LETTER

Comment on the subsidence adjustment applied to the Kemp et al. proxy of North Carolina relative sea level

Kemp et al. (1) presented a new salt-marsh proxy record of relative sea level (RSL) from North Carolina (NCRSL). The salt marsh is slowly subsiding as a result of glacial isostatic adjustment (GIA), and the NCRSL record needs to be adjusted to remove this vertical land movement from the sea level record. Kemp et al. (1) corrected for a constant subsidence rate of approximately 1 mm/y. This is a "geologic" estimate based on sea level index points, which are determined from linear fits to data from other North American RSL proxy records. Thus, the geologic method implicitly assumes that the entire trend is a result of subsidence and leaves no room for any millennial-scale climate-driven changes in sea level. It is therefore not surprising that the adjusted RSL record has a preindustrial trend near zero.

To assess the uncertainty of the subsidence adjustment, we can look at several alternative estimates of the subsidence rate, and this is done by Engelhart et al. (2). Global modeling of glacial isostasy (3) gives a rate of subsidence of approximately 1.3 mm/y. Direct GPS measurements indicate an even higher rate of subsidence of the regional proglacial forebulge (2). Finally, local tide gauge records have a 20th century rate of sea level rise of close to 4 mm/y (2), or approximately 2 mm/y higher than the global mean rate of sea level rise. To summarize, all these alternative estimates point to a substantially greater rate of subsidence than the 1 mm/y geologic estimate. We therefore question the zero-trend assumption used in the geologic estimates. We prefer the midrange correction from modeled GIA (3), which incorporates many lines of evidence and additionally includes nonlinear terms. Until the disagreement in subsidence rate has been resolved, the uncertainty must be gauged from the spread in alternative estimates, which is clearly much greater than the 2σ estimate of 0.1 mm/y in the study of Kemp et al. (1). In Fig. 1, we tentatively use an uncertainty of 0.5 mm/y, which accumulates to 1 m over 2,000 y. The impact of a greater rate of subsidence is that the adjusted NCRSL has a negative preindustrial trend with a pronounced Little Ice Age minimum rather than being a record of predominantly rising sea level (Fig. 1).

We emphasize that the salt marsh record is an exceptional dataset on past sea level, but that great care must be taken to consider uncertainty in land movement that accumulates remorselessly over time, as we highlight here. Many of the primary conclusions of the work of Kemp et al. (1) were unaffected by a slightly greater subsidence correction, and the 20th century rate of rise is still exceptional. Hind-casts from semiempirical models (1, 4, 5) are consistent with the North Carolina salt-marsh proxy for a millennium (Fig. 1), but uncertainties are too large before that date.

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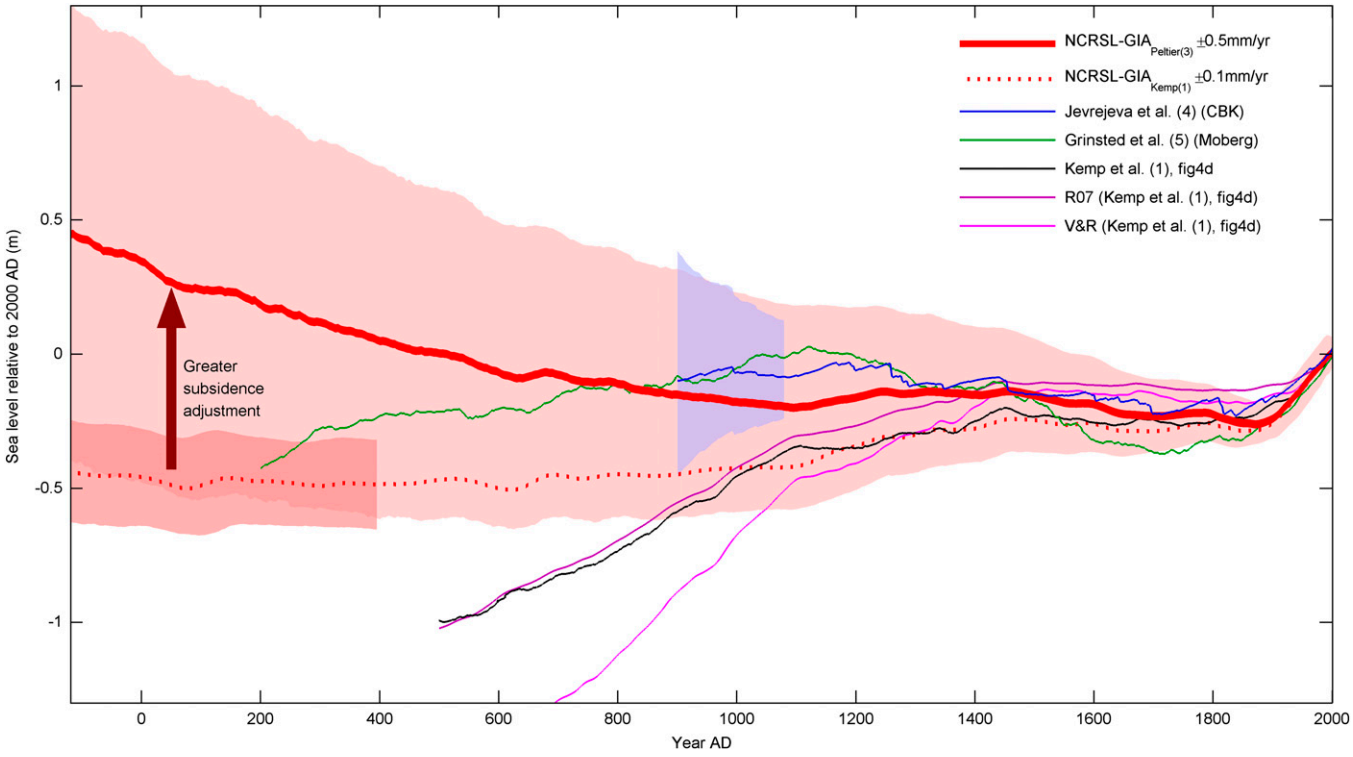

Fig. 1. Comparison of the North Carolina sea level reconstruction corrected for two different GIA adjustments (red lines) and global sea level hind-casts from semiempirical models (thin solid lines). The choice of GIA has a large impact on the adjusted North Carolina sea level. Semiempirical hind-casts of global sea level deviate slowly from the adjusted NCRSL curve, but confidence intervals overlap for more than a millennium. Illustrative 5% to 95% confidence intervals are shown by the shaded regions colored for the appropriate curves. A 50-y smoothing has been applied to NCRSL.