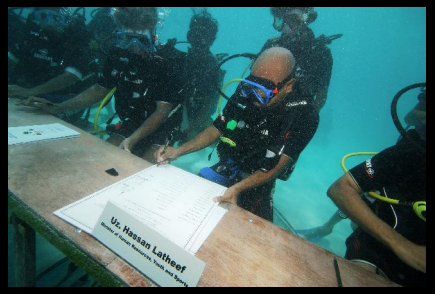
# Climate Change in the PNW and Implications for Public Health






Children's Environmental Health Working Group

14 May, 2015

Ingrid Tohver, UW Climate Impacts Group

Tania M. Busch Isaksen, UW Dept. Environmental and Occupational Health Sciences

CLIMATE IMPACTS GROUP

# The Climate Impacts Group

An interdisciplinary team based at UW studying climate impacts in the Pacific Northwest since 1995

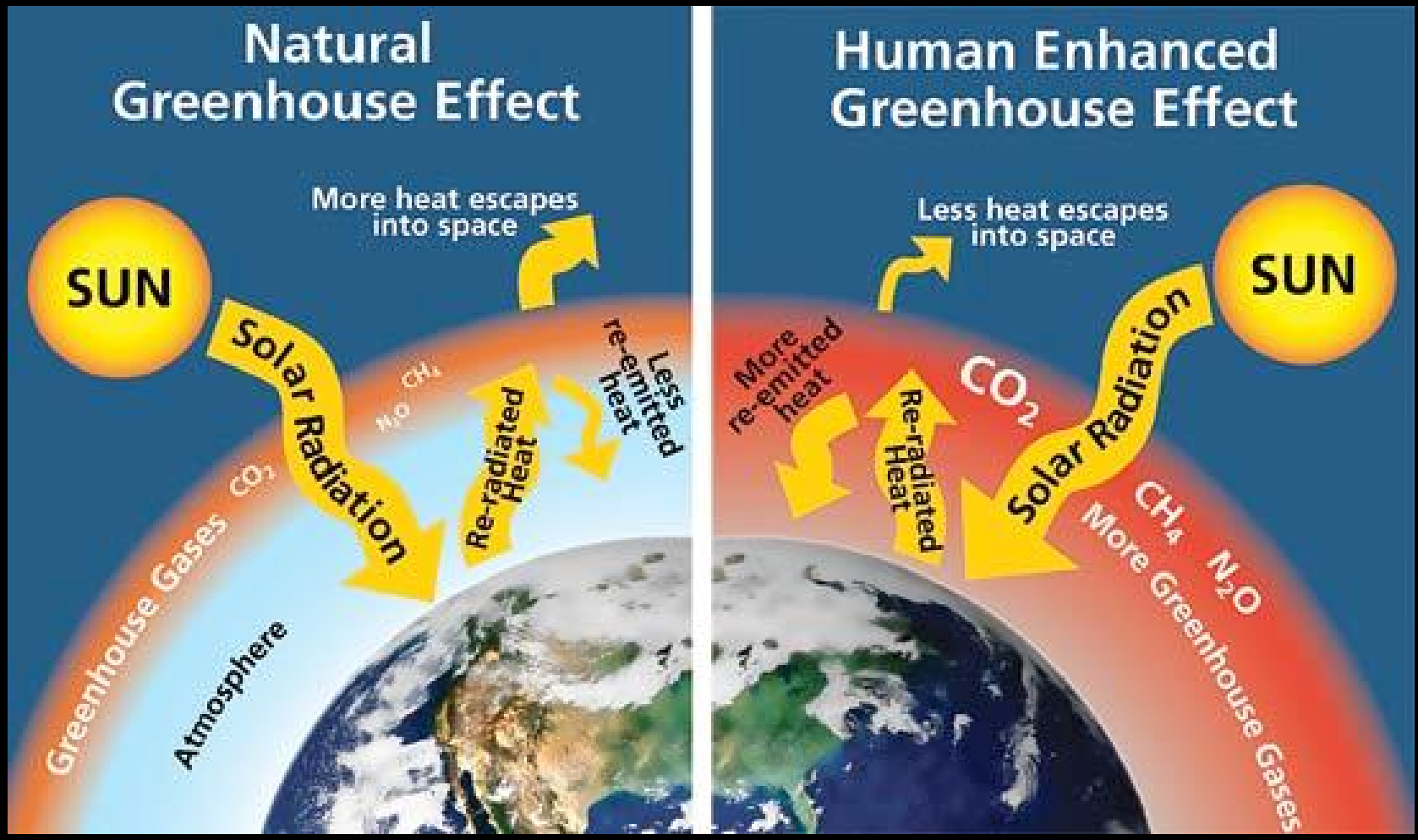

**Areas of study:**

- **Water resources**
- **Salmon**
- **Forests**
- **Coasts**
- ***(Agriculture, Human Health)***

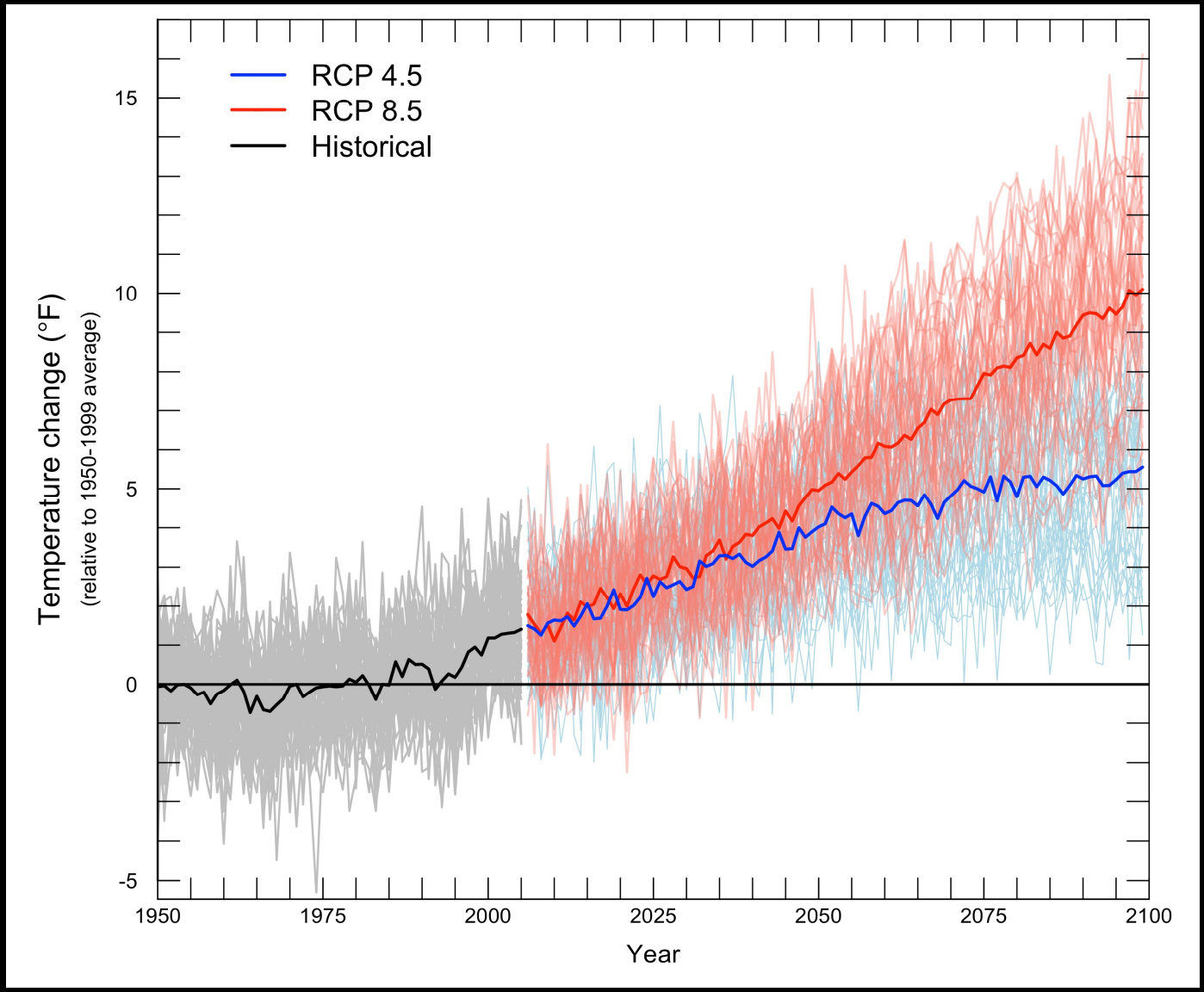
**Objectives**

- **Increase regional resilience to climate variability and change**
- **Produce science accessible to (*and useful for!*) the decision making community**

# Greenhouse Effect

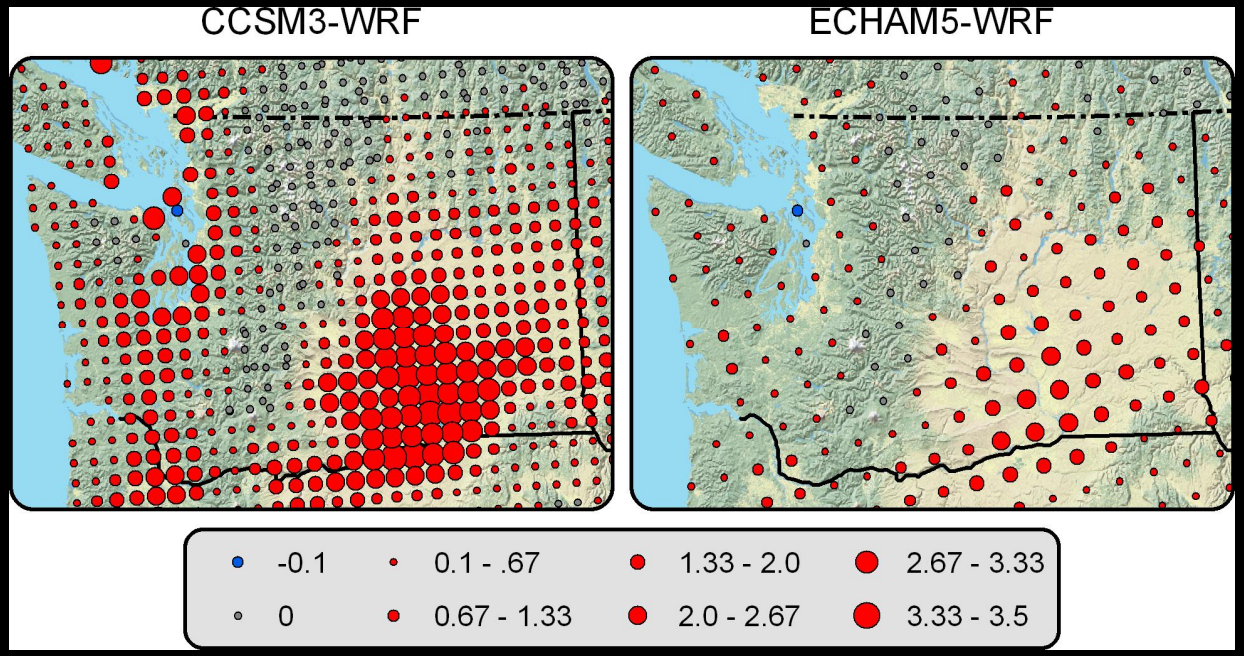


# Projected Increases in PNW Temp



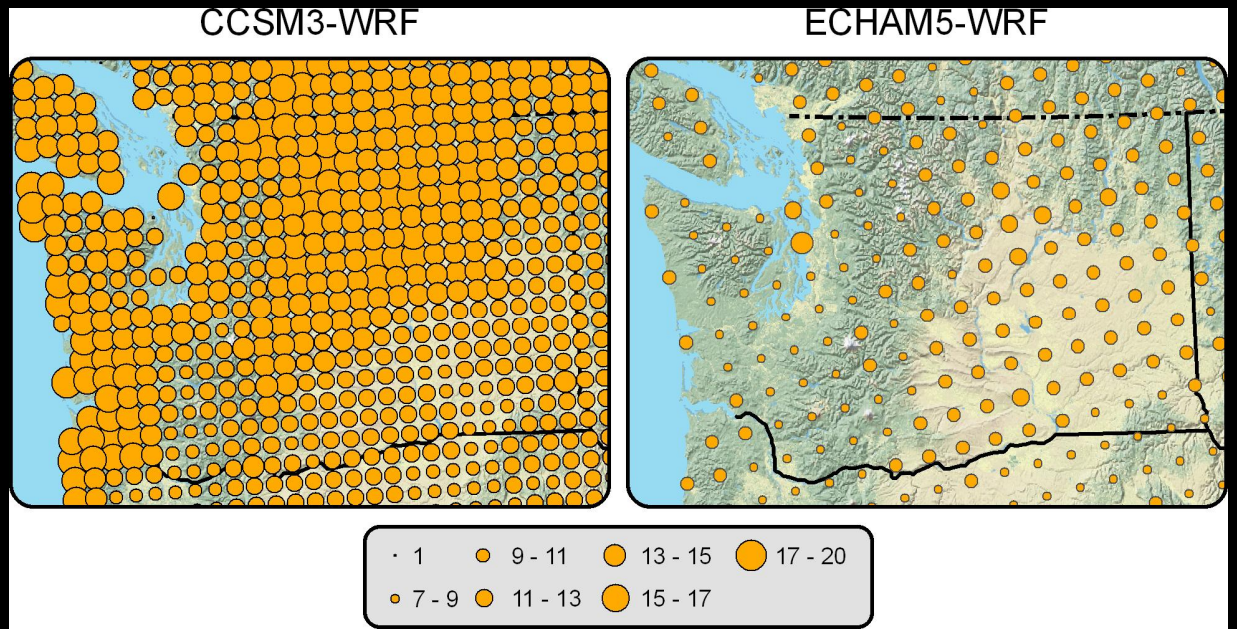

Data source: Abatzoglou (2013)

# Extreme Temperature Projections




Increase in number of heat waves (3+ days of HUMIDEX > 32°C) from historical levels to mid 21st century.

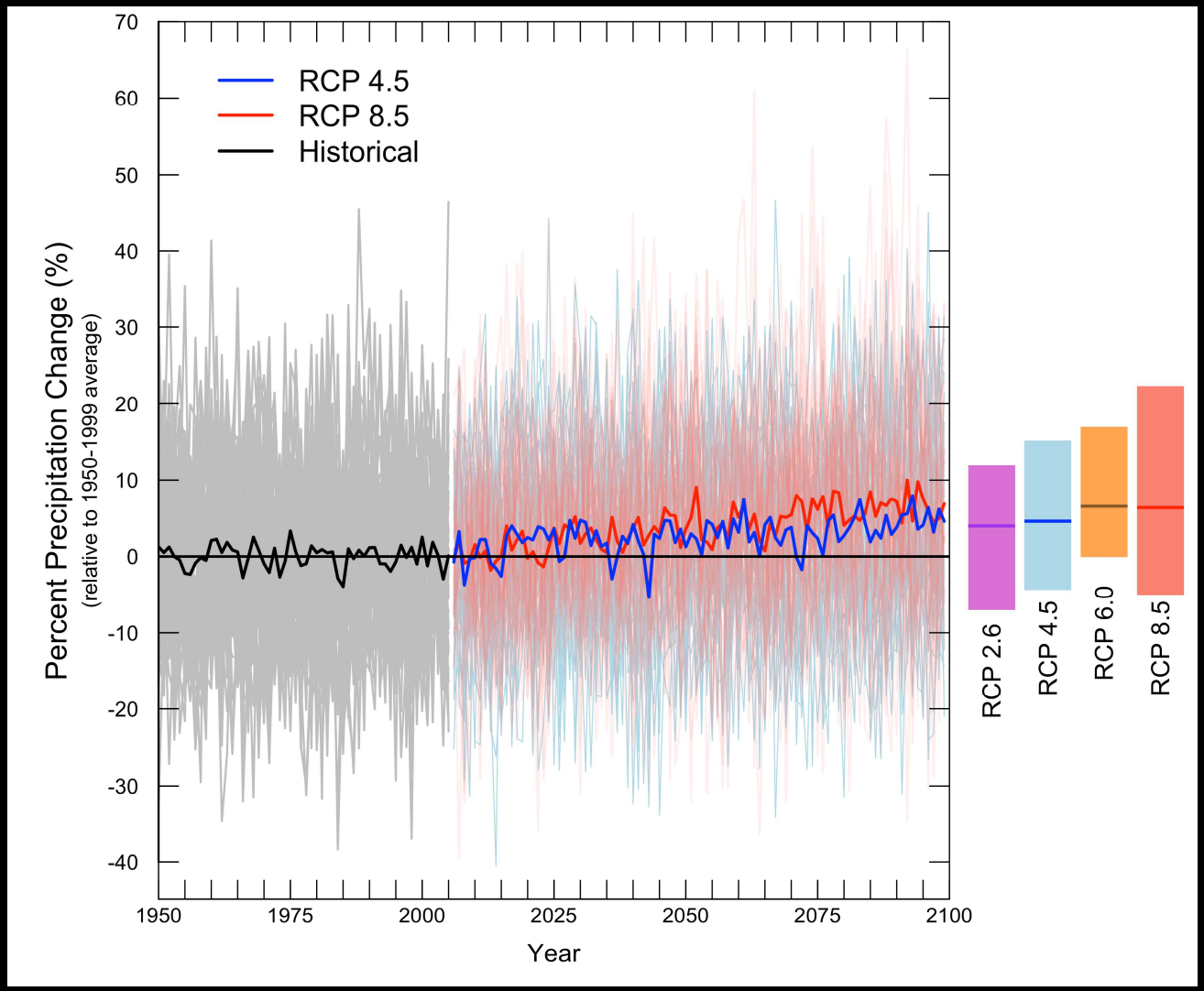
Number of days > 95°F increases from less than 3 days to upwards of 10 days by mid century.*




Increase in nighttime heat waves (Tmin > 90th percentile) from historical levels to mid 21st century.

Salathe 2010, *Kunkel 2013

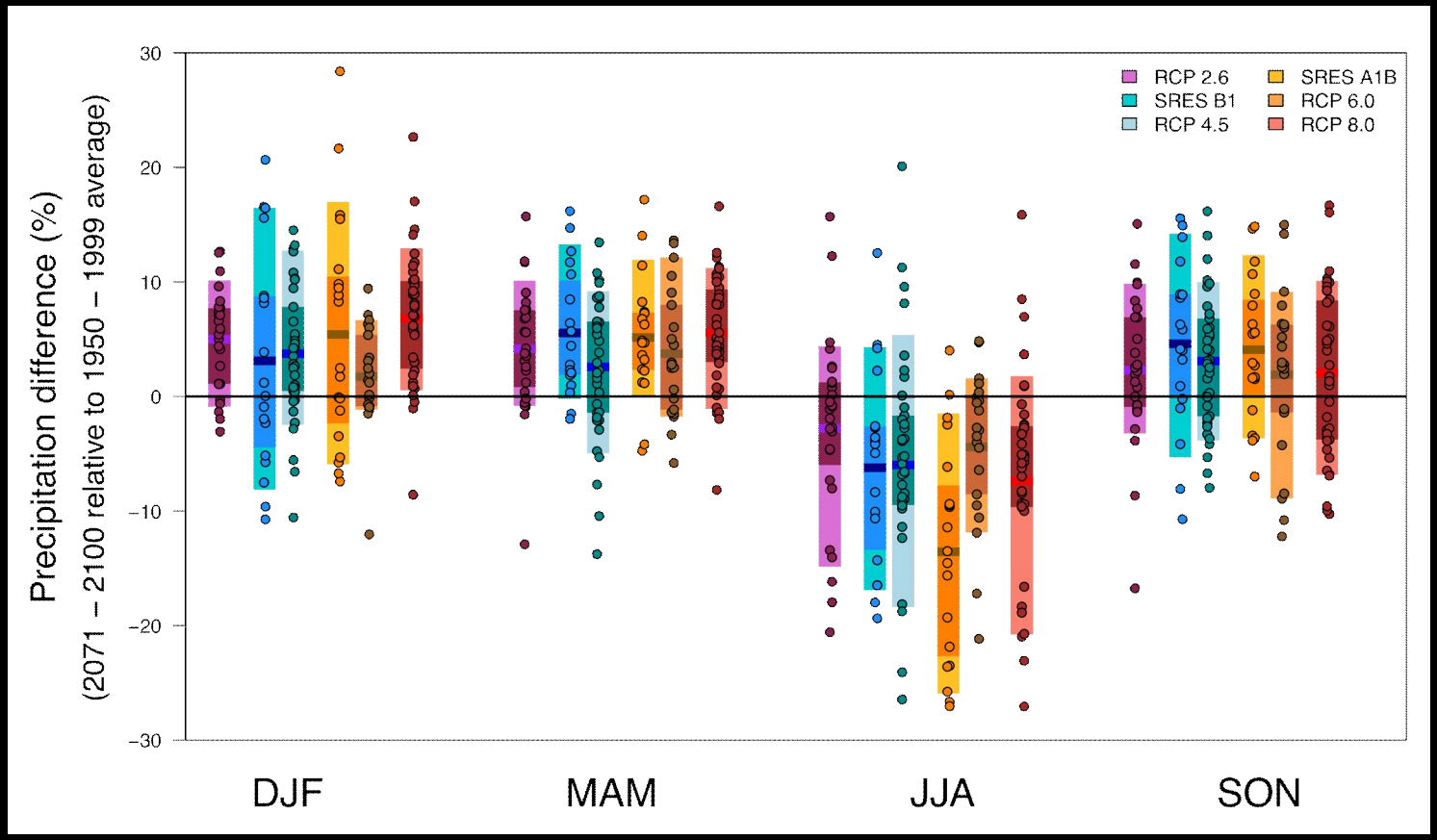
# Projected Changes Annual Precipitation




Small changes in annual precipitation (-5% to +10 %)

Data source: Abatzoglou (2013)

# Projected Changes in Seasonal Precipitation

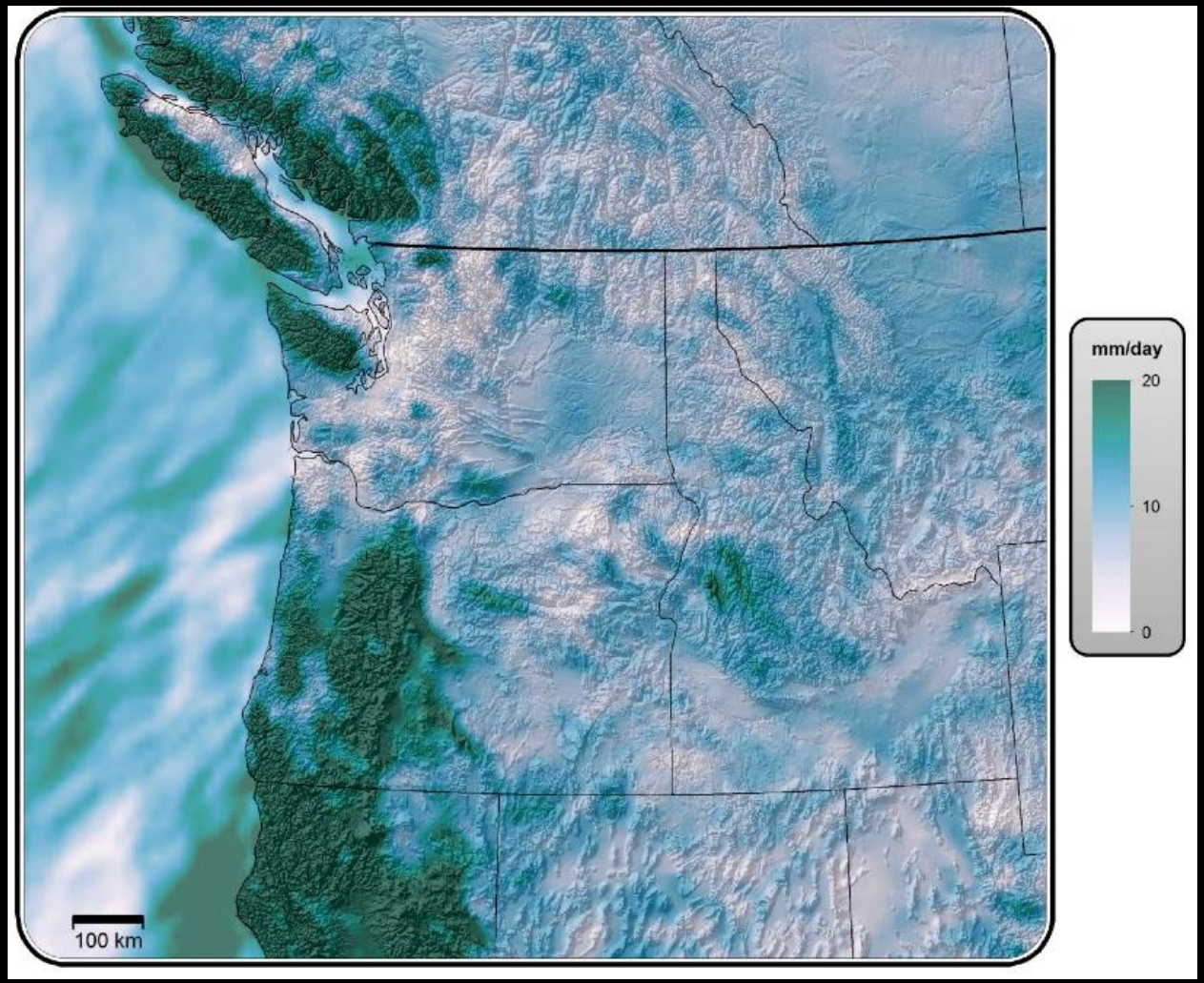



Some models show large seasonal changes

Most indicate drier summers and wetter winters, springs and autumns

Data source: Abatzoglou (2013)

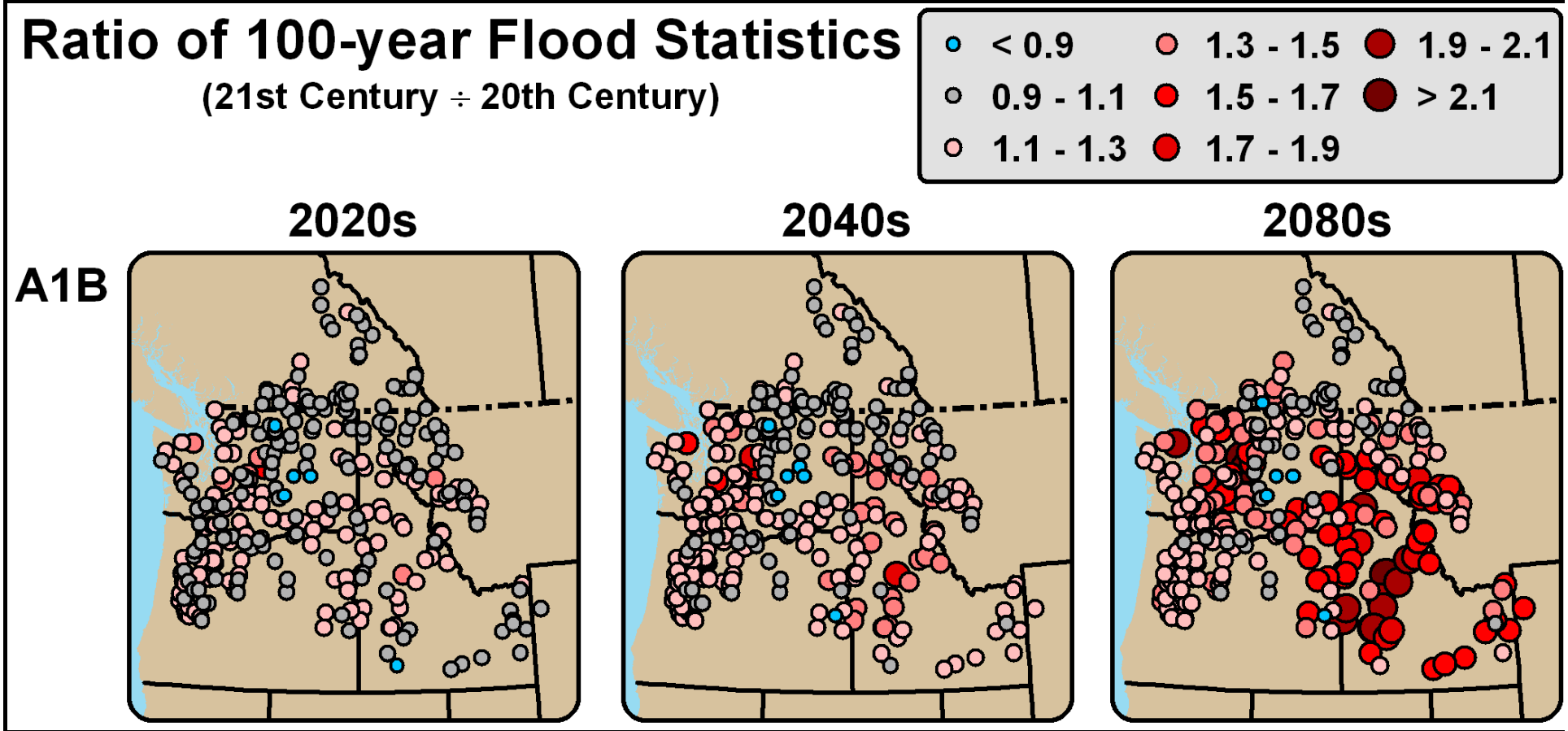
# Extreme Precipitation Projections




Increases in the maximum daily precipitation event averaged over 30-year periods:
historical (1970 – 1999) vs. future (2030 – 2069)

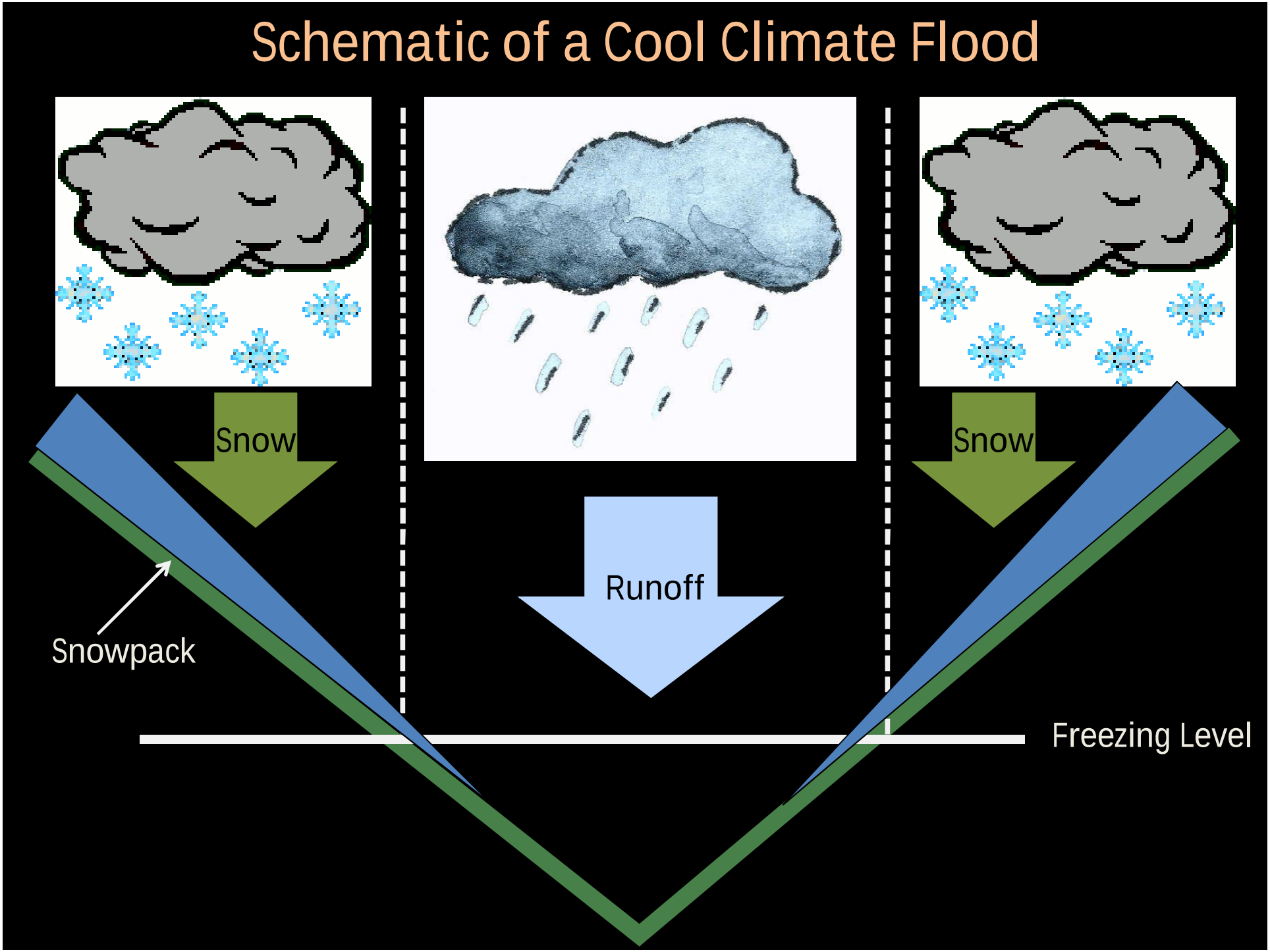
Salathé et al. 2014

# Increased Flood Risk

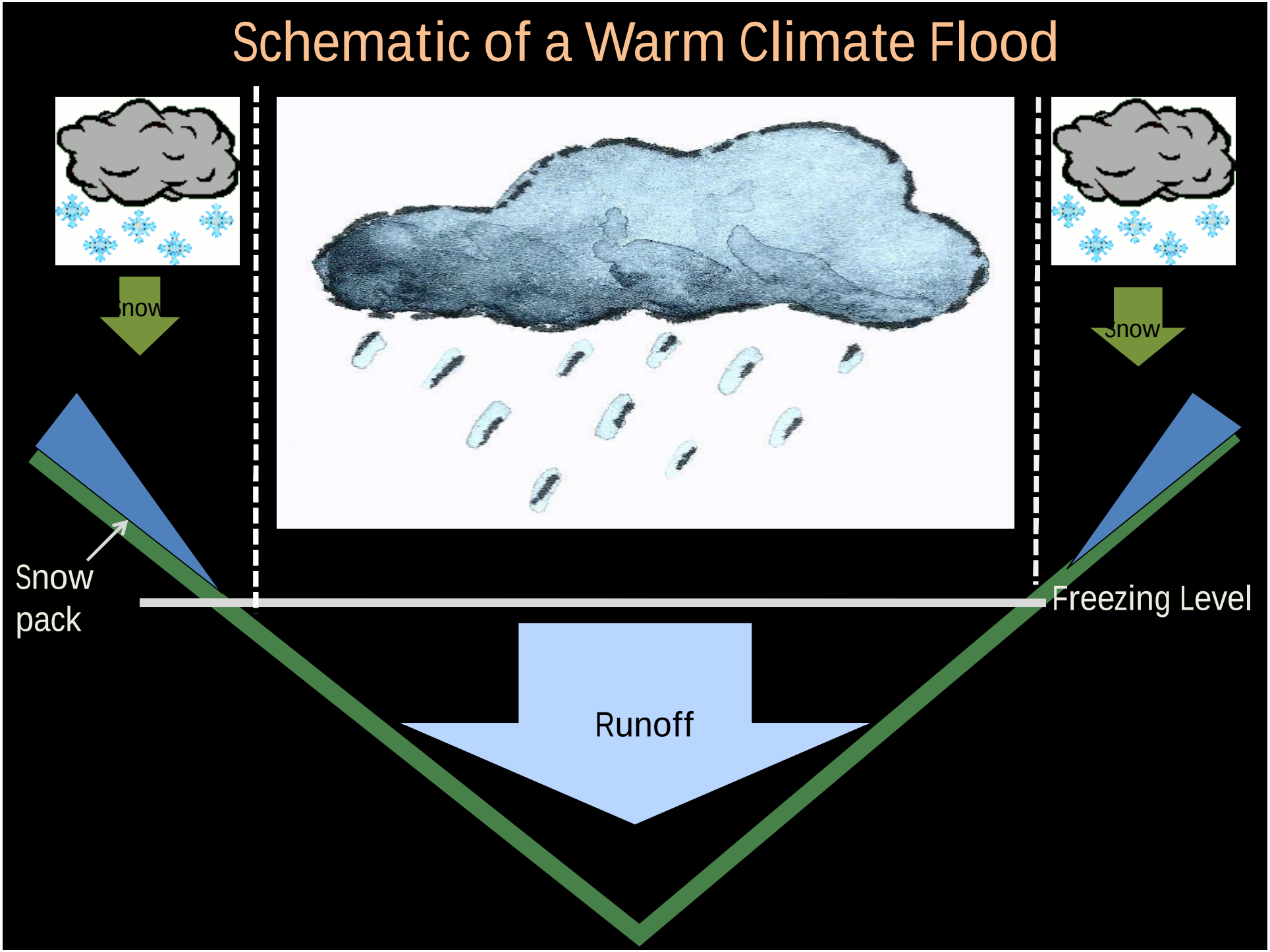



Tohver et al. 2014

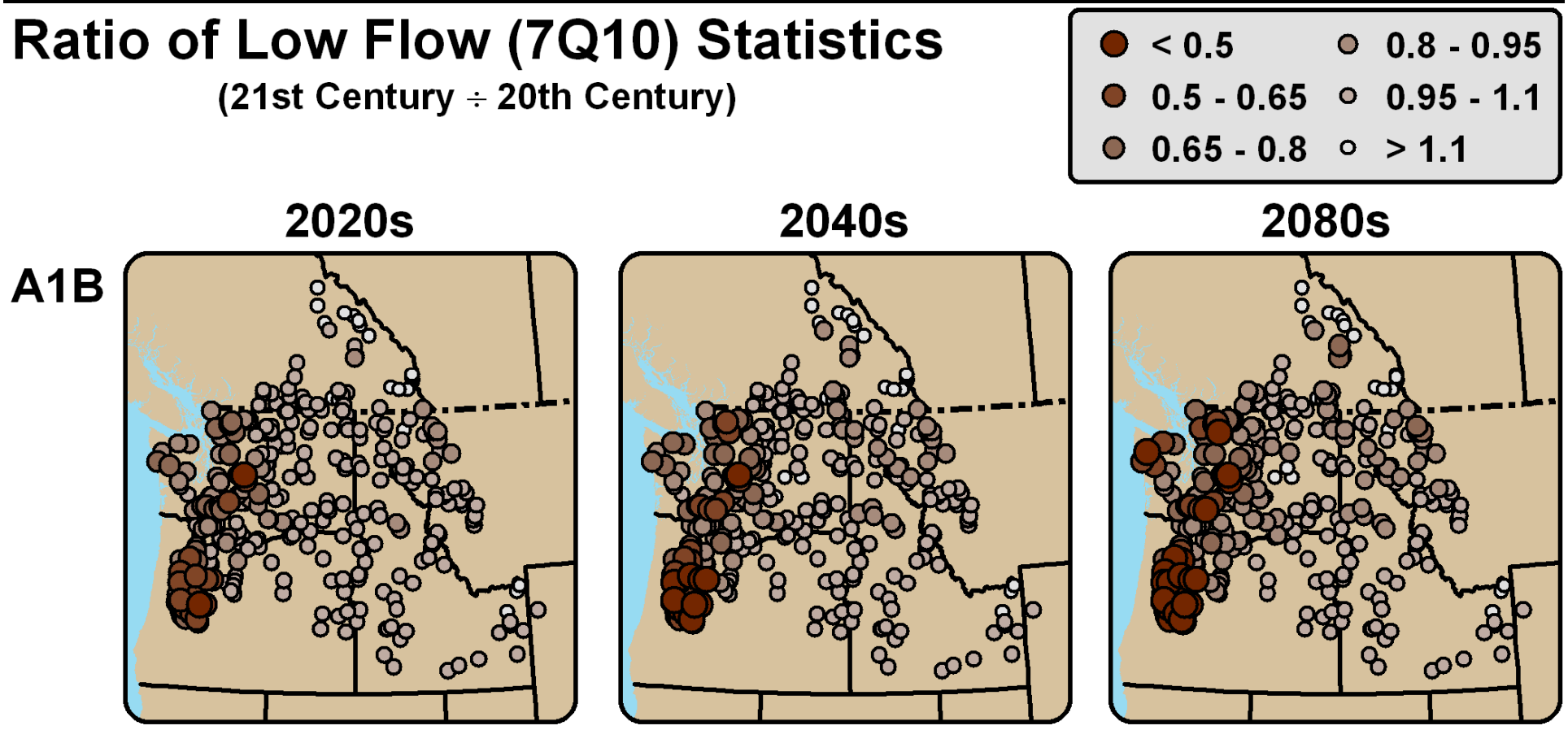
# Schematic of a Cool Climate Flood



# Schematic of a Warm Climate Flood

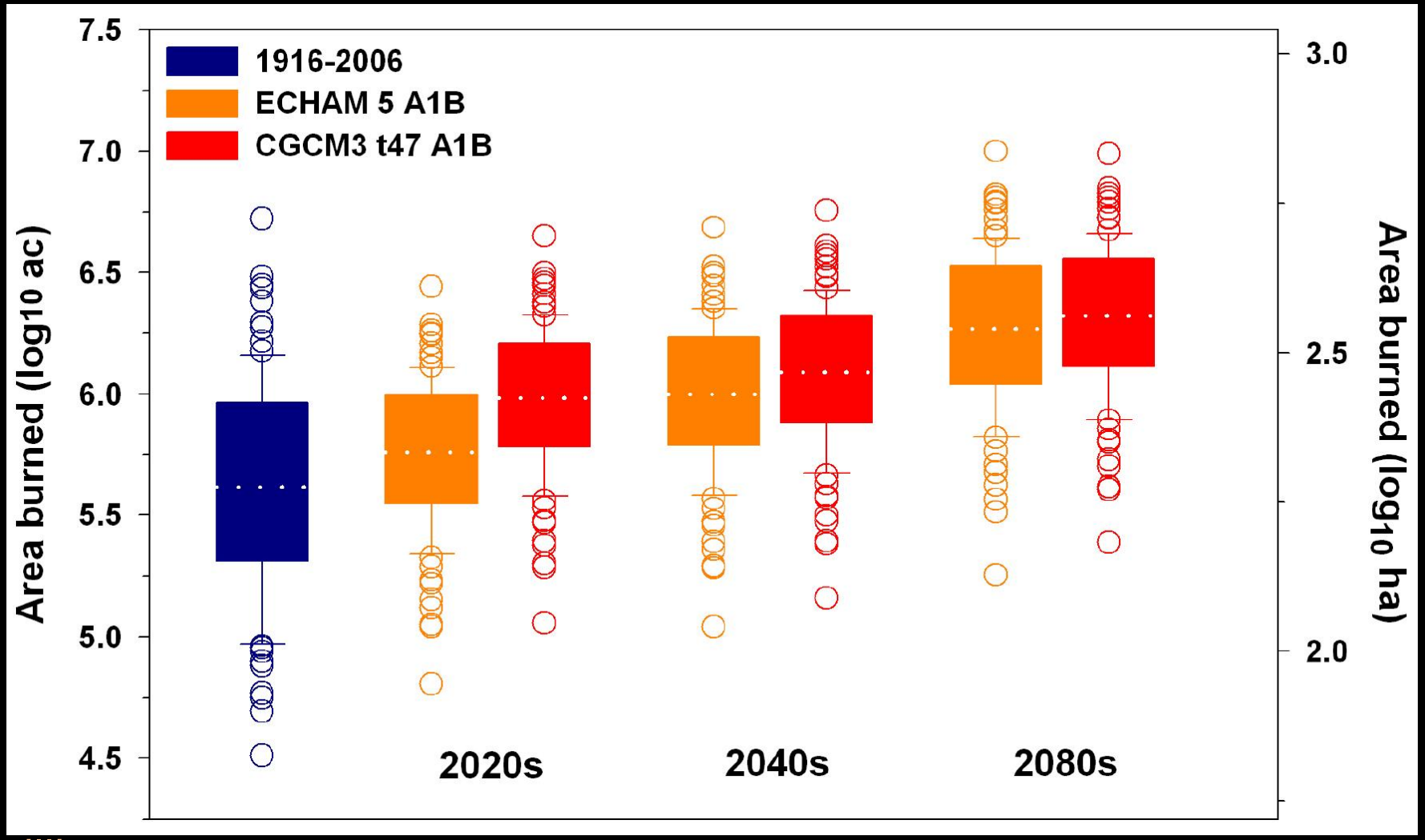


# Increased Drought Risk




Tohver et al. 2014

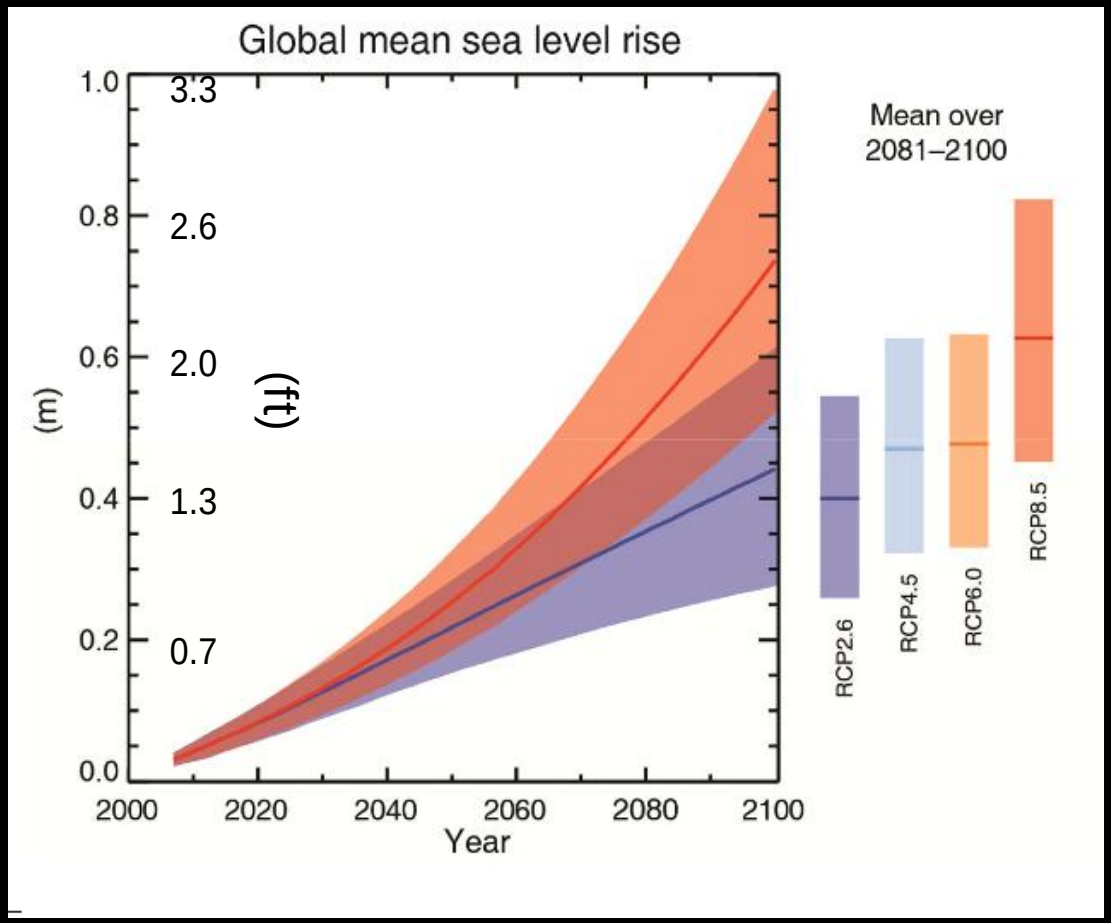
# Increased Wildfire Frequency




| Millions of acres in WA: | 0.5 | 0.8 | 1.1 | 2.0 |
|---|---|---|---|---|

Littell et al. 2010

# Projected Global Sea Level Rise



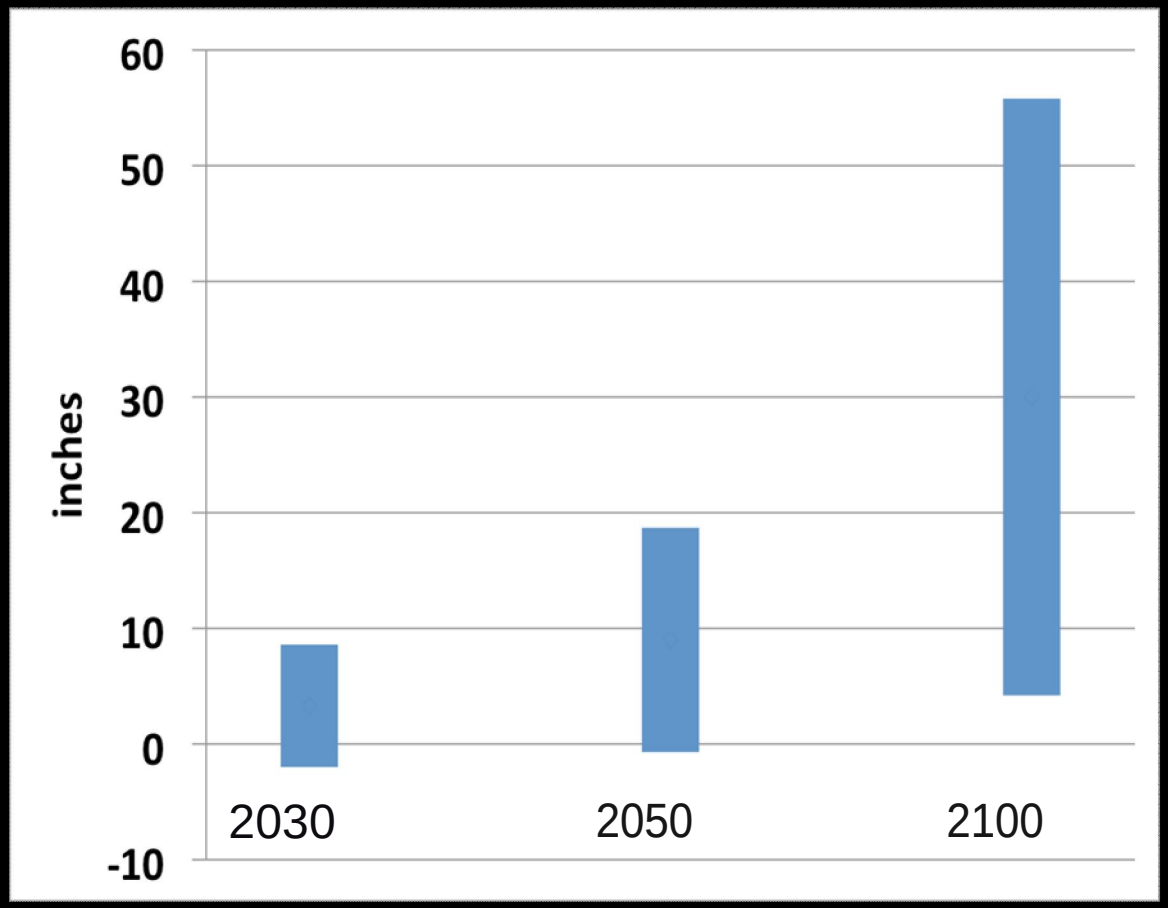

Key contributors to Global SLR

- Ocean has absorbed ~80% of warming associated with rising GHGs in last 50 years
- Thermal expansion – Water expands when warmed
- Melting of glaciers and land-based ice sheets – particularly Greenland and Antarctica since 1990s

**Changes are relative to the 1980-1999 mean**

Image source: IPCC 2013

# WA/OR Sea Level Rise Estimates




**Key contributors to regional SLR:**

- **Local tectonic processes *(subsidence and uplift)***
- **Atmospheric dynamics, i.e., wind-driven "pile-up" of waves along the coast**

National Research Council, 2012

# Implications for Public Health

Vulnerable populations:

- Young children & infants
- Elderly people
- People with compromised immune systems
- Mentally ill populations
- Urban poor, racial/ethnic minorities, the socially-isolated
- Subsistence farmers
- Coastal populations

# Impact Pathways for Public Health

Extreme Events (Flood, Storm Surge, Drought)

Warmer Temperatures (Heat stress)

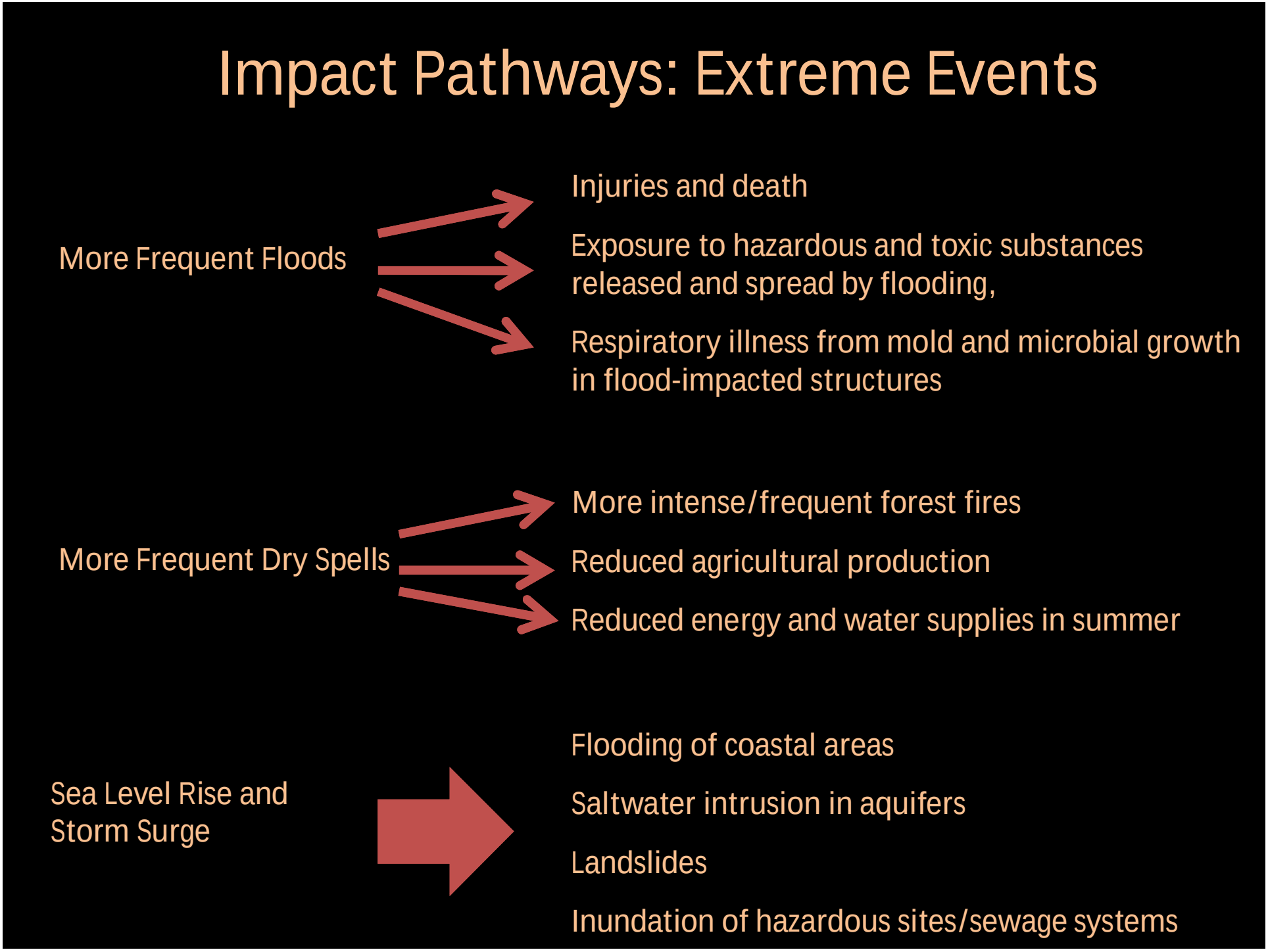
Air Quality (Increased ground-level ozone)

Water Quality

Infectious Diseases

Societal Disruptions

# Impact Pathways: Extreme Events



# Impact Pathways: Warmer Temperatures

Heat and Thermal Stress

- Worsening of existing problems with respiratory illness, cardiovascular disease, and kidney failure
- More heat exhaustion, heart attacks, strokes
- More heat related deaths, although the projected numbers vary widely.

One study for the greater Seattle area projected an additional 157 annual heat-related deaths by 2045 under a moderate (A1B) greenhouse gas emissions scenario.*

Another study projected only an additional 14 annual heat-related deaths in Seattle for approximately the same time period under a very high (A1FI) emissions scenario.#

*Jackson et al. 2010, #Greene et al. 2011

# Impact Pathways: Air Quality

Increased forest fires → Greater incidence of asthma, bronchitis, and pneumonia hospital admissions

Increased forest fires → Missed school/work days

Smoke from the 2012 wildfires in Chelan and Kittitas Counties contributed to an additional 350 hospitalizations for respiratory conditions and 3,400 student absences from school[#]

[#]Glen Patrick, Manager of the Environmental Epidemiology, Washington State Dept. of Health

Increased allergen/pollen production → More severe and longer-lasting allergy symptoms

Increased allergen/pollen production → More asthma attacks

Increased allergen/pollen production → Missed school/work days

Greater ground-level ozone production → Under a high emissions scenario (A2), projections of annual number of additional May-September deaths due to ozone increase from 69 in 1997-2006 to 132 by mid-century in King County, and from 37 (1997-2006) to 74 in Spokane[*]

*Jackson et al. 2010

# Impact Pathways: Water Quality

| | | |
|---|---|---|
| Increased winter flooding | → | Increased exposure to contaminants spread by flood water<br>Contaminated/disrupted public water supply |
| Increased summer drought | → | Decreased water supply<br>Inconsistent groundwater supply |
| Increased marine water temperature | → | Models project increased occurrence of Harmful Algal Blooms in the Puget Sound:<br>*A. catenella*, which paralytic shellfish poisoning, projected to increase by about 13 days by the end of the century under a moderate (A1B) scenario |
| Sea level rise | → | Increased salt water intrusion in freshwater supplies and agricultural floodplains |

# Impact Pathways: Infectious Diseases

Vector-borne diseases → West Nile appeared in WA State in 2006 with 3 reported cases (2005 was an El Niño year)

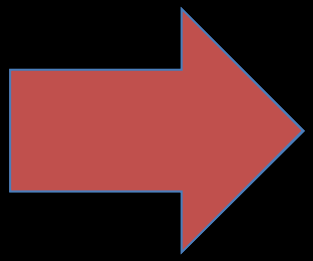
Water-borne diseases

- Marine → Diarrhetic Shellfish Poisoning (DSP) and *Vibrio parahaemolyticus* cases concurrent with toxic algal blooms during episodes of warmer ocean temperatures (also linked to increased run-off)
- Freshwater → Cases of Campylobacteriosis (*Campylobacter jejuni)* and E. coli (*Escherichia coli)* poisoning frequently reported after flood waters contaminated drinking water

(The impact of climate change on Lyme disease, hantavirus, malaria, and dengue in the PNW is unknown.)

# Impact Pathways: Social Disruptions

Climate-induced migrations

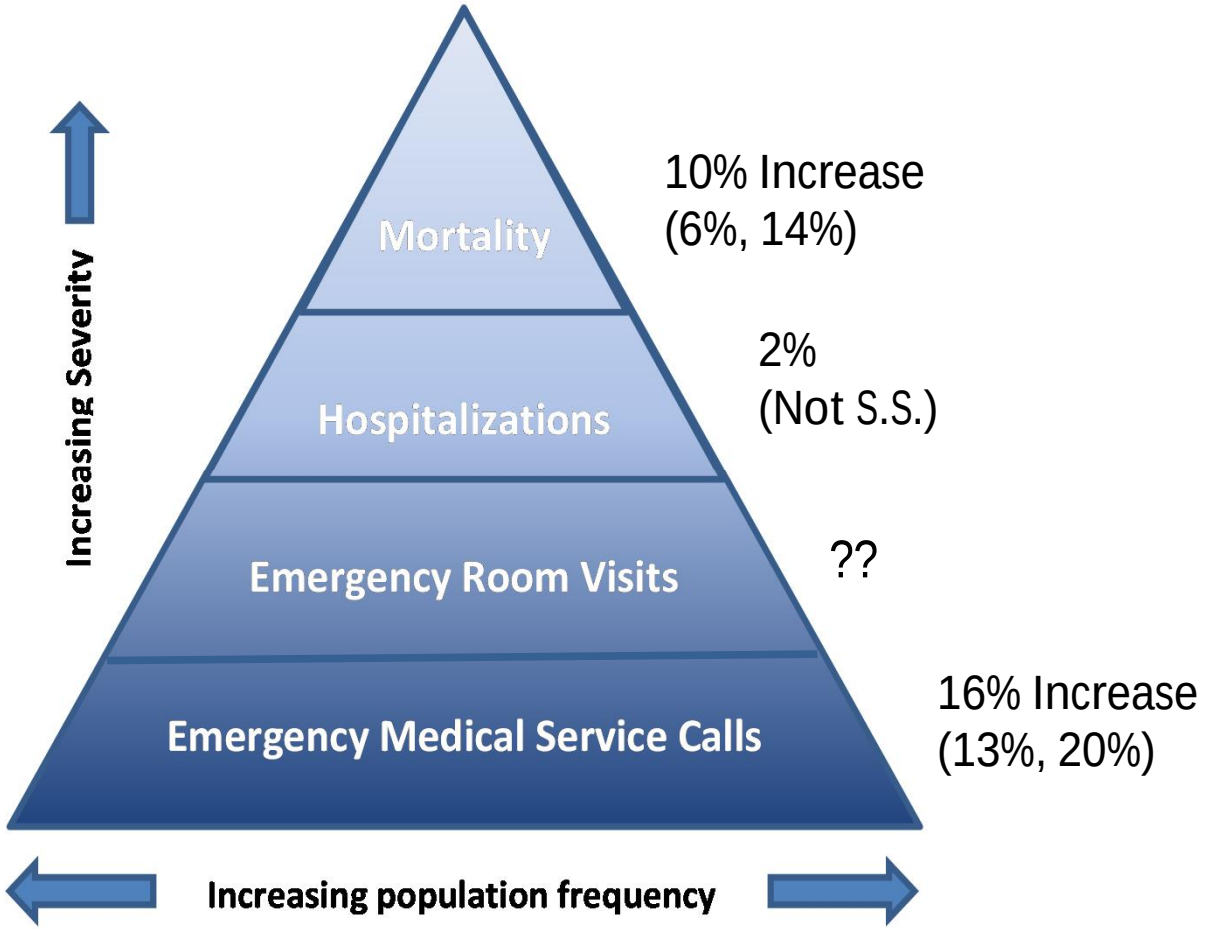


- Higher demand for social services
- Greater energy demand/production
- Overwhelmed emergency management systems
- Lower access to health care
- Poor hit harder
- WA industries at risk: agriculture, energy and forestry

# Methods

- Heat day vs. Non-heat day
  - Relative Risk – Poisson regression analysis
  - Top 1% of all days - 99$^{th}$ percentile
- Heat Intensity Effect
  - Time Series Poisson analysis; piece-wise linear fit summary
- Data
  - Mortality: 1980-2010, death certificate data
  - Hospitalizations: 1990-2010, CHARS data
  - Emergency Medical Service Calls: 2007-2012, King County data
- Exposure
  - Humidex: effect of temperature + humidity

# King County Heat-Health Risks
# All Ages above 99th percentile heat day




KC average 99th percentile day; with humidity = feels-like temp of ~36℃ or 97℉ humidex

# King County Heat-Health Risks

- Mortality effects:
  - All ages for Circulatory (9%), Cerebrovascular (40%), & Accidents (19%)
  - Chronic Renal (900%) 0-4 year age group *very small #s
- Hospitalization effects:
  - All ages for Acute Renal (68%), Chronic Renal (57%) and Natural Heat (244%)
  - Mental Health (318%) 0-4 year age group *very small #s
  - Natural Heat Exposure (399%) 15-44 year age group *small numbers
  - TSA: 15-44 yr age group ↑ 10 & 12% for COPD & Asthma

## EMS – BLS Relative Risk Results – 95$^{th}$ percentile (29.7 °C )

| Medical Issue | All Ages | 0-4 | 5-14 | 15-44 |
|---|---|---|---|---|
| All Causes | 1.08 (1.06, 1.09) | 1.14 (1.07, 1.21) | 1.07 (1, 1.14) | 1.11 (1.08, 1.13) |
| Trauma | 1.13 (1.07, 1.18) | 1.35 (1.18, 1.54) | 1.11 (0.98, 1.25) | 1.16 (1.09, 1.23) |
| Non-Trauma | 1.06 (1.04, 1.08) | 1.09 (1, 1.18) | 1.04 (0.95, 1.14) | 1.09 (1.06, 1.12) |
| Neurological | 1.03 (1, 1.06) | 1 (0.87, 1.15) | 0.99 (0.83, 1.17) | 1.06 (1, 1.12) |
| Heat Illness & Dehydration | 3.43 (3.07, 3.84) | 3.89 (2.08, 7.29) | 4.22 (2.67, 6.69) | 4.41 (3.65, 5.32) |
| Psychological | 1.03 (0.98, 1.08) | 1.68 (0.78, 3.6) | 0.99 (0.72, 1.34) | 1.07 (1.01, 1.14) |

Bolded relative risk values are significantly greater than 1 ($p < 0.05$

# Discussion

- Co-health benefits of reducing carbon pollution
  - EXAMPLE: Adar, S. D., D'Souza, J., Sheppard, L., Kaufman, J. D., Hallstrand, T. S., Davey, M. E., Sullivan, J. R., ... Liu, L. J. S. (April 13, 2015). Adopting Clean Fuels and Technologies on School Buses: Pollution and Health Impacts in Children. *American Journal of Respiratory and Critical Care Medicine.*
- Youth-related research needs:
  - Seasonal allergies
  - Extreme heat - are we ready?
  - Mental health impacts
  - Others???