

Characteristics of Long-Duration Heavy Precipitation Events along the West Coast of the United States

BENJAMIN J. MOORE,^a ALLEN B. WHITE,^a AND DANIEL J. GOTTAS^a

^a NOAA/Physical Sciences Laboratory, Boulder, Colorado

(Manuscript received 16 October 2020, in final form 3 February 2021)

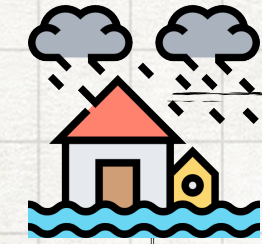
Speaker: Jo-Yu Wu

OUTLINE

1. Introduction
2. Data & Methods
3. Long-Duration HPEs in Northern California
4. Case Studies
5. Summary & Conclusions

INTRODUCTION

HPEs & LONG-DURATION HPEs



Long-Duration HPEs

- precipitation span several days to beyond a week
- extreme rainfall accumulations & high-impact flooding



Heavy Precipitation Events (HPEs)

- these systems are usually mobile (Wallace et al. 1988)
- precipitation tend to be short lived (<1 day)

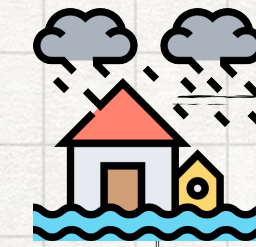
INTRODUCTION

HPEs & LONG-DURATION HPEs

A System Stalls And Becomes Quasi-Stationary For An Extended Period

1

- the movement of a system is impeded (Lenggenhager et al. 2019)
- a system moves into an environment of weak background flow



Long-Duration HPEs

- precipitation span several days to beyond a week
- extreme rainfall accumulations & high-impact flooding



2

Multiple Systems Pass Over The Location In Rapid Succession

- **repeated** passage of cyclones or mesoscale convective systems through a geographically fixed corridor over a period of several days



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INTRODUCTION

CYCLONE CLUSTERING

Serial **clustering of extratropical cyclones** is a principal process resulting in long-duration HPEs at midlatitudes.

(Weaver 1962; Lackmann and Gyakum 1999; Sodemann and Stohl 2013; Grams et al. 2014; Priestley et al. 2017a; Moore et al. 2020)

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Cyclone Families (Bjerknes and Solberg 1922)

Multiple cyclones develop and follow a **similar path** in rapid succession (separated by intervals of 1–2 days).

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Water vapor fluxes are often concentrated within **atmospheric rivers**.

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Cyclone Clustering

Zonally Upper-Level Jet

The jet acts as a persistent waveguide for synoptic-scale Rossby waves, which may **repeatedly** induce baroclinic instability and cyclogenesis.

(Martius et al. 2010)

Atmospheric Blocking

The blocking ridge acts to **impede** and **divert** synoptic-scale waves, causing **clustering** in a manner analogous to a traffic jam.

(Mailier et al. 2006; Nakamura and Huang 2018)

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OBJECTIVES & STUDIED REGION



To identify principal large-scale flow patterns linked to long-duration HPEs.

To diagnose, through composite analyses and case studies, processes within those patterns that act to sustain heavy precipitation.



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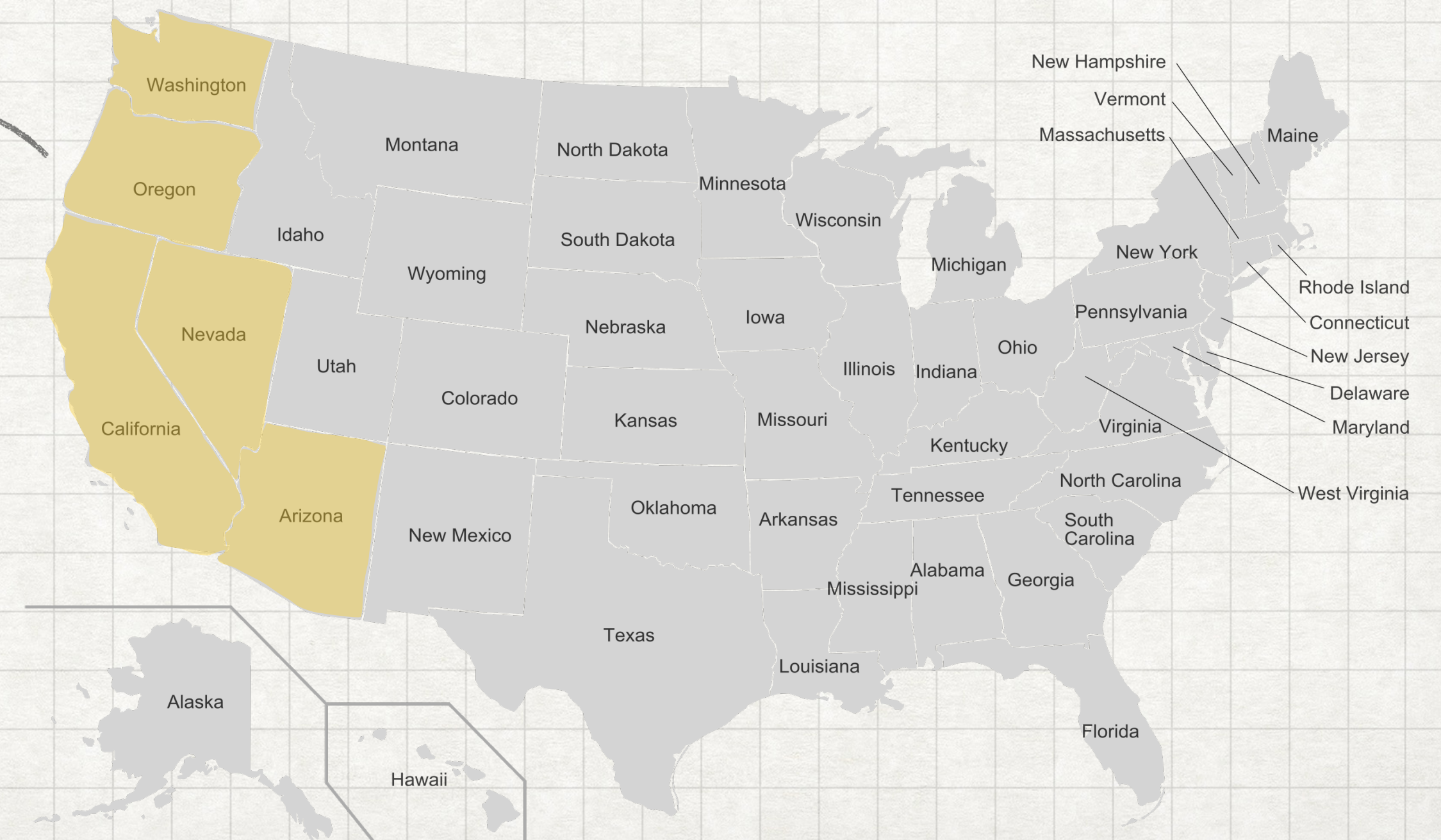


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West Coast Region of the United State

- the terminus of the North Pacific storm track
- the preponderance of complex orography



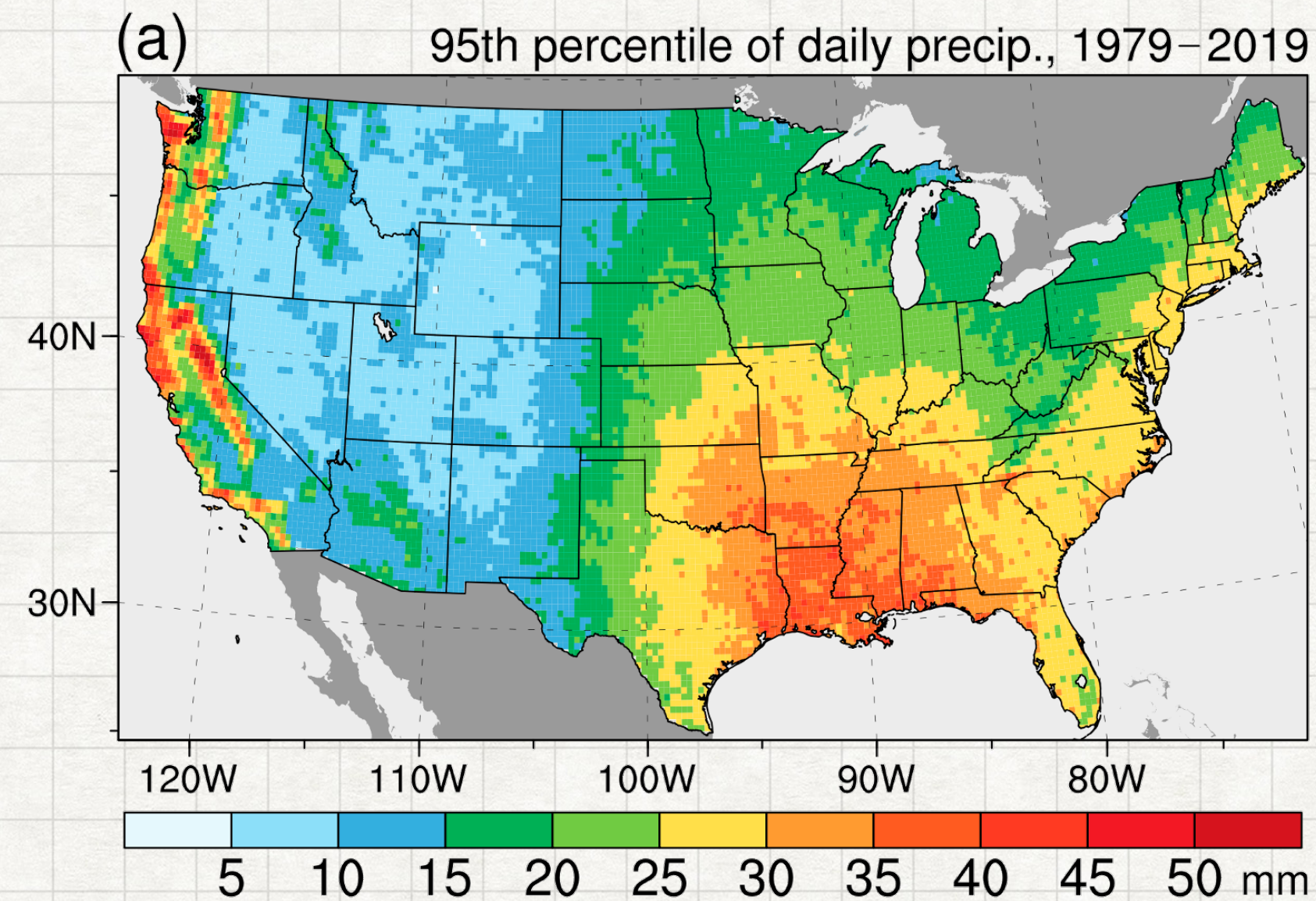
DATA & METHODS

CLIMATOLOGY

Precipitation Data

NOAA Climate Prediction
Center Unified Precipitation
Dataset (UPD)

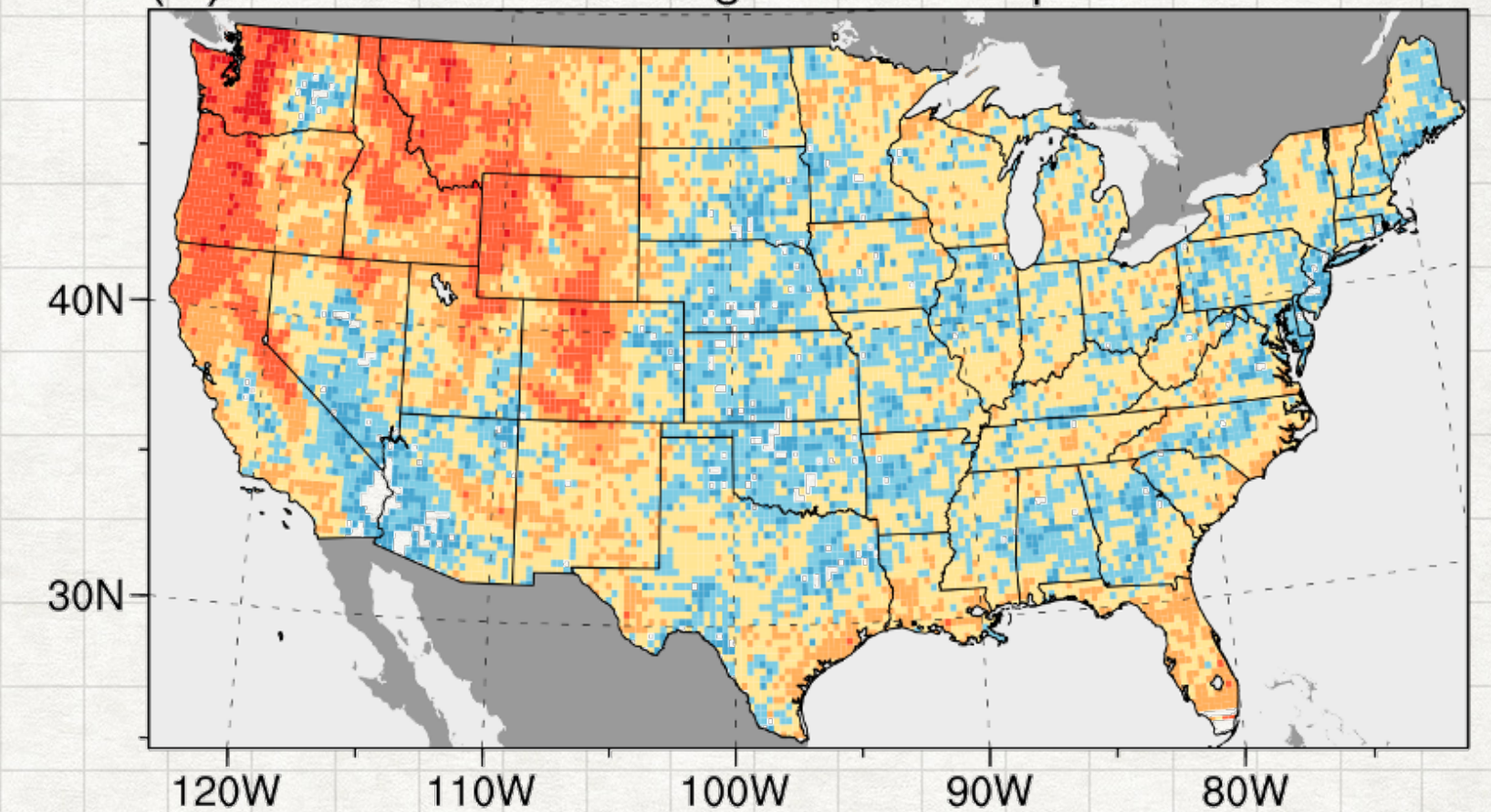
(Higgins et al. 2000)



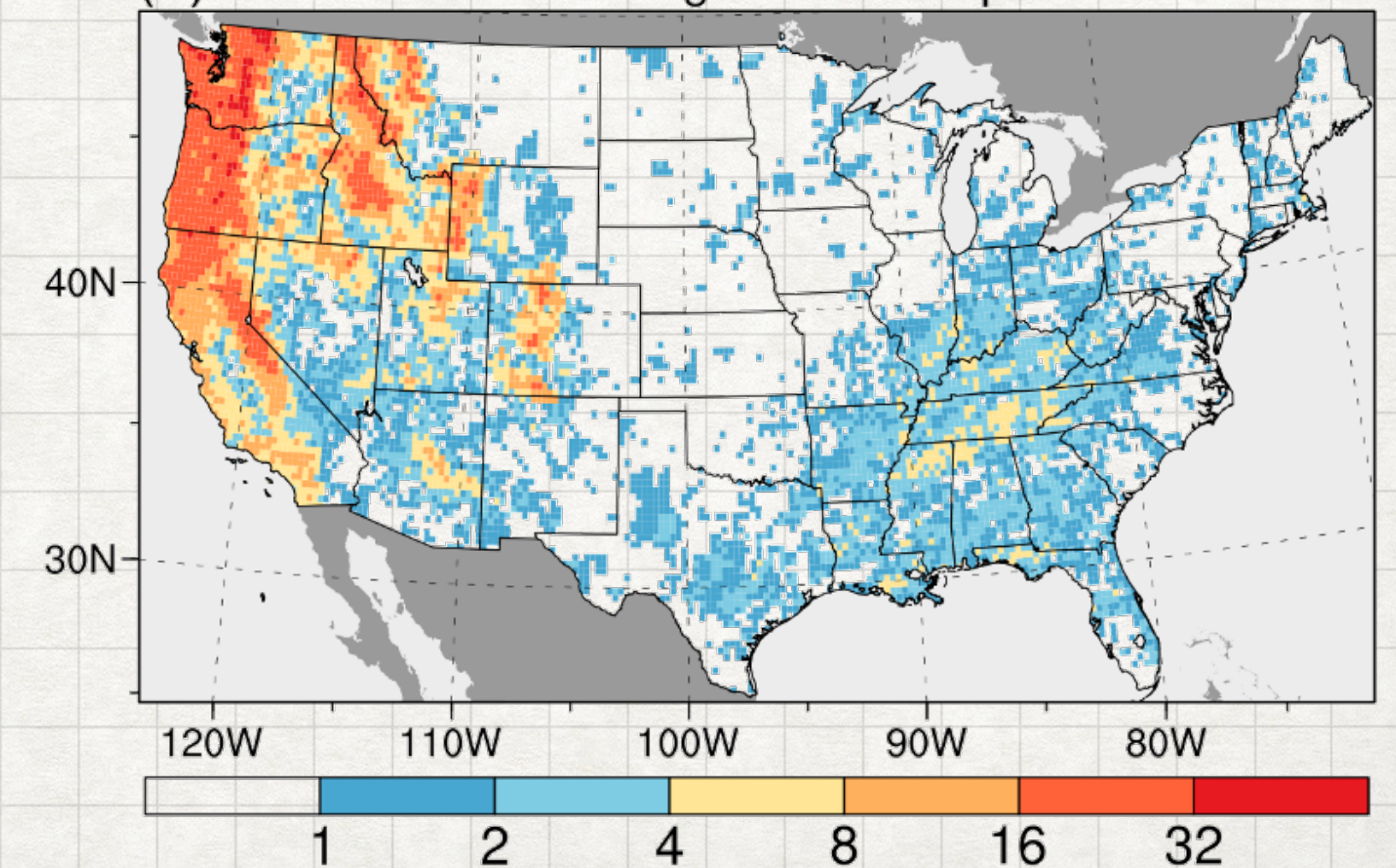
Criteria for Long-Duration HPEs

- 1 sequences separated by a gap ≤ 1 day
- 2 sequences comprising ≥ 3 days

(b) number of long-duration sequences: all months



(c) number of long-duration sequences: Nov–Mar

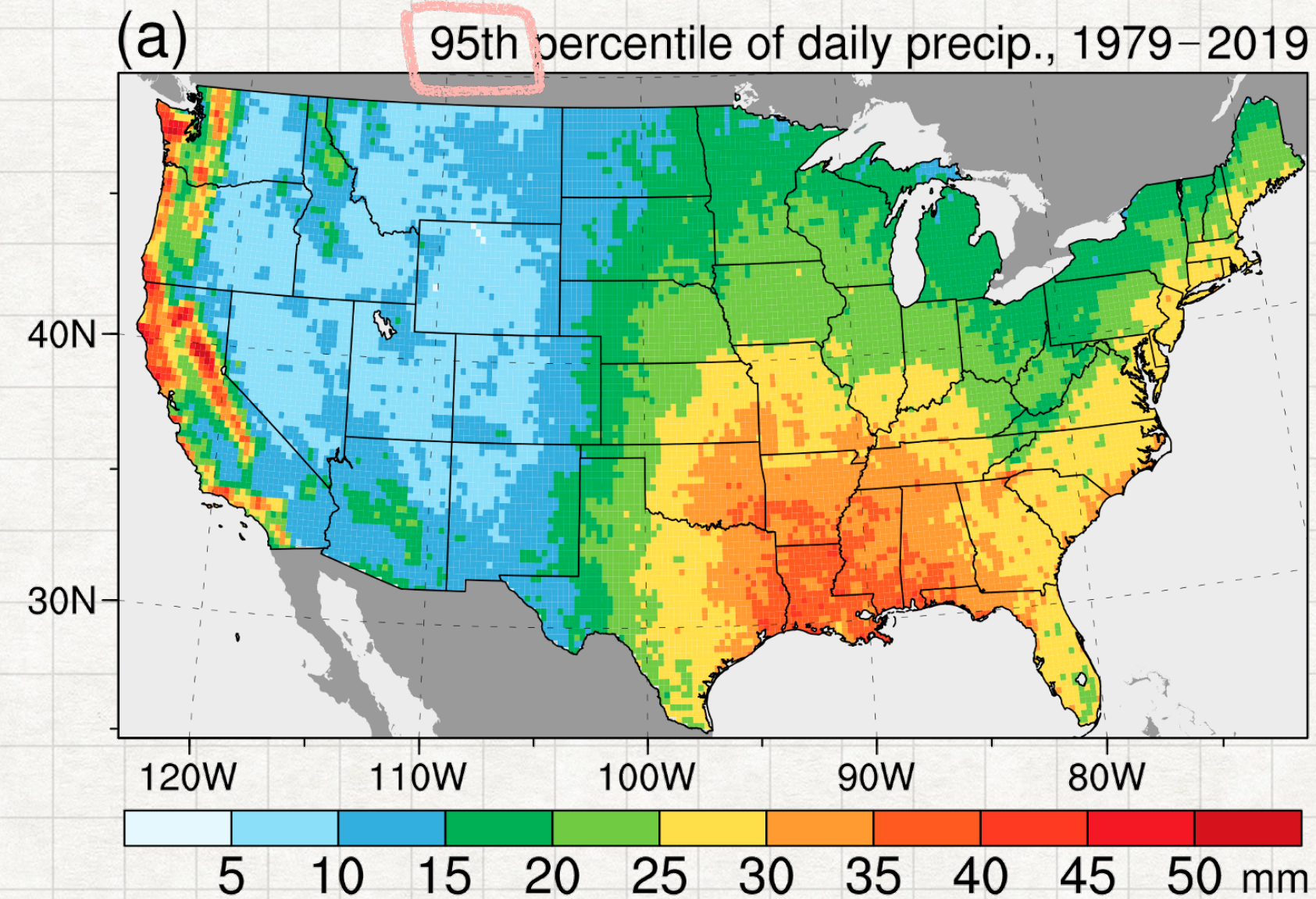


DATA & METHODS

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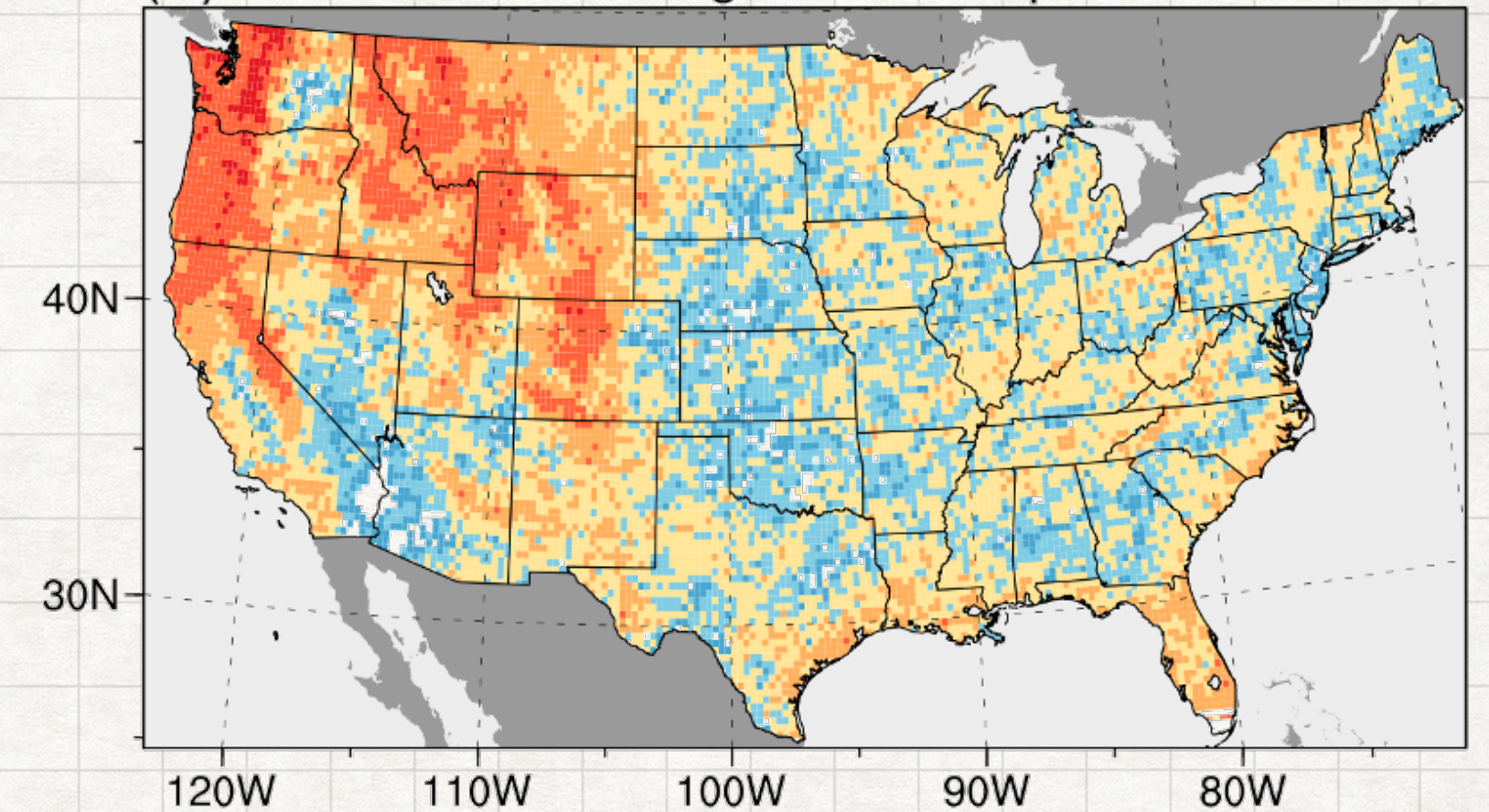
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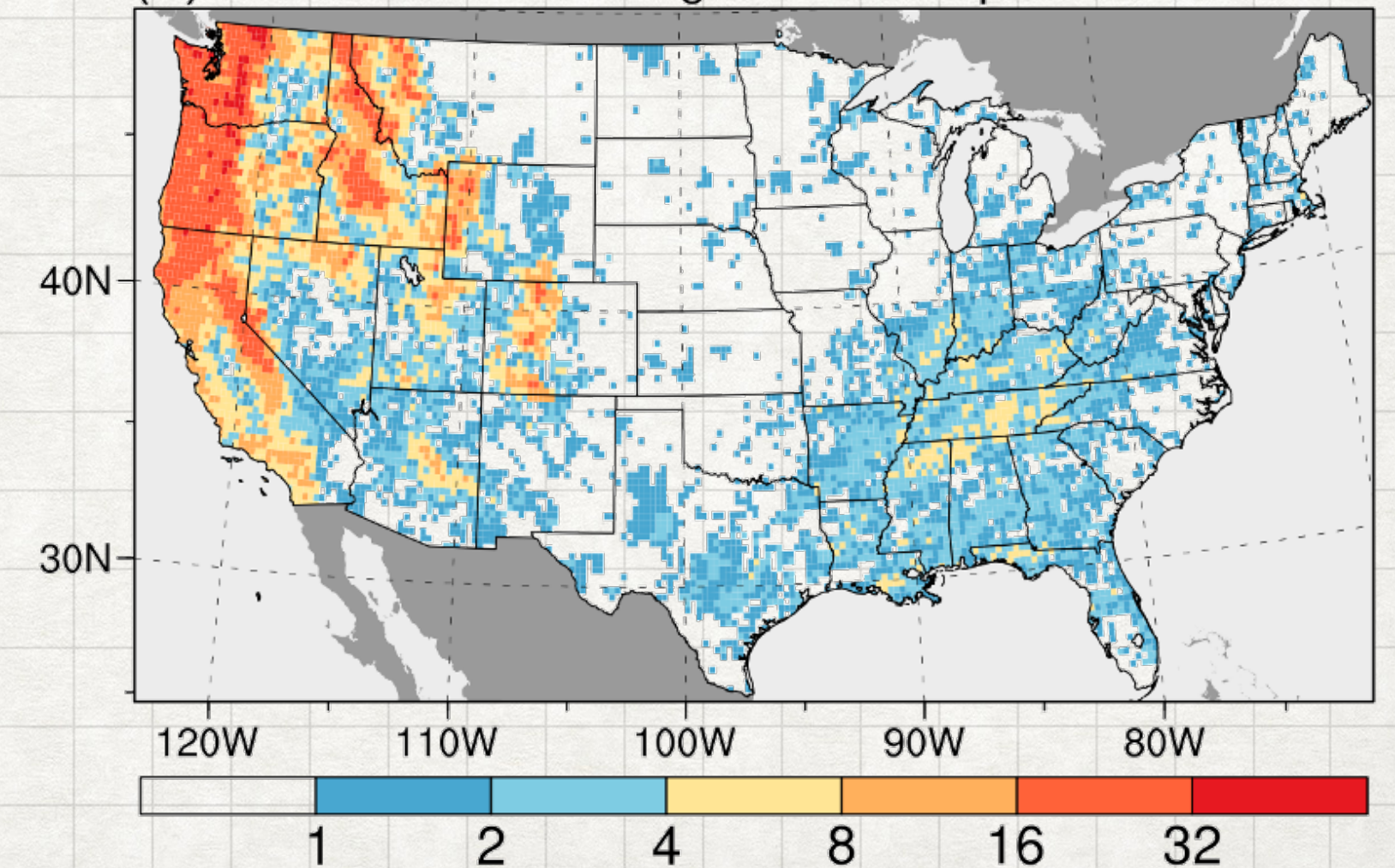
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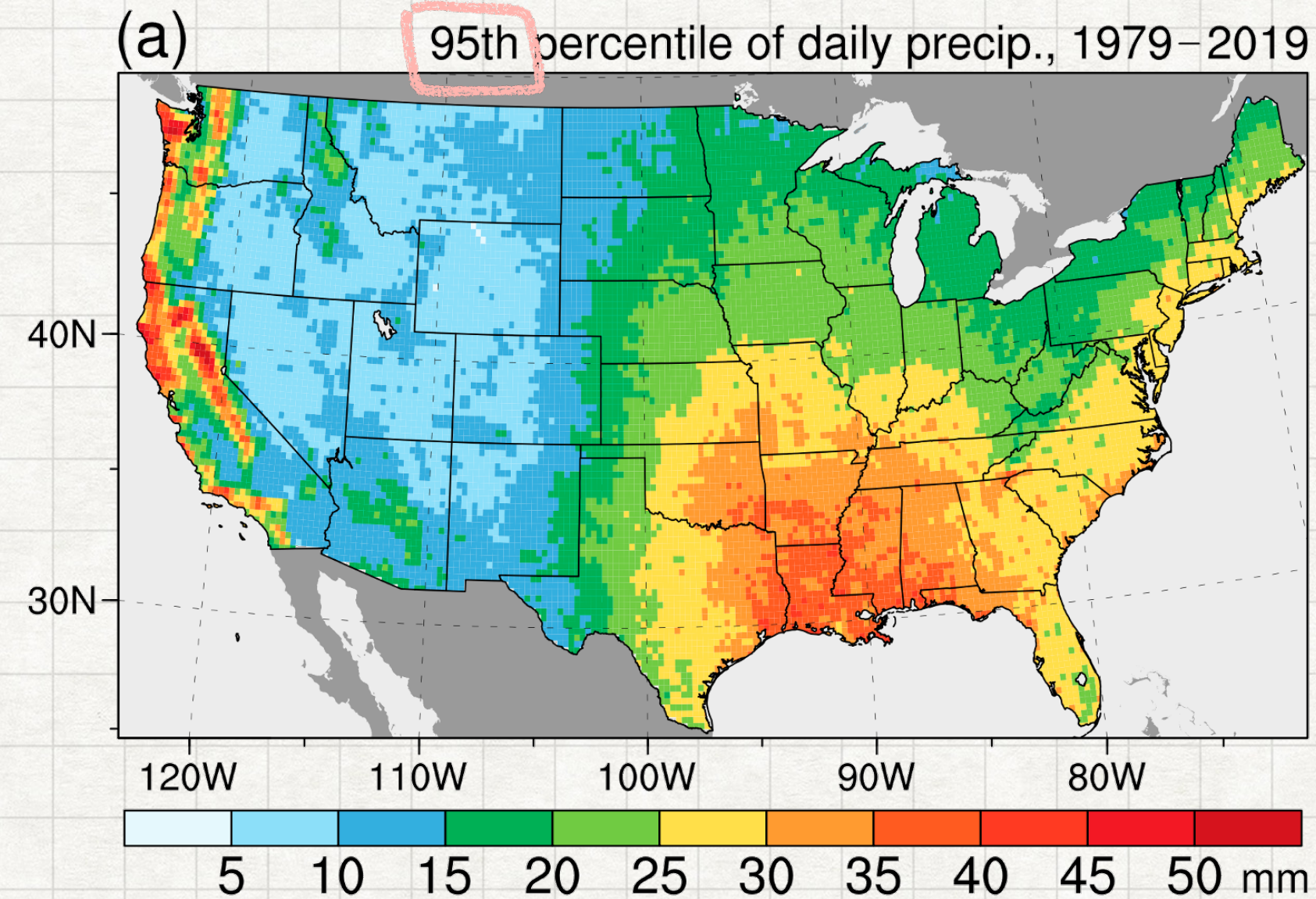


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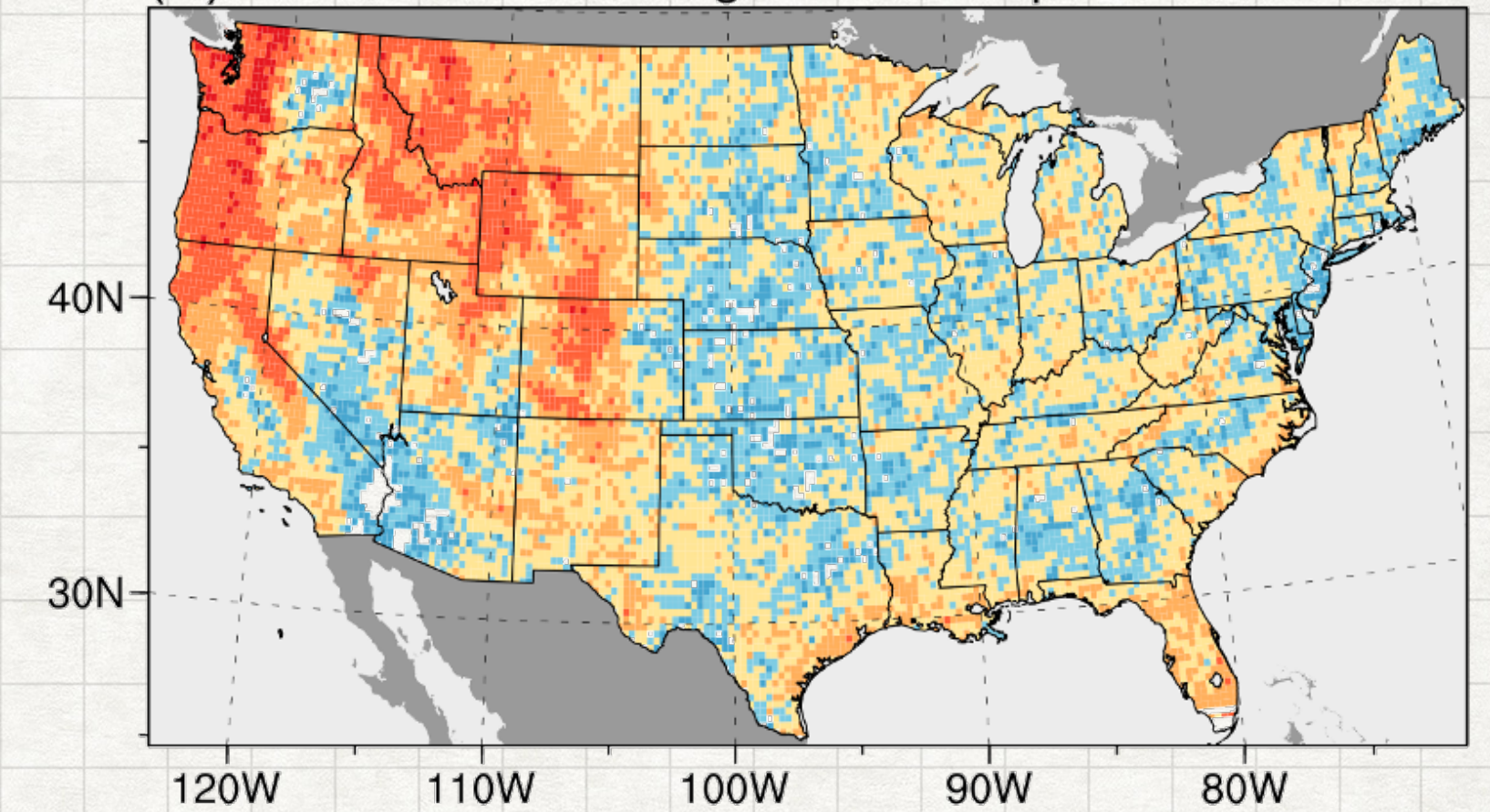
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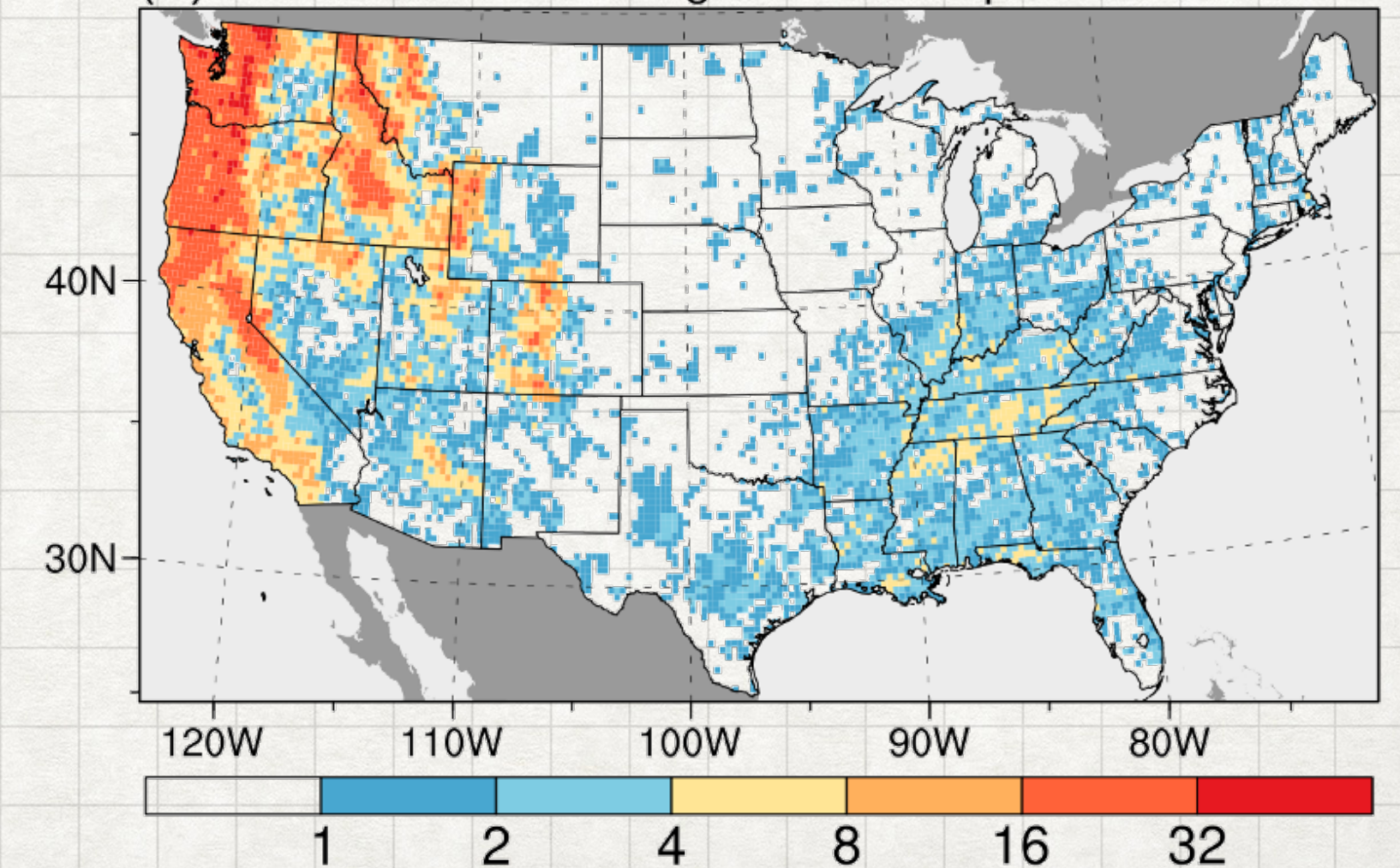
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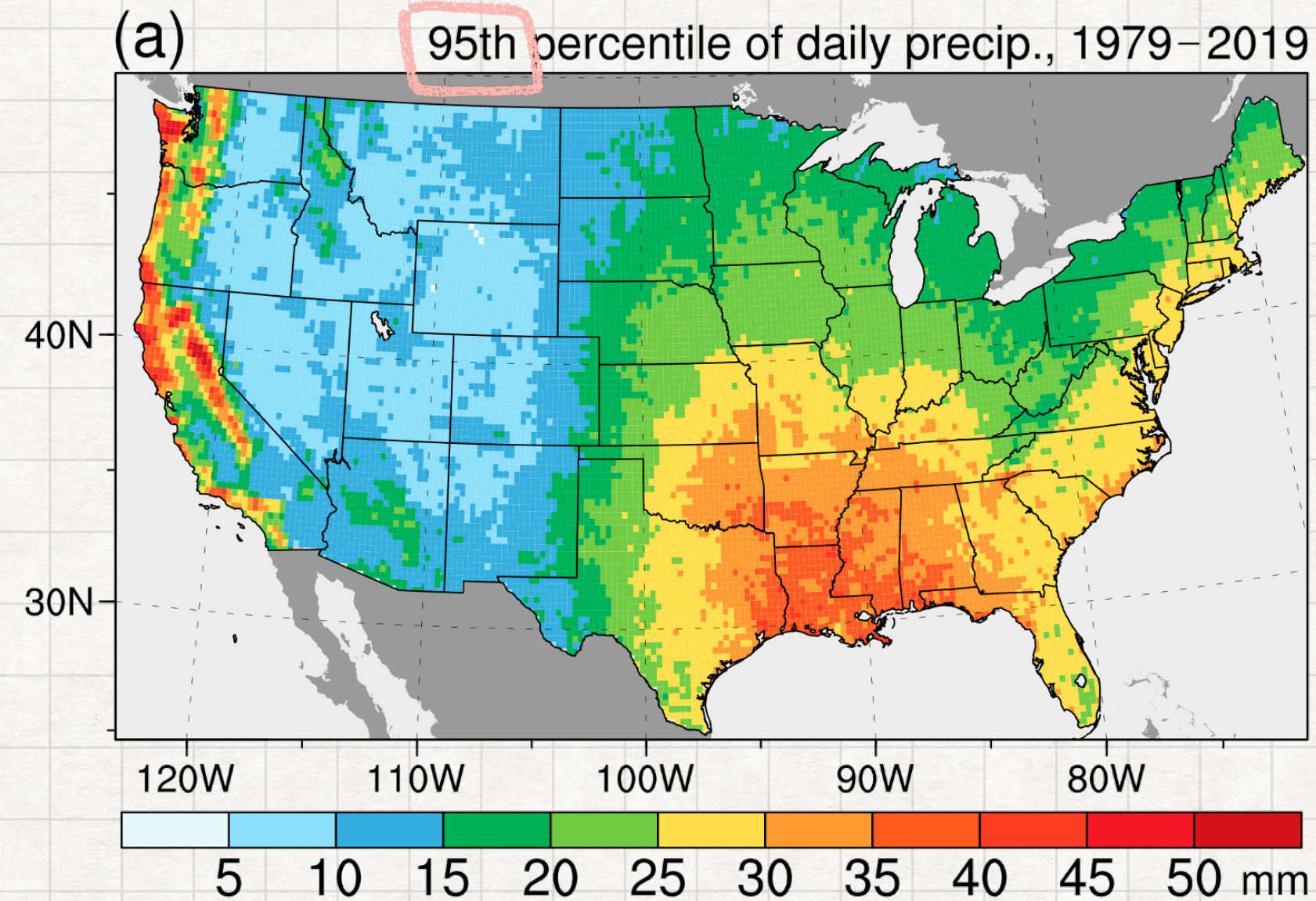


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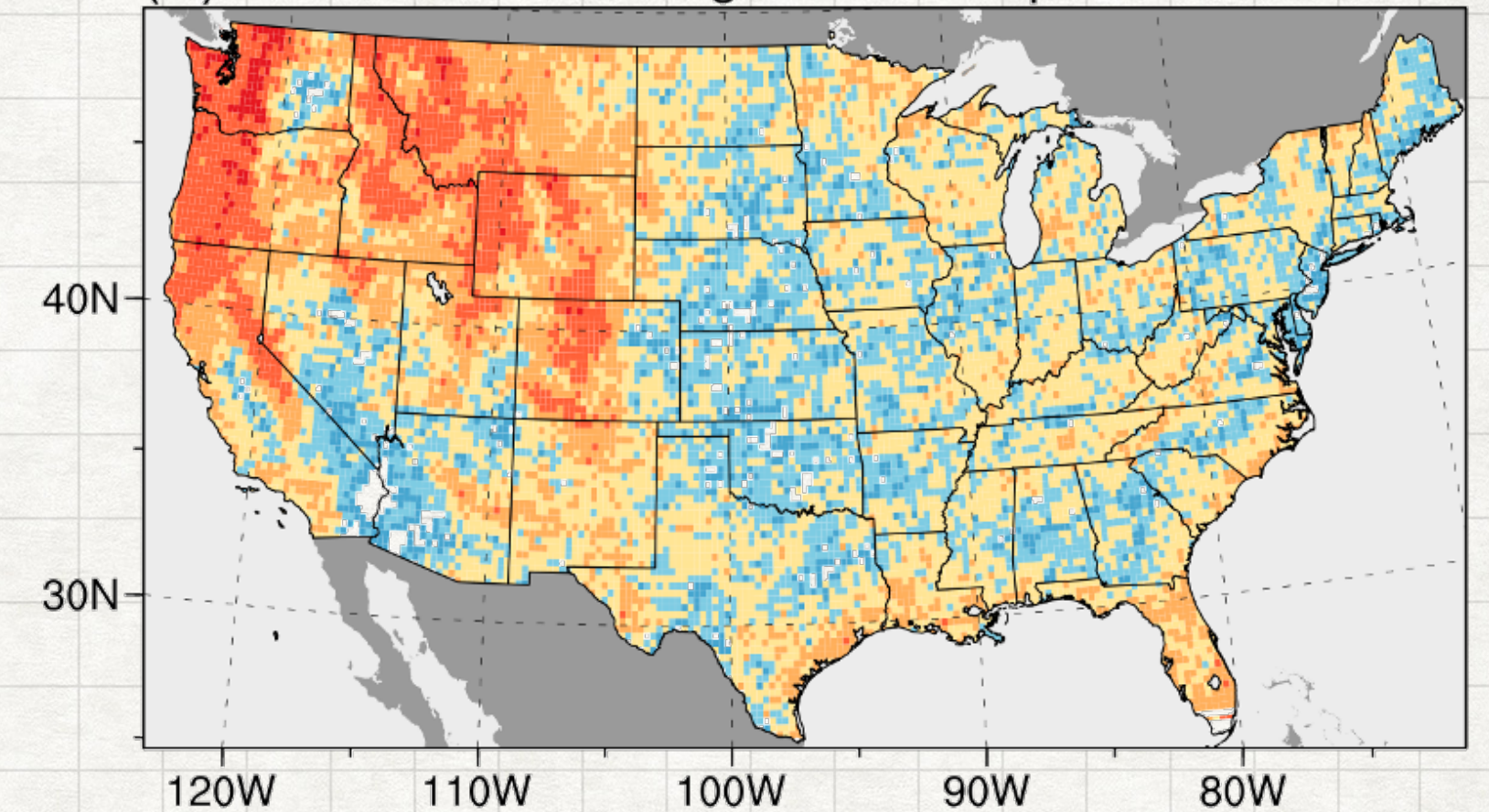
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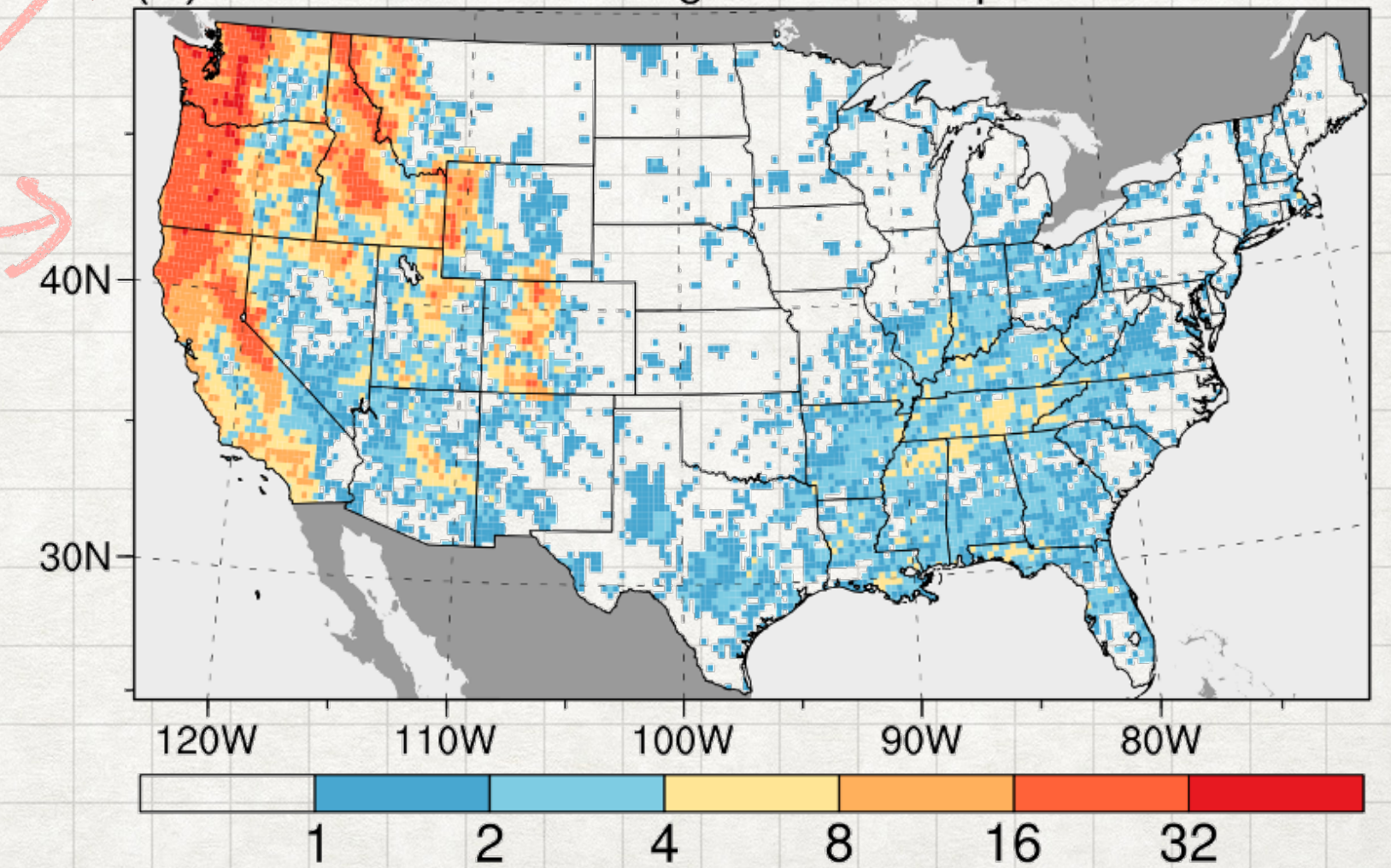
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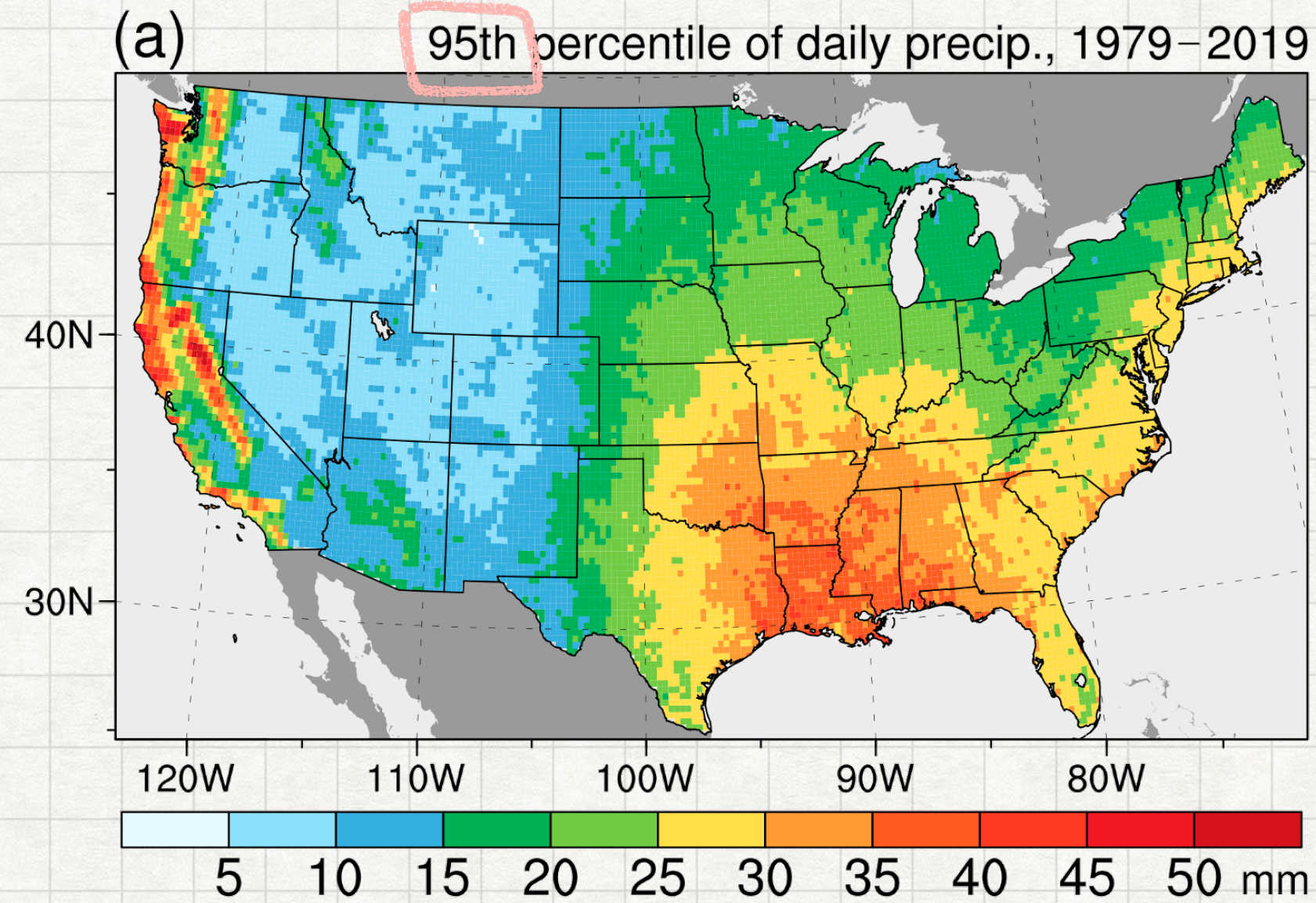


DATA & METHODS

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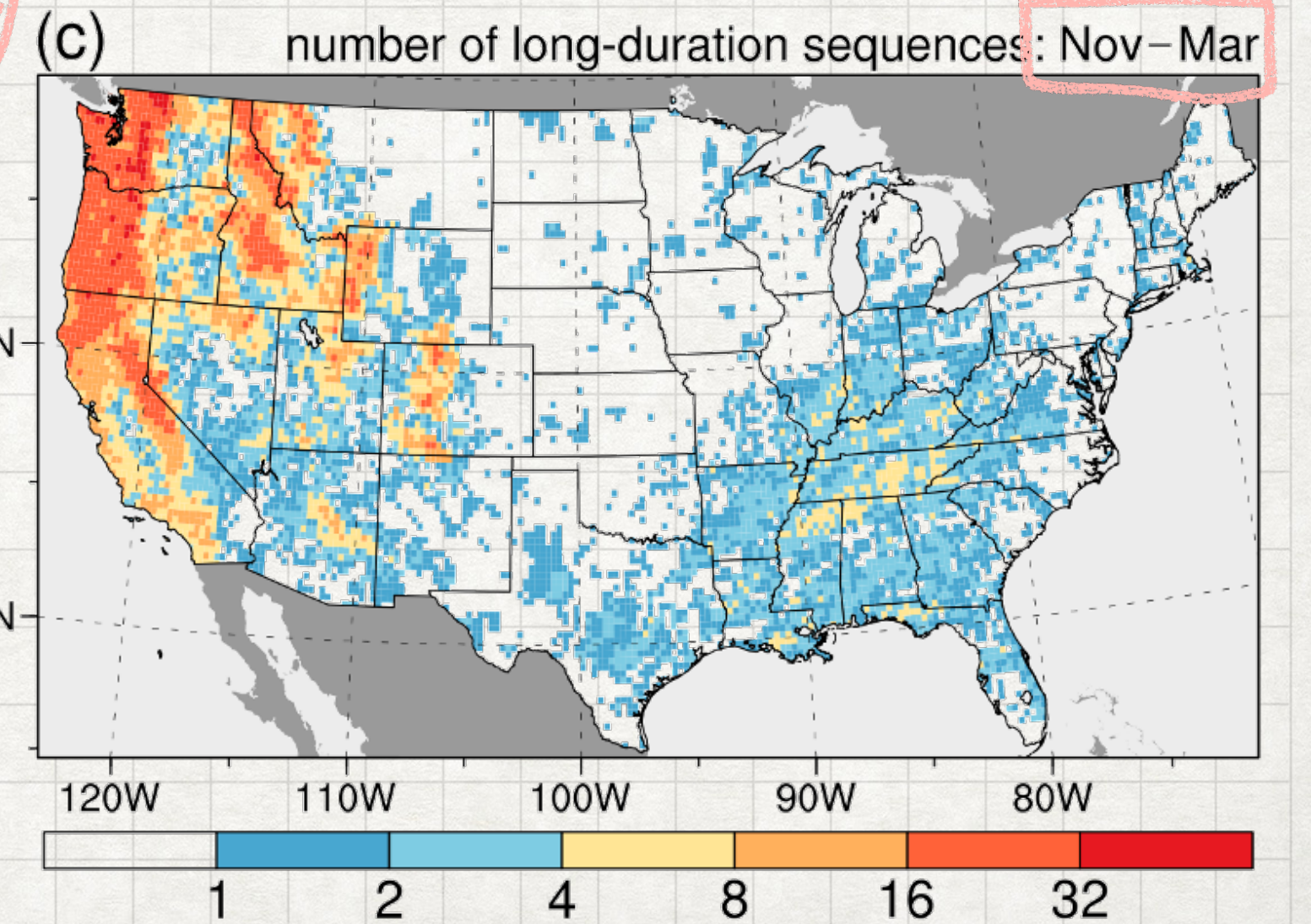
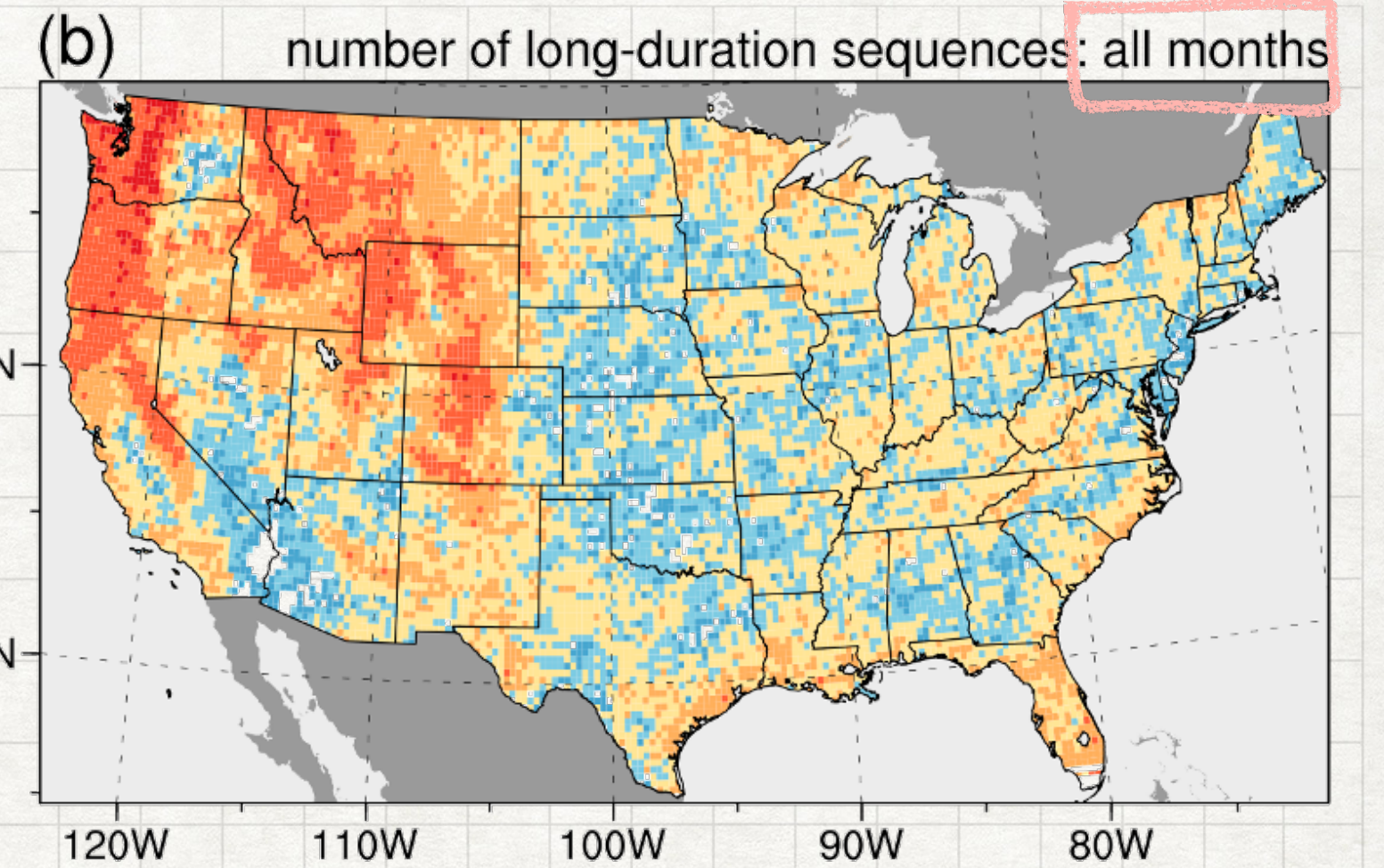
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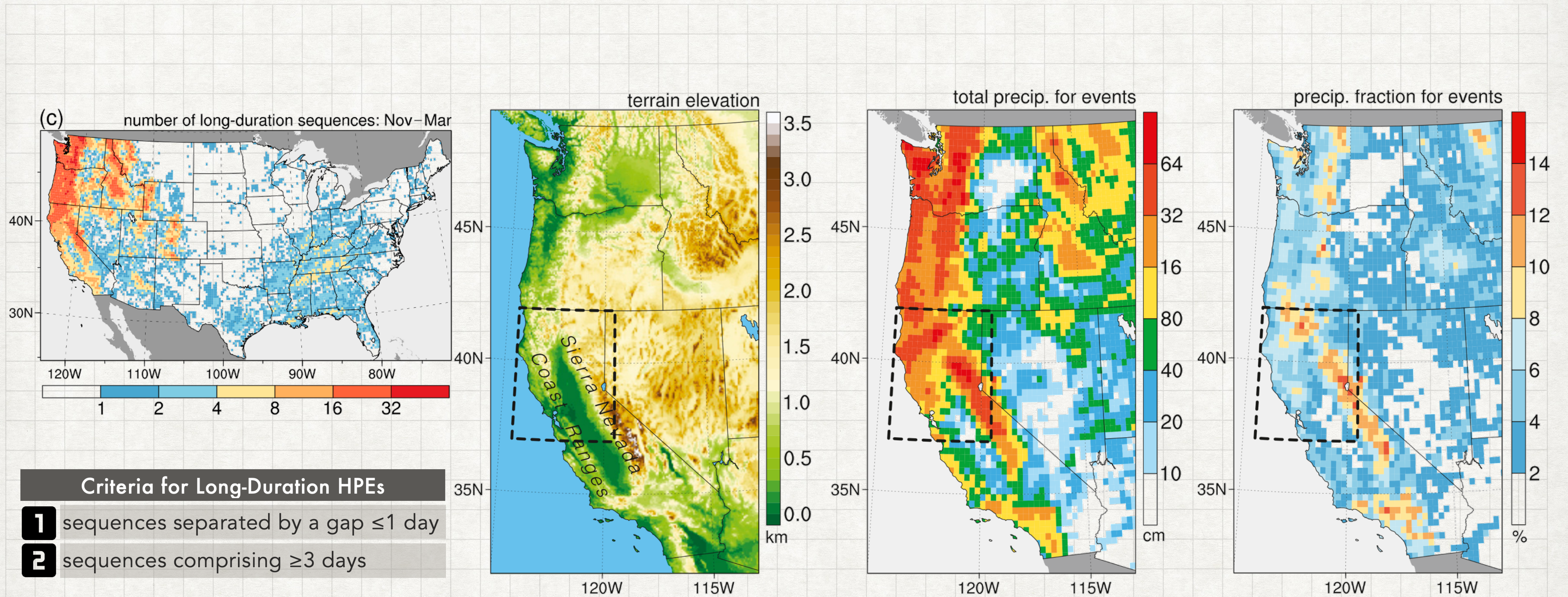
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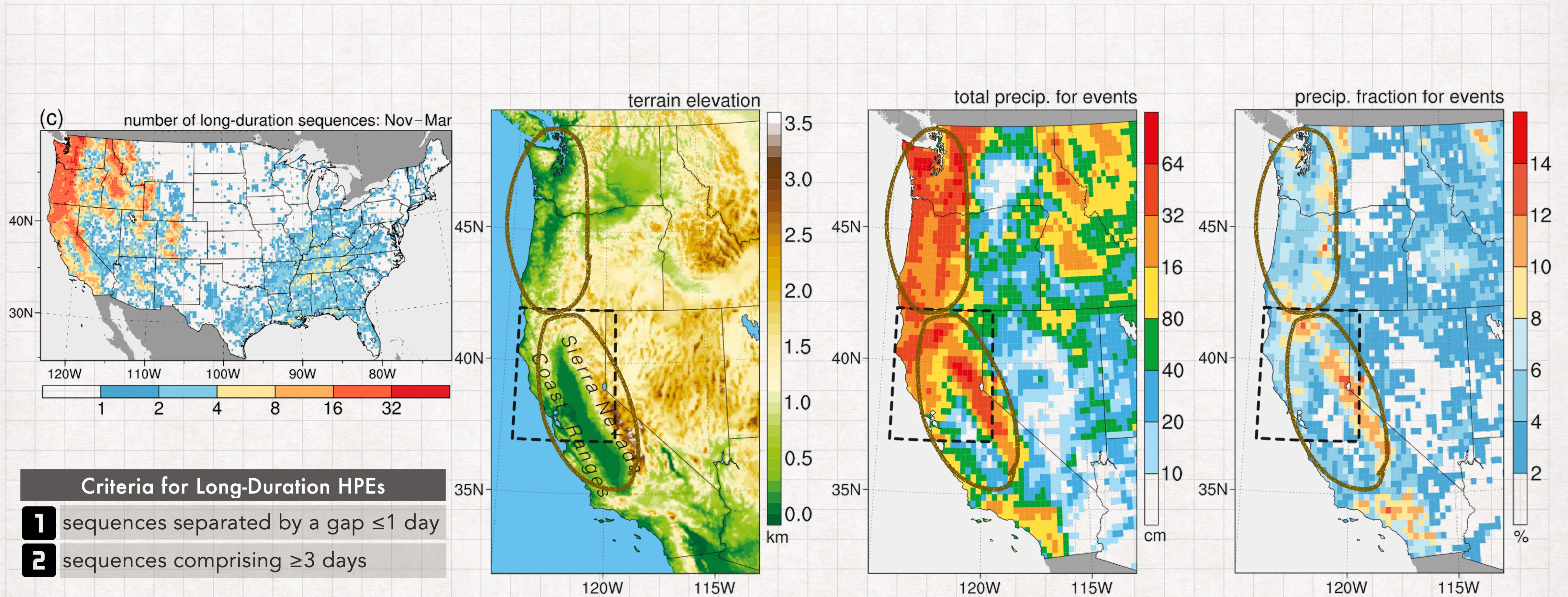
DATA & METHODS

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DATA & METHODS

COMPOSITE ANALYSIS

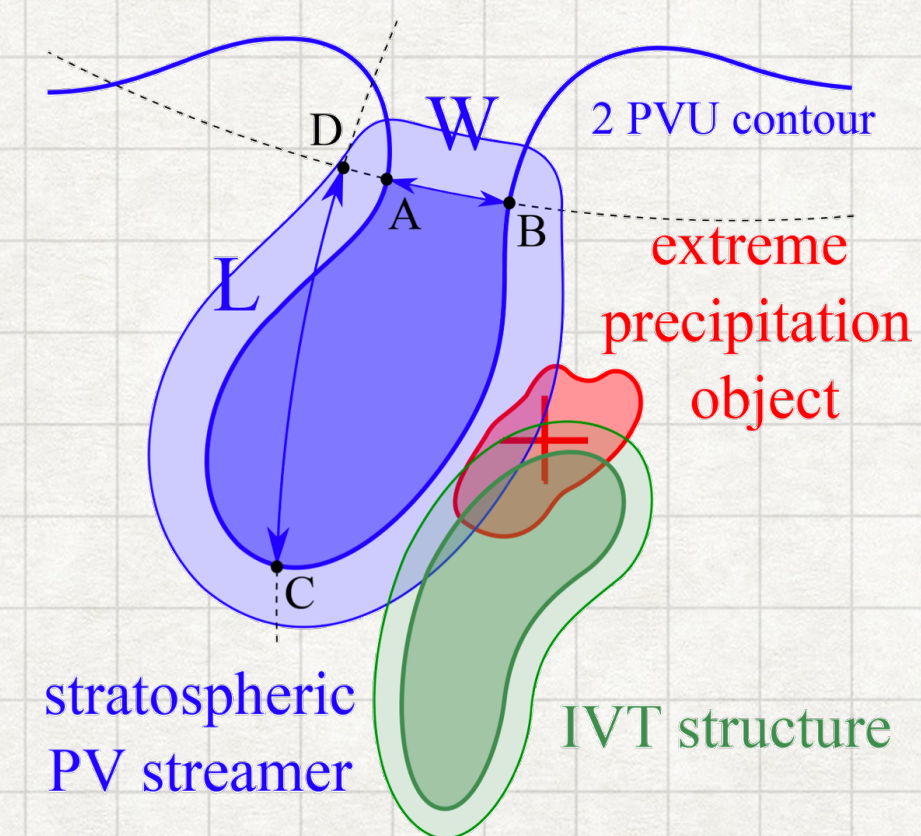
θ_{DT} Positive (negative) θ_{DT} anomalies correspond to negative (positive) PV anomalies

Eady Growth Rate a measure of baroclinic instability

Integrated Water Vapor Transport (IVT) water vapor flux

Q-vector synoptic-scale dynamically forced vertical motions

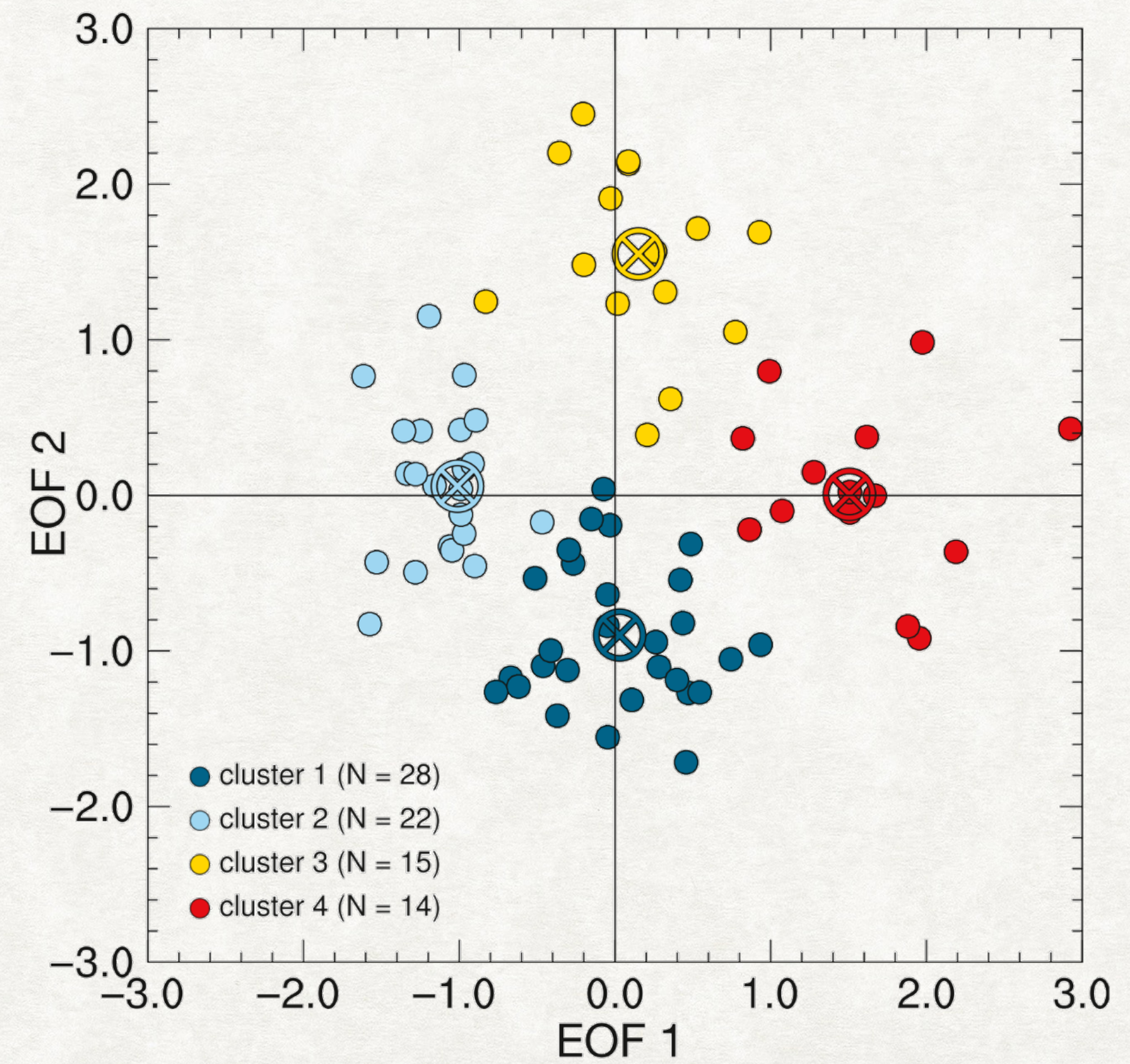
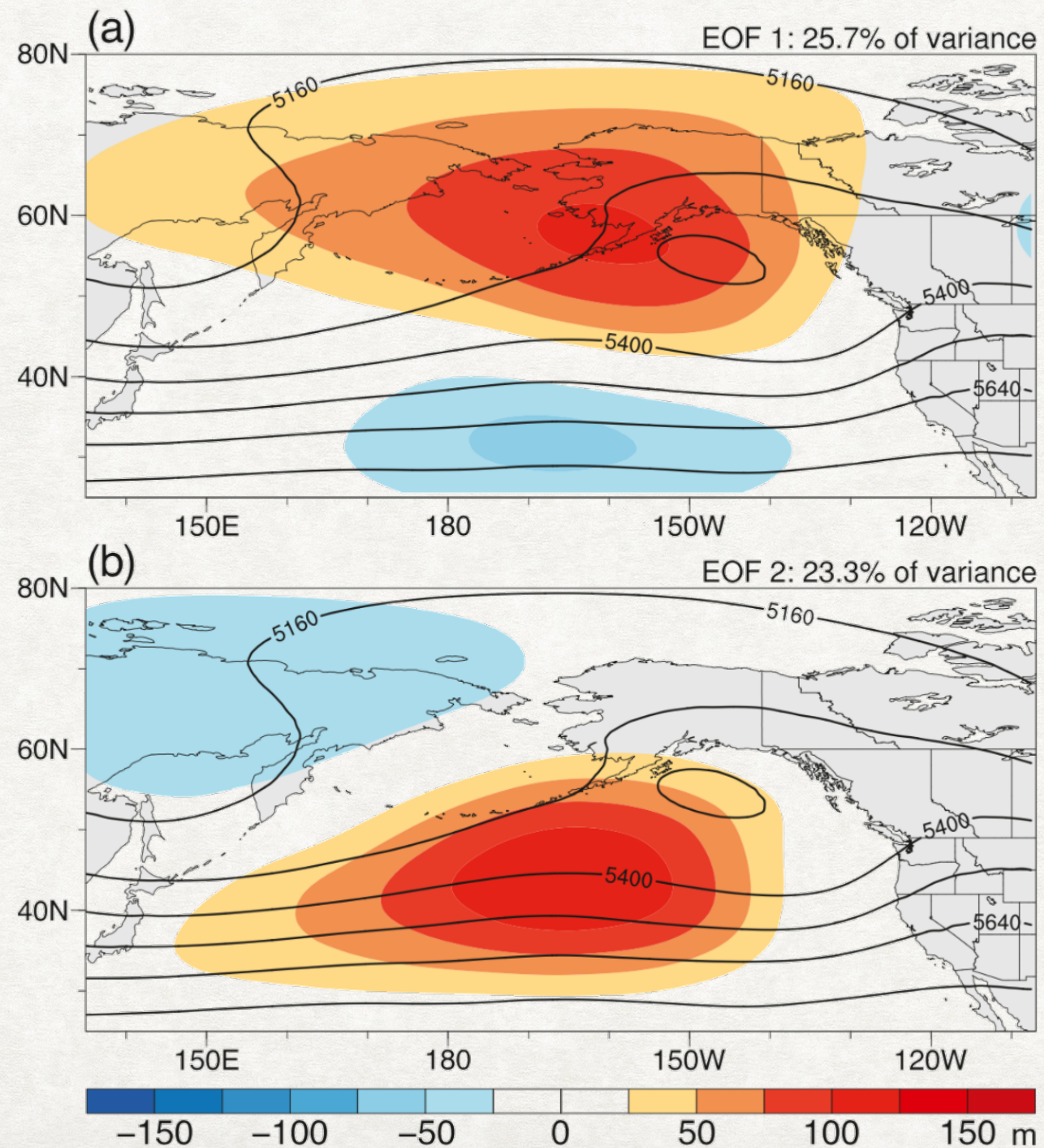
PV Streamer breaking of Rossby waves



(Andries Jan De Vries, 2021)

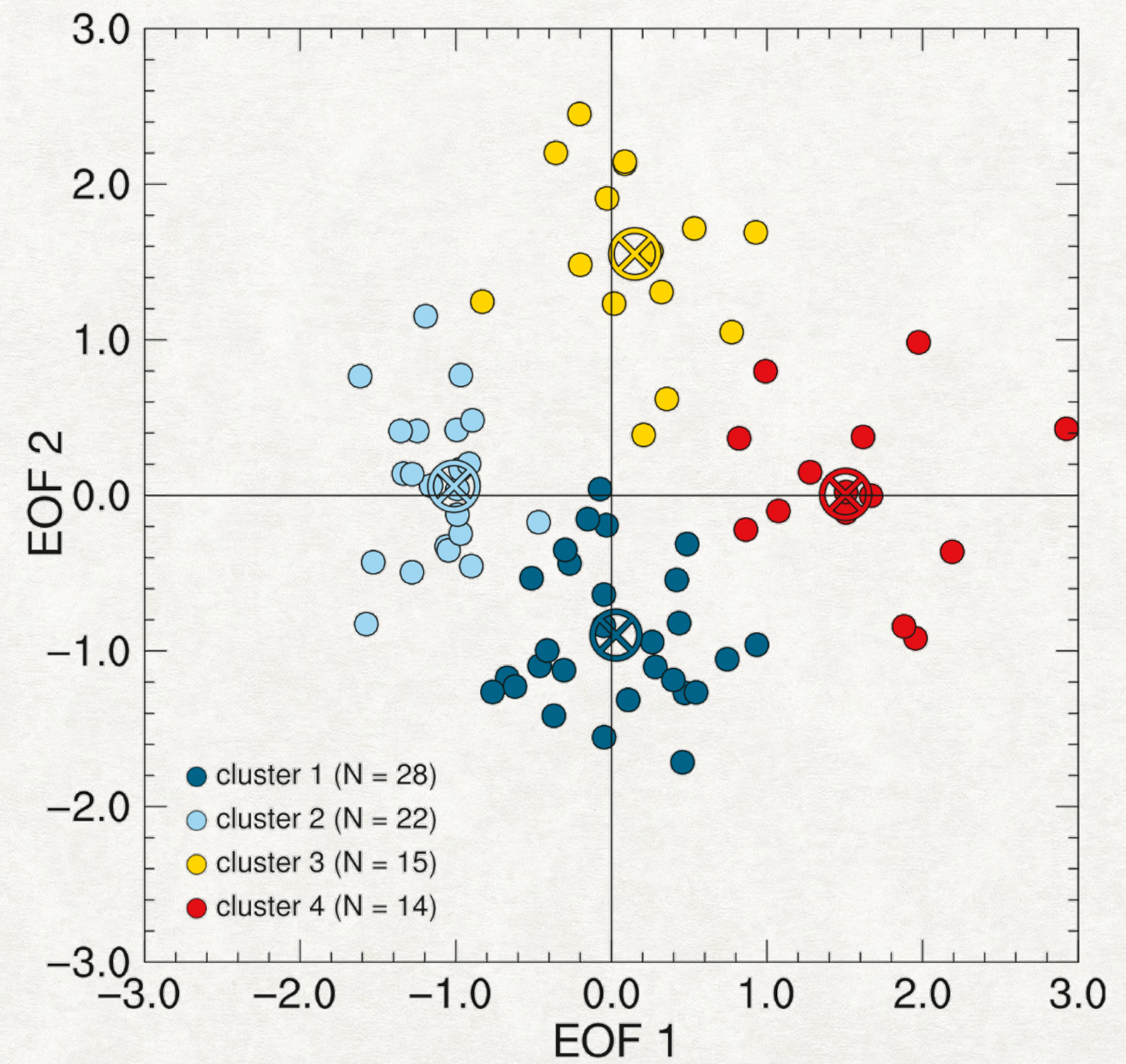
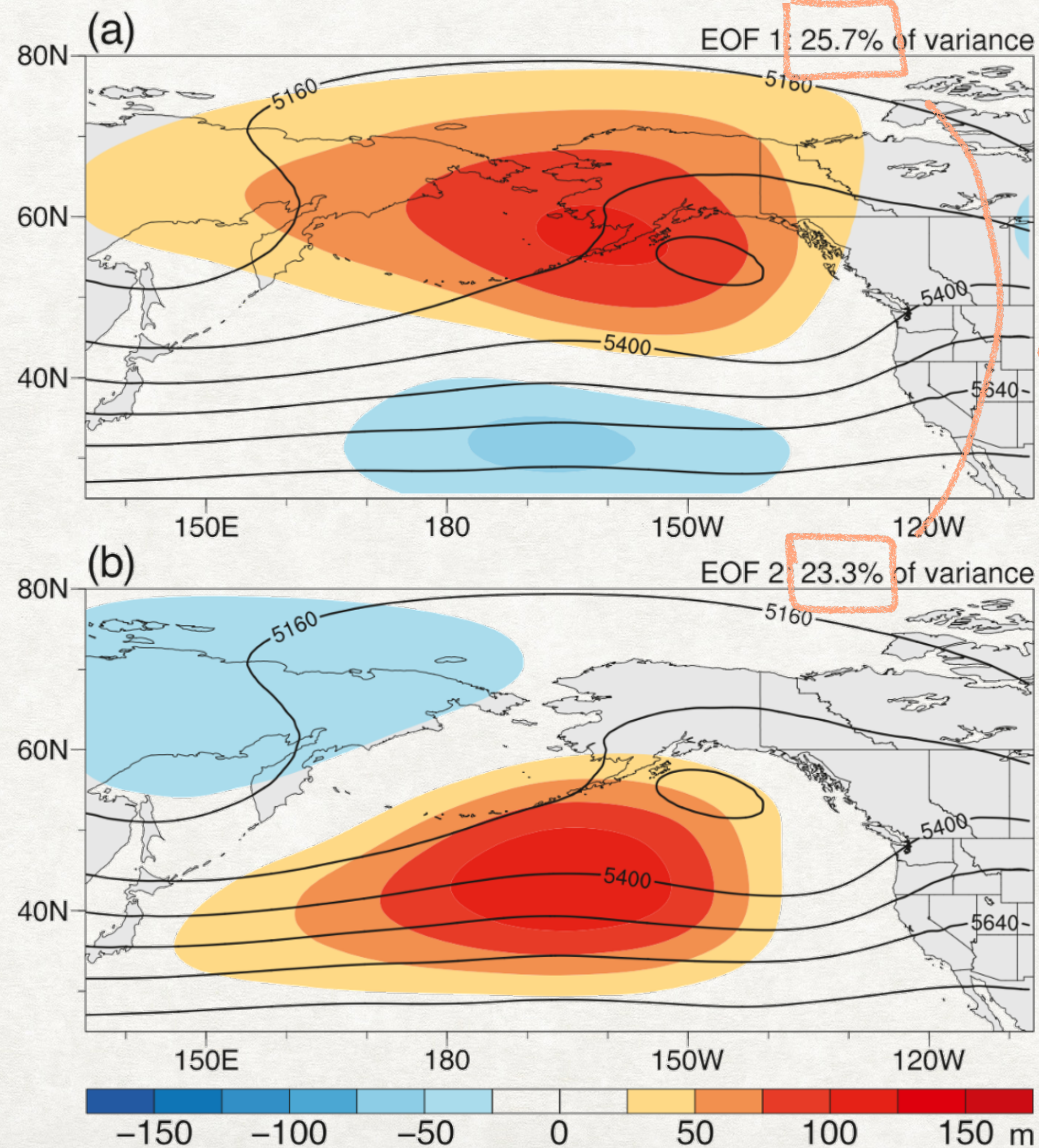
DATA & METHODS

FLOW-BASED CATEGORIZATION



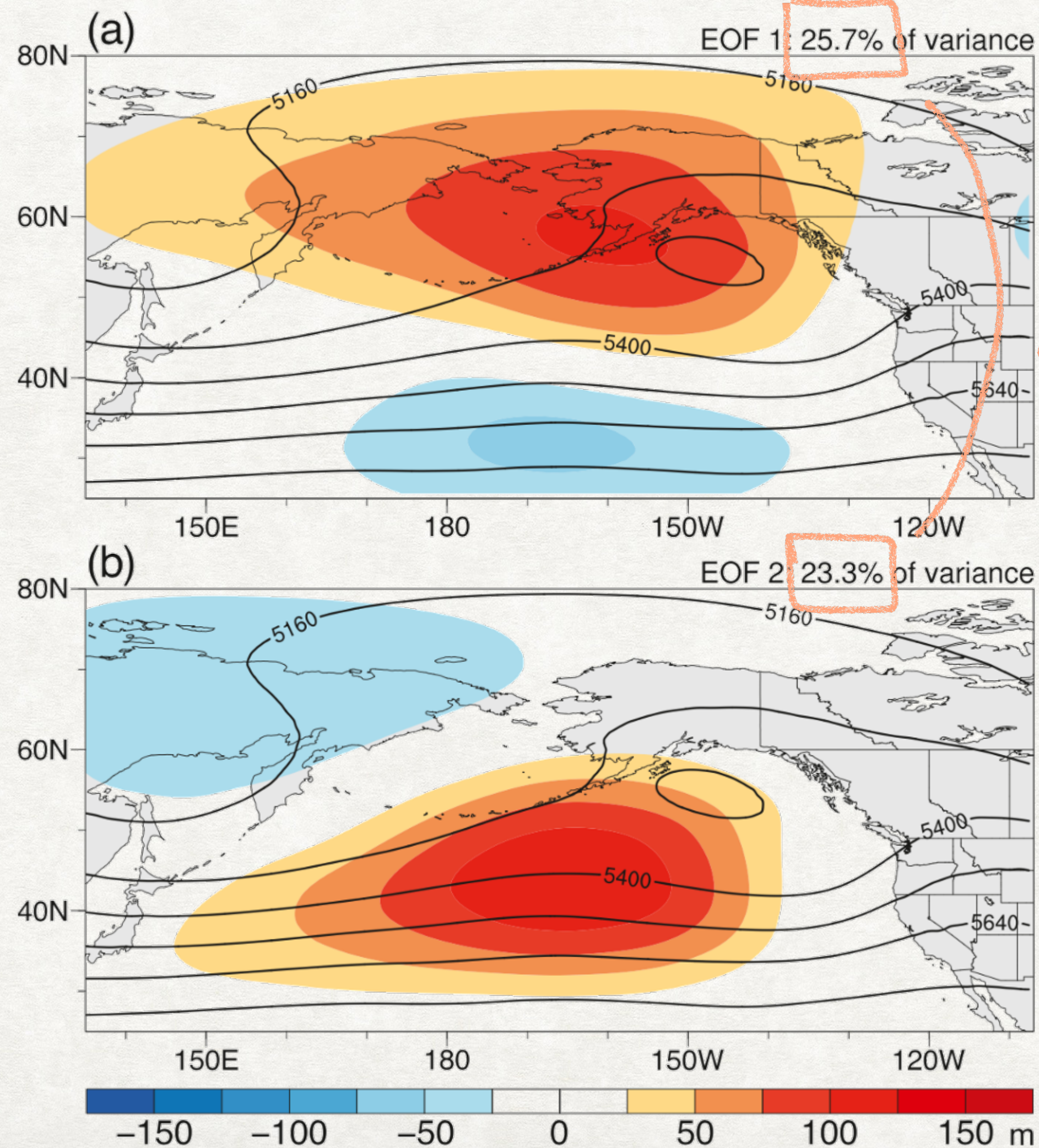
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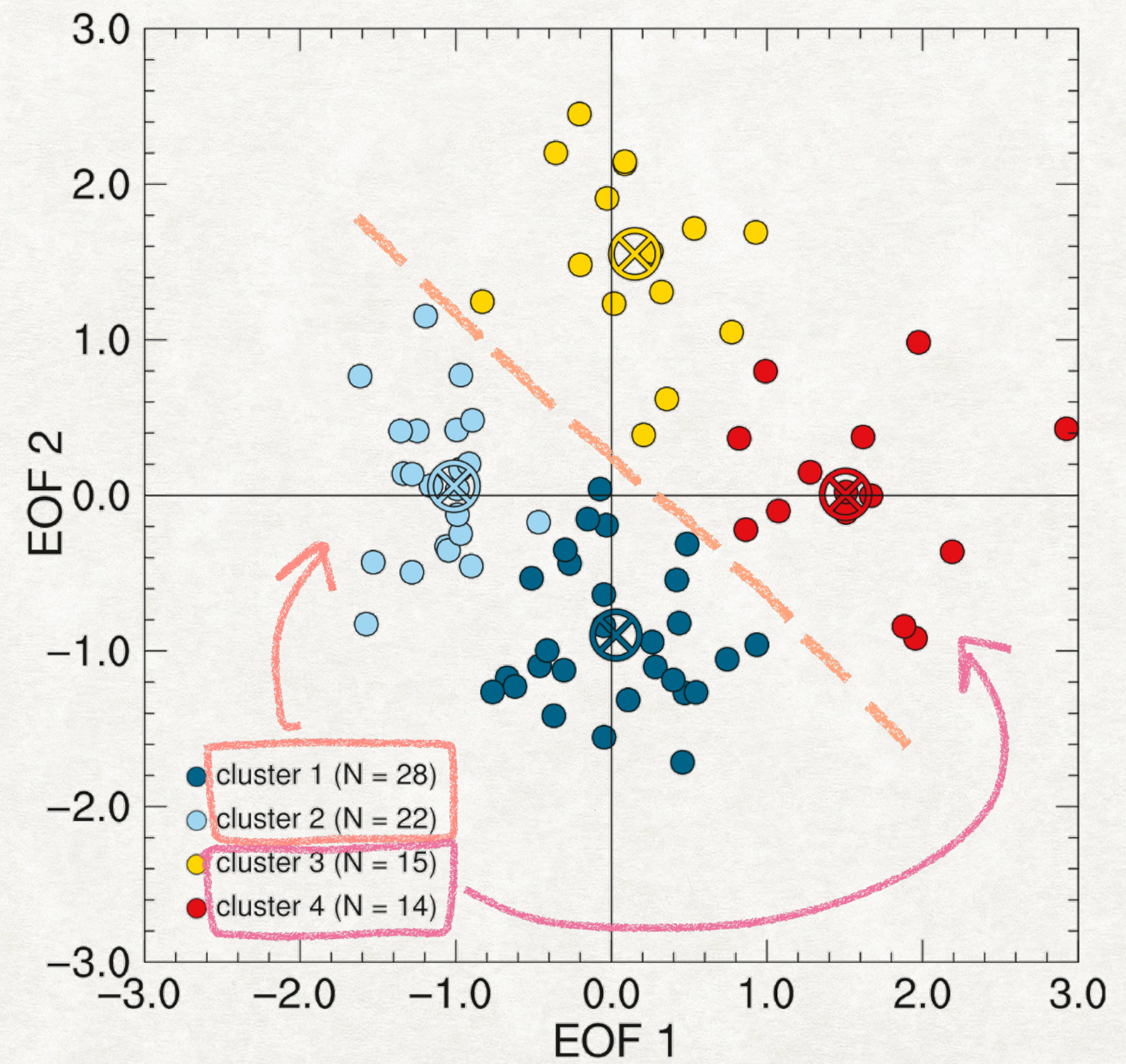


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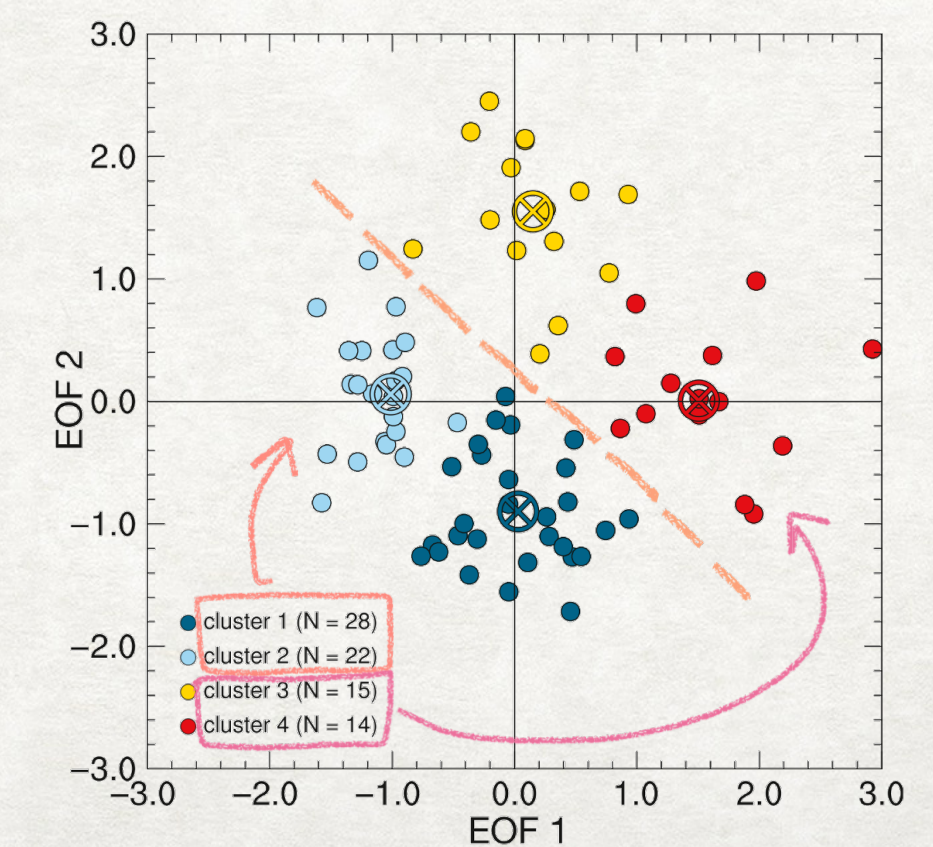
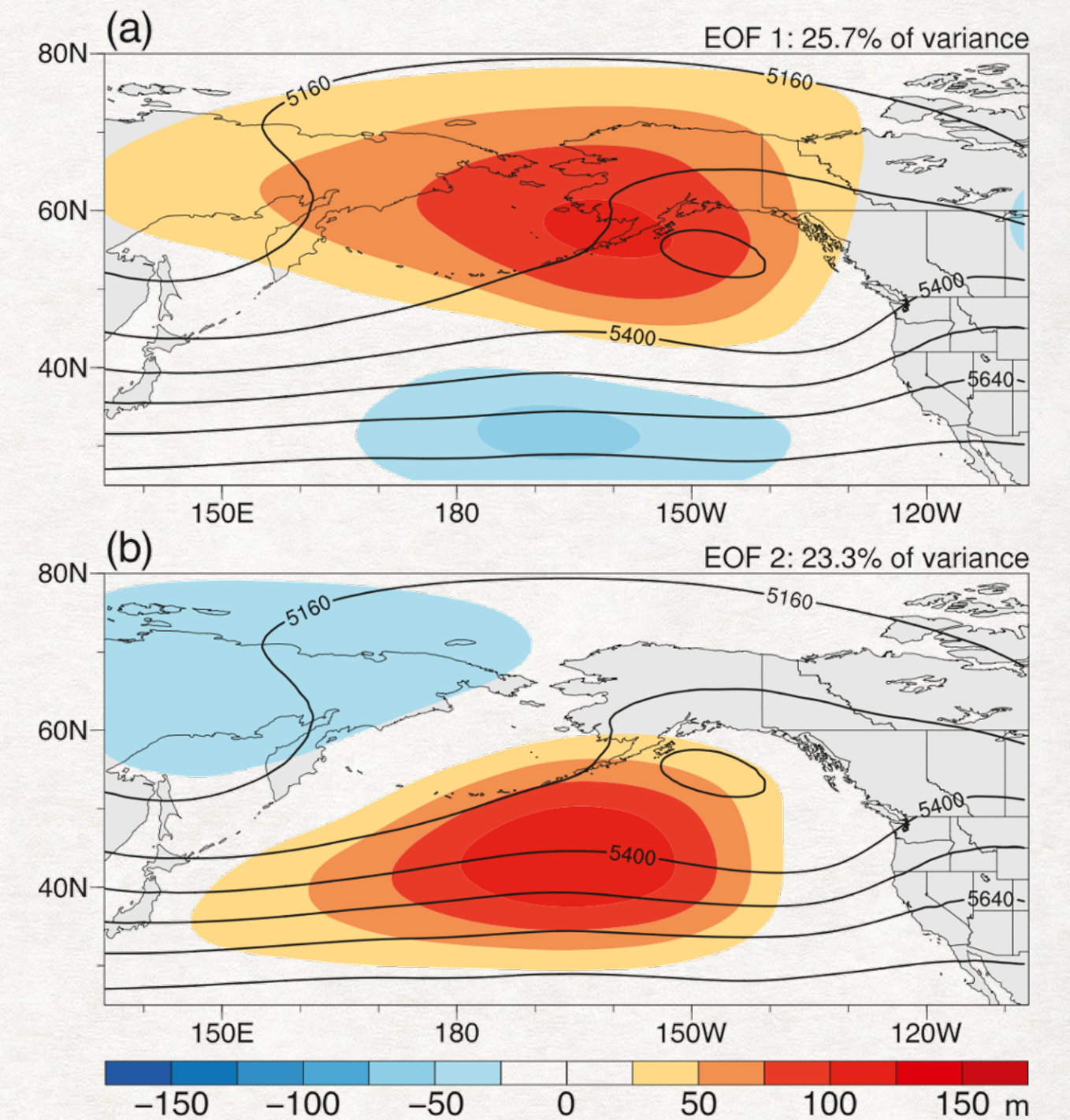
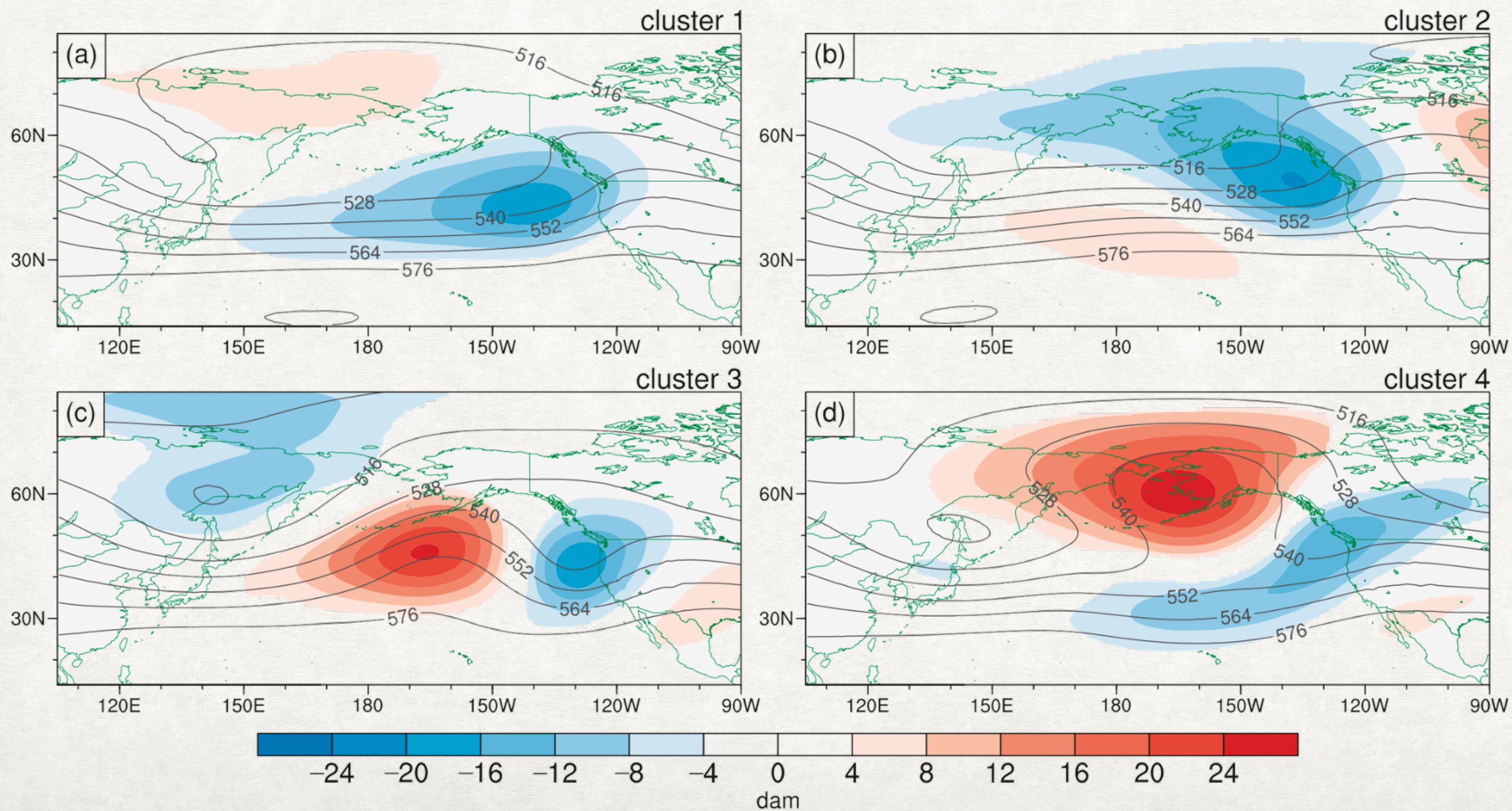
49%



LONG-DURATION HPEs IN NORTHERN CALIFORNIA

OVERVIEW OF THE HPEs

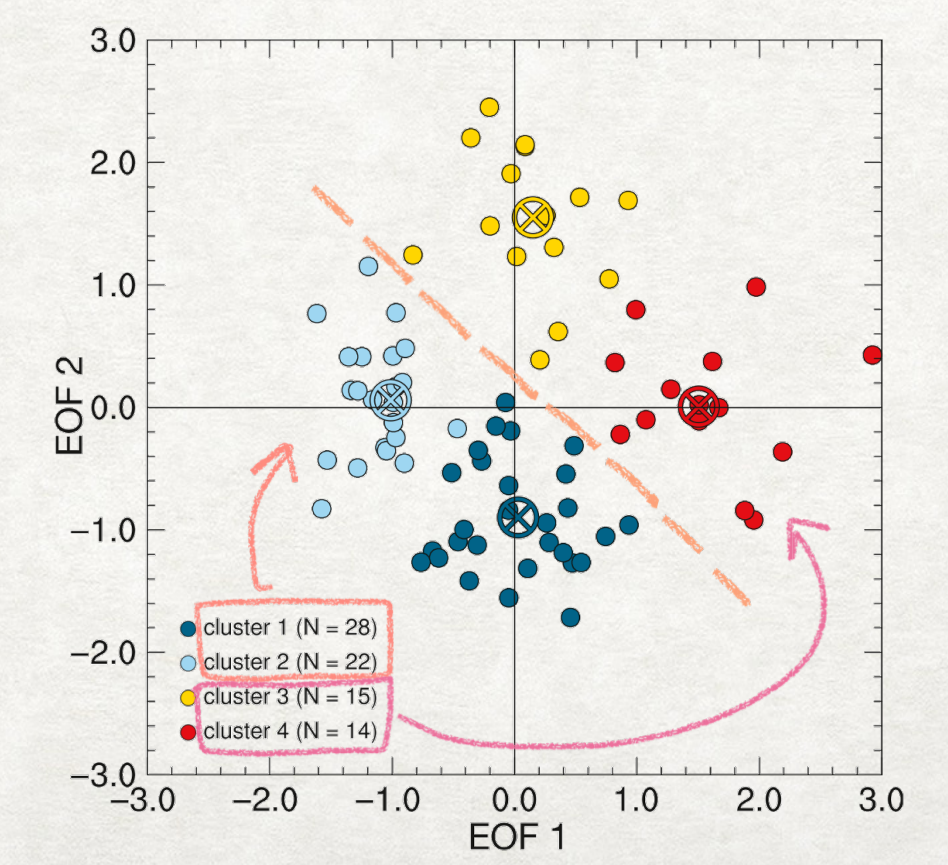
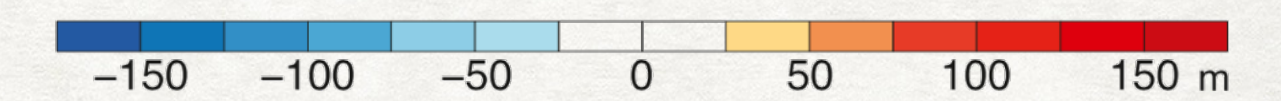
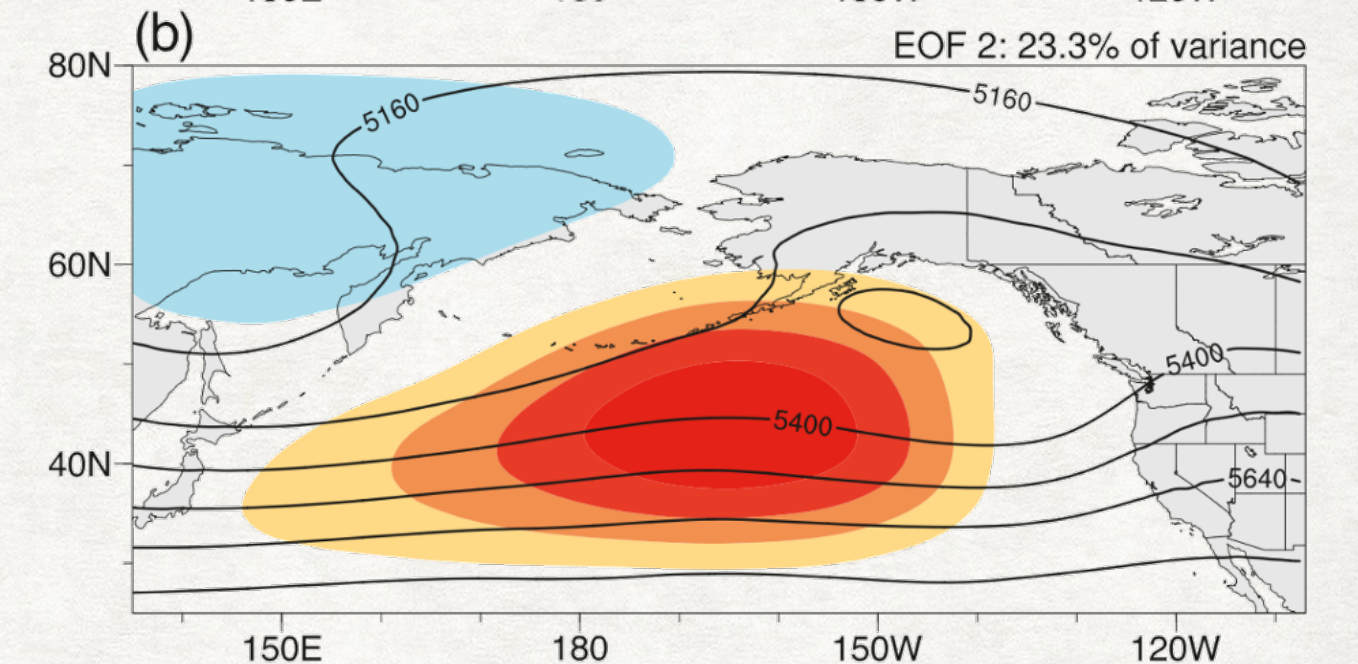
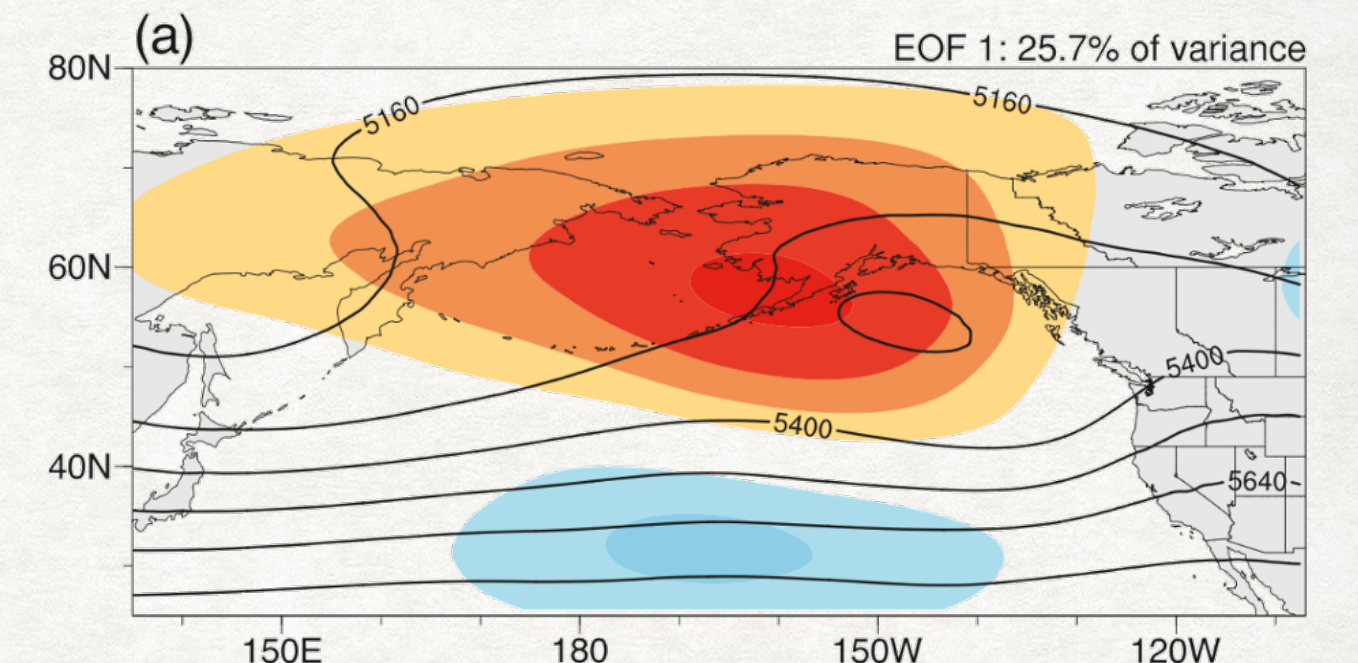
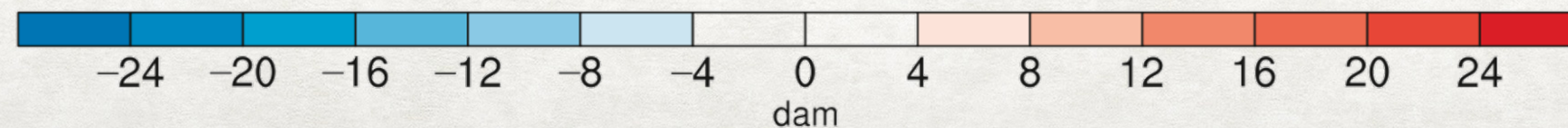
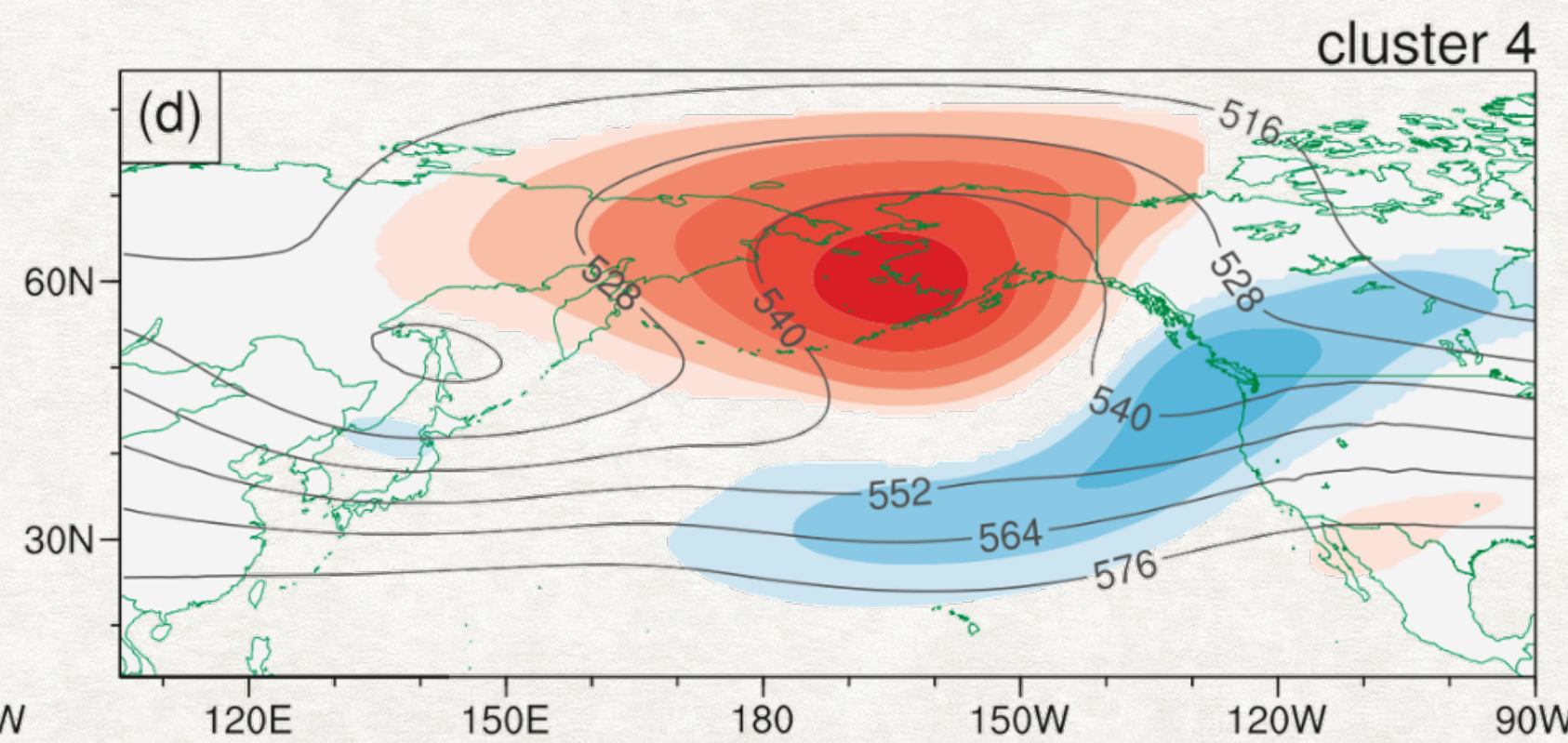
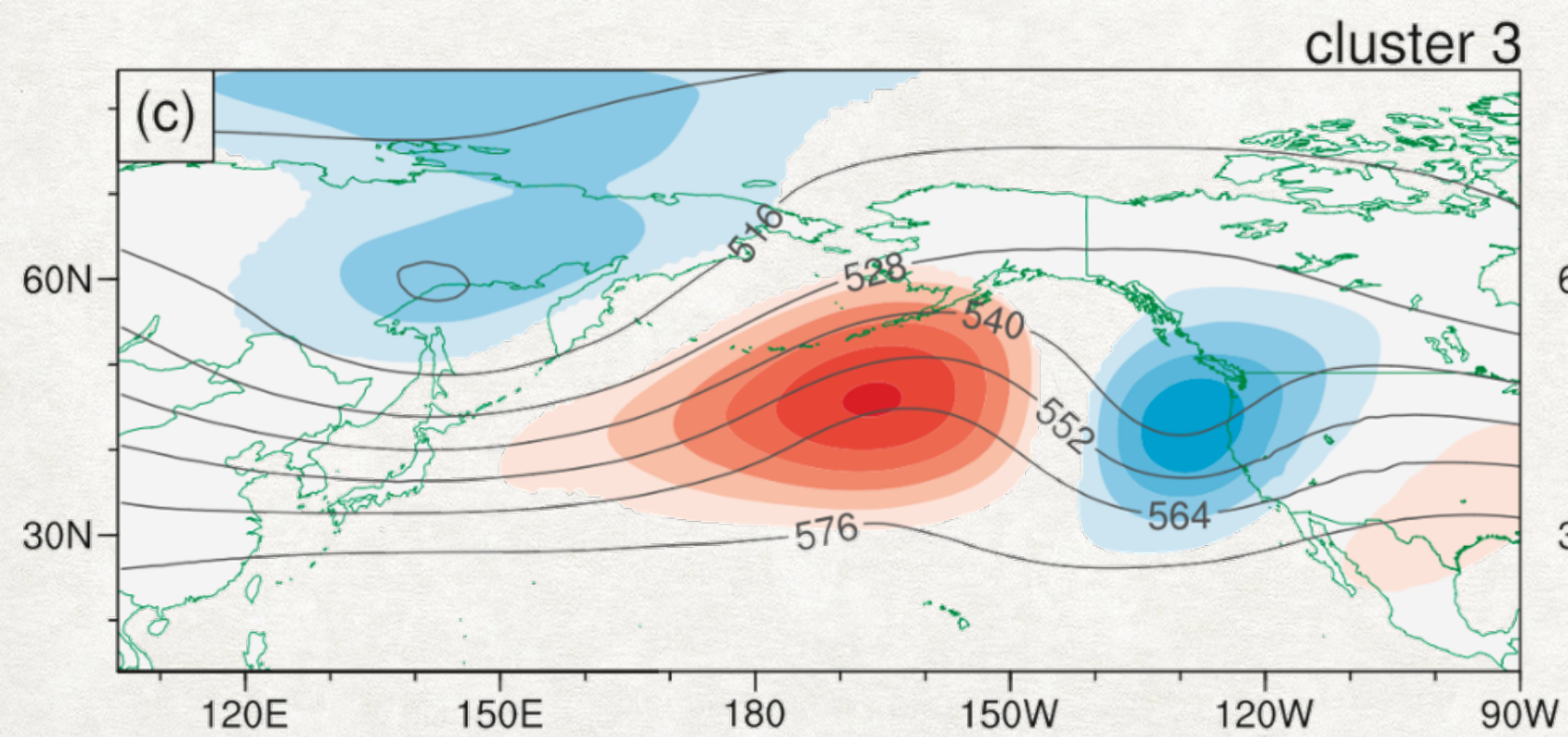
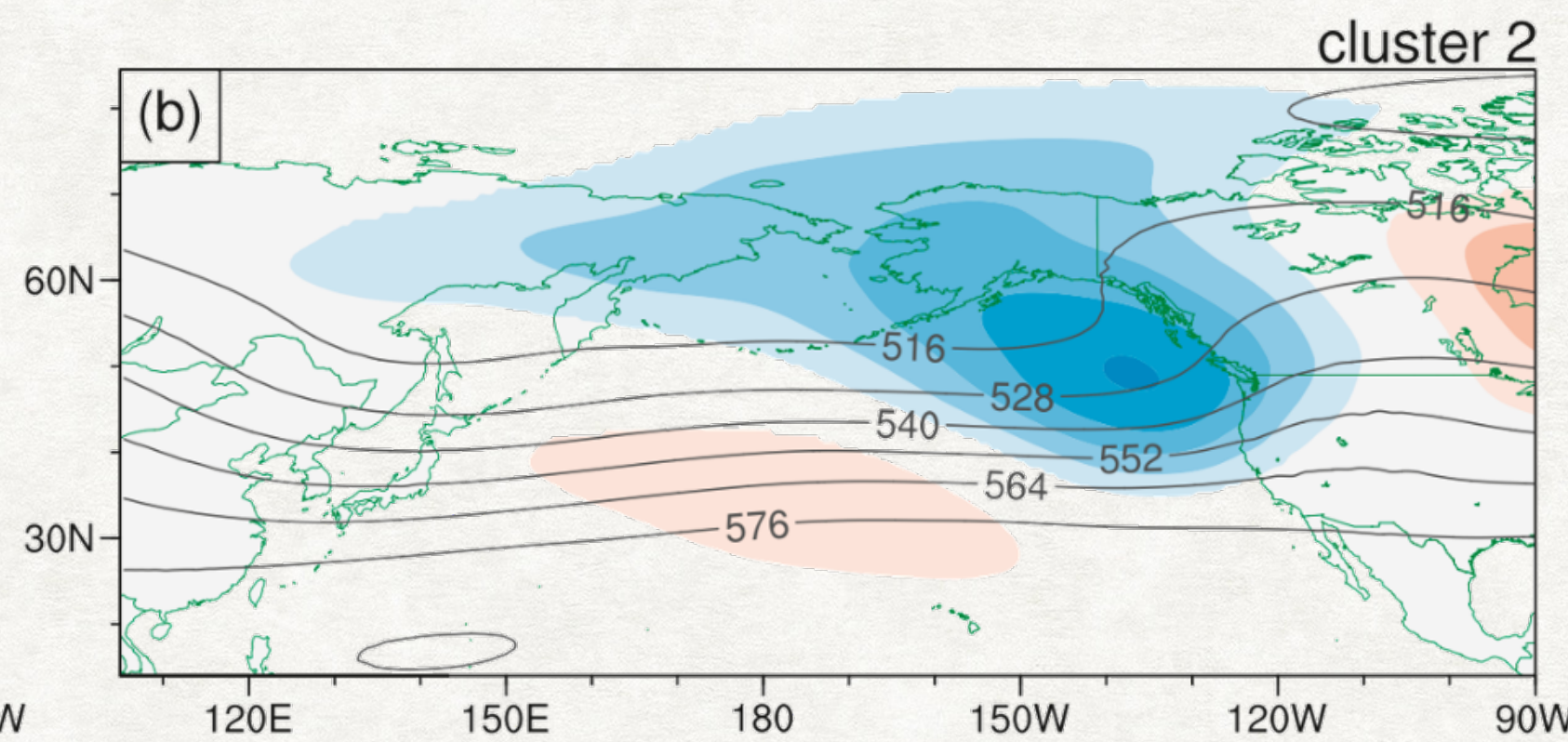
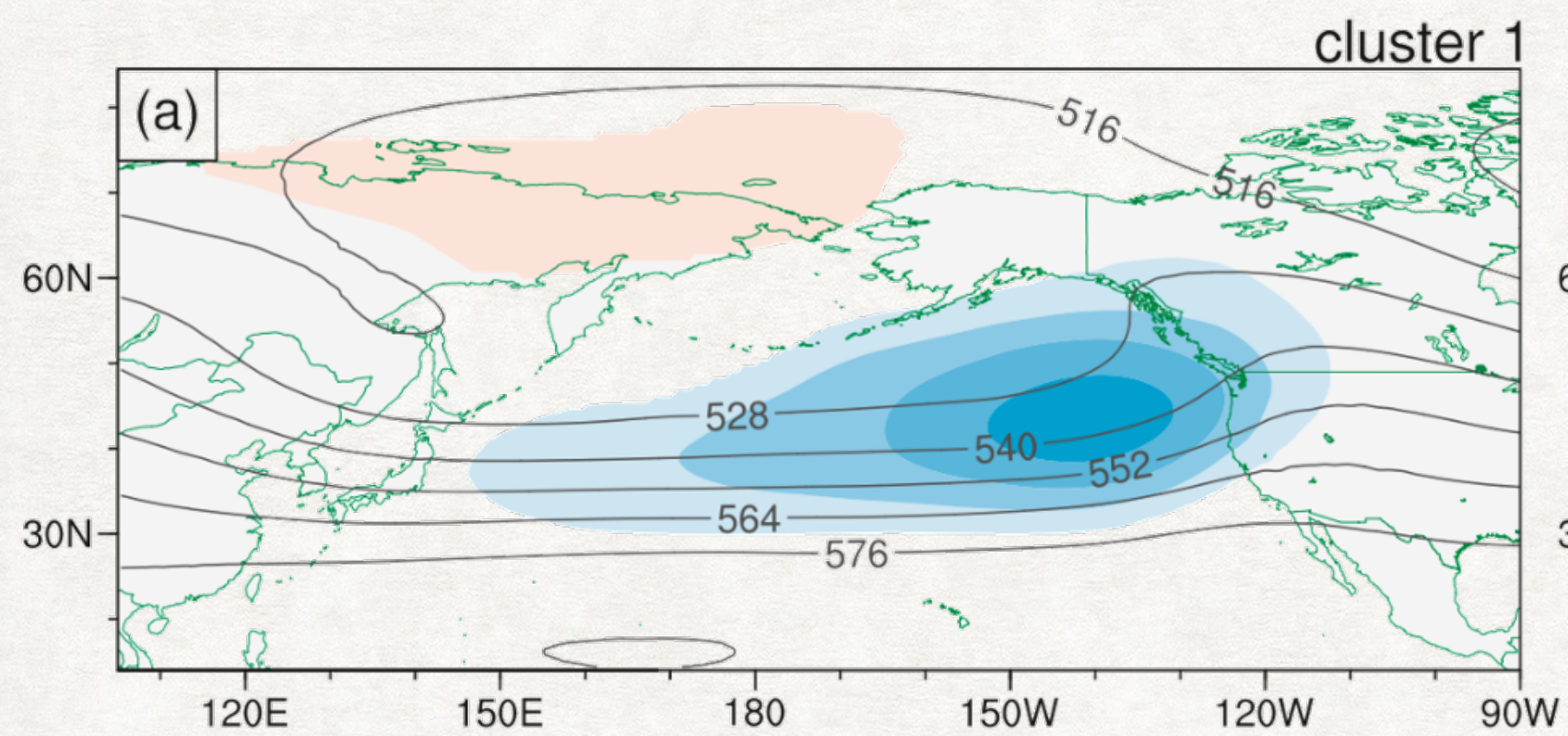
Cluster	No. of events	Flow pattern description	Duration (d)	Total precip. (mm)
1	28	Equatorward-shifted zonal jet	6 (5–8)	293.4 (251.1–363.0)
2	22	Poleward-shifted zonal jet	5 (4–6)	266.8 (221.7–364.7)
3	15	Midlatitude blocking	5 (4–6)	227.9 (175.3–269.6)
4	14	High-latitude blocking	6 (4–8)	336.2 (192.8–505.7)



LONG-DURATION HPEs IN NORTHERN CALIFORNIA

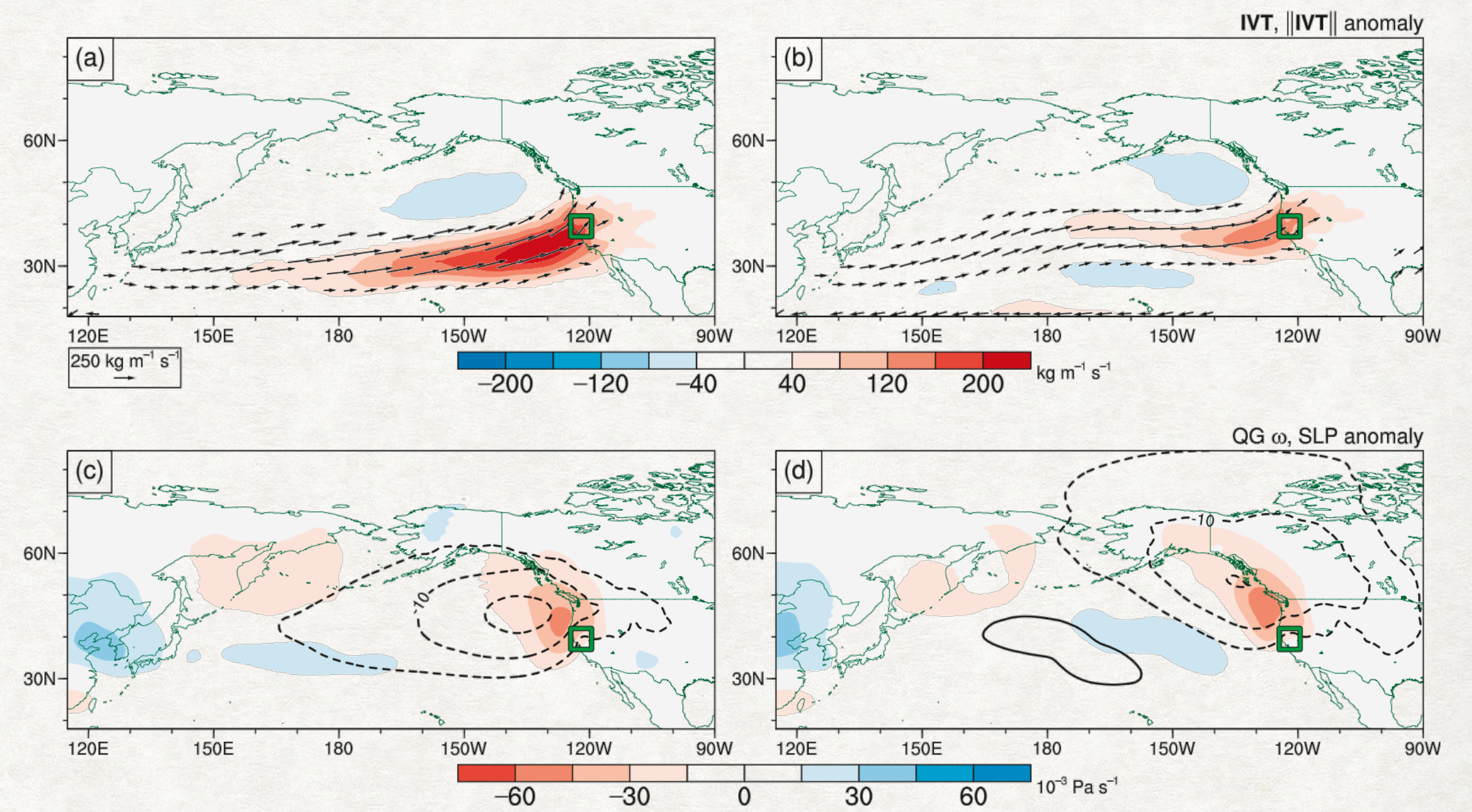
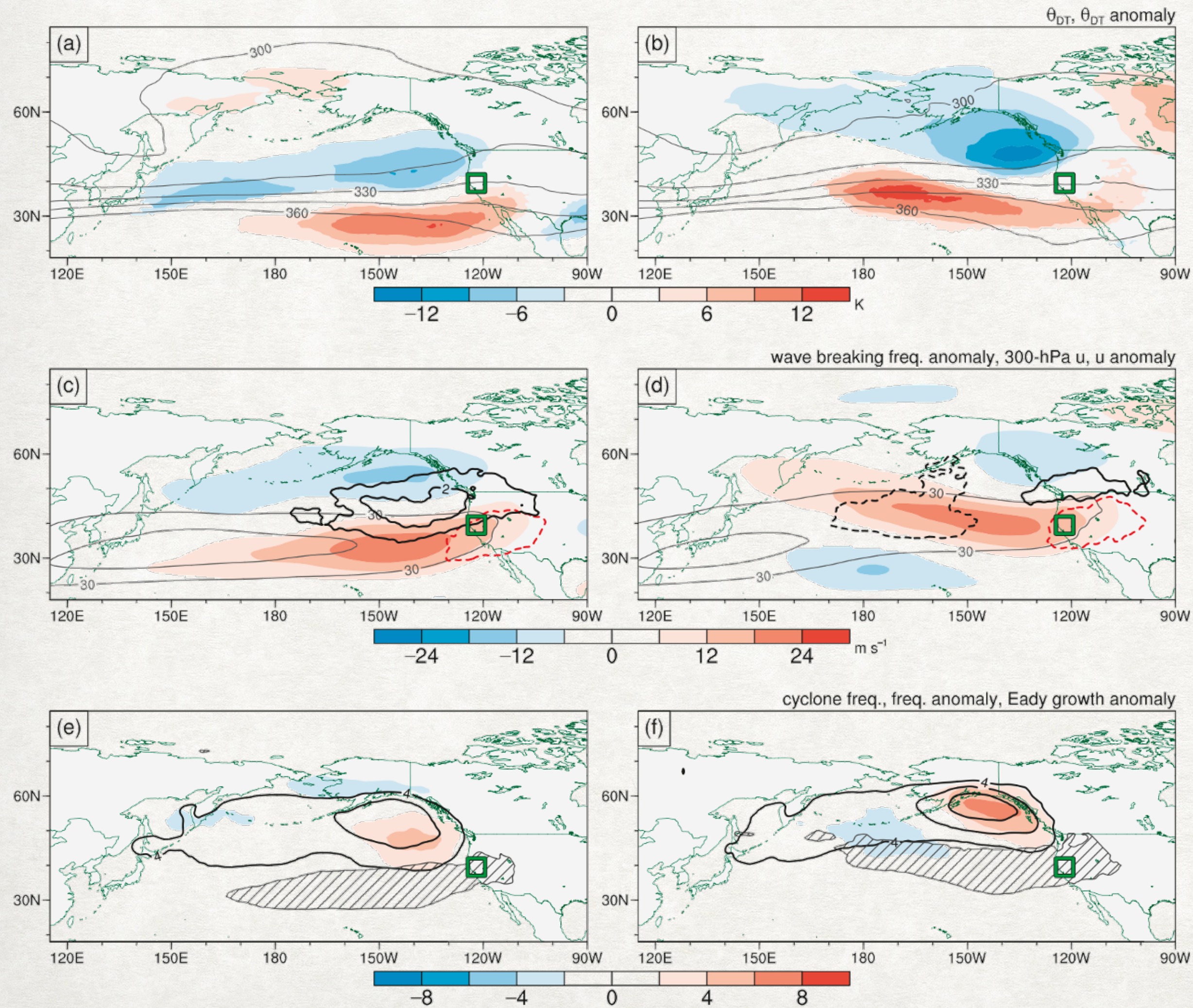
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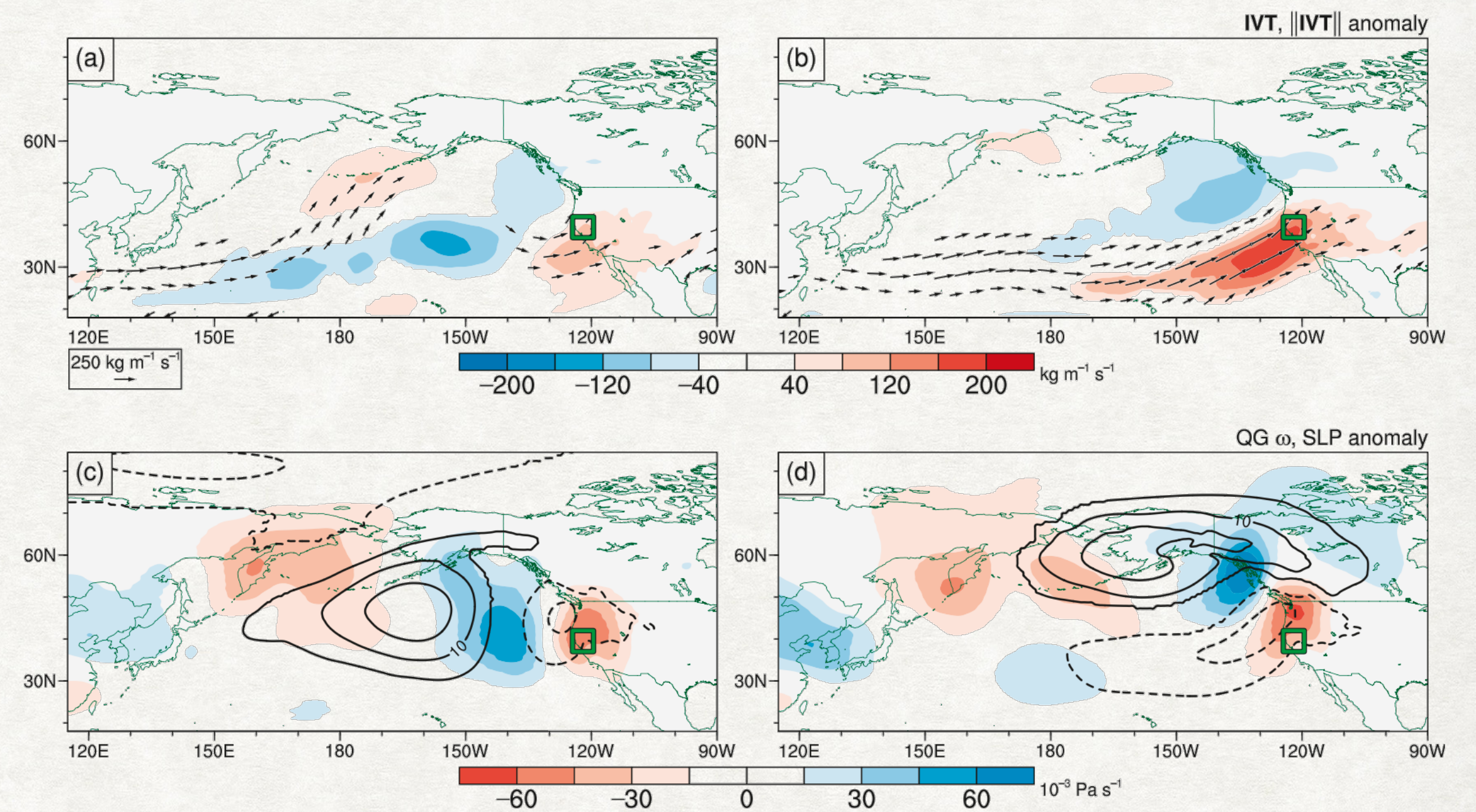
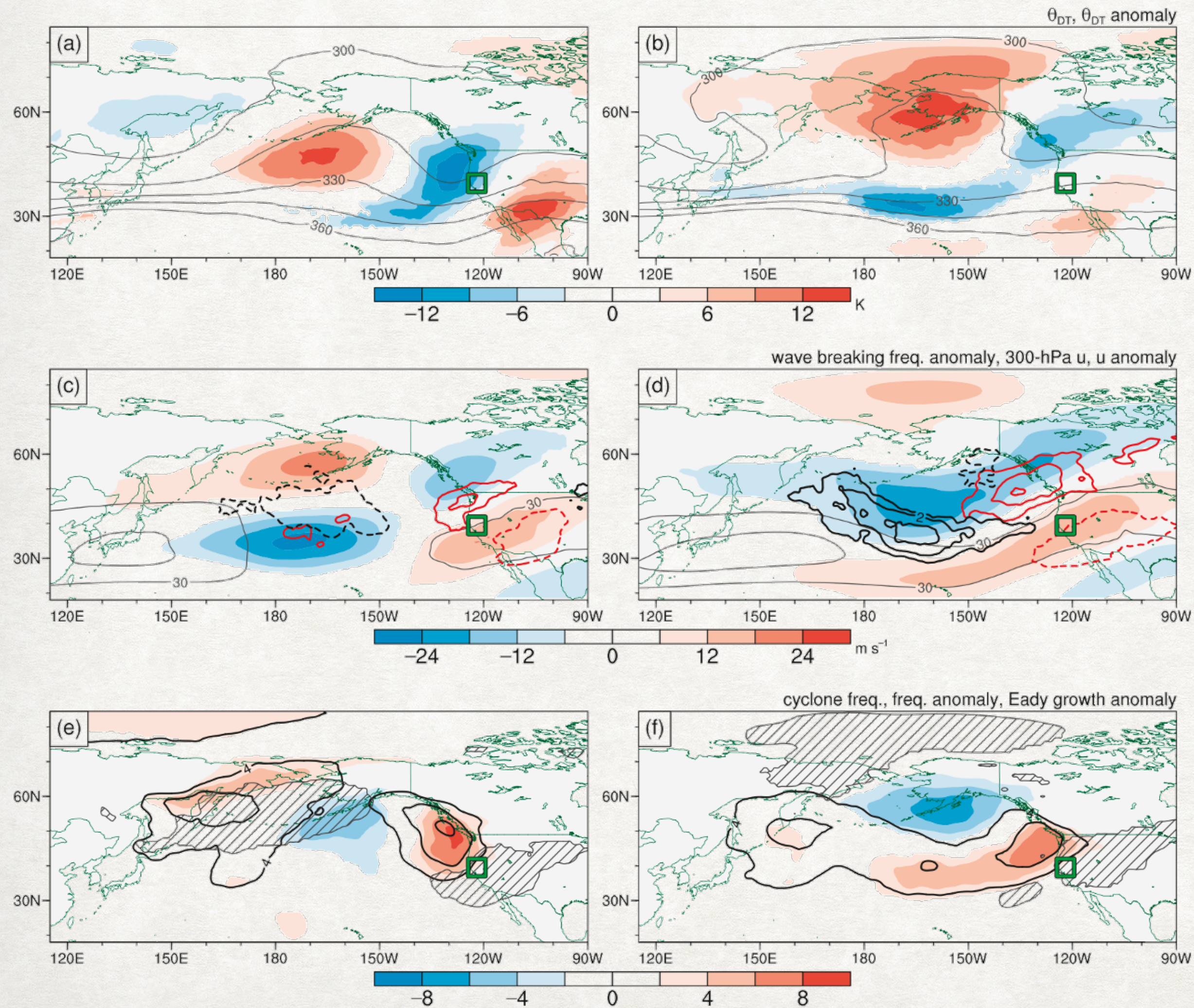
LONG-DURATION HPEs IN NORTHERN CALIFORNIA

ZONAL JET PATTERNS



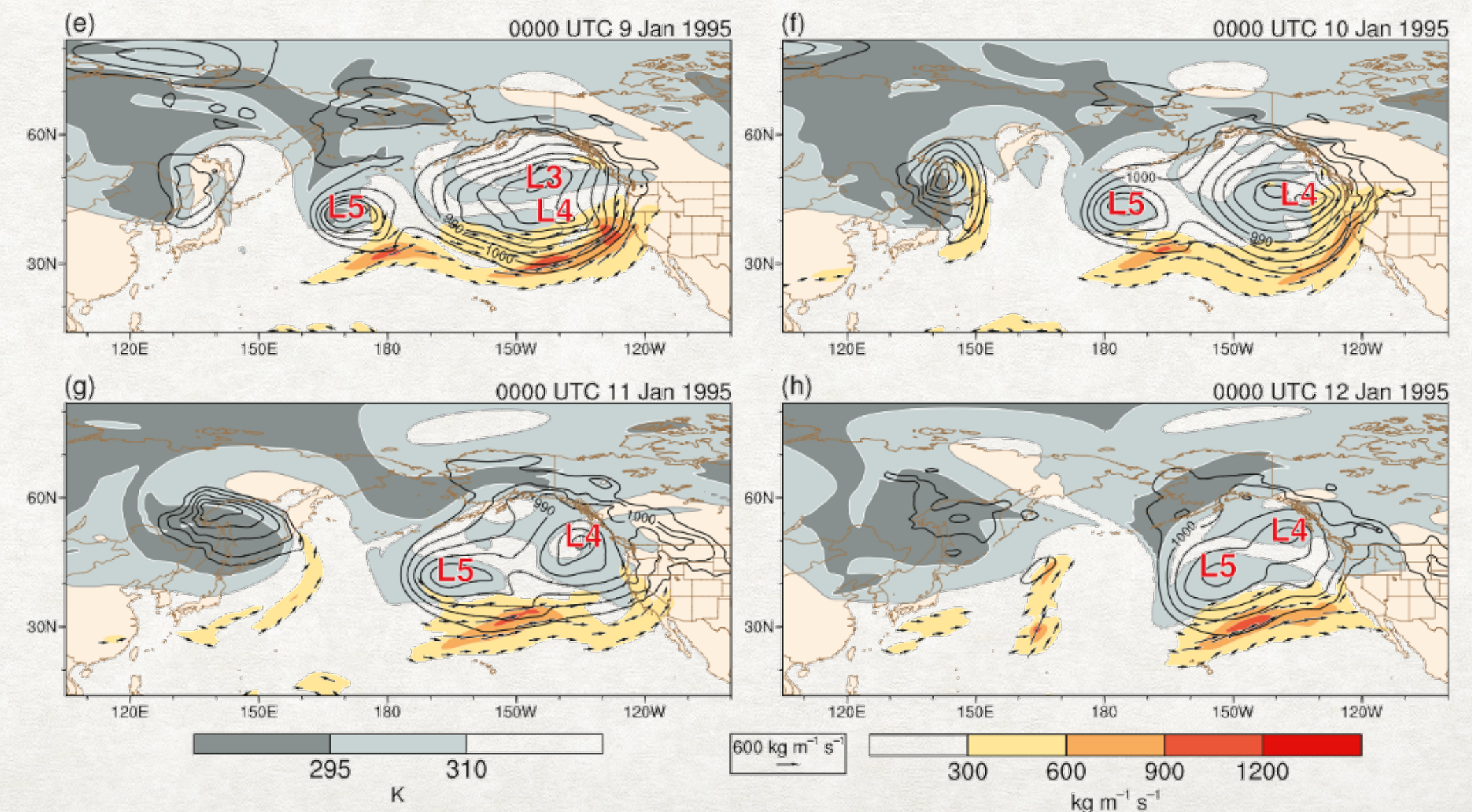
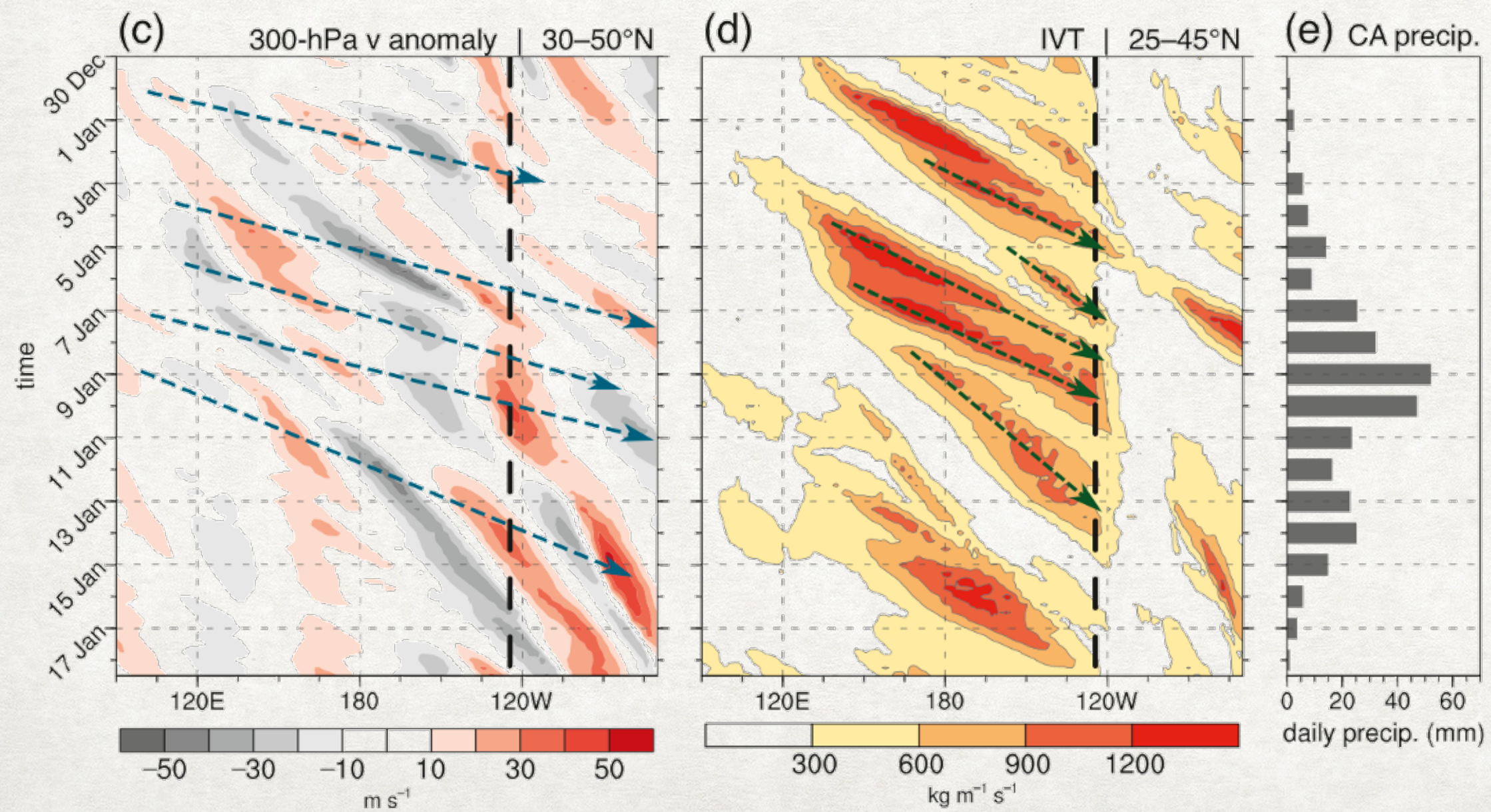
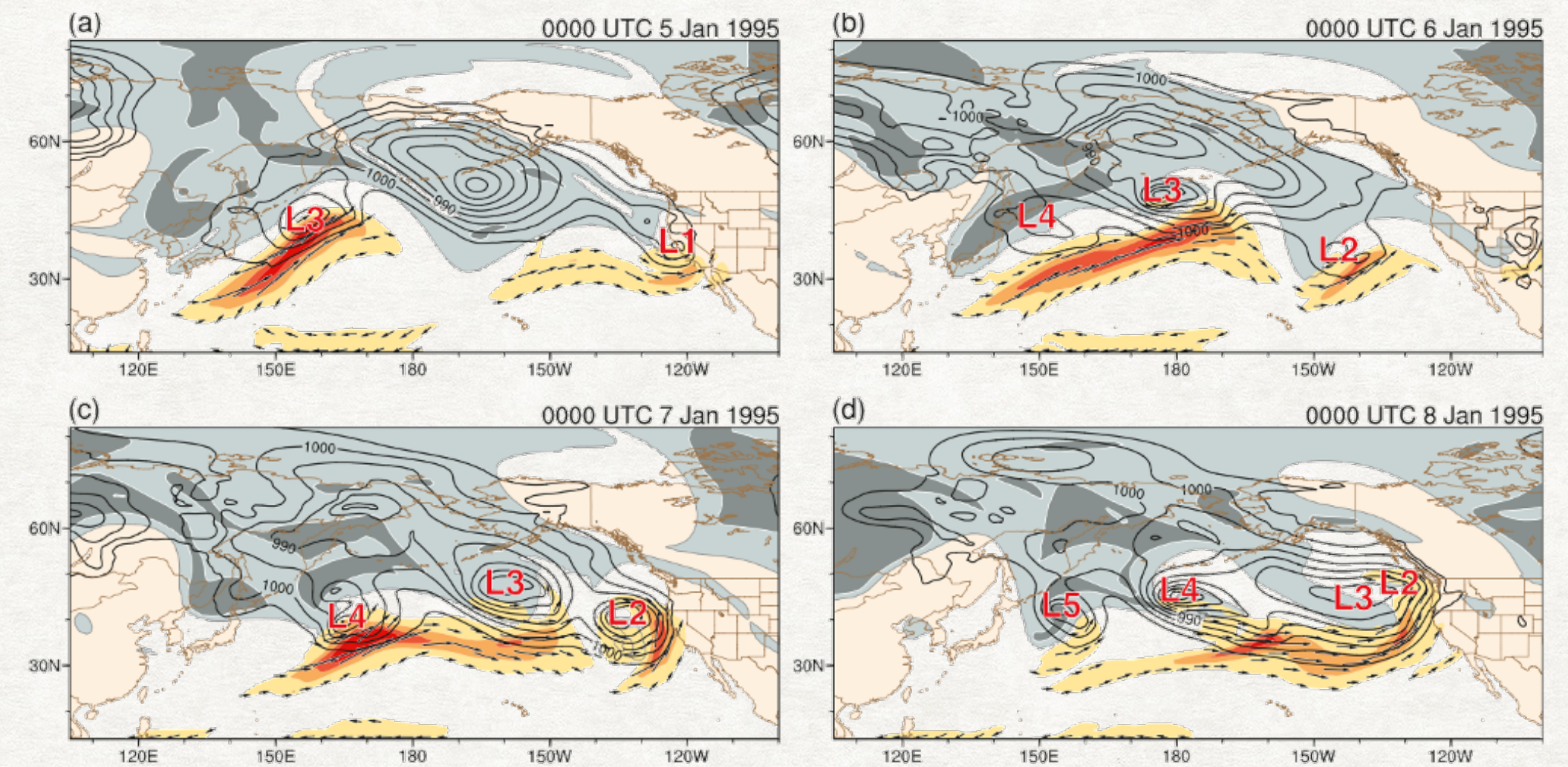
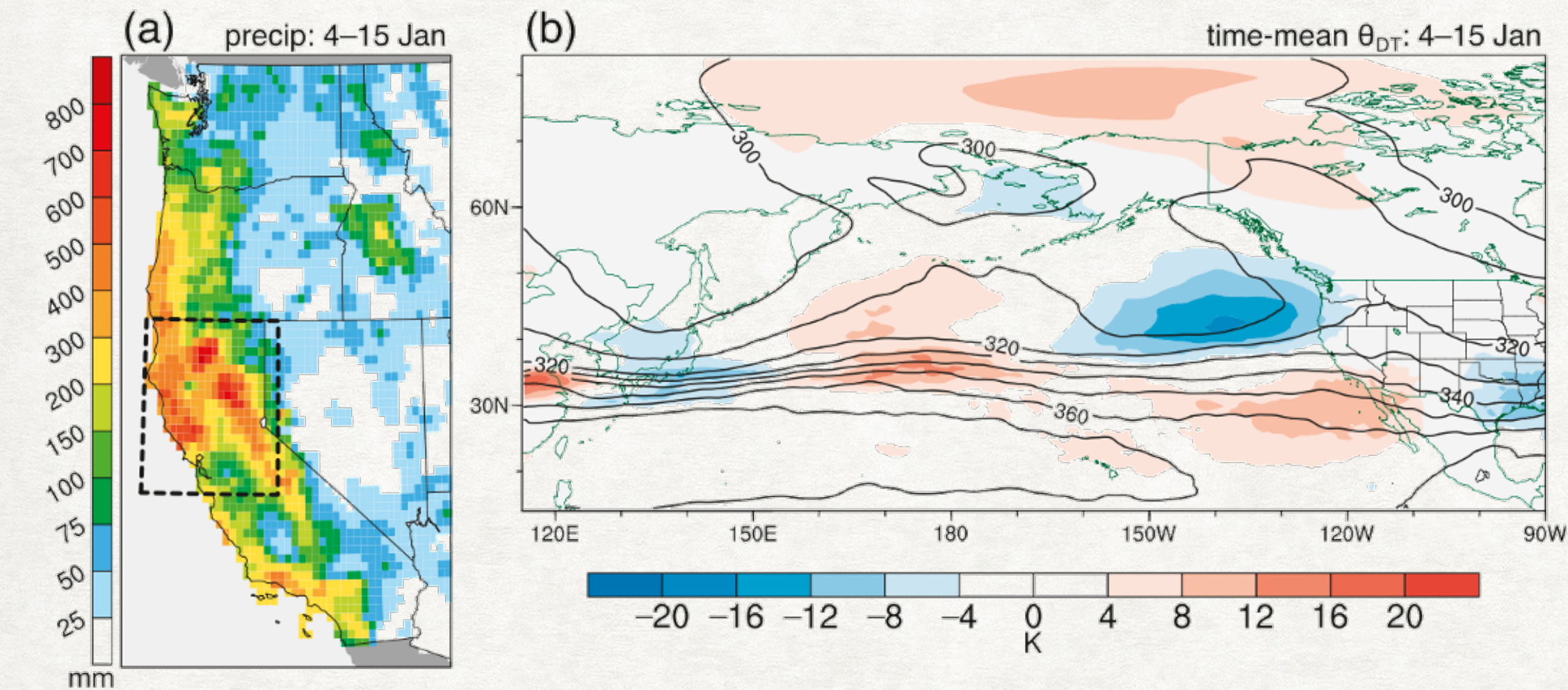
LONG-DURATION HPEs IN NORTHERN CALIFORNIA

BLOCKING PATTERNS



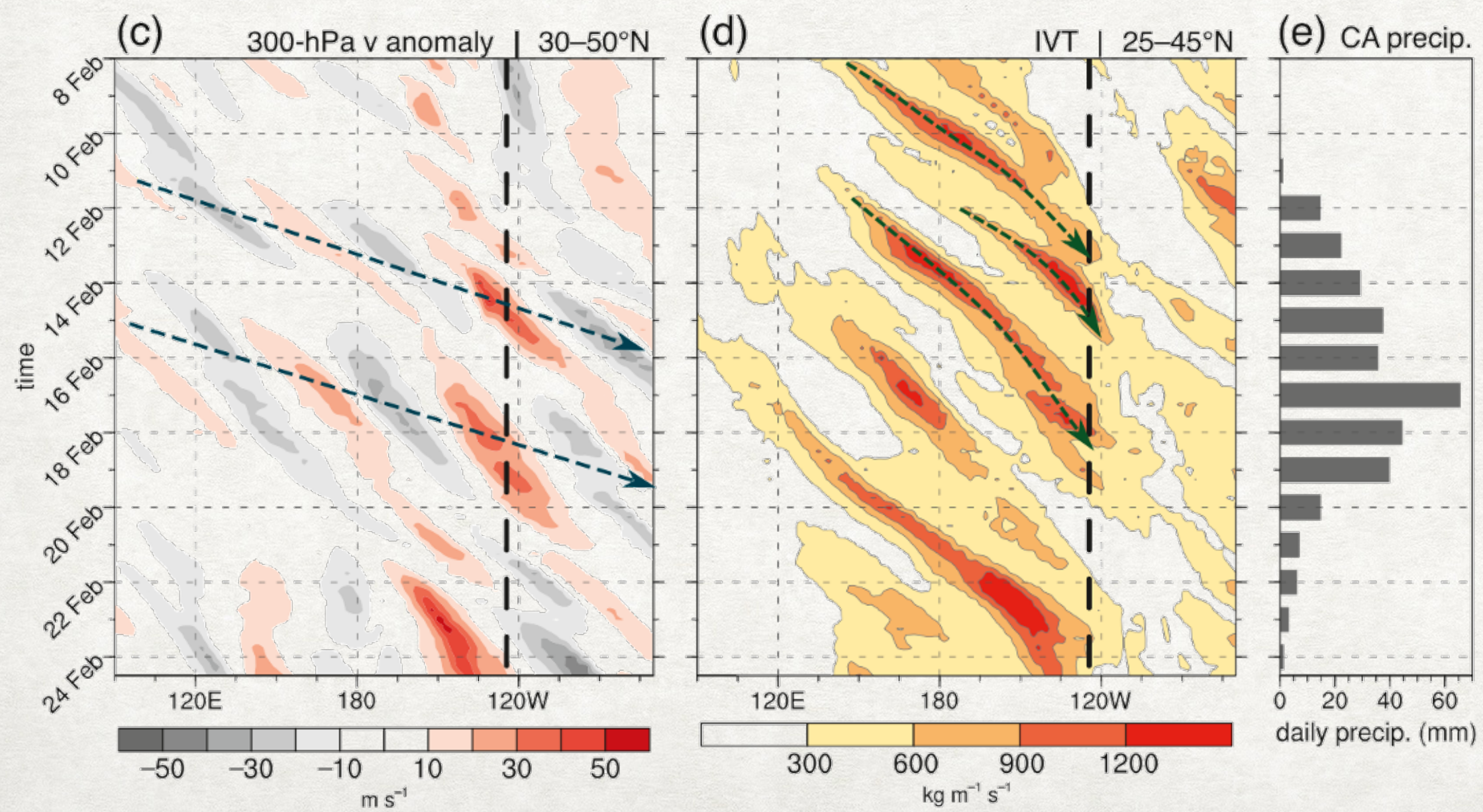
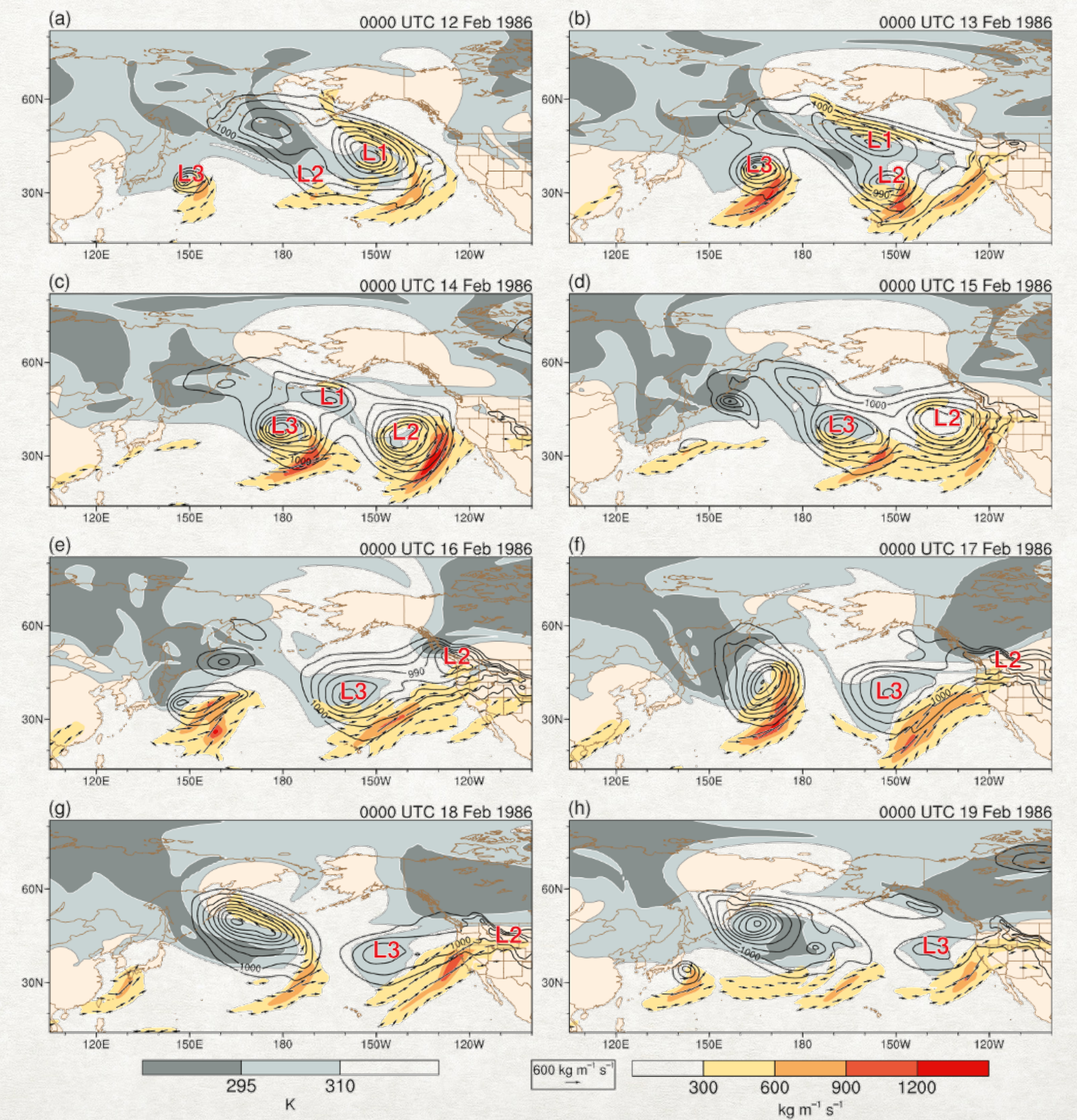
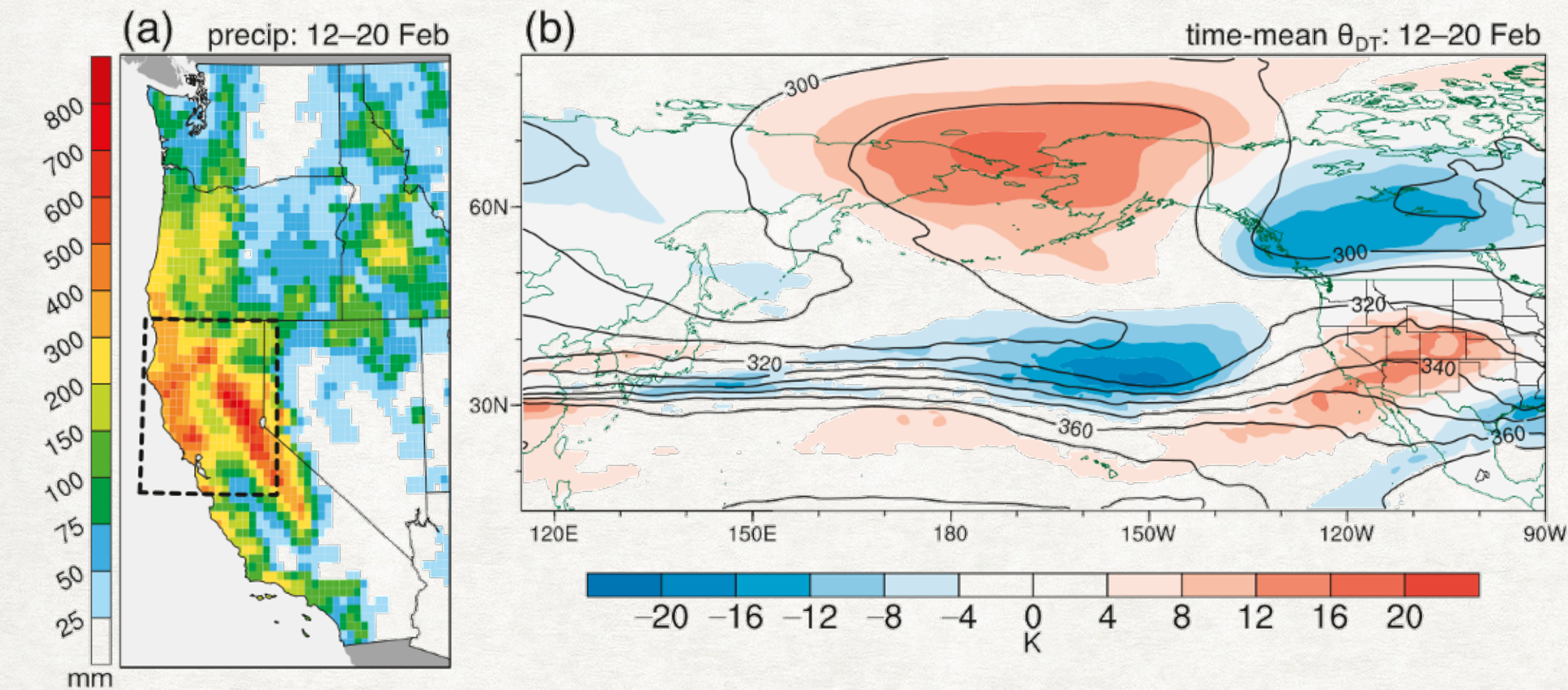
CASE STUDIES

C1 CASE: JAN 1995



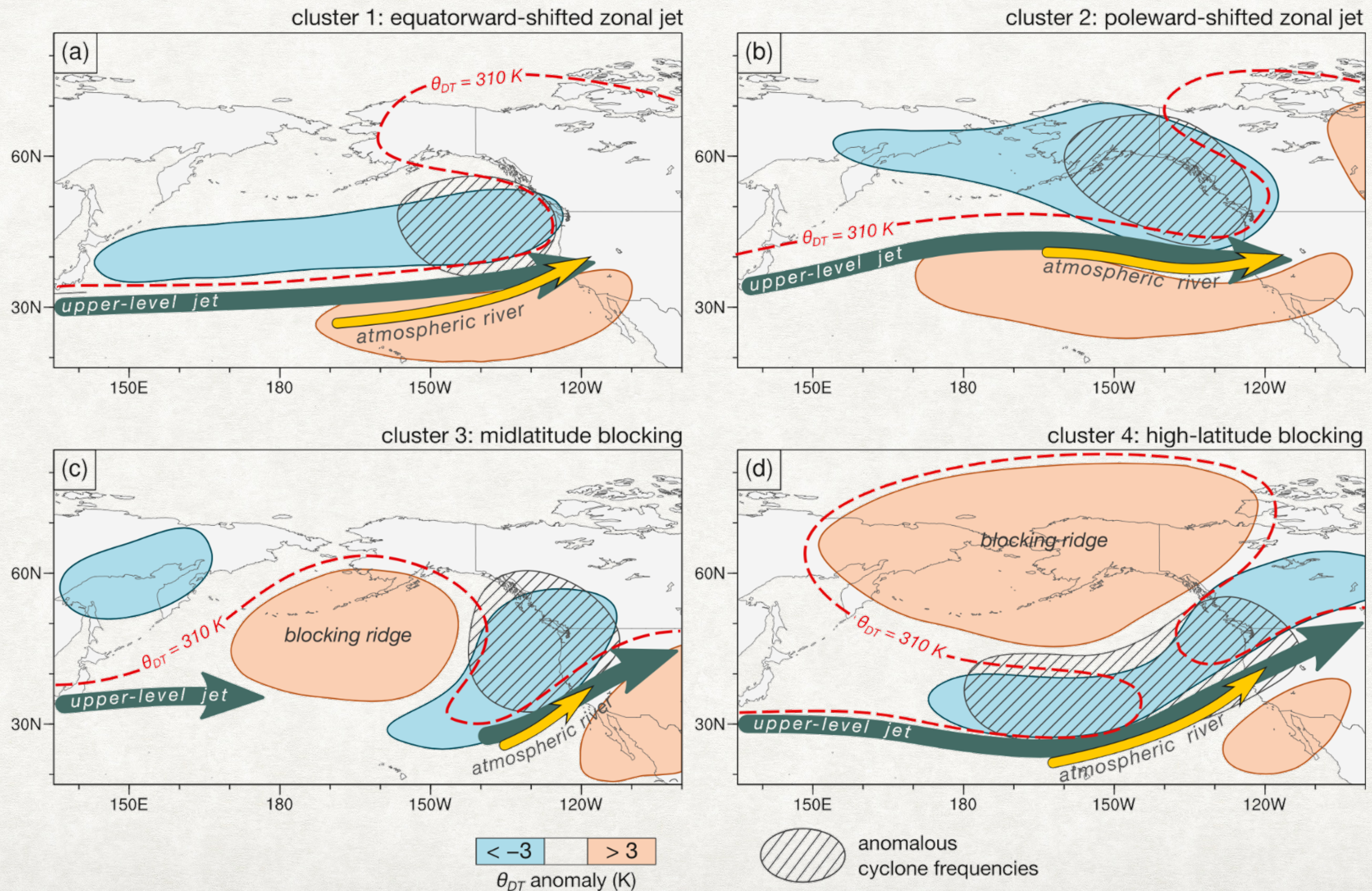
CASE STUDIES

C4 CASE: FEB 1986



SUMMARY & CONCLUSIONS

ZONAL JET



Thanks for listening!