

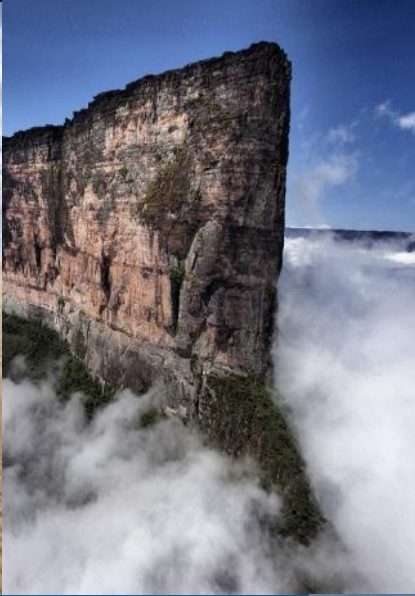
Physical Landscape and the Geosphere

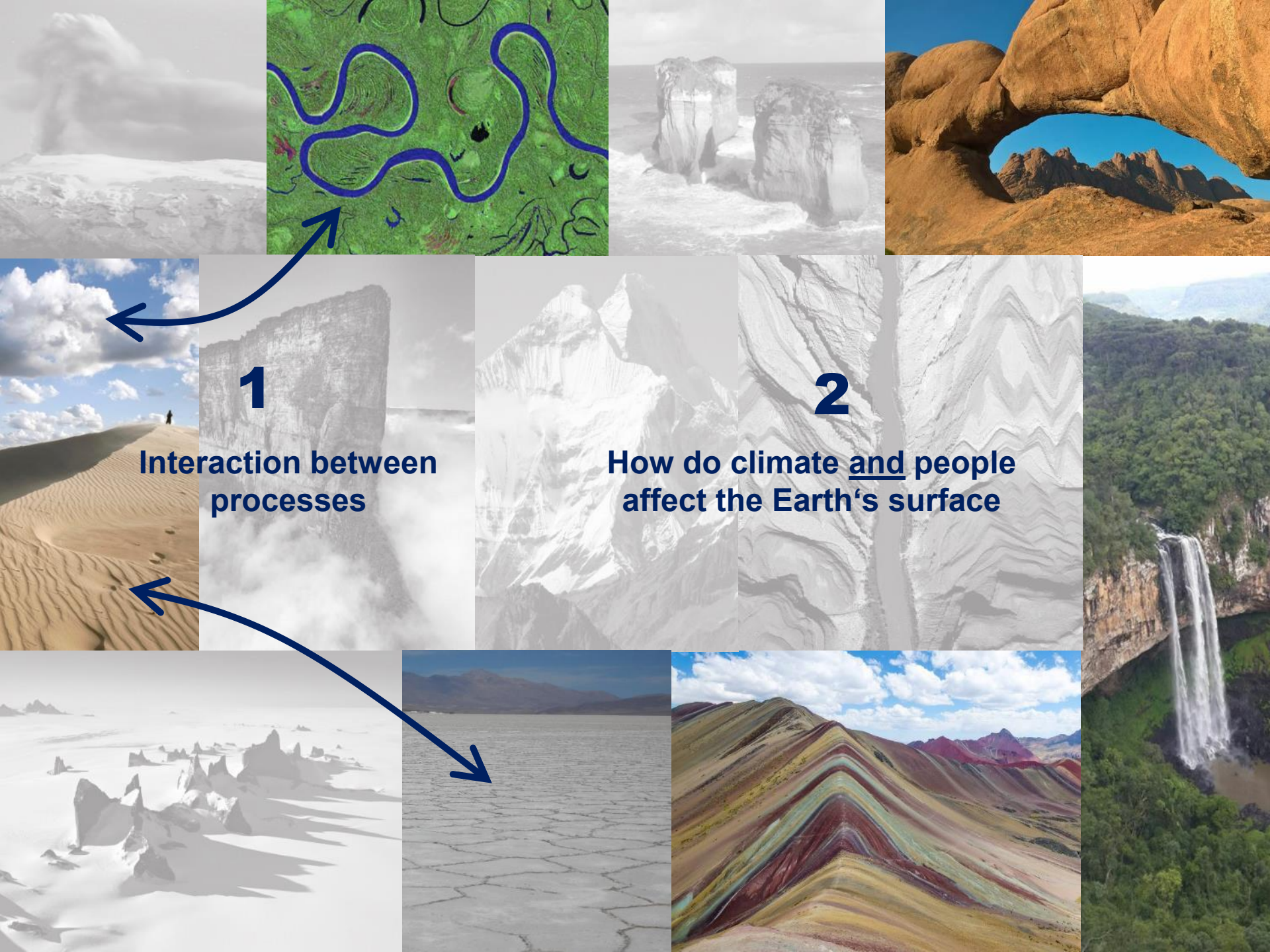
ACNA4007



Prifysgol Cymru
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Trinity Saint David

Course Introduction





1

Interaction between
processes

2

How do climate and people
affect the Earth's surface

Today's class...

Part I: Introduction

- Course aims
- Assessment
- Course readings
- Break and activity

Part II: Geomorphic theory

- What are landscapes?
- What is geomorphology?
- Spatial & temporal scales
- Unifying concepts in geomorphology



Course aims...

Aim: Upon the successful completion of this module, you should be able to: express an understanding of Earth systems and their influence on the environment, establish an understanding of the physical processes that influence the environment & complete practical fieldwork on a selected physical landscape.

Why is that important... ?



We all live on Earth surface...



Landscapes are „great“ – global and diverse !!

Key Issues (1)...

- Human settlements in relation to geomorphic processes



e.g. Natural hazards...

What is the relationship between these (recent) dynamic processes, and the longer-term dynamics of changing climates and landscapes

i.e. Do we understand enough to predict and protect?

- Forman, S. and Stinchcomb, G. E. 2015. Views on grand research challenges for Quaternary geology, geomorphology and environments. *Frontiers in Earth Sciences* 3: Article 47

Key Issues (2)...

- Human effects on geomorphic processes



e.g. Human Impact

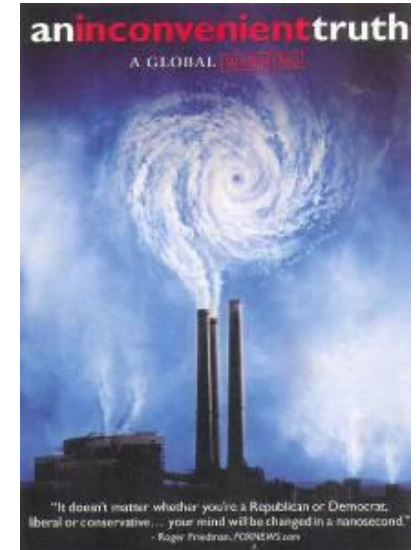
How are we changing geomorphic processes (e.g. erosion, sediment transport)?

i.e. which significance does this have for our environment?

- Forman, S. and Stinchcomb, G. E. 2015. Views on grand research challenges for Quaternary geology, geomorphology and environments. *Frontiers in Earth Sciences* 3: Article 47

Key Issues (3)...

- Humans, a key component of the Earth system



e.g. Global & Climate Change

Reconstruction
of the past



Where are we and
where are we going...?

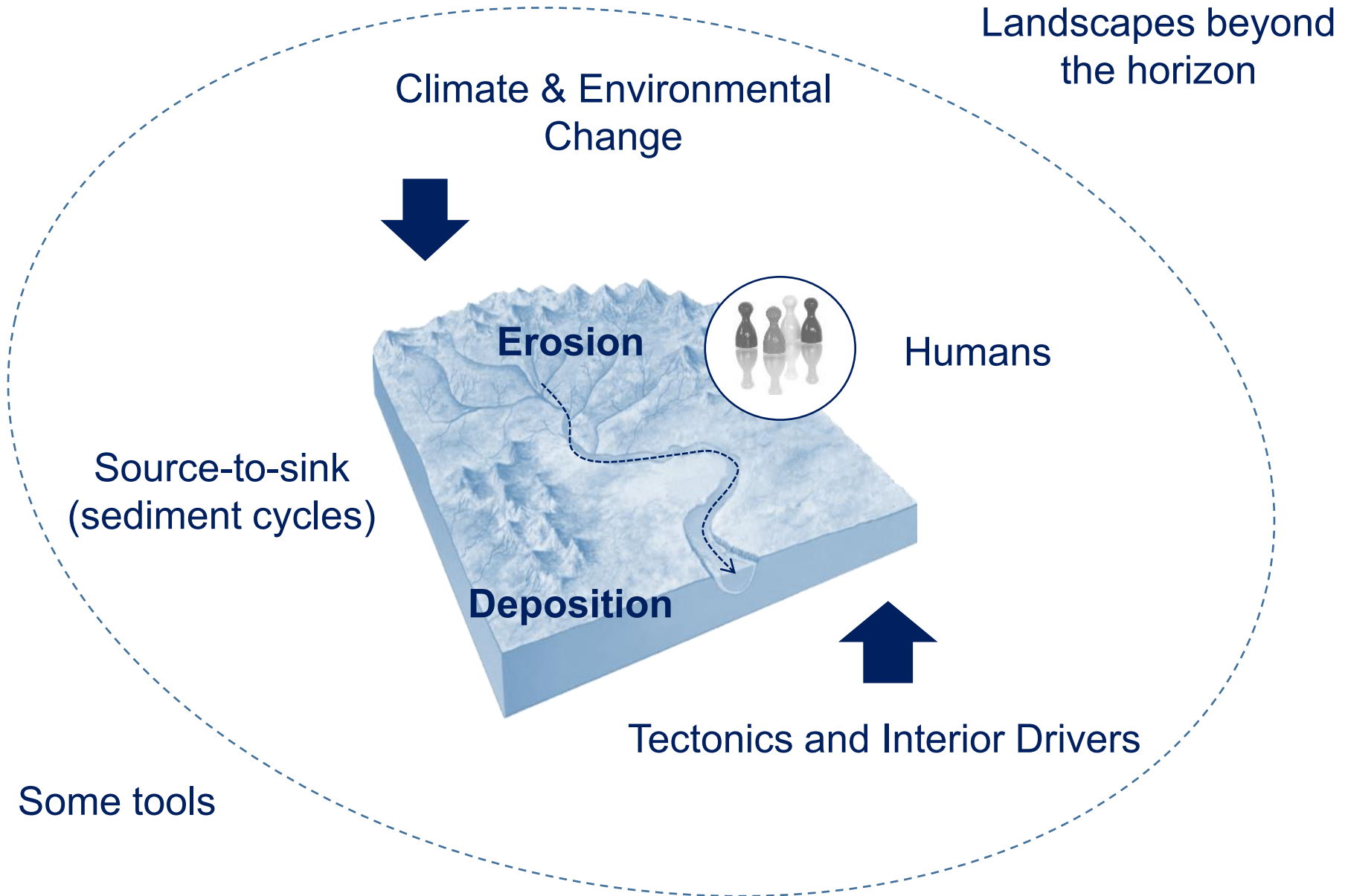


Prognosing
the future

How are we changing the Earth system, i.e. which significance does this have for the future on this planet?

- Forman, S. and Stinchcomb, G. E. 2015. Views on grand research challenges for Quaternary geology, geomorphology and environments. Frontiers in Earth Sciences 3: Article 47

Course themes...



Semester One

Week	Date	Topic
1	02/10/2026	Landscapes: Concepts and Geomorphic Theory
2	09/10/2026	Geologic Time and Continental Drift
3	16/10/2026	Endogenic Processes
4	23/10/2026	Field Work Week
5	30/10/2026	Aeolian Environments
6	06/11/2026	Bed Rock Rivers - Weathering and Erosion
7	13/11/2026	Hydrology: Lowland Rivers and Fluvial Landscapes
8	20/11/2026	Skills week: Assignment
9	27/11/2026	Sedimentology Lab: analysis of collected data
10	04/12/2026	Karst Environments
11	11/12/2026	Inland Seas - Geophysics

Semester Two

12	08/01/2027	Geochronology
13	15/01/2027	Biogeochemical Cycles & Remote Sensing
14	22/01/2027	Slope Processes
15	29/01/2027	Inter-Semester Week
16	05/02/2027	Glaciers
17	12/02/2027	Glaciation in Wales
18	19/02/2027	Periglacial Environments
19	26/02/2027	Soils and Soils Practical
20	05/03/2027	Marine and Coastal Landscapes
21	12/03/2027	Google Earth Engine
22	19/03/2027	REVISION SESSION FOR EXAM
	26/03/2027	Easter Break
	02/04/2027	Easter Break
	09/04/2027	Easter Break
23	16/04/2027	Anthropogenic Influences on Physical Processes
24	23/04/2027	Geo-futures
25	30/04/2027	Revision/Catchup

Time commitments...

1 x 2-hour lecture session per week:

- Friday 11am-1pm (**face-to-face lecture** & lecture capture)
- Swansea SA1 Campus, IQ Room 201 (this room)

Activity type	Hours	Percentage
Scheduled learning	48	24%
Independent learning	152	76%
Placement learning		
TOTAL	200	100%

Face-to-face field trip & assessment...

- Fieldwork Week (non-assessed)
- Report on River Processes(assessed) – We will collect data in the field.

Assessment (also see Moodle)...

Activity type	Percentage
Written exam	50%
Coursework	50%
Practical	
TOTAL	100%



Mode of assessment	Volume	Weighting
Field Report	2500 words	50%

Mode of assessment	Volume	Weighting
Examination	2 hours	50%



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Landscapes...

Concepts and Geomorphic Theory

ACNA4007 – Physical Landscape and the Geosphere

Definitions...

- Several definitions – depending on context
- A landscape includes the physical elements of *geophysically defined* landforms, human elements, and transitory elements.
- Natural vs Cultural landscapes



“Visible features of an area of land, its landforms and how they integrate with natural or man-made features”

Landscape and Geomorphology

“The whole is greater than the sum of its parts” (Aristotle)

1

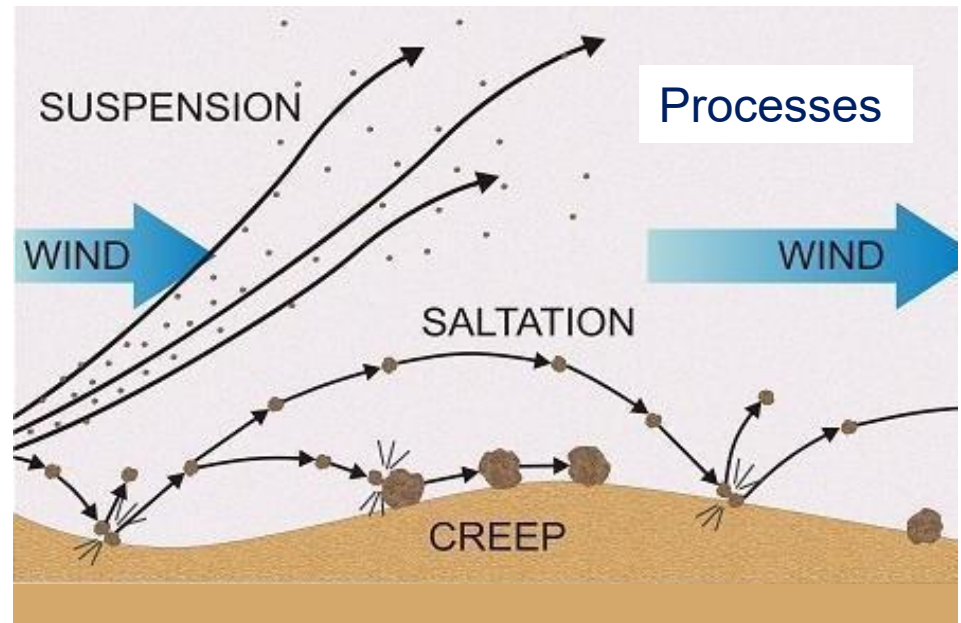
2

“Every feature of the landscape is there for a reason. We just have to be smart enough to figure out what the reason is”

- **Geomorphology** (from greek γῆ ge ,Earth‘, μορφή morphé ,Form‘, and λόγος λόγος ,Word‘, ,Science‘, ,Reason‘)...
- ... the science of landforms, **landscapes** and physical processes which create and shape them over time...

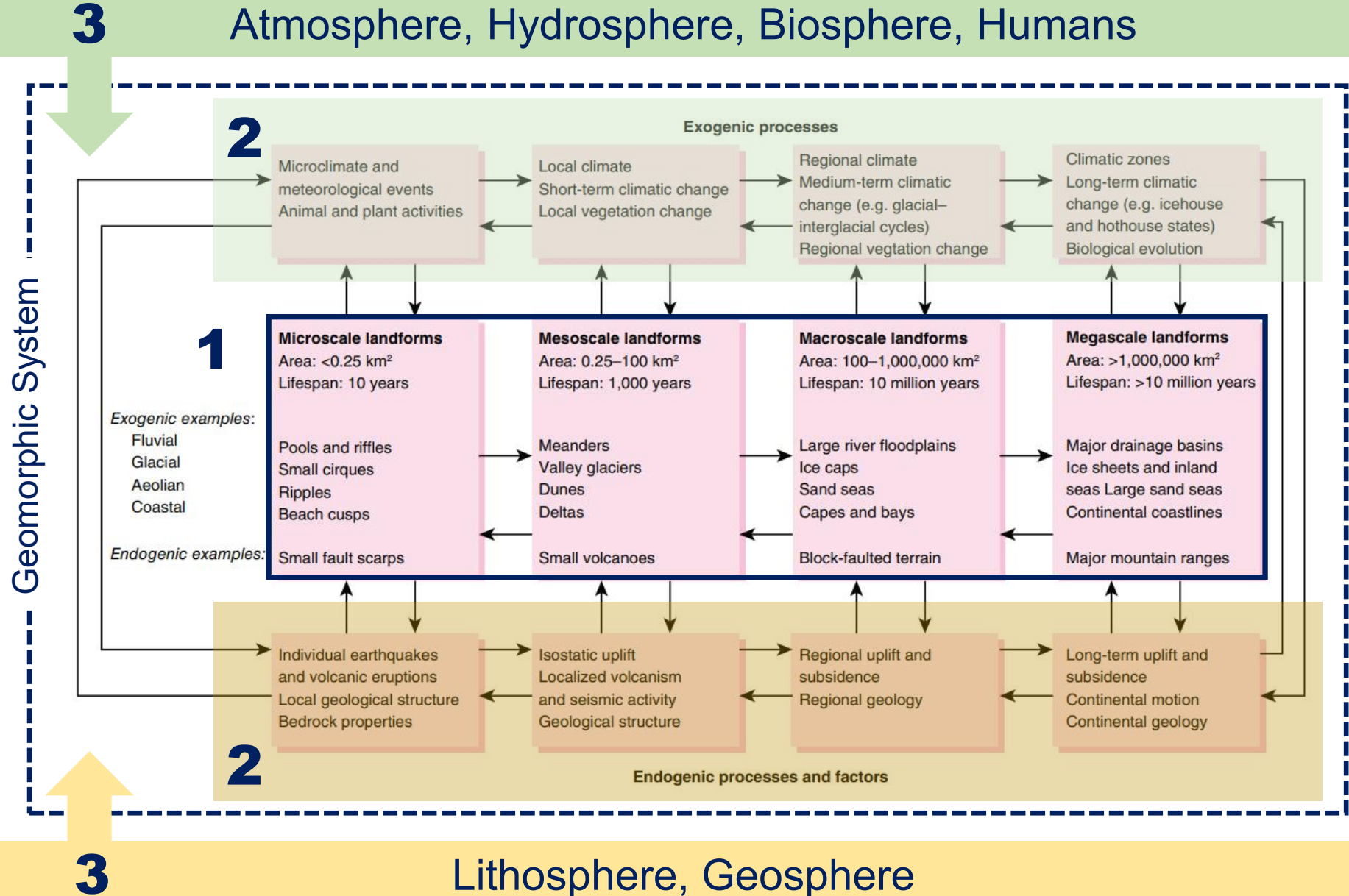
Intro to Geomorphology

1. **Landforms are:** features of the Earth's surface with a morphology (form) that results from the interaction of physical processes.
2. **Processes are:** Forces inducing a change in the materials or landforms at the Earth's surface.



3. **Earth surface dynamics** – how do processes and landforms interact over time, i.e. landscapes evolve ?

Process-Form Relations



(1) Exogenic vs Endogenic



Endogenic Processes: uplift
of mountains, formation of
new rock and relief

The form of the
Earth's surface at
any time is the
result of the
interaction of
endogenic and
exogenic
processes



Exogenic processes:
Surface processes,
destructional and
constructional



Exogenic Process: weathering,
erosion, transport and deposition
by ice, water, wind etc.

Endogenic processes:
forces within the Earth,
generally constructional

(2) Geomorphic System & Drivers

Atmosphere, Hydrosphere, Biosphere, Humans

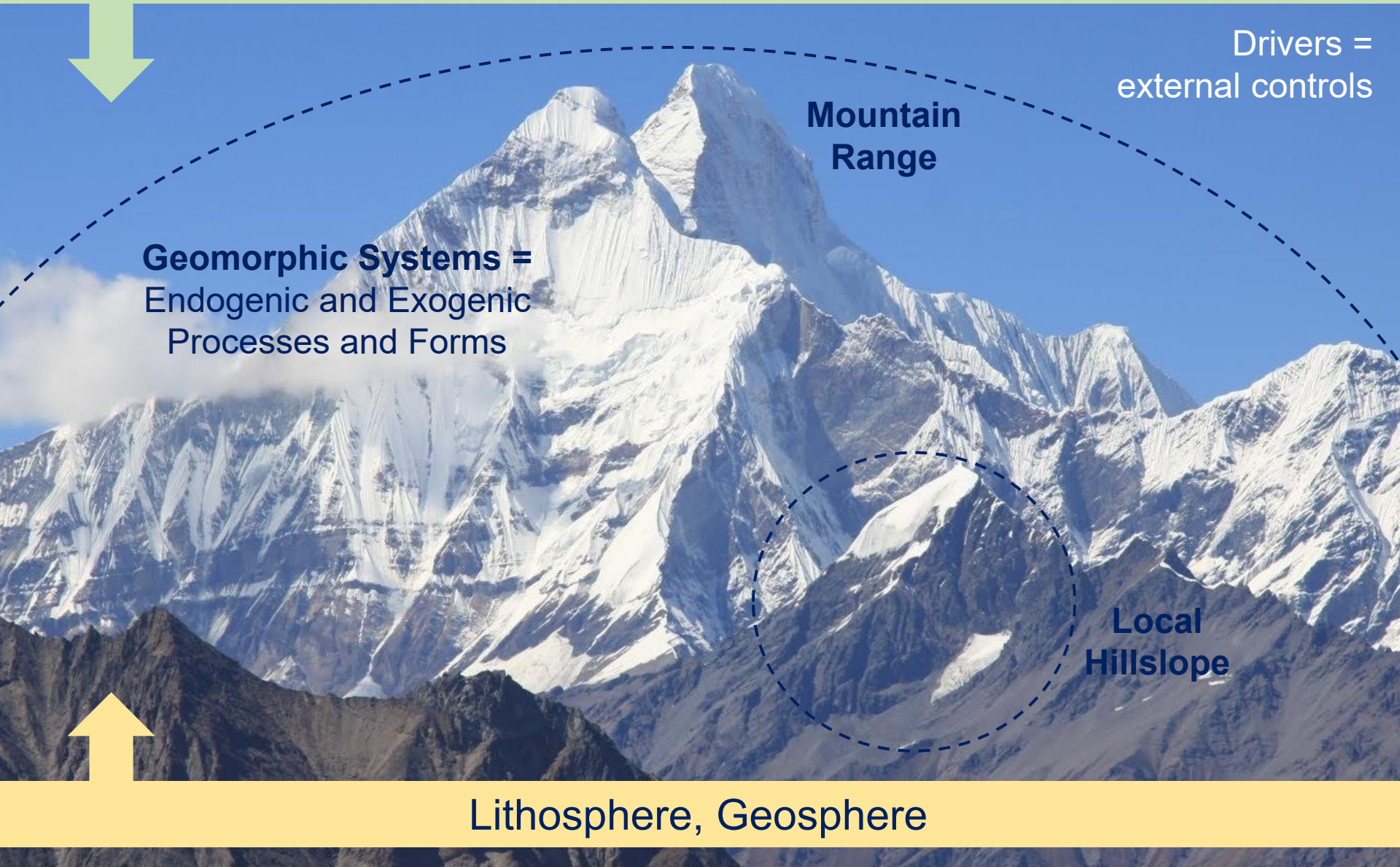
Drivers =
external controls

**Mountain
Range**

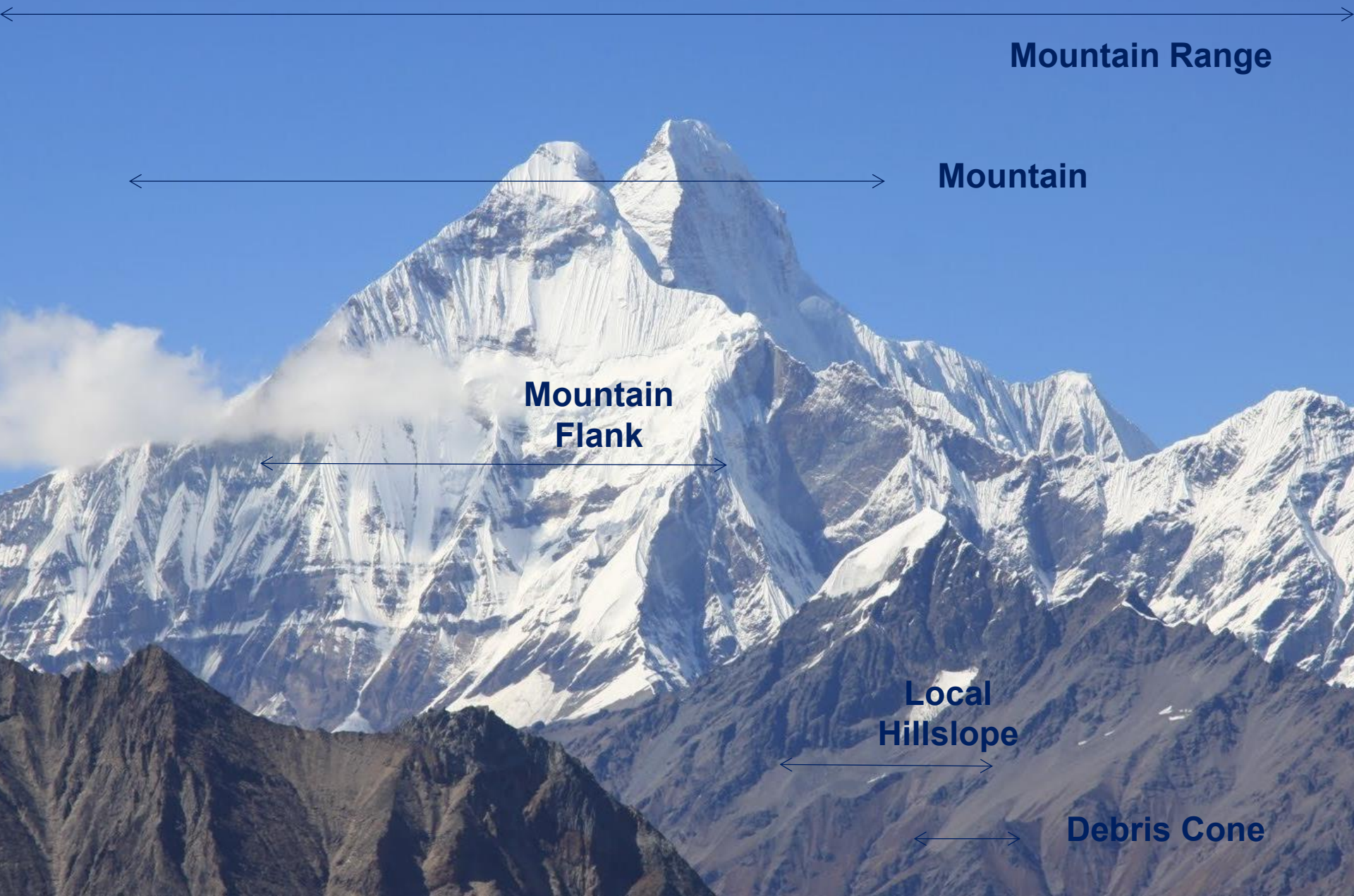
Geomorphic Systems =
Endogenic and Exogenic
Processes and Forms

**Local
Hillslope**

Lithosphere, Geosphere



(3) Landforms and Spatial Scales



Mountain Range

Mountain

**Mountain
Flank**

**Local
Hillslope**

Debris Cone

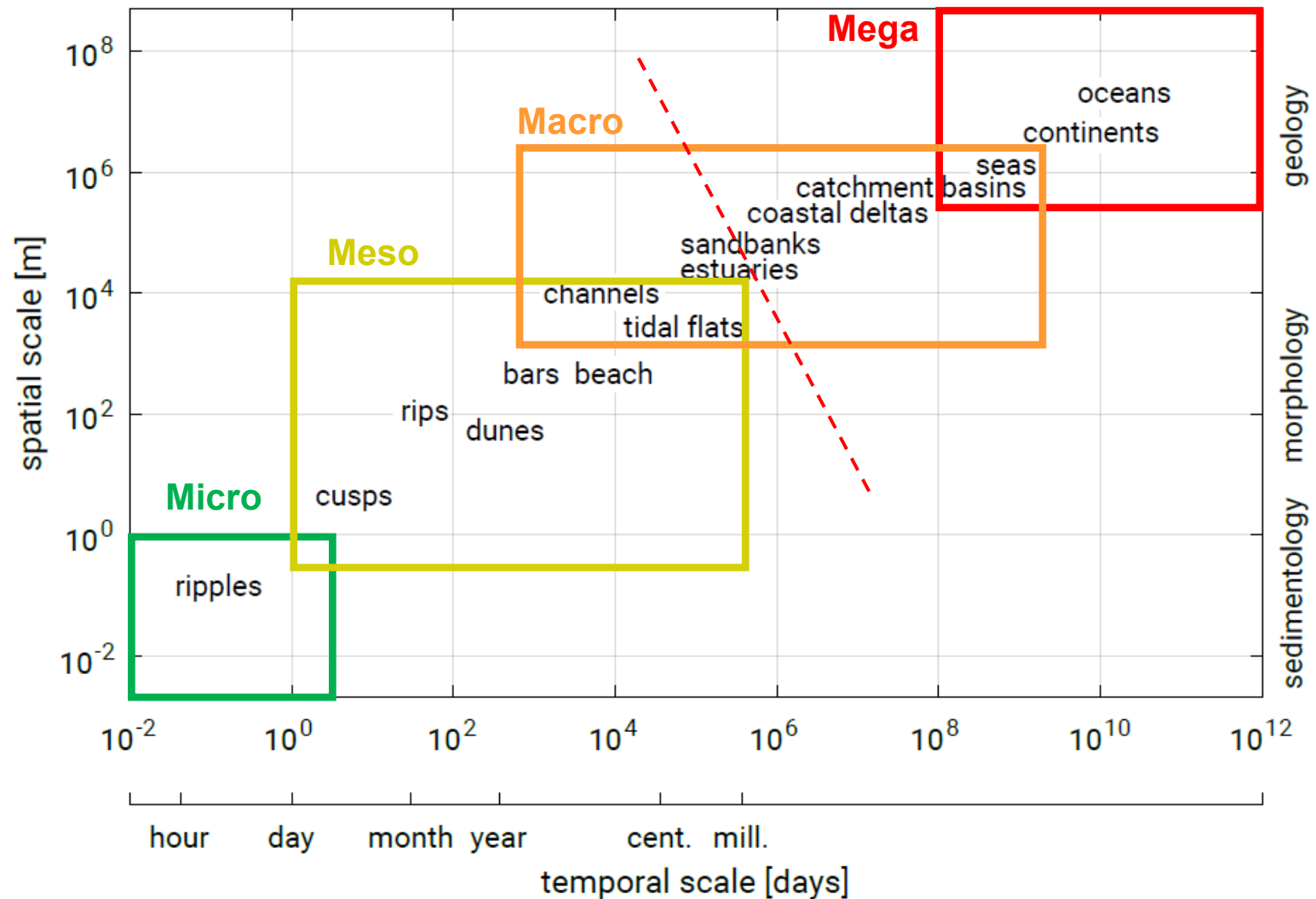
(4) Landforms and Spatial Scales

Within Geomorphology we work at four different scales,
Take a few minutes to look up the names of these 4 scales
and an example of each scale



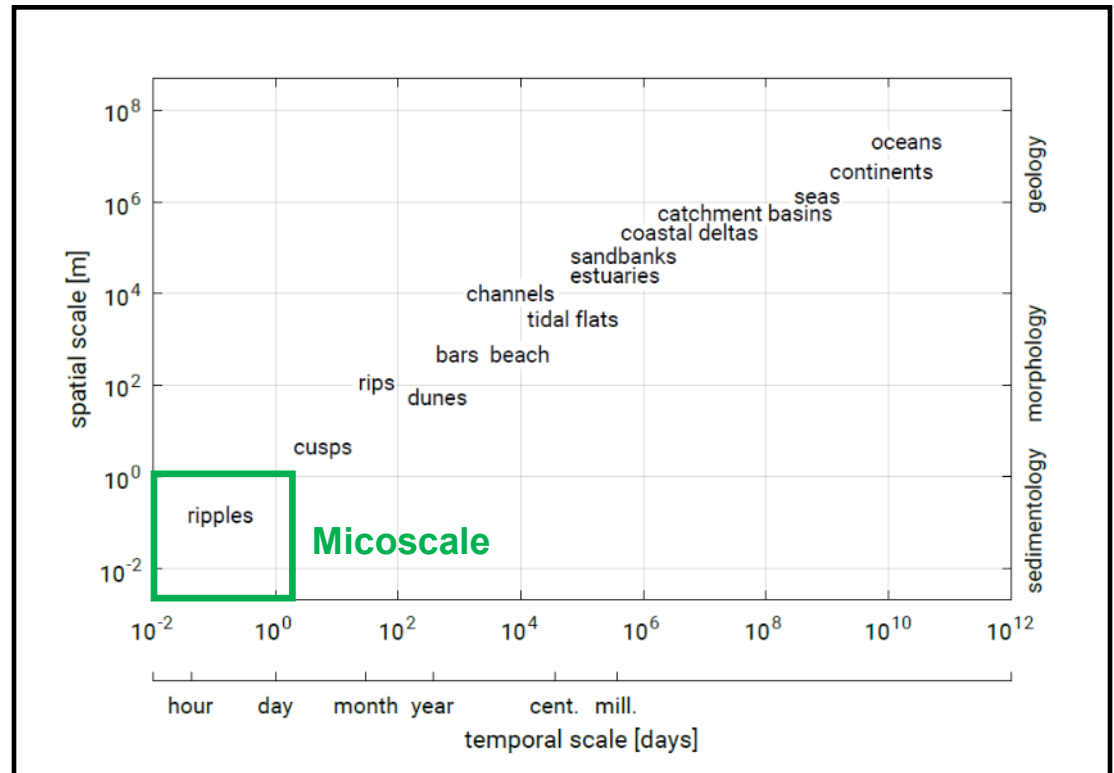
Spatial Scales

Orders of magnitude difference in scale



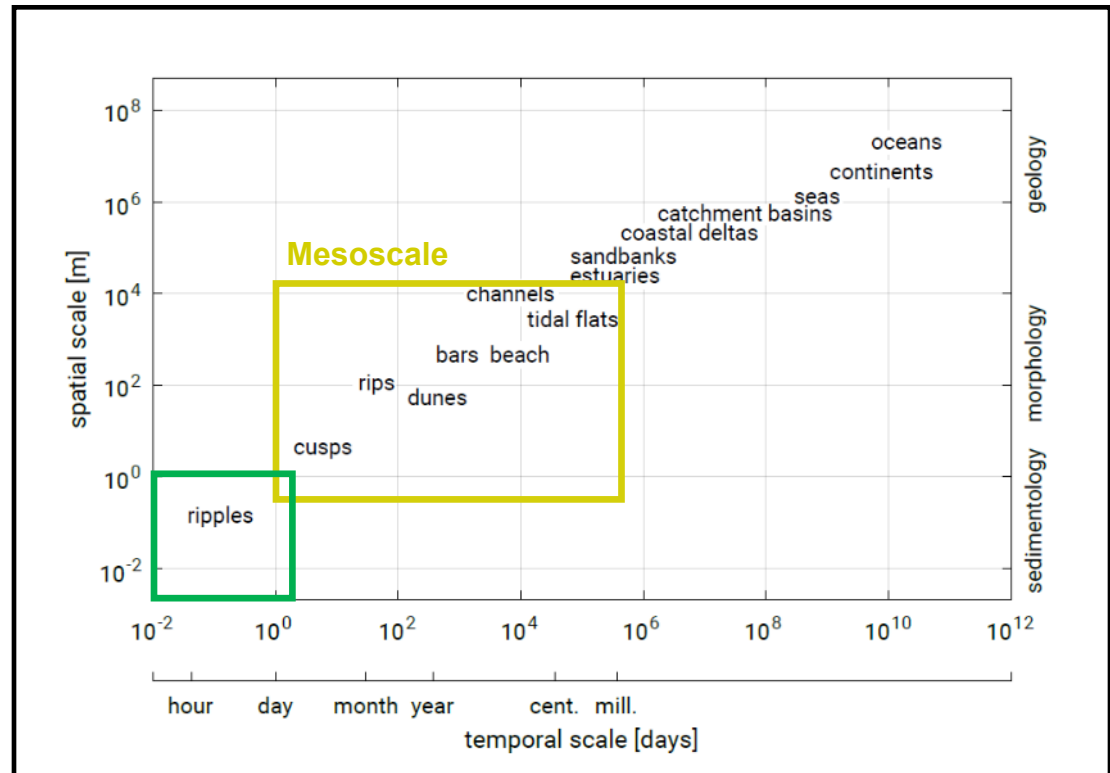
(1) Microscale

- Small and easily observable processes (mm-cm)
- Occur over seconds-days (instantaneous)
- e.g. hydrodynamics and sediment movement
- Predicted by mathematical models.



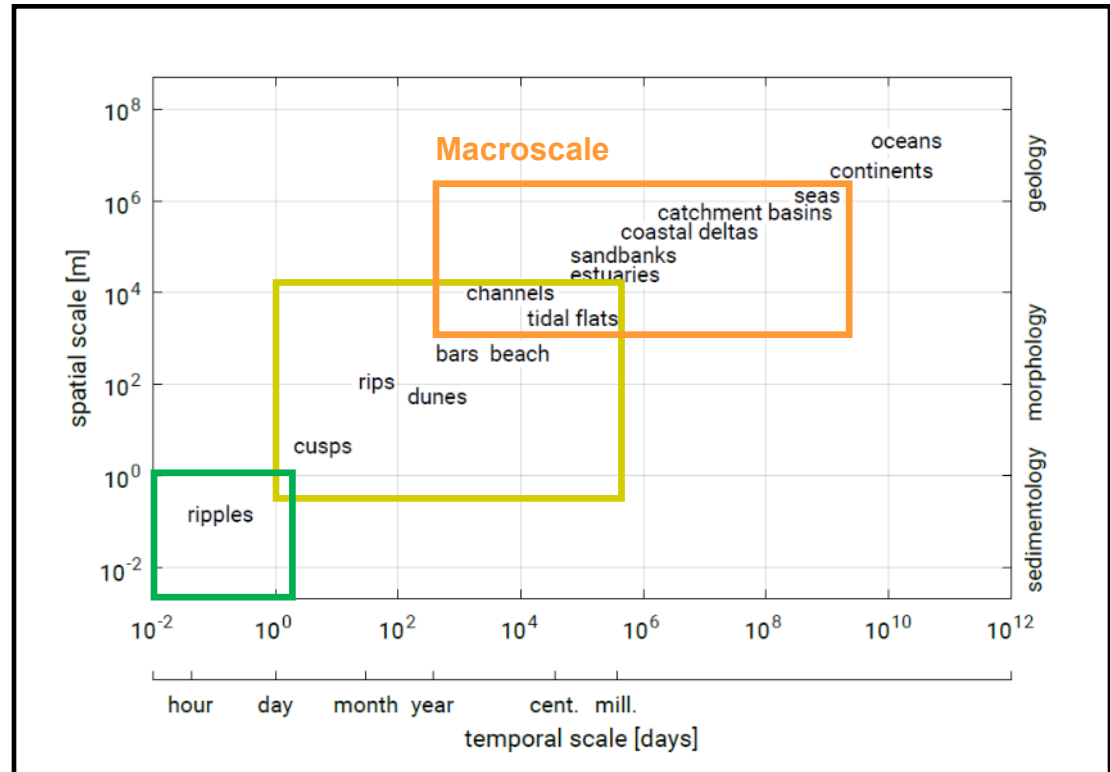
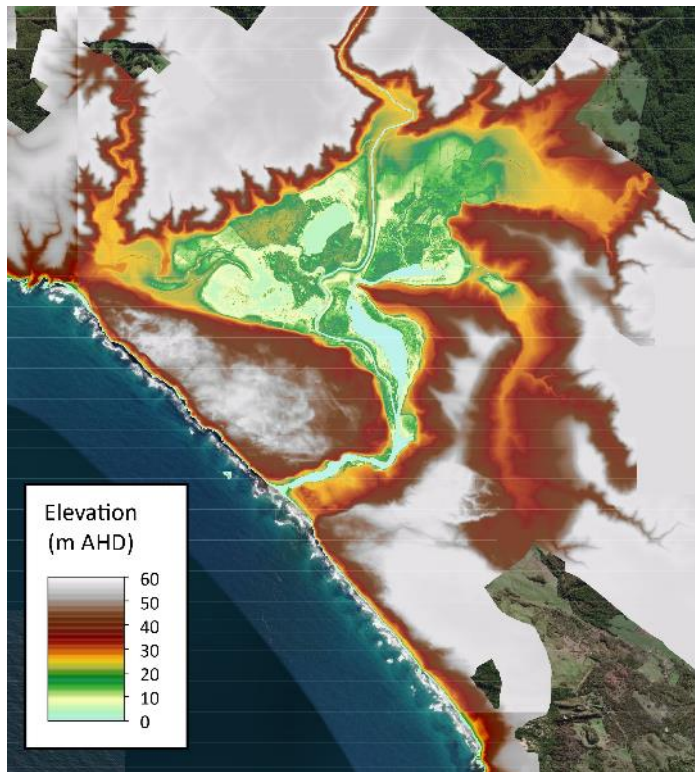
(2) Mesoscale

- Accessible, human memory (m - km; days - years)
- Change can have implications for management
- e.g. Beach state: erosion and deposition (days - years)
- Predicted by morphological models (change in form).



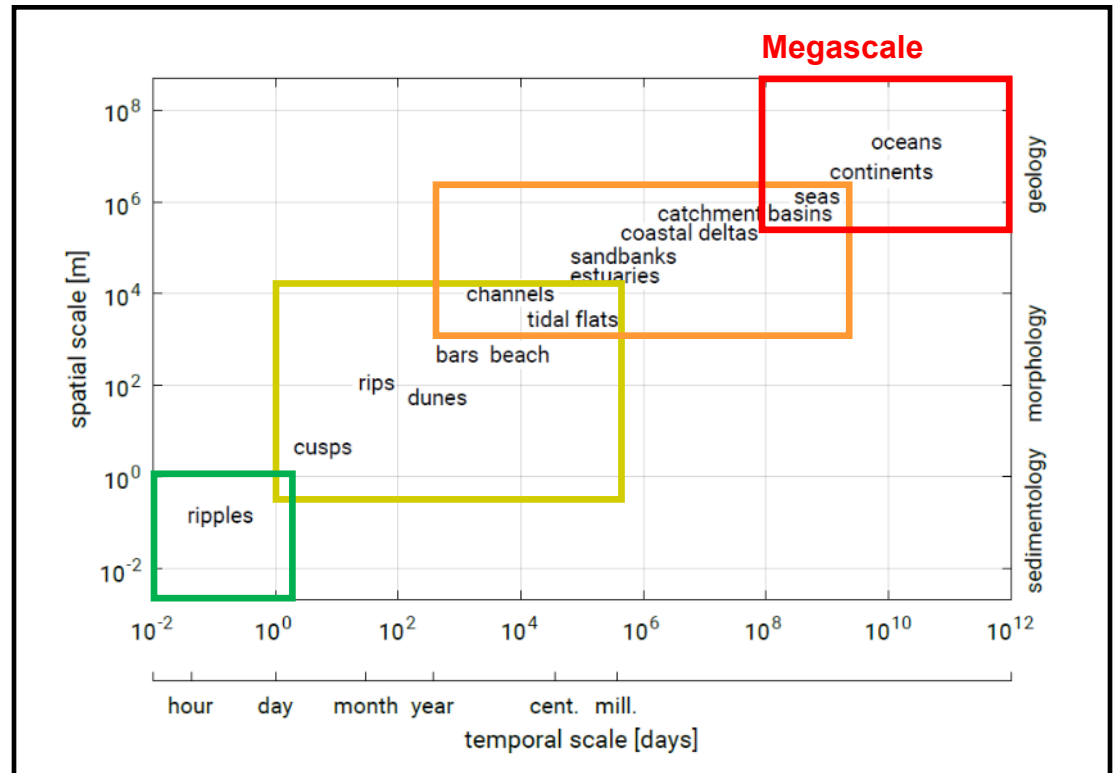
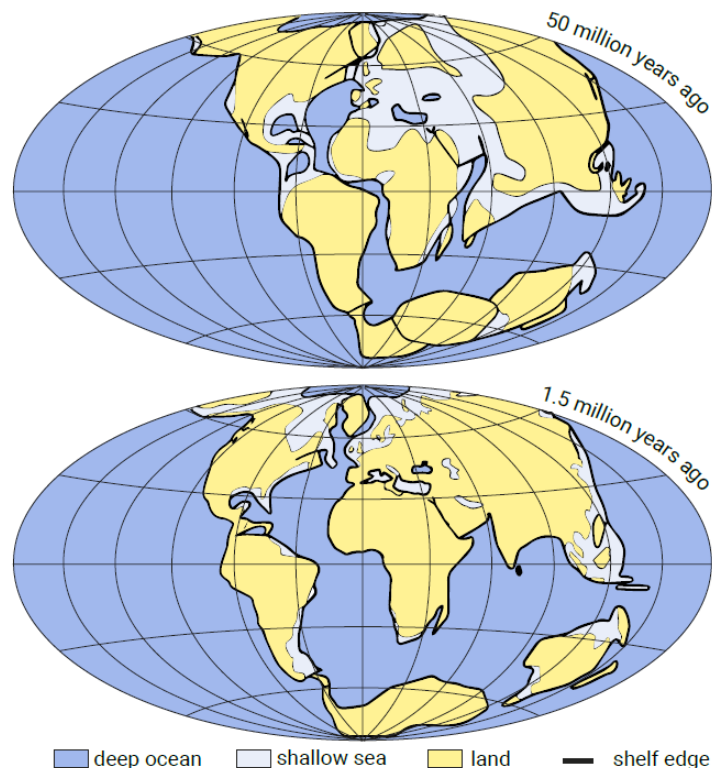
(3) Macroscale

- Long-term landscape evolution (100 - 1,000's km)
- Persist/operate over 1,000's - millions of years
- e.g. Long-term evolution of an estuary basin (infill)
- Landscape evolution models. Sedimentary data.



(4) Megascale

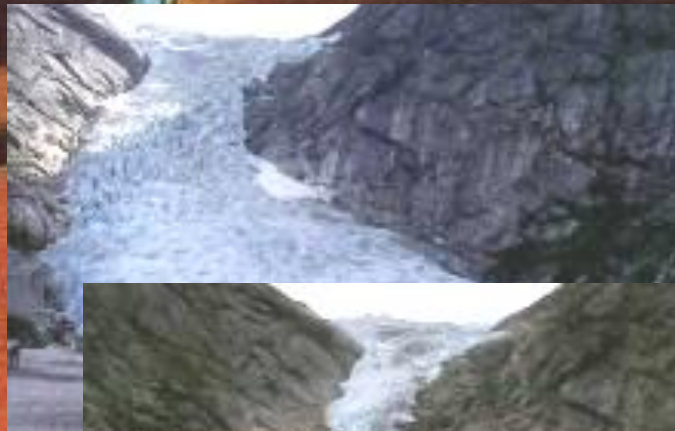
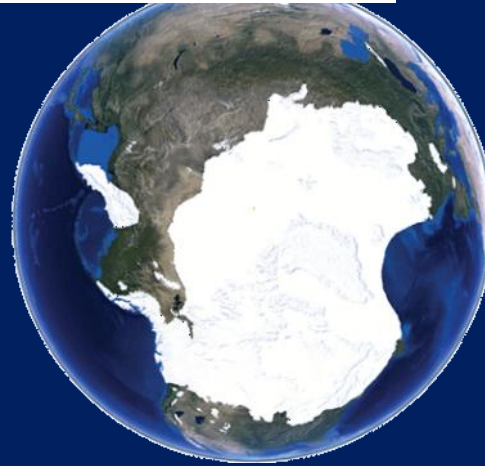
- Persist over geological time (> millions of years)
- Spanning >10's of thousands of km (continents/oceans)
- e.g. Continental configuration of coastlines
- Largely driven by tectonic activity and sea level change.



Temporal scales



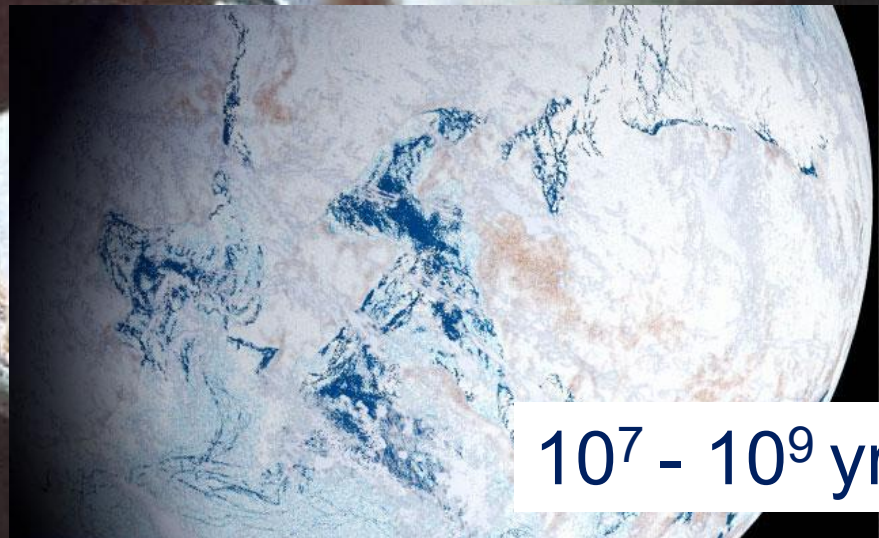
$10^4 - 10^6$ yrs



$10^1 - 10^3$ yrs

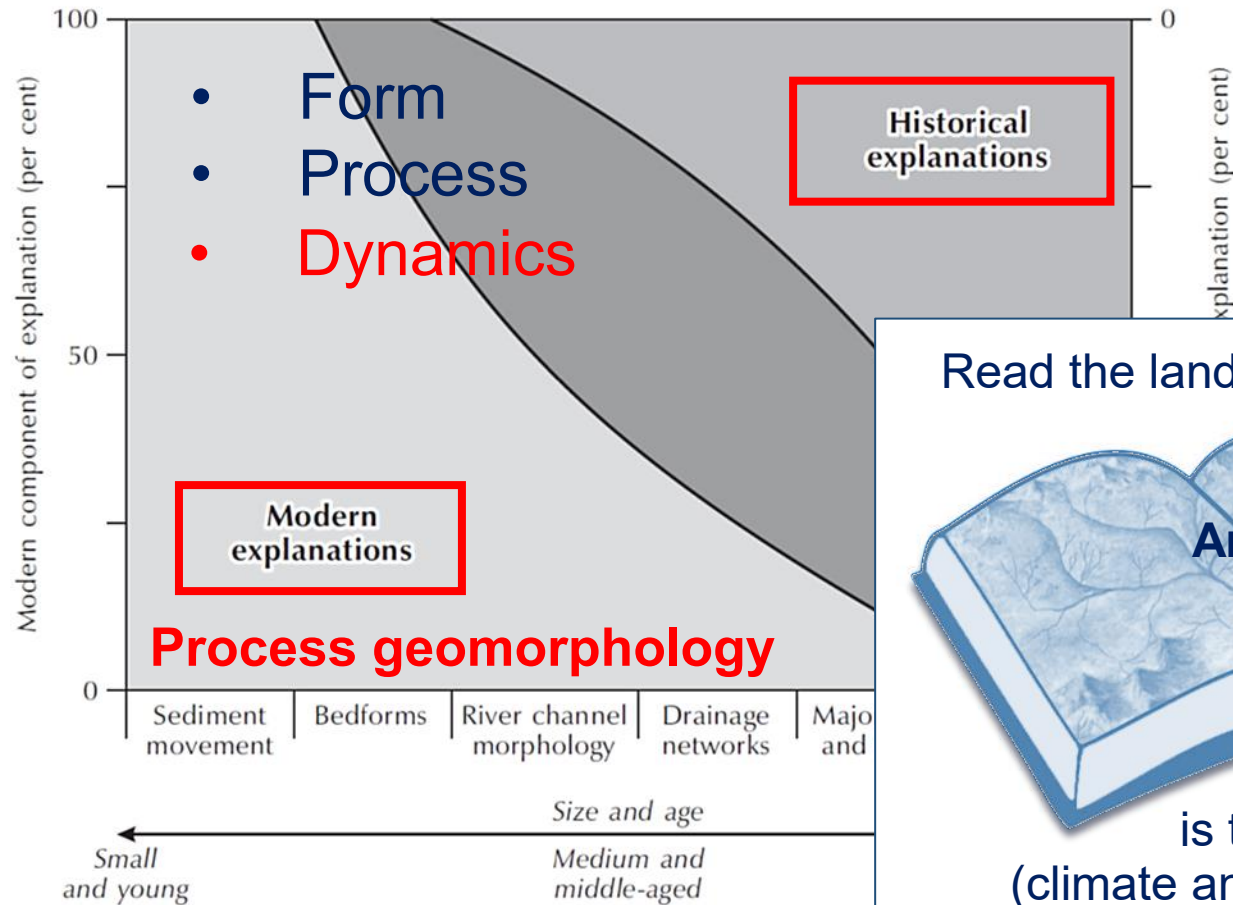


$10^7 - 10^9$ yrs



Spatial and temporal scales

“Every feature of the landscape is there for a reason. We just have to be smart enough to figure out what the reason is...”



**Historical
Geomorphology
/ Landscape
evolution**

Read the landscape...



is to learn about the past
(climate and landscape evolution)

- Temporal vs spatial scales

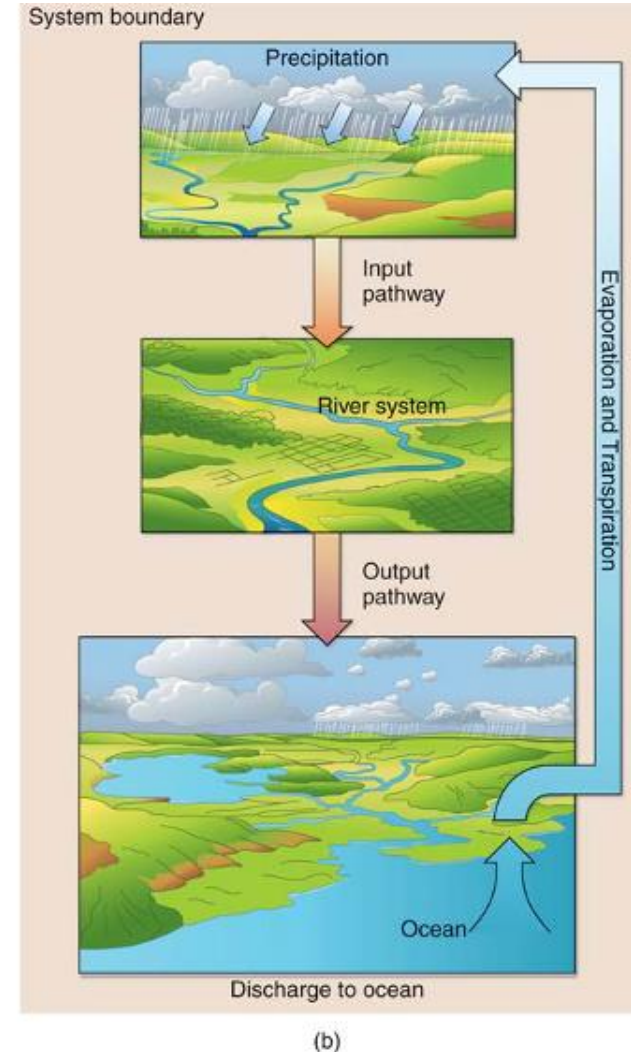
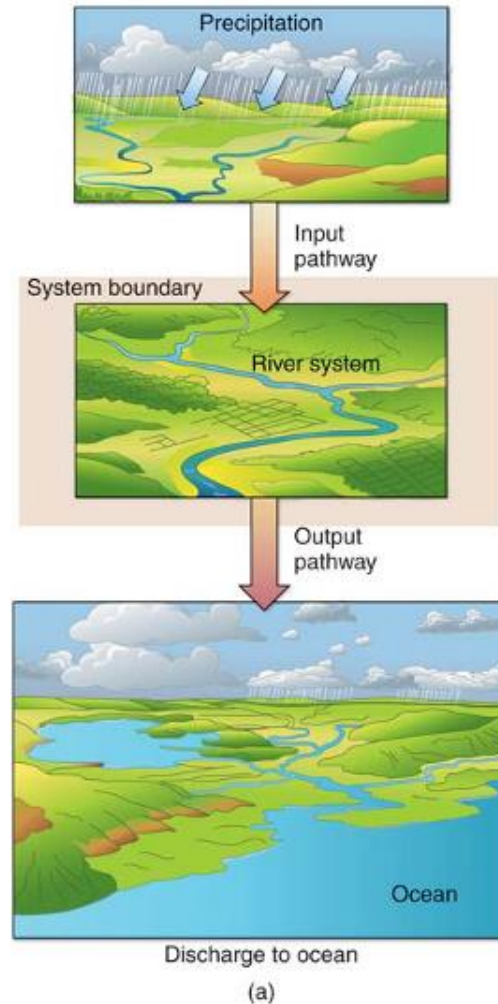
Unifying concepts - Activity

Across all spatial-temporal scales these concepts apply:

1. **Landscapes thought of as “systems”:** What is an Open System? What is a Closed System
2. **Conservation of mass (and energy):** How does this apply to sediment routing?
3. **Base level:** How does sea level sets erosion potential?
4. **Force balances / thresholds:** How do different forces in a river effect water speed in a channel?
5. **Equilibrium:** What is the difference between: Steady State Equilibrium, Dynamic Equilibrium, and threshold Jump?
6. **Feedback loops:** Give examples of Positive and Negative Feedback loops
7. **Magnitude-frequency:** Explain terms Magnitude and Frequency in geomorphology.

Concept 1 - Landscapes as Systems

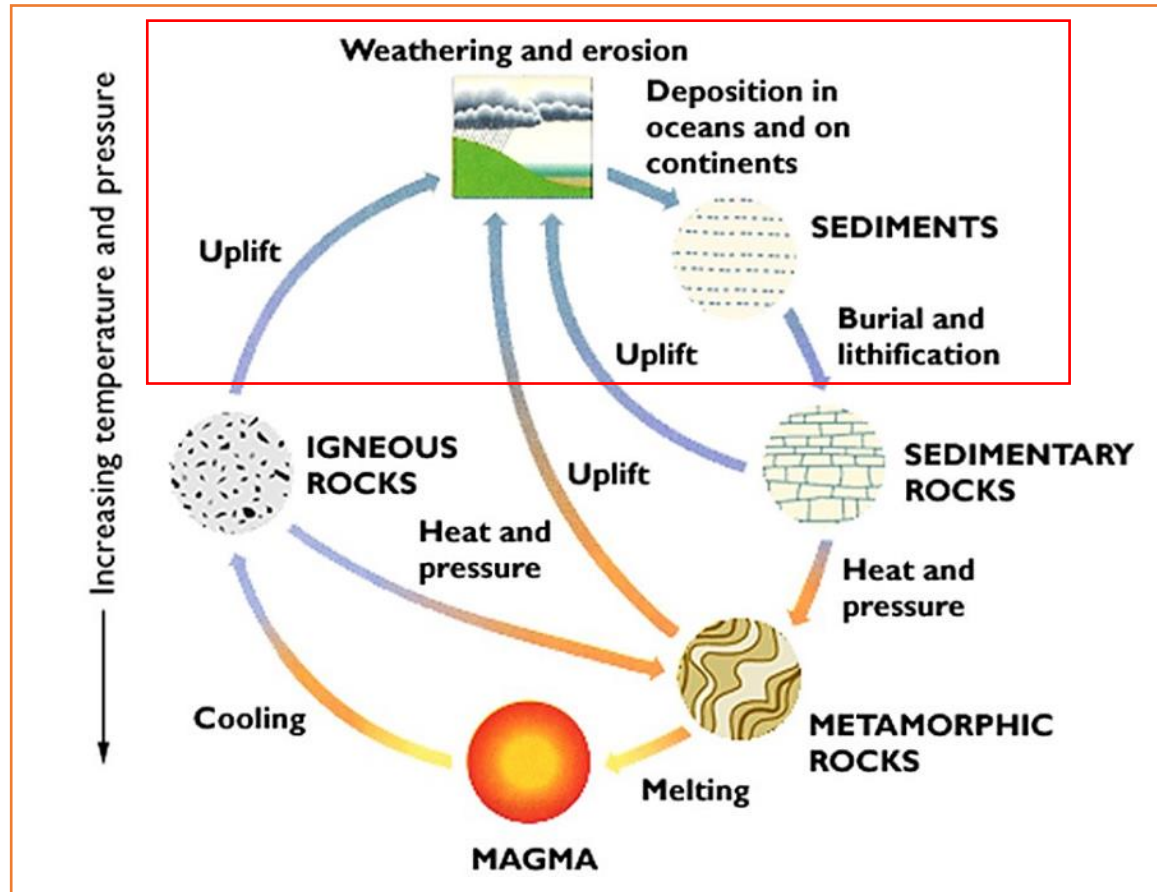
- Landscape
- The geomorphic system...
- Open vs. closed systems



= Global hydrological cycle !

Concept 1 - Landscapes as Systems

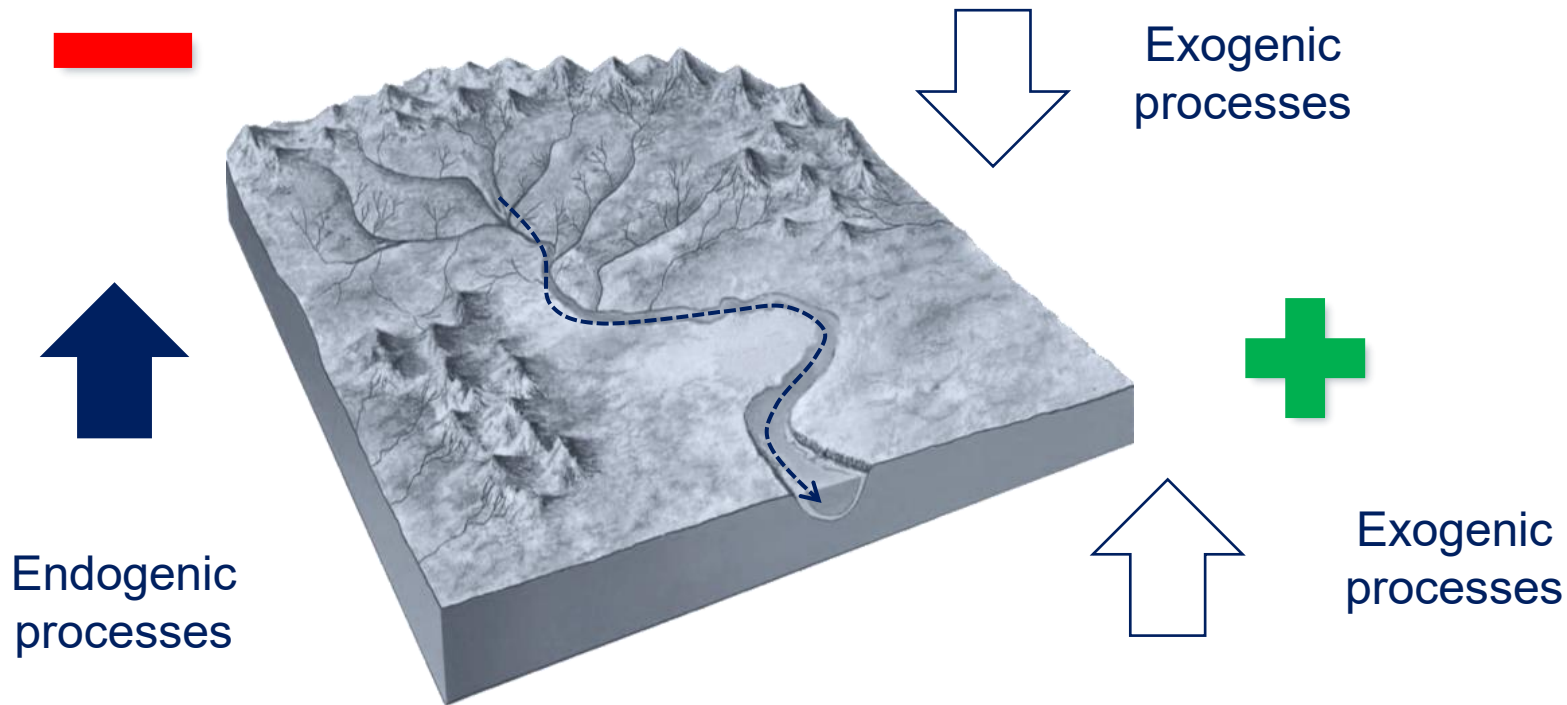
Landscapes an open system



The global rock cycle – a closed system

Concept 2 - Conservation of Mass

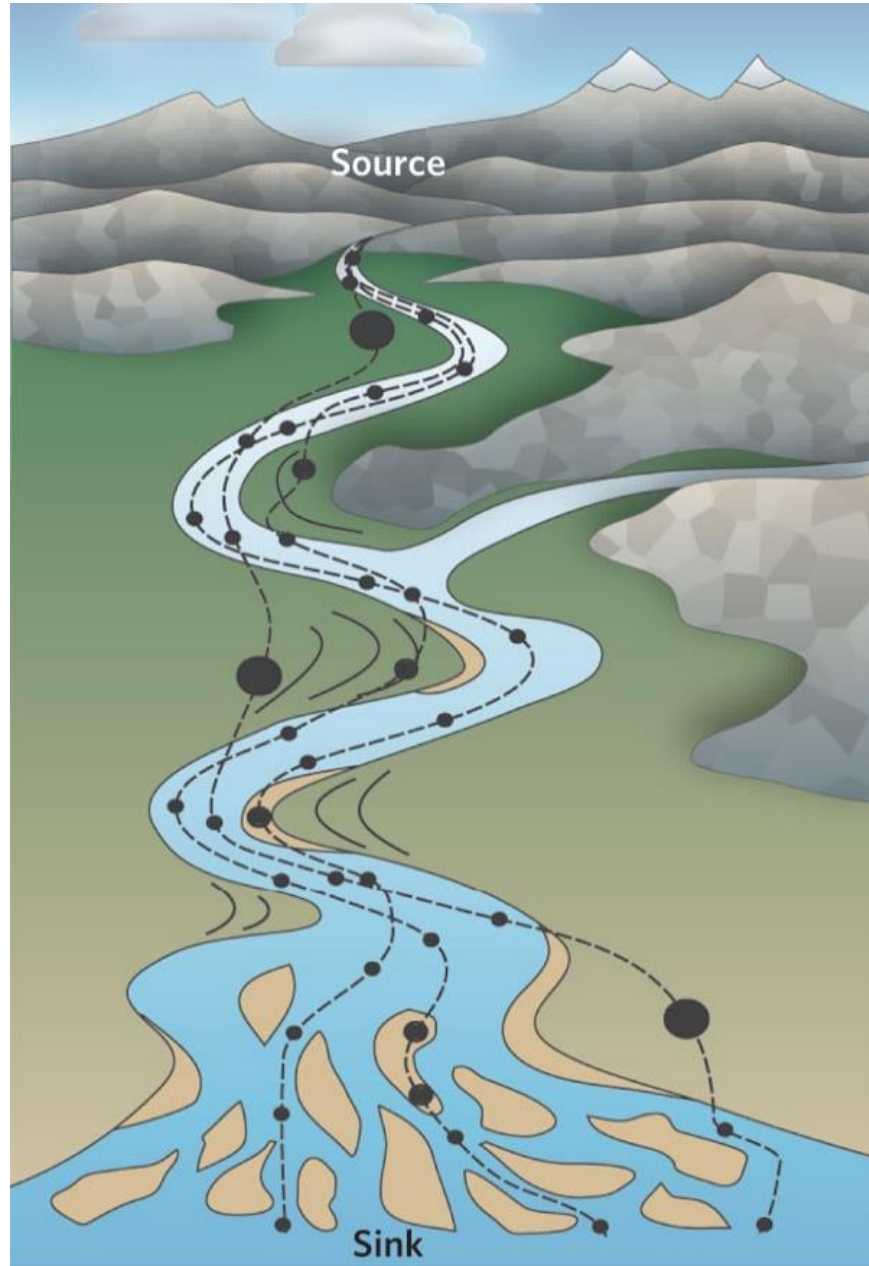
- Mass is continually moving through landscapes (via gravity, and others), BUT mass is conserved throughout the system !



Landscape evolution as product of
erosion, transport and **deposition**

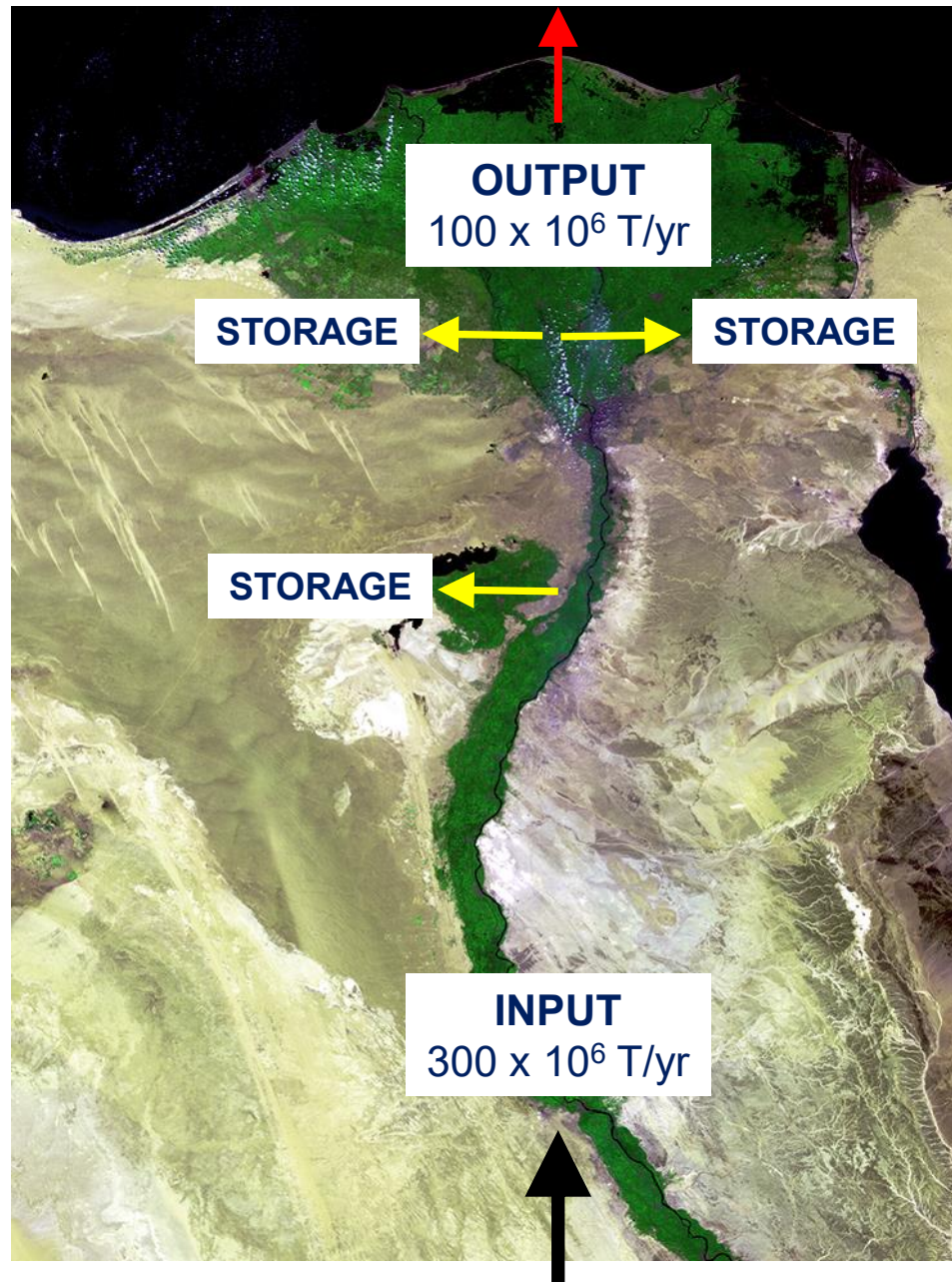
= transfer of mass = change (Δ) in **storage** (or topography)

Sediment-routing (Source-to-sink)



- **Sediment** is transferred from a **source** region to a **sink** along trajectories as shown by the dashed lines.
- Some trajectories involve short transit times with brief periods of storage in the sediment-routing system (as small circles) (e.g. on the river-channel bed).
- Others involve long transit times with prolonged periods of storage (as large circles) (e.g. in bars and on floodplains)
- Allen, P.A., 2008. From landscapes into geological history. *Nature*, 451(7176), pp.274-276

Example – the Nile Delta



- The delta receives its sediment input from rivers, this sediment routed through the system, and then eventually flows to the sea

$$I - O = \Delta ST$$

$$I = 300 \times 10^6 \text{ T/yr}$$

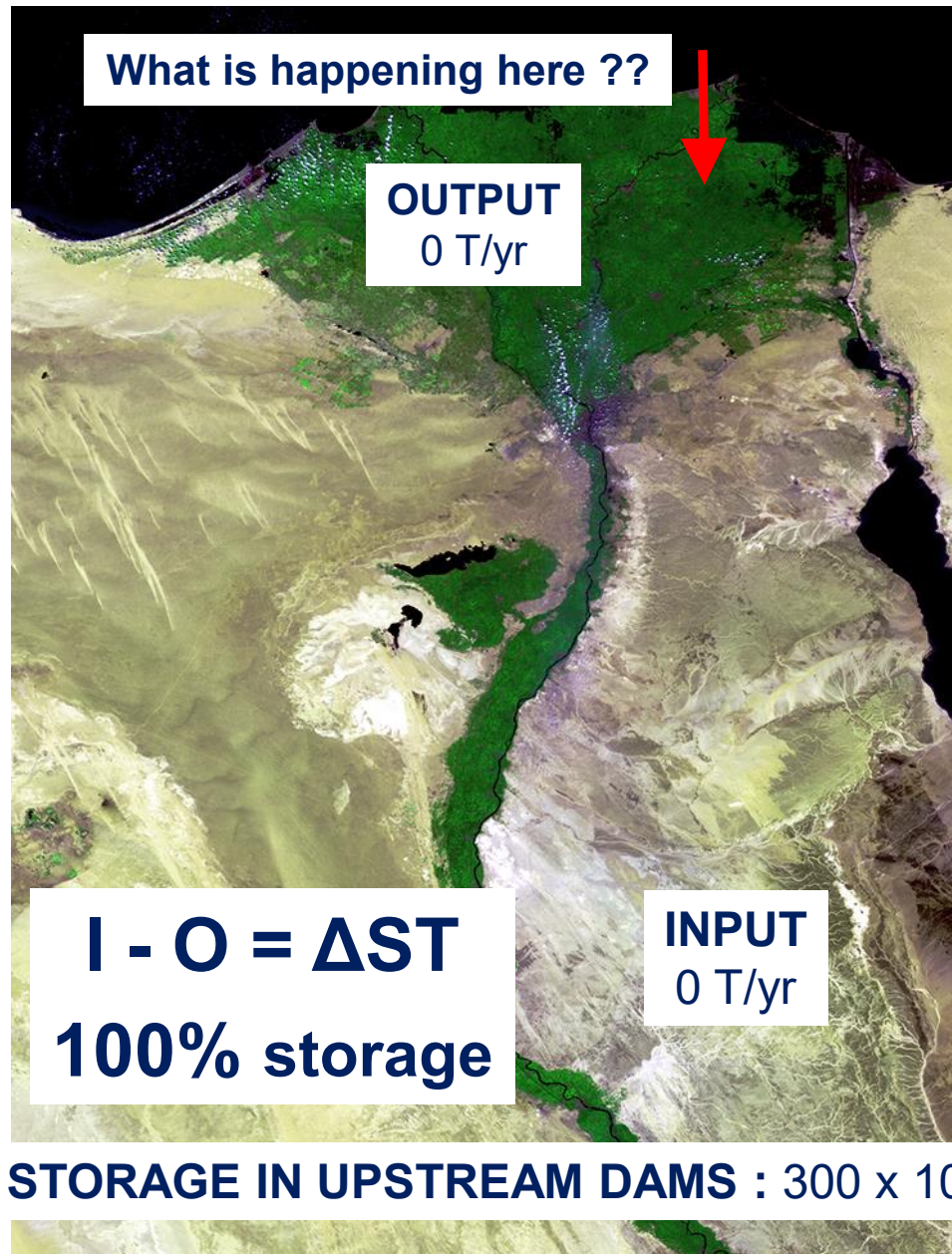
$$O = 100 \times 10^6 \text{ T/yr}$$

$$\Delta ST = 300 - 100 \times 10^6 \text{ T/yr}$$

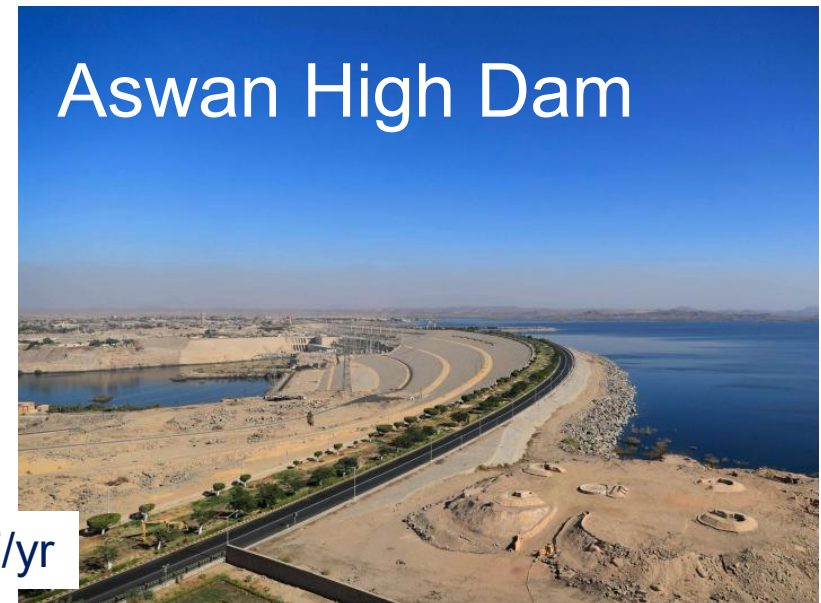
$$\underline{\Delta ST = 200 \times 10^6 \text{ T/yr}}$$

Stored in the delta and floodplain

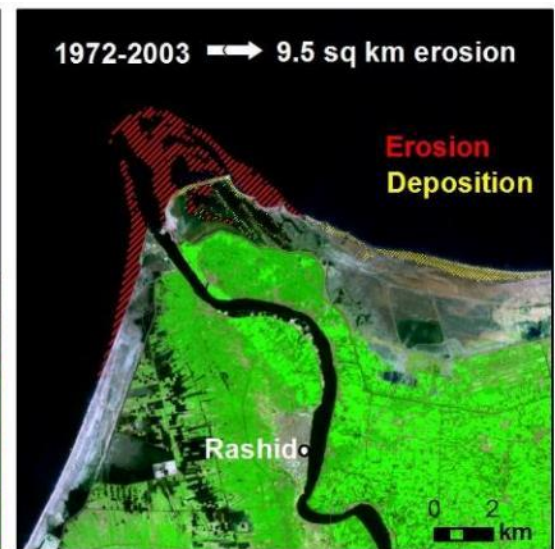
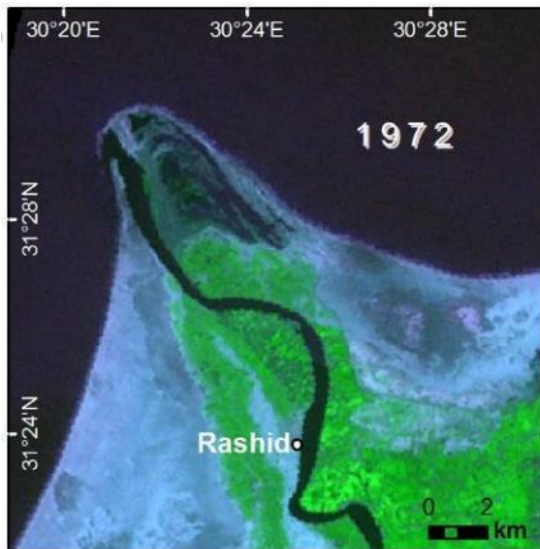
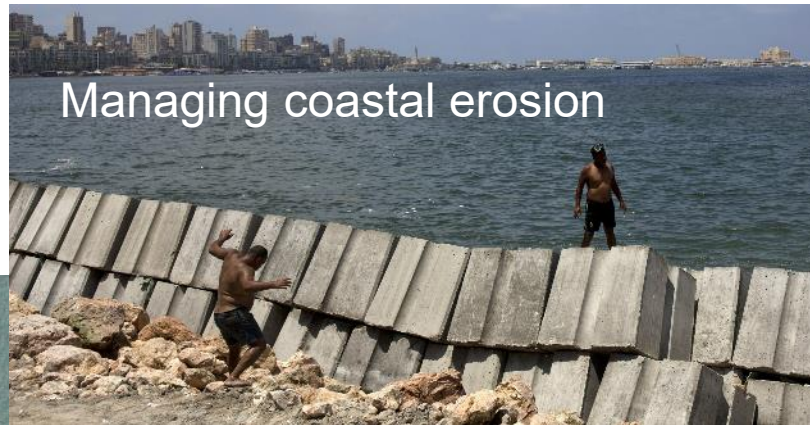
Example – the Nile Delta



- Dams now hold back nearly all sediment [100% storage]
- This has had downstream impacts - delta front is eroding at ~ 100 m/year as it is starved of sediment



Example – the Nile Delta

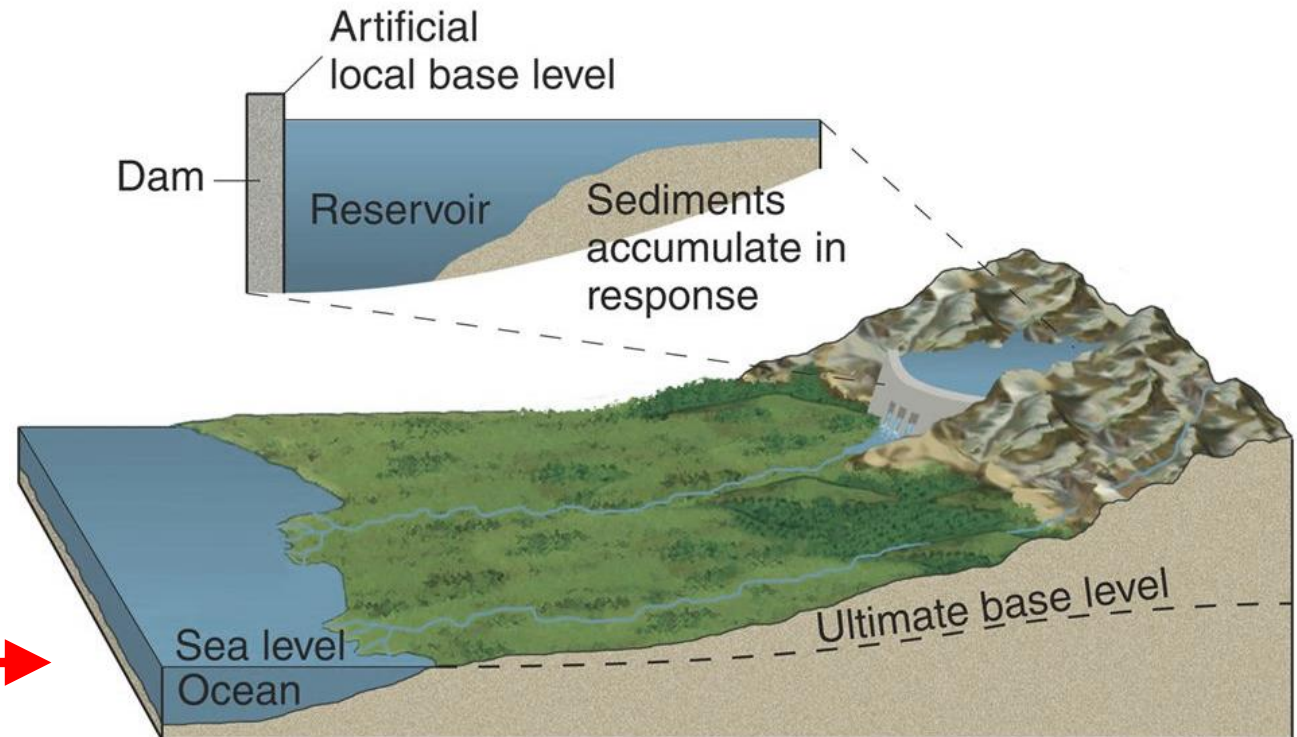


Concept 3 – Sea Level and “Base Level”

- **Base level** is the lower limit for processes of erosion
- **Sea level** = ultimate base level
- Lakes and dams can act as local base level

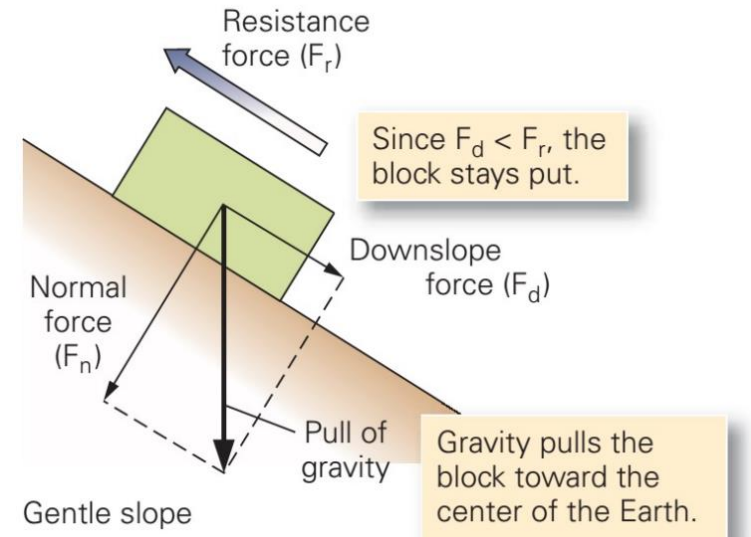
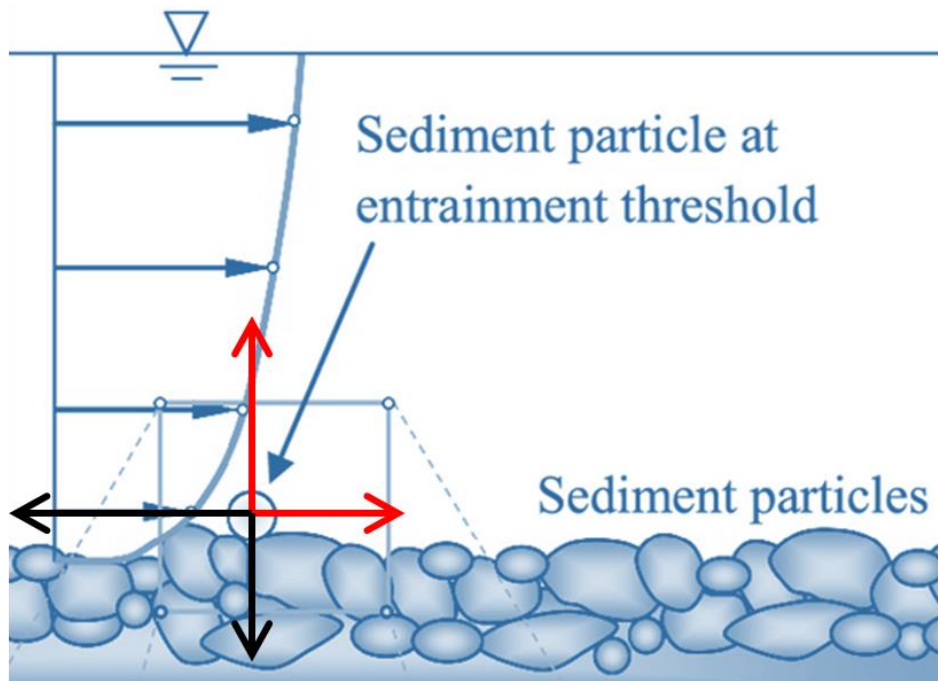
Changes
impact river
profiles

The level below which erosion cannot occur and above which deposition does not take place.



Concept 4 – Force Balances

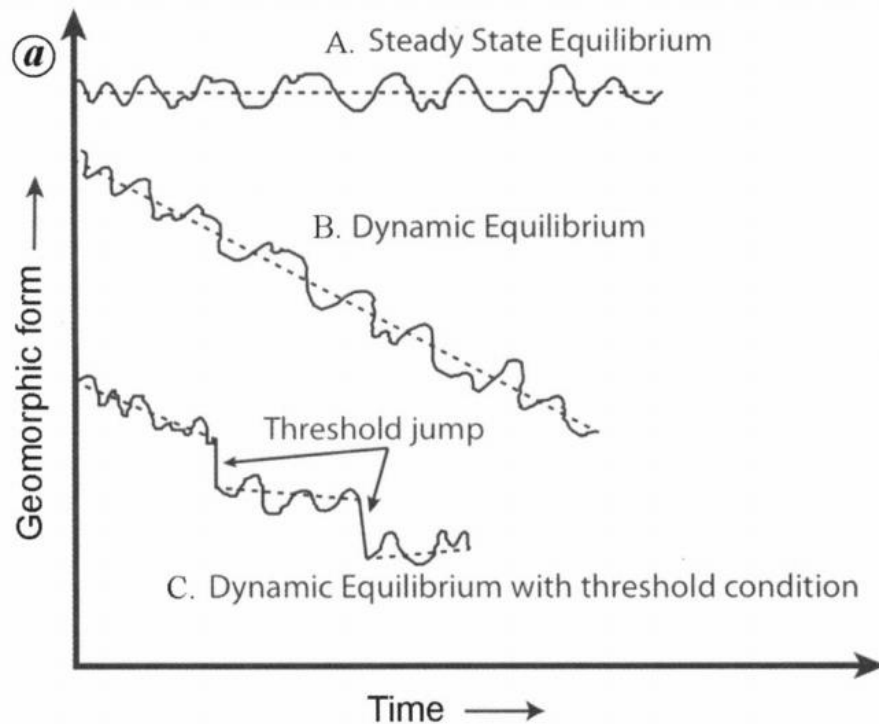
- Every force has an opposing force - the balance between these determines change vs stability (e.g. a hillslope)



- Movement of sediment along a channel bed

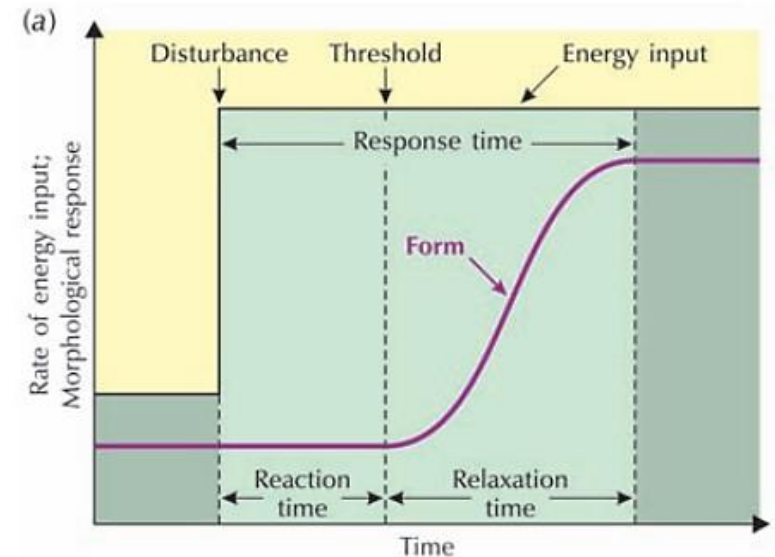
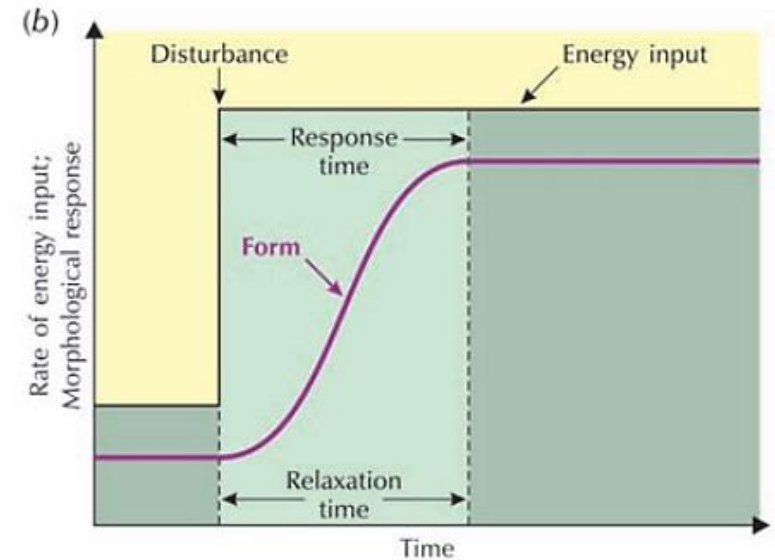
Concept 5 – Equilibrium and Thresholds

- **Equilibrium** is when a system is in a condition in which some sort of *balance* is maintained throughout time
- Geomorphic systems tend to show natural variability



Concept 5 – Equilibrium and Thresholds

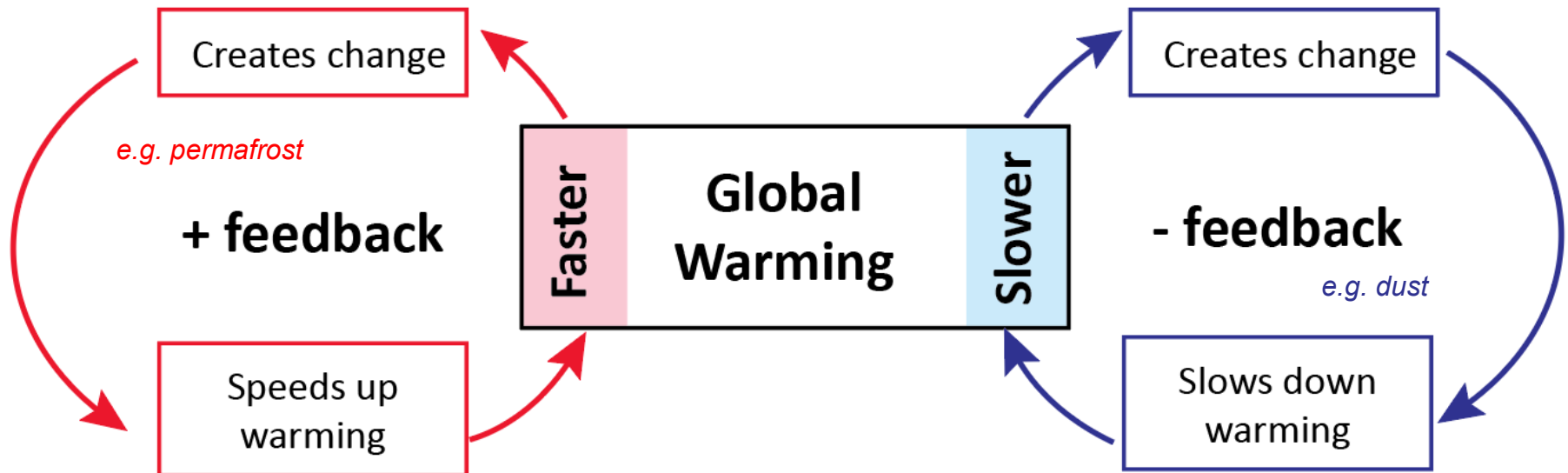
- A **disturbance** brings a change in conditions acting on a system
- **Response time**: The time for the system to respond (i.e. shift)
- **Relaxation time**: The time taken to adjust to a new equilibrium
- **Reaction time**: Time taken for a landform to react to a change in environmental conditions (lag)
- Some **threshold** is then crossed



Concept 6 – Feedback Loops

Natural systems can self-regulate over time...

- **Positive feedback:** A change that will further reinforce the change in the same direction (i.e. become more unstable)
- **Negative feedback:** A change that will help the system to resist further change (i.e. become more stable).



Concept 7 – Magnitude and Frequency

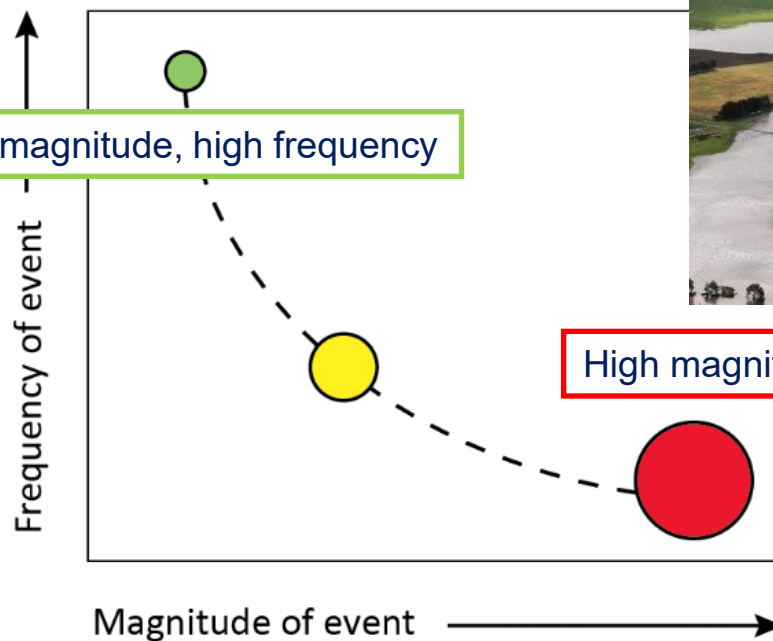
- **Frequency:** how often something occurs
- **Magnitude:** the intensity of different events
- High magnitude tends to be low frequency events



Low magnitude, high frequency

High magnitude, low frequency

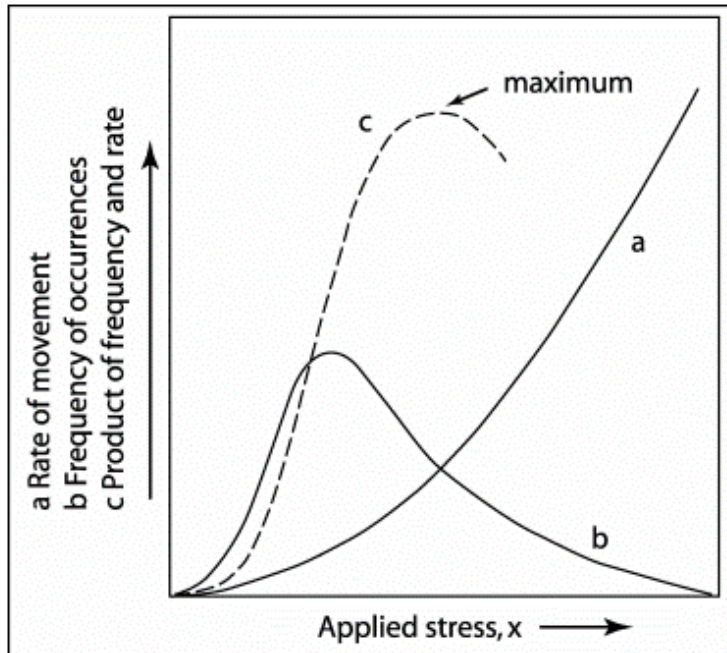
Important for
understanding
Natural Hazards !!



Does *magnitude or frequency* have the strongest impact on geomorphic systems (landscapes) over time?

Concept 7 – Magnitude and Frequency

- Wolman and Miller (1960) evaluated the amounts of work done on the landscape in the long-term by events of all magnitudes



- > 50 % of sediment transport was by flows of a magnitude that occurred at least once per year
- Intermediate magnitude-frequency events generally dominate fluvial sediment transport

- Wolman, M. and W.P Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *Journal of Geology*. 68: 54-74

Take-home...

- Geomorphology is the study of **landforms** and the **processes** which shape their **morphology**
- Endogenic and exogenic processes
- Processes interact over a variety of scales
- Unifying concepts - “the present is the key to the past”
- Increasingly important to accurately predict and understand rates of geomorphic change - we are in the Anthropocene?