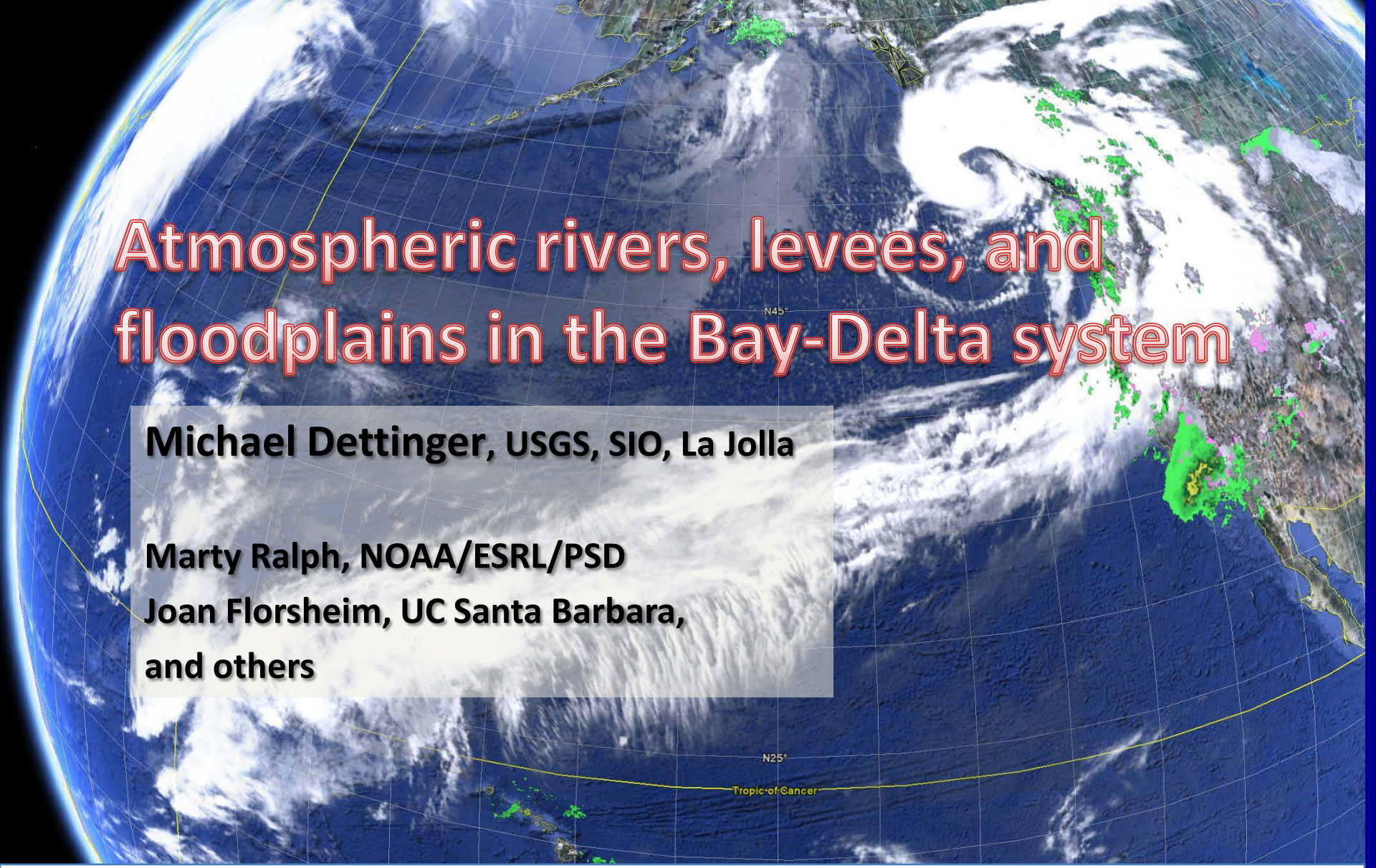

Atmospheric rivers, levees, and floodplains in the Bay-Delta system

Michael Dettinger, USGS, SIO, La Jolla

Marty Ralph, NOAA/ESRL/PSD

Joan Florsheim, UC Santa Barbara,

and others

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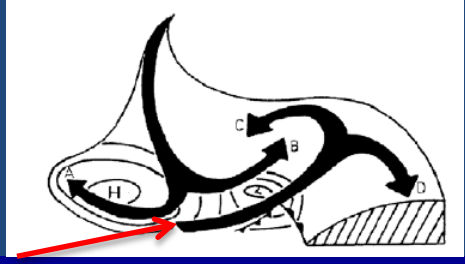
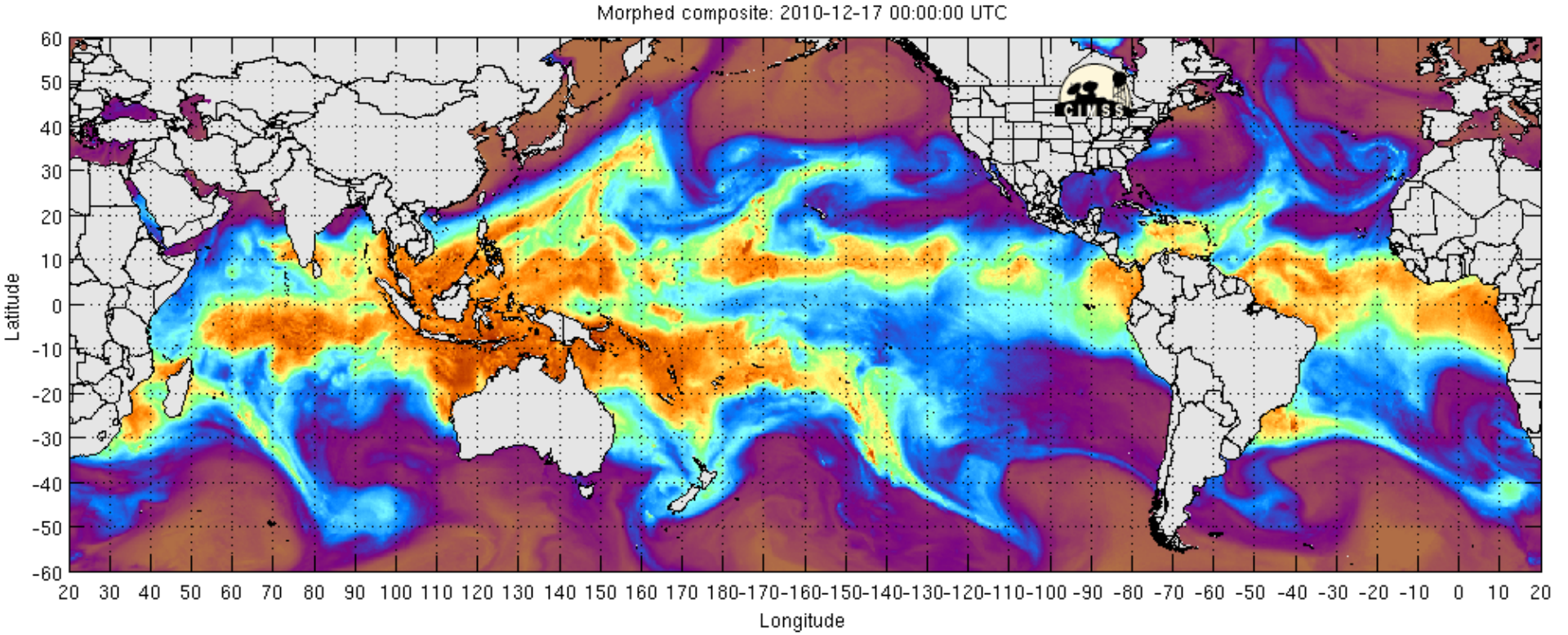
SCRIPPS INSTITUTION OF OCEANOGRAPHY

NOAA's California-Nevada Applications Program

Atmospheric rivers





December 17-19 2010

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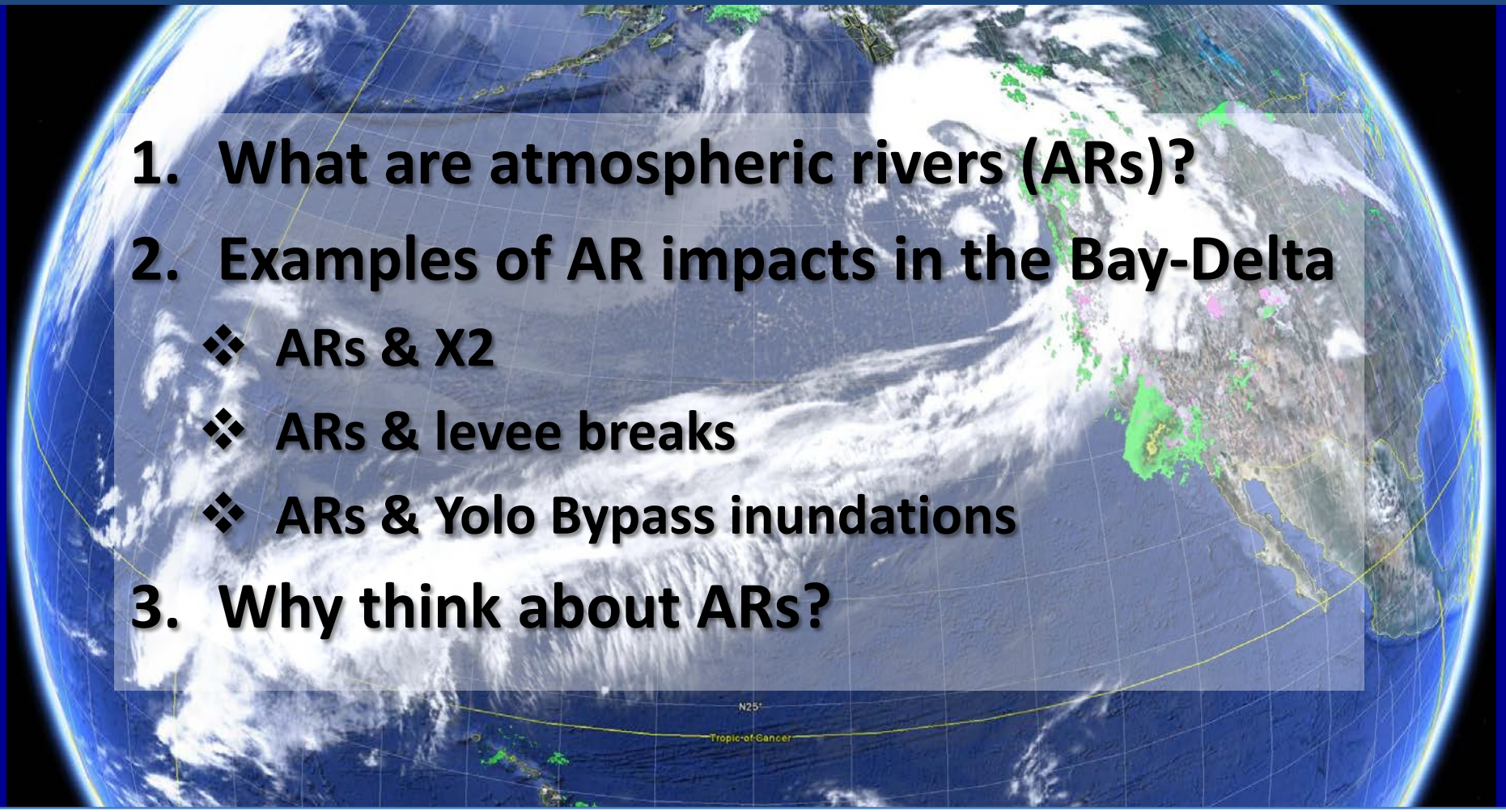
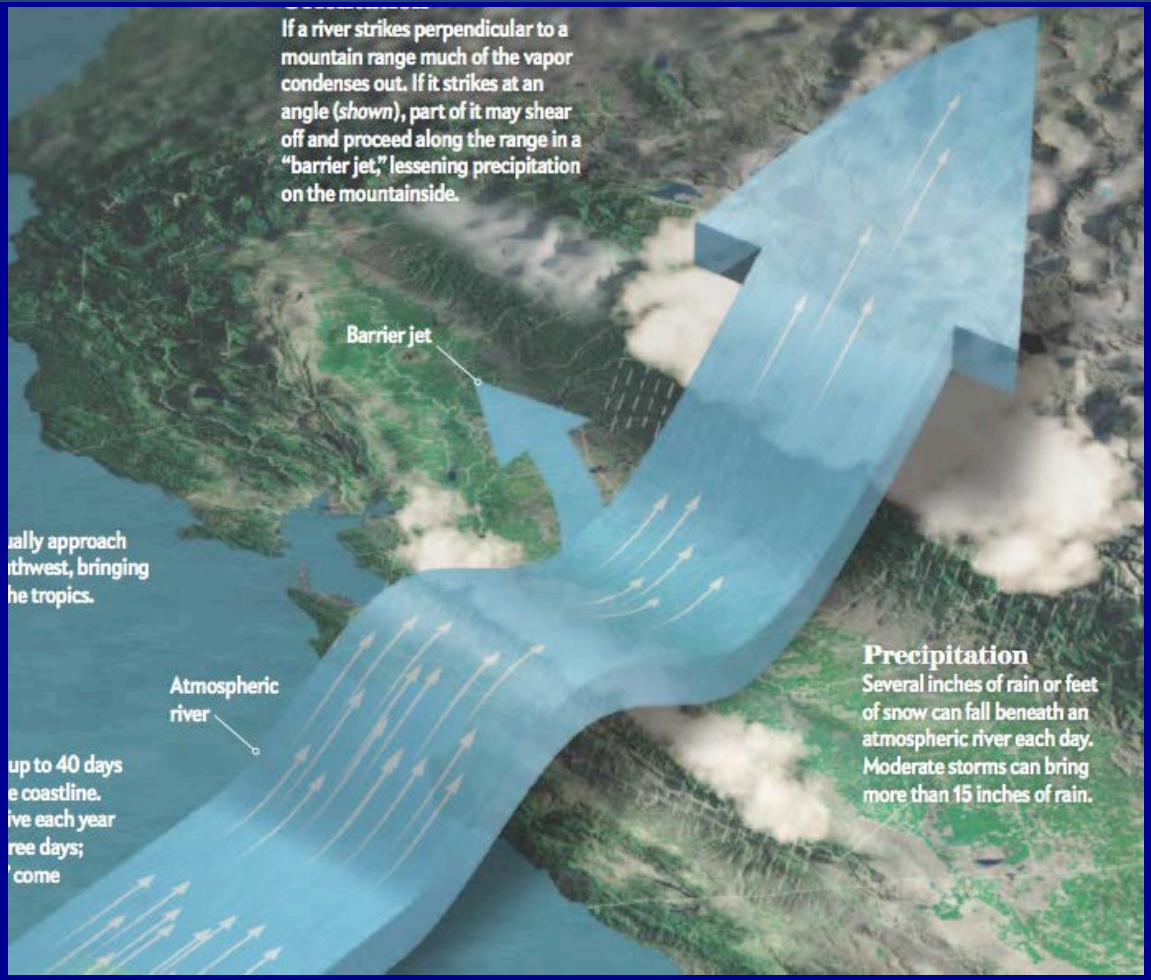
Outline



1. What are atmospheric rivers (ARs)?
2. Examples of AR impacts in the Bay-Delta
   - ❖ ARs & X2
   - ❖ ARs & levee breaks
   - ❖ ARs & Yolo Bypass inundations
3. Why think about ARs?

Landfalling atmospheric river



-Map-view structure *(~400 km width & 2000 km long)--from satellite data*

-Vertical structure *(intense jet of vapor between 1 – 2 km above sea level; 10-20 Mississippis; easily uplifted)--from airplanes & radar*

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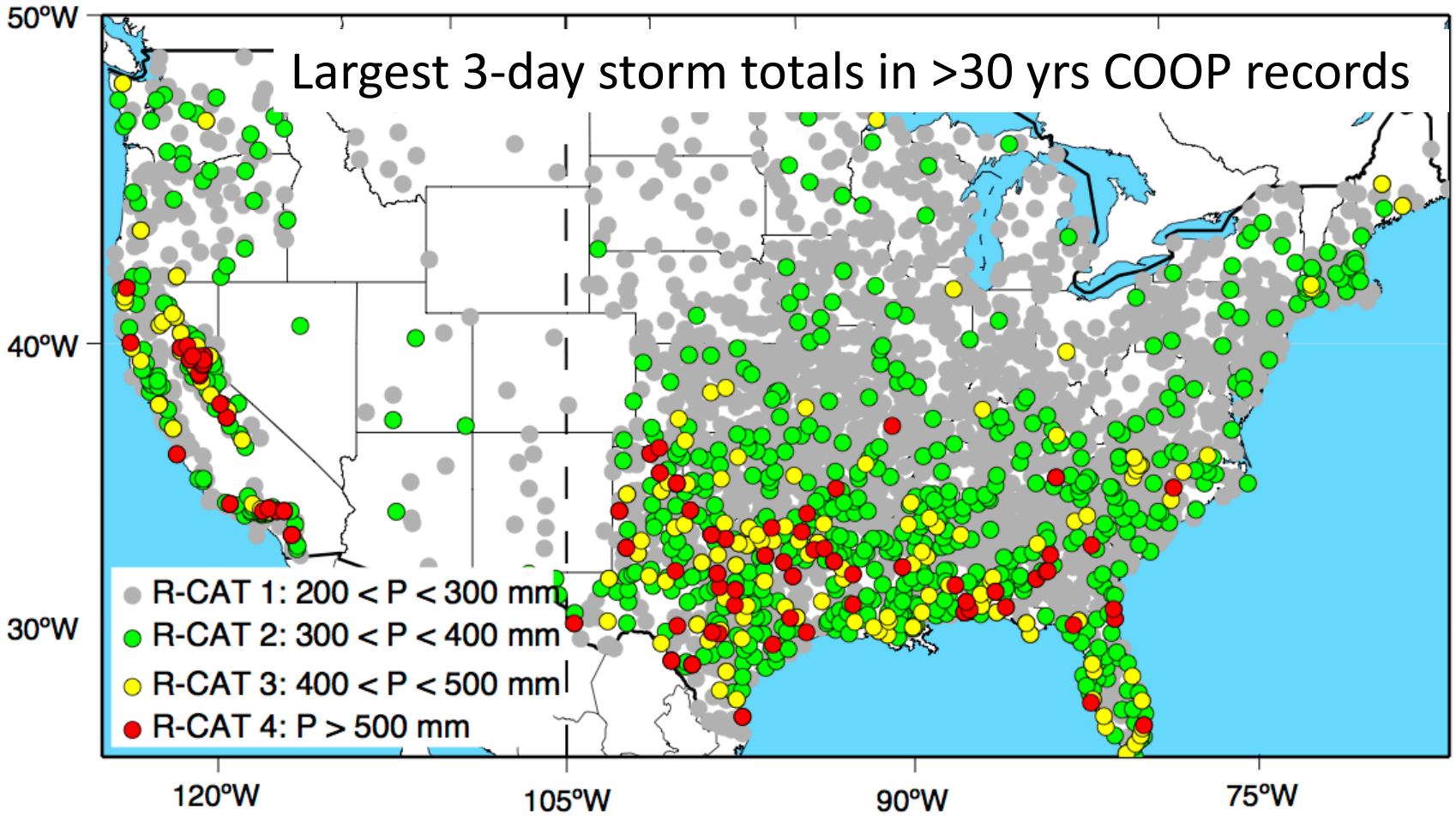
Ralph et al., MWR, 2004;
Dettinger & Ingram, Sci American, 2013

Just how BIG are these storms?



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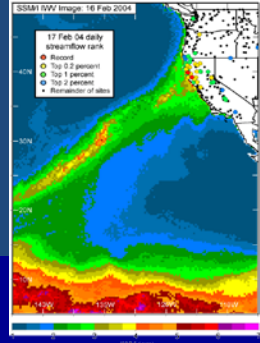
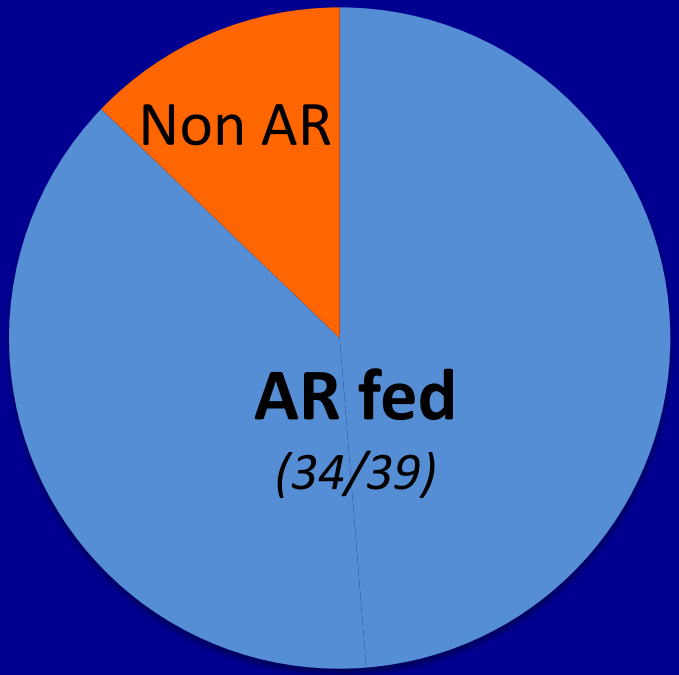
Ralph & Dettinger, BAMS, 2012

ARs & West Coast floods





• *ALL 7 major floods of Russian River since 1997 have been atmospheric rivers (Ralph et al, GRL, 2006)*

On a longer time scale, **among all 39 "declared" floods of the Russian River** *(39 cases with > 50,000 cfs)* **from 1948-2011…**

87% were caused by ARs

In Washington, 46 of 48 annual peak daily flows have been associated with ARs (Neiman et al, JHM, 2011)

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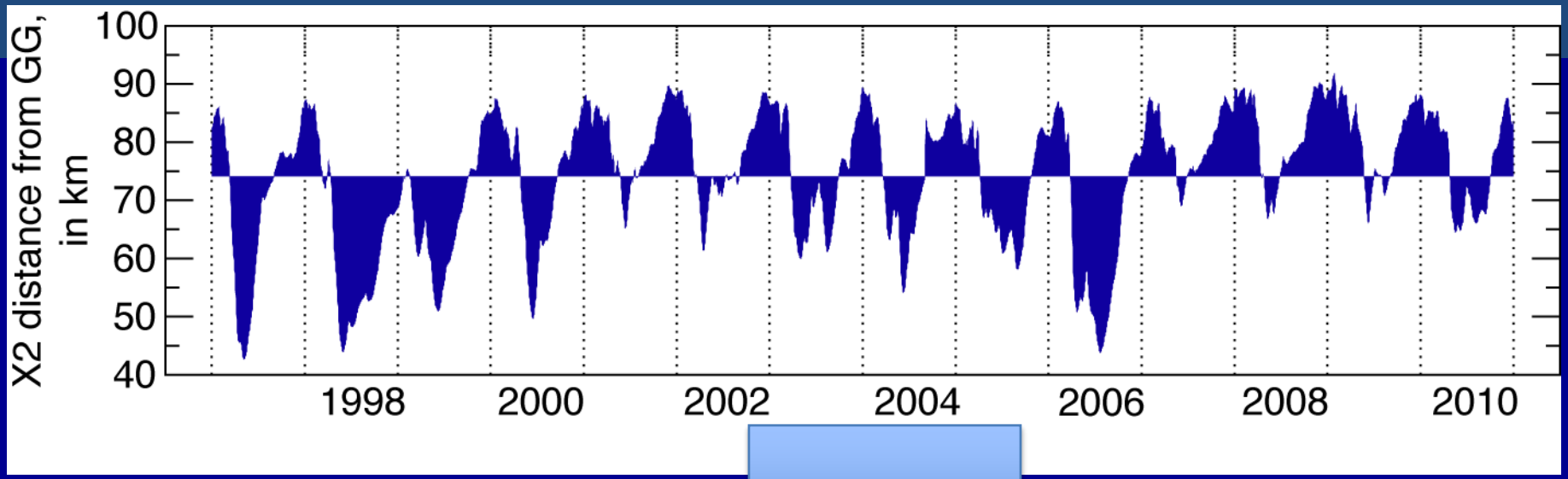
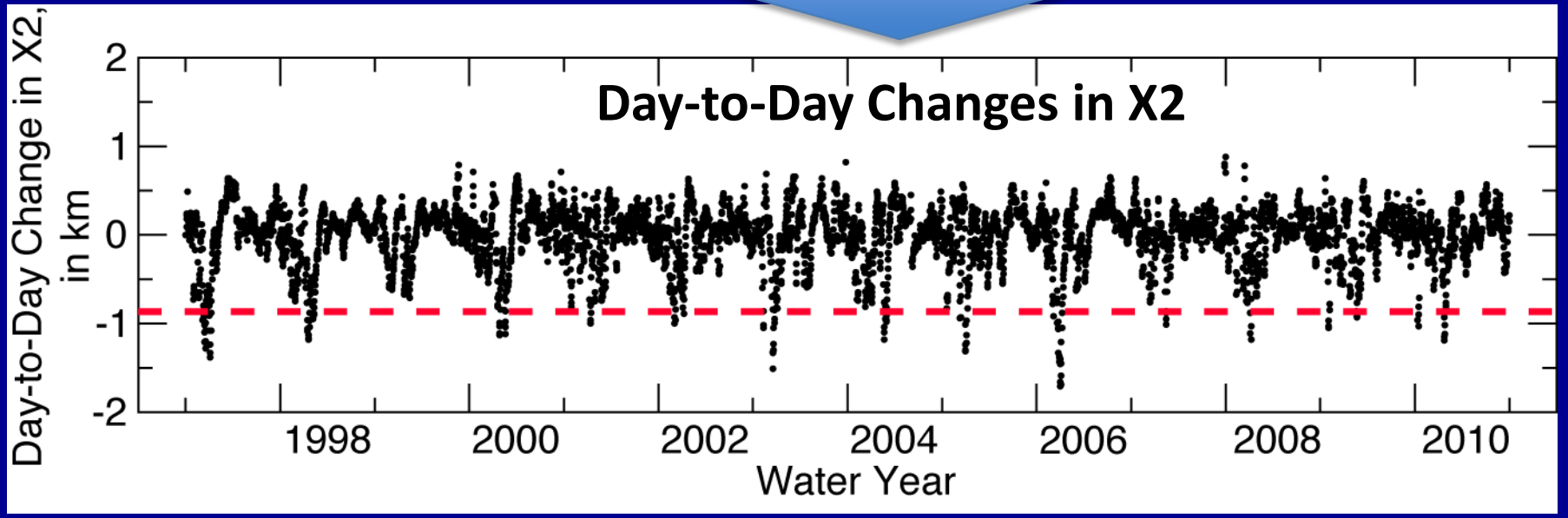
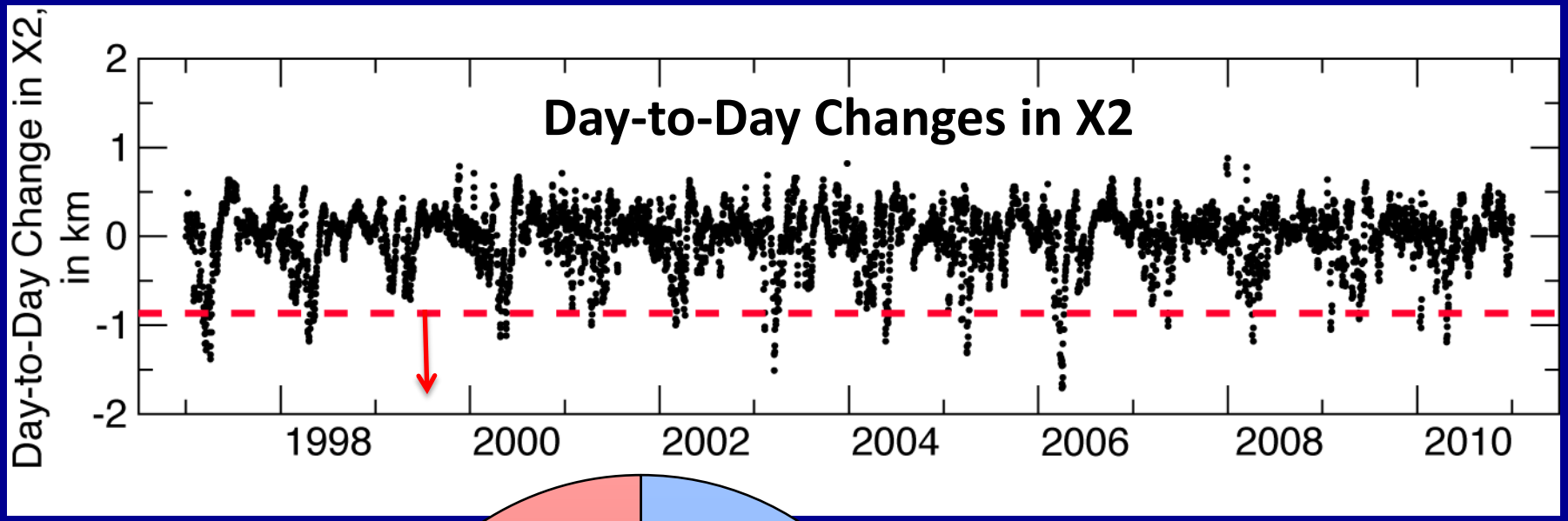
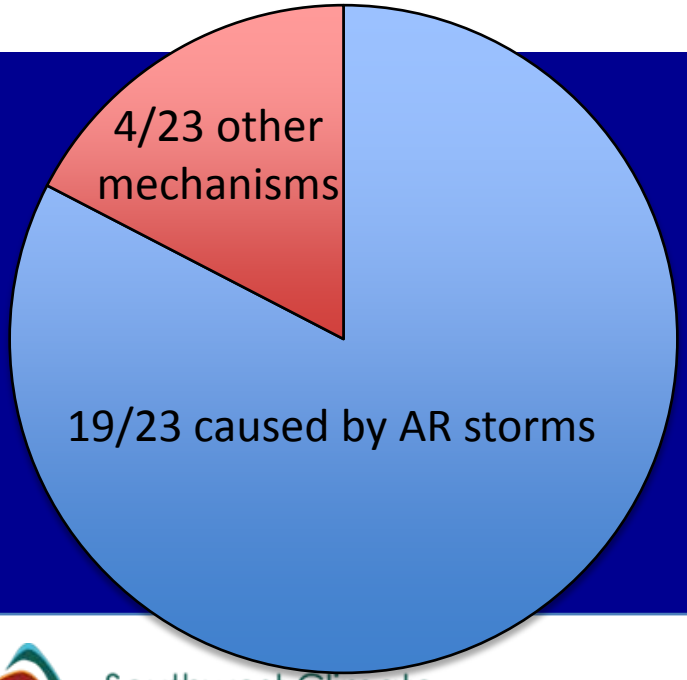
Atmospheric Rivers & X2: Distance from Golden Gate Bridge to where near-bottom salinity drops to 2 ‰









83% of largest (daily-scale) X2 retreats, WY1997 -2010, have been due to atmospheric-river storms

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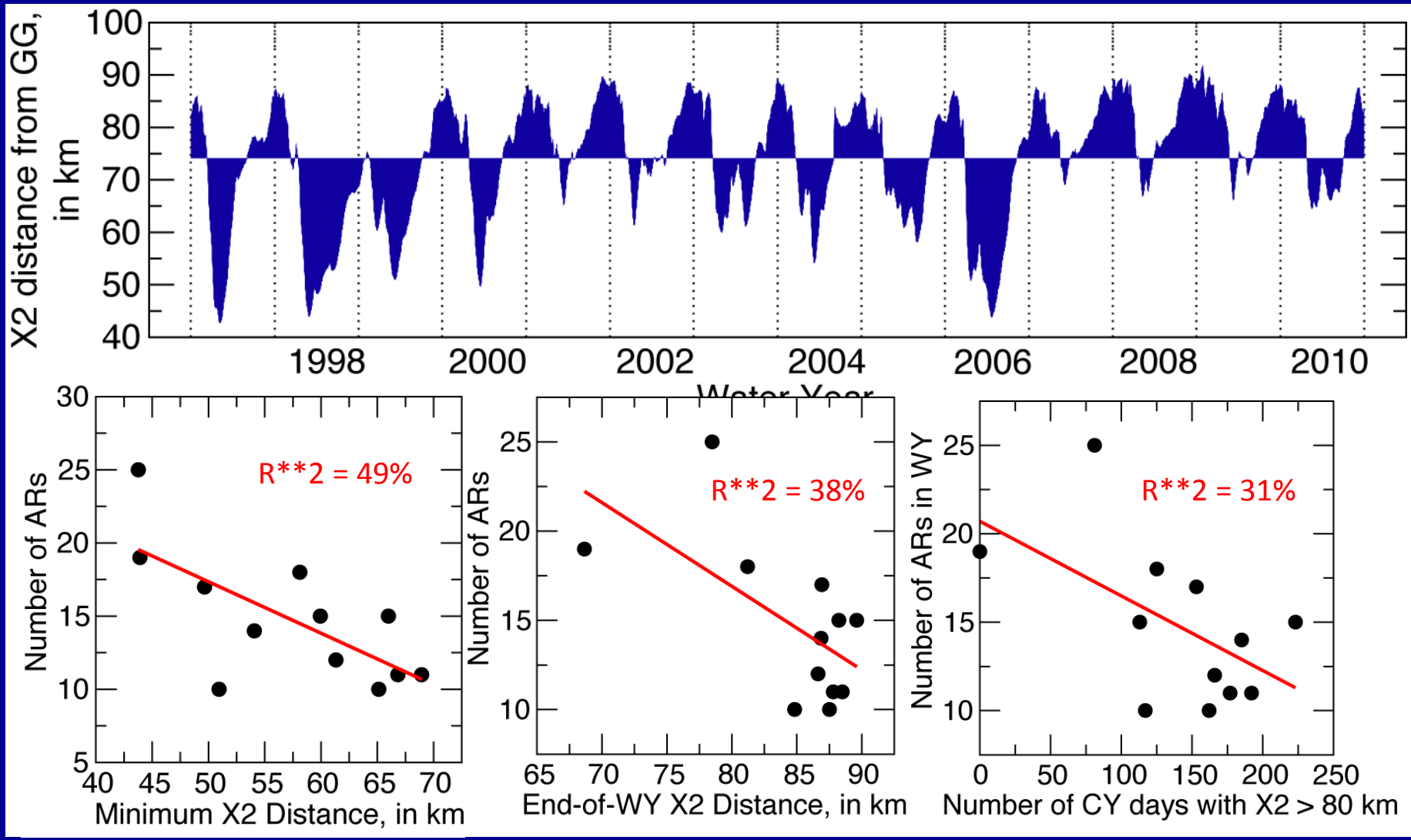
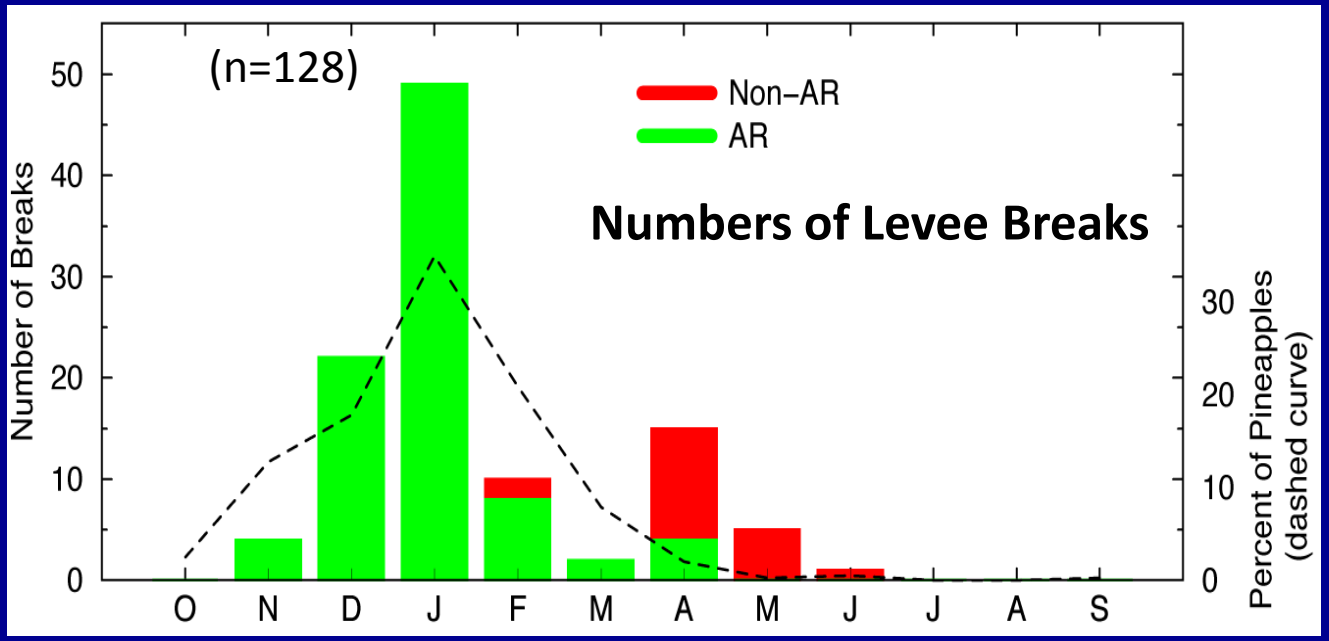
Atmospheric Rivers & X2: Distance from Golden Gate Bridge

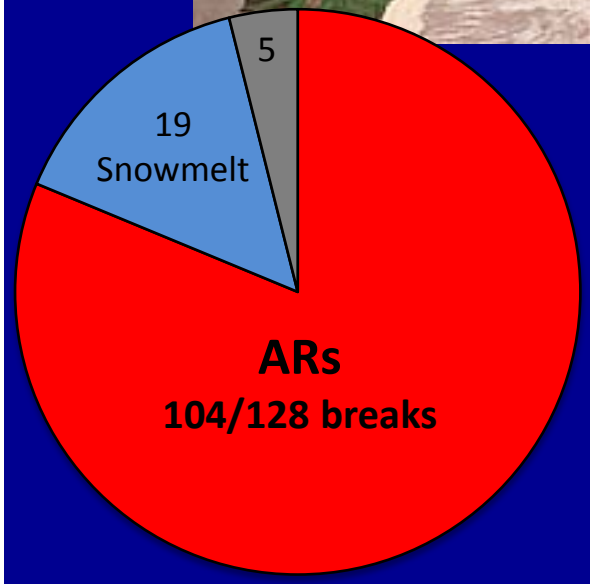
to where near-bottom salinity drops to 2 ‰



Central Valley levee breaks, 1951-2006

81% of well-dated levee breaks have been AR driven
(15% snowmelt)





During the times of year when ARs make California landfalls, they are THE mechanism behind historical levee breaks.

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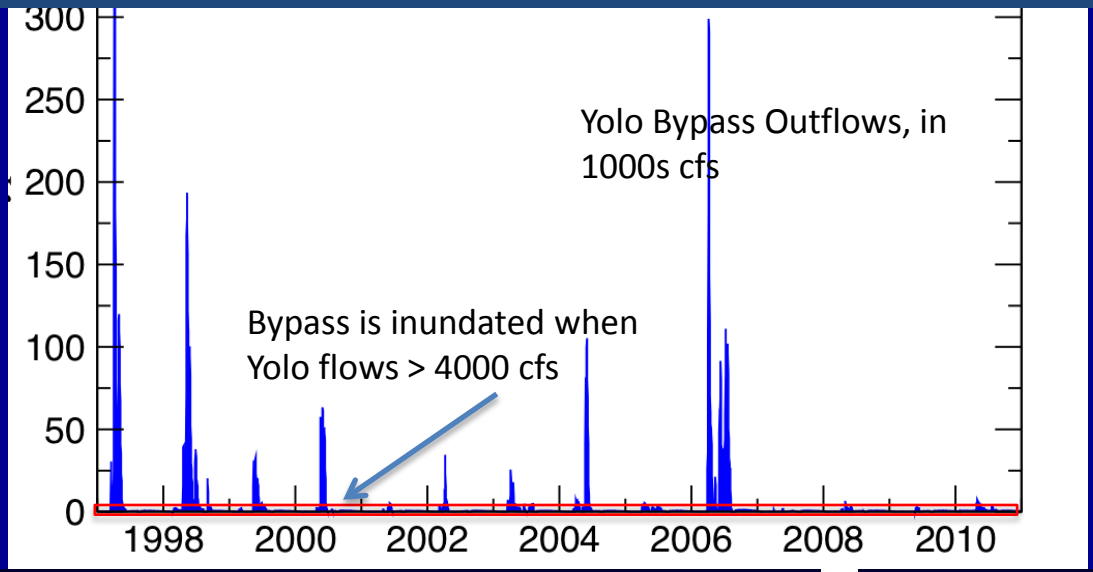
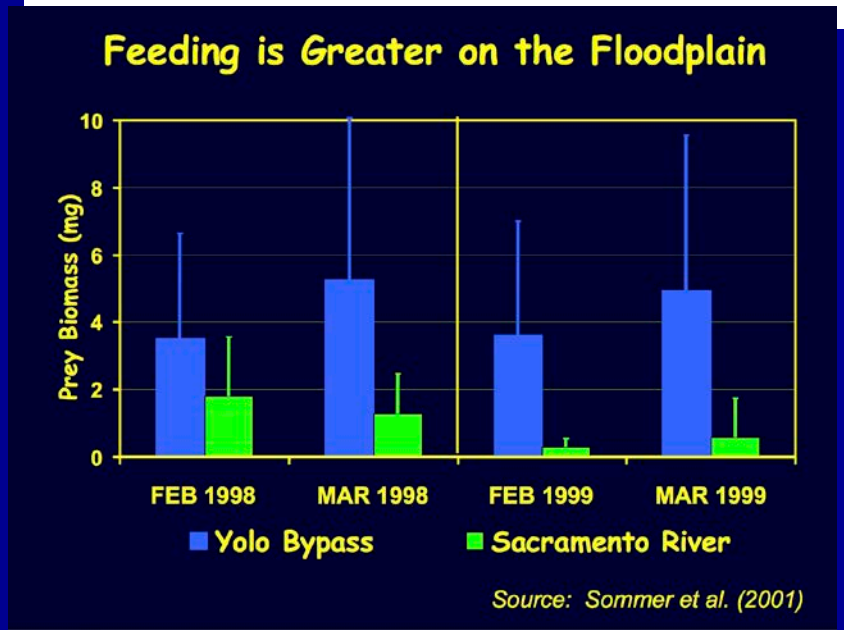
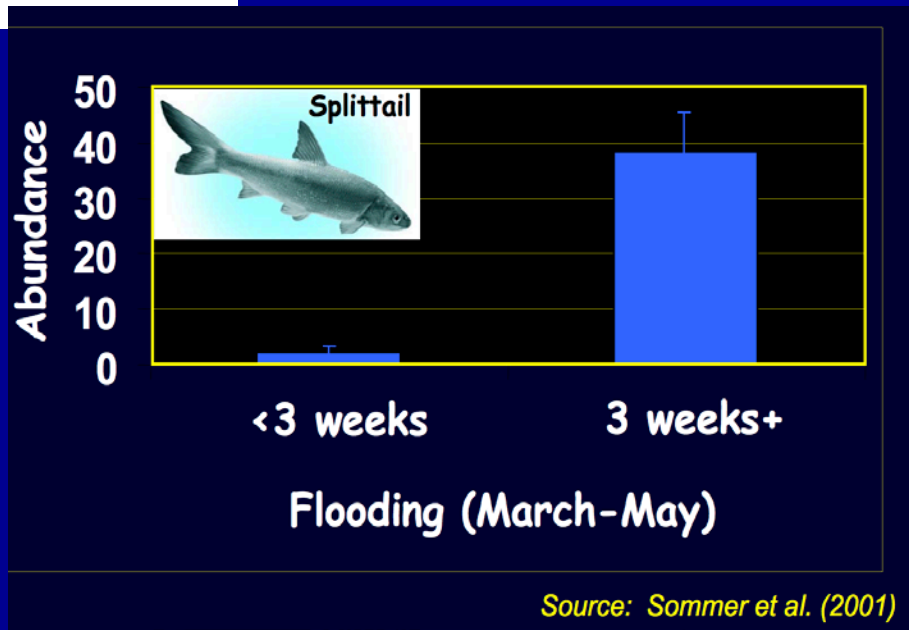
Florsheim & Dettinger, book chapter, in review; Florsheim & Dettinger, GRL, 2007

Recent Yolo Bypass Inundations



- **Inundated floodplains are key nurseries & cafeterias for Bay-Delta fisheries & ecosystems**
- **Extended inundations are necessary for these benefits to accrue**





Based on 55 yrs of Yolo Bypass Outflows

Yolo Bypass Floodplain

Inundations of Various Durations, WY1956–WY2010

Number of Inundations

120
100
80
60
40
20
0

Percentage

100
80
60
40
20
0

Number of inundations

Number of AR-initiated inundations

Percentages of inundations from ARs

>0 days
>7 days
>14 days
>21 days
>28 days

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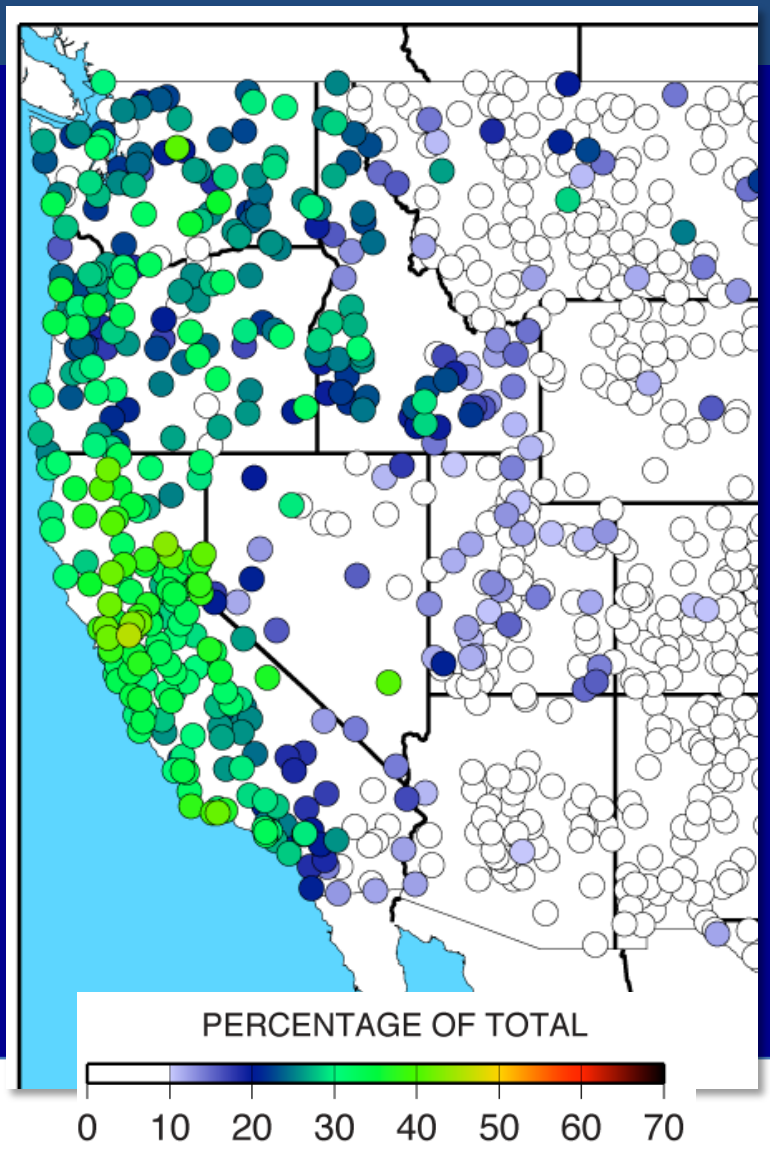
Florsheim & Dettinger, book chapter, in review

Atmospheric rivers as resource

CONTRIBUTIONS TO WATER YEAR TOTAL PRECIPITATION FROM ARs:
(days 0 to +1), 1998-2008

ARs provide 30 – 50% of all precipitation in the Bay-Delta catchment (and comparable amounts of streamflow)



Dettinger et al., Water, 2011

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Why atmospheric rivers?

Atmospheric rivers are their own special "species" of storms

- Typically about 10 ARs make landfall per winter
- ARs average 85% wetter than wet days in general
- ARs average +2ºC warmer than wet days in general
- Our largest storms & largest floods historically are from ARs
- ARs projected to become 10 – 15% more common & more intense this century, with addition of notable new extremes
  (Dettinger, JAWRA, 2011)

…and we have significantly modified AR hazards & contributions to the Bay-Delta system in ways not always well understood

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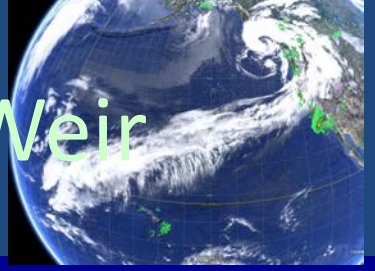
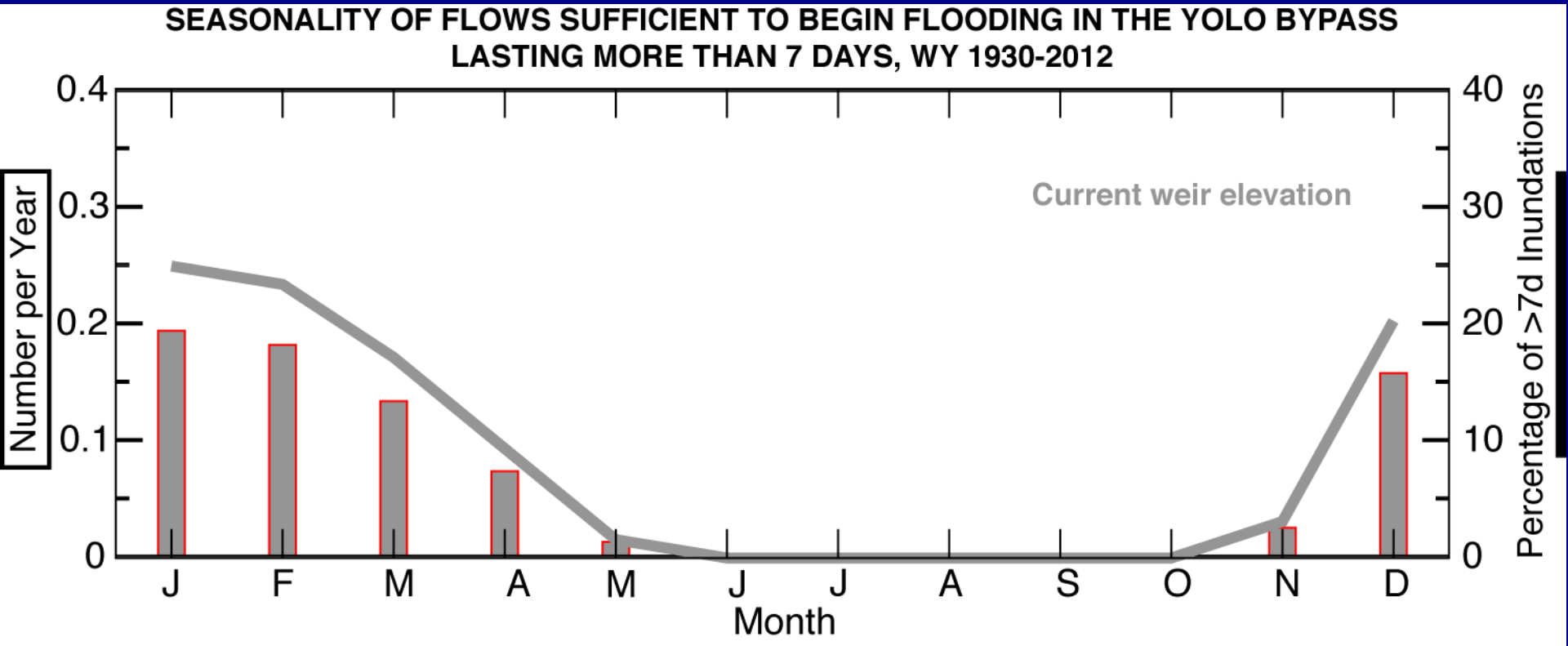
Flows sufficient to overtop Fremont Weir





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Florsheim & Dettinger, book chapter, in review

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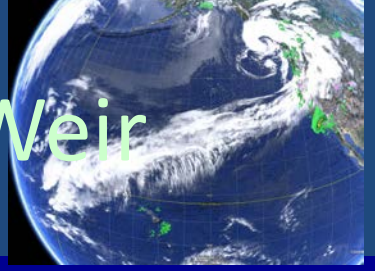

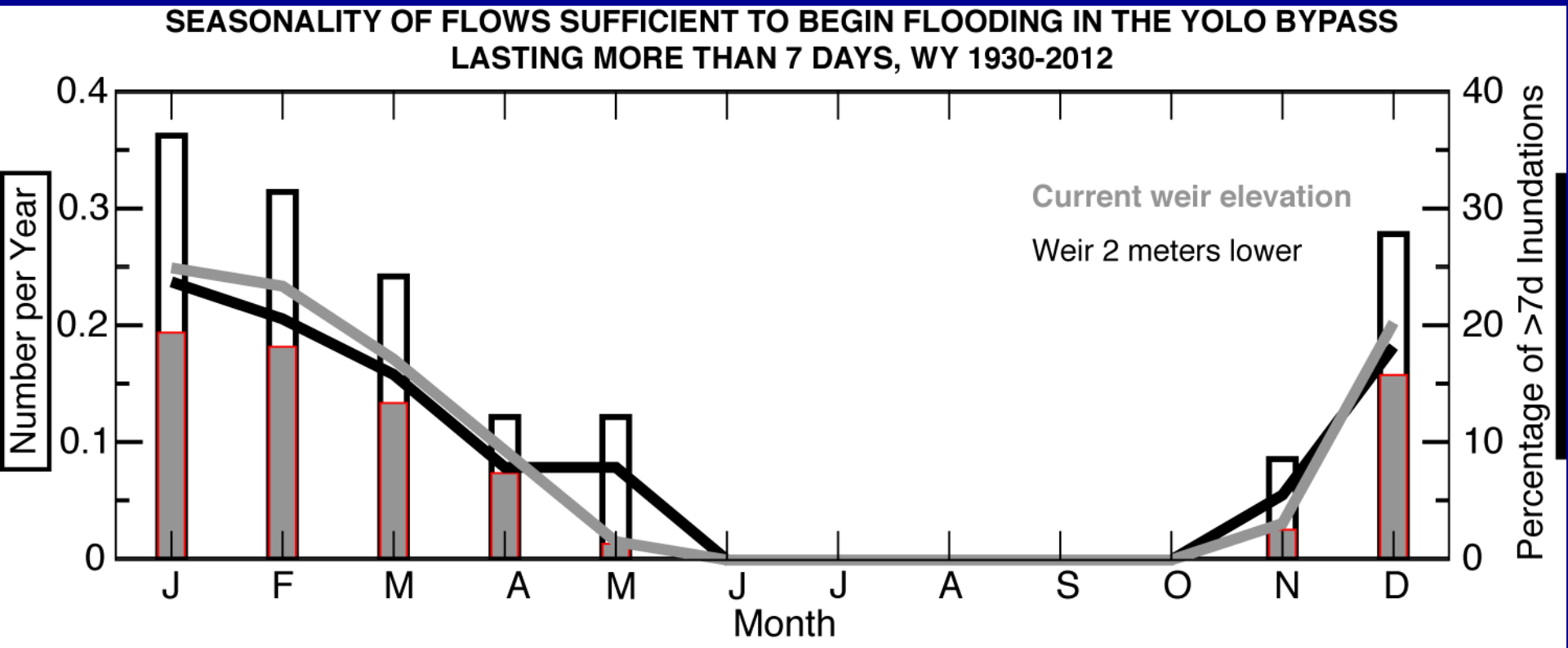

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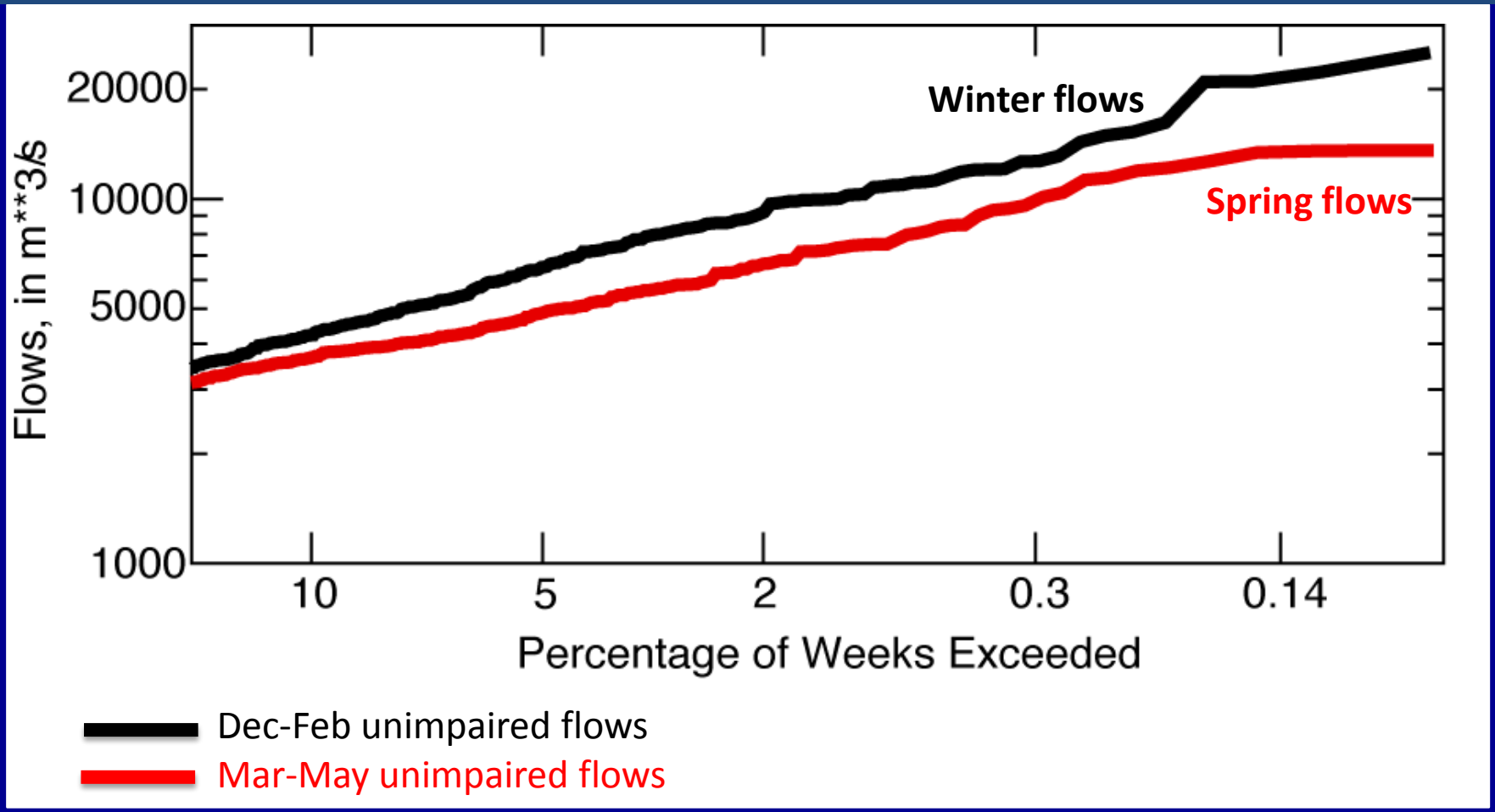
Florsheim & Dettinger, book chapter, in review

Unimpaired & Managed (Real) 7-day Delta Inflows, 1967-1987



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Florsheim & Dettinger, book chapter, in review; Knowles, WRR, 2002

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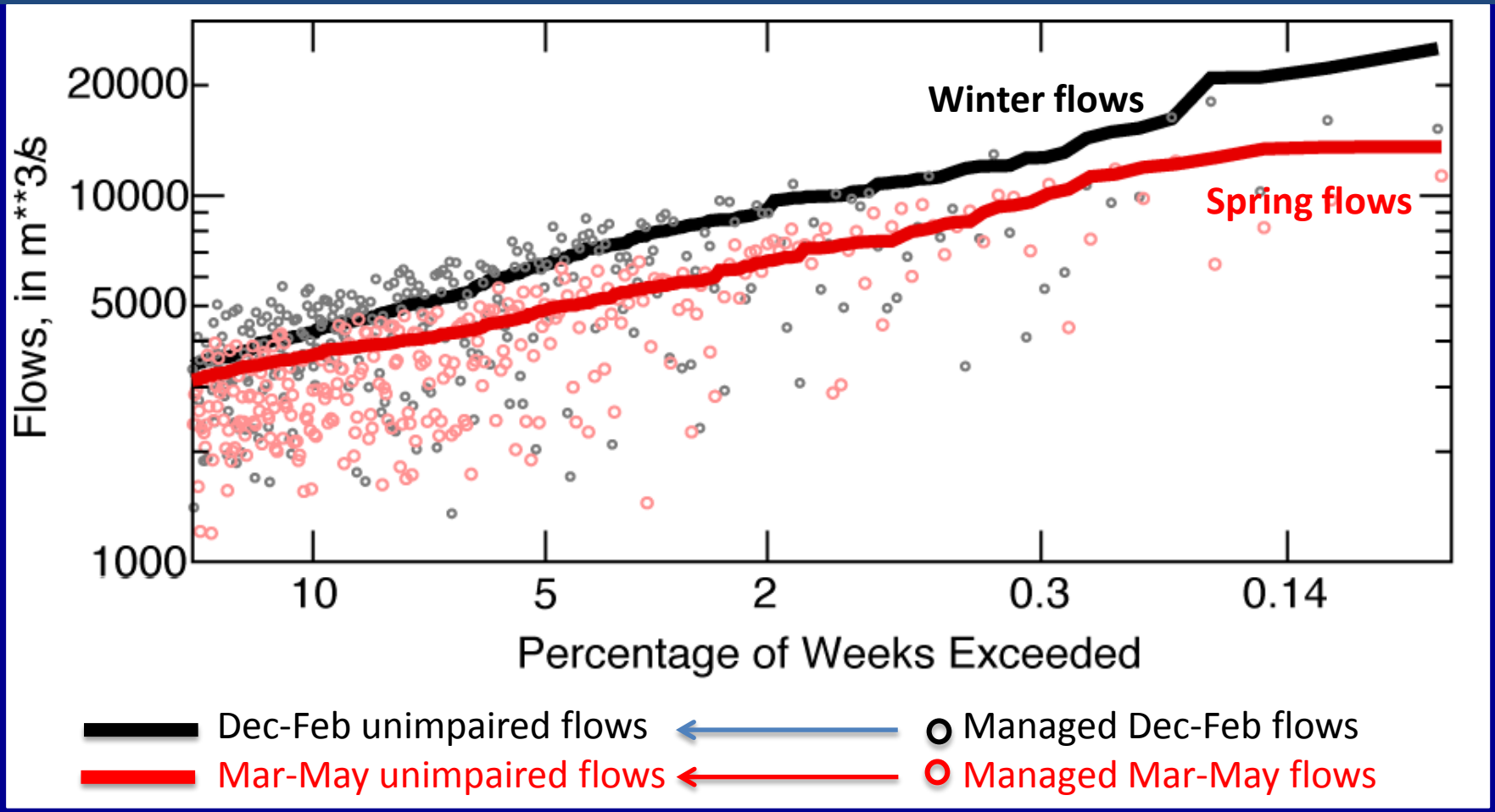

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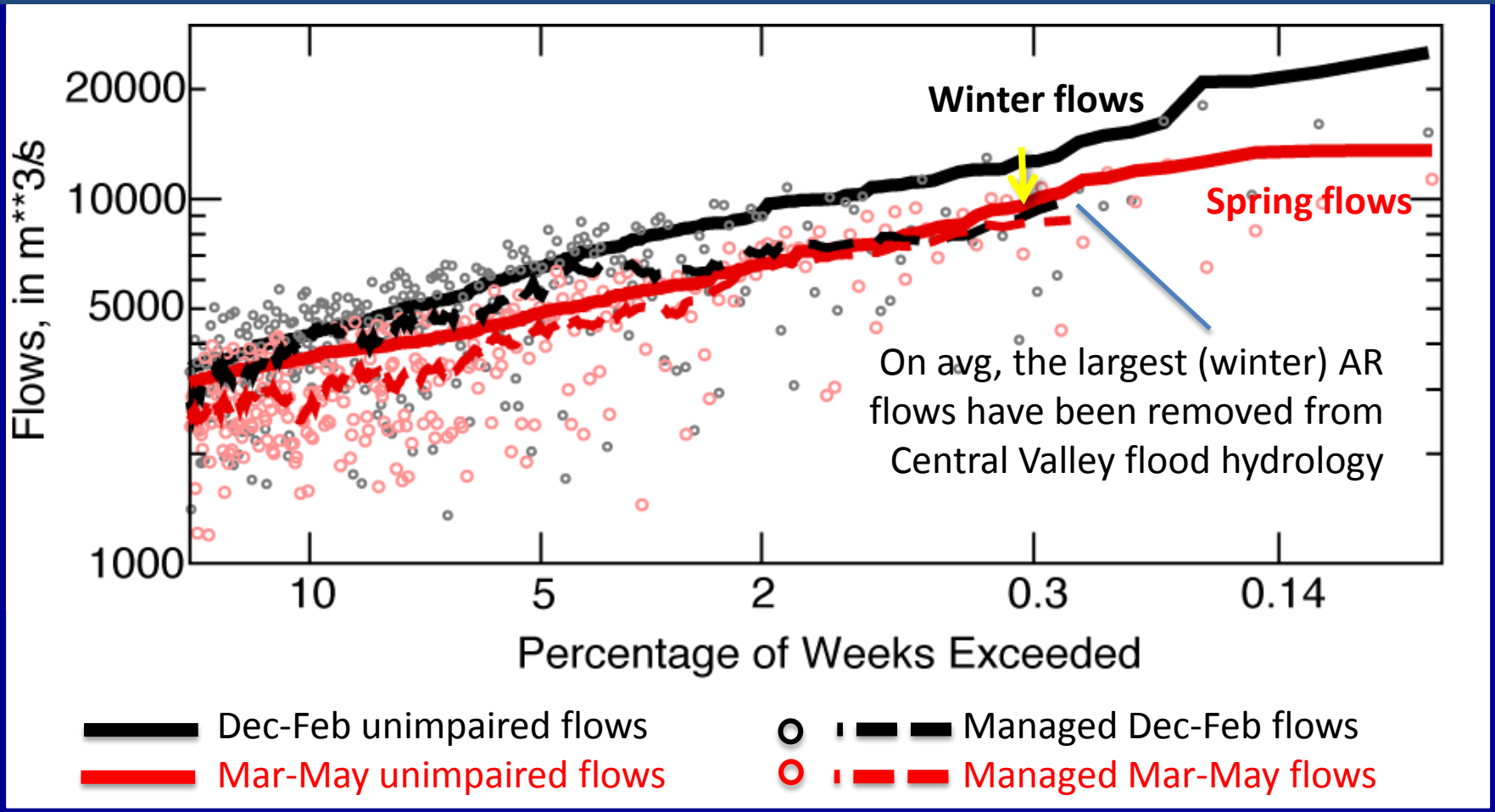

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Florsheim & Dettinger, book chapter, in review; Knowles, WRR, 2002

Conclusions

- Atmospheric rivers are crucial processes in natural regimes of floods, water resources & environmental processes in Bay-Delta
- Forecasting ARs is basic to planning/managing for key issues
  - ARs strongly influence salinity in the Bay-Delta (x2)
  - ARs dominate historical levee breaks
  - ARs initiate large majorities of ecologically significant inundations of Yolo Bypass & elsewhere
- More intense storms, higher snowlines, and resulting greater flood risks projected for the 21st Century; but we have (on avg) already increased the influence of ARs in system by removing many snowmelt peaks and reduced AR-flow sizes…

What future flood regimes will Bay-Delta ecosystems face?

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http://www.esrl.noaa.gov/psd/atmrivers/

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