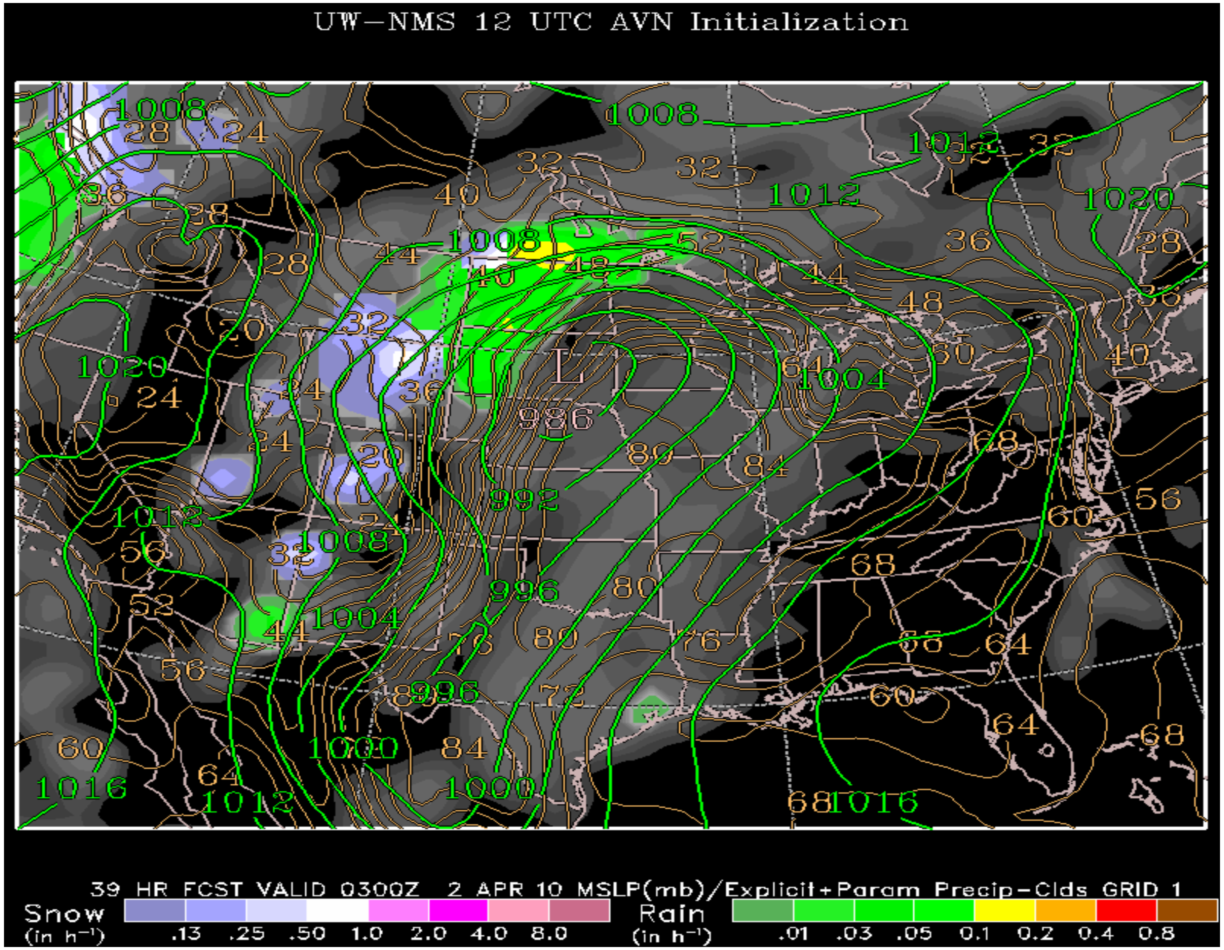
Mesoscale Modeling



- In the most general sense, what do we mean by a “model”, e.g., a model ship or airplane?

-- a representation of some physical system or entity

- The general purpose of modeling is to gain understanding of the modeled system. This may lead to practical ends such as improved forecasts.

Types of Models:

- Physical- a tangible representation of the modeled system. In meteorology, this can take the form of a model city or terrain in a wind tunnel or fluid tank. The so-called “rotating dishpan” studies of large-scale wave motions are a well-known example of a physical model
- Conceptual- a representation of a general understanding of the nature of the physical system, often in verbal or pictorial form. Defant’s diagrams of mtn-valley flow is an example

- Mathematical- use of mathematical principles(e.g. equations or inequalities) to represent the physical system. Various types of mathematical models exist:

  * statistical – models use techniques such as regression, principal components, etc. to summarize or infer relationships represented in the underlying data.

  * scale analysis – attaches typical magnitudes to various forcing terms in order to infer general characteristics of the physical system, e.g., which forcing terms are apt to dominate under a given set of circumstances

  * analytic models – usually proceed from a closed set of governing equations, applying various approximations so that an EXACT solution can be obtained. Analytic models usually (but not always) are linear in terms of the relationships between the dependent variables.

* numerical models – require the use of approximate solutions because the system cannot be solved exactly. In general, this is because nonlinear interactions exist between the dependent variables.

Here, we focus on nonlinear numerical models. The nonlinearity arises because of the presence of products of dependent variables (or their derivatives).

For example, in $\partial u/\partial t = -V \blacktriangledown V + \ldots$

the terms $u\partial u/\partial x$, $v\partial u/\partial y$, etc, are nonlinear

The nonlinear terms require the use of numerical methods to obtain approximate solutions to the equations.

Numerical methods

- We would like to have methods to give us the most accurate possible solutions to the governing eqs. To some extent this has to be balanced by practical considerations, e.g., computer resources.
- Numerical methods must have certain properties:

- Convergent – satisfy criteria $d\alpha/dx = \lim_{(\Delta x \to 0)} \Delta\alpha/\Delta x$
- Stable → $\alpha(t)$ bounded as $t \to$ infinity

- Desirable properties include:

 * amplitude preservation

 * phase accuracy; non-dispersion

 * maintenance of positive definite characteristics.