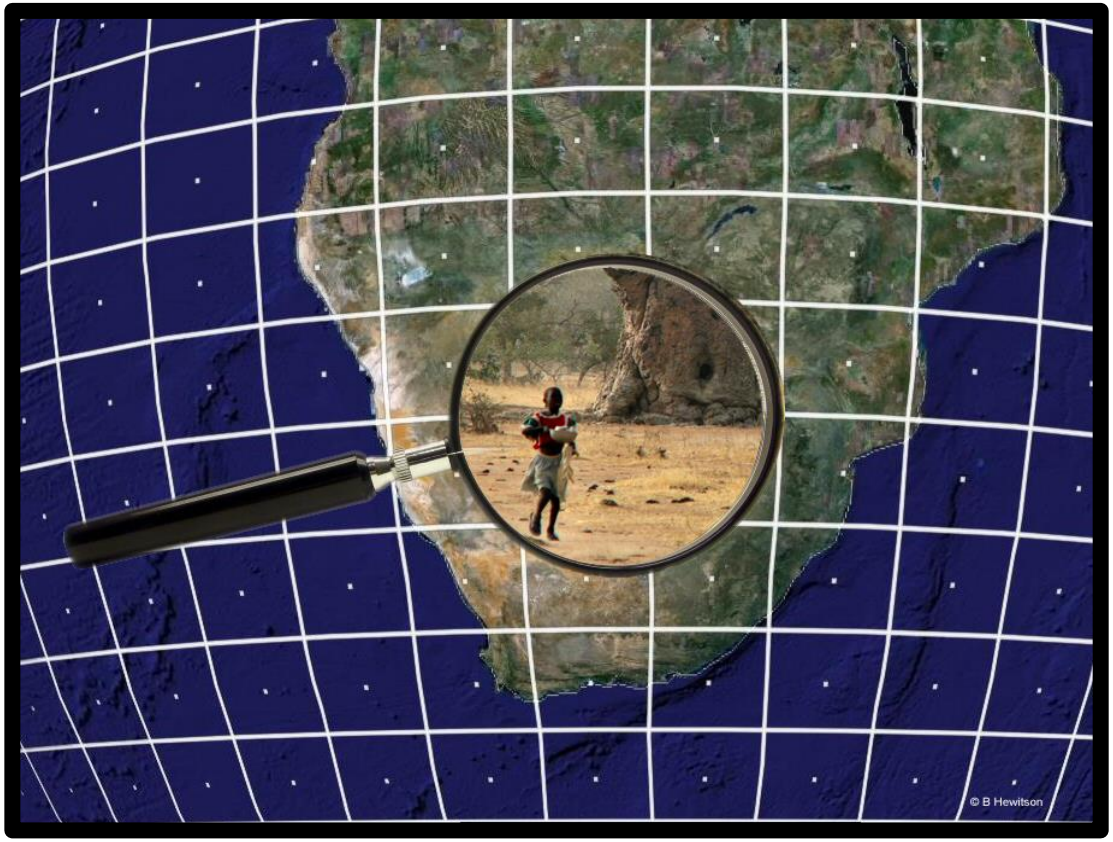
CC projections and impacts in SADC and importance of climate services for agriculture

Christopher Lennard and Lisa Van Ardenne

- The climate system
- Latest projections
- Regional challenges and downscaling
- Data vs information
- Other things we might need to know



South Africa - Cape Town (wave: NWW3 50 km 9.10. 2016 12 UTC) [Options]

Forecast | 2D | Map | Webcams | Wind reports | Accommodation | Schools/Rentals | Shops | Other... | WG spot

GFS 27 km
09.10.2016
12 UTC

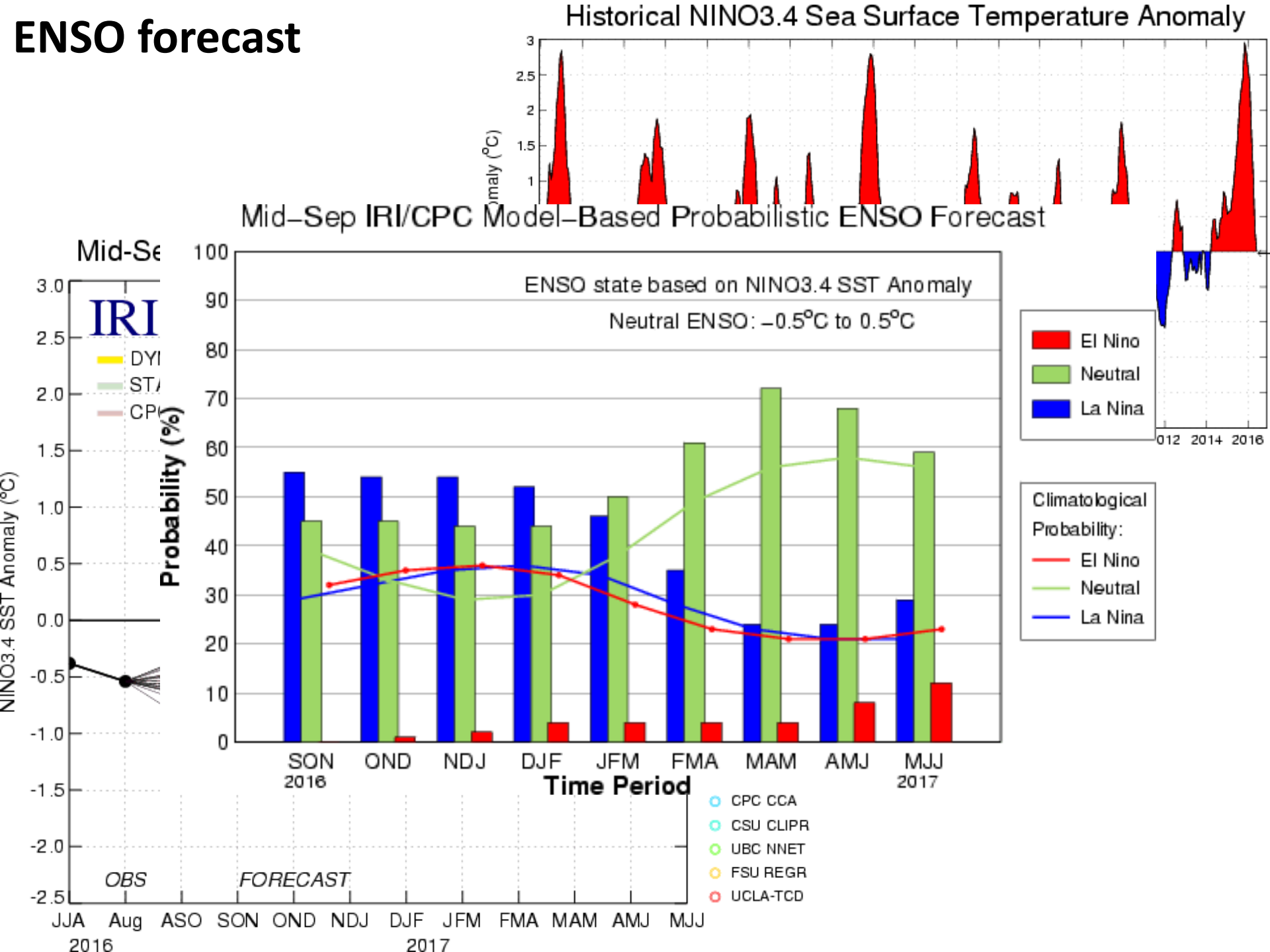
	Su 09. 14h	Su 09. 17h	Su 09. 20h	Mo 10. 05h	Mo 10. 08h	Mo 10. 11h	Mo 10. 14h	Mo 10. 17h	Mo 10. 20h	Tu 11. 05h	Tu 11. 08h	Tu 11. 11h	Tu 11. 14h	Tu 11. 17h	Tu 11. 20h	We 12. 05h	We 12. 08h	We 12. 11h	We 12. 14h	We 12. 17h	We 12. 20h	Th 13. 05h	Th 13. 08h	Th 13. 11h	Th 13. 14h	Th 13. 17h	Th 13. 20h	Fr 14. 05h	Fr 14. 08h	Fr 14. 11h	Fr 14. 14h
Wind speed (knots)	6	9	7	2	7	9	12	14	10	12	10	13	15	12	8	3	1	6	12	13	12	11	13	14	16	17	13	6	5	2	6
Wind gusts (knots)	4	9	8	3	9	11	16	19	17	20	17	16	17	14	12	4	3	6	11	15	17	16	18	17	18	21	19	6	6	3	5
Wind direction	↗	↗	↑	↓	↘	↘	↘	↘	↓	↘	→	→	→	↗	↗	↘	↓	↗	↗	↑	↑	↖	↖	↖	↖	↖	↖	↖	↖	↖	↗
Wave (m)	2.2	2.2	2.2	2	1.8	1.8	1.8	2.1	2.4	4.4	4.8	5	4.9	4.8	4.6	4.5	4.6	4.5	4.3	4.1	3.9	3.3	3.1	2.9	2.8	2.9	3	3	2.8	2.4	2.1
Wave period (s)	11	11	11	12	11	11	11	11	9	14	14	14	14	13	13	13	13	13	13	13	13	12	12	12	12	11	11	9	9	9	10
Wave direction	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↖	↖	↖	↗
*Temperature (°C)	16	16	12	12	15	17	19	16	13	14	14	15	16	14	12	11	12	14	16	14	12	10	13	16	18	17	14	9	14	20	23
Cloud cover (%) high	-		22	65	35																							17	30	65	68
Cloud cover (%) mid	-			91	77	81	69																								
Cloud cover (%) low										98	97	77	69	26	15	59	73	59	39												
*Precip. (mm/3h)	-									1.4	1.2	0.4																			
Windguru rating							★	★		★		★	★	★					★	★	★	★	★	★	★	★★	★				

GFS 27 km
09.10.2016
12 UTC

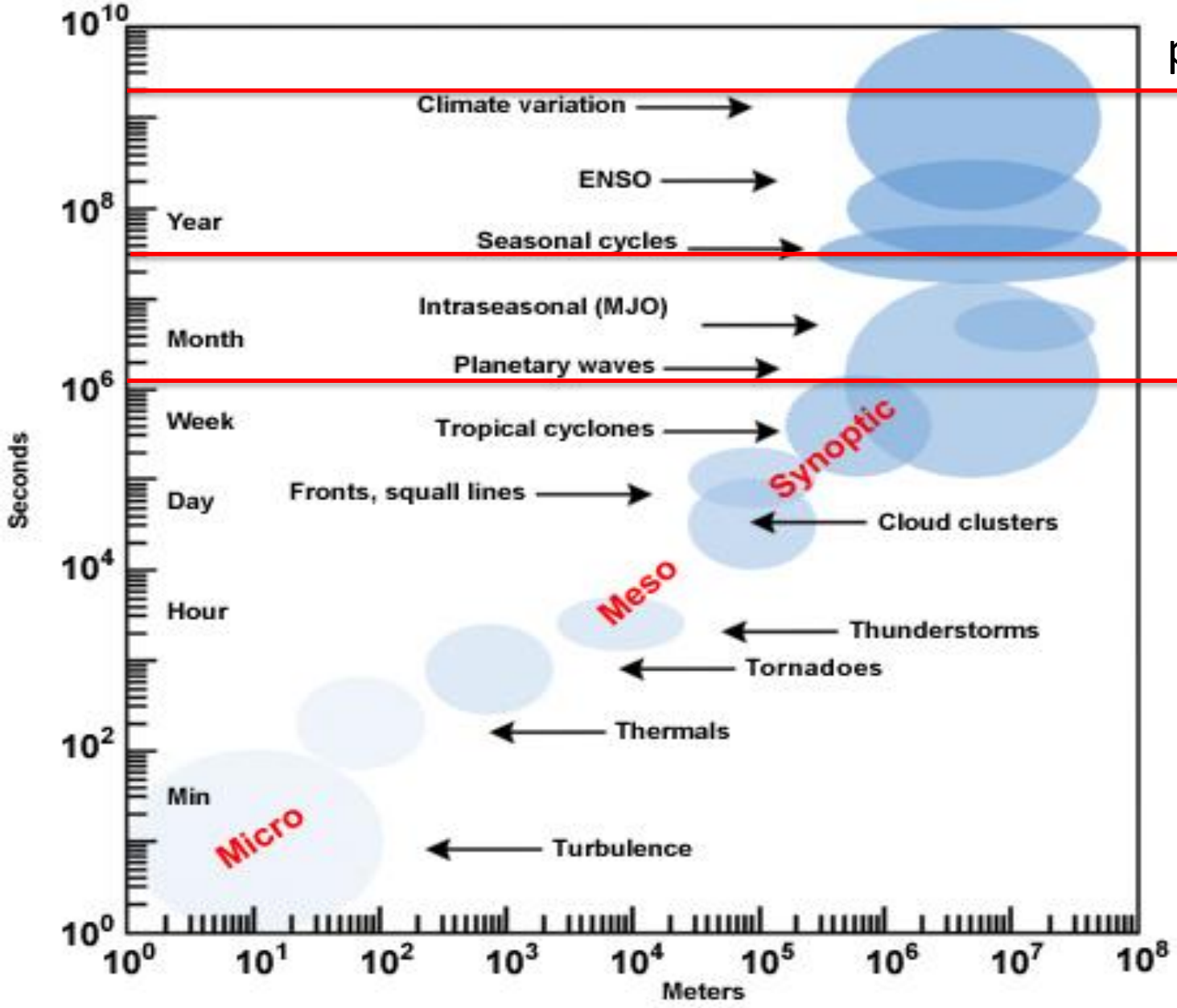
	Fr 14. 17h	Fr 14. 20h	Sa 15. 05h	Sa 15. 08h	Sa 15. 11h	Sa 15. 14h	Sa 15. 17h	Sa 15. 20h	Su 16. 05h	Su 16. 08h	Su 16. 11h	Su 16. 14h	Su 16. 17h	Su 16. 20h	Mo 17. 05h	Mo 17. 08h	Mo 17. 11h	Mo 17. 14h	Mo 17. 17h	Mo 17. 20h	Tu 18. 05h	Tu 18. 08h	Tu 18. 11h	Tu 18. 14h	Tu 18. 17h	Tu 18. 20h	We 19. 05h	We 19. 08h	We 19. 11h	We 19. 14h
Wind speed (knots)	9	7	5	5	6	9	10	7	9	12	12	13	14	9	6	6	9	11	12	9	7	7	10	12	13	10	2	4	9	11
Wind gusts (knots)	11	9	7	7	6	10	12	10	16	17	15	15	17	15	8	8	10	11	14	14	9	11	11	14	16	15	3	5	10	13
Wind direction	↑	↖	↑	↑	↗	↗	↑	↑	↗	↑	↑	↑	↑	↑	↖	↖	↗	↗	↗	↑	↖	↖	↑	↖	↑	↖	↗	↘	↘	↘
Wave (m)	1.9	1.8	1.5	1.5	1.4	1.3	1.3	1.3	1.5	1.8	1.9	1.8	1.7	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wave period (s)	10	10	10	9	9	9	9	9	7	6	7	7	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wave direction	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Temperature (°C)	21	17	14	18	21	21	18	15	15	16	18	18	17	14	13	15	18	18	17	13	12	15	18	19	17	14	11	15	18	18
Cloud cover (%) high	82	78	92	95	94	93	96	98	6								37	63	25	12	37	18					11	11	13	29
Cloud cover (%) mid				19	12	6		27																						
Cloud cover (%) low									83	51																				
*Precip. (mm/3h)									0.6	1.9	1.4	0.8																		
Windguru rating									★	★	★	★						★	★					★	★					★

Lat: **-33.9**, Lon: **18.46**, Alt: **0 m**, Timezone: **SAST** (UTC+2) 06:13 - 18:52 ≈15 °C [Detail / Map] [Archive] [Link]

ENSO forecast



Scale is the key…



"Climate projections"

"Decadal prediction"

"Seasonal forecasting"

"Weather forecasting"

©The COMET Program

What climate information is important to me?

1. Where are you from and what are your work responsibilities?

1. What time scales are you most interested in (daily/weekly weather; seasonal; next 4-5 years; next 10 years; next 40 years)?

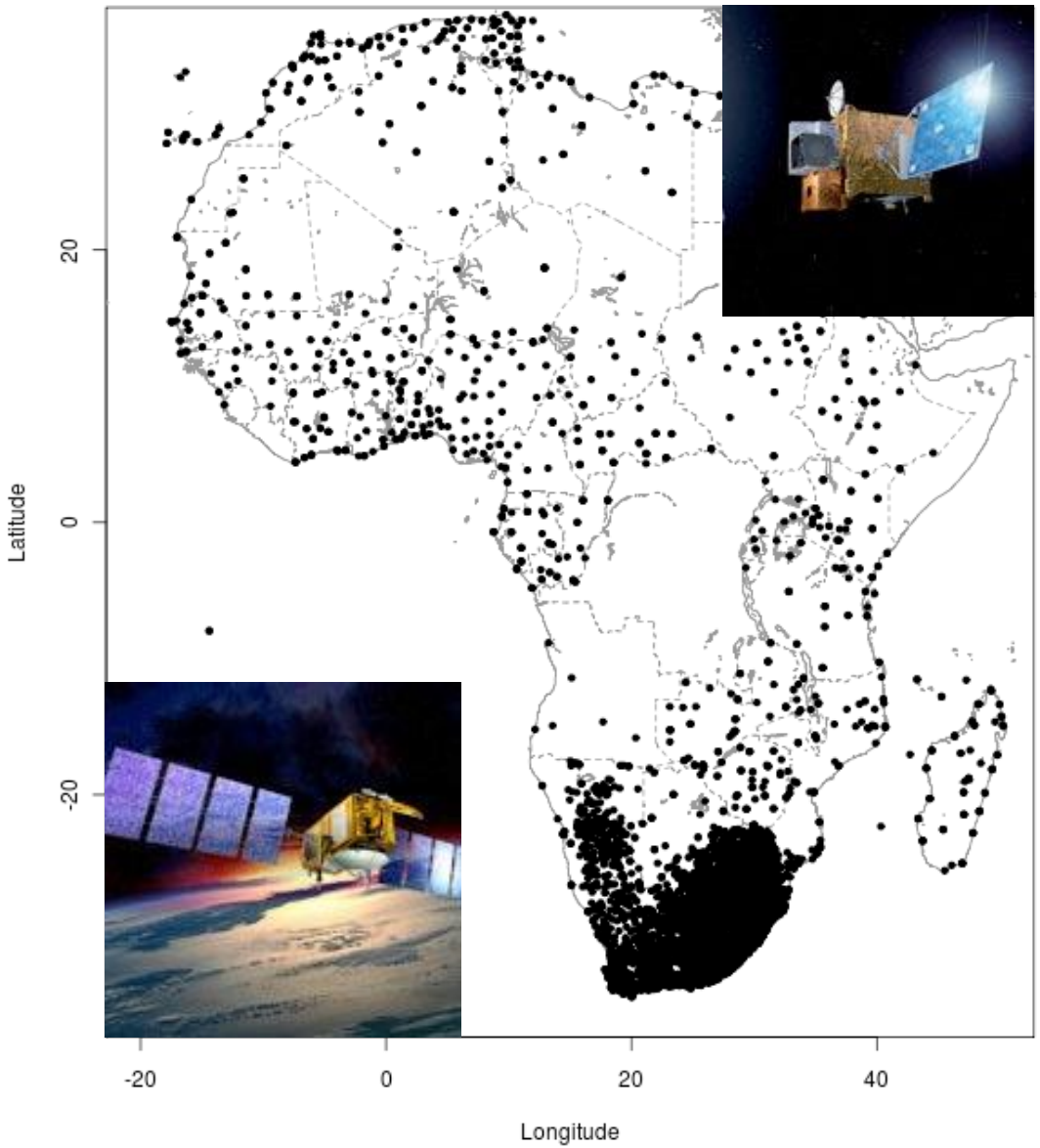
2. What spatial scale are you most interested in (regional, national, provincial, city, individual farms, etc)

3. What type of climate information is useful/desirable to you at these time and space scales?

4. Of all the factors that come into play when you decide on a course of action, how important is climate information in making these decisions?

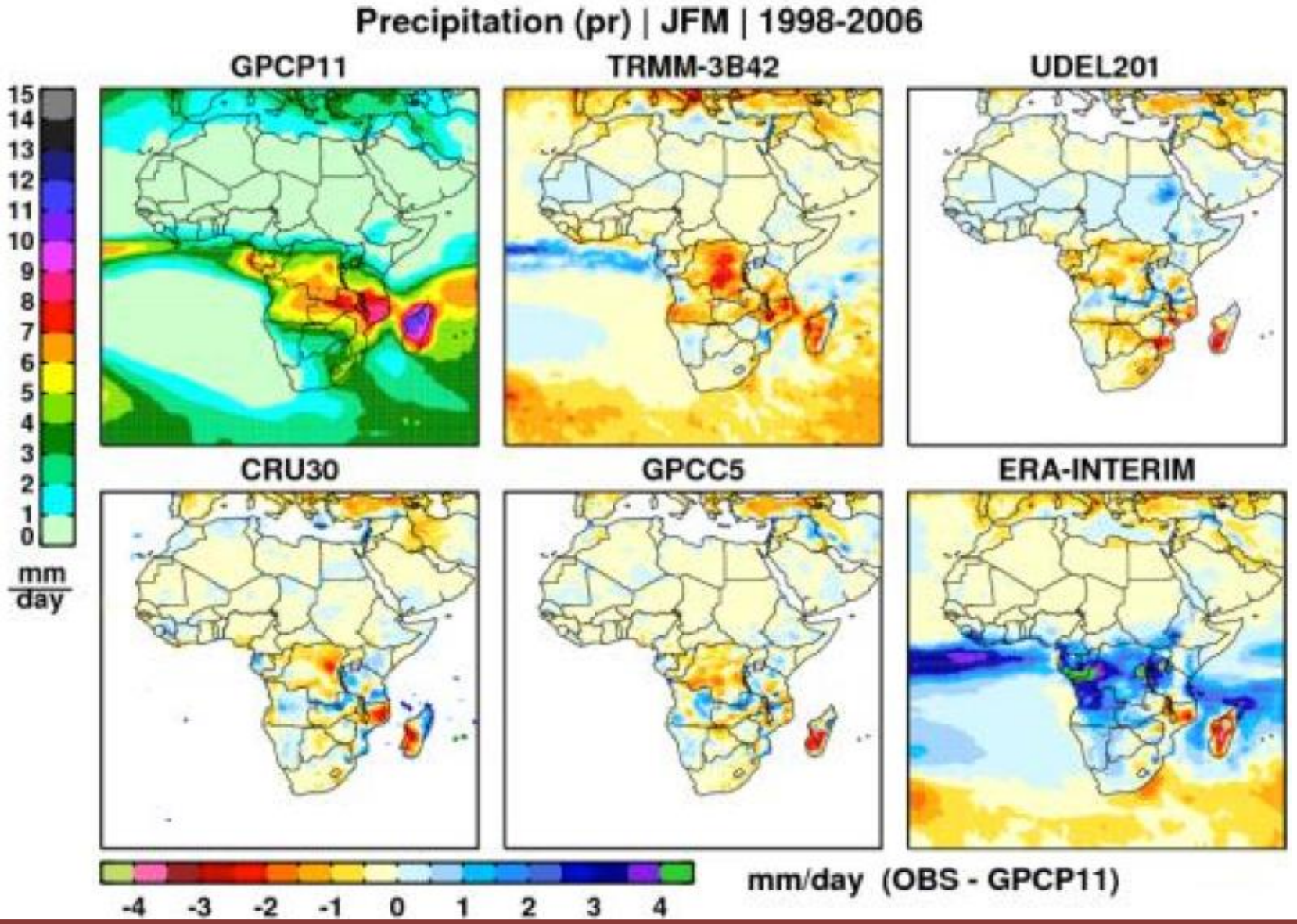
Our climate system

Observing the climate system....a challenging undertaking...

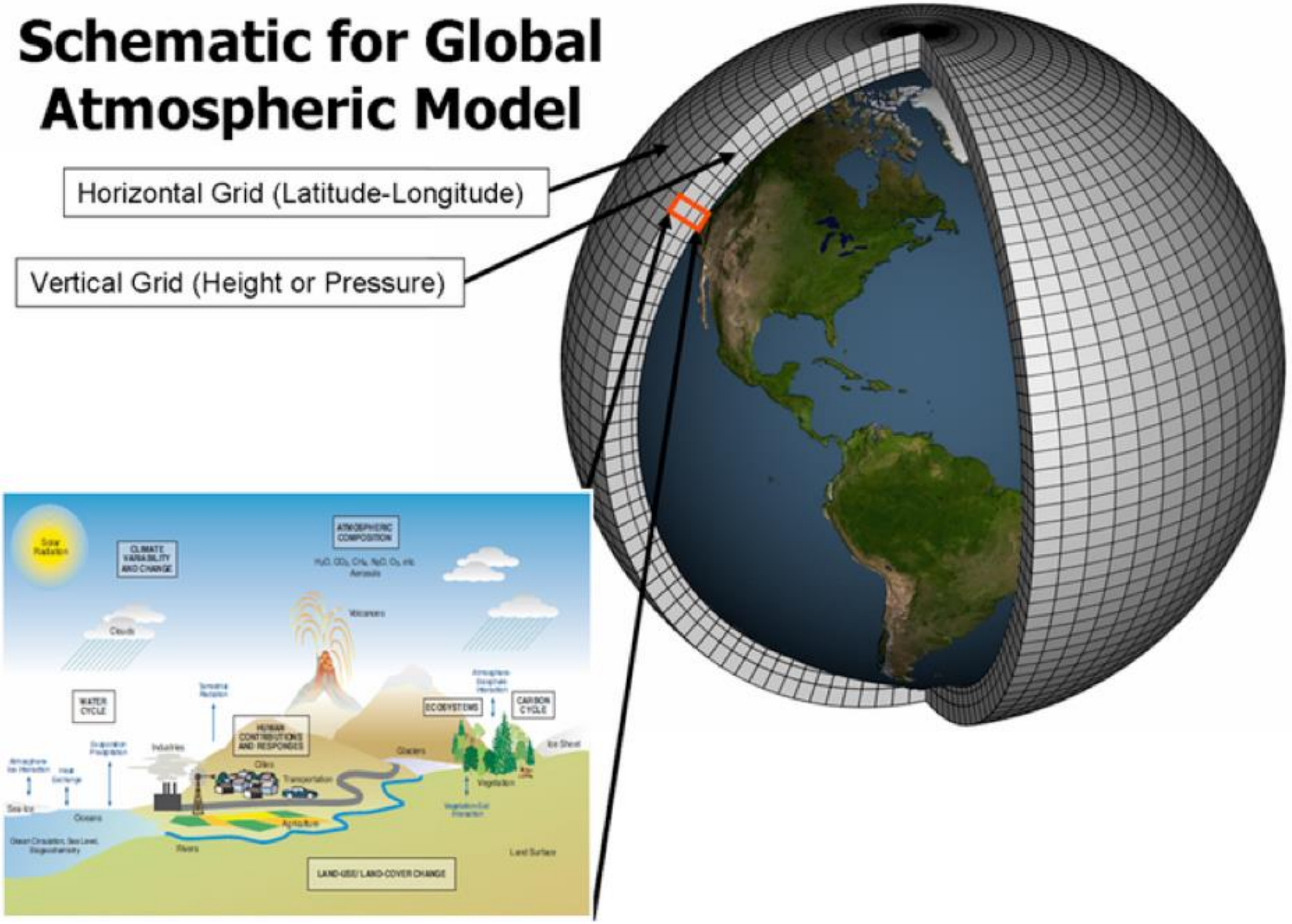


- Some moderate data rescue balanced by network decline
- New developments in high resolution reanalysis data sets (MERRA, CFSR, JRA25)
- Supplemented (but not replaced) by growing satellite products...and these products make it easier.....right?

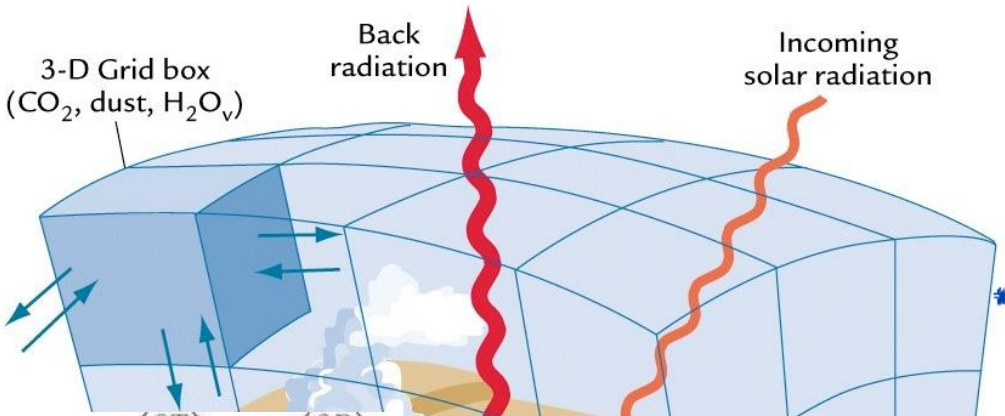
Observing the climate system....gridded products help...right?



Climate projections - How do we make them?



A earth system climate model....



$$dU = TdS - PdV \implies \left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

$$dA = -SdT - PdV \implies \left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$$

$$dH = TdS + VdP \implies \left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$$

$$dG = -SdT + VdP \implies -\left(\frac{\partial S}{\partial P}\right)_T = \left(\frac{\partial V}{\partial T}\right)_P$$

$$\frac{\partial u}{\partial \lambda} + \frac{\partial}{\partial \phi}(v \cos\phi) = 0\,, \qquad (1)$$

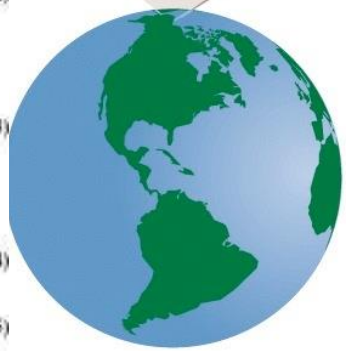
$$\frac{\partial a}{\partial \lambda} + \frac{\partial}{\partial \phi}(b \cos\phi) = 0\,. \qquad (2)$$

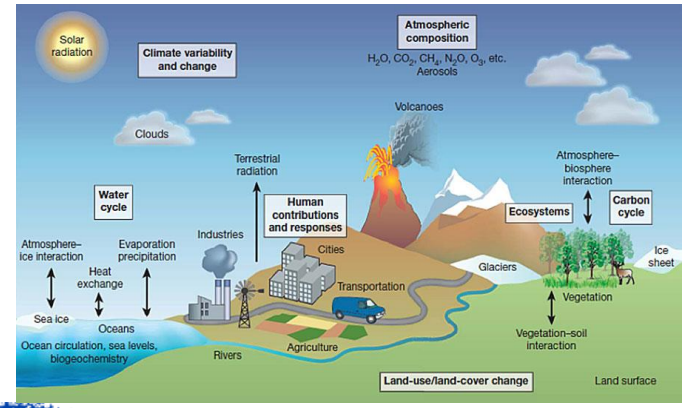
$$\frac{\partial u}{\partial t} + \frac{1}{\cos\phi}\frac{\partial}{\partial \lambda}\left(\frac{u^2+v^2}{2}\right) - \frac{v}{\cos\phi}\left[\frac{\partial}{\partial \lambda}v - \frac{\partial}{\partial \phi}(u\cos\phi)\right] = -\frac{1}{\cos\phi}\frac{\partial \pi}{\partial \lambda} - \frac{b}{\cos\phi}\left[\frac{\partial b}{\partial \lambda} - \frac{\partial}{\partial \phi}(a\cos\phi)\right], \qquad (3)$$

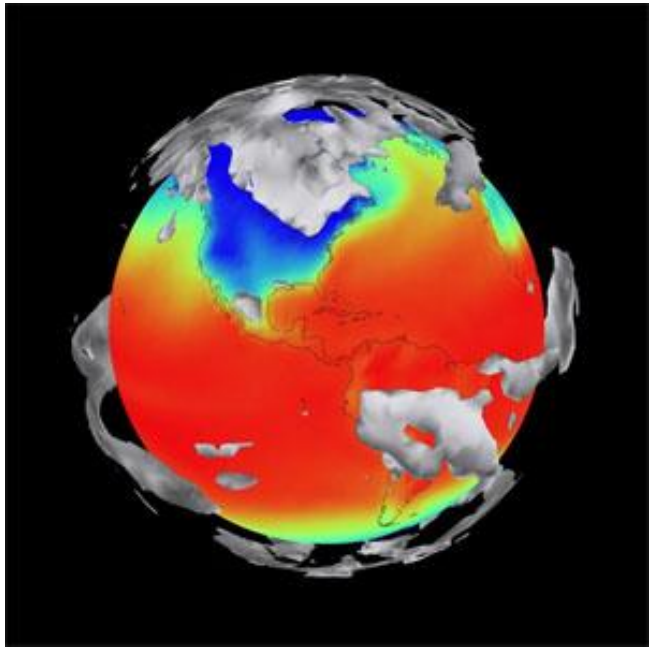
$$\frac{\partial v}{\partial t} + \frac{\partial}{\partial \phi}\left(\frac{u^2+v^2}{2}\right) + \frac{u}{\cos\phi}\left[\frac{\partial}{\partial \lambda}v - \frac{\partial}{\partial \phi}(u\cos\phi)\right] = -\frac{\partial \pi}{\partial \phi} + \frac{a}{\cos\phi}\left[\frac{\partial}{\partial \lambda}b - \frac{\partial}{\partial \phi}(a\cos\phi)\right], \qquad (4)$$

$$\frac{\partial a}{\partial t} - \frac{\partial}{\partial \phi}(ub - va) = 0\,, \qquad (5)$$

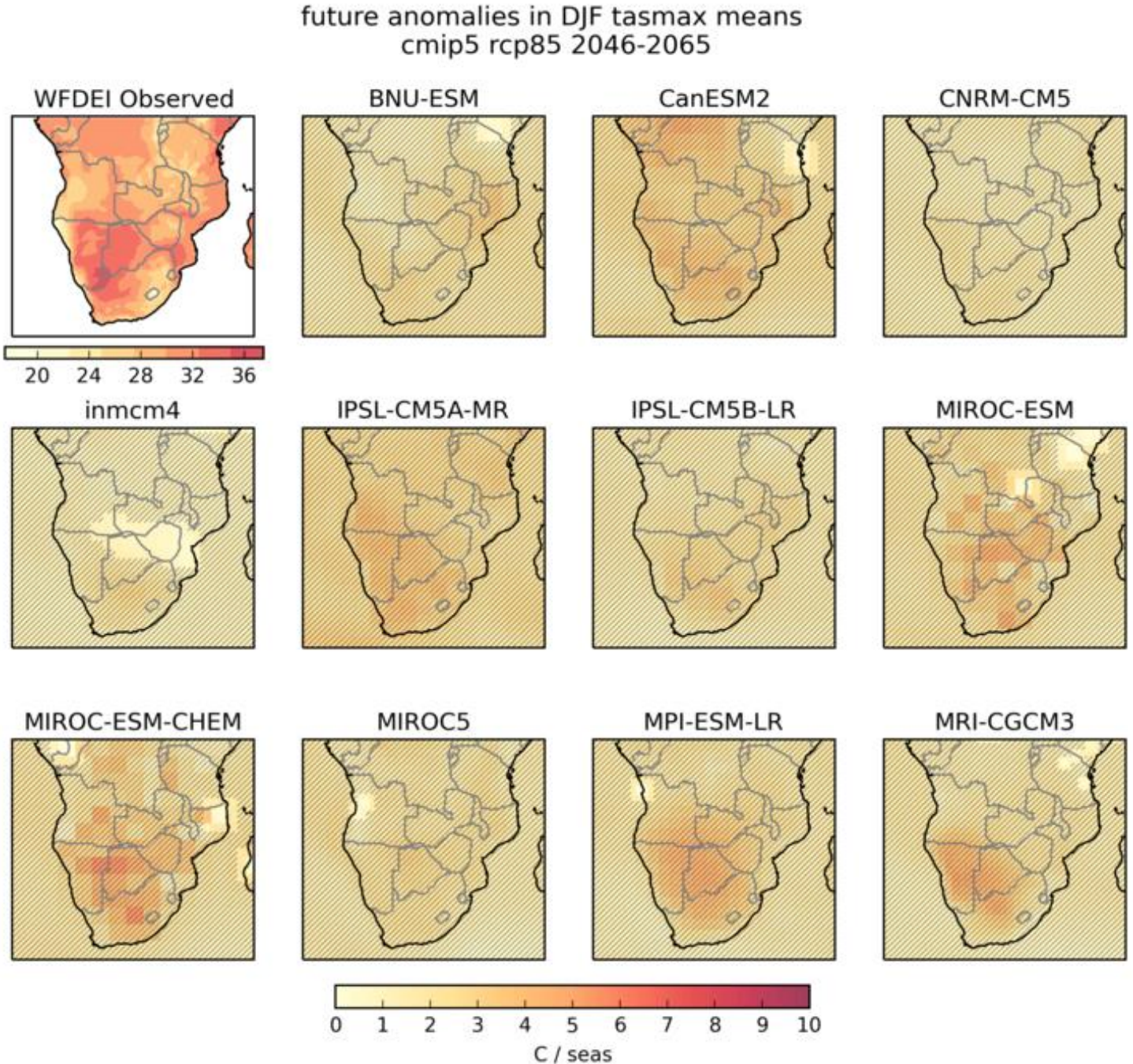
$$\frac{\partial b}{\partial t} + \frac{1}{\cos\phi}\frac{\partial}{\partial \lambda}(ub - va) = 0\,. \qquad (6)$$



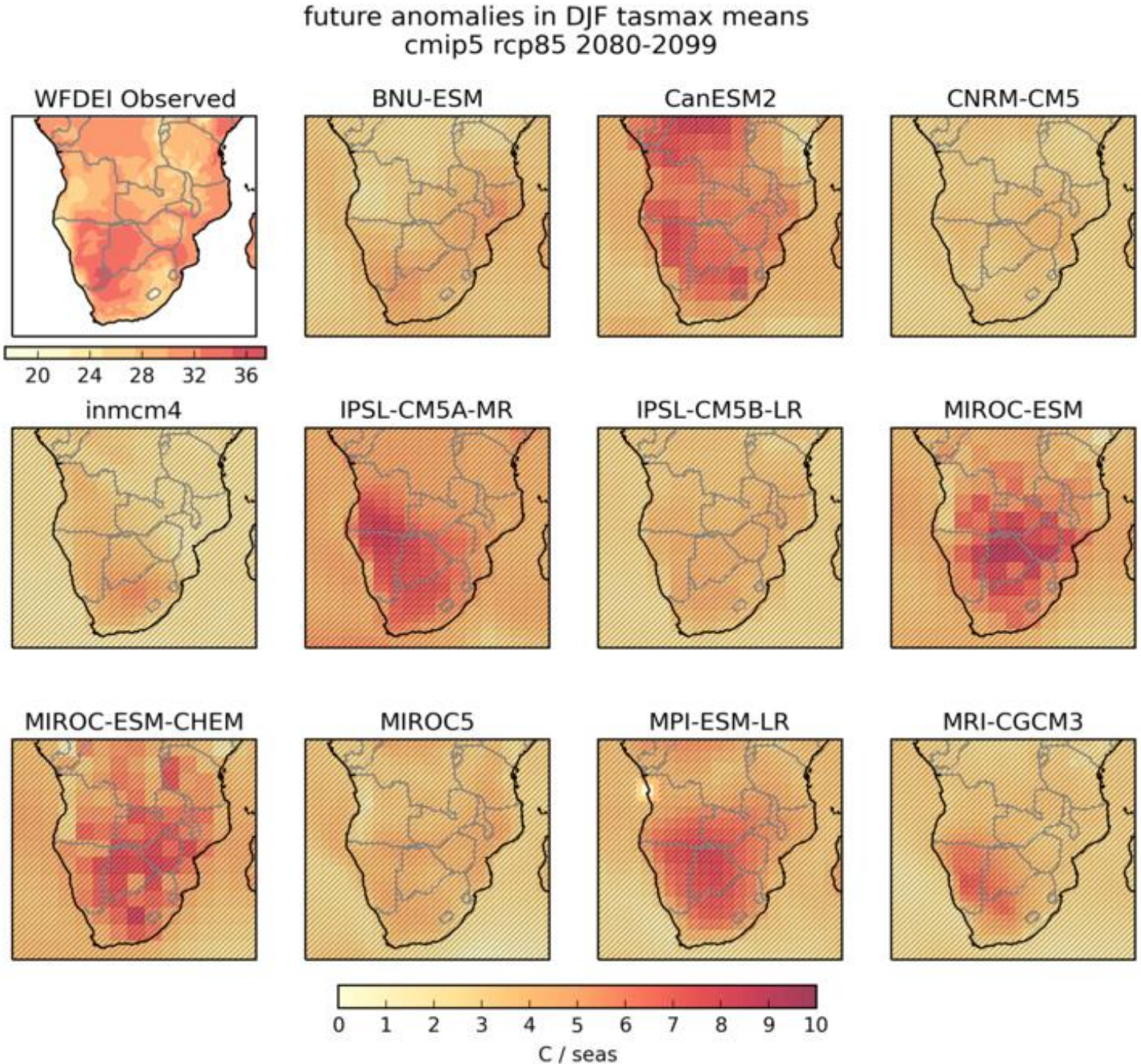




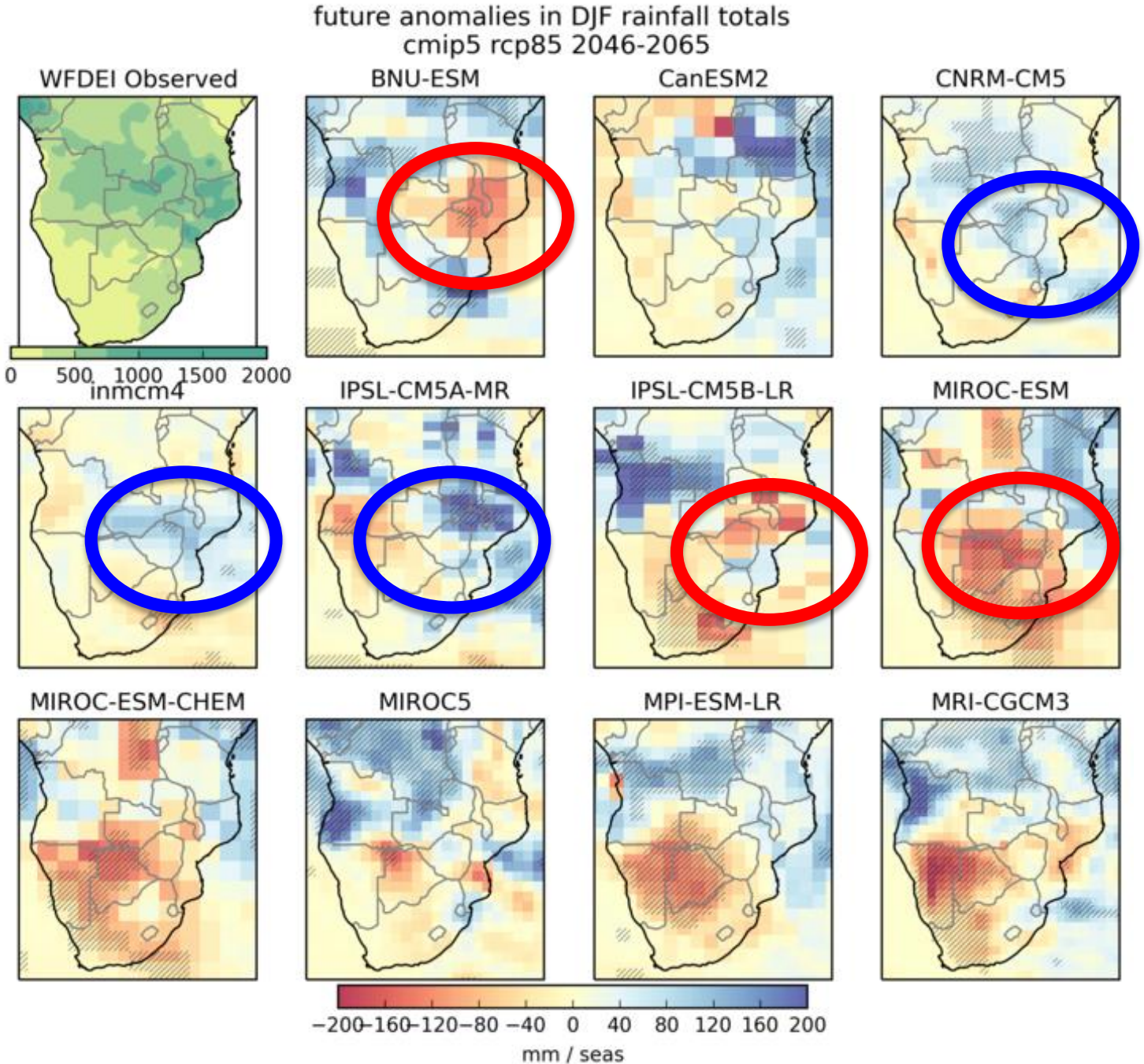
They give us these types of results…



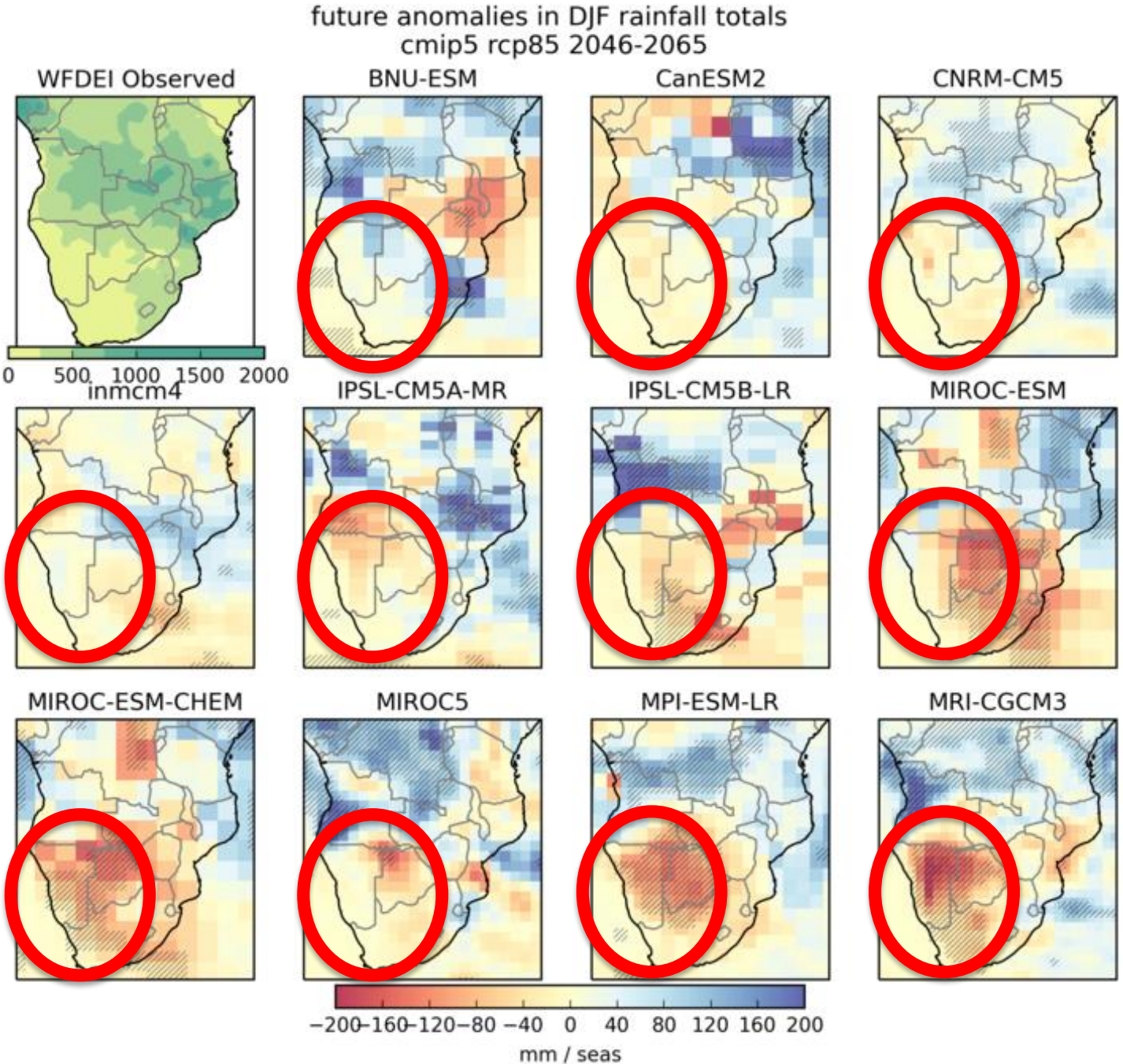
They give us these types of results…

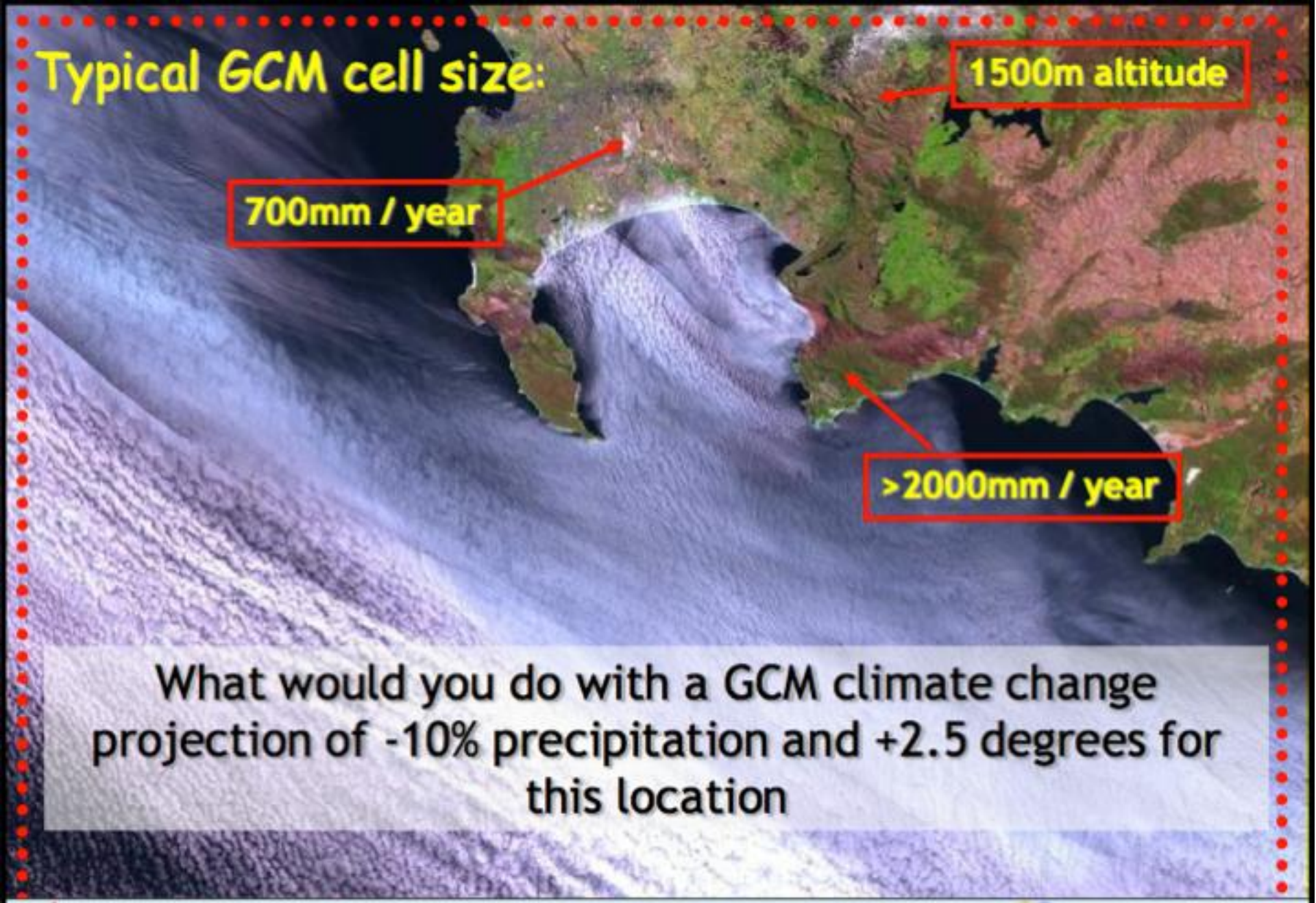


Rainfall is more uncertain…



Rainfall is more uncertain…

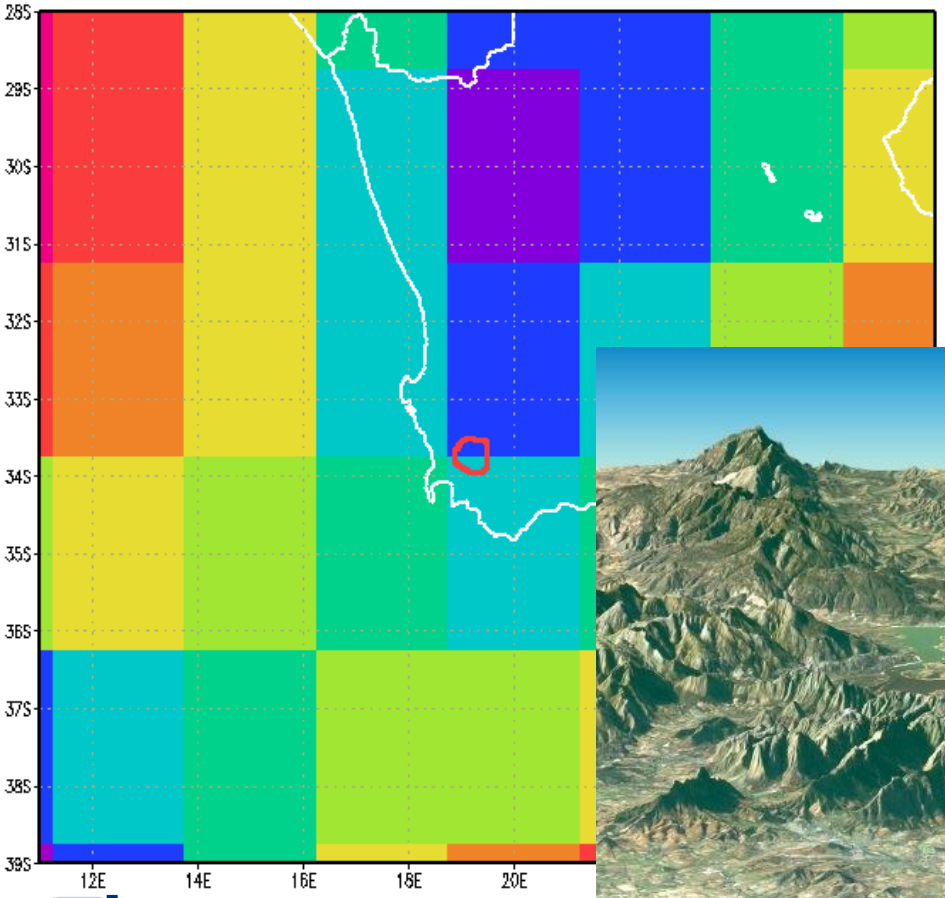


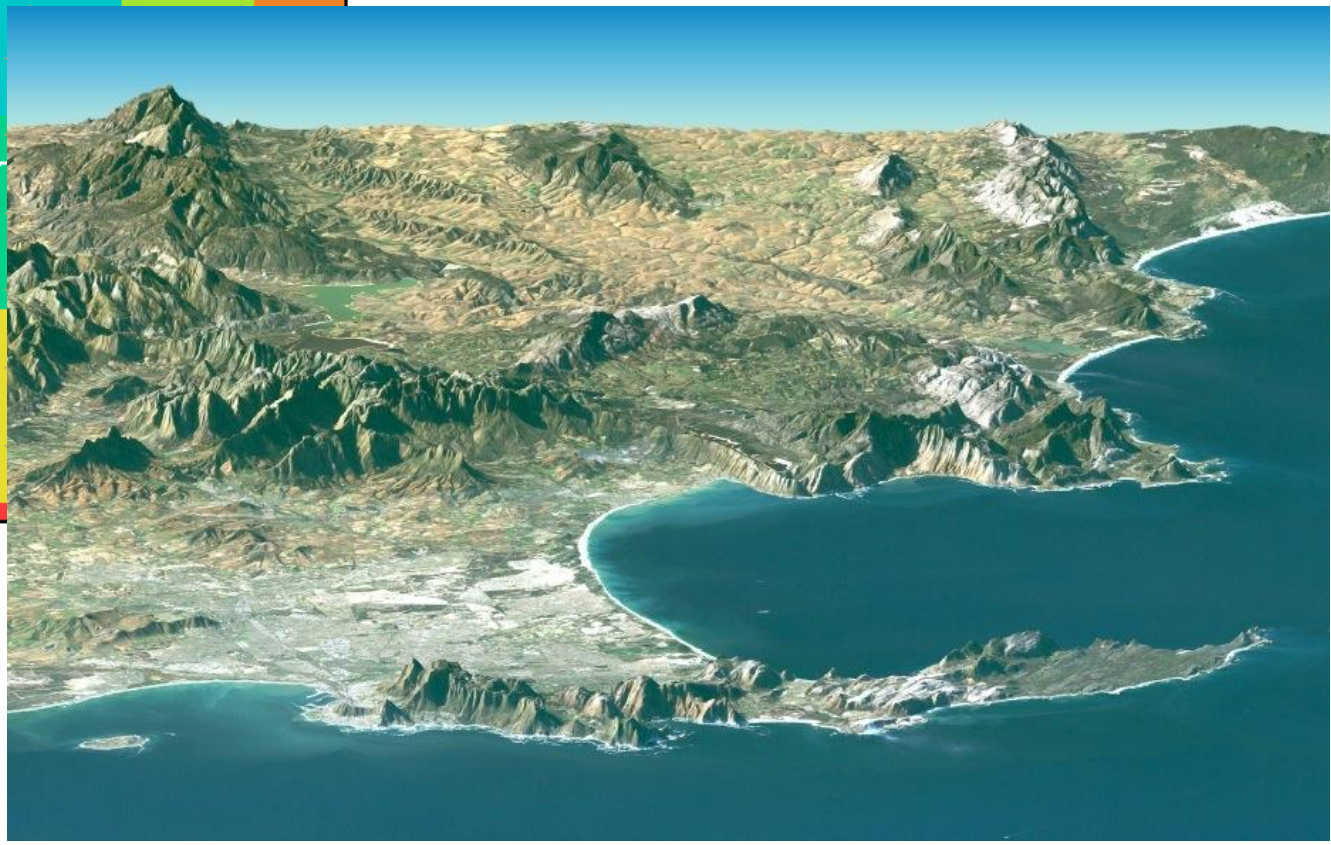


What would you do with a GCM climate change projection of -10% precipitation and +2.5 degrees for this location

Moving to the regional (relevant) scale...

Global Climate Model resolution



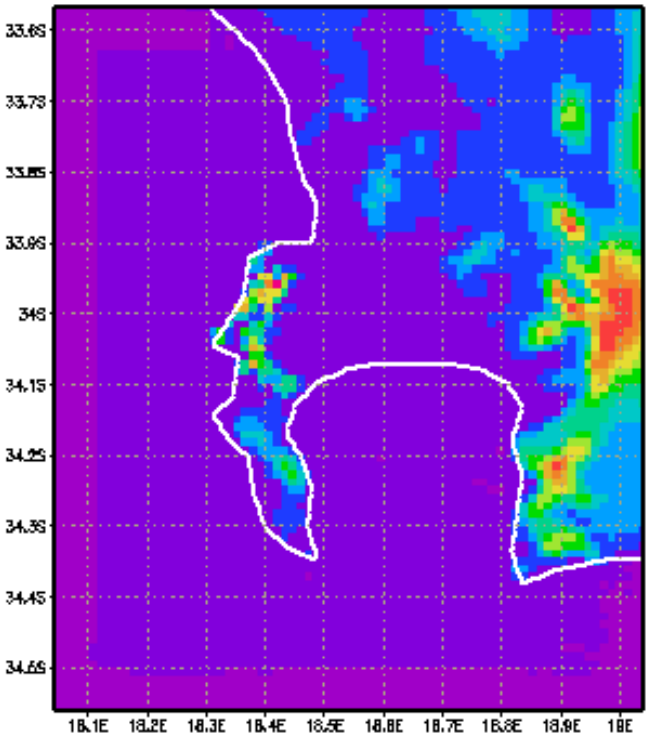


There are two methods used to downscale

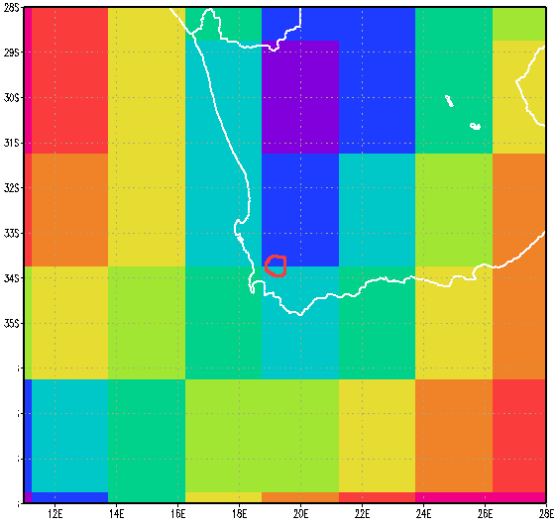
The regional climate model....still about scale...

Numerical Downscaling

Data from the GCM is used by Regional Climate Models (RCMs) to numerically simulate the climate characteristics at a much higher resolution. Results in a gridded product.

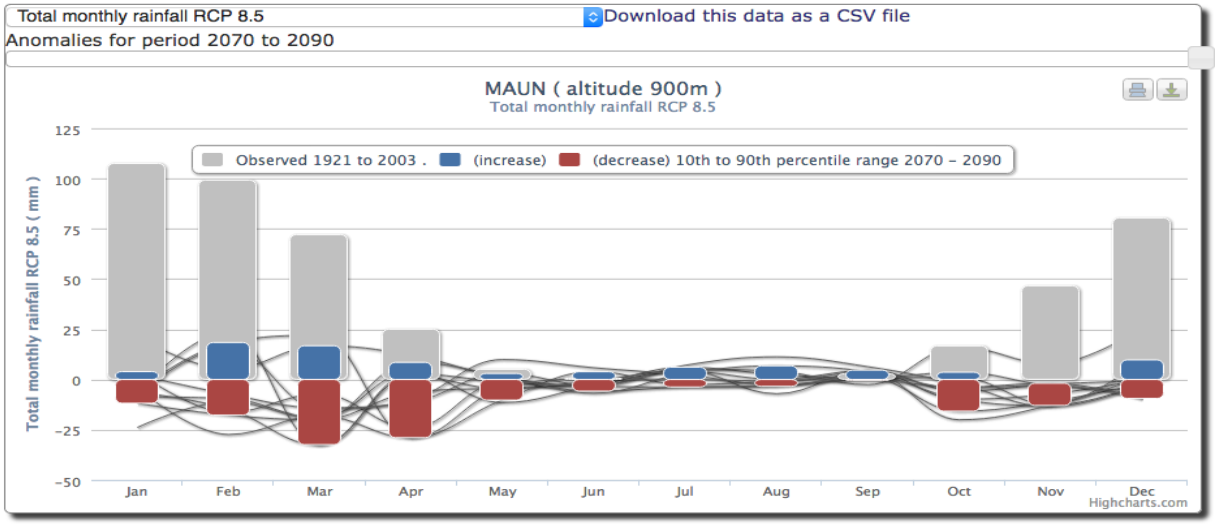


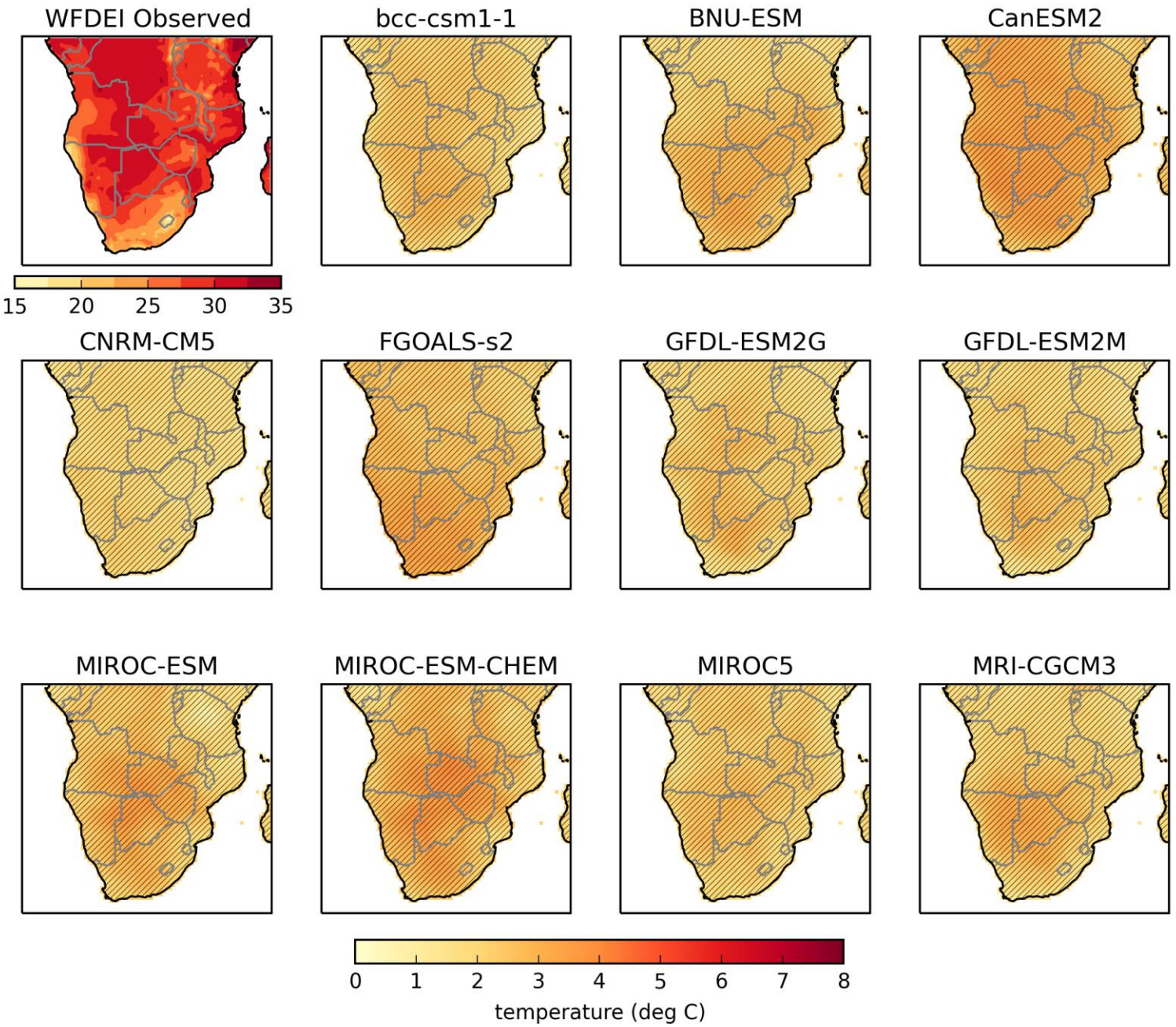
Global Climate Model

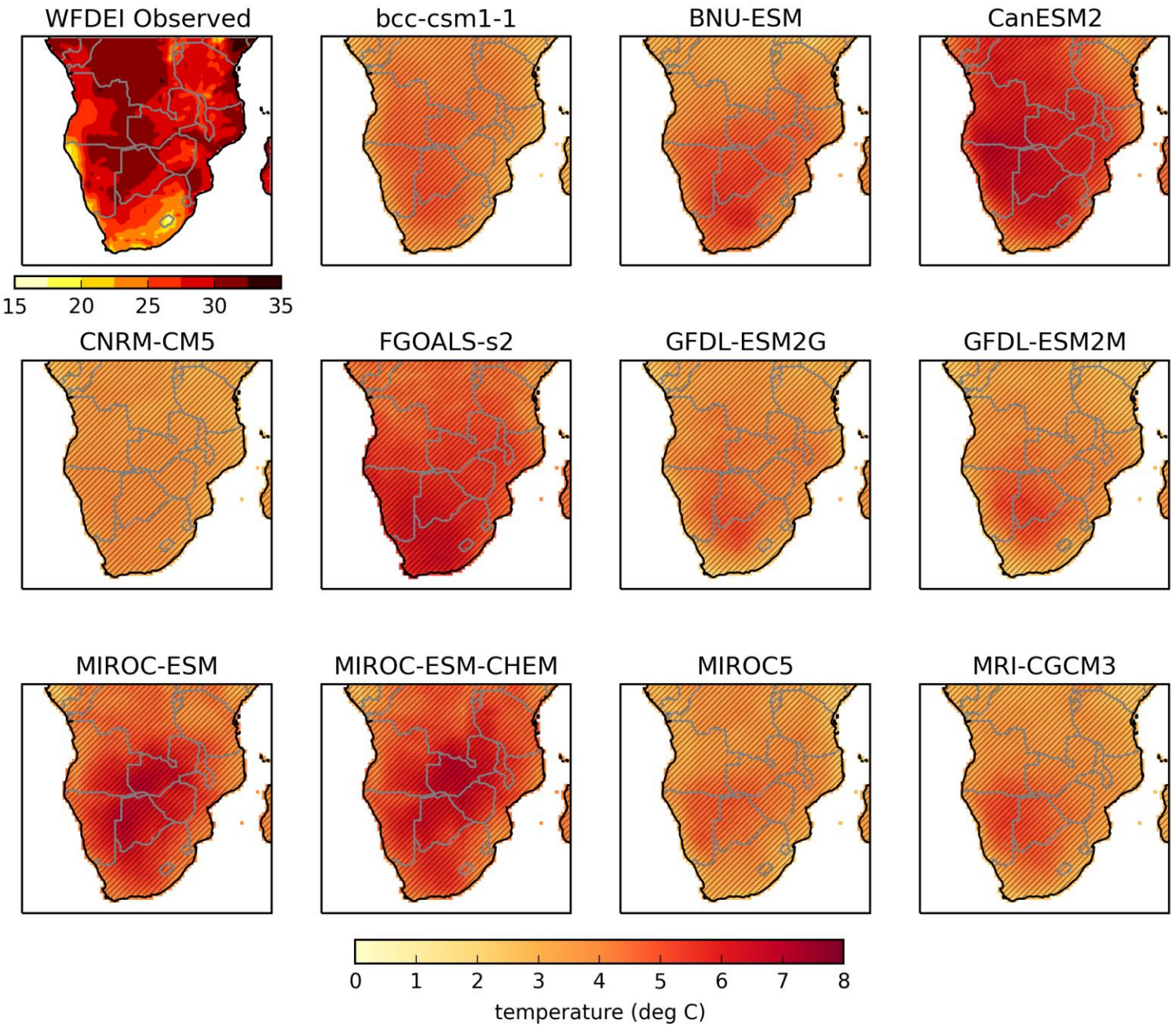


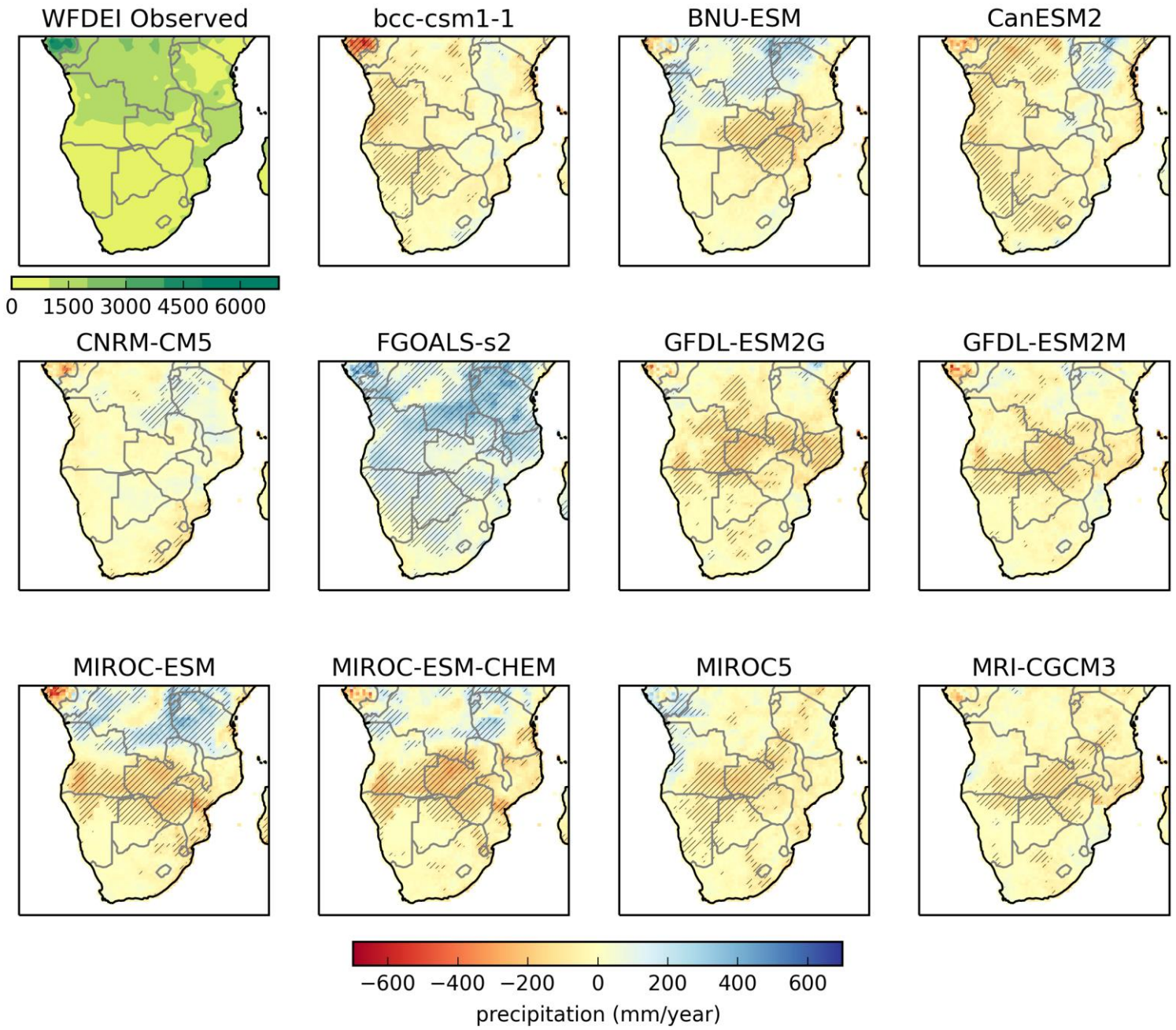
Statistical Downscaling

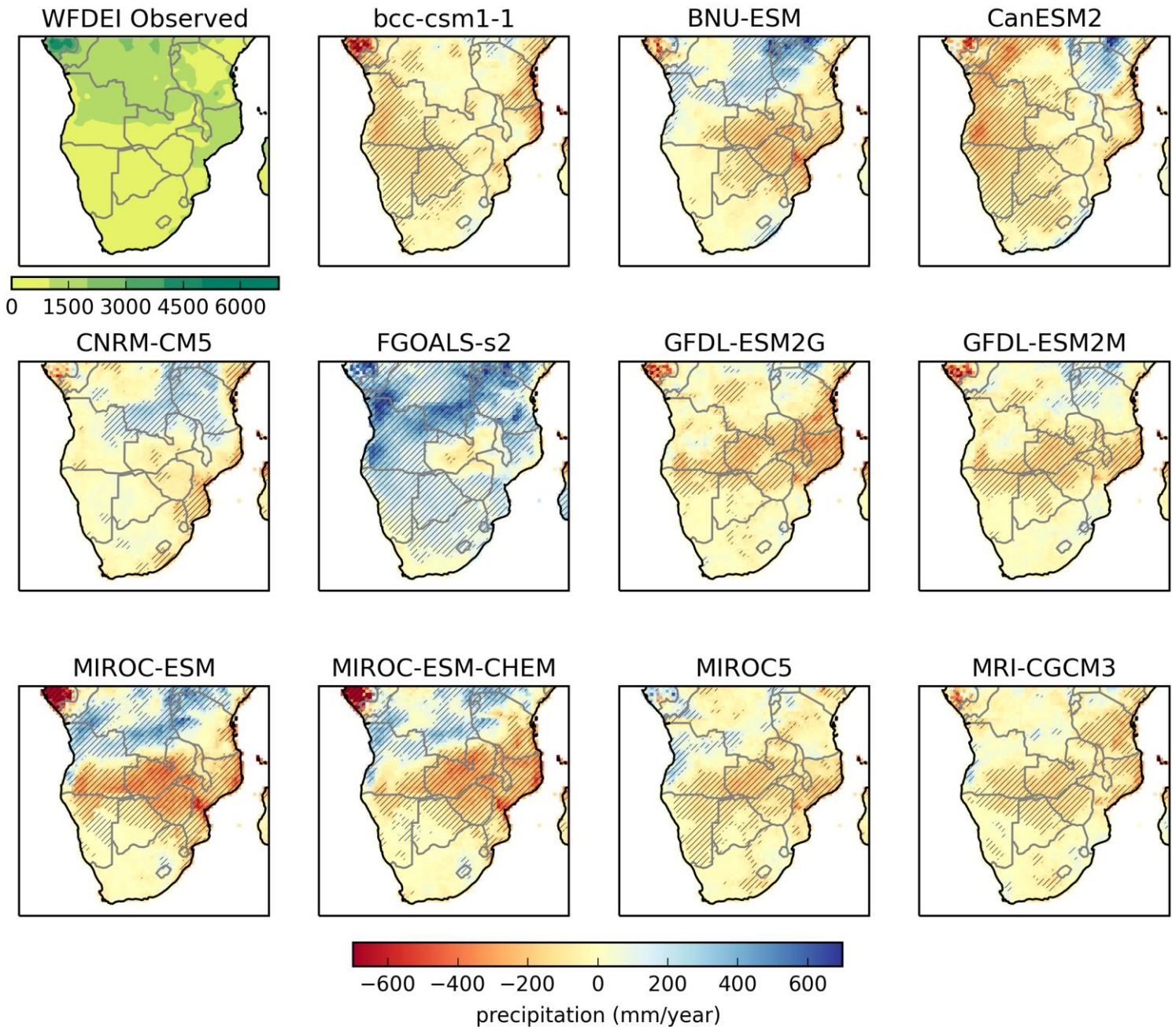
Statistical relationships between weather stations on the ground and atmospheric circulations are established. GCM-produced atmospheric circulations can then be downscaled to the station scale.




future anomalies in annual tasmax means
somd rcp85 2046-2065
WFDEI Observed
bcc-csm1-1
BNU-ESM
CanESM2
15
20
25
30
35
CNRM-CM5
FGOALS-s2
GFDL-ESM2G
GFDL-ESM2M
MIROC-ESM
MIROC-ESM-CHEM
MIROC5
MRI-CGCM3
0
1
2
3
4
5
6
7
8
temperature (deg C)

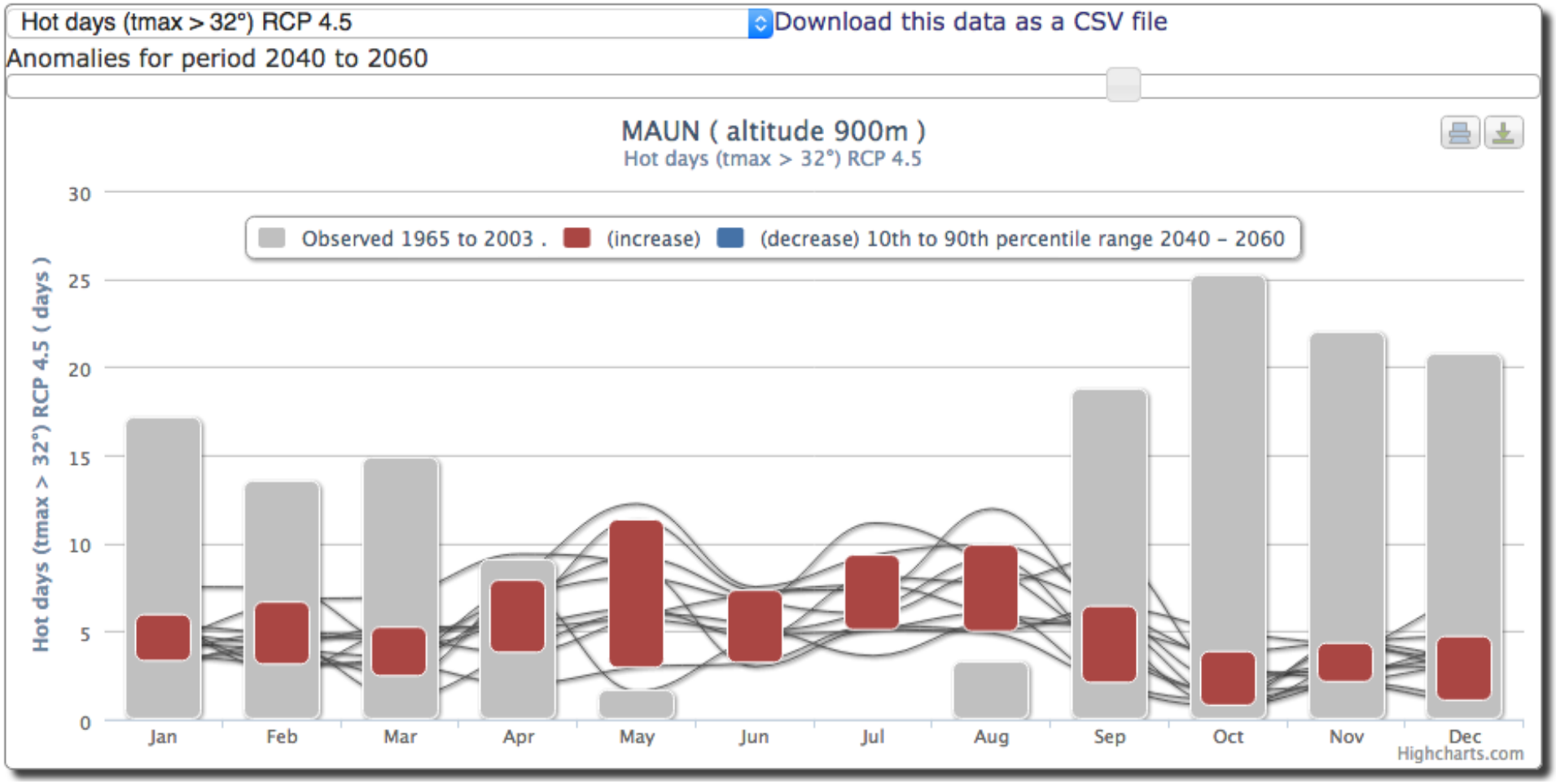

future anomalies in annual tasmax means
somd rcp85 2080-2099
WFDEI Observed
bcc-csm1-1
BNU-ESM
CanESM2
15
20
25
30
35
CNRM-CM5
FGOALS-s2
GFDL-ESM2G
GFDL-ESM2M
MIROC-ESM
MIROC-ESM-CHEM
MIROC5
MRI-CGCM3
0
1
2
3
4
5
6
7
8
temperature (deg C)


future anomalies in annual pr totals
somd rcp85 2046-2065
WFDEI Observed
bcc-csm1-1
BNU-ESM
CanESM2
0 1500 3000 4500 6000
CNRM-CM5
FGOALS-s2
GFDL-ESM2G
GFDL-ESM2M
MIROC-ESM
MIROC-ESM-CHEM
MIROC5
MRI-CGCM3
−600 −400 −200 0 200 400 600
precipitation (mm/year)


future anomalies in annual pr totals
somd rcp85 2080-2099
WFDEI Observed
bcc-csm1-1
BNU-ESM
CanESM2
0 1500 3000 4500 6000
CNRM-CM5
FGOALS-s2
GFDL-ESM2G
GFDL-ESM2M
MIROC-ESM
MIROC-ESM-CHEM
MIROC5
MRI-CGCM3
−600 −400 −200 0 200 400 600
precipitation (mm/year)

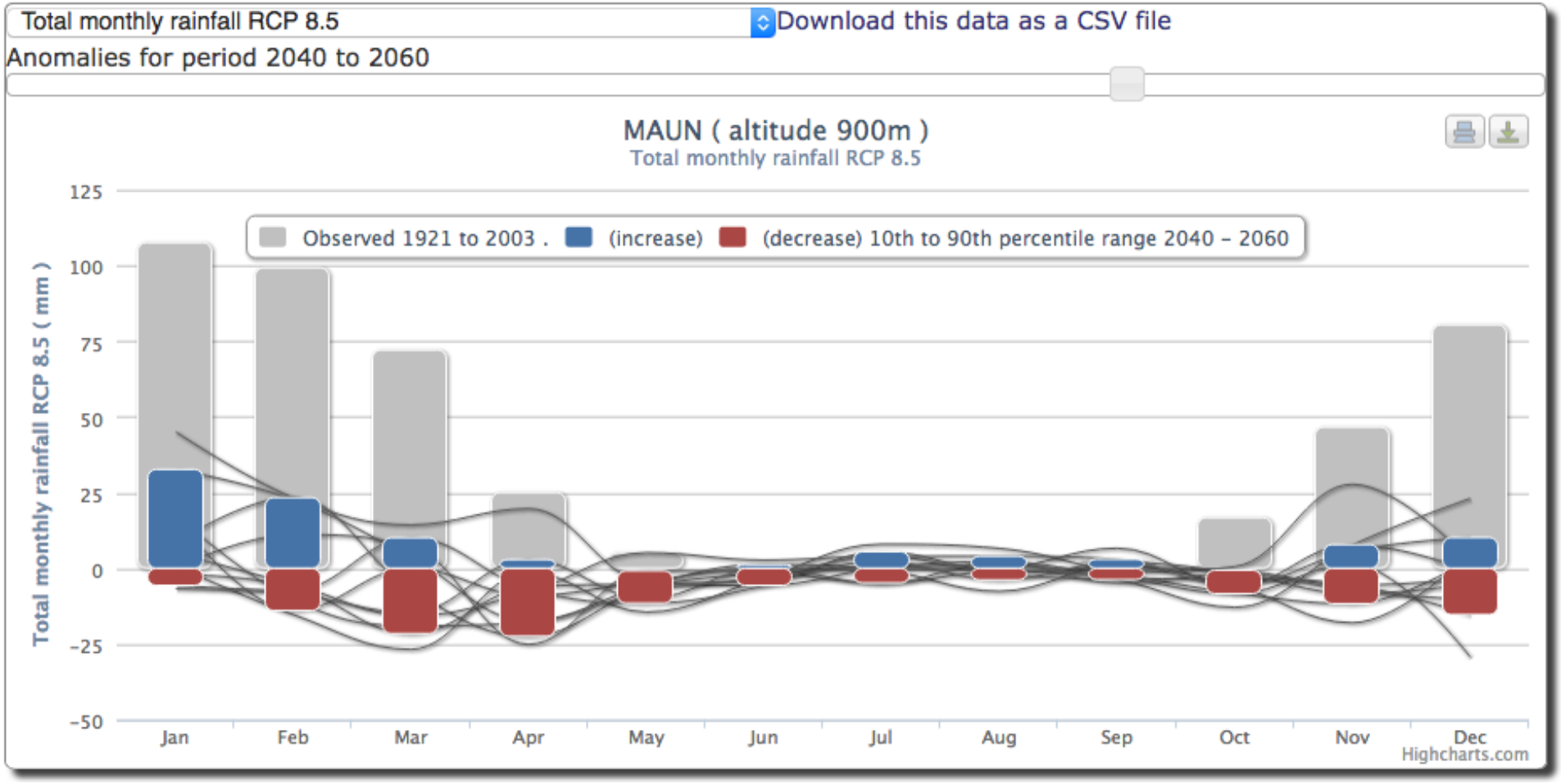
Statistical downscaling can be at point scale…

http://cip.csag.uct.ac.za

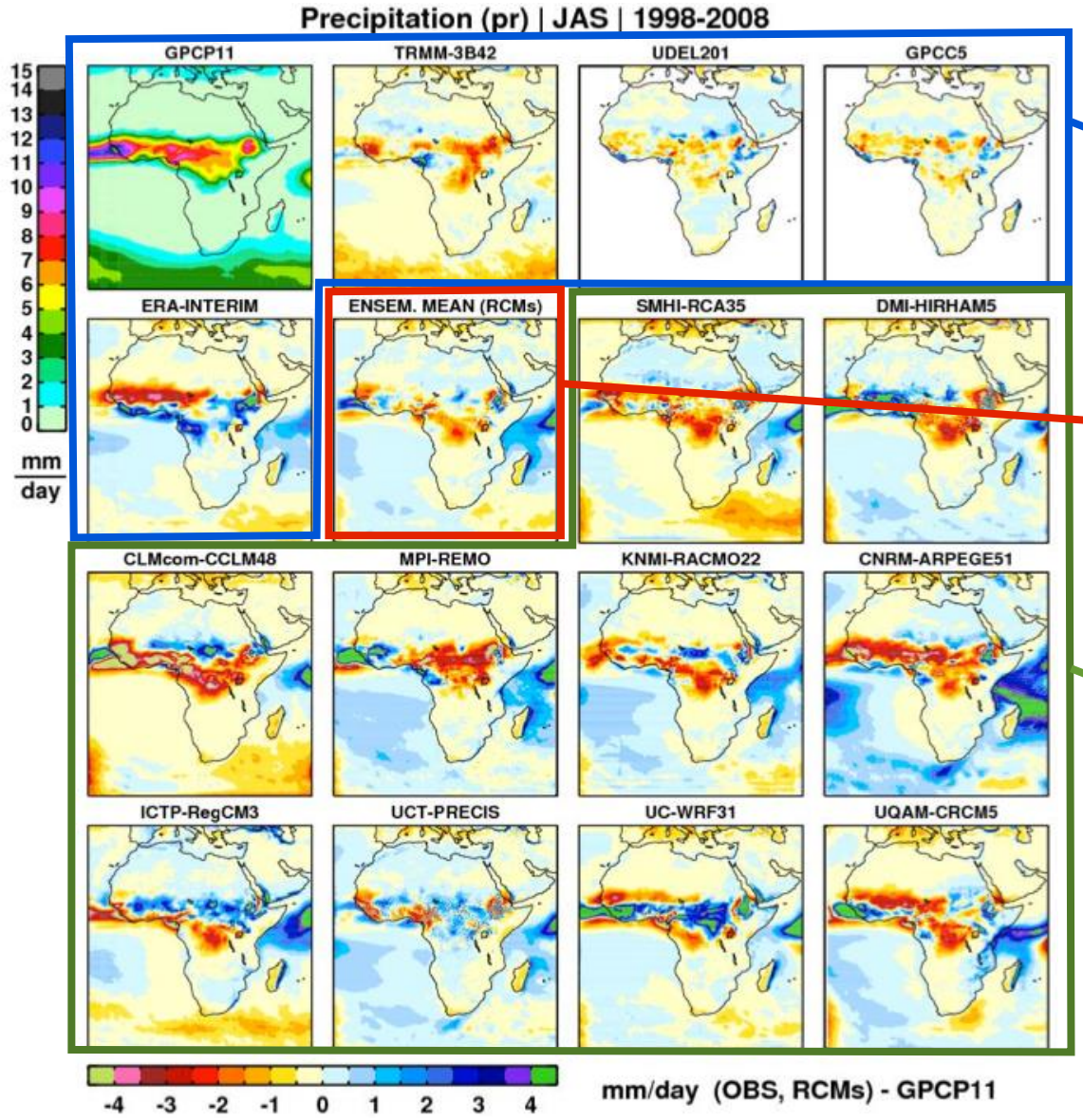


…but rainfall is still tricky.

http://cip.csag.uct.ac.za



What about the dynamical downscaling?



Observed

Average of the 9 models

Nine Regional Climate Models Evaluation runs

Is this information useful to you in this state?

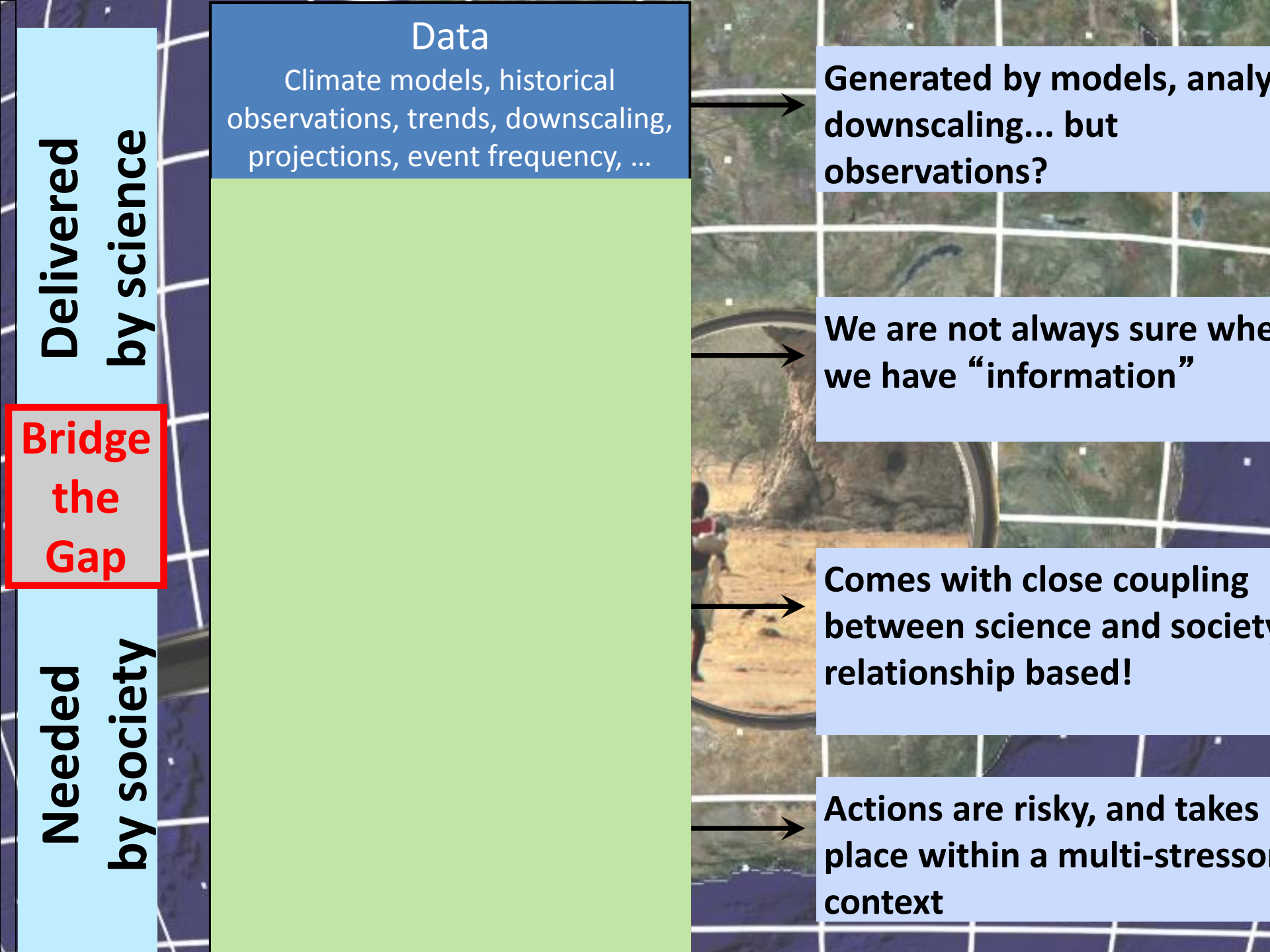
What climate information is important to me?

1. Where are you from and what are your work responsibilities?

1. What time scales are you most interested in (daily/weekly weather; seasonal; next 4-5 years; next 10 years; next 40 years)?
2. What spatial scale are you most interested in (regional, national, provincial, city, individual farms, etc)

3. What type of climate information is useful/desirable to you at these time and space scales?

4. Of all the factors that come into play when you decide on a course of action, how important is climate information in making these decisions?


Delivered by science
Bridge the Gap
Needed by society
Data
Climate models, historical observations, trends, downscaling, projections, event frequency, …
Generated by models, analy
downscaling… but observations?
We are not always sure whe
we have “information”
Comes with close coupling
between science and society
relationship based!
Actions are risky, and takes
place within a multi-stresso
context

When is the information good enough for me to make a decision?

The cahllaenge of birdgnig the sceicne-soictey dvidie

In summary...

1. We don't know the observed climate in many regions....let alone ocean "climate"

2. Downscaling from global to regional scales is an imperative

3. Good certainty around hotter, but how does it get hotter (days above threshold degree days, heat waves, etc)?

4. Less certain about rainfall change, similar questions about how rainfall changes apply.

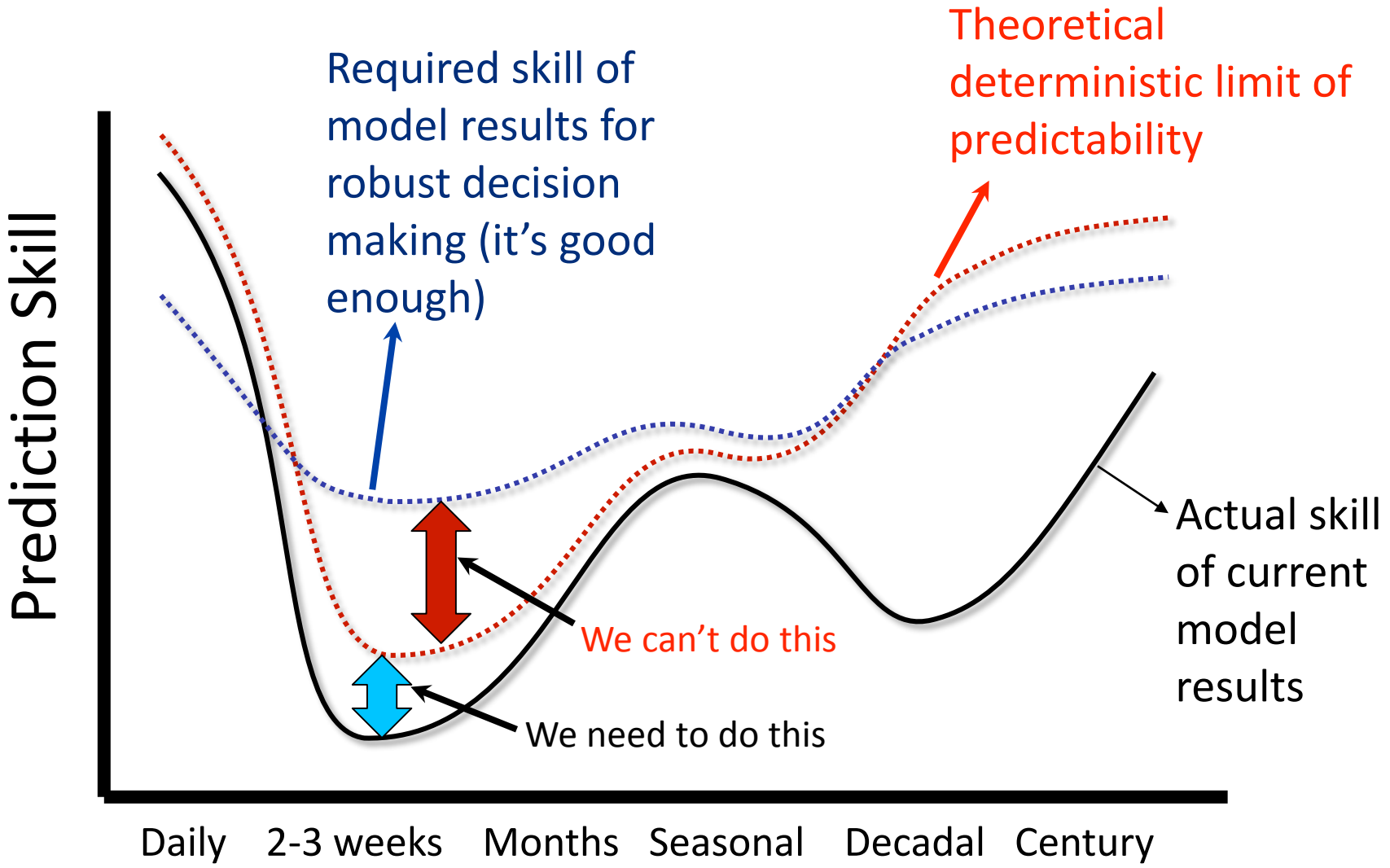
In summary...

3a. *"Data data data, I cannot make bricks without clay"....Sherlock Holmes.*

Data is not information! There needs to be an interpretive chain (Why do you need bricks - build, throw, sell....)

3b. We have to learn to work in a context of an envelope of climate information to reach actionable outcomes

4. This is most robustly done in collaborative efforts between stakeholder community and user-sensitized climate community

Simulating the climate system....what are we trying to achieve?

For a given spatial scale, variable, and application, the prediction skill is a function of time scale