Changes in extreme IVT on the US west coast in NA-CORDEX, and relationship to mountain and inland precipitation

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Coauthors: Dustin Swales, Jamie Scott, Kelly Mahoney, Mike Alexander, Rachel McCrary

Funding from: SERDP DOD • EPA • DOE

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

PI Mike Wright, Mid Pacific

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Are mountains drying?

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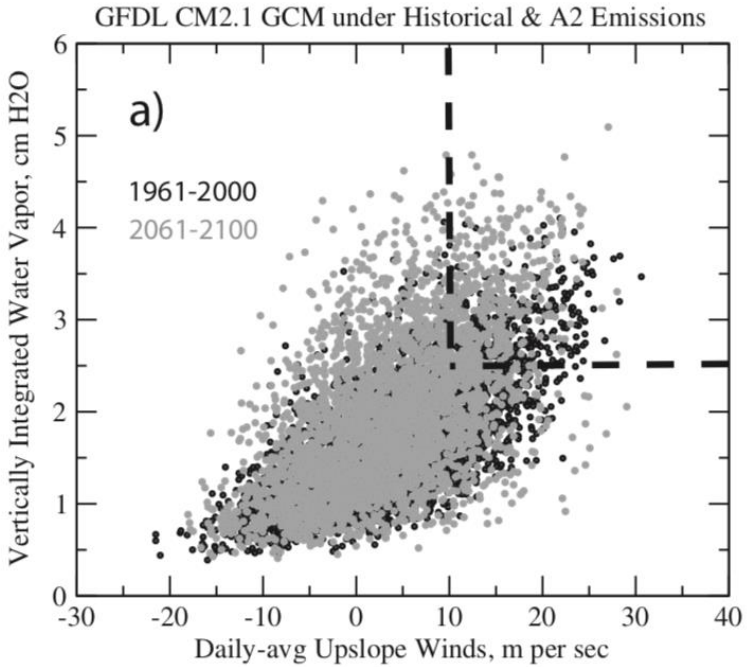
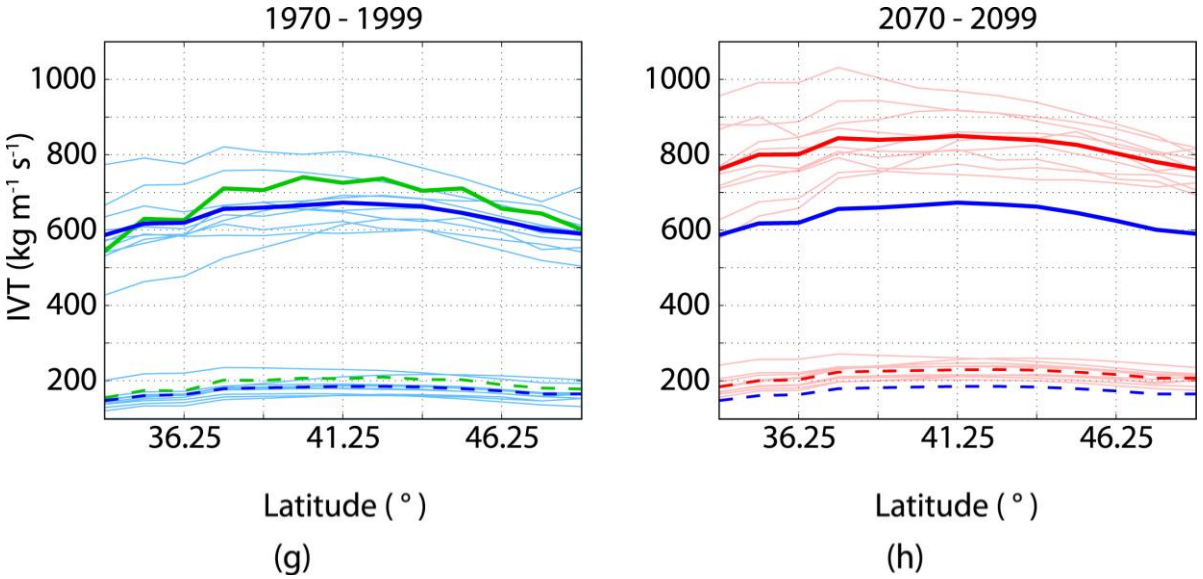
What has previous work shown? ARs/IVT generally increase by end of century



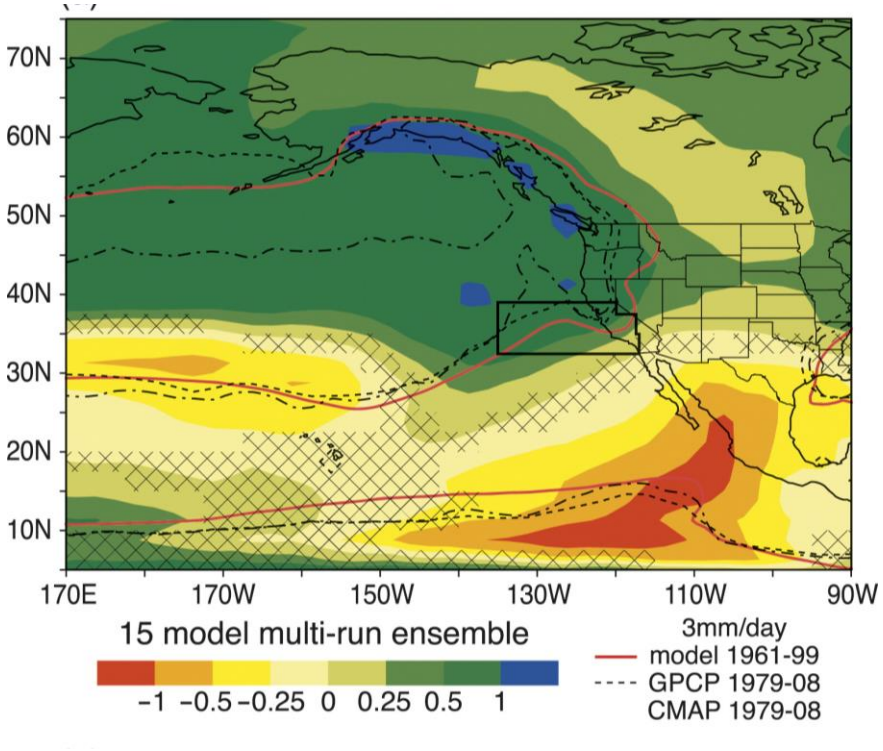
From Dettinger 2011: NOAA GFDL's GCM Integrated water vapor (Y-axis) versus Upslope winds (X-axis) for historical period (black) and end-of-century projections (grey).



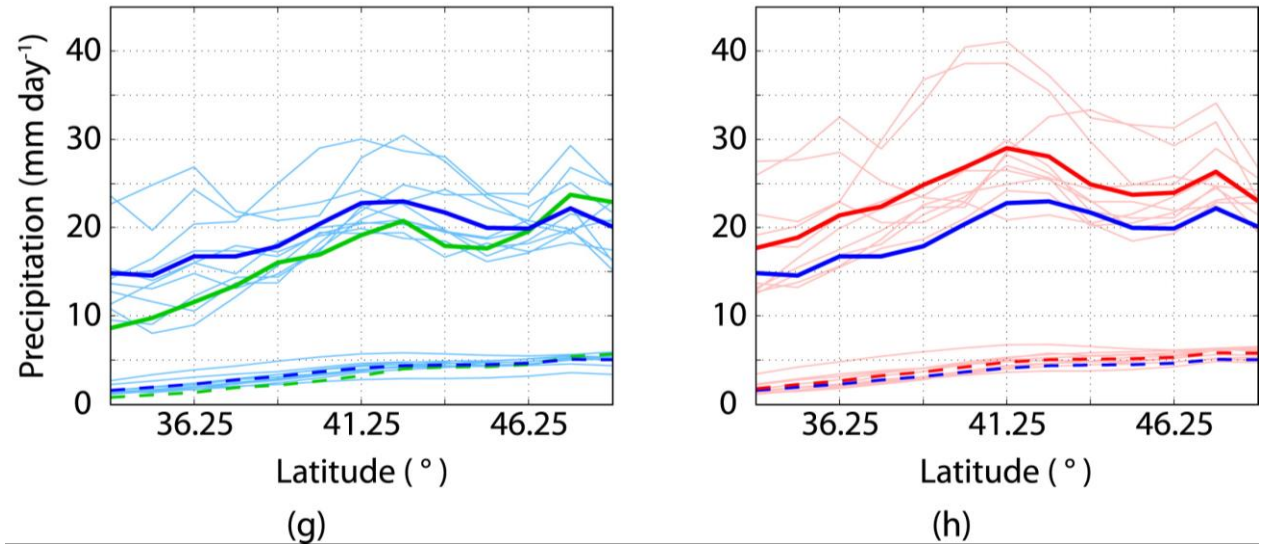
From Warner et al. 2015: (upper lines) 10 GCM 99th percentile Integrated Water Vapor Transport (IVT), for historical (left) and future (right, with blue line showing historical mean) periods, at US west coast locations. Lighter lines show individual model values and bold lines show multi-model means.

Payne and Magnusdottir 2015 find an equatorward broadening of AR locations, increased frequency, and increased average peak IVT in ARs, but no shift in the distribution of AR IVT.

What has previous work shown? Precipitation also generally increase by end of century (but more uncertain)



From Neelin et al. 2014: Multi-model mean projected change in daily DJF precipitation (mm/day).



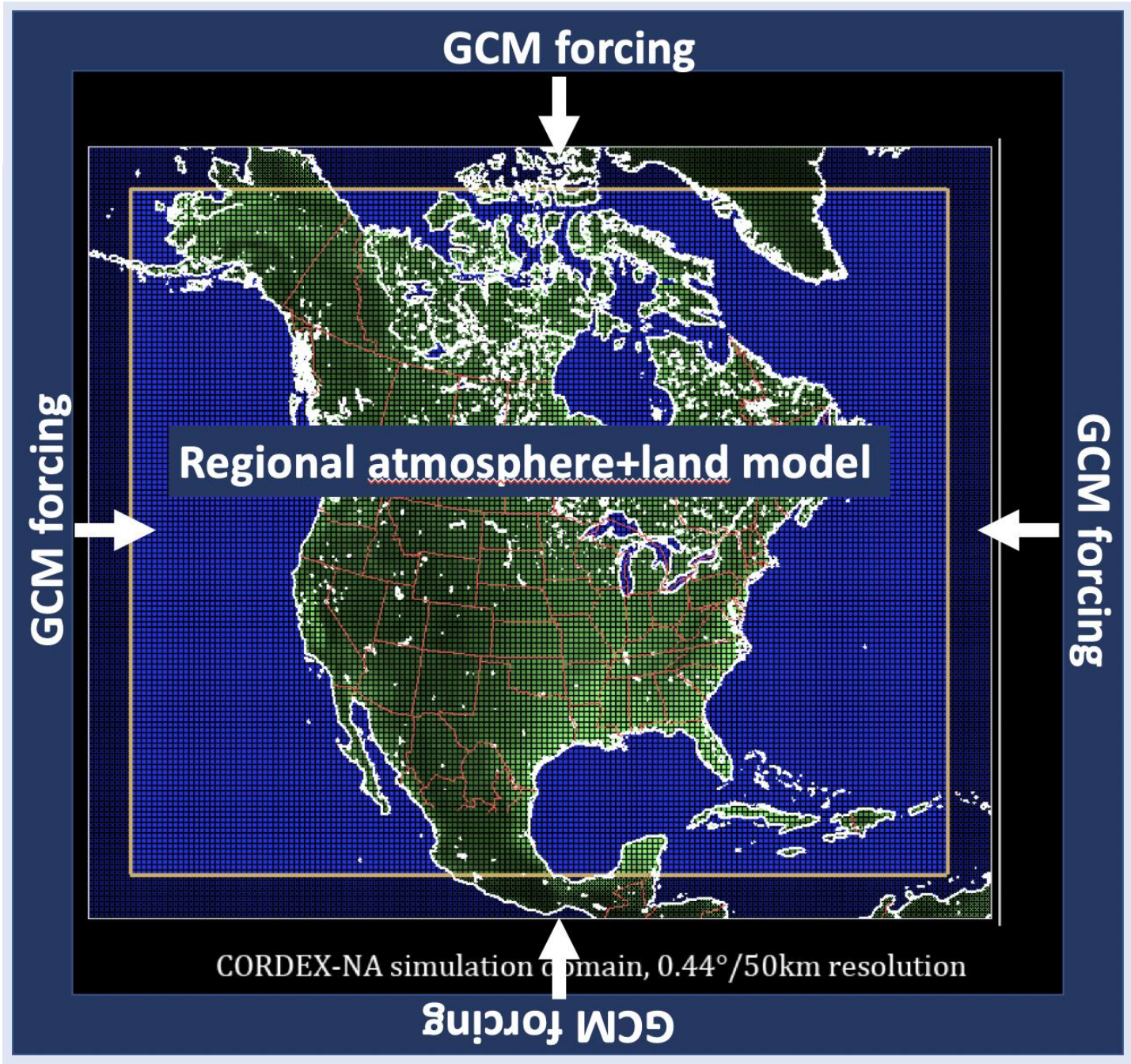
Warner et al. 2015: (upper lines) 10 GCM 99th percentile precipitation for historical (left) and future (right, with blue line showing historical mean) periods , at US west coast locations. Lighter lines show individual model values and bold lines show multi-model means.

Swain et al. 2018: Find a projected increase in frequency of extremely wet cool seasons from the CESM large ensemble, as well as increased swings between extreme wet and extreme dry years.

Enter Regional Climate Models…

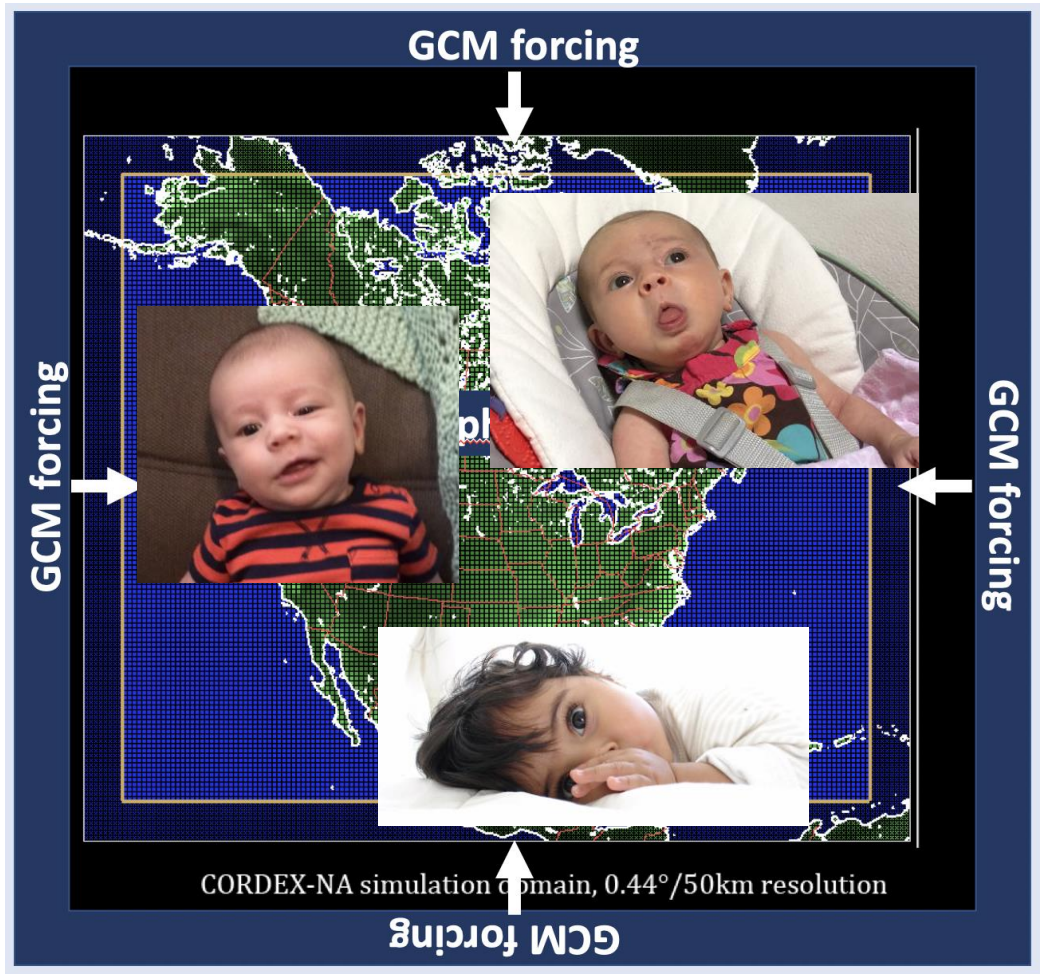
NA-CORDEX == **N**orth **A**merican **CO**ordinated **R**egional **D**ownscaling **EX**periment

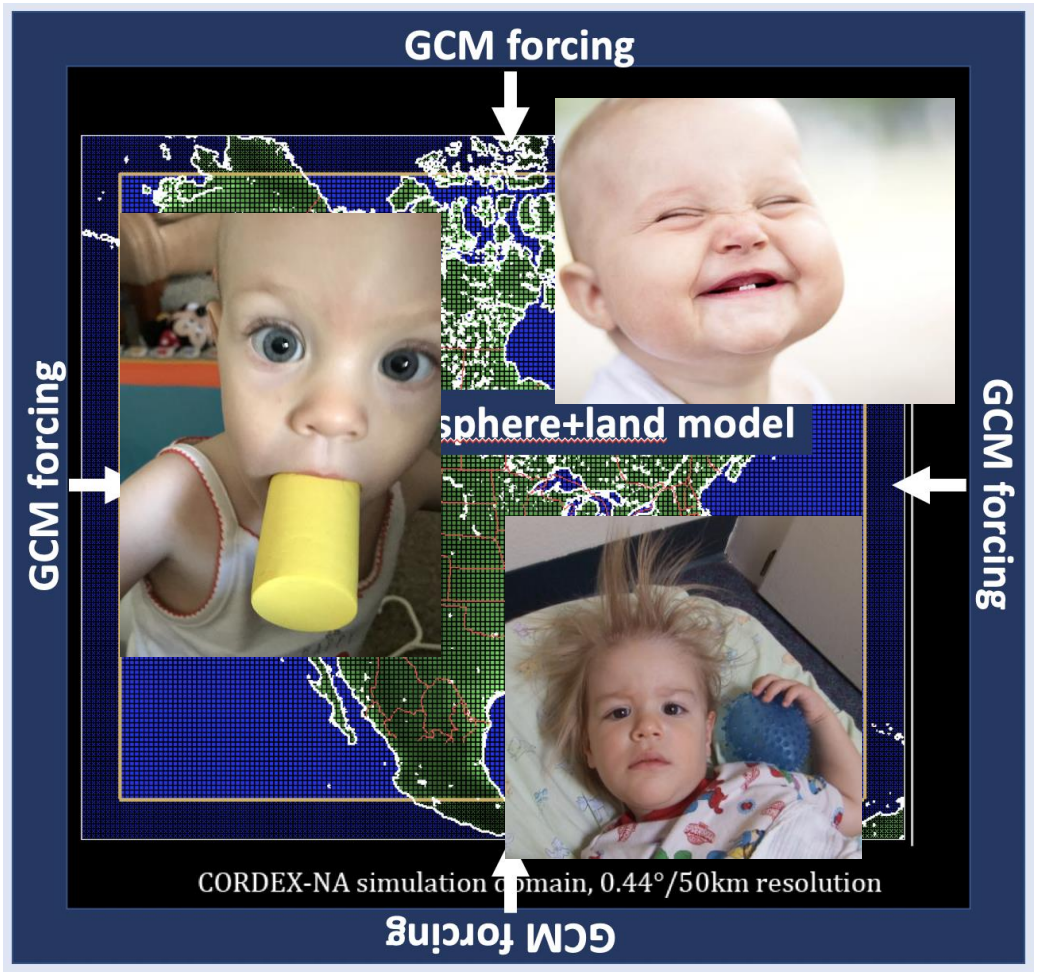
	CRCM5 (UQAM)	CRCM5 (OURANOS)	RCA4	RegCM4	WRF	CanRCM4	HIRHAM5	RCP	ECS (°C)
ERA-Int	0.44° 0.22° 0.11°	0.22°	0.44°	50km 25km	50km 25km	0.44° 0.22°	0.44°		
HadGEM2-ES								4.5	4.6
				50km 25km	50km* 25km*			8.5	
CanESM2	0.44°		0.44°			0.44° 0.22°		4.5	3.7
	0.44° 0.22°	0.22°	0.44°			0.44° 0.22°		8.5	
MPI-ESM-LR	0.44°							4.5	3.6
	0.22° 0.44°	0.22°		50km* 25km*	50km 25km			8.5	
MPI-ESM-MR								4.5	3.4
	0.44° 0.22°							8.5	
EC-EARTH†			0.44°					2.6	~3.3
			0.44°				0.44°	4.5	
			0.44°				0.44°	8.5	
GFDL-ESM2M								4.5	2.4
		0.22°		50km 25km	50km* 25km*			8.5	
Access	PoC	PoC	ESGF	PoC	PoC	CCCma	ESGF		
Institution	UQAM	OURANOS	SMHI	Iowa State *NCAR	U Arizona *NCAR	CCCma	DMI		
Modeler	K. Winger	S. Biner	G. Nikulin	R. Arritt *M. Bukovsky	H-I Chang *M. Bukovsky	J. Scinocca	O. Christensen		



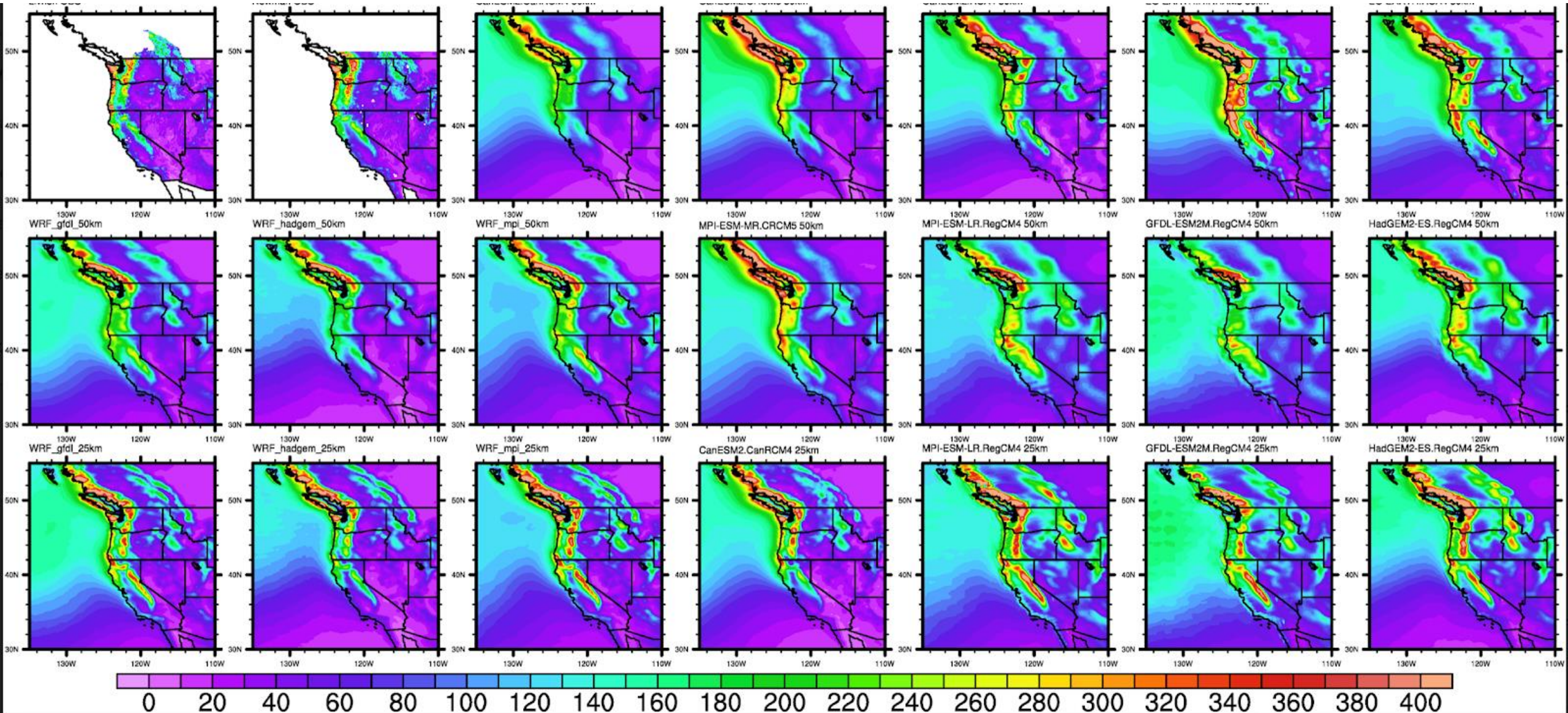
Enter Regional Climate Models…

GCM ‘babies’

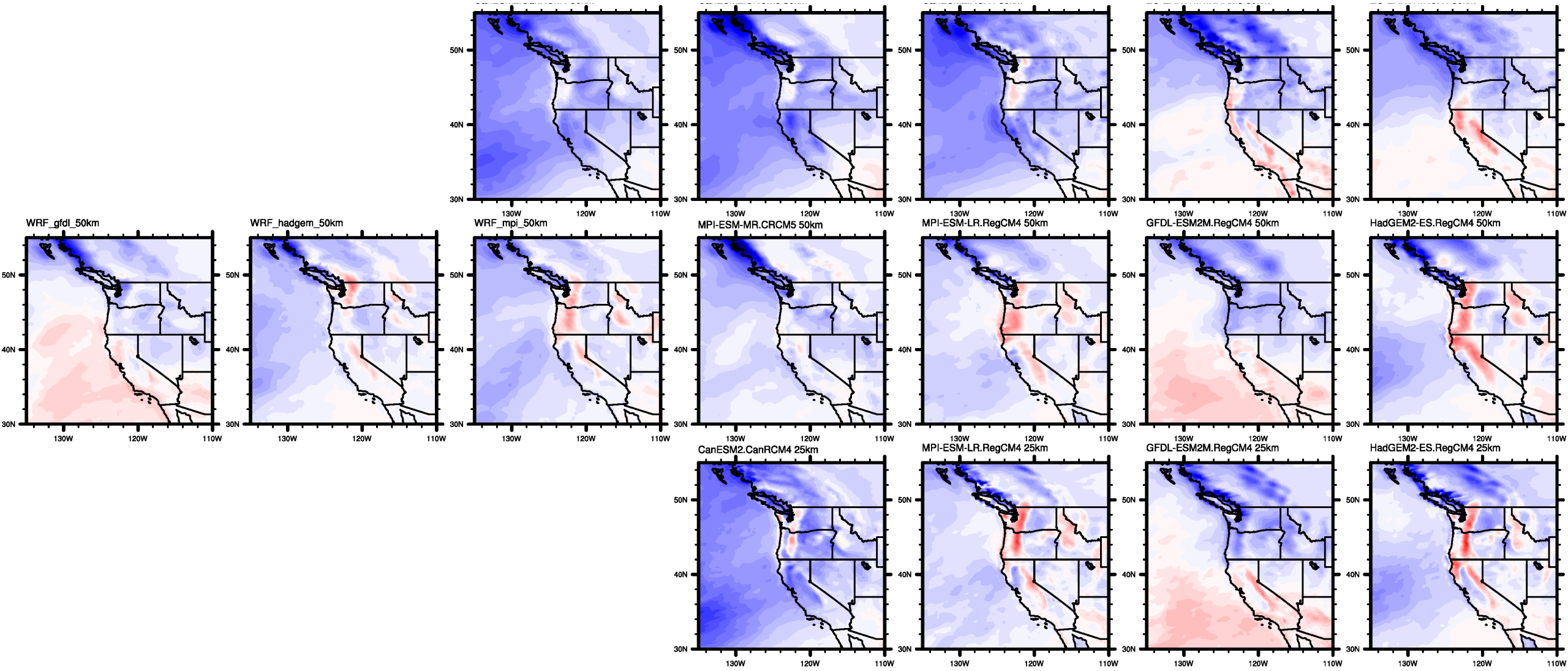




Cool season (Oct-Mar) mean monthly precipitation for 1980-2010. Observation-based estimates in upper left.



Projected change in cool season (Oct-Mar) mean monthly precipitation for 2070-2100 (future-historical)



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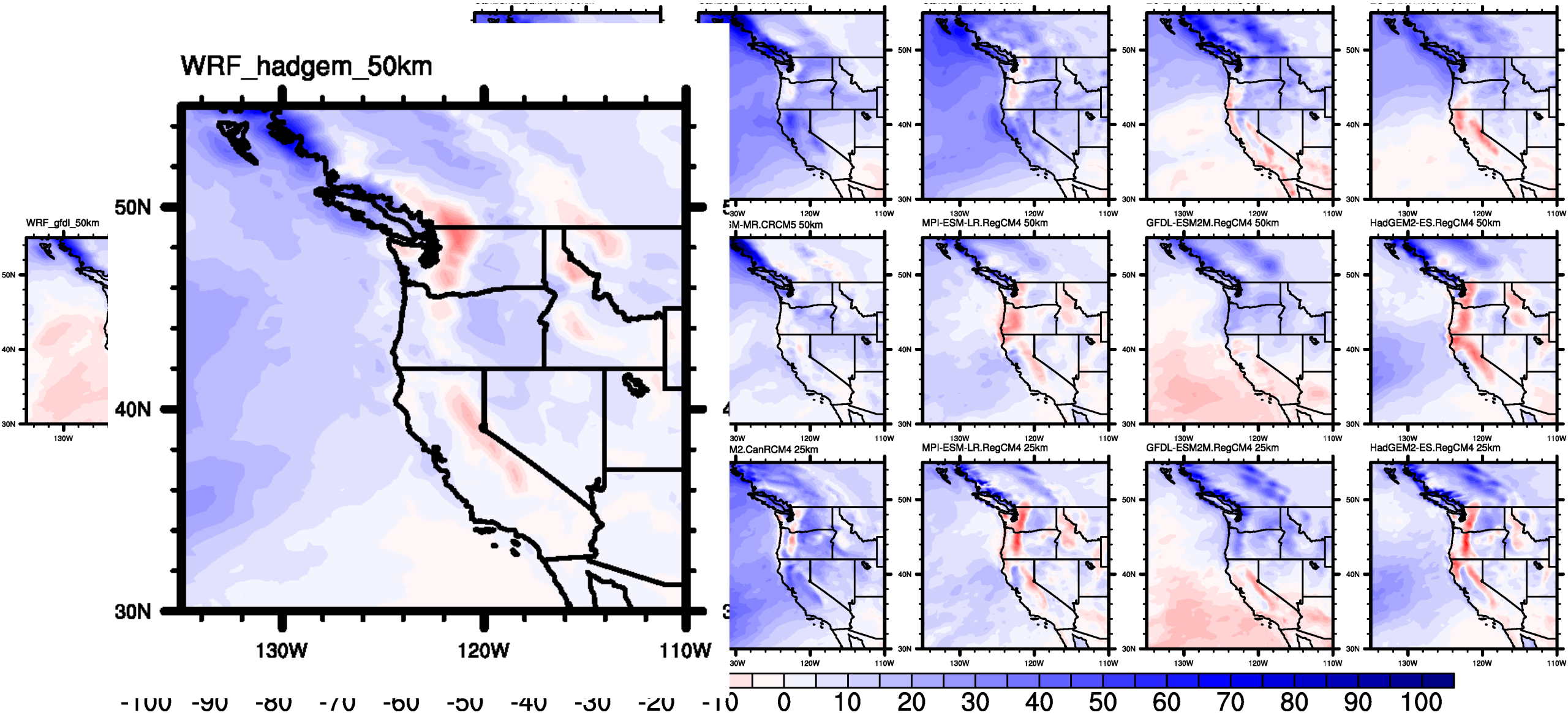

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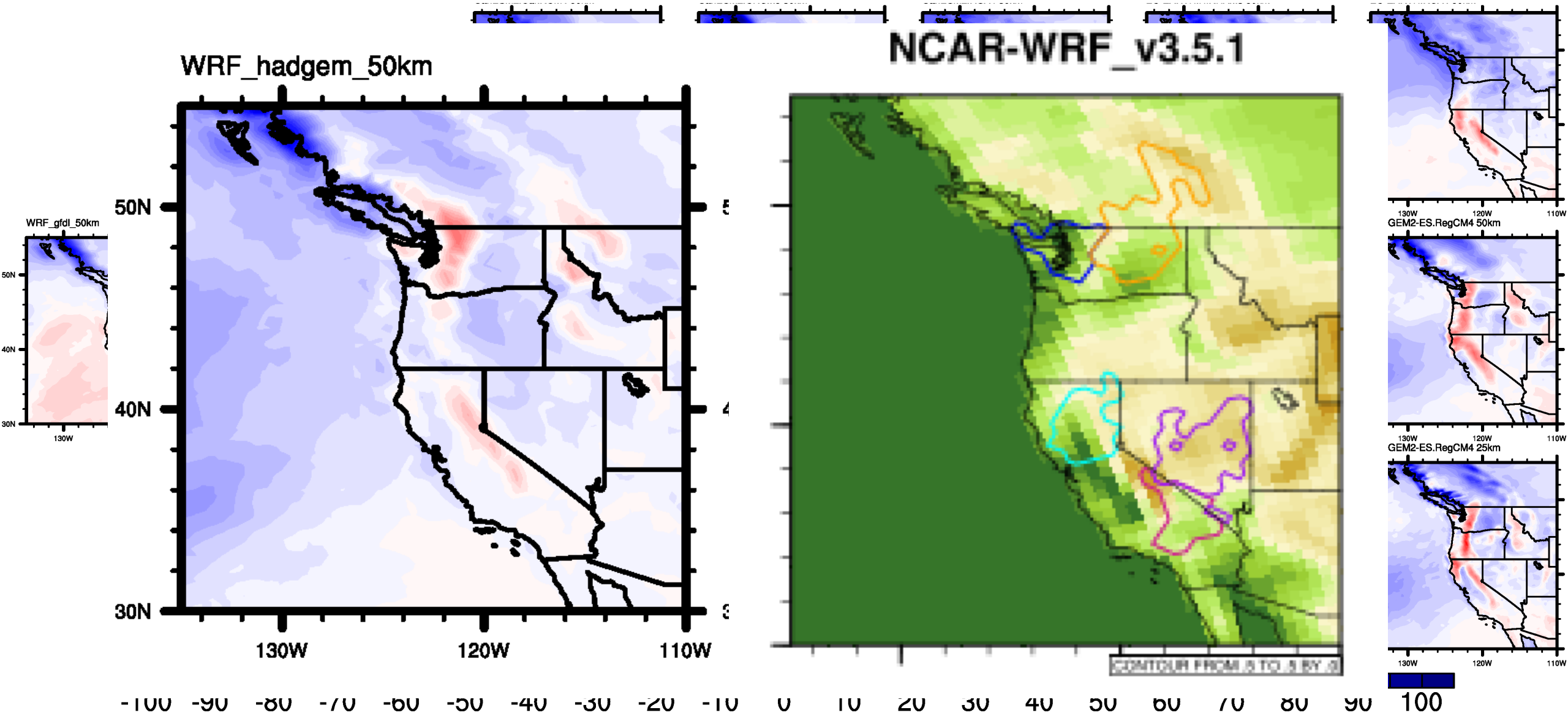

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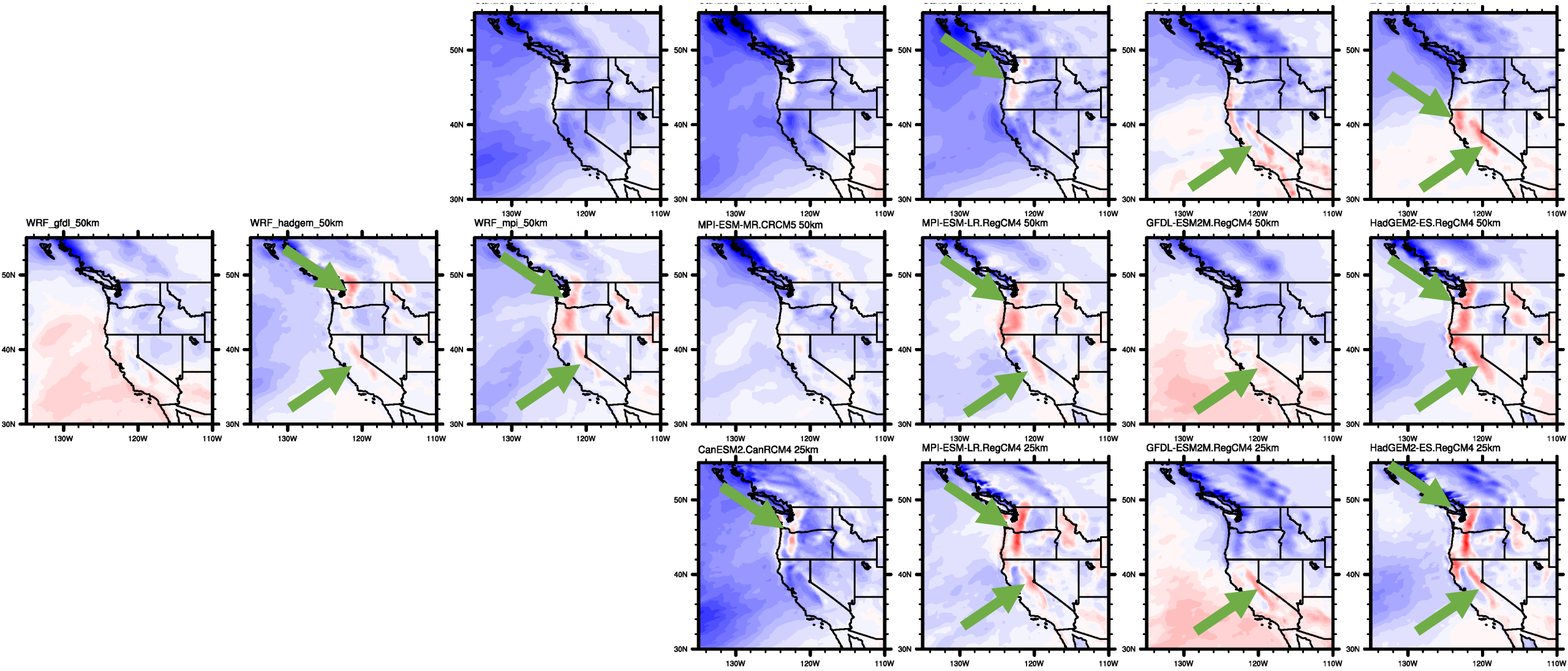
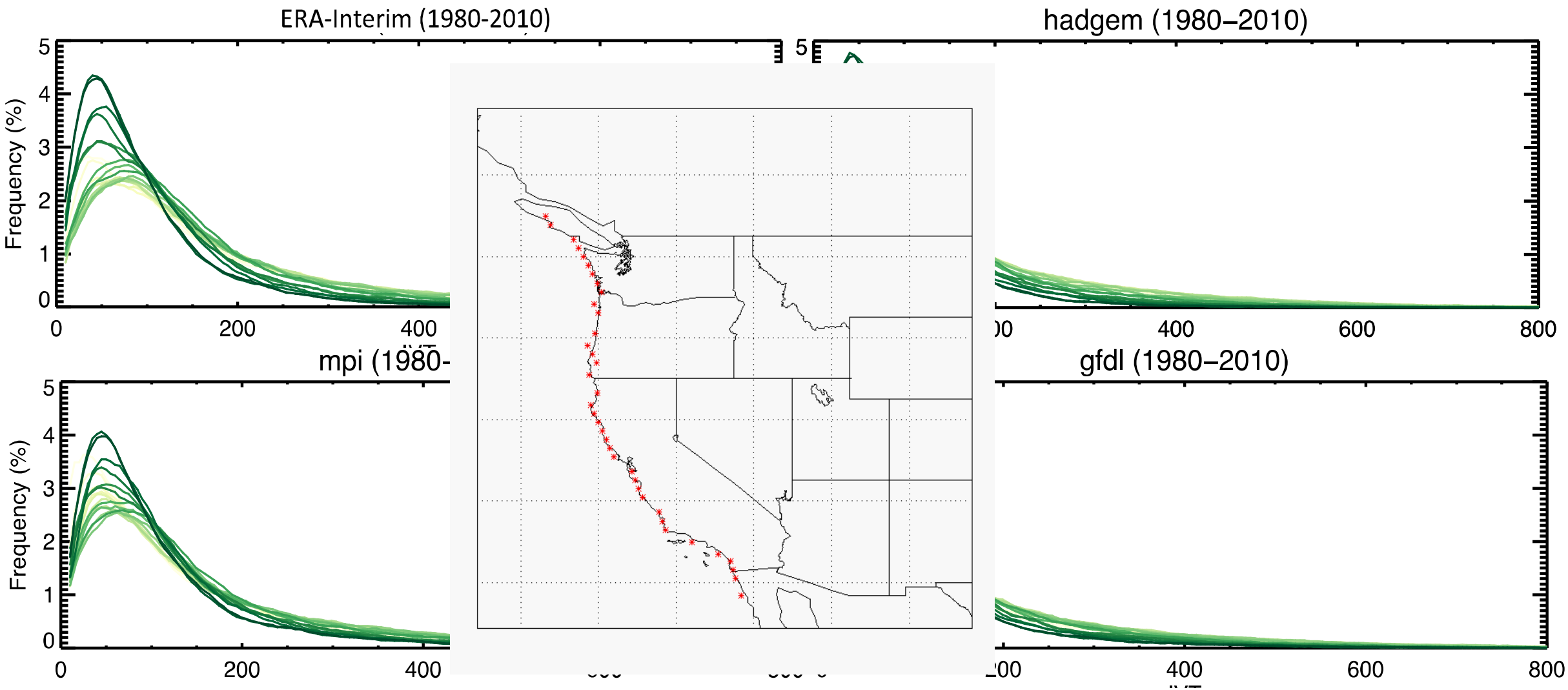


IVT at the coast: historical



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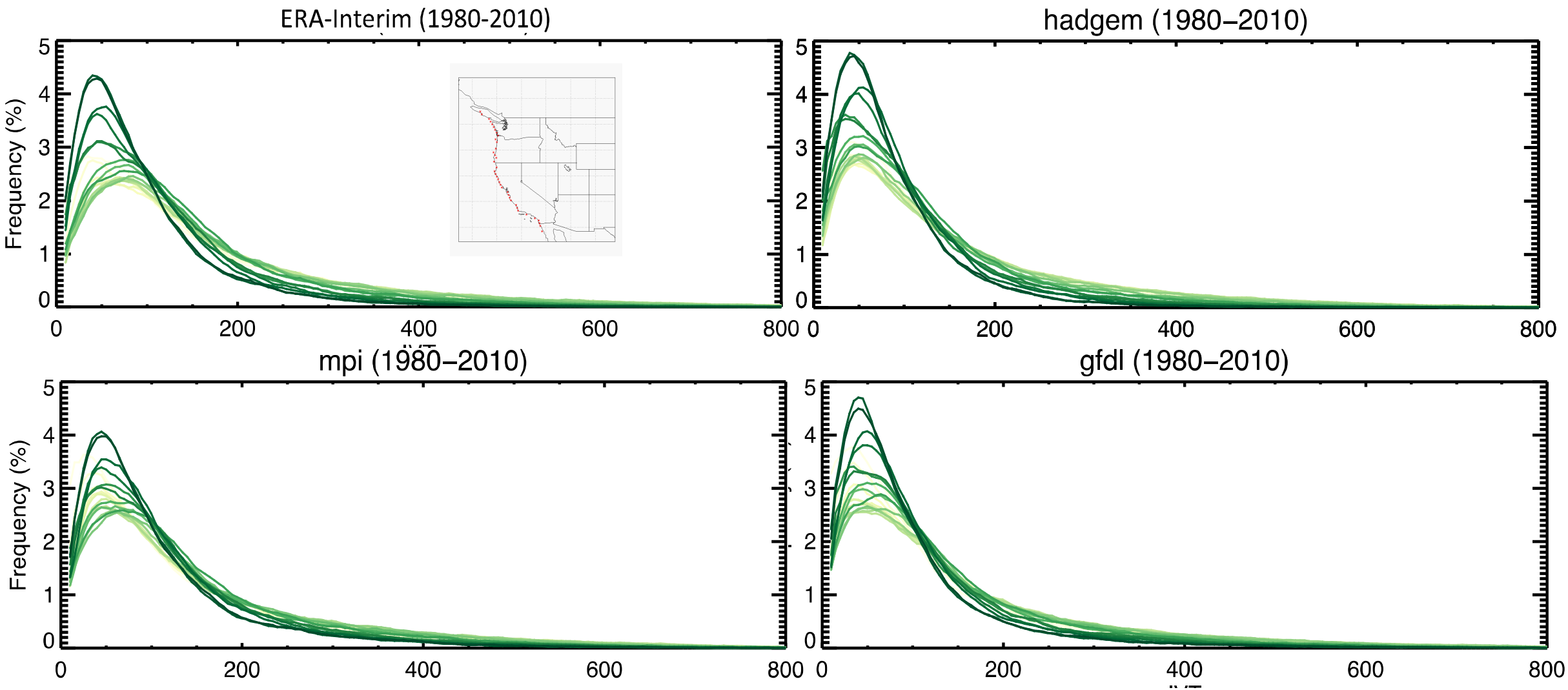


IVT at the coast: projected

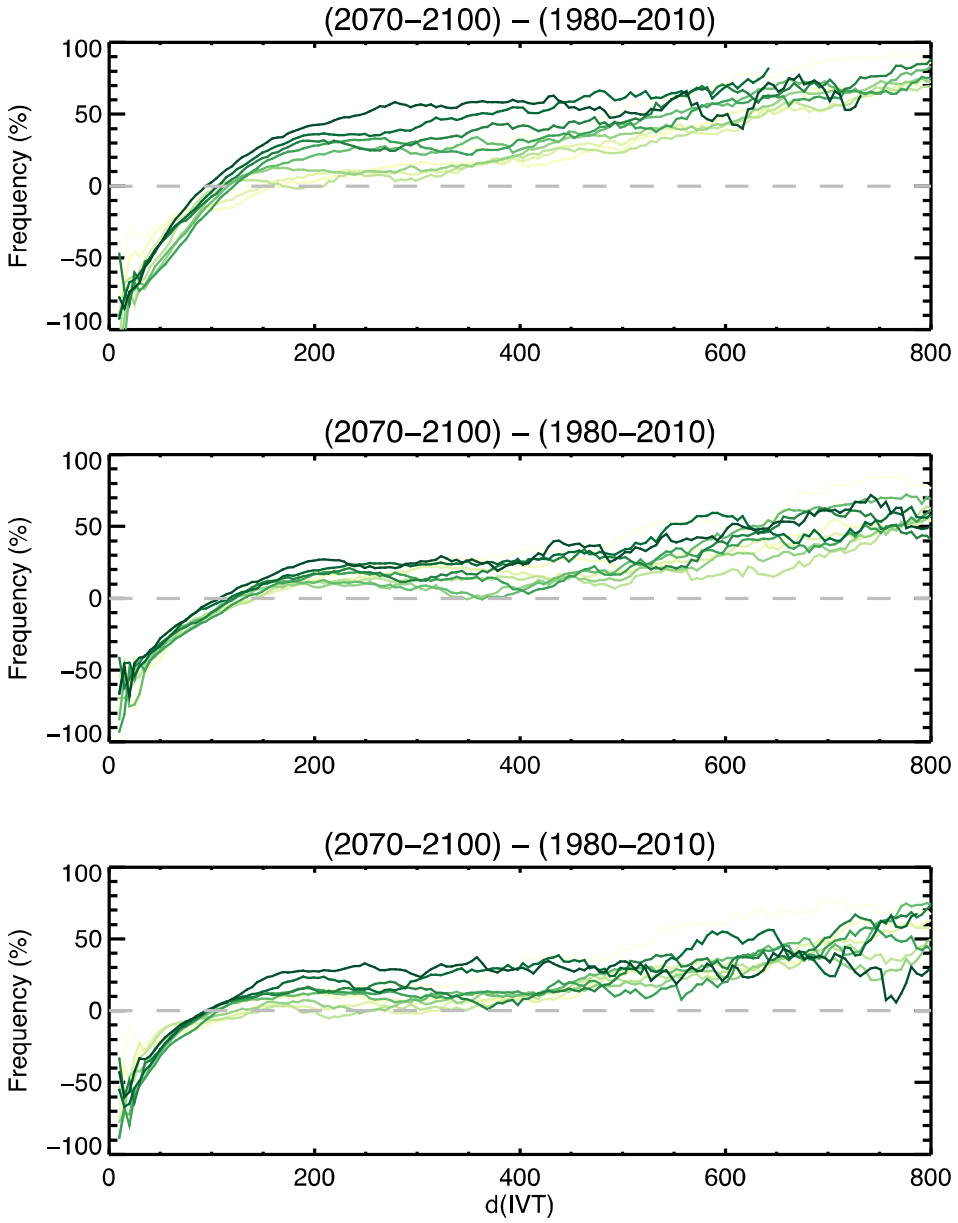


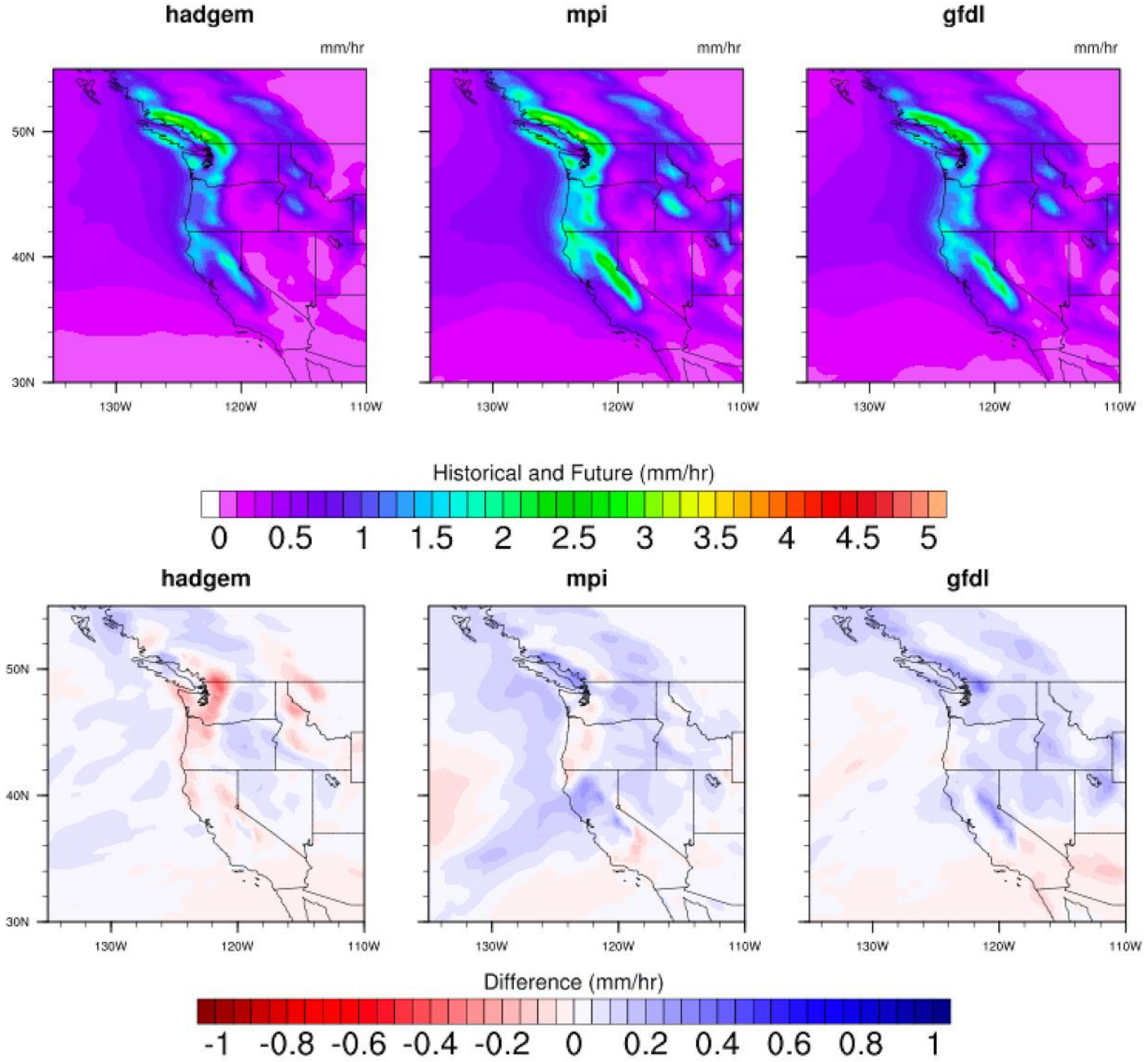
Figure displays the projected change in the distribution of coastal IVT events.

Shift in the distribution: Increased frequency of large IVT events. This shift toward events with larger IVT is generally larger for southern coastal locations (dark green) than for northern coastal locations (light green).

IVT ‘events’ (not only ARs) at the coast: Precipitation

IVT ‘events’ defined by the 96th percentile from the historical distributions – not only ARs (“I’m lookin at you, cut-off lows”)

Top row shows average hourly IVT event precipitation from the historical period, and the bottom row shows the projected change in hourly IVT event precip.



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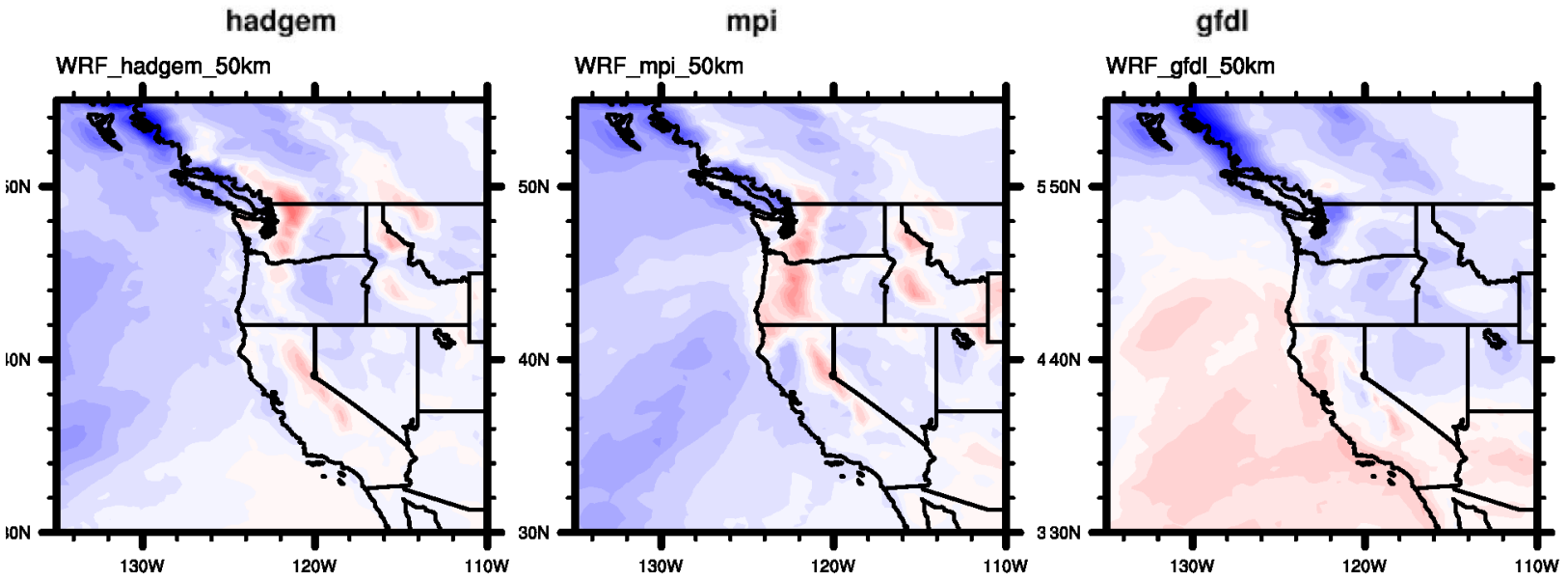

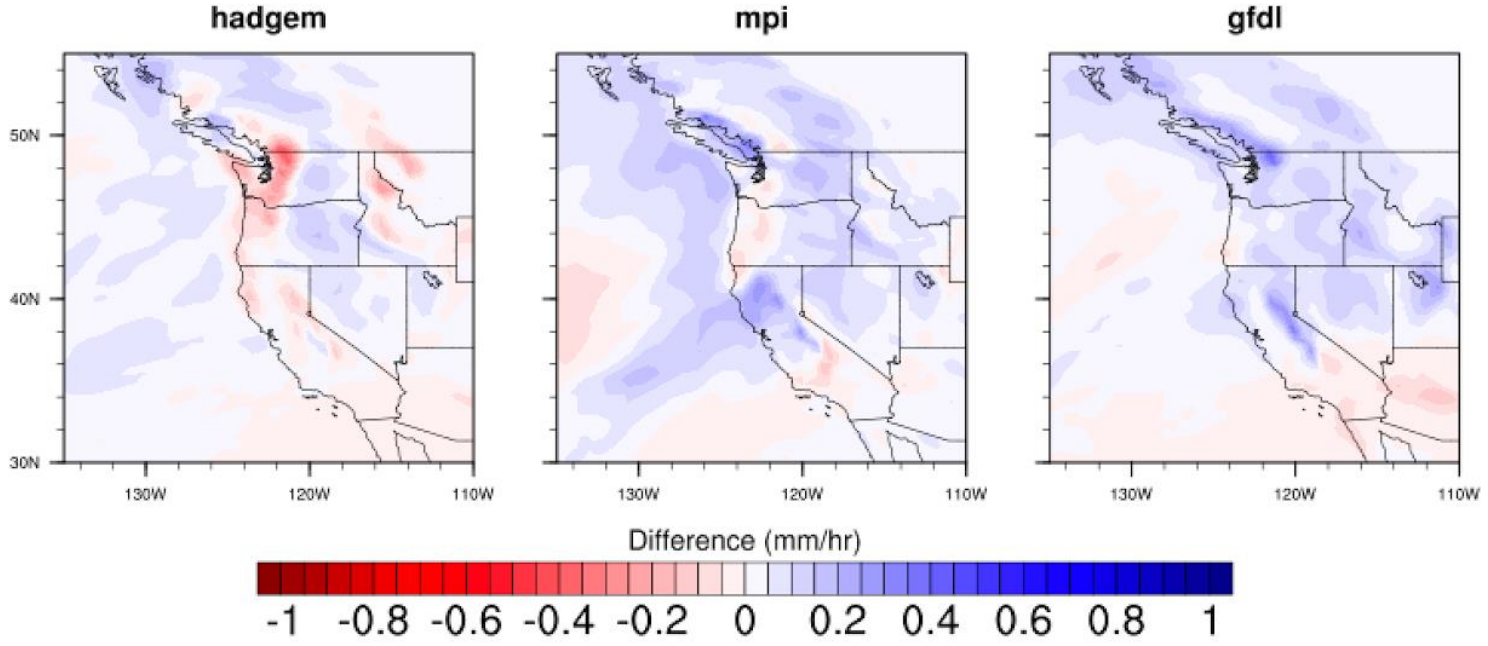

Key Takeaways and Next steps

- Current generation GCMs do not resolve terrain very well: This has physical implications
- NA-CORDEX (GCM 'babies'):


  - Shows increased frequency of large IVT events (consistent with GCM projections)
  - Shows projected reductions in cool season precipitation in some of the mountainous regions of the Western US (not seen with GCMs)
  - IVT 'event' precipitation also decreases at some high elevations, but the relationship to the cool season mean decreases is complex
- Reason for 'mountain drying' is likely a combination of signals from shift in the storm track (and resulting IVT 'plinko') and precipitation efficiency impacts: More research to come!

Key Takeaways and Next steps

- FIRO relevance: Both the previous GCM work and this RCM study point to a future that is more variable and more difficult to manage from a floods/droughts perspective

- This talk showed precipitation -- snow…
- Future work: Explore impacts of even finer grid spacing and sensitivity to physics assumptions with an intermediate complexity atmospheric model.