# Uncertainty in gap-filled meteorological input forcing:

## Impacts on modeled carbon and energy fluxes

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# Background

- Major focus of NACP site synthesis: *uncertainty*
  - Uncertainty among models – structural (large!)
  - Flux observation uncertainty covered well (Barr et al.)
  - Plans to include within-model uncertainty (e.g., parametric)
  - But what about driver data uncertainty? Is it important?

- Key questions:
  - How much model-data mismatch is from errors in forcing?
  - Is forcing-driven model prediction uncertainty
    - Significant when compared to other sources of error?
    - Highly model dependent?

# Methods

- Collected 10 different forcing datasets
  - Five observational, five reanalysis
  - Extracted nearest station or gridcell for NACP sites

- Analysis of selected forcing variables
  - Focus on two sites:  US-Ho1, US-MMSF
  - Focus on interannual variability and seasonal cycle

- Terrestrial carbon cycle model prediction
  - LoTEC model with literature-based parameters
    - 5 soil carbon pools, 4 vegetation pools
    - Rothamsted soil C + Farquhar photosynthesis
  - Model run with all 10 driver datasets at two sites
  - Examine differences in NEE, GPP (interannual and seasonal)

# Forcing datasets

- **Observations**

  **Hourly / half-hourly site data**
  - Gap-filled forcing for NACP
  - Gap-filled AmeriFlux files (La Thuile)

  *Crude estimate of gap-filling uncertainty*

  **Daily climate**
  - Nearest NCDC station (T, precip)
  - DAYMET (T, precip, SWrad, humidity)
    - 1km interpolation+model product
  - Tower observations, averaged to daily

  *Temporally downscaled to hourly*

  *Other variables filled using site monthly diurnal mean*

- **Reanalysis**

  3, 6 or 12-hourly
  - ECMWF - interim
  - NARR
  - NCEP
  - NCEP2
  - Princeton

# Forcing variables

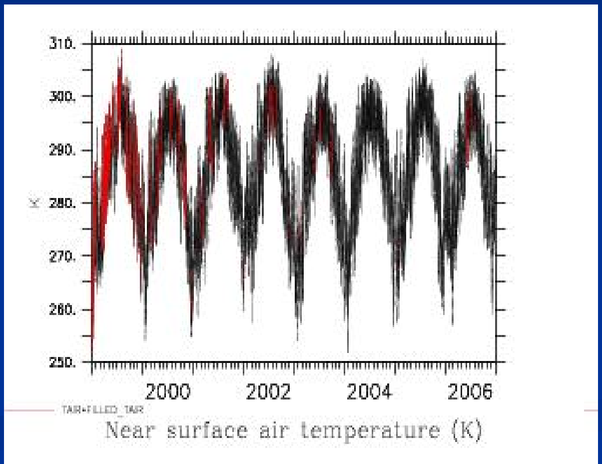
Variables analyzed in detail here:

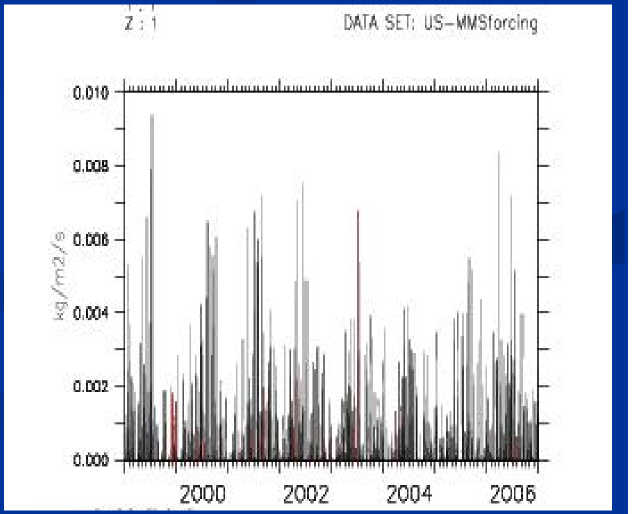
- SWdown – downward shortwave radiation at surface
- Tair – surface air temperature
- Rainf – precipitation rate

Other necessary variables for modeling:

- Psurf – surface pressure
- LWdown – downward longwave radiation at surface
- Wind – wind speed
- Qair – specific humidity

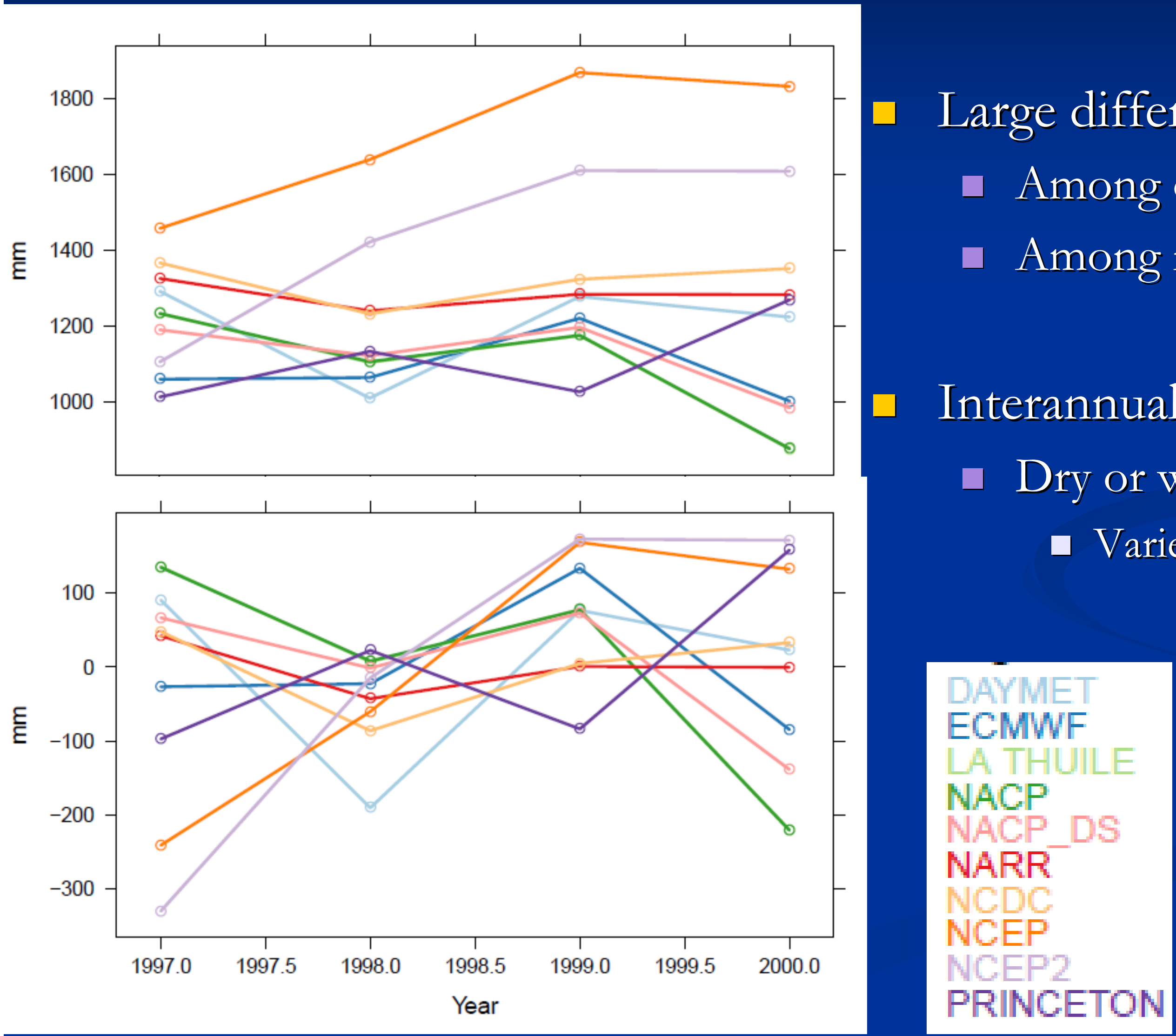
Currently provided for NACP site synthesis at over 50 sites



# Rainfall: interannual patterns

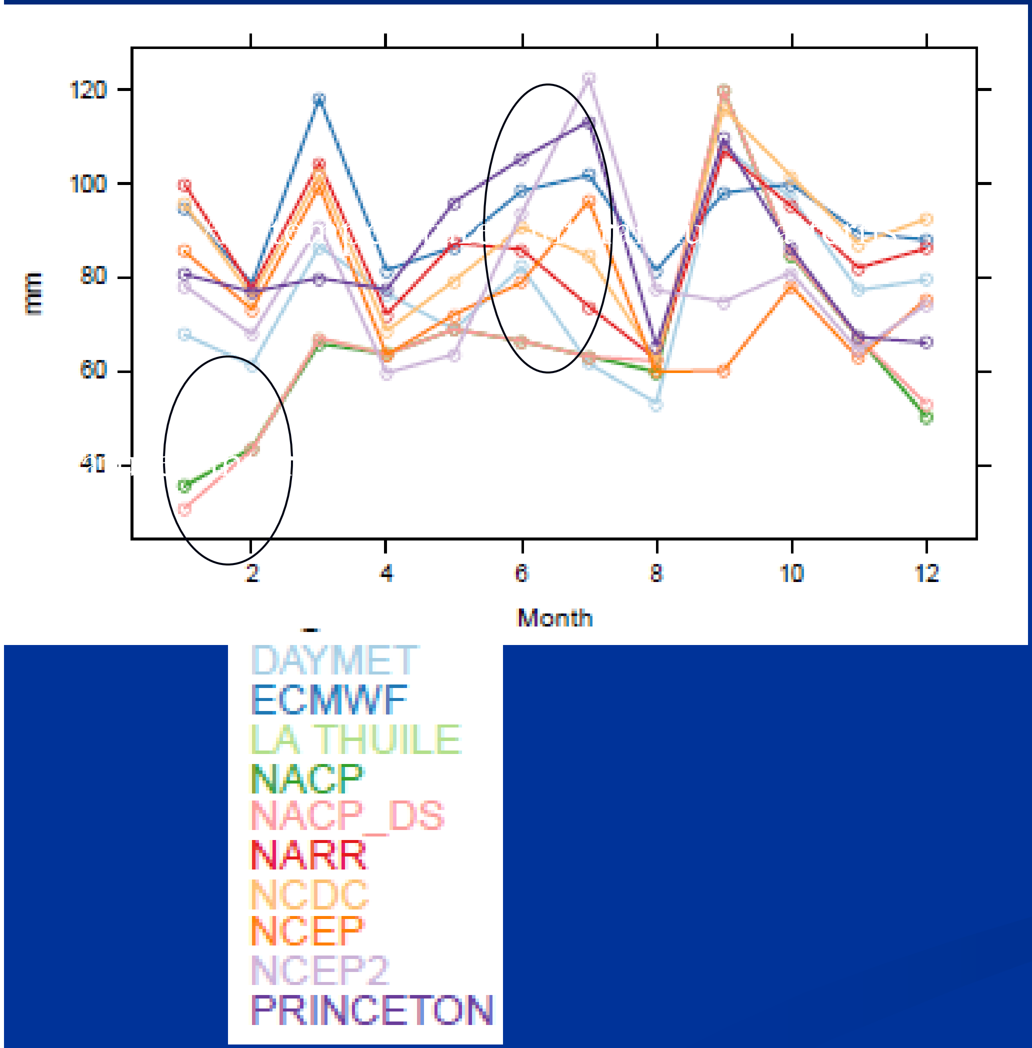
Morgan Monroe




- Large differences in mean
  - Among observations
  - Among reanalyses
- Interannual patterns inconsistent
  - Dry or wet year?
    - Varies among datasets

# Rainfall: seasonal patterns

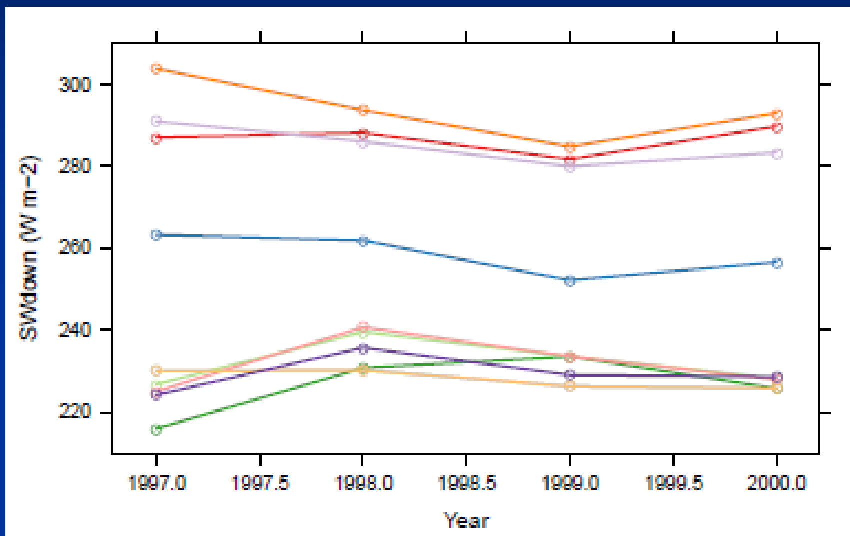
Howland



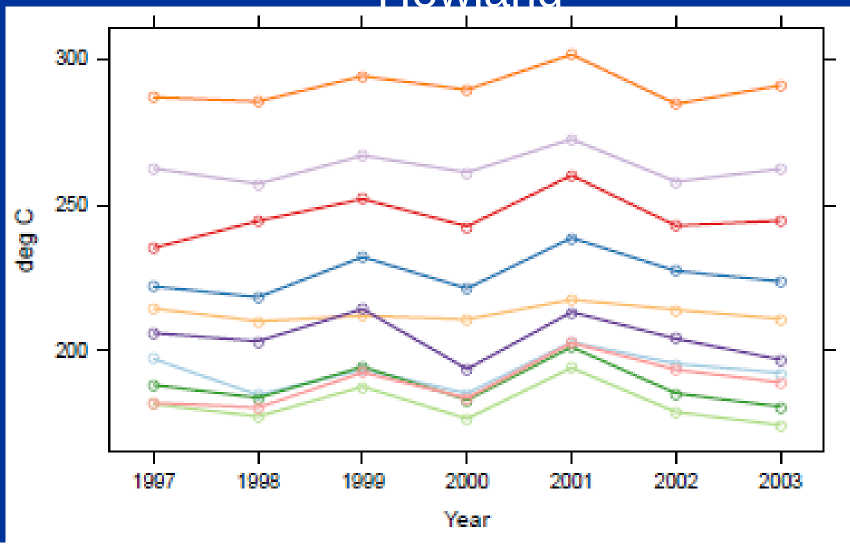

- Differences in seasonal cycle
  - Among observations
  - Among reanalyses
- Winter precip undermeasured?
  - Feature of many cold sites
- High growing season variation
- DAYMET, NCDC inconsistent patterns with tower data
  - growing season bias?

# SW Radiation: biases and patterns

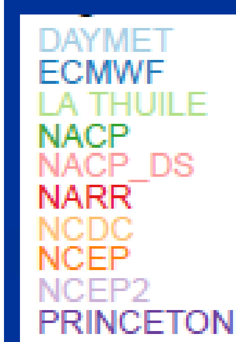
Morgan Monroe



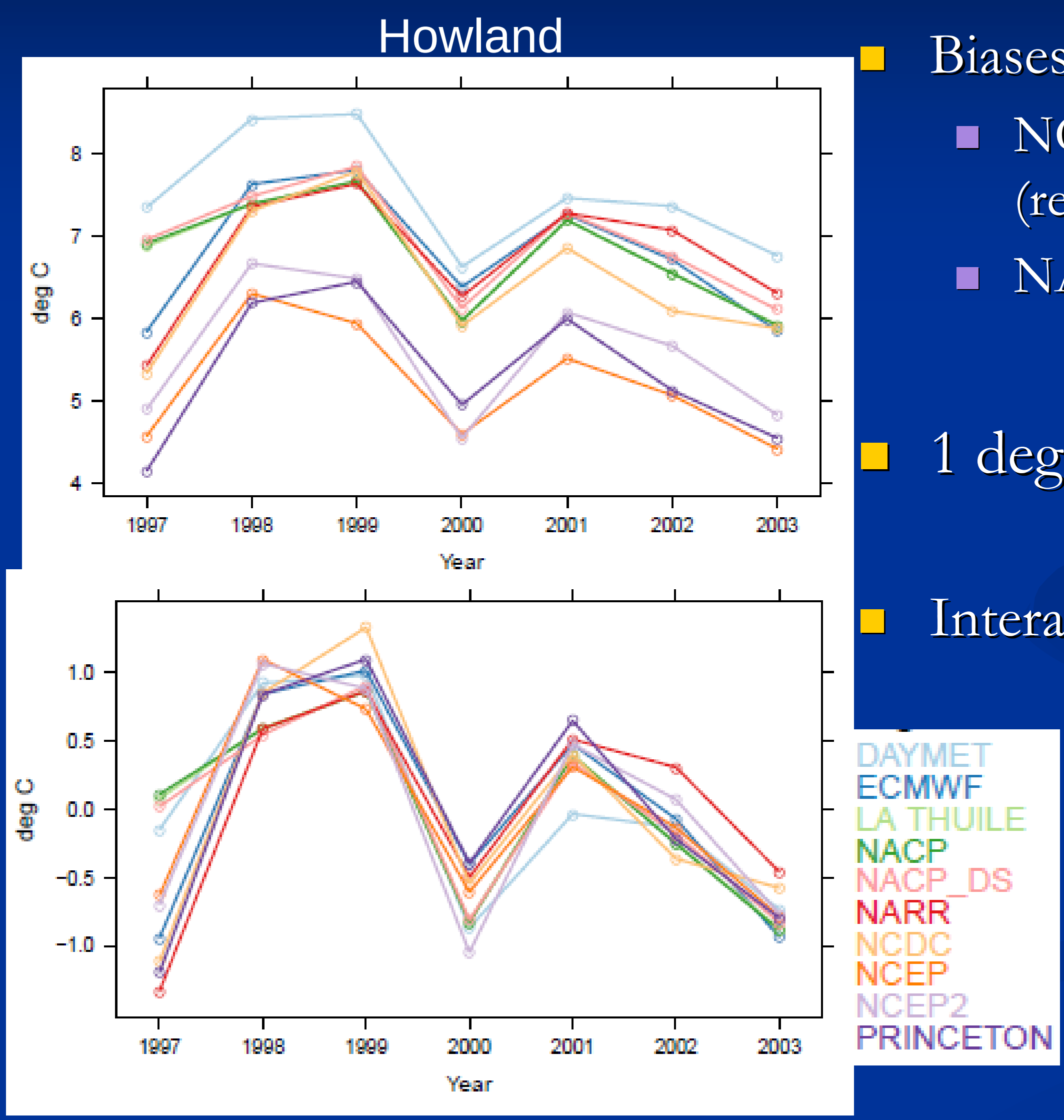

Howland




- Biases in reanalysis data
  - NCEP, NARR +25-40%
  - ECMWF +10-20%
  - Princeton nearly unbiased
  - Consistent at other NA sites
- Differences in observations
  - NACP vs. La Thuile
  - NACP fills with DAYMET



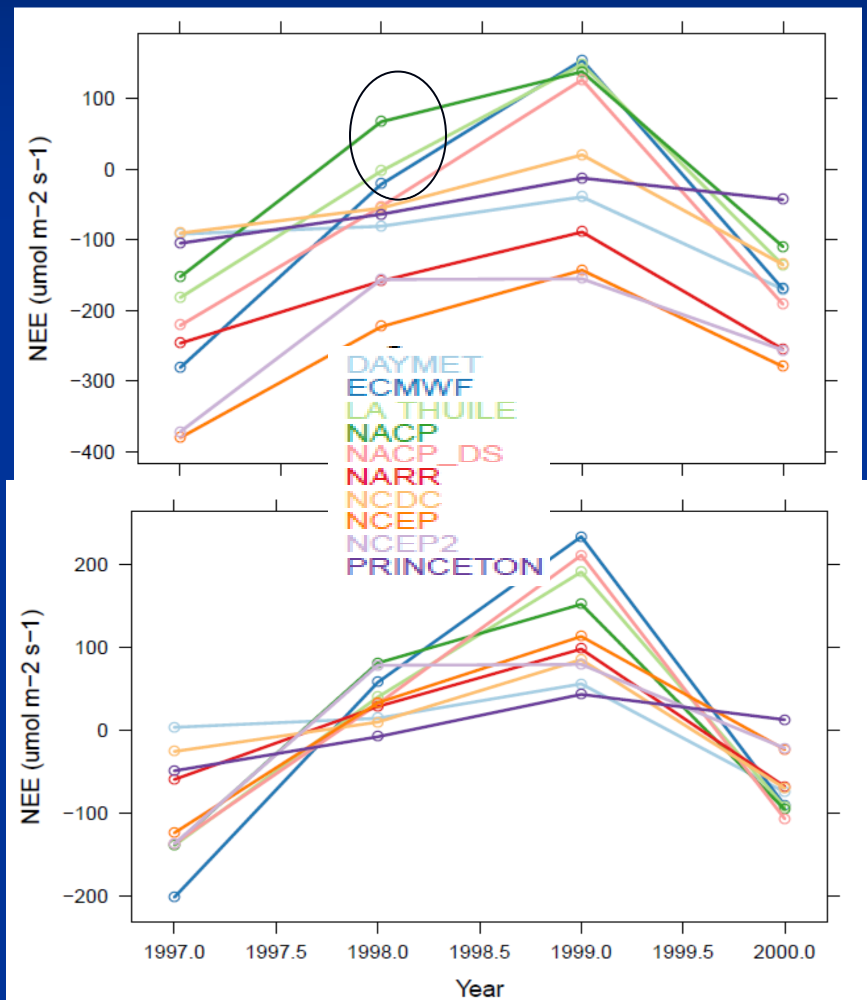
# Air temperature:  interannual patterns




- Biases in reanalysis data
  - NCEP, NCEP2, Princeton low (representativeness?)
  - NARR, ECMWF good
- 1 degree spread in obs
- Interannual patterns consistent

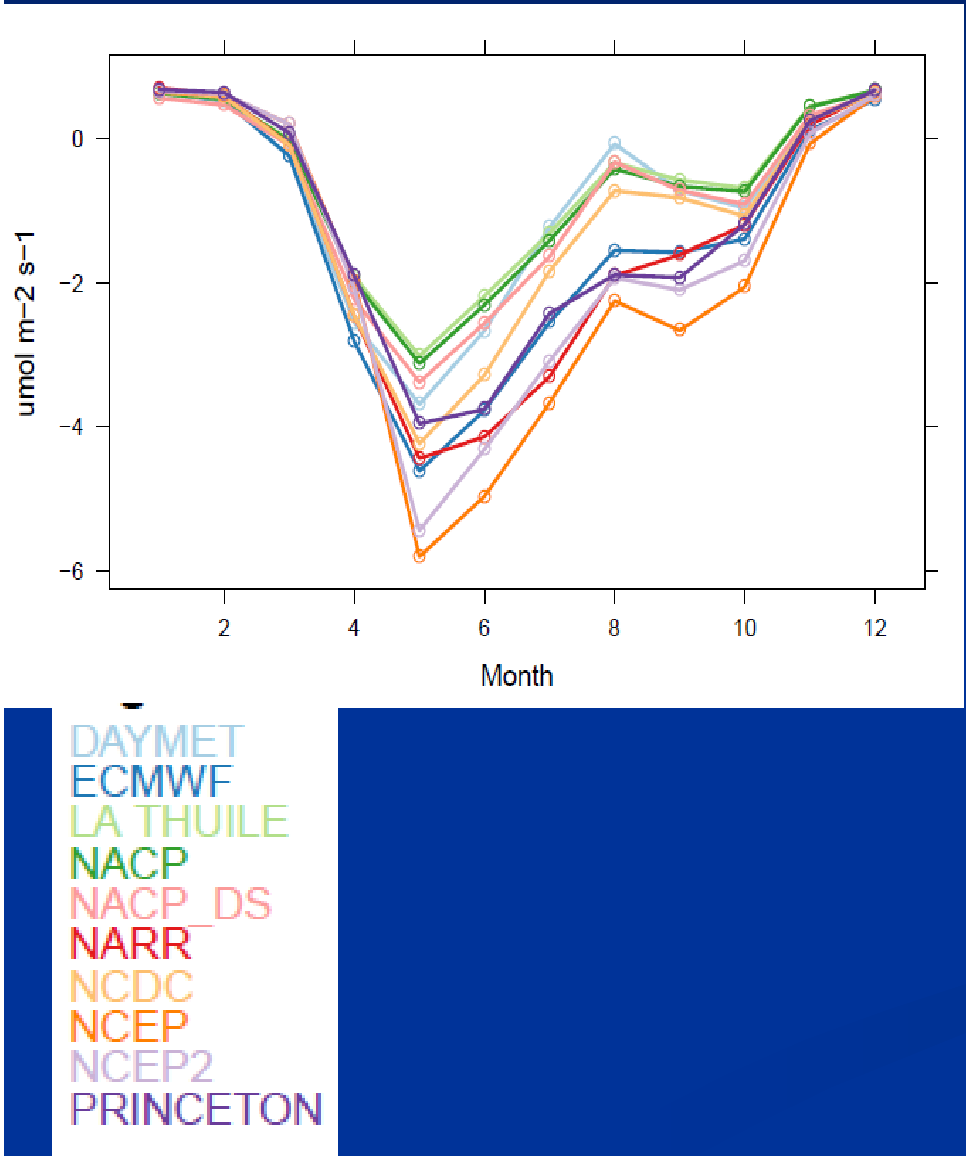
# NEE: Interannual patterns

Morgan Monroe



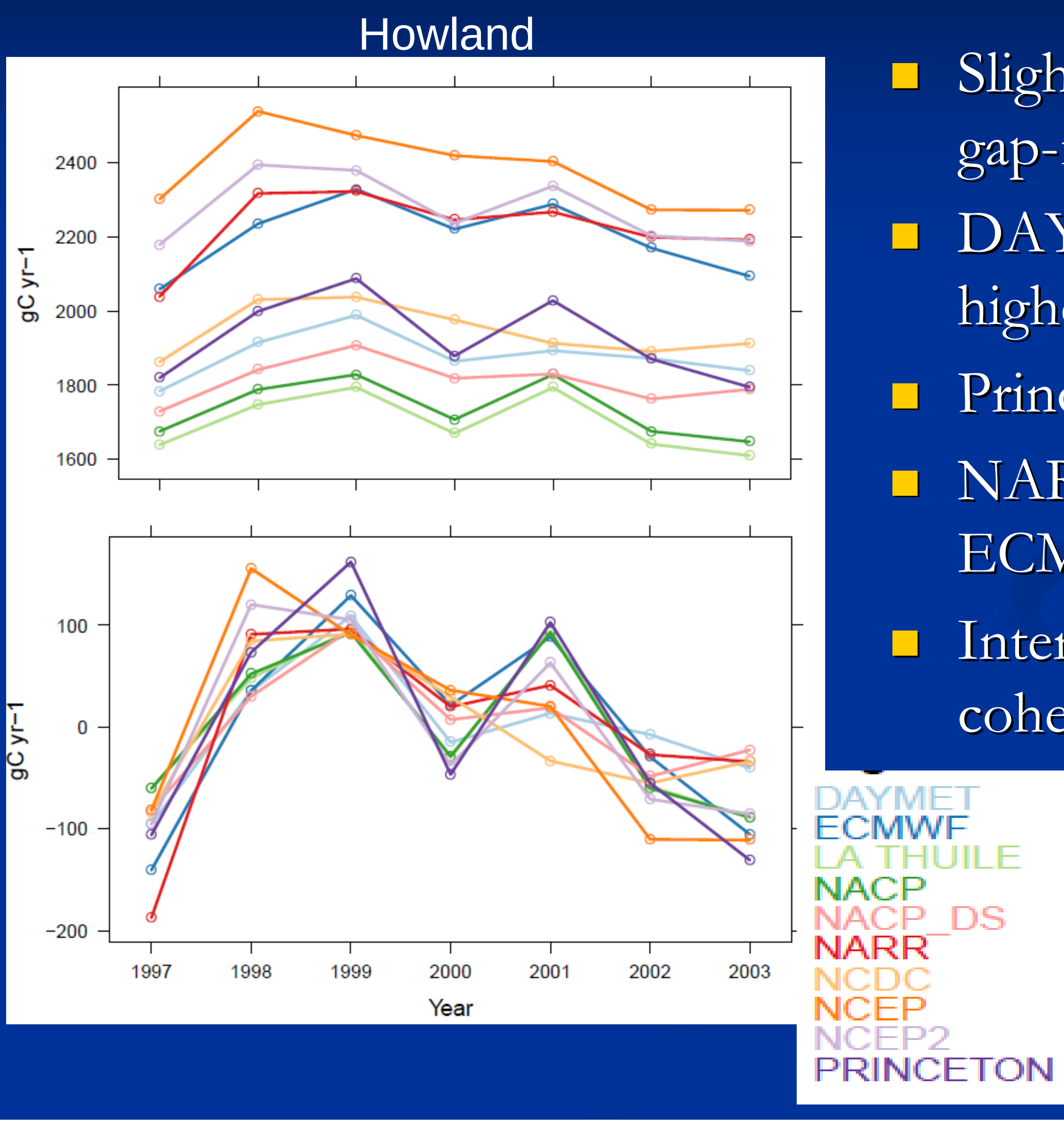

- Differences between gap-filling methods
  - Average 10% gap-filling
  - Significant – up to 50 gC $m^{-2}$ $yr^{-1}$
  - Same order as flux uncertainty
  - Interannual pattern roughly consistent
- Differences among obs
  - Up to 150 gC $m^{-2}$ $yr^{-1}$ difference
  - Interannual patterns different
- Differences among reanalyses
  - Up to 300 gC $m^{2}$ $yr^{-1}$ difference

# NEE: seasonal cycle




- Howland: Better agreement between filling methods
- DAYMET, NCDC show higher growing season uptake
- Reanalysis
  - NCEP extreme bias (SW radiation)
  - NARR, ECMWF, Princeton better

# GPP: Interannual patterns




- Slight differences between gap-filling methods
- DAYMET, NCDC 10% higher than tower forcing
- Princeton similar
- NARR, NCEP family, ECMWF 20-30% high bias
- Interannual patterns largely coherent among methods

# Modeling results: discussion and caveats

- Results are strongly dependent on site
  - Sensitivity of fluxes to forcing differences
    - Will depends on limiting factors (e.g. is the site water limited?)
    - Will depend on timing, maybe lagged effects
  - Amount of gap-filled data, differences among datasets
  - Consistent themes:
    - High SW radiation bias among reanalysis datasets → GPP bias
    - Wintertime precipitation measured at sites often too low

- Results are strongly dependent on model structure
  - Equilibrated fast soil C pools in LoTEC, kept slow pools constant
  - Less variation in NEE among methods if full spinup
  - However – GPP biases should be consistent due to SW bias

# Conclusions

- Modeled interannual NEE/GPP is sensitive to:
  - Gap-filling technique
  - Relatively small local climate variations (e.g., tower vs. NCDC station)
  - Variations among reanalysis datasets
- Reanalysis shortwave radiation data display large biases
  - Large impacts on GPP, variable impacts on NEE
- Modeled interannual flux patterns can depend on forcing datasets
- More work to quantify uncertainty across sites and models
  - New NACP analysis to study these effects
  - Likely 5-10 models at 5-10 sites, voluntary effort