The Impact of Atmospheric Rivers on the Cold Season Hydrology in California

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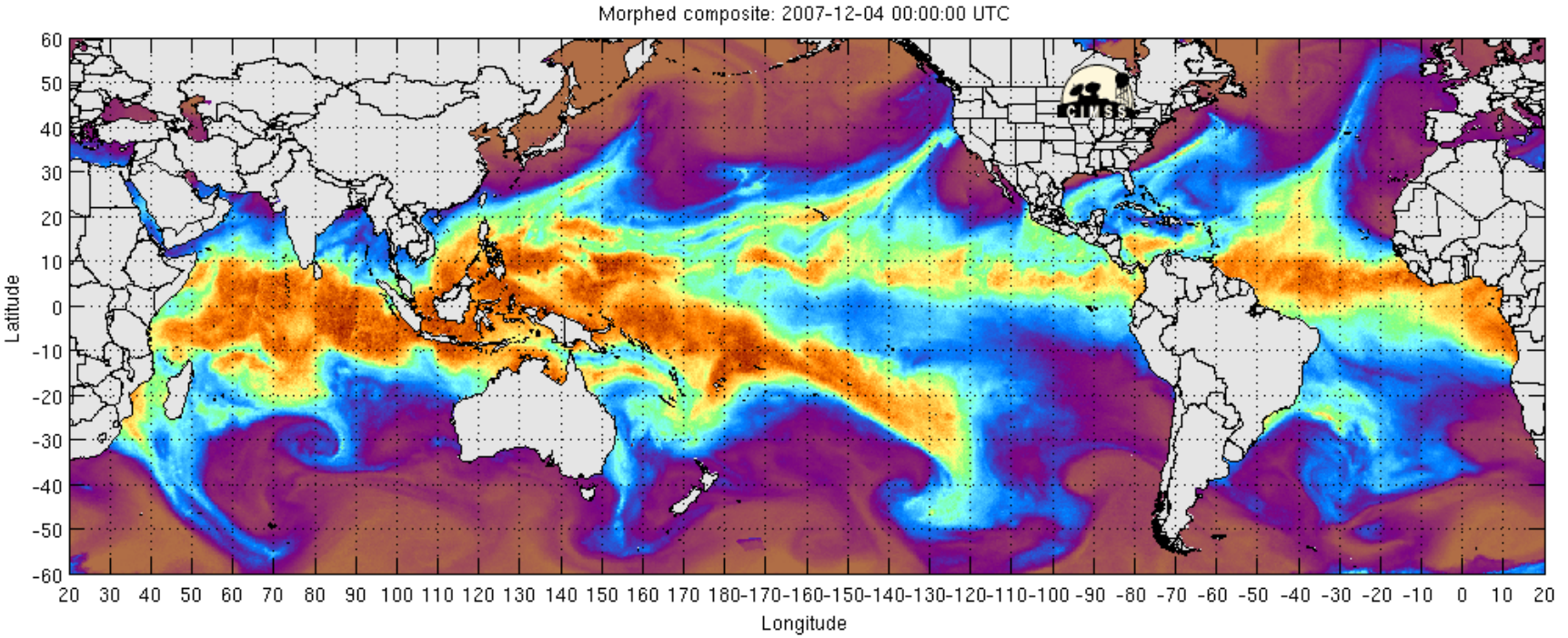
Atmospheric Rivers: *Characteristics*



- Narrow (*O*[10^2km]) and elongated (*O*[10^3km]) regions of strong water vapor fluxes
- PWV>20 mm within the core region
- Typically located within the warm sector of extratropical cyclones
- Large amounts of poleward moisture transports
- *Frequently cause extreme hydrologic events in California*

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Major Goals/Methodology of this Study

- Understand the impact of land-falling AR events on cold season water cycle in California
- Examine the performance of nested regional modeling in diagnostics/prediction of AR-related hydrology in California

- NCEP-CPC daily precipitation datasets (0.25°) are analyzed for the 10 *cold seasons* (Oct-Mar) of WY2001-WY2010.
- SNODAS data are used for the AR-ΔSWE relationship for WYs2004-2010
- Land-falling AR inventory along the CA coast was developed *on the basis of satellite-retrieved PWV* (SSM/I and SSMIS) by P. Neiman & G. Wick
- **AR-related ongoing/planned studies at JIFRESSE and JPL**:
  - Numerical modeling of regional water cycle and circulation for California
  - The origins/pathways of moisture using a trajectory model (Ryoo et al.)
  - Assimilation of the Sierra Nevada SWE (Guan et al.)
  - The relationship with tropical convection, MJO, and AR (Guan et al.)
  - The impact of climate change on ARs and water cycle in California

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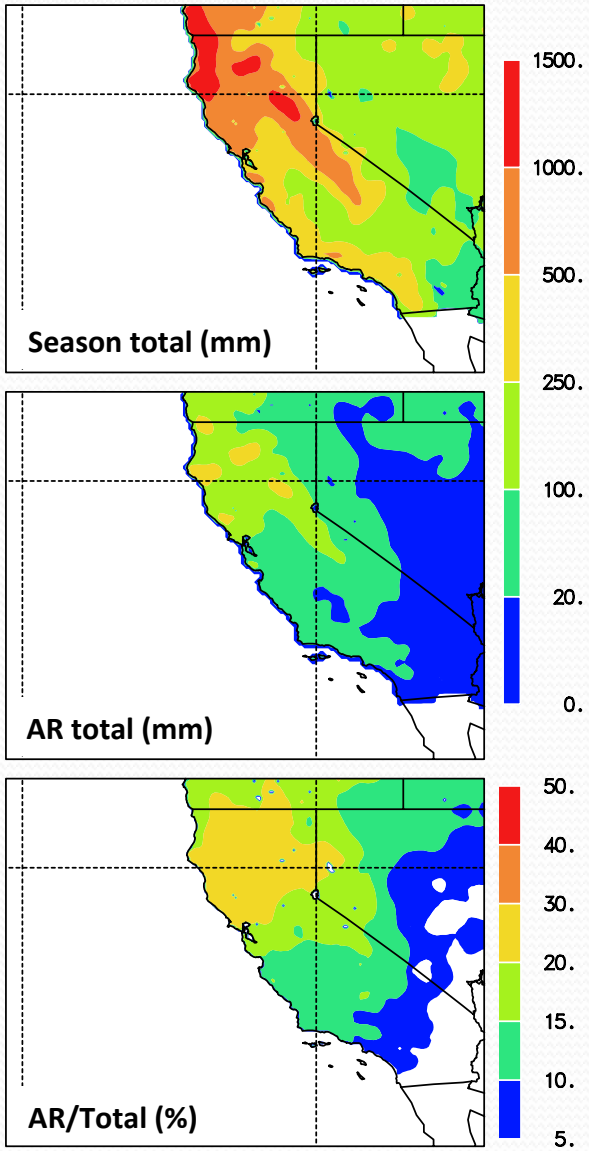
The season-total and AR-related Precipitation



- AR precipitation closely resembles the geographical distribution of the season-total precipitation except *the absence of precipitation maximum over the southern CA Coast Range that is clearly distinguished from the Central Valley*
- 10-30% of cold season precipitation totals is related with ARs
- ARs affect cold season precipitation mainly in the northern CA region

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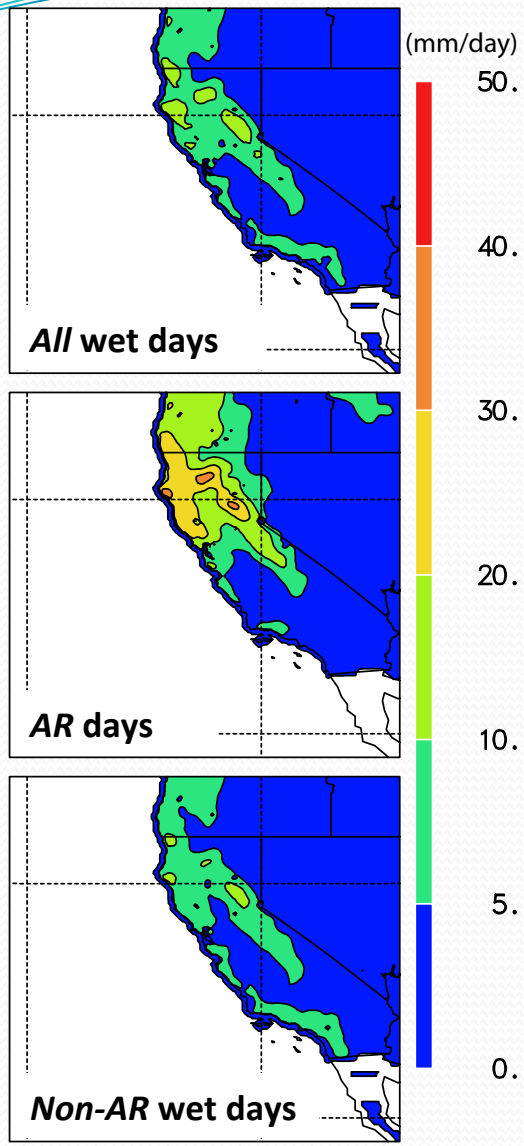
Daily-mean Precipitation Intensity

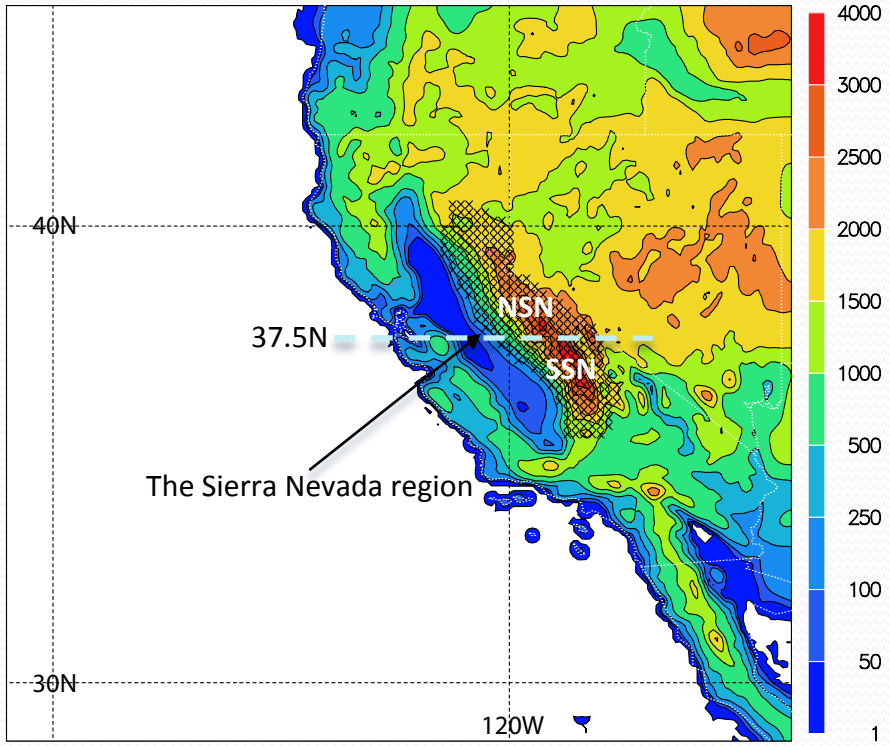


Daily-mean precipitation intensity for the WYs 2001-2010 from the CPC data

- Wet days: Days with *PR* > *0.1* mm
- Larger precipitation intensities occur in the mountainous regions (*the Coast Range*, *Sierra Nevada*, and *northern CA* region).
- *Precipitation intensity for AR days show contrasts between the northern and southern CA regions that are characterized by:*
  - *Larger daily-mean precipitation intensity* during ***AR***/***non-AR*** days in the ***northern***/***southern*** CA region

Precipitation and SWE in the Sierra Nevada region

- Precipitation and SWE in the Sierra Nevada region are closely related with water resources and flooding.
- The Sierra Nevada region is sub-divided into northern and southern regions across the 37.5N.



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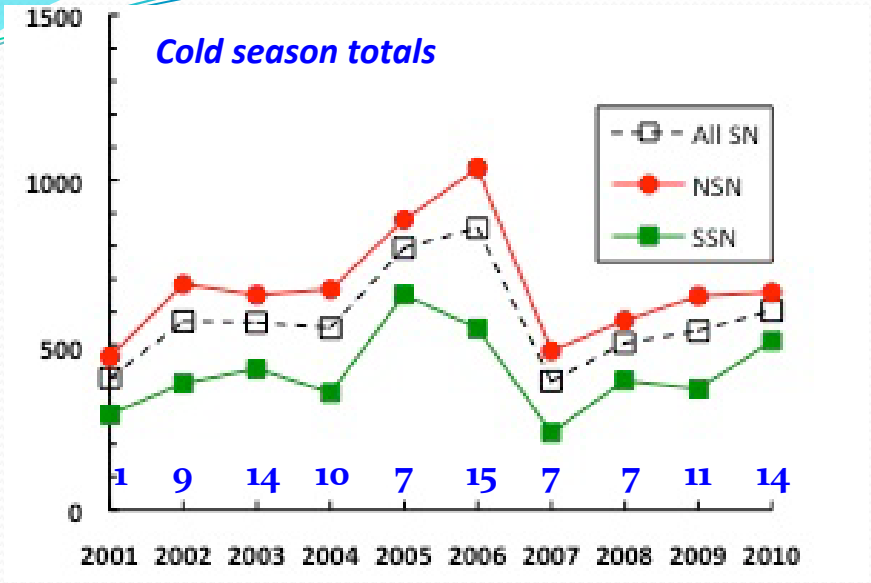
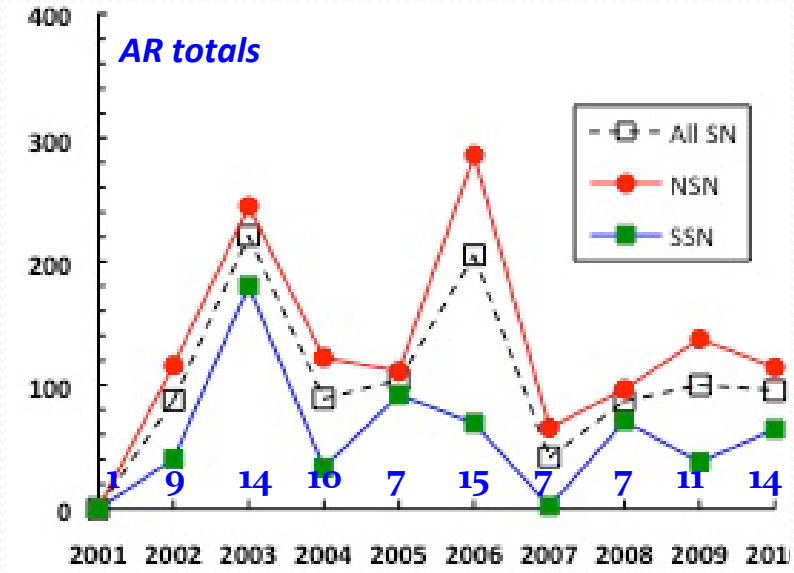
Interannual variations

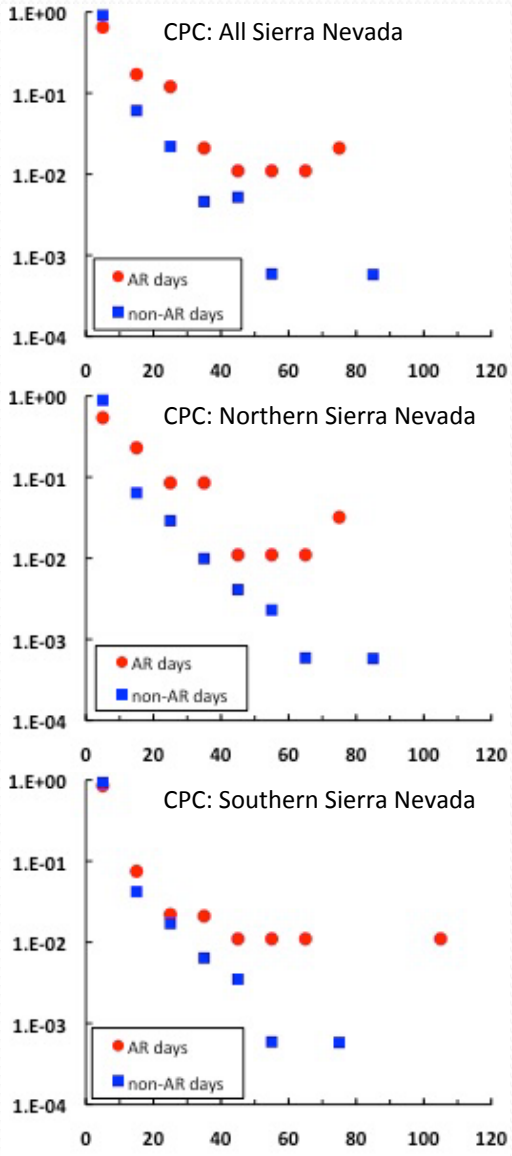


- The number of AR events undergoes a large interannual variations (*mean=9.4*)
- The relationship between the number of ARs and the seasonal precipitation total is not clear, especially in the *SSN*
- Correlation Coefficients:
  - *All SN*=0.55, *NSN*=0.57, *SSN*=0.44



- The *NSN* region generally receives more AR precipitation than the *SSN* region
- The number of ARs and the AR-total precipitation are more closely correlated
- Correlation Coefficients:
  - *All SN*=0.83, *NSN*=0.85, *SSN*=0.56

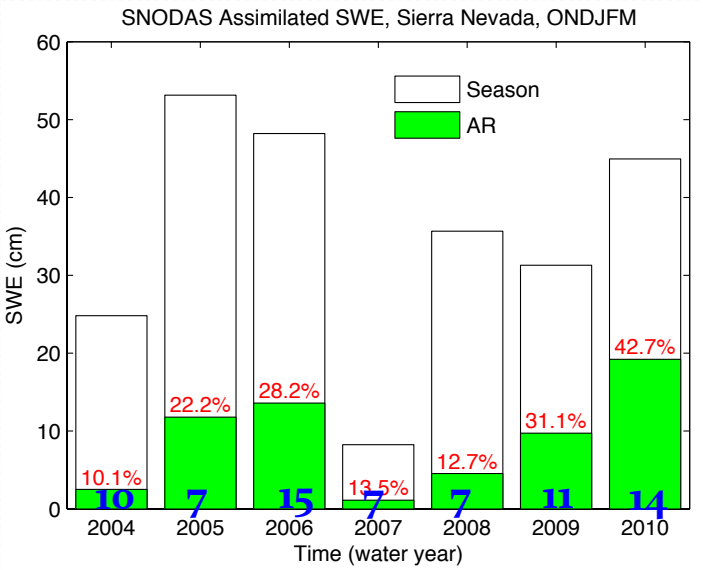
Daily Precipitation PDF in the Sierra Nevada Region



- For the relationship between AR and daily precipitation extremes, the PDF of wet-day precipitation intensity in the three SN regions are examined for:
  - Wet days
  - AR days
  - non-AR days

- AR days generally show much higher frequency of heavy precipitation events than non-AR days in all three SN regions

Snow accumulations in the SN (above 1.5km)
Season totals and AR portions



- 10-40% of the cold season snow accumulation in the SN region has occurred during AR events; however, interannual variation is large.
  - *On average, ARs generate four times as much daily ΔSWE as non-AR storms*
- The relationship between the number of AR events and ΔSWE is not clear
- ARs are more closely related with extreme daily ΔSWE
  - *AR contribution was dominated by just two events in WY2005 and a single event in WY2008 and WY2010*

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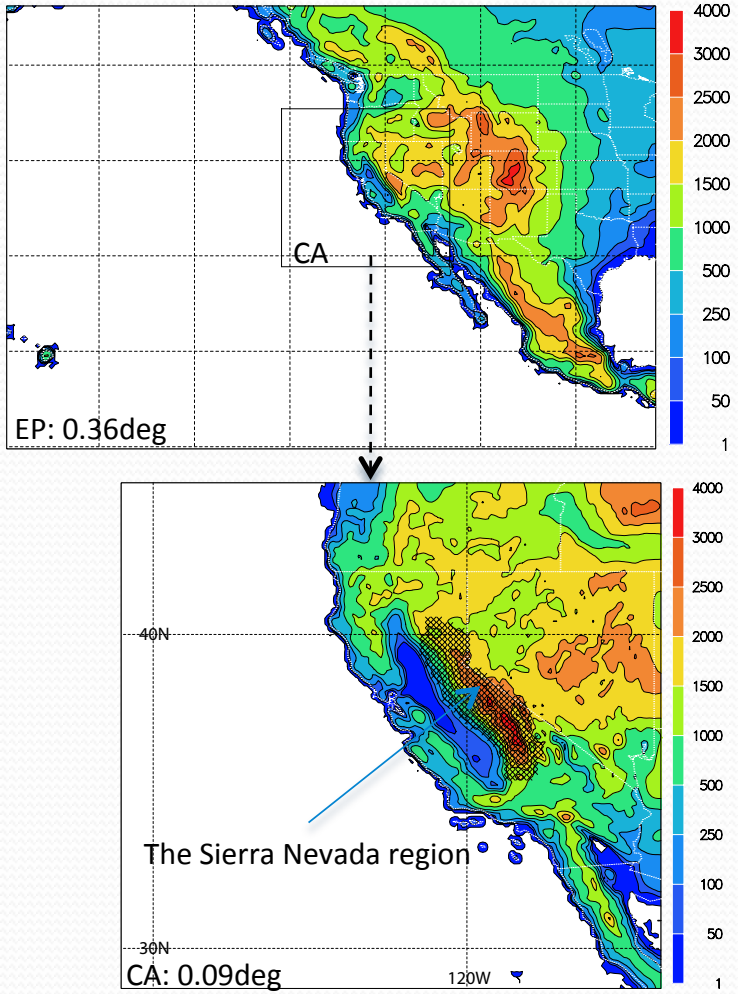
Numerical Experiment

Evaluate RCM performance in simulating AR-related cold season hydrology for the CA region for extended-range forecasts and climate change impact assessment studies

- ***Model and Domain***
  - WRF3.1.1
  - 27 sigma layers in the vertical
  - Physics schemes: *Kain-Frisch convection*, *YSU PBL*, *WSM-5 microphysics*, *Dudhia SW*, *RRTM LW*, *NOAH LSM*
  - One-way nested EP-CA domain.
  - Ten cold season (Oct-Mar) runs for the Water Years 2001-2010
  - Large-scale forcing data from 1°x1° NCEP Final Analysis



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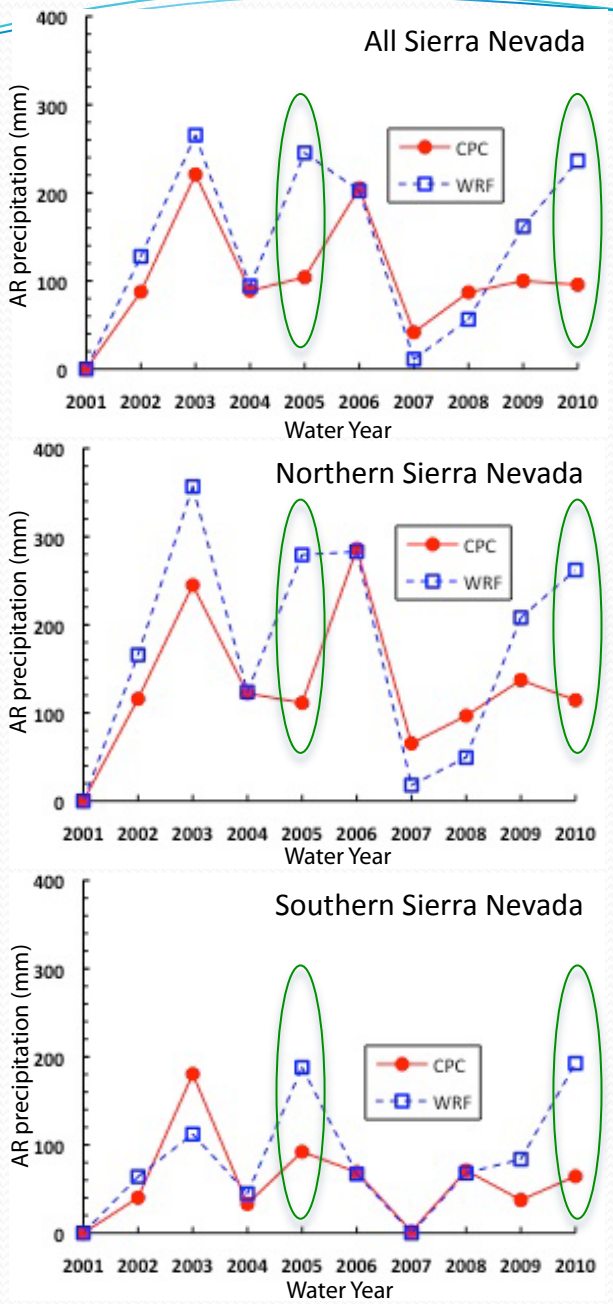
AR-total Precipitation in the Sierra Nevada Region



- The model well simulates AR precipitation in the all three Sierra Nevada regions.
- The most notable model errors are the general overestimation of the AR precipitation especially for the WYs 2005 and 2010.

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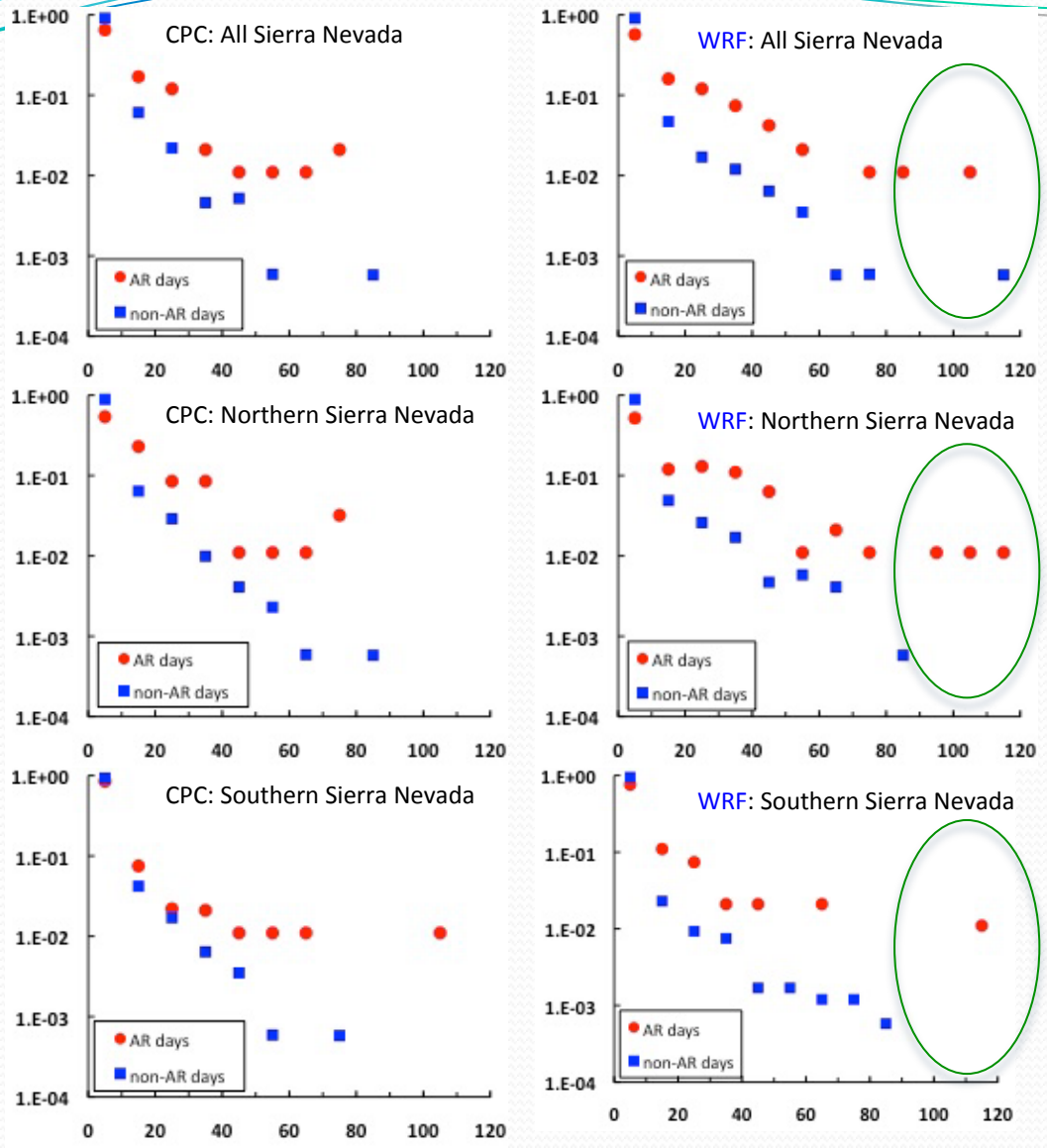
Daily Precipitation Characteristics in the Sierra Nevada Region



- The hindcast reasonably simulates reasonably the daily precipitation intensity PDFs related with AR events
- Good agreement in the all and northern SN region
- Peak precipitation values are overestimated, especially in the NSN region.

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Summary and Conclusions

- The impact of land-falling ARs on California's hydrology is investigated for the cold season (Oct-Mar) of 10 water years 2001-2010.
- NCEP CPC data show 10-30% of the season-total precipitation falls during AR events with *large interannual variations in the number of AR events* and *AR precipitation*
- ARs affect precipitation more in the northern CA than in the south; *similar for the Sierra Nevada region*.
- *ARs are more closely related with heavy precipitation events than the season-total precipitation*
- Similar to precipitation, *ARs are more closely related with large snow accumulation events than the season-total snow accumulation*.
- The cold season hindcast reasonably simulates several features in the AR-related precipitation in the Sierra Nevada region.
- One of the most noticeable biases in the model simulation is overestimation of *daily precipitation extremes* and *their frequencies*

Related Presentations: Trajectory Analysis, AR and MJO

- ***Additional posters on AR studies*:**
  - Winter storm trajectory analysis: Ryoo et al. A53B-0208
  - MJO vs. AR frequency/precipitation in California: Guan et al. A53B-0212