Assessing uncertainty in total reactive nitrogen deposition estimates for North American critical load applications

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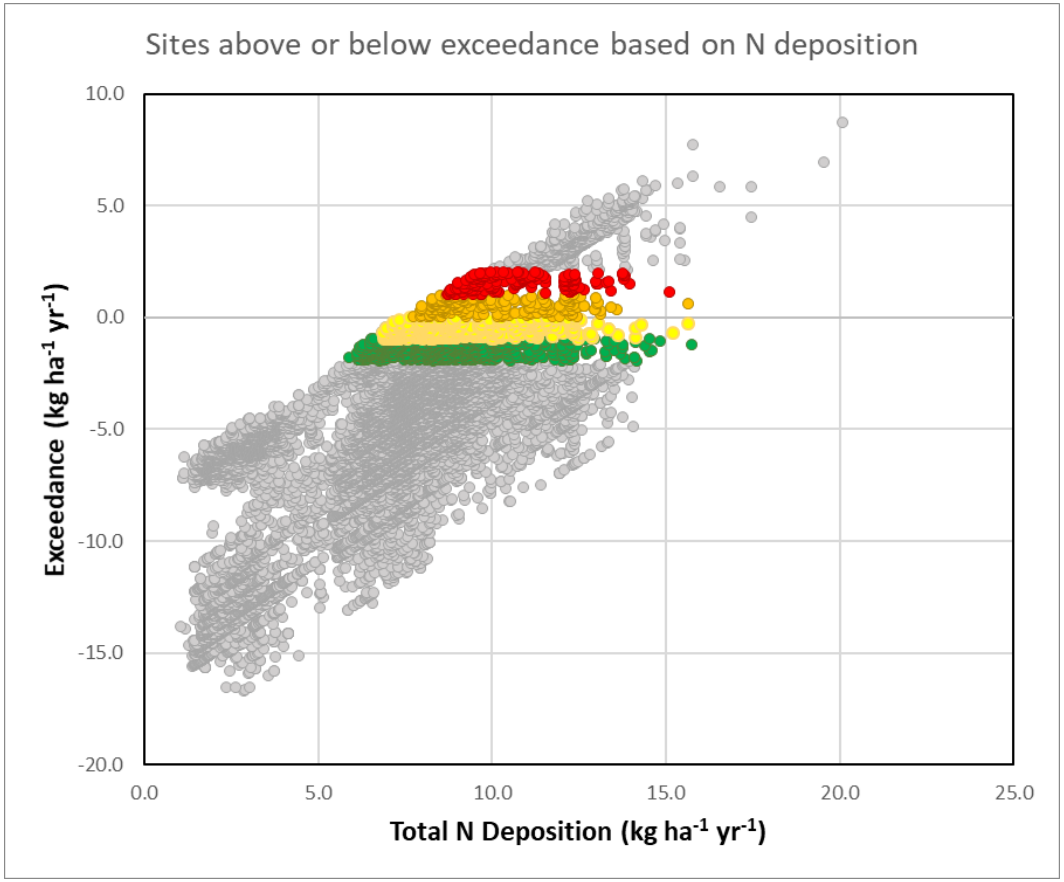
Motivation

- Determination of the amount of deposition in excess of the ecosystem critical load (i.e. “exceedance”) requires an estimate of total deposition.
- Total deposition is typically derived from gridded chemical transport models (CTMs) or a combination of measurements and CTM output.
- Because the critical load exceedance is a metric used to inform policy decisions, uncertainty estimates for both the critical load and the exceedance itself are preferred.
- The deposition estimate used to evaluate a critical load can influence whether an exceedance is expected and can change management and policy response.
- Estimates of uncertainty are not currently available for the reactive nitrogen (Nr) total deposition estimates most commonly used for North American ecosystem assessments.

Motivation

Exceedance of herbaceous richness critical load based on TDep total N deposition 2013-2015



Critical Load Exceedances

kg ha^{-1} yr^{-1}

- -2 to -1 (900)
- -1 to 0 (464)
- 0 to 1 (258)
- 1 to 2 (238)
- Other exceedances (14,973)

Exceedances from Simkin et al, 2016

- 1860 sites (12.4%) are within +/- 2 kg-N/ha/yr of exceedance
- These near exceedances occur at deposition levels of 6-16 kg/ha/yr.
- *Uncertainty is important at both high and low levels of deposition.*

Aspects of uncertainty in deposition budgets

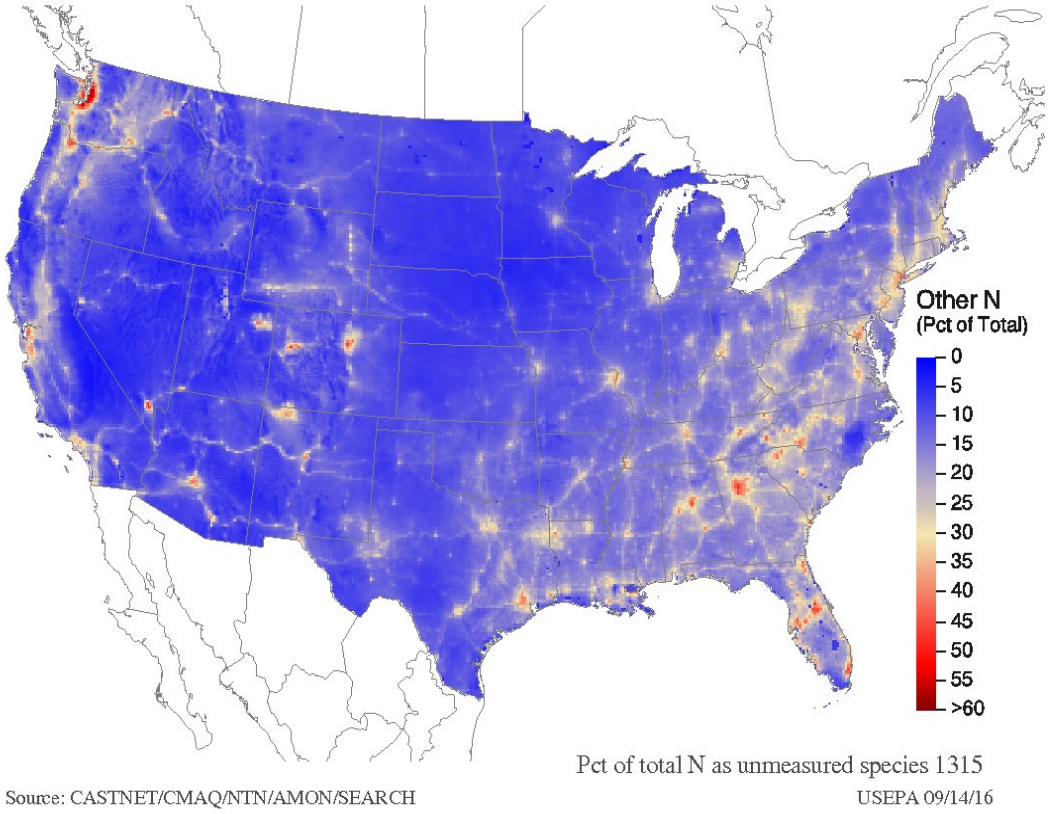
Measured deposition

- Random and systematic uncertainty in flux measurements
- Completeness of the Nr chemical budget
- Temporal representativeness
- Spatial representativeness

Modeled deposition

- Completeness of the Nr chemical budget
- Uncertainty in inputs of emissions and meteorology
- Representation of chemical reactions
- Deposition algorithms
- Measurement-model fusion procedures
- Spatial averaging of sub-grid processes

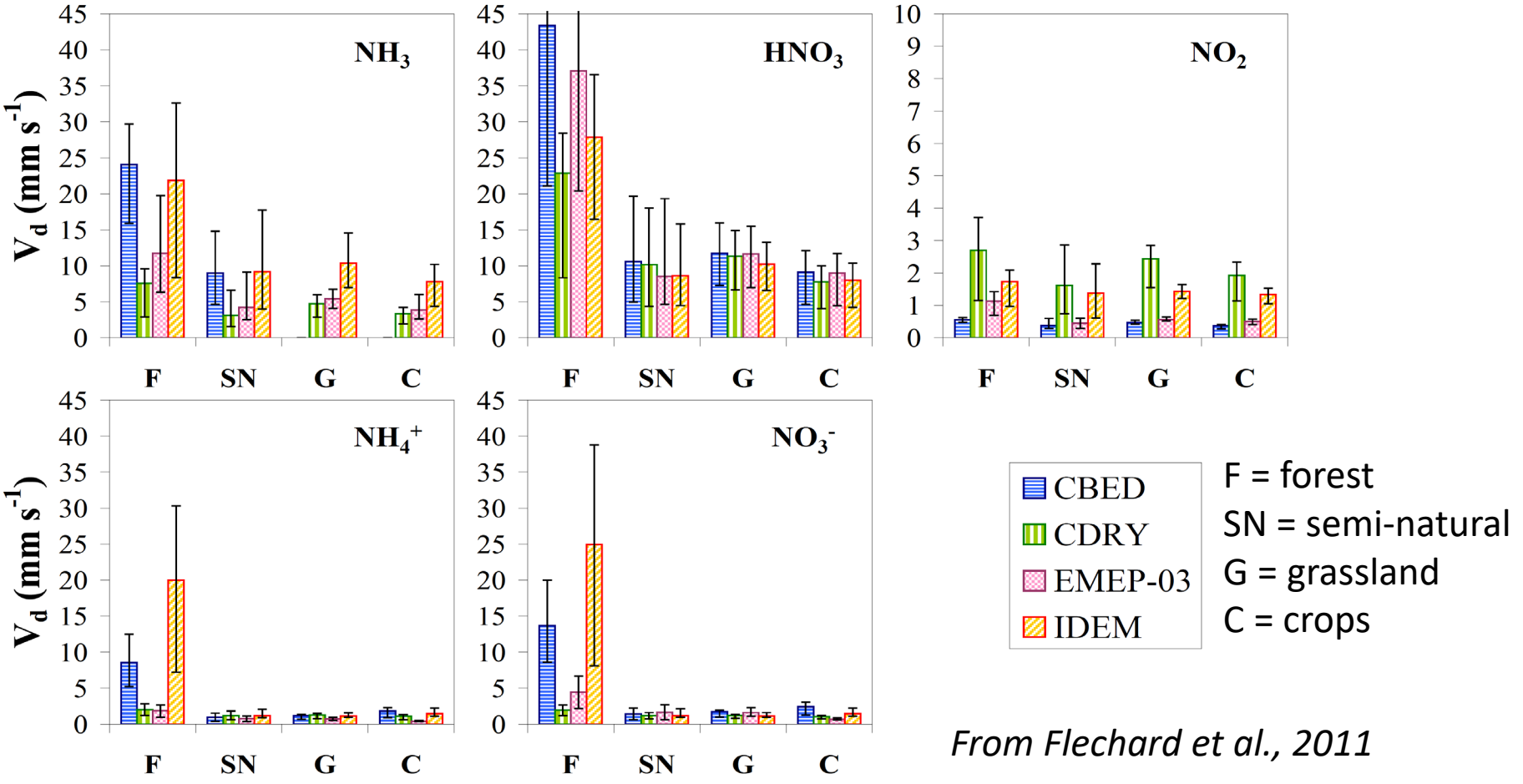
Completeness of modeled deposition budgets



NADP TDEP map of the contribution of "other" dry N to total Nr deposition. "Other" N represents unmeasured compounds and comprises NO, NO_2, HONO, N_2O_5, and organic N.

- Unmeasured N species contribute 13% of CMAQ modeled deposition budget (Version 5.0.2), on average, over the CONUS
- Very small fraction of wet organic N in CMAQ V5.0.2. (TDep)
- Organic N chemistry incomplete (dry dep)
- *Modeled total N wet dep may be up to 25% low without full treatment of organic N*

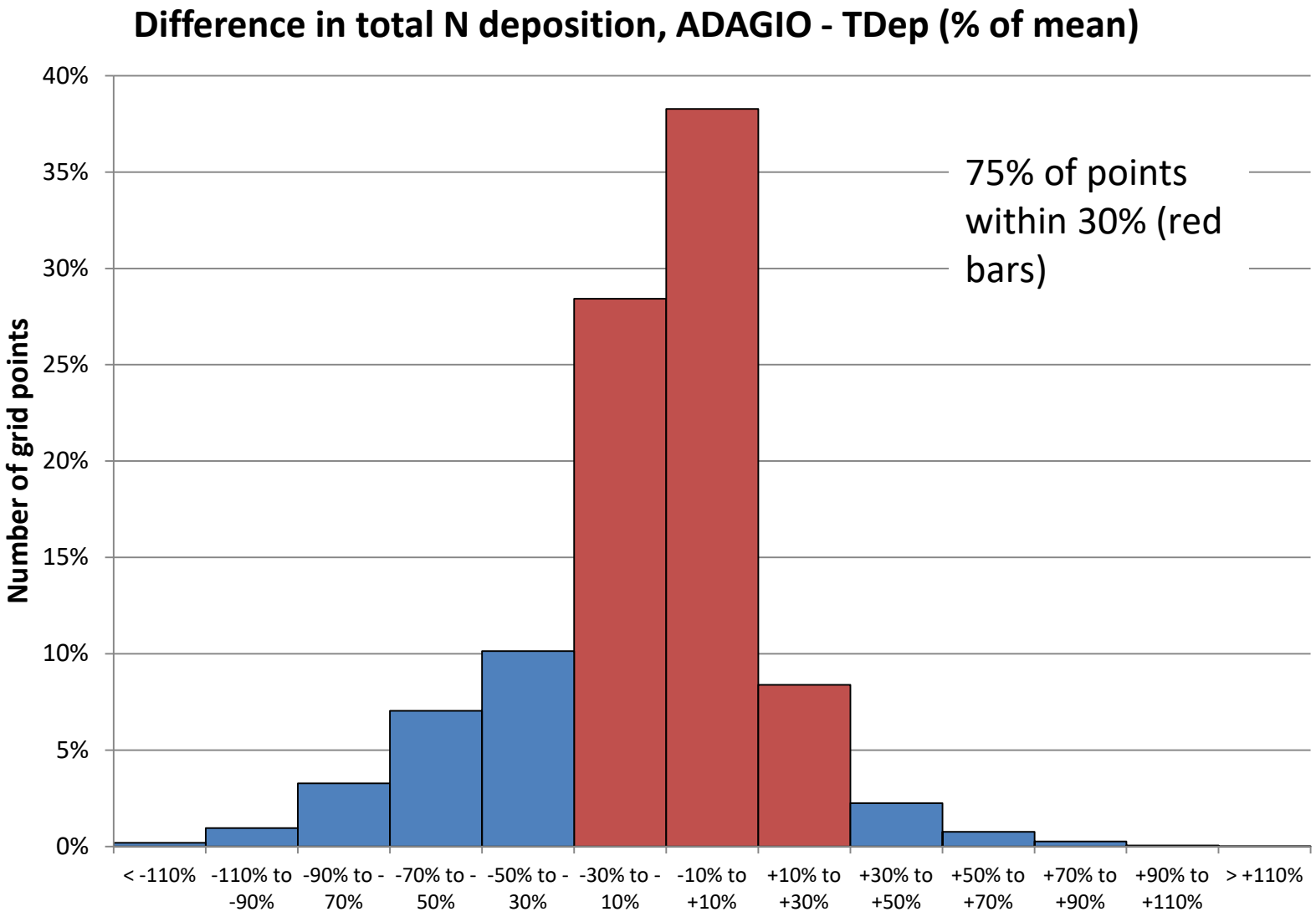
Dry deposition algorithms



From Flechard et al., 2011

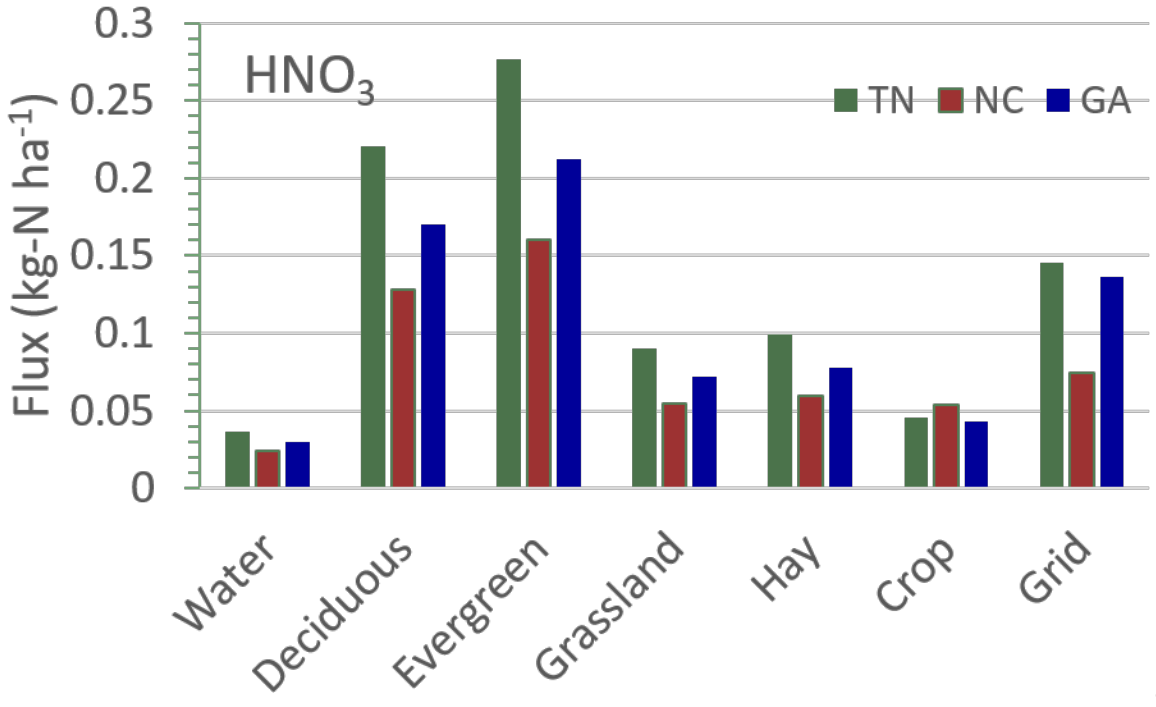
- Field scale inferential models for dry deposition may differ by factor of 3 or more within land-use categories
- Non-stomatal pathways and forests particularly uncertain

Measurement – model fusion



Spatial representativeness

Surface Tiled Aerosol and Gaseous Exchange (STAGE)
Dry Deposition Option for CMAQ V5.3



July, 2011

Land use specific fluxes

Total uncertainty estimates

- Uncertainty methodology for application to TDep total deposition grids

At each location, apply an "uncertainty rating" to each component of the total deposition estimate

Component	Rating
HNO3 dry	2
NO3 dry	3
NH4 dry	3
NH3 dry	4
NOM dry	4
NH4 wet	1
NO3 wet	1
NOM wet (new)	4

Calculate the fraction of total deposition contributed by each component

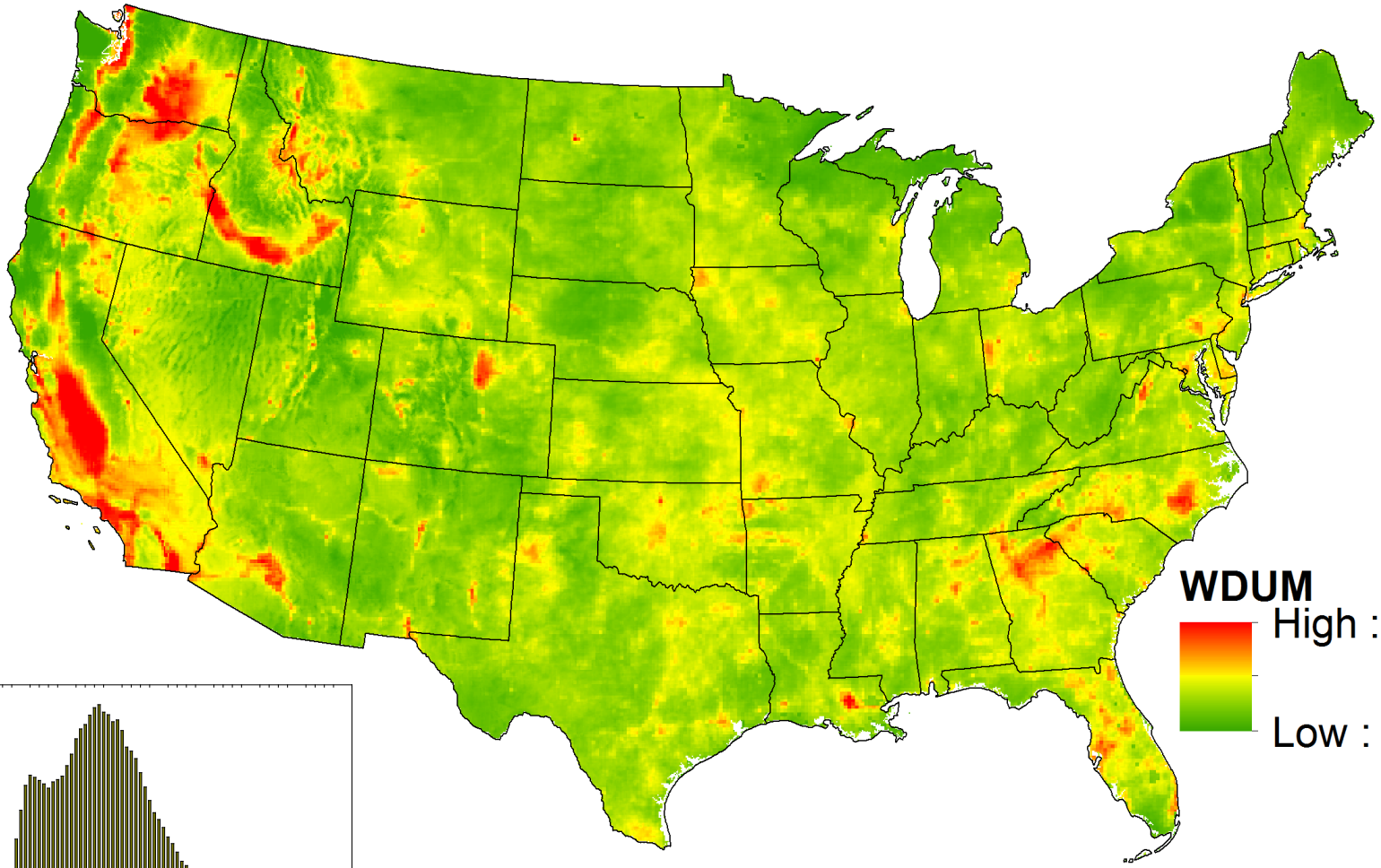
Calculate fractional deposition weighted uncertainty for each component using uncertainty ratings

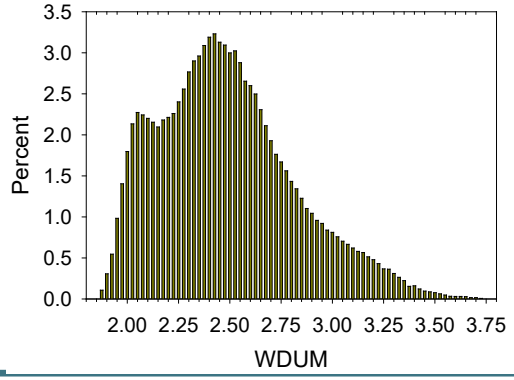
Sum deposition weighted uncertainties for each component

Weighted deposition uncertainty metric (WDUM) for total N deposition

Weighted deposition uncertainty metric (WDUM)

WDUM for 2016 TDep total N deposition





- High value corresponds to greater uncertainty

Future research

Near-term

- Compilation of non-network deposition measurements
- Use of STAGE approach to assess sub-grid variability

Long-term

- Measurement of bulk organic N in monitoring networks
- Improved treatment of organic N in CTMs
- Adoption of STAGE MMF approach
- Establishment of NH_3 MMF bias correction
- Improvement of dry deposition algorithms in CTMs
- Fully quantitative uncertainty maps for critical load assessments

Eddy flux tower, Coweeta, NC

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