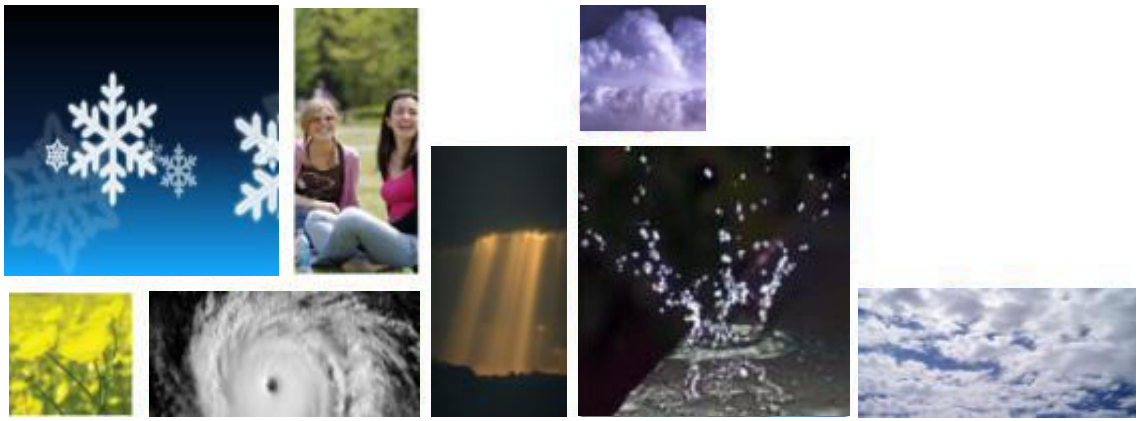


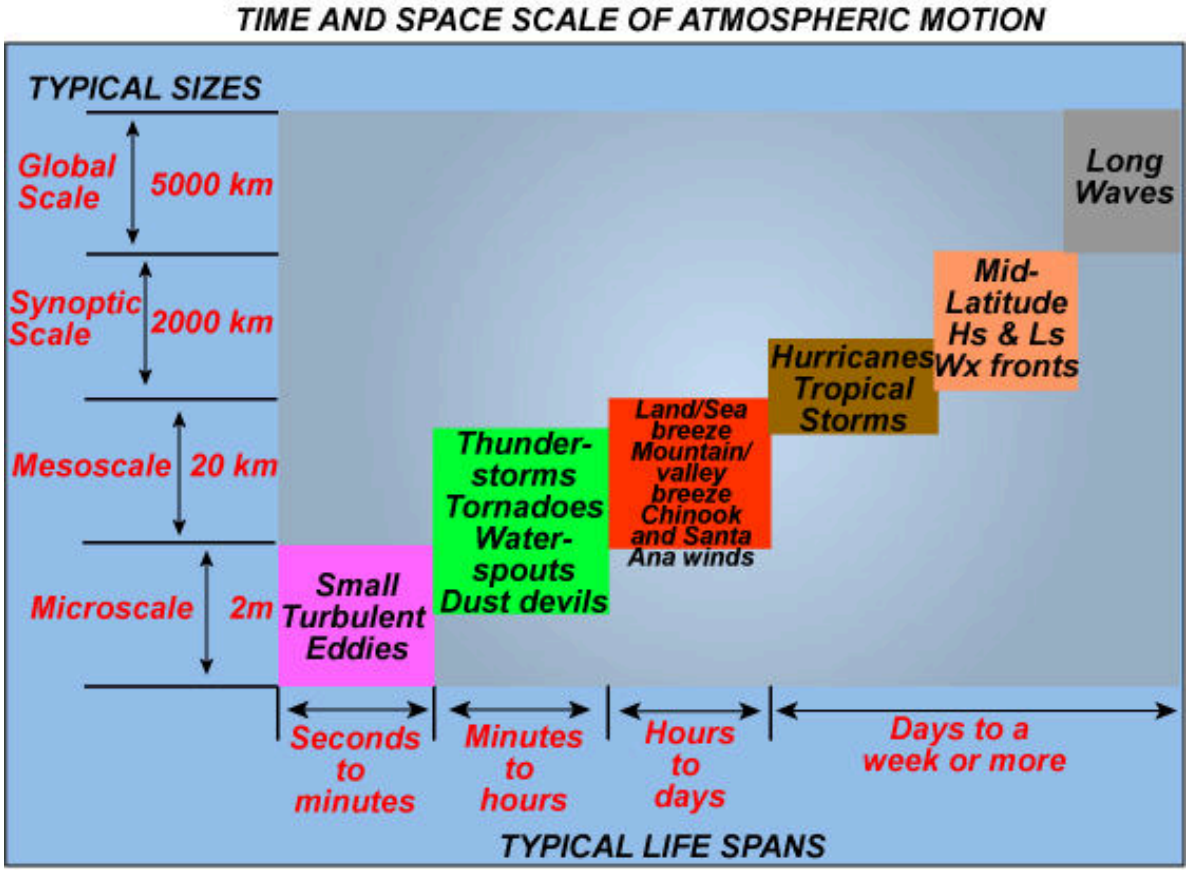
Atmospheric Flows

Curtis Wood

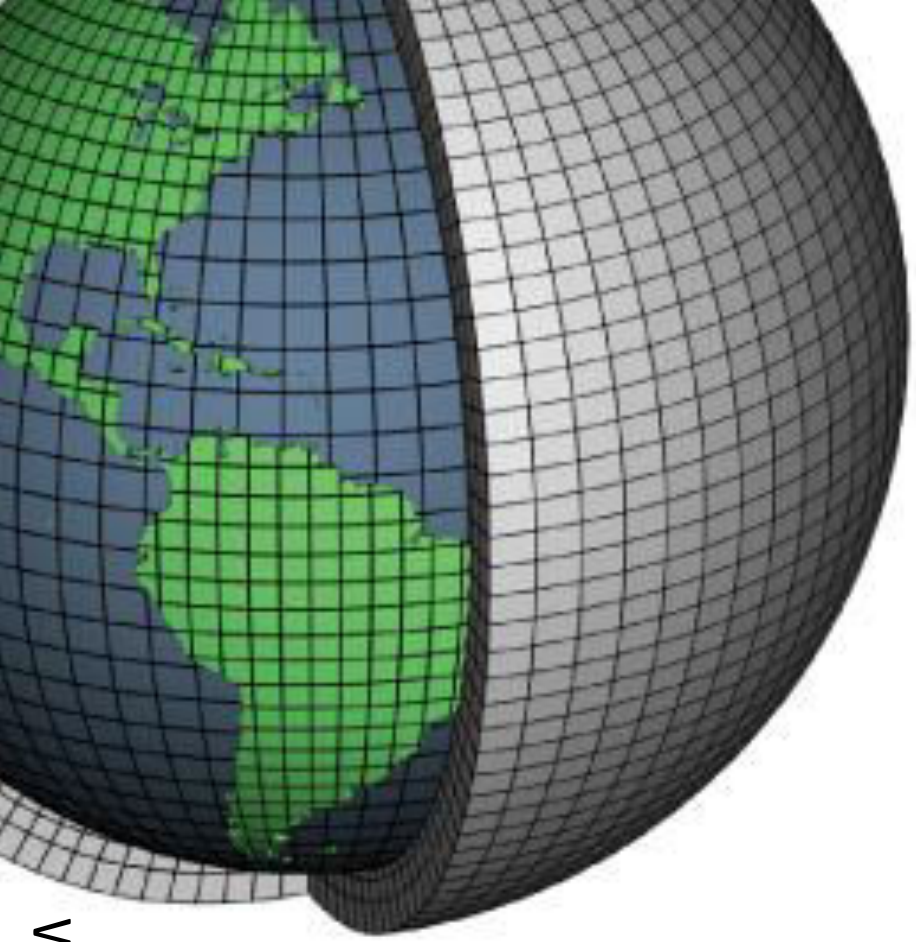
SILAM Winter School 2013

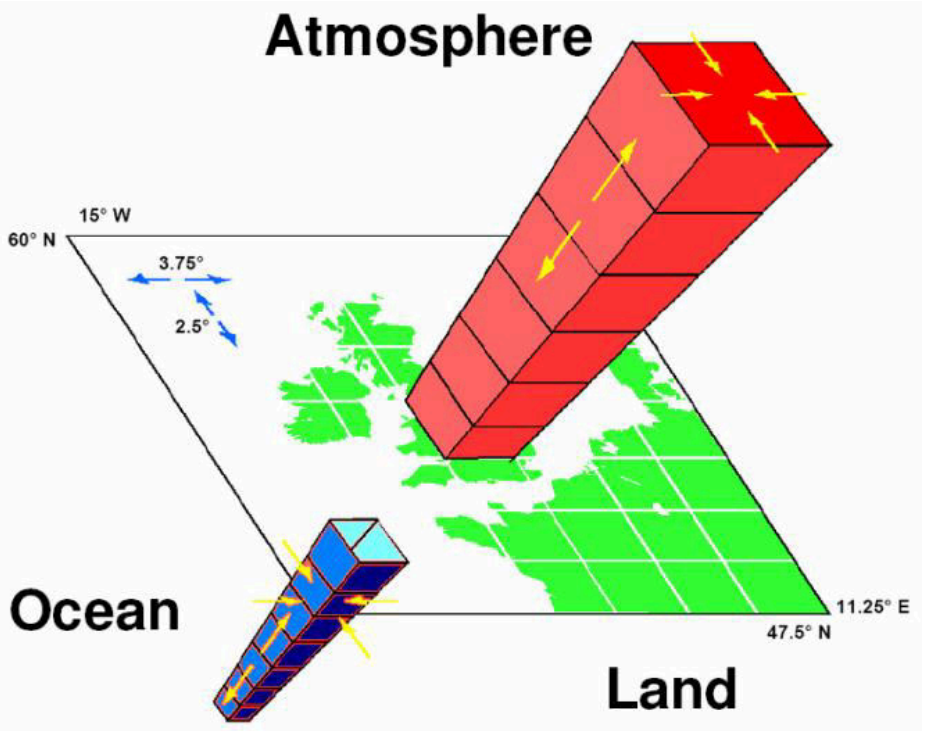
Scales

For SILAM, the input (e.g. ECMWF) would deal with many of these scales 'automatically'



Numerical models





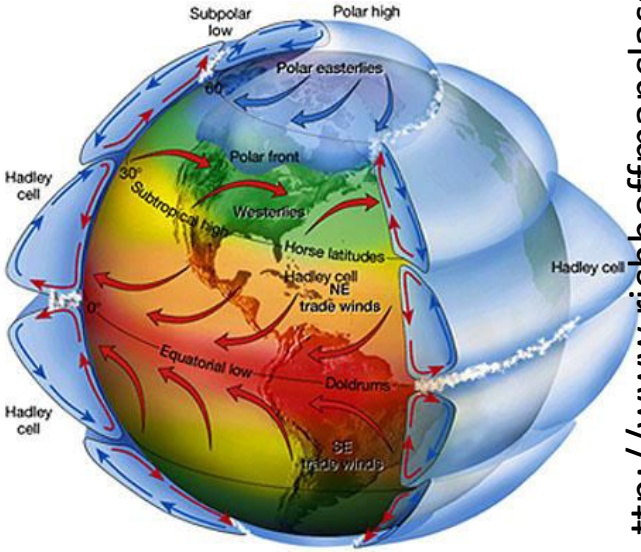
Wikipedia / NOAA

E.g. ~ Eulerian co-ordinate system (millions of grid-cells)

Resolve -vs- parametrize

Explicitly resolved flows:

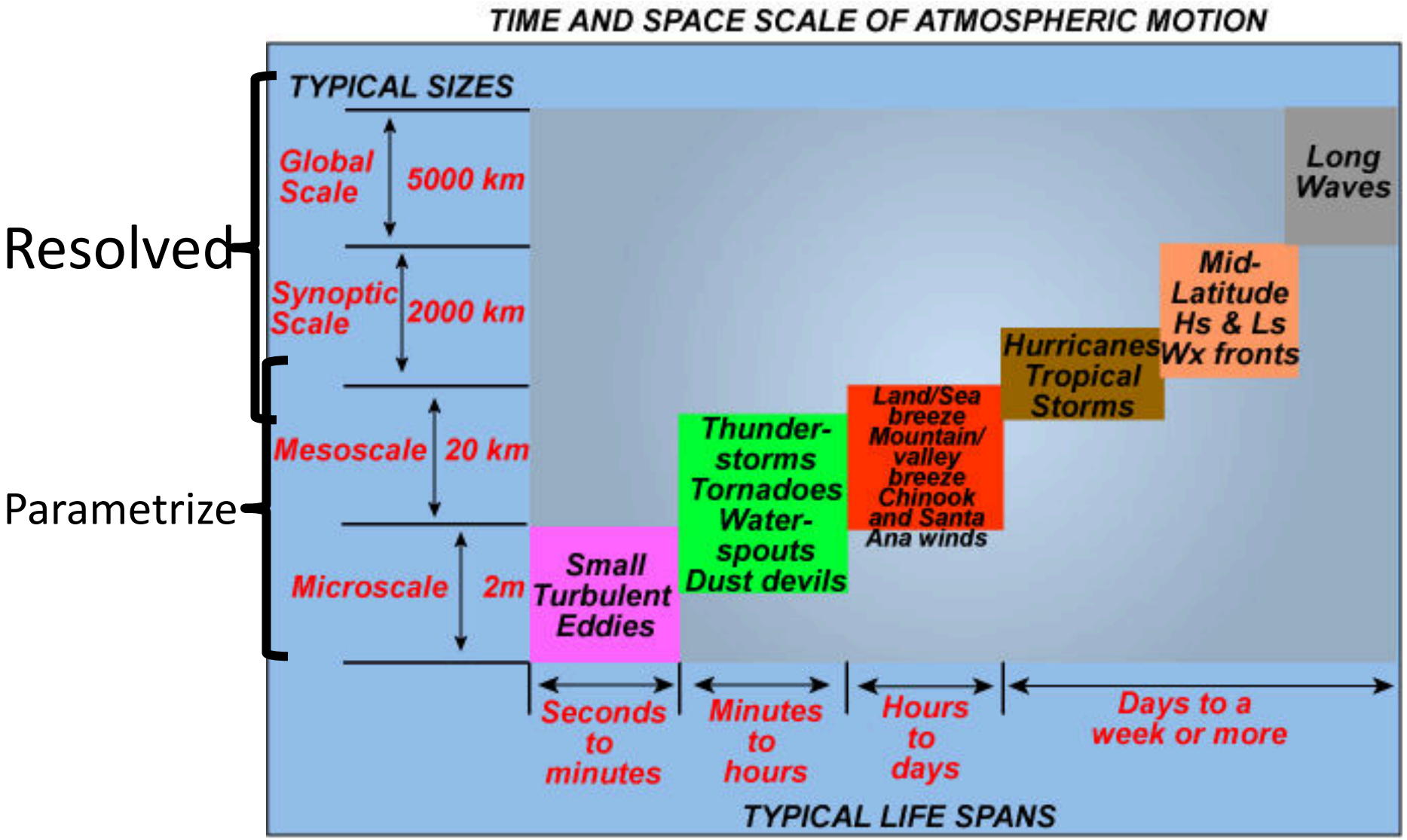
- Larger scales (> gridscale)
- i.e. using pressure and thermal gradients, gravity, rotation, etc



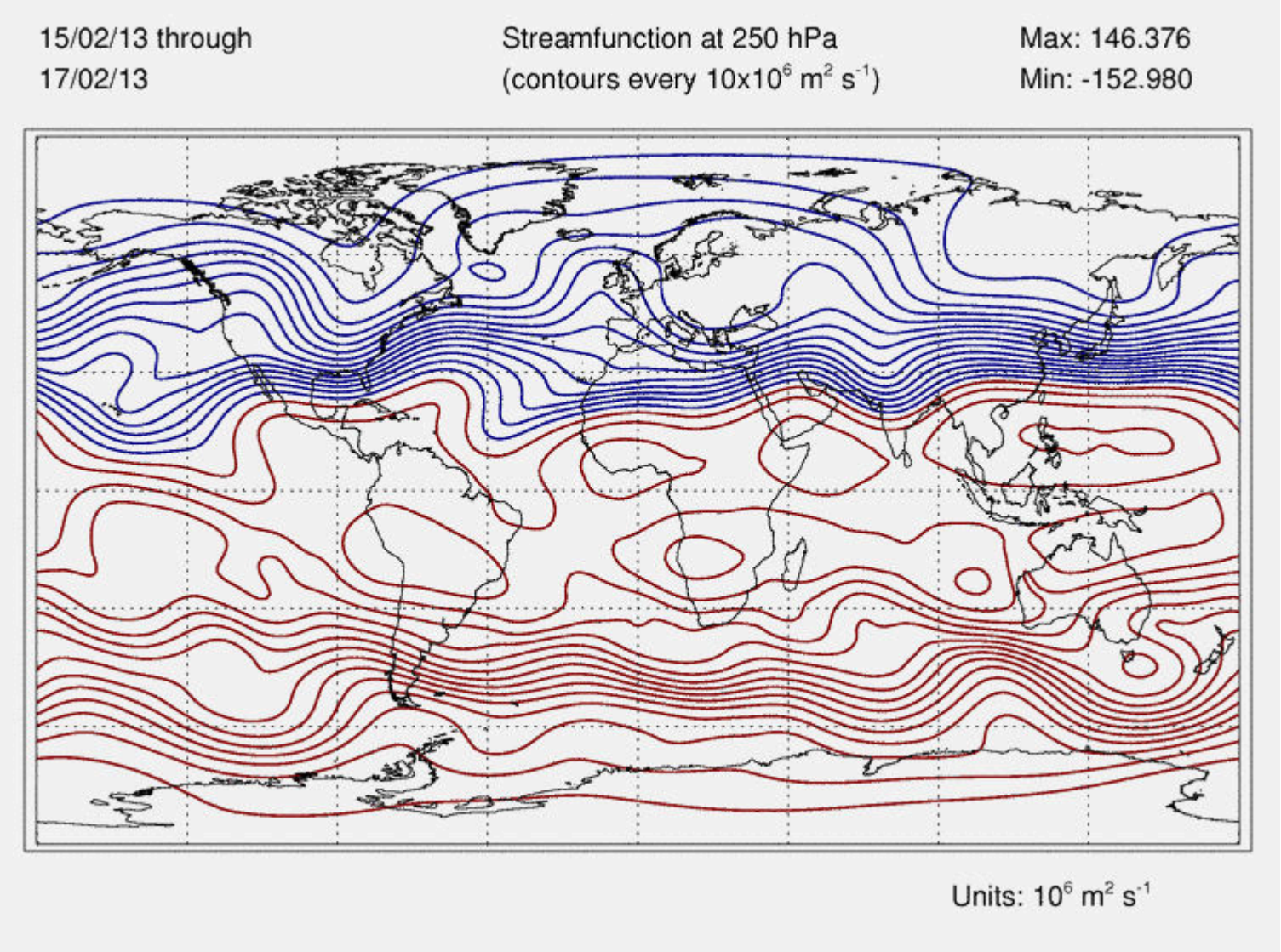
ttp://www.richhoffmanclass.com

Parametrizations:

- Smaller scales / sub-gridscale
- Turbulence
- Cloud physics
- Radiative transfer

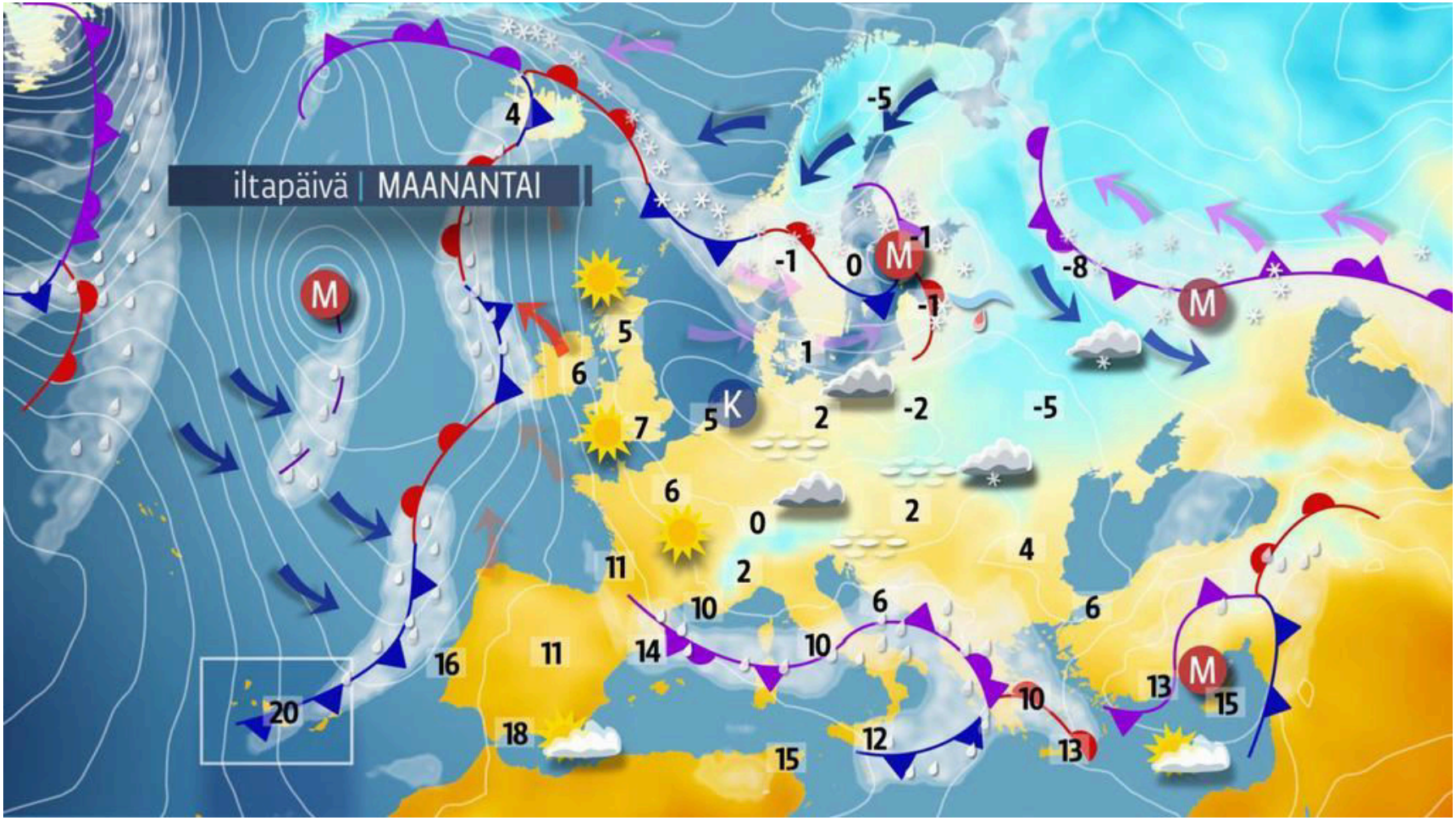

TIME AND SPACE SCALE OF ATMOSPHERIC MOTION
TYPICAL SIZES
Global Scale
5000 km
Synoptic Scale
2000 km
Mesoscale
20 km
Microscale
2m
Resolved
Parametrize
Small Turbulent Eddies
Thunder-storms Tornadoes Water-spouts Dust devils
Land/Sea breeze Mountain/ valley breeze Chinook and Santa Ana winds
Hurricanes Tropical Storms
Mid-Latitude Hs & Ls Wx fronts
Long Waves
Seconds to minutes
Minutes to hours
Hours to days
Days to a week or more
TYPICAL LIFE SPANS

Global / upper-air flows



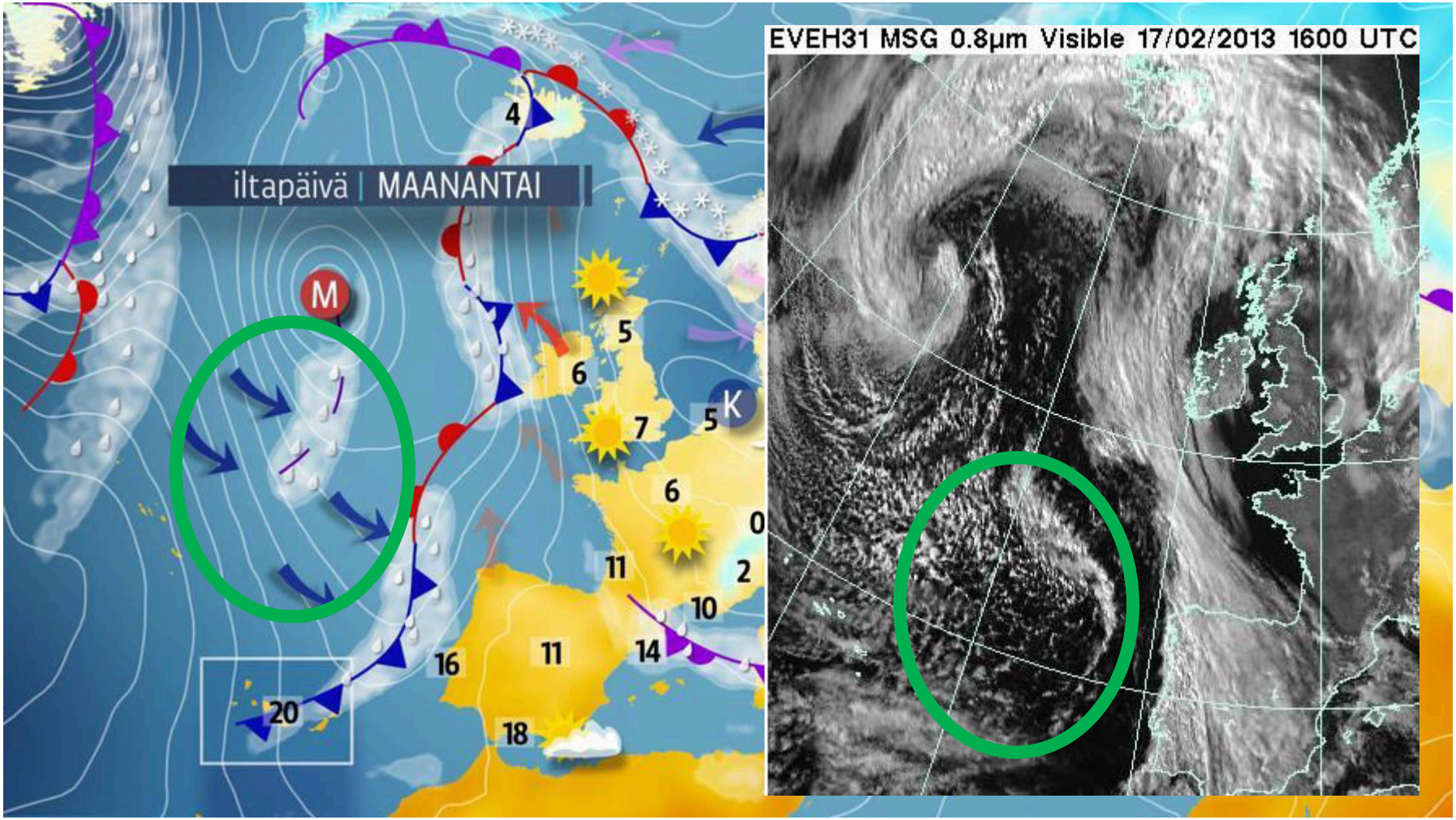
ECMWF

Synoptic scale



YLE / IL

Synoptic-Meso scale



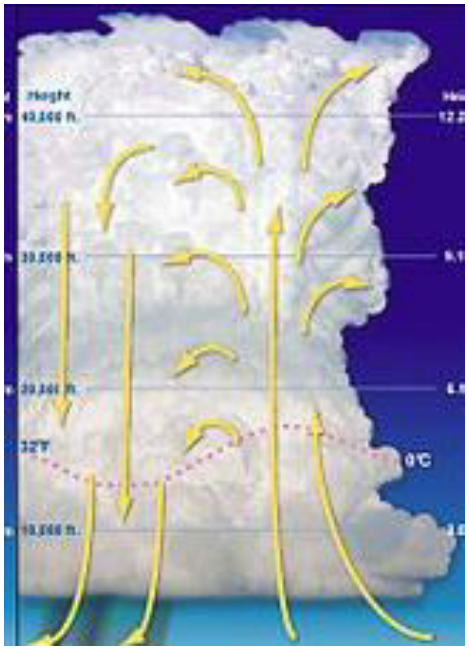
YLE / IL / Met office

Mesoscale

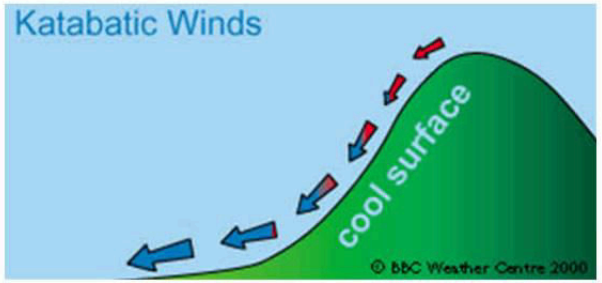
Resolved in some models, parametrized in others

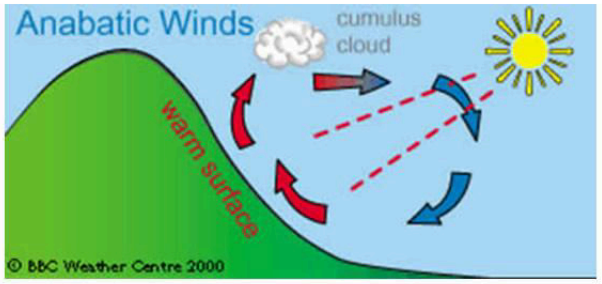
e.g.

- Thunderstorms/convection
- Sea/lake breezes
- Mountain flows



Wikipedia





Daytime clear-sky ABL
(Atmospheric Boundary Layer)

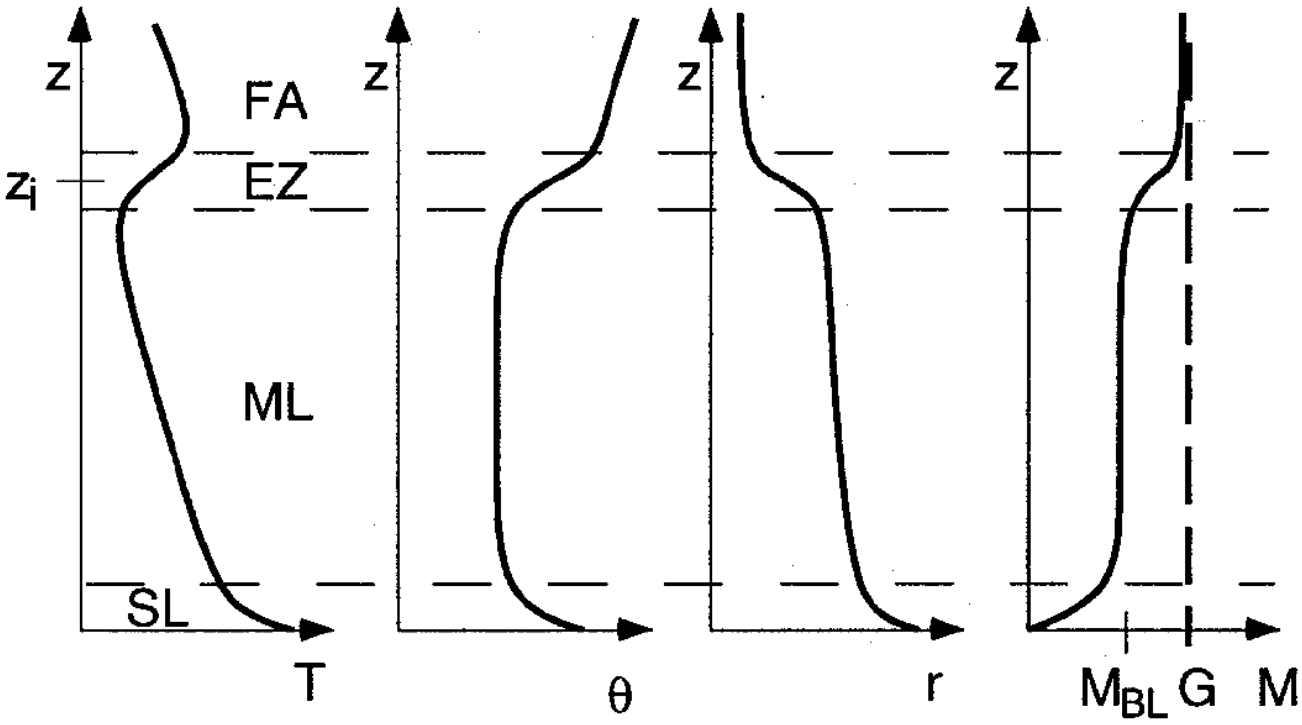
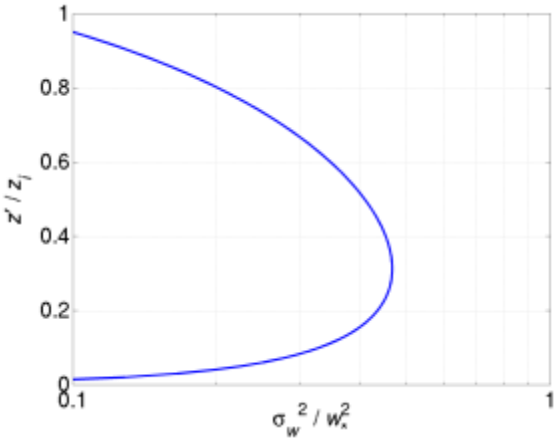


Figure 1·4 – *Typical daytime profiles in the CBL of temperature (T), potential temperature (θ), humidity mixing ratio (r), and horizontal wind speed (M). Geostrophic wind is denoted as G. Altitude is z, and inversion height is z_i. From Stull (2000).*

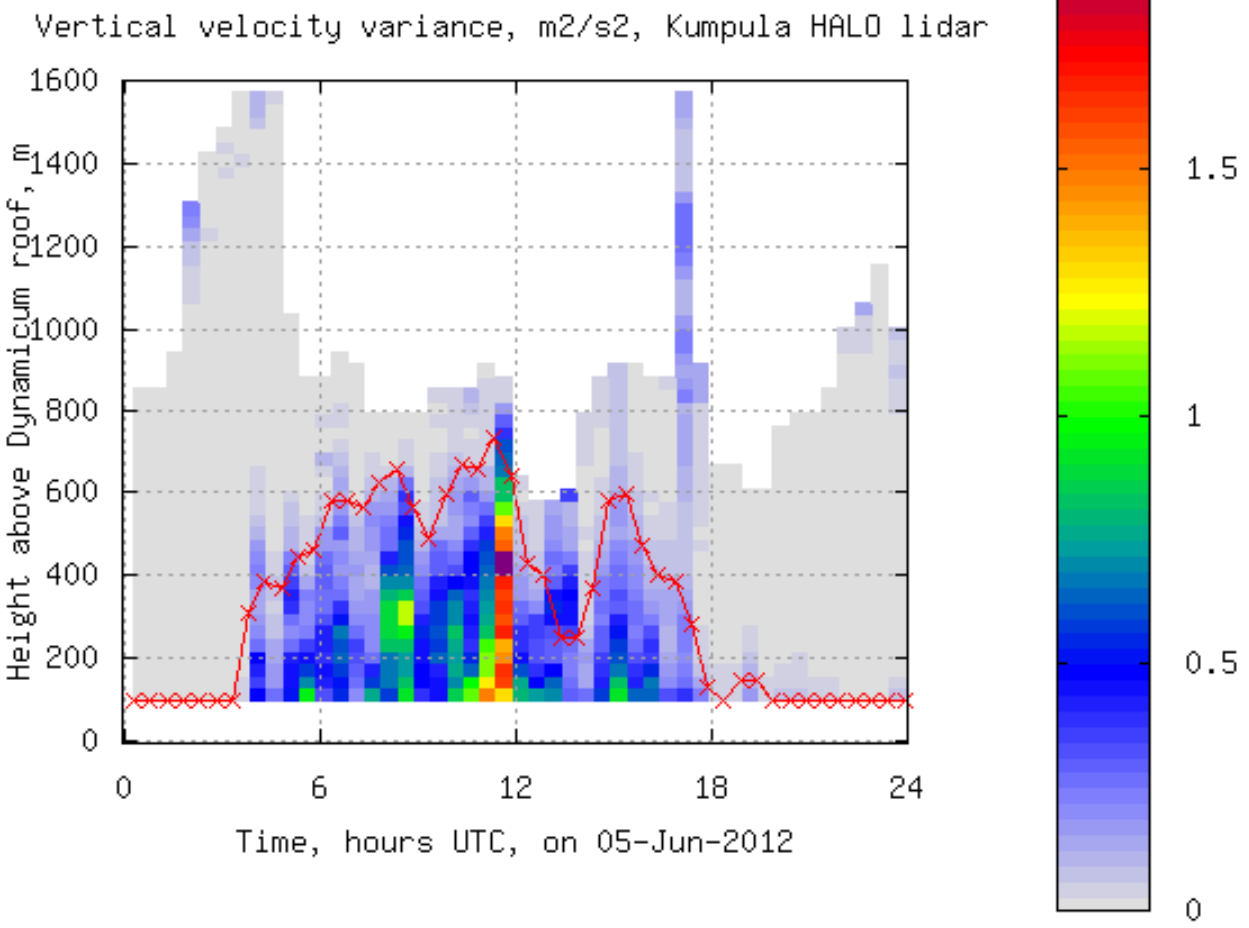
Vertical velocity variance in ABL

$$\frac{\sigma_w}{w_*} = f\left(\frac{z}{z_i}\right)$$

$$w_* = f\left(H, z_i\right)$$



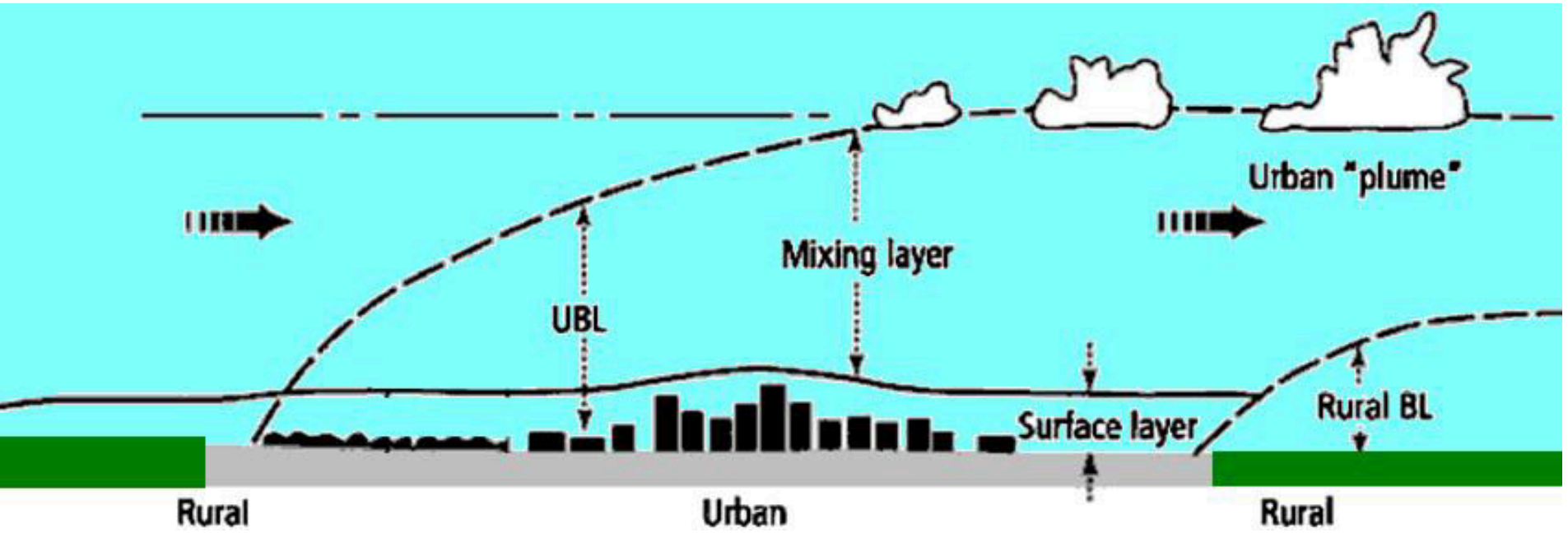
Lenschow et al. (1980) JAS



w* (convective scaling parameter)

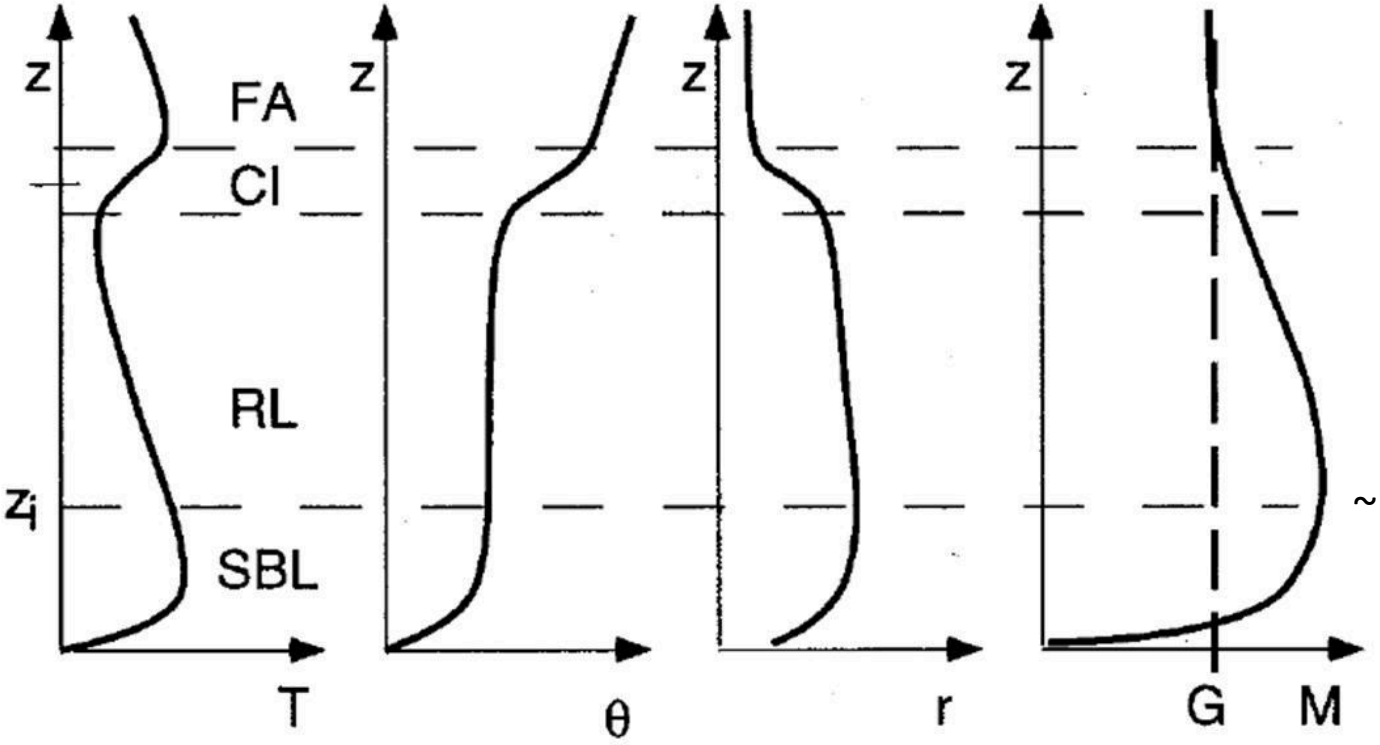
Complex 3-4D motions

Internal boundary layers



Grimmond (2006) Theor. Appl. Clim.

Stable ABL (e.g. clear nights)



~ 10-500 m

Figure 1·7 – *Typical nocturnal profiles in the NBL of temperature(T), potential temperature(θ), humidity mixing ratio(r), and horizontal wind speed(M). Geostrophic wind is denoted as G. Dashed horizontal lines indicate the boundaries between layers. Layers are stable boundary layer (SBL), residual layer (RL), capping inversion (CI), and free atmosphere (FA). Altitude is z, inversion altitude is z_i. From Stull (1997).*

Complex 3-4D motions

Shallow and stable ABL (chimneys 100 m, 150 m)

Sat 4th Feb 2012,
23:48 (Helsinki)