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Resolving Holocene hydroclimate and seasonality in the Pacific Northwest

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The Pacific Northwest (PNW) is projected to experience substantial hydroclimate change, but the seasonal expression of that change remains poorly constrained, and the instrumental record is insufficient to establish pre-industrial baselines. Paleoclimate records can extend this context, yet few marine records from the region resolve seasonal variability beyond mean conditions. From Oregon continental slope sediments (core OC1706B-11; 45.87°N, 124.85°W, 828 m water depth), we reconstruct Holocene (~12,000 years ago to present) hydroclimate and seasonality using individual foraminiferal analysis (IFA) of trace elements (Mg/Ca) and clustered stable isotope ($\delta^{18}O$, $\delta^{13}C$) measurements, paired with the alkenone unsaturation index (Uk'37). We apply novel mode-based decontamination of trace element data and clustering techniques for stable isotope grouping to the planktic foraminifera *Neogloboquadrina pachyderma* and *Globigerina bulloides*, capturing seasonal and water-column variability in temperature and salinity, including changes in Columbia River freshwater influence. Pairing this variability with time-averaged Uk'37 sea surface temperatures distinguishes changes in mean climate from changes in seasonality—a critical distinction for the PNW, where modern warming is amplifying the seasonal contrast between wetter winters and drier summers. Systematic multi-element and isotopic screening reveals a progressive diagenetic cascade downcore, with authigenic carbonate precipitation associated with methane oxidation affecting the deepest sediments. From well-preserved intervals, alkenone-based temperatures indicate the early Holocene was ~1°C warmer than present, while IFA reveals that this warming was accompanied by more frequent warm-dry conditions, increased variance, and greater thermal stratification inferred from divergence in Mg/Ca between surface- and thermocline-dwelling species. A consistent positive correlation between temperature and salinity indicates that warmer periods correspond with reduced freshwater discharge, mirroring modern climate relationships in the region. This coupling persists across different mean climate states, suggesting that mechanisms governing modern PNW hydroclimate have operated throughout the Holocene.