How do extremes from the CRCM5 Large Ensemble

scale in space and time in past and future climate?

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A.J. Cannon[3] M. Leduc[2]

[1] INRS, [2] OURANOS, [3] ECCC

May 10, 2018

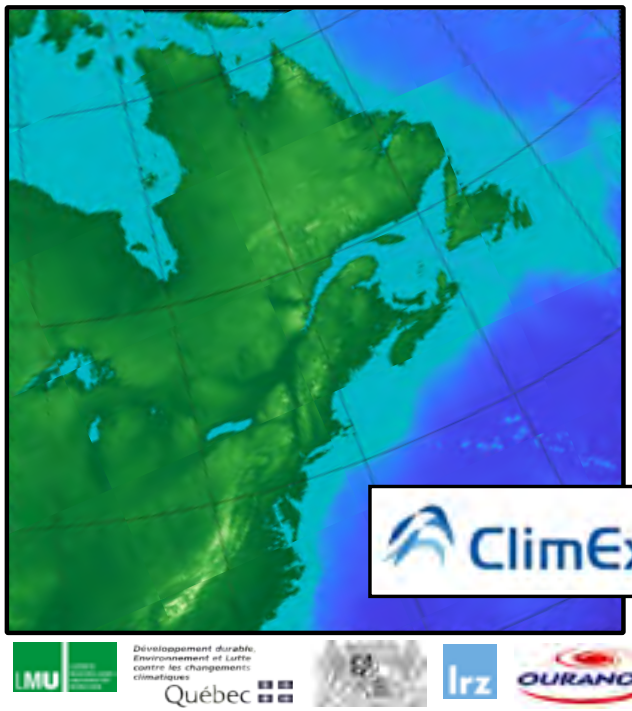
Centre - Eau Terre Environnement

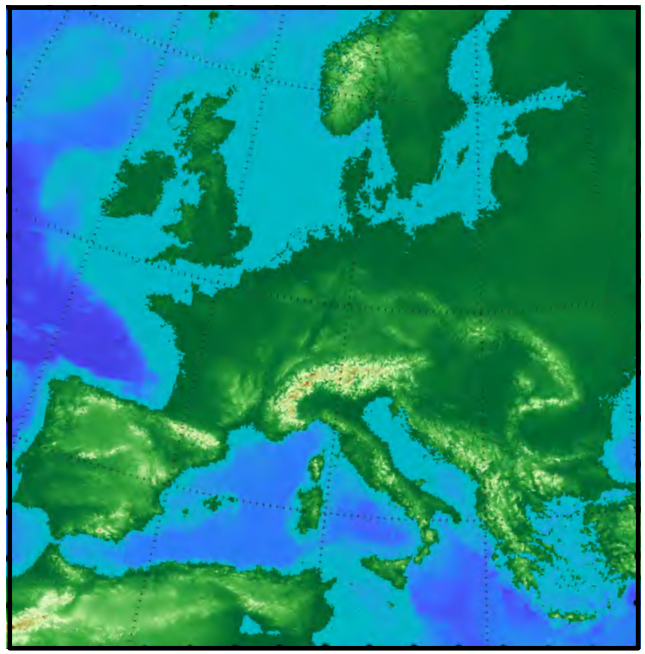
INRS
Université d'avant-garde

ClimEx Large Ensemble — ClimEx-LE

ClimEx project: **regional scale assessment of climate change and natural variability for extreme events.**

[Leduc et al., under revision]





www.climex-project.org

ClimEx Large Ensemble ClimEx-LE

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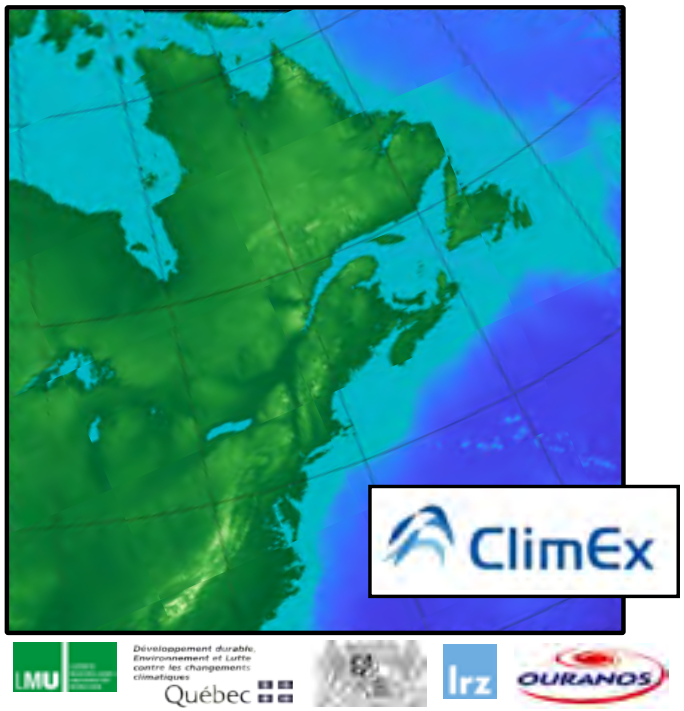
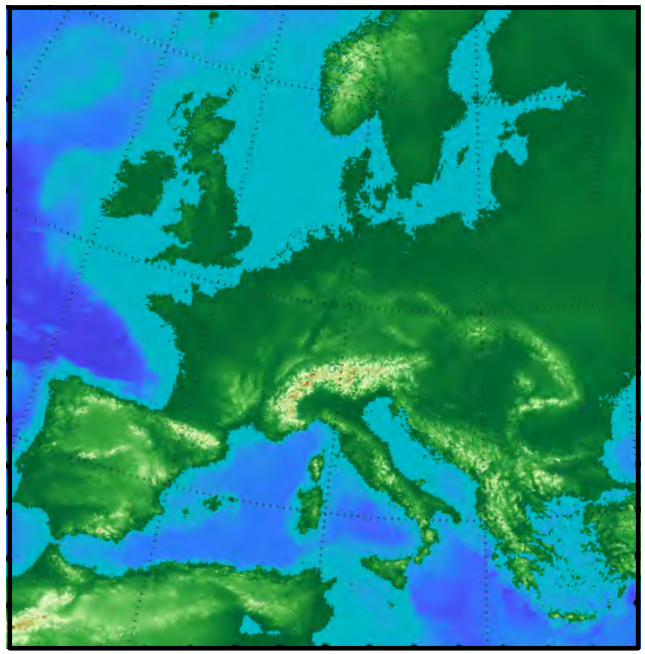
CRCM5-LE: 50 members
1950 - 2100, 0.11°, $1h$

[Martynov et al. 2013, Separovic et al. 2013]

driven by the **CanESM2-LE** under RCP8.5 scenario

[Fyfe et al. 2017]





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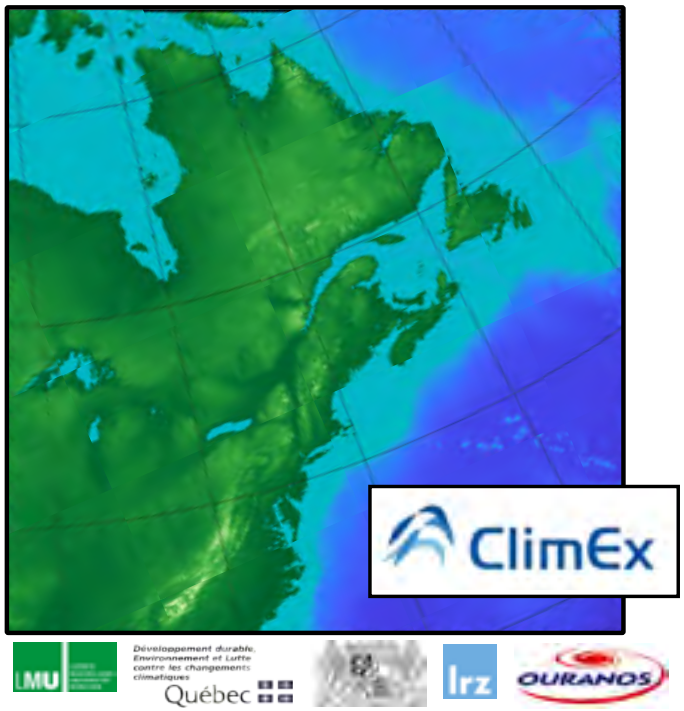

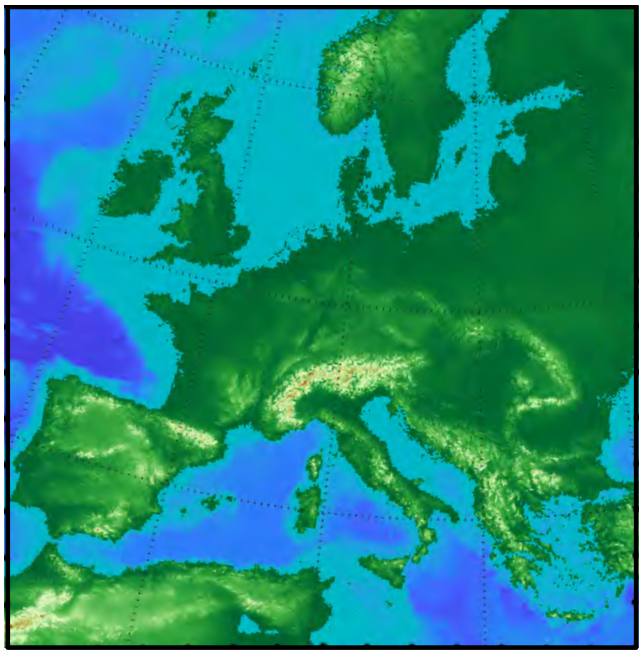

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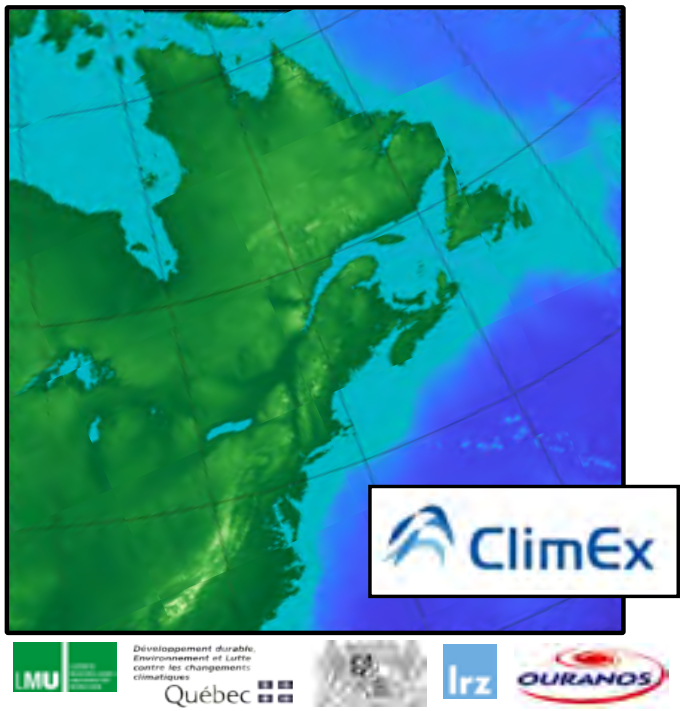

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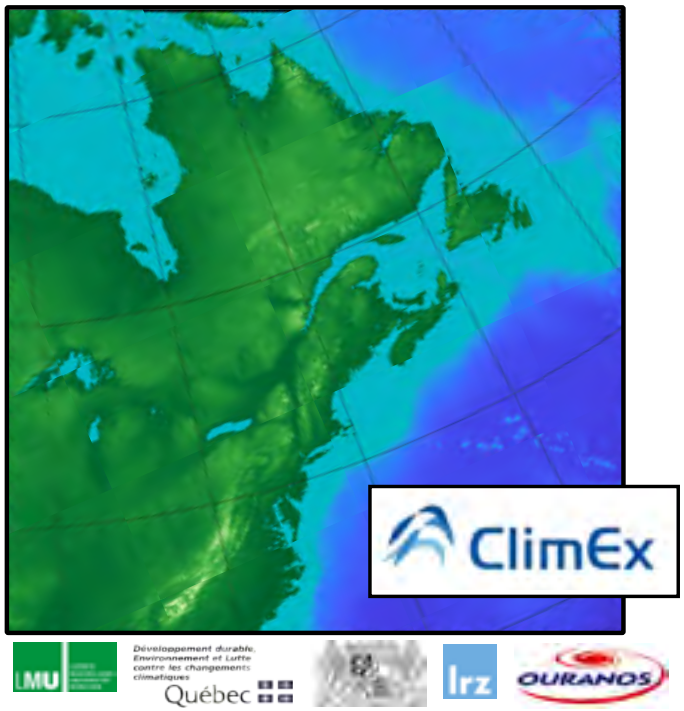

Strength of the statistic signal for rare events:

- 150-year series at high spatio-temporal resolution
- 50 members: natural climate variability

ClimEx Large Ensemble ClimEx-LE

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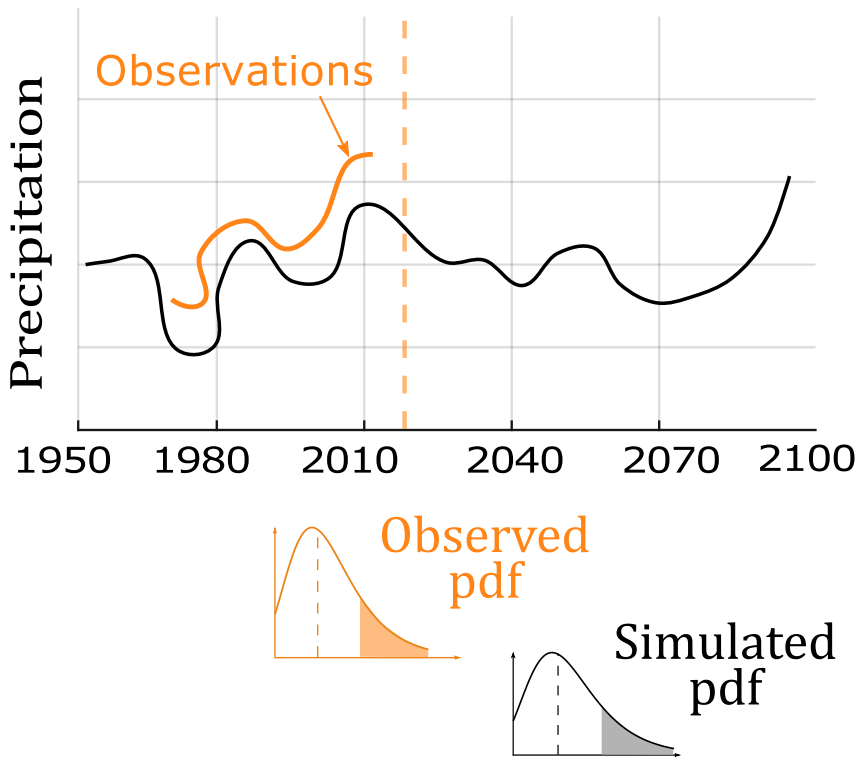

To evaluate: how well do the model reproduce extreme climatology?

- Magnitude of extremes

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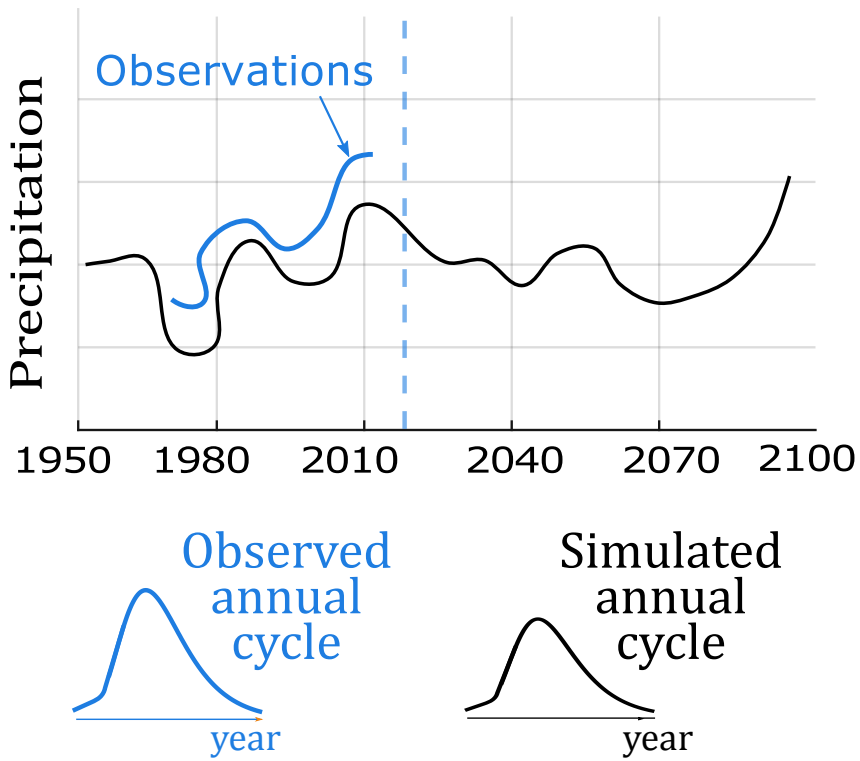

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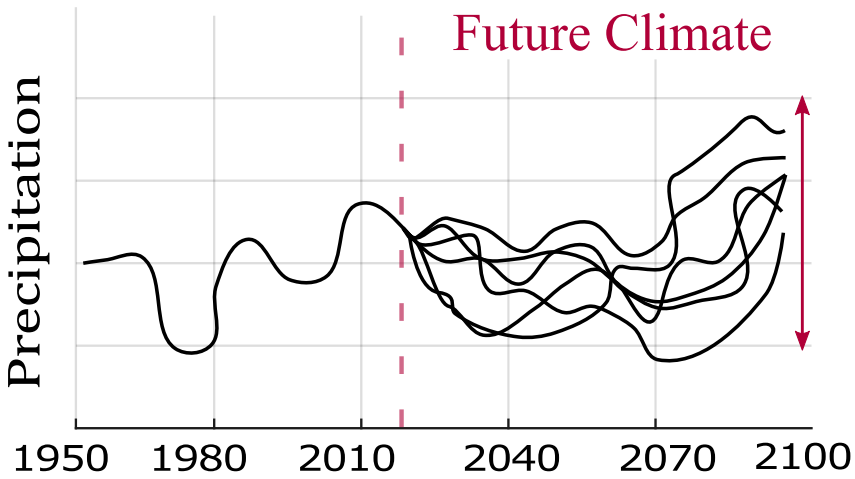

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Temporal evolution:

- Effects of climate change

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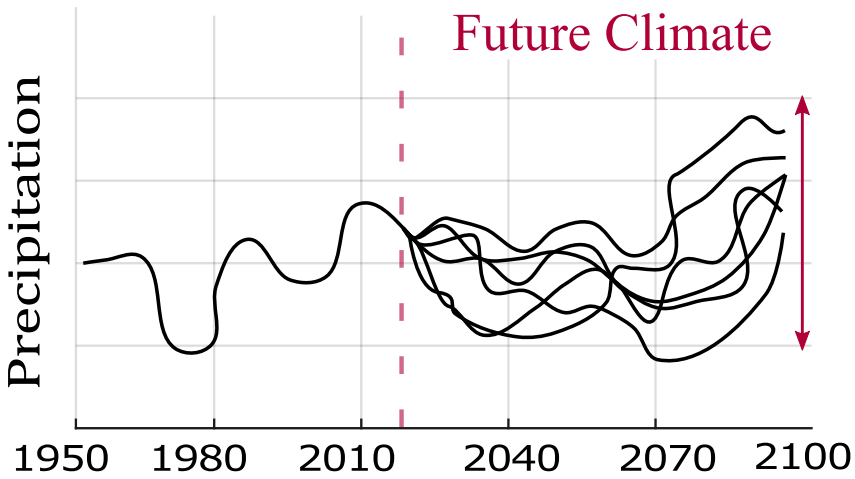
Objectives



To evaluate: how well the model reproduces extreme climatology?

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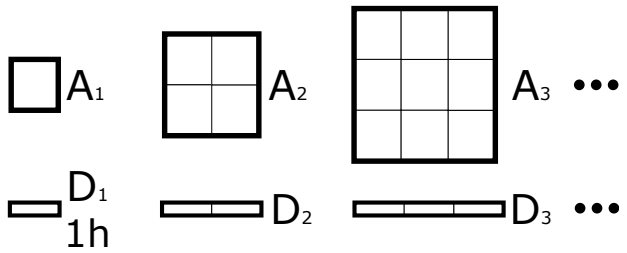
This study

ClimEx-LE to estimate extreme rainfall properties at various spatial scales A and temporal durations D



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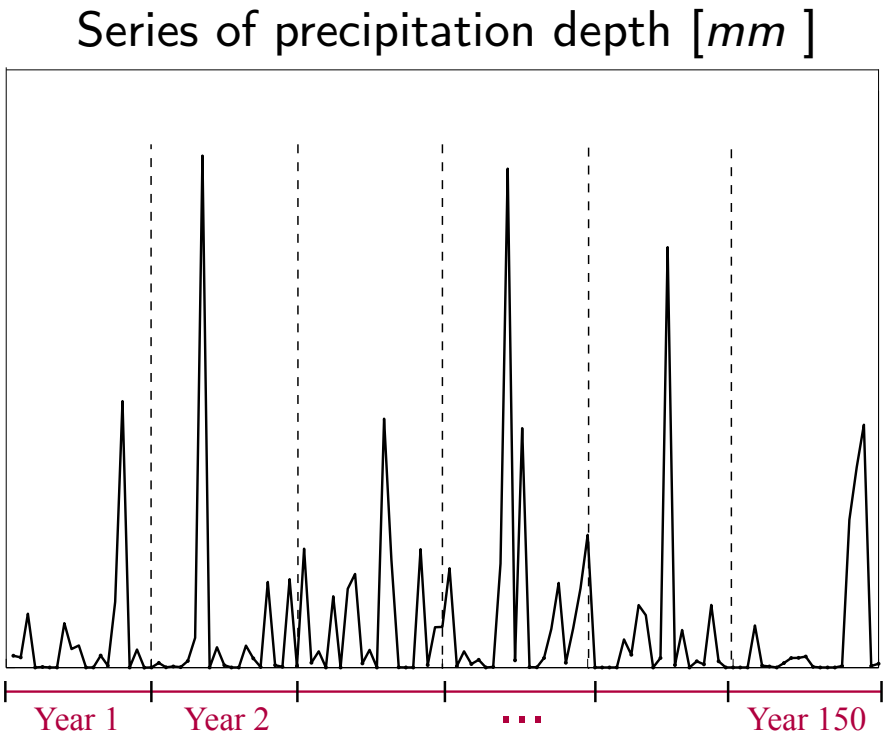
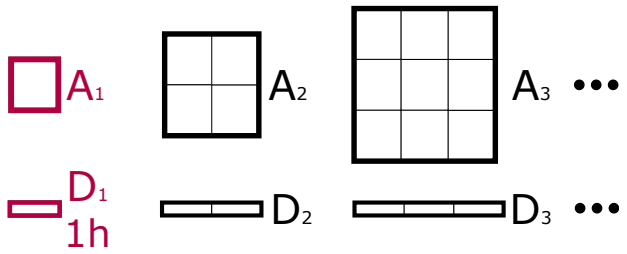
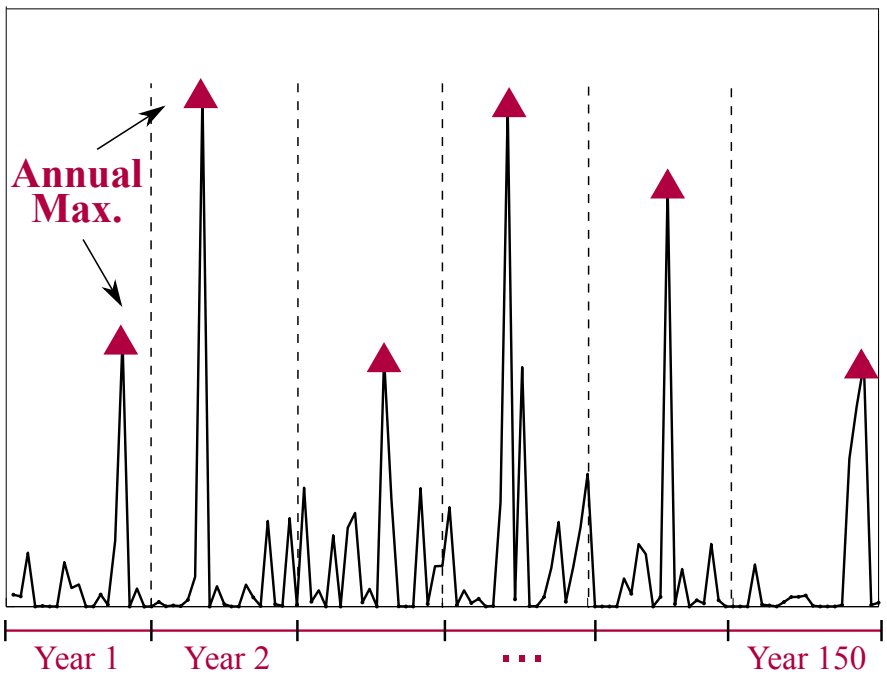


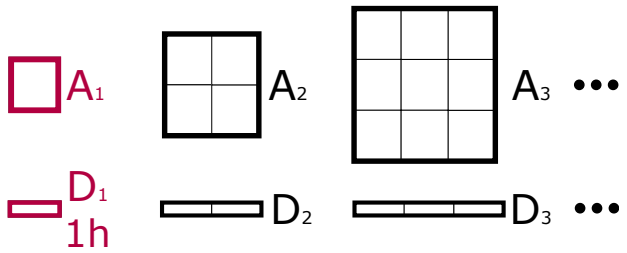


This study

ClimEx-LE **to estimate extreme rainfall properties at various spatial scales** *A* **and temporal durations** *D*

Series of precipitation depth [*mm*]





$\Rightarrow$ **Annual Maxima Series at (A,D)**

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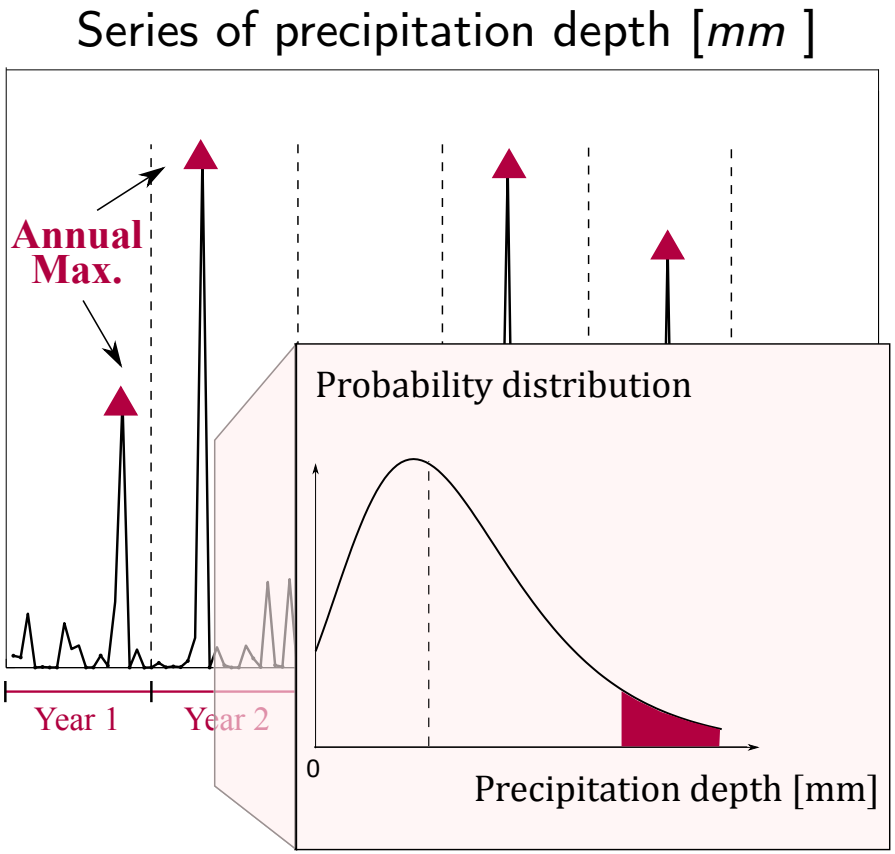

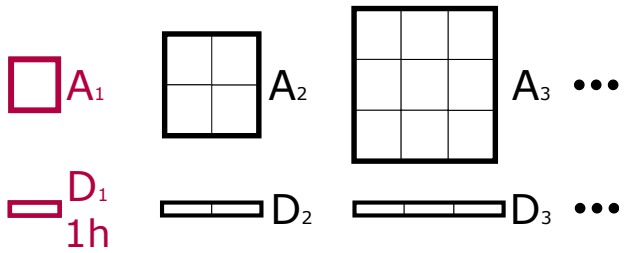

⇒ **Annual Maxima Series at (A,D)**

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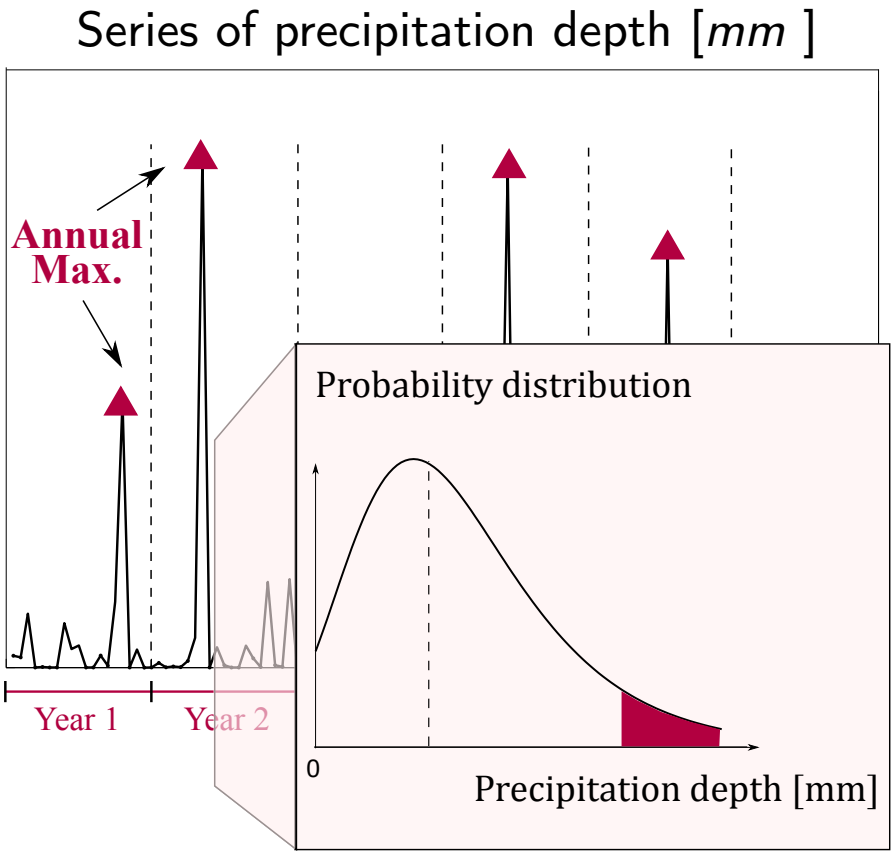

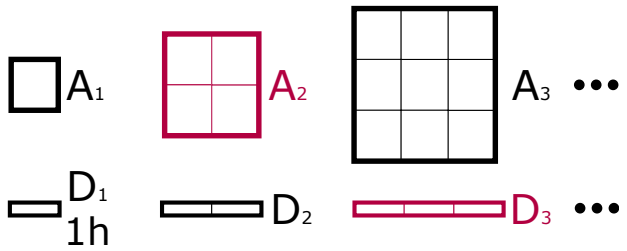

⇒ **Annual Maxima Series at (A,D)**

- Statistical properties [e.g., quantiles]
- Change with the spatio-temporal scales (A, D)

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***ClimEx-LE* to estimate extreme rainfall properties at various spatial scales A and temporal durations D**

50 members CRCM5-LE
1950 - 2100, $\approx 12km$, $1h$

1^{st} Obj. Comparison with other datasets in past climate

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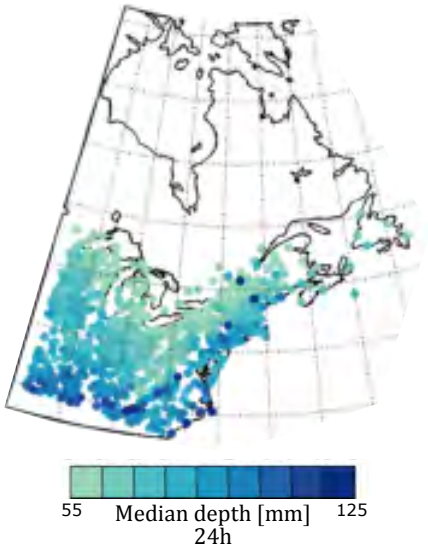
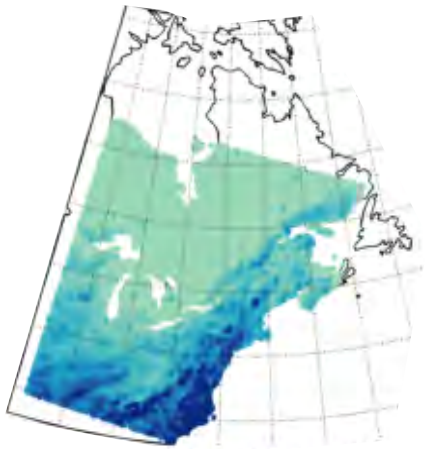
Stations
[MDDELCC, ECCC, NOAA]

15 min - 1h, 1950-2013



Conv. Perm. WRF

4km - 1h, 2001-2013



driven ERA-Interim
[Liu et al, 2017]

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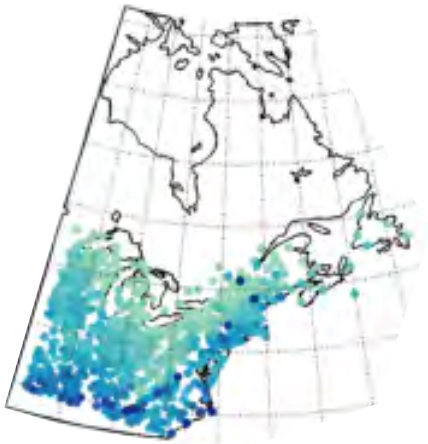
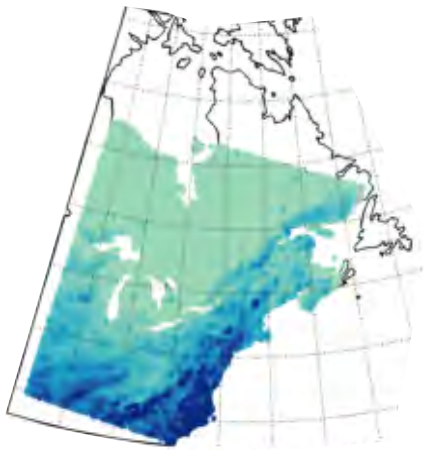


CMORPH
[CPC, Joyce et al. (2004)]
8 *km*, 30 *min*, 1998-2016

MSWEP v2
[Beck et al. 2017]
≈10*km*, 3*h*, 1979-2016

Conv. Perm. WRF
4km - 1h, 2001-2013



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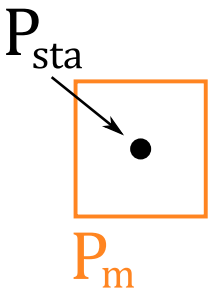
ClimEx evaluation

Comparison of AM quantiles among datasets:



$$\frac{P_{sta} - P_m}{P_{sta}} \times 100$$

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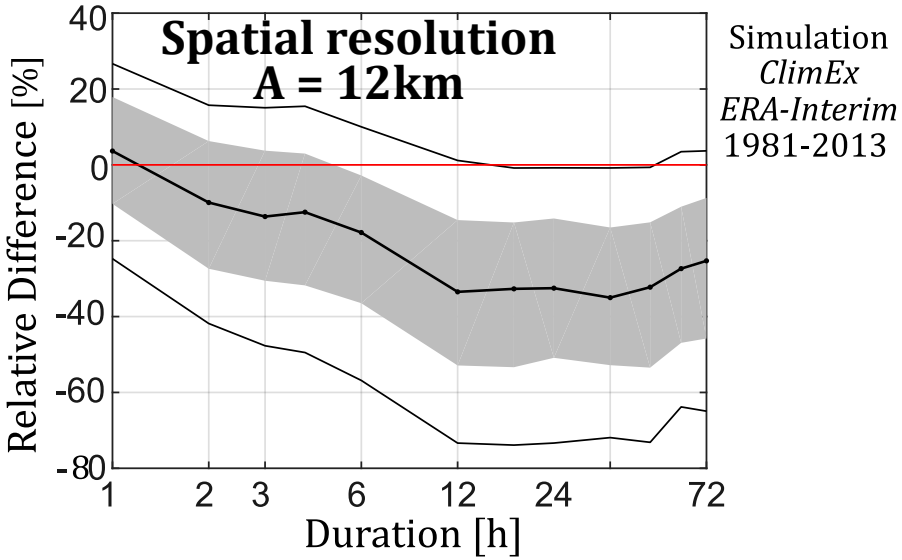

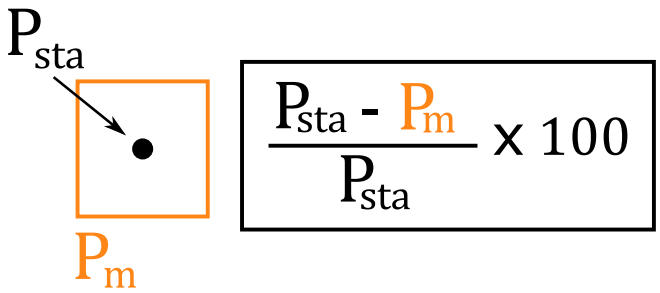

Return period 25 years

Quantile differences across durations

- Small and positive for short D
  $P_{sta} > P_m$
- Negative for longer D
  $P_{sta} < P_m$

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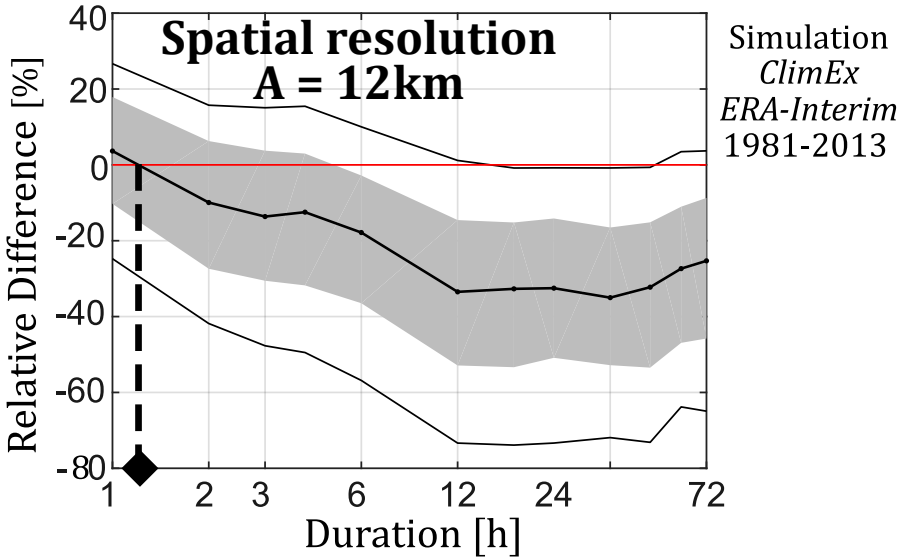

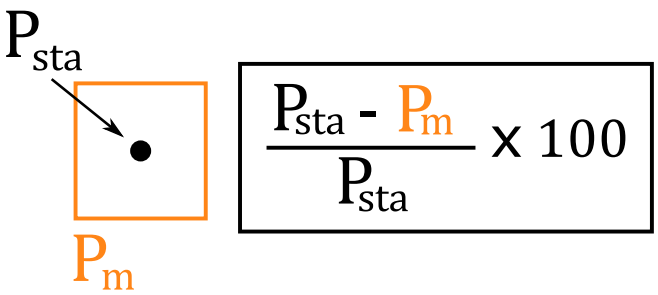

Return period 25 years

Quantile differences across durations

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  $D < d^{\blacklozenge}$ $P_{sta} > P_m$
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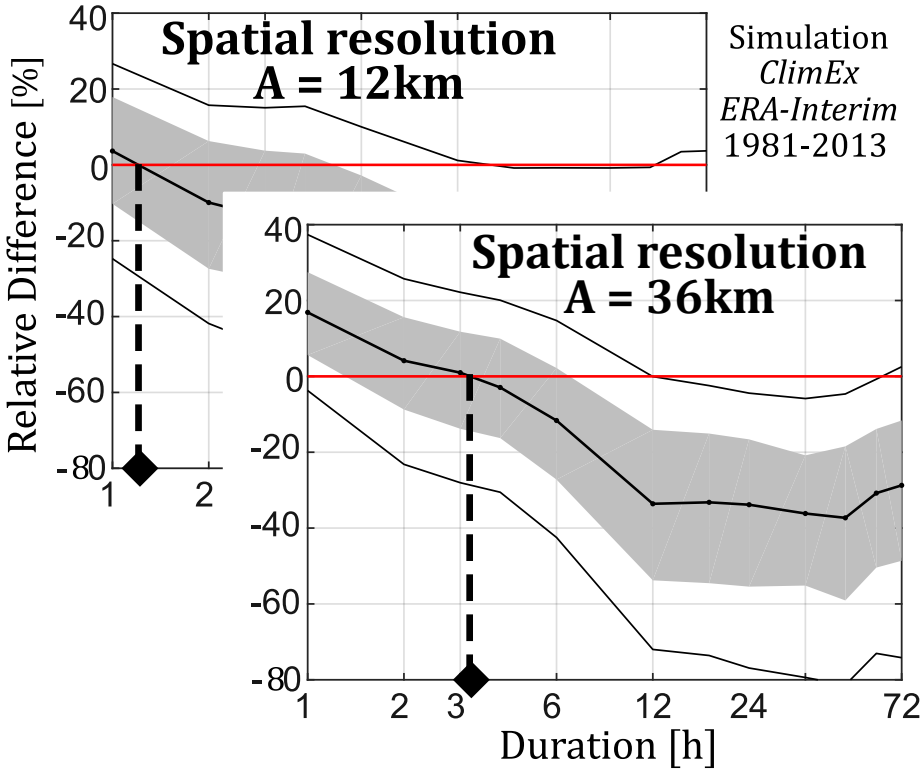

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Scaling with (D, A)

bias correction,
distribution downscaling, etc.
[e.g., Haerter et al. 2015]

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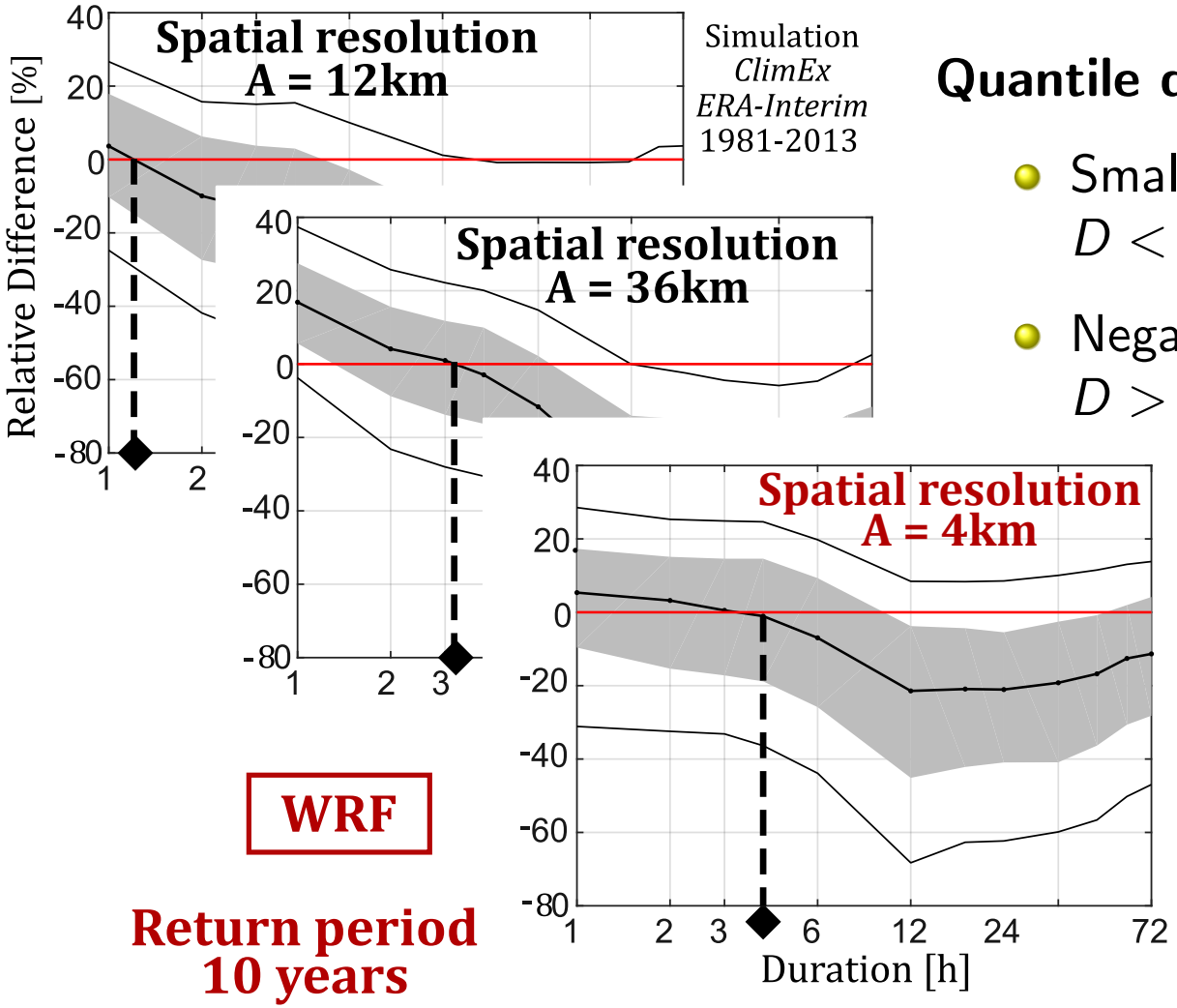

WRF

Return period 10 years

Quantile differences across durations

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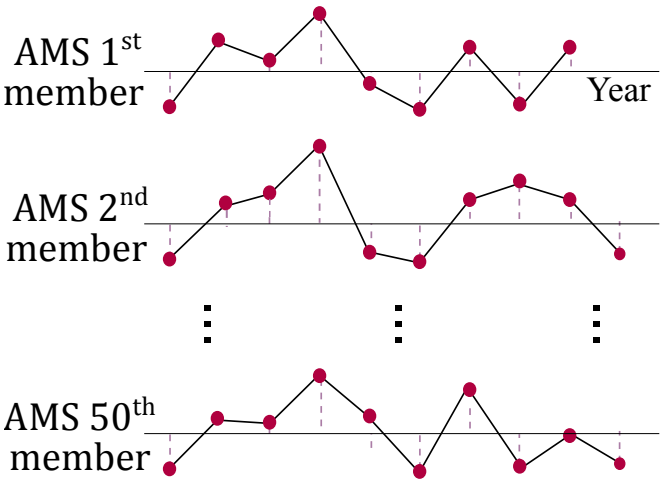
Comparable results for both models

Extremes under climate change

***ClimEx* simulations to study the future evolution of AM characteristics at different spatio-temporal scales (D, A).**

50 members CRCM5-LE
1950 - 2100

2nd Obj.: Climate change and **natural variability?**



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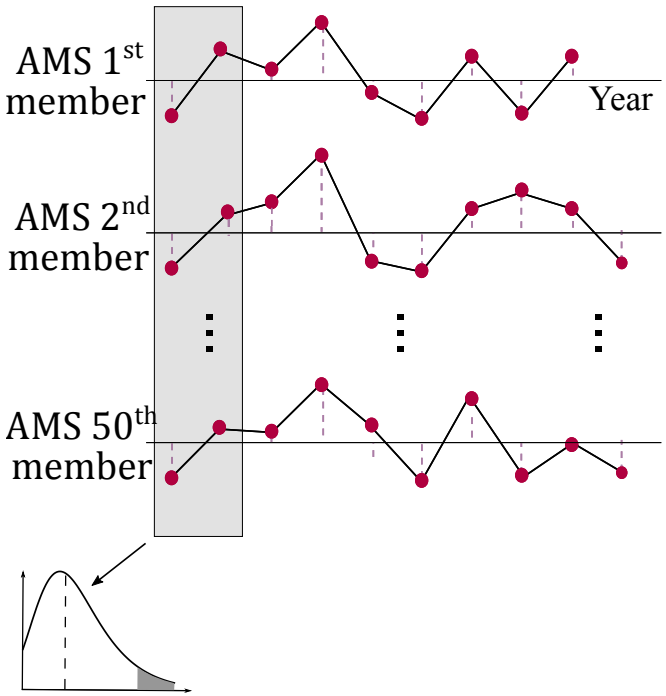

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Combine AM from the 50 simulations

over short periods
[e.g., 3 years]

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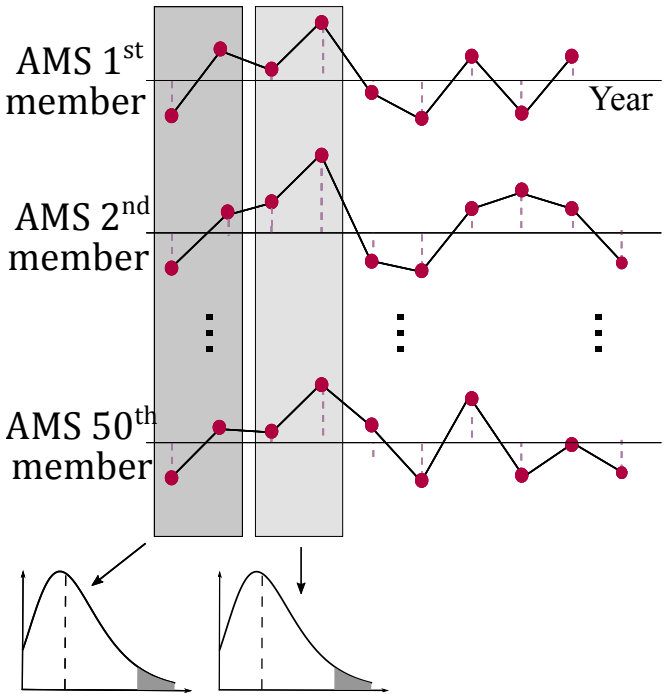

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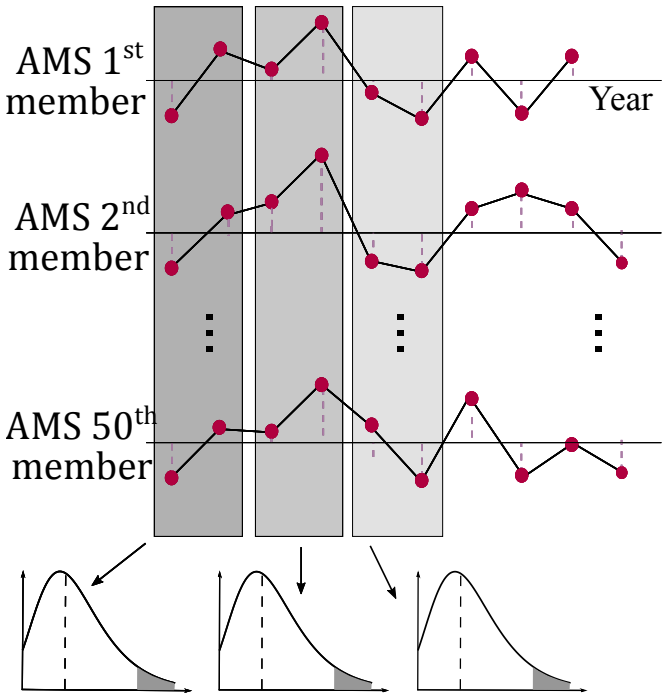

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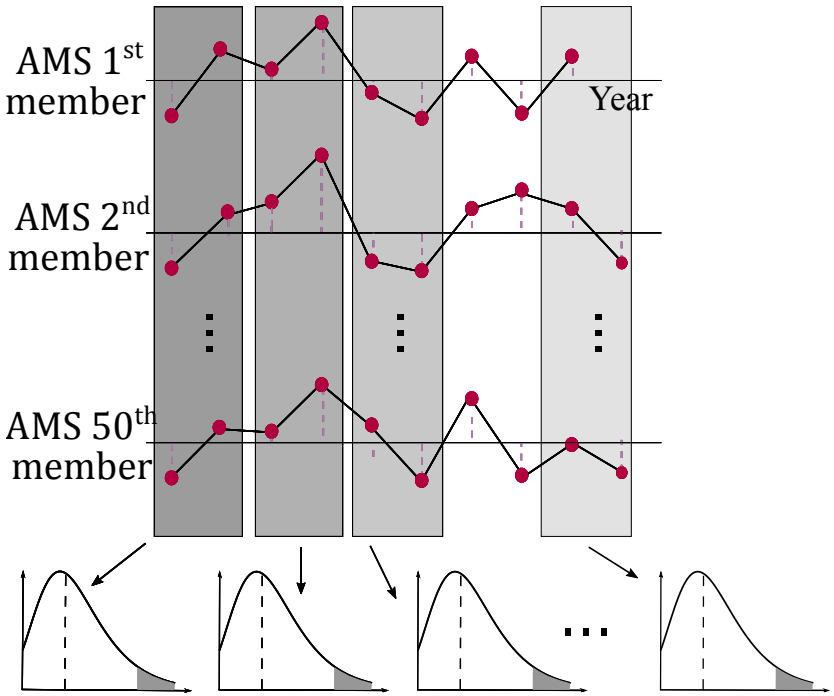

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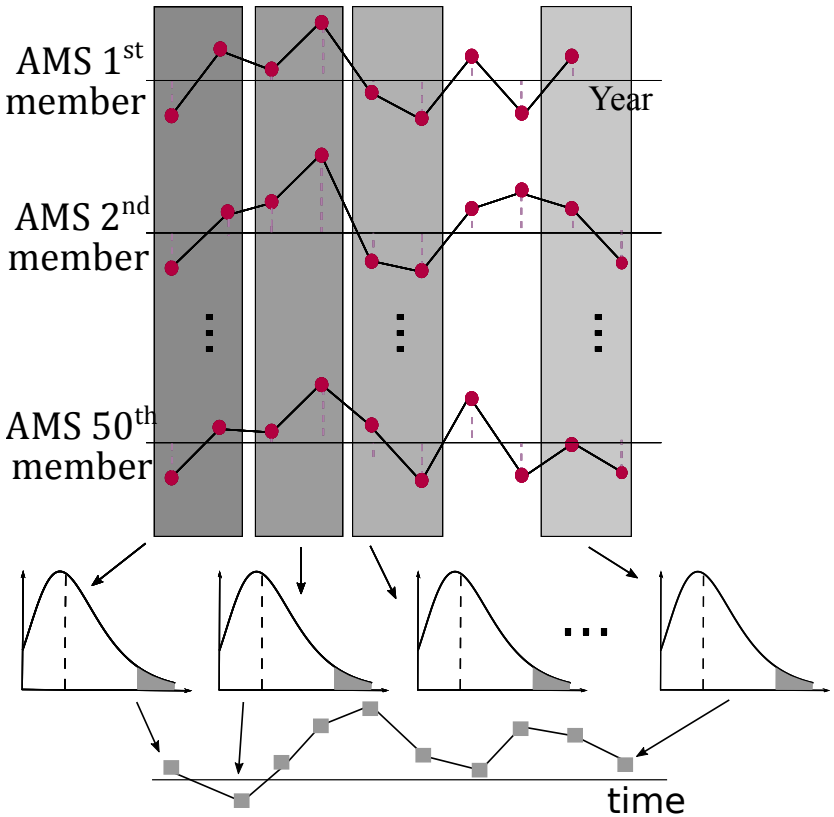

2nd Obj.: Climate change and natural variability?

Combine AM from the 50 simulations
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[e.g., 3 years]

Time series of AM statistics
[e.g., series of quantiles]

Changes in quantiles

1950 - 2100: 3-year periods, each composed by 150 AM.

$\Rightarrow$ **50 estimates of the 100-yr quantile of distributions**

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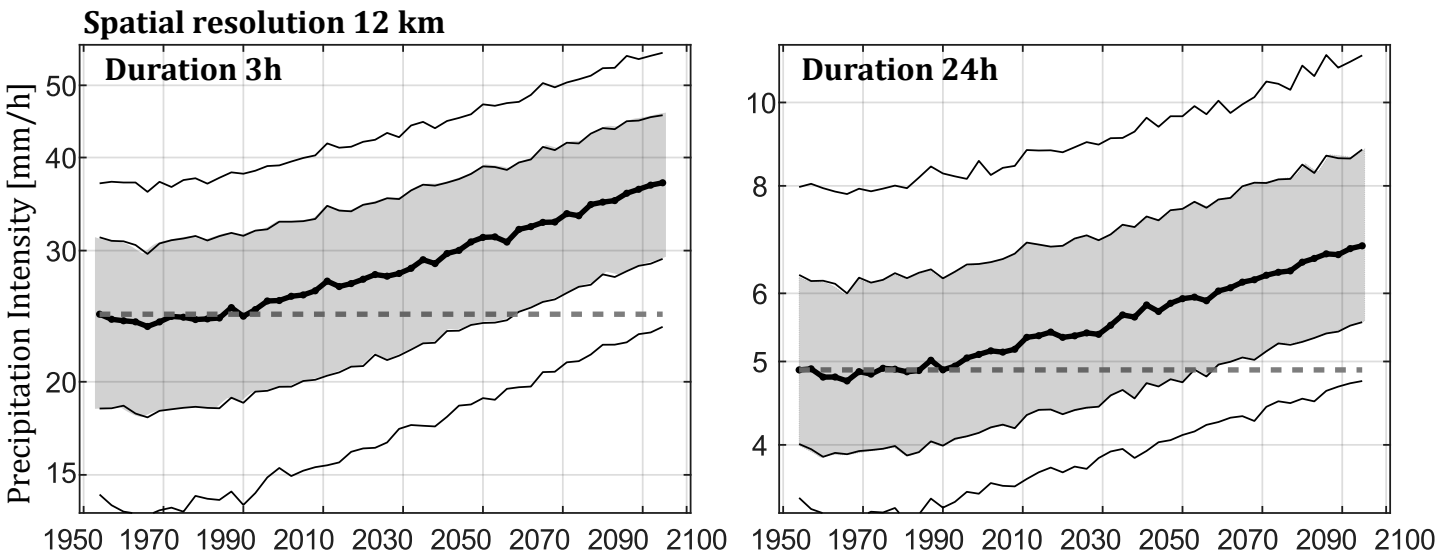

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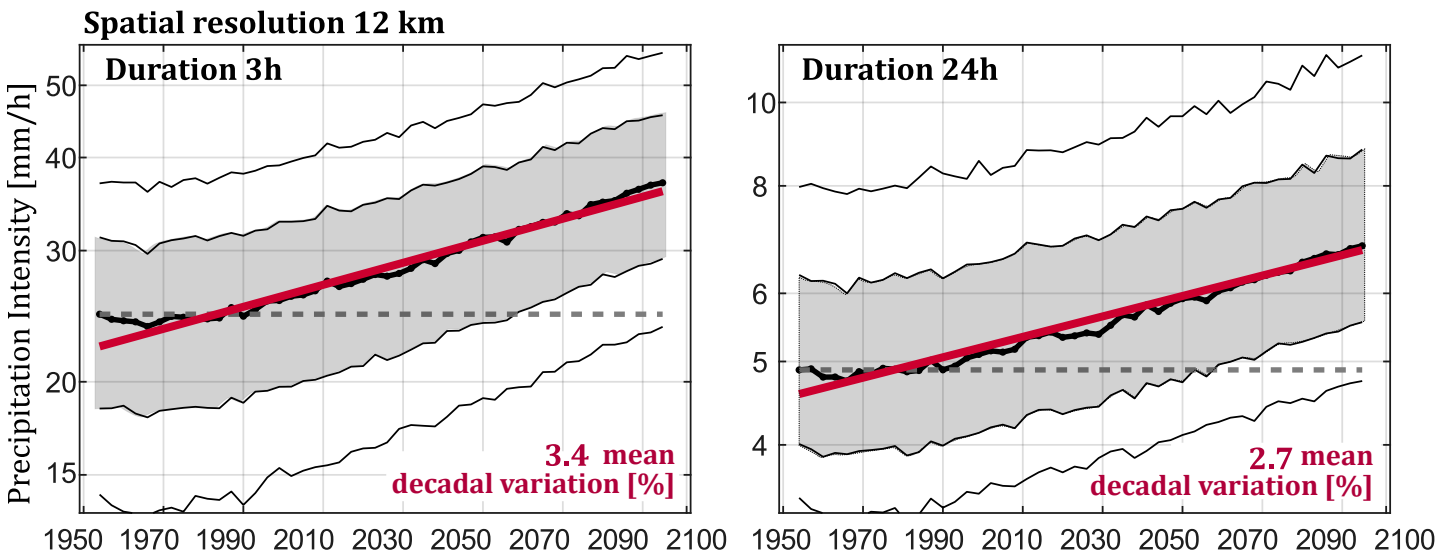

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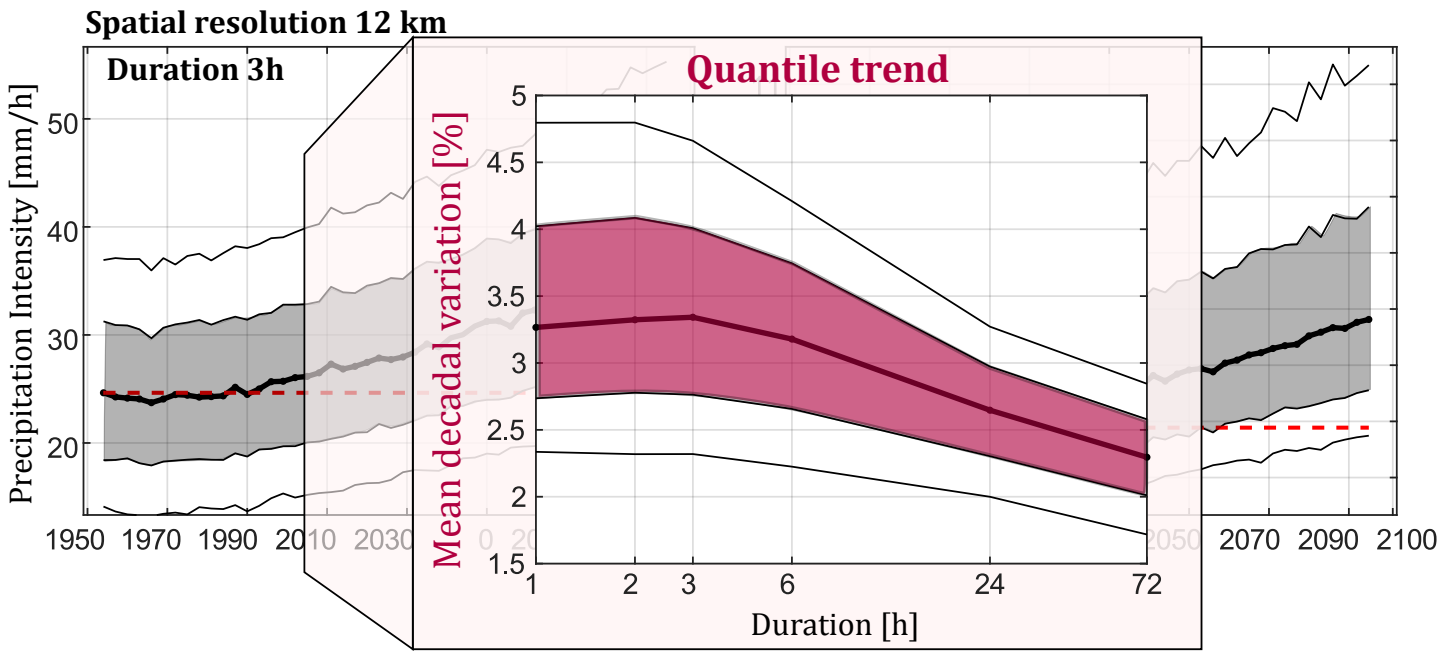

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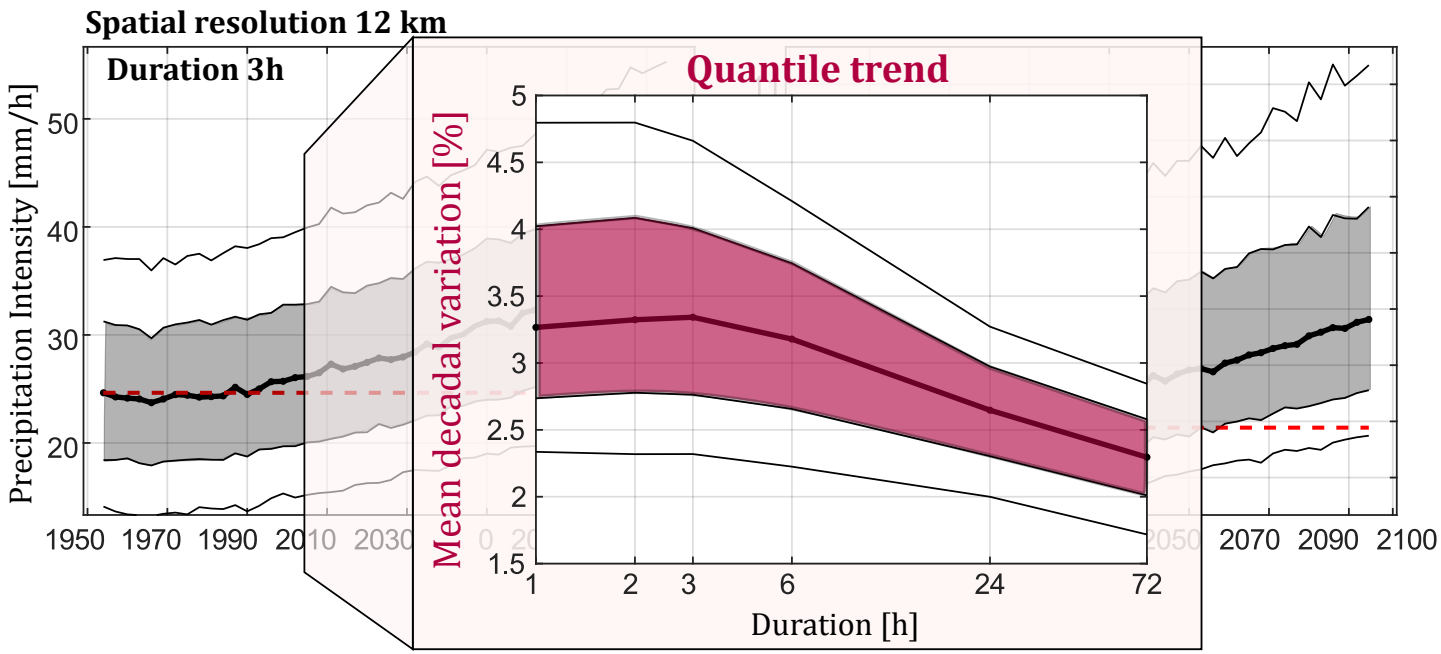
  ⇒ **Evolution of scaling relationships and meteorological systems.**

Changes in quantiles

1950 - 2100: 3-year periods, each composed by 150 AM.

⇒ **50 estimates of the 100-yr quantile of distributions**



- Significant increase for most of grid points [99% Mann-Kendall rejection].
- Stronger increases for longer return periods and **shorter** D
  ⇒ **Evolution of scaling relationships and meteorological systems.**

Conclusions

ClimEx-LE to estimate extremes at various scales A et D:

- Validation against stations and comparison with gridded datasets:
  - ◇ Small differences for short durations D.
  - ◇ Variation with D et A: Scaling relationships.

    $\Rightarrow$ Extreme event features [e.g., annual and diurnal cycles]

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- **50 members** ⇒ Strong signal for the impact of climate change, especially on short duration extremes:
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Next step: assessment of inter-member variability

⇒ AM distribution features [e.g. shapes] and scaling laws [e.g., bias correction]

Thank you for your attention

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Université d'avant-garde

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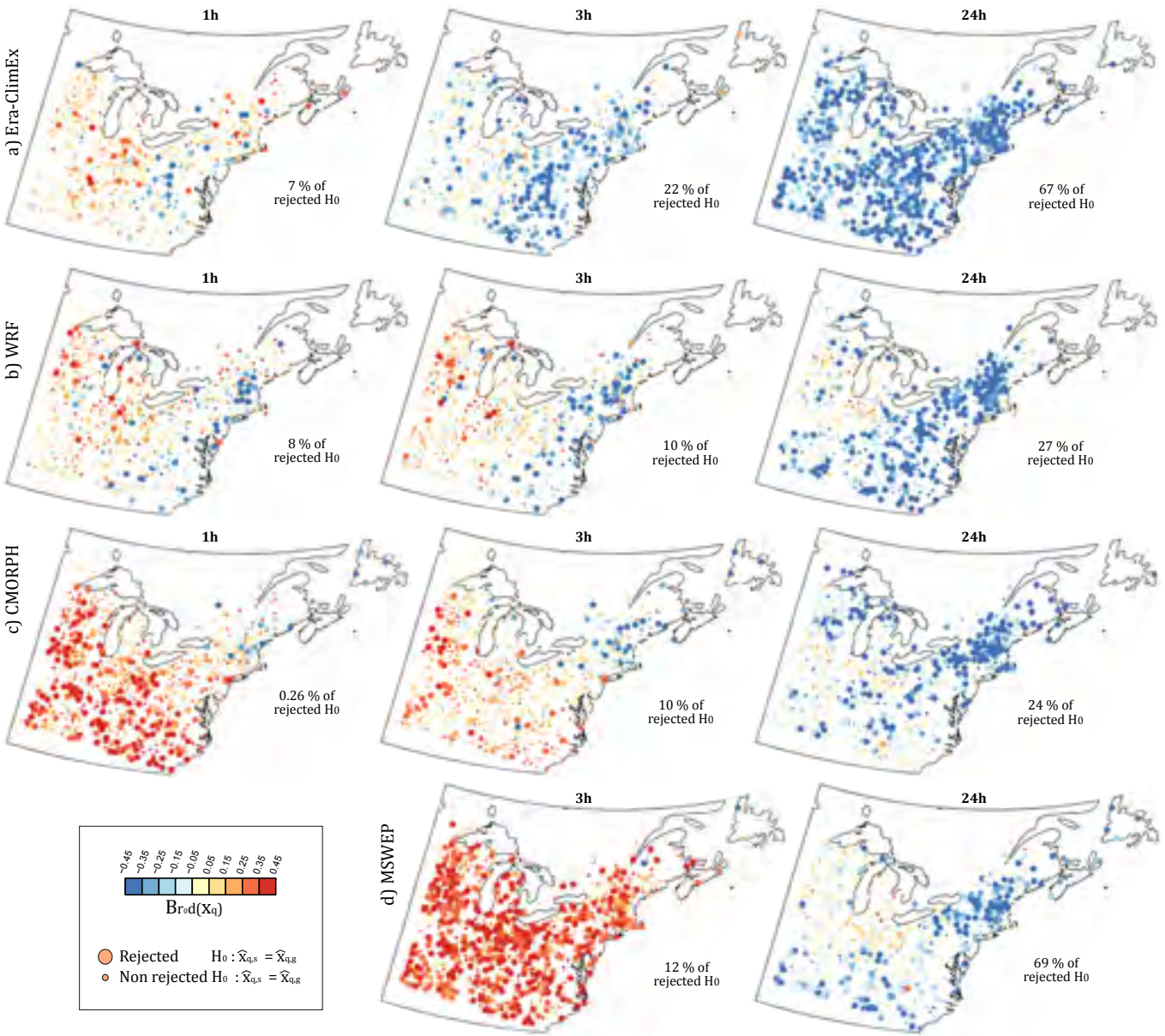
Appendix

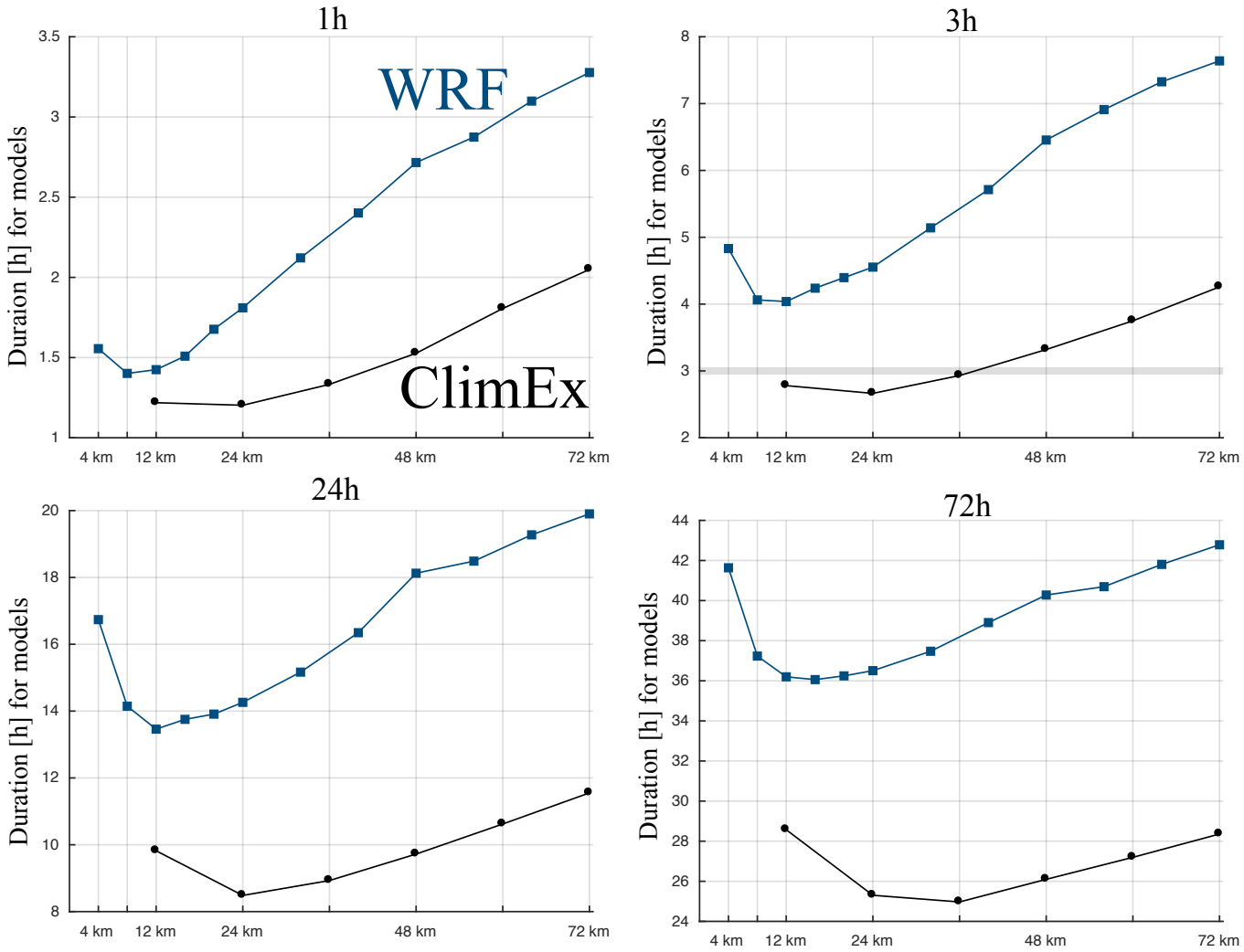
More results

Quantile bias: spatial distribution of biases for x_{10yr}



Quantile scaling

Equivalent scales: durations with zero relative bias, 10-yr quantile.



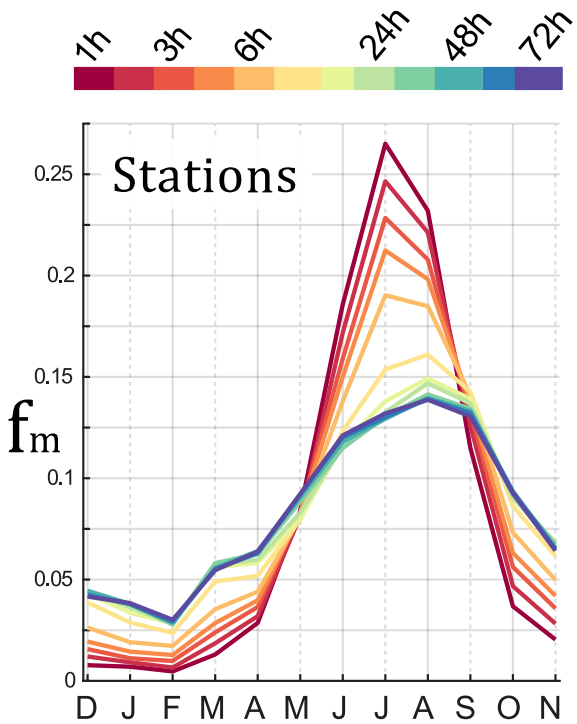
ClimEx evaluation: annual cycle

Occurrences of AM in simulated and observed series:

Monthly frequencies of AM, $\mathbf{f}_m$

$\Rightarrow$ average over stations

Annual cycle



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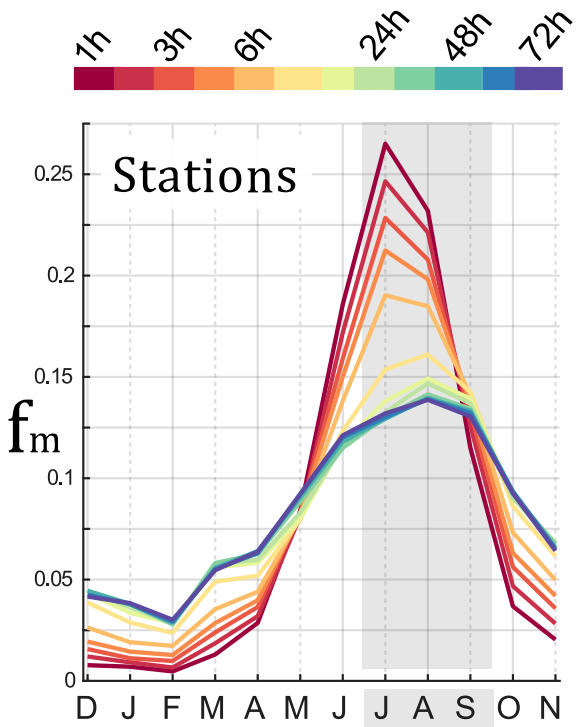

ClimEx evaluation: annual cycle

Occurrences of AM in simulated and observed series:

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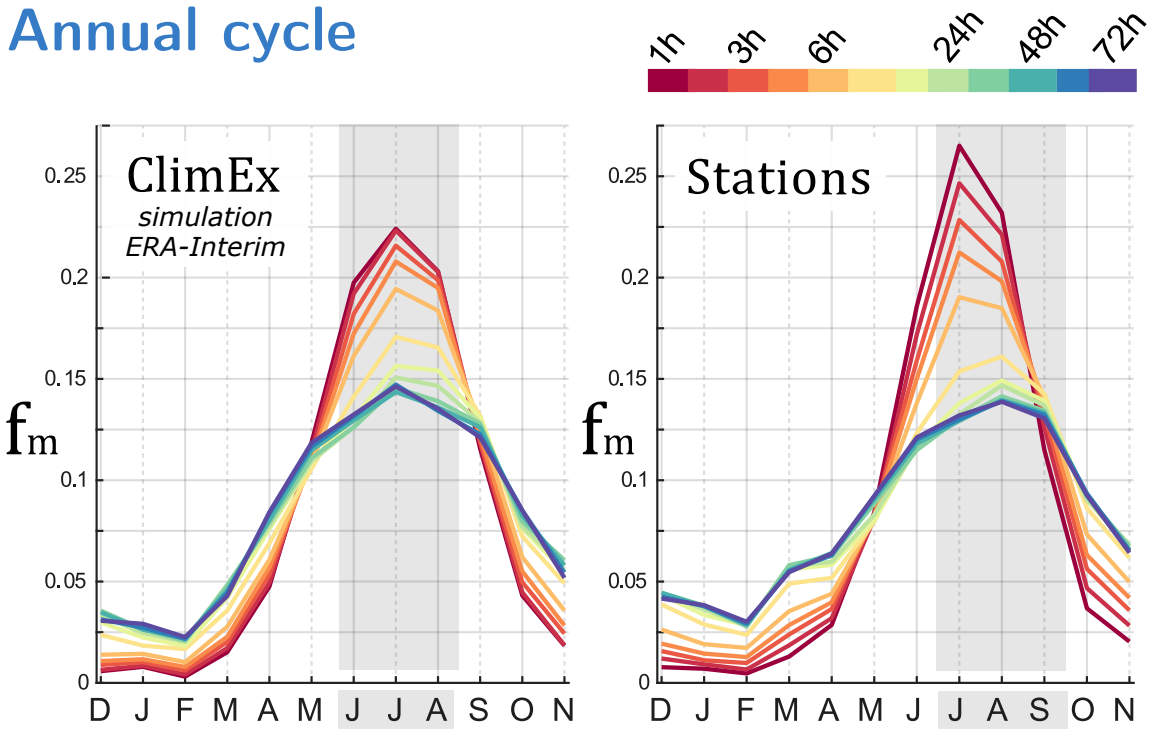
- Cycles reproduced at short D
  Anticipated peak, for long D

Annual cycle



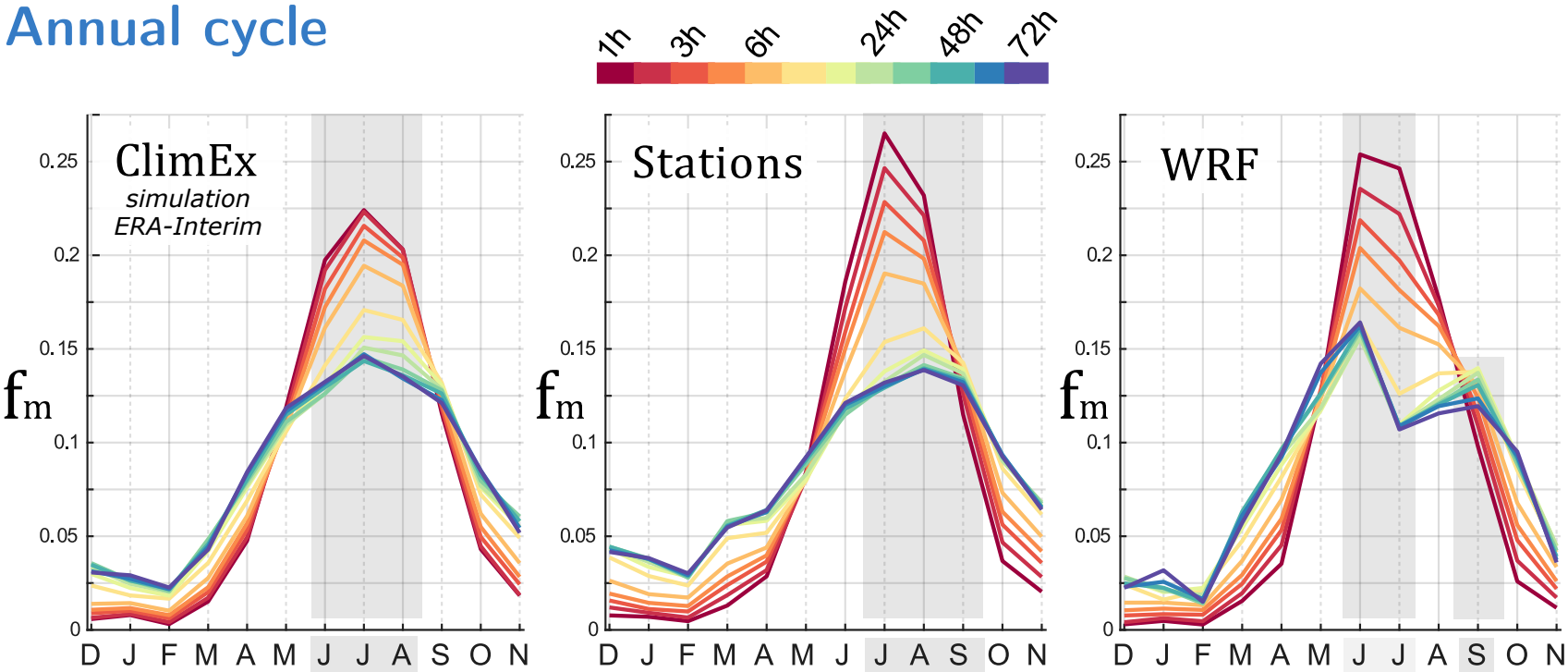
ClimEx evaluation: annual cycle

Occurrences of AM in simulated and observed series:

Monthly frequencies of AM, $\mathbf{f}_m$
$\Rightarrow$ average over stations
and corresponding grid boxes

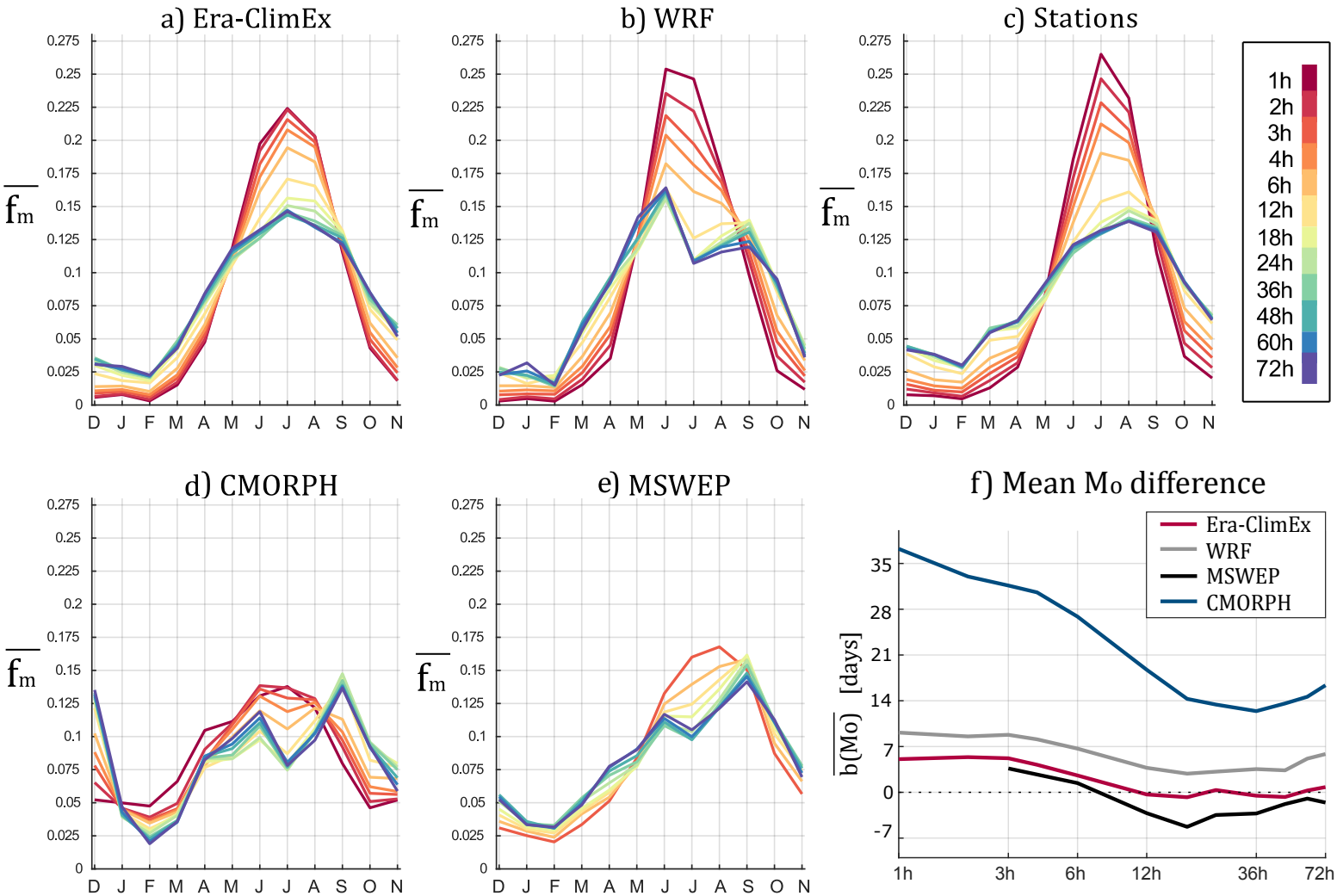
- Cycles reproduced at short D
  Anticipated peak, for long D
- WRF: two peaks for long D
  $\Rightarrow$ 2001 - 2013 period

Annual cycle



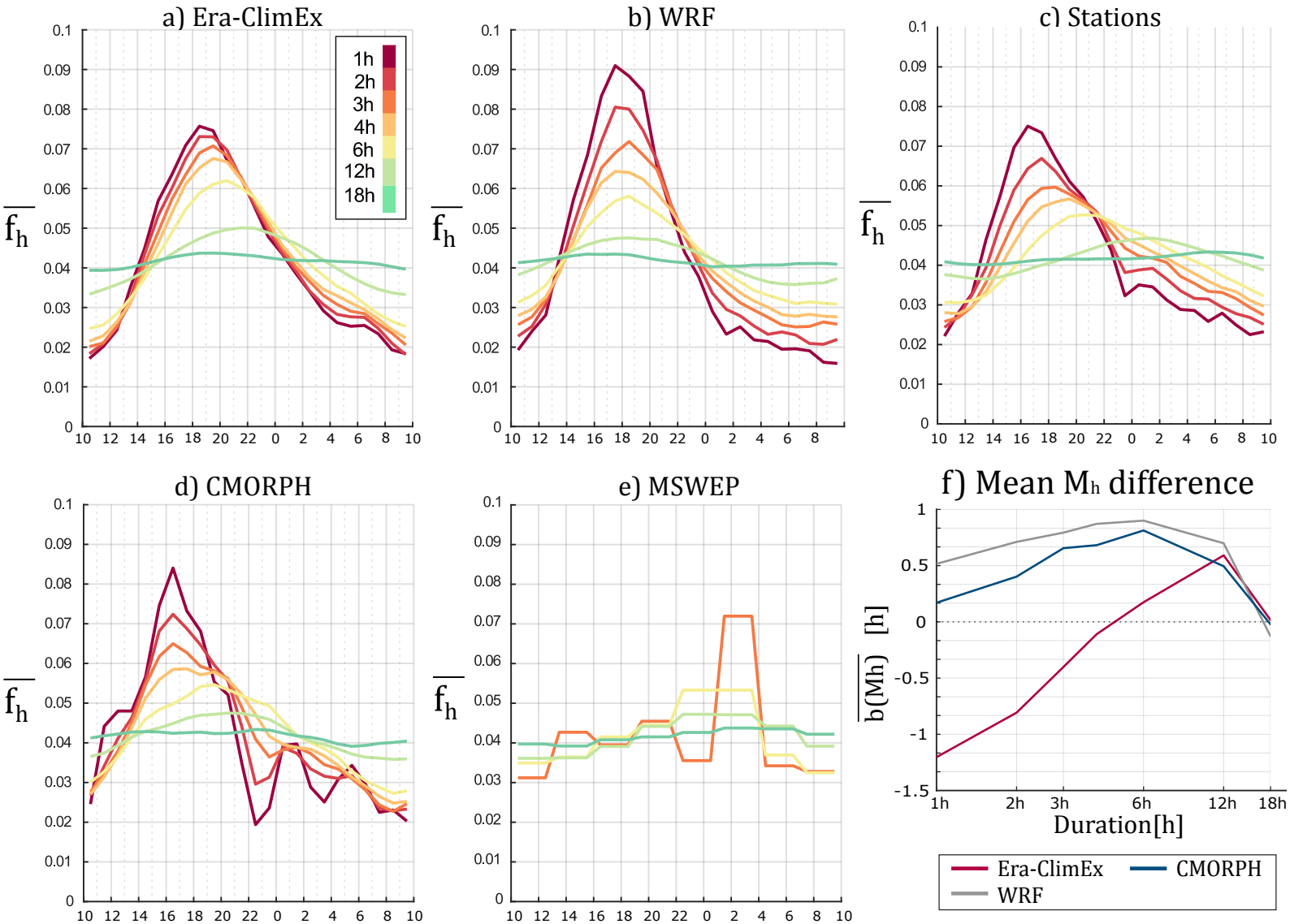
Annual cycle of AM

All datasets

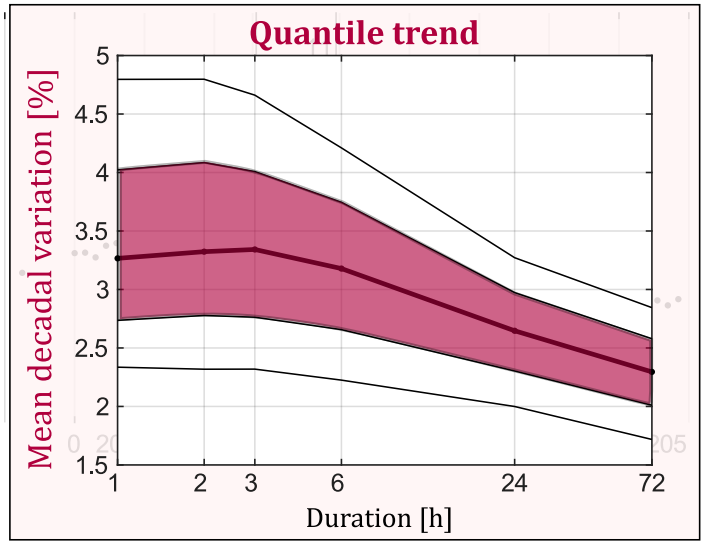


Diurnal cycle of AM

All datasets



Scaling of AM quantiles



Increases in temperature:
Fig.10 Leduc et al. [under review].

CRCM5 50-member ensemble mean CC signal for surface-air temperature: difference between the 2080-2099 and 2000-2019 monthly means.