subjective adaptive sampling strategy (Robinson, personal communication). Presently, the flight of Sept. 18 and that of Sept. 22 are assimilated (Fig. 4b–c). The flight of Sept. 24 (Fig. 4d) is only utilized to evaluate the estimation methodology.

2.2. Dynamical model

The dynamical model is the nonlinear primitive equation (PE) model of HOPS (e.g., Robinson, 1996), in its rigid-lid configuration. The state variables are the (dynamical) tracers, the temperature T and salinity S, the barotropic transport stream function ψ, and the zonal (x) and meridional (y) internal velocities, $\hat{u}$ and $\hat{v}$, respectively (see Appendix A for notations). External velocities are obtained from $\bar{u} = -\nabla_h \wedge \psi e_z / H$, where the operator $\nabla_h \wedge (\cdot)$ is the horizontal curl, e_z the vertical and H the local depth. The values of the numerical and physical parameters used in this study are listed in Table 1. The horizontal resolution is 9 km. The domain extension is 630 km in the zonal and 459 km in the meridional direction, respectively (Fig. 2). In the vertical (z), 20 levels are distributed based on a ‘‘double sigma’’ transformation (Lozano et al., 1994; Sloan, 1996). This is a piecewise linear transformation which uses two ‘‘topography-following’’ sigma systems: one from the surface to an intermediate depth $h_c(x, y)$, the other from h_c to the bottom. For suitably chosen h_c, this maintains relatively flat levels above h_c in both the shelf and deep ocean. The dimension of the state vector is 299,052. The time step was bracketed to 450 s.

Horizontally, the parameterization of the subgrid-scale mixing processes and filtering of numerical noise is based on a Shapiro filter (Shapiro, 1970). Its parameters are the order p, number q of application per time step and number r of time steps in between applications. For each state variable (Table 1), the values p, q, r were determined based on curves of effective diffusivity as a function of horizontal-scales, and on a compromise between smoothing computational noise and allowing physical instabilities to occur (Lermusiaux, 1997). The vertical mixing is a Laplacian mixing, with fixed eddy

Table 1
Dynamical model parameters

Numerical Parameters	Centroid latitude and longitude	36.25°N, 14°W
	Domain extension	630 km (x), 459 km (y)
	Grid resolution	9 km
	Grid size	71 (x), 52 (y), 20 (levels, double sigma)
	Time step	450 s
	State vector size	$n = 299{,}052$
Physical Parameters	Shapiro filter	F_u, F_v: 1611; F_T, F_S: 411; $F_{\overline{\omega}_t}$: 211
	Open bond condition	$\hat{u}, \hat{v}$: (ORI); T, S: (ORI); ψ: (ORE$_{1/2}$); $\overline{\omega}_t$: (ORE$_{1/2}$)
	Vertical mixing	$A_v = 0.5$ cm^2 s^{-1}, $A_v^{evet} = 50$ cm^2 s^{-1} $K_v = 0.1$ cm^2 s^{-1}, $K_v^{evet} = 50$ cm^2 s^{-1}
	Drag coefficient	$C_d = 2.5 \times 10^{-3}$
	Rayleigh coastal friction	$\tau_c = 7200$ s, $L_c = 9$ km
	Rayleigh bottom friction	$\tau_b = 3600$ s, $H_b = 2$ bottom levels, with $H_b \leq 50$ m