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WASHINGTON STATE
Academy of Sciences

TH ANNUAL MEETING & SYMPOSIUM
CLIMATE CHANGE IN WASHINGTON STATE
Research Questions Critical to Preparing for the Future

**Regional Climate Modeling Technology:
Initial Results – *Regional Climate
Modeling Consortium***

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Regional Climate Modeling for Washington State



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WSAS Climate Change Symposium

Washington State needs reliable information on the regional implications of climate change

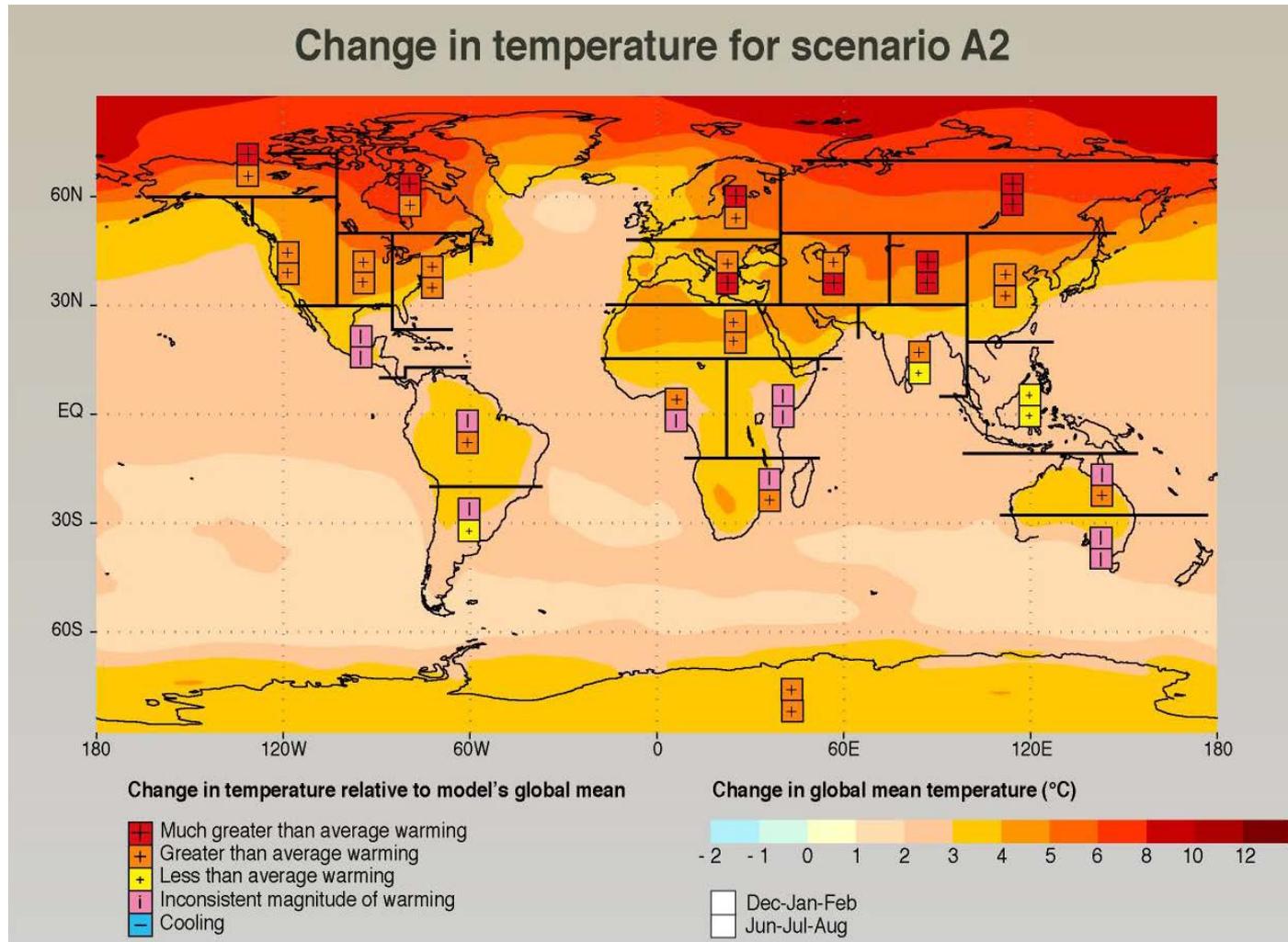
- Infrastructure decisions are being made now for assets that will last well into the current century
- Need projections for adaptation/resilience



Can we provide the State with actionable information on the future climate? Reduce surprises?



Global Climate Models (GCMs) provide a large-scale view of climate change impacts

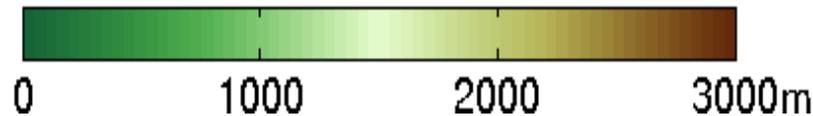
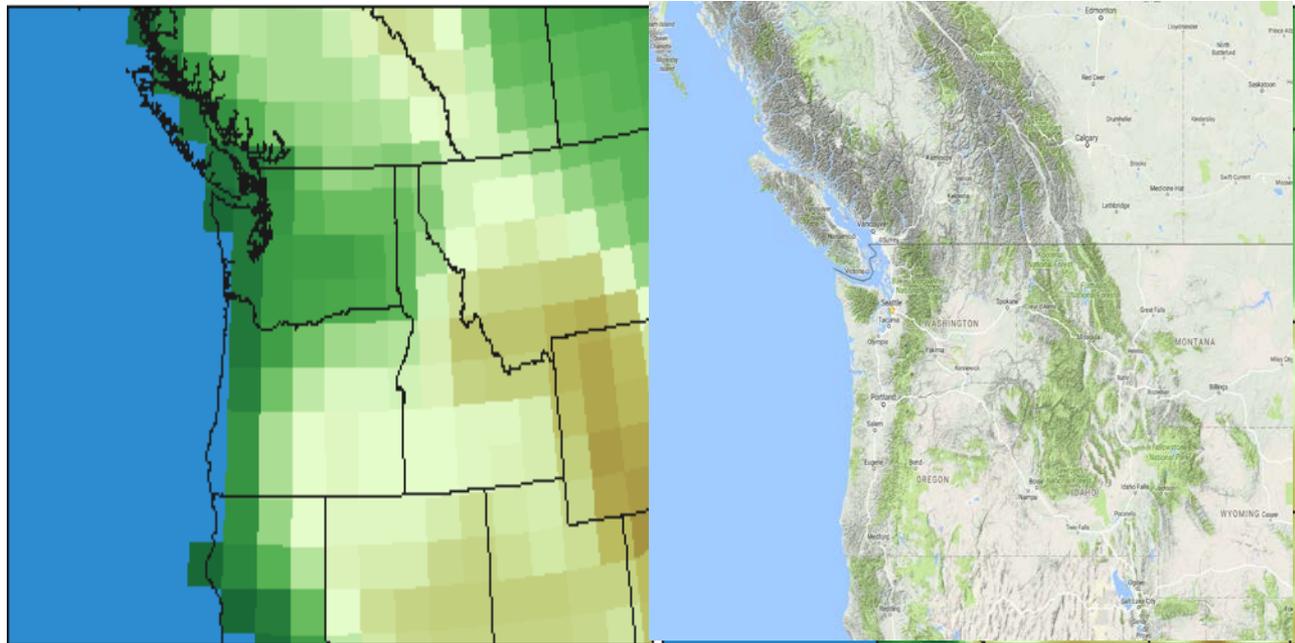


Problem: GCMs are too coarse to simulate the effects of critical terrain/coastal effects of our region.

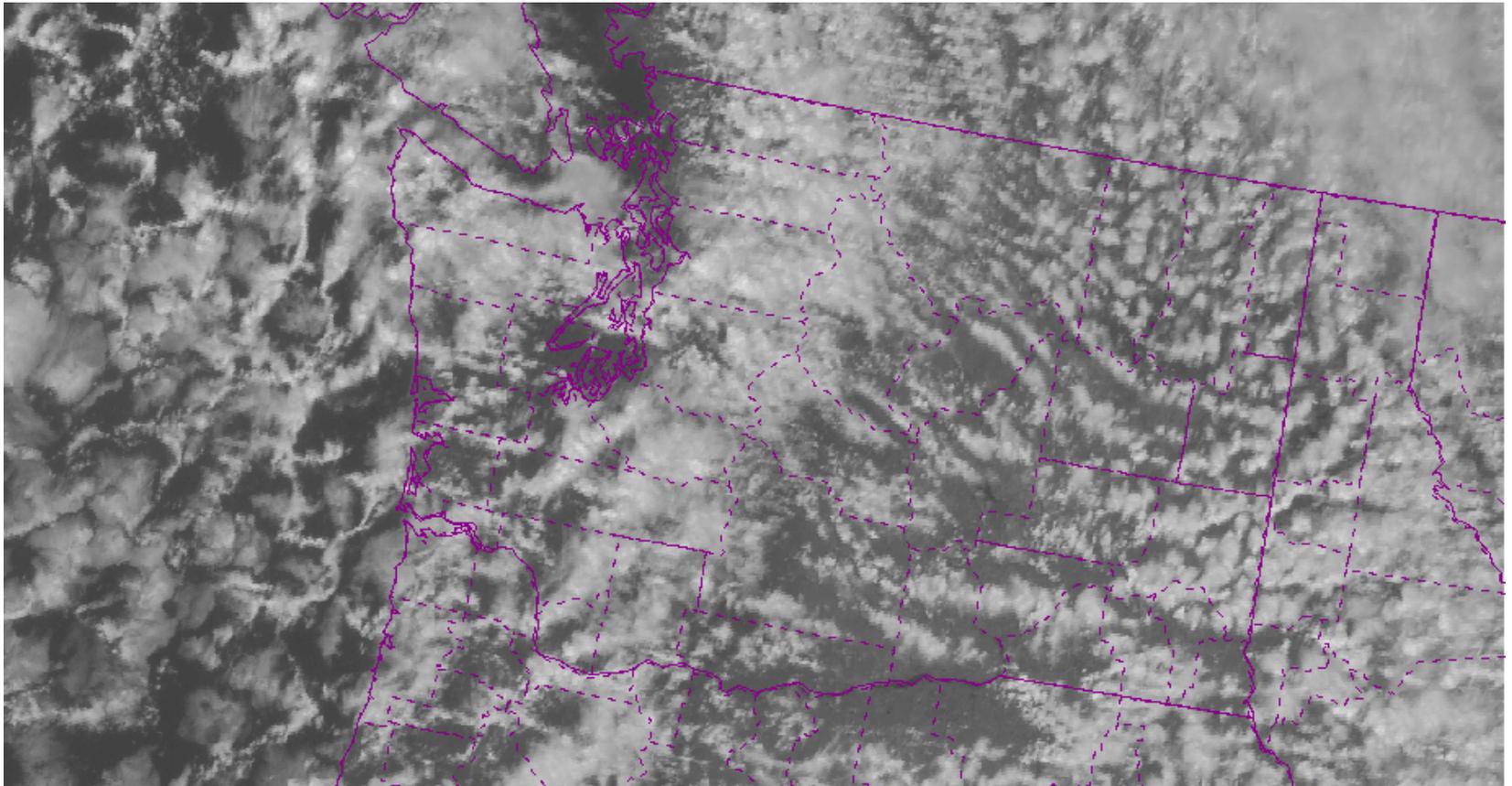
Climate Model Terrain

CCSM4

WRF-12km



And terrain and water contrasts dominate the meteorology of our region

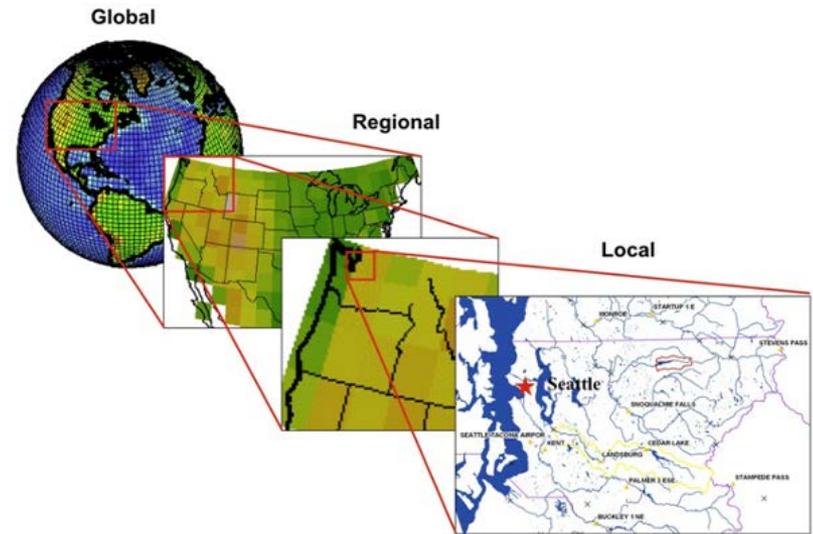


Since we can't run the climate models using sufficiently high resolution must find a practical way to determine the local implications of the global climate model forecasts.

This is called downscaling.

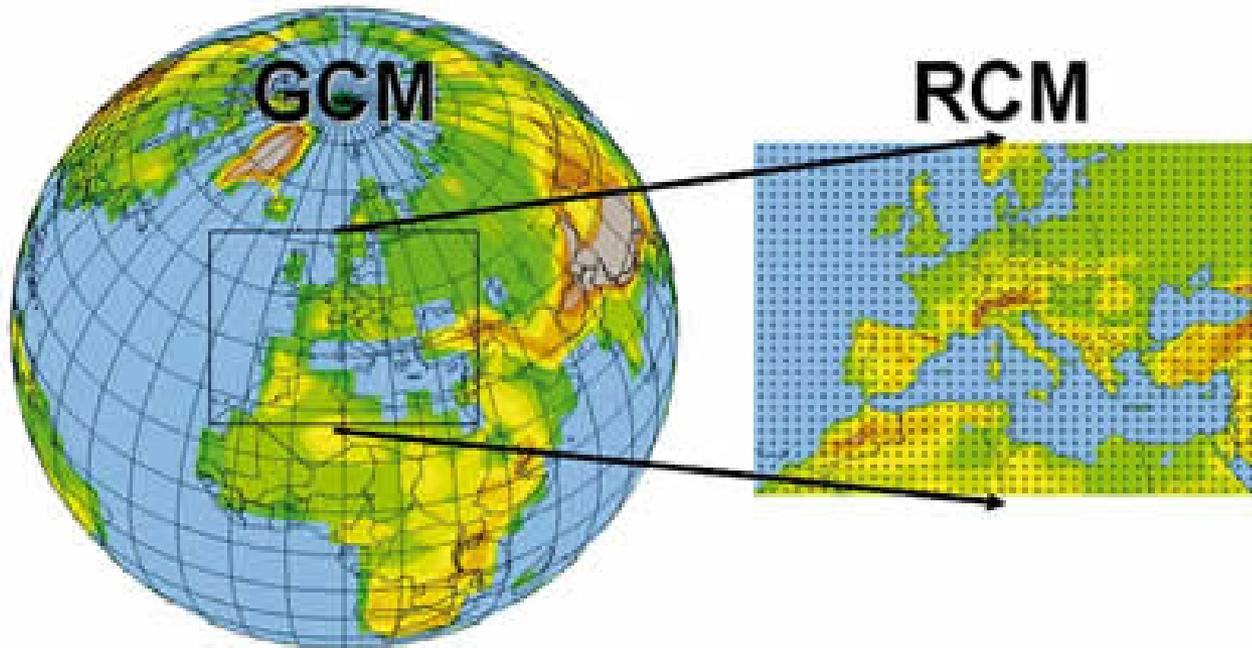
Two Main Approaches for Downscaling GCMs to Secure Regional Climate Implications

- **Statistical:** using **contemporary** statistical relationships between large-scale fields and local effects.
- **Dynamical:** using high-resolution **regional climate models** with boundary conditions driven by GCMs.



The best approach for downscaling GCMs is Regional Climate Modeling through dynamical downscaling.

Why?



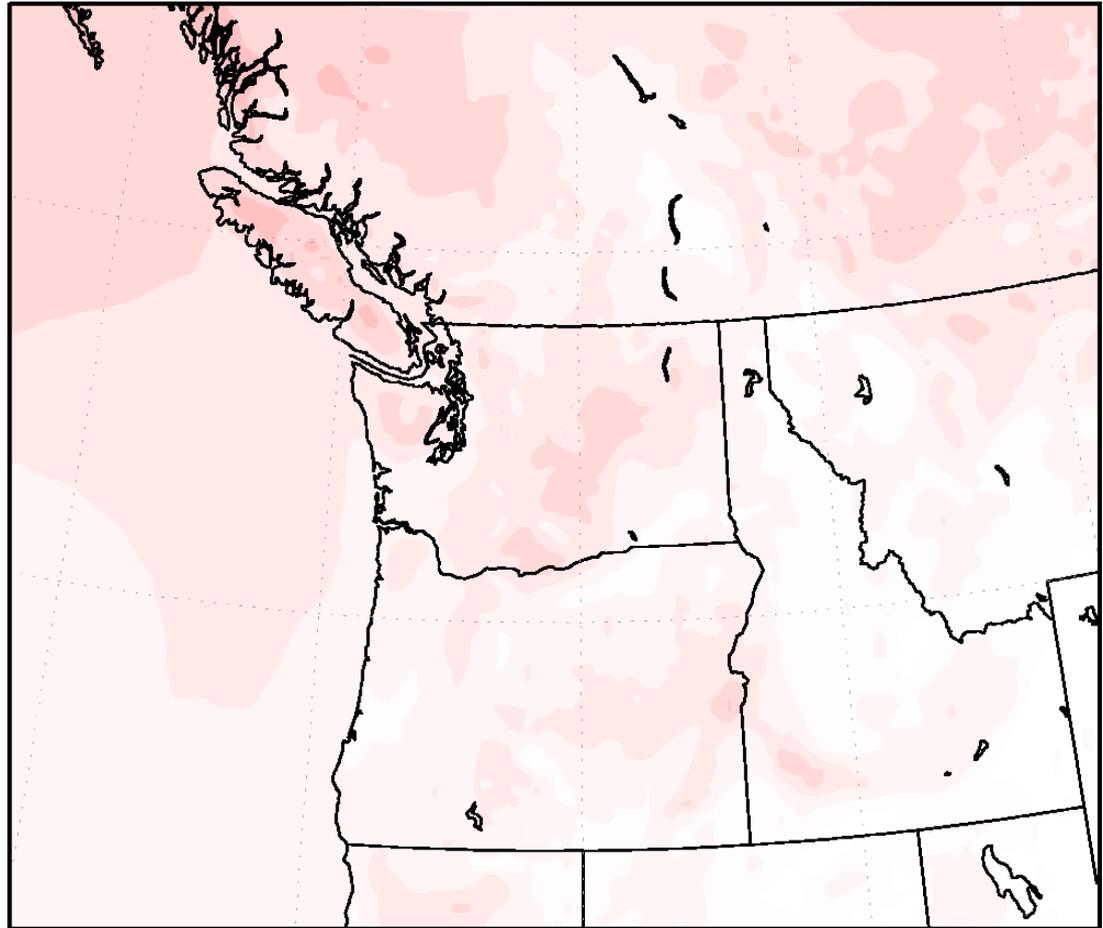
Dynamical Downscaling Not Statistical Downscaling

- Only dynamical downscaling can simulate the complexities of the local response to large-scale changes.
- The connection between the large-scale and local scale might change as the earth warms.
- Two examples:
 - Location and distribution of precipitation might alter as atmospheric stability changes.
 - Albedo feedbacks as mountain snow melts.

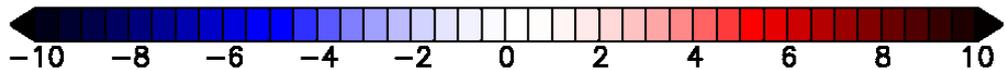
**An example:
Changes in surface air
temperature (2-m)**

Change 1990s to 2020s DJF 2-m Temperature (F)

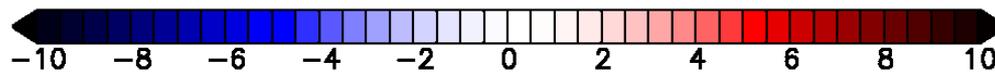
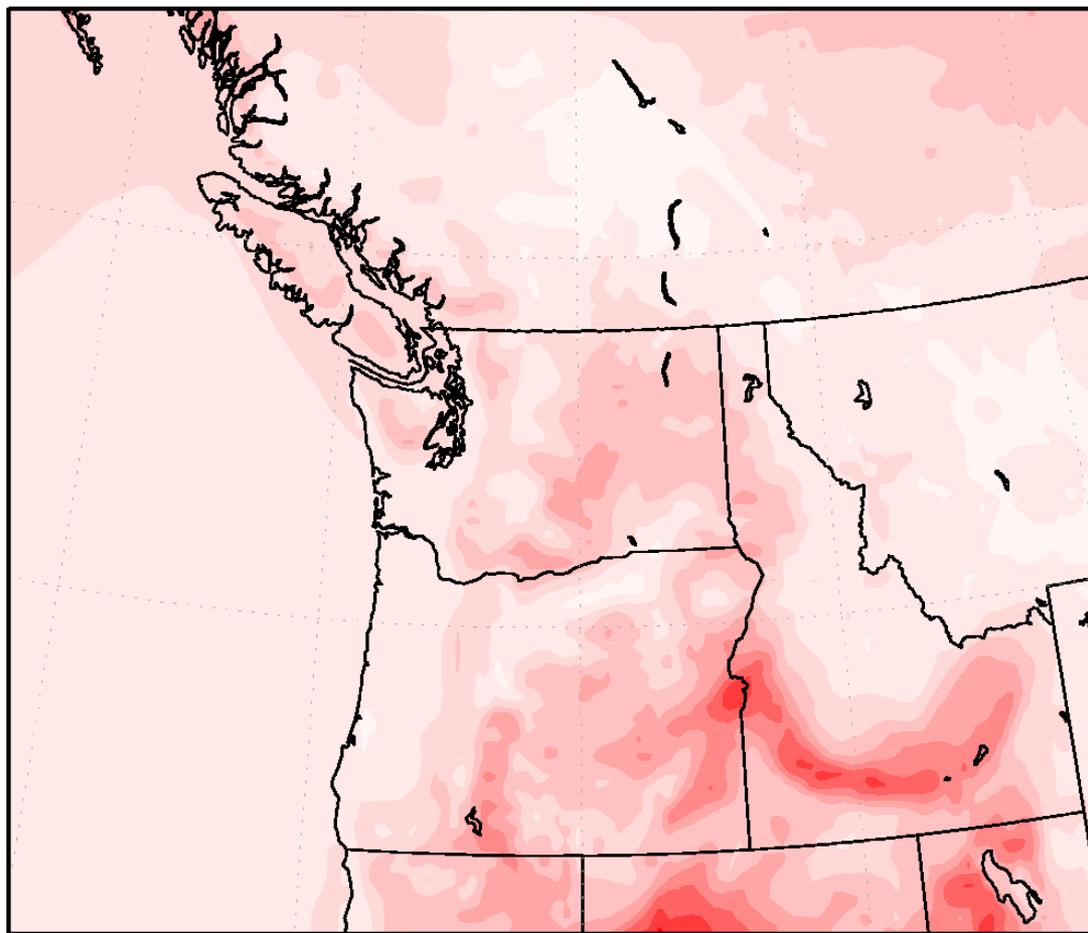
**12-km RCM
downscaling
of
ECHAM5
GCM**



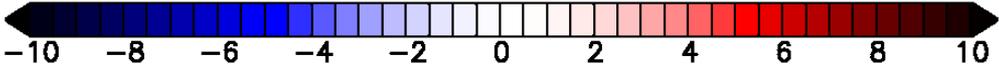
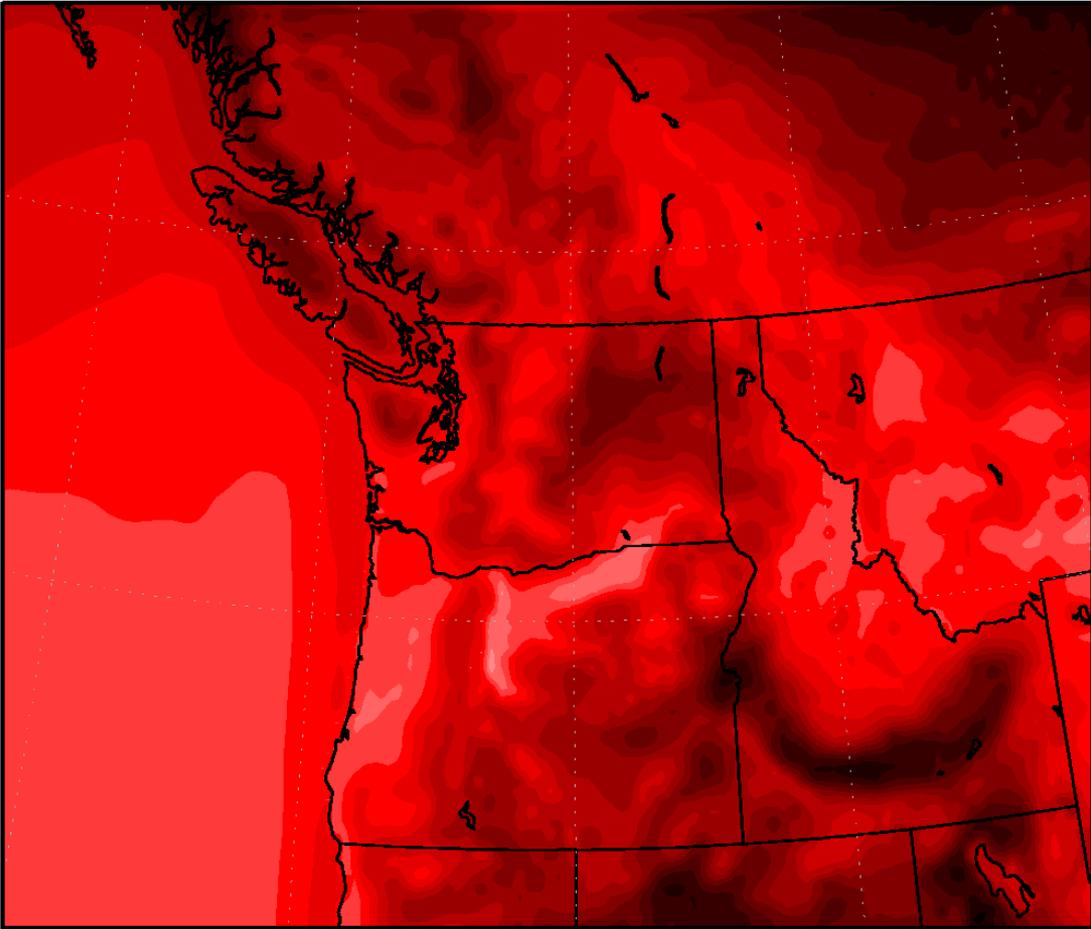
Change in Winter Surface Air Temperatures (F)



Change 1990s to 2050s DJF 2-m Temperature (F)

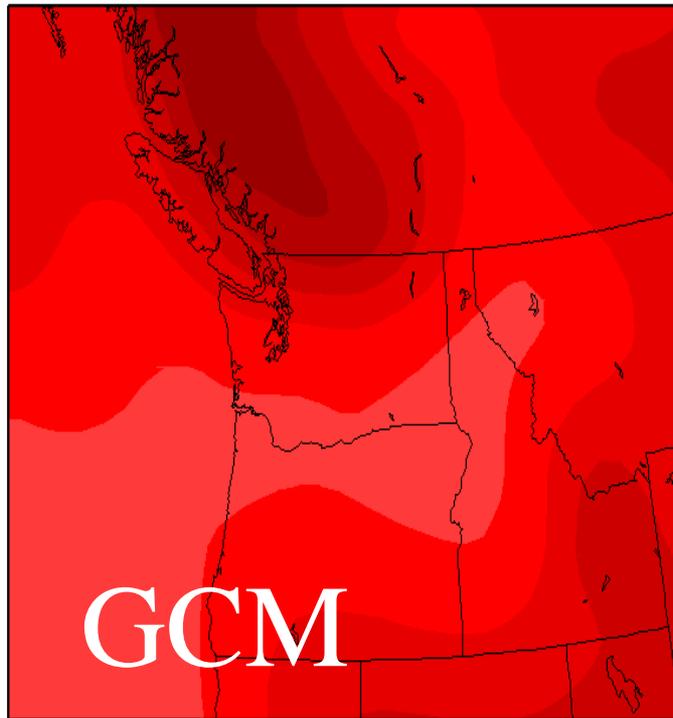


Change 1990s to 2090s DJF 2-m Temperature (F)



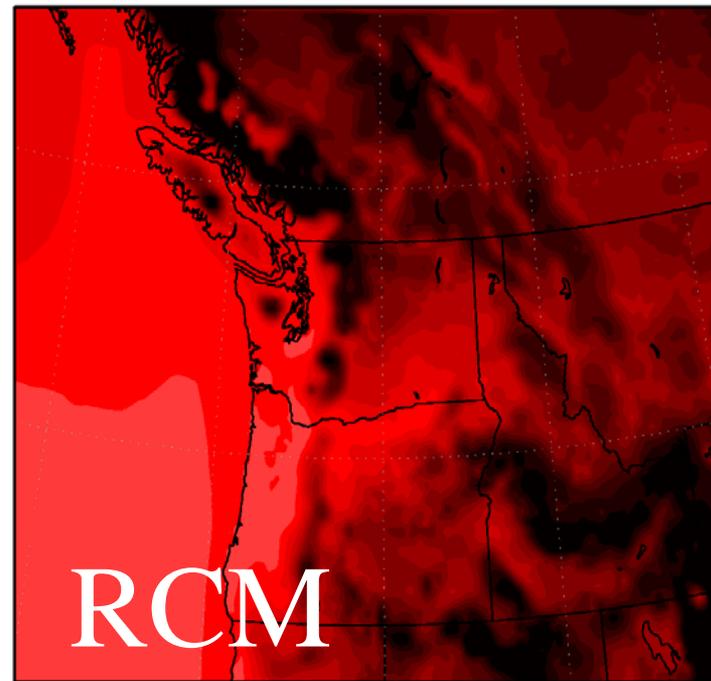
Global versus regional climate models for NW temperatures

ECHAM5 2-m Temperature (F) Change 1995 to 2095

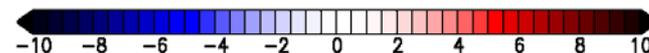


Global model

Change 1990s to 2090s MAM 2-m Temperature (F)



Regional climate model



1995 to 2095

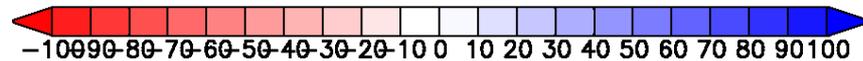
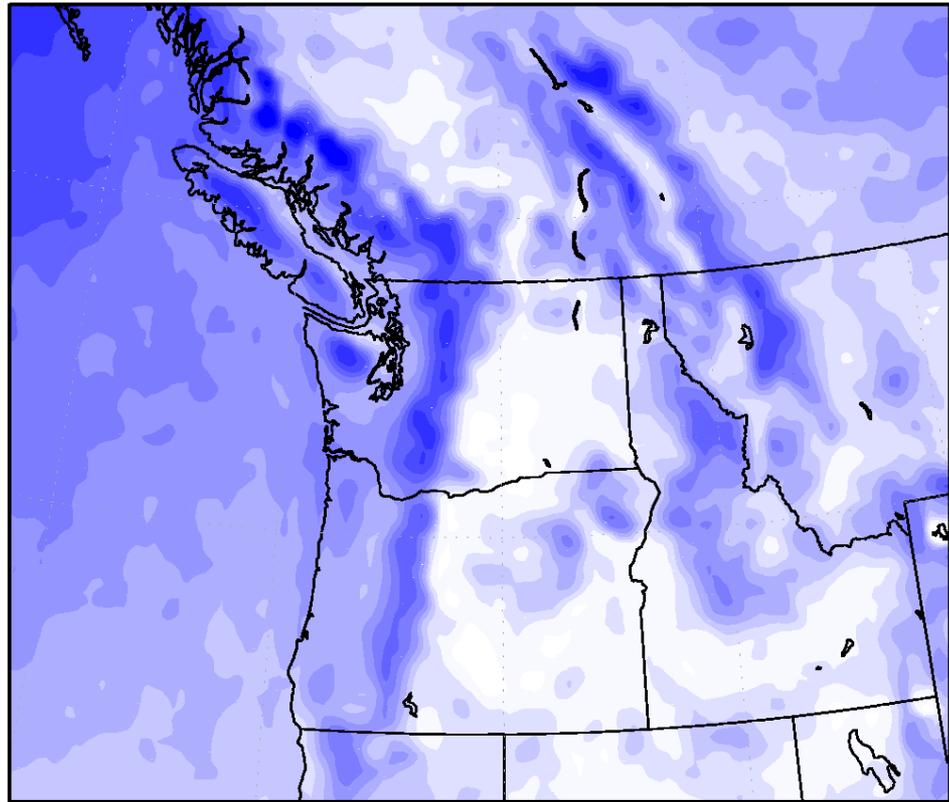
Why local hot spots?

Regions of melting snow on terrain



Change in springtime low clouds

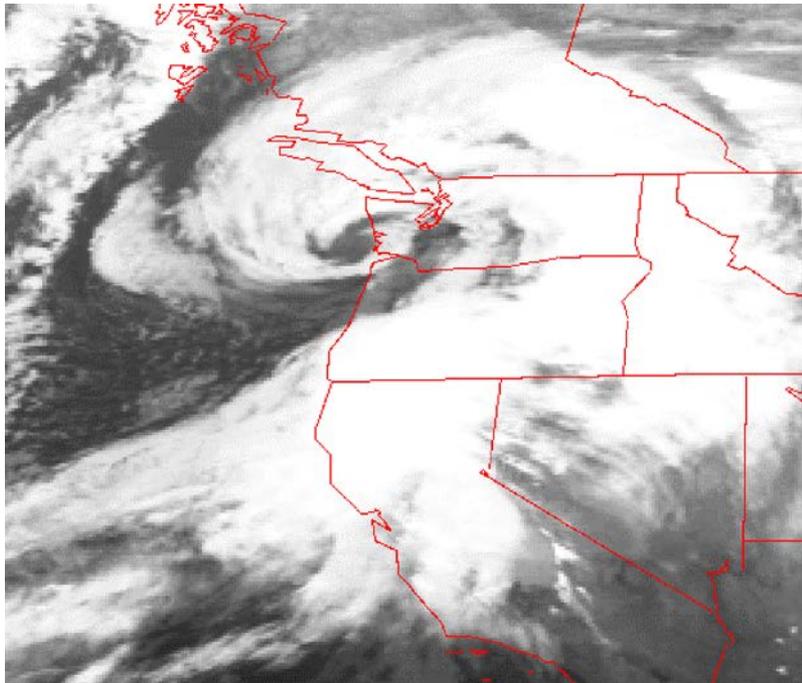
Percent Change 1990s to 2090s MAM Cloud Water



Only dynamical downscaling can inform about changes in short-period precipitation intensity



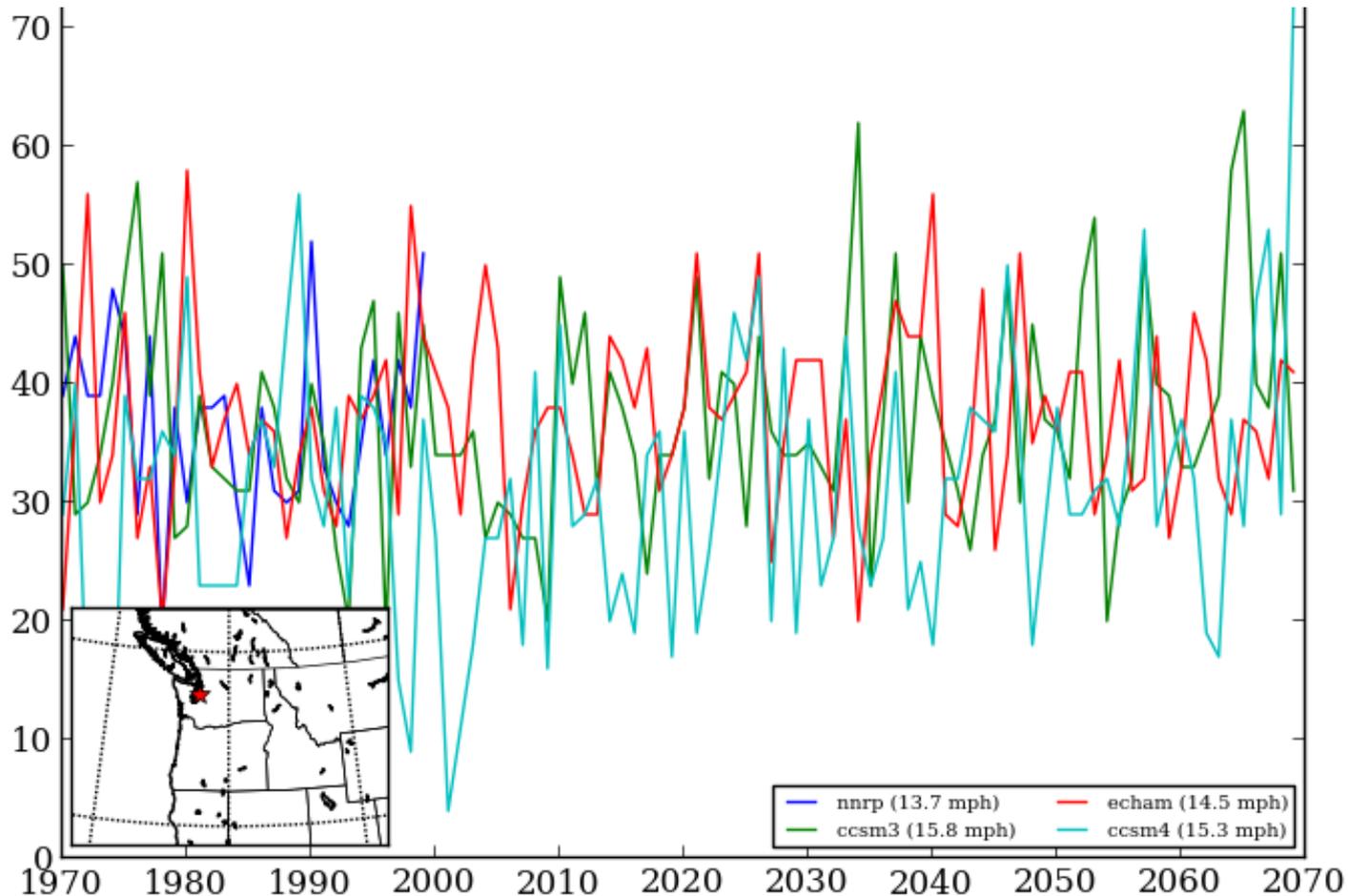
Only dynamical downscaling can tell us whether Pacific windstorms will bring stronger peak winds under GW



The Inauguration Day Storm
1993

It appears the answer is no.

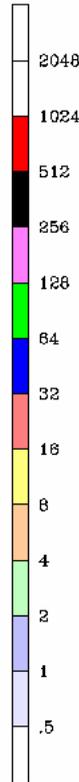
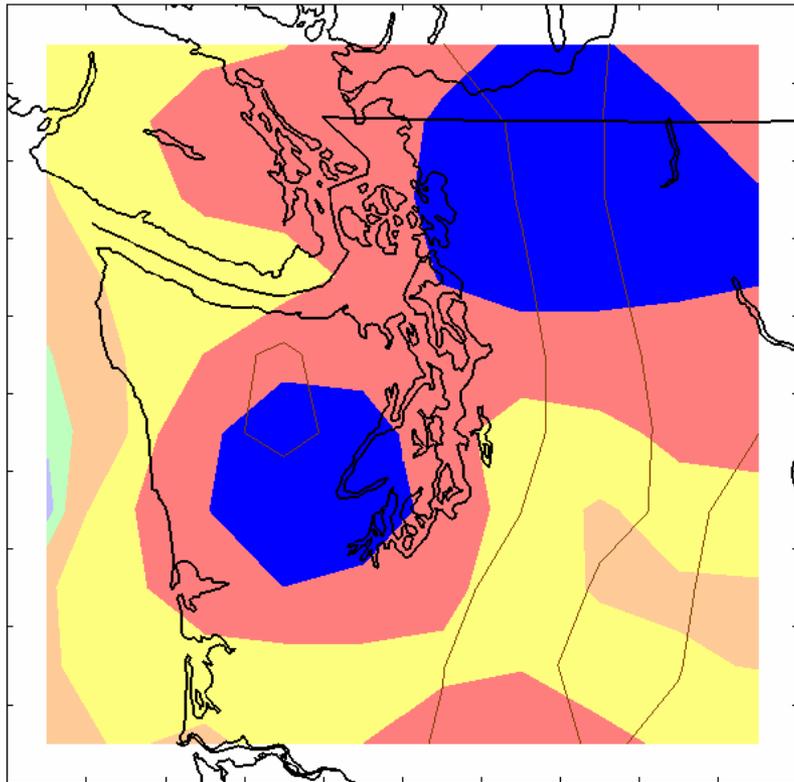
Number of times per year winds exceed a high-wind threshold (DJF) at Seattle for several RCM simulations



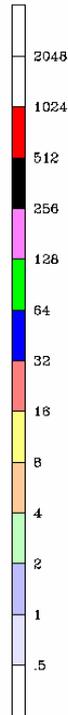
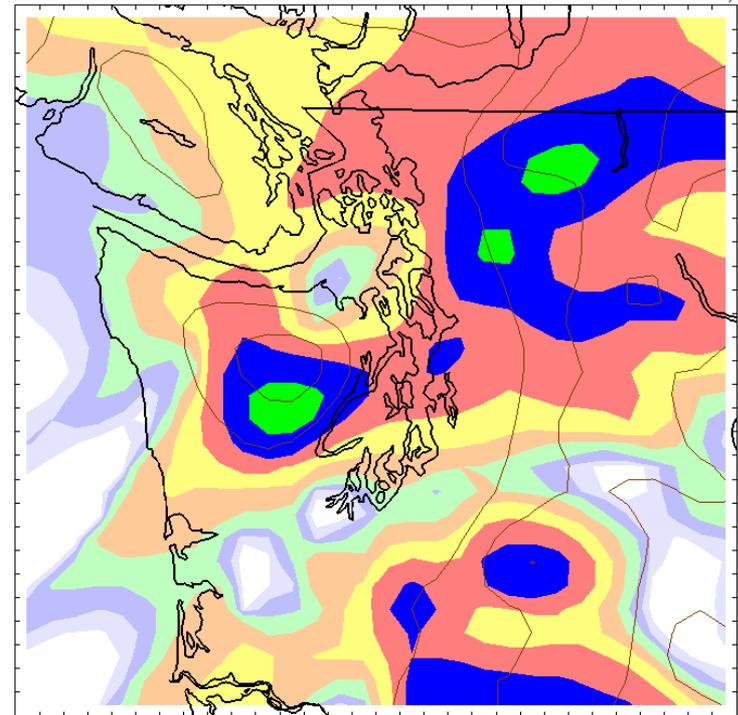
For our area, regional climate simulations must have a grid spacing of 12-15 km or less

Demonstrated by over 20 years of twice-daily simulations at 36-12-4 km grid spacing at the University of Washington, with objective verification

36-km



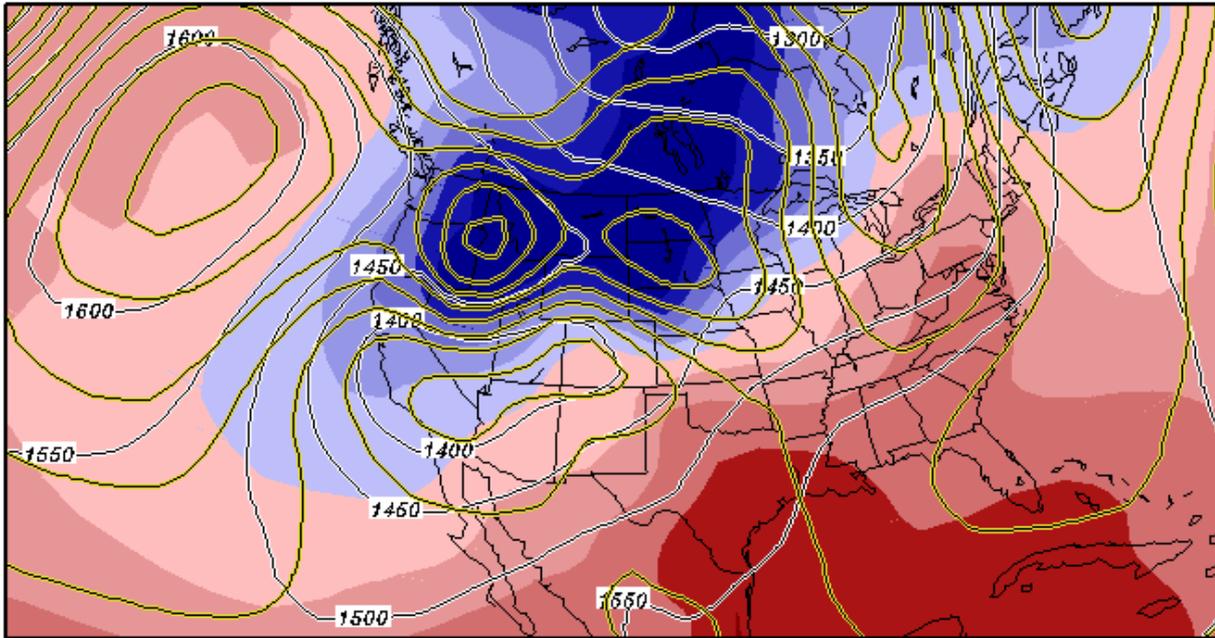
12-km



Low-Resolution Global Climate Models Can Produce Crazy Results Locally

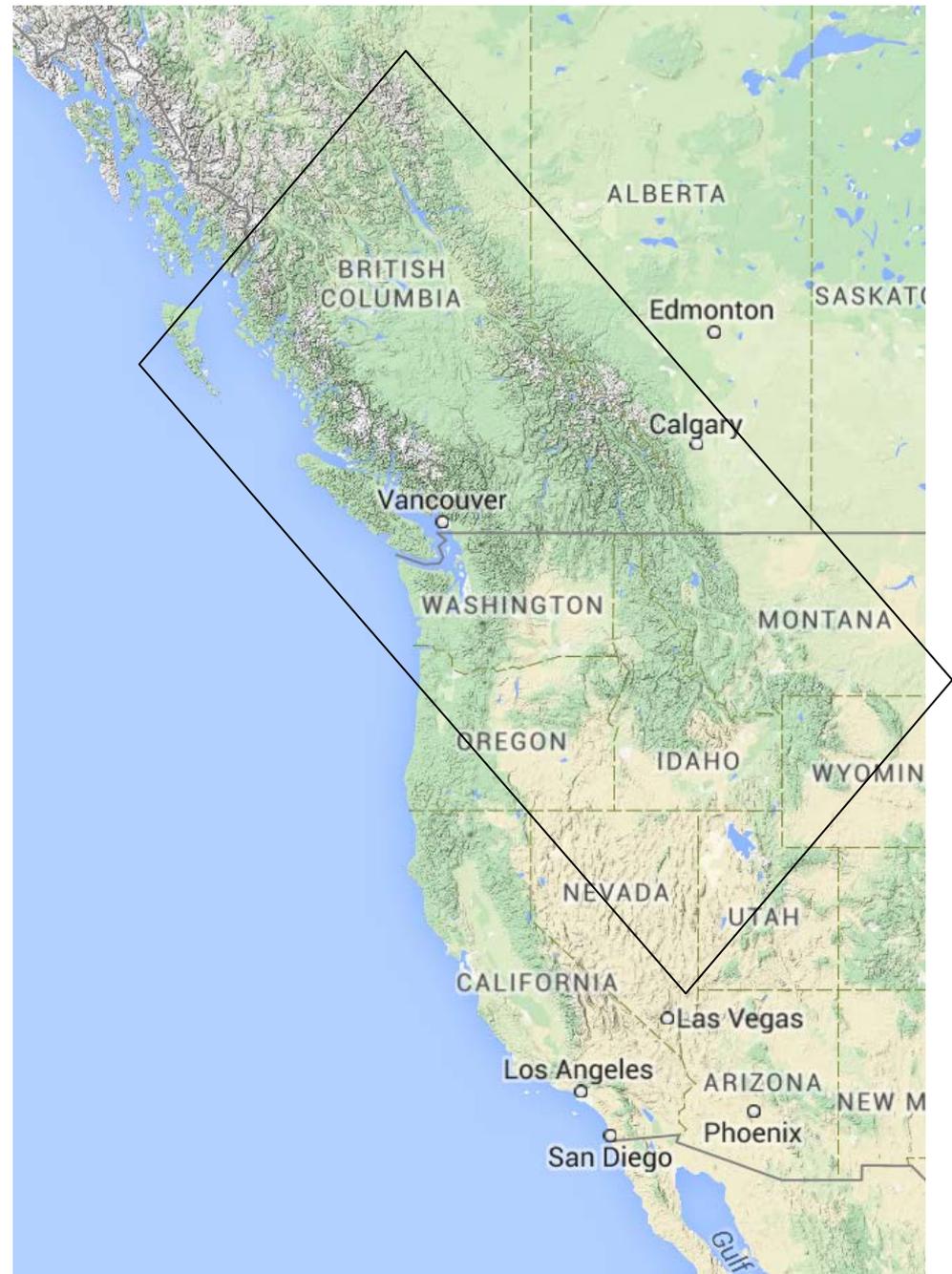


More Cold Waves Under Global Warming!



PCM
GCM
850 hPa
(about
5000 ft)
Temps

The
Problem?
Not enough
resolution to
get the
Rockies and
Cascades
correct

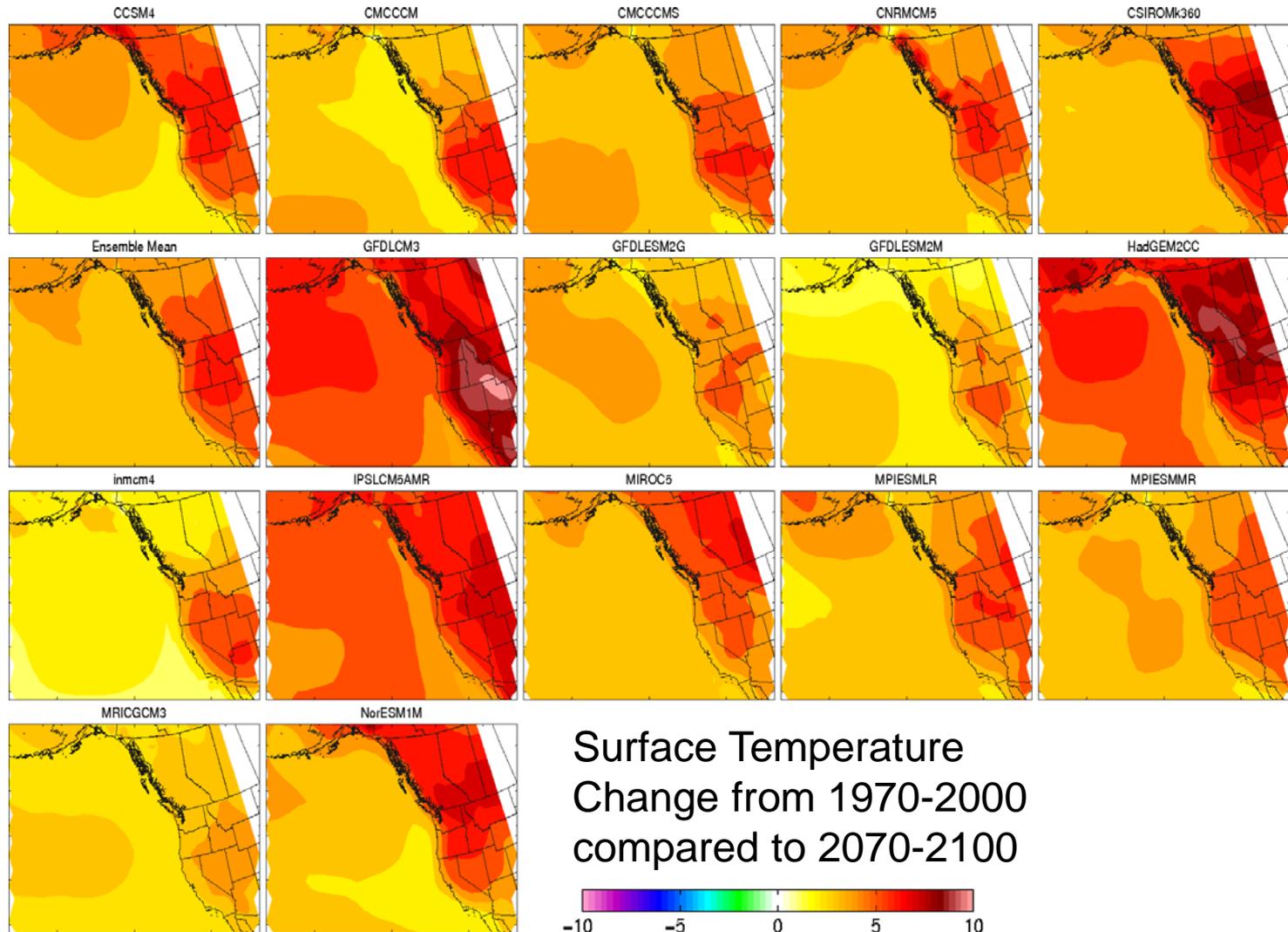


But there is another issue

There is substantial uncertainty and variation in GCM projections.



Temperature Change from CMIP-5 GCMs Vary



Thus, we must downscale large numbers of GCM simulations to explore the potential variability of regional climate impacts and to produce **probabilities of what will happen.**

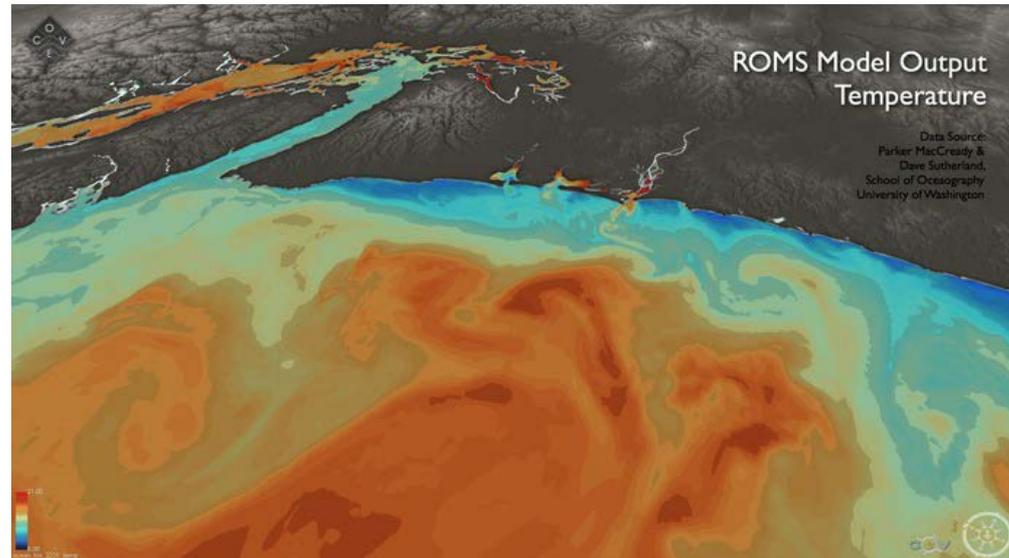
How to Explore Uncertainties

- GCMs from many different groups/centers
- GCMs starting on different dates
- Varying physics in RCMs
- Varying start dates in RCMs
- Using GCMs with various amounts of greenhouse gases



And more...

We must couple regional atmospheric climate models with ocean, air chemistry, hydrological and other models to understand the **implications of climate change.**



To do all this work is a large but doable task. Why not accomplish it together, sharing the costs and effort?



Can Combine Regional Resources

- University of Washington
- Washington State
- Oregon State
- University of Idaho
- PNNL
- Private Sector (e.g., Amazon)
-and more

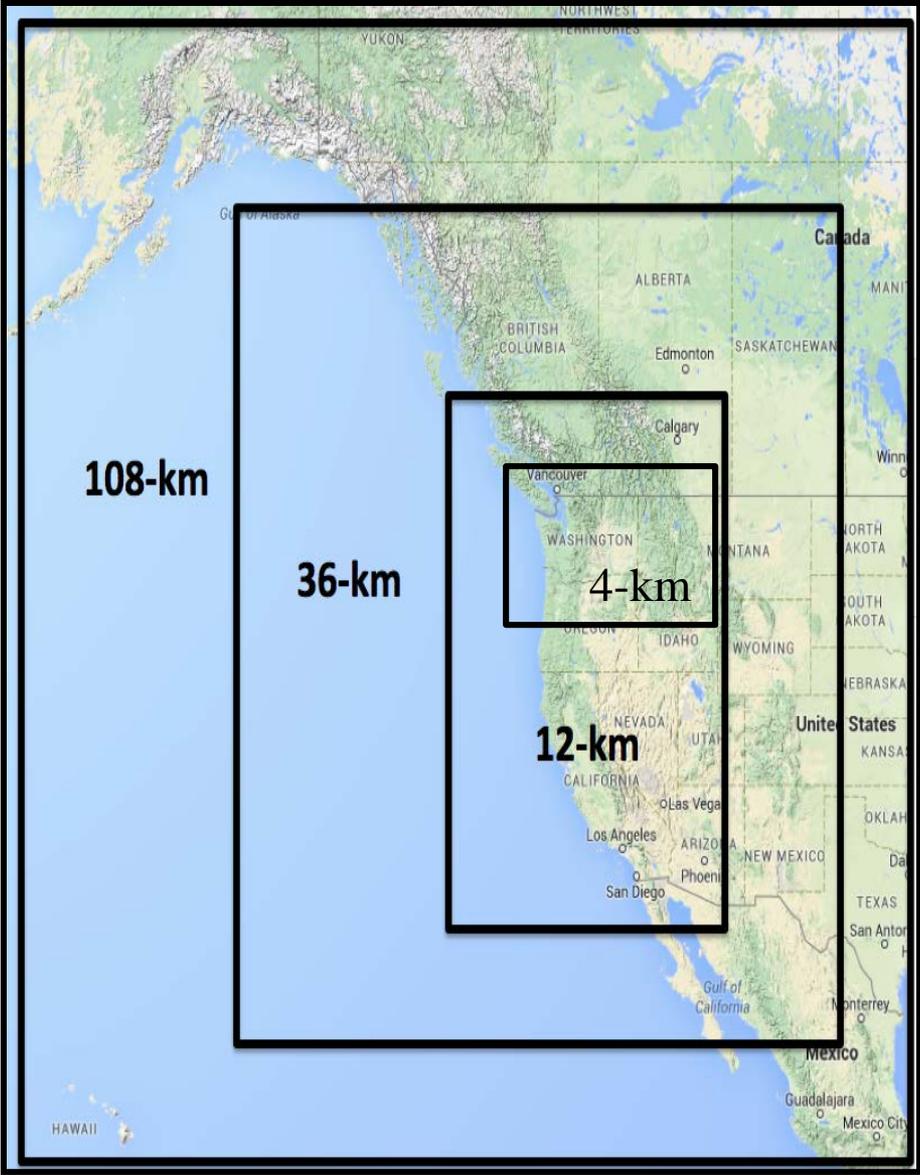


Proposal: The Northwest Regional Climate Modeling Consortium

- Combine resources of regional government entities, state and Federal agencies, foundations, academic institutions, tribes, and others.
- Similar to the current NW Modeling Consortium, with decisions could be made by contributing stakeholders

Regional Climate Modeling Consortium Tasks

- Acquire sufficient computer resources for regional climate model dynamical downscaling.
- Acquire GCM runs and filter out poor performers
- **Run dozens of high-res regional climate simulations for 100-150 years**
- **Apply sophisticated statistical post-processing**
- **Run ancillary modeling systems, such a hydrological models.**



The Work Has Begun

- Amazon has provided initial support for personnel and computer resources.
- Now doing dynamical downscaling for WRF using 15 GCMs
- But not sustainable without more support



Regional Climate Modeling is Essential for Preparing Our State: Can We Make it Happen?



The END

