Imposing penalty both on gravity and Rossby modes in the Variational Initialization

Kyuichiro Tamiya
Meteorological Research Institute, 1-1 Nagamine,Tsukuba,Ibaraki,305-0052,Japan
e-mail:ktamiya@mri-jma.go.jp

1 introduction

How does the variational initialzation represent the data void regions such as the mountainous land in the meso-scale context. We have conducted an (time-1, space-2 dimensional) data assimilation experiment using a flux type shallow water equation. The case in our interest is such as the mountainous region with no reliable observation around. We may take the aproximately uniform flow near the mountain, but such flow should not be appropriate for the initial field because they show an apparent transient character due to the mountain forcing. But we show in this short note that we can control such transient character and get the spin-up-free initial fields by imposing penalty upon tendencies not only of gravity modes but also of Rossby modes.

2 numerical experiment

Cost function $I(\psi)$ consists of three parts, the first two of which is the background term $J_b(\psi)$ and the observation term $J_o(\psi)$ which constrains $\psi = (U, V, H)$ near background (U_b, V_b, H_b) and obserbations (U_o, V_o, H_o) each:

$$J_b(\psi) = (U - U_b)^2 + (V - V_b)^2 + g\bar{H}(H - H_b)^2 \tag{1}$$

$$J_o(\psi) = (U - U_o)^2 + (V - V_o)^2 + g\bar{H}(H - H_o)^2 \tag{2}$$

and the last is the penalty term $J_B(\psi)$:

$$J_B(\psi) = \left(\frac{\partial U}{\partial t}\right)^2 + \left(\frac{\partial V}{\partial t}\right)^2 + g\bar{H}\left(\frac{\partial H}{\partial t}\right)^2 \tag{3}$$

adding up them with weights $w(\vec{x})$ and an adjustable constant c,

$$I(\psi) = \int dt d\vec{x}(w(\vec{x})J_o(\psi) + c\frac{a^2}{g\bar{H}}J_B(\psi)) \tag{4}$$

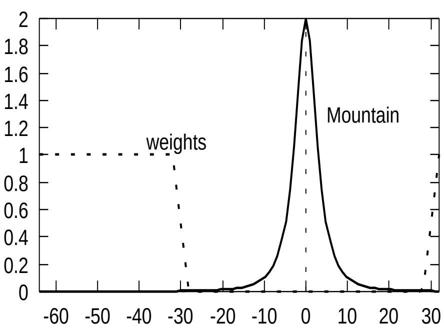
where $w(\vec{x})$ goes to zero near the mountain (centerd at $\vec{x} = \vec{x}_0$! 'with raious a)(Fig. 1), representing to be no available data there.

A time integration from an uniform flow was conducted and the short assimilation period $[0, T](T \leq a/\sqrt{gH})$ was selected after fully vortex sheddings started(Fig. 2). We assumed the background field to be an uniform flow and instead of taking $J_b(\psi)$ as a part of the cost function, we searched after the minimum starting from this uniform background.

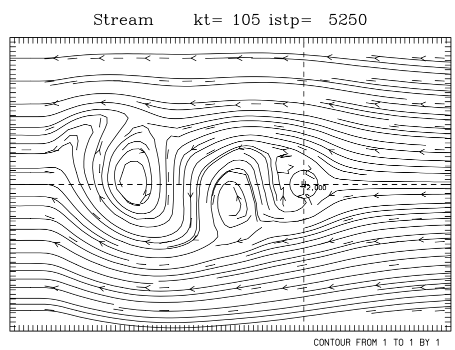
We have studied the effect of c on variational calculations. In case of $c \ll 1$, we have got an uniform flow near the mountain not going around the mountain nor over the mountain.(Fig 3). On the other hand when $c \gg 1$,we have got a pair of steady vortex quite different from observations. In the medium range of c, there are some vortices produced by the mountain shown in Fig 4.

The weak constraint by the term $J_B(\psi)$ is an extension of the balance condition, usually applied for gravity mode control but here also for Rossby modes. This term results in vortex creation behind the mountain. In figure 4 there are two vortices(a pair of vortex) just behind the mountain. This inconsistency with the observation is caused by the ambiguous uniform background field not by the inapropriateness of the applied penalty condition.

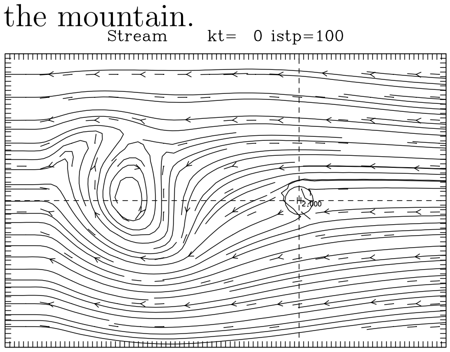
The forecast from this initial field(Fig. 4) was close to the original one and did not show a transient feature as the vortex shedding started at the begining of the forecast, while from the figure 3 initial, The vortex shedding followed a time-consuming creation of vortex pair from the uniform flow.



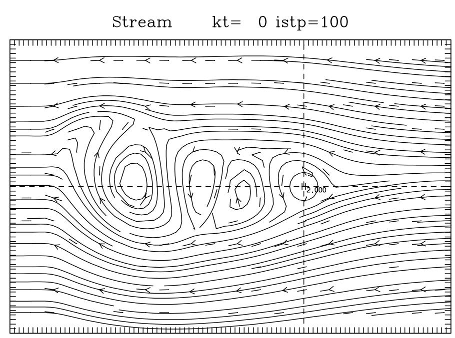
(FIg. 1)Lateral view: the mountain height is double of the water depth. There's uniform flow from the right. $w(x) = 0$ near the mountain.



(Fig. 2)Pseudo-observation produced by the time integration. We can see some eddies emitted in the wake of the mountain.



(Fig. 3)Uniform flow is seen near the nountain in case of $c \ll 1$



(Fig. 4)Two eddies are generated just behind the mountain when $c = 1$, one of them is excess compared with Fig. 2 above but that is effective for quick startup.