Mesoscale Meteorology

The mesoscale is somewhat ill-defined. The obvious definition is that the mesoscale lies between the synoptic scale (> 1000 km) & the cloud scale (< 10 km).

A slightly more rigorous definition is that the meso-β scale is defined in terms of:

(1) horizontal scale is sufficiently large so that the atmosphere is in hydrostatic balance > 10 km

(2) horizontal scale is sufficiently small so that the flow field is substantially different from gradient wind balance, even in absence of friction < 1000 km

In contrast, the meso-α scale is sufficiently small so that vertical accelerations are important < 10 km. Thus, meso-α is non-hydrostatic while meso-β is hydrostatic.

Mesoscale atm. systems can be divided into 2 parts:

(1) those that are primarily forced by instabilities in traveling larger-scale disturbances.

(2) those that are forced by surface inhomogeneities (elevation, temperature, soil moisture, etc.)

Examples:

(1) squall lines, symmetric instability, mesoscale convective complexes (MCCs)

(2) sea/land breezes, lake breezes, mountain valley circulations, urban circulations

Instabilities may arise as energy is transferred from the synoptic scale to the mesoscale or from the cloud scale to the mesoscale. The latter often arises from the physical & dynamical processes of clouds

What Defines the Mesoscale?

Physical Processes

Planetary / Synoptic Scale
1000-100 km
0-5 days

Instabilities
(frontal contraction, CSI, gravity waves)

Mesoscale 0-1+ days
5-500 km

Terrain-Forced Circulations
(Puget Sound convergence zone; lake effect bands)

Organized Convection
(MCS, squall lines)

Local Scale
Terrain effects
vegetative differences
land/sea contrasts
0-1 day
1-100 km

Convective Scale
Temperature, moisture perturbations
.1-50 km
0-12 h

What Defines the Mesoscale?
Operational Tools

Planetary/Synoptic scale
- Analysis of synoptic data
- satellite imagery
- global/regional NWP

Mesoscale

- model output?
- mesonets
- satellite
- radar
- lightning

Local/Convective Scale

Here we will focus on the first class of mesoscale systems, since terrain-forced circulations are covered in other courses.

During your career, you will be testing theories every day, accepting some & discarding others as the need arises. Some weather events occur frequently enough that you will develop an intuitive understanding of the phenomenon. Others occur infrequently & your basic understanding of the underlying principles will be necessary to grasp what is going on.

All too often people latch onto "synoptic" or "mesoscale" rules, without understanding the principles behind them. There are dozens of ways to evaluate vertical motion & movement of wx systems. However, all of these approaches rely on a half-dozen primitive equations that describe fluid motion on all spatial & temporal scales : m's – 1000's km & minutes to years.

Course Themes

1) Weather is messy - don't focus on the "classic" case study. You need to be able to understand every case as it arises

2) Don't search for the ultimate diagnostic crutch
   - use conceptual models appropriately & know their limitation
   - no one parameter will provide understanding in all situations

3) Use appropriate tools for diagnosing mesoscale weather
   - mesonet observations
   - radar/profiler
   - satellite
   - lightning
   - etc.