8th GEWEX Open Science Conference
6-11 May 2018, Canmore, Canada

Global high-resolution observational rainfall data set for convection-permitting model evaluation

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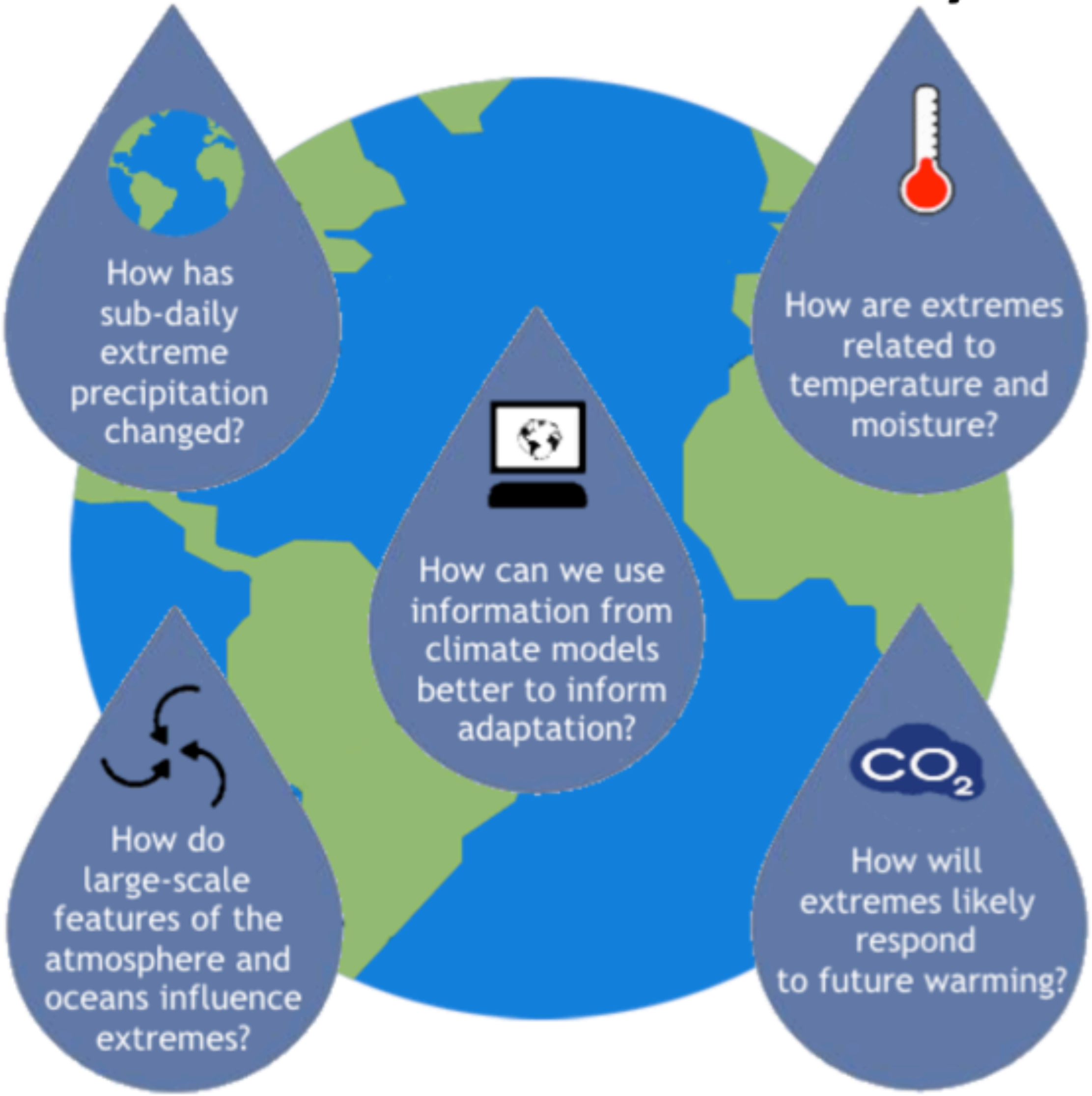
INTENSE aims to understand the nature and drivers of extreme sub-daily rainfall



- Lizzie Kendon and team, Robert Dunn, Nigel Roberts (UK Met Office)
- Stephen Blenkinsop, Steven Chan, Liz Lewis, Selma Guerreiro, Xiao-Feng Li (Newcastle University)
- INTENSE partners (especially Geert Lenderink, Seth Westra, Christoph Schär, Nicolina Ban, Jason Evans, Lisa Alexander, Renaud Barbero, Mari Tye, Andy Prein)

INTENSE: INTElligent use of climate models for adaptatioN to non-Stationary hydrological Extremes – also GEWEX GHP cross-cut on sub-daily precipitation

Global Energy and Water cycle EXchanges project

Developing consistent approach for quality control, including data homogenisation

Developing a comprehensive international repository for sub-daily precipitation data

GEWEX Cross-cut sub-daily rainfall (INTENSE)

Analysis of new observed dataset – indices, trends and process mechanisms

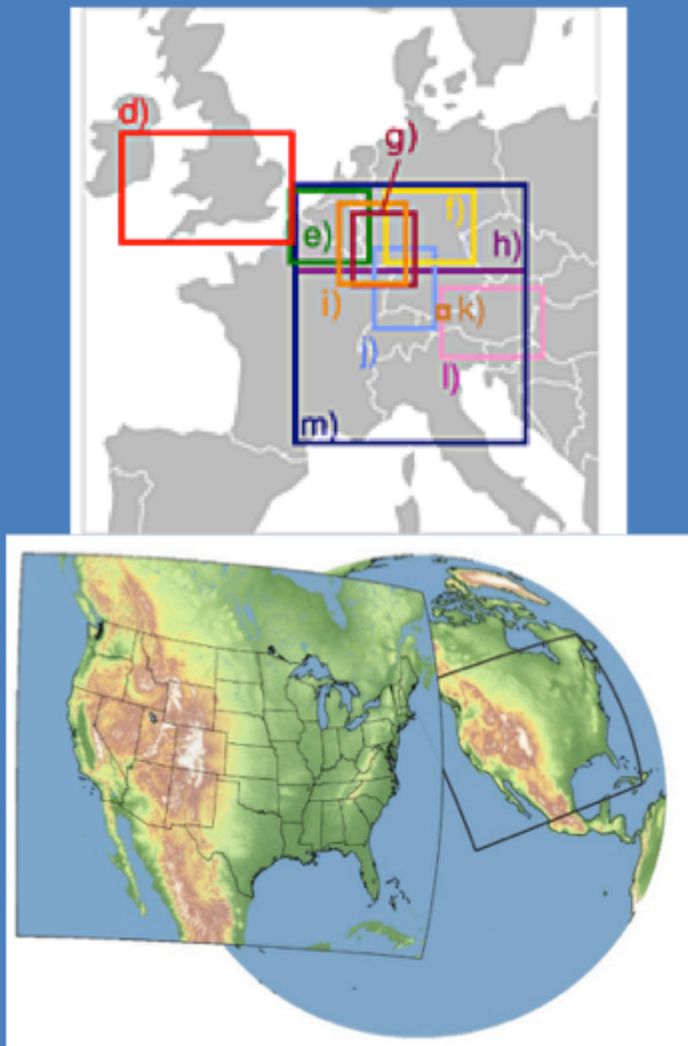
CPM model intercomparisons using common diagnostics, e.g. CORDEX Flagship Pilot Study

State of the science on:

(a) sub-daily extremes: *Westra et al. 2014, Revs. Geophys.*

(b) CPM projections: *Kendon et al. 2017, BAMS.*

Future change: Convection Permitting Models (CPMs)

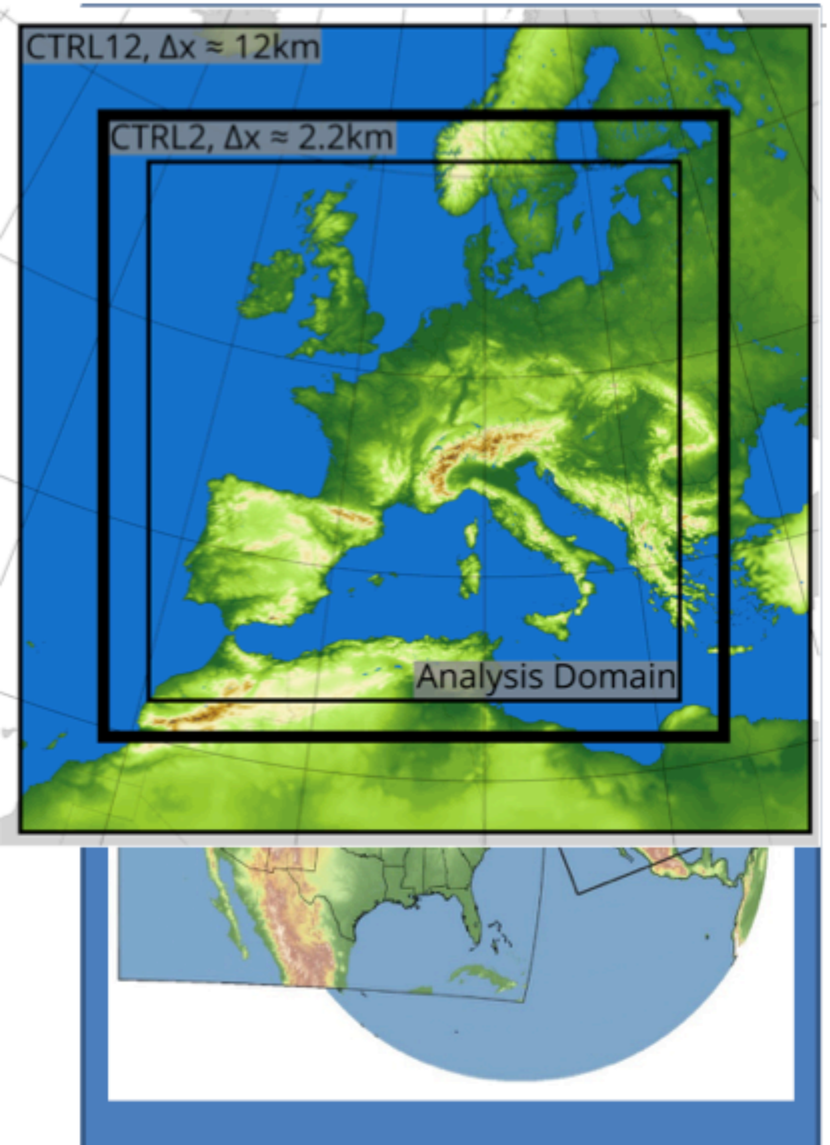


CPM grid spacing ≤ 4 km
Explicitly represent convection without need for parameterisation scheme.

Many studies including CORDEX flagship pilot study – first comparisons of CPM over Alps

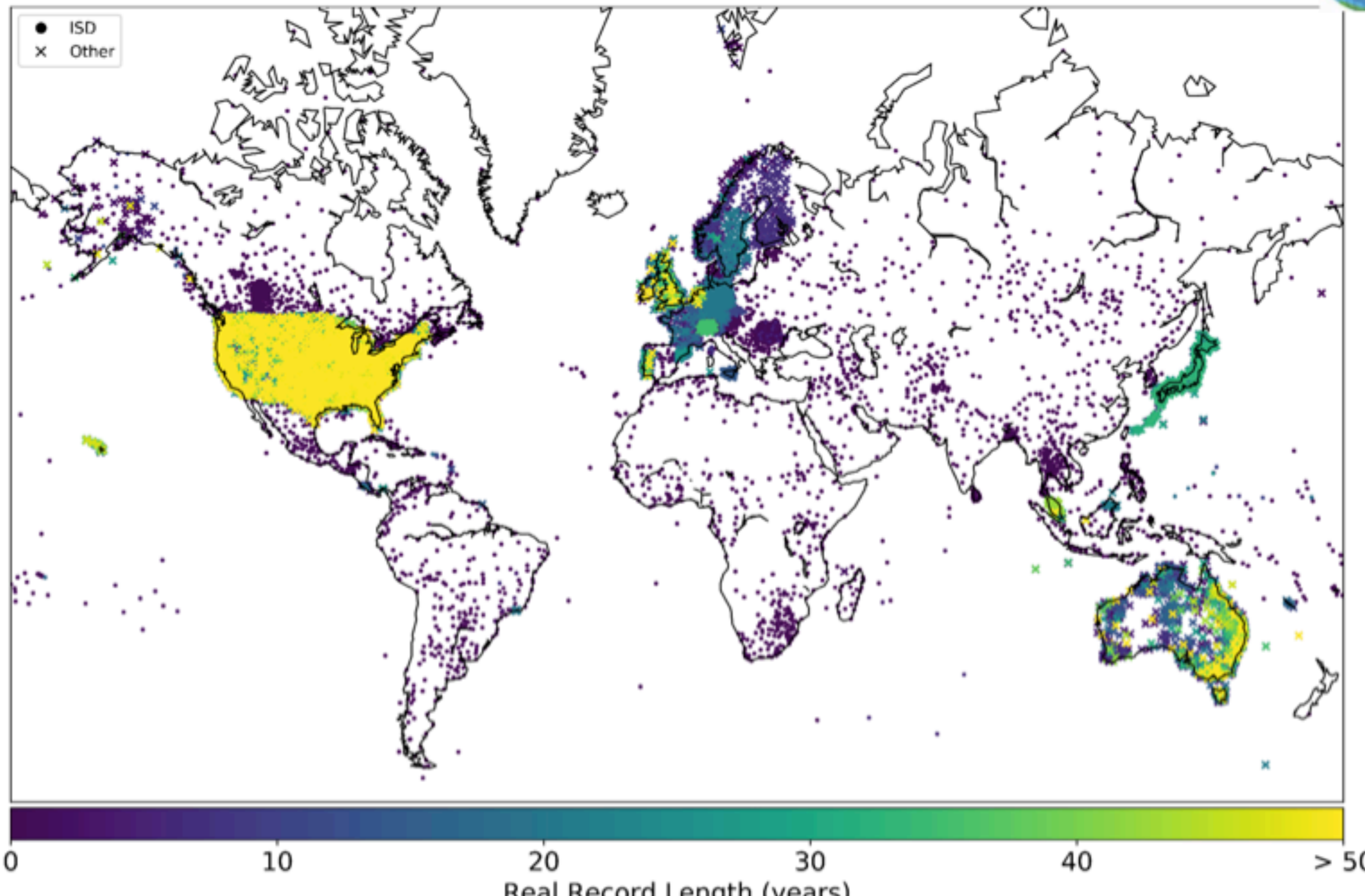
Needed for robust projections of change to duration and intensity of summer convective rainfall - *Kendon et al, BAMS, 2017*

Future change: Convection Permitting Models (CPMs)



The Met Office (UKMO) and ETH Zurich (ETH) are conducting pan-European 2.2km convection-permitting regional climate simulations, and contributing to the CORDEX flagship pilot study. Separate 12-km parameterised convection simulations are also carried out. None of the simulations use nudging.

So far, collected hourly data from ~25,000 stations…



National datasets: 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, Dominica, Trinidad & Tobago

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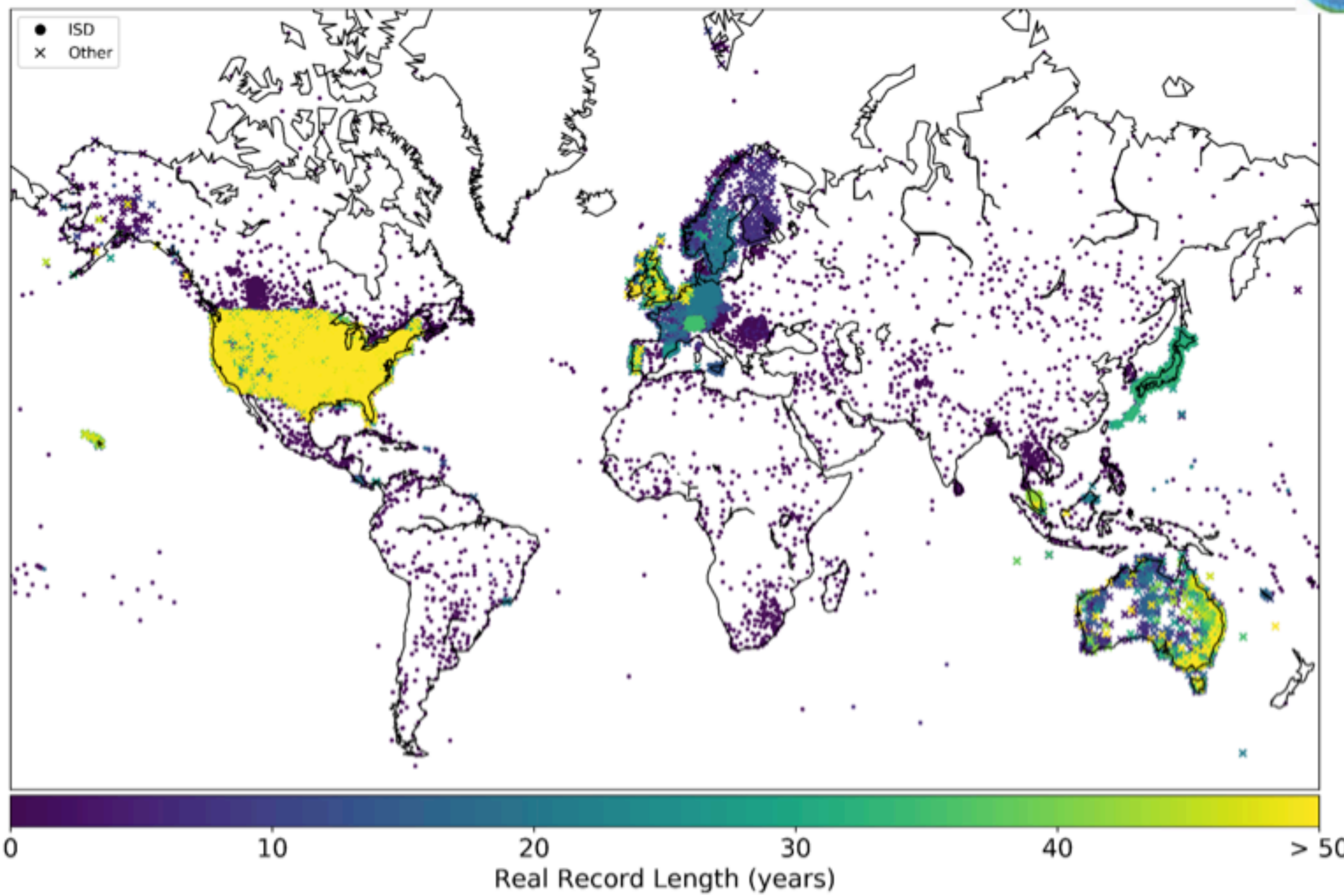
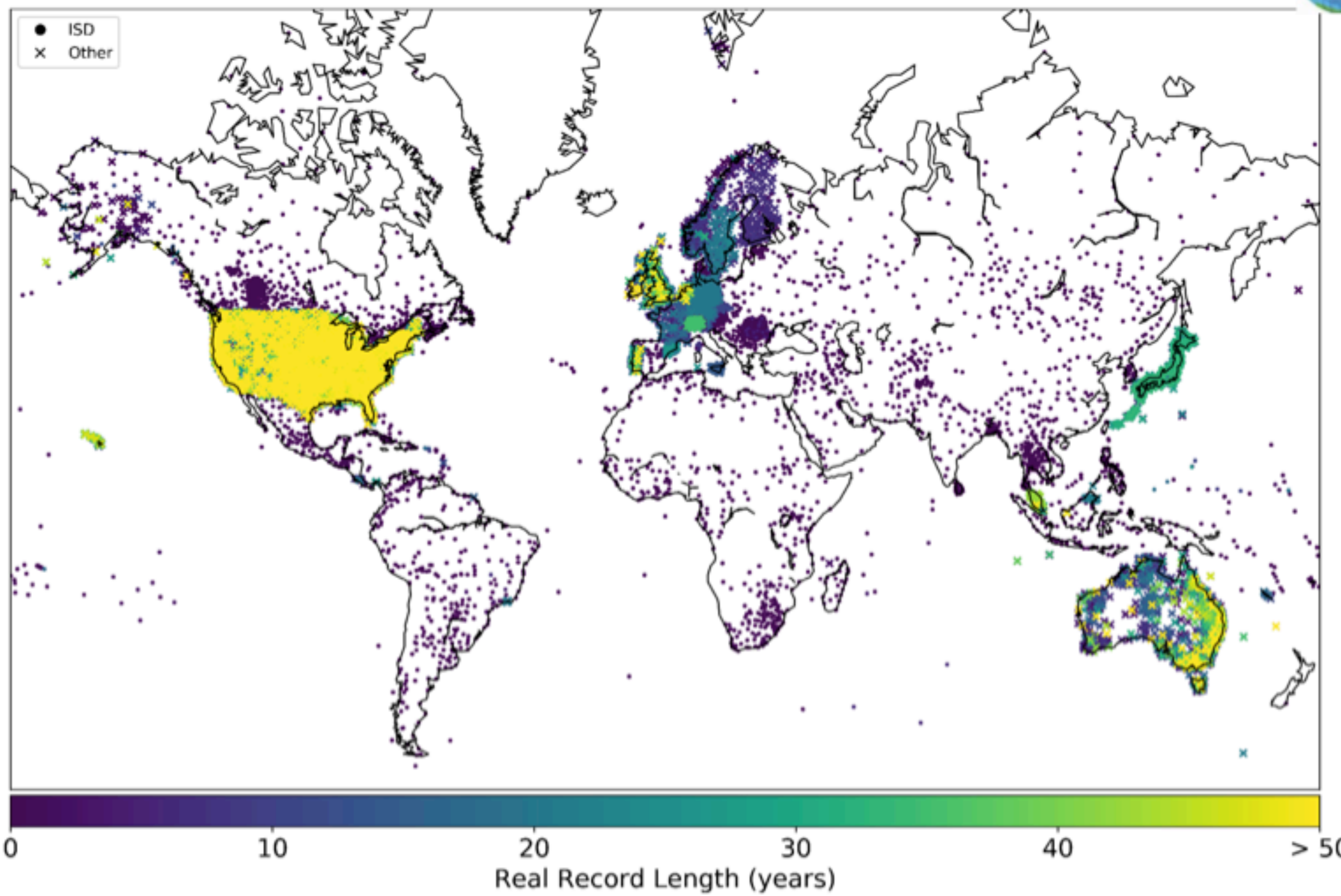


<u>Global dataset:</u> HadISD, approx. 10,000 stations (varying data quality, more useful data at 3h and 6h), freely available <u>sub-daily</u> precipitation data. Plus access to additional datasets (i.e. E Europe, China) to calculate indices.

So far, collected hourly data from ~25,000 stations…



See talk by Liz Lewis on Wed at 13:30: Creating a global sub-daily precipitation data set in **S4. Sub-daily Rainfall Extremes**

1. Quality control of hourly data
(Blenkinsop et al, 2017; IJC & Lewis et al., submitted)

2. Adapt checks to work globally using CLIMDEX daily indices and DWD daily dataset (Lewis et al, in prep)

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)

Produce new sub-daily precipitation indices from new global dataset

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Monthly maximum indices

- **Rx1hr** Monthly maximum 1-hour precipitation
- **Rx3hr** Monthly maximum 3-hour precipitation
- **Rx6hr** Monthly maximum 6-hour precipitation
- **Rx1hrP** Percent of daily total that fell in the Monthly maximum 1-hour precipitation

Diurnal cycle indices

- **LW1H** Monthly likely wettest hour within a day
- **LD1H** Monthly likely driest hour within a day
- **DLW1H** Dispersion around Monthly likely wettest hour within a day
- **S1HII** Simple hourly precipitation intensity index
- **CW1H** Maximum length of wet spell

Frequency/threshold indices

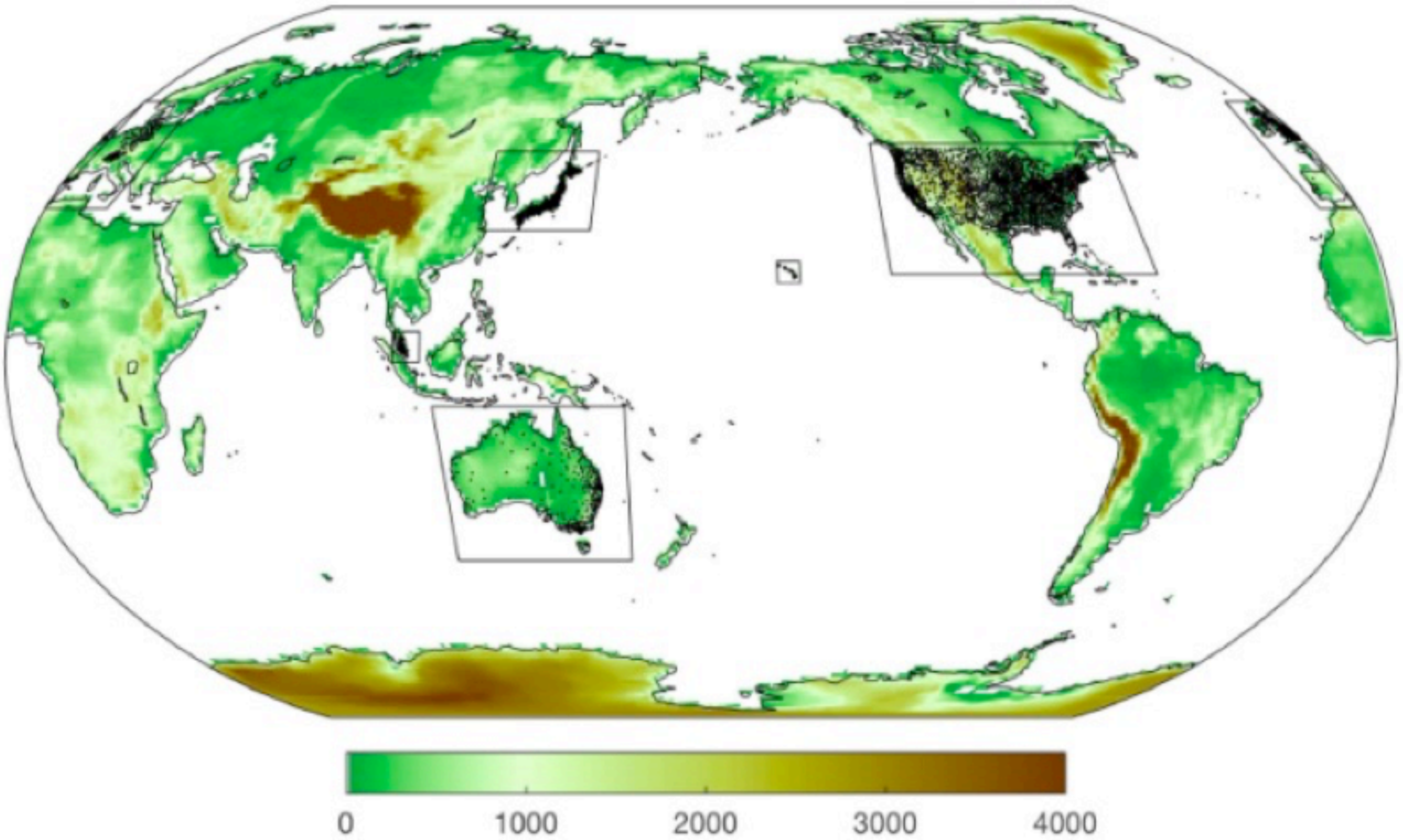
- **R10mm1hr** Monthly count of hours when PRCP ≥ 10mm
- **R20mm1hr** Monthly count of hours when PRCP ≥ 20mm
- **Rxmm1hr** Annual count of hours when PRCP ≥ nnmm, nn is a user defined threshold

General indices

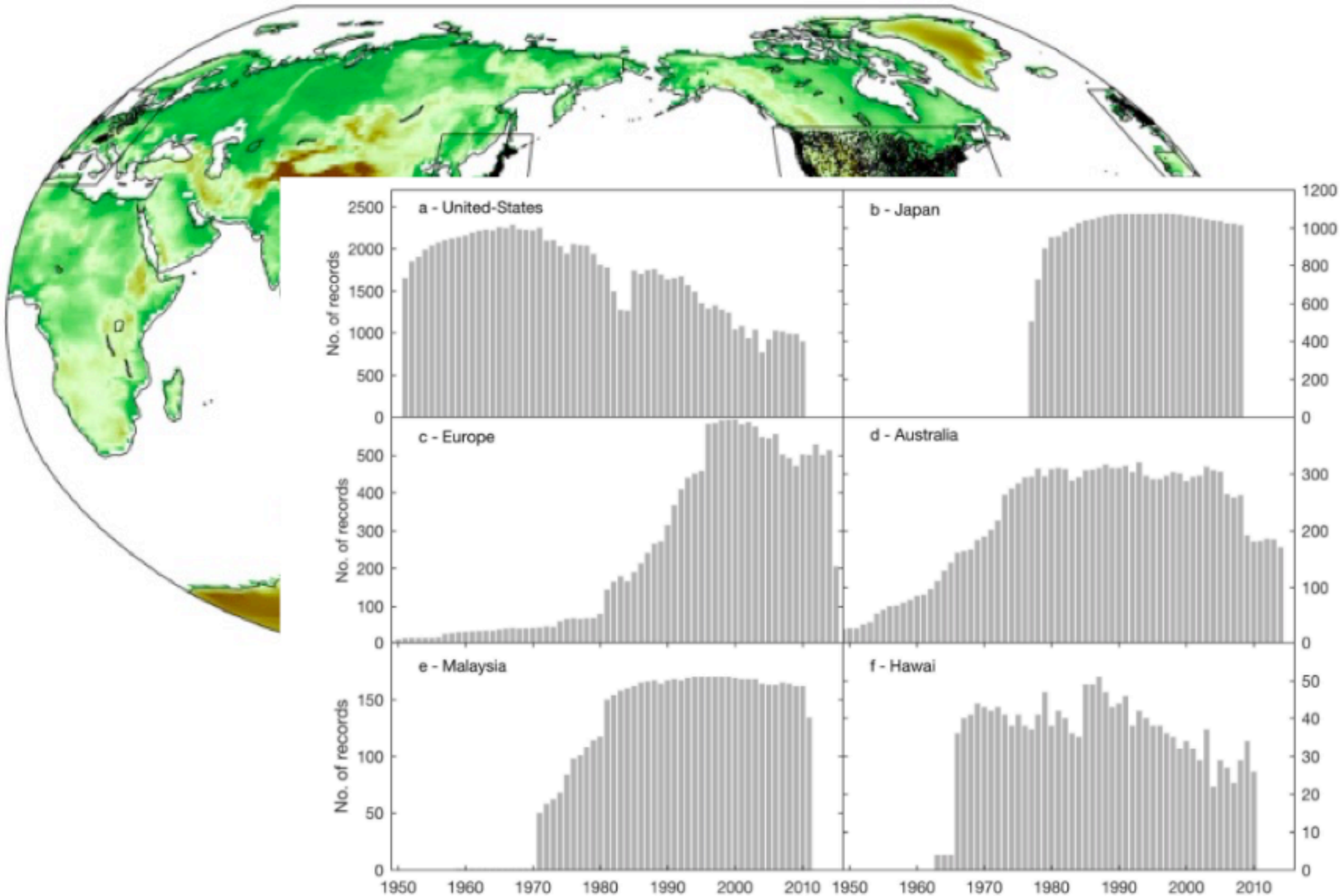
- **PRCPTOT1hr** Annual total precipitation in wet hours

Lewis et al, in prep

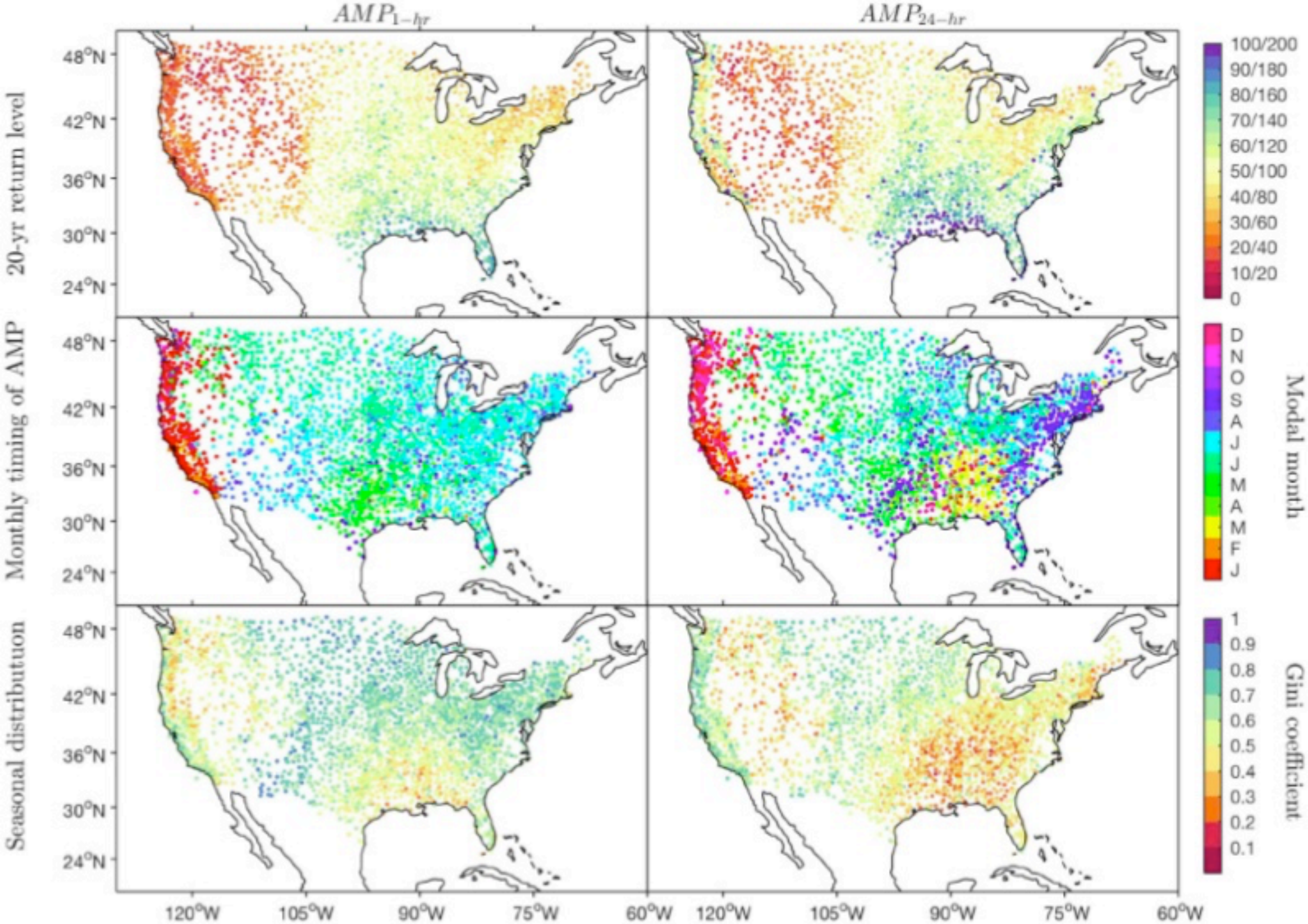
Assessing hourly rainfall climatology



Assessing hourly rainfall climatology

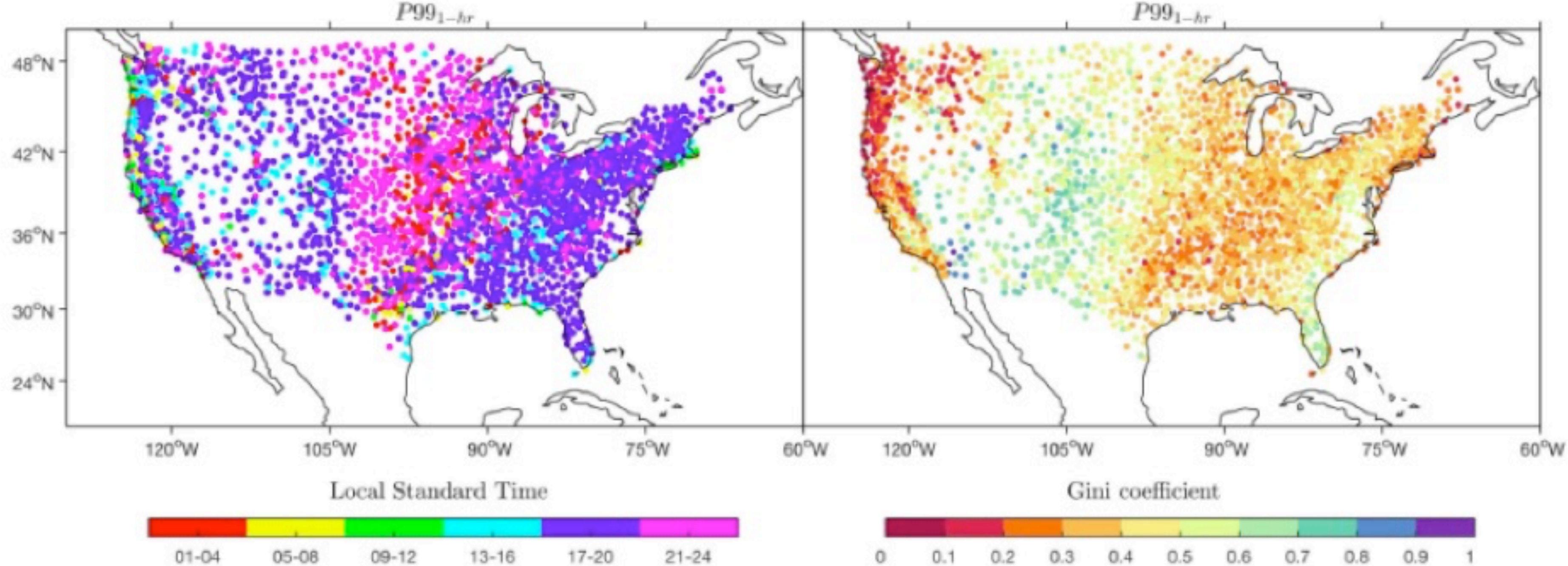


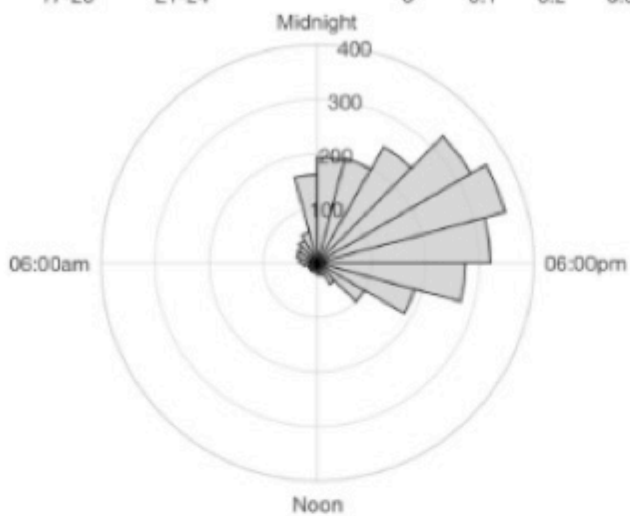
Example metrics: 20yr RL, monthly timing



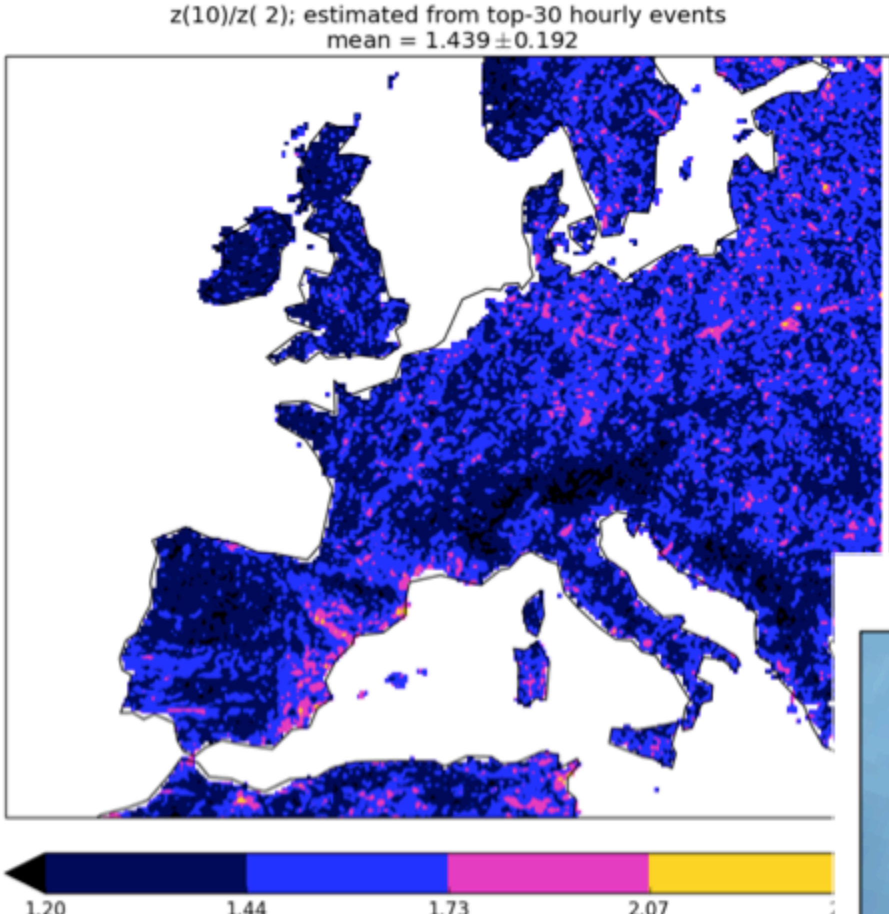
Barbero et al, in prep

Example metrics: diurnal cycle



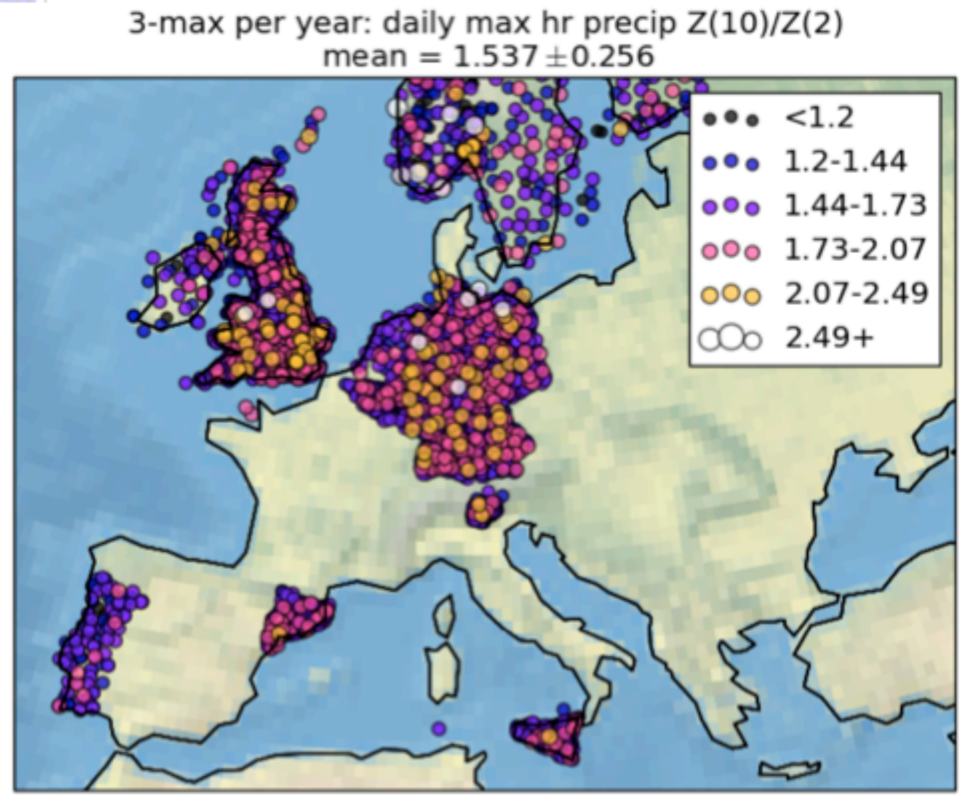


Barbero et al, in prep



Modelled and observed 10y growth factors from POT3 series

Hindcast has a lower 10-y growth factor for hourly extremes than the gauges



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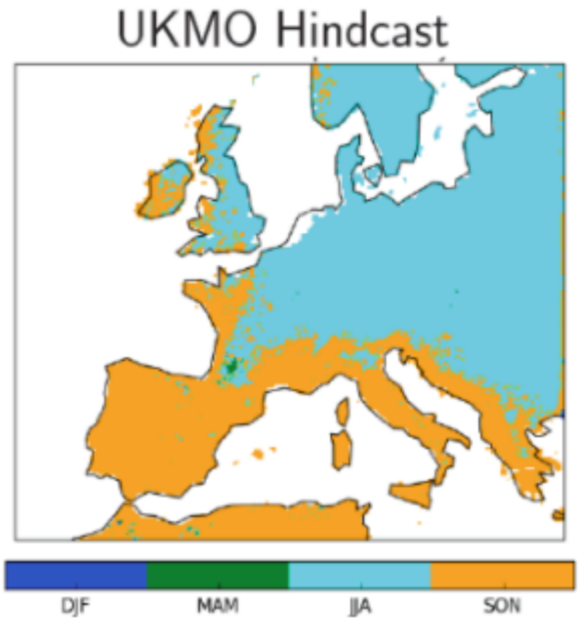
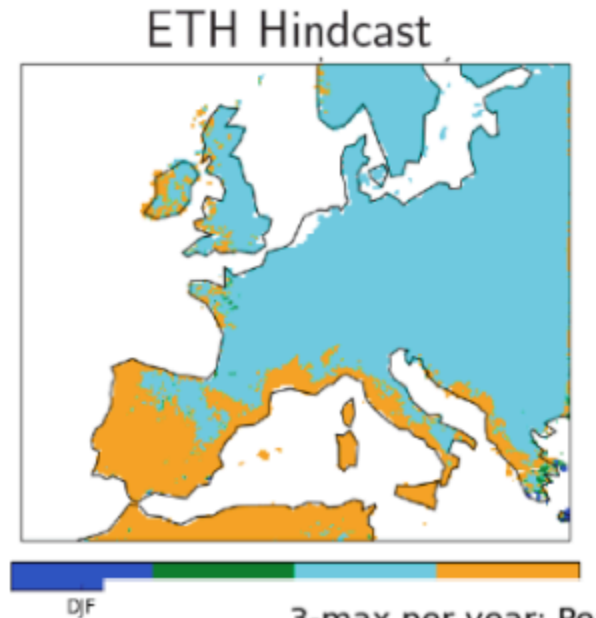
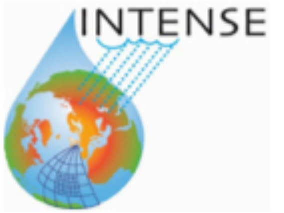
Chan et al, in prep

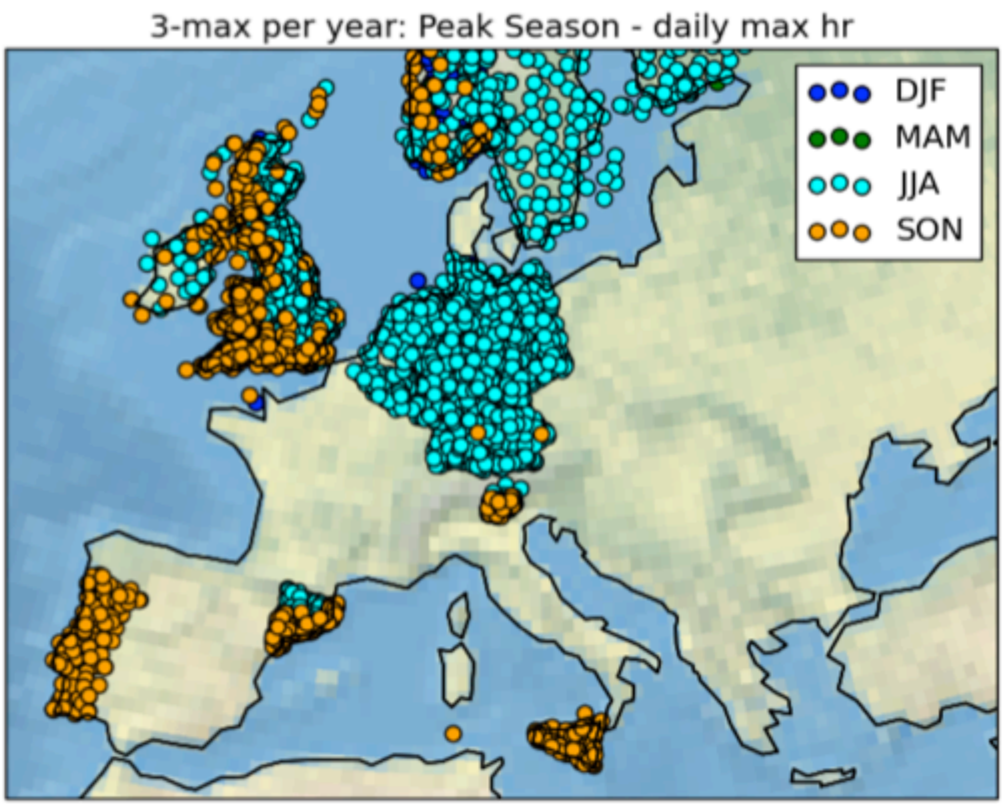






Peak season for POT3 series

Hindcast seasonality matches well with that of hourly extremes from gauges



Chan et al, in prep

Summary

<u>**We have collected a global sub-daily precipitation dataset, and applied automated quality control**</u>

- We have ~16,000 gauge records > 1yr data, ~11,000 > 10yr data
- We will develop sub-daily extreme precipitation indices at the station-level and gridded indices to be hosted on the DWD and CLIMDEX websites (end 2018)
- We will develop a set of climate model evaluation metrics/indices for assessment of high resolution simulations (end 2018) and satellite data products – we would appreciate input on metrics needed – should this be hosted alongside indices or elsewhere?
- We are testing model evaluation metrics using European-scale simulations but happy to provide metrics to additional modelling groups for testing and use in model evaluation.
- DWD will host the hourly gauge data (most not public) and an associated website with metadata (in progress).

There is great potential for further analysis and development of scientific studies using this new dataset

To find out more about INTENSE:

https://research.ncl.ac.uk/intense/

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INTENSE publications (2018)

- Barbero, R., Westra, S., Lenderink, G., Fowler, H.J. 2018: Temperature-extreme precipitation scaling: a two-way causality? **International Journal of Climatology**, DOI: 10.1002/joc.5370.
- Barbero, R., Abatzoglou, J., Fowler, H.J. 2018: Contribution of large-scale midlatitude disturbances to hourly precipitation extremes in the United States. **Climate Dynamics**, DOI: 10.1007/s00382-018-4123-5.
- Chan, S.C., Kendon, E.J., Roberts, N.M., Blenkinsop, S., Fowler. H.J. 2018. Synoptic predictors for extreme hourly precipitation events in convection-permitting climate simulations. **Journal of Climate**, 31(6), doi: 10.1175/JCLI-D-17-0404.1.
- Chan, S.C., Kahana, R., Kendon, E.J., Fowler, H.J. 2018. Projected changes in extreme precipitation over Scotland and Northern England using a high-resolution regional climate model. **Climate Dynamics**, DOI: 0.1007/s00382-018-4096-4.
- Kendon, E.J., Blenkinsop, S., Fowler, H.J. 2018: When will we detect changes in short-duration precipitation extremes? **Journal of Climate**, DOI: 10.1175/JCLI-D-17-0435.1.
- Forestieri, A., Lo Conti, F., Blenkinsop, S., Fowler, H.J., Noto, L.V. 2018: Regional frequency analysis of extreme rainfall based on an objective data analysis. Application to Sicily (Italy). **International Journal of Climatology,** DOI: 10.1002/joc.5400.
- Forestieri, A., Arnone, E., Blenkinsop, S., Candela, A., Fowler, H.J., Noto, L.V. 2018: The impact of climate change on extreme precipitation in Sicily, Italy. **Hydrological Processes,** DOI: 10.1002/hyp.11421.

INTENSE publications (2016-17)

- Lochbihler, K., G. Lenderink, and A. P. Siebesma (2017), The spatial extent of rainfall events and its relation to precipitation scaling, **Geophys. Res. Lett.,** 44, doi:10.1002/2017GL074857.
- Lenderink, G., Fowler, H.J. 2017. Understanding Precipitation Extremes. **Nature Climate Change**, 7, 391–393, doi:10.1038/nclimate3305.
- Lenderink, G., Barbero, R., Loriaux, J.M., Fowler, H.J. 2017. Super Clausius-Clapeyron scaling of extreme hourly precipitation and its relation to large-scale atmospheric conditions. **Journal of Climate**, DOI: 10.1175/JCLI-D-16-0808.1
- Barbero, R., Fowler, H.J., Lenderink, G., Blenkinsop, S. 2017. Is the intensification of precipitation extremes with global warming better detected at hourly than daily resolutions? **Geophysical Research Letters**, DOI: 10.1002/2016GL071917
- Chan, S.C., Kendon, E.J., Roberts, N.M., Fowler. H.J., Blenkinsop, S. 2016. The characteristics of summer sub-hourly rainfall in a high-resolution convective permitting model. **Environmental Research Letters**, 11, 094024, doi:10.1088/1748-9326/11/9/094024.
- Kendon, E.J., Ban, N., Roberts, N.M., Roberts, M.J., Chan, S. Fowler, H.J., Fosser, G., Evans, J. and Wilkinson, J. 2016. Do convection-permitting regional climate models improve projections of future precipitation change? **Bull. Am. Meteorol. Soc.**, DOI: 10.1175/BAMS-D-15-0004.1.
- Blenkinsop, S., Lewis, E., Chan, S., Fowler, H.J. 2016. Quality control of an hourly rainfall dataset and climatology of extremes for the UK. **International Journal of Climatology**, DOI: 10.1002/joc.4735.
- Chan, S.C., Kendon, E.J., Roberts, N.M., Fowler, H.J., Blenkinsop, S. 2016: Downturn in scaling of UK extreme rainfall with temperature for future hottest days. **Nature Geoscience**, 9, 24–28, DOI: 10.1038/NGEO2596.

INTENSE publications (2014-15)

- Hegerl, G.C, Black, E., Allan, R.P., Ingram, W.J., Polson, D., Trenberth, K.E., Chadwick, R.S., Arkin, P.A., Sarojini, B.B., Becker, A., Dai, A., Durack, P.J., Easterling, D., Fowler, H.J., Kendon, E.J., Huffman, G.J., Liu, C., Marsh, R., New, M., Osborn, T.J., Skliris, N., Stott, P.A., Vidale, P.L., Wijffels, S.E., Wilcox, L.J., Willett, K.M., Zhang, X. 2015: Challenges in Quantifying Changes in the Global Water Cycle. **Bulletin of the American Meteorological Society,** 96, 1097–1115, doi: http://dx.doi.org/10.1175/BAMS-D-13-00212.1
- Blenkinsop, S, Chan, S, Kendon, E.J, Roberts, N.M., Fowler, H.J. 2015. Temperature influences on intense UK hourly precipitation and dependency on large-scale circulation. **Environmental Research Letters**, 10, 054021, doi:10.1088/1748-9326/10/5/054021.
- Westra, S., Fowler, H.J., Evans, J.P., Alexander, L.V., Berg, P., Johnson, F., Kendon, E.J., Lenderink, G. and Roberts, N.M. 2014. Future changes to the intensity and frequency of short-duration extreme rainfall. **Rev. Geophys.**, 52(3), 522–555 DOI: 10.1002/2014RG000464.