Using JULES to Model the Congo Peatlands

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CongoPeat Project Meeting

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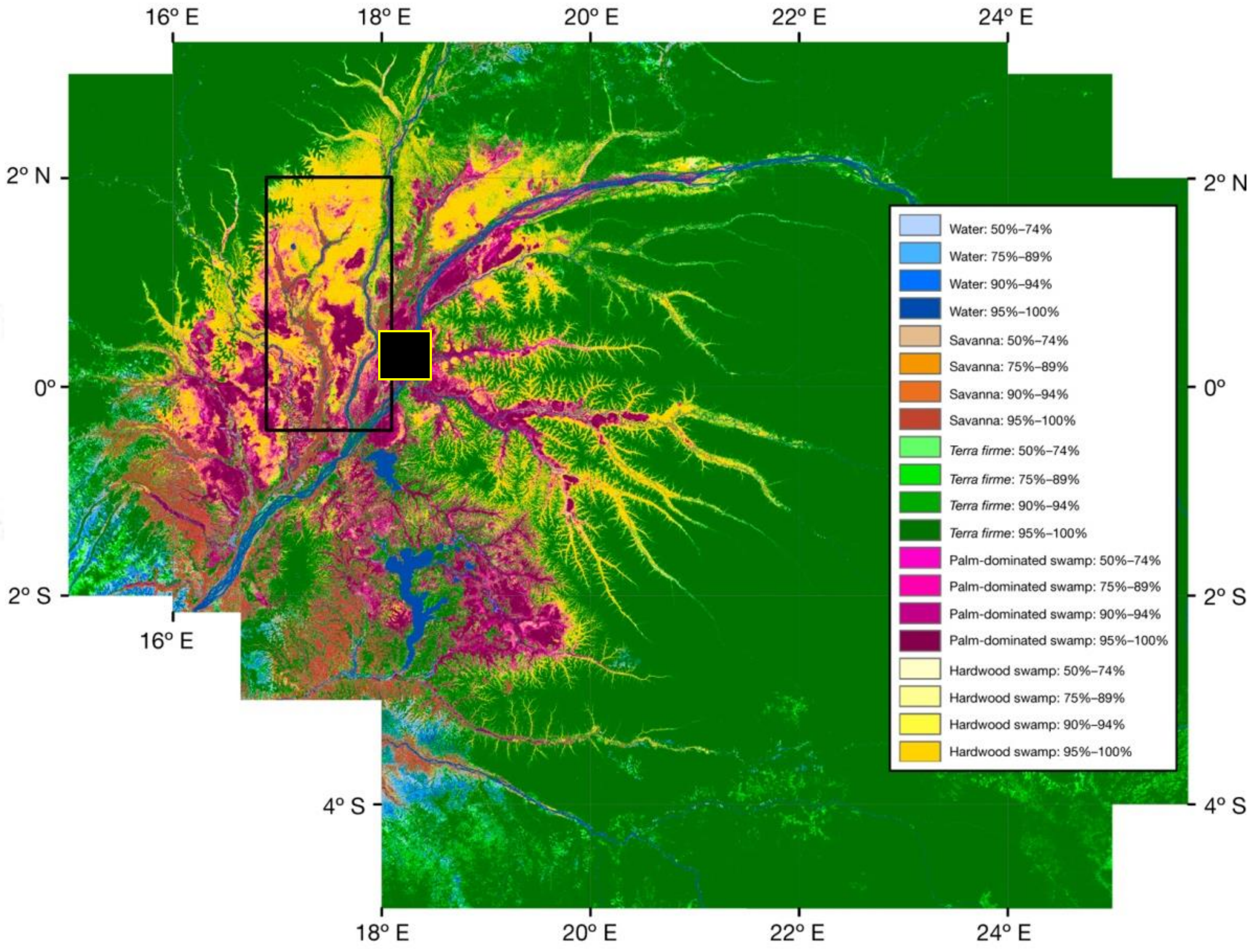
Representing peatlands in JULES

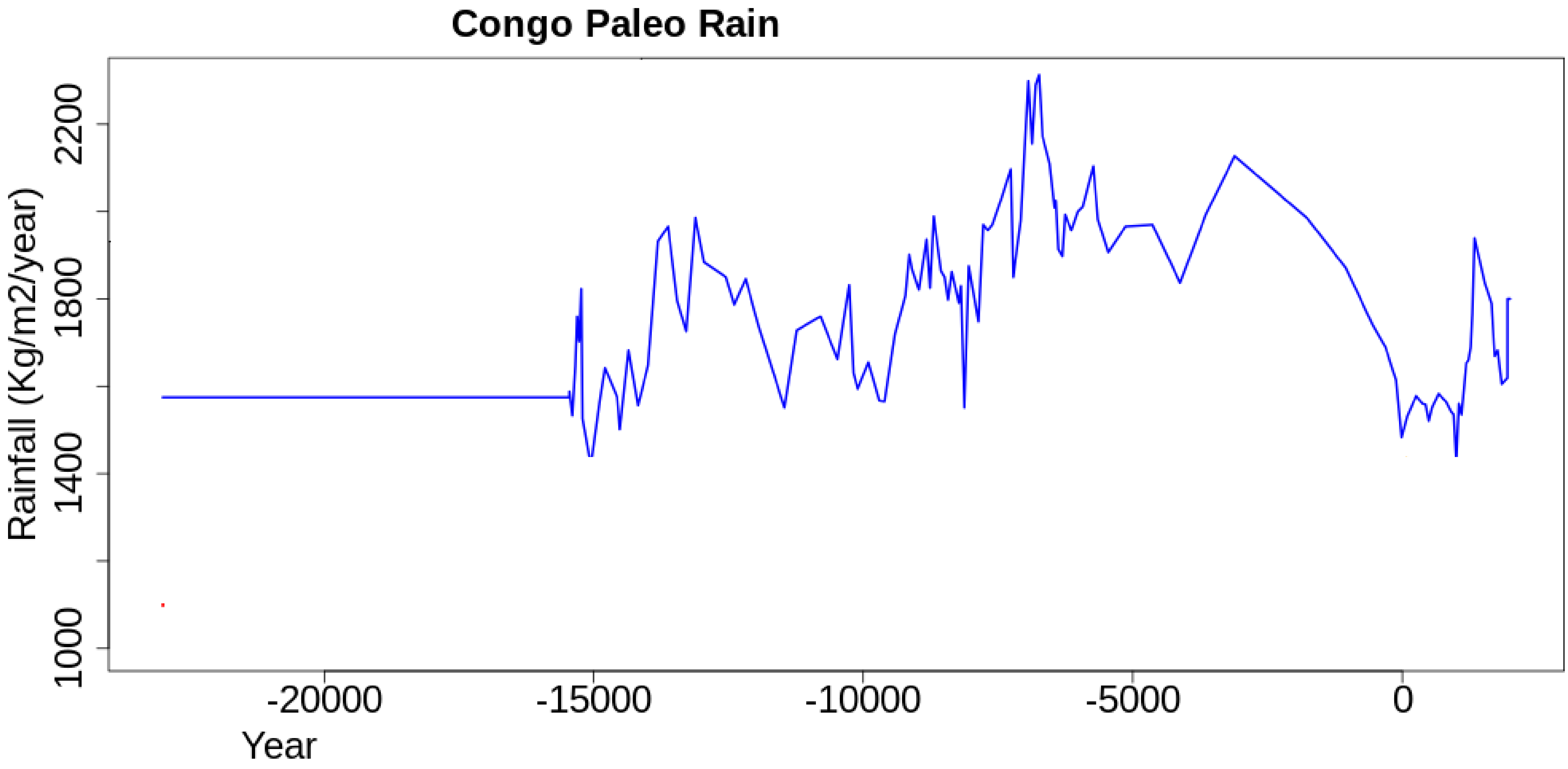
- Deeper soil column made deeper: >7m instead of 3m
- Soil layers increased from 4 to at least 20
- Soil layer thicknesses between 0.05 and 0.64m
- New method to accumulate carbon into the soil, without increasing the depth of the soil layers below original surface
  - Only lowest layer has increased depth: other layers move up
- Drainage from the soil modified as peat builds up or becomes compressed for realistic changes to the peatlands under drying or drainage
  - peatlands may be resilient to moderate drying by establishing a new water table
- Physical properties of soil change with carbon content
- No baseflow
- Simulations initialised with zero soil and vegetation carbon
- For Congo: set physical soil properties to those for clay
- Congo vegetation: swamp forest

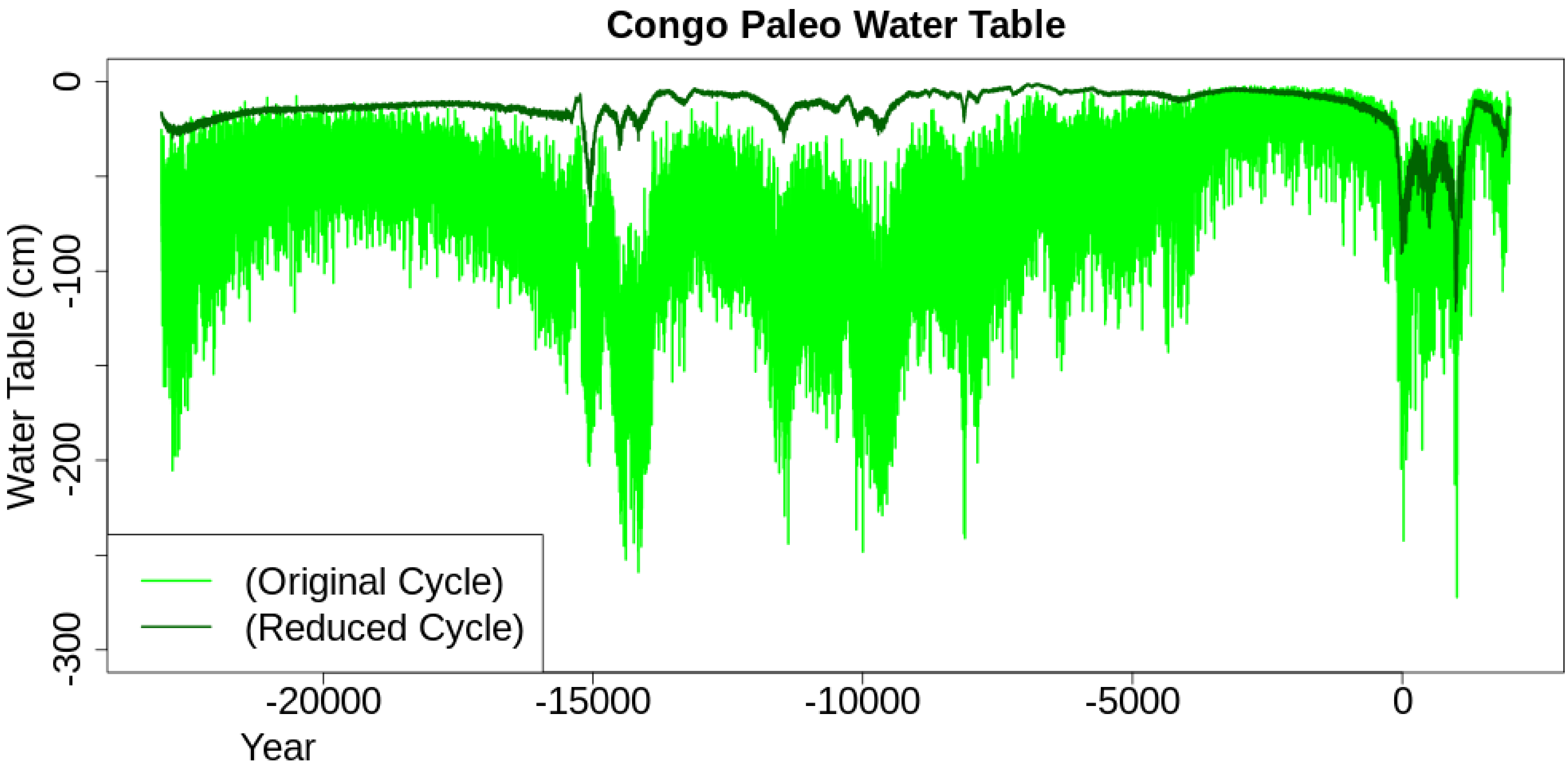
Cuvette Centrale peatlands and initial modelling site

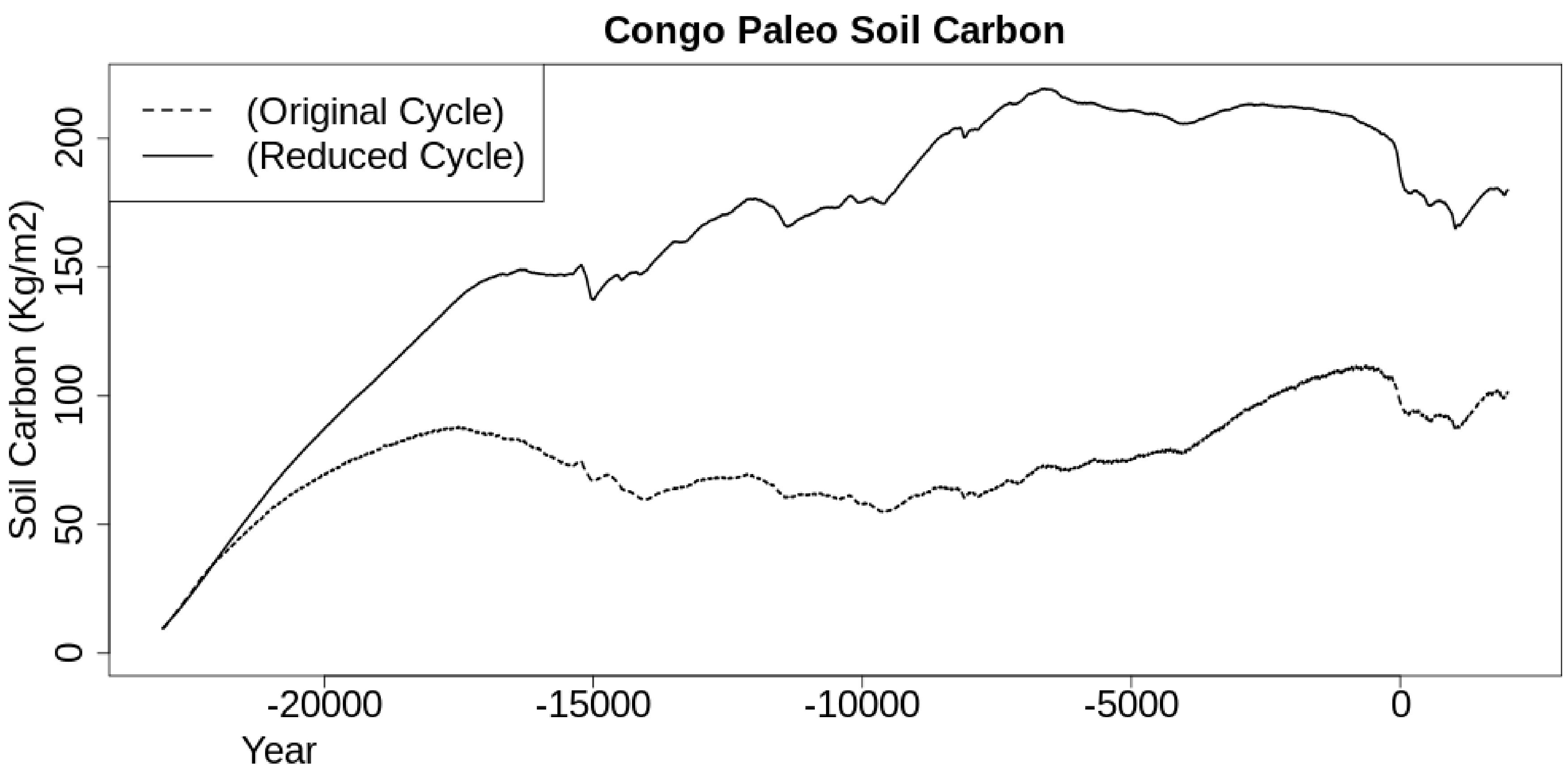


JULES CongoPeat Palaeo simulations: climate data

- Most variables from HadCM3 global climate model palaeo simulation (23000BCE-2000CE)
- Single gridpoint at 0 North, 18 East
- Annual total rainfall scaled to match palaeo rainfall reconstruction from leaf wax records (15450BCE-1950CE)
- Shaped of modelled seasonal cycle of rainfall retained
- Also modified the downwelling shortwave radiation to be consistent with leaf wax rainfall reconstruction


Congo Paleo Rain
Rainfall (Kg/m2/year)
1000
1400
1800
2200
-20000
-15000
-10000
-5000
0
Year


Congo Paleo Water Table
Water Table (cm)
0
-100
-200
-300
-20000
-15000
-10000
-5000
0
Year
(Original Cycle)
(Reduced Cycle)

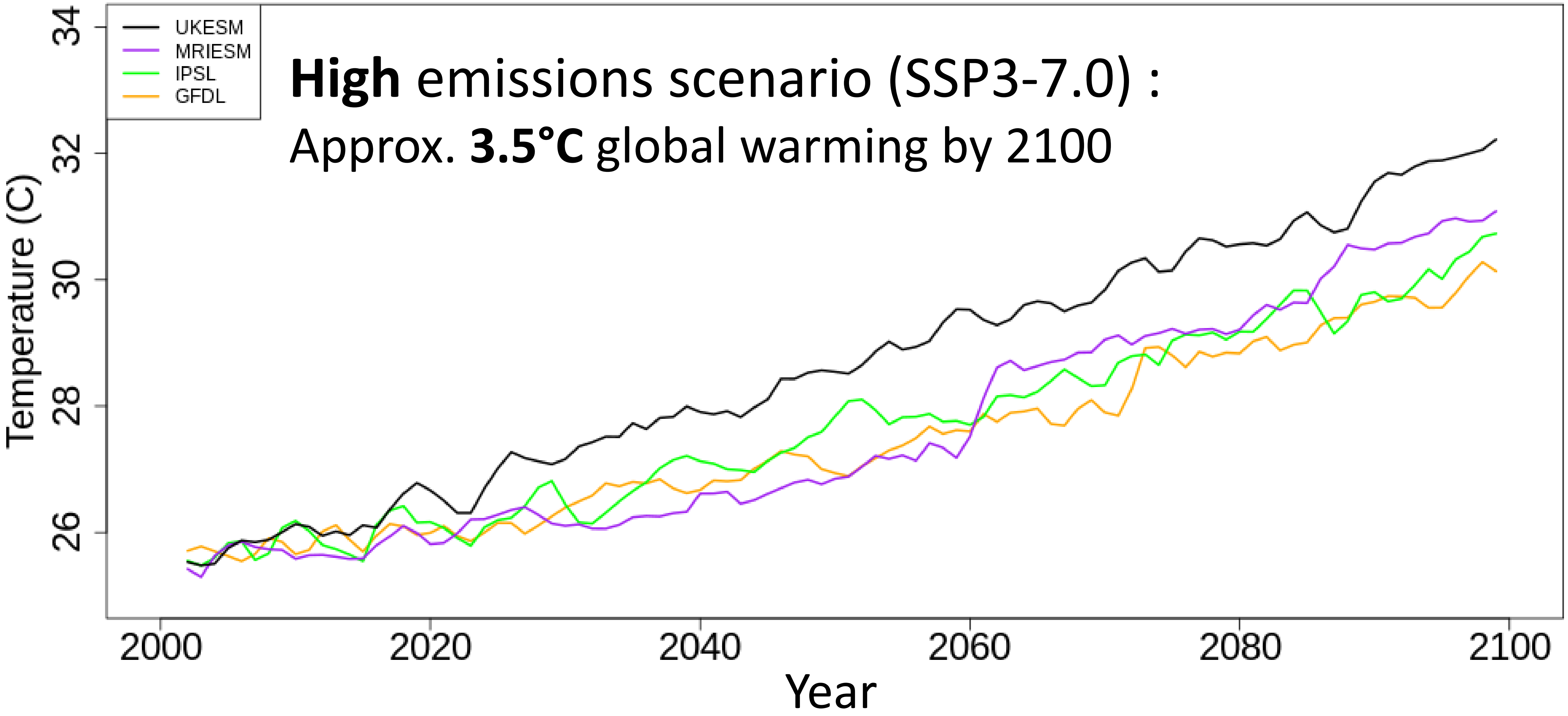


Soil carbon (kg/m²)	
Mean of several peat cores	550
JULES driven by HadCM3, rainfall adjusted to leaf wax data	100
JULES driven by HadCM3, rainfall adjusted to leaf wax data, reduced seasonal cycle	200
JULES driven by UKESM1 1901-2020 repeated	370
JULES driven by ISIMIP3a 1901-2020 repeated	400

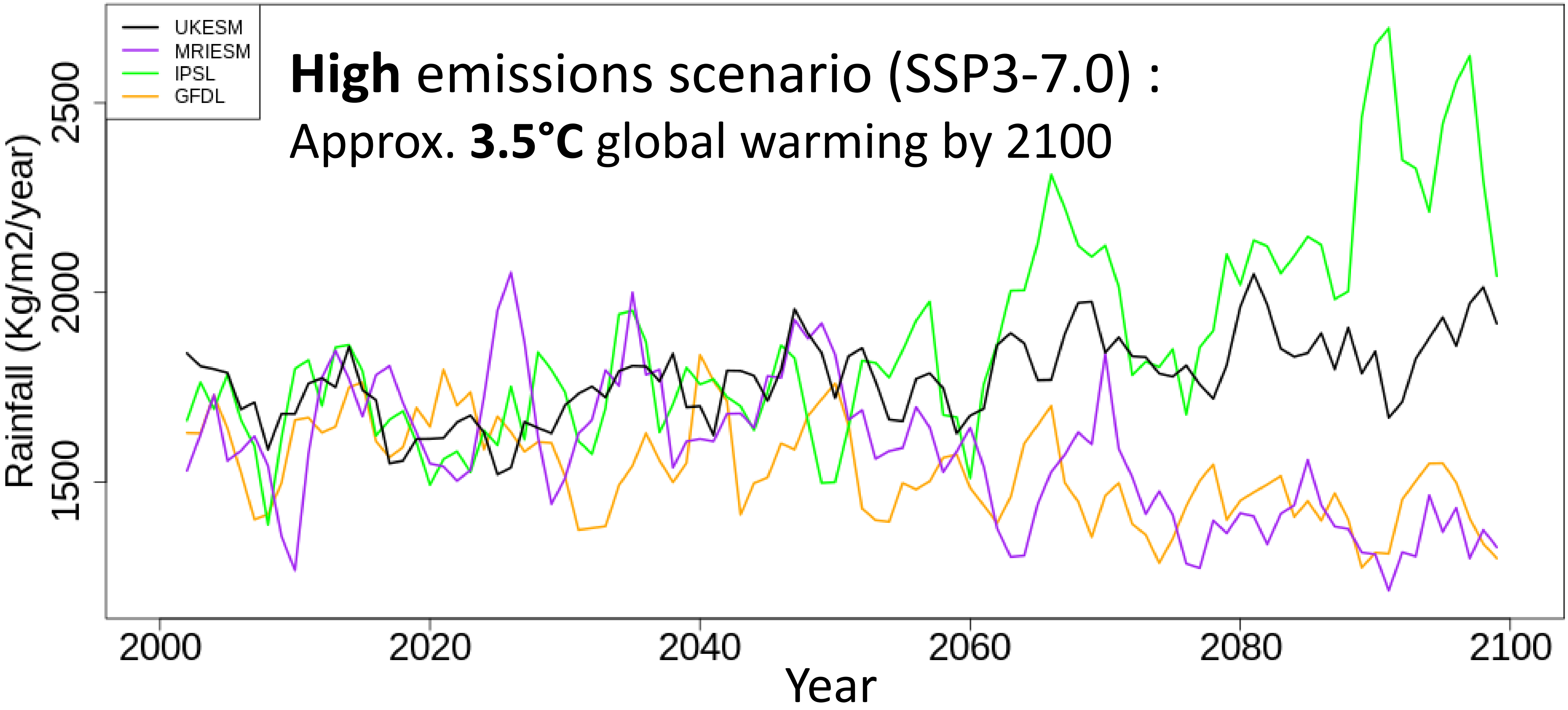
JULES CongoPeat Future Runs

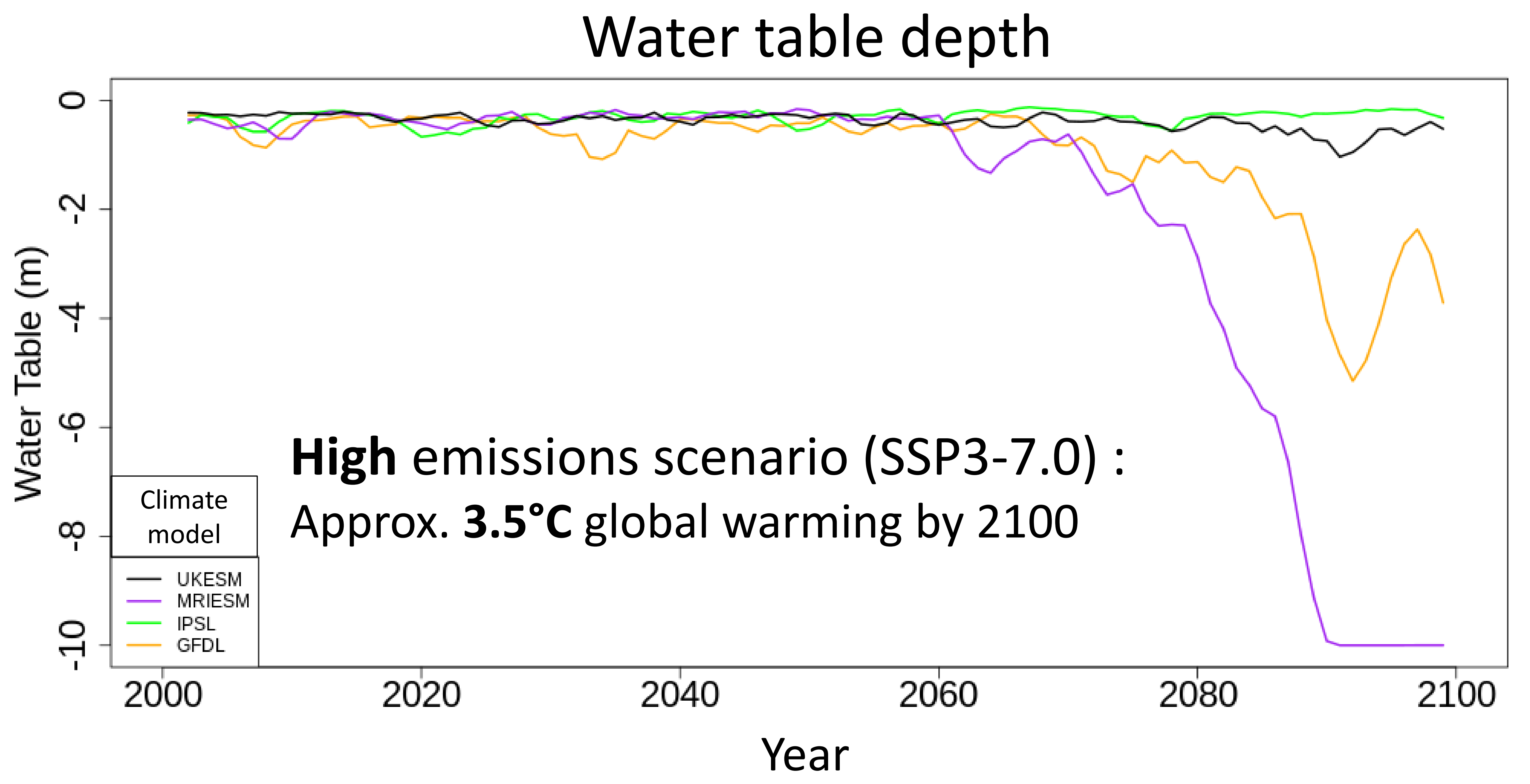
- Initialise from end of 30,000- year run using UKESM1 data repeating 1901-1920
  - Stable vegetation cover
  - Simulated soil carbon 370 kg/m^2
  - Measured soil carbon in peat cores: 550 kg/m^2
- Drive with 200 years of data (1901-2100) from 4 global climate models, each having 3 climate projections (SSP126, 370, 585), using the associated CO_2 concentrations and nitrogen deposition

Near-surface air temperature



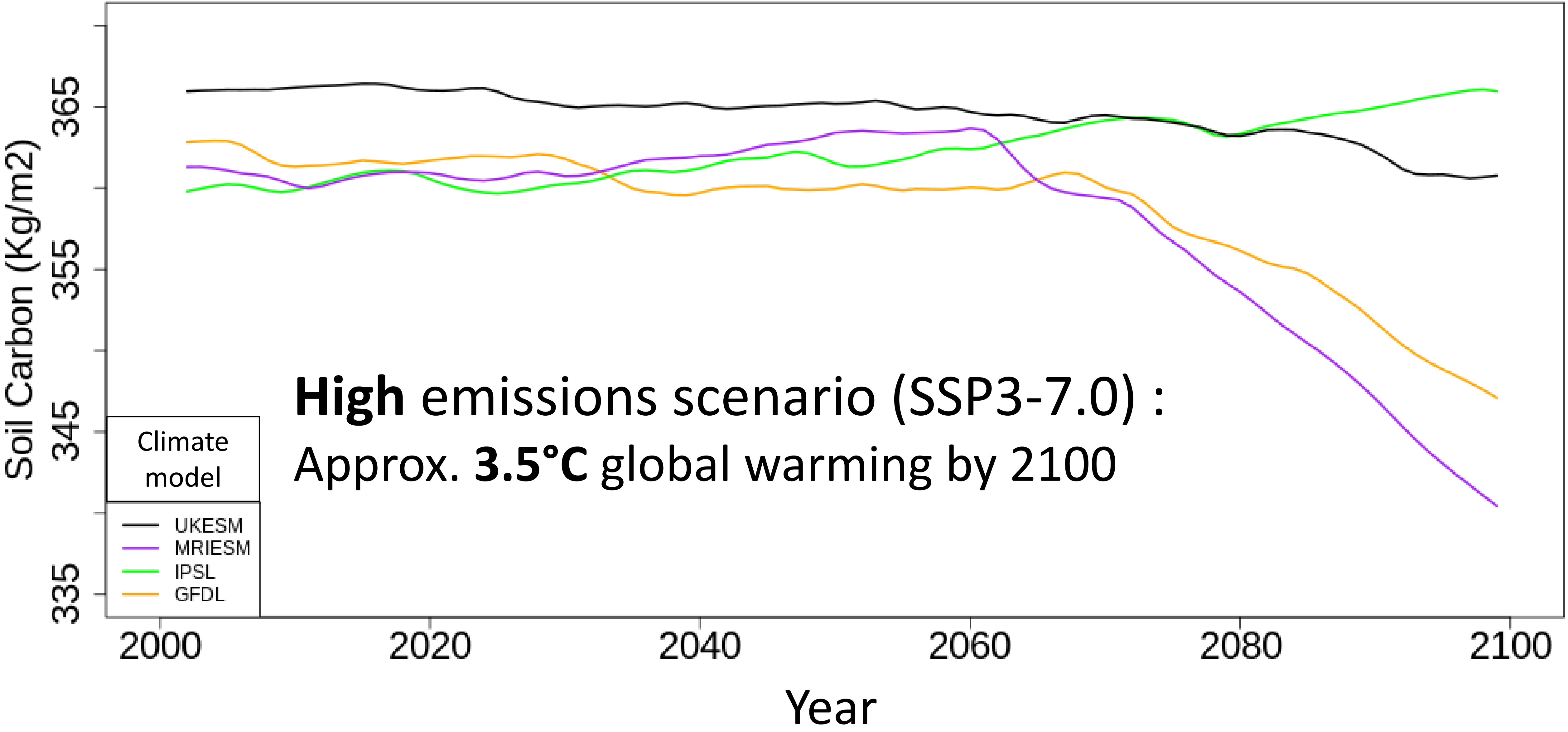
Annual rainfall



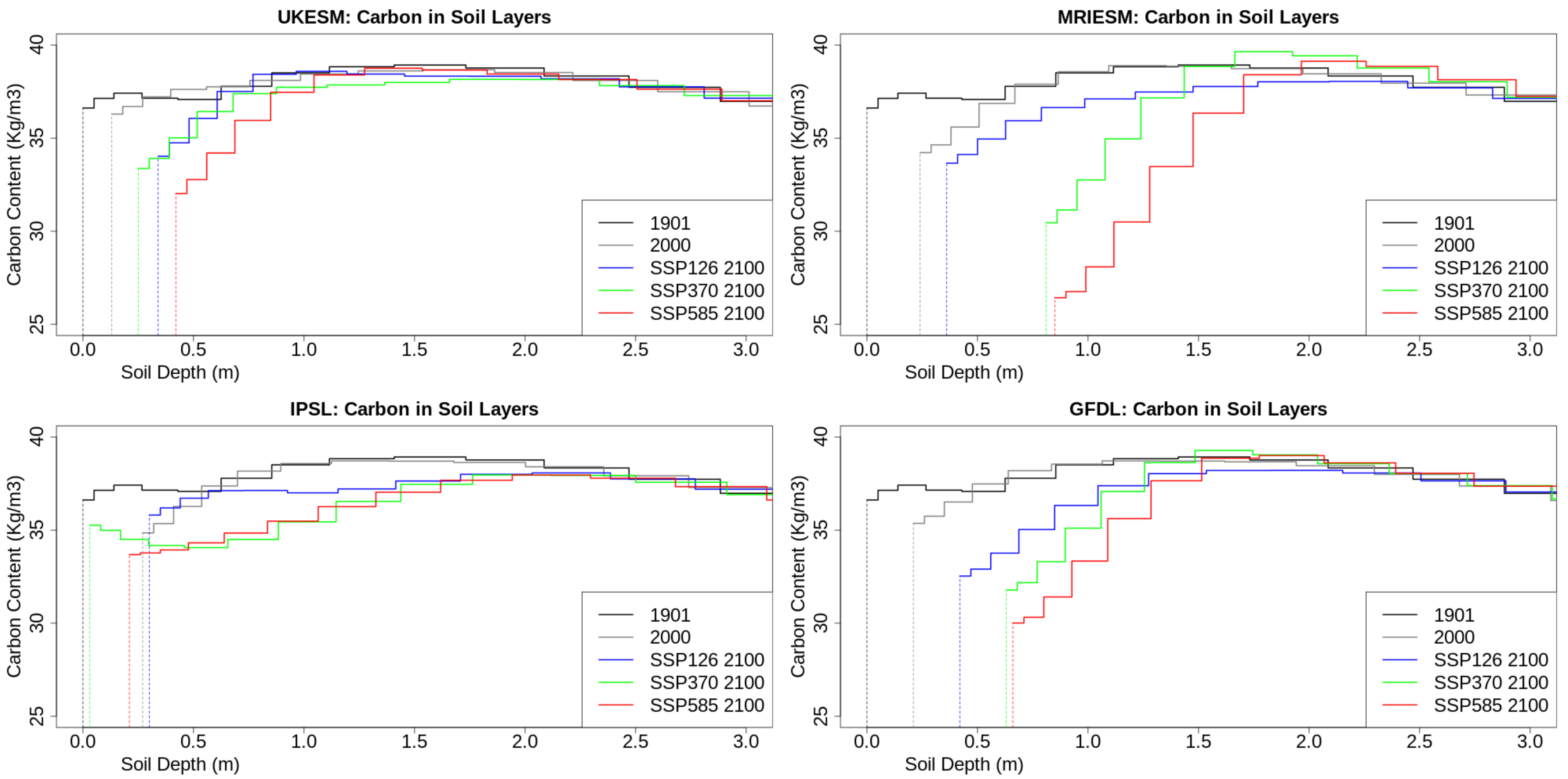


Water table depth
Water Table (m)
0
-2
-4
-6
-8
-10
2000
2020
2040
2060
2080
2100
Year
High emissions scenario (SSP3-7.0) :
Approx. **3.5°C** global warming by 2100
Climate model
UKESM
MRIESM
IPSL
GFDL

Soil carbon



Soil Carbon (Kg/m2)
335
345
355
365
2000
2020
2040
2060
2080
2100
Year
High emissions scenario (SSP3-7.0) :
Approx. **3.5°C** global warming by 2100
Climate model
UKESM
MRIESM
IPSL
GFDL


UKESM: Carbon in Soil Layers
MRIESM: Carbon in Soil Layers
IPSL: Carbon in Soil Layers
GFDL: Carbon in Soil Layers
Carbon Content (Kg/m3)
Soil Depth (m)
25
30
35
40
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1901
2000
SSP126 2100
SSP370 2100
SSP585 2100

Summary

- First palaeo simulation produced only small quantities of peat due to the large seasonal cycle in rainfall causing low water table
- Second simulations with reduced rainfall seasonal cycle produced more peat, but still not as much as spin-up with repeated early 20th-century climate
- Future projections: increased evapotranspiration due to increased temperatures is projected to lead to lower water tables, especially using climate models where rainfall is reduced, resulting in an overall decay of the peat
- The water table drop and decay of peat increase with higher warming scenario (but is a rapid water table drop realistic?)
- But even low scenario (SSP126) results in some drying and peat loss
- The peat loss occurs in spite of the increased vegetation and litterfall due to the fertilisation from the increased CO_2, and the reduction in plant transpiration also due to increased CO_2