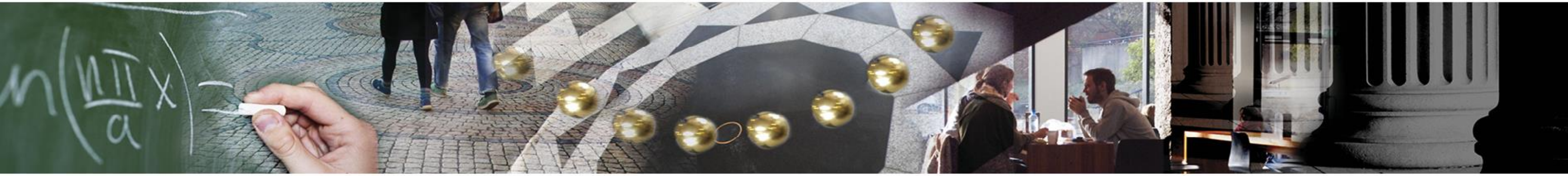

UiO : University of Oslo

Evaluating global and regional land warming trends in the past decades with both MODIS and ERA5-Land land surface temperature data

You-Ren Wang [a], Dag O. Hessen [a], Bjørn H. Samset [b], Frode Stordal [a]

[a] UiO, [b] CICERO

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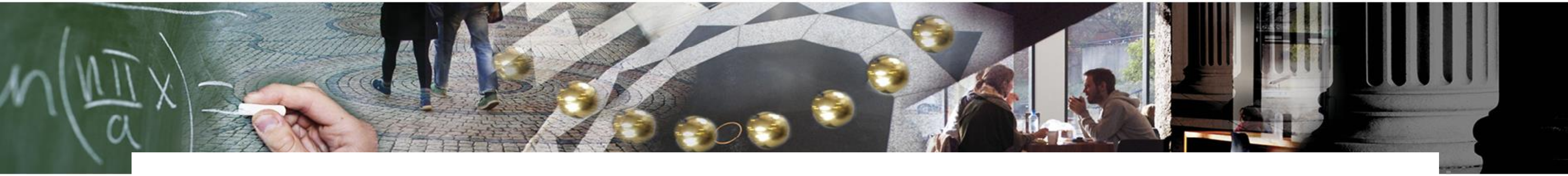
Centre for Biogeochemistry in the Anthropocene

UiO : LATICE

EMERALD webinar, October 12, 2022



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Remote Sensing of Environment 280 (2022) 113181

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Remote Sensing of Environment

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Evaluating global and regional land warming trends in the past decades with both MODIS and ERA5-Land land surface temperature data

You-Ren Wang [a,*], Dag O. Hessen [a], Bjørn H. Samset [b], Frode Stordal [a]

[a] Centre for Biogeochemistry in the Anthropocene, University of Oslo, Oslo, Norway
[b] CICERO Center for International Climate Research, Oslo, Norway

Centre for Biogeochemistry in the Anthropocene

UiO LATICE

Plants are “not silent witnesses to the passage of time but dynamic components that shape and are, in return, shaped by the environment.”

Vegetation

Energy cycle

Water cycle

Temperature

EMERALD

UiO University of Oslo

Dagens Næringsliv

Frans-Jan W. Parmentier, Dag O. Hessen og You-Ren Wang

Innlegg: Ekstremoppvarmingen av Arktis gir økte CO2-utslipp

Klimaendringene kan bli enda verre på grunn av ukontrollerbare utslipp av drivhusgasser fra Arktiske økosystemer – men kunnskap om dette krever langsiktige forskningsprosjekter.

1 MIN | PUBLISERT: 22.08.22 — 19.05 | OPPDATERT: 2 MÅNEDER SIDEN

nature climate change

ARTICLES

https://doi.org/10.1038/s41558-022-01428-z

Warming response of peatland CO_2 sink is sensitive to seasonality in warming trends

M. Helbig[1]✉, T. Živković[2], P. Alekseychik[3], M. Aurela[4], T. S. El-Madany[5], E. S. Euskirchen[6], L. B. Flanagan[7], T. J. Griffis[8], P. J. Hanson[9], J. Hattakka[4], C. Helfter[10], T. Hirano[11], E. R. Humphreys[12], G. Kiely[13], R. K. Kolka[14], T. Laurila[4], P. G. Leahy[13], A. Lohila[4,15], I. Mammarella[15], M. B. Nilsson[16], A. Panov[17], F. J. W. Parmentier[18,19], M. Peichl[16], J. Rinne[19,20], D. T. Roman[14], O. Sonnentag[21], E.-S Tuittila[22], M. Ueyama[23], T. Vesala[15], P. Vestin[19], S. Weldon[24], P. Weslien[25] and S. Zaehle[5]

Peatlands have acted as net CO_2 sinks over millennia, exerting a global climate cooling effect. Rapid warming at northern latitudes, where peatlands are abundant, can disturb their CO_2 sink function. Here we show that sensitivity of peatland net CO_2 exchange to warming changes in sign and magnitude across seasons, resulting in complex net CO_2 sink responses. We use multiannual net CO_2 exchange observations from 20 northern peatlands to show that warmer early summers are linked to increased net CO_2 uptake, while warmer late summers lead to decreased net CO_2 uptake. Thus, net CO_2 sinks of peatlands in regions experiencing early summer warming, such as central Siberia, are more likely to persist under warmer climate conditions than are those in other regions. Our results will be useful to improve the design of future warming experiments and to better interpret large-scale trends in peatland net CO_2 uptake over the coming few decades.

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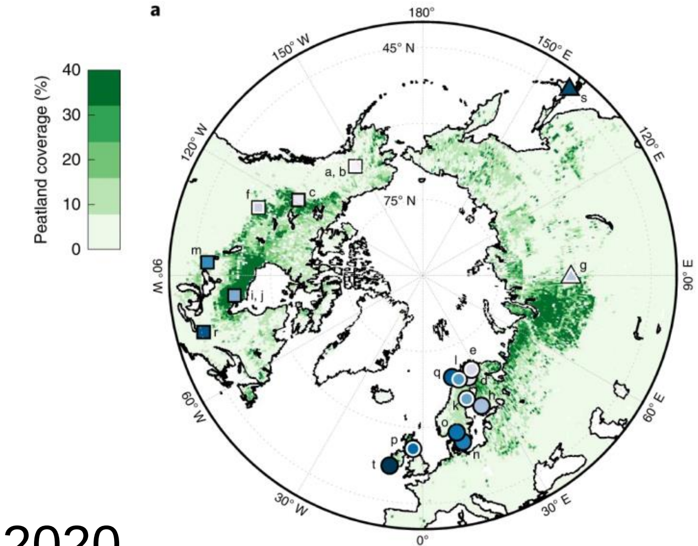
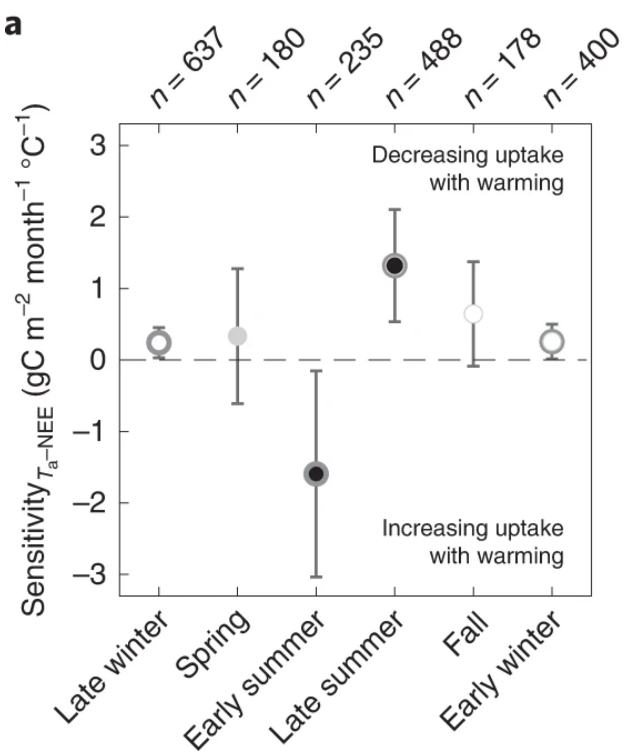


NEE temperature sensitivity

1951-1970 -> 20012020

Warming rates

NEE changes



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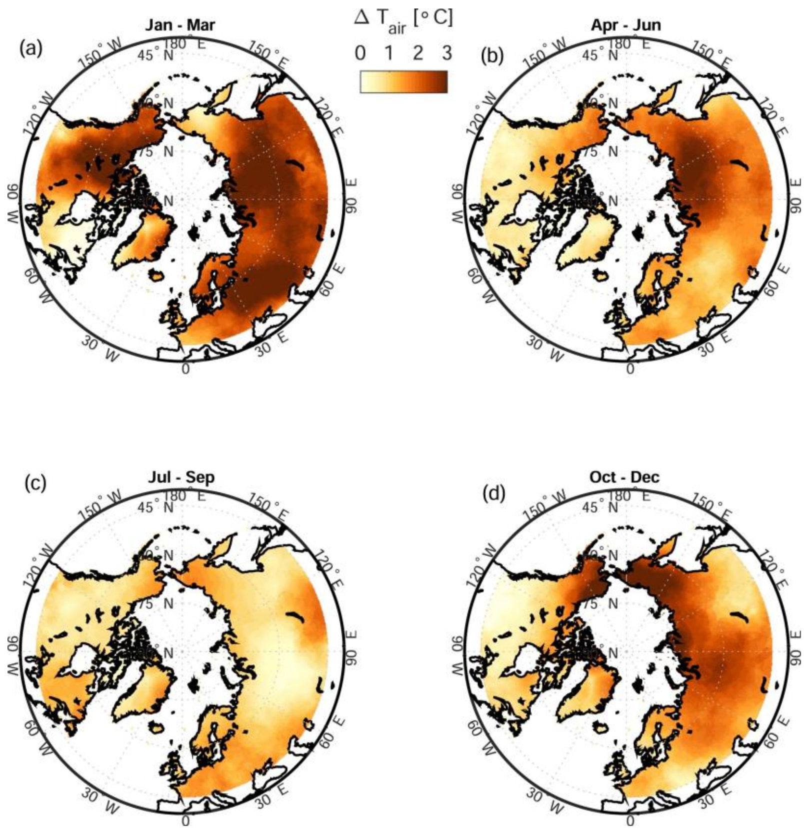

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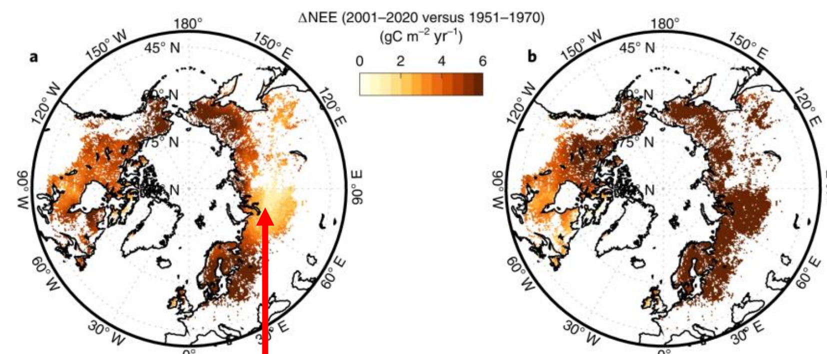
Sesonally varying warming

Sesonally uniform warming



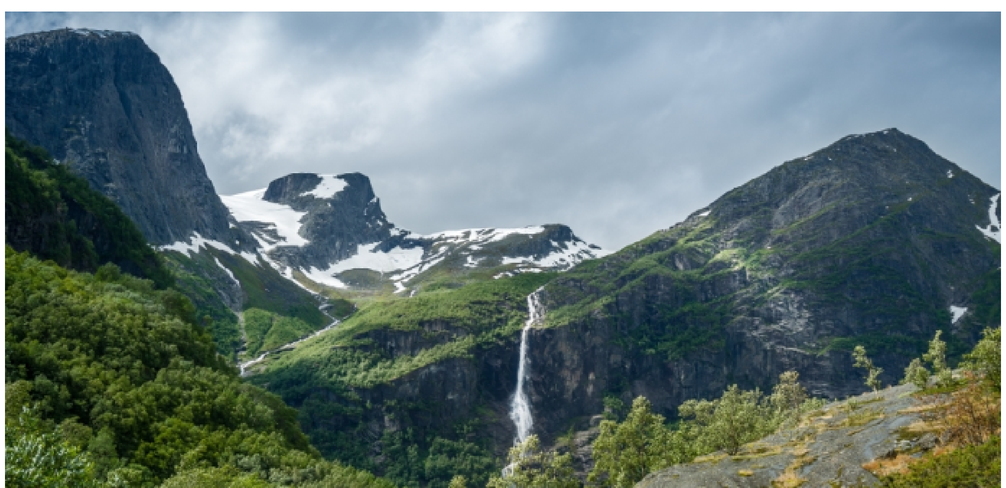
Early summer warming:
CO_2 sinks more likely to persist

Helbig et al., NCC, 2022

UiO

EMERALD – Terrestrial ecosystem–climate interactions of our EMERALD planet

EMERALD is an interdisciplinary and nationally coordinated research project. Emerald will improve the representation of high latitude ecosystems and their climate interactions in The Norwegian Earth System Model (NorESM) by integrating empirical data and knowledge in model development.



The spring green mountain slopes in Briksdalen, in the Western part of Norway. Photo: Colourbox/Alexander Nikiforov.

Contact

Lena M. Tallaksen, Professor and Project Leader

Terje K. Berntsen, Professor and Co-leader

People

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- PhD/Doctoral Research Fellows
- International Experts Network

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Article on tundra isoprene emissions published in PNAS

Published Sep. 19, 2022 9:17 AM

New papers in the journal Remote Sensing of Environment

Published Aug. 16, 2022 7:48 PM

EMERALD at EGU General Assembly, 23–27 May 2022

Published Apr. 29, 2022 9:50 AM

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Webinar October 2022

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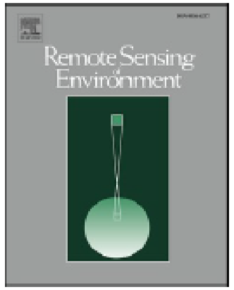

An artificial intelligence approach to remotely assess pale lichen biomass

Rasmus Erlandsson[a,*], Jarle W. Bjerke[a], Eirik A. Finne[a,b], Ranga B. Myneni[c], Shilong Piao[d], Xuhui Wang[d], Tarmo Virtanen[e], Aleksi Räsänen[e,f], Timo Kumpula[g], Tiina H.M. Kolari[h], Teemu Tahvanainen[h], Hans Tømmervik[a]

[a] *Norwegian Institute for Nature Research, FRAM – High North Research Centre for Climate and the Environment, NO-9296 Tromsø, Norway*

[b] *Department of Geosciences, University of Oslo, Postboks 1047 Blindern, NO-0316 Oslo, Norway*

[c] *Department of Earth and Environment, Boston University, 685 Commonwealth Avenue, Boston, MA US-02215, USA*

[d] *Sino-French Institute for Earth System Science, College of Urban and Environmental Sciences, Peking University, Shaw Building No.2, 5 Yiheyuan Road, Haidian District, CH-100871 Beijing, China*

[e] *Ecosystems and Environment Research Programme, Faculty of Biological and Environmental Sciences, and Helsinki Institute of Sustainability Science (HELSUS), University of Helsinki, Yliopistonkatu 3, FI-00014, Finland*

[f] *Natural Resources Institute Finland (Luke), Paavo Havaksentie 3, FI-90570 Oulu, Finland*

[g] *Department of Geographical and Historical Studies, University of Eastern Finland, Joensuu Campus, PO Box 111, FI-80101 Joensuu, Finland*

[h] *Department of Environmental and Biological Sciences, University of Eastern Finland, Joensuu Campus, PO Box 111, FI-80101 Joensuu, Finland*

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The spring green mountain slopes in Briksdalen, in the Western part of Norway. Photo: Colourbox/Alexander Nikiforov.

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PNAS RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES
ENVIRONMENTAL SCIENCES

Strong isoprene emission response to temperature in tundra vegetation

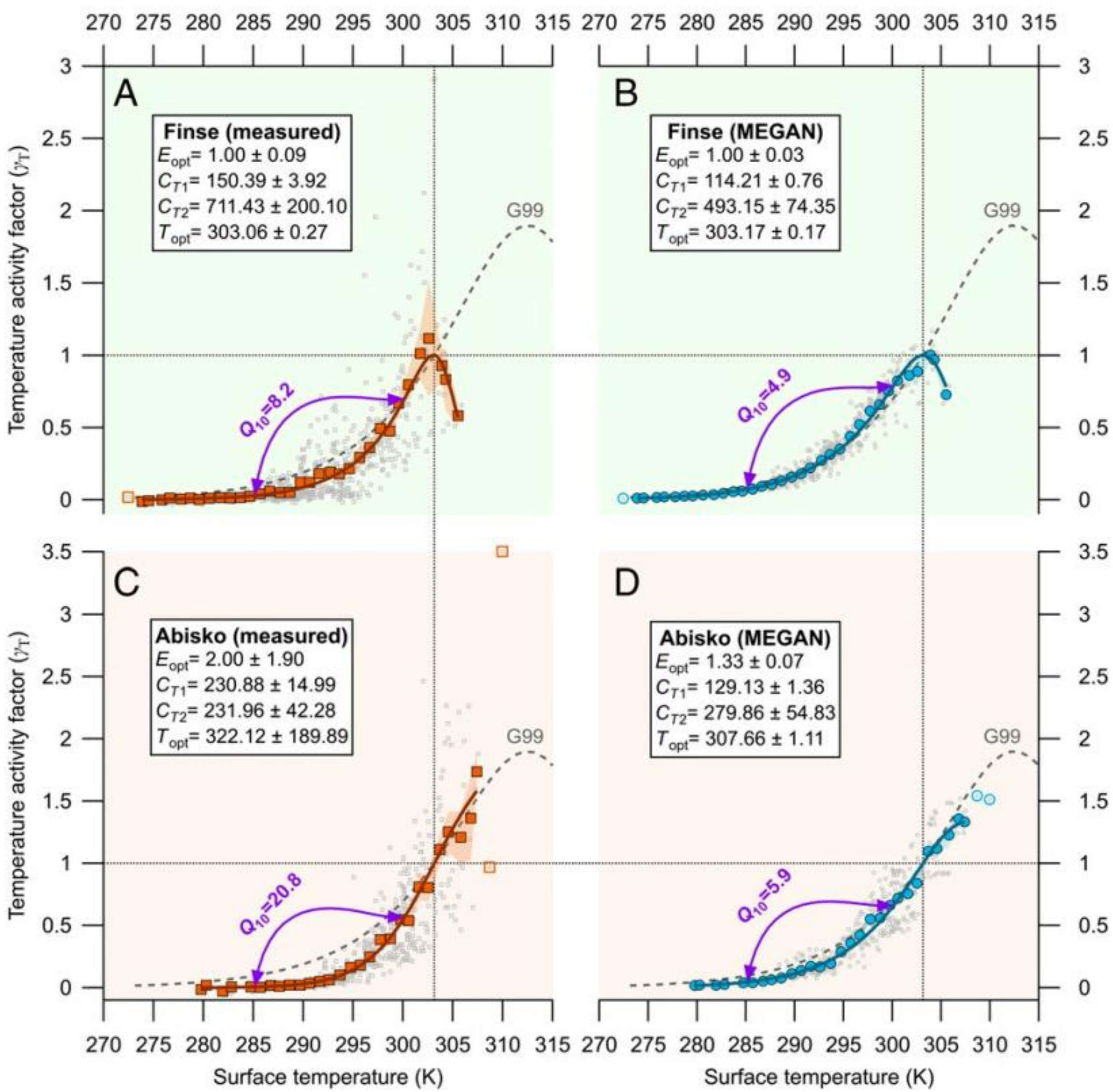
Roger Seco[a,b,c,1], Thomas Holst[d], Cleo L. Davie-Martin[a,b], Tihomir Simin[a,b], Alex Guenther[e], Norbert Pirk[f], Janne Rinne[d], and Riikka Rinnan[a,b,1]

Edited by Dominick Spracklen, University of Leeds, Leeds, United Kingdom; received October 7, 2021; accepted July 31, 2022 by Editorial Board Member Robert E. Dickinson

How ecosystem–atmosphere exchange of reactive hydrocarbons, biogenic volatile organic compounds (BVOCs), responds to climate change may provide important feedbacks on the regional climate. We combined direct measurements with model predictions of ecosystem-scale fluxes of isoprene — the most emitted BVOC worldwide — from two contrasting tundra sites, to characterize their temperature response.

PNAS RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES
ENVIRONMENTAL SCIENCES

Strong isoprene emission response to temperature in tundra vegetation



The continuous time series provide clear evidence that **tundra vegetation will substantially boost its isoprene emissions in response to rising temperatures** and allow for **improvement of models** that **currently underestimate the temperature dependence of highlatitude isoprene emissions**. These insights have implications for the atmosphere in a high-latitude region where climate is changing more than anywhere else on our planet.

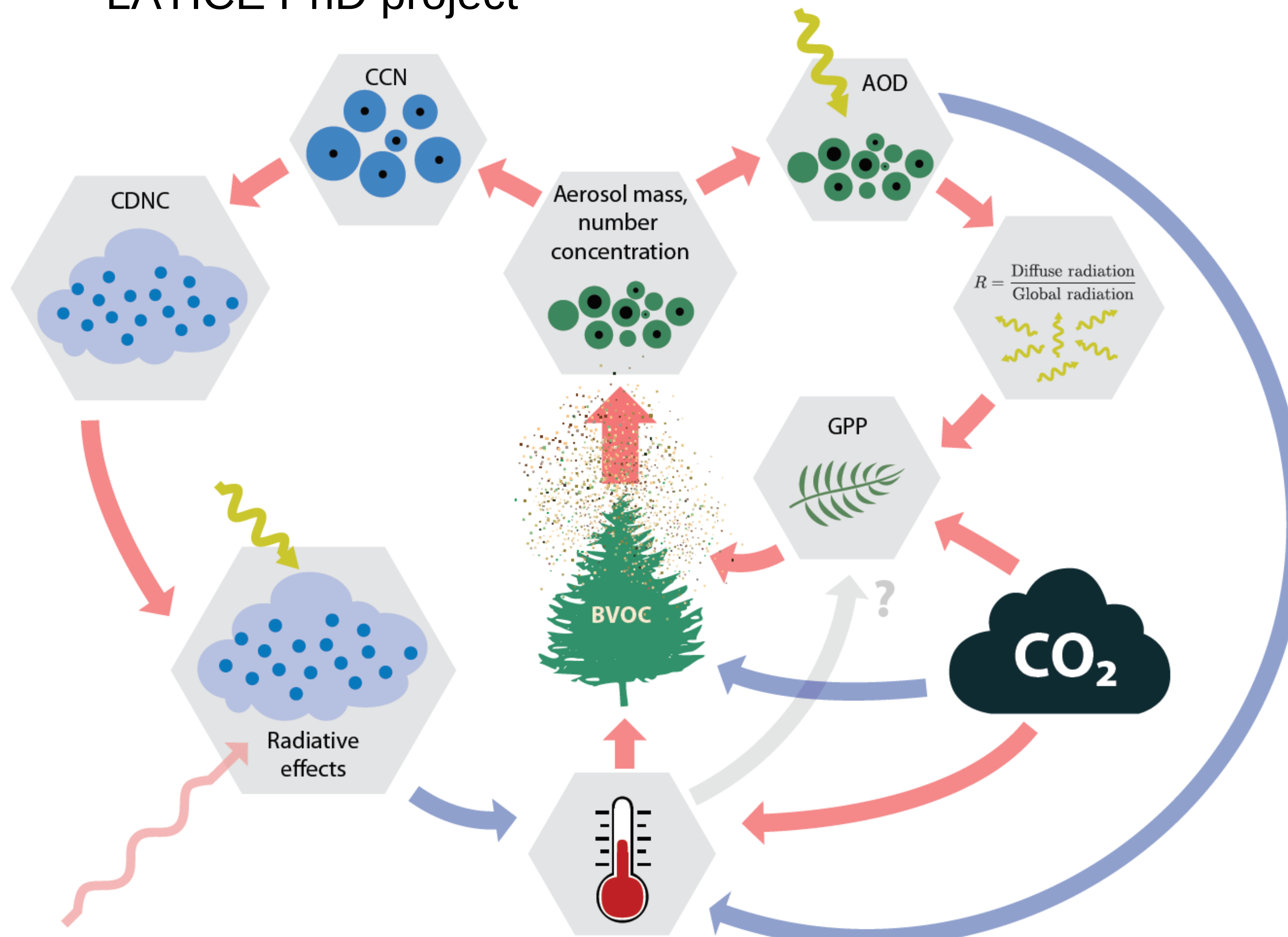
Q10 (the factor by which the emission rate increases with a 10 ° C rise in temperature)

UiO : University of Oslo

From trees to cloud seeds: Modelling the climate influence of BVOC

LATICE PhD project

- The combined effects from both altered cloud properties and AOD: -0.49 Wm^{-2}
- Context: the radiative forcing from a doubling of CO_2 is about 3.7 Wm^{-2}
- The strong impact of the BVOC feedback in the Arctic during summer could possibly **counteract part of the Arctic amplification**



Sara M Blichner, PhD thesis

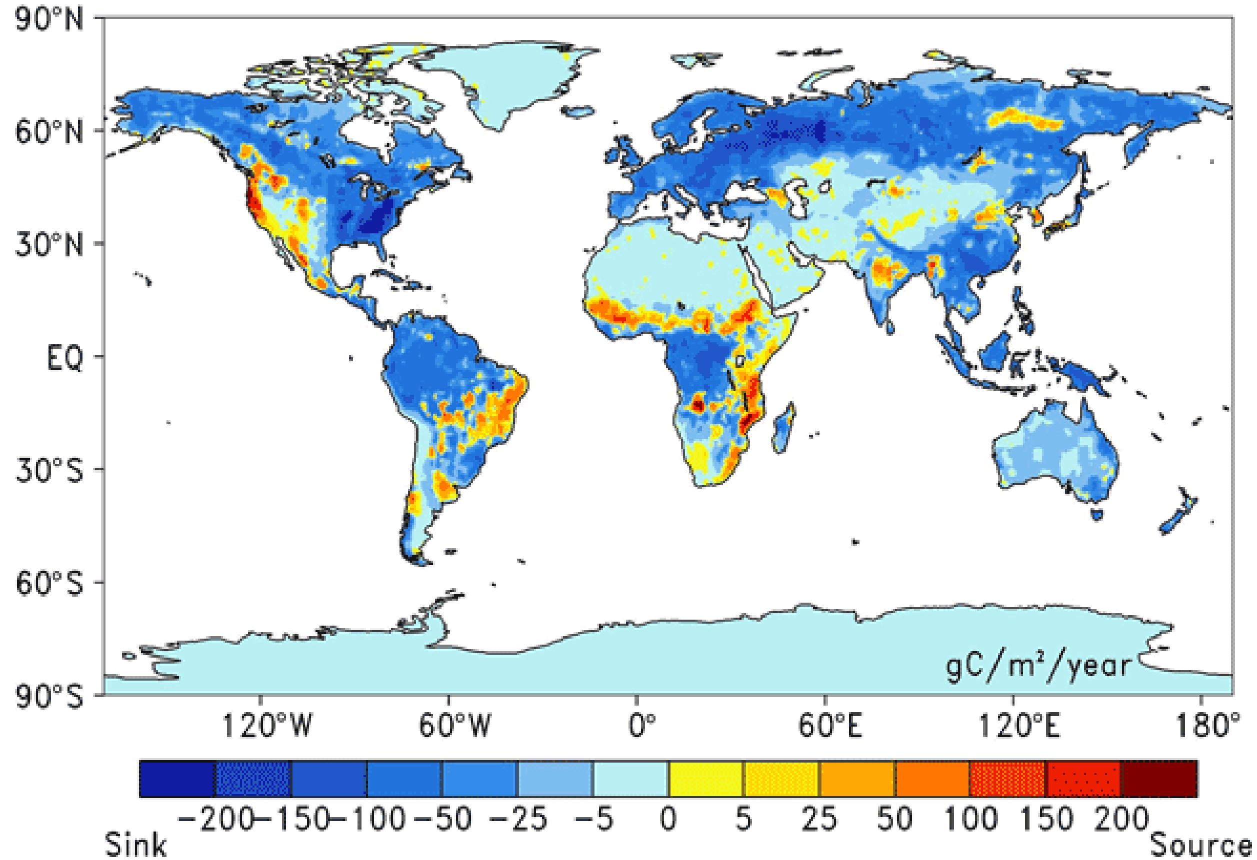
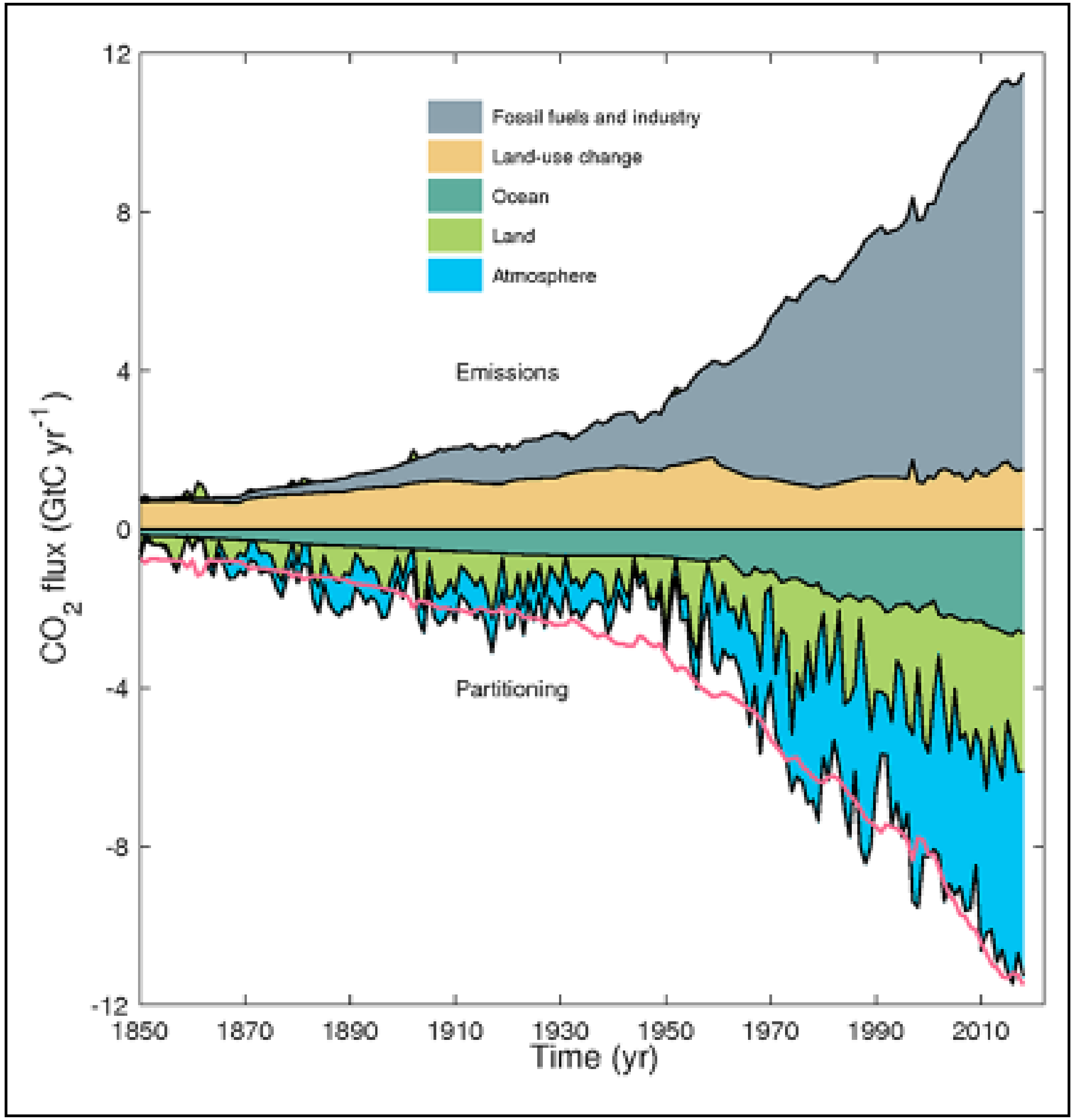


Figure 5. Global distribution of mean annual NEE during 2010–2019

Jiang et al., ESSD, 2022

UiO : University of Oslo



So far, the land biosphere has stored a sizeable fraction of our emissions, imposing a negative biogeochemical climate feedback

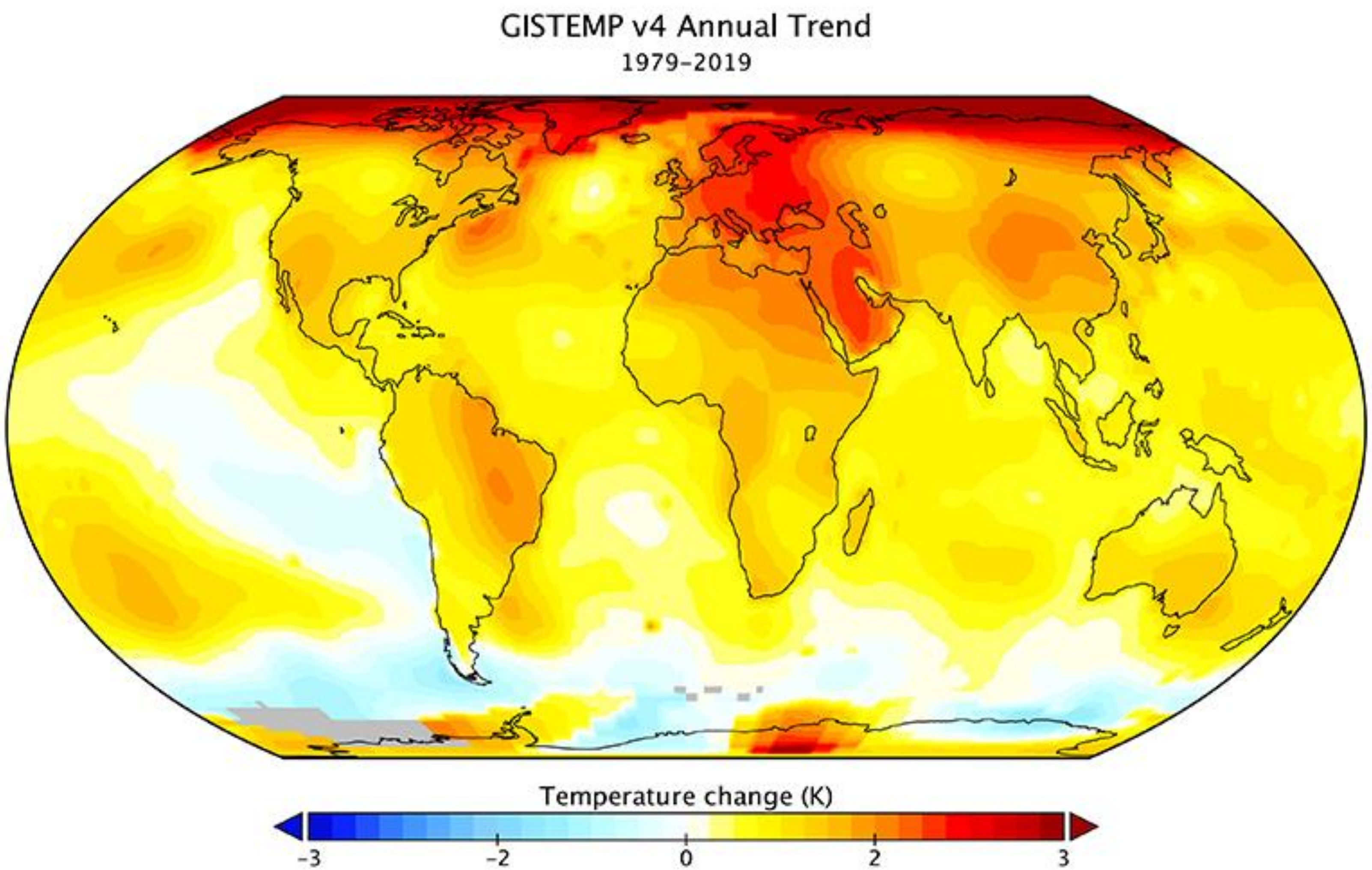
Can we count on this in the future?

EMERALD

Friedlingstein et al., 2019
https://doi.org/10.5194/essd-11-1783-2019,

Global warming is well documented from observations

We offer yet another analysis based on two high resolution datasets



NASA GISS Surface Temperature Analysis (GISTEMP v4)

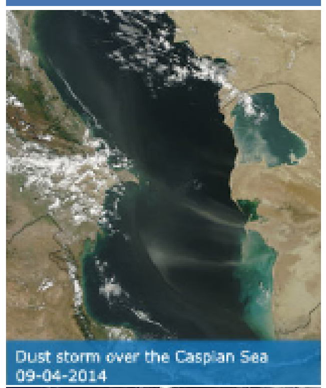
Datasets: NASA MODIS satellite datasets

Data

Data Products

Algorithms

Direct Broadcast



Home >> Data >> Data Products

Data Products

There are many standard MODIS data products that scientists are using to study global change. These products are being used by scientists from a variety of disciplines, including oceanography, biology, and atmospheric science. This section provides some detail for each product individually, introducing you to the products, explaining the science behind them, and alerting you to known areas of concern with the data products. Additional information about these products can be obtained by going to the appropriate URL's noted below. Select a data product below for a detailed overview of the product and links to product specific information.

Level 1

MODIS Raw Radiances
MODIS Calibrated Radiances
MODIS Geolocation Fields

MODIS Atmosphere Products

MODIS Aerosol Product
MODIS Total Precipitable Water
MODIS Cloud Product
MODIS Atmospheric Profiles
MODIS Atmosphere Joint Product
MODIS Atmosphere Gridded Product
MODIS Cloud Mask

MODIS Land Products

MODIS Surface Reflectance
MODIS Land Surface Temperature and Emissivity (MOD11)
MODIS Land Surface Temperature and Emissivity (MOD21)
MODIS Land Cover Products
MODIS Vegetation Index Products (NDVI and EVI)
MODIS Thermal Anomalies - Active Fires
MODIS Fraction of Photosynthetically Active Radiation (FPAR) / Leaf Area Index (LAI)
MODIS Evapotranspiration
MODIS Gross Primary Productivity (GPP) / Net Primary Productivity (NPP)
MODIS Bidirectional Reflectance Distribution Function (BRDF) / Albedo Parameter
MODIS Vegetation Continuous Fields
MODIS Water Mask
MODIS Burned Area Product

MODIS Cryosphere Products

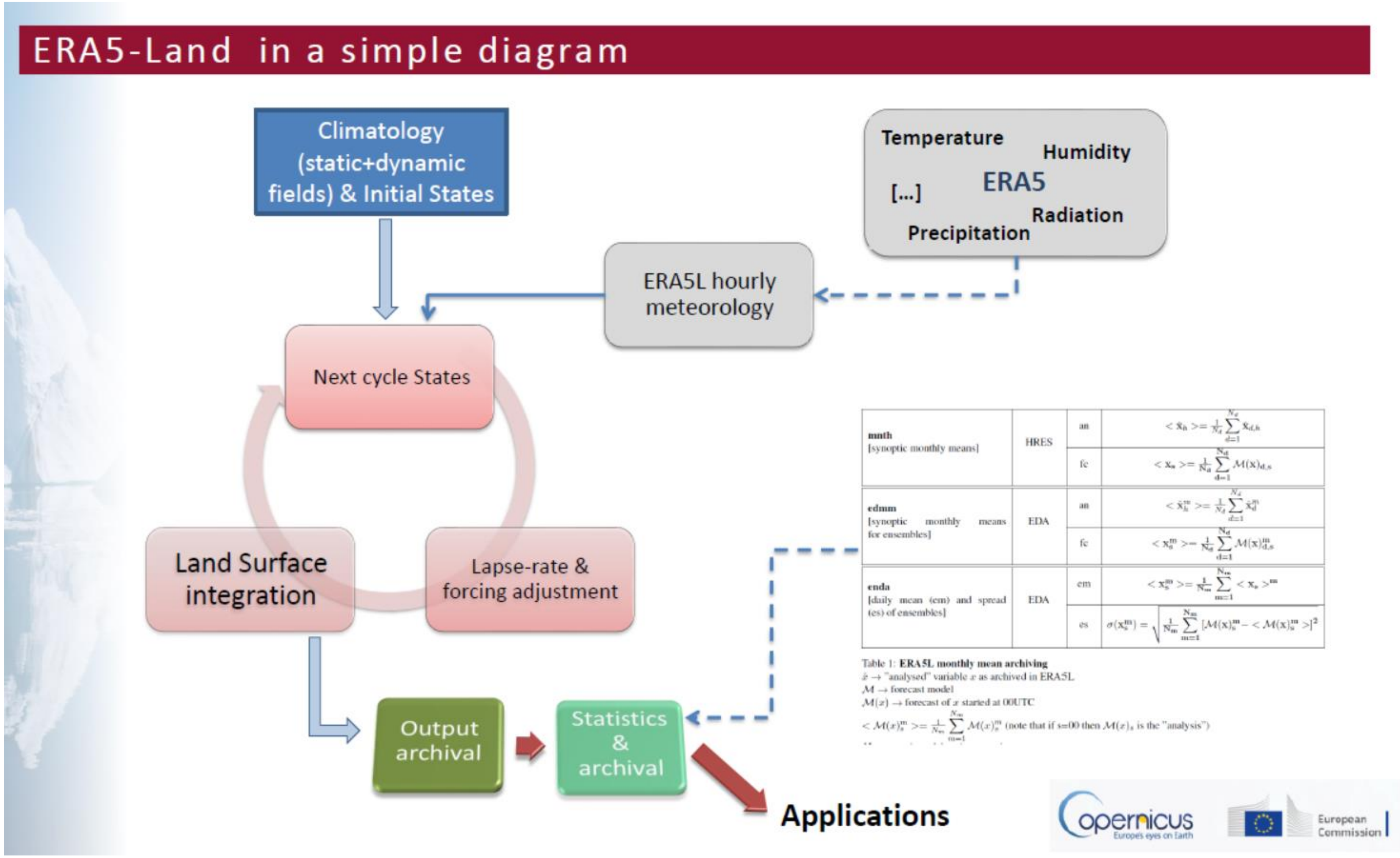
MODIS Snow Cover
MODIS Sea Ice and Ice Surface Temperature

MODIS Ocean Products

MODIS Sea Surface Temperature
MODIS Remote Sensing Reflectance
MODIS Chlorophyll-a Concentration
MODIS Diffuse Attenuation at 490 nm
MODIS Particulate Organic Carbon
MODIS Particulate Inorganic Carbon
MODIS Normalized Fluorescence Line Height (FLH)
MODIS Instantaneous Photosynthetically Available Radiation
MODIS Daily Mean Photosynthetically Available Radiation

- temporal resolution : monthly
- spatial resolution: 0.05º x 0.05º (5km x 5km)

Datasets: ECMWF ERA5-Land scheme



- temporal resolution : monthly
- spatial resolution: 0.1º x 0.1º (10km x 10km)

Diagram of the algorithm used in the production of ERA5-Land. The land surface model is integrated in 24 h cycles, using short-forecast meteorological forcing fields from ERA5. Data are available from 1981.

Air temperature vs surface temperature

- In order to assess the difference in global and regional rate of change between air temperature and surface temperature, we used the “ERA5- L T2M” dataset for temperature 2-m above ground for this purpose

- To obtain global and regional 2-m air temperature rate of change, the dataset was processed in the same procedure performed for ERA5-SKT

- The results revealed that the trends of ERA5-L T2M and SKT temperatures are very similar in global and regional scales, even with very close *p*-values

- Thus, the temperature trends shown in this work using MODIS LST and ERA5-L SKT can also reasonably represent the temperature trends of air temperature

Regions

Based on the land regions defined in the RECCAP project
(Canadell et al., 2011; Ciais et al., 2021)

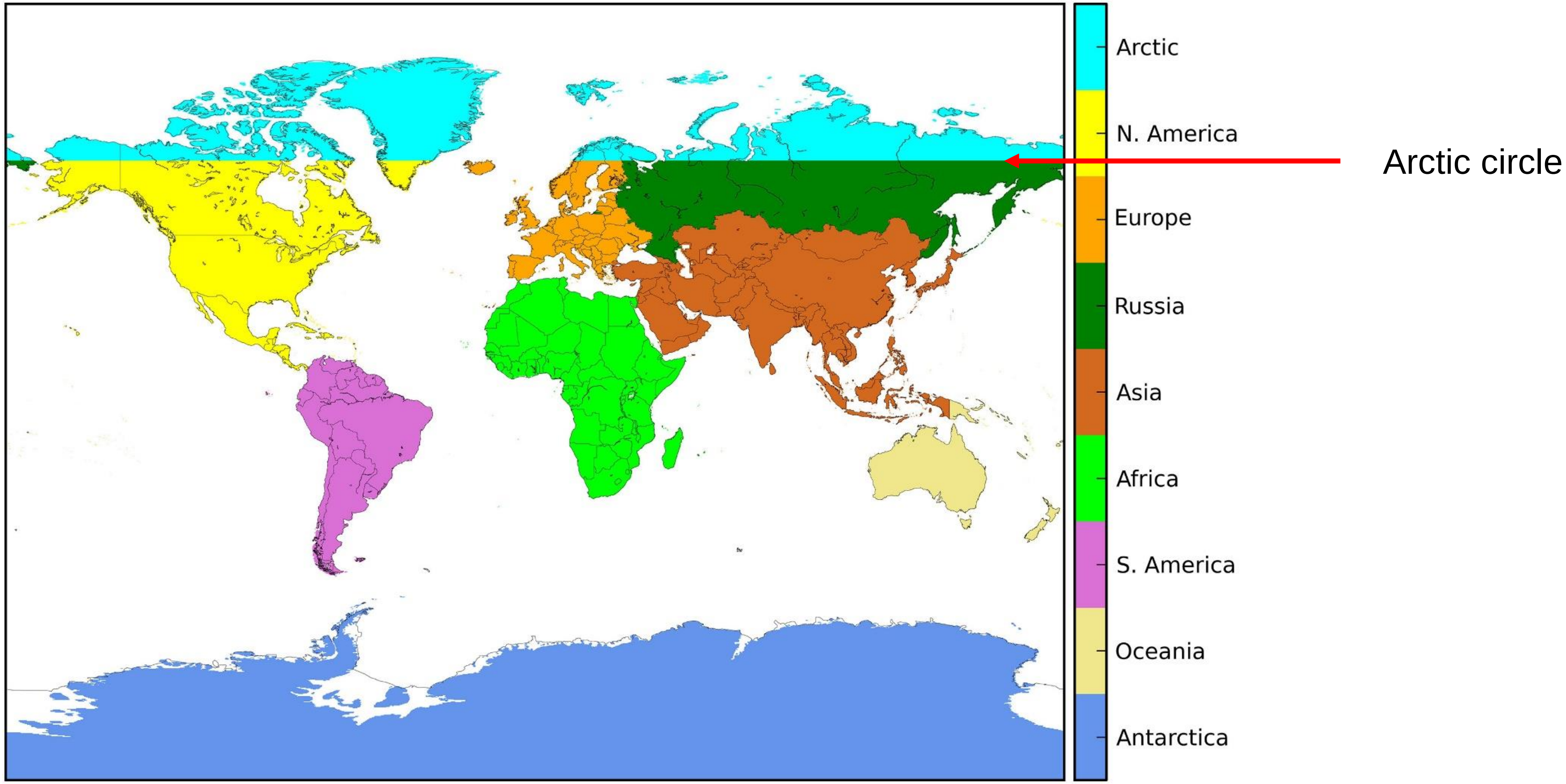


Fig. 1. Classification of nine regions of the world used in this study. North America, Europe, and Russia refer to their regions excluding the parts in the Arctic.

Global temperature 2001–2020

MODIS LST & ERA5-Land SKT
Broadly similar

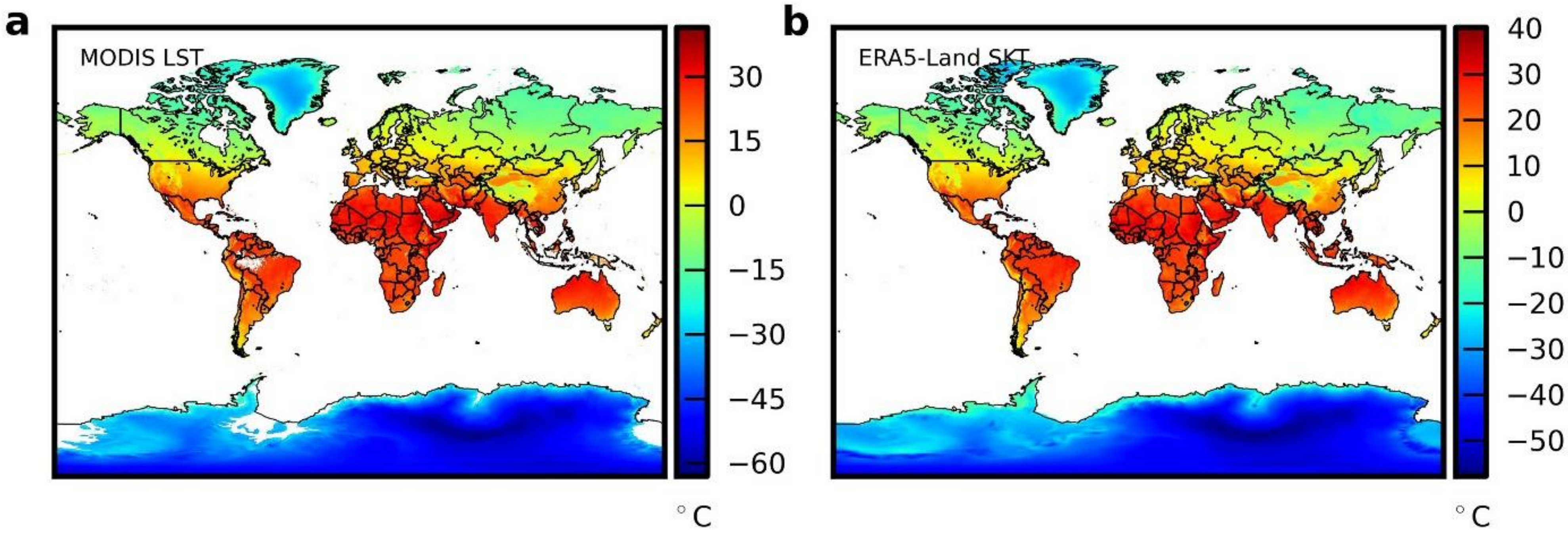


Fig. 2. Global land surface temperatures in 2001–2020. (a) From MODIS LST. (b) From ERA5-Land SKT.

Global temperature 2001–2020

MODIS LST & ERA5-Land SKT
Some differences

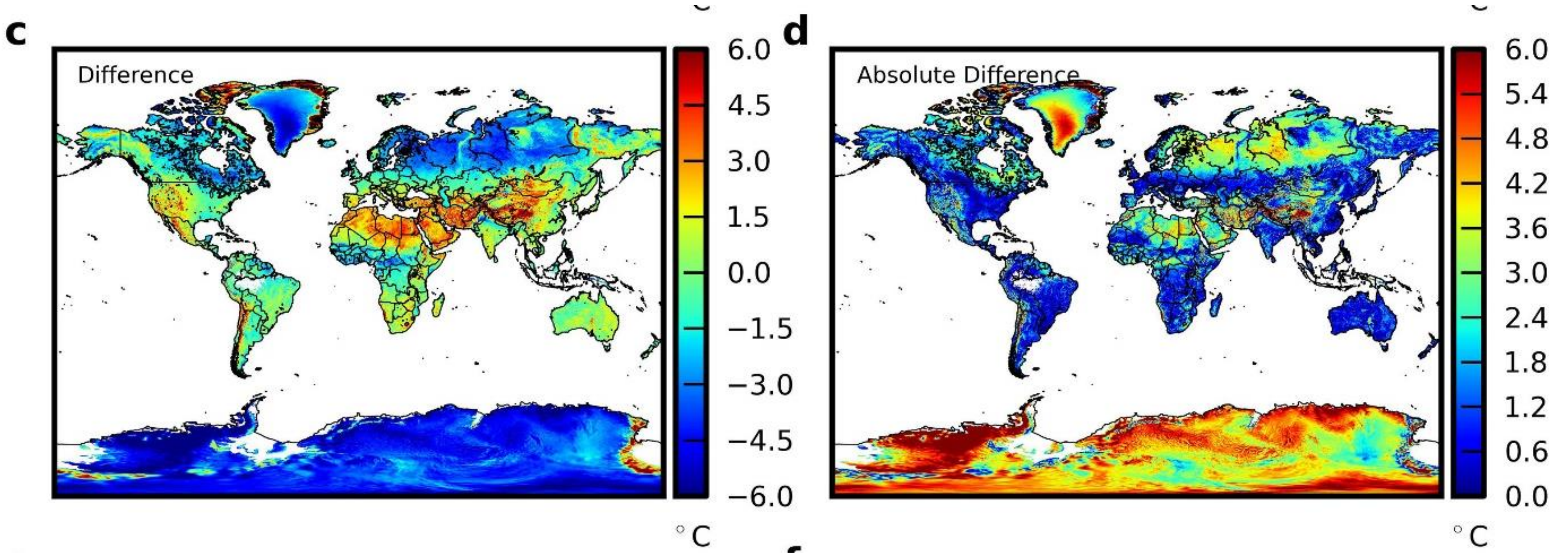


Fig. 2. Global land surface temperatures in 2001–2020. (c) Difference between the 20-yr mean MODIS LST and mean ERA5-Land SKT, shown as the former subtracted by the latter. (d) Panel (c) shown in absolute values. MODIS data were resampled in the grid of ERA5-Land before performing the comparisons in (c) and (d).

Temperature rate of change 2001-2020

		Global	Arctic	N. America	Europe	Russia	Asia	Africa	S. America	Oceania
2001-2020	MODIS	0,26	0,72	0,13	0,62	0,65	0,16	0,05	0,25	0,34
2001-2020	ERA5-L	0,34	0,86	0,20	0,63	0,68	0,20	0,31	0,32	0,34

Global and regional yearly mean land temperature rate of change (° C/decade). Values with p-value <0.05 in the regression for rate of change are shown in red

Temperature rate of change 2001-2020

All pixels

MODIS LST | ERA5-Land SKT

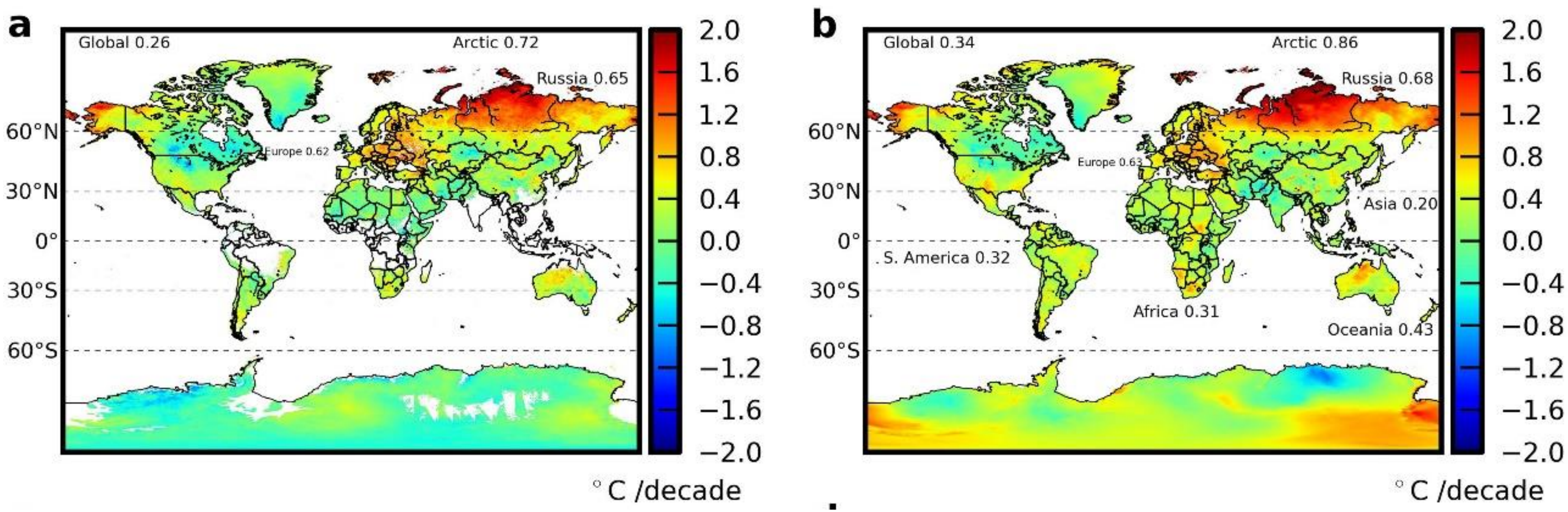
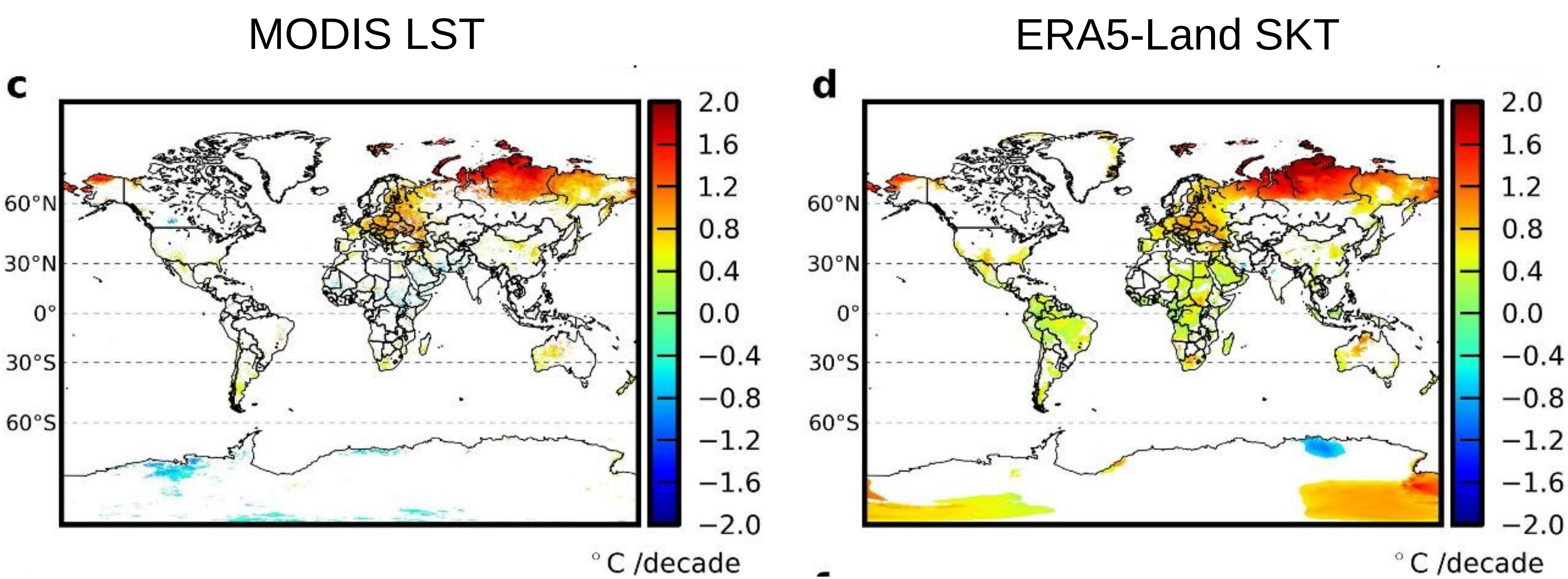


Fig. 5. Land surface temperature rate of change (ºC/decade) in 2001–2020 from MODIS LST and ERA5-Land SKT. (a) From MODIS. (b) From ERA5-Land. (c) Pixels with statistically significant trends from MODIS. (d) Pixels with statistically significant trends from ERA5-Land. Note that in (a) and (e), South America, Africa, South Asia, and northern Australia contain blank areas due to the requirement in this study that a pixel must have 20-yr complete, non-cloud-masked data for performing the regression for temperature rate of change. Regional temperature rates of change that are statistically significant are labeled in (a) and (b).

UiO : University of Oslo

Temperature rate of change 2001-2020

Significant pixels



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Temperature rate of change 1981-2020

All pixels

ERA5-Land SKT

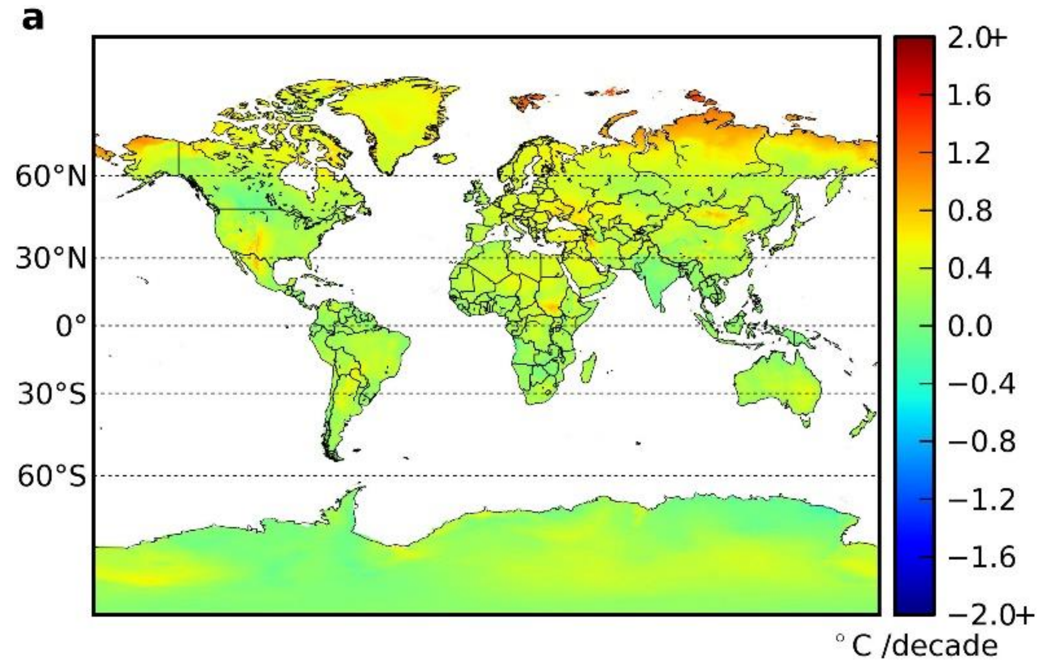


Fig. 7. Land surface temperature rate of change (ºC/decade) in 1981–2020 from ERA5-Land SKT. (a) All pixels. (b) Pixels that have statistically significant rates only.

UiO : University of Oslo

Temperature rate of change 1981-2020

Significant pixels

ERA5-Land SKT

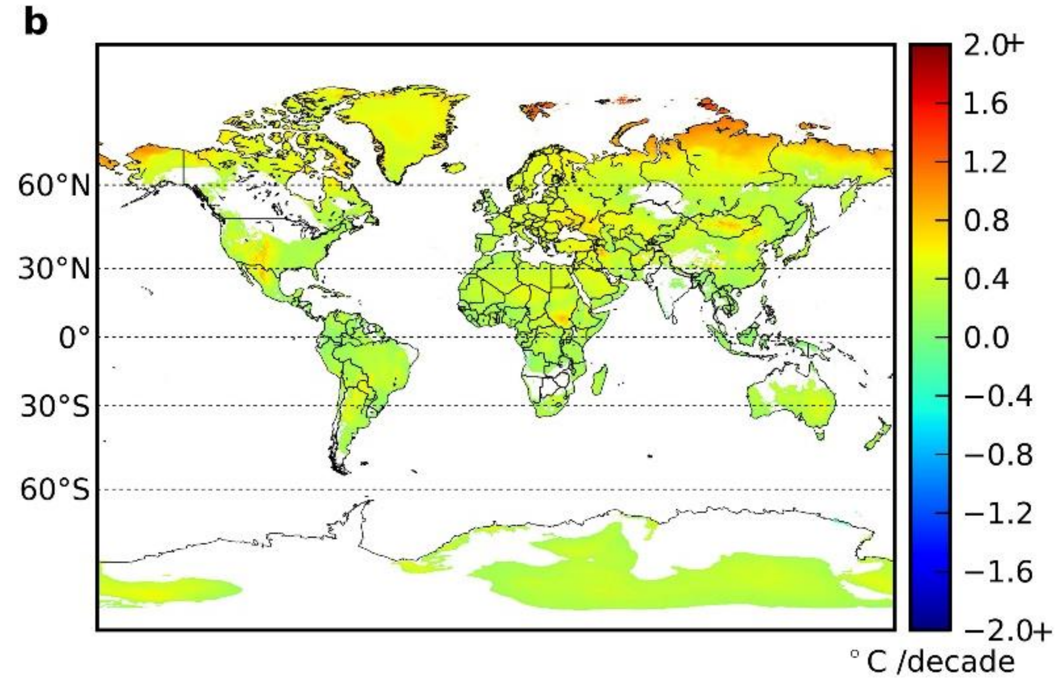
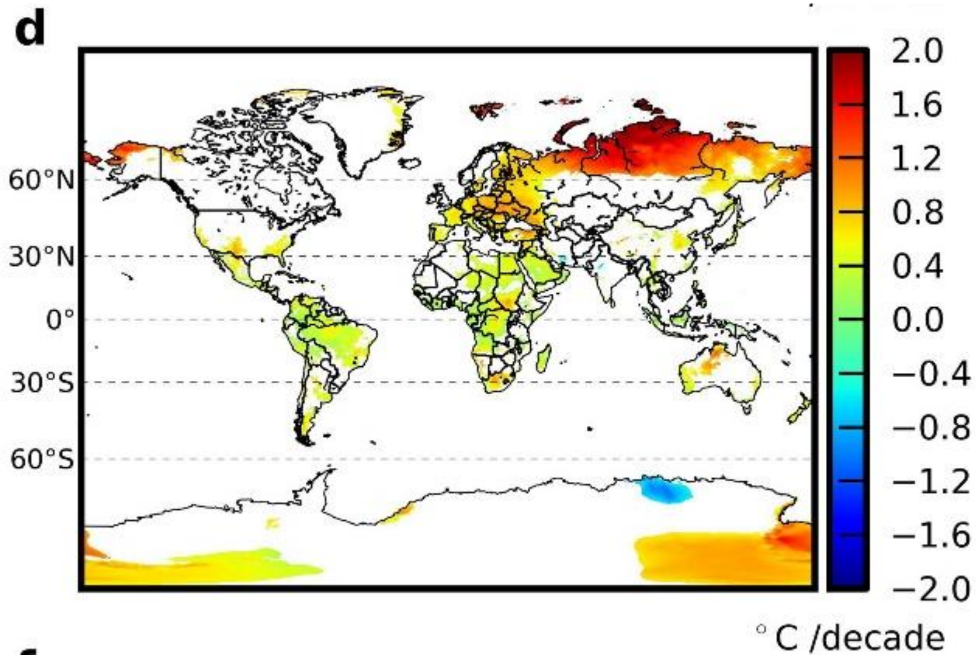


Fig. 7. Land surface temperature rate of change (ºC/decade) in 1981–2020 from ERA5-Land SKT. (a) All pixels. (b) Pixels that have statistically significant rates only.

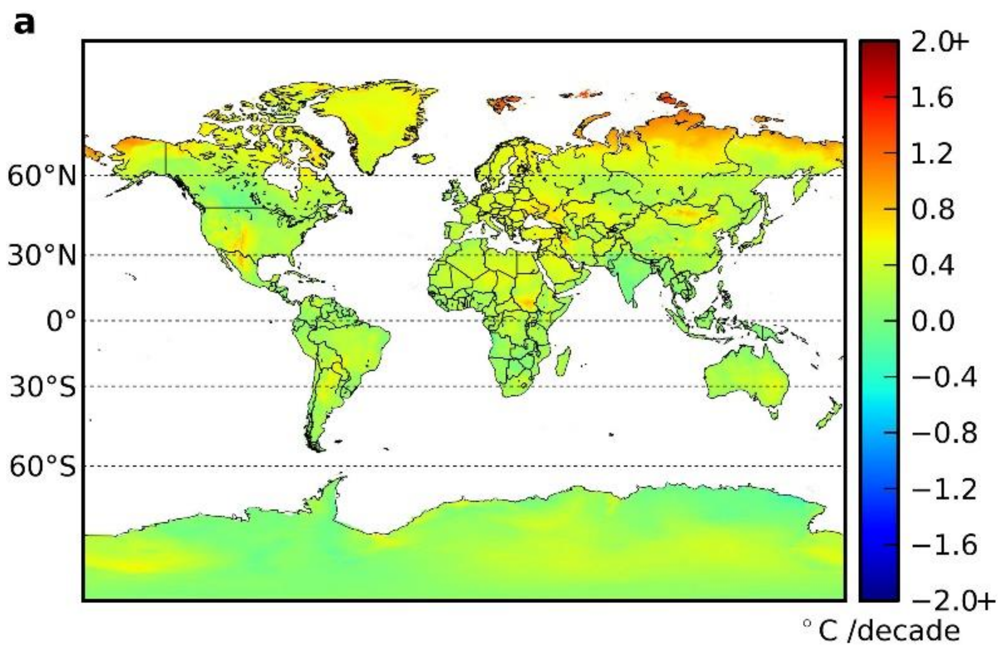
Temperature rate of change: acceleration

All pixels

ERA5-L 2001-2020



ERA5-L 1981-2020



Temperature rate of change: acceleration

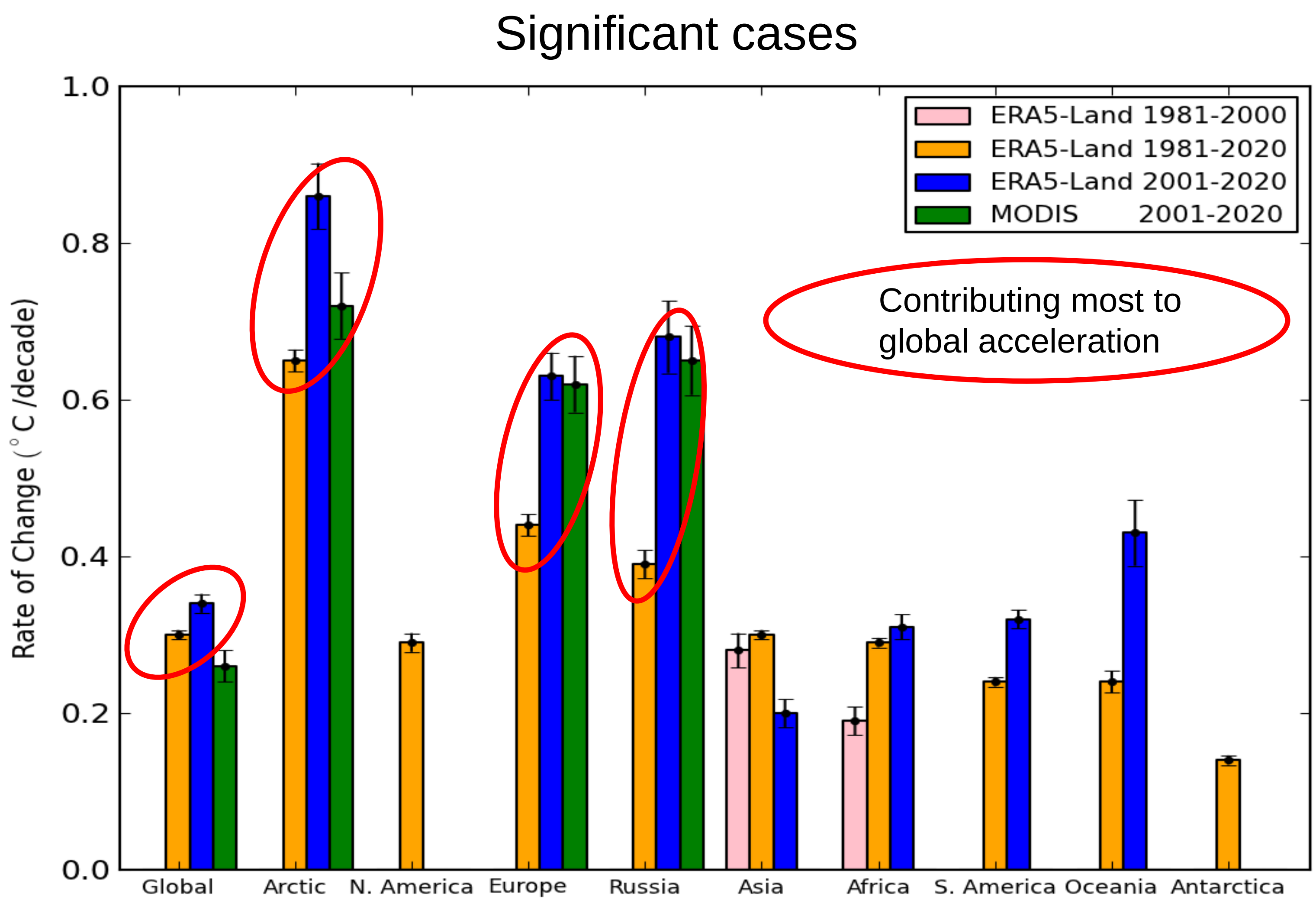


Fig. S1. Global and regional temperature rate of change analyzed by ERA5-Land 1981-2000, ERA5-Land 1981-2020, ERA5-Land 2001-2020, and MODIS 2001-2020. Only the rates that are statistically significant are shown.

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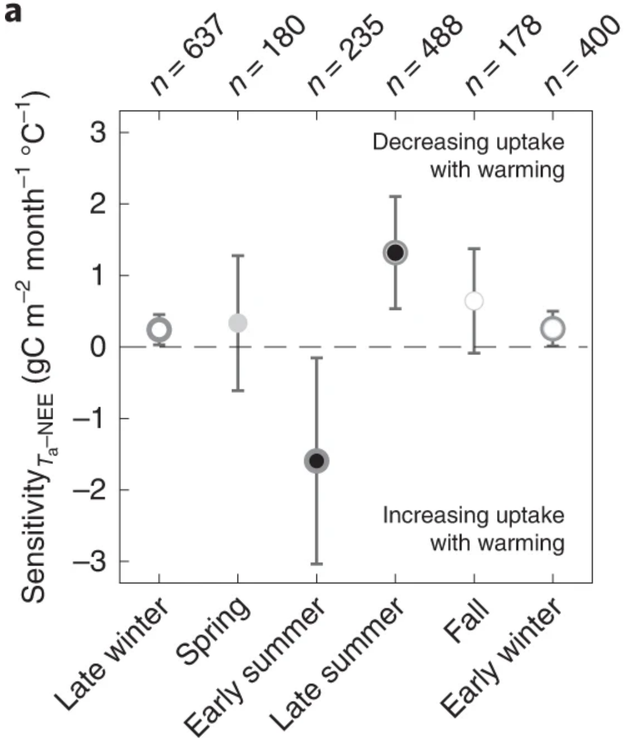
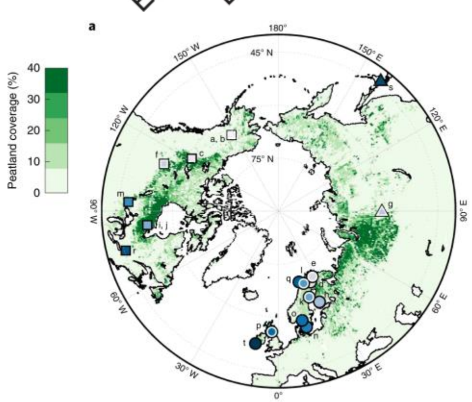
1951-1970 -> 2001-2020

NEE temperature sensitivity





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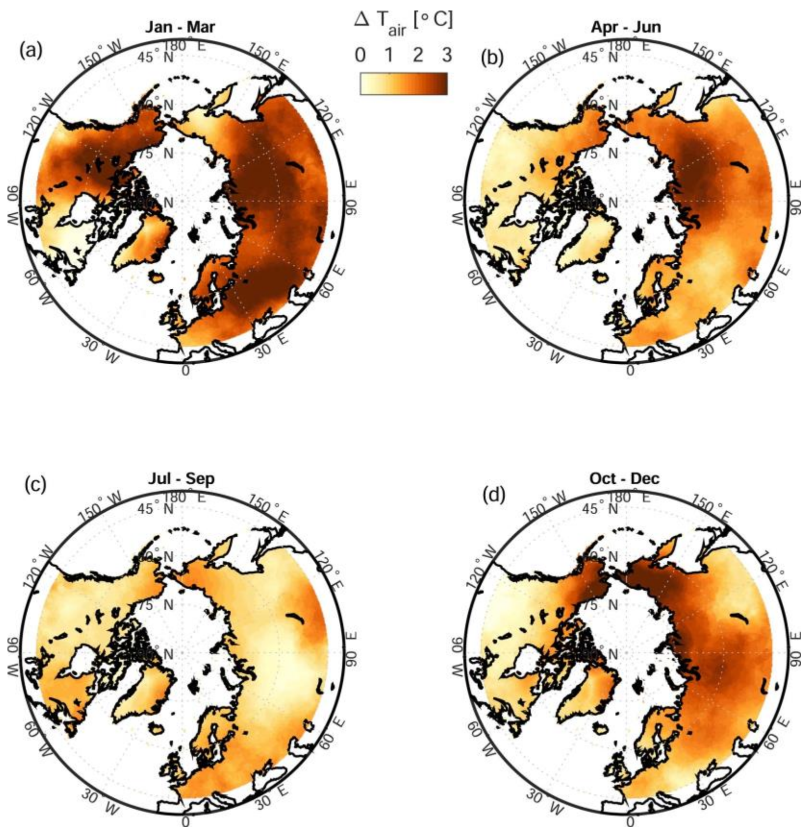
Warming rates



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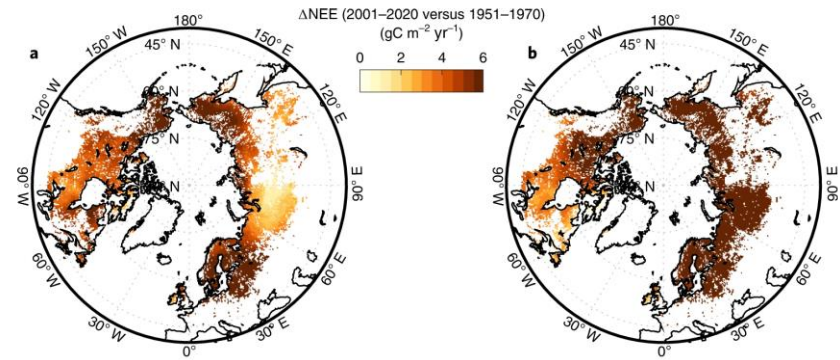
NEE changes



Helbig et al., NCC, 2022

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ENVIRONMENTAL SCIENCES

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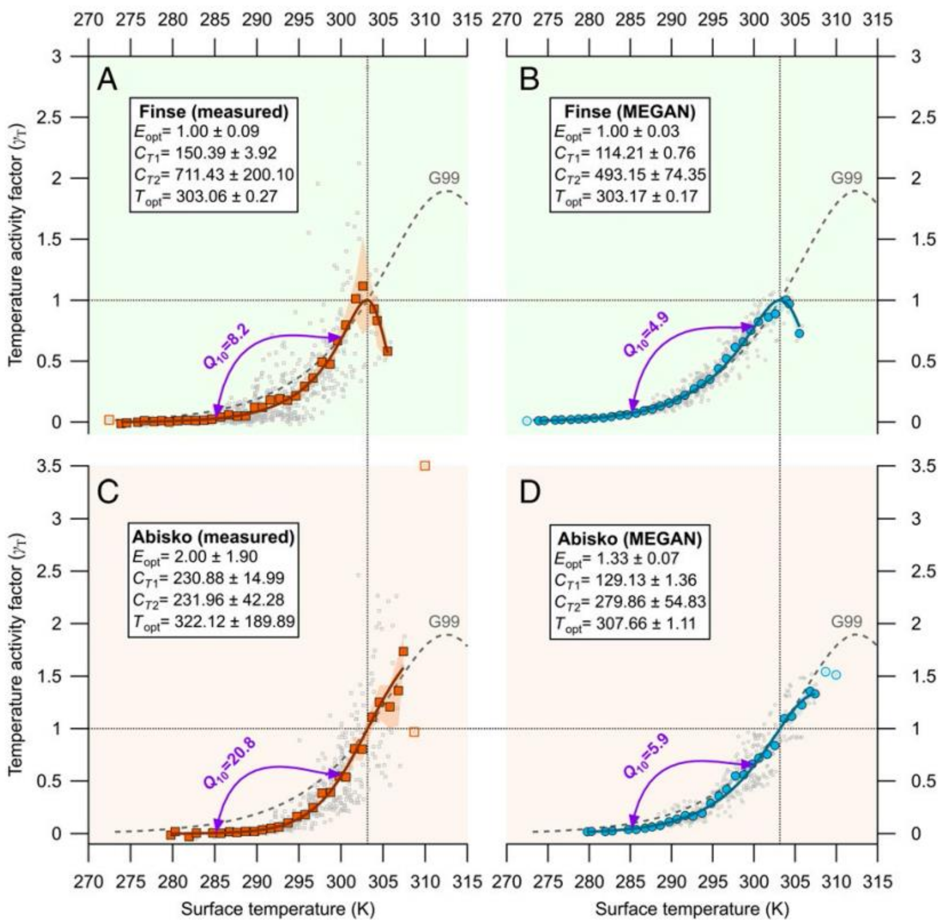


Temperature rate of change: Arctic

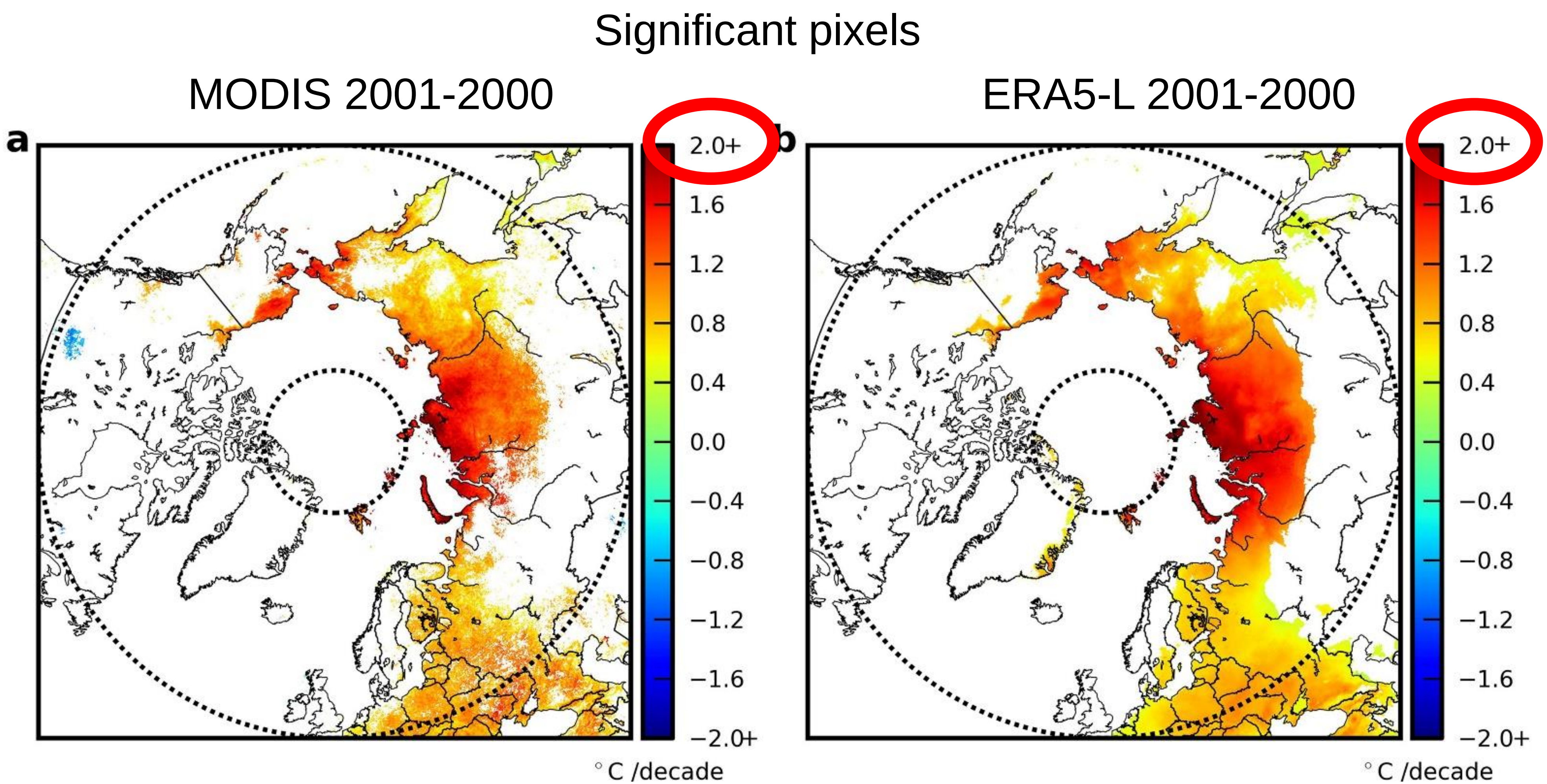
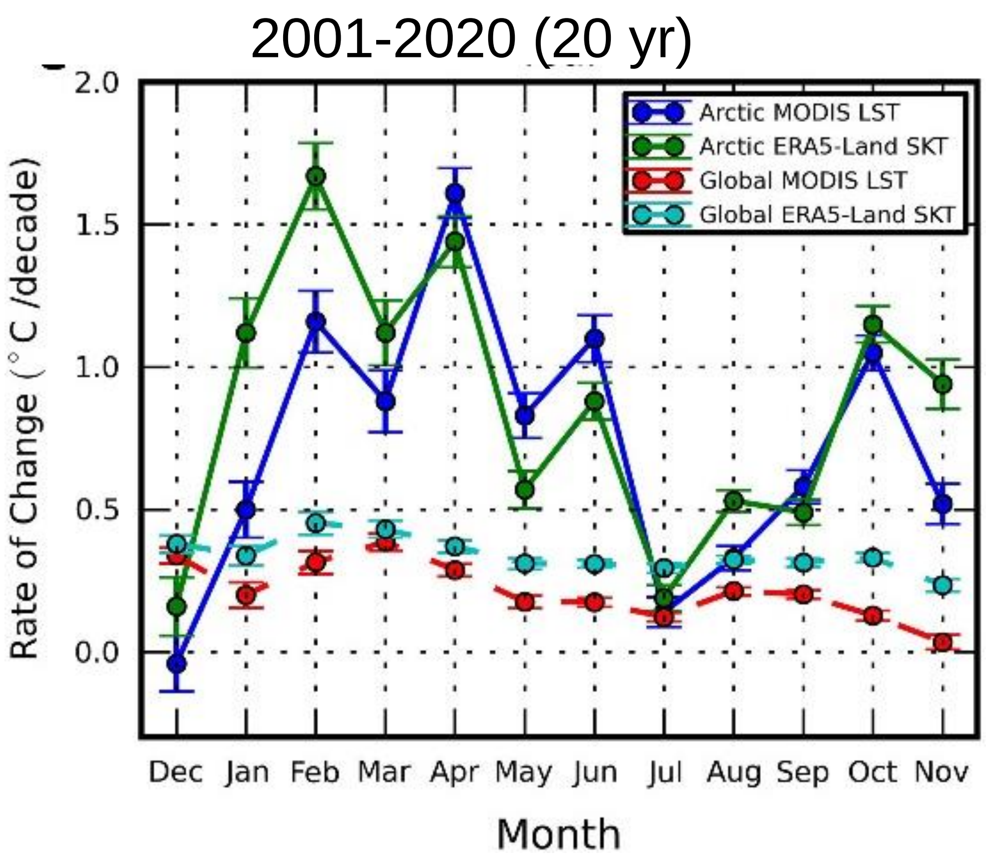


Fig. 9. Areas with significant temperature rate of change, permafrost, and land cover in the circumpolar region. (a) From MODIS LST. (b) From ERA5-Land SKT. (c) Map of circumpolar permafrost areas made by UNEP/GRID-Arendal using data from International Permafrost Association (1998). (d) Map of land cover types made by UNEP/GRID-Arendal using data from GEO3 Global Environment Outlook (2002).

Arctic temperature rate of change 1981–2020



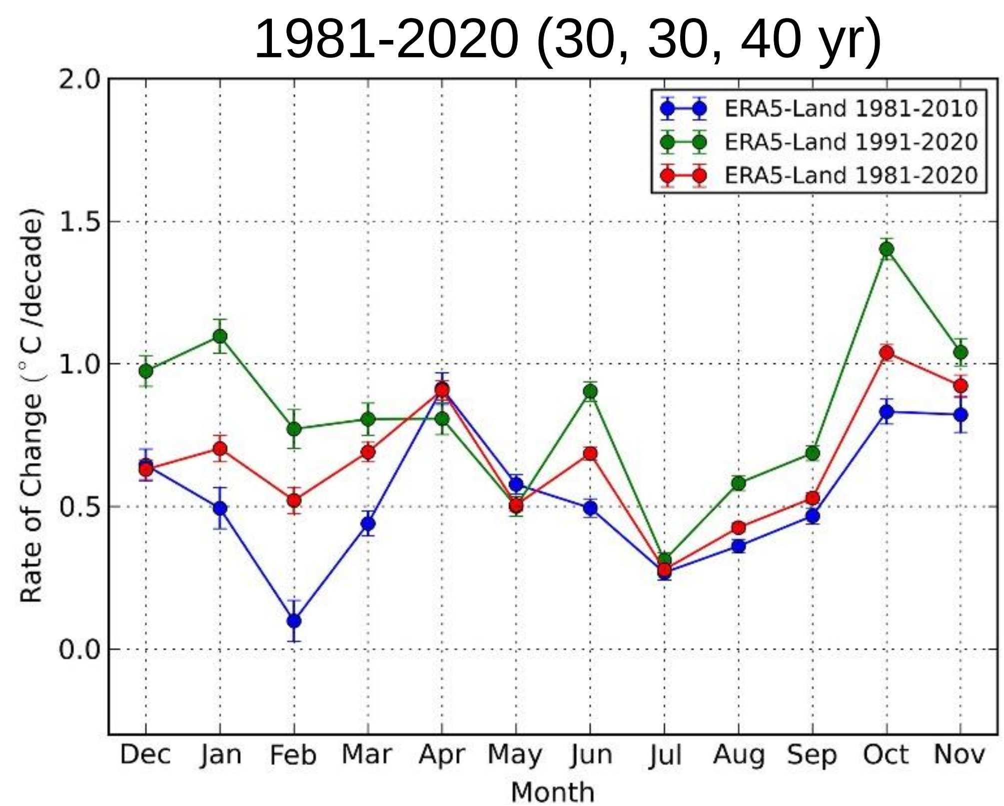


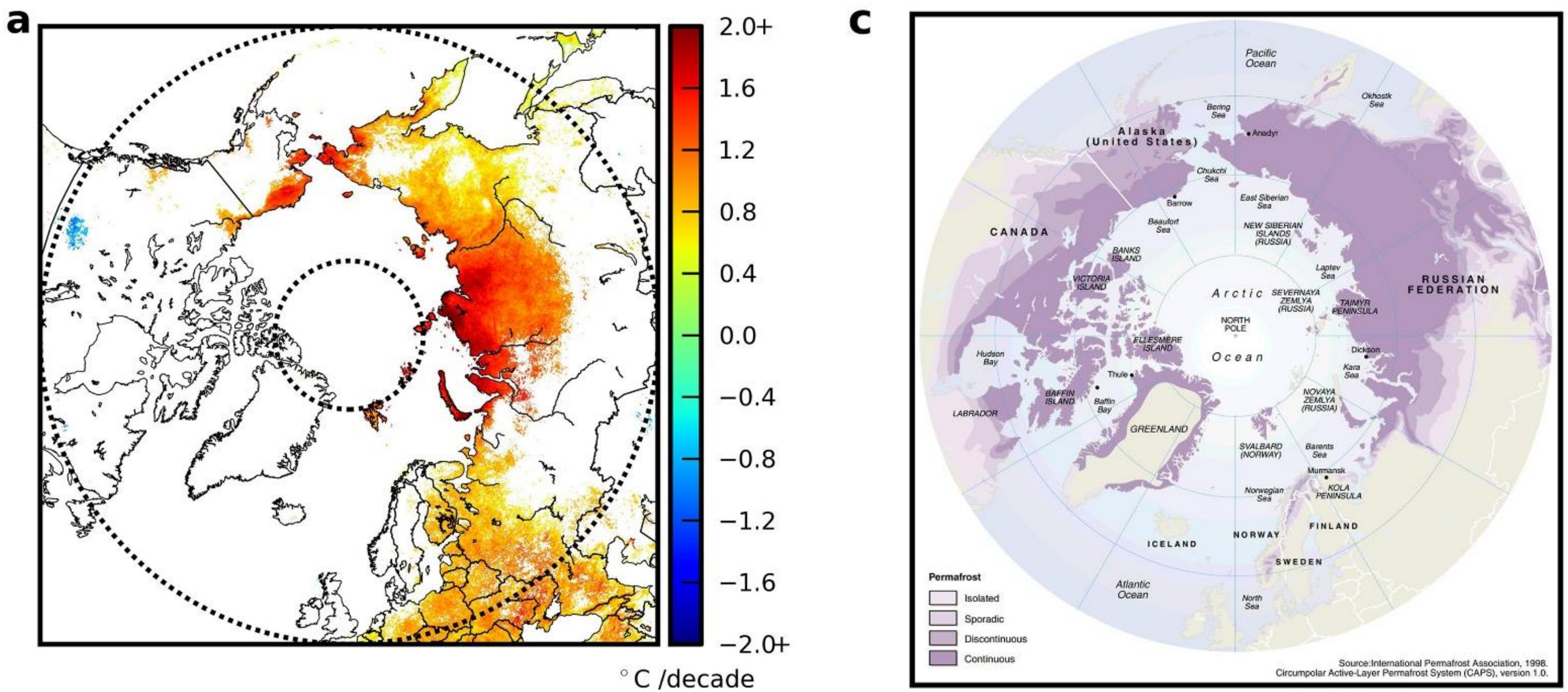
Fig. 3 (left). Monthly land temperature averaged in the Arctic in 2001–2020 from MODIS LST and ERA5-Land SKT and temperature rate of change by month. (a) From MODIS for March to August(b) From ERA5-Land for March to August. (c) From MODIS for September to February. (d) From ERA5-Land for September to February. (e) Arctic temperature rate of change by month from MODIS and ERA-Land temperatures, where error bars indicate ±2 standard error for 95% confidence interval from the regression for the rate of change of each month. Global mean temperature change rates by month are also shown for comparison.

Fig. 4 (right). Temperature trends in the Arctic obtained by two 30-yr periods and one 40-yr period in ERA5-Land. Error bars indicate ±2 standard error for 95% confidence interval from the regression for the rate of change of each month.

Temperature rate of change: Arctic

Significant pixels

MODIS 2001-2000



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Conclusions

- Temperature trends obtained from the relatively short 20-yr period 2000-2020 (MODIS&ERA5-L) are conforming to the general distribution in the 40-yr period 1980-2020 (ERA5-L)

- Continents and large regions warming at substantially different rates, with the Arctic, Europe, and Russia being the fastest warming regions around the globe

- Warming in the Arctic and in most of the continents is accelerating during the 40-yr period 1981–2020 (ERA5-L)

- The fastest warming land on Earth during 2001–2020 coincides with the tundra biota in circumpolar regions

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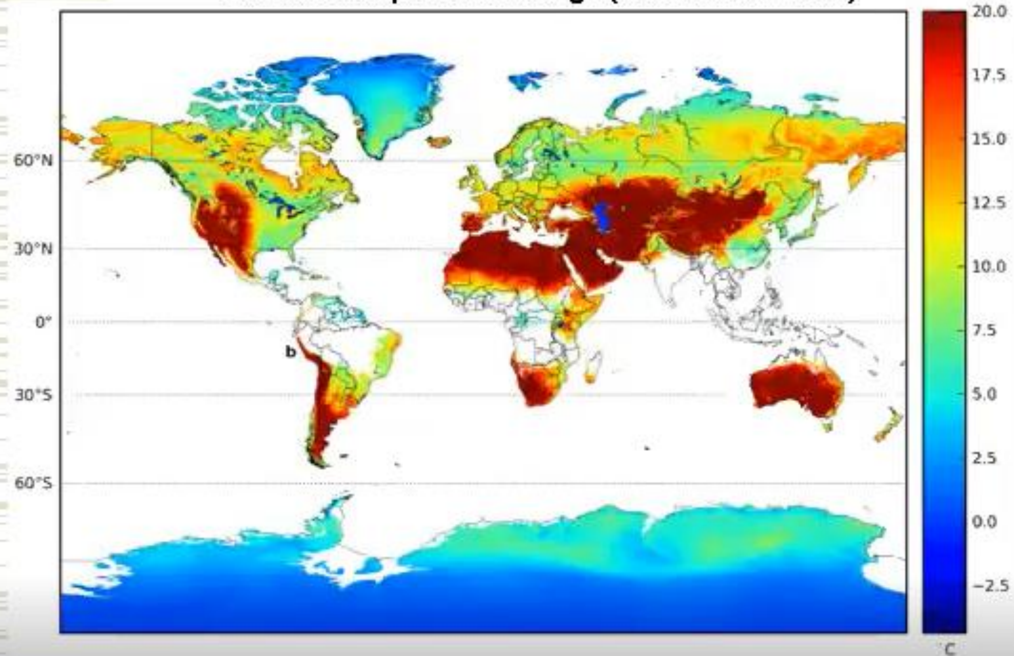
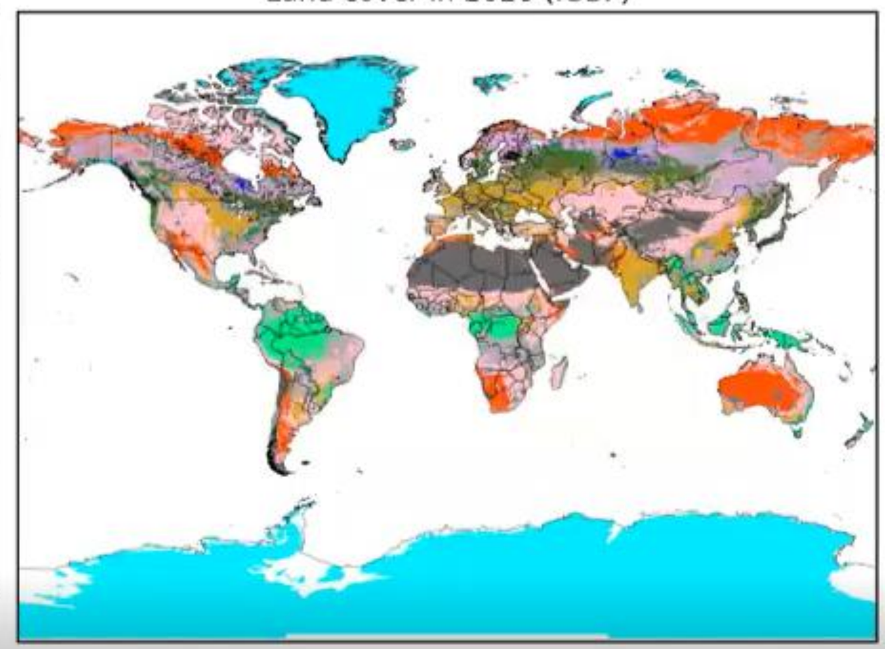
Centre for Biogeochemistry in the Anthropocene

Global trends of temperature and diurnal temperature range (DTR) by land cover type with MODIS remote sensing

Diurnal Temperature Range (2001-2020 mean)



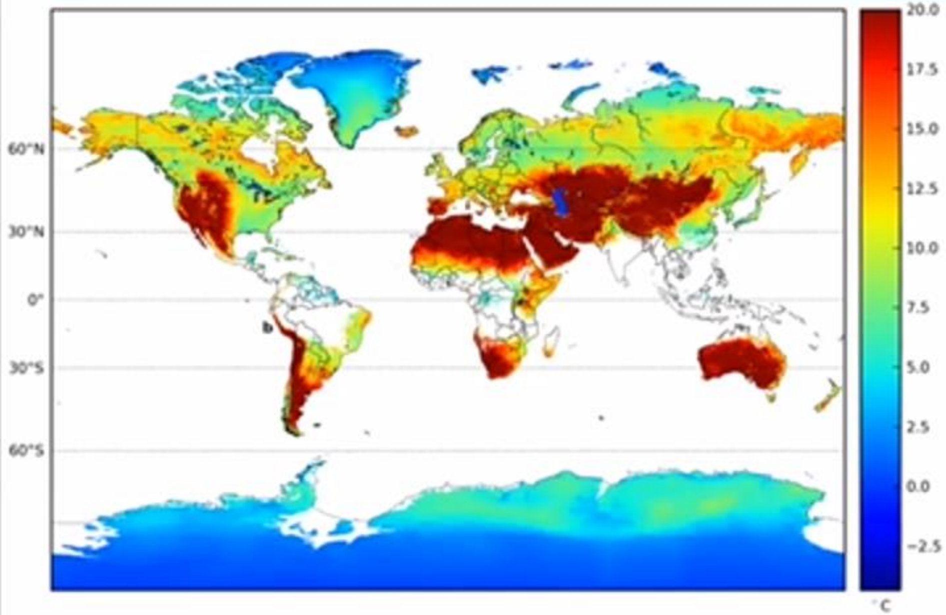
Land cover in 2020 (IGBP)

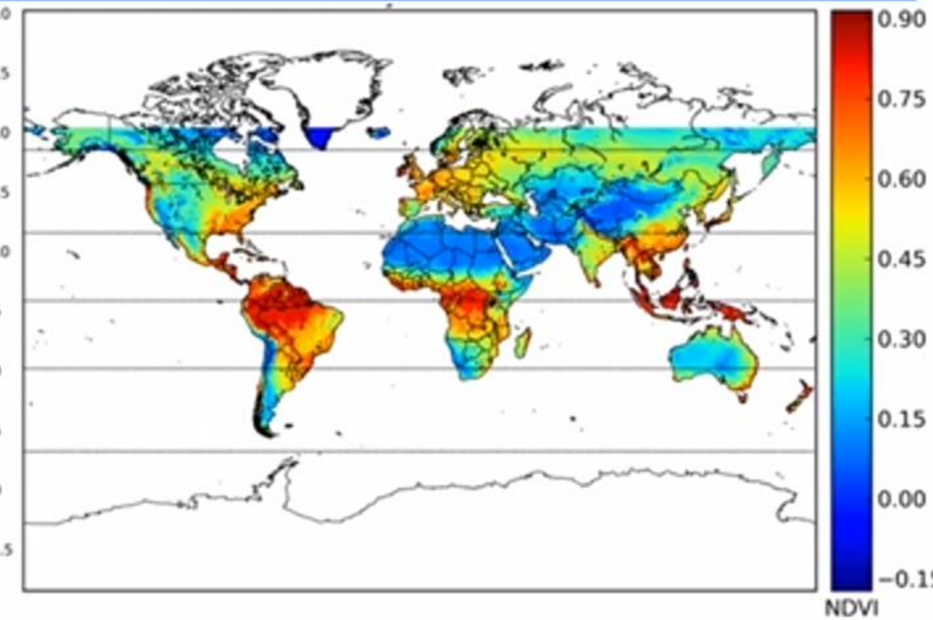


Dr. You-Ren Wang
(on behalf of Frode Stordal, Anders Bryn, Bjørn Samset and Dag Hessen)
for CBA annual meeting 2022, Hurdal.
27.Sep.2022

2022

Spatial correlation coefficients between mean DTR and mean NDVI





- By visual comparison, annual mean DTR and annual mean NDVI have quite similar distribution patterns. The higher the DTR, the lower the NDVI, and vice versa.
- Excluding the white pixels, correlation coefficient between global DTR and global NDVI (both using 2001-2020 average) is -0.61, indicating they are quite strongly negatively correlated.

Thanks for your attention!

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