# INTENSE:
# INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes

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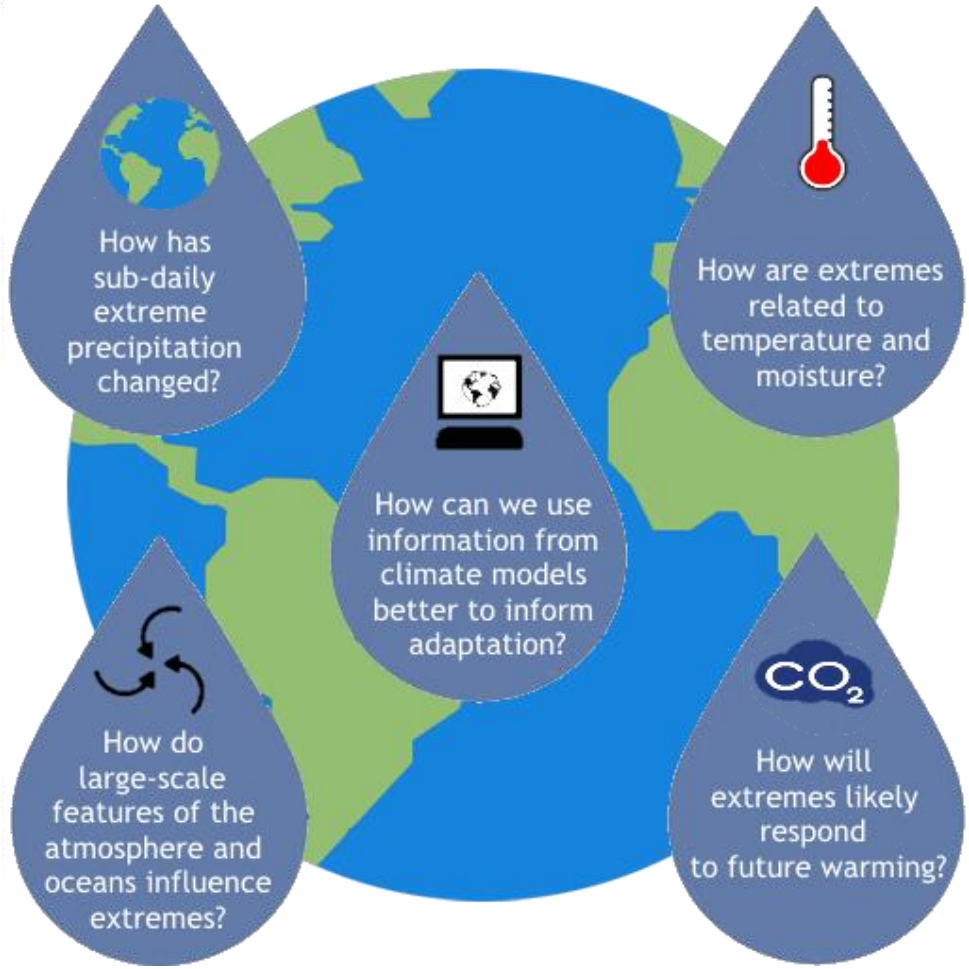
For more details visit: http://research.ncl.ac.uk/intense/

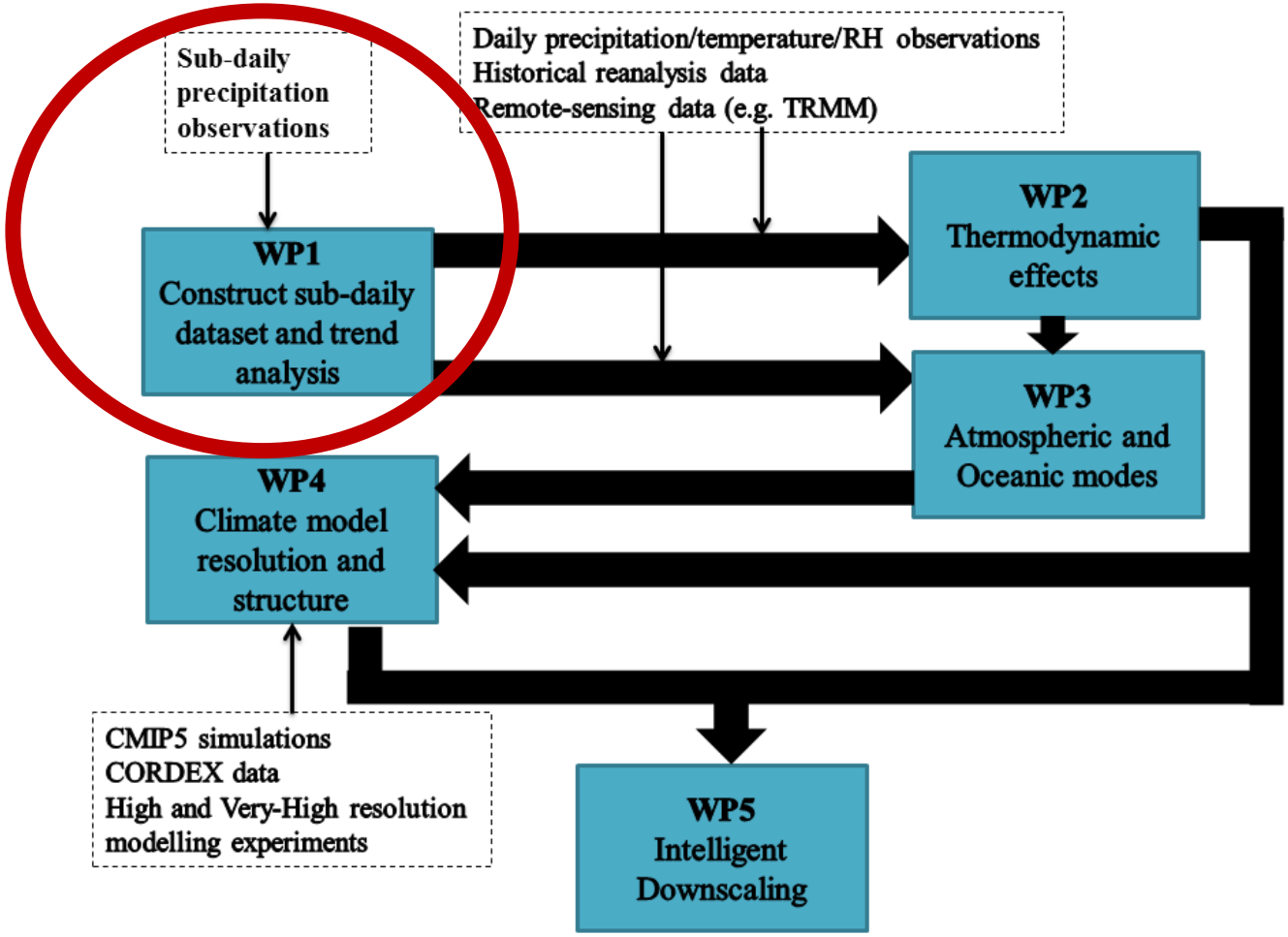
## Our main aim…

**INTENSE aims to understand the nature and drivers of extreme sub-daily rainfall**

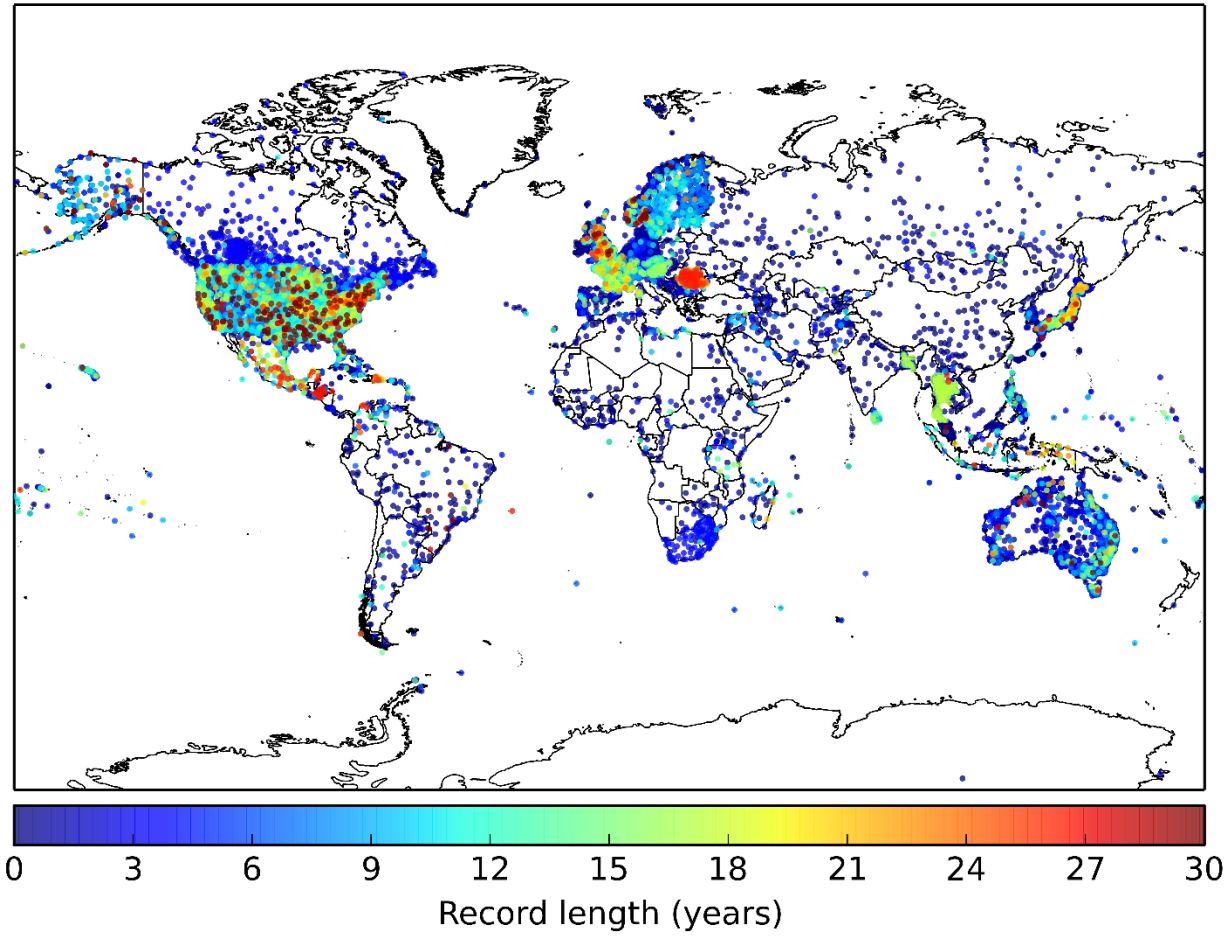
# INTENSE aims to answer these questions…



# …by following this work plan…



# So far, have collected data from ~25,000 stations…




- UK, US, Canada, Brazil, France, Germany, Spain, Portugal, Italy, Philippines, India, Norway, Sweden, The Netherlands, Finland, Australia, Kenya, Indonesia, Slovenia, Costa Rica, Argentina, Switzerland, Austria, Hungary, Panama, Ireland, Japan, Malaysia, Singapore,
- Global datasets: ISD

# Which we will quality control…

Newcastle University
UK | Malaysia | Singapore

**Site specific tests**

- rain gauge metadata,
- implausible large values (1h & 24h records)
- Monthly maximum 1-day precipitation
- long dry periods due to gauge malfunction
- accumulated totals (often at 9am)
- repeated values
- Change in resolution
- Duplicate records

**Nearby gauge comparisons**

- Statistical test of consistency with nearby gauges but problematical for extremes in summer/autumn therefore only partially applied

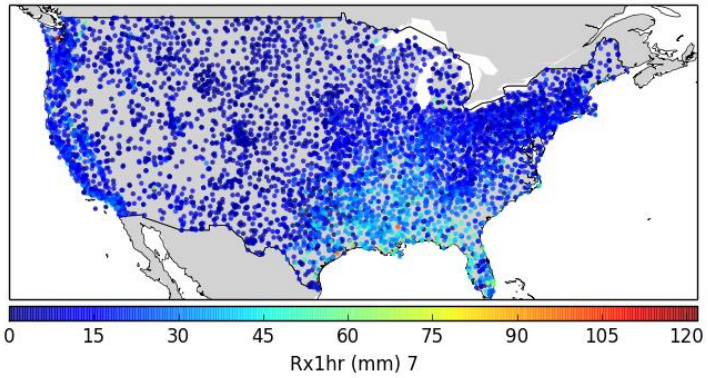
**Multiple QC flags applied to each hour for each test**

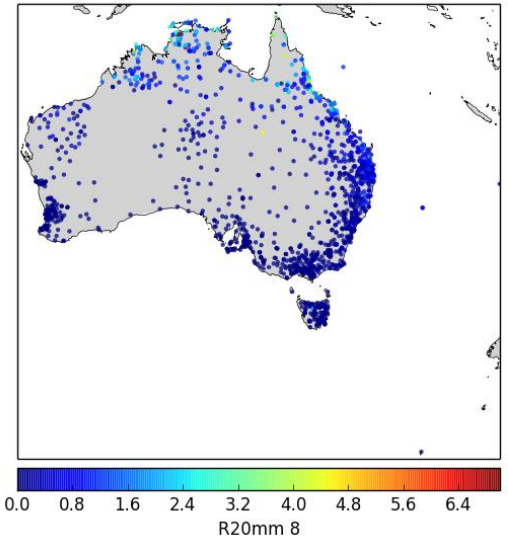
**Automated rule base to define exclusions**

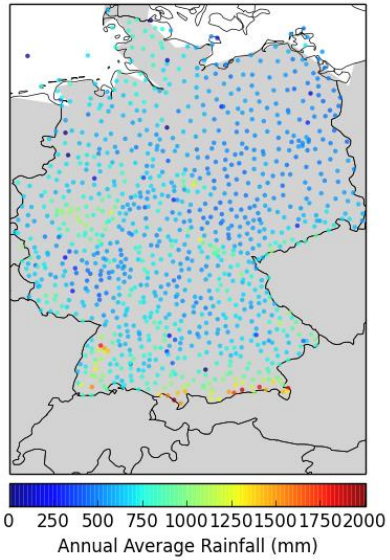
For example:

- all implausible hourly totals
- "large" hourly totals if in winter at 9am after ≥23 dry hours
- "large" hourly totals if after gauge non-operation (long dry spell)

# We want to use this data to calculate useful indices…



# The indices we have decided to calculate are…

**Monthly maximum indices**

- Monthly maximum 1-hour precipitation
- Monthly maximum 3-hour precipitation
- Monthly maximum 6-hour precipitation
- Percent of daily total that fell in the Monthly maximum 1-hour precipitation

**Diurnal cycle indices**

- Monthly likely wettest hour within a day
- Monthly likely driest hour within a day
- Dispersion around Monthly likely wettest hour within a day
- Simple hourly precipitation intensity index
- Maximum length of wet spell, maximum number of consecutive hours with RR ≥ 1mm

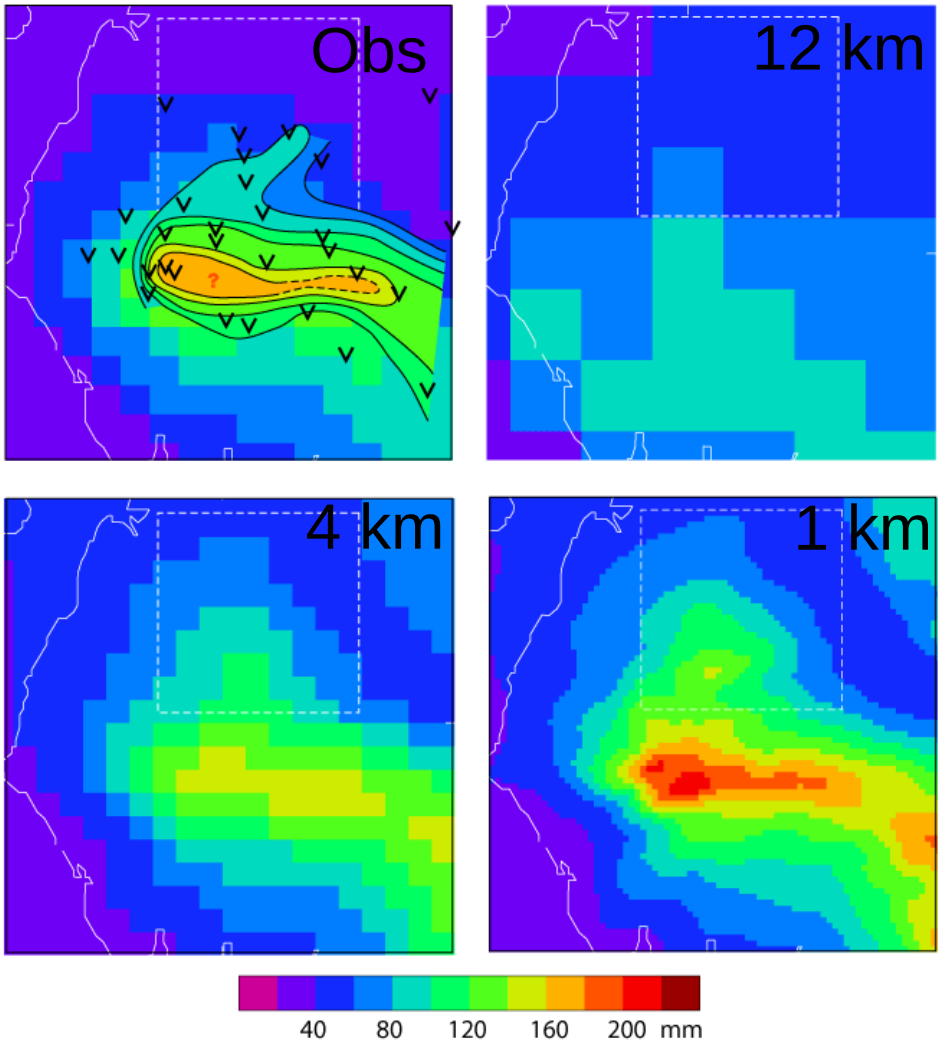
**Frequency/threshold indices**

- Monthly count of hours when hourly PRCP ≥ 10mm
- Monthly count of hours when hourly PRCP ≥ 20mm
- Annual count of hours when hourly PRCP ≥ nnmm, nn is a user defined threshold

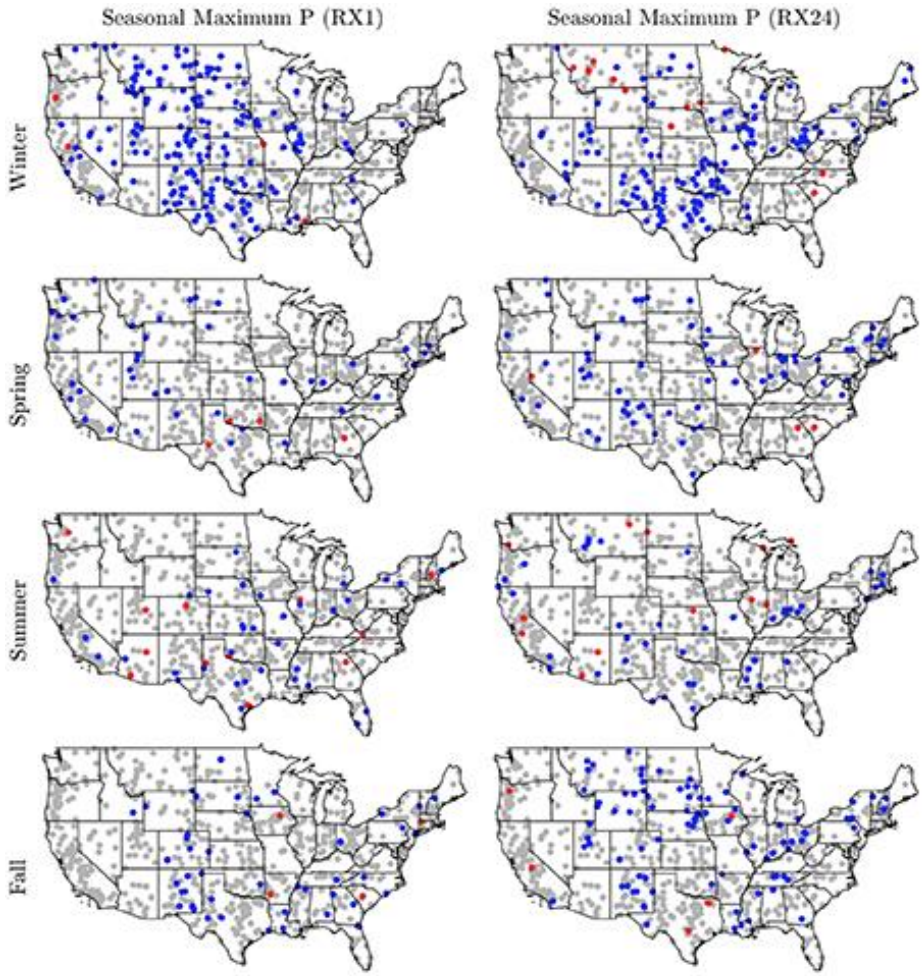
**General indices**

- Annual total precipitation in wet hours

# We will use the indices to improve/validate high res climate models…

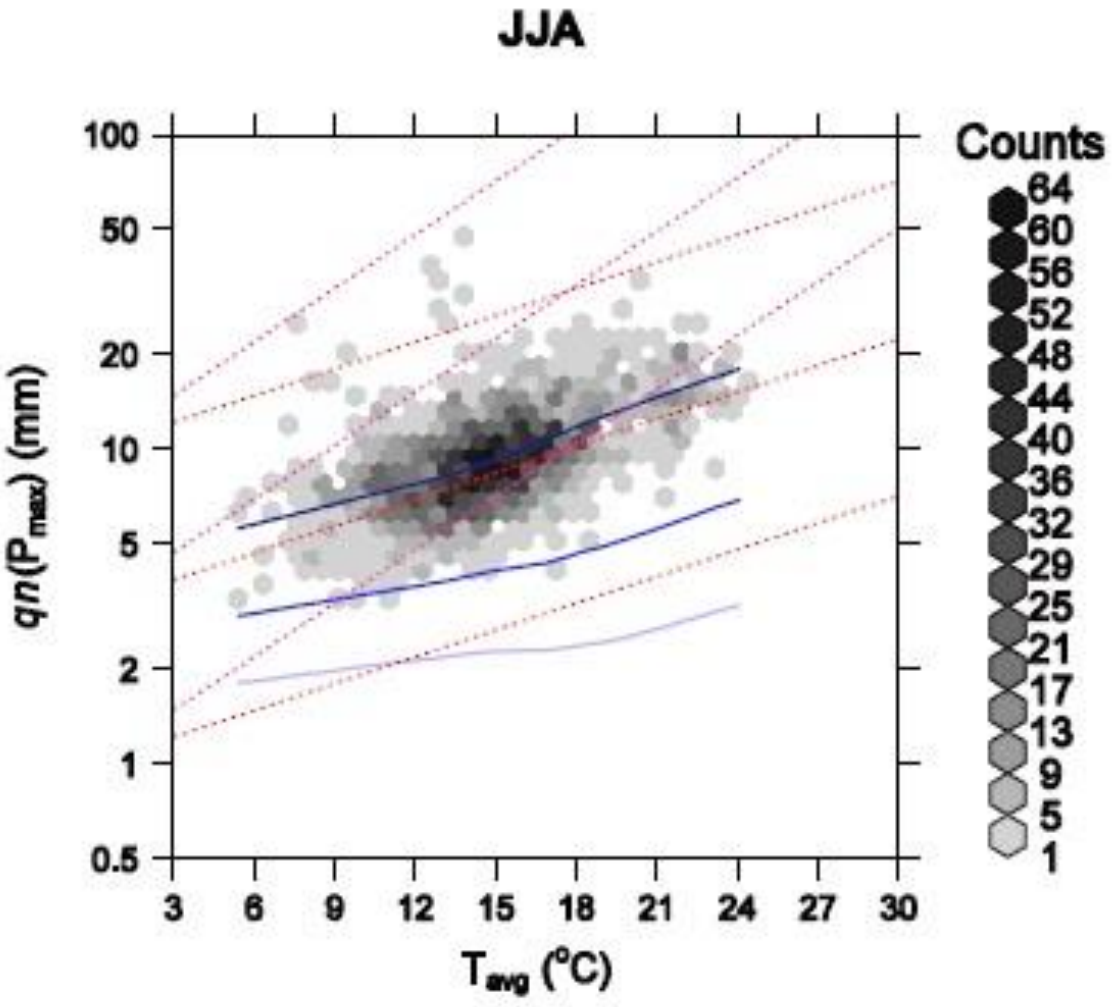


# We are also looking at trends in extreme rainfall…



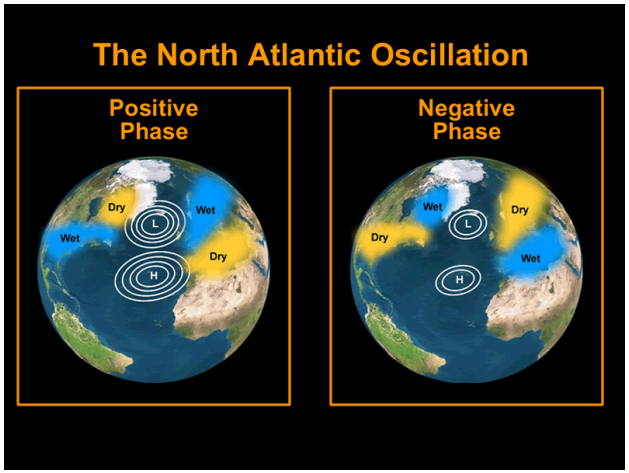

*The blue (red) dots indicate stations with statistically significant increasing (decreasing) trends at the 5% level according to the Mann-Kendall test. The grey circles refer to the location of the stations that did not experience statistically significant changes at the 5% level.*

# Temperature scaling of extreme precipitation…

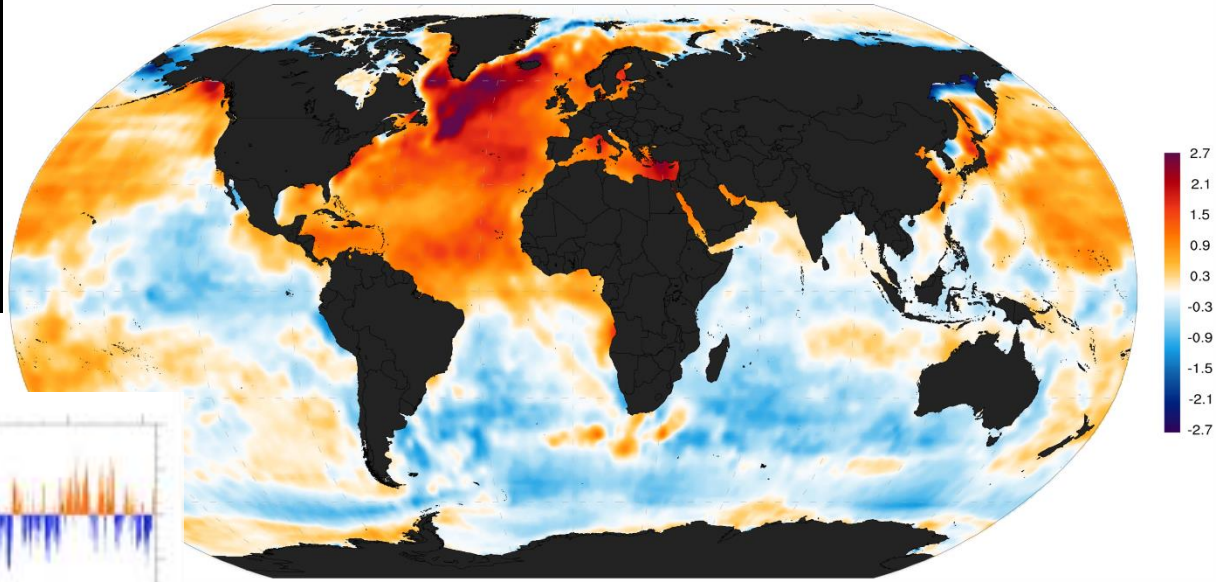


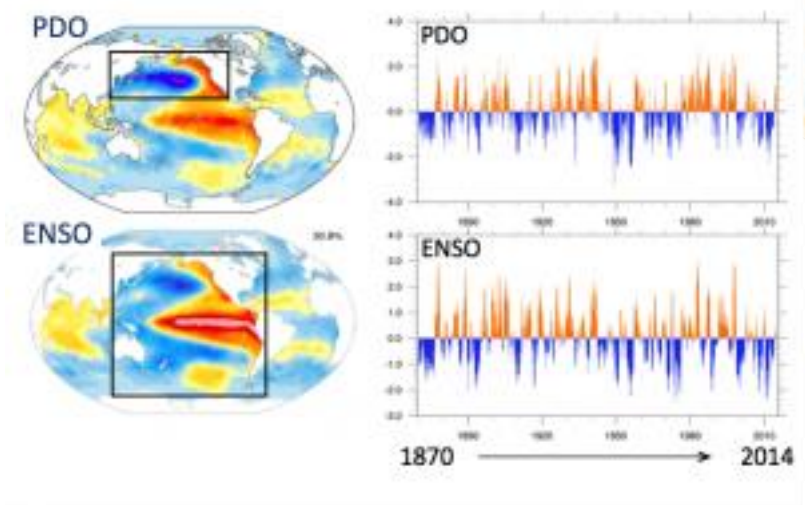

*The density plot shows the relationship between mean daily temperature - $T_{avg}$ and the* nth quantile of *maximum hourly rainfall for events binned by temperature - $qn(P_{max})$ for UK gauges (JJA). Blue lines indicate relationships for n=99, 75 and 50.*

# And the impact of large scale circulation patterns on extreme rainfall…




Atlantic Multi-decadal Oscillation(AMO)




Pacific decadal Oscillation (PDO)

# Monthly maximum indices…

- **Rx1hr,** *Monthly maximum 1-hour precipitation* :
  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. The maximum 1-hour value for period *j* is:
  $Rx1hr_j = \max ( RR_{ij})$

- **Rx3hr,** *Monthly maximum 3-hour precipitation* :
  Let $RR_{ij}$ be the 3 hour precipitation amount on 3 hour period *i* in period *j*. The maximum 3-hour value for period *j* is:
  $Rx3hr_j = \max ( RR_{ij})$

- **Rx6hr,** *Monthly maximum 6-hour precipitation* :
  Let $RR_{ij}$ be the 6 hour precipitation amount on 6 hour period *i* in period *j*. The maximum 6-hour value for period *j* is:
  $Rx6hr_j = \max ( RR_{ij})$

# Monthly maximum indices…

- **Rx1hrP,** *Percent of daily total that fell in the Monthly maximum 1-hour precipitation*:

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. Let *RD* be the total rainfall for the day containing $RR_{ij.}$:

  $$Rx1hr_jP = \frac{Rx1hrj}{RD}$$

# Diurnal cycle indices…

- **LWH,** *Monthly likely wettest hour within a day*:

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. Let $MWHI_h$ be the mean monthly wet hour intensity for hour *h where* $RR_{ij} \geq 0.2$mm

  $LWH = h \text{ where } max\ (MWHI_h)$

- **LDH,** *Monthly likely driest hour within a day* :

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. Let $MWHI_h$ be the mean monthly wet hour intensity for hour *h where* $RR_{ij} \geq 0.2$mm

  $LDH = h \text{ where } min\ (MWHI_h)$

- **DLWH,** *Dispersion around Monthly likely wettest hour within a day*:

  Let *DT* be the dispersion threshold. Let $MWHI_h$ be the mean monthly wet hour intensity for hour *h where* $RR_{ij} \geq 0.2$mm

  $DT = \frac{max(MWHIh) - min(MWHIh)}{2}$

  Count the number of hours where $MWHI_h > DT$

# Diurnal cycle indices…

- **SHII,** *Simple hourly precipitation intensity index* :

  Let $RR_{wj}$ be the hourly precipitation amount on wet hours, *w (RR ≥ 0.2mm)* in period *j*. If *W* represents number of wet hours in *j*, then:

$$SHII_j = \frac{\sum_{w=1}^{W} RR_{wj}}{W}$$

- **CWH,** *Maximum length of wet spell, maximum number of consecutive hours with RR ≥ 0.2mm*:

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. Count the largest number of consecutive hours where $RR_{ij} \geq 0.2mm$

# Frequency over threshold indices…

- **R10mm,** *Monthly count of hours when hourly PRCP ≥ 10mm*:

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. Count the number of hours where:

  $RR_{ij} \geq 10mm$

- **R20mm,** *Monthly count of hours when hourly PRCP ≥ 20mm*:

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. Count the number of hours where:

  $RR_{ij} \geq 20mm$

- **Rnnmm,** *Annual count of hours when hourly PRCP ≥ nnmm, nn is a user defined threshold*:

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j* . Count the number of hours where:

  $RR_{ij} \geq nnmm$

# General indices…

- **PRCPTOT,** *Annual total precipitation in wet hours* :

  Let $RR_{ij}$ be the hourly precipitation amount on hour *i* in period *j*. If *i* represents the number of hours in *j*, then:

$$PRCPTOT_j = \sum_{i=1}^{I} RR_{ij}$$

# Ideas?

- We copied the naming convention of the ETCCDI climate change indices, but recognise that they need to be different!
- Any advice on standards for calculating indices (e.g. % missing data, length of record)
- Any thoughts on other useful indices to calculate?
- Any questions?