Yale 耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

Deuterium and oxygen 18 variations in the ocean and the marine atmosphere

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Jan 18, 2013

Introduction

Why do we have to use isotopes instead of salinity with the study?

- More freedom;
- More convenient ;
- Plausible.

Table 3. — *Oxygen isotopic composition of the principal deep water masses.*

	Salinity	δO^{18} (‰)
North Atlantic Deep Water	34.93	+0.12
Antarctic Bottom Water	34.65	−0.45
Indian Deep Water	34.71	−0.18
Pacific Deep Water:		
Pacific Antarctic (55-65°S)	34.700	−0.21
South Pacific (22-40°S)	34.707	−0.17
Equatorial Pacific (6°S-30°N)	34.692	−0.17
North Pacific (44-54°N)	34.700	−0.17
Circumpolar Water	34.69	−0.3 to −0.2

Relationship between O^{18} and D

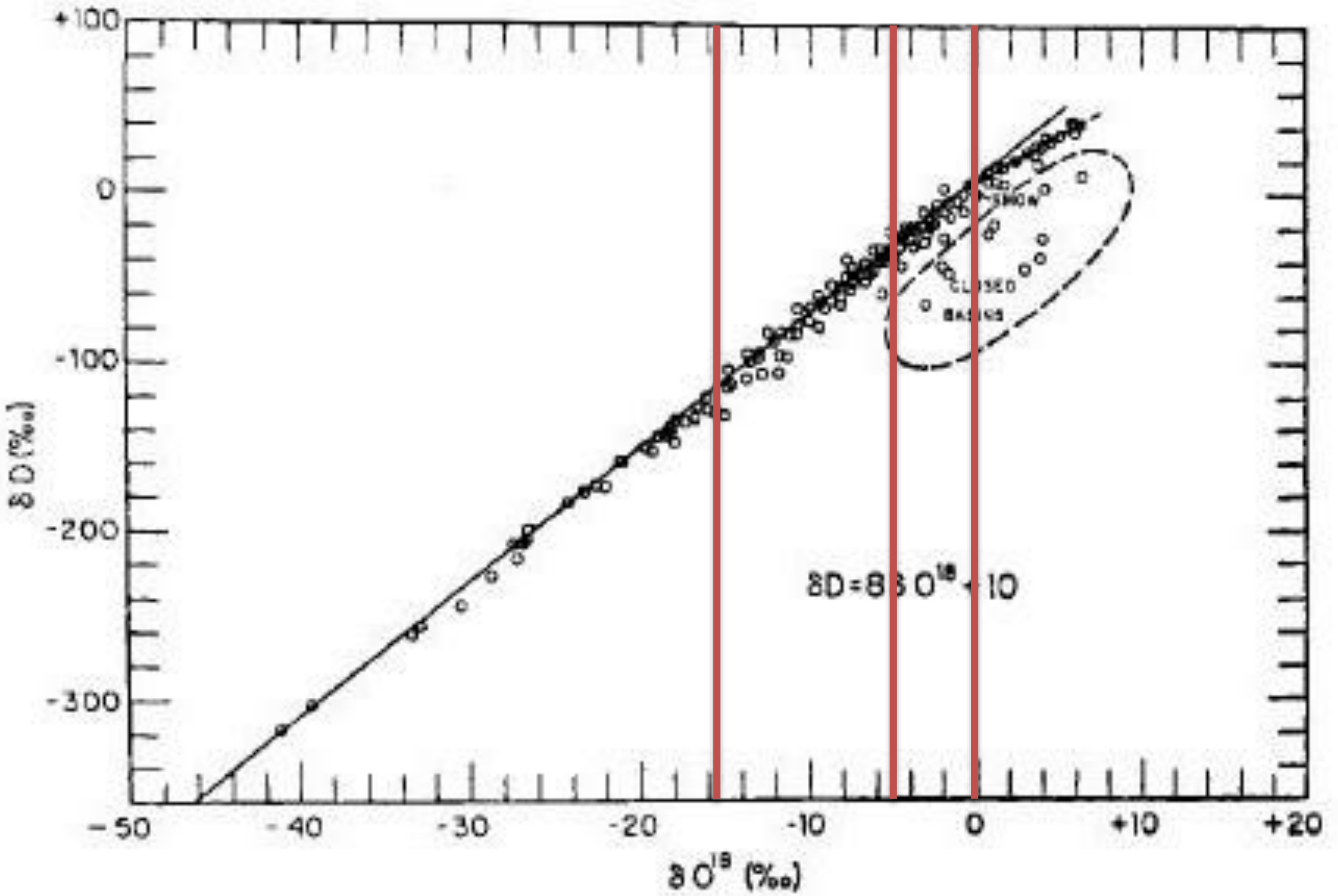

FIGURE 1. — *Deuterium and oxygen 18 variations in precipitation and meteoric waters, relative to the SMOW standard (from* H. CRAIG, 1961 a).

Evaporation and Molecular Exchange

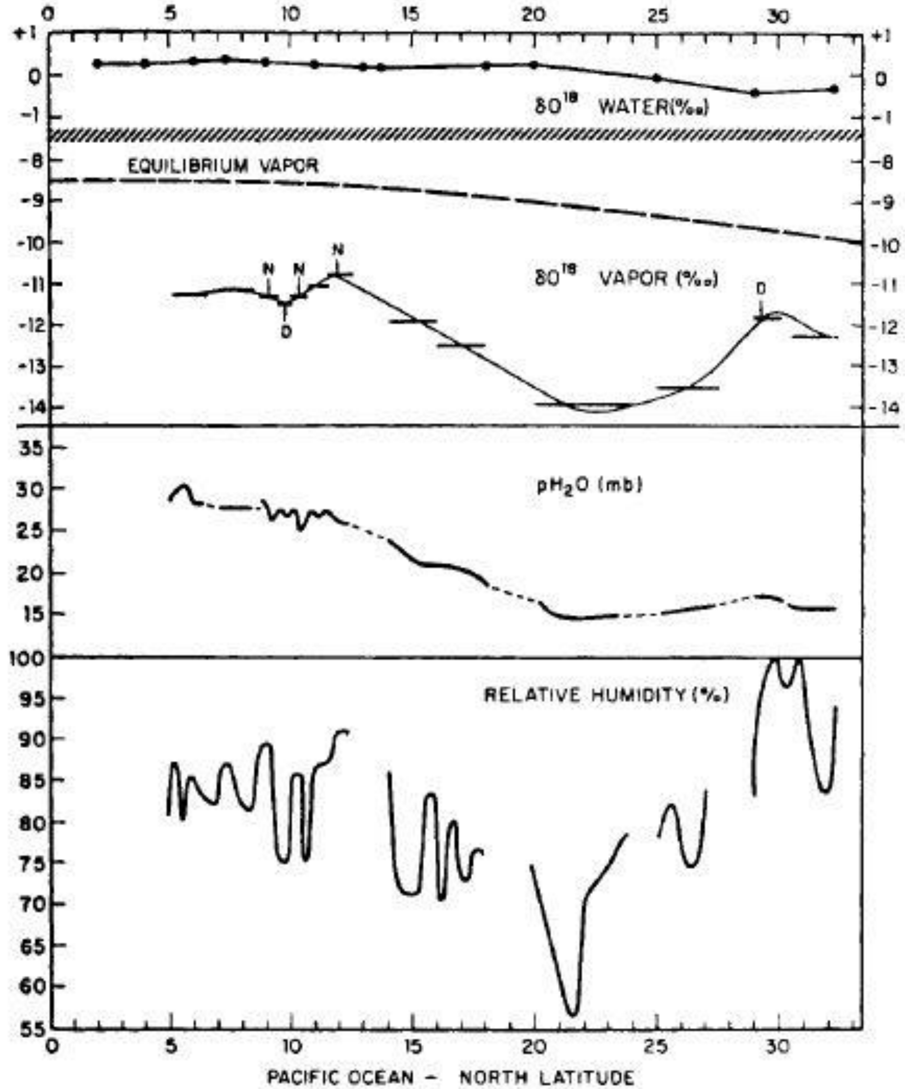

FIGURE 2. — *Oxygen 18 variations in vapor collected at mast height in the North Pacific (Expedition Monsoon, track shown in figure 6). At the top of the figure the variations in the surface water are shown, and a dashed line for the composition of the vapor which would be in isotopic equilibrium with the observed surface water.*

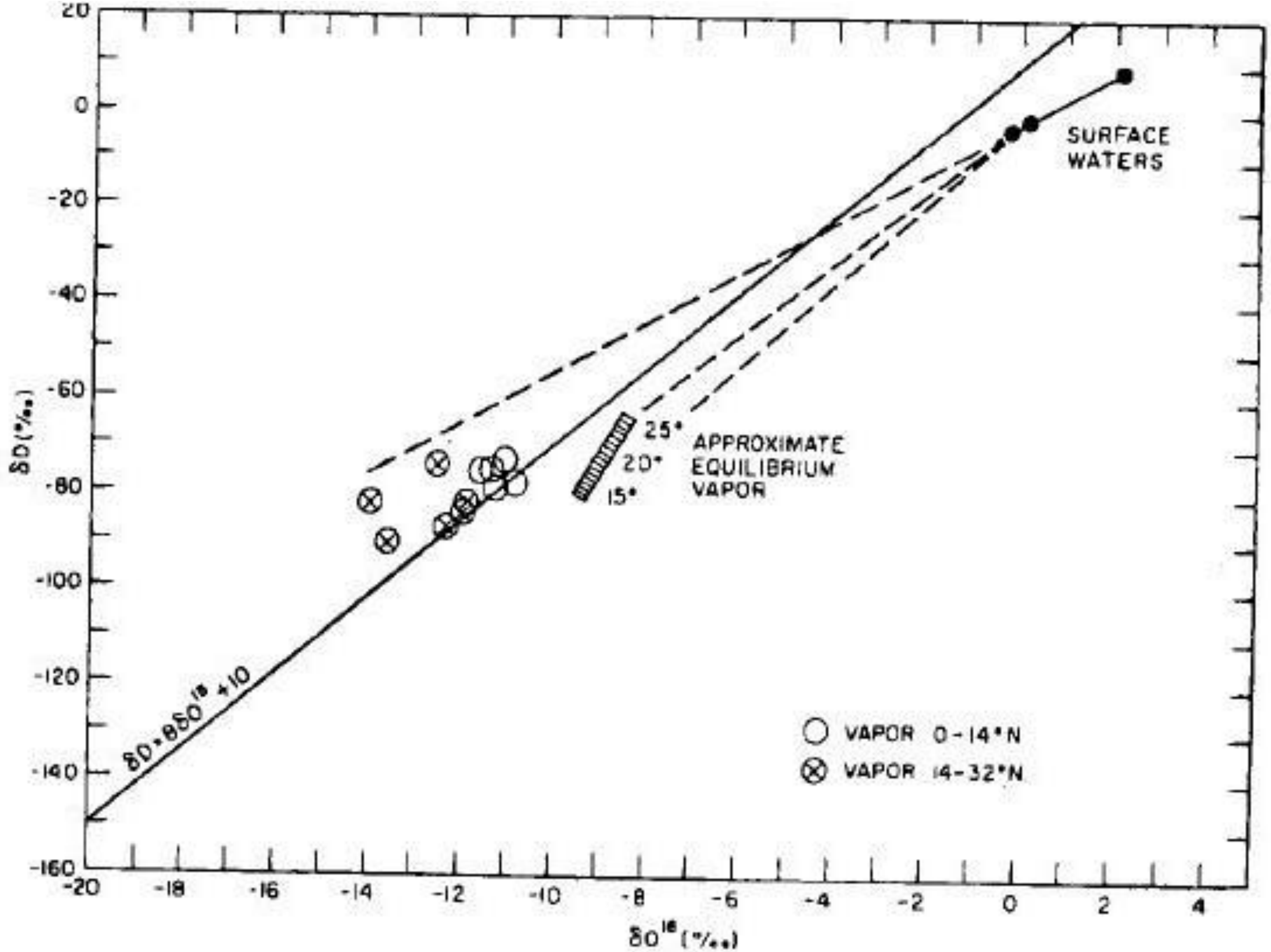

FIGURE 4. — *Deuterium and oxygen 18 values observed in N. Pacific marine vapor collected on Monsoon Expedition. The solid line is the trajectory of precipitation and meteoric waters shown in figure 1. The barred area shows the composition of vapor which would be in equilibrium with the surface sea water.*

Comparison with previous data

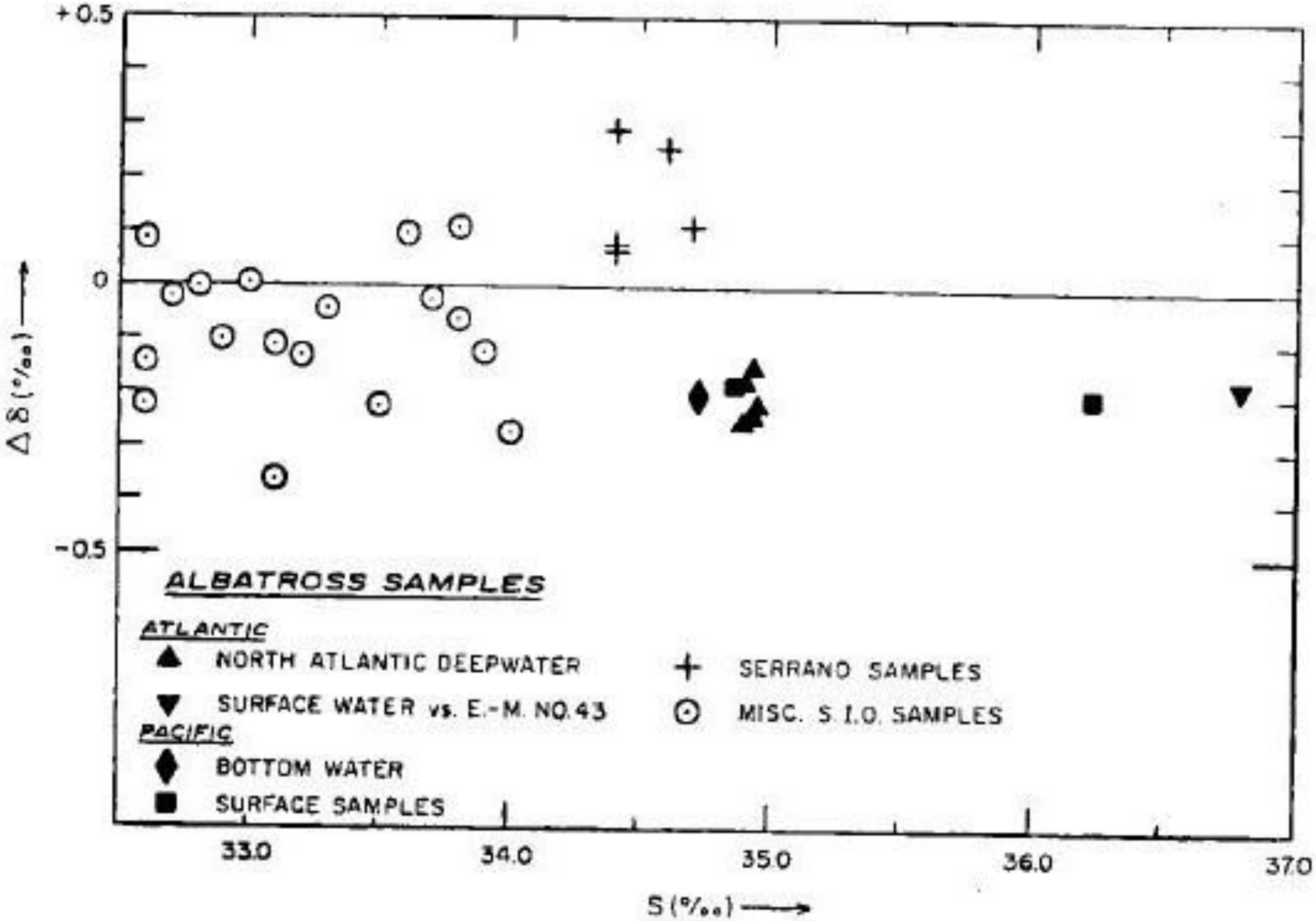

FIGURE 5. — *Deviations of the δO[18] values measured by* EPSTEIN *and* MAYEDA *(1953) and expressed vs. SMOW from our data on the same waters, plotted as their delta value minus ours, vs. salinity of the water. The inverted solid triangle is an intercomparison of two of their waters (see text). The Albatross expedition samples are uniformly 0.2 per mil light because of HCl solution addition to the samples when collected.*

Oceanographic data

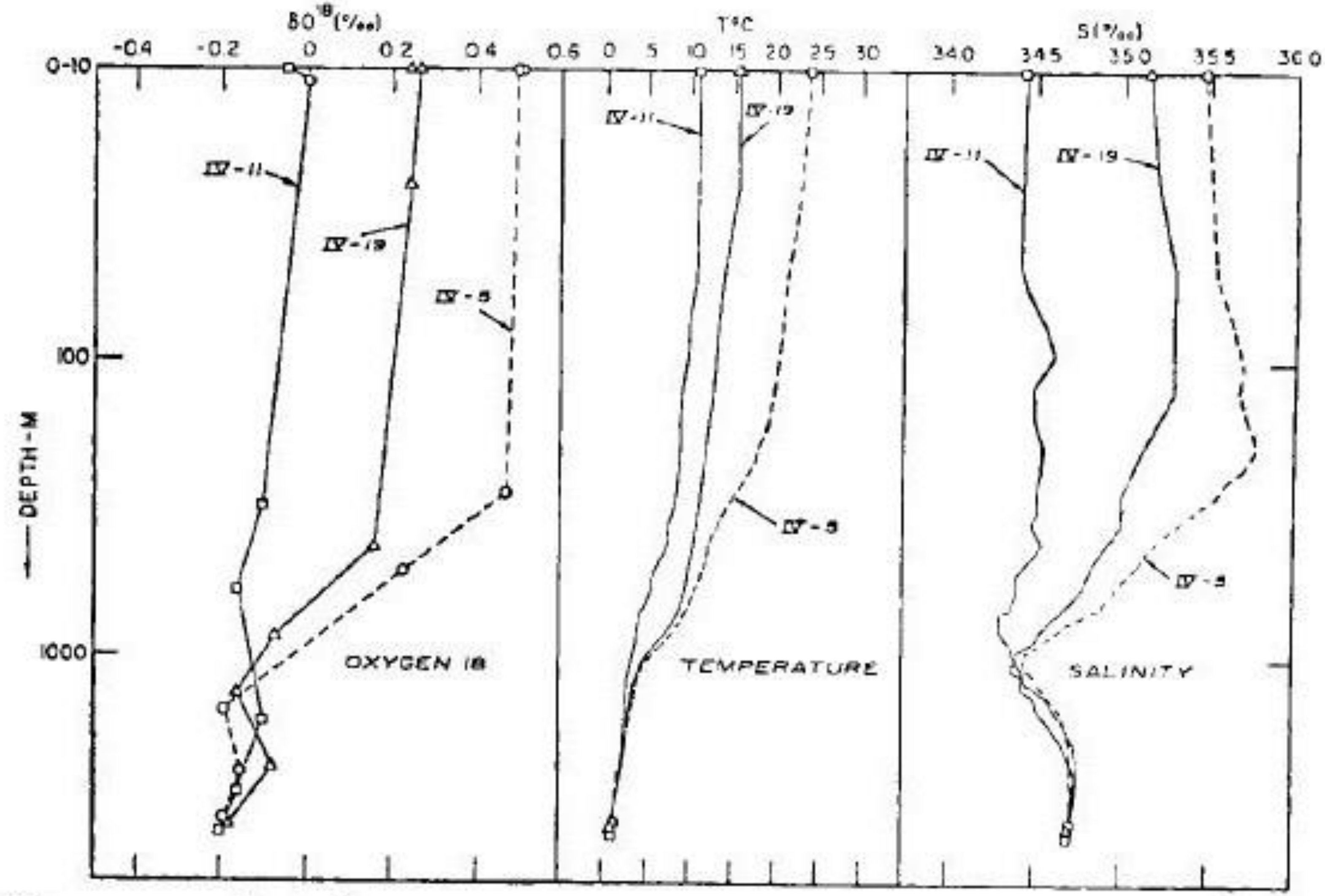

FIGURE 7. — *Isotopic, temperature, and salinity profiles at three stations in the Indian Ocean. Station locations are shown in Figure 6.*

Oxygen 18- salinity relationships in surface and deep Pacific Ocean samples

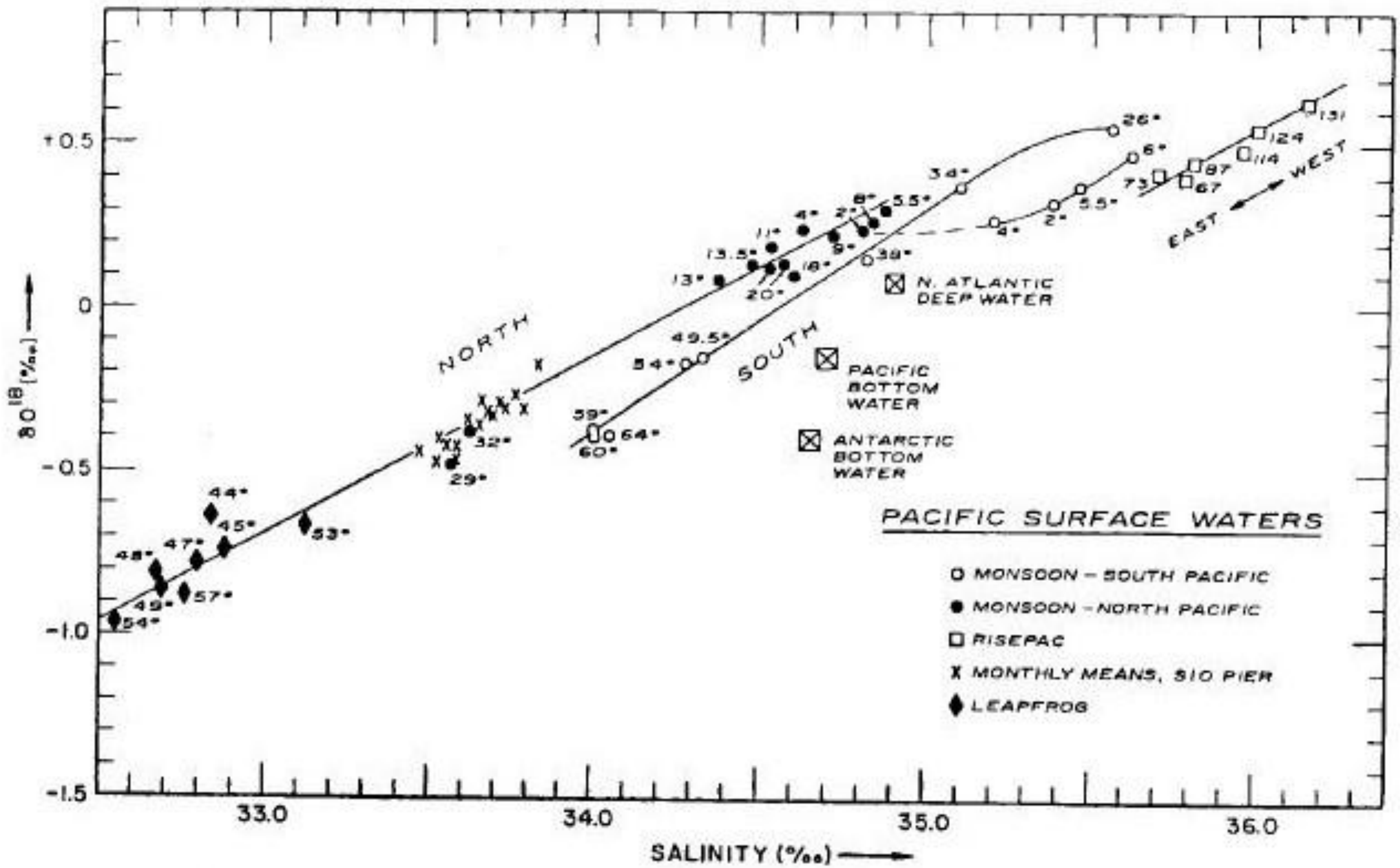

FIGURE 10. — *Oxygen 18-salinity relationships in surface and deep Pacific Ocean samples. Latitudes are shown for Monsoon and Leapfrog samples; the figures on the Risepac expedition points are station numbers shown in figure 6.*

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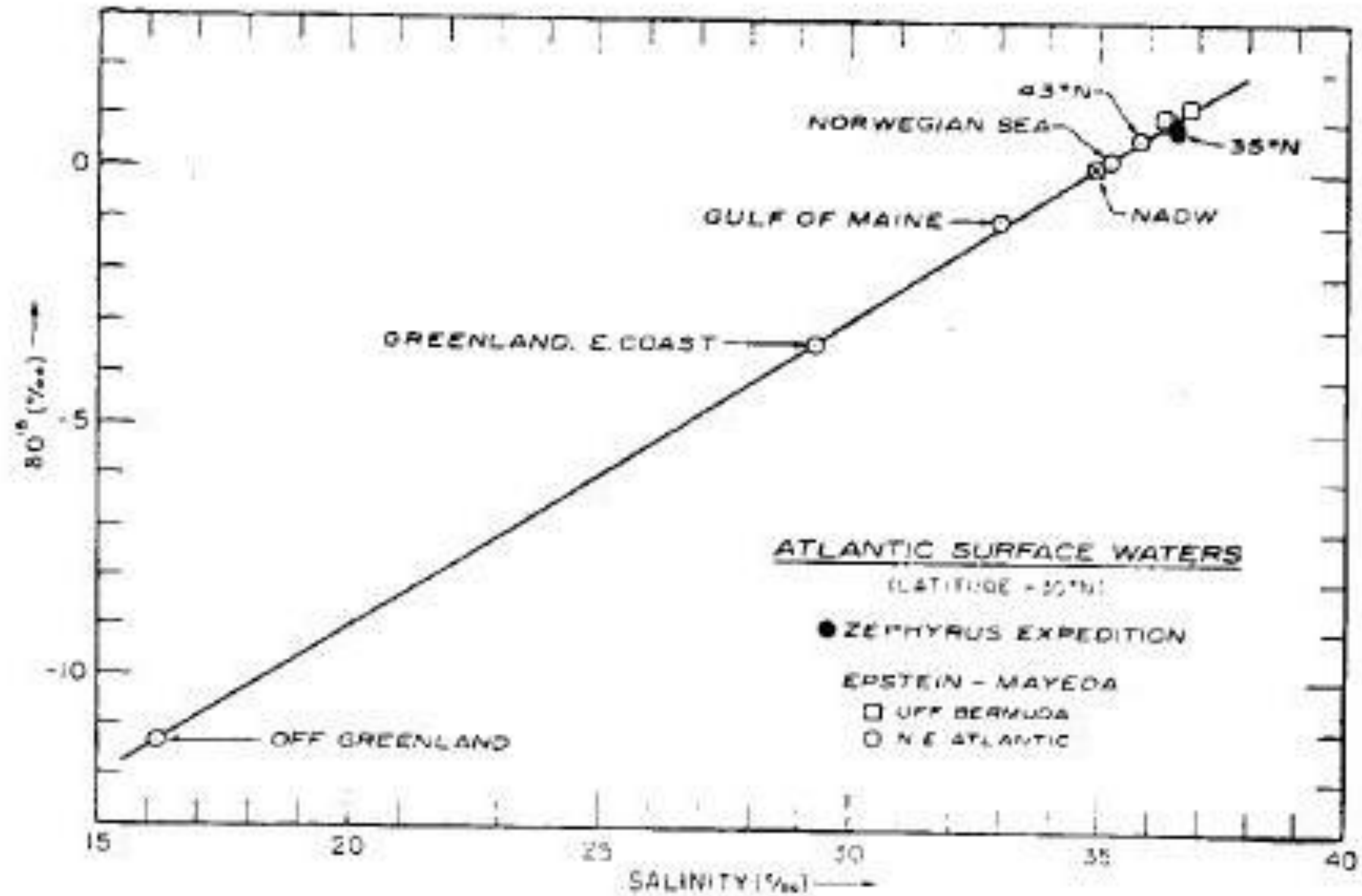

FIGURE 11. — *Oxygen 18-salinity relationship of North Atlantic surface waters and the North Atlantic Deep Water (NADW). Deep water data from the present work; surface waters from* EPSTEIN *and* MAYEDA *(1953) and present work.*

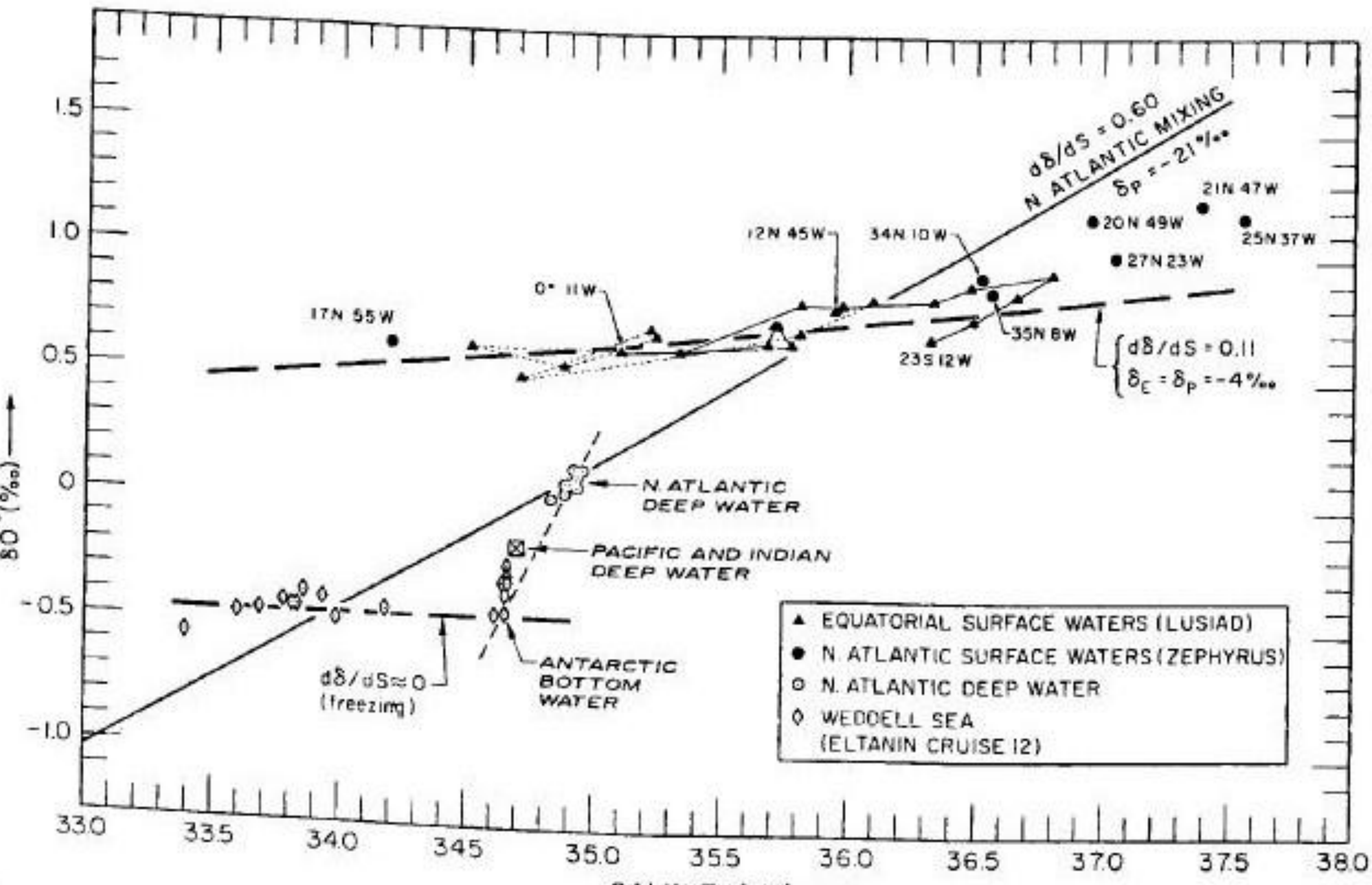

FIGURE 12. — *Oxygen 18-salinity relationships in Atlantic surface and deep waters.* δ_E *and* δ_P *refer to t*[...]*topic composition of evaporating vapor and precipitation respectively.*

Figure 10-12 have shown that:

The North Atlantic Deep Water has a purely convective origin;

The Pacific and Indian Ocean Deep Water have the “third component”.

An laminar model for an isolated liquid

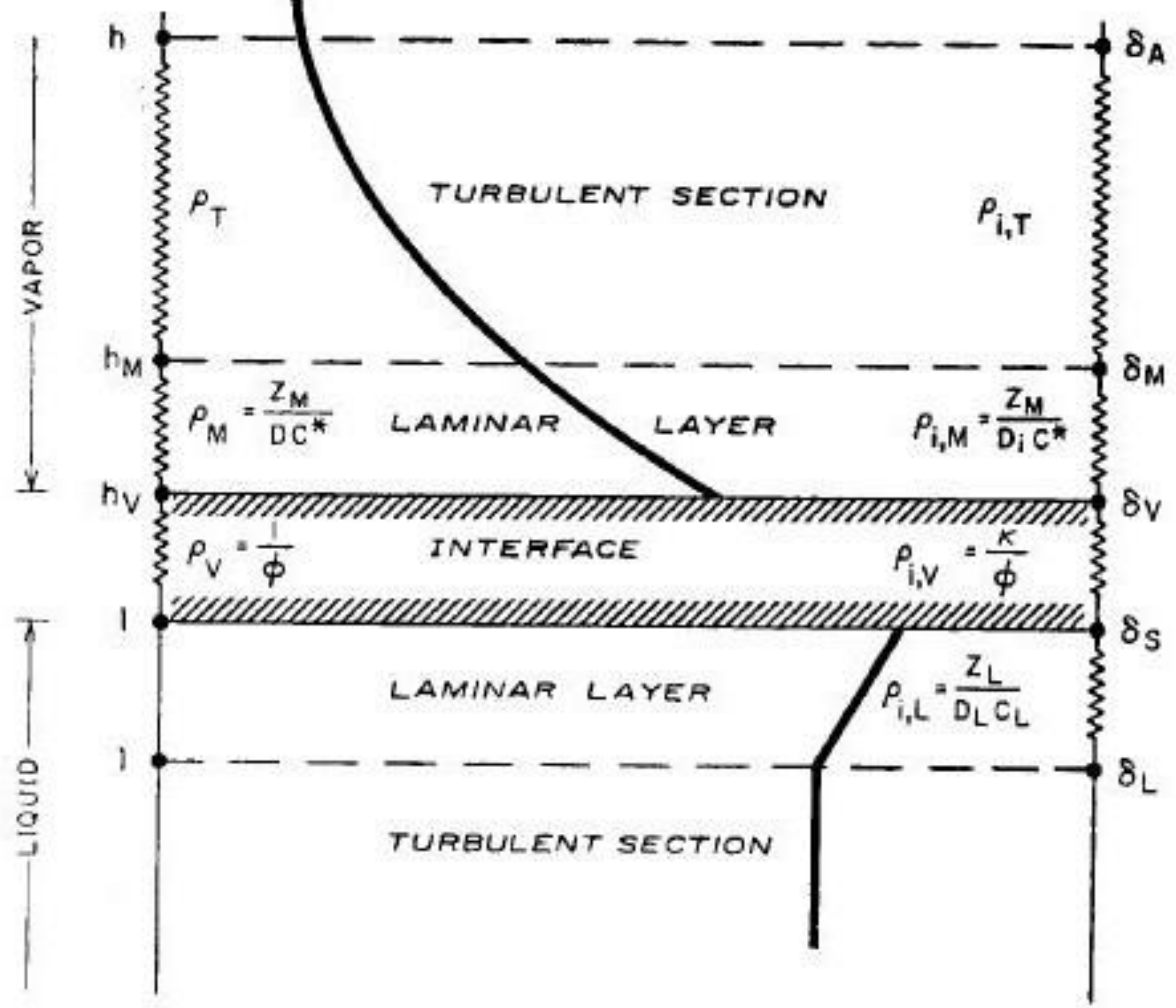

FIGURE 13. — *A laminar layer model for an isolated liquid. The heavy curve in the vapor phase represents water vapor concentration or isotopic delta value of the vapor. The heavy profile in the liquid represents the isotopic delta value of the liquid. The various ρ and ρ_i expressions are the transport resistances for* H_2O^{16} *and for the heavy isotopic species. The other symbols are defined in the text.*

Observing data compared with the hydro dynamically rough surface model

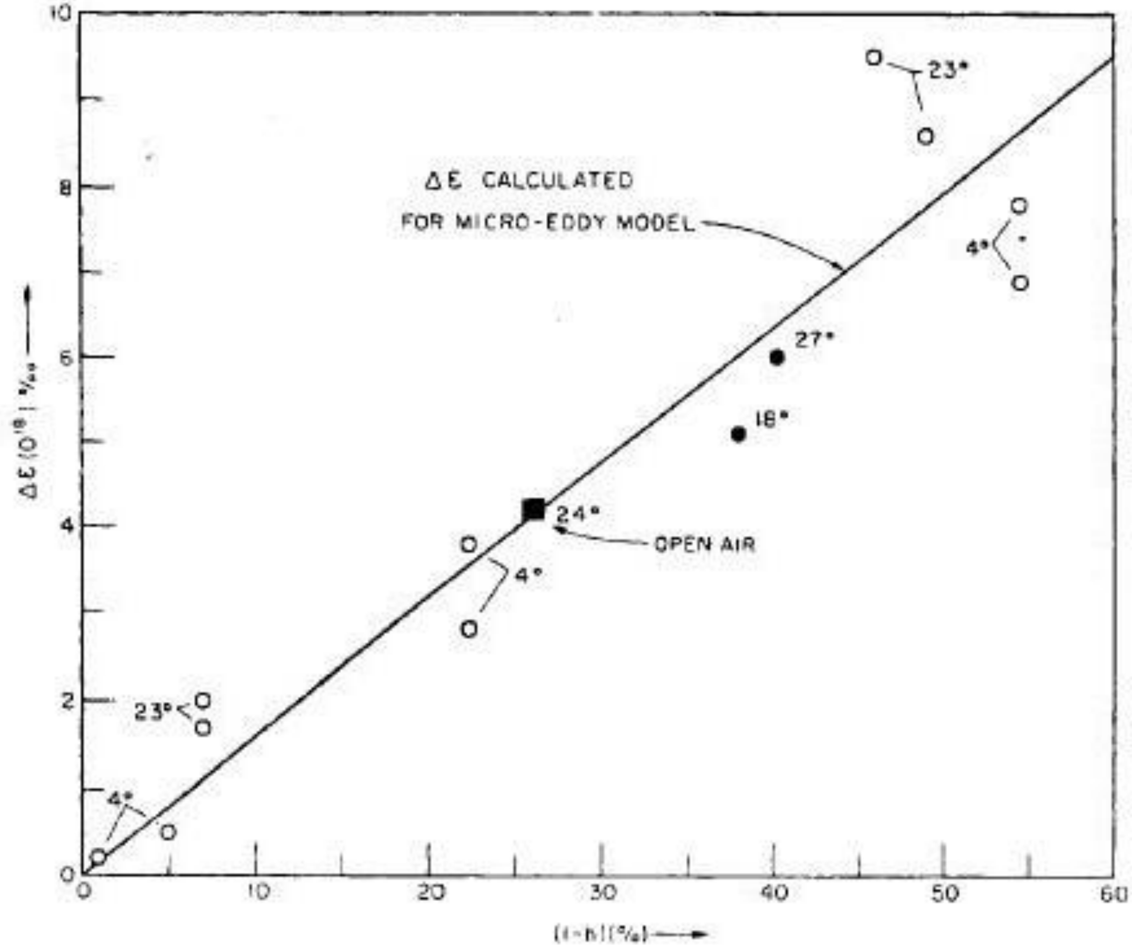

FIGURE 14. — *Observed values of Δε for H_2O^{18} from experiments compared with values calculated for a hydrodynamically rough surface, as a function of the humidity of the air emerging from the apparatus. Solid points from CGH experiments (and one later experiment not given in that paper); open circles calculated from data of* DANSGAARD *(1961). Temperatures refer to the liquid during the experiment. The point marked « open air » is plotted relative to the humidity of the ambient « free air ». The line represents the values calculated from the model, which differs from that shown in Figure 13 by having no fixed laminar layer over the rough surface.*

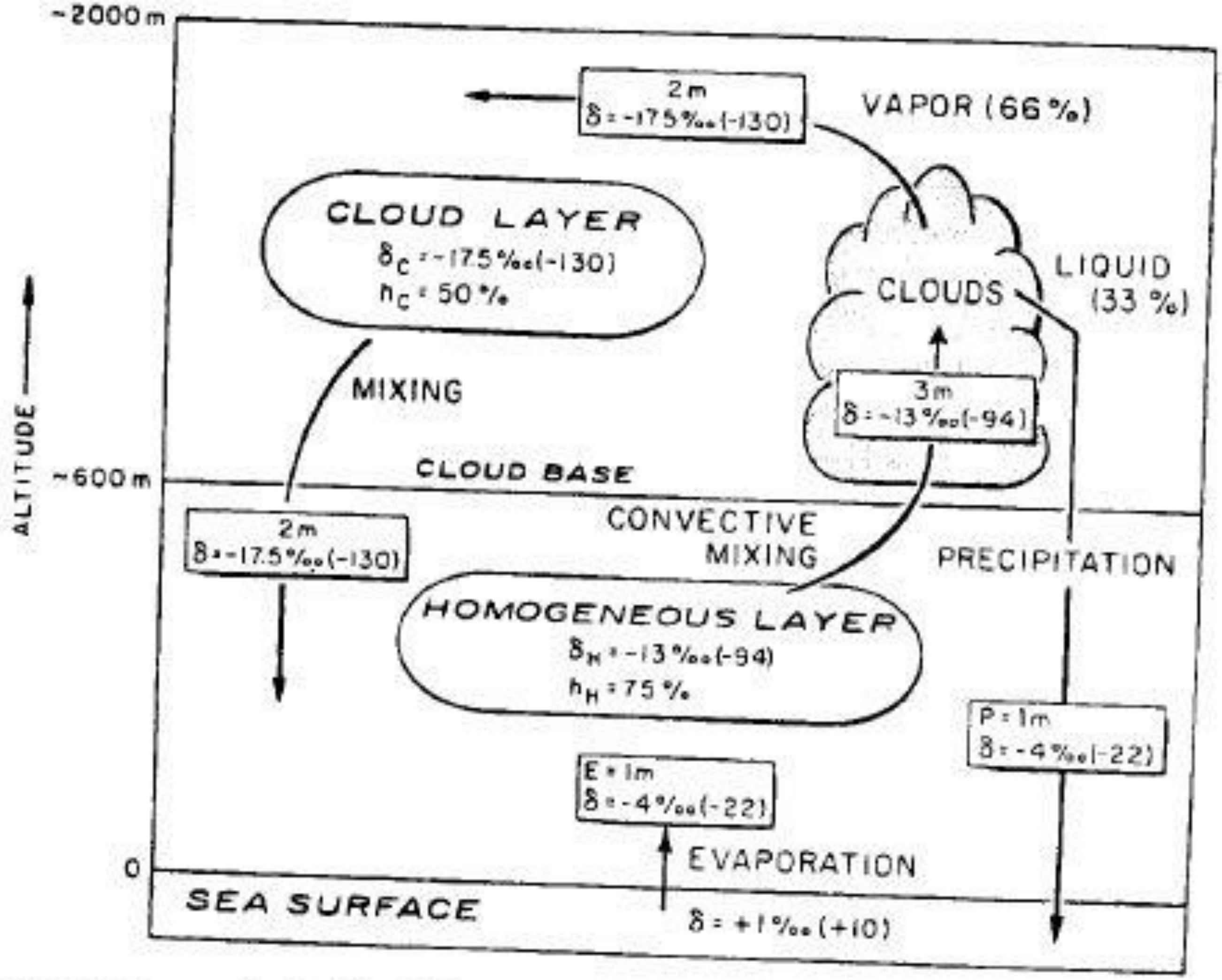

FIGURE 15. — *A model of the evaporation, mixing, and precipitation conditions over the sea, based on the atmospheric structure in the trade winds regions. The water transport values shown on the arrows, e.g. 2 m, represent meters/year of liquid water. The isotopic delta values give first* δO^{18}, *then in parentheses the corresponding value of* δD. *Data within the ovals marked « Cloud Layer » and « Homogeneous Layer » show the assumed values of relative humidity* (h), *normalized to sea surface temperature, and the assumed or calculated delta values for these atmospheric regions. The terminology is that of* BUNKER et al. (1949).

Conclusion

The isotopic variations in the surface waters are produced by the processes of precipitation, evaporation, mixing, and in some cases freezing .

The core waters are remarkably uniform, but increased precision of measurement results in a range of little more than 0.1 per mil in oxygen 18 in the NADW.

The end, thank you!