UF/IFAS

Stochastic Downscaling of Hourly Precipitation Series from Climate Change Projections

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Overview

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- Methodology
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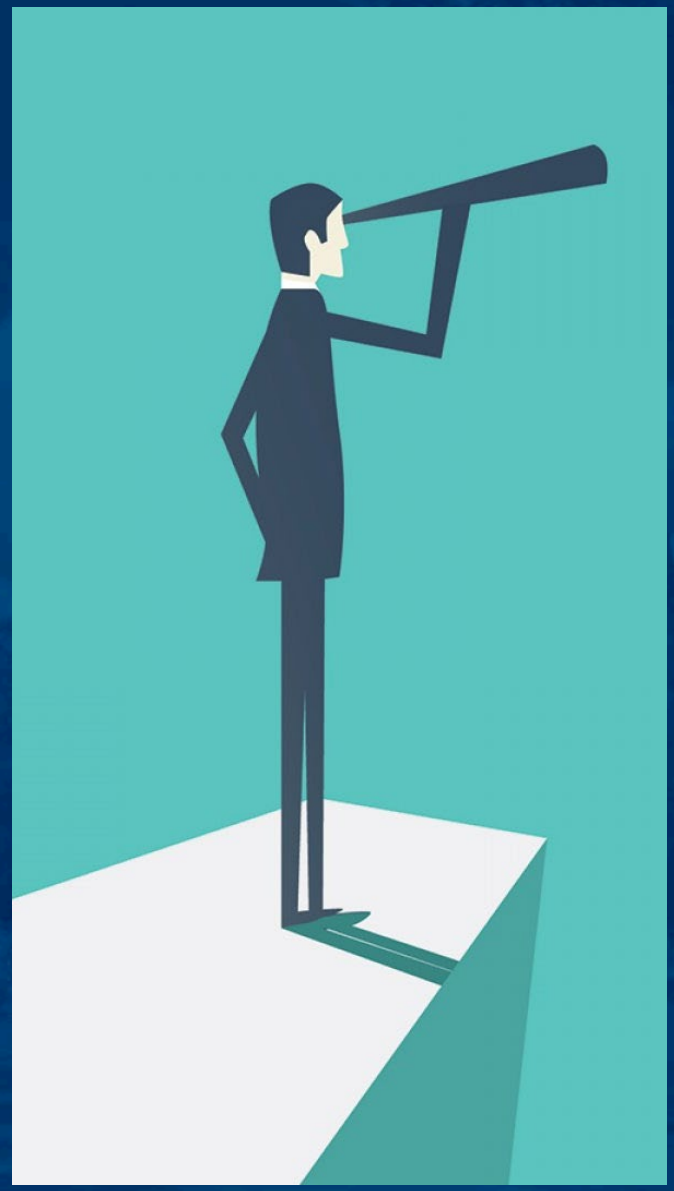
- Summary



Motivation

- Stochastic precipitation generators (SPGs) is widely used in water resource management
- SPG usually assumes stationary climate
- Non-stationary climate is expected in the future change
- Global Climate Models (GCMs) provide more reliable projections for temperature than precipitation

- **A trustable SPG needs to bridge the gap between temperature and precipitation.**

Data and valid Geographical Area

Data sources

- NCDC airport gages in NYC, Boston, Philadelphia
- > 50 years of hourly precipitation, temperature, sea level pressure from each gage
- Over 1,000,000 rows of data

Data quality

- Gaps (1.04%)
  - Missing data
  - Cumulative period
- Inconsistent time interval

GCM projections:

- Monthly temperature projections for 2035~2099 generated by MIROC model with A2 scenario
- Provided by GISS NASA

Yu et al. 2018

Atmospheric causes of precipitation

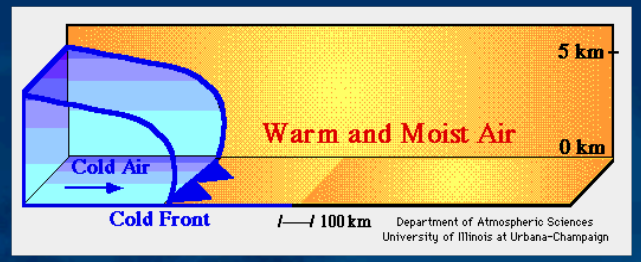
Meteorological interpretation

- Moist air rises
- Air moisture saturation
- Moisture condensation
- Growth of the precipitation particles
- Type of air lifting
  - Frontal movement
  - Orographic effect
  - Local convection

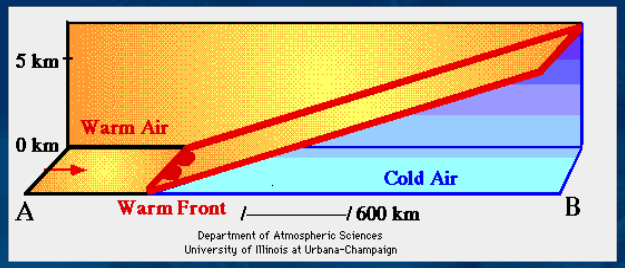
Finding:

- Air moisture is drawn by *pressure decrease* during precipitation formation

Yu et al. 2018



http://ww2010.atmos.uiuc.edu/guides/mtr/af/frnts/cfrnt/gifs/prcp1.gif



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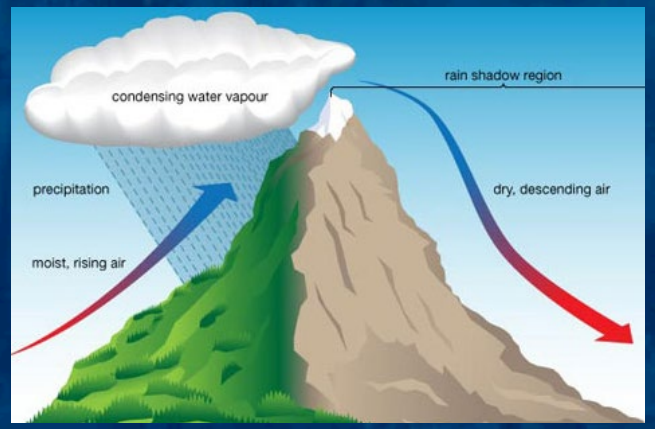
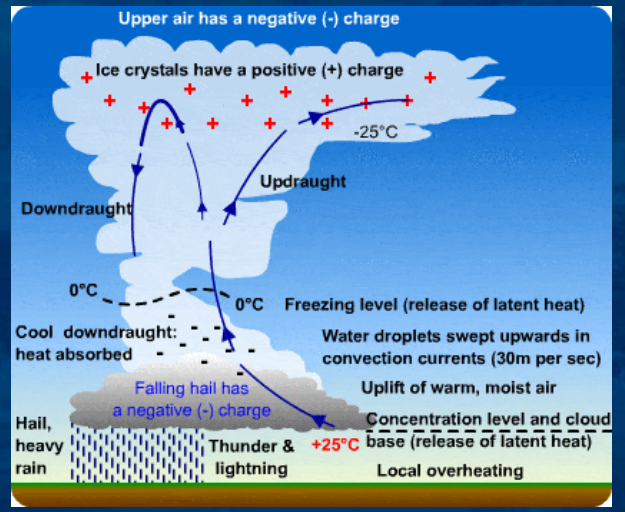


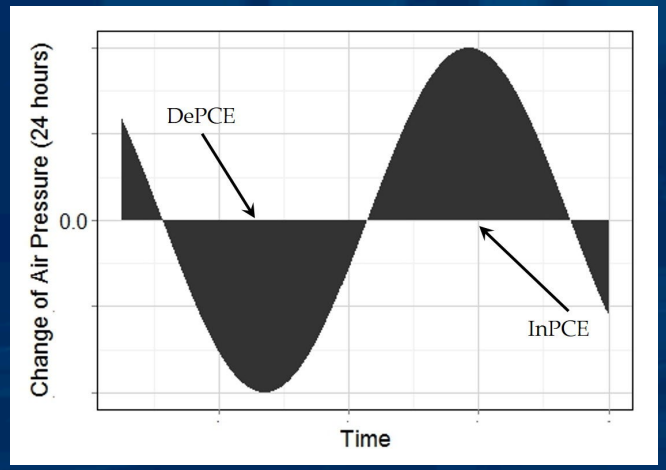
http://peter-mulroy.squarespace.com/how-do-clouds-and-precipitation-form/

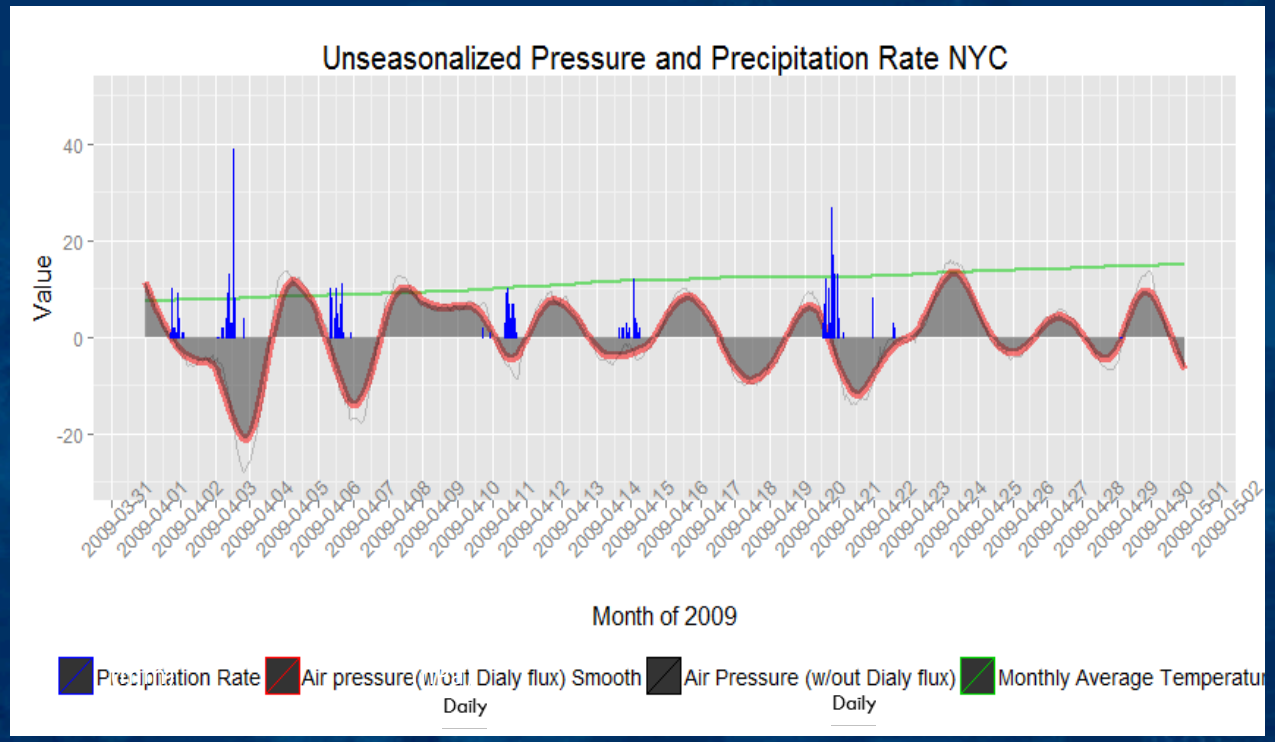


https://www.s-cool.co.uk/a-level/geography/weather-conditions/revise-it/atmospheric-moisture-and-precipitation

What is a pressure change Event?

- Computed 24 hour pressure differences as pressure change (no daily fluctuation)
- Two pressure change events (PCEs)
  - Increase pressure change events (InPCEs)
  - Decrease pressure change events (DePCEs)

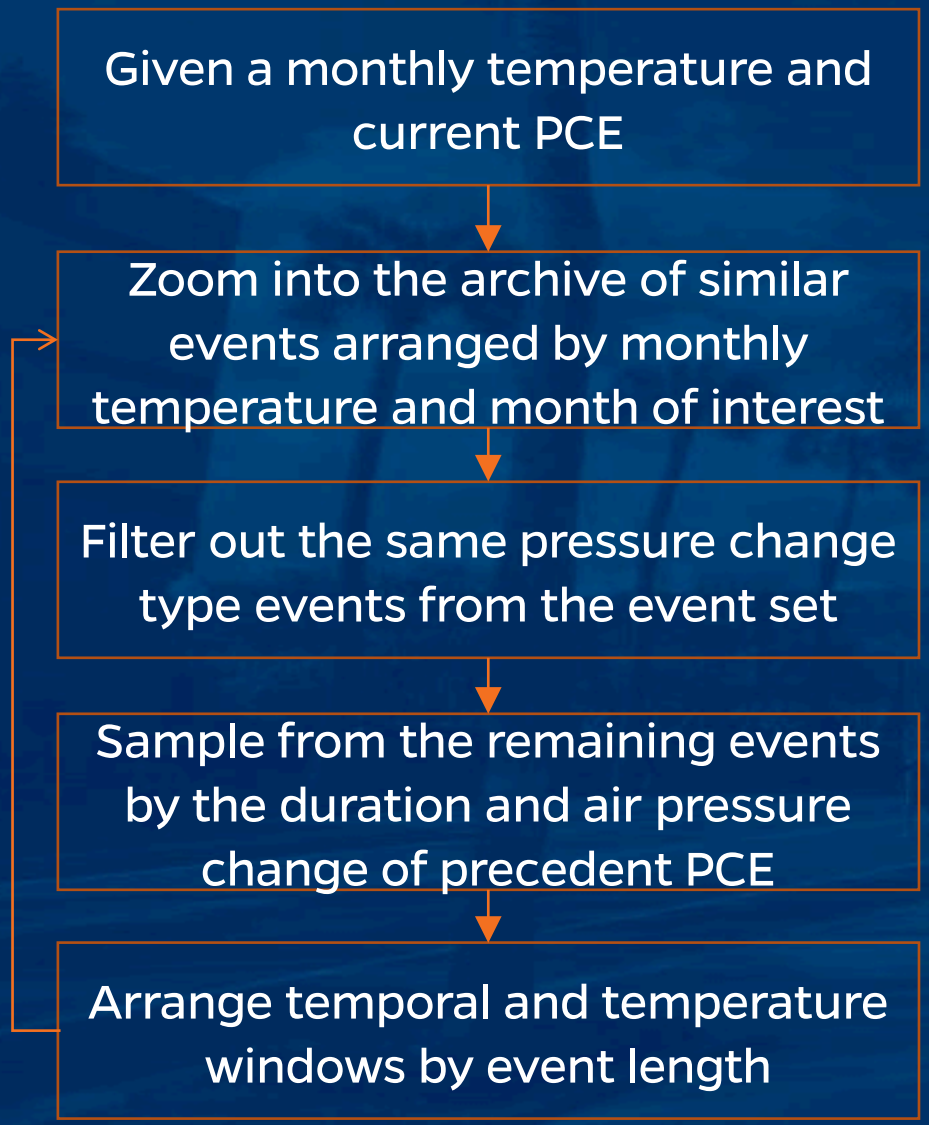




Precipitation is more associated with DePCEs than InPCEs

Yu et al. 2018

Methodology



$$PCE_1 = f(t_0, AMT_0, PCE_0)$$

$$\{PCE\} = f(t_0, AMT_0, Win)$$

$$PCE_1 = f(\{PCE\}, PCE_0)$$

PCE: Pressure Change Event
t: Time
AMT: Average Monthly Temperature
Win: window for narrowing selection region

Concatenate corresponding precipitation records for final weather series.

Methodology

Window size: **6°C * 30 days**

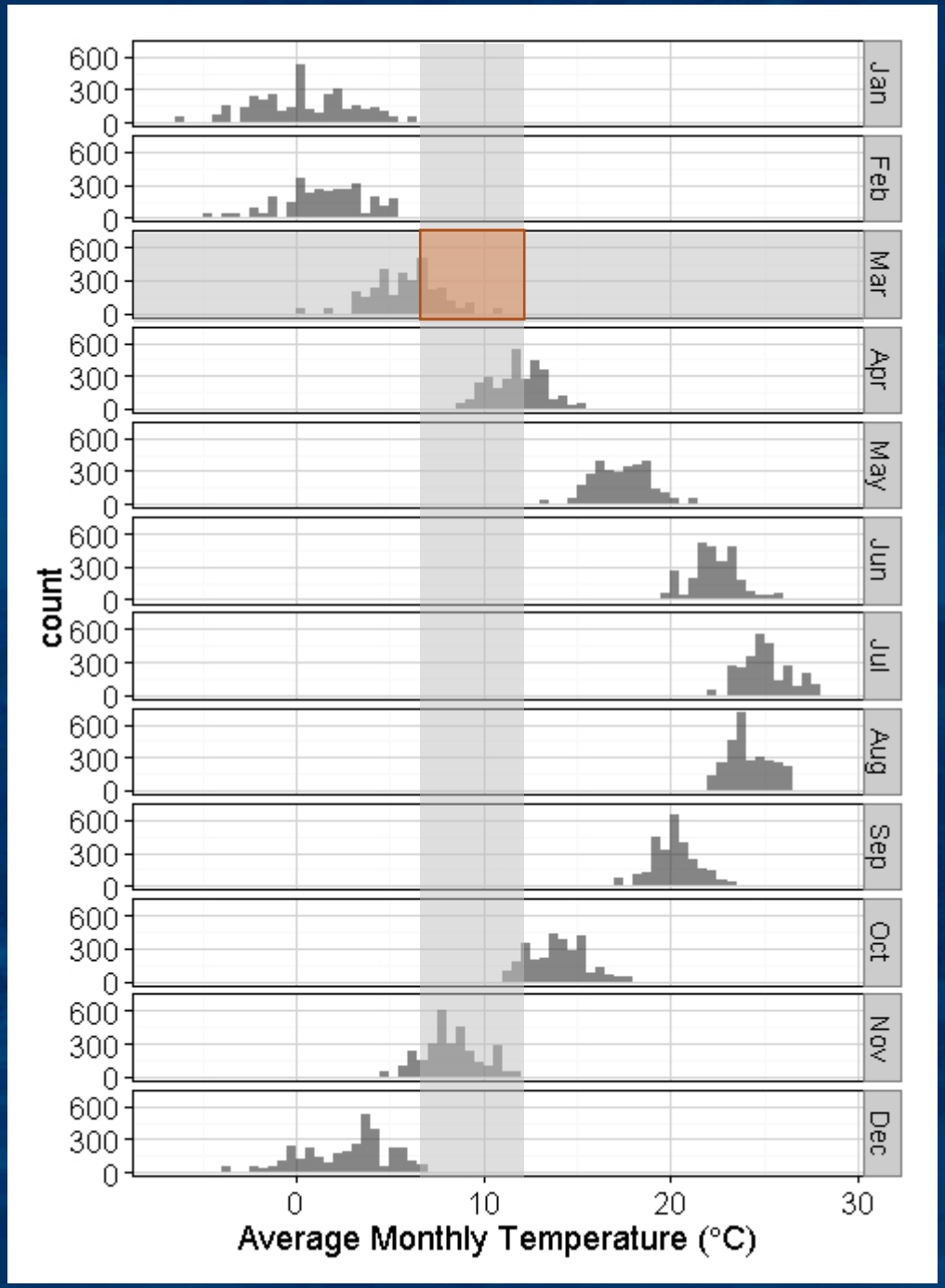
Example:

Precedent event:

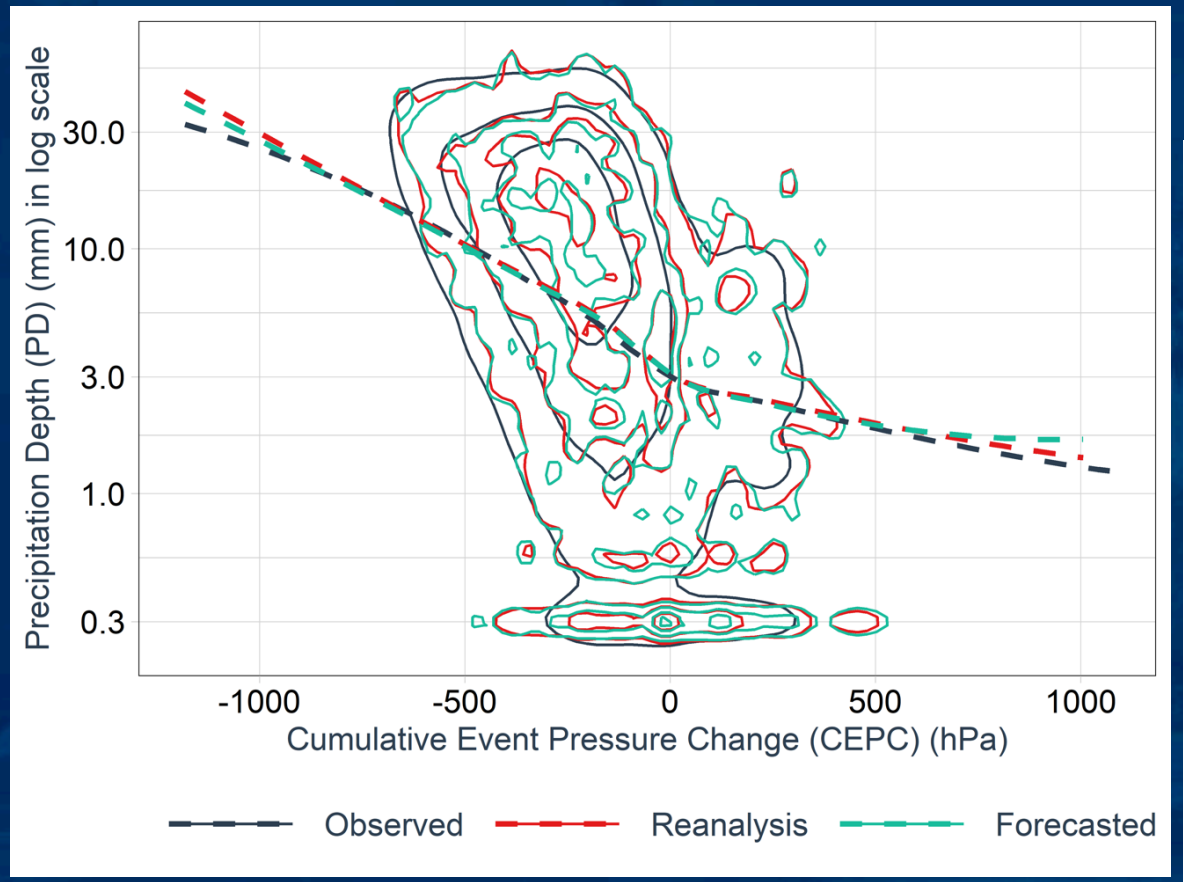
- March
- AMT = 9°C

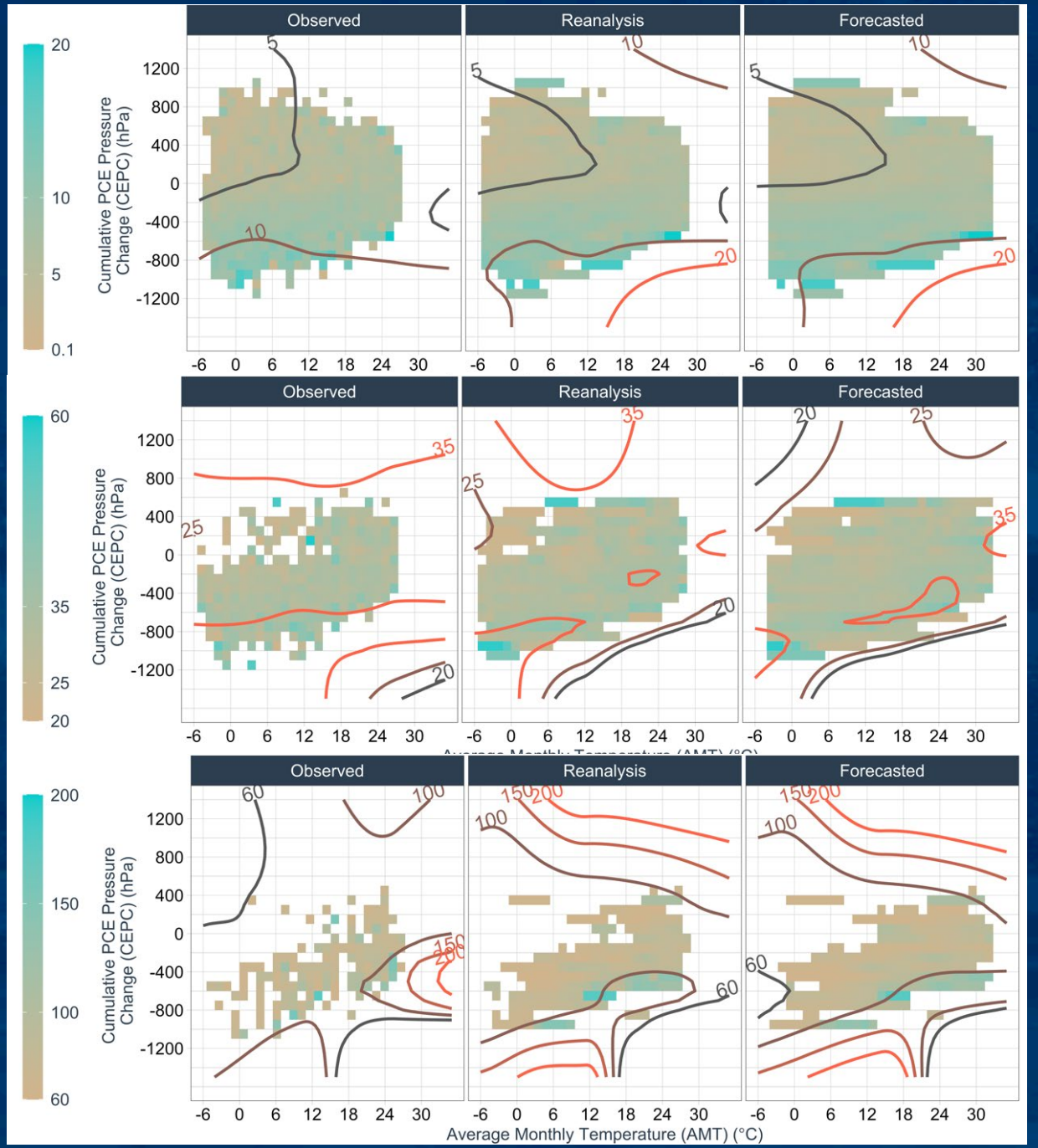
Simulation:

- Validation period (1975~2021)
- Climate change period (2035~2099)
- 100 replications of precipitation

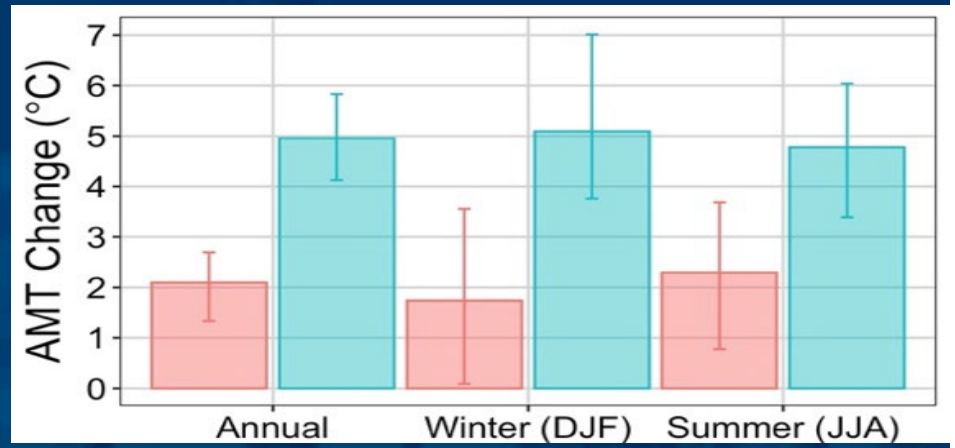


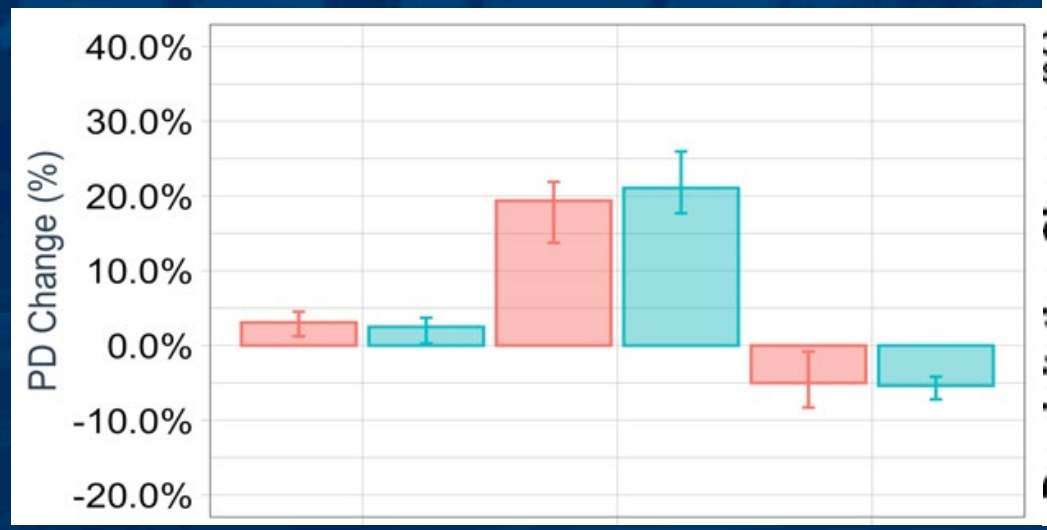
Results

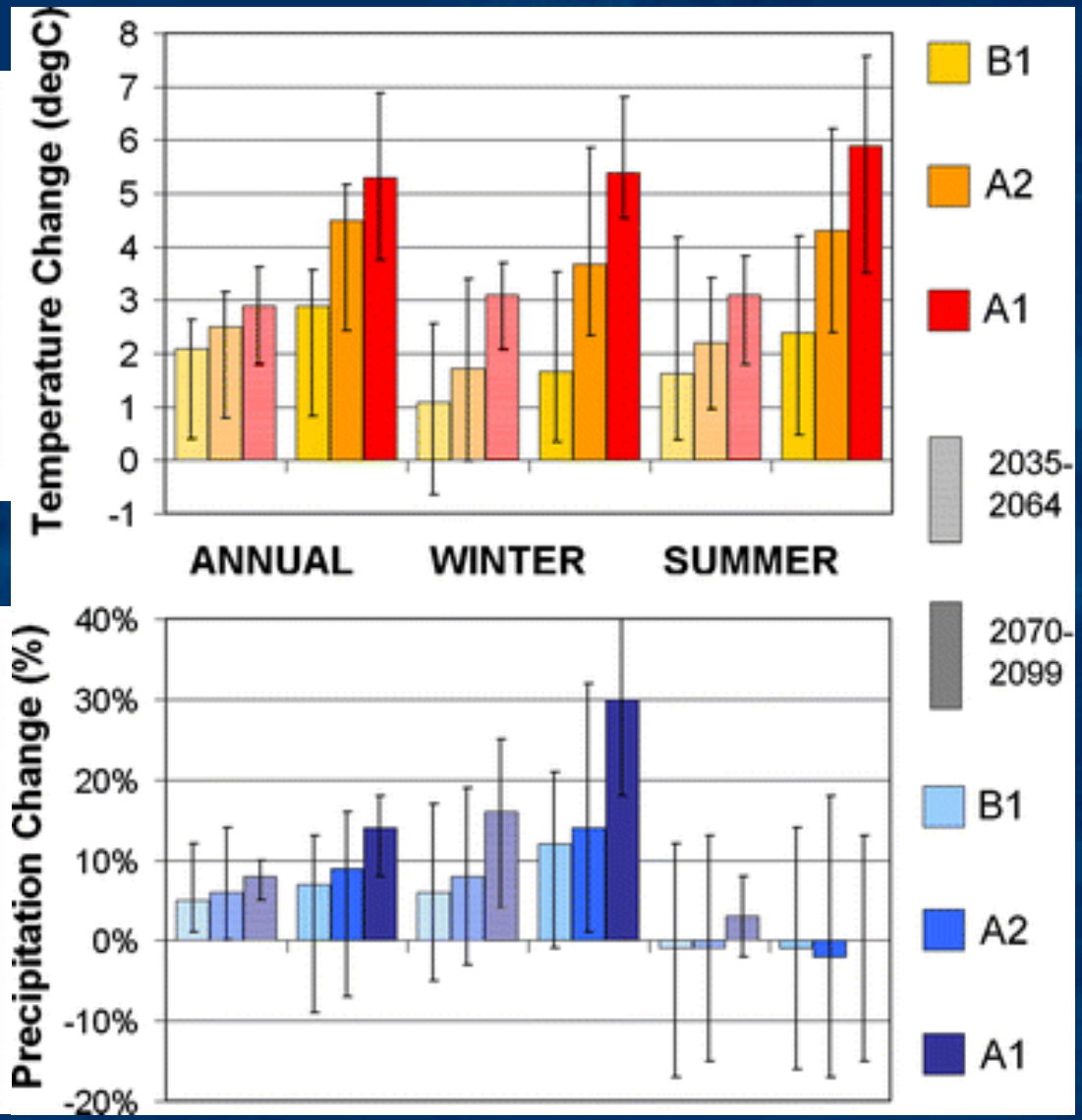

Precipitation Depth (PD) (mm) in log scale
30.0
10.0
3.0
1.0
0.3
-1000
-500
0
500
1000
Cumulative Event Pressure Change (CEPC) (hPa)
Observed
Reanalysis
Forecasted


Observed
Reanalysis
Forecasted
Cumulative PCE Pressure Change (CEPC) (hPa)
1200
800
400
0
-400
-800
-1200
-6
0
6
12
18
24
30
20
10
5
0.1
60
35
25
20
200
150
100
60
Average Monthly Temperature (AMT) (°C)

Results



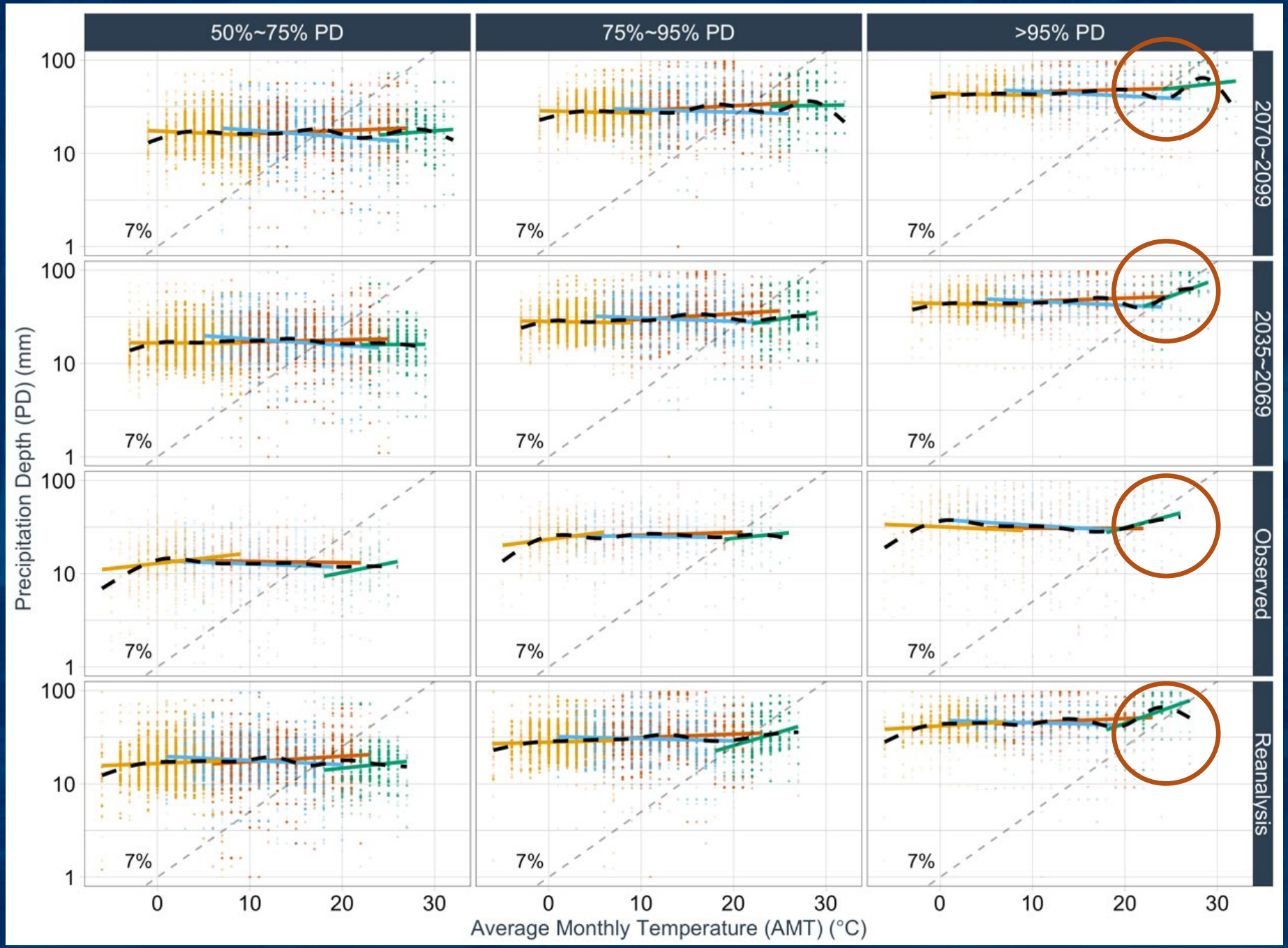




[*Hayhoe et al.*, 2007]

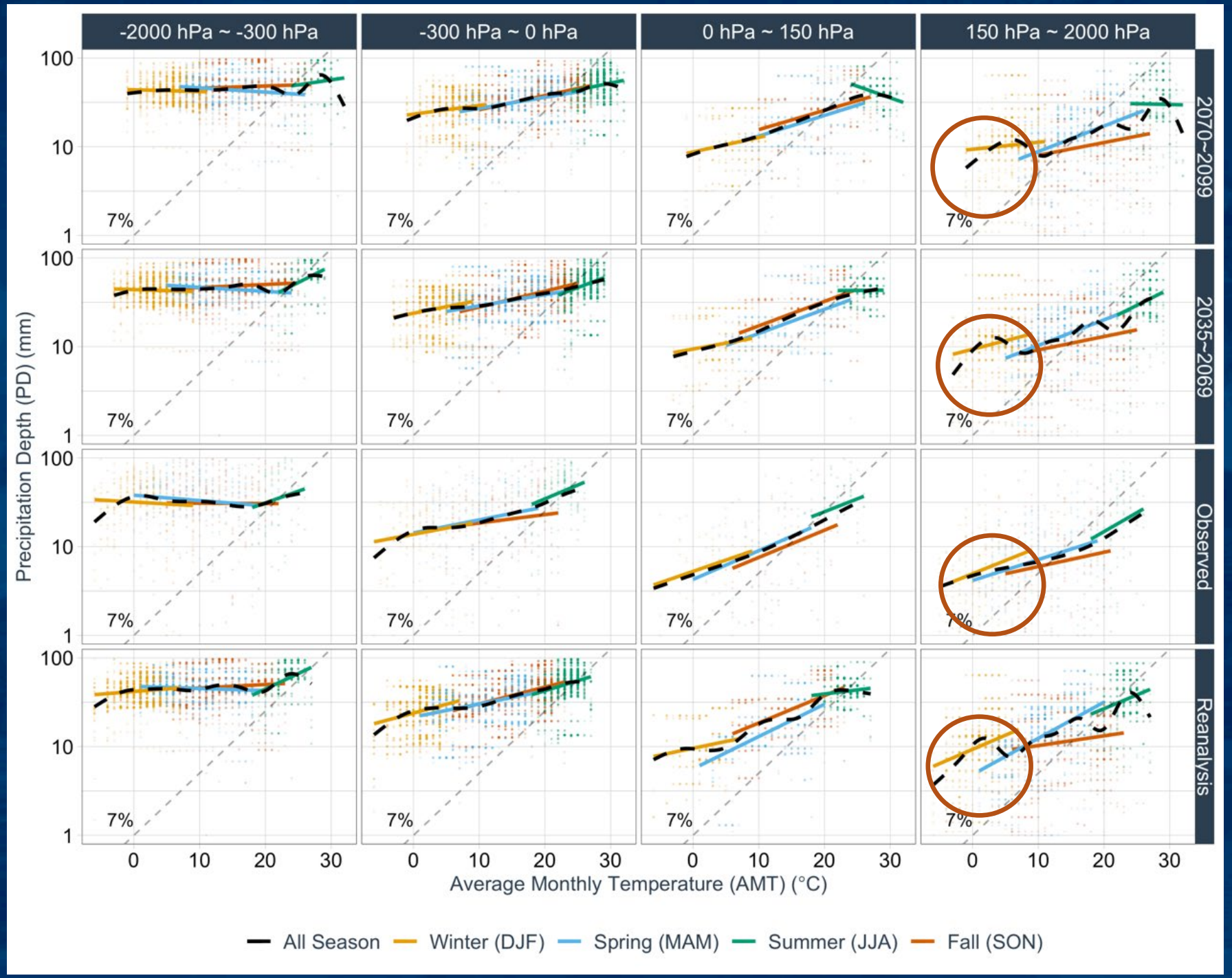
Results

Cumulative Event Pressure Change (CEPC) <-300 hPa



Results

Precipitation Depth (PD) > 95%



Summary

- The Clausius-Clapyron (CC) relationship is embodied in PCE precipitation associated with high intensity air convection
- Increasing Pressure Change Event (InPCE) PD increases with AMT more significantly than with Decreasing Pressure Change Event (DePCE) which could be due to the point sourced data in this study
- In the NE US, more frequent mild and lighter precipitation events are likely to occur in the future during all seasons
- Less frequent but more high intensity extremes are also likely to occur during all seasons
- Overall, Summer precipitation is likely to be reduced, while Summer extreme events are likely to become more frequent under climate change
- Winter precipitation is likely to increase

Thank you

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