

Interactive comment on “Observation of a tidal effect on the Polar Jet Stream” by C. H. Best and R. Madrigali

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Reply to comments by J.B. Mathews

1. The subject of our paper is not related to the work of Richard Lindzen. He is referenced simply because he is an acknowledged expert on Atmospheric Tides, and a co-author with Sydney Chapman of a benchmark review published in 1970. Our paper is not concerned with Anthropogenic Global Warming (AGW) at all and Richard Lindzen's views on AGW are not relevant to this paper.

2. The definition of tractional force is described in the appendix. The definition agrees exactly with that given by NOAA. <https://tidesandcurrents.noaa.gov/restles3.html>

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<Quote>: "The Tractive Force. It is significant that the influence of the moon's gravitational attraction superimposes its effect upon, but does not overcome, the effects of the earth's own gravity. Earth-gravity, although always present, plays no direct part in the tide-producing action. The tide-raising force exerted at a point on the earth's surface by the moon at its average distance from the earth (238,855 miles) is only about one 9-millionth part of the force of earth-gravity exerted toward its center (3,963 miles from the surface). The tide raising force of the moon, is, therefore, entirely insufficient to "lift" the waters of the earth physically against this far greater pull of earth's gravity. Instead, the tides are produced by that component of the tide-raising force of the moon which acts to draw the waters of the earth horizontally over its surface toward the sublunar and antipodal points. Since the horizontal component is not opposed in any way to gravity and can, therefore, act to draw particles of water freely over the earth's surface, it becomes the effective force in generating tides.

At any point on the earth's surface, the tidal force produced by the moon's gravitational attraction may be separated or "resolved" into two components of force - one in the vertical, or perpendicular to the earth's surface - the other horizontal or tangent to the earth's surface. This second component, known as the tractive ("drawing") component of force is the actual mechanism for producing the tides. The force is zero at the points on the earth's surface directly beneath and on the opposite side of the earth from the moon (since in these positions, the lunar gravitational force is exerted in the vertical - i.e., opposed to, and in the direction of the earth-gravity, respectively). Any water accumulated in these locations by tractive flow from other points on the earth's surface tends to remain in a stable configuration, or tidal "bulge"." <End Quote>

Tractional tidal forces clearly exist and are the cause of horizontal tidal flows in the ocean and tidal winds in the Atmosphere. The movement of water in and out of tidal estuaries and the generation of tidal bores in rivers demonstrate this.

3. The paper by Francis and Varfus (2012) concerns 'Arctic Amplification' or long time scale warming in the Arctic leading to lower zonal winds and to larger meanders in

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Rossby Waves. Francis and Varfus do not study the 'Arctic Oscillation' or changes to Jet Stream flow on monthly timescales, which is the topic of our study. Therefore the paper is not relevant.

4. The paper by Douglas concerns the multi-annual phase locking of climate indices PDO/NAO and ENSO to the solar cycle. However, we are studying short timescales variations of the AO which are unaffected by the solar cycle.

5. Our paper concentrates on one topic - a possible influence of tides on Jet Stream flow. We find there is strong evidence that atmospheric tides do indeed affect Jet Stream flow and polar circulation, especially in winter months. The cross correlation between the 2 signals for AO and tides proves an underlying causal relationship across 65 years of daily data. We do not claim that this is the only effect on Jet stream flow, but that strong changes in atmospheric tides at high latitude distort the Jet Stream flow.

6. The comments about Ocean heat content, climate change and the effects of the solar cycle are interesting, but are not really relevant to the paper in question. The results of our paper are unaffected.

In conclusion, there are no substantive criticisms made by J.B. Mathews that undermine any of the arguments or conclusions of our paper.

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