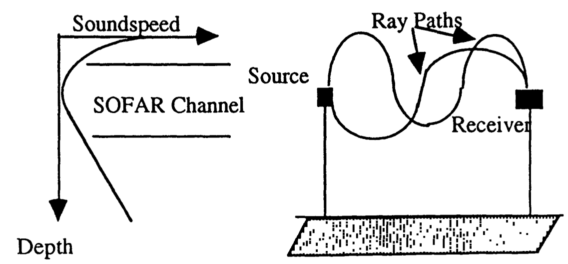

FIG. 3. *Cartoon illustrating the concept of acoustic tomography.*

nomenon is not well understood, because it is difficult to decide how to go from theory to data, because extracting nonlinear structures from data is difficult or because the sensitivity of measurement techniques to various phenomena is not well understood. Informed statistical expertise is essential to alleviate these difficulties.

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Comment

Greg Holloway

The panel has done a commendable job of collecting material of such diverse nature into a concise, readable overview which recounts a brief history of the subject, present state of the art and also some research outlook. Here I only mention a research thread which is not included in the report—not included for good reason: the topic is sufficiently controversial that it may well be set outside of more "mainstream" directions. The question is to what extent methods from statistical mechanics may help clarify what we suppose are the "equations of motion" for oceans.

First reaction to this question is often dismay. Although ability to observe the ocean is limited, and ability to model the ocean numerically is limited, at least we have the equations of motion. They come from textbooks after all. Yet, when we think of some of the very reasons that move us to statistics (viz., limited ability to observe a noisy system), we may reconsider the confidence with which we know the equations of motion. When a numerical model computes temperature or velocity or elevation at some grid point at some time, do we really mean that is supposed to be the temperature at that point at that time? Or do we have in mind some expectation for some space-time "lumped" temperature? Conceptually we might pose the problem as follows: Given a probability distribution for possible states of an ocean at time t_0, and given a probability distribution for forcing functions (possibly also probabilistic boundary geometries), what is the probability distribution for states of the ocean at later time t_1? In principle one might imagine solving a prognostic equation for evolution of probability. In practice this is too ambitious. However, if one had probability at t_1, then it would make sense to ask for temperature, velocity, kinetic energy, etc. as moments of probability. If we cannot realistically hope to solve for time-dependent probability, perhaps we can write equations of motion only for moments of probability. Here our dilemma becomes clear: which textbooks give us equations of motion for moments of probability of ocean states?

It is in this sense that we may not have the right equations of motion. Is this only fancy talk that makes a hard problem harder? It is possible—but here is the controversy—that we might start making skillful ocean modelling easier. At least we may identify systematic corruptions in the presently assumed equations of motion that can be improved upon. There are theoretical hurdles. The few problems that can be dealt with carefully from statistical mechanics are so idealized (such as unforced, inviscid, finite degrees of freedom, quasi-geostrophic) that they are too far from oceanic reality to be deemed meaningful. More meaningful applications including forcing and dissipation can be approached from disequilibrium statistical mechanics but the effort is

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