REVIEWER-2 (anonymous)

The manuscript by Lorente et al. investigates an alternative index for tracking the presence and strength of coastal upwelling and downwelling circulation patterns based on observed and modeled surface currents. In the case of the observed currents, analyses are presented from two coastal regions with time series extending over several months in each case. For the case of the modeled currents, an analysis is presented for one of the geographic regions for an entire 12-month period.

The surface-current-based coastal upwelling index (CUI) is compared against the traditional wind-based index. In that sense, there is no available ground-truth observation of vertical upwelling current. Independent evidence of upwelling circulation is provided in the form of sea surface temperature and chlorophyll observations whose spatial and temporal patterns match those predicted by the large events in the CUI indices.

The proposed surface-current-based CUI utilizes observations from various networks of high frequency (HF) radar installations. The availability of those observations is growing as more coastal HF radar sites are being added in many parts of the world. Extending the utility of HF radar observations is, therefore, of interest to a wide range of marine scientists and resource managers. This manuscript is generally well written and documented and the results support the use of a surface-current-based CUI. For these reasons, I recommend the manuscript for publication with only minor corrections.

Many thanks to the anonymous reviewer-2 for the detailed review and the number of useful tips provided. Please find below a thorough point-by-point response with the hope of improving the quality of the document to make it acceptable for final publication. All those minor comments provided by the reviewer have been carefully addressed.

Overall, the manuscript is well motivated and documented with references from the community. If anything, the Introduction could be condensed because it is slightly repetitive and long compared with the results section.

The introduction has been shortened by 10 lines as some redundant information has been removed and few paragraphs have been reformulated and condensed.

The main results are well documented, and they support the idea that surface-current-based CUI can be used as an alternative to an overwater wind-based CUI. I do think that the conclusions section could focus more on why a surface-current-based CUI is advantageous.

The following paragraph has been inserted in the conclusions section to clarify the benefits of the proposed CUI-HFR:

"In this context, the proposed CUI-HFR presents additional advantages with respect to previous traditional CUIs, namely:

i) it takes into consideration the direct influence of coastal surface water dynamics, providing thereby a more complete portrait of this phenomenon.

ii) it provides high-resolution two-dimensional maps that can aid to elucidate the spatial distribution and magnitude of the coastal UPW together with the potential existence of recurrent patterns and/or filaments in intricate regions with complex-geometry configurations.

iii) it is generated from consistent remote-sensed hourly surface current observations (obtained in near real-time), not from coarse-resolution atmospheric forecasts which are in general affected by higher uncertainties. This interpretation is supported by the fact that operational atmospheric and ocean models include assimilation schemes where remote observations are routinely ingested to improve their predictive skills (Wilczak et al., 2019; Hernández-Lasheras et al., 2021).”

References:

Wilczak, JM, Olson, JB, Djalalova, I, et al. Data assimilation impact of in situ and remote sensing meteorological observations on wind power forecasts during the first Wind Forecast Improvement Project (WFIP). Wind Energy. 2019; 22: 932– 944. https://doi.org/10.1002/we.2332

Hernández-Lasheras, J., Mourre, B., Orfila, A., Santana, A., Reyes, E., and Tintoré, J.: Evaluating high-frequency radar data assimilation impact in coastal ocean operational modelling, Ocean Sci., 17, 1157–1175, https://doi.org/10.5194/os-17-1157-2021, 2021.

I am a little skeptical that using a numerical circulation model to obtain surface currents to then estimate a CUI is better than simply using the winds that drive the model.

Since coastal upwelling is a process strongly influenced by the wind but also modulated by the local bathymetry, the coastal morphology or the coastline orientation, we humbly consider that GLOBAL circulation model (with its well-known limitations) might act as a useful tool for CUI assessment as it takes into account the secondary (but not negligible) role of the abovementioned factors

Although we have previously listed some advantages related to HFR-CUI, we do not intend to categorize this novel approach as better than previous traditional wind-based methodologies. All of them are valid (even complementary). In the same line of thought, in this paper we have presented a proof-of-concept investigation to assess the prognostic capabilities of the GLOBAL circulation model to accurately reproduce UPW/DOW events in the NWI area. This brief exploration might establish new pathways for future research but does not aim at ranking existing CUIs, which is out of the scope of the present paper.

All in all, the authors are convinced that both wind and circulation forecast models have still room for improvement. Powerful techniques such as data assimilation and machine learning will likely lead to more precise, robust predictions and therefore to more reliable CUIs. In this context, we guess that the development and operational implementation of a high-resolution fully coupled atmospheric-ocean model could constitute a step ahead to better reproduce this coastal process.

The main benefit of a surface-current-based CUI that is suggested in the manuscript is the possibility to create a 2-D map of the CUI. For that additional level of CUI fidelity to be meaningful there should be some discussion of the relevant divergence scale that is controlling the upwelling process. The traditional wind-based CUI assumes a very large horizontal scale with surface currents diverging from the coastal boundary being responsible for the upwelling circulation. Two-dimensional observations of surface currents from HF radar (or a numerical circulation model) can, in theory, expose horizontal divergence in the flow field and the associated upwelling patterns. Such direct observations of divergence are very sensitive to errors and I'm not convinced by the results in this manuscript that the two-dimensional variations in CUI are meaningful. There should be, at a minimum, some discussion of scale and that fact that the mapping results are suggestive at best.

The authors fully agree with the reviewer that the horizontal divergence (DIV) at the sea surface is a useful diagnostic to discriminate between zones of contraction and expansion of the flow where vertical fluxes might be significant. Indeed, we already computed maps of DIV from HF radar current observations in the same study region (Figure 5, in Lorente et al., 2020) to unveil localized areas of upwelling (UPW) and downwelling (DOW) associated with positive and negative DIV, respectively. As stated in Lorente et al. (2020), under UPW-favourable winds, positive divergence is exposed in the central portion of the radar domain and also in the periphery of Cape Finisterre, indicating accumulated upward vertical motions and strong UPW. The analysis of DIV corroborated not only the key role of the Galician shoreline orientation in modulating UPW conditions but also the importance of Cape Finisterre promontory and its ambient waters as a locus of recurrent positive DIV and offshore advection, independently of the dominant along-shore wind regime. This is in agreement with previous historical works in the same region (Torres et al., 2003; Álvarez et al., 2011; McClain et al., 1986).

In the present manuscript, we firstly decided not to include a discussion about the divergence scale that is controlling this coastal process in order to: i) avoid potential redundancies and overlapping with Lorente et al. (2020); and ii) fulfill the journal requirements for the "Ocean State Report" Special Issue (limit of 4 Figures). Following the reviewer's suggestion, we have added the following paragraph in the conclusions section that is further supported by those previous findings exposed in Lorente et al. (2020):

"The small-scale belt of UPW, confined in shallower coastal areas and evidenced in Figure 3 (a, c), is consistent with HFR-derived maps of horizontal divergence previously published in Lorente et al. (2020). In this work, it was suggested that positive divergence, localized at the tip of CF, induced topographic UPW and then upwelled waters were advected southwards away from the promontory. Similar initiatives with HFR current observations were effectively addressed in the west coast of the USA (Roughan et al., 2005), proposing that confined areas of semi-persistent UPW were not due to local or remote wind forcing but rather to the divergence of the prevailing southerly flow as it passed the Point Loma headland."

References:

Lorente, P.; Piedracoba, S.; Montero, P.; Sotillo, M.G.; Ruiz, M.I.; Álvarez-Fanjul, E. Comparative Analysis of Summer Upwelling and Downwelling Events in NW Spain: A Model-Observations Approach. Remote Sens. 2020, 12, 2762. https://doi.org/10.3390/rs12172762

Torres, R.; Barton, E.D.; Miller, P.; Álvarez-Fanjul, E. Spatial patterns of wind and sea surface temperature in the Galician upwelling region. J. Geophys. Res. 2003, 108, 3130

Álvarez, I.; Gómez-Gesteira, M.; deCastro, M.; Lorenzo, M.N.; Crespo, A.J.C.; Dias, J.M. Comparative analysis of upwelling influence between the western and northern coast of the Iberian Peninsula. Cont. Shelf Res. 2011, 31, 388–399

McClain, C.R.; Chao, S.Y.; Atkinson, L.P.; Blanton, J.O.; Decastillejo, F. Wind-Driven Upwelling in the Vicinity of Cape Finisterre, Spain. J. Geophys. Res.-Ocean. 1986, 91, 8470–8486

Roughan, M.; Terril, E.J.; Largier, J.L.; Otero, M. Observations of divergence and upwelling around Point Loma, California. J. Geophys. Res. 2005, 110.

MINOR COMMENTS:

Line 12: “ecosystems, impacting on” should be “ecosystems, which has impacts on”

Done!

Line 28: “As the interface” should be “The interface”

Done, the entire sentence has been reformulated.

Line 45: “process denominated Ekman” should be “process referred to as Ekman”

Done!

Line 74: “hence two” should be “two”

Done!

Line 160: “those situ” should be “those in situ”

Done!

Line 178: “CUI-HFR which” should be “CUI-HFR, which”

Done!