Towards a hydrologic budget for mountainous regions: relative influence of critical climatic parameters

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The Gateway to Austronaut Photography, http://eol.jsc.nasa.gov

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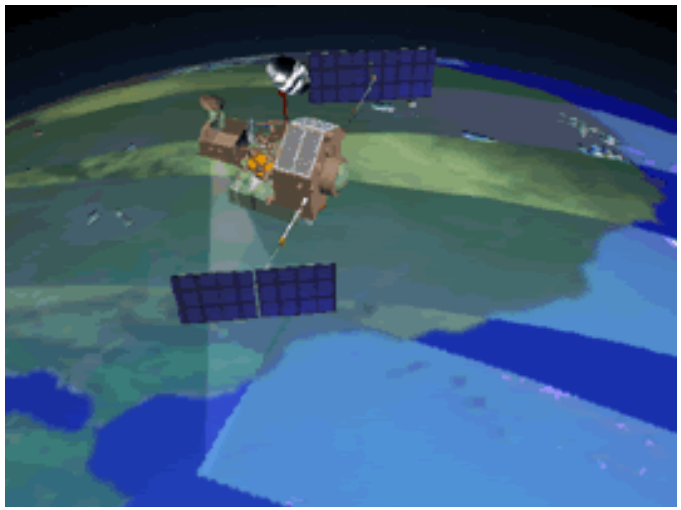
Hydrologic Budget: Relative influence of critical climatic parameters

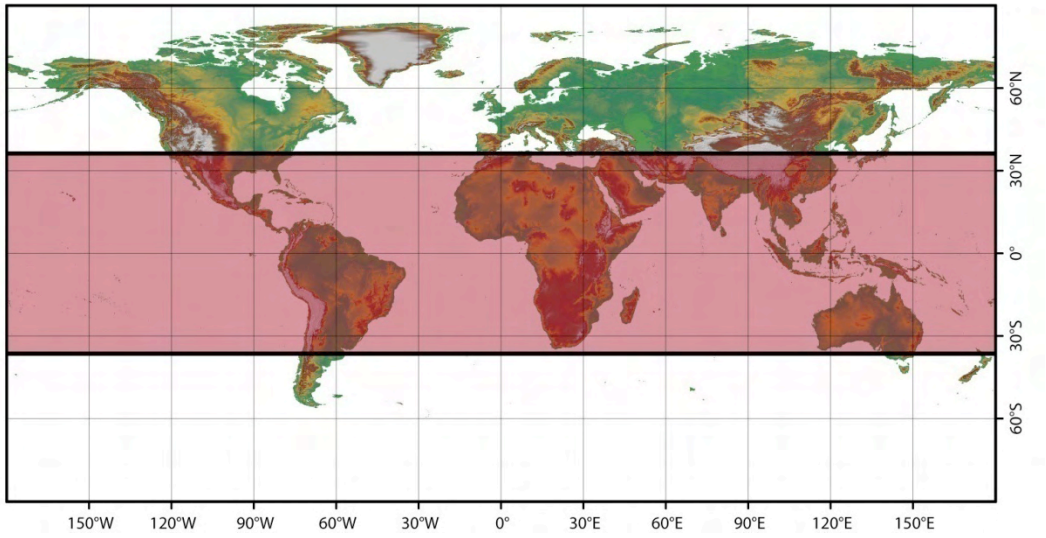
I. **Spatiotemporal climatic gradients and hydrologic budgets**
   - Most mountainous regions are characterized by steep climatic gradients -> require high *spatial* resolution (1-10km) and *temporal* (2-6x per day) ground or satellite measurements
   - Hydrologic budget of mountainous rivers is dominated by rainfall and snowmelt -> relative contribution is not well constrained

II. **Rainfall-magnitude frequency relation**
   - Determination of storm ("extreme ") events, flooding
   - Driver of large mass-transport processes

TRMM platform (Tropical Rainfall Measurement Mission)

- Joint operation of NASA and JAXA
- High-resolution weather parameter measurement between 36°N and 36°S
- Several instruments on the platform
- Will be followed by the GPM (Global Precipitation Measurement) project





PR Precipitation Radar

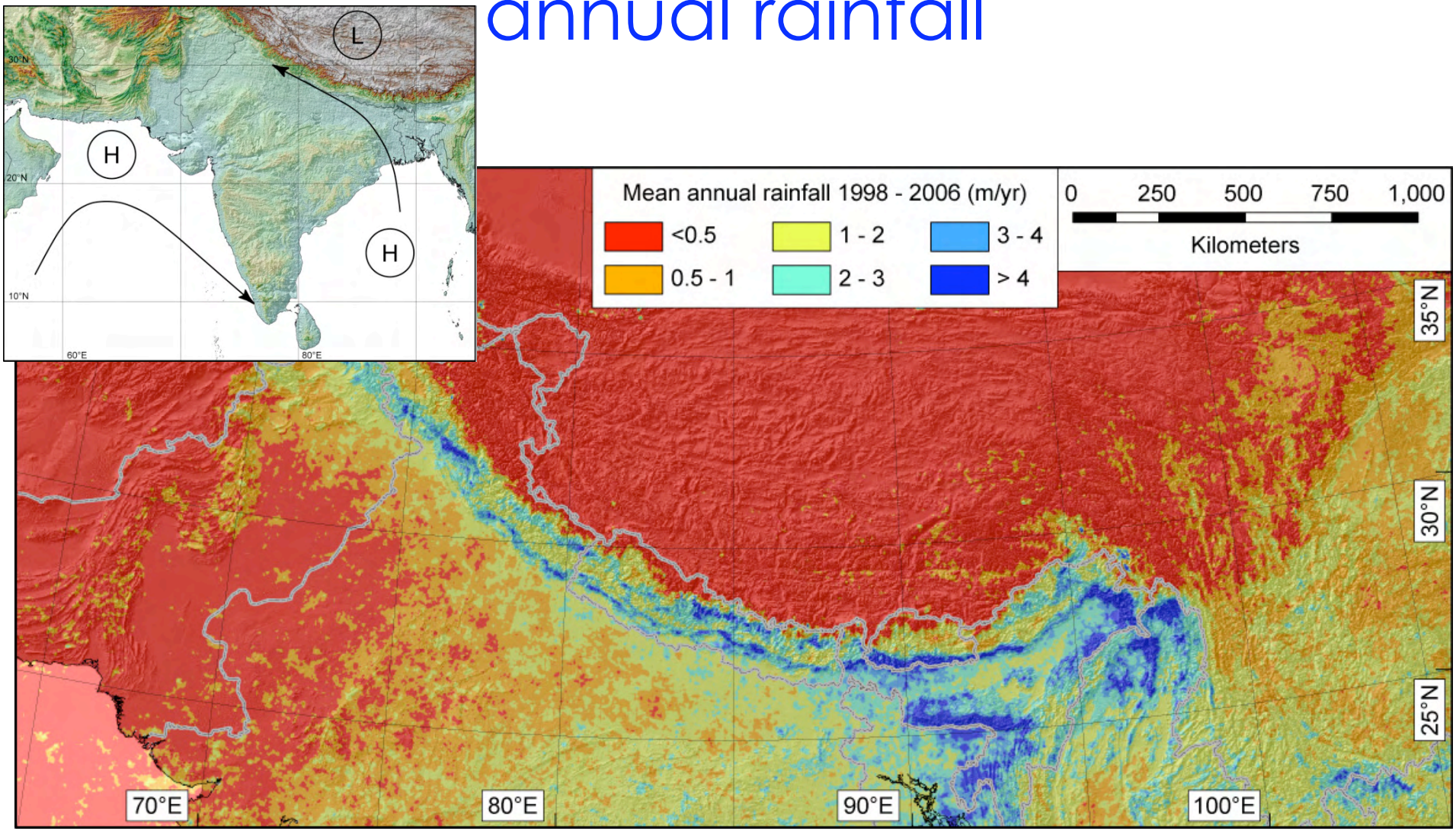
TMI TRMM Microwave Imager

VRS Visible Infrared Scanner

LIS Lightning Image Sensor

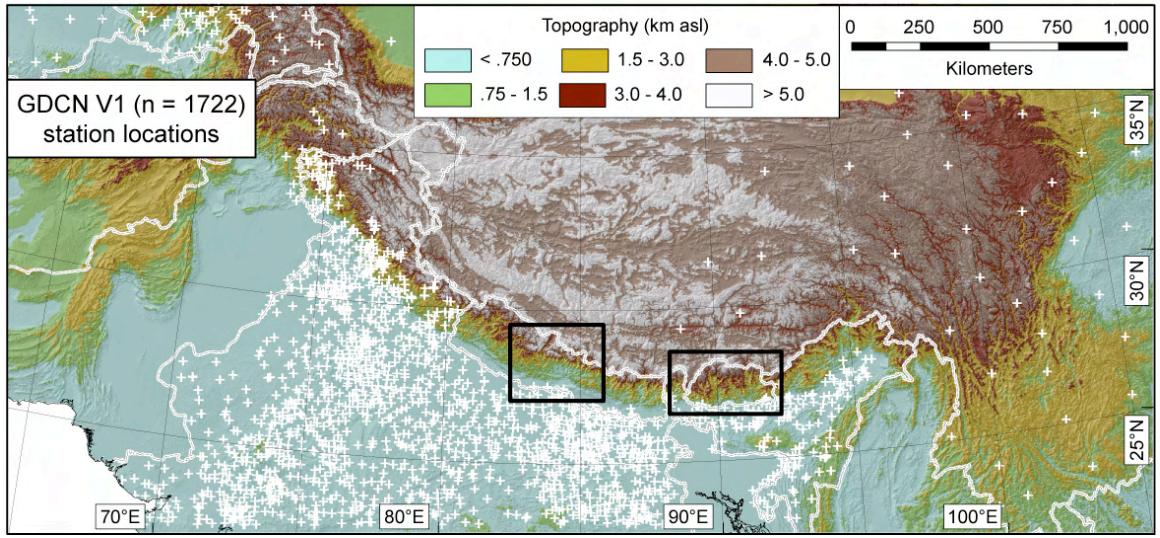
CERES Cloud and Earth's Radiant Energy System

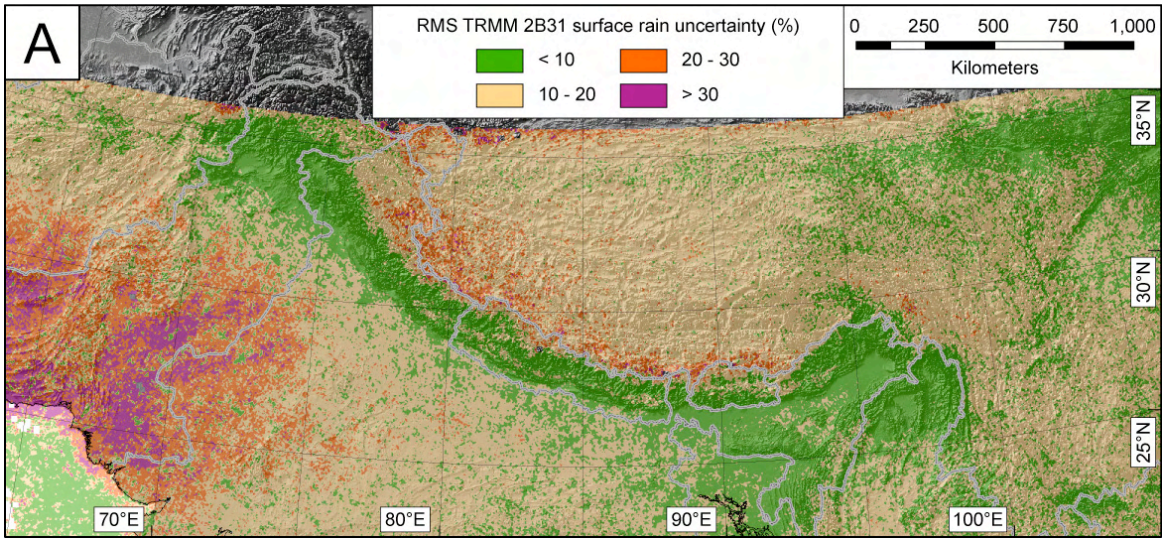
Rainfall distribution in the Himalaya annual rainfall

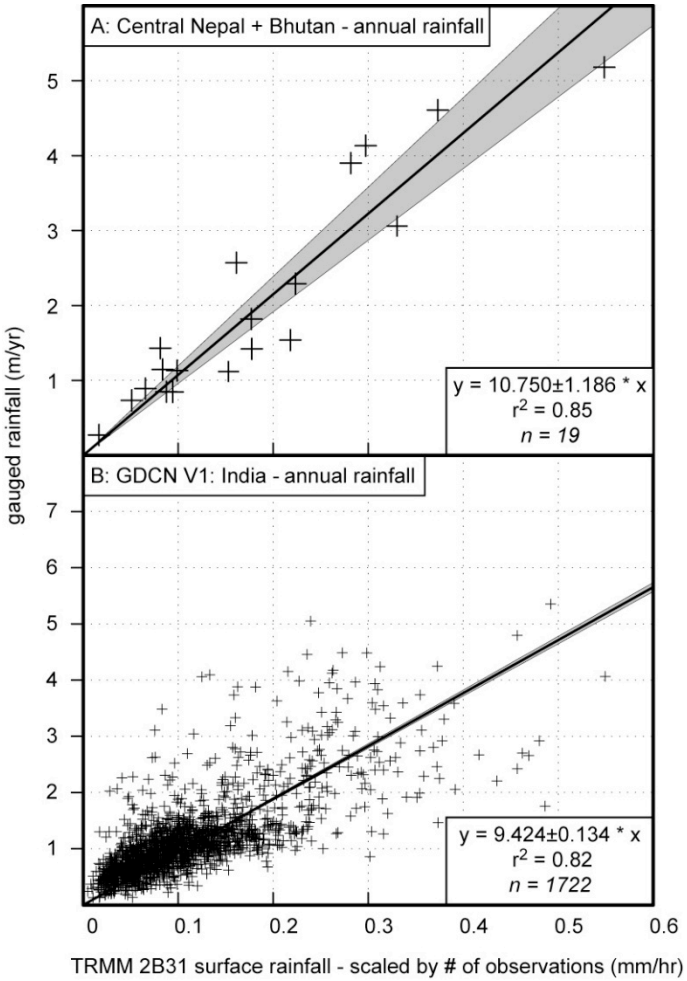


Bookhagen and Burbank, 2006

Calibration & Errors of TRMM2B31 surface rainfall

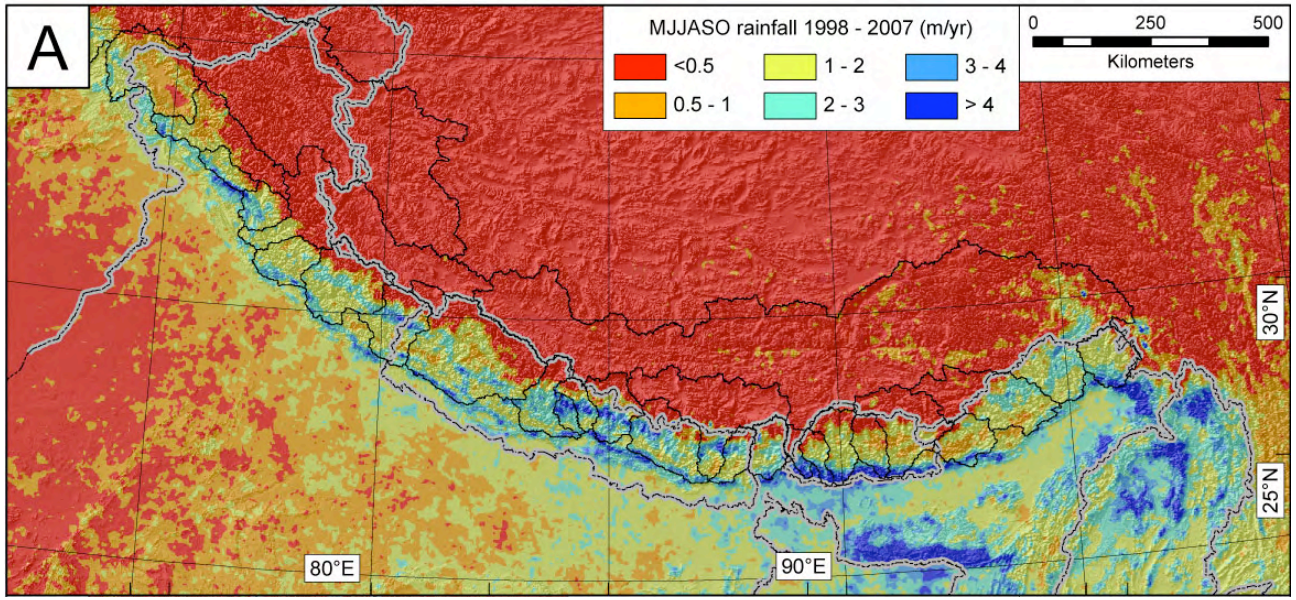




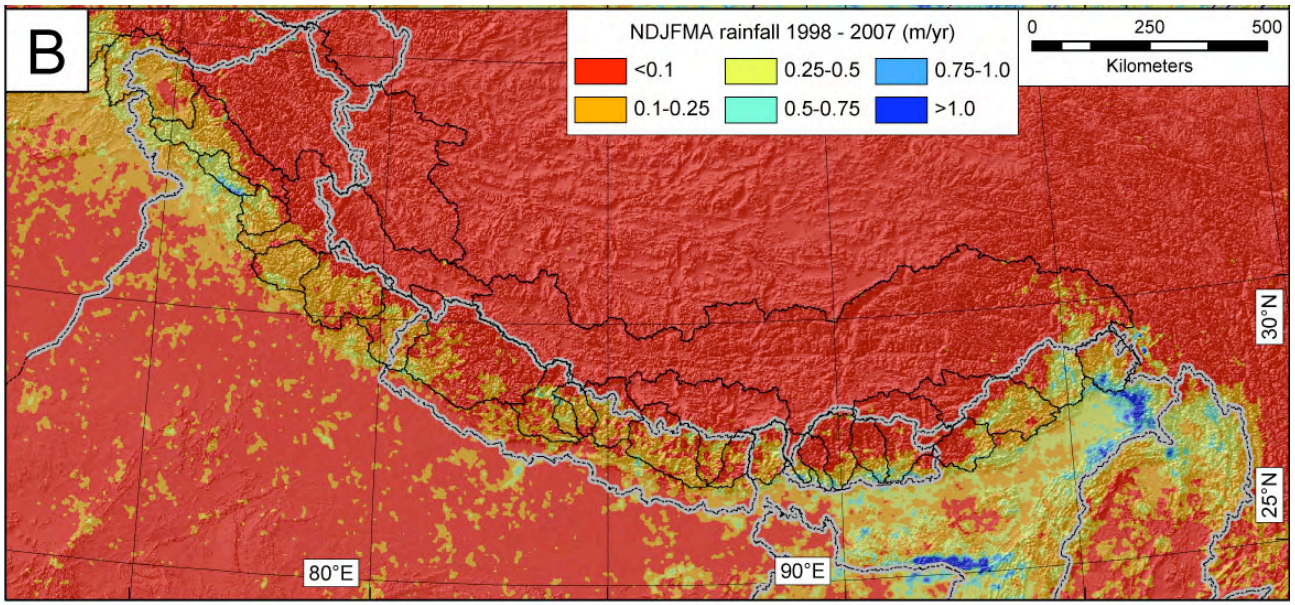


Bookhagen and Burbank, in review

Rainfall distribution in the Himalaya seasonal (summer + winter) rainfall

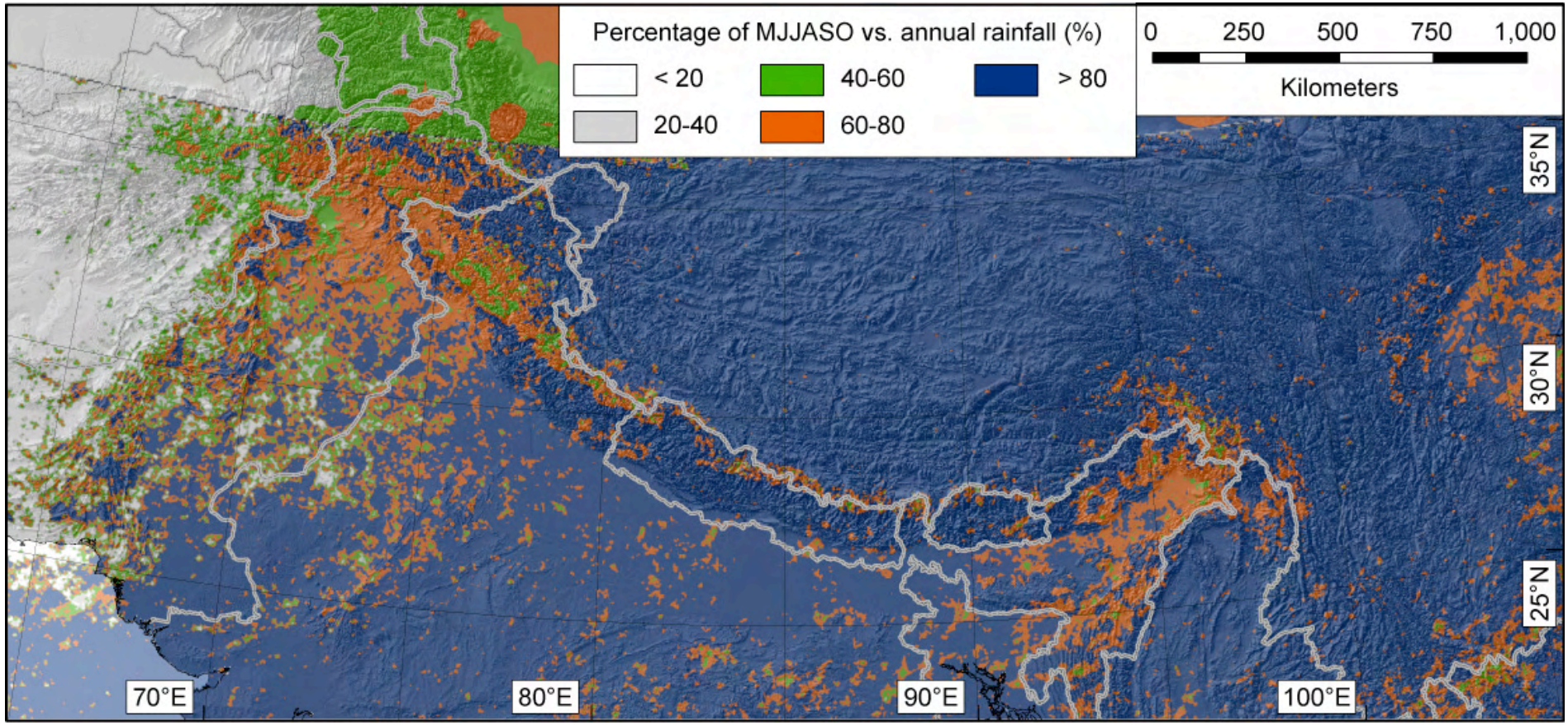


summer (May to October)



winter (November to April)

Temporal Rainfall Distribution in the Himalaya



Areas in blue indicate regions where more than 80% of the annual rain falls during the summer.

Bookhagen and Burbank, in review

Integrating remote-sensing datasets to estimate discharge

Hydrologic budget ("discharge") for large spatial and monthly temporal scales:

discharge = rainfall + snowmelt – evapotranspiration

I. Rainfall

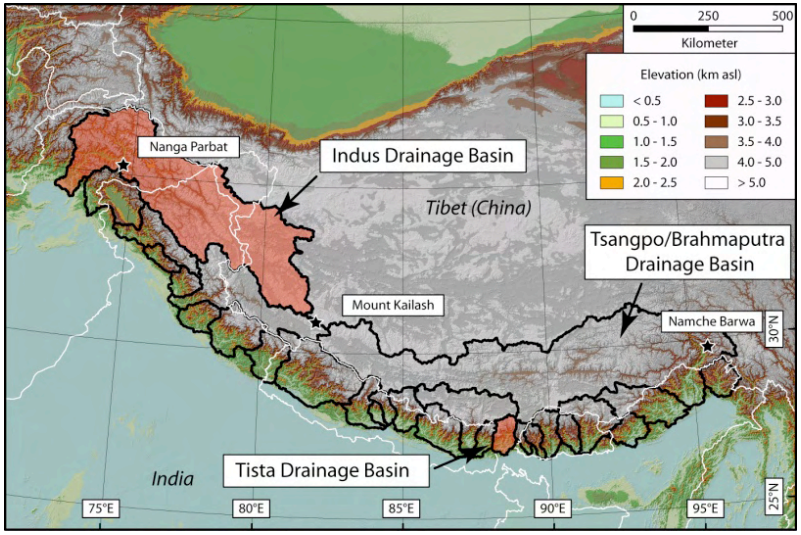
- Calibrated TRMM 2B31 rainfall at 5x5km^2 (Bookhagen and Burbank, in review)

II. Snowmelt Runoff Model

- convert snow-covered area into melt-water runoff
- *snowcover based* on MODIS MOD10 (Hall et al., 2002) at 1x1km^2
- *surface temperature* based on MODIS MOD11 (Wan et al., 2004) at 5x5km^2
- *Solar radiation* based on clear-sky radiation corrected for incident angle and diffuse and reflected radiation at 1x1 km^2

V. Evapotranspiration

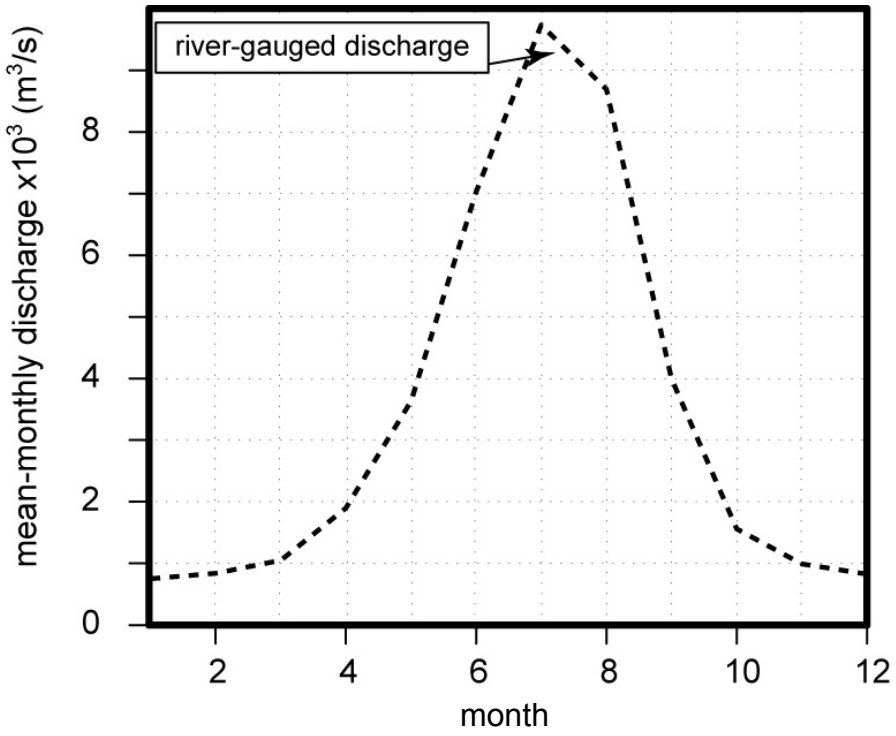
- Algorithm based on MODIS and meteorology data (Cleugh et al., 2007)



Discharge Estimation

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

Indus



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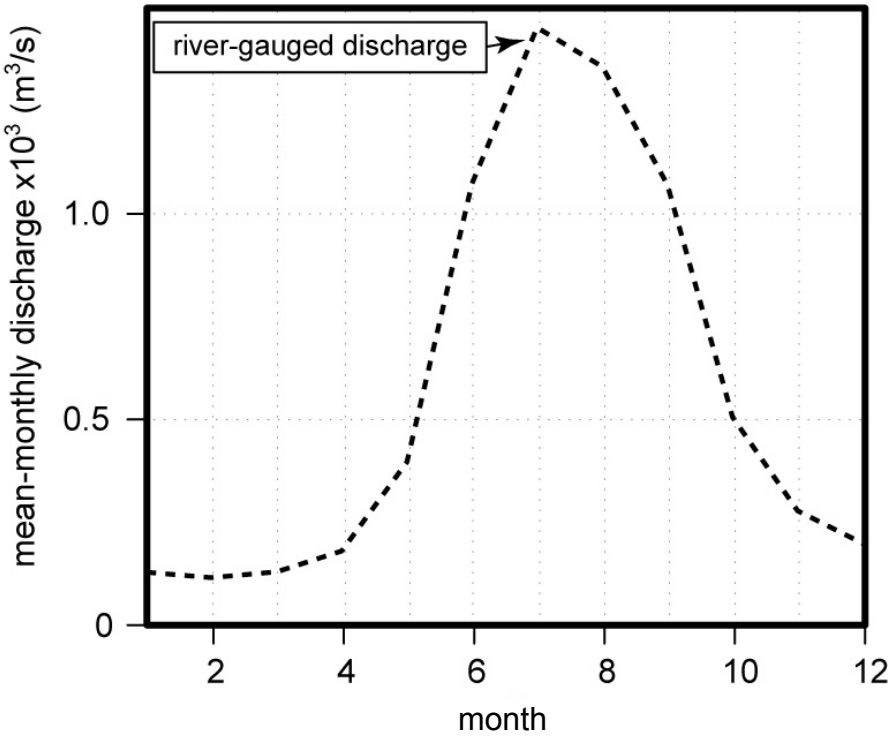

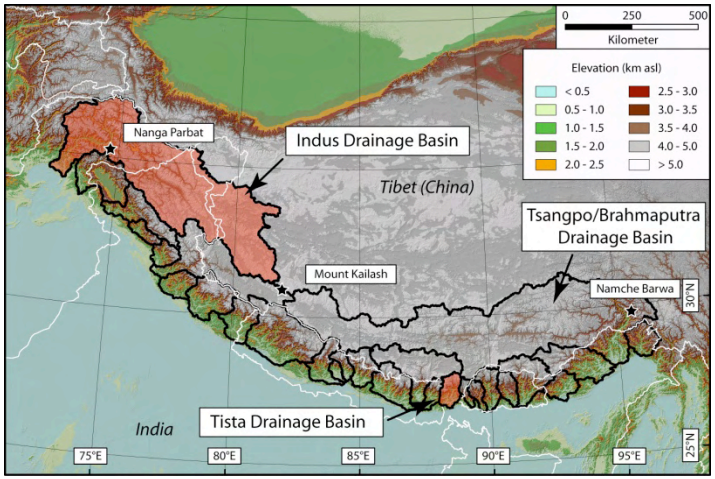

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Rainfall-derived discharge

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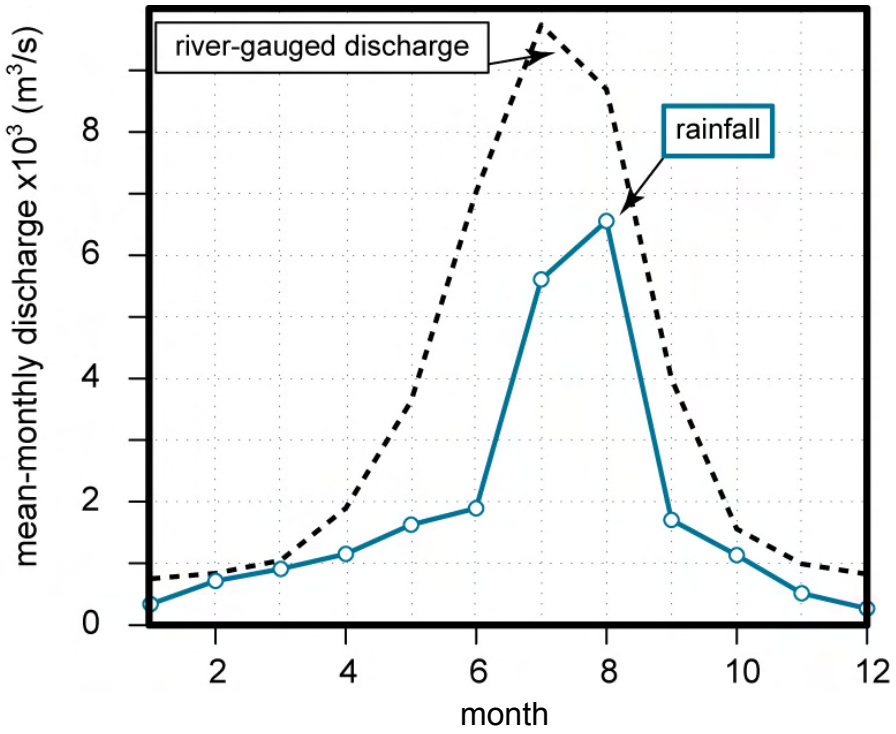

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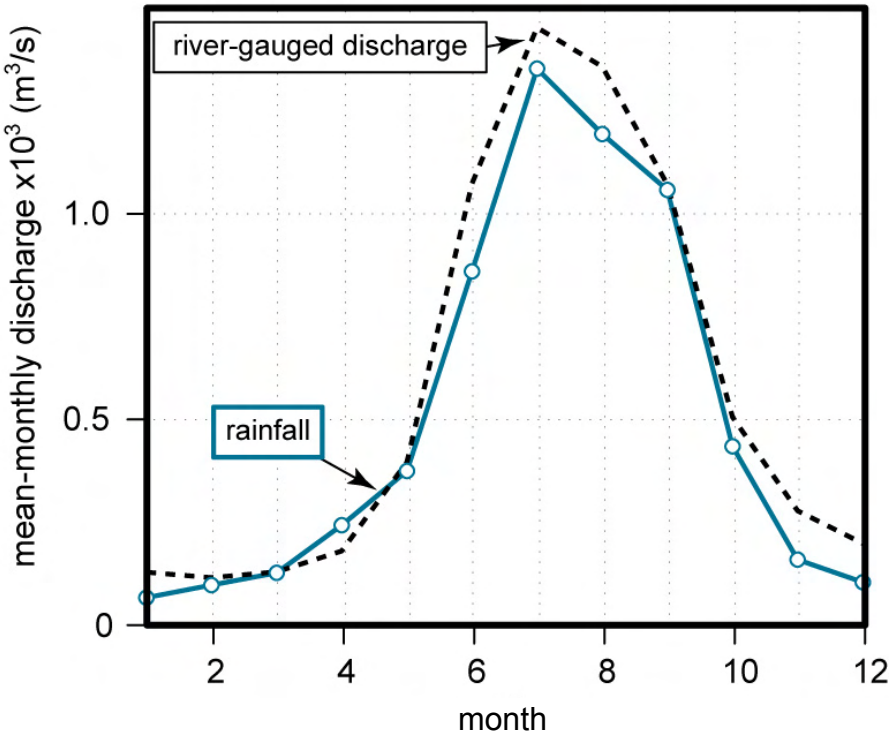

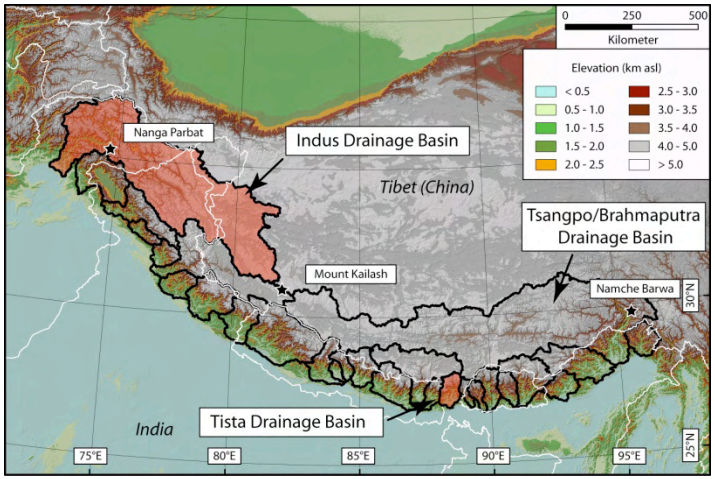

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Snow-model derived discharge

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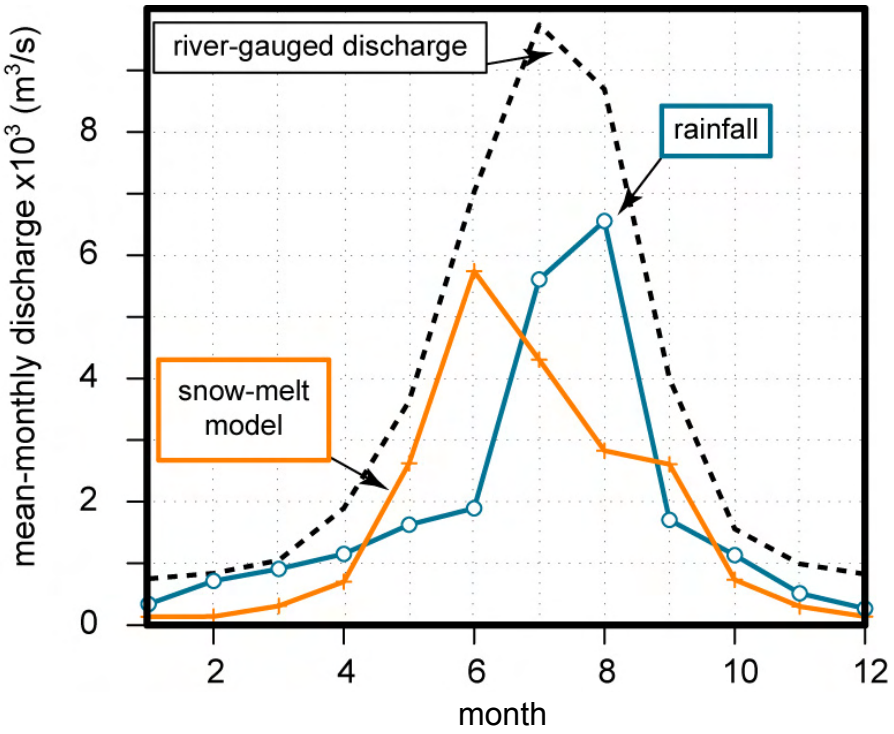

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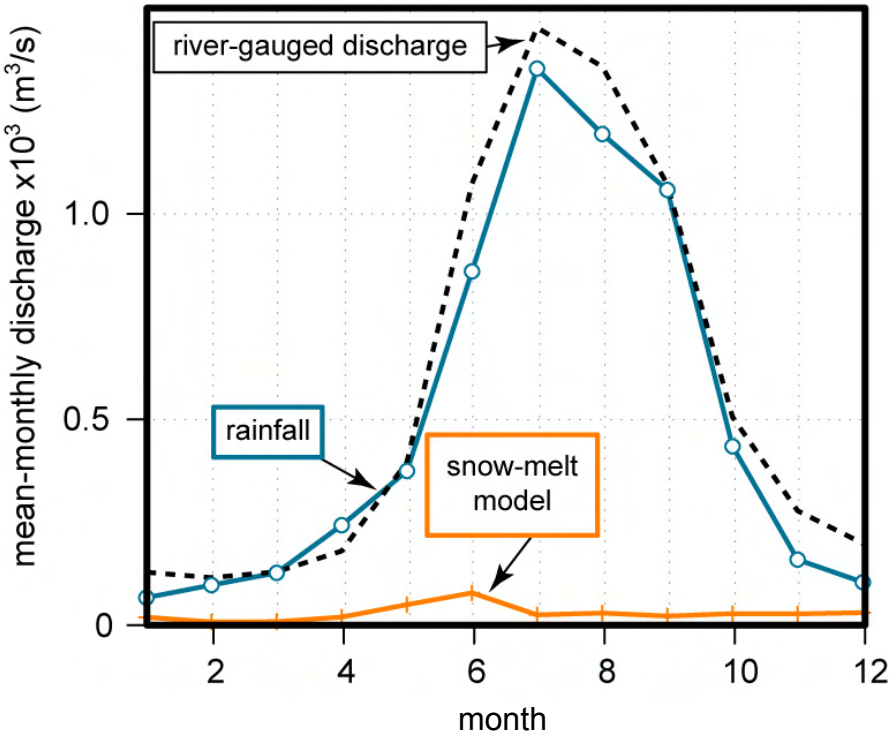

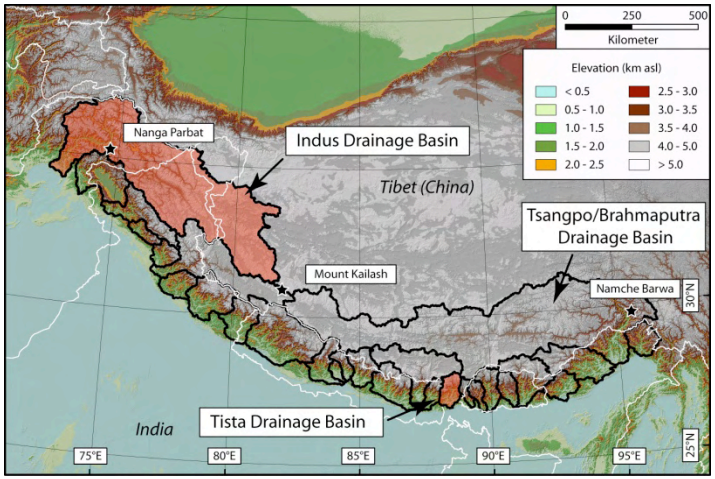

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Snow-model derived discharge

Evapotranspiration-derived discharge

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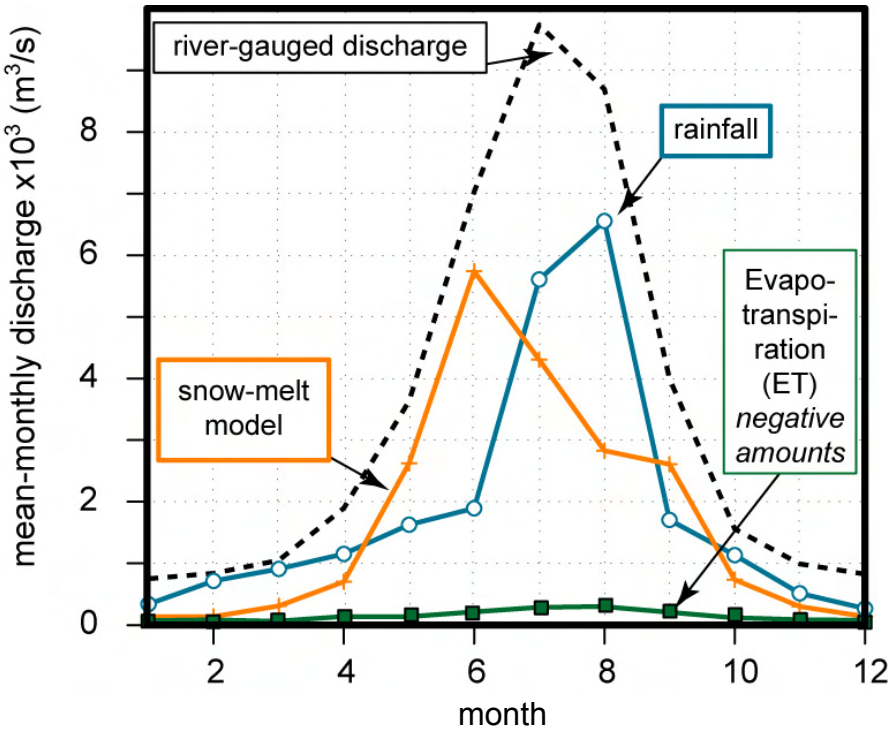

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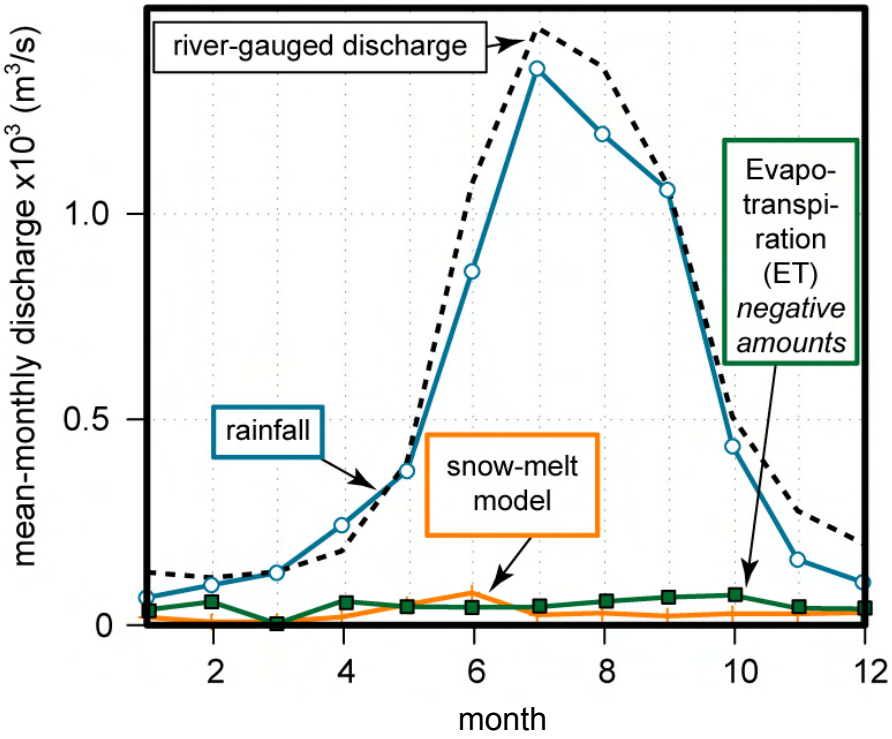

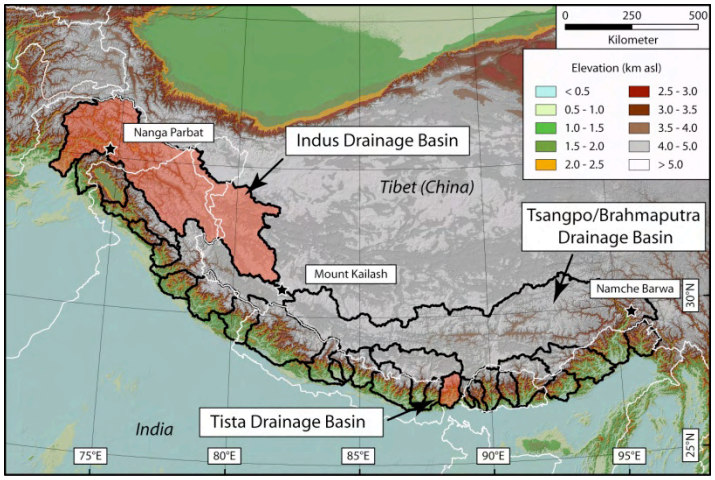

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Rainfall-derived discharge

Snow-model derived discharge

Evapotranspiration-derived discharge

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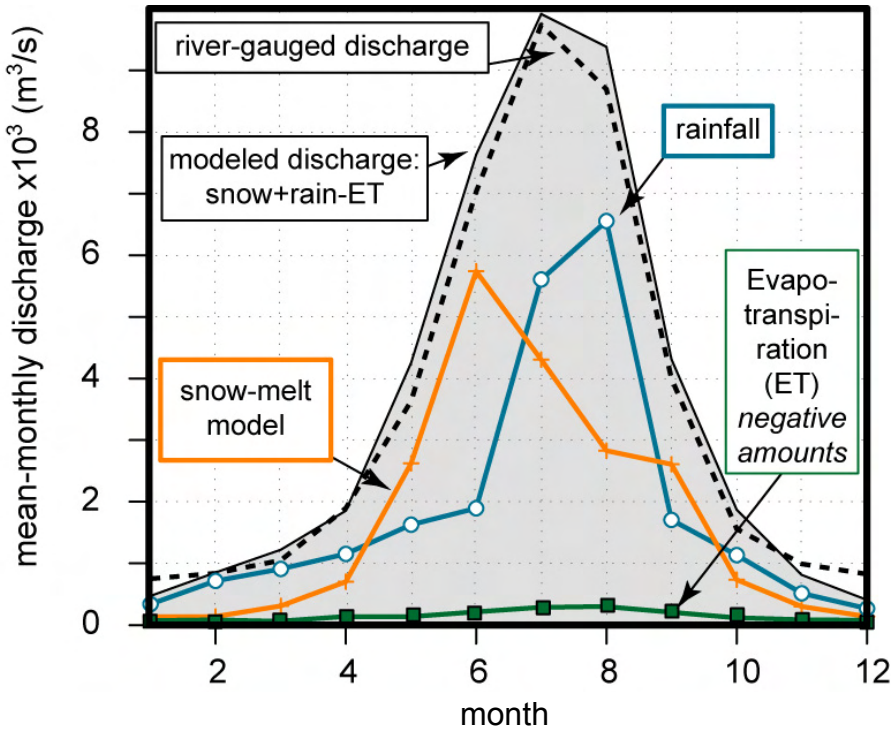

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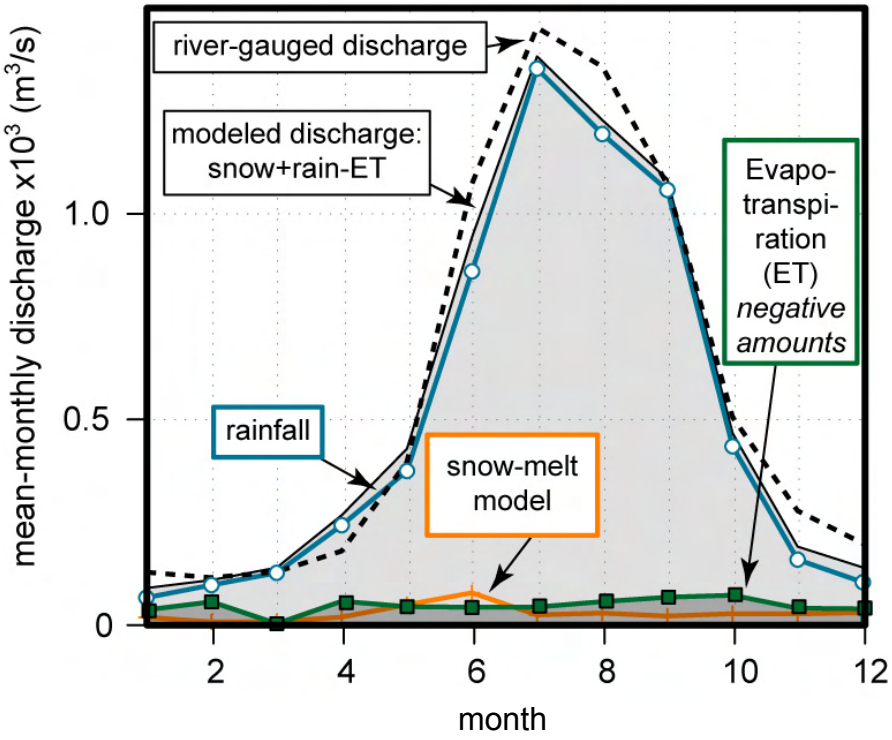
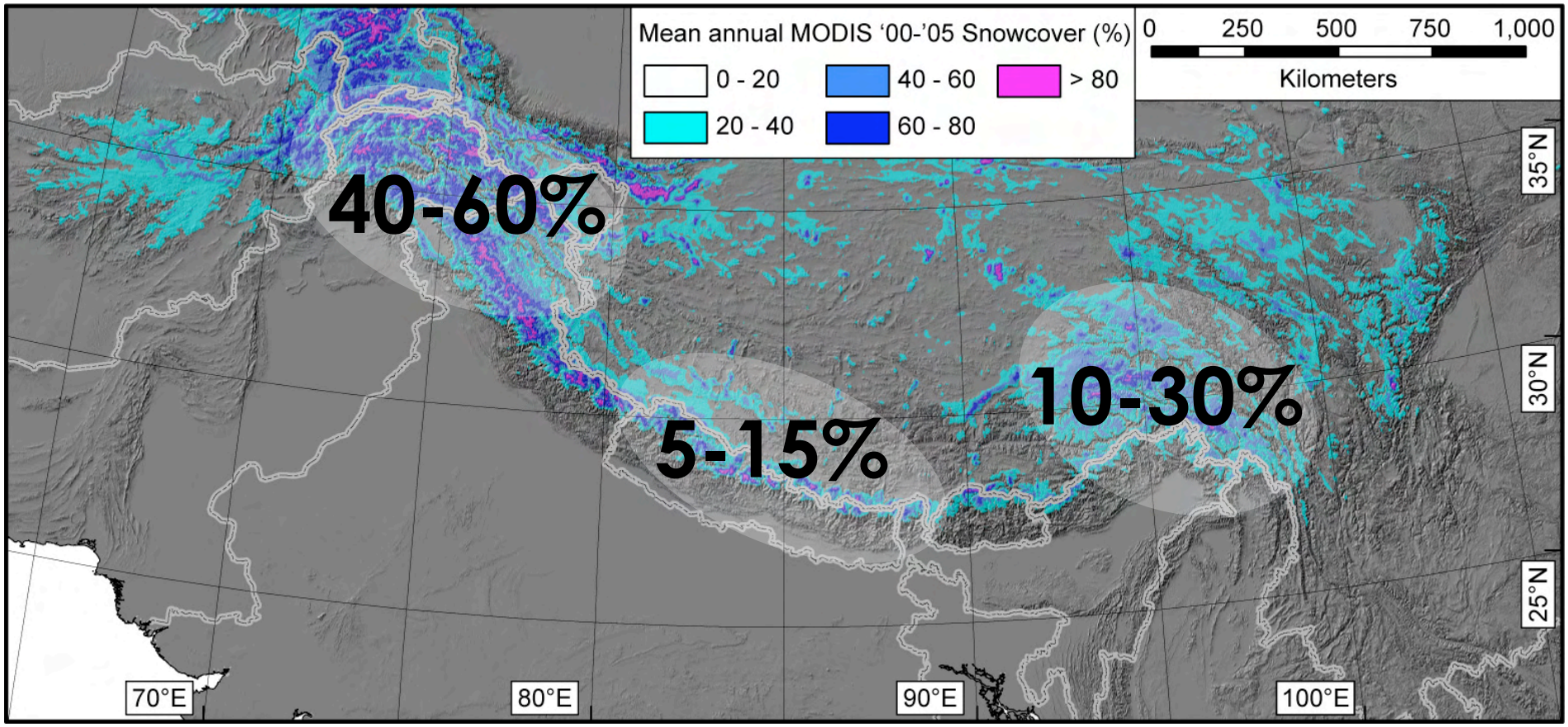
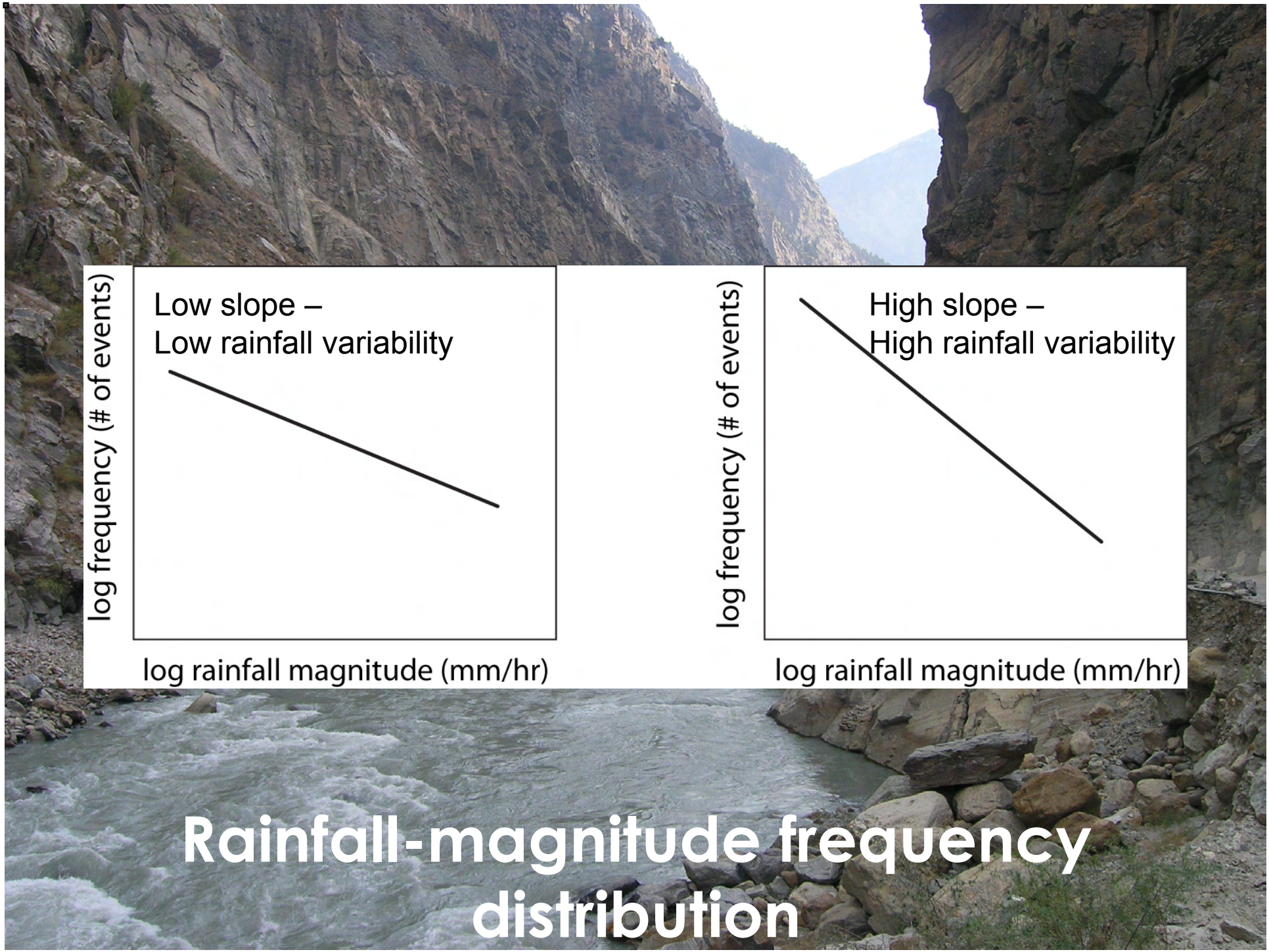


Spatiotemporal Rainfall, Snowmelt and ET Distribution in the Himalaya



Numbers indicate approximate percentage of snowmelt contribution to annual discharge (rainfall+snowmelt-ET)

MODIS MOD10 data from Hall, 2005; Bookhagen and Burbank, in review



Rainfall-magnitude frequency distribution