High-accuracy single-pass InSAR DEM for large-scale flood hazard applications

G. J-P. Schumann*[,1], D. R. Faherty[1,2], and D. K. Moller[1]

[1] Remote Sensing Solutions, Inc. (gjpschumann@gmail.com) , [2] Cal Poly Pomona, COAST Student Internships

The Red River of the North flows along the border between North Dakota and Minnesota in the U.S. and terminates in Manitoba, Canada. During early Spring, the basin often experiences large flood events (Fig. 1), due to ice jams on the river, snowmelt and in part, the remarkably low relief over the floodplain. The timing of these events is fairly predictable, however, generating accurate models and maps of flood extent is highly dependent on the availability of regional DEM data. Ideally, these data are derived from LiDAR acquisitions, although the cost of these surveys often precludes acquisitions for floodplains in the developing world, therefore prohibiting accurate flood modeling and inundation mapping for these regions. Single-pass InSAR offers a cost-effective alternative that captures micro-topographic features on the floodplain - structures that ultimately control flooding and dictate the accuracy of hydrodynamic models.

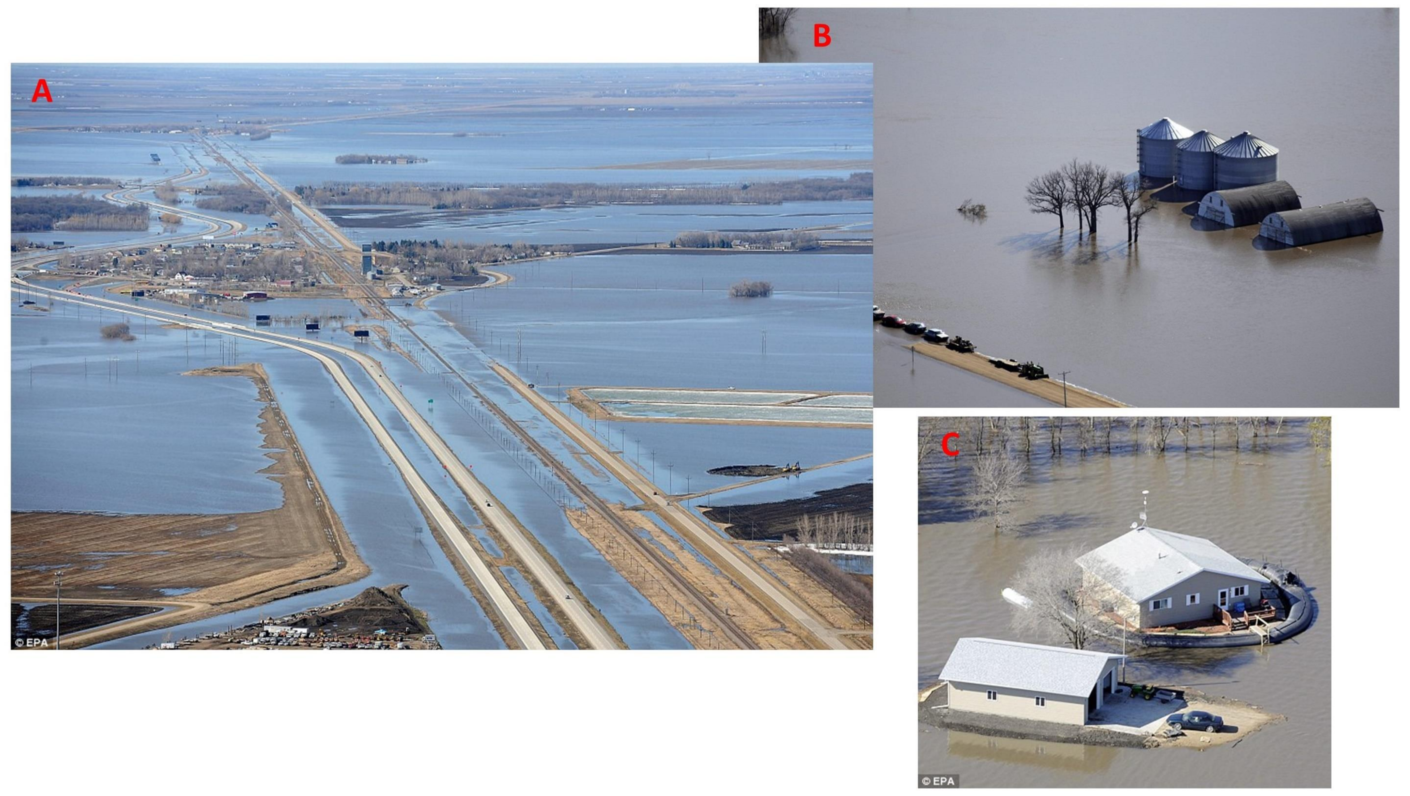
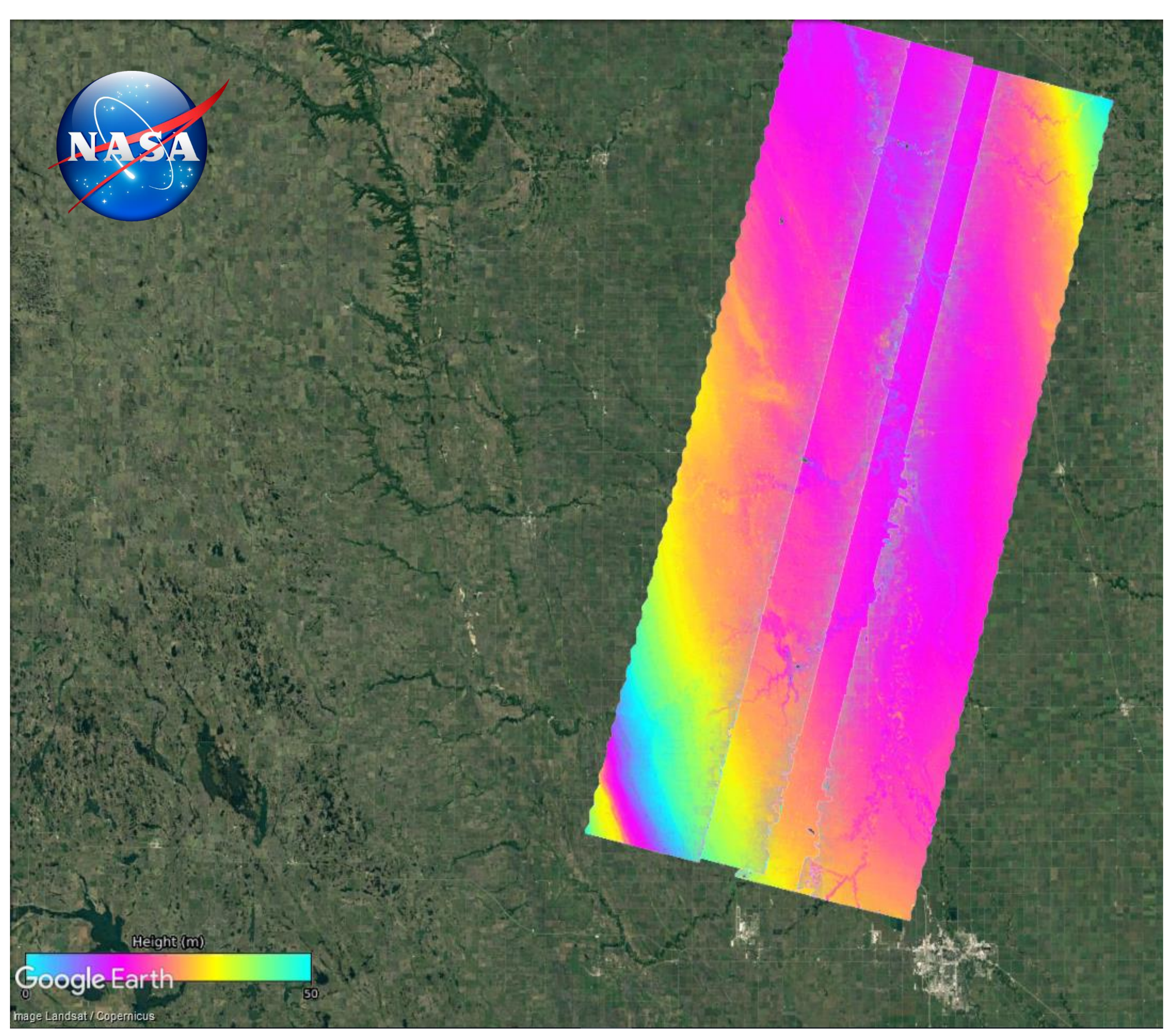


Fig. 1 - Devastation of the 2011 flood: The Red River spills over Highway 29 and other roads north of Fargo (A). Cars and farm vehicles line a road on slightly higher ground while grain containers from a farm are engulfed by water (B). Flooding was so devastating that extreme measures of protection became the last resort for some home owners (C).



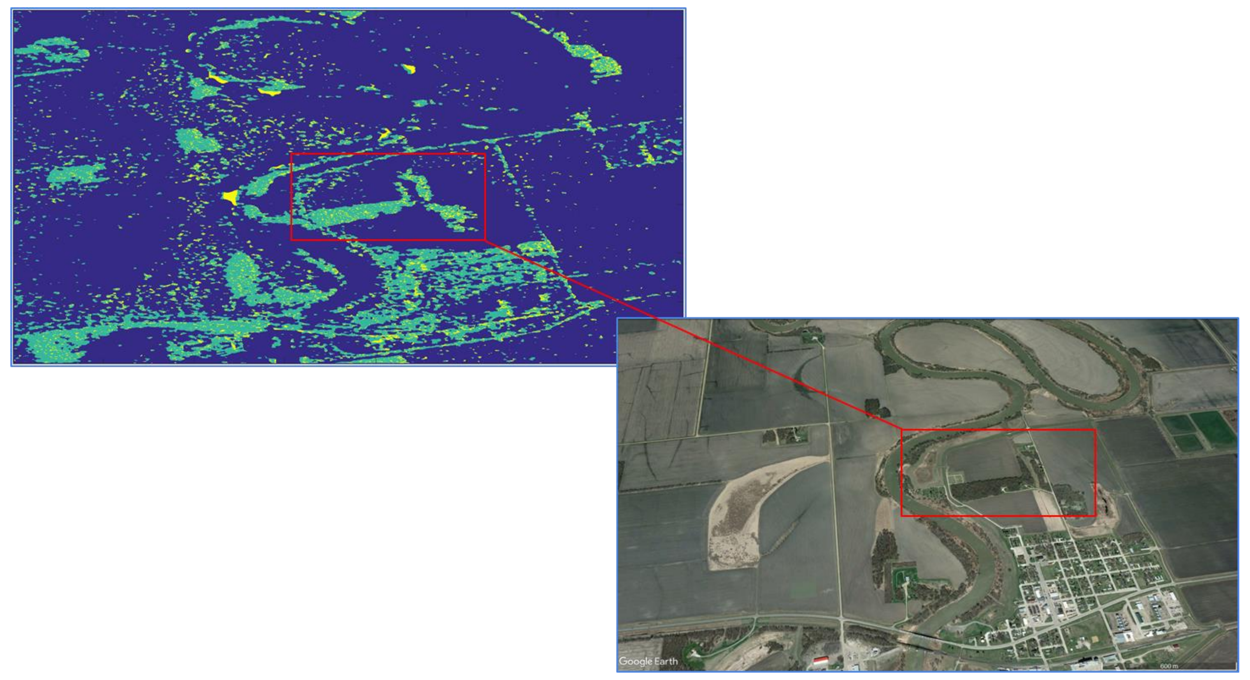


Fig. 2.2 - Intelligent classifier based on informed relationships between InSAR height and correlation was used to distinguish between bare-earth, buildings and tall vegetation (yellow and green).

Fig. 2.1 - We used a unique opportunity of the GLISTIN-A (NASA airborne mission designed to characterizing the cryosphere) track to Greenland to acquire a high-resolution InSAR DEM of a large area in the Red River of the North Basin (north of Grand Forks, ND).

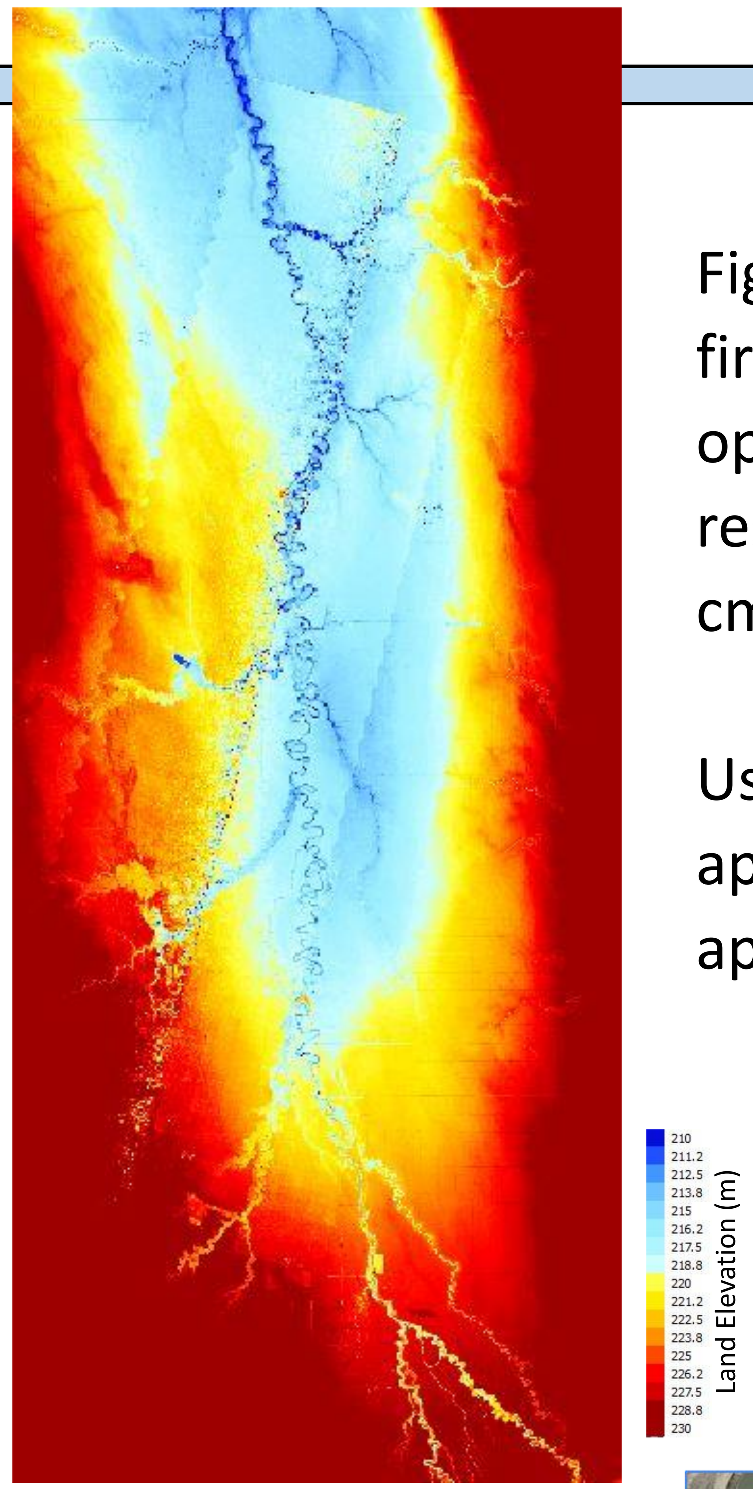


Fig. 2.3 - We derived a bare-earth DEM in SAR geometry by first removing the inherent far range bias related to airborne operation, which at the more typical large-scale DEM resolution of 30 m resulted in an overall negligible bias of -2.5 cm.

Using state-of-the-art LiDAR terrain data, we demonstrate applicability to flood modeling by achieving a mean error of approximately 0.5 m.

To date, there are no defined criteria for delineating ice, snow, and ice-covered water within the same SAR dataset. To better characterize these potential flood hazards, we will use existing GLISTEN-A acquisitions over the Red River of the North to conduct SAR classification of snow cover, ice, and surface water on the floodplain. Furthermore, we will determine whether ice sheets and ice jams (Fig. 3) are distinguishable on the river. The results of this study will be invaluable in evaluating NASA SAR technological capabilities, as well as amending certain deficiencies in flood and river forecasting models for NOAA.

Fig. 3 – GLISTIN-A Height Precision map, clearly showing ice jams.