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Rain Impact on Near-Surface Salinity Stratification using the Rain Impact Model (RIM)

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1. Extended Abstract

Under conditions of light ocean winds without precipitation, the ocean is well-mixed and the near-surface ocean salinity is approximately constant with depth; however, when rainfall occurs, it produces a vertical salinity profile that is fresher at the surface. This influx of rainwater will be mixed downward by turbulent diffusion through gravity waves and the wind stress [1], thereby creating a salinity gradient in the upper ~2 m of the ocean, which dissipates over a few hours until the upper layer becomes well mixed at a slightly fresher salinity value. Therefore, the salinity measured by in-situ instruments (1-5 m depth) will be different than the satellite-measured sea surface salinity (SSS) that is representative of the first cm of the ocean depth. Thus, it is important to understand the transient upper ocean salinity stratification caused by rainfall, for proper interpretation of satellite surface salinity measurements.

Under rainy conditions, the Aquarius satellite measurements of SSS showed significant differences compared to the bulk salinity at 1-5 m depth from the global Hybrid Coordinate Ocean Model (HYCOM). Therefore, a rain impact model (RIM) was developed to estimate the change in SSS due to precipitation near the time of the satellite observation [2]. RIM uses ocean surface salinities from HYCOM, and the NOAA global rainfall product CMORPH, to model transient changes in the near-surface salinity profile. Subsequently, in the presence of rain events, the RIM analysis was applied to SMOS (Soil Moisture and Ocean Salinity) and SMAP (Soil Moisture Active Passive), and the satellite remotely sensed SSS changes were successfully predicted by the RIM calculations.

The original version of RIM assumes a constant vertical diffusivity, which neglects the effect of wind speed. However, near-surface salinity measurements using in-situ probes have shown that the persistence of rain-induced salinity stratification depends on wind speed [3]; and the mechanical mixing of the ocean caused by wind and waves rapidly reduces the salinity stratification caused by rain. Also, from satellite SSS observations, with rain accompanied by moderate to high wind speeds, RIM calculations overestimates the effect of rain on the SSS [4]. This suggests that for RIM to accurately model the near-surface salinity stratification, the effect of wind needs to be included in the vertical mixing model.

Thus, this paper will focus on modifying RIM to include the effects of wind on vertical diffusivity at the ocean surface, giving RIM the ability to model the sensitivity of the result to different peak rain rates, and understanding how environmental conditions such as net heat flux and diurnal warming affect RIM estimates of surface freshening. This translates into developing a parameterization of the vertical near-surface turbulent diffusivity that can be incorporated into the existing version of RIM. Then, the vertical diffusivity may be a function of several environmental parameters, such as rain accumulation, surface wind speed, and significant wave height, etc. Results will be presented of comparisons of RIM measurements at depth of a few meters with measurements from in-situ salinity instruments. Also, numerical results will be shown, which characterize RIM salinity profiles under a variety of rain rate, wind/wave conditions.

4. References

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