MONASH University

IITB-Monash Research Academy
An Indian-Australian research partnership

MONASH ENGINEERING

On the impacts of location, timing, and frequency of inundation extent assimilation on flood forecast skill

Antara Dasgupta, Renaud Hostache*, RAAJ Ramsankaran, Stefania Grimaldi, Guy Schumann, Valentijn Pauwels, and Jeffrey Walker

University of BRISTOL

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY | LIST

GROUP OF EIGHT AUSTRALIA

IIT BOMBAY

H-RSA
Hydro-Remote Sensing Applications Group
Department of Civil Engineering
Indian Institute of Technology Bombay

Accurate Forecasts Needed to Mitigate Flood Risk

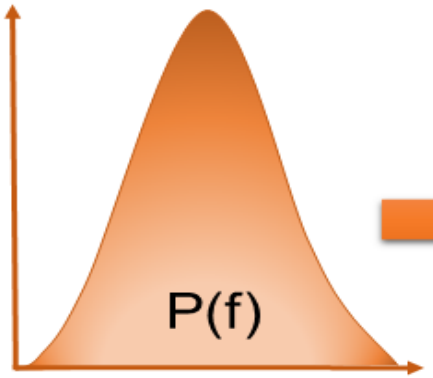
Monsoon floods, Maharashtra, Western India, 2019

Floods in Evesham, River Avon, UK, 2019

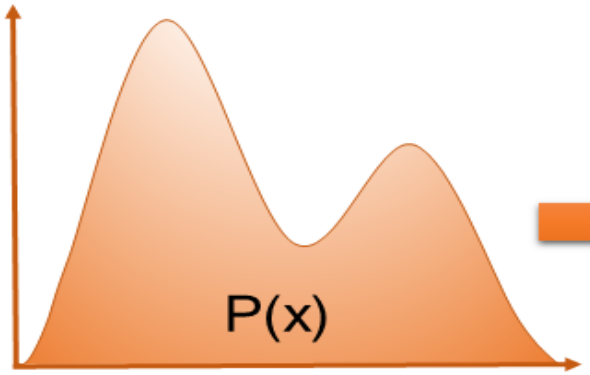
Source: Image #1News 18 (https://www.news18.com/photogallery/india/maharashtra-floods-dramatic-visuals-of-monsoon-fury-2214801-1.html); Image #2 BBC (https://www.bbc.com/news/uk-england-50430743)

Flood Data Assimilation for Improved Forecasts?

"True" flood extent + Measurement errors =



Uncertain forcings/parameters

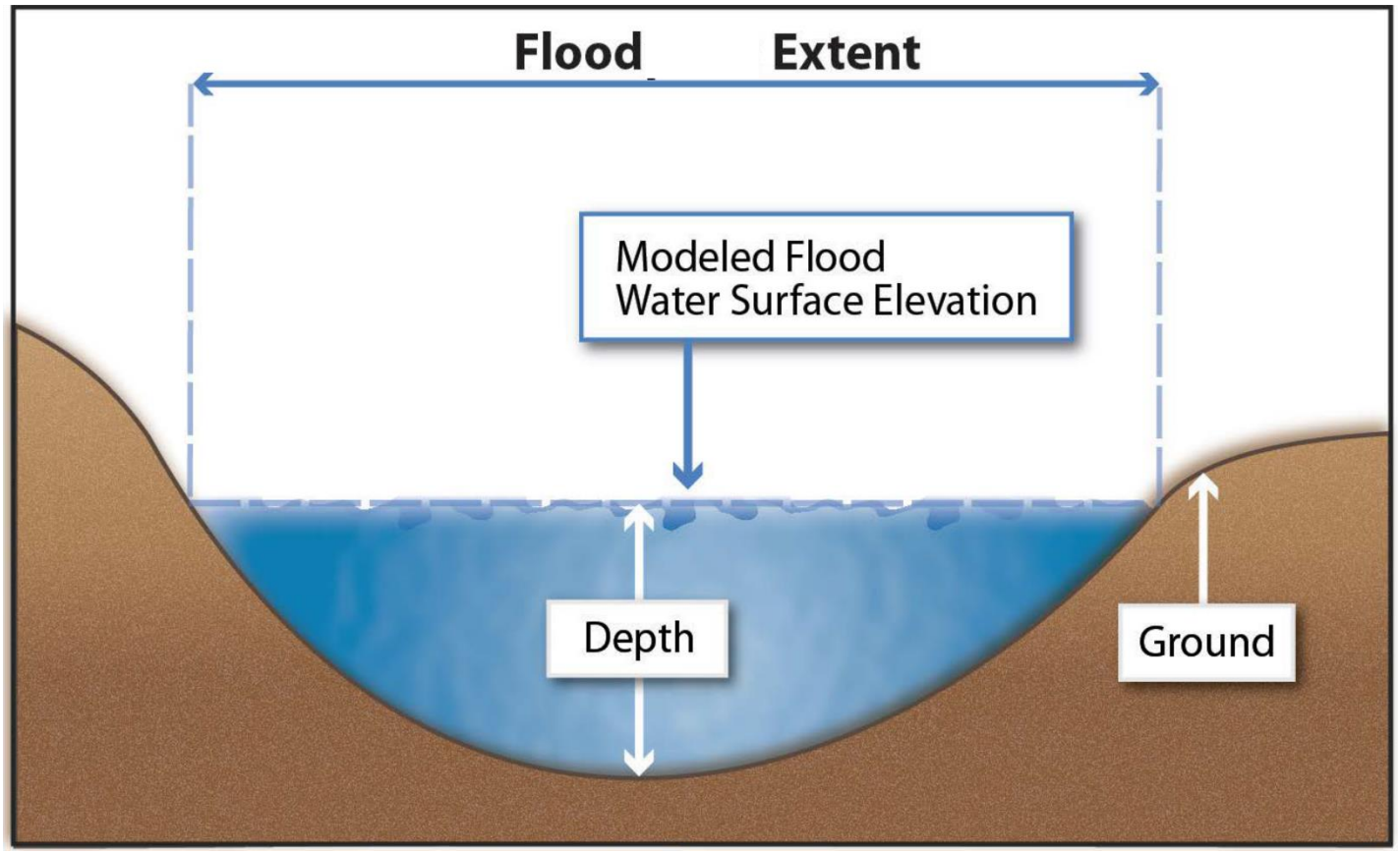


"Open loop" model states

Data Assimilation

Updated model states

Optimizing Flood Extent Assimilation

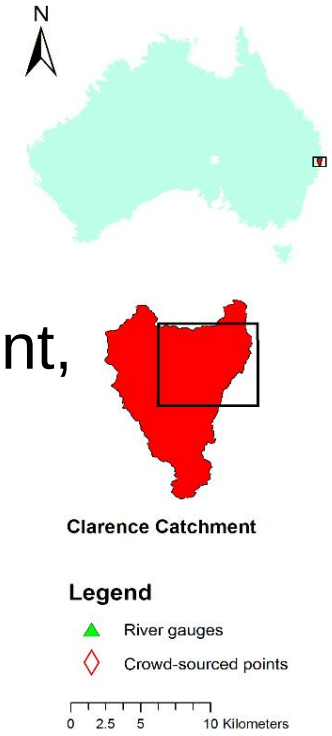


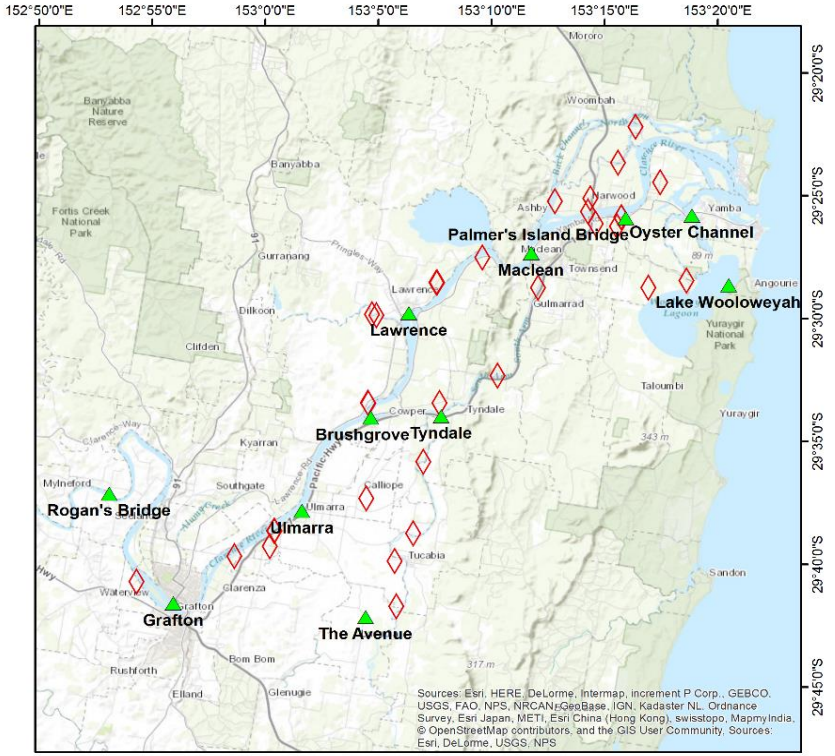
Where, when, and how often should RS data be acquired for flood extent assimilation?

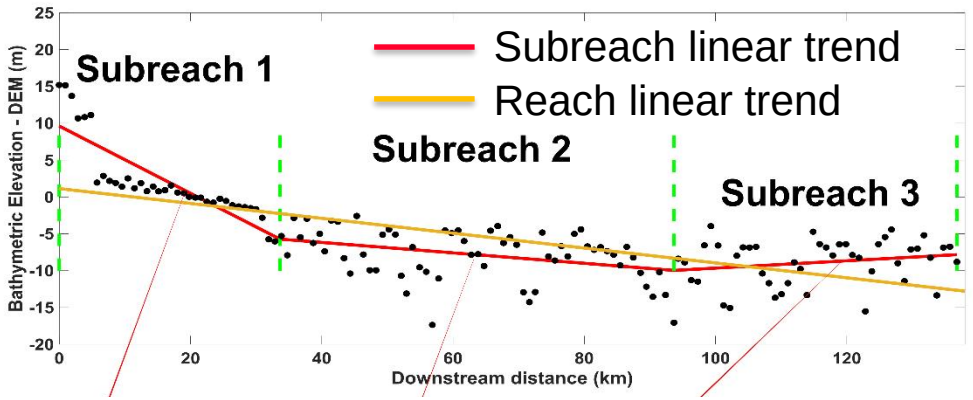
Source: FEMA, USA (https://www.fema.gov/media-library-data/1523562952942-4c54fdae20779bb004857f1915236e6c/Flood_Depth_and_Analysis_Grids_Guidance_Feb_2018.pdf)

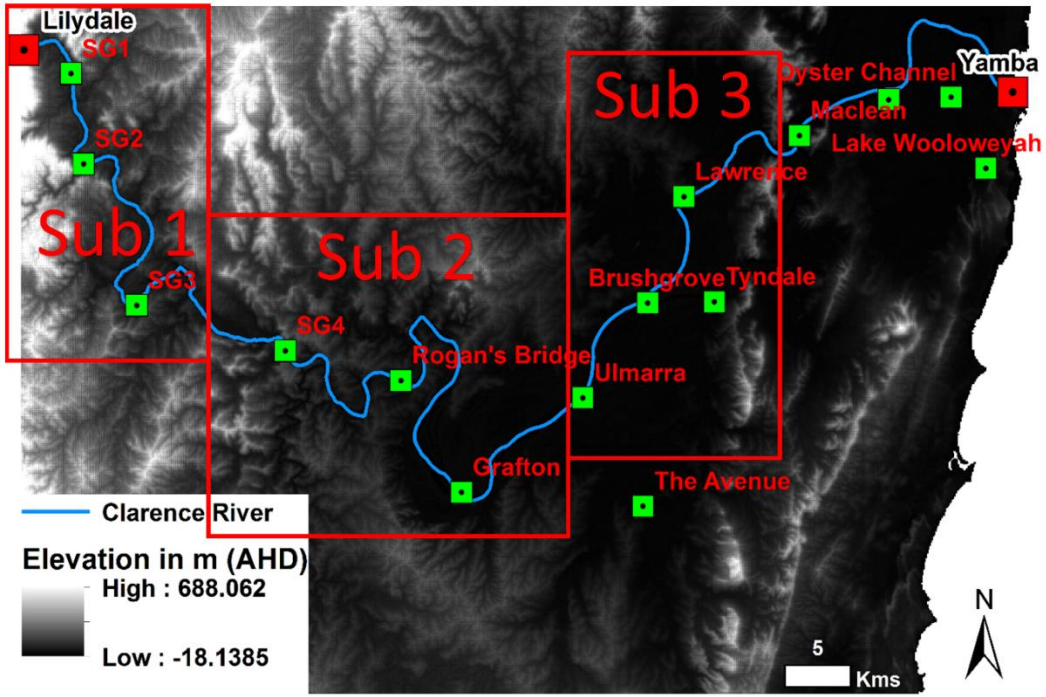
Study Site, Data Summary, and Experimental Setup

Clarence Catchment, NSW, Australia



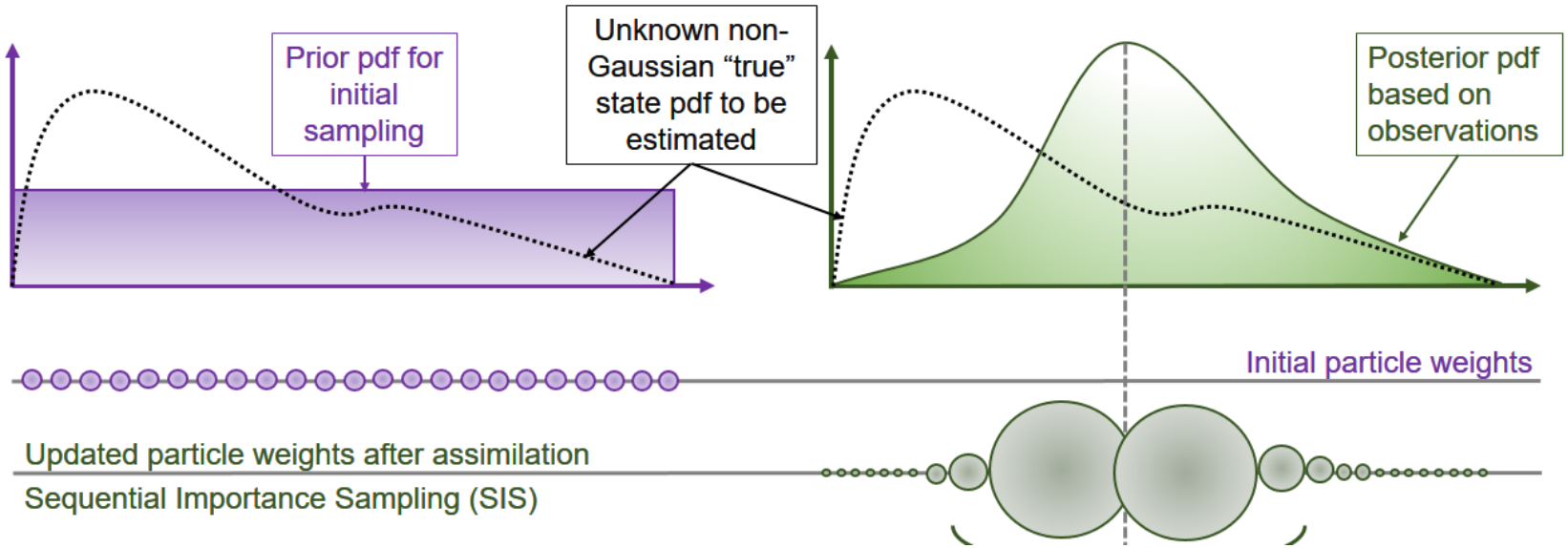


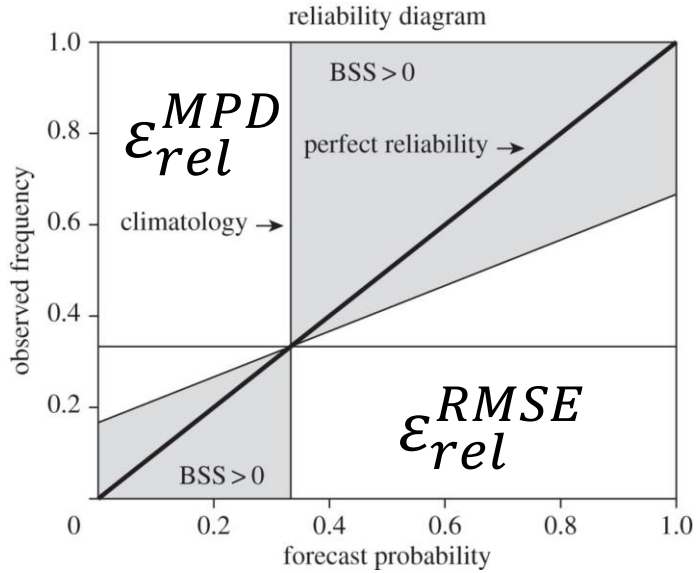




- Subreach identification using interpolated + surveyed bathymetric data.
- LiDAR DEM at 90m (±30cm), inflow hydrograph for 2011 floods (~ARI 27) + forecast inflow uncertainties, downstream tidal levels Lisflood-FP Full2D.
- Impacts on channel and floodplain water depth evaluated.

Particle Filter for Flood Extent Assimilation





Particle weight calculation

$$Ag_i = abs(\ln(\varepsilon_{rel}^{MPD} \times \varepsilon_{rel}^{RMSE}))$$

Quantify agreement

$$w_i = \frac{\left(Ag_i - \min_i Ag\right)}{\left(\max_i Ag - \min_i Ag\right)} \times \left(\frac{Ag_i}{\max_i Ag}\right)^4$$

Calculate probabilities based on the agreement, by rescaling from 0 to 1

$$nw_i = \frac{(w_i)}{\left(\sum_i^{Np} w\right)}$$

Normalize so weights sum up to 1 as in a PDF

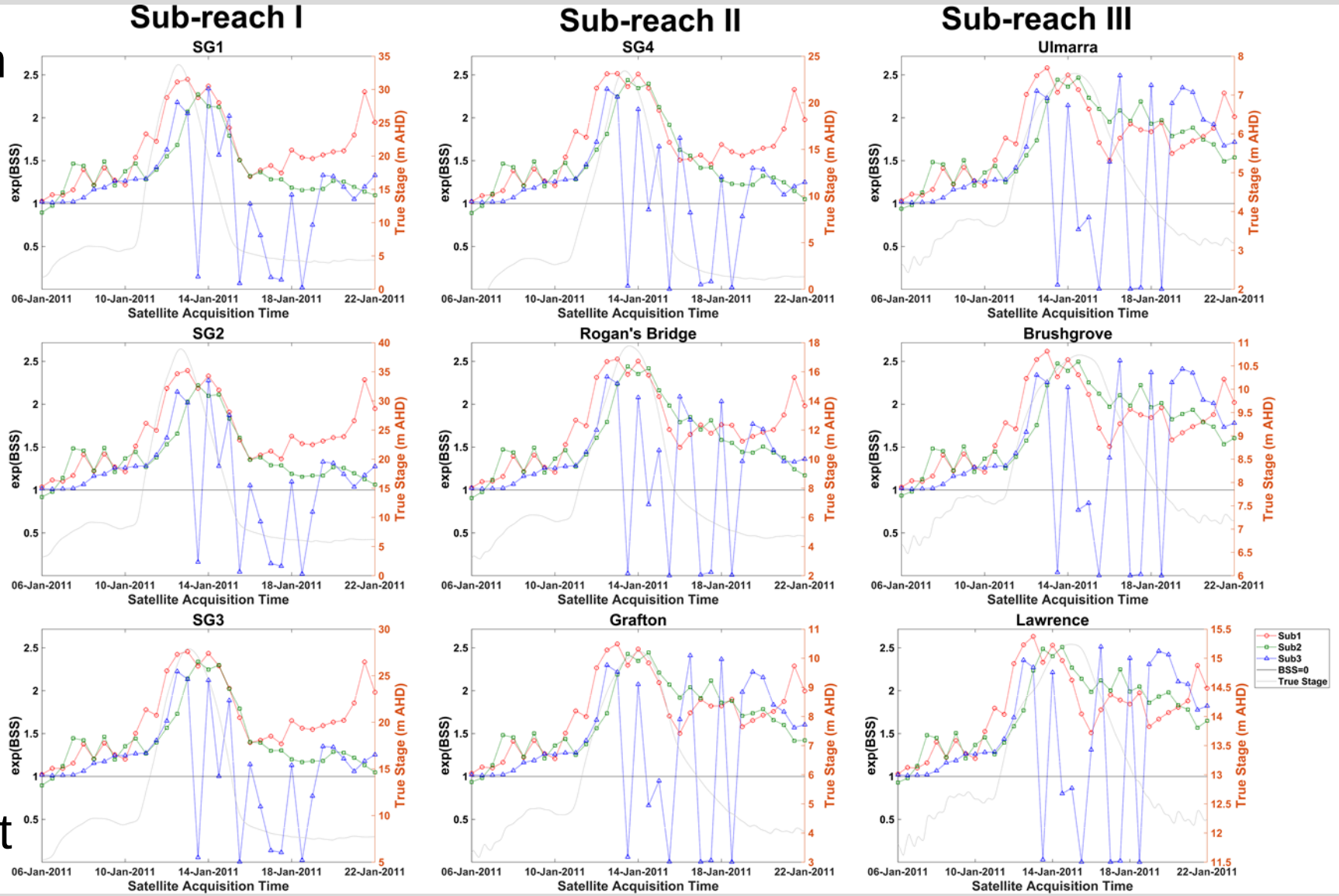
Q: When and where is a single image most helpful for the whole forecast?

- Single image assimilation experiment
- Images assimilated only at given subreach
- Impact from first visit to 22 Jan evaluated

$$\mathrm{BSS} = 1 - \frac{\overline{(\mathbf{Assim.} - \mathbf{Truth})^2}}{\overline{(\mathbf{OL} - \mathbf{Truth})^2}}$$

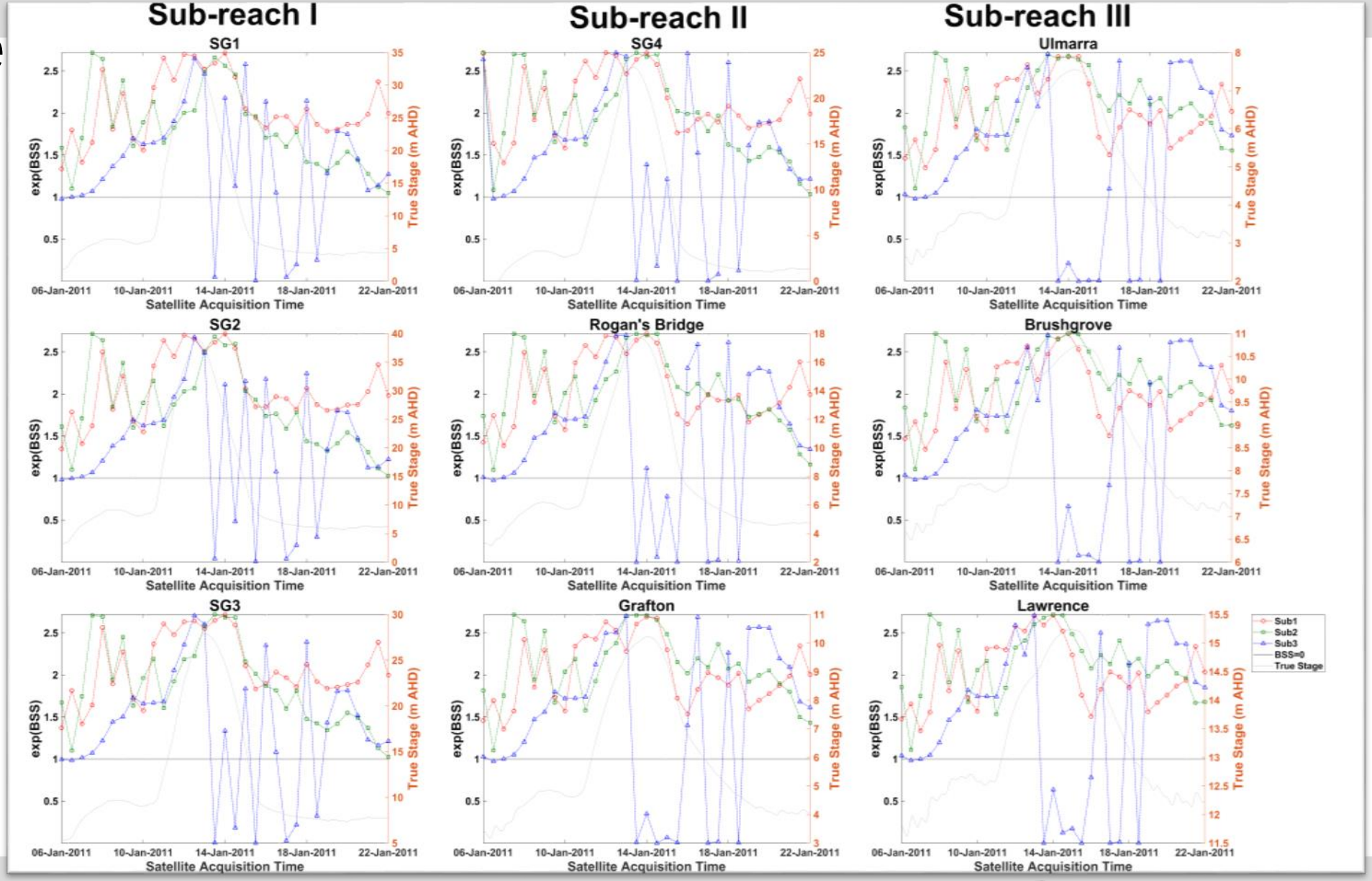
$$\exp(\mathrm{BSS}) \in [0\ 2.7]$$

- exp(BSS)=1 – no impact
- exp(BSS)<1 – -ve impact
- exp(BSS)>1 – +ve impact



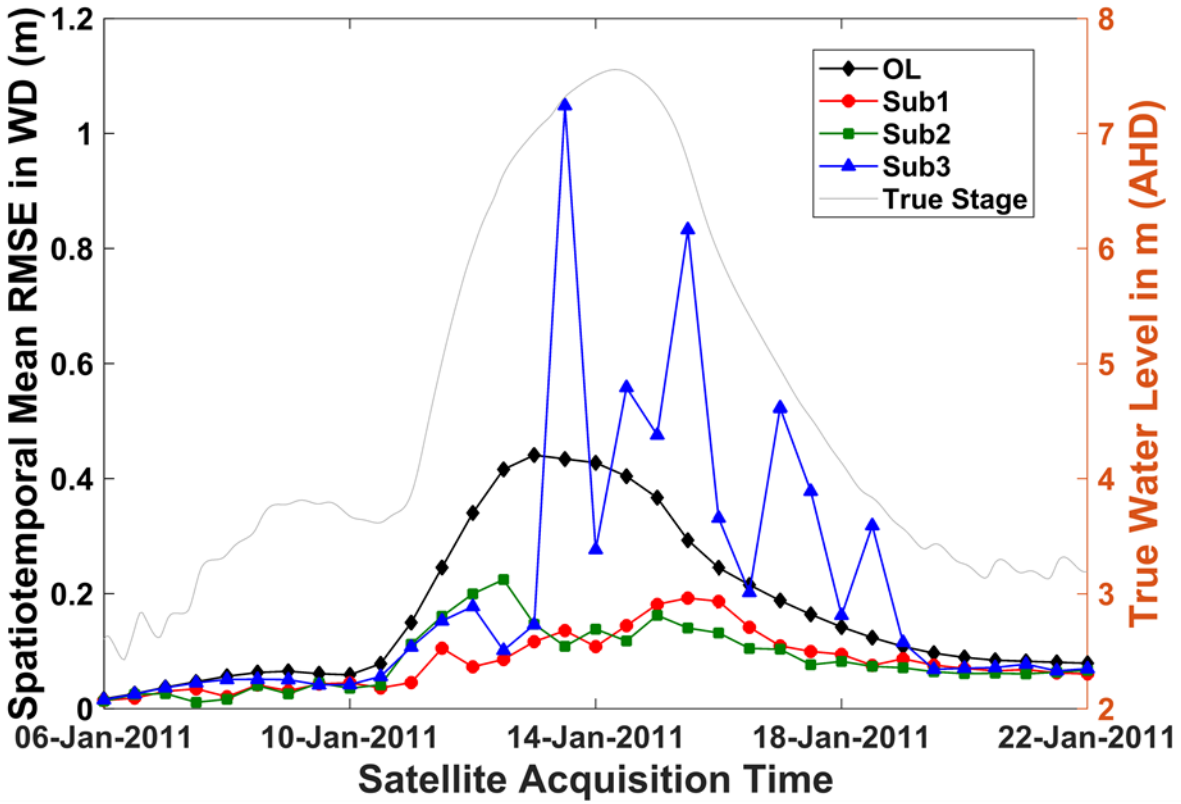
Q: When and where is a single image most helpful for the next assimilation time step?

- Assimilation impact on next 12h after the assimilation evaluated

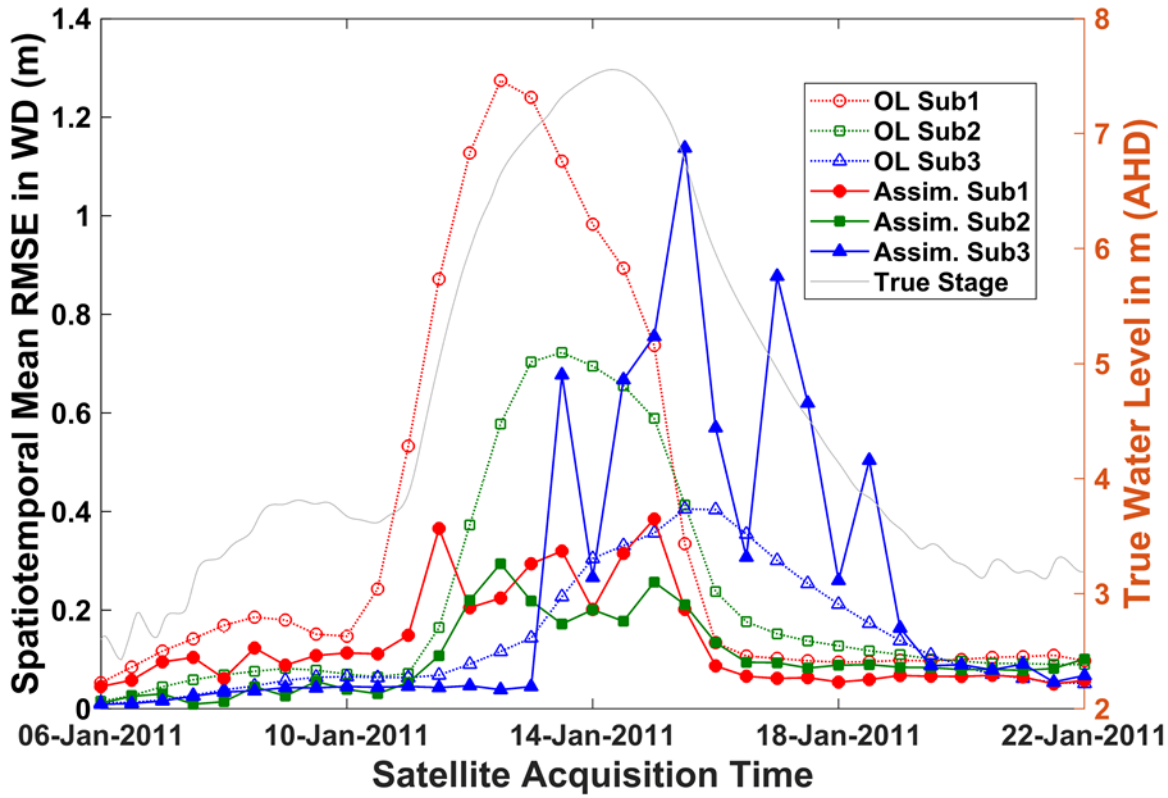


Impact on Floodplain Water Depth Simulation

GLOBAL



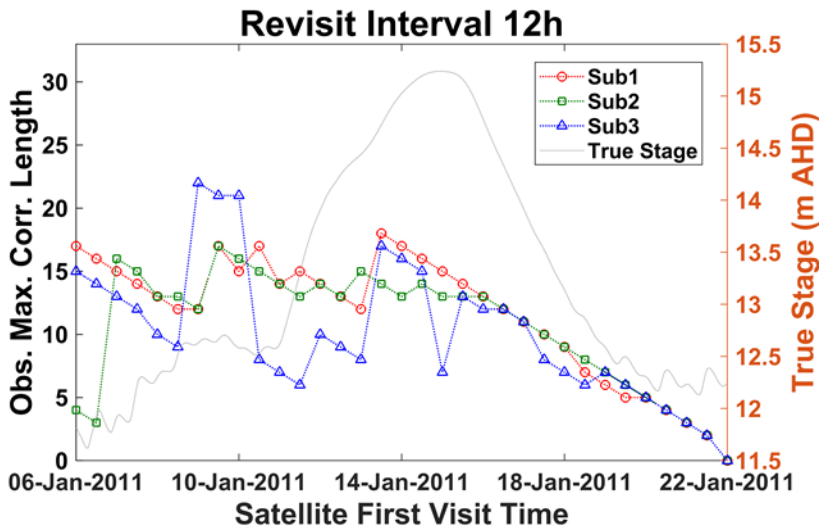
LOCAL

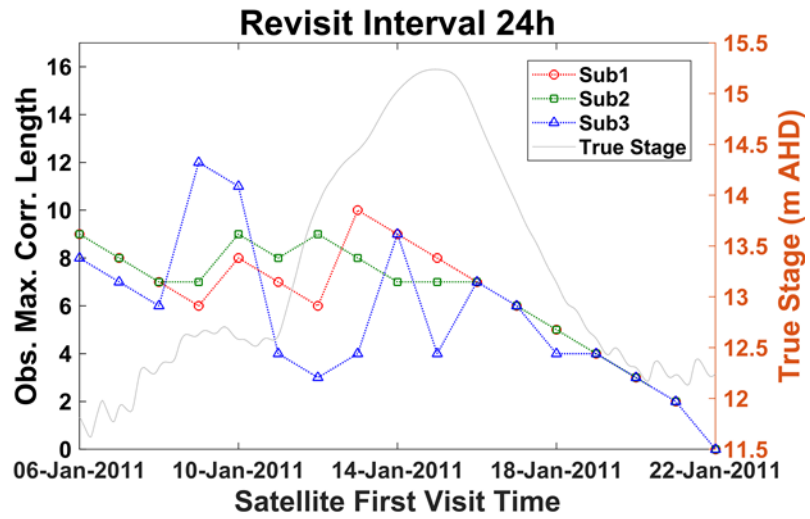


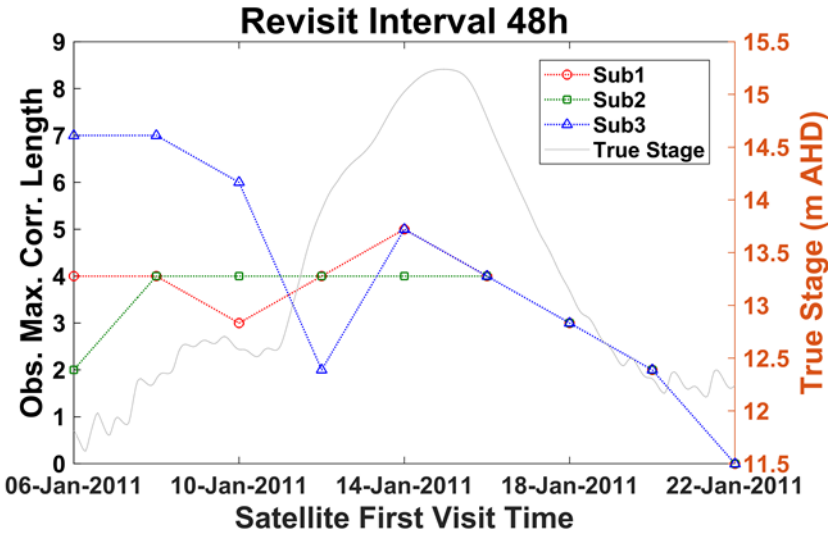
- Spatial impact on next 12h after the assimilation evaluated
- RMSE averaged across whole model domain – Global case
- RMSE averaged across assimilation sub-domains – Local case

Q: How many observations together have the maximum positive impact?

- Weights multiplied forward
- Plots the number of images following the first visit time at which maximum positive impact is observed vs. first visit time







Conclusions

Except for the downstream reach:

- DA of flood extent maps systematically improves model result.

→ during 12 hours after the DA time step

→during the whole flood event

- Results are improved both in the floodplain and the river stream
- Higher improvements occur closer to the peak, when model error variance is larger
- Sub-reach 3 (hydrodynamic with back water effects) showed more contrasting results (need for further investigation).

Perspective

- Further investigation of sampling frequency effect
- Real test case

Conclusions

Thank you for your attention

Questions ?