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ACR Methodology for Emissions Reductions in Rice Management Systems

Nicholas Martin, American Carbon Registry
Robert Parkhurst, Environmental Defense Fund
Bill Salas, Applied Geosolutions
Erica Meta Smith, Terra Global Capital

Agenda

Development of a Rice Offset Protocol

Robert Parkhurst, Environmental Defense Fund

ACR Methodology: Emission Reductions in Rice Management Systems

Nicholas Martin, American Carbon Registry

Quantification of Rice GHG Emissions using DNDC

Bill Salas, Applied Geosolutions

Data Gathering, Monitoring and Verification of Rice Projects

Erica Meta Smith, Terra Global Capital

Webinar Logistics

Asking questions

- Either during presentation or Q&A period at end
- Type questions into '**Chat**' box near bottom of your webinar pane or click hand icon to ask in person. Please include your name and organization.
- We will direct questions to the appropriate person during the Q&A period at the end
- We will try to answer all questions and will make our best effort to respond via e-mail to any questions not addressed during the webinar

Webinar will be recorded

- Both the presentation and a link to the recording will be sent to all registered webinar participants

ACR Background

First U.S. voluntary carbon registry, founded in 1996

- Enterprise of Winrock International since 2007
- 37.5 million offsets issued

May 2012*:* Opened office in Sacramento to support the California cap-and-trade offset program

Dec 2012: Approved by ARB as an Offset Project Registry (OPR) and Early Action Offset Program (EAOP) for the California cap and trade market

2012 average price \$7.40/ton CO_2e (voluntary only)

Development of a Rice Offset Protocol

Robert Parkhurst,
Environmental Defense Fund

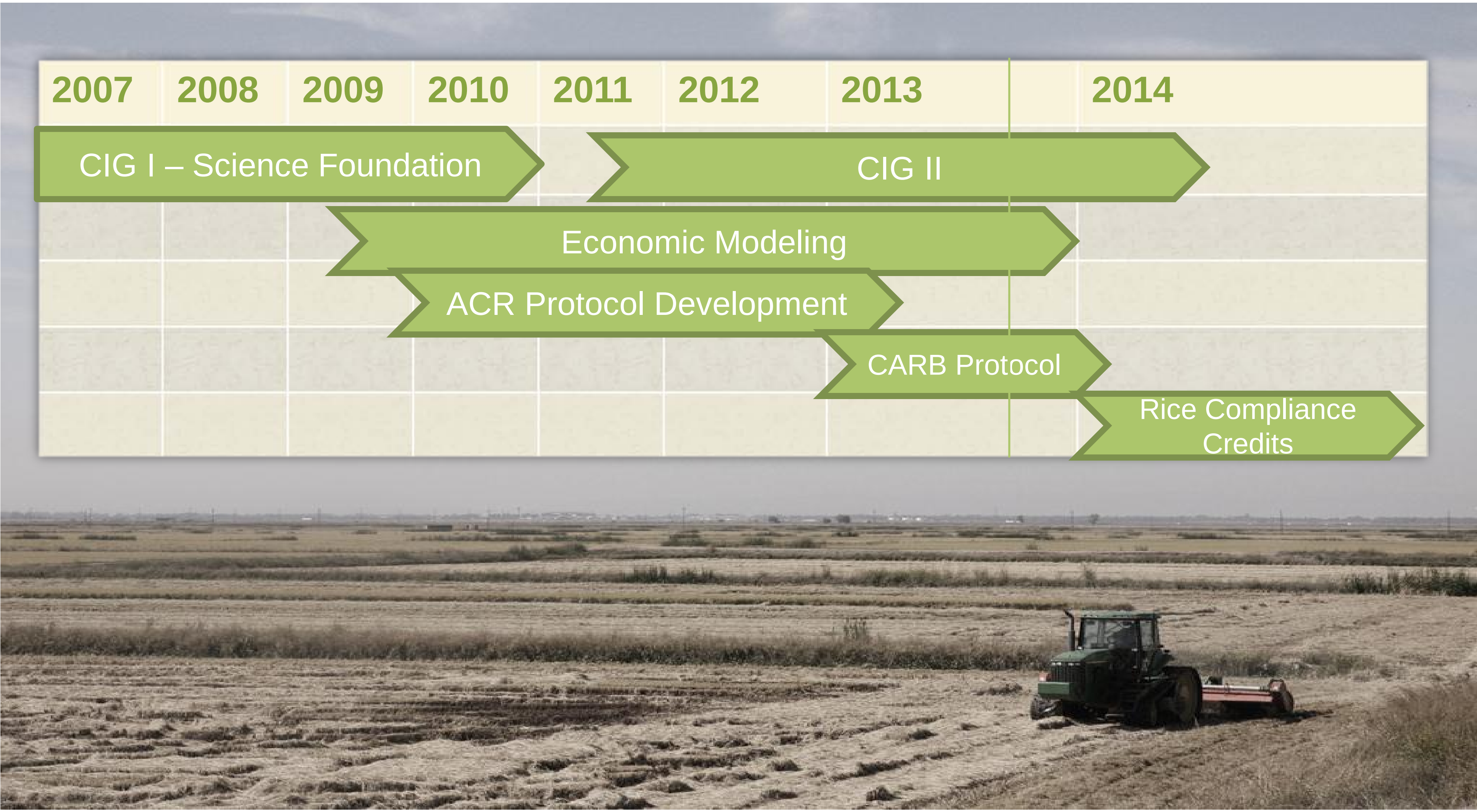
Conservation Innovation Grant (CIG)

- Voluntary program developed by Natural Resource Conservation Service
- "…intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging Federal investment in environmental enhancement and protection, in conjunction with agricultural production."
- Funded by the Environmental Quality Incentives Program
- Fiscal Year 2011 focus on greenhouse gas mitigation (9 projects awarded)

Goals of the Rice CIGs

- Demonstrate methane emission reductions from rice production in the U.S. using market-based incentives (sale of credits)
  - Field-test a subset of GHG-reducing practices
  - Produce offset protocol and user-friendly technology for producers to access carbon markets
  - Determine replication potential across the United States
- Assess environmental and economic impacts

Rice Offset Efforts



Offset Project Steps

I. Project Feasibility → II. Project Development → III. Project Registration → IV. Project Implementation → V. Offset Issuance → VI. Credit Sale

ACR Methodology: *Emission Reductions in Rice Management Systems*

Nicholas Martin, American Carbon Registry

Emission Reductions in Rice Management Systems

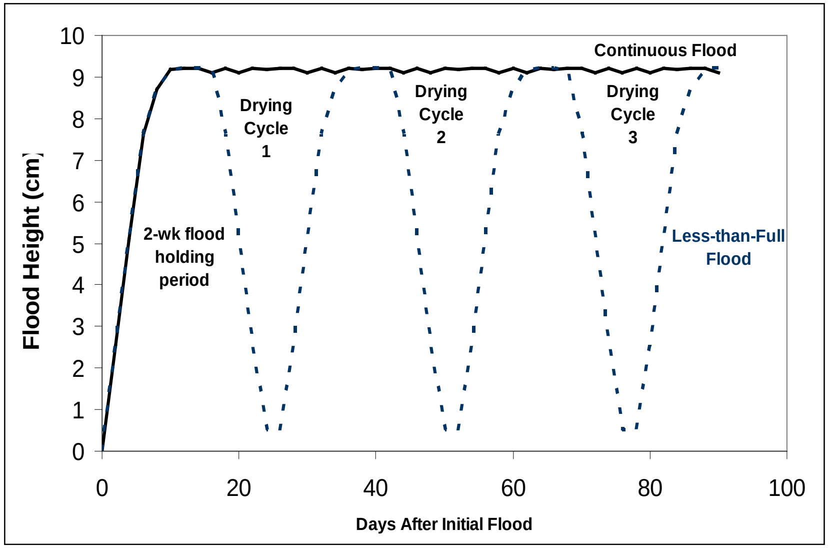
- Parent methodology (May 2013)
  - Definitions, eligibility criteria, project boundary
  - Baseline setting and additionality
  - DNDC quantification of baseline and project
  - Calculation of structural uncertainty deduction
  - Up-front cal/val of DNDC by Rice-Growing Region
  - Flexible verification requirements
- California module (May 2013)
- Midsouth module (**open for public comment now**)
- Pilots with rice growers in California and Midsouth U.S. under GHG CIG

Credit: Dennis Carman, WRID

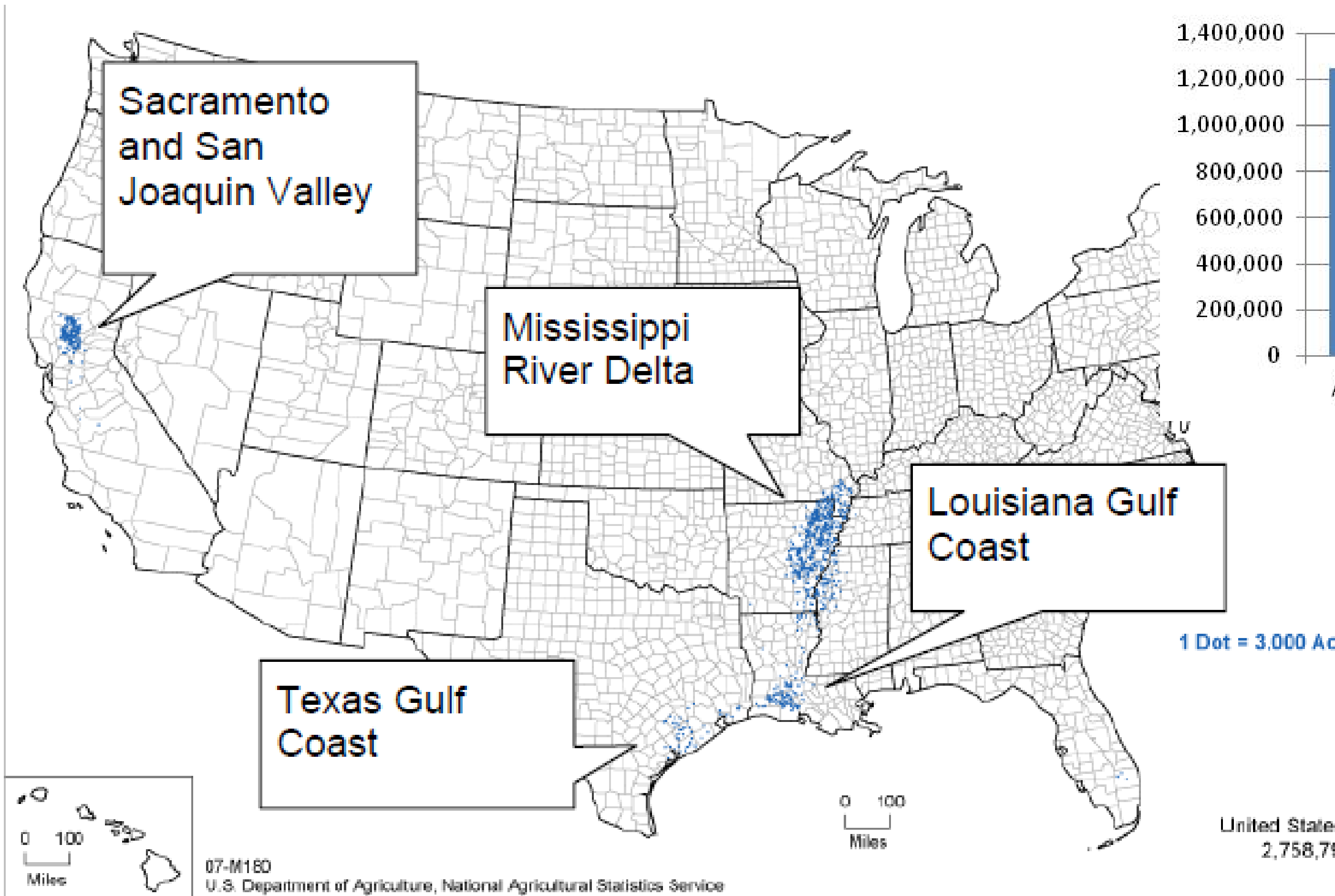
http://americancarbonregistry.org/carbon-accounting/carbon-accounting/emission-reductions-in-rice-management-systems

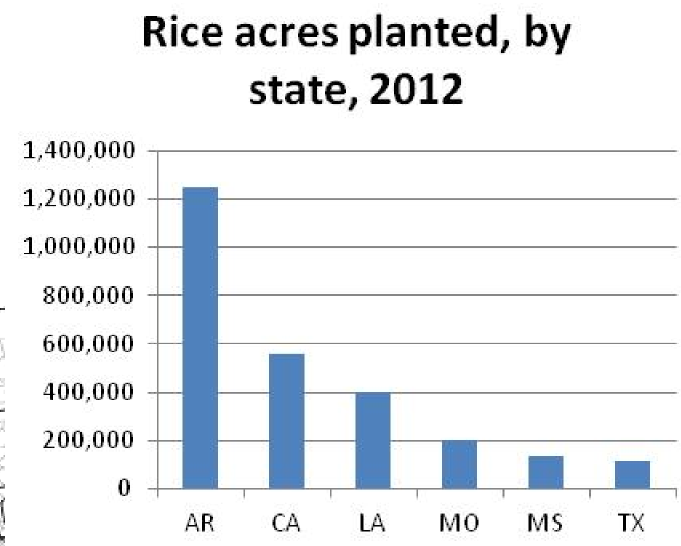
Eligible Practices

- California:
  - Straw removal after harvest
  - Switch to dry seeding
  - Early drainage at end of growing season
- Midsouth U.S.:
  - Straw removal after harvest
  - Early drainage at end of growing season
  - Intermittent flooding
    - N rate reduction and single N application
  - Increased water and/or energy use efficiency
    - Convert contour levees to precision or zero grade
    - Side inlet/poly piping systems
    - More efficient diesel pumps
    - Switch to electric pumps
    - Soil moisture sensors to tailor flood to water needs



Rice-Growing Regions





Project Boundary

- Minimum of five rice fields or 1,000 acres
  - Geographic coordinates provided to VVB but may remain confidential
- Programmatic aggregated projects
  - Add new fields to existing Project during Crediting Period
- Included GHG sources:
  - **Baseline**: CO_2, CH_4 and N_2O in soil; GHGs from burning straw
  - **Project**: CO_2, CH_4 and N_2O in soil; GHGs from alternative uses of straw; GHGs from production and transport of fertilizer added after straw removal
- Crediting Period: 5 growing seasons
  - No credits in years rice not grown
  - Applies to Project overall, not field-specific

Baseline and Additionality

- Practices adopted on ≤5% of rice acres in Rice-Growing Region:
  - Common Practice Baseline
  - Deemed additional as long as no regulatory requirement
- Practices at 5% to 50% adoption:
  - Field-Specific Baseline
  - Three-prong additionality test (exceeds regulatory requirements, goes beyond common practice, faces higher implementation barriers than management prior to project start)
- Determining adoption rates:
  - Statistically valid survey of randomly selected fields in Rice-Growing Region
  - Expert opinion: 3 independent experts assert that adoption is ≤4%

Early Adopters

- Even if practices not required by regulation and at low adoption rate are deemed additional, if baseline = last 5 years on own fields → no credit to early adopters
- Rewarding early adopters may be best way to increase adoption by others
  - Beware perverse incentives to discontinue practice
- Uncommon practice (≤5% of rice acres) deemed additional and uses “common practice baseline”
  - Critical input parameters set by typical management on at least 5 non-project fields
  - Crediting period renewed at most once if adoption rate remains <5% → ten years to prove efficacy of early adopters incentive

Quantification using DNDC

- Process-based simulation model of carbon and nitrogen biogeochemistry
- Run separately for each field and for baseline and project
- Outputs: emissions of GHGs (CO_2, CH_4, N_2O)
- Inputs:
  - Management data: cultivar planted, yields, planting and harvesting dates, flooding depths, flooding and draining dates, residue management, fertilization dates and amounts
  - Information on soils, precipitation, etc. specific to project
  - Many inputs are defaults or can be pre-loaded in model

Leakage

- *Ex ante*, assumed to be negligible
- *Ex post*, calculated using actual yields for that season
- Calculating leakage:
  - Is there a significant decrease in rice yield, compared to yields in at least 3 out of 5 years before project start?
  - Yields normalized against NASS/NRCS county-level yield statistics to distinguish between seasonal variations and project-induced leakage
  - Emissions from leakage = (normalized baseline yield – actual yield) * own-price elasticity * baseline emissions intensity in tCO_2e/tons yield

American Carbon Registry

Verification

- Completeness audit: desk review of monitoring parameters for all fields
- In-depth audit: random and risk-based sampling of fields
  - For each year verified, greater of 20% of fields or 2 fields subject to in-depth audit
  - Random selection, with replacement, among all fields generating credits
  - Did project activity occur? Are critical management parameters within specified range?
- Use of industry experts for field visit allowed
  - VVB selects fields, unknown to grower until after practice implemented
- Triangulate farmer records with other sources

Verification Data Sources

- Remote sensing – eligibility of field; implementation of dry seeding; approximate flood-up date; drain date (?); harvest date
- In-field sensors/probes for water and soil moisture, temperature, etc.
- Precision agriculture, variable rate technology – management choices logged and georeferenced
- Date-stamped photos taken by farmer, uploaded to secure account
- Monitoring equipment installed at pumping station (water use, date start/stop pumping, diesel use, photos)
- Independent publicly accessible data (e.g. climate, precipitation, county-level crop yield statistics…)
- Assertions from independent credentialed experts (e.g. on common practices, adoption rates…)

Aggregation and Programs of Activities

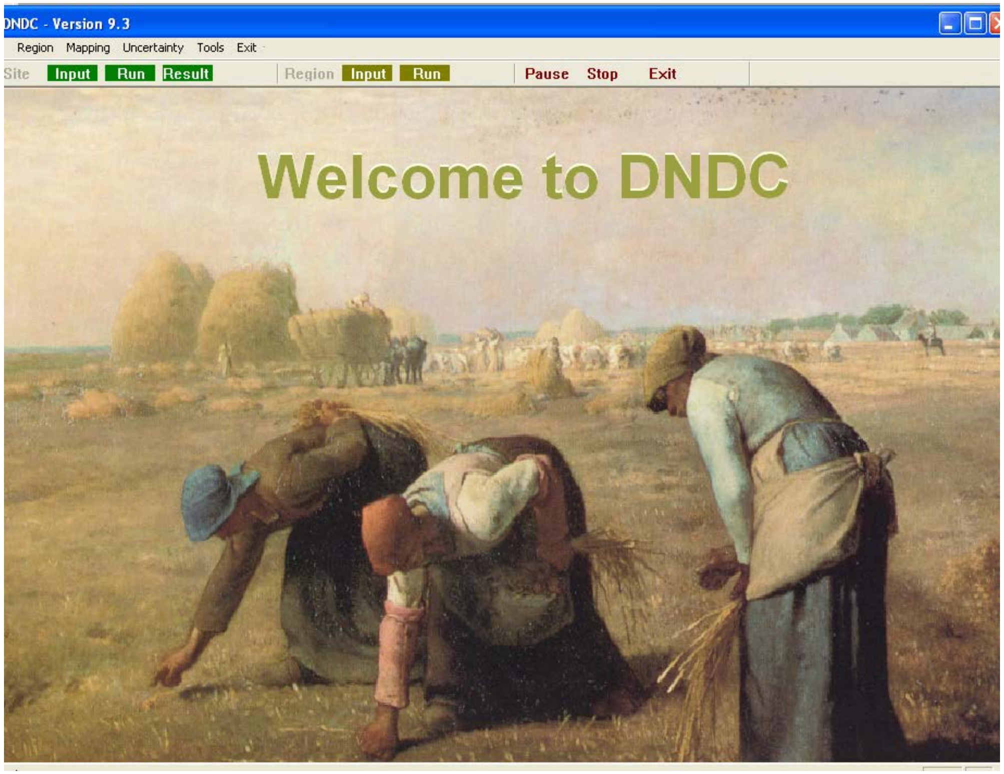
- Entire group of fields treated as aggregate
  - Random and/or risk-based sampling of fields for verification
  - Crediting to aggregate; aggregator holds account on registry and distributes revenues among growers
- Aggregation at program level for purposes of structural uncertainty deduction
  - More fields over time → lower uncertainty deduction for all participating fields
  - Program-level uncertainty deduction published separately from methodology
- Fields joining/leaving Project
  - Add and remove fields during Crediting Period
  - Credits only issued if 5 fields or 1,000 acres are in Project at time of verification; may postpone issuance and add fields

Quantification of Rice GHG Emissions using DNDC

Bill Salas, Applied Geosolutions

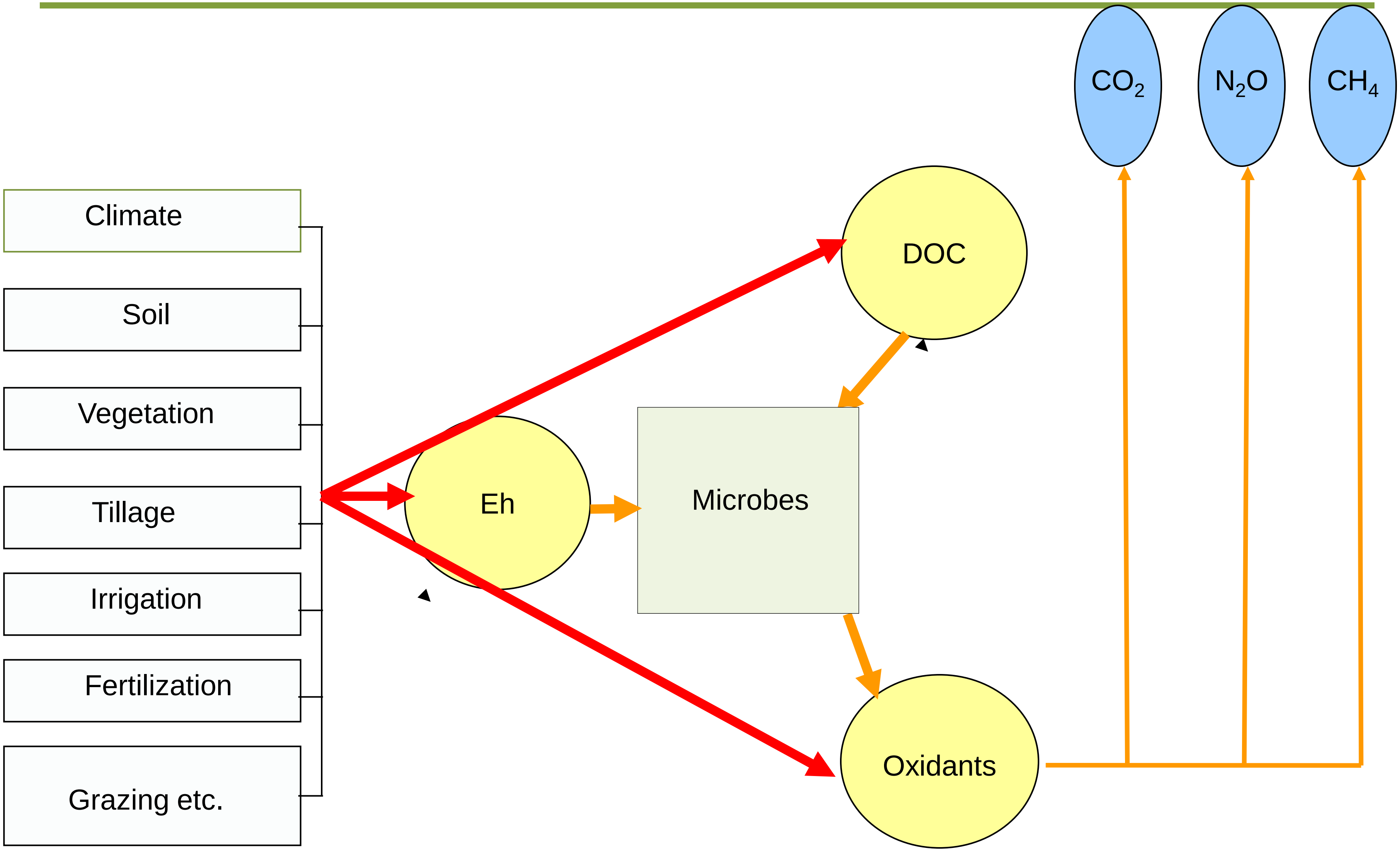
DNDC Biogeochemical Model

- DNDC
  - First model, development started in 1990
  - Initial focus on N2O
  - Focus on crop lands (>20 types of crops)
  - Models CO2, CH4, N2O, and crop growth/yields



DNDC is a process (mechanistic) model

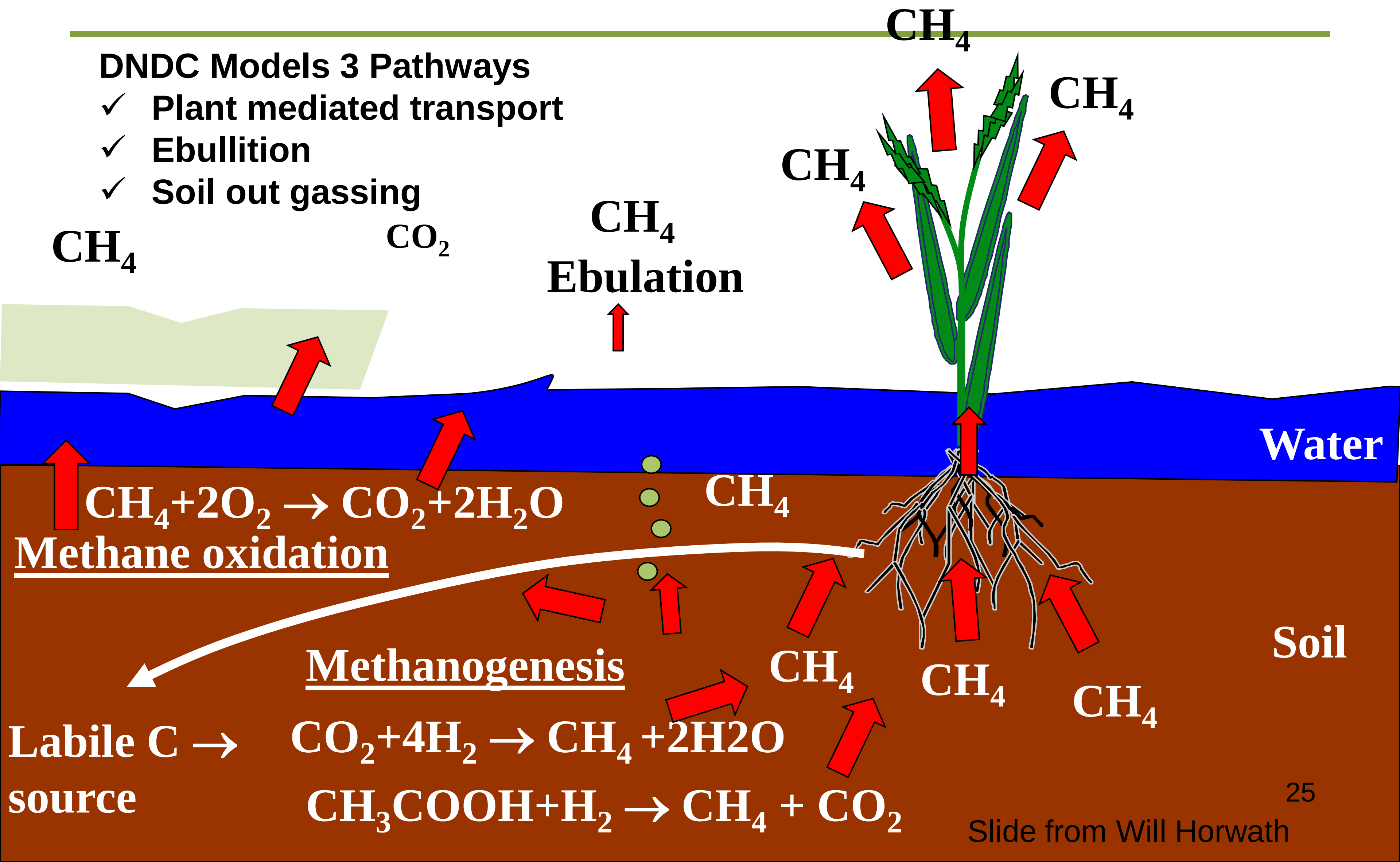
DNDC Modeling Approach



Rice: CH_4 production and emission

(REDOX < -100 to -200 mv)

DNDC Models 3 Pathways
- ✓ Plant mediated transport
- ✓ Ebullition
- ✓ Soil out gassing



Slide from Will Horwath

DNDC Model Parameterization

- Parameterization of a process-based model is the step of selecting Model input Parameters that the model will use for simulation.
- DNDC parameters include:
  - agricultural management (planting and harvest dates, tillage, fertilizer use, irrigation, flooding, etc.).
  - soil conditions and daily weather

DNDC Model Parameterization

- Soils Data

Input Parameters	Unit
Clay content	kg kg^{-1} soil
Organic carbon content	kg kg^{-1} soil
Bulk Density	g cm^{-3}
pH	-

- Daily Weather Data

Input Parameters	Unit
Jday (Julian day)	Day of year
MaxT (Maximum temperature)	˚C
MinT (minimum temperature)	˚C
Rainfall	mm day^{-1}
Radiation	MJ m^{-2} day^{-1}

Crop Calibration

- Field specific rice crop calibration
  - Proper modeling of rice growth and yields is critical for ensuring model performance
- Calibration process:

  Step 1: Select default calibration parameters for region (provided in regional modules)

  Step 2: Perform model simulations for last 5 years.

  Step 3: Compare modeled yields with measured yields. If RMSE is <10% of observed mean yields, then done. If not, go to step 4.

  Step 4: Adjust the maximum biomass parameter.

    - Adjust water and TDD parameters if needed.

Modeling Baseline and Project Emissions

- Baseline and Project emissions of CO_2, CH_4 and N_2O must be calculated using DNDC.
- For each individual Rice Field, a separate set of model simulations must be executed for the Baseline and Project scenario with the appropriate input parameter file ("*.dnd")

Modeling Period

- The duration of a DNDC model simulation must be at least 20 years before the start of the Crediting Period so that the model can attain equilibrium in certain critical variables for which empirical data is lacking.

Year -20 to -15	Year -15 to -10	Year -10 to -5	Year -5 to 0	Year 0 to 5	Year 5 to 10
Historical Period				*Crediting Period*	
Model Equilibration			Crop Yield Calibration	Period 1	Period 2

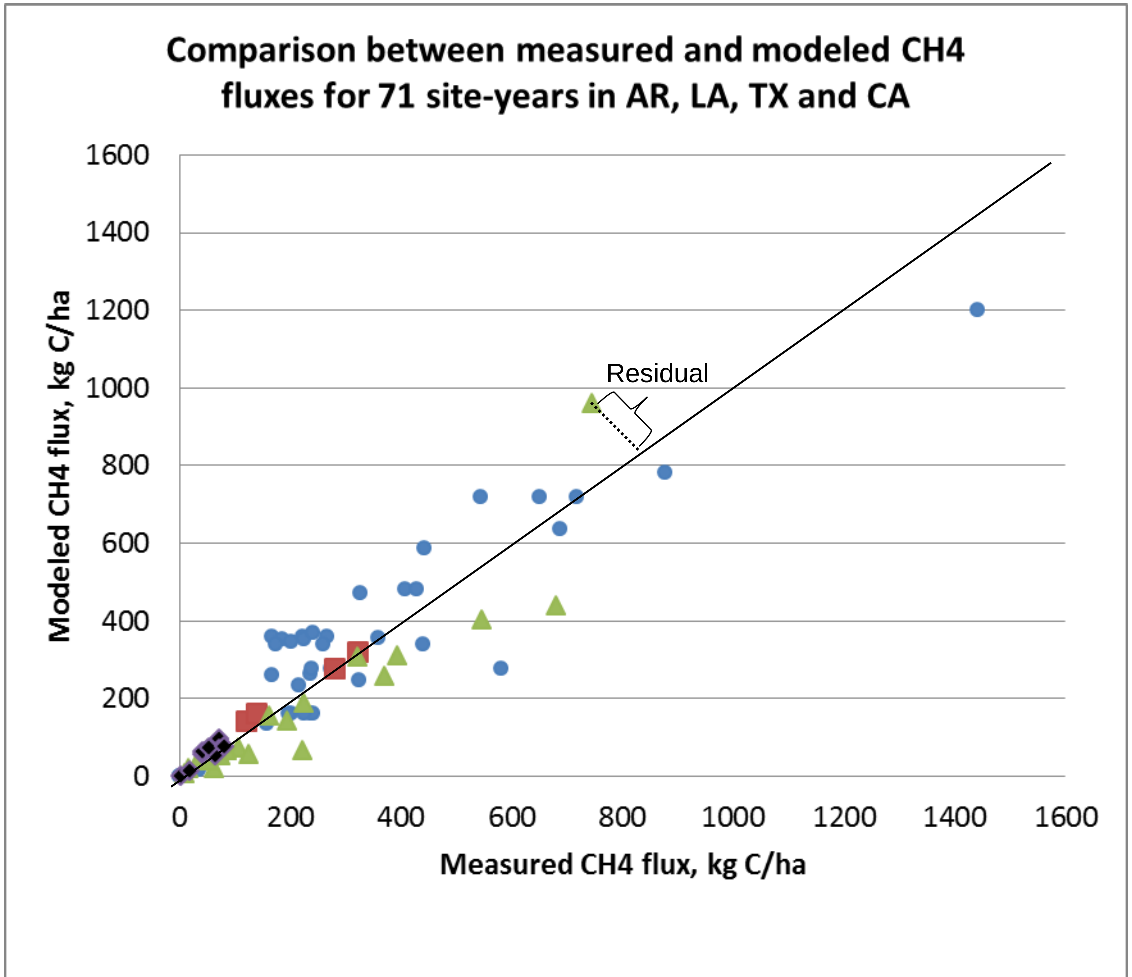
DNDC Model Uncertainty

- Two sources of uncertainty in using DNDC: model **structure** and **input** data errors
- Structural Uncertainty is related to the inherent uncertainty of model that remains even if all input data were error-free;
- Input uncertainty is related to the impact of errors in the input data on simulated results.

DNDC Model Structural Uncertainty

- Model Validation is the process of evaluating a calibrated model's results using field-measured data and quantifying the residual (structural) uncertainty.
- Model Validation requires independent measurements (measurements that were not used in calibration of internal parameters) for comparison with model estimates.

DNDC Model Validation



Calculating Structural Uncertainty

- The Structural Uncertainty is related to the inherent uncertainty of process-based models that remains even if all input data were error-free.
- A deduction factor for the Structural Uncertainty must be calculated based on the residuals between modeled results and measured gas fluxes.

Calculating Structural Uncertainty (cont.)

The Structural Uncertainty deduction should then be calculated as:

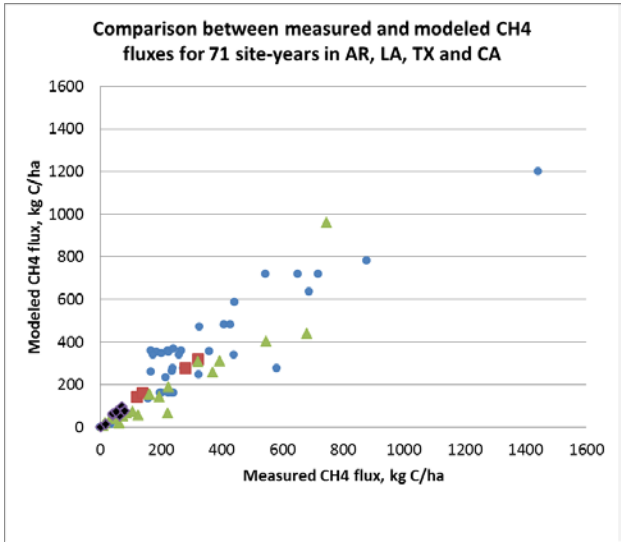
$$u_{struct} = \frac{s\sqrt{2(1-\rho)}}{\sqrt{n}} \cdot t_{inv}(0.90, k) \qquad \text{[EQ 1]}$$

Where:

s	=	Standard deviation of the residuals between modeled and measured values
$Y_{field,i}$	=	Field measurement of experiment i
$Y_{model,i}$	=	Simulated flux of experiment i
u_{struct}	=	Structural uncertainty factor
ρ	=	Correlation between Project residuals and Baseline residuals
t_{inv}	=	Inverse of the cumulative t-distribution with a specific confidence and degrees of freedom
k	=	Number of pairs of modeled and measured values used for model verification.
n	=	Size of Project Area [ha]

Structural Uncertainty Deduction

Project Area size (n) [ha]	u_{struct} [kg CO_2-eq ha^{-1} yr^{-1}]	u_{struct} [kg CO_2-eq ha^{-1} yr^{-1}]
	MRD	LGC
405 (minimum)	35.6	268.8
500	32.0	241.9
750	26.2	197.5
1000	22.7	171.1
2500	14.3	108.2
5000	10.1	76.5
10000	7.2	54.1



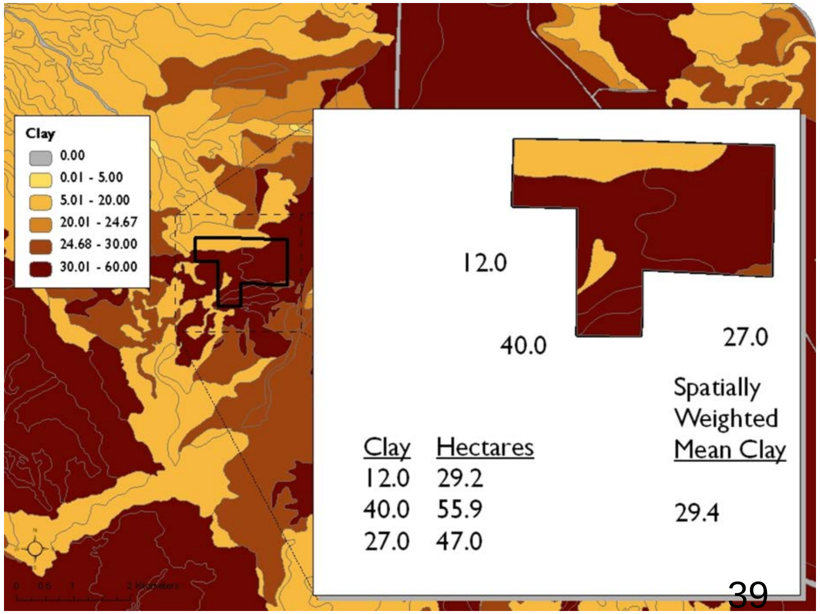
Monte Carlo simulation for capturing impacts of soil uncertainty on DNDC modeled emission reductions

Uncertainty in Soil Parameters

- Soil physical and chemical properties have a significant impact on CH_4 and N_2O production, consumption, and emissions.
- Choice of estimating soil conditions based on field samples or soil surveys
- If NRCS SSURGO soil survey data are used for setting soil parameters, then default uncertainty estimates shall be set based on uncertainty estimates and probability distribution functions (PDF) listed in Table 7.

Monte Carlo Simulations

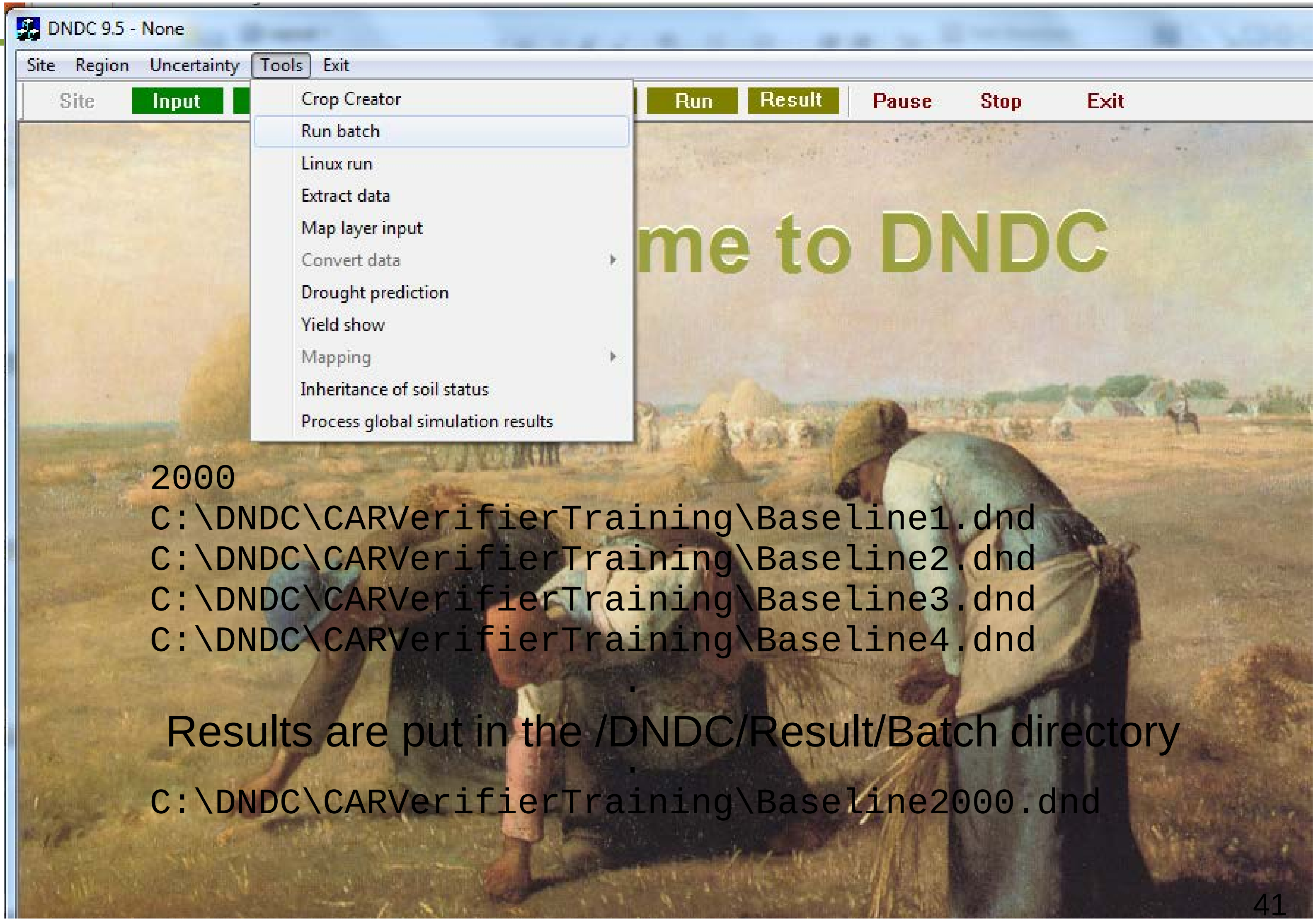
- For each field, the mean value shall be calculated as the area-weighted sum of the representative values for all compartments with the SSURGO MUKEY
    - NB: Field is defined as contiguous area with homogeneous management practices



Monte Carlo Simulations cont.

- A selection of at least 1,000 soil parameter (SOC, pH, clay, and bulk density) combinations shall be compiled for the Monte Carlo DNDC model runs
- The soil parameter combination will be a random selection for each parameter based on the Probability Density Function (PDF), parameter correlation and uncertainty estimates given in table 7 of the rice methodology.

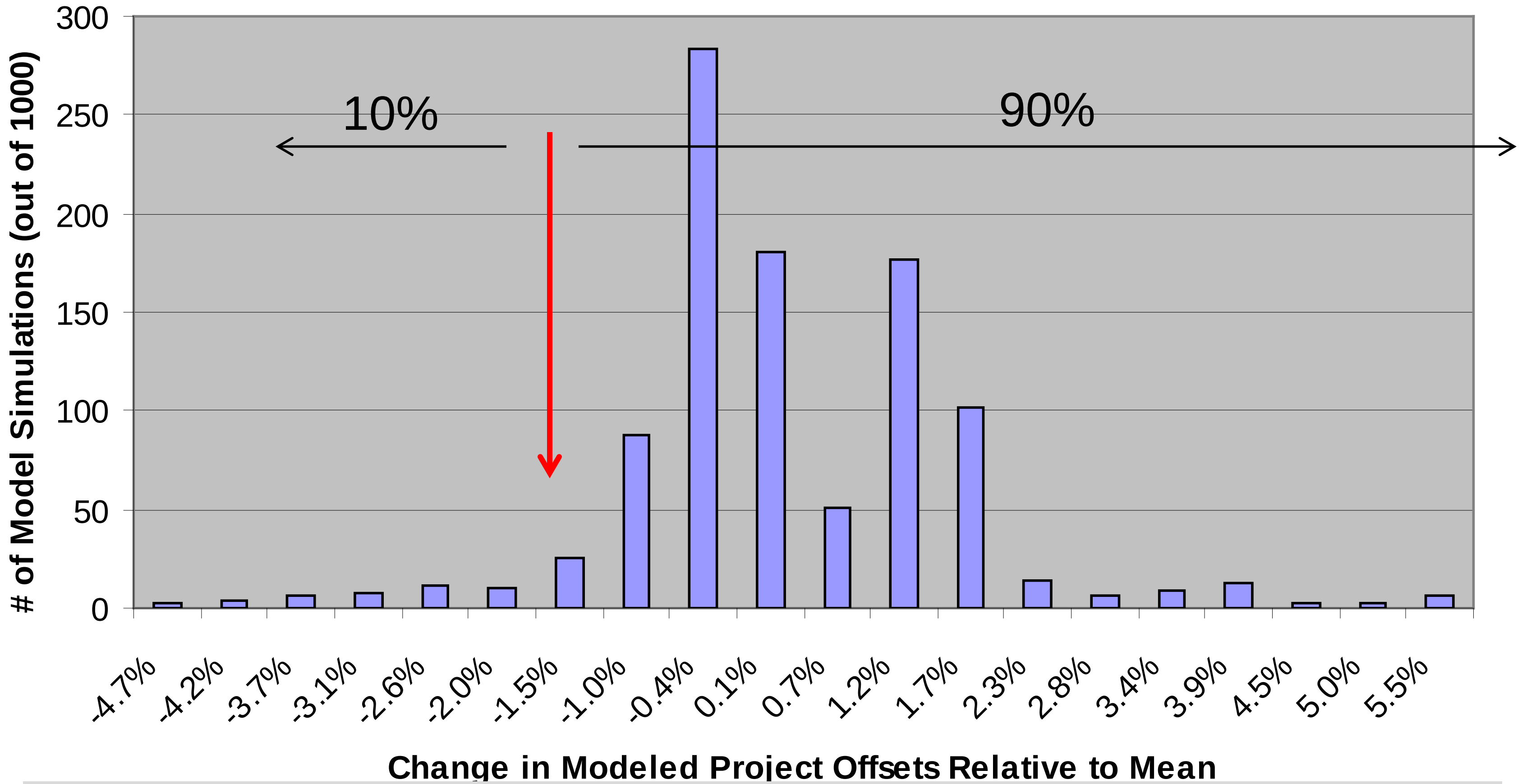
DNDC Batch Option for MC




```
2000
C:\DNDC\CARVerifierTraining\Baseline1.dnd
C:\DNDC\CARVerifierTraining\Baseline2.dnd
C:\DNDC\CARVerifierTraining\Baseline3.dnd
C:\DNDC\CARVerifierTraining\Baseline4.dnd
.
.
C:\DNDC\CARVerifierTraining\Baseline2000.dnd
```

Results are put in the /DNDC/Result/Batch directory

Histogram of Modeled Reductions



$\mu_{inputs,i}$ = Soil Input Uncertainty deduction = Calculate the uncertainty as the value corresponding to the 10% quantile for the distribution of n values expressed as a percent of the mean GHG emission reduction of field *i.*

Deducting Uncertainties

- Combine the input uncertainty deduction with structural uncertainty (kg CO2eq/ha) at field level.

$$\text{Total Uncertainty} = u_{inputs,i} + u_{struct}$$

- ACR requirements: no Uncertainty Deduction must be applied if the deduction is within 10% of the mean at 90% confidence.

Data Gathering, Monitoring and Verification of Rice Projects

Erica Meta Smith, Terra Global Capital

Data Gathering, Monitoring, Verification and Aggregation

Data Gathering for California Rice Aggregation:

- Data Requirements for Methodology:
  - Management data
  - Information on soils, precipitation, etc.
  - Many default values can be pre-loaded in the model.
- Field Monitoring and New Tools
  - Data gathered every year
  - Middle layer - interface to support data collection and monitoring.
- Verification and Field Audits
  - Specifics on what farmers need for verification and field visits.

Data Gathering

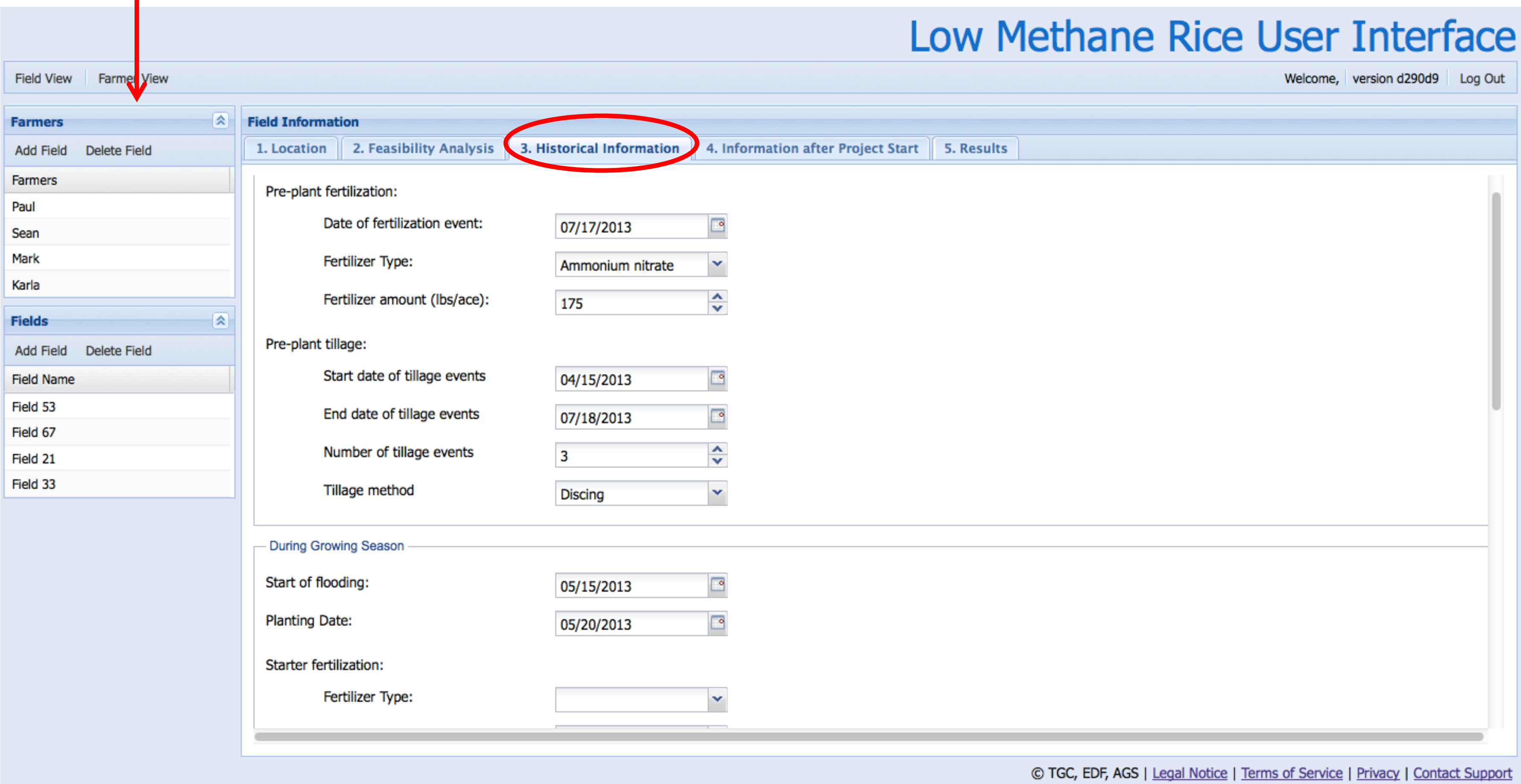
- Data Gathering Underway in California
  - Phone calls, emails, farm visits, meetings through UC Extension
  - All data is gathered on a per field basis.
- General Field Data
  - Location, soil type, (general input for model).
- Information after Project Start
  - Dates, amounts, practices, yields, management regime, flooding schedule, etc.
  - Easily known by producer or data is easily gathered
- Historical Information
  - 3 years of past management data
  - Often poor record keeping
  - Some fields are ineligible due to lack of data.

Middle Layer - Tool

User-friendly tool to streamline project development, monitoring and verification

- Client-side graphical user interface for farmers, aggregators and verifiers.
  - Simplify the process of data entry, safe data storage and easy access
  - Built in quality assurance and quality control - erroneous data flagged
  - Streamlining the verification process, data and information easily accessed by third party verifying body.
- Designed for aggregation or “collectives”
  - Multiple farmers, each may have multiple fields enrolled but one Aggregator
  - Presents data in understandable formats, shown by date or field to match farmers records.

Middle Layer - Interface



CA Aggregation

TGC acting as the Aggregator for California rice farmers

Creating a project plan that combines different fields on behalf of the farmers.

- Streamlining data exchange,
- Producing the project document,
- Managing validation and verification,
- Creating farmer agreements,
- Facilitating the marketing of credits.

Benefits: Small farms can participate, risk is distributed and minimized, uncertainty reduced and costs decreased without sacrificing rigor

Monitoring and Verification

- Monitoring current practices: (information after project start)
  - Fields may leave the project temporarily or permanently
  - Potential reduction in yields - if yields decrease it must be accounted for (market leakage).
- Audit: Locations of fields are given to the verification body only. Field visit to only 20% or 2 fields whichever is bigger.
  - Certain aspects of field audits maybe replaced by industry experts or remote sensing when appropriate
  - Timing is critical for specific parameters.

  Purpose of Verification and Audit:
  - Whether a Project Activity occurred
  - Whether critical parameters are within an expected (or verifiable) range.

Questions?

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Thank You!