

Conference Title: 2016 CoRP Symposium

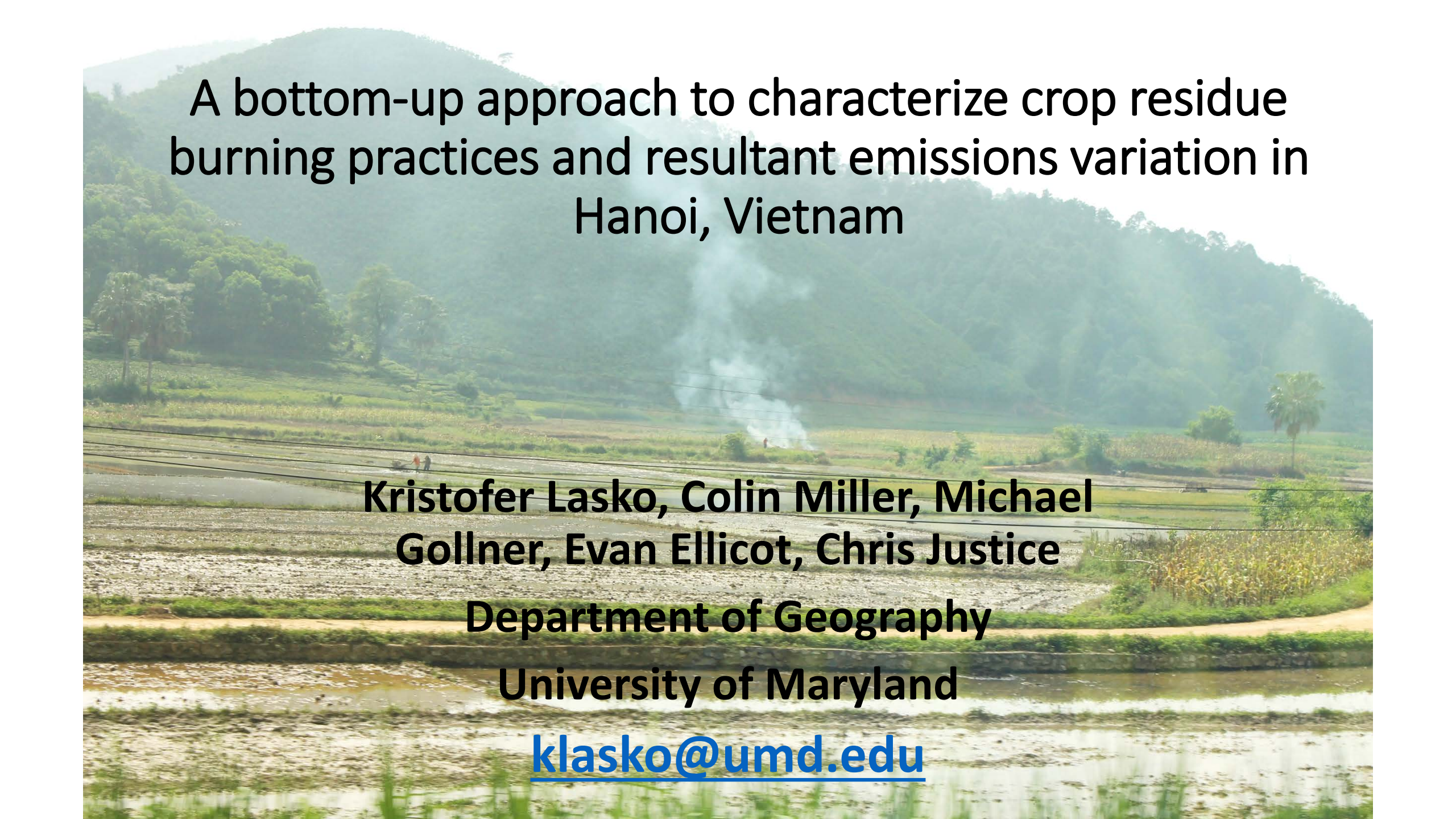
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Title: A bottom-up approach to characterizing crop residue burning practices and estimating resultant emissions variations in Hanoi, Vietnam

Type of Presentation: ☐ Poster

☒ Oral

Short Abstract: The systematic burning of crop residues contributes to approximately one-third of global biomass burning emissions with impacts on air quality, public health, and greenhouse gas emissions. Though significant research has characterized emissions from crop residue burning, to date studies typically assume one level of emissions without accounting for emissions variation due to differential burning practices. In this project, we employ a case study approach in Hanoi, Vietnam to map dominant crop rotations and quantify crop residue burning practices in the field and with smallholder input. We then inform case study findings by emulating a multitude of crop residue burning scenarios in the lab and estimating associated emissions levels. This bottom-up approach to characterizing and quantifying residue burning practices and emissions contributes not only to improved emissions calculations, but also to better understandings of how burning practices influence emissions totals in agricultural regions. This study additionally has the potential to guide incentives and policies that may encourage farmers to follow improved practices that reduce residue burning emissions and thereby improve local and global environments and public health while still maintaining economic viability and preserving livelihoods.



A bottom-up approach to characterize crop residue burning practices and resultant emissions variation in Hanoi, Vietnam

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Project Objectives

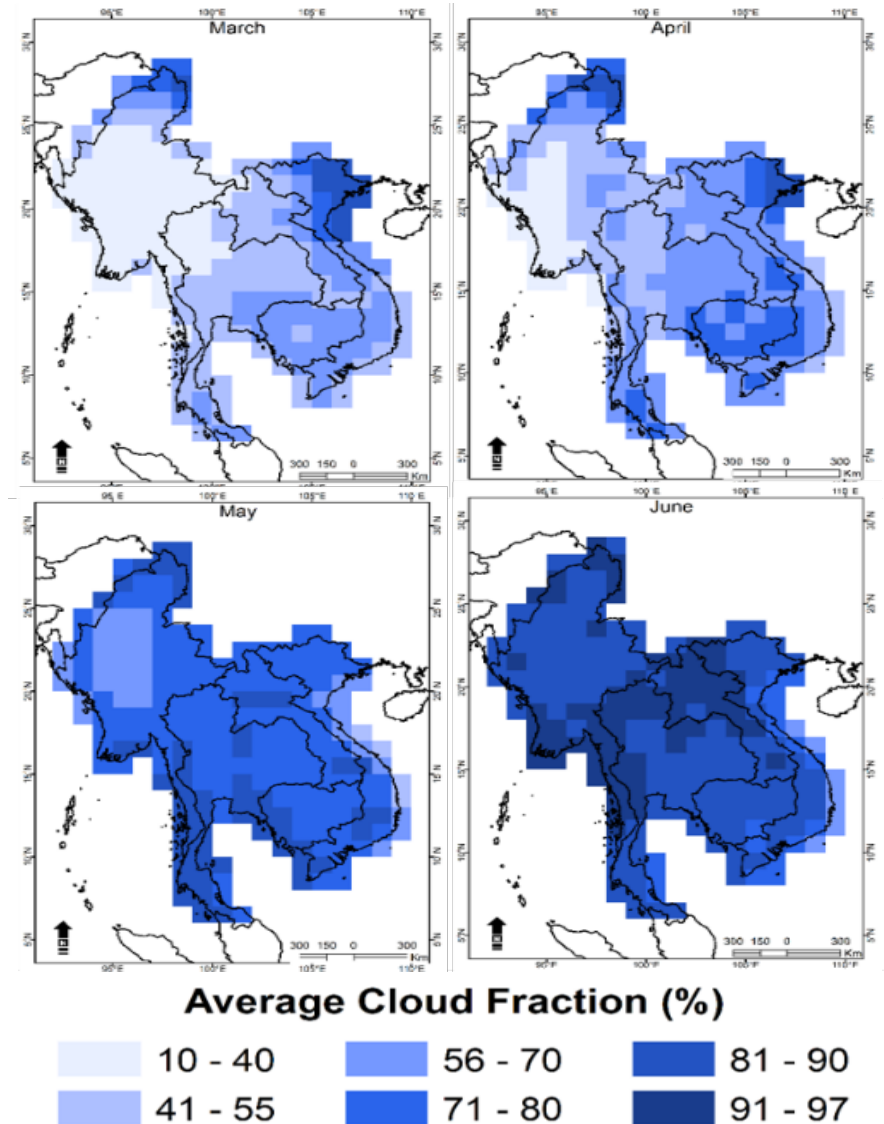
- Quantify local rice burning emissions factors for Vietnam.
- Assess how altering rice residue burning practices will reduce emissions
- Estimate spatial variation in emissions based on burning practices and using remote sensing imagery
- Provide the basis for subsequent air quality analyses



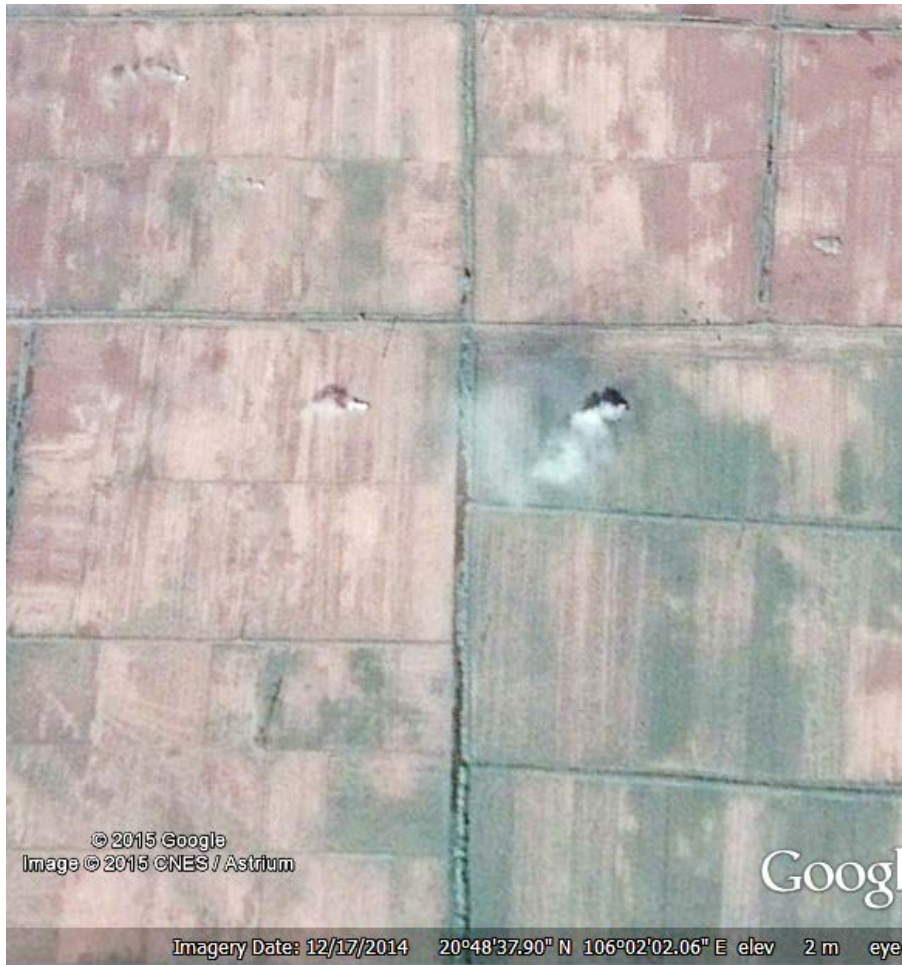
**Rice Straw burning in Hanoi Vietnam:
May 2016**

Motivation

- Crop residue burning impacts public health, air quality, greenhouse gas emissions, and the economy (Streets et al 2003,2004; Korontzi et al 2006;)
 - Emission of CO, BC, PM_{2.5}
- *Hanoi, Vietnam has no known field or survey measurements of agricultural residue burning*
 - *Combustion completeness, amount subject to burning, variation in emissions from burning practices*
- Satellite detection of fires is difficult in the Hanoi Capital Region
- Findings guide incentives to alter burning practices to reduce emissions; emissions scenarios forecast potential future changes

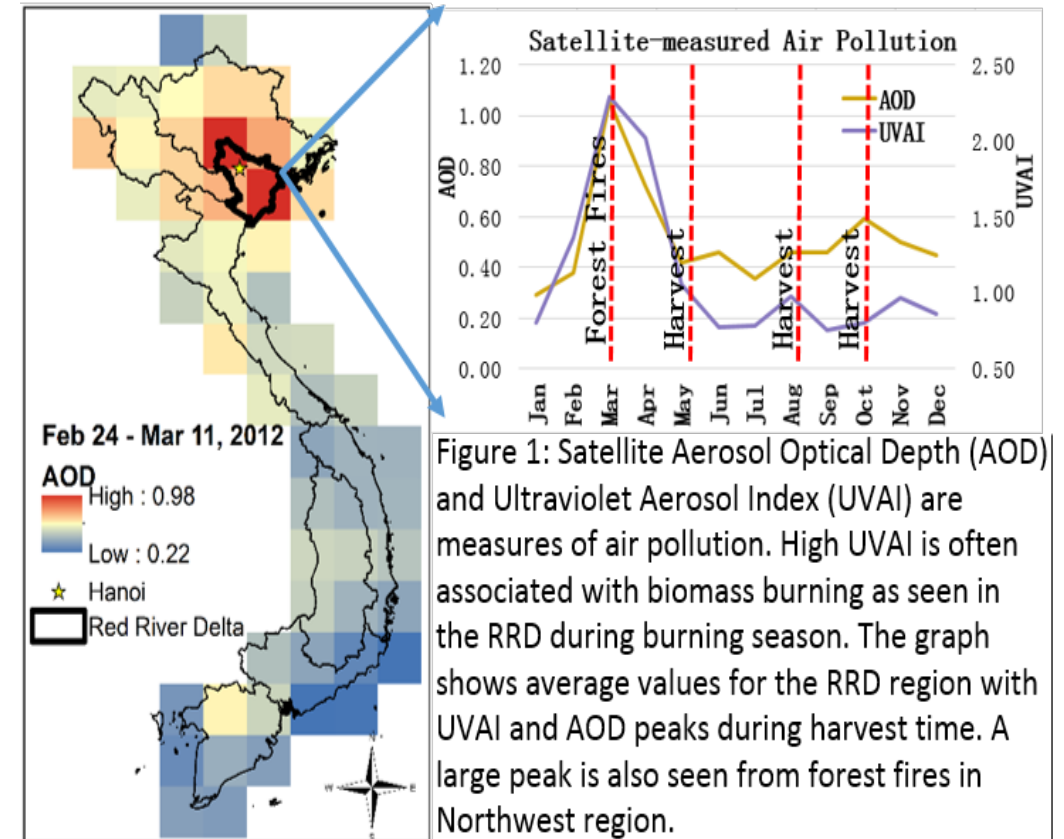


Biomass Burning Near Hanoi



Background

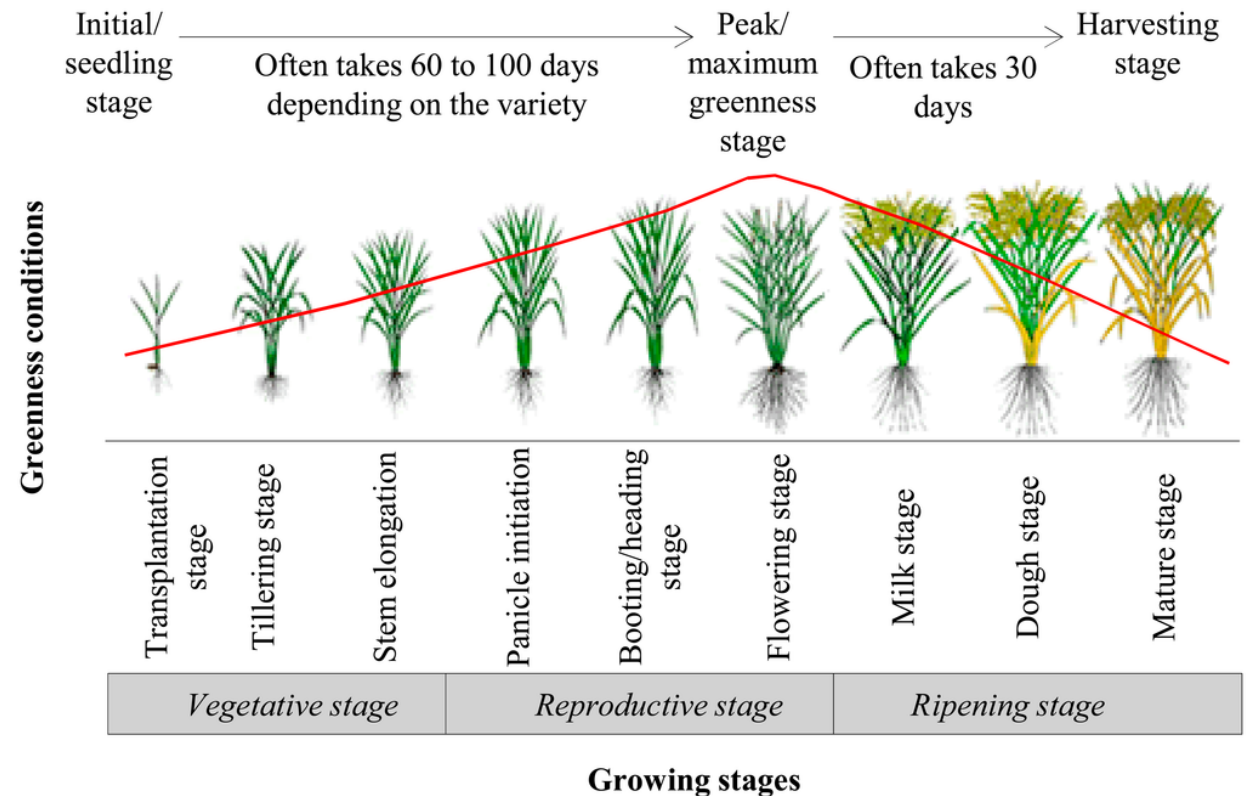
- Ambient air pollution contributes to ~3million premature deaths per year globally (WHO 2015), (6.7% of all deaths).
- Hanoi, Vietnam regularly affected by degraded air quality (Hopke 2009; Nguyen 2015)
- Hanoi typically has highest pollution level for Vietnam.
- Potential to reduce emissions based on future residue burning practice changes



Background

- Typical crop rotations: Rice – rice, Rice – Rice - Fallow
- Rice accounts for at least ~85% of cropped area (VN stats 2014)
- Typical rice paddy field size varies from 0.025 ha to 0.28 ha (Jésus & Dao 1997 ;Patanothai & Yost 1996, field work).

- Thus, Landsat scale alone may not be suitable for some fields. However, high resolution SAR data at 10m x 10m can cover most fields.



Source: Mosleh et al 2015; IRRI

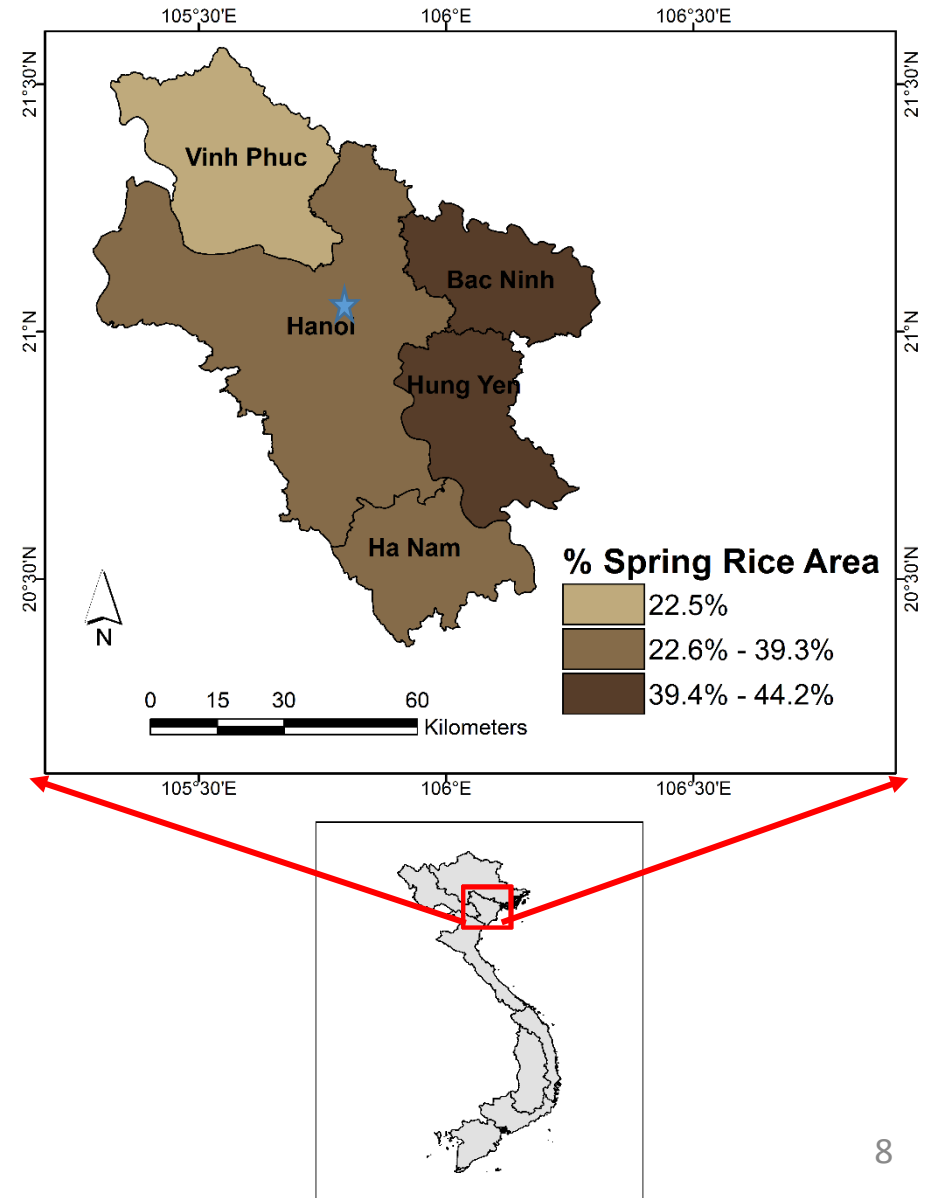
Background

- Rice straw is a burned residue as compared with the 2nd most dominant crop, corn (Zwebe 2012) and other residues.
- Corn residues are most often used for animal feed cooking/fuel, fertilizer as opposed to field burning (Cuong 2009).
- No known regional characterization of crop residue burning and practices
- Will help to better refine emissions calculations in future



Study Area: Hanoi Capital Region

- 5 provinces, 700,000 ha, 15million people
- Located within Red River Delta
- Has highest cloud cover of continental SE Asia (Whitcraft et al 2015)
- Hanoi experiences high levels of air pollution (Hopke 2009, Nguyen 2015).
- Rice cropland areas surround much of the city, making it unique for crop residue burning studies and impacts on air quality

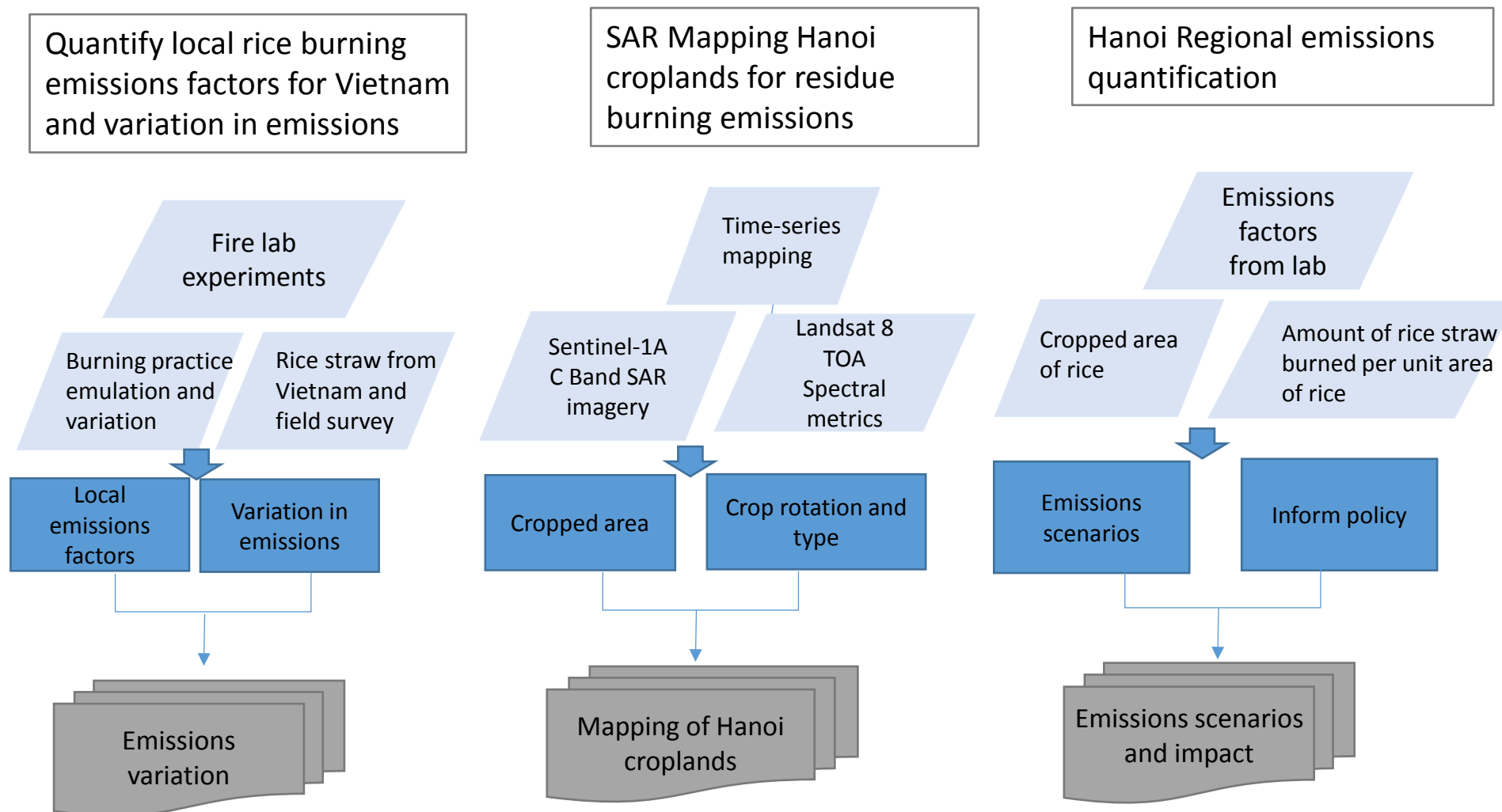


Project Objectives

- Quantify local rice burning emissions factors for Vietnam.
- Assess how altering rice residue burning practices will reduce emissions
- Estimate spatial variation in emissions based on burning practices and using remote sensing imagery
- Provide the basis for subsequent air quality analyses



Project approach and overview



Field study underway

Field study in Hanoi in conjunction with Vietnam National University characterizing the residue burning practices



**Rice straw burning,
Hanoi province
May 30th, 2016**

Characterize and Map croplands

Mapping Crop rotations and area

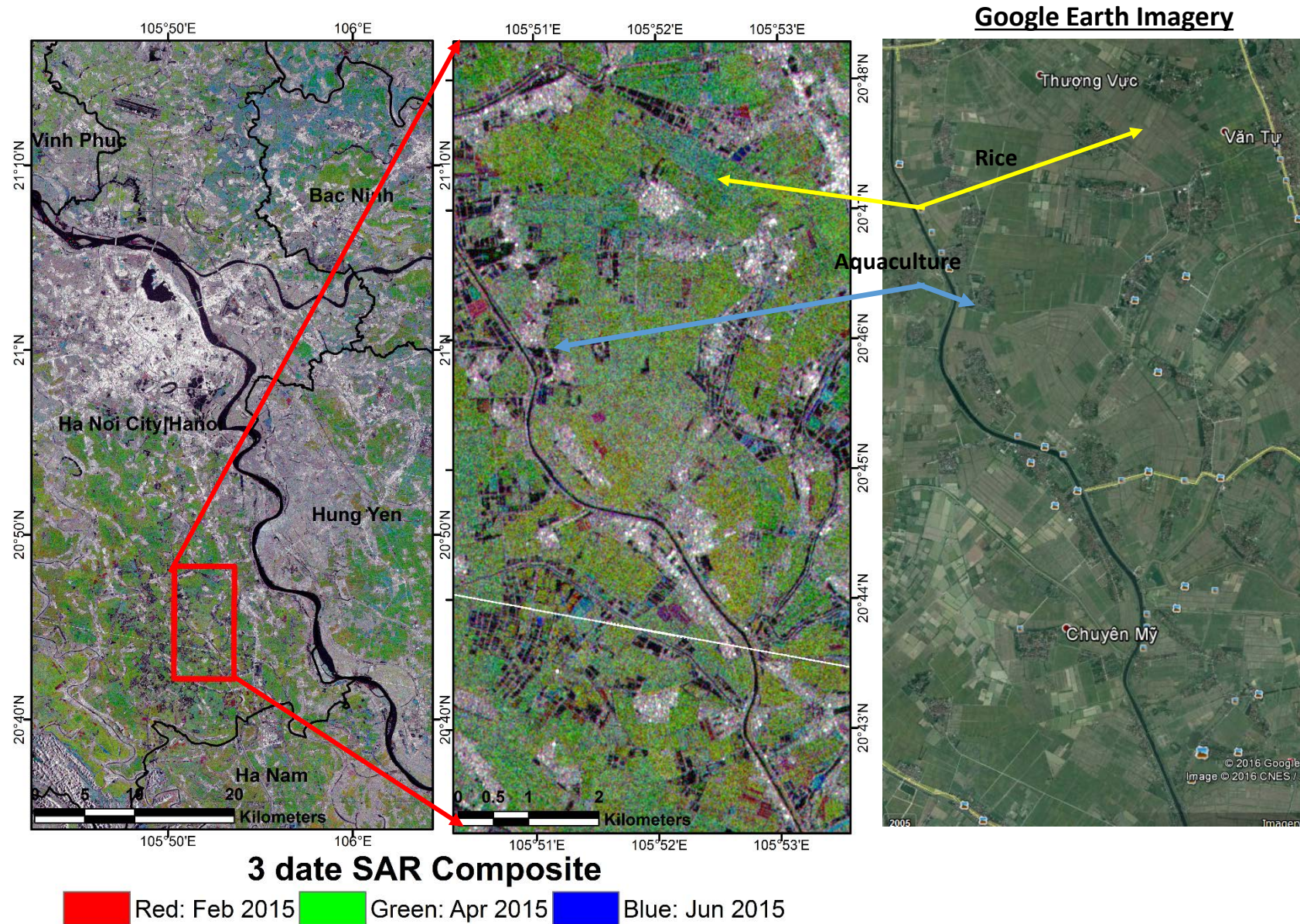
- Basis for residue burning emissions
- Sentinel 1A C-band SAR imagery (year 2015 time-series)
 - VV and VH polarizations
- Landsat 8 TOA imagery (year 2015 composites)
 - EVI
 - NDWI/LSWI

Date	Stage	Scene count
1/6/2015	Inundate	
1/30/2015	Inundate	
2/23/2015	Inundate	
2/27/2015	Inundate	
3/4/2015	Inundate	x2
3/28/2015	Growth	x2
3/19/2015	Growth	
4/12/2015	Growth	
4/21/2015	Growth	x2
5/6/2015	Growth	
5/15/2015	Harvest	
5/27/2015	Harvest	x2
5/30/2015	Harvest	
6/8/2015	Harvest	x2
6/18/2015	Harvest	
6/23/2015	Harvest	
6/30/2015	Harvest	
7/2/2015	Inundate	x2
7/12/2015	Inundate	
7/14/2015	Inundate	
7/17/2015	Inundate	
7/24/2015	Inundate	
8/17/2015	Inundate	
8/19/2015	Inundate	x2
8/29/2015	Growth	
9/3/2015	Growth	
9/10/2015	Growth	
9/12/2015	Growth	x2
9/22/2015	Growth	
9/27/2015	Growth	
10/4/2015	Growth	
10/6/2015	Growth	x2
10/16/2015	Growth	
10/18/2015	Growth	x2
10/21/2015	Harvest	
11/9/2015	Harvest	
11/11/2015	Harvest	
11/14/2015	Harvest	x2
11/23/2015	Harvest	x2
12/3/2015	Harvest	
12/5/2015	Harvest	x2
12/8/2015	Harvest	x2

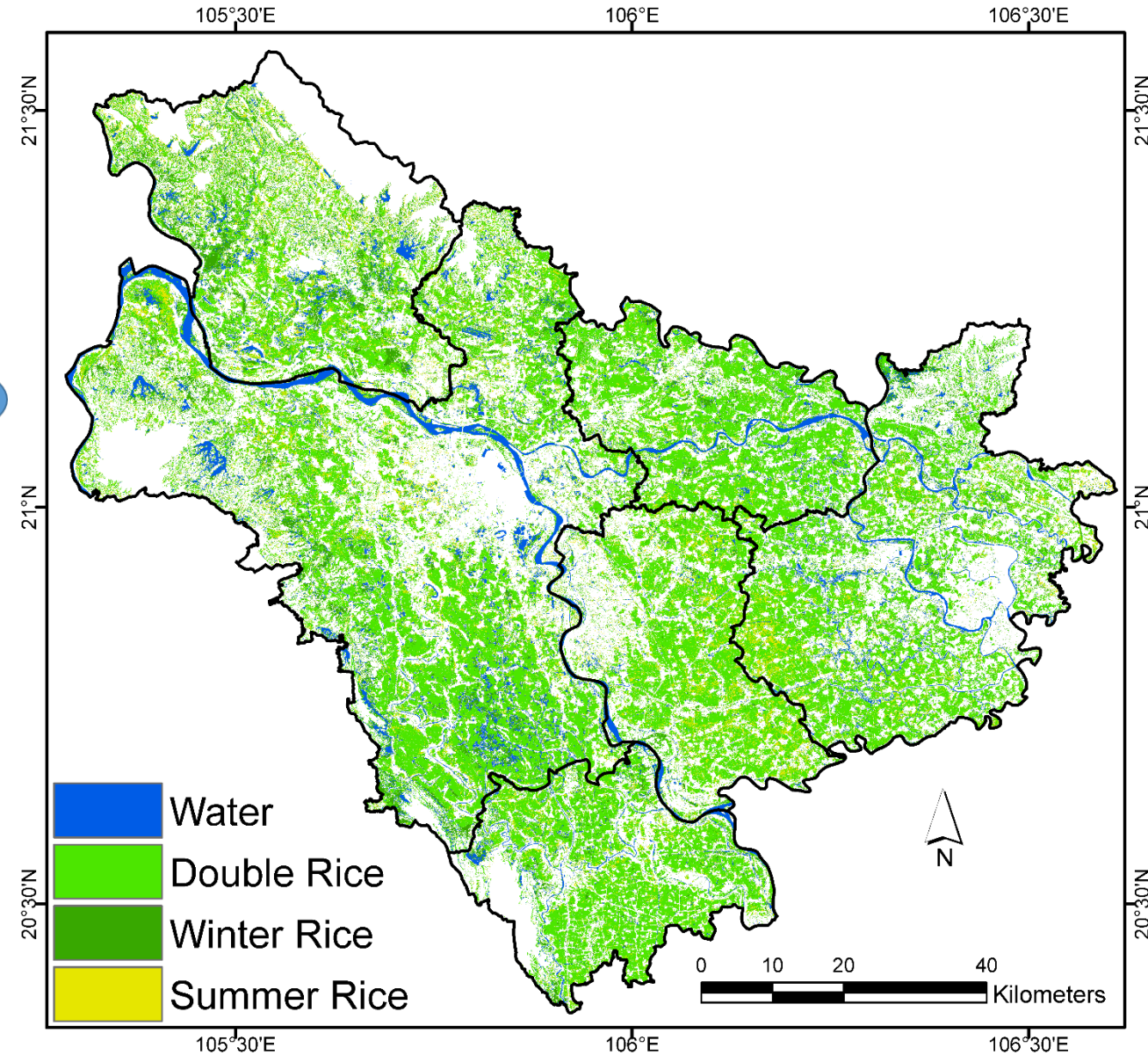
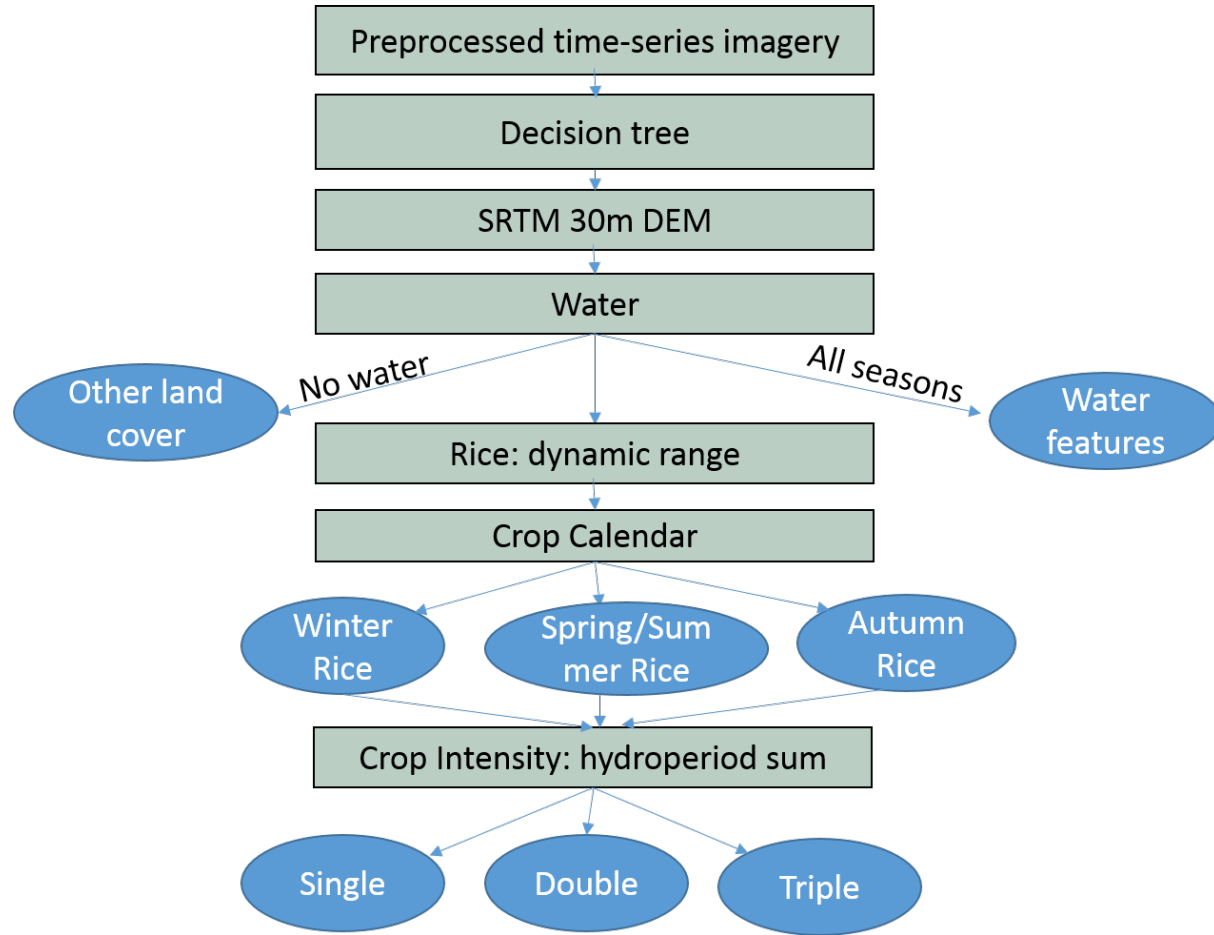


Sentinel-1A Image list

Sentinel-1A Image Composite



Time-series Rice Map



Broader Impacts

- Inform policy makers and basis for incentives to change burning practices to reduce emissions
- Potential emissions scenarios and variation based on changes to the residue burning practices
- Encourage alternative uses for residue
 - Bioenergy, fertilizer, mushroom straw, etc.



Other Outputs

- first bottom-up interdisciplinary framework on crop residue burning practice differences and associated emissions variation with a regional case study.
 - Development of emissions factors from rice residue burning practices
 - Bioenergy quantification using agricultural residue data
 - Spatial mapping of agricultural residue burning events around the Hanoi region
 - Results to guide policy or incentives on crop residue burning practices, directly impacting emissions, air quality, human health and the sustainability of agriculture.

A bottom-up approach to characterize crop residue
burning practices and resultant emissions variation in
Hanoi, Vietnam

Questions?

Introduction

- **Introduction:** Crop residue burning in agricultural areas of the world impacts public health, air quality, and greenhouse gas emissions
- The burning of crop residues, which are defined as the inedible plant material left in fields after harvest, contributes to at least 34% of global biomass burning emissions
- Significant research has been done to characterize the amount of emissions from burning of most major crop residues
- however studies assume one level of emissions per crop [5-7]. Little is known about emissions variation due to residue burning practice differences (i.e. time between harvest and burning, orientation of residues, etc.).
- Hanoi, Vietnam, a large city in Southeast Asia, as well as the focus of our proposal, experiences high levels of air pollution on a regular basis due to both urban and agricultural emissions [2,8]. The Hanoi region is located in the Red River Delta, a primarily rice producing area [9]. The area is currently plagued by air quality measurements exceeding US EPA standards [10], with crop residue burning emissions linked to various hospitalizations and extreme air pollution episodes [11].

Implementation

- **Implementation:** We will implement an integrated bottom-up approach to better understand different crop residue burning practices, and the associated emissions variation for rice. Our collaboration enables direct access to the Fire Protection Engineering laboratories for well-characterized, small-scale experimentation combined with remote sensing and field expertise from the geography department. Accordingly, we will begin by acquiring samples of crop residues from collaborators (e.g. Vietnam National University) properly packed and shipped following USDA shipping protocols. Subsequently, rice residue burning and emissions (e.g., CO, CO₂, PM_{2.5}, BC, O₂ consumption, heat-release rate) will be assessed under different conditions. Relevant factors include moisture content, newly collected vs. older residue, ventilation conditions, residue density, and fuel orientation (open residue burning vs. residue piling). The aforementioned variables impact residue combustion completeness (amount of unburned residue), and thus the resulting variation in emissions.
- Laboratory tests will be performed on the cone calorimeter, an apparatus which can simulate different levels of heating to variously-arranged residue samples while simultaneously measuring CO, CO₂, and heat-release rate [17]. A hydrocarbon analyzer will be used to measure PM_{2.5} [18]. These low-impact, well-characterized tests provide an important benchmark for further emissions characterization.
- Secondly, we will apply the lab results to the regional scale using available field data, statistical data, and remote sensing imagery. We will estimate 1.) Current rice crop residue burning emissions based on the lab results; 2.) Map rice residue burning areas using remote sensing imagery and statistical data; 3) Quantify potential emissions reduction based on changes to crop residue burning practices (piling and burning of residues vs. open-burning of residues, length of time between harvest and burn, etc.). 4) Use available maps of rice area, and apply crop residue-product ratios obtained from freely-available agricultural production datasets to quantify bioenergy potential. We will leverage ongoing collaboration with Vietnam National University to obtain insight into the aforementioned residue burning practices, and percent of residues burned.