Spatial and seasonal variability of the Wet Tropospheric Correction Spectral characteristics

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1: CLS 2: CNES

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Context

- The present study is in the continuity of last year presentation

    - A. Ollivier et al. OST/ST 2014:
    "Towards a spectral error budget of Nadir Altimetric missions"

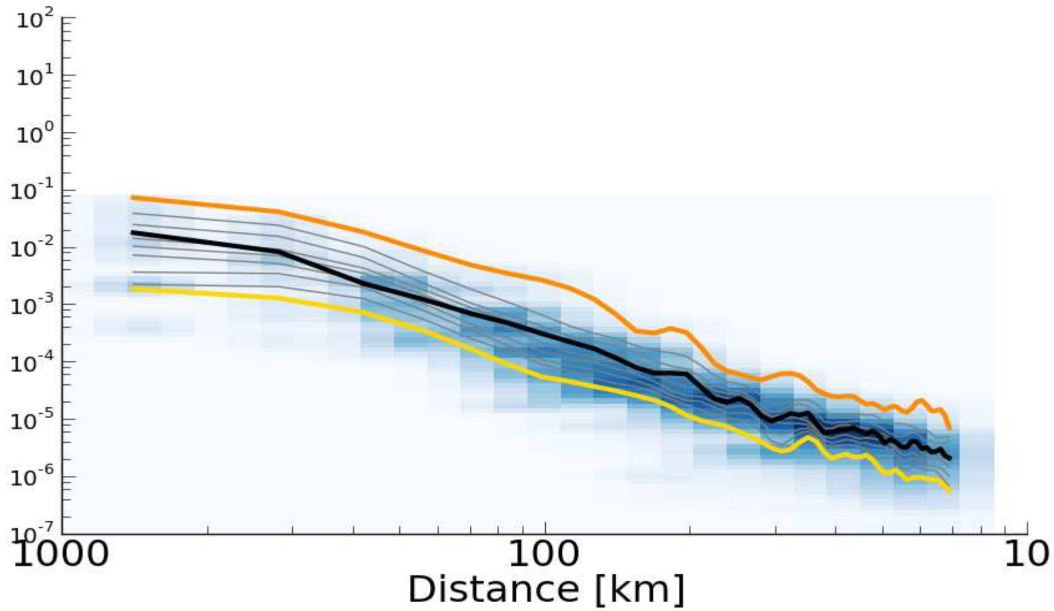
- the long term perspective is

    - to provide to **altimetry users** an estimation of altimetry product associated error

    - and to **decline the error budget for various temporal and/or spatial scales.**

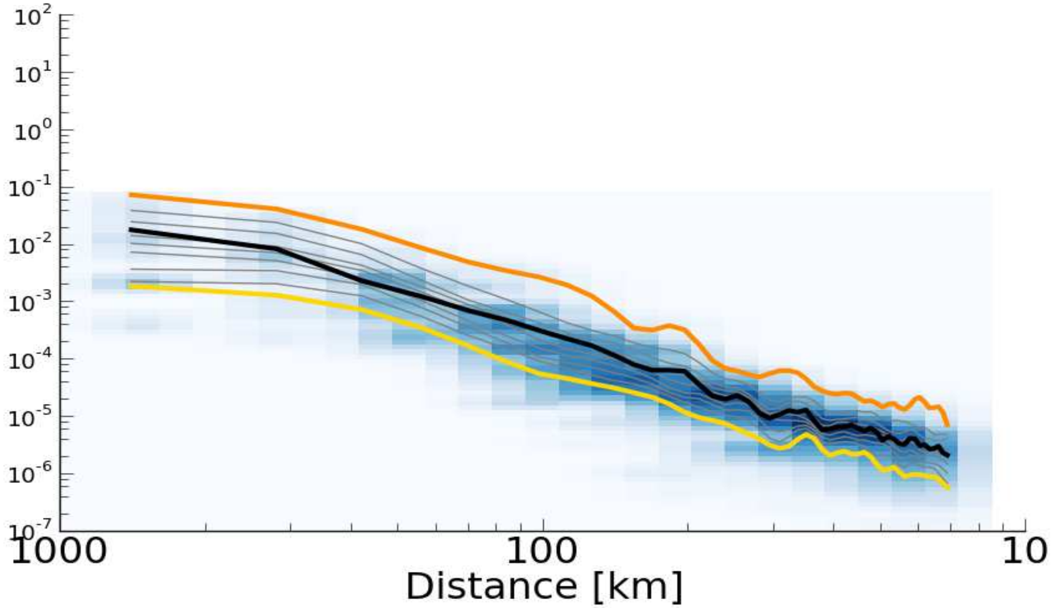
Context

- Focusing on the wet tropospheric correction (WTC), it has been shown that:
  - Global average of spectra integrates many geophysical events.
  - Considering the envelope around the average sprectrum enables to better take into account all the temporal/spatial situations



Objectives

- The objectives of the current study are:
  - to expand the « 1D » analysis of WTC spectra
    to a « 2D » geographical analysis
  - to assess the impact of rain on the geographical patterns
    of the linear fit slope of the average spectrum = scaling exponent
  - to quantify the seasonal and spatial variability of the scaling exponent



Overview

This presentation is splitted into 3 parts:

1. Producing maps and first analysis of geographical variability

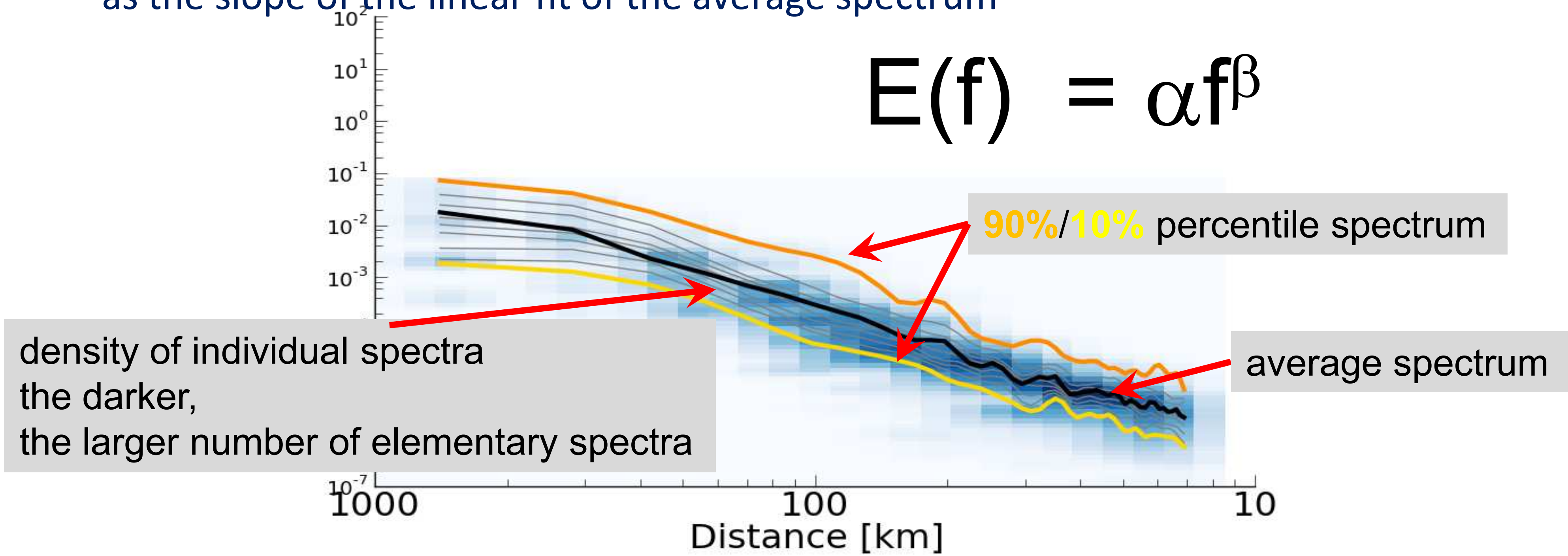
2. To characterize the geographical impact of rain on
   the distribution discrepancy of elementary spectra

3. To characterize the geographical impact of rain on
   the scaling exponent

Producing maps and first analysis

- Ubelman et al. (2013) presented the global average of the WTC spectra for Jason-2
- For the current study, we will use AltiKa WTC spectra
- and an analysis of the distribution of elementary spectra used for the averaging
- **the scaling exponent** β characterizes the scaling behavior of the WTC: it is estimated as the slope of the linear fit of the average spectrum

$$E(f) = \alpha f^{\beta}$$



Producing maps and first analysis

- In order **to produce maps** with a sufficient resolution and a good statistical representativity, we have to fulfill the following constraints:
  - to average a sufficient number of individual spectra
  - to represent scales up to 300 km
  - to have a sufficient resolution of the grid

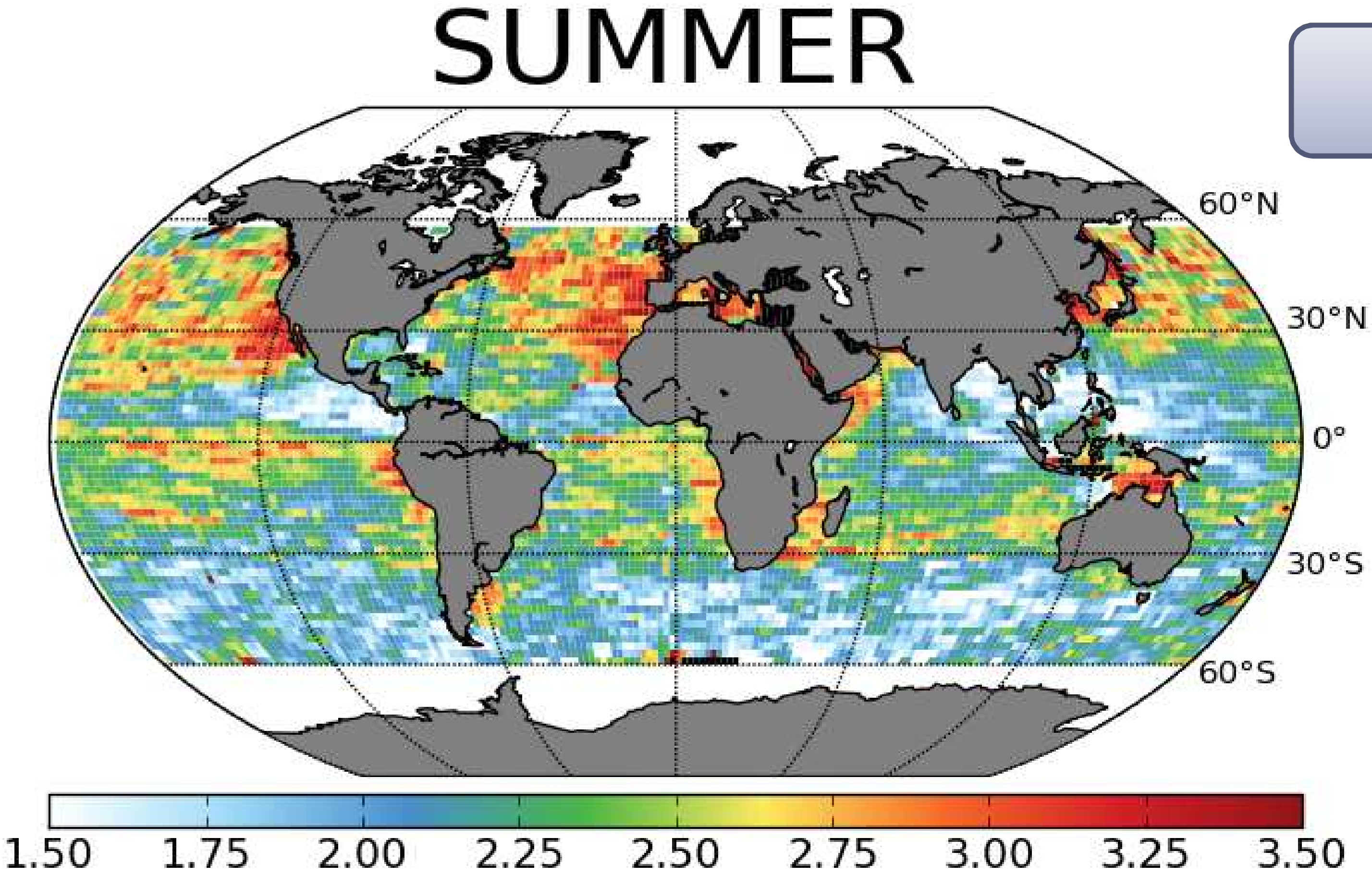
- Then, we applied the following methodology, similar to Pressel & Collins 2012 (Journal of Climate) used for the analysis of AIRS water vapor scale exponent

- **for each season**
  - selection of 700 km granules (along-track segments) on a 10°x10° box
  - computation of elementary spectra, averaged spectrum
    + characterization (linear fit, slope estimate …)
  - shift of the 10°x10° box by 2° (longitudes then latitudes)

➔ resulting in 4 seasonal maps of 2°x2° resolution

Producing maps and first analysis

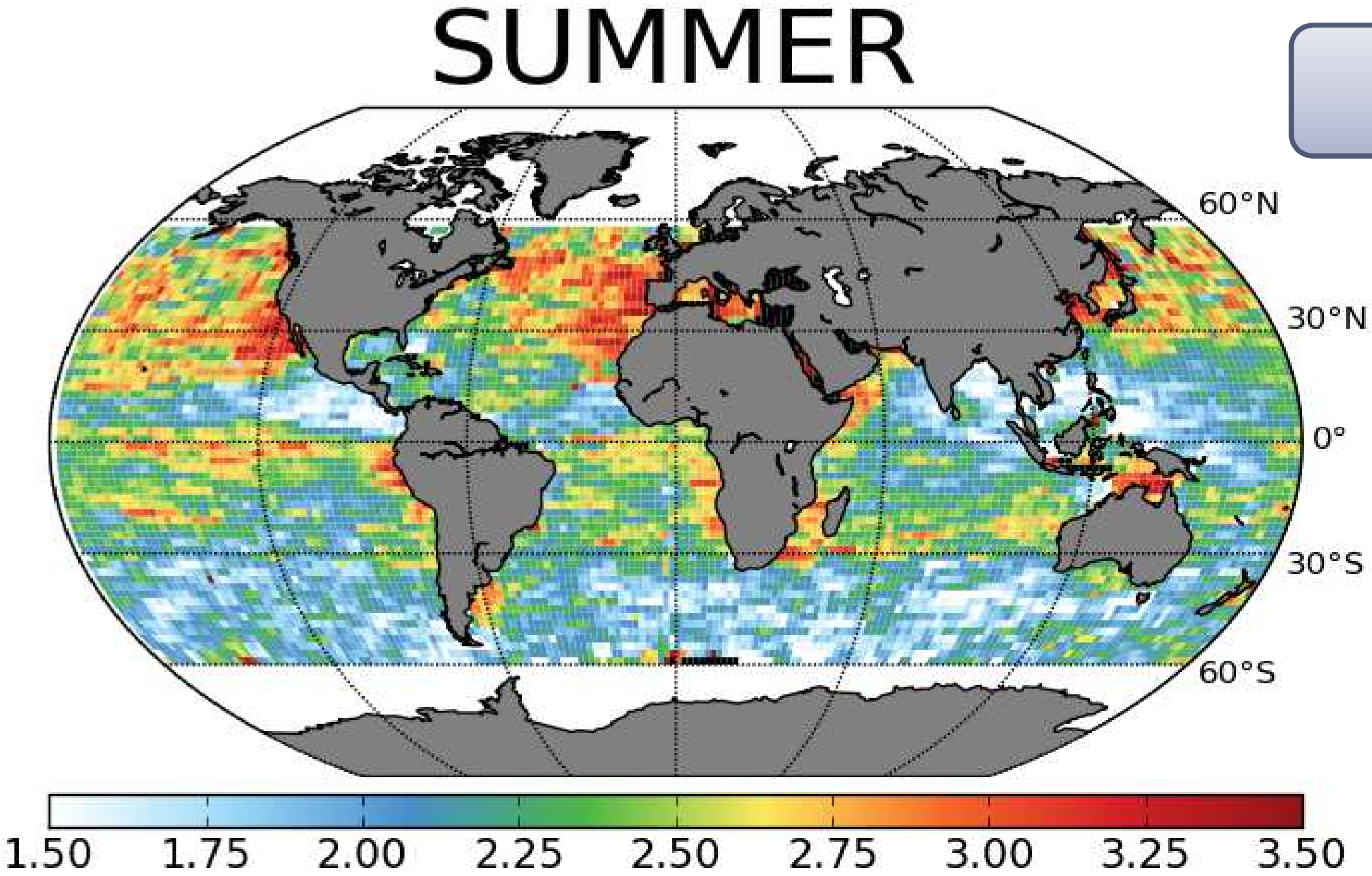
- This is a map of the **scaling exponent (=slope) of AltiKa WTC**, estimated through a linear fit of the average spectrum between 50 km and 250 km wavelength



Scaling Exponent

Producing maps and first analysis

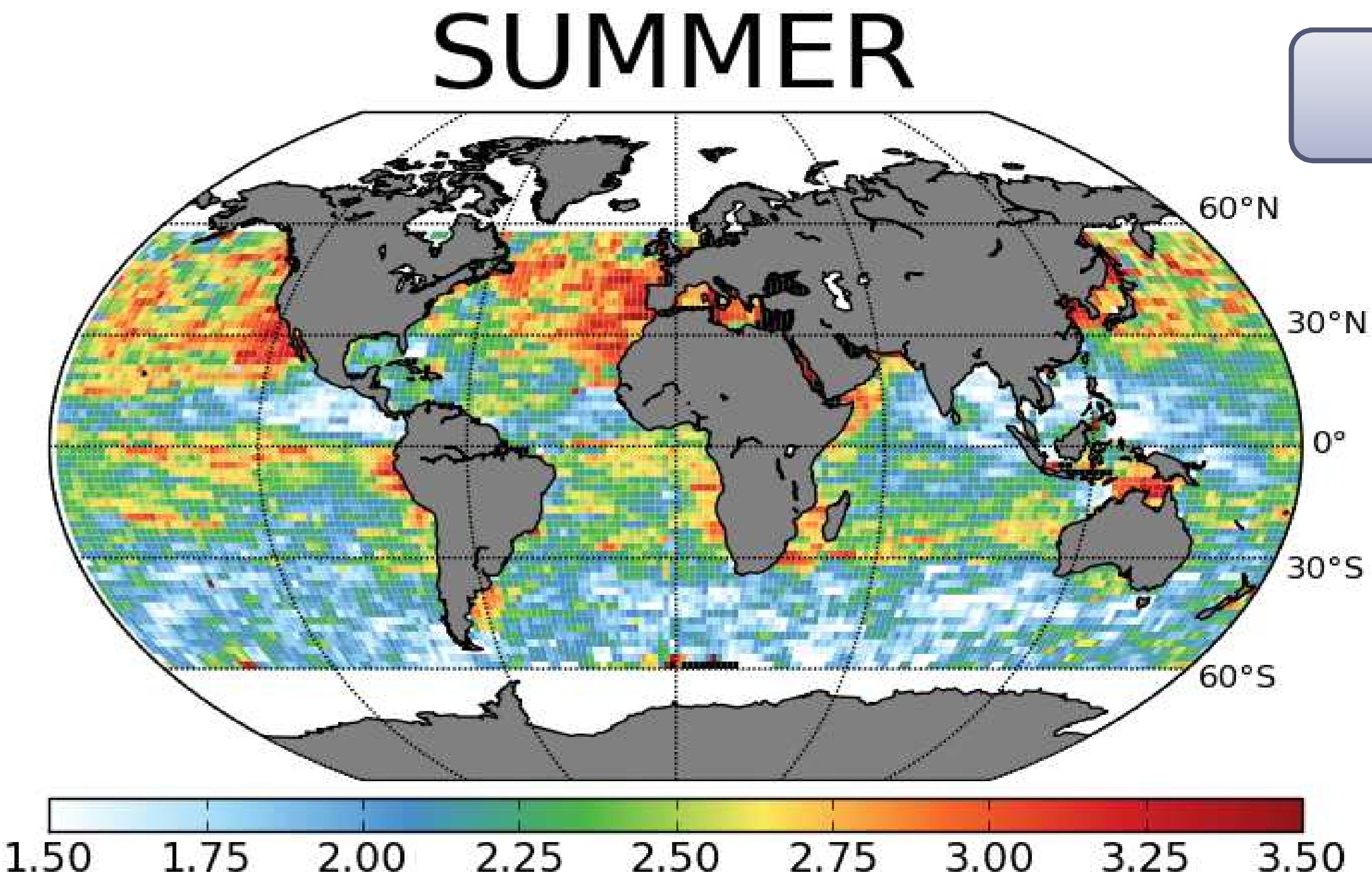
- **The global mean is ≈ 2.3**, close to Ubelman et al. 2013 on Jason-2 (≈ 2.5)
- a large geographical dispersion is observed,
  plus or minus 50% around the global mean



Scaling Exponent

Producing maps and first analysis

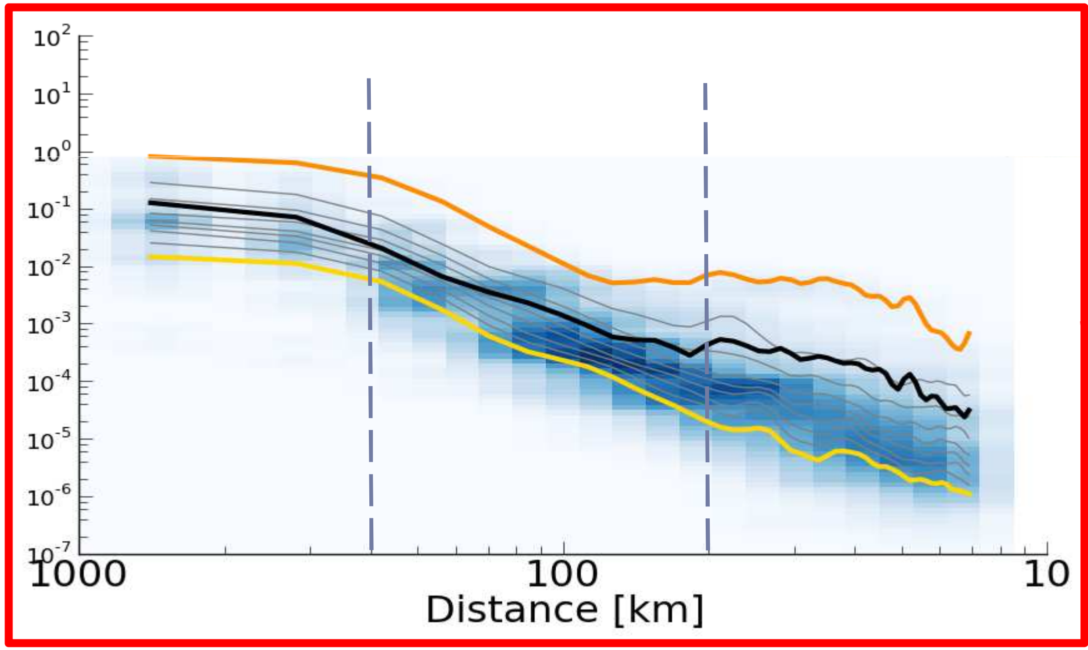
- are the estimated local slopes relevant ?
- which geophysical phenomenons cause these discrepancies ?

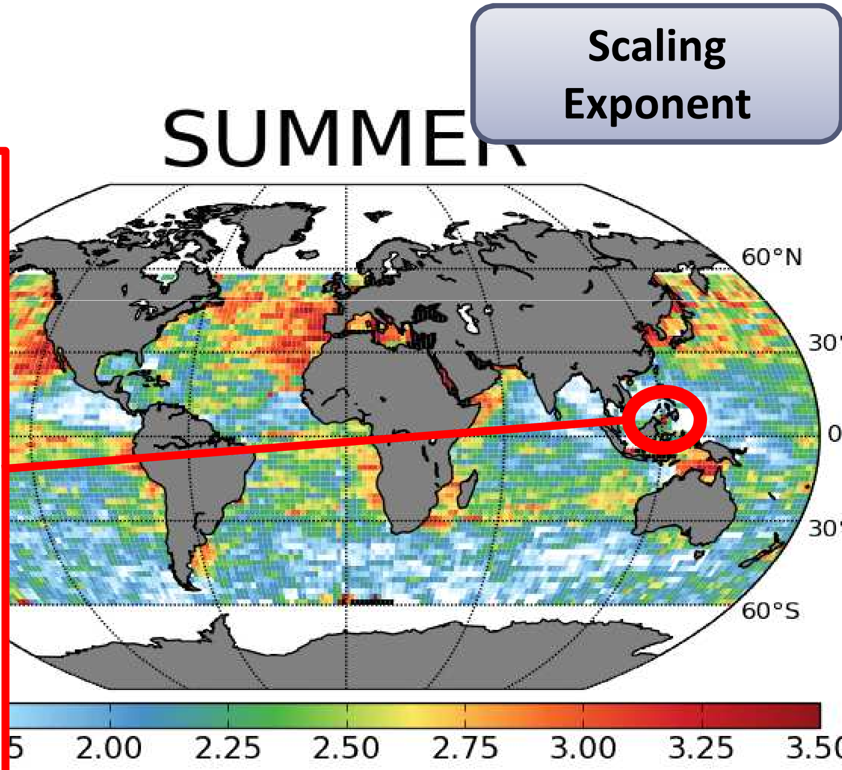


Scaling Exponent

Producing maps and first analysis

- some areas exhibit low slopes
- actually artificially decreased by a bump below 100 km
- this bump on the average spectrum is caused by « spurious » elementary spectra, highly energetic, making the distribution non-gaussian
- the non-gaussian distribution is the signature of « extreme events » (wrt to the average)

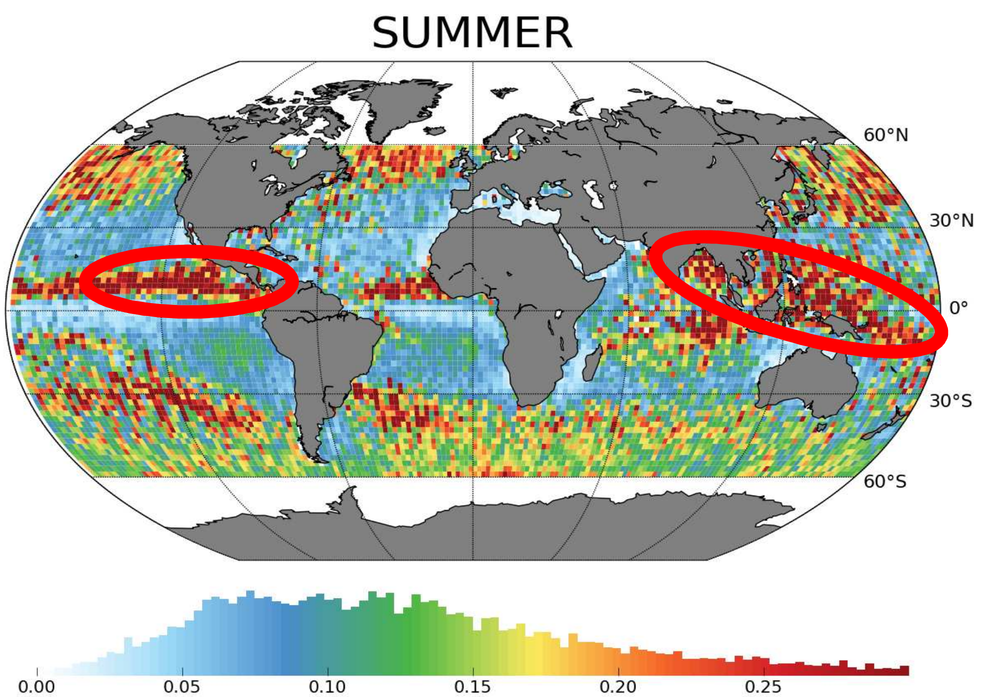




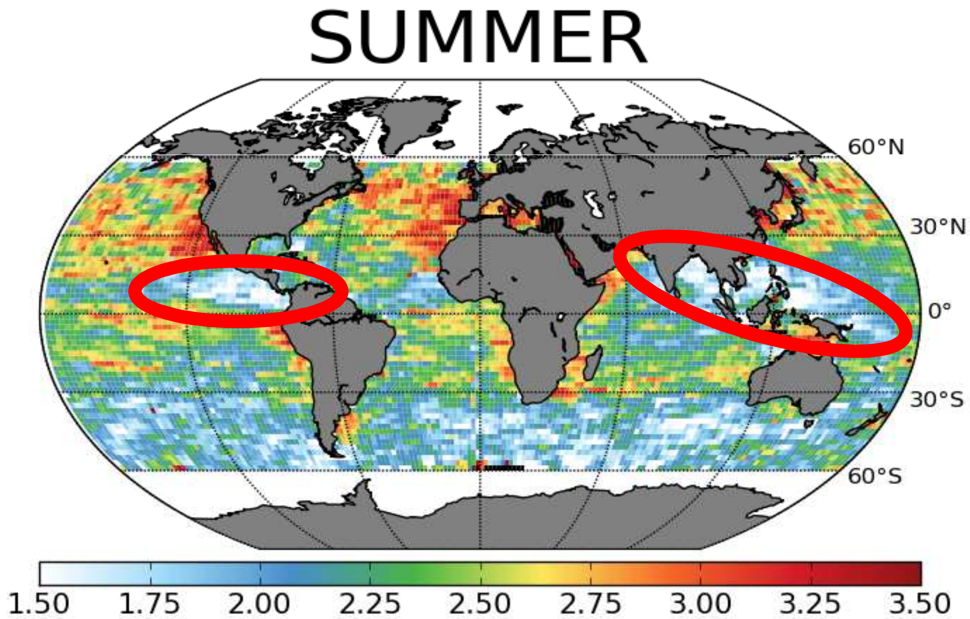
Producing maps and first analysis

- these two areas being regions of large values of cloud liquid water content (CLWC), the bump can be attributed to small scales impact of rain events (large WTC values due to large CLWC values at scales around 50 km cause additionnal energy at these scales)

AltiKa CLWC

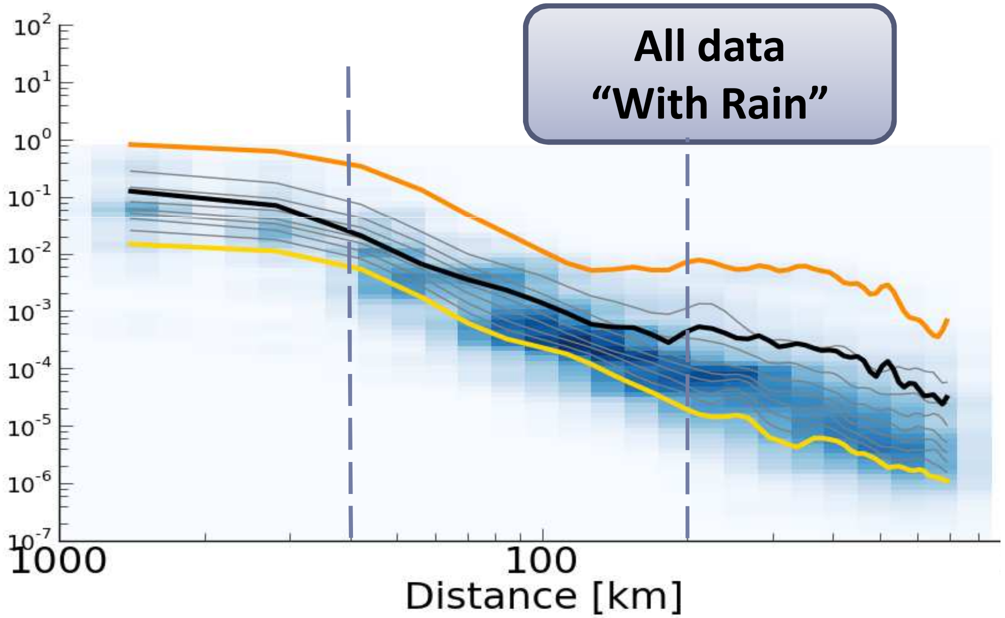


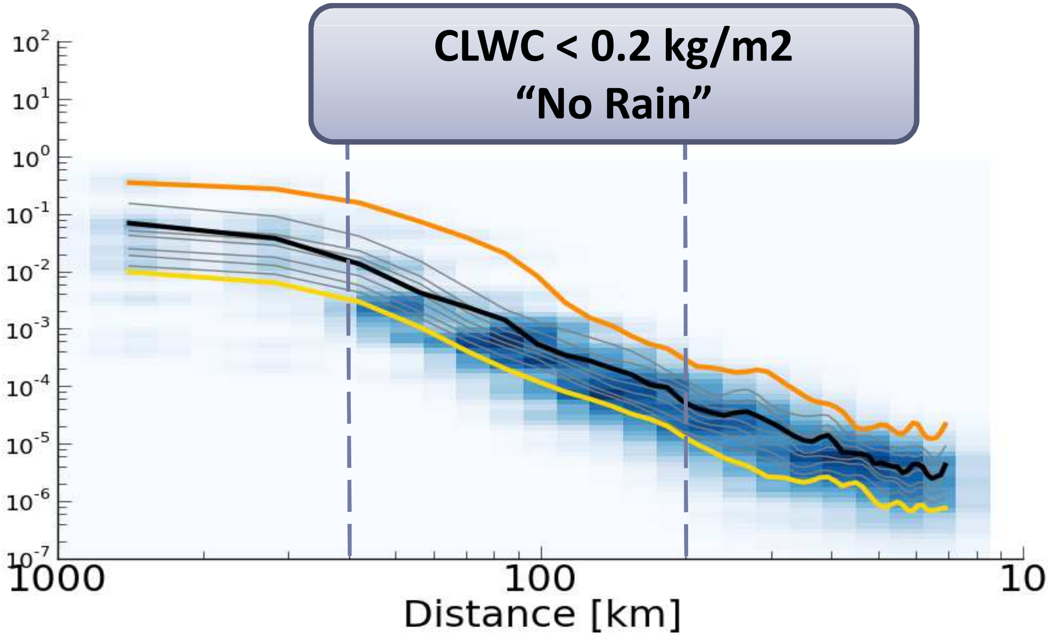
Scaling Exponent



Producing maps and first analysis

- filtering out CLWC >= 0.2 kg/m^2 makes the bump disapear
- this threshold is usually adequate for rain filtering
- the average spectrum is now linear
  and the linear fit will be consequently more legitimate



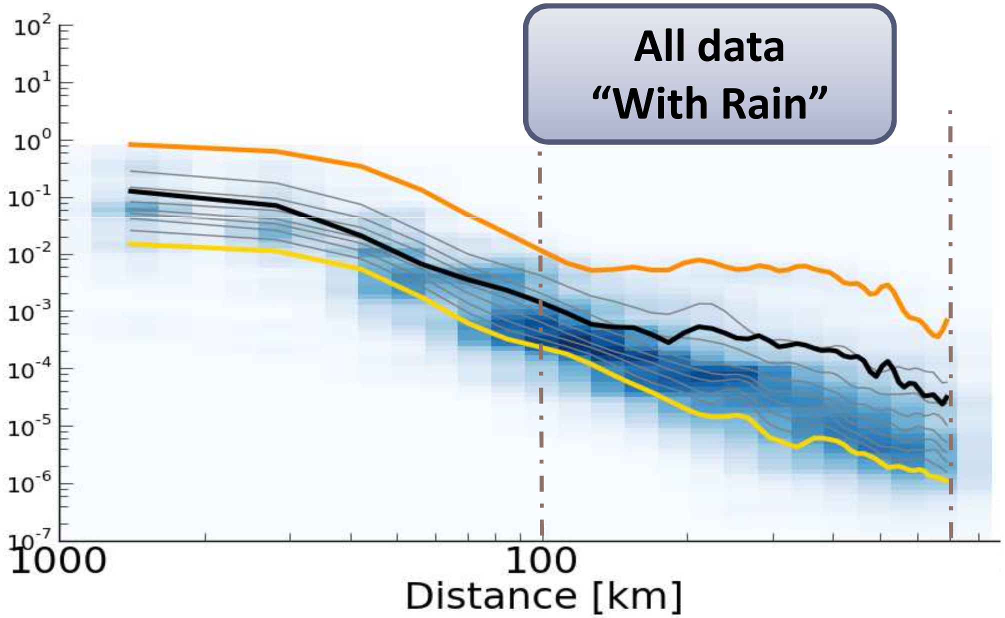


Producing maps and first analysis

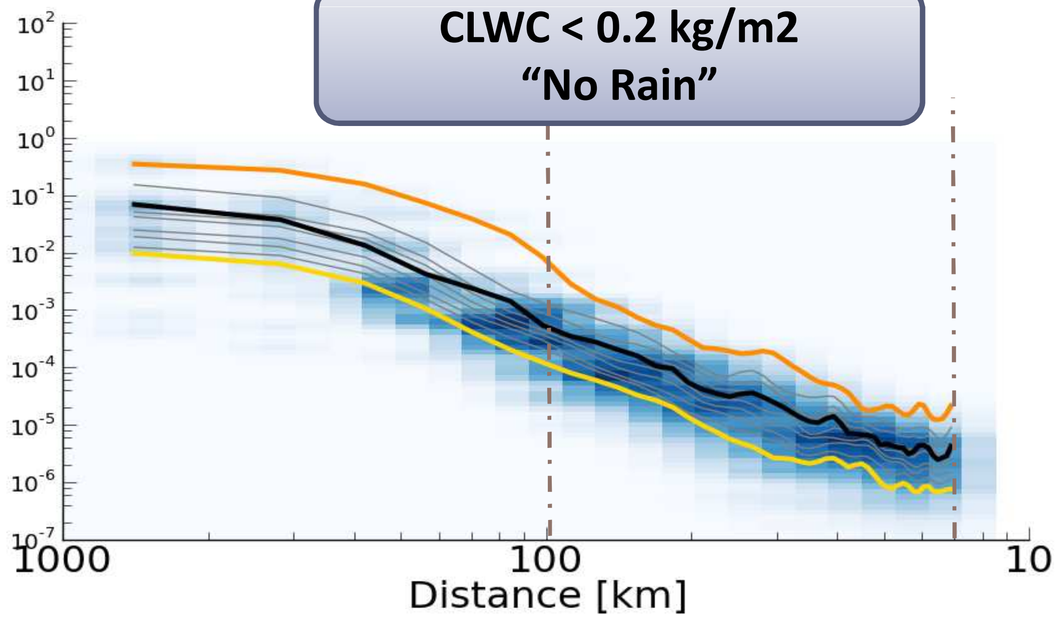
- the discrepancy of the distribution caused by "extreme events" can be characterized by the average ratio of the 90% and the 10% percentile spectra, averaged here between the 14 km and 100 km

ratio_pct = log_10(sp_pct_90/sp_pct_10) [decades]

All data
"With Rain"



CLWC < 0.2 kg/m2
"No Rain"

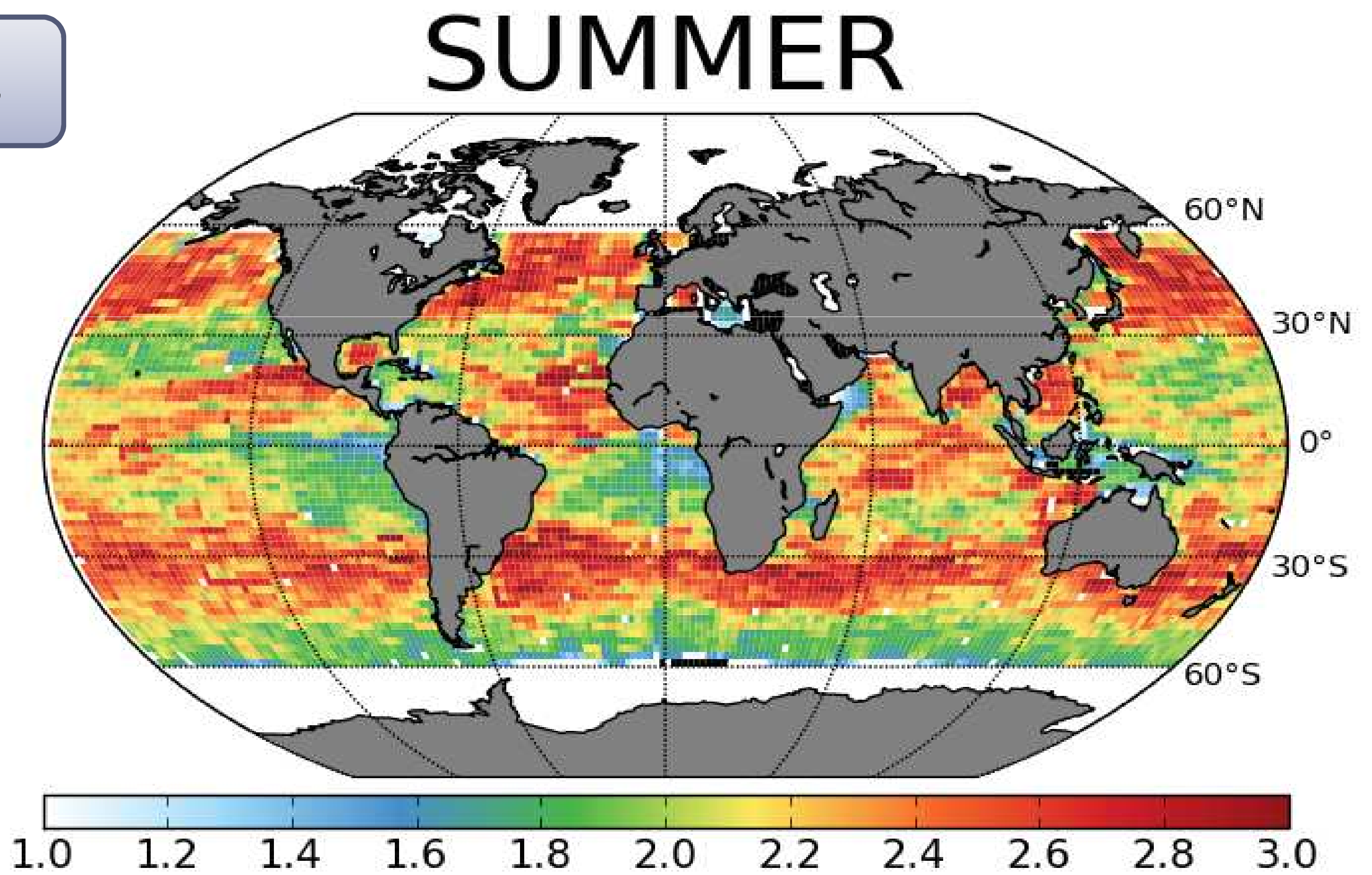


Impact of rain on
Maps of ratio_pct

Impact of rain on the distribution discrepancy

- This is a map of the **ratio_pct** computed between 14 km and 100 km, “with rain”

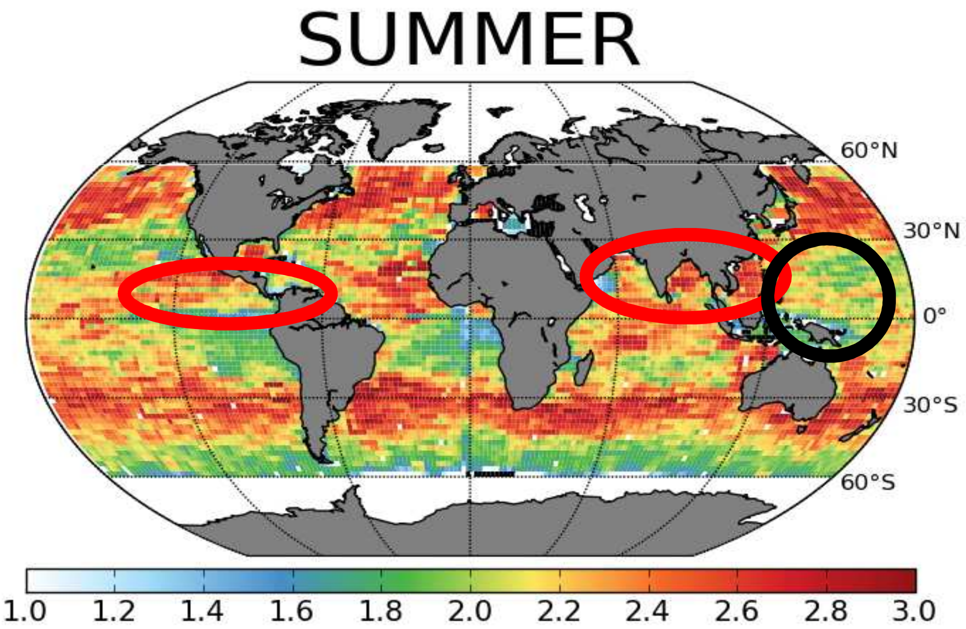
ratio_pct
“With Rain”



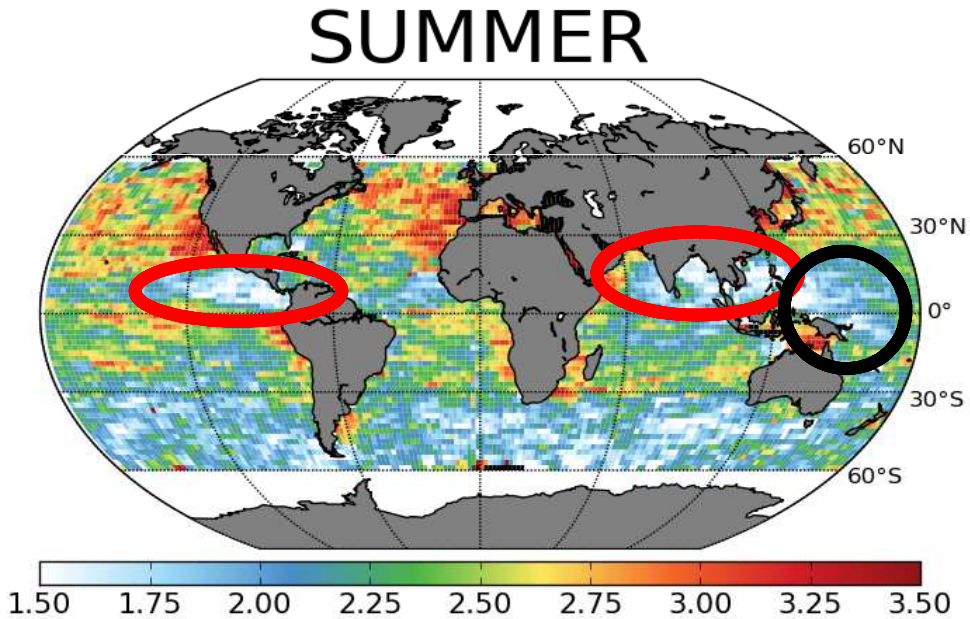
Impact of rain on the distribution discrepancy

- Some of the "low slopes" areas are identified as **large ratio_pct areas**
- Some of the "low slopes" areas are **not** identified as **large ratio_pct areas**

ratio_pct "With Rain"



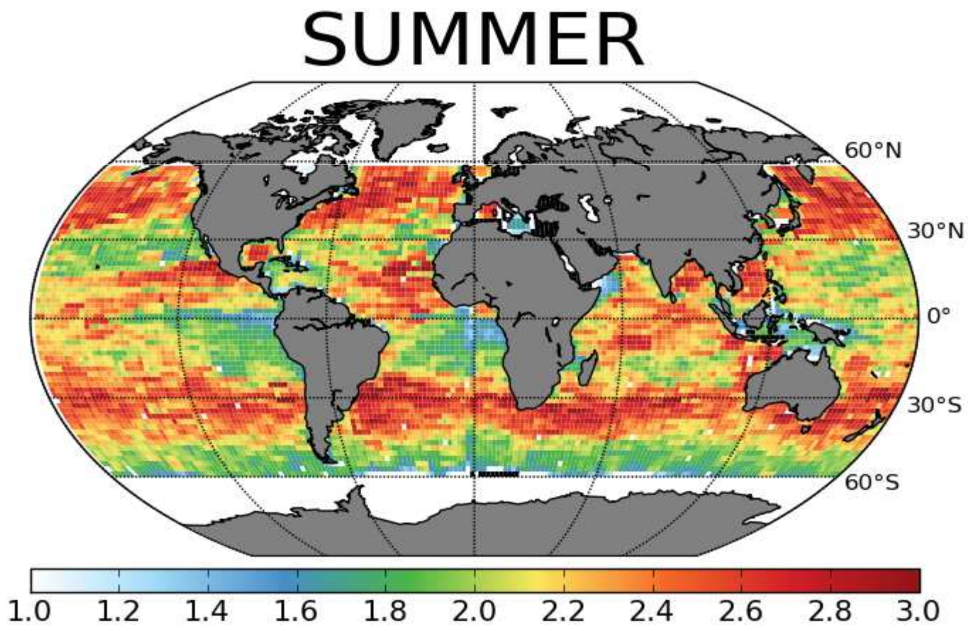
Scaling Exponent



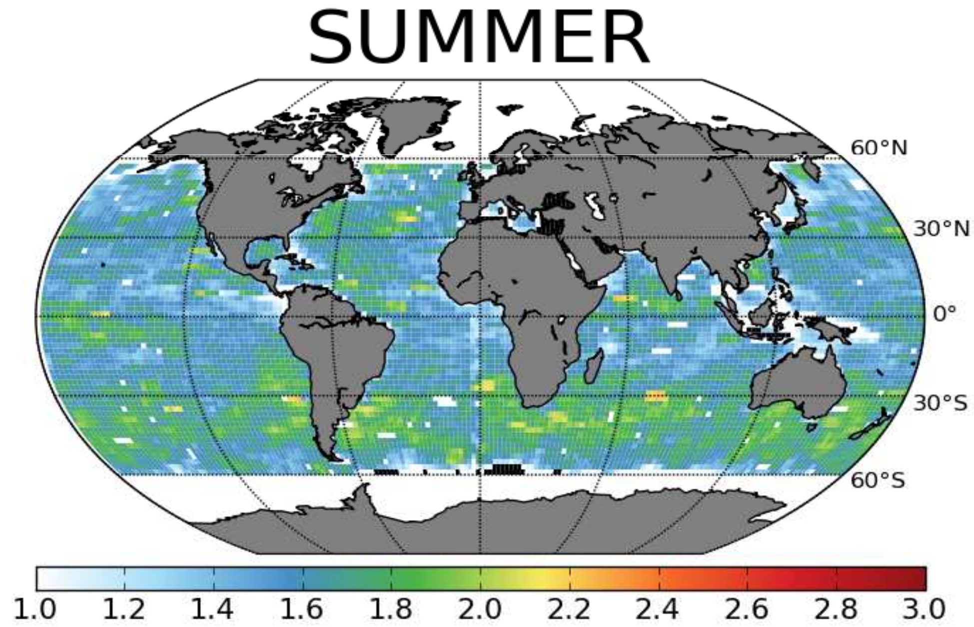
Impact of rain on the distribution discrepancy

- Applying the rain filtering (on the right)
  clearly reduces the discrepancy of the distribution of the ratio_pct

ratio_pct
“With Rain”



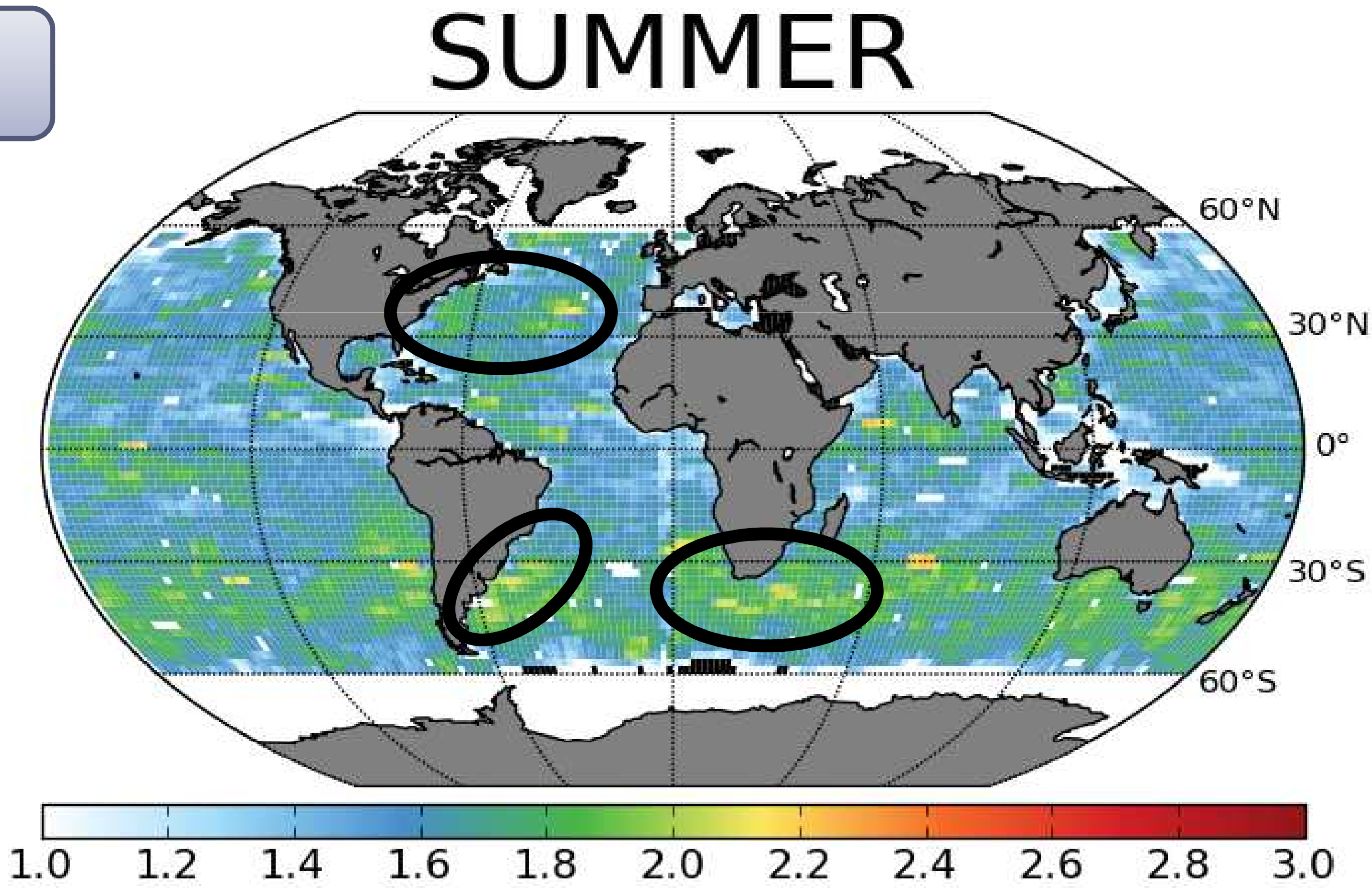
ratio_pct
“No Rain”



Impact of rain on the distribution discrepancy

- Once the rain is discarded, new areas are highlighted,
  the discrepancy of the distribution may be related to large ocean variability (currents: gulf stream, agulhas …) but this need further analysis.

ratio_pct
“No Rain”



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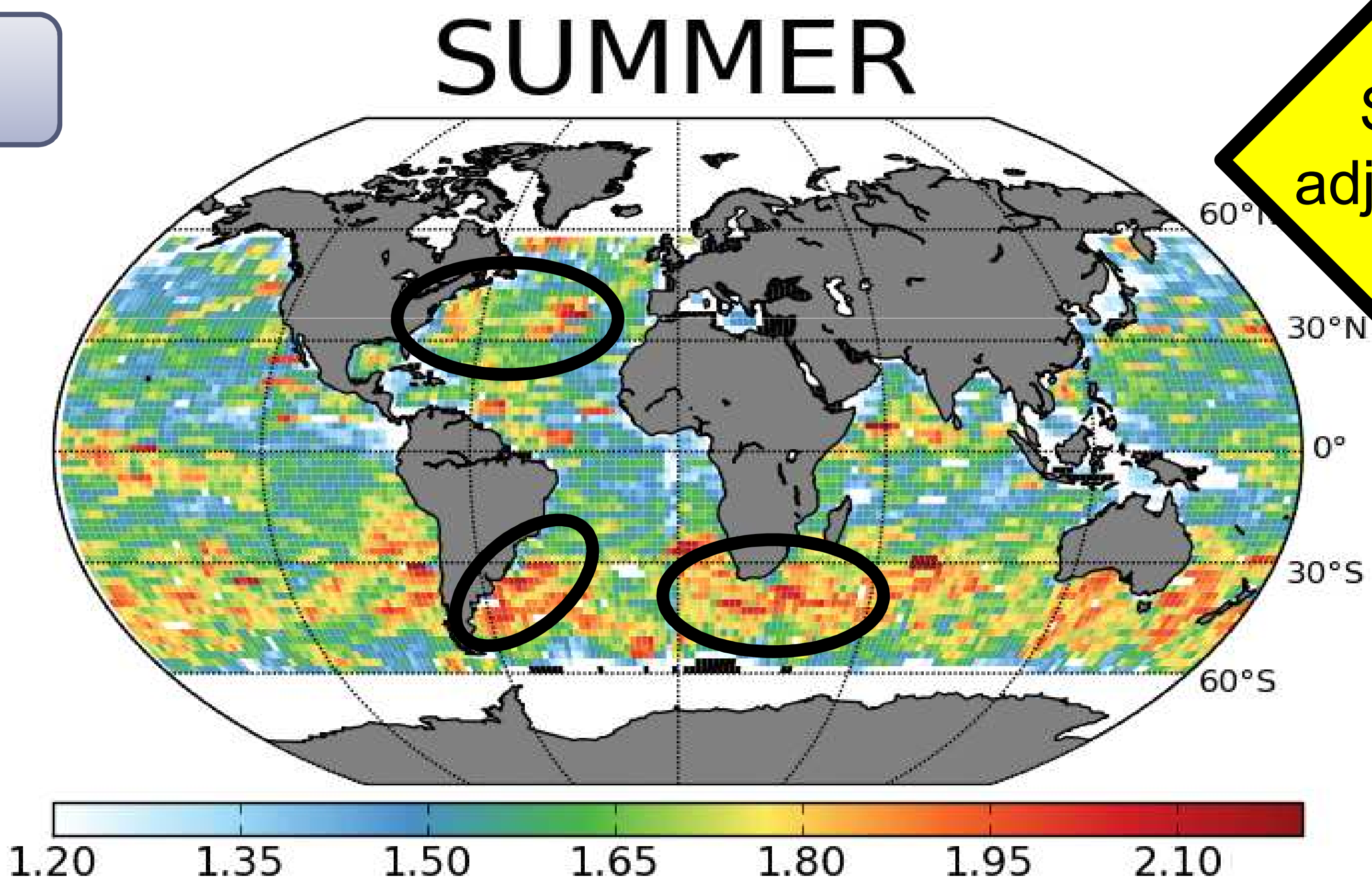
ratio_pct
“No Rain”



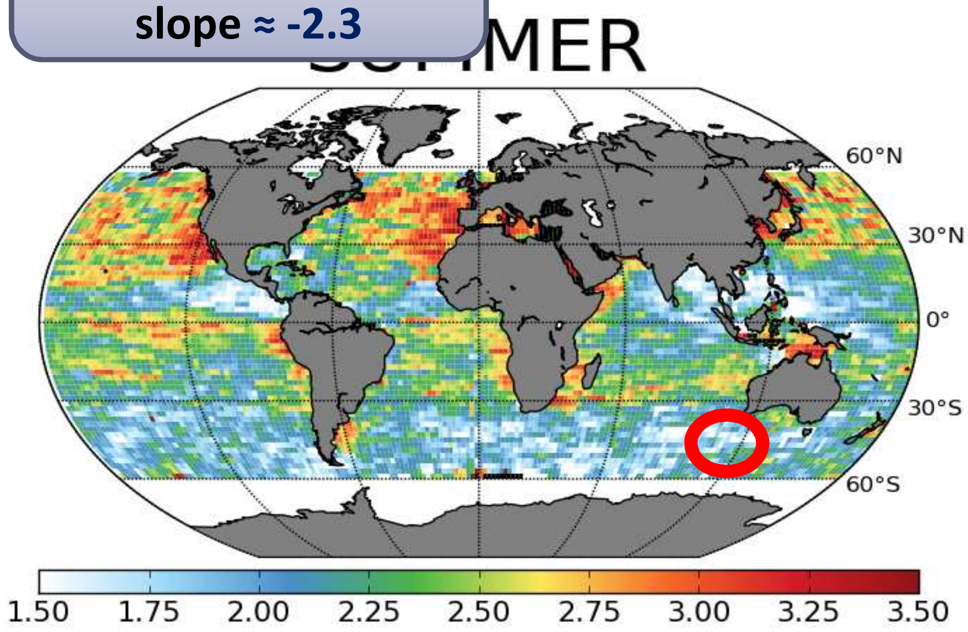
Scale adjustment

Impact of rain on Maps of scaling exponent

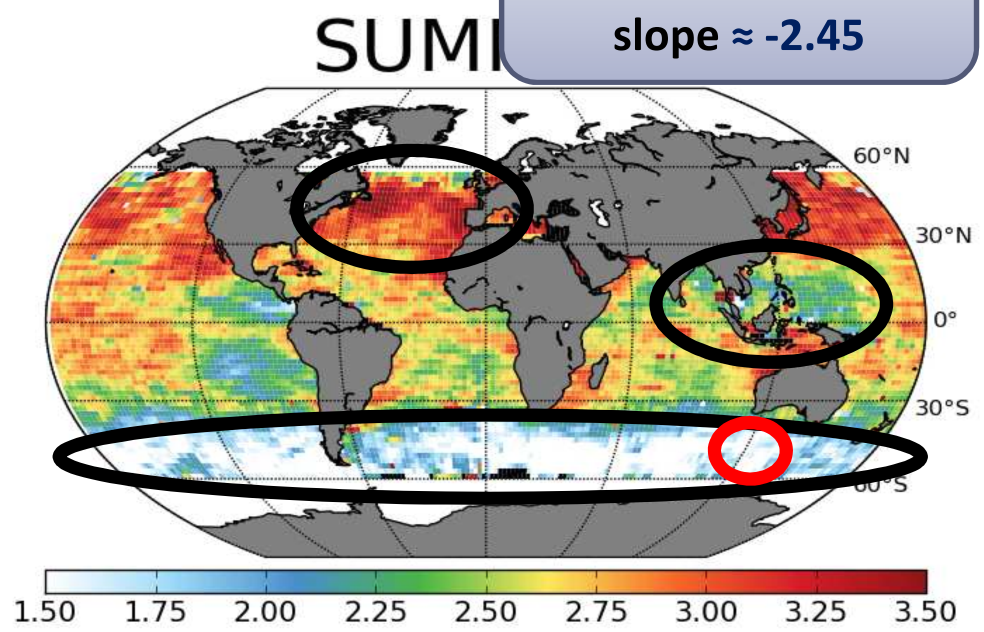
Impact of rain on the scaling exponent

- Once the rain is discarded
  - slopes are larger in north hemisphere
  - slopes in “rain areas” are larger
  - slopes are smaller below -40°S

Scaling Exponent
“With Rain”
slope ≈ -2.3

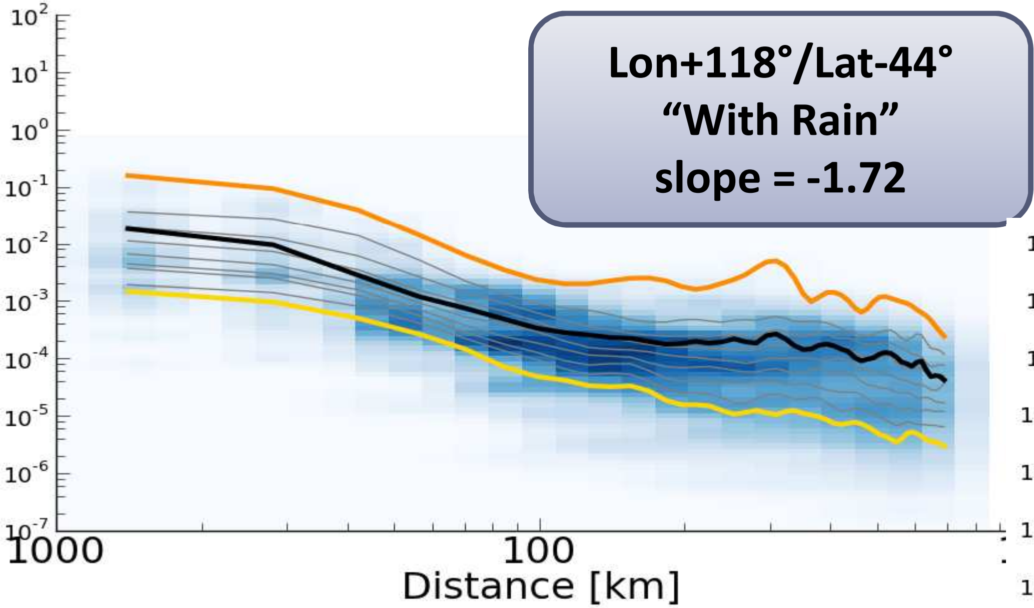


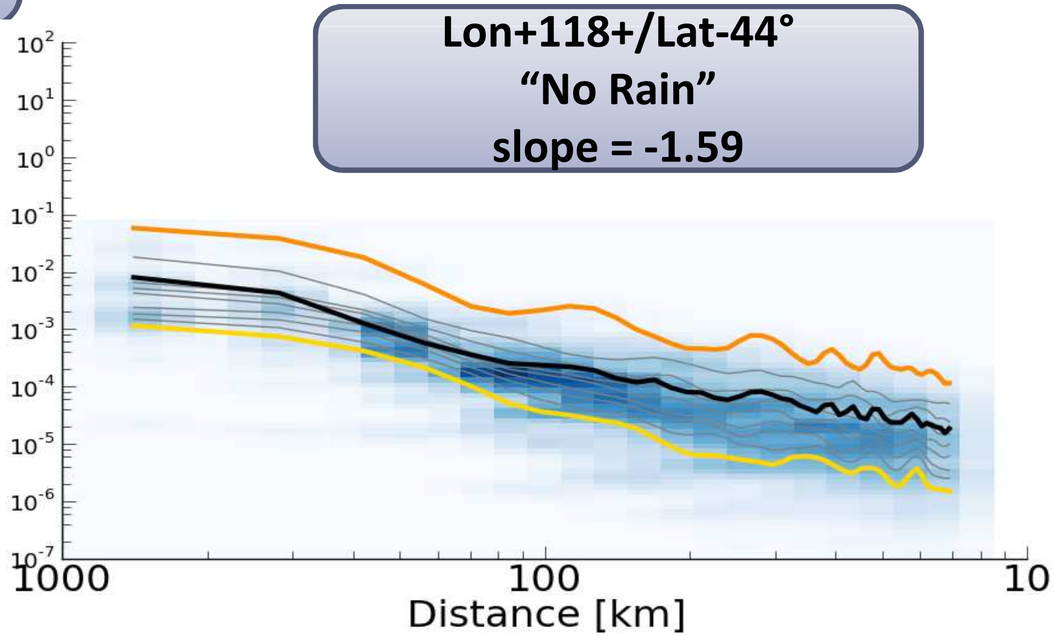
Scaling Exponent
“No Rain”
slope ≈ -2.45



Impact of rain on the scaling exponent

- slopes are smaller below -40°S
  - less energy in large scales / more energy in small scales compared to distribution in tropics
  - Questions remain open: are these distributions statistically valid ?
    if yes, what is the geophysical explanation ?

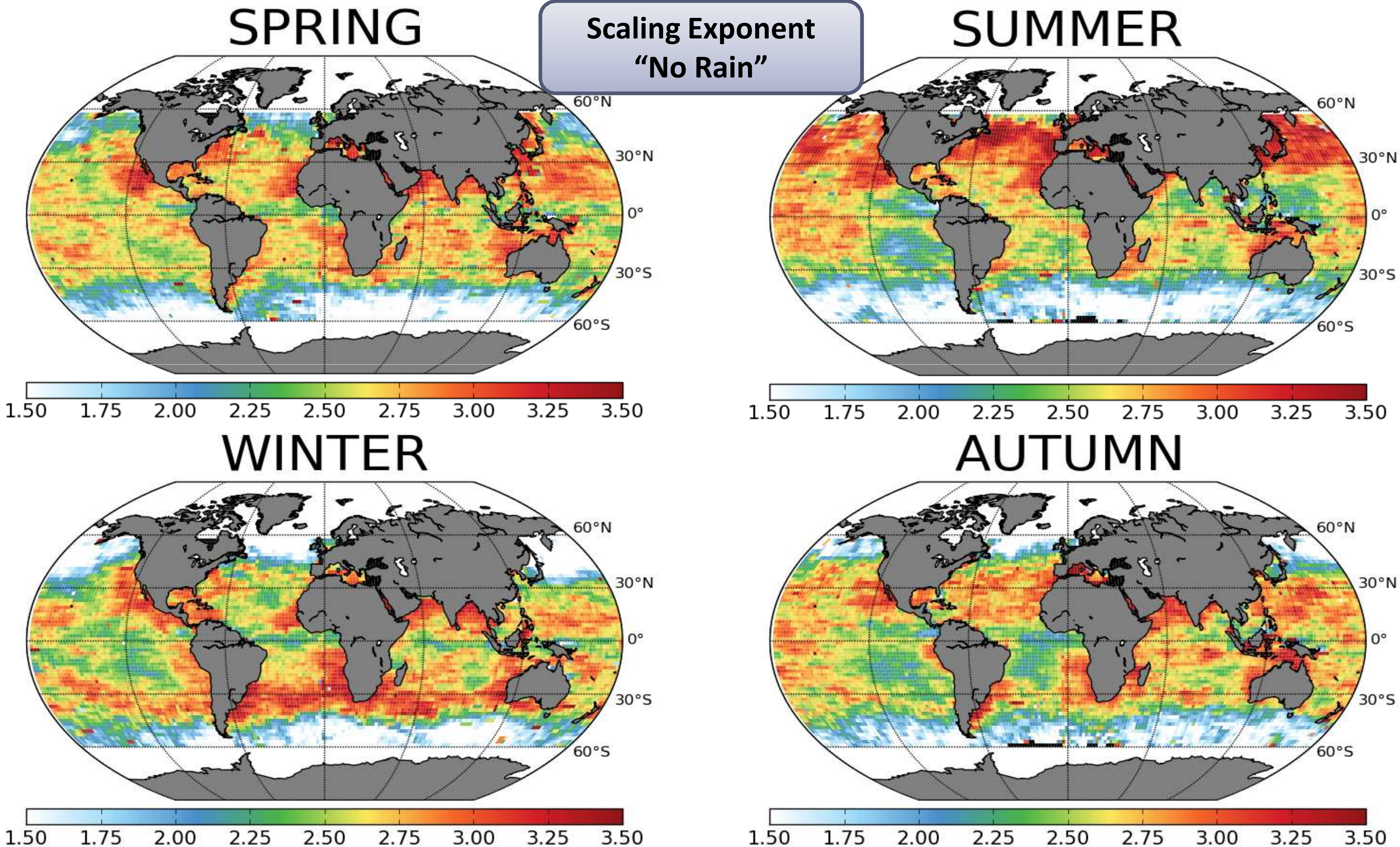




Seasonal and geographical variability of the scaling exponent [No rain]

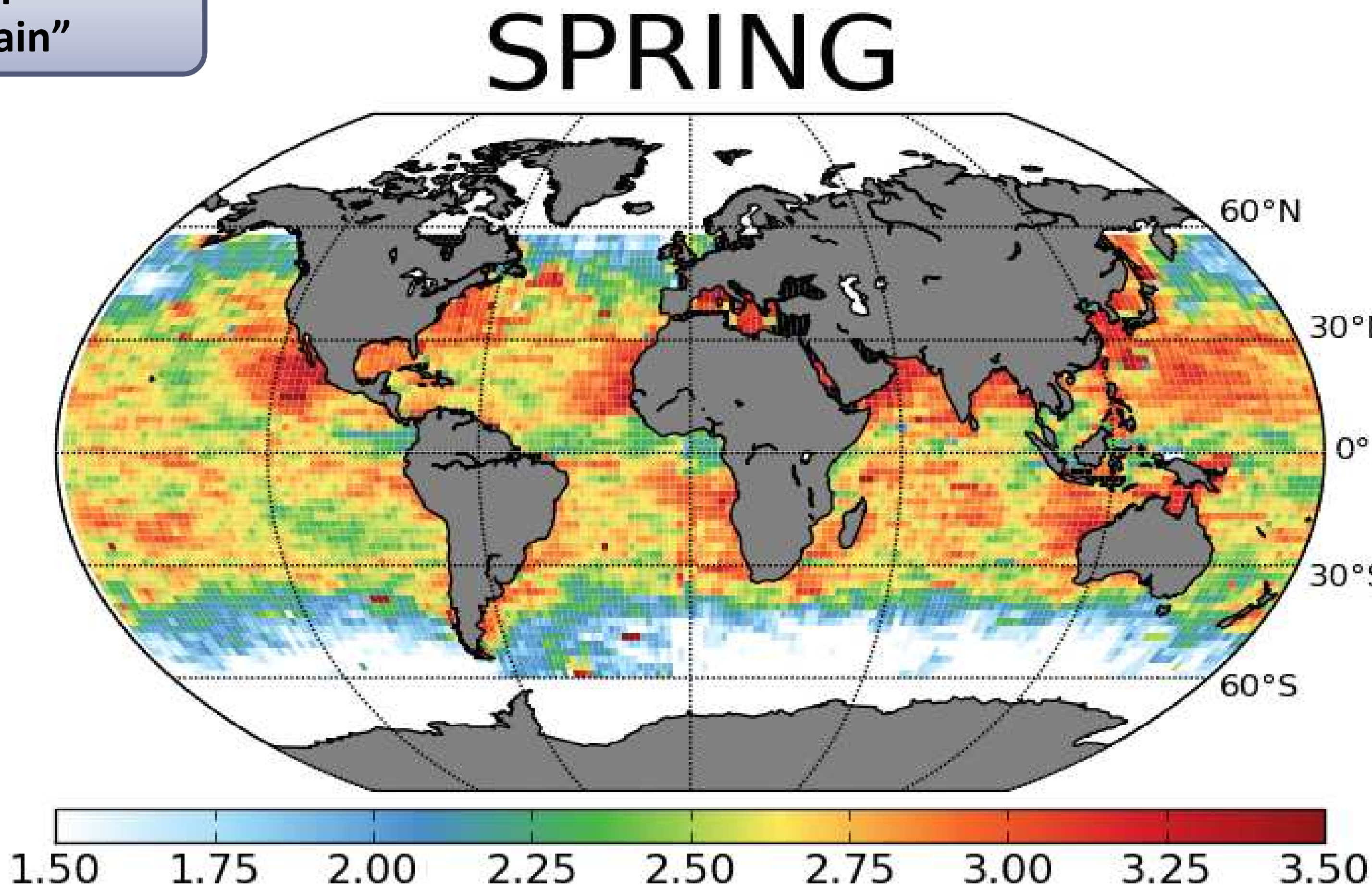
Seasonal and geographical variability of the scaling exponent

Scaling Exponent
"No Rain"



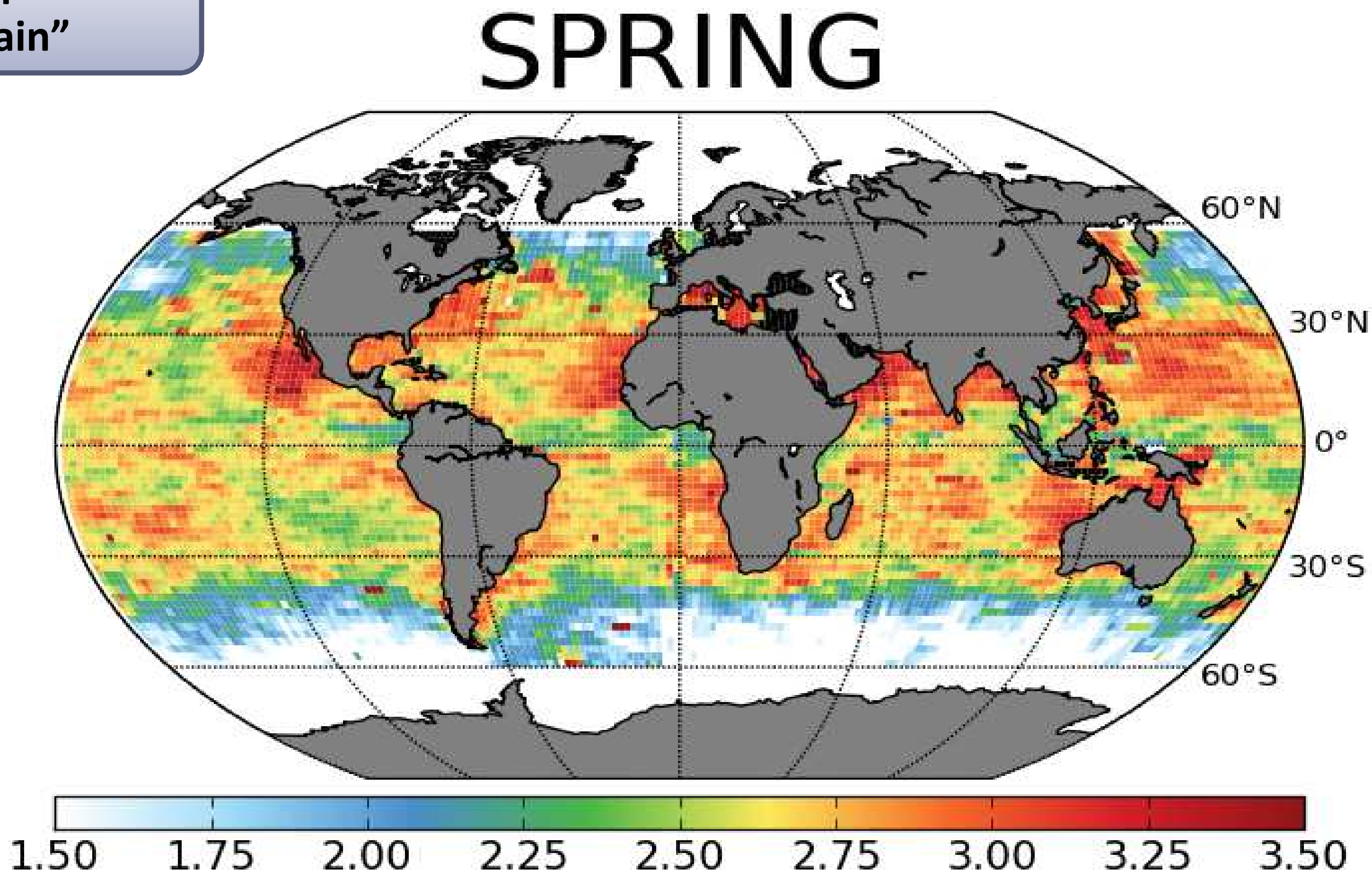
Seasonal and geographical variability of the scaling exponent

Scaling Exponent "No Rain"



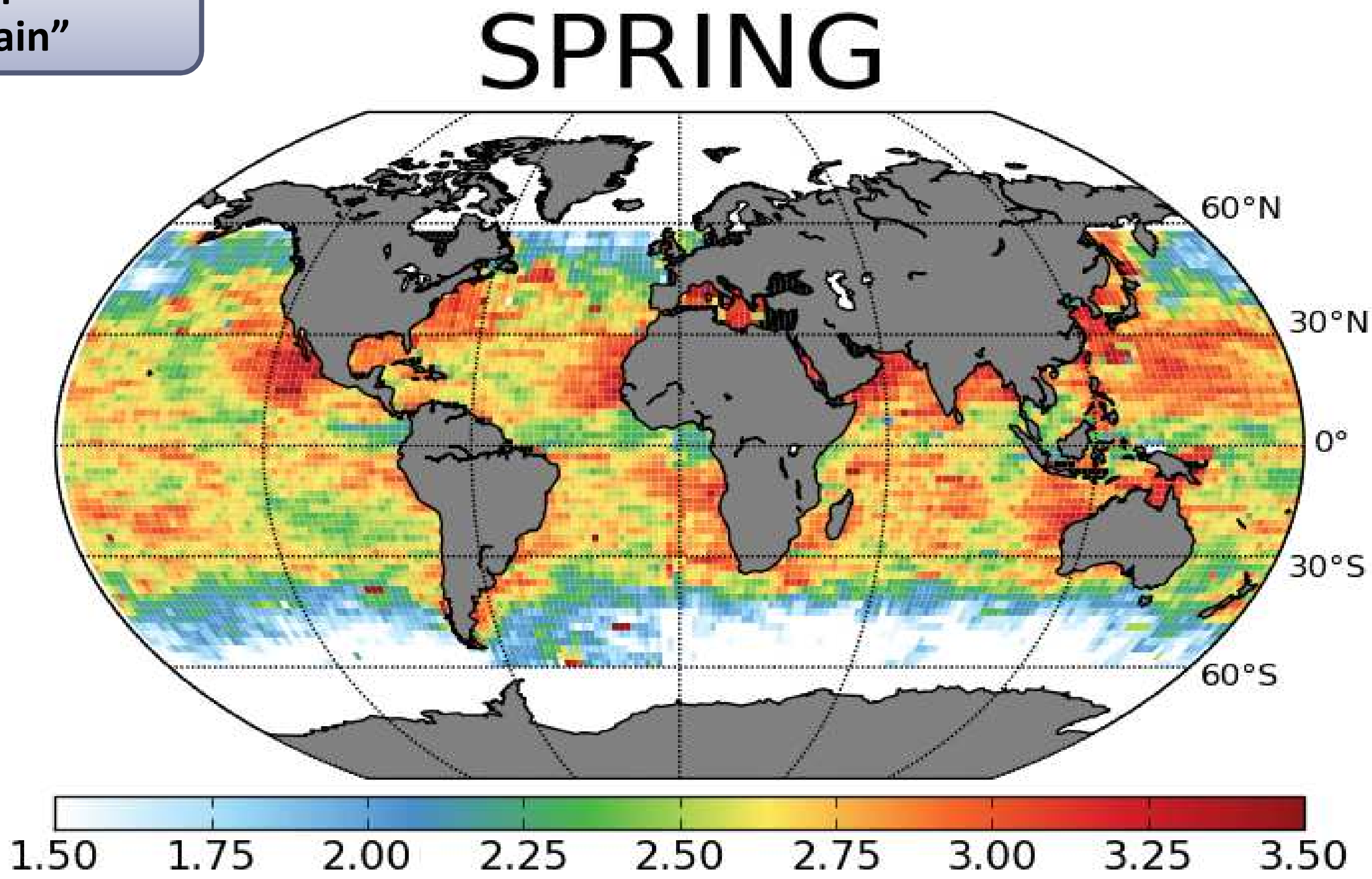
Seasonal and geographical variability of the scaling exponent

Scaling Exponent "No Rain"



Seasonal and geographical variability of the scaling exponent

Scaling Exponent "No Rain"



Conclusion & Perspectives

- we quantified spatially and temporally the variability of one characteristic of WTC spectrum, the scaling exponent

- we show how “extreme events” (including rain events) have a signature on the average spectrum

- we propose a metric to characterize the occurrence of “extreme events” within the distribution of elementary spectrum

- once rainy event discarded, the estimate of the slope is more robust

- **lessons learned:**
  - the spectral analysis, as any other statistical metric, is based on an “average”/global observation and this kind of regional study would allow to better characterize the amplitude of the different components of the SSH spectra
- next step: from correction to residual error

Thank you for your attention

Contact: bpicard@cls.fr

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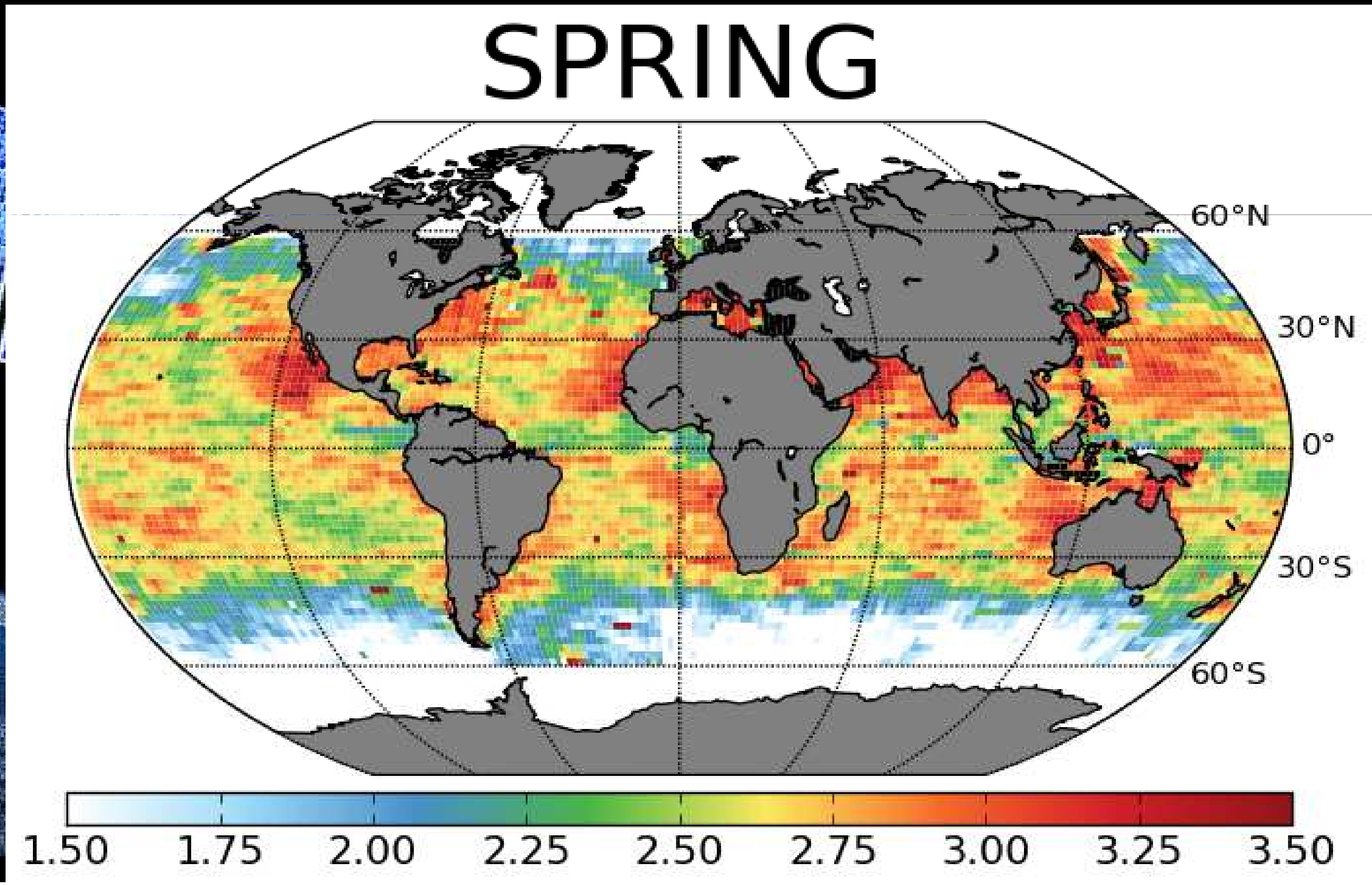

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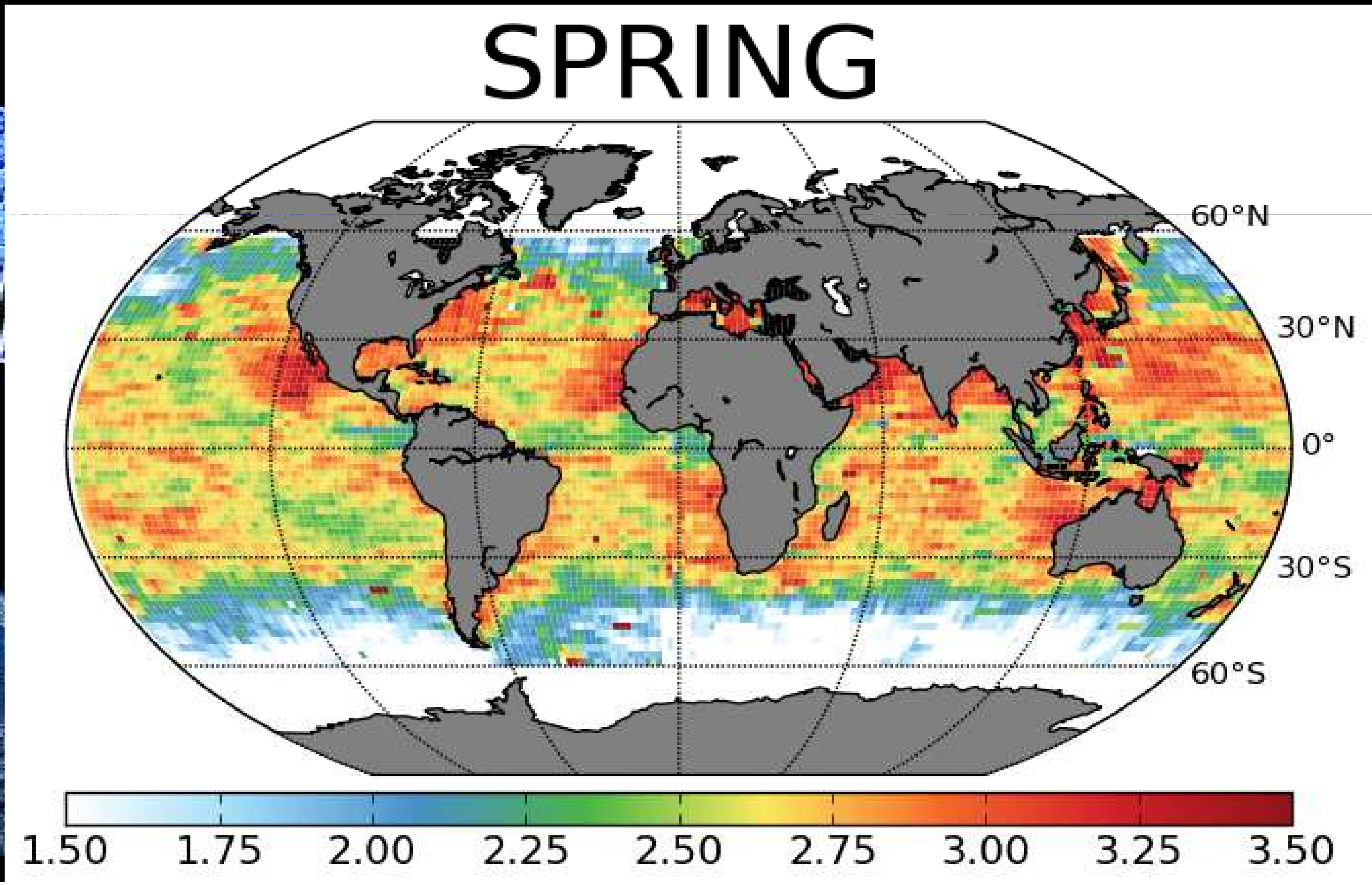

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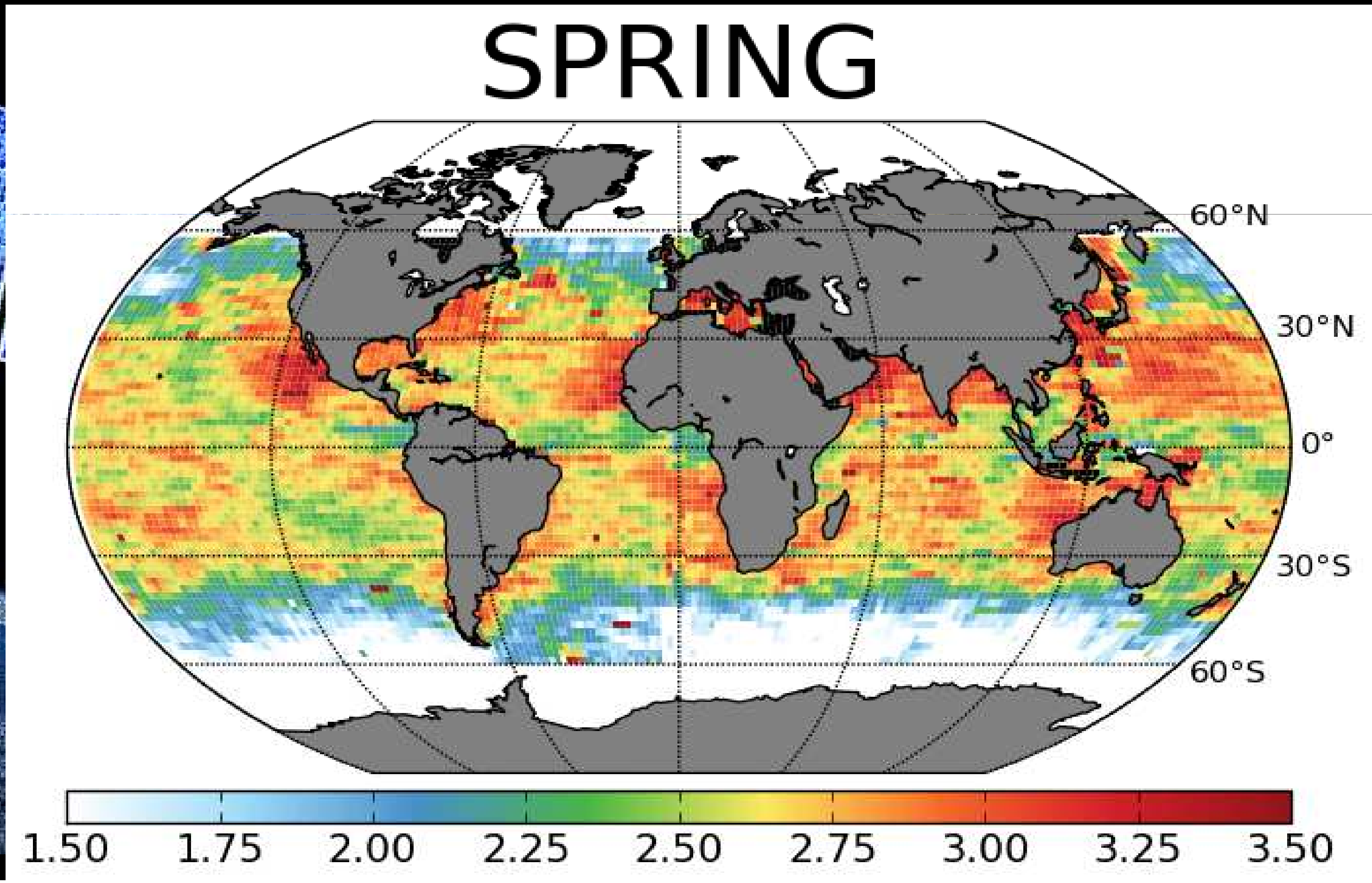

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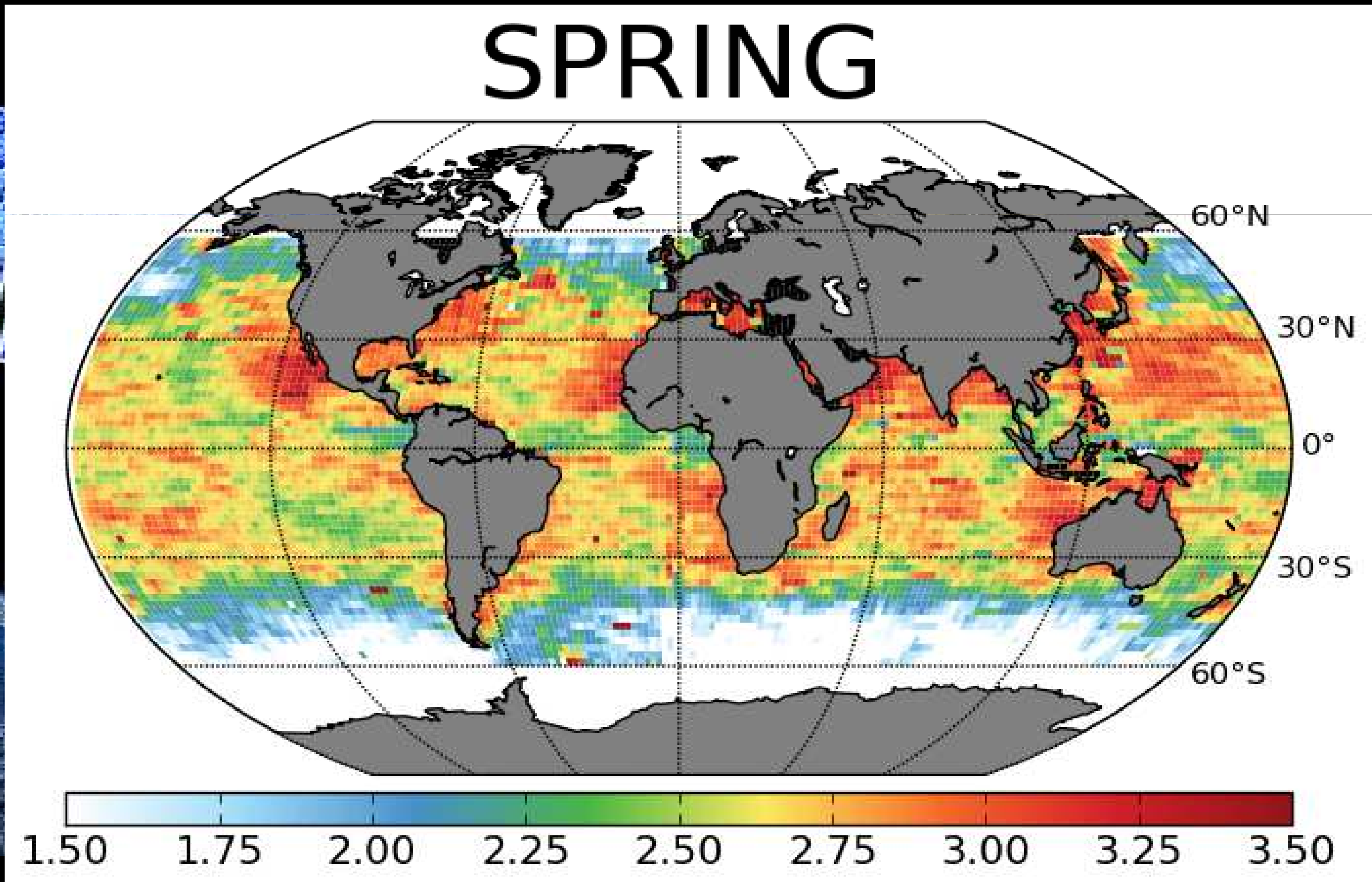

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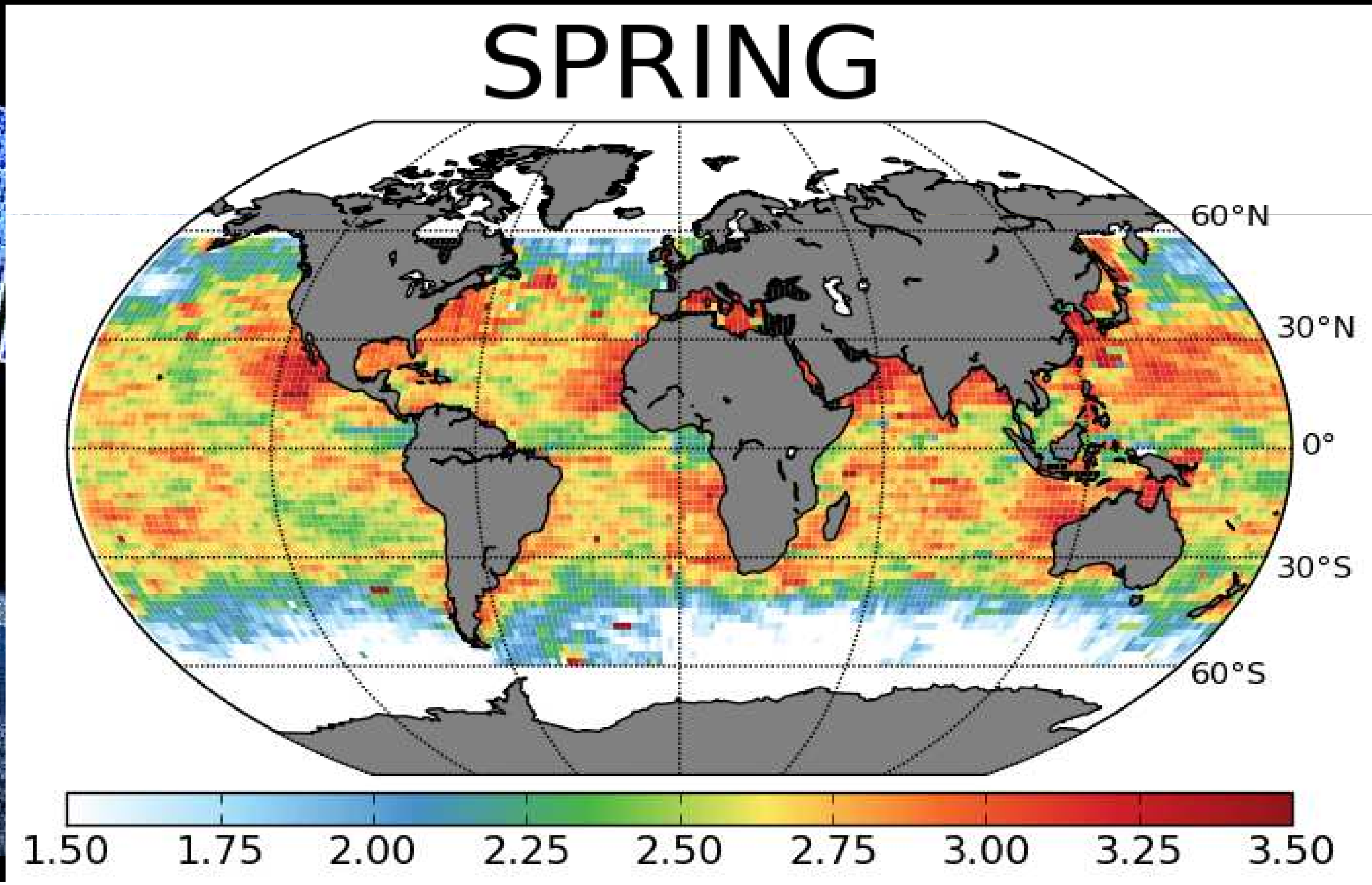

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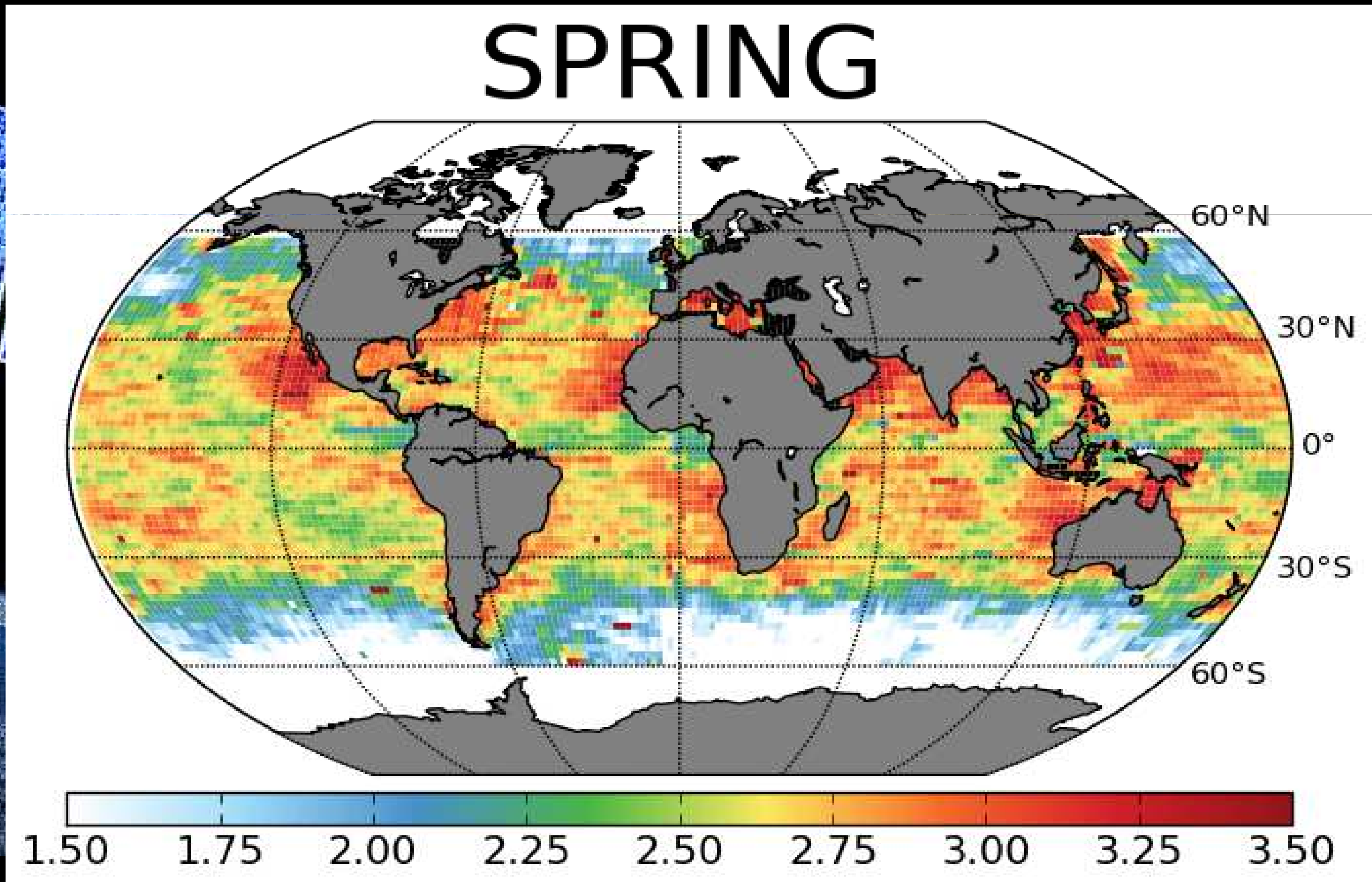

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