

Researching and Shaping Climate Futures

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L. Kutzbach, K. Linscott, A. Oberg**

2nd course day – April 16th, 2026

Moderator: Michael Brüggemann

Course coordination: Michael Brüggemann, Lars Kutzbach, Kat Linscott
Contact: Kat Linscott (katherine.linscott@studium.uni-hamburg.de)

Today's Schedule

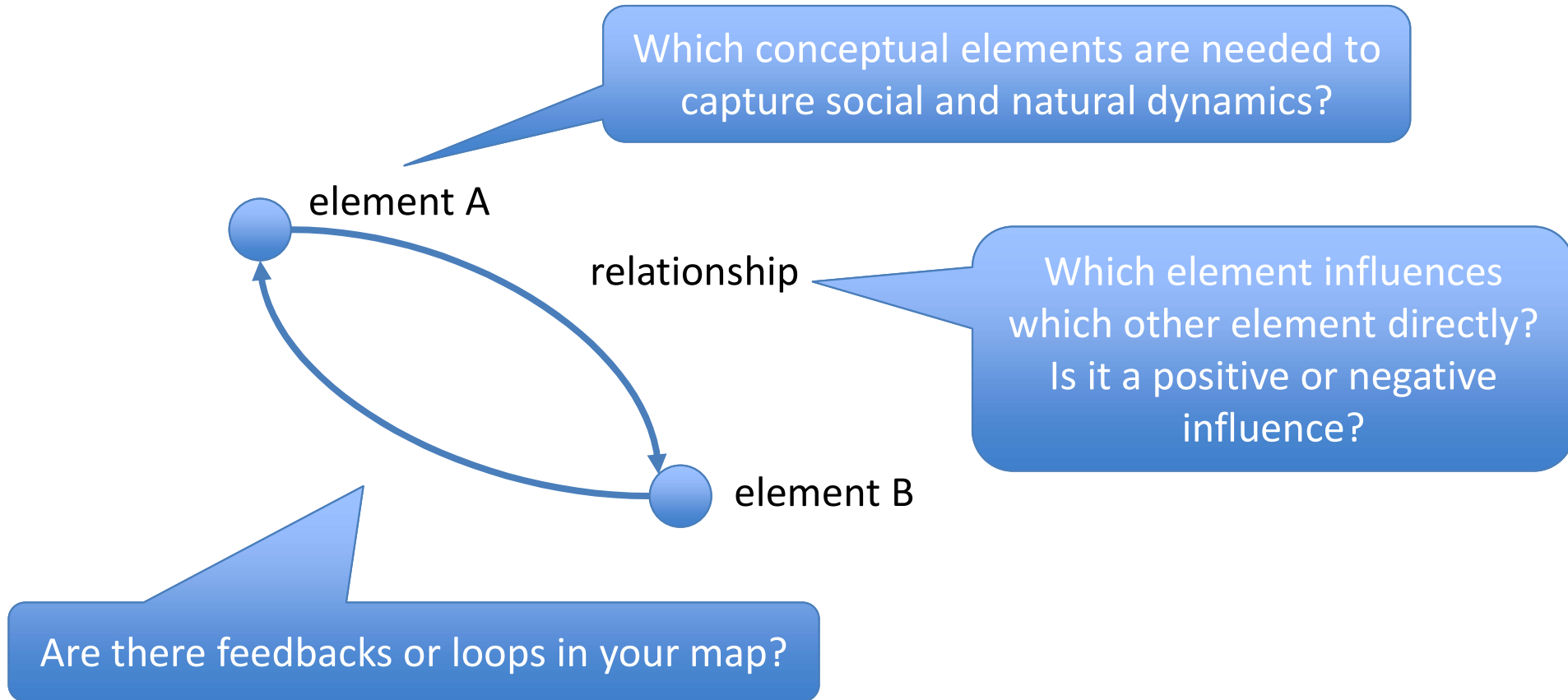
- Mapping natural and societal dynamics constituting climate futures (Achim Oberg), 60 min
- Introduction to poster task and grading criteria, and poster session task (Lars Kutzbach), 25 min
- Homework #2 (Michael Brüggemann), 5 min



Mapping natural and societal dynamics constituting climate futures

Achim Oberg

Drawing a conceptual map



Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. *Ecological modelling*, 176(1-2), 43-64.

Drawing a conceptual map

In small groups of 2-3 students (15 minutes)

- Explain your map to your neighbor
- Discuss similarities and differences

Together

- Present two or three interesting examples
- Summary of similarities and differences



Map of shared concepts in CLICCS

--- independent slide deck with CLICCS design ---



Introduction to poster tasks and grading criteria; poster session task

Lars Kutzbach

Introducing the poster tasks

- What are the tasks?
- Why a poster?
- What should the poster be about?
- What to think about before designing a poster?
- What does a good poster involve?
- Some Examples
- Poster grading criteria
- Convincing poster presentation
- Poster timeline

What is the task?

- Each student prepares her/his own poster (individually graded), but accompanied by group work / peer feedback / lecturer feedback.
- The group of students will organize two poster sessions on July 2nd and July 9th, 2026, where posters will be exhibited and presented.
- Students will work in groups on specific tasks needed for poster sessions.
- Best three posters will be presented by authors at CLICCS retreat on September 30th to October 2nd, 2026.

Why a poster?



AGU Fall Meeting Dezember 2018, ©Jörn Behrens

Why a poster?

- Important form of communicating research results in the natural (and social) sciences.
- Presents complex information as simple as possible.
- Is a communicative device / conversation starter.
- Supported by much more information than can be presented on the printed poster itself.

What should the poster be about?

- Address the course question:

How can we research and shape the complex web of natural and societal dynamics constituting climate futures?

- Your poster: select **one** specific strategy of adapting to or of mitigating climate change (e.g., strategies of city governments, of companies, of environmental or science activists, of the oil industry, of media, ...)
- The poster should deal with
 - 1) knowledge and research on dynamics supporting or hindering this strategy and
 - 2) an effective way to communicate/implement this strategy.

What to think about before designing a poster?

■ Audience

- What is the target group? (in our case: the extended CLICCS/SICSS community)
- Which knowledge can be assumed?
- Which language will be used?

■ Core message

- Which message do I want to convey?
- What should be the main takeaway?

What to think about before designing a poster?

■ Balancing act

- Poster must stand on its own (but will also be presented)
- Textual information ↔ visual information
- Scientifically sound ↔ attention-grabbing

What to think about before designing a poster?

■ Preparation

- What do I want to say (1 sentence)
- Thinking, material collection
- Sorting (5-step procedure):



1. **Topic**, relevance for audience (motivation)
2. **Starting point**, current situation, the problem/knowledge gap
3. **Description of improvement** – where do I want to go?
4. **Path to solution**, methods, tools, strategies
5. **Generalization**
 - What does this mean for audience?
 - What is the take-home message?
 - Summary

What does a good poster involve?

- Tells a story (textually/visually);
- Clearly points to the key information;
- Is well-designed,
incl. legible, efficient use of space, not too much text,
good combination of visual/textual information, clear
structure and sequence
(→ separate input on April 30th by Kat)

What does a good poster involve?

■ Introduction

- Motivation, overview
- Mental road map
- Raise interest
- Clear description of problem/knowledge gap
- Clear statement on objectives/research questions/hypotheses

■ Sections

- Structure
- Create re-entry points

■ Closing

- Repeat core message
- Find good closing sentence

What does a good poster involve?

- Can be read from top left to lower right. Stress positions: top left and lower right, here you find the core information.
- Balance visuals and text - 50:50, but better 60:40 (start with key visuals; do they cover the main point?).
- Can be understood from far/ on an A4 print-out.
- Use headers to structure your poster.
- Start with figures and adapt text accordingly. (NOT the other way around!)

Examples – what works for you, what doesn't?

Long-term observations reveal rise in early summer CH₄ emissions from Siberian tundra

N. Röbger^{1,2}, T. Sachs², C. Wille², J. Boike³, L. Kutzbach¹

¹Institute of Soil Science, CEN, Universität Hamburg, ²GFZ Potsdam, ³Alfred-Wegener-Institut, Potsdam

Relevance of arctic CH₄ emissions for global climate-carbon cycle feedback?

- The warming of the Arctic, which is at least twice the global average, is likely to have pronounced effects on arctic CH₄ emissions.
- Changes of arctic CH₄ emissions can be driven by soil warming, permafrost degradation, a deepening of the seasonally thawed active layer, enhanced decomposition rates and a lengthening of the thawing season.
- However, it has remained unclear whether rising temperatures affect the two counteracting processes of methane production and consumption equally or not.
- Hence, there is only medium evidence with low agreement, whether northern permafrost regions are already releasing additional CH₄.

Eddy covariance CH₄ flux measurements in Siberian lowland tundra

- Here, we present multi-annual CH₄ flux data from the Lena River Delta in the Siberian Arctic (72.4° N, 126.5° E, Fig. 1) acquired by the eddy covariance method (Fig. 2).
- The polygonal tundra landscape is characterized by a mosaic of ponds, water-saturated cryosols with high organic carbon contents in polygon centers and drier cryobated cryosols with lower organic carbon contents at polygon rims.
- Mean annual air temperature -12.3 °C, mean annual precipitation 169 mm.

Intra-annual CH₄ flux dynamics and budget

- Mean annual budget of 171.5 ± 12.3 mmol m⁻² yr⁻¹ (2.7 ± 0.5 g CH₄ m⁻²)
- Between 25th and 50th percentile of circumpolar tundra (Treat et al., 2018, Glob. Chang. Biol.)
- Maximum rates in early August (Fig. 4 left)
- 61 % of the mean annual during the thawing season, 14 % during autumn refreezing season, 25 % during frozen season (Fig. 4 right)

Flux trends and their seasonality

- Significant increasing trends of CH₄ emissions for June and July (Fig. 6).
- No trend in August during period of maximum CH₄ source strength.
- Decreasing trend in September, but too few data years.
- Not enough data for trend analyses for cold months October to May.
- Changes in June and July equivalent to an increase of the mean annual methane budget by 0.5 % yr⁻¹.

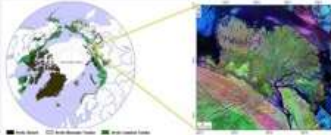


Figure 1: Location of the Lena River Delta in the lowland tundra of Siberia (left); location of the flux measurement station on Samoylov Island in the southern Lena River Delta (right).




Figure 2: Eddy covariance flux measurement systems 2002-2008 (left) and 2009-2017 (right) in the polygonal tundra of the Lena River Delta.

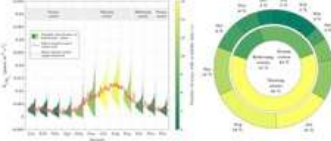


Figure 4: Monthly distributions of half-hourly methane fluxes and their mean annual course (left); mean monthly and seasonal contribution to the annual budget (right). The three seasons reflect the three freeze states of the active layer of the permafrost (frozen soil).

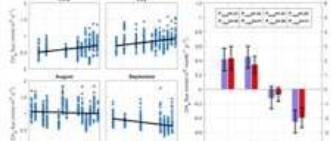


Figure 6: Methane flux trends estimated for the four month thawing season. Left: Gap filled time series of daily means and their associated trend lines (sample sizes: n_{June}=270, n_{July}=241, n_{Aug}=10, n_{Sept}=412, n_{Oct}=276). Right: Absolute trends (left axis, blue bars) and relative trends (right axis, red bars) of each month. P-values obtained from two modifications of the two-sided Mann-Whitney U-test after Horned and Rao (1988) and after Kao and Wang (2004), respectively.

Flux controls on various time scales

- CH₄ fluxes and the explanatory power of associated flux drivers varied strongly depending on time scales, from diurnal to inter-annual (Fig. 5).
- On the **daily to synoptic scale**, the variations in methane fluxes were affected by friction velocity, which was subject to a diurnal cycle (data not shown).
- On the **intra-annual scale** (Fig. 5, top line), CO₂ fluxes served as a proxy for CH₄ fluxes between October and May, suggesting that both soil gases were subject to the same physical transport processes.
- From **June to August**, thaw depth held explanatory power as an indicator of the maximum soil volume available for methanogenesis.
- In **September and October**, surface albedo had explanatory power, when it formed a proxy for enhancing snow coverages, and thus the decreasing coupling between vegetation and soils and the atmosphere.
- On the **annual scale** (Fig. 5, middle line), most of the variability could be explained by air and soil temperatures as fundamental variables driving metabolic processes such as photosynthesis as well as methane production and consumption. The soil temperature in a polygon centre at 20 cm depth was the best explanatory variable in comparison to soil temperatures at other depths and locations within the polygon. This soil temperature reflects water-saturated conditions in the center, the timing of the annual thaw/thaw cycle and high organic matter content in the top soil.
- On the **inter-annual scale** (Fig. 5, bottom line), explanatory power was provided by drivers that best describe cumulative heat input to the ecosystem in the thawing season: soil temperature at 30 cm depth, thaw depth, and growing degree days.

Longest CH₄ flux dataset from the Arctic: 16 campaigns from 2002 to 2019

- Though not continuous, this dataset represents the longest eddy covariance CH₄ flux record from the Arctic (Fig. 3).
- 70,202 half-hourly CH₄ flux records observed during 1986 days within 16 years.

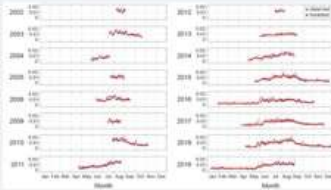


Figure 3: Time series of daily average quality-corrected CH₄ flux measurements and modelled daily CH₄ fluxes. Flux modelled by random forest (ensemble of regression trees). R²=0.75, mean absolute error 158 μmol m⁻² d⁻¹, mean relative error 18 %.

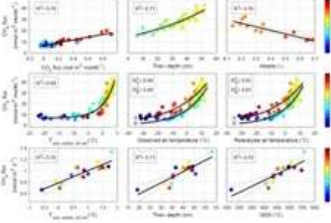


Figure 5: Relationships between CH₄ flux and environmental drivers at different time scales. Top: Intra-annual scale with monthly means of CO₂ flux (October to May, n=30), thaw depth (June to August, n=47) and surface albedo (September and October, n=15). Middle: Annual scale with monthly means of soil temperature (n=48) as well as an air temperature (n=48) that derives from observational data (n=18) and reanalysis data (n=48). Curve A represents the period August to February, while curve B denotes the period March to July. Bottom: Inter-annual scale, which covers the period 1st July to 15th September, with means of soil temperature (n=16), thaw depth (n=12) and growing degree days (n=16).

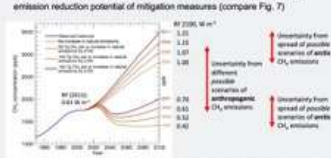


Figure 7: Comparison of the effects of possible scenarios of anthropogenic CH₄ emissions vs. possible scenarios of arctic CH₄ emissions on atmospheric CH₄ concentrations and radiative forcing. Diagram from Christensen et al. (2015, Scientific Reports).

More information: www.clicca.uni-hamburg.de/en/research/theme-cx1/
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Examples – what works for you, what doesn't?

A3: EFFECTS OF GEESE AND SHEEP GRAZING ON PLANT-MEDIATED GHG FLUXES FROM MARSH SOILS TO THE ATMOSPHERE

BACKGROUND

- Marsh ecosystems are severely impacted by the presence of herbivores.
- Herbivores modulate greenhouse gas (GHG) dynamics by altering plant species composition and thereby rhizosphere conditions and organic matter (OM) decomposition.



RESEARCH QUESTIONS AND HYPOTHESES

1. How does sheep grazing effect GHG fluxes?

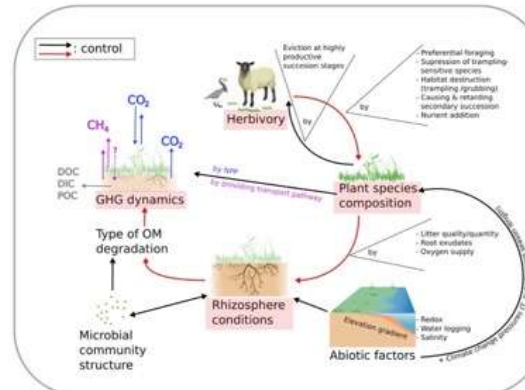
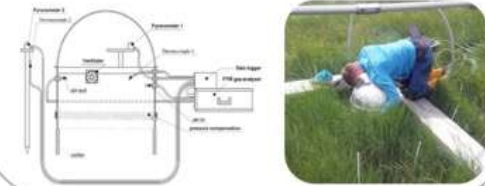
Sheep grazing and trampling is expected to slow down heterotrophic respiration due to soil compaction and resultant oxygen limitation. At the same time, methane fluxes will increase in freshwater marshes where sulfate is absent.

2. How does geese grazing effect GHG fluxes?

Geese grazing and grubbing is expected to enhance soil respiration due to bioturbation and aeration and severely decrease gross primary production as a result of vegetation removal.

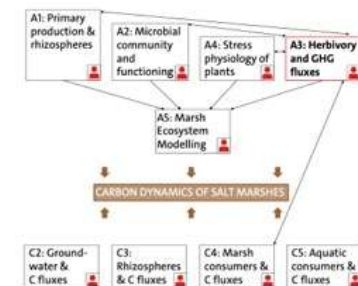
METHODS

- The manual chamber method is suitable to resolve small-scale GHG flux patterns
- With a Fourier transform infrared (FTIR) gas analyzer, multiple gas species can be measured simultaneously.
- The impact of grazers will be studied with exclusion experiments at different positions within the elevation gradient in marsh ecosystems.



COOPERATION IN BICEST

- Concerted field work at common salt marsh sites of projects A1, A2, A3, A4, C2, C3, and C4.
- A3 delivers process understanding on effects of herbivory on GHG fluxes to modelling project A5.
- Detailed process knowledge of A1, A2, A4 needed for interpretation of A3 results on grazing impacts on GHG fluxes.
- Findings of all projects of RT A combined with findings of C2, C3 and C5 on lateral C fluxes will allow a comprehensive evaluation of the C cycle dynamics of salt marshes.
- A3 results will be discussed with respect to marsh consumer motility as studied in C4.



Examples – what works for you, what doesn't?

Mass Public Participation in Climate Movements in India

Pritha Mandal

Background

Although climate activism and movements in India have gradually gained traction over the last decade, their publicization and mass participation remain limited.

Objective

To explore potential strategies that can help promote publicization of and mass public participation in climate movements in India.

Context

- India has a rich history of mass social movements: The country was born out of an *andolan* (a nation-wide movement). [1]
- The recent **Farmers' Protests of 2020-2021** demonstrated the positive, successful impact of a large-scale movement in India. [2]
- The nation-wide, large-scale public participation in the Farmers' Protests can be drawn on to contextualize climate activism in India.
- Discourses used by popular climate movements in the West (such as Fridays for Future and Extinction Rebellion, among others) can serve as a guiding framework.

Roadmap for Strategy Development



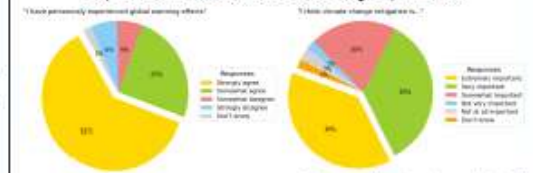
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Strategies to Promote Mass Public Participation in Climate Movements in India

Existing Data

Perspectives of Indian Adults on Climate Change Topics in 2023



Required Knowledge

Quantitative Research

- Extending existing national survey databases on societal perspectives on climate change topics.
- Conducting representative nation-wide surveys through schools, universities, and governmental offices.

Qualitative Research

- Identifying primary climate change concerns of the public, especially those of the most vulnerable groups (farmers and people living below the poverty line).
- Exploring the willingness to act and potential focus areas of specific groups of the public.

Potential Strategies

- Developing targeted, relatable climate change narratives for specific groups of the public based on research data.
- Utilizing social media and public outreach of independent Indian media groups, such as India Development Review (media platform), Mint (newspaper outlet), and Editorji (information platform), to publicize these narratives and enhance participation in climate movements.

Summary

- Publicization of and mass participation in climate movements in India are limited.
- To overcome these limitations and develop potential strategies, the 2020-2021 Indian Farmers' Protests can be used as an inspiration, and discourses of popular Western climate movements as a framework.
- Potential strategies can be informed by conducting representative nation-wide surveys and exploring the public's climate change concerns and willingness to act.
- Corresponding strategies can involve utilizing social media and public outreach of independent Indian media groups to communicate relatable climate change narratives.

[1] Chandra, S., Mukherjee, M., Mukherjee, A., Panikkar, K. N., & Mahajan, S. (2016). India's struggle for independence. Penguin UK.
 [2] Behl, N. (2022). India's farmers' protest: an inclusive vision of Indian democracy. American Political Science Review, 116(3), 1141-1146. <https://doi.org/10.1017/S0003055422000156>
 [3] Illustration by Michael Leo. <https://www.thegazette.org/issue/195/farm-india-fight>

References

[4] Fridays for Future. Wiki. <https://wm.fridaysforfuture.in/>
 [5] Wikipedia Commons. https://commons.wikimedia.org/wiki/File:Logo_extinction_rebellion.svg
 [6] Yale Program on Climate Change Communication. (May, 2024). Climate Change in the Indian Mind, 2023.

Examples – what works for you, what doesn't?

Path To Fossil Freedom for Oil Addicted Countries

What strategies can oil-rich nations use to transition their economies away from oil?

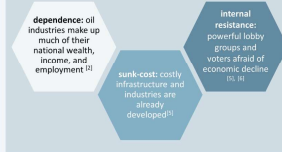
Kat Linscott

The Problem

- Decarbonization is urgently required to mitigate climate change, but every step of the way, oil-rich nations are delaying progress.^[1]
- These nations are also typically the highest emitters, a phenomenon termed the carbon curse.^[2]
- Currently, relying on market mechanisms to pressure these countries to conform is failing.^[3]
- **Reaching decarbonization goals will require reform driven by fossil fuel nations.**

1. Why are they like this?

There are enormous incentives to stay on carbon-intensive developmental pathways:

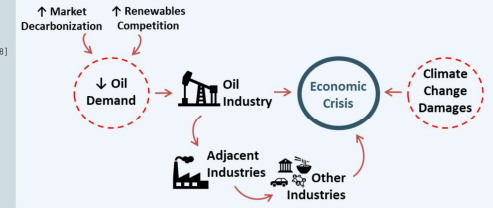


2. Why should they care?

Relying on oil puts these nations' economies at enormous risk.^[2]

- Oil-based economies are **volatile**.^[7, 8]
- **Peak oil demand** will occur this century.^[9]
- **Decreasing profitability** of oil due to the rise in renewables and carbon markets.^[9]
- The **cost of climate change damage** are likely to exceed the oil profits.^[10]

Figure 2: Risks for Oil Nations



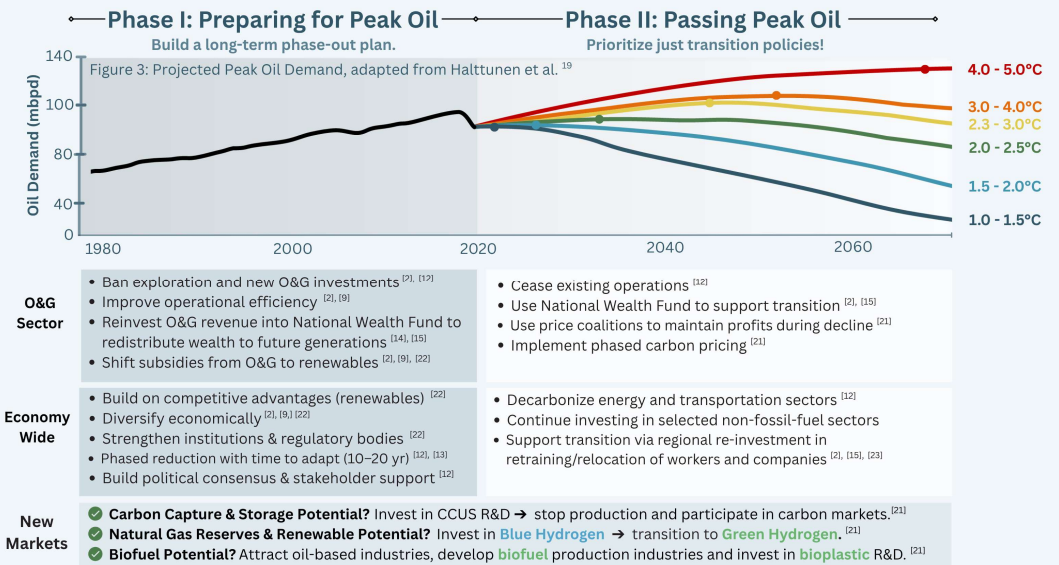
3. What are countries currently doing?

	Denmark (0.3% of GDP)	Norway (6.1% of GDP)	Saudi Arabia (24% of GDP)
Plan	<ul style="list-style-type: none"> • Cease oil exploration now & end oil production by 2050^[13] 	<ul style="list-style-type: none"> • Maintain level of production, continued O&G exploration^[16] 	<ul style="list-style-type: none"> • Increase production to reclaim market share, create a price war^{[18] [17]}
Strategies	<ul style="list-style-type: none"> • Renewables, CCUS & biofuels^[13] • Just transition policies: regional re-investment and stakeholder involvement^{[12] [13]} 	<ul style="list-style-type: none"> • National Oil Fund to buffer the economy for future generations • Investments in extraction^{[14], [15]} efficiency, renewables, CCUS, & Green H₂^[15] 	<ul style="list-style-type: none"> • Economic diversification (manufacturing, tourism, etc.) • Investments in extraction efficiency, renewables, CCUS, & Green H₂^[16]

4. The Research Gaps

- Guidelines and case studies
- Equity for developing nations
- Societal drivers and barriers
- Managing uncooperative actors
- Technological feasibility of CC&S, H₂ & biofuels
- Economics: implementing carbon tax, producer coalitions, & compensating oil sectors^[9]

So how can they get there? A framework for reaching fossil freedom for oil-addicted countries.



Transitioning away from fossil fuels is necessary, feasible and economically smart. Plan long-term. Start Today. Just Transition.



Convincing poster presentation

- Clear and confident presentation to poster visitors.
- Key messages & highlights are made clear during presentation.
- Answers to questions are knowledgeable and clear.
- Find different ways through the poster
 - for your own little presentation speech,
 - for your answer to a specific question.

Poster grading criteria

- **Design (30 %)**
- **Content (50 %)**
- **Poster presentation to poster visitors (20%)**

Poster Grading Scheme

■ Design (30 %)

- Follows format guidelines (A0, portrait orientation)
- Visual appeal
- Clear and organized layout
- Logical flow of information
- Text and graphics readable from 1-2 m
- Efficient use of space
- Correct formatting and orthography

Poster Grading Scheme

■ Content (50 %)

- Relevant and appropriate content:
 - ✓ Poster contributes to answering the overarching course question
 - ✓ Poster addresses one specific strategy of adapting to or of mitigating global change
 - ✓ Poster deals with both: 1) knowledge/research on dynamics supporting or hindering this strategy and 2) an effective way to communicate/implement this strategy. Both aspects do not need to be addressed equally.
- Clear structure of poster content: clear objectives, clear take-home messages

Poster Grading Scheme

■ Content (50 %)

- Good depth of coverage
- Correctness regarding content
- Usage of relevant literature
- Useful images/figures
- Figures intuitively comprehensible
- Appropriate references of sources
- Precise language

Poster Grading Scheme

- **Poster presentation to poster visitors (20%)**
 - Precise, concise and clear oral presentation (2-3 min)
 - Convincing and comprehensible “guided tour” through poster
 - Able to competently answer questions

Poster: Timeline

Task	until
Class: Introduction to poster tasks and grading (Lars)	16.04.26
Class: Start of poster session organisation (Kat)	23.04.26
Homework: Post first ideas for a poster (100-200 words)	30.04.26
Class: Input on poster design (Kat)	30.04.26
Homework: Post proposal for poster topic including references (200-400 words blog post), comment one poster idea: 50-100 words	21.05.26
Class: Poster session organization (Kat)	21.05.26
Q&A poster task	02.06.26
Homework: prepare first version of poster (digital and A4 printout)	11.06.26
Class: Poster drafts feedback - speed dating	11.06.26
Time for students to prepare poster session	18.06.26
Poster clinic; Time for students to prepare poster session	25.06.26
Poster Session events I and II	02.07.26, 09.07.26
CLICCS Retreat: Presentation of awarded posters	Sept 30 th -Oct. 2 nd

Updated preliminary session plan

09.04.	Introduction to the course (L. Kutzbach); Introduction to the course blog (J. Behrens); Introduction to <i>Climate Futures</i> (L. Kutzbach)
16.04.	Mapping natural and societal dynamics constituting climate futures (A. Oberg); Introduction to poster task and grading criteria; poster session task (L. Kutzbach)
23.04.	Climate Agency: Our Role in the System (M. Brüggemann); Input on Epistemic Pluralism in Climate Science (K. Linscott et al.), organisation of self-organized poster session
30.04.	Mathematical perspectives on climate futures (J. Behrens); Introduction to poster design (K. Linscott); Introduction to roles and role-playing (M. Brüggemann, K. Linscott)
07.05.	Can we predict climate? (Johanna Baehr); 1 st role-play (students)
21.05.	The changing Arctic in a warmer world - combining observations, experiments and modelling (L. Kutzbach); Poster session organization (K. Linscott)
28.05.	Communicating climate futures (Michael Brüggemann); 2 nd role-play (students)
04.06.	Narrative-based near-term prediction of climate futures (Leo Borchert); Q&A poster task
11.06.	Poster drafts feedback - speed dating
18.06.	Organisation of poster session
25.06.	Poster clinic; preparation of poster session
02.07.	Poster Session event I
09.07.	Poster Session event II
16.07.	Feedback and Conclusions (students and lecturers)



Homework # 2

Michael Brüggemann

Homework # 2: Scientists' agency in the climate system

Please review from your notes or the reading from semester 1 (Introduction by Simone/Michael) what you know about different role perceptions of scientists.

Please read (at least) one of the texts below closely:

- write down one question: concerning something you do not fully understand
- Write down some notes: (how) do the ideas of transformative science and diverse ways of knowing challenge the established role conceptions of scientists? If climate science were transformative, how would it be different?

Brüggemann, M., Carvalho, A., Brevini, B., & Downey, J. (2023). Still Watching From the Sidelines? The Case for Transformative Environmental Communication Scholarship. *International Journal of Communication*; Vol 17 (2023). <https://ijoc.org/index.php/ijoc/article/view/20507>

Orlove, B., Sherpa, P., Dawson, N., Adelekan, I., Alangui, W., Carmona, R., Coen, D., Nelson, M. K., Reyes-García, V., Rubis, J., Sanago, G., & Wilson, A. (2023). Placing diverse knowledge systems at the core of transformative climate research. *Ambio*, 52(9), 1431–1447. <https://doi.org/10.1007/s13280-023-01857-w>

(Even more reading, optional: David Tàbara, J., Jäger, J., Mangalagiu, D., & Grasso, M. (2019). Defining transformative climate science to address high-end climate change. *Regional Environmental Change*, 19(3), 807–818. <https://doi.org/10.1007/s10113-018-1288-8>)