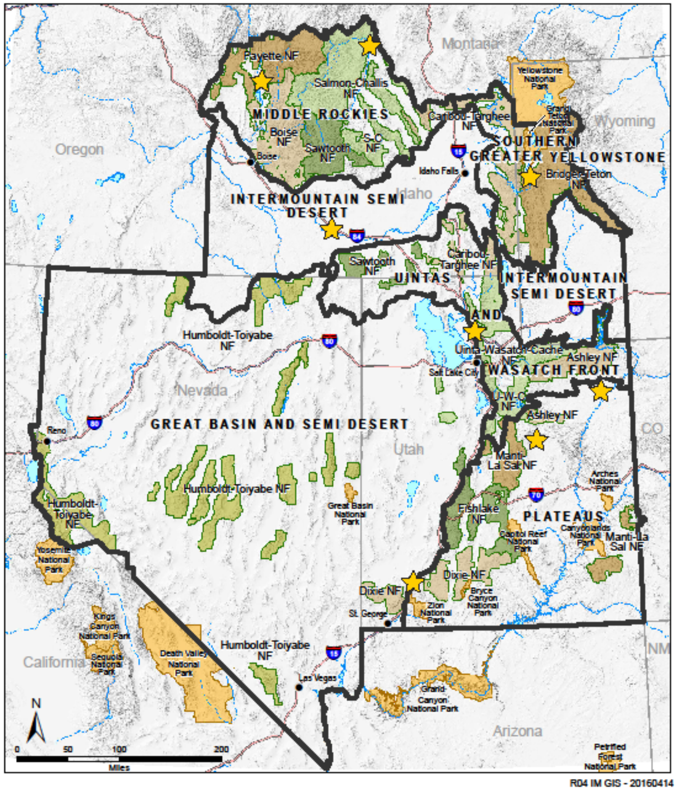
Intermountain Climate Assessment Workshop

May 22-24, 2018

Main location: Ogden, UT

Virtual locations:
Ashley National Forest (NF), Vernal, UT
Bridger-Teton NF, Jackson, WY
Dixie NF, Cedar City, UT
Manti-La Sal NF, Price, UT
Payette NF, McCall, ID
Salmon-Challis NF, Salmon, ID
Sawtooth NF, Twin Falls, ID

More info at: www.fs.usda.gov/goto/cc



United States
Department of
Agriculture

Housekeeping
Special Announcements
Safety

Nora Rasure

Regional Forester

Intermountain Region

USDA Forest Service

Ogden, Utah

Cynthia West, PhD

Director, Office of Sustainability and Climate

USDA Forest Service

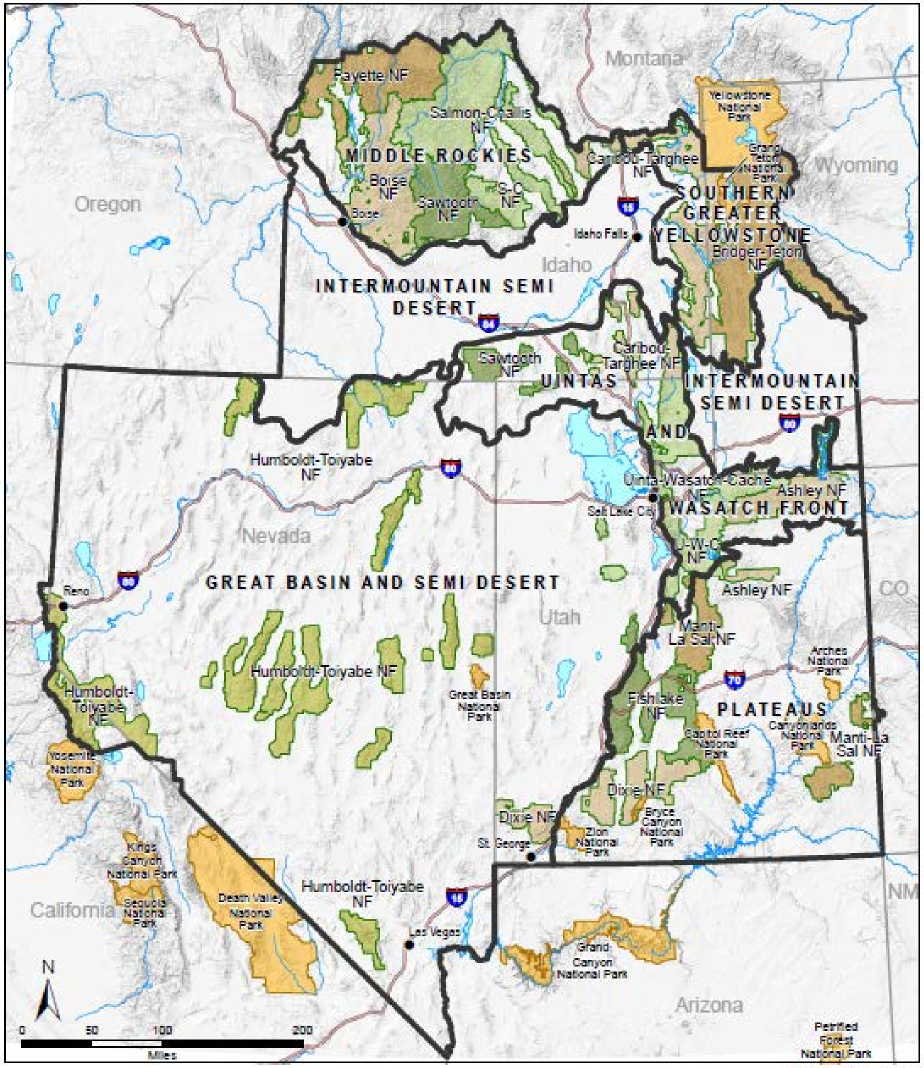
Washington, D.C.

Natalie Little

Regional Sustainability and Climate Coordinator
Intermountain Region
USDA Forest Service
Ogden, Utah

Forest Service – 193 million acres
Intermountain Region – 32 million acres

Intermountain Region's Subregions Climate Assessment



R04 IM GIS - 20160414

We have lots of information!
What is important? What isn't?
Who decides?

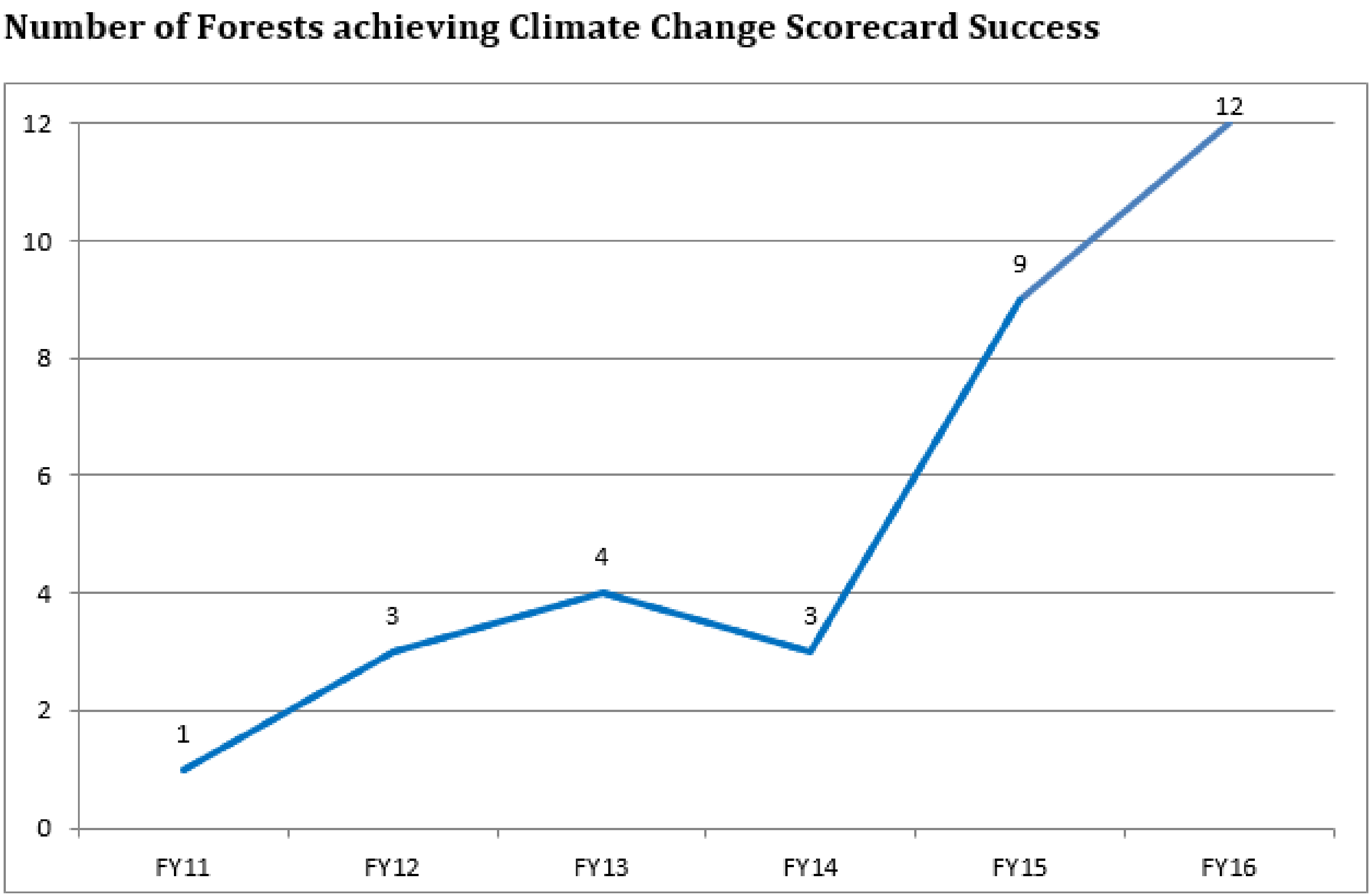
Important:

- Multi-perspective
- Structured

Climate Change Performance Scorecard FY11 – FY16

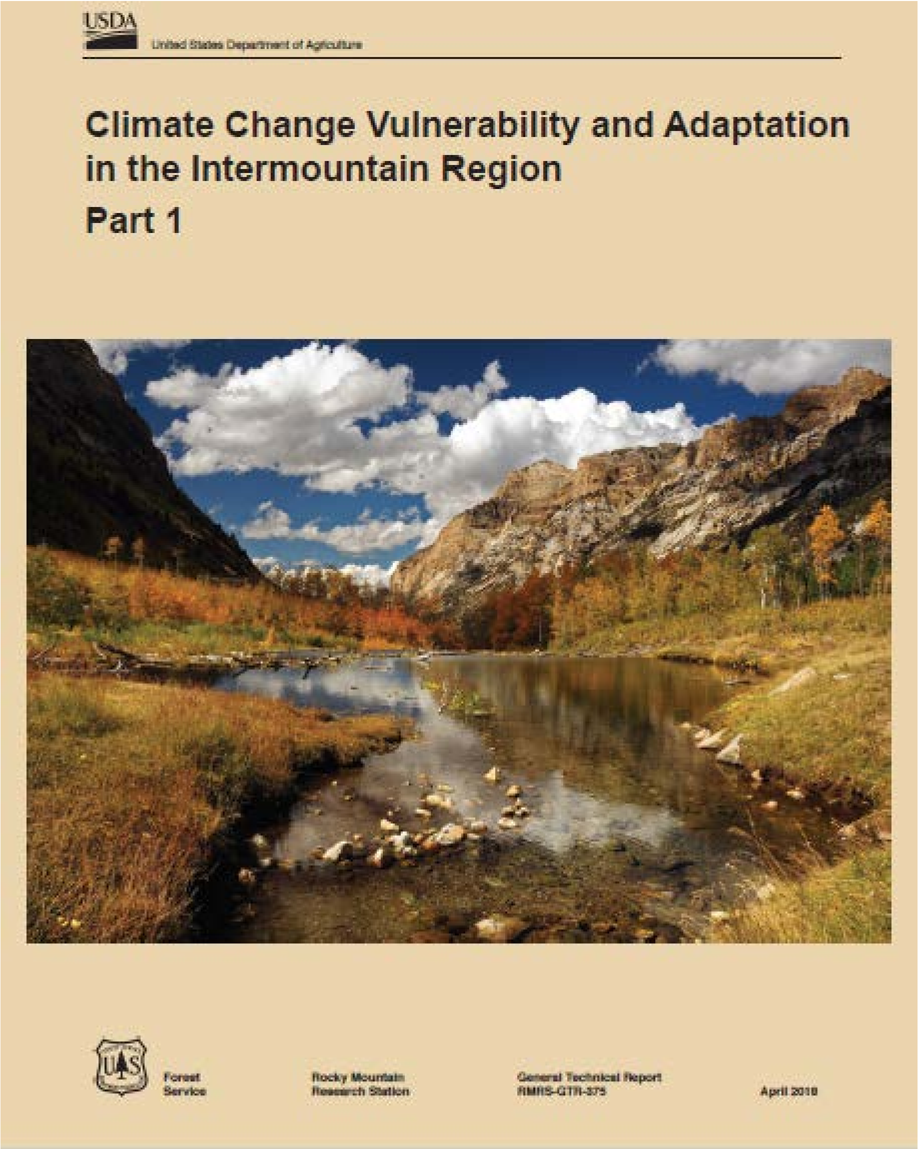
Organizational Capacity	
1	Employee Education
2	Designated Climate Change Coordinators
3	Program Guidance
Engagement	
4	Science and Management Partnerships
5	Other Partnerships
Adaptation	
6	Assessing Vulnerability
7	Adaptation Actions
8	Monitoring
Mitigation and Sustainable Consumption	
9	Carbon Assessment & Stewardship
10	Sustainable Operations

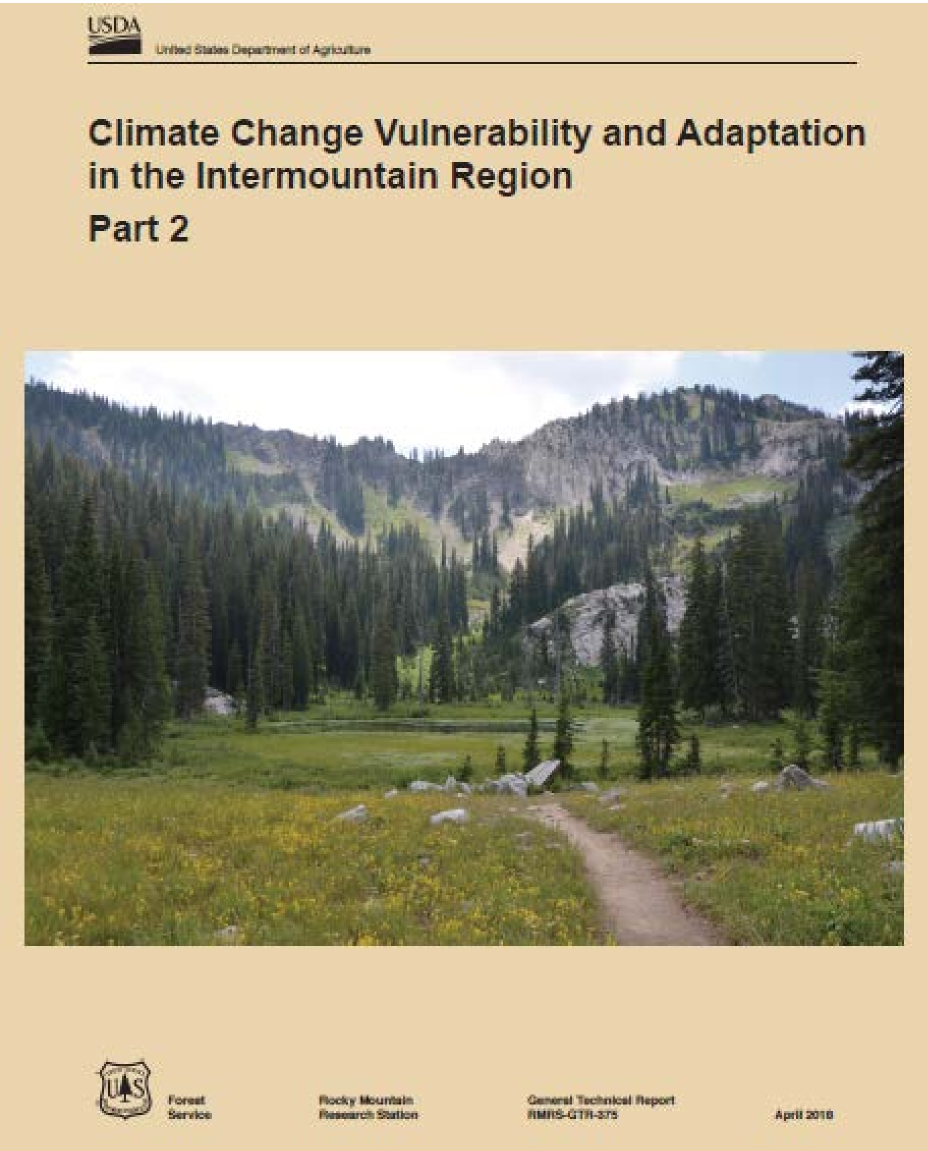
Climate Change Performance Scorecard
FY11 – FY16 for Intermountain Region



Climate Assessment Schedule

- **June 2014**: Regional coordinator conference call
- February 2015: Leadership meeting and approval
- April 2015: Kick-off meeting
- March 2016: Webinar series
- May – June 2016: Two-day workshops
- 2016 – 2017: Writing & review
- 2017 – 2018: Into edit, layout, press
- **May 2018**: GTR Published/Roll-out workshop





IAP / R4 Climate Assessment posted:
www.fs.usda.gov/goto/cc

Intermountain Adaptation Partnership (IAP)

Goals for the science-management partnership:

- Increase climate change awareness
- Assess vulnerability of natural resources
- Develop adaptation strategies and tactics

http://adaptationpartners.org/iap

March 2016 Two-Hour Webinars

Dates	Topics
March 3	Climate, Hydrology, Soils, Water Resources
March10	Vegetation, Ecological Disturbance
March 17	Fisheries, Aquatics, Terrestrial Species
March 24	Recreation, Infrastructure
March 31	Cultural Heritage, Ecosystem Services



2016 Two-Day Workshops

Dates	Location	Total Attendees	Forest Service	Partners
May 4-5	Ogden, Utah	50	41	9
May 11-12	Boise, Idaho	53	32	21
May 18-19	Salt Lake City, Utah	54	37	17
May 25-26	Reno, Nevada	43	28	15
June 1-2	Idaho Falls, Idaho	51	37	14

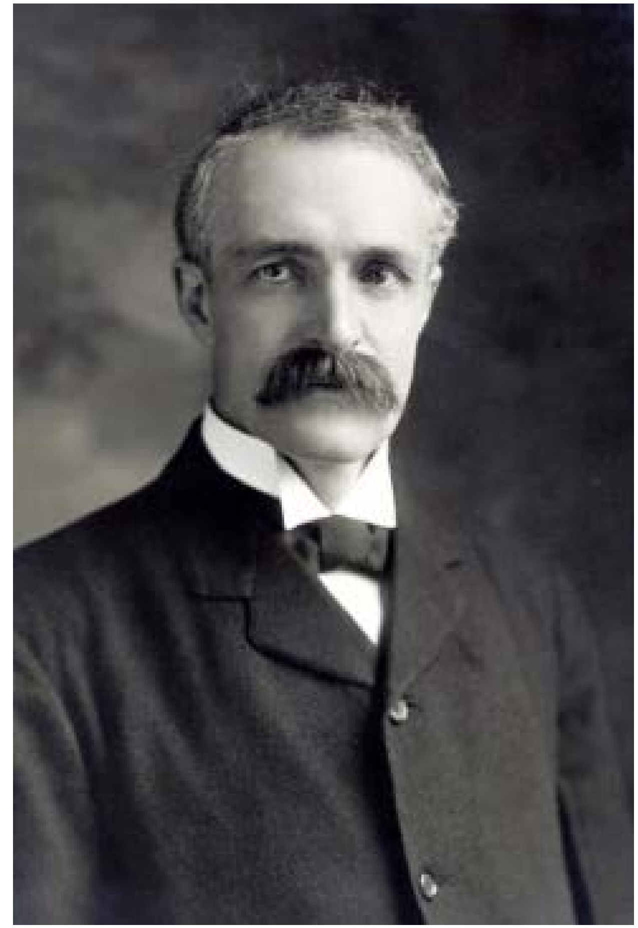


Focus Areas

- Climate
- Hydrology, Soil, and Water
- Aquatic Species
- Vegetation
- Ecological Disturbance
- Terrestrial Species
- Recreation
- Infrastructure
- Cultural Heritage
- Ecosystem Services

"Where conflicting interests must be reconciled, the question shall always be answered from the standpoint of greatest good for the greatest number in the long run."

- Gifford Pinchot, 1st Chief of Forest Service,
- 1905-1910



Forest Service Mission Statement

Incorporating climate science is essential if the Forest Service is to fulfill its mission:

- “to sustain the health, diversity, and productivity of America’s forests and grasslands for the benefit of present and future generations.”

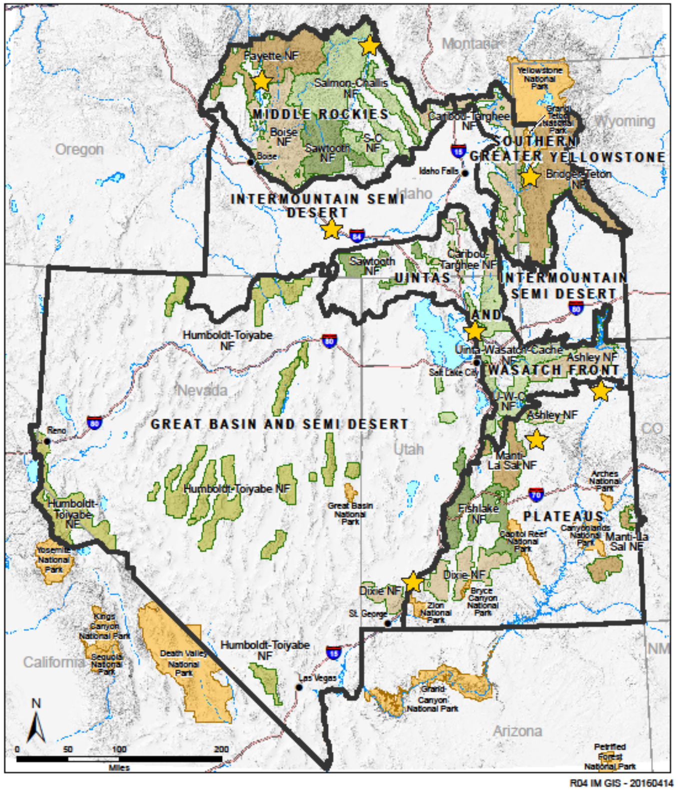
Dave Peterson, PhD

USDA Forest Service, retired

Professor

University of Washington, Seattle

Introductions



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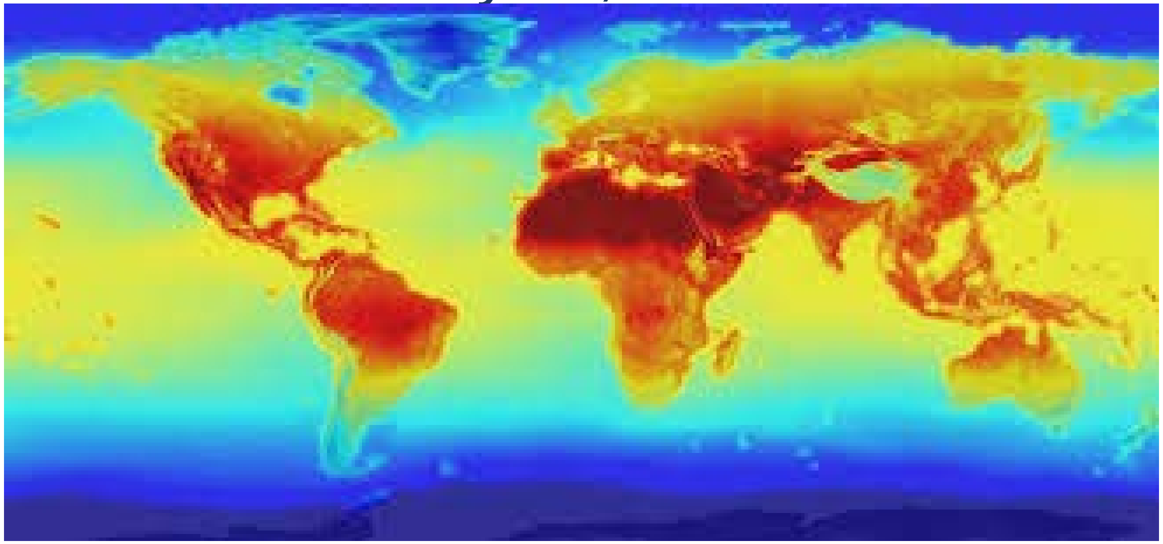
GROUP EXERCISE - ICEBREAKER

BREAK TIME

Background Information on Climate

Intermountain Region – Climate Assessment Workshop

May 22, 2018



Holly R. Prendeville, PhD

Coordinator

USDA Northwest Climate Hub

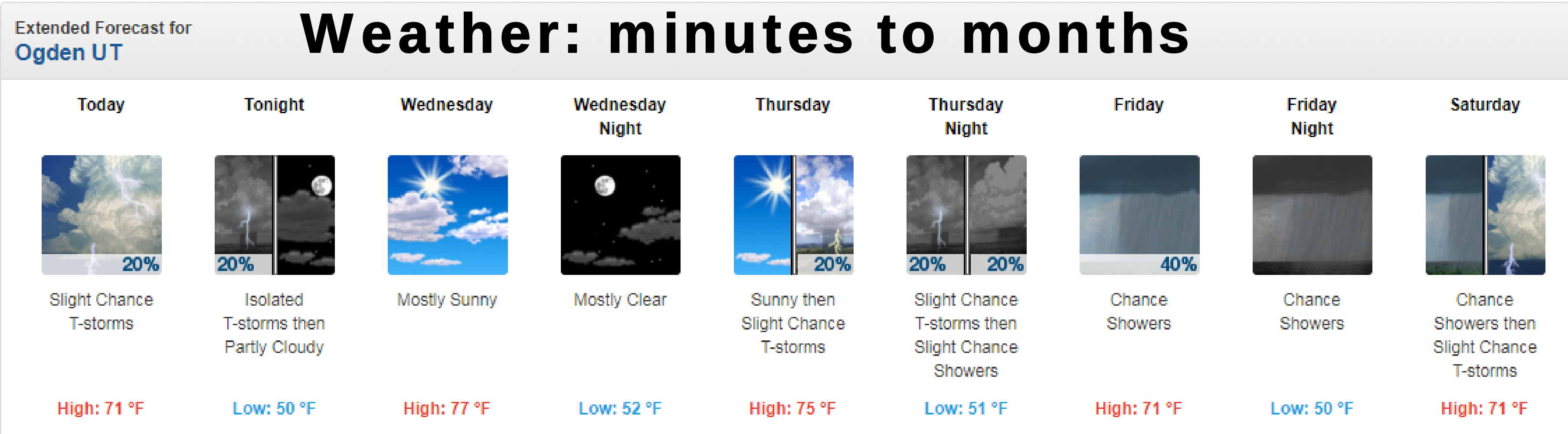
FS Pacific Northwest Research Station

USDA Northwest Climate Hub

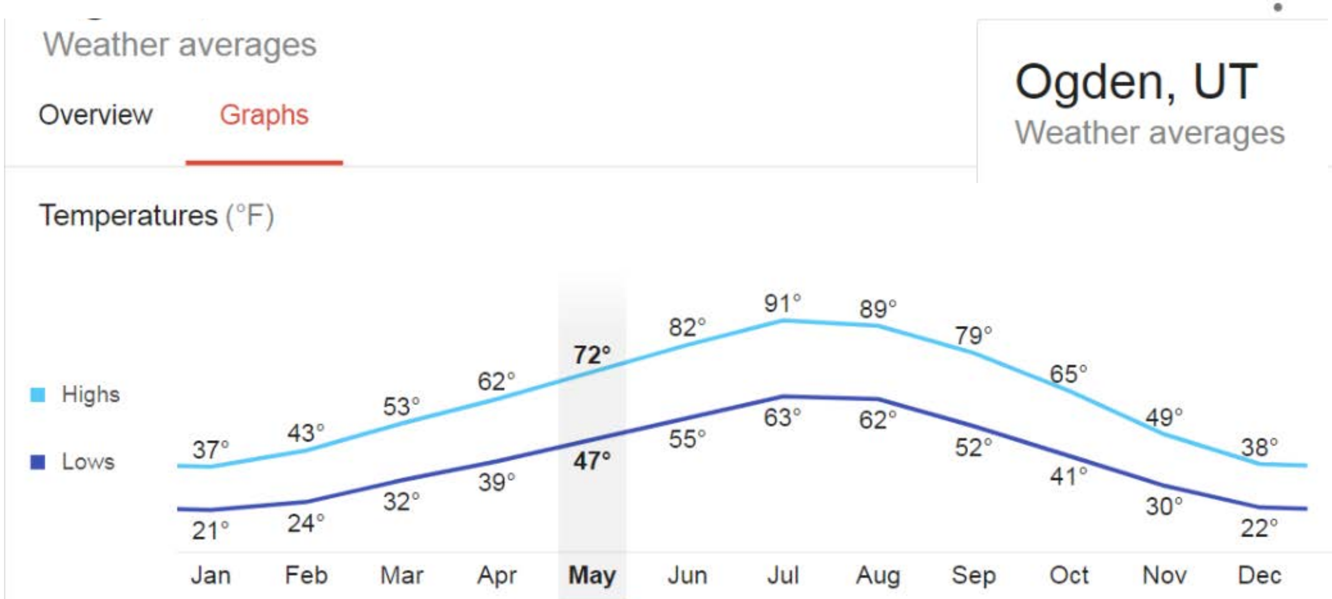
U.S. DEPARTMENT OF AGRICULTURE

The difference between weather and climate is <u>time</u>

Weather: minutes to months

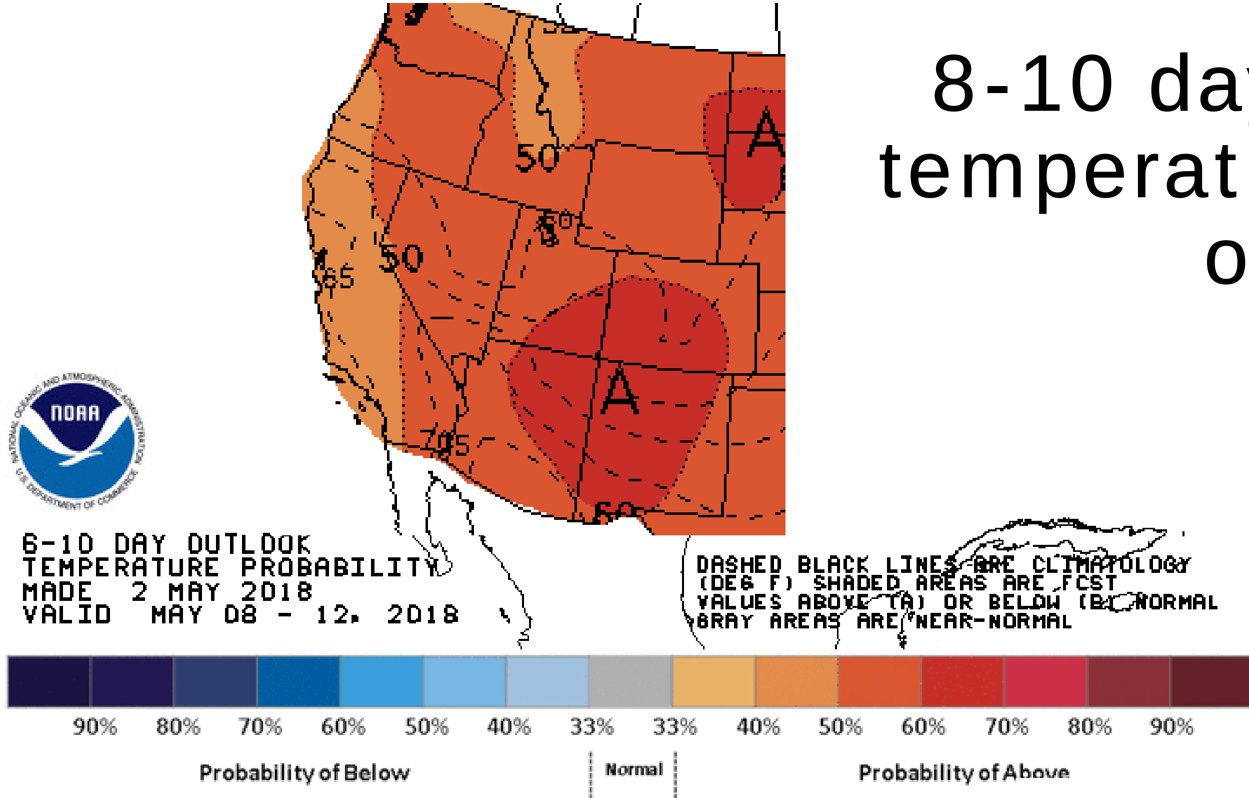


Climate: months, years+

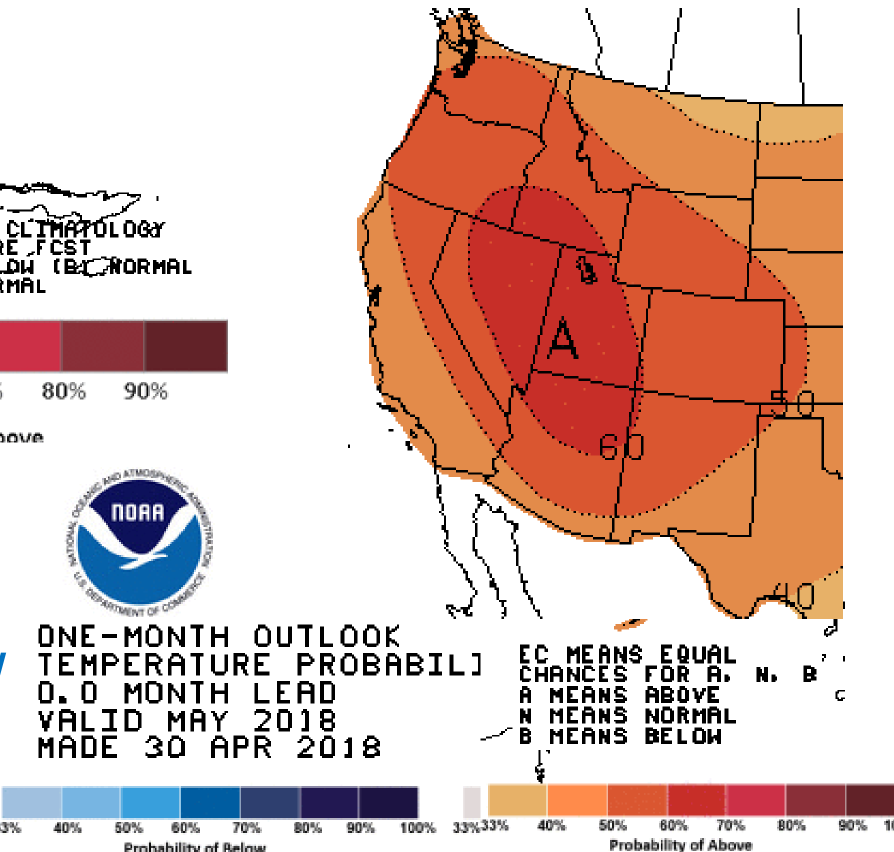


Short-term projections

8-10 day vs 1 month temperature probability outlook

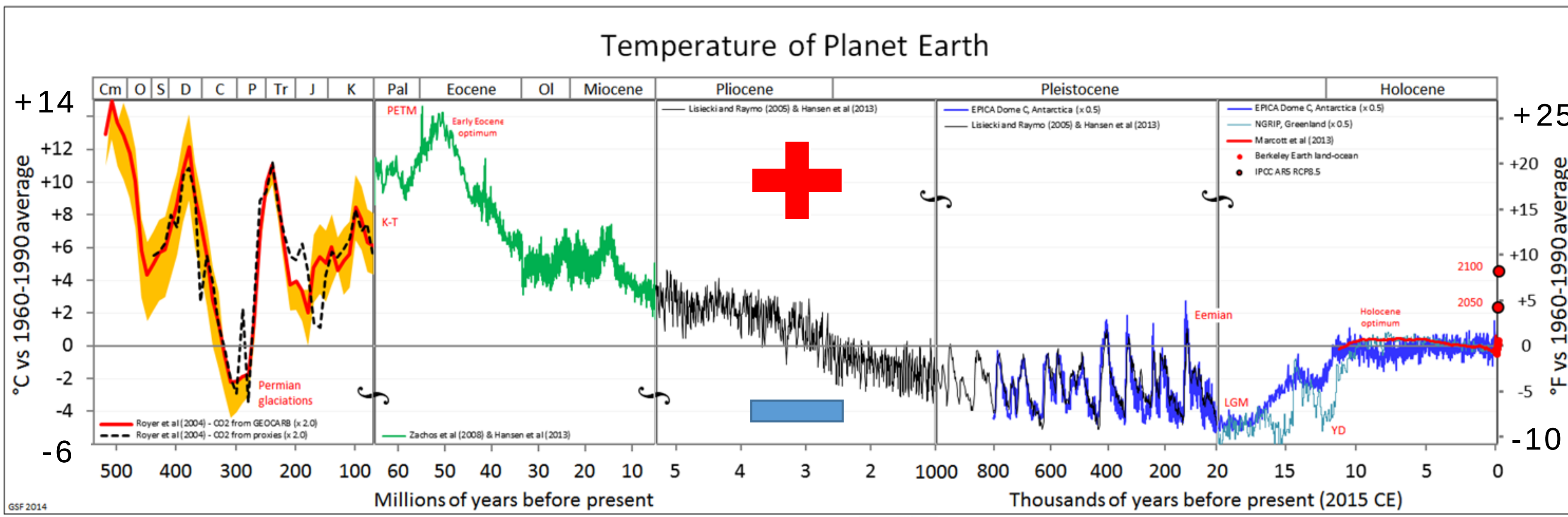


http://www.cpc.ncep.noaa.gov/



Global temperatures over geological time

“Normal” climate has meant different things through the history of the Earth.

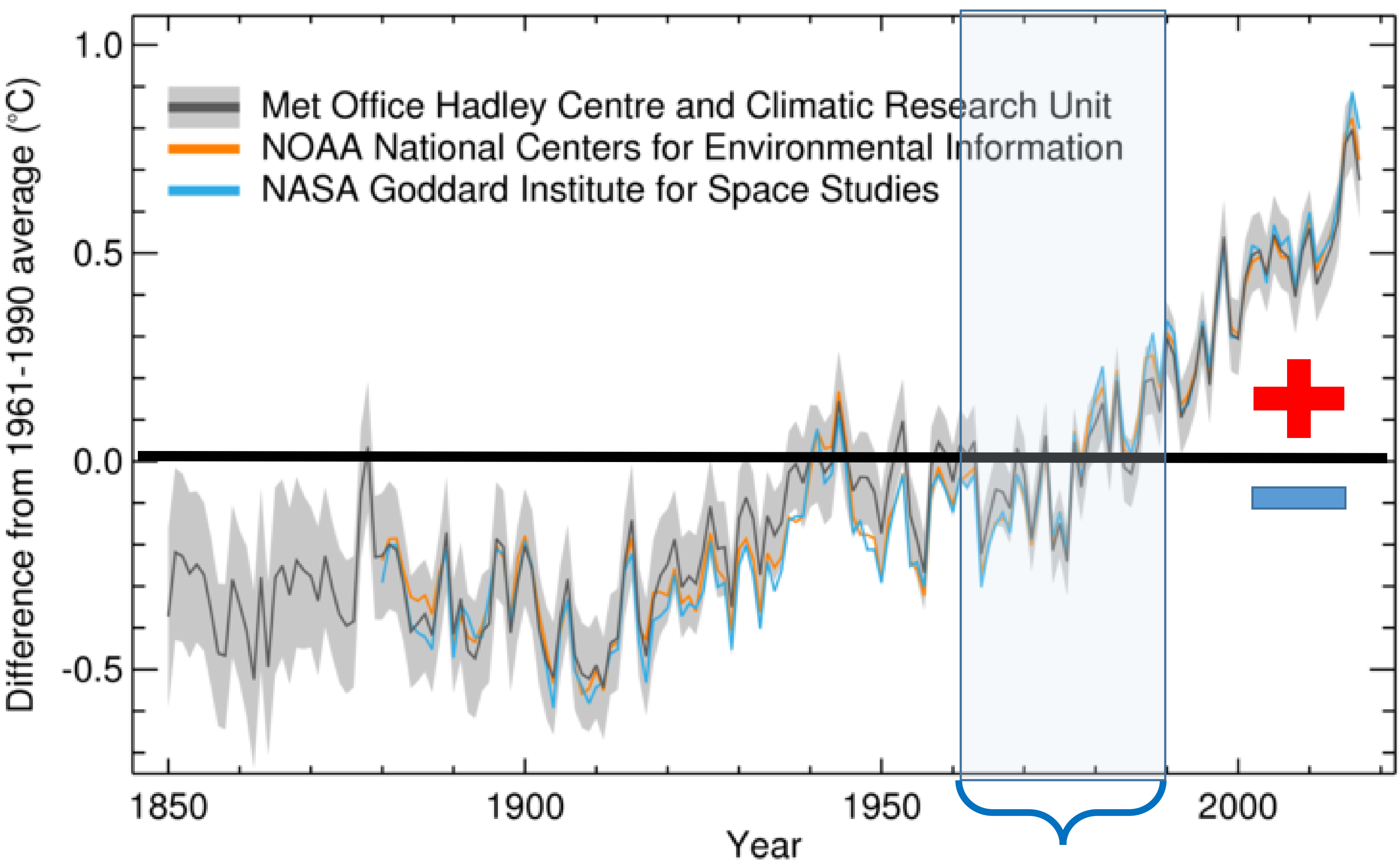


http://gergs.net/2015/06/updating-the-geological-temperature-plot/all_palaeotemps/

Observations in Global Climate

Global average temperature anomaly (1850-2017)

http://www.metoffice.gov.uk/research/monitoring/climate/surface-temperature#how



Some processes often included in models of the Earth's climate system.

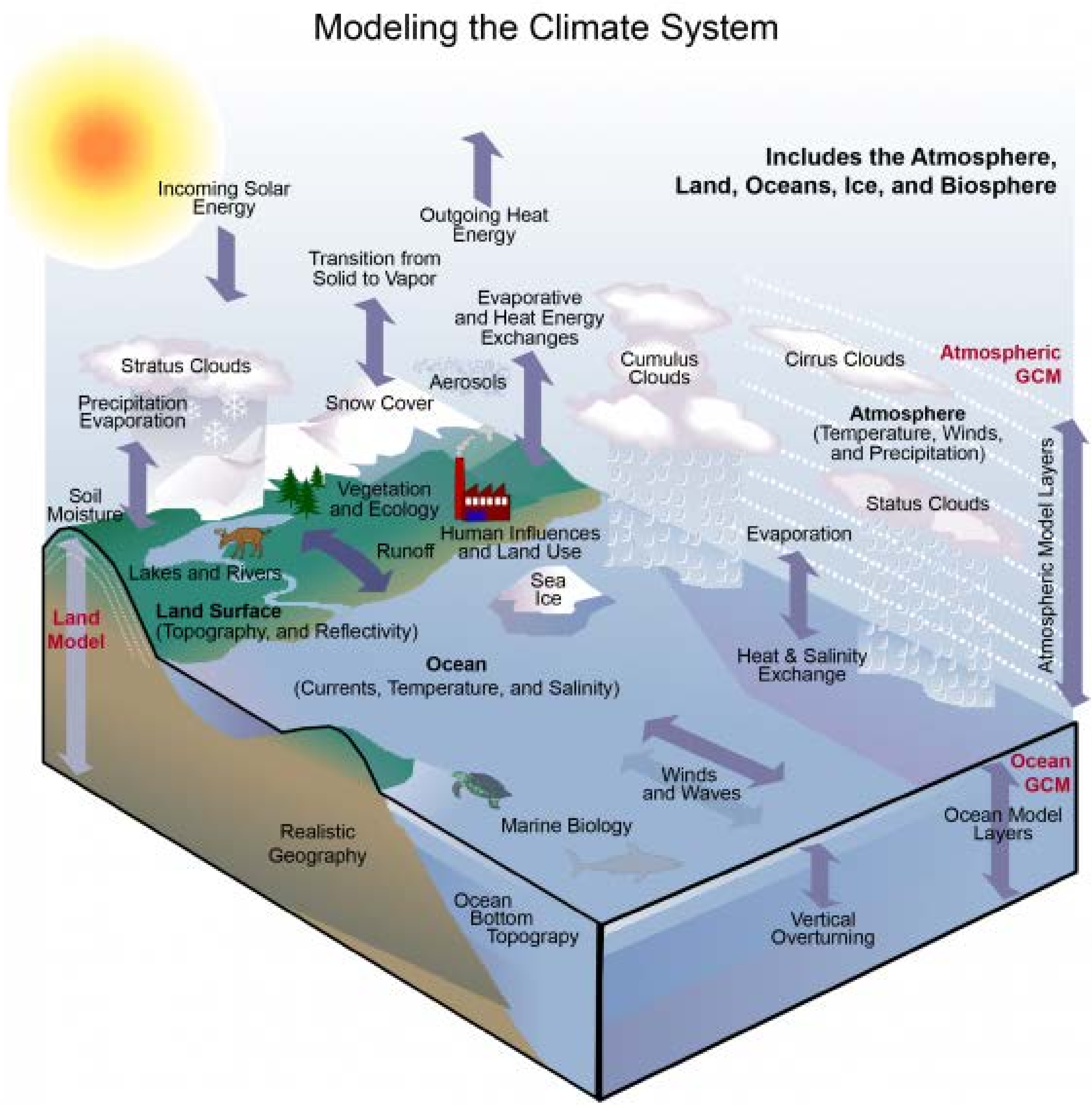
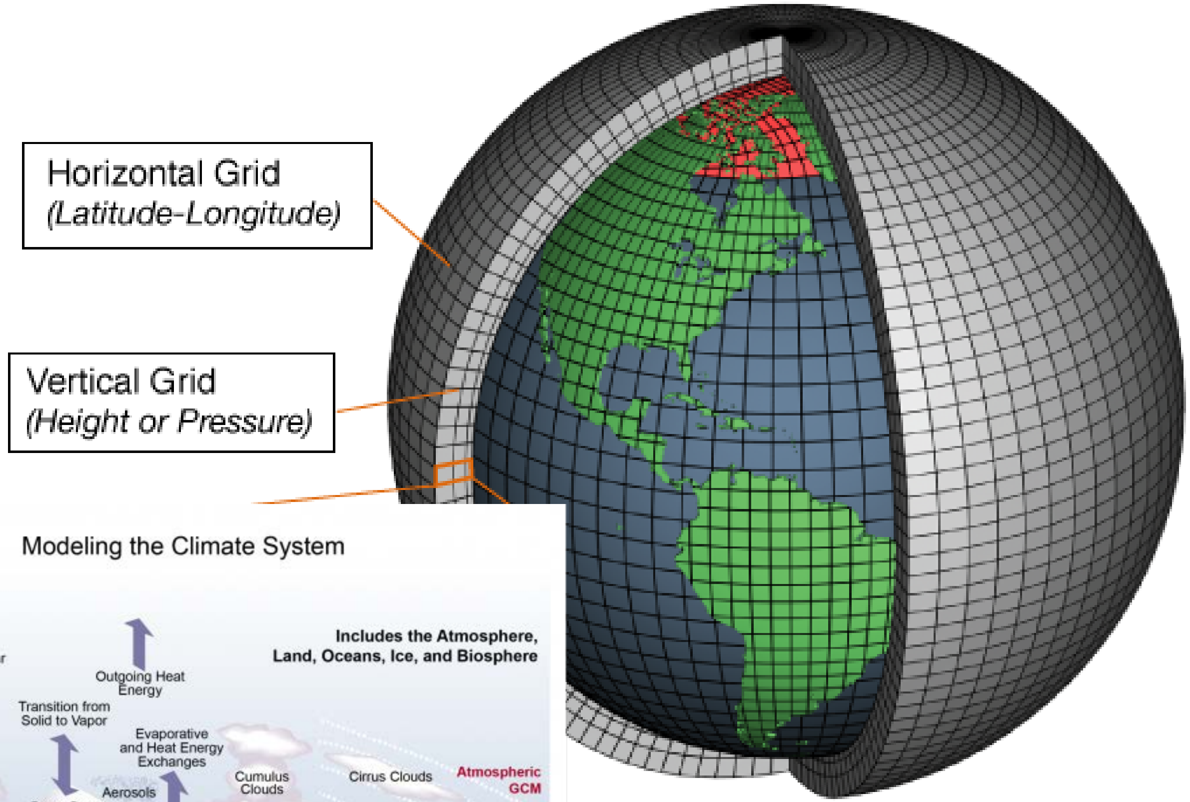
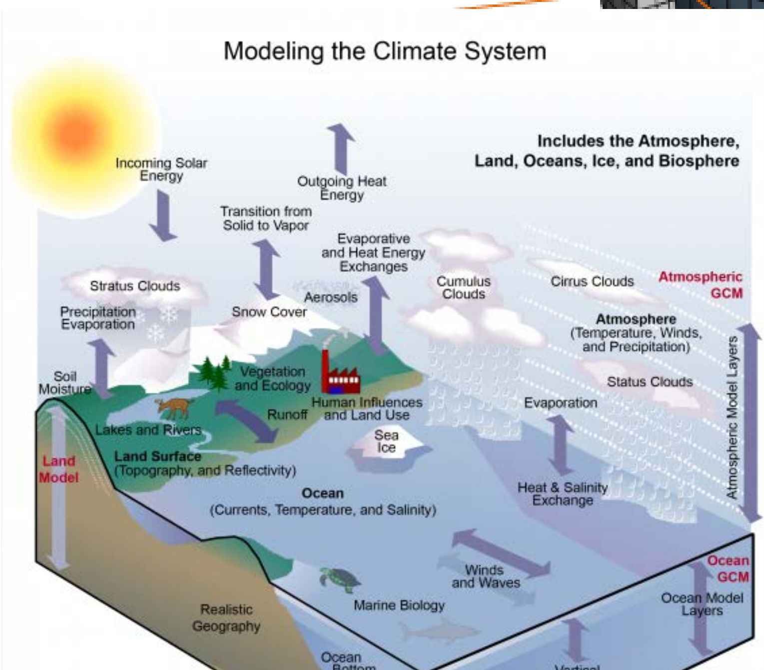


Figure source: Karl and Trenberth 2003

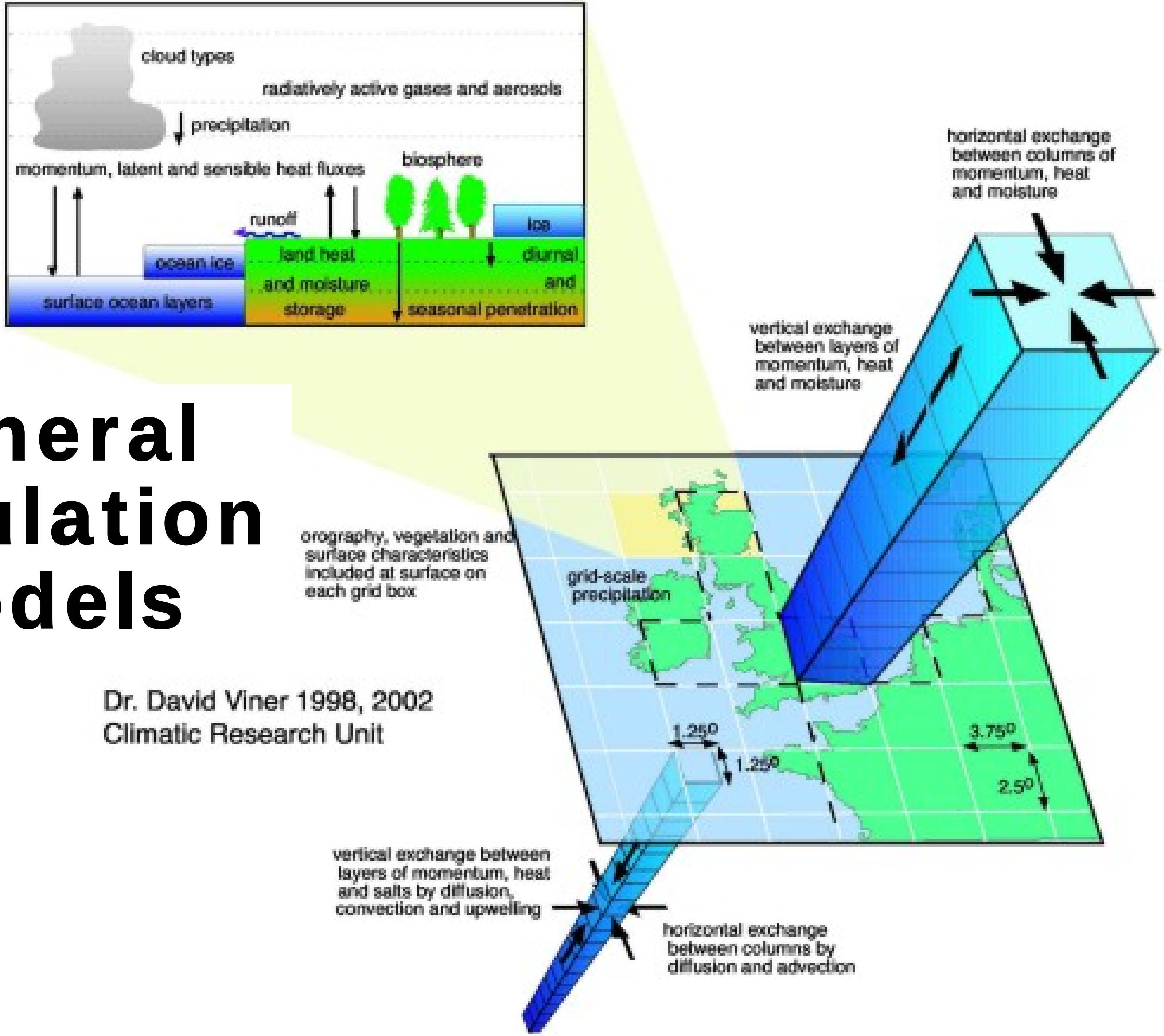
Global Climate Models



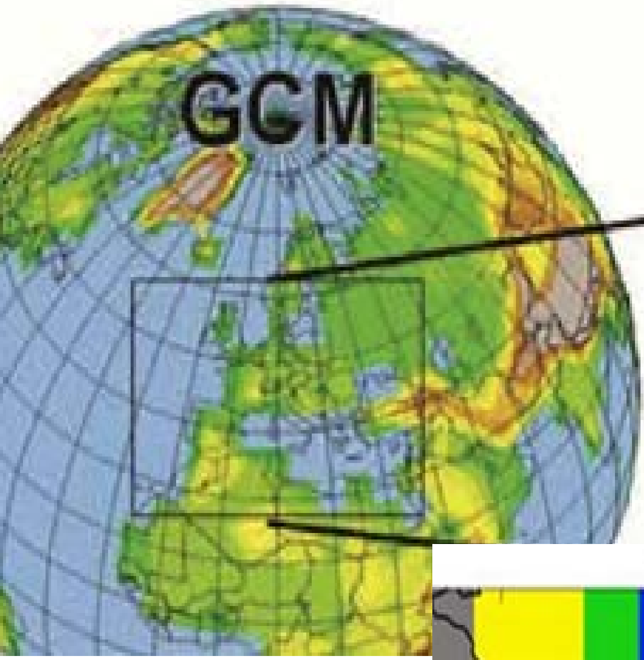


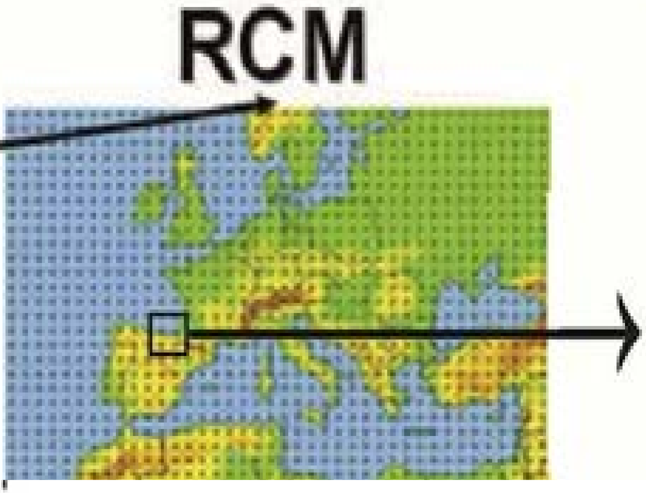
General Circulation Models

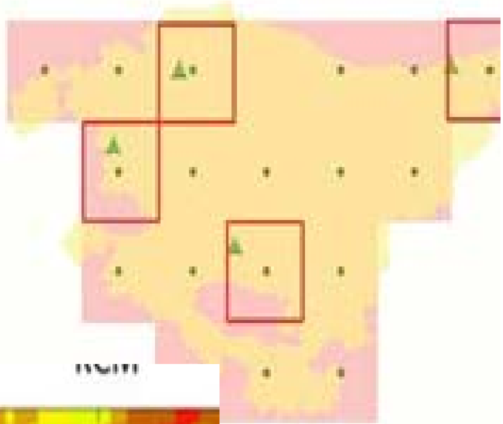
Dr. David Viner 1998, 2002
Climatic Research Unit

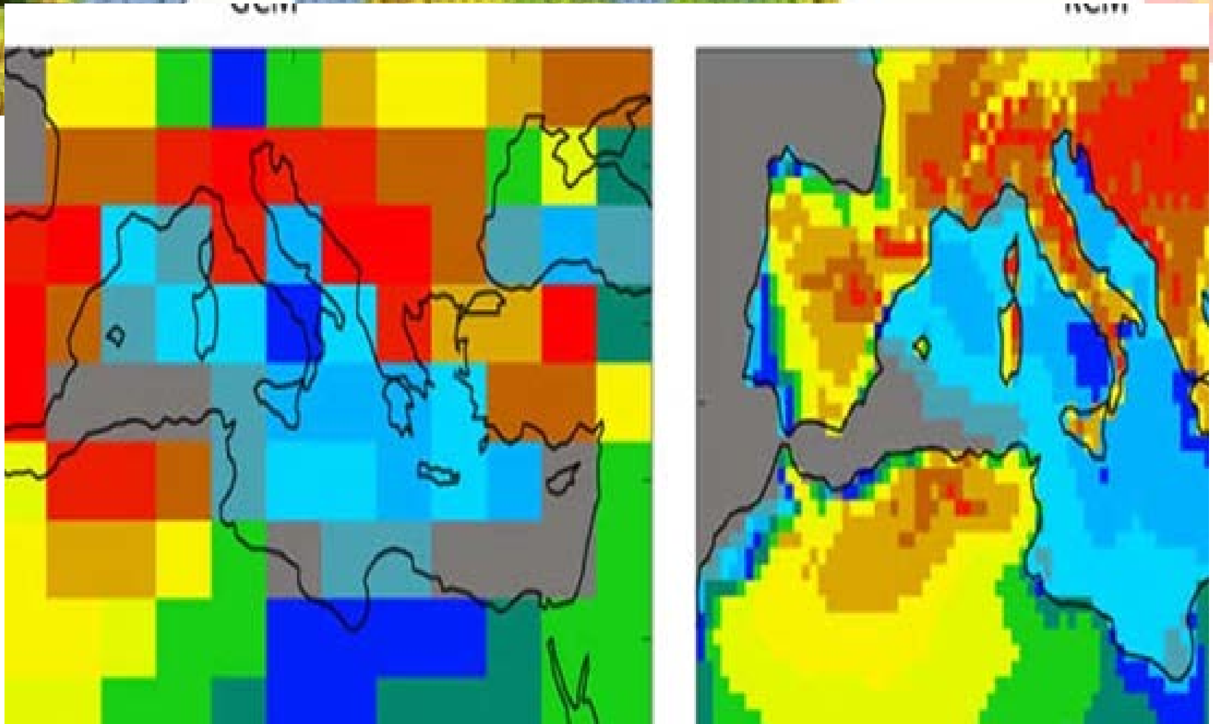


for downscalling at local st









Online Resources

Northwest Climate Hub
https://www.climatehubs.oce.usda.gov/hubs/northwest

NOAA Climate Predictions Center
http://www.cpc.noaa.gov

Adaptation Partnership
http://www.adaptationpartners.org/

Climate mapper
https://climatetoolbox.org/tool/climate-mapper

Holly R. Prendeville, PhD

Coordinator of USDA Northwest Climate Hub
Alaska, Idaho, Oregon, Washington

Based out of Corvallis, Oregon

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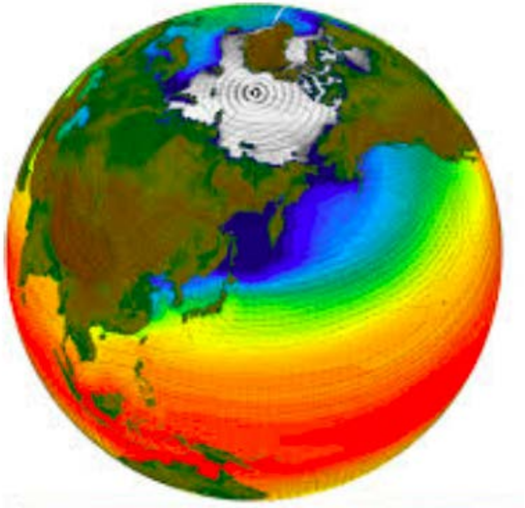
USDA Northwest Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

Historical and Projected Climate: Climate models

Intermountain Region – Climate Assessment Workshop

May 22, 2018



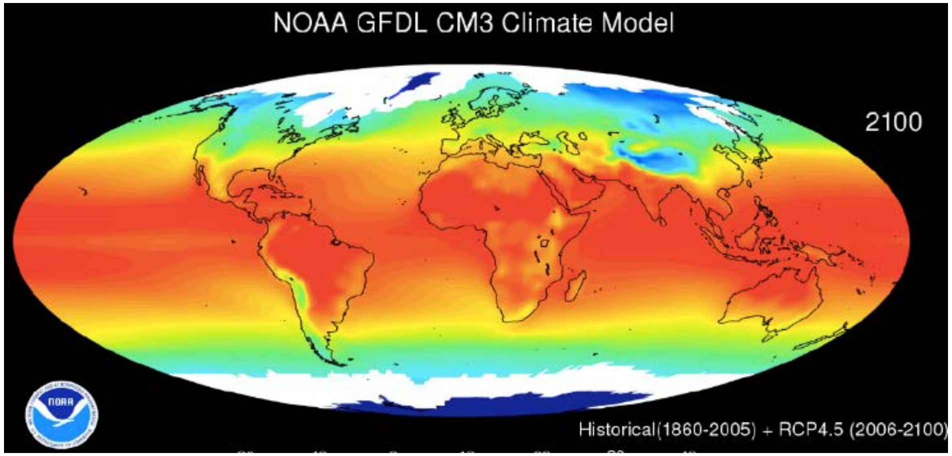
Seth Arens

Research Scientist

Western Water Assessment

Global Climate Models in the IAP

- Tools for projecting future climate
- CMIP: Couple Model Intercomparison Project
    - CMIP3 vs. CMIP5
- Model selection – Median results
- Emissions scenarios
- Scenario differences



Coupled Model Intercomparison Project (CMIP)

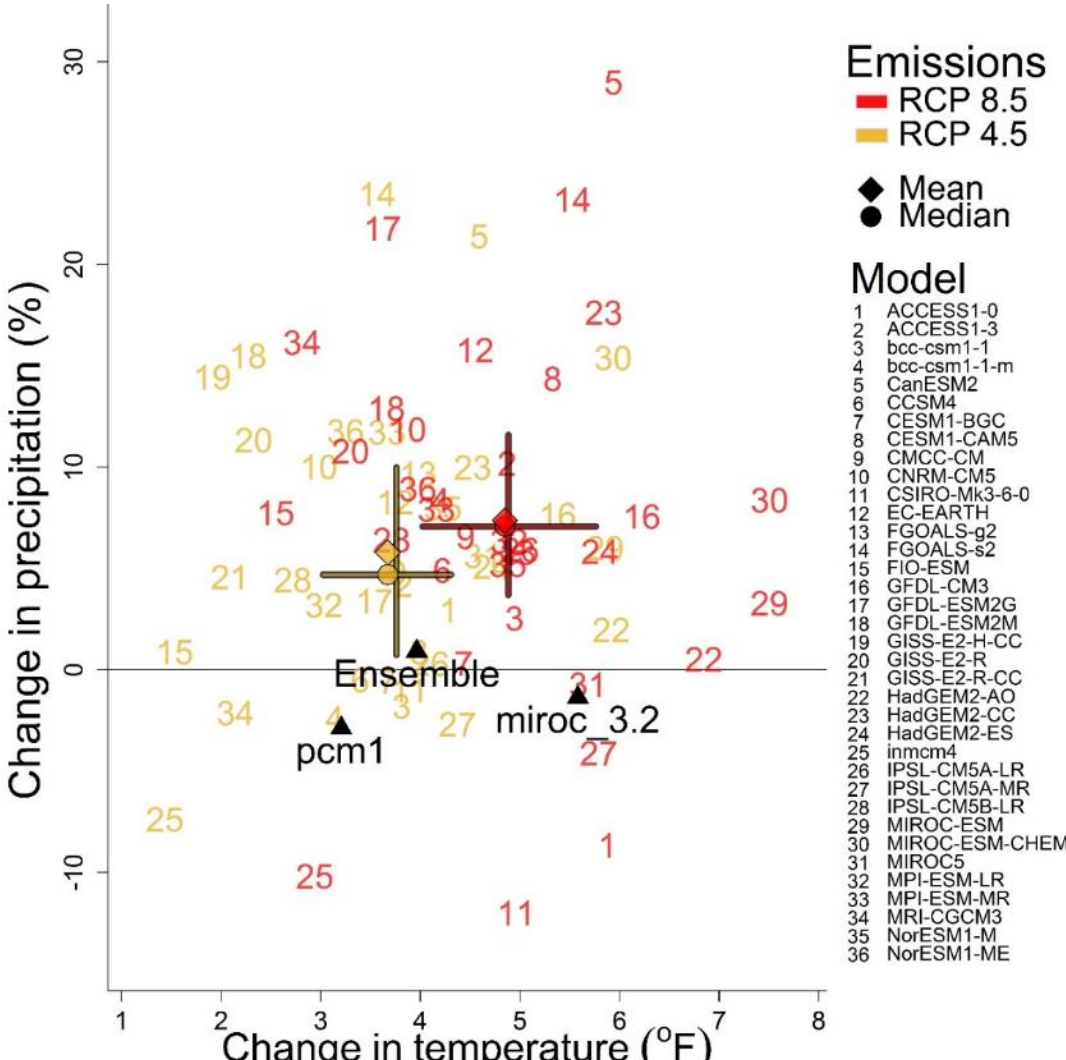
- Which climate model is correct?
- Compare long-term and near-term projections
- CMIP compares hundreds of climate models
- CMIP3 – 2007
  - IPCC Fourth Assessment Report
- CMIP5 - 2013
  - IPCC Fifth Assessment Report
  - 20 modeling groups; > 50 models compared
  - More models, more complex models than CMIP3
- Both datasets provide valid projections of future climate

Model selection

- CMIP3 and CMIP5 data used in IAP report
- Chapter 3 uses CMIP5 data
- Individual models NOT used to present data
- Median or mean of a group of models used
  - Accounts for variability between models
  - Median/mean not necessarily the most likely outcome
  - More “extreme” model solutions also likely

- 2050 change in temperature vs. change in precipitation for entire IAP region
- CMIP5 data
- 36 global climate models
- Report uses median or mean values of models
  - CMIP3 and CMIP5
- Temperature changes same for CMIP3, CMIP5
- More precipitation projected in CMIP5

2050 temperature/precipitation change



IAP report, Chapter 3, Figure 3.3

Emissions scenarios: CMIP3 vs. CMIP5

- **CMIP3** scenarios = SRES (Special Report on Emission Scenarios, 2007) → specific emission scenarios
- **CMIP5** scenarios = RCP (Representative Concentration Pathways, 2014) → radiative forcing
- RCP4.5 = SRES B1
- RCP8.5 = SRES A1F1

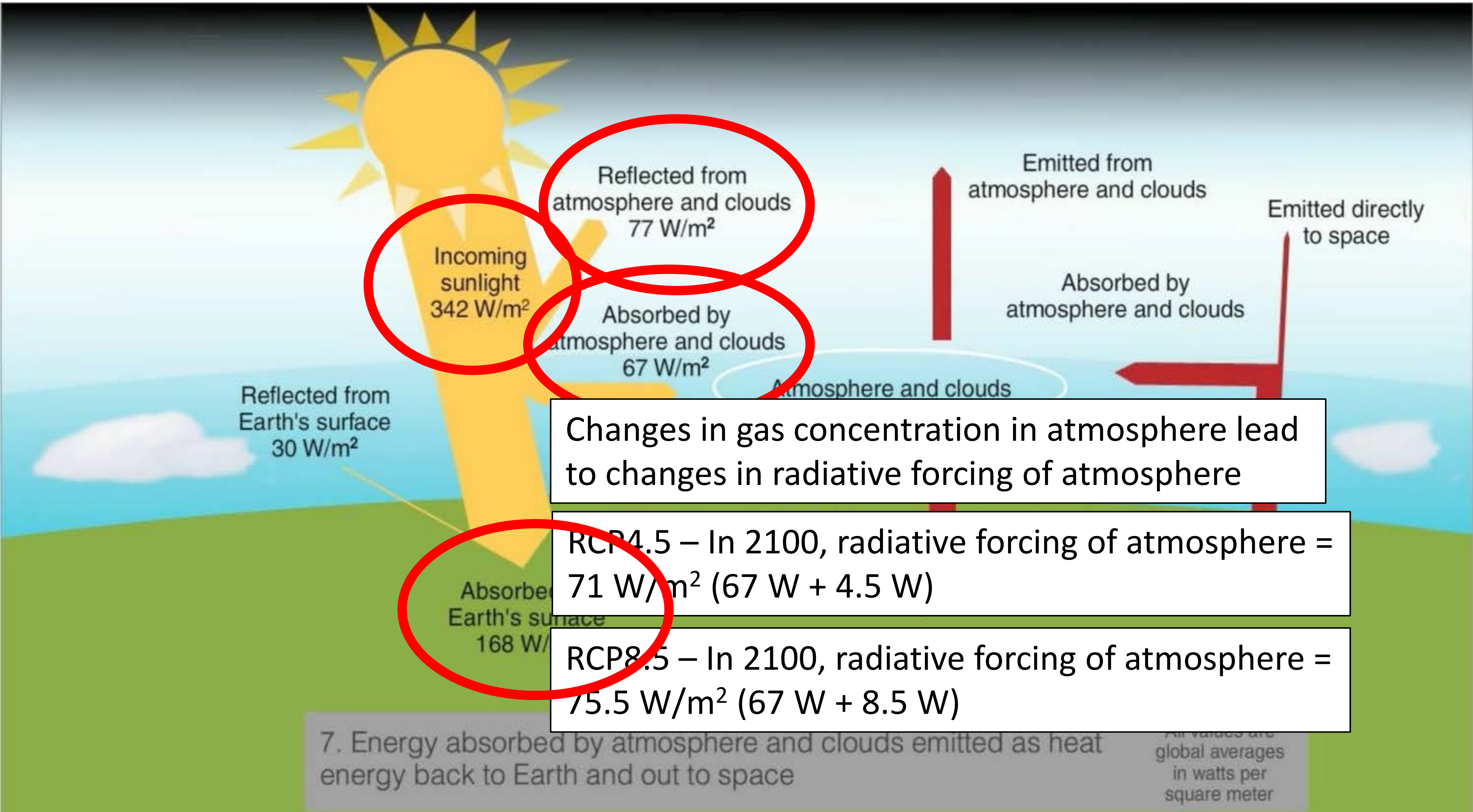
Scenario	2090–2099 Median	2090–2099 66% range	2100 Median	2100 66% range
	°F			
SRES B1	4.3	3.6–5.6	4.5	3.6–5.8
SRES A1T	5.2	4.5–6.7	5.4	4.5–6.8
SRES B2	5.2	4.3–6.3	5.4	4.7–6.7
SRES A1B	6.1	5.0–7.6	6.3	5.2–7.9
SRES A2	7.0	5.8–8.6	7.6	6.3–9.4
SRES A1F1	8.5	7.0–10.4	9.0	7.4–11.2
RCP 3-PD (2.6)	2.7	2.3–3.4	2.7	2.3–3.4
RCP 4.5	4.3	3.6–5.2	4.3	3.6–5.4
RCP 6.0	5.2	4.5–6.5	5.4	4.7–6.7
RCP 8.5	8.3	6.8–10.3	8.8	7.2–11.0

IAP report, Chapter 3, Table 3.2

RCP: Representative Concentration Pathway

- SRES based on specific emission scenarios
- RCP based on **radiative forcing**
  - Used in CMIP5 climate data
- **Radiative forcing** is the difference between energy absorbed by Earth and reflected into space
- **RCP 4.5** means 4.5 Watts/m^2 of radiative forcing
- **RCP 8.5** means 8.5 Watts/m^2 of radiative forcing
- Indirect measure of emissions
- Changed in atmospheric concentrations of gases alter radiative forcing

Radiative Forcing



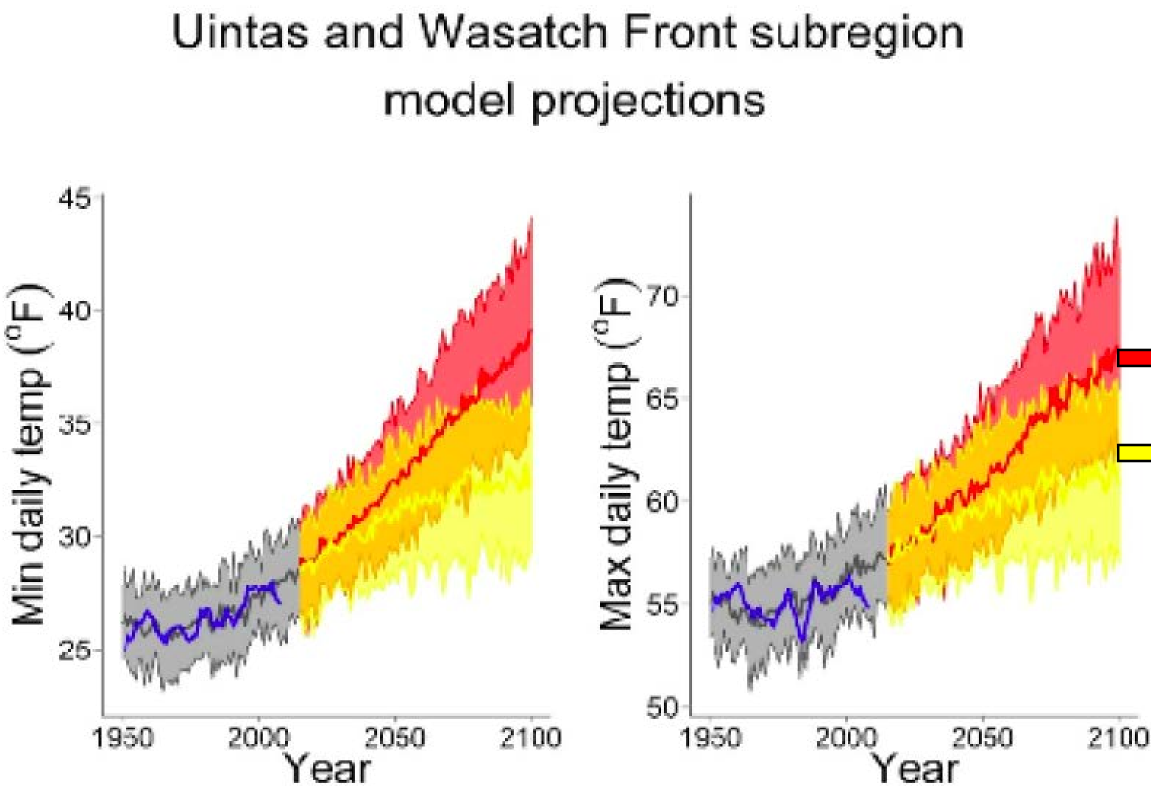
Changes in gas concentration in atmosphere lead to changes in radiative forcing of atmosphere

RCP4.5 – In 2100, radiative forcing of atmosphere = 71 W/m² (67 W + 4.5 W)

RCP8.5 – In 2100, radiative forcing of atmosphere = 75.5 W/m² (67 W + 8.5 W)

Emission scenarios and RCPs

- Indirect measure of emissions



RCP 8.5 in 2100
+ 8.8˚ F
~ 1300 ppm CO_2

RCP 4.5 in 2100
+ 4.3˚ F
~ 630 ppm CO_2

IAP report, Chapter 3, Figure 3.13

Different approaches to building scenarios

- Median model approach
  - Used by IAP report
  - Common practice in many reports by local, state and federal agencies
  - Most reports use different emissions scenarios
  - May over-emphasize the middle result of a group of climate models

- Scenario approach
  - Provides an array of future climates
  - Often grouped in warm/hot and wet/dry scenarios for region
  - Provides better understanding of a range of future climate

Summary

- Report uses both CMIP3 and CMIP5 data
    - Climate chapter (3) uses CMIP5 data
- Different emission scenarios for CMIP3 and CMIP5
    - RCP4.5 = SRES B1
    - RCP8.5 = SRES A1F1
- RCP scenarios based on radiative forcing
- Median model approach to presenting climate modeling data in IAP report

Seth Arens

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University of Utah
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Uncertainty in Climate Projections

Intermountain Region – Climate Assessment Workshop

May 22, 2018

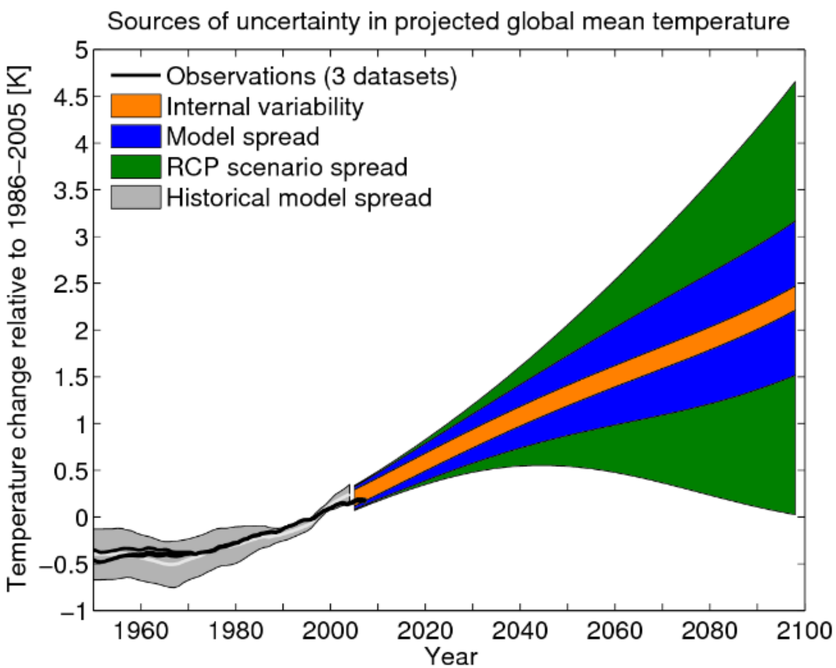
Caiti Steele, PhD

Coordinator

USDA Southwest Climate Hub, Jornada Experimental Range

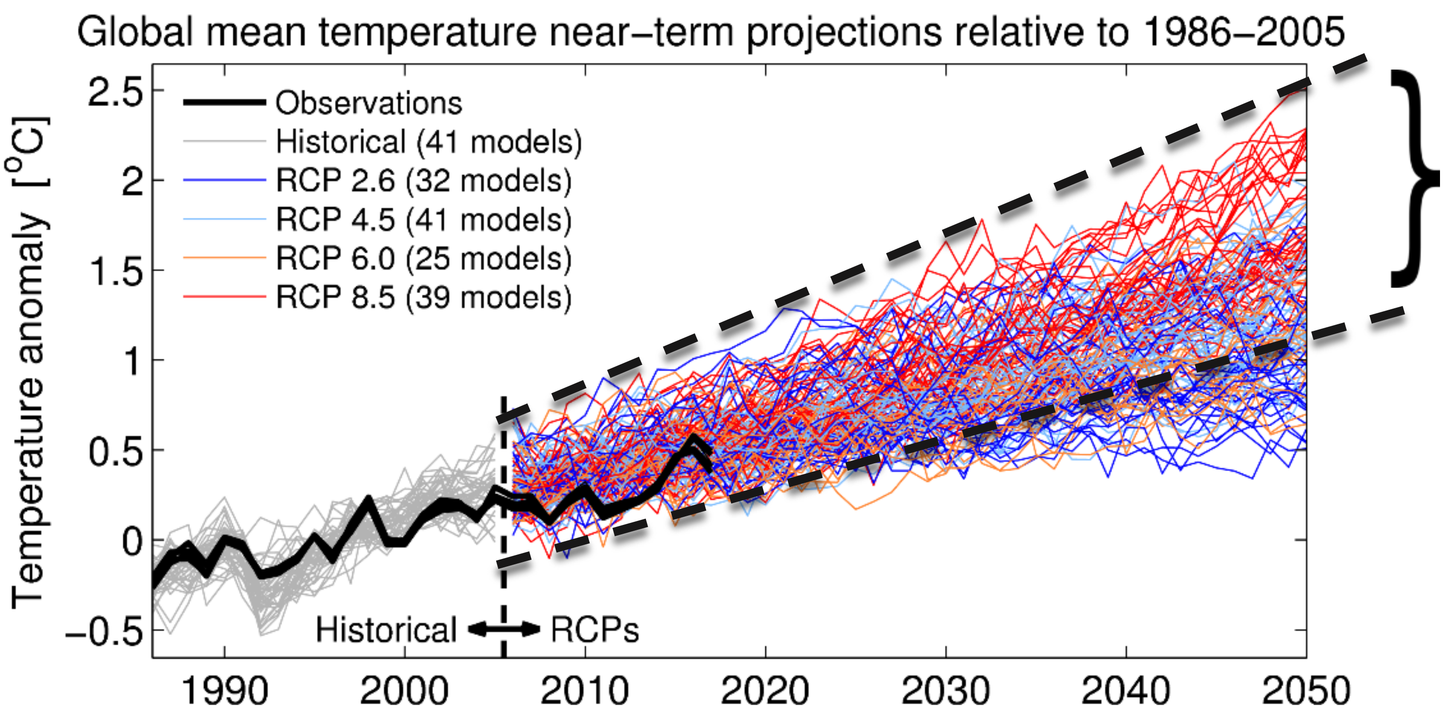
What is *climate uncertainty*?

- 3 main sources of uncertainty in projections of future climate
  - Inter-model differences (Blue)
  - Future emissions - scenario uncertainty (Green)
  - Internal climate variability (Orange)



What is *climate uncertainty*?

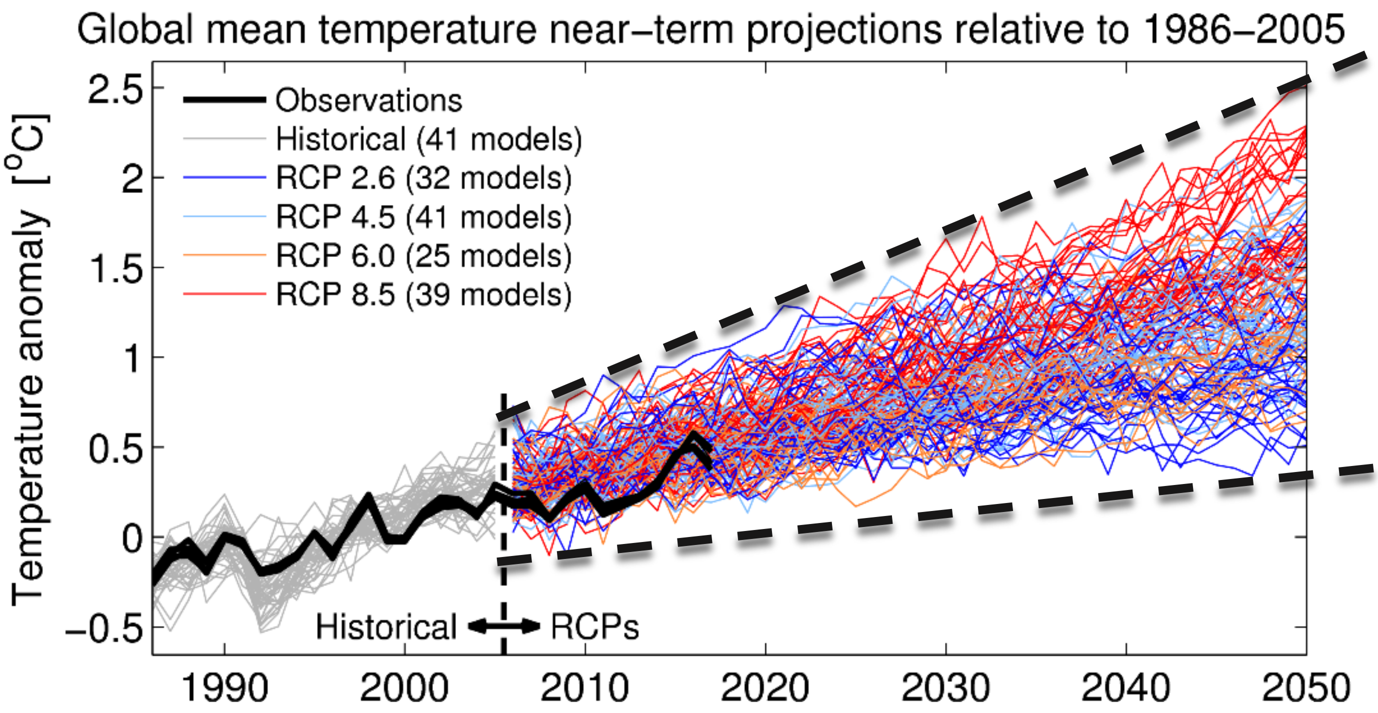
- Inter-model differences – each model gives a different result



Range of temperature anomalies for 39 models all using the same scenario (RCP 8.5)

What is *climate uncertainty*?

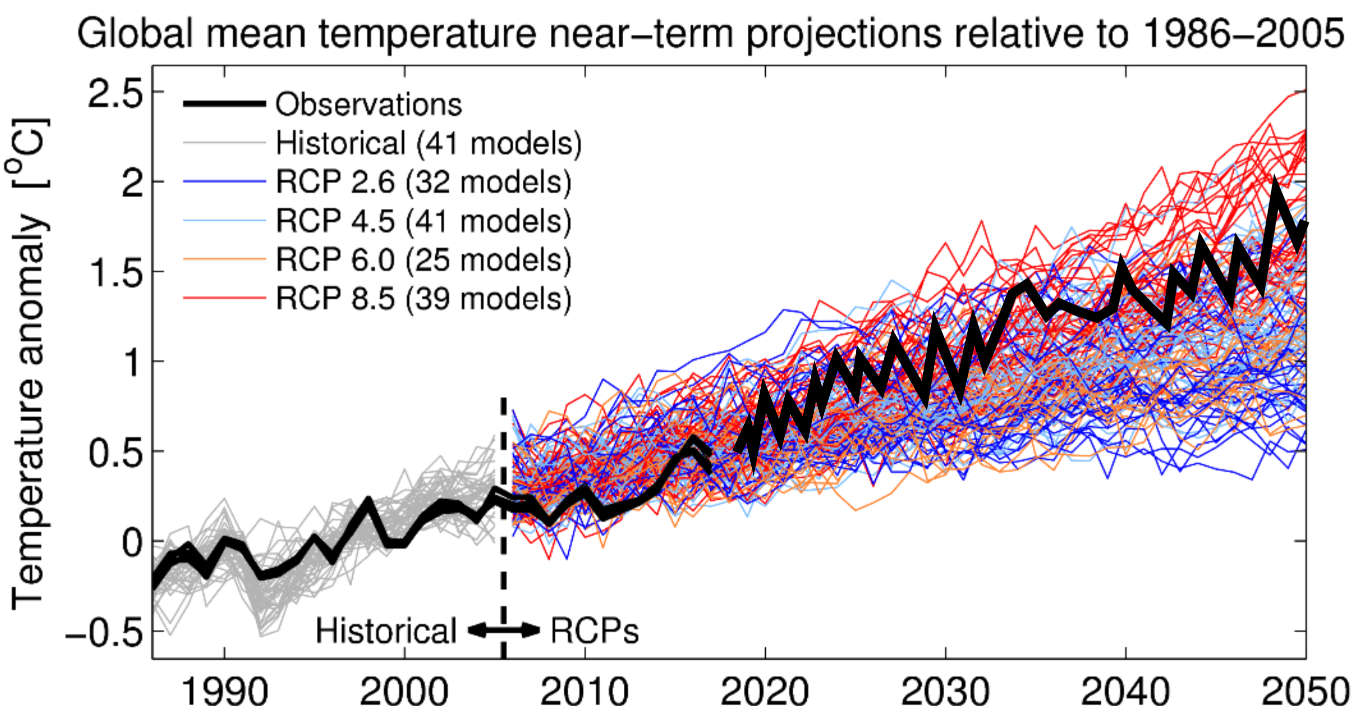
- Future emissions - scenario uncertainty



Range of temperature anomalies for multiple models using 4 scenarios

What is *climate uncertainty*?

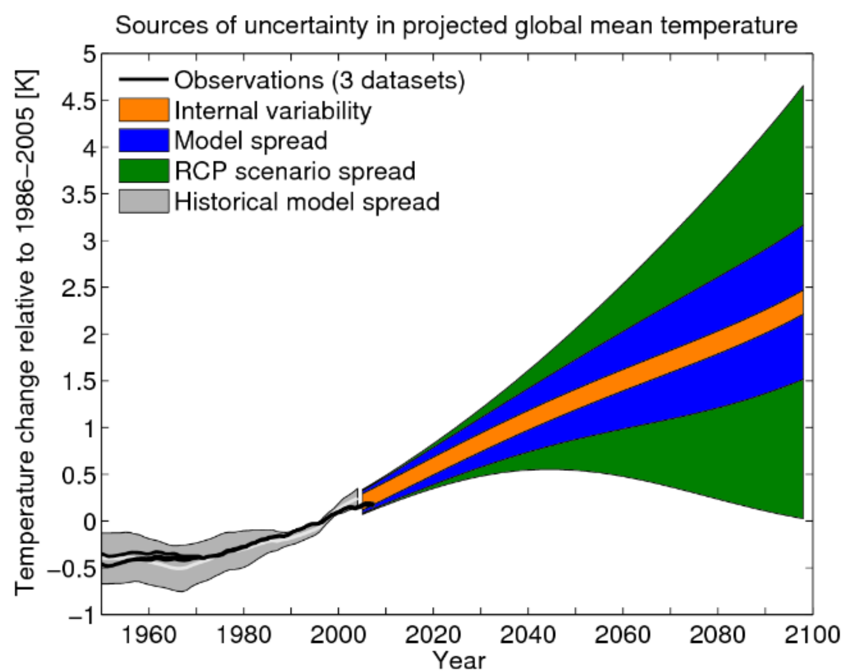
- Internal climate variability



Natural climate system processes cause variability in climate over short time scales

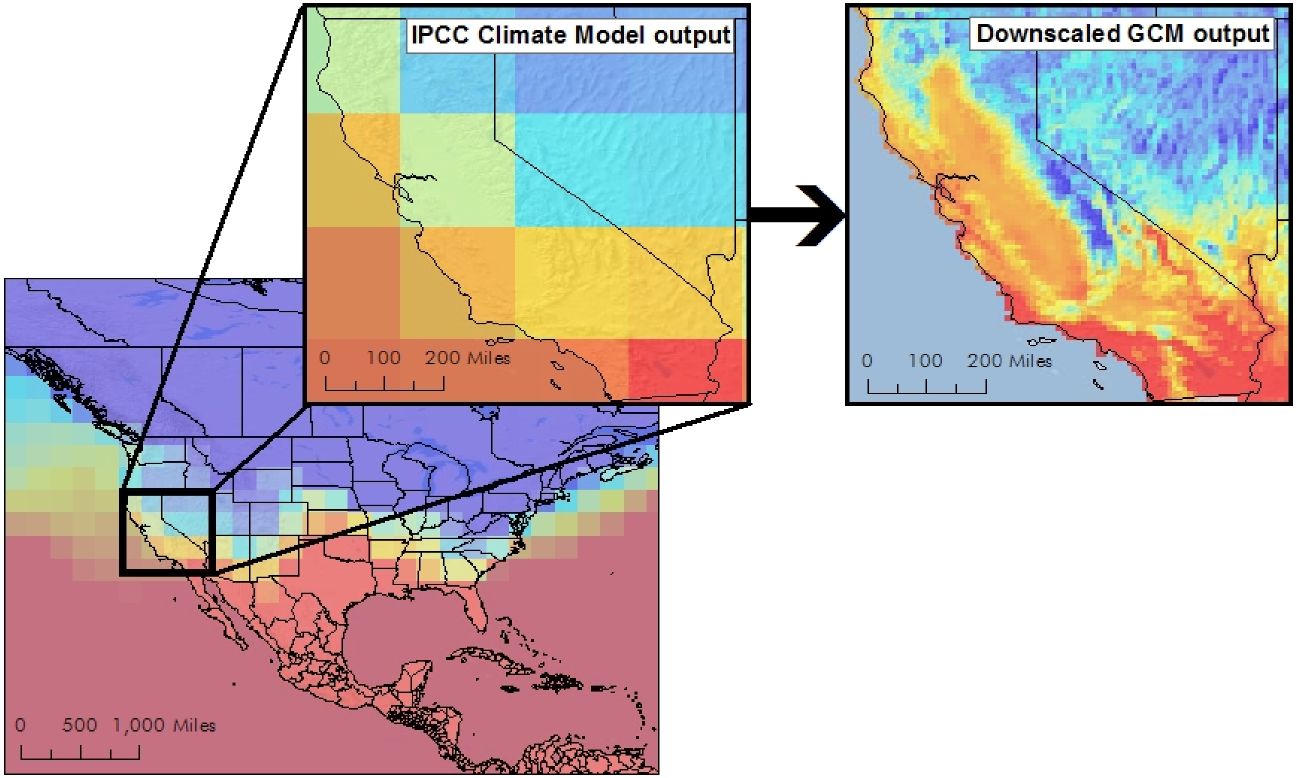
Sources of uncertainty

- 3 main sources of uncertainty in projections of climate
  - Internal climate variability (Orange)
  - Future emissions - scenario uncertainty (Green)
  - Inter-model differences (Blue)



Sources of uncertainty: downscaling

- There are different methods for downscaling a 200 km GCM grid cell – to provide more detail at the local to regional scale – different methods > different results



Using Model Ensembles

- To understand uncertainties, we can use multiple scenarios – e.g., Joyce and Talbert's work on Historical and Projected Climate in chapter 3 of the GTR-375 uses RCP 4.5 (36 models) and RCP 8.5 (34 models)

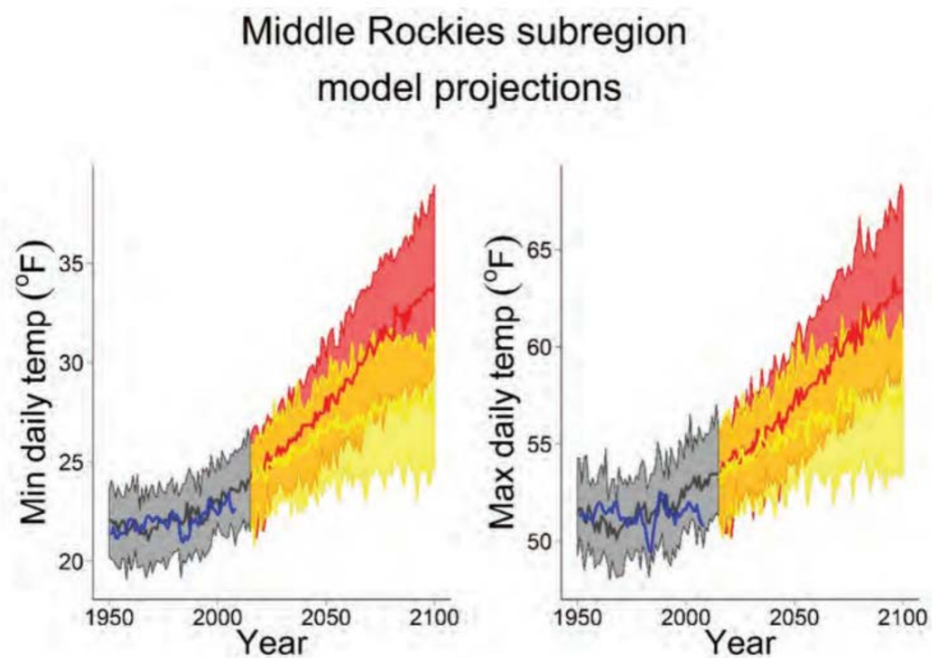
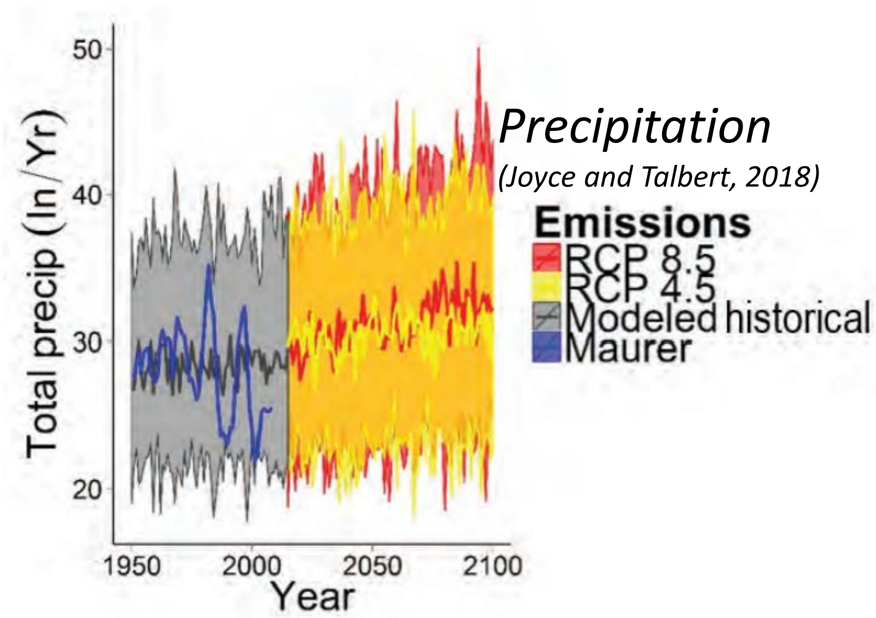


Fig 3.7, p44

Projecting future precipitation changes

- Precipitation is much more challenging to model than temperature, therefore uncertainty is higher than for precipitation than for temperature



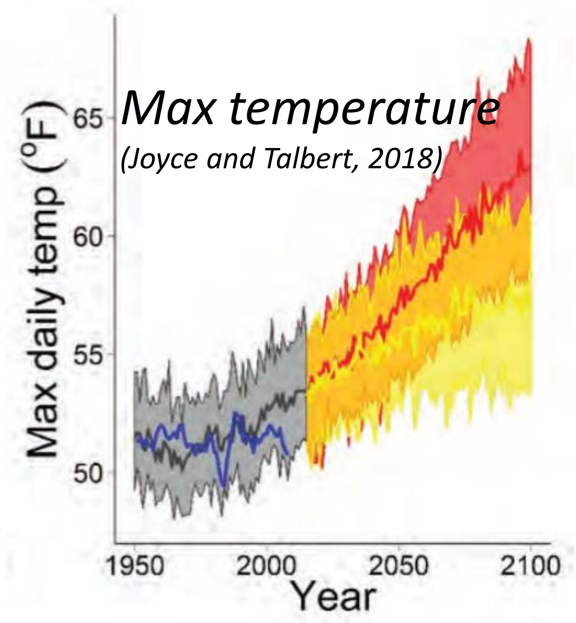


Fig 3.7, p44

Summary

- GCMs project a range of climate futures for any given location because of
  - Inter-model differences
  - Using different scenarios
  - Internal climate variability
- Recommended approach - use ensemble of climate models to try to capture some of the uncertainty
- Precipitation projections contain much greater uncertainty than temperature projections
- Adaptation planners must understand what uncertainty means for decision-making – do you use model outputs from RCP 8.5 simulations and to 2100

Weblinks & Additional Resources

- Uncertainty in Climate Change Projections (Latif, 2011) https://www.sciencedirect.com/science/article/pii/S0375674210001433
- Sources of uncertainty in CMIP5 Projections https://www.climate-lab-book.ac.uk/2013/sources-of-uncertainty/
- The uncertainty in climate modelling https://thebulletin.org/uncertainty-climate-modeling
- Cover picture http://www.atkinson.cornell.edu/news/blog/for-better-science-communication-reduce-uncertainty

Caiti Steele PhD
Coordinator, USDA SW Climate Hub
Location: USDA-ARS Jornada Experimental Range
Email: caiti@nmsu.edu
Phone number: 575-646-4144

Expected Climate Changes: Temperature and Precipitation

Intermountain Region – Climate Assessment Workshop

May 22, 2018

Charles Luce, Ph.D.

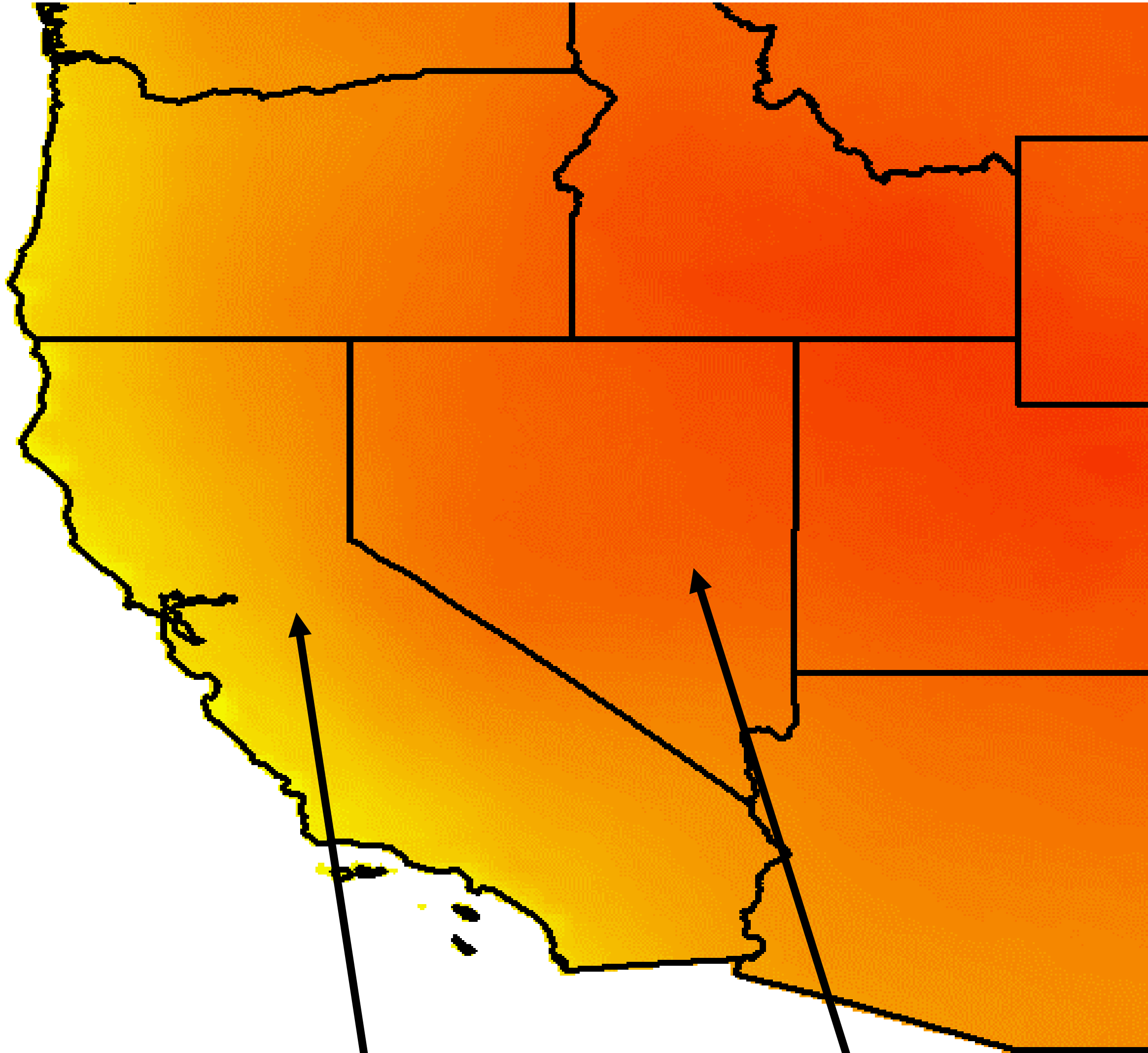
Research Hydrologist

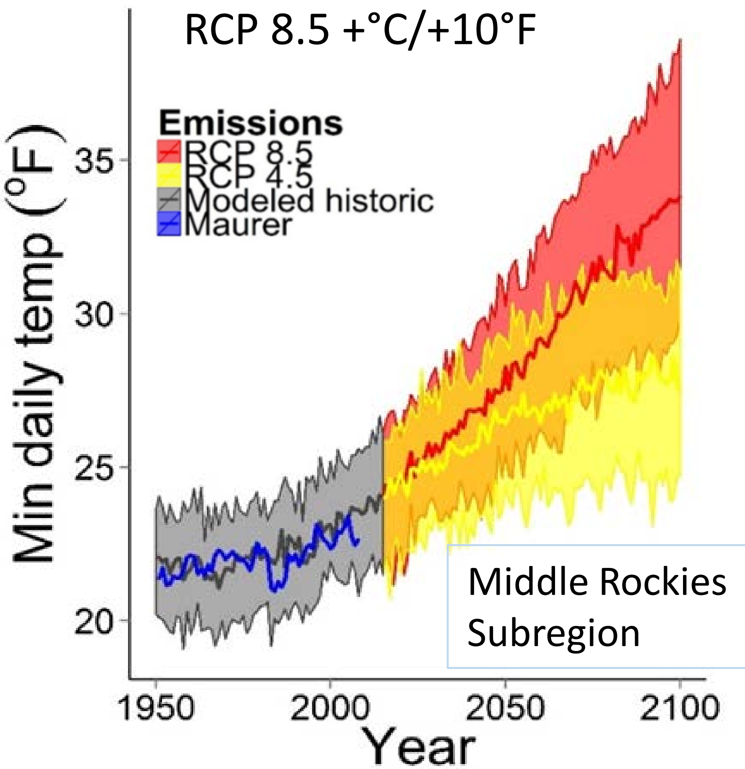
US Forest Service Research

Overview

- Temperature
- Precipitation
- Snow
- Drought

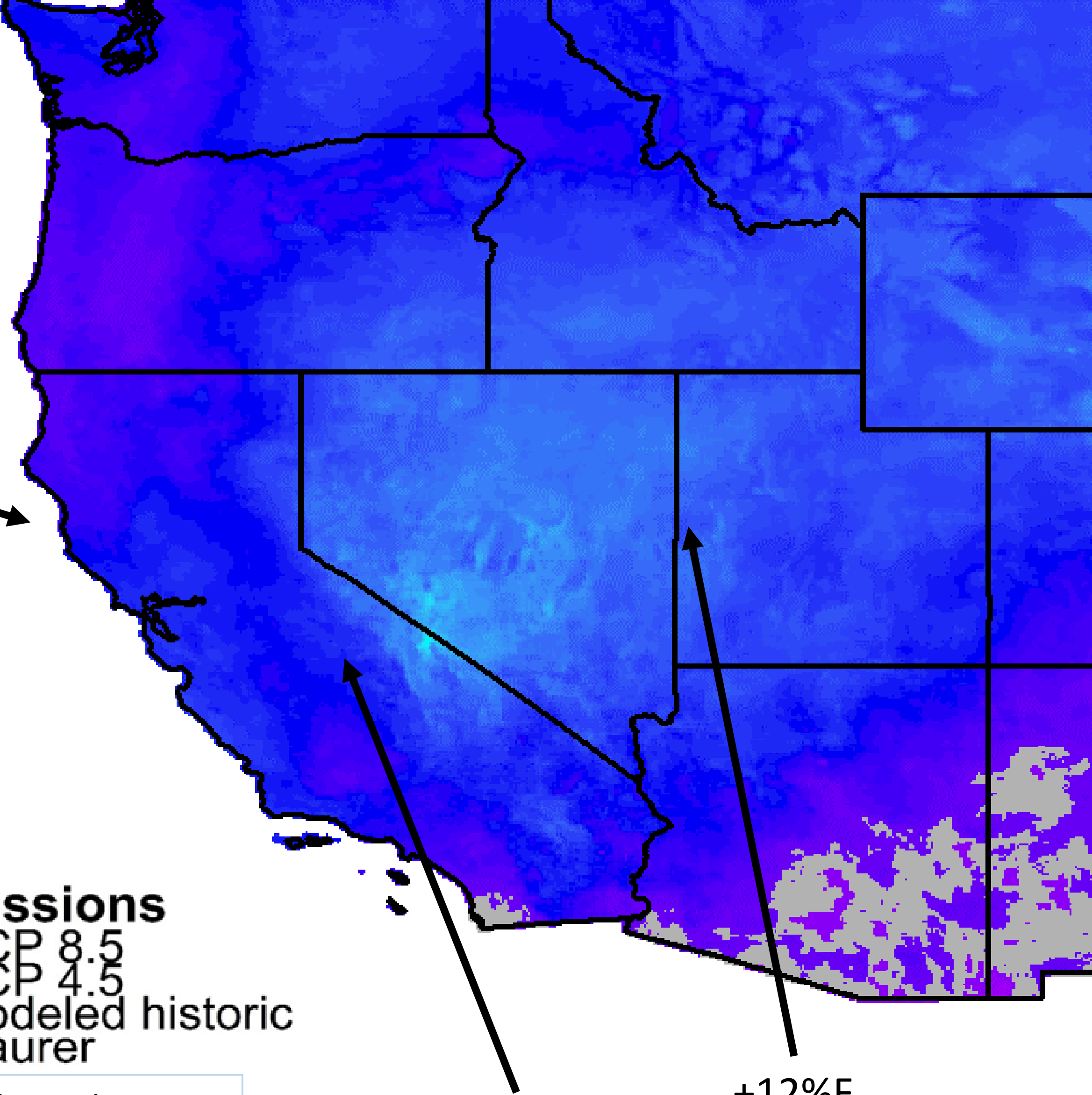
Change in Annual Average Temperature

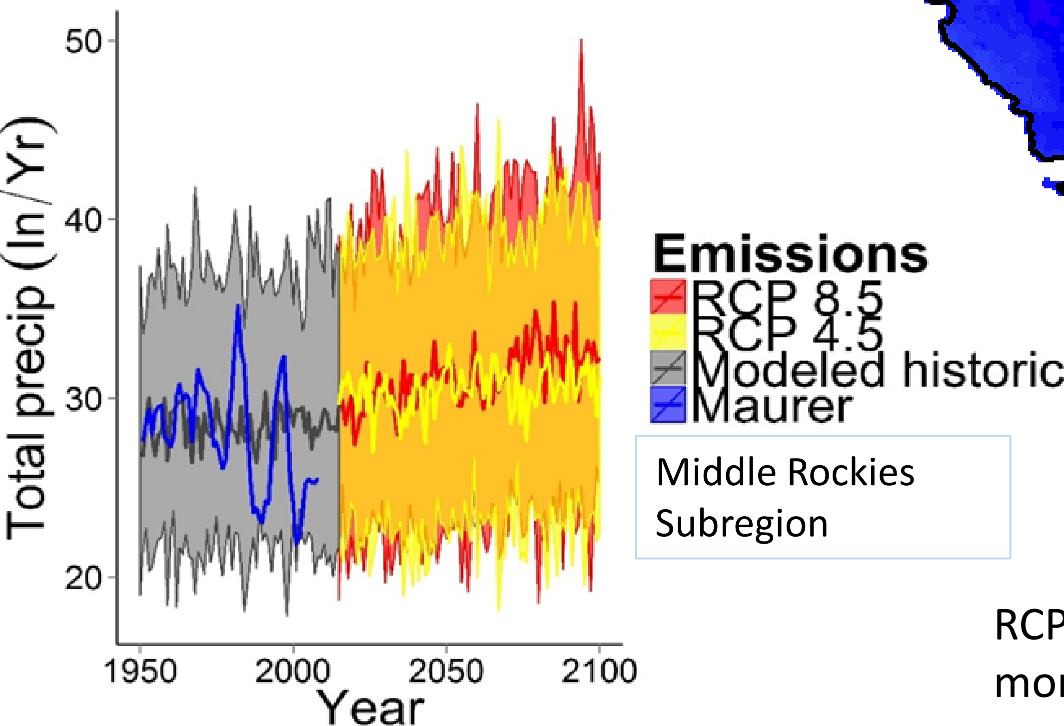




RCP 8.5 2080's, data from MACAv2-Metdata monthly, Abatzoglou and Brown 2012

% Change Total Annual Precipitation

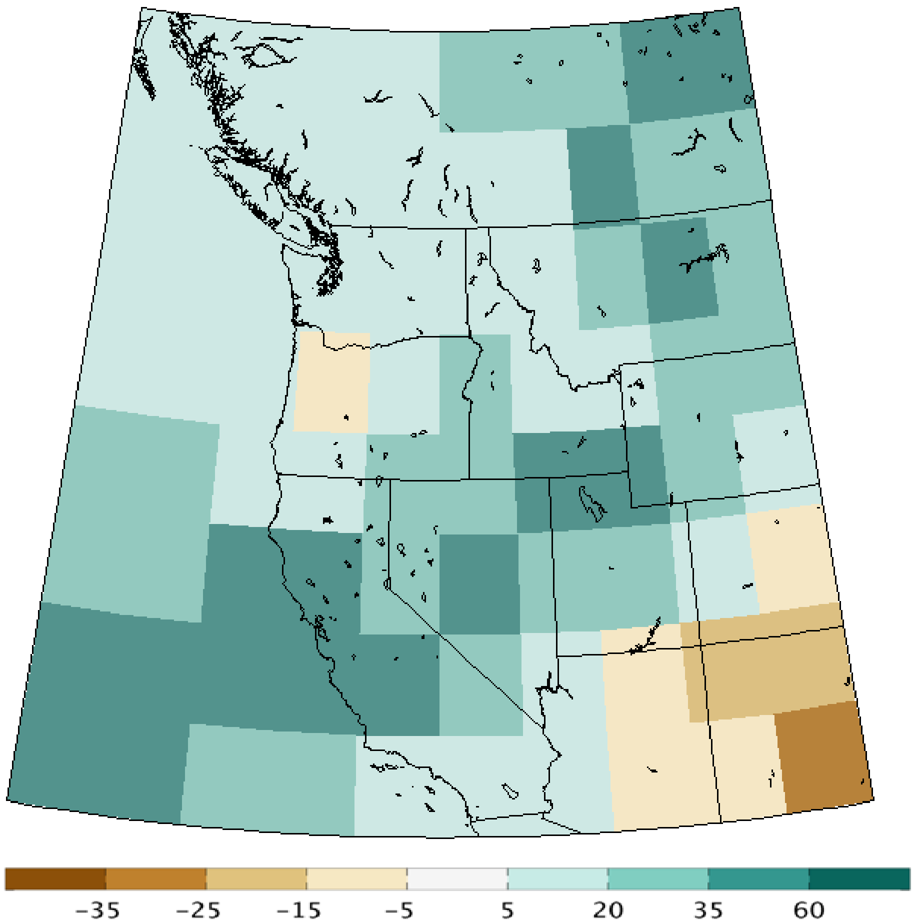




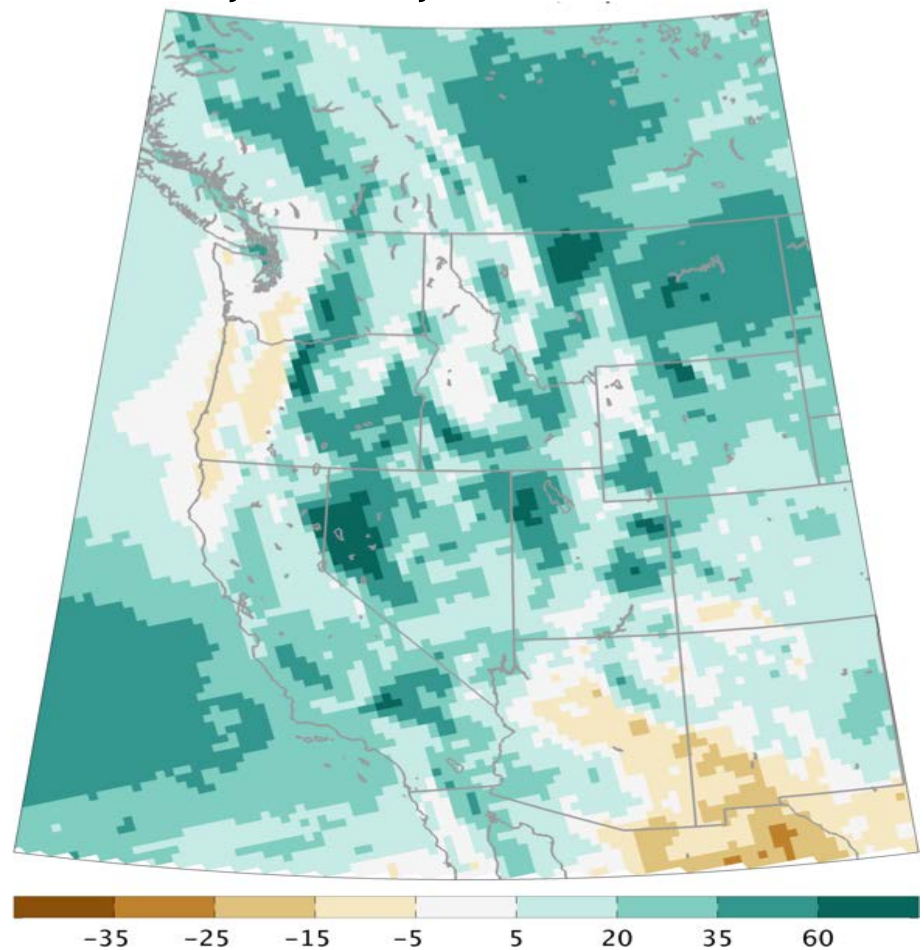
RCP 8.5 2080's, data from MACAv2-Metdata monthly, Abatzoglou and Brown 2012

CanESM2 Oct-Mar Precipitation Change 2041-2070 vs 1971-2000

Raw GCM output

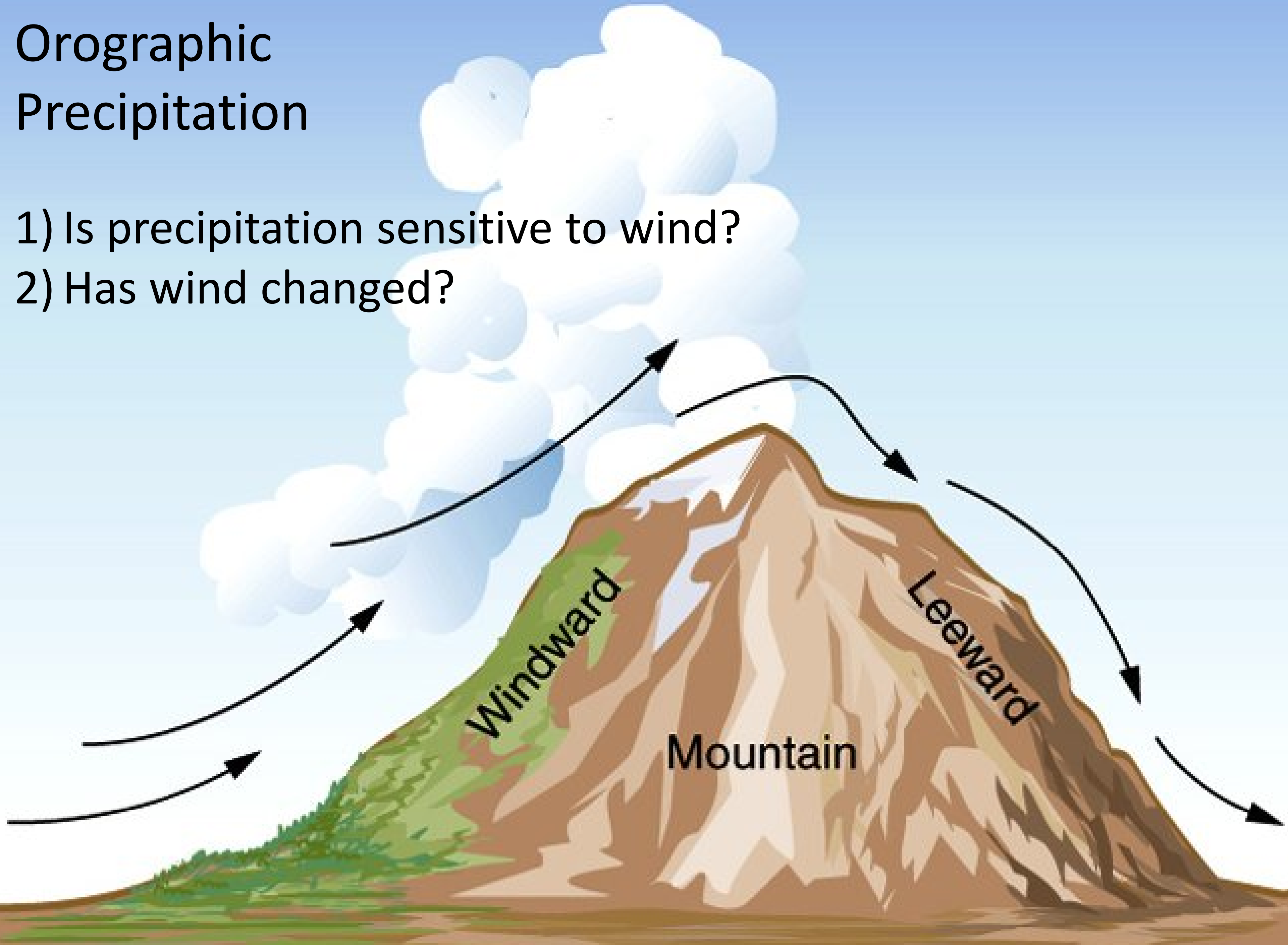


Dynamically Downscaled

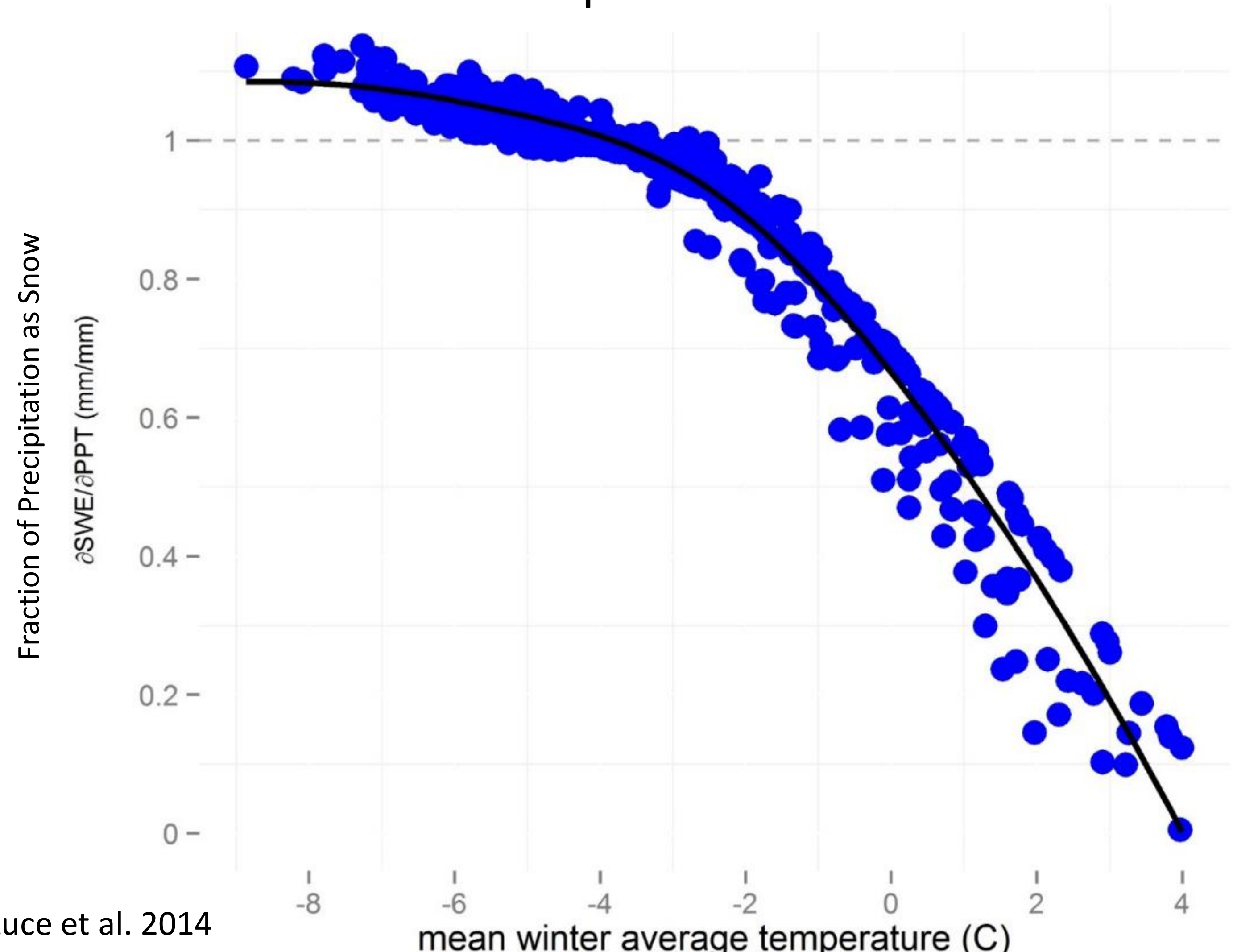


Orographic Precipitation

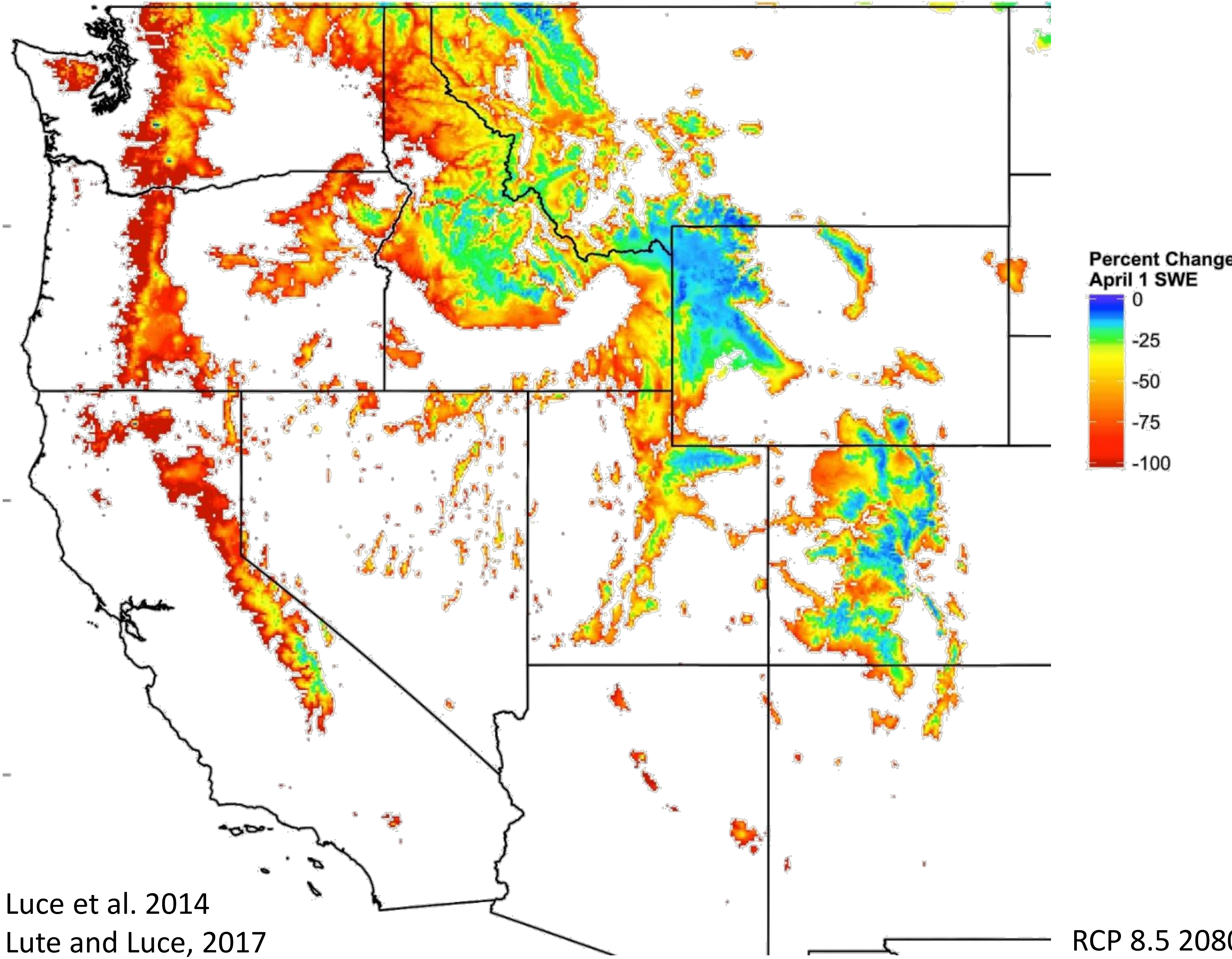
1) Is precipitation sensitive to wind?
2) Has wind changed?



Fraction of Precipitation as Snow



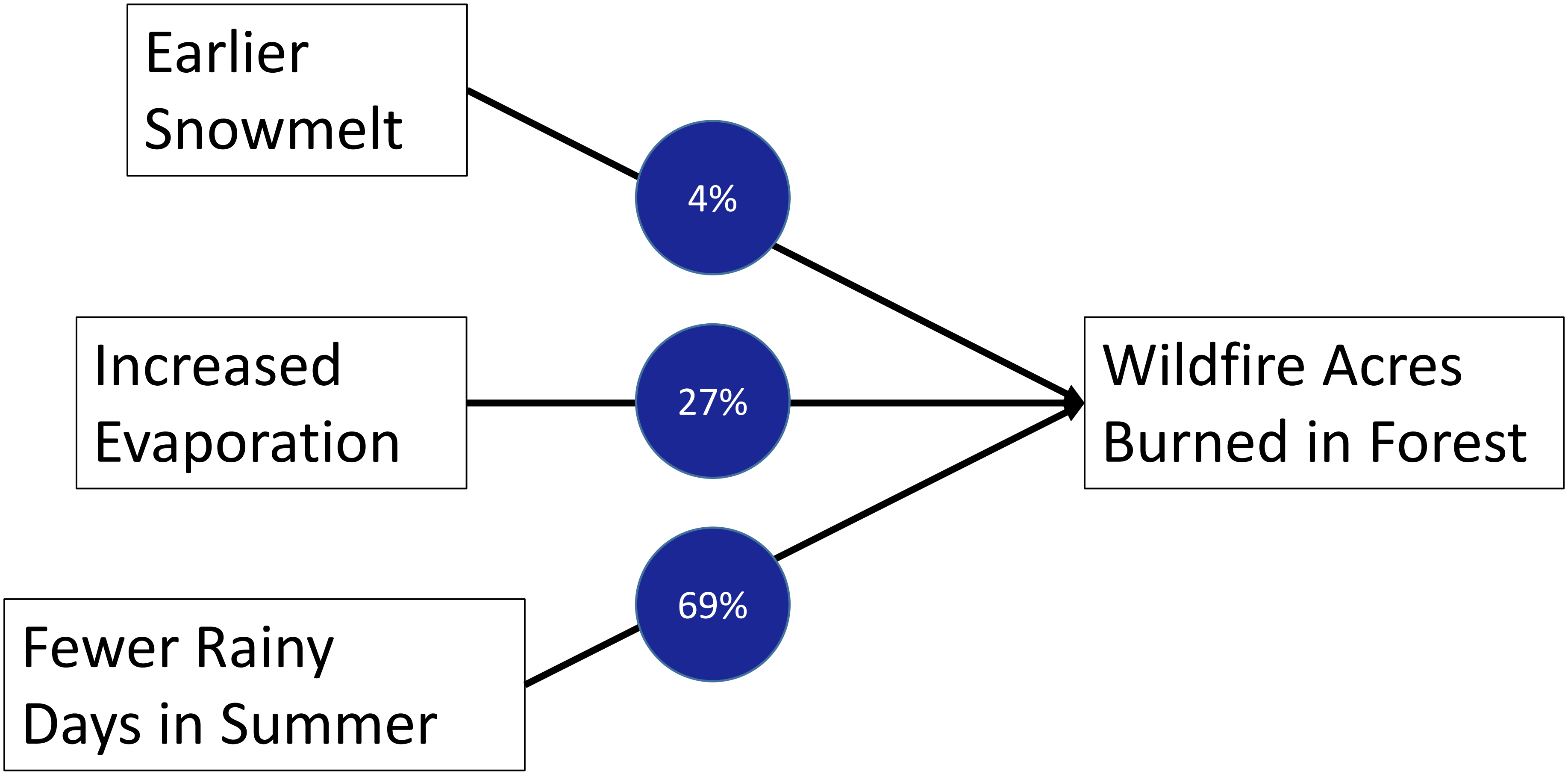
Luce et al. 2014
Lute and Luce, 2017



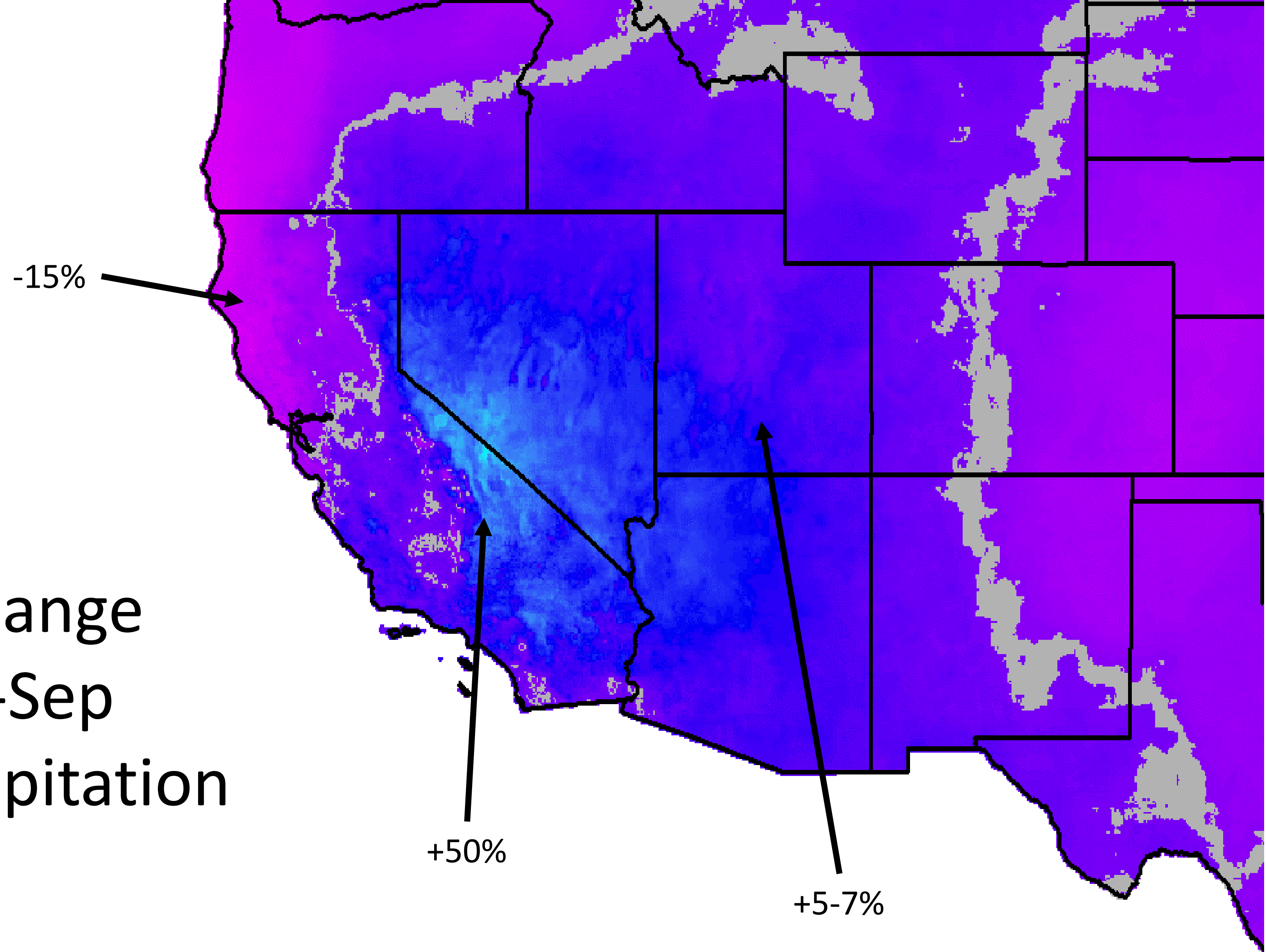
Luce et al. 2014
Lute and Luce, 2017

RCP 8.5 2080s

Drought and Fire



Holden et al, in review



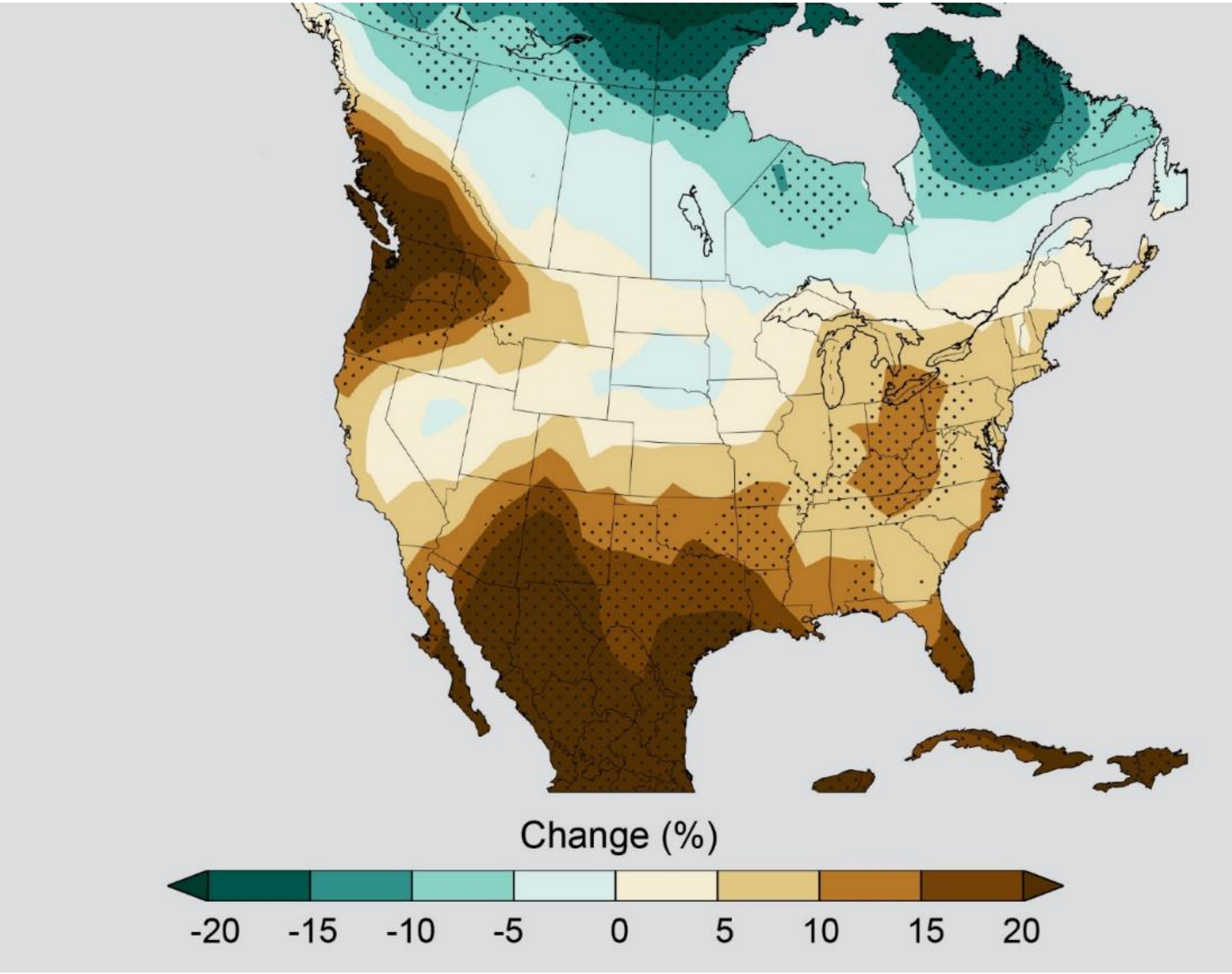
% Change May-Sep Precipitation

RCP 8.5 2080's, data from MACAv2-Metdata monthly, Abatzoglou and Brown 2012

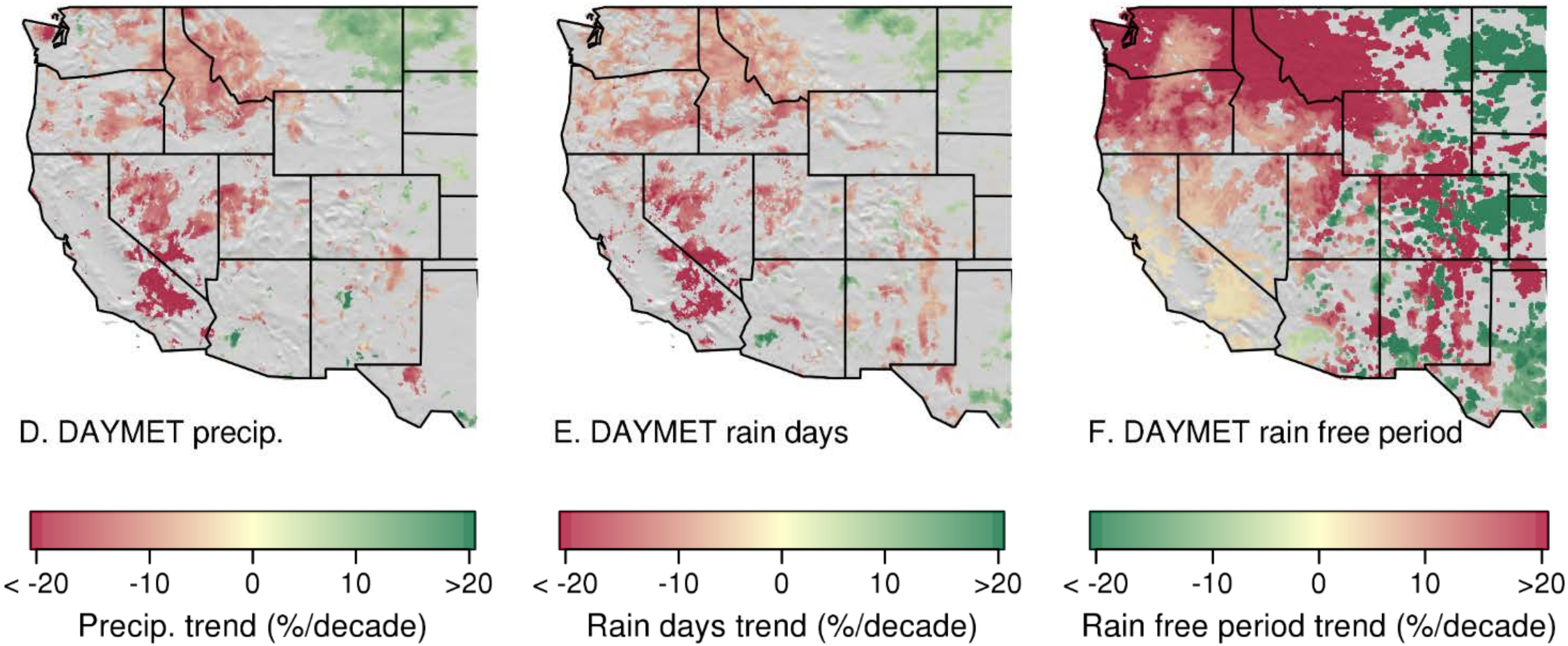
Change in Number of Consecutive Dry Days

From NCA 2014

RCP8.5 2080s



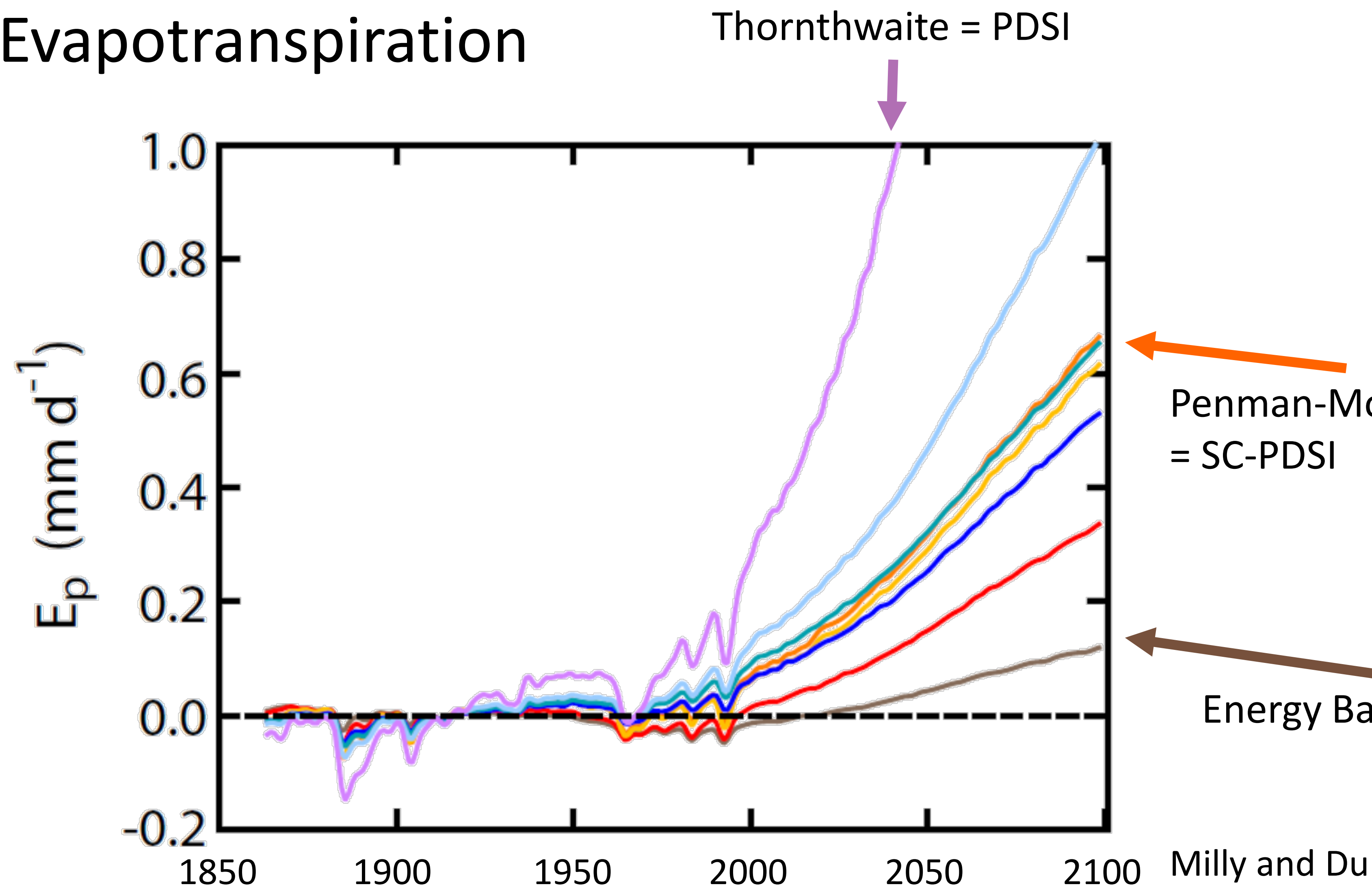
Less Rain and Fewer Rainy Days in Summer: Historical



May-Sep, 1980-2016

Holden et al, in review

Change in Potential Evapotranspiration



Milly and Dunne, 2017

Summary & Major Results

- Temperature is increasing
- Precipitation
  - Mottled pattern
  - Growing understanding of mountains
  - Strong seasonal shifts
- Snow
  - Warm snow going away faster than cold snow
- Drought
  - Greatest controls are precipitation and snowmelt
  - Worsening

See Chapter 3
Esp. Table 3.3 for more detail on T and P

Charles Luce
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DIALOGUE AND Q&A

GROUP EXERCISE

LUNCH TIME