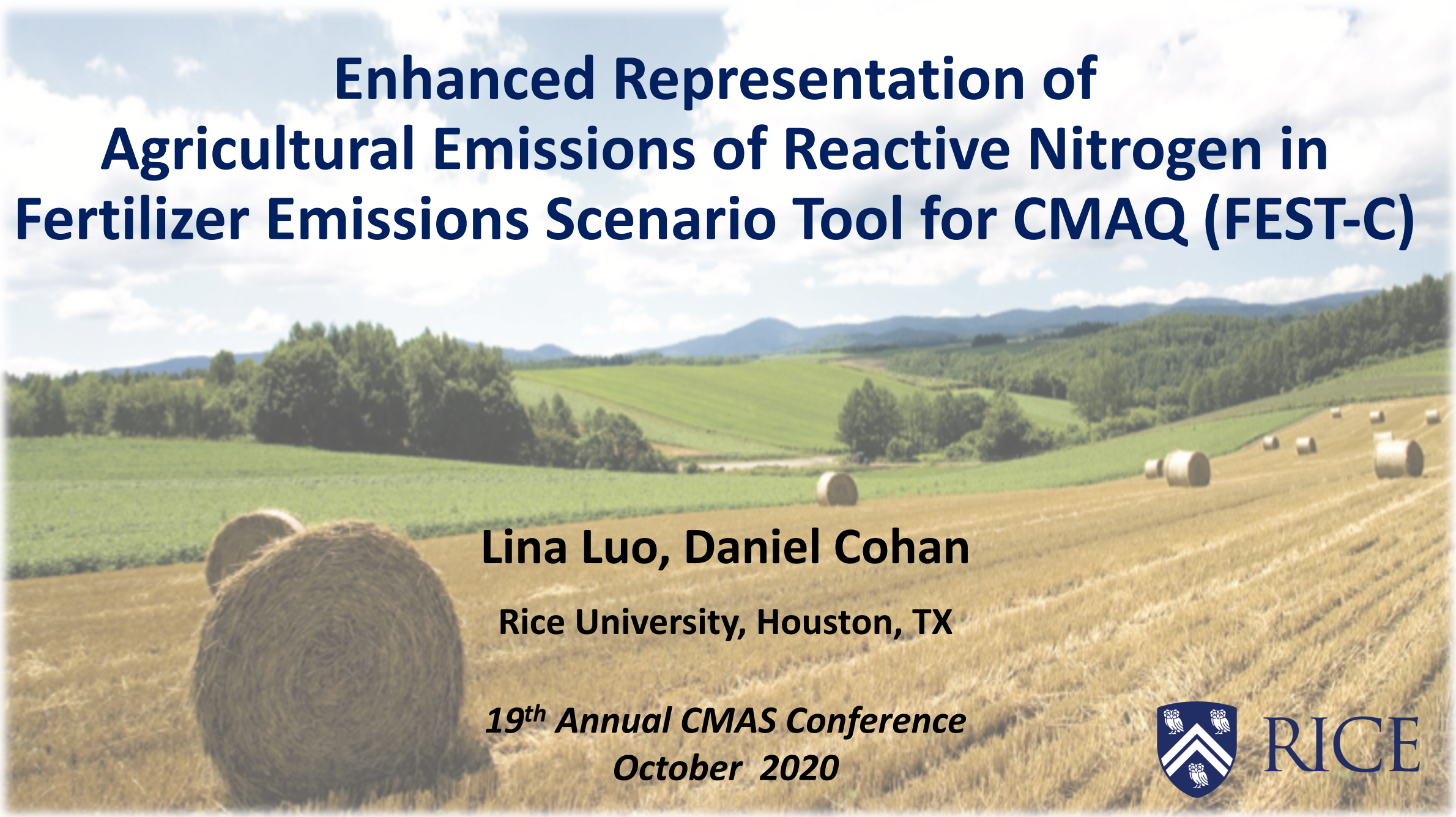
Enhanced Representation of Agricultural Emissions of Reactive Nitrogen in Fertilizer Emissions Scenario Tool for CMAQ (FEST-C)



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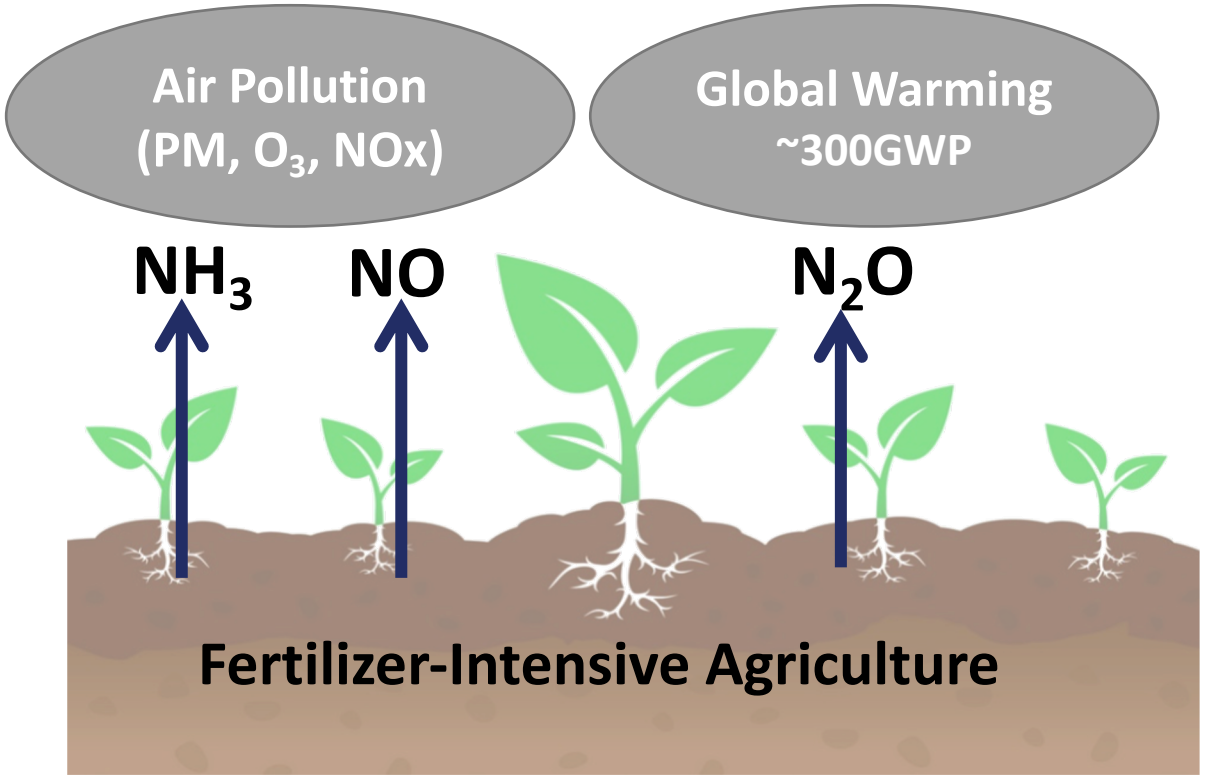
RICE

Outline

- Motivation – importance of agricultural emissions of reactive nitrogen
- State of Art – limitations of current N schemes
- Method – enhanced N scheme in FEST-C
- Performance Evaluation – FEST-C N scheme vs. other schemes
- Conclusion

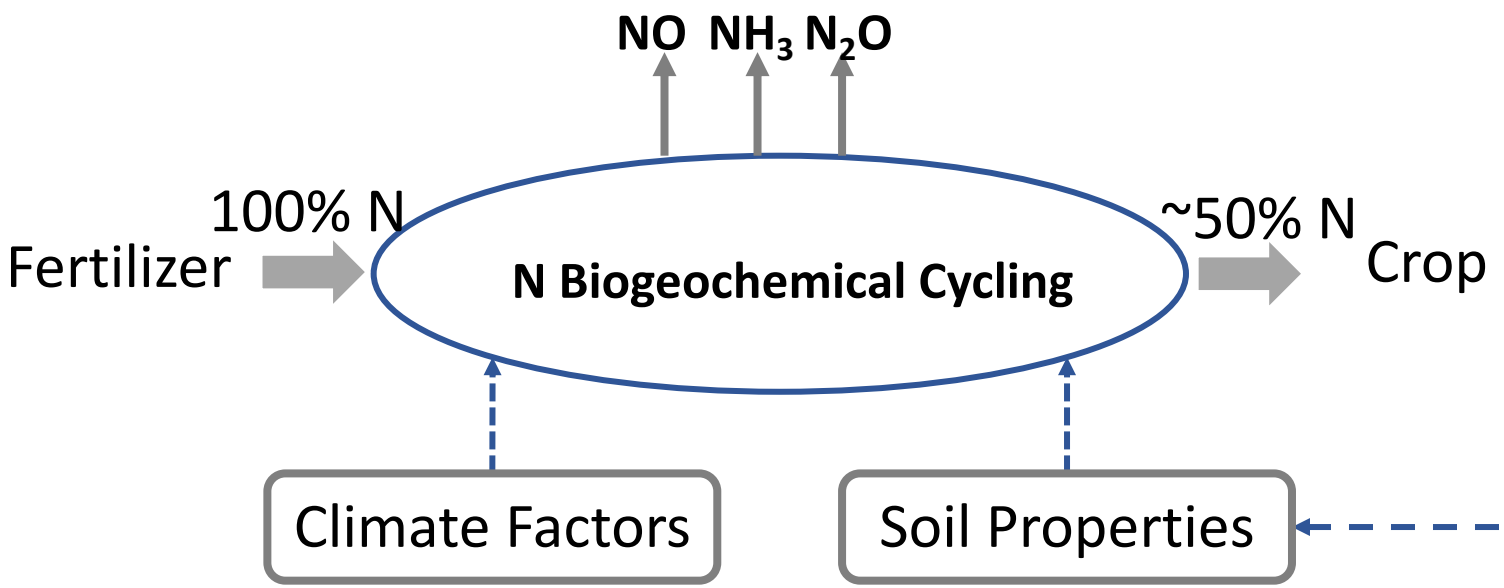
Agriculture – largest source of reactive nitrogen (Nr) emissions



- Agriculture – 84% NH_3; 73% N_2O; 20% NO in U.S.
- Half of added nitrogen in fertilizer is lost
- Release multiple forms of Nr
- Adverse environmental impacts
- Leading contributor to $PM_{2.5}$ health impacts

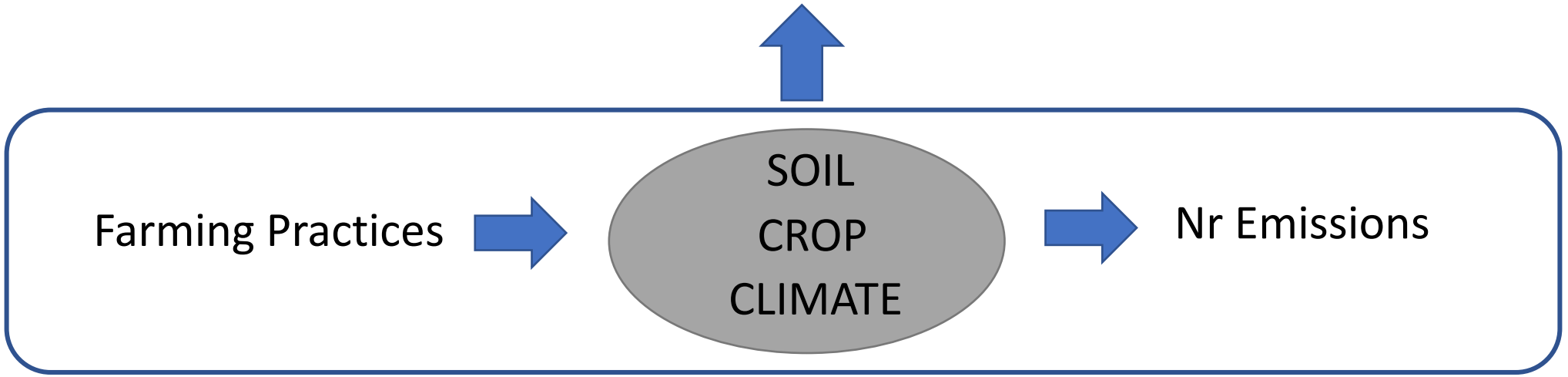
Managing nitrogen emissions from agriculture is thus essential.

Farming Practices Mitigate Nr – co-benefits or trade-offs?



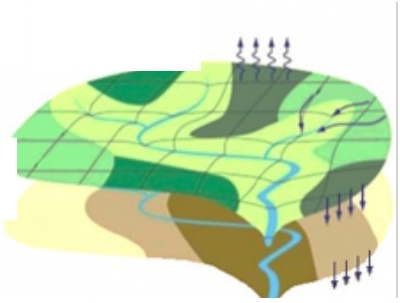
- Fertilizer management
  -Type; amount; timing; placement
- Other practices:
  -No-tillage, biochar, etc.

Farming practices impacts on emissions of Nr: co-benefits or trade-offs?



State of Art – Modeling Agricultural Emissions of Nr

Process-based Agroecosystem Modeling



homogeneous area
(up to 100ha)

Input Data

- Weather
- Soil
- Topography

Farming practices

- crop rotation
- tillage
- irrigation
- drainage
- fertilizer

…

Process-based N cycling module

volatilization $NH_4^+ \rightarrow NH_3(g)$

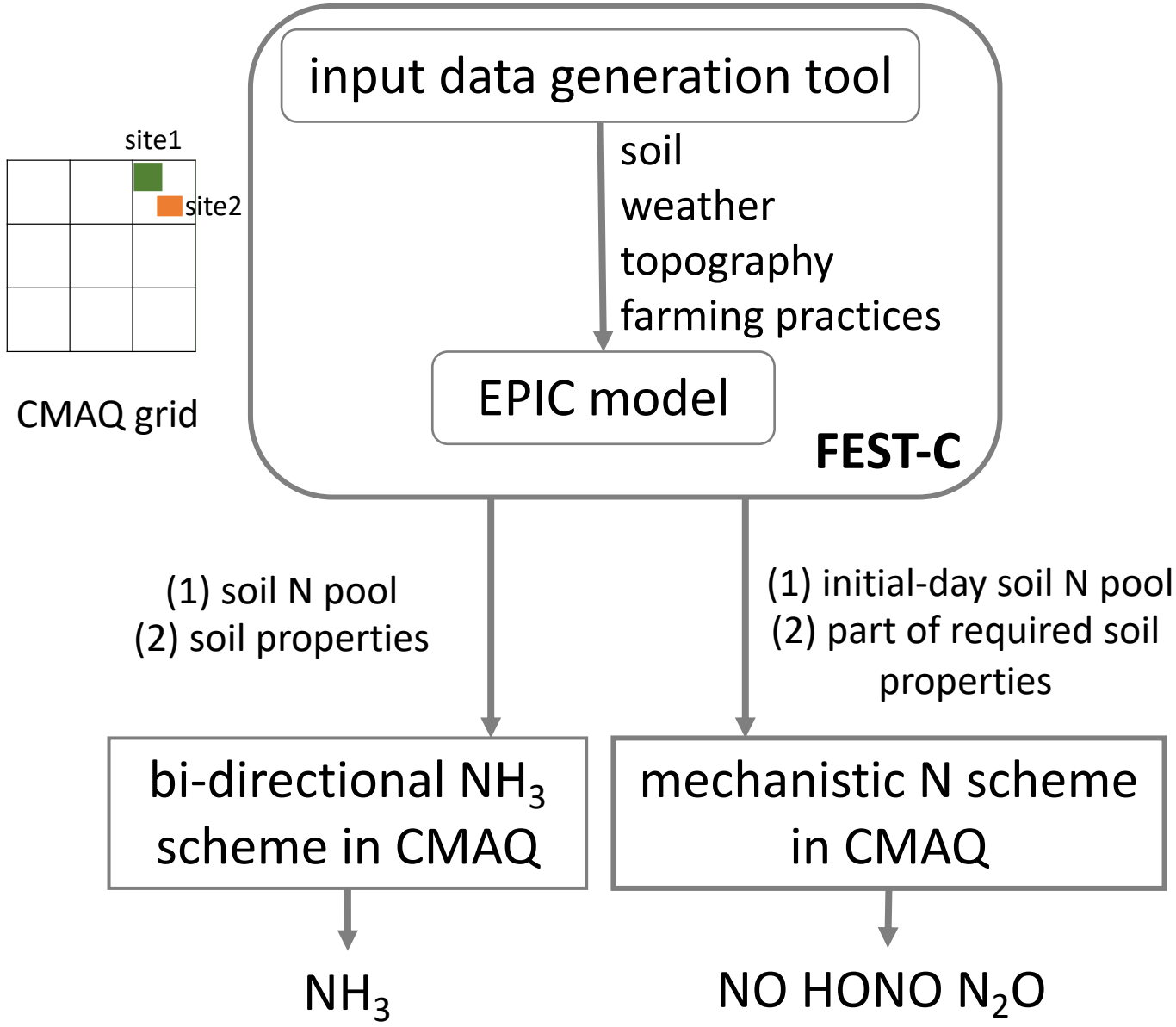
nitrification $NH_4^+ \rightarrow NO_3^-$ (NO & N_2O)

denitrification $NO_3^- \rightarrow N_2$ (NO & N_2O)

other processes

Challenge of agroecosystem modeling: high demand of input data

State of Art – Modeling Agricultural Emissions of Nr
FEST-C & soil N scheme in CMAQ



Limitations of N schemes in CMAQ:

- linking part of required soil properties >>>

  x farming practices ⇢ Nr emissions

- only use initial-day soil N pool >>>

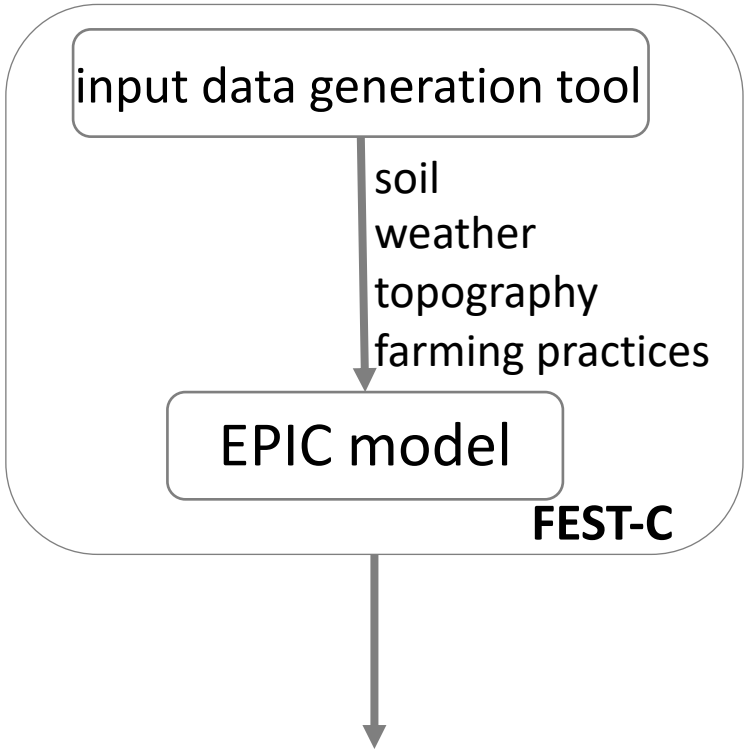
  x N pool ↑ after initial day, e.g. applying fertilizer

- separate N schemes (bidi NH_3 & mech N) >>>

  x consistently predict trade-offs

Enhanced Representation of N Scheme in FEST-C

Incorporating DayCent N scheme into EPIC

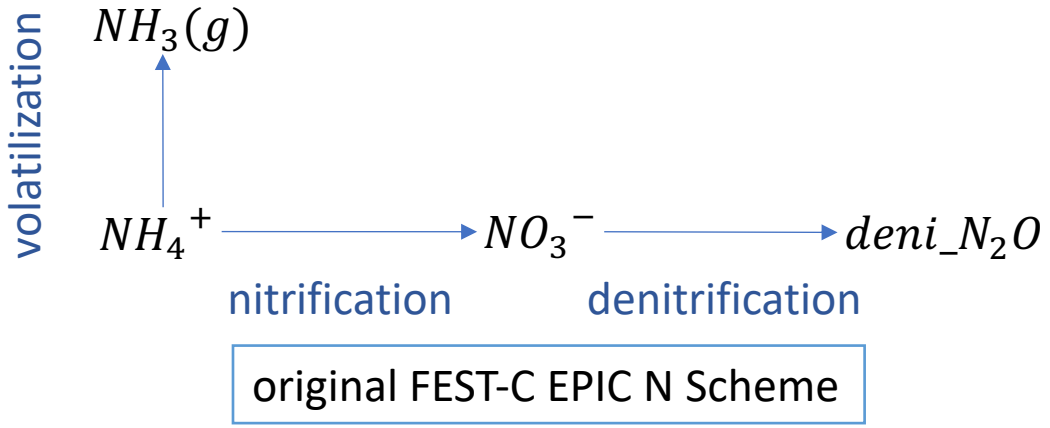


NH_3 & denitrification N_2O

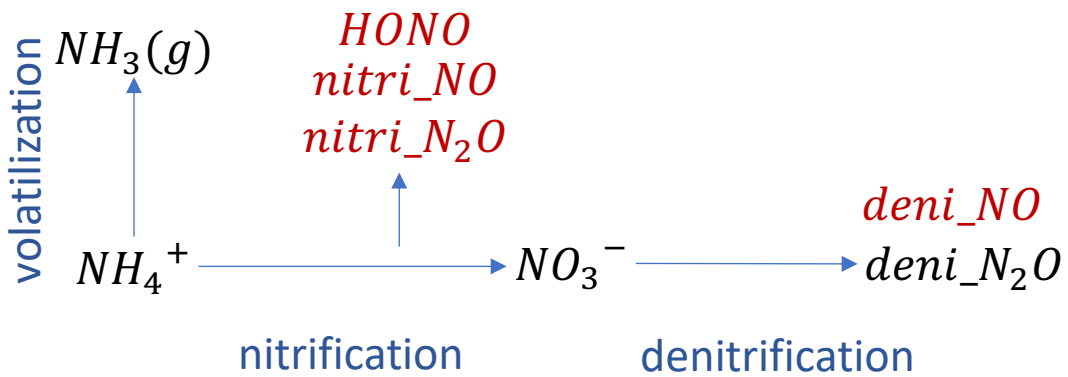
nitrification NO & N_2O & HONO ?

denitrification NO ?

enhanced N scheme in EPIC

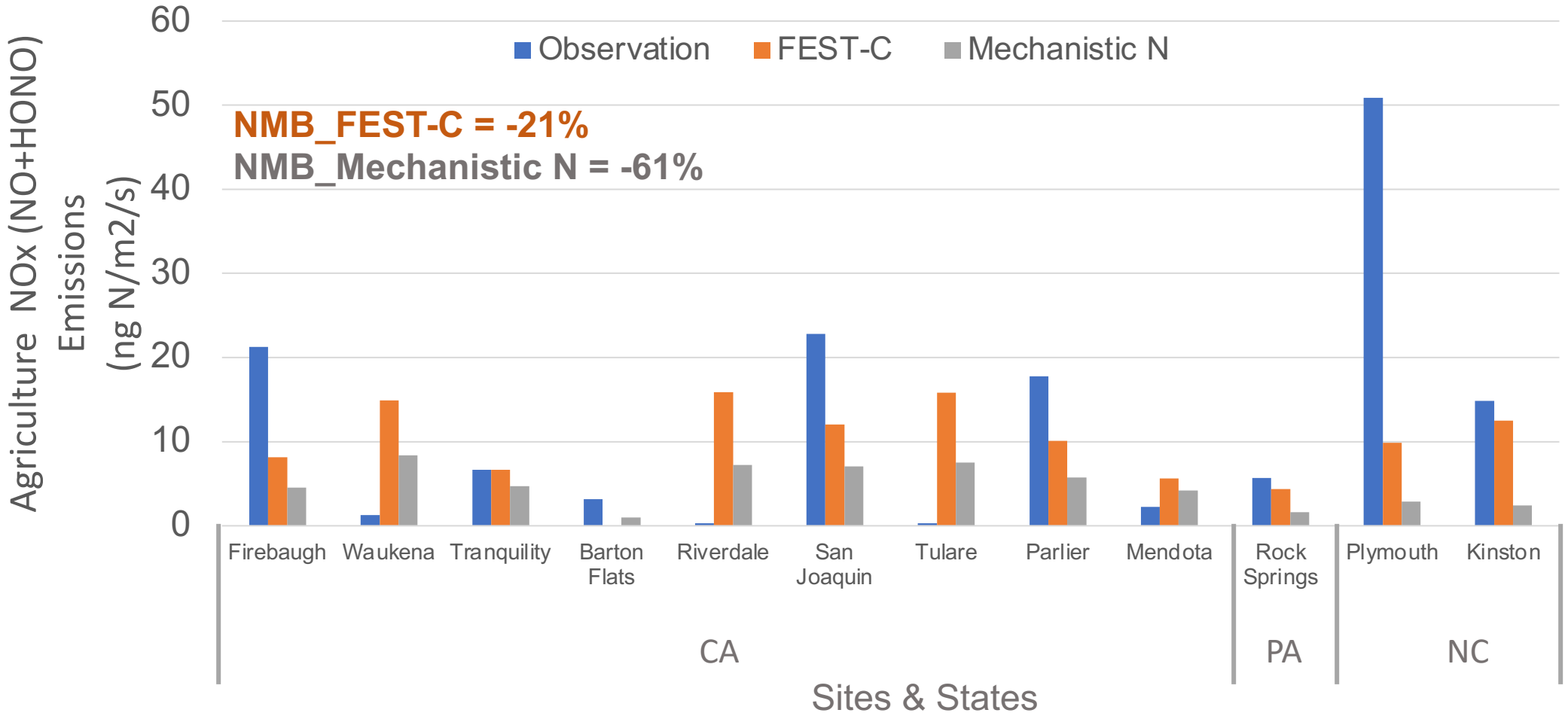


original FEST-C EPIC N Scheme



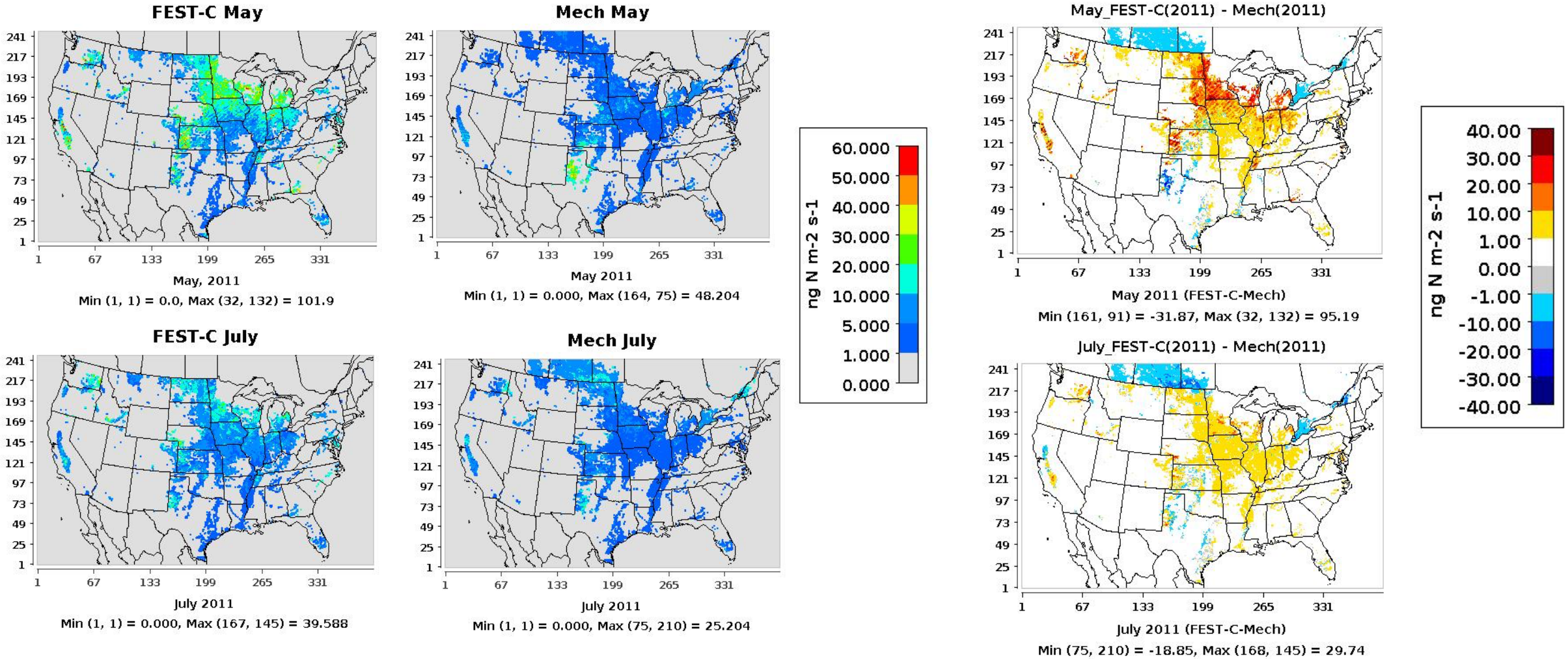
enhanced FEST-C EPIC N Scheme

Enhanced Representation of N Scheme in FEST-C – NO and HONO
Monthly Average Soil NO in Growing Season in 2011



Observation Data Source: Almaraz et al., Sci. Adv. 2018 for CA; Miller et al., GRL. 2018 for PA; Roelle et al., AE. 2000 for NC
Sampling Period: May to September
Modeling Data: per day in May and July in 2011

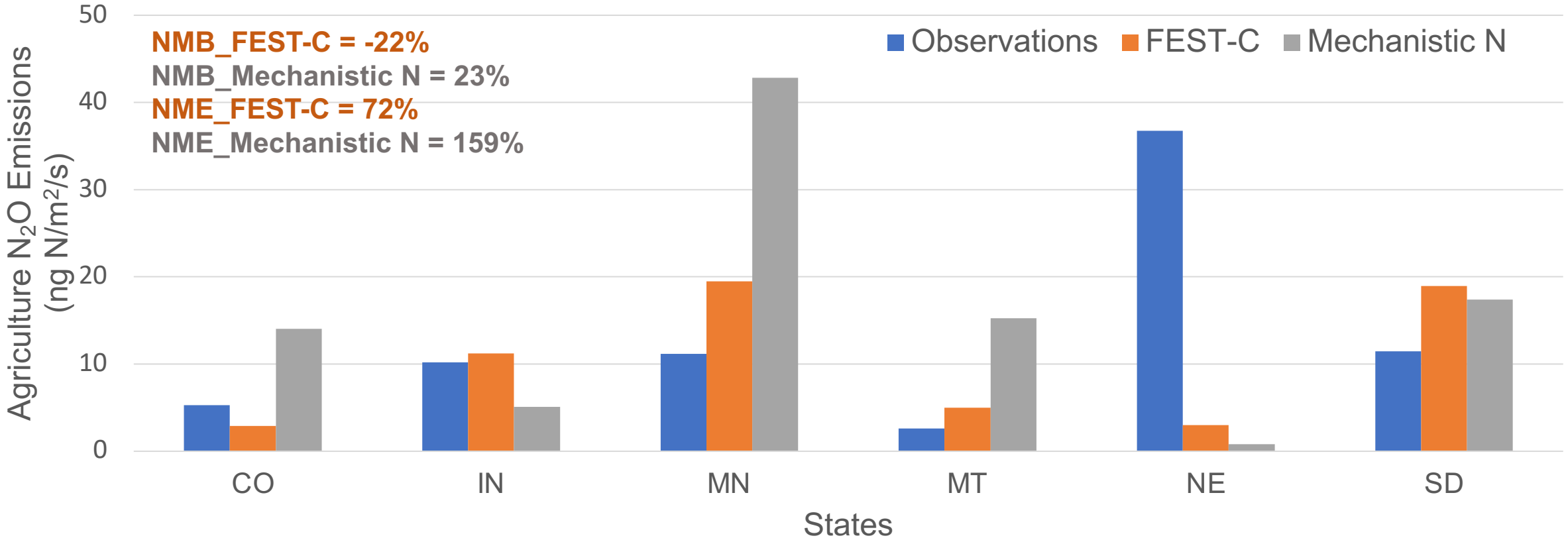
Enhanced Representation of N Scheme in FEST-C – NO and HONO
Monthly Average Soil NO in Growing Season



FEST-Cv1.4.1 N scheme with 2011 fertilizer database vs FEST-Cv1.3 Mech N scheme with 2006 fertilizer database

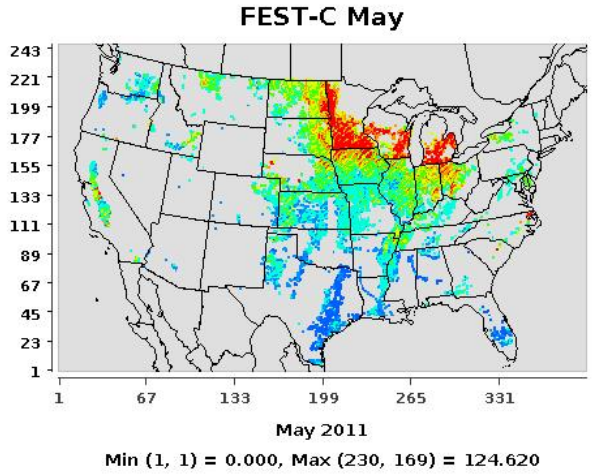
Data Source of N Schemes in CMAQ: Rasool et al., GMD. 2019

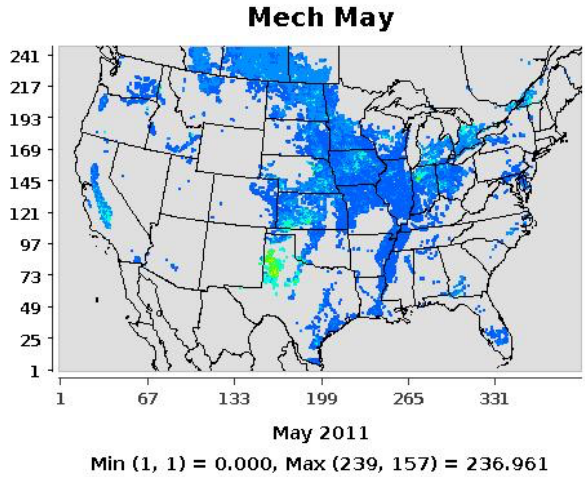
Enhanced Representation of N Scheme in FEST-C – N_2O
Monthly Average Soil N_2O in Growing Season

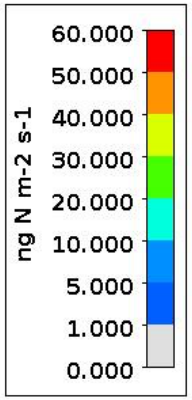


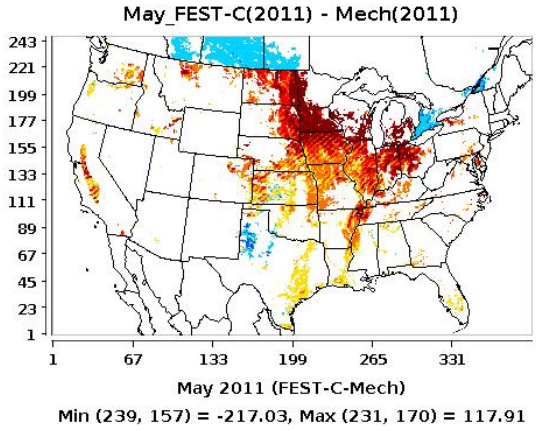
Observation Data Source: USDA Agricultural Collaborative Research Outcomes Systems;
Sampling Period: per day in May and July in 2011
Modeling Data: per day in May and July in 2011

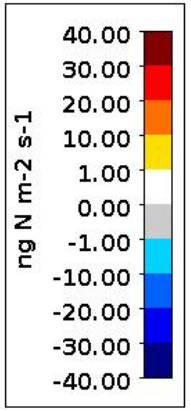
Enhanced Representation of N Scheme in FEST-C – N_2O
Monthly Average Soil N_2O in Growing Season

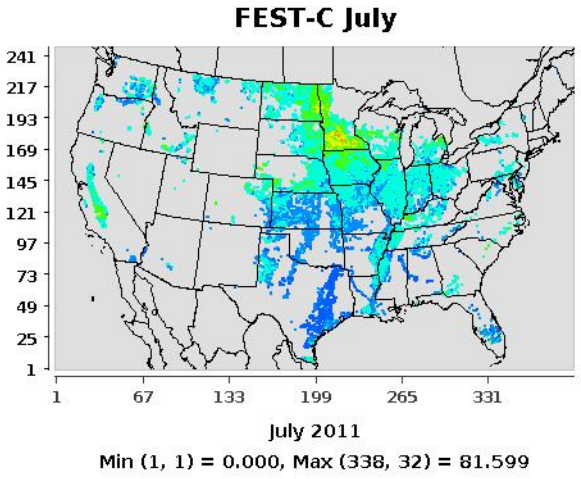


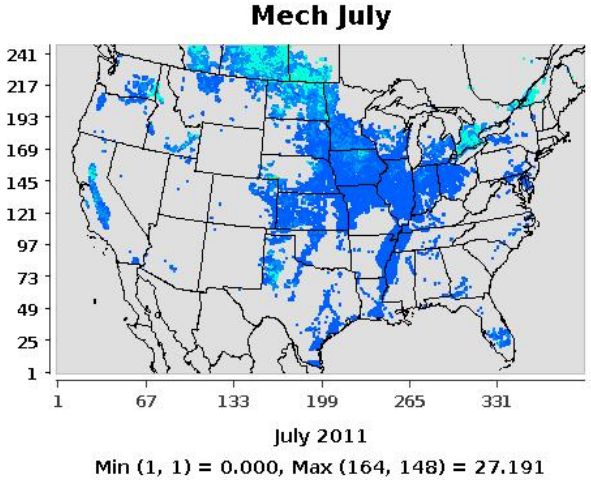


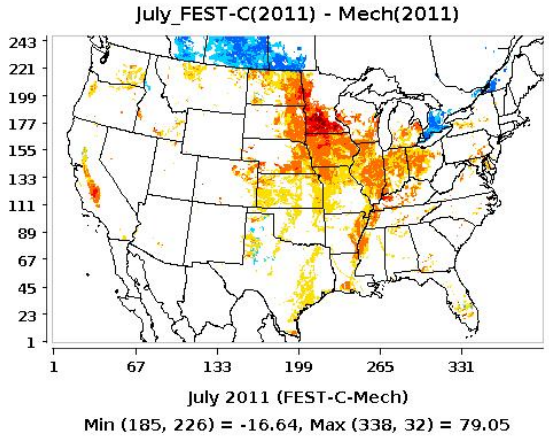




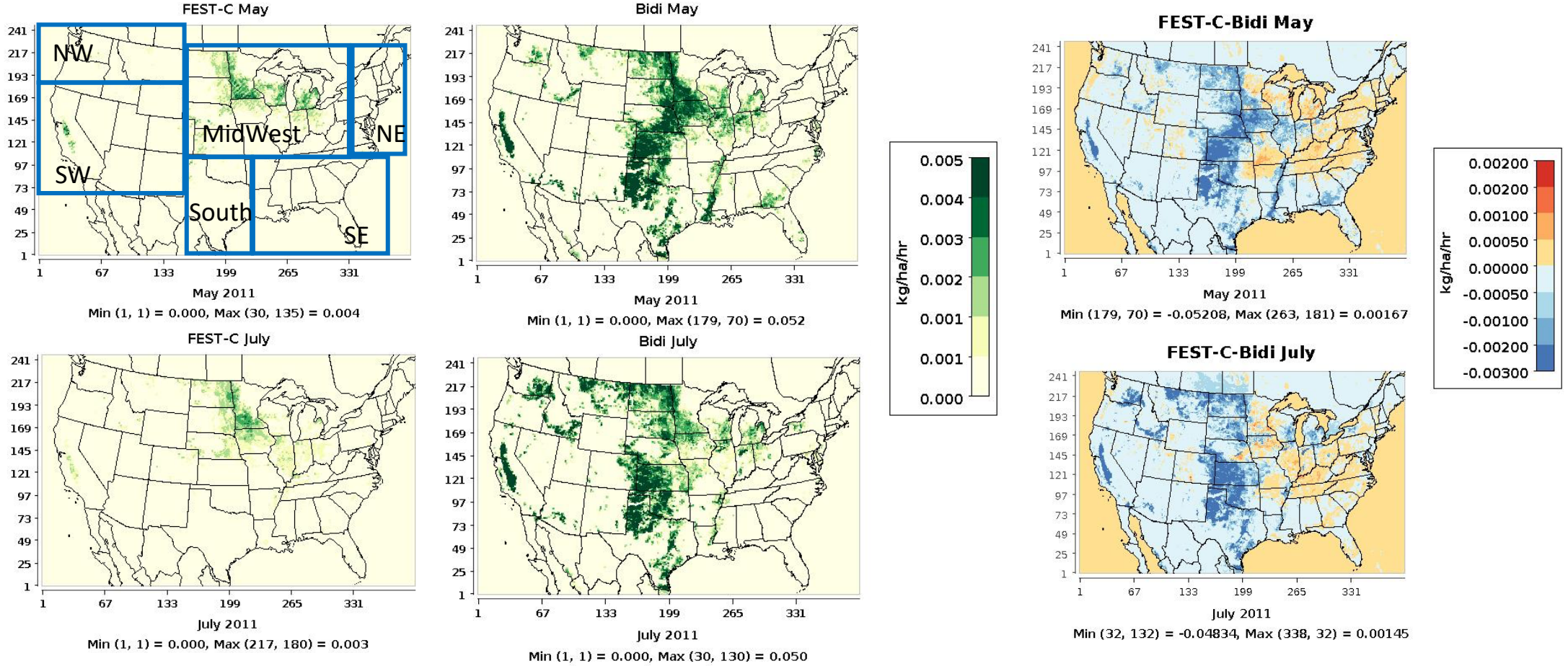








Enhanced Representation of N Scheme in FEST-C – NH_3
Monthly Average Soil NH_3 in Growing Season



NH_3 emissions (ton/day)	MidWest	NW	SE	South	NE	SW	CONUS
FEST-C	4292	325	377	332	411	359	6200
Bidirectional NH_3	8502	1272	999	4424	394	2450	18006

Conclusion

- Enhanced process-based N Scheme in FEST-C
  - ✓predicts NO emissions from N cycling and N_2O emissions from nitrification
  - ✓consistently represents emissions of reactive nitrogen
  - ✓dynamically links farming practices and N cycling
- Improves estimation of agricultural emissions of NO and N_2O
- Need further improvement of NH_3 estimation method


Thanks!
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