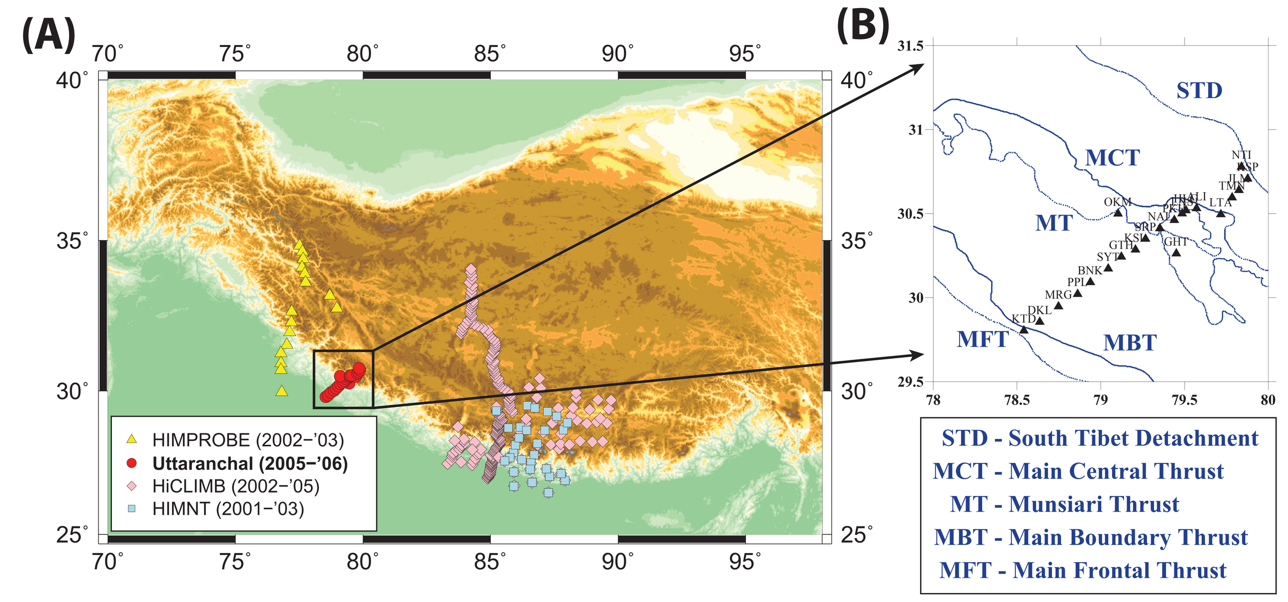
Receiver function imaging in the western Himalaya

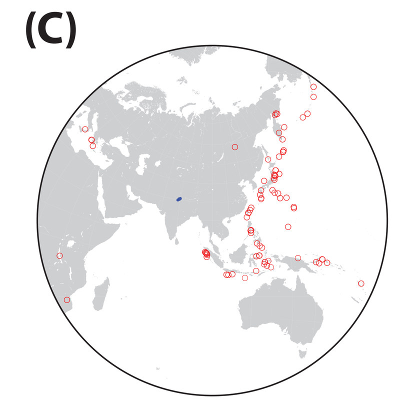
Warren Caldwell[1], Shyam Rai[2], Ashish[2], Simon Klemperer[1], Jesse Lawrence[1]

[1] Stanford University, Stanford, CA 94305-2215 [2] National Geophysical Research Institute, Uppal Road, Hyderabad 500 007, India

Introduction: In this work we generate crustal images by stacking P-S receiver functions. We calculate receiver functions using an iterative time-domain method and depth-convert them by back propagation in an assumed velocity model. We then bin and stack them to obtain two-dimensional images. This method, called common conversion point (CCP) stacking, stacks coherent energy from crustal conversions at the appropriate depths, while simultaneously canceling random noise. This generates a two-dimensional image of converting layers in the crust and mantle, such as abrupt changes in density or lithology caused by faults or other boundaries.

Data: Our array was deployed in 2005-2006 by India's National Geophysical Research Institute (Mahesh *et al.* 2010). Panel (A) shows the array in relation to nearby arrays. Panel (B) shows the 23 3-component broadband stations spanning a distance of 200 km from the Main Frontal Thrust to the South Tibetan Detachment. Panel (C) shows the locations of events used to calculate receiver functions.



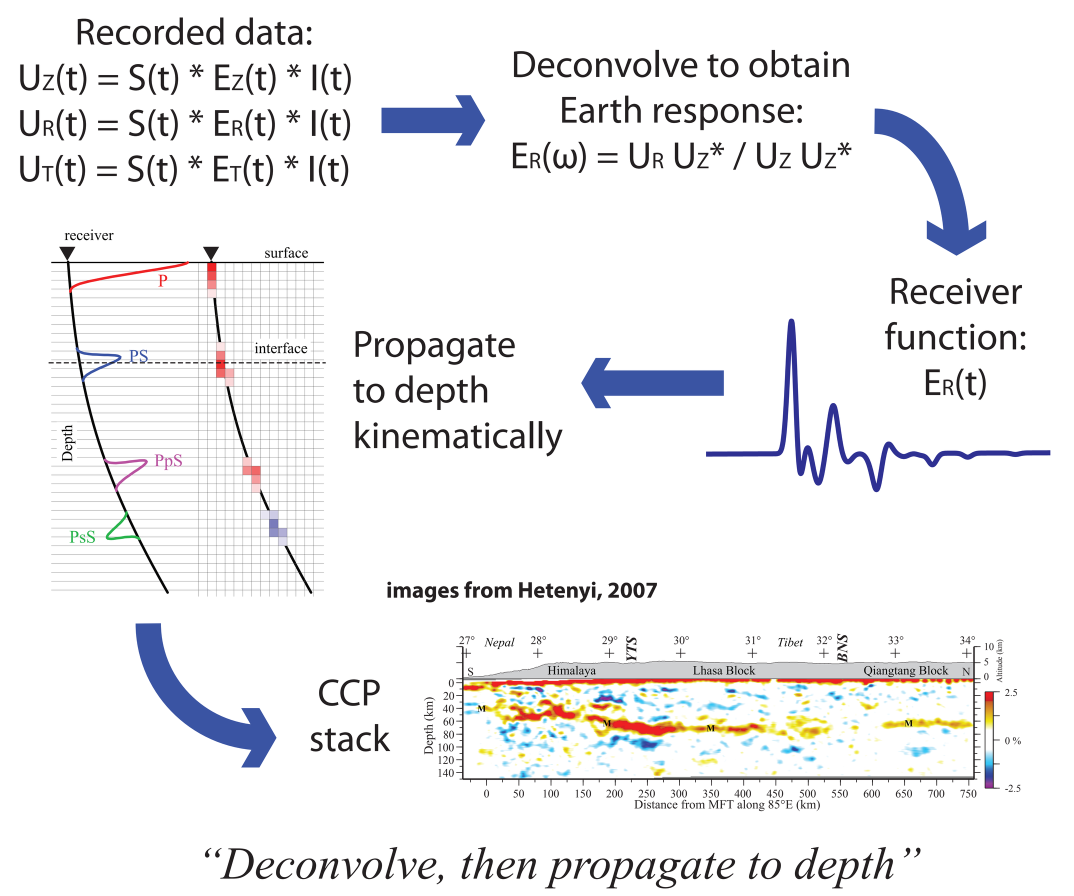


Locations of earthquakes used to generate receiver functions.

References:

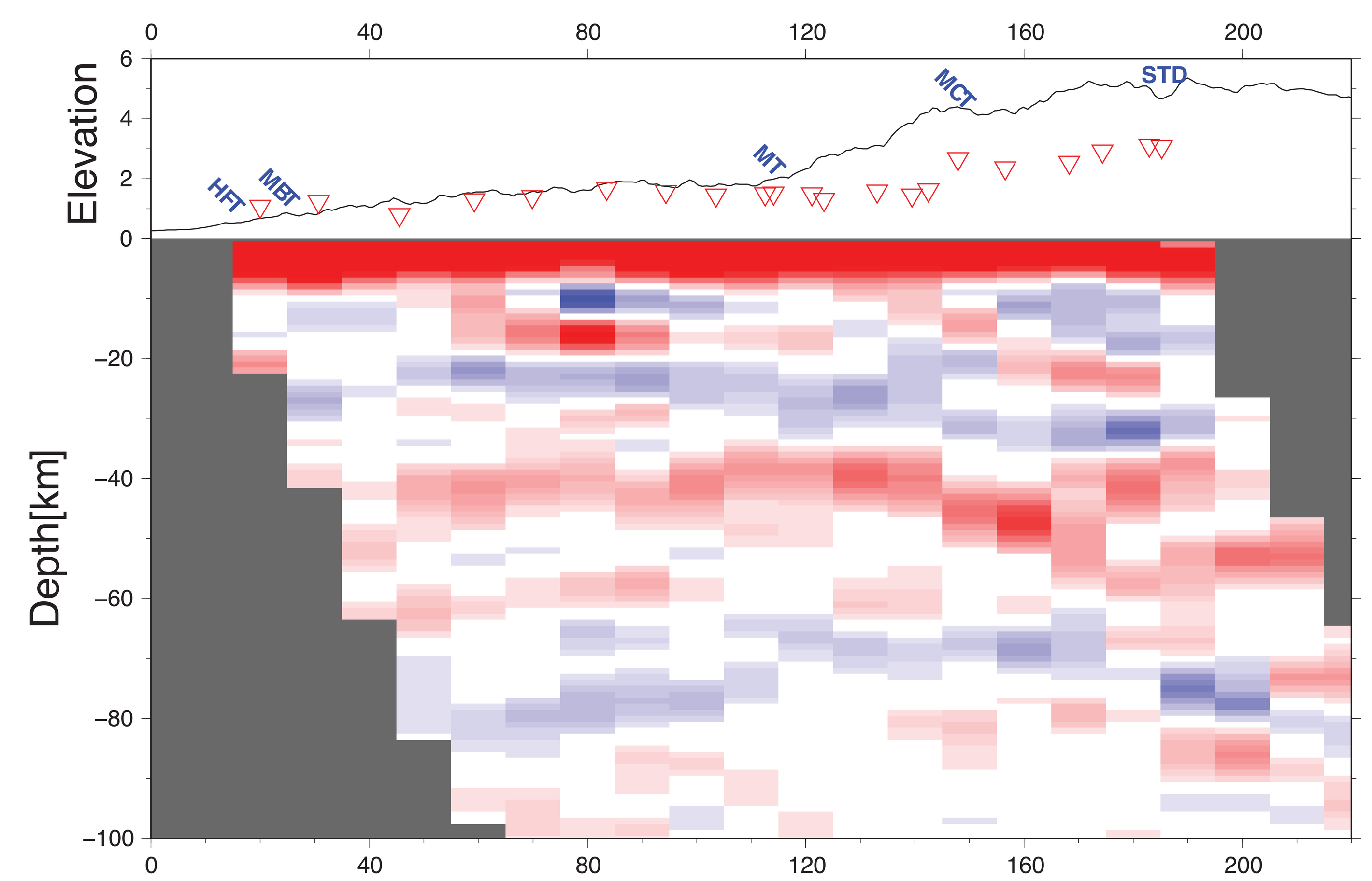
Hetenyi, G. (2007), Evolution of deformation of the Himalayan prism: from imaging to modelling, PhD Thesis, Université Paris XI.
Mahesh, P., Rai, S.S., Sarma, P.R., Gupta, S., Sivaram, K., and Suryaprakasam, K., 2010, High resolution earthquake location and 3-D velocity imaging of crust beneath the Kumaon Himalaya, in Leech, M.L., and others, eds., online proceedings for the 25th Himalaya-Karakoram-Tibet Workshop, San Francisco, California, U.S.A.
Nabelek, J., Hetenyi, G., Vergne, J., Sapkota, S., Kafle, B., Jiang, M., Su, H., Chen, J. Huang, B. and the Hi-CLIMB Team, 2009, Underplating in the Himalaya-Tibet Collision Zone Revealed by the Hi-CLIMB Experiment. Science, 325, 1371-1374.
Searle, M.P., Law, R.D., Godin, L., Larson, K.P., Streule, M.J., Cottle, J.M., Jessup, M.J., 2008, Defining the Himalayan Main Central Thrust in Nepal. Journal of the Geological Society, London, 165, 523-534.
Schulte-Pelkum, V., Monsalve, G., Sheehan, A., Pandey, M.R., Sapkota, S., Bilham, R., and Wu, F., 2005, Imaging the Indian subcontinent beneath the Himalaya. Nature, 435, 1222-1225.
Vannay, J., B. Grasemann, M. Rahn, W. Frank, A. Carter, V. Baudraz, and M. Cosca. 2004. Miocene to Holocene exhumation of metamorphic crustal wedges in the NW Himalaya: Evidence for tectonic extrusion coupled to fluvial erosion. Tectonics 23 (February 6): 24 PP.

Method:



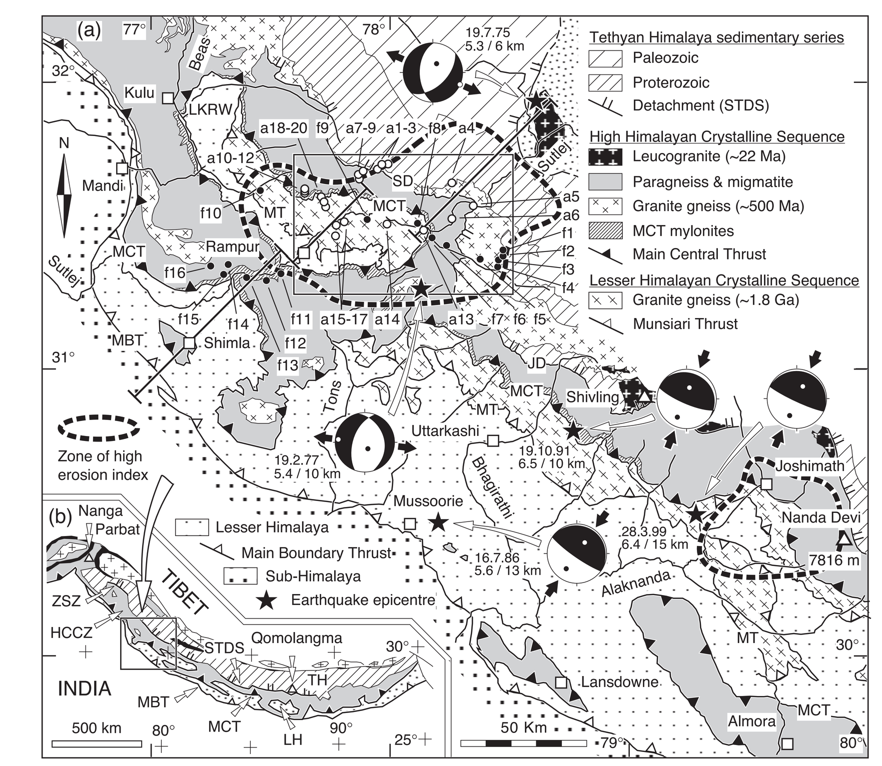
"Deconvolve, then propagate to depth"

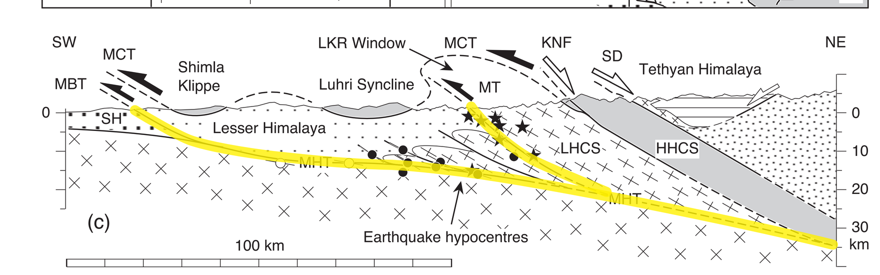
We image the Moho at a depth of 40 km beneath the southern margin of the Himalaya and at a depth of 55 km beneath the Tethyan Himalaya. Most of this 15 km increase in depth occurs in a prominent, forty-kilometer-wide step beneath the Greater Himalaya. This step is spatially coincident with the rise in elevation of the Tibetan plateau and with the currently-active Munsiari Thrust.



We also image the Main Himalayan Thrust and Munsiari Thrust, two of the recently-active strands of the Himalayan fault system (Vannay *et al.* 2004).

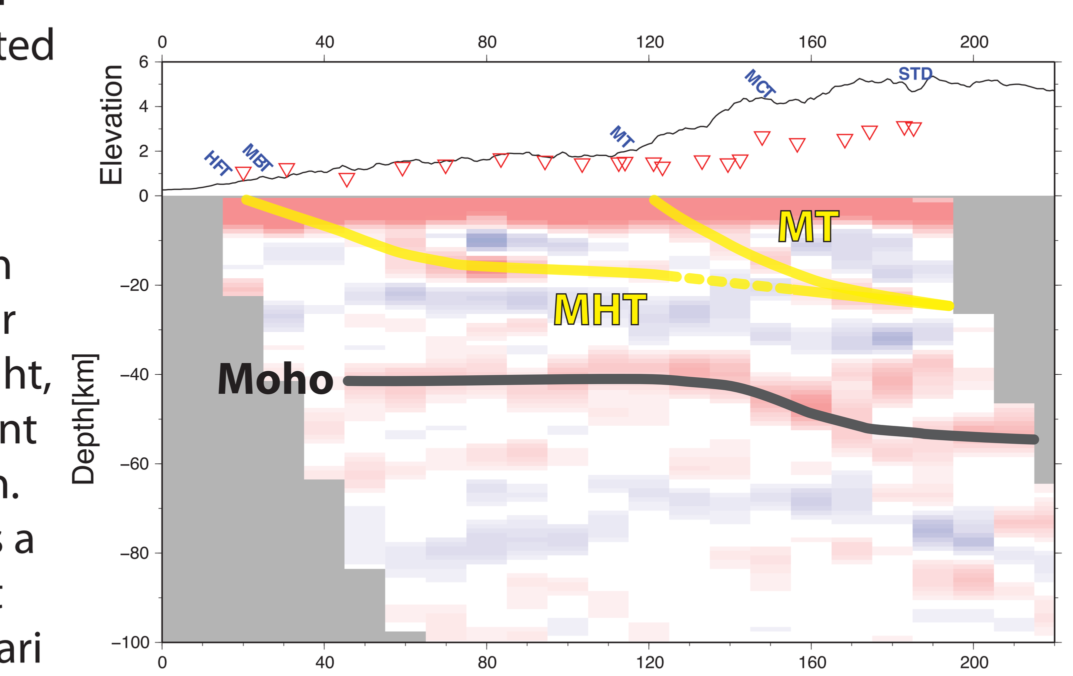
The Munsiari Thrust is recognized by some as the lower bound of the Main Central Thrust zone of high ductile strain, and is therefore sometimes referred to as MCT-1. It also goes by the names Almora Thrust, Mahabharat Thrust, and Dadelhura Thrust in different regions of the range (Searle *et al.* 2008).





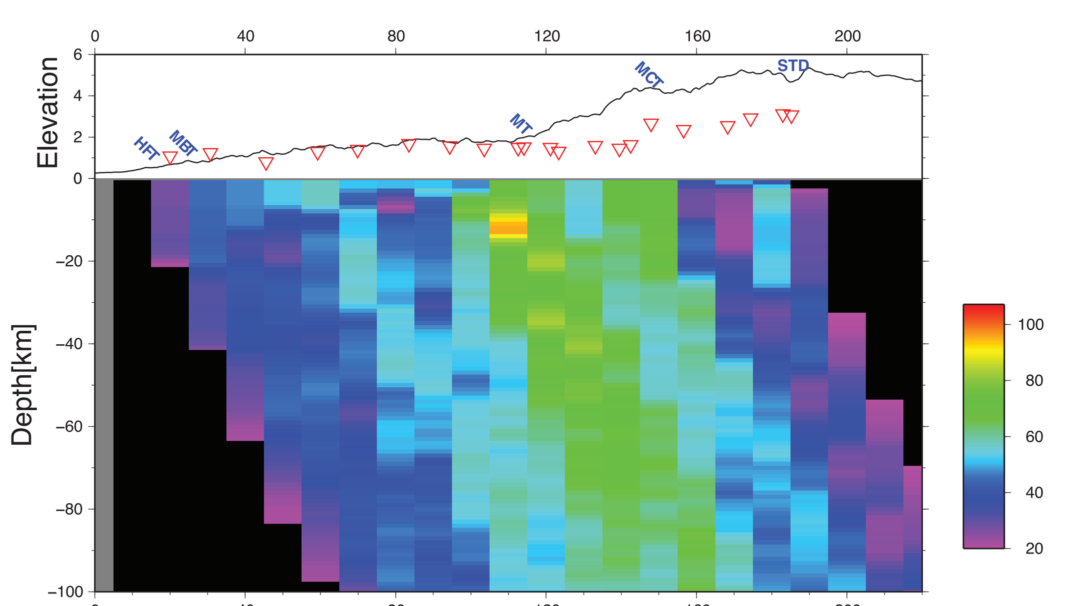
The map and cross-section at right (from Vannay *et al.* 2004) show the geologic setting and proposed structure of the MHT and Munsiari Thrust (both highlighted in yellow).

The depth to these faults and the location of their juncture in our intrepreted image, right, shows good agreement with this cross-section. Our image also shows a Moho step coincident with the active Munsiari Thrust.



Resolution:

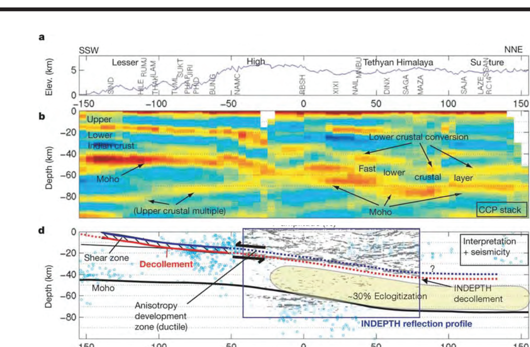
- Figure below shows ray density per bin.
- Model bins are 1 km high and ~10 km wide.
- Bins with fewer than 20 rays are removed from the image.
- The average number of high-quality receiver functions per station was ~40.



Comparison with existing Himalayan RF images:

Schulte-Pelkum *et al.* (2005), using the 2-D HIMNT array in Central Nepal, and Nabelek *et al.* (2009), using the 800 km-long HiCLIMB array:
- imaged the Moho and MHT decollement
- observed strong seismic anisotropy in the Indian crust
- proposed the presence of eclogitized Indian lower crust.

The depths to our observed Moho and decollement agree with their findings.



Receiver function images and interpretations from the HIMNT array (left) and HiCLIMB array (below) shown in their approximate relative positions.