port scheme of Piriou et al. (2007), hereafter called PCMT. For some members, modified versions of B85 are activated. Two turbulent schemes are used: the turbulent kinetic energy scheme of Cuxart et al. (2000) and the turbulence scheme of Louis (1979). Four shallow convection schemes are considered: the mass flux scheme of Kain and Fritsch (1993) and Bechtold et al. (2001), PCMT, the eddy diffusivity and Kain–Fritsch scheme, and the Pergaud et al. (2009) scheme. Surface oceanic fluxes are represented by the Belamari (2005) scheme or by an alternate version in which the evaporative fluxes are enhanced. The paper is focused on two particular members of this EPS, corresponding to the REF member and seventh member respectively as it appears in Table 1 of Ponzano et al. (2020). They only differ in the representation of deep convection, one using the B85 scheme and the other the PCMT scheme. The two simulations share the same physical parameterizations for turbulence (turbulent kinetic energy scheme; Cuxart et al., 2000), shallow convection (Kain and Fritsch, 1993; Bechtold et al., 2001), large-scale microphysics (Lopez, 2002) and oceanic flux (Exchange Coefficients from Unified Multi-campaigns Estimates; Belamari, 2005). Finally, a third simulation is performed without any active deep convection scheme (hereafter called NoConv) but with the same other physical packages as the other two simulations and will serve as a reference to assess the impact of B85 and PCMT schemes.

The three simulations are hereafter systematically compared. The starting time and date are 12:00 UTC on 1 October 2016 when the surface cyclone is already in its mature stage and located in the middle of the North Atlantic (see the position of the minimum sea level pressure at 1 d lead time in Fig. 1).

2.1.1 The Bougeault (1985) deep convection scheme

This mass flux scheme is triggered when the resolved plus subgrid-scale moisture convergence is positive in the low levels and the atmospheric profile is unstable. So the scheme is closed with moisture convergence. Following Kuo (1965) the total moisture convergence is either detrained in the convective environment or precipitated. This scheme was further developed by Ducrocq and Bougeault (1995) for downdraughts. It is part of the global operational NWP (numerical weather prediction) system at Météo-France and is currently used to perform ARPEGE deterministic operational simulations.

2.1.2 The Prognostic Condensates Microphysics and Transport scheme of Piriou et al.(2007)

This convection scheme separates microphysics and transport in grid-scale equations to overcome stationary cloud budget assumptions, as proposed by Piriou et al. (2007). Liquid and ice cloud condensates, as well as rain and snow, have prognostic mixing ratios to deal with the same level of sophistication inside convective updraught as in the resolved-scale microphysics (Lopez, 2002; Bouteloup et al., 2011), therefore including autoconversion, aggregation, collection, riming, melting, etc. The closure of all experiments run with PCMT in the present study is based on CAPE (convective available potential energy). As previously said, this scheme is used in PEARP but also is part of the CNRM Earth System Model for CMIP6 (Roehrig et al., 2020).

2.2 Model output and diagnostics

The output datasets of the simulations are provided on a regular longitude–latitude grid of 0.5°, a pressure grid spacing of 50 hPa in the vertical and a frequency of 15 min.

2.2.1 WCB trajectories

The Lagrangian trajectory code is designed to work with latitude × longitude × pressure files of zonal wind u, meridional wind v, vertical velocity ω, and other variables such as temperature and diabatic tendencies. The algorithm is based on a prediction-correction method of the advection at the midpoint of the trajectory. Let DT be the time interval between two model outputs. To account for curvature effects, the trajectory model has higher resolution than the model outputs, and its time step dt is such that $n \times \mathrm{d}t = \mathrm{DT}$. At $t = i \times \mathrm{DT} + j \times \mathrm{d}t$ (where $j = 1, \ldots, \cancel{n}$) and for each point $(x(t), y(t), p(t))$ (p denotes pressure, x and y are horizontal coordinates) belonging to a trajectory, we look for the previous position $(x(t-\mathrm{d}t), y(t-\mathrm{d}t), p(t-\mathrm{d}t))$, with the advection being made with u, v and ω in the middle of the trajectory portion at $t - \mathrm{d}t/2$, which is not known a priori. We first apply a time interpolation to compute the 3D wind field at time t using the two closest model outputs for (u, v, ω) at time $i \times \mathrm{DT}$ and $(i+1) \times \mathrm{DT}$ and referred to as $\mathbf{U}(x, y, p, t)$. We then apply an iterative method starting with the wind at the point of the trajectory at time t (i.e. $\mathbf{U}(x(t), y(t), p(t))$) to build up a first estimation of the previous position of the trajectory $(x_1(t-\mathrm{d}t), y_1(t-\mathrm{d}t), p_1(t-\mathrm{d}t))$ and extract the wind along this first estimated trajectory at $t - \mathrm{d}t/2$ (called $\mathbf{U}_1(x(t-\mathrm{d}t/2), y(t-\mathrm{d}t/2), p(t-\mathrm{d}t/2))$) by horizontal, vertical and time interpolation. Horizontal interpolation is bilinear (four neighbouring points are used). A second estimated trajectory is calculated using $\mathbf{U}_1$, leading to a second estimation of the previous position $(x_2(t-\mathrm{d}t), y_2(t-\mathrm{d}t), p_2(t-\mathrm{d}t))$. The process can be repeated several times, but practical tests show it converges after about two iterations. If a trajectory goes beyond 975 hPa, its position is shifted to 975 hPa. Note that such an algorithm allows the computation of both backward and forward trajectories. In what follows, DT and dt are equal to 15 and 7.5 min respectively ($n = 2$).

Forward trajectories are initialized at 12:00 UTC on 1 October in the warm sector of the extratropical cyclone and computed during 48 h. To select WCB trajectories, a criterion of ascent exceeding 300 hPa within 1 d during the period be-