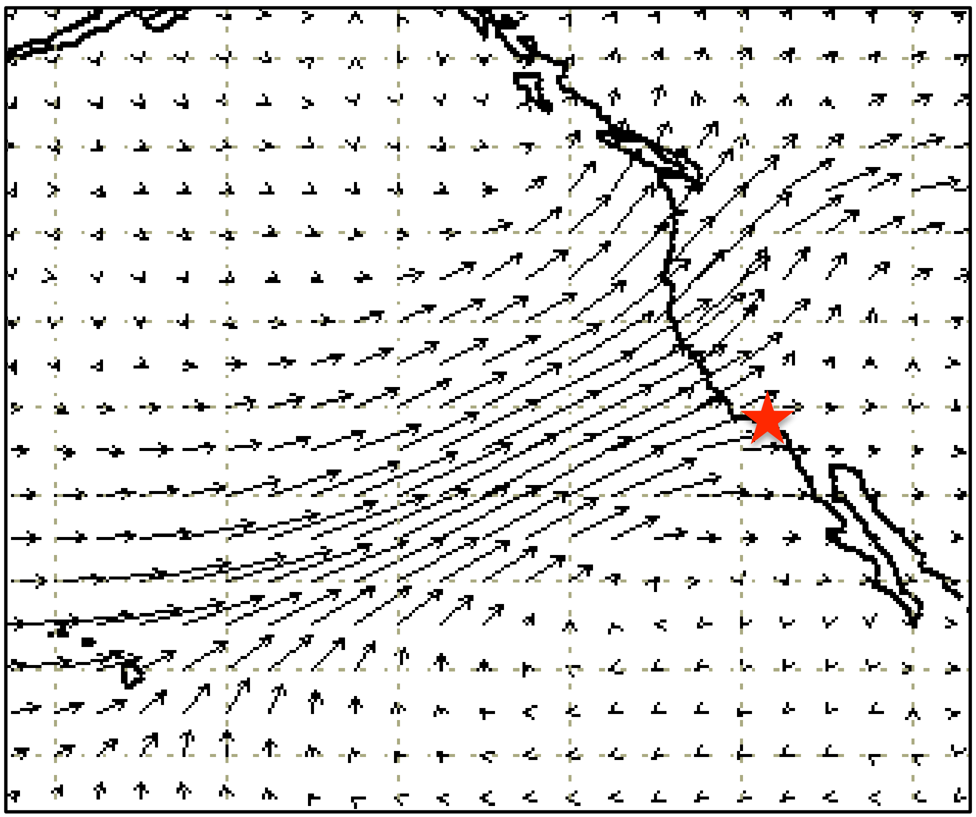
Timing is Everything: The Role of River-Ocean Coherence in Ocean Sediment Dispersal & Accumulation

Rob Wheatcroft



Dettinger, 2004

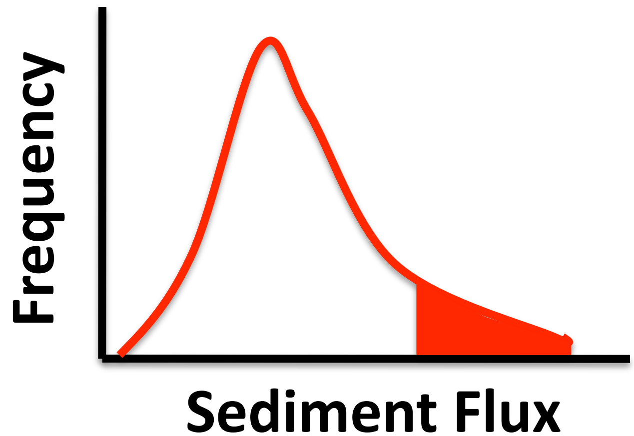
- Motivation
- The concept of ROC
- Importance of basin size
- Three examples
- The *real* source in S2S?

Motivation (platitudes?)

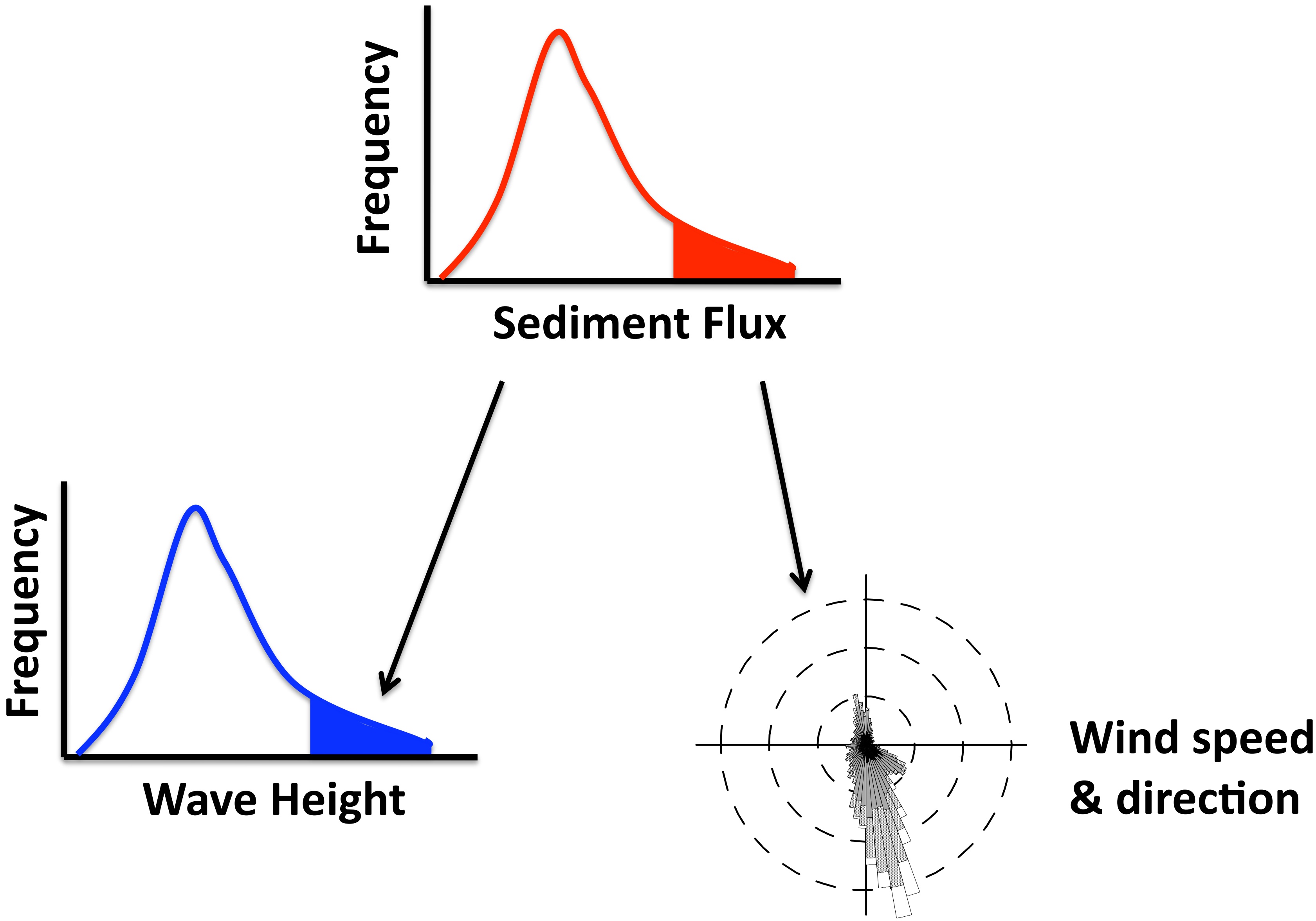
- Most sediment (& POC) is delivered to the ocean during short-lived, **high-discharge** events
- **Wave** energy during delivery influences the cross-margin dispersal of sediment
- **Wind** speed & direction influence coastal currents, hence along-margin dispersal
- Once deposited, sediment is more difficult to disperse further due to **consolidation** effects
- **Hence, wind & wave conditions during floods are key!**

But, there is tremendous variation in forcing conditions in the coastal ocean… ☹

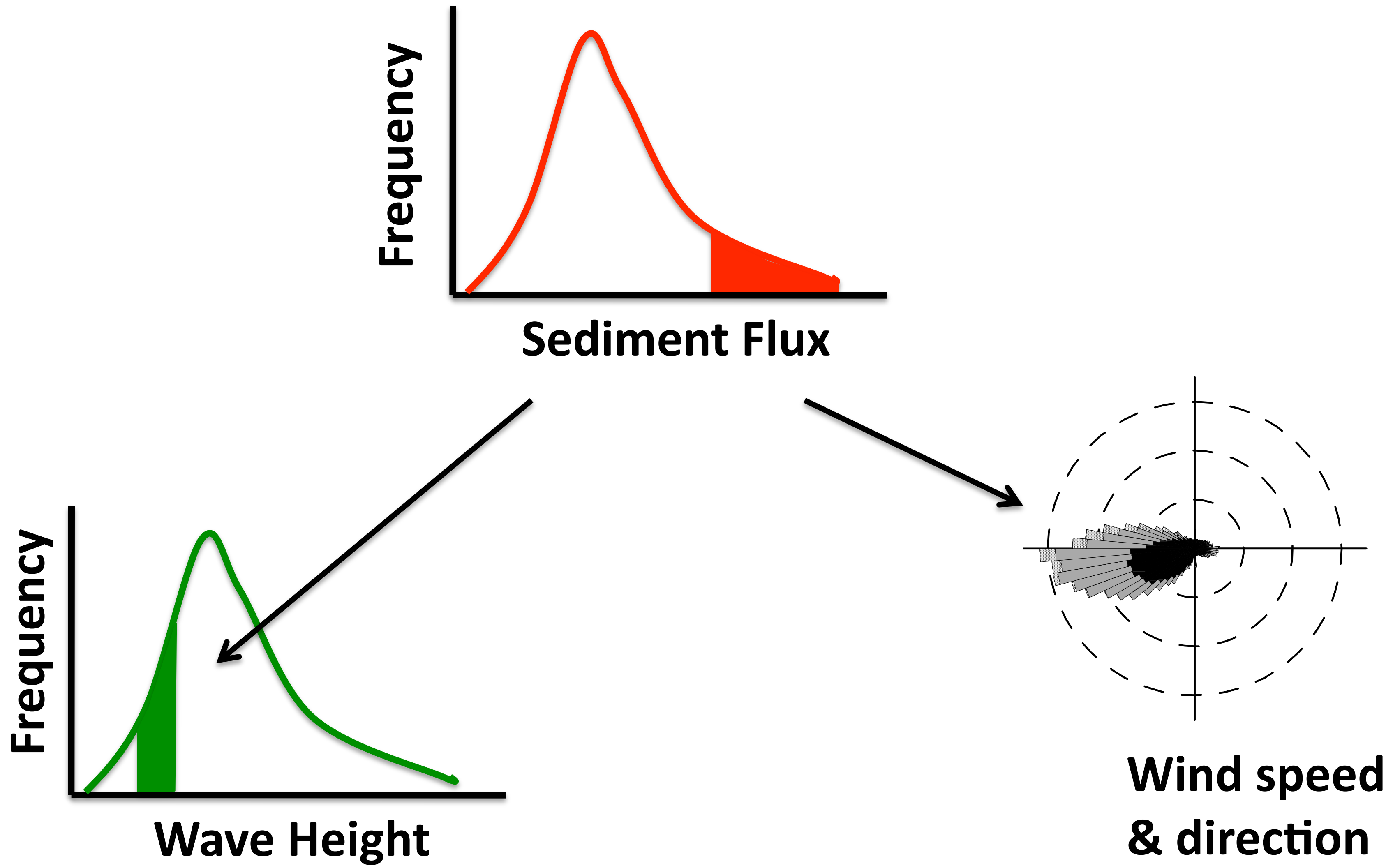
There exists a pdf of sediment flux & we mainly care about the right tail of the distribution…



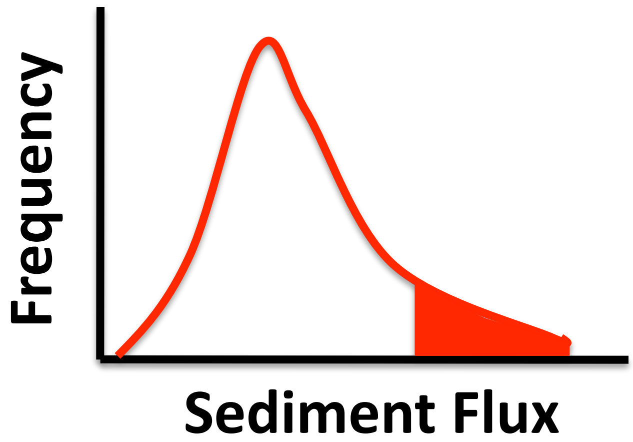
Possibility 1: High waves, strong, southerly winds during flooding

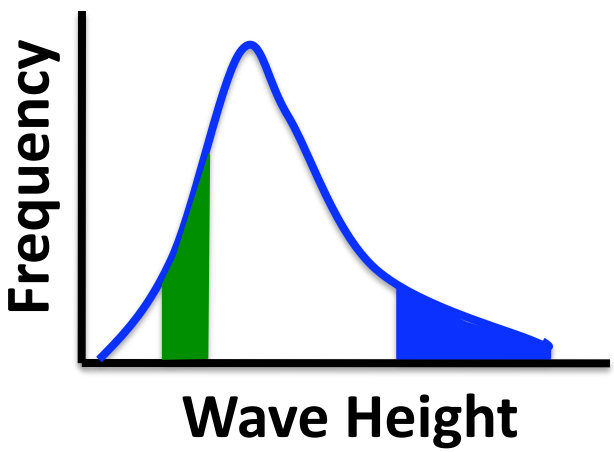


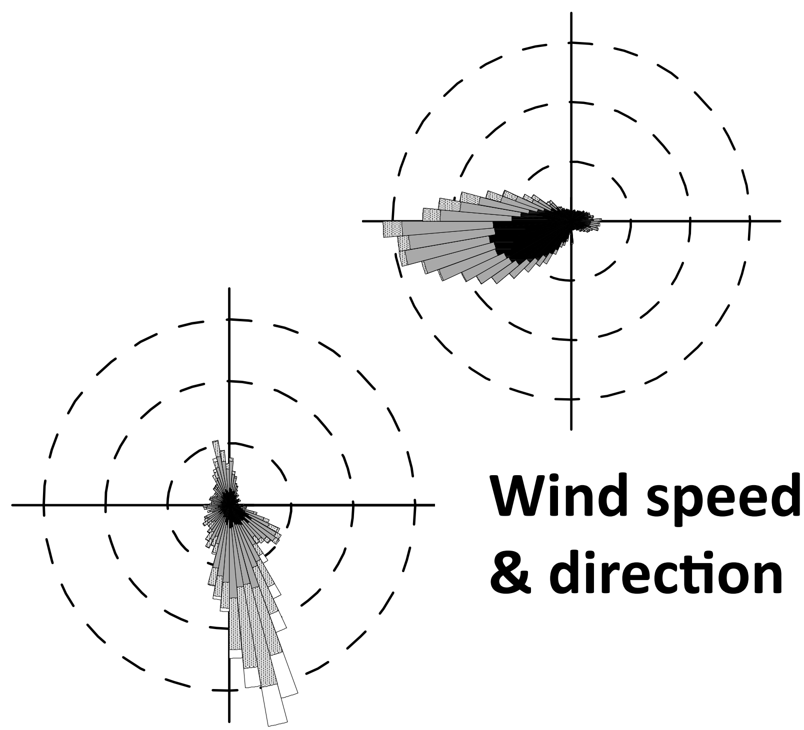
Possibility 2: Low waves, weaker, westerly winds during flooding



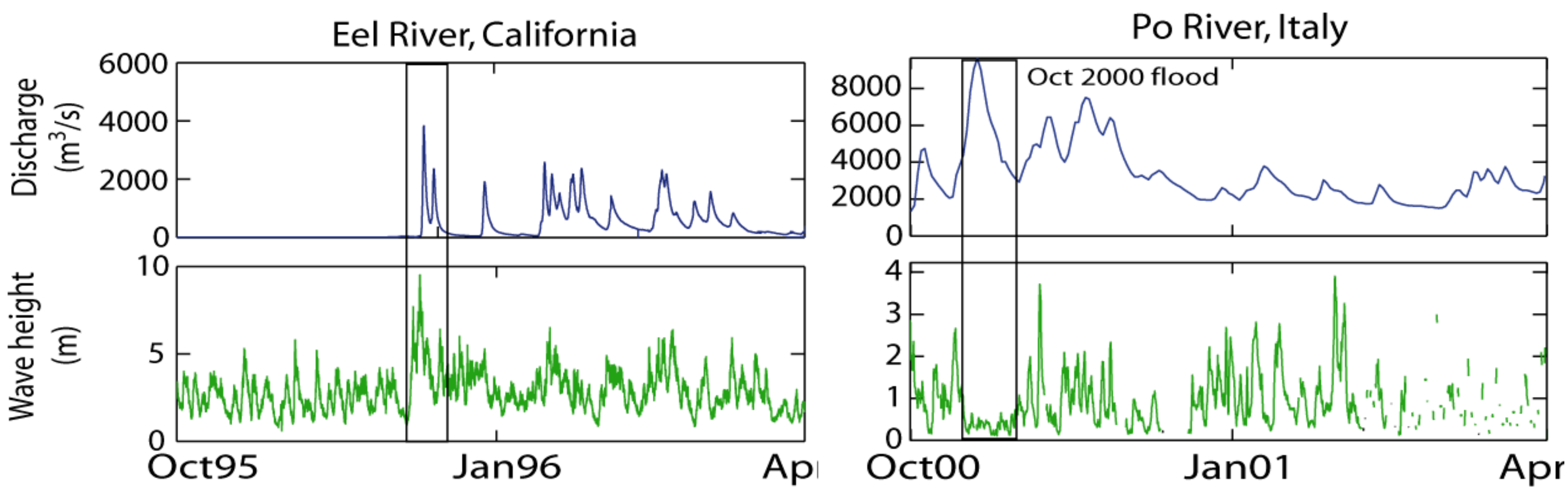
River-Ocean Coherence (ROC) implies that both wave/wind possibilities do not exist during floods







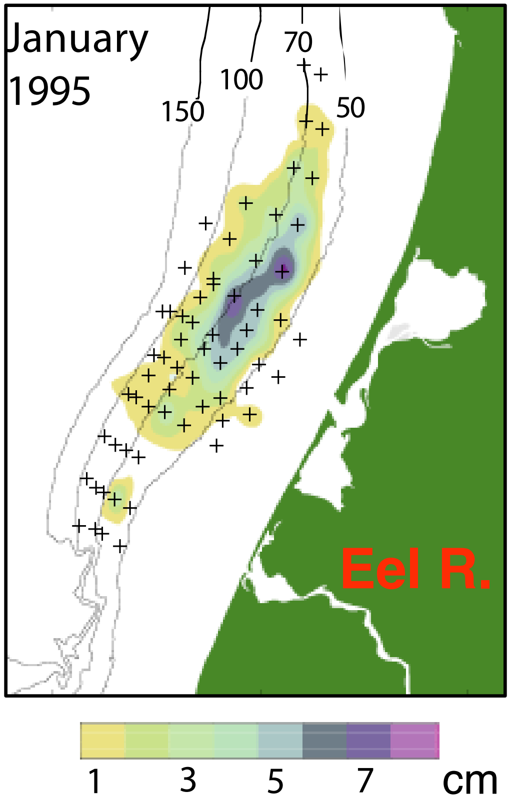
In the case of ROC, size matters!



- **~9K km²**, floods: 1 - 3 days
- Storms & floods are highly coherent
- Ocean conditions: low variability, but energetic

- **~70K km²**, floods: 2 - 3 weeks
- Storms & floods are not necessarily coherent
- Ocean conditions: high variability, but mostly fair-weather

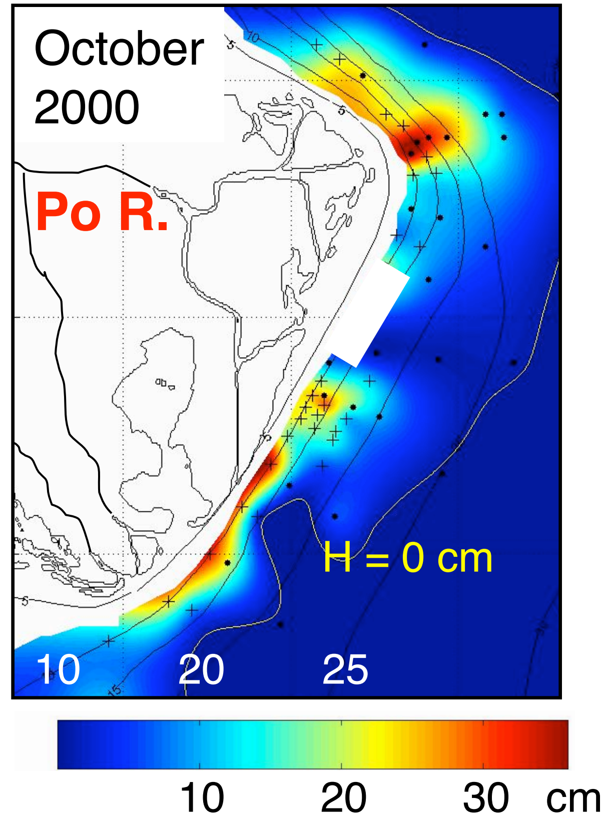
Coupled river-ocean system



Wheatcroft & Borgeld, 2000

- Deposit displaced from river
- No proximal-distal pattern
- Gentle thickness gradients
- Stratigraphically simple

Uncoupled river-ocean system

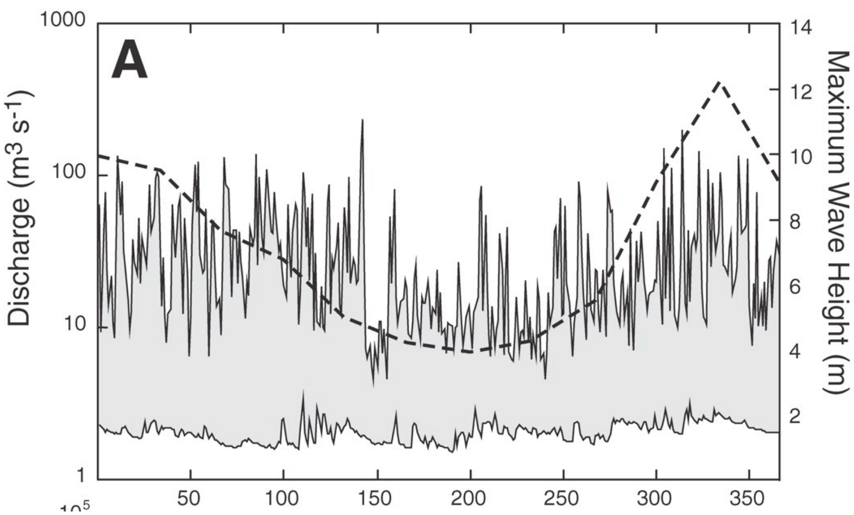


Wheatcroft et al. 2006

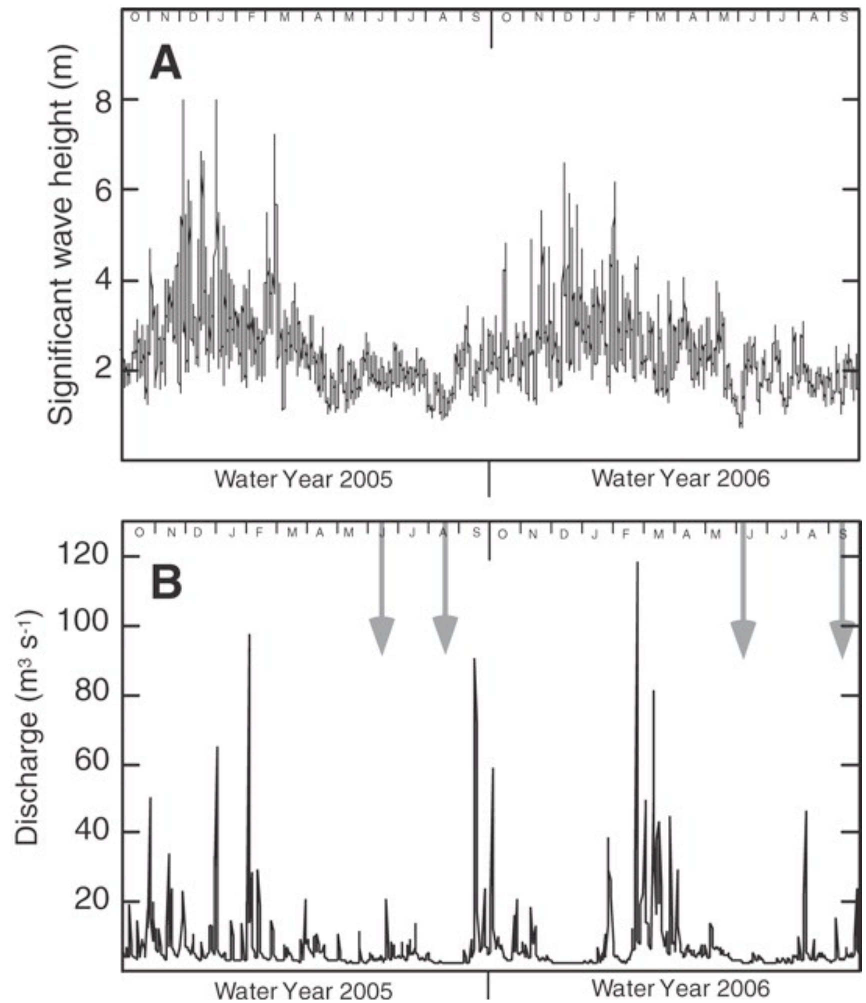
- Deposit adjacent to river
- Clear proximal-distal pattern
- Sharp thickness gradients
- Stratigraphically complex

Hanalei River, Kauai, Hawaii

- 54 km^2 basin area
- Multiple sources of rainfall:
  - NE trades, diurnal sea breezes, orographic
  - Mid-latitude cold fronts
  - "Kona lows", cutoff lows from subtropical westerlies
- Mismatch between high discharges & high waves

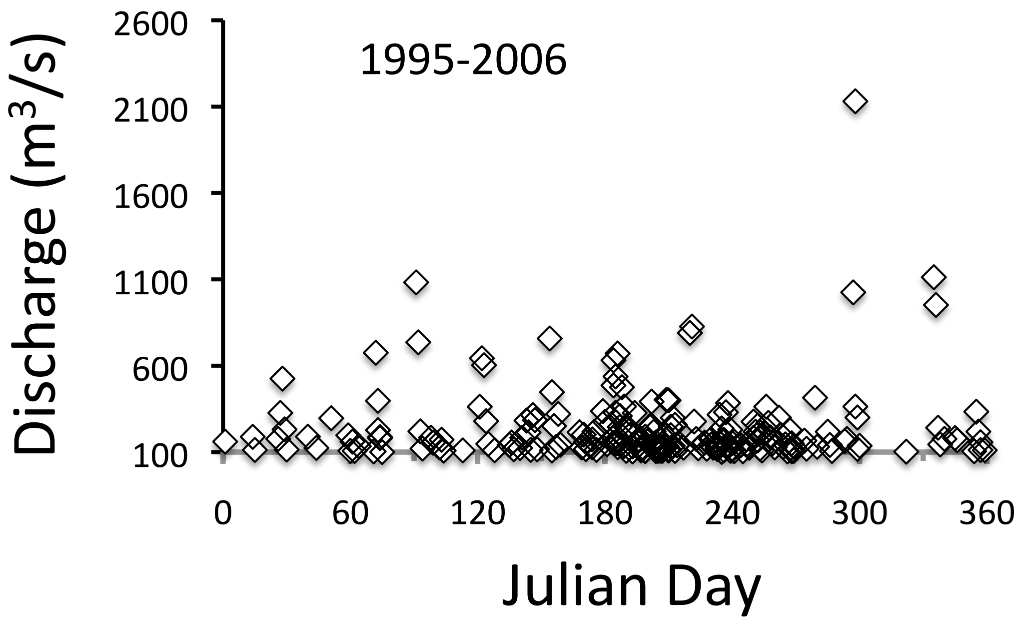


Year Day

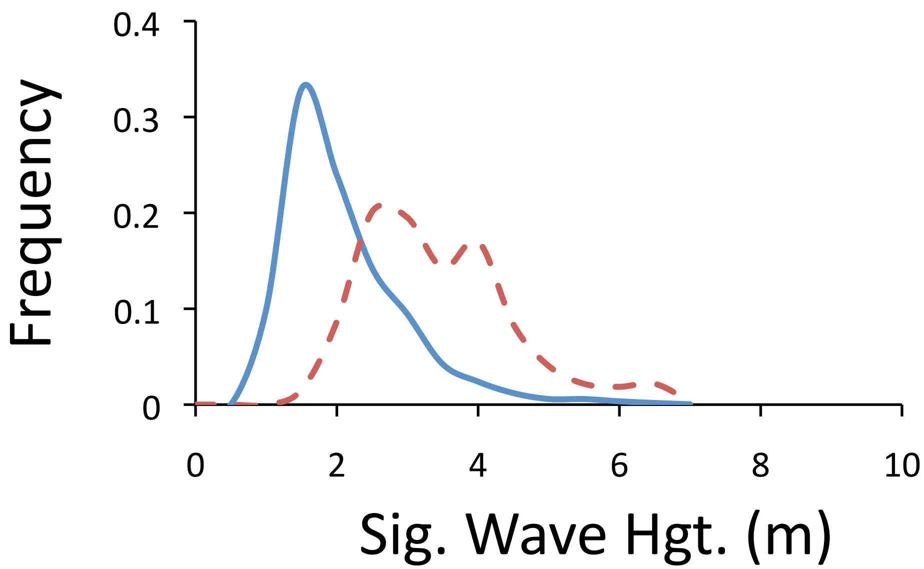


Draut et al. 2009

Waipaoa River, New Zealand



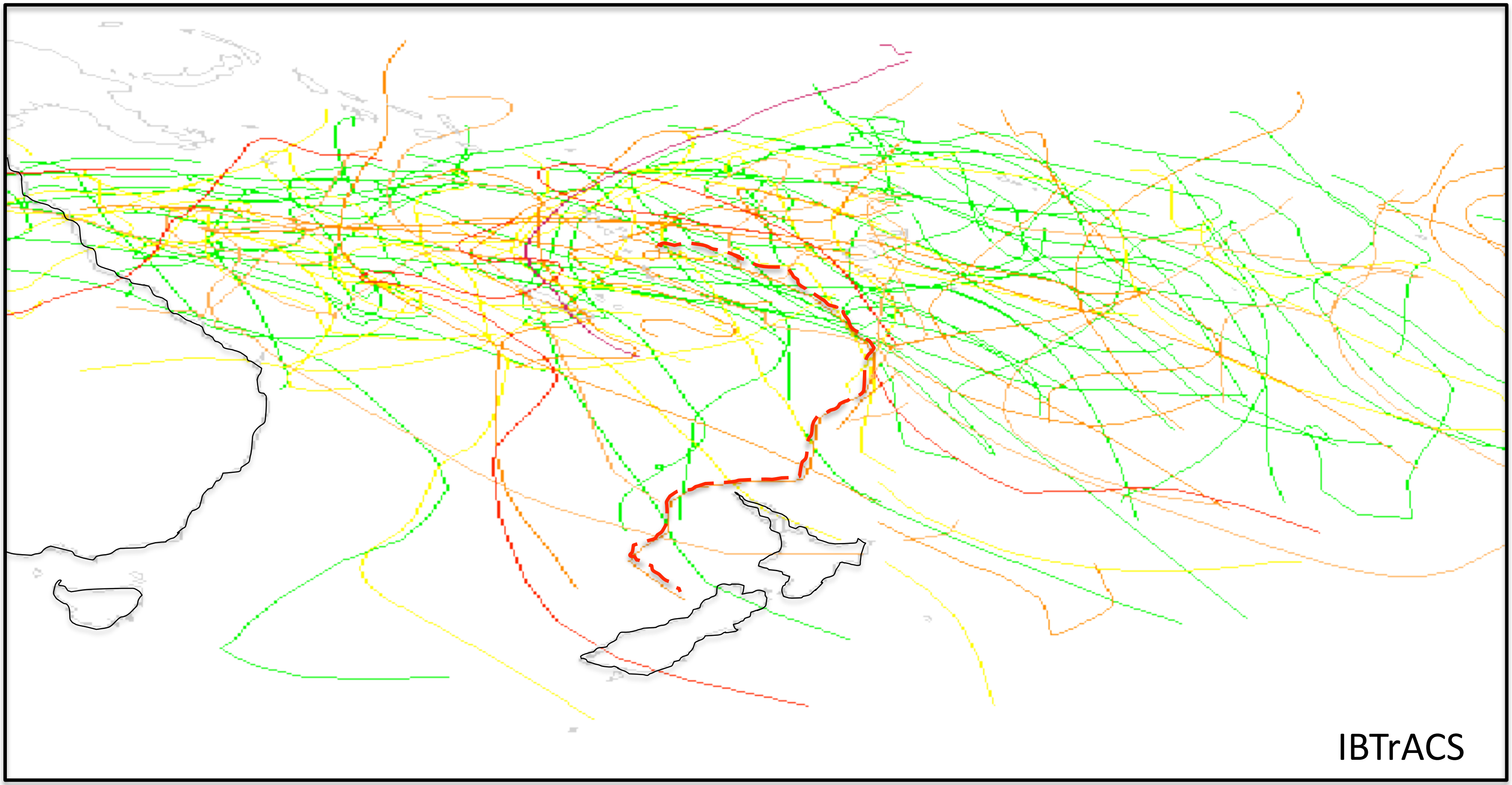
- 2,200 km² basin area
- River floods during all parts of the year
  - Westerly mid-latitude cyclones
  - Tropical cyclones
  - Southerlies

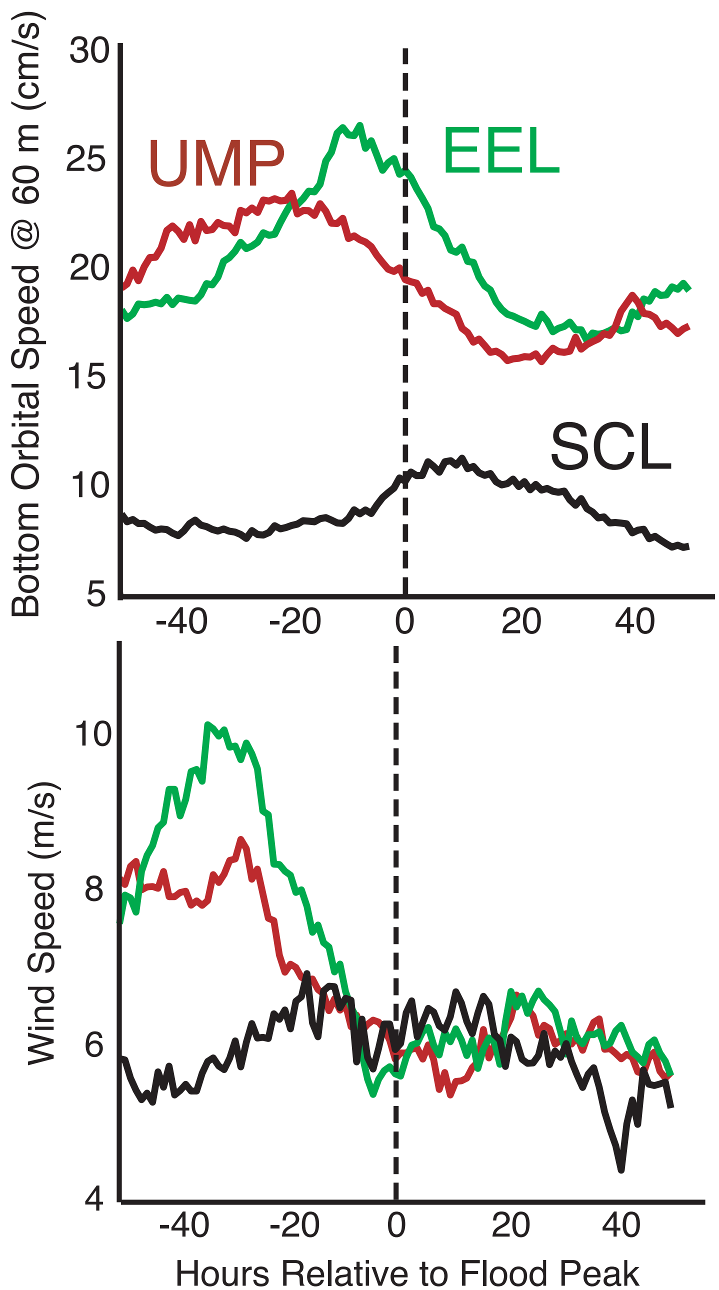


- pdf of significant wave height (m) for
  - $Q/Q_{mean} > 8$ (events) - - - -
  - $Q/Q_{mean} < 8$ ———

Data from T. Kniskern, NIWA, Gisborne District Council

Tropical Cyclones S Pacific (1980-1989)





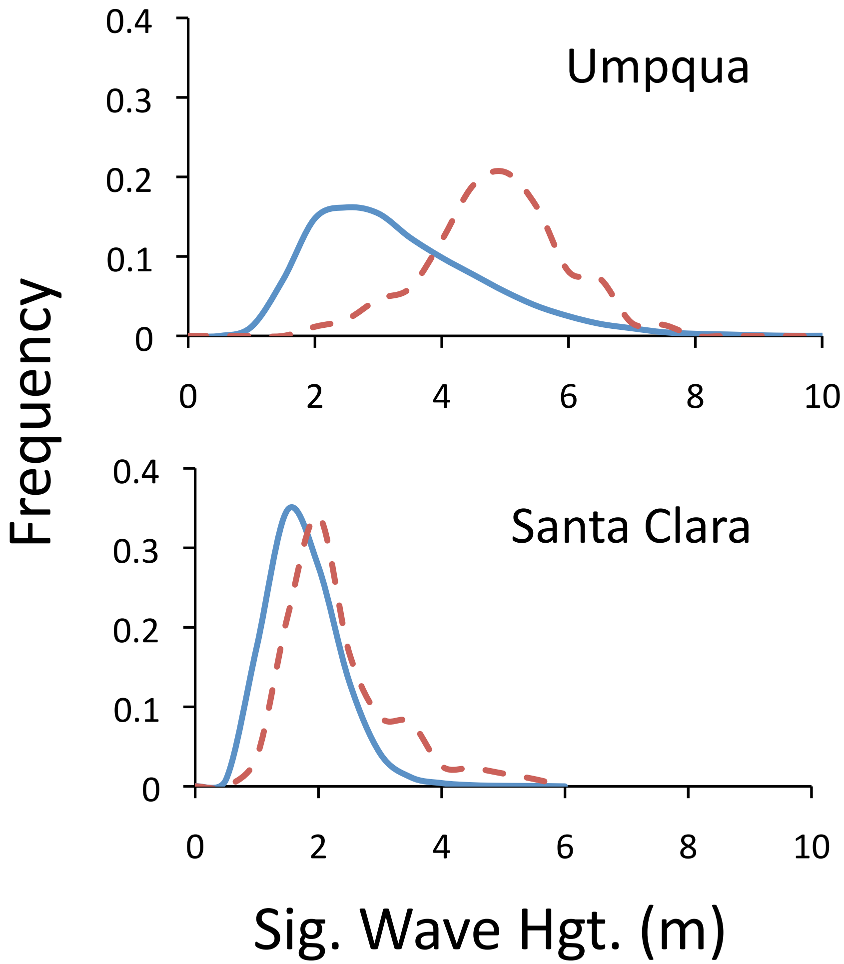
Kniskern et al. 2011

US West Coast

- 11 years of hourly discharge & buoy data for:
  - Umpqua: 44° N; ~9K km^2
  - Eel: 41° N, ~9K km^2
  - Salinas: 37° N, ~11K km^2 (not shown)
  - Santa Clara: 34°N, ~4.5K km^2

- Identified floods based on >90 percentile & calculated U_b at 60 m, wind speed & direction

- Clear pattern for northern rivers, less so for the Santa Clara



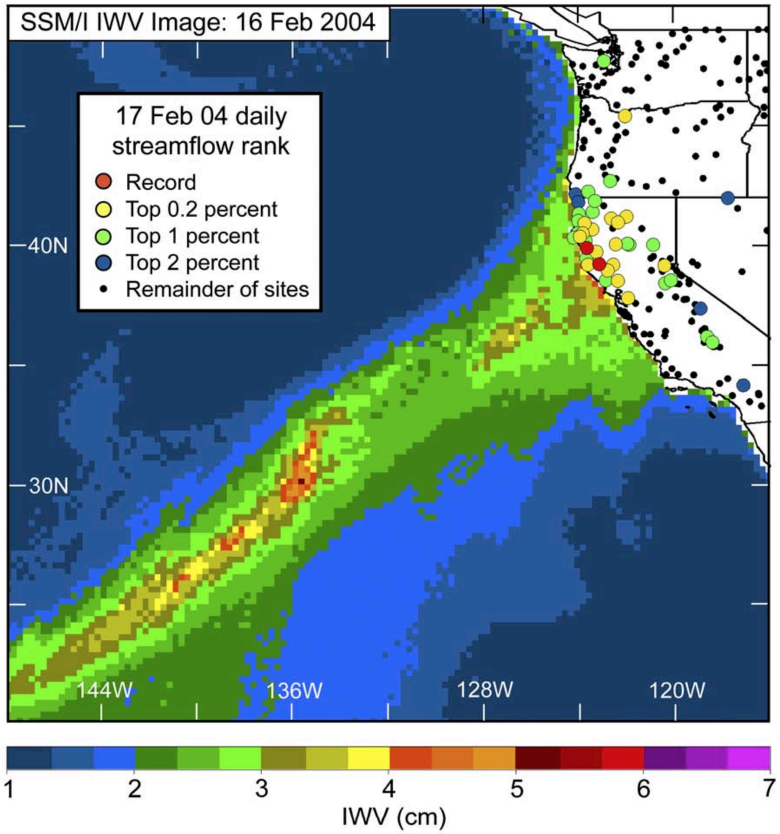
Pdfs of wintertime (NDJFMA) significant wave height (m) for

- $Q/Q_{mean} < 8$ ('normal')
- $Q/Q_{mean} > 8$ (events)

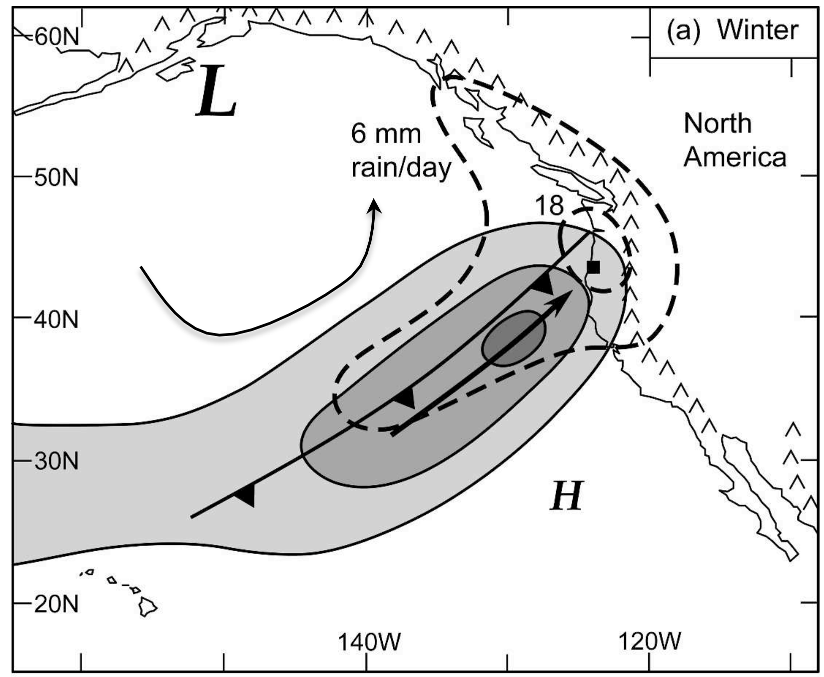
Source: USGS & NOAA

Atmospheric Rivers

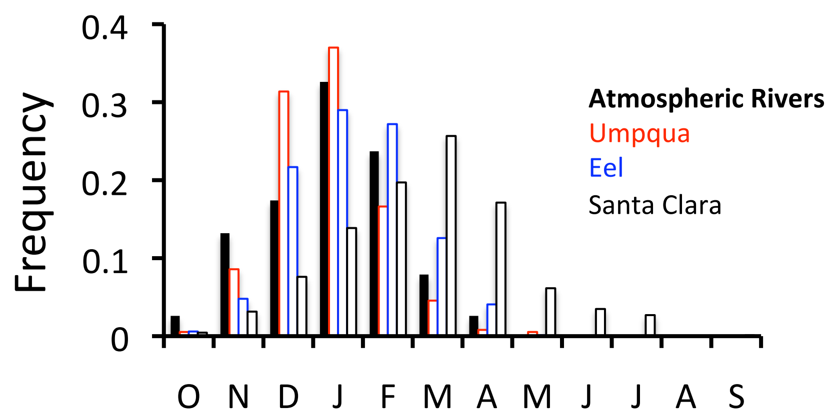
Ralph et al. 2006



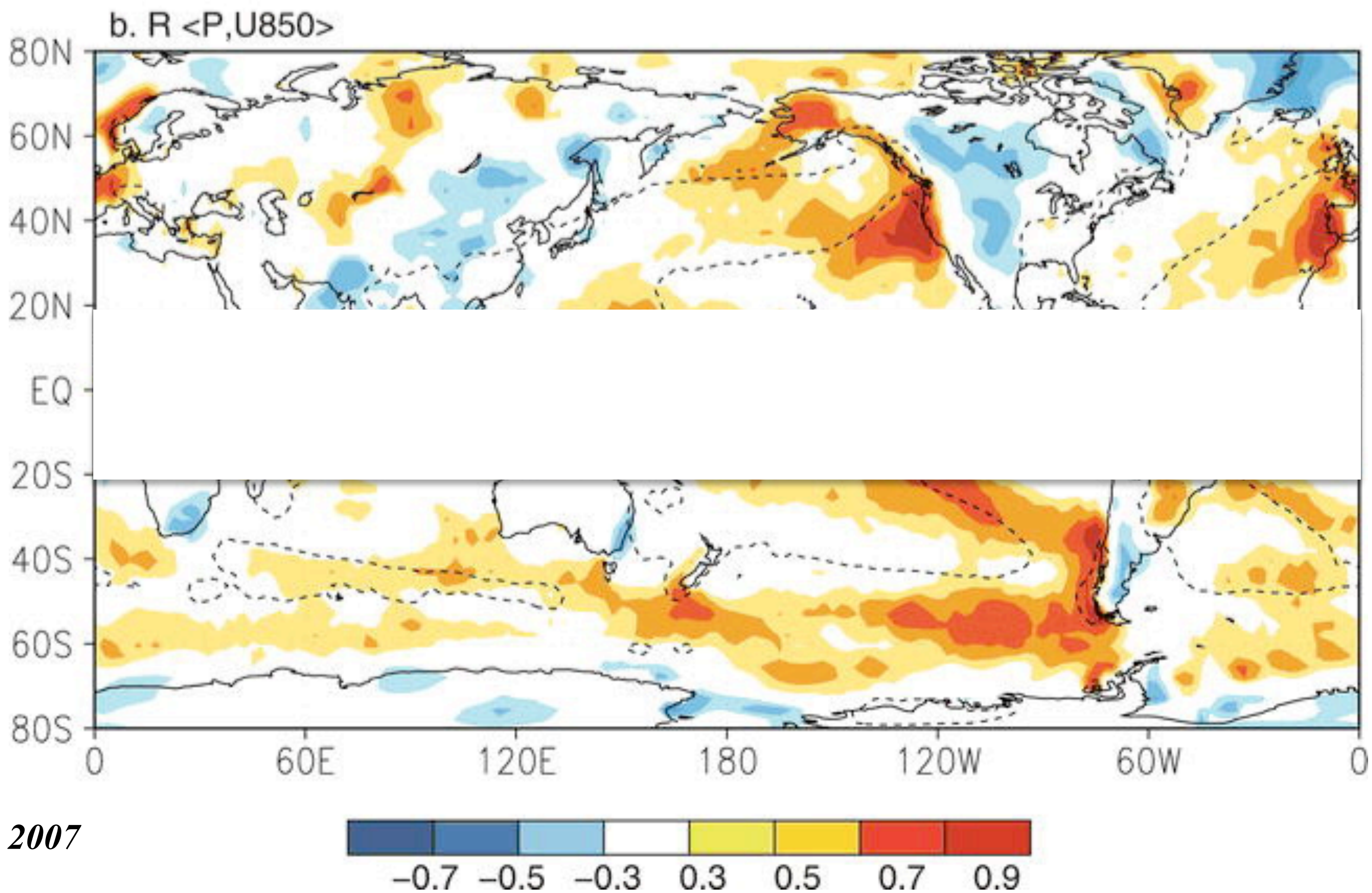
Neiman et al. 2008



- Extratropical cyclones, with:
  - Large IWV fluxes + mountains = rain
  - Strong, southerly surface winds
  - Large waves from Gulf of Alaska



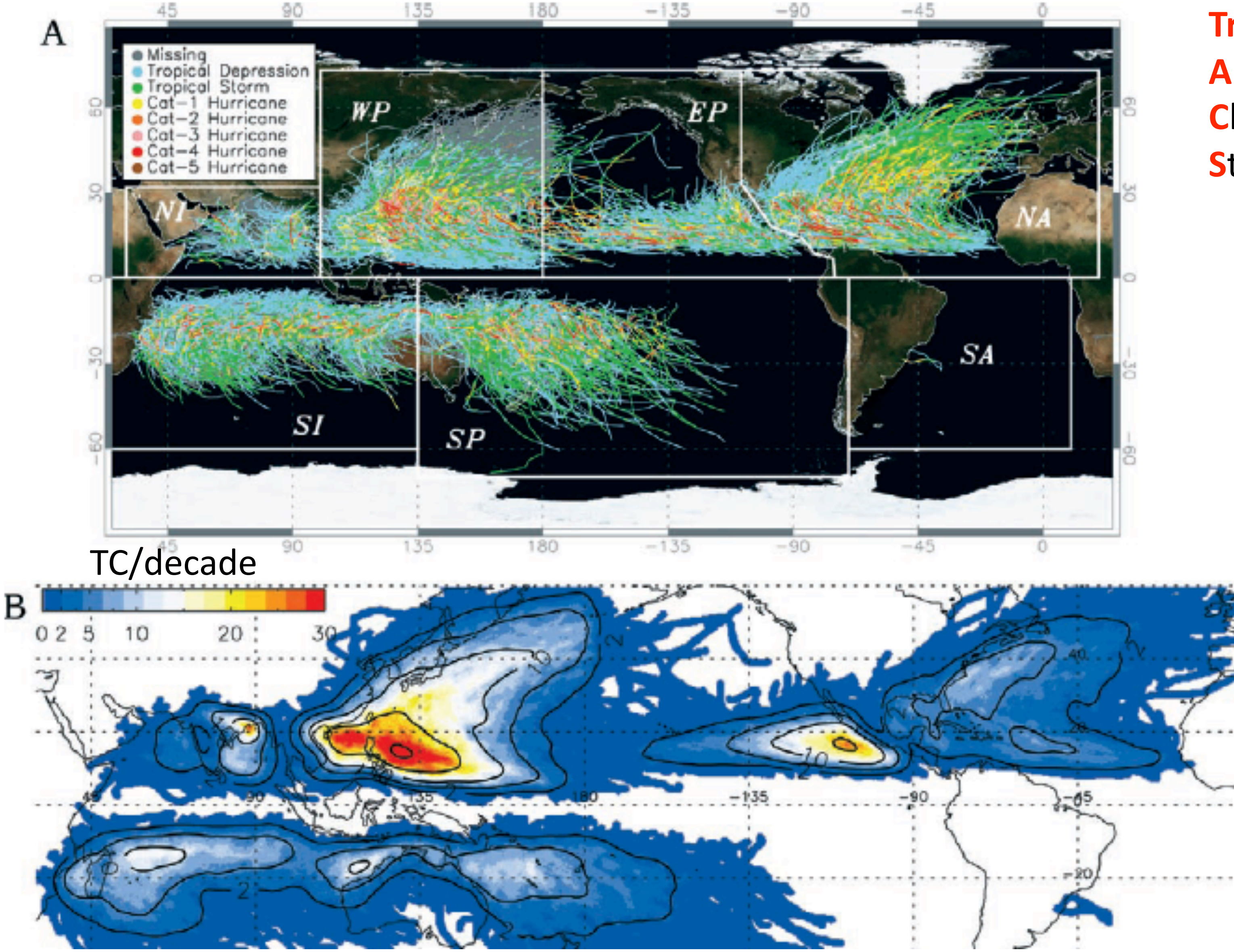
Extratropical Stratiform Precipitation



Garreaud, 2007

- Local correlation between zonal wind @ 850 hPa (~1.5 km) & rainfall
- Norway, Iberian W coast, S Chile, SW NZ & US West Coast

Tropical cyclones



International
Best
Track
Archive for
Climate
Stewardship

Knapp et al. 2010

What else to consider?

- Runoff-infiltration issues causing leads or lags of the flood wave
- Impoundments (Apennine margin example)
- Wave dispersion from distant storms leads to distal/proximal considerations (Liu et al. 2006)
- Shifts in storm tracks due to climate change

Summary

- River-ocean coherence (ROC) implies a *decrease in the variance* of ocean conditions
- Basin size is critical, with ~20K km^2 the upper limit
- Not all small basins exhibit ROC
- Precipitation source plays an important role in ROC
  - Convective vs. cyclonic
  - Tropical vs. extratropical cyclones

- Much to be learned from 'forensic' analysis of events