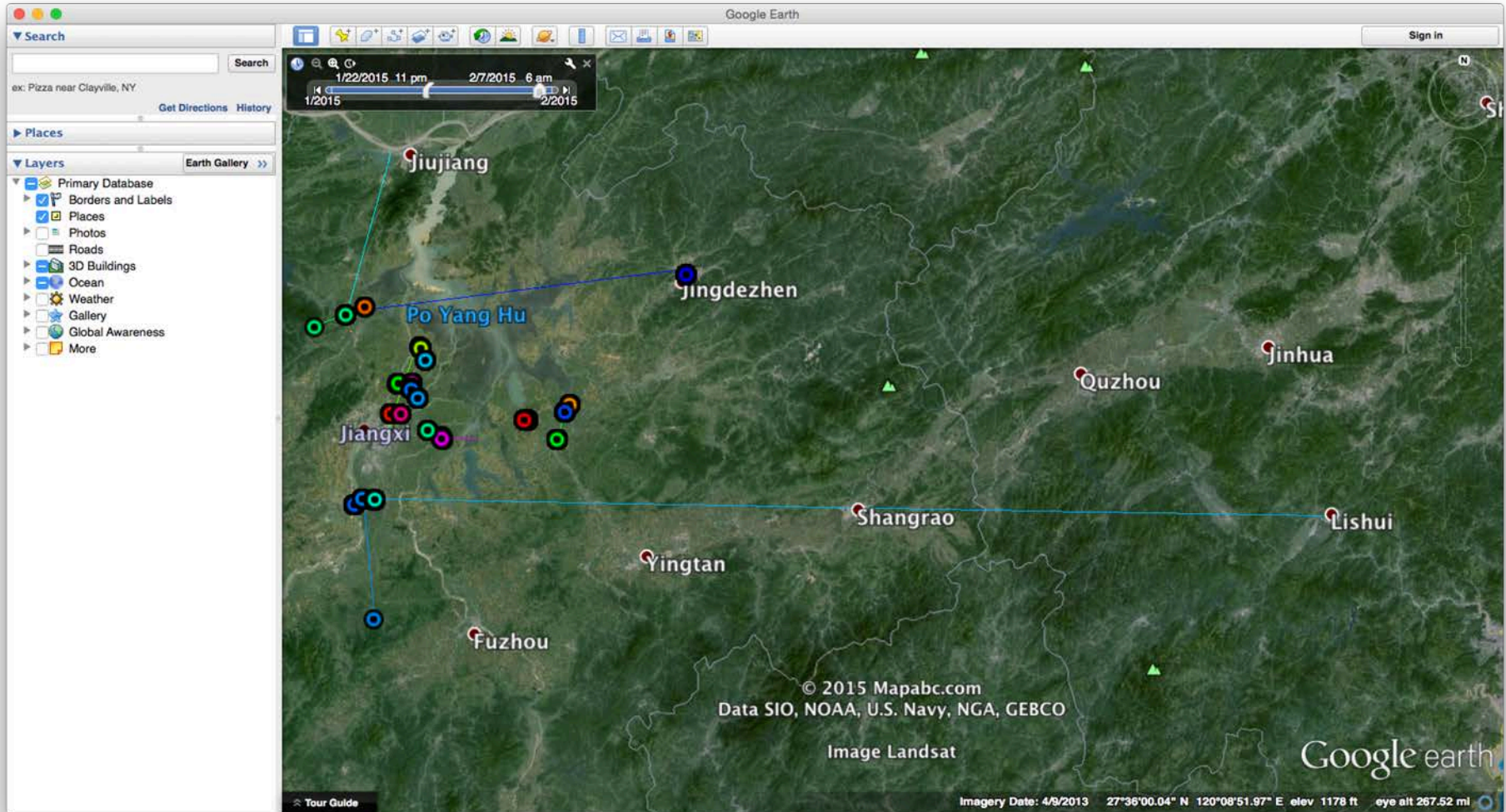


Movement of domestic ducks from poultry farm to live bird markets

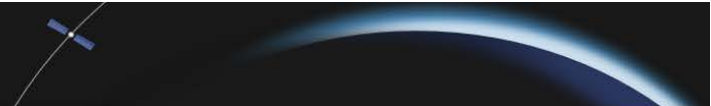




Movement of domestic ducks from poultry farm to live bird markets



As 2/9/2015, 6 broiler and 3 layer ducks (out of 40 ducks, 27 farms) were transported and sold in live bird markets. One went from Nanchang, Jiangxi to Lishui, Zhejiang.

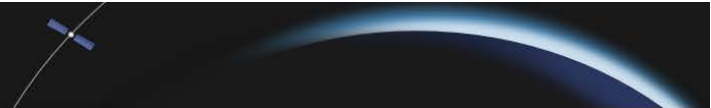


Market Chain Study



Live bird market in Nanchang city





Human Health

Scientific questions to be addressed

What are exposure risks of poultry farmers, traders, and sellers in live bird markets?

Geospatial datasets to be developed

Avian influenza virus in poultry farms, wetlands and live bird markets through surveillance of environmental samples

Serum samples from poultry workers, traders and sellers in live bird markets.





- I hope that USAID EPT-2 project will help solve some of these gaps.*

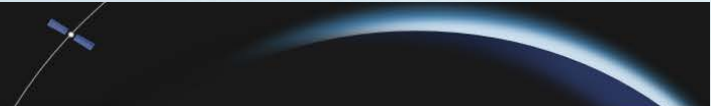


Infectious Disease Pandemic Preparedness

-- BIG DATA Era

Research theme to be pursued within next 5-10 years

- **Ecology and evolution of infectious diseases under global change**
e.g., Climate variability and change; Land cover and land use change; Agricultural intensification (poultry and livestock production); Urbanization, human settlement; Biodiversity (wild birds); Globalization (transportation and trade)
- **Integration of eco-informatics, geo-informatics, bio-informatics, health informatics**
e.g., host, epidemiological, clinical, molecular, environmental data;



Thank you

<http://www.eomf.ou.edu>



1. Smartphone App “Field Photo”
2. Geo-referenced field photo library
3. Images (MODIS, Landsat, PALSAR)

**Individual photos are linked with time series
MODIS data (2000 - present)**

