Wavelet transform applied to ERA5 global daily precipitation fields to assess changes in the rainfall patterns

Cristian Lussana[1], Barbara Casati[2], Rasmus E. Benestad[1], Julia Lutz[1], Andreas Dobler[1], Oskar Landgren[1], Jan Erik Haugen[1], Abdelkader Mezghani[1] and Kajsa M. Parding[1]

1. The Norwegian Meteorological Institute, Oslo, Norway
2. Meteorological Research Division, Environment and Climate Change Canada, Gatineau, Canada

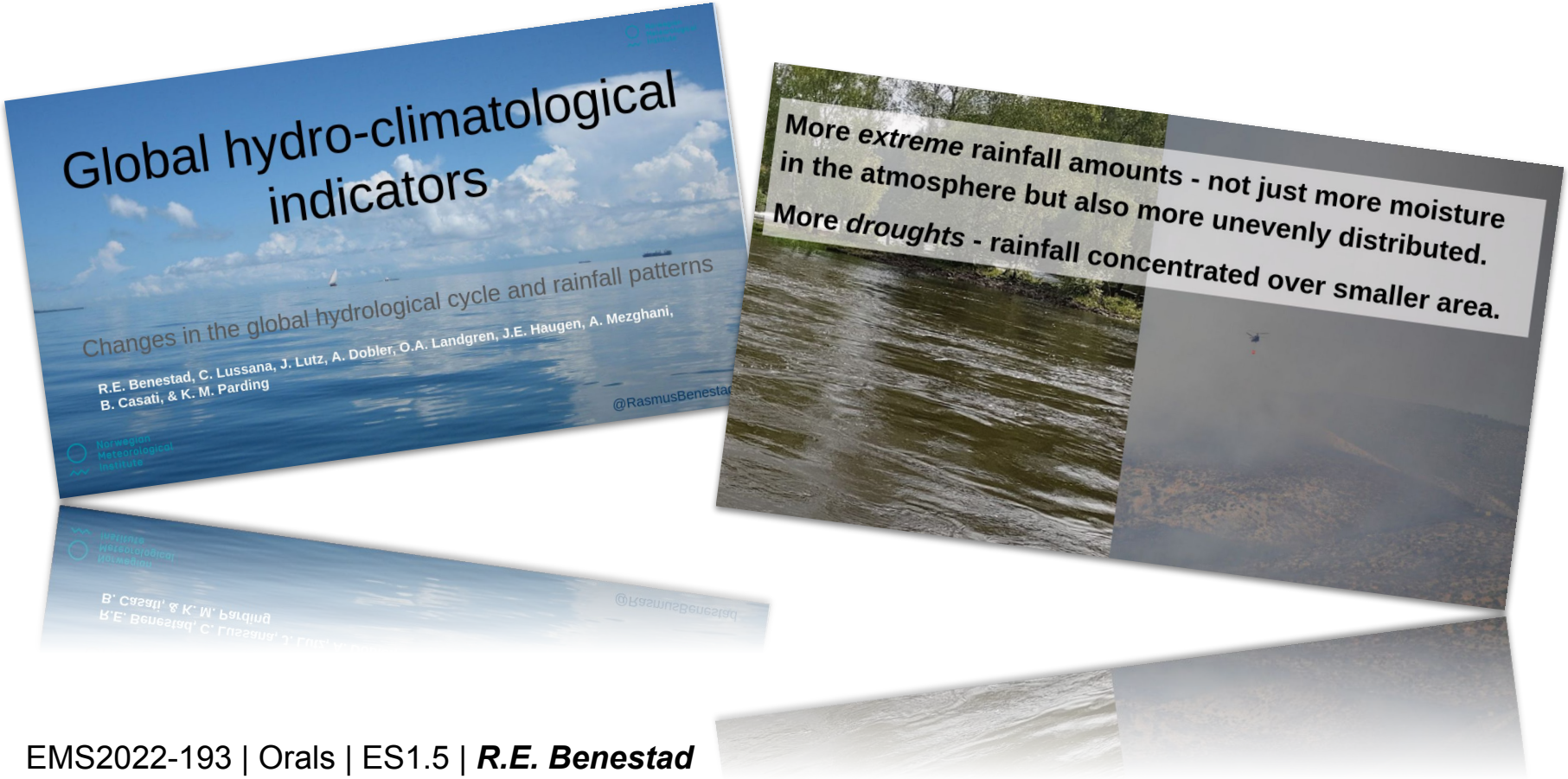
Norwegian Meteorological Institute

SCREEN CAPTURE WELCOME

2022-09-07

EMS2022-181 UP3.6

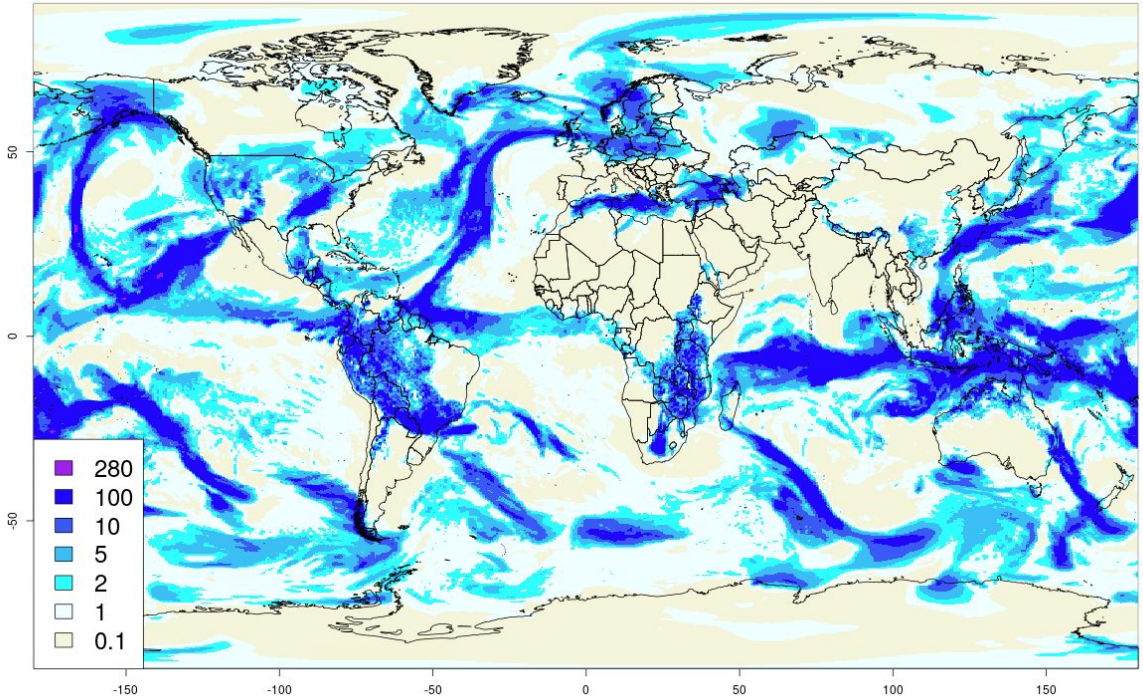
This work is part of a wider activity on global climate indicators



EMS2022-193 | Orals | ES1.5 | ***R.E. Benestad***
Wed, 07 Sep, 14:45–15:00 | Room HS 2

The dataset used: ERA5 (Hersbach et al. 2020)

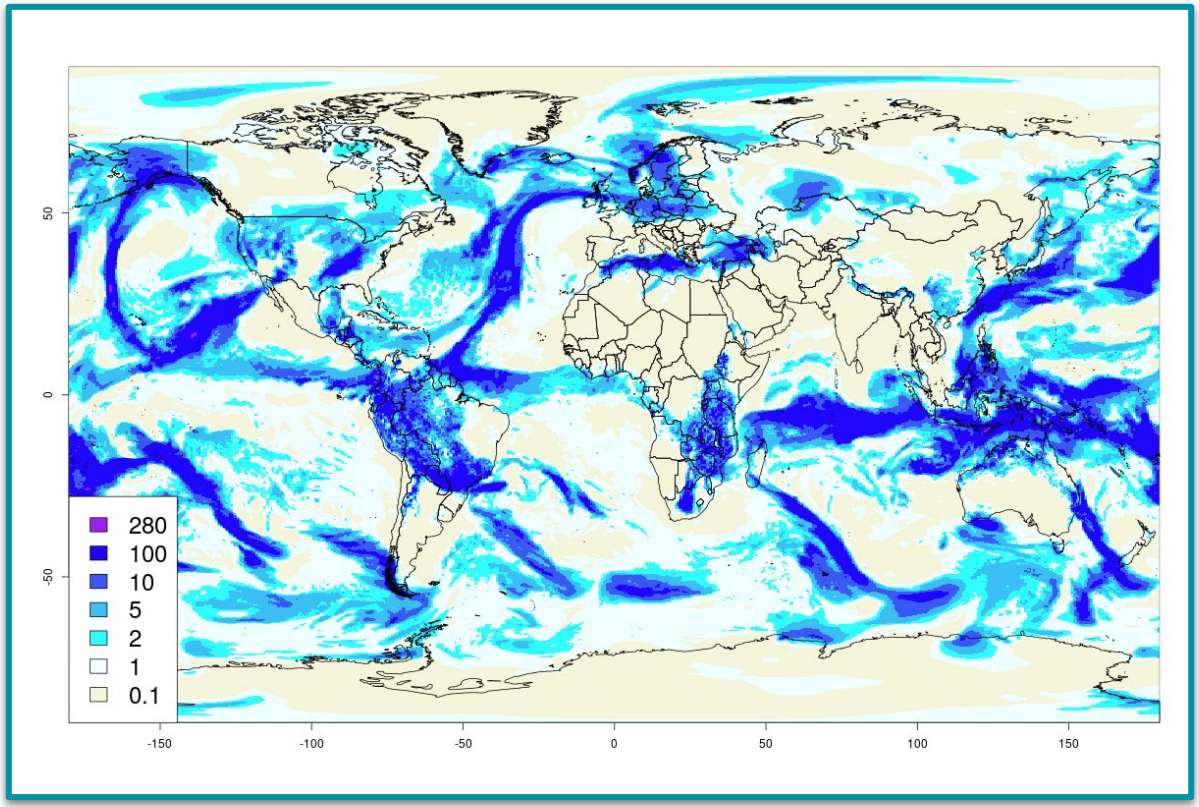
Daily total precipitation (mm/day) for 1950-01-01



ERA5 - Daily total precipitation

- Global Coverage
- 0.25 degrees
- Time period 1950 - 2020

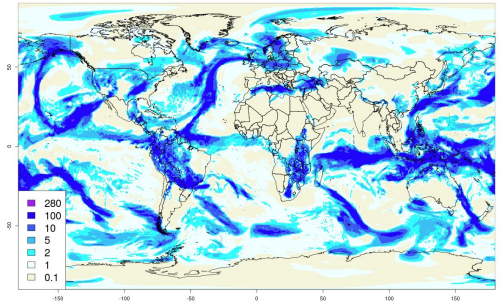
Main Research Question: assessing changes in the spatial patterns of daily precipitation

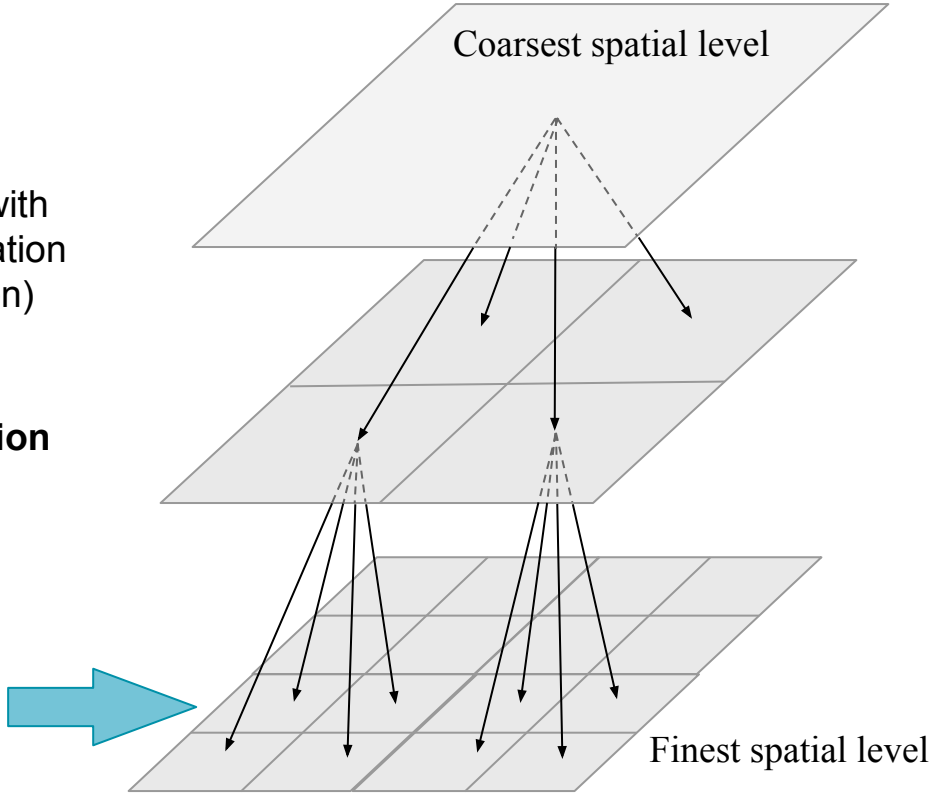


2D Haar Wavelet discrete transform

Powerful way to look at data with different spatial scales of variation (multi-resolution decomposition)

ERA5 - Daily total precipitation

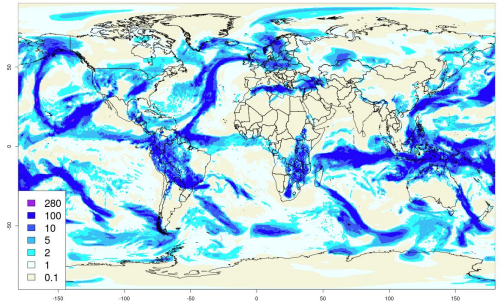


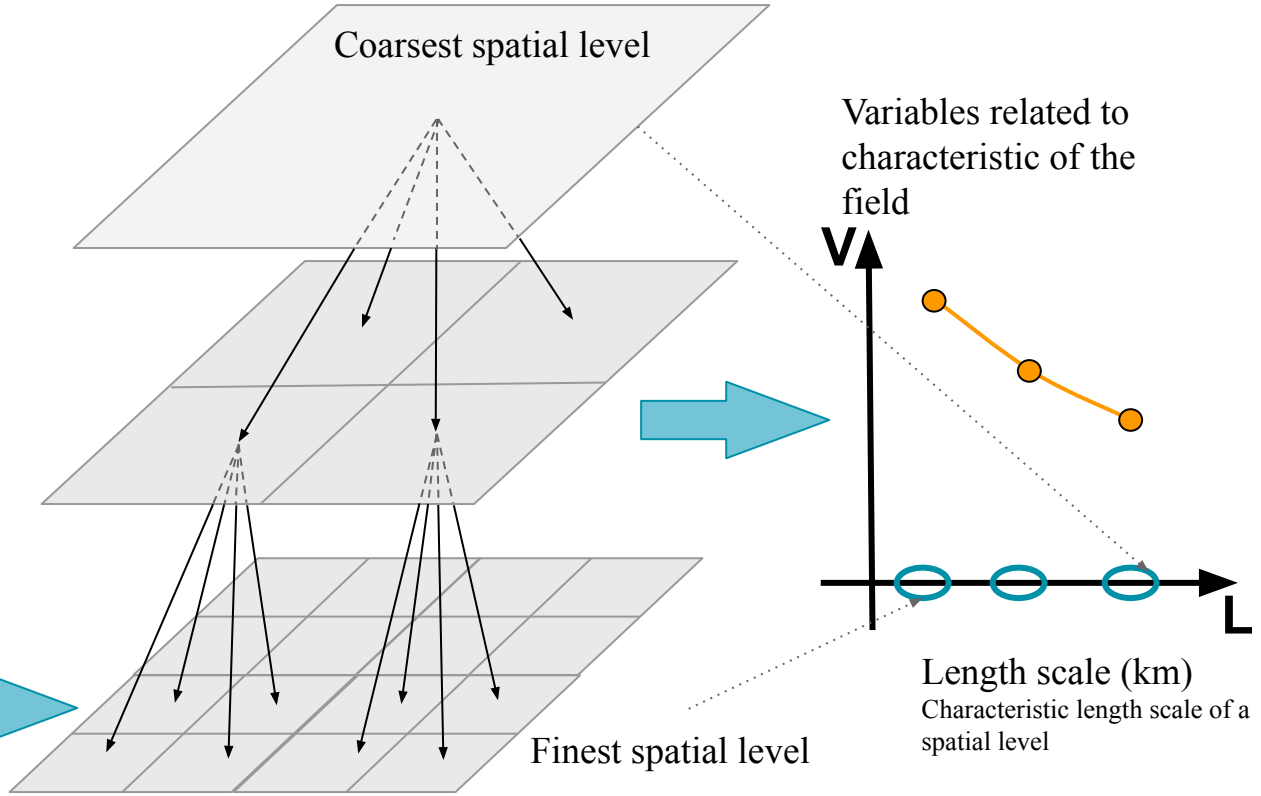


2D Haar Wavelet discrete transform

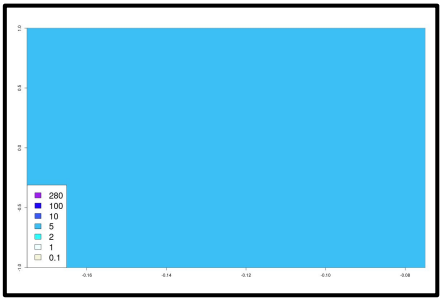
Powerful way to look at data with different spatial scales of variation (multi-resolution decomposition)

ERA5 - Daily total precipitation

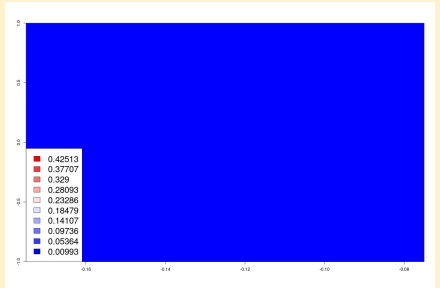




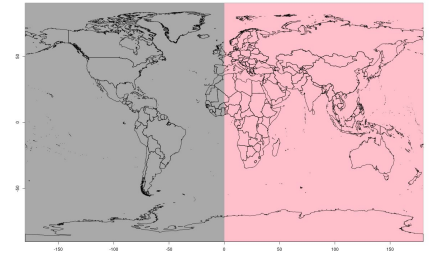
L=255 deg (≈28300 km)



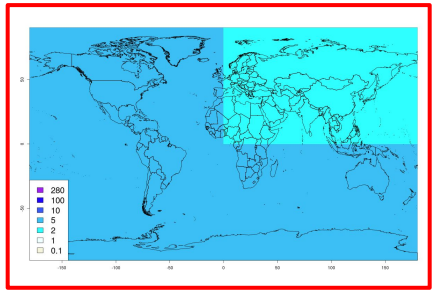
+



*



=

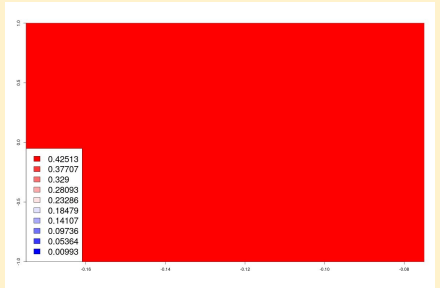


Coarsest spatial level

1 value = global average

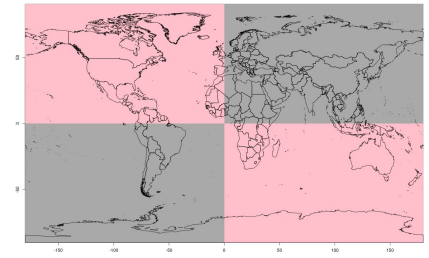
Next (finer) level

2 x 2 matrix



coefficients

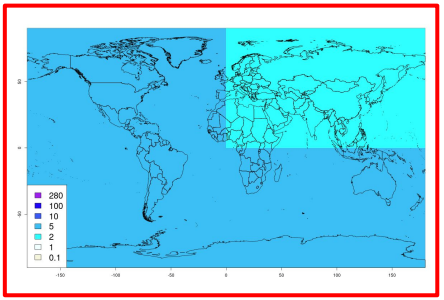
*



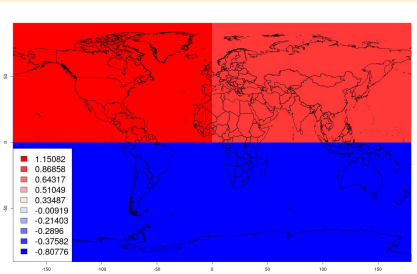
Wavelet bases

L=127 deg (≈14100 km)

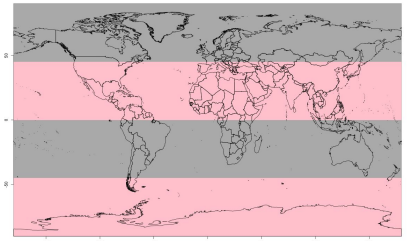
L=64 deg (≈7100 km)

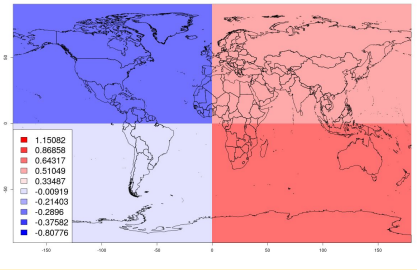


+

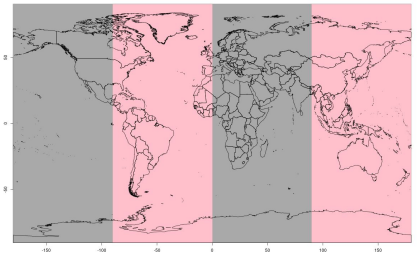


*

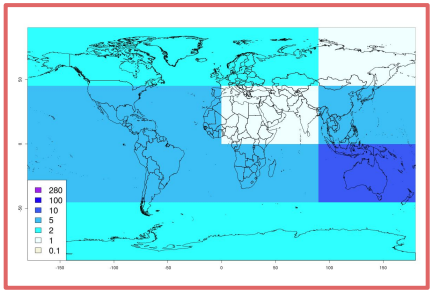


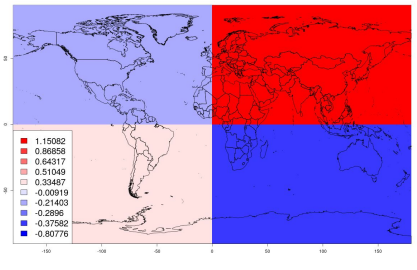


*

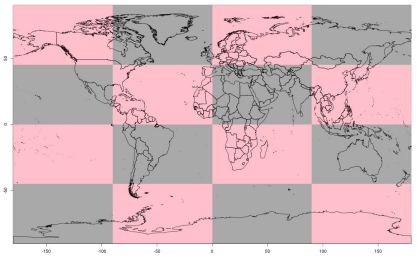


=





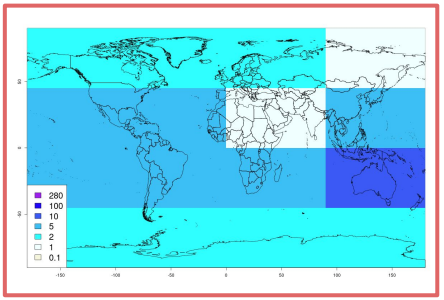
*



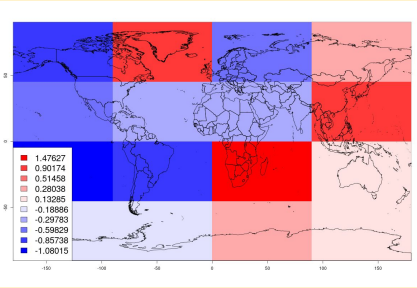
Norwegian Meteorological Institute

L=64 deg (≈7100 km)

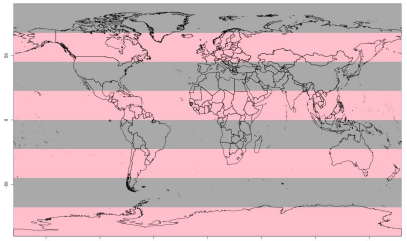
L=32 deg (≈3550 km)

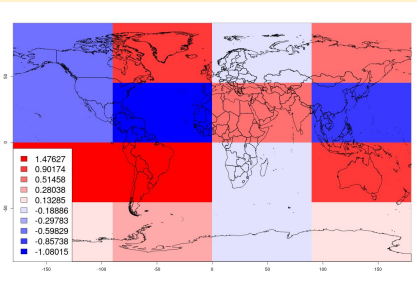


+

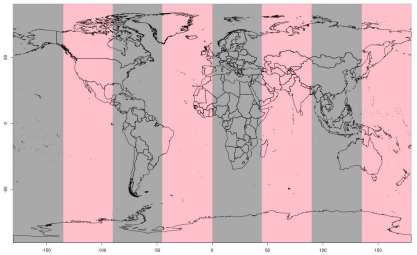


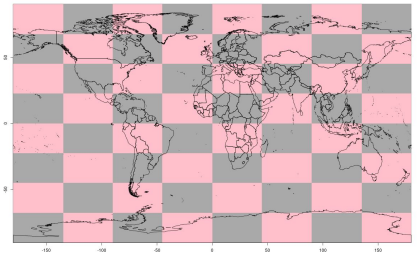
*



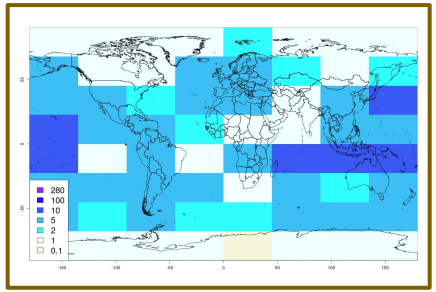


*



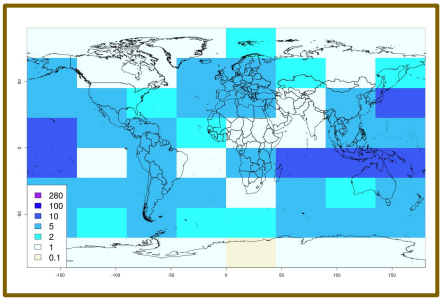


=

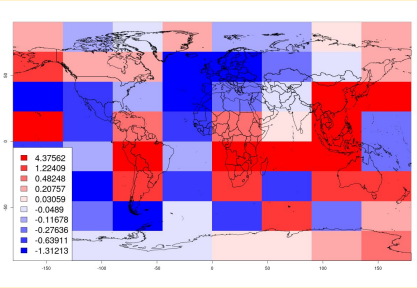


L=32 deg (≈3550 km)

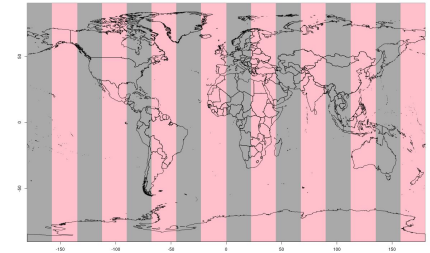
L=16 deg (≈1780 km)



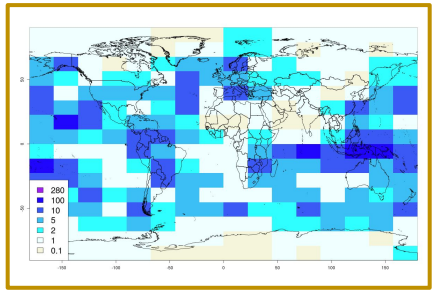
+

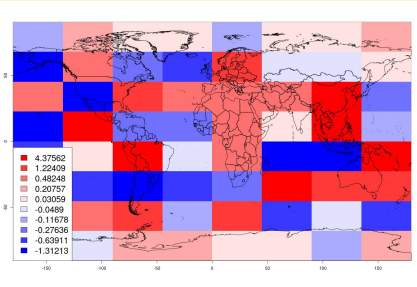


*

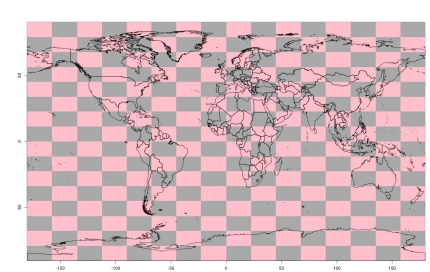


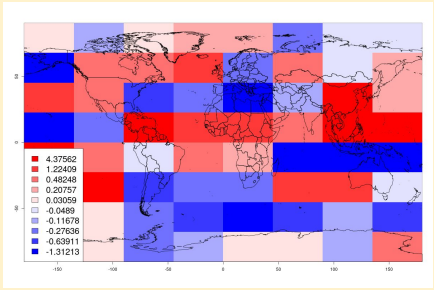
=



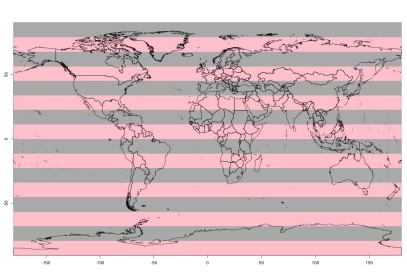


*





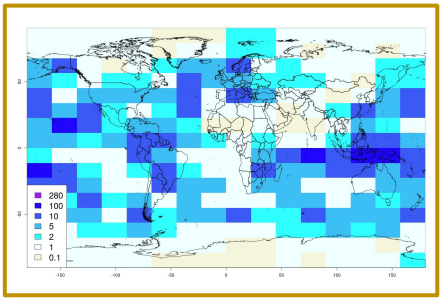
*



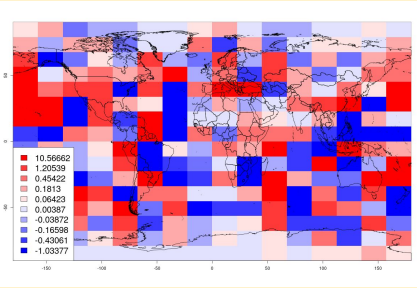
Norwegian Meteorological Institute

L=16 deg (≈1780 km)

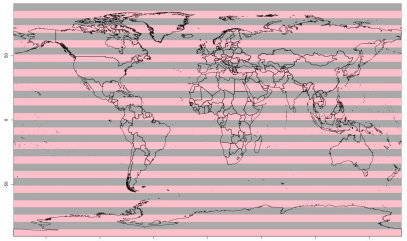
L=8 deg (≈890 km)

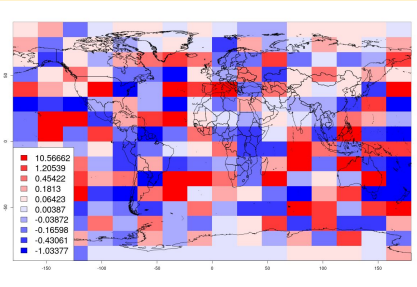


+

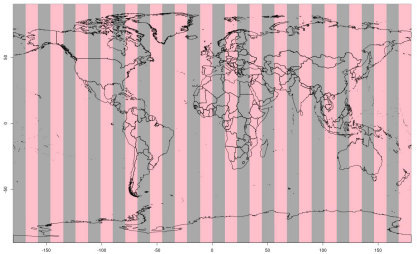


*

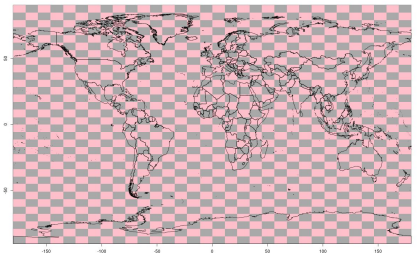




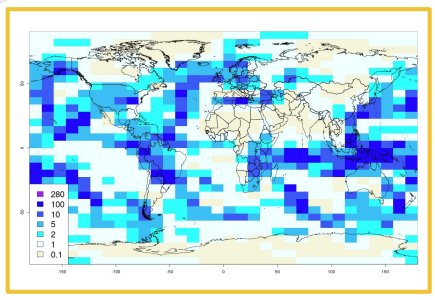
*



*

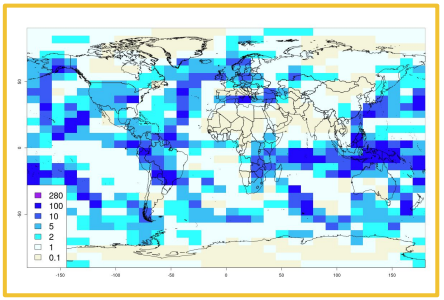


=

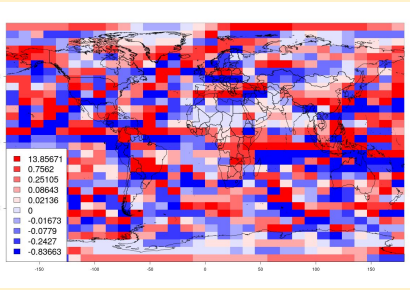


L=8 deg (≈890 km)

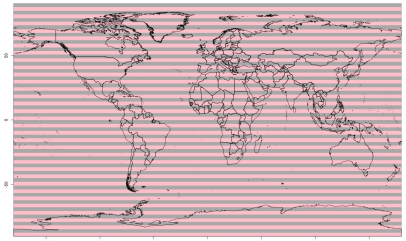
L=4 deg (≈440 km)

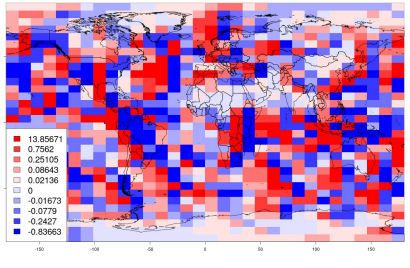


+

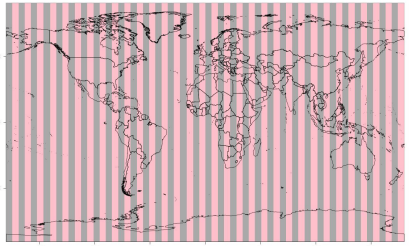


*

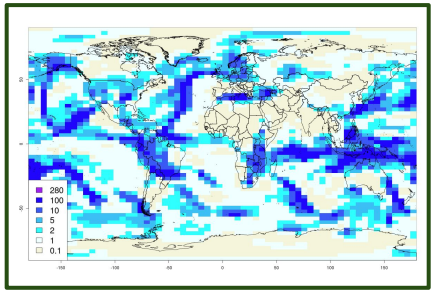


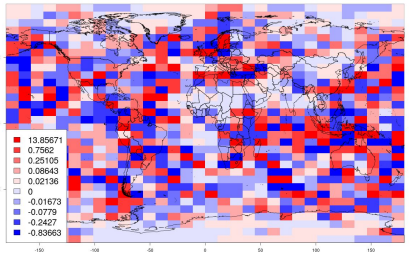


*

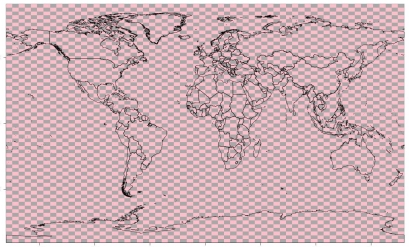


=





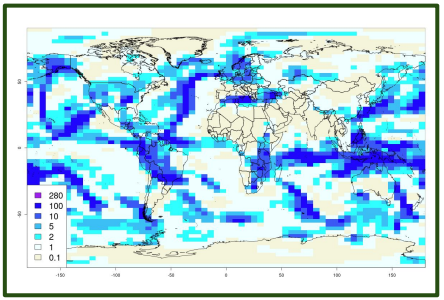
*



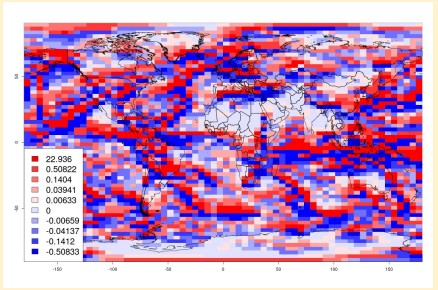
Norwegian Meteorological Institute

L=4 deg (≈440 km)

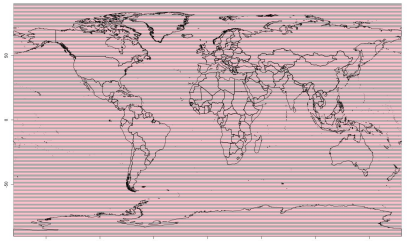
L=2 deg (≈220 km)

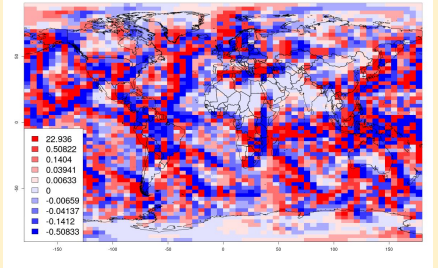


+

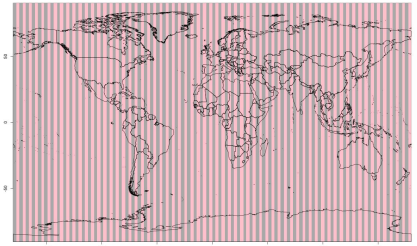


*

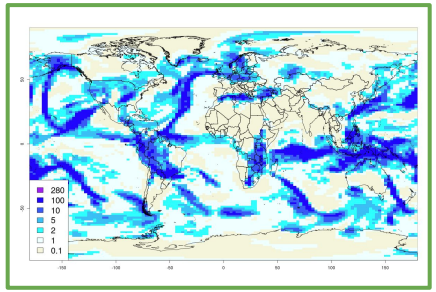


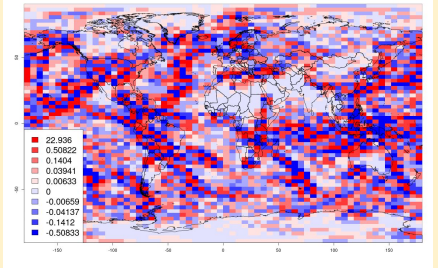


*

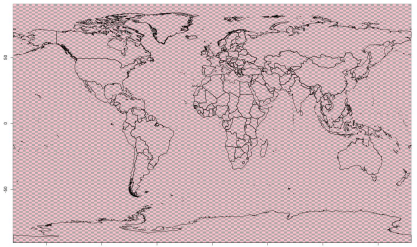


=





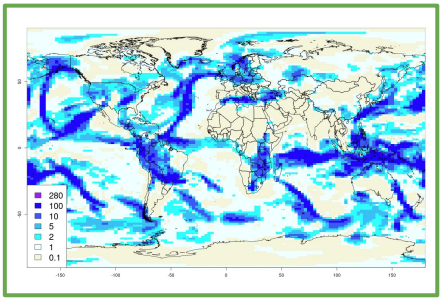
*



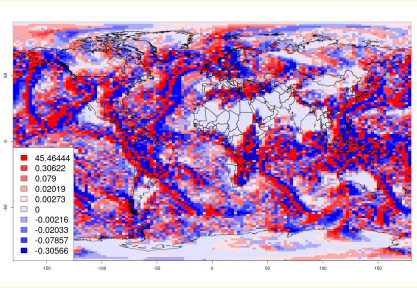
Norwegian Meteorological Institute

L=2 deg (≈220 km)

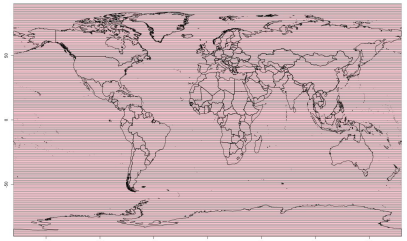
L=1 deg (≈110 km)

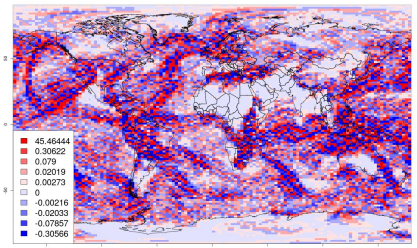


+

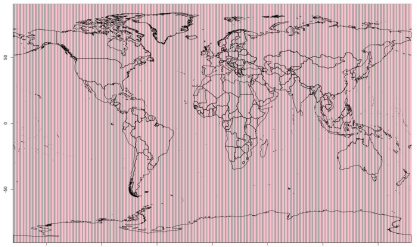


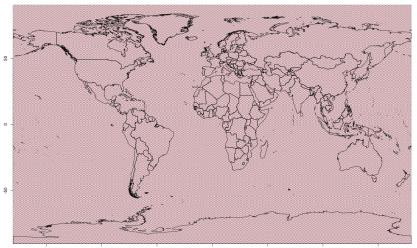
*



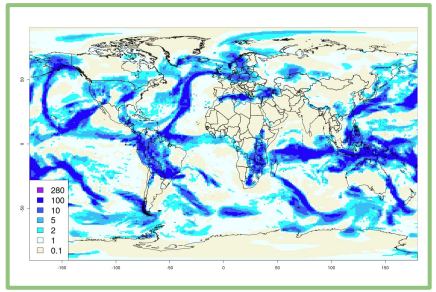


*



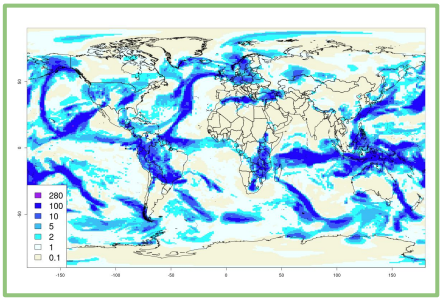


=

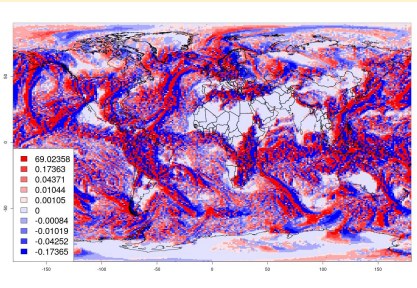


L=1 deg (≈110 km)

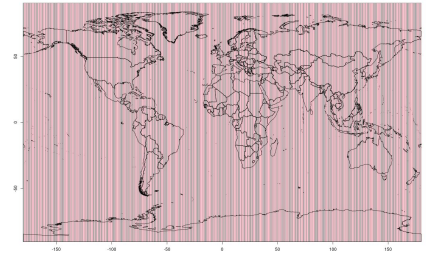
L=0.5 deg (≈60 km)



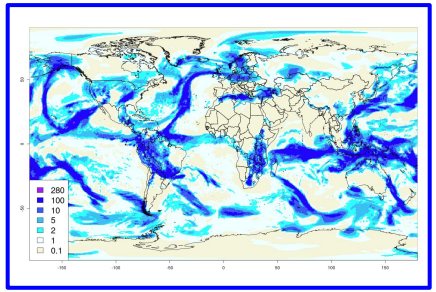
+

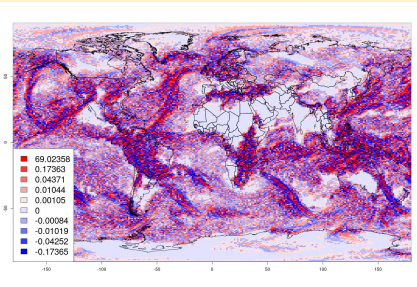


*

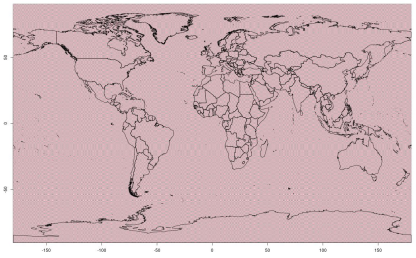


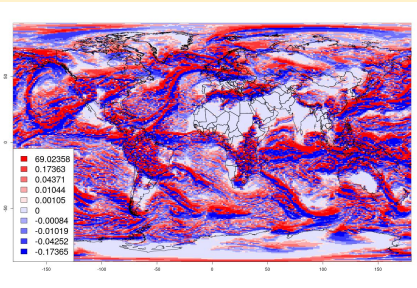
=



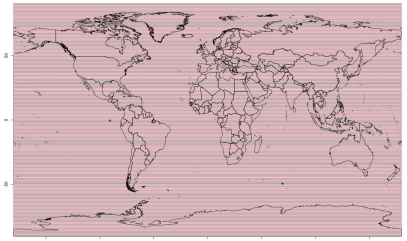


*



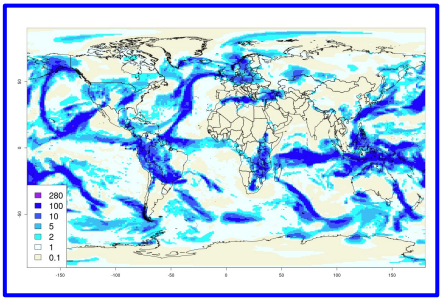


*

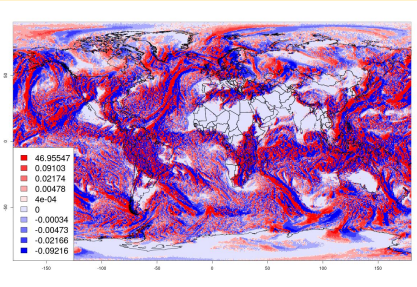


L=0.5 deg (≈60 km)

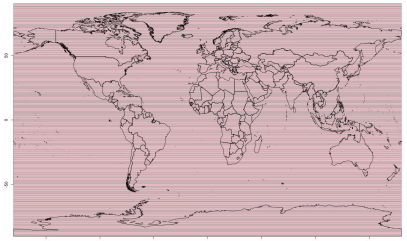
L=0.25 deg (≈30 km)



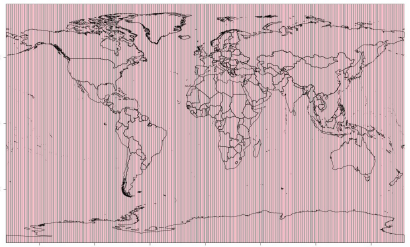
+



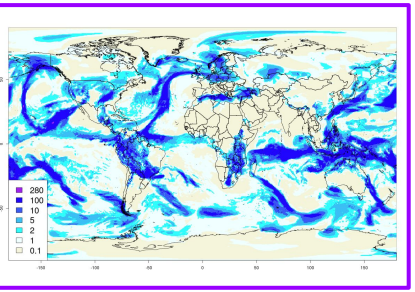
*

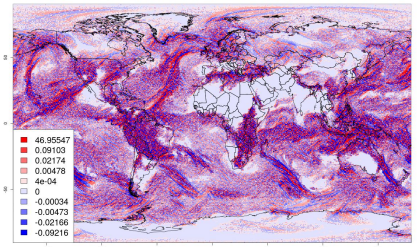


*

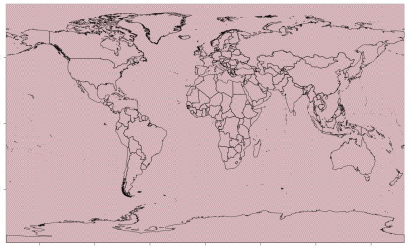


=





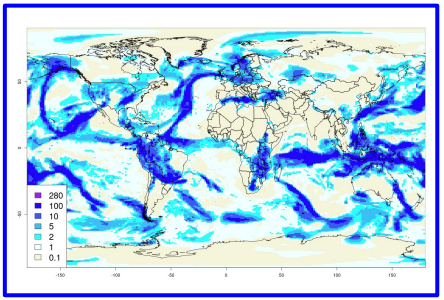
*



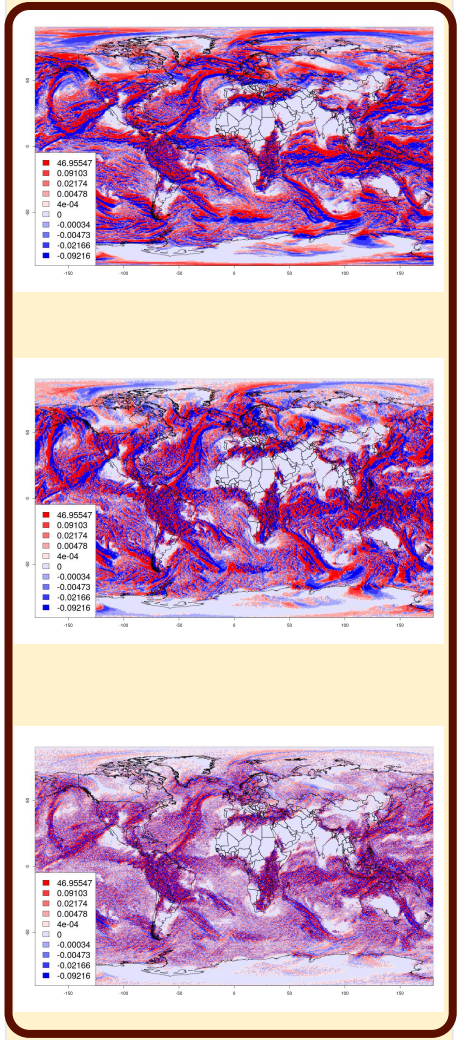
Norwegian Meteorological Institute

L=0.5 deg (≈60 km)

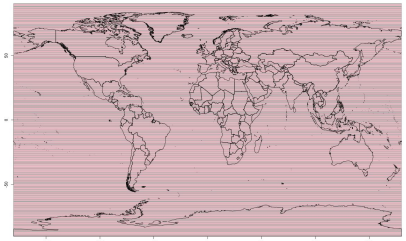
L=0.25 deg (≈30 km)



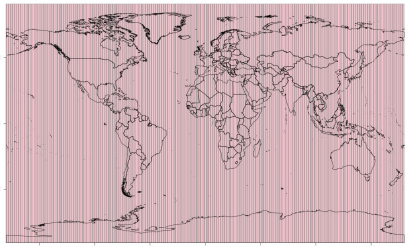
+



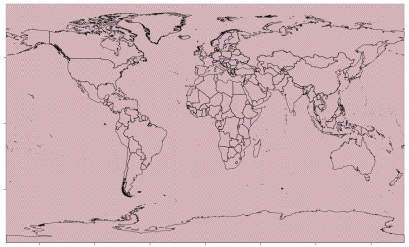
*



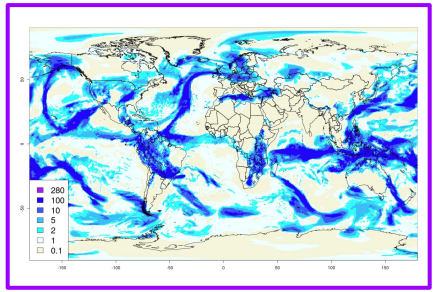
*



*

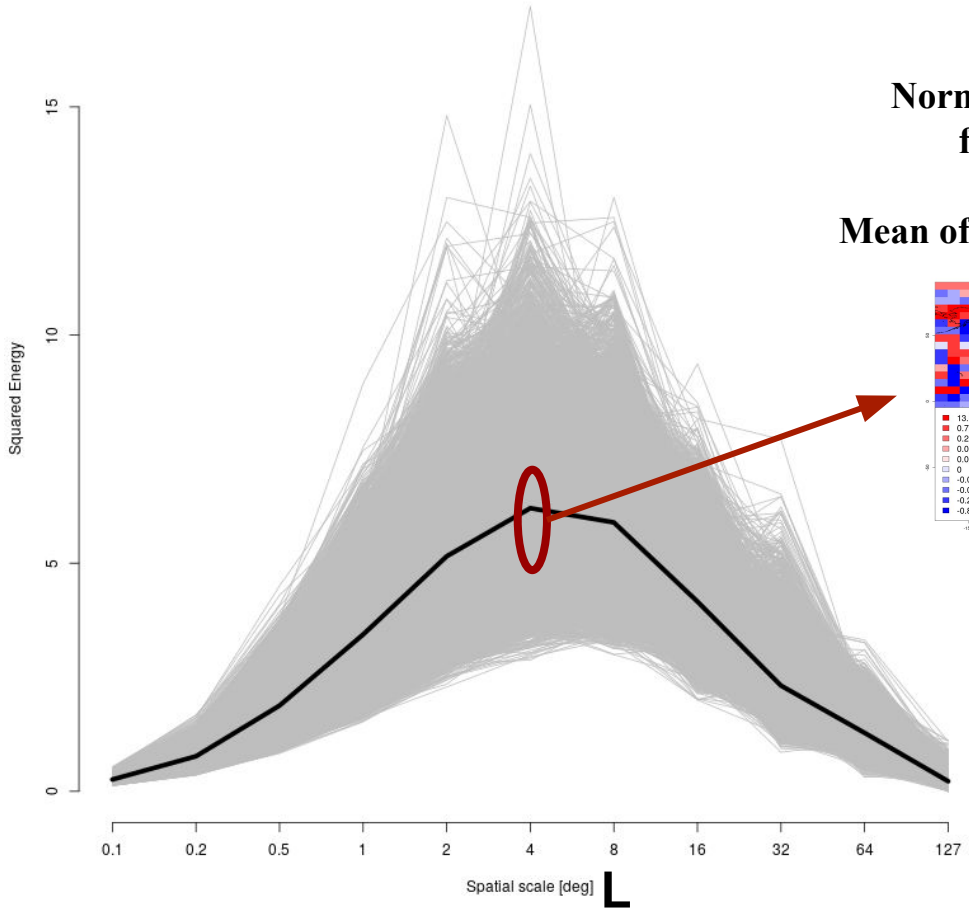


=

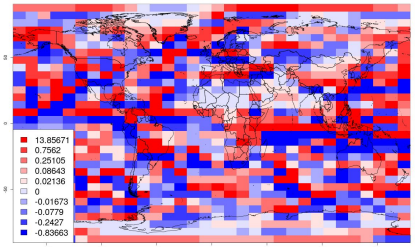


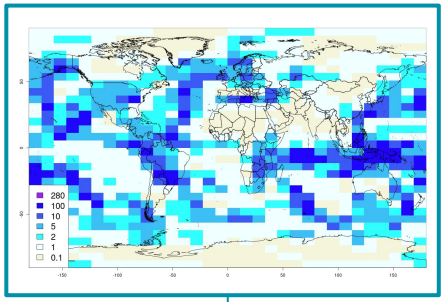
Norwegian Meteorological Institute

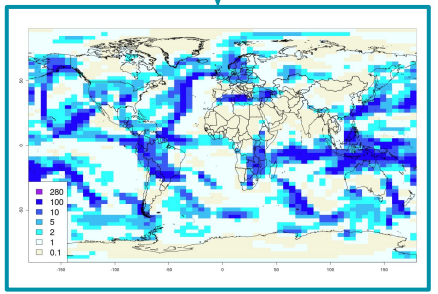
Energy spectrum for each day 1950-2020



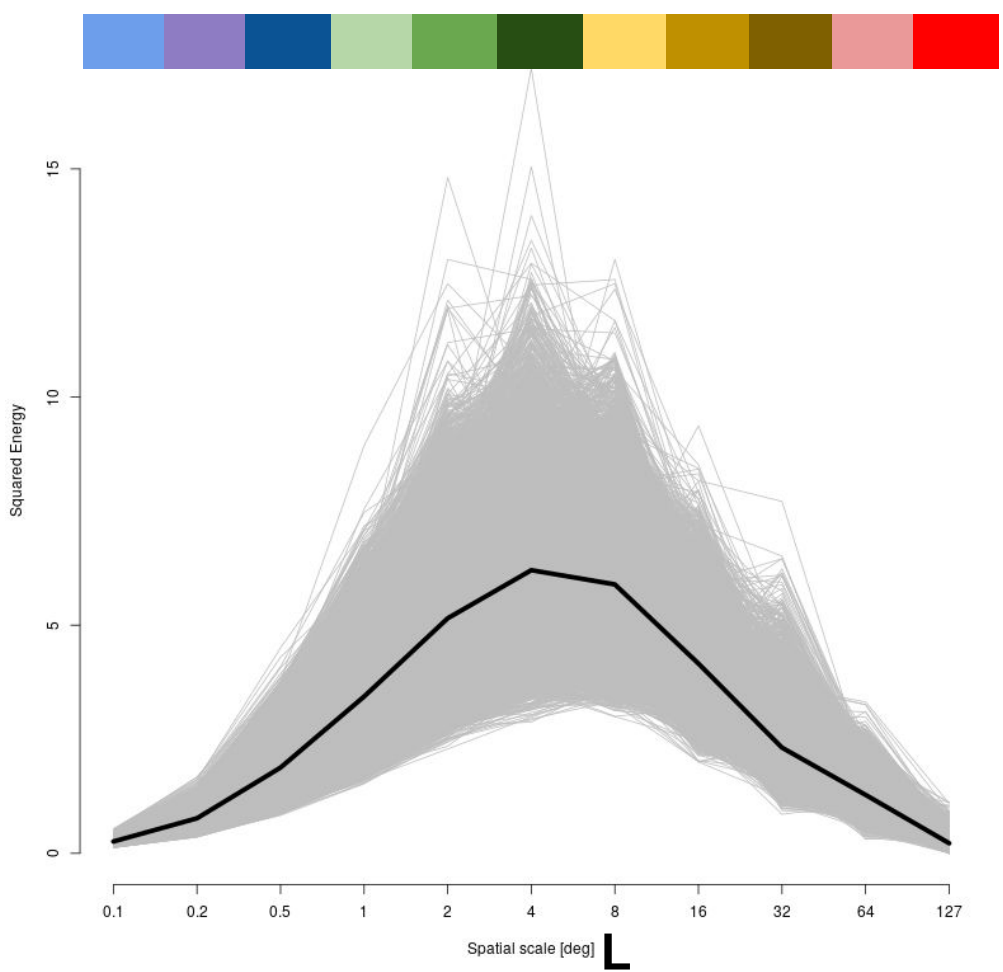
Normalized squared energy from 8 deg to 4 deg proportional to Mean of the (wavelet coefficients)^2







Energy spectrum for each day 1950-2020



127°	≈ 14100 km
64°	≈ 7100 km
32°	≈ 3550 km
16°	≈ 1780 km
8°	≈ 890 km
4°	≈ 440 km
2°	≈ 220 km
1°	≈ 110 km
0.5°	≈ 60 km
0.25°	≈ 30 km
0.1°	

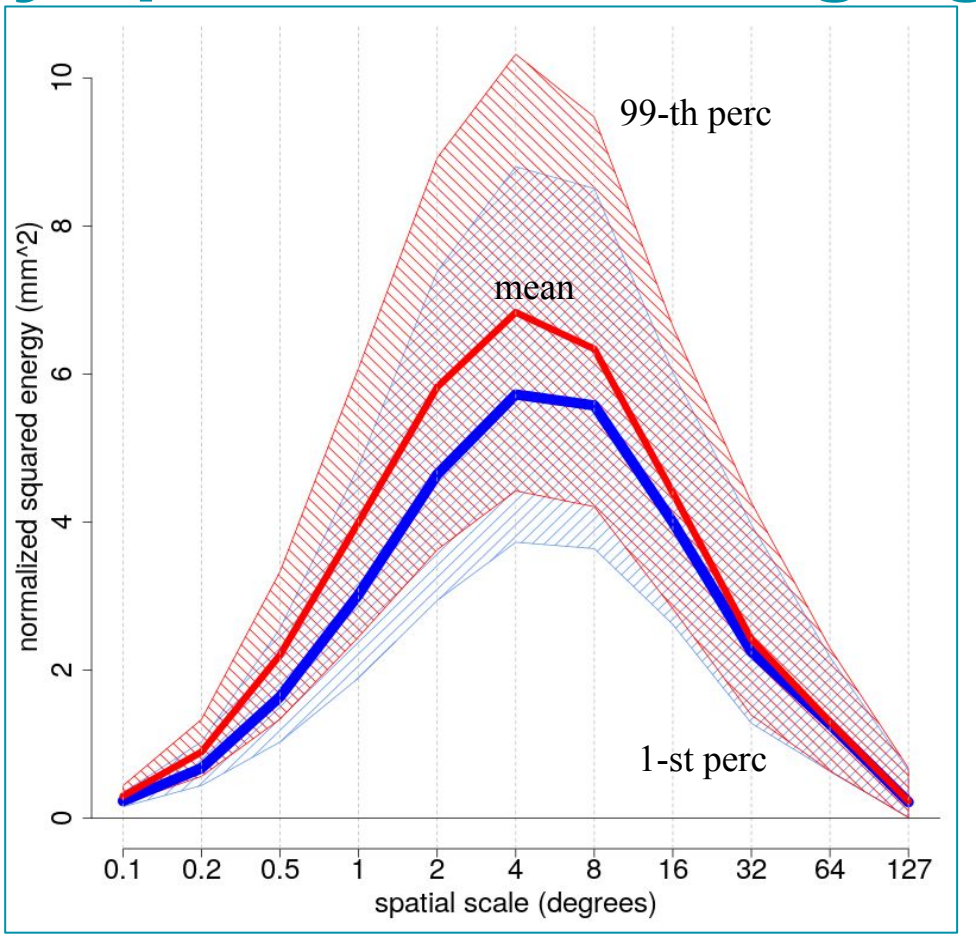
Macro-β scale
Synoptic cyclones

Macro-γ scale
Fronts, hurricanes

Meso-β scale
Thunderstorm groups

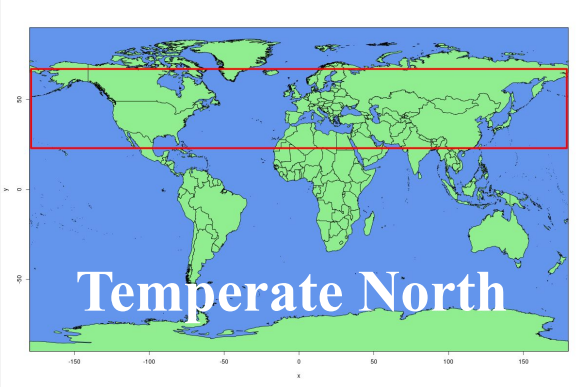
Scales def: Thunis and Bornstein, 1996

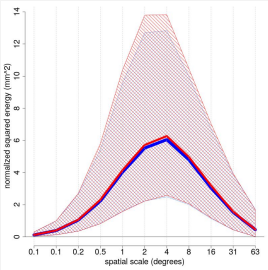
The Energy spectrum is changing over time

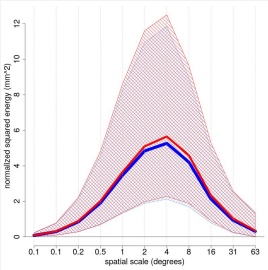


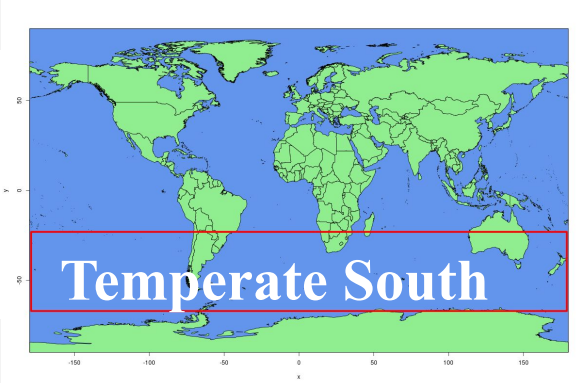
Energy spectra
1961-1990 blue
1991-2020 red

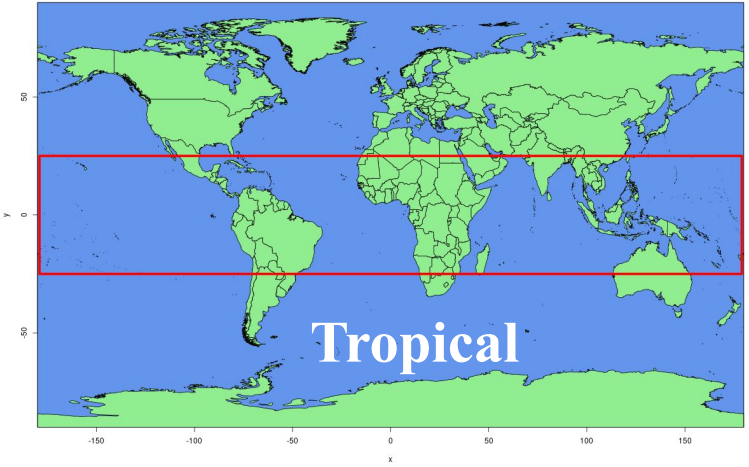
Regional Differences

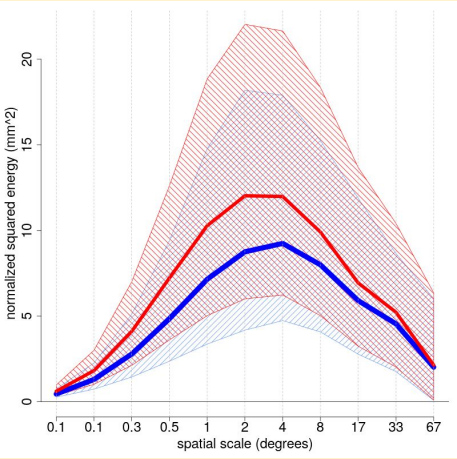




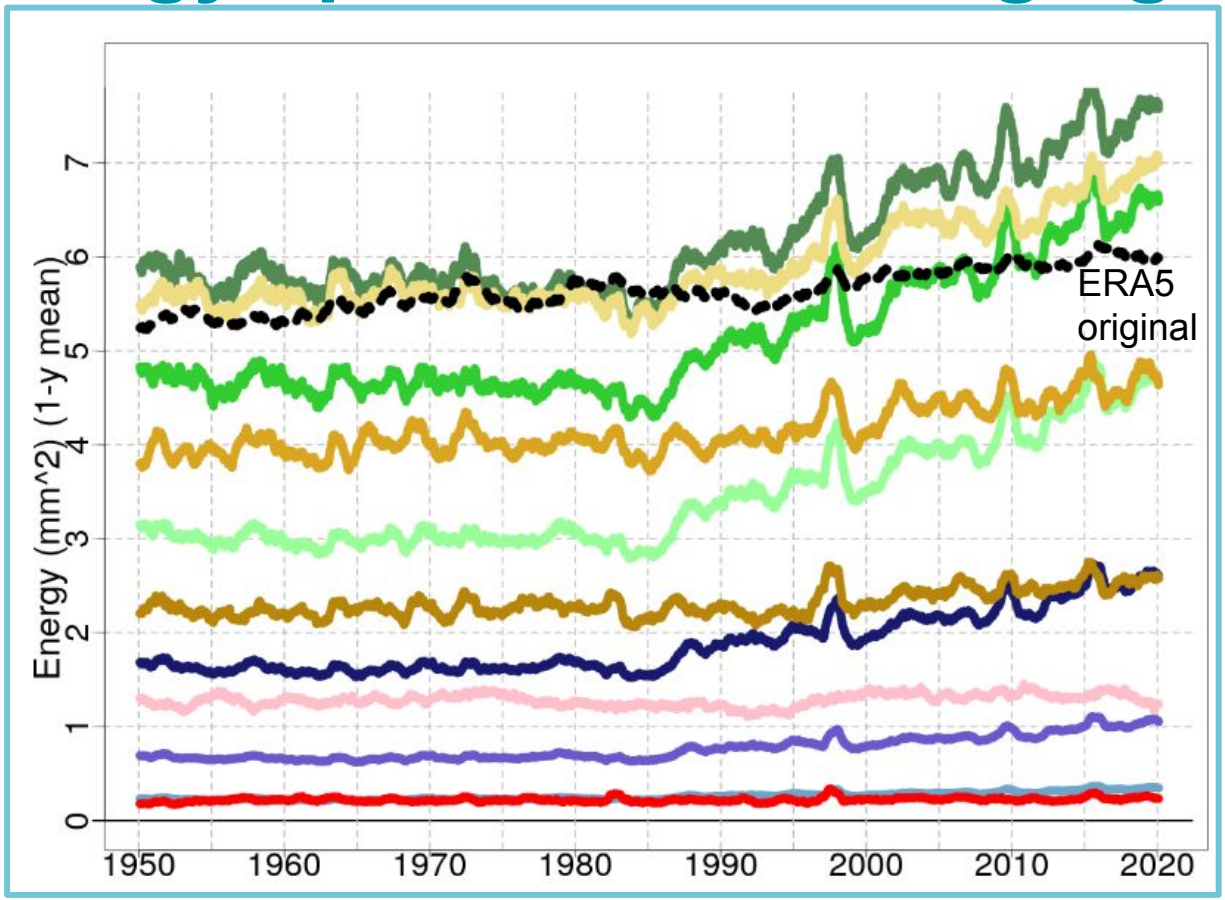






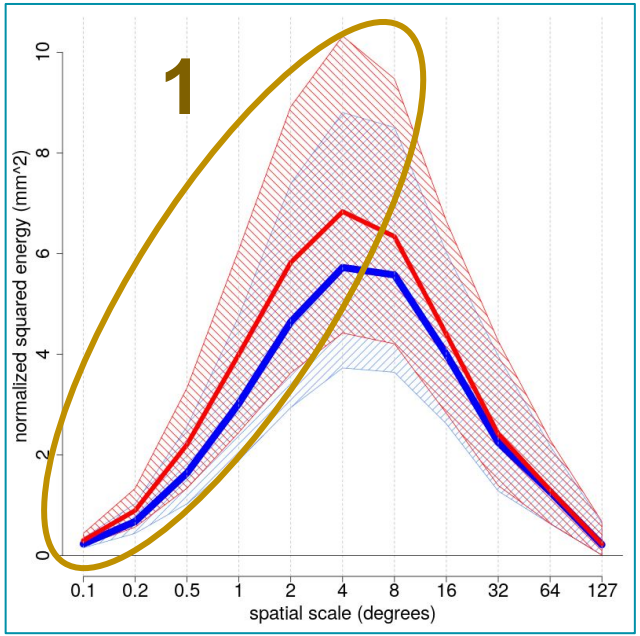


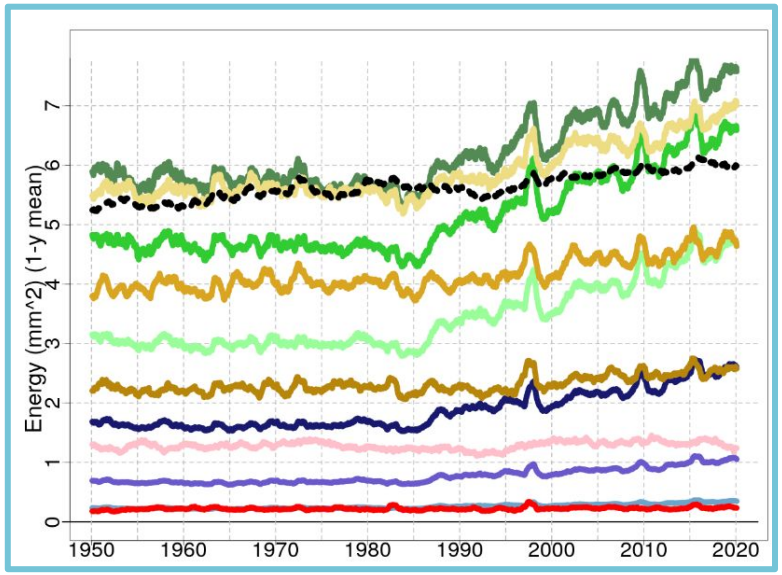
The Energy spectrum is changing over time



Norwegian Meteorological Institute

The Energy spectrum is changing over time

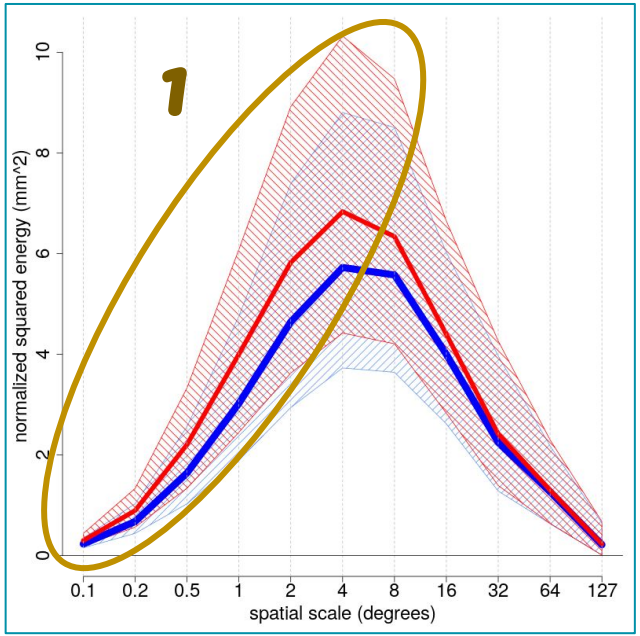


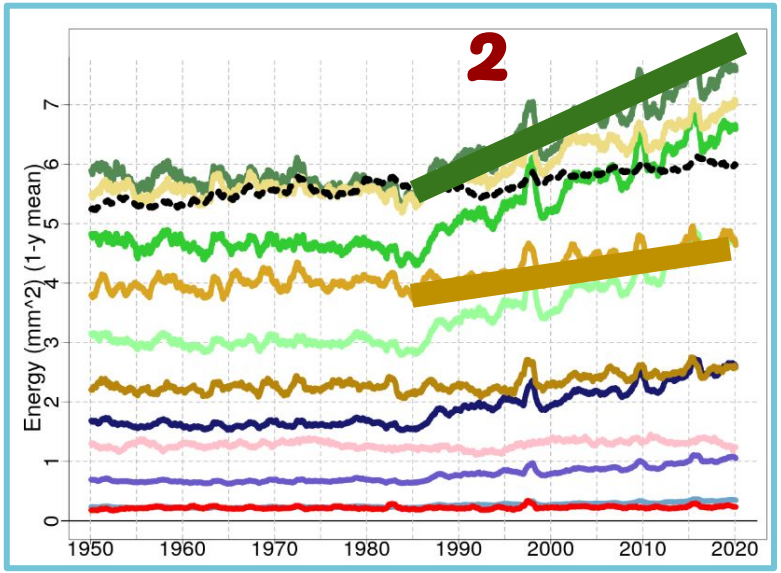


127° ≈ 14100 km
64° ≈ 7100 km
32° ≈ 3550 km
16° ≈ 1780 km
8° ≈ 890 km
4° ≈ 440 km
2° ≈ 220 km
1° ≈ 110 km
0.5° ≈ 60 km
0.25° ≈ 30 km
0.1°

Norwegian Meteorological Institute

The Energy spectrum is changing over time



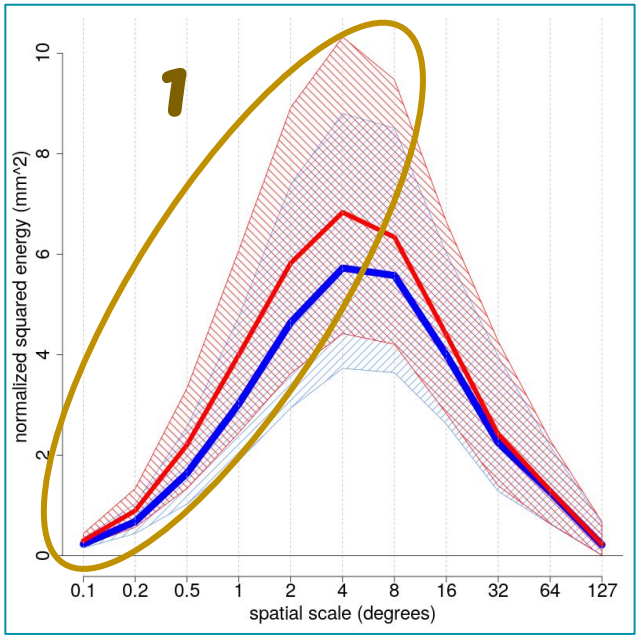


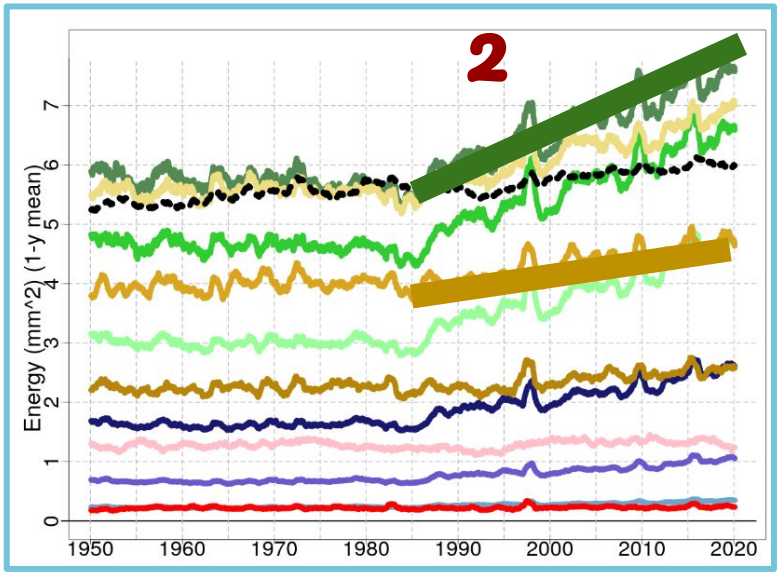
127° ≈ 14100 km
64° ≈ 7100 km
32° ≈ 3550 km
16° ≈ 1780 km
8° ≈ 890 km
4° ≈ 440 km
2° ≈ 220 km
1° ≈ 110 km
0.5° ≈ 60 km
0.25° ≈ 30 km
0.1°

Norwegian Meteorological Institute

Conclusions

- Precipitation systems have shrunk while becoming more intense
- Acceleration of the rate of the global hydrological cycle, combined with a diminishing global area of rainfall





Norwegian Meteorological Institute

Reference

Rasmus E. Benestad, Cristian Lussana, Julia Lutz, Andreas Dobler, Oskar Landgren, Jan Erik Haugen, Abdelkader Mezghani, Barbara Casati, Kajsa M. Parding (2022) **‘*Global hydro-climatological indicators and changes in the global hydrological cycle and rainfall patterns*’**, *PLOS Climate*, DOI: 10.1371/journal.pclm.0000029.



2D Haar Wavelet discrete transform

