Evaluation of ALOS-based DEM for use in inundation simulations and flood hazard mapping

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Objective

- To examine the availability of ALOS-based DEM for making flood-inundation simulation and flood hazard mapping in the areas, where any other DEM data are not available, such as developing countries.

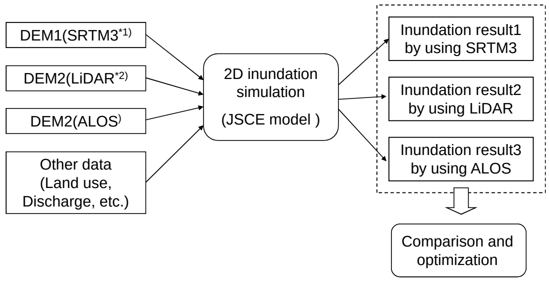
Approach

- In our research plan, 2-D inundation simulations will be conducted in three different flood-prone regions such as Japan, Thailand and Malaysia, using three different DEM sources, i.e. SRTM-DEM, LiDAR-DEM and ALOS-PRISM-DEM, and their results will be compared with each other. The effect of the difference of simulation models are also to be checked. Then, the availability of flooding simulations with satellite-derived DEM such as ALOS-PRISM-DEM for flood hazard mapping will be discussed.

Today's presentation

- So far, 2-D inundation simulations have been conducted by using SRTM and LiDAR-DEM in a flood-prone plain ($880km^2$) of the Tone River Watershed.
- ALOS-PRISM-DEM has just been constructed in cooperation with Dr. Takeo TADONO, EORC, JAXA. This has not been used in today's contents yet.

Materials and methods



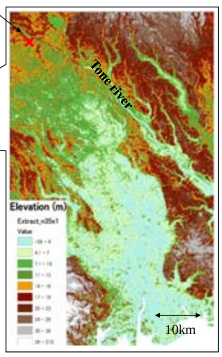
*1: Shuttle Rader Topography Mission

*2: Light Detection and Ranging

Case study

- Target area -

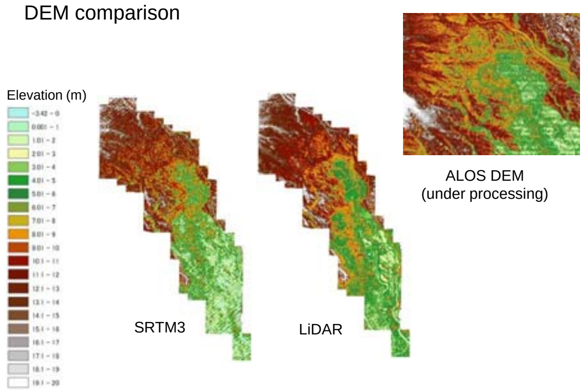
Levee breach point in Kathleen typhoon, 1947



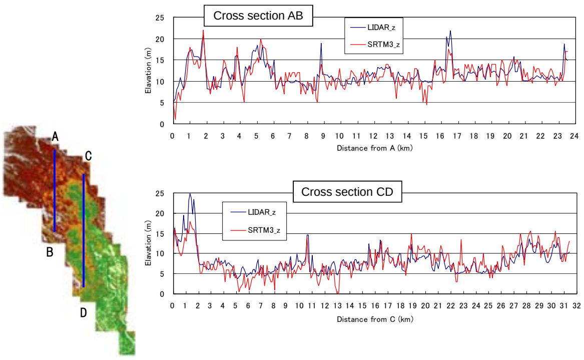
There is an anticipated inundation area (inundation simulation result) made by Tone Upper River Work Office, MLIT.

So, it was compared with the result of our case study.

DEM comparison



Comparison of cross section (LiDAR and SRTM)



Simulation Techniques

- JSCE-Standard 2D inundation model -

Basic equations

・Continuity equation

$$\frac{\partial h}{\partial t}+\frac{\partial M}{\partial x}+\frac{\partial N}{\partial y}=0$$

・Momentum equation

$$\frac{\partial M}{\partial t}+\frac{\partial}{\partial x}uM+\frac{\partial}{\partial y}vM=-gh\frac{\partial H}{\partial x}-\frac{\tau_x(b)}{\rho}$$

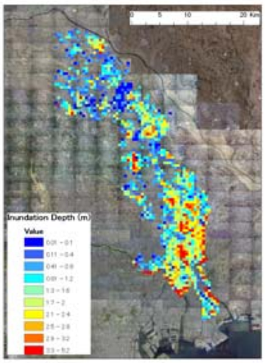
$$\frac{\partial N}{\partial t}+\frac{\partial}{\partial x}uN+\frac{\partial}{\partial y}vN=-gh\frac{\partial H}{\partial y}-\frac{\tau_y(b)}{\rho}$$

where h is water depth, H is water level, u and v are velocities along horizontal x and y axes, $M=uh$, $N=vh$, *and*

$$\frac{\tau_{x_{or}y}(b)}{\rho}=\frac{gn^2(u_{or}v)\sqrt{u^2+v^2}}{h^{1/3}}$$

- Condition of 2D simulation -

- ・DEM: SRTM or LiDAR
- ・500m square mesh
- ・Time step: 1.0 sec
- ・Input hydrograph is given at breach point
- ・No other flows
- ・Manning roughness coefficients are referred from previous research



84 hours after levee breach

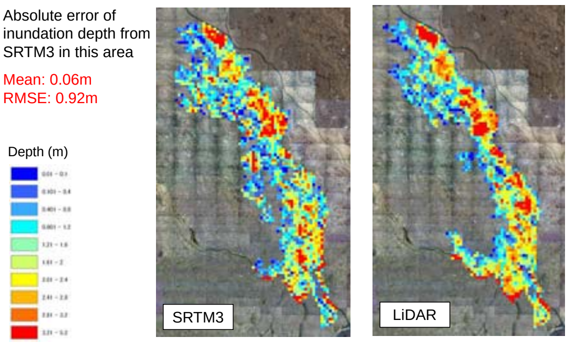
Simulation result

- Inundation depth -

Each grid have maximum value for the calculation period

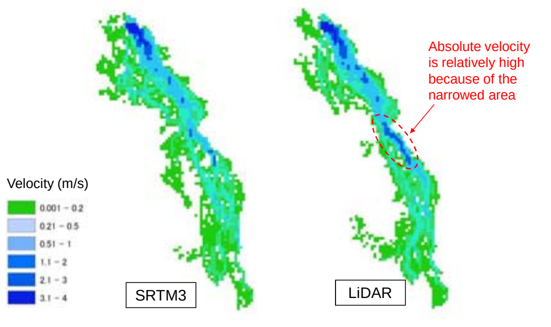
Absolute error of inundation depth from SRTM3 in this area

Mean: 0.06m
RMSE: 0.92m



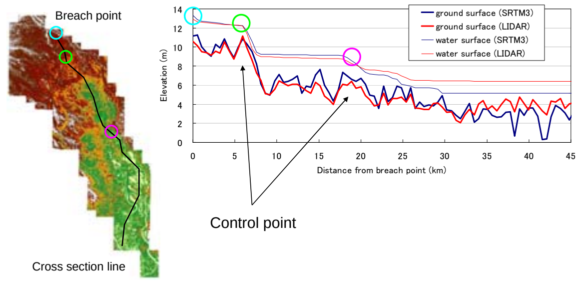
Simulation result
- Absolute velocity -

Each grid have maximum value for the calculation period



Simulation result
- Water level -

Each grid have maximum value for the calculation period



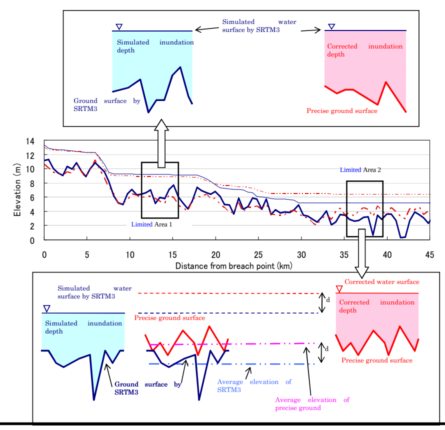
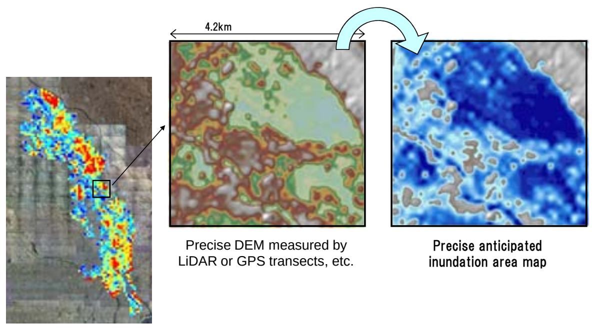


Image of this method



Evaluation of this method

$$R = \left| H_{LIDAR} - \left\{ H_{SRTM3} + \left(E_{LIDAR} - E_{SRTM3} \right) \right\} \right|$$

where

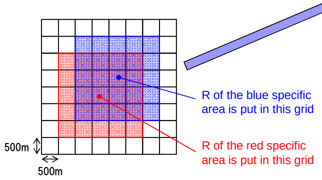
R =Absolute error of water level

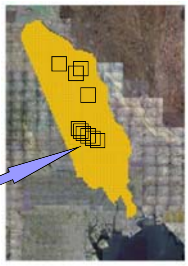
H_{LiDAR} =Average water level in specific area (LiDAR)

H_{SRTM3} =Average water level in specific area (SRTM3)

E_{LiDAR} =Average elevation of LiDAR ground in specific area

E_{SRTM3} =Average elevation of SRTM3 ground in specific area

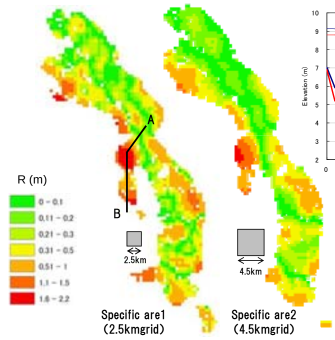


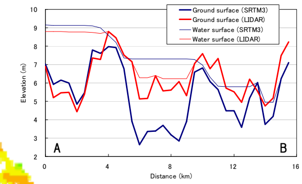


A lot of specific area were located in the target area and each R is put in each their central grid

Evaluation of this method

The central grids of the specific area of less than 60% in the number of inundated grid were excluded from the evaluation





Conclusion

Subject	Additional method and data	Average (m)	RMSE (m)
DEM itself made by SRTM3	-	0.62	2.38
Anticipated inundation depth distribution by simulation and SRTM3	-Inundation simulation	0.061	0.92
Corrected anticipated inundation depth distribution	-Inundation simulation -Precise DEM in specific area	0.076 (2.5km grid) 0.068 (4.5km grid)	0.58 (2.5km grid) 0.44 (4.5km grid)

Future subjects:

- To check the performance of the flooding simulations with ALOS-PRISM-DEM in the same target area.
- To verify the algorithms proposed here (Tone model) for other target flood prone areas: Chao Phraya River of Thailand & Johor Region of Malaysia, for the purpose of the enhancement of flood hazard mapping with DEM made from satellites in developing countries.