INTRODUCTION

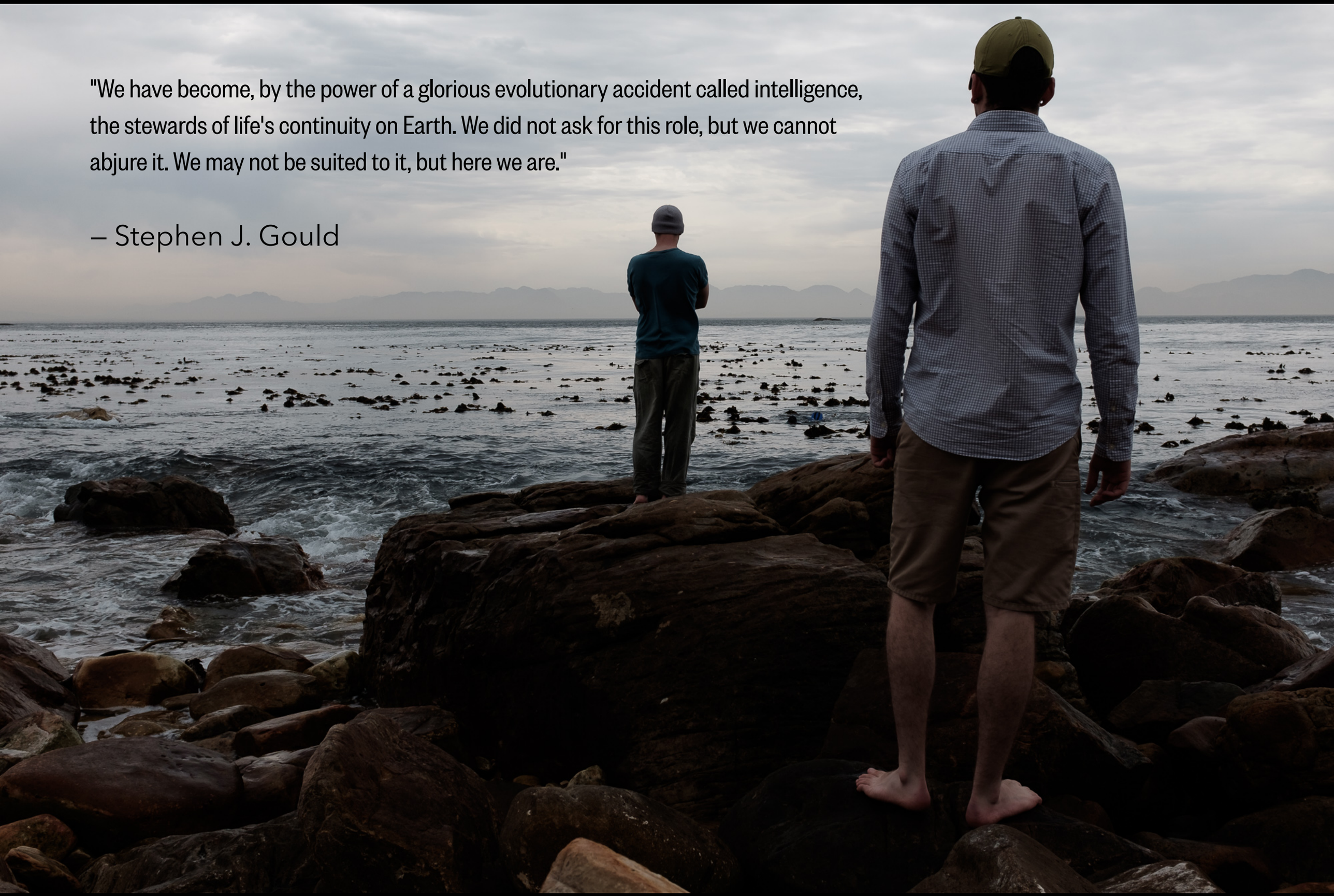
QUANTITATIVE ECOLOGY

AJ Smit

© 2012 AJ Smit

TOPIC 1

INTRODUCTION TO QUANTITATIVE ECOLOGY


"We have become, by the power of a glorious evolutionary accident called intelligence, the stewards of life's continuity on Earth. We did not ask for this role, but we cannot abjure it. We may not be suited to it, but here we are."
– Stephen J. Gould

In this section...

- What is ecology?
- Ecological questions:
  - What kinds of questions have been asked by ecologists?
  - What kinds of questions can be asked?
  - What has caused the difference is kinds of questions being asked?
- What is QE?
  - Why not use the biology and statistics knowledge you already have?

© 2014 AJ Smit

What is ecology?

Community ecology vs. population ecology...

© 2014 AJ Smit

What kinds of questions?

Community ecology underpins the vast fields of biodiversity and biogeography, and concerns spatial scales from squares of meters to all of Earth. We can look at historical and contemporary processes that have been implicated in shaping the distribution of life on our planet. And the processes that will shape Earth in the Future.

The Future

Global change

Climate change,
N cycle, etc.

Biogeochemistry

Long-term data

Ecophysiology

N, P, C, Si
rate processes

The Present

Earth
observation

Ecological
outcomes

Classical eco. methods
Modern methods: e.g. stable isotopes

High-res spatial data

Biogeography

The Past

Kelp forest example: Premise 1

The world is changing...

The physical environment...

How do we know this?

How do we measure it?

What is changing?

Over which spatial scales?

Over which temporal scales?

Kelp forest example: Premise 2

Kelp forests have multiple ecological services...

The biological environment...

How do we know this?

How do we measure it?

What is changing?

Over which spatial scales?

Over which temporal scales?

The question

What consequences stemming from the changing environment are there for kelp forests?

The physical environment...

How do we know this?

How do we measure it?

What is changing?

Over which spatial scales?

Over which temporal scales?

+

The biological environment...

How do we know this?

How do we measure it?

What is changing?

Over which spatial scales?

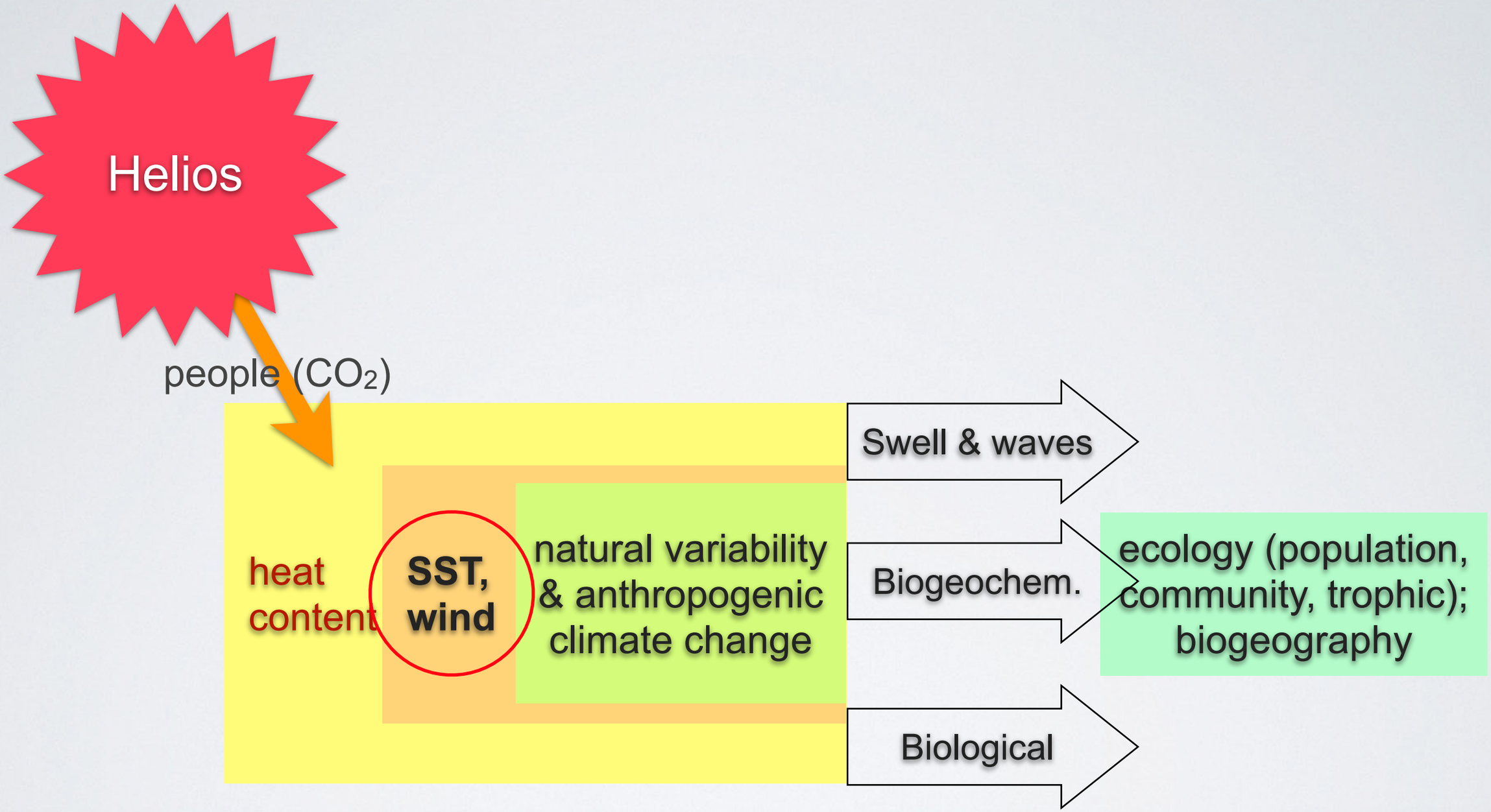
Over which temporal scales?

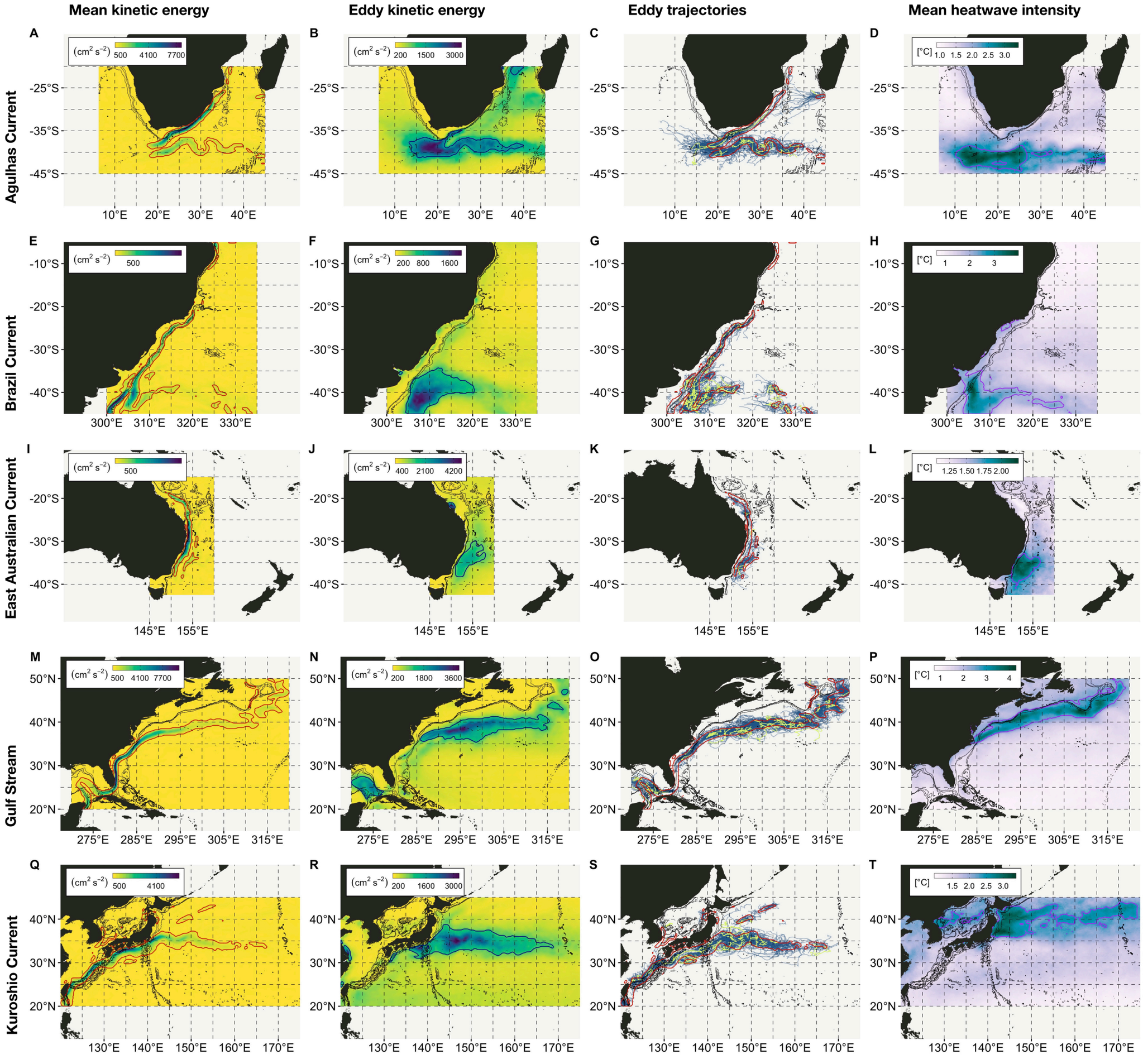
Consequences

Why we care

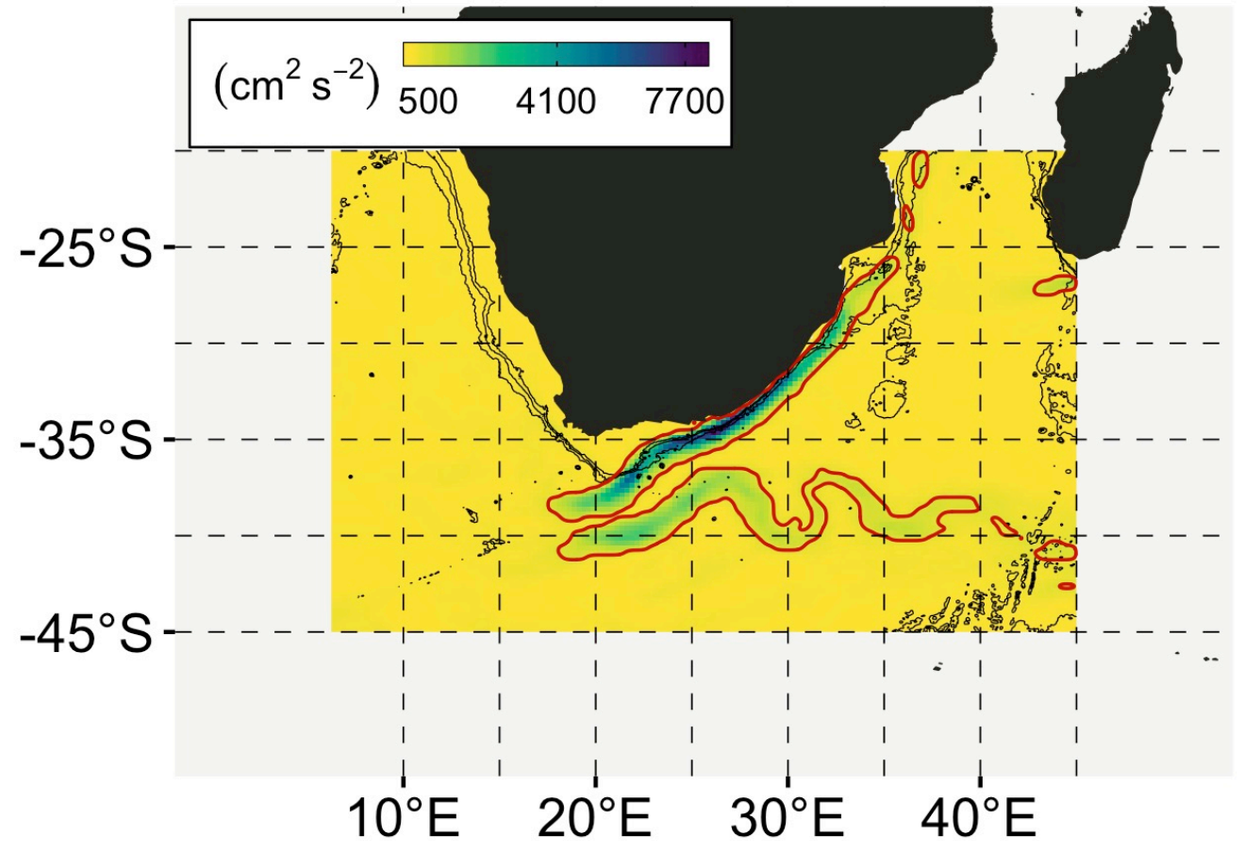
What does this mean for people?

Example: Agulhas Current's influence at multiple scales

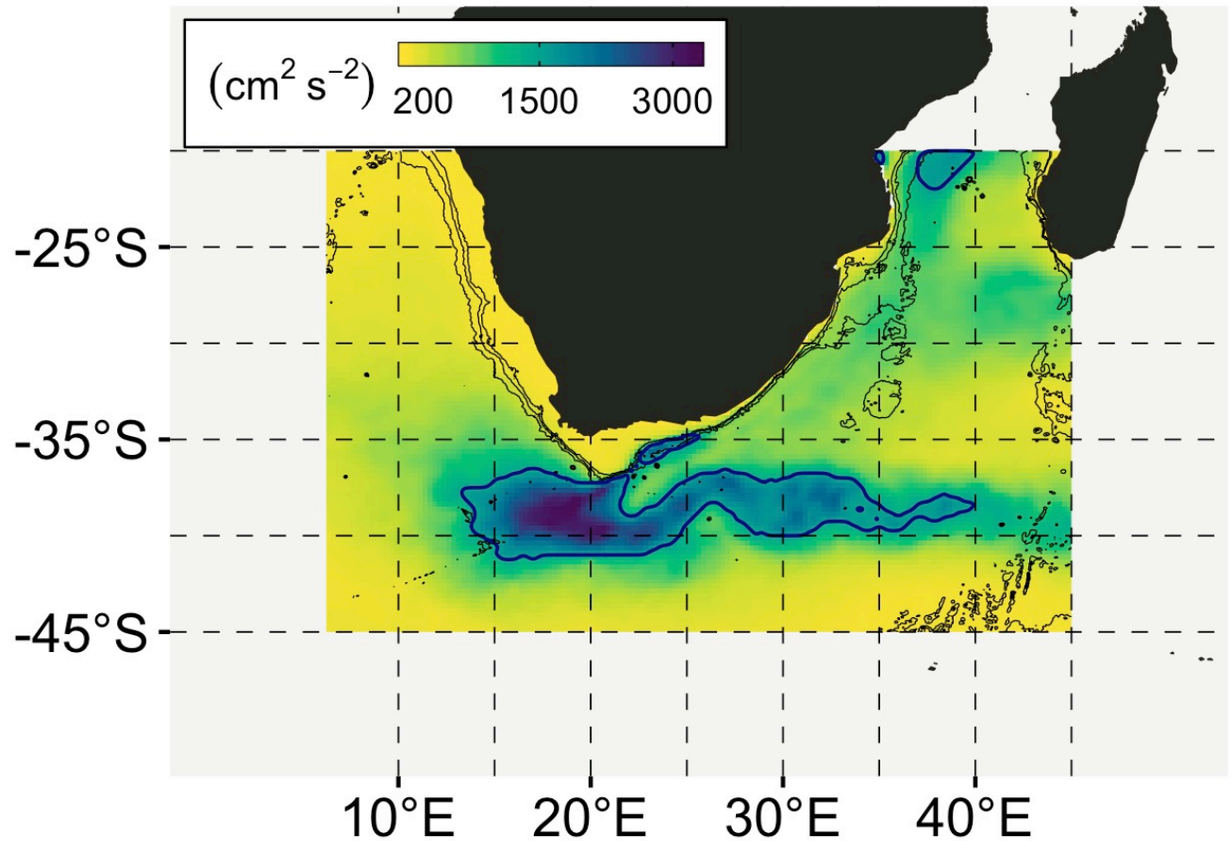



Mean kinetic energy
Eddy kinetic energy
Eddy trajectories
Mean heatwave intensity
Agulhas Current
Brazil Current
East Australian Current
Gulf Stream
Kuroshio Current
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
(cm² s⁻²) 500 4100 7700
(cm² s⁻²) 200 1500 3000
[°C] 1.0 1.5 2.0 2.5 3.0
(cm² s⁻²) 500
(cm² s⁻²) 200 800 1600
[°C] 1 2 3
(cm² s⁻²) 500
(cm² s⁻²) 400 2100 4200
[°C] 1.25 1.50 1.75 2.00
(cm² s⁻²) 500 4100 7700
(cm² s⁻²) 200 1800 3600
[°C] 1 2 3 4
(cm² s⁻²) 500 4100
(cm² s⁻²) 200 1600 3000
[°C] 1.5 2.0 2.5 3.0
-25°S
-35°S
-45°S
10°E 20°E 30°E 40°E
-10°S
-20°S
-30°S
-40°S
300°E 310°E 320°E 330°E
-20°S
-30°S
-40°S
145°E 155°E
50°N
40°N
30°N
20°N
275°E 285°E 295°E 305°E 315°E
40°N
30°N
20°N
130°E 140°E 150°E 160°E 170°E

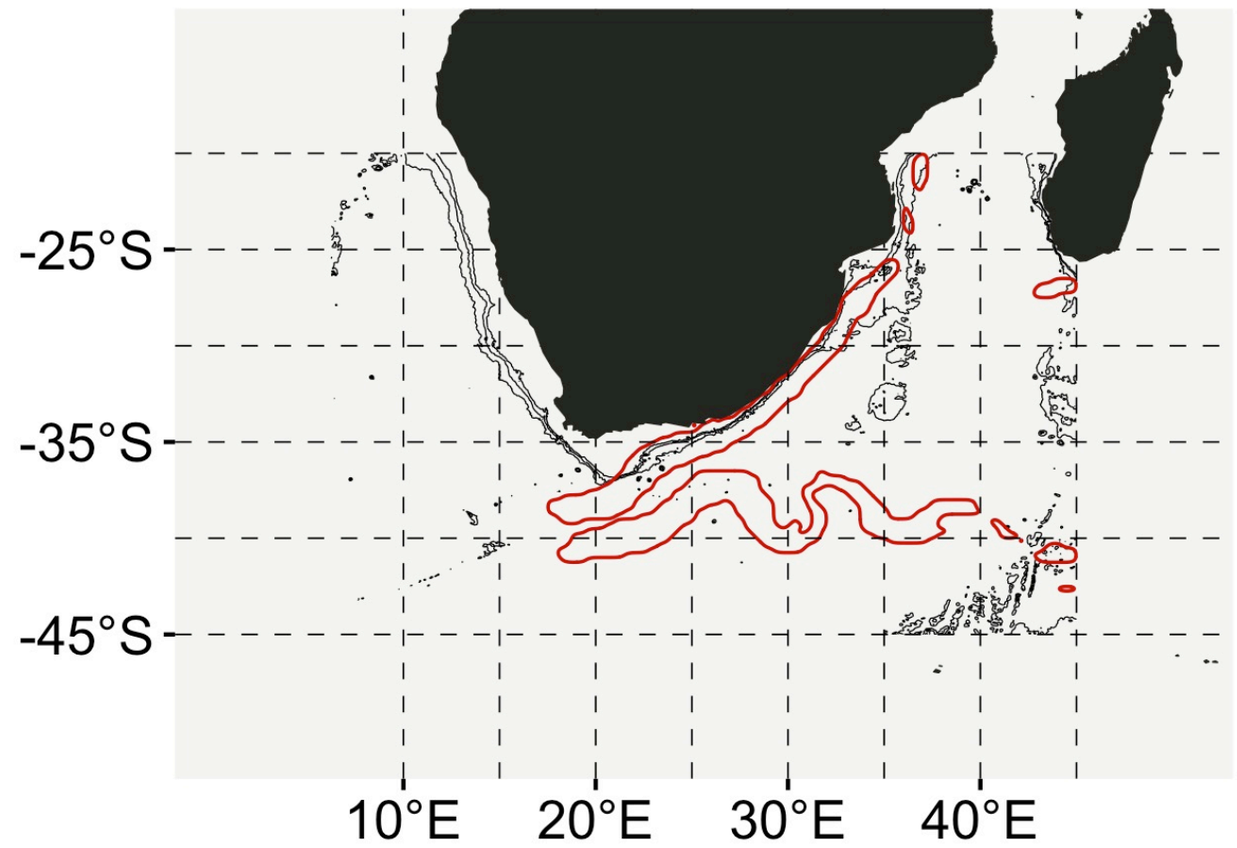
A Mean kinetic energy



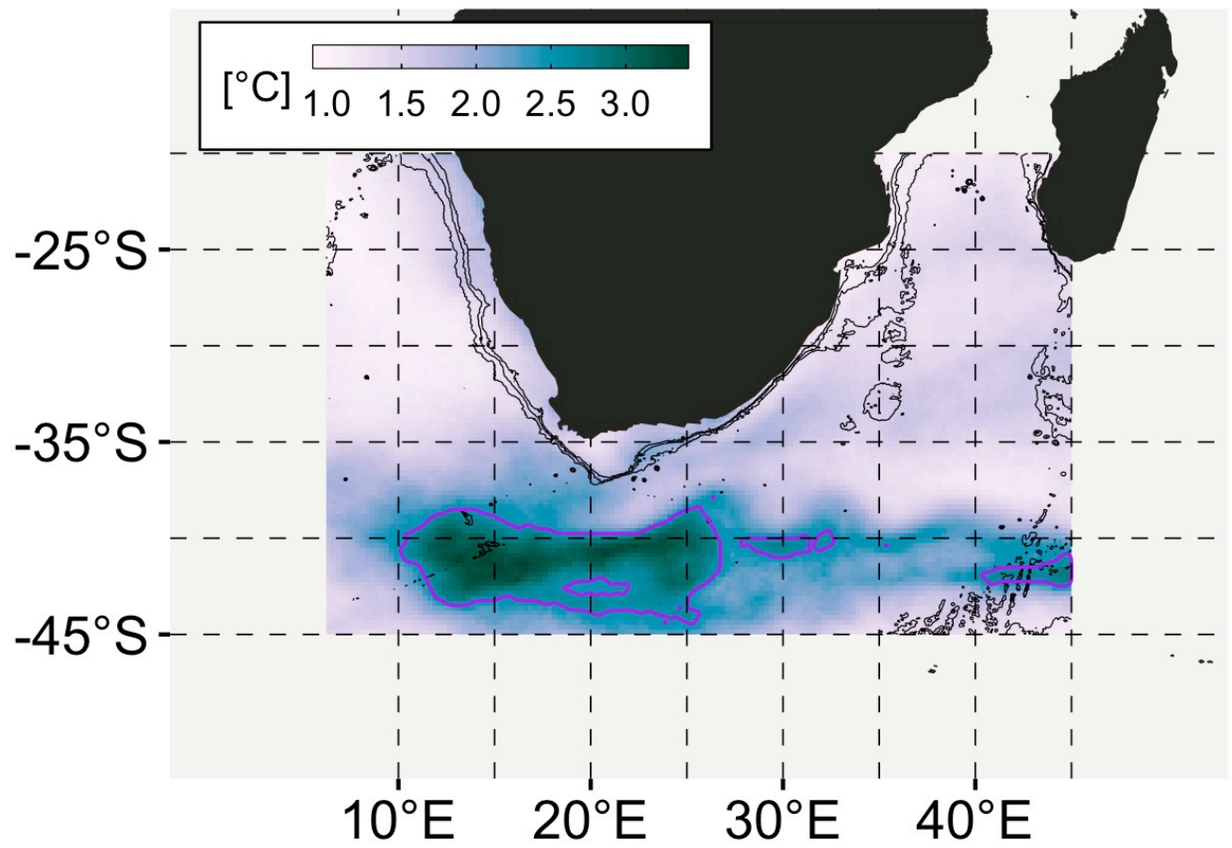
B Eddy kinetic energy



C Eddy trajectories

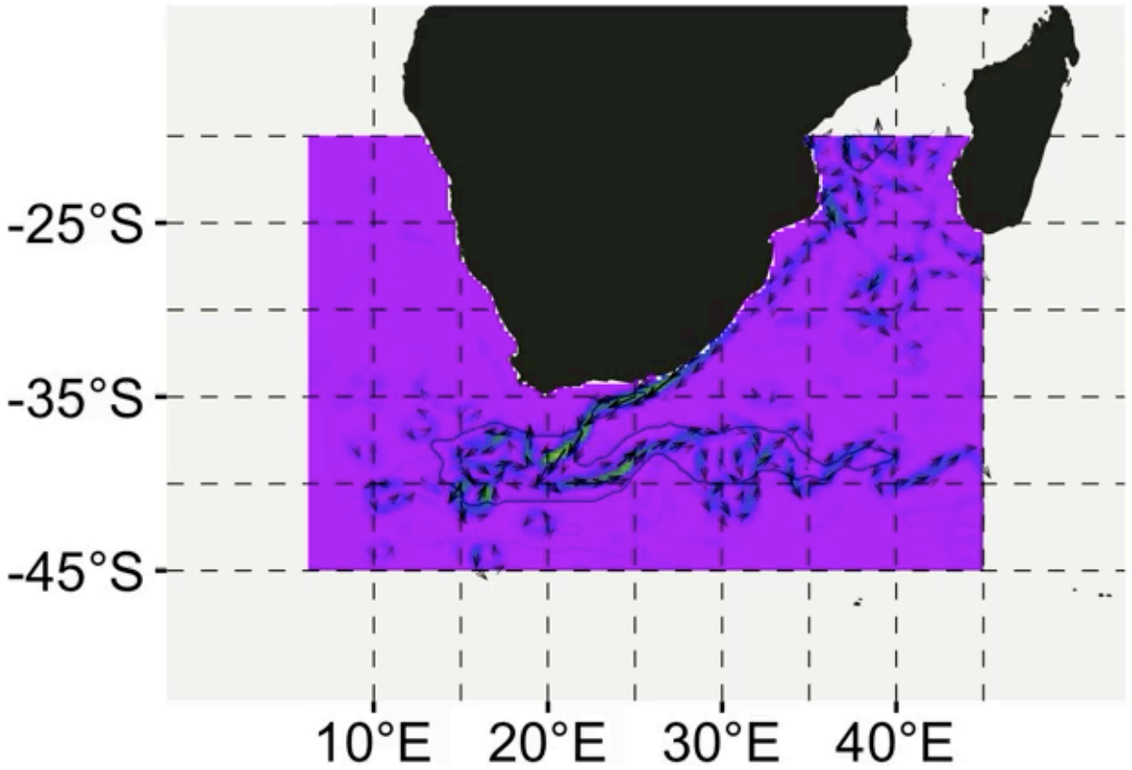


D Heatwave intensity

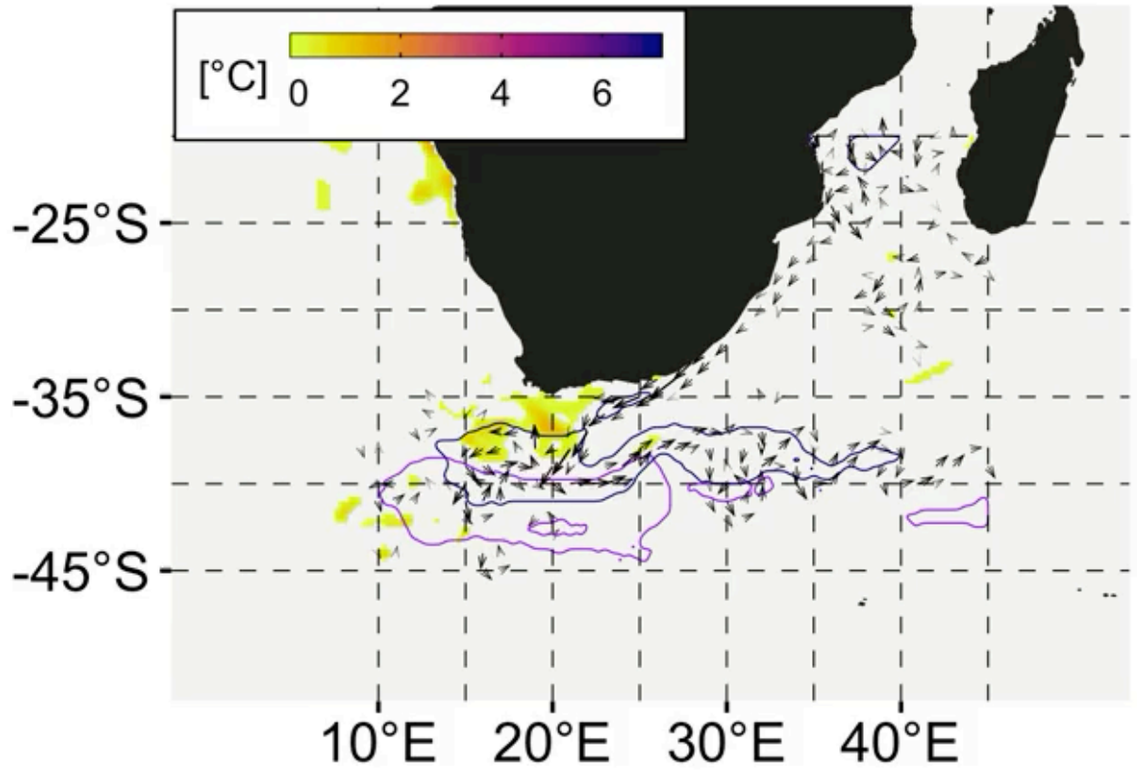


2006-01-01

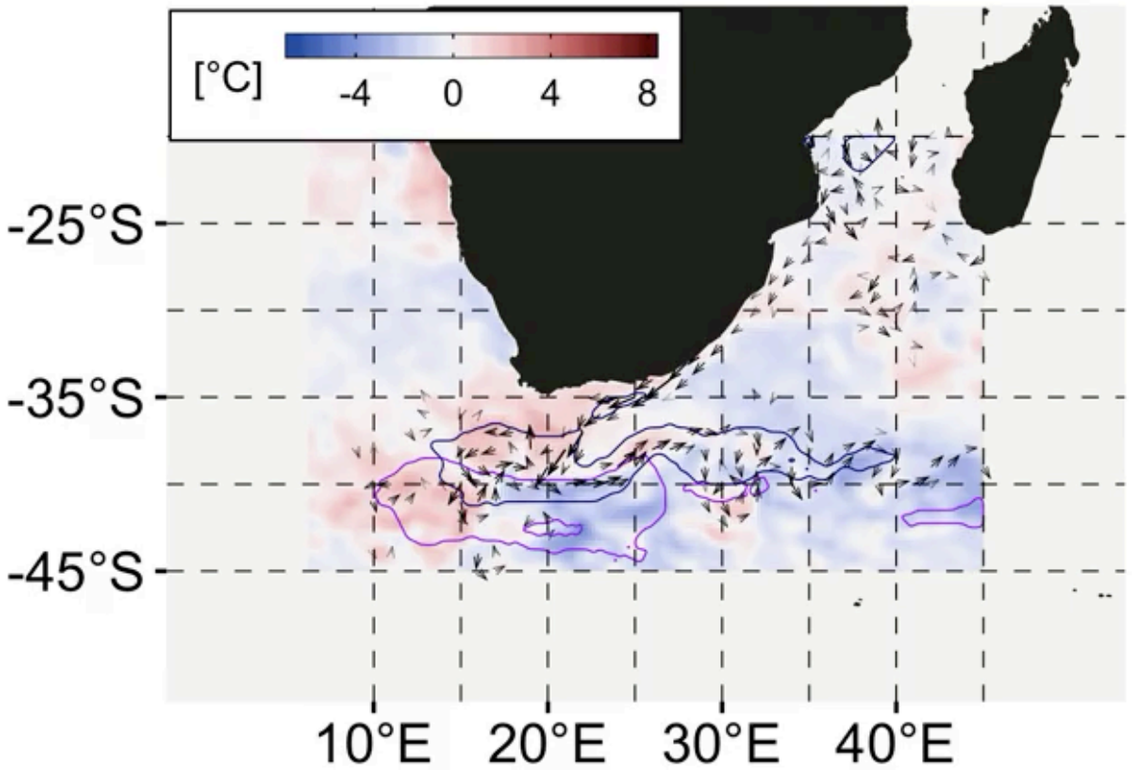
Geostrophic velocity



SST exceedence over threshold



SST anomaly



Effect 1: temperature gradient

Temperature

- Geographic distribution
- Survival, reproductive limits
- Biochemical and physiological rates
- Nutrient availability
- Localised influences on morphology?

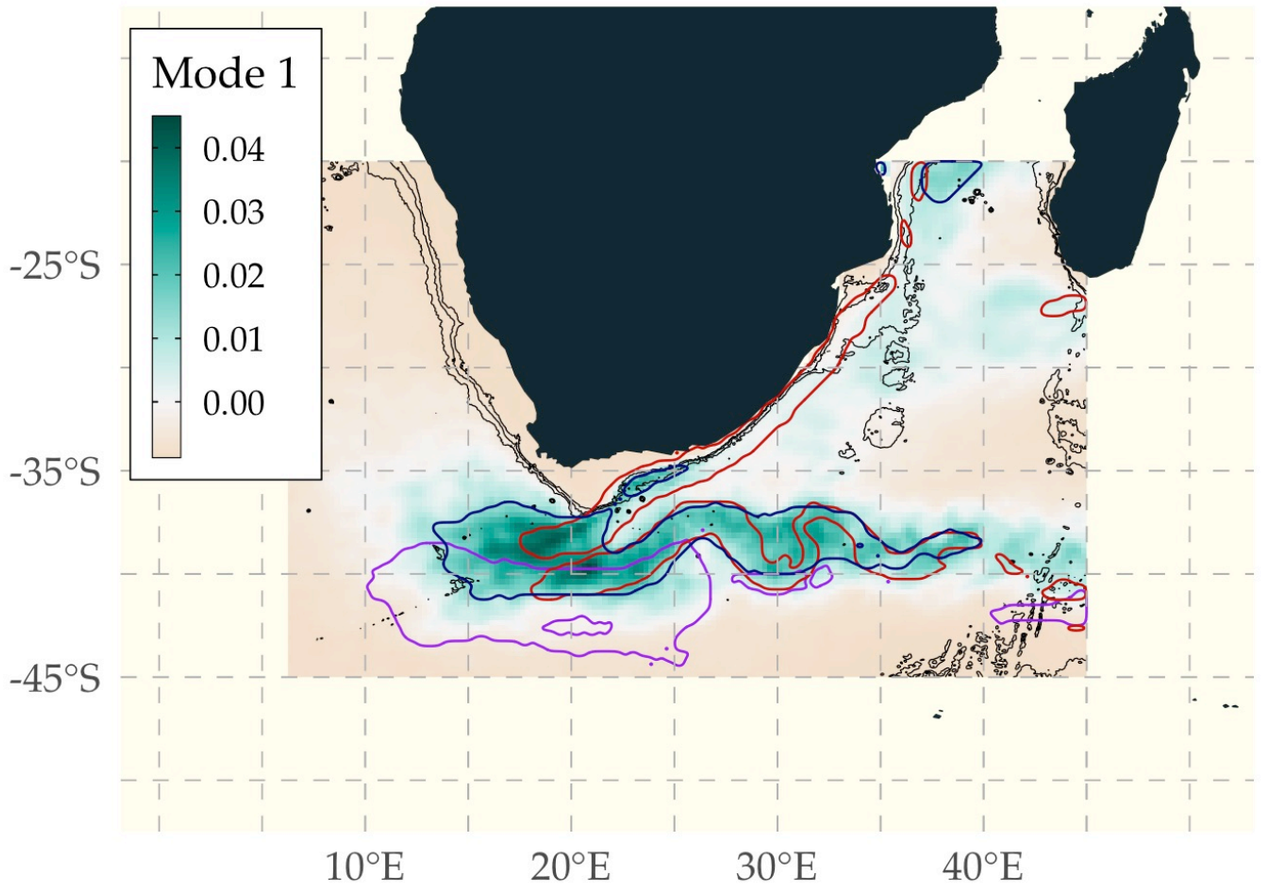
Port Nolloth
Kleinzee Pump
Hondeklipbaai
Groenrivier
Dead Whale Gulley
Doringbaai
Lamberts Bay
St Helena Bay
Jacobsbaai
Dassen Island
Sea Point
Kommetjie
Hermanus
De Hoop
Stilbaai
Cape Agulhas
Mossel Bay
Plettenberg Bay
Oyster Bay
Seaview
St Croix
Woody Cape
Eastern Beach
Hamburg
Hluleka
Cwebe
Mzamba
Margate
Mtwalumi
Umgababa
Brighton Beach
La Mercy
Zinkwazi
Richards Bay
Leadsmanshoal
Sodwana
Saxon

- KZNSB (45)
- SAWS (41)
- SAEON (31)
- UWC (30)
- DEA (15)
- DAFF (6)
- EKZNW (5)

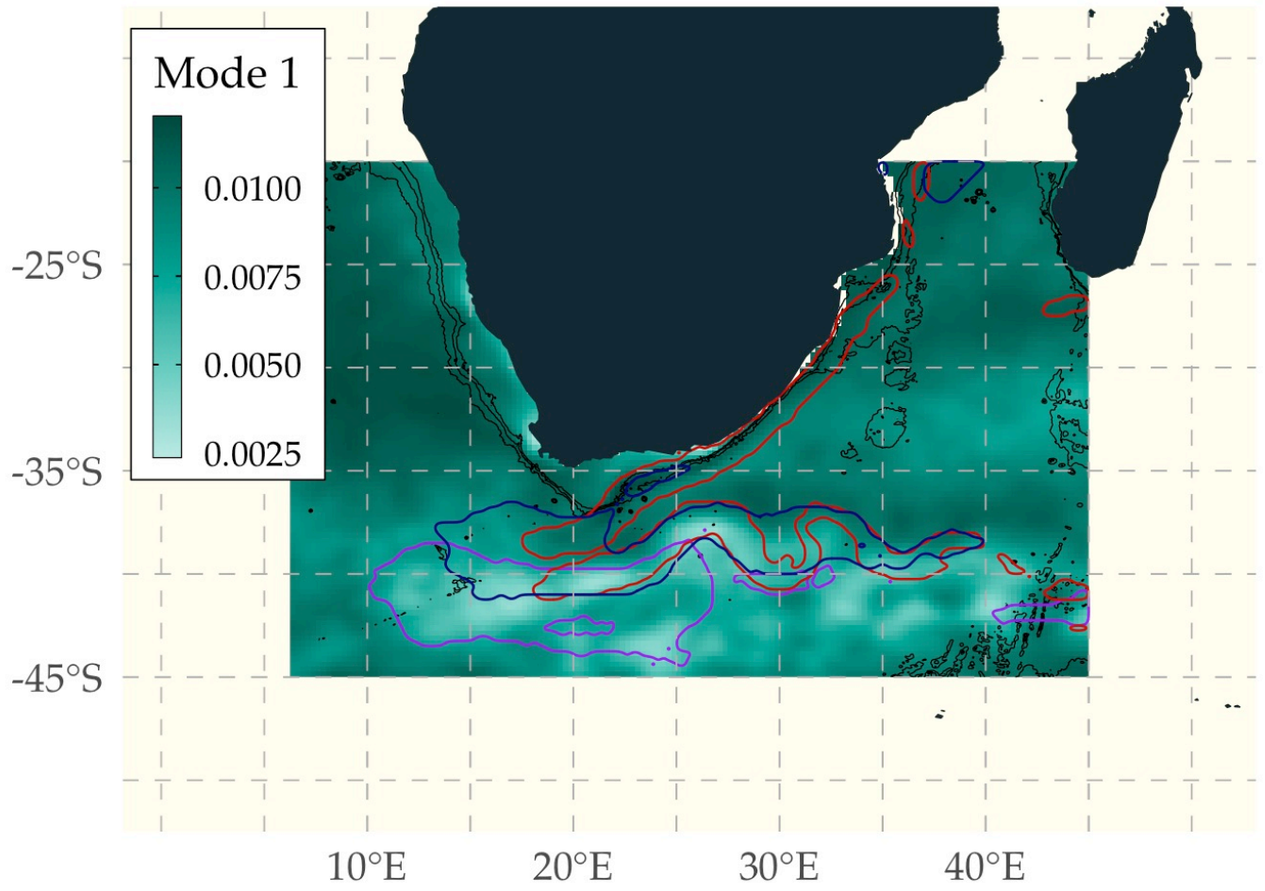
UNIVERSITY of the WESTERN CAPE
SAEON
EZEMVELO KZN WILDLIFE
South African Weather Service
KWAZULU-NATAL SHARKS BOARD
National Research Foundation
environmental affairs
Department: Environmental Affairs
REPUBLIC OF SOUTH AFRICA
agriculture, forestry & fisheries
Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Effect 2: marine heat waves

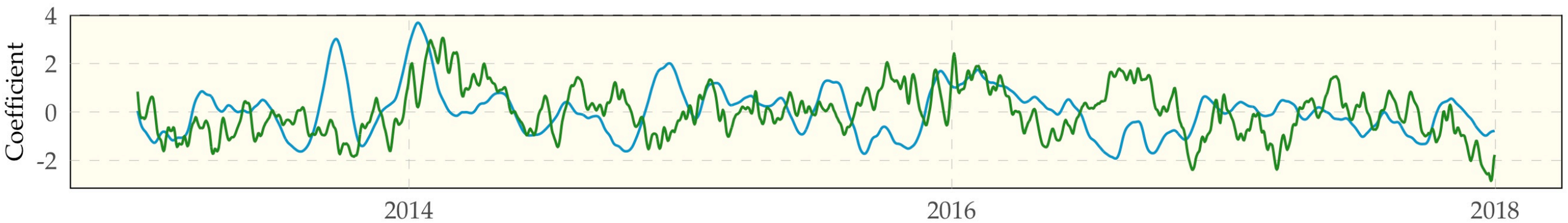
EKE anomaly



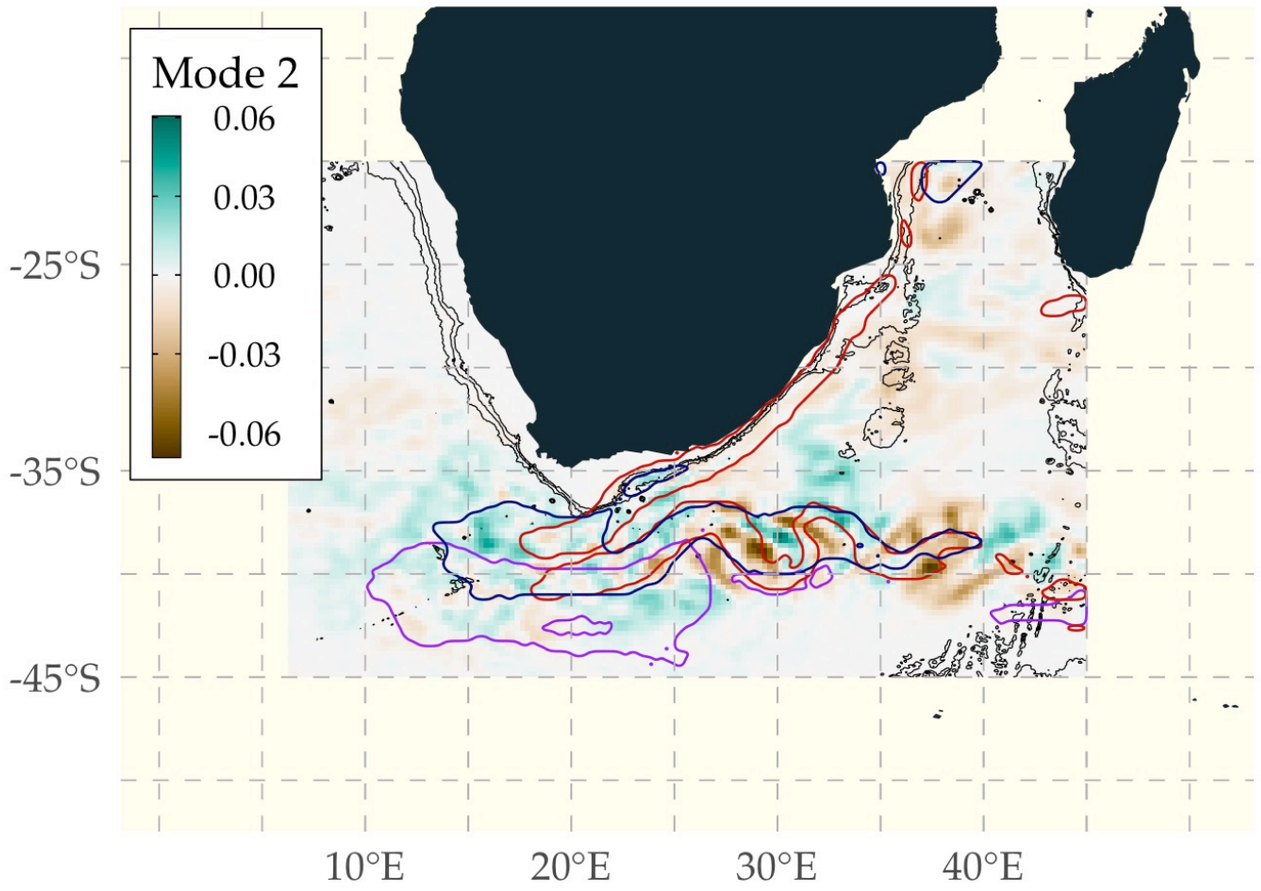
Exceedance anomaly



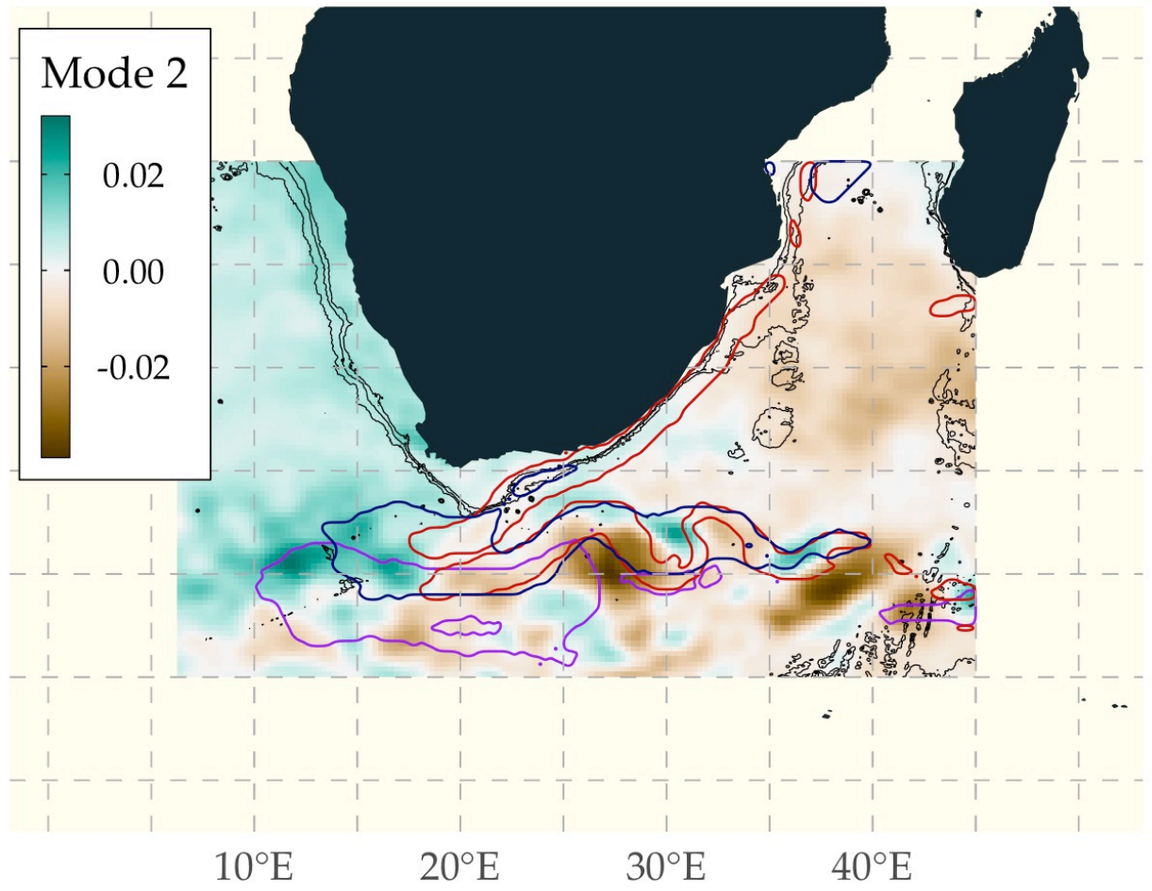
SCF = 99.5%; r = 0.07



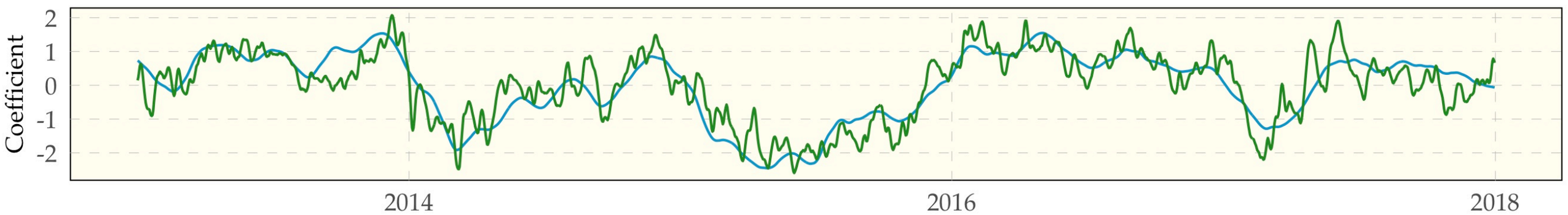
EKE anomaly



Exceedance anomaly



SCF = 0.1%; r = 0.87



SENTINEL Hub Playground 2018-07-13 20 % Search places

Rendering Effects

Custom

Natural color
Based on bands 4,3,2

Color Infrared (vegetation)
Based on bands 8,4,3

False color (urban)
Based on bands 12,11,4

Agriculture
Based on bands 11, 8, 2

Vegetation Index
Based on combination of bands (B8 - B4)/(B8 + B4)

Moisture Index
Based on combination of bands (B8A - B11)/(B8A + B11)

Geology
Based on bands 12,4,2

Bathymetric
Based on bands 4,3,1

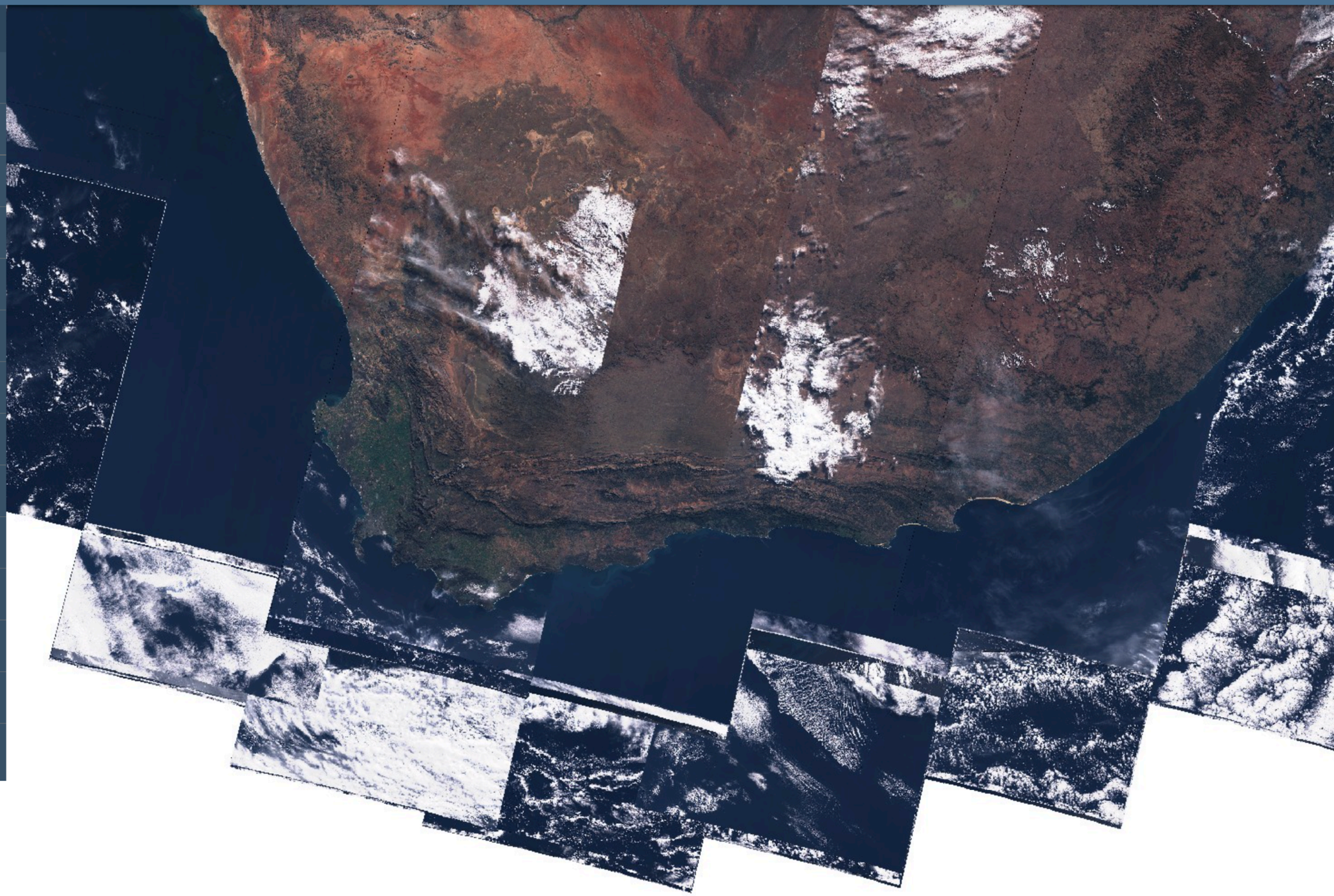
Atmospheric penetration
Based on bands 12,11,8A

SWIR
Based on bands 12,8A,4

NDWI
Based on combination of bands (B3 - B8)/(B3 + B8)

SWIR-2,11,12
Based on bands 2,11,12

GENERATE

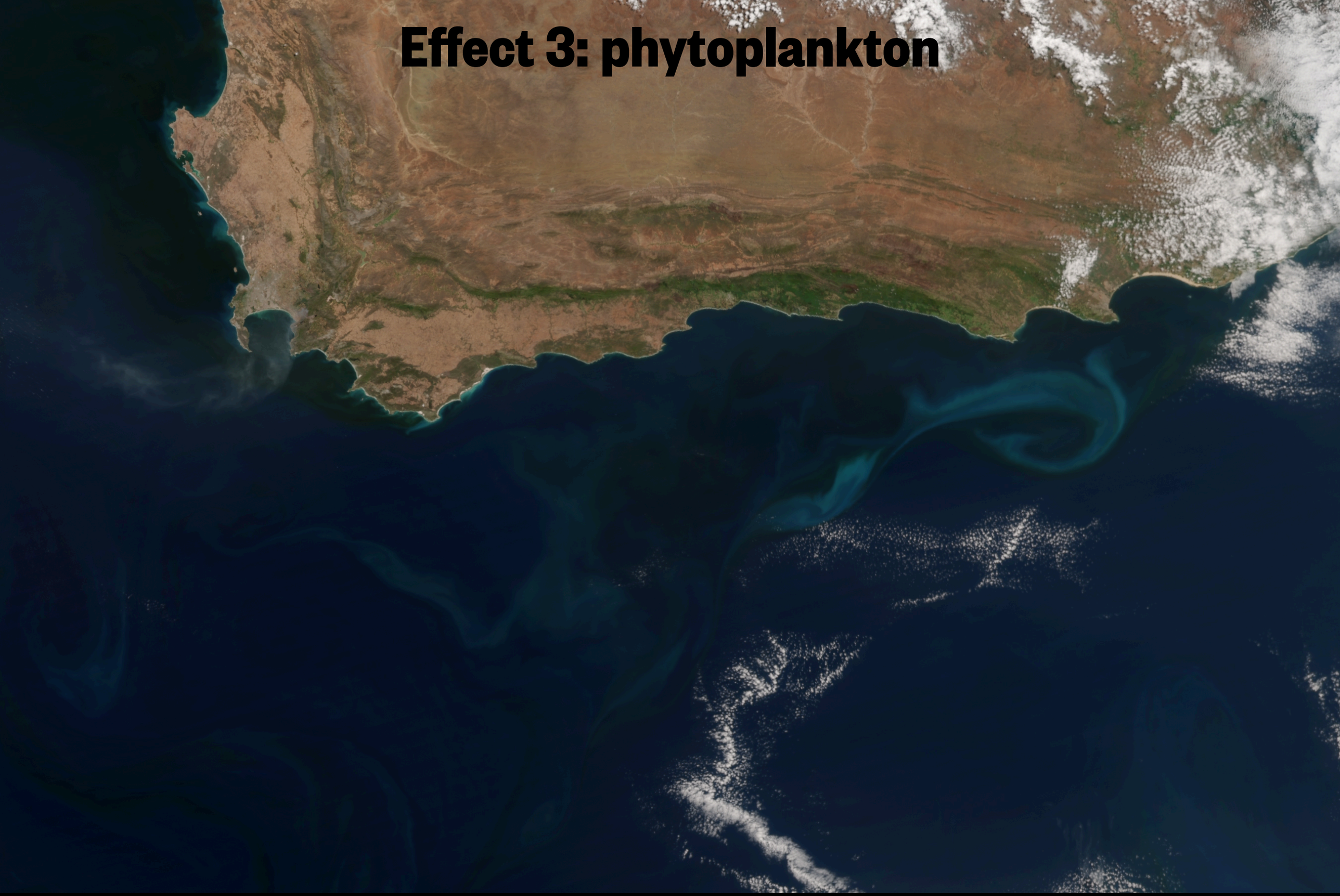


Get Sentinel and Landsat imagery in your GIS

100 km

OpenStreetMap © Sentinel Hub

Effect 3: phytoplankton



The Visible Infrared Imaging Radiometer Suite (VIIRS) on Suomi NPP acquired the image of southern Africa on January 4, 2017.

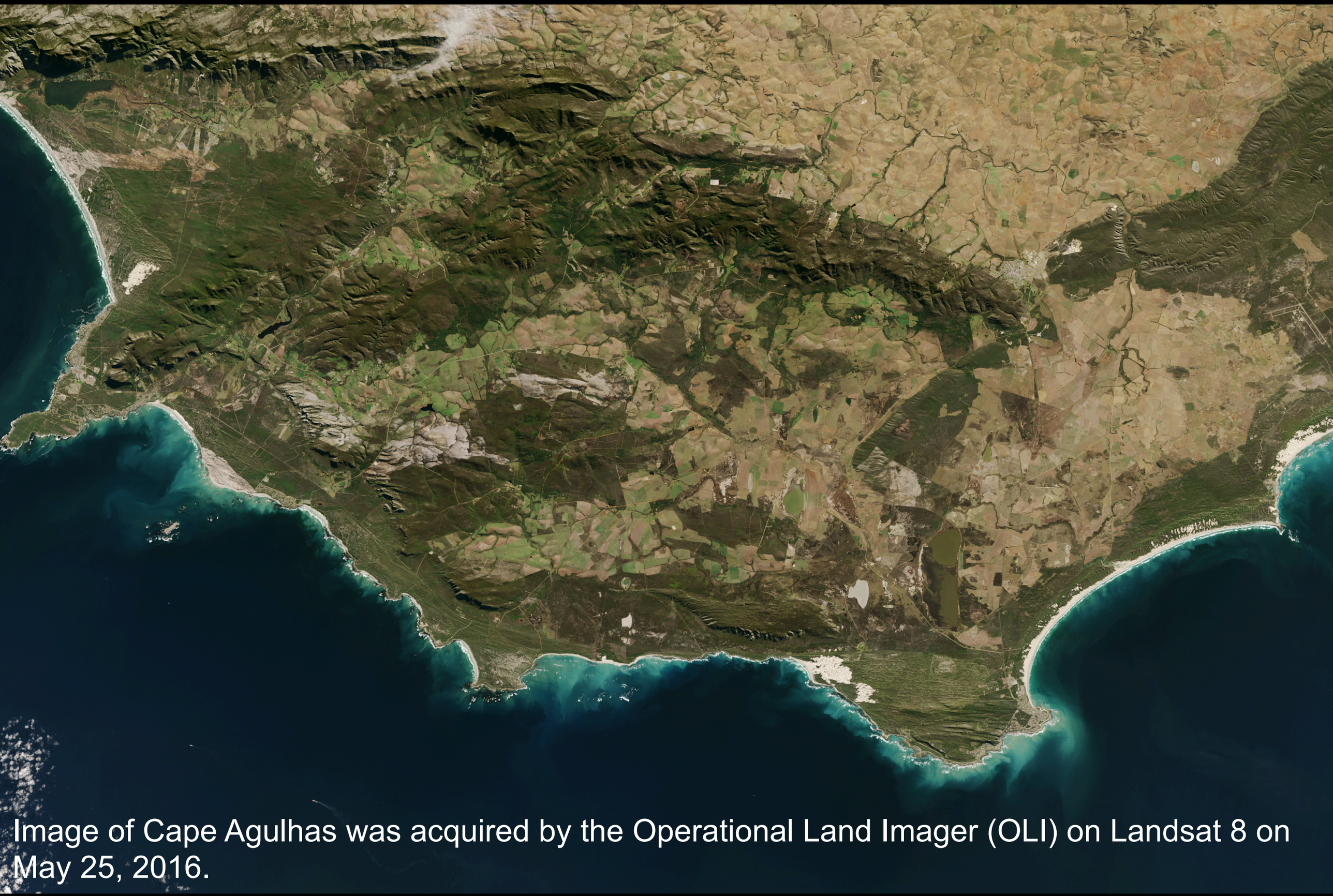
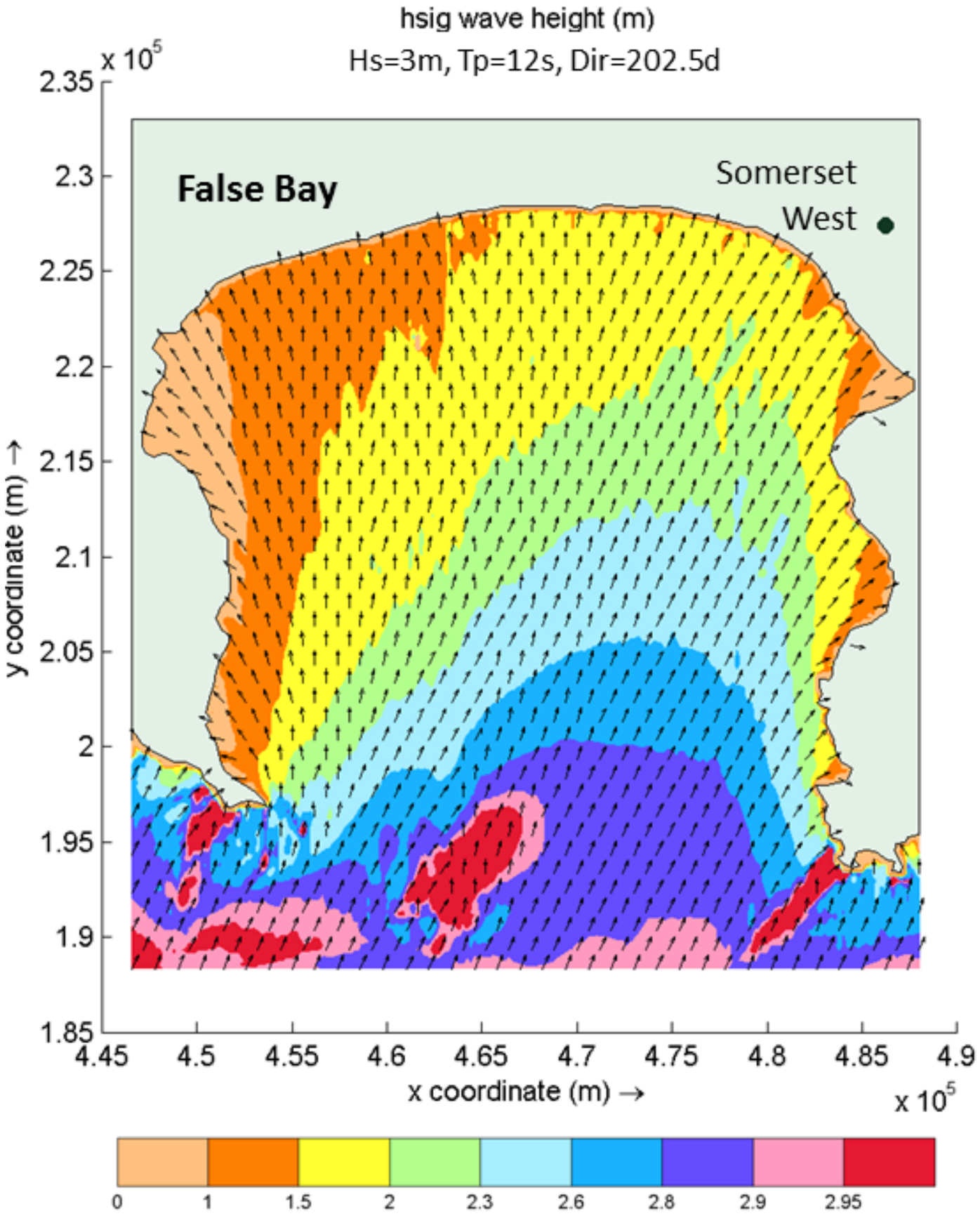
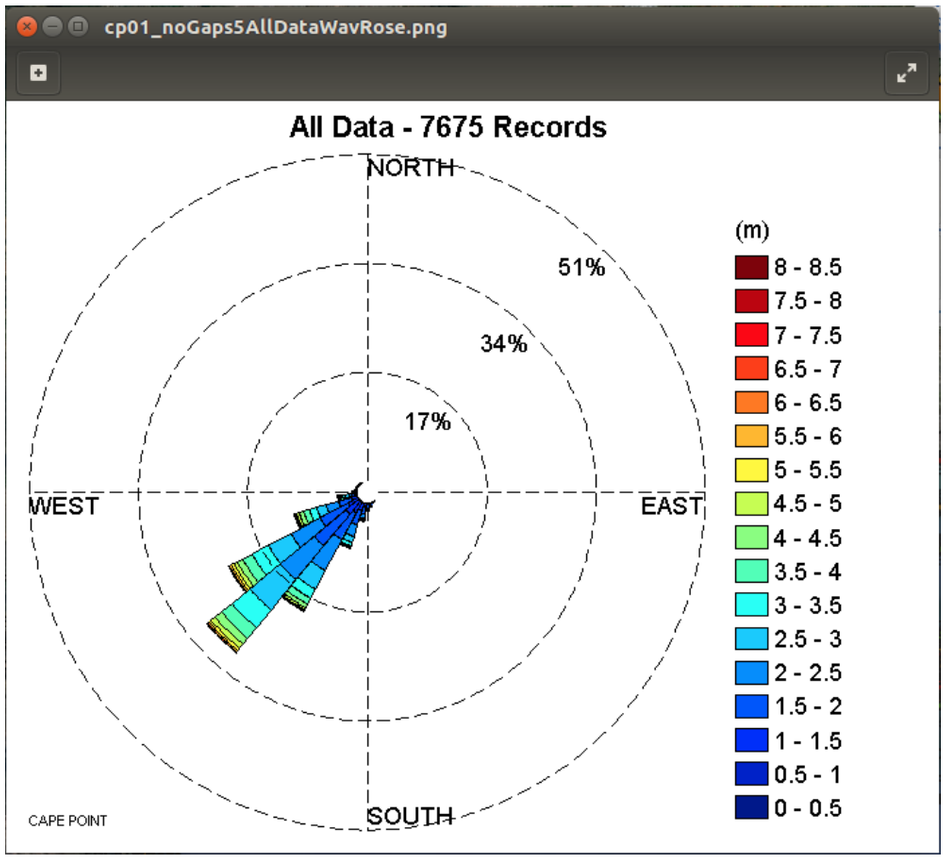


Image of Cape Agulhas was acquired by the Operational Land Imager (OLI) on Landsat 8 on May 25, 2016.

Effect 4: waves





Numerical wave model

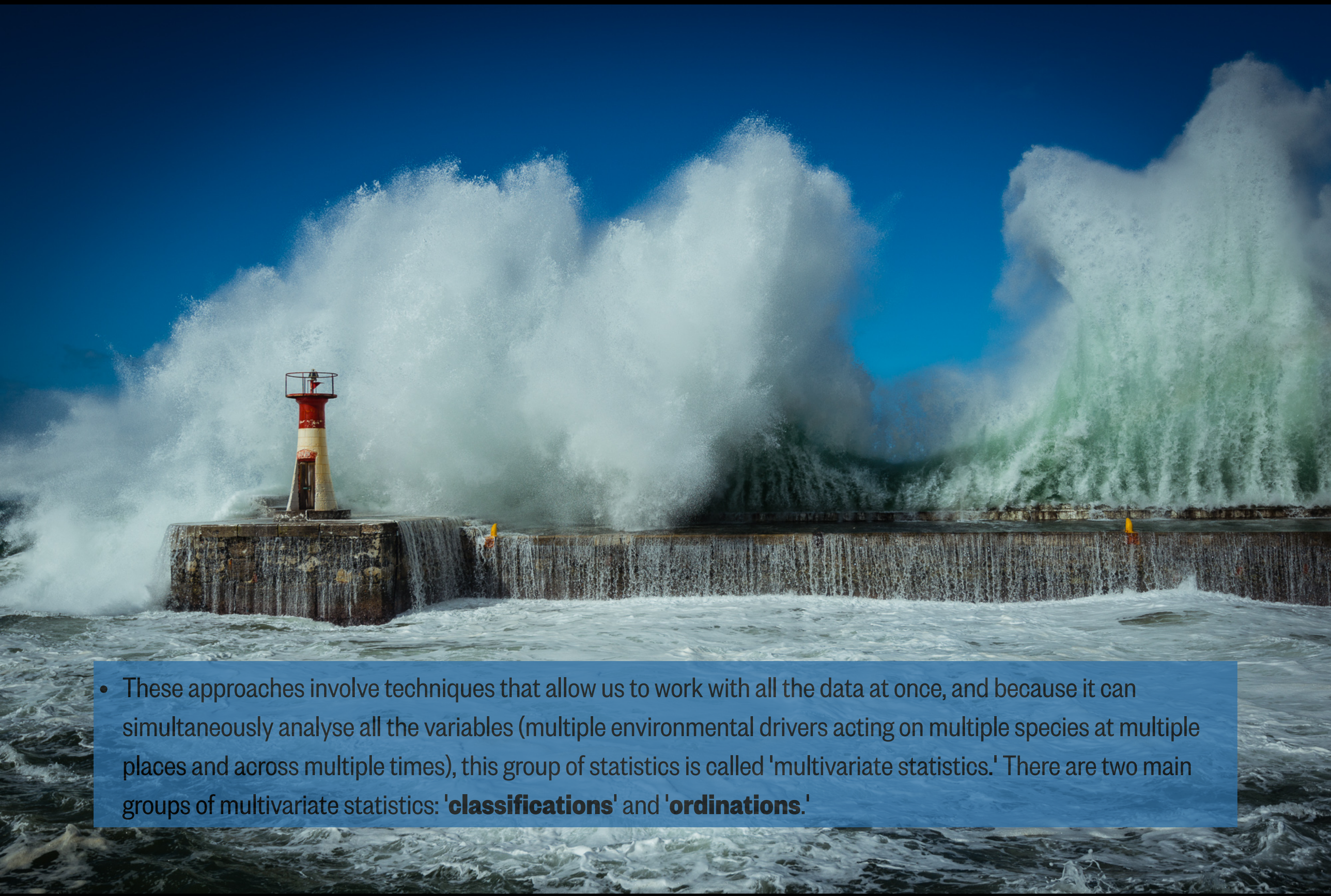
- **Wave Watch III forced by NCEP winds at 3hr resolution, hindcast from 1994-2013**
- **Wave parameters modelled using SWAN**
- **200m alongshore resolution**

2018-06-13
2018-04-11
2018-06-13
2018-06-05
SENTINEL Hub

What is Quantitative Ecology?

- Community ecologists tend to analyse how multiple environmental factors act as drivers that influence the distribution of tens or hundreds of species.
- These data are often be messy and statistical considerations need to be understood within the context of the data available to us.

- This translates to errors of measurement and errors due to extreme values, the presence of a few very rare or very abundant species, autocorrelated residuals (due to repeated sampling, for example), collinearity, issues of scaling, etc.
- These challenges make the application of 'basic' statistical approaches problematic, and a new branch of inferential and exploratory statistical needs to be followed.



- These approaches involve techniques that allow us to work with all the data at once, and because it can simultaneously analyse all the variables (multiple environmental drivers acting on multiple species at multiple places and across multiple times), this group of statistics is called 'multivariate statistics.' There are two main groups of multivariate statistics: '**classifications**' and '**ordinations**.'

- Classification generally concerns placing samples (species or environments) into groups or hierarchies of groups.
- Ordination is best suited for analyses that involve arranging samples along gradients.
- Often they complement each other, but we shall see later that each approach has its own strengths. Irrespective of the analysis, the data share a few characteristics.