Circulation
Upper level (200hPa) flow and height field anomaly: DJF
Upper level (200hPa) flow and height field anomaly: JJA

(Peixoto and Oort, fig 7.13c)
Upper level (200hPa) zonal wind: JJA

NCEP/NCAR Reanalysis
200mb Zonal Wind (m/s) Composite Mean

NOAA/ESRL Physical Sciences Division

Jun to Aug: 1980 to 2001

(CDC interactive plotting website)
Near-surface flow and height field anomaly

(Peixoto and Oort, fig. 7.1 a)
Mean zonal wind (m/s) in latitude-height plane

(ERA40 reanalysis 1980-2001)
Mean meridional streamfunction \((10^{10} \text{ kg s}^{-1})\)

Contour interval 2

Contour interval 0.5

(ERA40 reanalysis 1980-2001)
Eulerian mean meridional streamfunction ($10^{10} \text{ kg s}^{-1}$)

(DJF)

(JJA)

(ERA40 reanalysis 1980-2001)
Eulerian mean meridional streamfunction \((10^{10} \text{ kg s}^{-1})\)

\[ \text{Latitude} \quad \text{Sigma} \]

\[ -60 \quad -30 \quad 0 \quad 30 \quad 60 \]

(ERA40 reanalysis 1980-2001)
Dry-isentropic mean meridional streamfunction ($10^{10}$ kg s$^{-1}$)

Red: Tropopause
Magenta: 10, 50, 90 percentiles of surface potential temperature distribution

(ERA40 reanalysis 1980-2001)
Mean meridional circulation on dry and moist isentropes

**Fig. 1.** The global mean circulation from the NCEP-NCAR Reanalysis. (A) Stream function on pressure surfaces $\Psi_p$. (B) Same as (A) for the stream function on dry isentropes $\Psi_\theta$. (C) Same as (A) for the stream function on moist isentropes $\Psi_{\theta_e}$. Contour interval is $2.5 \times 10^{10}$ kg s$^{-1}$. Solid contours are positive values of the stream function and correspond to northward flow at low levels, whereas dashed contours are negative values of the stream function and correspond to southward flow at low levels. In (B) and (C), the thin solid line and two dotted black lines show the 50, 10, and 90 percentiles, respectively, of the surface potential or surface equivalent potential temperature distributions.

(Pauluis et al, Science, 2008)
Kinetic energy (m s\(^{-2}\))

Total

Transient

Stationary

Mean

(Peixoto and Oort, fig 7.22)
ERA40 based on 850hPa relative vorticity from Bengtsson et al 2006

Cyclone tracks:
NH DJF

Figure 4 shows the storm track statistics for the Southern Hemisphere (SH) winter (JJA). For ERA-40 the generation of cyclones (Fig. 4c) occurs throughout the storm track regions but with preferred regions occurring to the east of the southern Andes. The area of cyclogenesis is extended both northward and southward along the same longitude with the southern area extending to the northern part of the Antarctic Peninsula. These areas of cyclogenesis are more confined in the SH summer and more extended in the other season.

(a) ERA-40 track density (color) and mean intensity (line), (b) ECHAM5 track density (color) and mean intensity (line), (c) ERA-40 cyclogenesis density, and (d) ECHAM5 cyclogenesis density. Densities are number density per unit area per month where the unit area is equivalent to a 5° spherical cap ($10^6$ km$^2$) and mean intensities are in units of $10^{-5}$ s$^{-1}$. Dashed lines indicate specific mean intensities.
Figure 4 shows the storm track statistics for the Southern Hemisphere (SH) winter (JJA). For ERA-40 the generation of cyclones (Fig. 4c) occurs throughout the storm track regions but with preferred regions occurring to the east of the southern Andes. The area of cyclogenesis is extended both northward and southward along the same longitude with the southern area extending to the northern part of the Antarctic Peninsula. These areas of cyclogenesis are more confined in the SH summer and more extended in the other season.

Cyclone tracks: SH JJA

Track density (per month per $10^6$ km$^2$)

Intensity (contours; $10^{-5}$ s$^{-1}$)  

ERA40

Based on 850hPa relative vorticity from Bengtsson et al 2006
Large-scale turbulent flow in the atmosphere
Illustration of large-scale atmospheric flow: satellite water vapor imagery

October 7, 2007 00:12 UTC

Animation: Robert Simmon, NASA
Data: Seviri water vapor (IR)
Power spectrum of meridional wind at 45S

Based on ERA40 winds. The spectrum sums to the vertically averaged zonal variance of $v \cos(\phi)$ where $\phi$ is latitude.
Nastrom et al, Nature, 1984: Fig. 1 commercial aircraft data near the tropopause (meridional data is shifted one decade to the right)
Water vapor and the hydrological cycle
Precipitation (mm/day)

GPCP Precipitation
Precipitation (mm/day) Composite Mean

NOAA/ESRL Physical Sciences Division

Jan to Dec: 1980 to 2001

(CDC interactive plotting website)
Time and zonal mean specific humidity

ERA40, 1980-2001
Time and zonal mean *saturation* specific humidity

**ERA40, 1980-2001**
Time and zonal mean relative humidity

ERA40, 1980-2001
Next steps

• Project selection

• Understand maintenance of:
  - thermal structure
  - kinetic energy
  - mean surface winds
  - relative humidity and precipitation