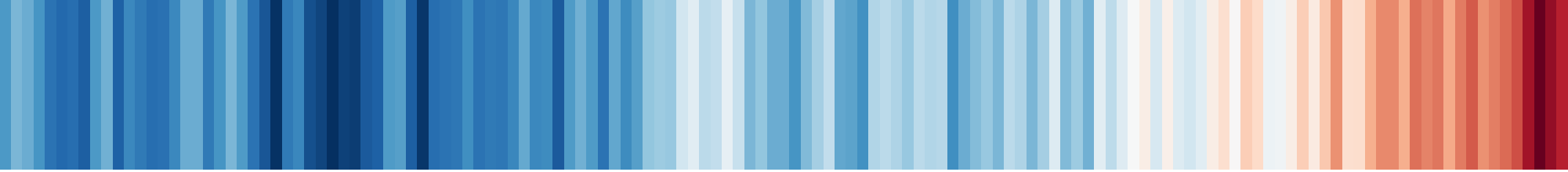
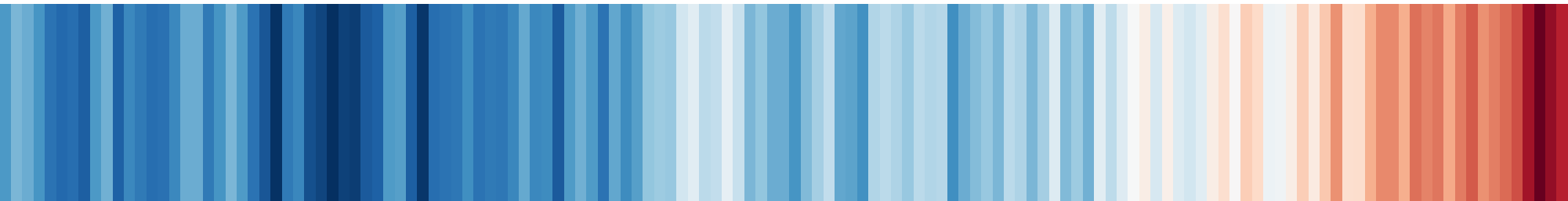


GIVE THE CLIMATE A BREAK

Niklas Beisert – 2019 HS

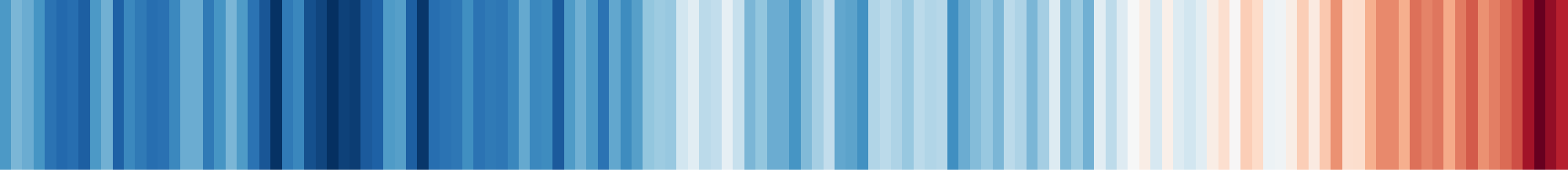


Copyright

The current version of this work can be found at:
http://people.phys.ethz.ch/~nbeisert/ClimateBreak/

Figure sources linked; Warming Stripes: Ed Hawkins, G.S. Völker

And now for something completely different:



GIVE
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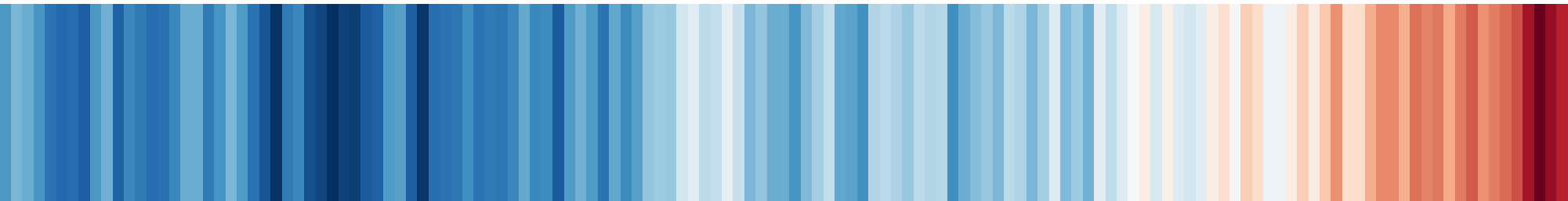
Week 1



Goals

- reinforce awareness
- basic understanding of mechanisms
- encourage discussions in everyday context
- meet other people interested in topic
- ETH Zürich / academia has a significant climate impact; need to understand own actions in order to adjust
- expertise for potential future in other institutions, business, education, industry

Potential Topics

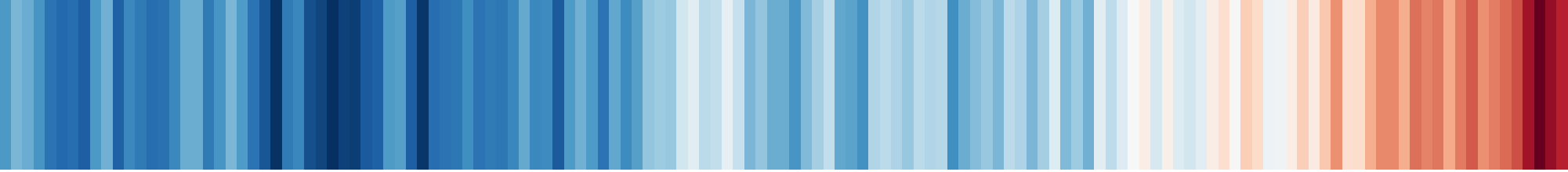
- micro-presentations:
  - physics of global heating
  - contributing sectors
  - reduction paths, implementations
  - reduction options, comparison
  - measuring footprint
  - mechanisms in society
  - pitfalls
- discussions / your contributions
- what can we do? in our immediate environment?
- issues of current interest
- ask questions / find answers
- up to you . . . ; please let me know!

Current Opportunities

- explore interdisciplinary courses/events on this topic
- Global Week of Climate Action: 20–27 September 2019
- can show support and voice own demands at marches:
  - Zurich Fri 27 Sep
  - Bern Sat 28 Sep

  (encourage society to act on scientific results)
- study programmes of political parties in view of reaching goals of Paris agreement (= lowest common denominator)

Your suggestions? questions? remarks?



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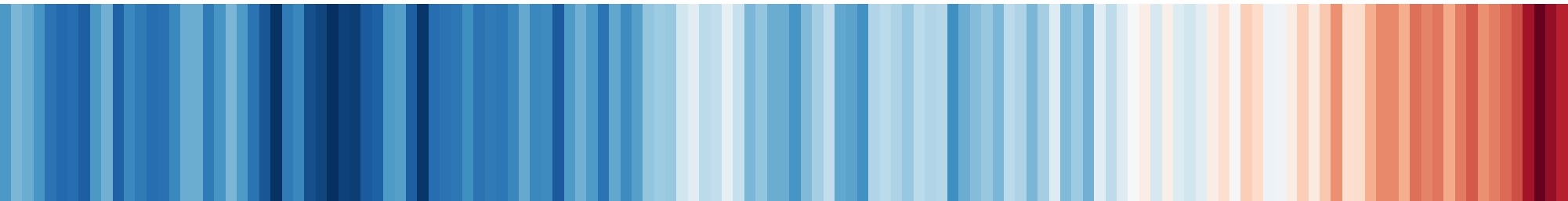
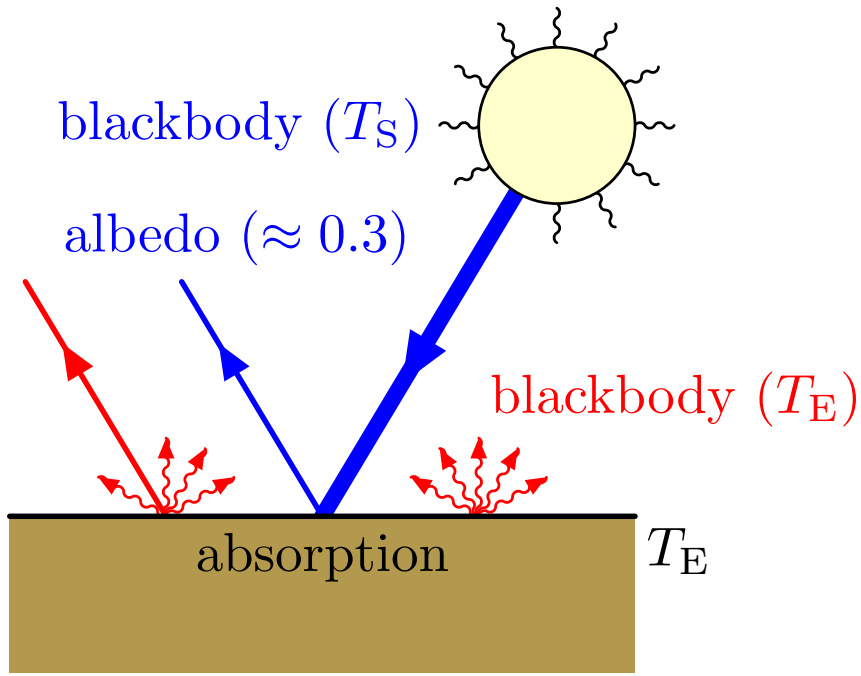
Week 2



Earth as Greenhouse

Energy Balance

Earth surface temperature T_{E} determined by radiation balance.
Leading order effect:



Resulting equilibrium surface temperature of bare earth:

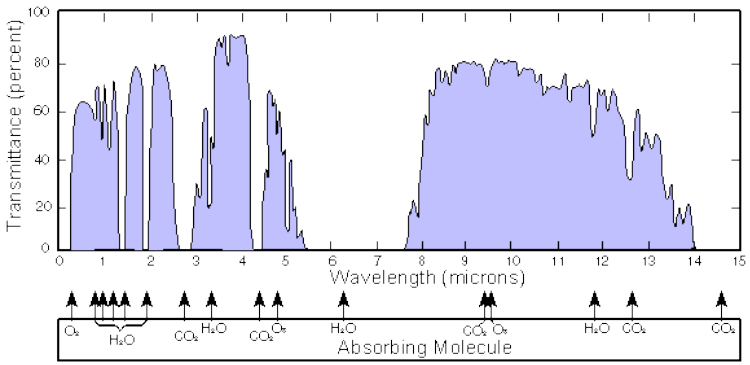
$$\boxed{T_{\mathrm{E}} \simeq -18^{\circ}\mathrm{C}}$$

Energy Balance Including Atmosphere

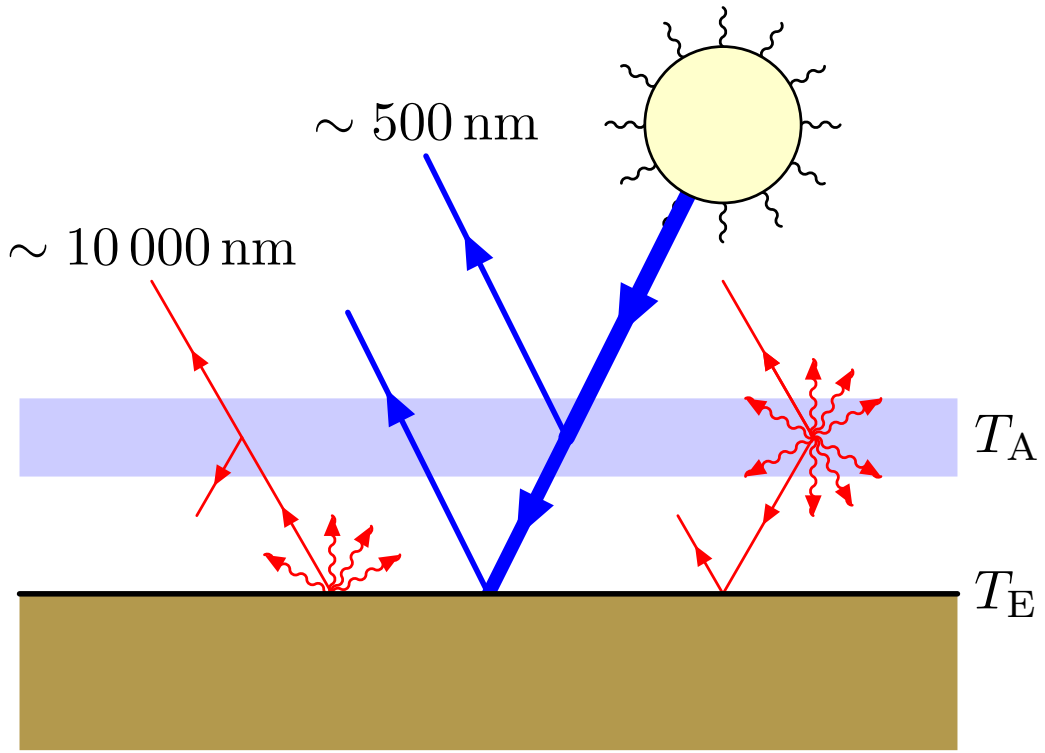
Include (one layer of) atmosphere (gas, clouds, aerosols, . . .)

Effect of atmosphere:

- reflect, absorb, transmit
- white: high transmission
- IR: low transmission



wikimedia: U.S. Navy



Resulting equilibrium earth surface temperature:

$$T_\mathrm{E} \simeq +14^\circ\mathrm{C}$$

Atmosphere and Temperature

More accurately: many layers of atmosphere. Then:

- Temperature gradient in atmosphere.
- Blackbody radiation $-18°\mathrm{C}$ effectively from some altitude.
- Higher surface temperature (increases with effective BB altitude).

Asymptotic temperature depends on:

- atmospheric composition (water vapor, CO2, methane, ...),
- albedo (ice, water, stone, desert, plants, clouds, ...).

Parameters of atmosphere and surface can change. **Currently:**

$$T_{\mathrm{E}} \approx +14.9°\mathrm{C}$$

Equilibrium/Dynamics:

- temperature surplus will be radiated out to space,
- decay constant $\sim$ month(s),
- heat transport into ground and ocean slow (oceans lagging).

Climate Models

Much more elaborate and accurate models:

- surface resolution of surface (water, desert, plants, . . .)
- spacial resolution of atmosphere (clouds, aerosols, gases)
- temporal evolution, dynamics
- greenhouse gas absorption/emission (water/permafrost/plants)
- air/water cycles (horizontal/vertical mixing)
- non-linear, statistical, Monte-Carlo
- . . .

Post/predict climate well.

Current Issues

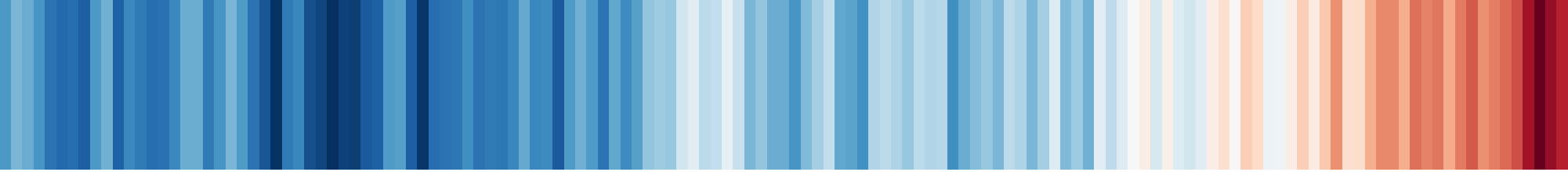
Current Issues

Germany: Klimapaket

- starting in 2021
- equalised by Pendlerpauschale (more than)
- bailout of bankrupt air carrier

Switzerland: Demos regarding climate change

- 27 September: Klimastreik Zürich
- 28 September: Nationale Klimademo Bern



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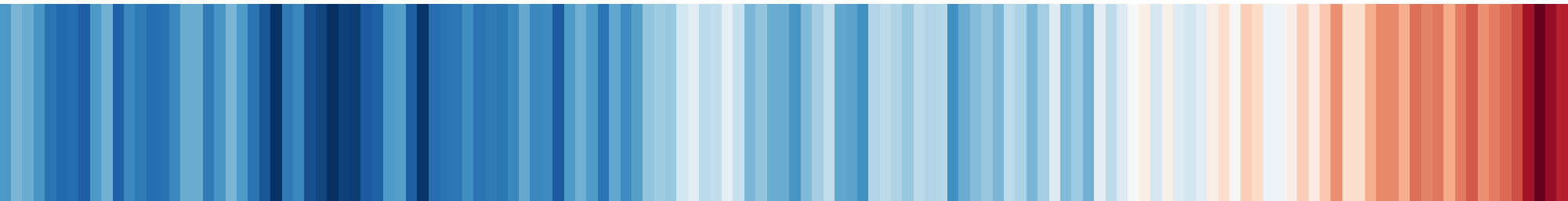
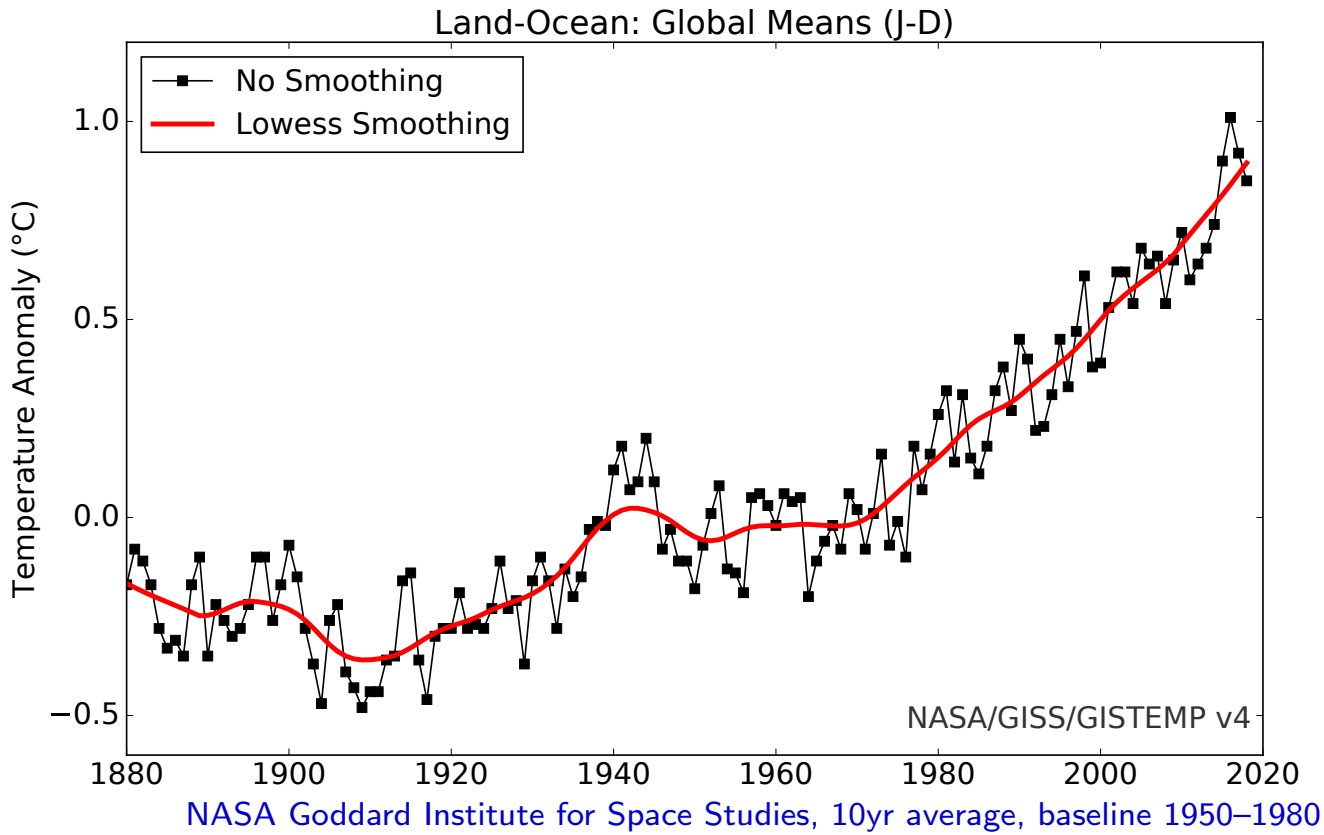
Week 3



Global Heating

Surface Temperature Anomaly

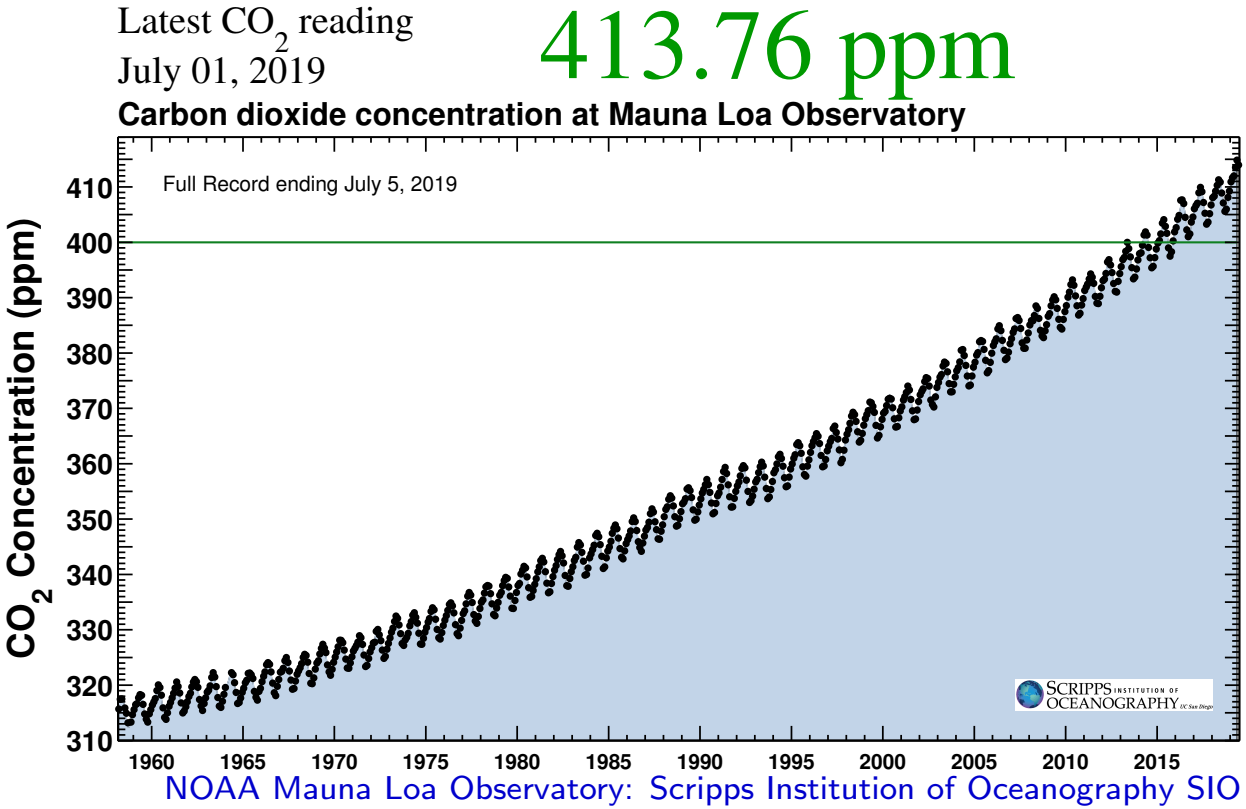
Observe mean surface temperature increase:



Currently: $\approx +1^\circ$ compared to pre-industrial era ca. 1800–1850.

CO2 Concentration

Observe atmospheric CO2 level increase (Keeling curve):

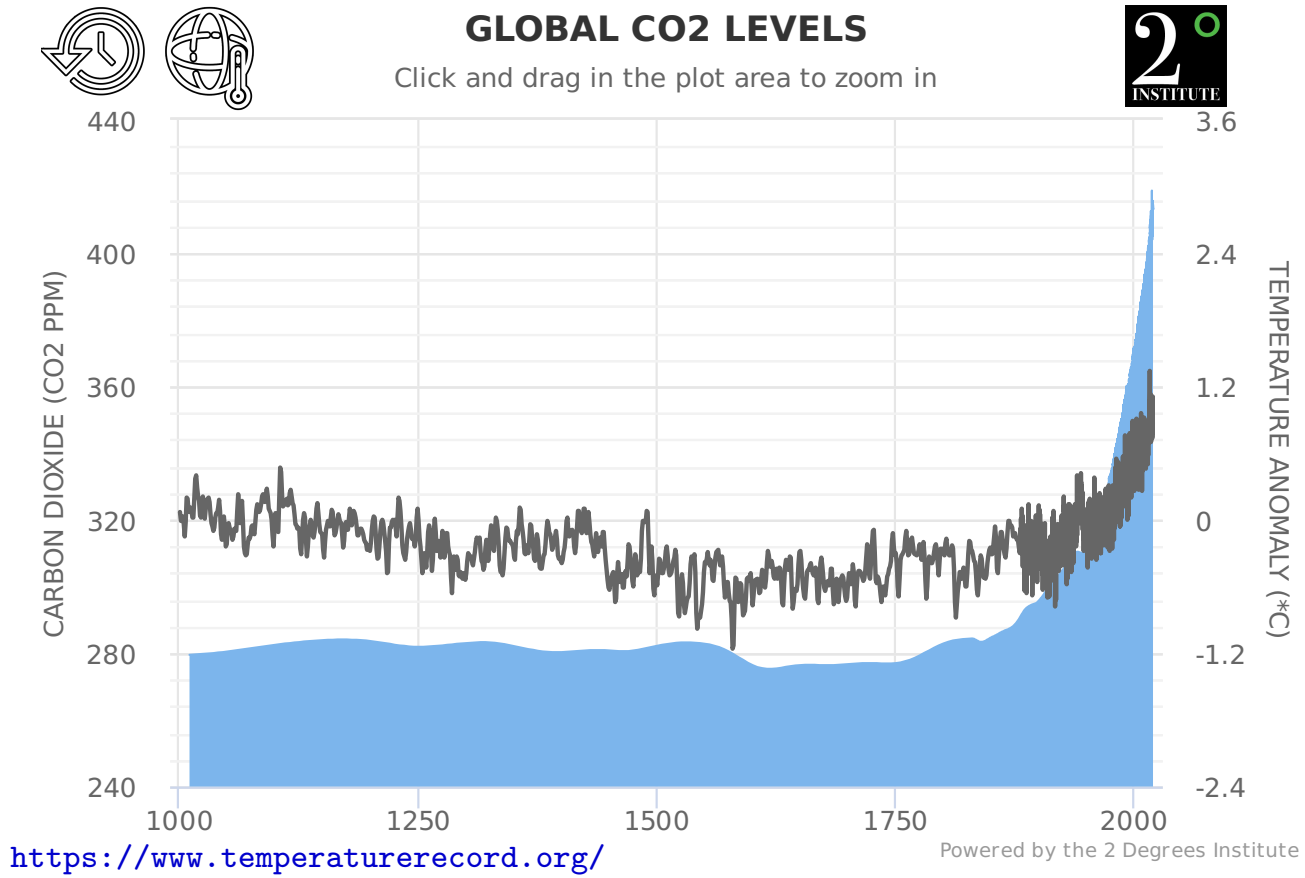


Peak concentration: $\boxed{415 \cdot 10^{-6}}$ in May 2019.

- annual oscillations: biomass cycles in northern hemisphere.
- annual mean: linear trend, clearly accelerating;
  consistent with dominant cause of surface temperature trend.

Historic Data

Has such an increase happened before?

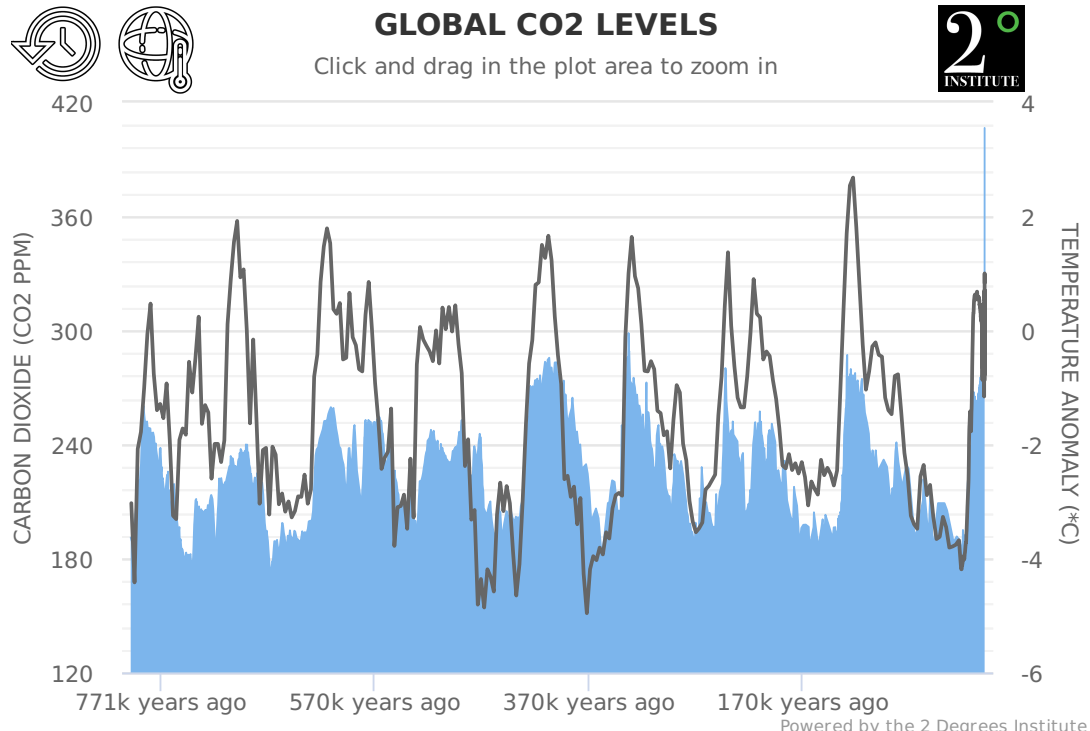


Data available for 2000 years:

- lake and ocean sediments, ice cores, stalagmites, tree-rings

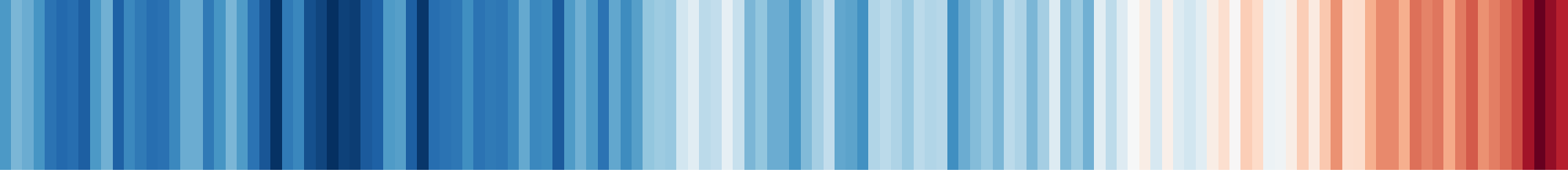
Paleo-Climatology

Even further:



https://www.temperaturerecord.org/

- CO2 from antarctic ice cores; temp from ocean sediment cores
- CO2 concentration remained below $300{\cdot}10^{-6}$ (now $> 400{\cdot}10^{-6}$)
- temperatures gauged to glacial/inter-glacial periods of $\Delta T \approx 4°$
- current rate of warming 10–20 times faster than ice age recovery



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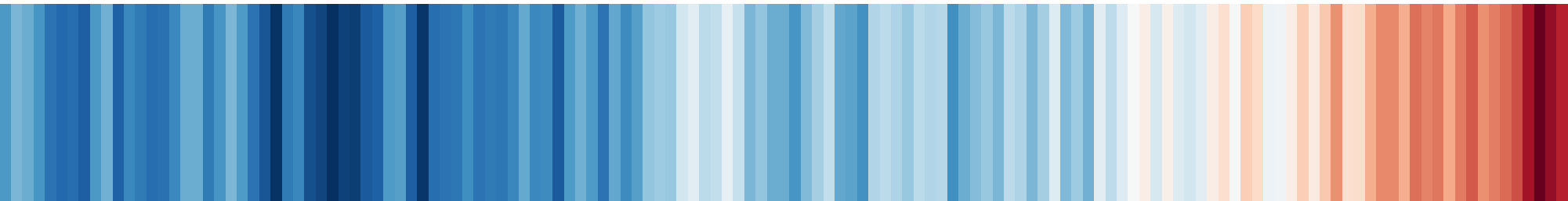
Week 3 – References



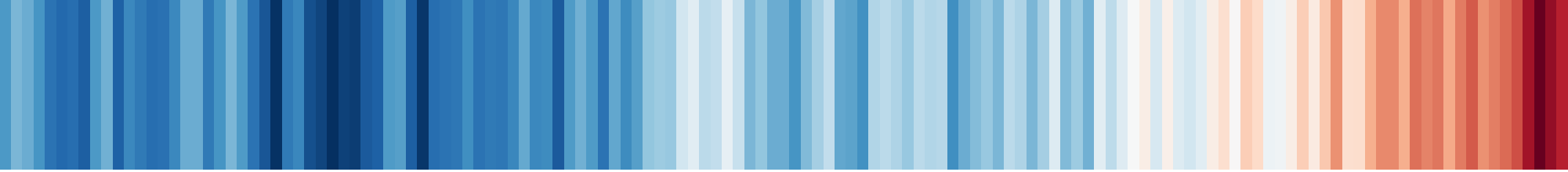
Announcement, References

Switch Thursday → Monday:

- more time before/after lectures;
- continue this Thursday, next Monday.

References, Data:

- NASA Goddard Institute for Space Studies temperature anomaly: http://data.giss.nasa.gov/gistemp/graphs/
- NOAA Mauna Loa Observatory, Keeling Curve: https://scripps.ucsd.edu/programs/keelingcurve/
- data collections: https://www.2degreesinstitute.org/ https://climate.nasa.gov/
- IPCC Reports, 1.5° special report; summary chapters: https://www.ipcc.ch/reports/
- find references yourselves ...
- read fine-print: What do the data actually describe (in detail)?



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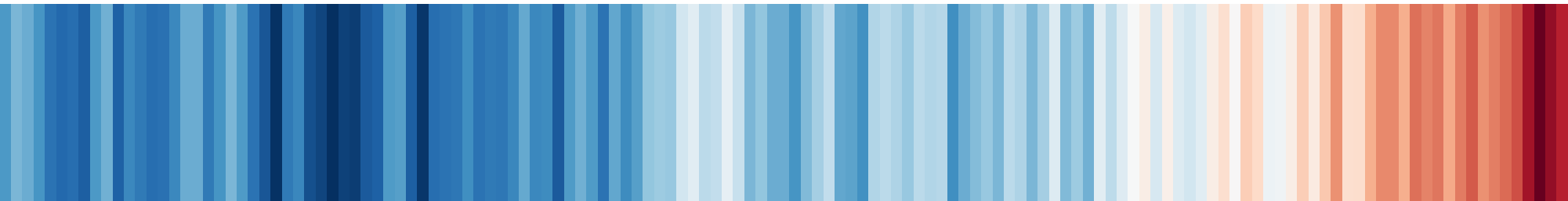
Week 4



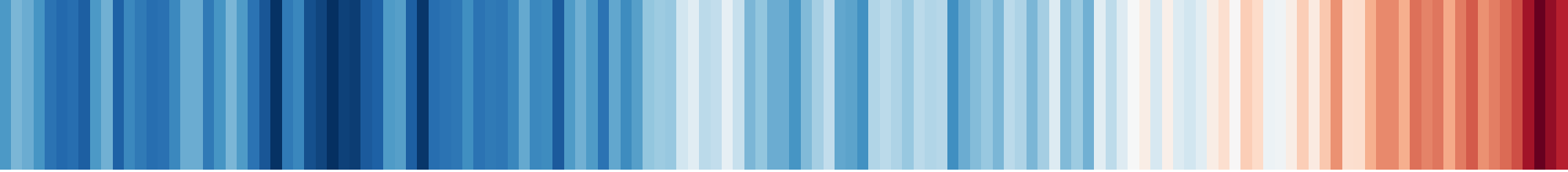
Invoking Change

Science case settled:

- $\sim$ 1960: first measurements
- $\sim$ 1970: first computer models
- $\sim$ 1980: solid predictions
- 1988: politics, IPCC;
- 1992: UNFCCC; 1997: Kyoto Protocol; 2015: Paris Agreement

Question: How to make life more sustainable?

- Rely on individuals changing?
- Rely on industry to become sustainable?
- Rely on politics to change rules, implement taxation, subsidies?



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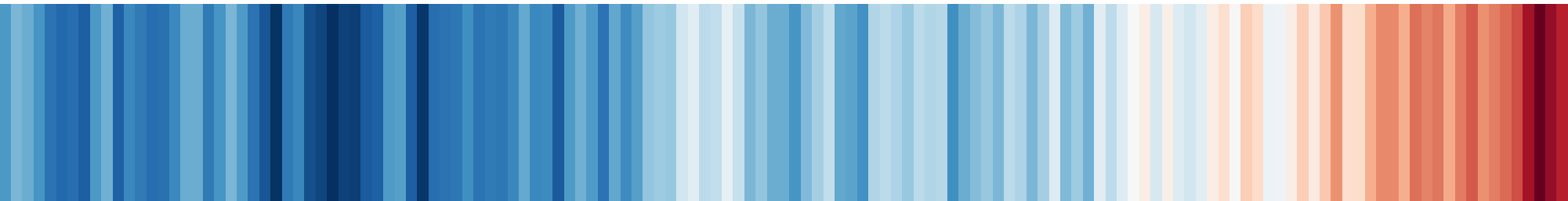
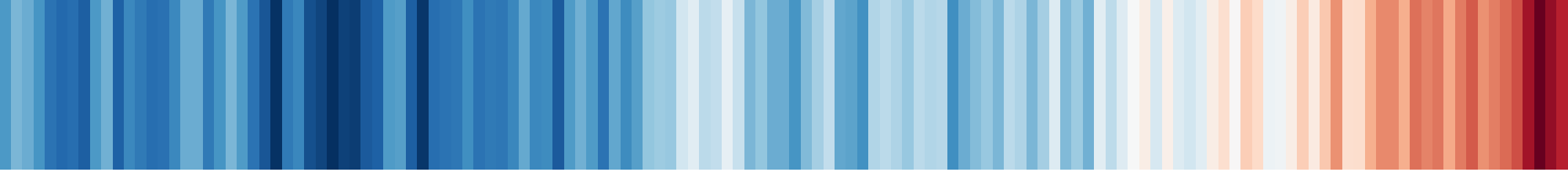
Week 5



Questions to the Audience

Two questions to you:

- Suppose emissions remain level or continue at current rate:
  How do you think you will be affected by global heating here?
  What might be a significant event of progressing climate crisis?
- What do you plan to do during the next year to counteract?
  Name the action that you think will be most effective.



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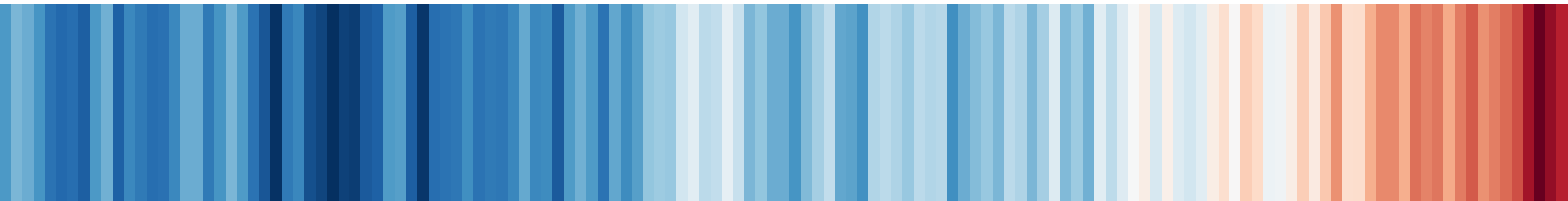
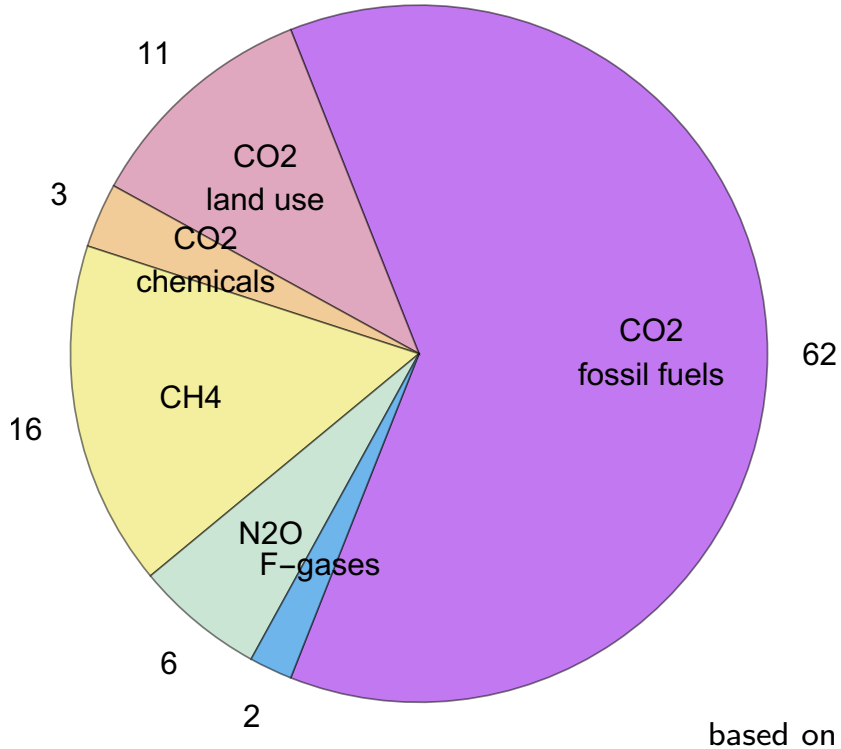
Week 6



Emissions

Greenhouse Gas Types

What types of greenhouse gases are emitted?

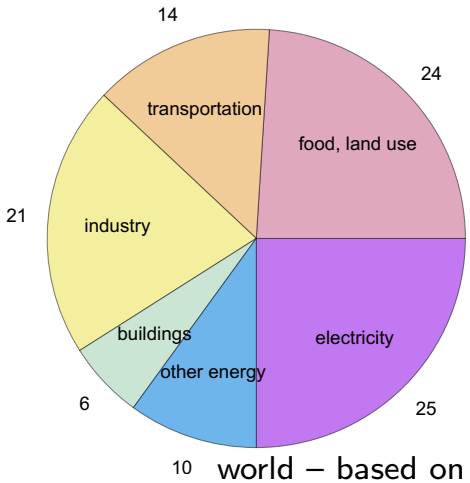


based on J. Foley

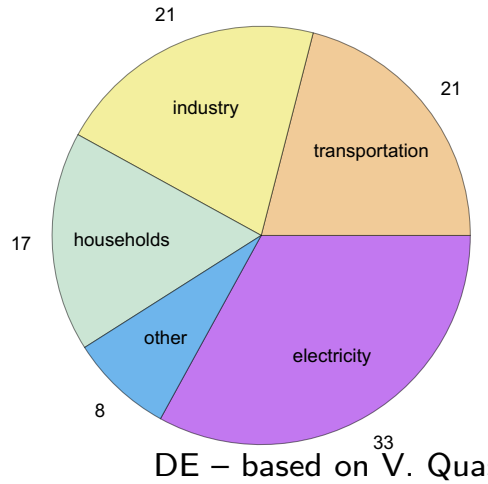
- CO2 is dominant contributor to increase of greenhouse effect
- other gases converted to CO2 equivalent (100 year average); source of confusion: period of activity, only CO2/all gases, C/CO2

Greenhouse Gas Emissions

What causes greenhouse gas emissions into atmosphere?



world – based on J. Foley



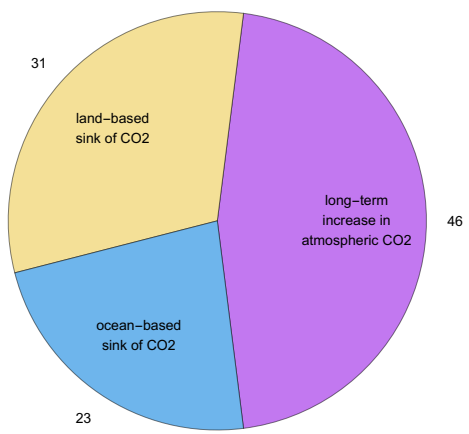
DE – based on V. Quaschning

Sizable differences for:

- industrialised / developing
- urban / rural
- particular countries (coal)

Fate of CO2:

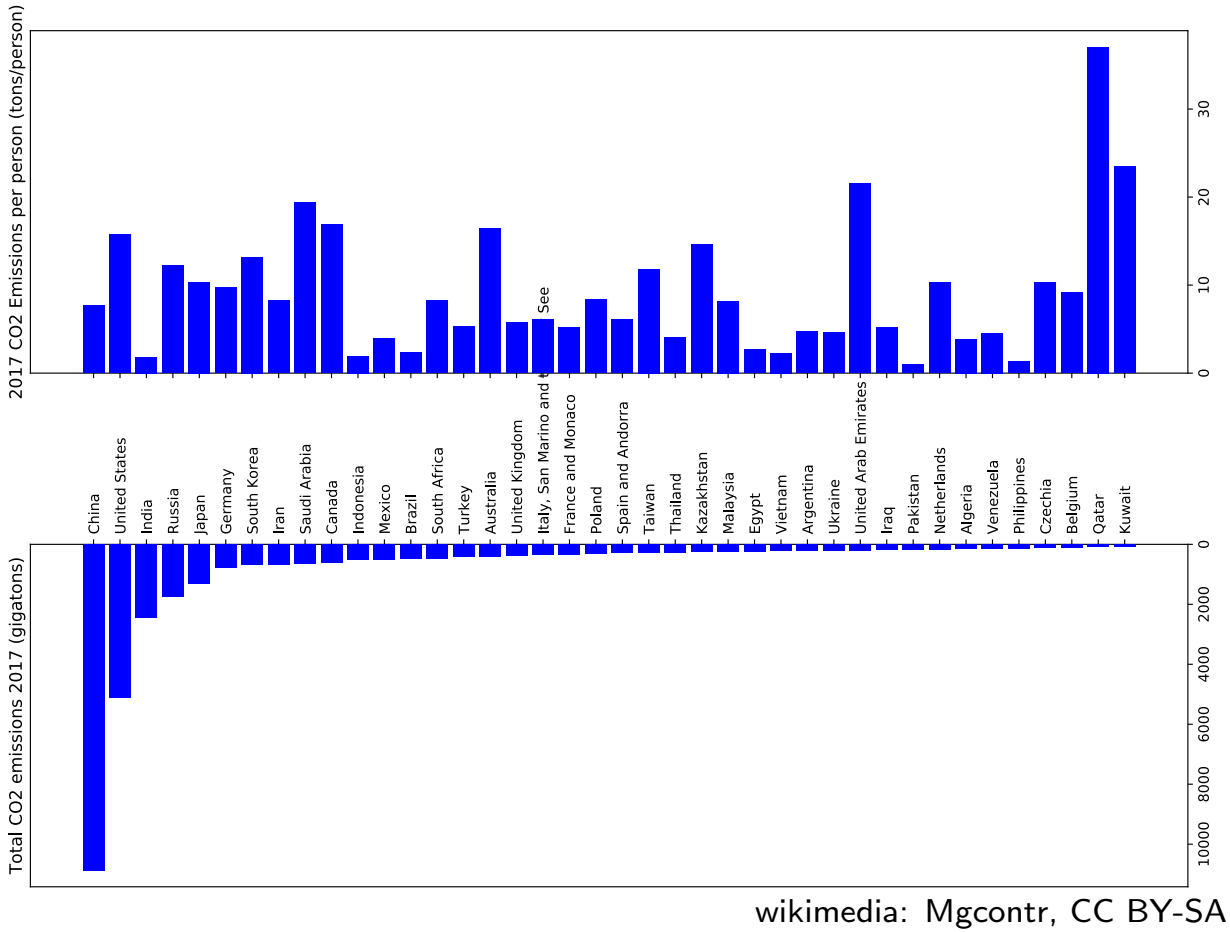
- absorbed by ground, oceans
- $\sim {}^{1}/_{2}$ increases atm. concentration



based on J. Foley

Emissions by Country

Who causes greenhouse gas emissions?

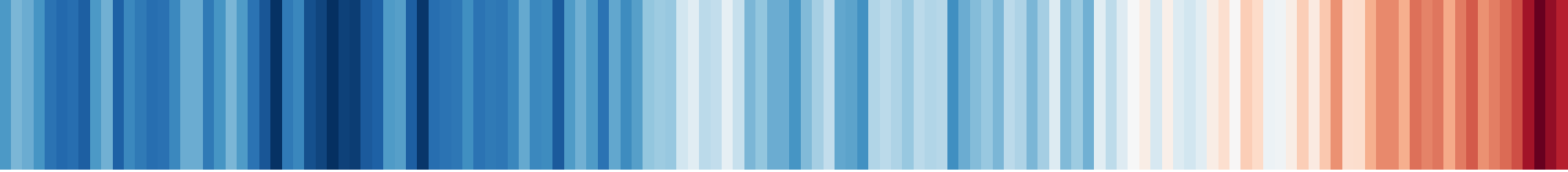


wikimedia: Mgcontr, CC BY-SA

per capita av. annual emissions [tons CO2 eq]

- World: ~ 5
- Europe, Japan: ~ 10
- USA, Canada: > 15
- India, Brasil: $\ll 5$

Note: + high indirect emission by industrialised nations (consumption)



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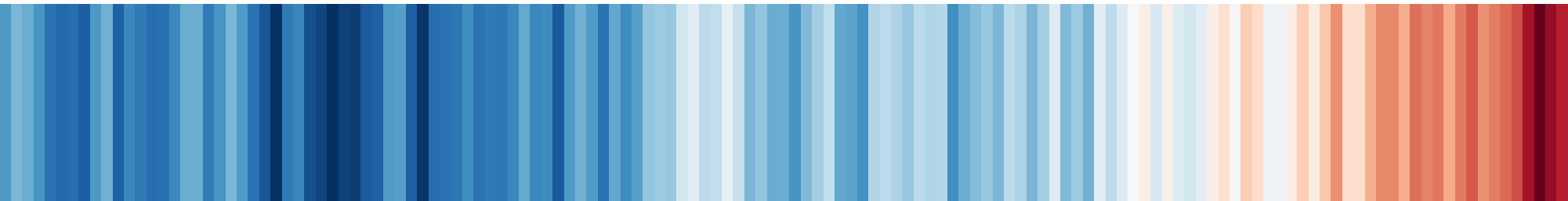
Week 7



Climate Crisis

Implications

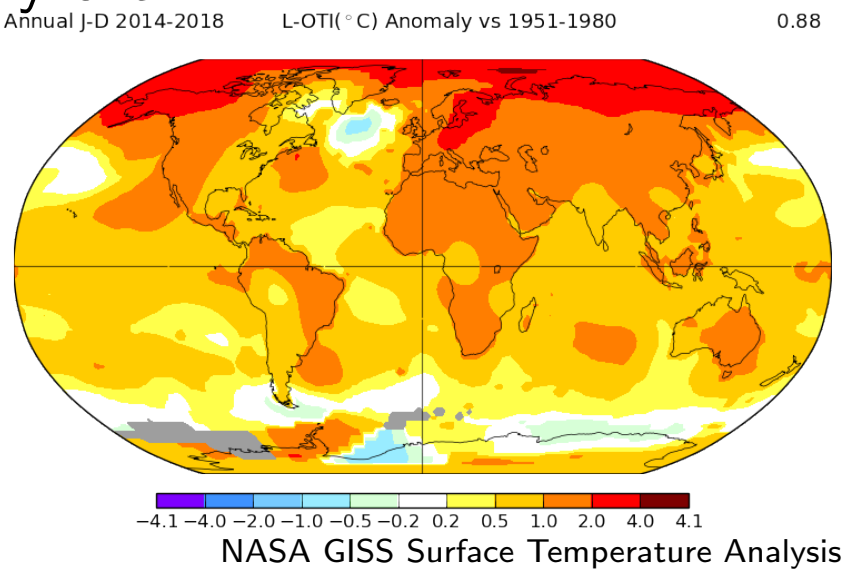
Effects to be expected at higher average surface temperatures:

IPCC reports, $1.5°$ special report (Oct 2018)

- heat waves, droughts
- greater weather variability, extremes, intense rainfall
- sea level rise (slow): ice melt, density of water
- uninhabitable regions (flooding, deserts)
- threshold effects: sudden, irreversible processes (permafrost CO2)
- biodiversity, species extinction, supply chain
- . . . , see IPCC reports
- unforeseen effects

Geographical distribution of heating:

- map: compared to $0.88°$ average
- higher over land, cities (factor 1–3)
- oceans absorb heat (delays)



Prospects

Take for granted:

- emissions raise temperature;
  near future, years: linear dependency
  medium future, decade(s): non-linear effects
  (simulations, unforeseen effects)
- increased temperature reduces inhabitable area
- finiteness of fossil resources
  (will hardly enjoy full exploitation of coal)
- sustainable technology available
  (to some extent, not fully competitive)

Uncertain:

- tipping points (non-linear, unidirectional; e.g. permafrost melting)
- technological advances (CO2 capture, power to gas, fusion?)
- global society (acceptance, response, willingness to change)

Risk Assessment

No determinism – no certainty.

Risk analysis:

- How likely?
- How intense?
- How severe?

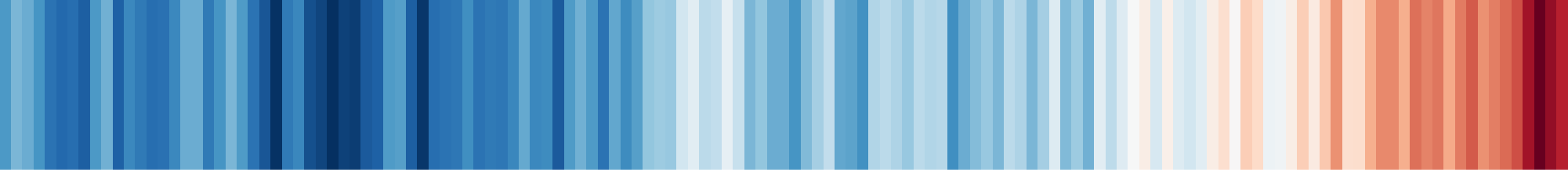
Risks related to global heating severe.

Helps to think basic: Take for granted?

- food from (super)market
- potable water from tap
- electricity from outlet
- peace

Effects related to heating (will/did/do) become reality:

- We can tune intensity. We can tune course.
- Can we afford to delay action?



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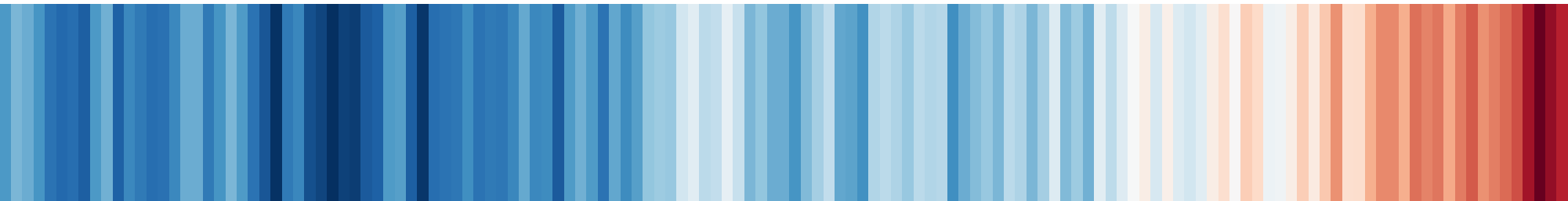
Week 8



Reduction

Paris Agreement

Paris Agreement (December 2015):

- keep surface temperature increase significantly below 2° (global average temperature compared to pre-industrial levels),
- pursue efforts to limit increase to below 1.5°,
- facilitate lower greenhouse gas emissions and climate resilience,
- adjust finance flows towards climate neutrality.

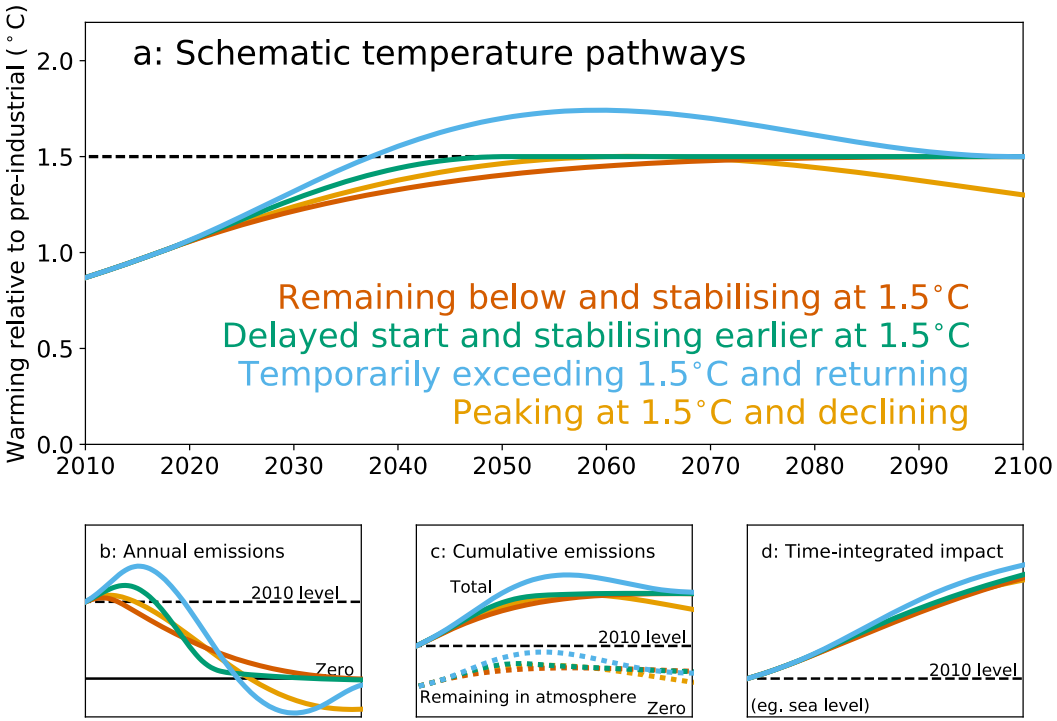
International agreement, ratified by almost all UNFCCC nations.

Status and projections:

- currently: $+1^\circ$,
- remaining: $+0.5$–1.0° (magnitude will affect intensity),
- present rate: $+0.2^\circ$ per decade (accelerating),
- estimates without policy adjustments: $+3$–5° by 2100.

Reduction Scenarios

Different scenarios analysed in IPCC SR1.5:

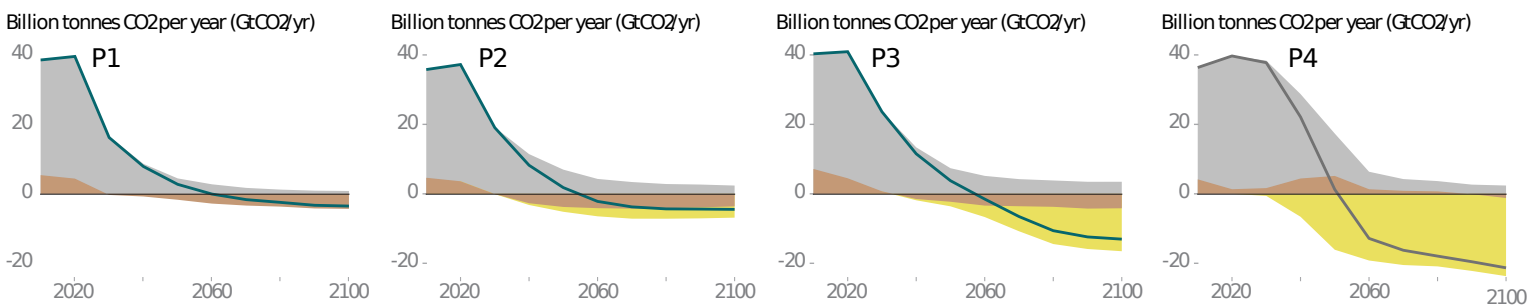


IPCC SR1.5 Fig 1.4

common features P1–3:

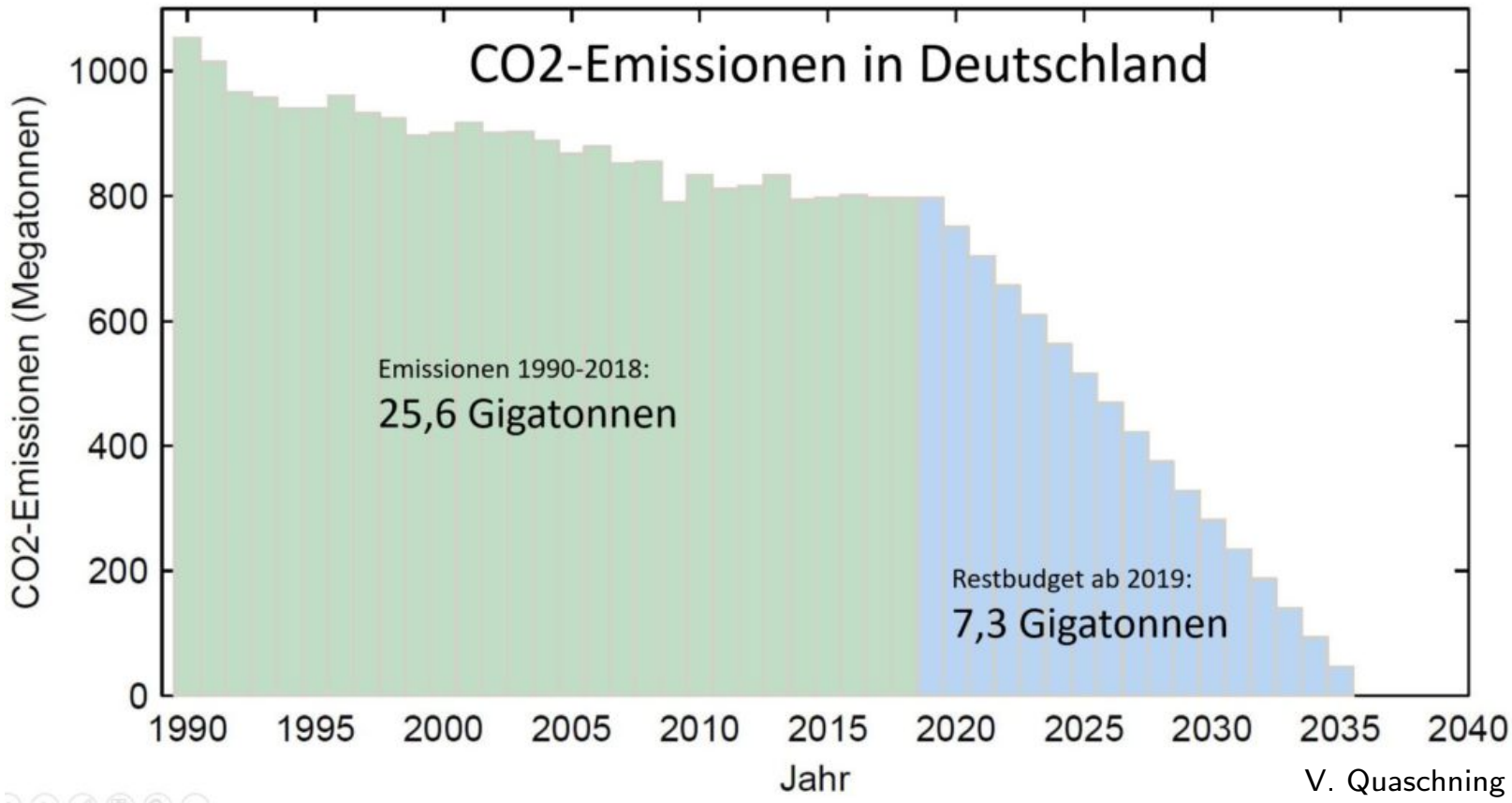
- reduce to $^1/_2$ by 2035
- **net zero** before 2060
- require some CO2 capture (risk!)

P4 (delays); requires substantial CO2 capture



IPCC SR1.5 Fig SPM.3b

Reduction Scenarios (cont.)



Towards Climate Neutrality

Reduction possibilities:

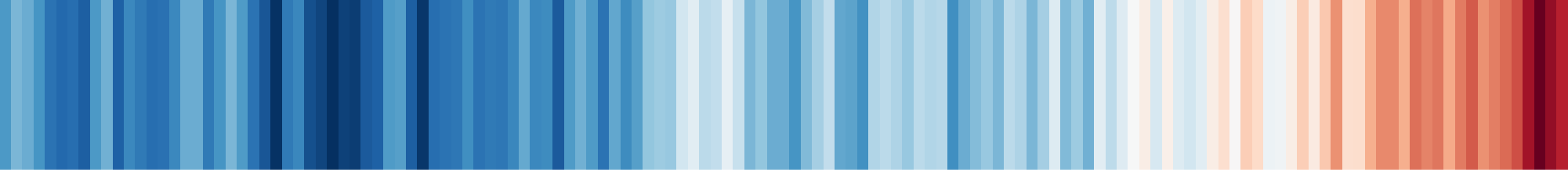
- nutrition (meat, dairy)
- traffic (individual, flights, commerce)
- buildings (concrete, heating/cooling)
- electric energy (coal)
- consumption (short-lived, unnecessary)
- CO2 capture (reforestation, solar to liquid, to be developed)
- for useful ideas, see e.g. "Project Drawdown"

Most importantly: all needed (AND not OR) / everywhere

Furthermore:

- Transition (convince, legislate, enact) needs time; initiate now.
- Need margin to compensate for delays in individual sectors.
- Changes towards sustainable future are useful in their own right!

Can we afford to delay action?



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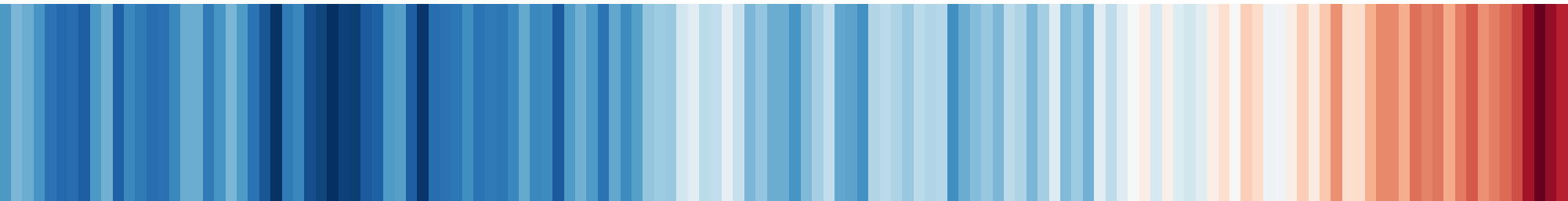
Week 9



Numbers

Relevant Numbers

Useful to know some estimate figures:

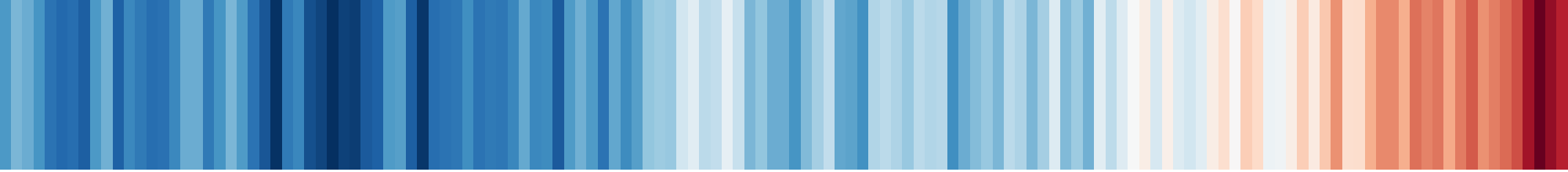
remaining CO2 budget:	300–$1000\,\mathrm{Gt}$ (Paris Agreement goals)
current rate of emissions:	$40\,\mathrm{Gt/yr}$
global population:	$7.5\,\mathrm{G}$ (unintuitively large)
per capita budget:	50–$150\,\mathrm{t}$ (until CO2 capture available)

Estimates depend on precise definition and risk level!

Can decide how to use budget. **Some CO2 emission figures:**

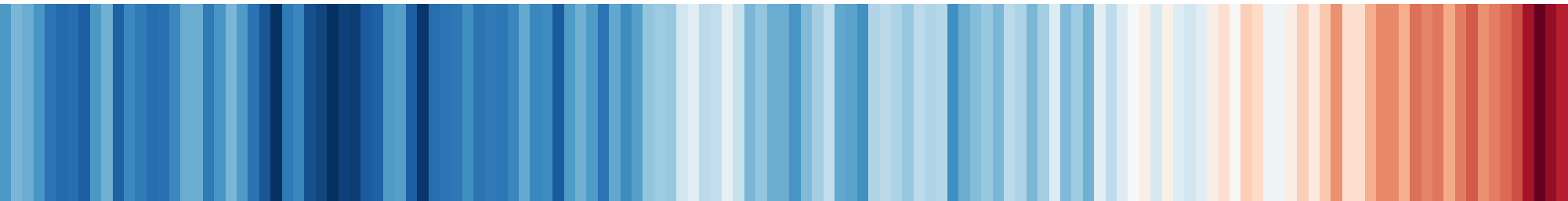
av. per capita emission (we):	$\gtrsim 10\,\mathrm{t/yr}$
$1\,\ell$ fuel:	$2.3\,\mathrm{kg}$ (0.1–$0.2\,\mathrm{t}/1000\,\mathrm{km}$)
continental return flight:	0.3–$1.5\,\mathrm{t}$ (with RFI)
overseas return flight:	2–$12\,\mathrm{t}$ (with RFI)
subsistence:	(!) ... (footprint calculators)
public services baseline:	... (admin, army, public institutions)

No sharp cut-off; global average matters; excess affects intensity.



GIVE
THE CLIMATE
A BREAK

Week 10



Society

Timeframe for Changes

2° goal:

- reduction of GHG emissions to 50% by 2030–35
- net-zero emissions by 2050–60

Reduction technologically feasible but ambitious (within timeframe):

- electricity: wind, water, ...
- buildings: heating, cooling, materials, ...
- food, land-use: towards vegetarian, vegan diet; preserve forests
- industry: packaging, methods, ...
- transport: alternative fuels, public transport, local products

Most importantly: **5 R's**

Refuse, Reduce, Reuse (repair), Recycle, Rot

Changes are: • feasible, • often beneficial in other regards,
• not happening, • not at necessary rate.

Society, Psychology

Climate action (dominantly?) slowed by society:

- loss of convenience (highly developed countries, 80/20 rule)
- afraid to move backward, fall behind (vs. supercharged)
- inertia, fabric of society (imitate surroundings)
- different risk behaviour for gain/loss situations (low/high)
- cognitive dissonance
- individual, short-term gains / socialised long-term losses
- capitalism, perpetual growth economy
- deception, campaigns ($\sim$ tobacco industry)

Changes

Facts:

- perpetual growth clashes with sustainability on a finite planet;
- climate crisis will introduce changes to all aspects of life & society;
- effects will be fundamental in our lifetime.

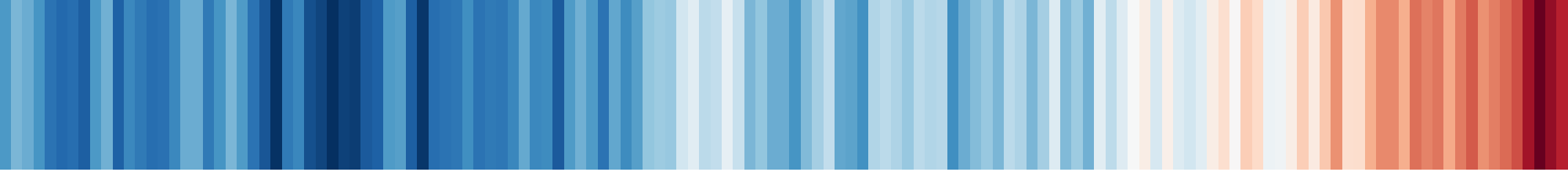
Progress:

- avoid sudden, forced change;
  achieve change adiabatically, requires sufficient time;
- accept partial solutions (start somewhere);
- be open-minded about way of life, society.

Current Issues

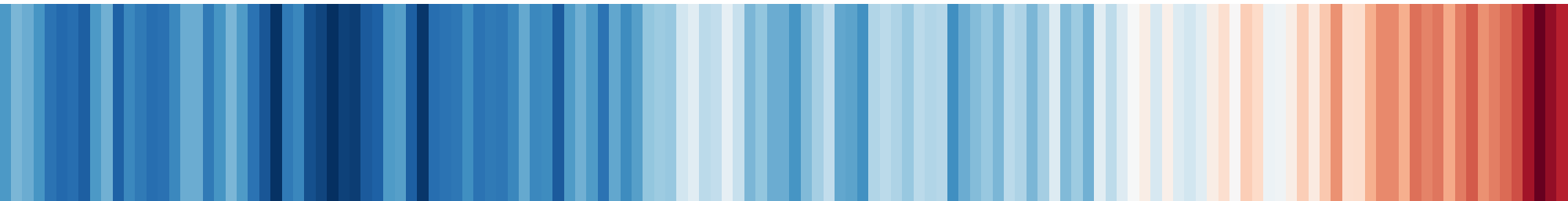
Friday, 29 November

- 12:00: Klimastreik Bern
- 16:00: Klimastreik Zürich



GIVE
THE CLIMATE
A BREAK

Week 11



ETH Zürich

ETH Zürich Process

ETH Zürich found following distribution of its CO2 emissions:

$$> 50\% \text{ business travel} = 17\,\mathrm{kT/yr}$$
$$93\% \text{ from flights } (85\% \text{ from inter/transcontinental})$$

School board asks departments to define reduction goals (2017).
Discussion revealed some conflicts of interest, open questions:

- Evaluation criteria: conference talks & organisation, careers.
- Reduction compared to what?

Department/school decide soft measures (2018):

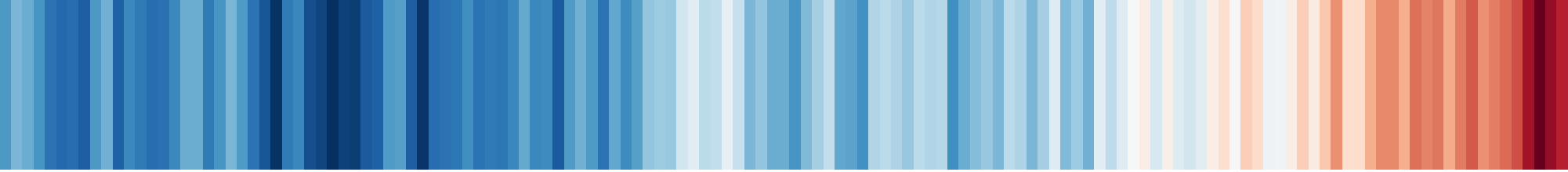
- Take trains where possible; use video-conferencing.
- Reduction of travel emissions: 11% by 2025 (per capita).
- School monitors business travel, will improve buildings, catering.

2019 federal administration target: 50% reduction by 2030.
How ambitious are goals (even if achieved) towards Paris agreement?
Nonetheless: start process, awareness, declaration of goal important.

Current Activities

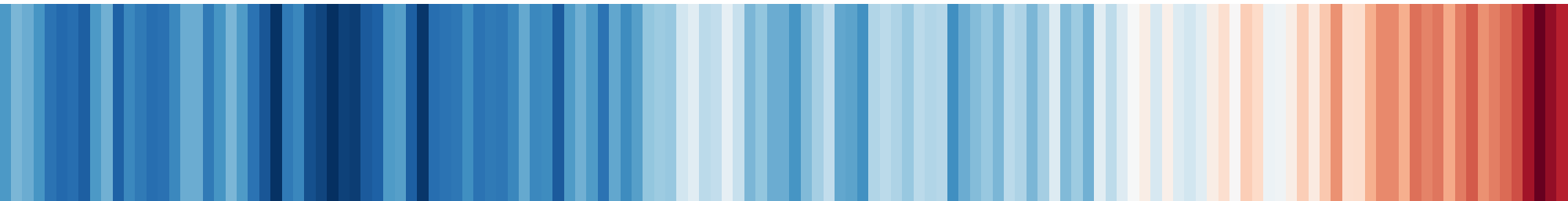
Some current news, activities, links:

- ETH Agenda 2030, ETH Zürich Air Travel Project
- ETH sustainability,
  eth-sustainability-student-mailing-list@sympa.ethz.ch
- "Forderungen der AG Studierende des Klimastreiks Zürich an die Hochschulen der Region"; "Antwort der ETH Zürich auf die Forderungen [...]"; Interview Prof. Reto Knutti: "Die ETH nimmt die Forderungen der Studierenden ernst"
- Petition: "Mehr pflanzliche Mahlzeiten in den Mensen der ETH Zürich" (peoplepower.ch, currently: $\sim$ 900/1000 signatures)
- Talk by Prof. Renate Schubert on Flight Taxation
  Tue, 10 Dec: 18:00 HG D7.1
- Forum on the ETH Zurich Air Travel Project
  Mon, 20 Jan 2020, 16.30, HG (registration needed)



GIVE
THE CLIMATE
A BREAK

Week 12



Deniers

Responses to Deniers

Web resources to address doubts, scepticism, denial, misinformation:

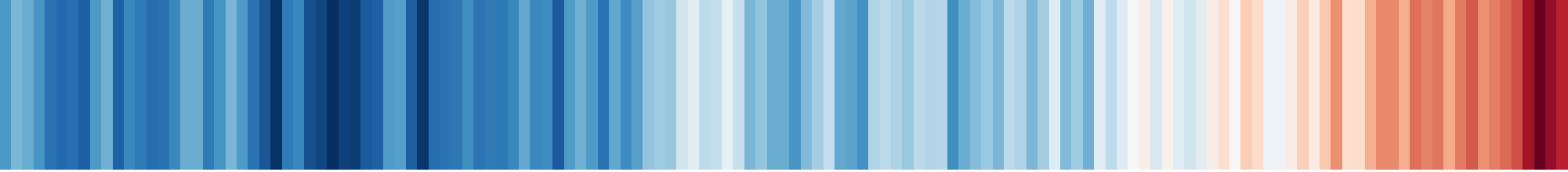
- skepticalscience.com
- Scientists for Future – Infomaterial (in German)

Perhaps even more relevant:

- Large part of population not in denial, opposition ...
  ... but want to go along relatively unperturbed.
- There are many pressing global issues.
  Are there? Are they unrelated?
- Discuss, inform, show opportunities, express concerns, ...

Save the date:

Physics Colloquium, 11 March 2020



GIVE
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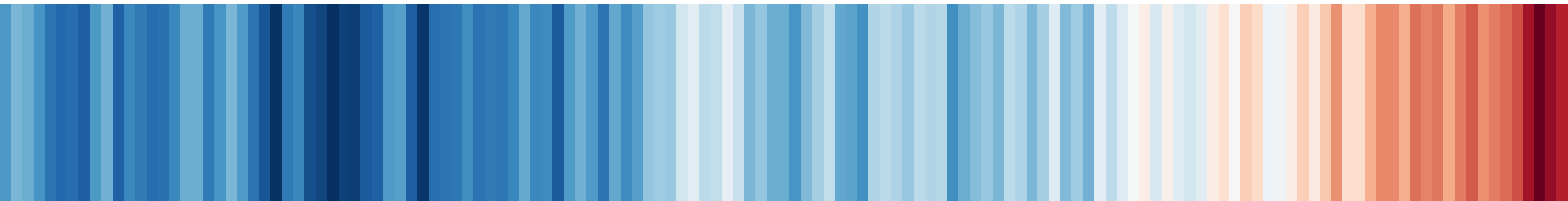
Week 13



COP25

COP25 Chile, Madrid 2019

First World Climate Conference: February 1979, Geneva

- led to establishment of World Climate (Research) Programme;
- led to creation of Intergovernmental Panel on Climate Change;
- Tagesschau (in German)

United Nations Framework Convention on Climate Change
25th Conference of the Parties (UN Climate Change Conference)

Opening Remarks on Climate Emergency: 11 December 2019

- 09:43 – 16:22: Johan Rockström
  Director of the Postdam Institute of Climate Impact Research
- 24:05 – 29:39: Jennifer Morgan
  Executive Director of Greenpeace International
- 30:10 – 41:47: Greta Thunberg, herself

. . . sleepless nights, compromise declaration.

The End

The End

Where did we get?

- awareness
- learned/refreshed some basic facts, insights
- thoughts on mechanisms in society
- forum for discussions

The End? The Beginning? Up to you:

- live and promote sustainable way of life
- seek discussions in your communities; display support
- scientists: oppose misinformation, misrepresentation, . . . ; inform
- not (only) rely on summary information;
  read (some) original references!
- do not expect (swift) progress . . .
- how can you be useful, effective?
  connect the dots . . .

Thanks for your attention!