Quantifying GHG emission from paddy field in China under climate change: Based on the coupling of DNDC,DSSAT and AEZ models

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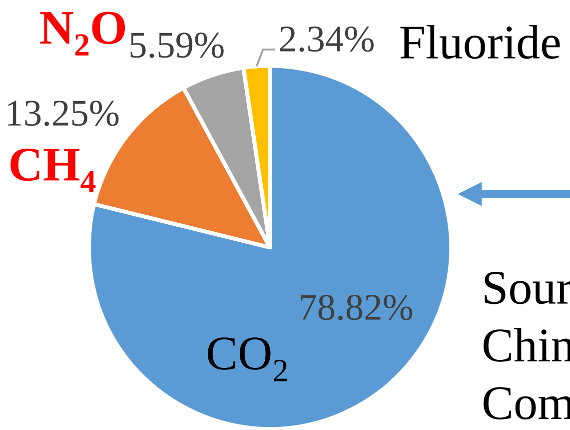
Outline

- Background & Introduction
- Methodology & Results
- Conclusions & Discussions

Background & Introduction

Climate Change



Nitrogenous Fertilizer

Source: The People's Republic of China Second National Communication on Climate change

Paddy

Agricultural GHG emission ⟷ Trade Off ⟷ Food Security

Background & Introduction

Question:

- How to mitigate GHG emission without decreasing rice yield?
- How to upgrade site-level results to the regional level?

Solution:

- Reduce the application of fertilizer to optimum/balance level.
- Coupling the biogeochemistry model and the agro-ecological model.

Background & Introduction

Denitrification and Decomposition(DNDC) model

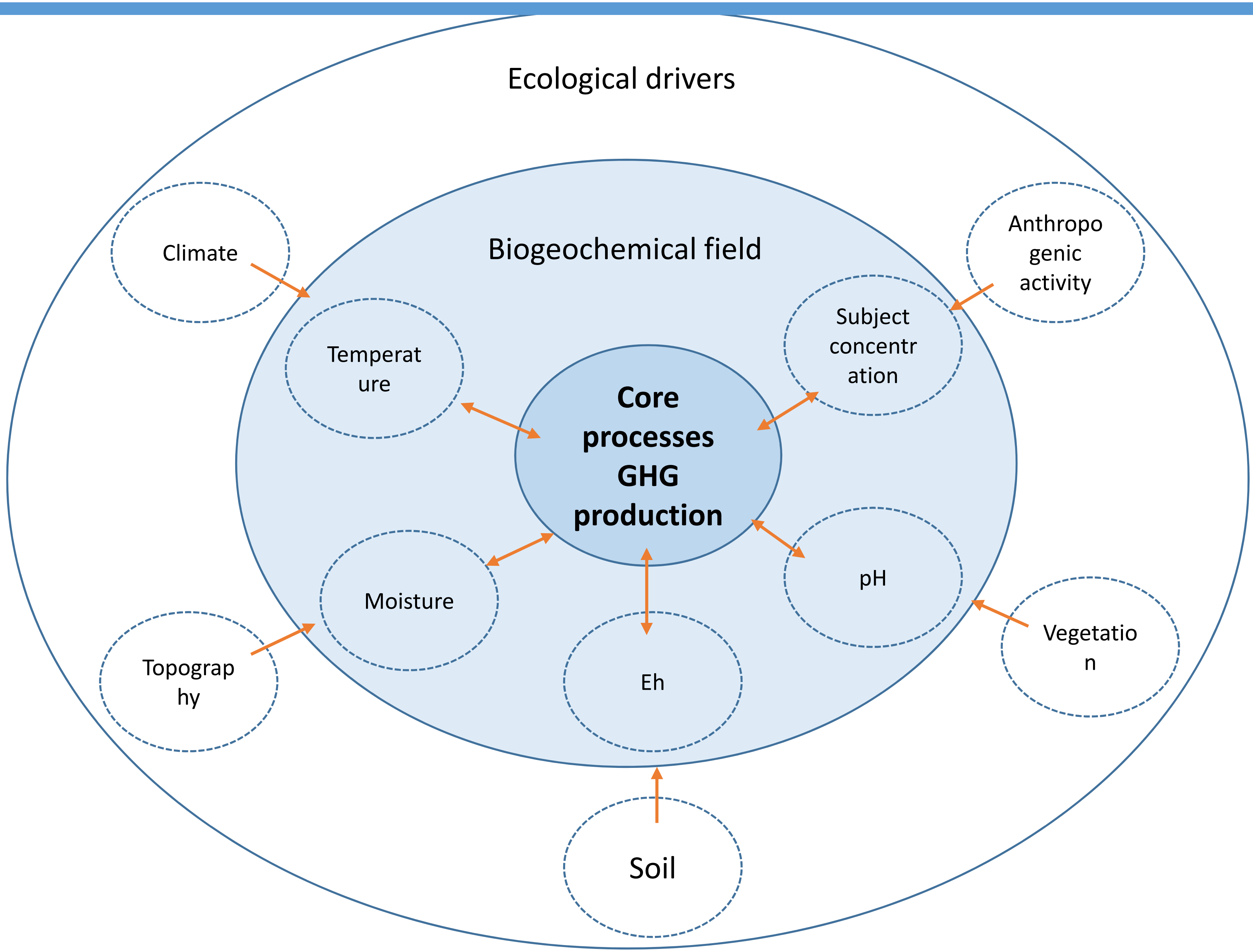
- A biogeochemistry process-based model.
- To simulate the dynamics of denitrification-decomposition process in agroecosystem at farm level.

- Communicate with DSSAT model and AEZ model

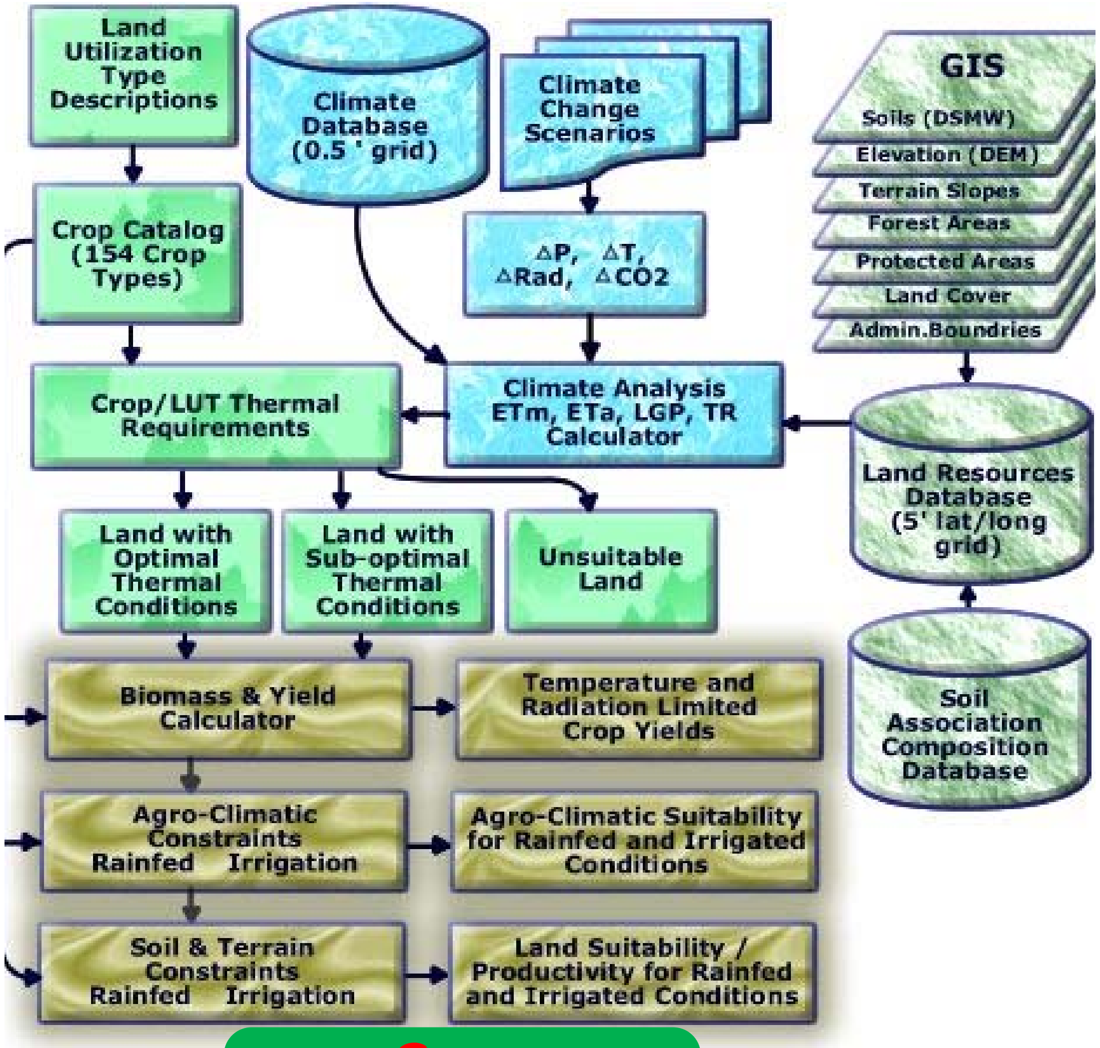
- An agro-ecological productivity model.
- To simulate the crop productivity and potential yield at regional, national and global scale.

Zhan TIAN, Honglin ZHONG, Laxiang SUN, et al, Improving Performance of Agro-ecological Zone (AEZ) Modeling by Cross-scale Model Coupling: An Application to Japonica Rice Production in Northeast China[J]. Ecological Modeling, 2014, 290: 155-164.

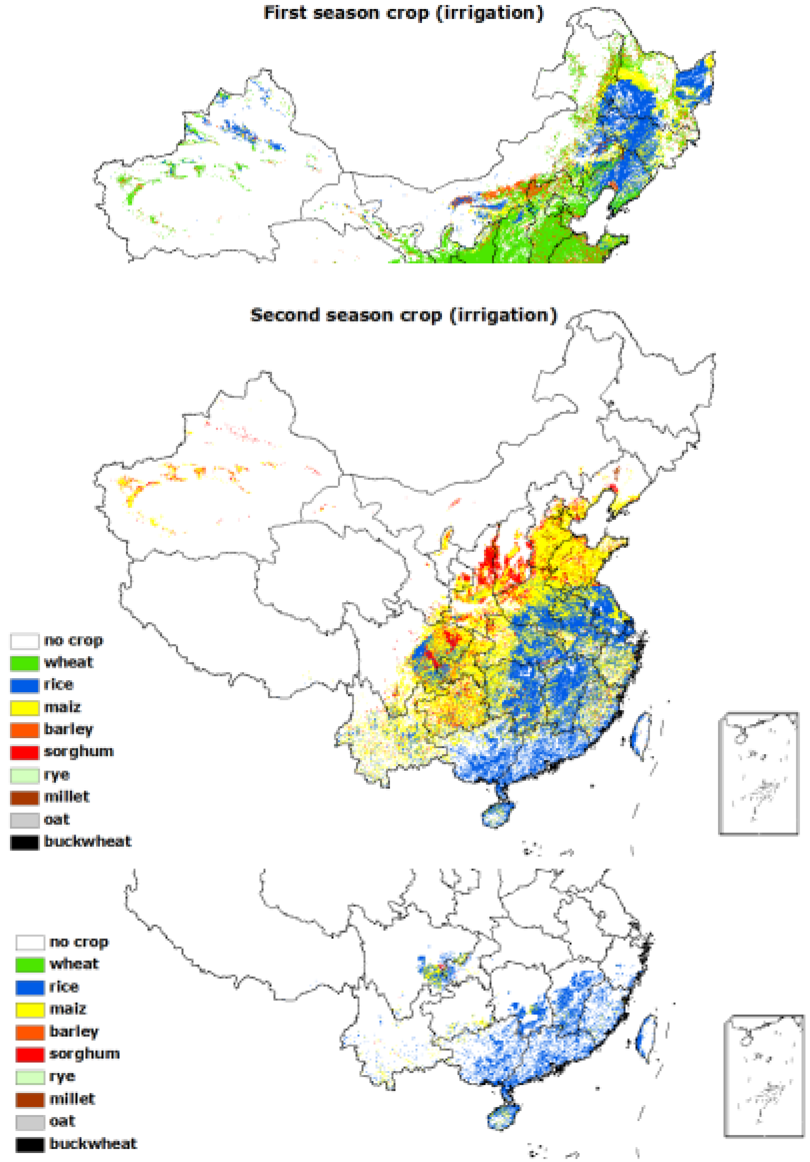
DNDC Model Philosophy



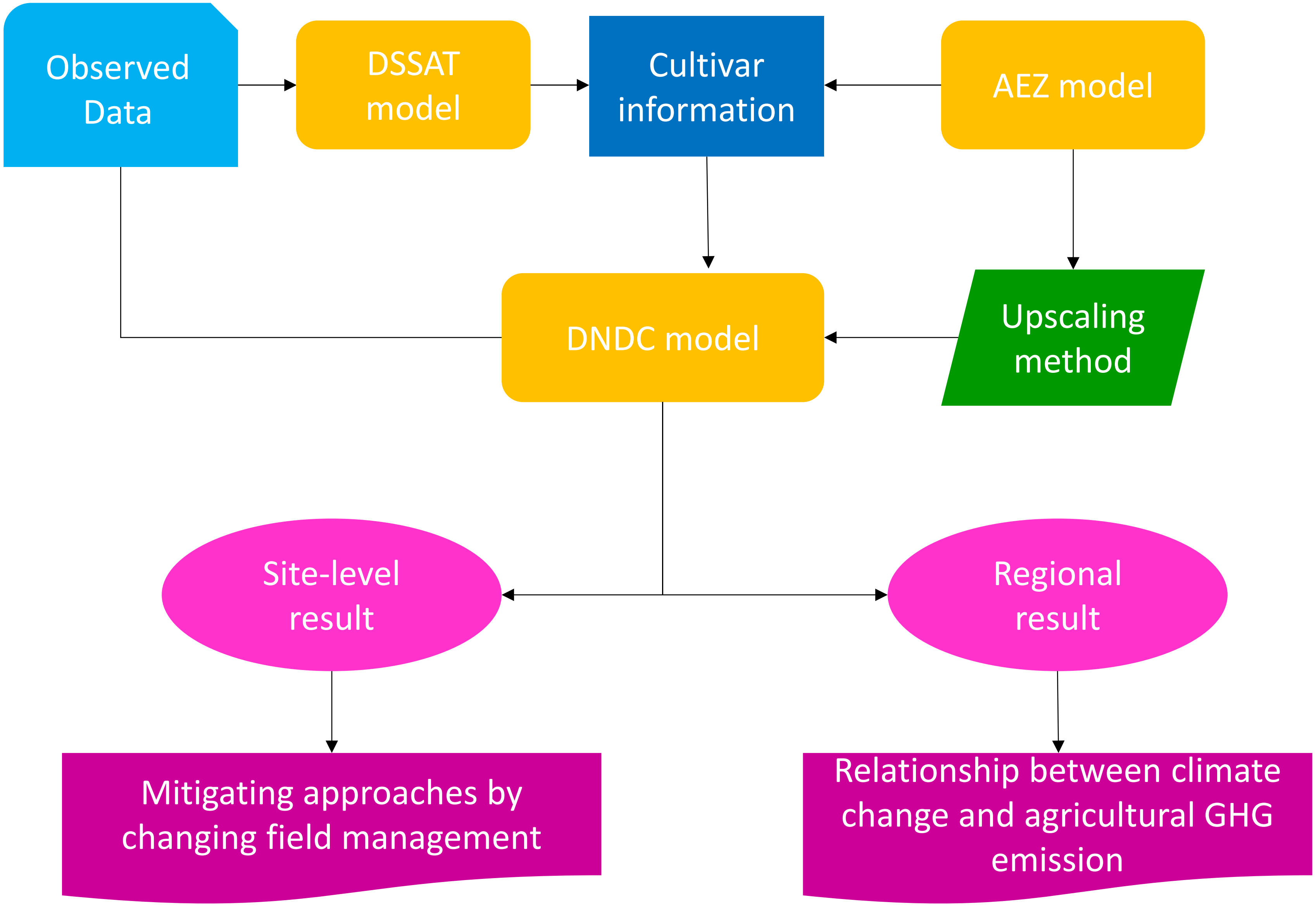
AEZ Model Structure



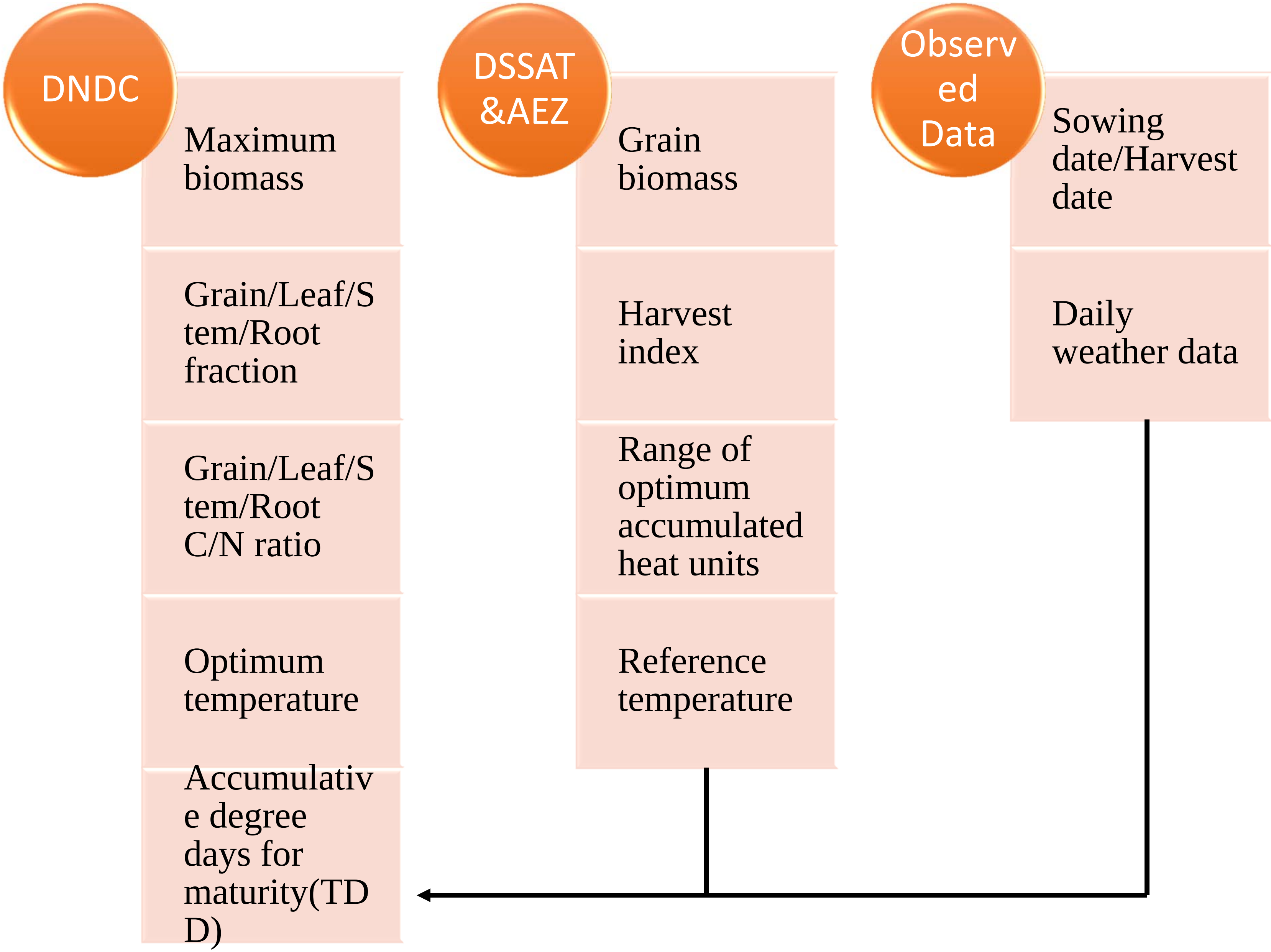
Crop Productivity



Methodology



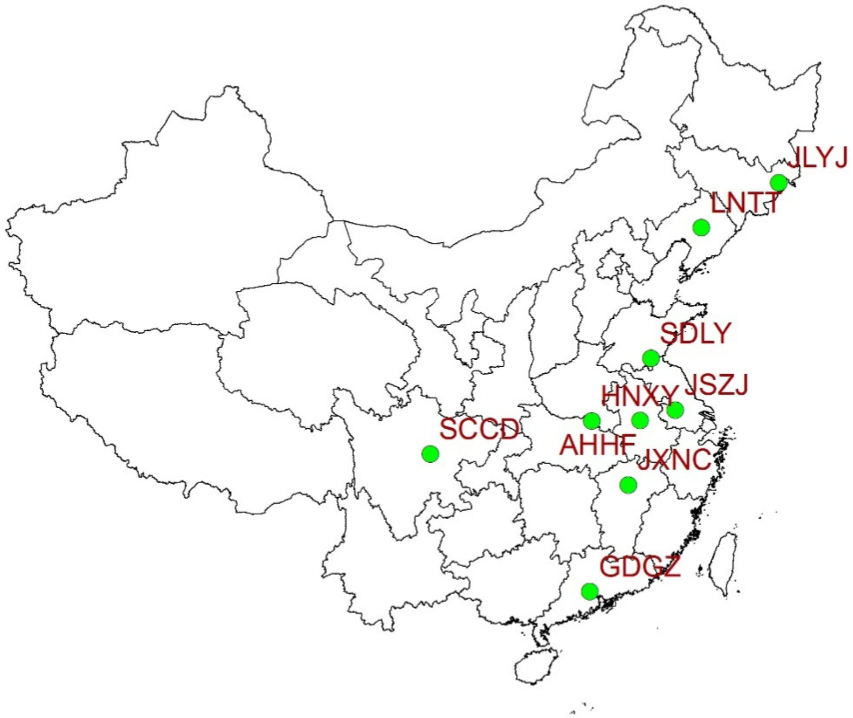
Key Cultivar Parameters



New Parameters Calculation

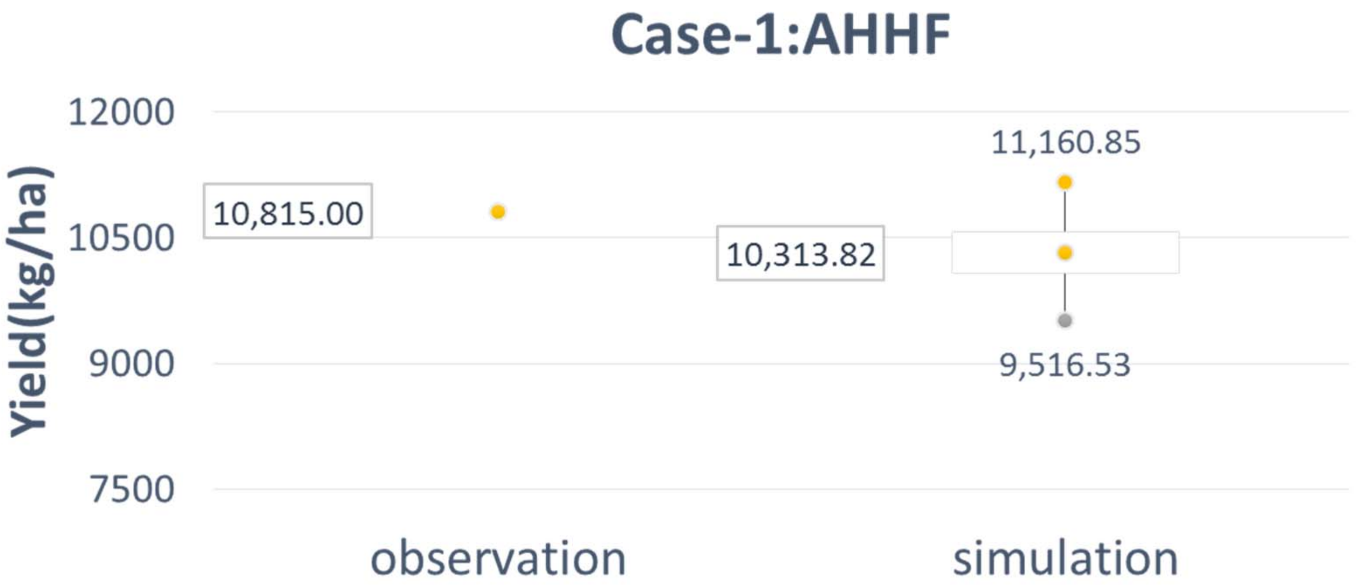
- Maximum biomass (total biomass)
  From observed data and DSSAT simulation result(with GLUE module).
- Grain/Leaf/Stem/Root fraction
  $F_g = \frac{grain\_biomass}{total\_biomass}$
  $F_r = 0.15$
  $F_l = F_s = \frac{1-Fr-F_g}{2}$
- Grain/Leaf/Stem/Root CN ratio
- Calculate with N-uptake data and biomass data from statistic data
- N demand
  $N_d = \sum \frac{F_i \times total\_biomass}{CN_i}$ i= g(grain), r(root), l(leaf), s(stem)
- Optimum temperature
  From reference temperature in AEZ.
- Accumulative degree days for maturity(TDD)
  TDD= Median(T_i) i=1981,1982,…,2010
  $T_i = \sum_{j=sowing\ date}^{harvest\ date} \frac{Tj_{max}+Tjmin}{2}$

Cultivar Parameters Translation



Crop_name	grain-bio	Harvest	total biom	grain_fr	leaf_f	stem_	root_	totalC	N demand	Optimu	TDD	(
Rice-AHHF	11436.33	0.5273	25516.4052	0.4482	0.201	0.201	0.15	52.658	209.588	27	3859	
Rice-HNXY	11597.39	0.5179	26344.902	0.44021	0.205	0.205	0.15	52.913	215.382	25	3776	
Rice-JLYJ	10761.25	0.5311	23840.098	0.45139	0.199	0.199	0.15	52.555	196.186	22	2965	
Rice-JSZJ	11539.5	0.5078	26737.1765	0.43159	0.209	0.209	0.15	53.189	217.479	25	3884.3	
Rice-JXNC	9055.583	0.6058	17585.4902	0.51495	0.168	0.168	0.15	50.522	150.094	30	2594.95	
Rice-SCCD	9883.211	0.5644	20602.291	0.47971	0.185	0.185	0.15	51.649	172.349	25	3873.8	
Rice-SDLY	12396.41	0.4958	29415.9862	0.42142	0.214	0.214	0.15	53.515	237.829	25	3808.6	
Rice-LNTT	12908.6	0.5521	27504.5882	0.46933	0.19	0.19	0.15	51.982	228.716	22	3471.55	
Rice-GDGZ	7801.4	0.5486	16731.1373	0.46628	0.192	0.192	0.15	52.079	138.883	30	3351.45	

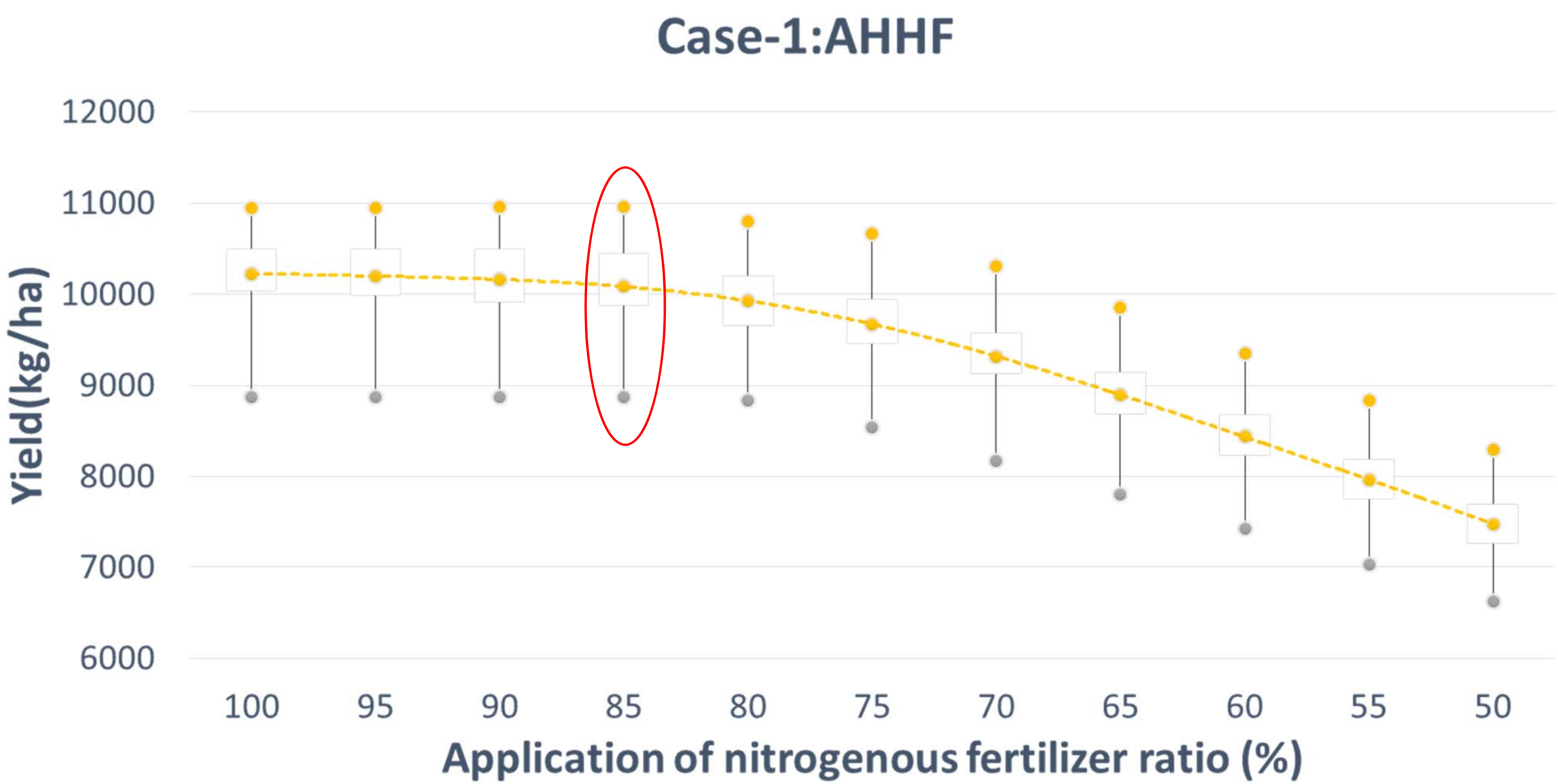
Yield Validation Results



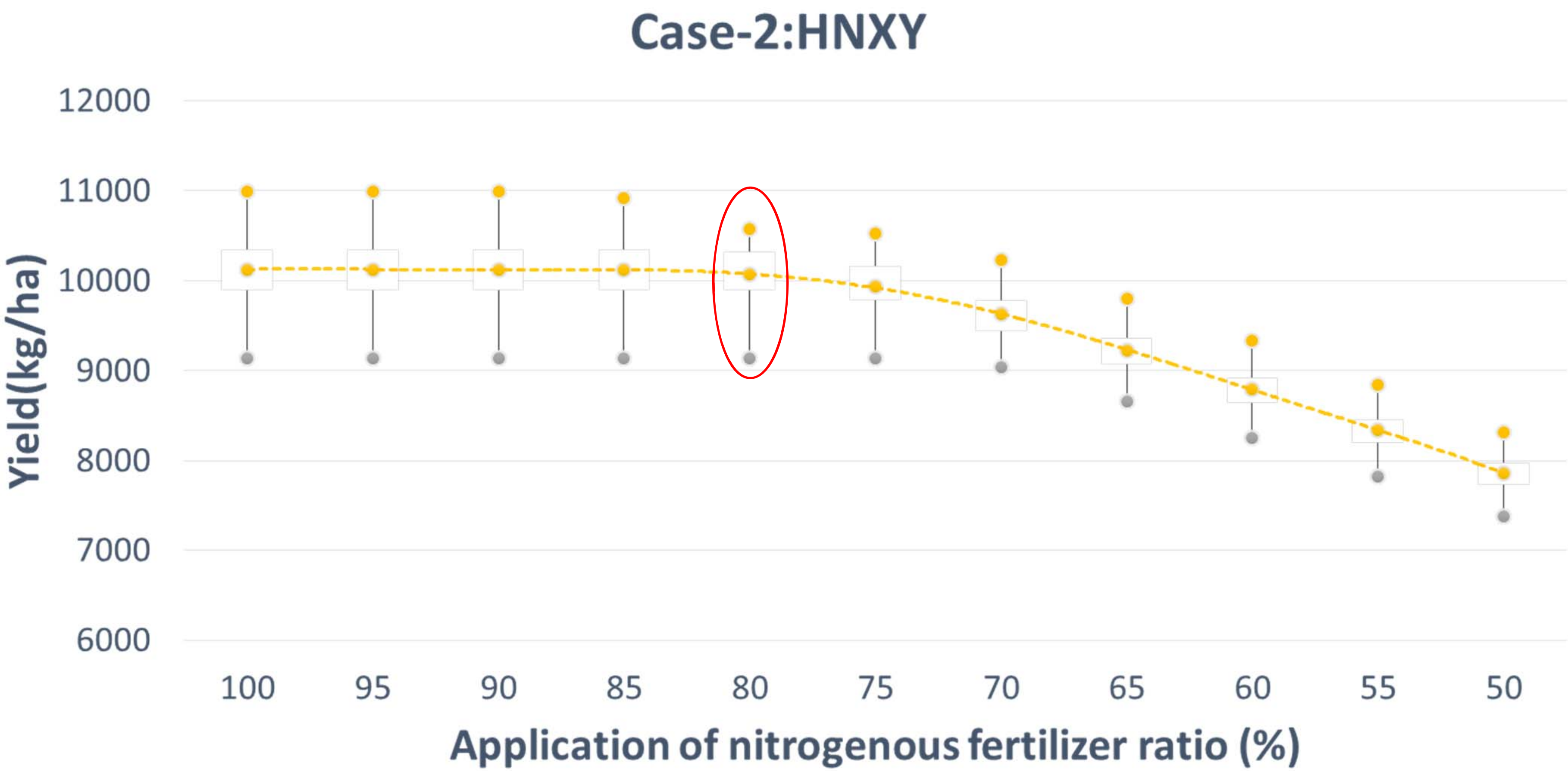
Yield Validation Results

The updated DNDC with new cultivar parameters can simulate the rice growing progress accurately in all stations.

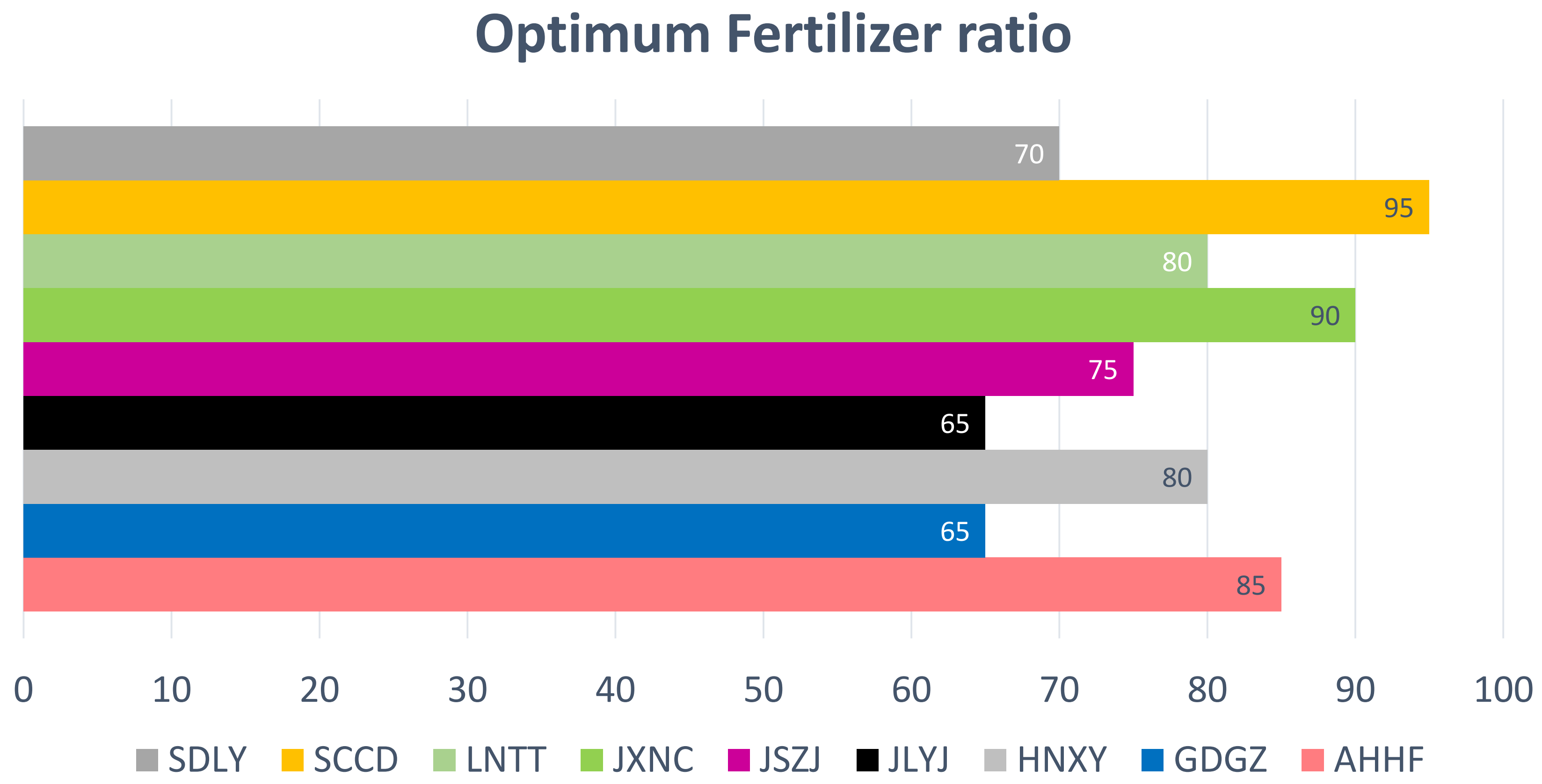
Fertilizer Scenarios Result



Fertilizer Scenarios Result



Fertilizer Scenarios Result



The recorded nitrogenous fertilizer application is higher than crop growth requirement by a scale of 5% - 35%.

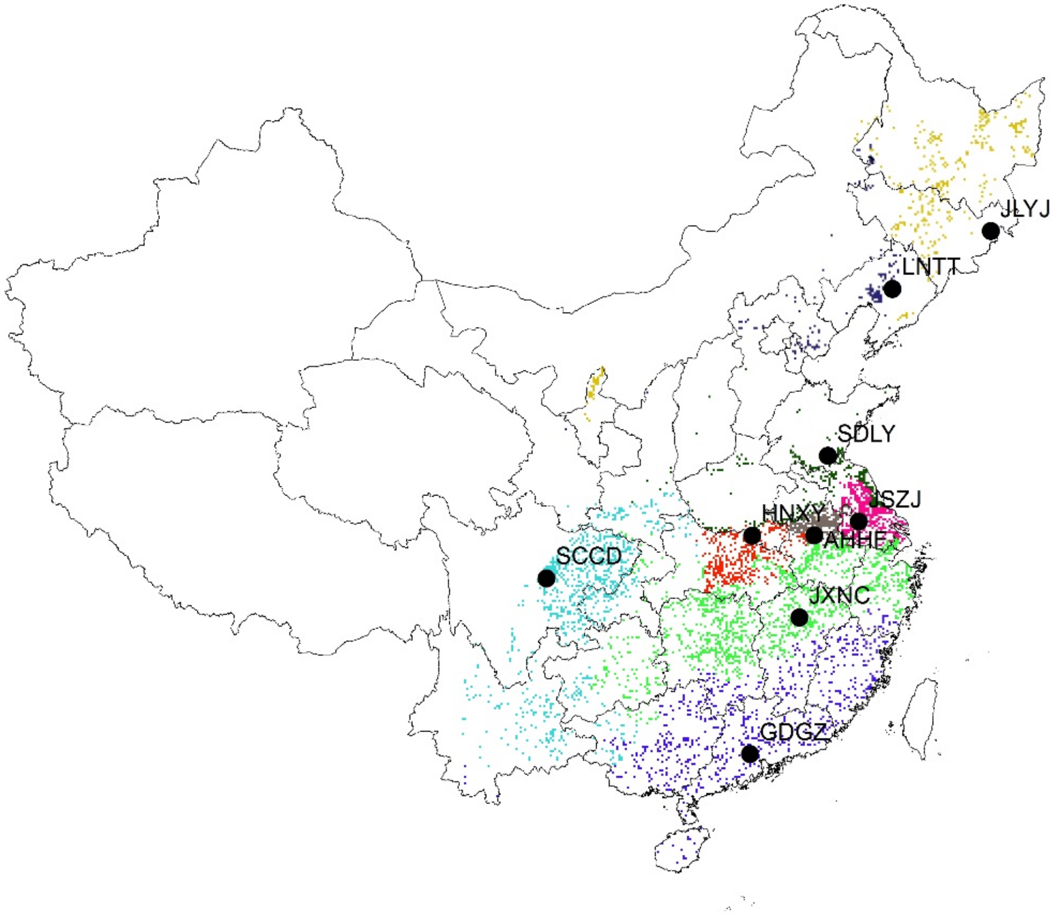
GHG Emission Result

	Actual fertilizer use (kgN/ha)	Balanced fertilizer application ratio	GHG changing(kg/ha/year)	
			CH_4	N_2O
AHHF	335	85%	0.402(0.11%)	-0.671(-27.96%)
GDGZ	255.3	65%	1.058(0.49%)	-0.913(-22.65%)
HNXY	330.5	80%	-2.580(-0.75%)	-0.055(-29.85%)
JLYJ	273	65%	6.072(4.25%)	-0.241(-68.65%)
JSZJ	334.5	75%	3.130(0.89%)	-0.486(-44.82%)
JXNC	203.6	90%	-0.882(-0.58%)	-0.148(-12.42%)
LNTT	252.9	80%	-0.234(-0.12%)	-2.587(-76.66%)
SCCD	186	95%	1.355(0.58%)	-0.059(-9.76%)
SDLY	250	70%	11.410(3.15%)	-0.430(-32.53%)

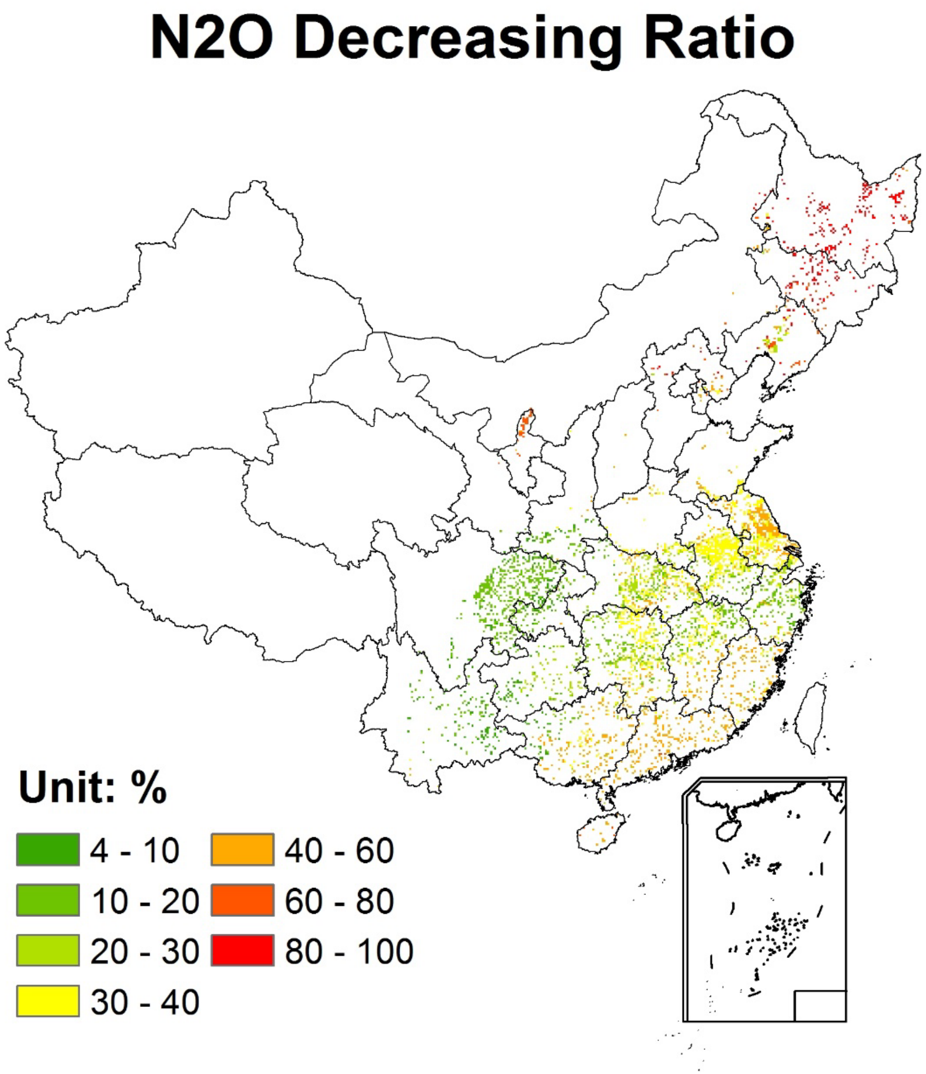
Adopting the balanced application level will mitigate the N_2O emission significantly, but lead to irregular and insignificant changes in CH_4 emission.

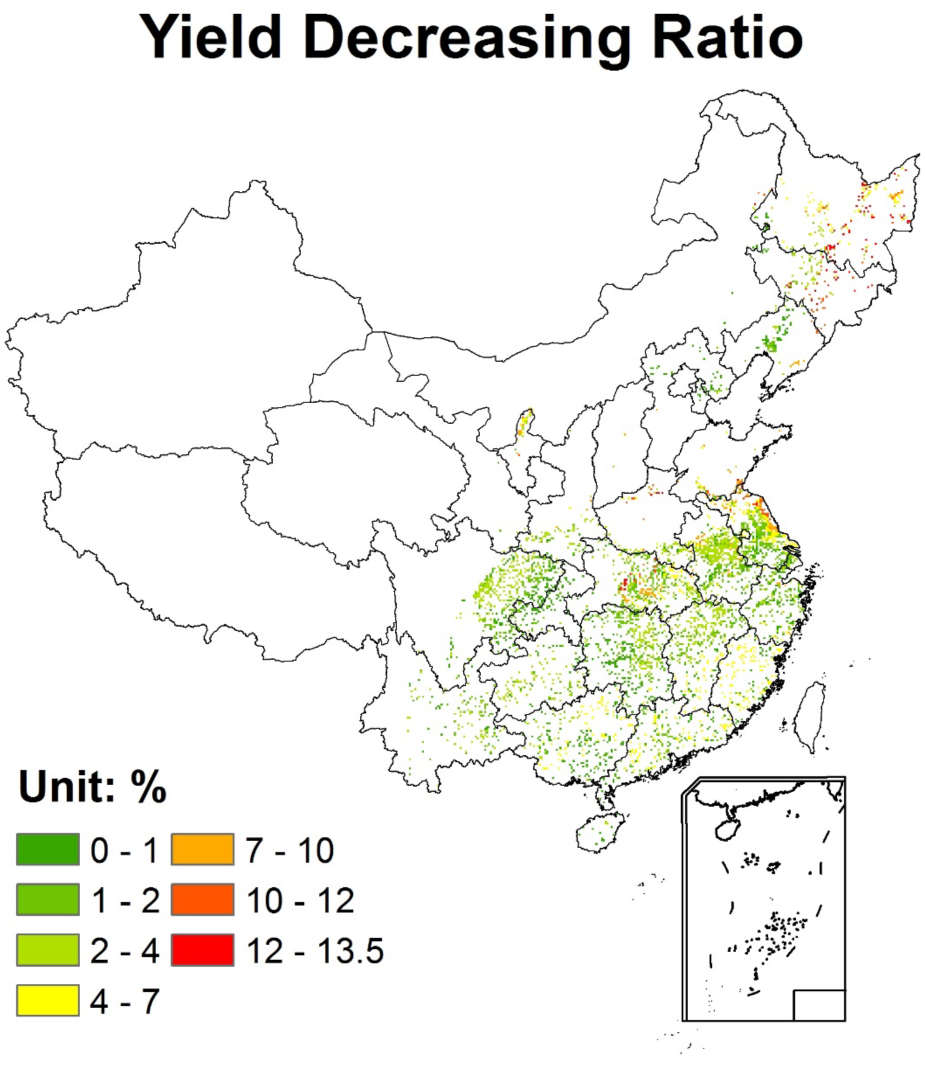
Upscaling Method

Cropping zones reclassification



Regional Preliminary Result





Conclusions & Discussions

- The application of nitrogenous fertilizers is excessive in all nine case-study stations.
- To reduce the application level of nitrogenous fertilizers to the balanced level will significantly reduce N_2O emission without negative consequence on yield.
- The approach of mitigating CH_4 emission
  - Employ effective irrigation method?
  - Increase straw back ratio?
  - No tillage farming?
  - The regional result in the future under different scenarios
  - The crop rotation in different areas

Thank you!