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Near-surface salinity stratification following rainfall using the Aquarius Rain Impact Model (RIM)

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Rainfall freshens the near-surface ocean, producing a vertical salinity profile that is fresher at the surface than at a depth of a few meters. As a result, there is a discrepancy between sea surface salinity (SSS) measured by satellites (which sample only the top few centimeters of the ocean surface) and salinity measured by in situ platforms (e.g., Argo floats, drifters, and moorings) that typically sample at a 1-5 m depth. Therefore, accurate comparisons between satellite and in-situ salinities in rainy conditions requires knowledge of how the upper ocean responds to rainfall.
At moderate wind speeds in the absence of rain, the ocean upper layer (i.e. from the surface to a depth of 5 m) is well-mixed and SSS is constant as a function of depth. However, under rainy conditions the near-surface salinity is diluted by the freshwater input from rain. This fresher water is mixed downward by turbulent diffusion through gravity waves and the wind stress. These processes create a salinity gradient in the upper 1-2 m of the ocean, which dissipates over a few hours until the upper layer becomes well mixed at a slightly fresher salinity value. As part of the Aquarius/SAC-D mission, a rain impact model (RIM) was developed to estimate the change in SSS due to precipitation near the time of the satellite observation. RIM uses ocean surface salinities from HYCOM (Hybrid Coordinate Ocean Model), which does not include the short-term rain effects, and the NOAA global rainfall product CMORPH to model transient changes in the near-surface salinity profile in 0.5 h time increments. The mechanical mixing of the ocean caused by wind and waves rapidly reduces the salinity stratification caused by rain. The persistence of rain-induced salinity gradients has been shown to depend on wind speed, with rain freshening during weak winds (less than 2 m/s) persisting for 8 hours or more. The original RIM assumes a constant vertical diffusivity, which neglects the effect of wind speed on the salinity gradient. Moreover, previous results from CFRSL show examples where, in the presence of moderate/high wind speeds, RIM overestimates the effect of rain on the observed surface salinity. This suggests that including the effect of wind would improve RIM. To address this issue, this paper introduces a revision to the RIM-2 model that accounts for the effect of wind speed on the mechanical mixing. This translates into a vertical diffusivity that is a function of wind and other known environmental parameters e.g. rain accumulation, surface wind speed, and significant wave height. The objective is to determine how rain and wind forcing control the thickness, stratification strength, and lifetime of fresh lenses and to quantify the impacts of rain-formed fresh lenses on the fresh bias in satellite retrievals of salinity. Results will be presented of comparisons of RIM-2 measurements at depth of a few meters with measurements from in-situ salinity instruments. Also, numerical results will be shown, which characterize RIM-2 salinity profiles under a variety of rain rate, wind/wave conditions.