

Climate Impacts Projections: Where the numbers come from and how to put them in context

Guillaume Mauger

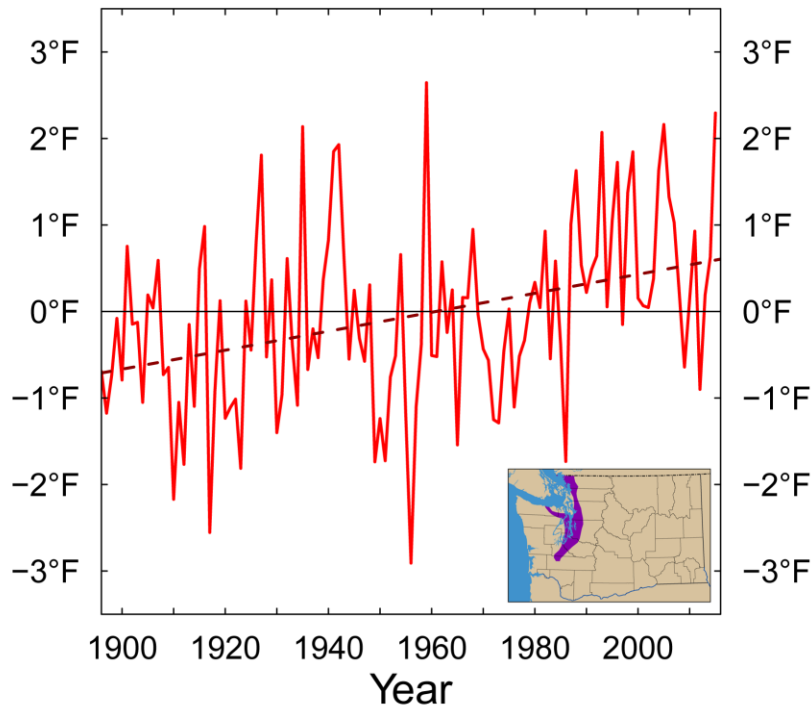
Climate Impacts Group
University of Washington



Long-term Warming, Short-term Variability

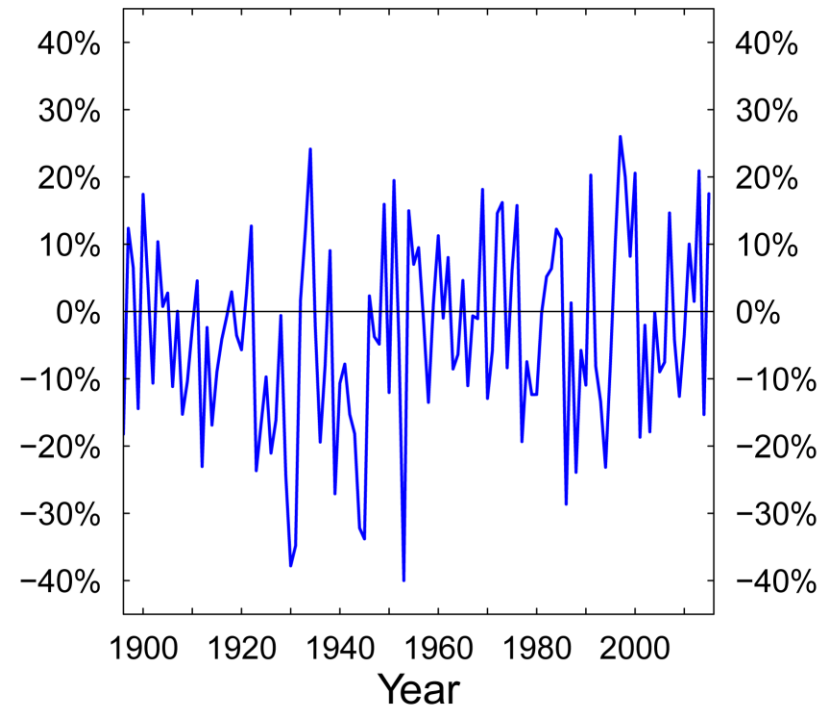
Temperature Difference

(Relative to 1950–1999 average)



Precipitation Change

(Relative to 1950–1999 average)



All but six of the years from 1980-2014 were warmer than the 20th century average.

Variable type and network

Temperature, Seasonal, (USHCN)

Metric

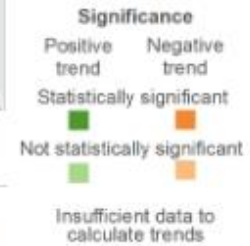
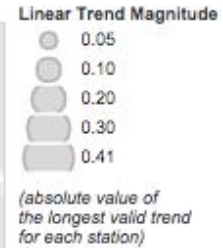
- Average Maximum Temperature, Calendar Year
- Average Maximum Temperature, July-Septem...
- Average Maximum Temperature, October-Ma...
- Average Minimum Temperature, Calendar Year
- Average Minimum Temperature, July-Septem...
- Average Minimum Temperature, October-March
- Average Temperature, Calendar Year
- Average Temperature, December-February
- Average Temperature, March-May
- Average Temperature, July-September
- Average Temperature, October-March

After selecting a metric, click on a station to get an updated graph.

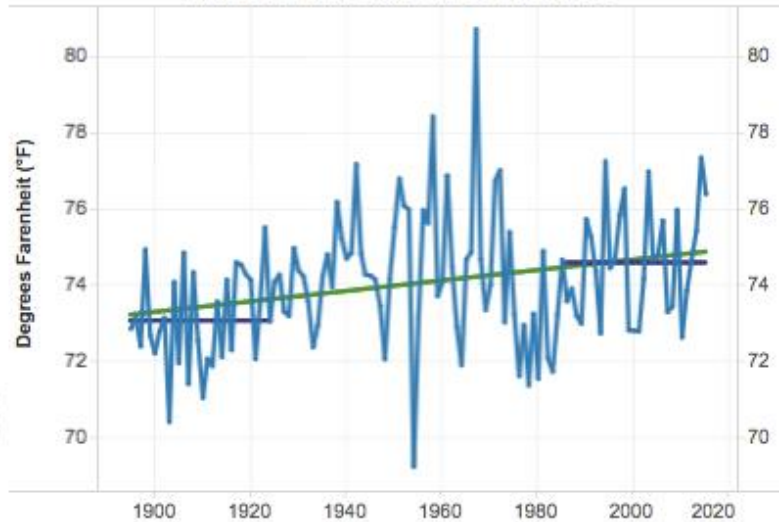
For linear trends, choose 1895 or later:

1895

USHCN Stations Reporting Average Maximum Temperature, July-September



Average Maximum Temperature, July-September, Seattle (USHCN)
Time series, linear trend, and 30 year averages



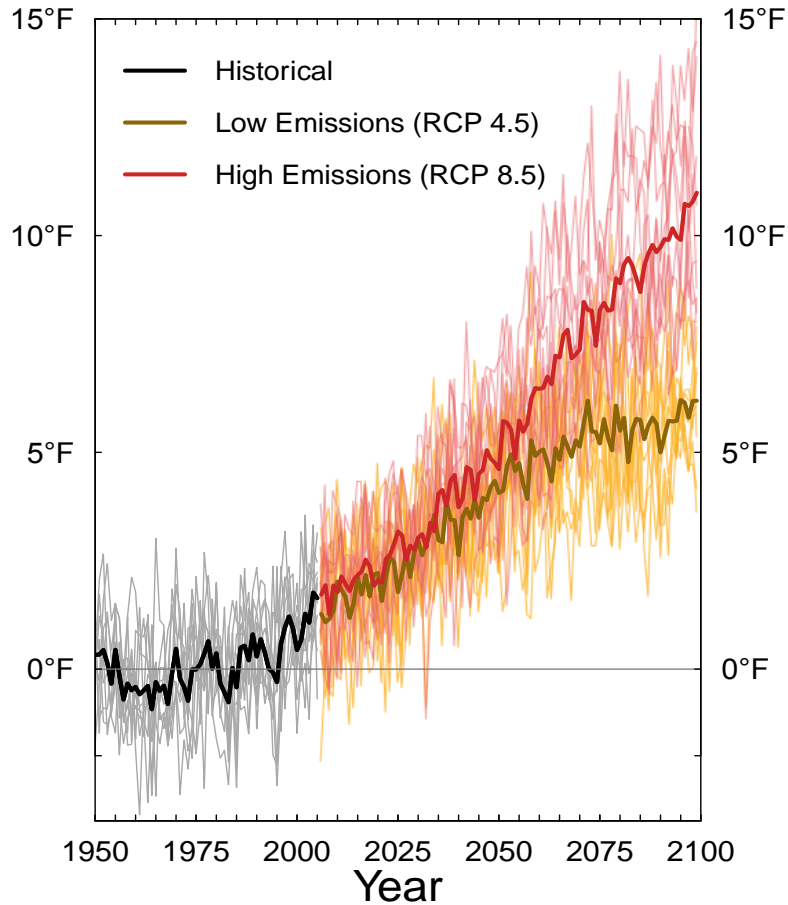
Linear trend: 0.1380°F per decade
P-values: 0.0030 (T-test); 0.002 (Mann-Kendall)
Statistically significant



Same story, but much more warming

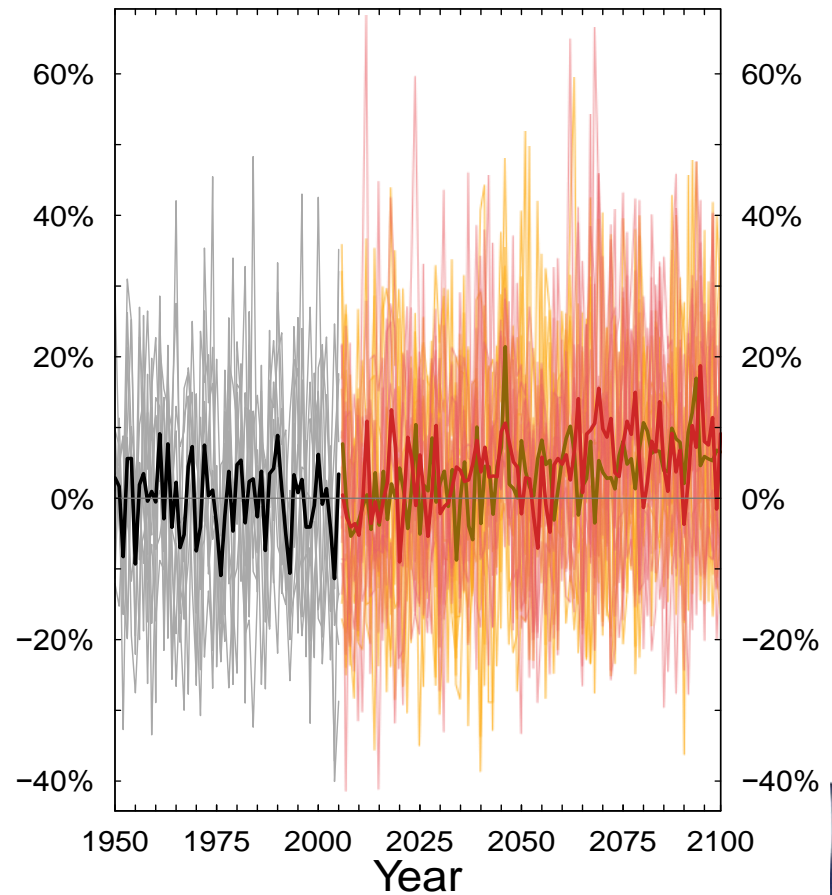
Temperature Difference

(Relative to 1950–1999 average)

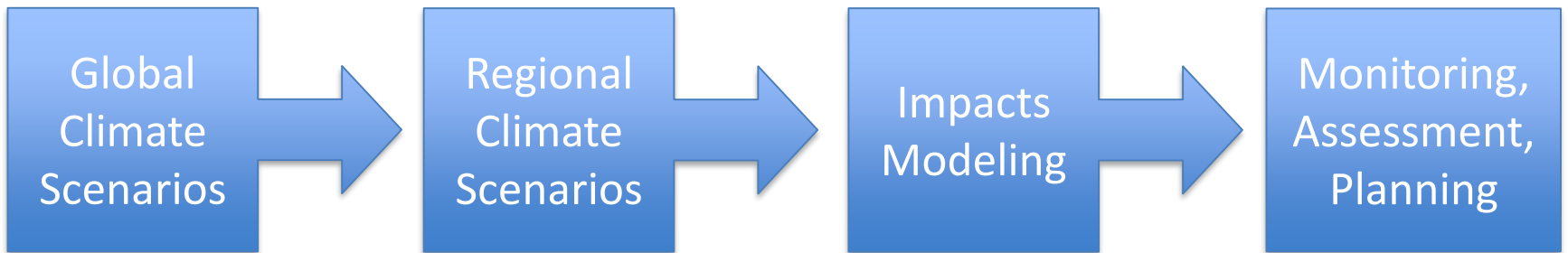
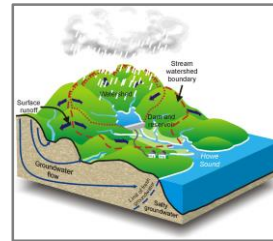
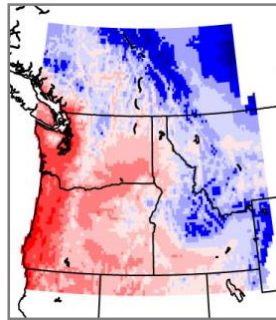
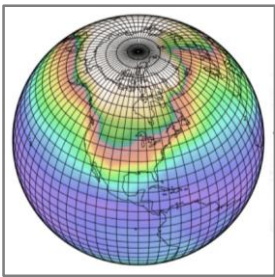


Precipitation Change

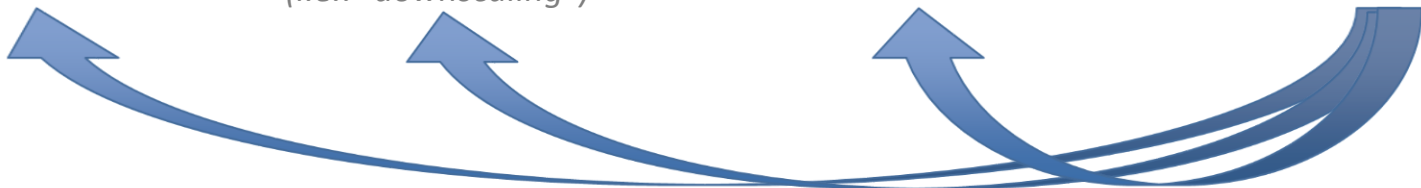
(Relative to 1950–1999 average)



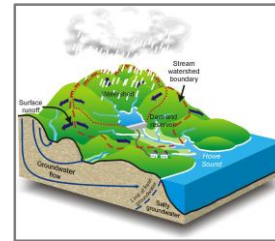
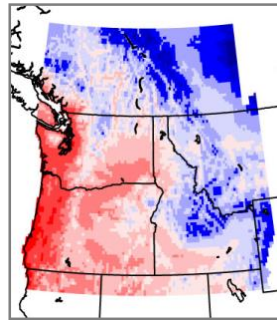
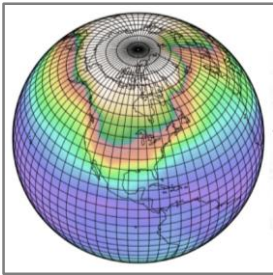
Quantifying Climate Impacts



(i.e.: "downscaling")



Quantifying Climate Impacts



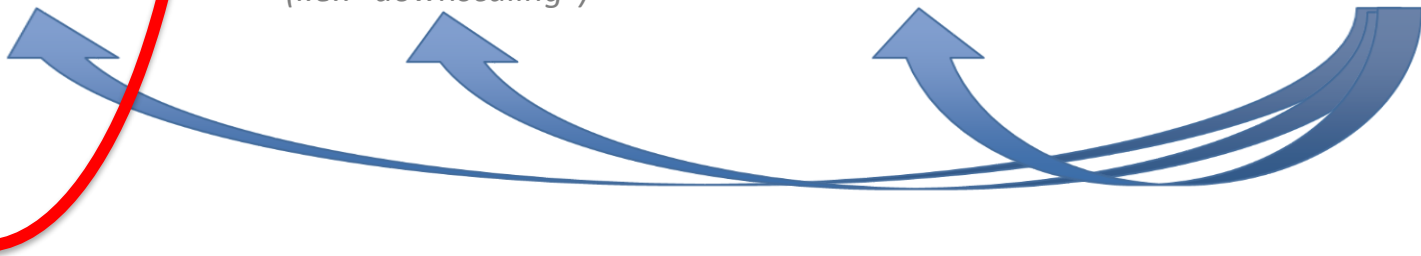
Global
Climate
Scenarios

Regional
Climate
Scenarios

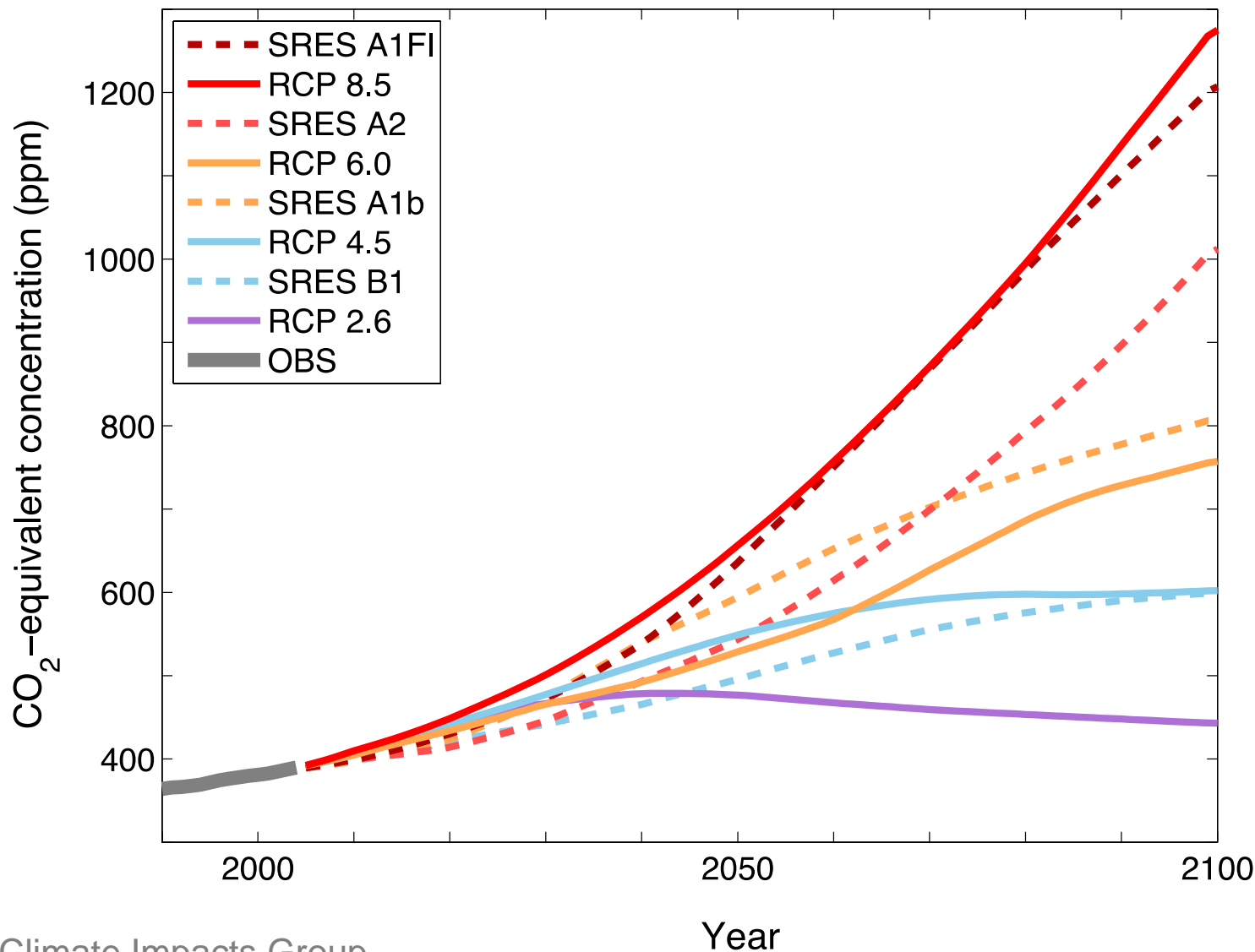
Impacts
Modeling

Monitoring,
Assessment,
Planning

(i.e.: "downscaling")

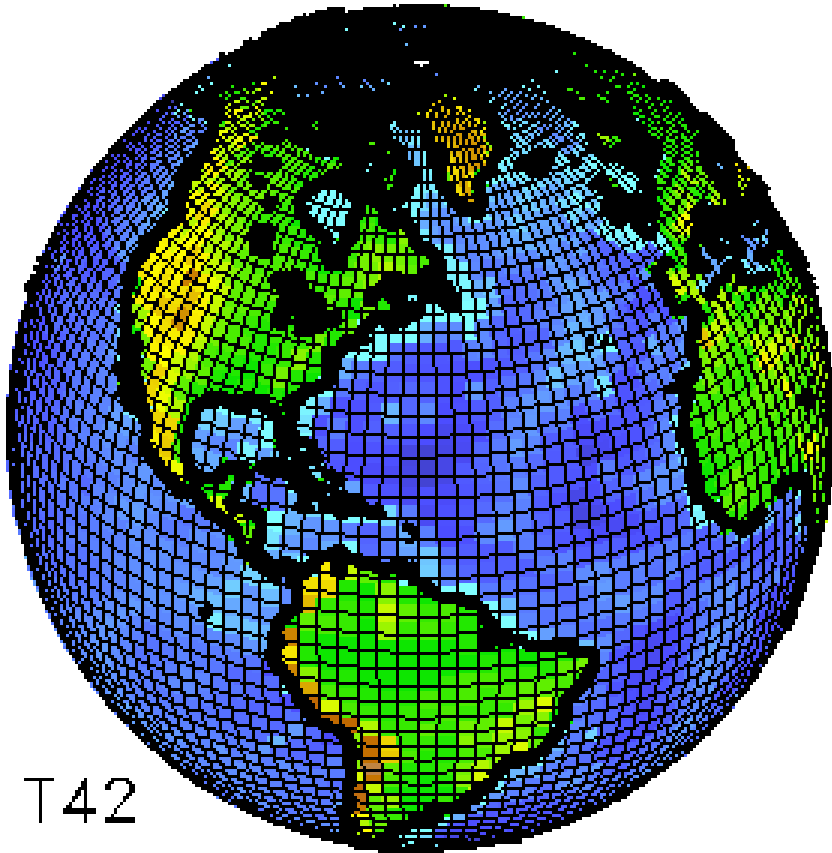


Greenhouse gas “scenarios” are best guesses about future emissions



Source: Climate Impacts Group

Global Climate Models (GCMs)



T42

GCMs break the world into boxes (“grid cells”, each ~50 to 200 km on a side)

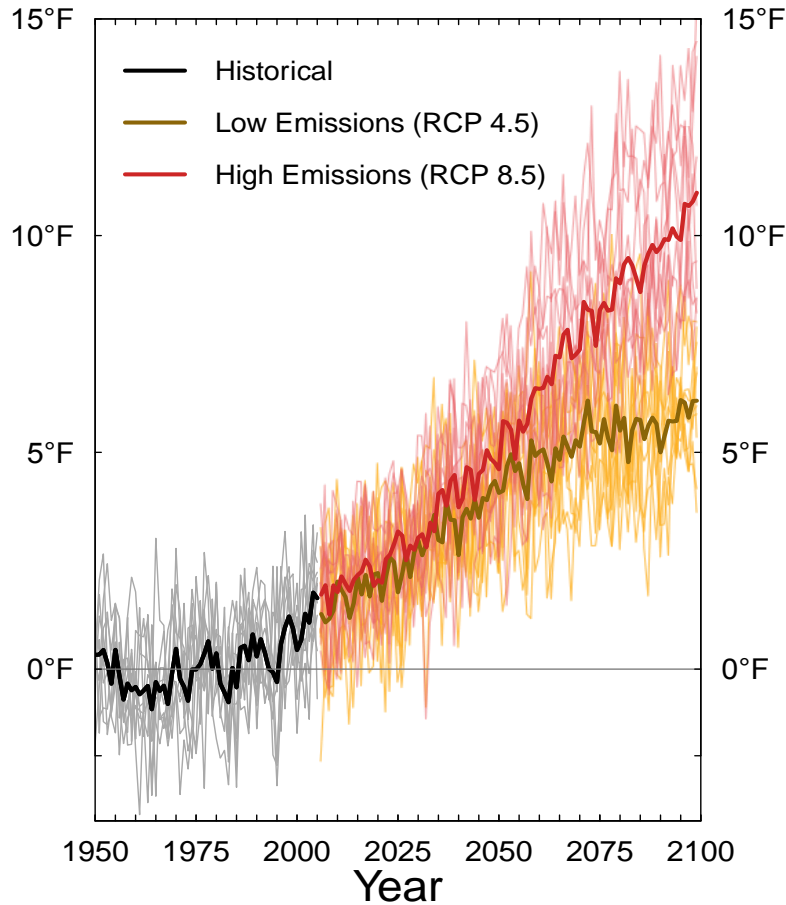
State of the art, highly complex models

Most are “coupled”: they simulate interactions among the land surface, ocean, sea ice, and atmosphere.

Ex: Annual Temperature & Precipitation

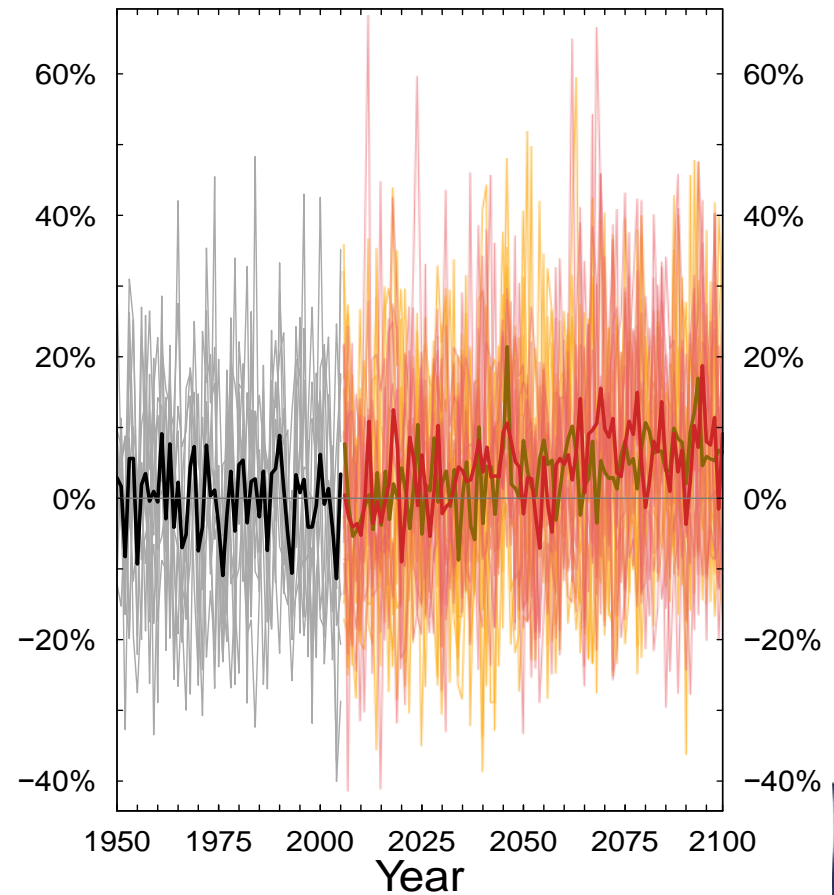
Temperature Difference

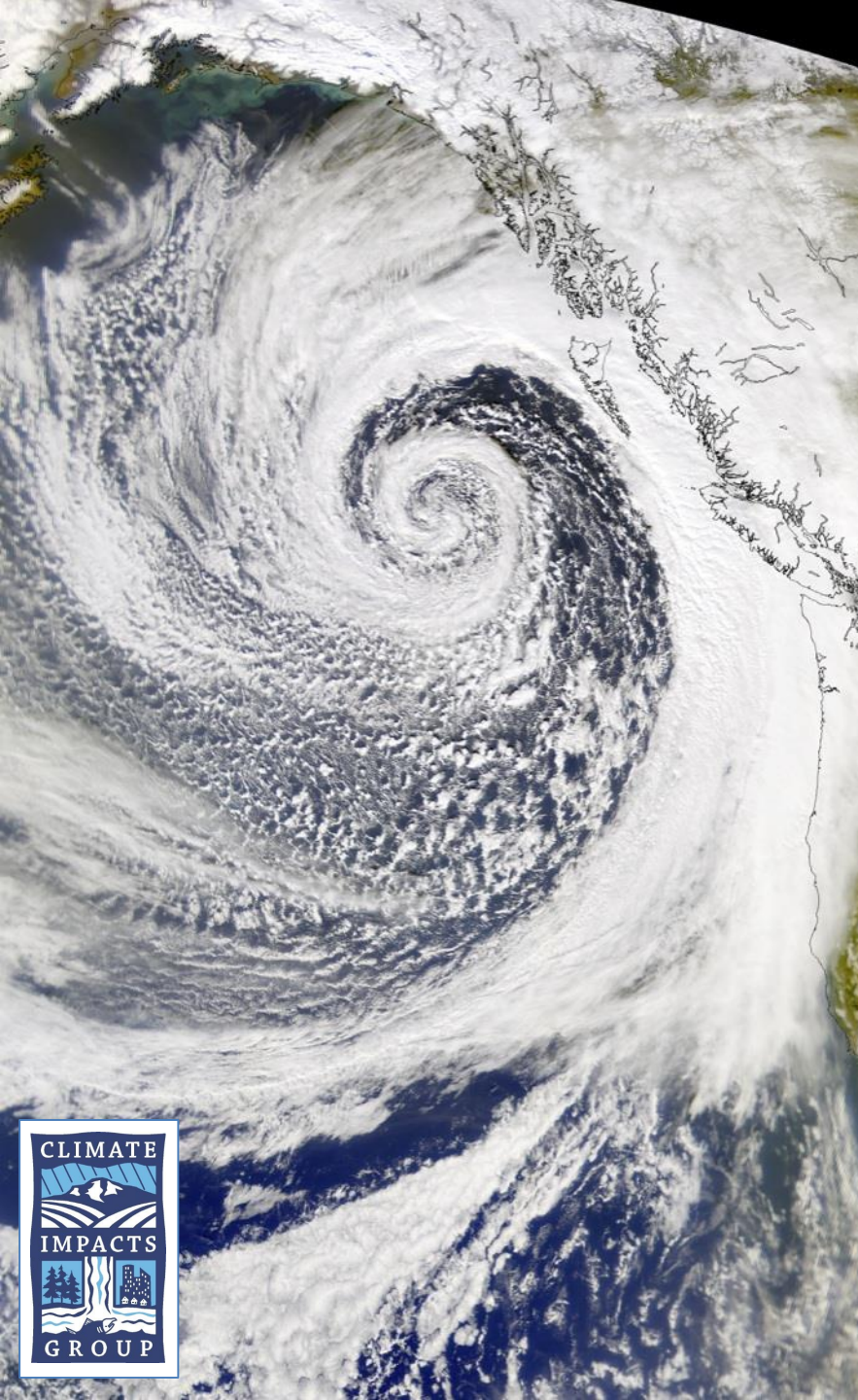
(Relative to 1950–1999 average)



Precipitation Change

(Relative to 1950–1999 average)





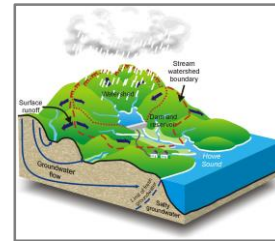
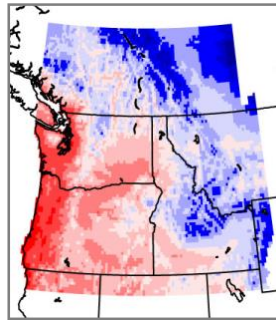
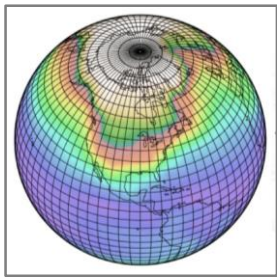
More Intense Heavy Rains

Heaviest rain events are projected to become **+22% more intense** (*range: +5 to +34%*) by the 2080s.

Changes in Winter Atmospheric Rivers along the North American West Coast in CMIP5 Climate Models

Warner, Mass, Salathé, J Hydromet, 2014

Downscaling

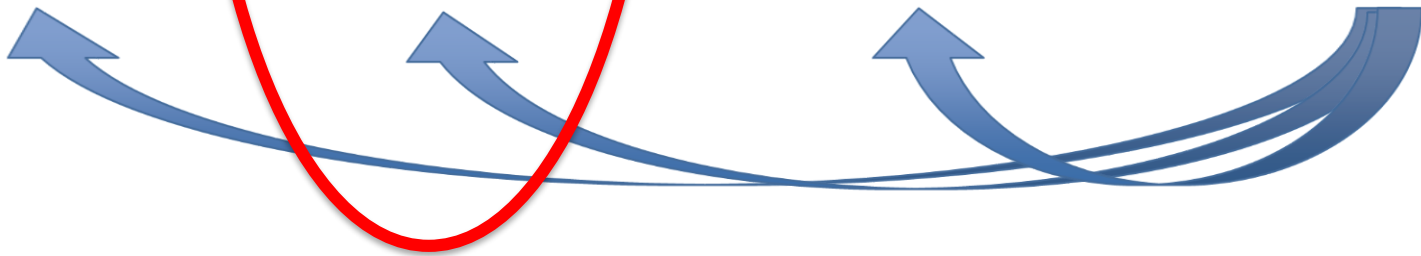


Global
Climate
Scenarios

Regional
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Scenarios

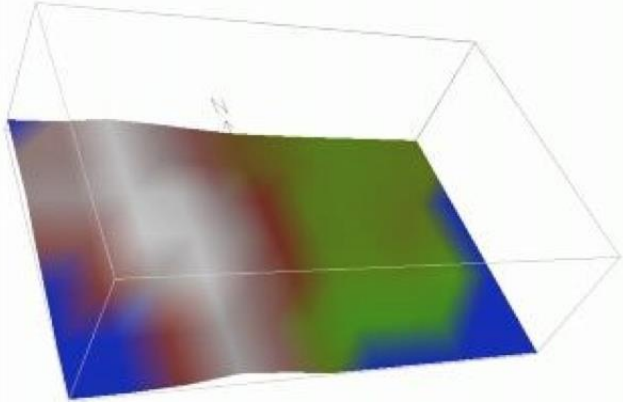
Impacts
Modeling

Planning
&
Design



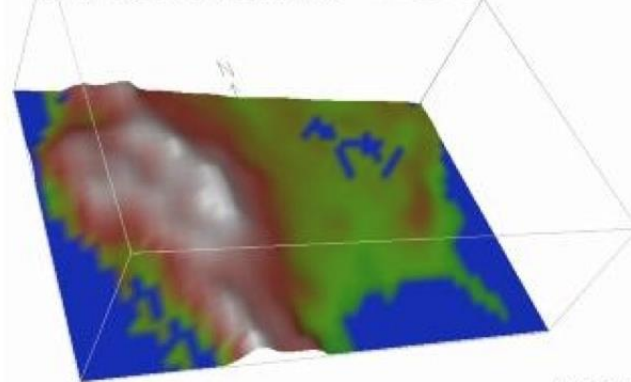
Model Scale:

Climate Models circa early 1990s



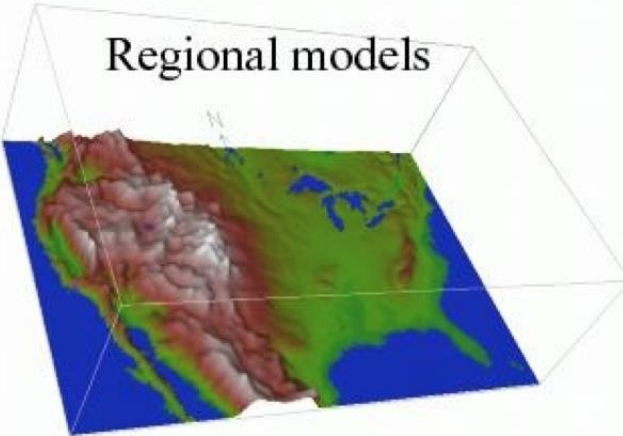
400 km

Global coupled climate models in 2006



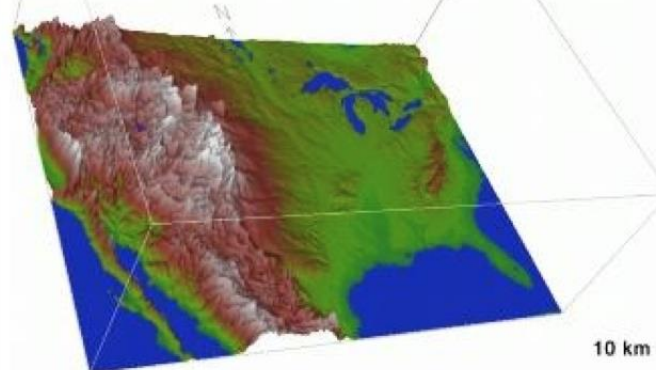
100 km

Regional models



25 km

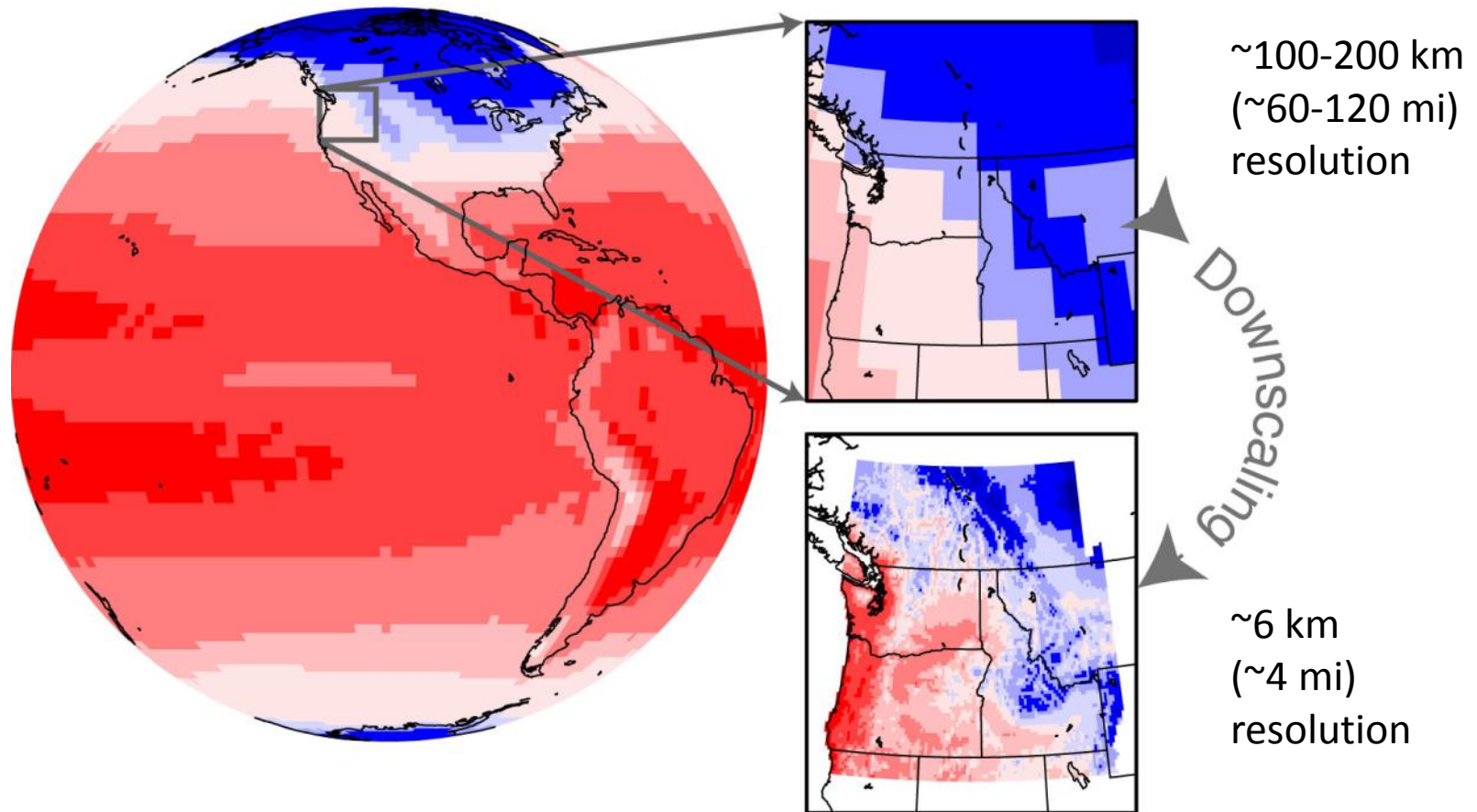
Global models in 5-10 yrs



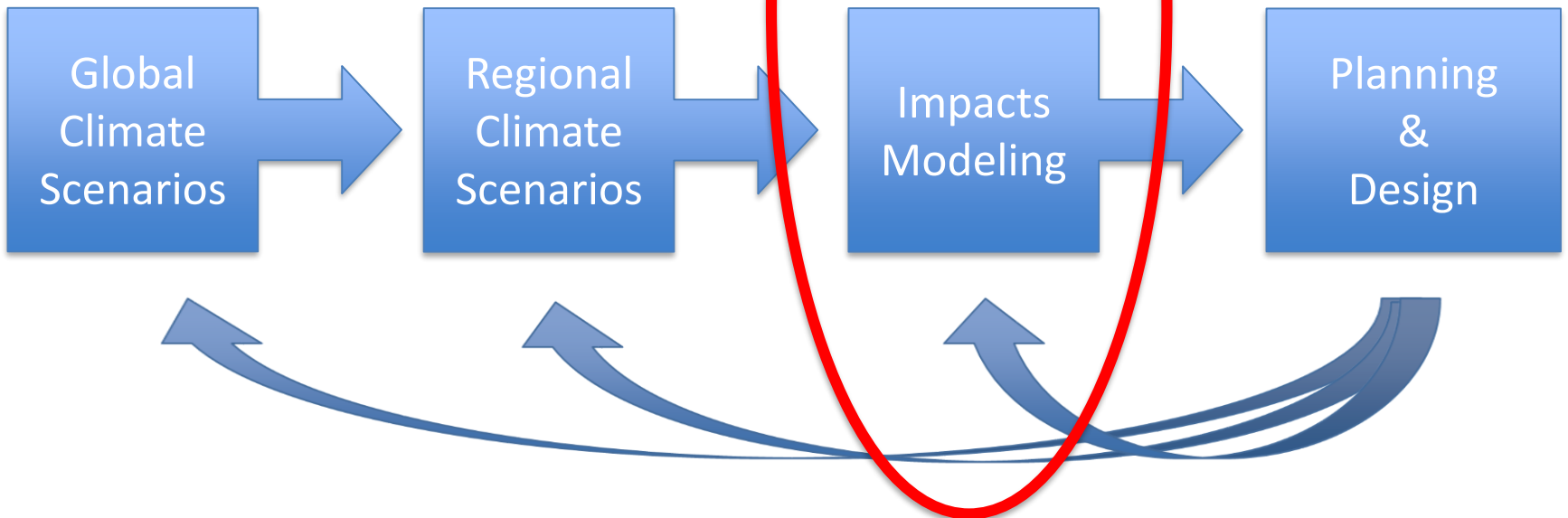
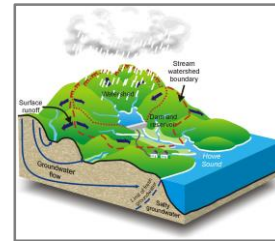
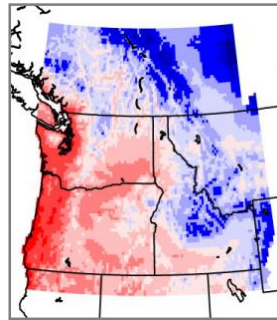
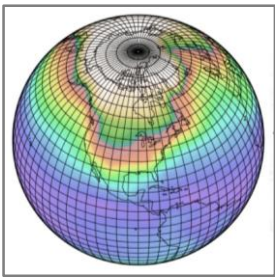
10 km

Downscaling relates the large to the small

Global Climate Model Air Temperature



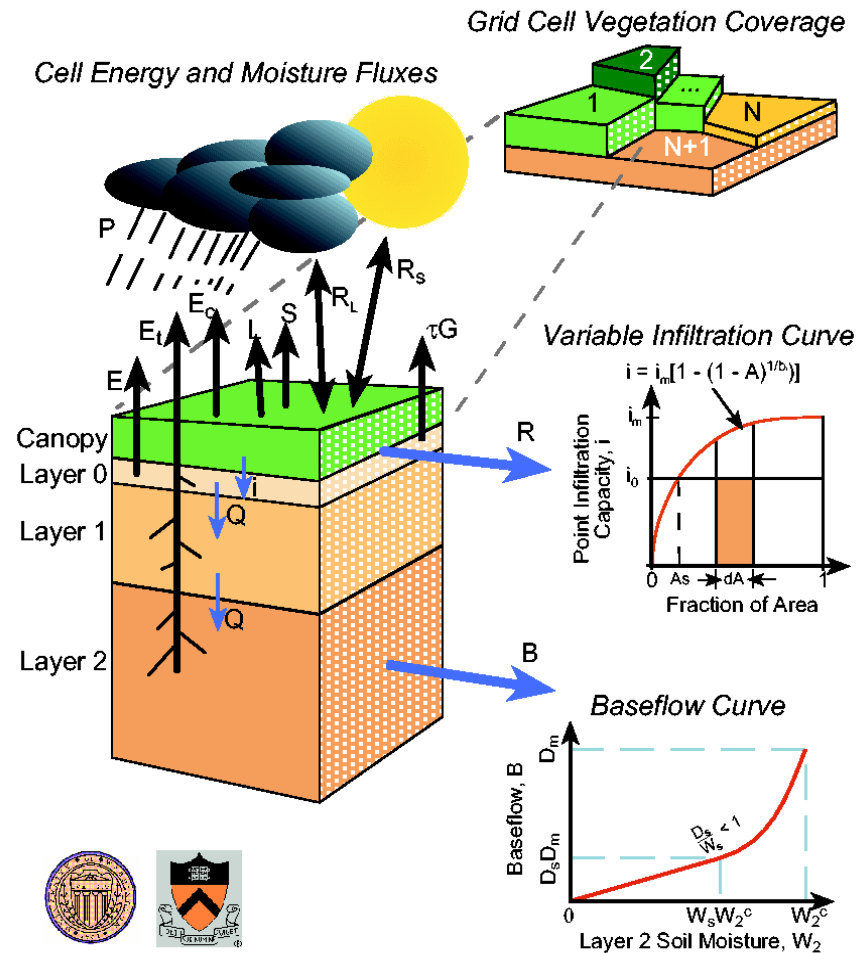
Impacts Modeling



ex: Hydrologic Modeling

Translation from climate to water impacts

Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model

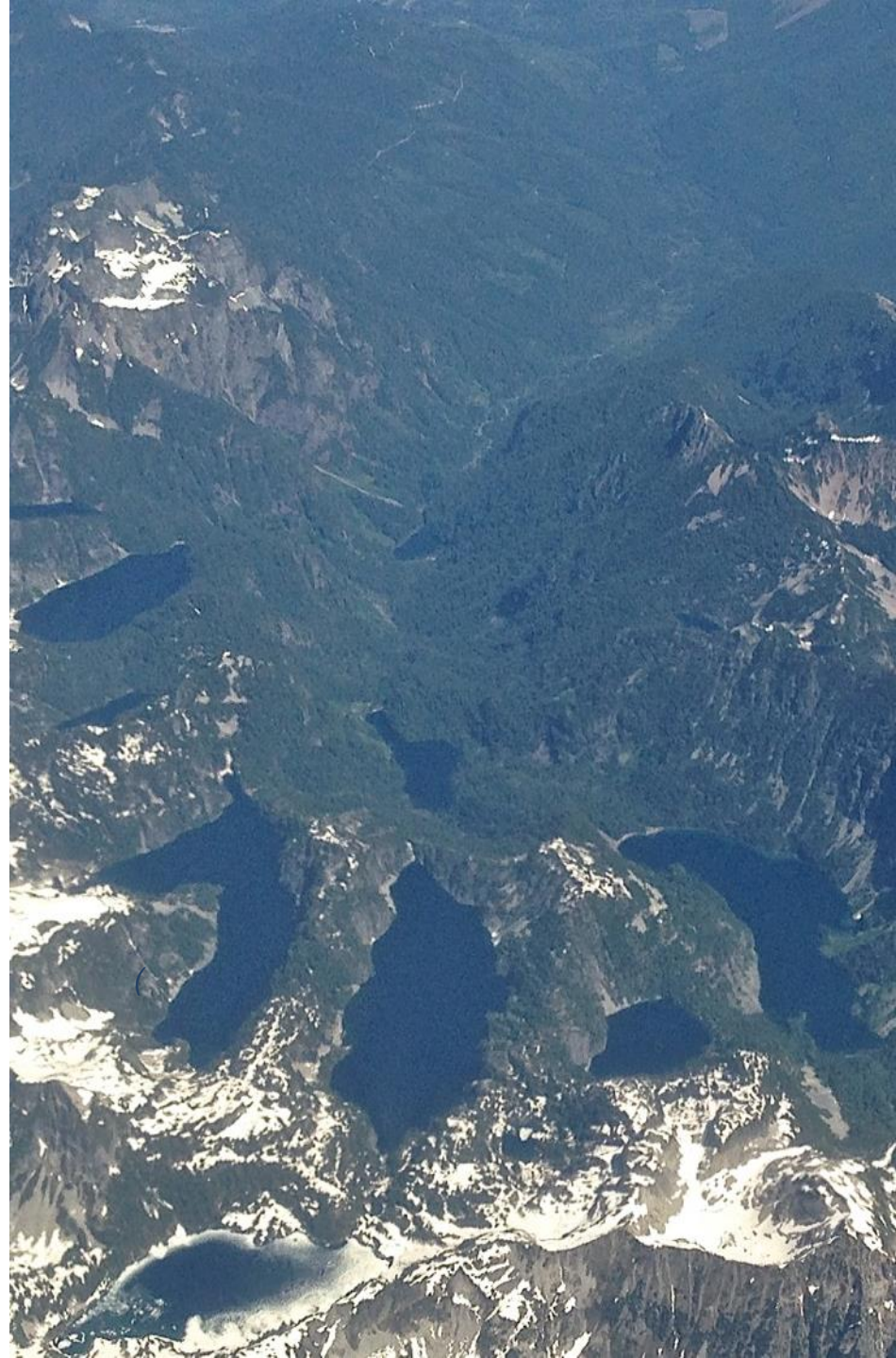


Snow

Our primary mechanism for storing water – snow – is sensitive to warming.

The Cascade and Olympic Mountains have the highest fraction of “warm snow” (snow falling between 27-32°F) in the continental U.S.

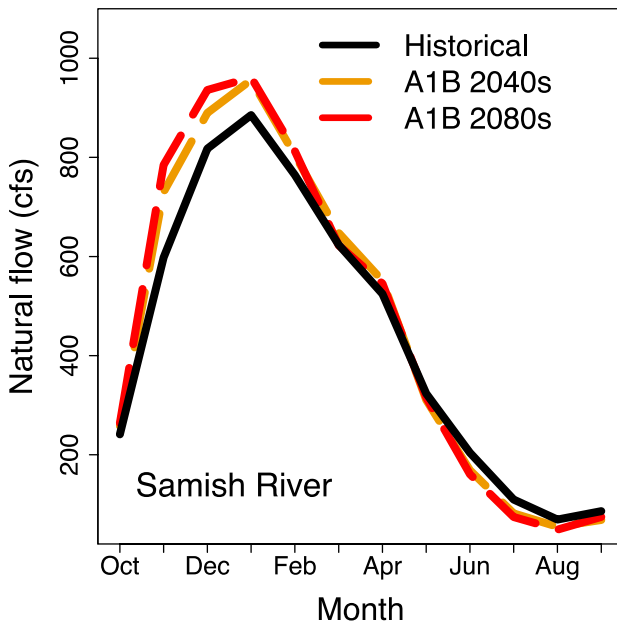
(Mote et al. 2008)



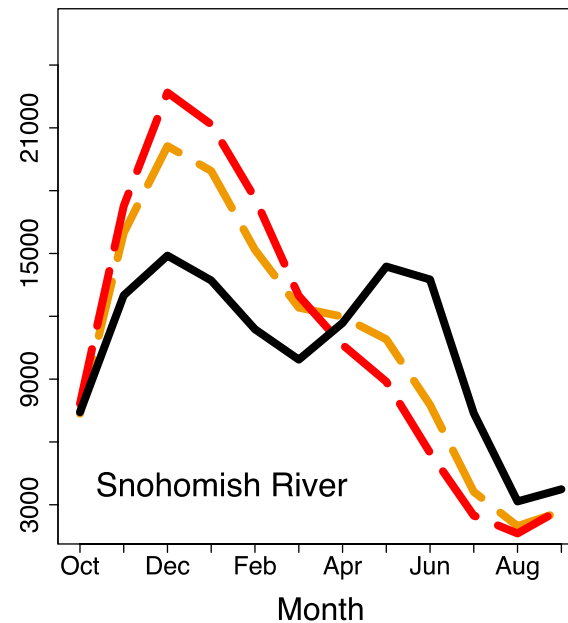
Implications of losing snowpack



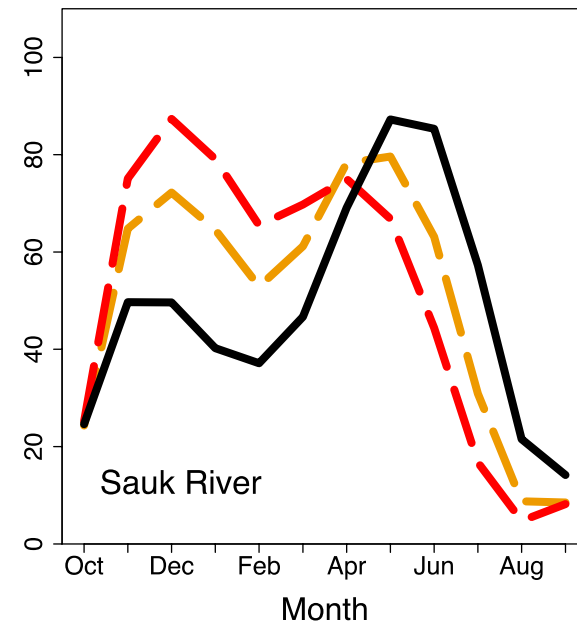
Rain Dominant



Mixed Rain & Snow

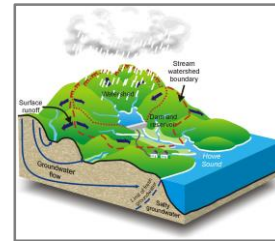
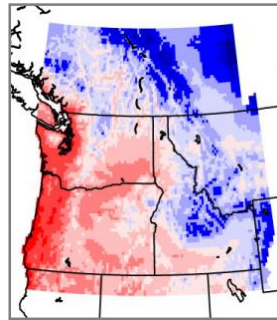
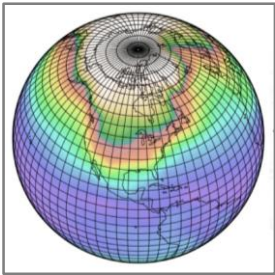


Snow Dominant



(these projections do not include changes in heavy rain events)

Doing Something

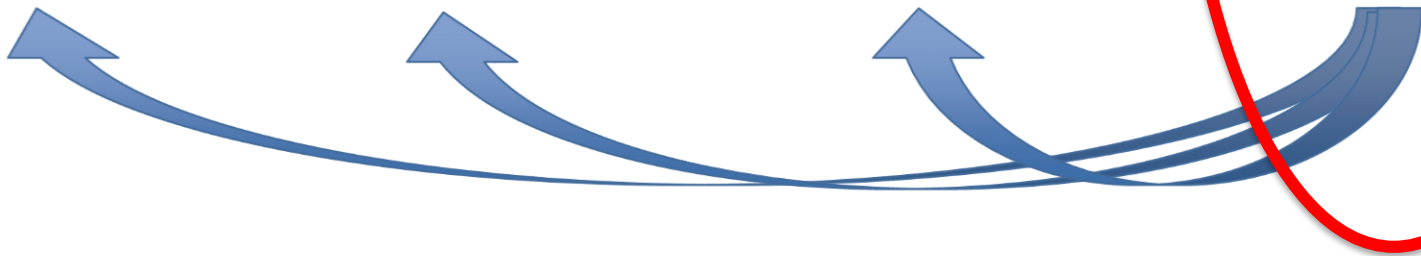


Global
Climate
Scenarios

Regional
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Scenarios

Impacts
Modeling

Planning
&
Design



**At its core, planning for climate change is about
*risk management***



Choosing & Using Scenarios

Information / Context	Expertise
1. Conceptual model: <ul style="list-style-type: none">• Understanding of system• Sensitivity to climate	Manager Biologist Engineer Toxicologist...
2. Climate science: <ul style="list-style-type: none">• Climate effects on system• Able to simulate?• Spatial resolution• Temporal scales (variability v. trends)	Climate scientist
3. Decision context: <ul style="list-style-type: none">• Robust v. most likely• Best vs. worst case• Time horizon	Policymaker Risk Tolerance

Source: Snover et al., *Cons. Bio.*, 2013

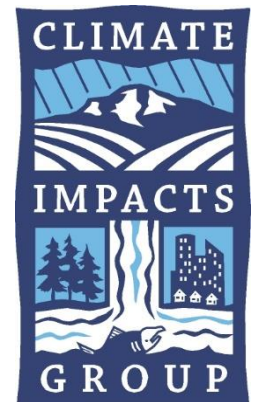
Take-Homes



- **There will always be a range of projections:** some uncertainties are irreducible. Best to consider a variety of approaches.
- **Downscaling relates the large to the small:** different approaches needed for different applications.
- **Translating from climate change to impacts:** additional modeling is often needed to do this.
- **Context determines what matters:** Sensitivity to climate change, time frame, risk tolerance.

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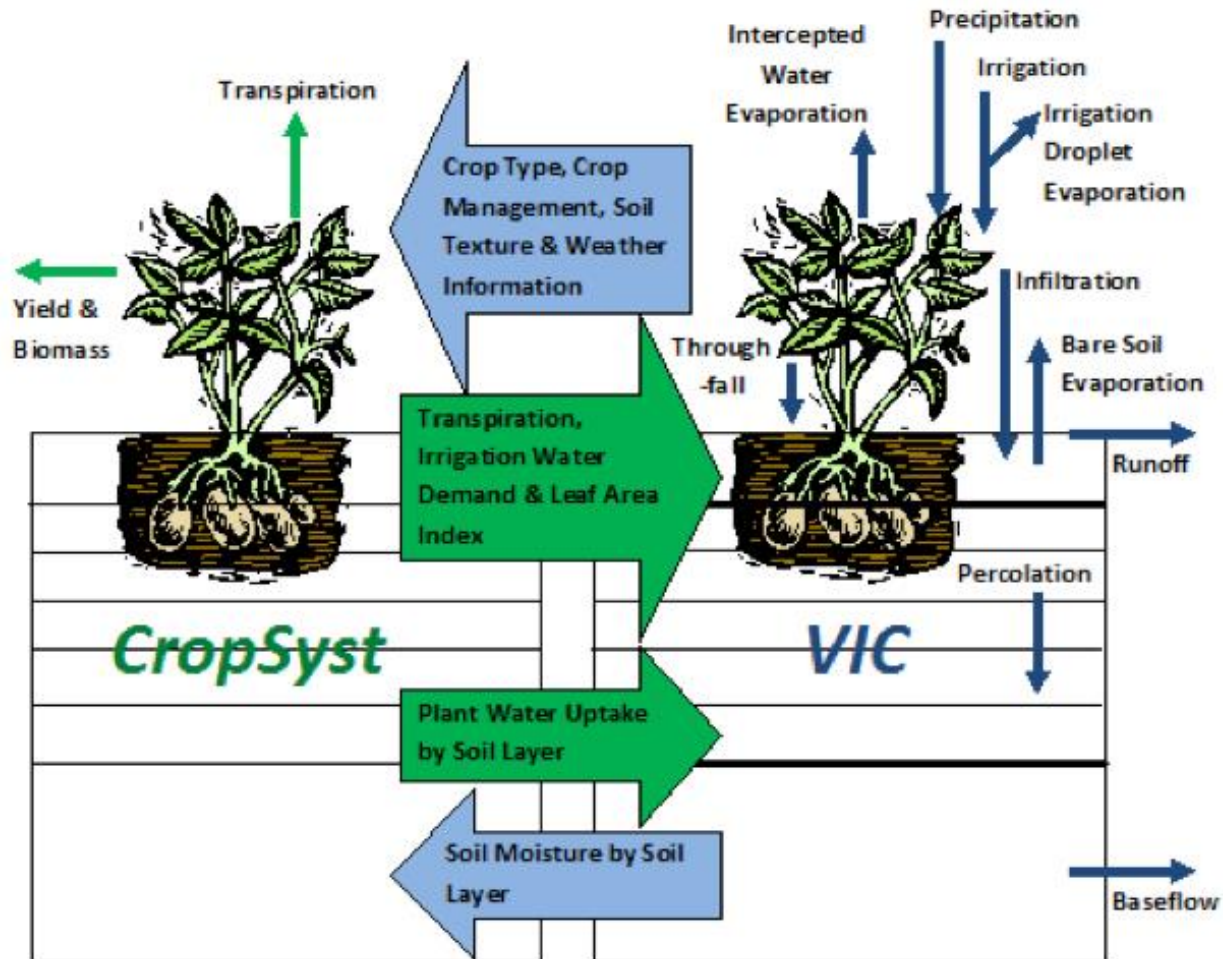
*Climate Science in the
Public Interest*



COLLEGE OF THE ENVIRONMENT
UNIVERSITY *of* WASHINGTON

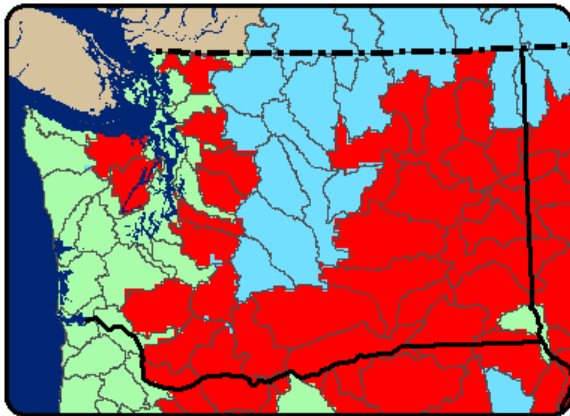
ex: Crop Modeling

Translation from climate to ag production

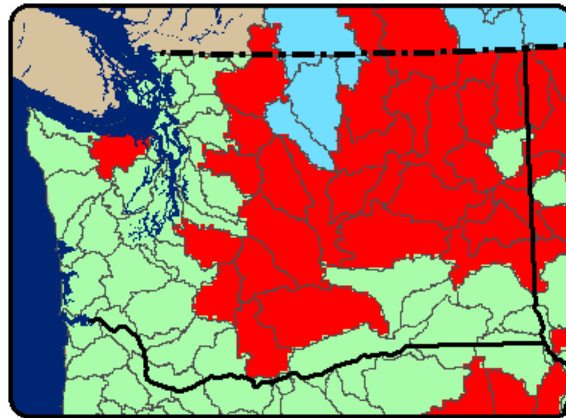


Ex: Hydrologic Projections

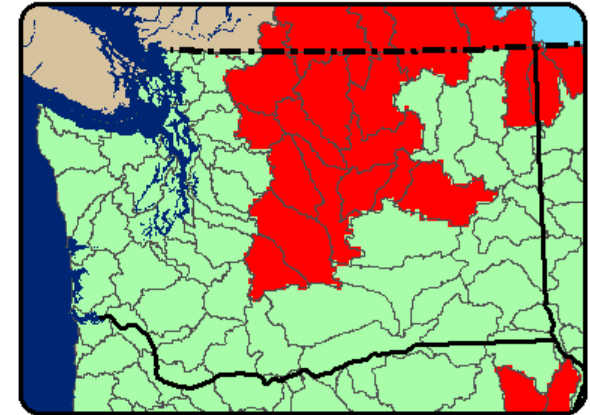
Historical






2040s



2080s



Percentage of Winter Precipitation Captured in Peak Snowpack

< 10%  Rain dominant
 10% - 40%  Mixed rain and snow
 > 40%  Snow dominant

Remember that all models
are wrong;
the practical question is
how wrong do they have to
be to not be useful.

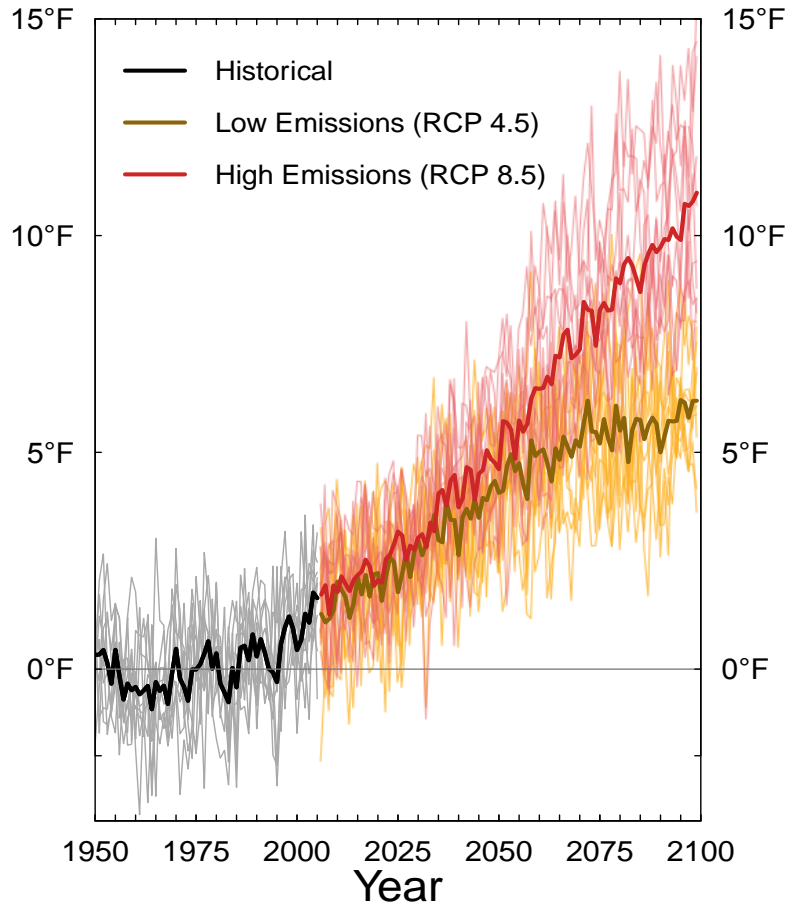
Good questions to ask:

- What are the inputs, outputs, internal equations, limitations, assumptions?
- Are there competing models? How do they differ?
- What parts of the model are certain?
- How good are the inputs?
- What is the range of possible outputs given known uncertainties in the model?

Ex: Annual Temperature & Precipitation

Temperature Difference

(Relative to 1950–1999 average)



Precipitation Change

(Relative to 1950–1999 average)

