Recent trends in precipitation, temperature and stream flow extremes – from gauges to reanalysis to climate models – impact of spatial scale

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ONTARIO POWER GENERATION
Hydro Québec
OURANOS
NSERC CRSNG

Why ?

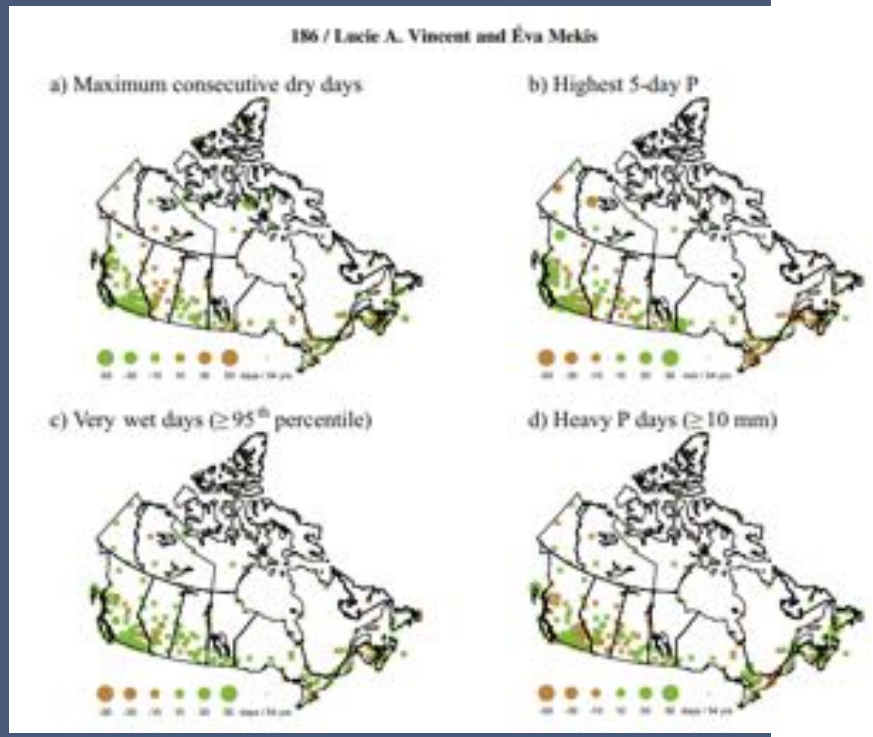
MAIN OBJECTIVE

Estimate recent hydroclimatic trends to help decisions makers in adopting relevant vulnerabilty-impact-adaptation solutions

Challenges

- Difficulties in adopting a relevant reference dataset
- Large variability in spatial and temporal coverage of observations
- Separating anthropogenic trends from natural (internal) climatic variability

Traditional approach



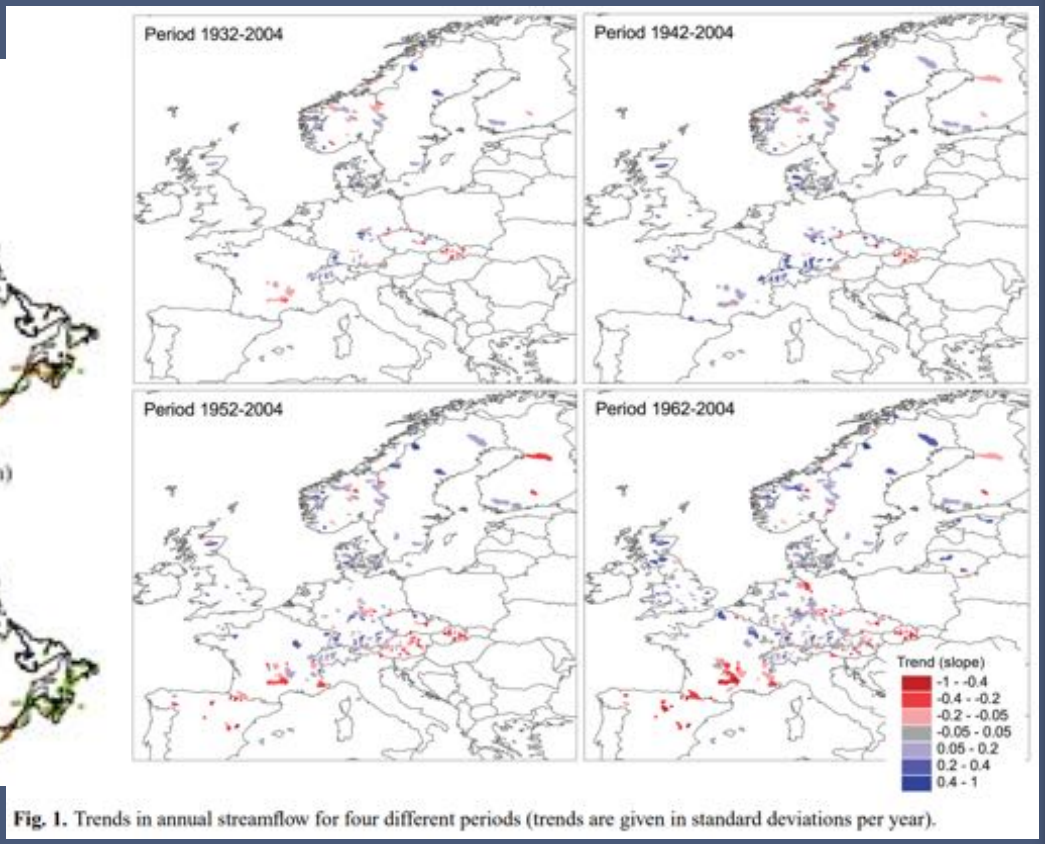
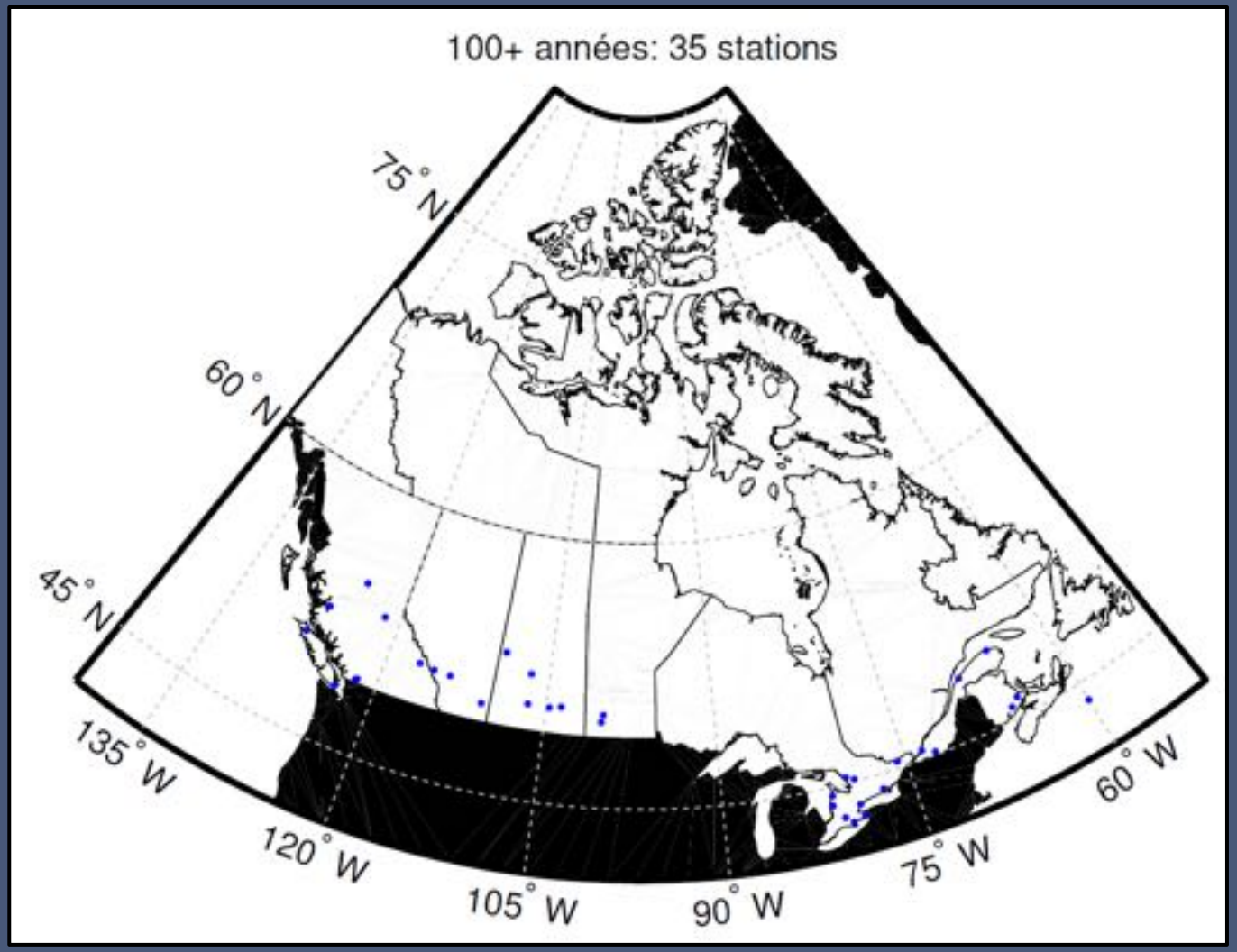


Fig. 1. Trends in annual streamflow for four different periods (trends are given in standard deviations per year).

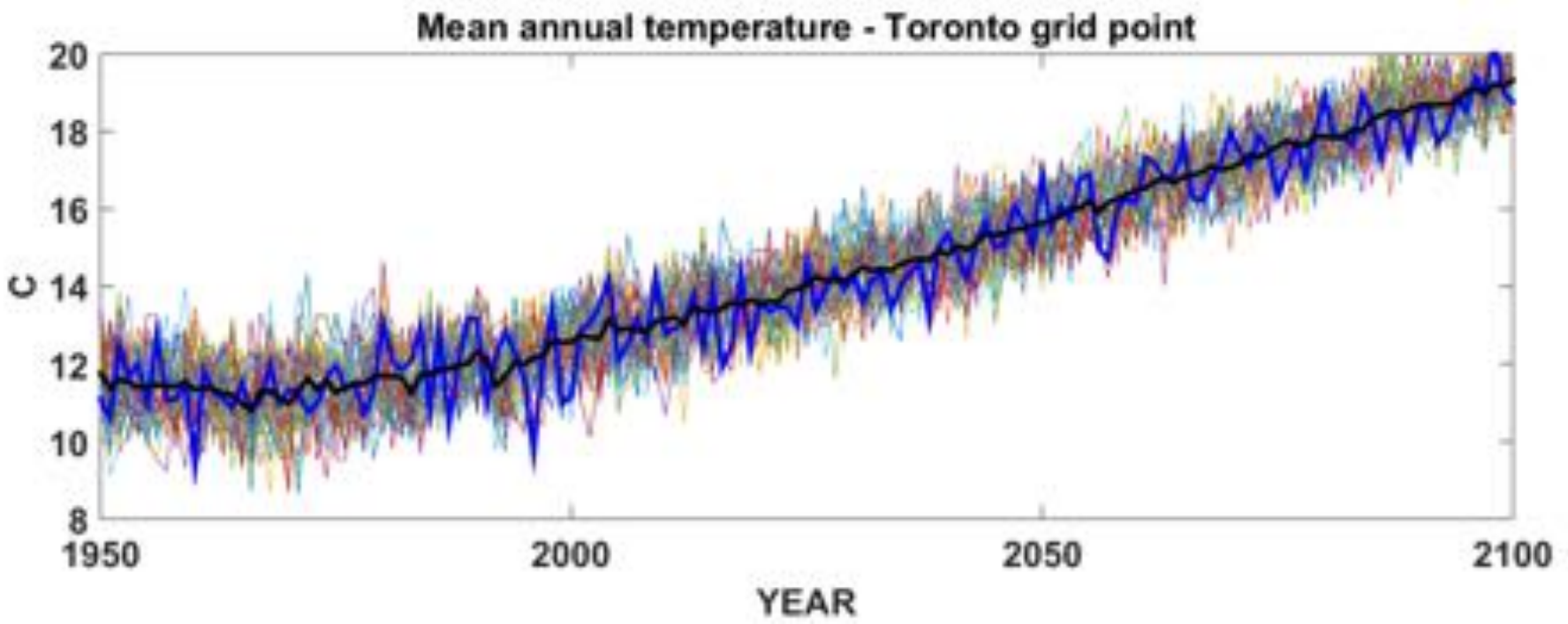
Vincent, L. A., & Mekis, E. (2006). Changes in daily and extreme temperature and precipitation indices for Canada over the twentieth century. *Atmosphere-Ocean*, *44*(2), 177-193.

Stahl, K., et al. "Streamflow trends in Europe: evidence from a dataset of near-natural catchments." *Hydrology and Earth System Sciences* 14 (2010): p-2367.

Temporal and spatial coverage

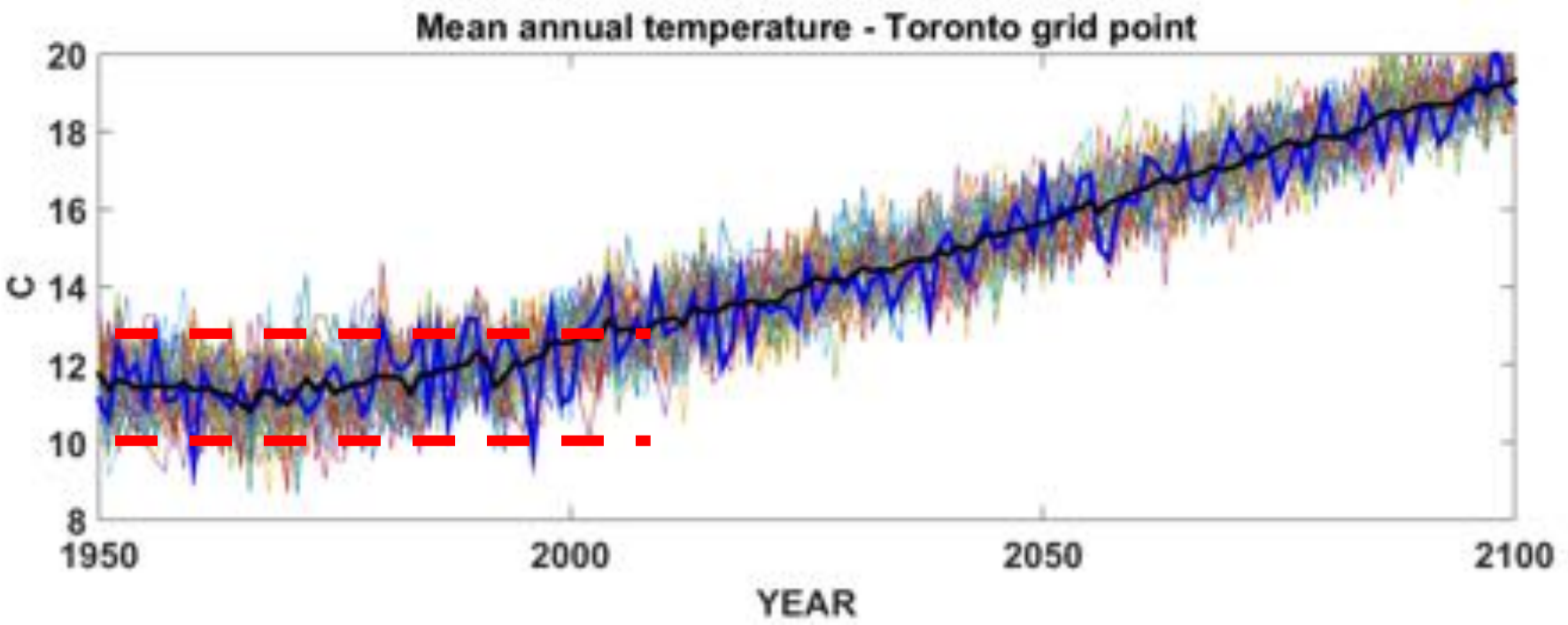


Problem 2: Seeing through the fog of internal variability



CanESM2 Large ensemble (50 members)
Black – ensemble mean Blue – member 1

Problem 2: Seeing through the fog of internal variability



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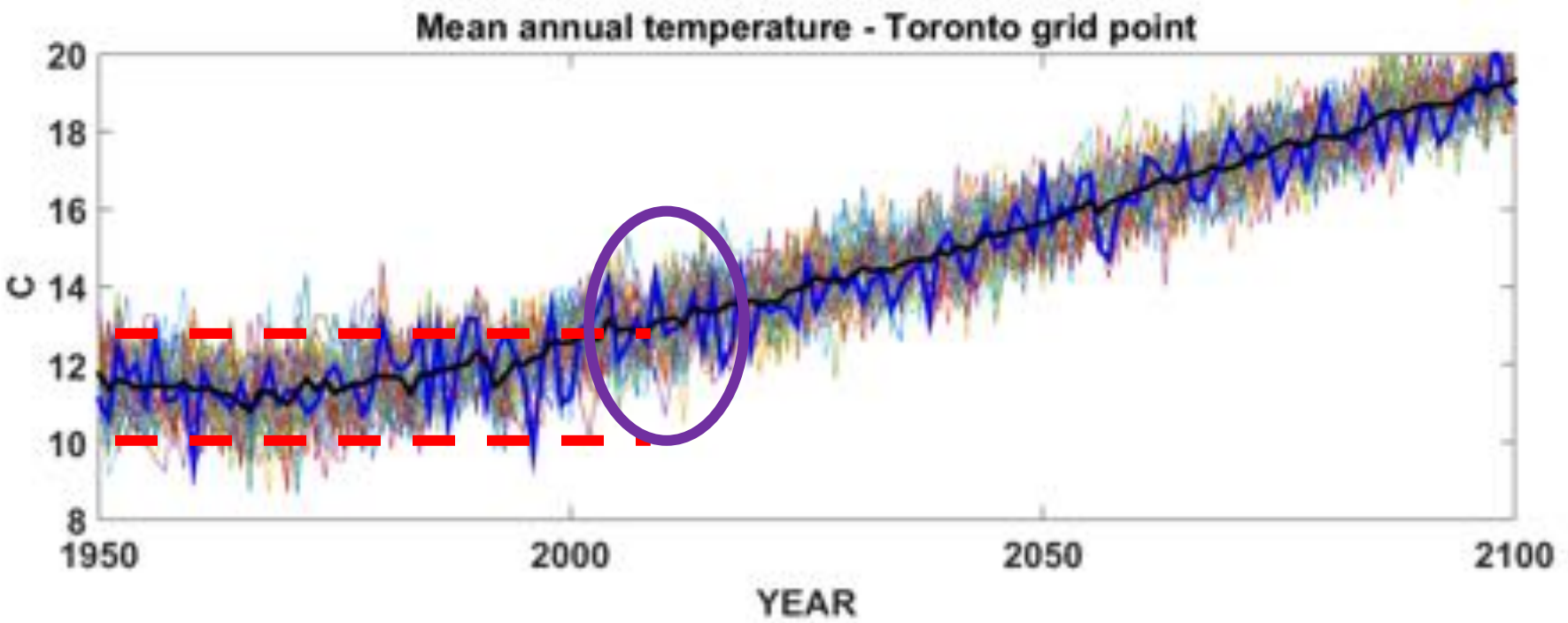

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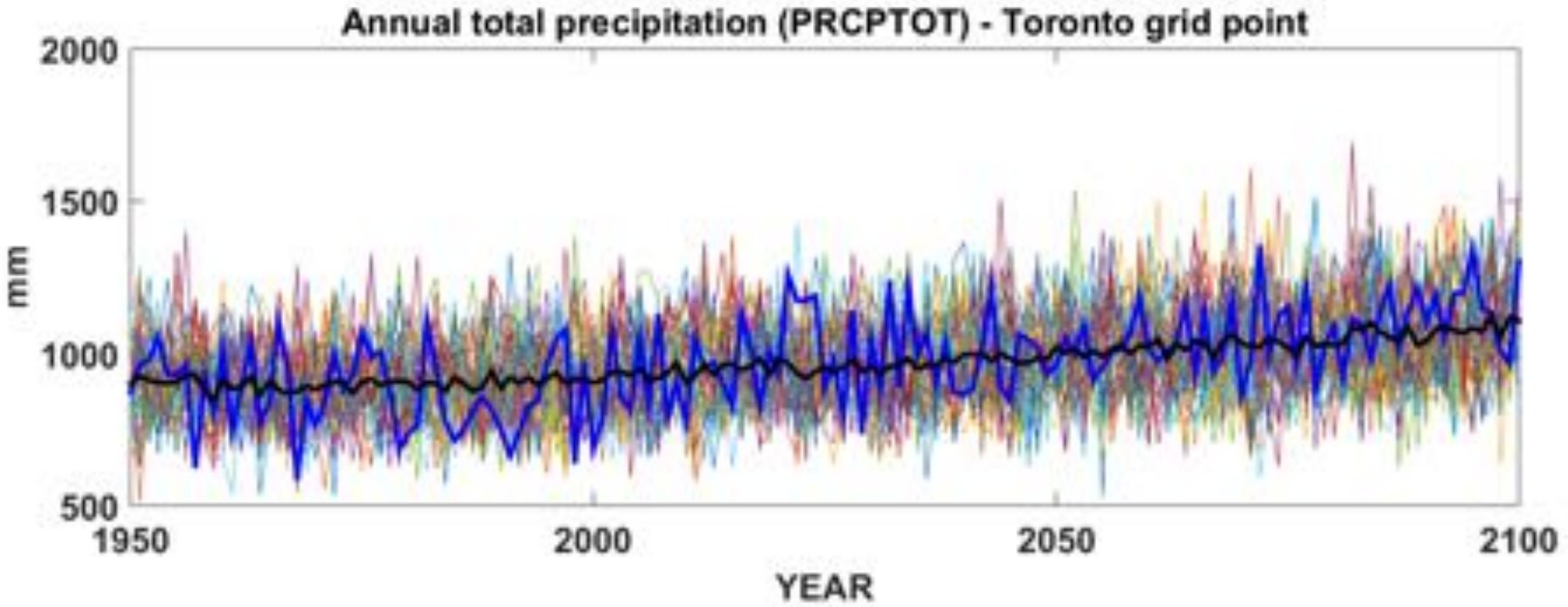

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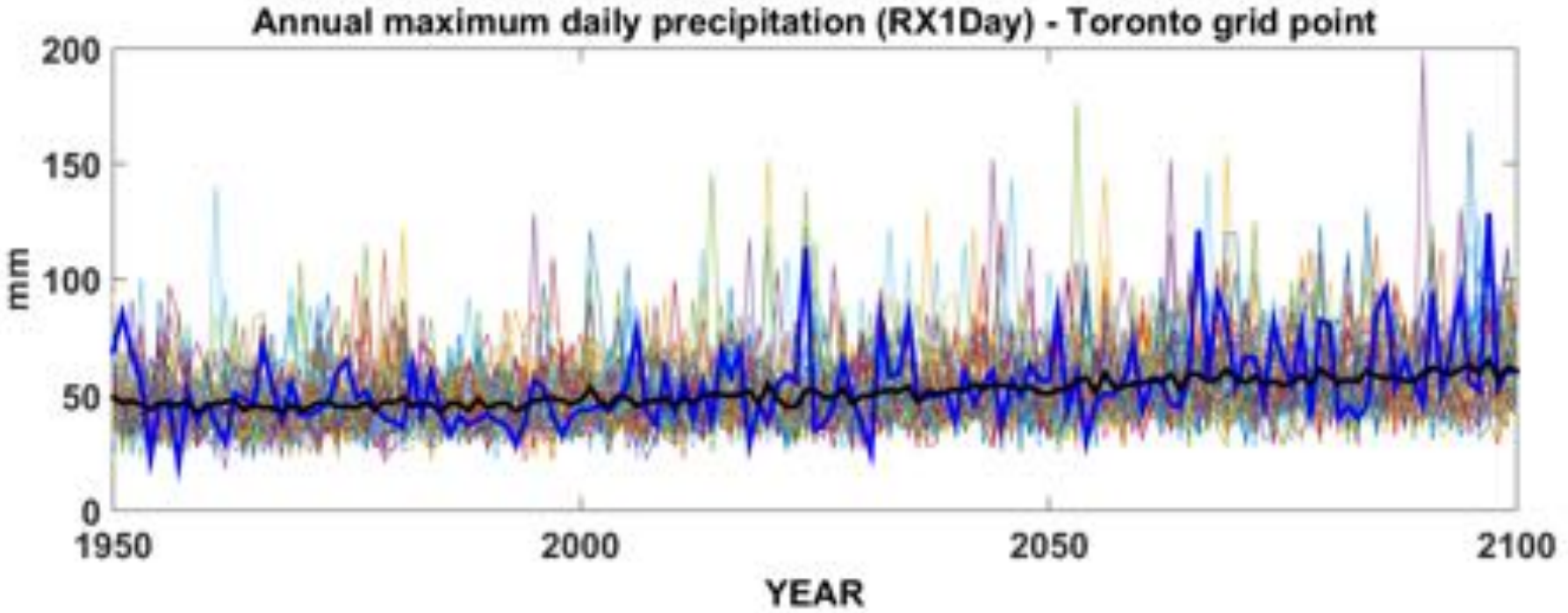

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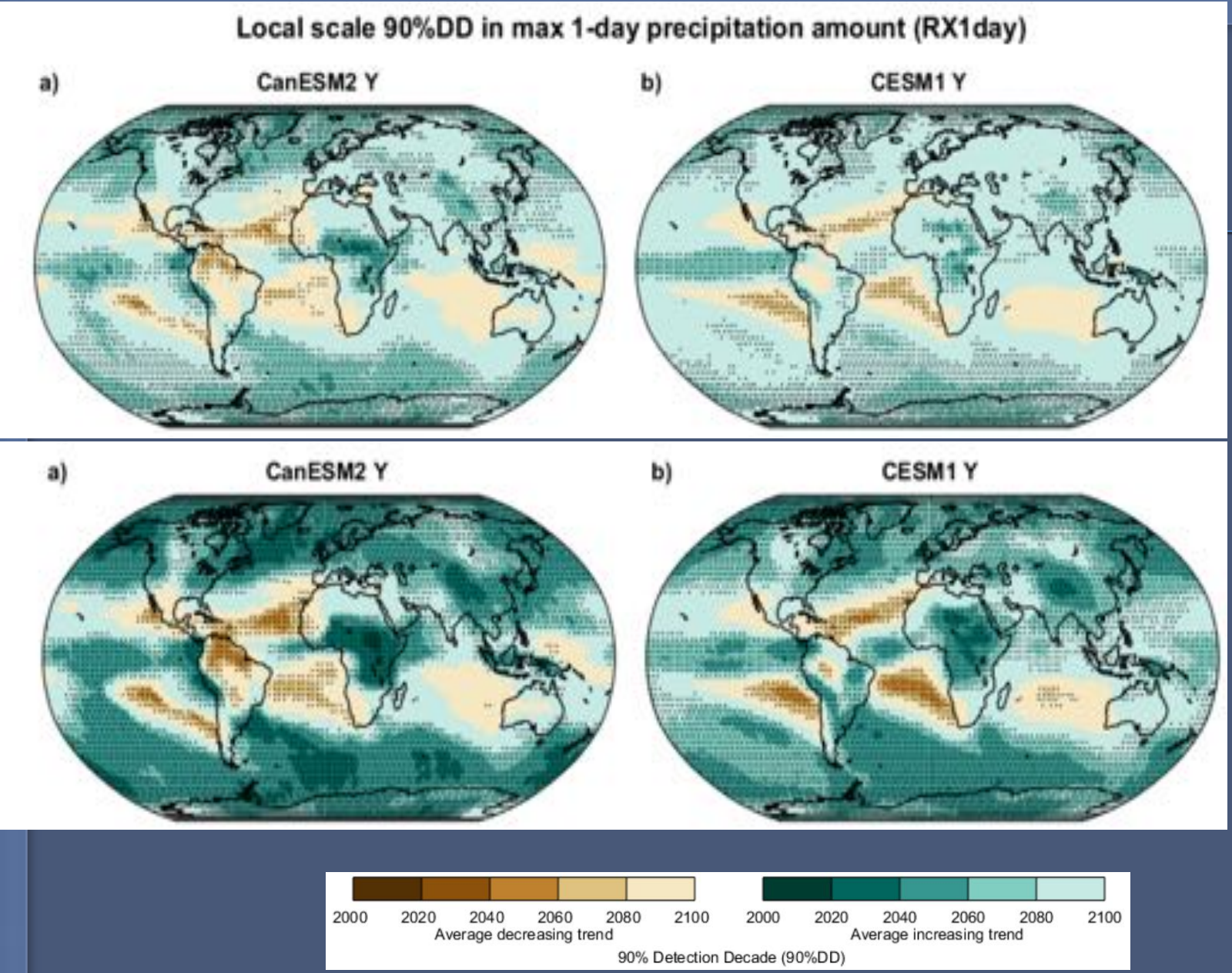
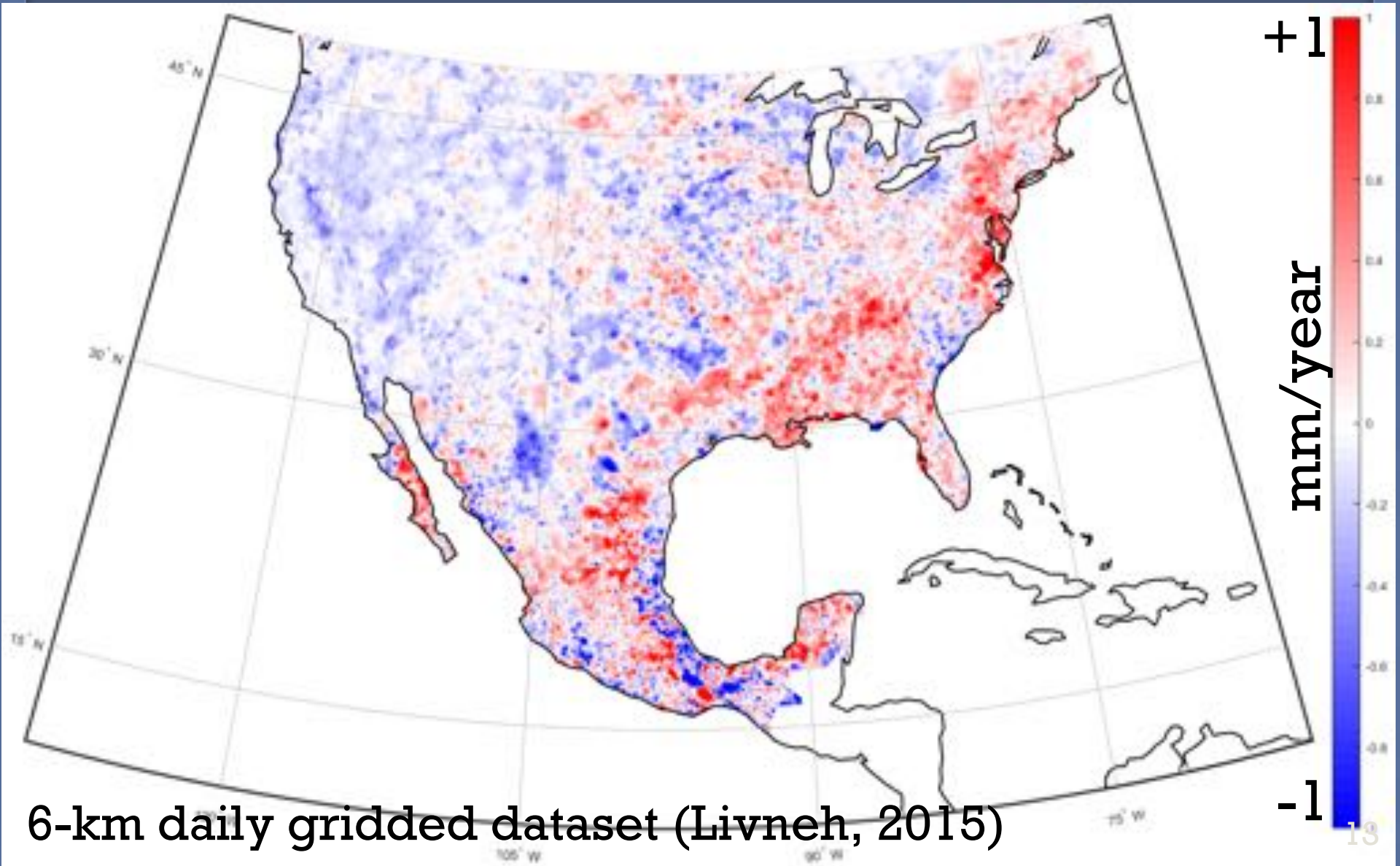


Grid point analysis

Regional analysis (field sigificance)

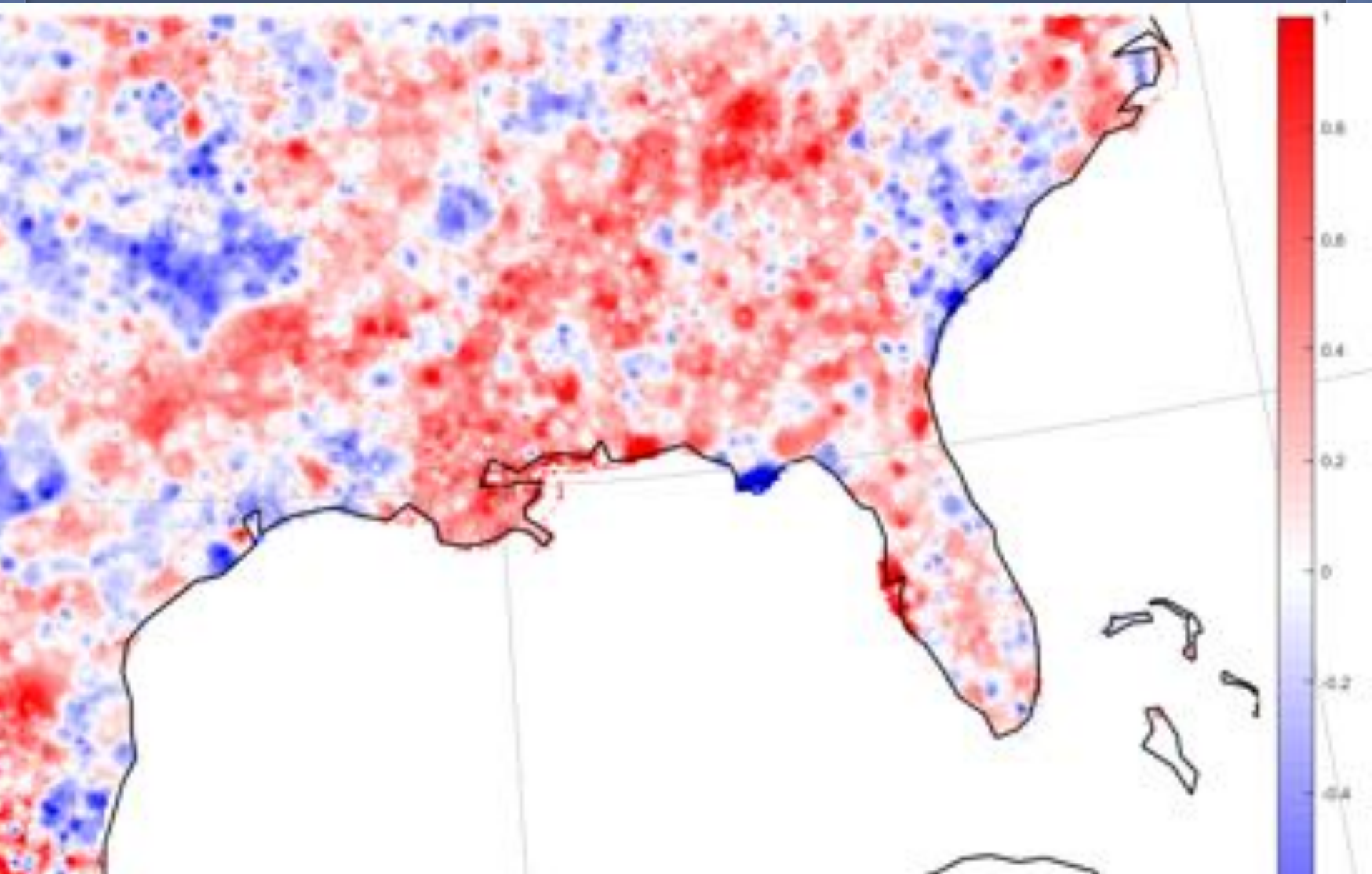
Martel, Jean-Luc, et al. "Role of Natural Climate Variability in the Detection of Anthropogenic Climate Change Signal for Mean and Extreme Precipitation at Local and Regional Scales." *Journal of Climate* (2018).

1979-2013 trends RX1-Day

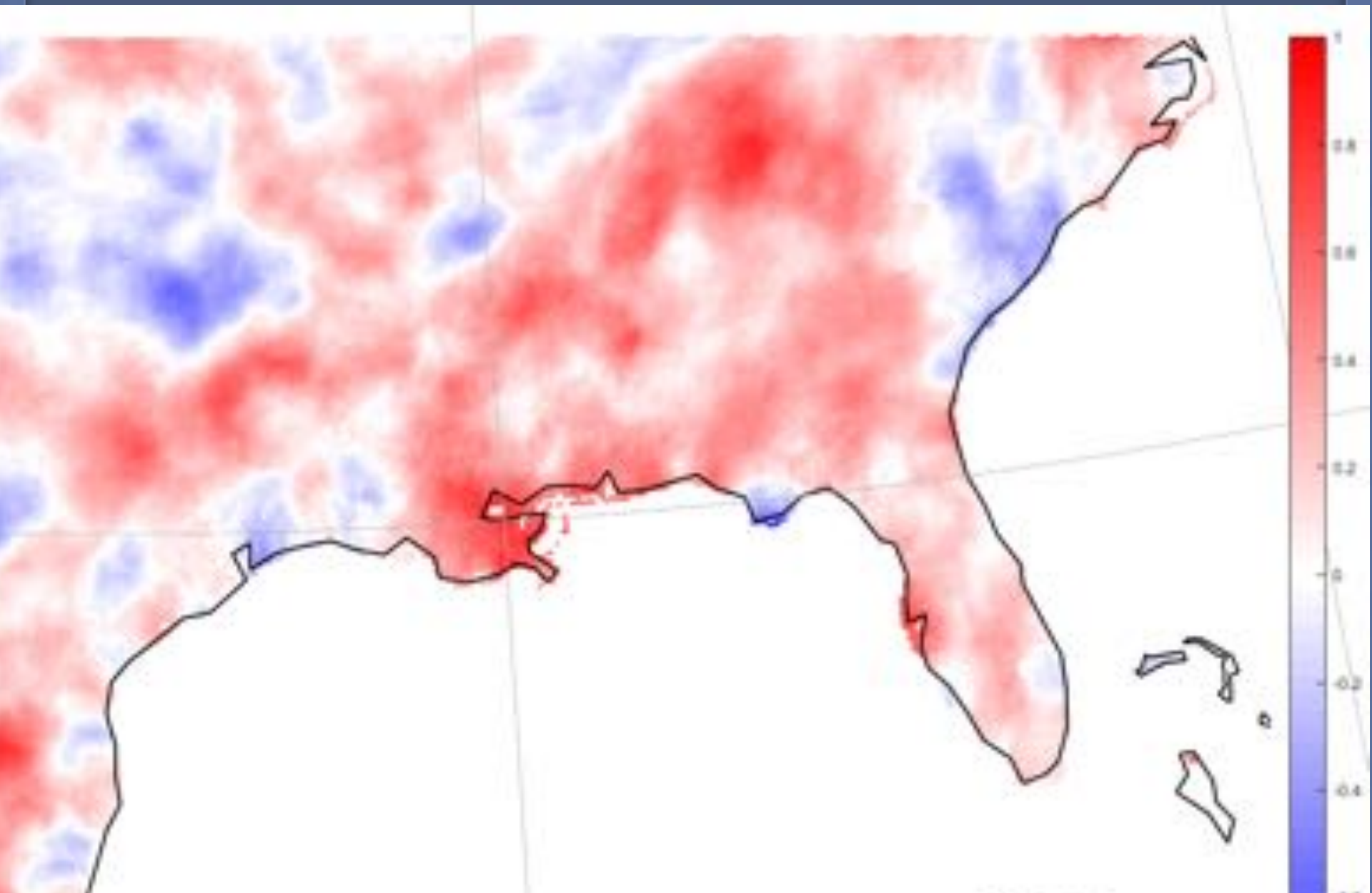


6-km daily gridded dataset (Livneh, 2015)

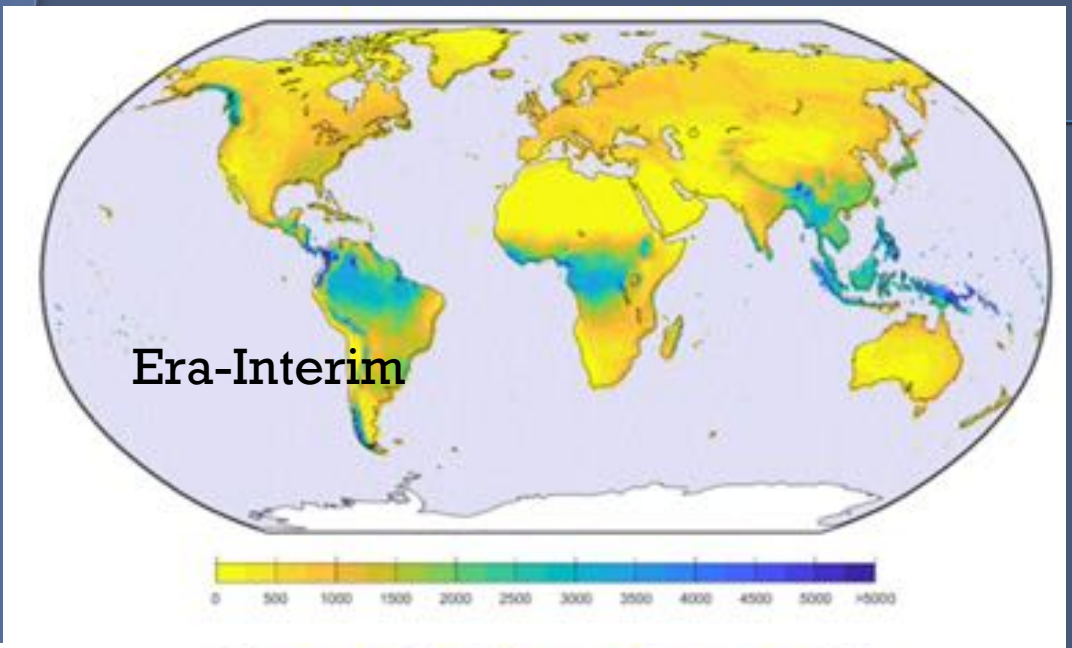
1979-2013 trends RX1-Day

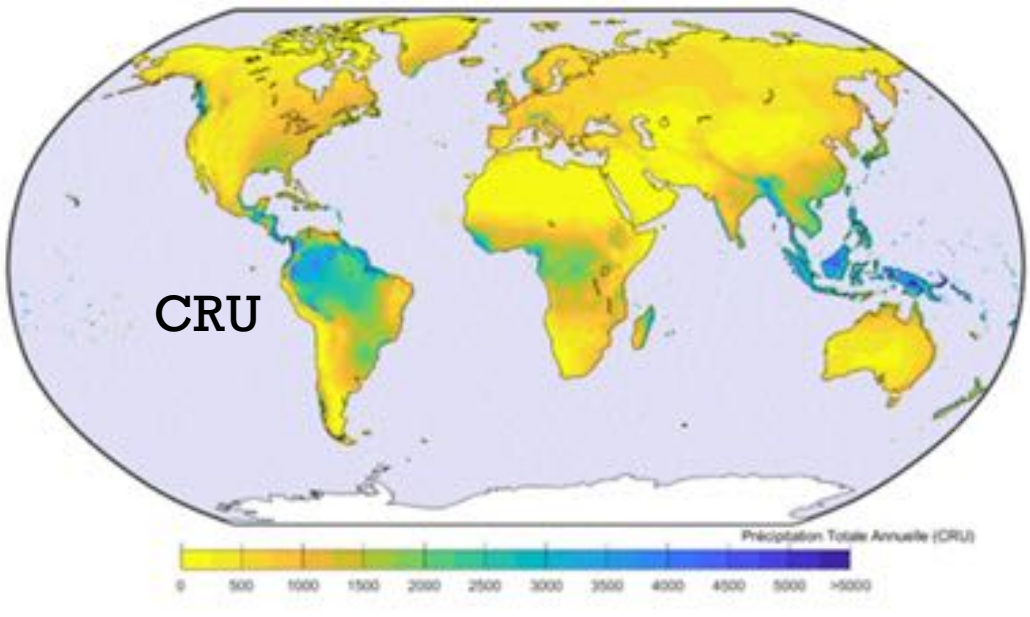


1979-2013 trends RX1-Day

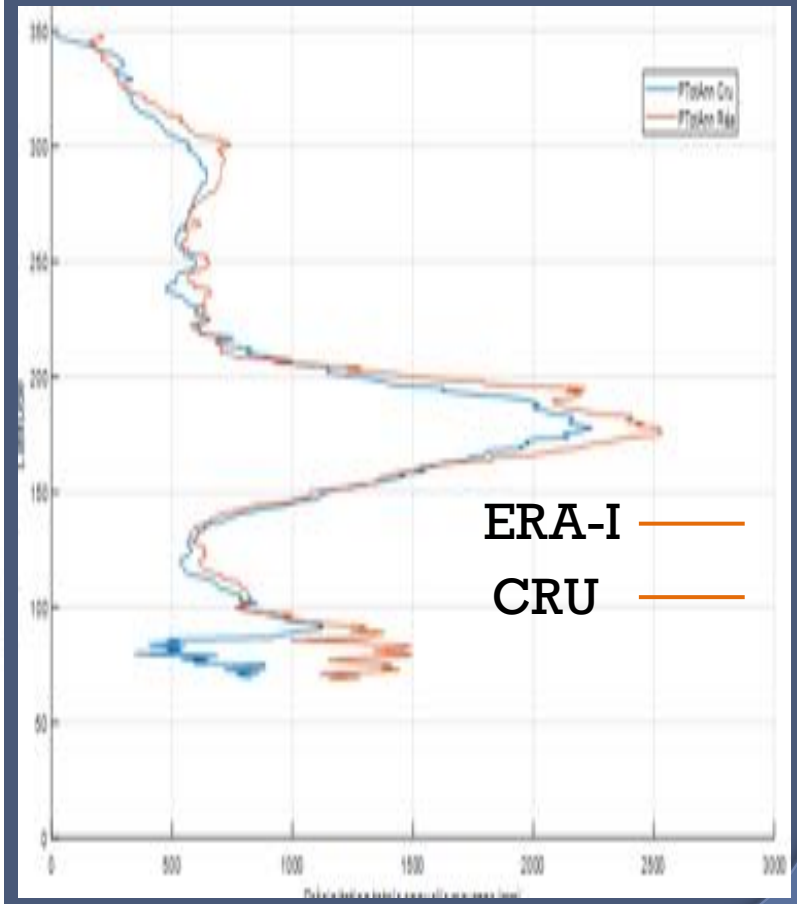


Total annual precipitation (mm)



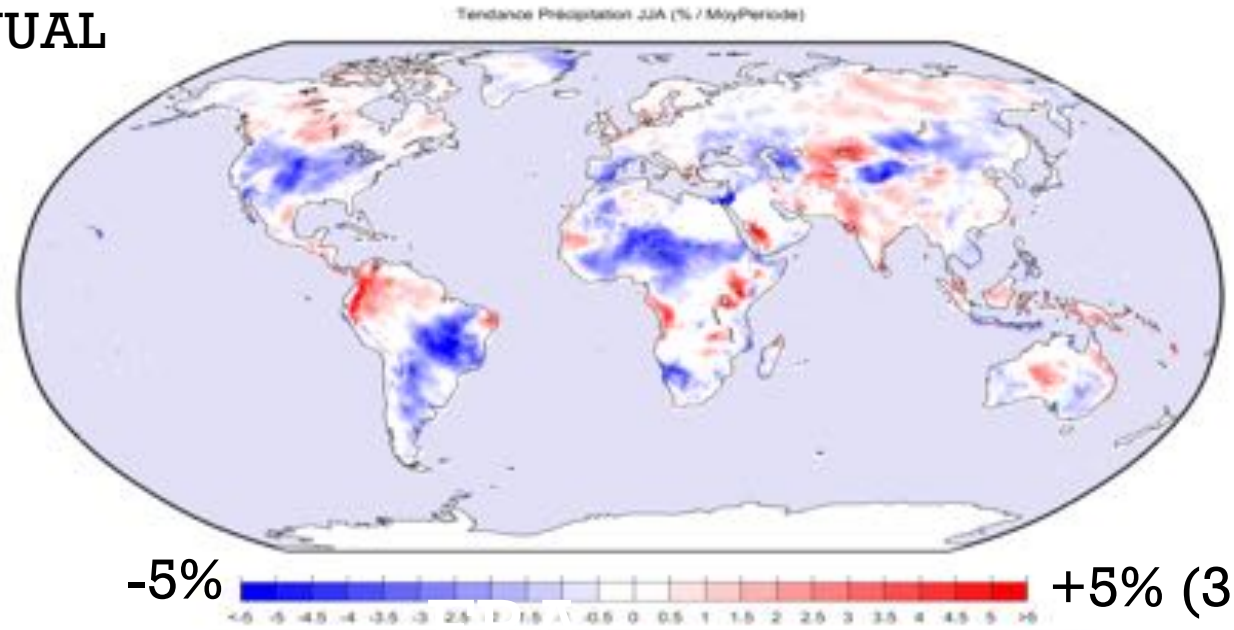


Latitude averaged total annual precipitation

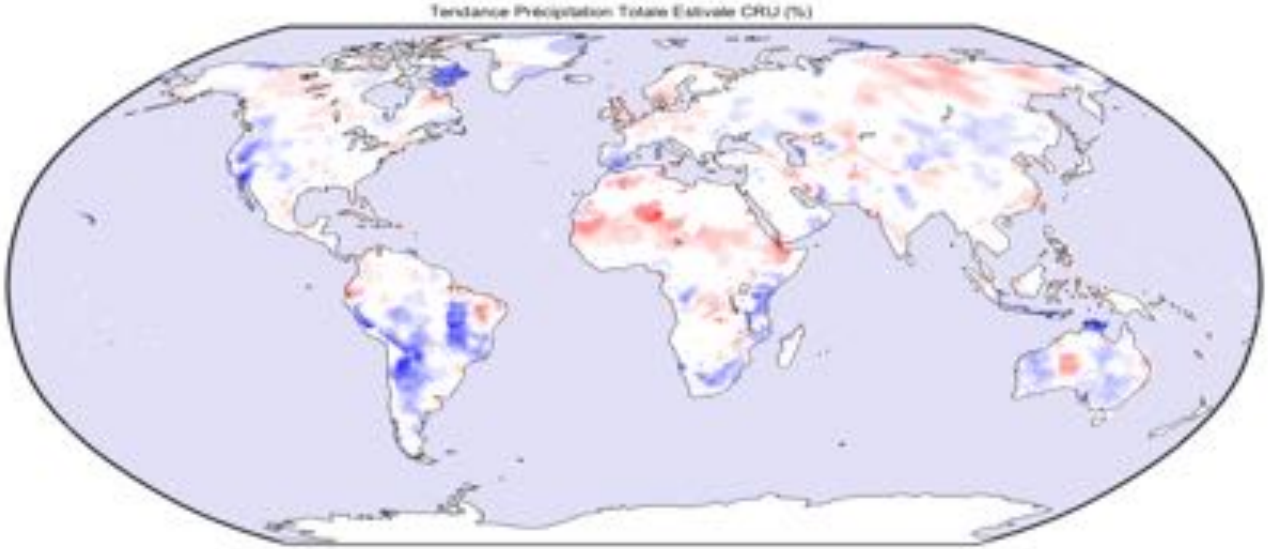


Trends 1979-2016 JJA-PRCPTOT

ANNUAL



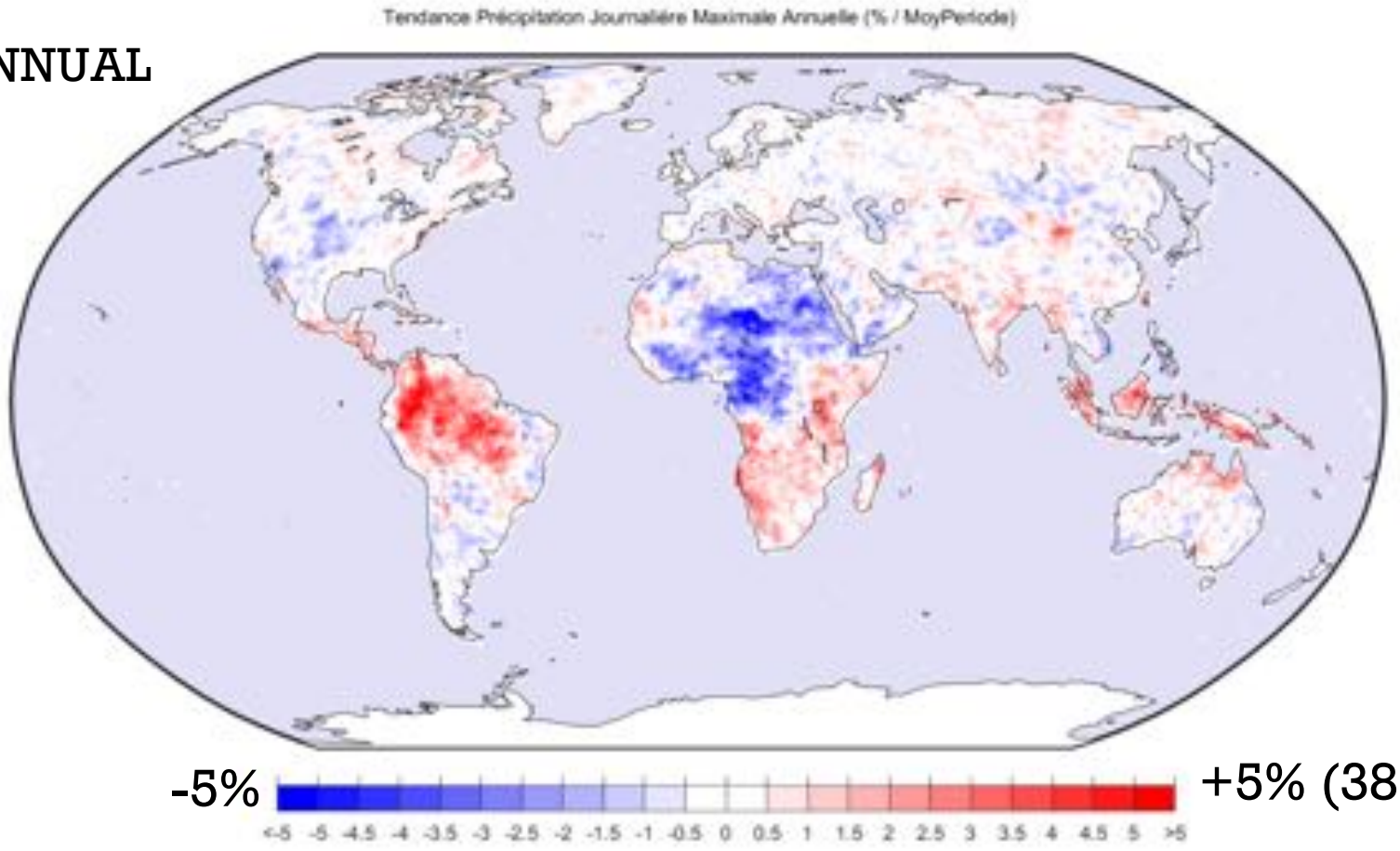
ERA



CRU

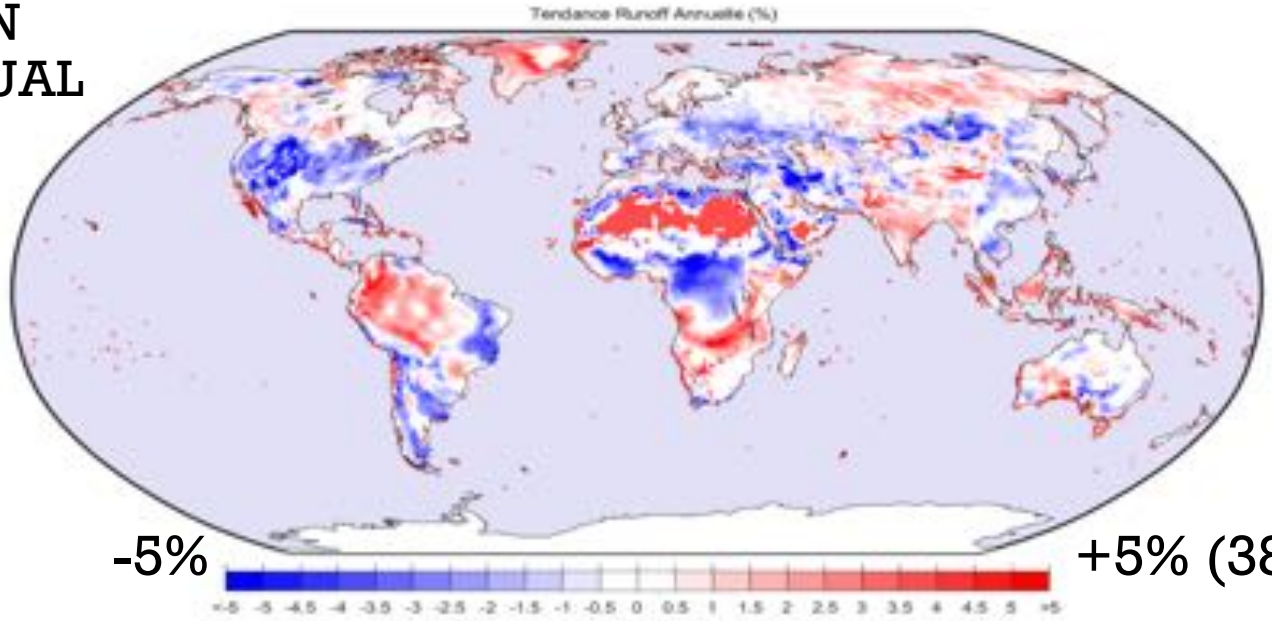
Trends 1979-2016 RX1Day ERA-I

ANNUAL



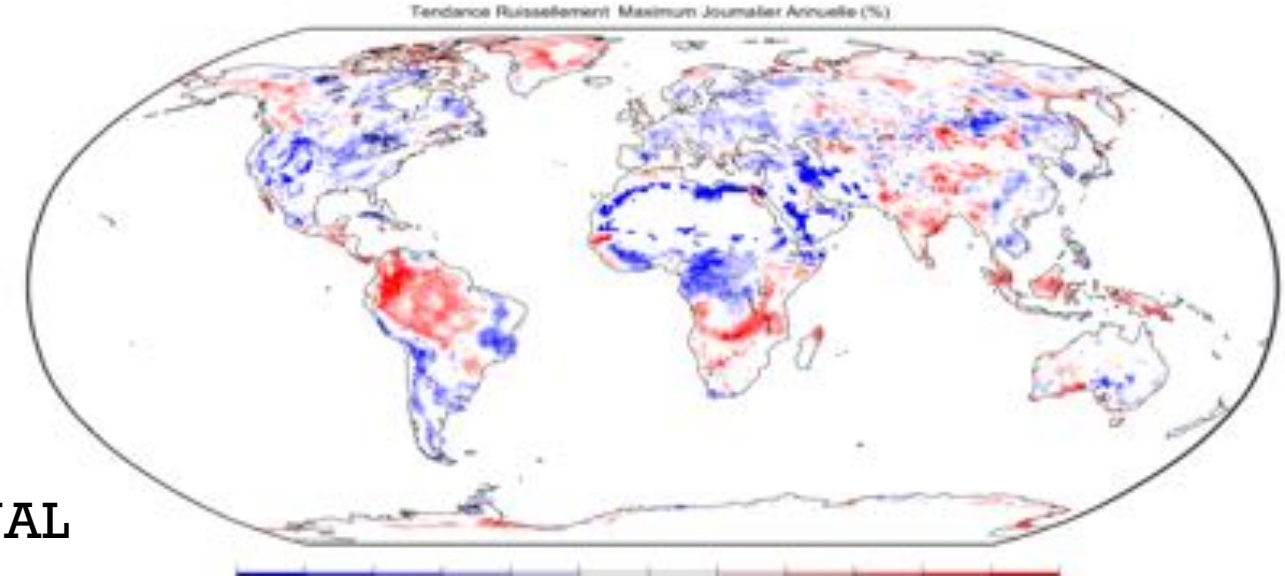
Trends 1979-2016 Runoff ERA-I

MEAN ANNUAL



-5%

+5% (38 yrs)

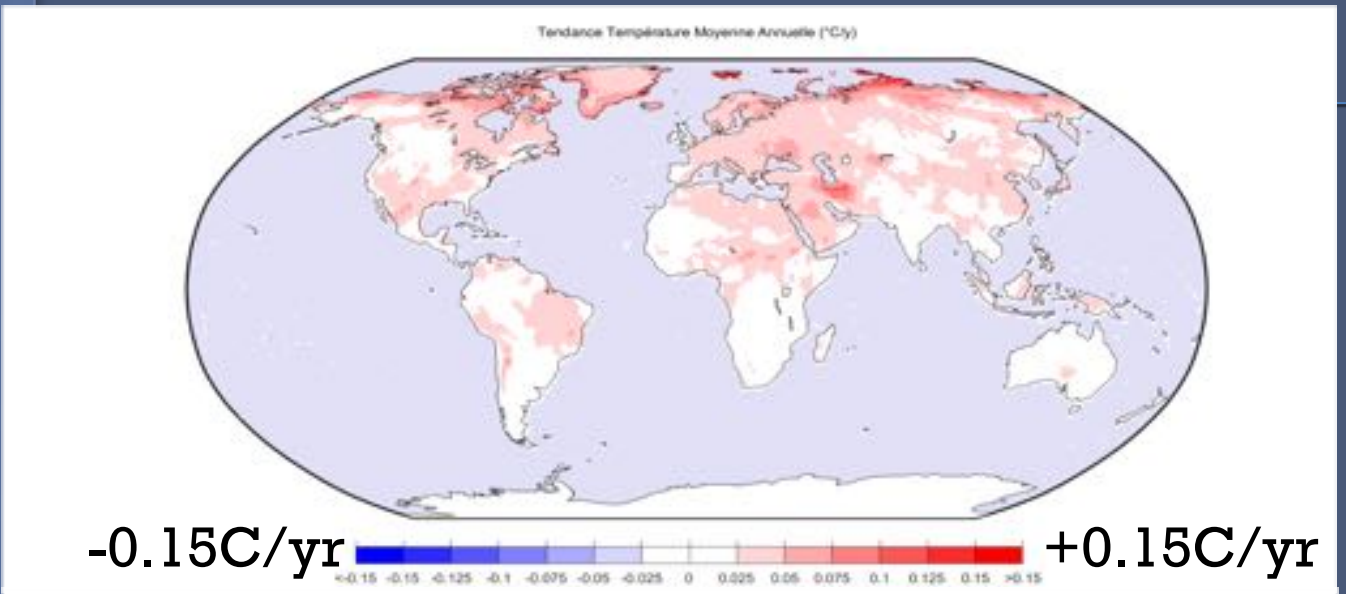


MAX ANNUAL

Conclusions

- A lot to learn from ESM/RCM large ensembles with respect to our ability to detecting a significant trend
- Reanalysis appears to be robust for trend detection
- Signal to noise ratio is much larger for precipitation than temperature
- Signal to noise ratio is much larger for extremes than mean values
- Internal variability increases when the spatial and temporal resolutions increase
- Trend detection better done at the regional scale

annual T



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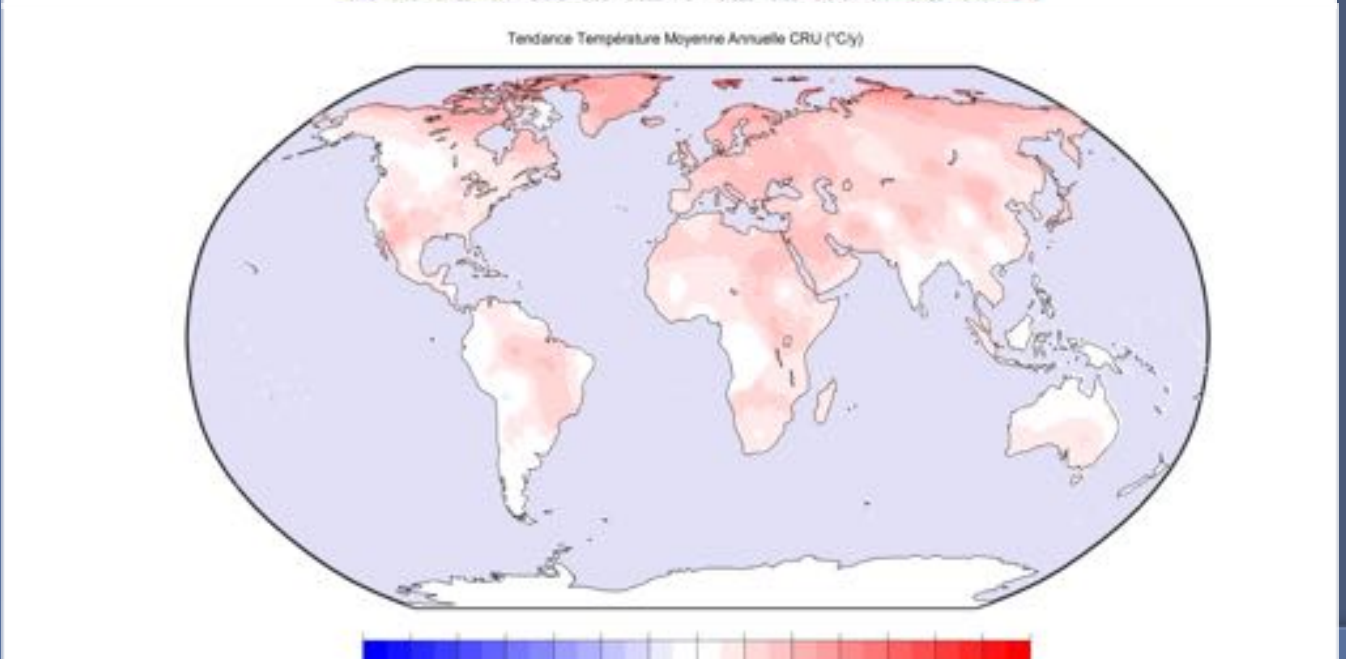
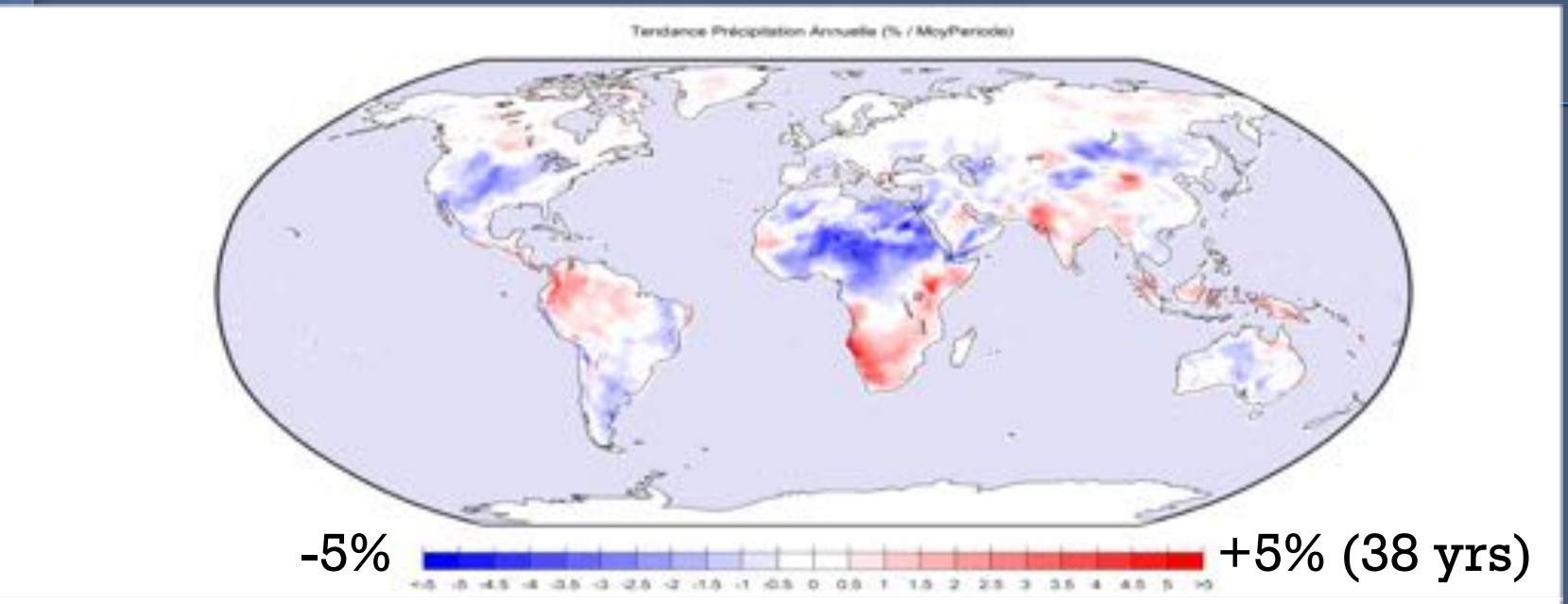


CRU

Trends 1979-2016 PRCPTOT



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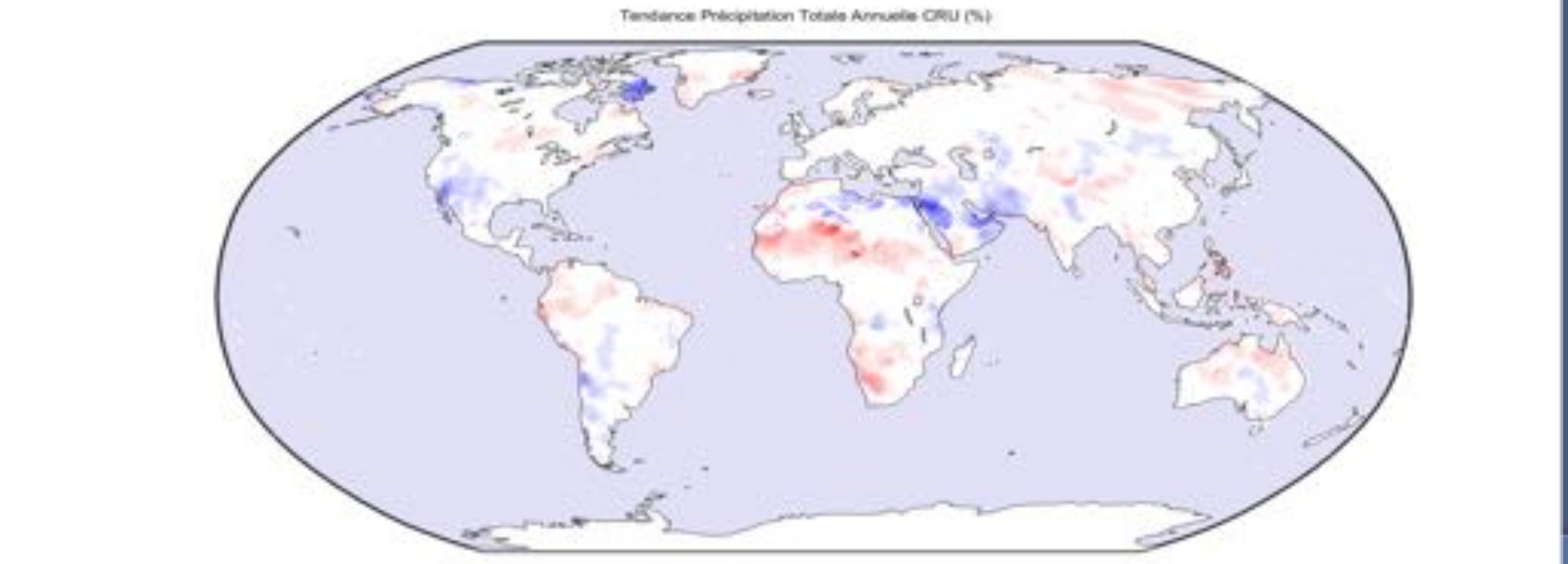
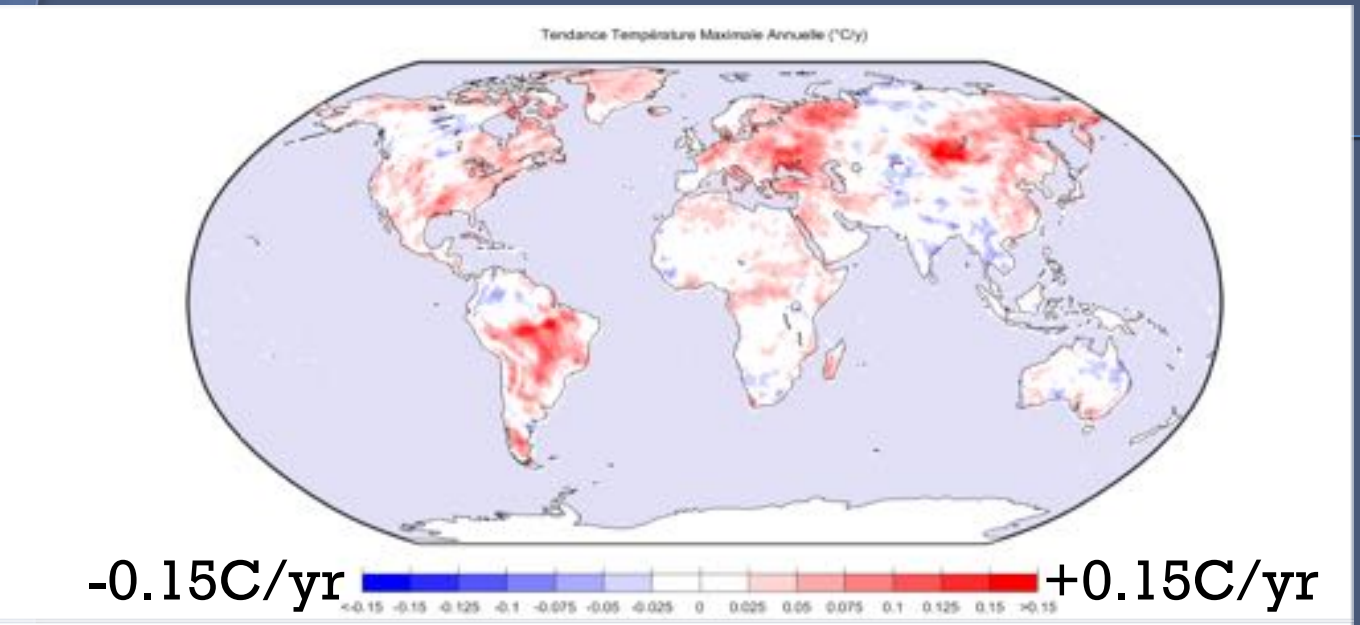
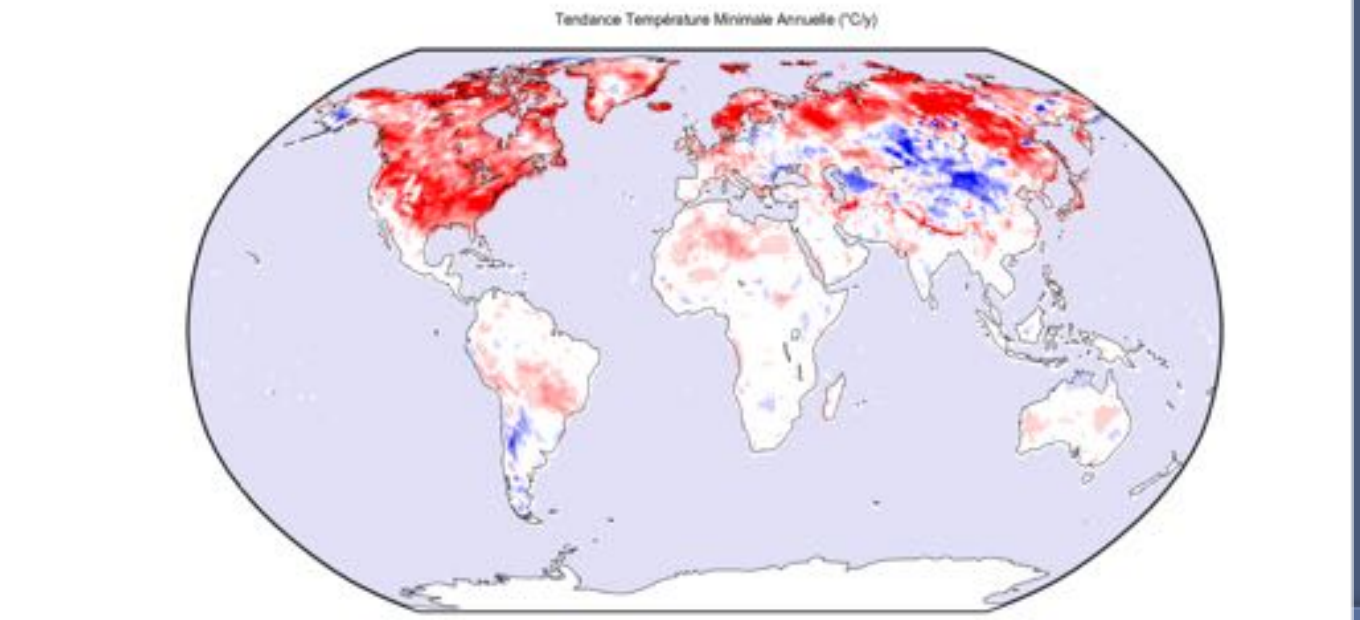


CRU

Trends 1979-2016 largest annual value



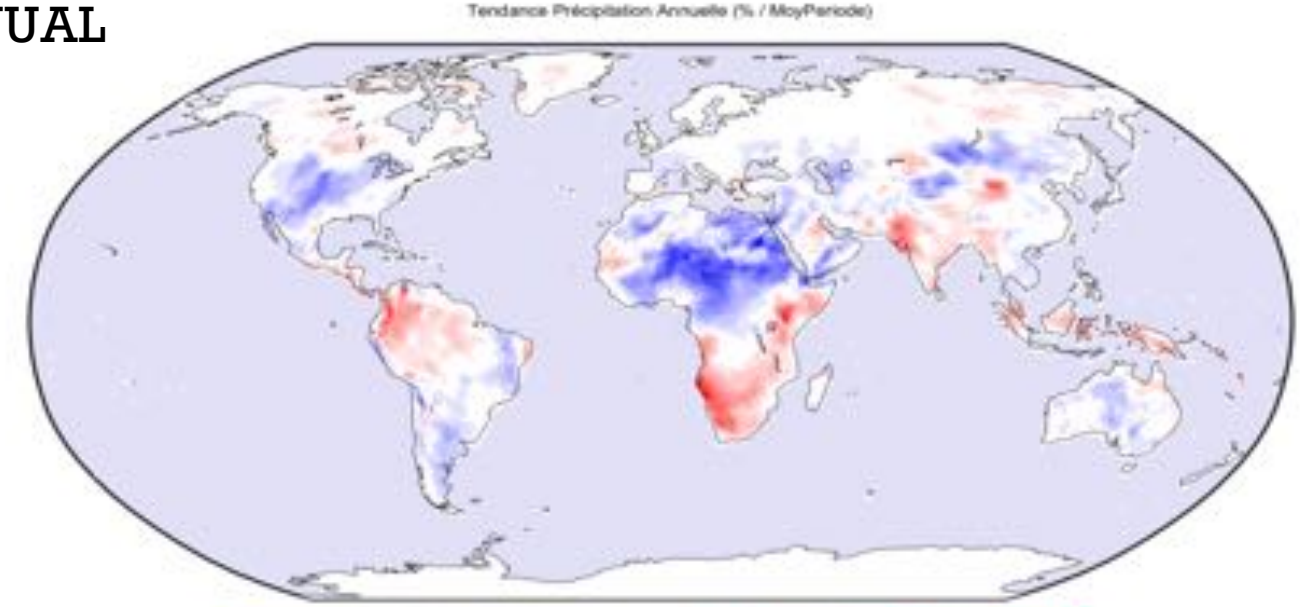
ERA-I Tmax



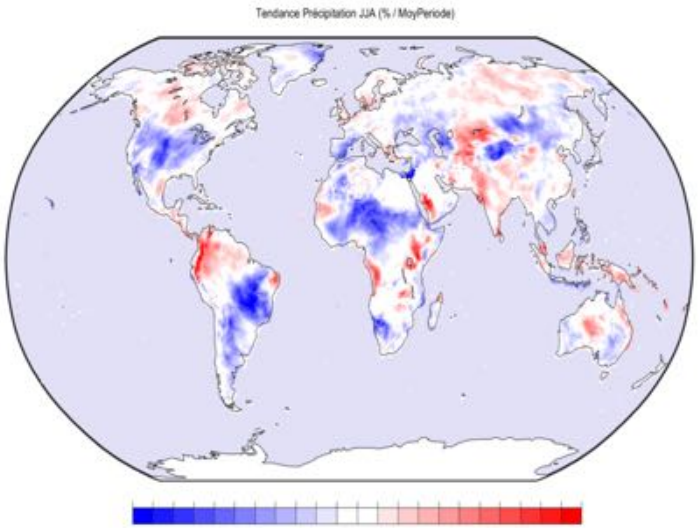
ERA-I Tmin

Trends 1979-2016 PROPTOT ERA-I

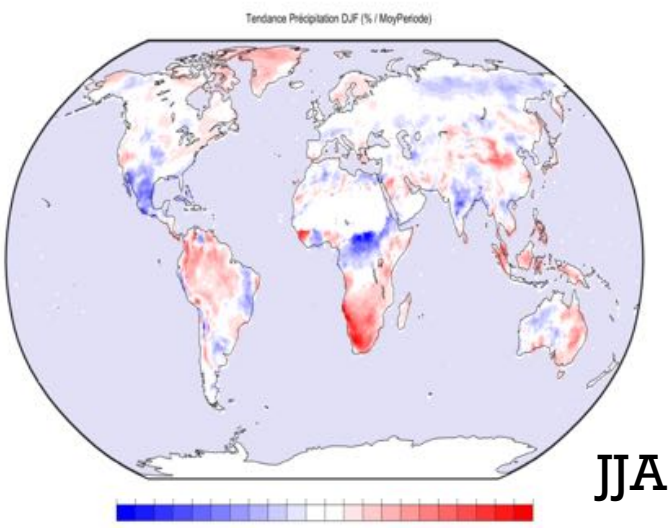
ANNUAL



-5% +5% (38 yrs)

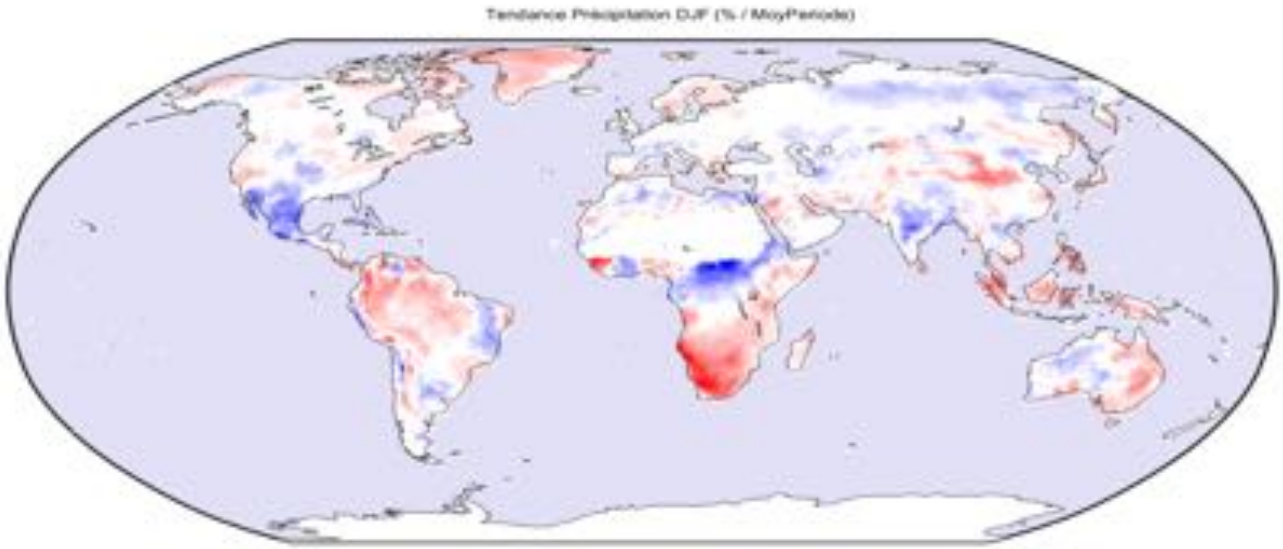


DJF



JJA

Trends 1979-2016 DJF-PRCPTOT



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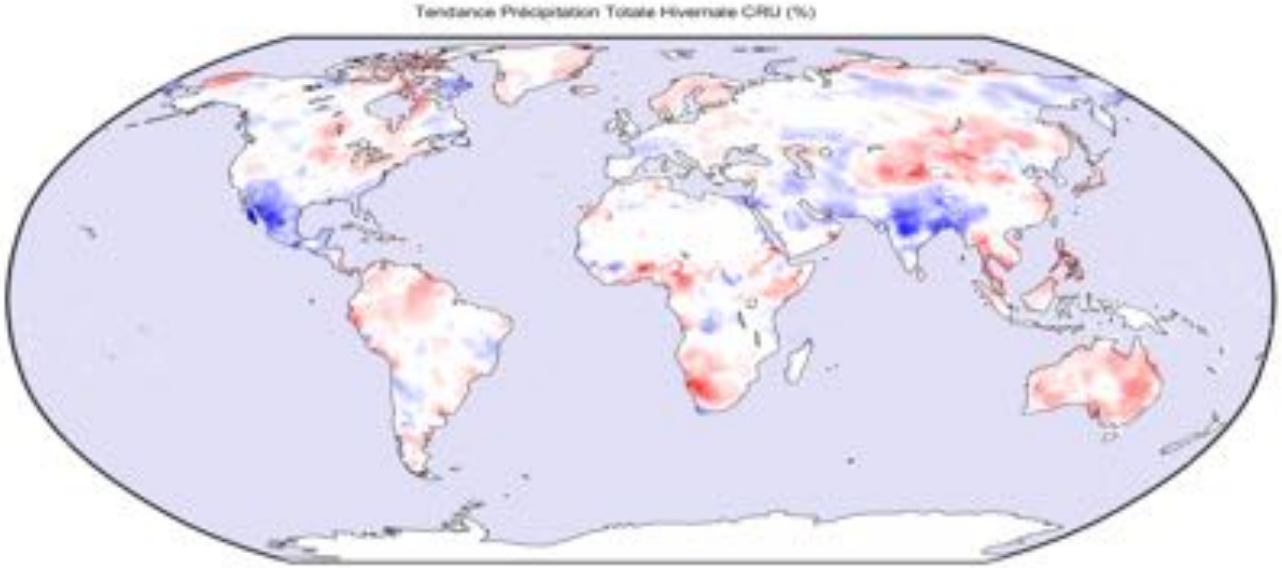
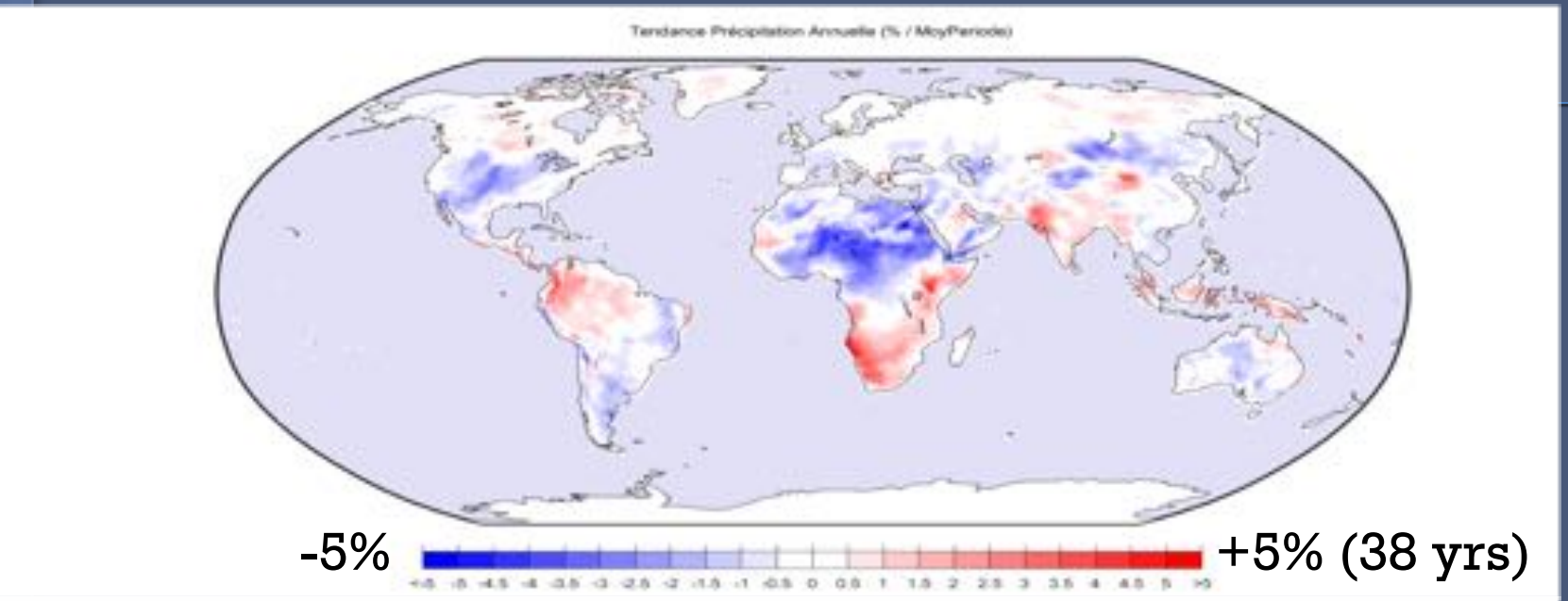
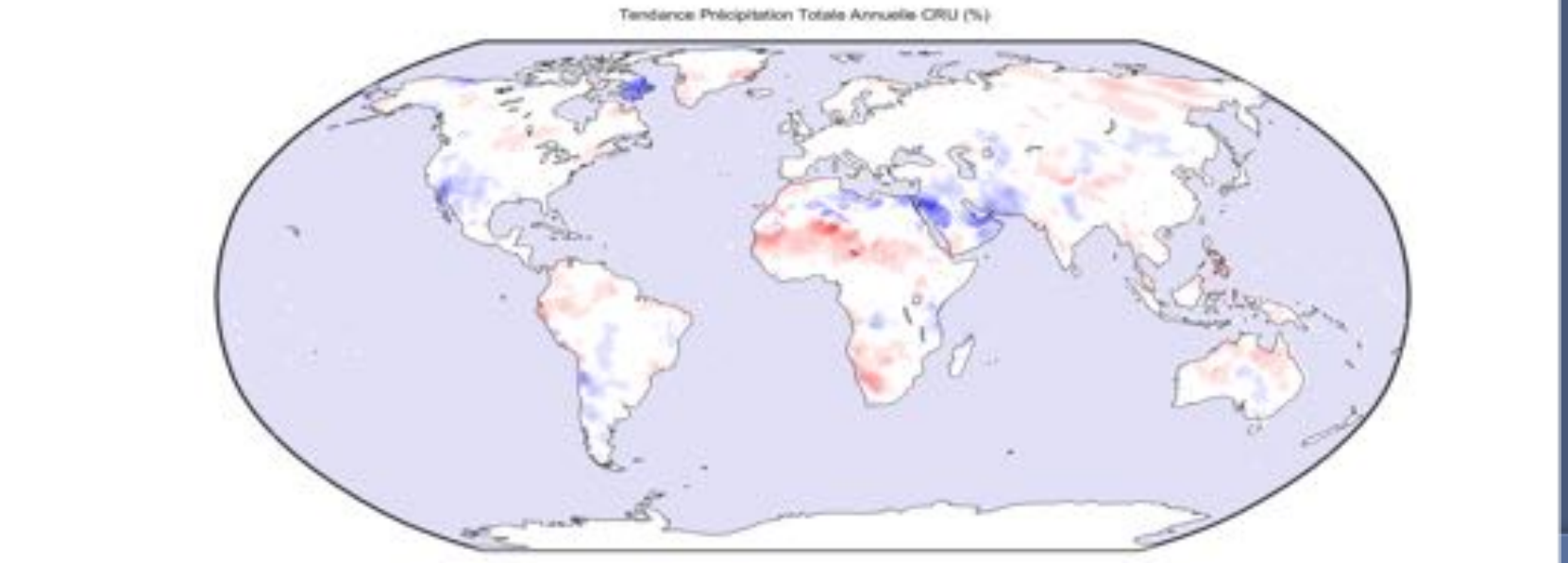


CRU

Trends 1979-2010 PROPTOT ERA-I



ERA



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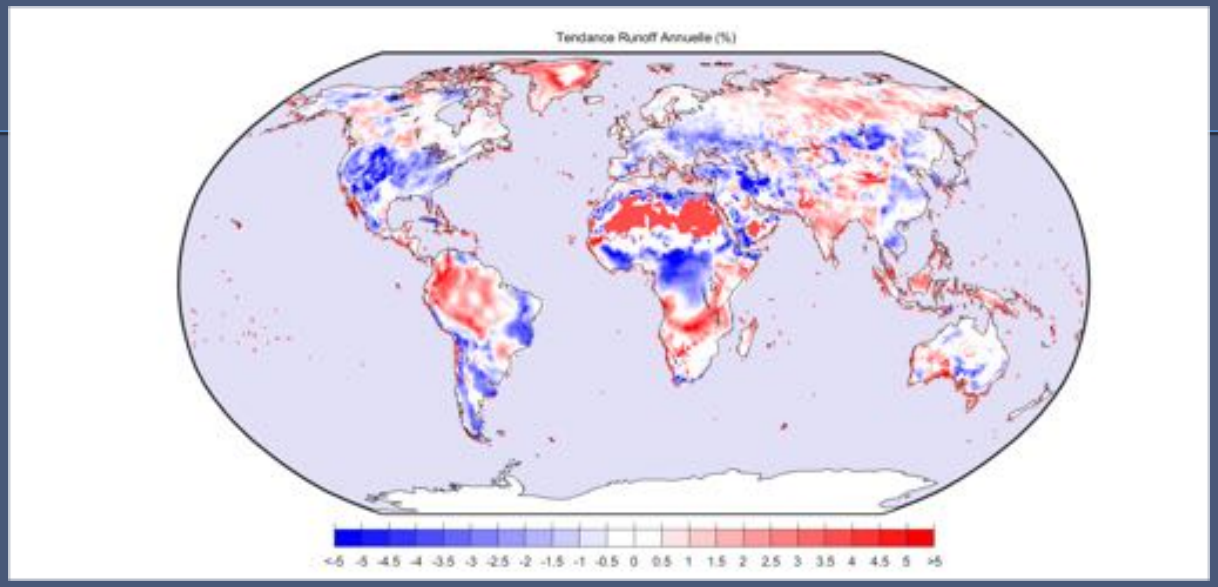
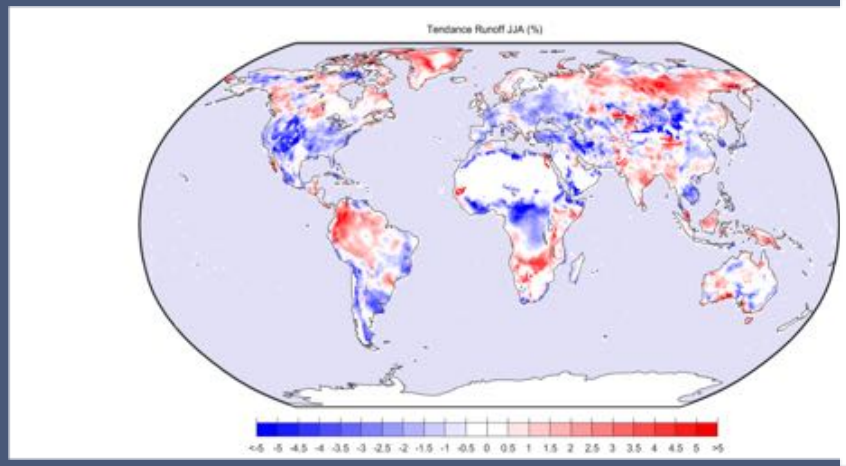
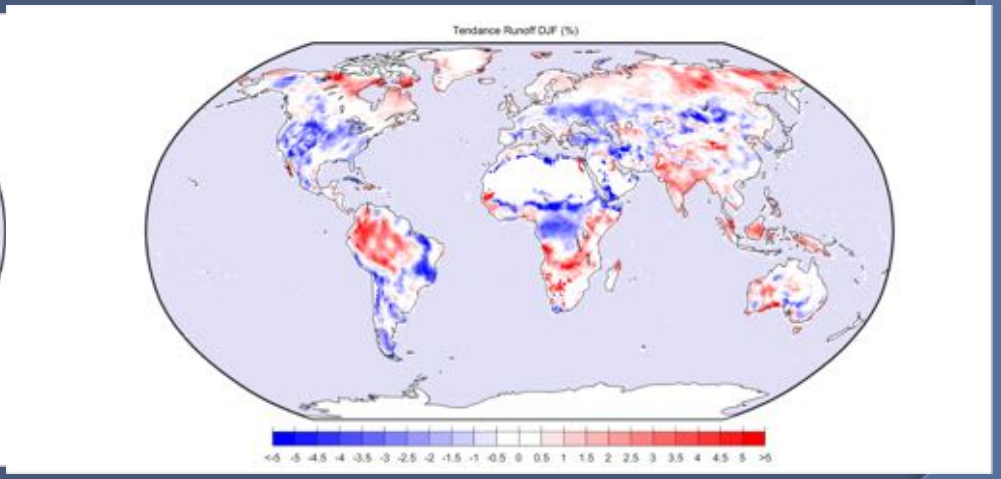
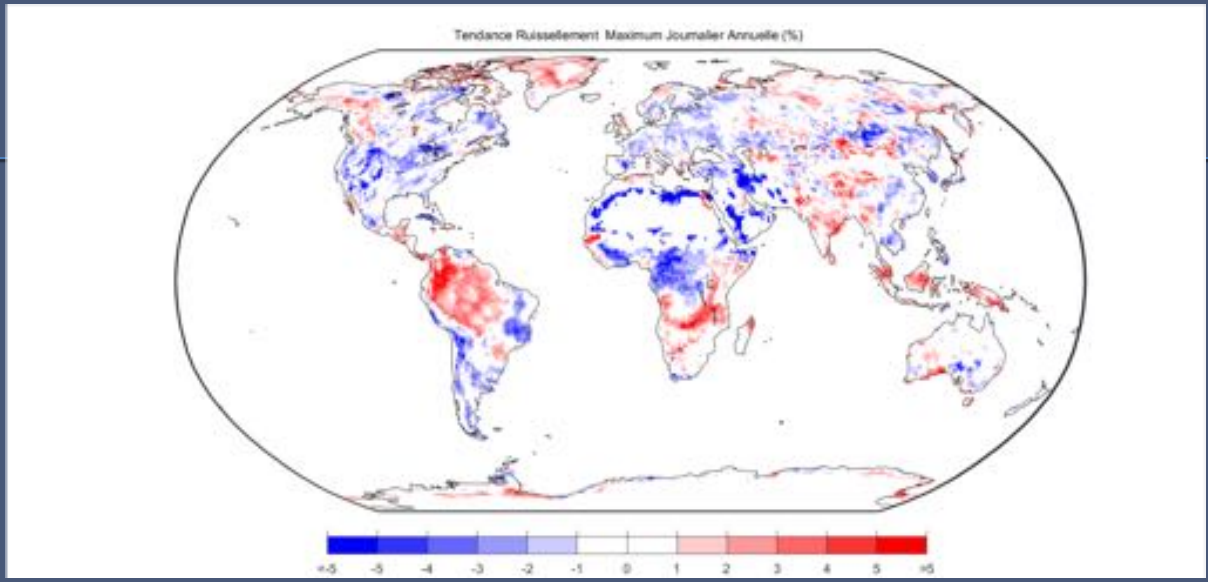
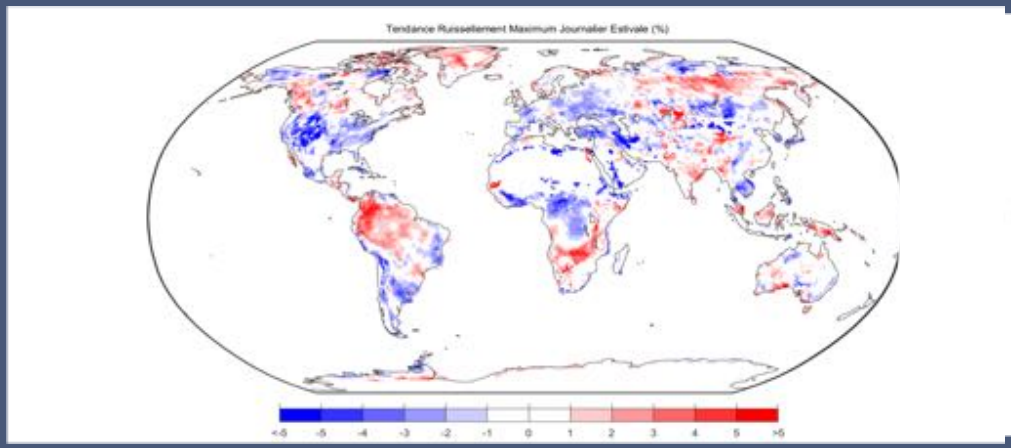
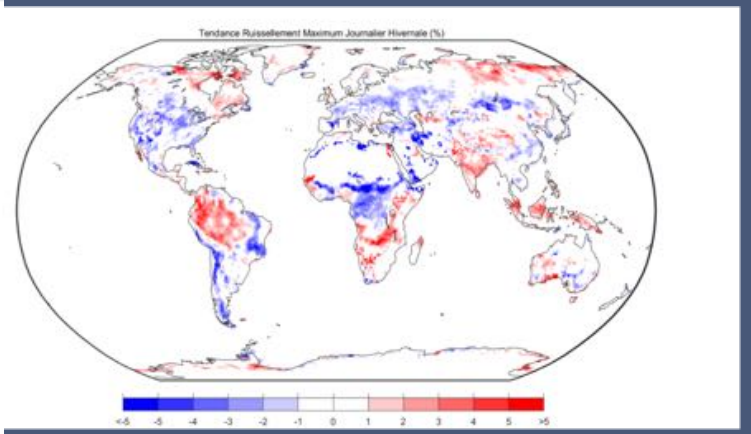

Tendance Runoff Annuelle (%)
<-5 -5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 >5

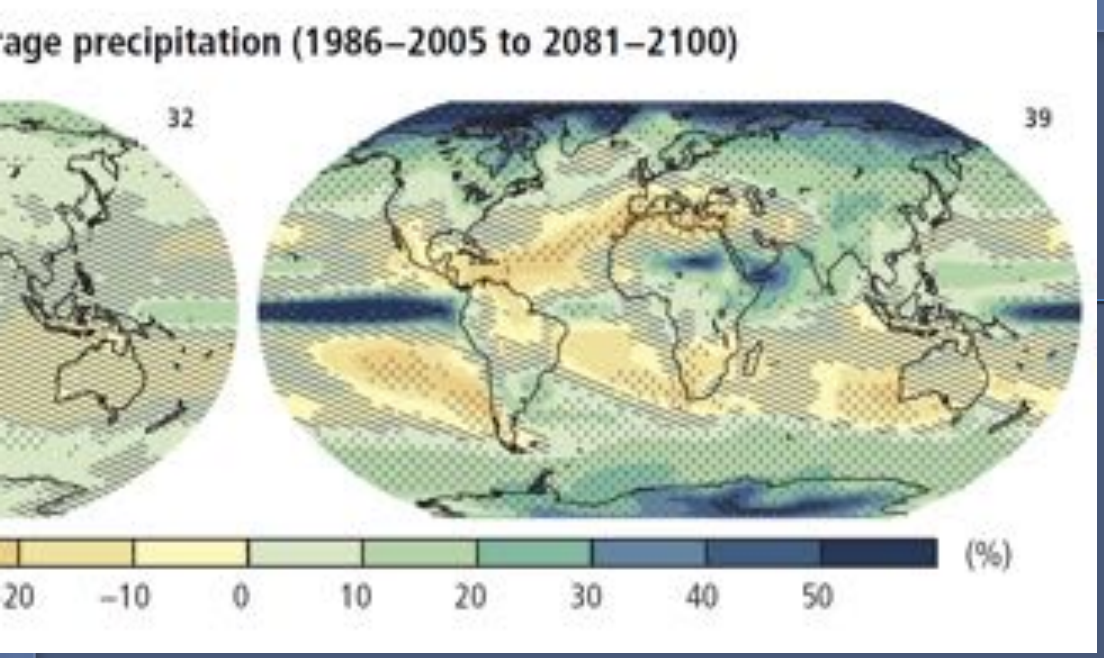

Tendance Runoff JJA (%)
<-5 -5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 >5

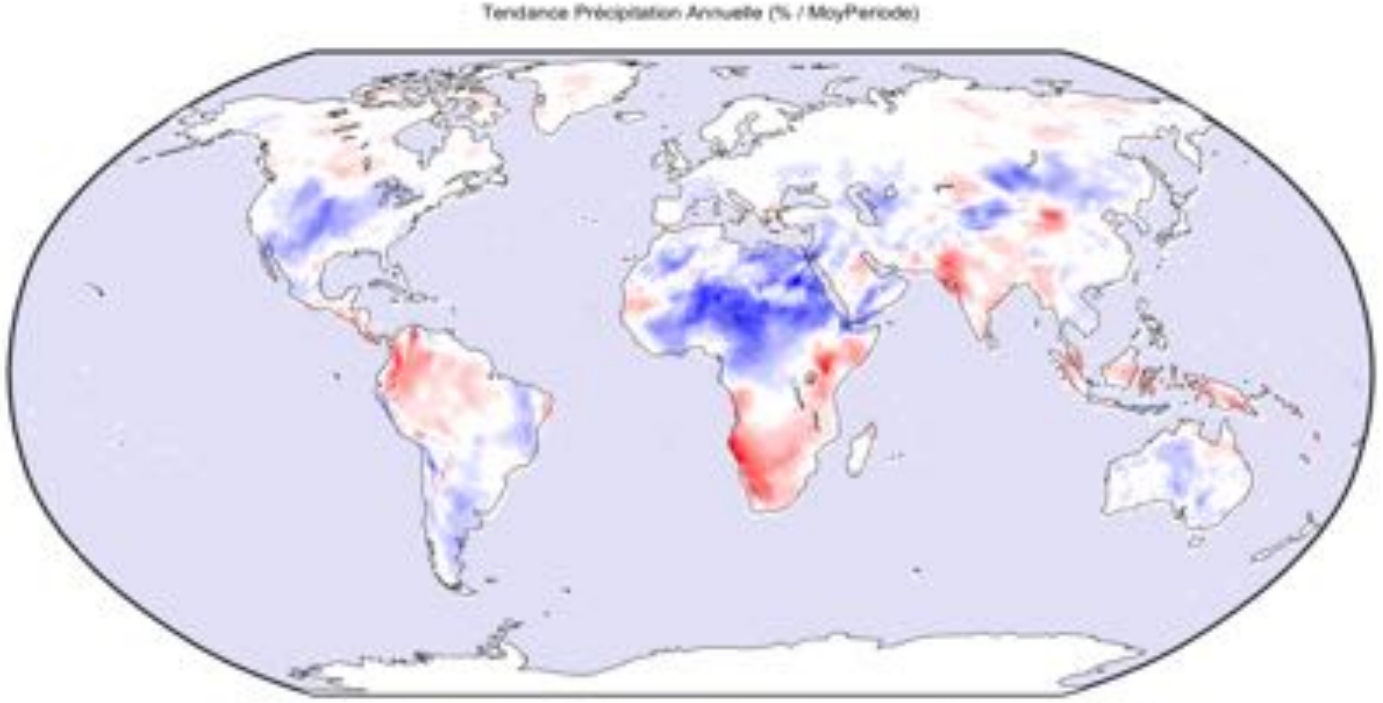

Tendance Runoff DJF (%)
<-5 -5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 >5

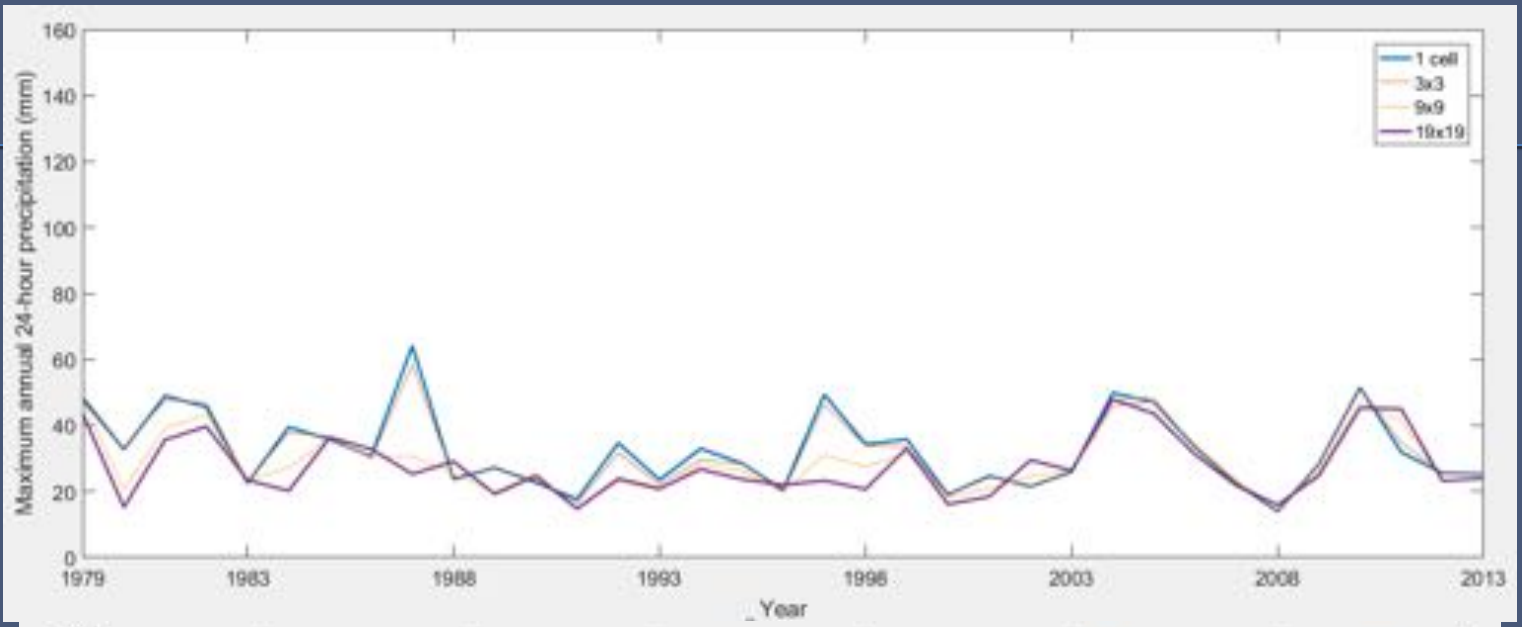

Tendance Ruissellement Maximum Journalier Annuelle (%)
<-5 -5 -4 -3 -2 -1 0 1 2 3 4 5 >5

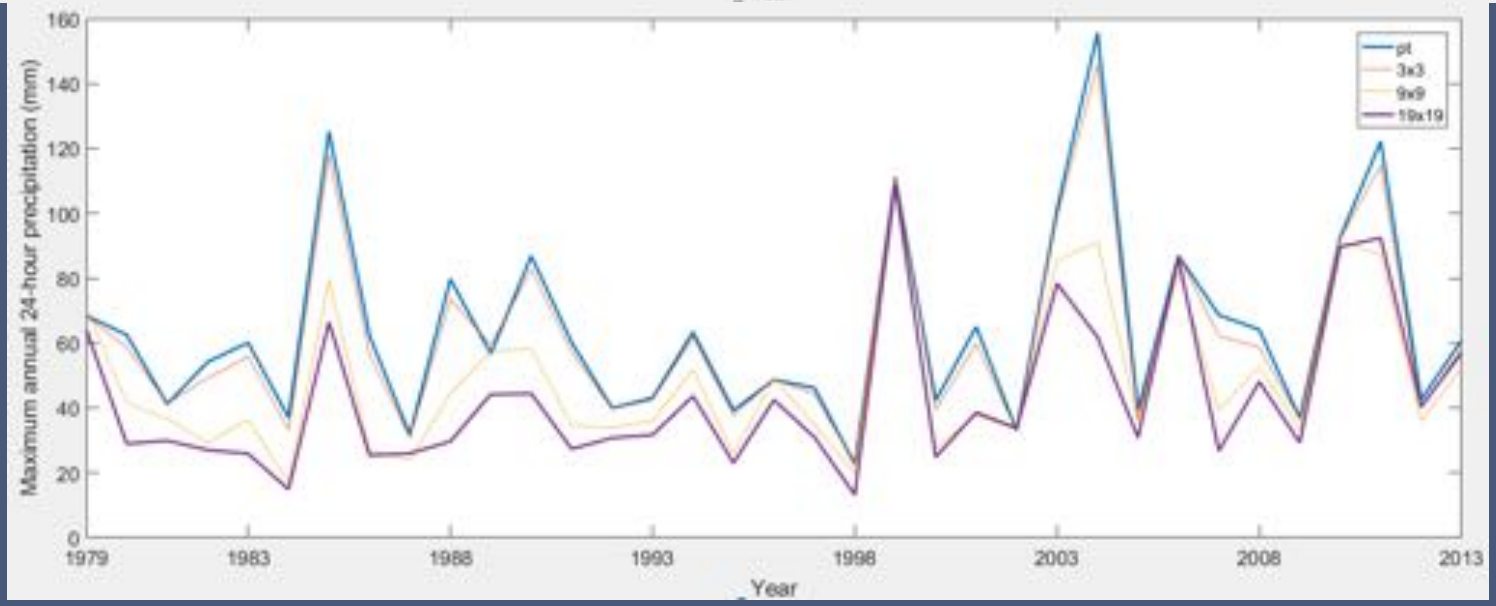

Tendance Ruissellement Maximum Journalier Estivale (%)
<-5 -5 -4 -3 -2 -1 0 1 2 3 4 5 >5


Tendance Ruissellement Maximum Journalier Hivernale (%)
<-5 -5 -4 -3 -2 -1 0 1 2 3 4 5 >5


age precipitation (1986–2005 to 2081–2100)
32
39
(%)
20
–10
0
10
20
30
40
50


Tendance Précipitation Annuelle (% / MoyPeriode)


Maximum annual 24-hour precipitation (mm)
160
140
120
100
80
60
40
20
0
1979
1983
1988
1993
1998
2003
2008
2013
_Year
1 cell
3x3
9x9
19x19


Maximum annual 24-hour precipitation (mm)
160
140
120
100
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0
1979
1983
1988
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2003
2008
2013
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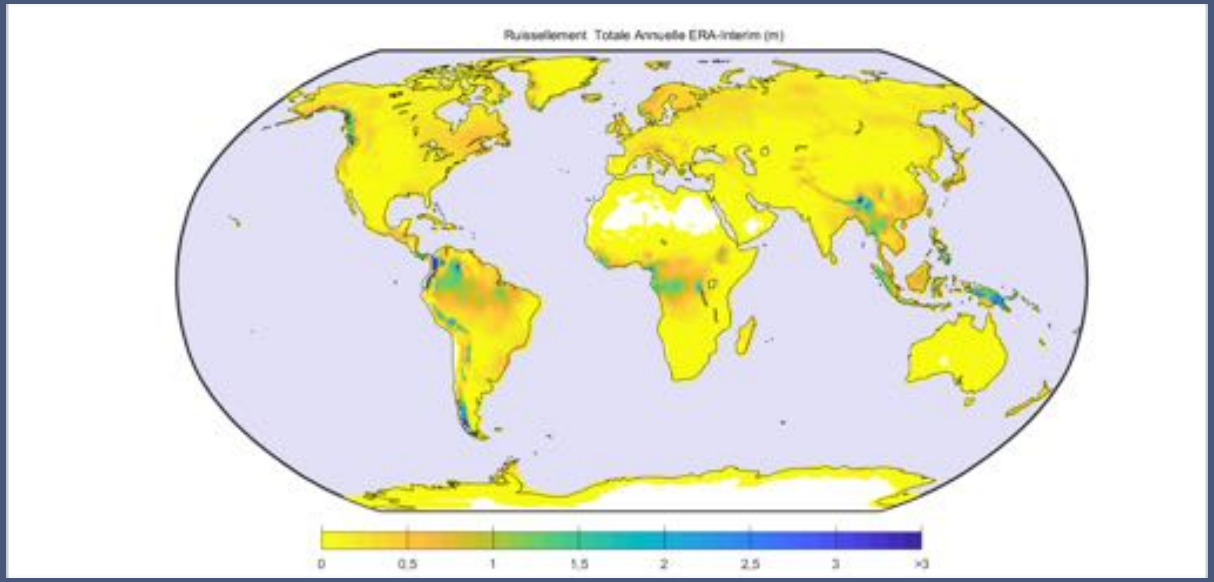
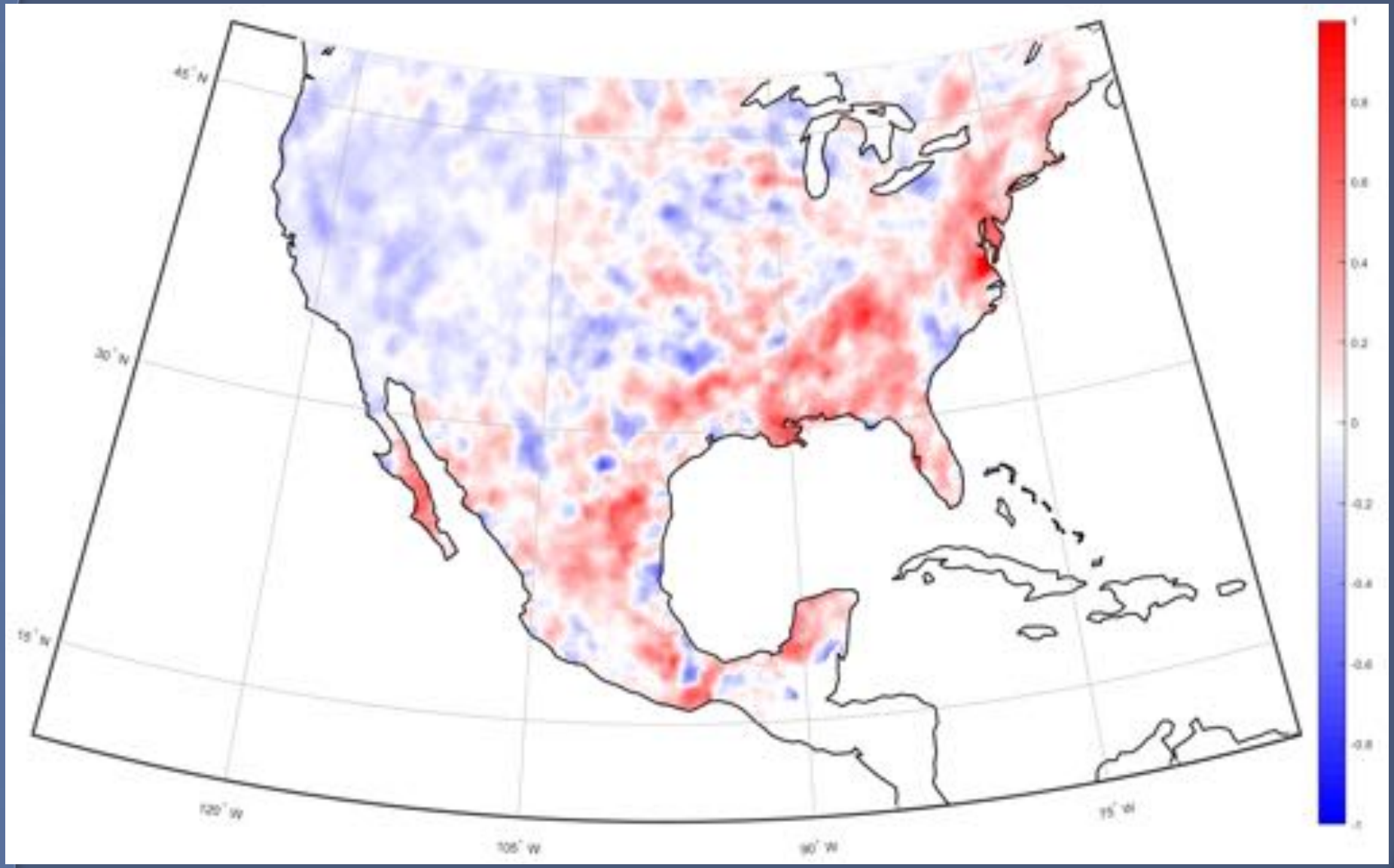
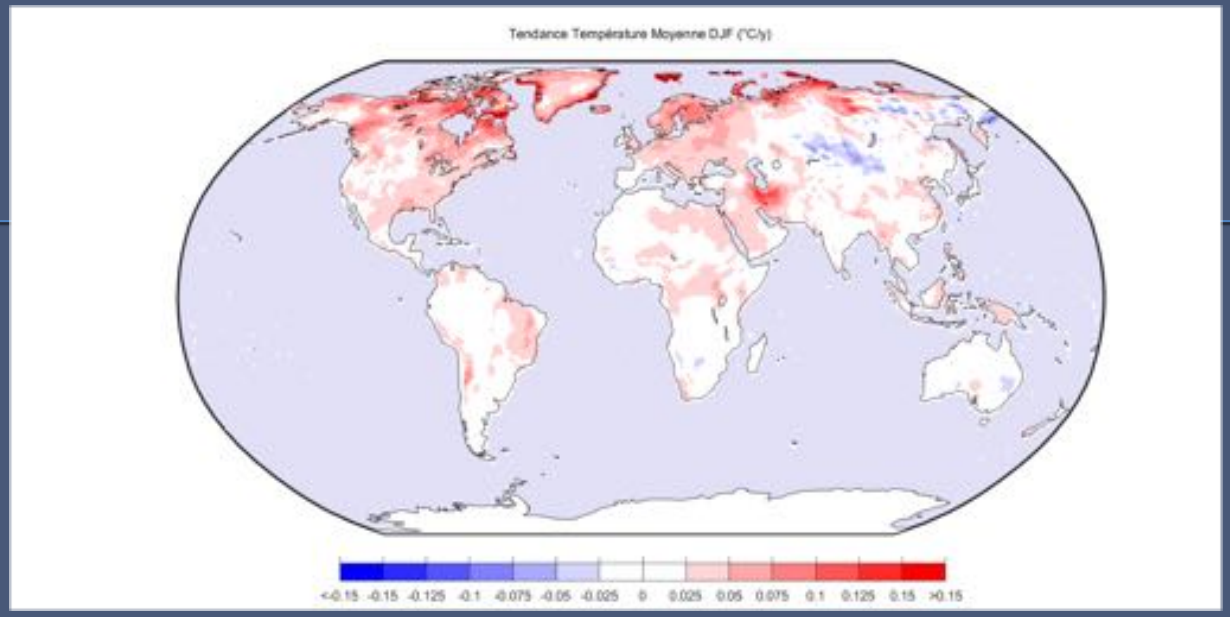
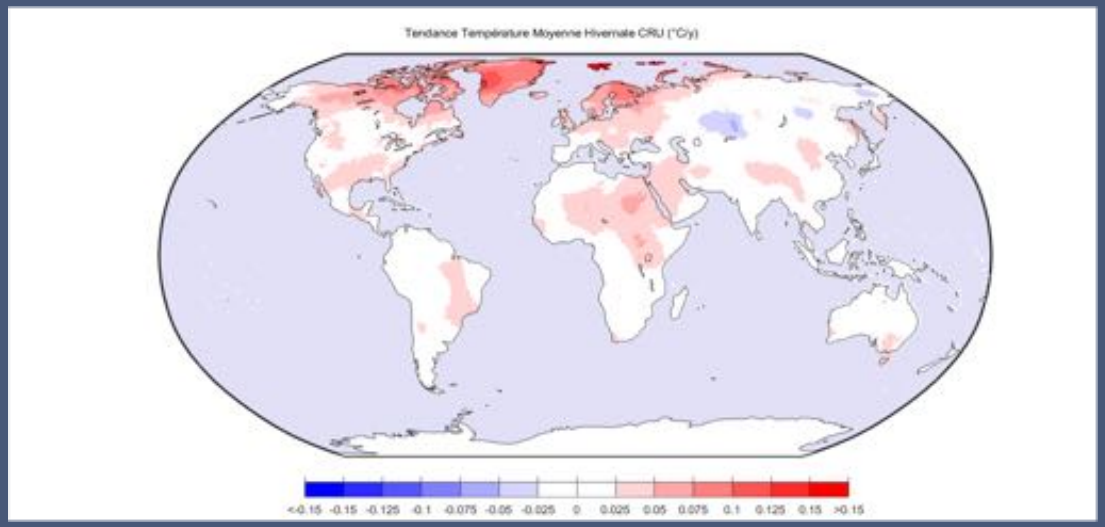
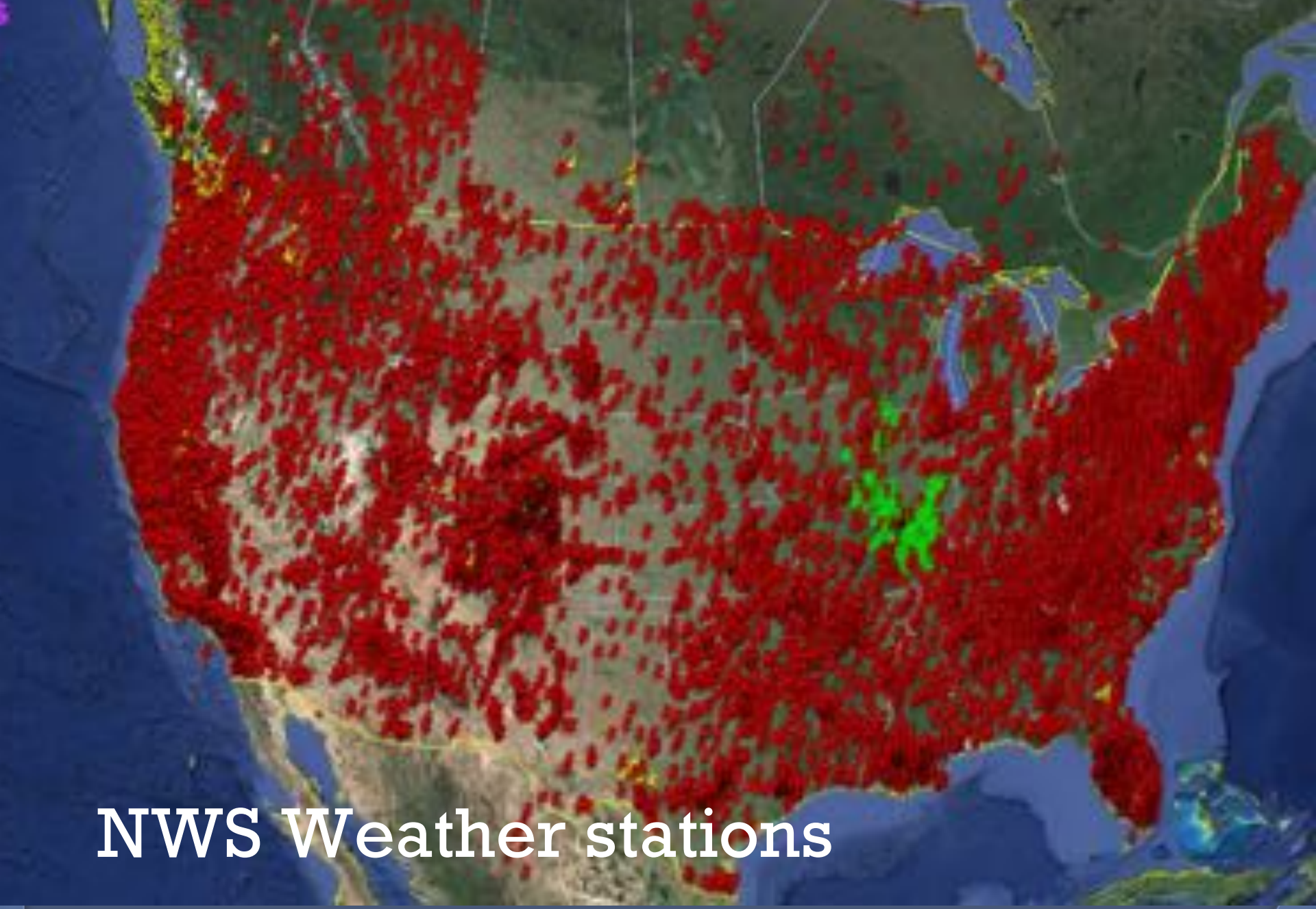
9x9
19x19


Ruissellement Totale Annuelle ERA-Interim (m)
0
0.5
1
1.5
2
2.5
3
>3

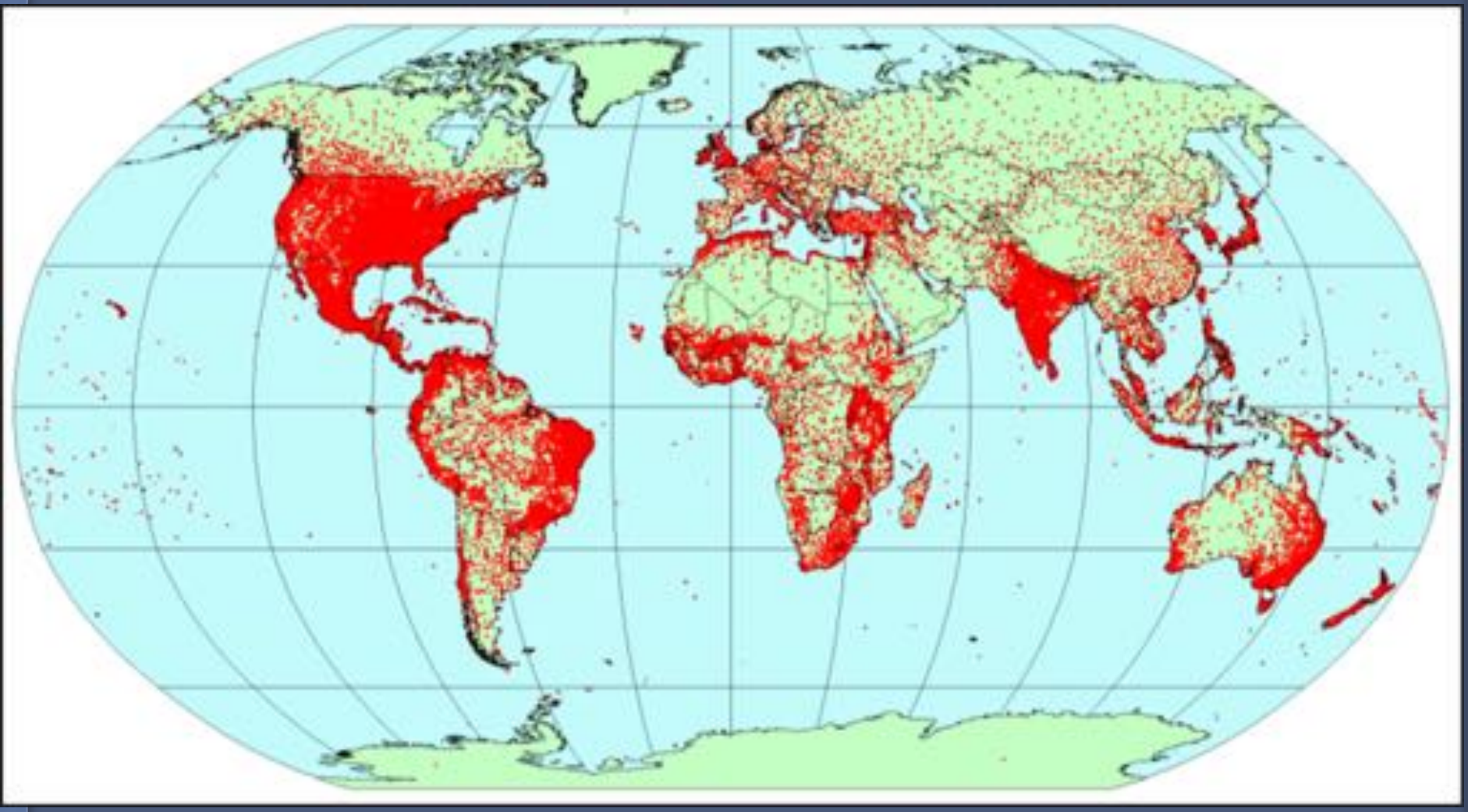

45° N
30° N
15° N
120° W
105° W
90° W
75° W
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1


Tendance Température Moyenne DJF (°C/y)
<-0.15 -0.15 -0.125 -0.1 -0.075 -0.05 -0.025 0 0.025 0.05 0.075 0.1 0.125 0.15 >0.15


Tendance Température Moyenne Hivernale CRU (°C/y)
<-0.15 -0.15 -0.125 -0.1 -0.075 -0.05 -0.025 0 0.025 0.05 0.075 0.1 0.125 0.15 >0.15



NWS Weather stations



Hijmans et al. (2005)