INTERNATIONAL CONFERENCE ON
MOUNTAINS AND CLIMATE CHANGE

Spatiotemporal hydrologic gradients in High Mountain Asia

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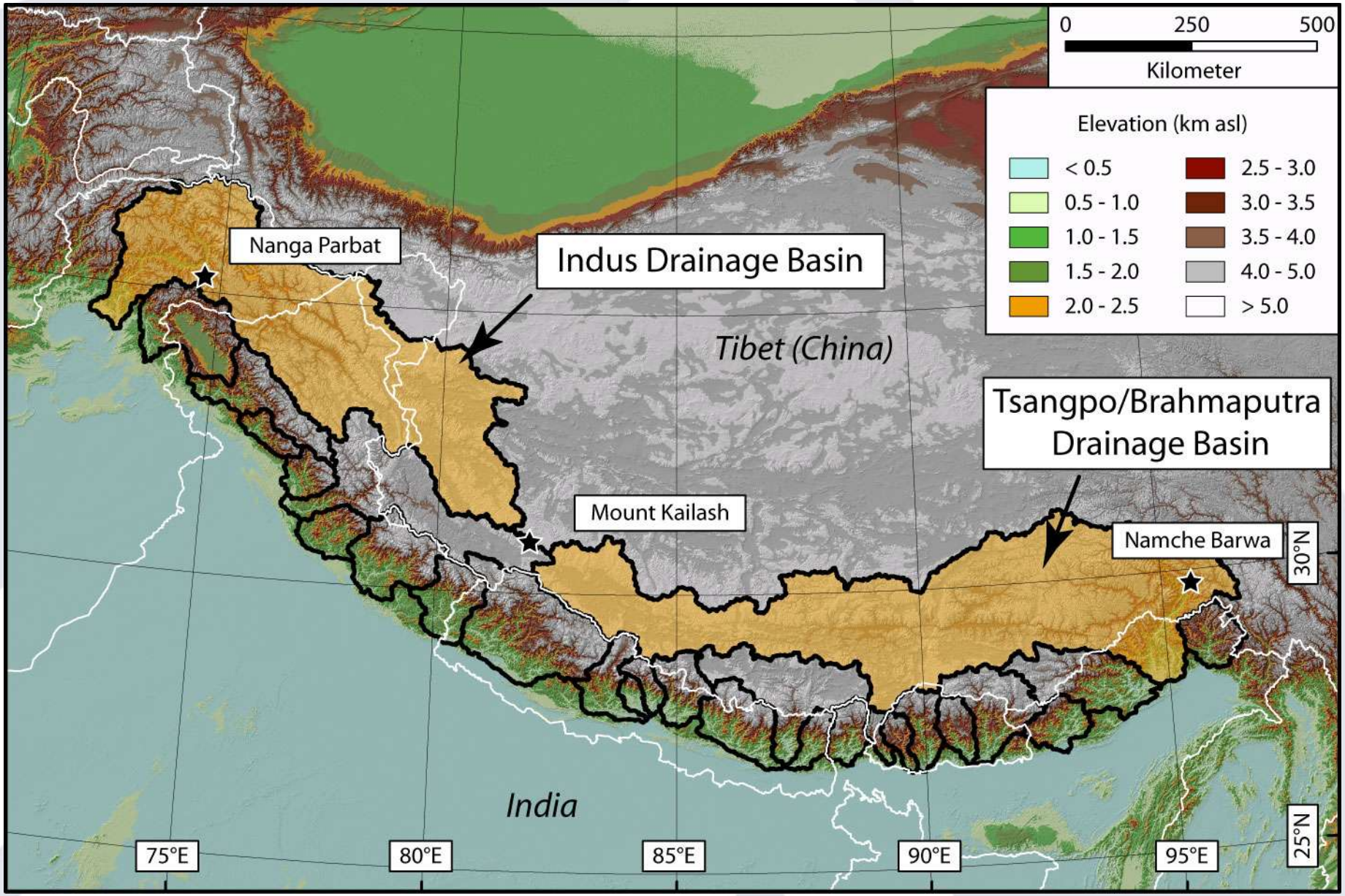
High Summit
LECCO 2013

The seasonal hydrologic budget of High Mountain Asia

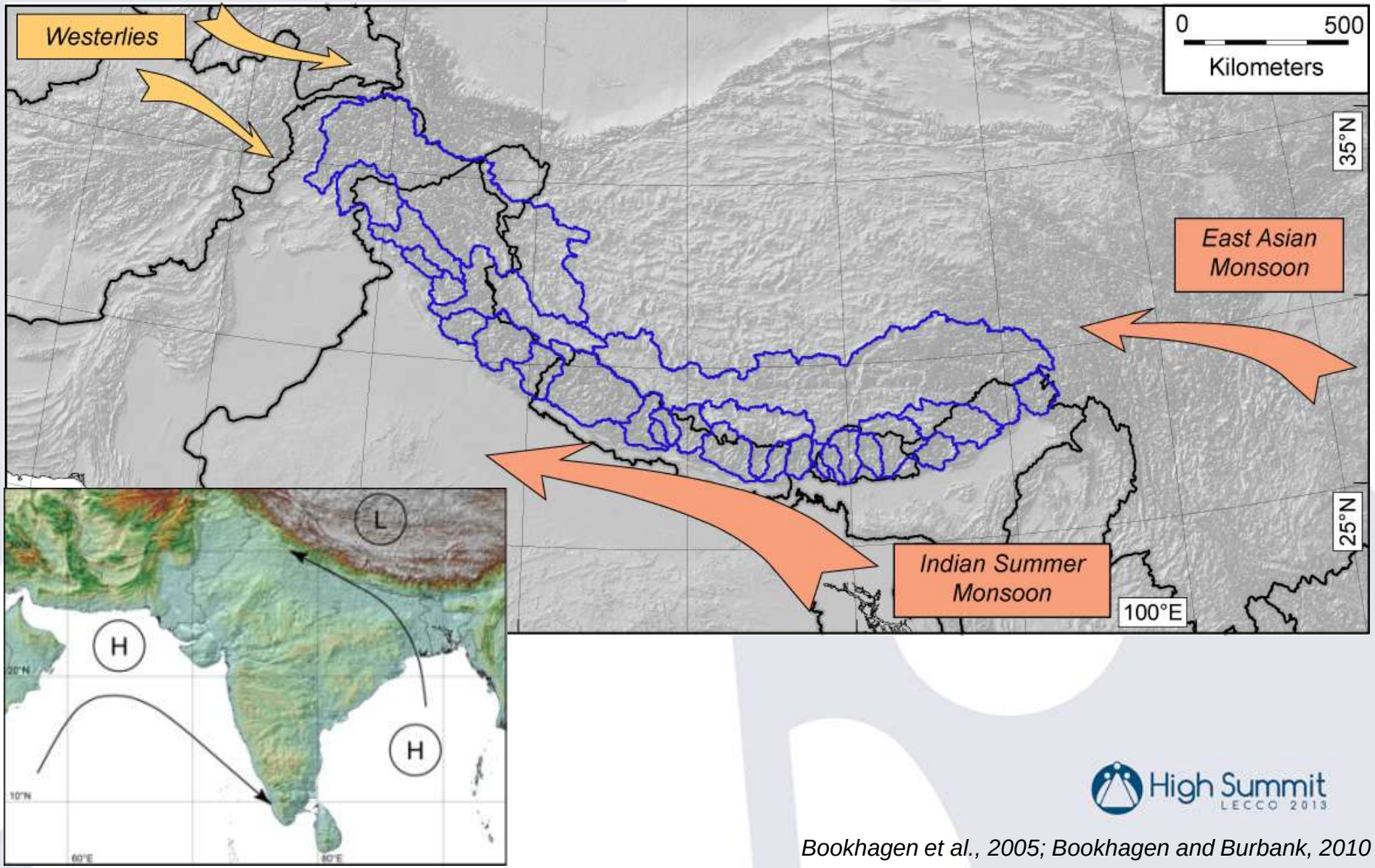
I. Spatial distribution of seasonal rainfall and snowmelt in High Mountain Asia
   - Using calibrated, high-spatial resolution remote-sensing data to characterize Himalayan rainfall and snowmelt

II. What are the magnitudes of snowmelt and glacialmelt contribution in the Himalaya?
   - Detailed example from the western Himalaya

High Asian Topography and River Catchments



General Atmospheric Circulation Patterns



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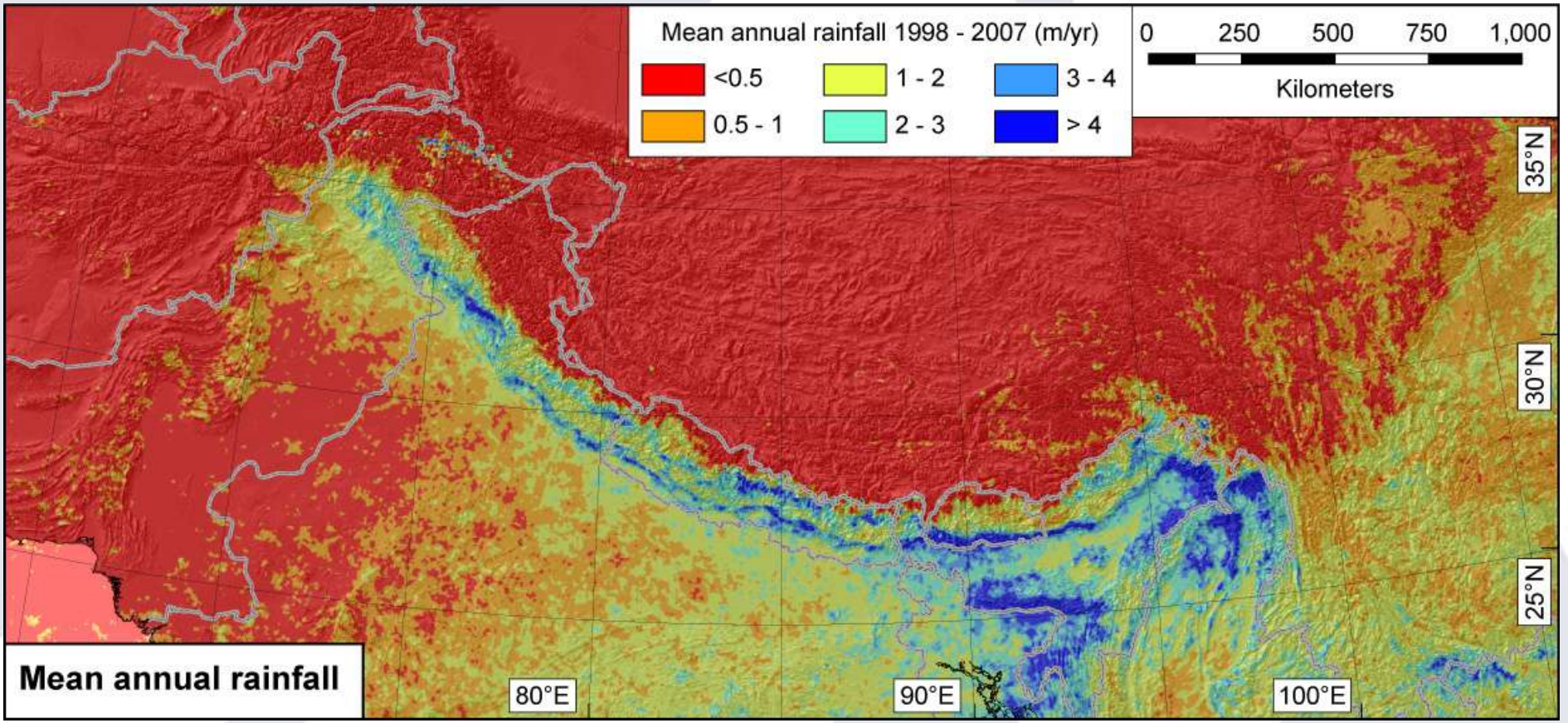
Bookhagen et al., 2005; Bookhagen and Burbank, 2010

TRMM Rainfall - High Spatial Resolution (5x5 km^2) Data



Bookhagen and Burbank, 2006 and 2010; Bookhagen, in review data calibrated with 1741 rain-gauge stations from this area

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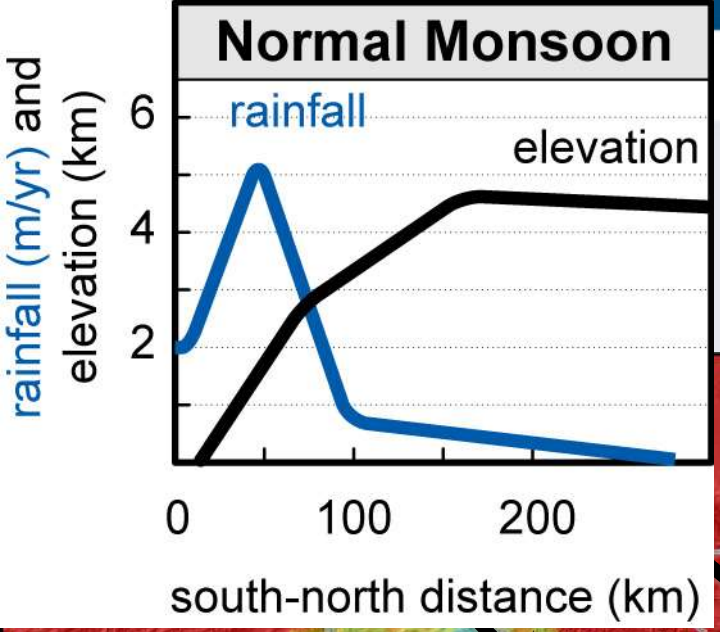
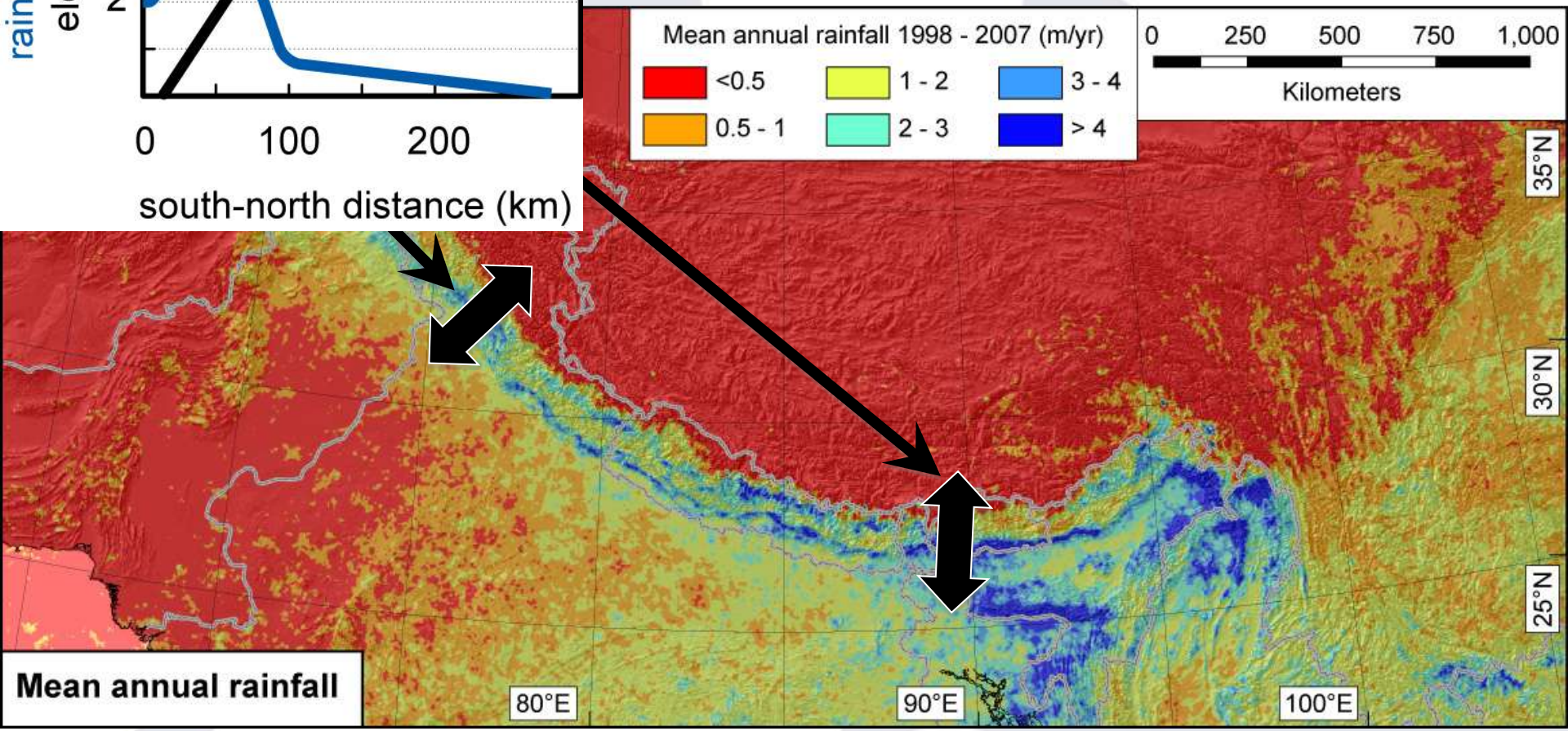
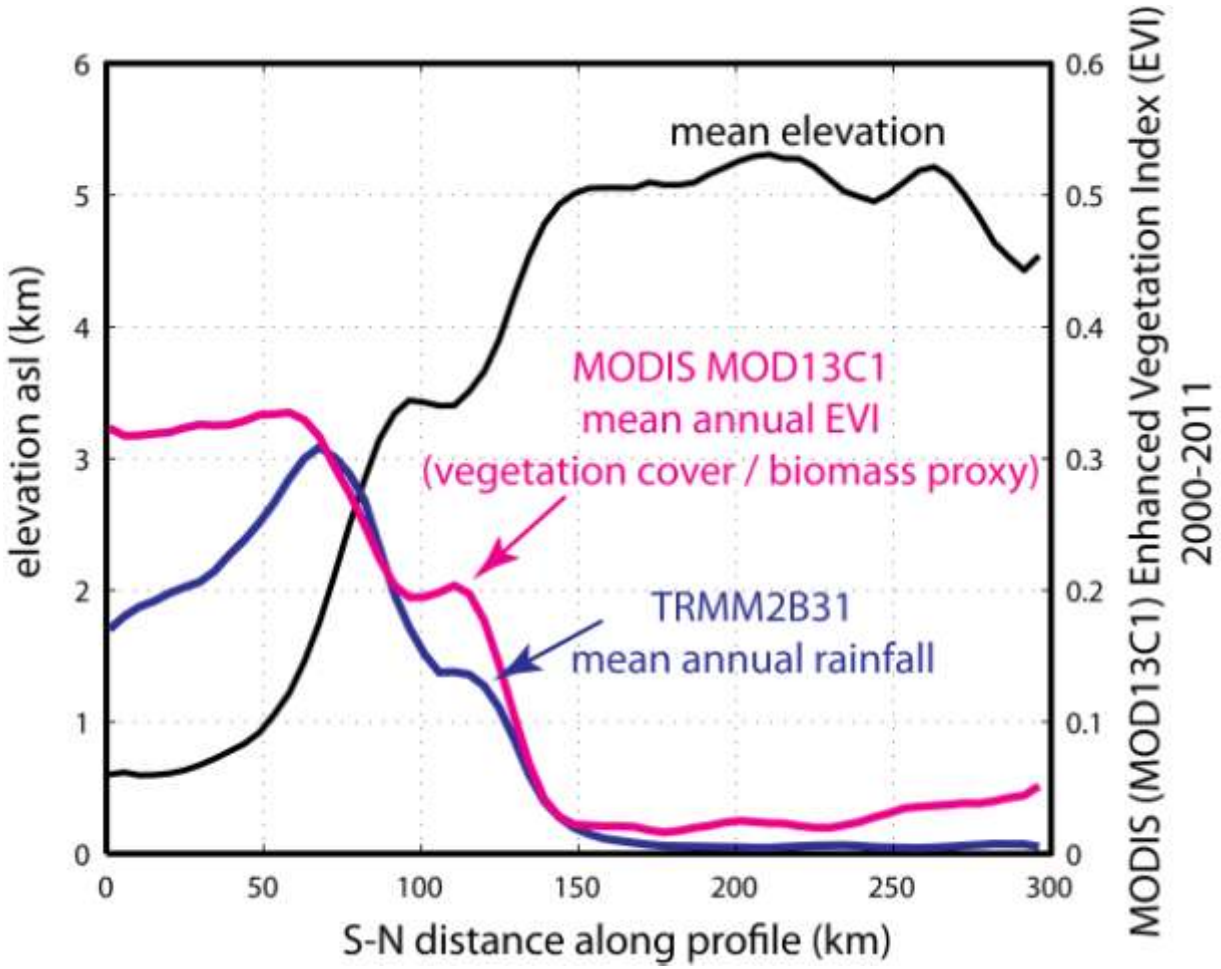




Bookhagen and Burbank, 2006;2010

Steep rainfall and vegetation gradients along the Himalaya



Characteristic example of one-step topography and associated vegetation cover and rainfall in the western Himalaya

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Bookhagen, work in progress

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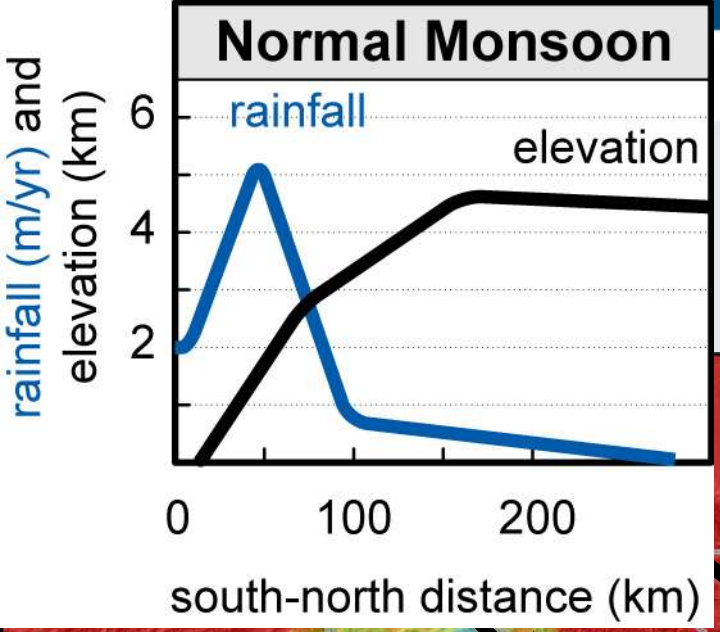

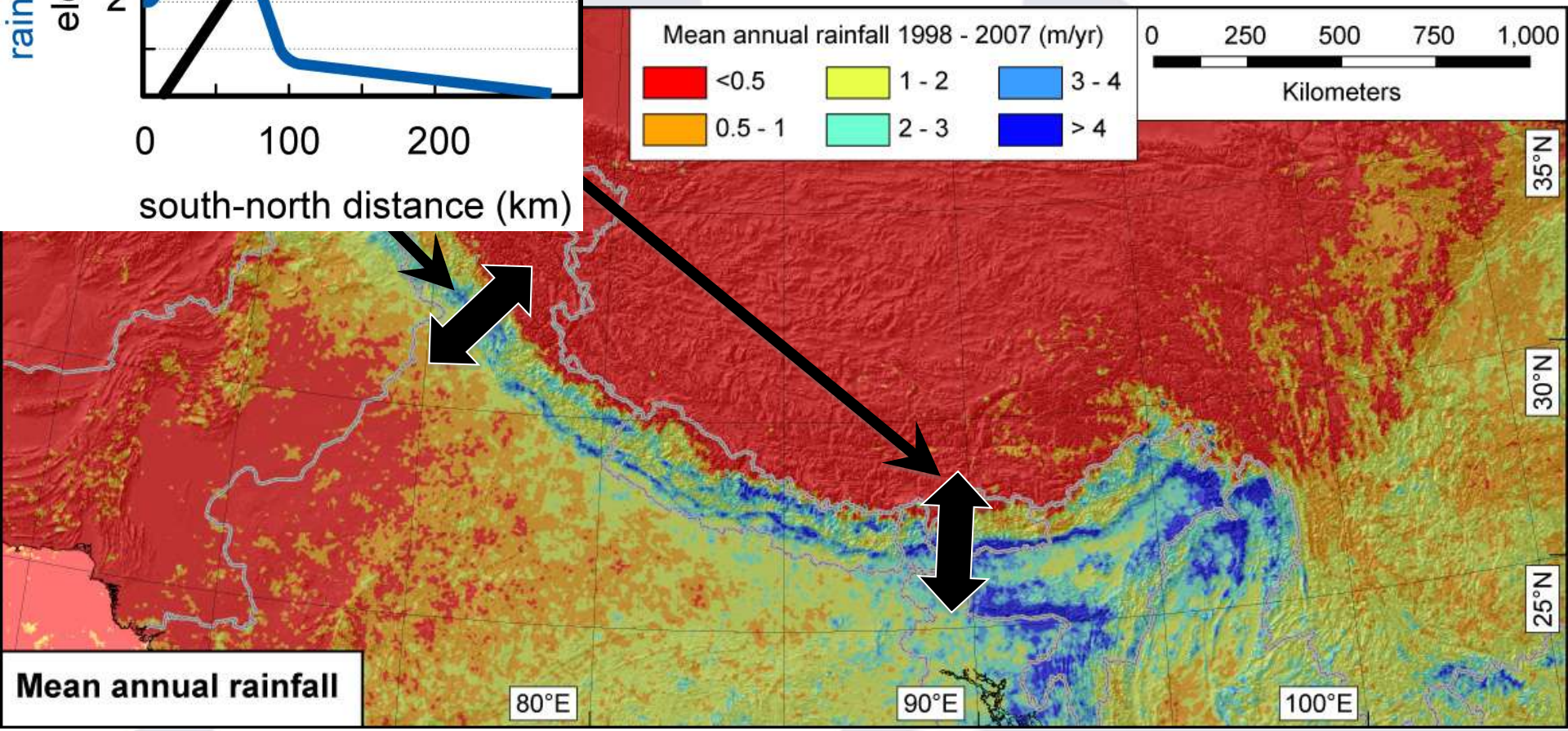

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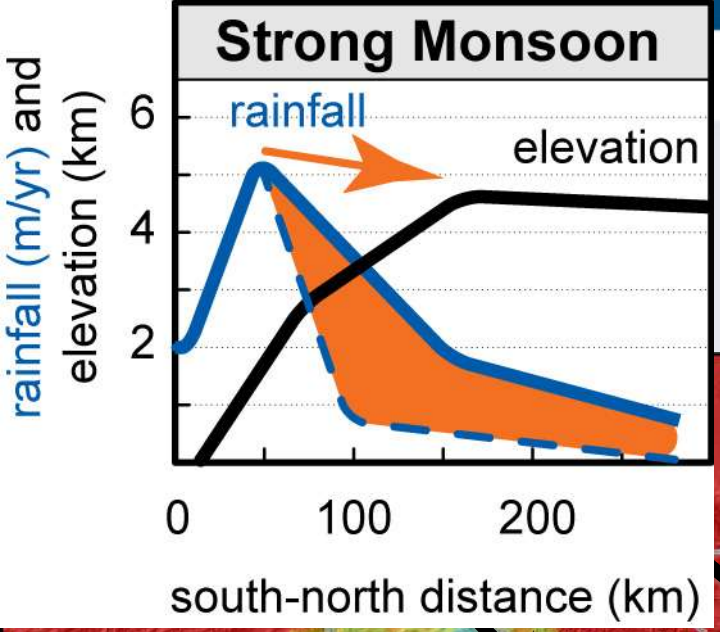
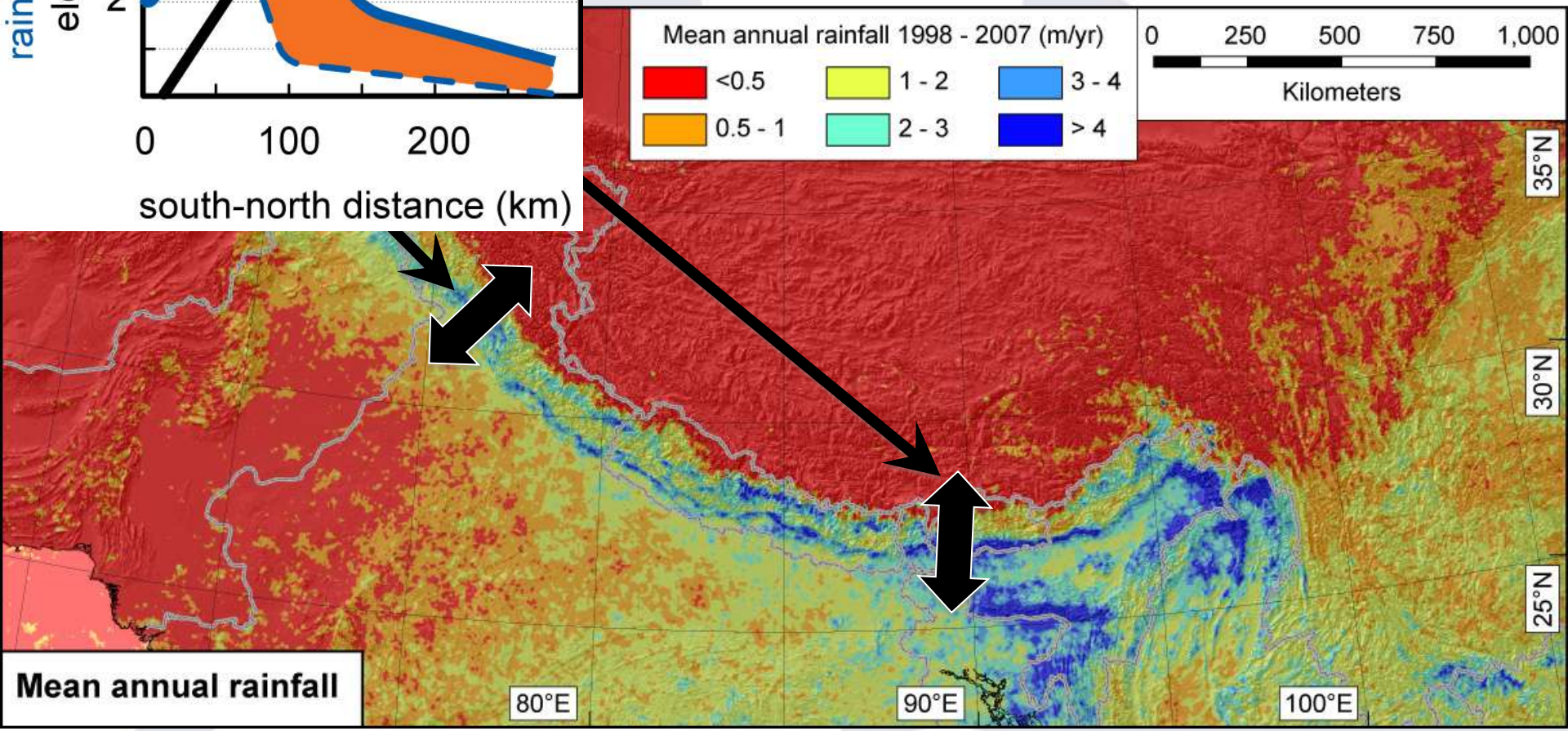


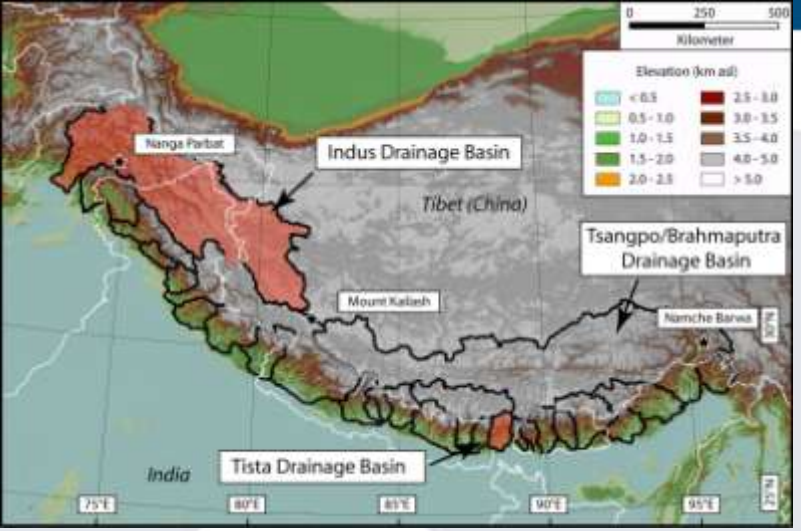


Bookhagen and Burbank, 2006;2010

The Himalaya as Water Towers

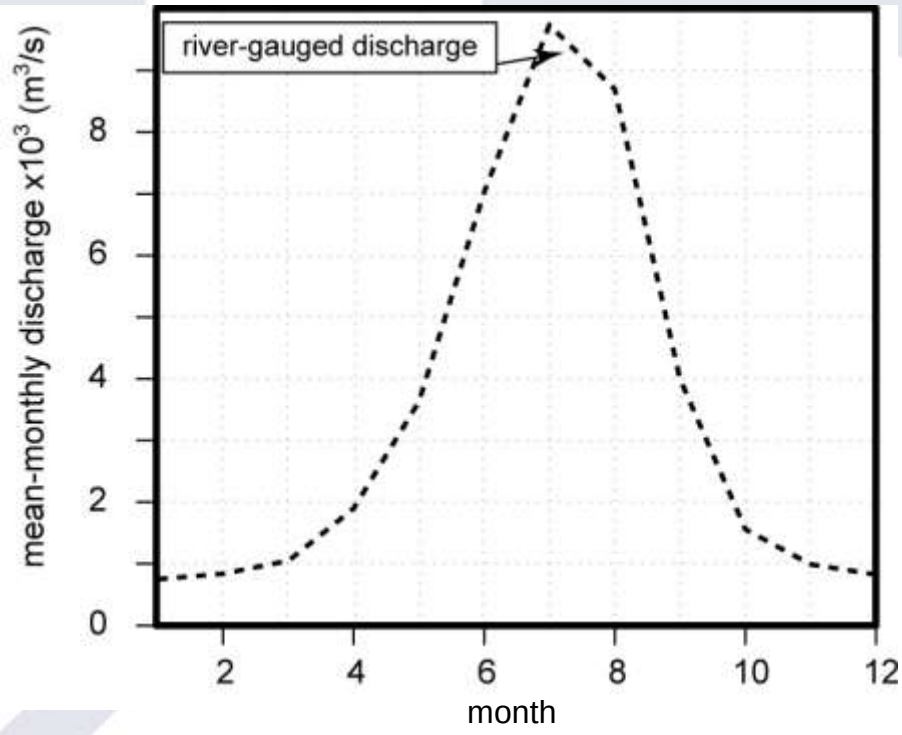
Where does the water come from?

Seasonal Discharge



Measured mean-monthly discharge for a 10-year period (*note the discharge-scale differences*)

Indus



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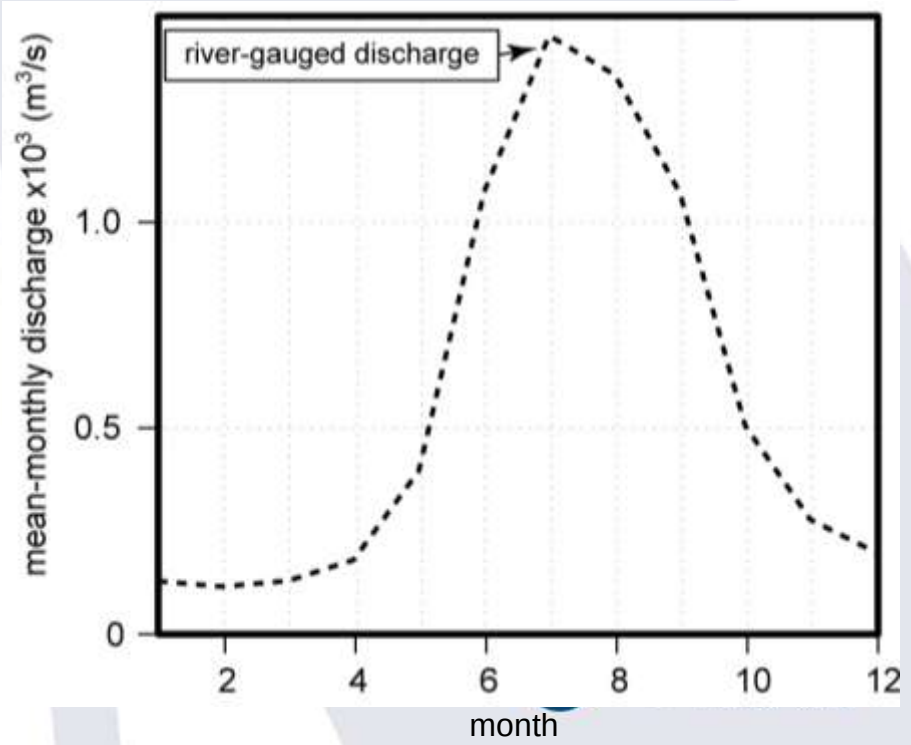
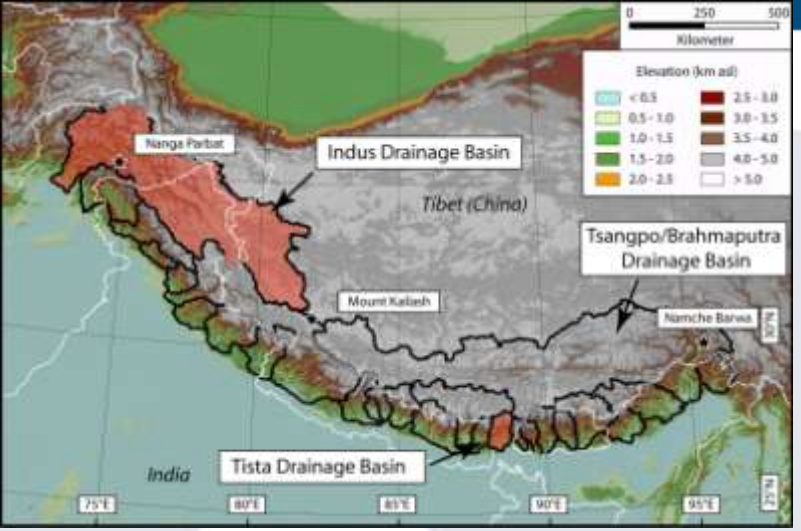


Seasonal Discharge



Measured mean-monthly discharge for a 10-year period (*note the discharge-scale differences*)

Rainfall-derived discharge

Snowmelt-model derived discharge

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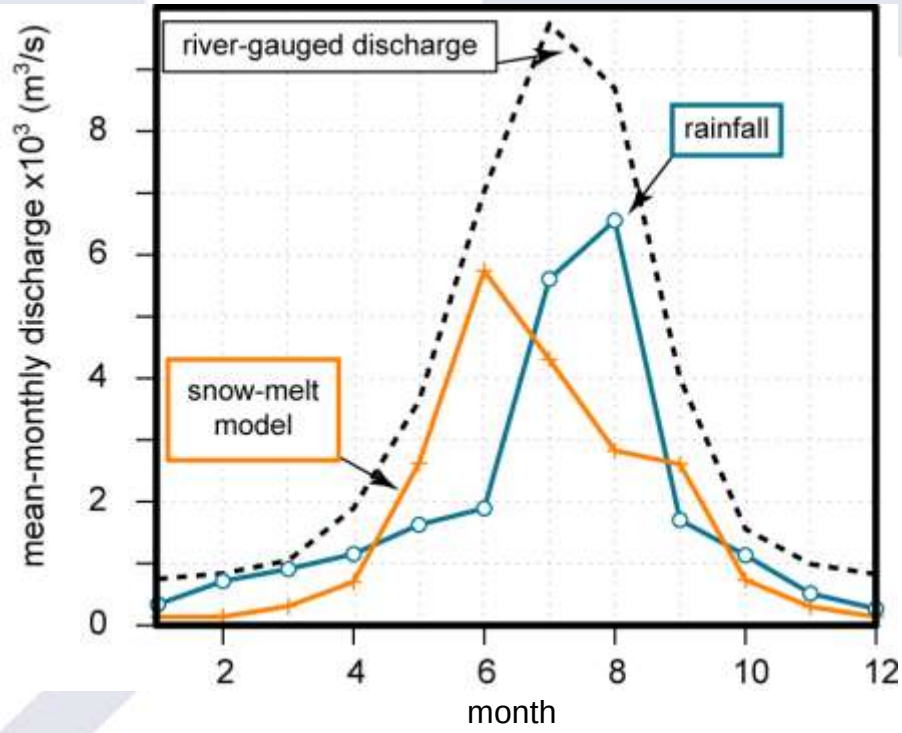

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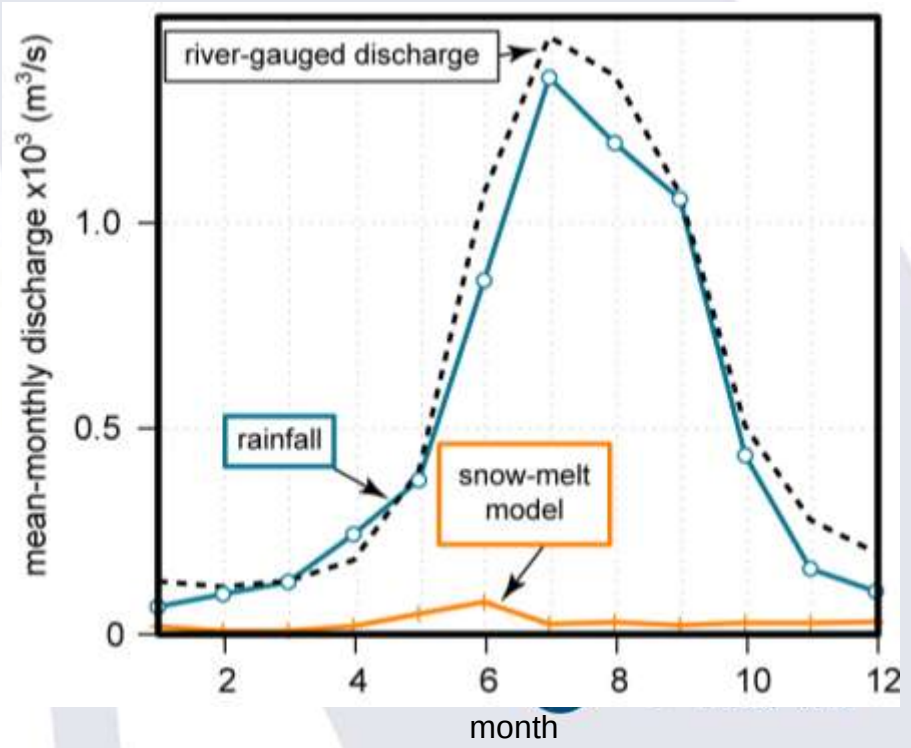
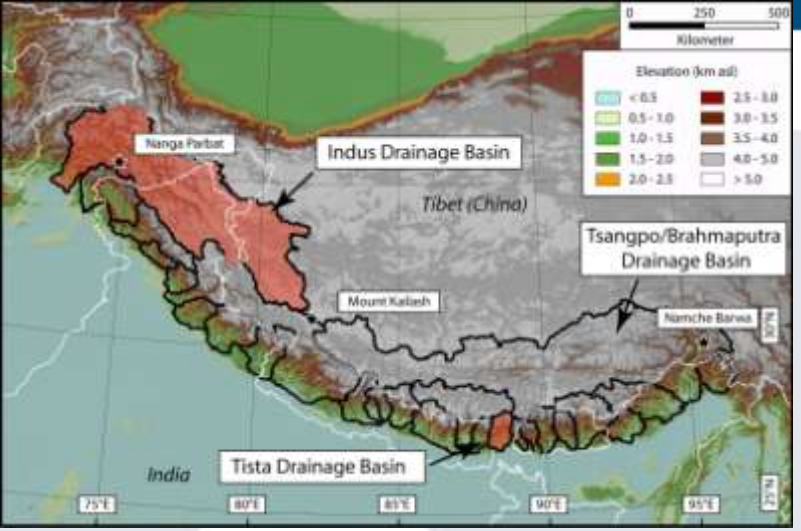


Seasonal Discharge



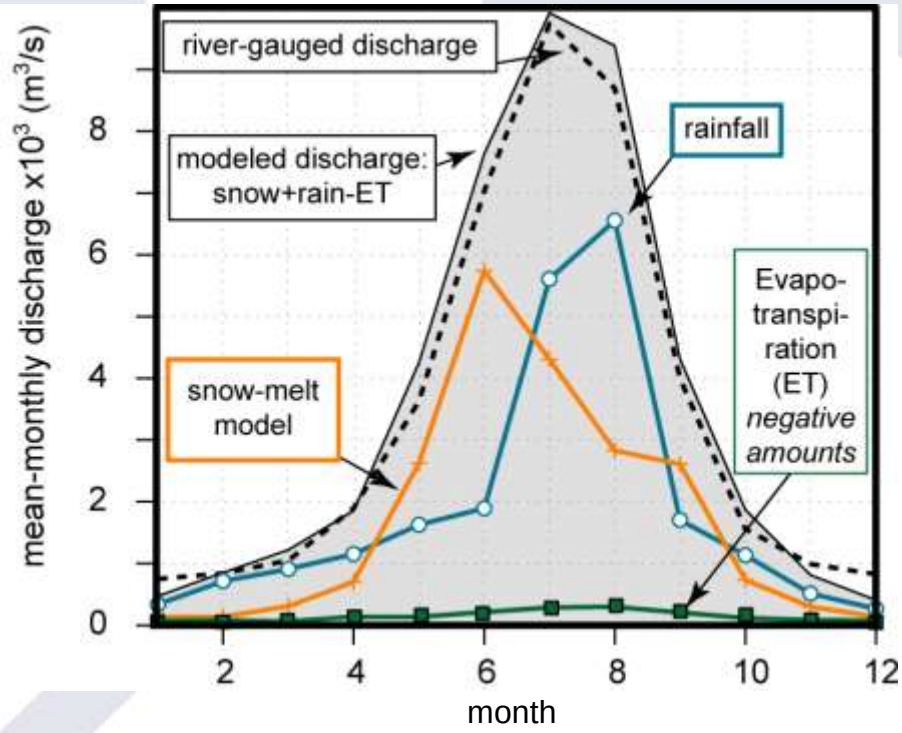
Measured mean-monthly discharge for a 10-year period (*note the discharge-scale differences*)

Rainfall-derived discharge

Snowmelt-model derived discharge

Evapotranspiration-derived component

Indus



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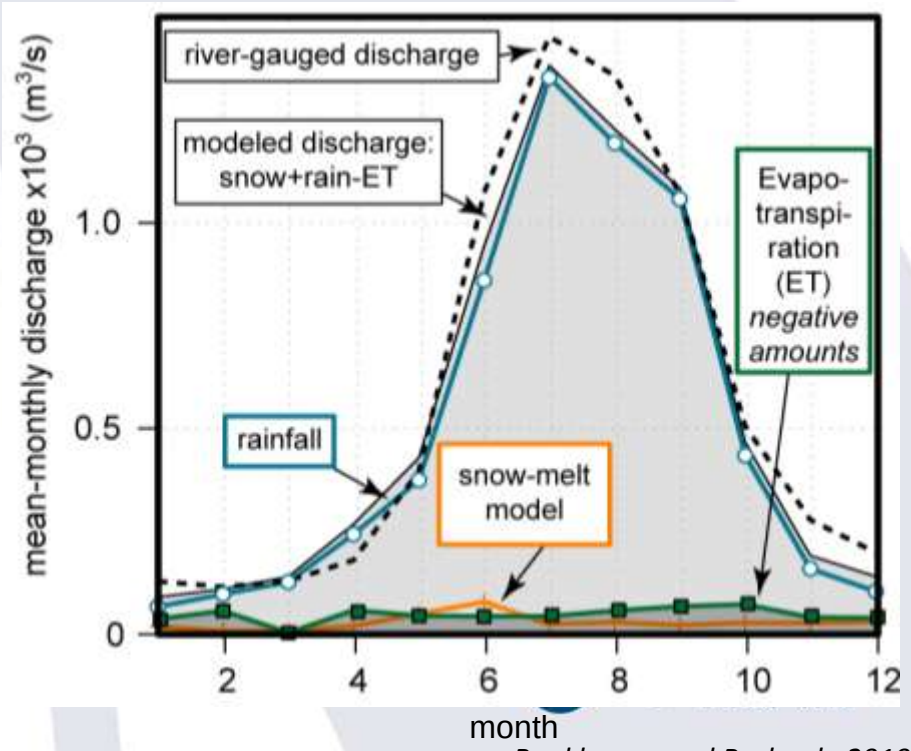
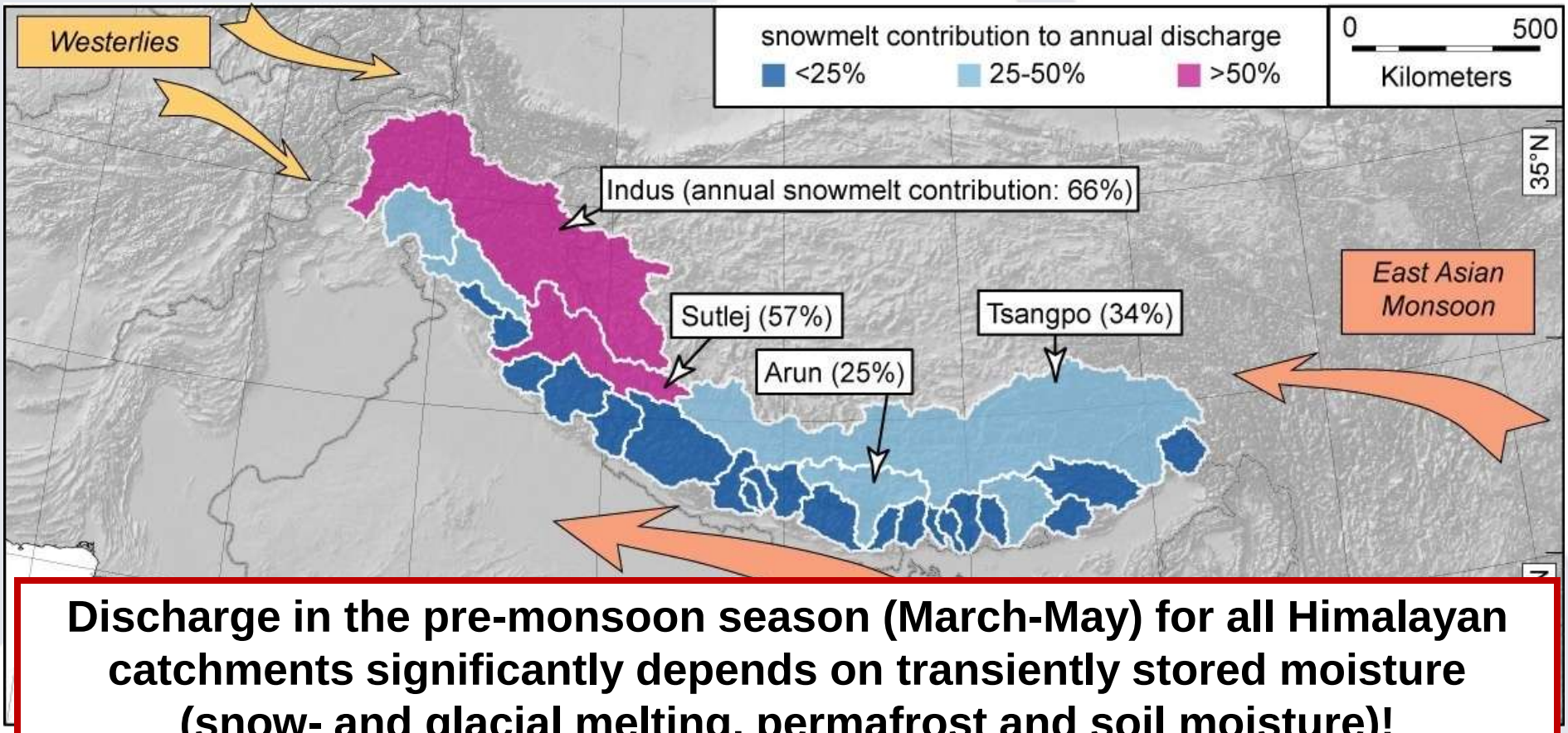


Bookhagen and Burbank, 2010

Predicting River Discharge in the Himalaya – Rainfall and Snowmelt Contribution



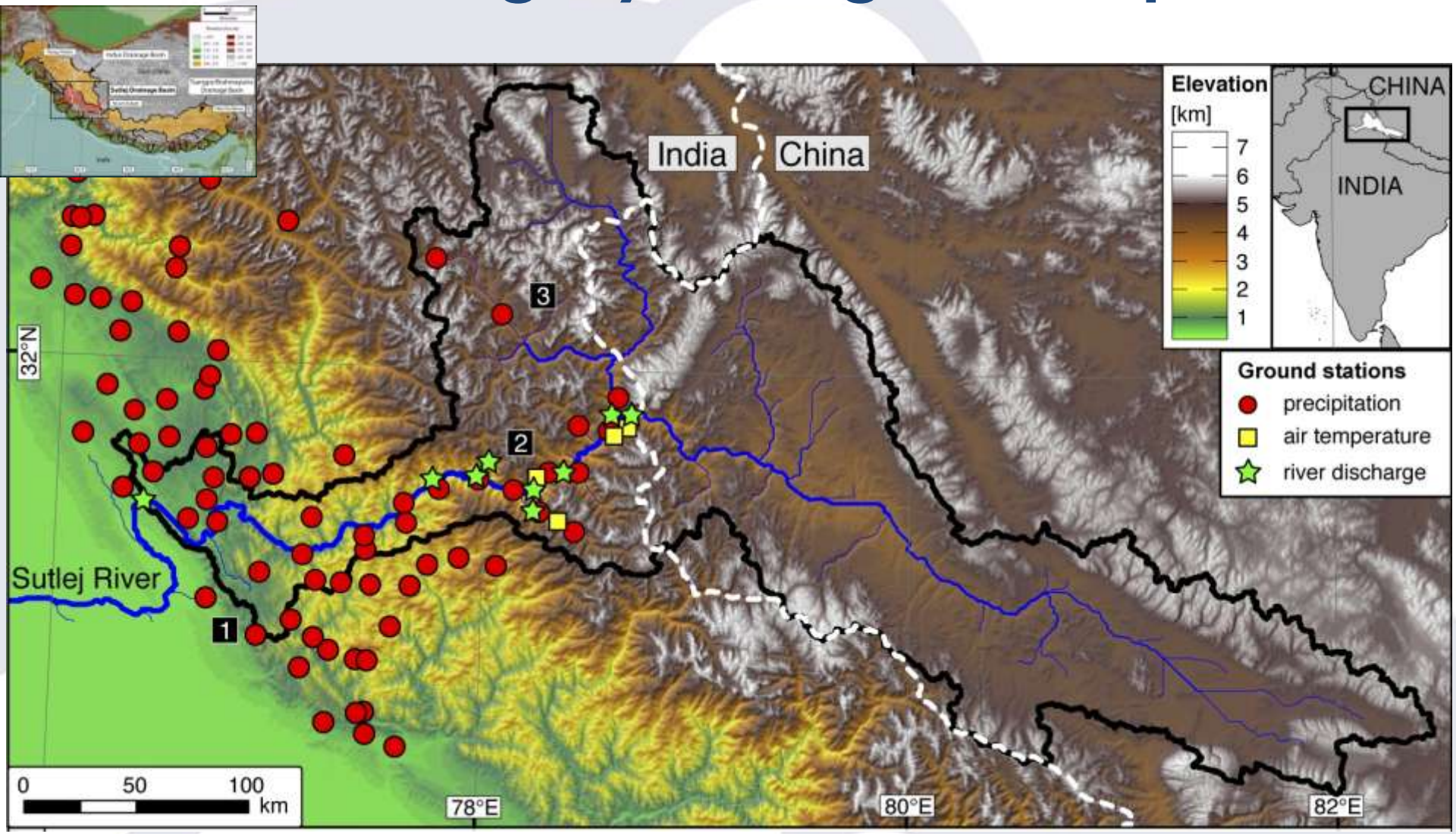
Discharge in the pre-monsoon season (March-May) for all Himalayan catchments significantly depends on transiently stored moisture (snow- and glacial melting, permafrost and soil moisture)!

- *Discharge is calculated by accounting for rainfall, snowmelt, and evapotranspiration*
- *Validated with 13 daily river-gauge stations throughout the Himalaya (Nash-Sutcliffe coefficients between 0.7 and 0.9)*

Bookhagen and Burbank, 2010

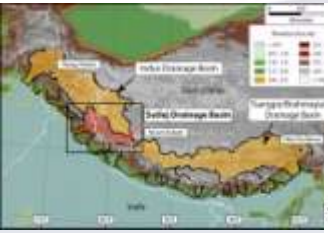
Snow and Glacial Melt Contribution to Discharge

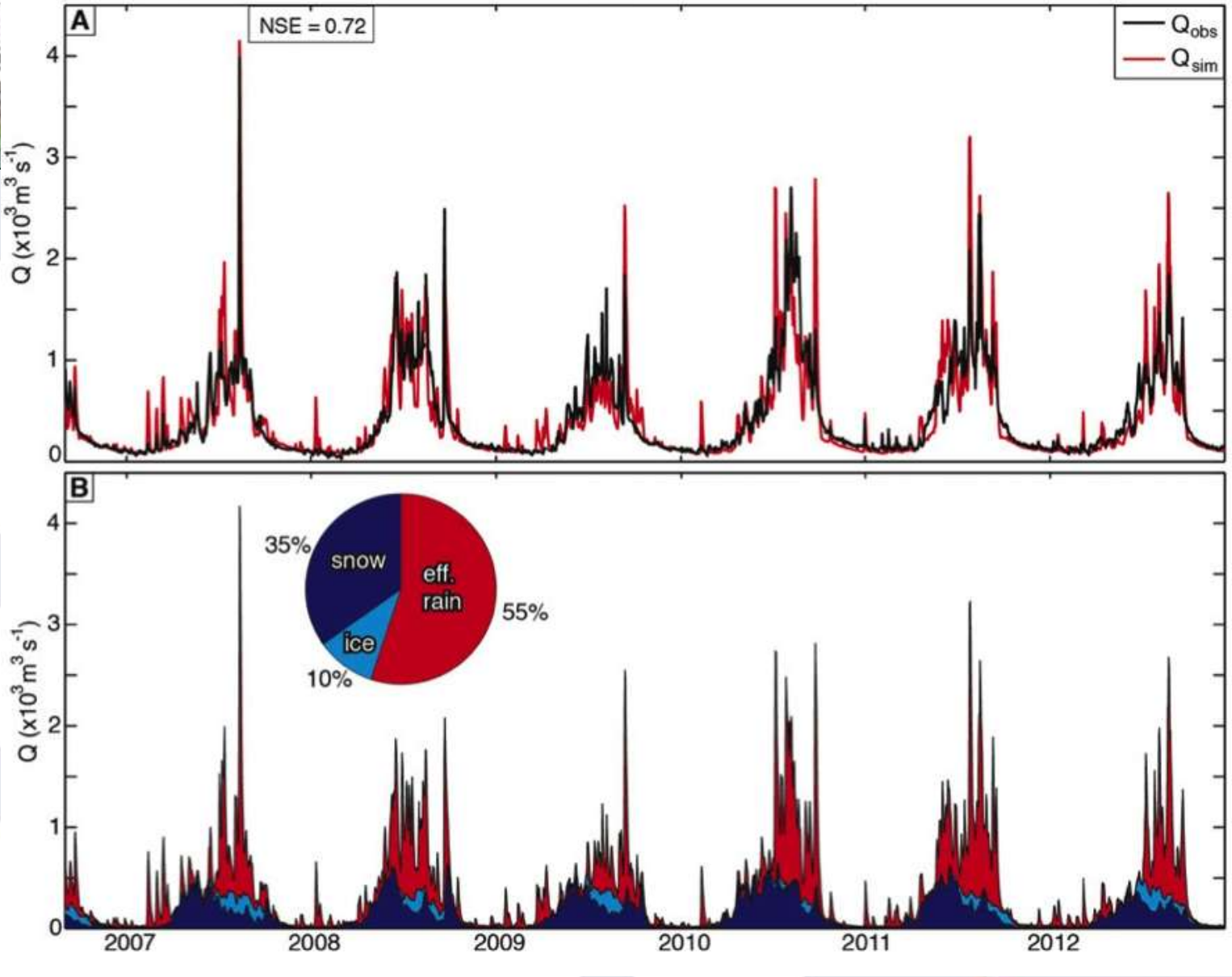
Understanding Hydrologic Components



Wulf, Bookhagen, Scherler (in review)

Understanding Hydrologic Components





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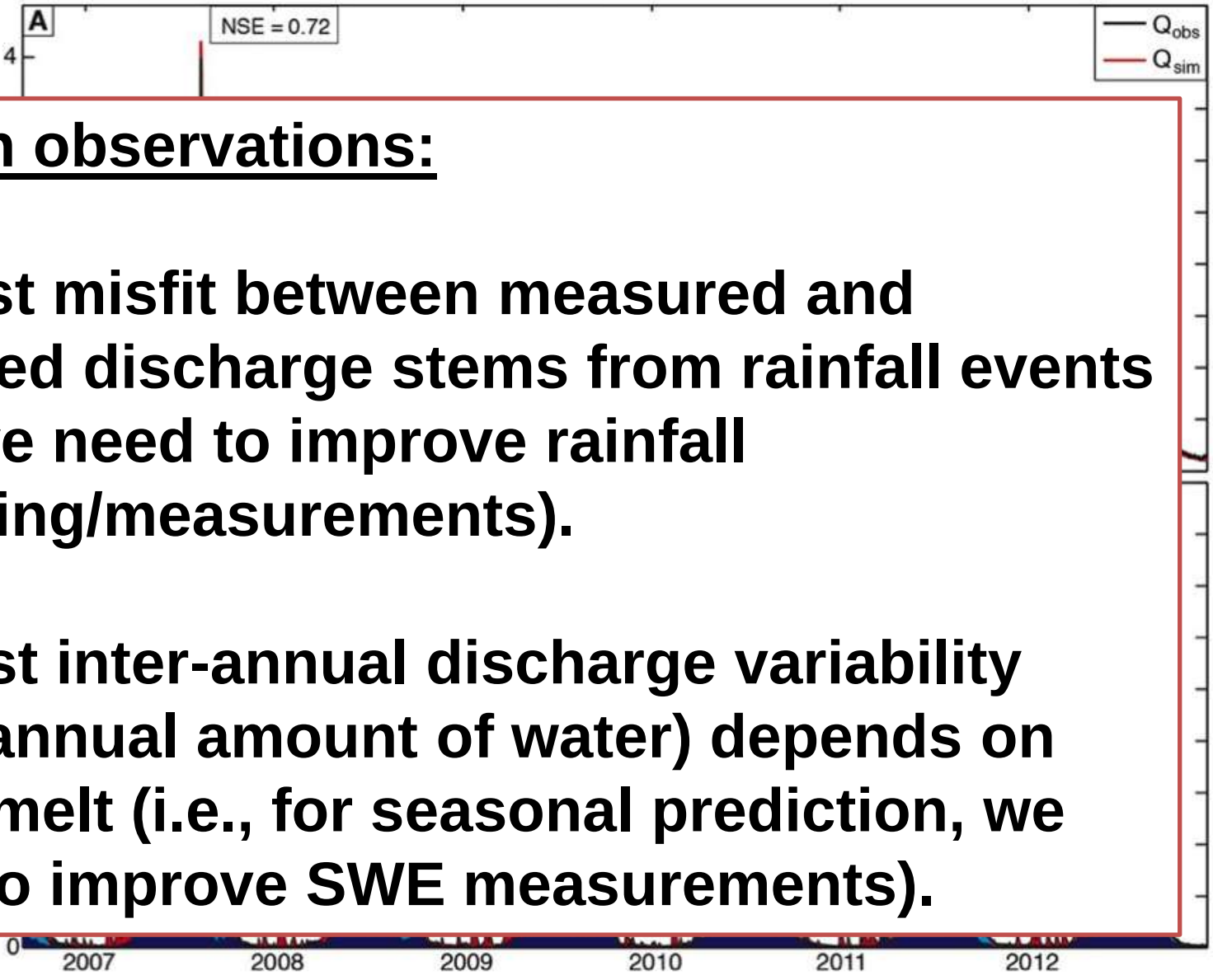
Understanding Hydrologic Components



Two main observations:

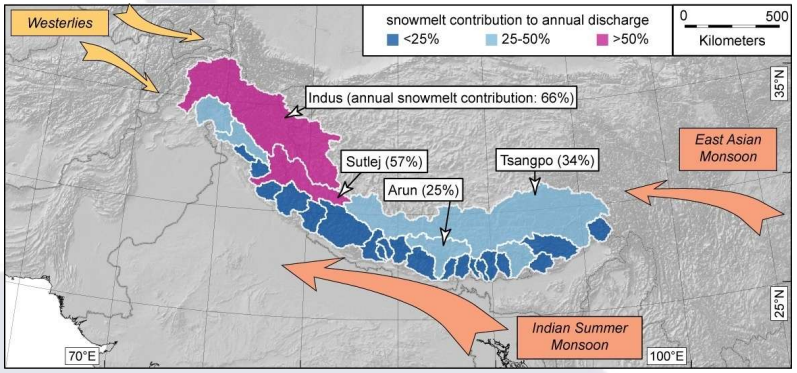
(1) Largest misfit between measured and modeled discharge stems from rainfall events (i.e., we need to improve rainfall modeling/measurements).

(2) Highest inter-annual discharge variability (total annual amount of water) depends on snow melt (i.e., for seasonal prediction, we need to improve SWE measurements).

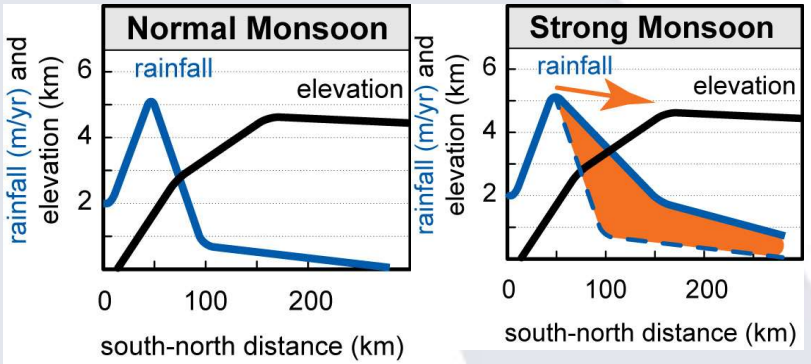
Wulf, Bookhagen, Scherler (in review)

Synthesis: Hydrologic Gradients, Climatic Extreme, and Surface Erosion in the Himalaya

I. There exists large spatiotemporal differences in hydrologic components of Himalayan rivers. Water-saving strategies need to account for these.



II. Propagation of heavy rainstorms into usually arid areas with no vegetation and soil cover are one of the major causes for flooding in the Himalaya.



III. Seasonal snowmelt is the dominant driver of discharge in the western Himalaya. *What is the impact of climate change on melting of seasonal snowpack?*