Optimising tile and bare soil albedo using bayesian inference

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Douglas Kelley, Rich Ellis,
Rhys Whitley, Alistair Sellar

UKESM

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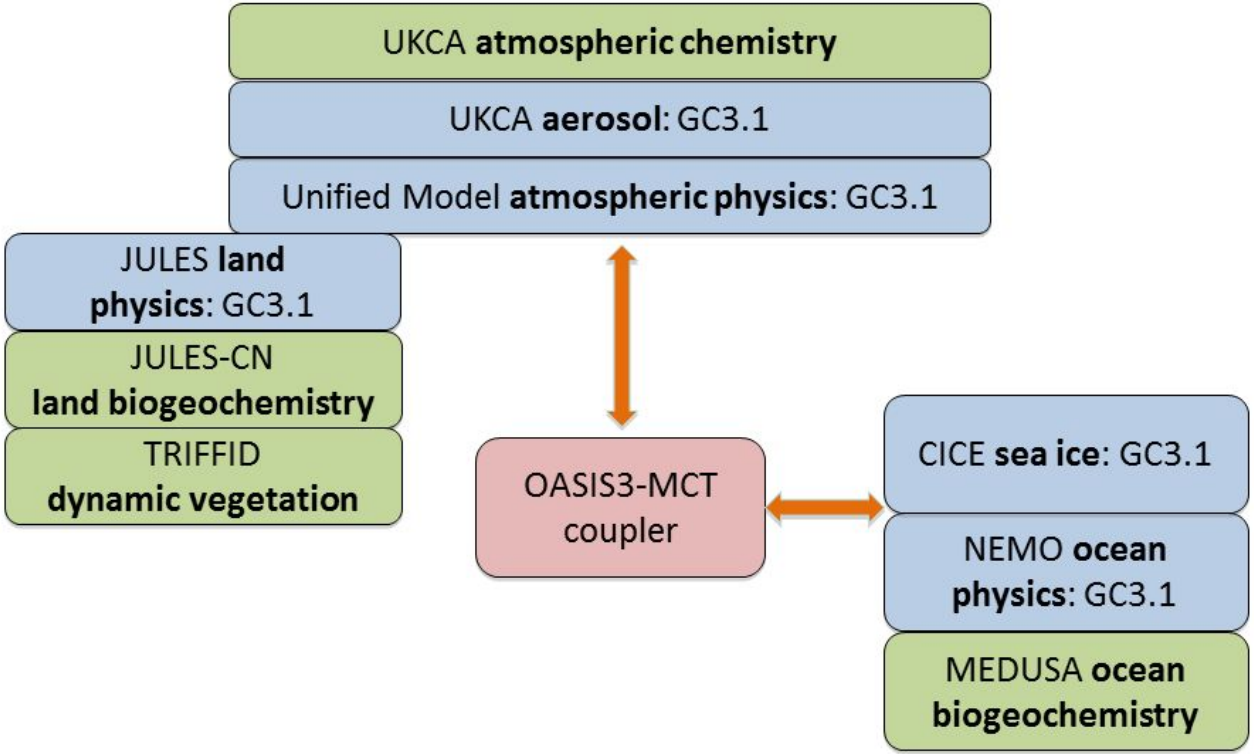
UKESM



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Model Tuning

Model Tuning

parameterization

Model ~~Tuning~~ parameterization

How "bendy" the grass is under the weight of snow

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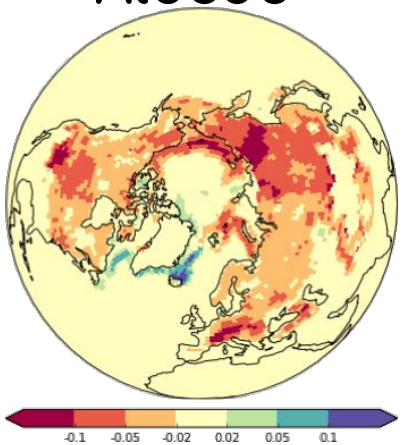
Model Tuning parameterization

"Steel" - "Rubber"

Albedo



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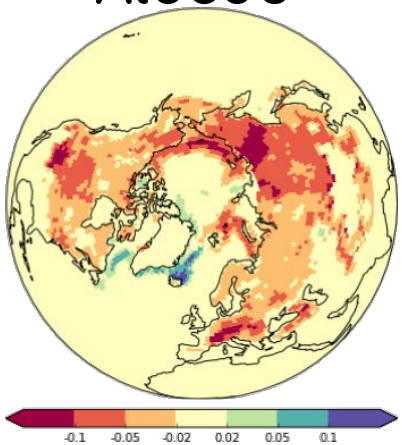

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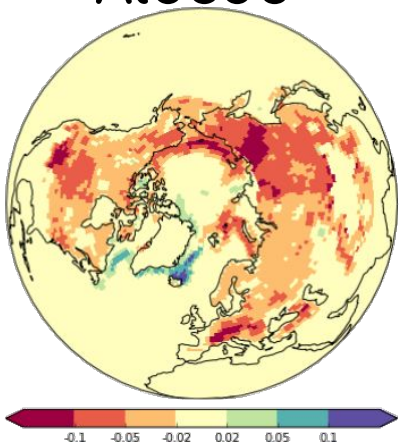
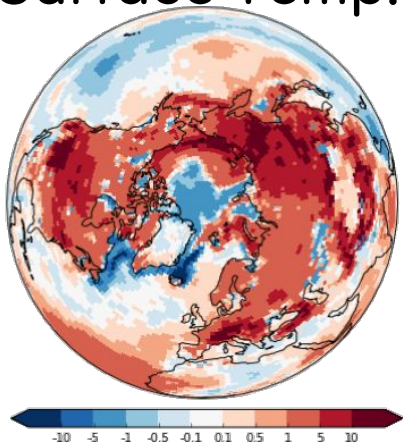
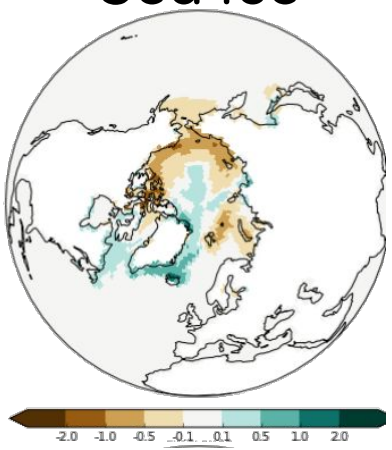


Surface Temp.



Sea Ice



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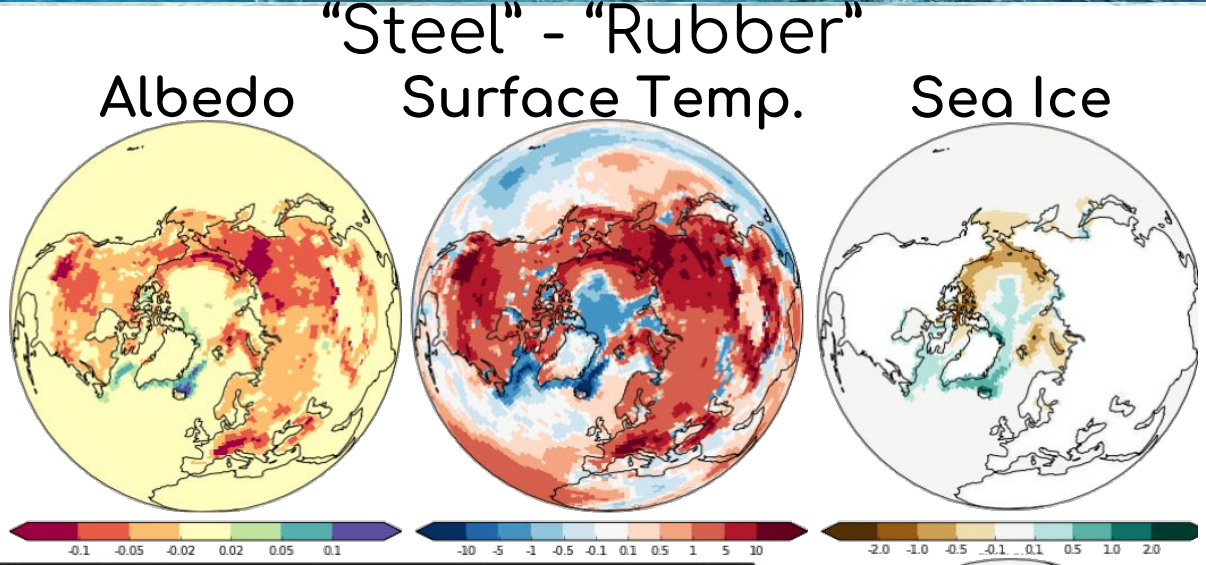
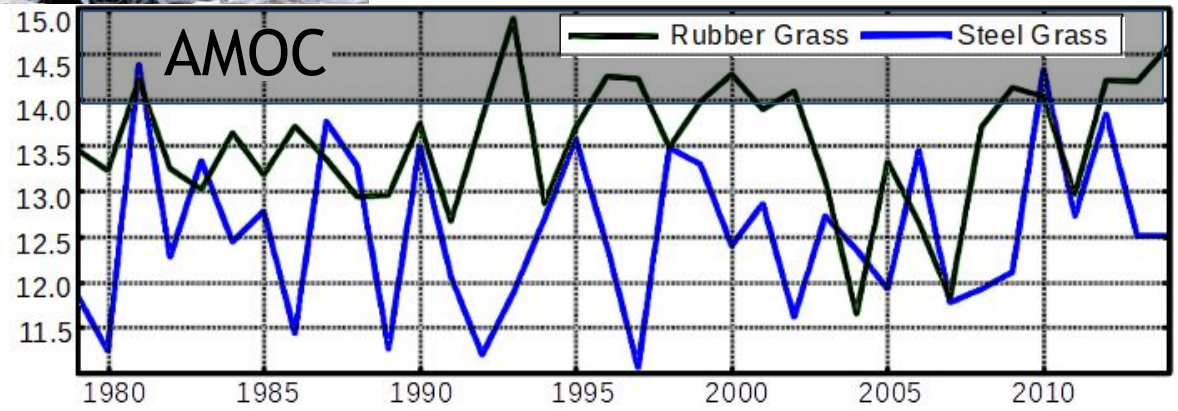
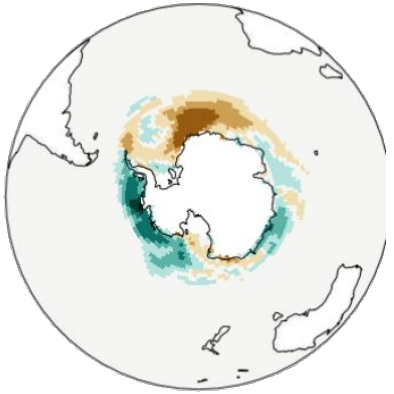
Model Tuning parameterization







Model Tuning parameterization

- Model specific observational constraints on parameters can be hard to find.
- Bayesian inference can be used to find range of plausible parameter values.

Albedo Schemes

Today:

- Simple albedo scheme (Best et al. 2011)

For UKESM:

- Spectral albedo scheme (Sellers 1985)
- Snow-veg albedo interactions

Using Bayes Theorem

$$P(A \mid B) \propto P(A) \cdot P(B \mid A)$$

Using Bayes Theorem to win at Rock Paper Scissors

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Using Bayes Theorem to win at Rock Paper Scissors against a T-Rex

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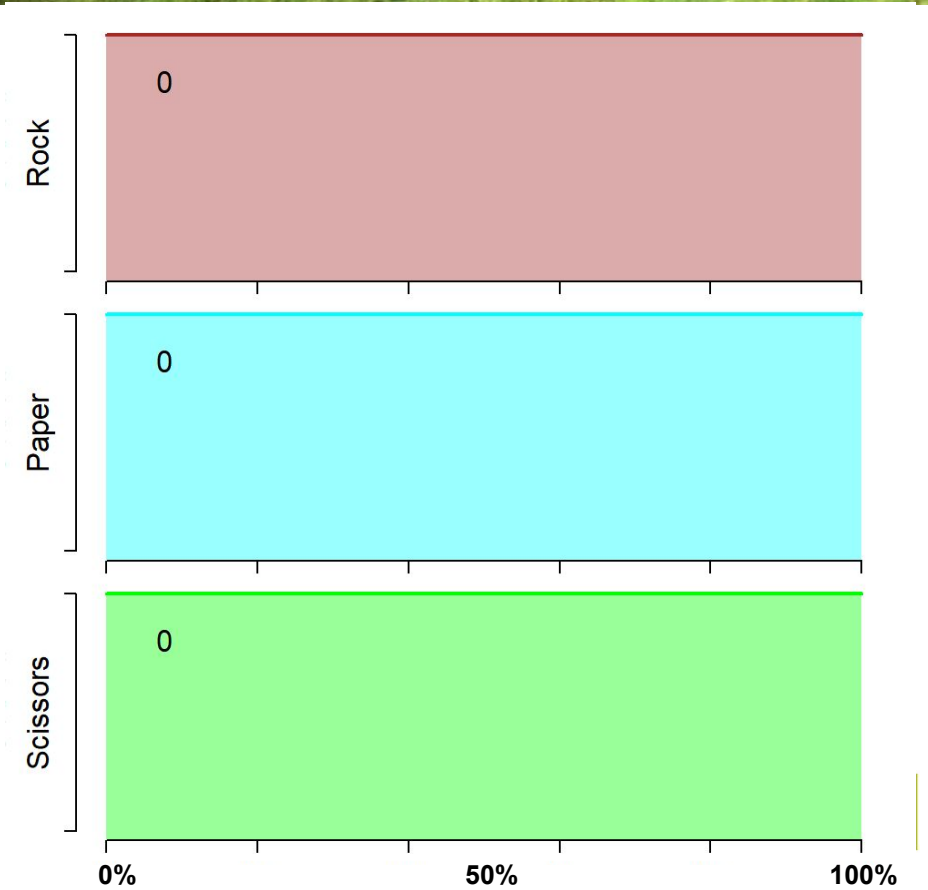
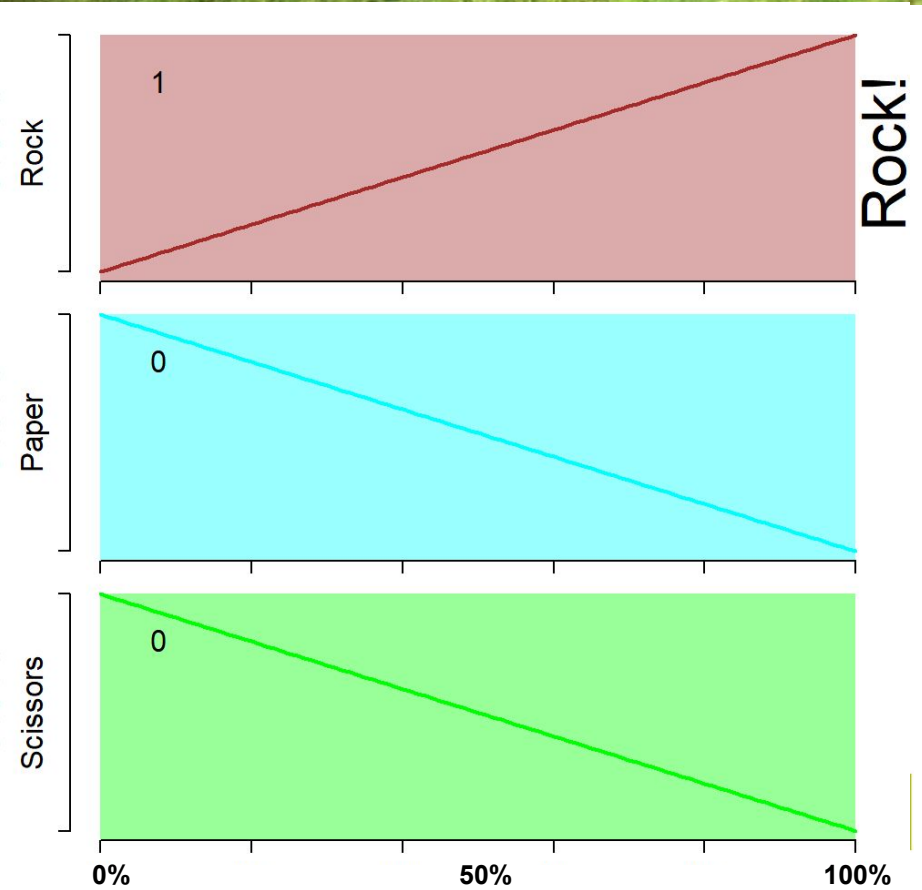


Using Bayes Theorem to win at Rock Paper Scissors against a T-Rex



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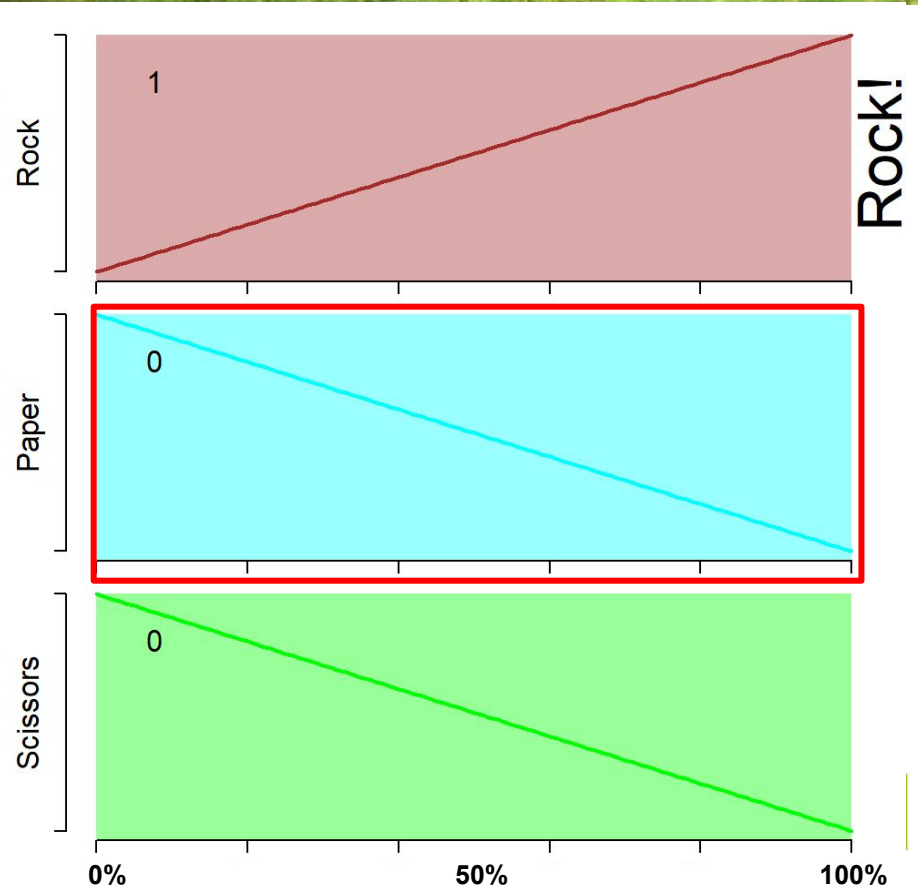

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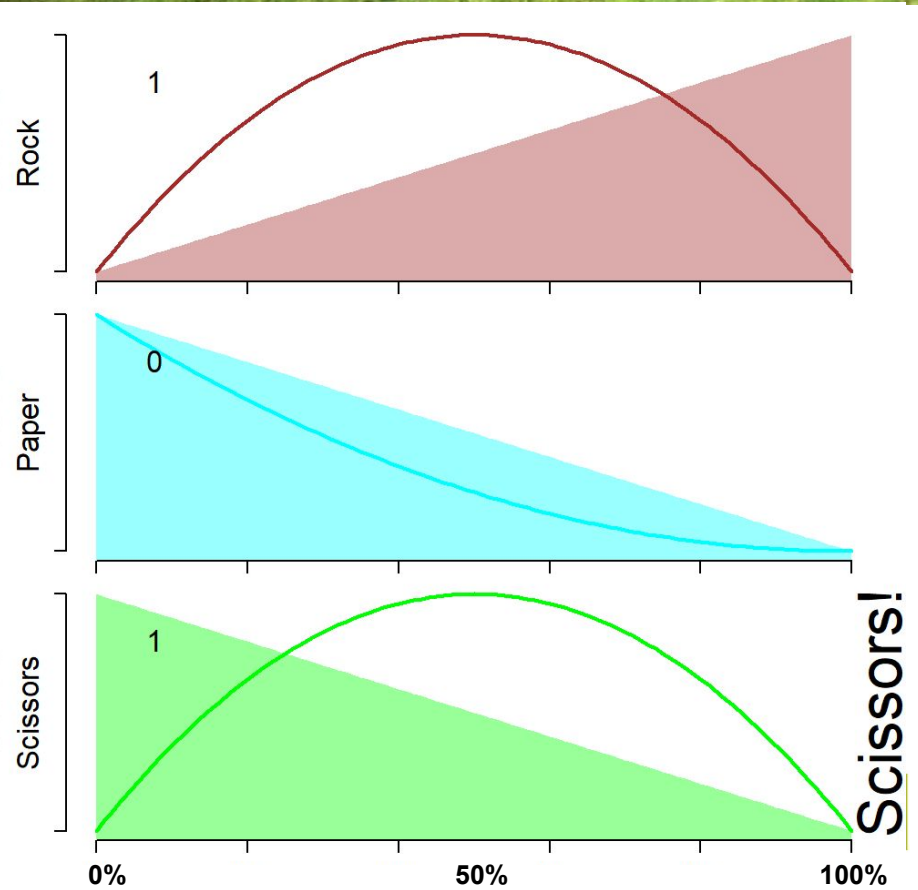

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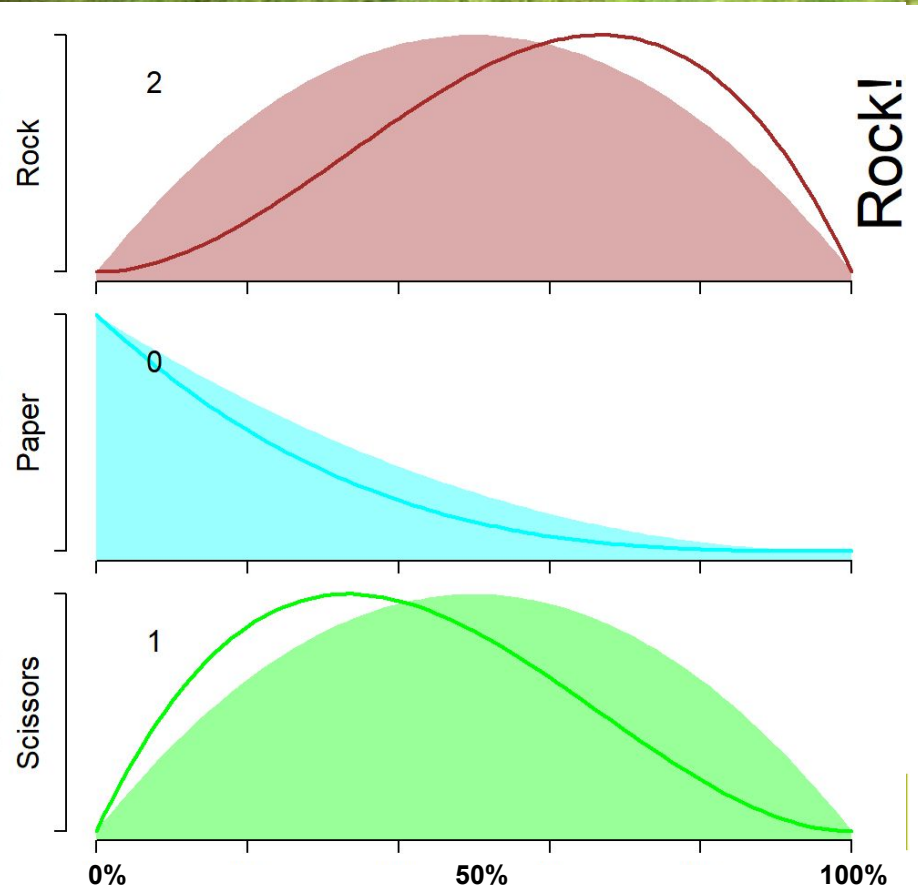

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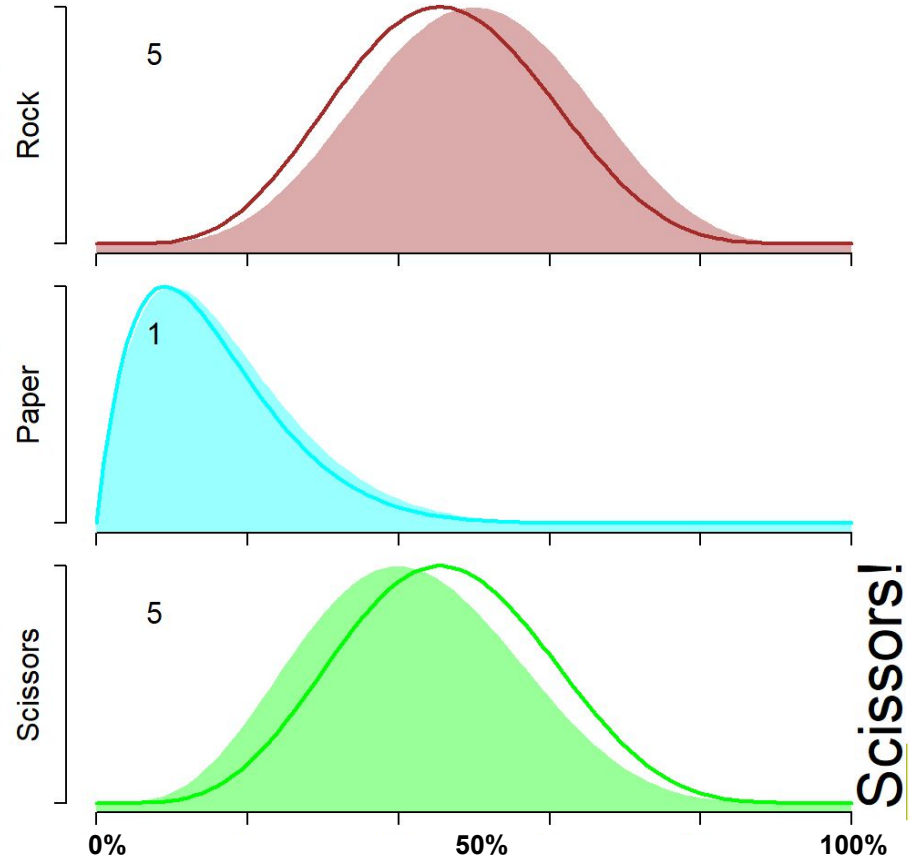
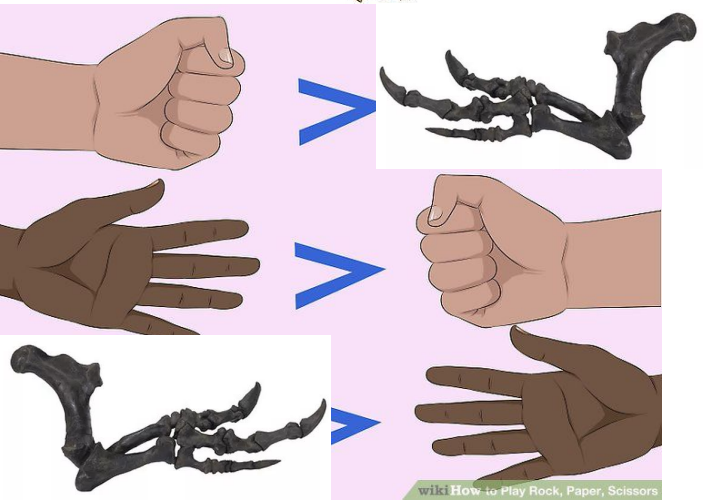
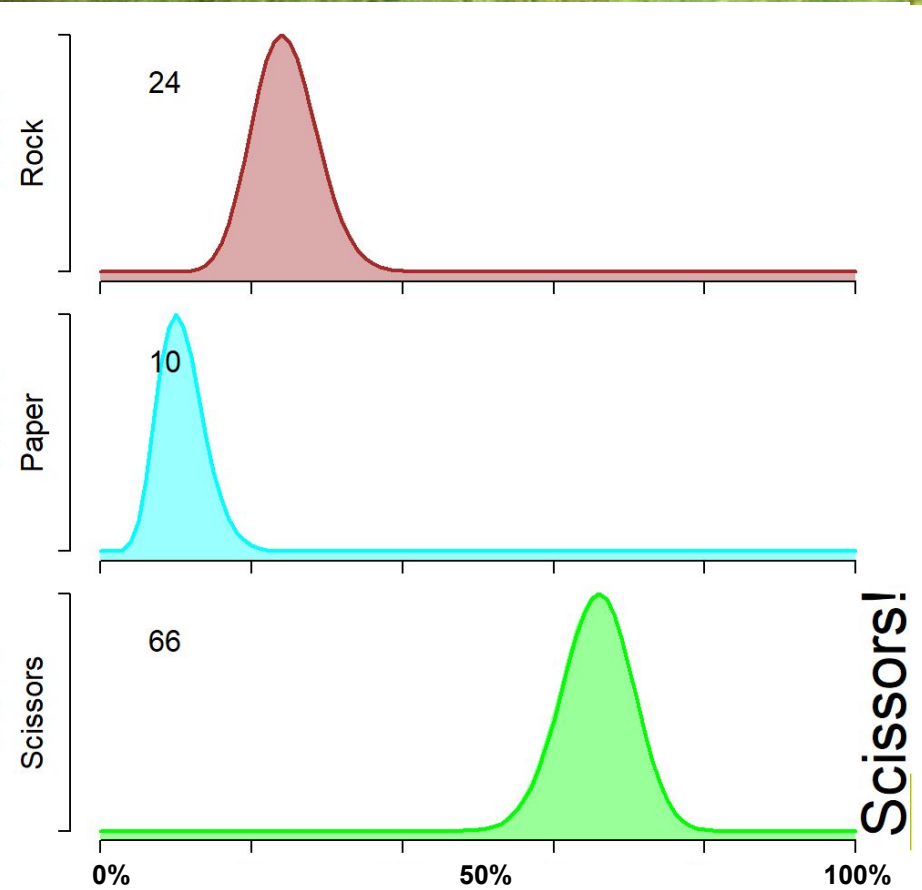
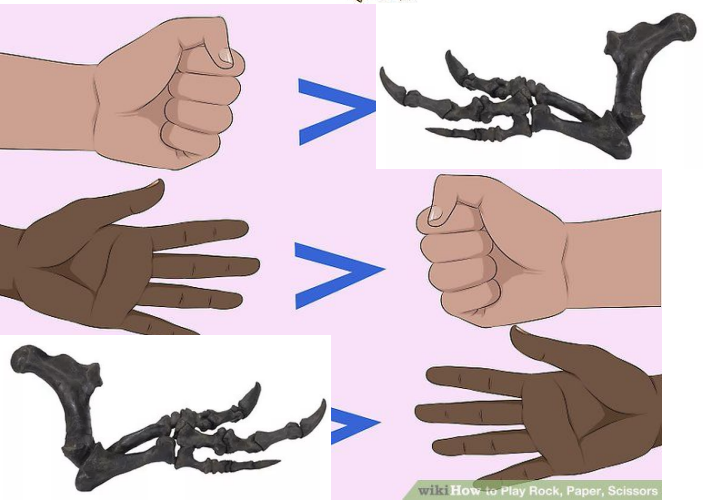


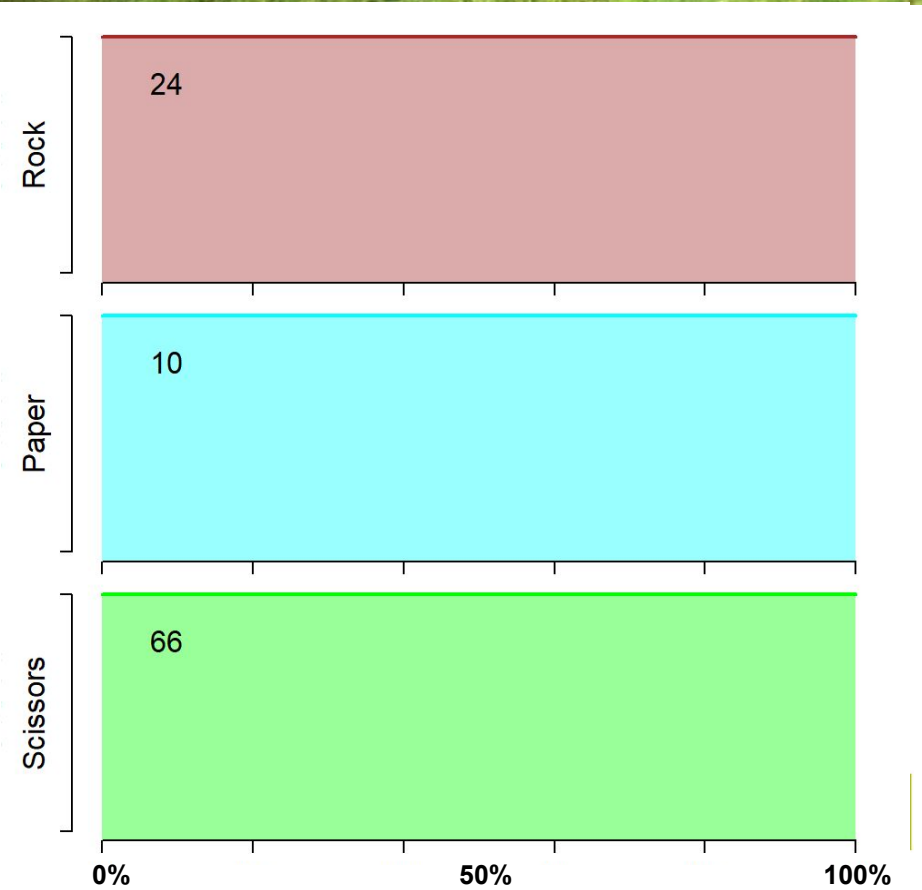
Using Bayes Theorem to win at Rock Paper Scissors against a T-Rex





Using Bayes Theorem inference to win at Rock Paper Scissors against a T-Rex





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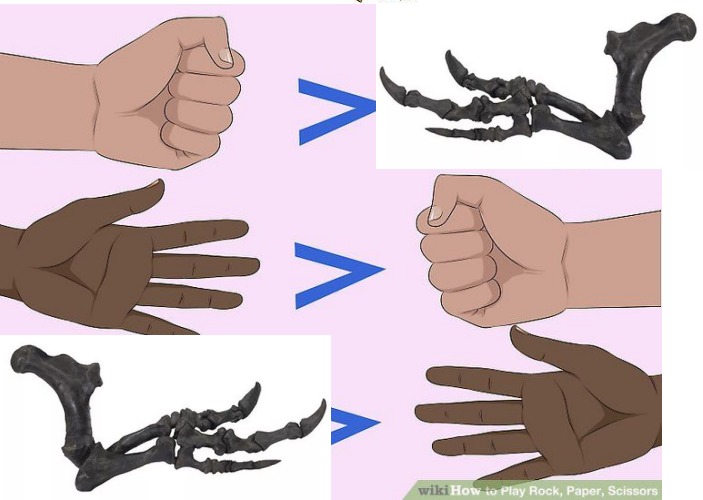

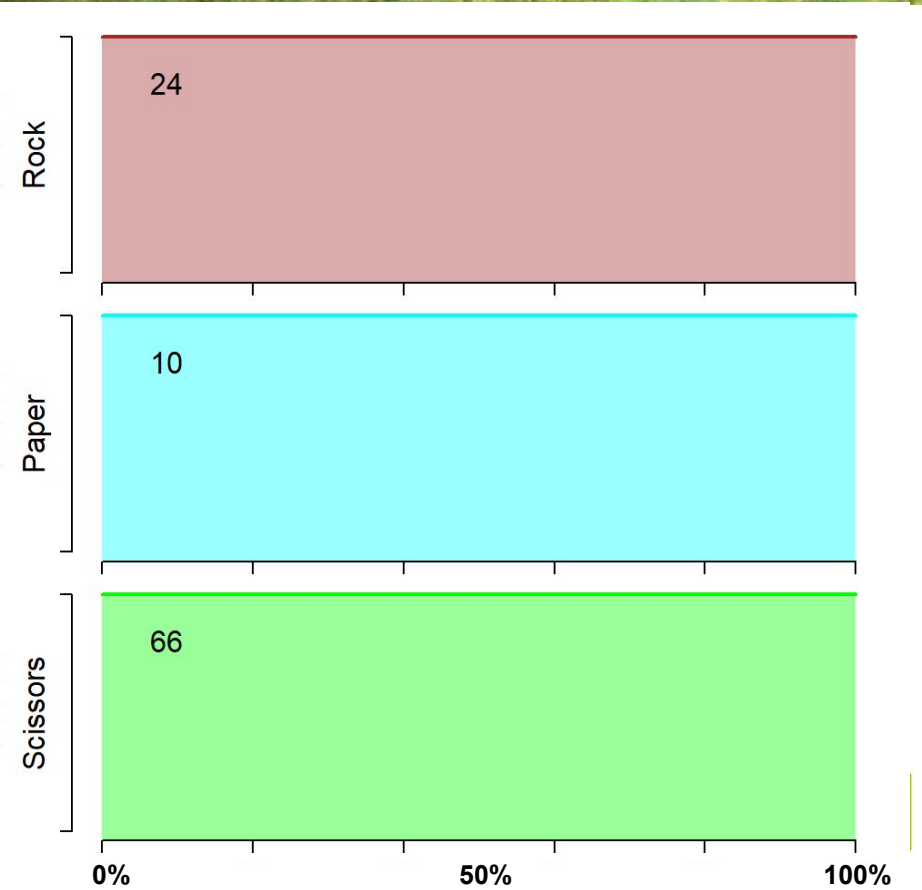

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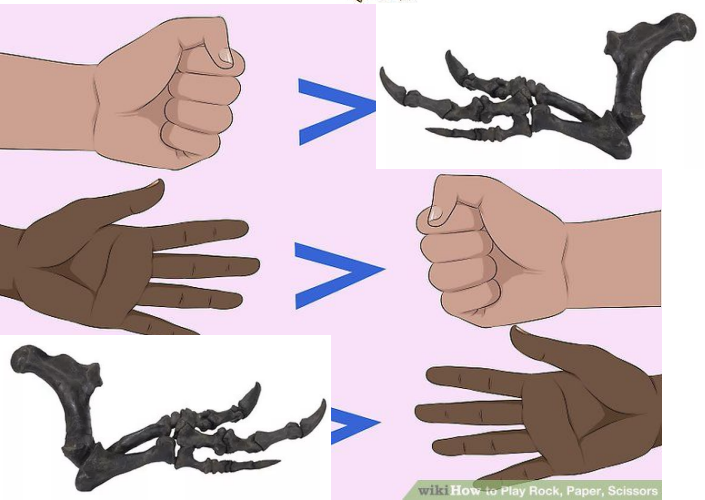

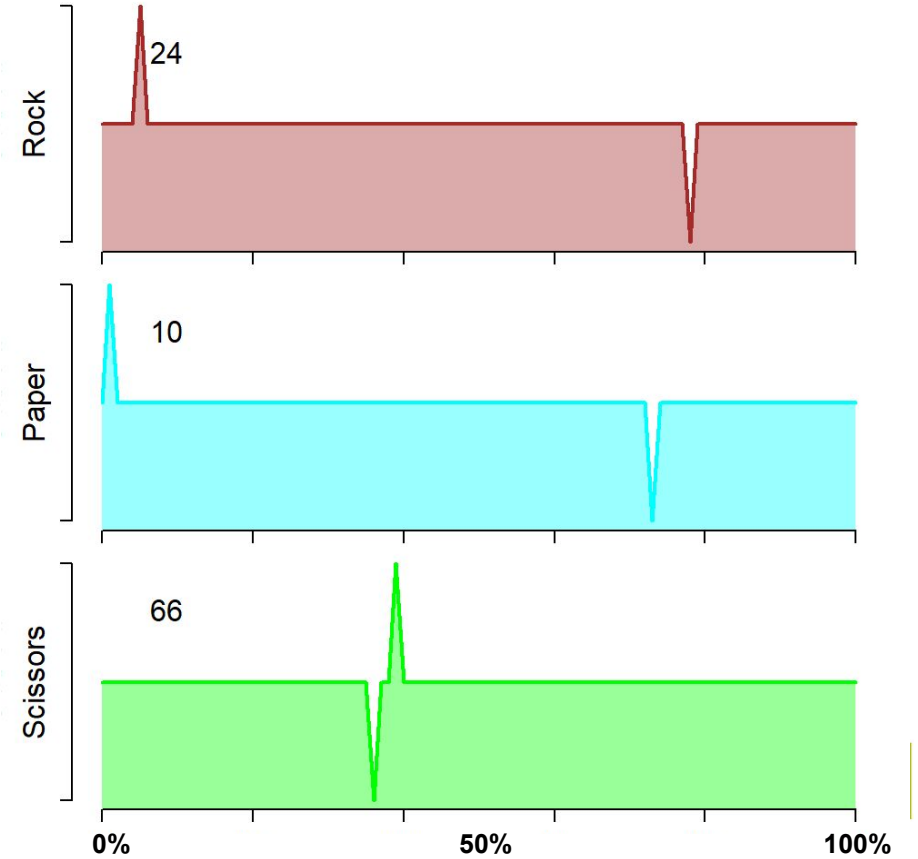

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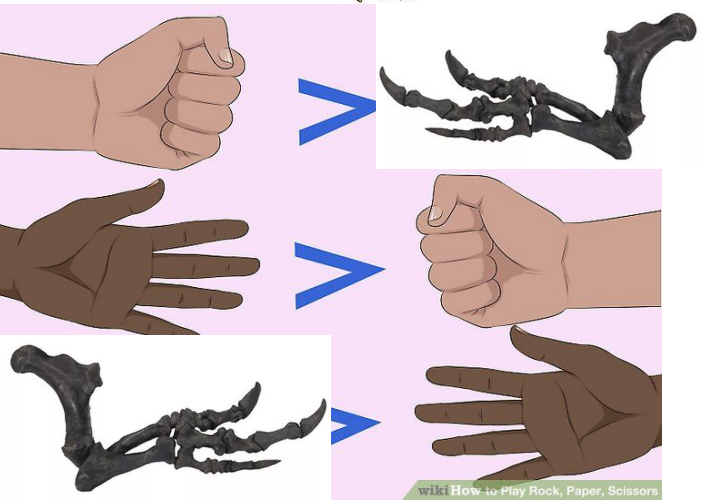
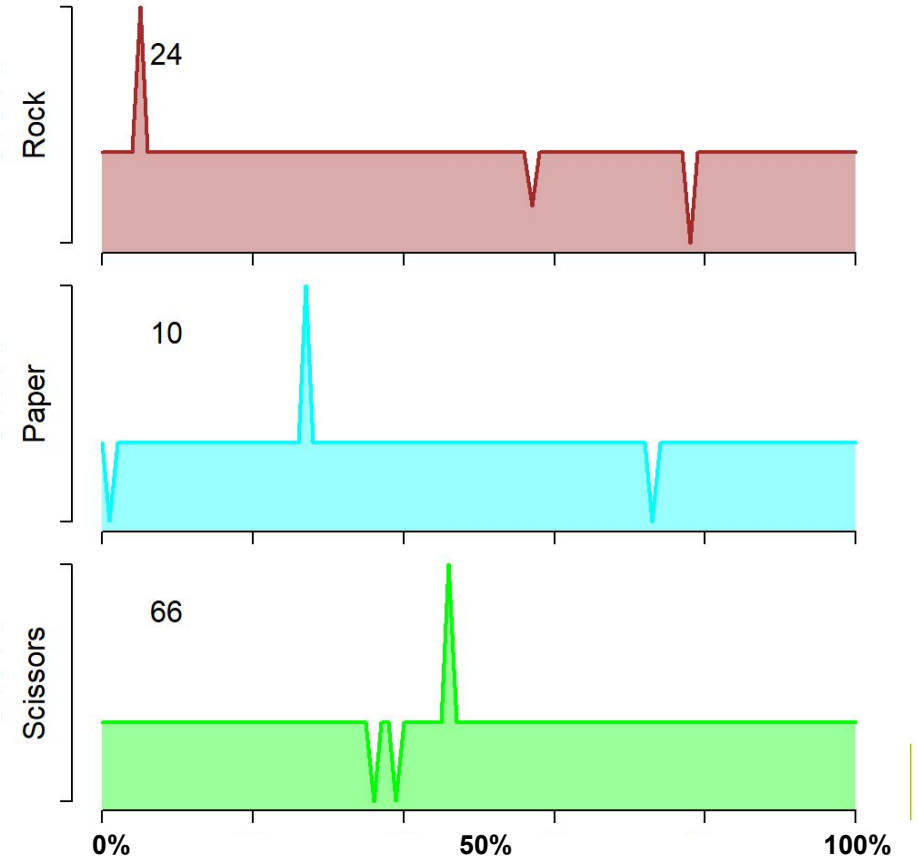
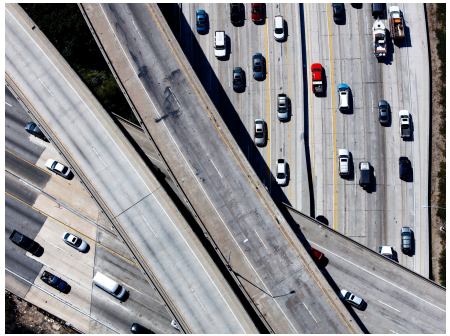


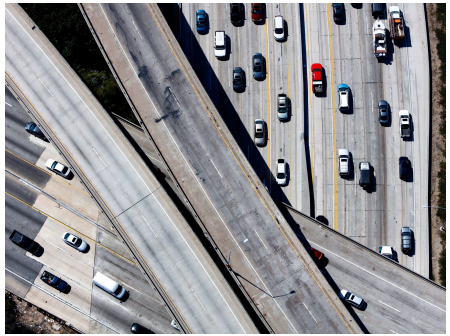


Simple snow-free albedo scheme



$$\alpha = \Sigma Area_{tile} \cdot \alpha_{tile}$$

Simple snow-free albedo scheme



$$\alpha = \Sigma Area_{tile} \cdot \alpha_{tile} + Area_{bare} \cdot \alpha_{bare}$$

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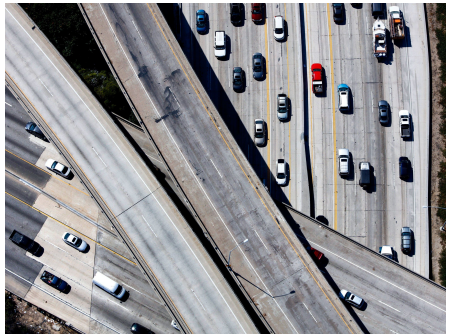



$$\alpha = \Sigma Area_{tile} \cdot \alpha_{tile} + Area_{bare} \cdot \alpha_{bare} + \Sigma Area_{pft} \cdot \alpha_{leaf}$$

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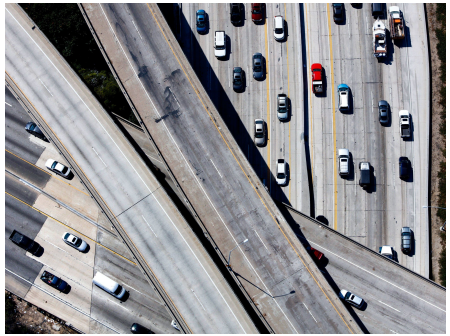




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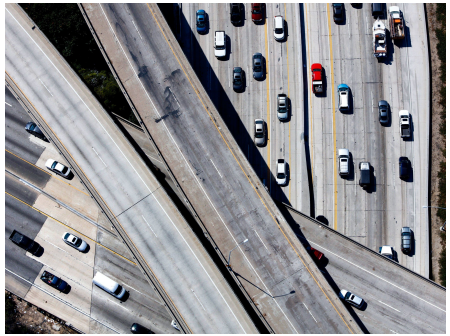
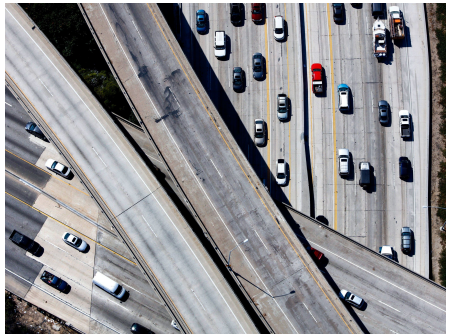






$$\alpha = \Sigma Area_{tile} \cdot \alpha_{tile} + Area_{bare} \cdot \alpha_{bare} + \Sigma Area_{pft} \cdot (\alpha_{leaf} \cdot (1 - e^{-k \cdot LAI}) + \alpha_{bare} \cdot e^{-k \cdot LAI})$$

Simple snow-free albedo scheme







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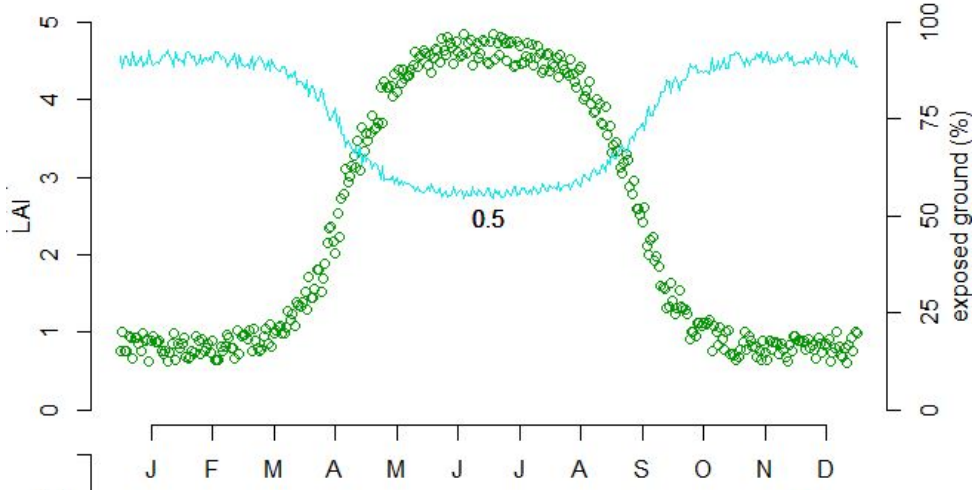
3 Tile parameter; (2 x 9) PFT parameters; Spatially varying soil

Spatially varying bareground albedo



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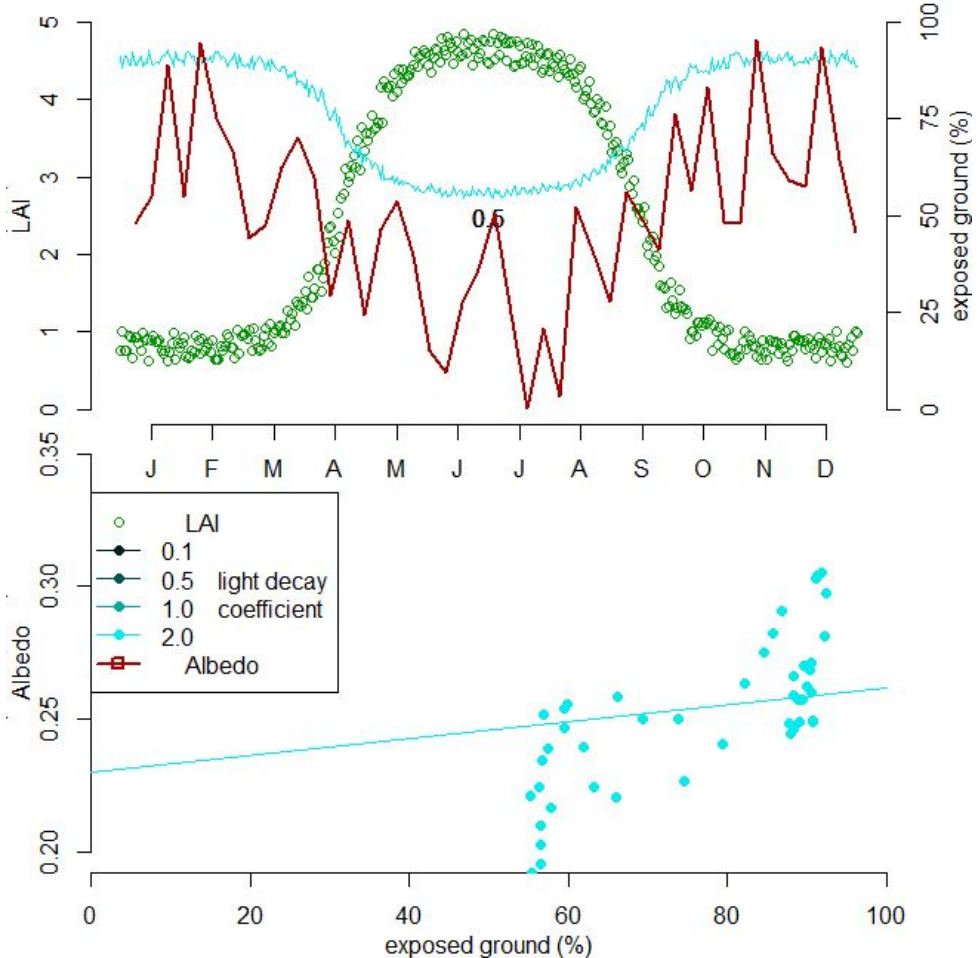
Spatially varying bareground albedo



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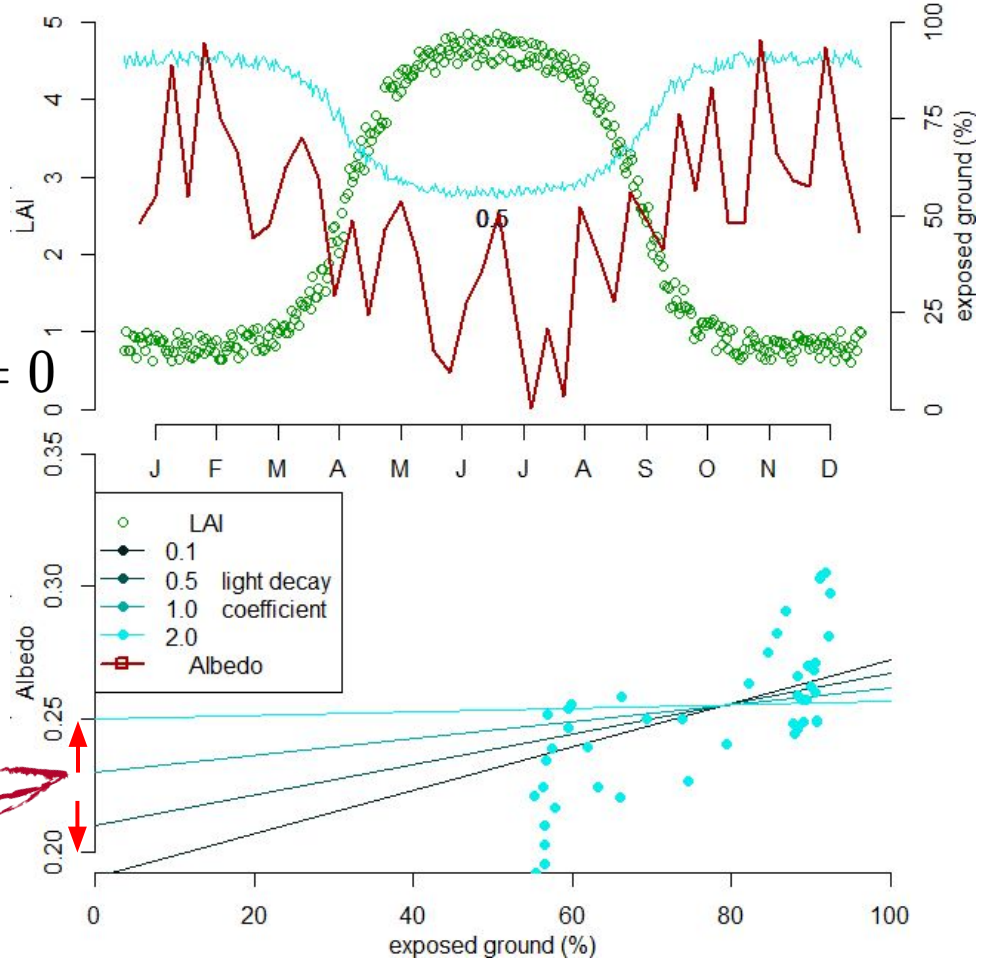
Spatially varying bareground albedo

Albedo when completely vegetated, i.e

$$Area_{tile}, Area_{bare} = 0$$
$$LAI \to \infty$$
$$\Sigma Area_{pft} \cdot \alpha_{leaf}$$



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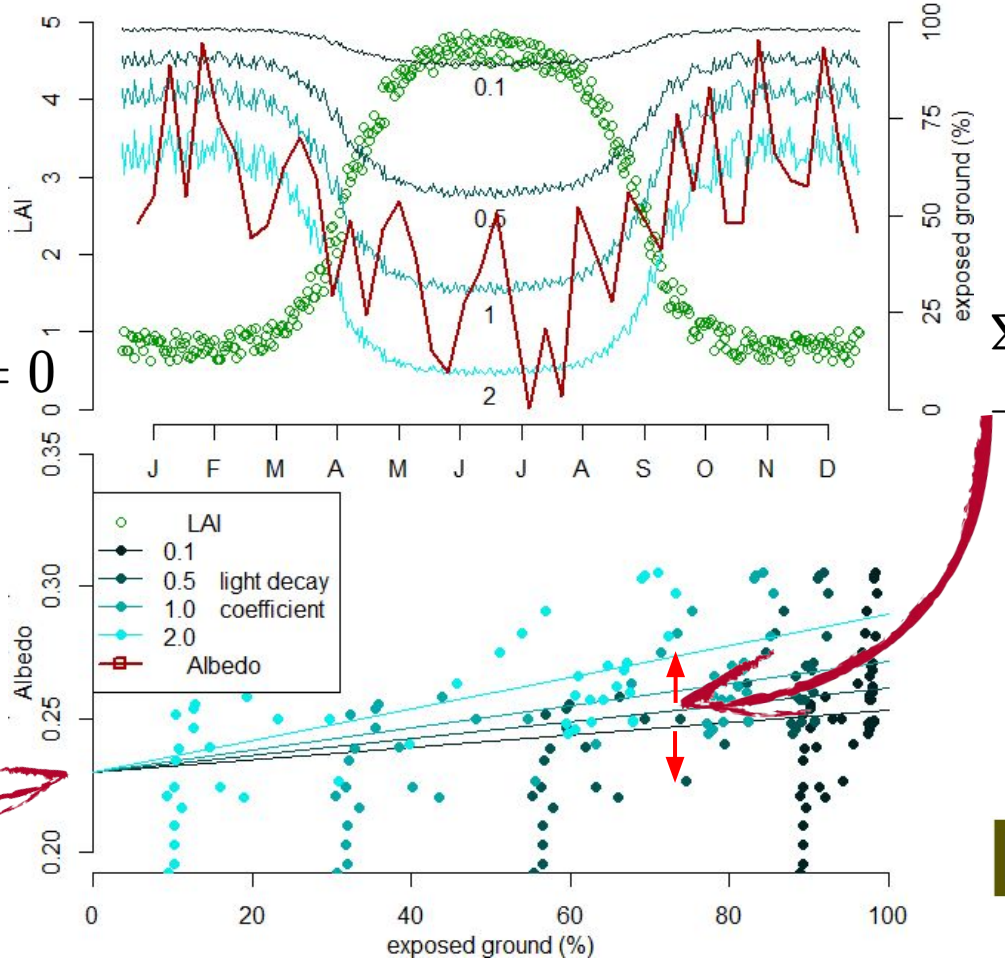

Gradient depends on actual exposed ground, i.e

$$\Sigma Area_{tile} + Area_{bare} + e^{-k \cdot LAI}$$

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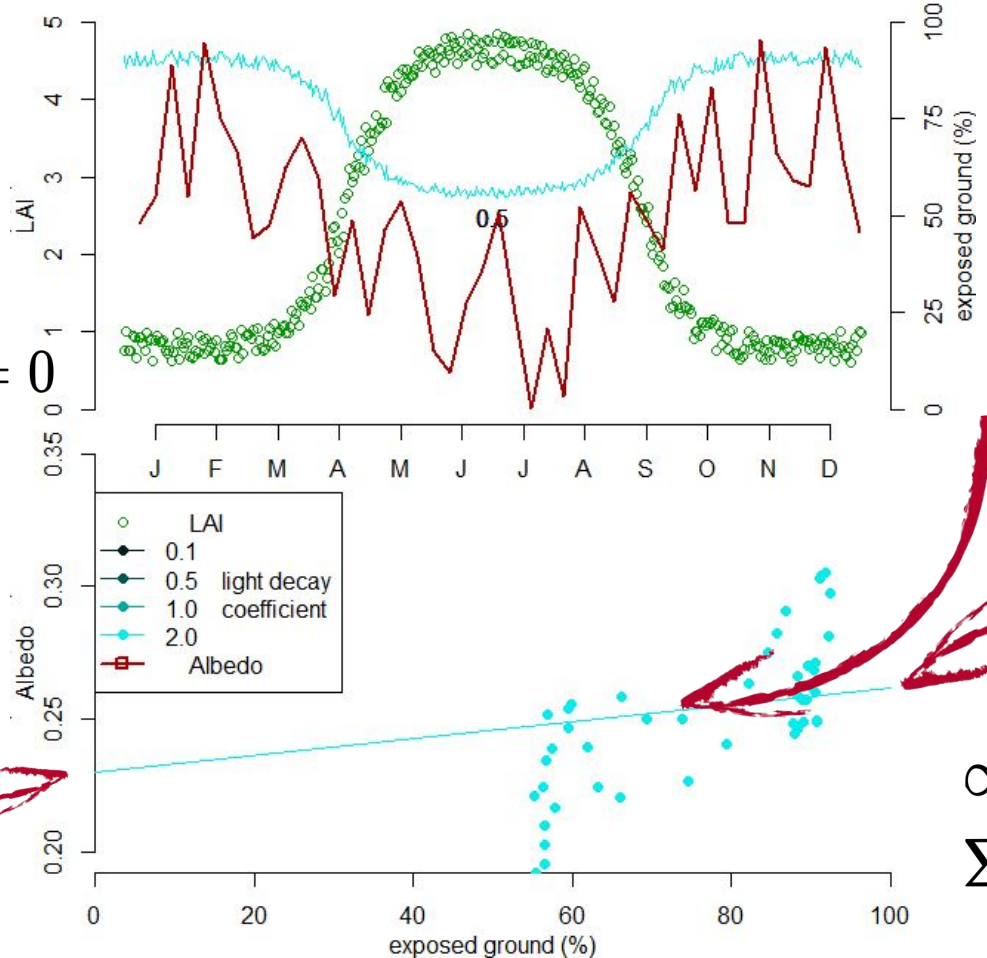

Gradient depends on actual exposed ground, i.e

$$\Sigma Area_{tile} + Area_{bare} + e^{-k \cdot LAI}$$

Bare ground albedo from residual after tile albeo

$$\propto \alpha_{lai=0} - \Sigma Area_{tile} \cdot \alpha_{tile}$$

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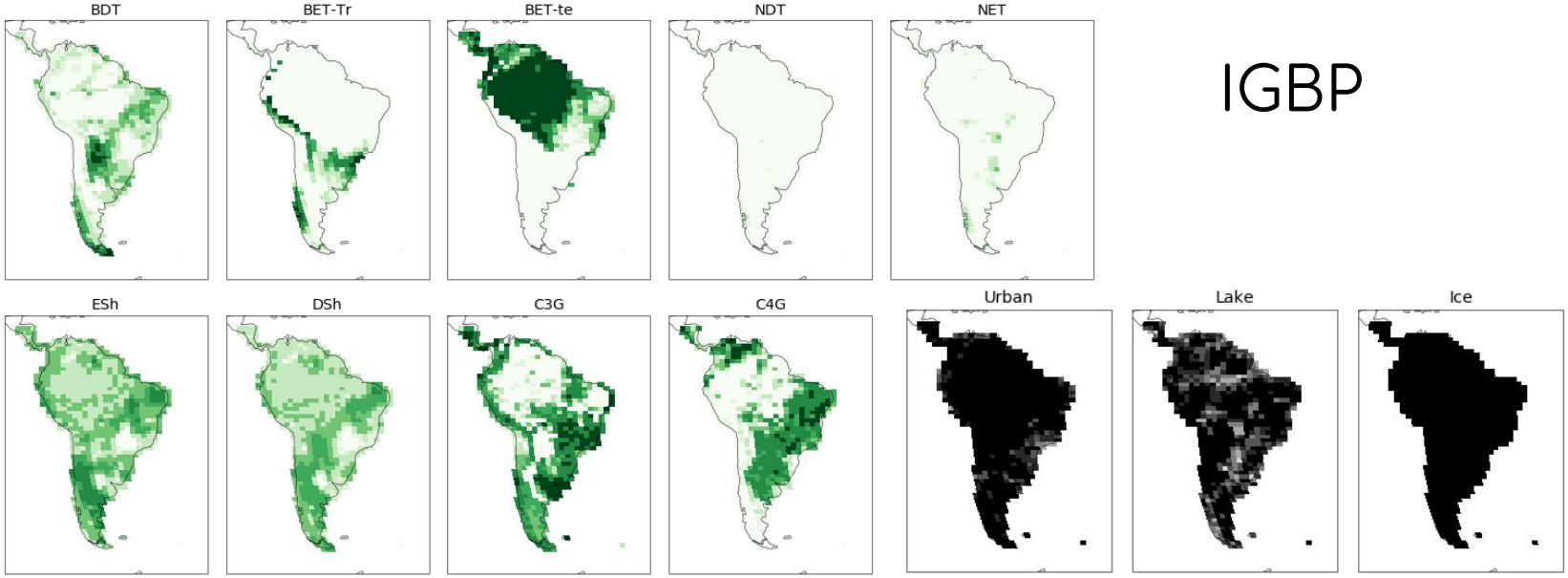
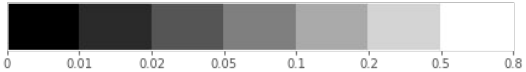
Driving data - vegetation fractions



IGBP



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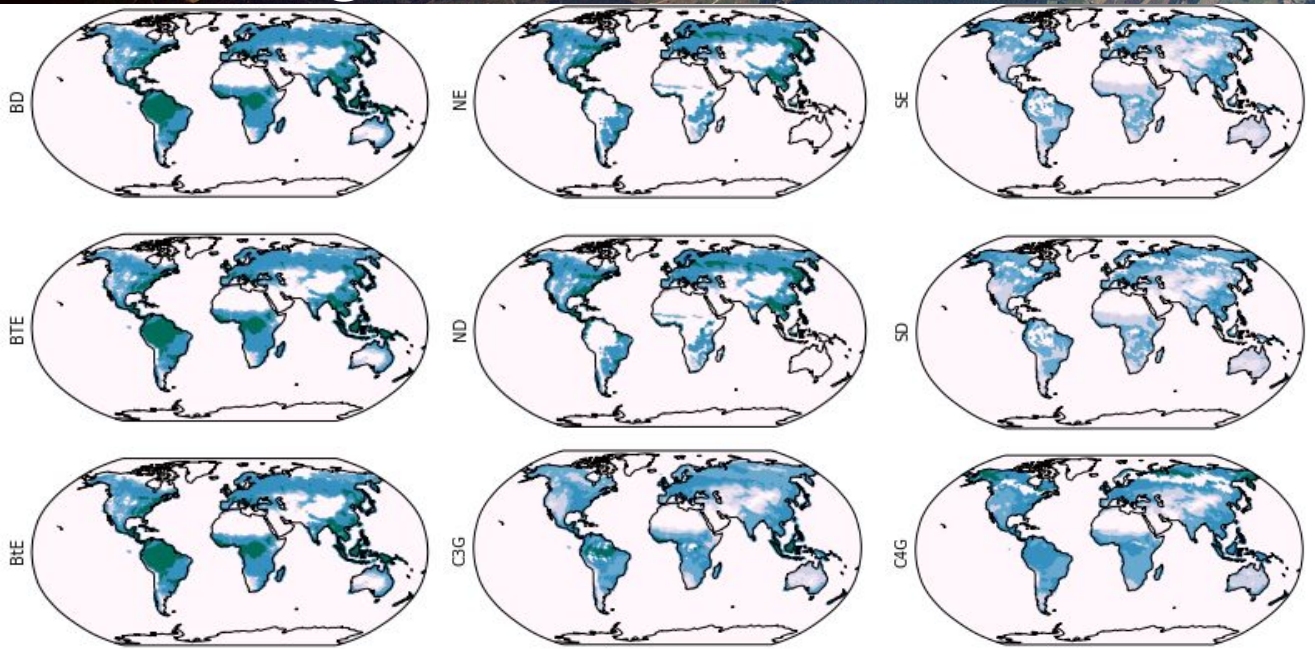
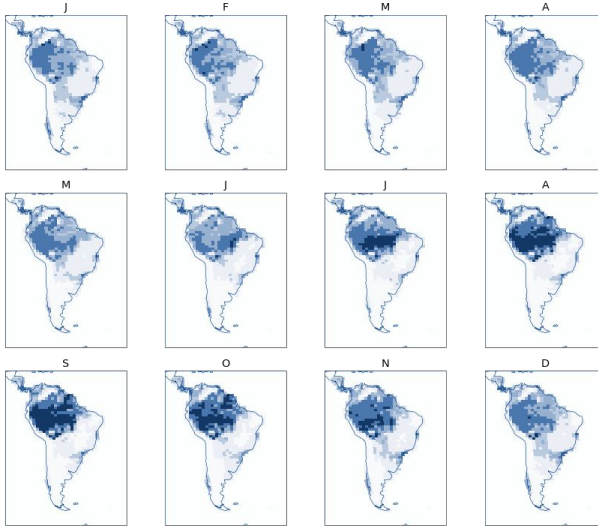
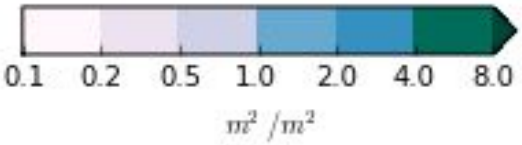
Driving Data - LAI







MODIS collection 5

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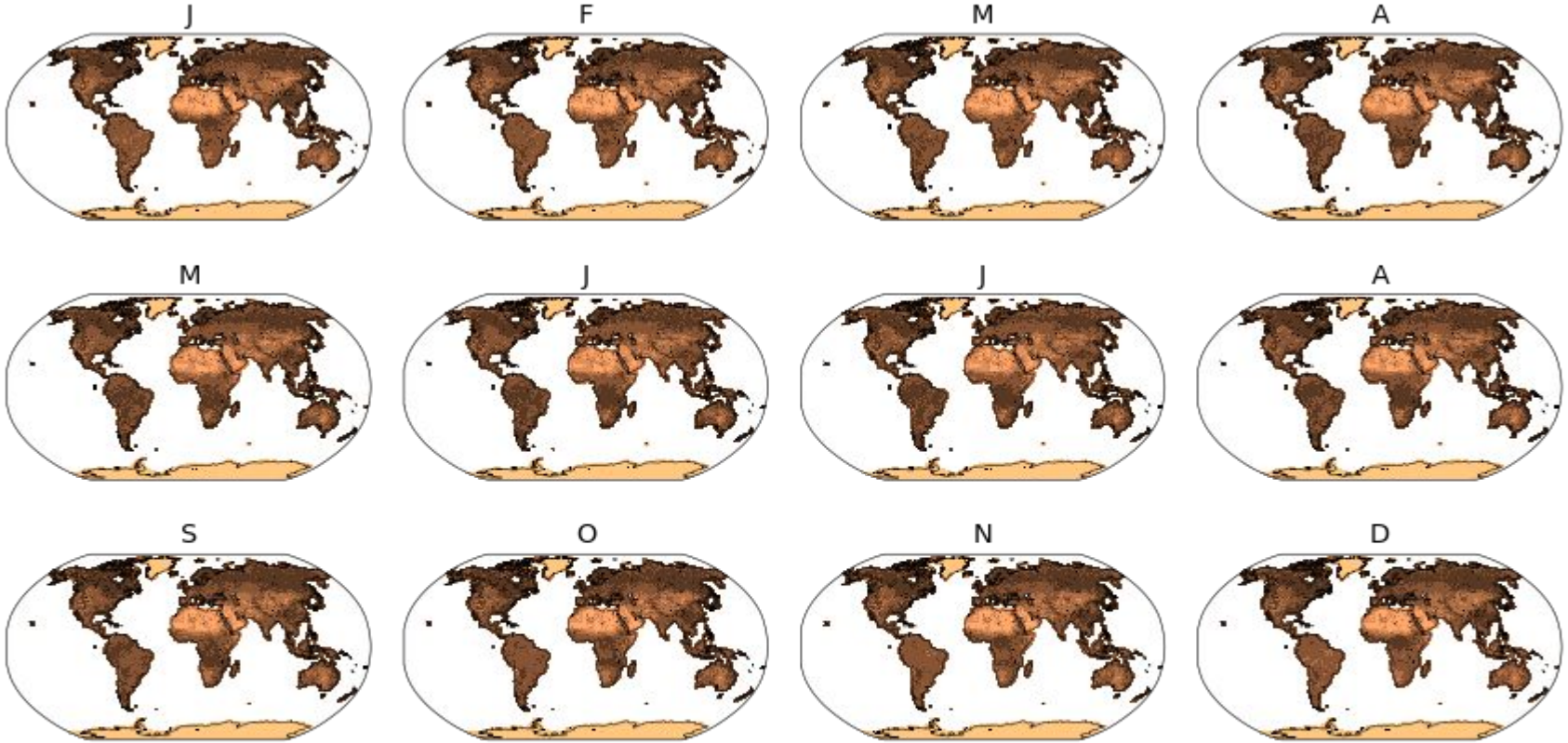
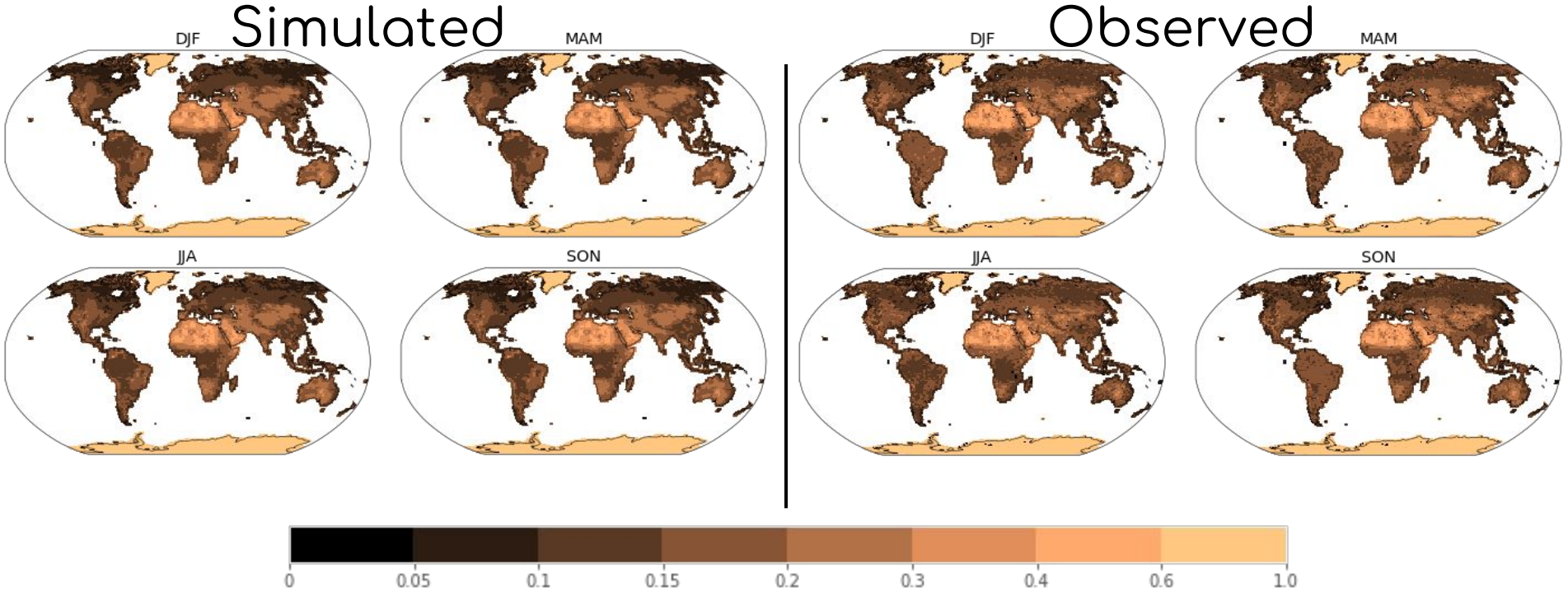
Training Data - snow free albedo

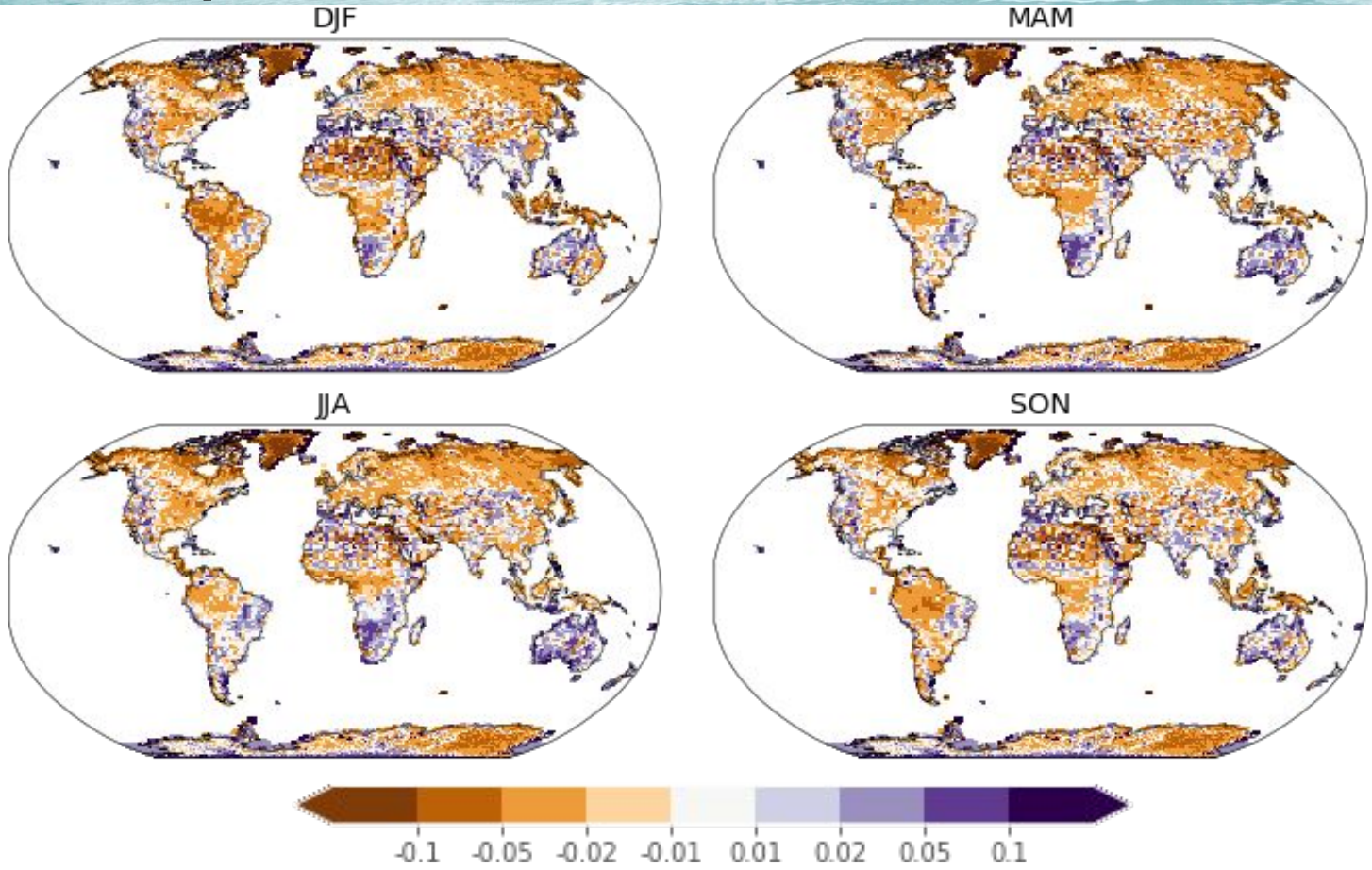


Houldcroft et al. 2009

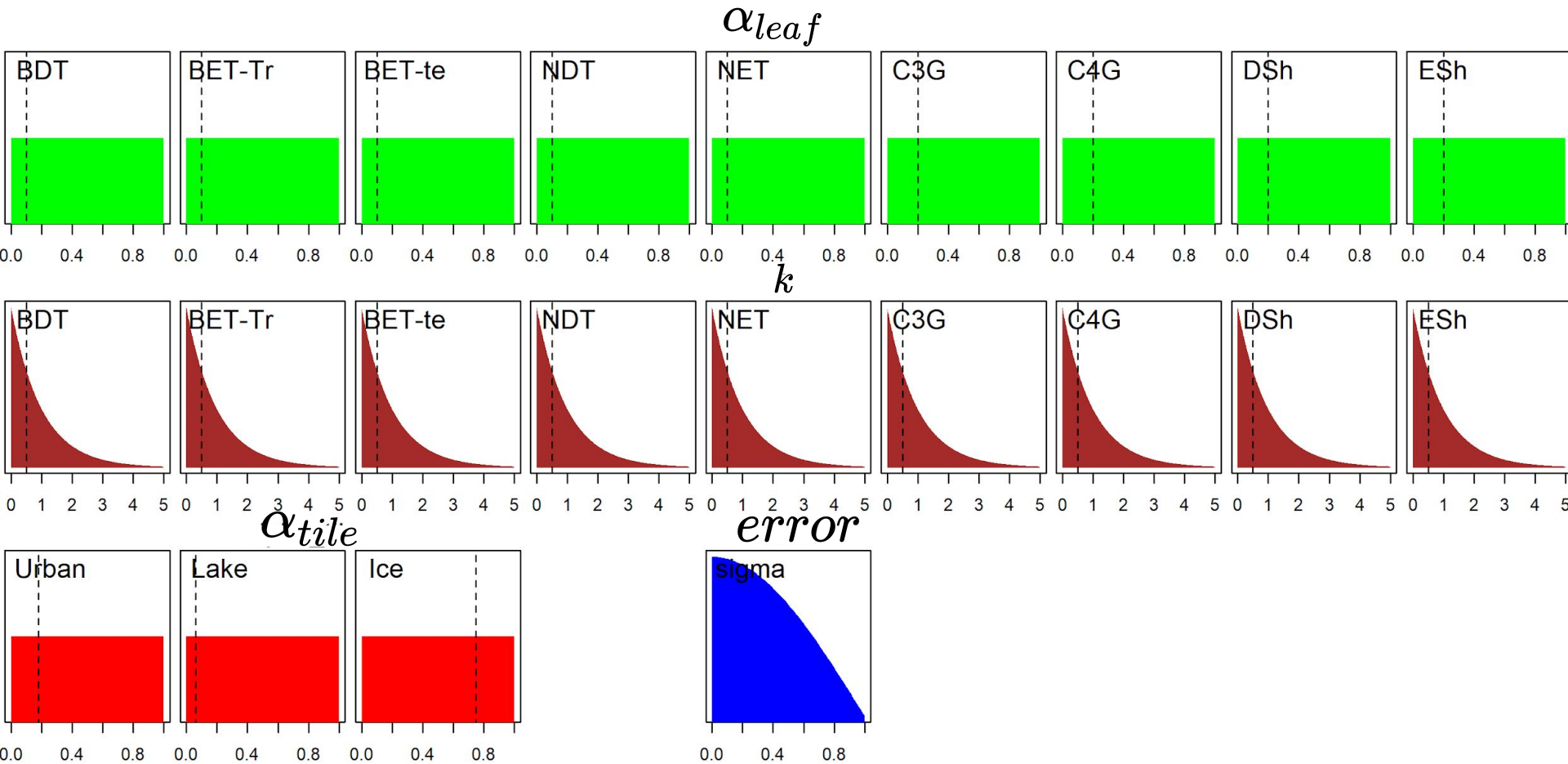
Old setup


Simulated
Observed
DJF
MAM
JJA
SON
DJF
MAM
JJA
SON
0
0.05
0.1
0.15
0.2
0.3
0.4
0.6
1.0

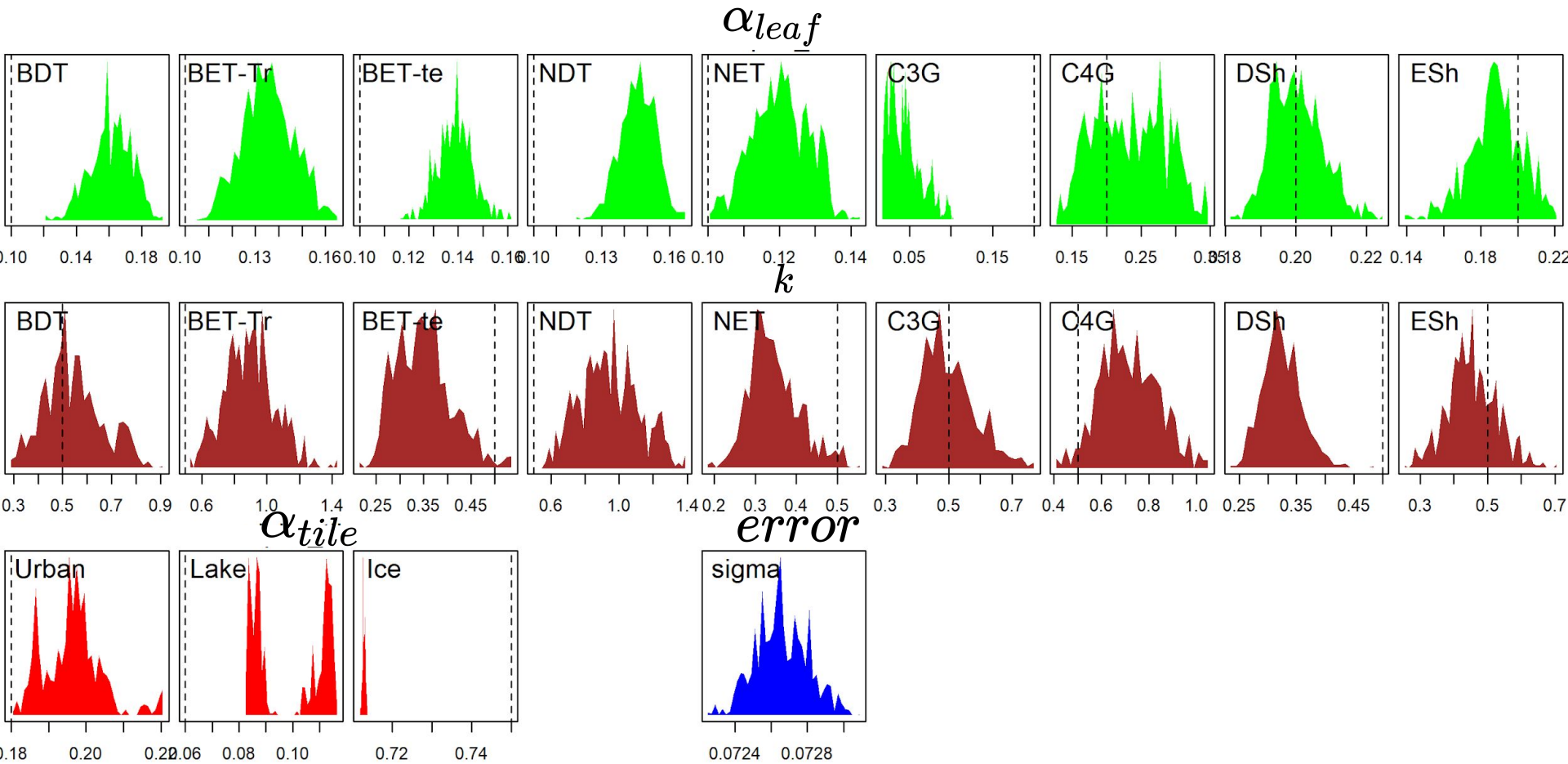
Old setup - difference from obs



Priors

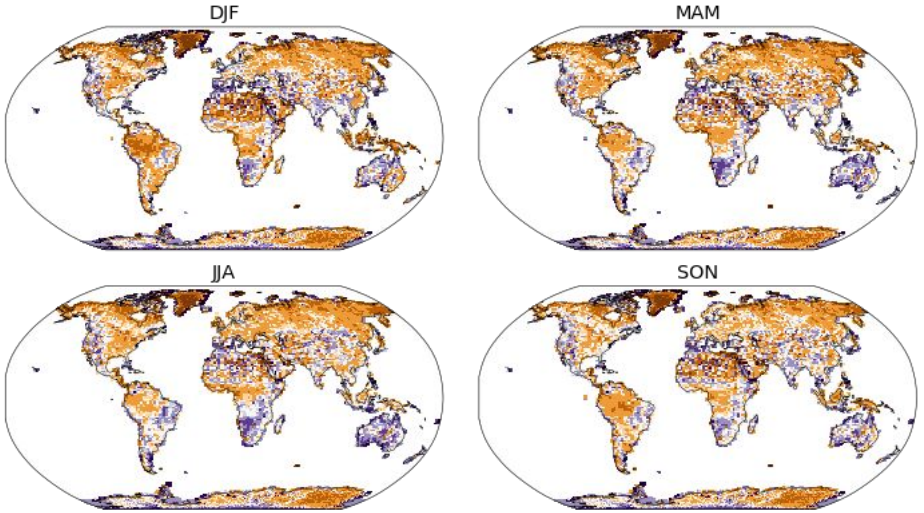

α_{leaf}
BDT
BET-Tr
BET-te
NDT
NET
C3G
C4G
DSh
ESh
0.0 0.4 0.8
k
0 1 2 3 4 5
α_{tile}
Urban
Lake
Ice
$error$
sigma

Posteriors

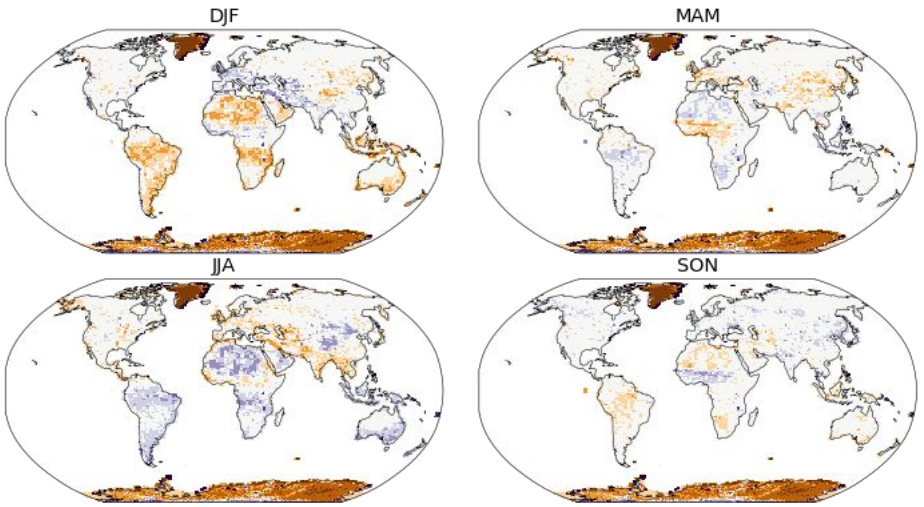

α_{leaf}
BDT
BET-Tr
BET-te
NDT
NET
C3G
C4G
DSh
ESh
k
BDT
BET-Tr
BET-te
NDT
NET
C3G
C4G
DSh
ESh
α_{tile}
Urban
Lake
Ice
$error$
sigma

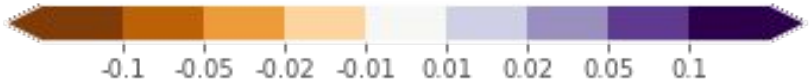
Posteriors

Old Parameters



"Median" new Parameters





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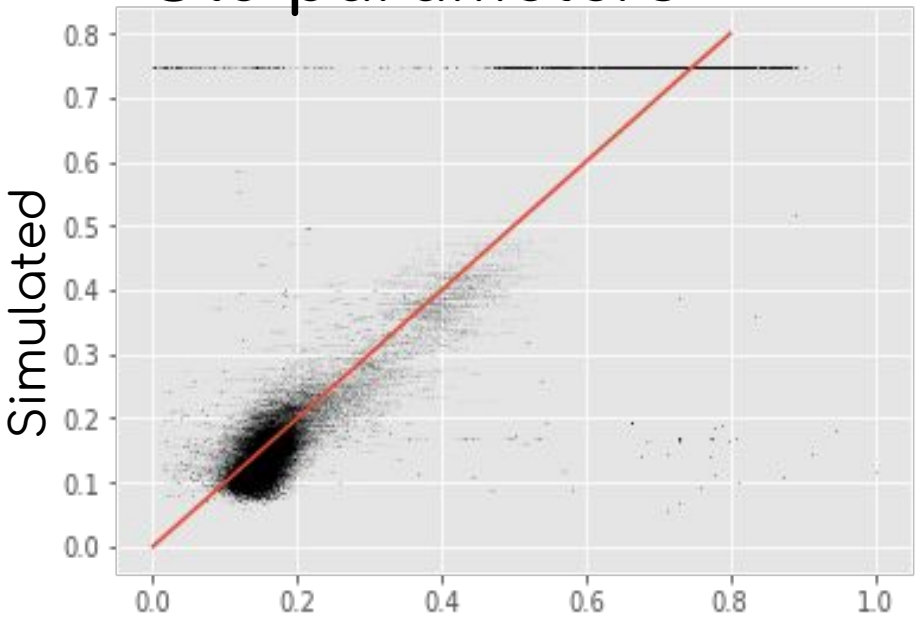
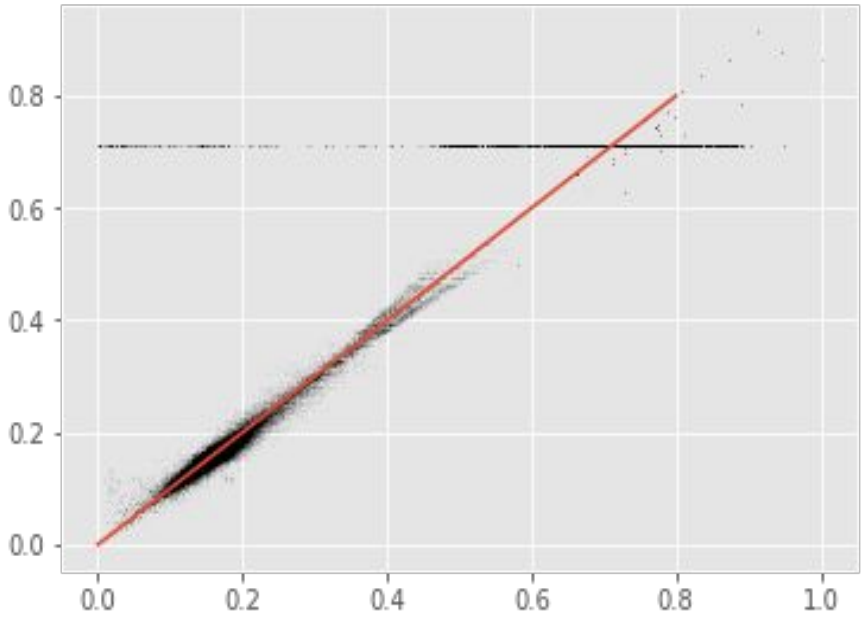
Posteriors

Old parameters



"Median" new parameters



Observations

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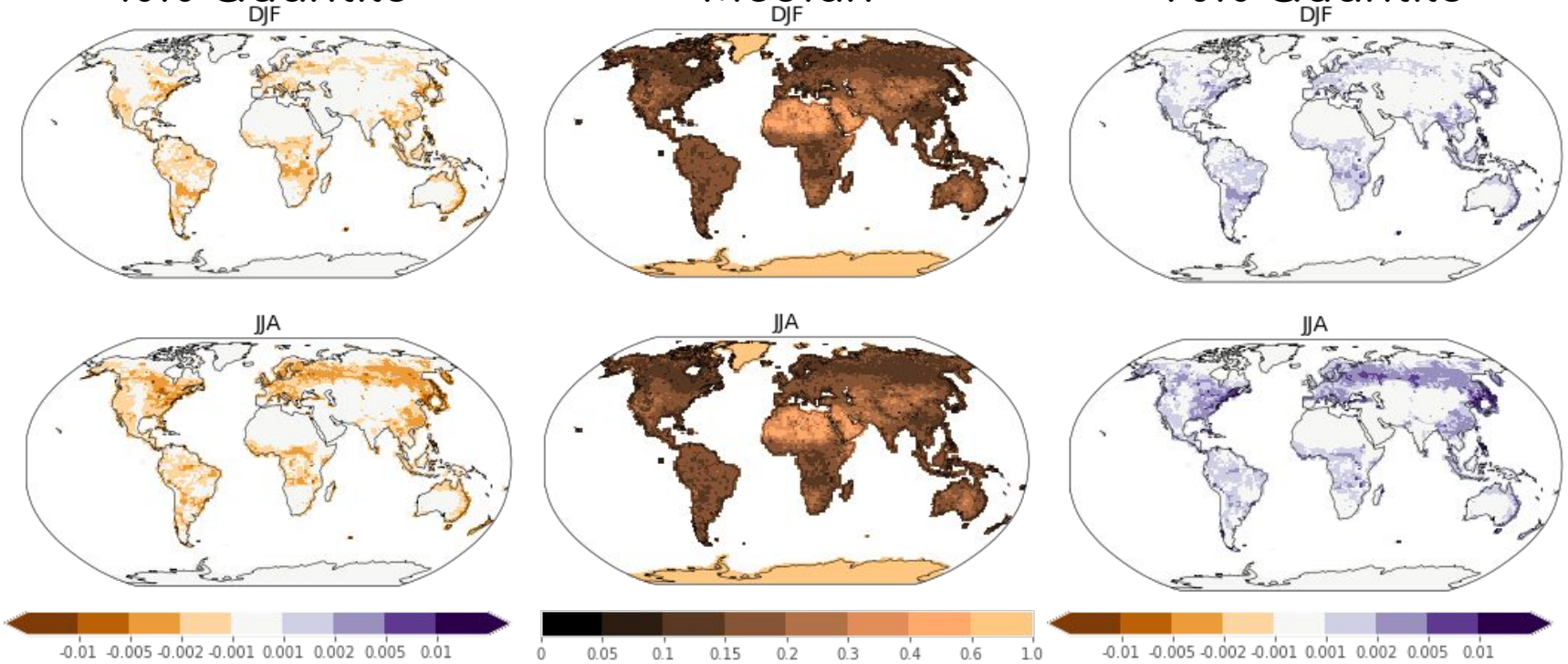
Posteriors



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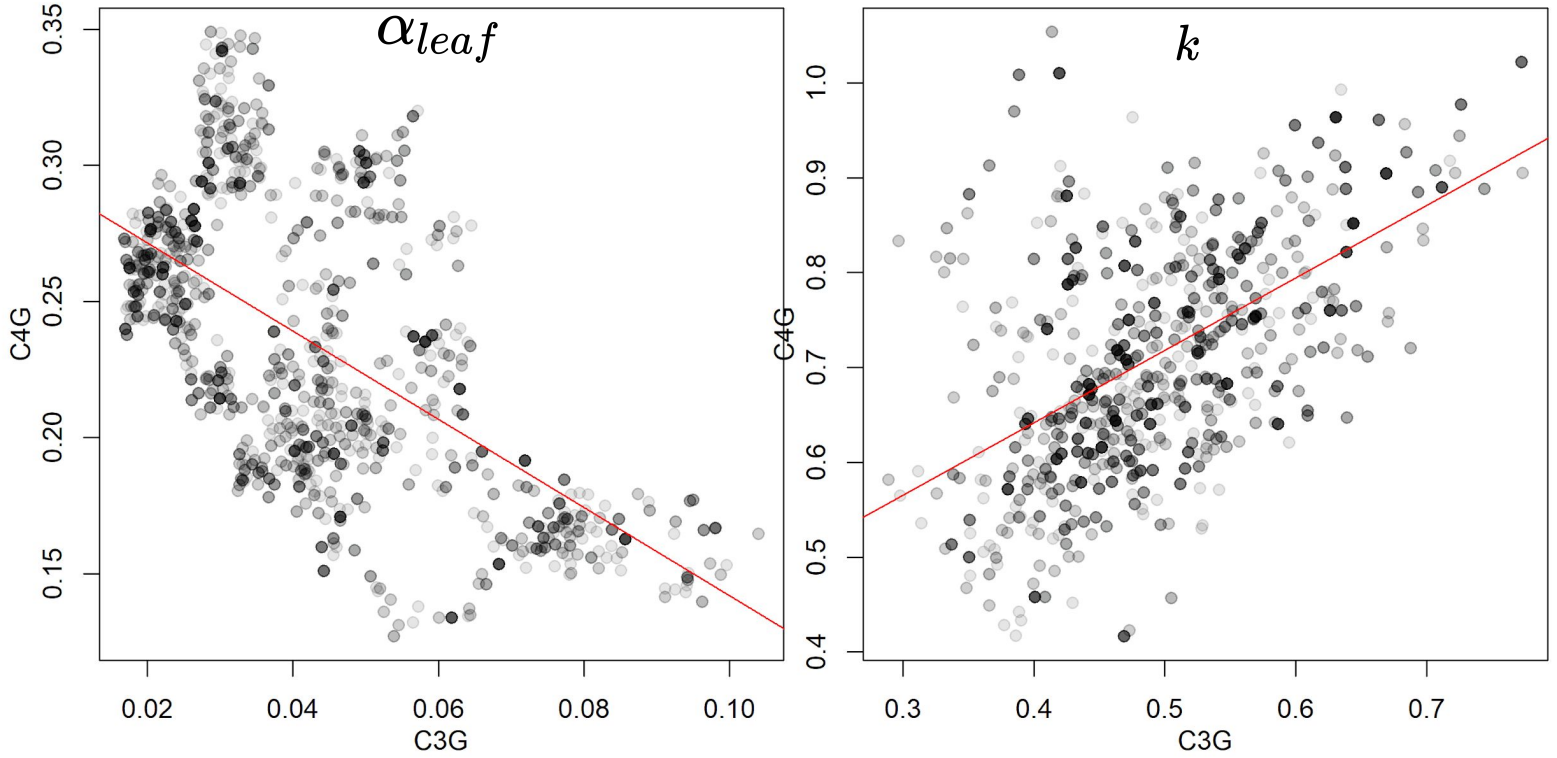
Selecting parameter set



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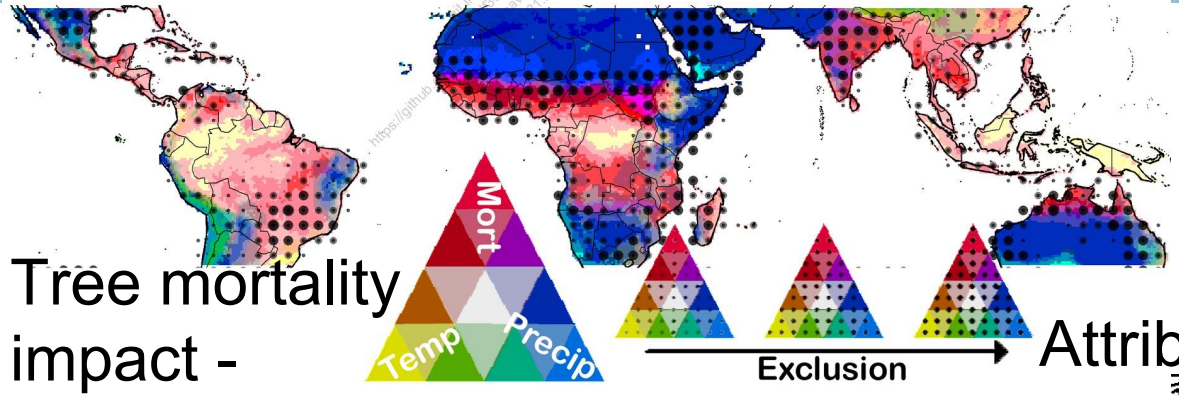
“Conclusions”

Some questions:

- How to choose from co-varying parameters
- Using prescribed or simulated vegetation (actual vs compensation optimization?)

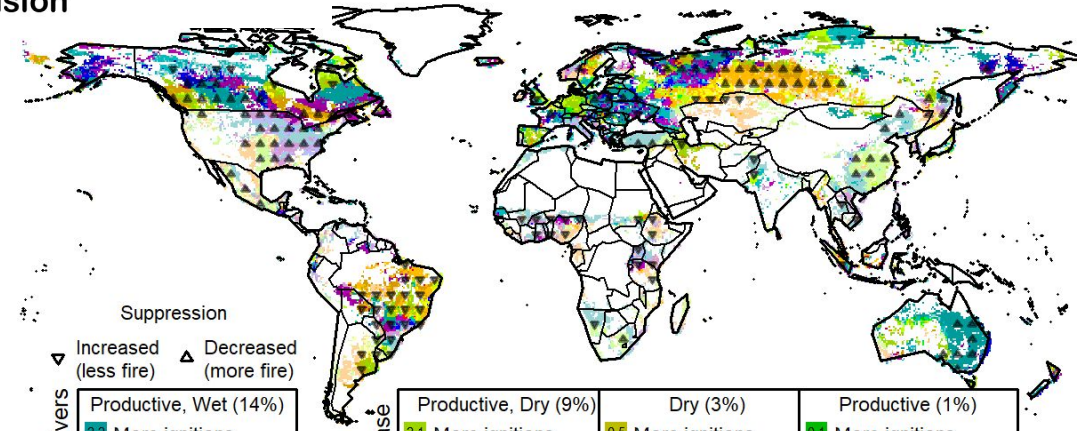
In future, expand to spectral albedo and veg/snow parameters

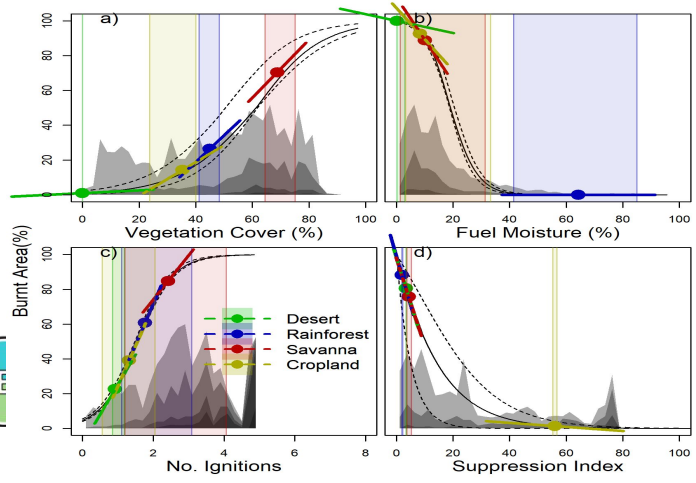
Parameter constraints from bayesian inference

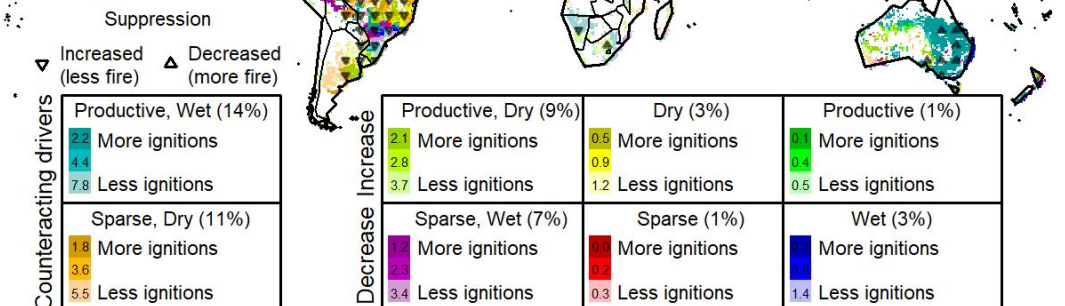


Tree mortality impact - tomorrow 11:05

Attribution of burnt area trends







Number of JULES talks with dinos in...