1 Constant Zonal Flow

1.1 Basic States

$$\Psi_1 = -U_1 y \qquad \Psi_2 = -U_2 y$$
$$Q_1 = (U_1 - U_2 + \beta) y \qquad Q_2 = (U_2 - U_1 + \beta) y$$

1.2 New States and Perturbations

$$\psi_1 = \Psi_1 + \psi_1' \qquad \psi_2 = \Psi_2 + \psi_2'$$
$$q_1' = \nabla^2 \psi_1' - F_1(\psi_1' - \psi_2') \qquad q_2' = \nabla^2 \psi_2' - F_2(\psi_2' - \psi_1')$$

1.3 QG Equations

$$0 = \partial_t q_1' + (u_1' + U_1)\partial_x q_1' + v_1' \partial_y (q_1' + Q_1)$$
$$0 = \partial_t q_2' + (u_2' + U_2)\partial_x q_2' + v_2' \partial_y (q_2' + Q_2)$$

1.4 Normal Modes

$$\hat{q_1'} = -\hat{\psi_1'}(F_1 + K^2) + F_1 \hat{\psi_2'} \qquad \hat{q_2'} = F_2 \hat{\psi_1'} - \hat{\psi_2'}(F_2 + K^2)$$
$$\hat{\psi_1'} = \frac{(F_2 + K^2)\hat{q_1'} + F_1 \hat{q_2'}}{F_1 F_2 - (F_1 + K^2)(F_2 + K^2)} \qquad \hat{\psi_2'} = \frac{F_2 \hat{q_1'} + (F_1 + K^2)\hat{q_2'}}{F_1 F_2 - (F_1 + K^2)(F_2 + K^2)}$$
$$\hat{u_1'} = -ik\hat{\psi_1'} \qquad \hat{u_2'} = -ik\hat{\psi_2'}$$
$$\hat{u_1'} = -il\hat{\psi_1'} \qquad \hat{u_2'} = -il\hat{\psi_2'}$$
$$K^2 = k^2 + l^2$$

2 x-independent Zonal Flow

2.1 Basic States

$$\Psi_1 = \Psi_1(y) \qquad \Psi_2 = \Psi_2(y)$$
$$Q_1 = \partial_{yy}\Psi_1 - F_1(\Psi_1 - \Psi_2) + \beta y \qquad Q_2 = \partial_{yy}\Psi_2 - F_2(\Psi_2 - \Psi_1) + \beta y$$

2.2 New States and Perturbations

$$\psi_1 = \Psi_1 + \psi_1' \qquad \psi_2 = \Psi_2 + \psi_2'$$
$$q_1' = \nabla^2\psi_1' - F_1(\psi_1' - \psi_2') \qquad q_2' = \nabla^2\psi_2' - F_2(\psi_2' - \psi_1')$$

2.3 QG Equations

$$0 = \partial_t q_1' + (u_1' + U_1)\partial_x q_1' + v_1'\partial_y(q_1' + Q_1)$$
$$0 = \partial_t q_2' + (u_2' + U_2)\partial_x q_2' + v_2'\partial_y(q_2' + Q_2)$$

2.4 Normal Modes

$$\hat{q_1'} = -\hat{\psi_1'}(F_1 + K^2) + F_1\hat{\psi_2'} \qquad \hat{q_2'} = F_2\hat{\psi_1'} - \hat{\psi_2'}(F_2 + K^2)$$
$$\hat{\psi_1'} = \frac{(F_2 + K^2)\hat{q_1'} + F_1\hat{q_2'}}{F_1F_2 - (F_1 + K^2)(F_2 + K^2)} \qquad \hat{\psi_2'} = \frac{F_2\hat{q_1'} + (F_1 + K^2)\hat{q_2'}}{F_1F_2 - (F_1 + K^2)(F_2 + K^2)}$$
$$\hat{u_1'} = -ik\hat{\psi_1'} \qquad \hat{u_2'} = -ik\hat{\psi_2'}$$
$$\hat{u_1'} = -il\hat{\psi_1'} \qquad \hat{u_2'} = -il\hat{\psi_2'}$$
$$K^2 = k^2 + l^2$$