

## ***Interactive comment on “Decadal regime shift linkage between global marine fish landings and atmospheric planetary wave forcing” by A. M. Powell Jr. and J. Xu***

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Comments: This work investigated a global forcing mechanism for decadal regime shifts of climate and their subsequent impacts. They argued that the global atmospheric planetary waves that can lead to changes in the global surface air–sea conditions and subsequently fishery changes. This is a very challenging topic. Manuscript is written well and fit the scope of this journal. I recommend to accept this paper after some minor revisions.

Answer: Thank you very much for your positive comments.

Question: (1) The Connection of troposphere and stratosphere: The connection between

troposphere and stratosphere is a controversial topic in the community. From my experience, the impact of stratosphere on troposphere exists, but it is weak and also the impact is only present in some specified regions (such as polar and tropical ocean regions) (see the following references). This should be discussed in the paper. Huang, B., Z.-Z. Hu, J. L. Kinter III, Z. Wu, and A. Kumar, 2012: Connection of stratospheric QBO with global atmospheric general circulation and tropical SST. Part I: Methodology and composite life cycle. *Clim. Dyn.*, 38 (1-2), 1-23. DOI: 10.1007/s00382-011-1250-7. Baldwin, M.P., L.J. Gray, T.J. Dunkerton, K. Hamilton, P.H. Haynes, W.J. Randel, J.R. Holton, M.J. Alexander, I. Hirota, T. Horinouchi, D.B.A. Jones, J.S. Kinnerson, C. Marquardt, K. Sato, and M. Takahashi, 2001: The Quasi-Biennial Oscillation. *Rev. Geophys.*, 39, 179-229. Liess, S., and M. A. Geller, 2012: On the relationship between QBO and distribution of tropical deep convection. *J. Geophys. Res.*, 117, D03108. DOI: 10.1029/2011JD016317.

Answer: You are right about the previous studies you mentioned, but we think the impacts of the stratosphere on the troposphere is not weak, and the connection is related to vertical wave propagation, vertical motions in the secondary circulation, as well as other factors. The connection is not just through the QBO, there is a lot of evidence and publications showing the impacts from the stratosphere. Our specific reference to the Wavenumber 2 vertical propagation was clearly intended to identify vertical wave propagation as one of the primary coupling methods. There are numerous other papers that discuss connectivity between the stratosphere and troposphere via wave propagation, and other factors, for example :

- 1) Kuroda, Y., and K. Kodera, 1999: Role of planetary waves in the stratosphere–troposphere coupled variability in the Northern Hemisphere winter. *Geophys. Res. Lett.*, 26, 2375–2378;
- 2) Perlwitz, Judith, Nili Harnik, 2003: Observational Evidence of a Stratospheric Influence on the Troposphere by Planetary Wave Reflection. *J. Climate*, 16, 3011–3026.

- 3) Christiansen, B., 2001: Downward propagation of zonal mean zonal wind anomalies from the stratosphere to the troposphere: Model and reanalysis. *J. Geophys. Res.*, 106, 27307–27322
- 4) Sun, Lantao, Walter A. Robinson, Gang Chen, 2011: The Role of Planetary Waves in the Downward Influence of Stratospheric Final Warming Events. *J. Atmos. Sci.*, 68, 2826–2843.
- 5) Shaw, Tiffany A., Judith Perlwitz, 2010: The Impact of Stratospheric Model Configuration on Planetary-Scale Waves in Northern Hemisphere Winter. *J. Climate*, 23, 3369–3389
- 6) Shaw, Tiffany A., Judith Perlwitz, Nili Harnik, Paul A. Newman, Steven Pawson, 2011: The Impact of Stratospheric Ozone Changes on Downward Wave Coupling in the Southern Hemisphere\*. *J. Climate*, 24, 4210–4229.
- 7) Tiffany A. Shaw, 2012, The life cycle of Northern Hemisphere downward wave coupling between the stratosphere and troposphere, *J of Climate*
- 8) Mark P. Baldwin<sup>1,\*</sup>, David W.J. Thompson, A critical comparison of stratosphere–troposphere coupling indices, *Quarterly Journal of the Royal Meteorological Society*, Volume 135, Issue 644, pages 1661–1672, October 2009 Part A
- 9) Gerber, Edwin P., and Coauthors, 2012: Assessing and Understanding the Impact of Stratospheric Dynamics and Variability on the Earth System. *Bull. Amer. Meteor. Soc.*, 93, 845–859.
- 10) Boville, B. A., and D. P. Baumhefner, 1990: Simulated forecast error and climate drift resulting from the omission of the upper stratosphere in numerical models. *Mon. Wea. Rev.*, 118, 1517–1530.
- 11) Charlton, A. J., A. O’Neil, W. A. Lahoz, and A. C. Massacand, 2004: Sensitivity of tropospheric forecasts to stratospheric initial conditions. *Quart. J. Roy. Meteor. Soc.*, 130, 1771–1792.

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- 12) Baldwin MP, Stephenson DB, Thompson DWJ, Dunkerton TJ, Charlton AJ, O’Neill A. 2003. Stratospheric memory and skill of extended range weather forecasts. *Science* 301:636–40
- 13) Powell, A and J Xu, 2011: Possible Solar Forcing of Interannual and Decadal Stratospheric Planetary Wave Variability in the Northern Hemisphere: An Observational Study. *Journal of Atmospheric and Solar-Terrestrial Physics*, DOI: 10.1016/j.jastp.2011.02.001

On the other hand, the discussing the details of the vertical stratosphere-troposphere connection is not the present paper’s main point. We just gave evidence that the regime shift appeared in stratosphere, and then provided evidence of the connection in the troposphere, surface and oceanic environment, and consequently the impacts on the marine ecosystem, such as changes in the normalized fish catch. Our paper was intended to reflect the connecting influences of the Earth’s system dynamics with the primary impact on the fish species changes.

Question:(2) Significance of the results: From Fig. 2, it seems that determination of the shifts are not objective, how to judge the rationality? For example, on page 10, it is necessary to make the significant test for the five regime shifts. Some regime shifts may not be able to pass the significant t-test. Also, how significance of these reconstructed fields and are they significance fields (for example based on Monte-Carlo test; Livezey and Chen 1983)? These questions at least should be discussed. Livezey, R. E., and W. Y. Chen, 1983: Statistical field significance and its determination by Monte Carlo techniques. *Mon. Wea. Rev.*, 111, 46–59.

Answer: We provided some discussion about the significance test(s) in the paper. The regime shifts identified in Fig.2 are based on the student t-test at the 90% confidence level.

Please check pages 10-11, we claimed that “the 90 percent confidence level was established for the running student t-test decadal period comparisons and provided an

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assessment of the most confident regime shift dates. For this analysis, the regime shift test was completed using 5 years on either side of the running target year (an 11-year interval in total, so it is called the 11-year (decadal) running t-test in the following sections) to determine whether a significant regime shift on the decadal time scale had occurred. Since we identified regime shifts with a decadal frequency, it intentionally precludes short term variations which may be due to interannual variability. For regime shifts which appear to be strong but do not pass the 90 percent significance test, we showed the 85 percent significance test which captures the remaining key decadal shifts mostly in the Indian Ocean. Since no data set is perfect, our intent was to demonstrate the fact that the regime shifts which did not pass the 90 percent confidence level would still be viable regime shift candidates for decadal change at the 85 percent confidence level. The highest percentage bars in Fig. 4 also show the distinctions between the synoptic mid-latitude forcing (Pacific and Atlantic Oceans) and the mostly tropical forcing in the Indian Ocean.

The 1998-99 regime shift does not clearly pass the significant t-test at 90% confidence level, but the shift is consistent with previous studies (Overland, et al, 2008; Powell and Xu, 2011).

1) Overland, J., Rodionov, S., Minobe, S. and Bond, N.: North Pacific Regime shifts: Definitions, issues and recent transitions, *Progress in Oceanography*, 77, 92-102, 2008.

2) Powell, A. M. and Xu, J.: Abrupt climate regime shifts, their potential forcing and fisheries impacts, *Atmospheric and Climate Sciences*, 4, 33-47, 2011.

Question (3) Others: In section 2, the fish catch data are used to represent the variation of marine ecosystem, better give more evidence to verify the reliability of the data? Fig. 5 is similar to the previous publication of Powell and Xu (2012), may remove it.

Answer: In section 2, please check, we provided more discussion about the FAO's fish capture data. We know the FAO fish data is not perfect for use in the current study.

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However, the FAO fish capture data is the only available data set on the global fish catch (Froese et al. 2012) and it is also the most broadly used and accepted database (Liddel 2014, personal communication). In addition, the database has been improved over time (Garibaldi 2012).

1) Froese, R., Zeller, D., Kleisner, K. and Pauly, D.: What catch data can tell us about the status of global fisheries, *Mar Biol*, DOI 10.1007/s00227-012-1909-6, 2012.

According to the recent publication (Garibaldi, 2012), the database provides a service to the community interested in fishery information although there are arguments about the data quality (Watson and Pauly, 2001; Hilborn and Branch, 2013). Over 600 articles from refereed journals cited the database in the last 15 years, making it one of the most cited databases used in research.

2) Garibaldi L.: The FAO global capture production database: A six-decade effort to catch the trend, *Marine Policy*, 36, 760–76, 2012

3) Hilborn, R and T. A. Branch, 2013: Does catch reflect abundance?, *Nature*, Vol 494, 21 Feb 2013, pgs 303-306.

4) Watson, R. and D. Pauly, 2001: Systematic distortions in world fisheries catch trends, *Nature*, Vol 414, 29 Nov 2001, pgs 534-536

The panels in Fig. 5 are similar to our previous study. In this paper, we emphasized the planetary wave pattern change between the five regime shift periods. Considering the logical relationship of the pattern changes to the fishery changes in the current study, we want to keep the Figure. Also, we are addressing a multidisciplinary audience with this paper and we think providing the figure helps follow a rather detailed analysis where those who work with fish/fisheries may not have detailed atmospheric expertise, for example, and this information helps bridge understanding across the disciplines (meteorology, oceanography, and fishery scientists). However, to address the connection to Fig 5 and its importance to the paper, we added a paragraph at

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the end of the paper's 'Discussion Section'. The additional discussion highlights why the association with the global pattern and its change is important in assessing the impacts on fish species changes related to the regime shifts. More work needs to be done in this area. However, we are trying to address global changes and the biological response consequences – namely fish species changes. The paragraph that was added sets a threshold for the number of fish species changes observed as a way to quantify the impact of decadal weather pattern changes on fish species changes. By looking at the periods when the most fish species were affected, it is possible to better understand the connections between the global wave pattern and the impacts in each ocean basin. In the new paragraph, we identified a potential reason for why the periods with relatively high numbers of fish species changes may have occurred: the locations of the decadal weather systems are more in the oceans than over central Asia or the North American continent. This likely drives the stronger influence on the fish species.

Please also note the supplement to this comment:

<http://www.earth-syst-dynam-discuss.net/5/C449/2014/esdd-5-C449-2014-supplement.pdf>

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Interactive comment on Earth Syst. Dynam. Discuss., 5, 945, 2014.