Are quasi-stationary waves and planetary waves the same?

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Key Points:

- List up to three key points (at least one is required)
- Key Points summarize the main points and conclusions of the article
- Each must be 100 characters or less with no special characters or punctuation

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Abstract

A good abstract will begin with a short description of the problem being addressed, briefly describe the new data or analyses, then briefly states the main conclusion(s) and how they are supported and uncertainties.

1 Introduction

Atmospheric planetary waves are blabalbaal... In some latitudes and tiems of the year they exhibit some degree of stationatiry...

2 Story

...

Zonal waves (ZW; sometimes also called planetary waves) are waves observed in each individual "instantaneous" field. Quasi-stationary waves (QS), on the other hand, are the resulting waves in the mean field. Of course, these definitions depend on which are the "instantaneous field" in question and the averaging timescales used. However, they illustrate that, given a set of tmospheric fields, ZWs are properties of the *elements* of the set, while the QS is a property of the set as a whole. This is an important distinction with theorical and methodological implications but is not always appreciated in the literature.

As an example, Figure 1 shows the monthly seasonal cycle of amplitude of planetary waves at 60°S using monthly fields from the NCEP/NCAR reanalysis (Kalnay et al., 1996) between 1950 and 1998. The left column ($\overline{ZW}$) reproduces Figure 3 from Rao et al. (2004) and is computed by taking –for each month and level– the average amplitude of the 49 individual amplitudes. The right column (QS), on the other hand, is computed by taking the amplitude of the average geopotential field for each month and level.

The resulting fields convey different information. First, the amplitude of $\overline{ZW}$ fields is always greater than the one for QS fields. This is a [c1]mathematical necessity that explains Rao et al. (2004)'s observation that their Wave 1 amplitude was greater than that reported by Hurrell, van Loon, and Shea (1998). Secondly, they have different annual cycles and vertical structures. QS2, for example, has a strong minimum in the low strato-

[c1] *elio*: Deberia demostrar eso? Vale la pena una demostracion en un material suplementario?

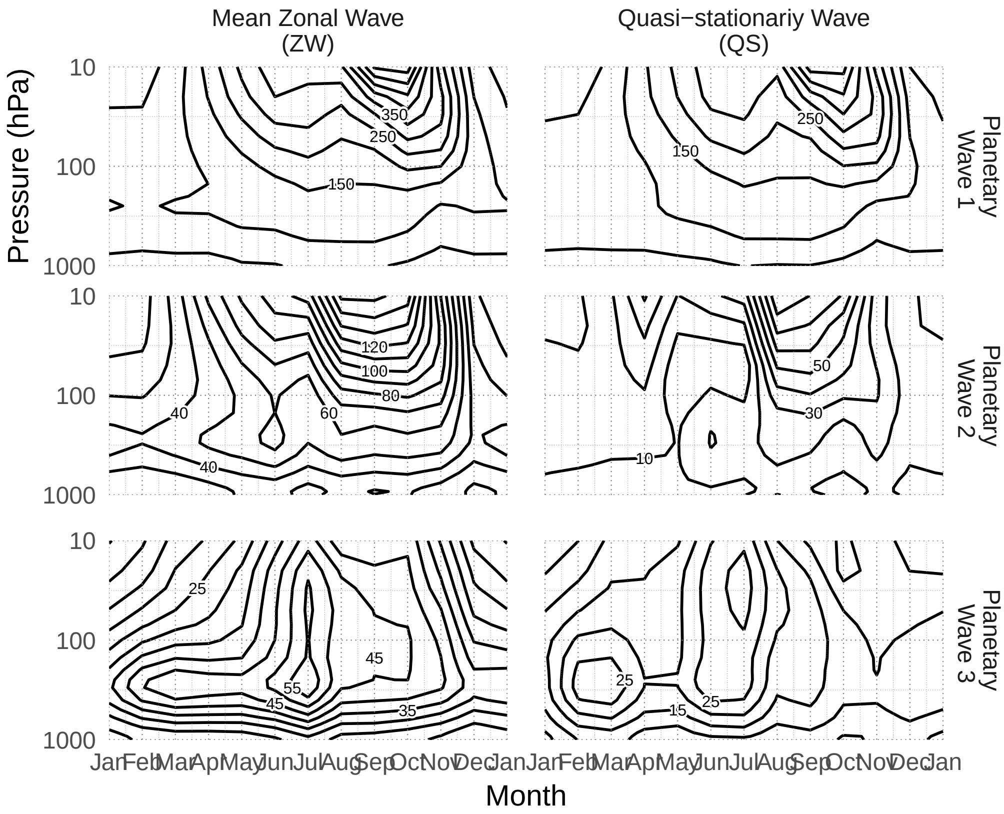

Figure 1. Seasonal cycle of amplitude of the geopotential planetary waves 1 to 3 at 60°S computed as the mean amplitude of the monthly waves ($\overline{ZW}$) and as the amplitude of the mean wave (QS). The period of analysis is 1950 to 1998. The left column reproduces Figure 3 from Rao et al. (2004).

sphere during the austral autumn that is not aparent in $\overline{ZW2}$. Similarly, the austral winter mid-troposferic maxmium is very well defined in $\overline{ZW3}$ but not so in QS3. Thirdly, the relative importance between each wavenumber vary. $\overline{ZW}$ fields show, for example, a preponderance of wave 2 over 3 in almost every level and month. However, the QS3 has greater amplitude than QS2 in the first half of the year. In contrast with wave-numbers 2 and 3, $\overline{ZW1}$ and QS1 fields are very similar.

These differences are related to the degree of stationatiry of zonal waves and are location-dependent. Figure 2 show the same variable that Figure 1 but for 300hPa. The contrast between the northern and shouthern hemisphere is not only evident in the amplitud of the planetary waves, but also in the comparison between $\overline{ZW}$ and QS. Specially for wave-numbers 2 and 3, $\overline{ZW}$ and QS fields are very similar in the north but they have significant diferences in the south. The theorical implication is that planetary waves are

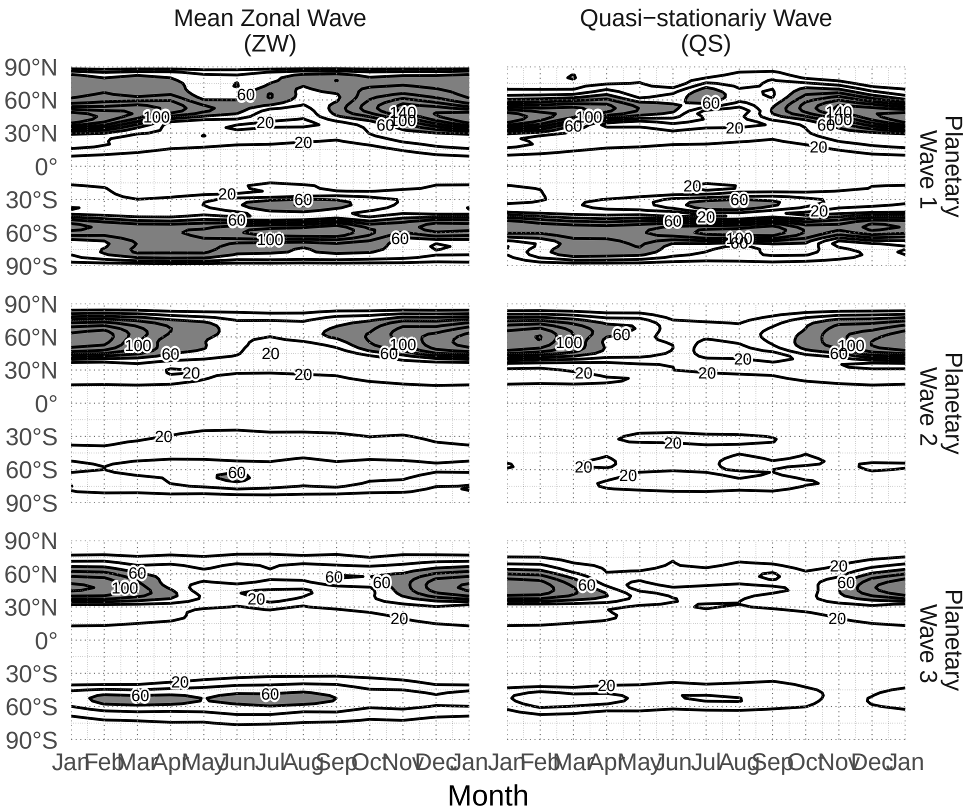

Figure 2. Seasonal cycle of amplitude of the geopotential planetary waves 2 at 300hPa computed as the mean amplitude of the monthly waves ($\overline{ZW}$) and as the amplitude of the mean wave (QS). The period of analysis is 1979 to 2017.

more stationary in the northern hemispher while the practical implication is that researchers of the southern hemisphere planetary waves should be specially atentive to the choice of metodology.

Another important consequence of the distinction between $\overline{ZW}$ and QS is that the quotient between the two can be used as a measure of stationarity. As an analogy with the steadiness of the wind (Singer, 1967), planetary wave stationarity can be calculated as

$$S = \frac{2}{\pi}\arcsin\left(\frac{QS}{\overline{ZW}}\right) \tag{1}$$

It can be shown that $S = 1$ for completely stationary waves and that $\lim_{n\to\inf} S = 0$ for completely non-stationary waves with convergence of $O\left(n^{1/2}\right)$ (where n is the sample size).

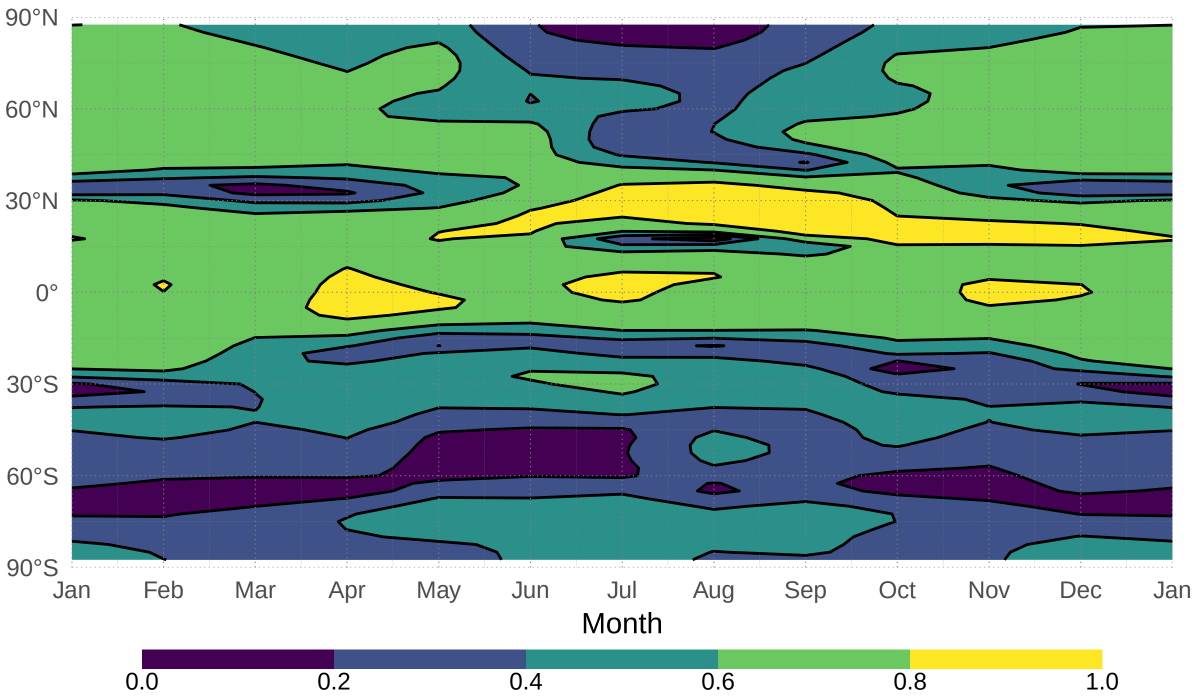

Figure 3. Stationarity of the 300hPa geopotential QS2

Figure 3 show S computed using Equation 1

2.1 Mathematical considerations

Let w_1, w_2 be two waves of wavenumber k defined by

$$w_1 = A_1 \cos(k(\phi - \alpha_1)) \quad w_2 = A_2 \cos(k(\phi - \alpha_2)) \tag{2}$$

where A_i, $alpha_i$ are their amplitudes and phases and ϕ is longitude. The amplitude of the sum of both waves is

$$A(w_1 + w_2) = A_3 = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\alpha_1 - \alpha_2)} \tag{3}$$

References

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