Lecture 1: Intro

T1 – references and web page

What is the middle atmosphere?
T2 – vertical T structure: describe various layers

Why we want to study middle atmosphere dynamics:

- Dynamics affect chemistry. Radiatively active gasses. Ozone, supersonic jets. **T3 – ozone hole**
- Clean dynamics: no moisture and complex lower boundary, planetary scales. Many theoretical advances made in studies of stratosphere.
- Cool phenomena: **T4- T6: Major warmings. QBO. Mesospheric gravity waves in airglow.**
- Stratosphere affects tropospheric climate and weather. Adds some predictability in certain cases. Need to resolve it in weather and climate models. Need to understand dynamics to know what to resolve.

Observations:
T7-Radisonode observations: Only 10-20% reach 10mb (30km)- mid stratosphere.
T8-Satellite observations: Higher spatial and lower vertical resolution compared to radiosondes. Sufficient spatial and temporal coverage for most dynamical phenomena. For the rest (gravity waves) need other ways.

T9- January zonal mean U and T:

- In troposphere equator warmest, poles coldest.
- In stratosphere T decreases from summer to winter pole.
- Tropical tropopause coldest region at that level, more than poles
- Mesospheric T decreases from winter to summer pole!
- Winds in thermal wind balance: $fU_z \alpha -T_y$. Vertical shear negative all th way up in summer hemisphere- easterly stratospheric jet. Jets close off in mesosphere where T gradient direction reverses.

T10- July zonal mean U and T: Reversed from Jan but SH winter polar stratosphere is much colder than the NH winter polar stratosphere.

T11- Climatological and radiative equilibrium T: There are differences between observed and radiative equilibrium temperature: Mesosphere; Winter pole warmer than RE, NH more so than SH.
Summer stratosphere quite close to radiative equilibrium- explains why summer pole warmer than equator.

Why is this so in stratosphere but not in troposphere? Has to do with the heating and cooling processes: **T12- vertical heating and cooling processes and Newtonian damping coefficient:** Short wave heating (ozone) and long wave cooling (CO_2).
Newtonian cooling $Q\alpha -(T-T_e)$
A piece of atmosphere in equilibrium means what is absorbed is emitted. Emission depends very strongly on temperature, so when T perturbed, IR cooling changes and brings T back to equilibrium. Newtonian cooling is a linear approximation for when the T perturbation is much smaller than T itself. Assumption- anomalous emission goes out to space and is not absorbed in adjacent air.