Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-327-RC2, 2020

Geoscientific Model Development Discussions

Interactive comment on "The Effects of Ocean Surface Waves on Global Forecast in CFS Modeling System v2.0" *by* Ruizi Shi et al.

Anonymous Referee #2

Received and published: 28 November 2020

This is another piece of work that is claiming that the coupling of an atmospheric model with the 3rd generation wave model for the specification of the surface momentum exchange is novel. Totally disregarding the work of Peter Janssen and colleagues at ECMWF. There is a whole book dedicated to the topic (Janssen 2004). The active two-way coupled system has been operational in ECMWF medium-range forecasting system since 1998, with frequent updates following thorough testing. See for instance the recent adaptation of ST4 based physics to the ECMWF IFS system (Bidlot 2019) and further enhancement of this parameterisation for tropical cyclone forecasts (Bidlot 2020). Robustness of the forecast performance requires many more cases. Obviously, this paper is a set of case studies. This needs to be clearly highlighted and discussed. In Janssen (2004), the impact of the coupling to waves is shown to be even more

important at longer lead time.

The addition of the coupling to an ocean circulation model in which a wave model interacts with both the atmosphere and the oceans for the purpose of medium-range forecast is not new either. Following the work of Breivik et al. (2015), all components of ECMWF forecast system have been fully coupled for the past few years. I agree that aspects of Upper Ocean mixing are still very crudely represented in many models. This study explores the potential of using the wave model surface Stokes drift to supplement a Langmuir mixing parameterisation. It is presented as a fast process acting quickly on the SST. But is it the right process? My understanding is that Langmuir turbulence might act much more slowly and is a factor in the determination of the mixed layer depth. Again, this study is a bit short to be really able to answer this question.

Is GFS only using the Charnock relation for the specification of the roughness length scale (z0) for momentum? There should also be a viscous contribution to z0. See Beljaars (1994). For this reason, I wonder about the coupling via z0. ST3 and ST4 in WW3 do not have a viscous term because they only deal with wave generation. From WW3, it is easy to determine the Charnock coefficient. Would it be more consistent to exchange it with GFS instead of z0? Moreover, the time steps of the different models imply that WW3 provides a new z0 every 900 s. Is it then kept constant until the next update? The Charnock relation implies that even if the Charnock coefficient is constant, the surface roughness can still change because the moment flux is still changing.

The implementation of ST4 in WW3 was selected. Noting that WW3 documentation suggests different set of values of the parameters for ST4, which one was used? The selections of the parameters for ST4 in WW3 were obtained by running experiments with the stand alone version of the code for given forcing in order to yield the best possible wave results, there is no absolute guarantee that the surface stress and hence z0 are what would be expected in a coupled system. There is obviously limited amount of observations of surface stress, however it would be reassuring that in the mean, the drag coefficient from WW3 is in agreement with field data as estimated from observations (Edson et al. 2013). It is also unclear to me that the surface stress that WW3 is specifying (via z0) is consistent with the surface stress used by MOM4, or is MOM4 surface stress specified using another bulk formula not necessarily consistent with the what prescribed by WW3. Finally, is the GFS formulation for heat and moisture fluxes dependent on z0 (as it is the case in the ECMWF system) and therefore the coupling with WW3 would also influence heat and moisture exchange (this can important in tropical cyclone simulation).

Some specific comments: In section 2.2, the wave model surface Stokes drift is used. The Stokes drift calculation from the wave model 2d spectrum is heavily weighted towards high frequency. Is the frequency cut-off in its calculation the same as the model cut-off ($\sim$0.41 Hz), without the addition of a high frequency tail? In this case, it would be probably be overly under estimated and one might wonder if a simpler parameterisation based on the wind speed will not suffice (ust(0) $\sim$ 0.016*U10), especially that it is mentioned that the potential misalignment between Ust and U10 has been found to be not important?

Anemometers mounted on buoys are rarely at 10m height. Nothing is mentioned regarding the adjustment of the buoy winds to 10m. The discussion regarding the bias reduction of 10m winds is only relevant if the buoy winds have been adjusted to 10m.

Minor comments: L50: you might want to add the following publications L63: modern reanalysis such as ERA5 is hourly L108: warm boots -> warm starts (?) Figure 1: so the low resolution surface currents are passed to the wave model, where the gradient in these is more important for wave refraction will therefore be poorly represented, but the same currents are not passed to the atmosphere where they could be used in a more consistent way to compute the momentum balance at the surface. L193: replace all reference to ERA5 by the Hersbach et al. (2020)

References:

Beljaars, A. C. M. 1994 : The parametrization of surface fluxes in large-scale models

under free convection. Q. J. R. Meteorol. Soc., 121, 255{270.

Jean-Raymond Bidlot, 2019: Model upgrade improves ocean wave forecasts. ECMWF newsletter, 159, 10-10. https://www.ecmwf.int/en/newsletter/159/news/model-upgrade-improves-ocean-wave-forecasts

Jean-Raymond Bidlot, Fernando Prates, Roberto Ribas, Anna Mueller-Quintino, Marijana Crepulja, Frédéric Vitart, 2020: Enhancing tropical cyclone wind forecasts, ECMWF newsletter, 164, 33-37. https://www.ecmwf.int/en/newsletter/164/meteorology/enhancing-tropical-cyclone-wind-forecasts

Edson, J.B., V. Jampana, R.A. Weller, S.P. Bigorre, A.J. Plueddemann, C.W. Fairall, S.D. Miller, L. Mahrt, D. Vickers and H. Hersbach, 2013: On the exchange of momentum over the open ocean. Journal of Physical Oceanography, 43:1589–1610, doi:10.1175/JPO-D-12-0173.1.

Hans Hersbach, Bill Bell, Paul Berrisford, Shoji Hirahara, Andras Horanyi, JoaquÄśnMunoz-Sabater, Julien Nicolas, Carole Peubey, Raluca Radu, Dinand Scheper1, AdrianSimmons, Cornel Soci, Saleh Abdalla, Xavier Abellan, Gianpaolo Balsamo, Peter Bechtold ,Gionata Biavati, Jean Bidlot, Massimo Bonavita, Giovanna De Chiara, Per Dahlgren, Dick Dee,Michail Diamantakis, Rossana Dragani, Johannes Flemming, Richard Forbes, Manuel Fuentes, Alan Geer, Leo Haimberger, Sean Healy, Robin J. Hogan, ElÄśas Holm, Marta Janiskova, Sarah Keeley, Patrick Laloyaux, Philippe Lopez, Cristina Lupu, Gabor Radnoti, Patricia de Rosnay, Iryna Rozum, Freja Vamborg, Sebastien Villaume, Jean-Noel Thepaut, 2020: The ERA5 Global Reanalysis, in final revision, Q. J. R. Meteorol. Soc. 00: 363 (2020).

Janssen, P , 2004: The Interaction of Ocean Waves and Wind. Cambridge, Cambridge University Press, doi:10.1017/CBO9780511525018.

Staneva J, Alari, V, Breivik O, Bidlot J.-R., Mogensen, K., 2016 : Effects of waveinduced forcing on a circulation model of the North Sea. Ocean Dynamics (2016). doi:10.1007/s10236-016-1009-0

Wiese, A., Stanev, E., Koch, W., Behrens, A., Geyer, B., & Staneva, J. (2019). The Impact of the Two-Way Coupling between Wind Wave and Atmospheric Models on the Lower Atmosphere over the North Sea. Atmosphere, 10(7), 386.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-327, 2020.