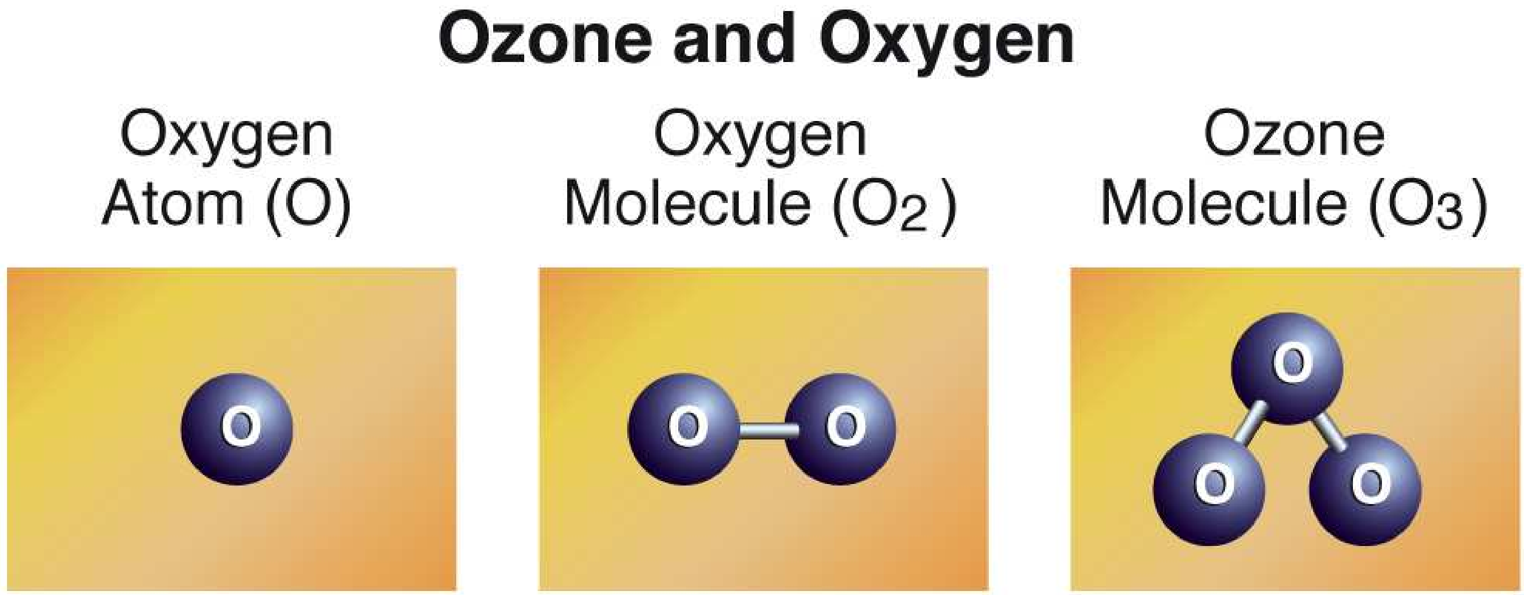
THE LMDZ-REPROBUS CHEMISTRY-CLIMATE MODEL: FIRST RESULTS ON IMPACT OF SOLAR VARIABILITY ON THE EARTH ATMOSPHERE

SHTI + IPSL climate modelling pole + Slimane Bekki

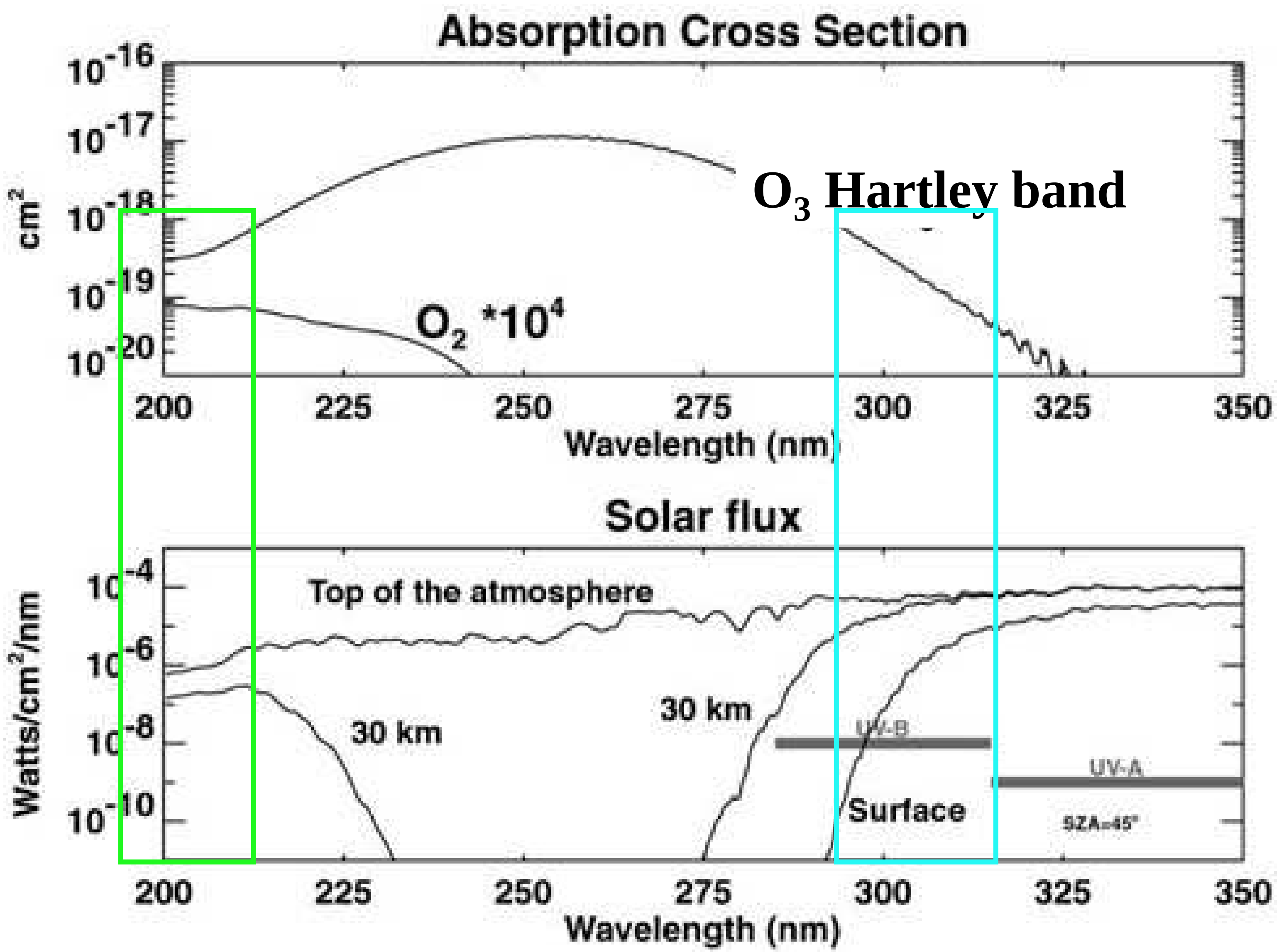
° Background (focus on stratospheric ozone and on how solar variability can impact ozone and climate)

°Solar impact on polar climate through ozone changes



Ozone:

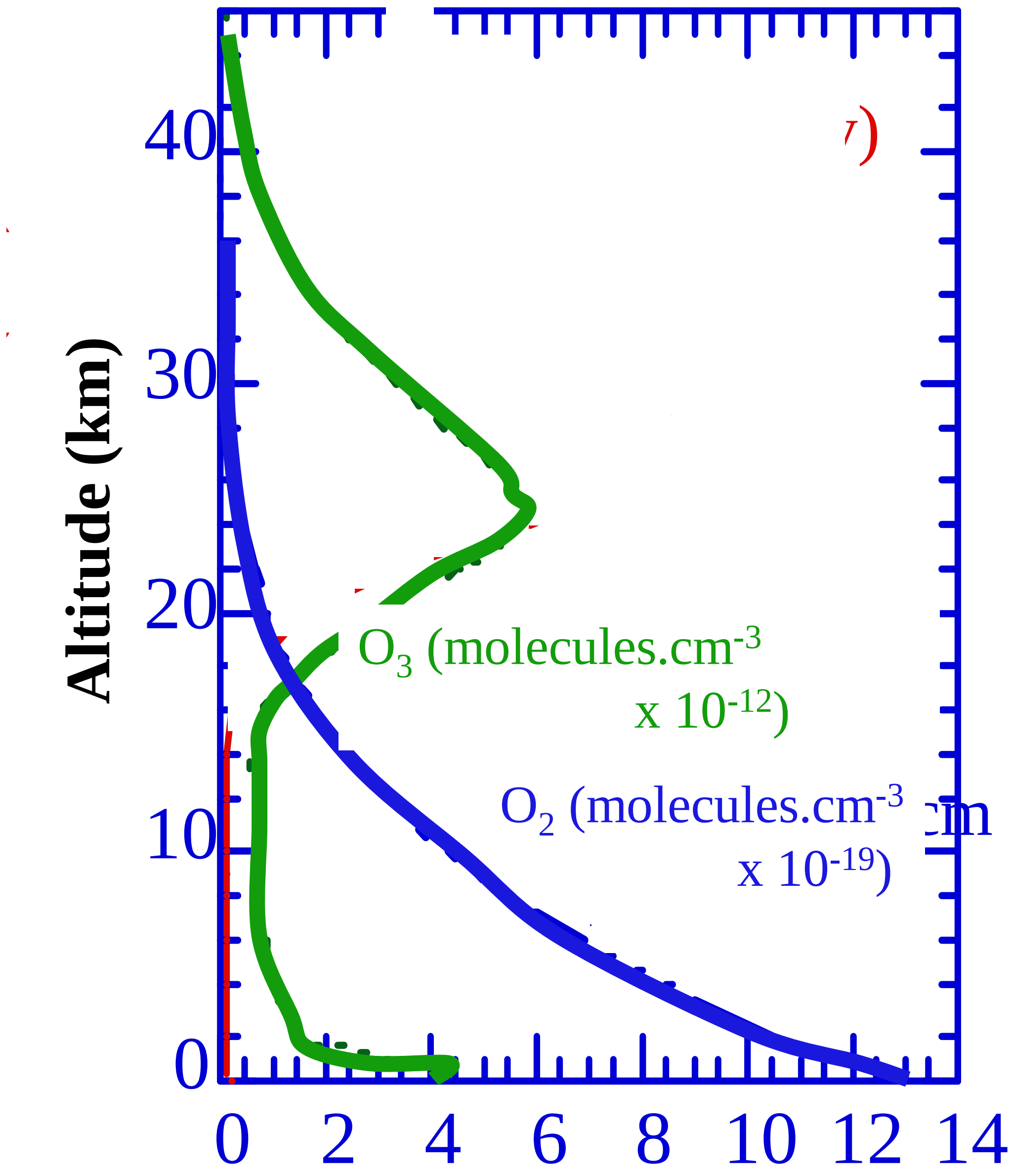
- Highly reactive gas.
- Important radiative gas (solar and terrestrial radiation)
  -> surface UV and dT/dz> 0 in the stratosphere.
- Main source of O_3 is photolysis of O_2

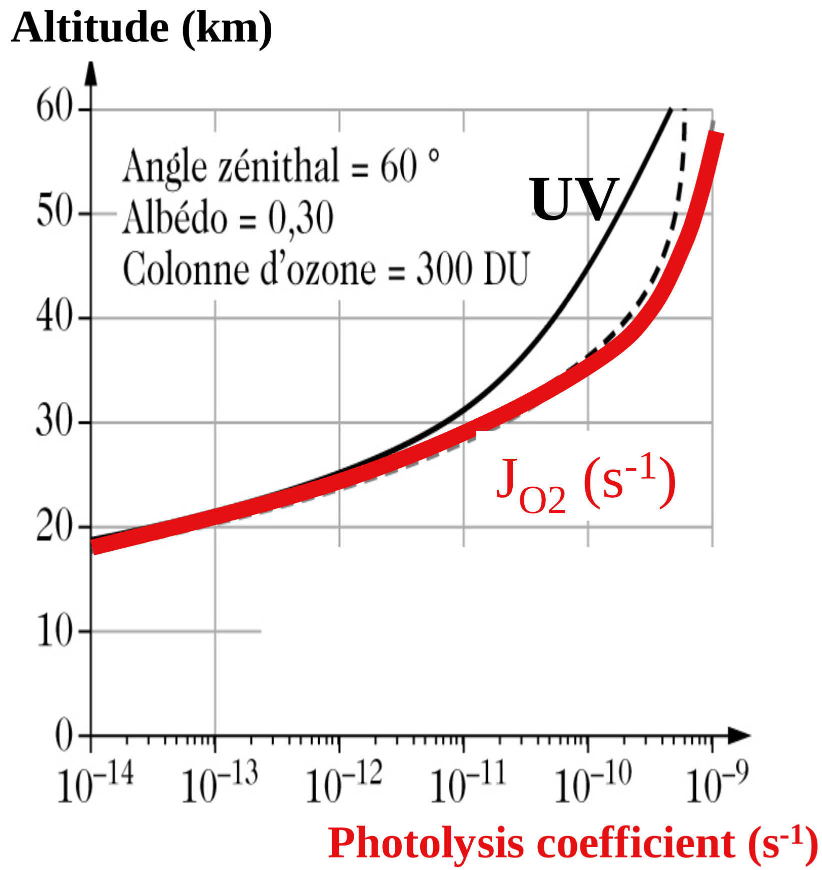


O_2 + UV(C) = source of O_3

O_3 + UV(B) = source of OH

SHAPE OF OZONE PROFILE



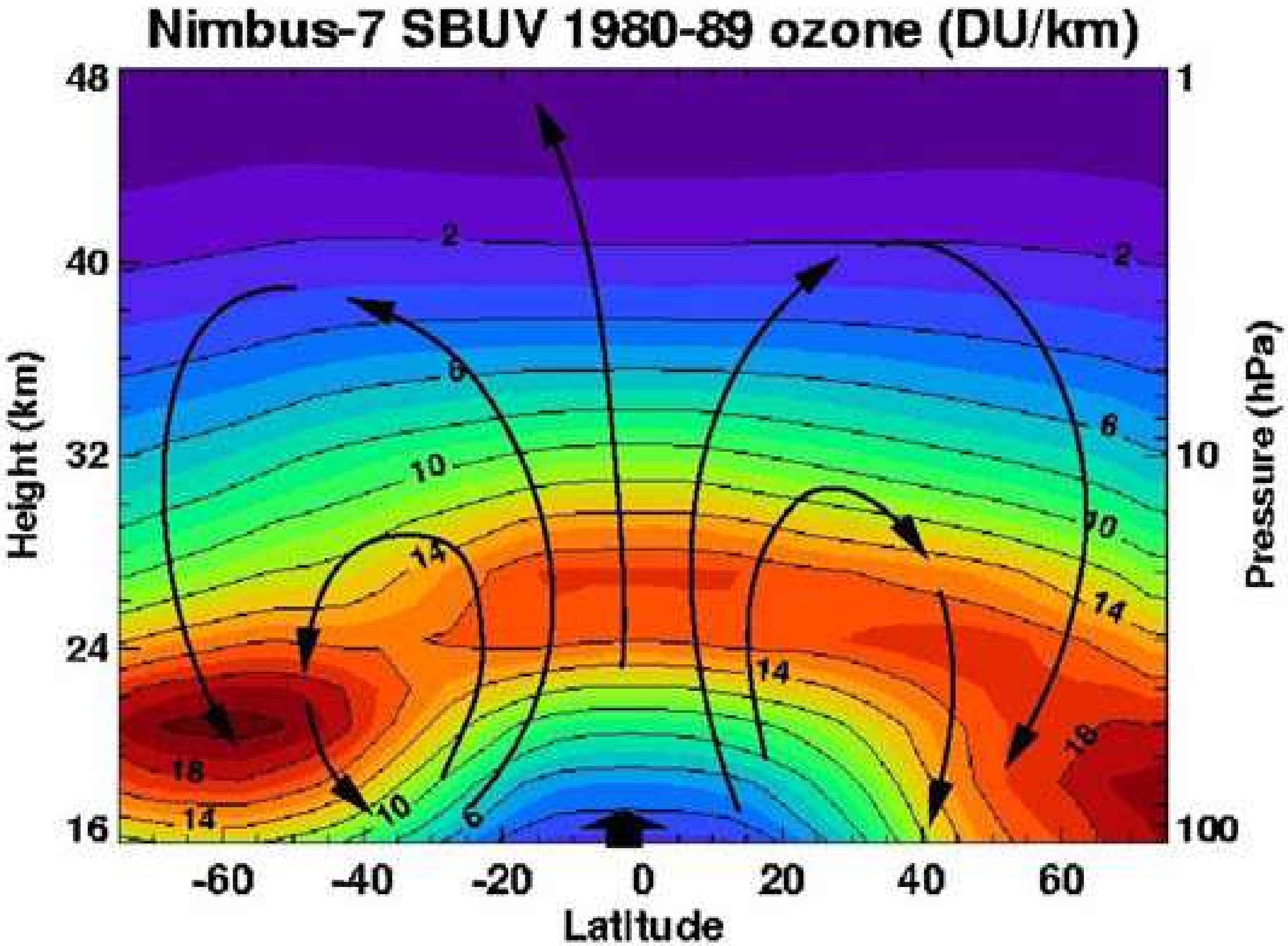


O_2 + UV-c -> O + O

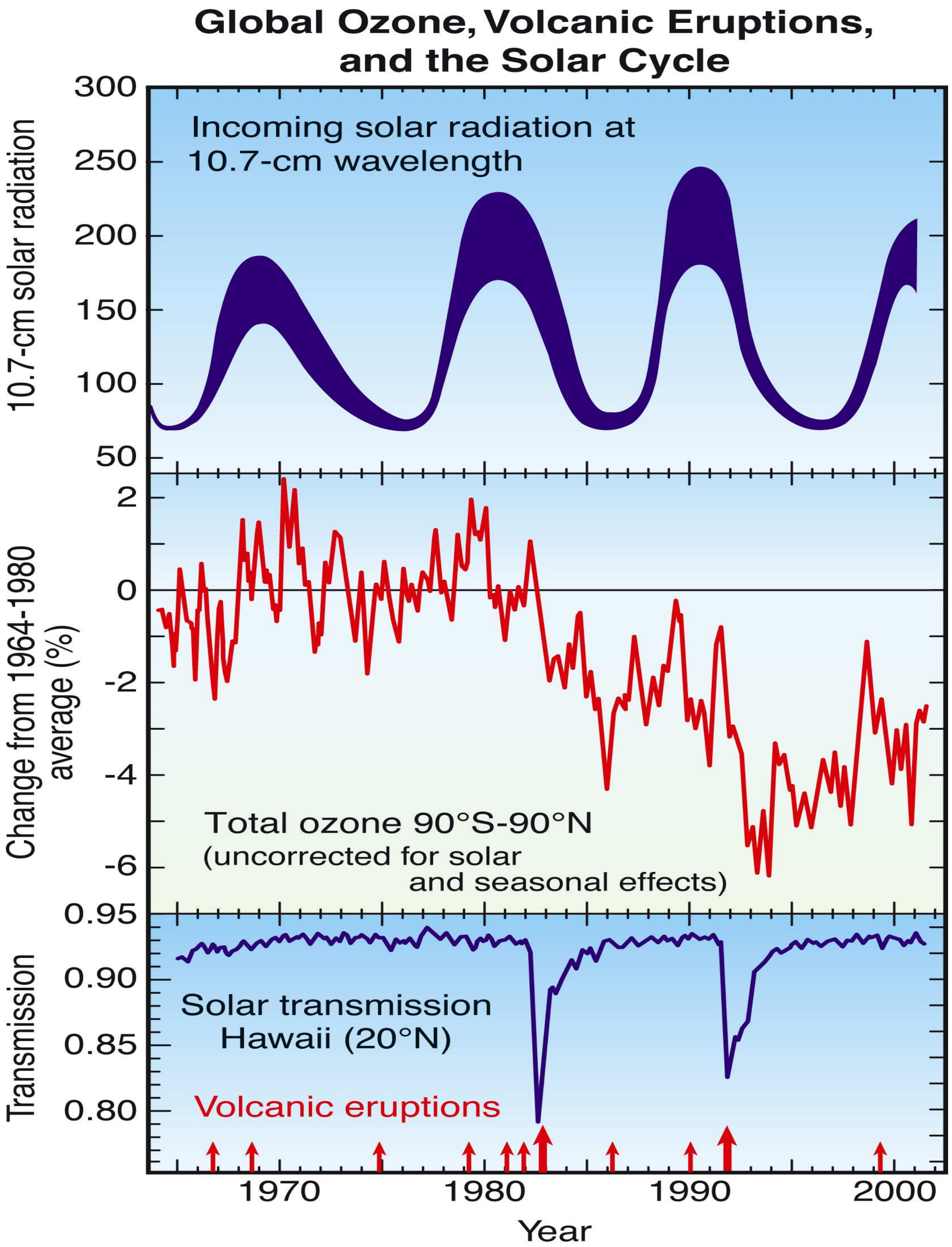
O + O_2 + M -> O_3 + M

$$d[O_3]/dt = 2 J_{O2} [O_2]$$

OZONE GLOBAL DISTRIBUTION



Stratospheric circulation driven by tropospheric wave forcing

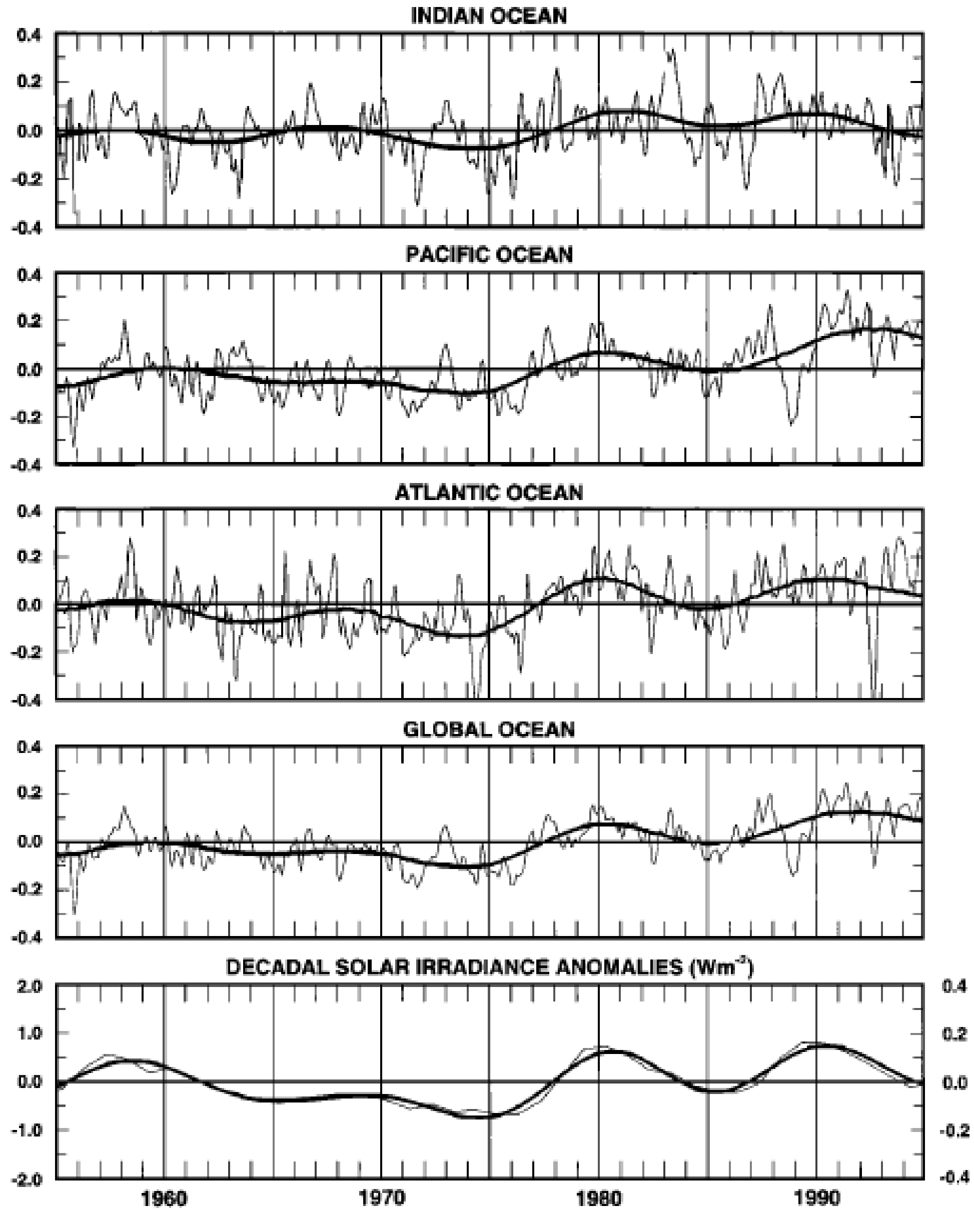


-> J_{O2} =f(UV)
(source of O_3)

-> long term trend in chlorine loading (destruction term)

-> heterogeneous chemistry (destruction term)

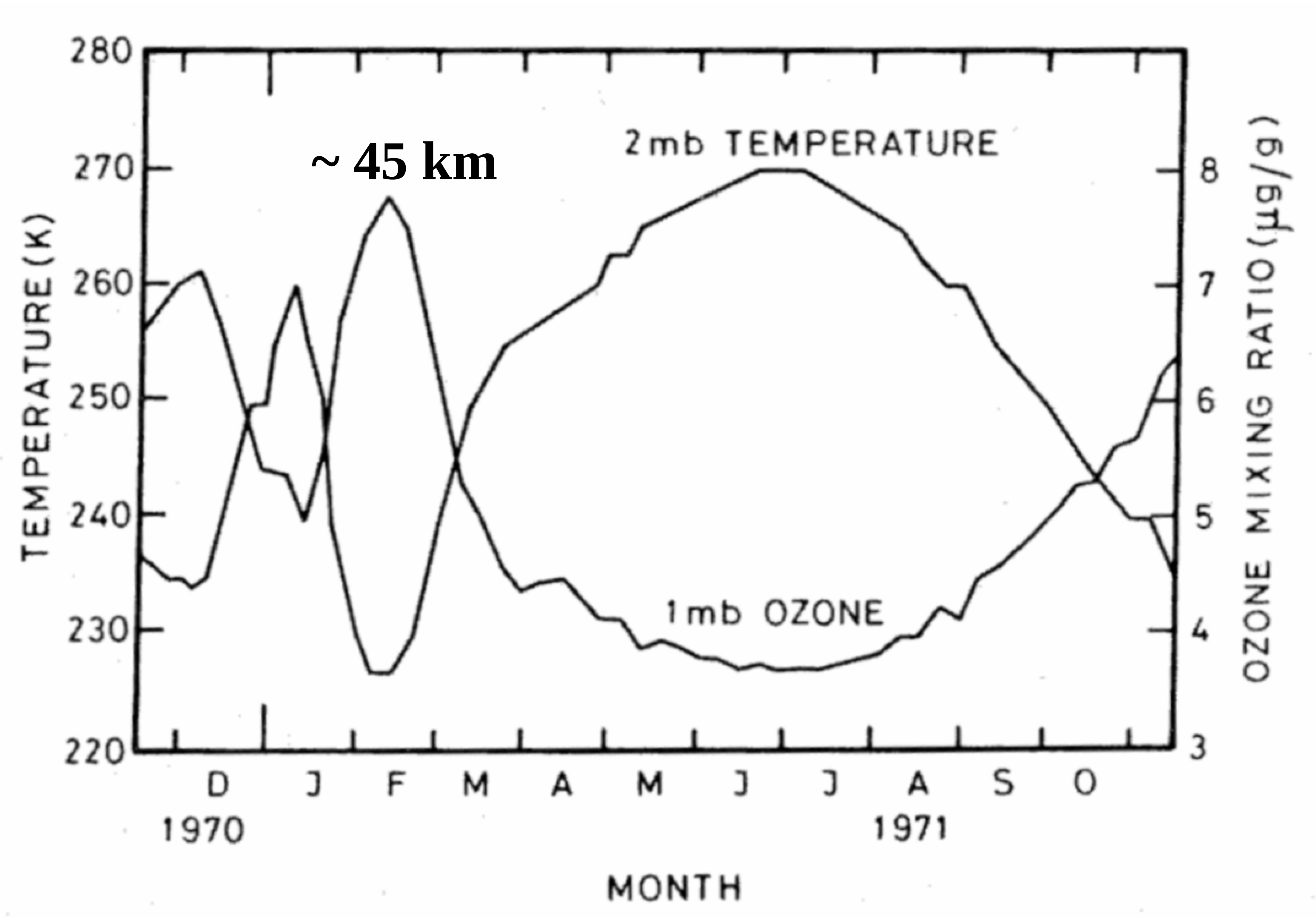
IMPACT OF SOLAR VARIABILITY ON SSTs



White et al, JGR,1997

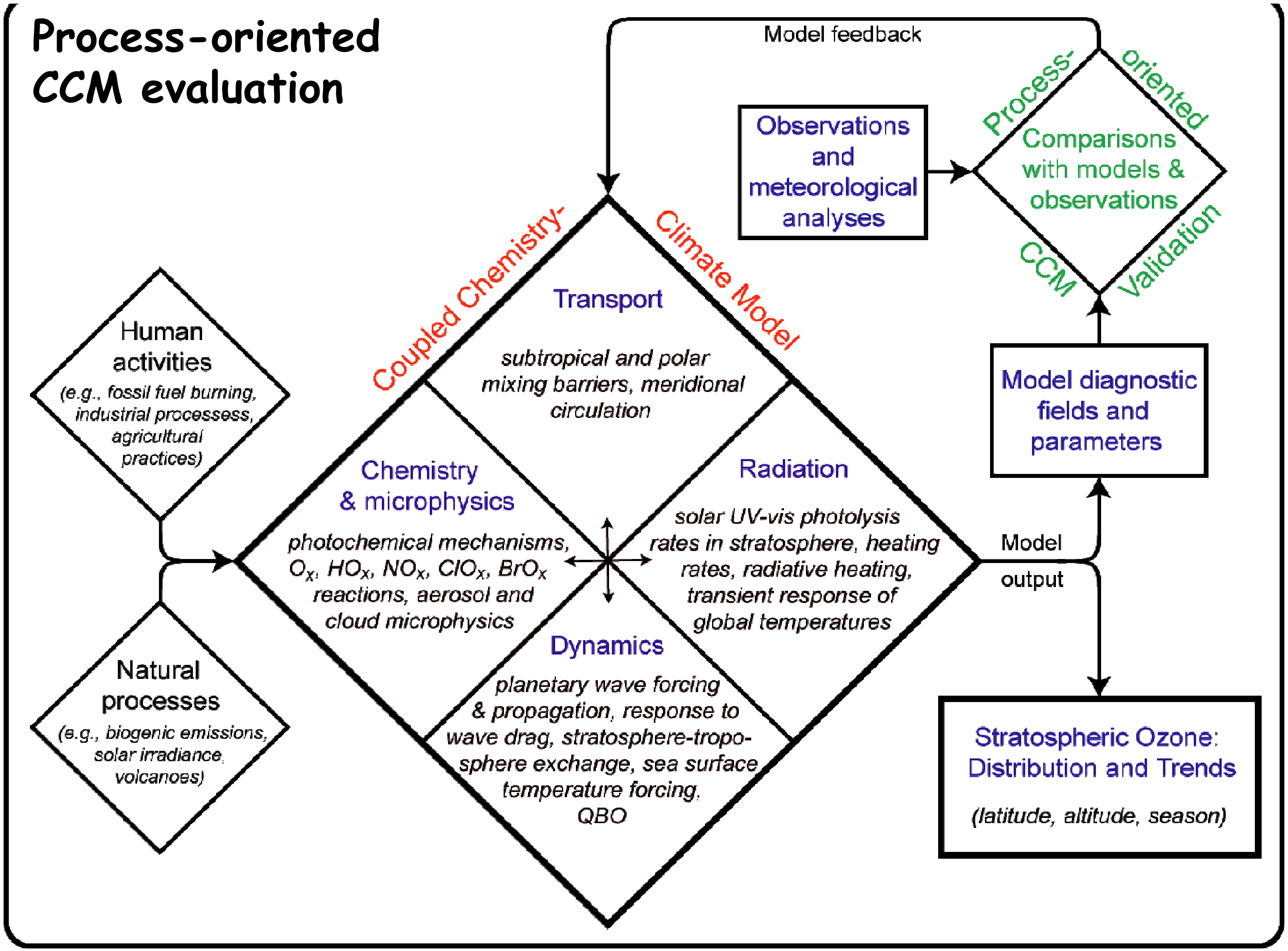
HOW SOLAR VARIABILITY CAN IMPACT SURFACE CLIMATE THROUGH OZONE CHANGES?

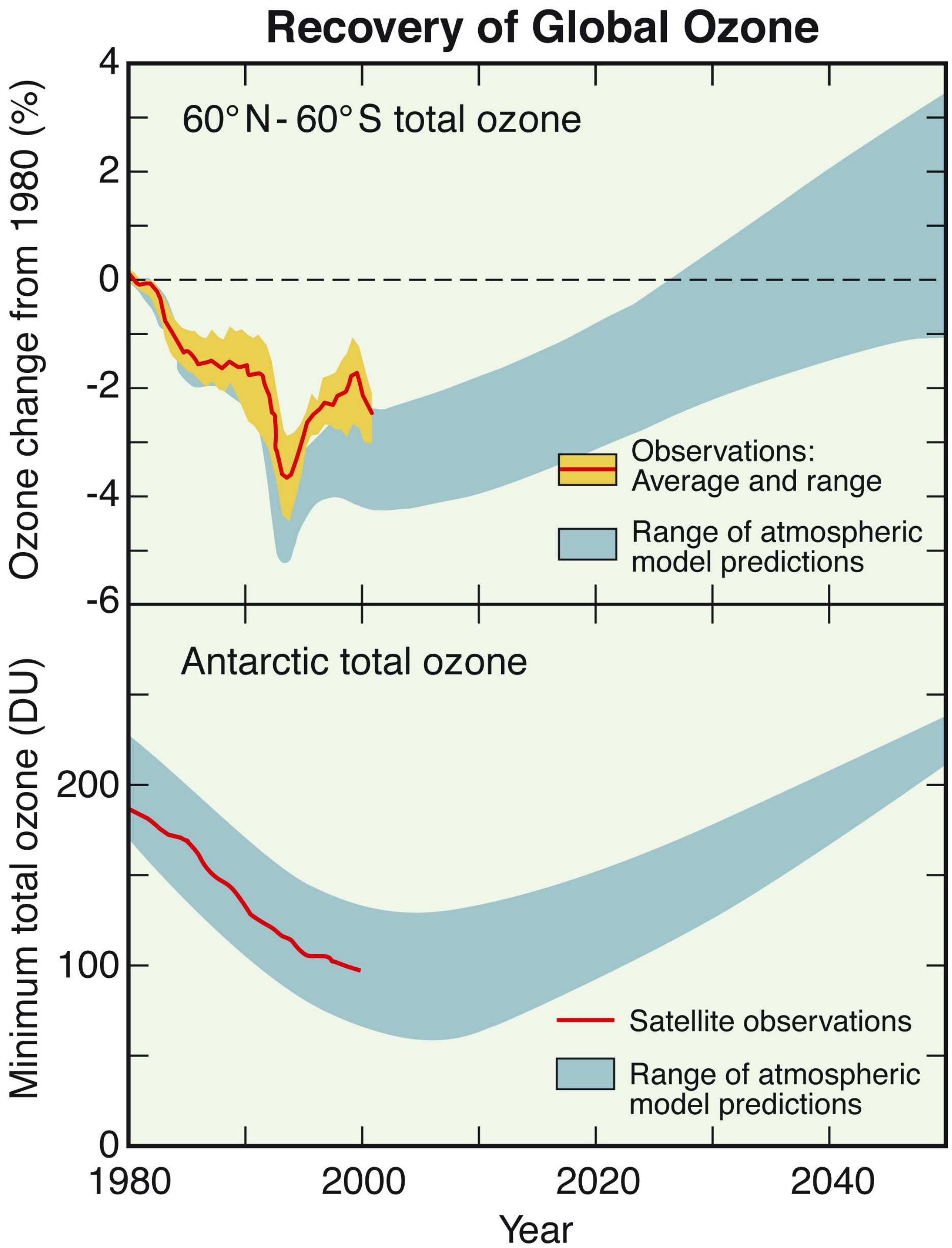
TEMPERATURE AND OZONE STRONGLY COUPLED IN THE MIDDLE ATMOSPHERE



UV changes -> O3 changes <=> T and wind changes

CHEMISTRY CLIMATE MODELLING

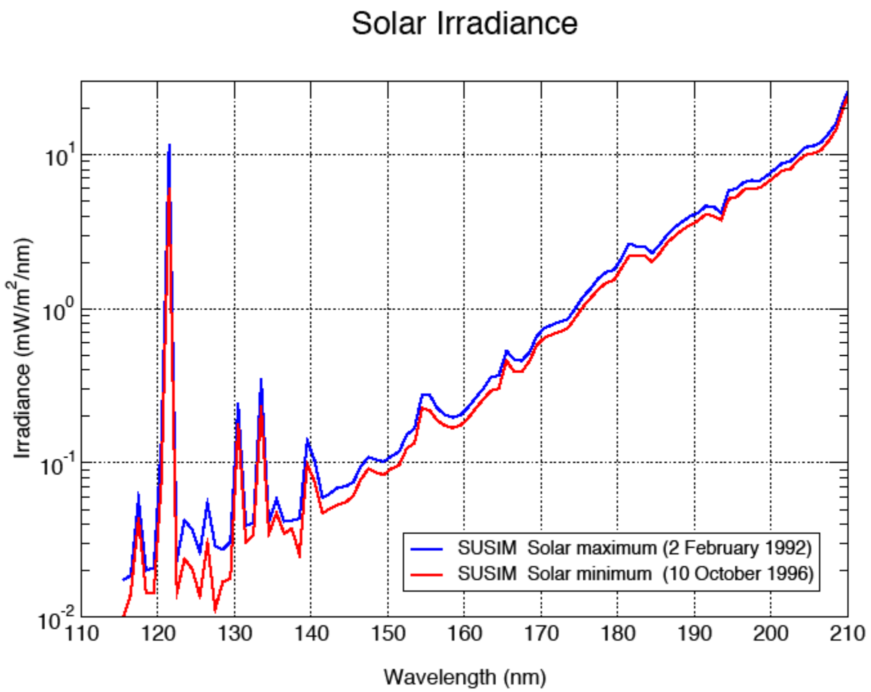


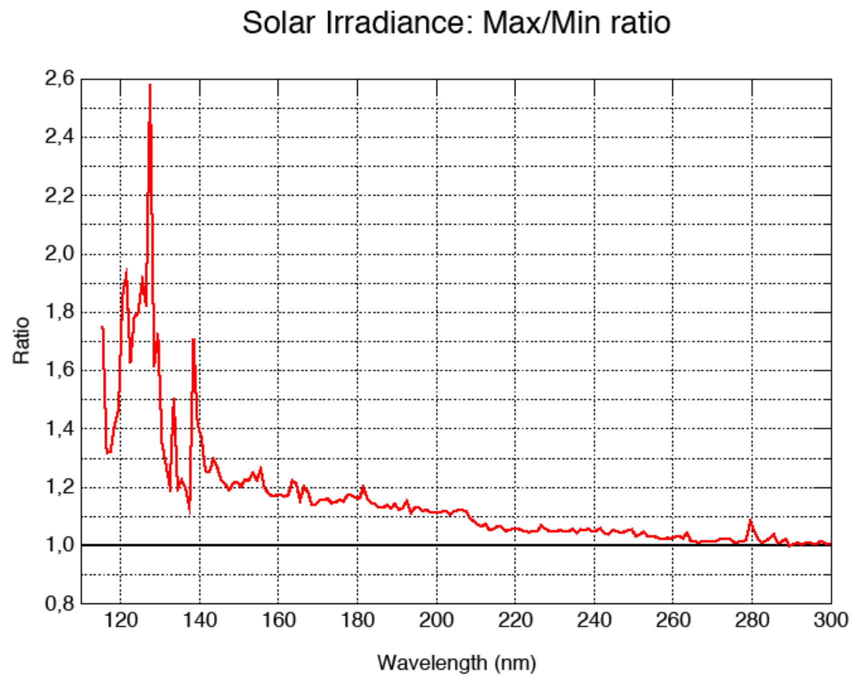


Future O_3 = f(CFCs, greenhouse gases)

What about solar variations?

LMDz-REPROBUS 30 YEARS SIMULATIONS: MINIMUM AND MAX SOLAR CONDITIONS FOR THE 11 YEAR CYCLE

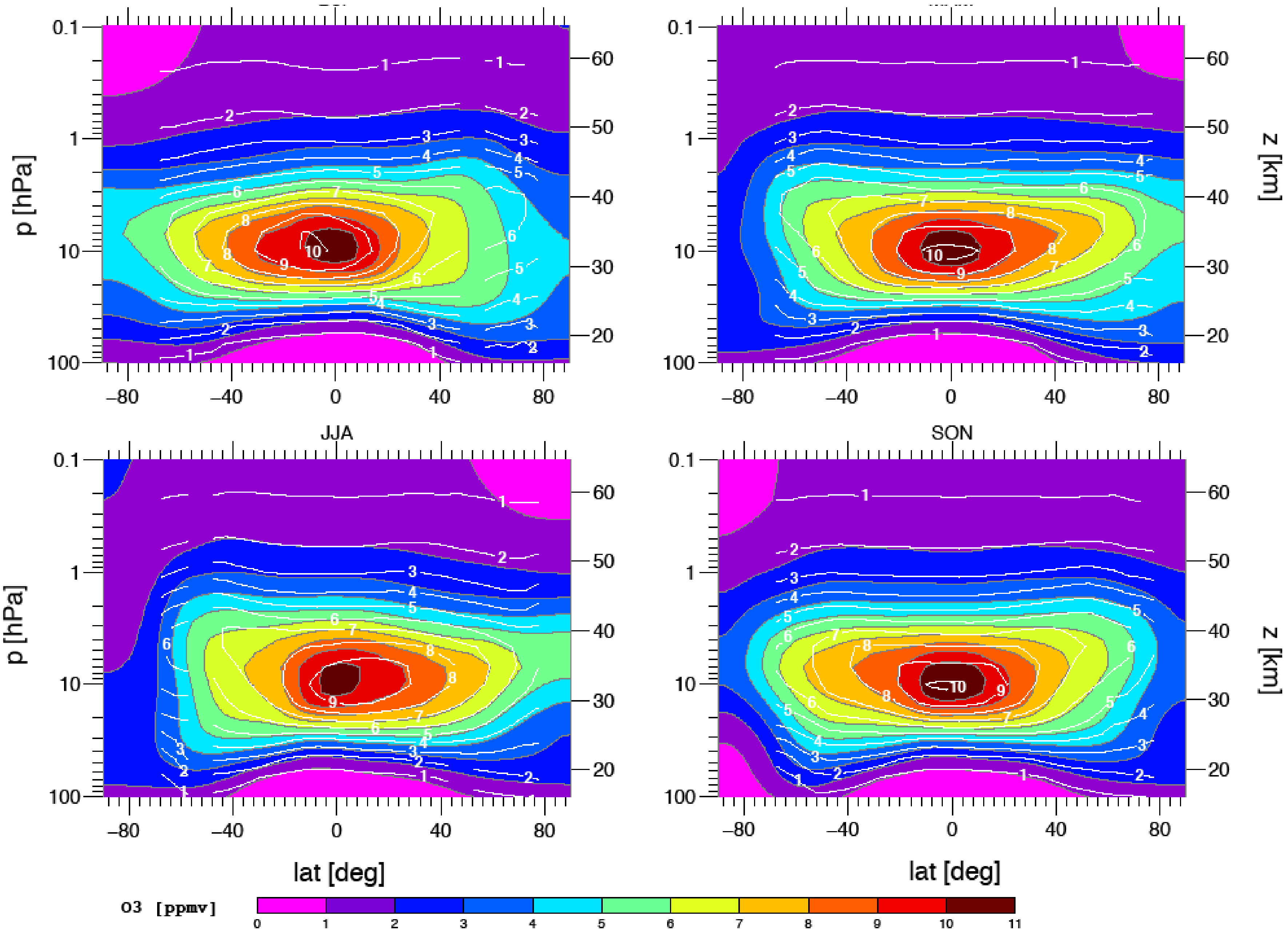




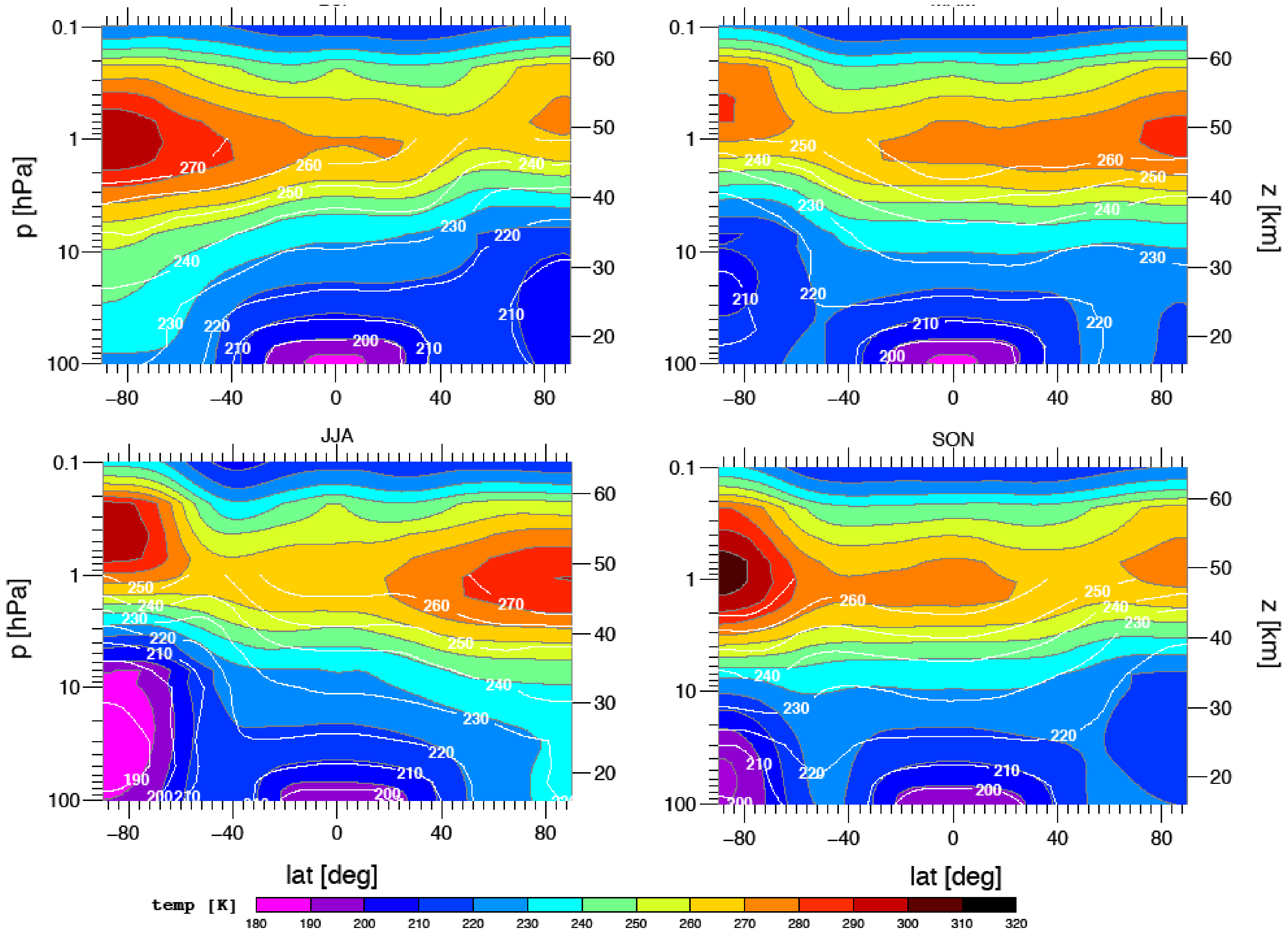
All the other forcings are kept constant:

SSTs, sea ice, stratospheric aerosols, CFCs, GHGs

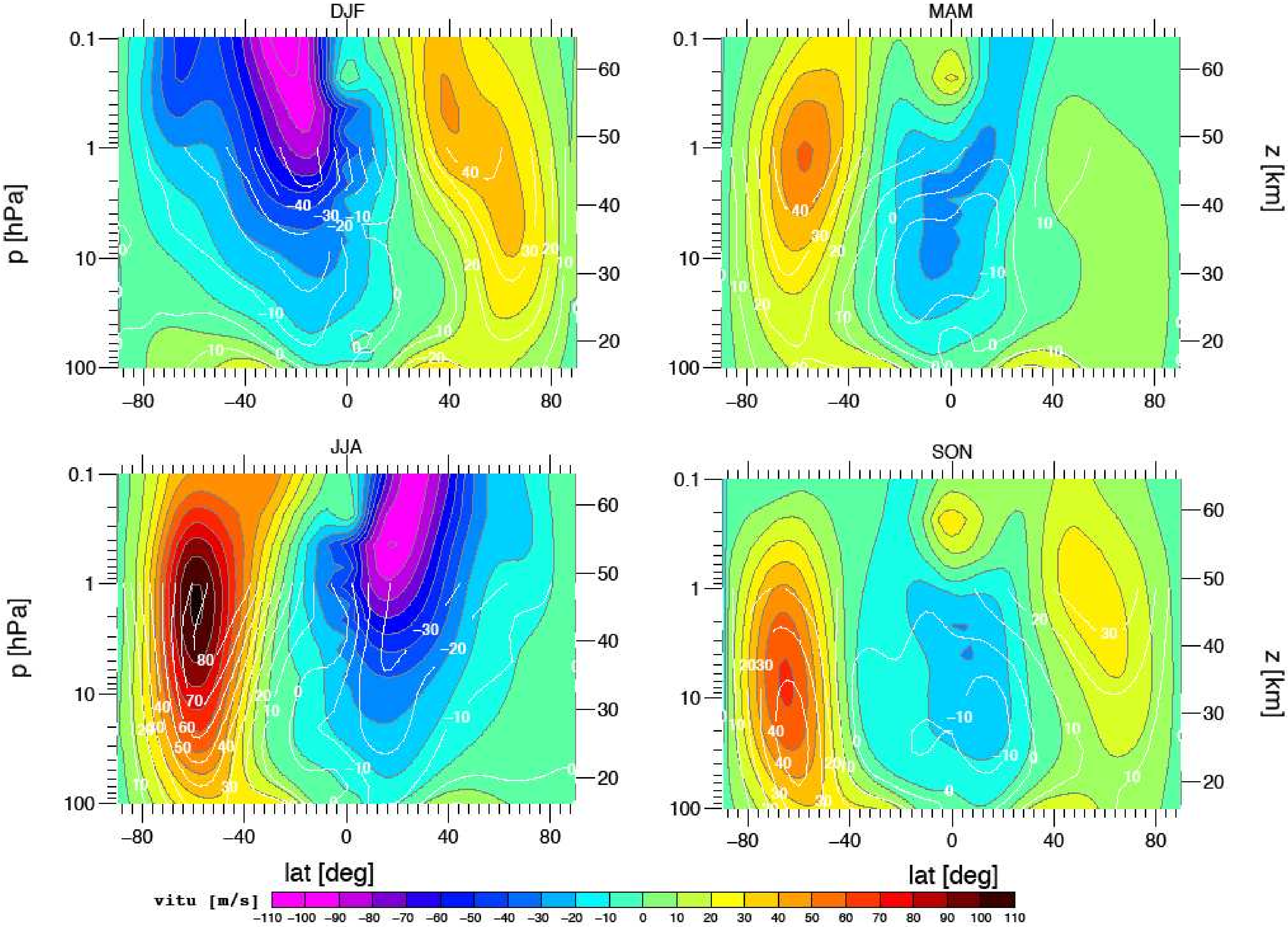
OZONE (PPMV)

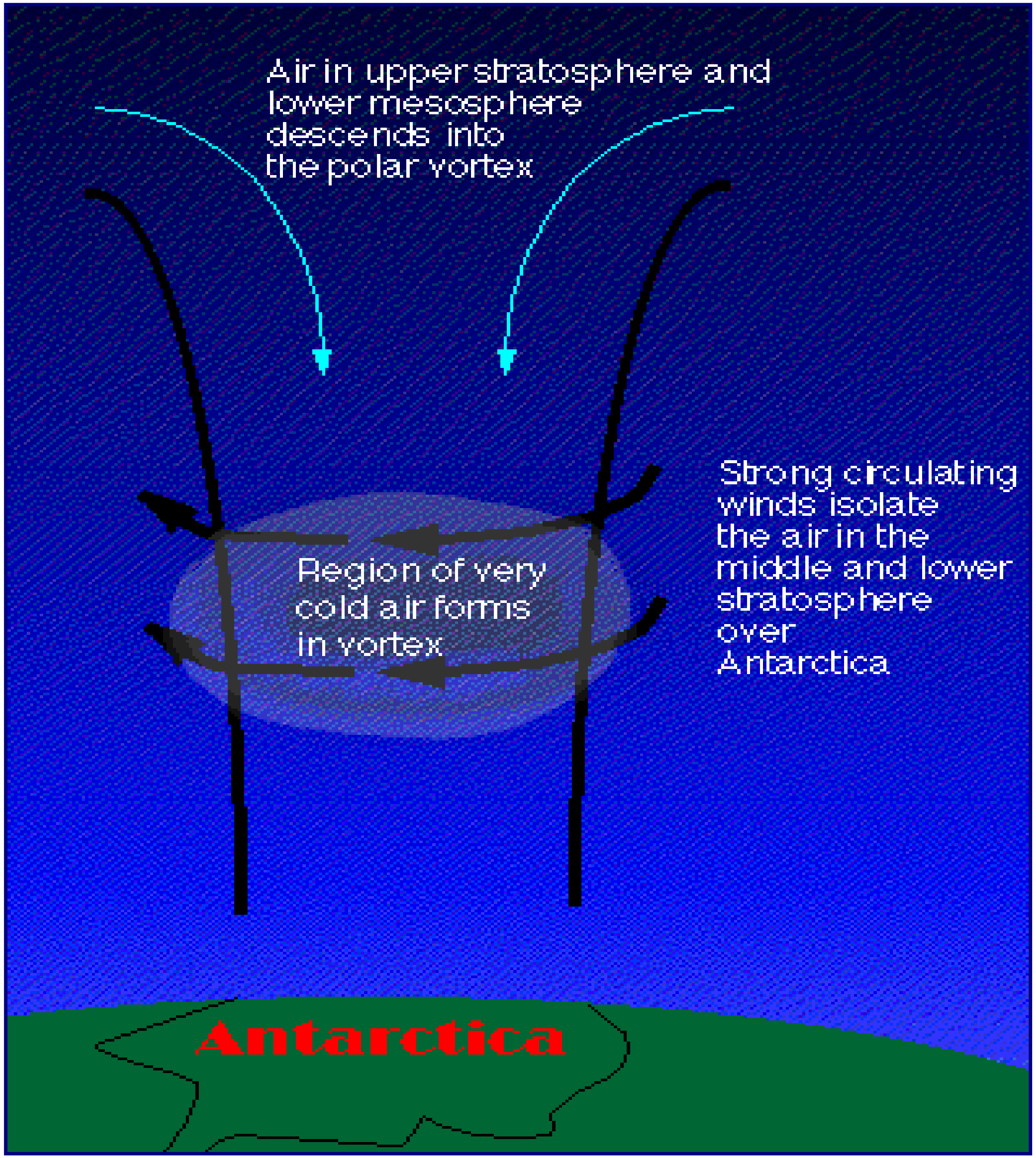


TEMPERATURE (K)

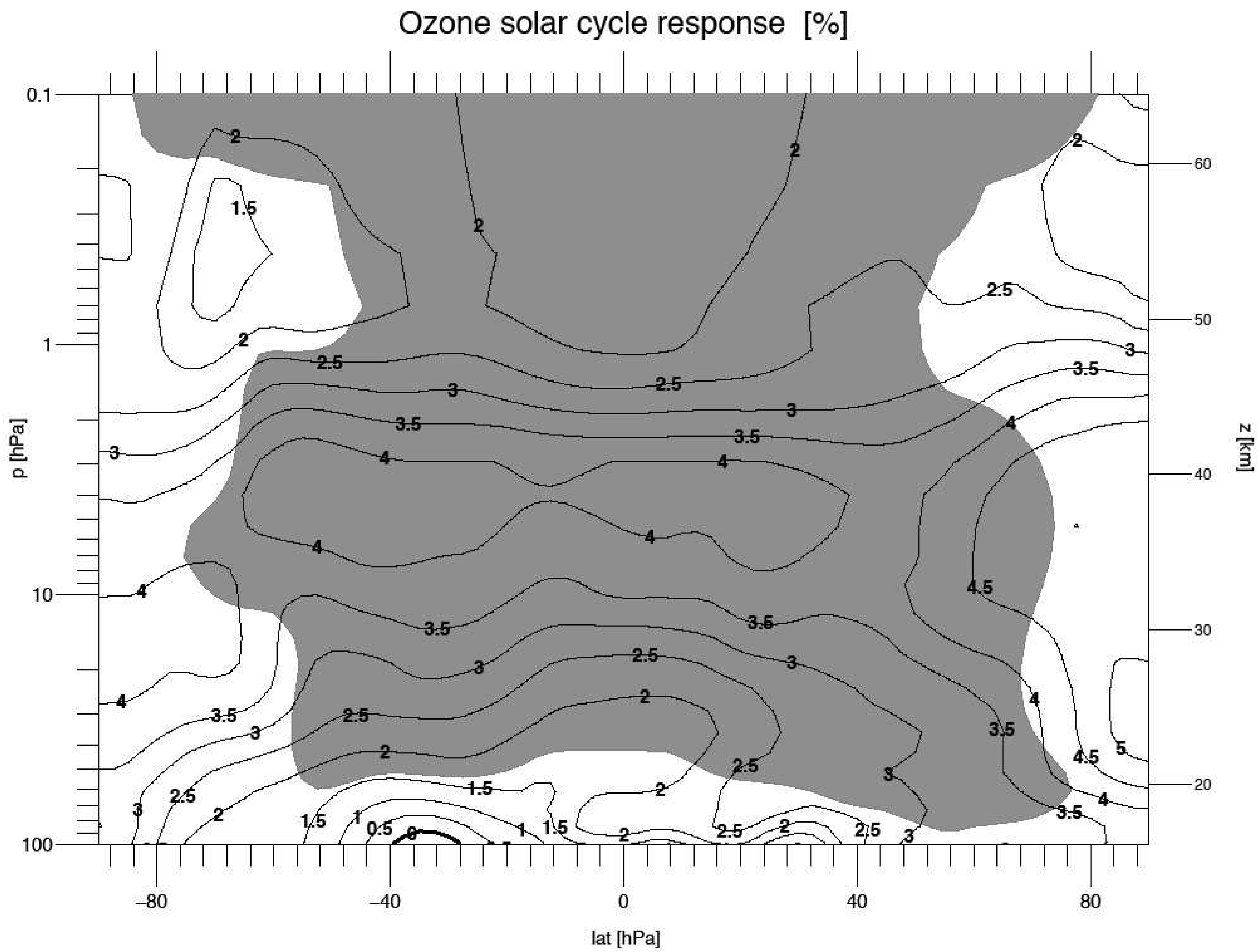


ZONAL WIND (M/SEC)

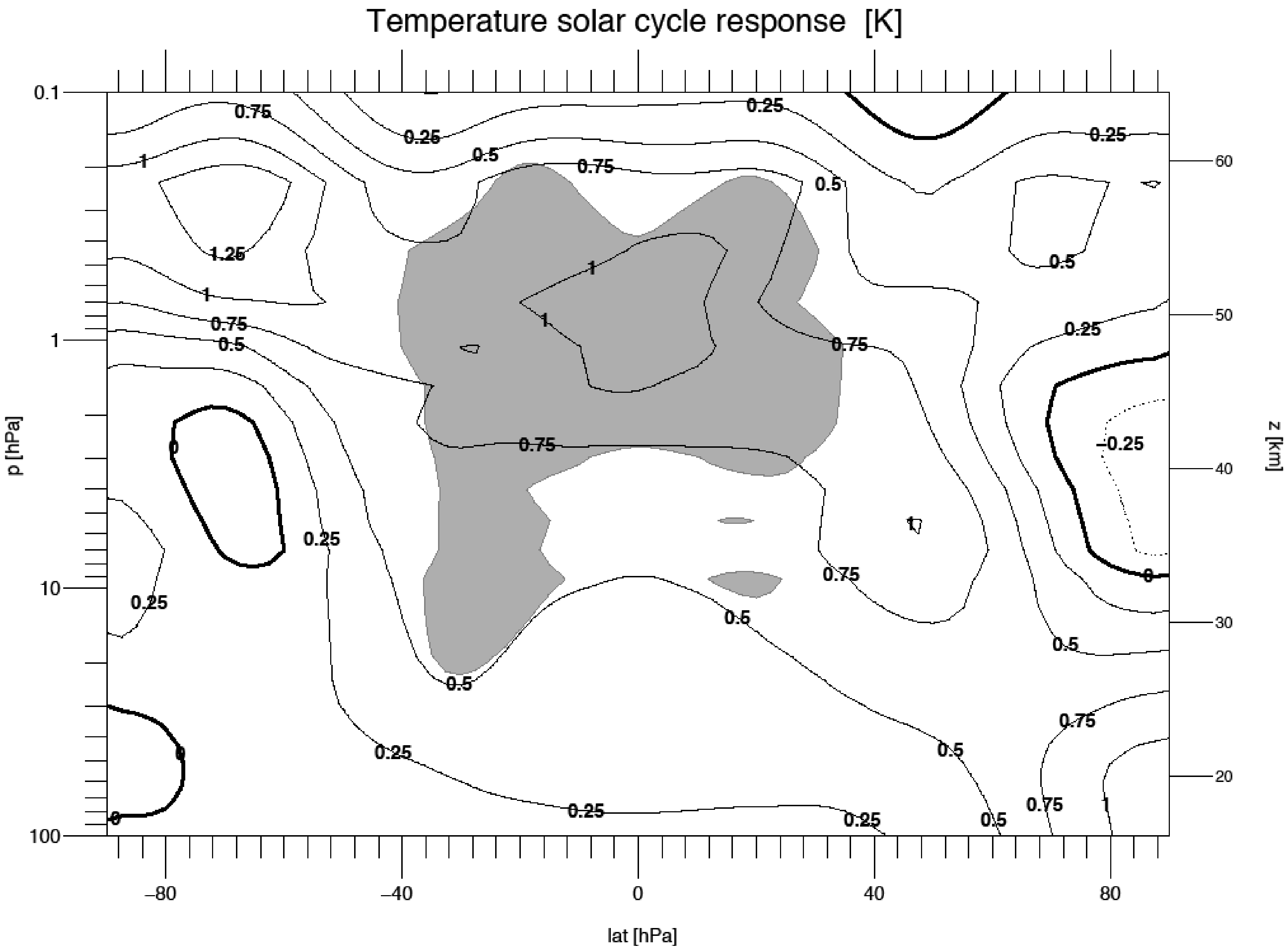


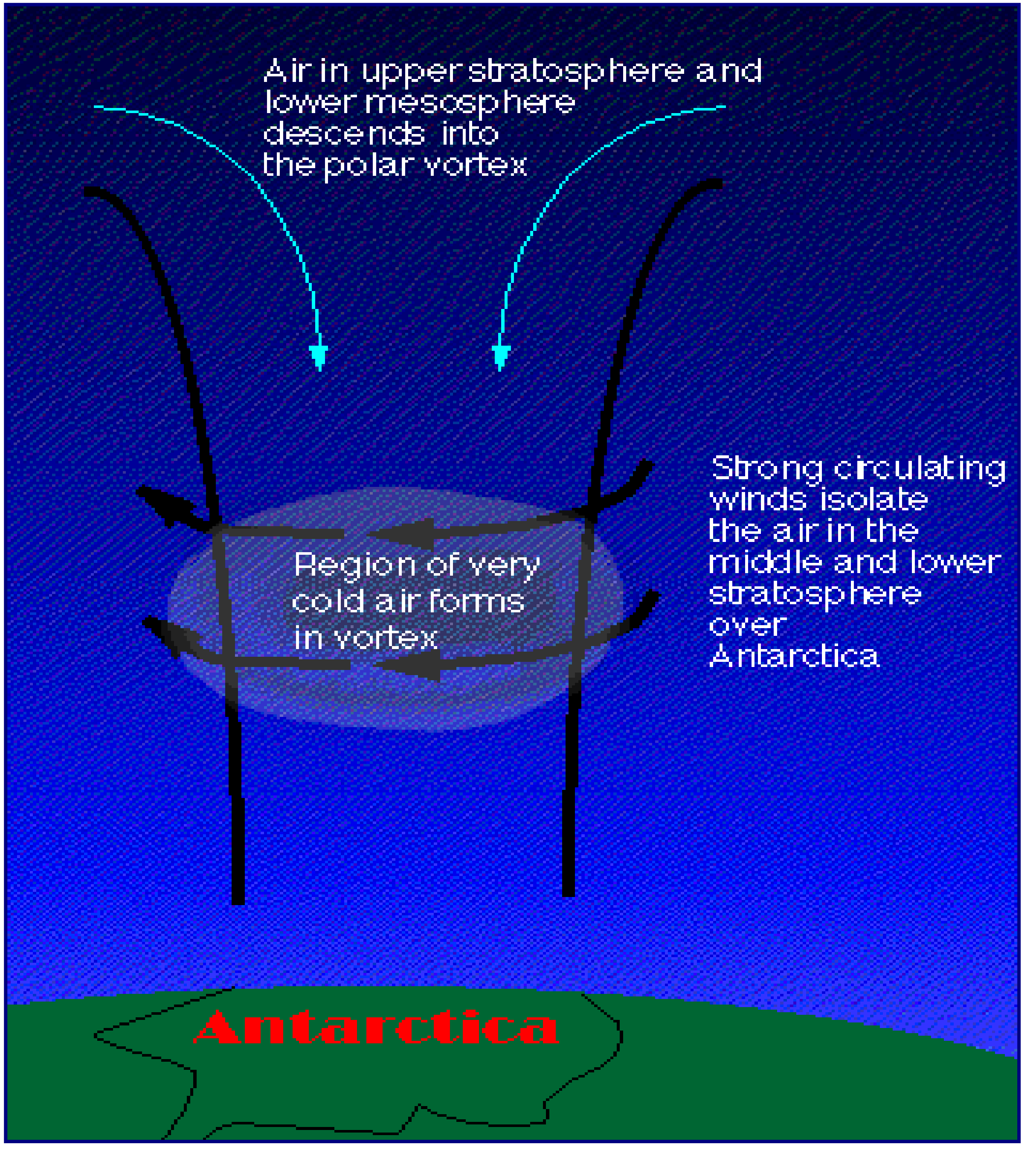


very cold and isolated polar vortex where the chemistry is perturbed (ClO increase, O_3 depletion)



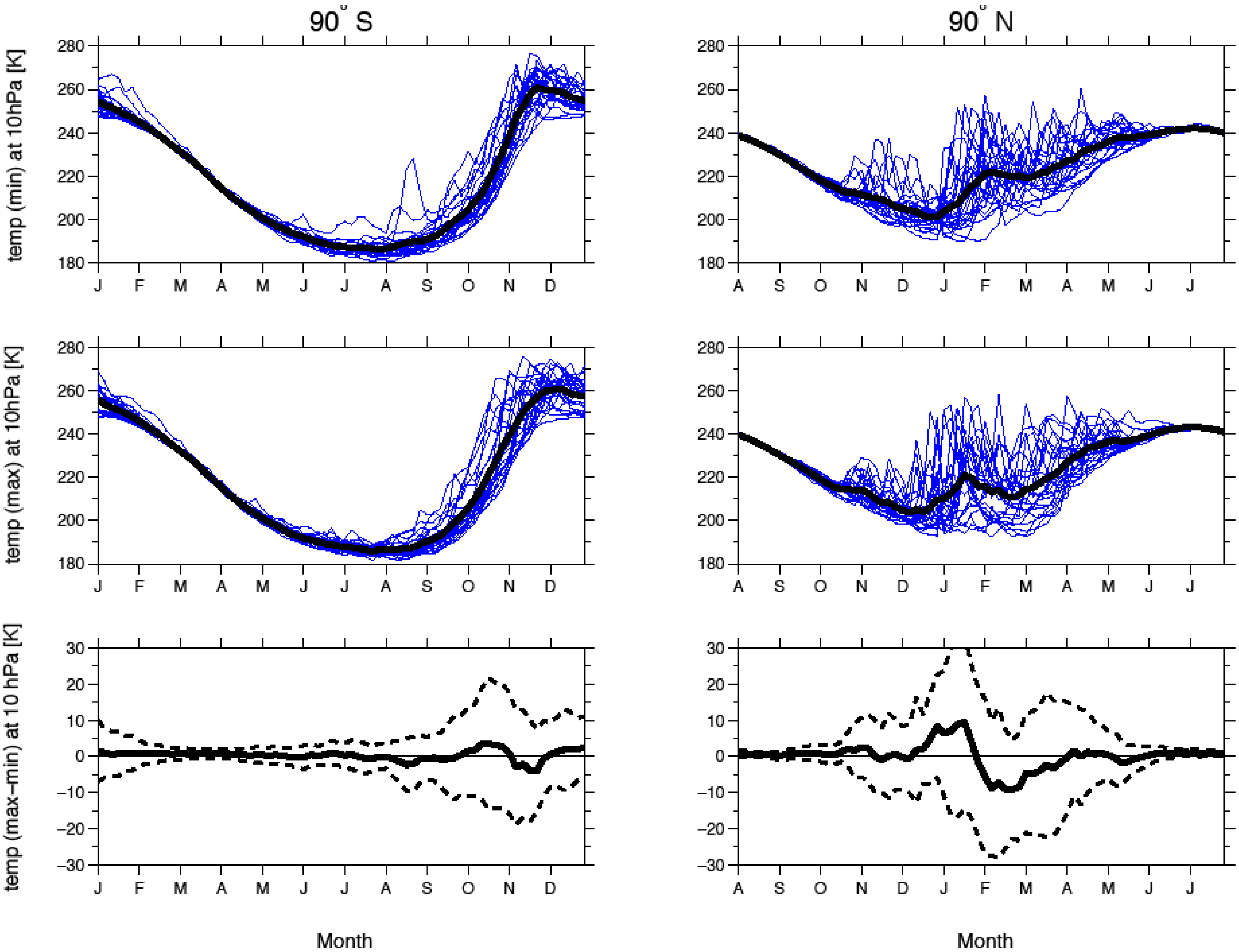
Ozone solar cycle response [%]
p [hPa]
z [km]
lat [hPa]
0.1
1
10
100
-80
-40
0
40
80
60
50
40
30
20


Temperature solar cycle response [K]
p [hPa]
z [km]
lat [hPa]
0.1
1
10
100
−80
−40
0
40
80
60
50
40
30
20

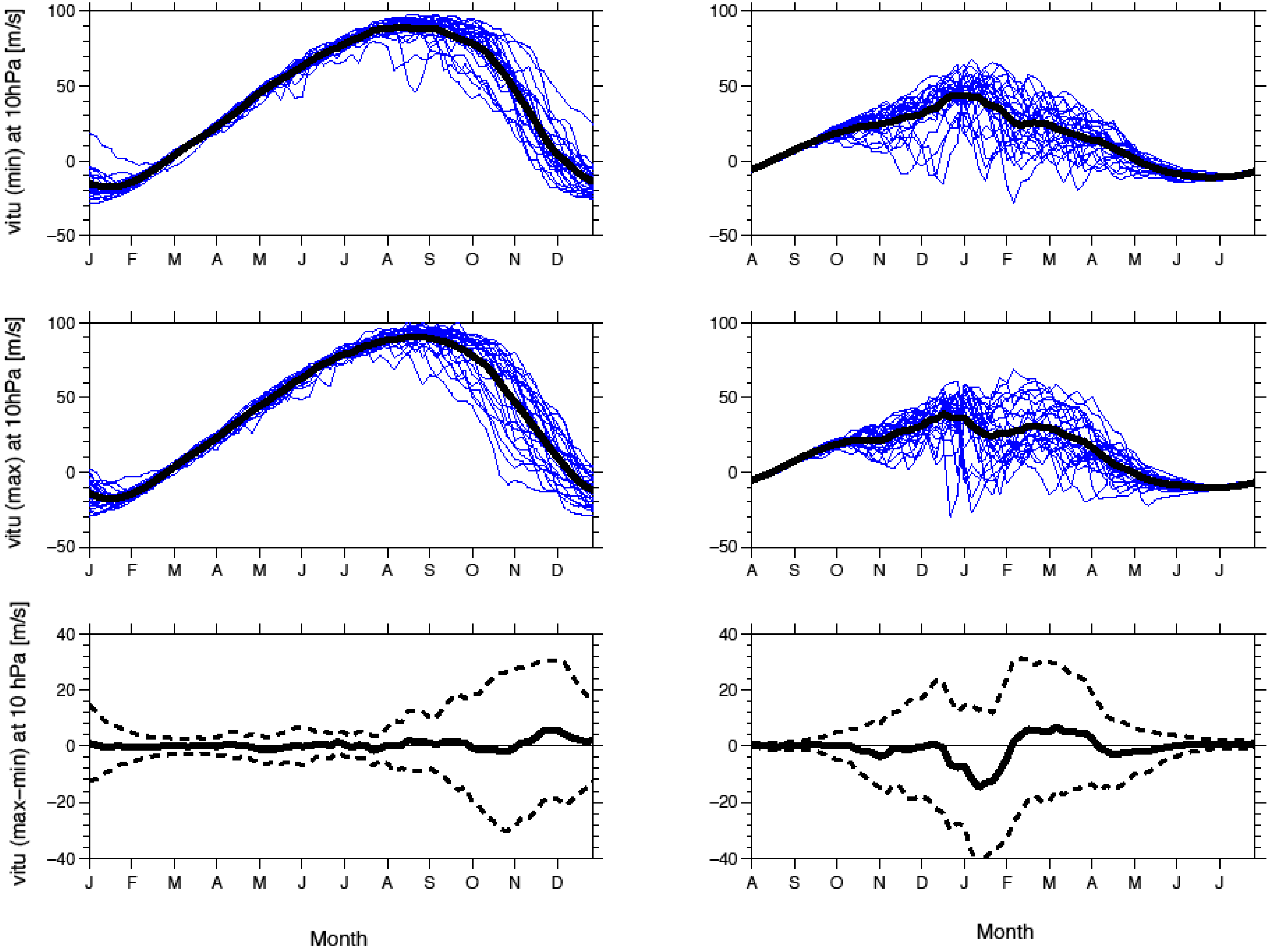


Polar T and Wind at 60 deg.

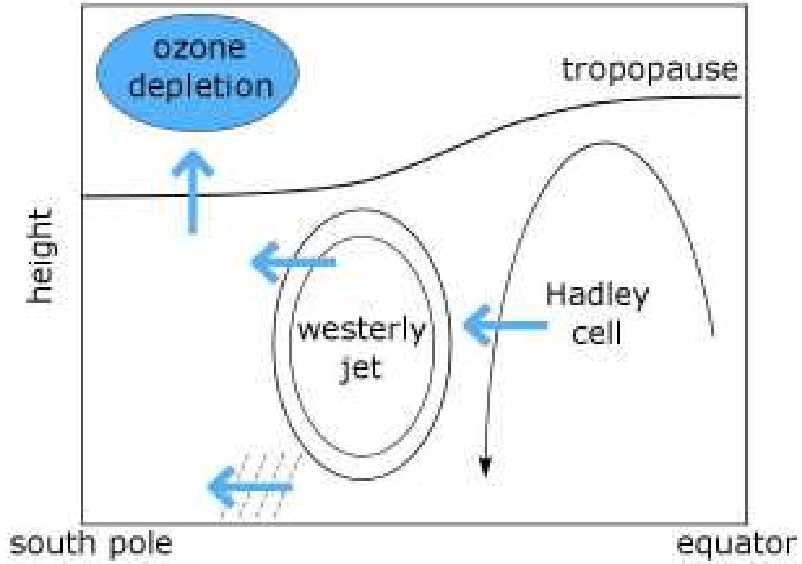
DIFFERENCE IN POLAR TEMPERATURE (K)

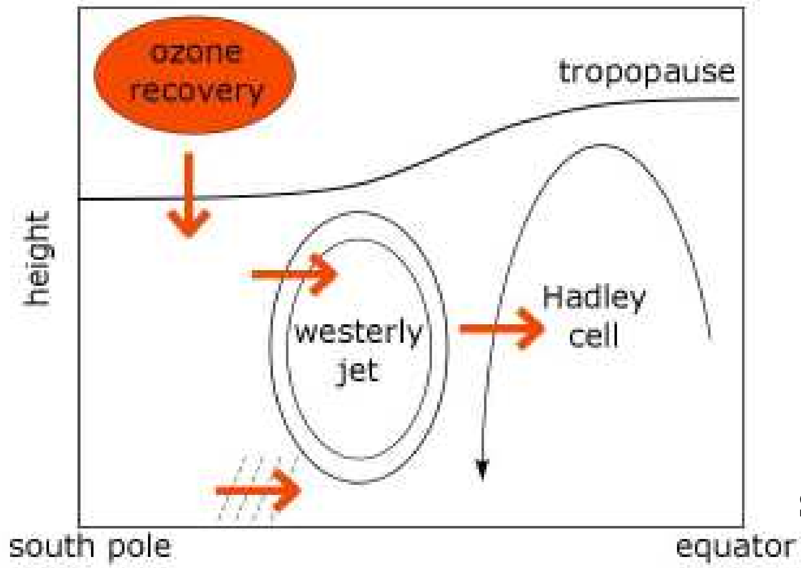


DIFFERENCE IN ZONAL WIND (K)

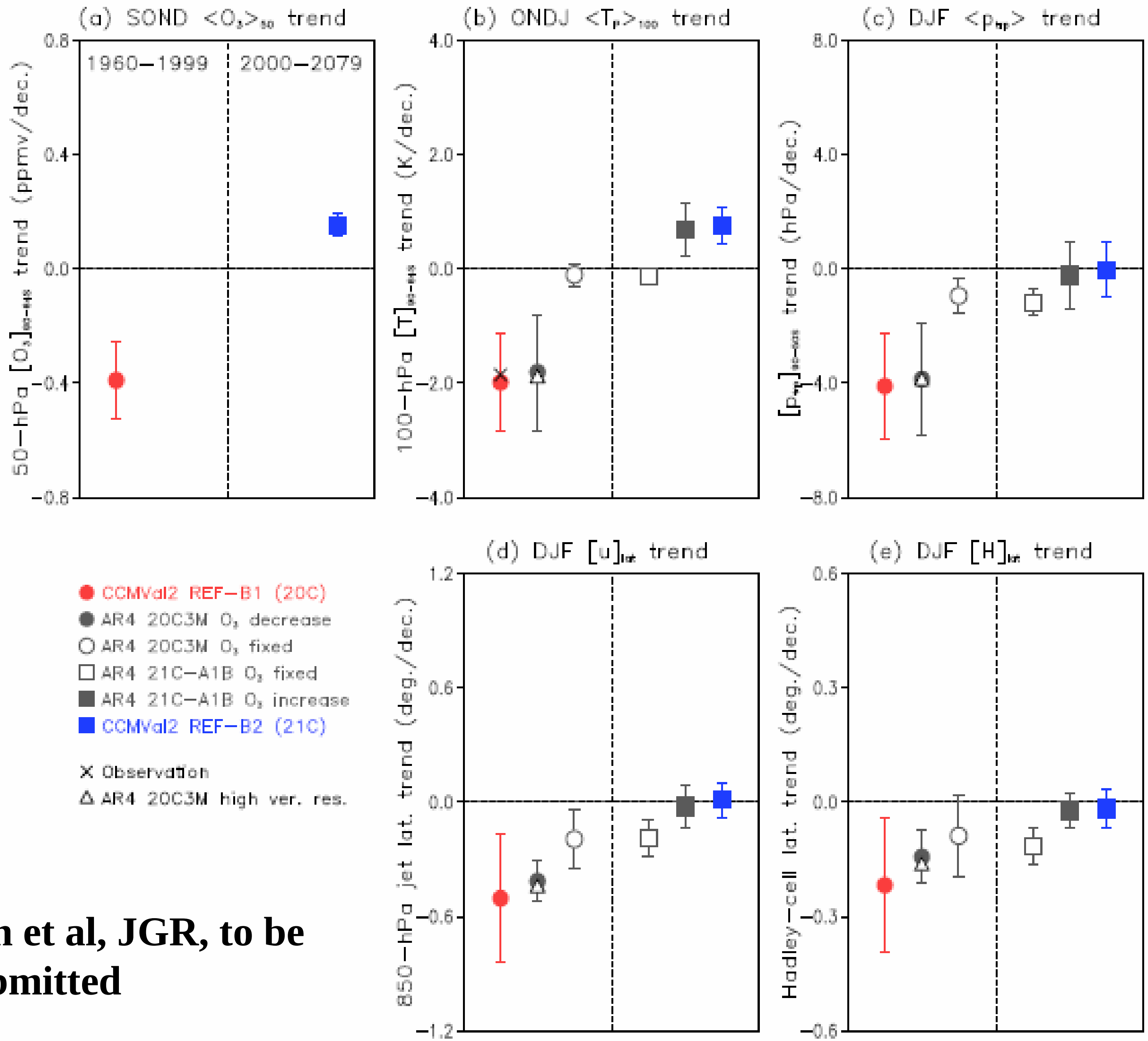


IMPACT OF ANTARCTIC OZONE CHANGES ON SURFACE CLIMATE





Son et al, JGR, to be submitted



Son et al, JGR, to be submitted

CONCLUSIONS

° Improvements to LMDZ-REPROBUS:
- new radiative scheme
- new physics in LMDz
- better microphysics

° To do:
- force model with PICARD data
- evaluate against observations

° Possible impacts of UV-driven stratospheric O_3 changes on surface climate

° Better representation of solar forcing in climate models for next IPCCC exercice.