

# The Likelihood of Rapid Climate Change

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# What is the risk?

- Policy makers (and society in general) needs to know what risks we are running from rapid climate change
- There are two parts to this
  - The severity of the changes
  - The probability of that change happening

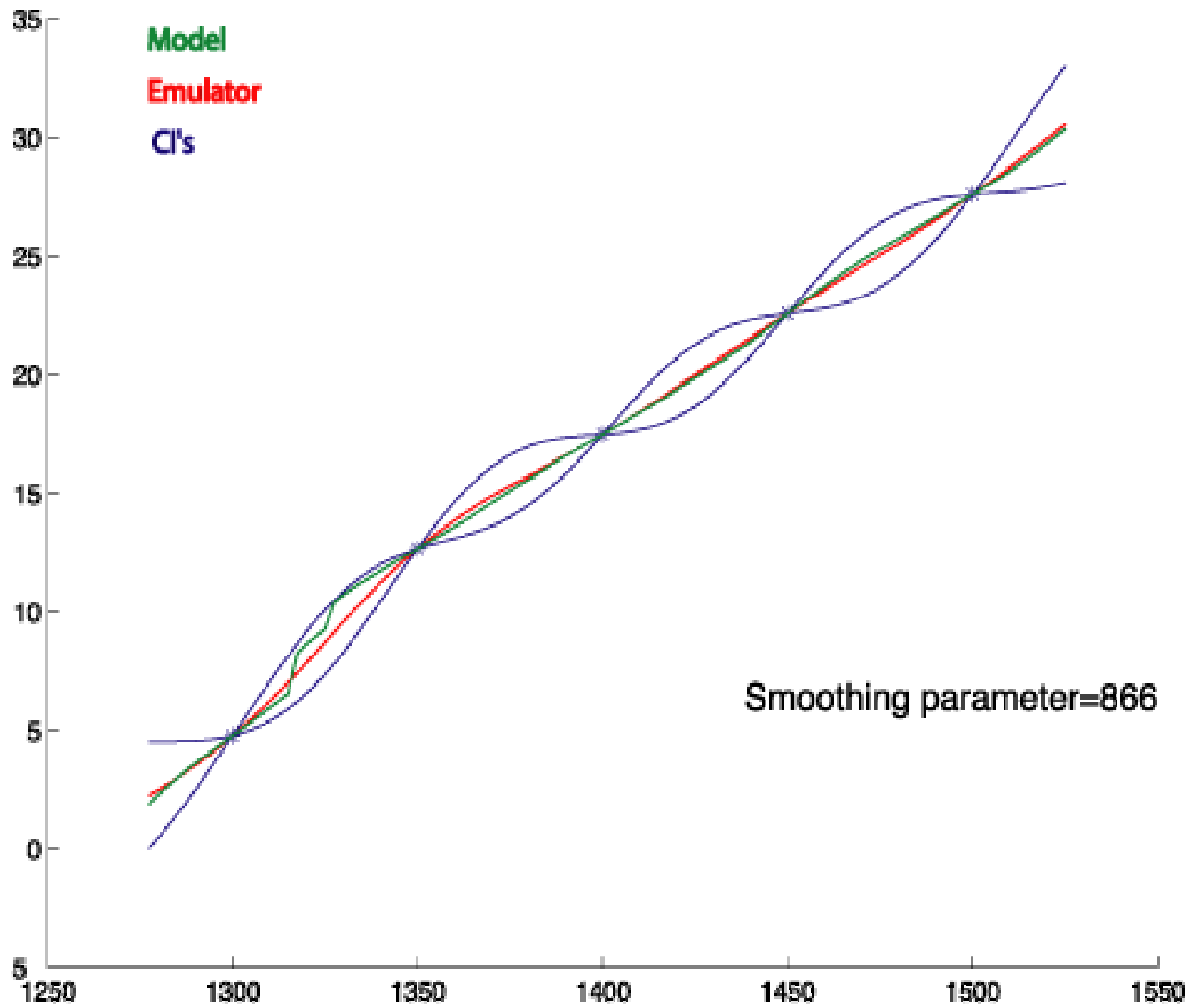
# How to tackle the problem?

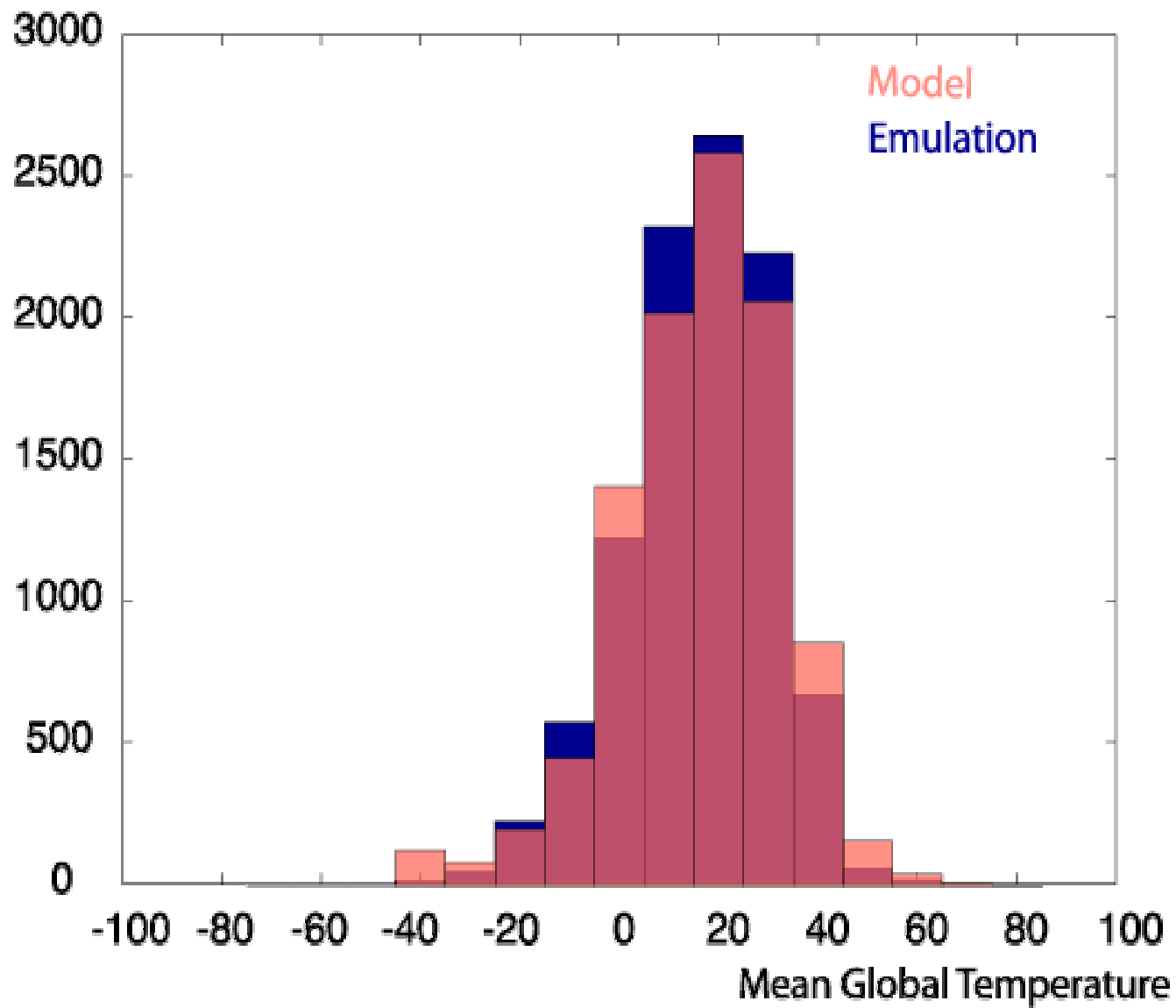
- Build a statistical model of rapid change
- Use this model to calculate the required probabilities
- Use Bayesian statistics
  - Very little data
  - Use models
  - (Add expert opinion)

# SACCO

## (Statistical Analysis of Computer Code Output)

- Most of our models take a long time to run
- We cannot therefore make as many runs as we would like
- Build a statistical approximation to the model (an emulator) with a few runs
- Use the emulator to make our statistical inferences





# What models to use

- Use a hierarchy of models
  - Methods to exploit this
- Main model will be C-GOLDSTEIN
- Aim to use HADCM3 (or equivalent) in a few years time

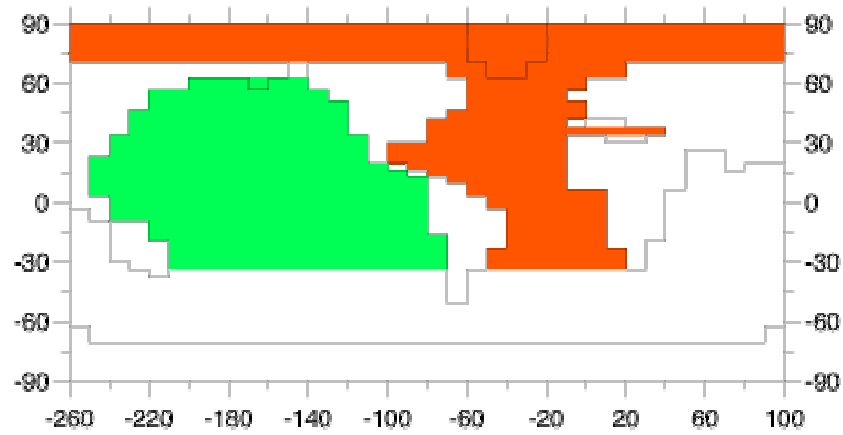
# C-GOLDSTEIN

- **C-GOLDSTEIN presently comprises three model components:**
  - 3-D ocean: “GOLDSTEIN” (Global Ocean-Linear Drag Salt and Temperature Equation INtegrator)
  - 2-D atmosphere: Energy Moisture Balance Model
  - 2-D sea ice: thermodynamics, advection, diffusion

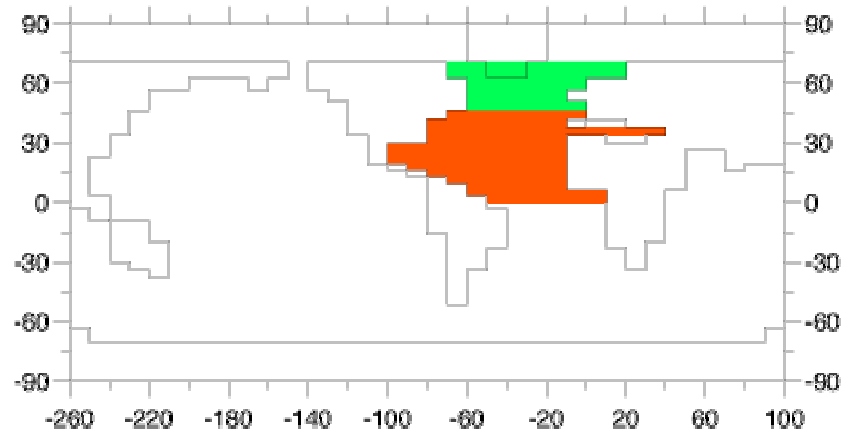
- Realistic world geometry on a 36x36 horizontal grid ( $\sim 5^\circ$  latitude x  $10^\circ$  longitude), incorporating basic 4-catchment runoff scheme and smoothed ocean topography (8 ocean depth levels spanning 5000m).

Perturbed freshwater transport (from red to green):

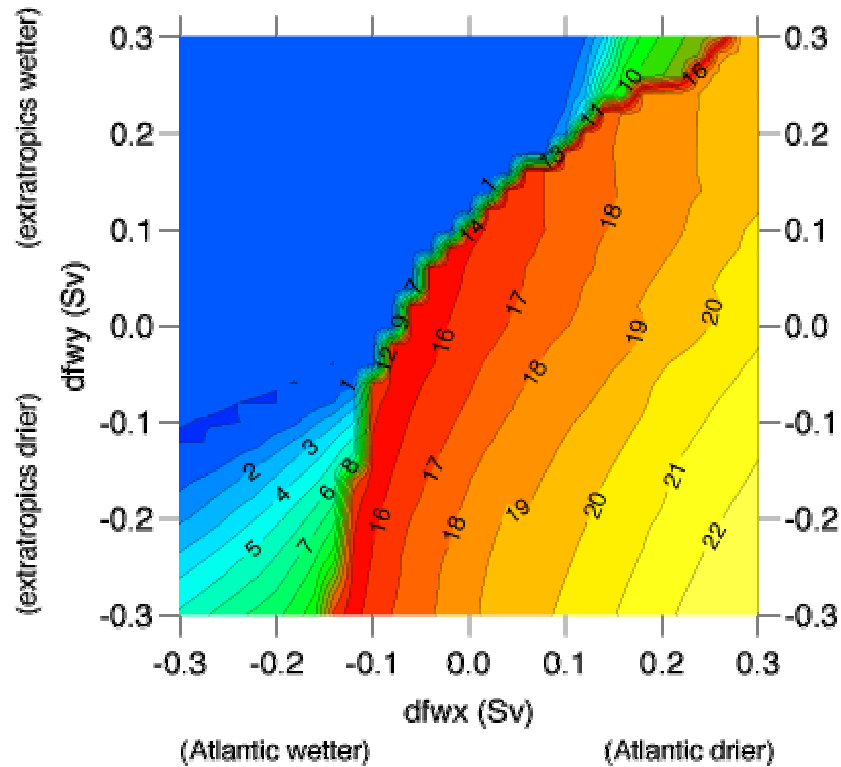
(a) dfwx



(b) dfwy



C-GOLDSTEIN v1: max Atl MOT (Sv) after 4000 yr  
Results of 31x31 Condor pool expt (GENIE test)  
- courtesy M. Gulamali (Imperial), R. Marsh (SOC)



dfwx = Atlantic-to-Pacific FWF

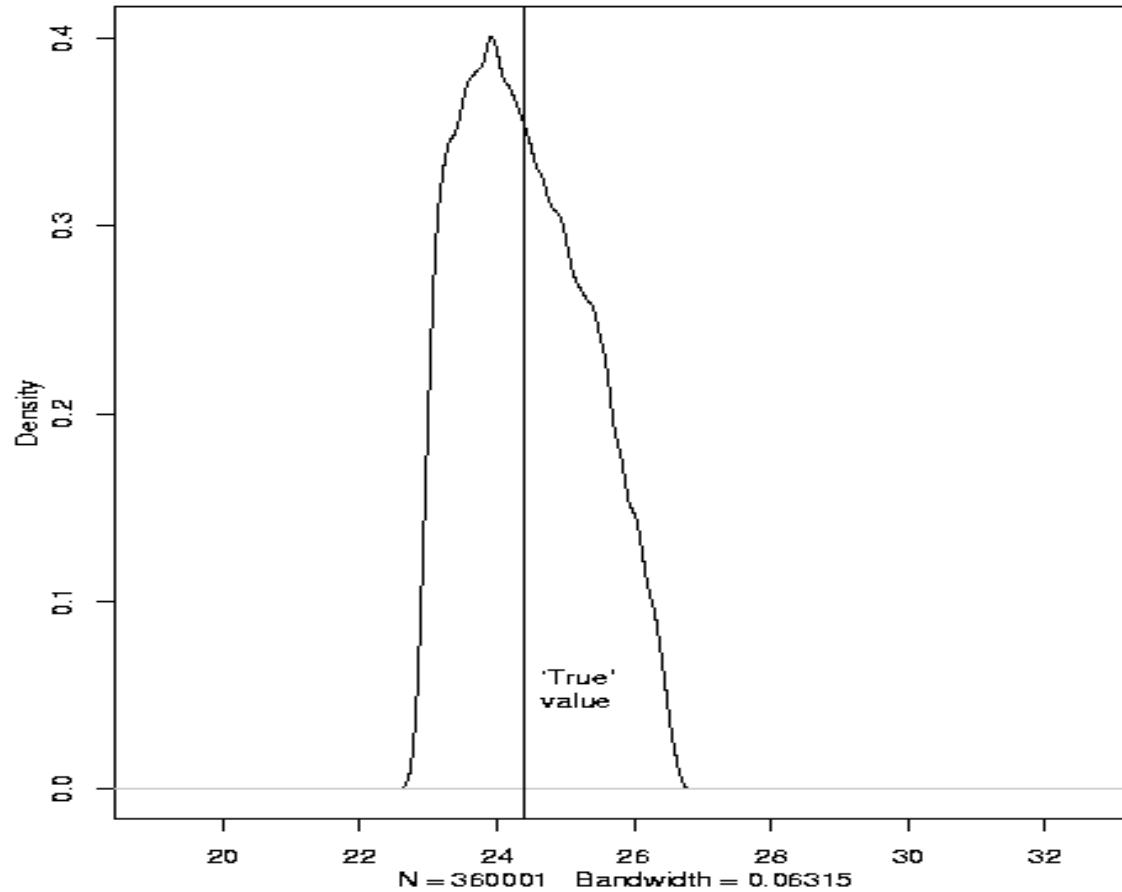
dfwy = tropical-to-extratropical FWF in N. Atlantic

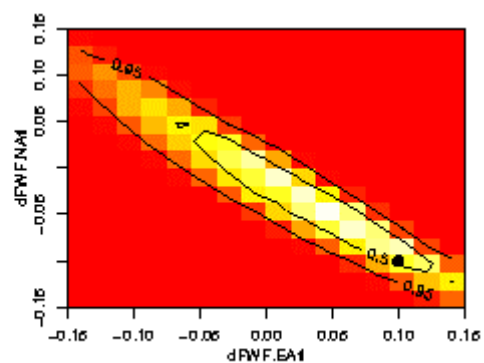
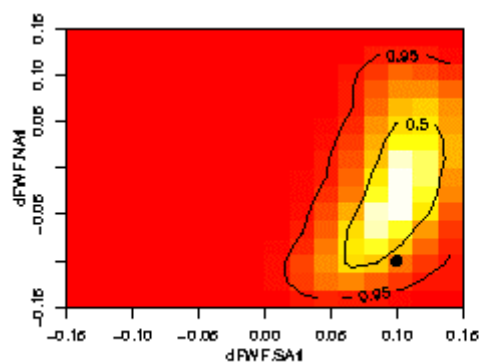
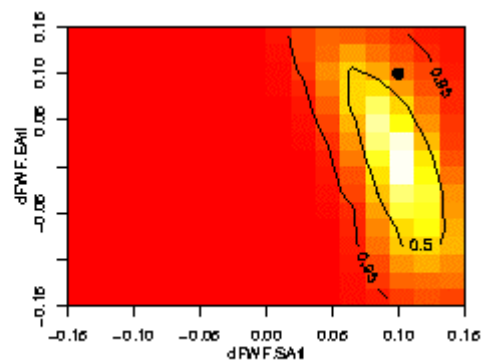
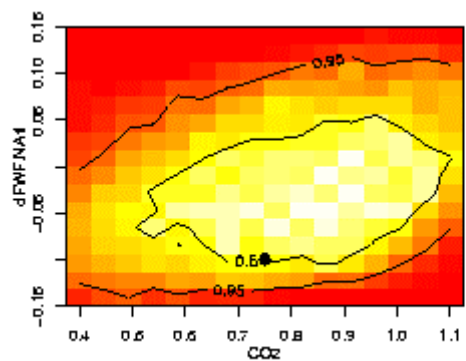
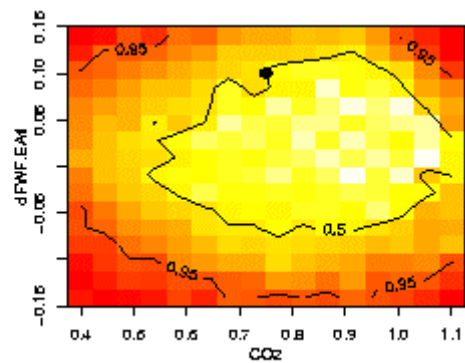
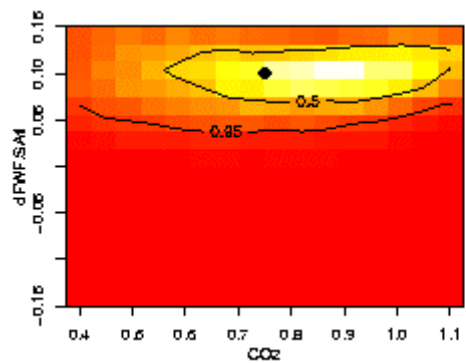
# Feasibility Study

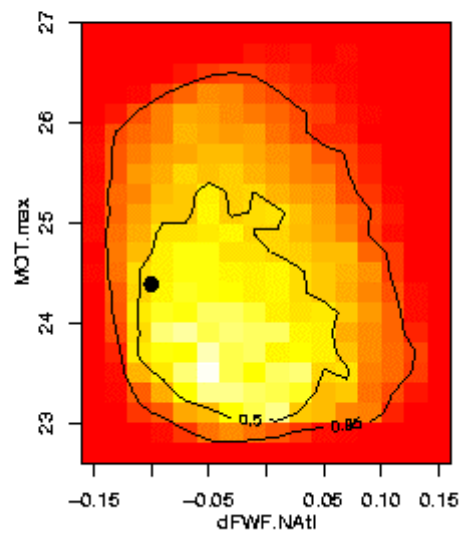
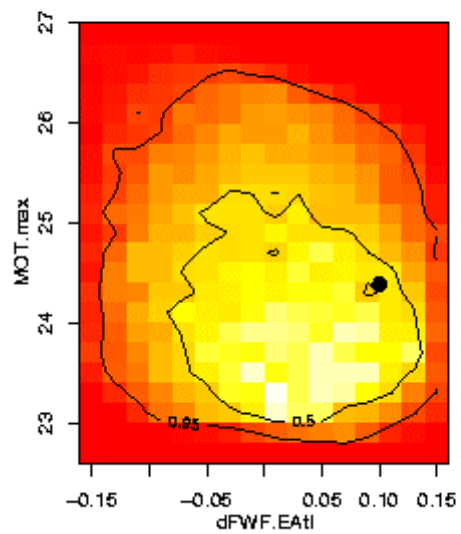
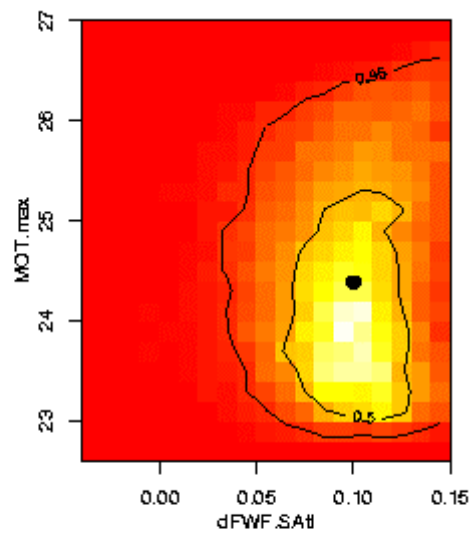
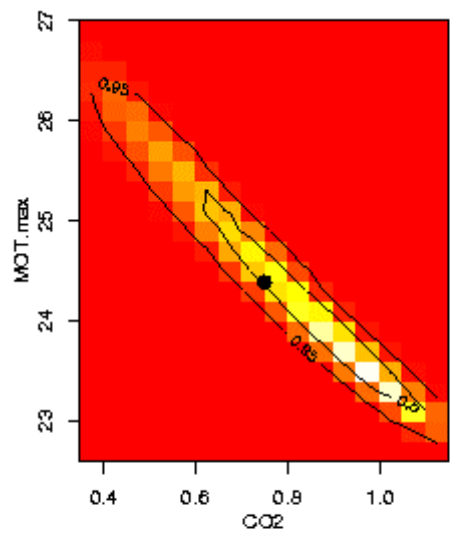
- Inputs - CO<sub>2</sub> increase, freshwater flux S At  
- S Pac, Eq At - Eq Pac, N At - N Pac
- Outputs - max overturn, overturning at s  
edge Atlantic, heat transport at 25 N
- Design 4<sup>3</sup> factorial

- Select one point as ‘truth’
- Take last two outputs as data
- Predict ‘true’ inputs and predict output
- Emulator - quadratic with all cross products
- Predict inputs and remaining output from two given outputs.

# Posterior prediction







# Challenges

- Dimensionality
  - Interpolation or extrapolation
- Non-smoothness
- How realistic are the models?
  - Data
    - Calibrate
  - Reality as a ‘super model’