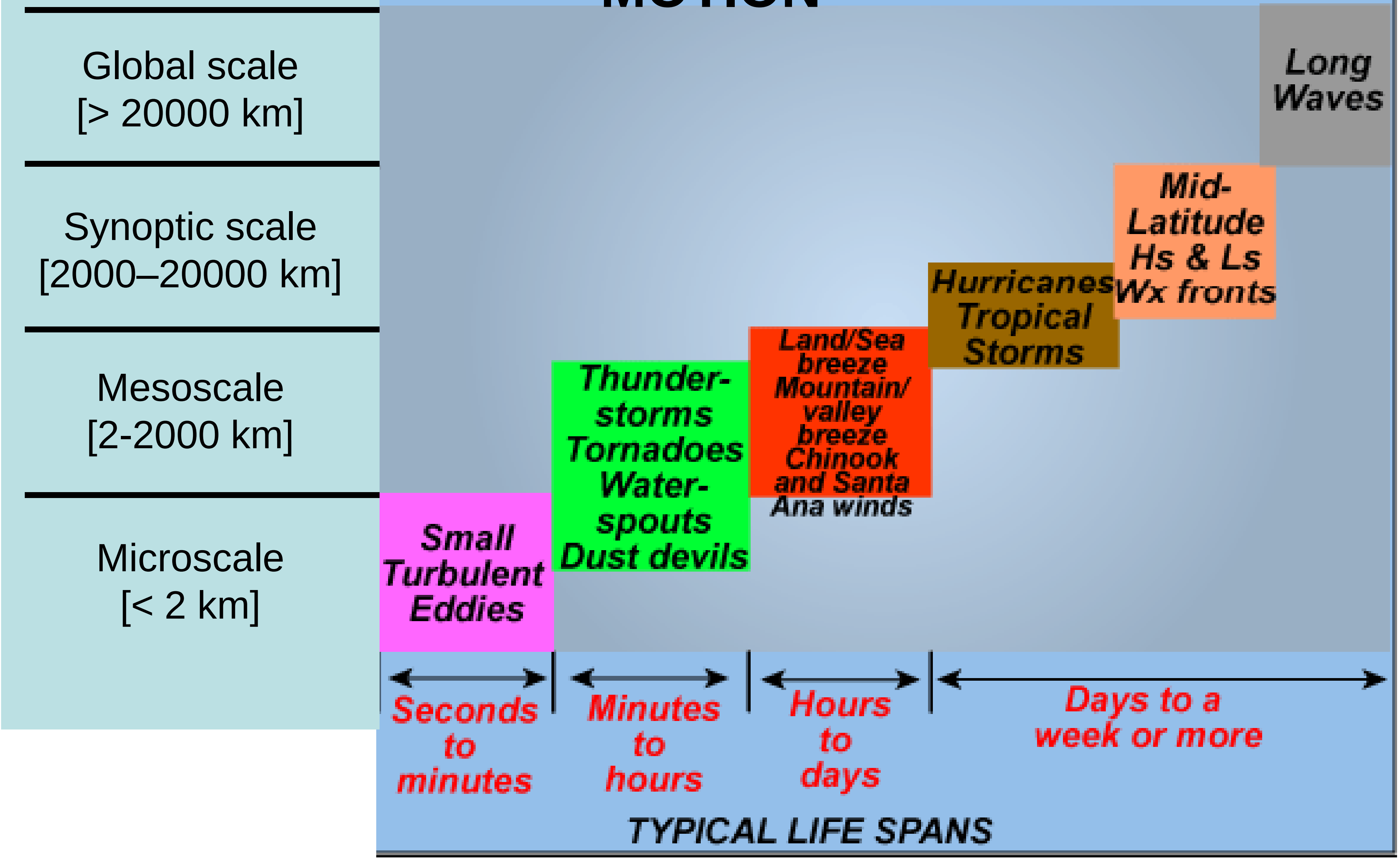
TIME and SPACE SCALES of ATMOSPHERIC MOTION



Smog layer over Santiago, Chile

Top of boundary layer (inversion)

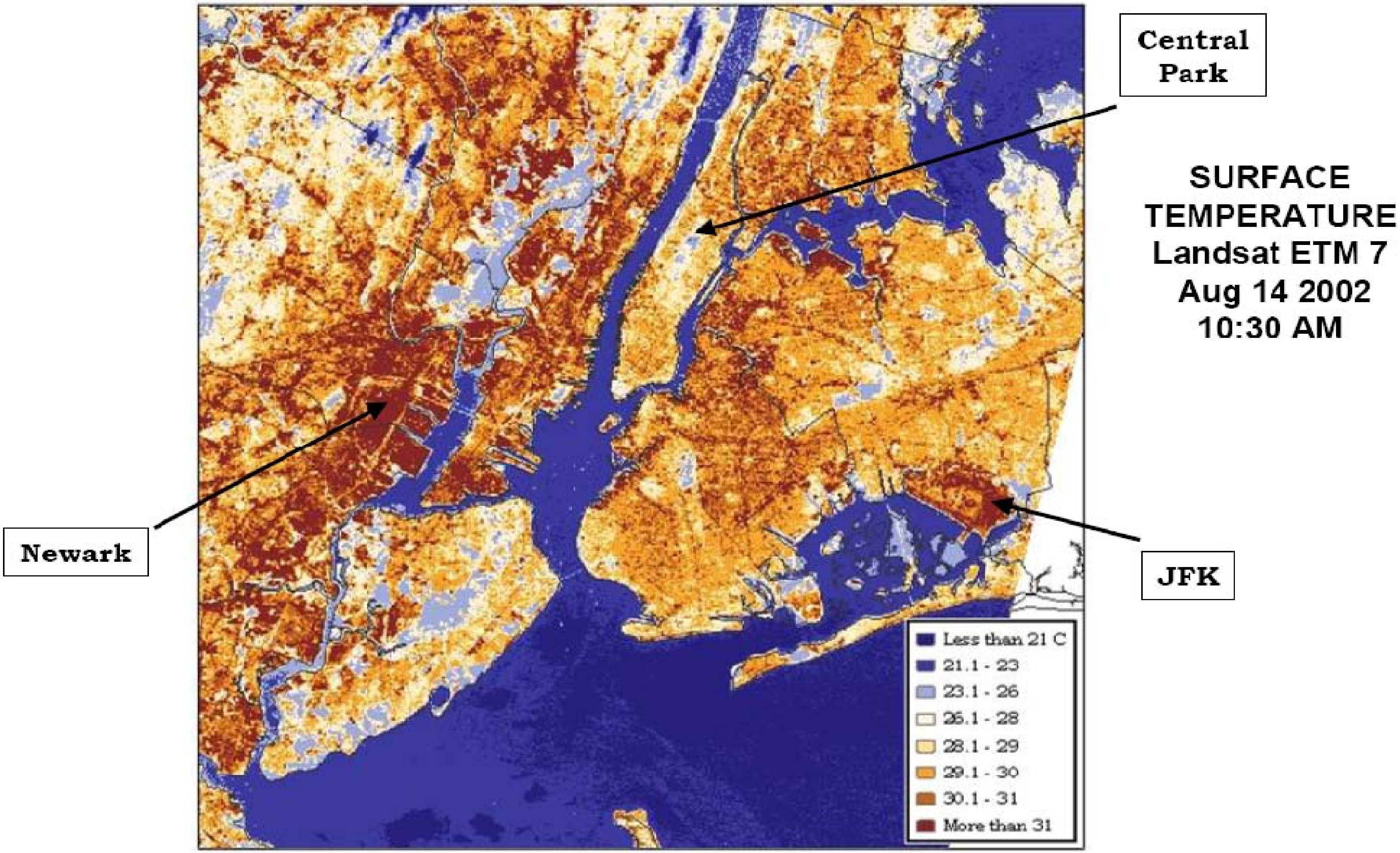
Boundary layer capped with clouds

Typical values of the Bowen Ratio ($B=H/H_L$)

Surface type	***B***
desert	>10
semi-arid grassland	5
grassland/forest	0.5
irrigated orchards/grass	0.2
ocean	0.1
ice/snow surfaces	-10 to 10*

* strongly dependent upon the meteorology/air-mass

Surface skin temperature over New York City



www.gisdevelopment.net/aars/acrs/1991/psq/ps015.as

Diurnal skin temperature range (July)

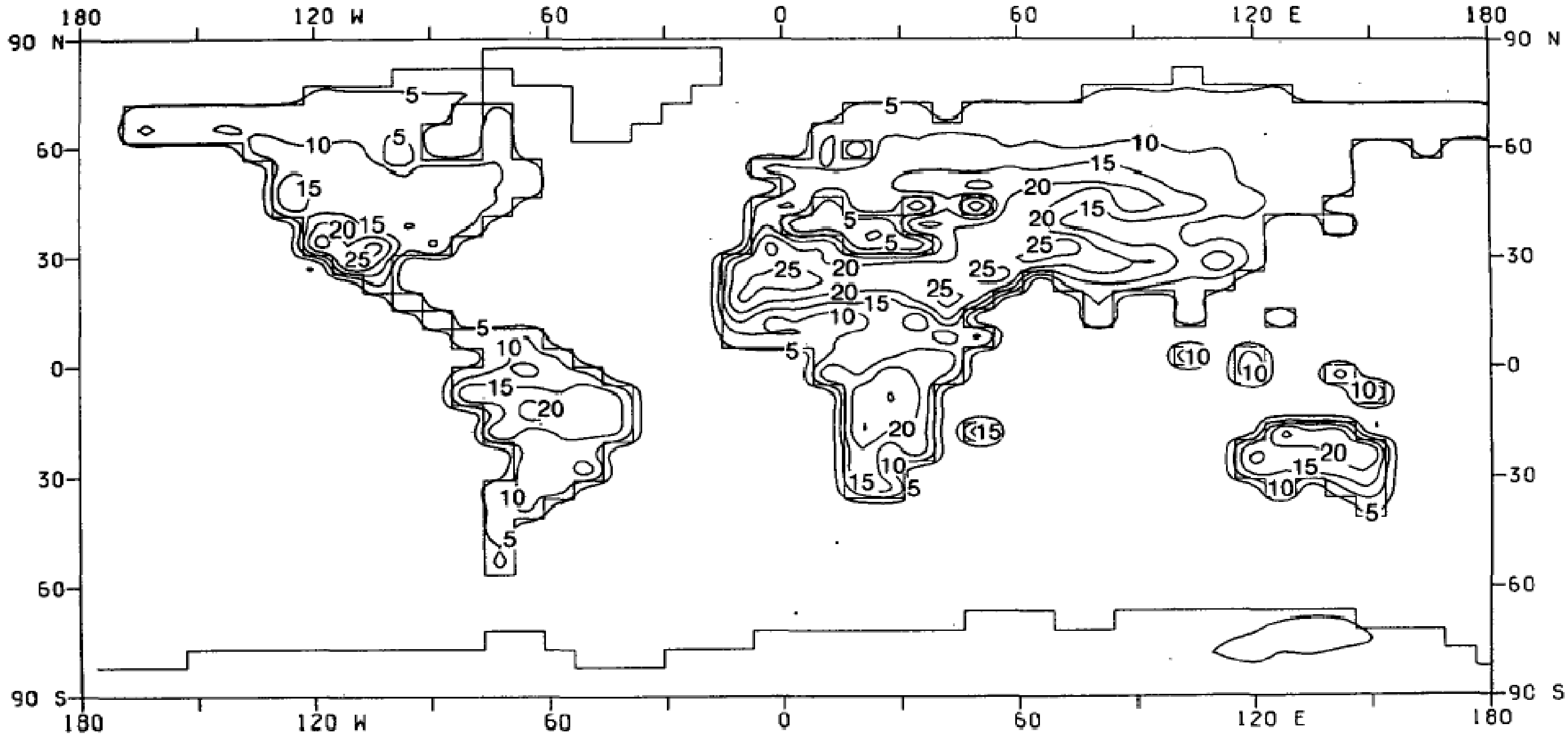
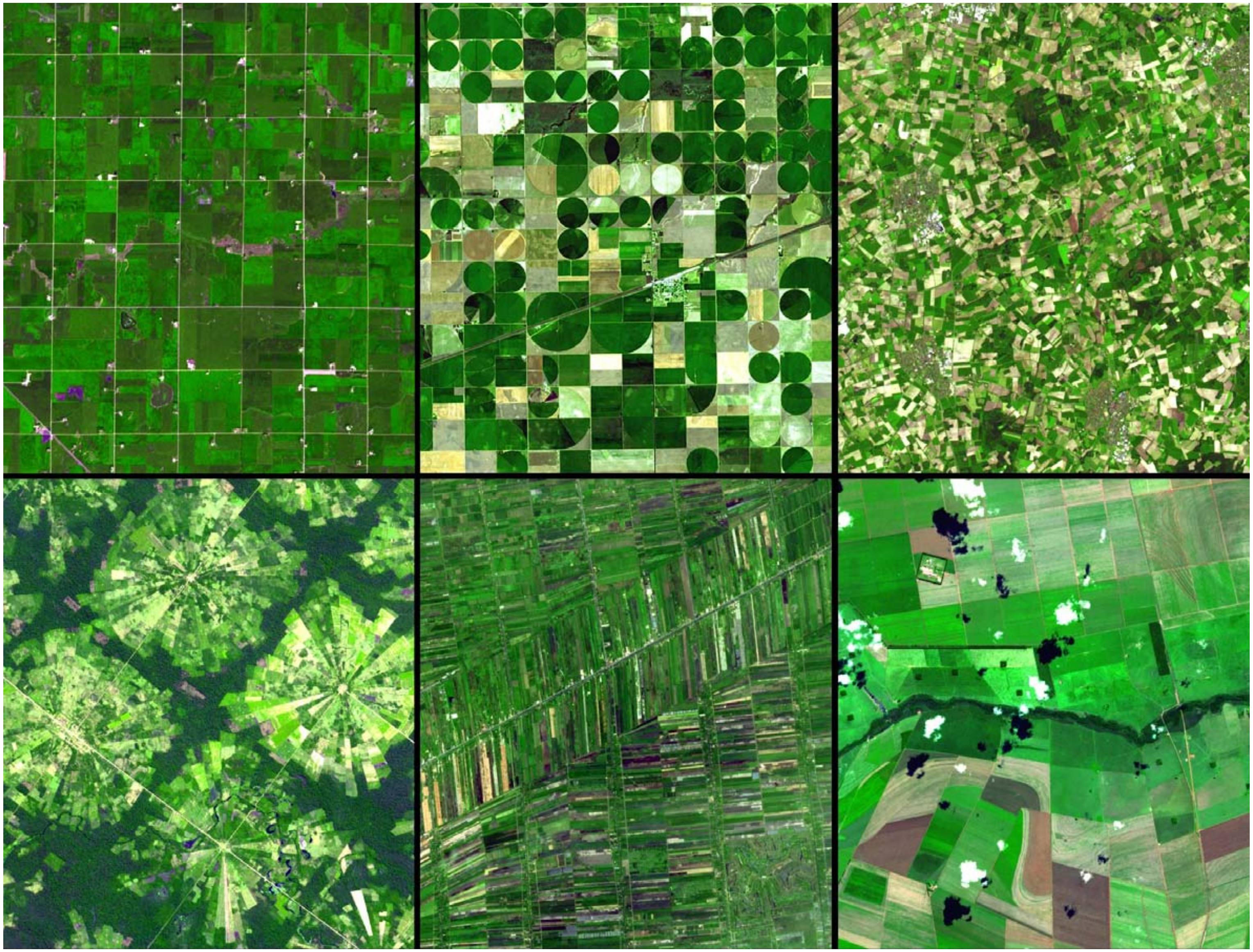


FIG. 1. Diurnal range of surface temperature in control simulation, with contour interval 5°C. (a) January and (b) July.

http://ams.allenpress.com/perlserv/?request=get-abstract&issn=1520-0442&volume=005&issue=09&page=0920

Land surface heterogeneity



- *http://asterweb.jpl.nasa.gov/gallery/images/ag-montage.jpg*

Profiles over the cloudy subtropical ocean

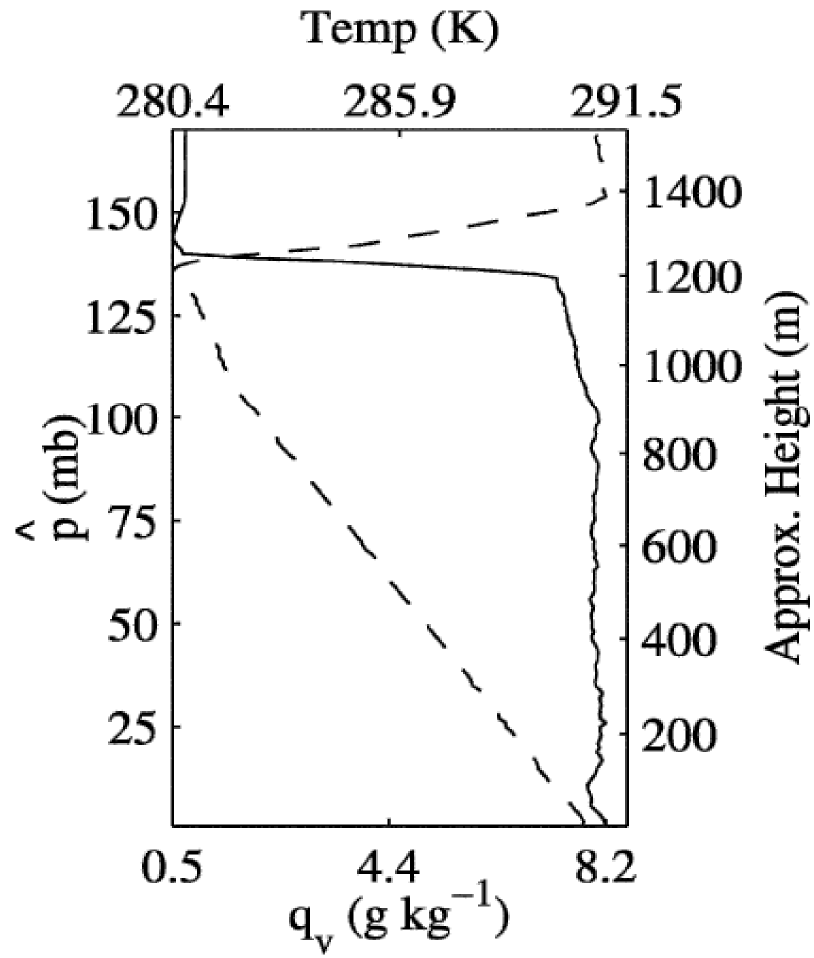


FIG. 3. Mixing ratio (solid line) and temperature (dashed line) profiles from the radiosonde launched at 0200 UTC (2000 LT) on 16 Oct 2001. The temperature inversion appears to be around 15 mb (≈150 m) deep, which is 5 times as thick as the moisture inversion.

From Caldwell et al. (2005)

Temperature profile from the South Pole

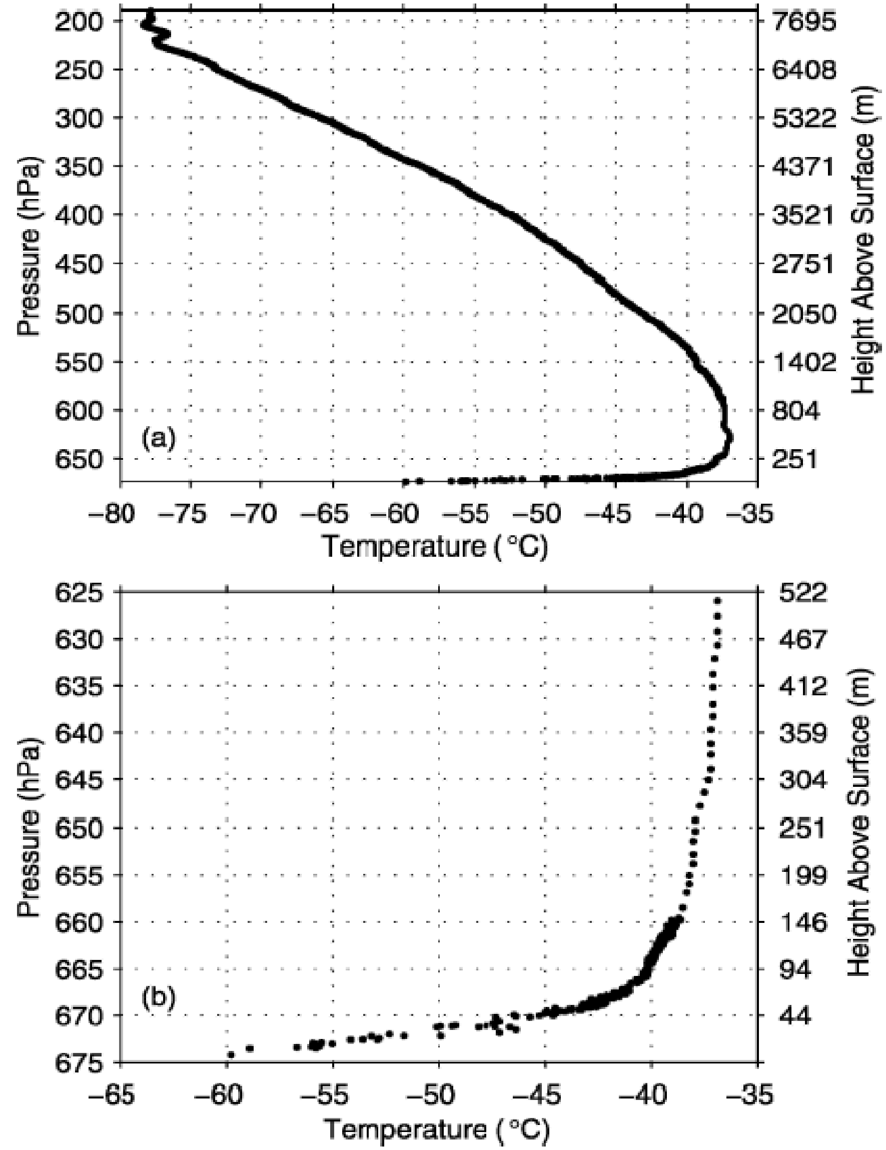
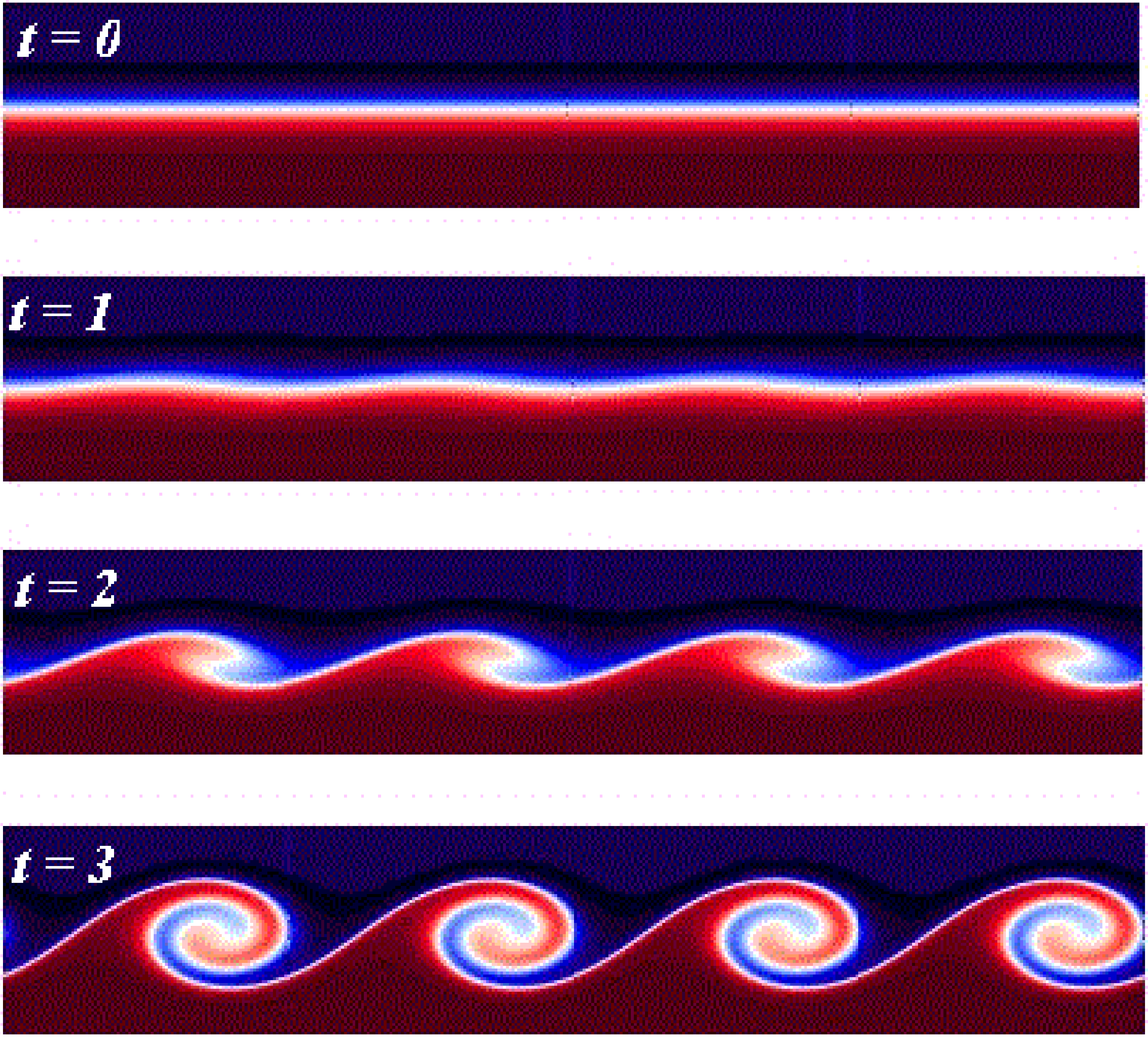


FIG. 3. Temperature profile measured at South Pole Station on 25 Sep 2001. Data above 660 hPa are from a routine radiosounding with an RS80; those below 660 hPa are from a tethered sounding with an RS80. (a) The full tropospheric sounding is shown, and (b) the lowest 500 m are enlarged. The surface pressure was 674 hPa.

From Hudson and Brandt (2005)



t = 0
t = 1
t = 2
t = 3

Example questions for midterm

1.
(a) On a summer day that is clear with no frontal activity over land, sketch diurnal variations of winds at 2 and 500 meters. Explain why.
(b) Describe general characteristics of turbulence.
(c) Describe Taylor's frozen turbulence hypothesis.

2.
Based on the following information derive a) the magnitude and direction of pressure gradient force, Coriolis force, and friction force per unit mass near the surface; b) the average magnitude of the actual wind shear across the boundary layer; and c) the frictional veering of the wind across the boundary layer; and d) the average value of the Richardson number and existence of turbulence in the PBL.

At 45°N, the surface geostrophic wind speed is 17 m s^{-1} at 145 deg (wind directions use meteorological convention);
PBL = 1000 m, assume the winds are geostrophic at this height;
Assume that the measurement at 1 m height is representative of the surface wind and the pressure at 1 m is 1000 mb;
The atmosphere is dry.
The observations are

Height (m)	1	1000
Wind speed (m s^{-1})	10	20
Wind direction (deg)	110	135
Temperature (°C)	25	23

3.
For the Ekman layer in the barotropic atmosphere, the equations of motion can be written as

$$-f(v-v_g) = K(d^2/dz^2)(u-u_g)$$
$$f(u-u_g) = K(d^2/dz^2)(v-v_g) \quad (1)$$

where K is the effective viscosity.
The boundary conditions are

$u = 0, v = 0$, at $z = 0$

$u = u_g$, $V = V_g$, as $z \to \infty$.

The solutions are

$$u-u_g = -e^{-az}[u_g\cos(az)+v_g\sin(az)]$$
$$v-v_g = e^{-az}[u_g\sin(az)-v_g\cos(az)] \quad (2)$$

where $a = (f/2K)^{1/2}$.

(a) Using Eq.(2), obtain the horizontal shear stress components τ_{zx} and τ_{zy}.
(b) In a coordinate system with the x axis parallel to the geostrophic wind, write down the expressions for the normalized vertical components (u/G and v/G where G is the magnitude of geostrophic wind).
(c) In the same coordinate system draw the wind hodograph using the expressions above as function of az from 0 to 2π.
(d) If f = 10^{-4} s^{-1} and K = 4 m^2 s^{-1}, what is the Ekman layer thickness?

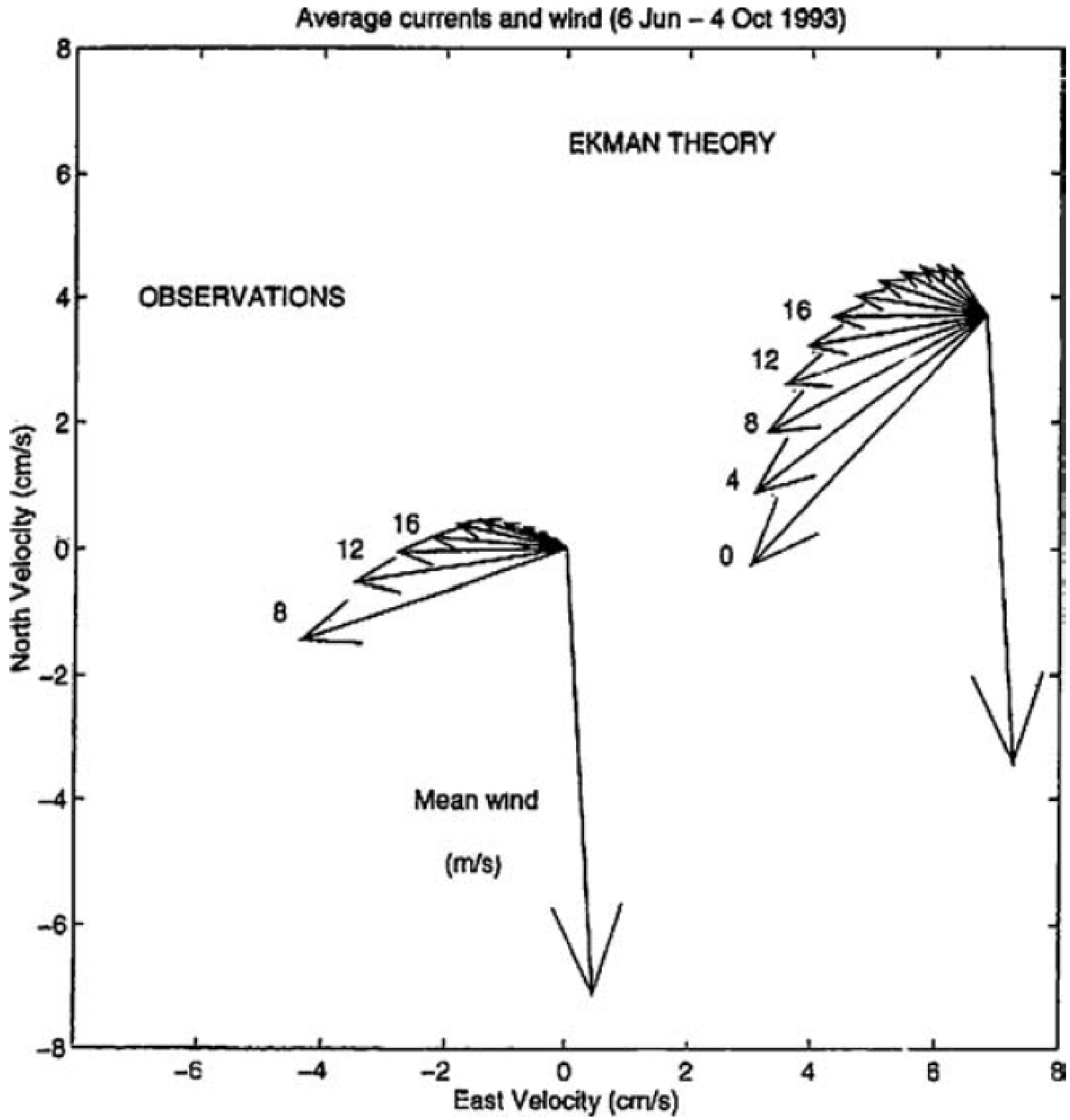


Fig. 2. Observed and theoretical Ekman spirals adapted from Figure 9 of Chereskin (1995). Note that the shallowest measurement depth is 8 m, and also that for a mean wind speed of 7 m s^{-1}, the authors estimate that the thickness of the wave boundary layer is 5 m. The eddy viscosity and the Ekman depth for the fitted theoretical profile are, respectively, ν_E = 2.7–10^{-2} m^2 s^{-1} and L = 25 m. The theoretical spiral has been offset from the origin for clarity. Scales are cm s^{-1} for currents, and m s^{-1} for wind.