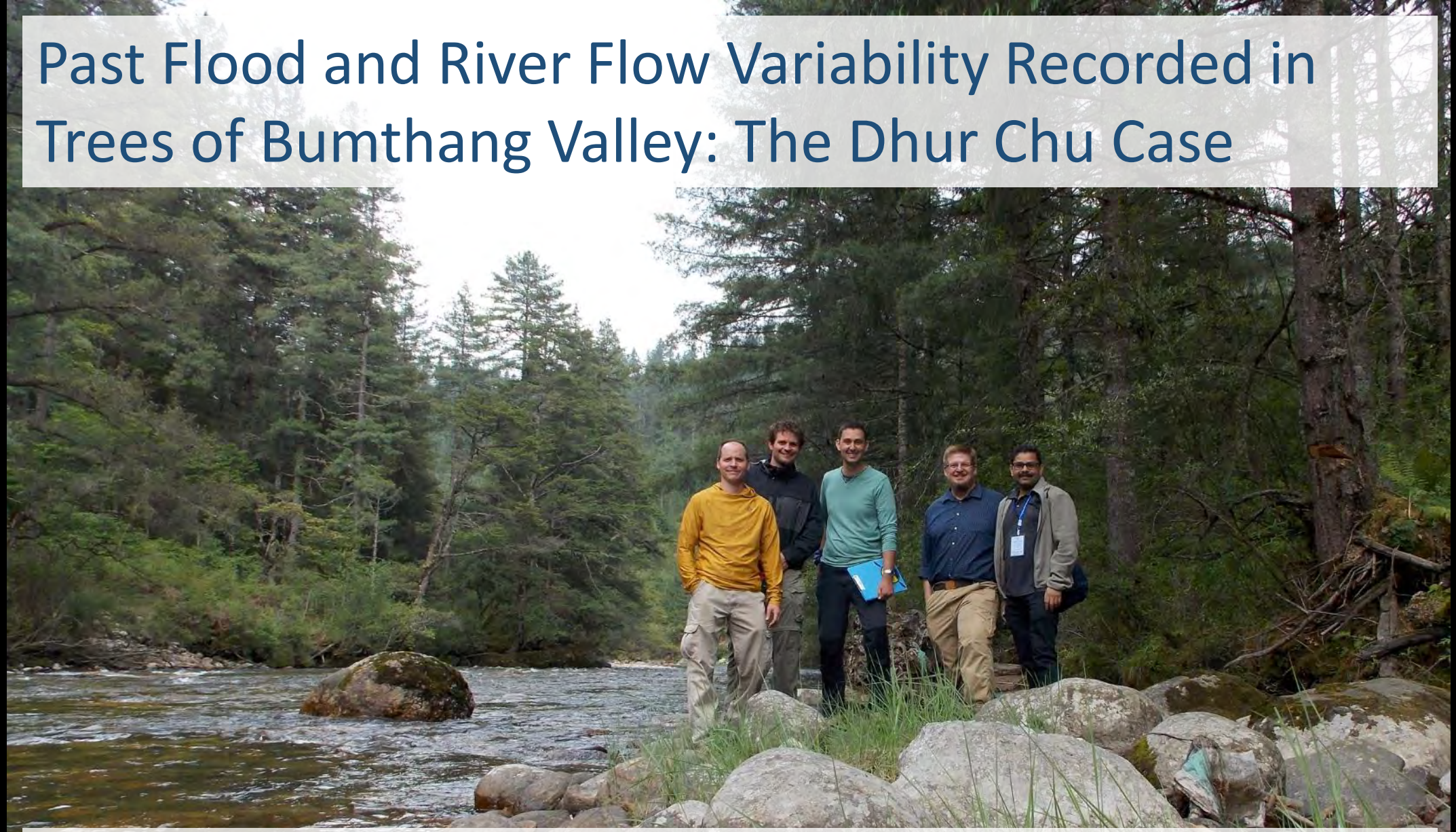
Past Flood and River Flow Variability Recorded in Trees of Bumthang Valley: The Dhur Chu Case



James H. Speer, Santosh K. Shah, Charles Truettner, Arturo Pacheco, Matthew F. Bekker, Dorji Dukpa, Edward R. Cook, Paul J. Krusic

World Dendro Fieldweek 2018 – UWICER, Bumthang, Bhutan

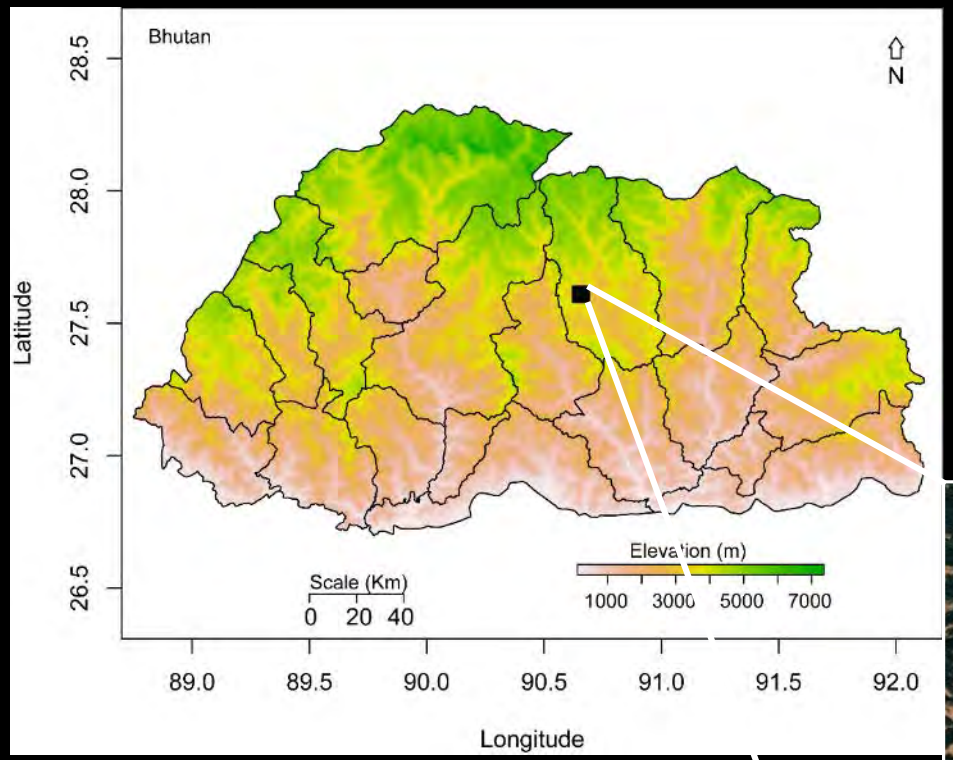
Objectives

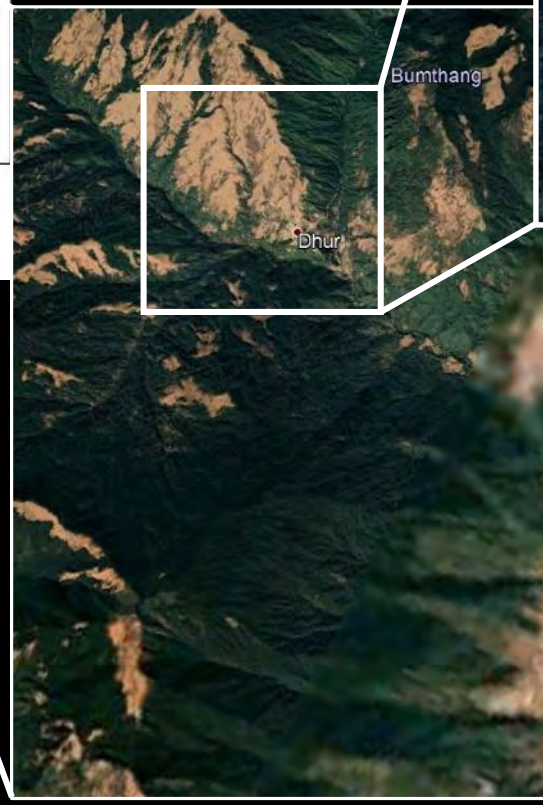
- Document flood responses for species and regional hydrological characteristics
- Identify tree-ring response to flooding “Cyclone Aila”
  - Detect previous flood events
- Reconstruct flow of Chamkhar Chu from existing spruce chronologies
- Examine ring structure in multiple species:
  - *Populus ciliata, Picea spinulosa, Tsuga dumosa, Quercus semecarpifolia, Pinus wallichiana*, and *Rhododendron arboreum*

Cyclone Aila

- May 2009
- 120 km/hr 1-minute sustained winds
- 339 deaths in Bangladesh and India, 4 in Bhutan, heavy damage in Bhutan

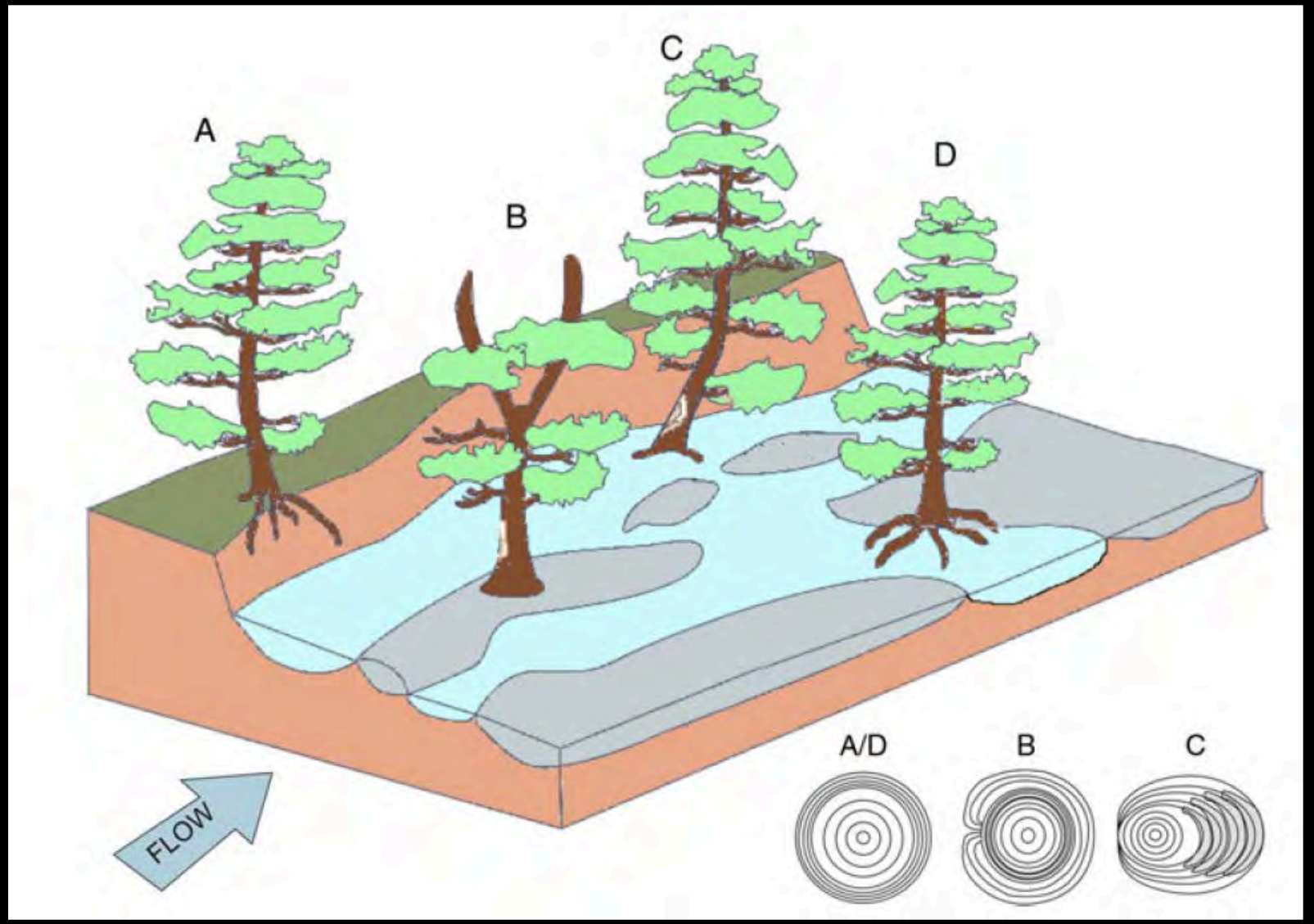
Study Site


Bhutan
N
Latitude
28.5
28.0
27.5
27.0
26.5
Scale (Km)
0 20 40
Elevation (m)
1000 3000 5000 7000
89.0
89.5
90.0
90.5
91.0
91.5
92.0
Longitude


Bumthang
Dhur
Kurjey
Jakar

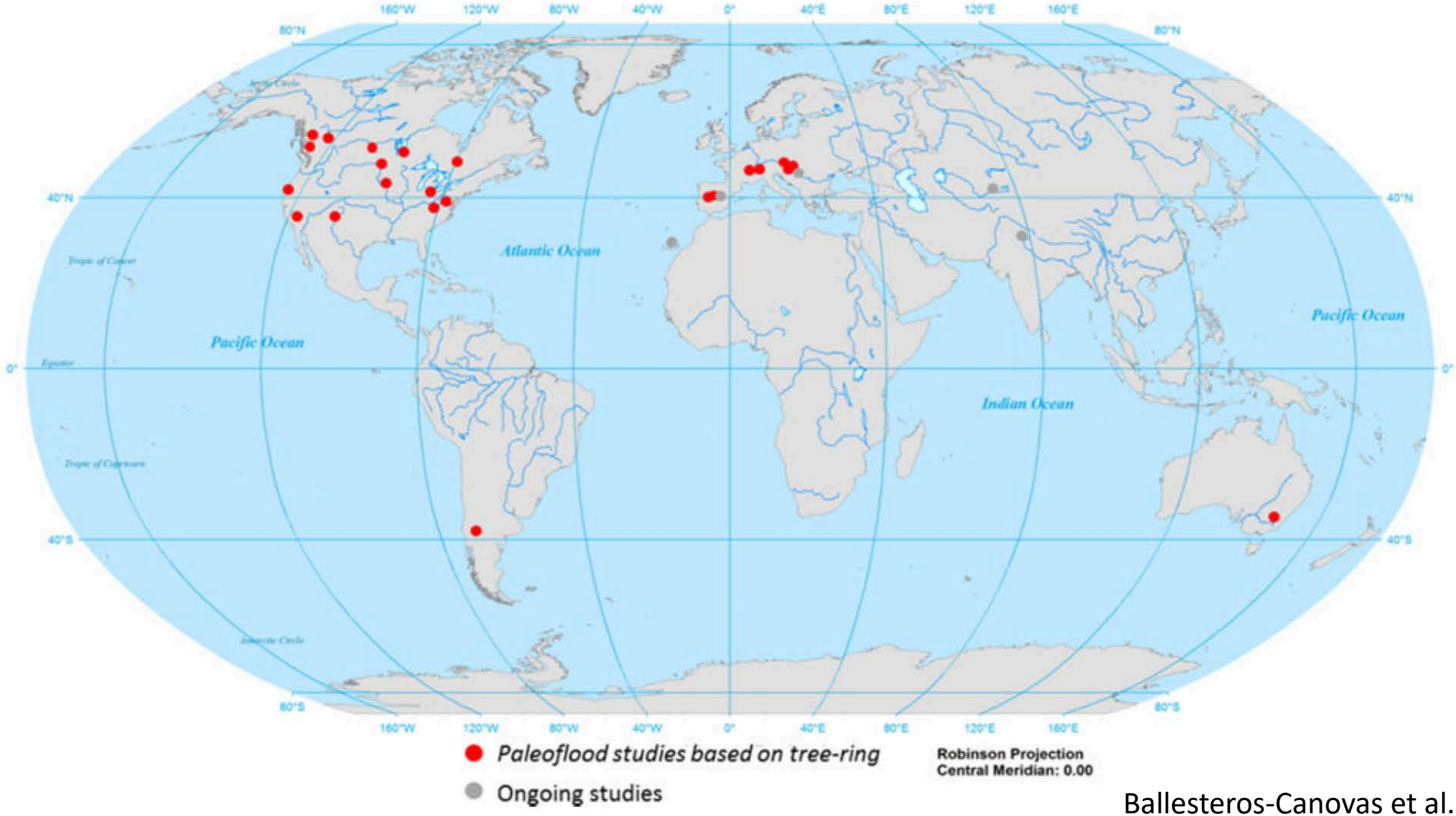

LOGGING SITE
LOGGING DEPOT
UPSTREAM
DOWNSTREAM

Potential tree-ring responses to floods



Ruiz-Villanueva et al. 2010

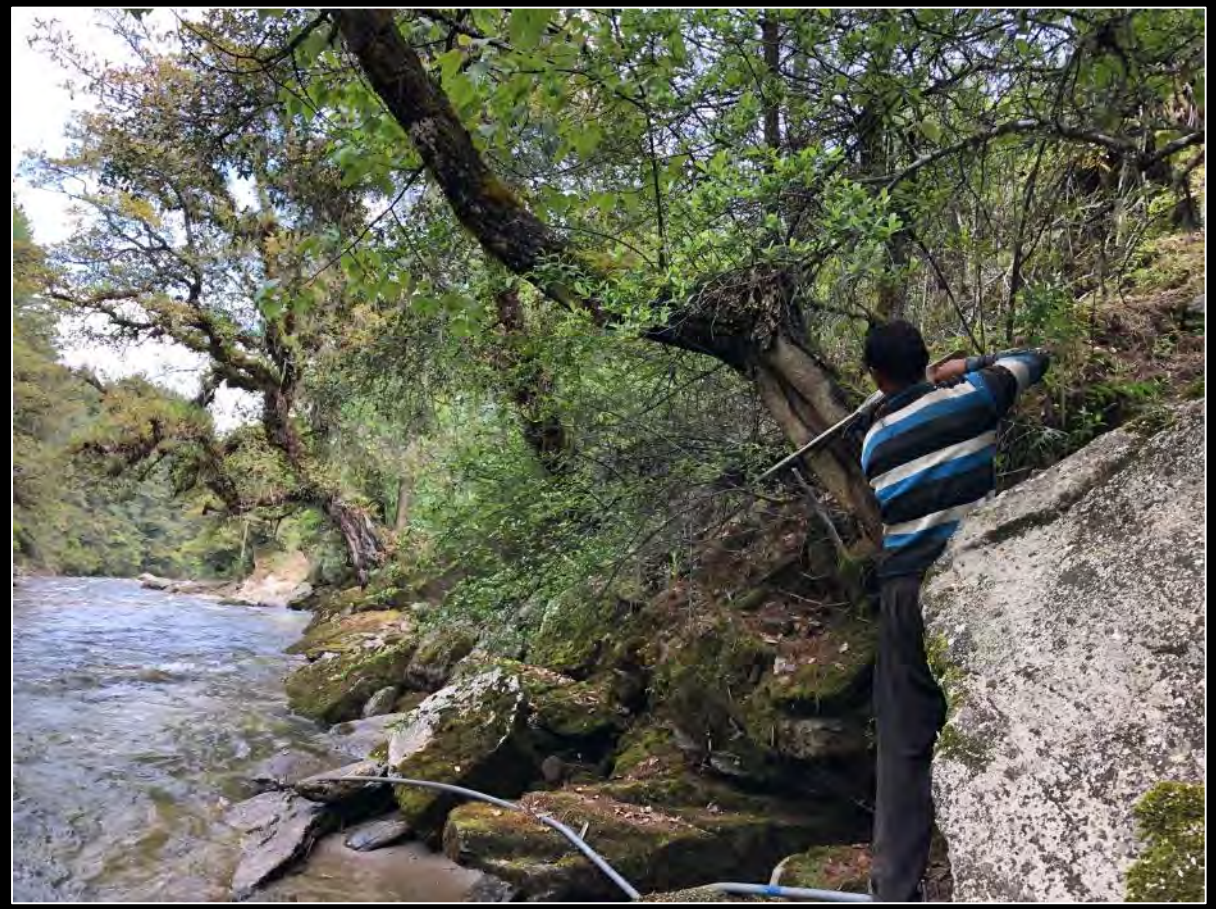
Previous Work



Ballesteros-Canovas et al. 2015

Measurement of scarred trees

Sampling scars



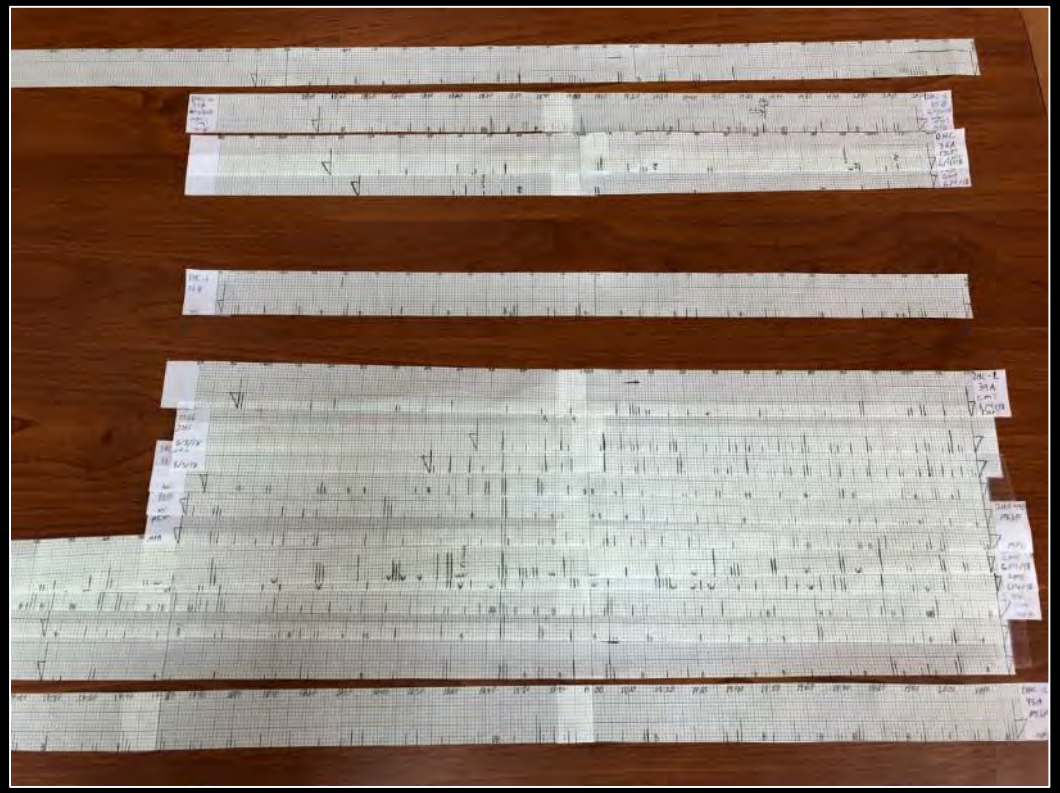
Buried scars

Tree establishment & chronology building

Pursuing a longer chronology

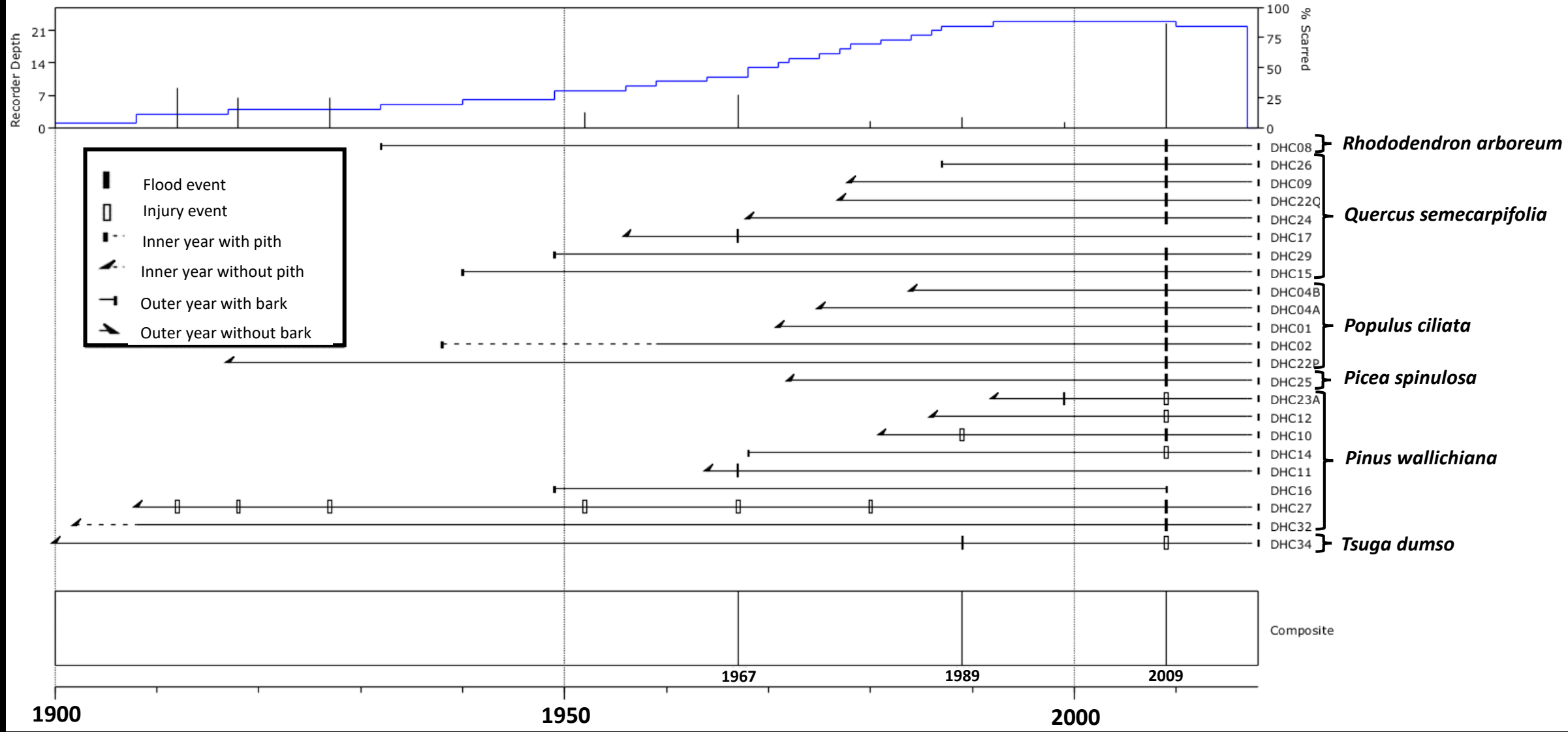
Estimating 2009 discharge

Crossdating



Our samples

Dhur Chu Flood Scar Chart



Radial growth initiation by species as of June 4, 2018

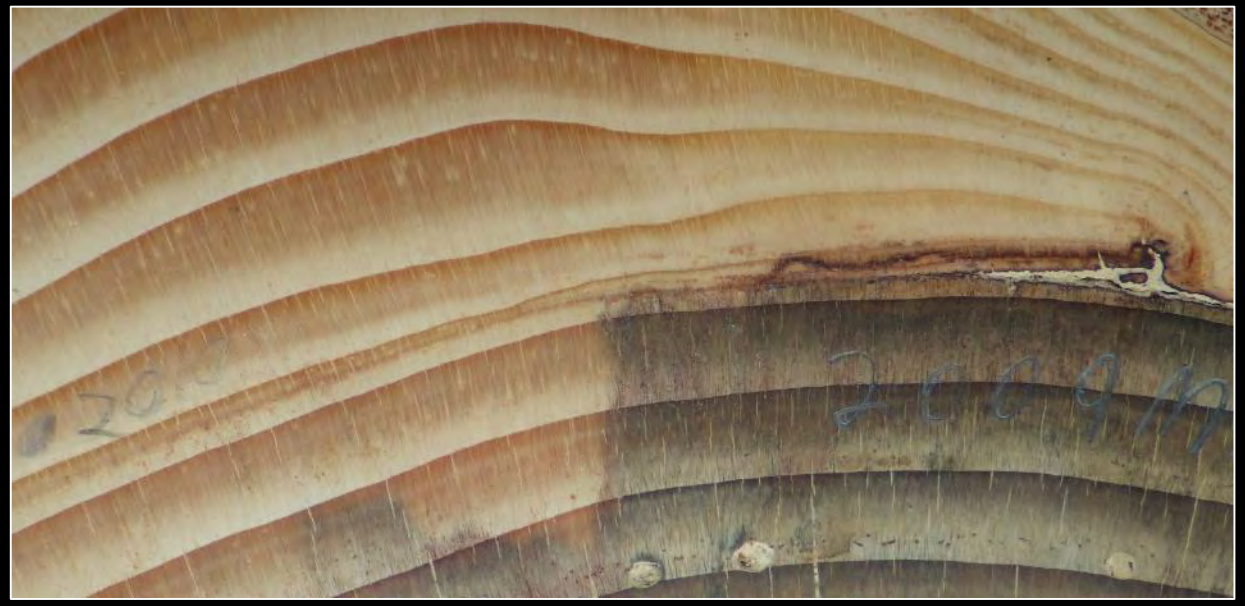
Species	Earlywood Rows
Quercus semecarpifolia	none
Rhododendron arboreum	none
Populus ciliata	0–3
Picea spinulosa	0–5
Tsuga dumosa	0–10
Pinus wallichiana	20+

Populus ciliata ring structure

Quercus semecarpifolia ring structure

Tsuga dumosa ring structure

Pinus wallichiana ring structure

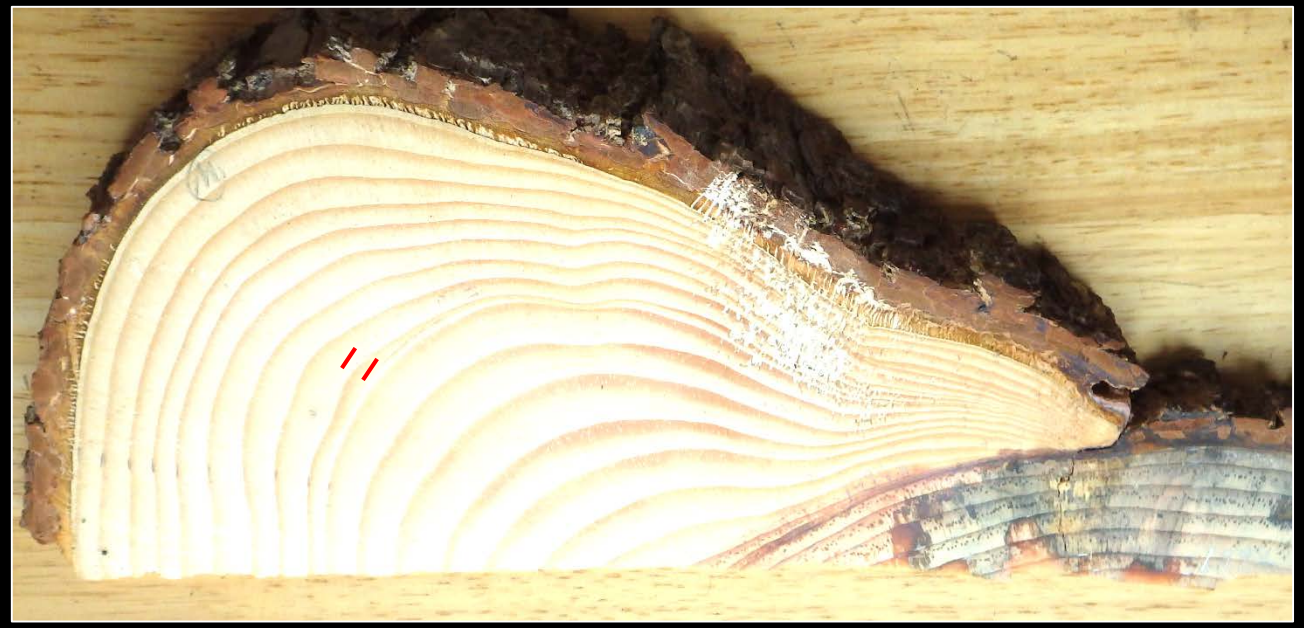


Picea spinulosa ring structure

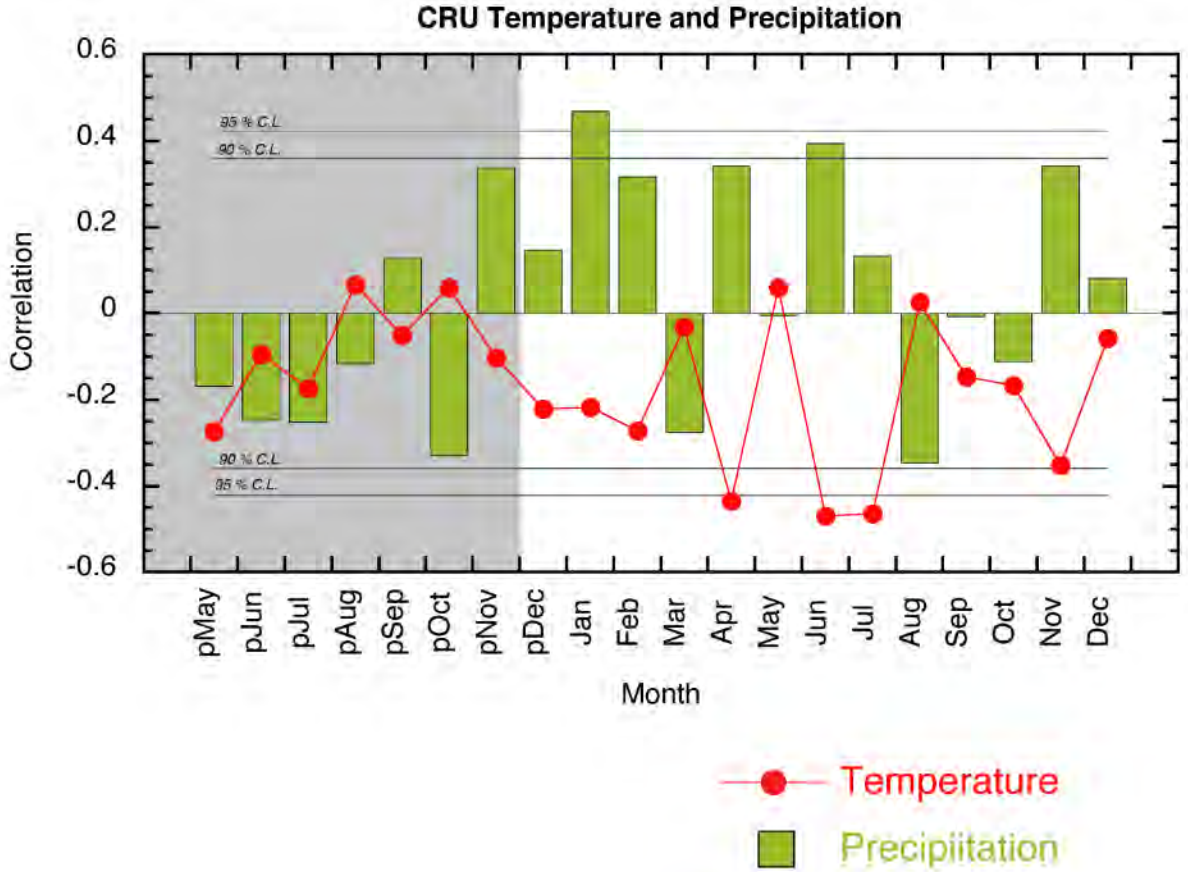
Rhododendron arboreum ring structure

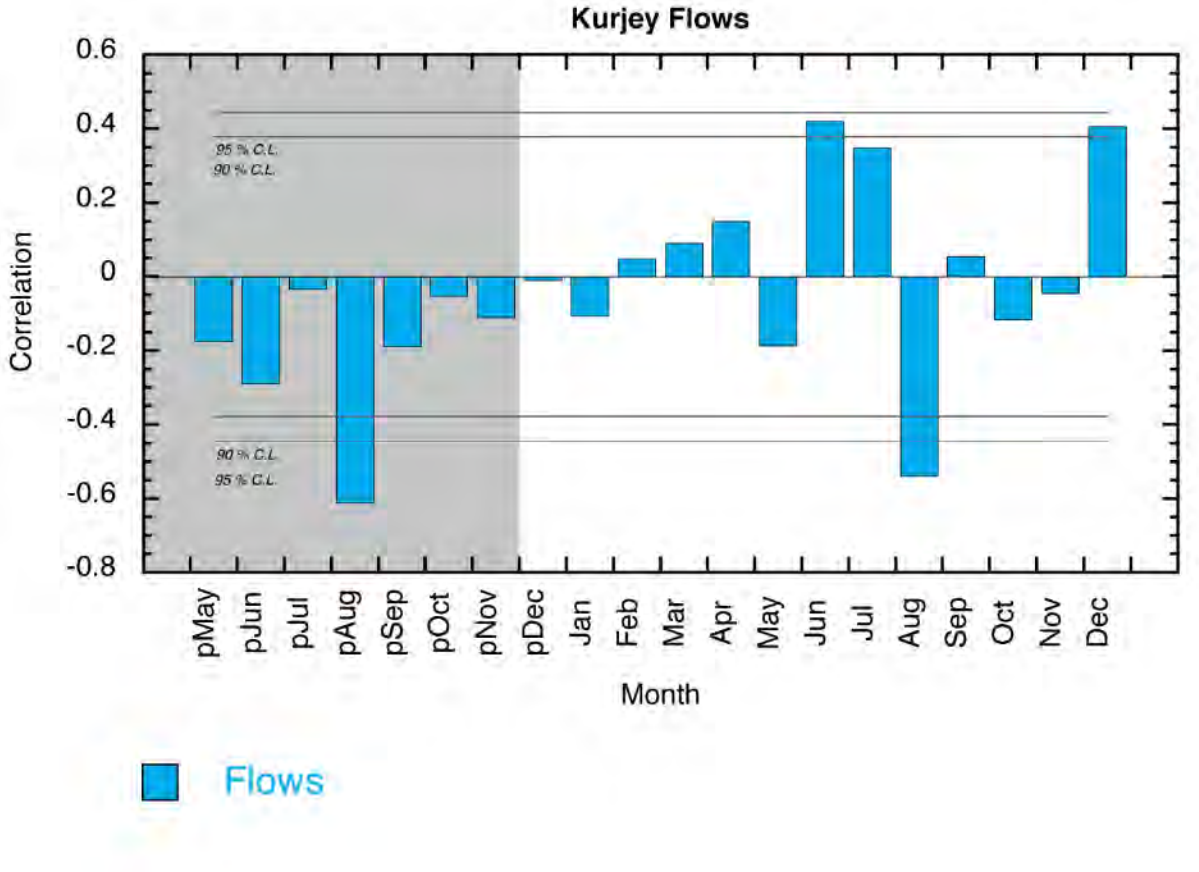
Multiple scarred samples

2009 “Flood Rings” in pines

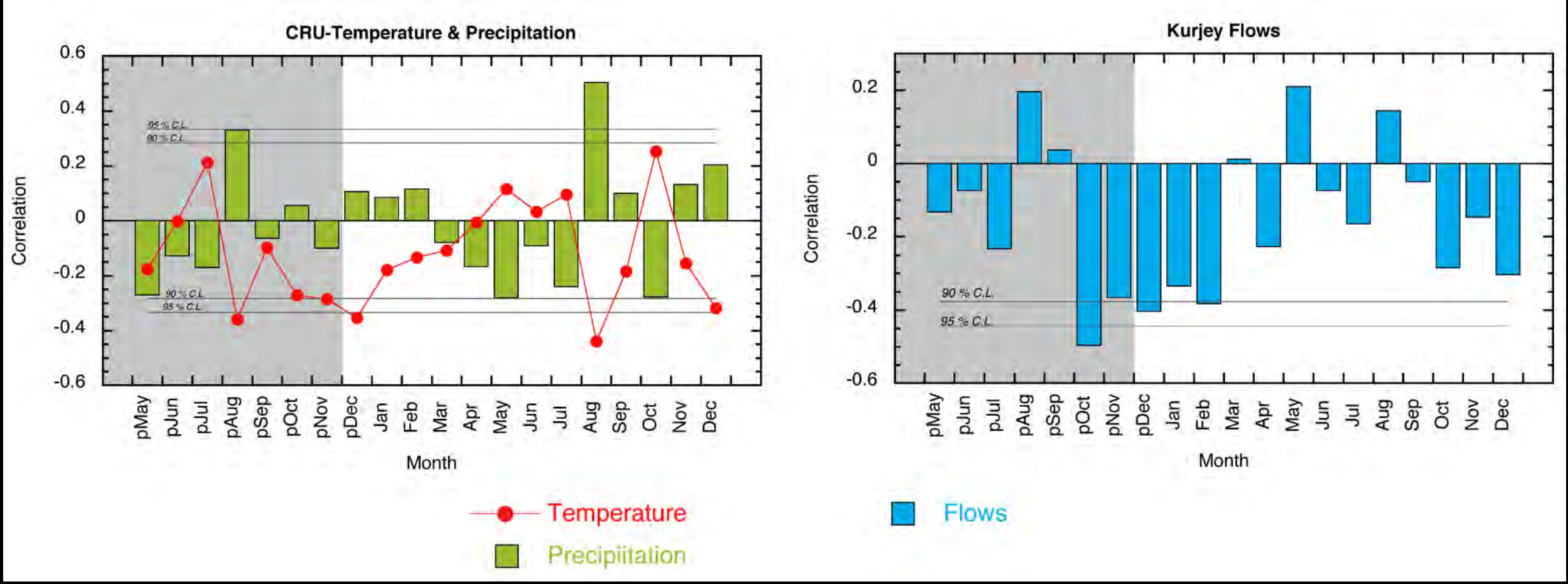


Correlation functions for *Pinus wallichiana*

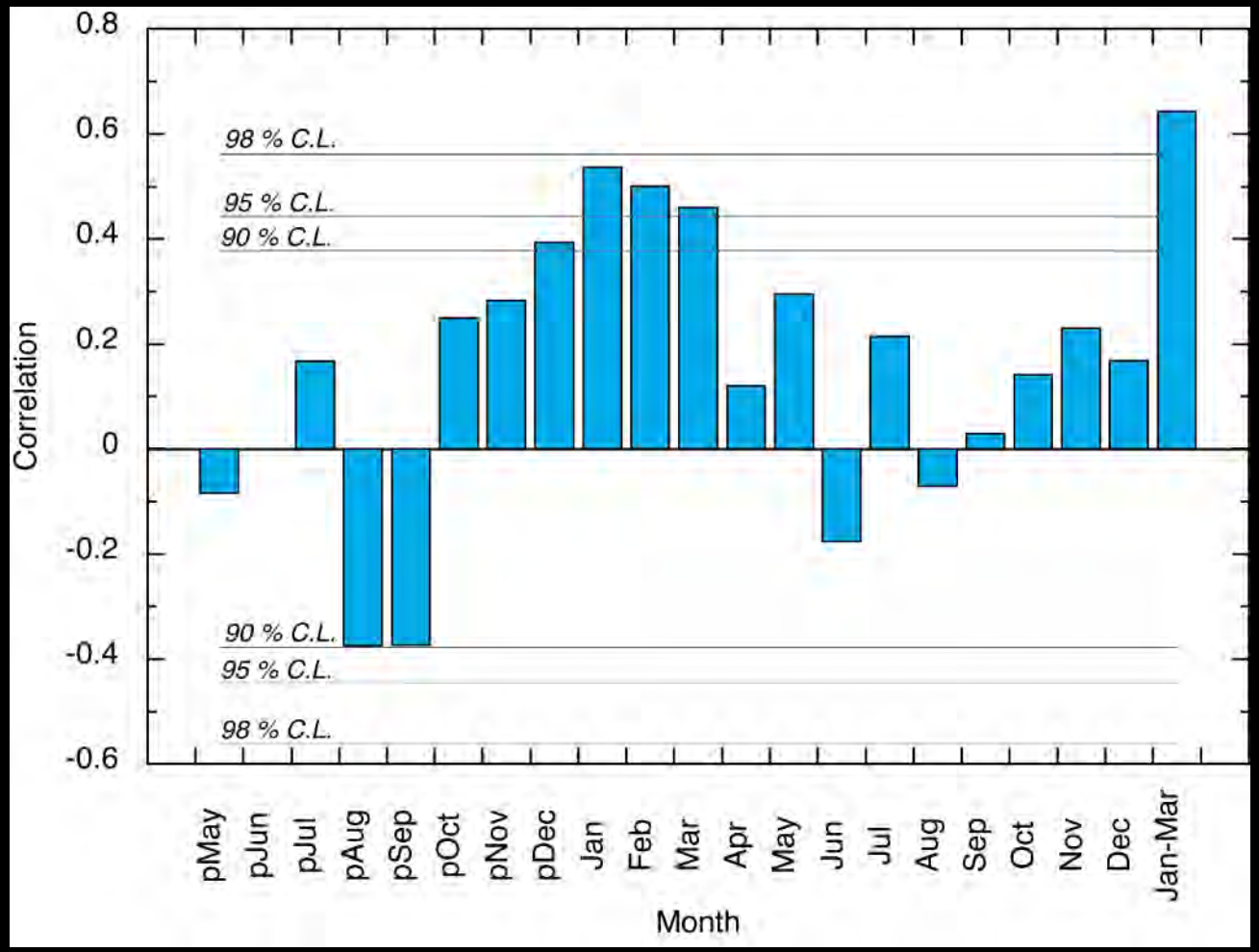


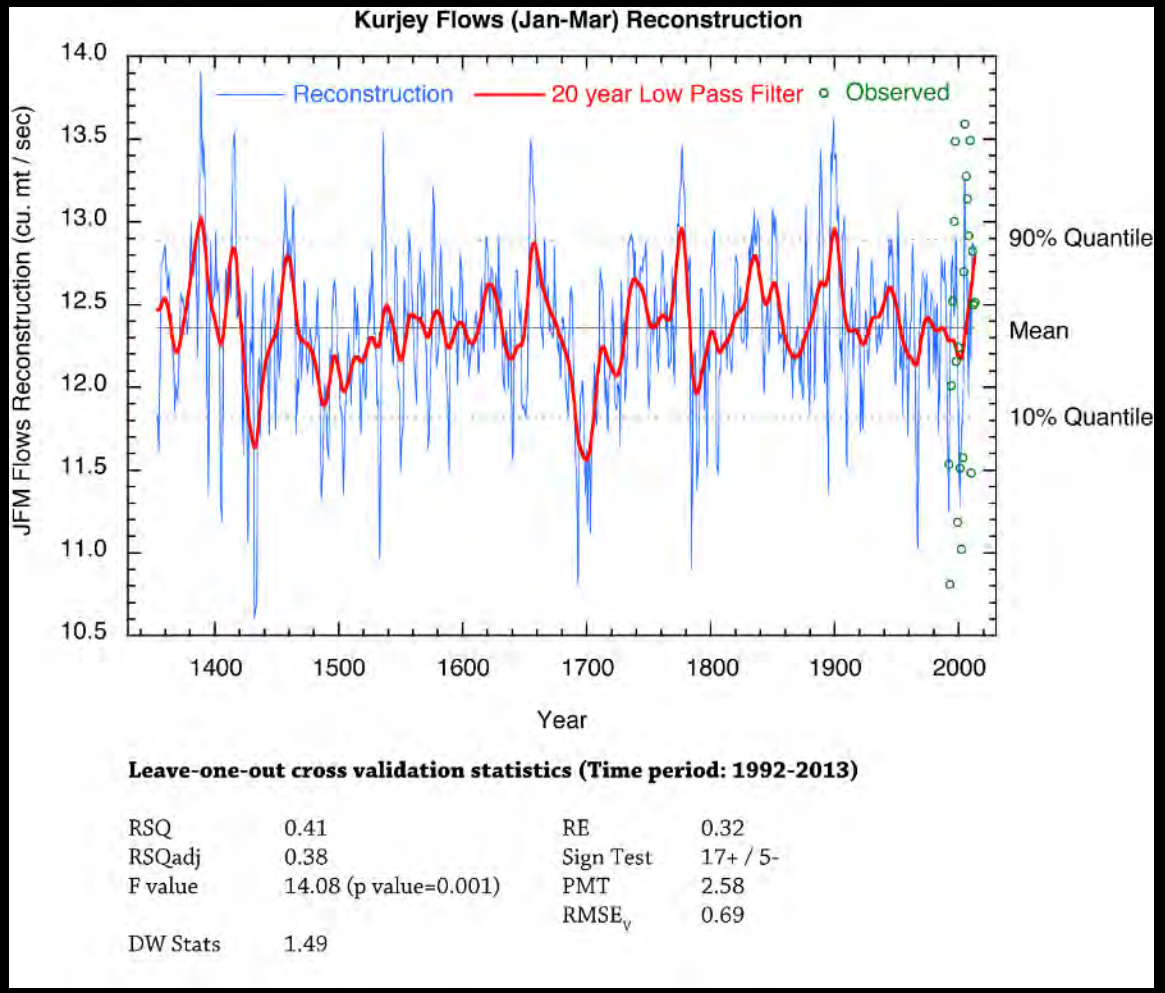


Correlation functions for *Populus ciliata*



Reconstruction of Chamkhar Chu at Kurjey based on Krusic et al. 2015 spruce data

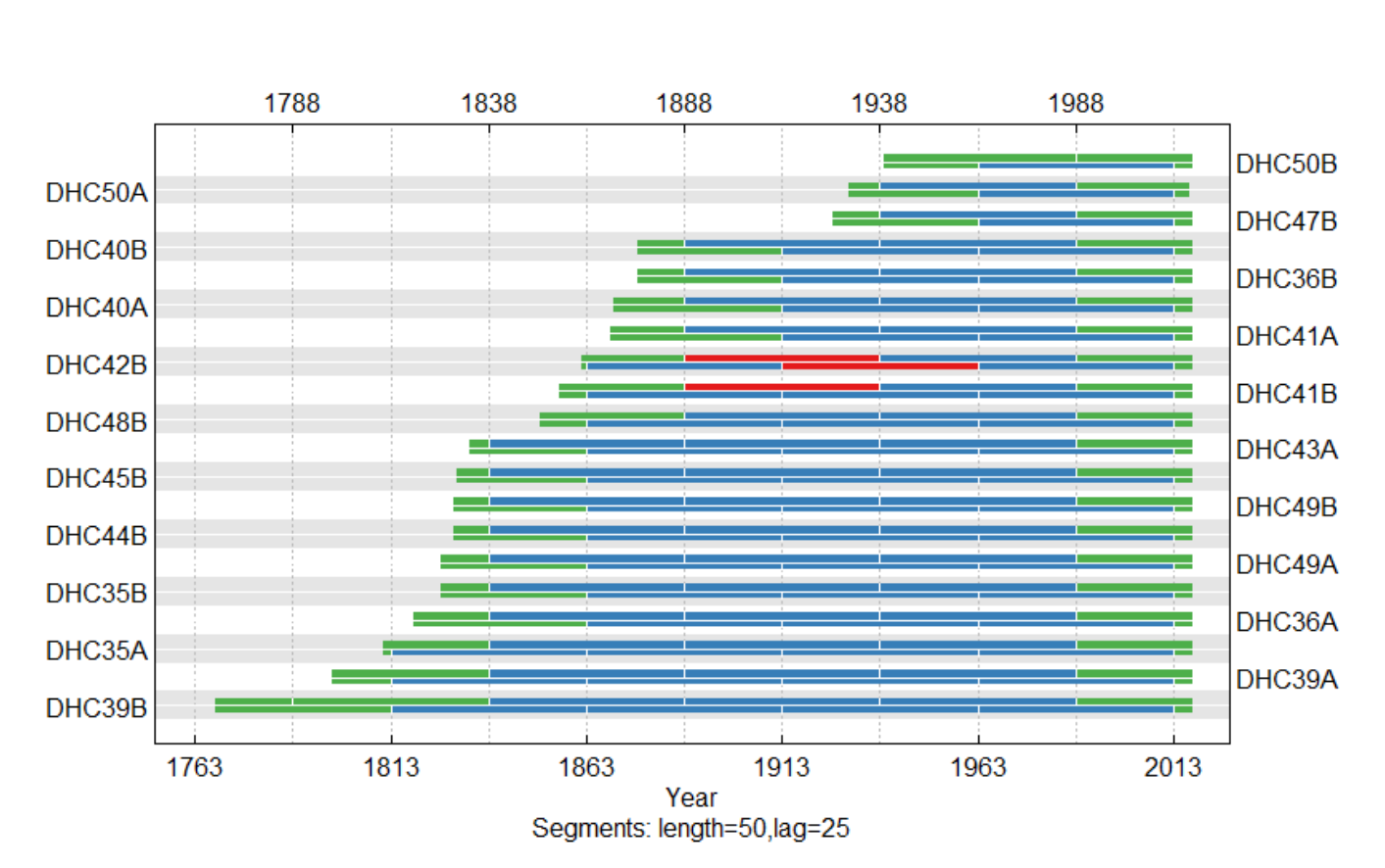


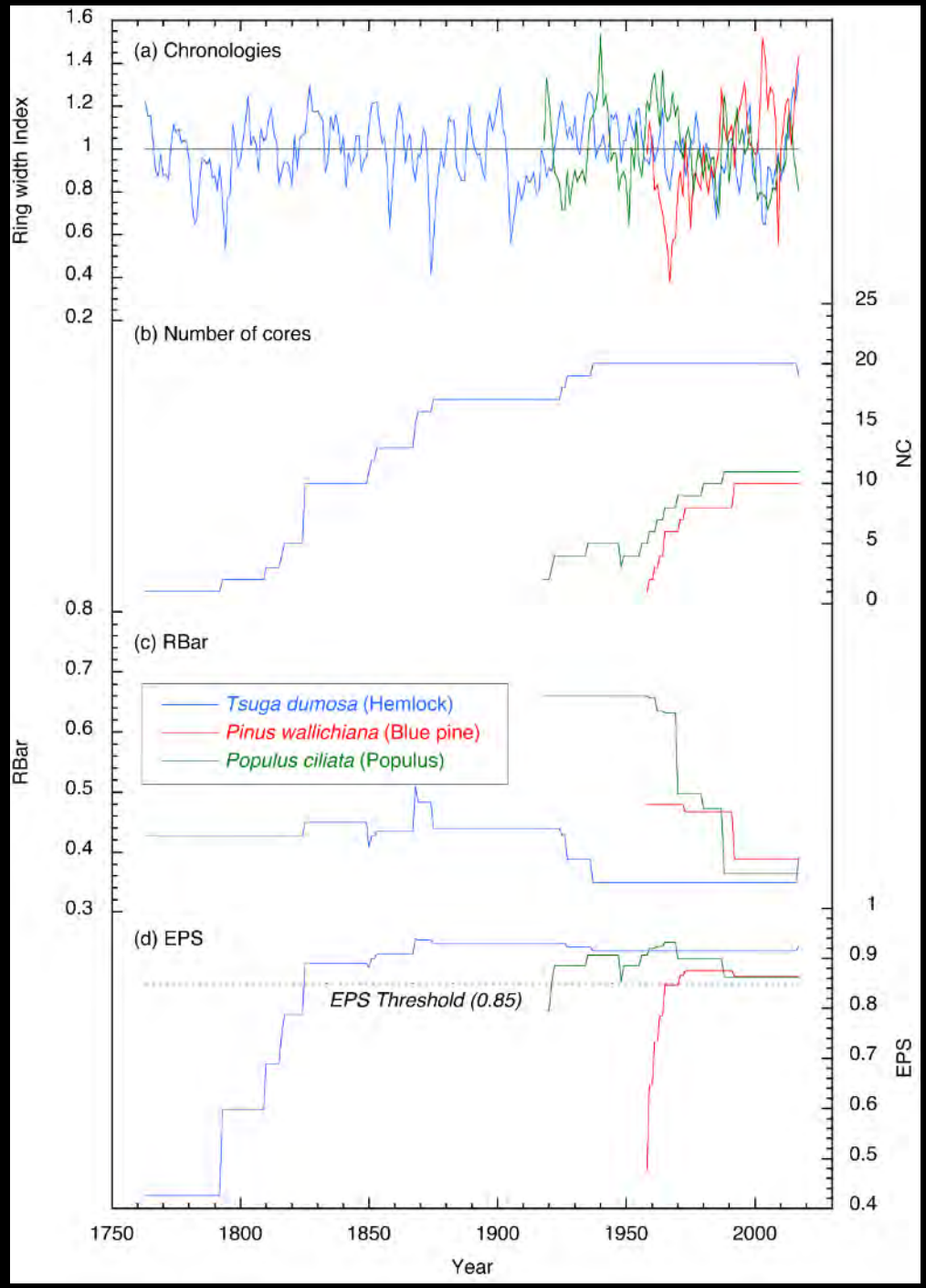


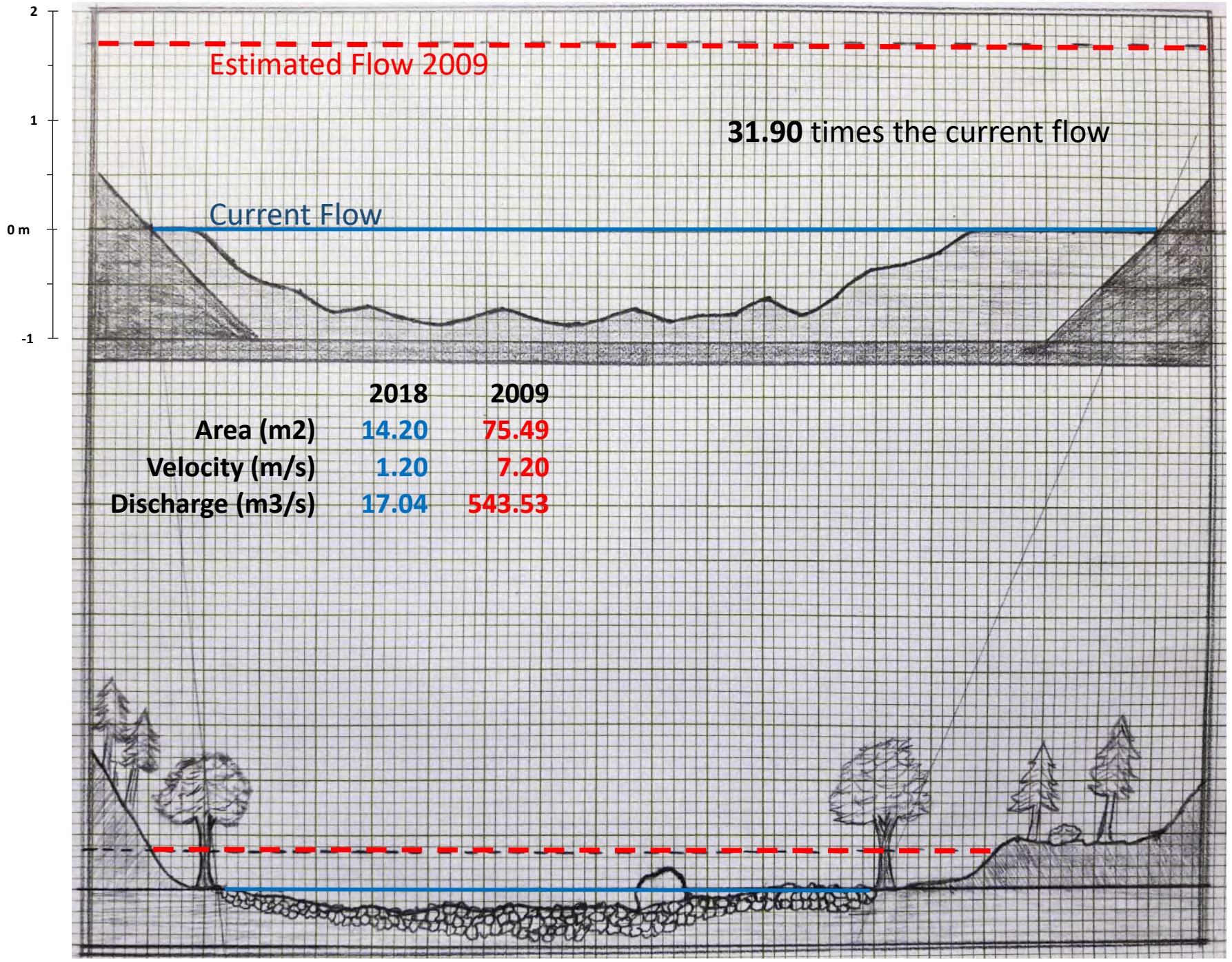
Leave-one-out cross validation statistics (Time period: 1992-2013)

RSQ	0.41	RE	0.32
RSQadj	0.38	Sign Test	17+ / 5-
F value	14.08 (p value=0.001)	PMT	2.58
		$RMSE_v$	0.69
DW Stats	1.49		

Chronologies



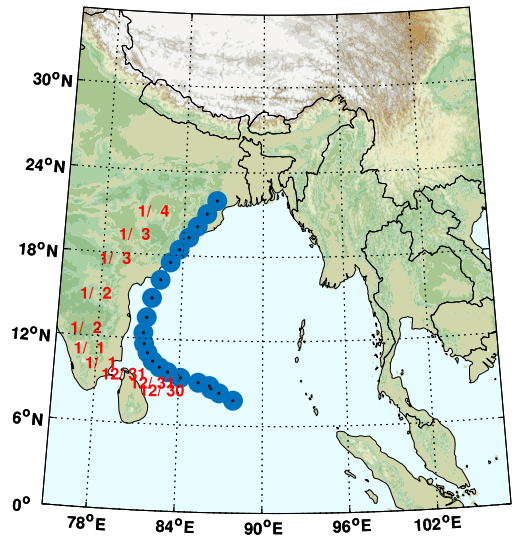


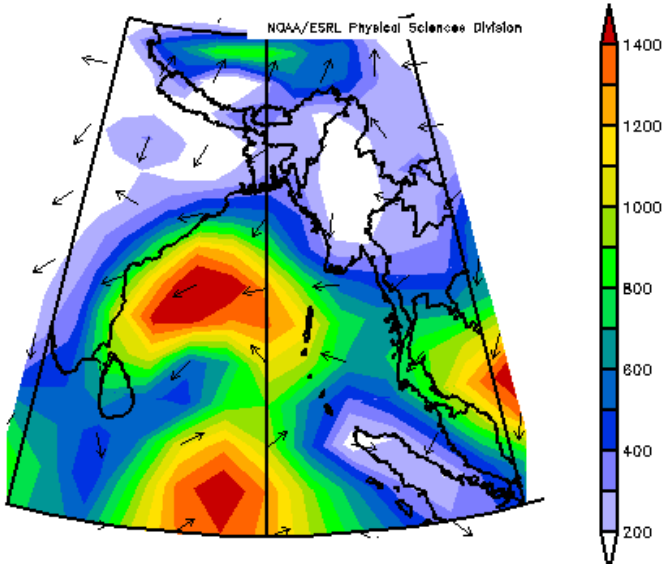

2
1
0 m
-1
Estimated Flow 2009
31.90 times the current flow
Current Flow
2018
2009
Area (m2)
14.20
75.49
Velocity (m/s)
1.20
7.20
Discharge (m3/s)
17.04
543.53

Minimum 2009 flood height

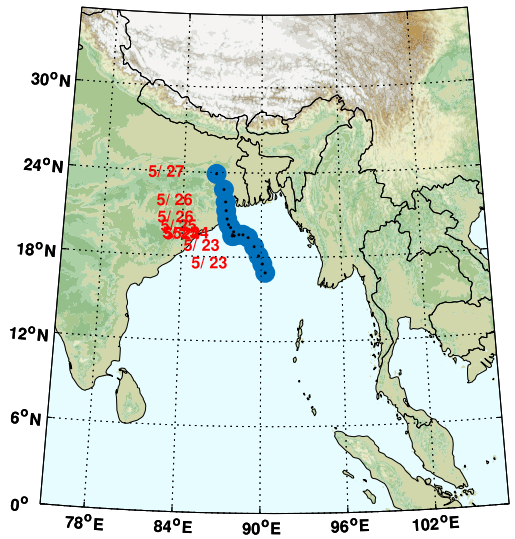
Tropical Cyclones (2 Days Prior)

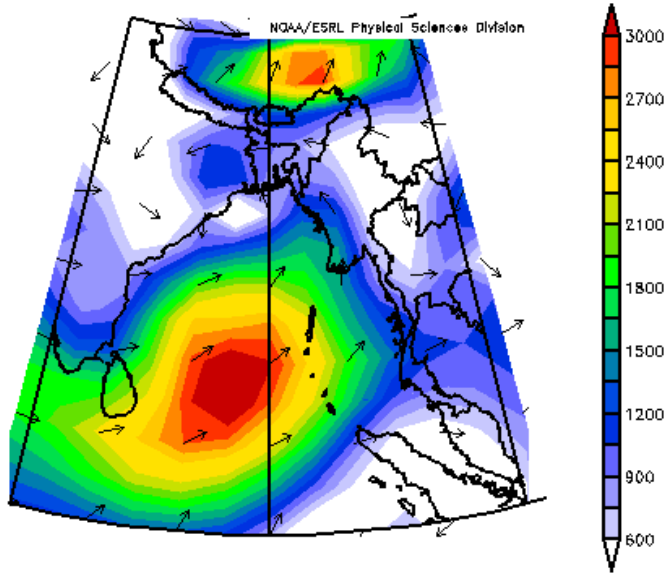
1967



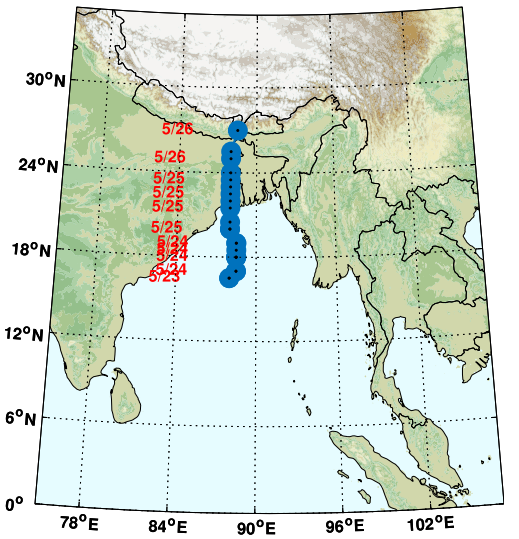


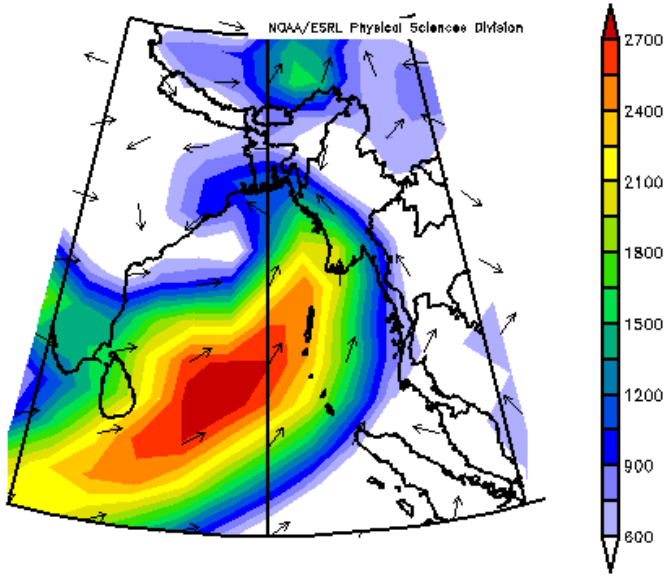
1989





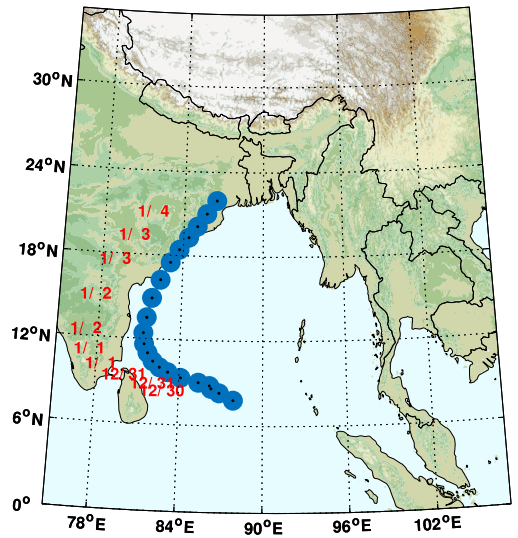
2009



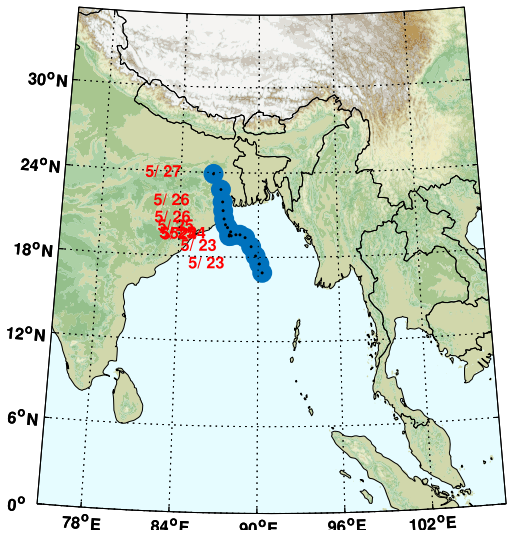


Tropical Cyclones (1 Day Prior)

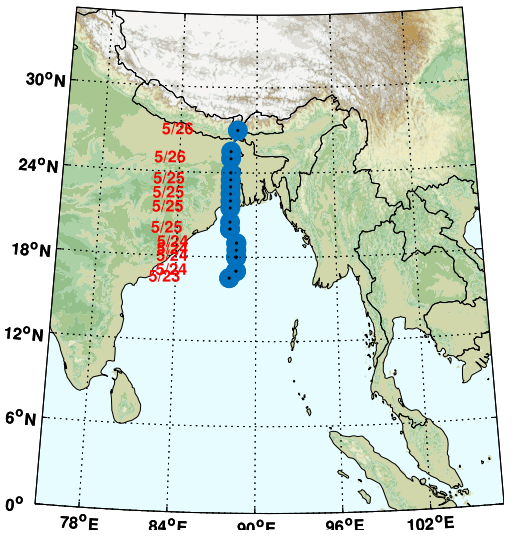
1967

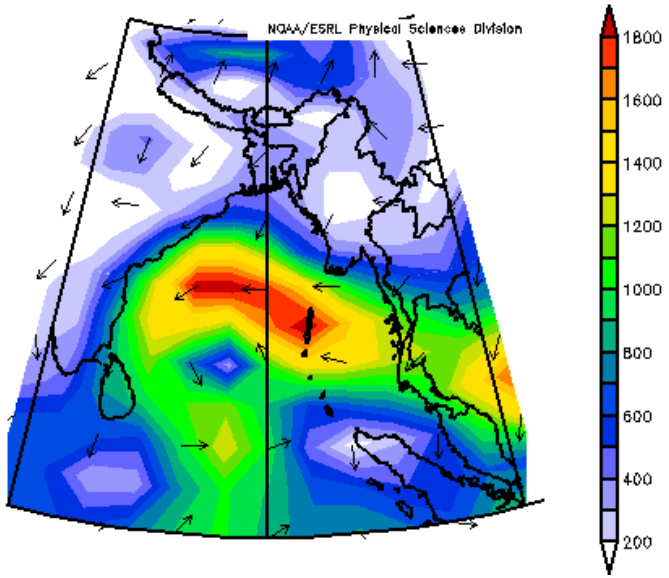


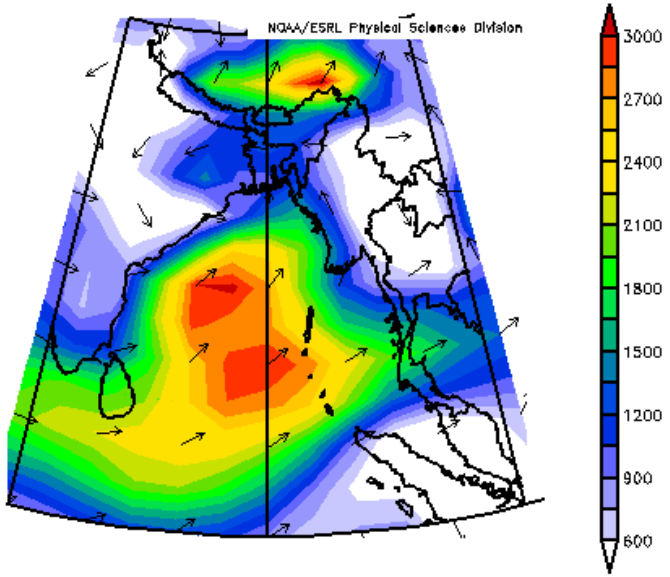
1989

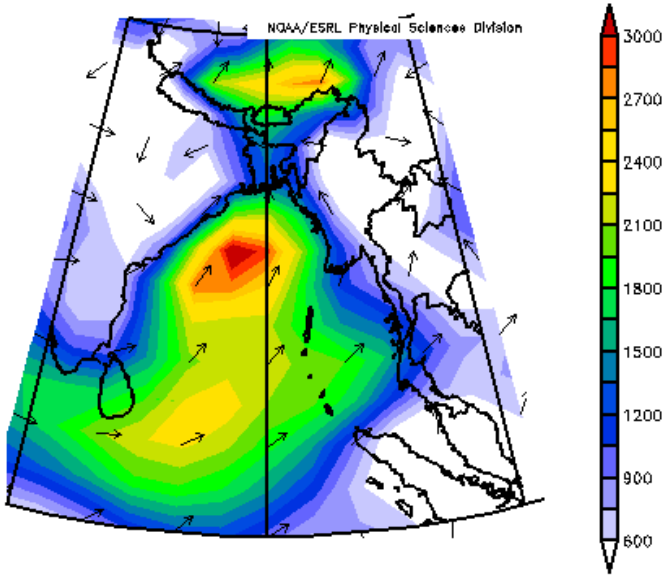


2009



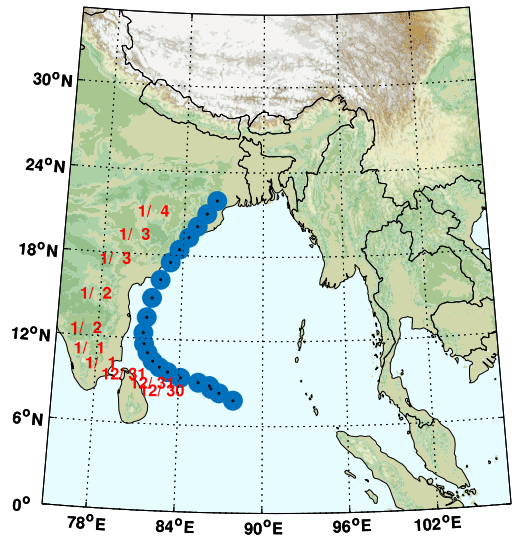


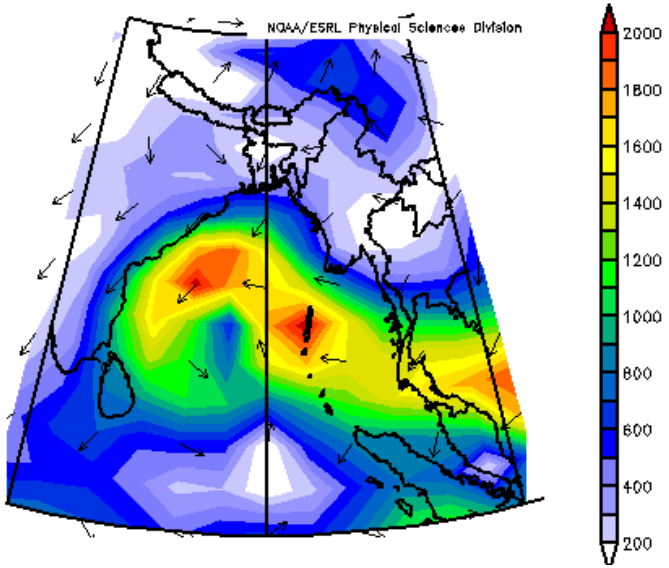




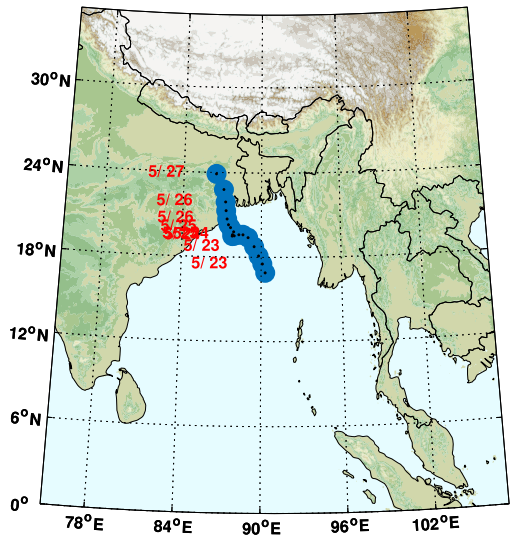
Tropical Cyclones (Day of Storm)

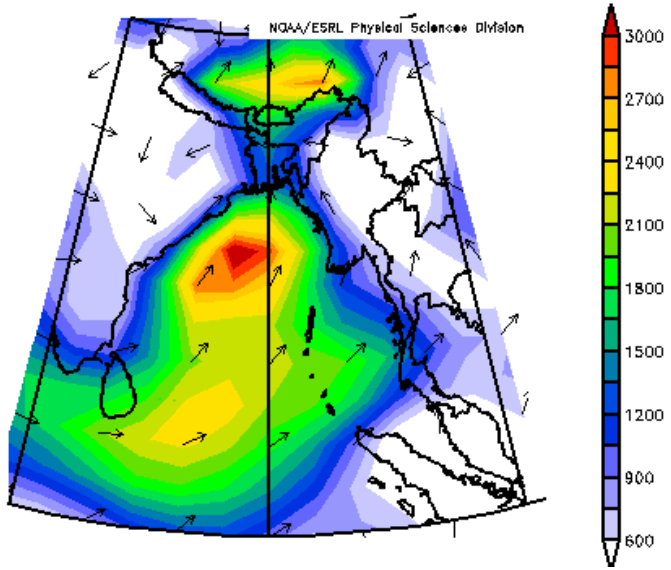
1967



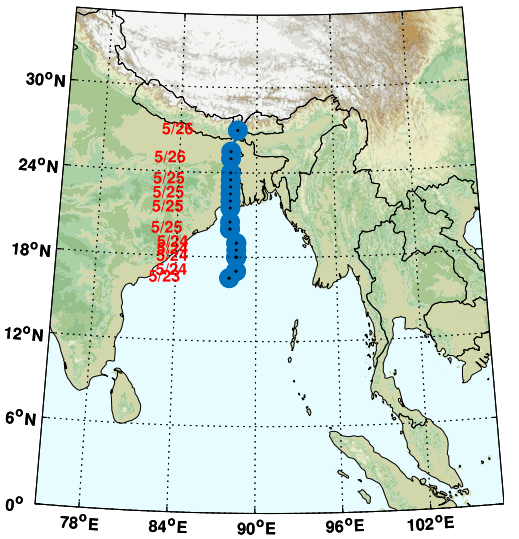


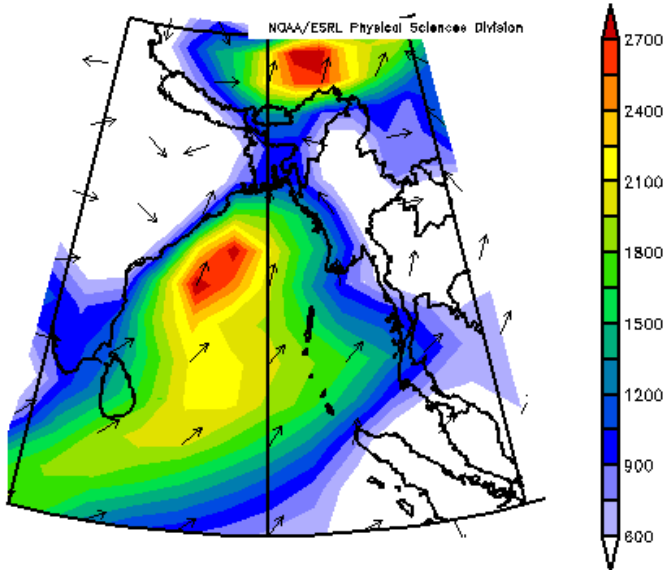
1989



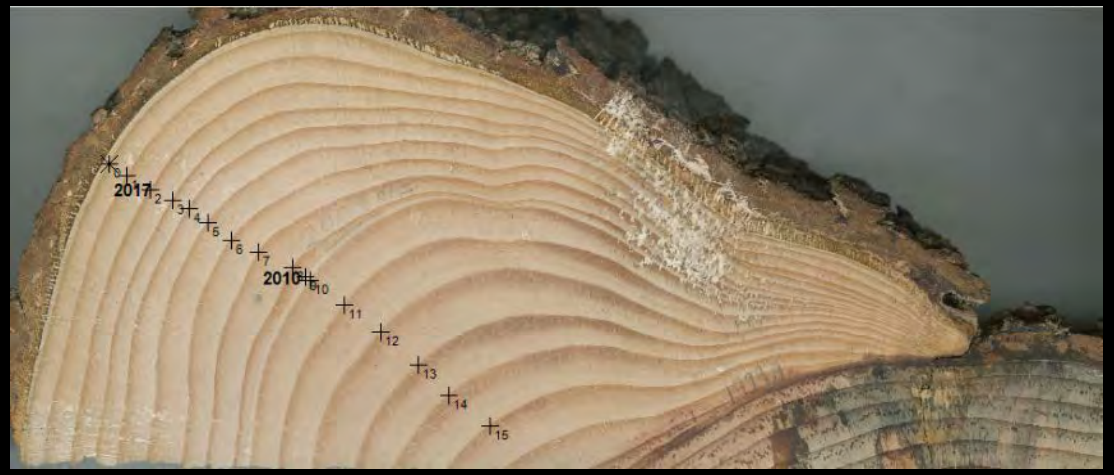


2009

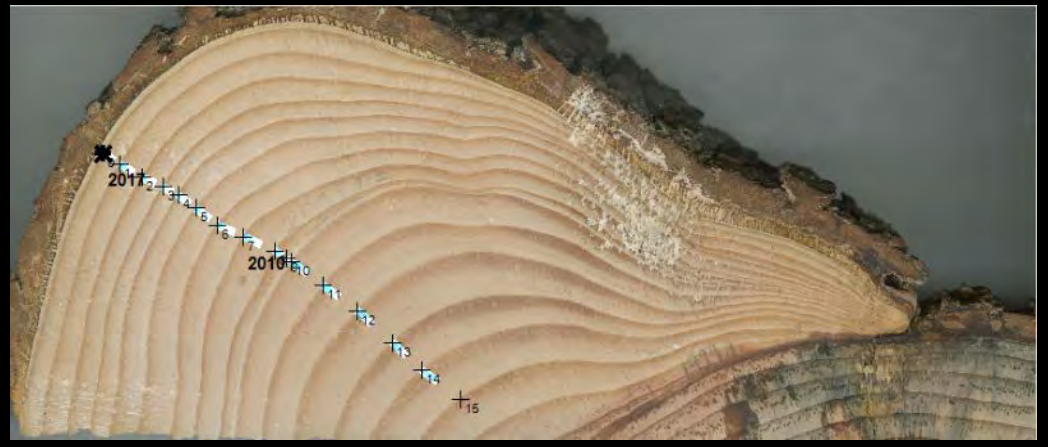




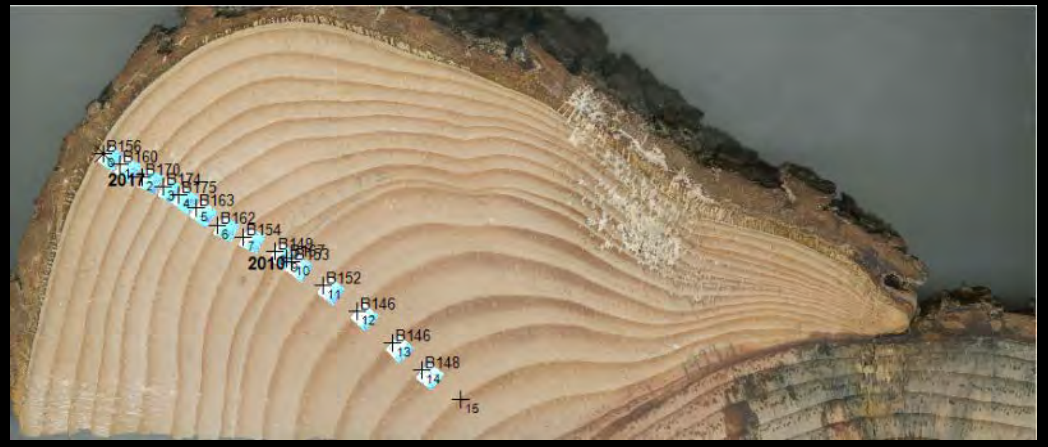
Evaluating 2009 Flood Ring with Blue Intensity

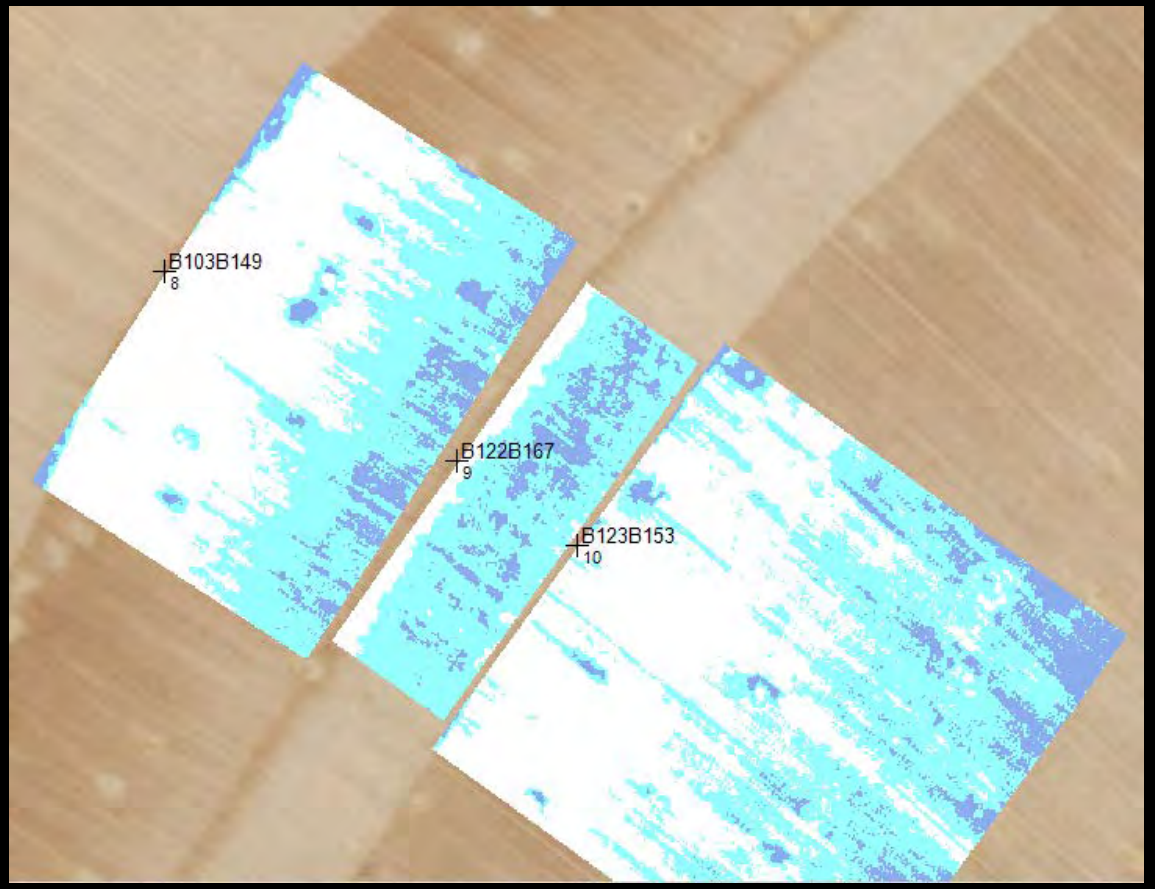


Evaluating 2009 Flood Ring with Blue Intensity

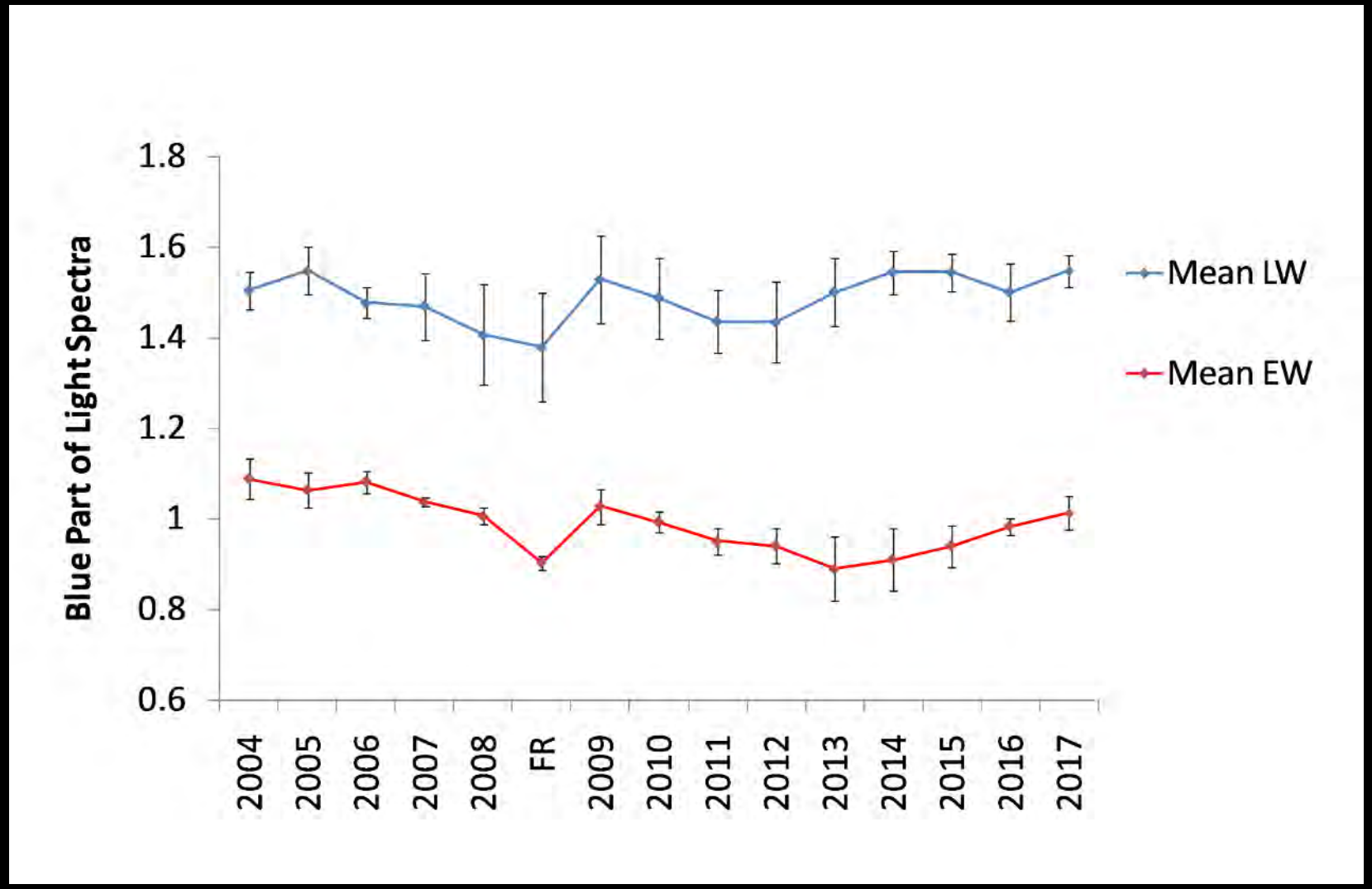


Evaluating 2009 Flood Ring with Blue Intensity





Evaluating 2009 Flood Ring with Blue Intensity



Conclusions

- Flood-scar reconstruction successful in documenting three events, likely associated with cyclones
- New flood information for a region lacking in past hydrologic information
- Multiple flood-sensitive species that respond differently
- Good potential for hydroclimatic reconstructions
- Potential for better understanding of recurrence intervals or probabilities of flood events
- Flood rings in pines may represent a new flood proxy

Acknowledgements

We would like to thank Dorji Dukpa and Karma Tenzin for their logistical support throughout the fieldweek.

We thank UWICER for their wonderful facilities.

Thanks!