RADIO SCIENCE, VOL. 38, NO. 4, 8064, doi:10.1029/2001RS002584, 2003

Sea surface salinity from space: Science goals and measurement approach

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Received 30 November 2001; revised 15 February 2002; accepted 18 November 2002; published 3 June 2003.

[1] Aquarius is a NASA/Earth System Science Pathfinder (ESSP) mission that proposes to make the first-ever global measurements of sea surface salinity. These measurements will enable improved understanding of oceanic thermohaline circulation and of the changes in oceanic circulation that are related to seasonal to interannual climate variability. Aquarius science goals also address tropical ocean-climate feedbacks and freshwater budget components of the coupled ocean-atmosphere system. These oceanographic science requirements for Aquarius dictate measurements of global sea surface salinity that are accurate to 0.2–0.3 psu, as averaged monthly and over 100–200 km areas. Key aspects of the Aquarius salinity mission design include the instrument with its high-stability L-band radiometers, the precise calibration of the measurements, and the salinity retrieval algorithm. The Aquarius mission will meet the science needs by providing complete global coverage of ocean surface salinity, with an 8 day cycle of observations using a three beam, L-band radiometer/scatterometer flying in a 6 am/6 pm polar orbit. This conceptual design has been verified using observations from aircraft flight instruments. The radiometer design for the instrument and the needed precise calibration is based on proven, temperature-stabilized radiometer designs with internal references, plus vicarious calibration approaches developed in the course of previous space missions. *INDEX TERMS:* 4294 Oceanography: General: Instruments and techniques; 4215 Oceanography: General: Climate and interannual variability (3309); 4279 Oceanography: General: Upwelling and convergences; *KEYWORDS:* ocean salinity, sea surface salinity, passive microwave, microwave radiometers

Citation: Koblinsky, C. J., P. Hildebrand, D. LeVine, F. Pellerano, Y. Chao, W. Wilson, S. Yueh, and G. Lagerloef, Sea surface salinity from space: Science goals and measurement approach, *Radio Sci.*, *38*(4), 8064, doi:10.1029/2001RS002584, 2003.

1. Salinity Science Goals

[2] The salinity of the ocean surface (Figure 1) is variable, reflecting the input of fresh water from precipitation, the melting of ice, river runoff, the loss of water through evaporation, and the mixing and circulation of ocean surface water with deep water below. Globally, the sea surface salinity (SSS) is at a minimum near the equator (where there is considerable precipitation) and in polar regions (due to the melting of ice), and is at a maximum in midlatitudes (where there is reduced precipitation and enhanced evaporation). SSS ranges from about 32 to 38 psu, where the practical salinity unit (psu) is approximately equal to the mole fraction of sea salt in water, given in parts per thousand.

[3] The sampling of global sea surface salinity (Figure 1) has been sparse, and is largely limited to shipping lanes and the summer season. A review of historical data

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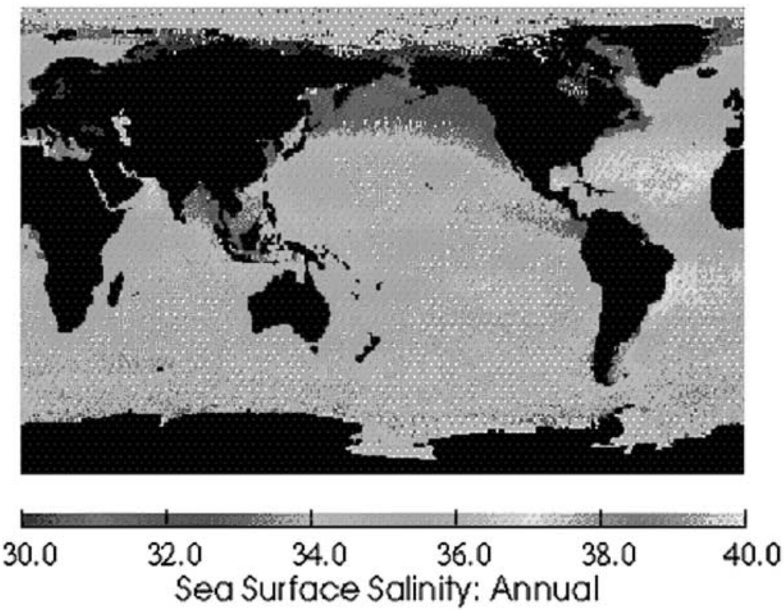

Figure 1. The estimated annual mean SSS field as derived from the World Ocean Database [*Levitus et al.*, 1998]. The data are gridded on a 1° × 1° area with gray areas representing no data. From 70°S–70°N, about 25% of the oceanic salinity has never been measured. See color version of this figure at back of this issue.

[*Levitus et al.*, 1998] indicates that in the ice-free areas of the ocean, about 25% of the 1° latitude-longitude squares have never been sampled, and >73% have fewer than 10 observations. The salinity measurements that do exist, therefore resolve only large, basin-scale salinity patterns; the present knowledge of seasonal-to-interannual variability of sea surface salinity is weak at best.

[4] A more exacting understanding of oceanic salinity is important to explanation of the relationship between ocean circulation and climate. This is because the ocean circulation is largely driven by buoyant forces that are roughly equal functions of seawater temperature and salinity. Additional forcing of the thermohaline ocean circulation is a result of wind stress at the sea surface and internal forces such as Coriolis and frictional forces and internal waves. Presently, the sea surface temperature, winds and sea surface topography are adequately measured on a global scale. The Aquarius global salinity measurements will provide the critical additional measurements needed to understand and predict the buoyant forcing of oceanic circulation. Improved understanding of the oceanic buoyancy field will improve our understanding and prediction of seasonal to interannual changes in oceanic circulation and the feedback between oceanic circulation and climate.

[5] The Aquarius mission has been proposed to the NASA Earth System Science Pathfinder Program. The science goals of Aquarius are to: (1) provide the first, global mapping of the complete oceanic SSS field, (2) to better describe the global thermohaline circulation, (3) to improve understanding of the tropical ocean-climate feedback such as el Niño, and (4) to facilitate investigations of the freshwater budget component of coupled ocean-atmosphere models.

[6] To meet these science goals, the Aquarius satellite will provide salinity measurements over the range from 32 to 38 psu, and with an accuracy of 0.2–0.3 psu. This required measurement accuracy results from the analysis of the underlying variability of salinity measurements at single locations, the observations of salinity anomalies [e.g., *Dickson et al.*, 1988; *Belkin et al.*, 1998], studies of the effects of rainfall and runoff [e.g., *Cronin and McPhaden*, 1999] and from studies of seasonal to interannual salinity variability [e.g., *Dessier and Donguy*, 1994; *Donguy and Meyers*, 1996; *Large and Nurser*, 2001; *Delcroix*, 1998; *Delcroix and McPhaden*, 2002]. The measurement domain will include the open ocean more than 150 km from coastal and sea ice boundaries. These global SSS measurements will be made with ~100 km resolution, every 8 days and will characterize salinity variability over the two year mission lifetime. These 100 km, 8 day cycle measurements will be averaged to produce a final monthly salinity product that has the spatial and temporal coverage and measurement accuracy that is needed to meet the Aquarius science goals.