Var_Obs2PenAndGrad

Determine the obs type and calculate the obs penatly and obs gradient, $\nabla_{Cx^+} J_O$ (e.g. *Var_NESDISPenAndGrad*)

Var_NESDISPenAndGrad (for sat120)

Calculate the model observations from the c_x^+ (call this y_{model}^{sat120})

Calculate the penalty contribution and the gradient $\nabla_y J_O^{Sat120} = -(E+F)^{-1}(y^{sat120} - y_{model}^{sat120})$ (*Var_NESDIS2PenAndGrad*)

Calculate the gradient $\nabla_{Cx^+} J_O^{sat120} = ((dy)/(dc_x^+))^T \nabla_y J_0^{sat120}$ (*Var_NESDISOperator_Adj*)

Calculate gradient $\nabla_{Cw} J_O = ((dc_x^+)/(dc_w)) \nabla_{Cx^+} J_O = (S^{-1})^T \nabla_{Cx^+} J_O$ (*Var_AddColumns_Adj*)

Calculate the gradient $\nabla_w J_O = ((dc_w)/(dw))^T \nabla_{Cw} J_O$, PF_hat (*PF_Forecast_Adj*)

Calculate the gradient $\nabla_v J_O = ((dw)/(dv))^T \nabla_w J_O = U^T \nabla_w J_O$, V_hat (*Var_Utransform_Adj*)

B. Calculate contribution from background term

Calculate background penalty $J_B = (V_B - V)^T (V_B - V)$ and the gradient, $\nabla_v J_B = -(V_B - V)$, BgV_hat (*Var_BgPenAndGrad*)

C. Calculate contrinution from “error of the day” (*Var_EmPenAndGrad*)

D. Calculate total gradient, $\nabla_V J$

E. Calculate total penalty

Minimize $J(V)$ using the calculated gradient (*m1qn3*)

Transform V back to model space, PF (*Var_Utransform*) to give the perturbation state analysis, $PF = U(V)$

$$\nabla_v J_o = \left(\frac{dw}{dv}\right)^T \left(\frac{dc_w}{dw}\right)^T \left(\frac{dc_x^+}{dc_w}\right)^T \left(\frac{dy}{dc_x^+}\right)^T \nabla_y J_o = U^T \left(\frac{dc_w}{dw}\right)^T \left(\frac{dc_x^+}{dc_w}\right)^T \left(\frac{dy}{dc_x^+}\right)^T (E+F)^{-1}(y - H(U^{-1}V))$$

Met Office 3d/4d Variational Data Assimilation

Inner Loop Control. Ross Bannister, July 2001

VarProg_AnalysePF

Read linearisation state, LS (*Var_ReadLS*)

Read perturbation forecast, PF (*Var_ReadModel*) at this stage this is the background expressed as a perturbation from LS (PF is initially zero)

Read error modes for "error of the day", EM (*Var_ReadModel*)

Read data items concerned with the covariances

Transform PF (here the background perturbation) to control variable space, Vb (*Var_Ttransform*), $V_B = T(PF)$

Transform EM to parameter space, Vem (*Var_Tptransform*), $V_{EM} = T_p(EM)$

Do the Var minimization, V (*Var_Minimize*)

Var_Minimize

Calculate the penalty $J(V)$ and its gradient $\nabla_V J(V)$ (*Var_simul*)

Var_simul

Call routine to calculate the penalty $J(V)$ and its gradient $\nabla_V J(V)$ (*Var_TotalPenAndGrad*)

Var_TotalPenAndGrad

A. Calculate contribution from observational term

Transform V to model space, PF (Var_Utransform), $PF = U(V)$

Calculate cws columns at observation positions (*PF_Forecast*). In 4d-var this involves a model run to use the correct times.

Calculate the obs penalty and the gradient $\nabla_{Cw} J_O$, Cw_hats (*Var_ObsControlPenAndGrad*)

Var_ObsControlPenAndGrad

Call routine to calculate the obs penalty and the gradient $\nabla_{Cw} J_O$, Cw_hats (*Var_ObsPenAndGrad*)

Var_ObsPenAndGrad (for each observation type)

Using linearisation state columns, c_x, and cws, c_w, calculate updated columns, $c_x^+ = c_x + S^{-1} c_w$ (*Var_AddColumns*)

Calculate penalty contribution and gradient, $\nabla_{C_x^+} J_O = ((dy)/(dc_x^+))^T \nabla_y J_0$ from ob. type (*Var_Obs2PenAndGrad*)