Mapping rice greenhouse gas emissions in the Red River Delta. Vietnam

Nathan Torbick. William Salas. Diya Chowdhury. Peter Ingraham
Applied Geosolutions. Newmarket. New Hampshire. 03857 USA
MAI VĂN TRỊNH
Institute for Agricultural Environment. Phu Do. South Tu Liem. Hanoi. Vietnam

Introduction:

- GHG emission from agricultural production activities

Sources of GHG emission/absorption (Gg CO_2 e,)	2005			2010		
	CH_4	N_2O	Total	CH_4	N_2O	Total
	55,282.0	**28,538.4**	**83,820.4**	**57,909.0**	**30,445.8**	**88,354.8**
4A Enteric Fegmentation	9,275.1	0.0	9,275.1	9,467.5	0.0	9,467.5
4B Manure management	2,149.6	5,906.5	8,056.2	2,319.5	6,240.5	8,560.0
4C Rice cultuvation	42,511.6	0.0	42,511.6	44,614.2	0.0	44,614.2
4D Agricultural soils	0.0	22,282.9	22,282.9	0.0	23,812.0	23,812.0
4E Burning savana	3.1	0.6	3.6	1.4	0.3	1.7
4F Burning crop residue	1,342.6	348.3	1,690.9	1,506.3	393.0	1,899.3

Sources: DMHCC, 2014

Rice Management & INDC Targets

- Rice produces significant methane (Global annual emissions 30-100 Tg (10-20% anthropogenic)
- Increased focus Short-lived climate pollutants (methane , black carbon and F-gases)
- 20-yr GWP = 86 (100-yr =34) [AR5]
- COP 21: 48 countries mention rice methane mitigation as part of INDC targets

MODELING RICE YIELDS AND GHG EMISSIONS

The DNDC Model

- **DNDC** stands for **D**e**N**itrification-**D**e**C**omposition
  - DNDC is a soil biogeochemical model that has been used for quantifying GHG emissions from agricultural
  - DNDC is a process (as know as mechanistic) model that simulates the biogeochemical processes to drive C and N cycling in agricultural soils.
  - Long history of peer-reviewed publications (well over 200 publications).

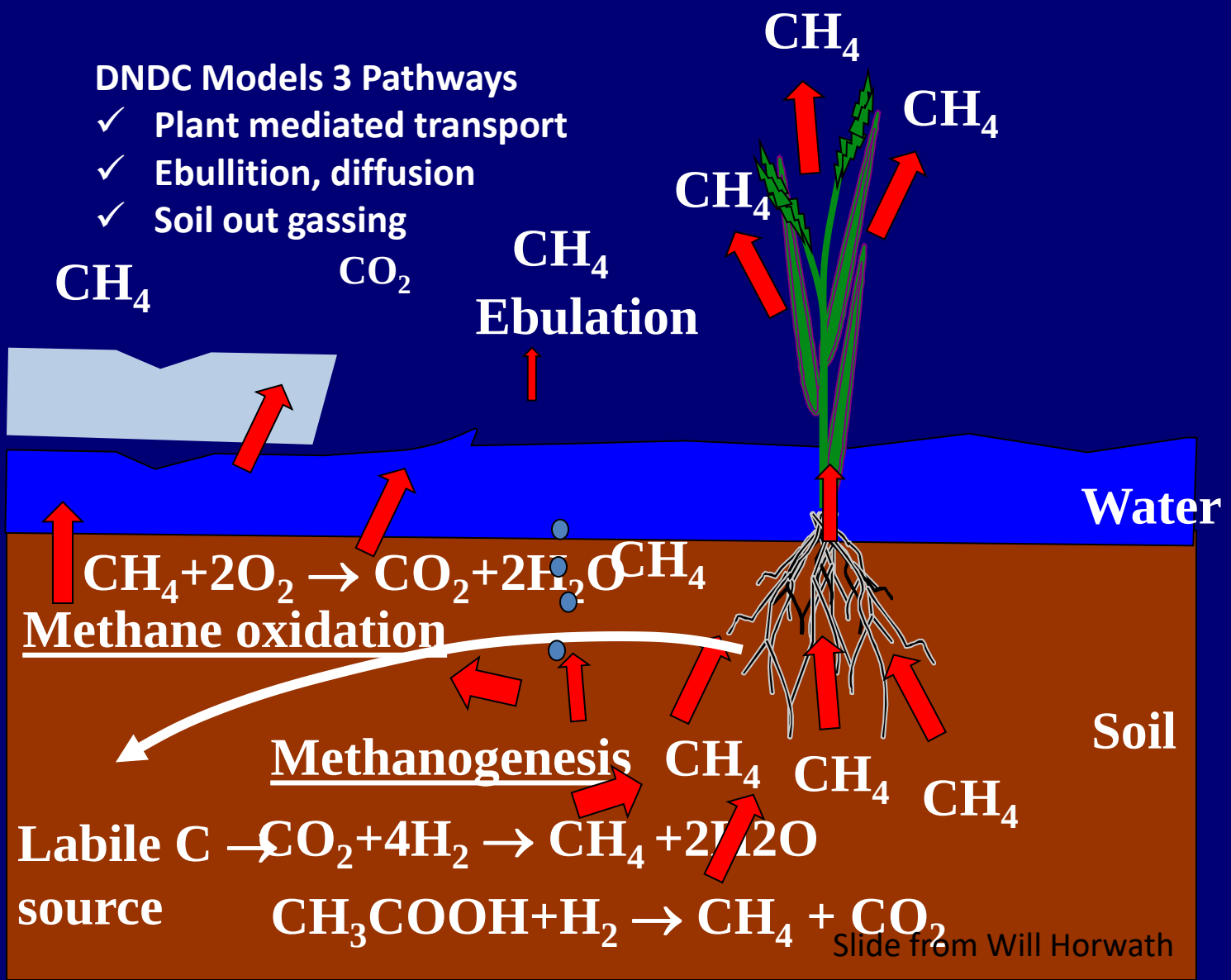
<u>Use for Rice Emissions Modeling</u>

1. What is the daily rice GHG footprint in region?
2. How can multiscale RS improve parameterization and spatiotemporal drivers?

- DNDC can simultaneously simulate anaerobic (flooded) and aerobic (non-flooded) conditions in soils.
- DNDC can model both Methane and Nitrous Oxide emissions: critical for rice agro-ecosystems.
- DNDC has been extensively validated for rice globally.

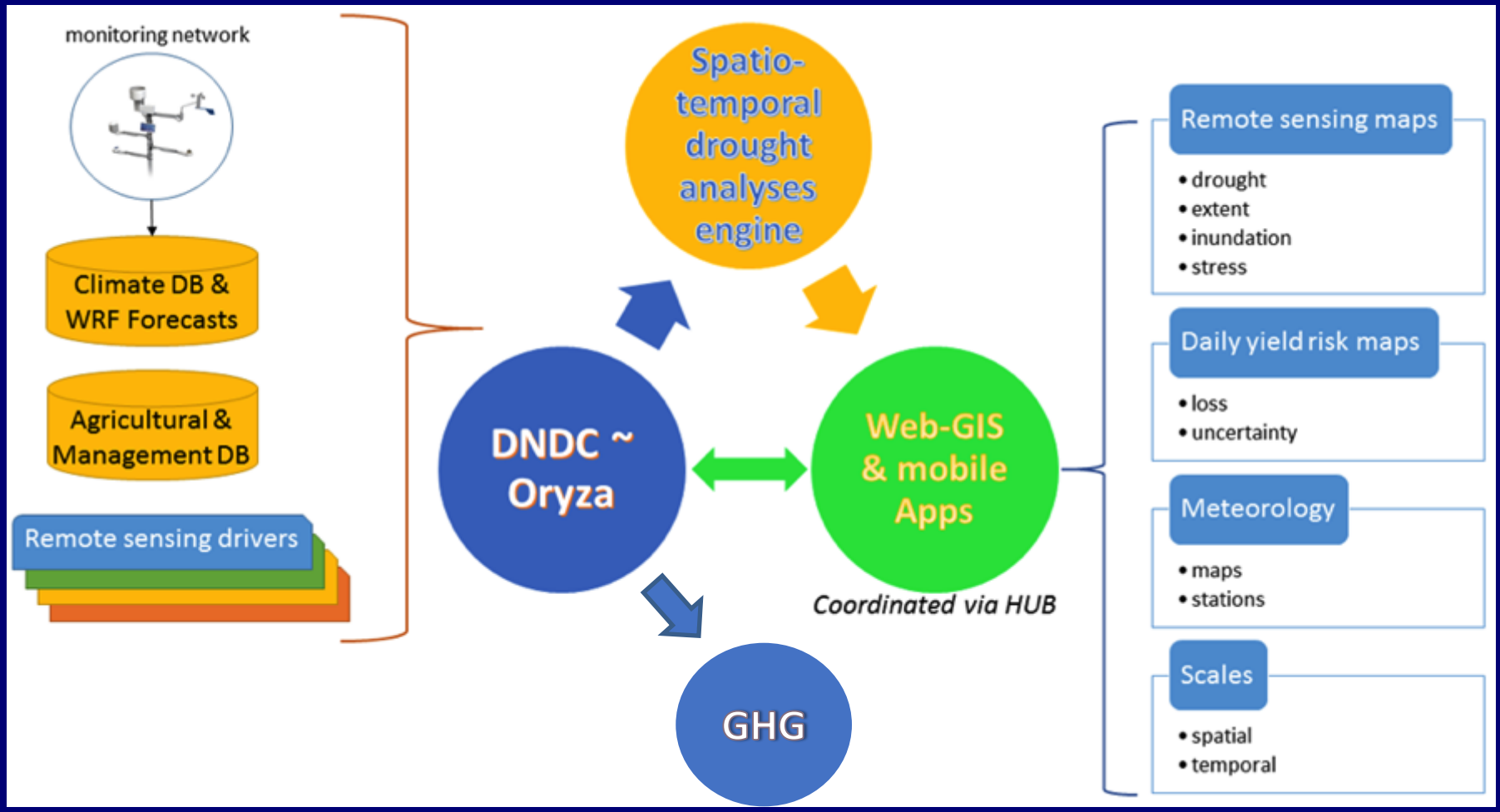
Rice: CH_4 production and emission

(REDOX < -100 to -200 mv)



Slide from Will Horwath

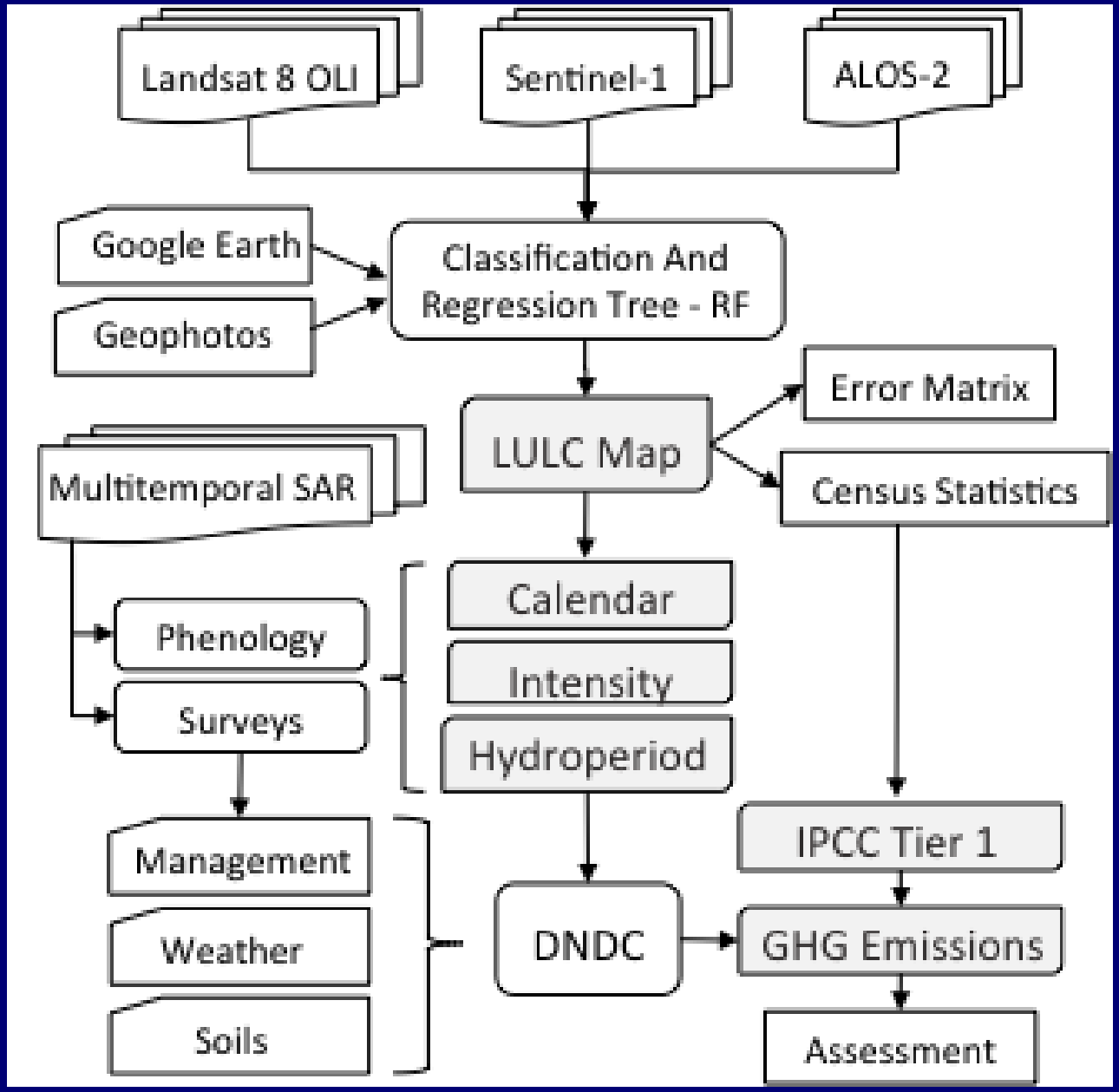
Integrated System



Objectives:

- To better understanding: current land use, rice agriculture, GHG emissions, mitigation opportunities,
- To map rice conditions, estimate GHG emissions, and advance Measurement, Reporting, and Verification (MRV) tools for landscape accounting.
- Technical objectives:
  - To map rice and paddy attributes, such as irrigation management by fusing new Sentinel-1A, PALSAR-2 and Landsat-8 OLI observations from the 2015 calendar year;
  - To drive the process-based DNDC model with spatiotemporally explicit earth observations and surveys; and
  - To assess GHG emissions and compare DNDC to IPCC Tier 1 estimates.

Methodology:



Conceptual flow for mapping rice and quantifying GHG emissions

Brief:

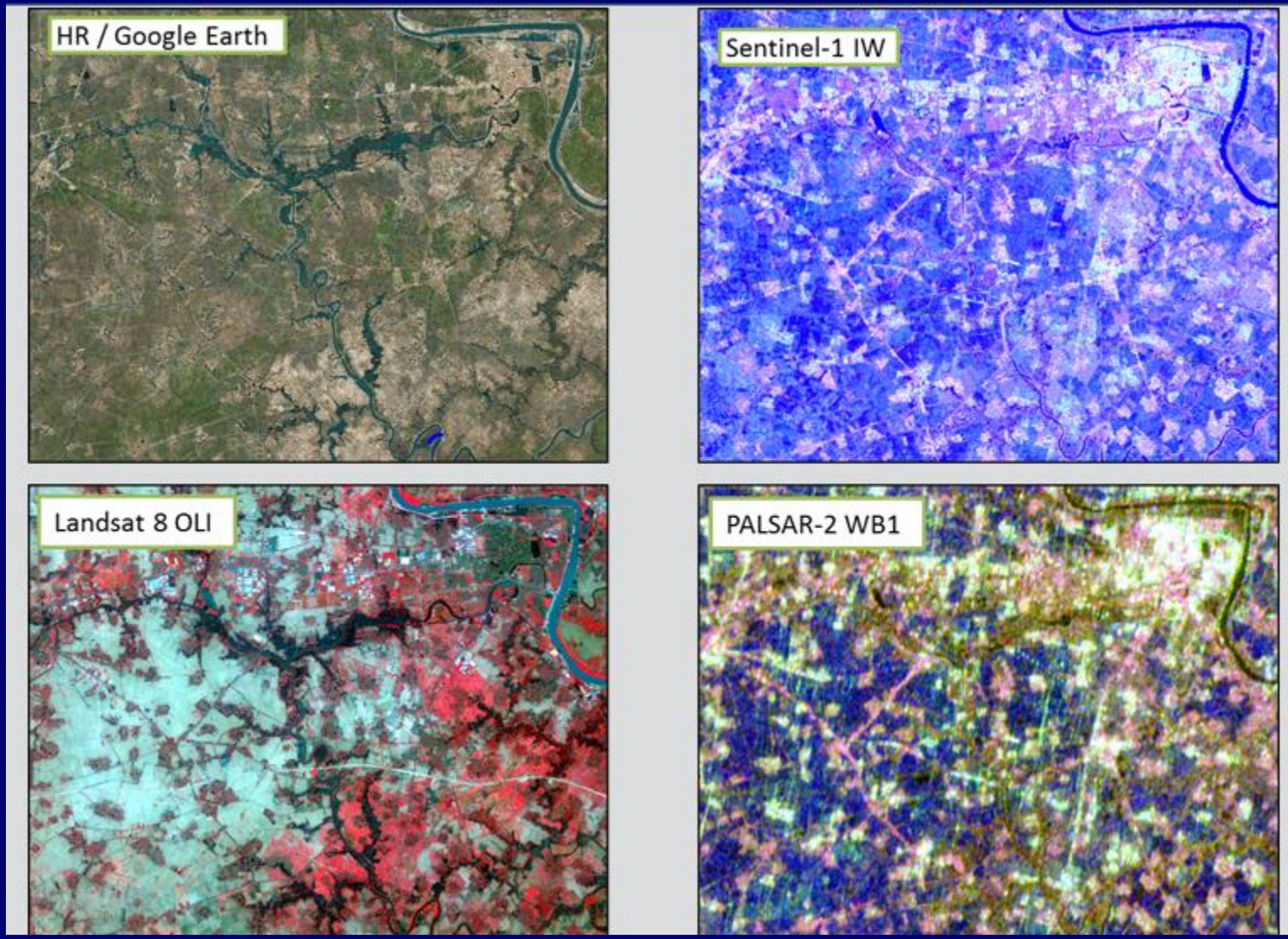
- PALSAR-2, Sentinel-1, Landsat 8 fusion high LULC accuracy
  - Multitemporal required for mapping rice attributes
  - Suite of parameters: extent, hydroperiod, intensity, calendar

- RRD GHG footprint characterized through integration of EO data and DNDC with uncertainty characterized

- Tuning & evaluating yield forecasts for select hot spots (irrigated and rainfed rice) this upcoming year

- Next steps:
  - Mapping AWD is TDB
  - Integration Sentinel-2

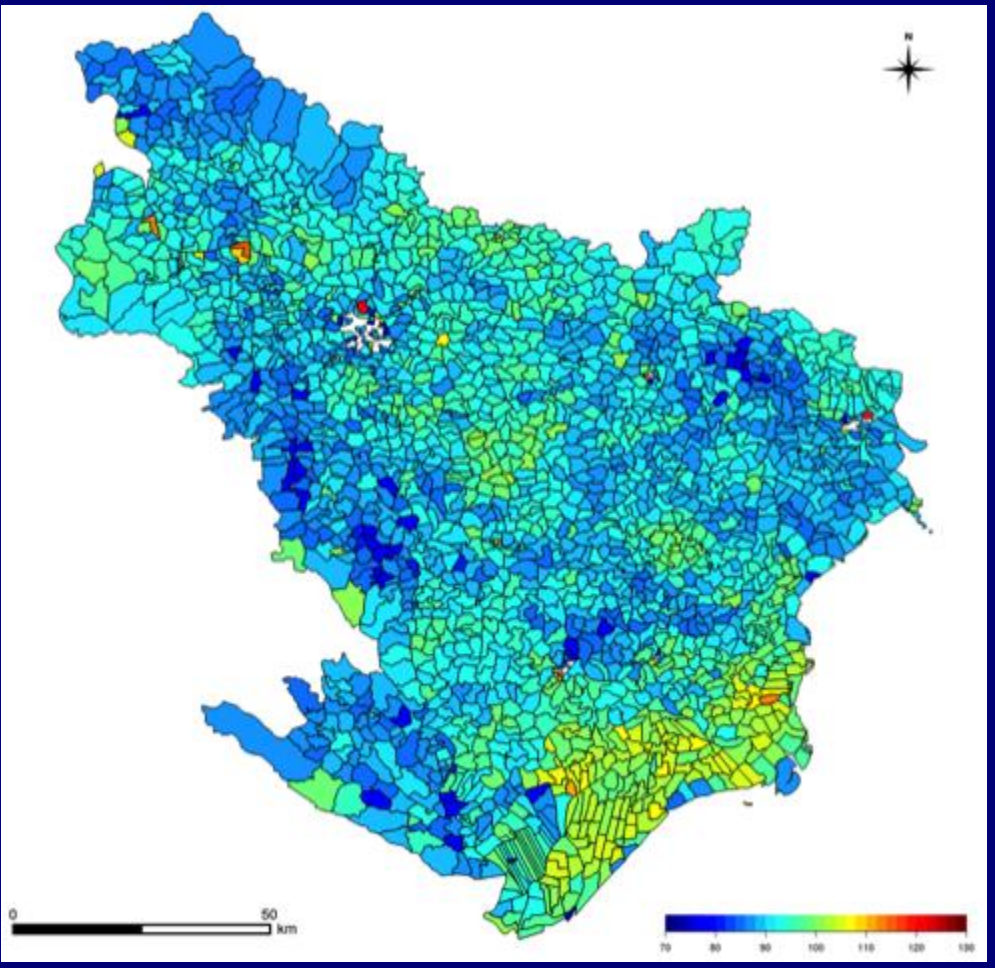
Red River Delta Multiscale Imagery

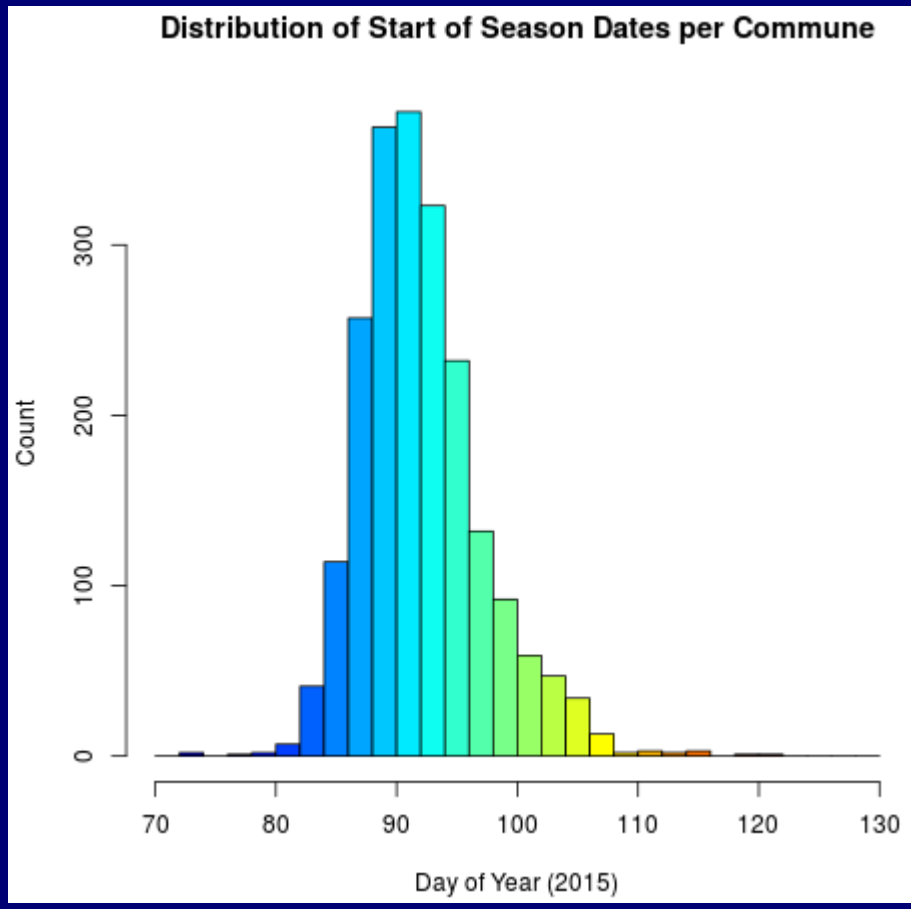


Calculation some Indexes:

Index	Equation
Land Surface Water Index (LSWI)	(nir-swir/nir+swr)
Normalized Difference Till Index (NDTI)	(swir-swir2/swir+swir2)
Normalized Difference Vegetation Index (NDVI)	(nir-red/nir+red)
Soil-Adjusted Total Vegetation Index (SATVI)	(swir-red/swir+red)*(1.1-(swir/2))

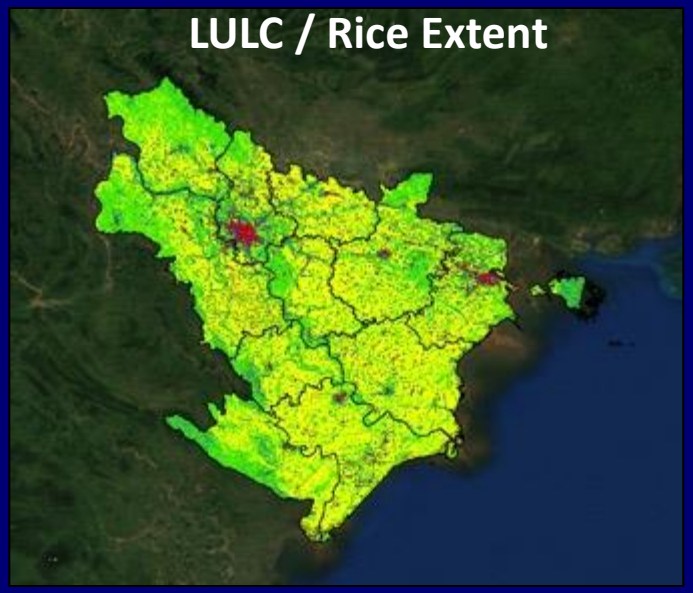
Seasoning:


N
0
50
km
70
80
90
100
110
120
130

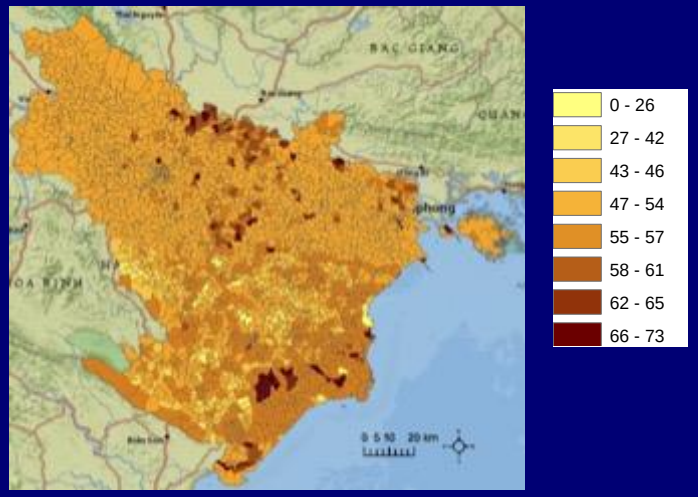

Distribution of Start of Season Dates per Commune
Count
0
100
200
300
70
80
90
100
110
120
130
Day of Year (2015)

Driving DNDC with Earth Observations for GHG Assessment

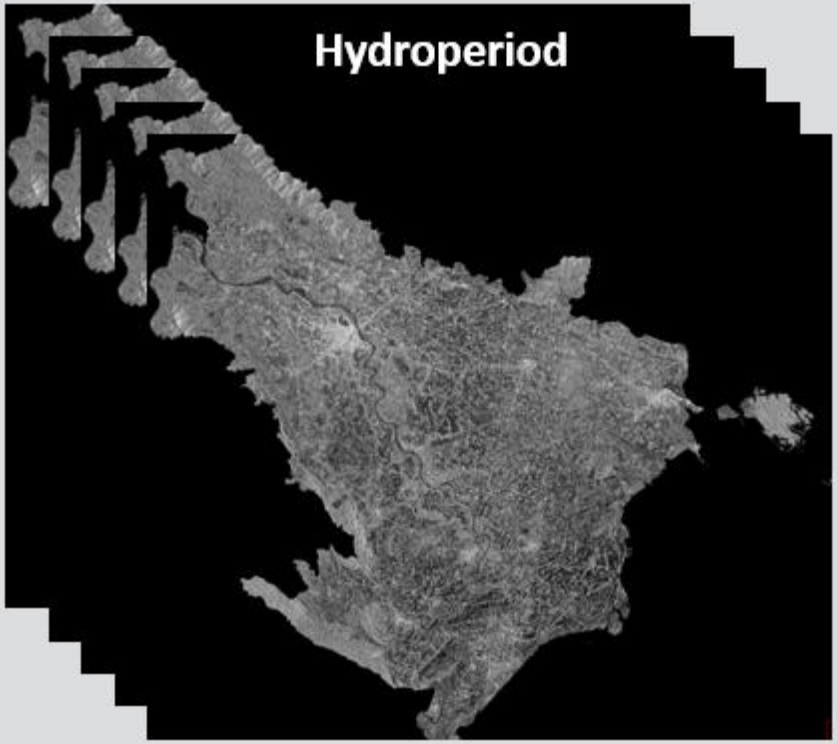
- Used Sentinel-1 to map rice extent, crop calendar, hydroperiod (duration of flooding) for Red River Delta

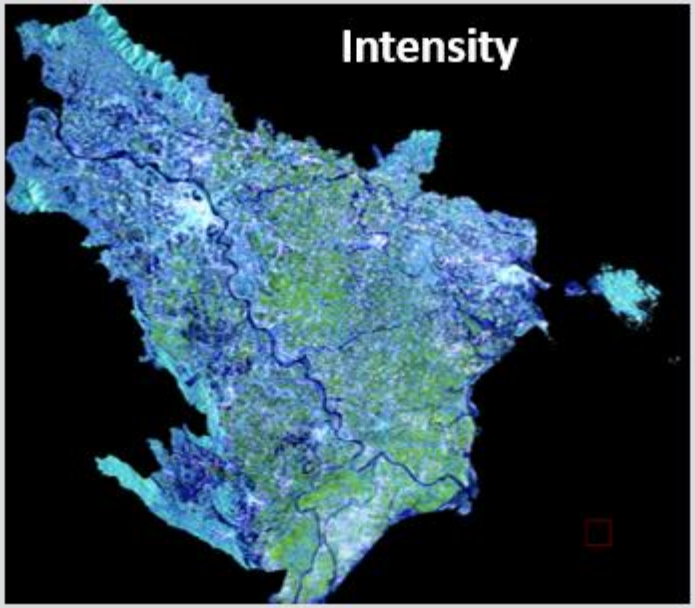


Crop calendar (1st crop planting DOY)



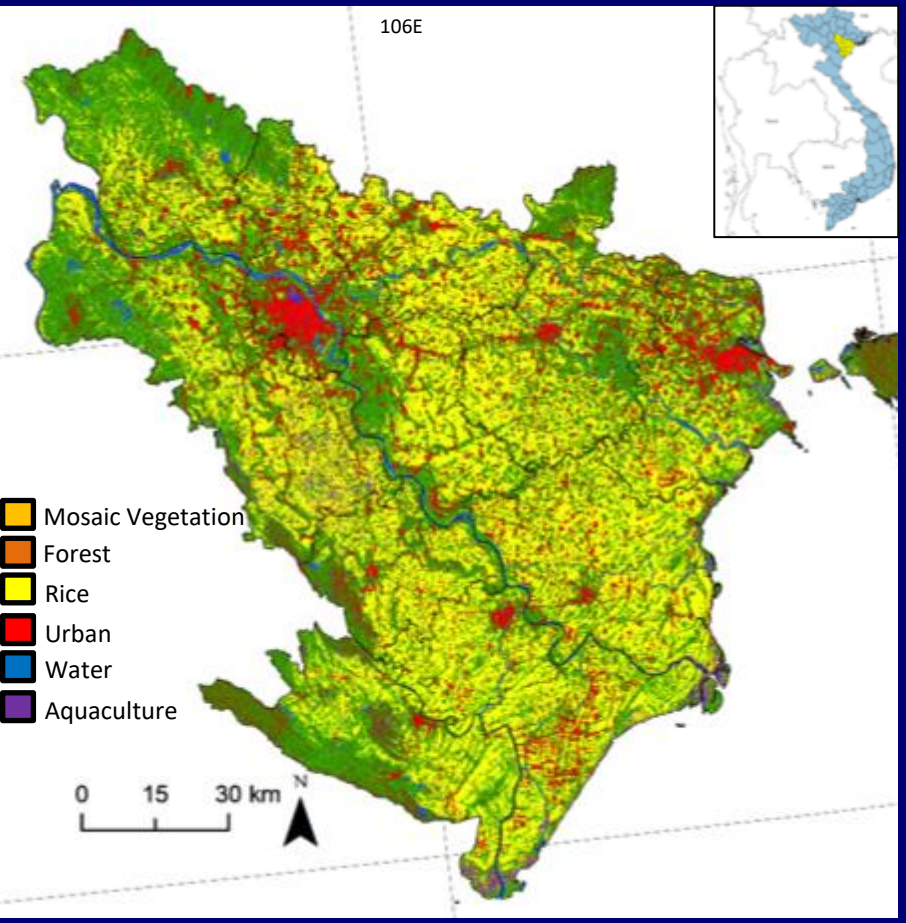
Driving DNDC with Earth Observations for GHG Assessment

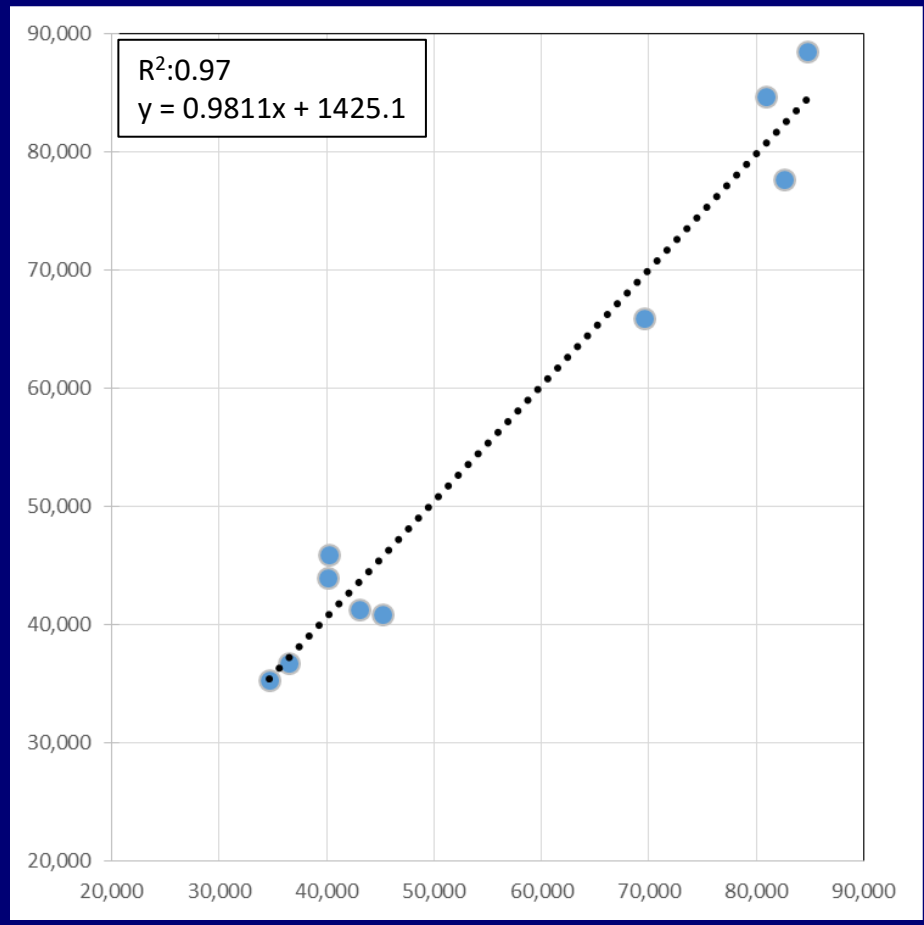




Field visit and measurements:

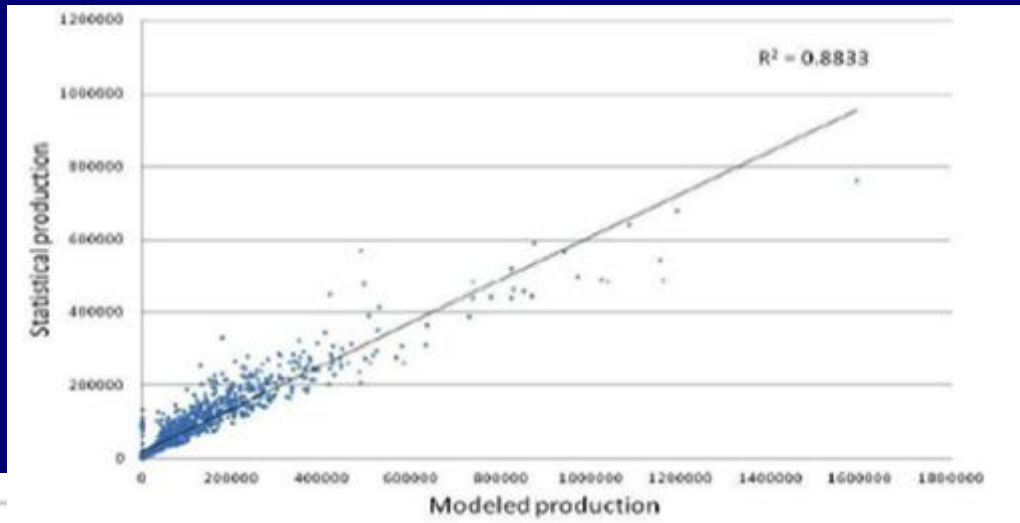
LULC Error matrix

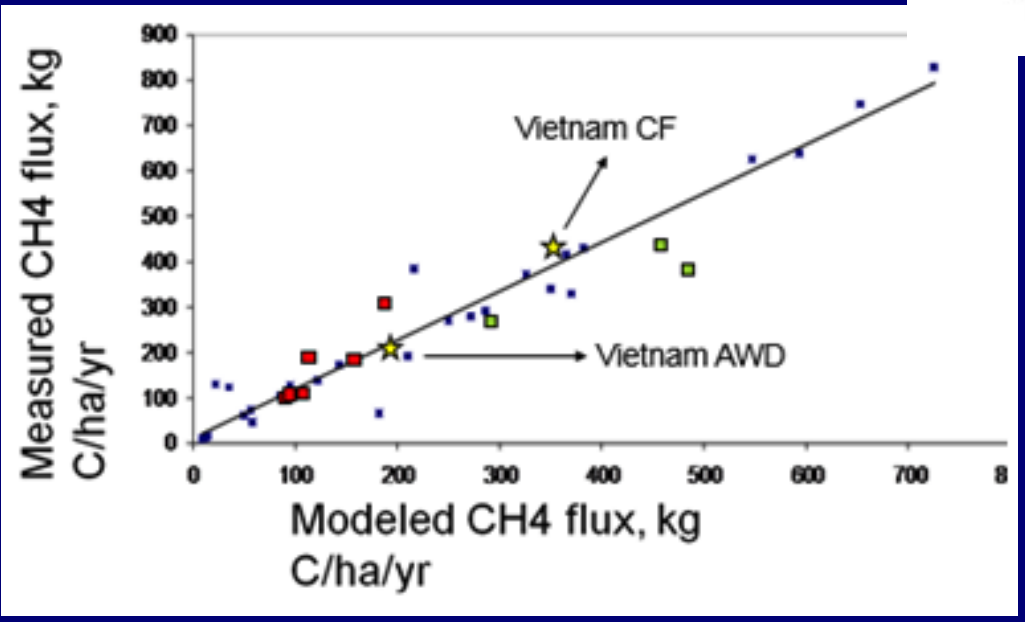




DNDC Model Validation

Validating Crop Yield Forecasts
(Corn example)





Validating Rice Methane

Statistical results:

```
[[13294     0    17     0     0     0     0]
 [    0  1064     0     0     0     0     0]
 [   67     0  5950     0     0     0     0]
 [    0     0     3   450     0     0     0]
 [    0     0     0     0    81     0     0]
 [    0     1     1     0     0    78     0]
 [    0     0     1     3     0     0   415]]
```

Number of training points
[13311 1064 6017   453   81   80   419]

Producer's accuracy
[0.99872285 1.   0.9888649   0.99337751 1.   0.97500002 0.99045342]

Consumers accuracy
[0.99498534 0.99906105 0.99631625 0.99337751 1.   1.   1.   ]

Mean producer's accuracy
0.992345

Mean consumer's accuracy
0.997677

Overall accuracy
0.995659

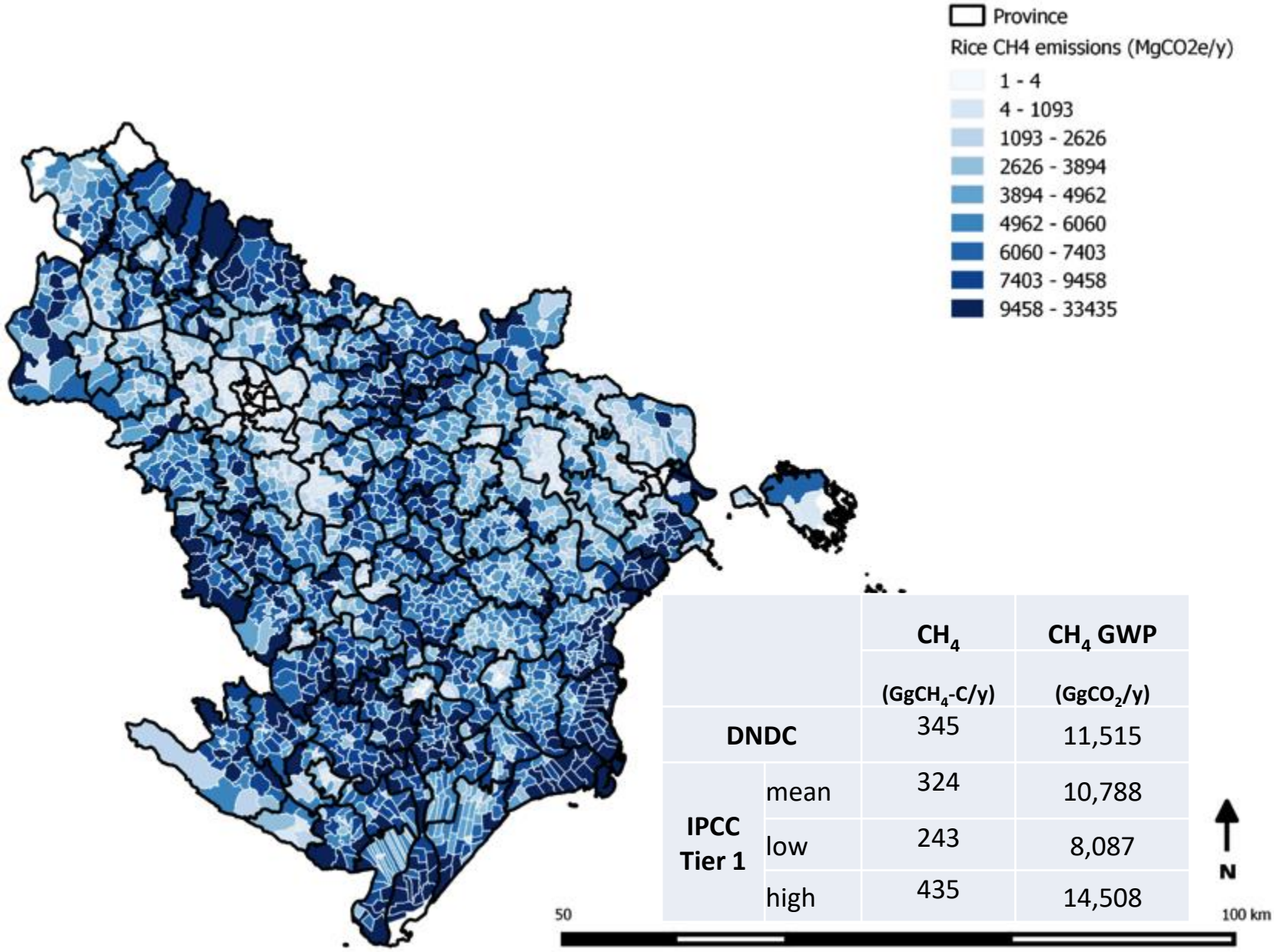
Max misclassified
0.00285714285714

Kappa coefficient
0.991824519235

performing crossvalidation...

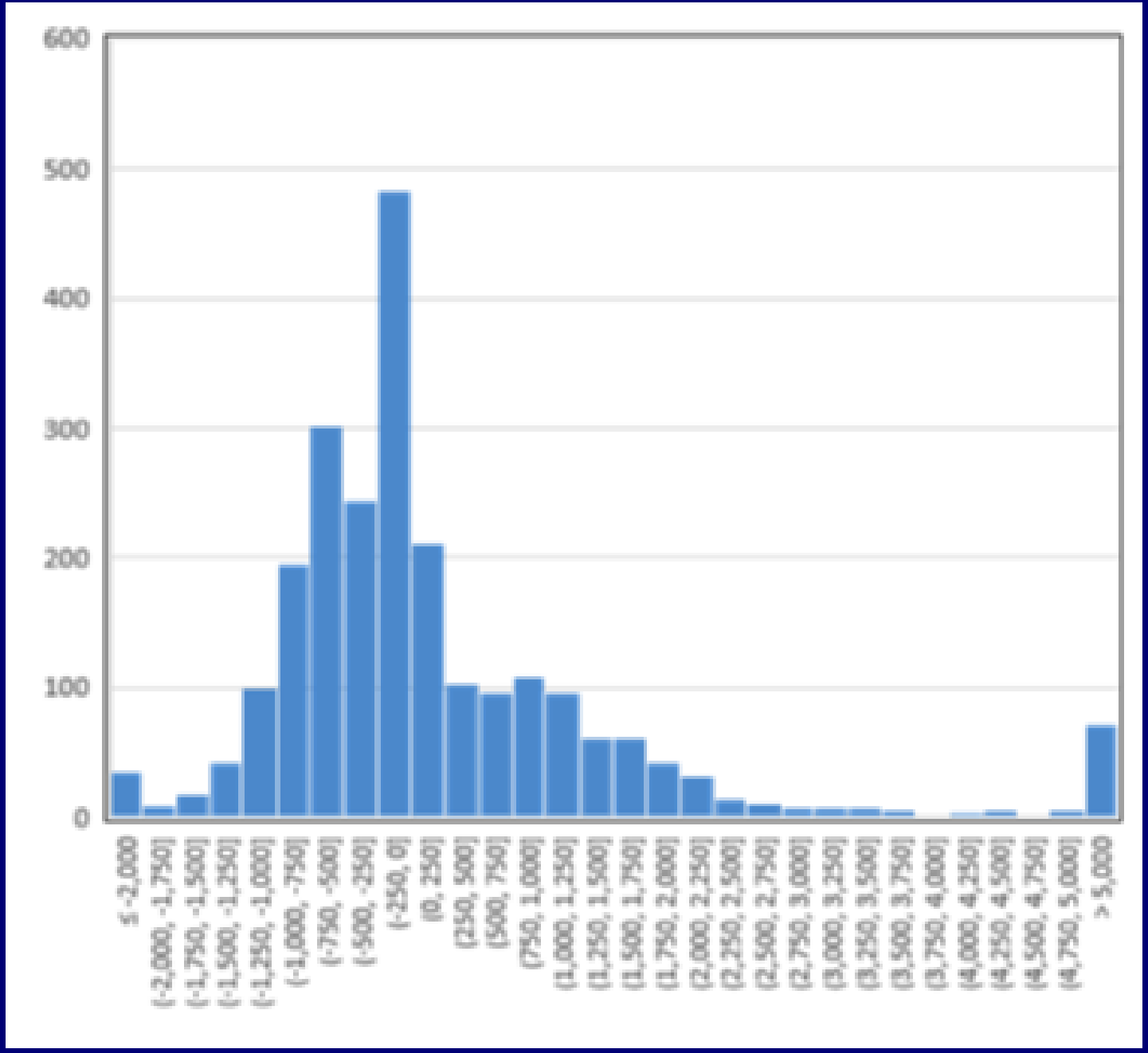
Mean out-of-sample accuracy
0.959255

Mean out-of-sample Kappa
0.922830964332



		CH_4 ($GgCH_4$-C/y)	CH_4 GWP ($GgCO_2$/y)
DNDC		345	11,515
IPCC Tier 1	mean	324	10,788
	low	243	8,087
	high	435	14,508

Commune-level rice GHG emissions for DNDC, and comparison to IPCC Tier 1 approach



Difference histogram of DNDC versus IPCC Tier 1 for commune-level rice emissions

Following project:

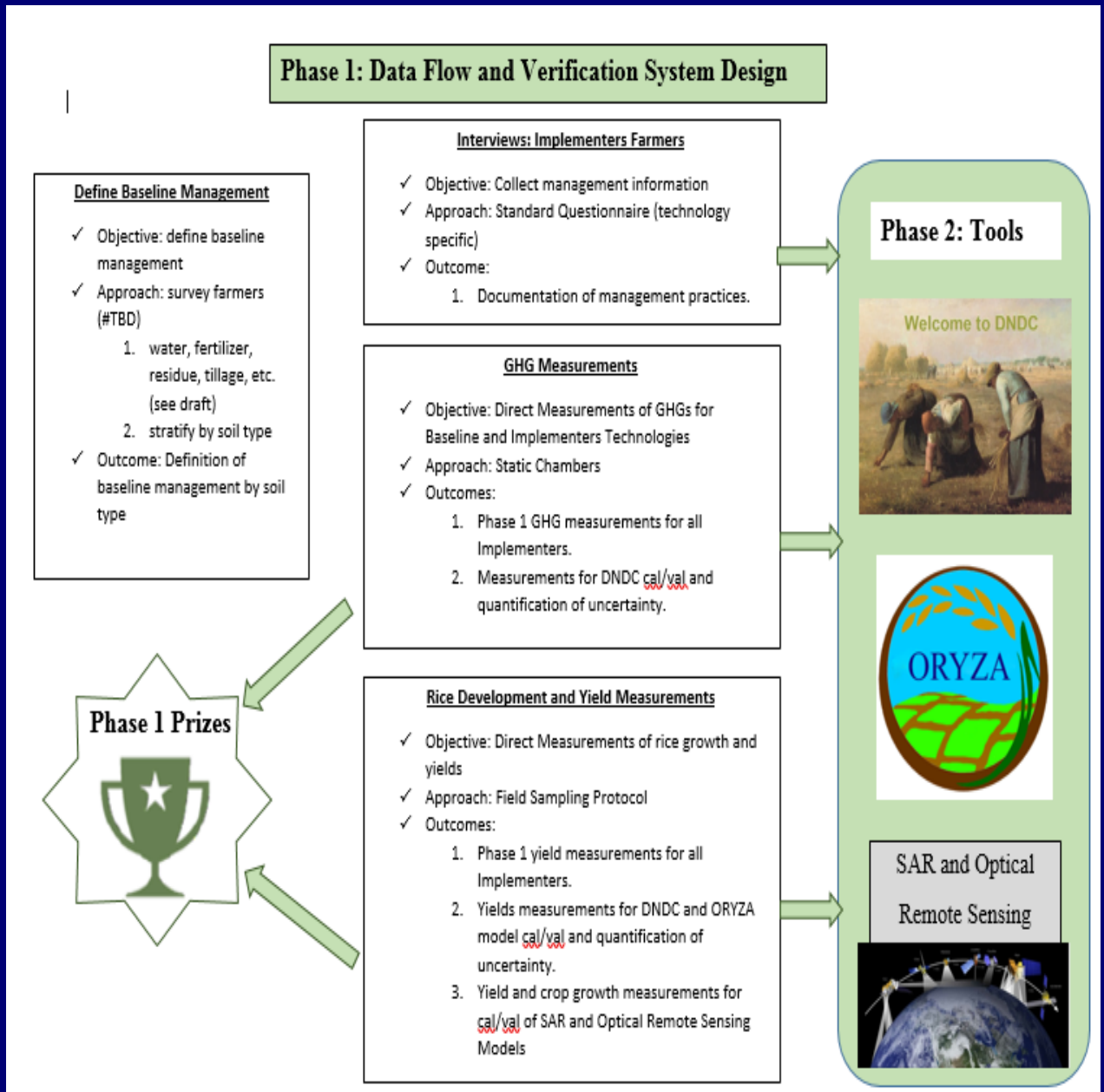
AgResults
INNOVATION IN RESEARCH AND DELIVERY

AgResults Vietnam
Emissions Reduction Pilot

Upcoming Prize Award Opportunities

Verification Design : Overall technical verification design for phase 1 and 2

Phase 1: Verification Approach



Phase 2: Verification Approach

Phase 2: Data Flow and Verification System Design

GeoSpatial Data Collection Platform

- ✓ Objective: Collect management information and field locations for all Phase 2 participants
- ✓ Approach: Use Customized Mobile Apps and Web-GIS Database Platforms
- ✓ Outcomes:
  1. Documentation of management practices and all field locations in Phase 2
  2. Standardized data collection system for modeling and verification

Remote Sensing Data Collection Platform

- ✓ Objective: Verify management information at all field locations for all Phase 2 participants and support yield quantification
- ✓ Approach: Use multi-temporal SAR and Optical imagery, ≤10m resolution
- ✓ Outcomes:
  1. Verification of management (rice, pant/harvest dates, flooding management) practices at all Phase 2 fields
  2. Support rice yield monitoring

GHG Modeling System

- ✓ Objective: Model GHG reductions for Phase 2
- ✓ Approach: DNDC Model
- ✓ Outcomes:
  1. Phase 2 GHG emission reductions for all Implementers.
  2. Quantification of uncertainty.

Rice Yield Monitoring System

- ✓ Objective: Direct Measurements of rice growth and yields
- ✓ Approach: Field Sampling Protocol
- ✓ Outcomes:
  1. Phase 1 yield measurements for all Implementers.
  2. Yields measurements for DNDC and ORYZA model cal/val and quantification of uncertainty.
  3. Yield and crop growth measurements for cal/val of SAR and Optical Remote Sensing Models

ORYZA

Uncertainty Quantification System

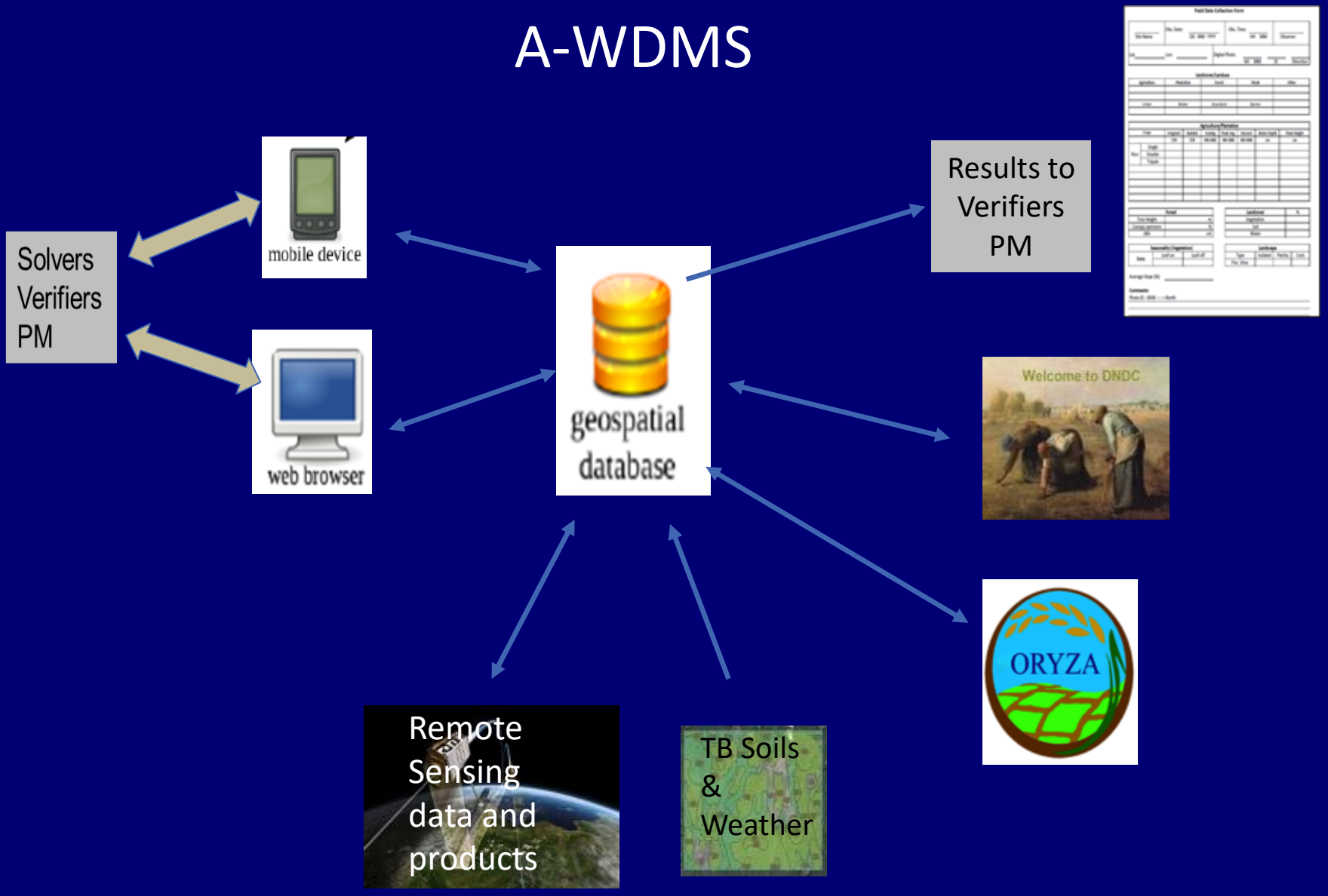
Phase 2 Prizes

AVERP WebGIS Database Management System (A-WDMS)

A-WDMS

- Background:
  - Phase 2 target is up to 75,000 households
  - Need a consistent, transparent and easy to use database management system
  - Must support geospatial data (site boundaries, remote sensing products, etc)
  - Must support direct link with mobile apps
  - Support user authentication to protect privacy
- Plan: Build a **W**ebGIS **D**atabase **M**anagement **S**ystem
  - Manage all spatial data – soils, weather, site locations, geotagged photos
  - User authentication – separate login accounts for Solvers, PM and Verifiers
  - Relational database – links sites, technologies and Solvers.
  - Reporting functions

A-WDMS


Solvers
Verifiers
PM
mobile device
web browser
geospatial database
Results to Verifiers PM
Welcome to DNDC
ORYZA
Remote Sensing data and products
TB Soils & Weather

Thank you!