The Role of Tropical Moisture on Atmospheric Rivers' Vapor Transport and Landfall

Huancui Hu, Francina Dominguez

Department of Atmospheric Sciences
University of Illinois, Urbana-Champaign

ILLINOIS

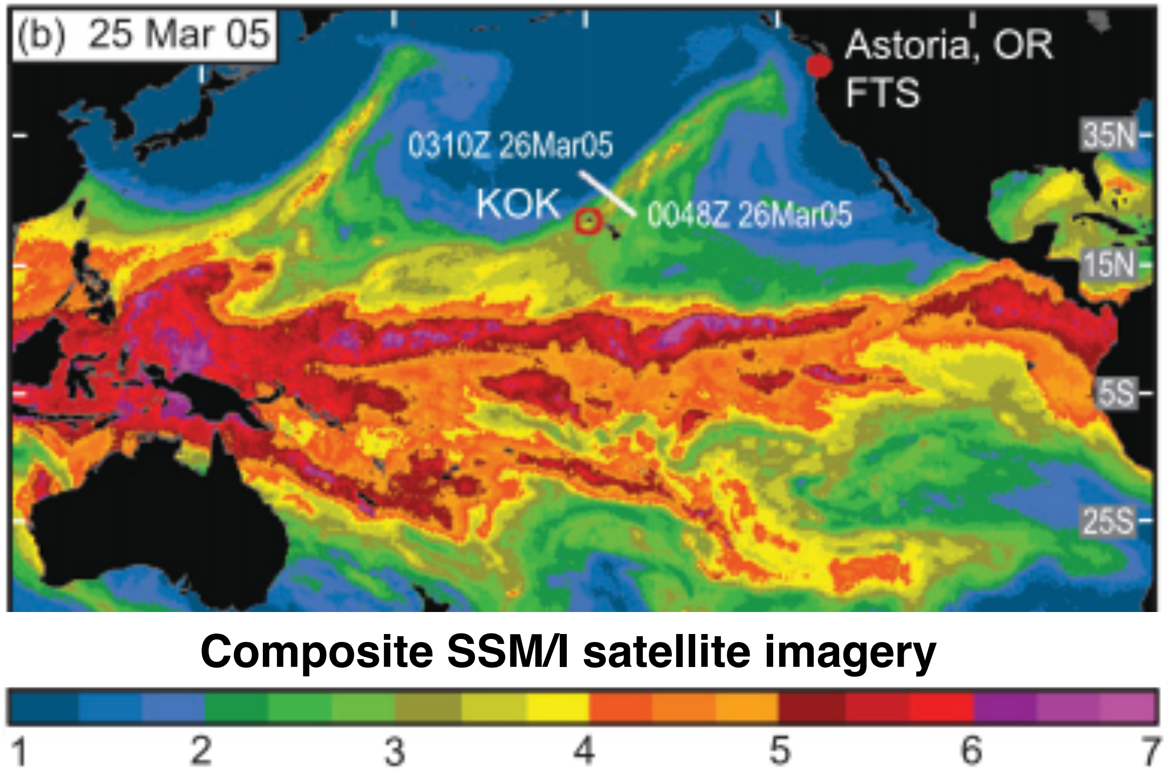
Motivation

1. **Some extreme AR events have been attributed to their tropical "tapping" signature.**
   Neiman et al. 2008, Ralph et al. 2011.

2. **Debate continues about the relative importance of tropical moisture export and local convergence on AR moisture and precipitation.**
   Bao et al. 2006; Knippertz et al. 2013; Sodemann and Stohl 2013; Dacre et al. 2015; Eiras-Barca et al. 2017

3. **No robust understanding of the mechanisms how tropical moisture may contribute to ARs exists.**

Vertically integrated water vapor (IWV) (cm)



Composite SSM/I satellite imagery

(Ralph et al. 2011)

Key Question:

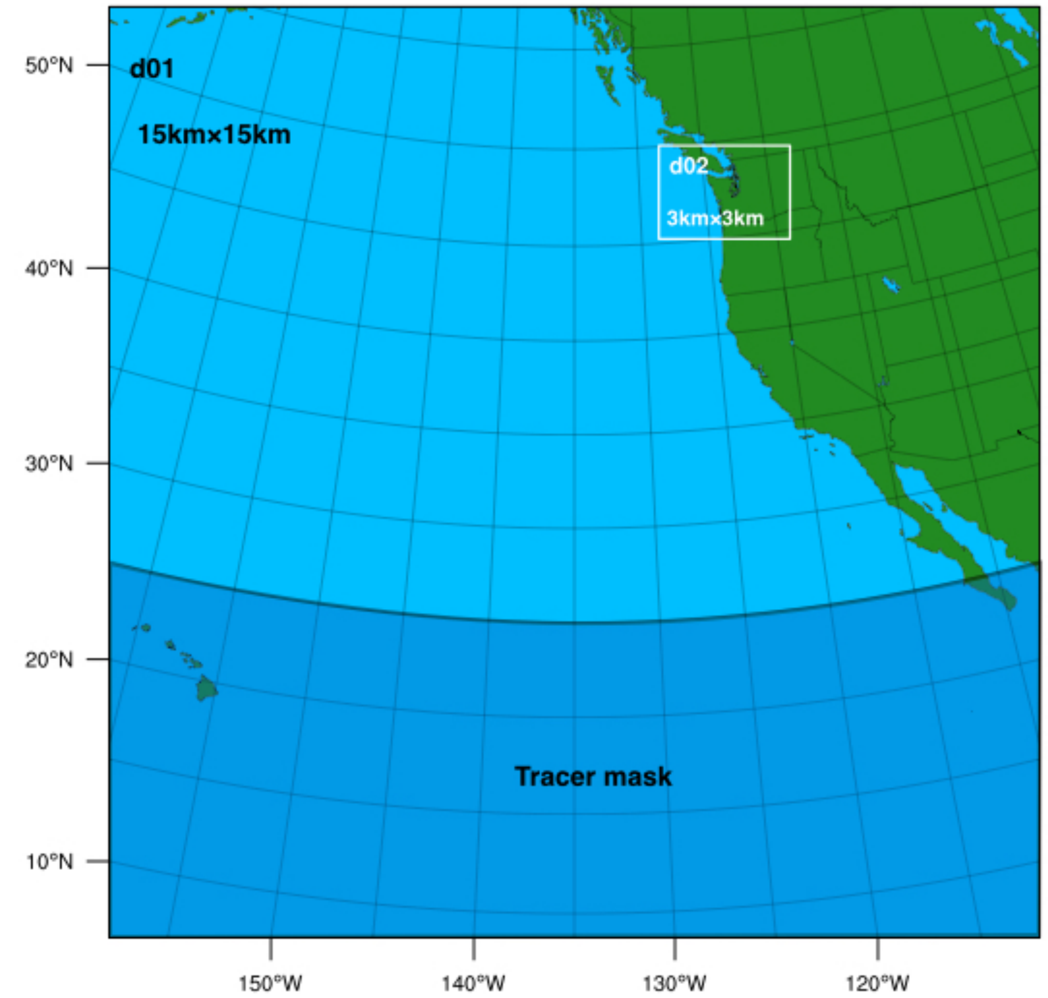
How is TME modulating AR intensity?

Use water vapor tracer tool in WRF (WRF-WVT) to “tag” tropical moisture (Miguez-Macho et al. 2013)

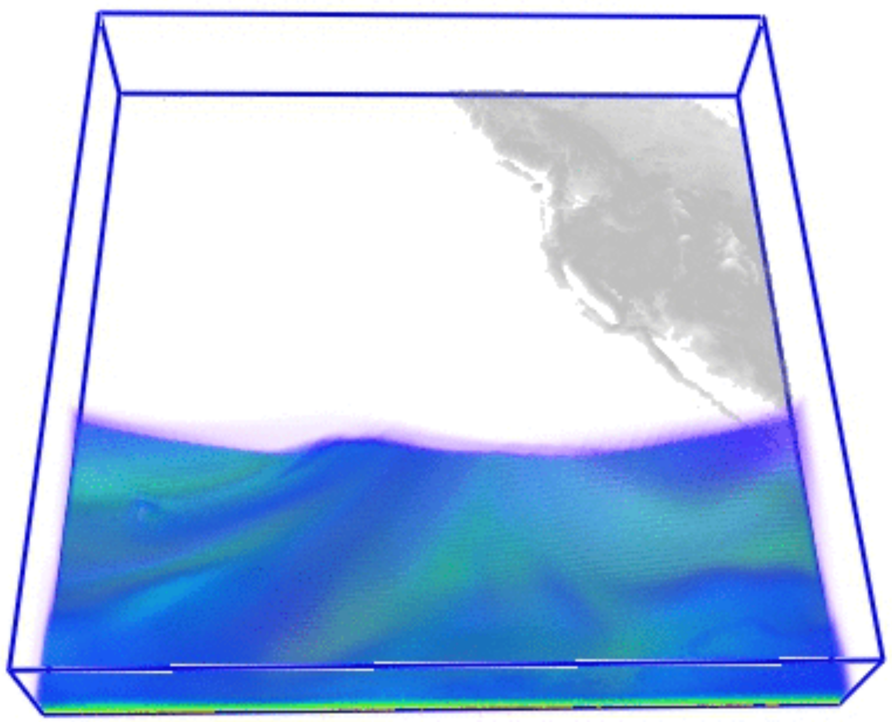
Simulate top 29 ARs (daily IVT) affecting the Northwest Coast (1979-2009)

AR intensity
(moisture and precipitation)

Simulation domains

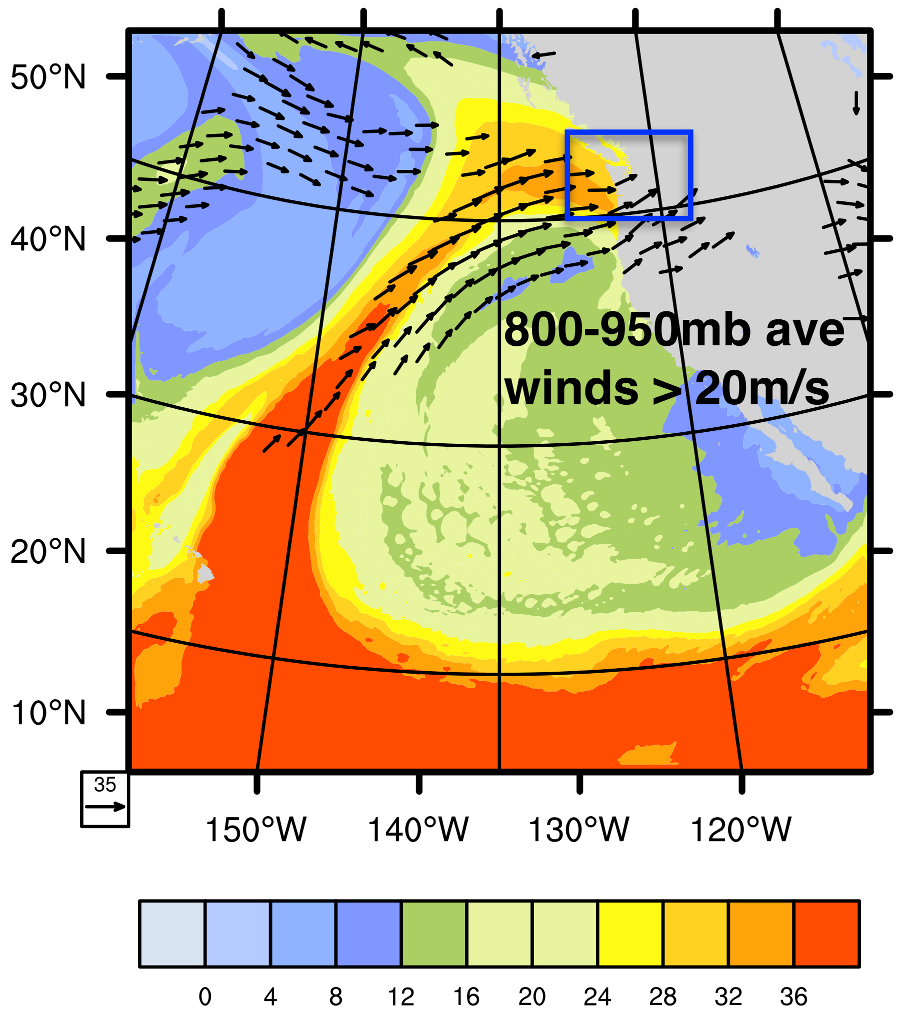


3-D view of tropical moisture “tagged”

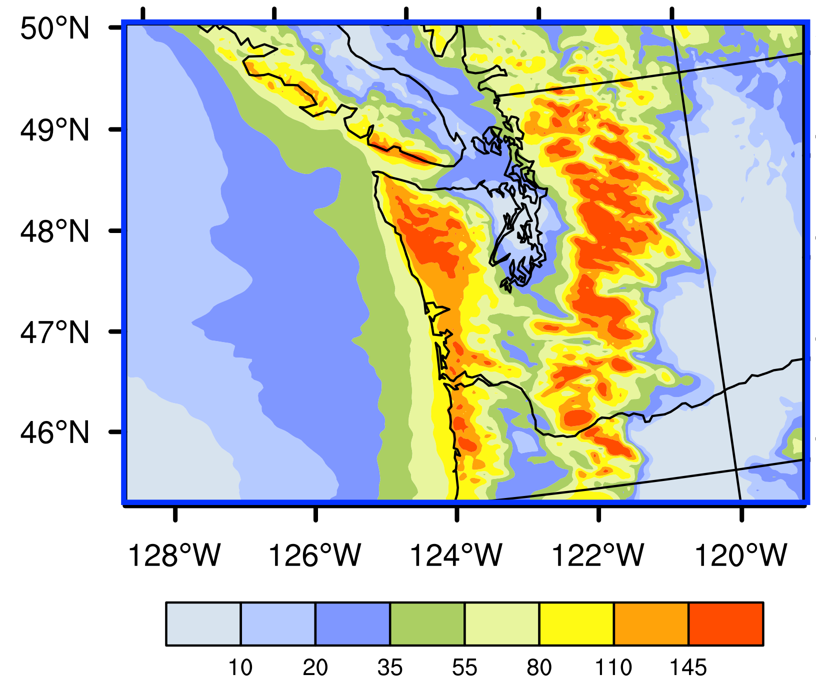


AR case: Jan 1982

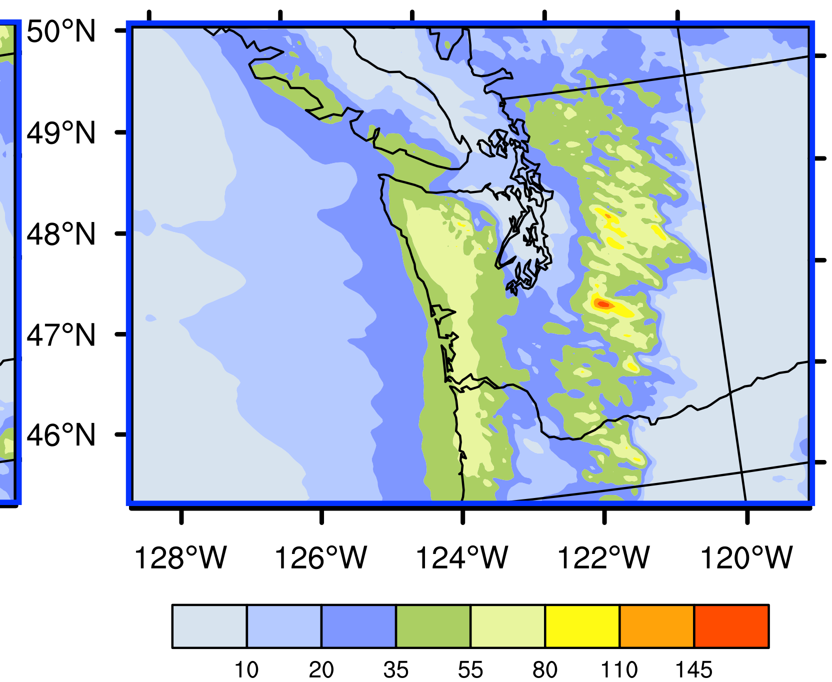
09Z Jan 23, 1982 (IWV; mm)



precipitation on Jan 23 (mm/day)



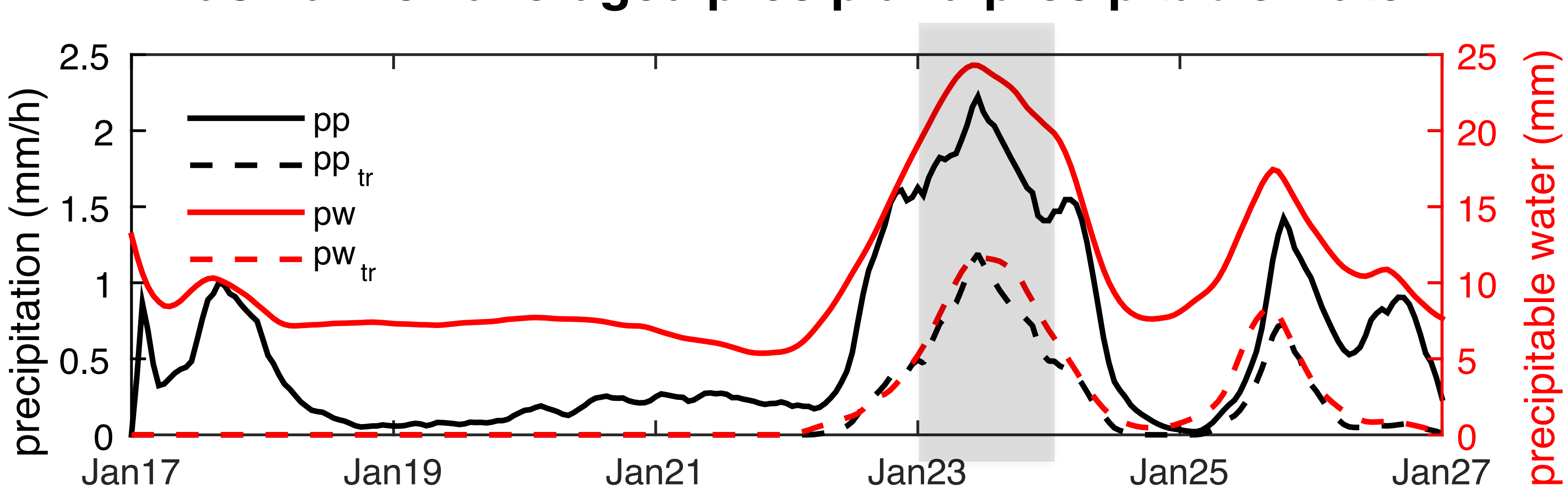
precipitation on Jan 23 due to tropical moisture



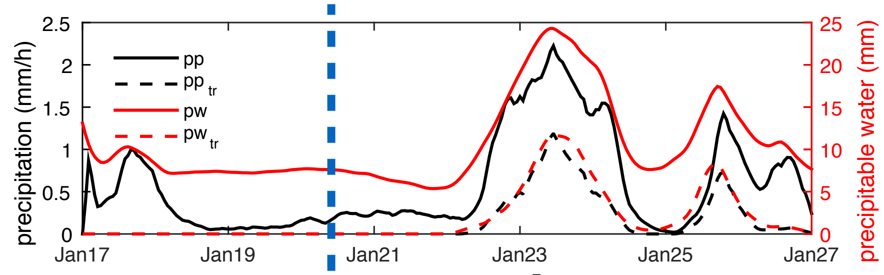
At peak precipitation (09Z Jan 23):

~50% of AR moisture and precipitation is due to TME

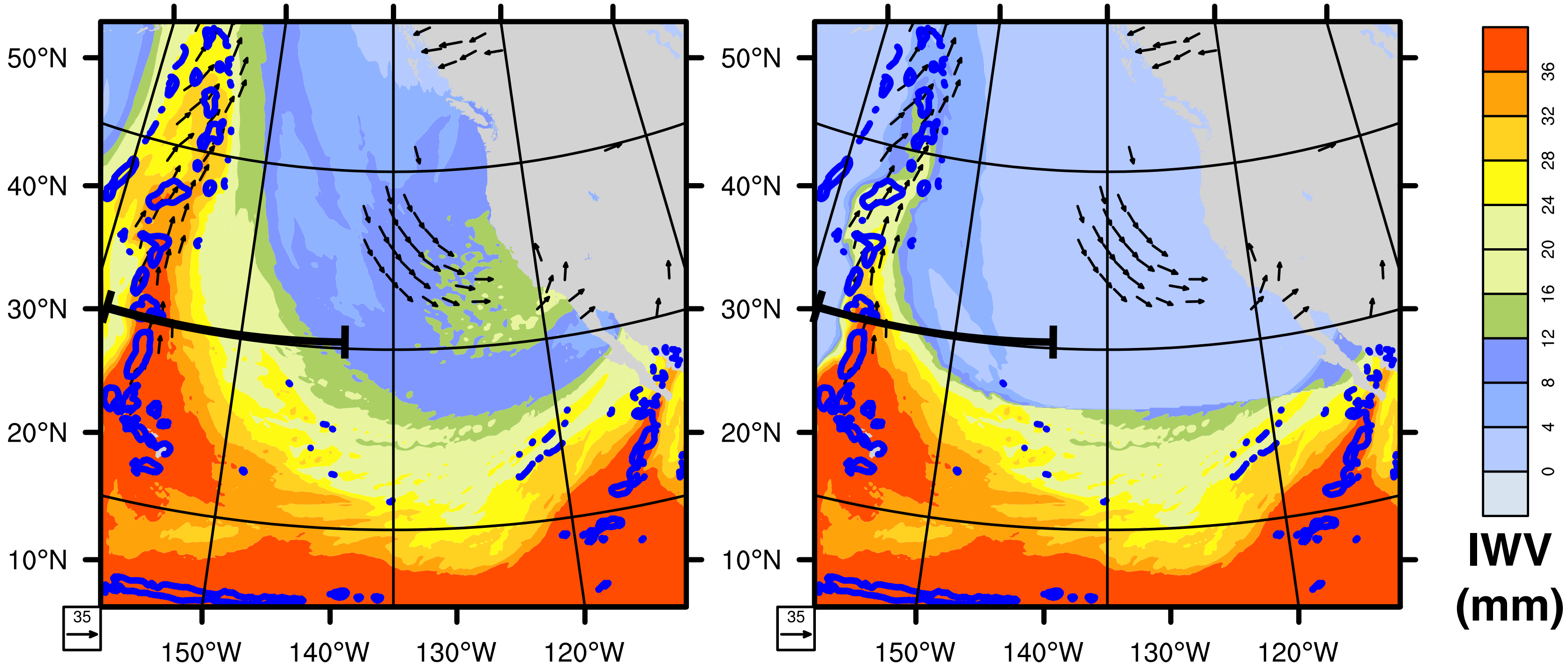
domain 02 averaged precip and precipitable water



12Z Jan 20, 1982



total moisture | tracer moisture



TME-resulted cold-front precipitation

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Latent heat release

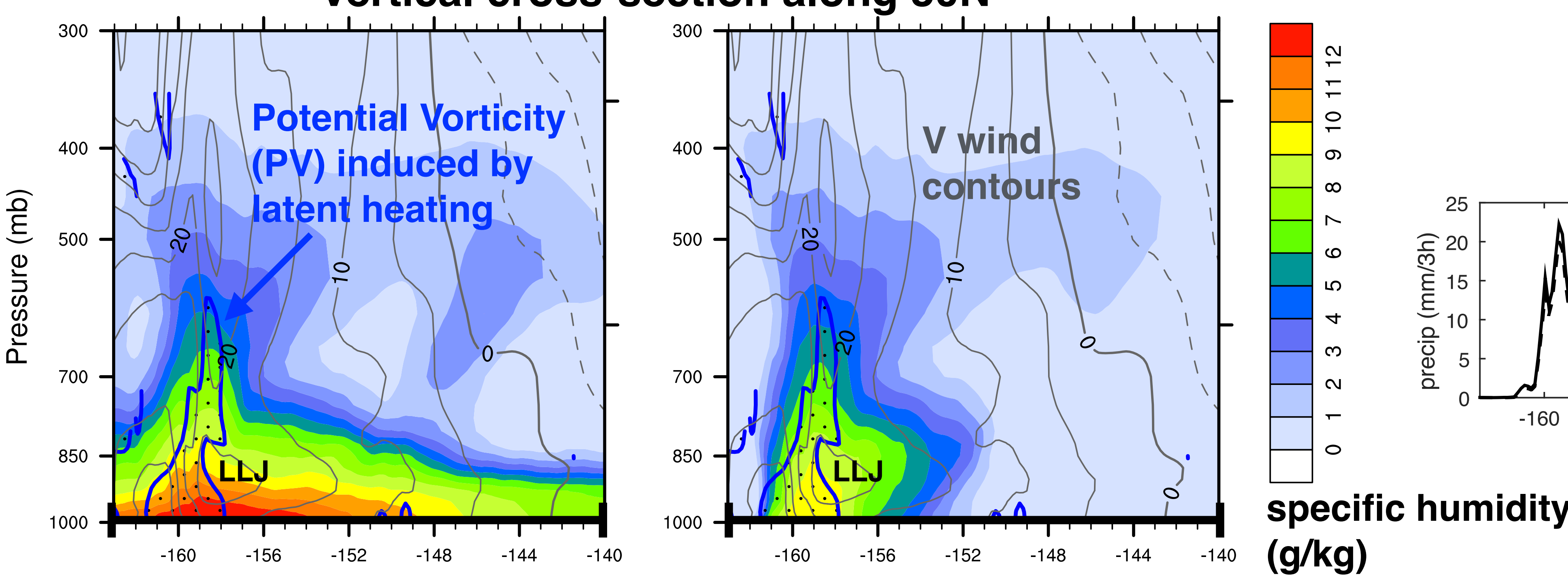
↓

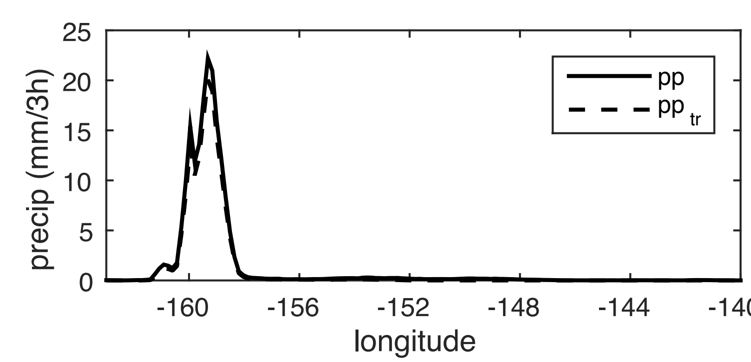
Potential Vorticity anomaly

↓

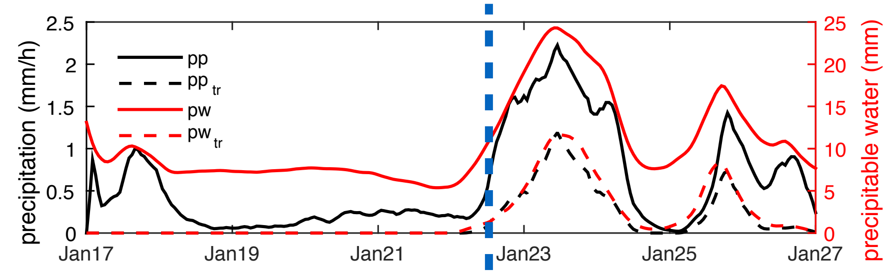
enhance low-level jet

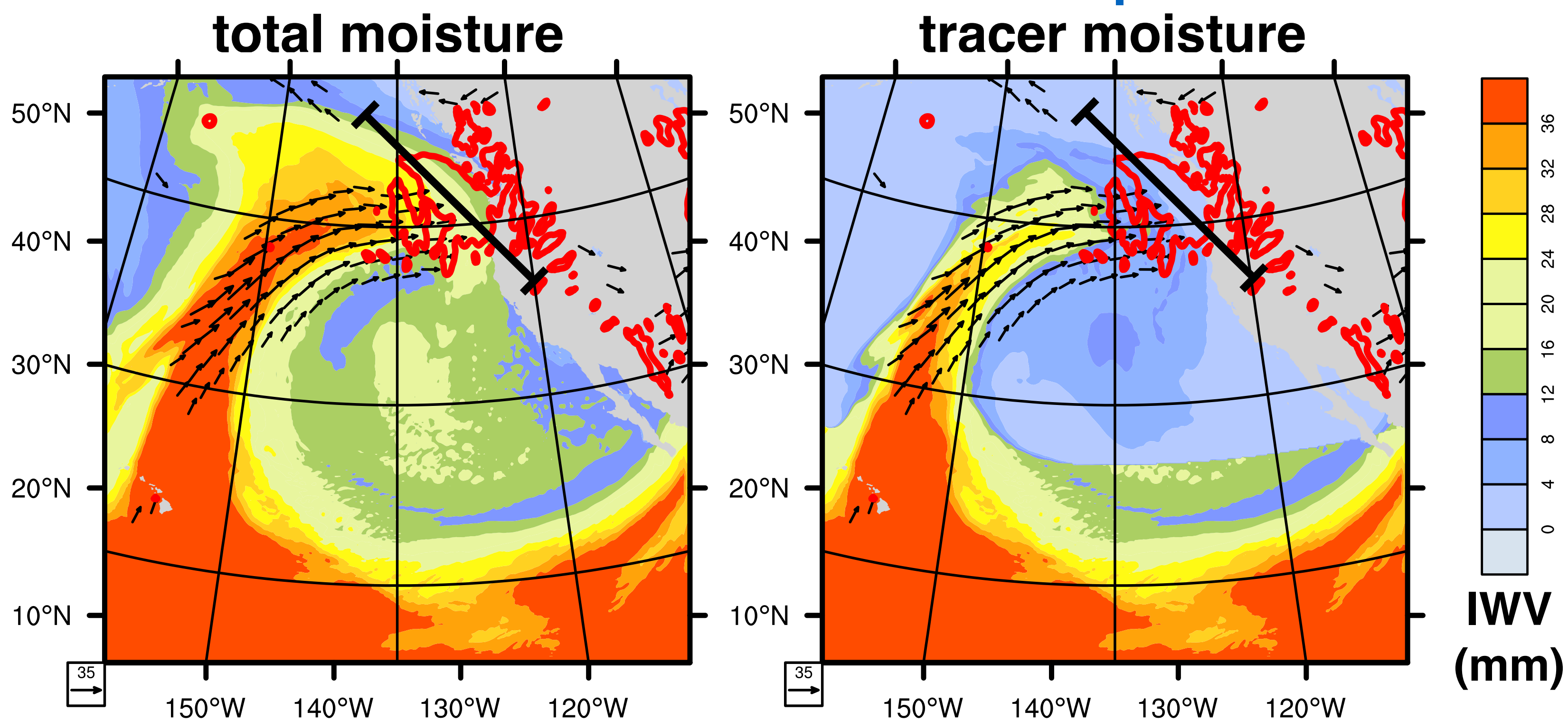
vertical cross-section along 30N





12Z Jan 22, 1982

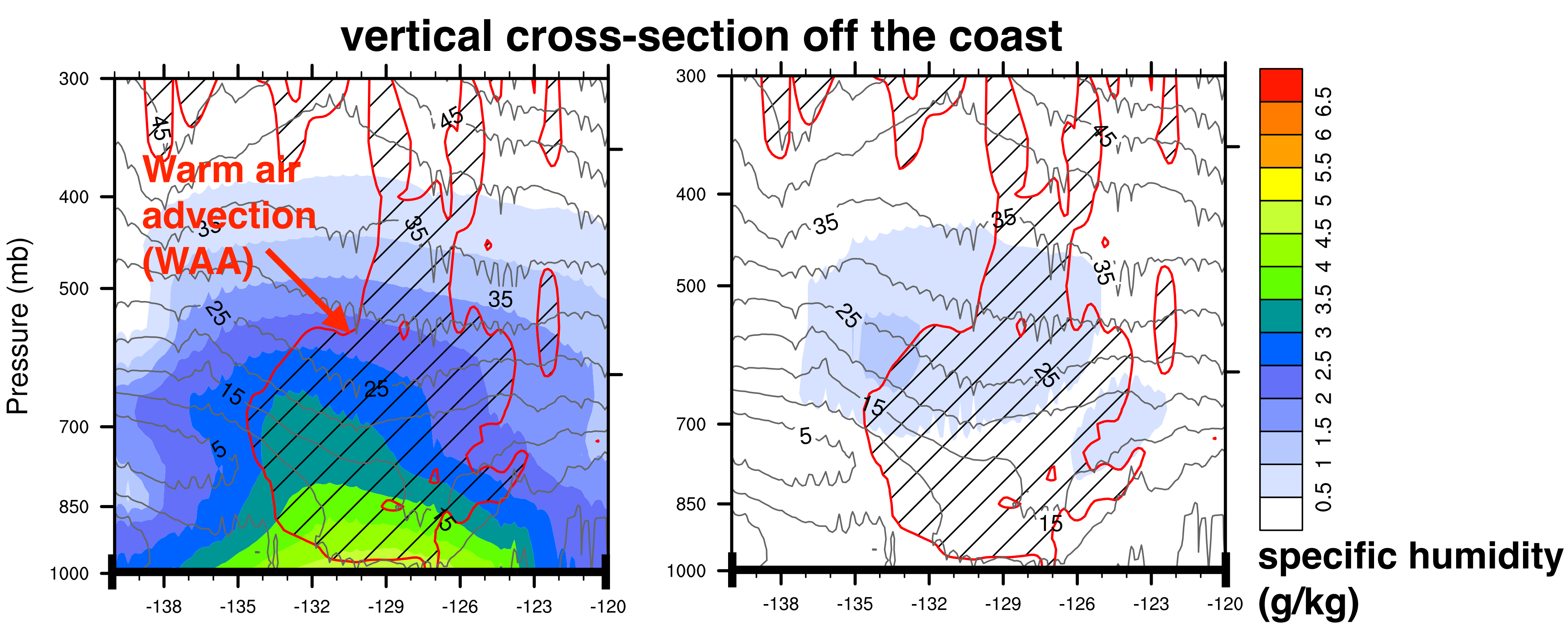




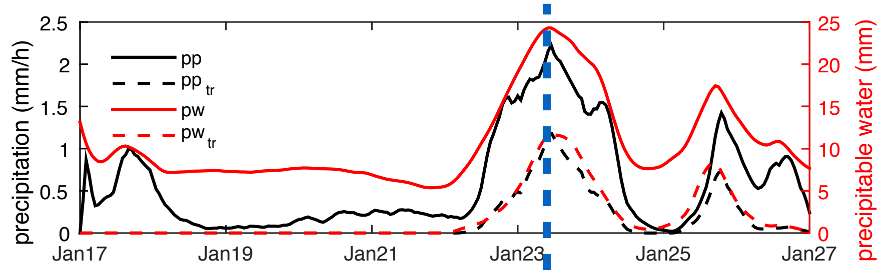
Warm Air Advection associated with TME

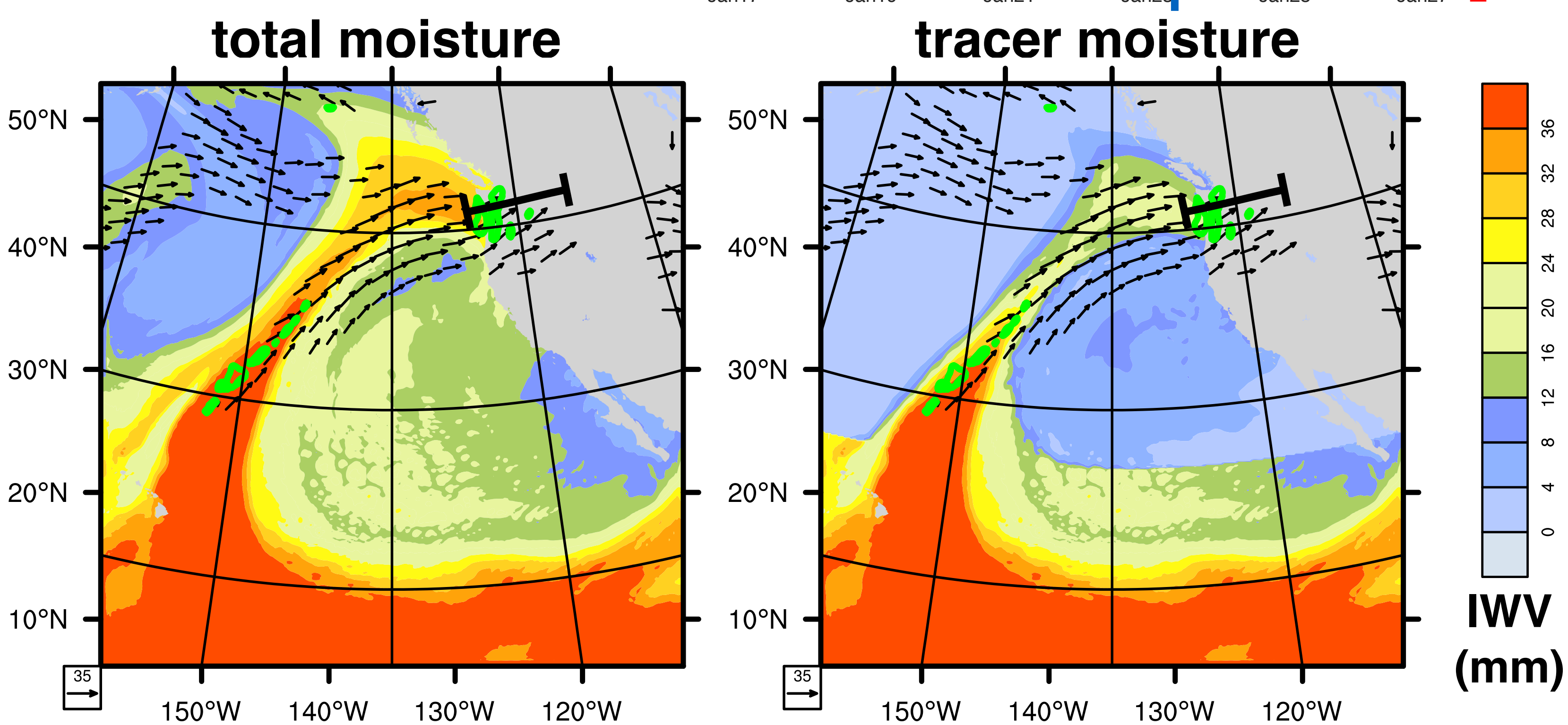
↓

Low-level moisture convergence



09Z Jan 23, 1982





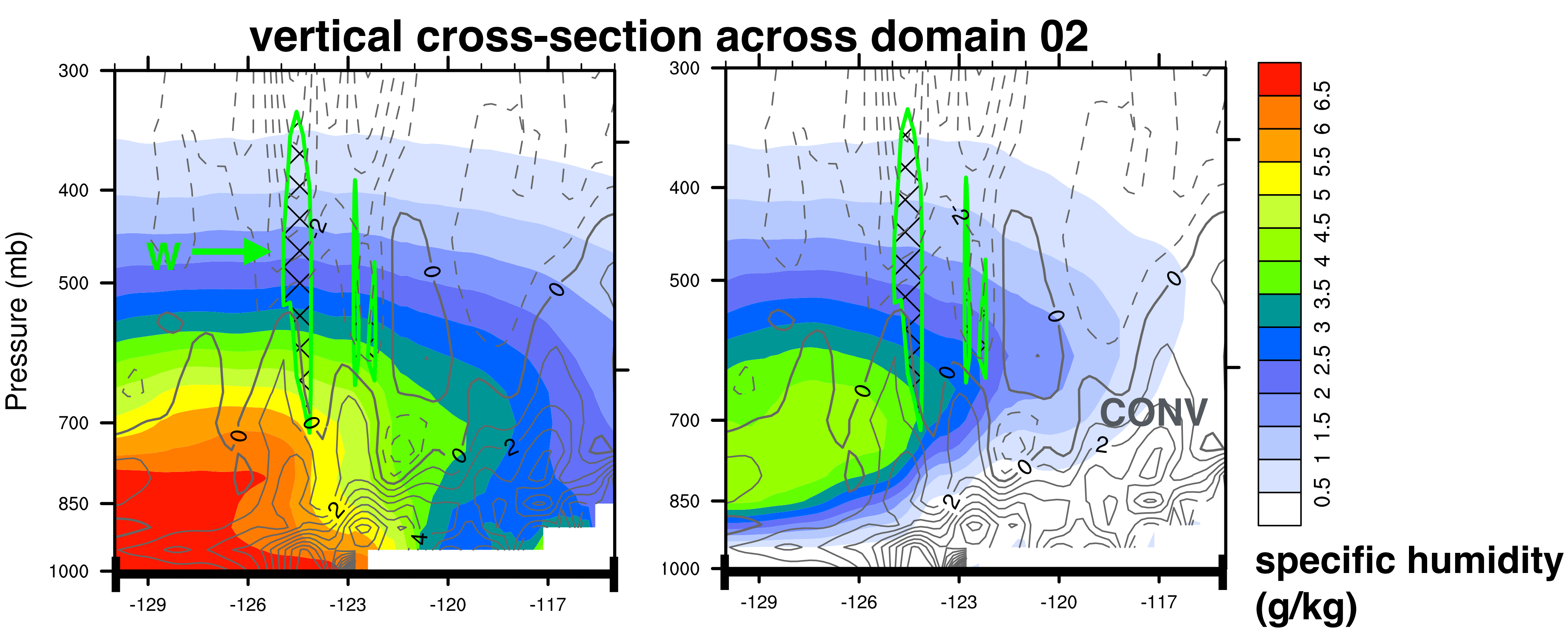
Warm Air Advection associated with TME

↓

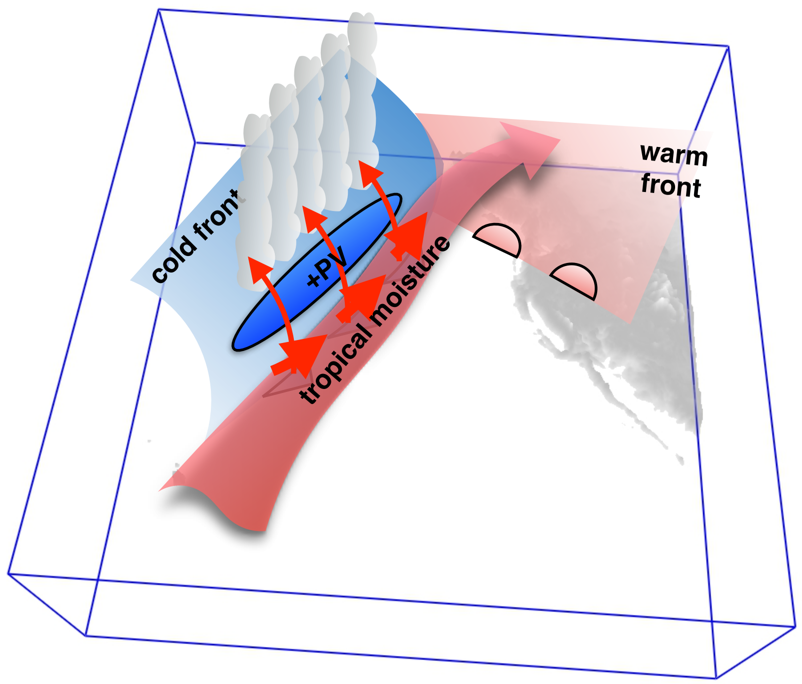
Low-level moisture convergence

↓

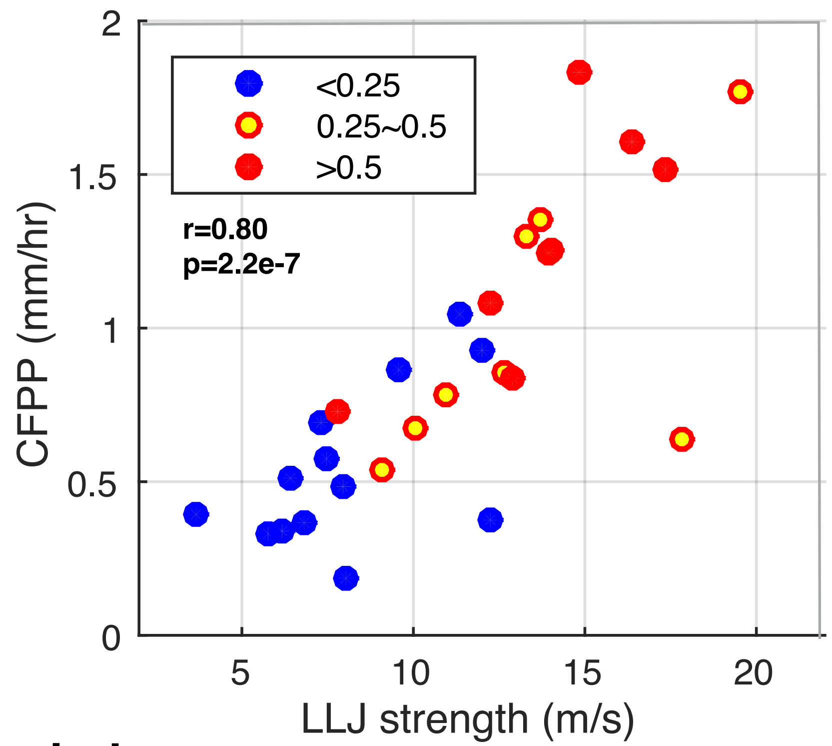
AR precipitation



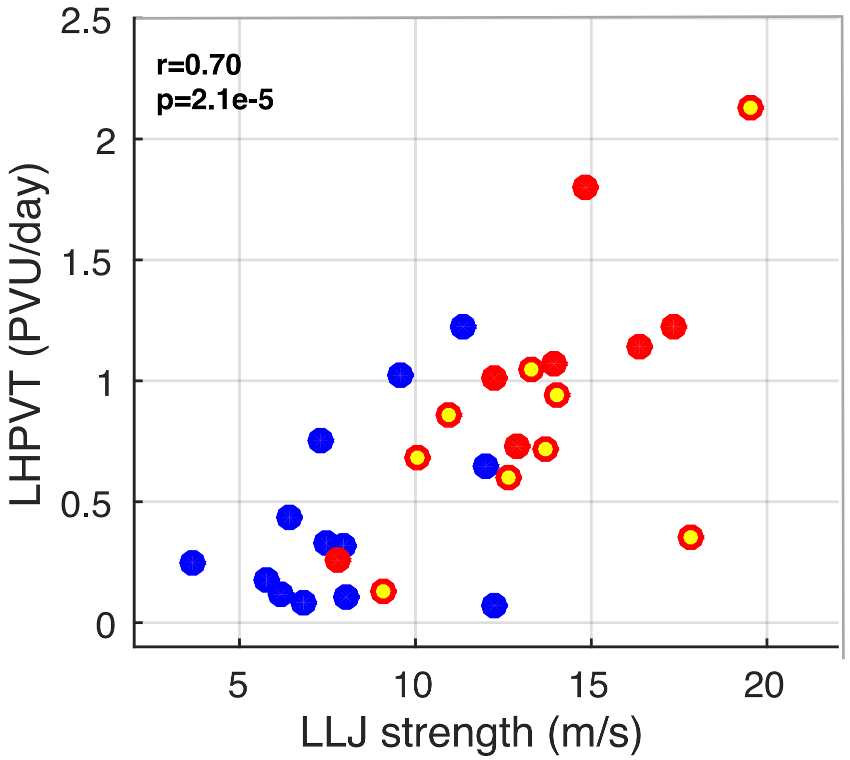
All Simulated cases:



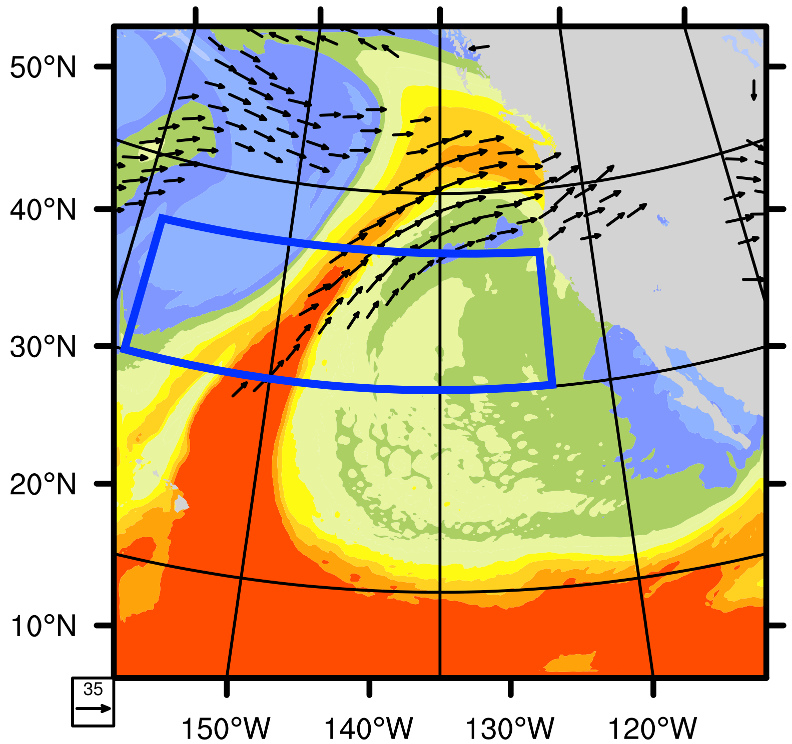
cold-frontal precipitation ~ LLJ



cold-frontal latent heat induced PV ~ LLJ

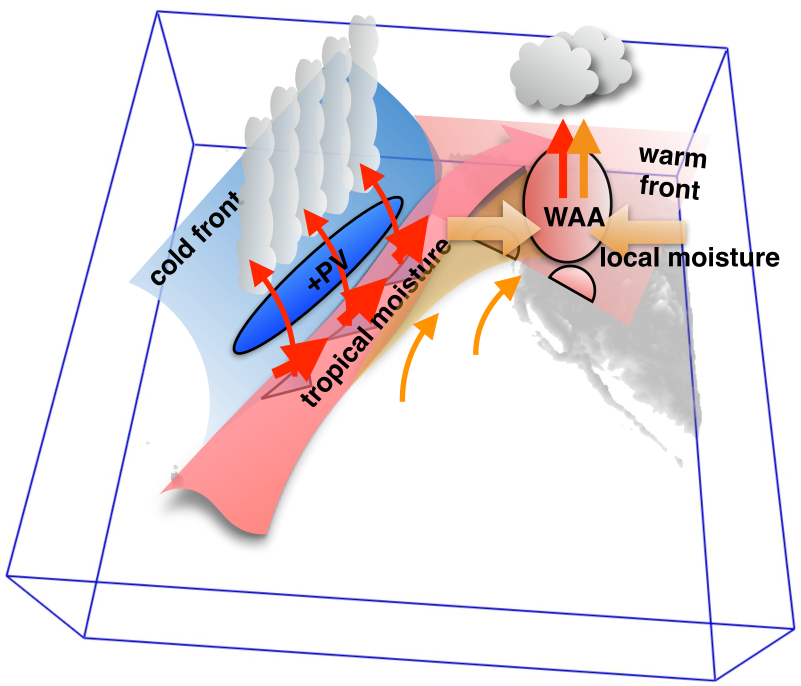


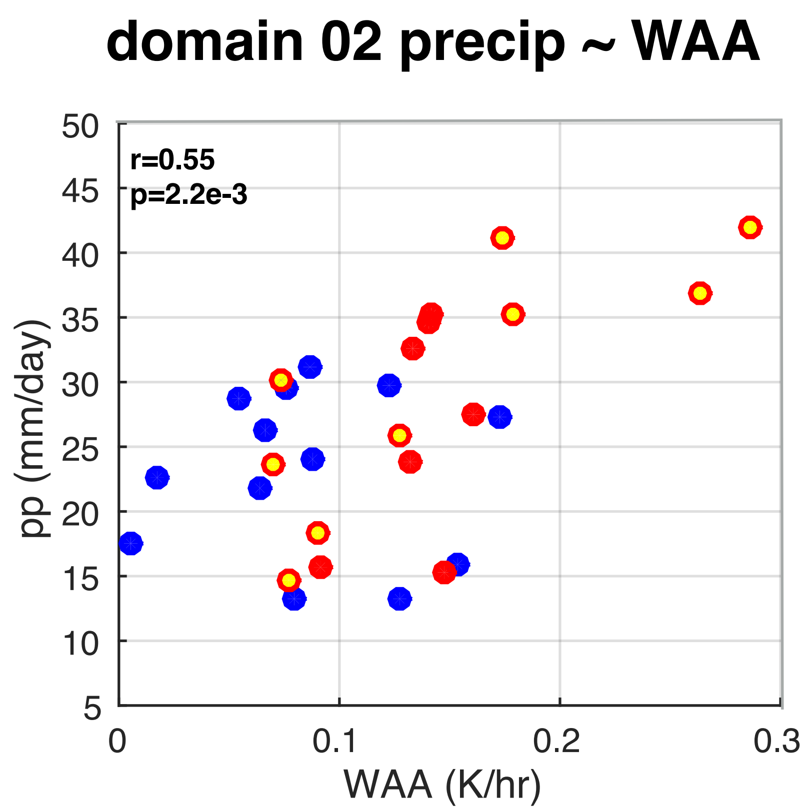
average over this box and 3-day period before peak precip in domain 02

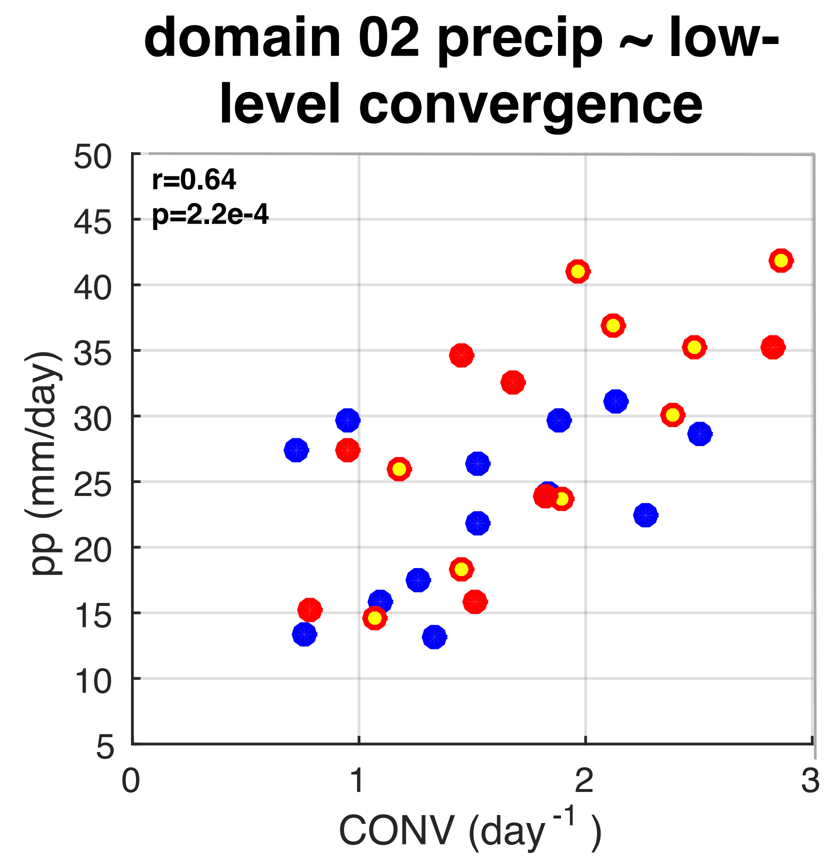


- **Positive correlations between pre-cold-frontal LLJ, cold-frontal precipitation and its induced PV;**
- **TME-ARs (>25% precip from tropical moisture) have stronger LLJ and LHPV**

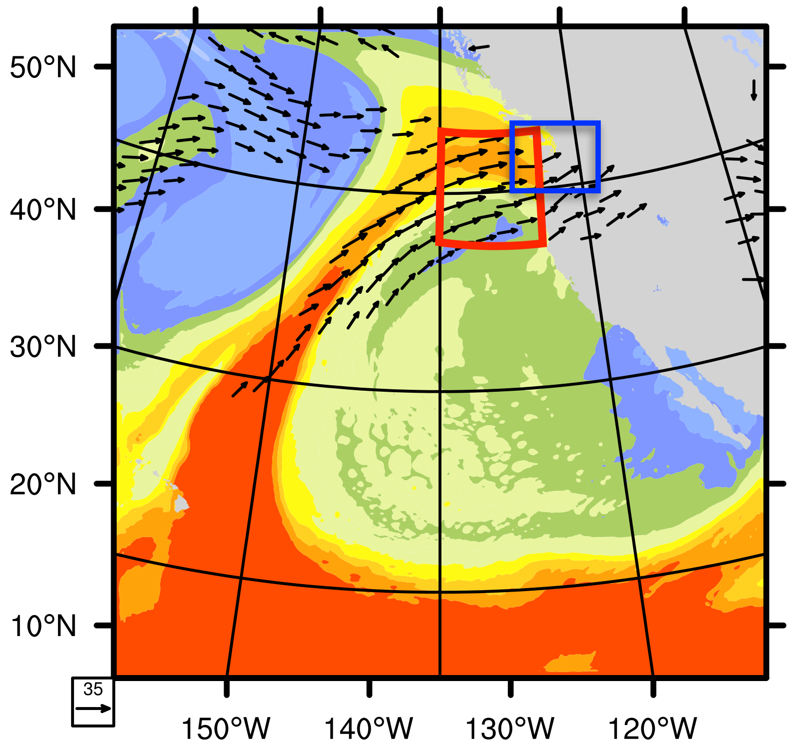
All Simulated cases:



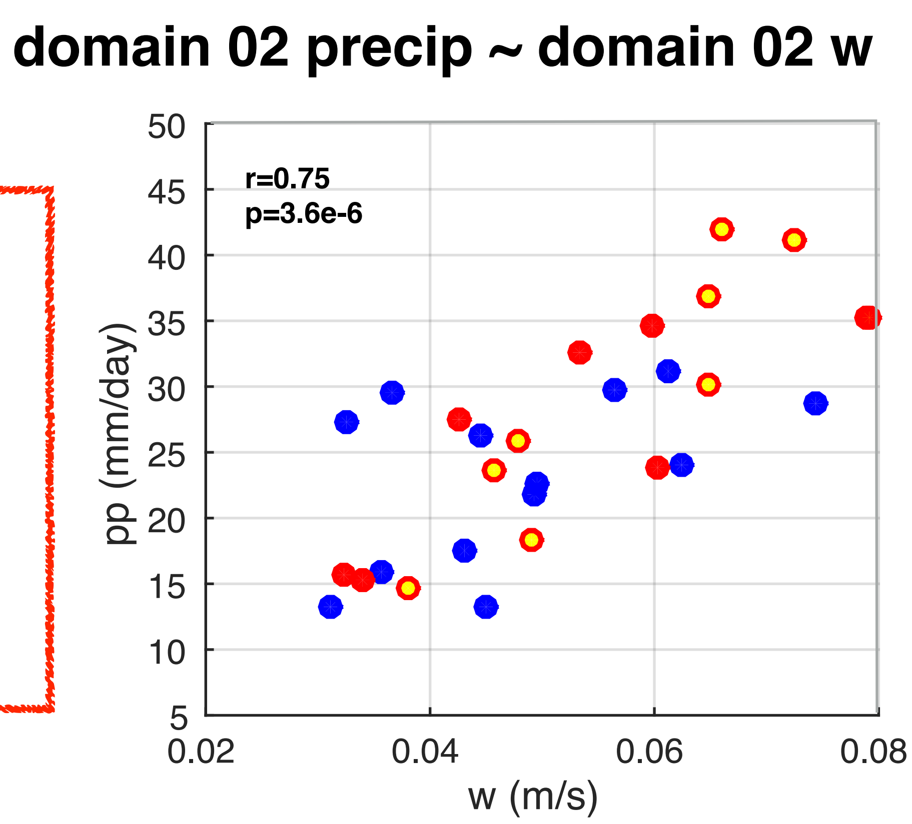




average over this box and 2-day period before peak precip in domain 02



- stronger WAA for TME-ARs
- no significant stronger ageostrophic circulation is associated with TME-ARs

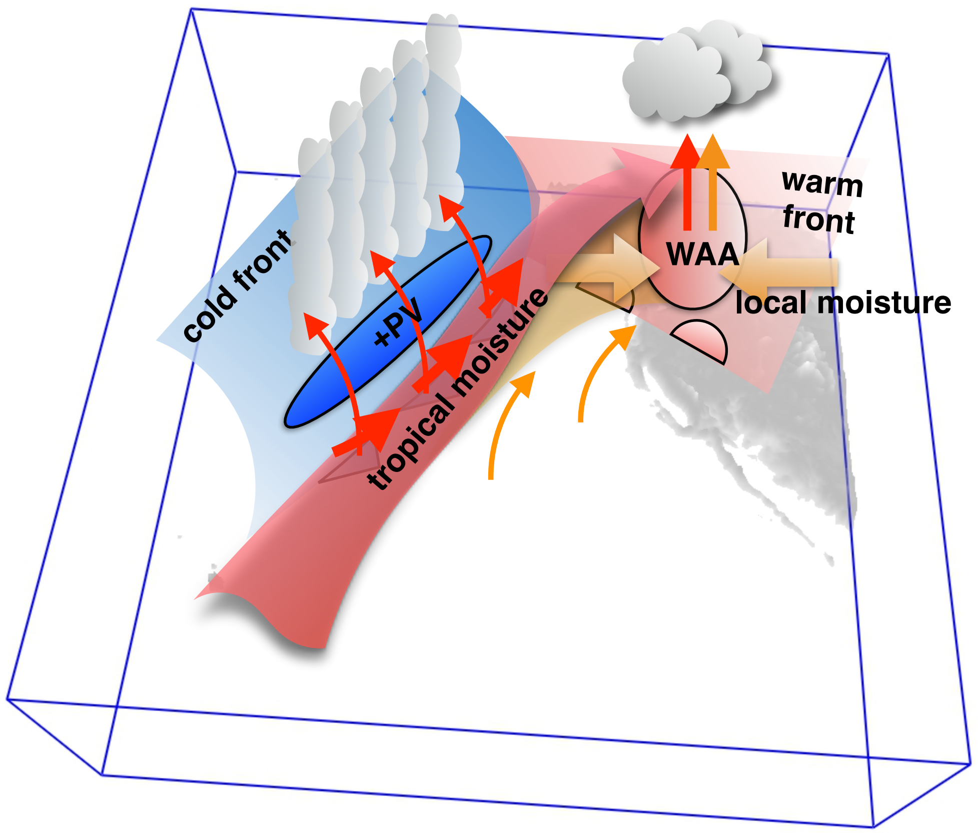


Summary

1. We used the "tagging" technique in WRF to isolate the role of TME on AR-related precipitation over the Pacific Northwest (29 ARs).

2. From the AR case in Jan 1982, we learn that TME can contribute to AR precipitation in three ways:

1) by directly contributing to moisture for precipitation
2) by enhancing the LLJ through cold-frontal rainband induced PV
3) by enhancing local moisture convergence in response to WAA



3. In all simulated cases, we found:

1) TME-ARs are characterized by stronger pre-cold-frontal LLJ and stronger WAA
2) no significant differences are found in the strength of ageostrophic circulation for TME-ARs