The use of eigendecompostion in sensitivity analysis of a land surface model

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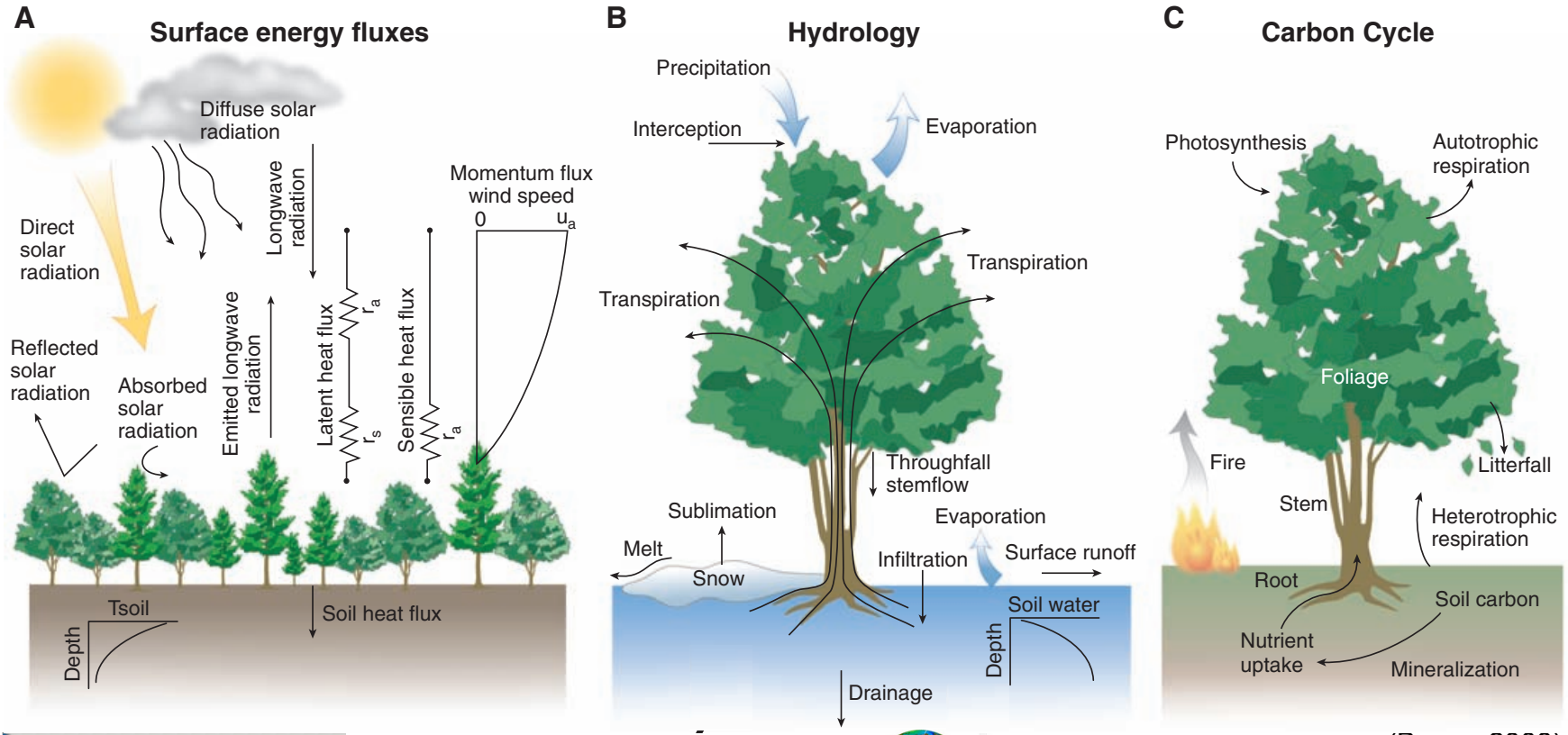
Community Land Model, rev. 3.5



(Bonan 2008)

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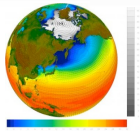

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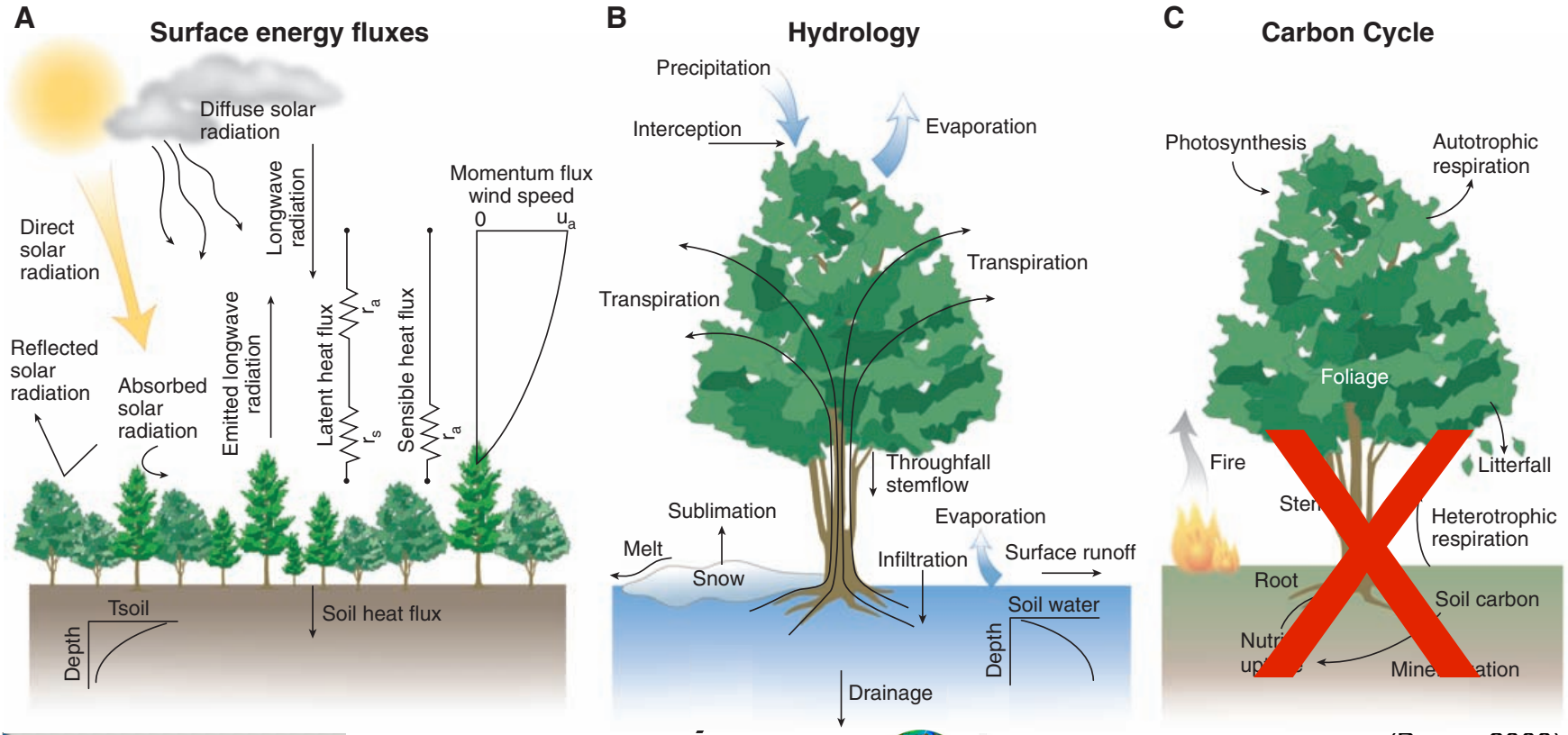
Community Land Model, rev. 3.5



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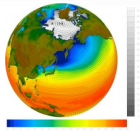

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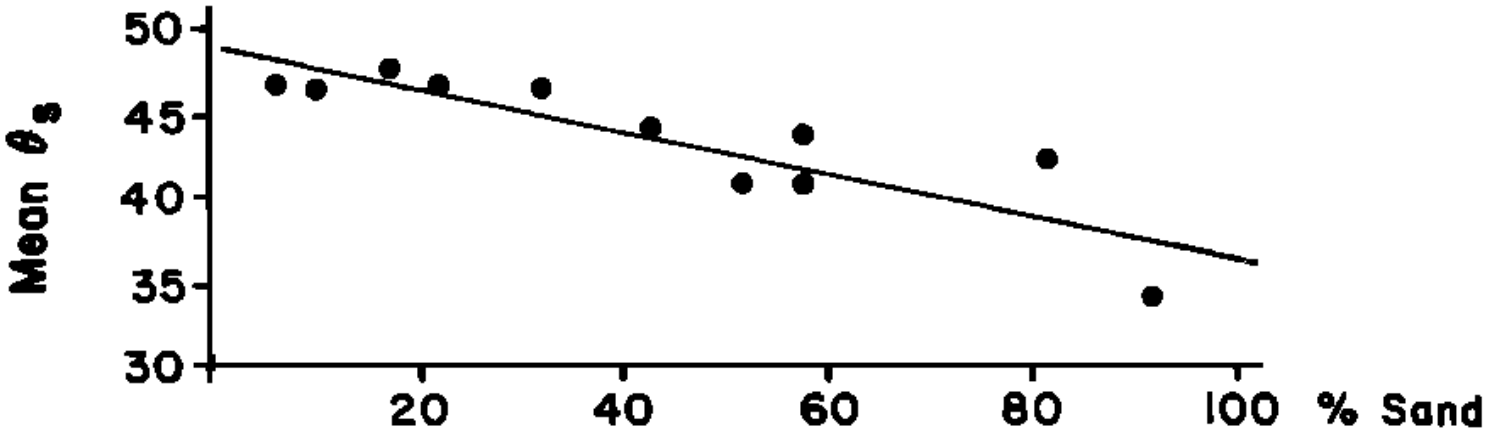
Parameter

Saturated water content = porosity

$$\theta_{sat} = 0.489 - 0.00126(\%Sand)$$



(Cosby *et al.* 1984)

$$\theta_{sat} = p_3 - p_4(\%Sand)$$

Objective Function

Model output flux

$$Q(\alpha) = \sum_{k=1}^{K} \sum_{c=1}^{C} \sum_{j=1}^{J} \sum_{n=1}^{N} \sum_{i=1}^{I} \left[w_{n,i} \frac{F_{c,j,n}(t_i, {}^{n}\alpha_k) - F_{c,j,n}(t_i, {}^{n}\alpha_k^0)}{F_{c,j,n}(t_i, {}^{n}\alpha_k^0)} \right]^2$$

Parameters

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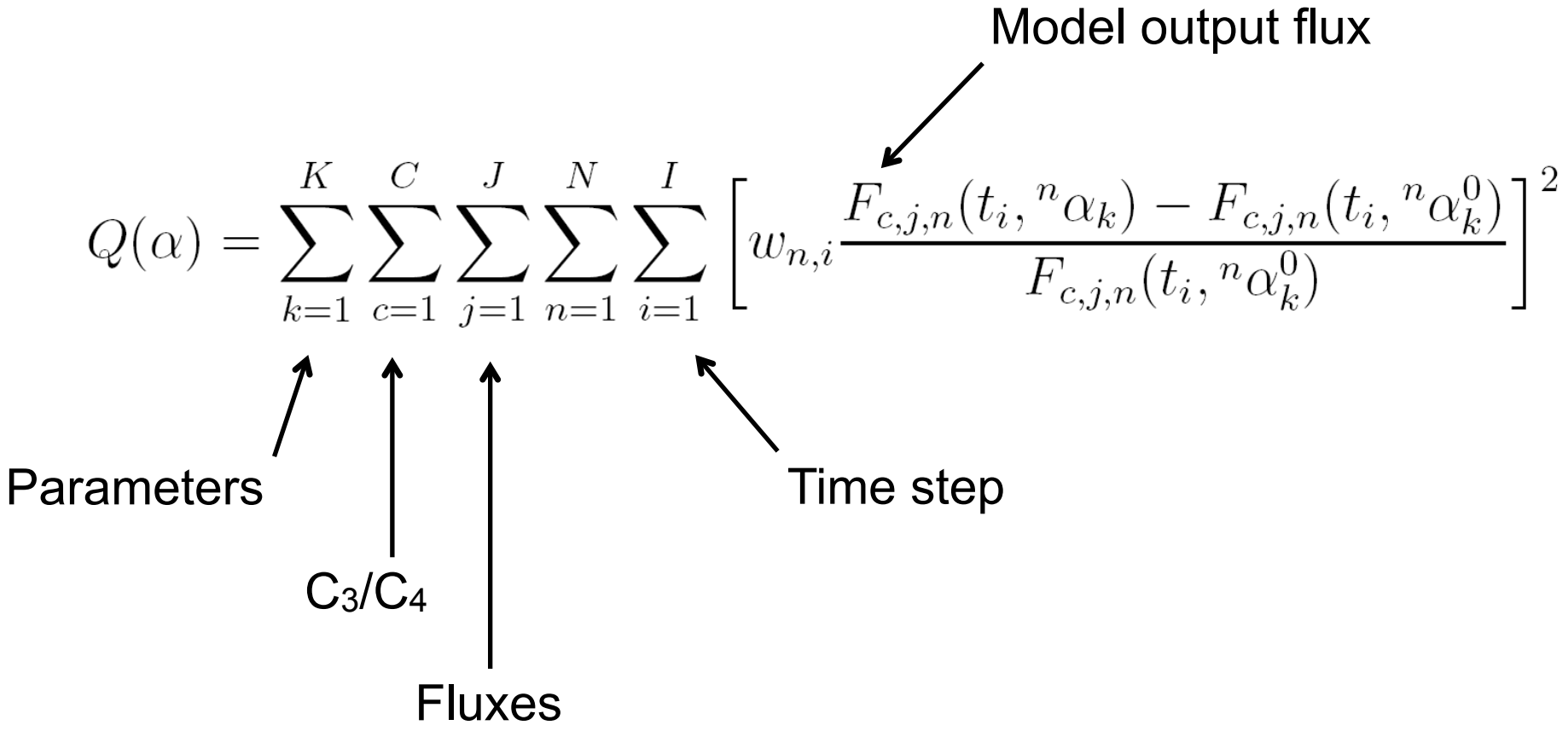
Objective Function



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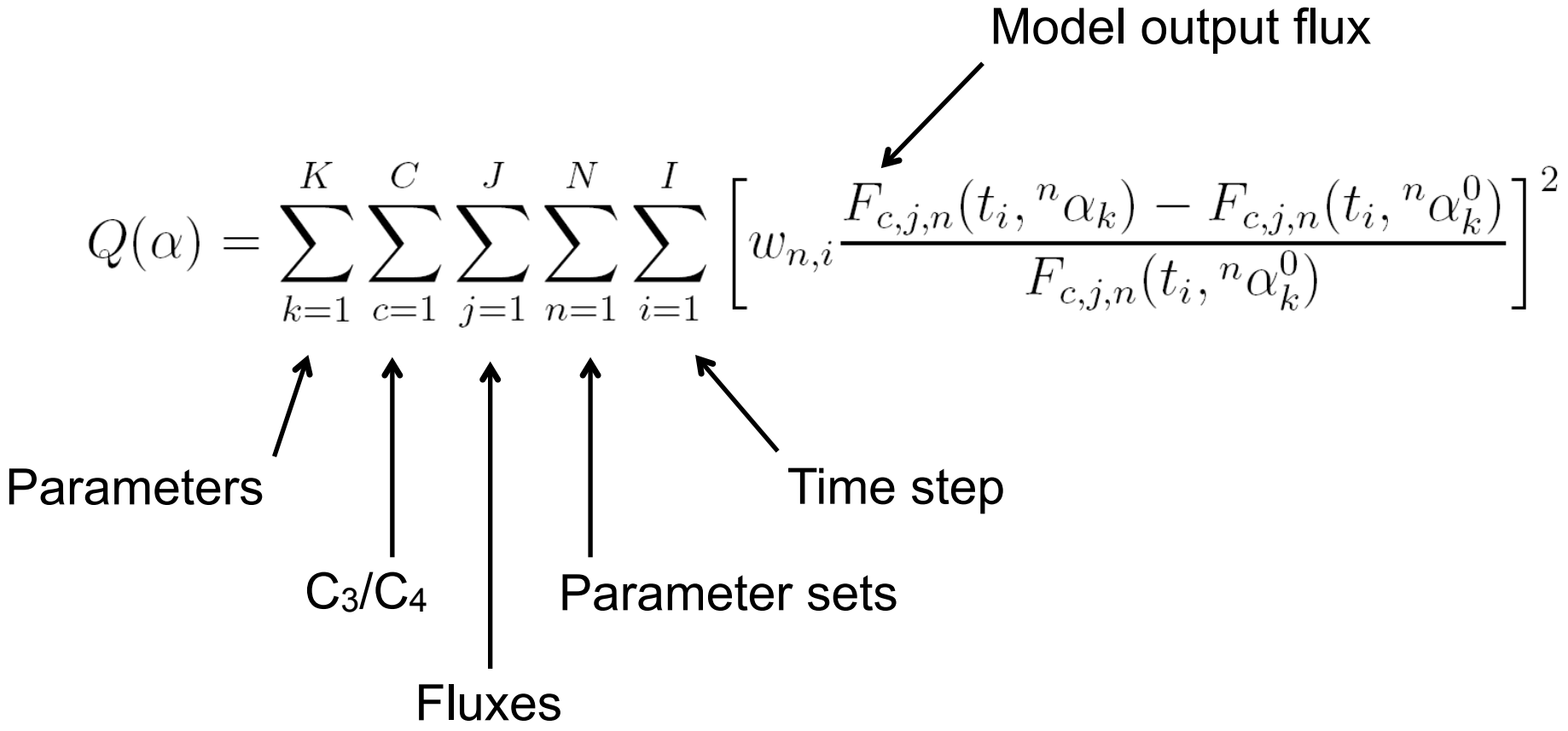
Objective Function



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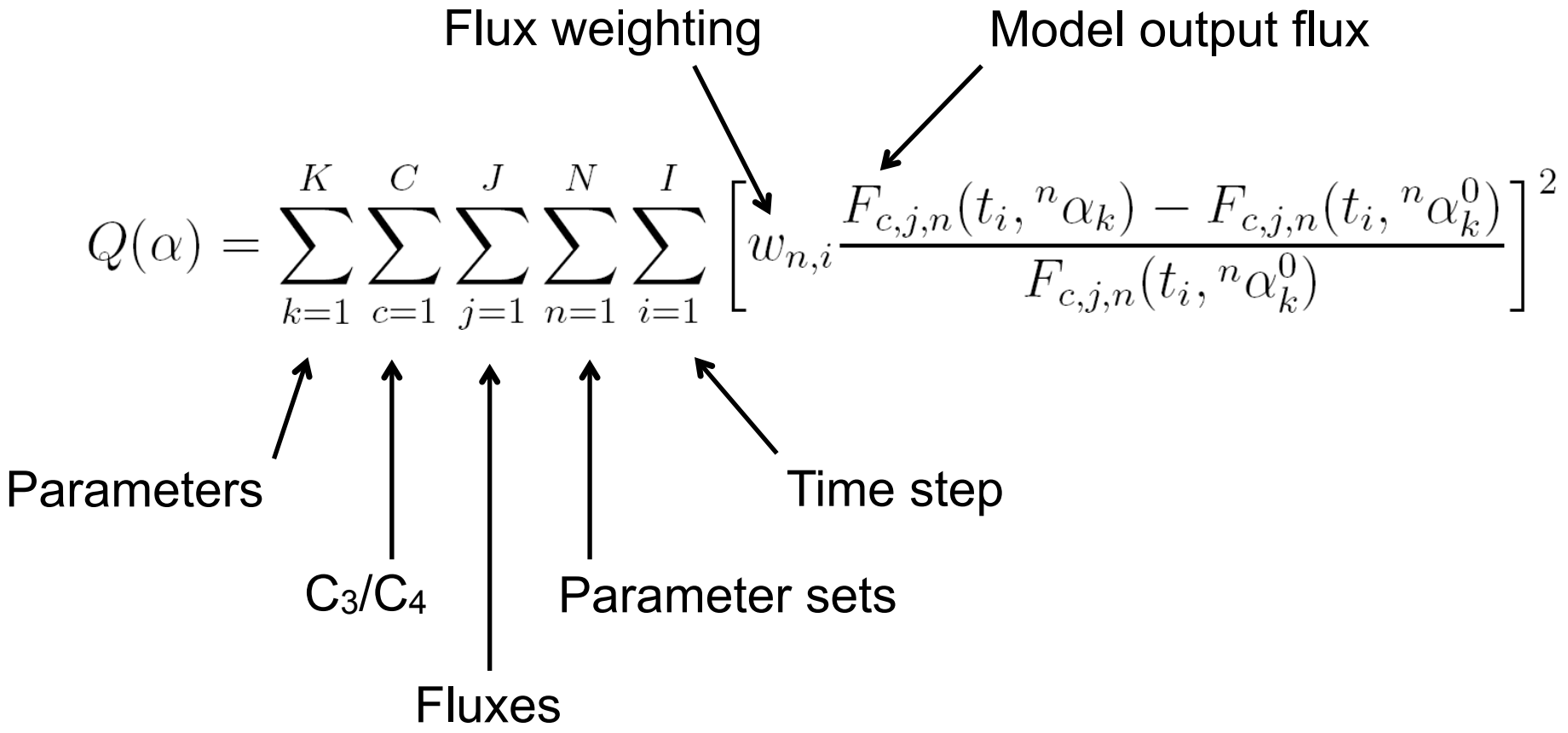
Objective Function



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Objective Function

$$Q(\alpha) = \sum_{k=1}^{K} \sum_{c=1}^{C} \sum_{j=1}^{J} \sum_{n=1}^{N} \sum_{i=1}^{I} \left[w_{n,i} \frac{F_{c,j,n}(t_i, {}^{n}\alpha_k) - F_{c,j,n}(t_i, {}^{n}\alpha_k^0)}{F_{c,j,n}(t_i, {}^{n}\alpha_k^0)} \right]^2$$

Objective Function

$$Q(\alpha) = \sum_{k=1}^{K} \sum_{c=1}^{C} \sum_{j=1}^{J} \sum_{n=1}^{N} \sum_{i=1}^{I} \left[w_{n,i} \frac{F_{c,j,n}(t_i, {}^{n}\alpha_k) - F_{c,j,n}(t_i, {}^{n}\alpha_k^0)}{F_{c,j,n}(t_i, {}^{n}\alpha_k^0)} \right]^2$$

$$M[k,r] = \sum_{c=1}^{C} \sum_{j=1}^{J} \sum_{n=1}^{N} \sum_{i=1}^{I} \left[w_{n,i} \frac{\partial \ln F_{c,j,n}(t_i, p_k)}{\partial \ln p_k} \cdot \frac{\partial \ln F_{c,j,n}(t_i, p_r)}{\partial \ln p_r} \right]$$

Square matrix of variations and covariations

k = r, variation
k ≠ r, covariation

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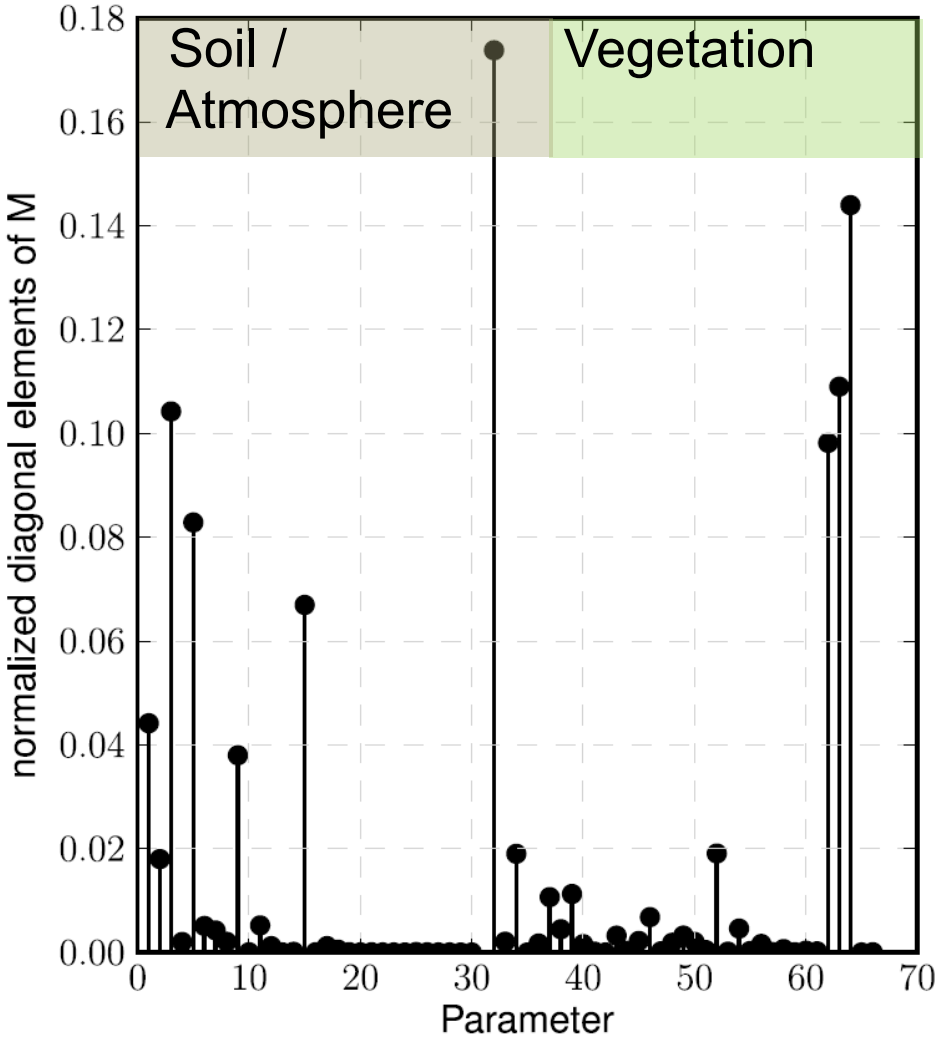
Parameter Importance



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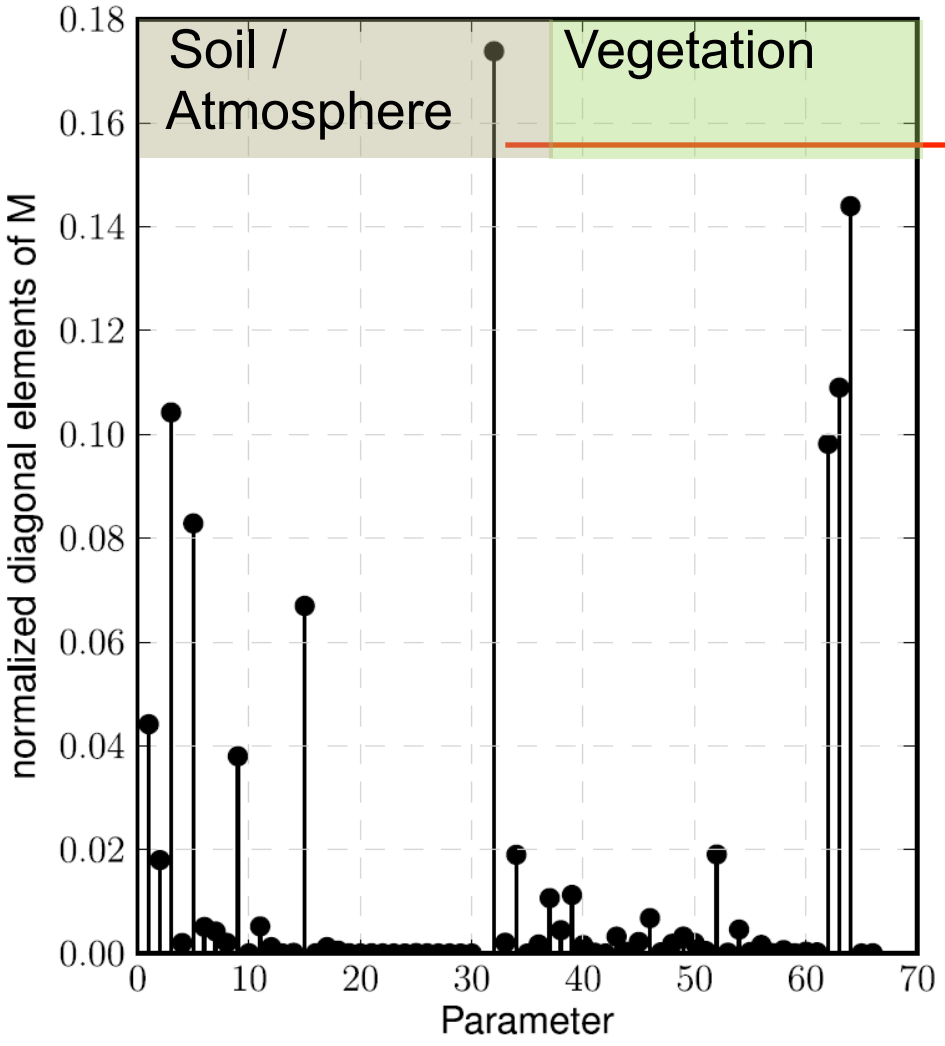
Parameter Importance



Soil evaporation resistance

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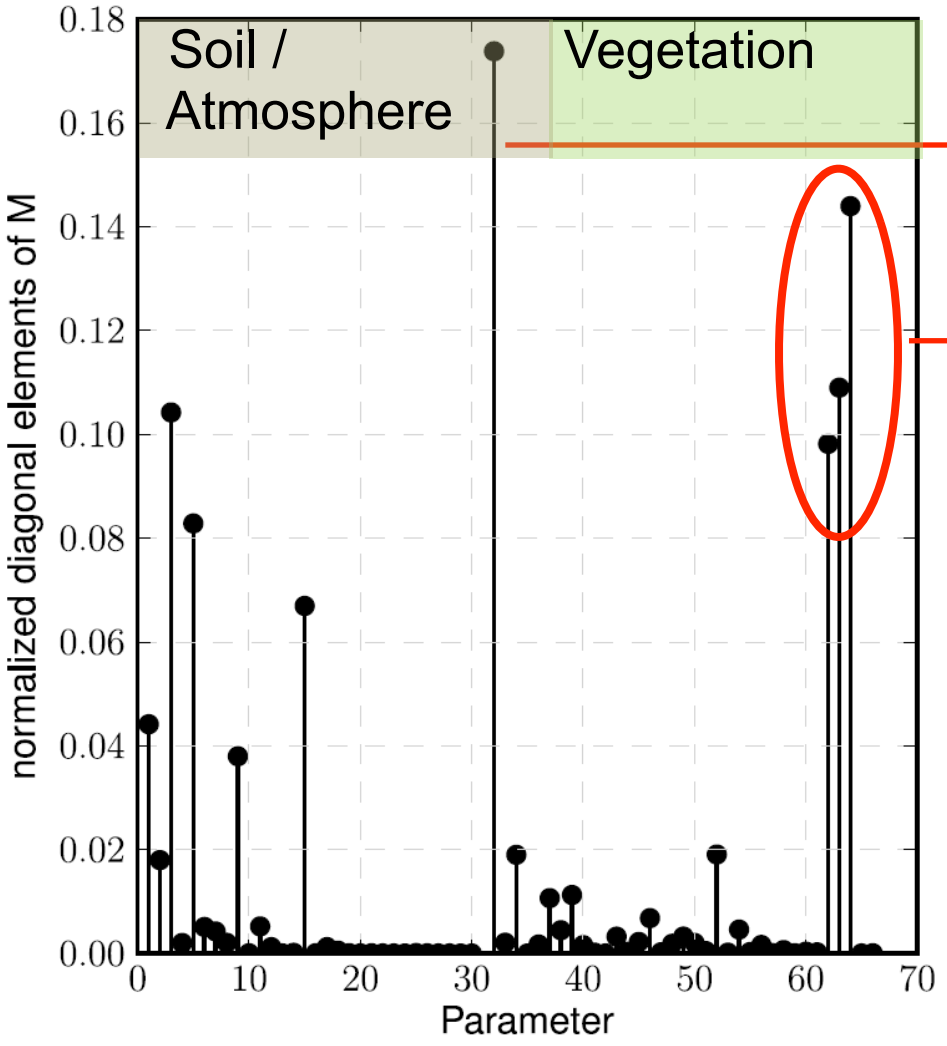
Parameter Importance



Soil evaporation resistance

Specific leaf area

$V_{c,max}$

Slope stomatal conductance

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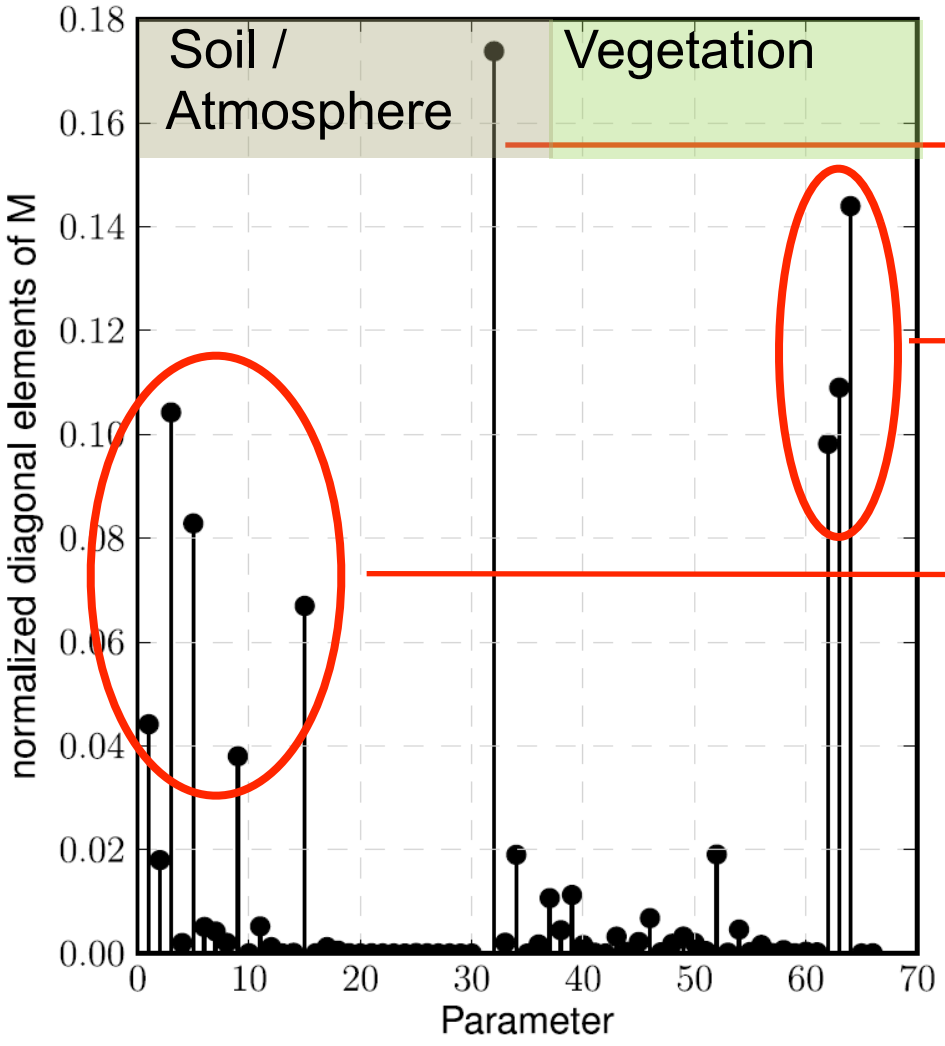
Parameter Importance



Soil evaporation resistance

Specific leaf area
$V_{c,max}$
Slope stomatal conductance

Soil water properties,
e.g. p_3 = porosity parameter

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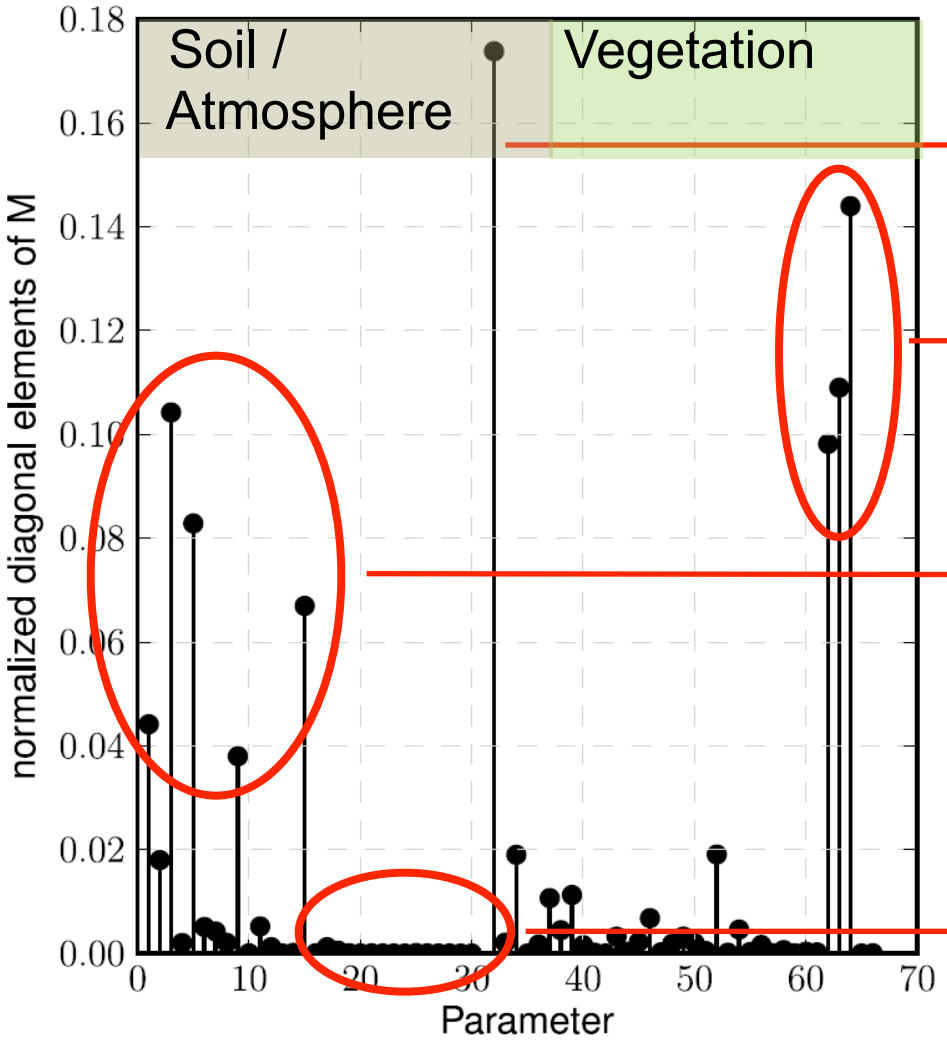
Parameter Importance



Soil evaporation resistance

Specific leaf area
$V_{c,max}$
Slope stomatal conductance

Soil water properties,
e.g. p_3 = porosity parameter

Soil thermal properties

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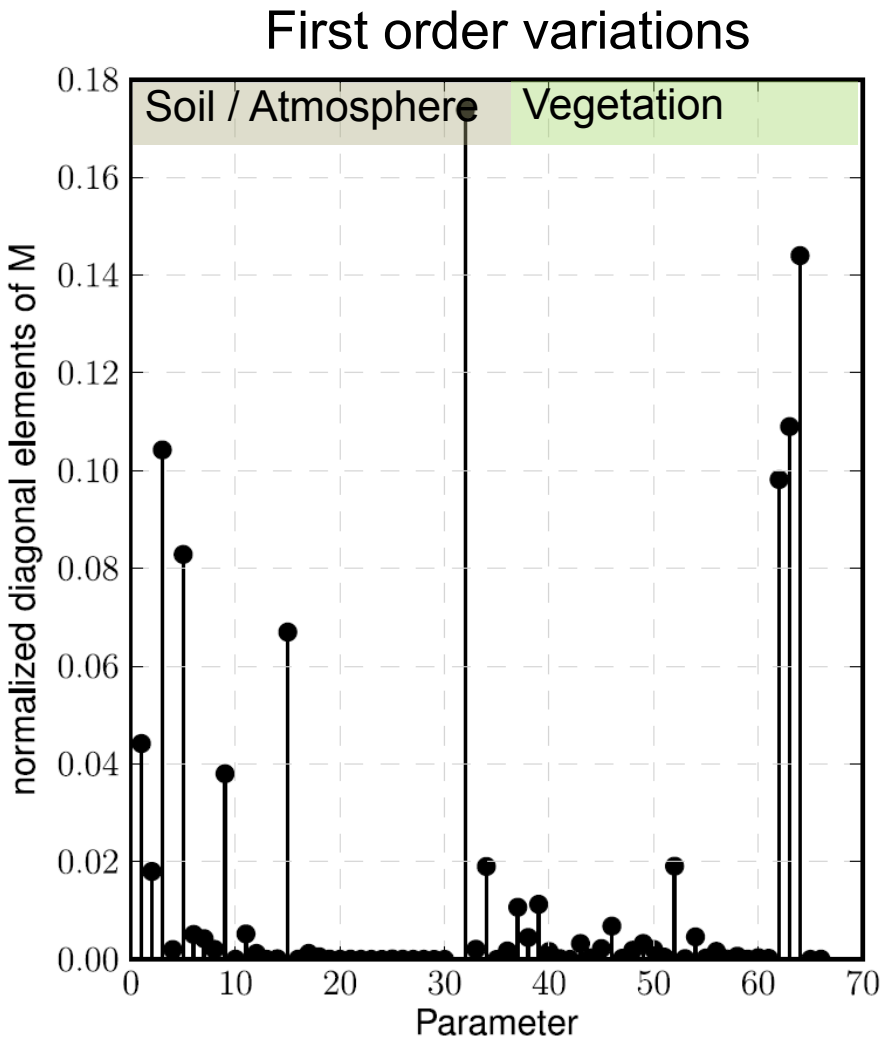
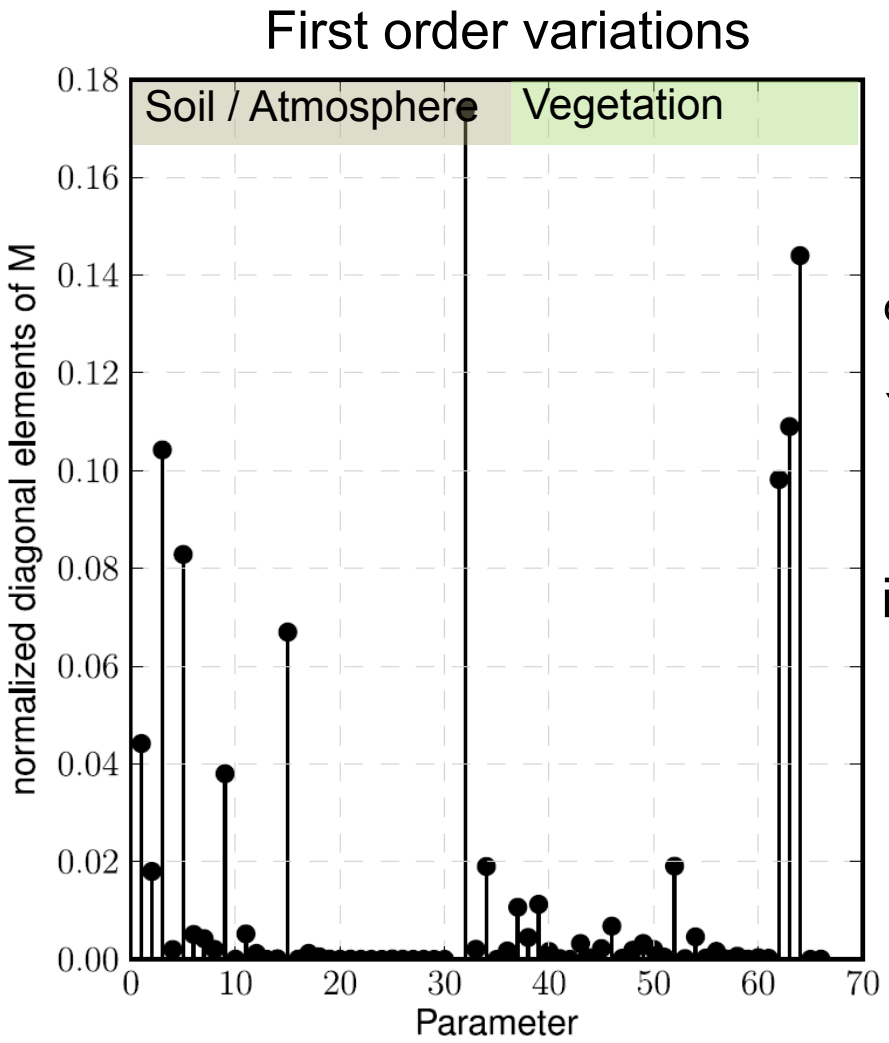
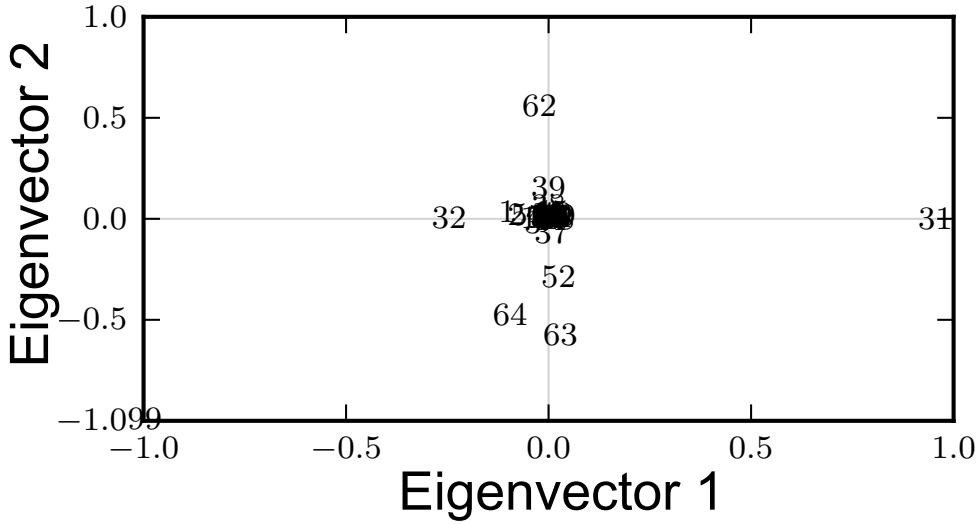
Parameter Importance



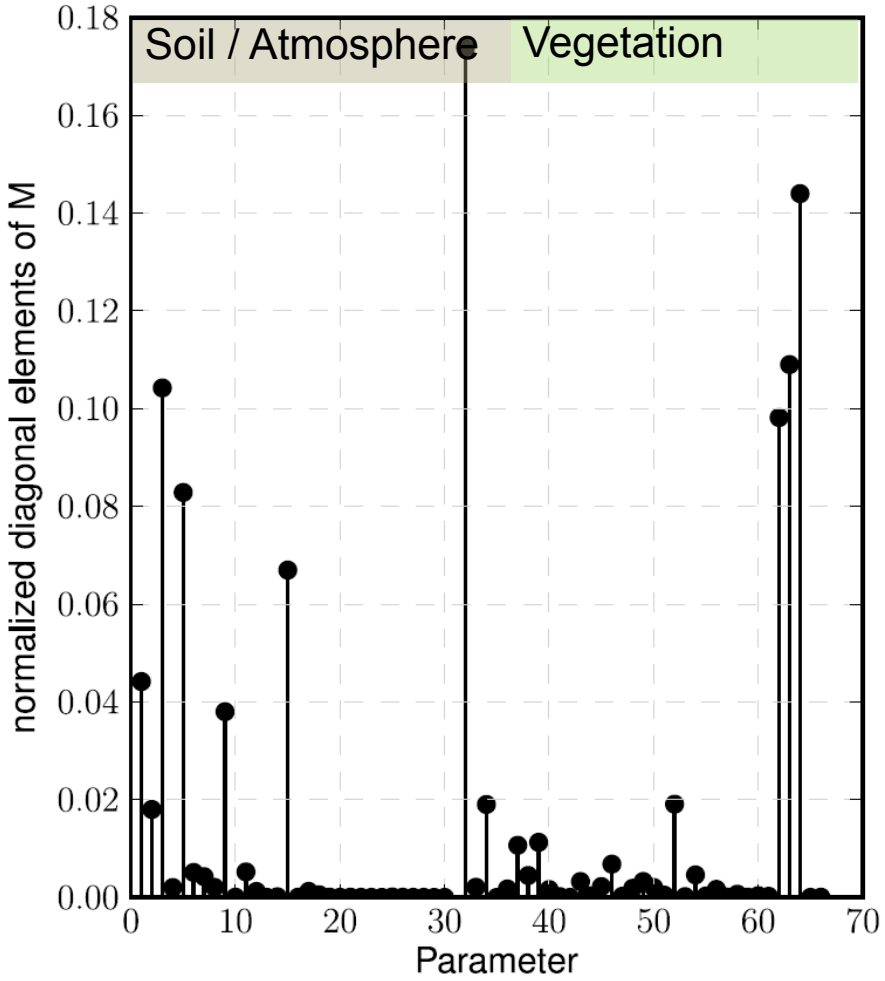
Parameter Importance



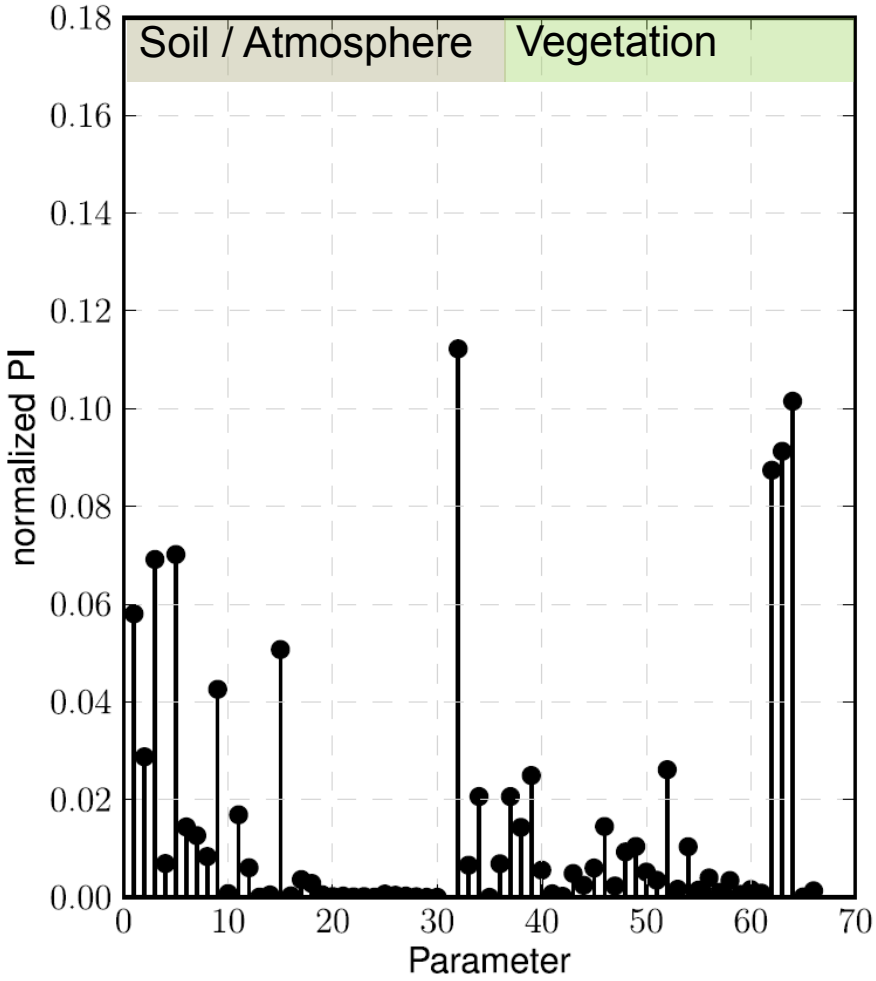


Parameter Importance

First order variations

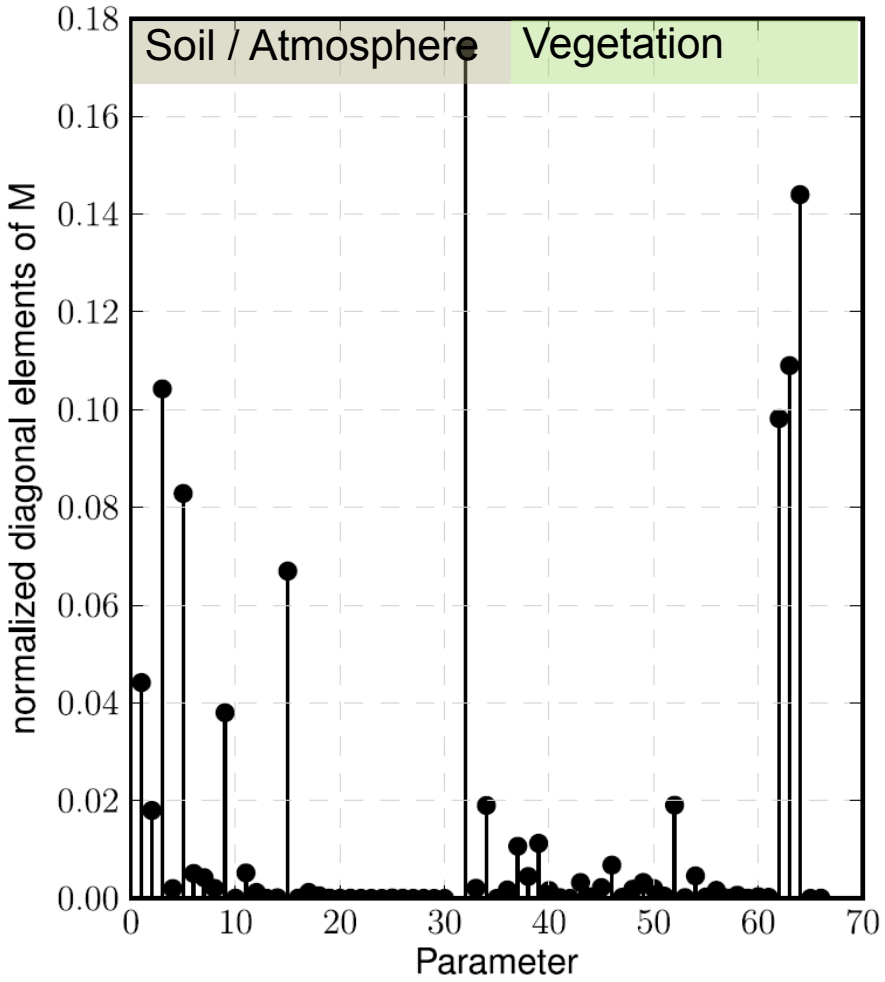


Including covariations ➜
Parameter Importance Index PI



Parameter Importance

First order variations



Including covariations ➜
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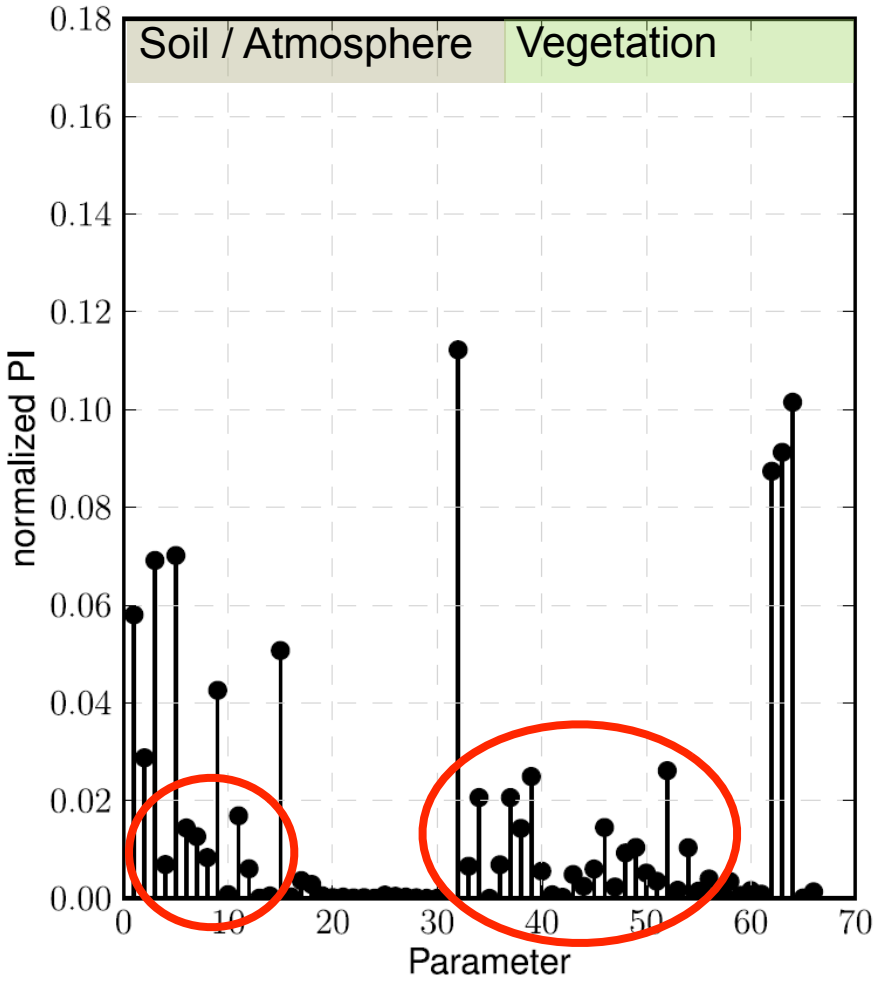
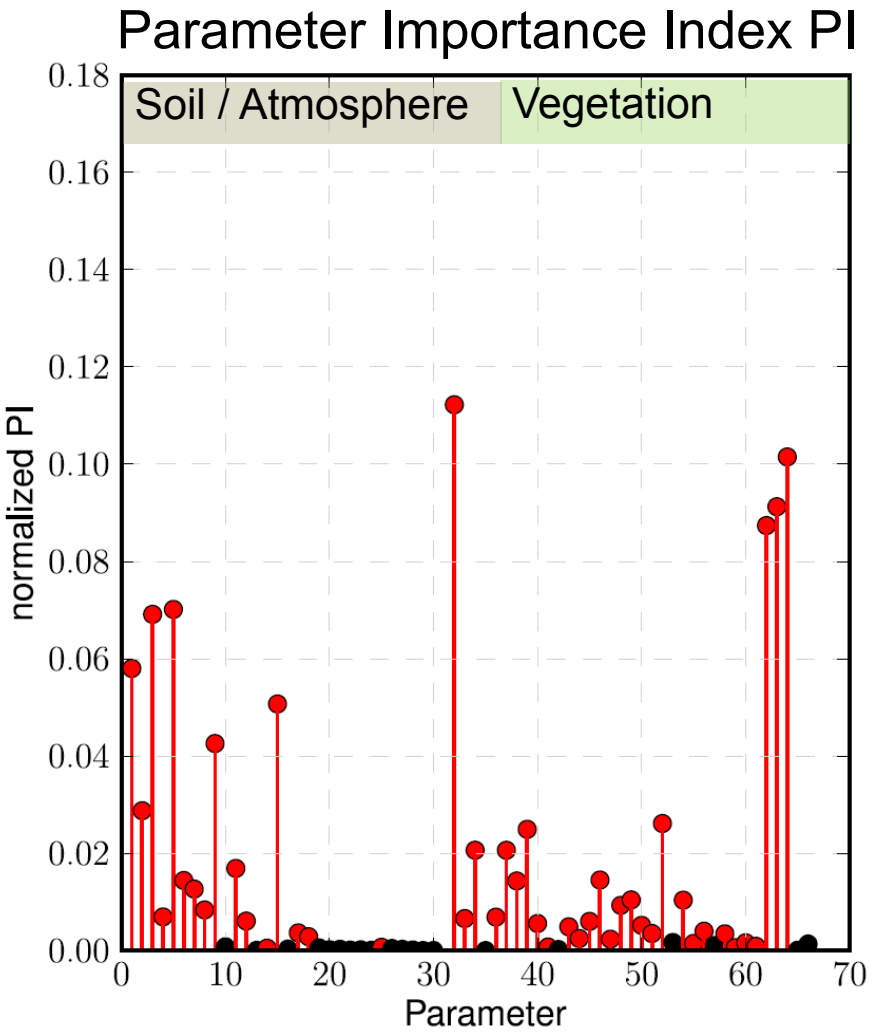
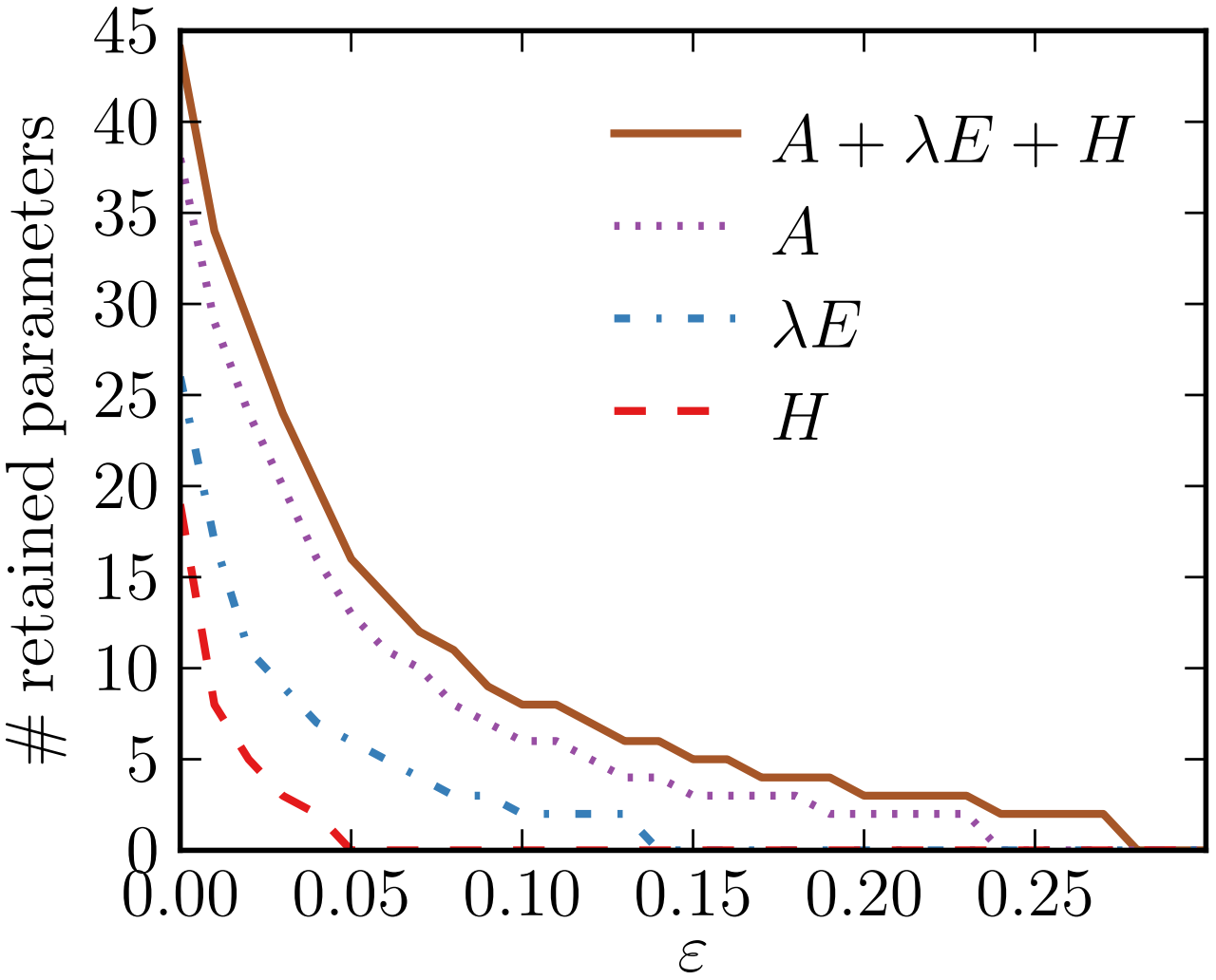


Parameter Selection

Select parameters that contribute to the eigenvalues by more than $\varepsilon = 1\%$

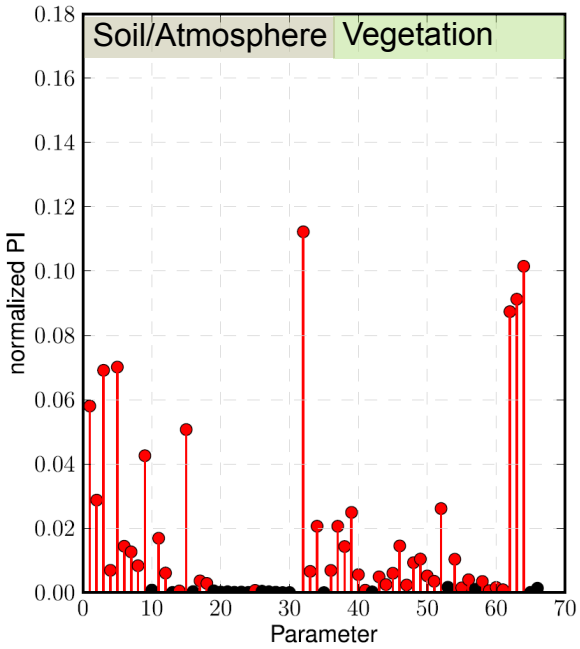


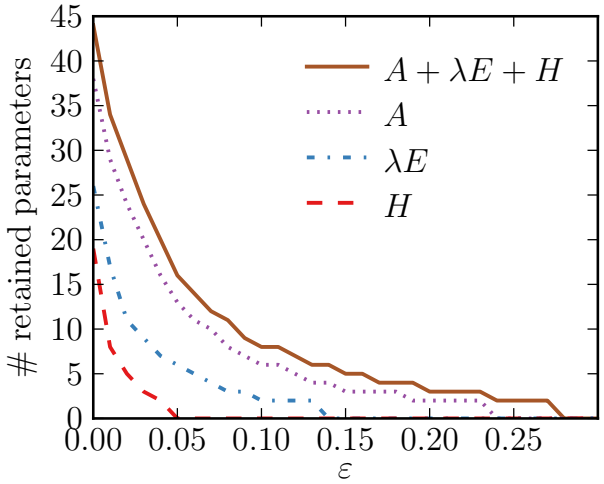
Parameter Selection



Conclusions

- Global sensitivity analysis of Community Land Model CLM3.5
- Eigendecomposition takes covariations between parameters into account
- Propose new parameter ranking & selection criteria
- Retains 44 of 66 parameters for ε = 1% and 10 of 66 for ε = 10%
- Photosynthesis most informative
  Sensible heat least sensitive output flux
- $V_{c,max}$ and slope of g_s very sensitive for photosynthesis
  soil water parameters important for latent heat





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