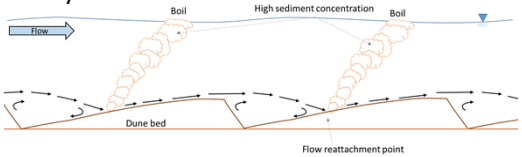
Study about Boil in actual river

Atsuhiro YOROZUYA (Public Works Research Institute) , **Ahmad Ali GUL** (Former ICHARM / GRIPS),
Tsuyoshi HOSHINO (Graduate school of Engineering, Hokkaido University), **Shoji OKADA** (National Institute of Technology, Kochi College)

Introduction

In order to deepen the discussion about the boil phenomena reported by Gul et al. (2018), the present study discuss about the flow field and the shear stress at the vicinity of the boil area. Regarding to the flow field, three data sets are compared; such as 1) the observed data by ADCP, 2) the observed data modified by the mass-consistent method, and 3) flow field simulated by 3-D numerical simulation with the URANS model. Regarding to the shear stress, two data sets are compared; such as 1) the shear stress observed by ADCP's bedload velocity, and 3) the one simulated by the URANS model.

During field observations in Brahmaputra, many **boil** are observed on the water surface



Methodology

- ADCP measurement with IDW (Inverse Distance Weighting) interpolation.
- The mass-consistent method
- RANS model(AHK model, Nays CUBE)

Numerical condition of RANS model

dt, s	dx/dy, m	Number of grid in z direction	Discharge from upstream	Water suface elevation at downsteam end, m	Roughness at bottom
0.005	2	50	3,500	0.0	0.02

The optimized model parameter of AHK is selected. Non-periodic boundary conditions in longitudinal/lateral direction are applied.

The mass-consistent method

$$E(u,v,w,\lambda) = \int_V \left[\begin{array}{c} \alpha_1^2(u-u^0)^2+\alpha_1^2(v-v^0)^2 \\ +\alpha_2^2(w-w^0)^2+\lambda\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}\right) \end{array} \right] dxdydz$$

$$\frac{\partial E}{\partial u}=0 \; then: \quad u = u^0 + \frac{1}{2\alpha_1^2}\frac{\partial \lambda}{\partial x} \quad (\boldsymbol{a}),$$

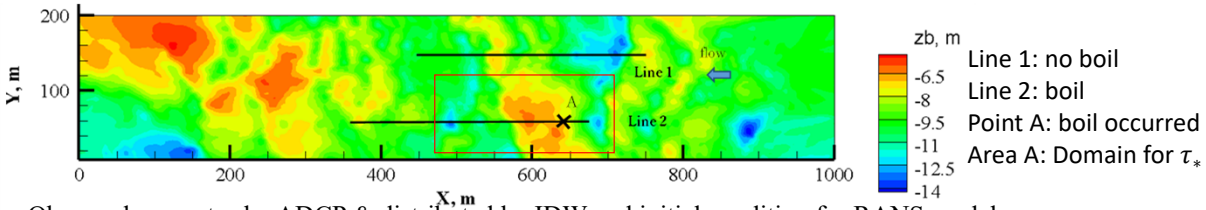
$$\frac{\partial E}{\partial v}=0 \; then: \quad v = v^0 + \frac{1}{2\alpha_1^2}\frac{\partial \lambda}{\partial y} \quad (\boldsymbol{b})$$

$$\frac{\partial E}{\partial w}=0 \; then: \quad w = w^0 + \frac{1}{2\alpha_2^2}\frac{\partial \lambda}{\partial z} \quad (\boldsymbol{c}),$$

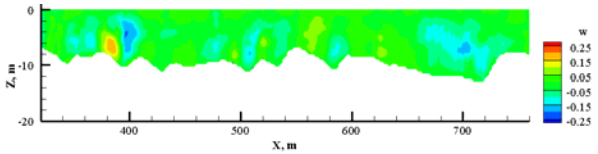
$$\frac{\partial E}{\partial \lambda}=0 \; then: \quad \frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \quad (\boldsymbol{d})$$

$$Plugging\ eq.(a),(b),(c) into\ (d):$$

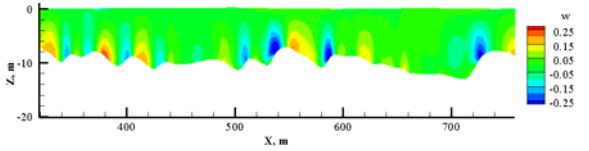
$$\frac{\partial^2 \lambda}{\partial x^2}+\frac{\partial^2 \lambda}{\partial y^2}+\left(\frac{\alpha_1^2}{\alpha_2^2}\right)\frac{\partial^2 \lambda}{\partial z^2} = -2\alpha_1^2\left(\frac{\partial u^0}{\partial x}+\frac{\partial v^0}{\partial y}+\frac{\partial w^0}{\partial z}\right)$$



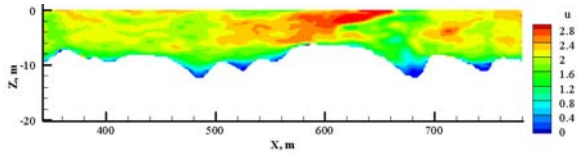
Observed geometry by ADCP & distributed by IDW and initial condition for RANS model (zb = 0: water surface)



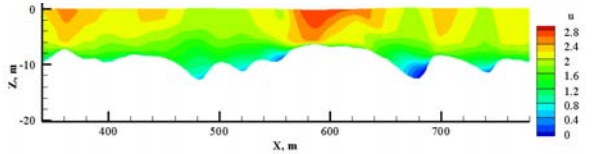
vertical velocity along the line 1 by ADCP-MASCON



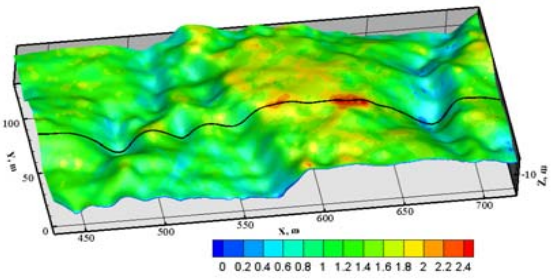
vertical velocity along the line 1 by RANS(115 sec)



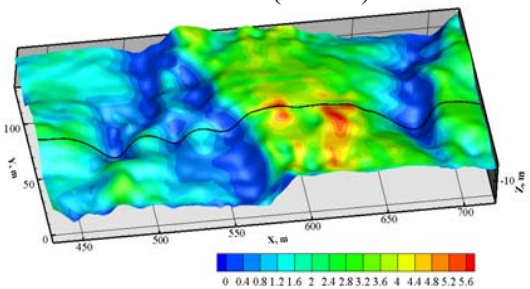
longitudinal velocity along the line 2 by ADCP-MASCON



longitudinal velocity along the line 2 by RANS(115 sec)



non-dimensional shear stress obtained converted from bedload velocity obtained by ADCP



non-dimensional shear stress (τ^* was calculated by Bed shear stress) by RANS(115 sec)

Conclusion

1. The present study discussed about the flow field related to the boil phenomena. For this purpose, three different flow were compared, such as a) observed results by ADCP, b) observed results modified by the mass-consistent method, and c) numerically simulated results with RANS model.
2. Regarding difference between ADCP observation and mass-consistent, the modification by the mass-consistent method does not change much for flow field on the line 1.
3. The vertical velocities were recognized at appropriate location, corelating with the shape of the bed form. However, observed velocity were smaller than that simulated by the RANS model.
4. The present study concluded that there are three significant characteristics of the boil, such as a) high upward velocity generates at the stoss side, b) longitudinal velocity is affected by the a), and c) the down-ward velocity generates at the top of the crest as a paired type flow with the a). The RANS model successfully simulated the boil phenomena in terms of a) and high Reynolds shear stress.
5. In addition to that, the present study discussed about the shear stress acting on the river bed by means of two different method, such as a) observed results by ADCP as bed load velocity, and b) numerically simulated results with RANS model.
6. Regarding 5., the both methods indicated the highest bed shear stress at the location of the boil, and it was about 1.05 times larger than the one at the top of the crest.