Process contributions of Australian ecosystems to interannual variations in the carbon cycle

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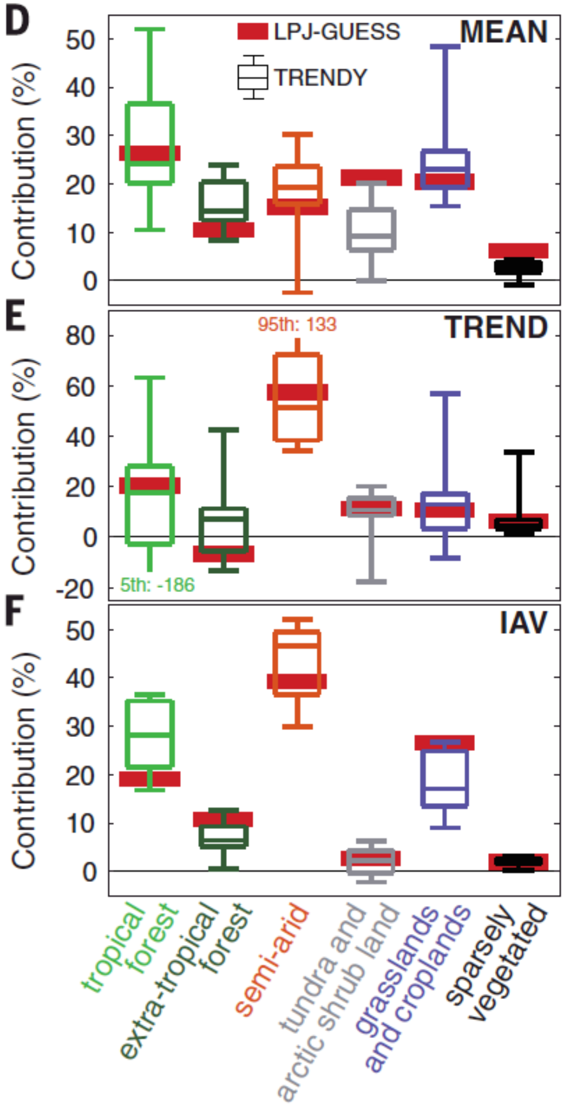
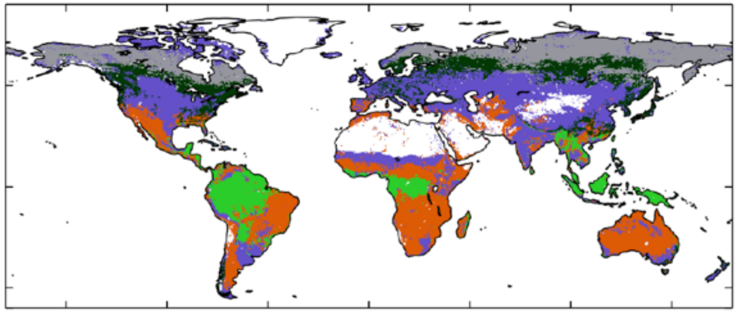
Vanessa Haverd, Cathy Trudinger, Ben Smith, Lars Nieradzik,
Peter Briggs, Pep Canadell

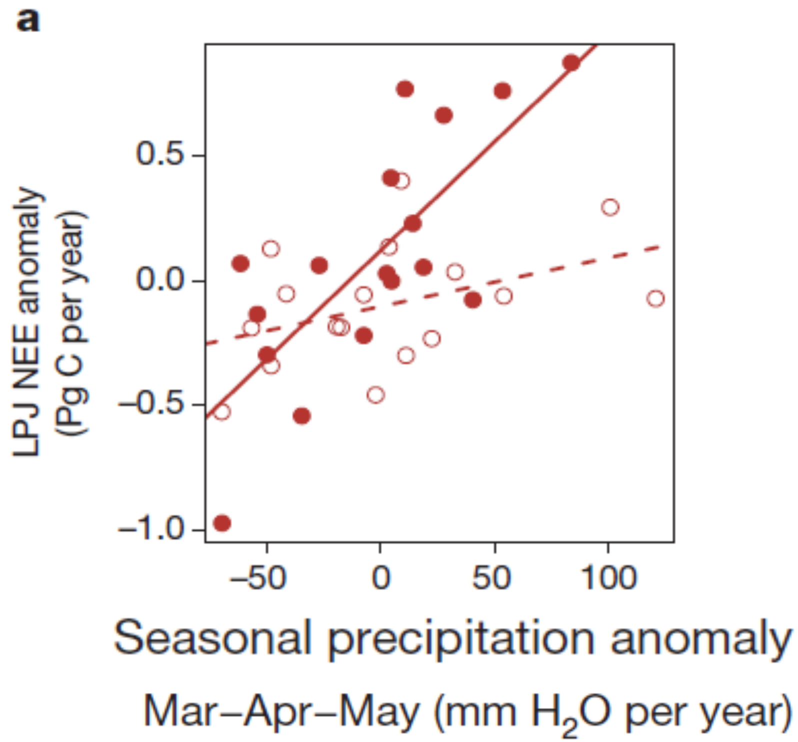
Ahlström, A. *et al.* The dominant role of semi-arid ecosystems in the trend and variability of the land CO2 sink. *Science* 348, 895-899 (2015)





Poulter, B. *et al.* Contribution of semi-arid ecosystems to interannual variability of the global carbon cycle. *Nature* 509, 600-603 (2014)

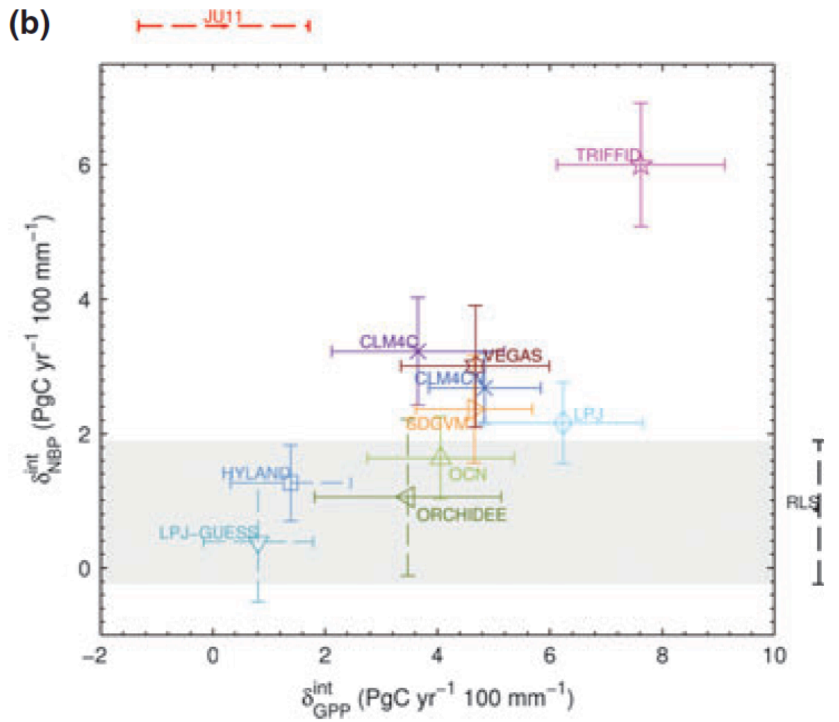
- Record global carbon uptake anomaly in 2011
- Australian ecosystems:
  - contributed 57% of 2011 anomaly of 1.5 ± 0.9 [1σ] Pg C
  - have entered a regime of enhanced sensitivity to rainfall since the mid-1990s.
- Lag between production and decomposition amplifies interannual variability of net carbon uptake.



"fourfold increase in net carbon uptake sensitivity to precipitation" (comparing 1982-1996;1997-2011)

Piao, S. *et al.* Evaluation of terrestrial carbon cycle models for their response to climate variability and to CO2 trends. *Global Change Biology* 19, 2117-2132 (2013).

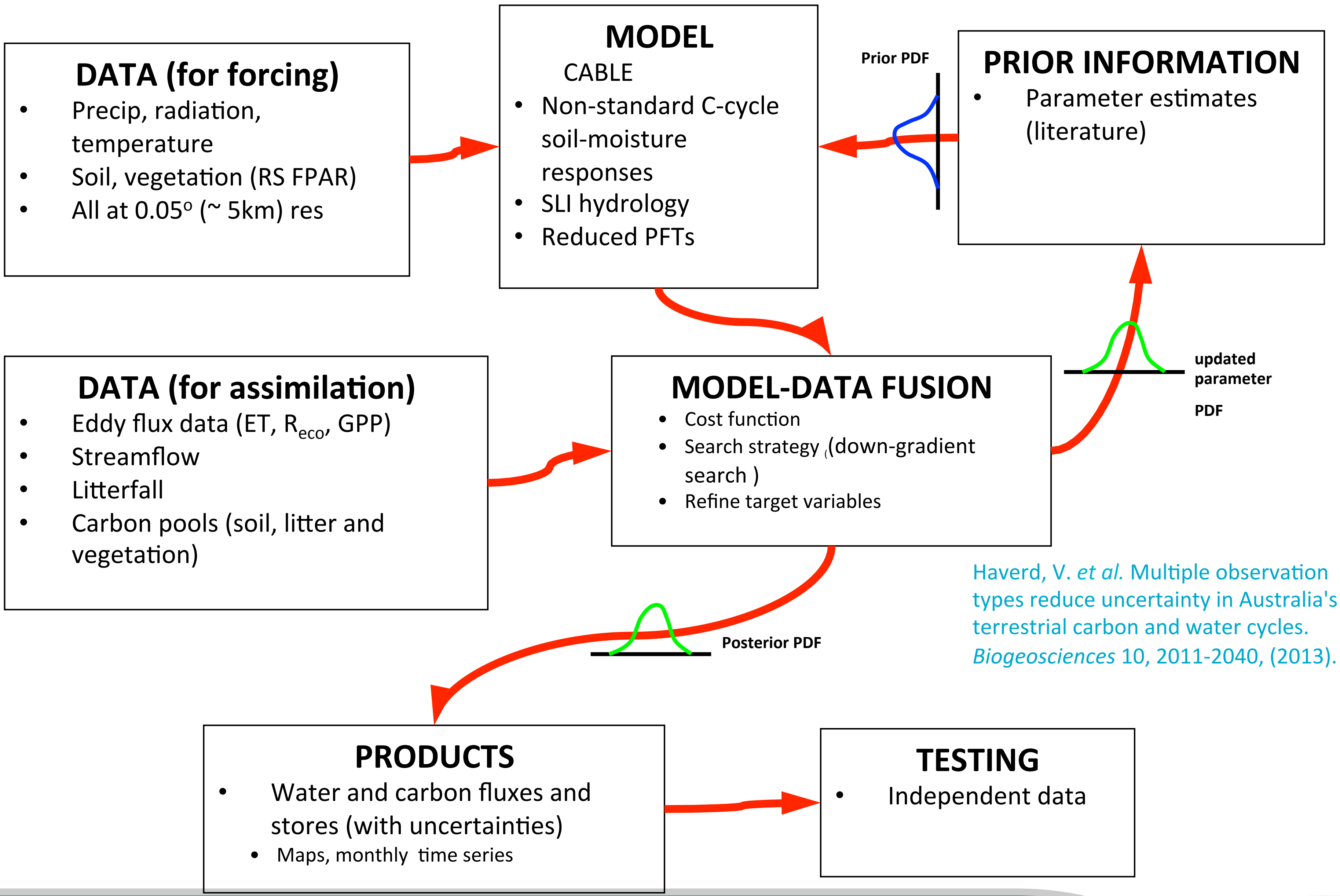
Sensitivity of Global Gross Primary Productivity to Precip



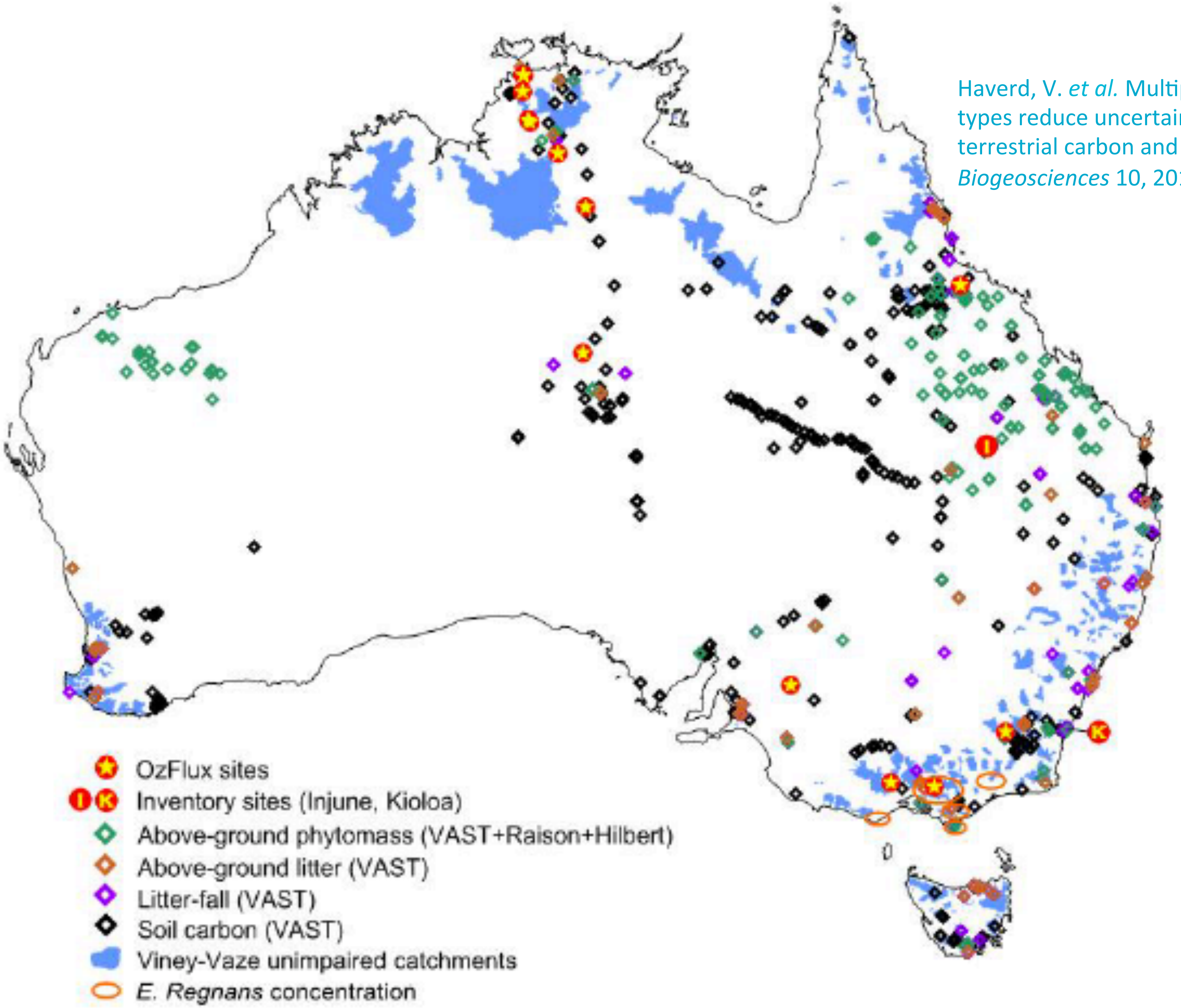
Sensitivity of Global Net Biome Productivity to Precip

Objectives

- Quantify interannual variability (IAV) of Australian Net Ecosystem Production and magnitude of 2011 anomaly
- Attribute IAV spatially and by process
- Quantify sensitivity of Australian Net Ecosystem Production to precipitation anomalies
- Demonstrate transfer of vegetation drought response from Australian to global context.

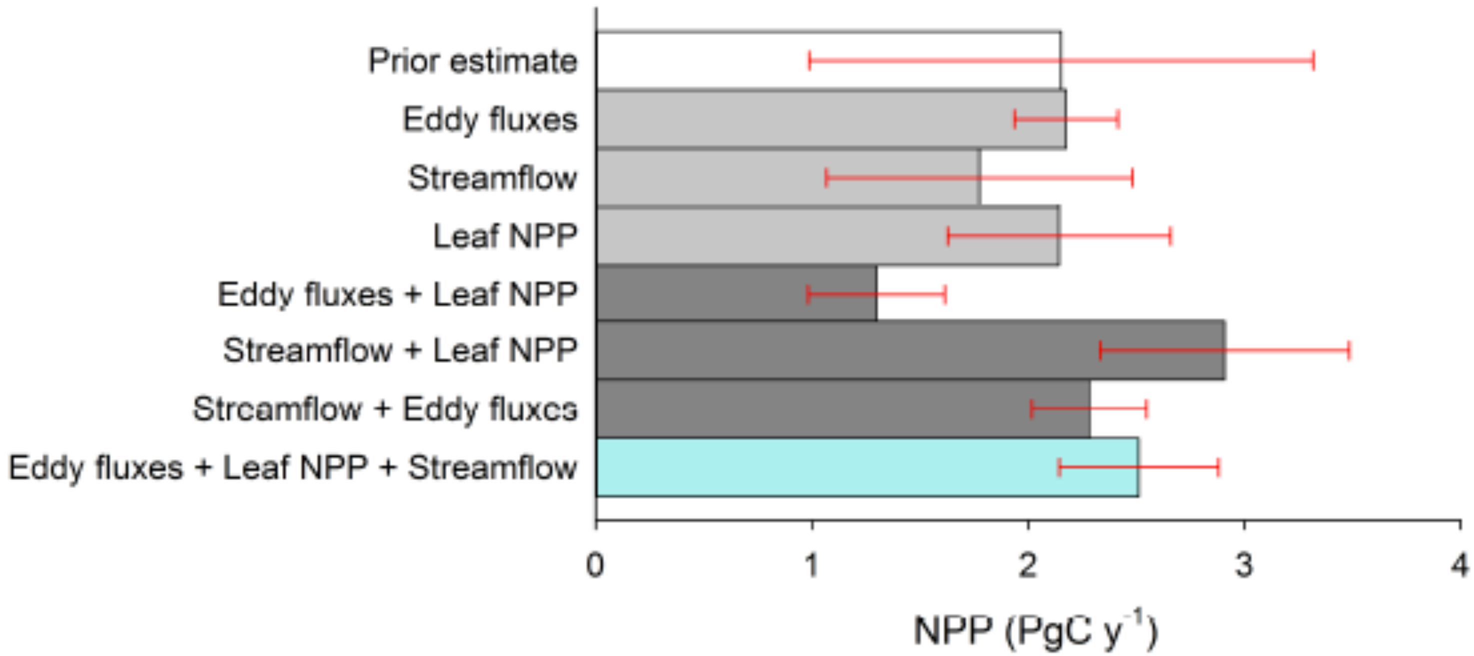


Haverd, V. *et al.* Multiple observation types reduce uncertainty in Australia's terrestrial carbon and water cycles. *Biogeosciences* 10, 2011-2040, (2013).



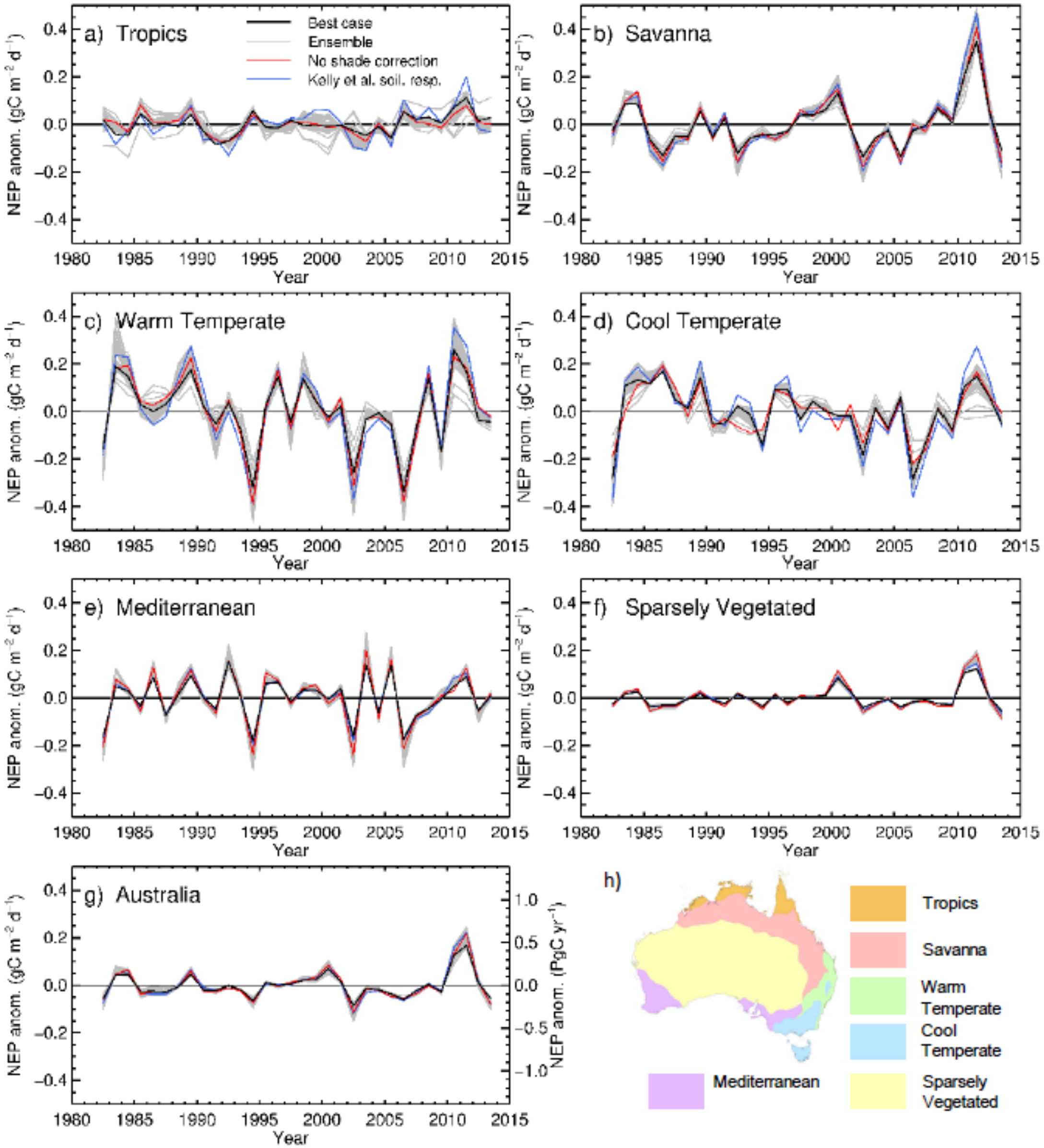
Haverd, V. *et al.* Multiple observation types reduce uncertainty in Australia's terrestrial carbon and water cycles. *Biogeosciences* 10, 2011-2040, (2013).

Multiple observation types reduce uncertainty in Australian continental NPP



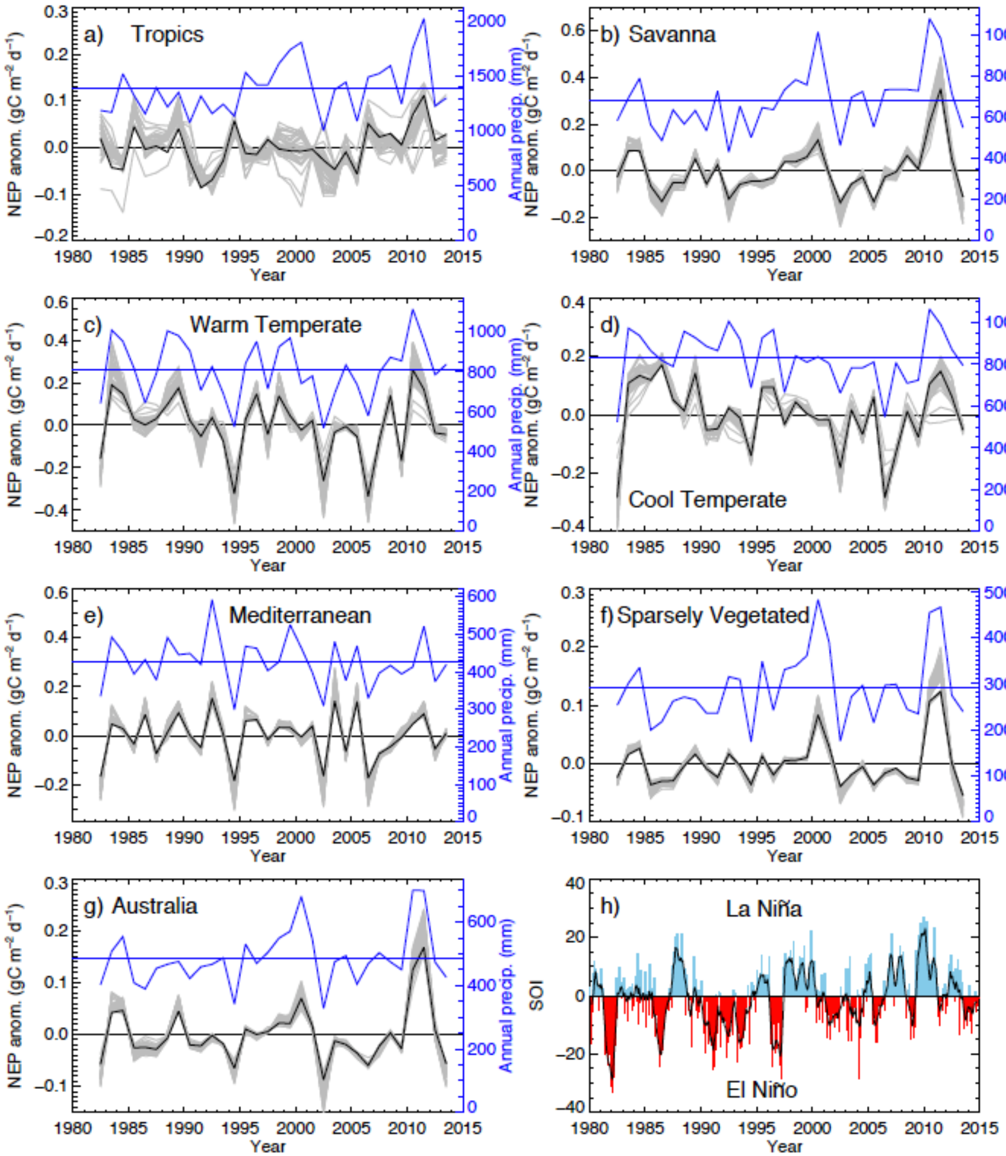
Haverd, V. *et al.* Multiple observation types reduce uncertainty in Australia's terrestrial carbon and water cycles. *Biogeosciences* 10, 2011-2040, (2013).

Interannual variability in Australia's terrestrial carbon cycle constrained by multiple observation types



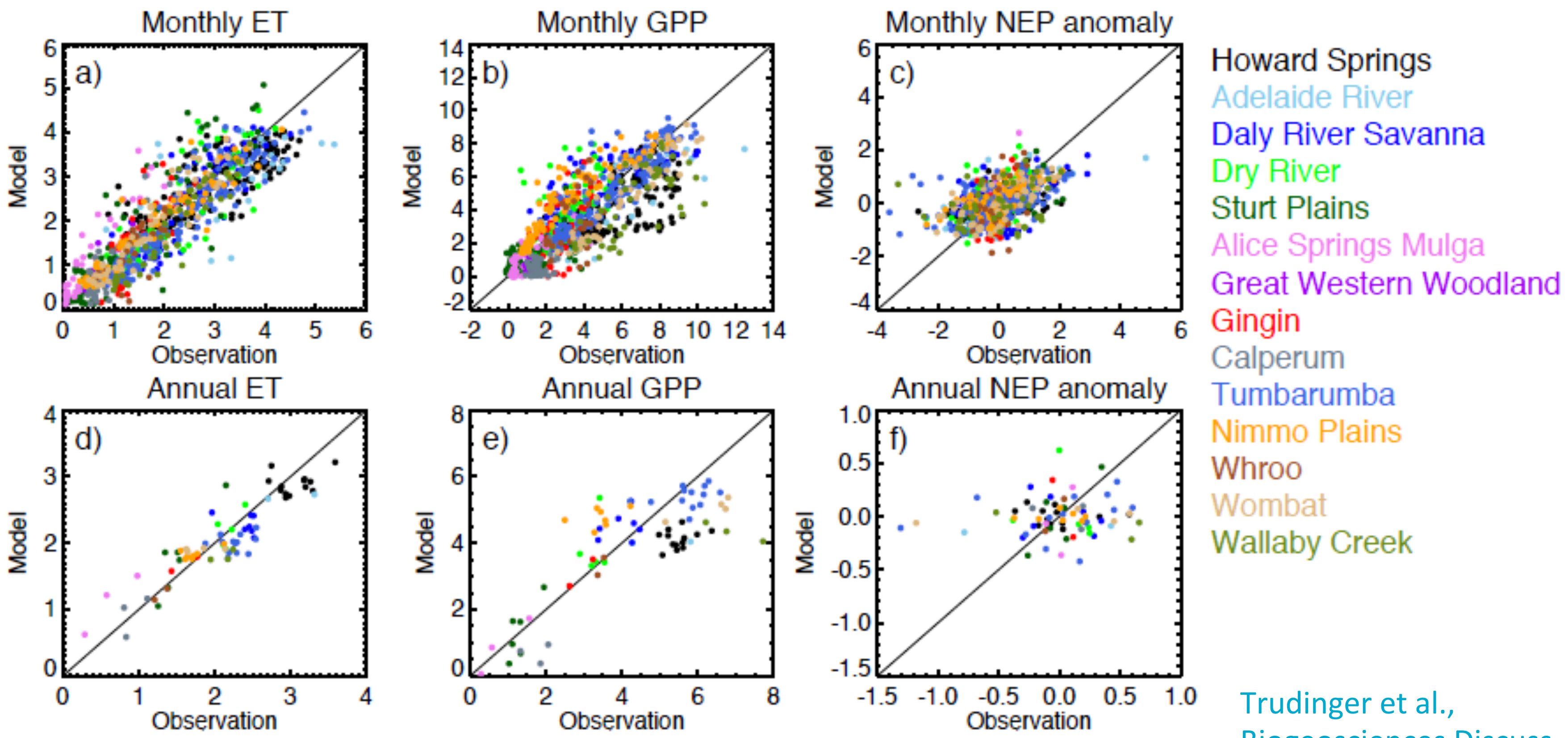
Trudinger et al., Biogeosciences Discuss., doi:10.5194/bg-2016-186, 2016

Interannual variability in Australia's terrestrial carbon cycle constrained by multiple observation types



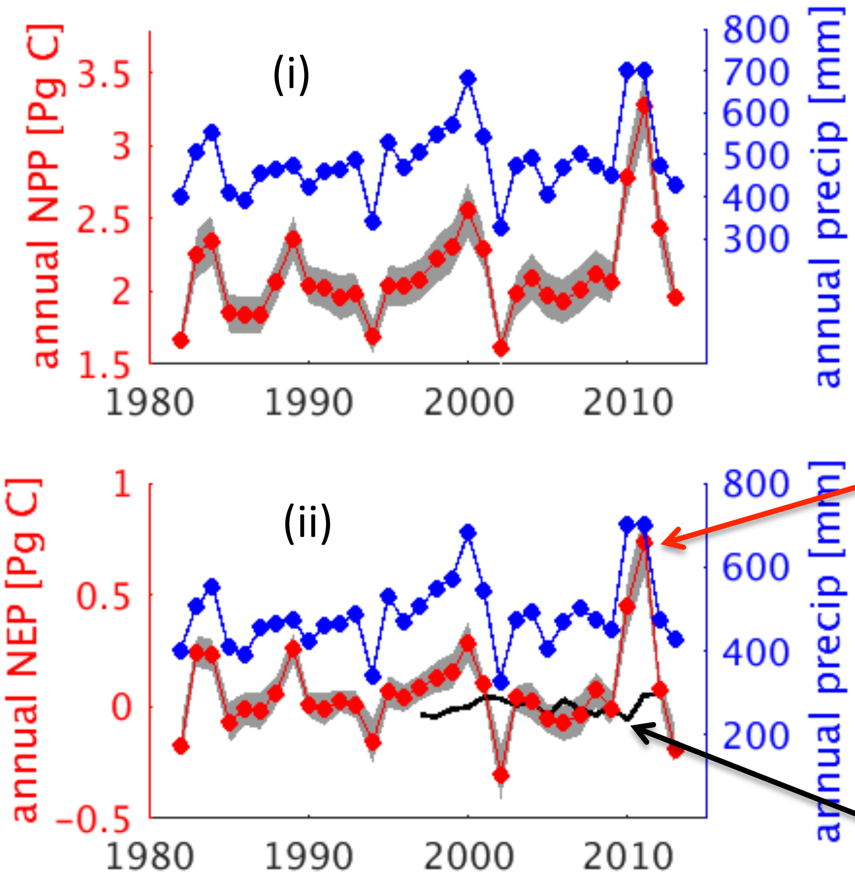
Trudinger et al., Biogeosciences Discuss., doi:10.5194/ bg-2016-186, 2016

Model-obs comparison: monthly and annual fluxes at 14 sites



Trudinger et al., Biogeosciences Discuss., doi:10.5194/bg-2016-186, 2016

Interannual variability in Australian vegetation productivity and net carbon uptake



Haverd et al., Env. Res. Lett., 11, 054013, 2016

Terrestrial ecosystems in Australia absorbed 0.6±0.2 [2σ] Pg C in 2011 or 40% of the record global residual land sink anomaly

Gross Fire Emissions Anomaly (GFED4)

Quantifying the contribution of partial time series anomaly to total time series anomaly

partial time series

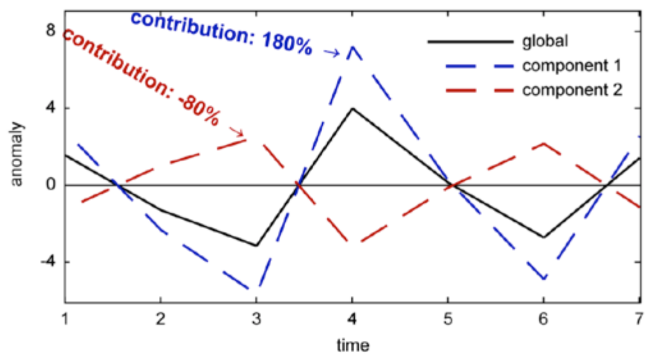
contribution

$$f_j = \frac{\sum_t \frac{x_{jt} |X_t|}{X_t}}{\sum_t |X_t|}$$

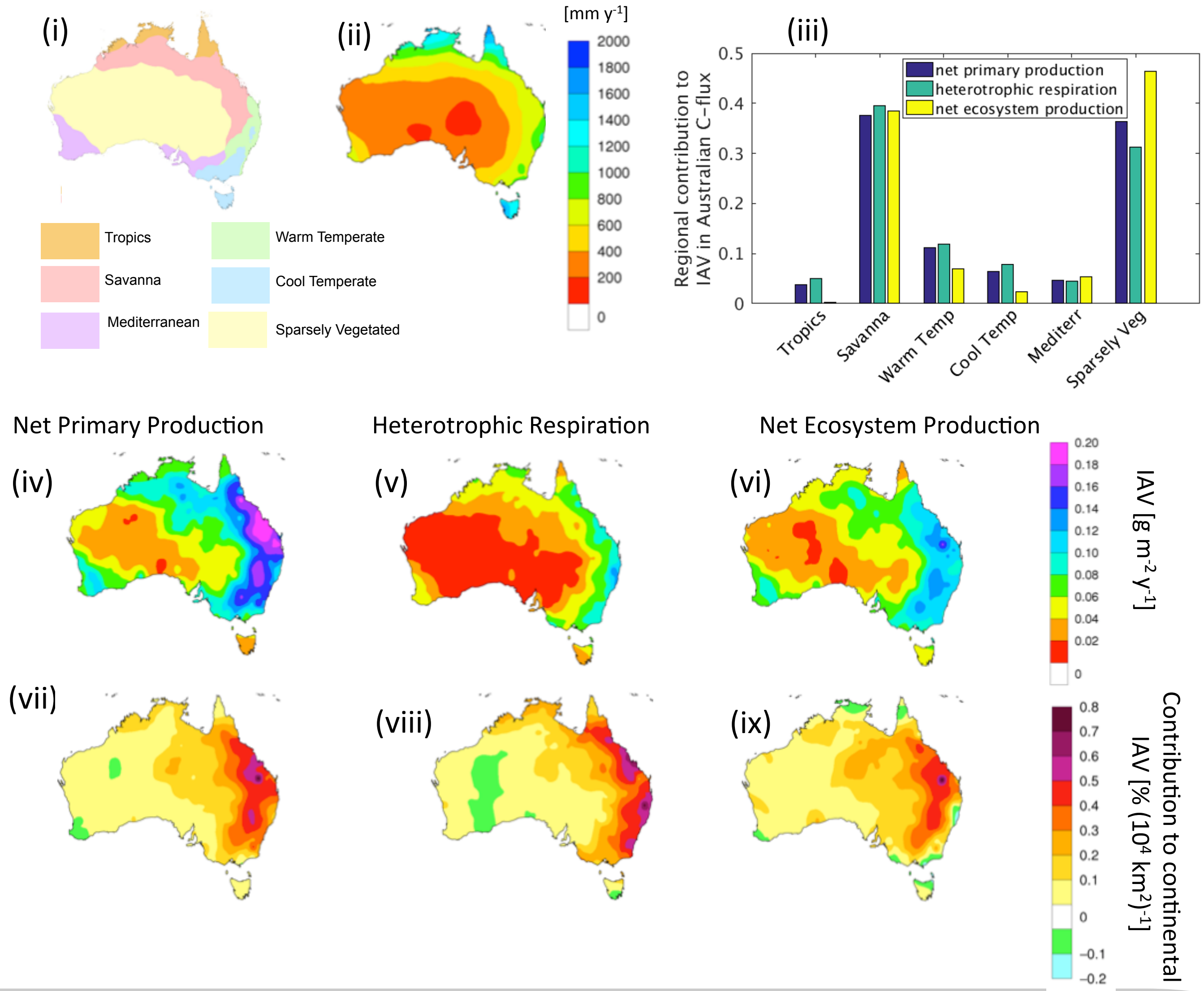
total time series

Ahlström, A. *et al. Science* 348, 895-899 (2015)

- contributions sum to one
- +ve contributions reflect correlation with total time series
- -ve contributions reflect negative correlation with total time series

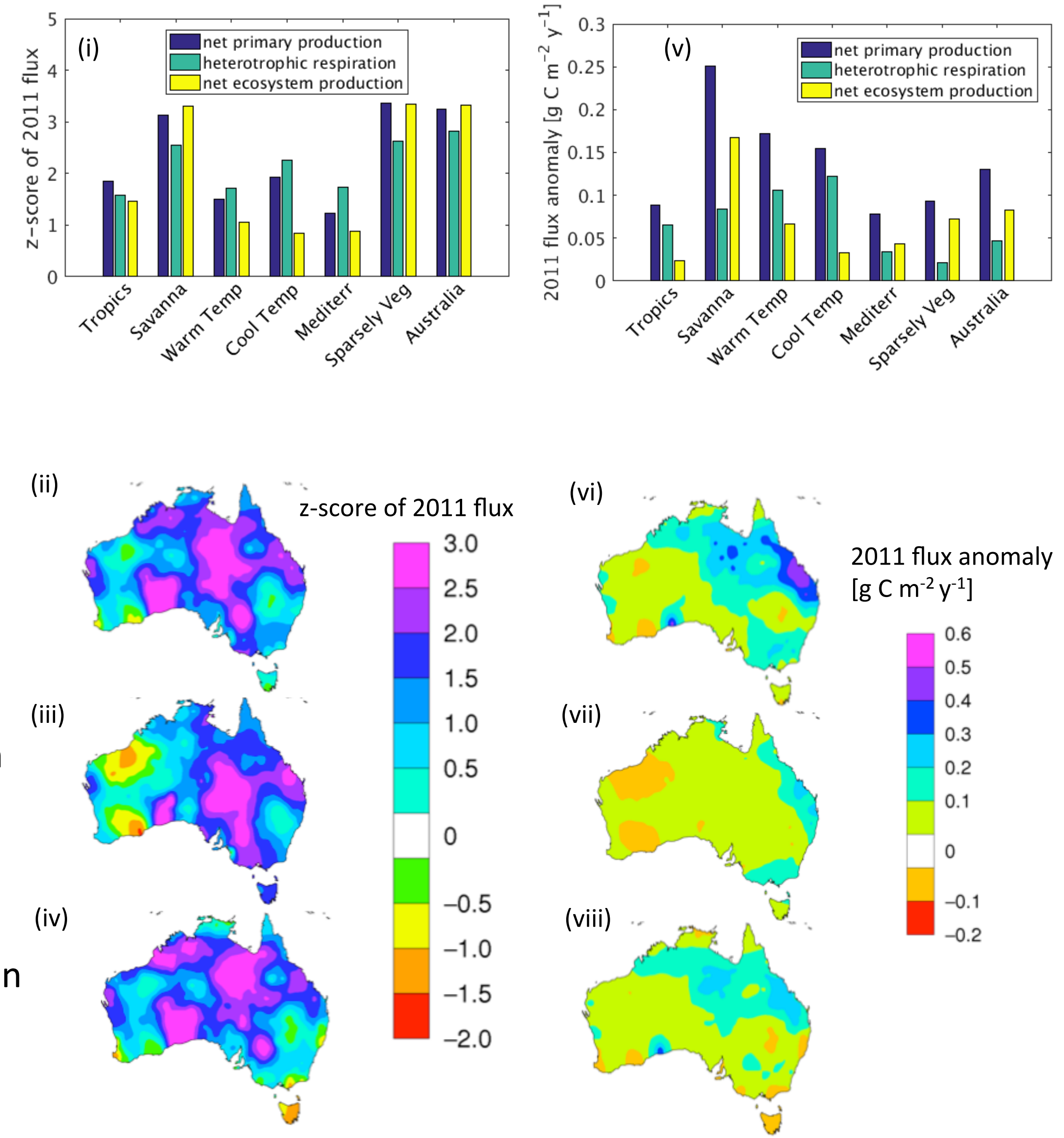


Regional Contributions to Interannual Variability of C-fluxes dominated by semi-arid ecosystems: “Savanna” and “Sparsely Vegetated”



Haverd et al., Env. Res. Lett., 11, 054013, 2016

Extremeness of 2011 C-fluxes highest in Semi-Arid Regions



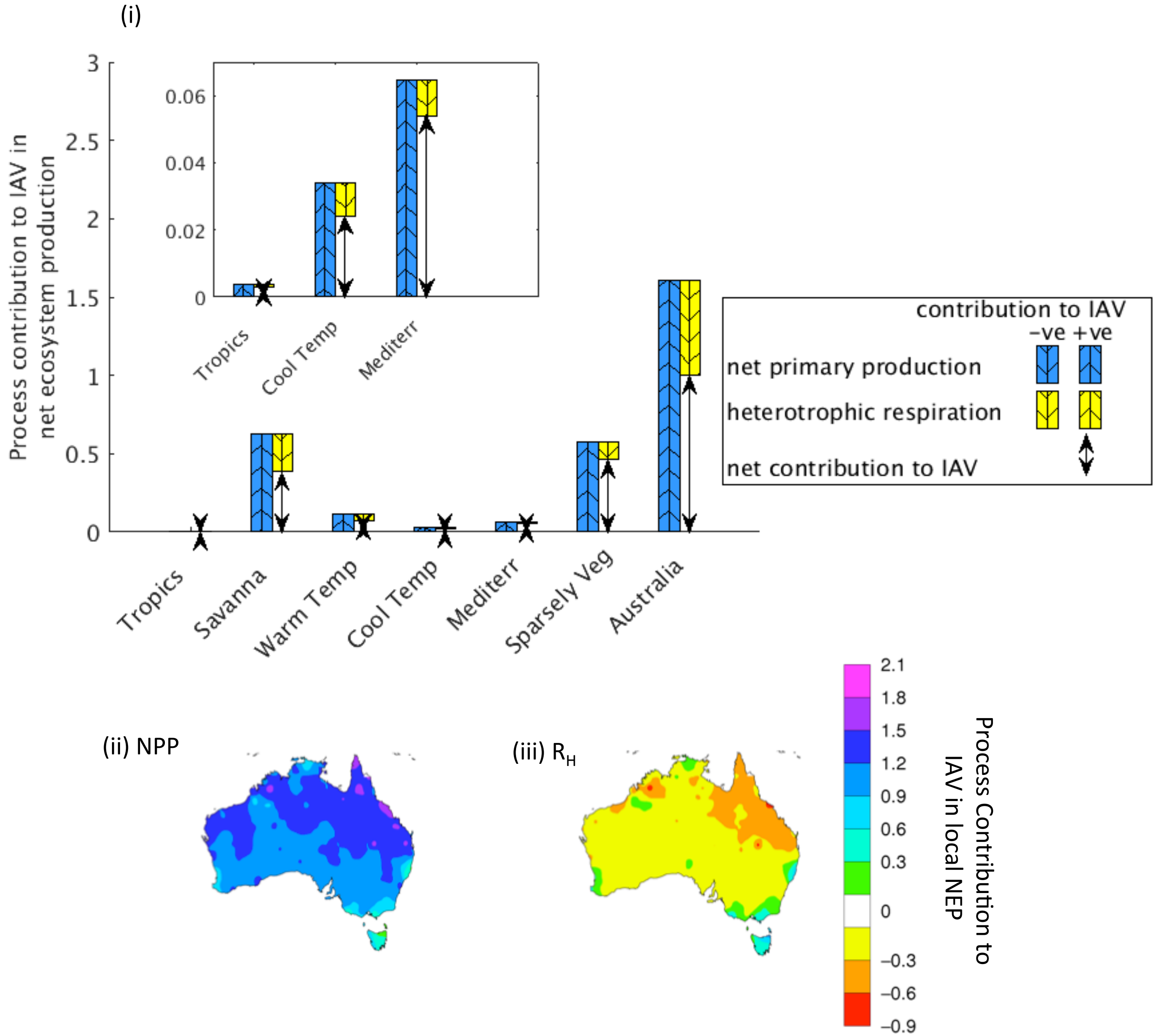
Net Primary Production

Heterotrophic Respiration

Net Ecosystem Production

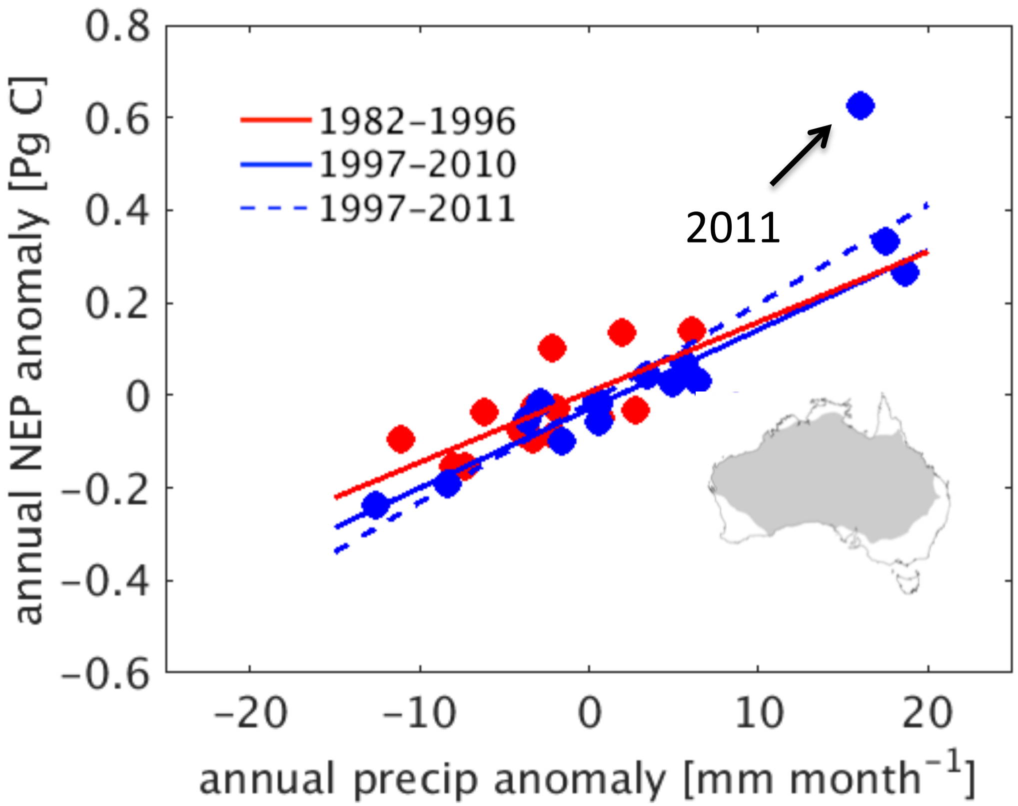
Haverd et al., Env. Res. Lett., 11, 054013, 2016

Variability in decomposition offsets variability in production at continental scale



Haverd et al., Env. Res. Lett., 11, 054013, 2016

Dryland vegetation response to wet episode, not inherent shift in sensitivity to rainfall, behind Australia's role in 2011 global carbon sink anomaly



1997-2010: $(1.7\pm0.1)\times10^{-2}$ PgC mm^{-1} month

1982-1996: $(1.5\pm0.4)\times10^{-2}$ PgC mm^{-1} month

Haverd et al., Global Change Biology, doi: 10.1111/gcb.13202 2016

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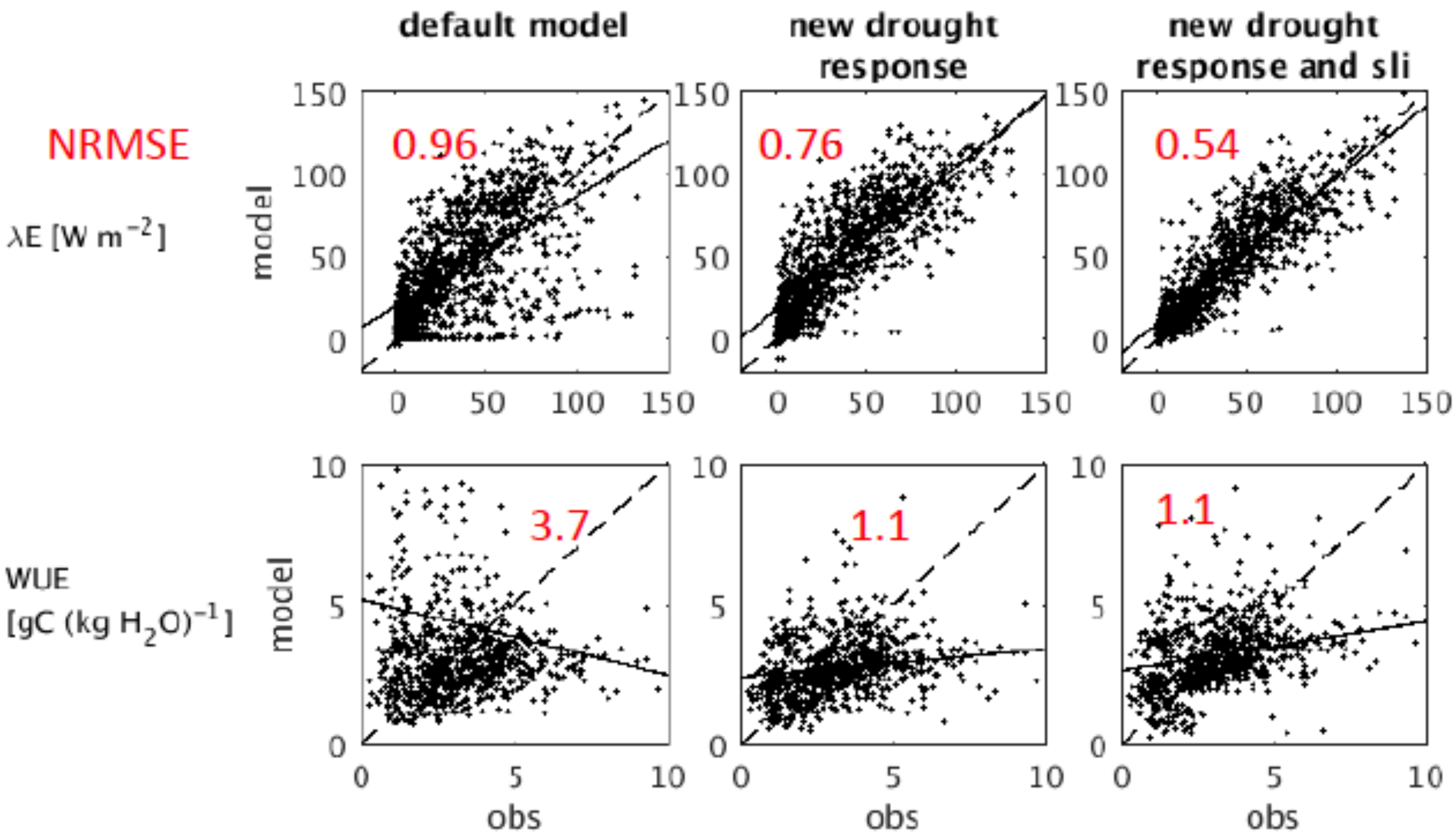
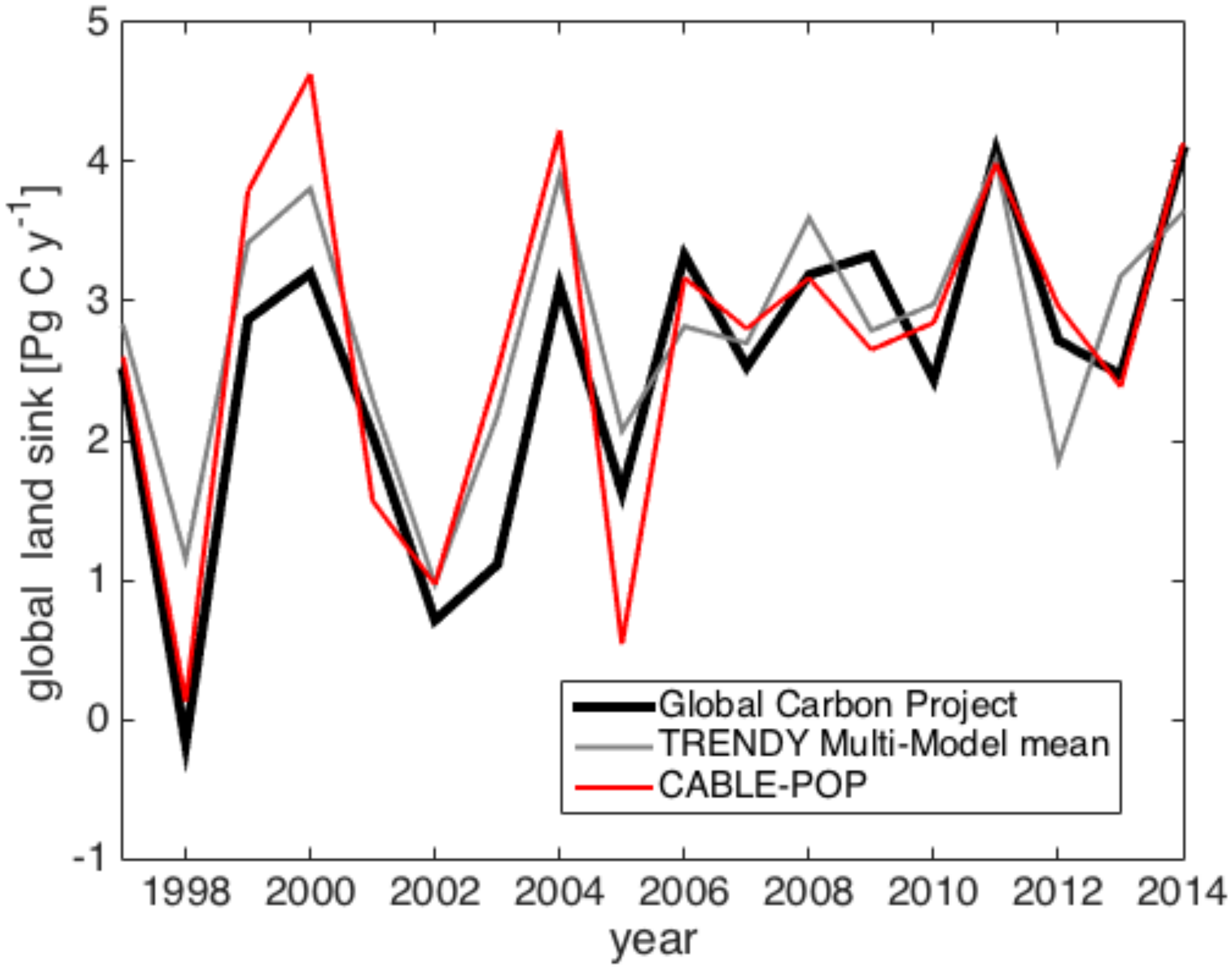
Transfer of drought response and soil evaporation from Australian regional modelling improve CABLE ET predictions at global Fluxnet sites



Haverd et al, Geosci. Model Dev. Discuss., 2016, 1-24, 2016.

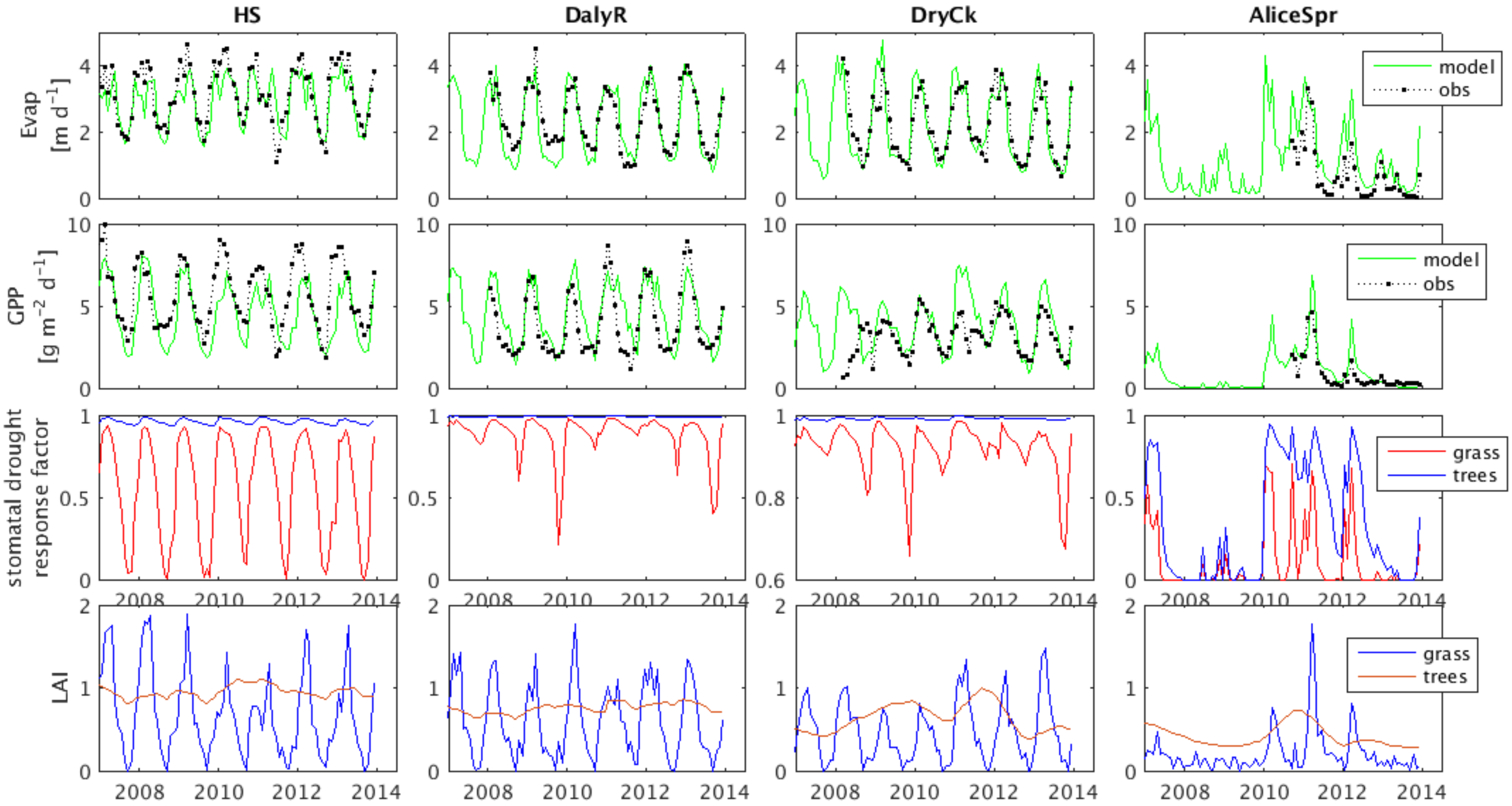
Transfer of drought response from Australian regional modelling helps to give good predictions of IAV in global terrestrial carbon uptake.



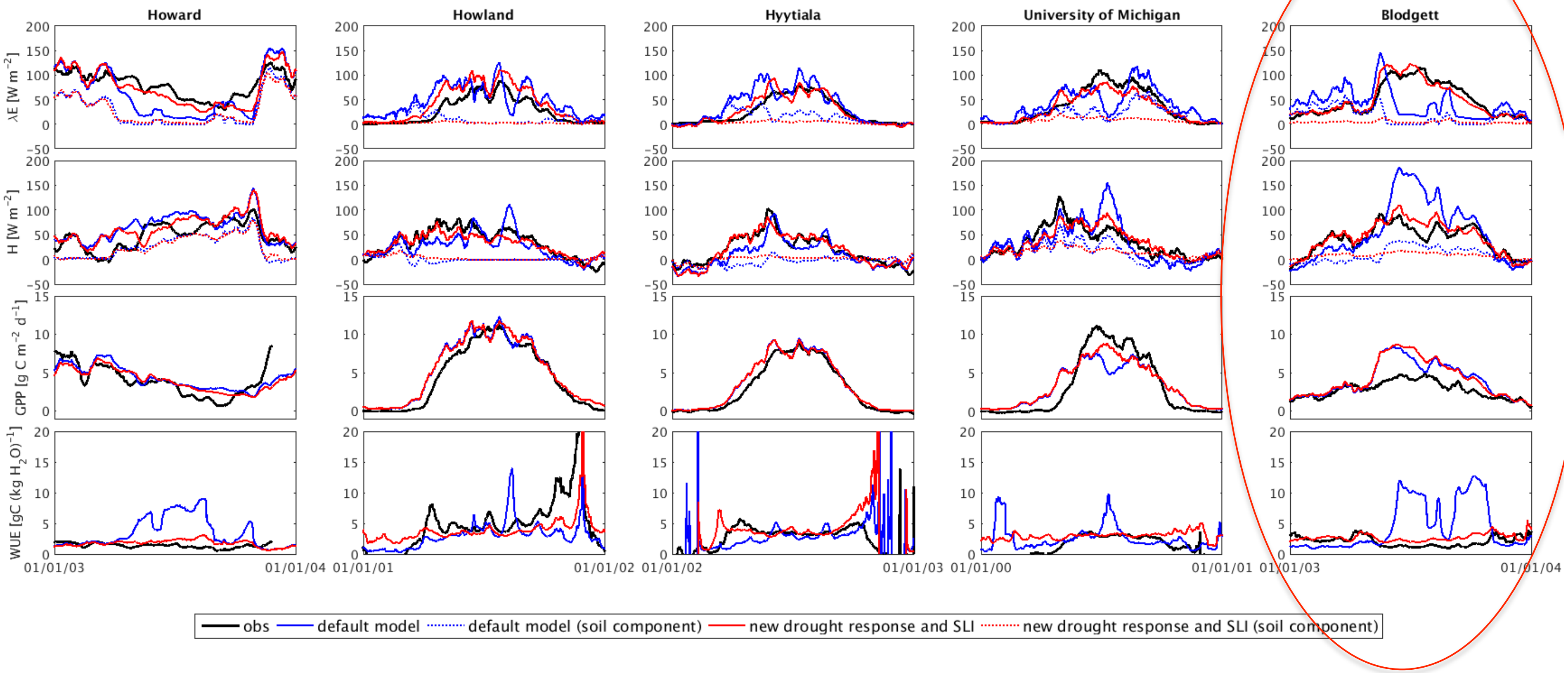
Summary

- Spatially, IAV contributions dominated by Eastern savannas
- By process, IAV contributions dominated by NPP, significantly offset by Rh, and negligibly influenced by fire.
- 2011 anomaly in Australian NEP (40% of record global sink) wide-spread across northern third of the continent.
- No evidence of inherent shift in the sensitivity of vegetation activity to moisture availability.
- Transfer of drought response from Australian regional modelling helps to give good predictions of IAV in global terrestrial carbon uptake.

Seasonal Drought: Northern Australian Tropical Transect



Alternate drought response and SLI hydrology improve CABLE ET predictions at global Fluxnet sites: examples



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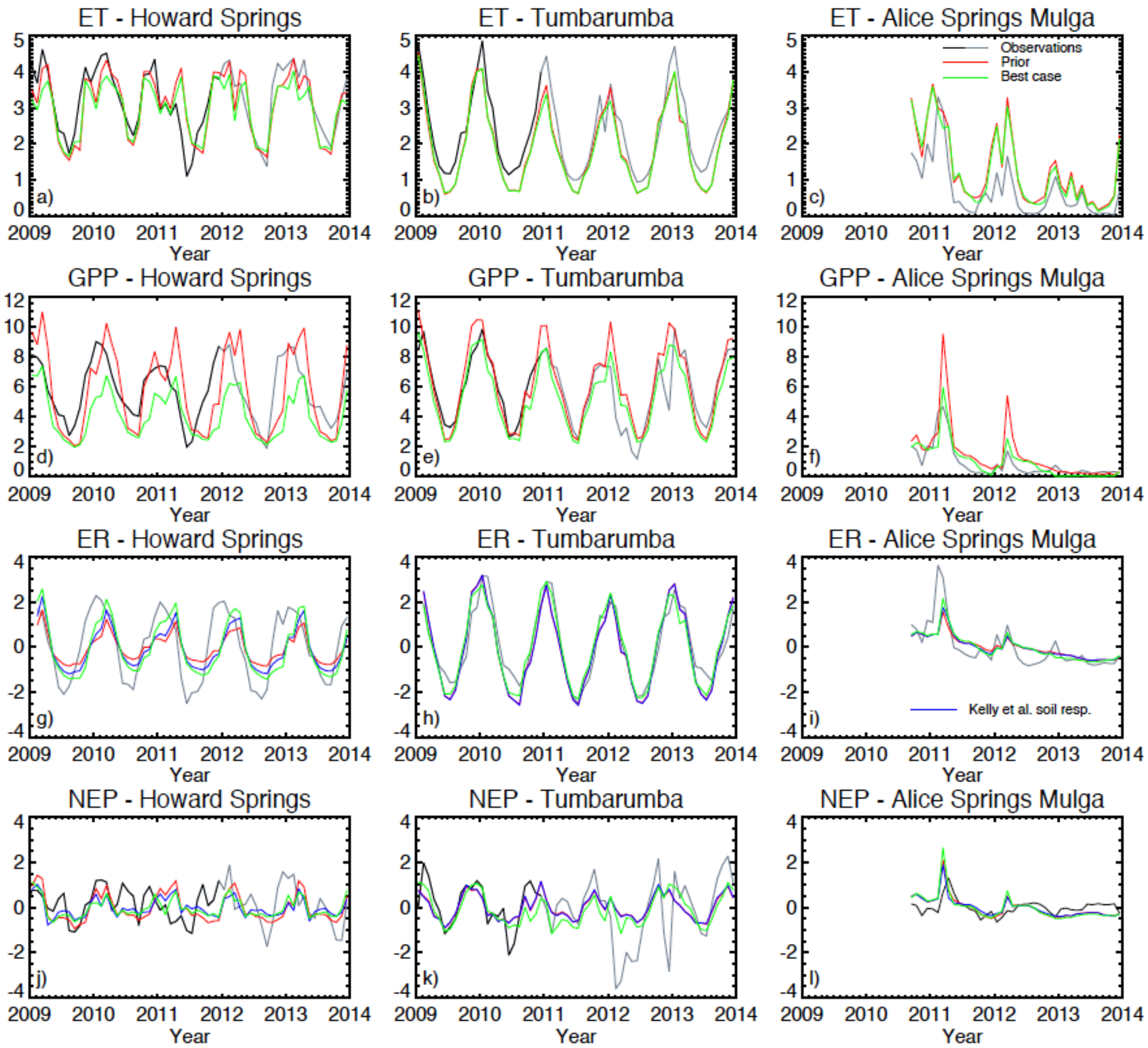
Model-obs comparison: monthly fluxes



Trudinger et al., Biogeosciences Discuss., doi:10.5194/bg-2016-186, 2016