



# RECONSTRUCTING THE VEGETATION OF THE CAPE PALEOLANDSCAPE USING CORRELATIVE AND MECHANISTIC MODELS

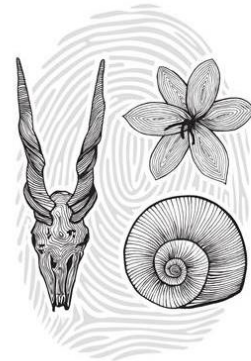
Alastair Potts

Botany Department

Nelson Mandela Metropolitan University



Janet Franklin, Glenn Moncrieff, Simon Scheiter, Steve Higgins, Hayley Cawthra,  
Guy Midgley, Brad Ripley, Richard Cowling, Curtis Marean etc.



Centre for  
Coastal  
Palaeoscience

*Fynbos Forum, Port Elizabeth, 2016*

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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# BACKGROUND

BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

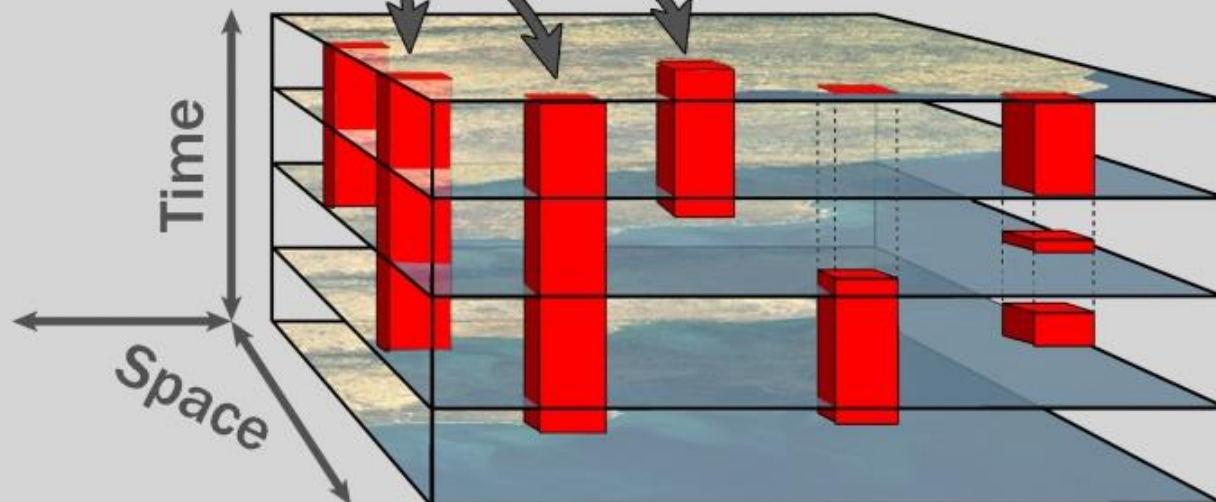
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CASE STUDY: C4 GRASSLAND

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Paleoenvironmental  
Records



BACKGROUND

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ENV. NICHE MOD.

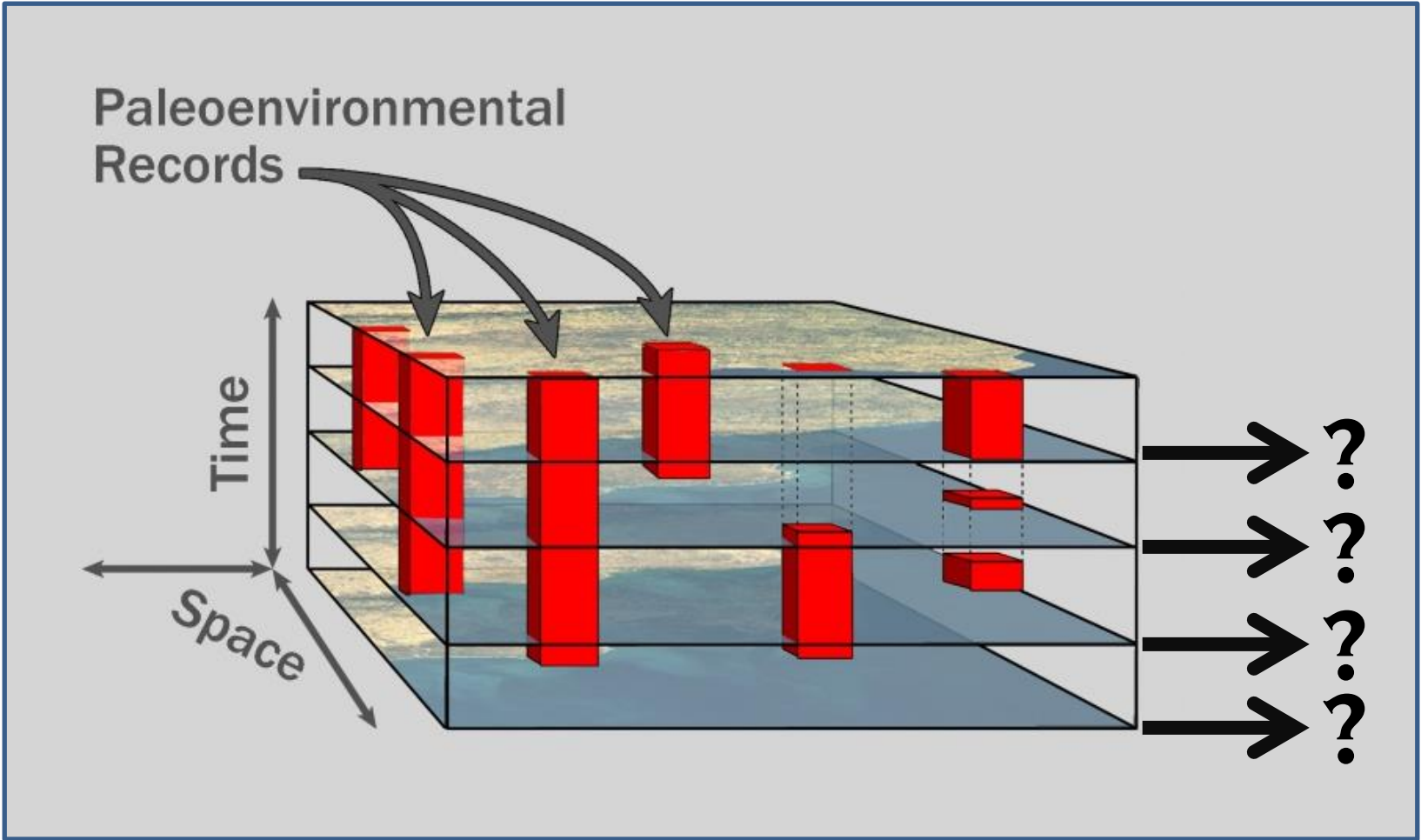
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

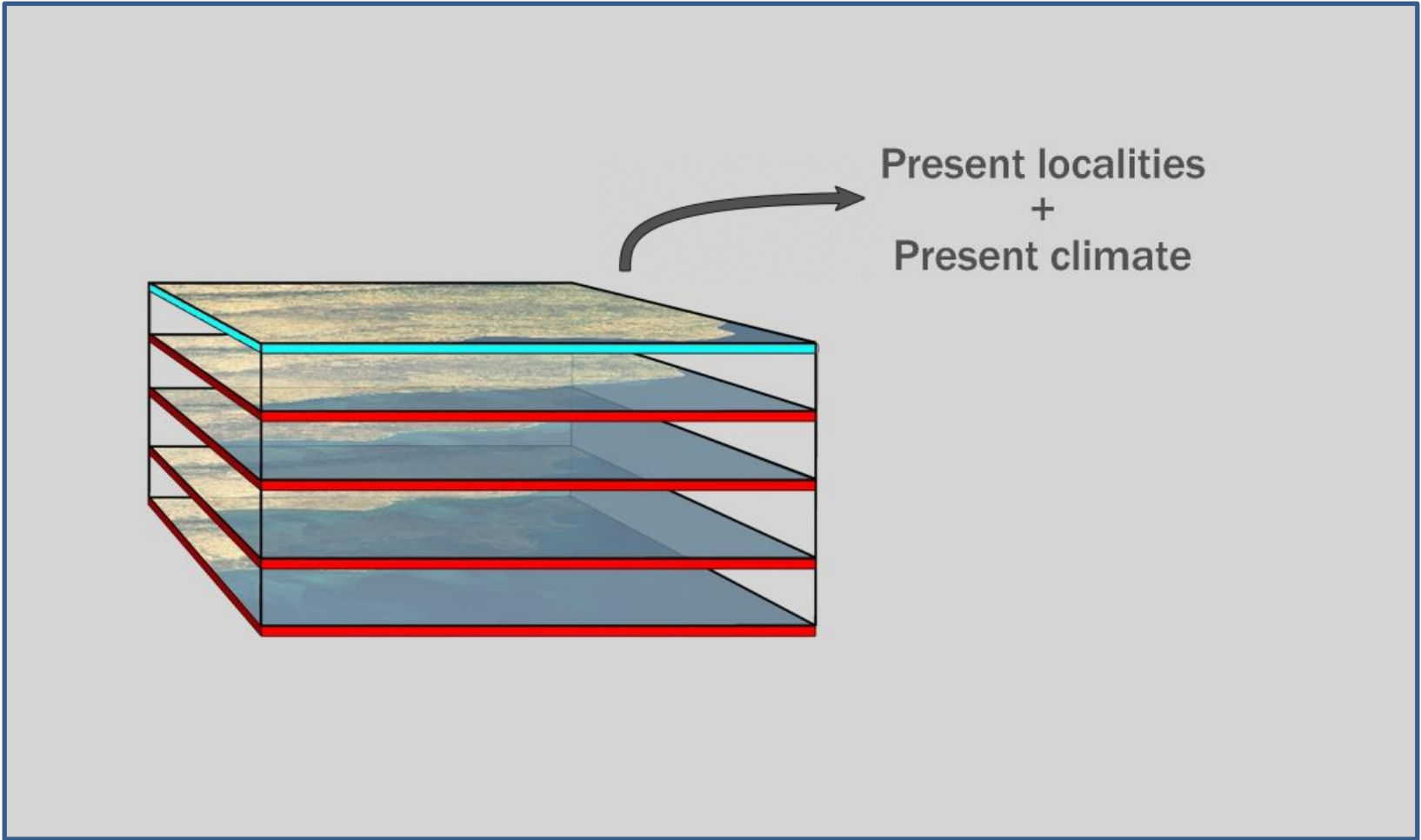
CASE STUDY: C4 GRASSLAND

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BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

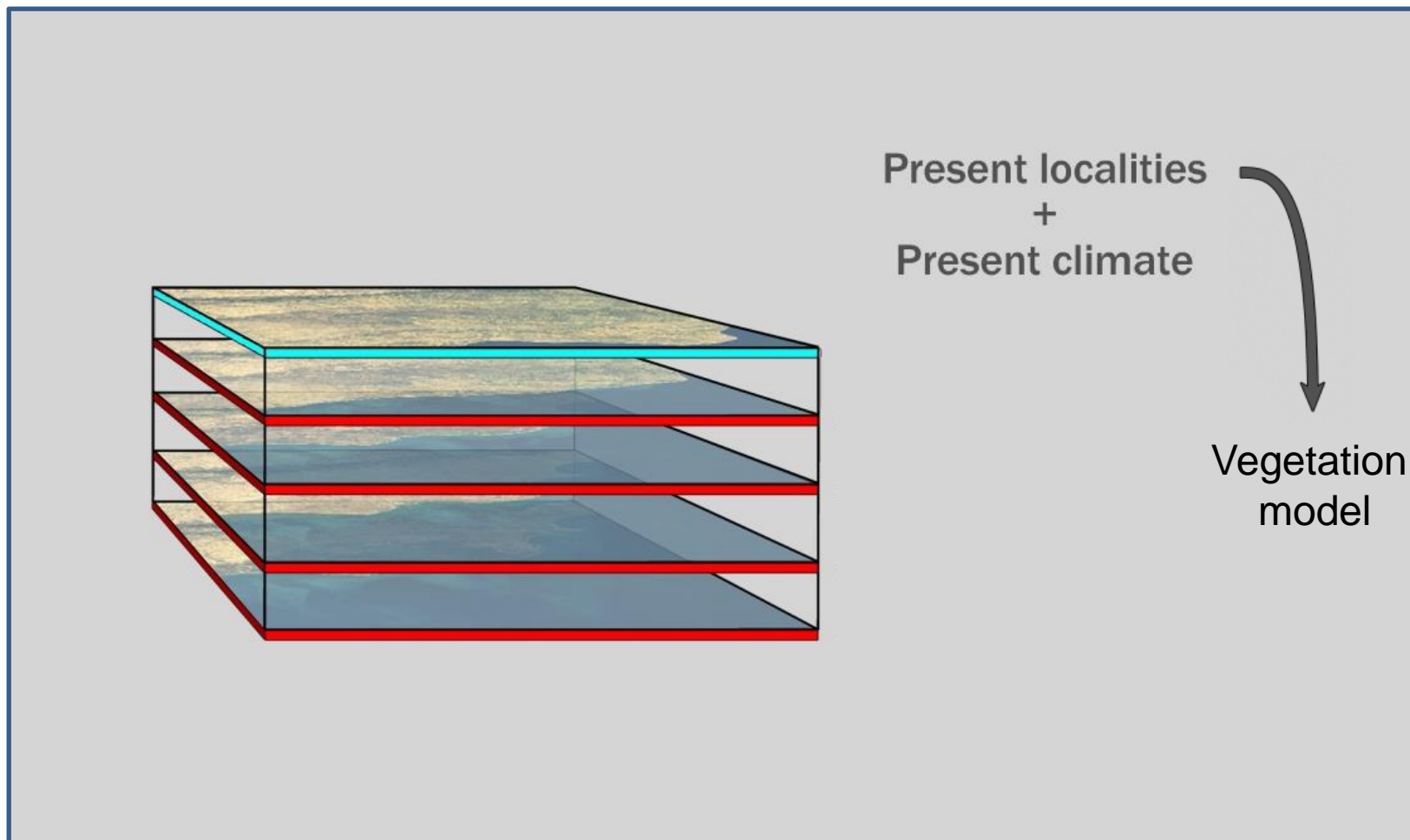
CASE STUDY: C4 GRASSLAND

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BACKGROUND

ENV. NICHE MOD.

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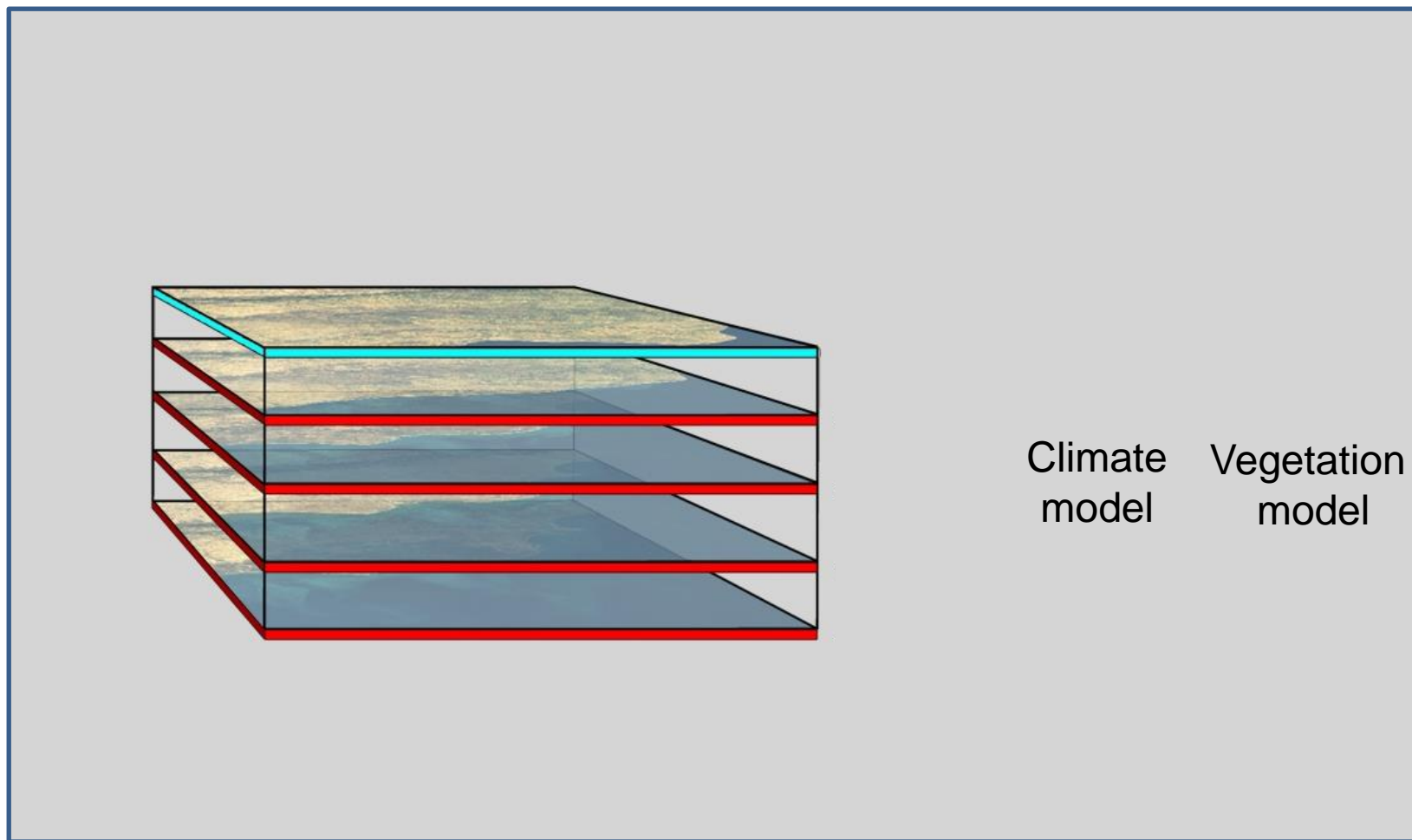
CASE STUDY: C4 GRASSLAND

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BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

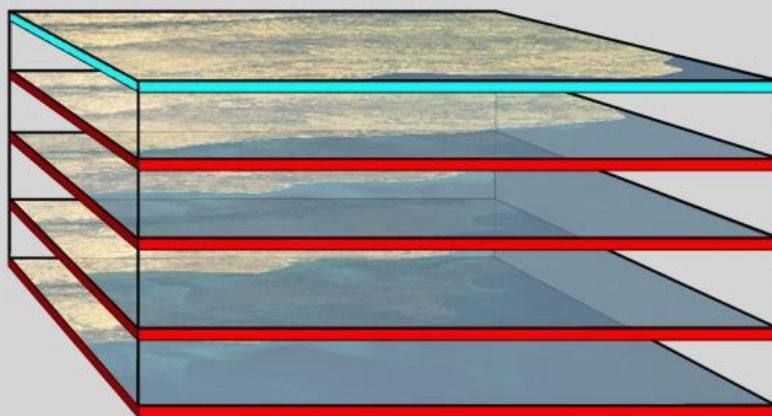
CASE STUDY: C4 GRASSLAND

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Climate model + Vegetation model



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

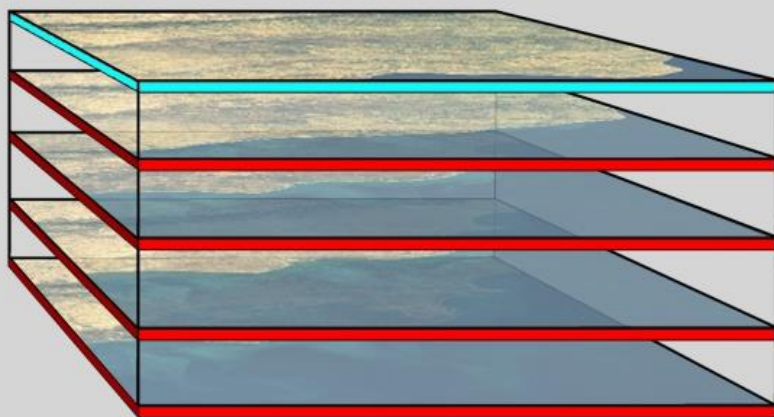
CASE STUDY: C4 GRASSLAND

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Climate model + Vegetation model

Paleodistribution Reconstructions



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

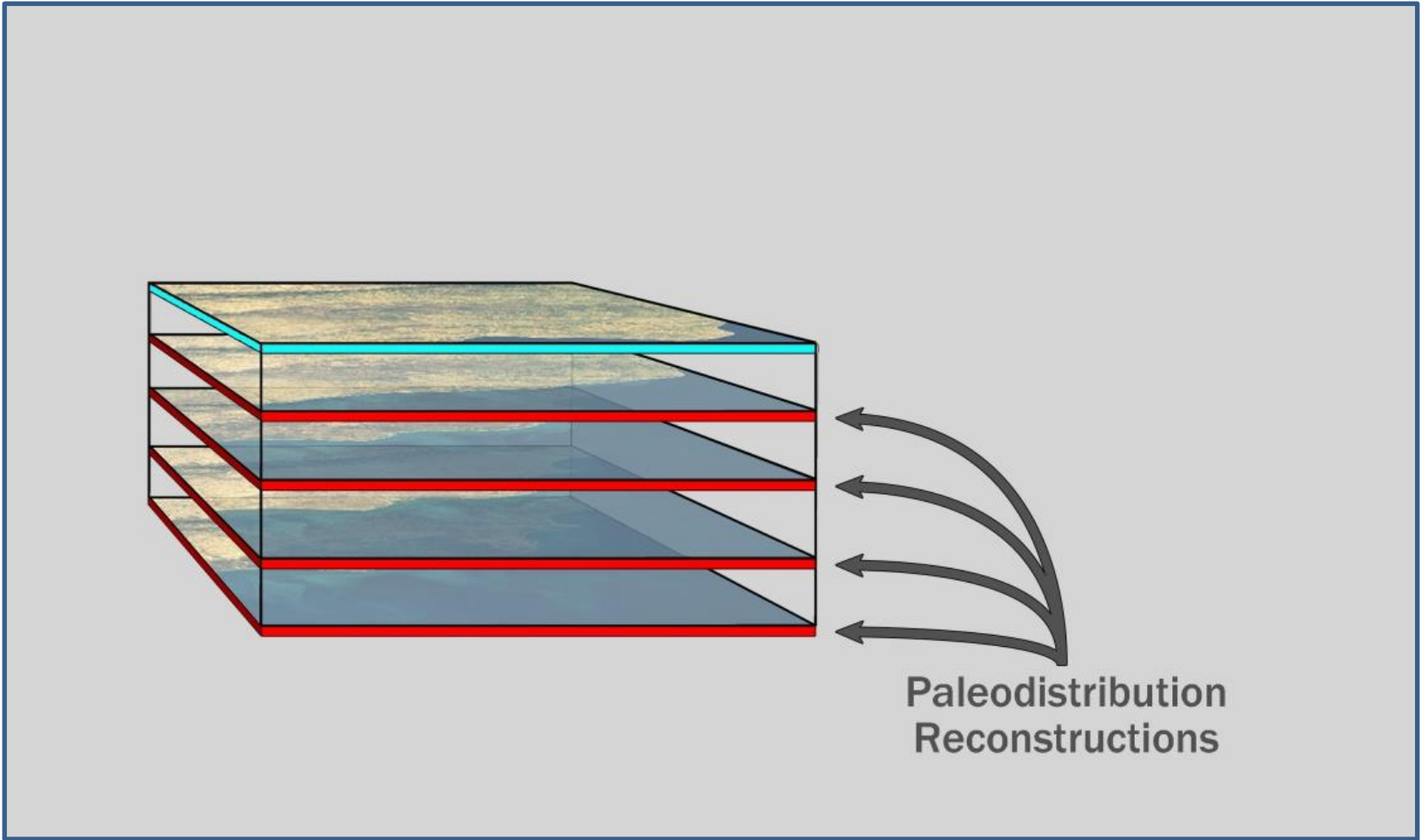
CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

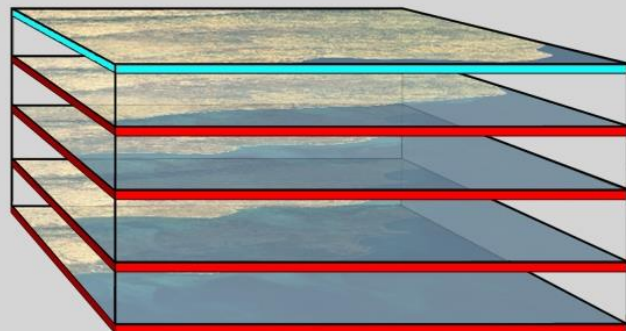
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CASE STUDY: C4 GRASSLAND

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## Paleovegetation reconstructions



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

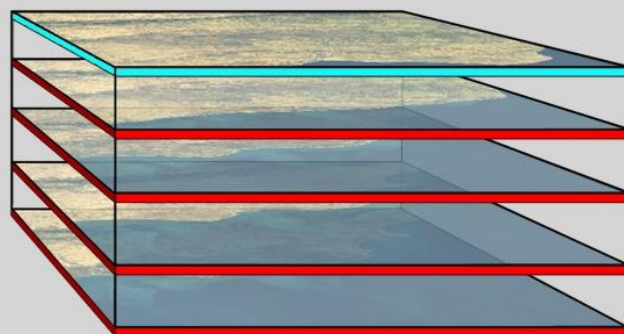
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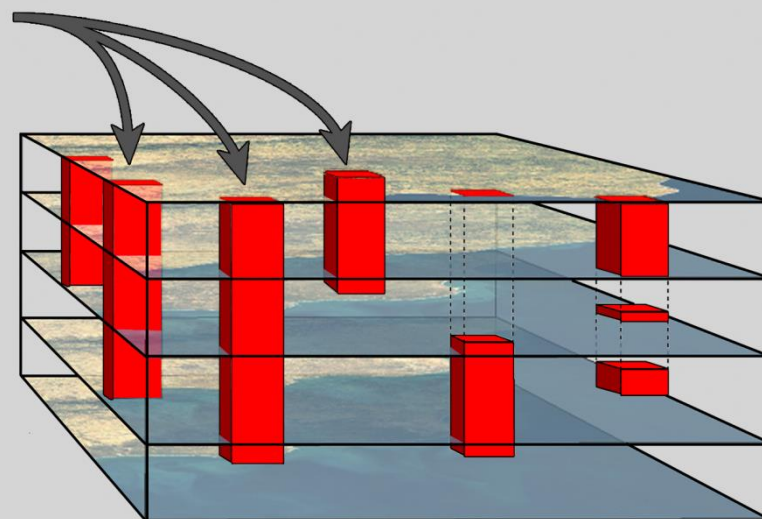
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### Paleovegetation reconstructions



Test



Paleoarchives

BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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# REGION OF INTEREST



BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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# REGION OF INTEREST



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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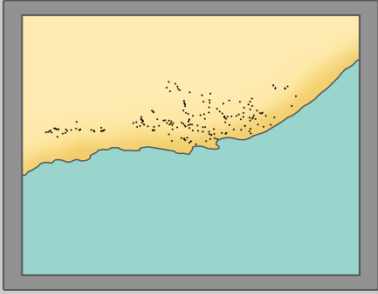
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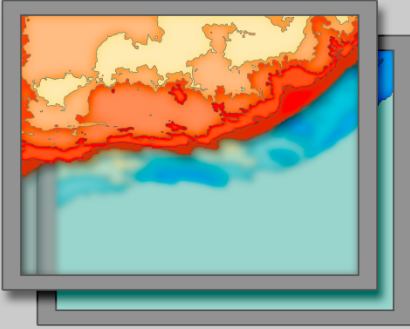


# ENVIRONMENTAL NICHE MODELLING

Species locations

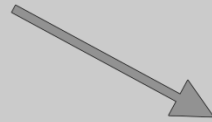
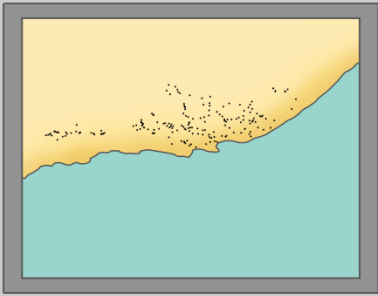


Current environment  
and climate



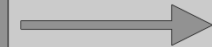
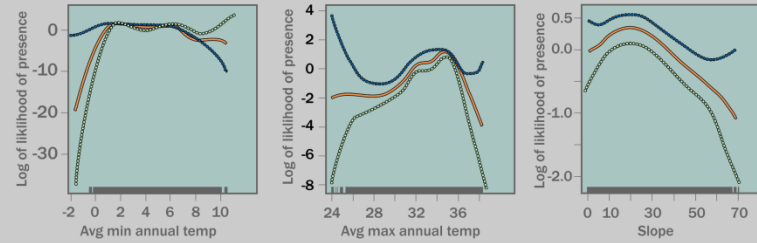


Species locations

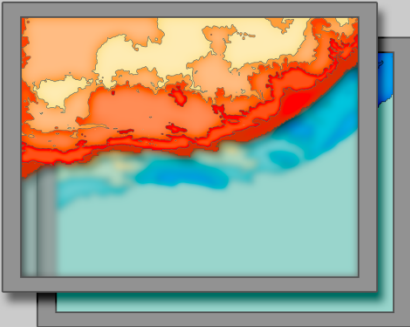


## Statistical model

### Model response functions or fitted parameters

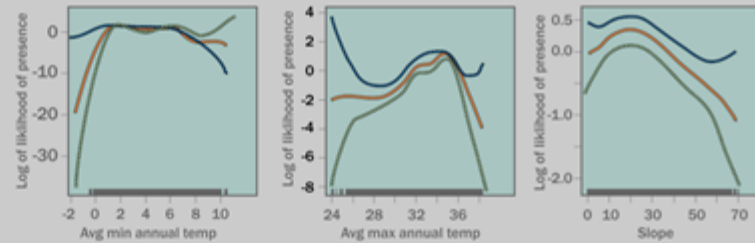


Current environment and climate



## Statistical model

### Model response functions or fitted parameters

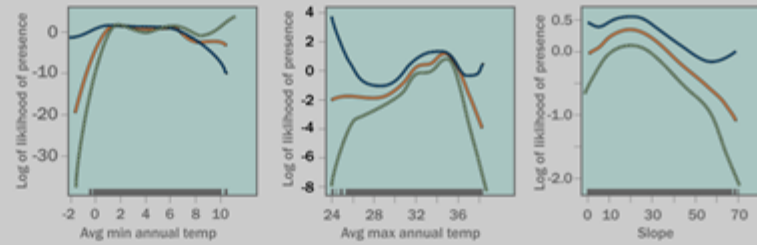


Model fitting and validation

Apply model coefficients or rules to environmental data

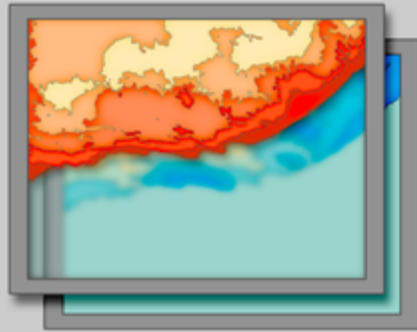
## Statistical model

### Model response functions or fitted parameters



Model fitting and validation

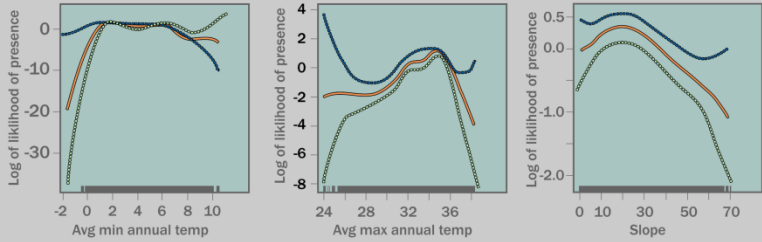
Apply model coefficients or rules to environmental data



Current environment and climate

# Statistical model

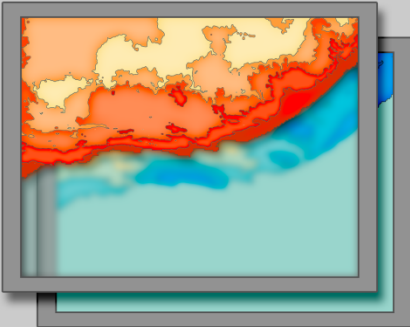
## Model response functions or fitted parameters



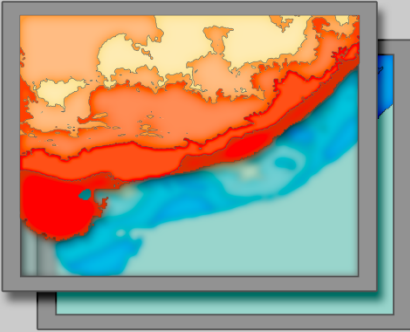
Model fitting and validation

Apply model coefficients or rules to environmental data

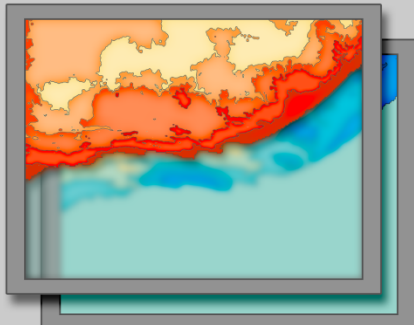
Current environment and climate



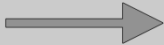
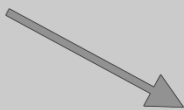
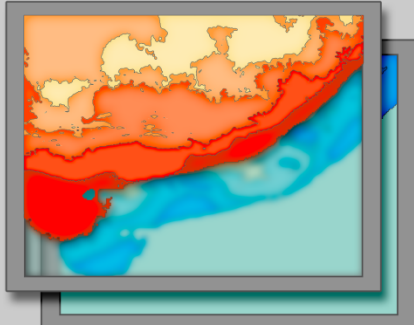
Past environment and climate



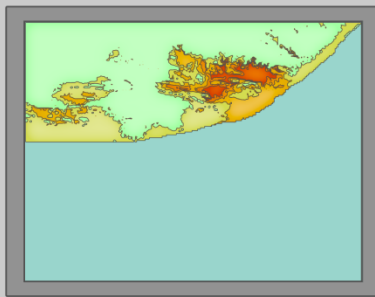
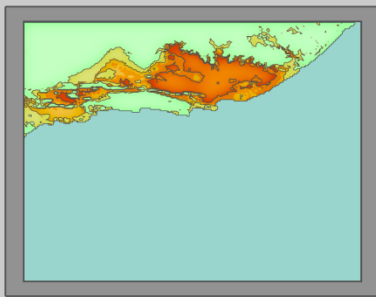
Current environment  
and climate



Past environment  
and climate



Predictive distribution maps



Current

Past

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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# EXAMPLE



BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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# SUBTROPICAL THICKET



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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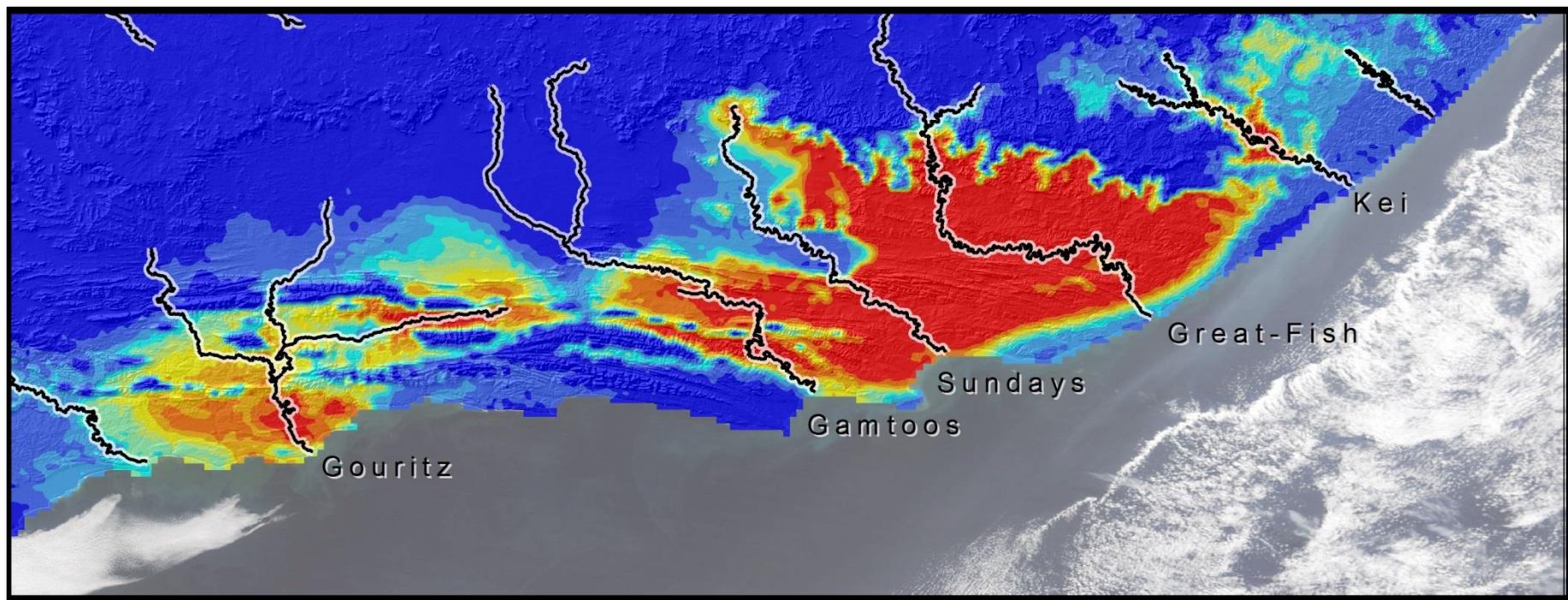
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# ENV. NICHE MOD. OF THICKET: PRESENT DAY CLIMATE





BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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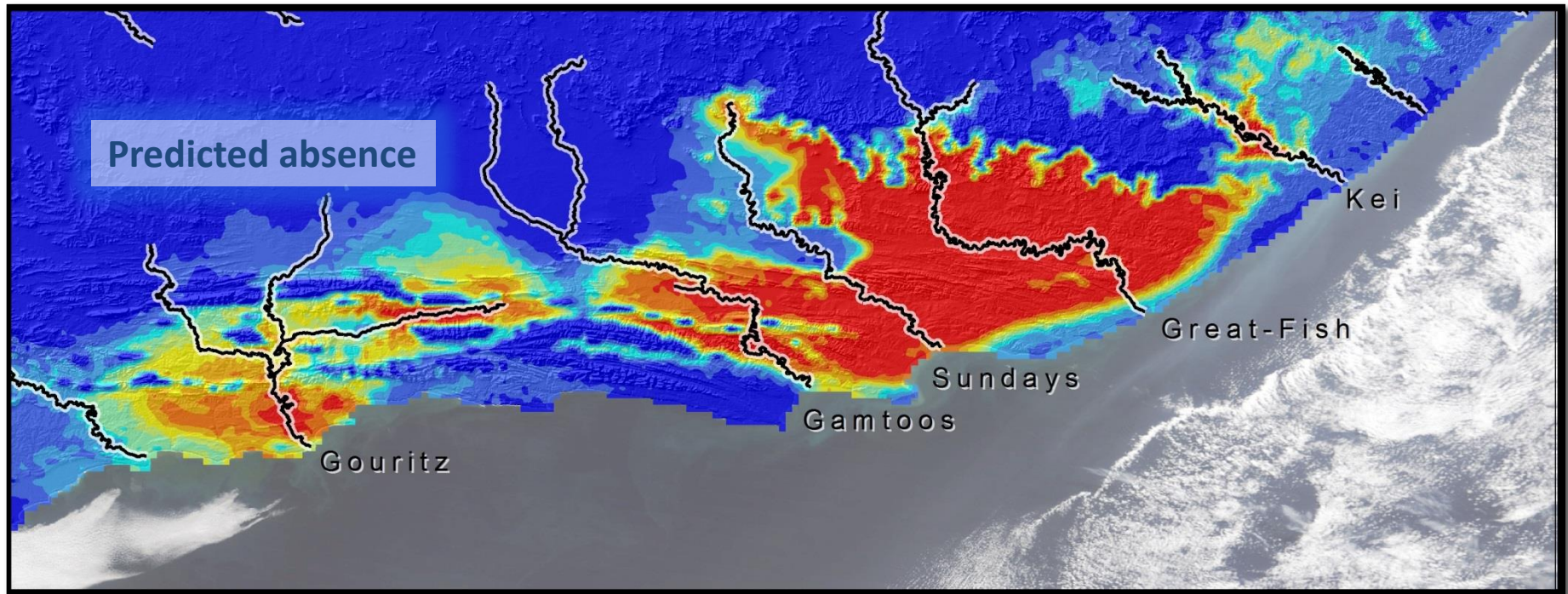
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# ENV. NICHE MOD. OF THICKET: PRESENT DAY CLIMATE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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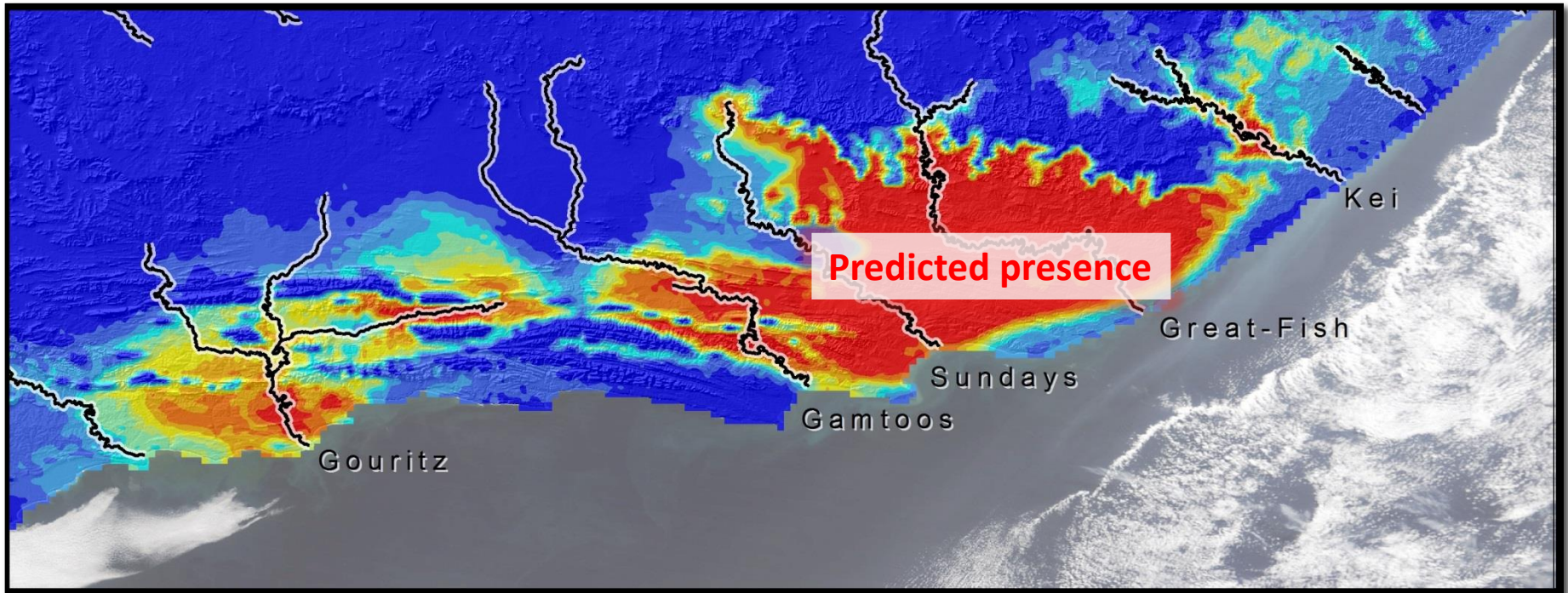
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# ENV. NICHE MOD. OF THICKET: PRESENT DAY CLIMATE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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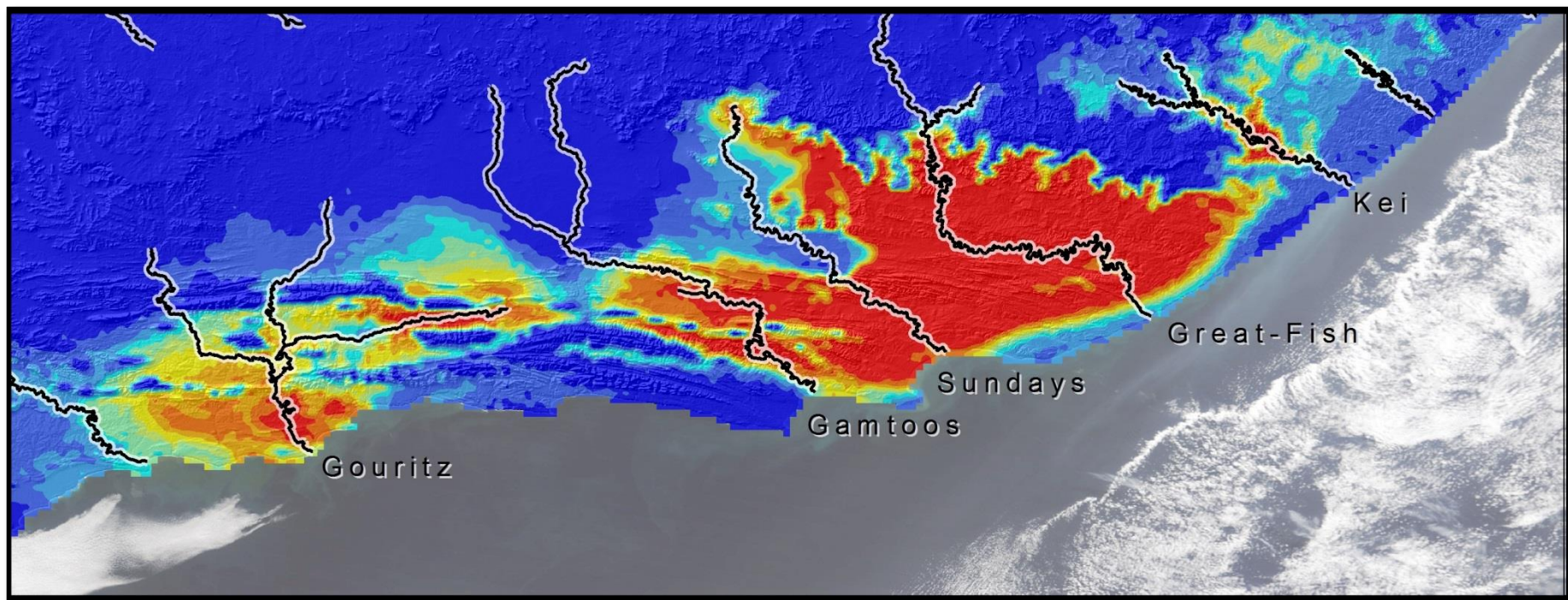
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# ENV. NICHE MOD. OF THICKET: PRESENT DAY CLIMATE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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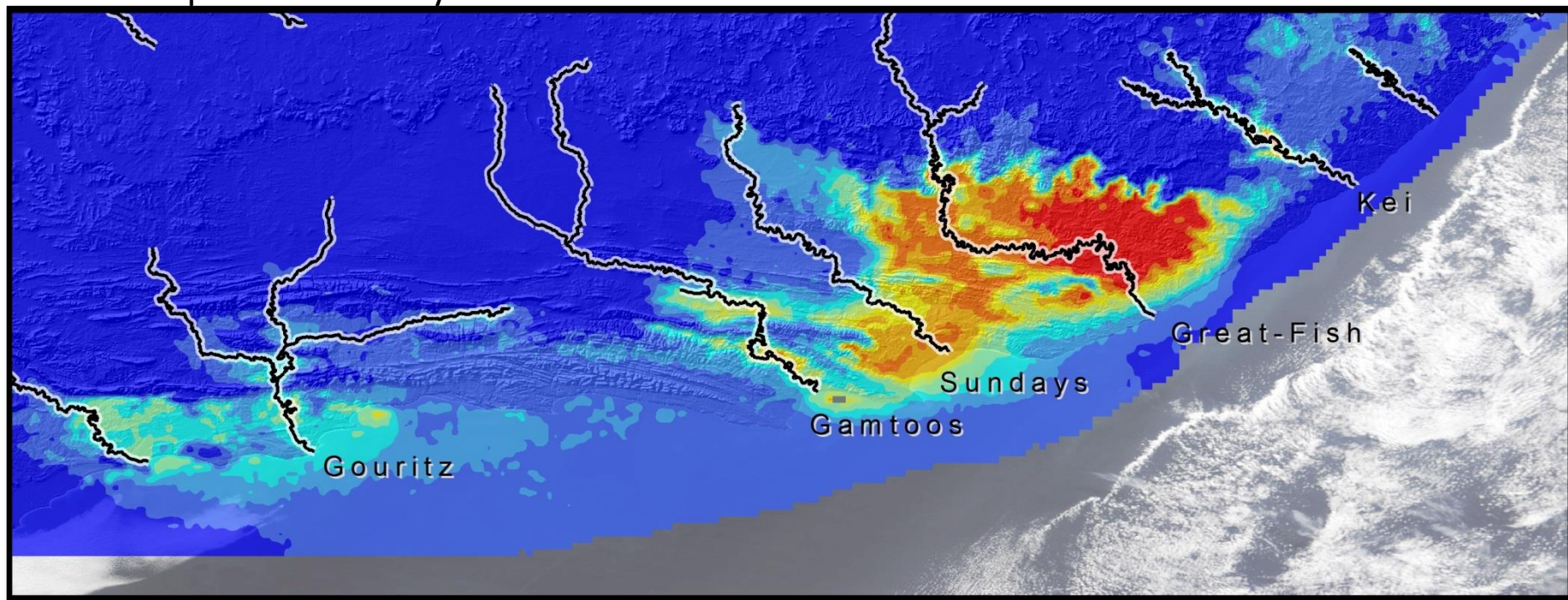
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# LAST GLACIAL MAXIMUM (~21 KA)

Climate input: statistically downscaled CCSM simulations for PMIP2



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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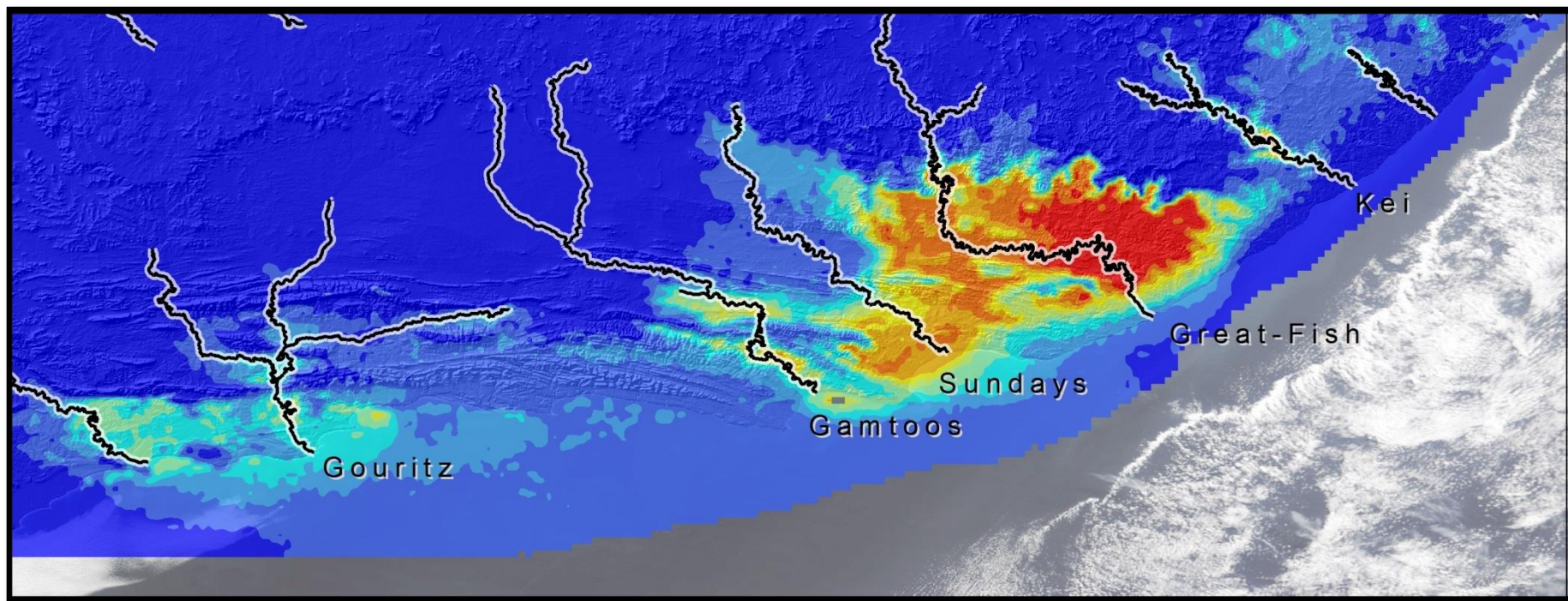
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# HOW MIGHT THIS HELP US INTERPRET THE ARCHAEOLOGICAL RECORD?



BACKGROUND

ENV. NICHE MOD.

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CASE STUDY: C4 GRASSLAND

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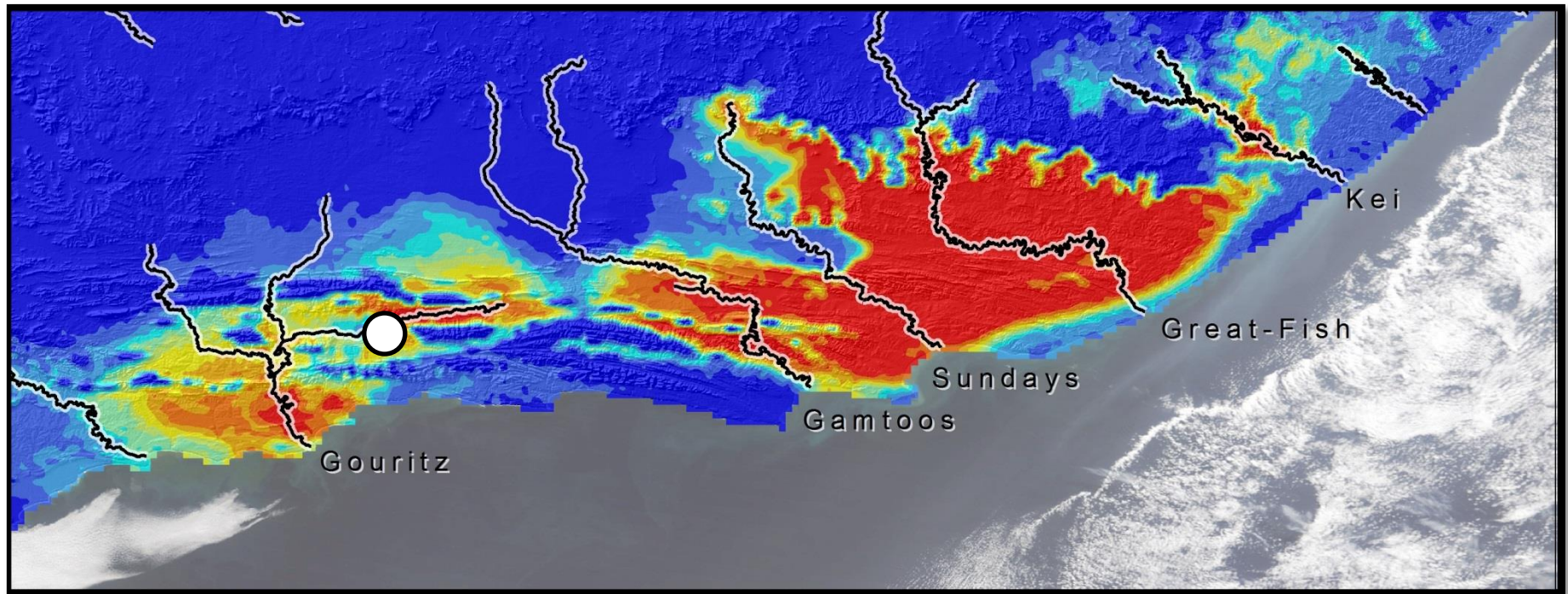
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# BOOMPLAAS CAVE & PAPPEA CAPENSIS

Deacon (1995) South Afr. Archaeol. Bull.



Franklin et al. (2015) Quaternary Science Reviews

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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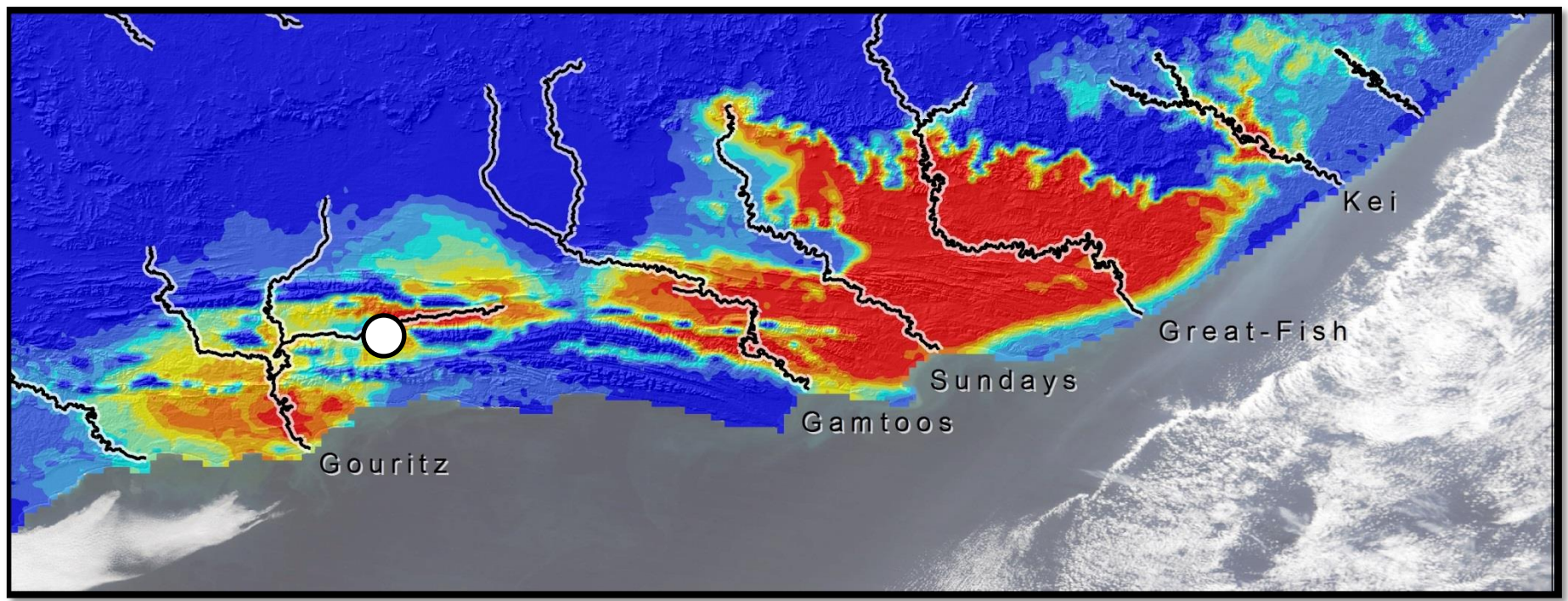
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# BOOMPLAAS CAVE & *PAPPEA CAPENSIS*

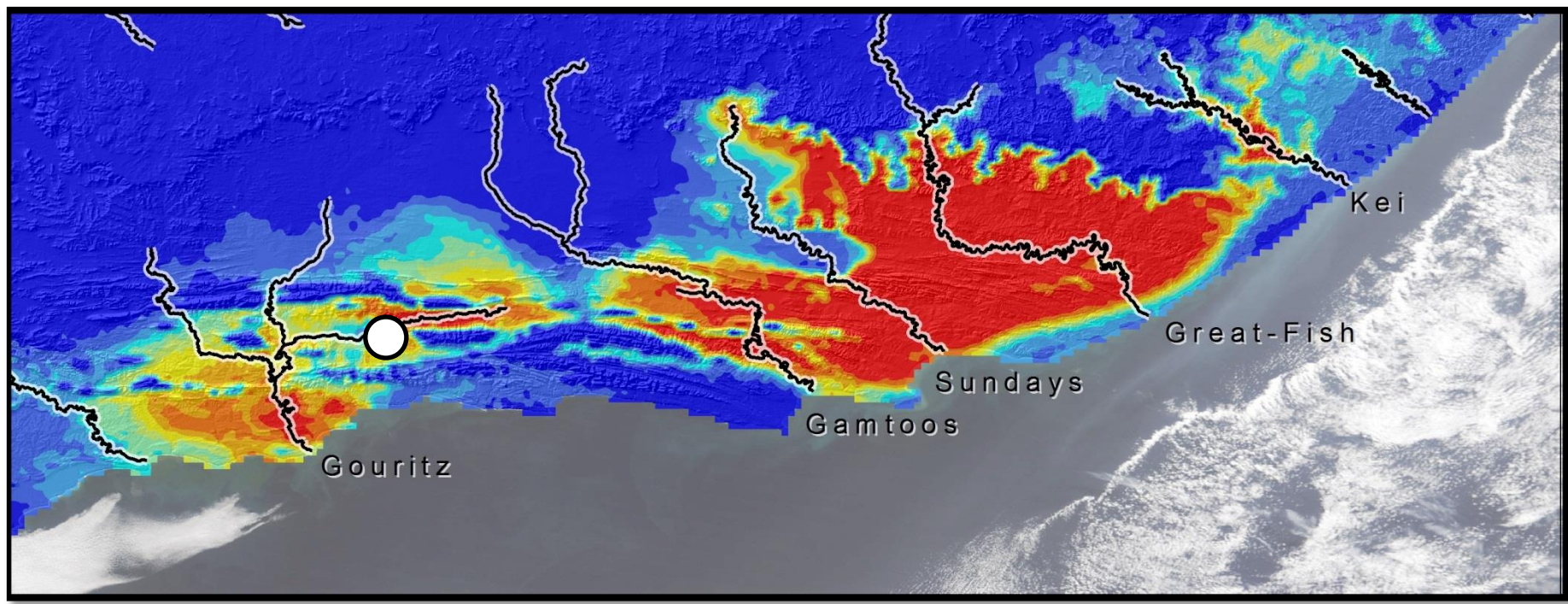
Deacon (1995) South Afr. Archaeol. Bull.





# BOOMPLAAS CAVE & *PAPPEA CAPENSIS*

Deacon (1995) South Afr. Archaeol. Bull.

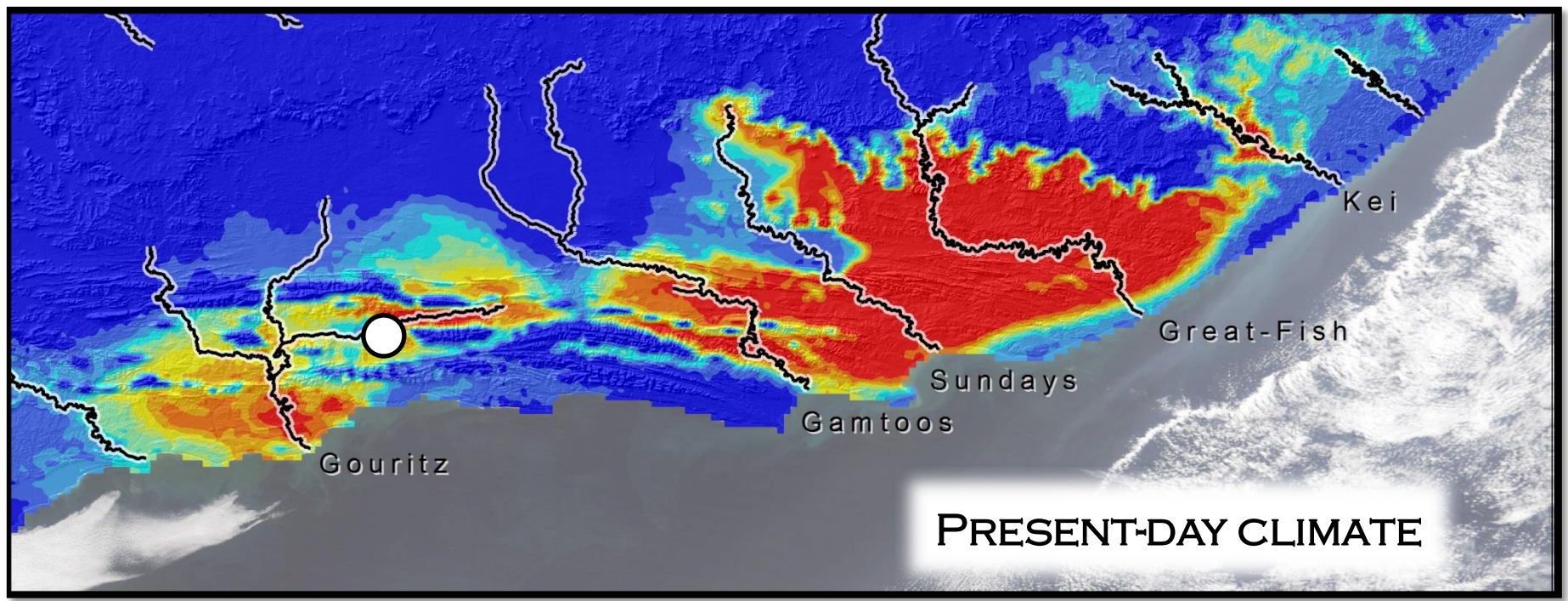






# BOOMPLAAS CAVE & PAPPEA CAPENSIS

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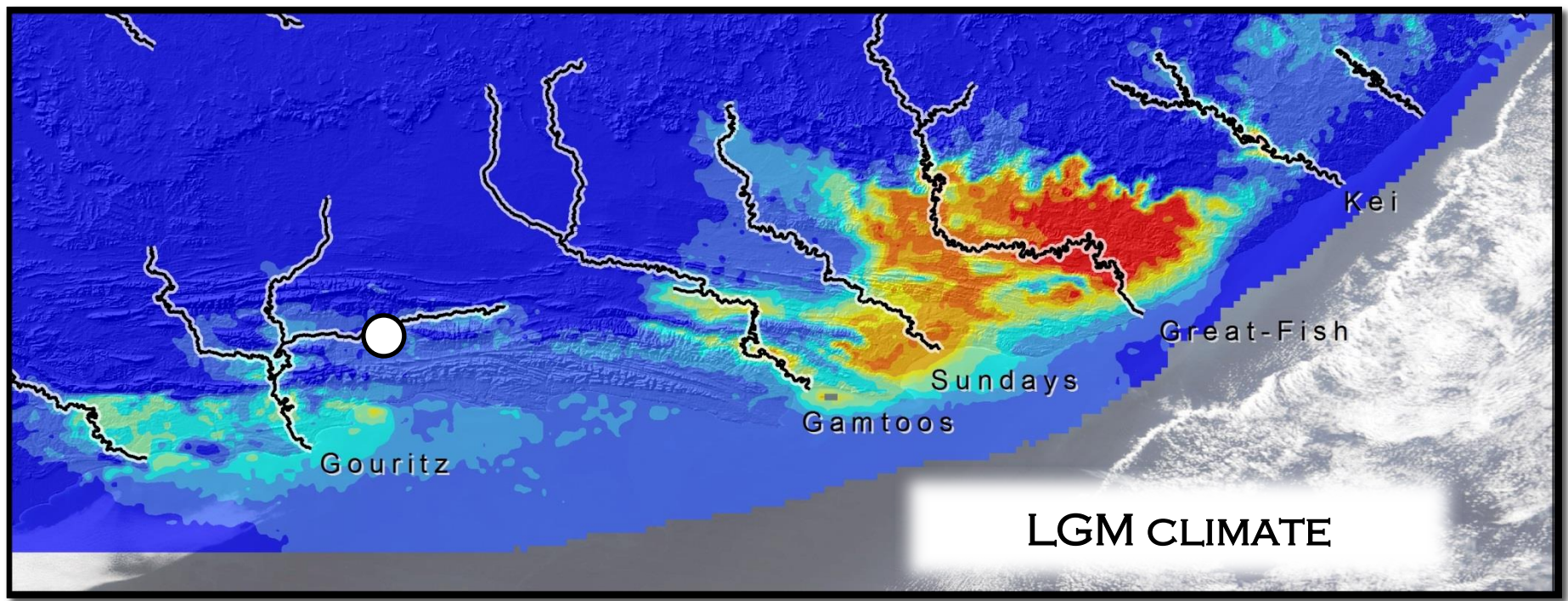
PRESENT-DAY CLIMATE





# BOOMPLAAS CAVE & *PAPPEA CAPENSIS*

Deacon (1995) South Afr. Archaeol. Bull.



LGM CLIMATE

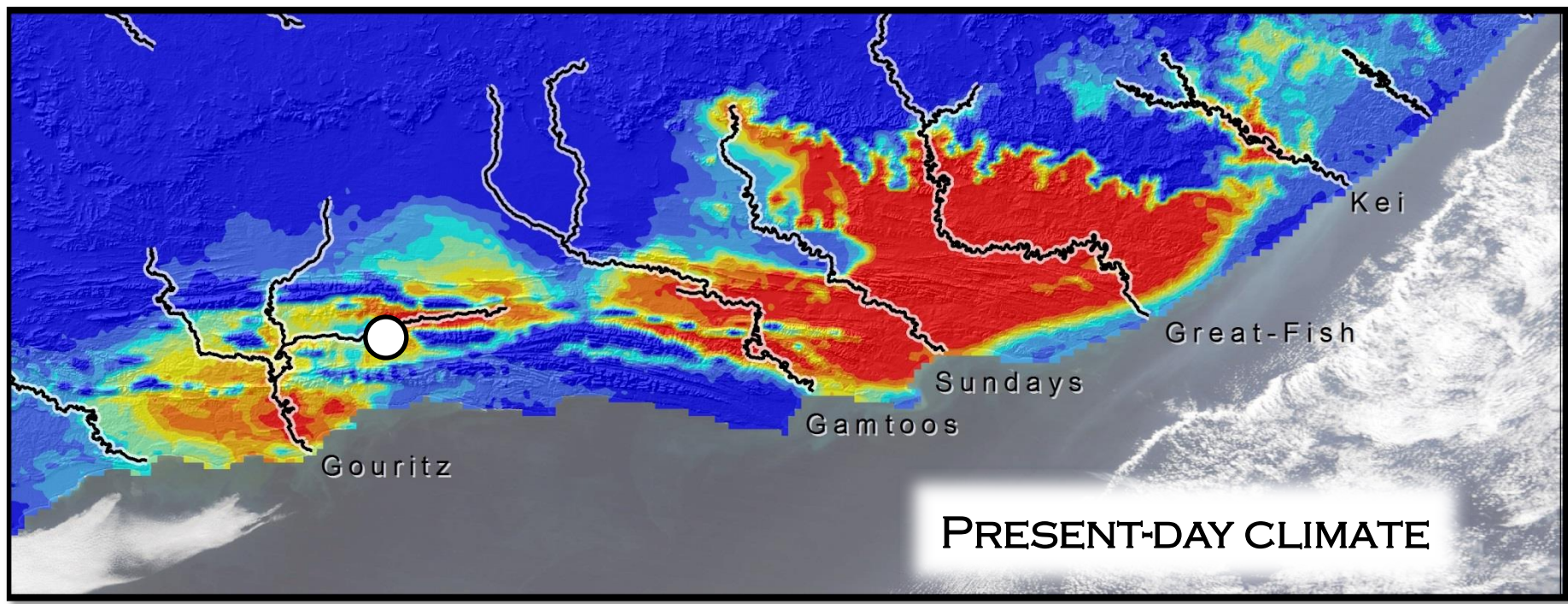




# BOOMPLAAS CAVE & *PAPPEA CAPENSIS*



Deacon (1995) South Afr. Archaeol. Bull.



PRESENT-DAY CLIMATE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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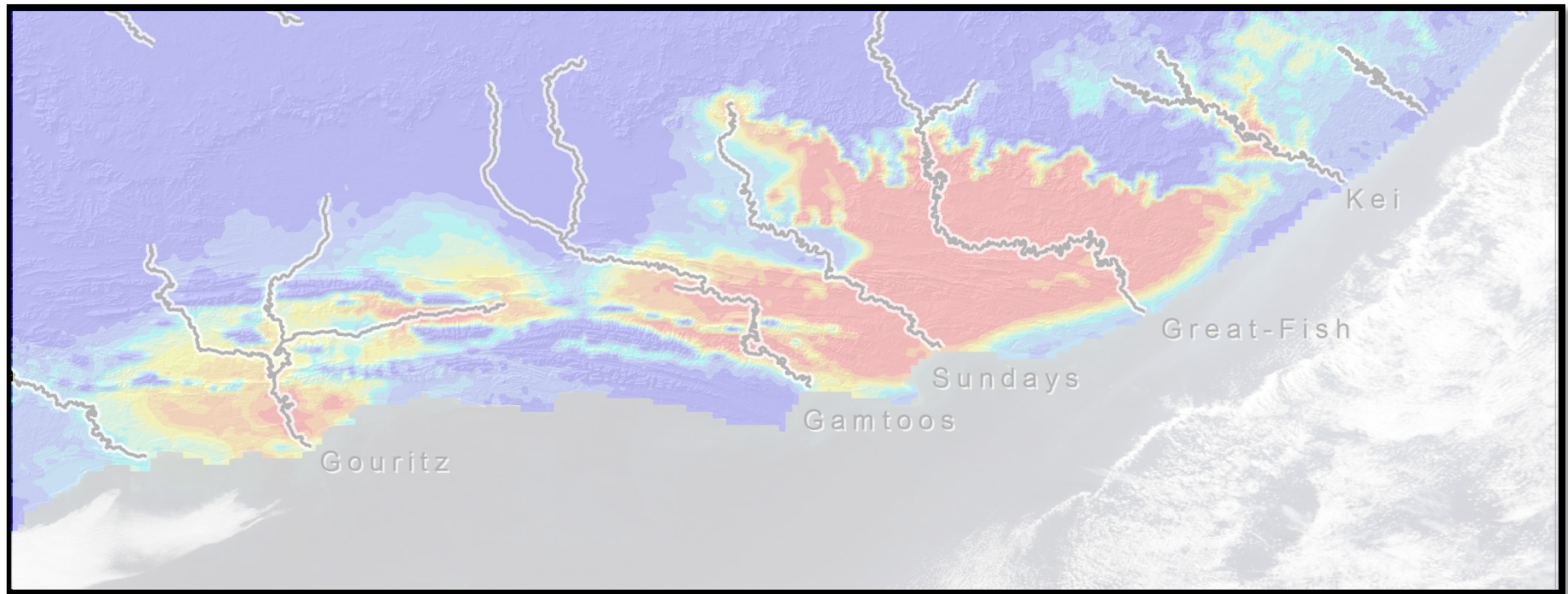
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# LIMITATIONS OF ENVIRONMENTAL NICHE MODELLING



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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# LIMITATIONS: ATMOSPHERIC CO<sub>2</sub>



**CO<sub>2</sub> plays an important role in shrub and tree physiology. They grow slower at lower CO<sub>2</sub> levels.**



**ACACIA KAROO (TREE) SEEDLING AFTER 2 YEARS OF GROWTH**



**ACACIA KAROO (TREE) SEEDLING AFTER 2 YEARS OF GROWTH**



***ACACIA KAROO* (TREE) SEEDLING AFTER 2 YEARS OF GROWTH**



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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## LIMITATIONS: FIRE



**Without fire, the majority of the fynbos, grassland & savannah biomes would be forest.**

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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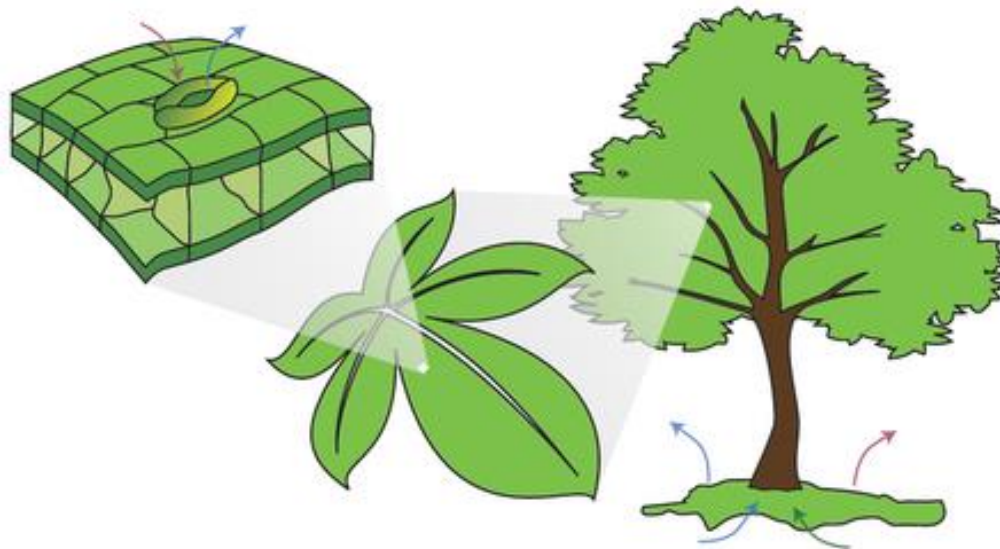
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# DYNAMIC VEGETATION MODELLING



# DYNAMIC VEGETATION MODELS



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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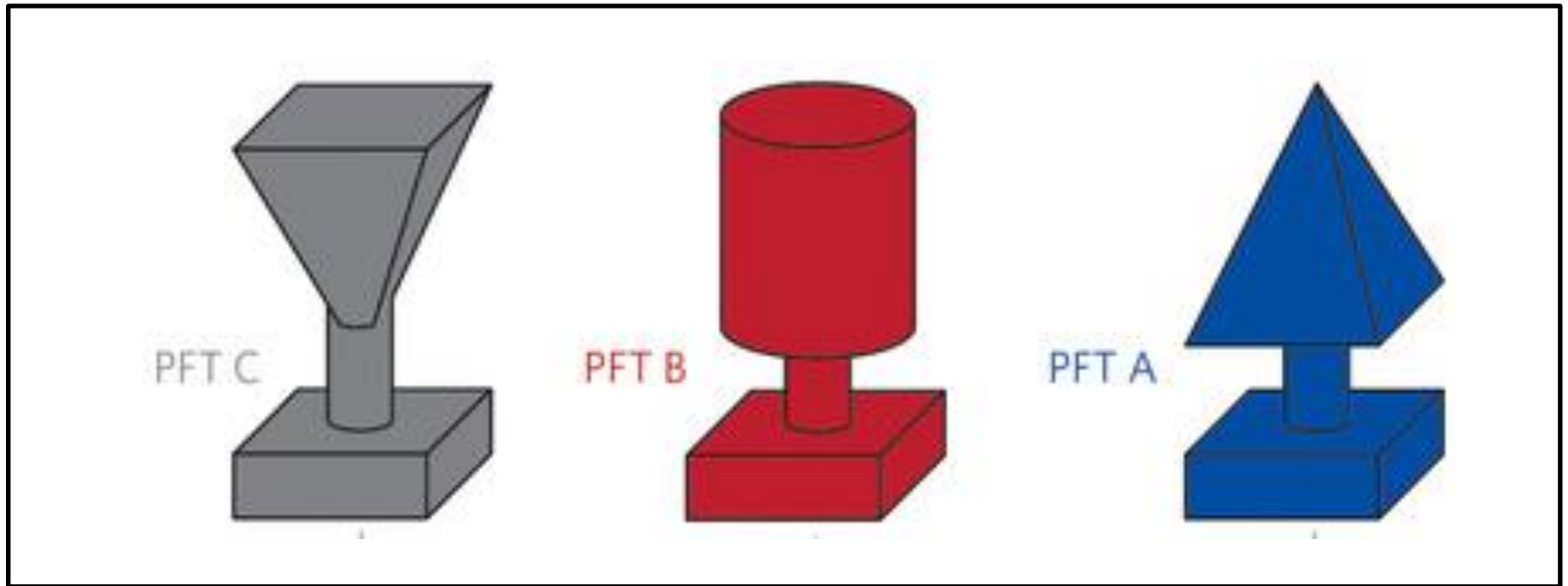
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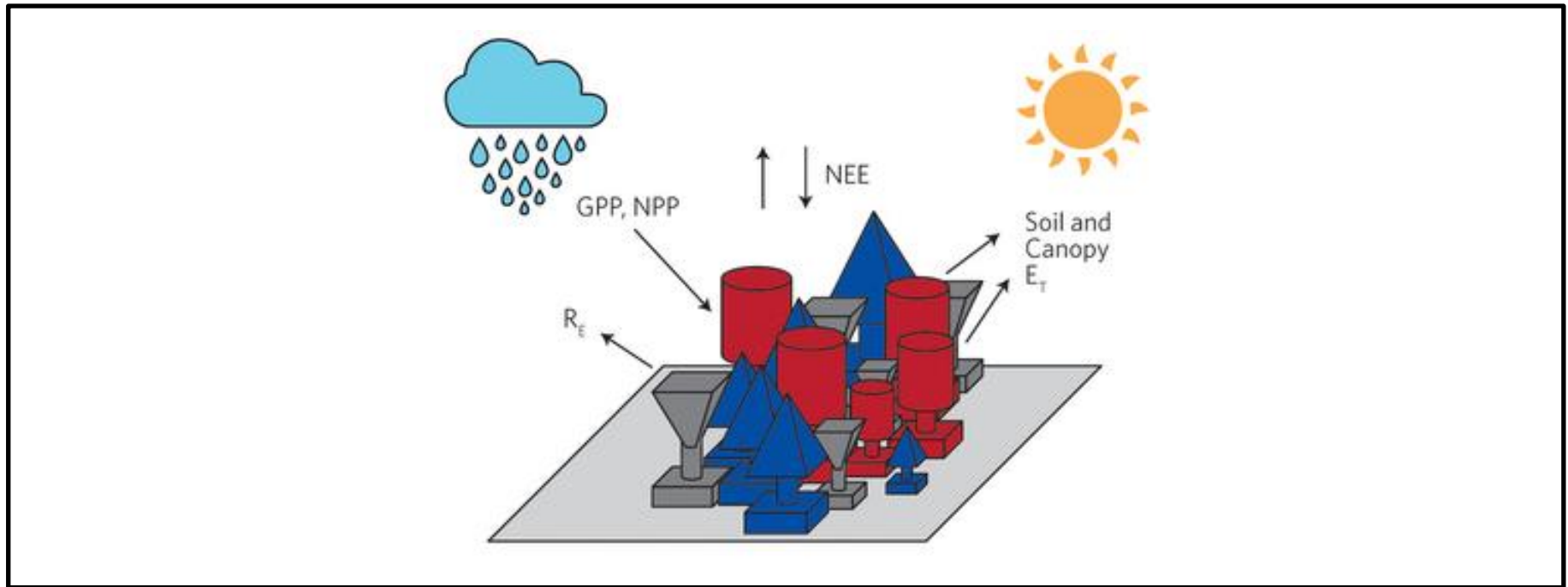


# DYNAMIC VEGETATION MODELS





# DYNAMIC VEGETATION MODELS



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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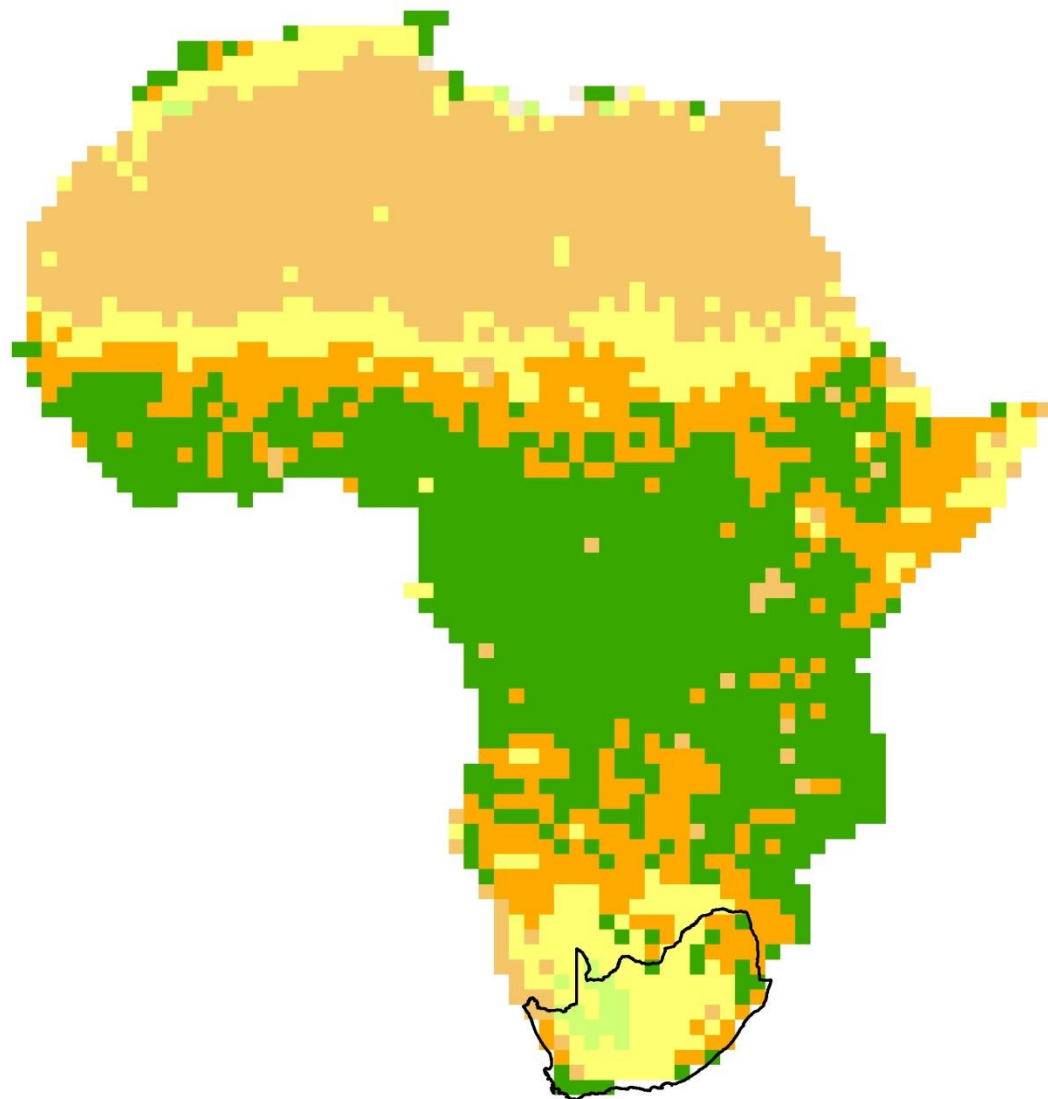
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# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
- C4 Savannah
- Forest and closed woodland



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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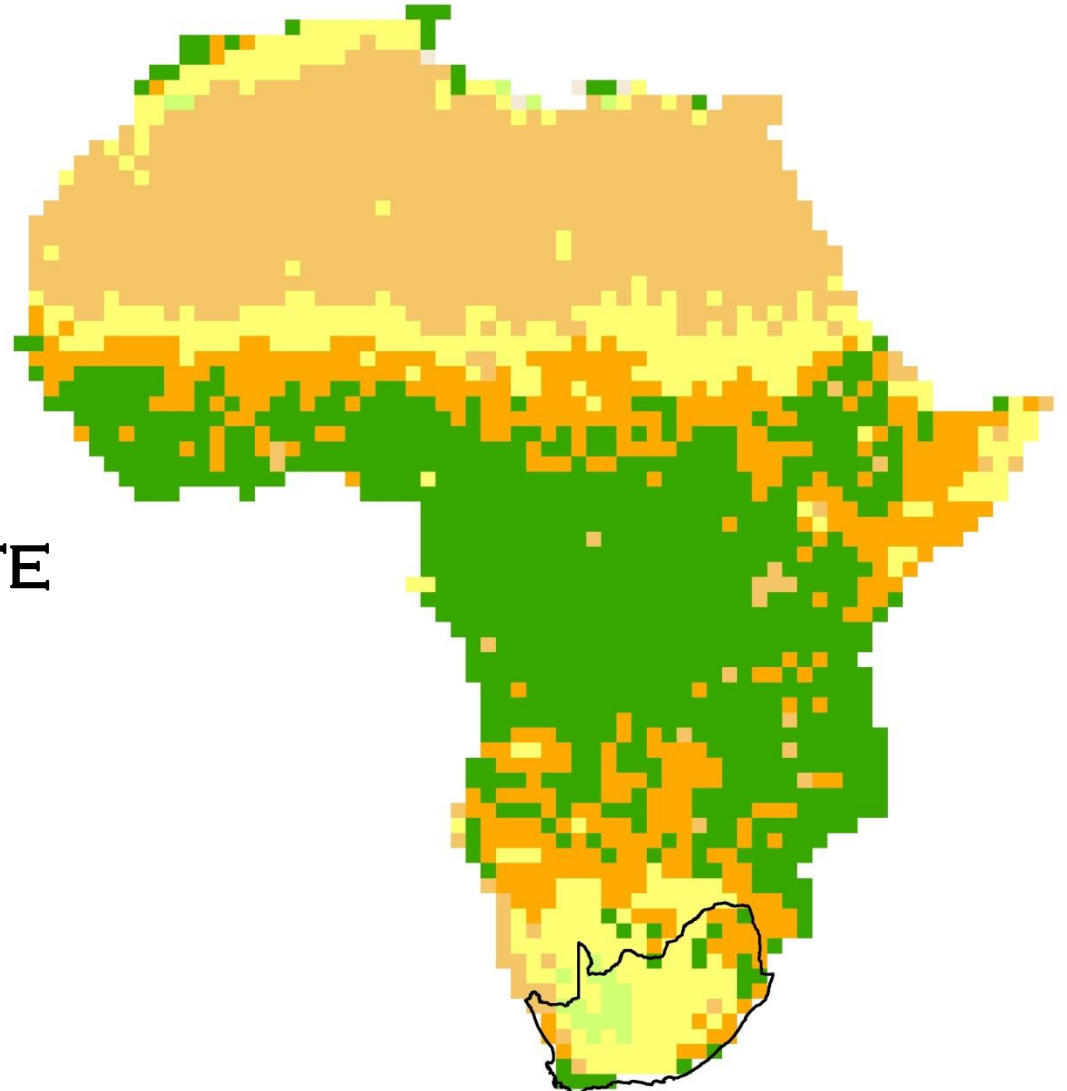


# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
- C4 Savannah
- Forest and closed woodland

## PRESENT DAY CLIMATE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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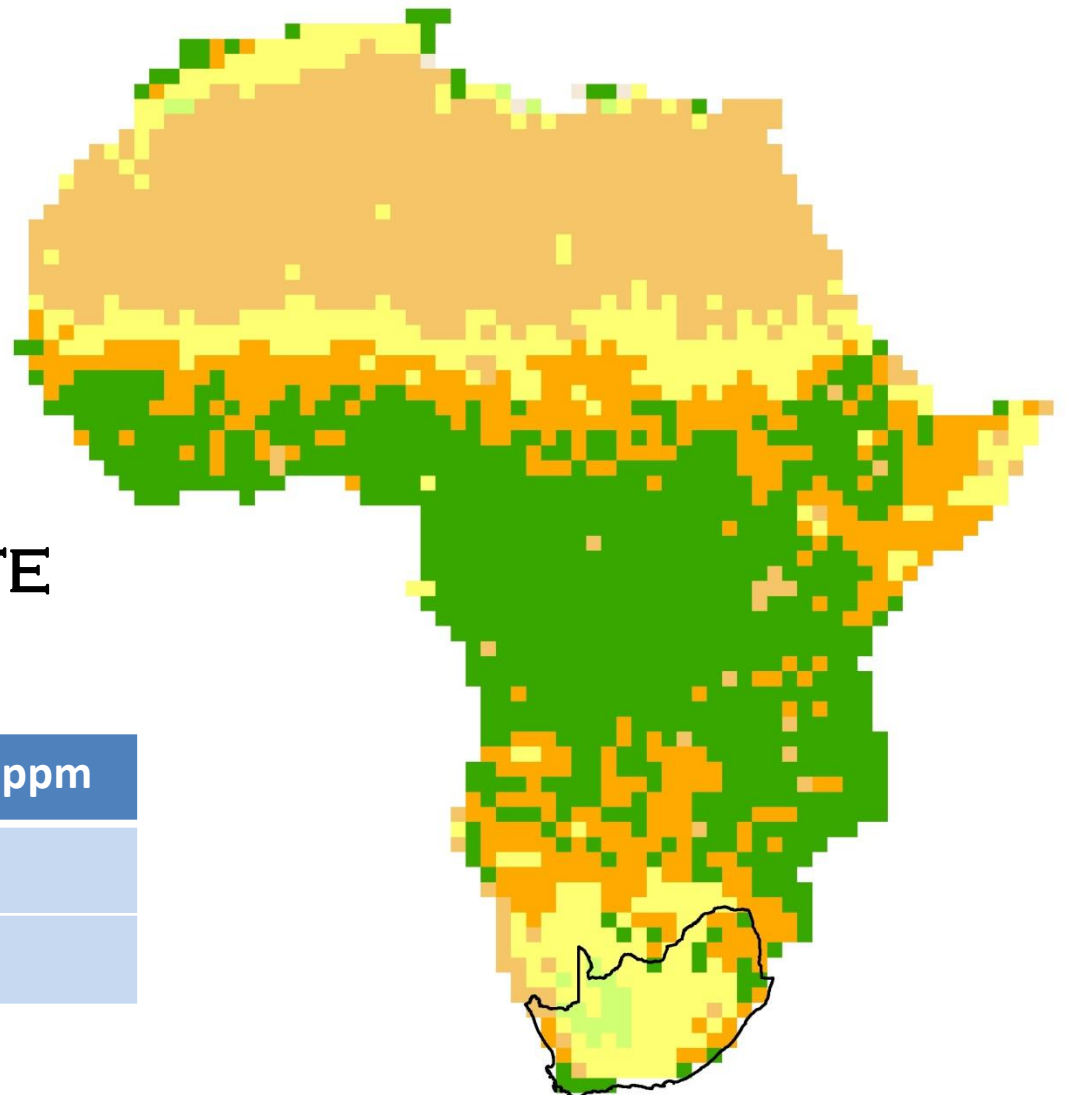
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# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
- C4 Savannah
- Forest and closed woodland



## PRESENT DAY CLIMATE

	350 ppm	150 ppm
Fire	●	
No fire		



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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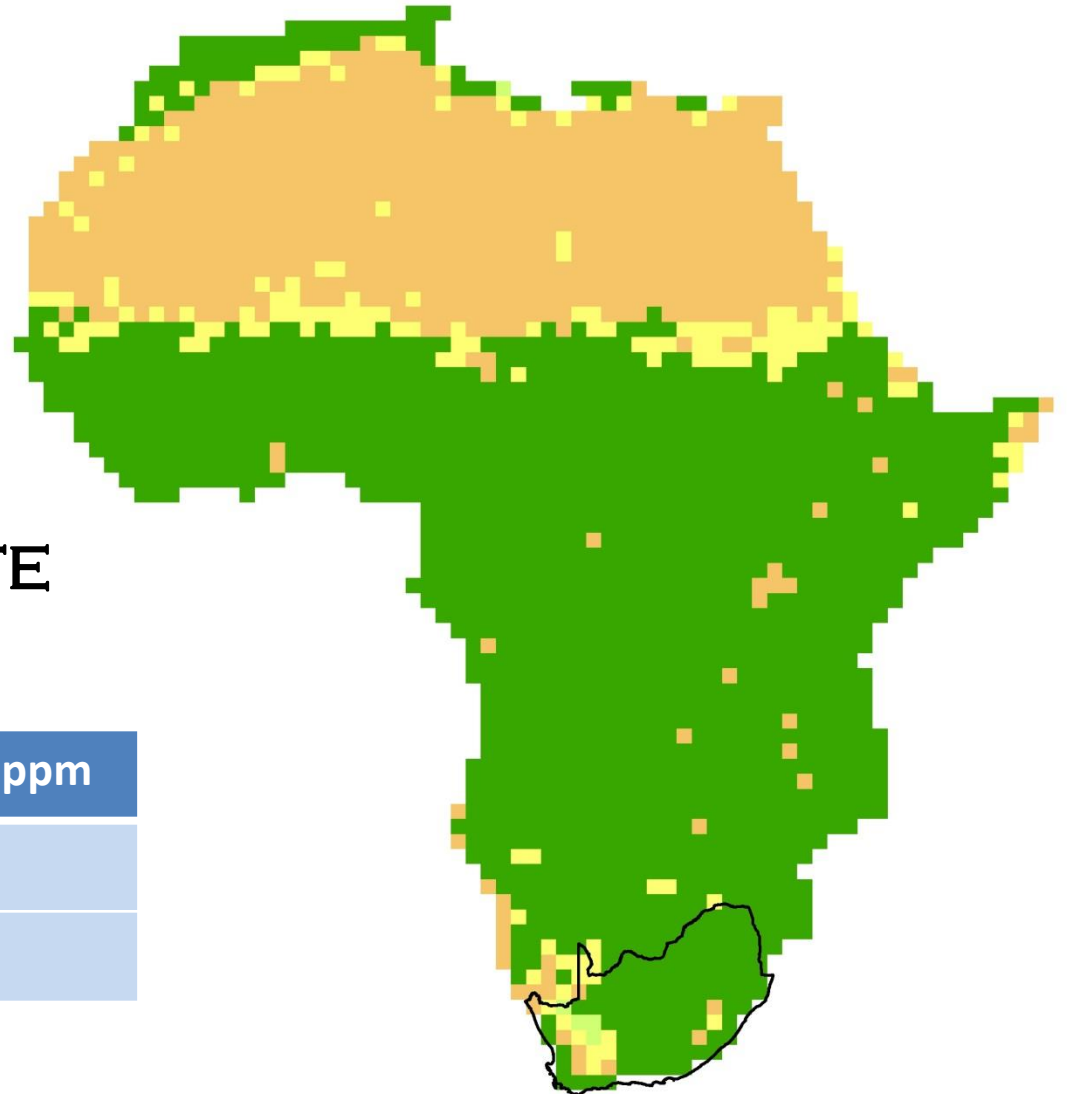
# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
- C4 Savannah
- Forest and closed woodland

## PRESENT DAY CLIMATE

	350 ppm	150 ppm
Fire		
No fire	●	



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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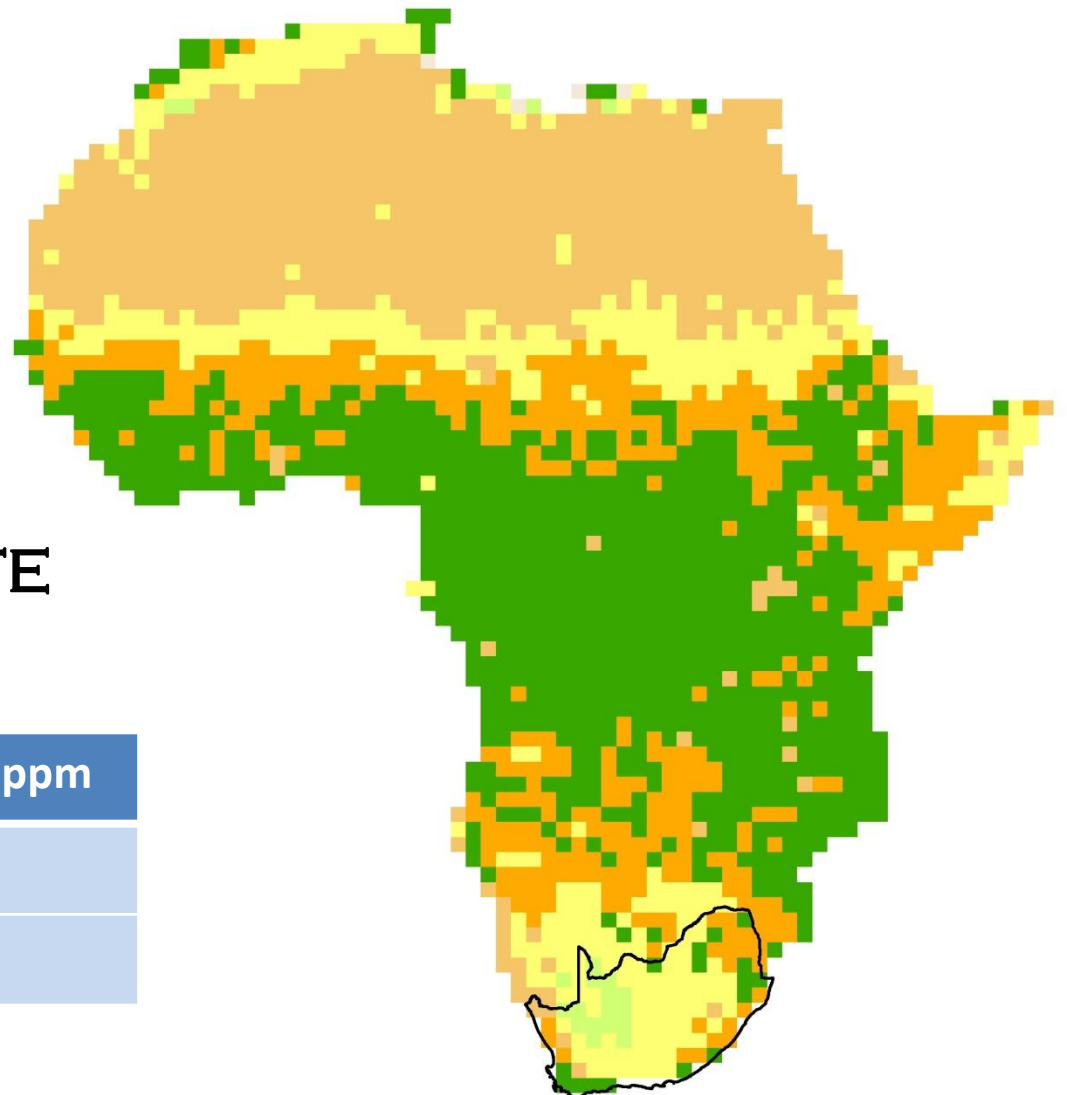
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# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
- C4 Savannah
- Forest and closed woodland



## PRESENT DAY CLIMATE

	350 ppm	150 ppm
Fire	●	
No fire		

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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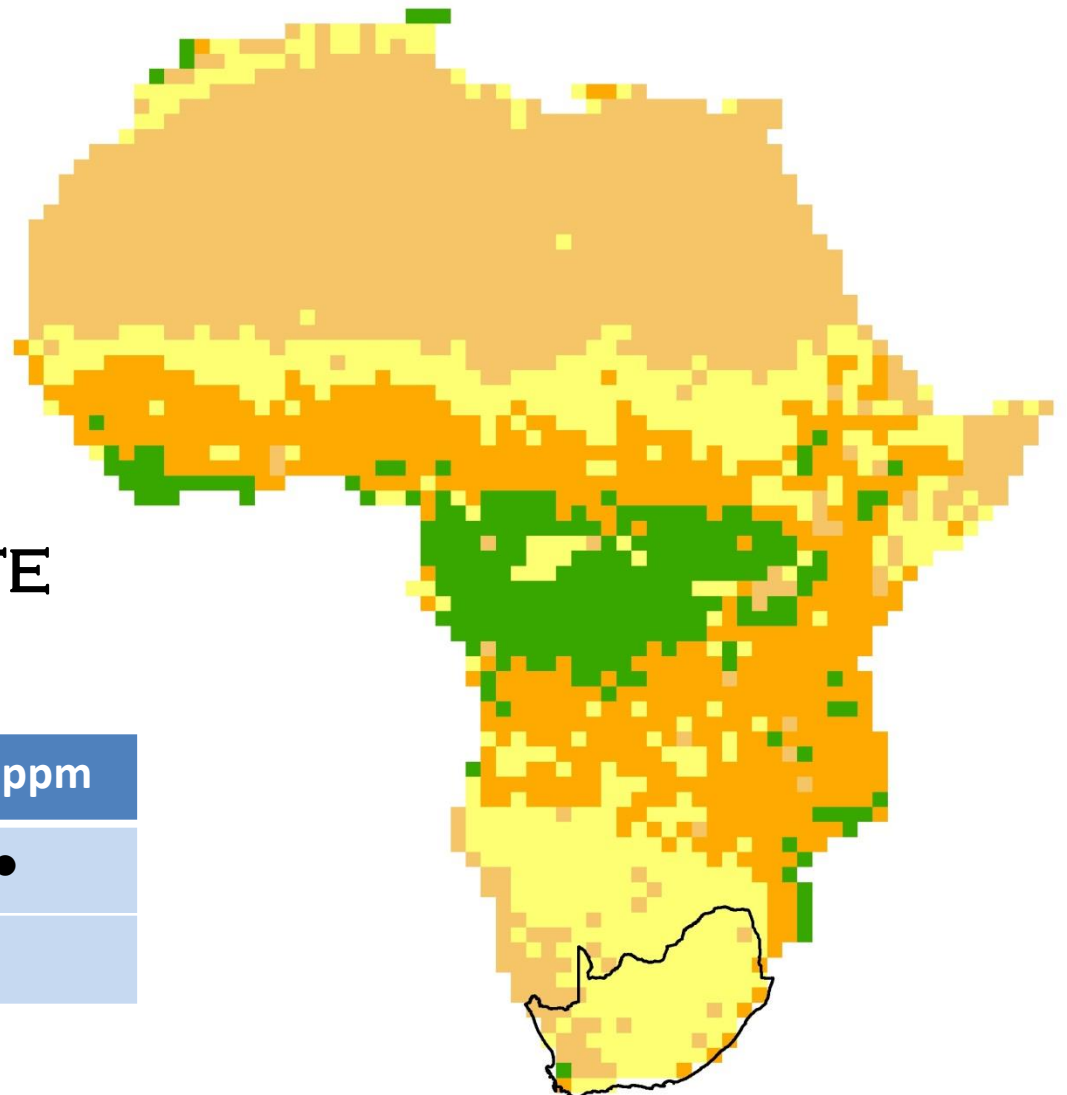
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# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
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## PRESENT DAY CLIMATE

	350 ppm	150 ppm
Fire		●
No fire		

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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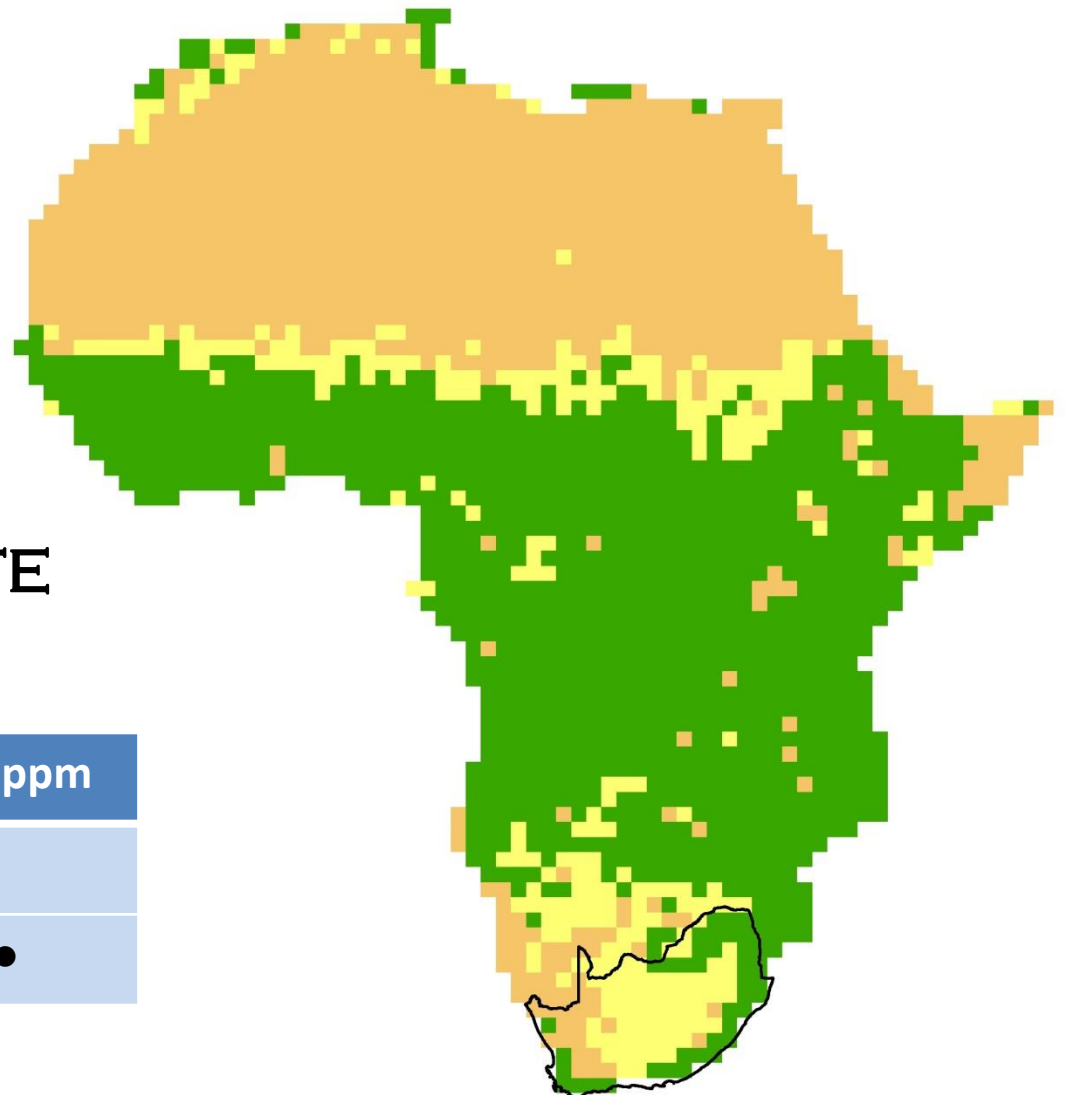
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# ADGVM

Scheiter & Higgins (2009) GCB

- C4 Grassland
- C4 Savannah
- Forest and closed woodland



## PRESENT DAY CLIMATE

	350 ppm	150 ppm
Fire		
No fire		●

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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## CASE STUDY:

# C4 GRASSLANDS ALONG THE SOUTH COAST DURING GLACIAL PERIODS

BACKGROUND

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ENV. NICHE MOD.

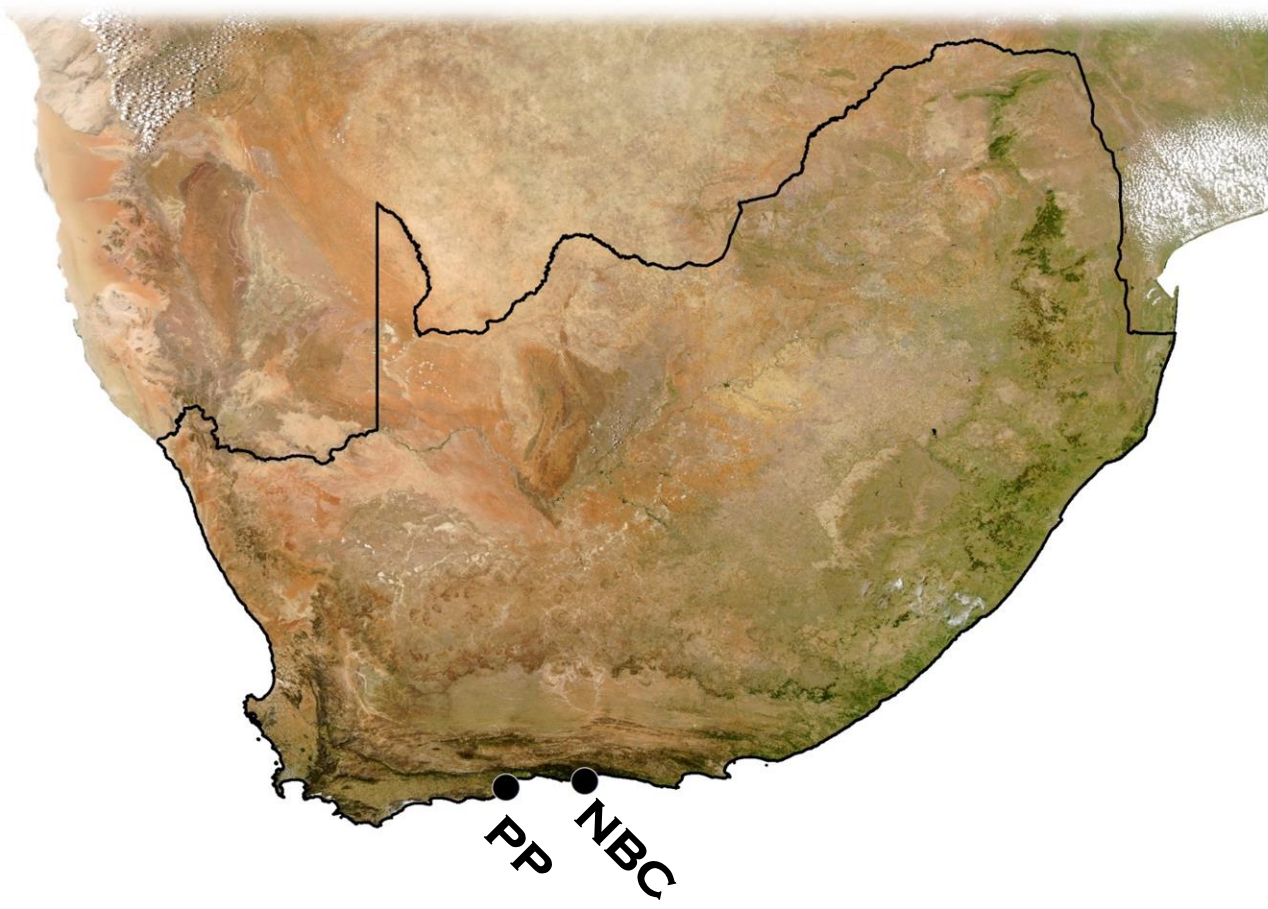
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

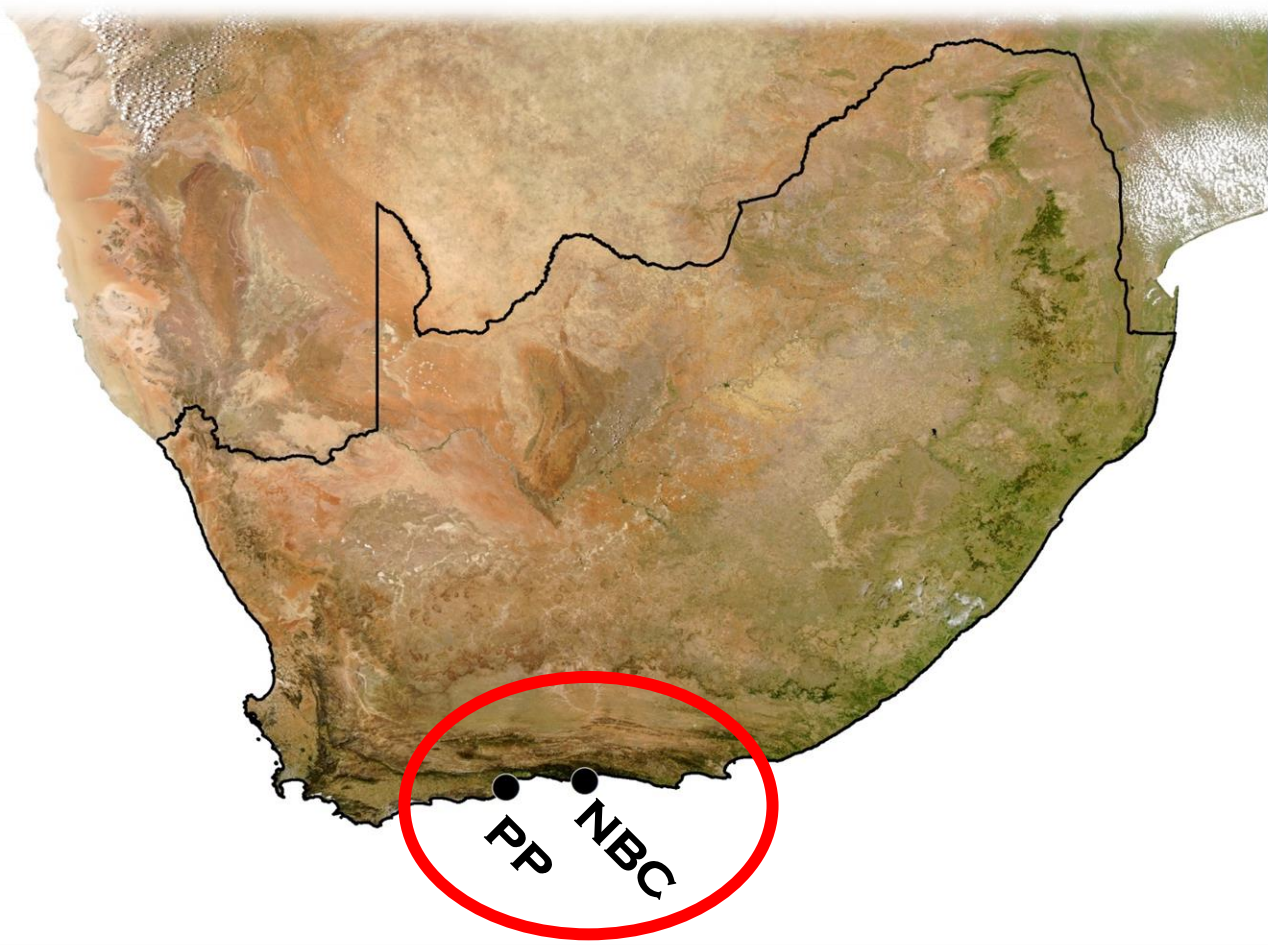
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

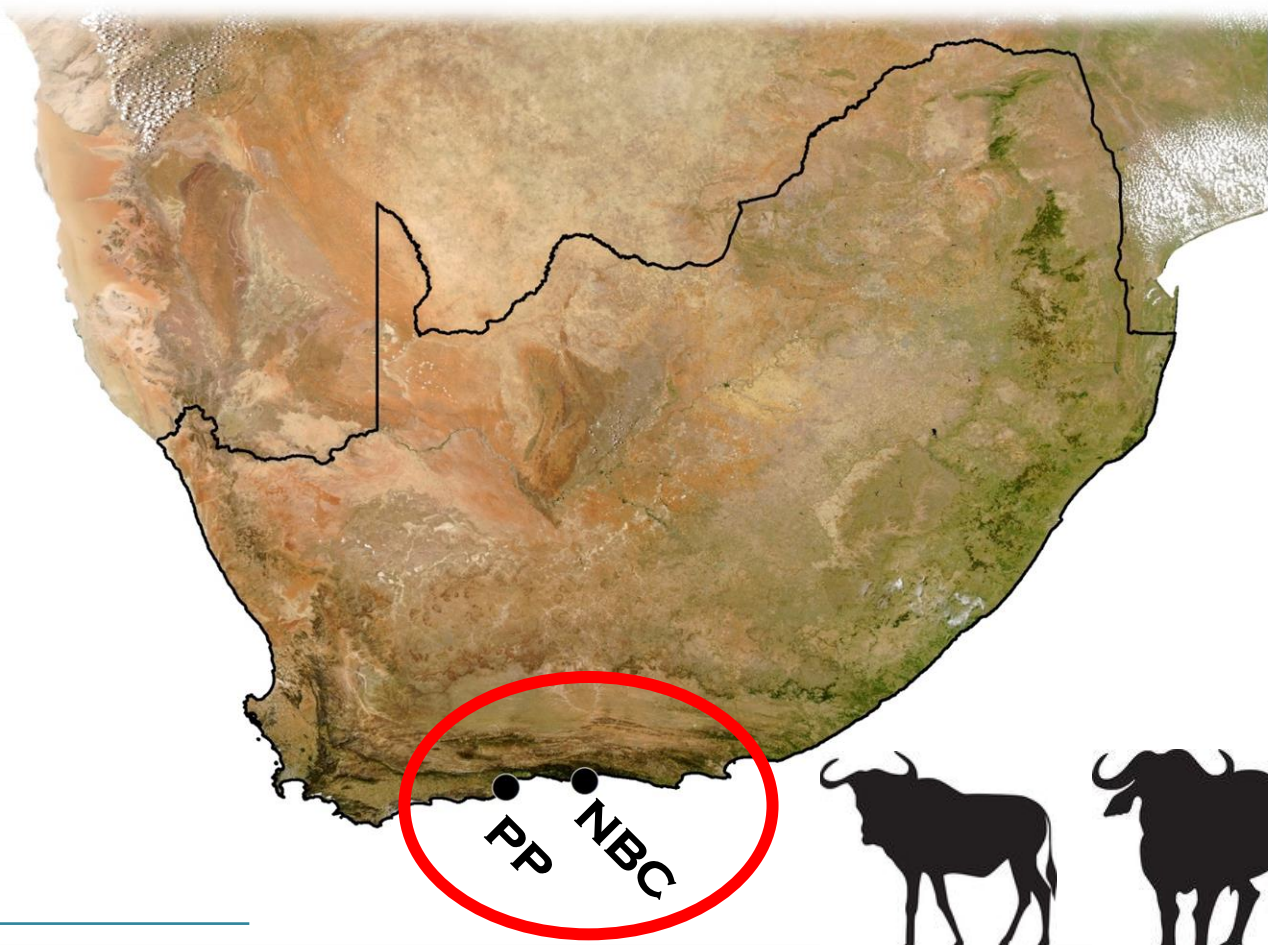
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

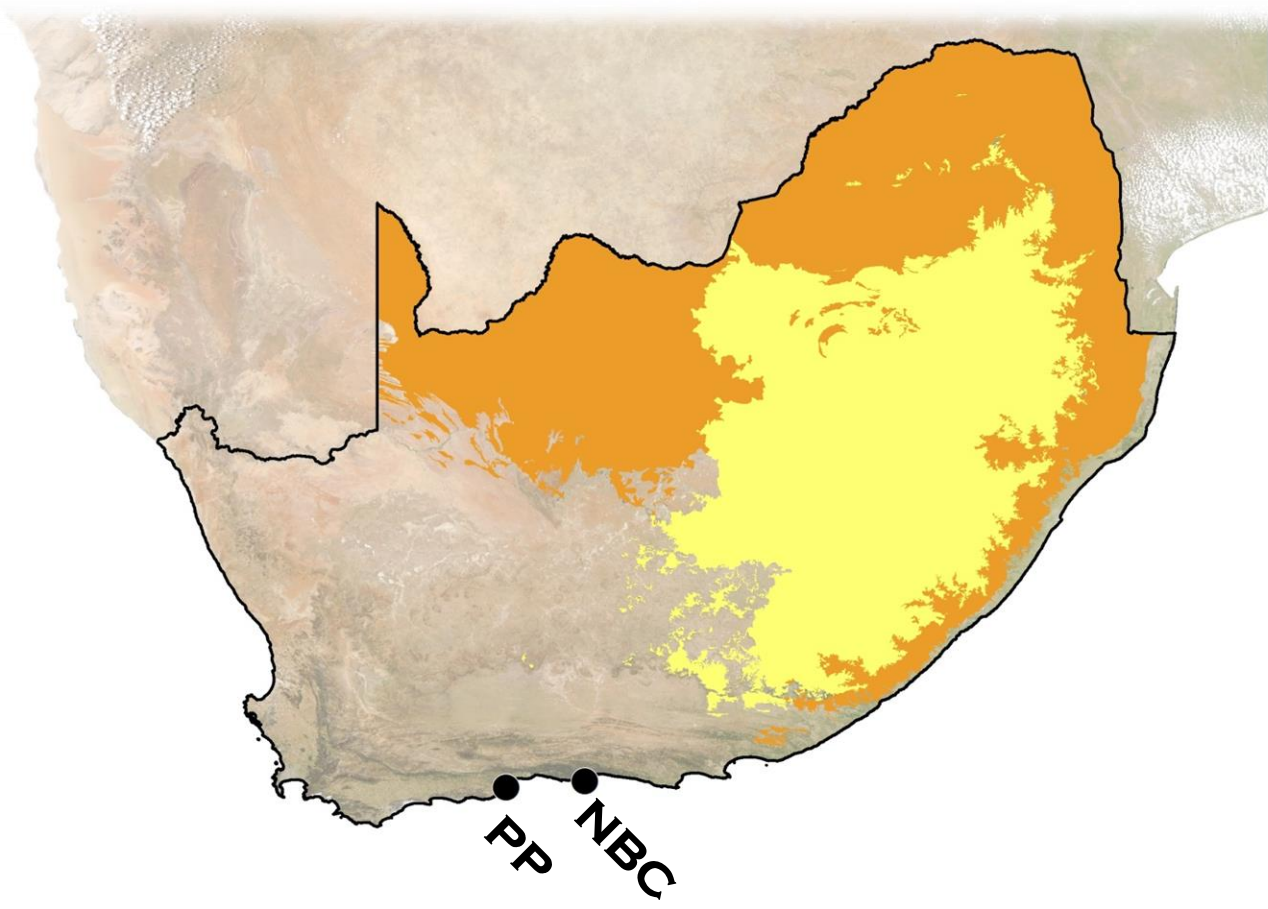
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

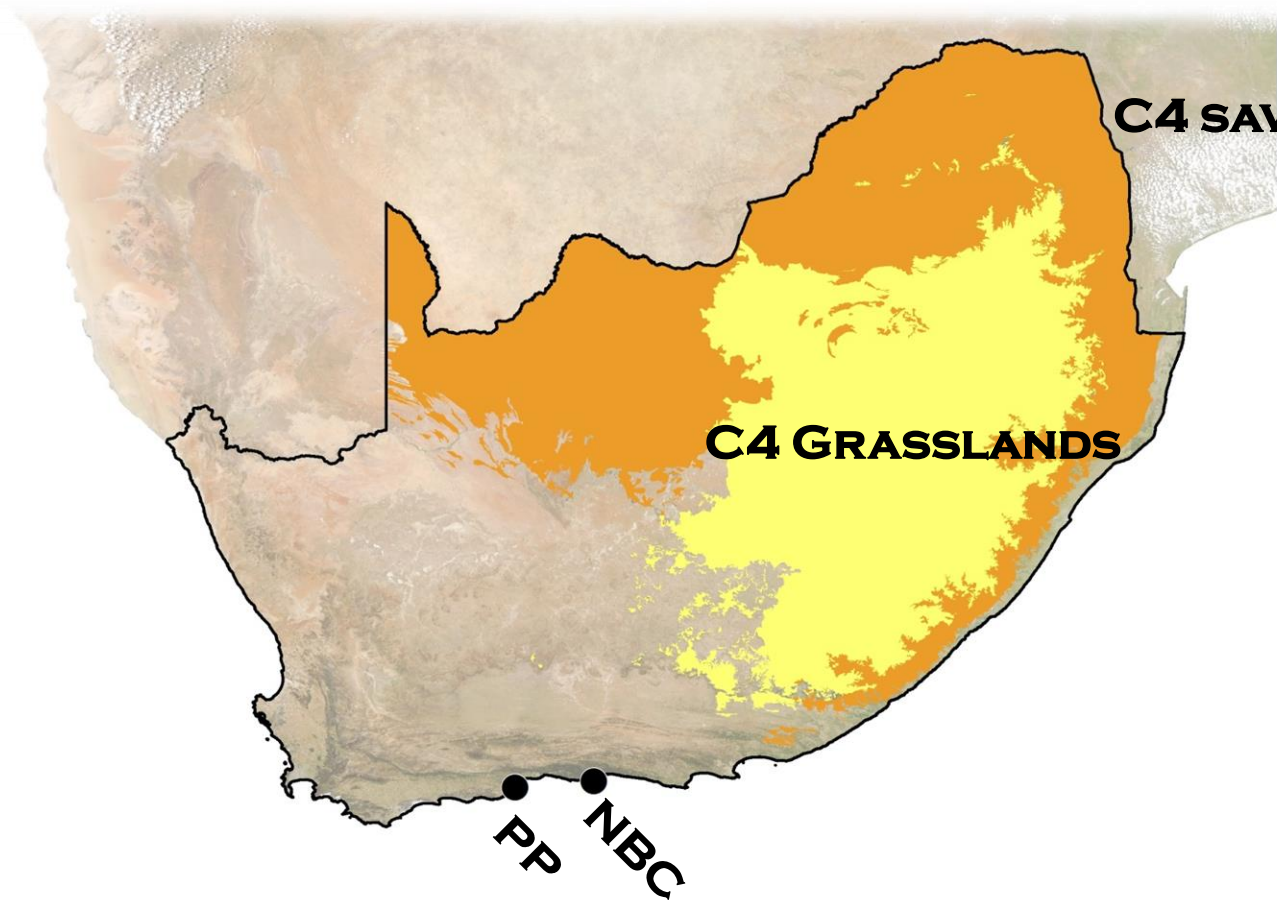
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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**C4 SAVANNAHS**

**C4 GRASSLANDS**

**PP**

**NBC**

BACKGROUND

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ENV. NICHE MOD.

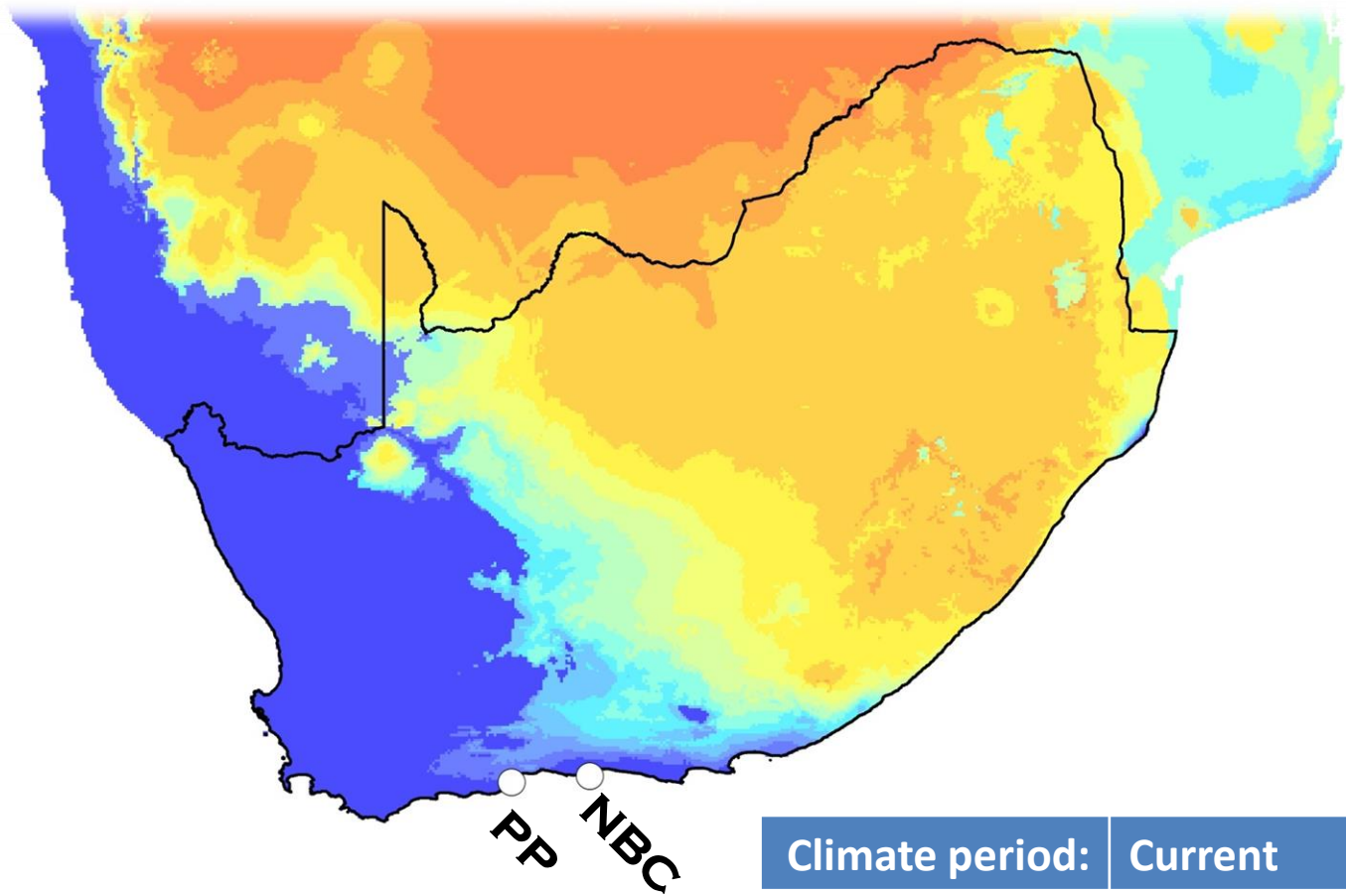
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Climate period: Current

BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

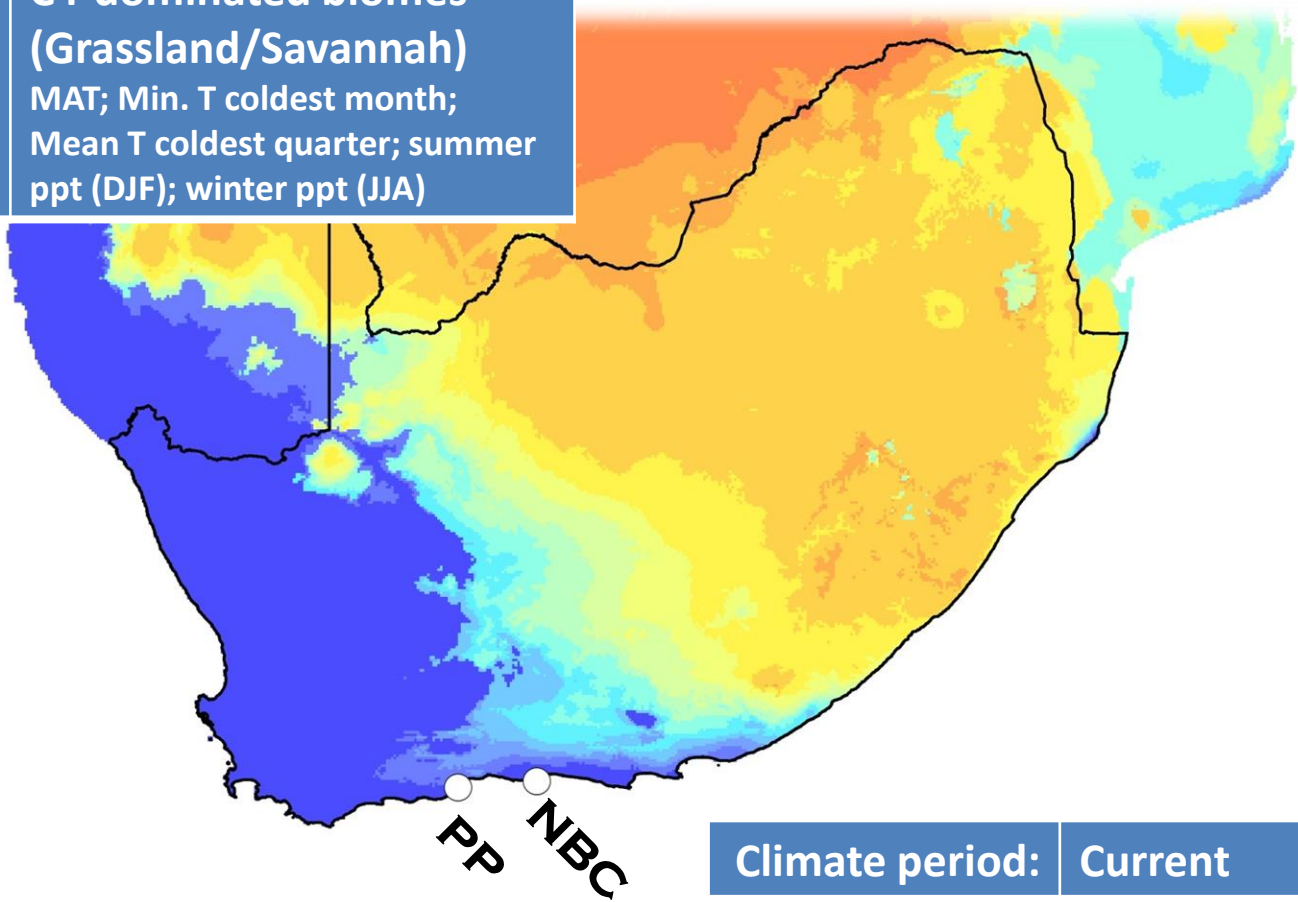
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CASE STUDY: C4 GRASSLAND

○●○○○○



**Algorithm:** Maxent  
**Vegetation:** C4-dominated biomes (Grassland/Savannah)  
**Input variables:** MAT; Min. T coldest month; Mean T coldest quarter; summer ppt (DJF); winter ppt (JJA)



**Climate period:** Current

BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

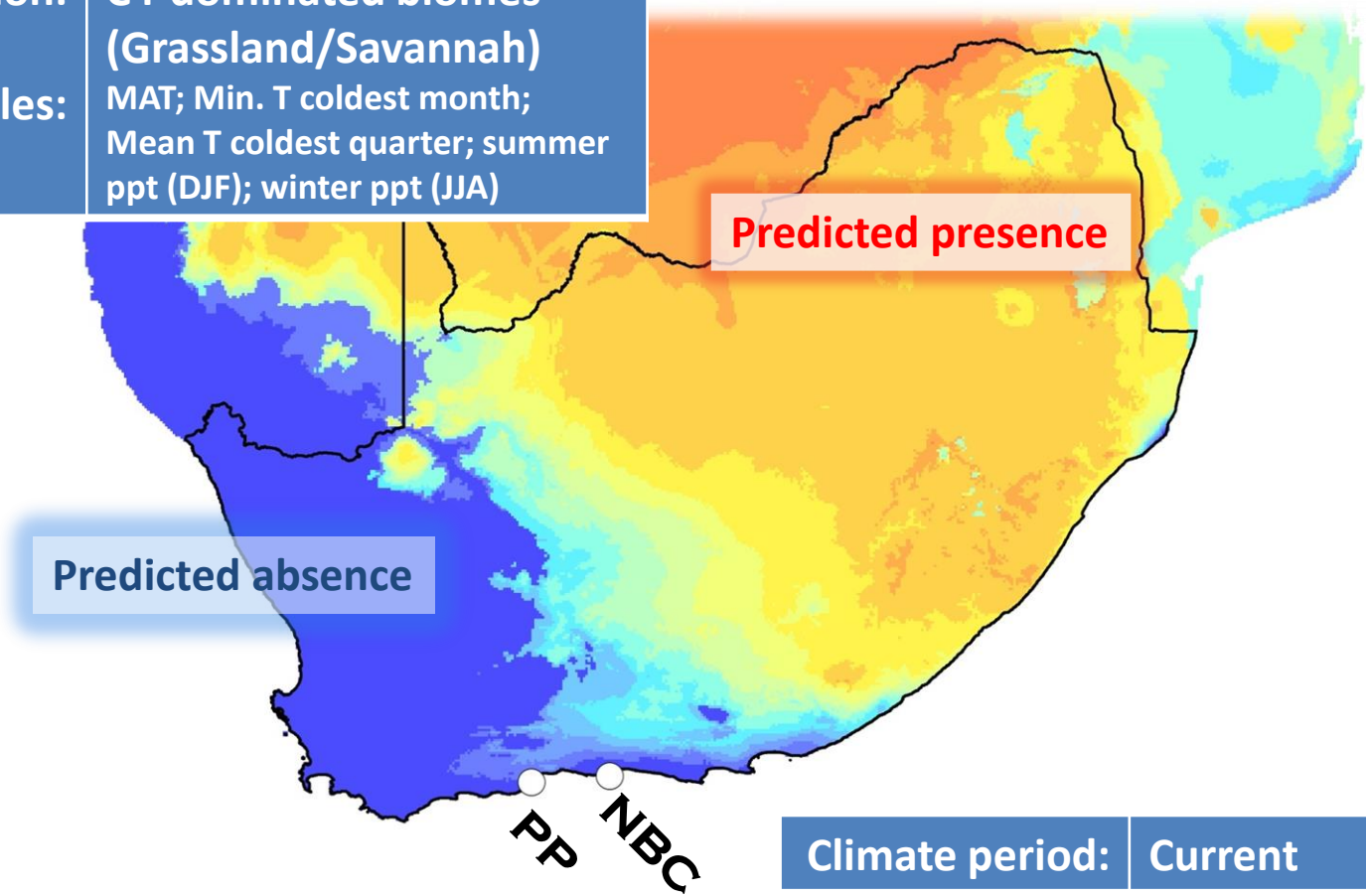
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CASE STUDY: C4 GRASSLAND

○●○○○○



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**Vegetation:** C4-dominated biomes (Grassland/Savannah)  
**Input variables:** MAT; Min. T coldest month; Mean T coldest quarter; summer ppt (DJF); winter ppt (JJA)



**Climate period:** Current

BACKGROUND

○○○

ENV. NICHE MOD.

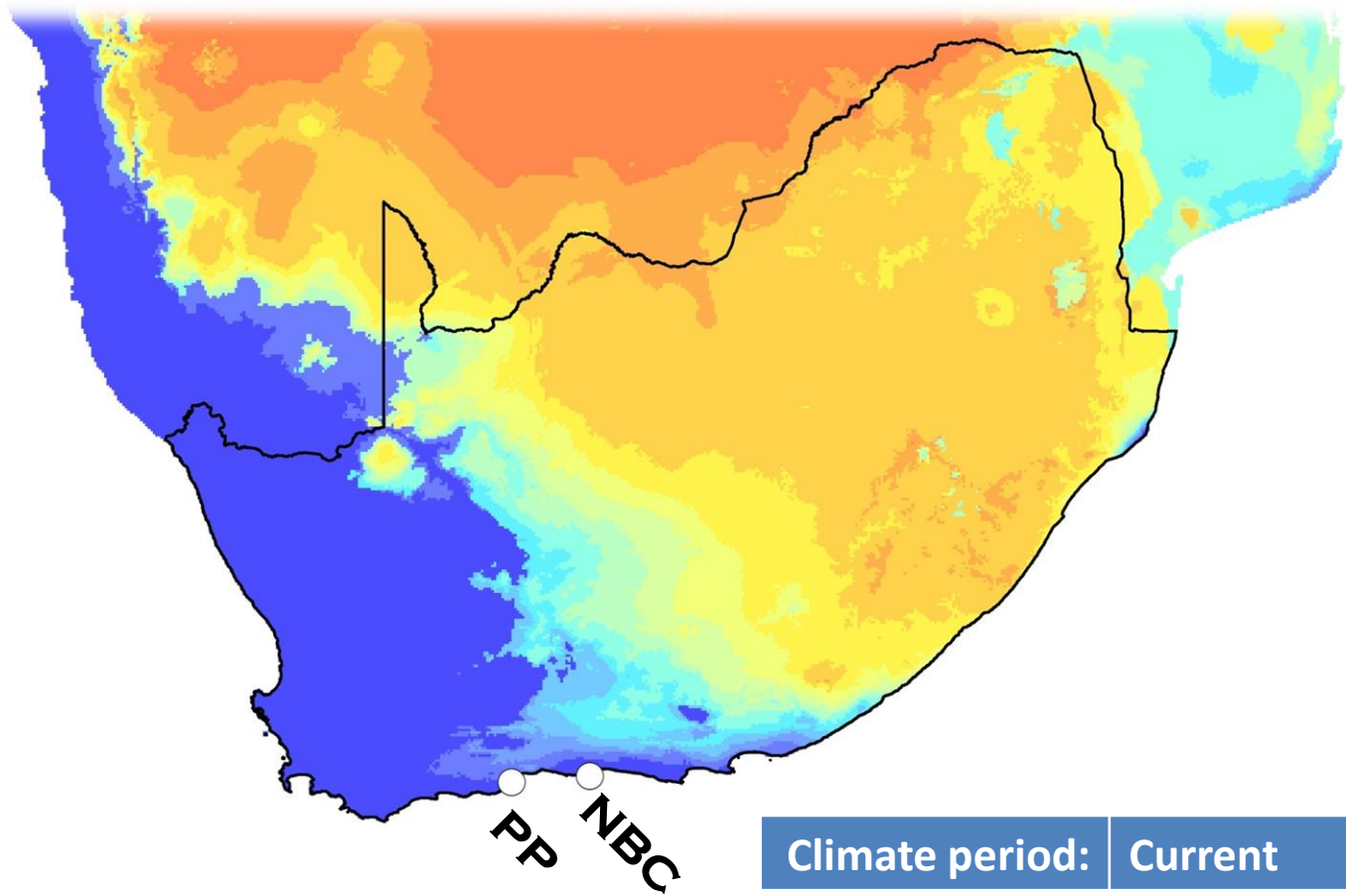
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Climate period: Current

BACKGROUND

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ENV. NICHE MOD.

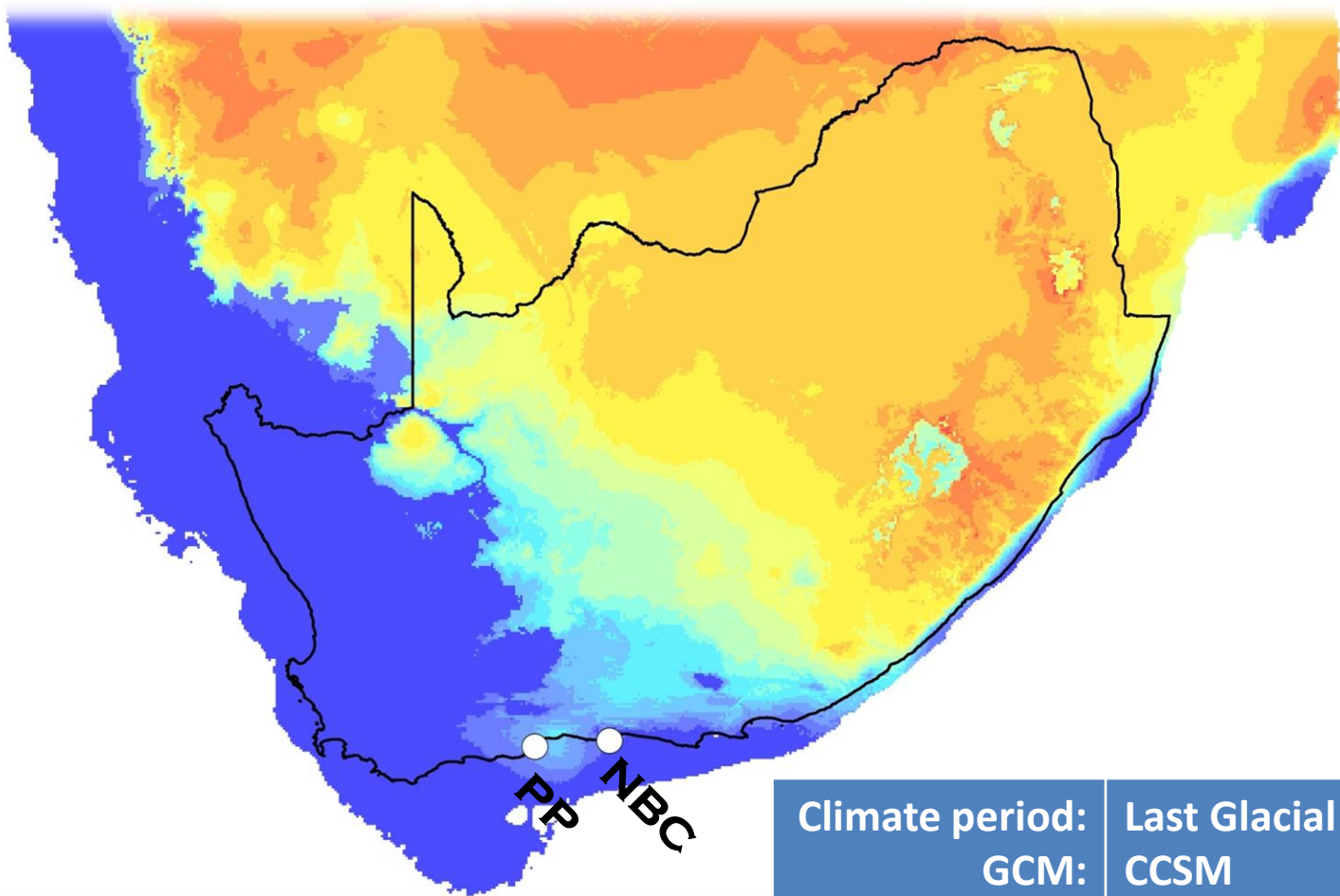
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

○●○○○○



Climate period:	Last Glacial Maximum
GCM:	CCSM

BACKGROUND

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ENV. NICHE MOD.

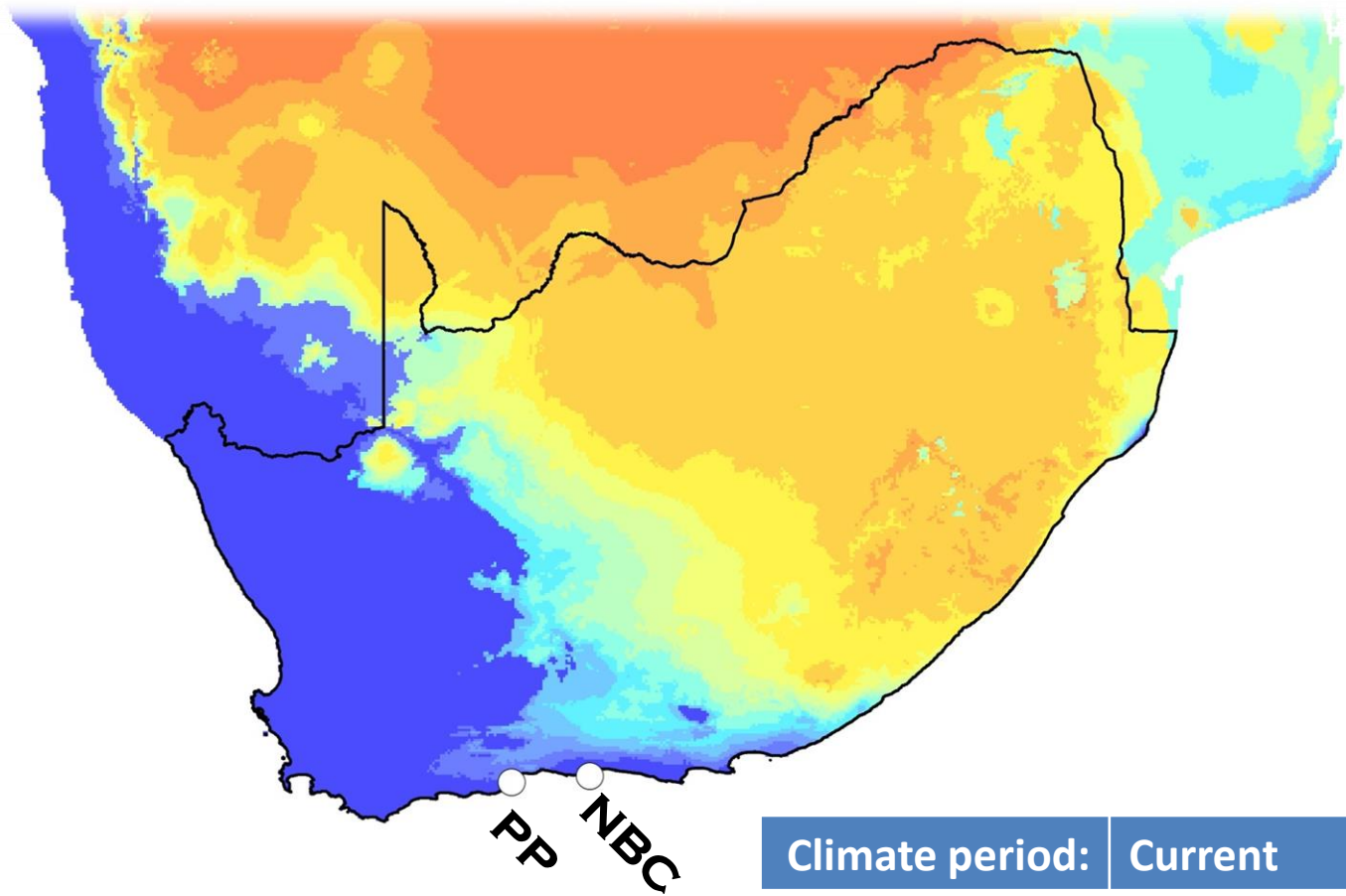
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

○●○○○○



Climate period: Current



BACKGROUND

○○○

ENV. NICHE MOD.

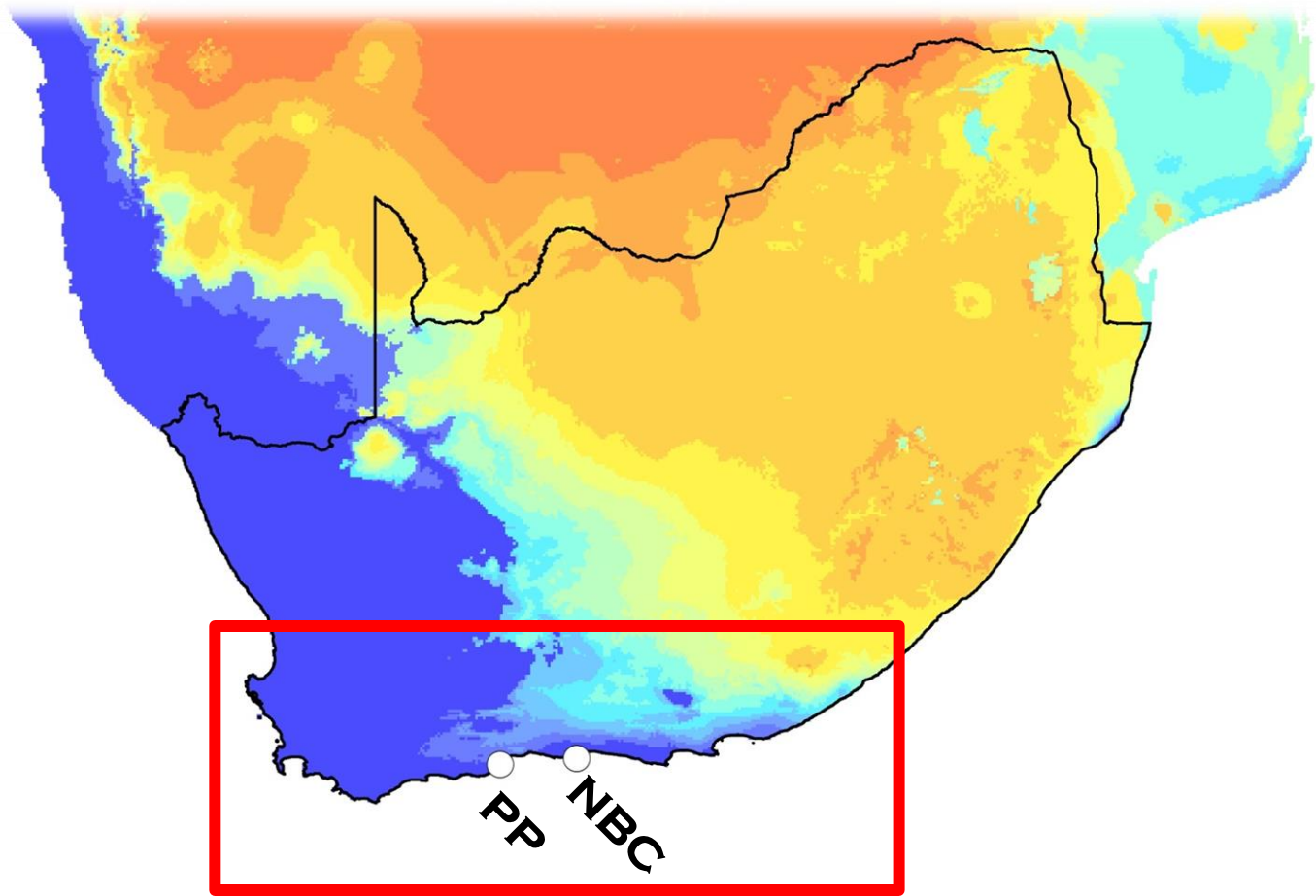
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

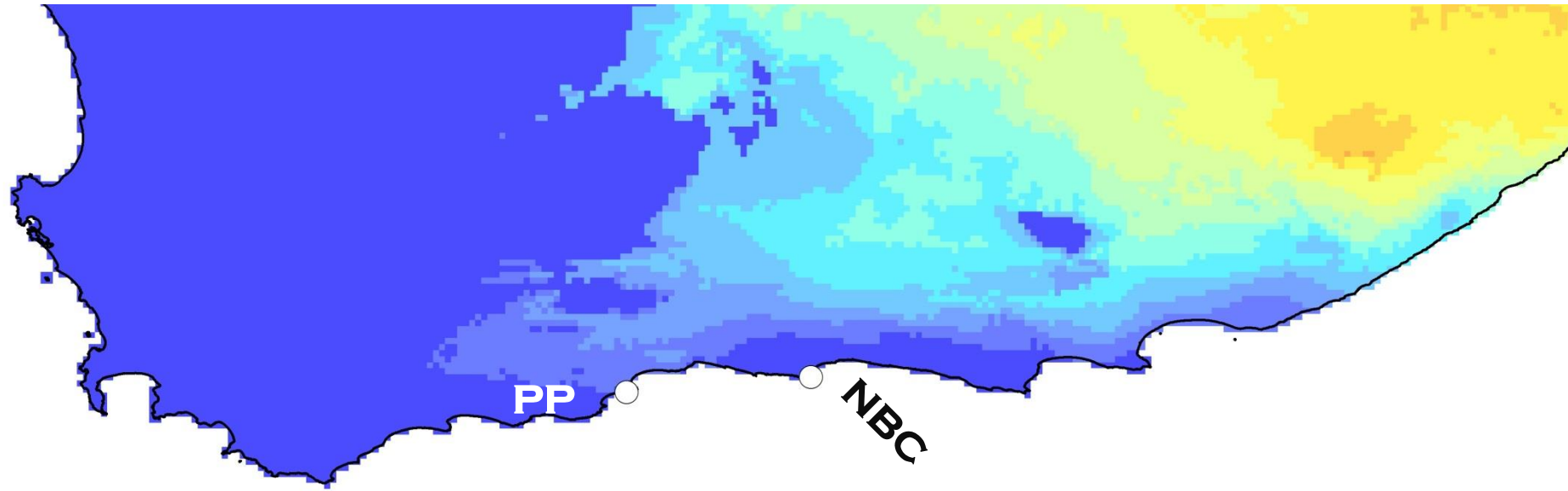
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Climate period:	Current
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BACKGROUND

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ENV. NICHE MOD.

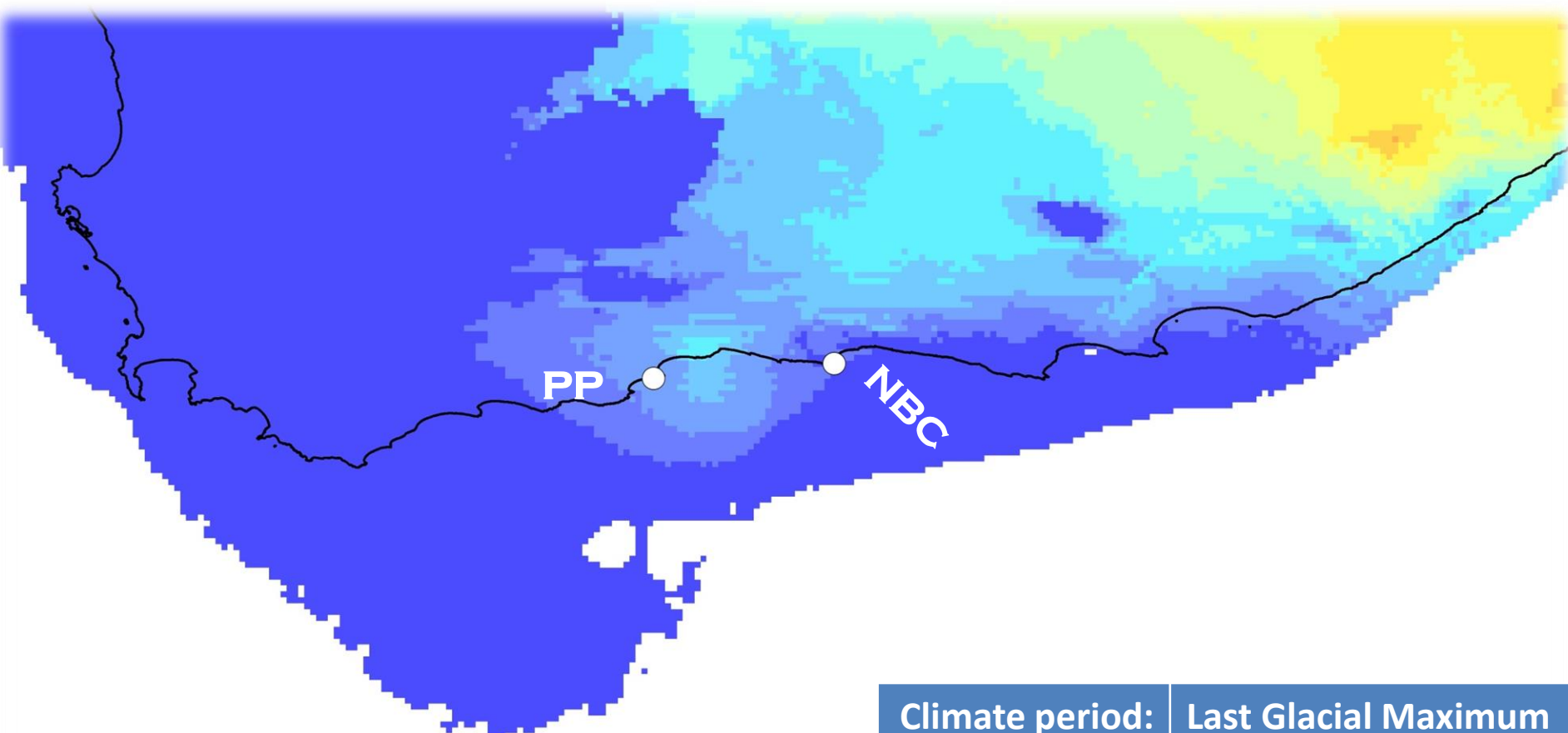
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Climate period:	Last Glacial Maximum
GCM:	CCSM

BACKGROUND

○○○

ENV. NICHE MOD.

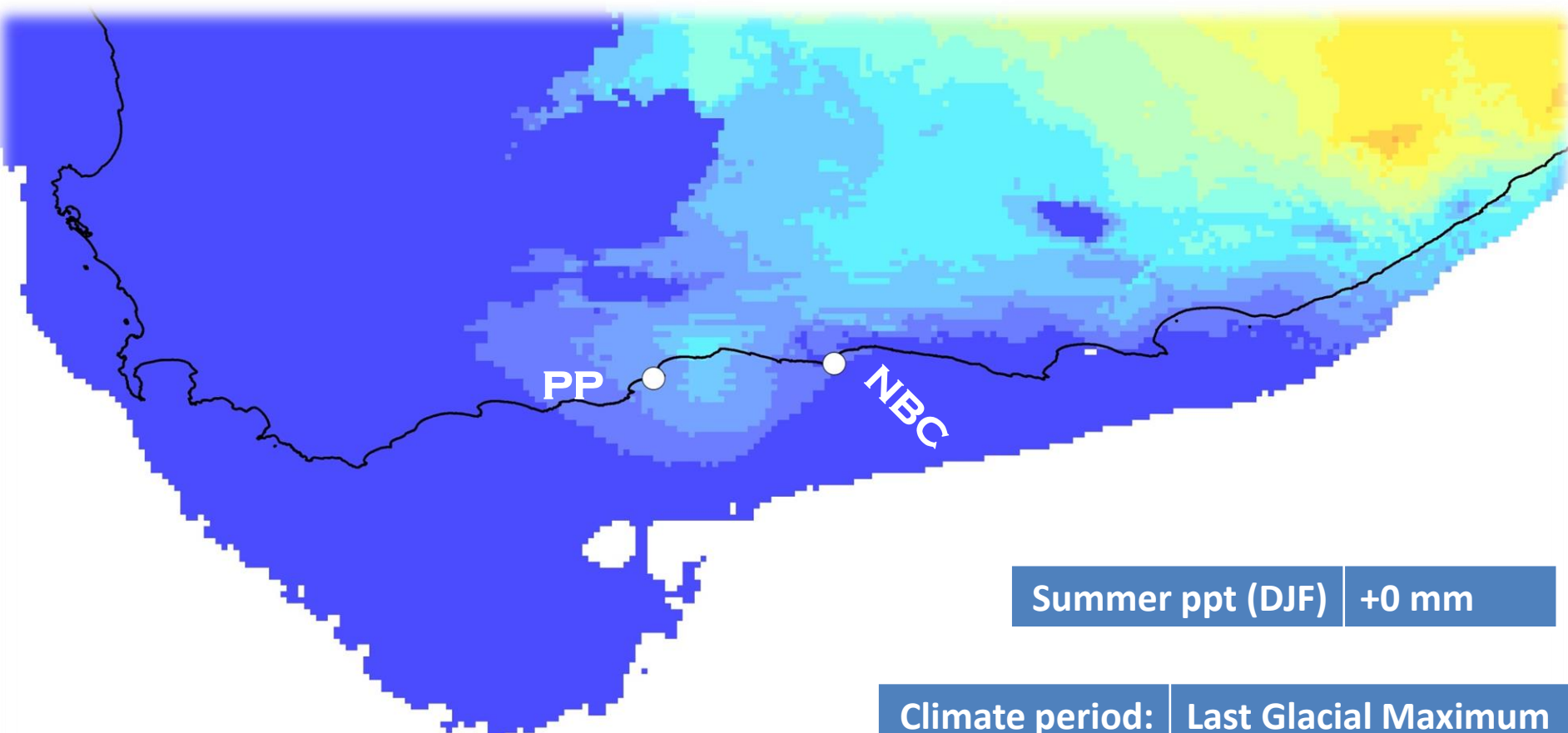
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Summer ppt (DJF)	+0 mm
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Climate period:	Last Glacial Maximum
GCM:	CCSM

BACKGROUND

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ENV. NICHE MOD.

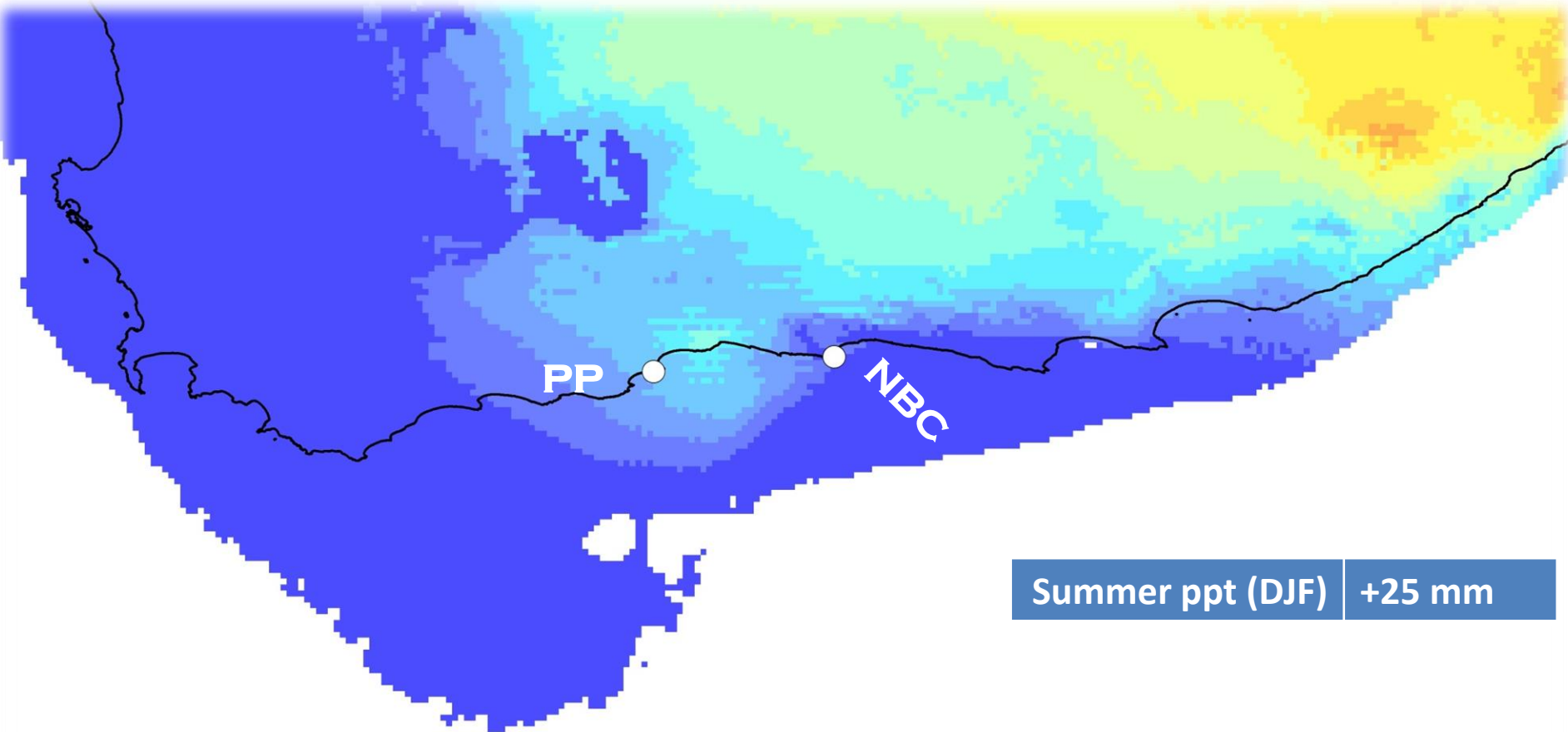
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Summer ppt (DJF)	+25 mm
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BACKGROUND

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ENV. NICHE MOD.

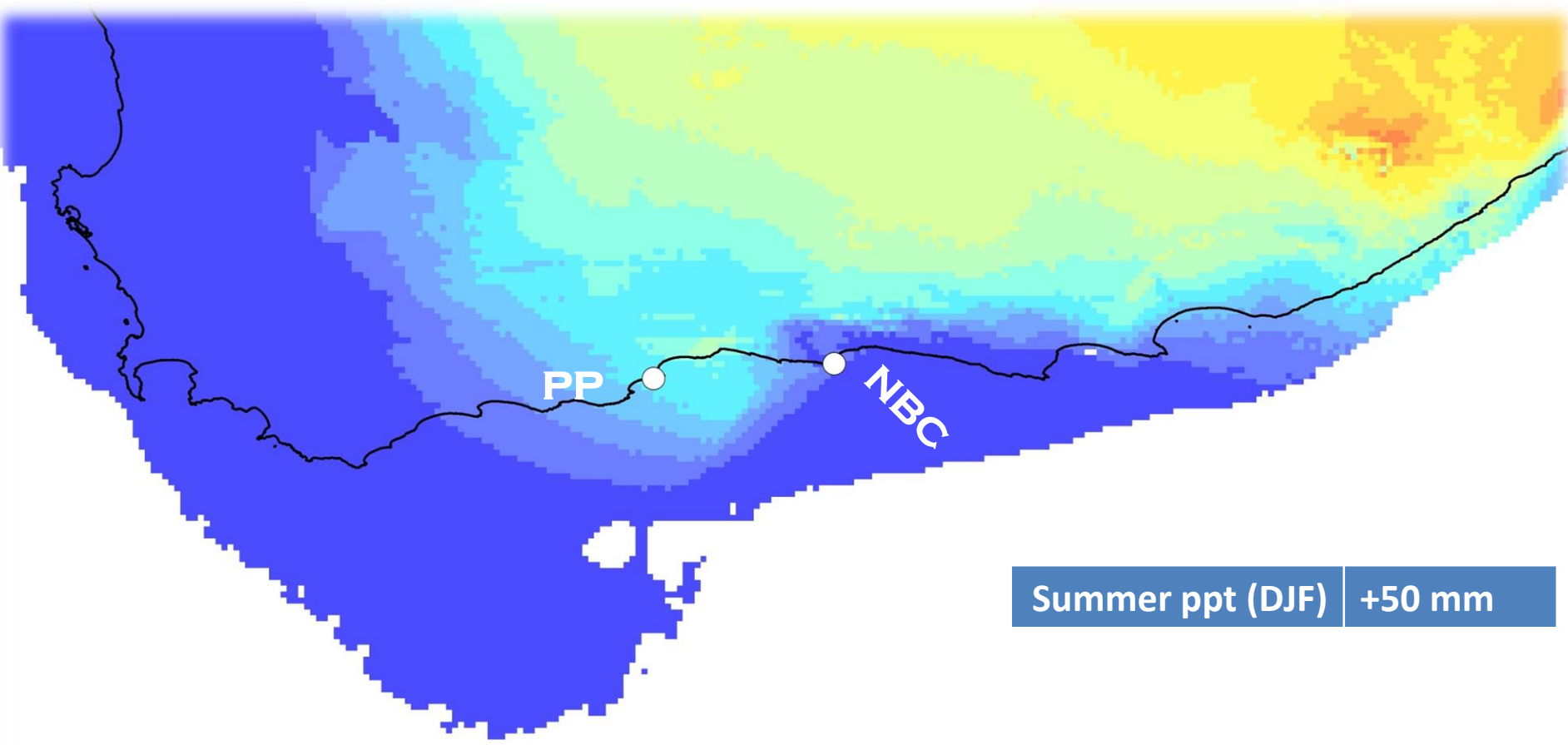
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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PP

NBC

Summer ppt (DJF) +50 mm

BACKGROUND

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ENV. NICHE MOD.

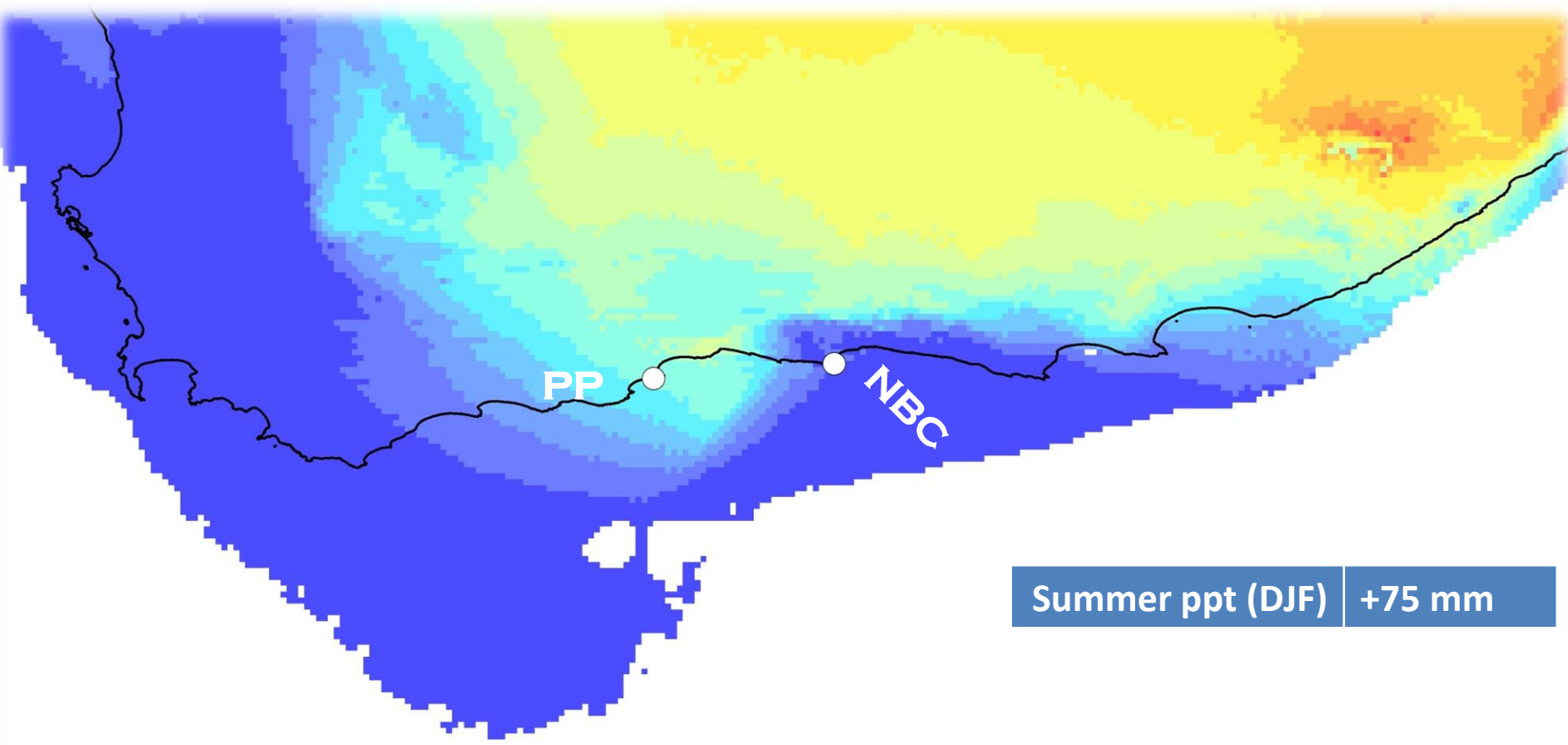
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Summer ppt (DJF) +75 mm

BACKGROUND

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ENV. NICHE MOD.

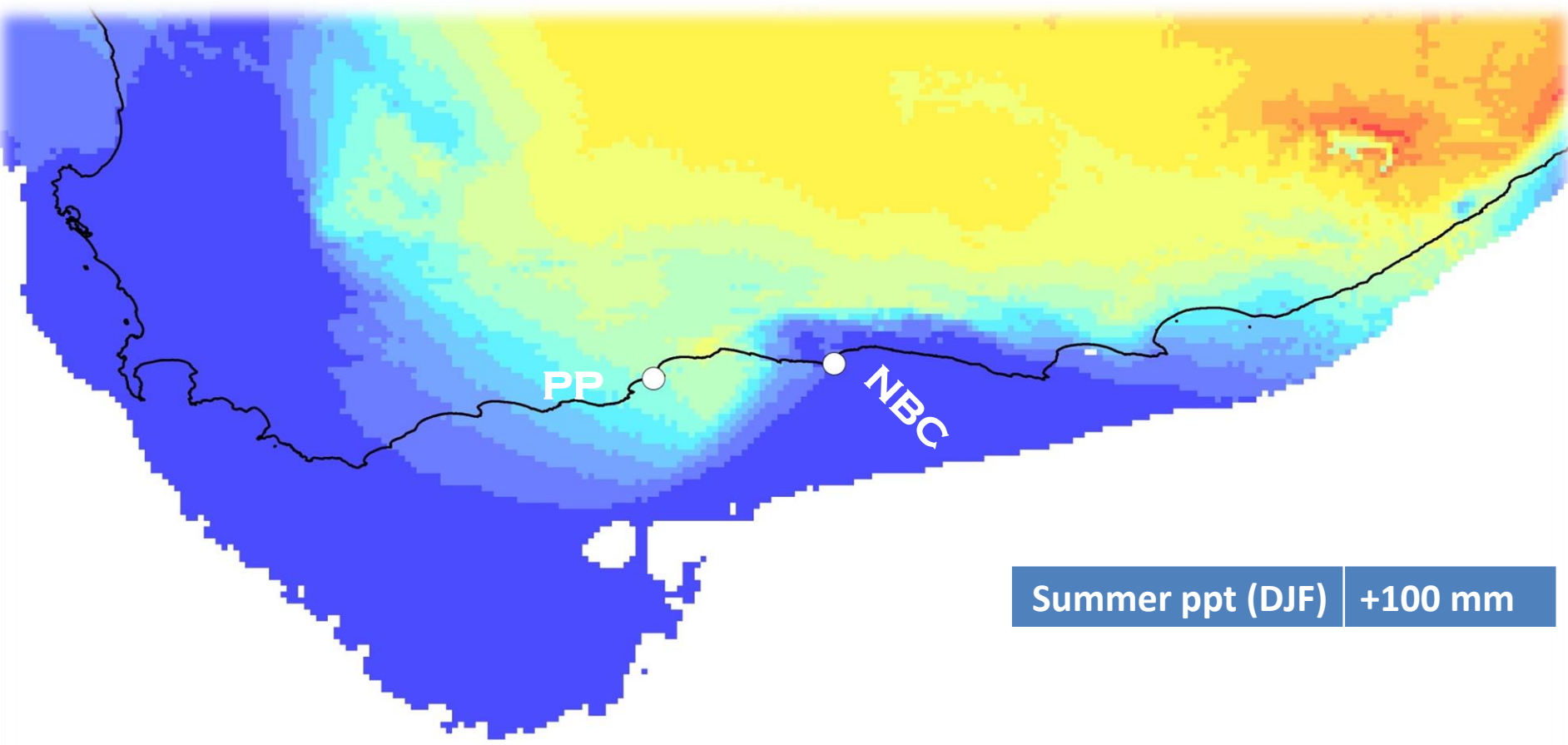
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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Summer ppt (DJF) +100 mm



BACKGROUND

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ENV. NICHE MOD.

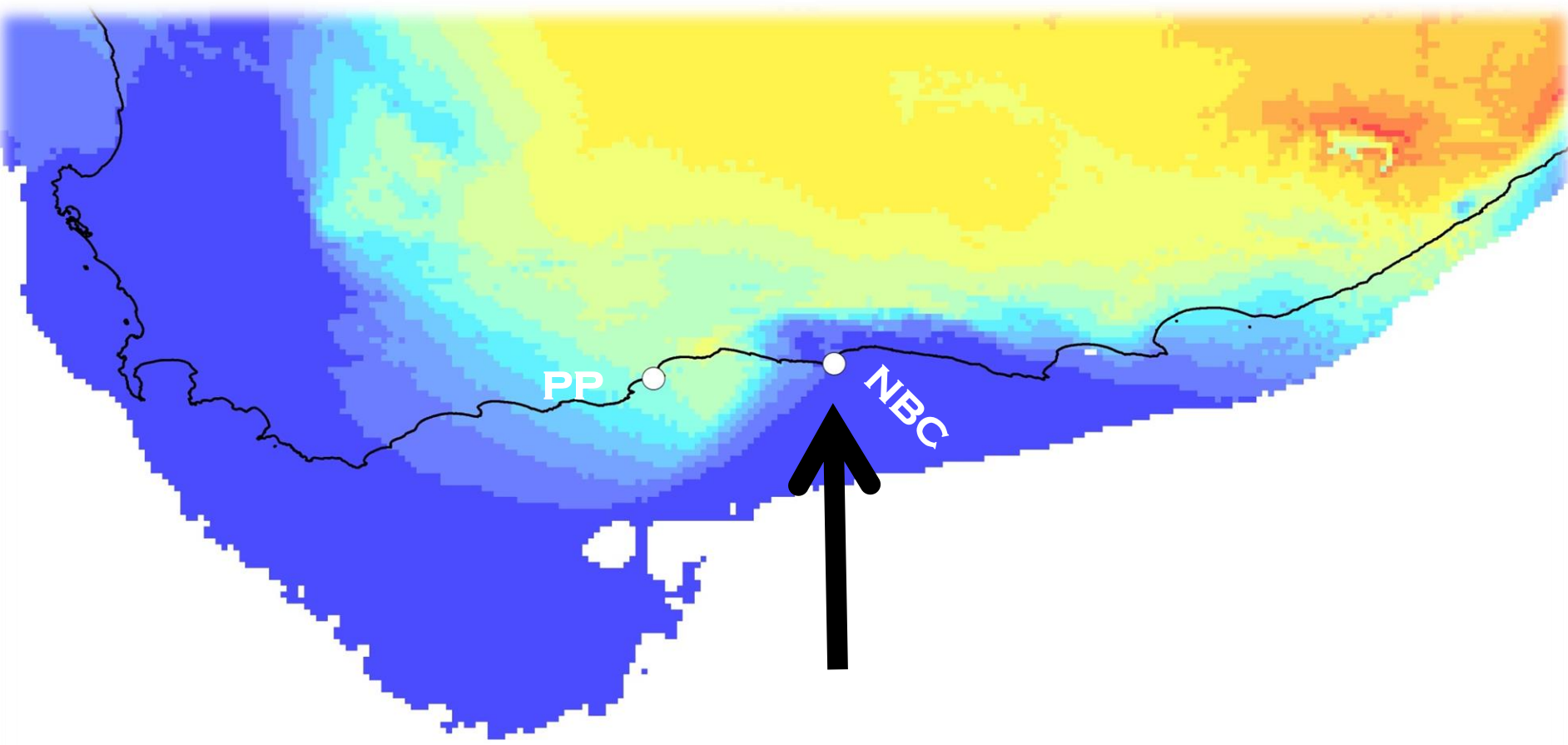
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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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BACKGROUND

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ENV. NICHE MOD.

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DYNAMIC VEG. MOD.

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CASE STUDY: C4 GRASSLAND

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# ADGVM?

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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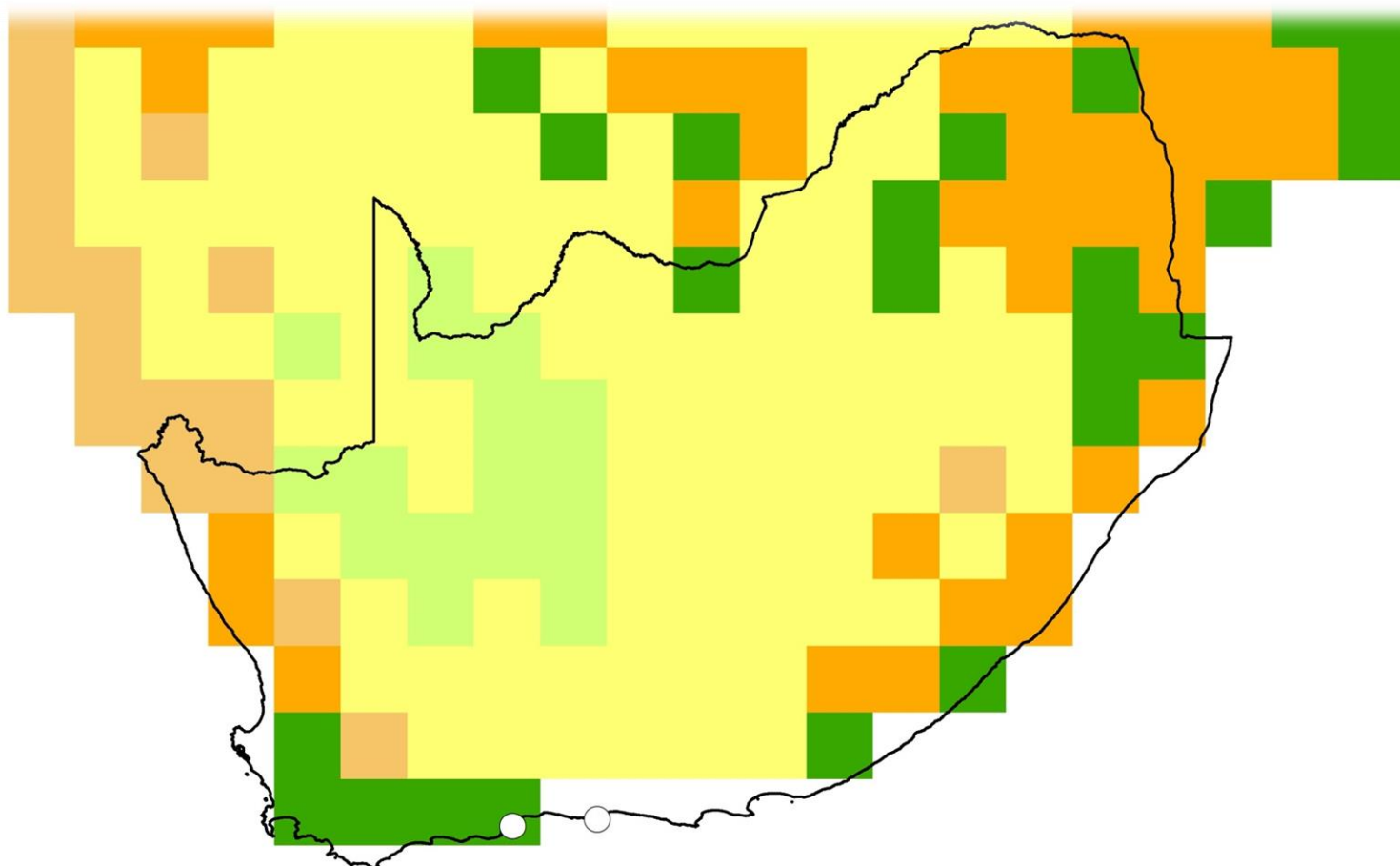
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# CURRENT CLIMATE – 350 PPM CO2 – WITH FIRE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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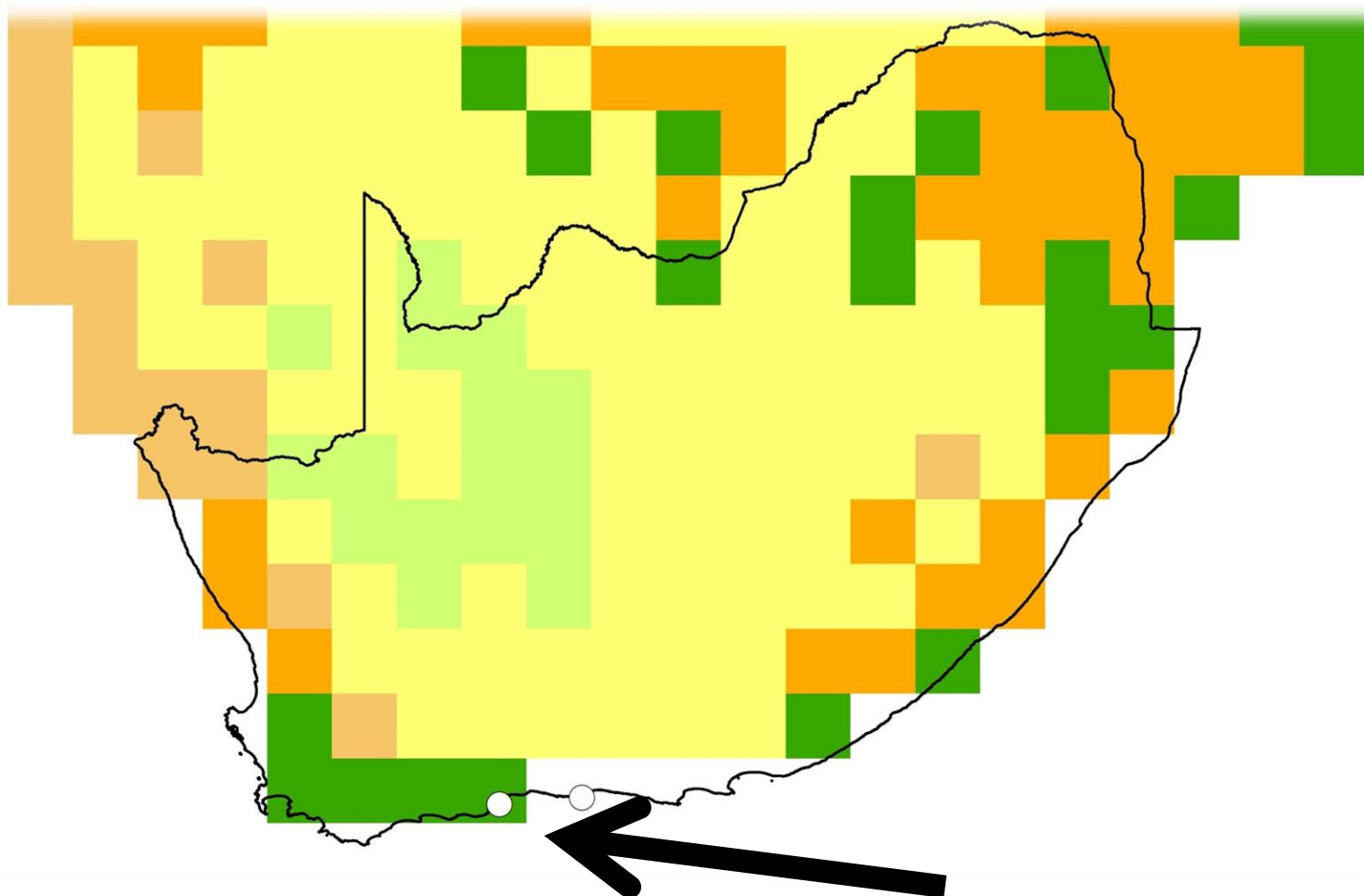
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# CURRENT CLIMATE – 350 PPM CO<sub>2</sub> – WITH FIRE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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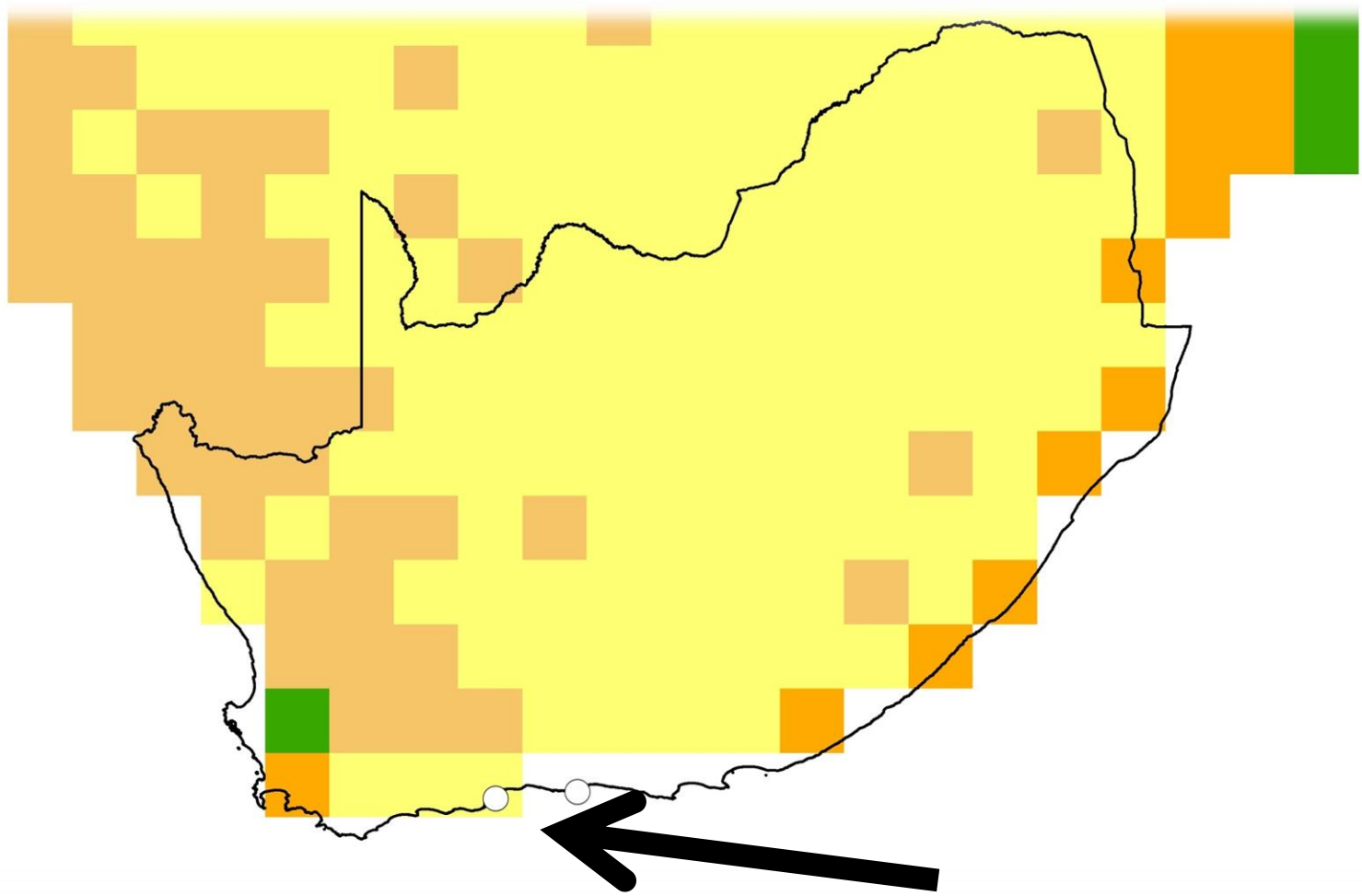
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# CURRENT CLIMATE – 150 PPM CO<sub>2</sub> – WITH FIRE



BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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# NO UNEQUIVOCAL SUPPORT FOR C4 GRASSLAND EXPANSION WESTWARD



**WHERE TO FROM HERE?**



# IMPROVED CLIMATE RECONSTRUCTIONS





# IMPROVED CLIMATE RECONSTRUCTIONS

FRANCOIS ENGELBRECHT  
(CSIR, SOUTH AFRICA)

BACKGROUND

ENV. NICHE MOD.

DYNAMIC VEG. MOD.

CASE STUDY: C4 GRASSLAND

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# REGIONAL CALIBRATION OF DYNAMIC VEGETATION MODELS

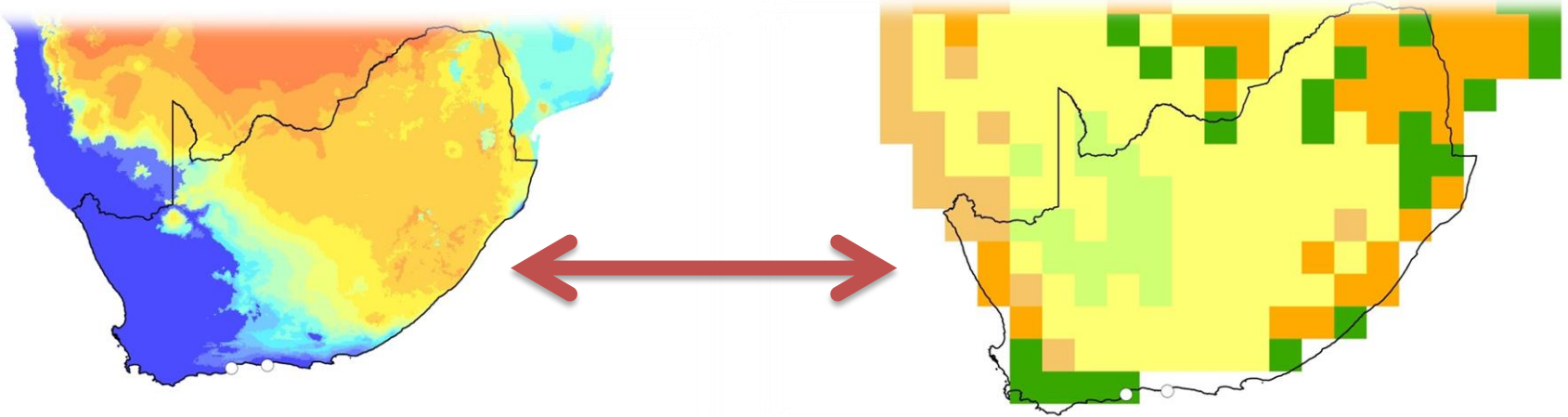


# **REGIONAL CALIBRATION OF DYNAMIC VEGETATION MODELS**

**GLENN MONCRIEFF**

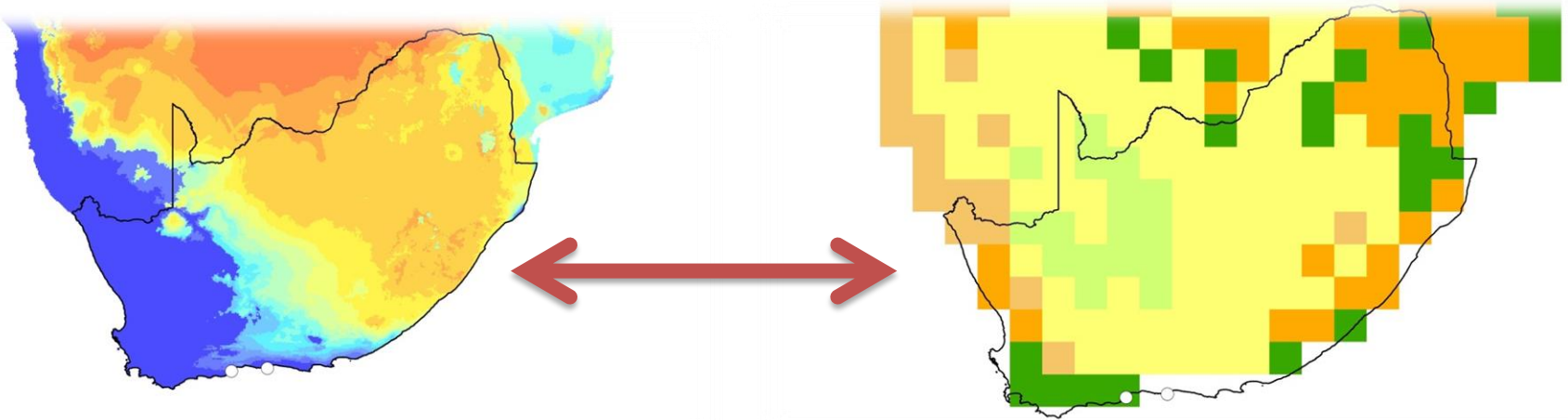


# DOVETAILING ENV. NICHE MODELLING AND DYNAMIC VEGETATION MODELLING





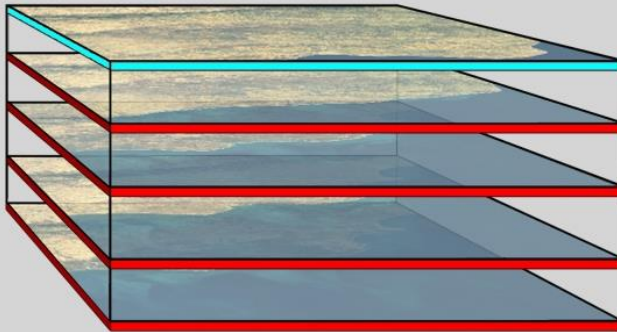
# DOVETAILING ENV. NICHE MODELLING AND DYNAMIC VEGETATION MODELLING



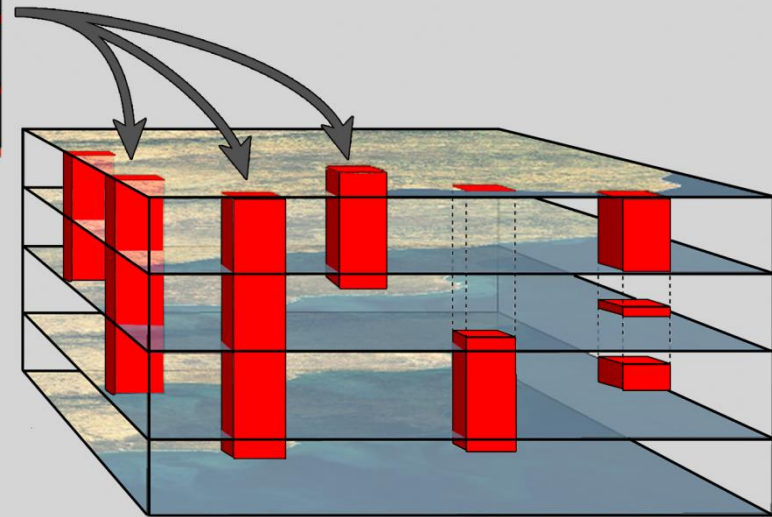
**ALASTAIR J. POTTS, JANET FRANKLIN, GLENN MONCRIEFF,  
SIMON SCHEITER, STEVE HIGGINS**



## Modelled distributions



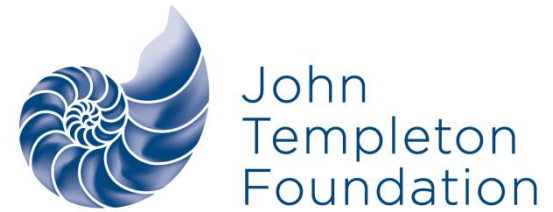
## Validation



## Paleoarchives



# Acknowledgements



This research is funded by the National Research Foundation (RCA13091944022), the National Science Foundation (BCS-1138073) and the John Templeton Foundation.

