Parameter estimation for Cabledyn and CASA-CNP in BIOS2

Cathy Trudinger and Vanessa Haverd

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BIOS2

- Haverd et al. (2013) implementation of CABLE (Cabledyn) and CASA-CNP for Australia, 5x5 km grid, daily meteorology (downscaled using a weather generator).
- SLI soil model and other modifications (see Haverd et al. (2013))
- Each cell is partitioned into woody and grassy tiles (not using PFTs).
- Cabledyn and CASA-CNP calibrated separately.

PEST

- Levenberg-Marquardt method, down-gradient.
- Cost fn (Phi) = weighted squares of residuals (we choose weights of different observation groups so that each group contributes equally to Phi).
- Prior constraint on some parameters.
- Used PEST's linear analysis tools including Null Space Monte Carlo.
- http://www.pesthomepage.org/

Equifinality (null space)

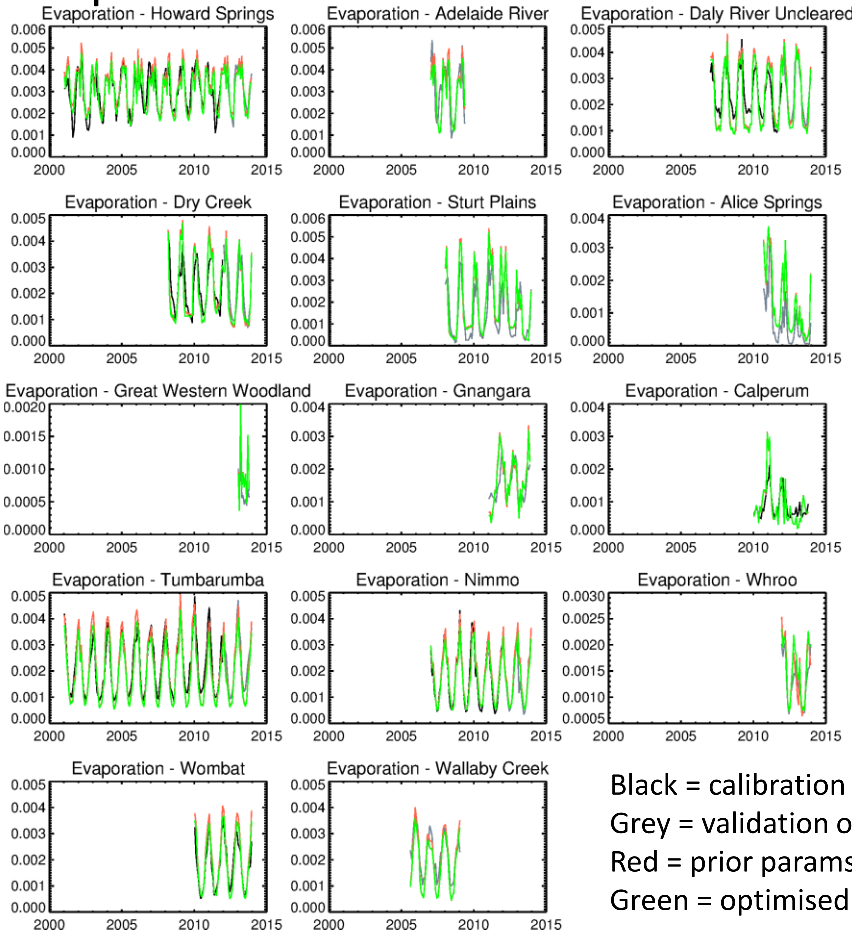
- Under-determined problem – no unique, correct parameter set, multiple parameter combinations can give an adequate match to observations.
- "Calibration solution space" = combinations of parameters informed by data. Errors in solution space parameter combinations are due to measurement noise.
- "Calibration null space" = combinations of parameters not informed by data.
- Best estimate of parameters in the null space is expert knowledge where available.
- Avoid manufacturing uniqueness where none exists (i.e. don't fix parameters to possibly incorrect values just because the available observations are not sensitive to them).

Cabledyn parameters optimized (18)

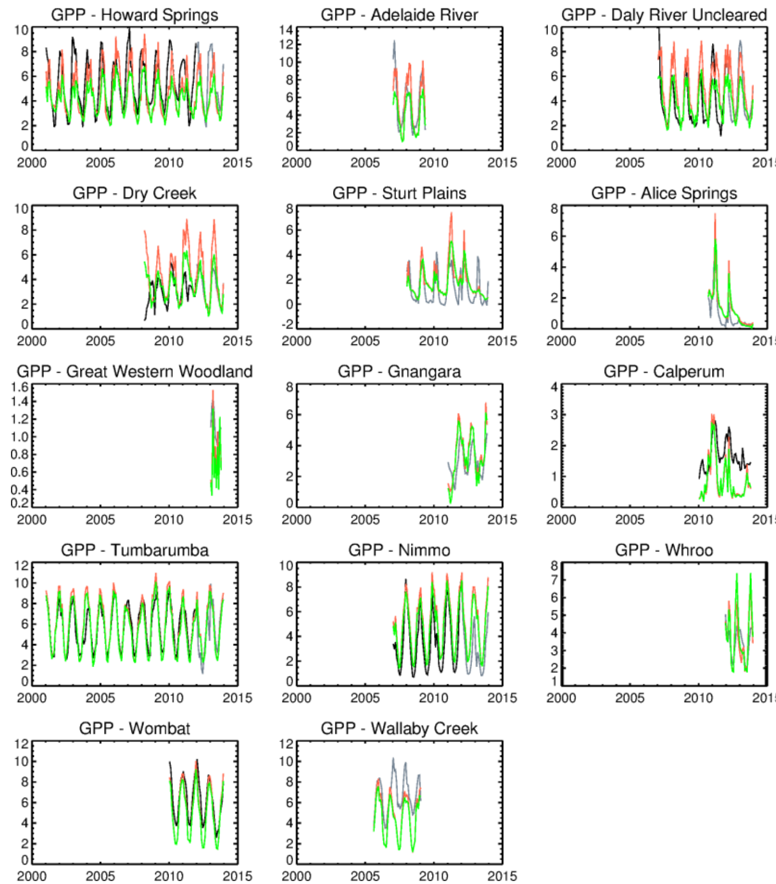
Parameter	Description
AllocLg, AllocLw	Allocation of C to leaves (grassy and woody)
ratiojv	Jmax/Vcmax
fsatmax	Multiplier for litter depth
dleaf_g, dleaf_w	Leaf length (grassy and woody)
vcmax_g, vcmax_w	Maximum RuBP carboxylation rate top leaf (grassy and woody)
hc_g, hc_w	Canopy height (grassy and woody)
f10_g, f10_w	Fraction of roots in top 10 cm (grassy and woody)
zr_g, zr_w	Maximum rooting depth (grassy and woody)
lgamma_g, lgamma_w	($\log_{10}$ of) parameter in root efficiency function (grassy and woody)
a1	Parameter in stomatal conductance function
ds0	Sensitivity of stomatal conductance to VPD

Observations for Cabledyn:

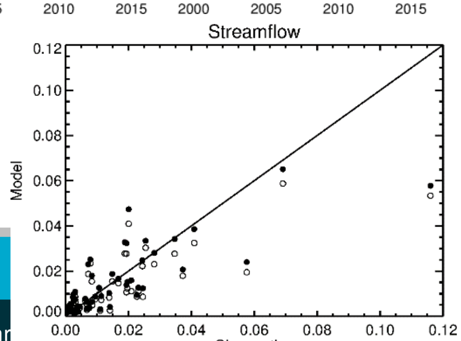
Evaporation

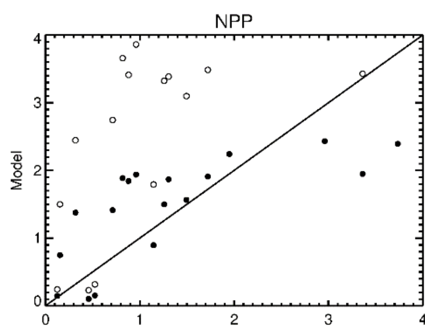


GPP



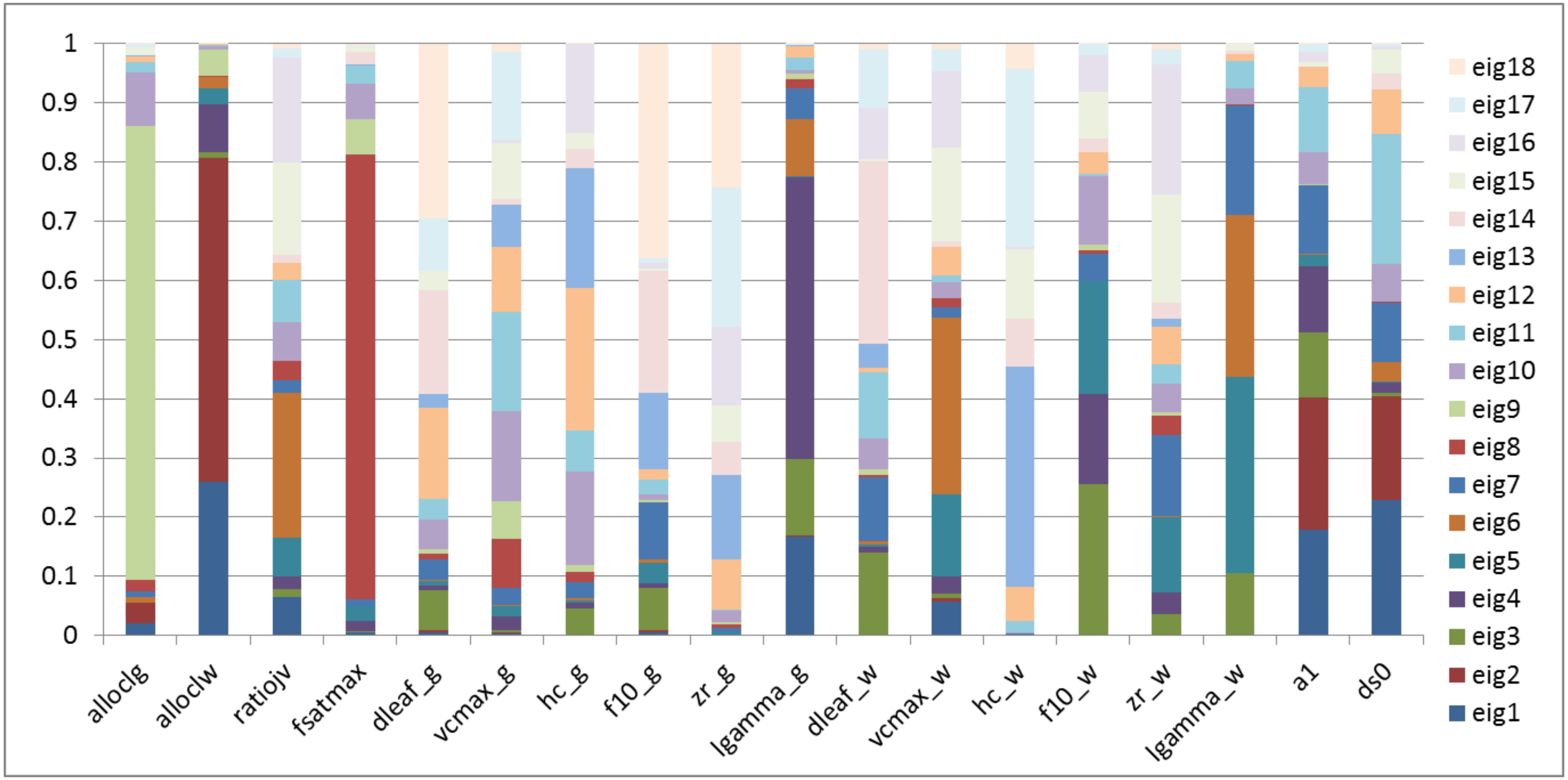
Black = calibration obs
Grey = validation obs
Red = prior params
Green = optimised params





Long-term averages:
Open circles = prior params
Closed circles = optimised params

Parameter identifiability (Cabledyn)



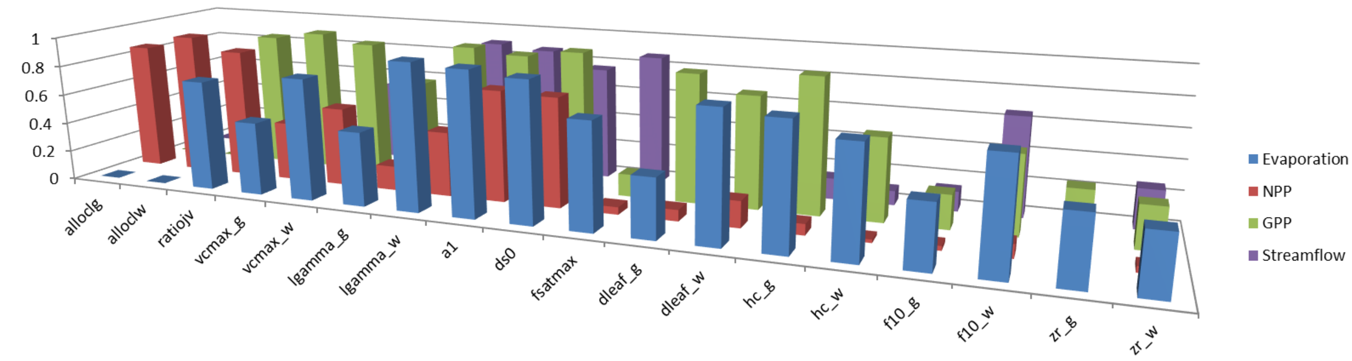
Identifiability from PEST's linear analysis tools.

Early eigenvectors (dark colours) are most identifiable, later eigenvectors are least identifiable (pastel colours).

Eigenvectors split across parameters = combinations of parameters are identifiable.

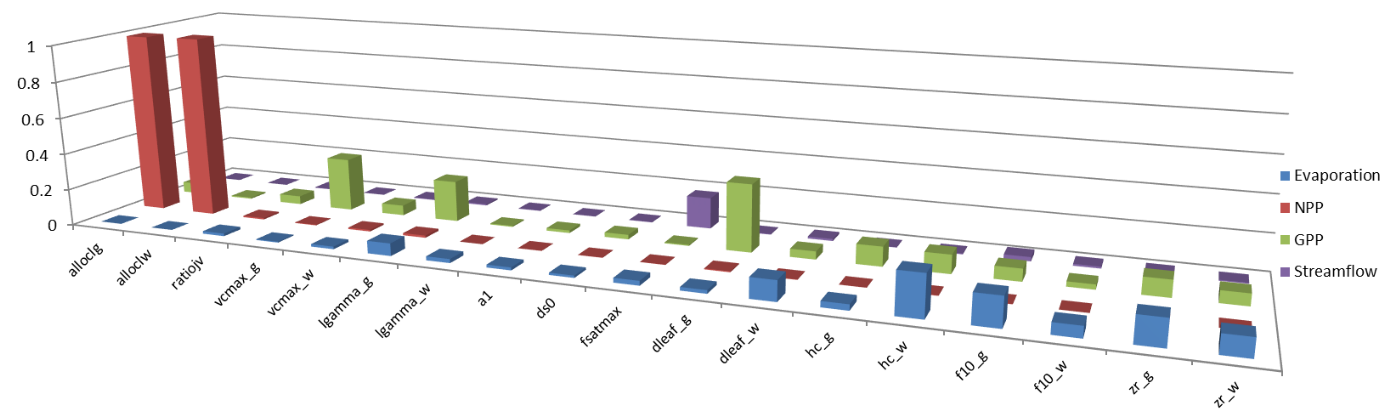
Observation worth (using PEST's linear analysis tools)

How does each observation group on its own decrease the pre-calibration uncertainty of each parameter:



Observation group addition (Decreases in pre-calibration predictive uncertainty variance incurred through addition of observations)

How does removing each observation group increase the post-calibration uncertainty of each parameter:



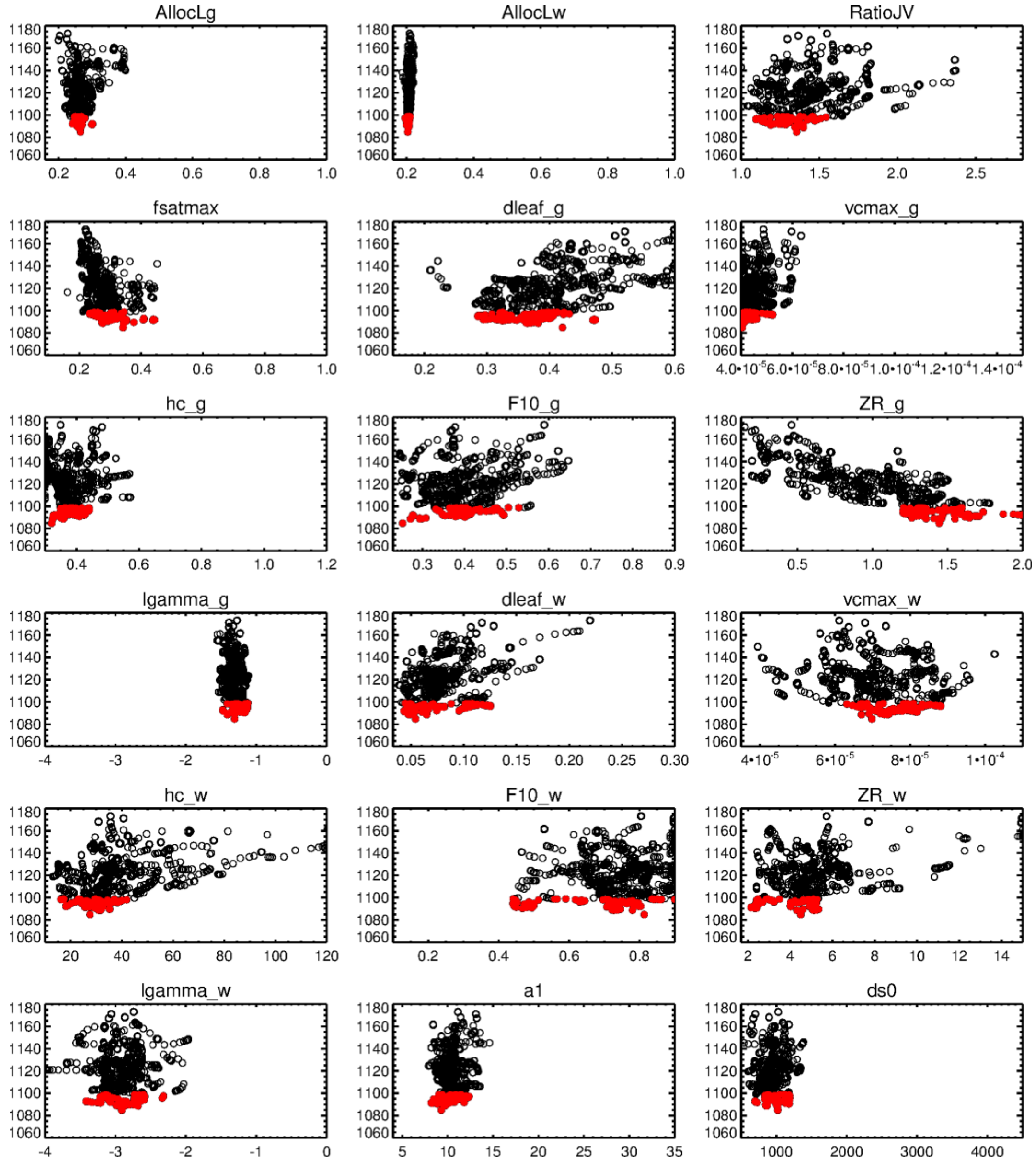
Observation group subtraction (Increases in predictive uncertainty variance incurred through loss of observations)

Null Space Monte Carlo

Null Space Monte Carlo is an efficient way to generate multiple parameter sets that are consistent with the observations. We can use these to quantify uncertainty due to parameter equifinality in model predictions.

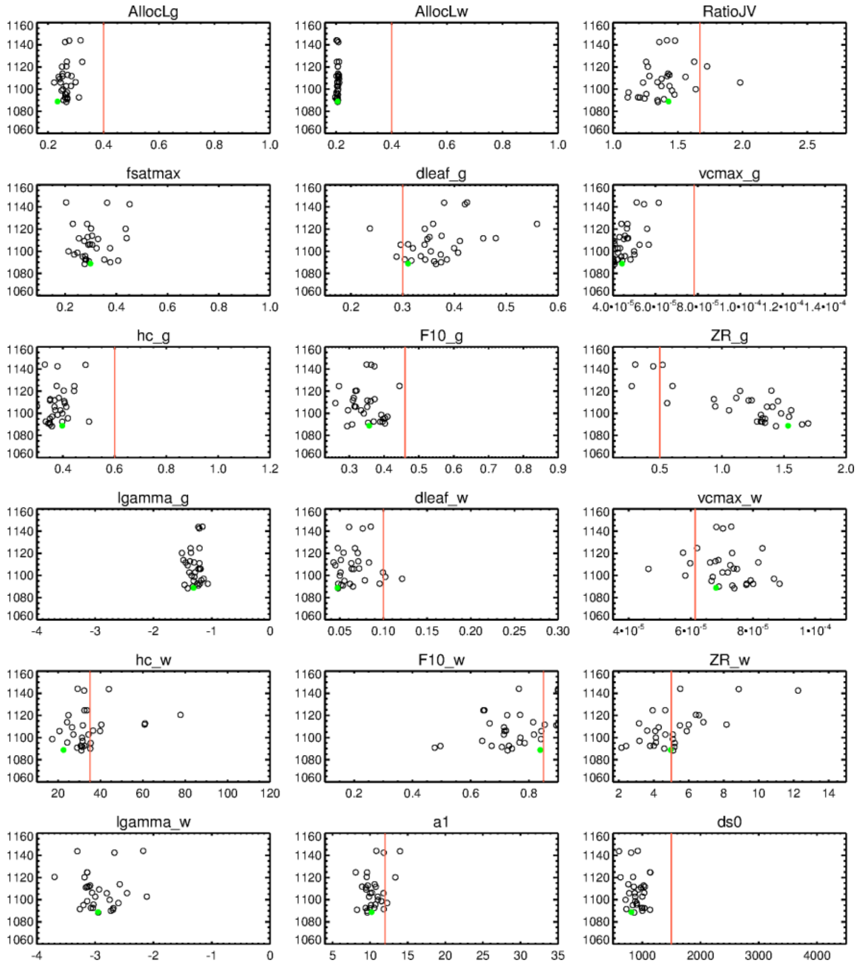
- Identify the null-space of the model's parameter field (from sensitivities).
- Generate many stochastic realizations of model parameters.
- Project realizations onto null- and calibration spaces. Retain null-space component, replace solution space component with that of the calibrated model.
- Recalibrate stochastic parameter sets (few iterations required, due to non-linearities and an indistinct boundary between solution- and null-spaces).

- All Cabledyn parameter sets tested while recalibrating the NSMC parameter sets.
- Vertical axis is Phi. Horizontal axis is parameter value (range corresponds to prior range).
- Red symbols show parameter sets with Phi up to 1.3% above the best Phi.
- Some parameters tightly clustered, others quite widely spread **relative to prior range.**



30 NSMC parameter sets after recalibration

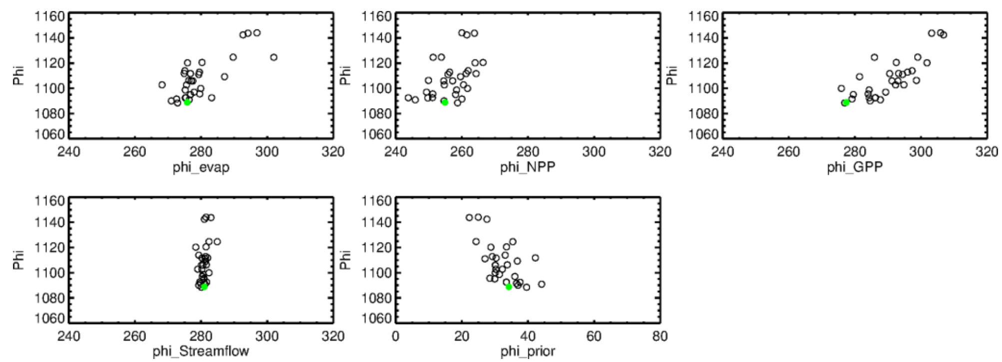
Phi vs parameters



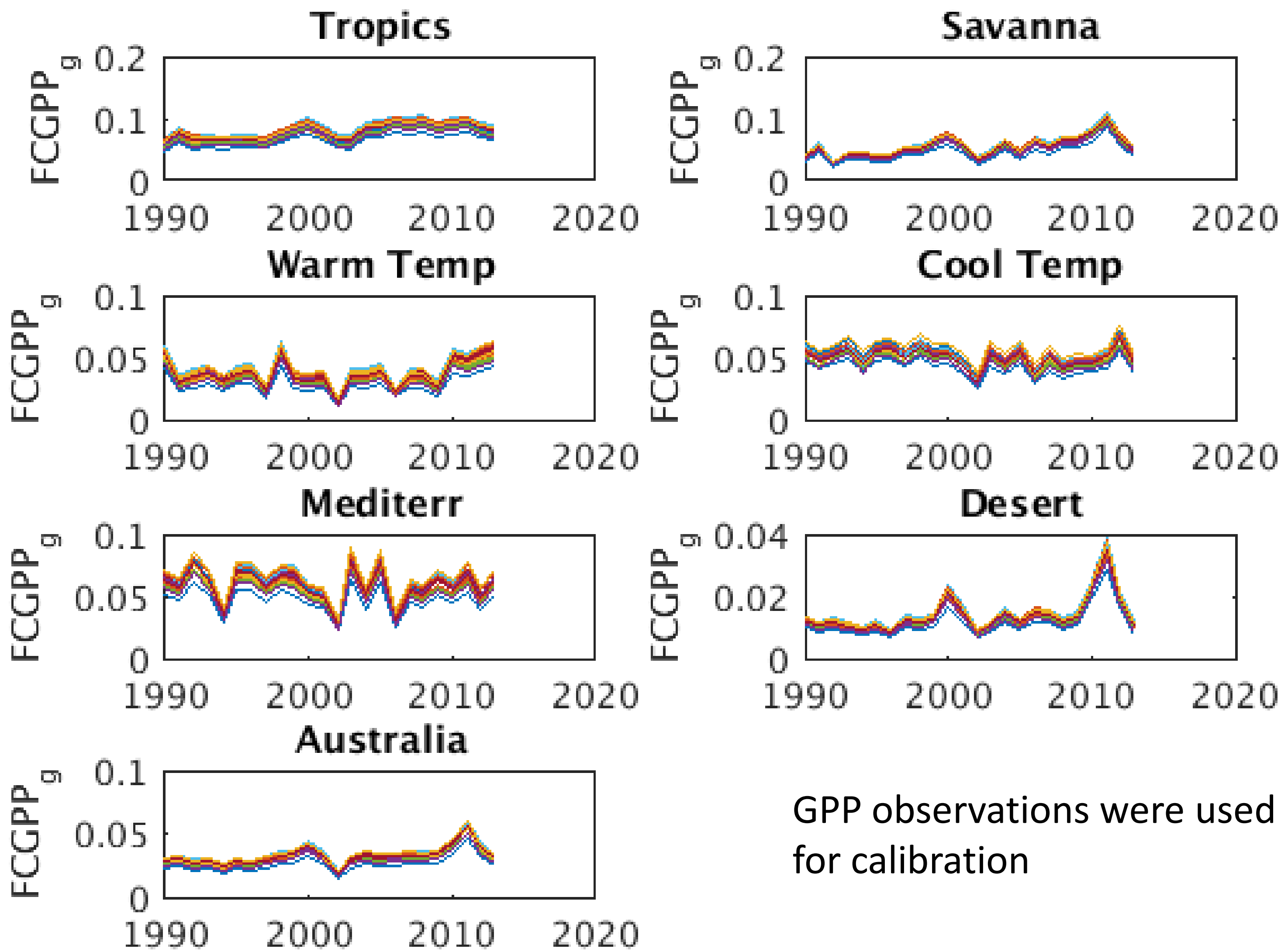
Red lines = prior constraint
Green symbols = original optimised parameters

Keep best 18 of these.

Total Phi vs Phi for observation groups

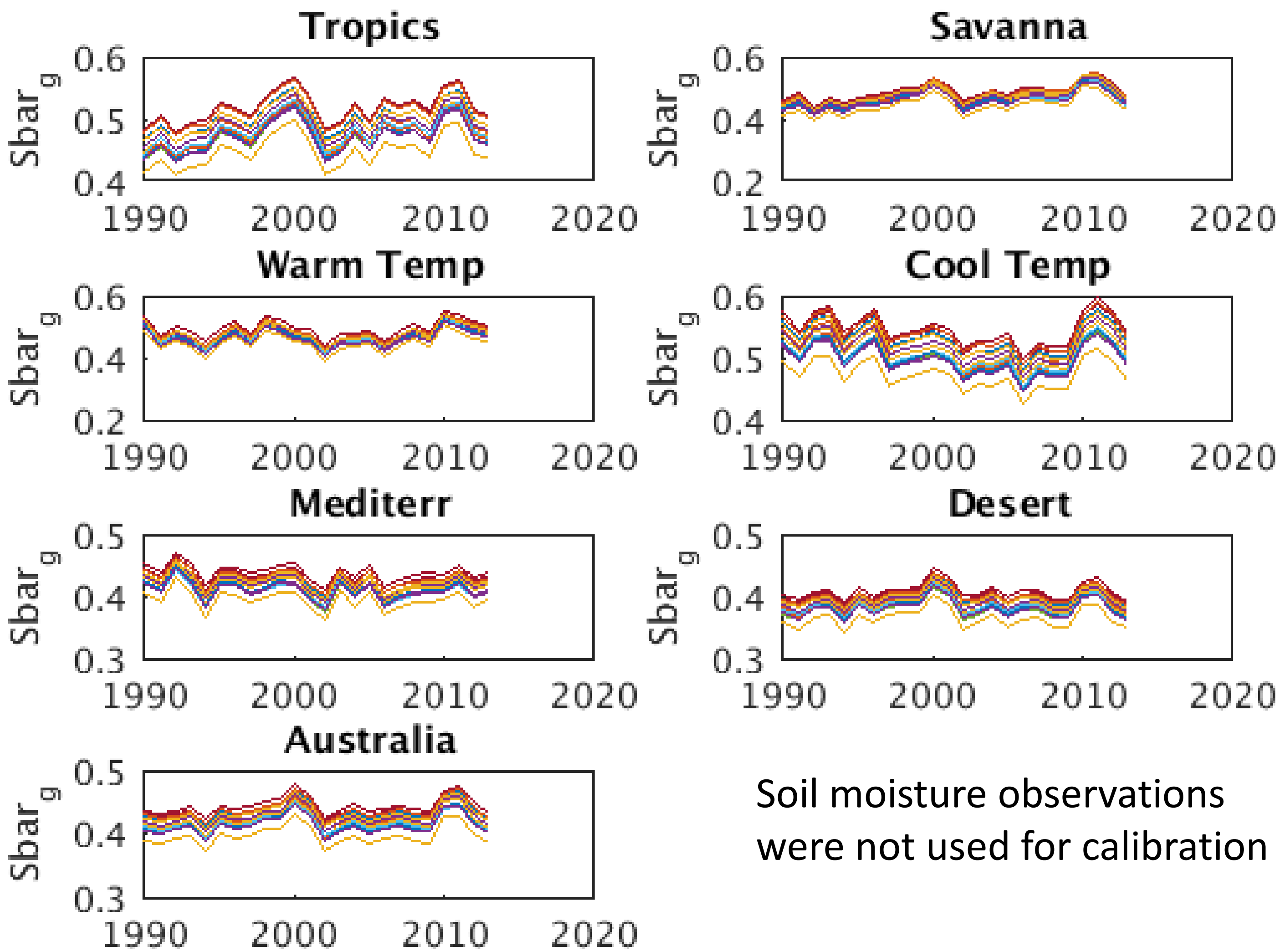


GPP for grass averaged over bioclimatic regions, for the 18 parameter sets



GPP observations were used for calibration

Soil moisture averaged over bioclimatic regions, for the 18 parameter sets



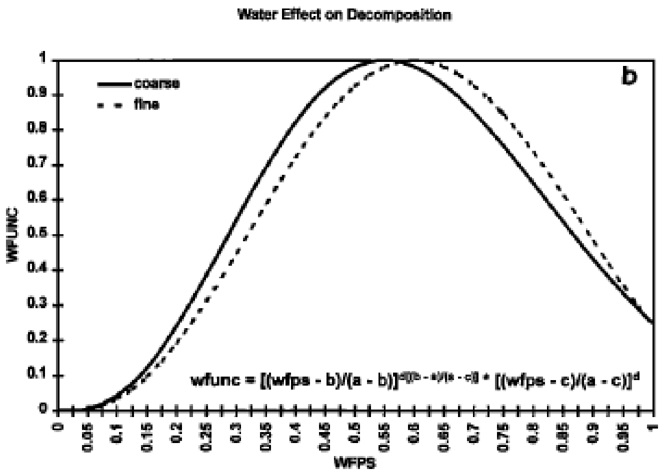
Soil moisture observations were not used for calibration

CASA-CNP parameters optimized (19)

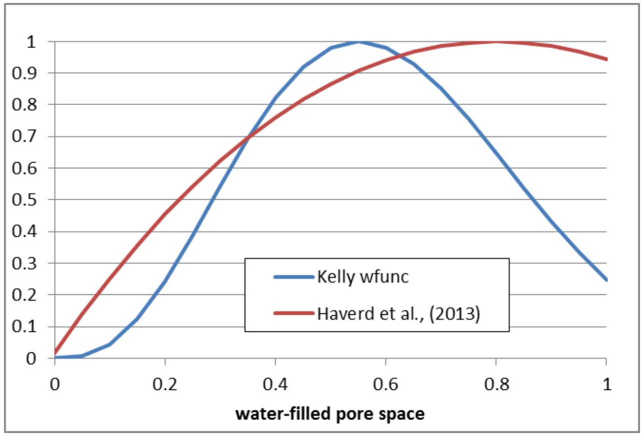
Parameter	Description
soilc0_frac	Fraction of soil C in top 15 cm
age_leaf_g, age_leaf_w	Leaf turnover time (grassy and woody)
age_wood	Woody biomass turnover time (yr)
age_clitt1	Base metabolic litter turnover time (yr)
age_clitt2	Base fine structural litter turnover time (yr)
age_clitt3	Base coarse woody debris turnover time (yr)
age_csoil1	Fast soil C pool turnover time (yr)
age_csoil2	Slow soil C pool turnover time (yr)
age_csoil3	Passive soil C pool turnover time
fallocc_w	Fraction of non-leaf C allocated to wood
rsratio_g, rsratio_w	Fine root to shoot ratio (grassy and woody)
	6 parameters to define function for effect of soil moisture on soil respiration

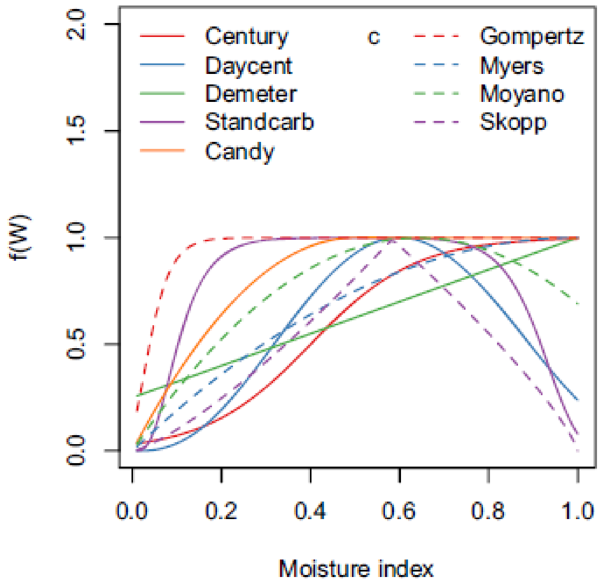
CSIRO

Effect of soil moisture on soil respiration



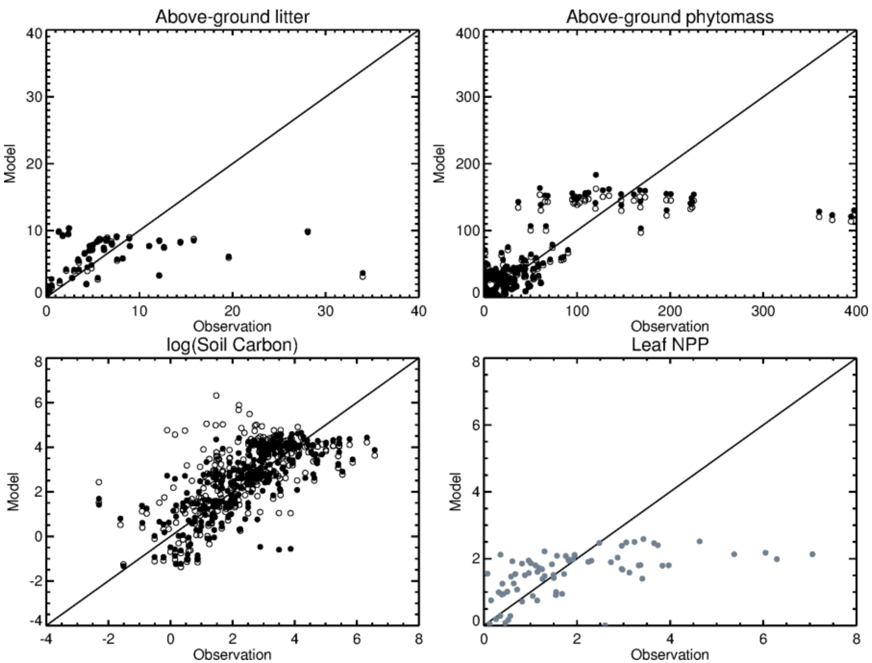
Kelly et al. (2000)

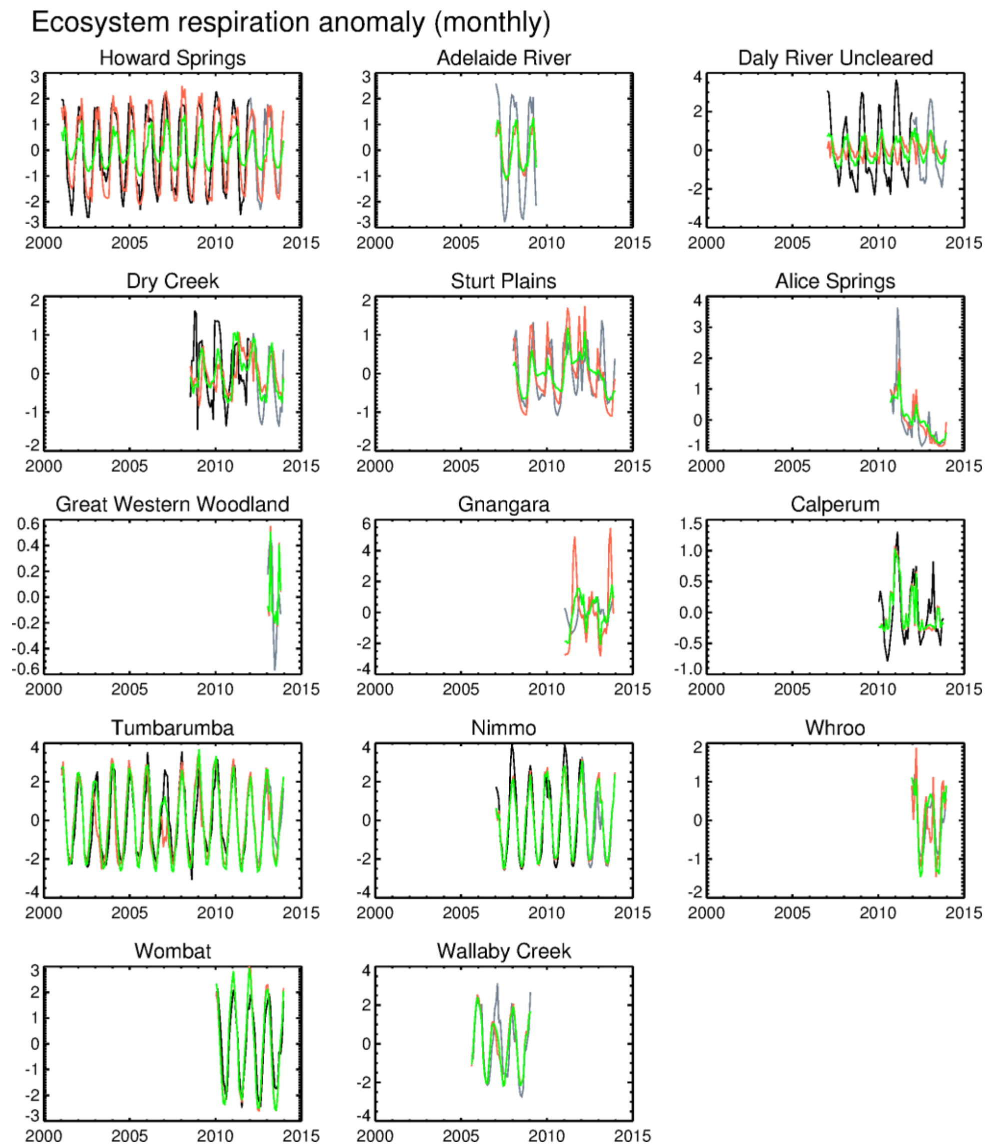




Sierra et al. (2015)

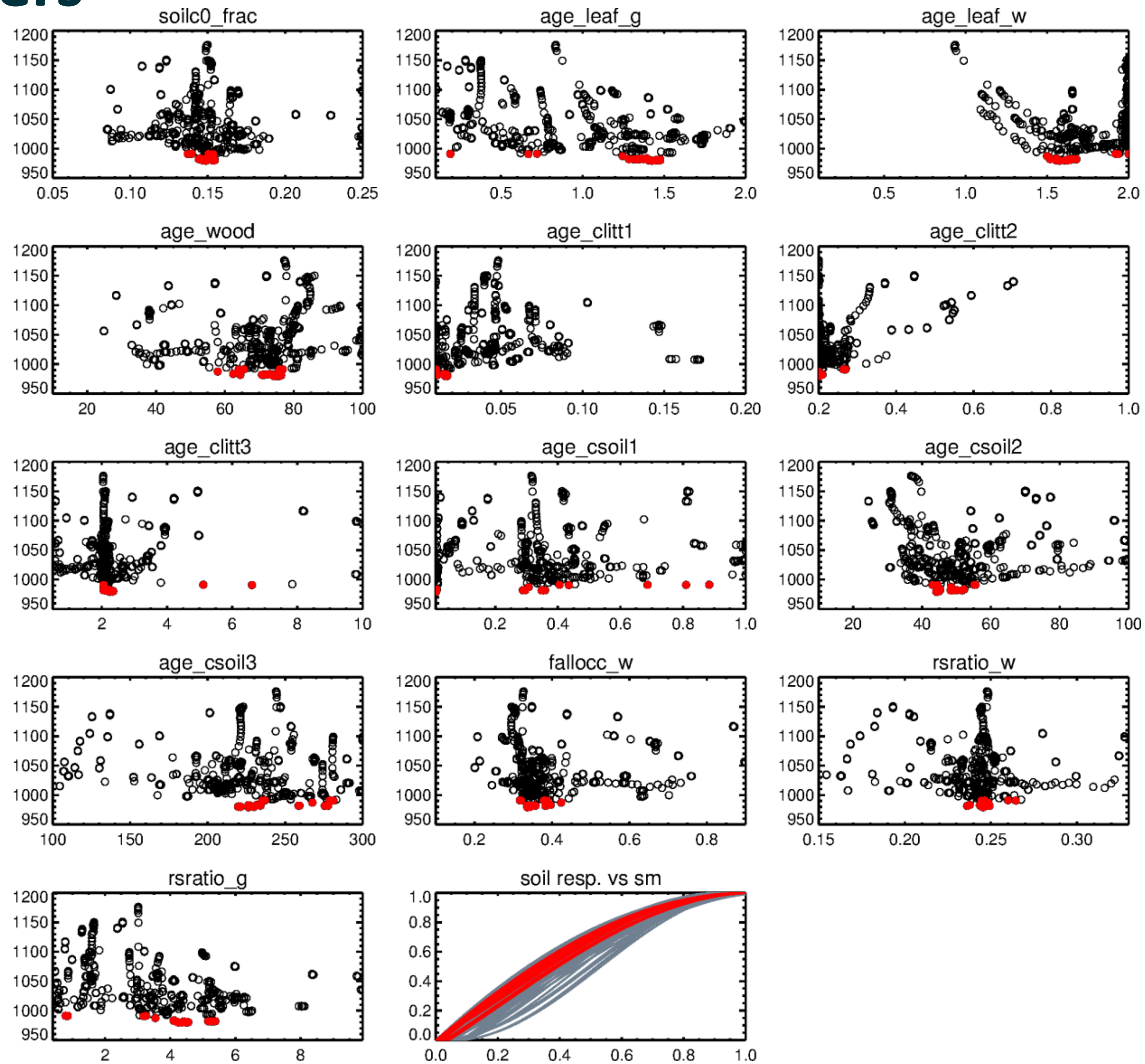
CASA-CNP observations

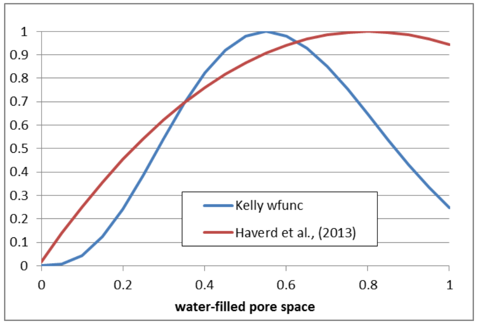




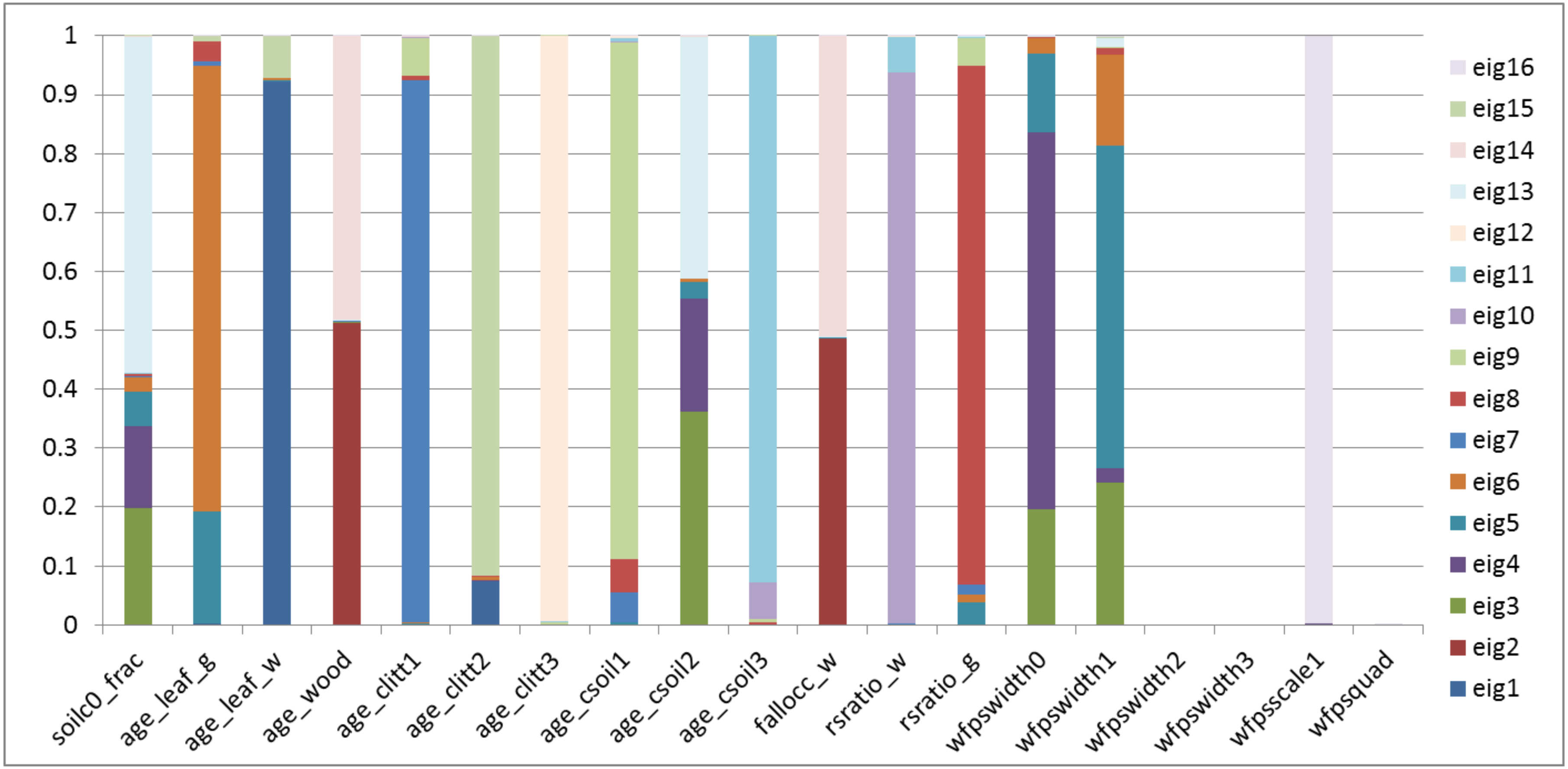
CASA-CNP parameters

Parameter sets tested during null space runs





CASA-CNP parameter identifiability



Next Steps:

- Finish parameter estimation for CASA-CNP.
- Calculate NEP for multiple parameter sets, look at range of results.
- Similar approach for estimating parameters involving N and P in CASA-CNP.

Thank you