Theory versus model: what's the difference?

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A consideration of this point inevitably underlines the cultural chasms that exist within the turbulence community. It was prompted by my consideration of turbulence phenomenology in the preceding post, and in particular by the discussion given in the book by Arkady Tsinober [1].

He argued that the broad phenomenology of turbulence "includes also most of the semiempirical approaches and turbulence modelling". He added a footnote to this which refers to "this enormous material" and cites ten books as an indication of the material that he is omitting. There are two points that I would like to make about this.

First, judging by the books he cites, he included in this category the statistical theories. In contrast, I think inclusion of this topic violates the definition of phenomenology as being a substitute for a satisfactory statistical theory. I would also draw a distinction between statistical theories which are an attempt at a fundamental solution of the problem and models which are intended to give numerical answers in practical situations.

Secondly, I am surprised by the use of the word "enormous", as I believe that pure theoretical work is a very small discipline indeed, and dwarfed by the enormous subject of phenomenology. As regards engineering models I would have thought that was a small field too, but I may well be very much out of date on this. However, these models may be seen as expedients, and not intended primarily to increase our understanding of the subject. They do not seem to me to be natural candidates for inclusion in the category of phenomenology.

Turning now to our initial question, the answer so far as turbulence is concerned, would seem to be the following. Theory involves general operations with a minimum of specific assumptions. Modelling relies on more specific assumptions with the introduction of one or more adjustable constants. That is to say you have to complete a theoretical model by a comparison with experiment in order to fix a value of the constant. A very clear case was Kraichnan's introduction of the *test field model* where in contrast to his direct interaction theories he had introduced a specific approximation along with an adjustable constant. Of course, the distinction may be different in other fields, but this is what it is for turbulence.

[1] A. Tsinober. An Informal Conceptual Introduction to Turbulence. Springer, Dordrecht, 2nd edition, 2009.