How do we make Ameriflux useful for ecosystem models?

And upscaling, and
model-data fusion,
and synthesis, and …

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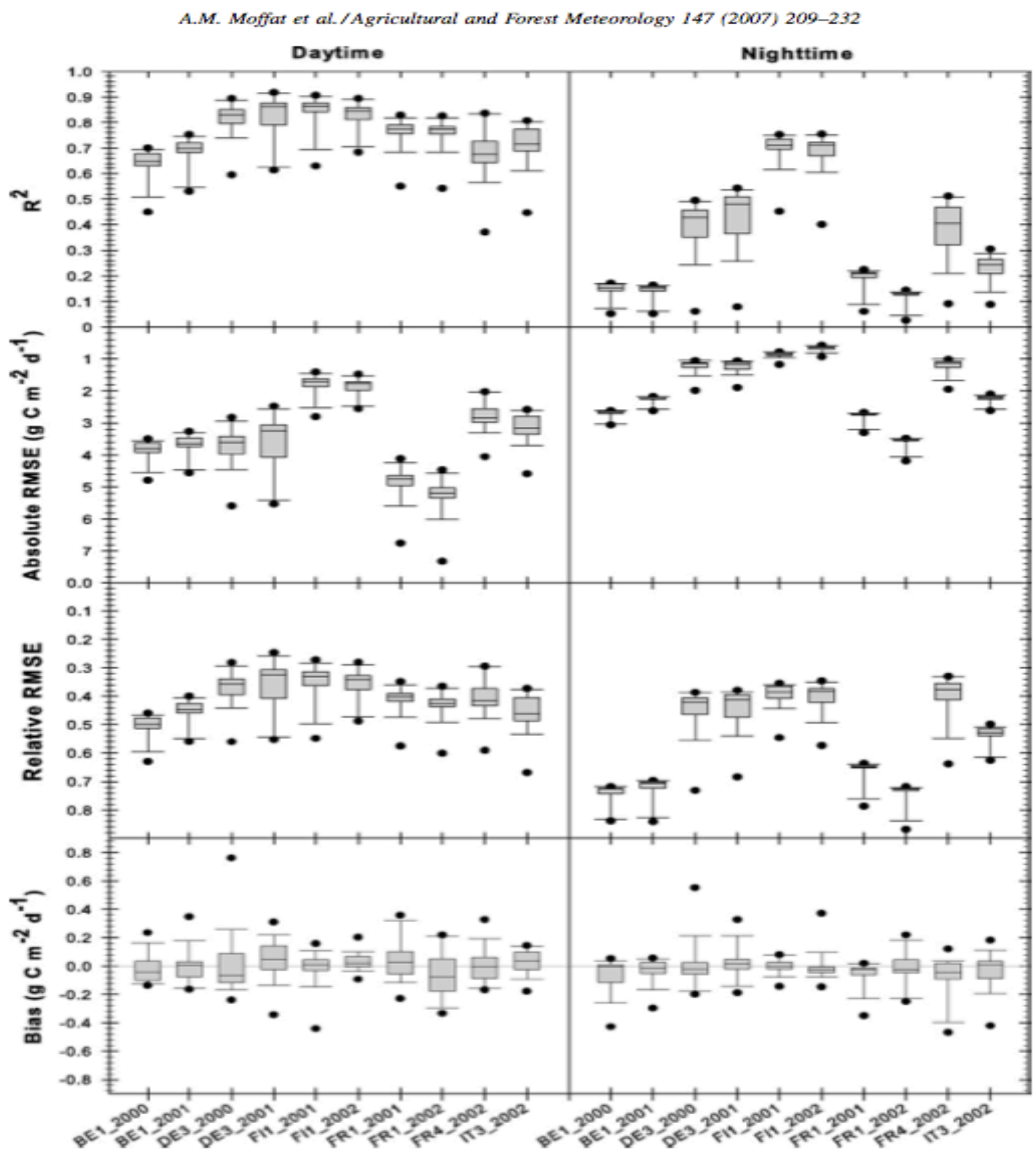
DOE LBNL Ameriflux Network Management Program Core Site Subcontract to ChEAS Cluster, NSF ABI #1062547 and #1062204, Karlsruhe Institute of Technology IMK-IFU MICMoR program, and NEON, Inc.

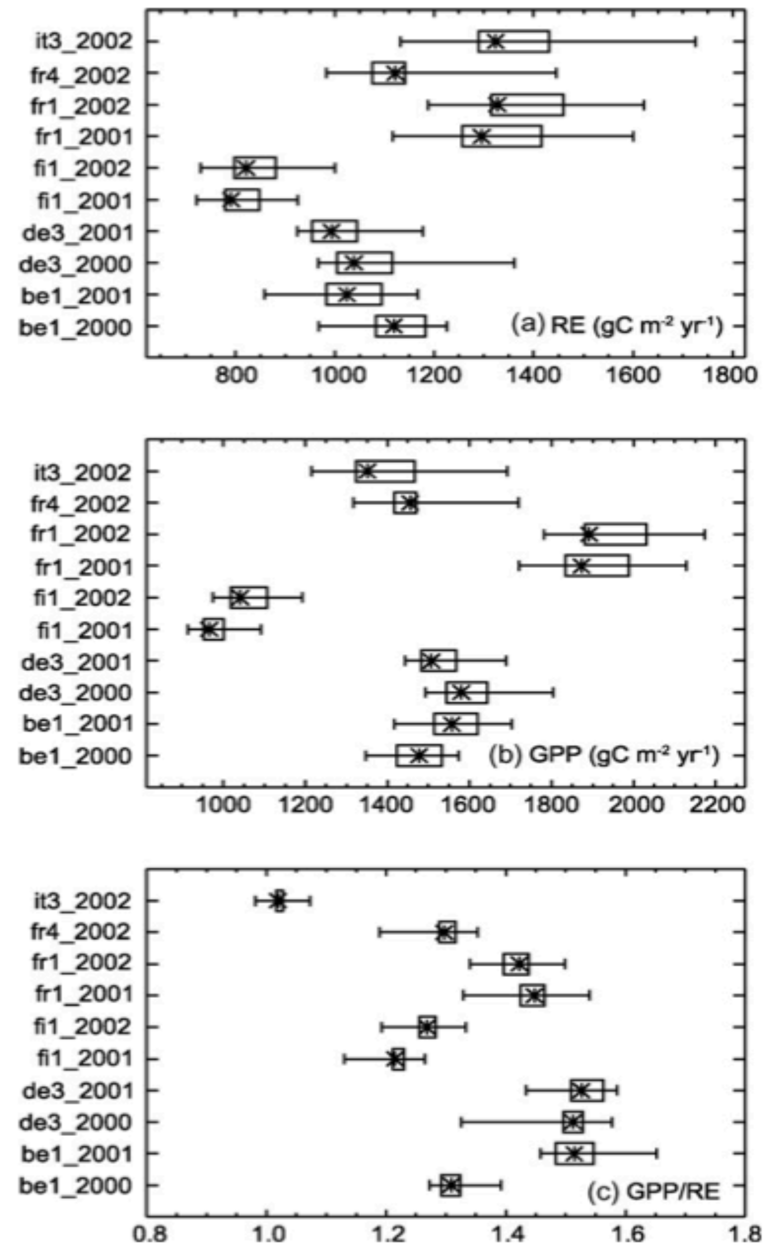
A rant

We've become good at gap-filling and flux partitioning

We even know how uncertain they are, not that we tend to tell anyone



Moffat et al., 2007, AgForMet



Desai et al., 2008, AgForMet

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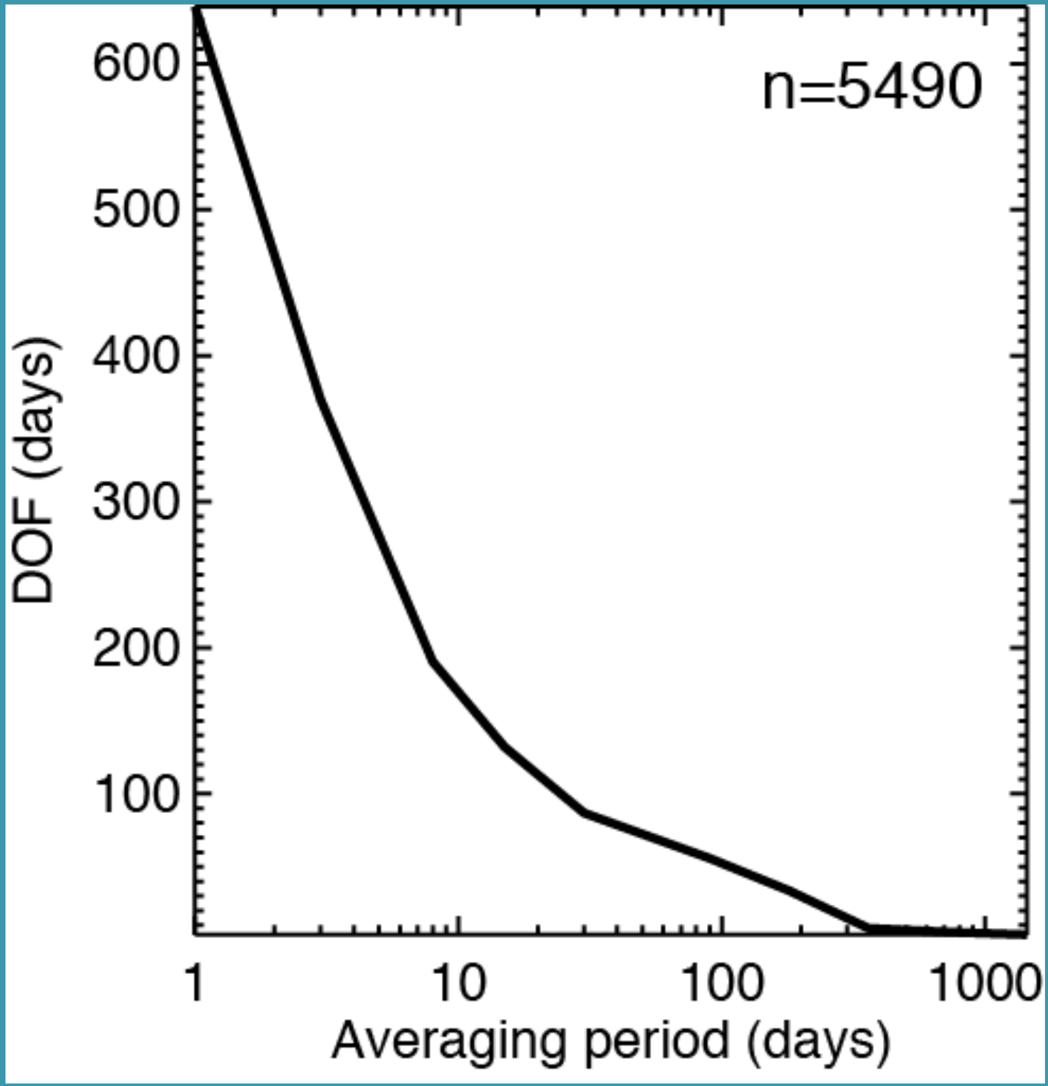
But it's led to massive abuse in the model evaluation and model-data fusion community (i.e., "observed GPP", gap-filled "data" for assimilation)

What could we do better to make Ameriflux useful for models?

Perform rigorous QA/QC

- Automate some of data quality reports (e.g., helpful reports from Bai Yang and Dario Papale)
- Automate flagging of suspect observations (NEON approach, Mauder TK3 method)
- We have a few hundred million observations in Ameriflux – we can choose to be picky!

N does not equal N



Desai, 2014, Photosynthesis Res.

QA/QC strategy for long-term EC measurements (TK3)

(Mauder et al., AgForMet, 2013)

Tests on high-frequency data

- Instrument diagnostic flags (e.g. CSAT3 0-63, LI7500 240-251)
- Instrumental/plausibility limits (site-specific)
- Spike-detection with MAD-test, *z* = 7

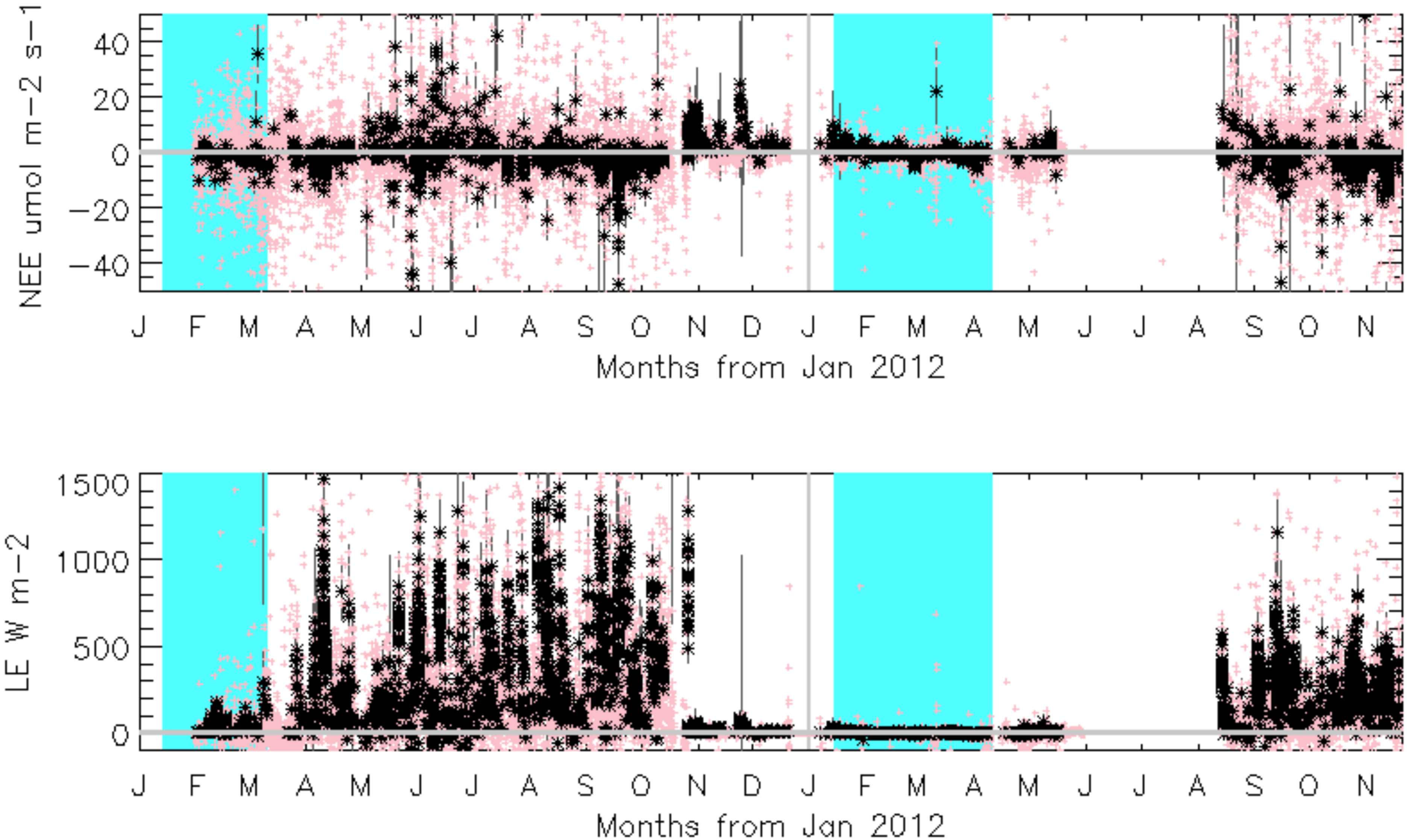
Tests on statistics, flux calculation + corrections

- Maximum number of missing values: <=10%: flags = 0, >10%: flags = 2
- Stationarity test covariances (FW96,MF04, <30%: flag = 0, <75%: flag = 1)
- Test on well-developed turbulence (ITC test: FW96,MF04, <30%: flag = 0, <100%: flag = 1)
- [w] after planar fit > 0.10 m s^{-1}: former flags +1, >0.15 ms^{-1}: flags = 2
- Interdependence of flags due to corrections/conversions:
  if *flagλE*==2 then former *flagH* +1
  else if *flagH*==2 then former *flagλE* +1
  else if *flagλE*==2 or *flagH*==2 then former *flagNEE* +1

Quantification of errors/uncertainty estimates

- Stochastic error: use Finkelstein&Sims (2001) on high-pass filtered time series.
- Instrumental noise error after Lenschow et al. (2000)
- Systematic error: flux underestimation and lack of energy balance closure, only applicable for *daytime*: *EBR* = sum (λE+H)/Sum(R_n-G-J) for one day
- Footprint: Kormann&Meixner(2001); calculate percentage of flux contribution from several targets of interest

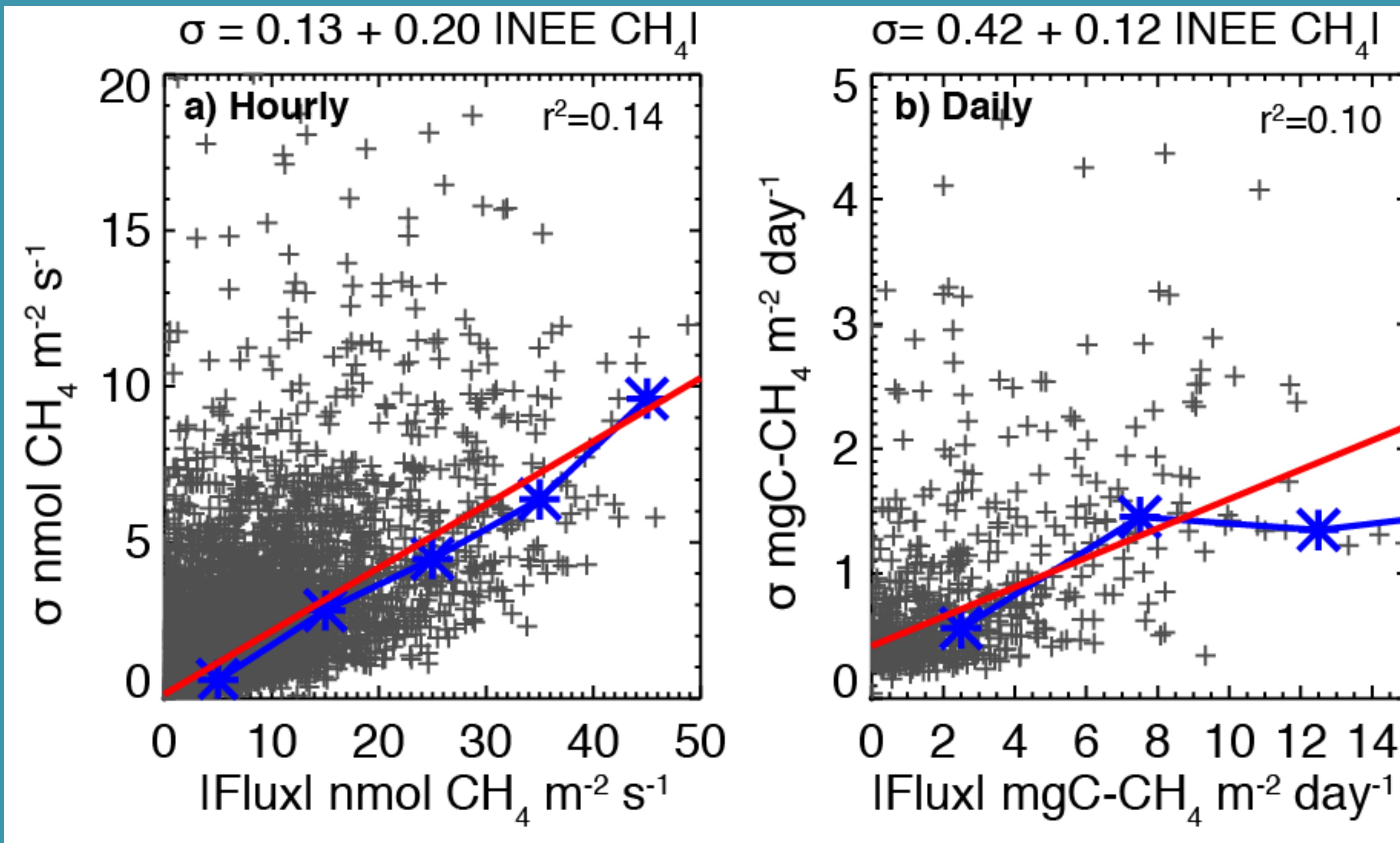
Signal from noise?



Address uncertainty

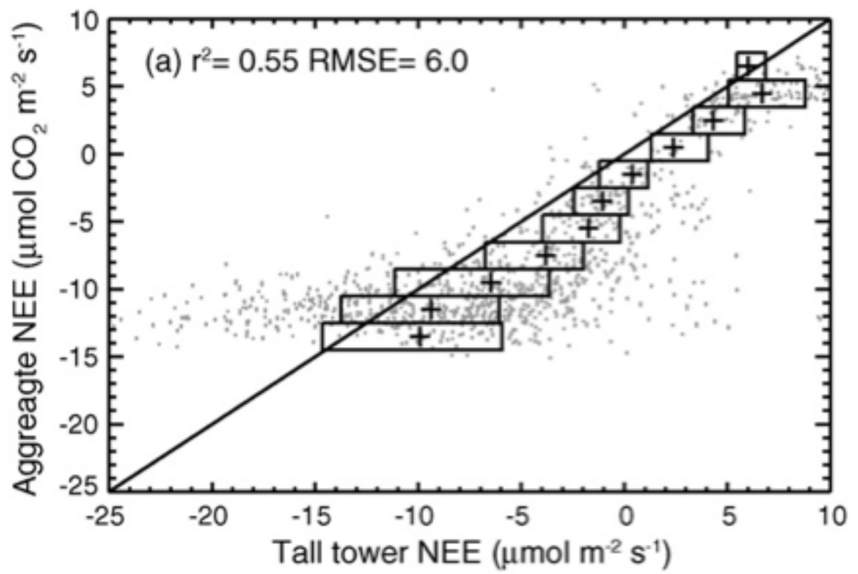
- Random flux uncertainty
  - Empirical approaches (Lenschow, Richardson/Hollinger)
  - Direct approaches (Billesbach, Finkelstein, Salesky)
- Systematic uncertainty
  - Primarily u* sensitivity (Barr, Papale)
  - Also footprint bias (Wang, Desai, Metzger)
- Meteorological and energy balance uncertainty might be a bigger deal for models
  - Models want gap-filled met as driver, usually assume energy balance or closed water budget
  - Ameriflux roving standard (Hanson/Biraud/Law)

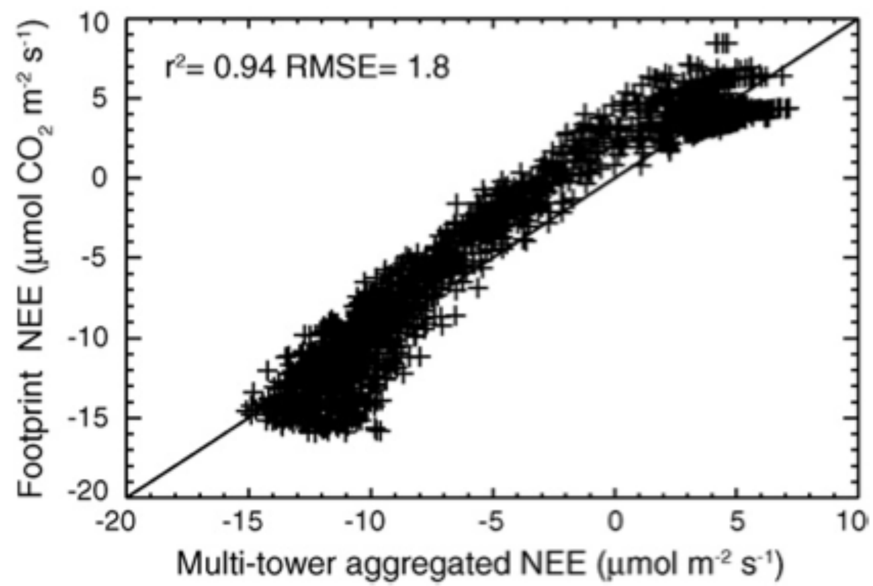
Random error is important!



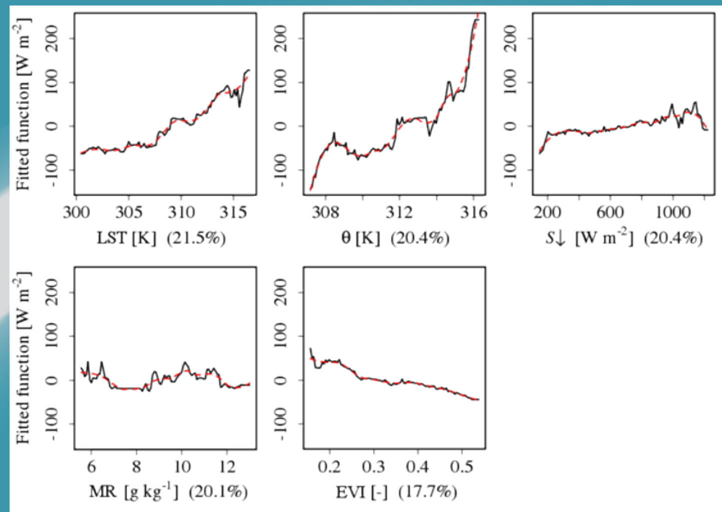
Desai, 2014, submitted

Footprint bias is important!



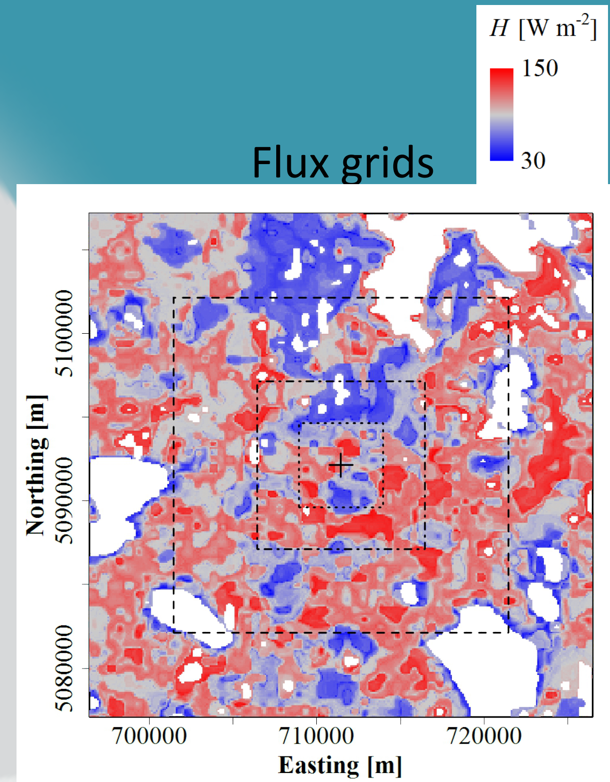


Desai et al., 2008b, AgForMet



Environmental response functions

Flux grids

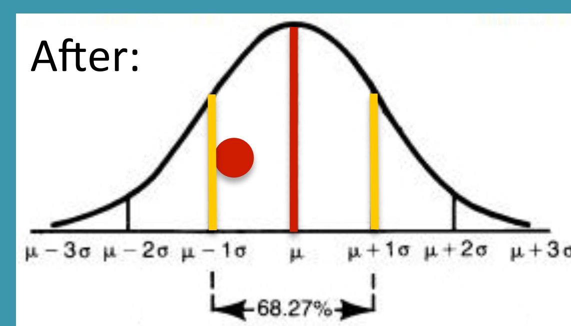


Ameriflux Park Falls ‘very tall tower’ (447 m): Eddy flux at 122 m.

Credit: Matt Rydzik (U Wisconsin)

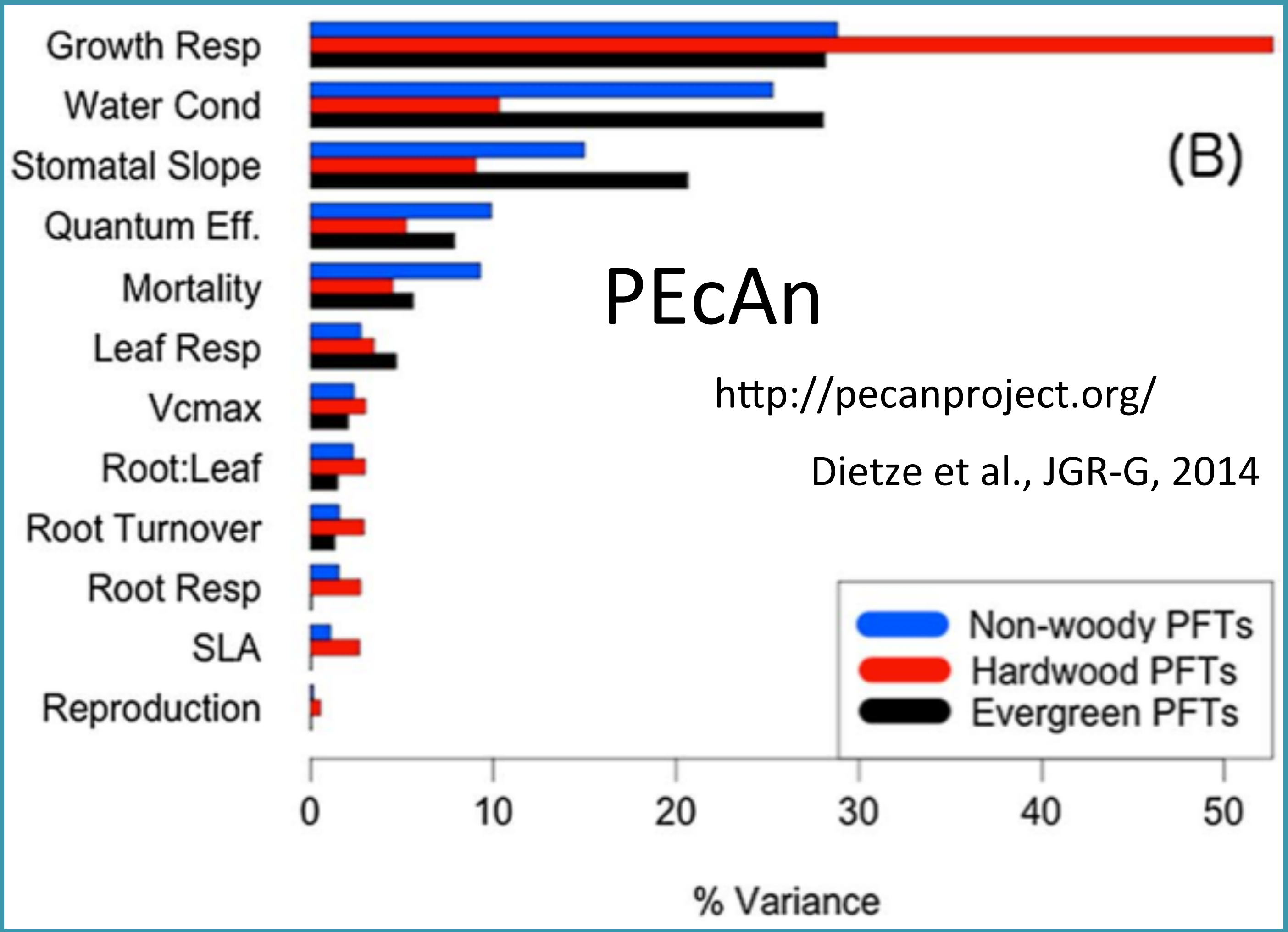
Before:

After:



Based on: Metzger et al., 2013, Biogeosci.

Use model informatics to identify observational needs



Recommendations

- Make all data available freely, in automated fashion!
- Gap-filling met (Ricciuto/Yang/Papale style) and ET > gap-filling NEE
- Systematic uncertainty > random uncertainty
- Uncertainty in energy balance, met components as important as NEE
- Stop calling GPP, RE observations
  - provide community tool to output range of GPP and RE based on methods and uncertainty
- Automate flagging and random/systematic flux uncertainty (TK3), report roving comparison met uncertainty or bias in tower metadata
  - May require archive and access to high-freq (10-20 Hz)
- Run footprint models for all sites, all hours
  - use methods like ERF to identify representative observations
- Make BADM files machine-readable (XML,NetCDF,CSV) to allow easy model ingest
  - using standard units, naming conventions – use model experiments to identify what key BADM obs every site should collect and at what frequency

Also: Engage future tower monkeys

Reading suggestions

- Barr AG, et al., 2013. Use of change-point detection for friction-velocity threshold evaluation in eddy-covariance studies. *Agric. Forest Meteorol.*doi:10.1016/j.agformet.2012.11.023
- Desai, A.R., 2014. Influence and predictive capacity of climate anomalies on daily to decadal extremes in canopy photosynthesis. *Photosynthesis Res*., doi:10.1007/s11120-013-9925-z
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- Metzger, S. et al., 2013. Spatially explicit regionalization of airborne flux measurements using environmental response functions. *Biogeosciences*, doi: 10.5194/bg-10-2193-2013
- Salesky, S., et al., 2012. Estimating the Random Error in Eddy-Covariance Based Fluxes and Other Turbulence Statistics: The Filtering Method. *Boundary-Layer Meteorol*., doi:10.1007/s10546-012-9710-0