Pathways to impact:

The ‘top-down’ UV stratospheric route

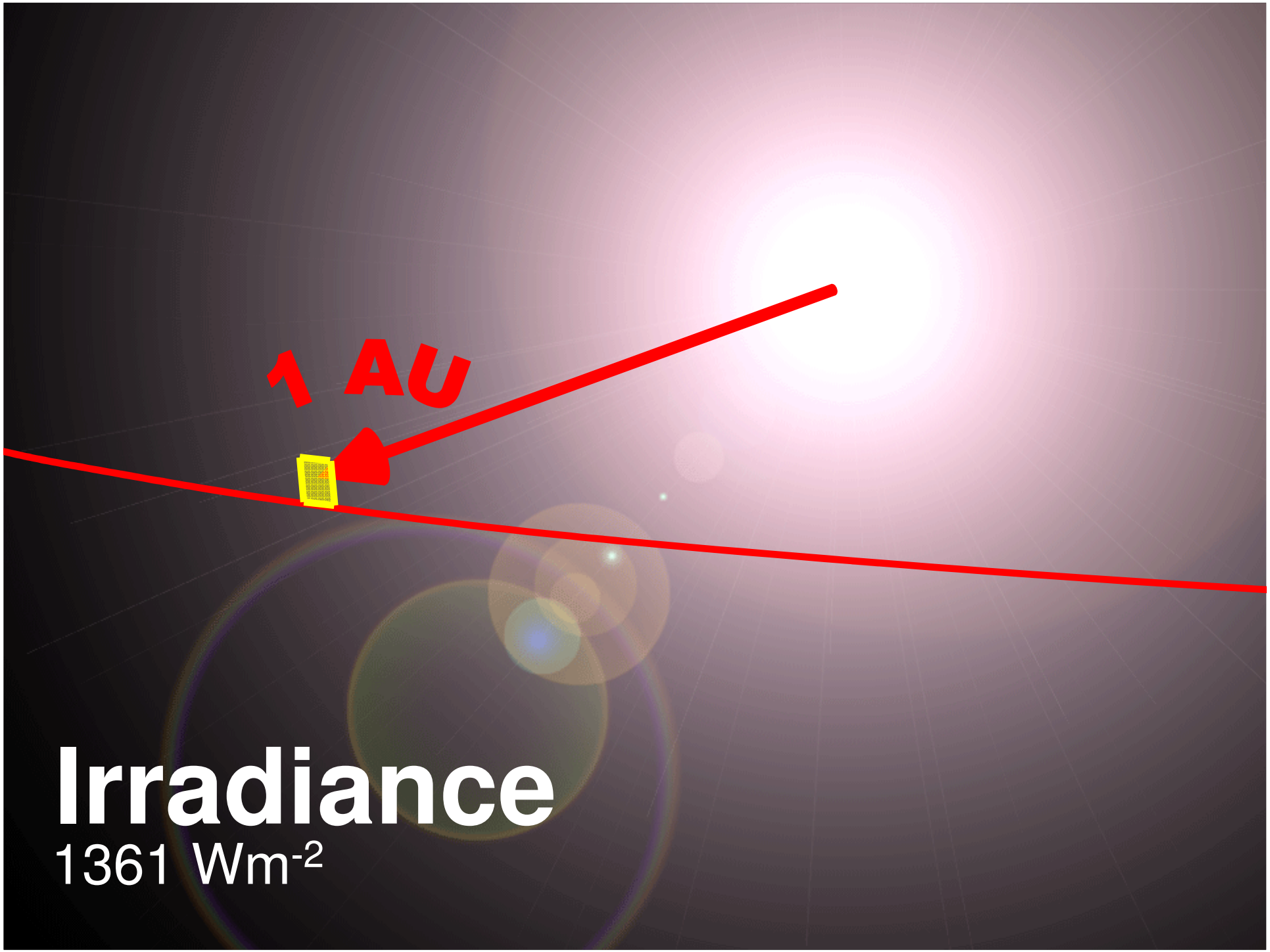
Will Ball

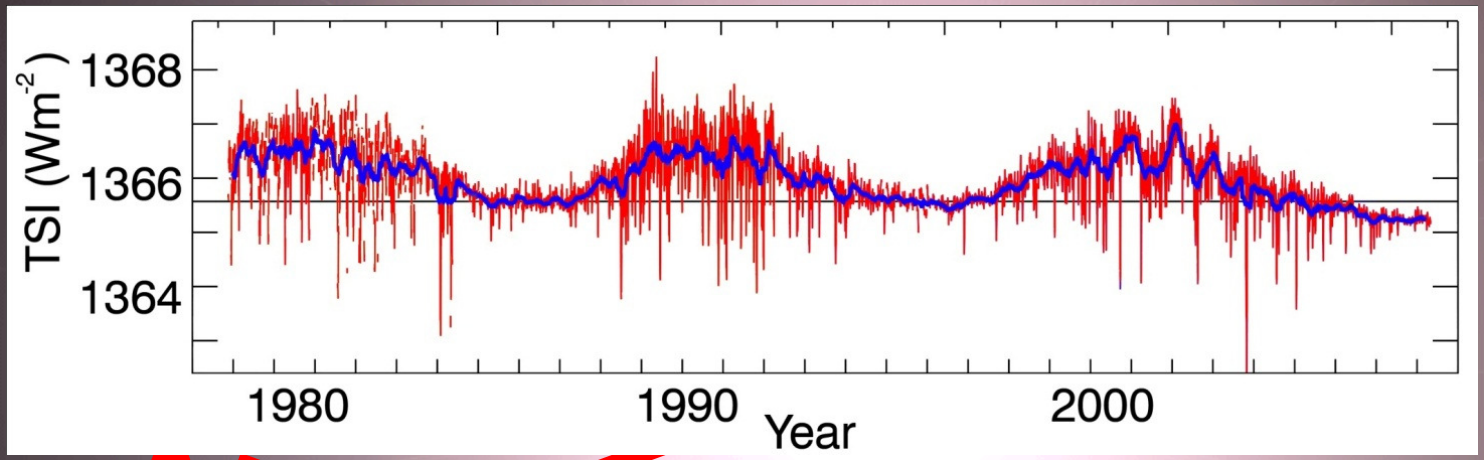
pmod wrc IACETH

Take away points:

i) UV variability >> TSI varb.
ii) More UV → more strato. O_3
iii) Changes in NH weather?
iv) UV variability uncertain

Solar irradiance
definition

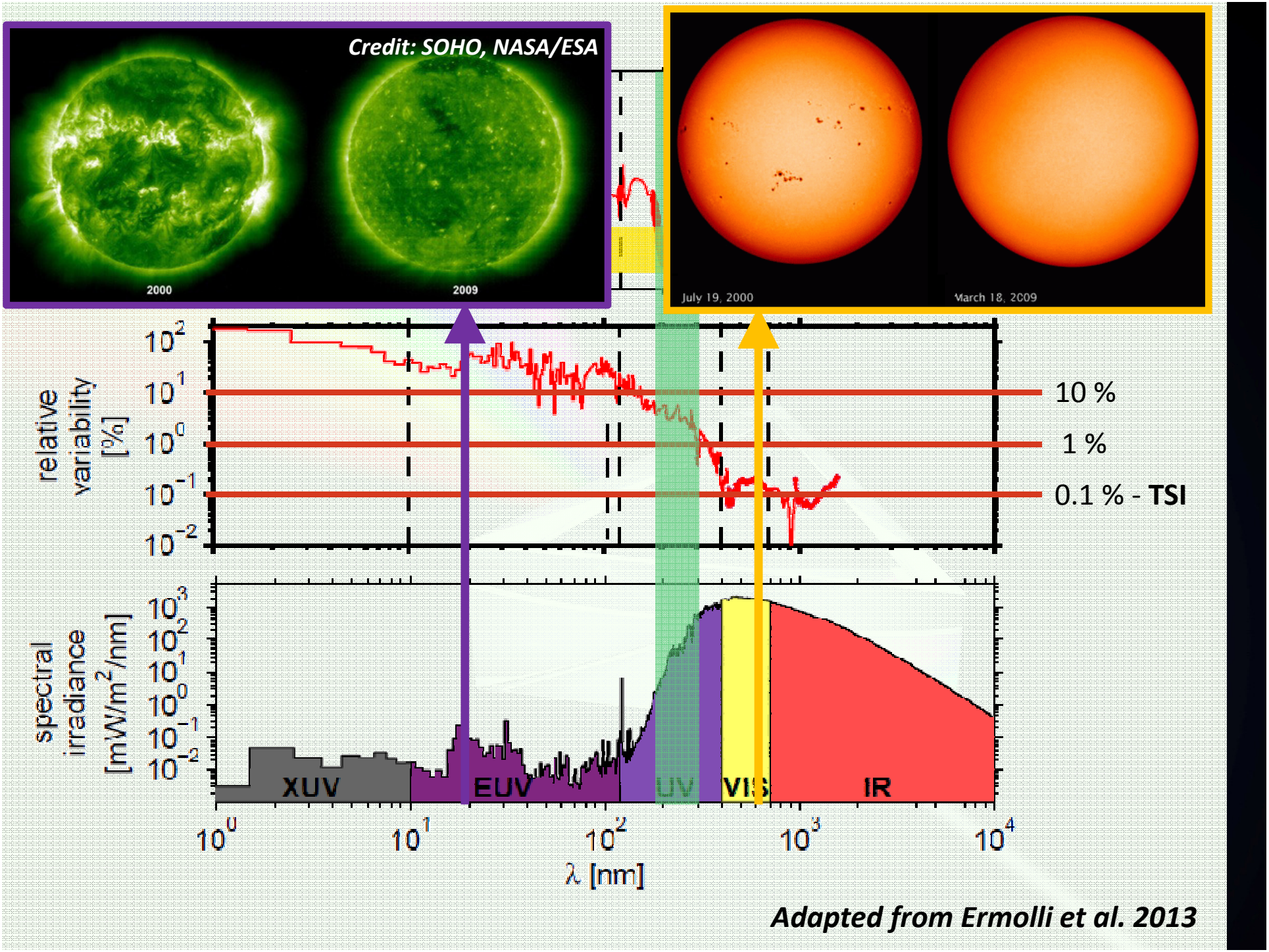

1 AU
Irradiance
1361 Wm-2

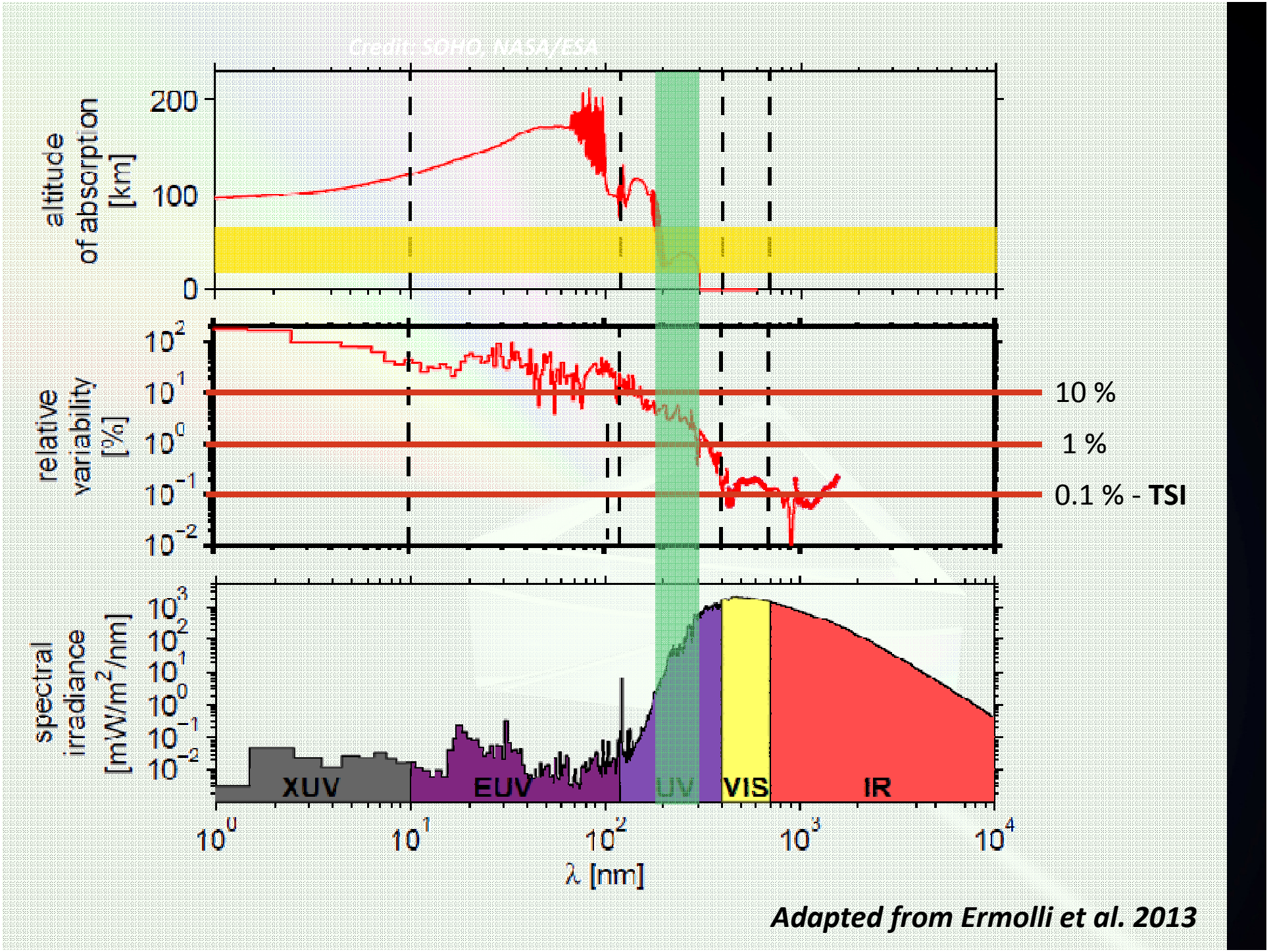


1 AU

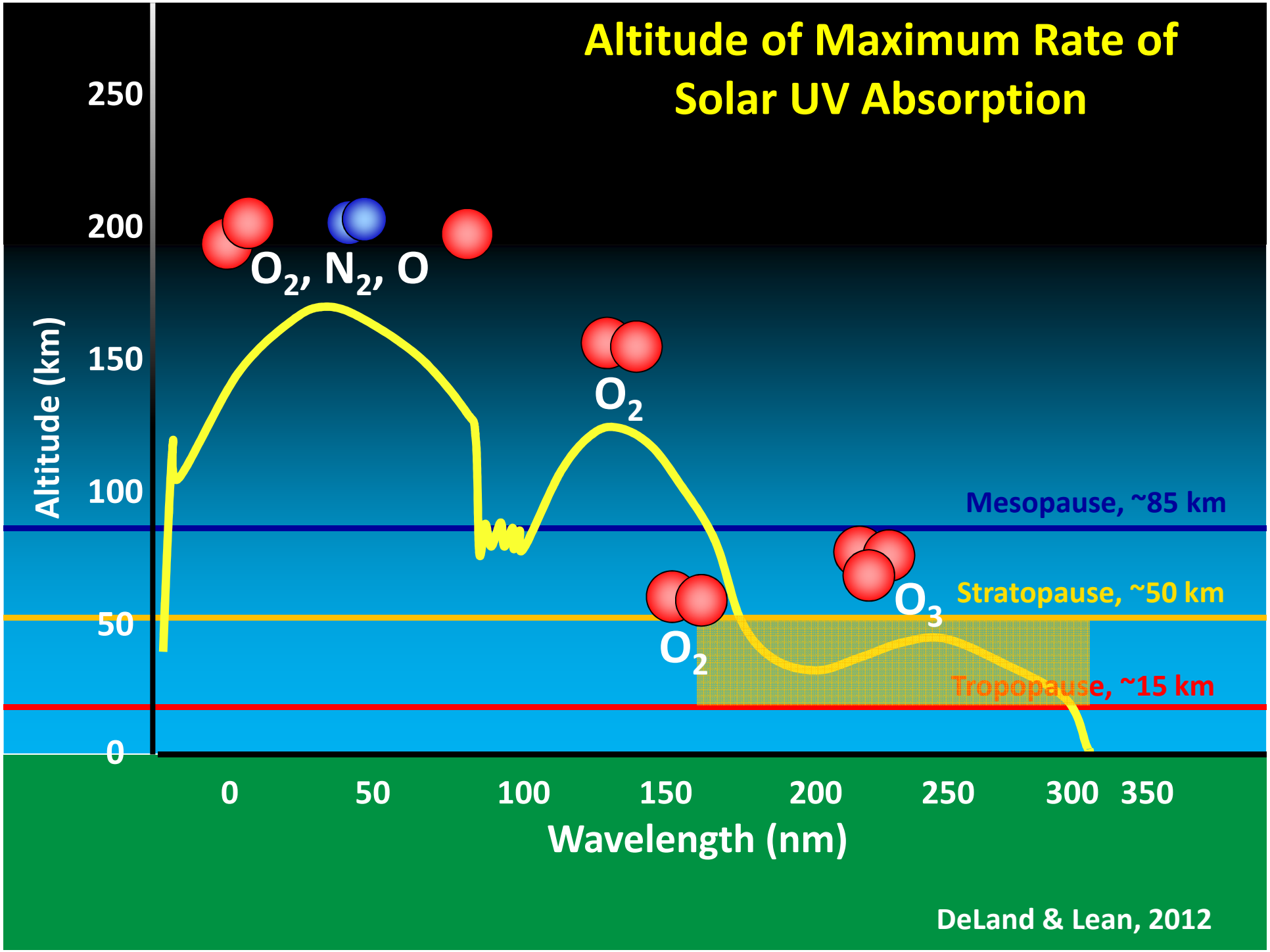
Irradiance

1361 Wm^{-2}


Credit: SOHO, NASA/ESA
2000
2009
July 19, 2000
March 18, 2009
relative variability [%]
10 %
1 %
0.1 % - TSI
spectral irradiance [mW/m²/nm]
XUV
EUV
UV
VIS
IR
λ [nm]
Adapted from Ermolli et al. 2013

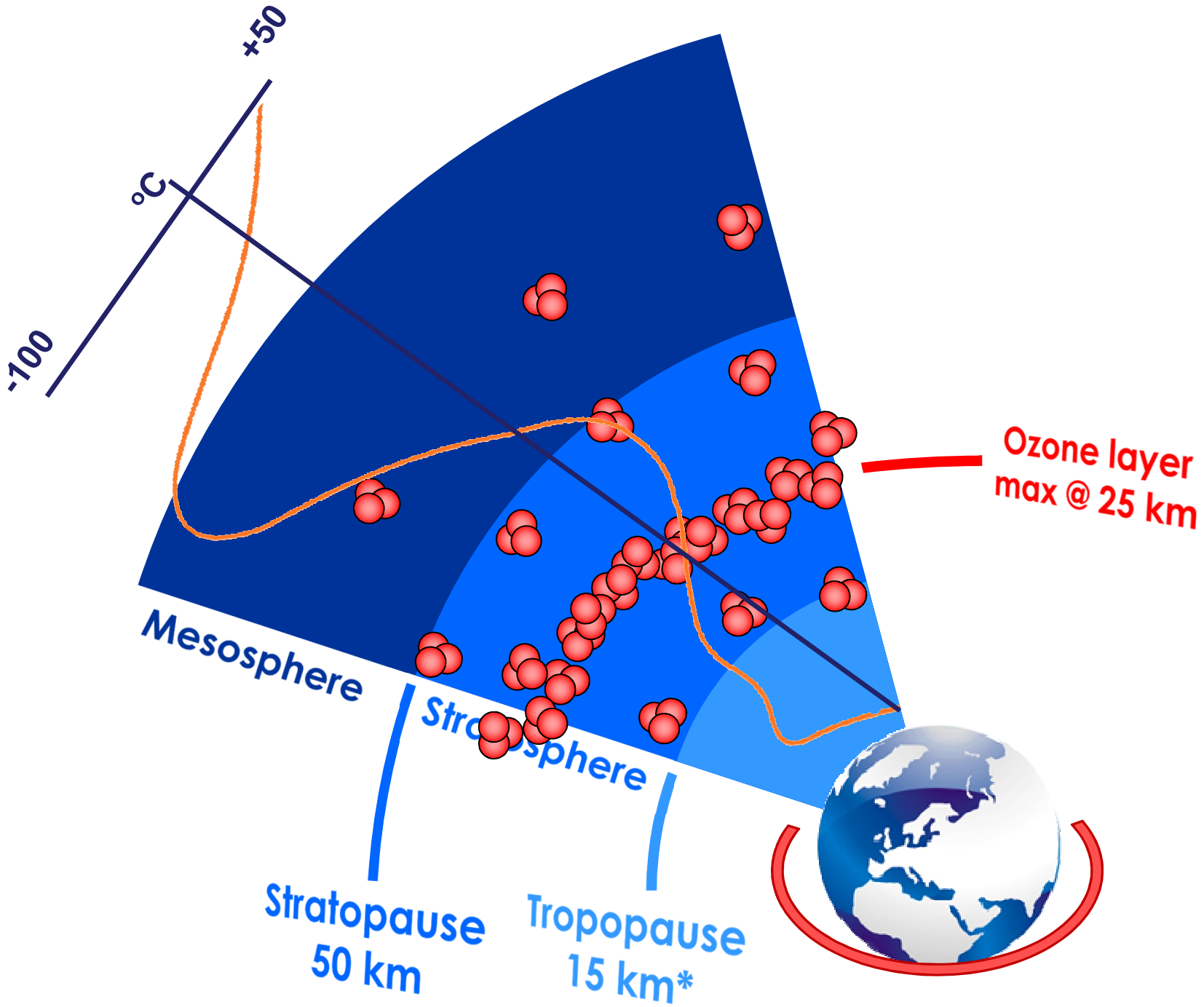


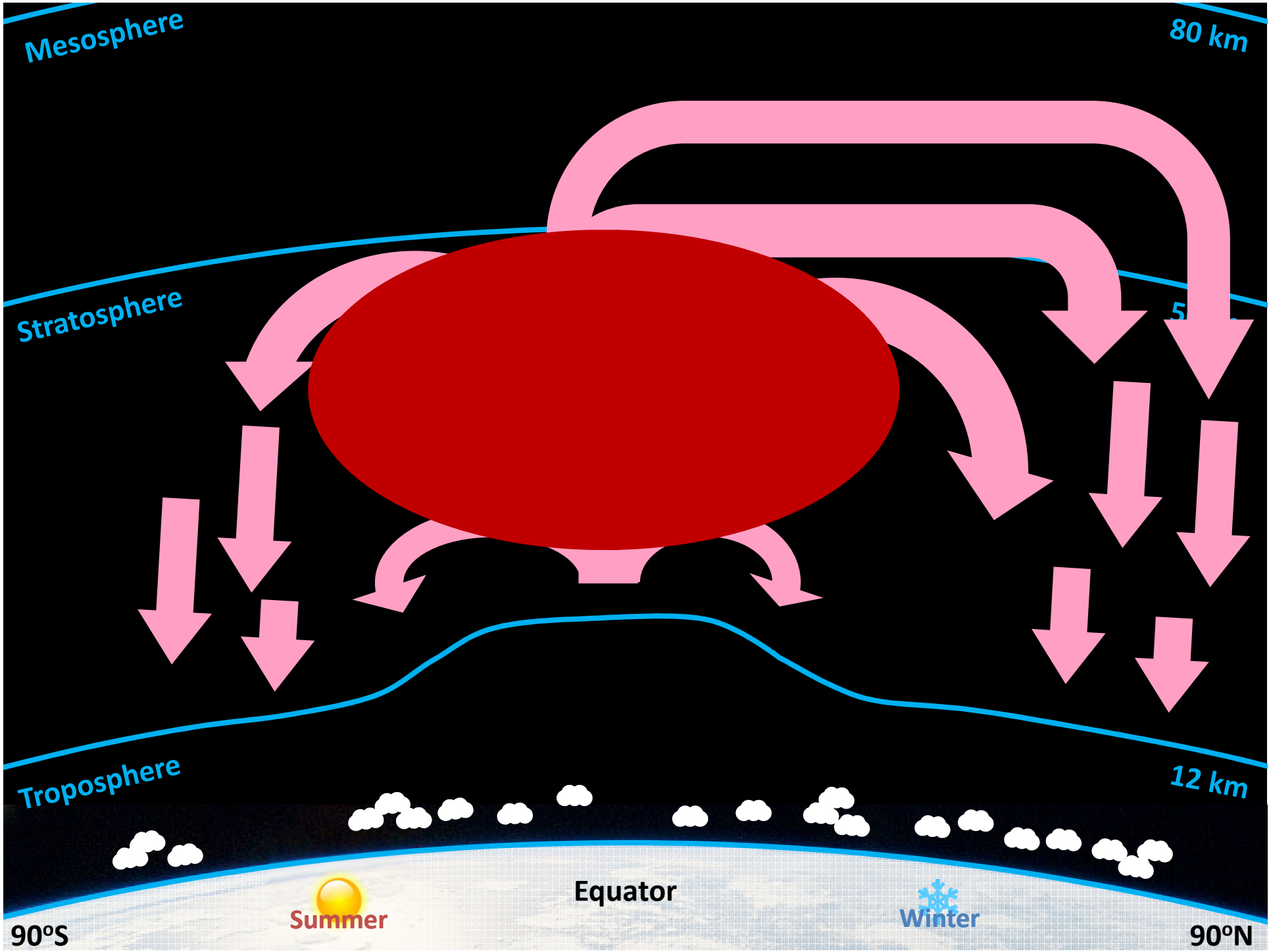
Adapted from Ermolli et al. 2013

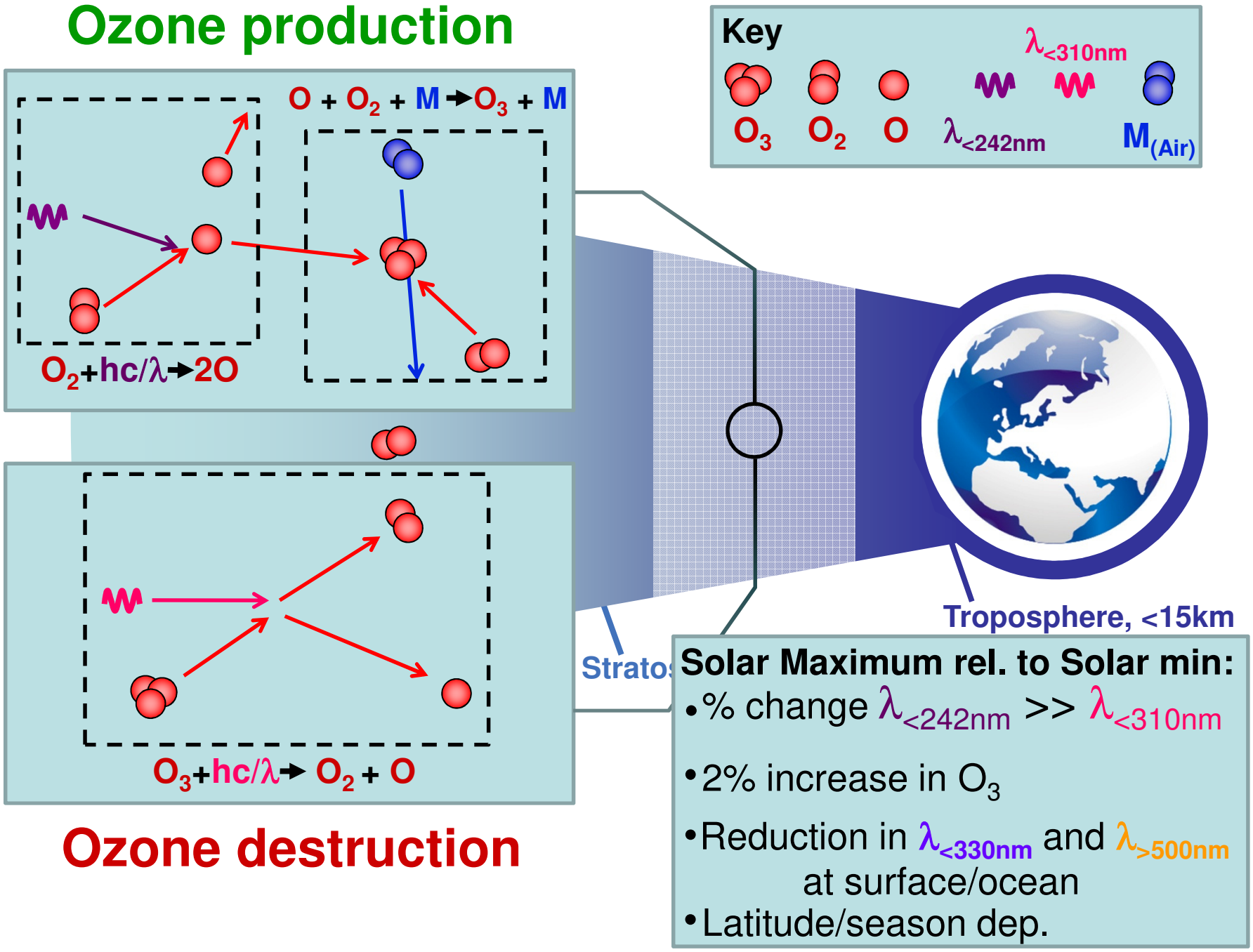

Altitude of Maximum Rate of Solar UV Absorption
250
200
150
100
50
0
Altitude (km)
O2, N2, O
O2
O2
O3
Mesopause, ~85 km
Stratopause, ~50 km
Tropopause, ~15 km
0
50
100
150
200
250
300
350
Wavelength (nm)
DeLand & Lean, 2012

Stratosphere

a general picture

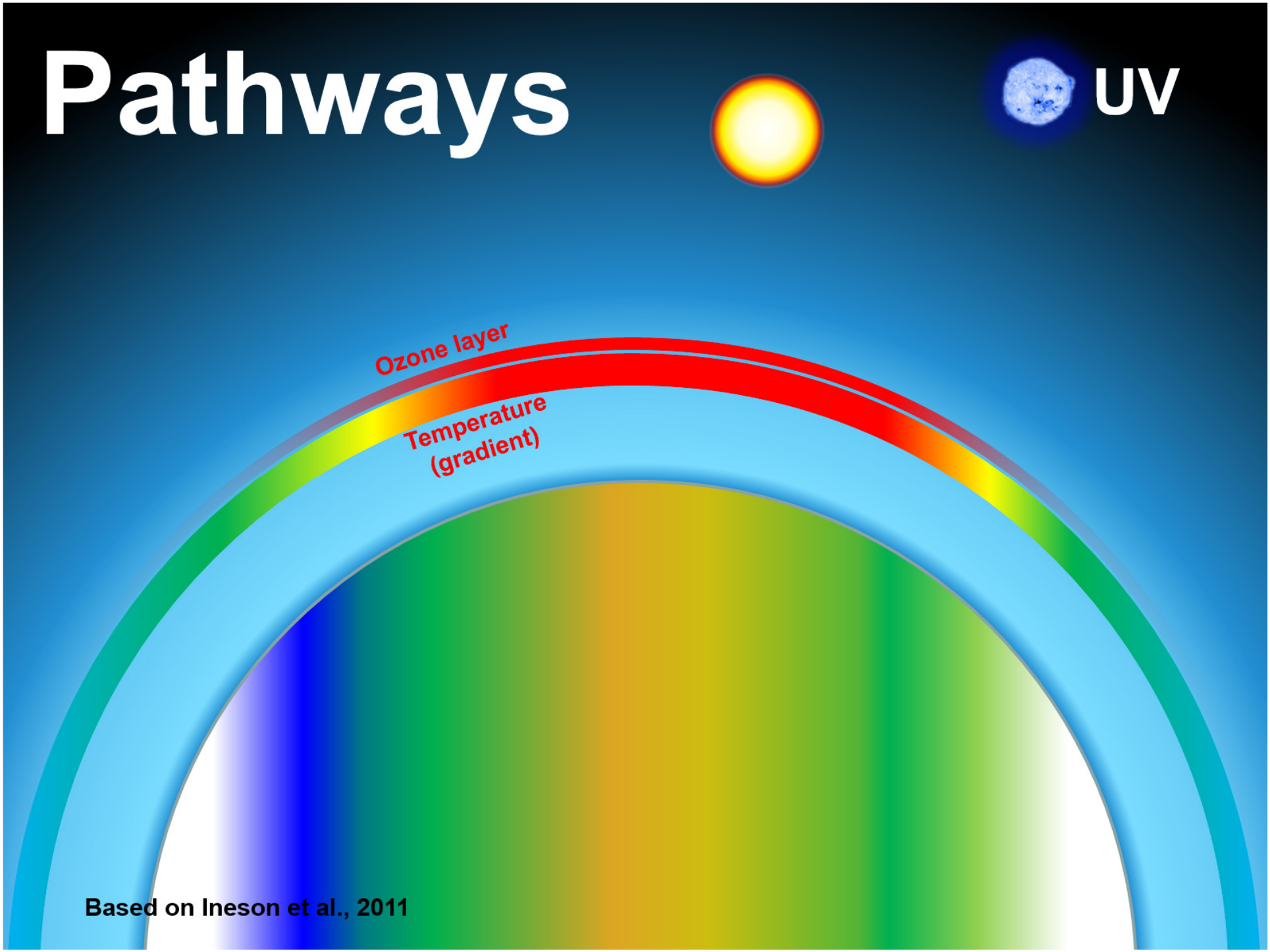

+50
°C
-100
Ozone layer
max @ 25 km
Mesosphere
Stratosphere
Stratopause
50 km
Tropopause
15 km*

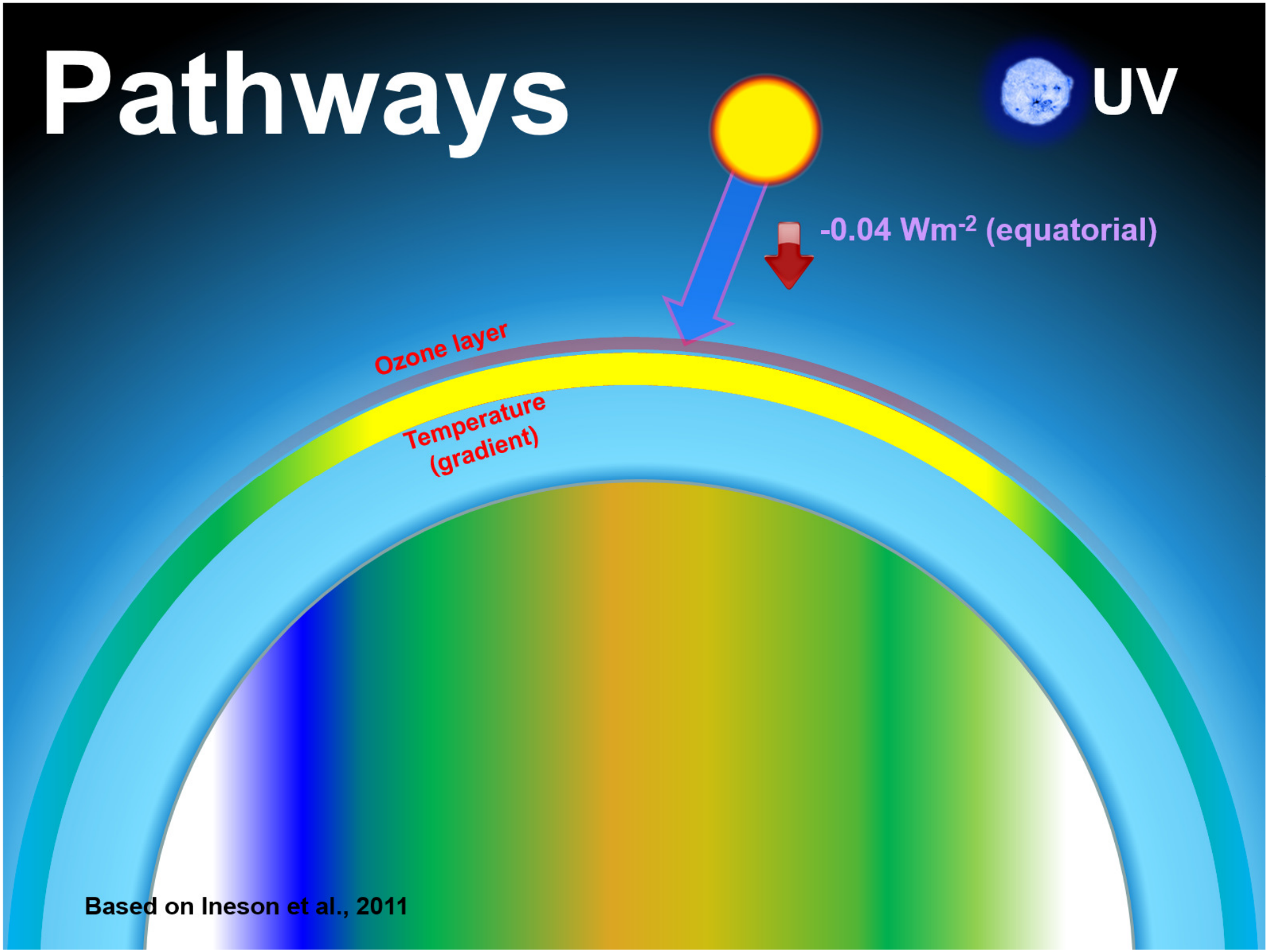

Mesosphere
80 km
Stratosphere
Troposphere
12 km
Summer
Equator
Winter
90°S
90°N

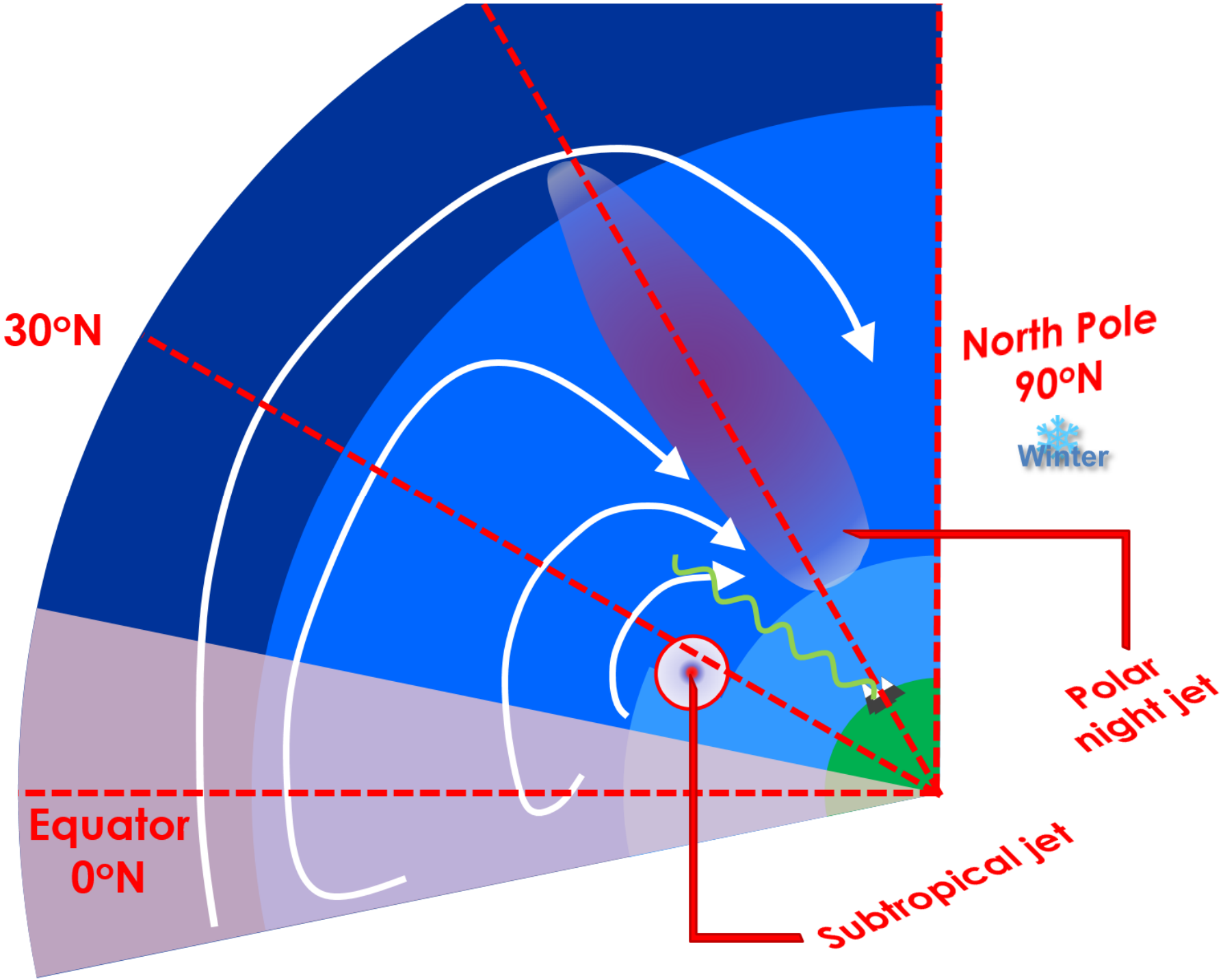

Ozone production
O + O2 + M → O3 + M
O2+hc/λ→2O
Key
λ<310nm
O3
O2
O
λ<242nm
M(Air)
Troposphere, <15km
Strato
Solar Maximum rel. to Solar min:
• % change λ<242nm >> λ<310nm
• 2% increase in O3
• Reduction in λ<330nm and λ>500nm at surface/ocean
• Latitude/season dep.
O3+hc/λ→ O2 + O
Ozone destruction

Stratosphere

The “Top Down” mechanism


Pathways
UV
Ozone layer
Temperature
(gradient)
Based on Ineson et al., 2011

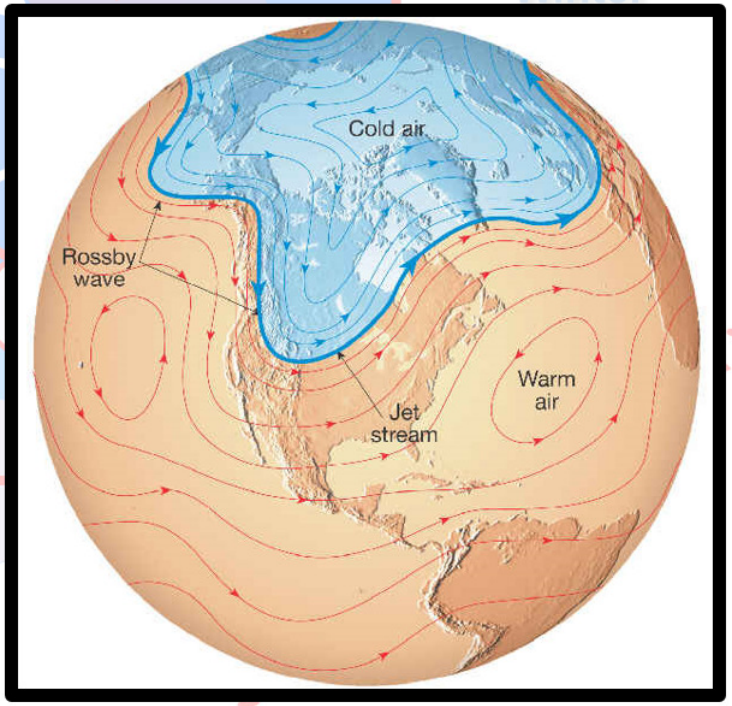

Pathways
UV
-0.04 Wm-2 (equatorial)
Ozone layer
Temperature
(gradient)
Based on Ineson et al., 2011

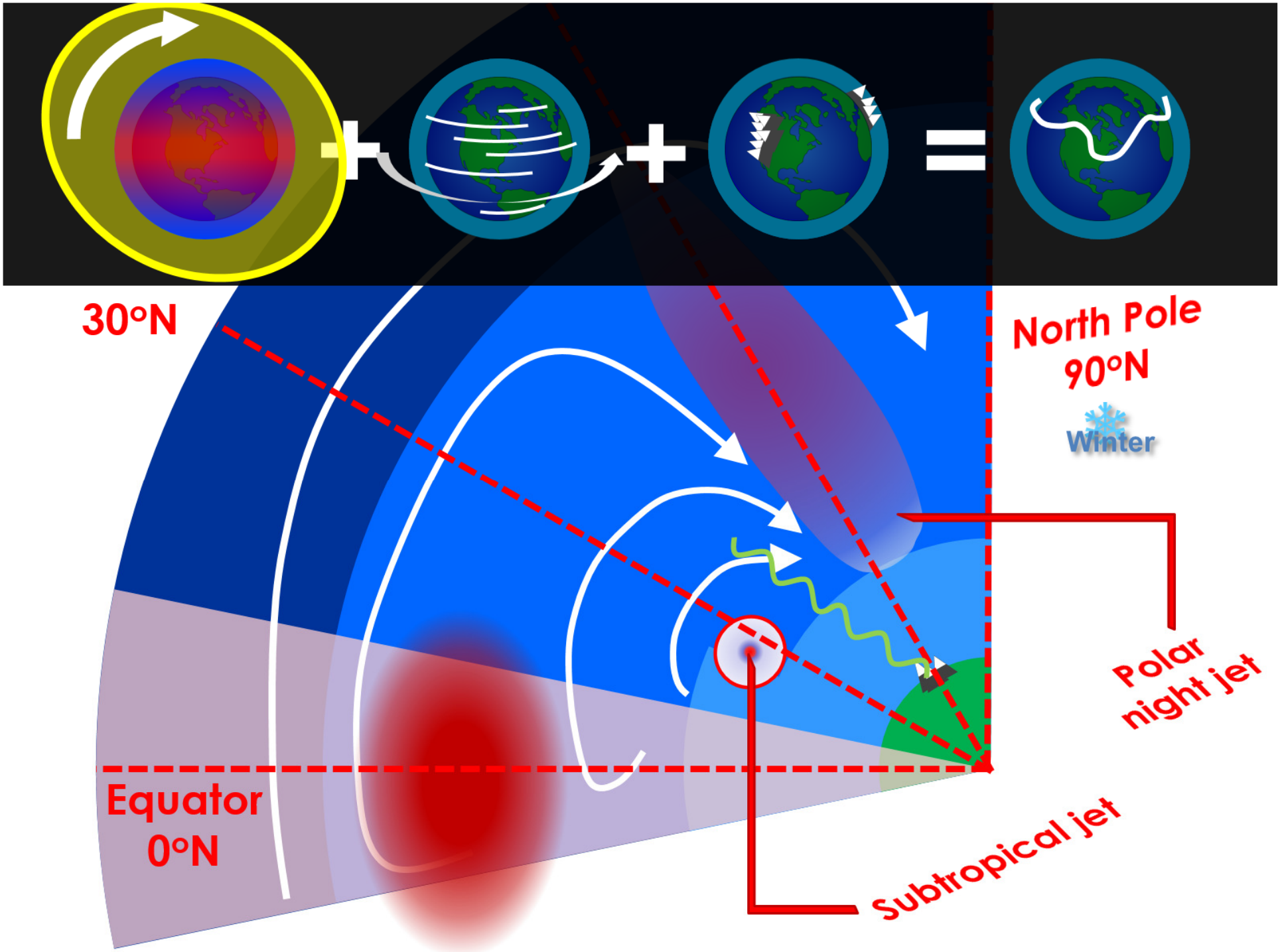

30°N
North Pole
90°N
Winter
Polar
night jet
Equator
0°N
Subtropical jet

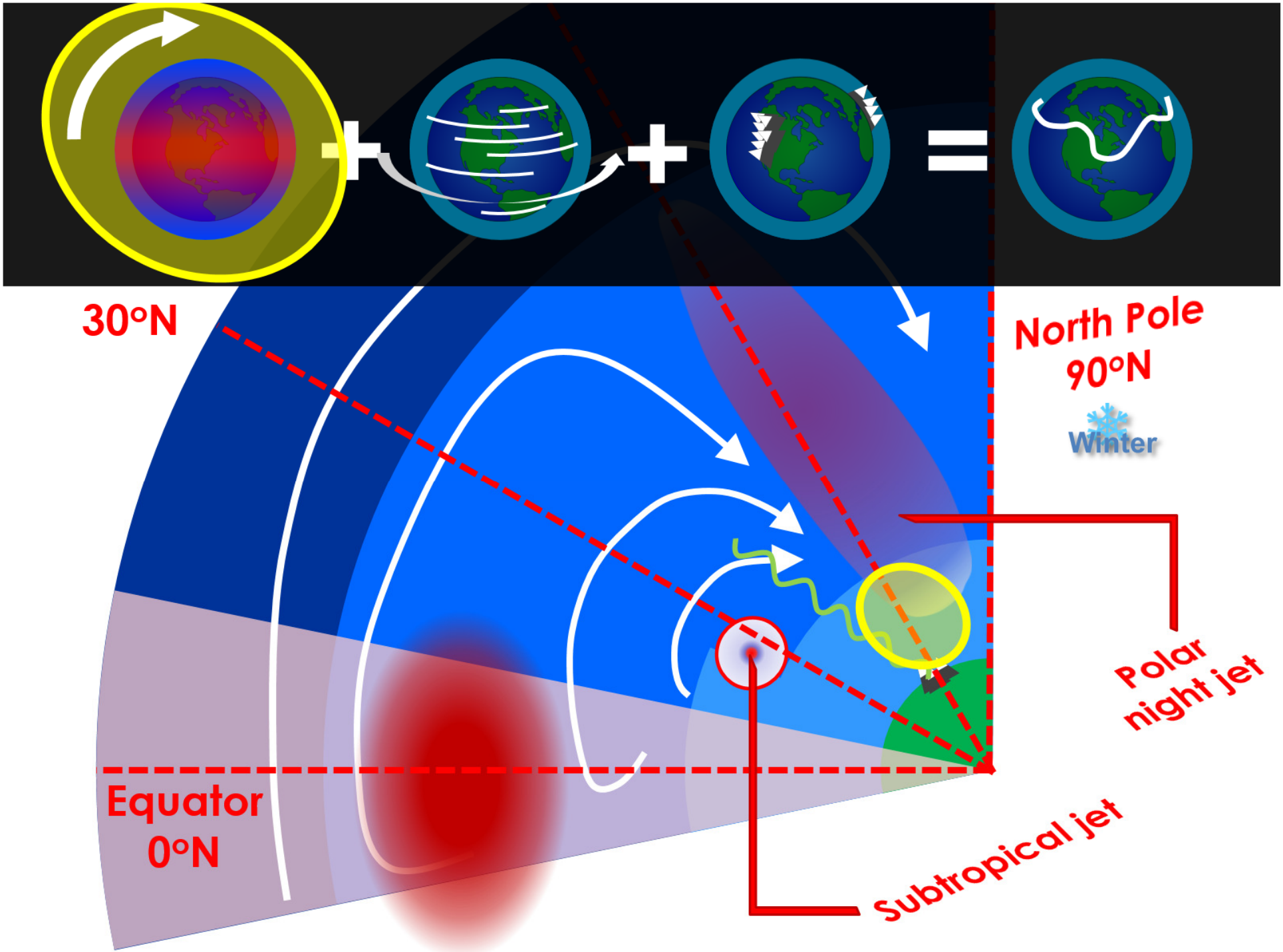
30°N

Mountain

Planetary

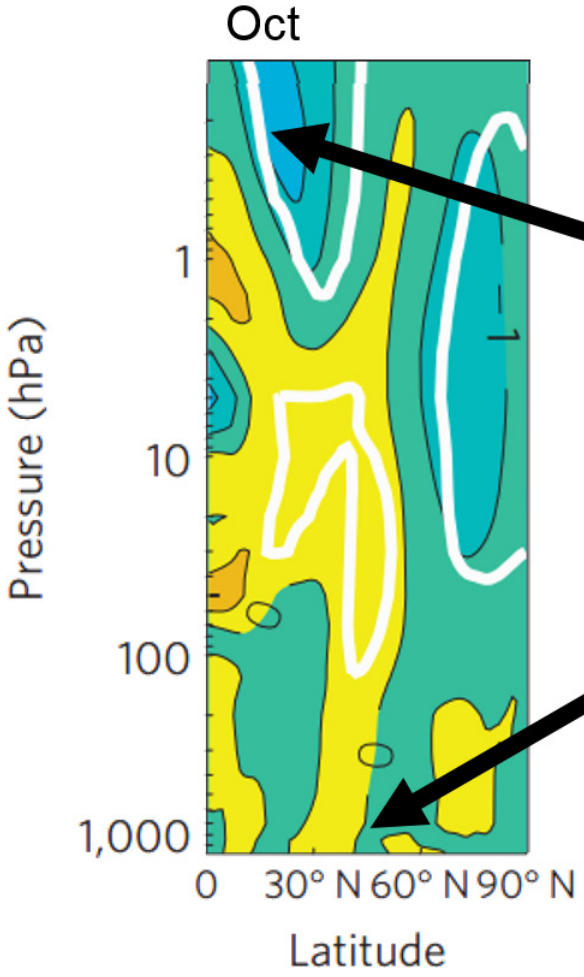



30°N
North Pole
90°N
Winter
Polar
night jet
Equator
0°N
Subtropical jet


30°N
North Pole
90°N
Winter
Polar
night jet
Equator
0°N
Subtropical jet

Pathways

UV



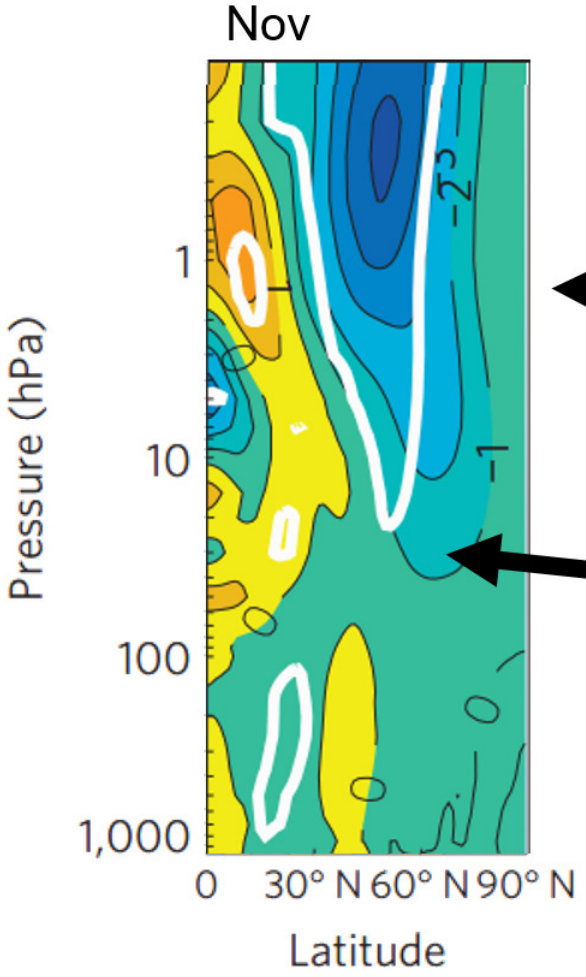
Weak easterly anomaly forms

Affects wave propagation

Ineson et al., 2011

Pathways

UV



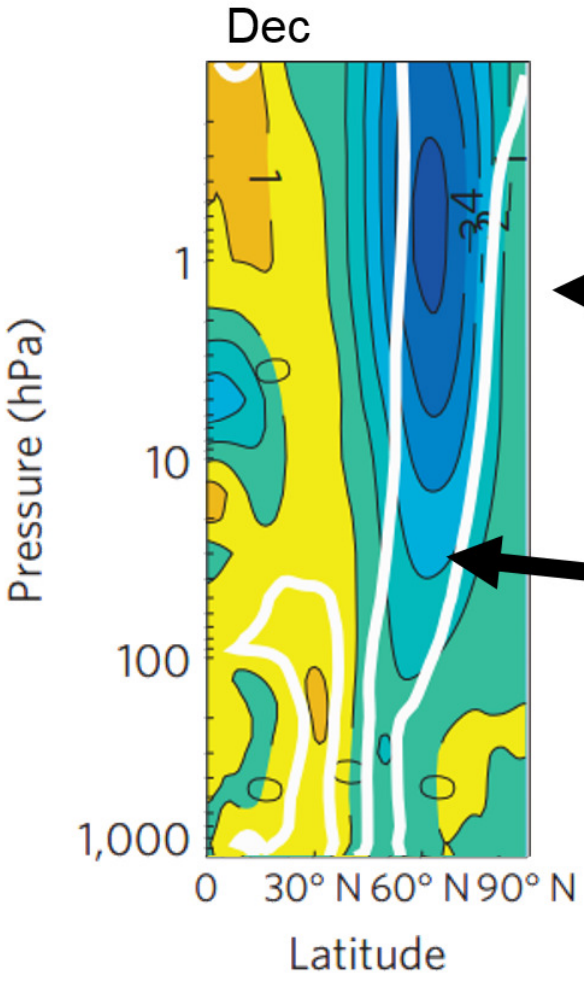
Anomaly propagates *poleward* and *downwards*

Increased wave driving (easterly forcing) of polar night jet

Ineson et al., 2011

Pathways

UV



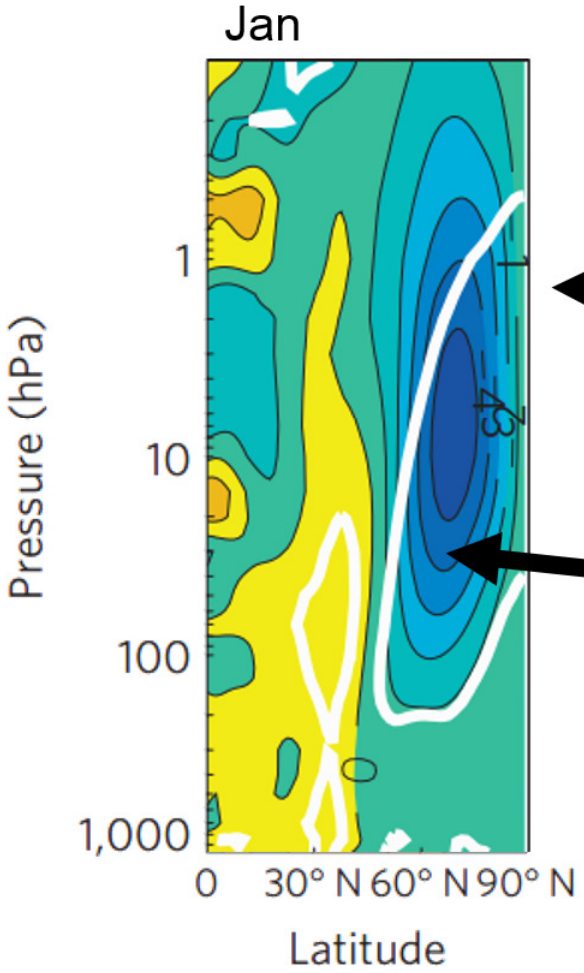
Anomaly propagates *poleward* and *downwards*

Increased wave driving (easterly forcing) of polar night jet

Ineson et al., 2011

Pathways

UV



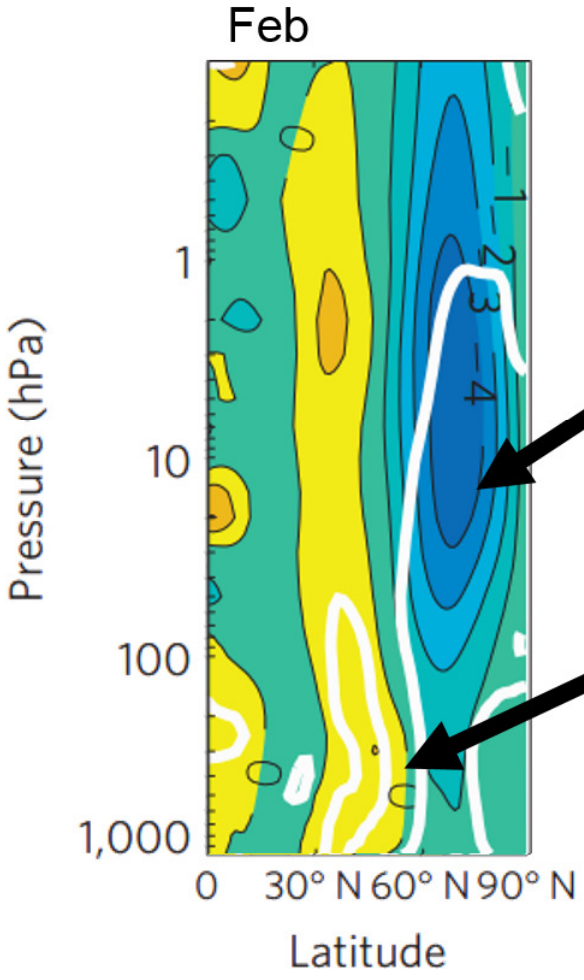
Anomaly propagates *poleward* and *downwards*

Increased wave driving (easterly forcing) of polar night jet

Ineson et al., 2011

Pathways

UV



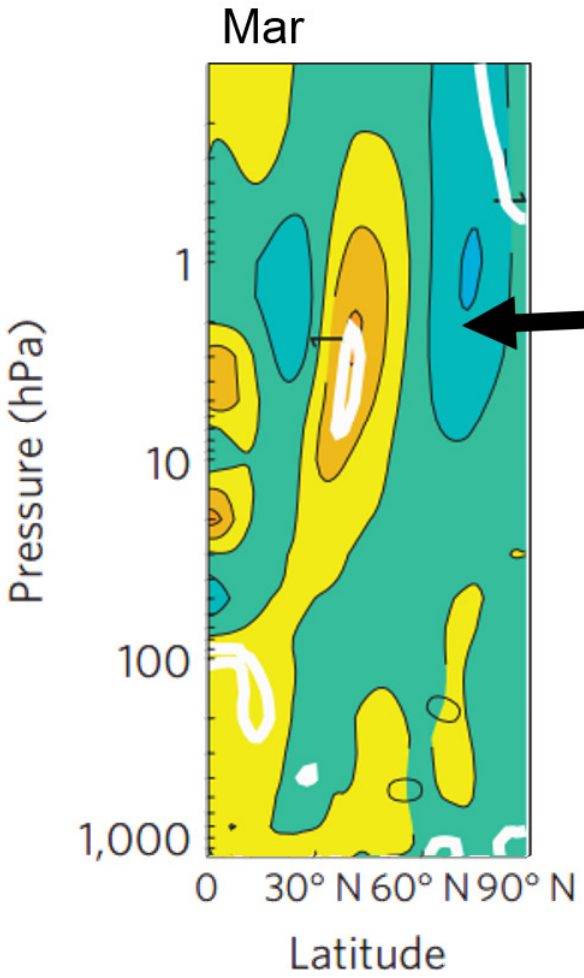
Further descent driven by large scale wave forcing

Influence on tropospheric storm tracks

Ineson et al., 2011

Pathways

UV

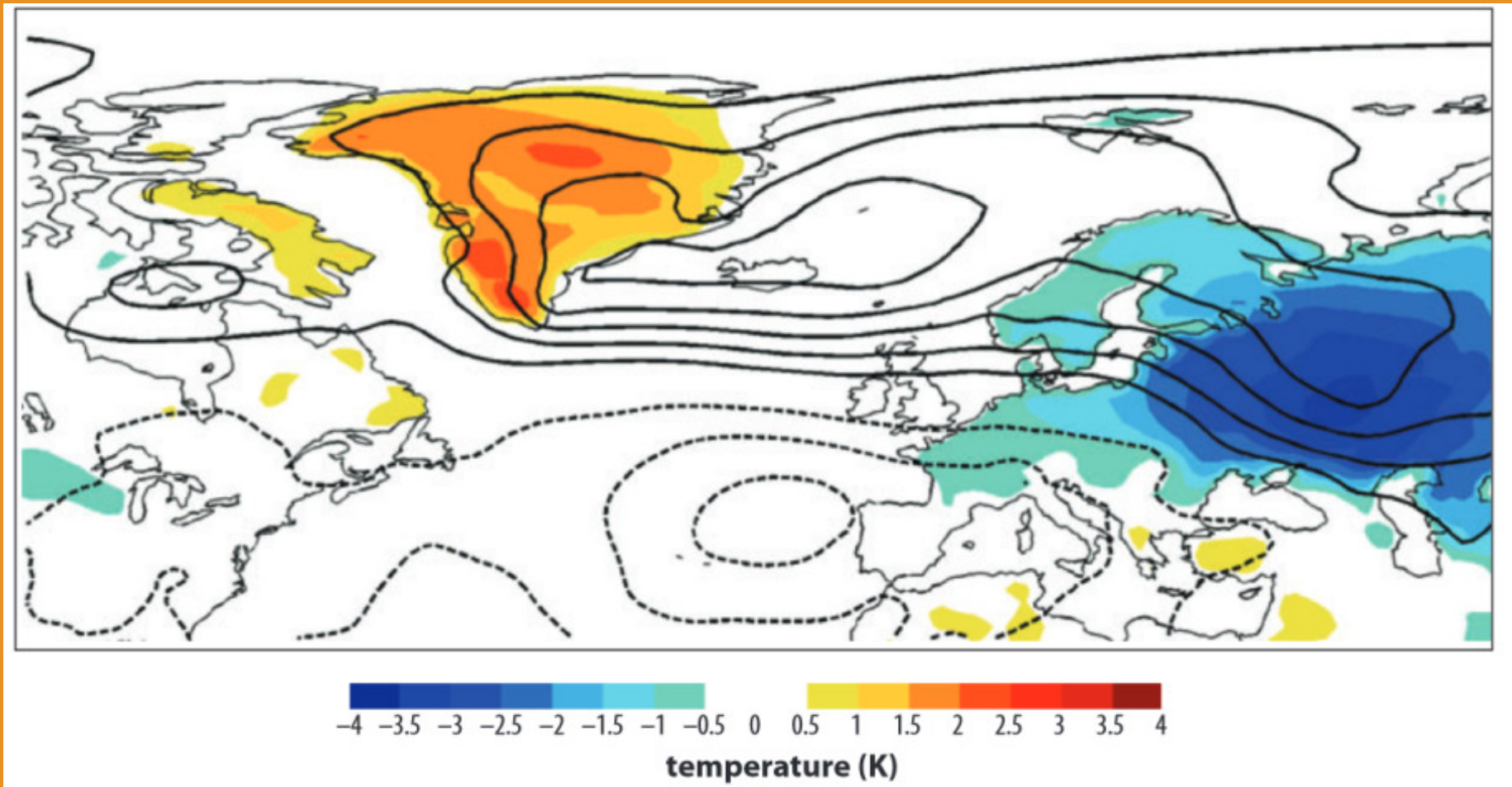


Sun rises

Anomaly disappates

Ineson et al., 2011

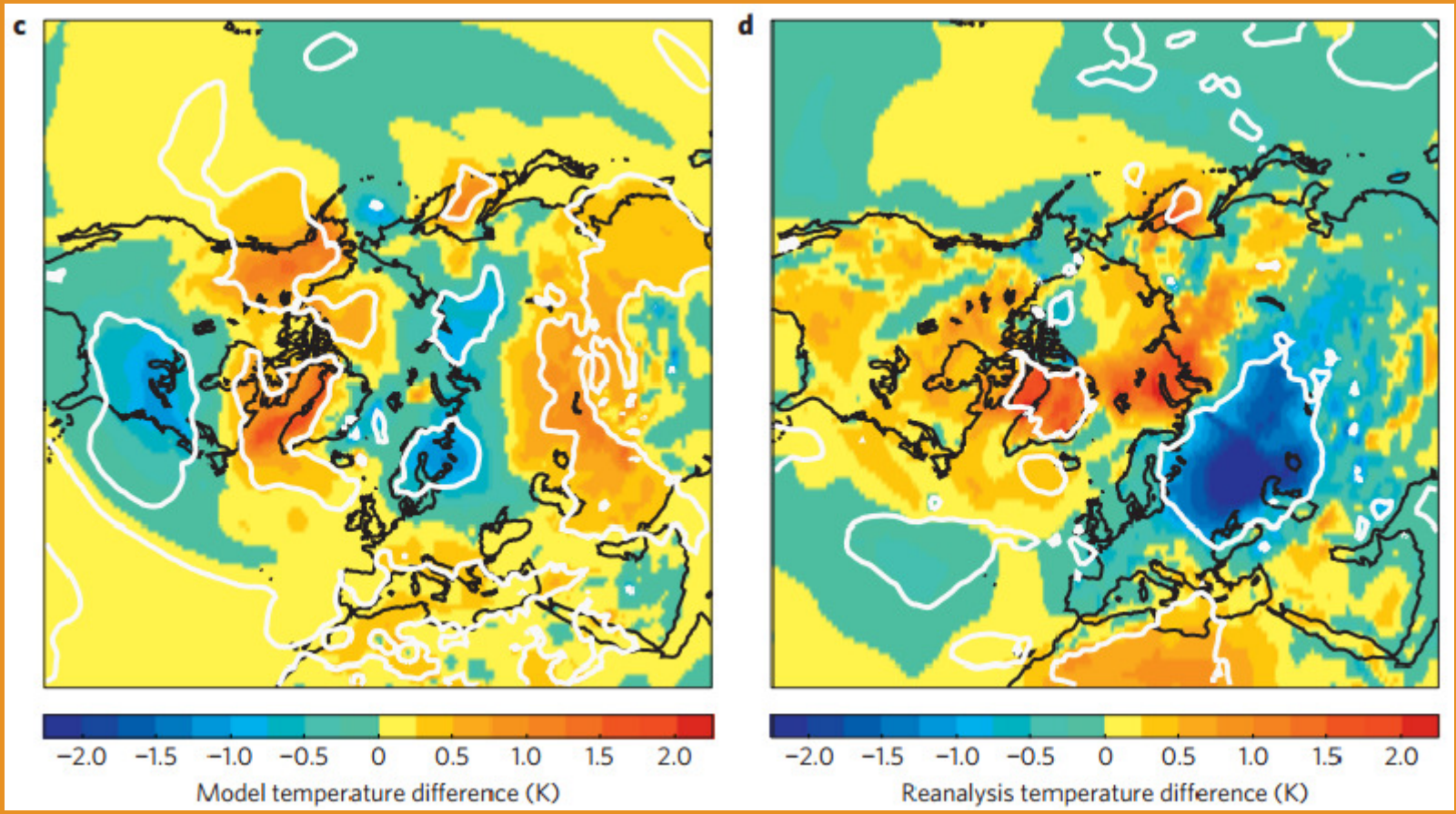
Weather patterns



Woolings et al., 2010

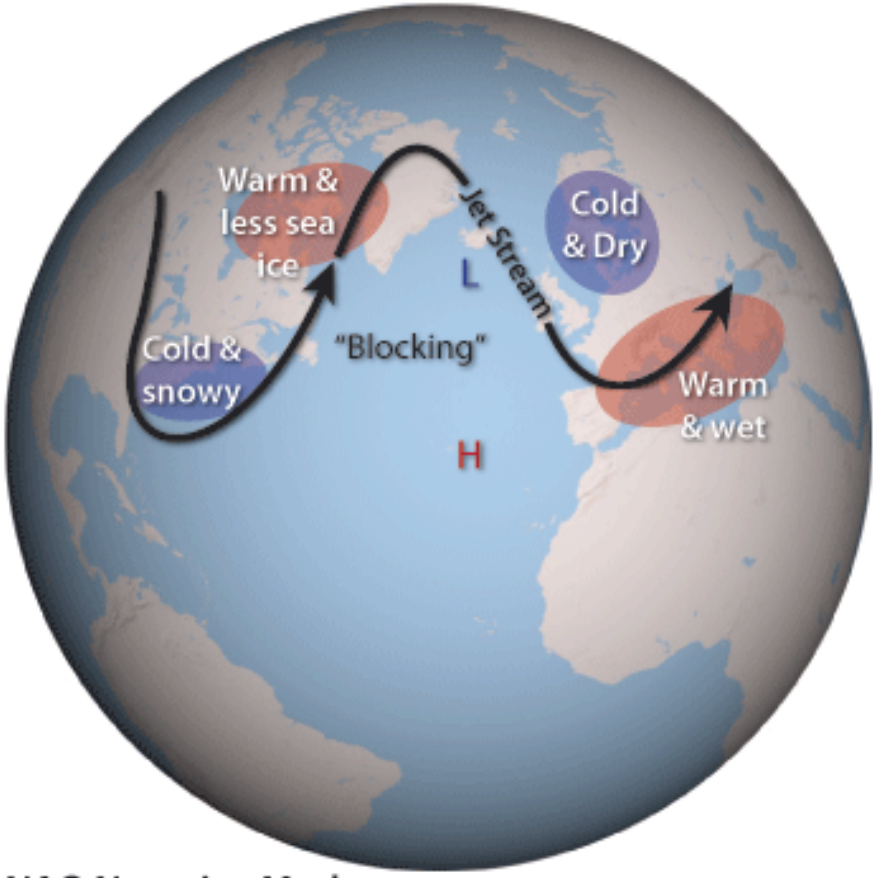
Low-High solar activity

Weather patterns

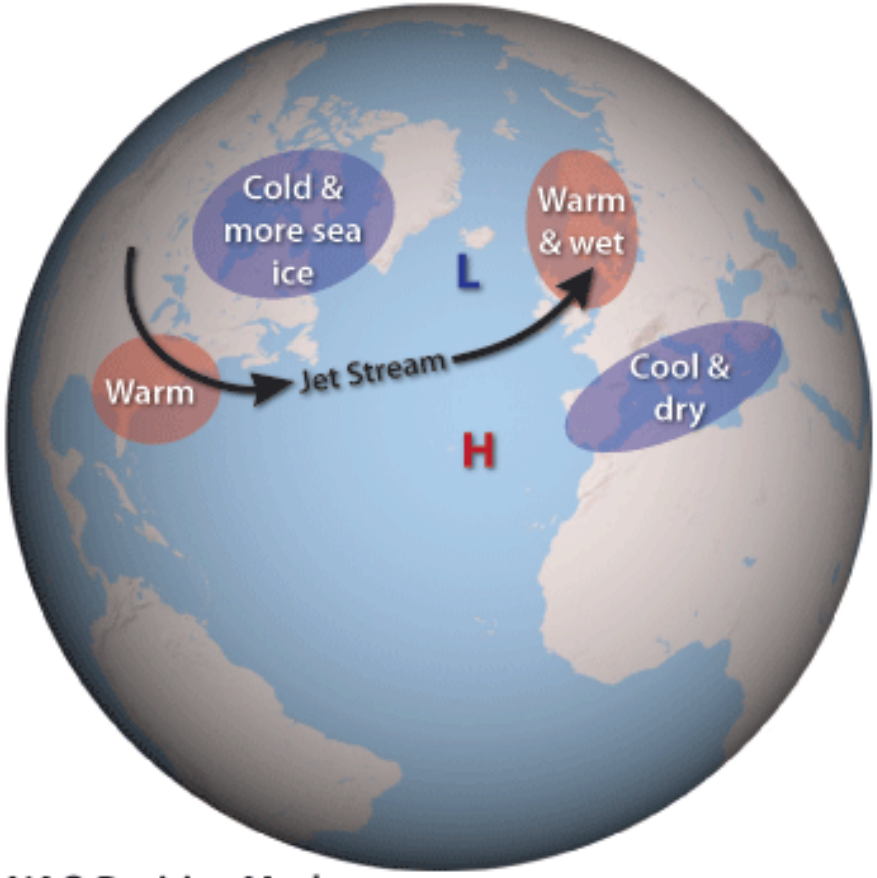


Ineson et al., 2011

Low-High solar activity



NAO Negative Mode

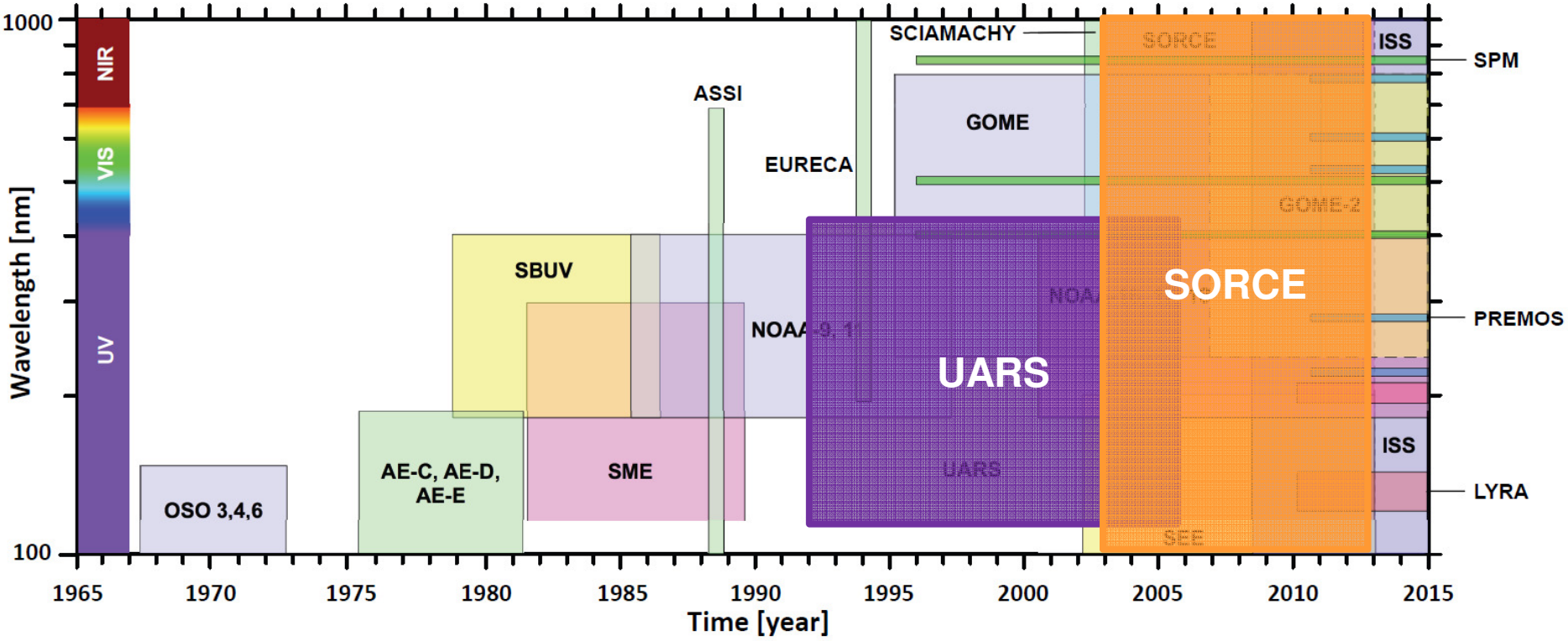


NAO Positive Mode

Solar irradiance

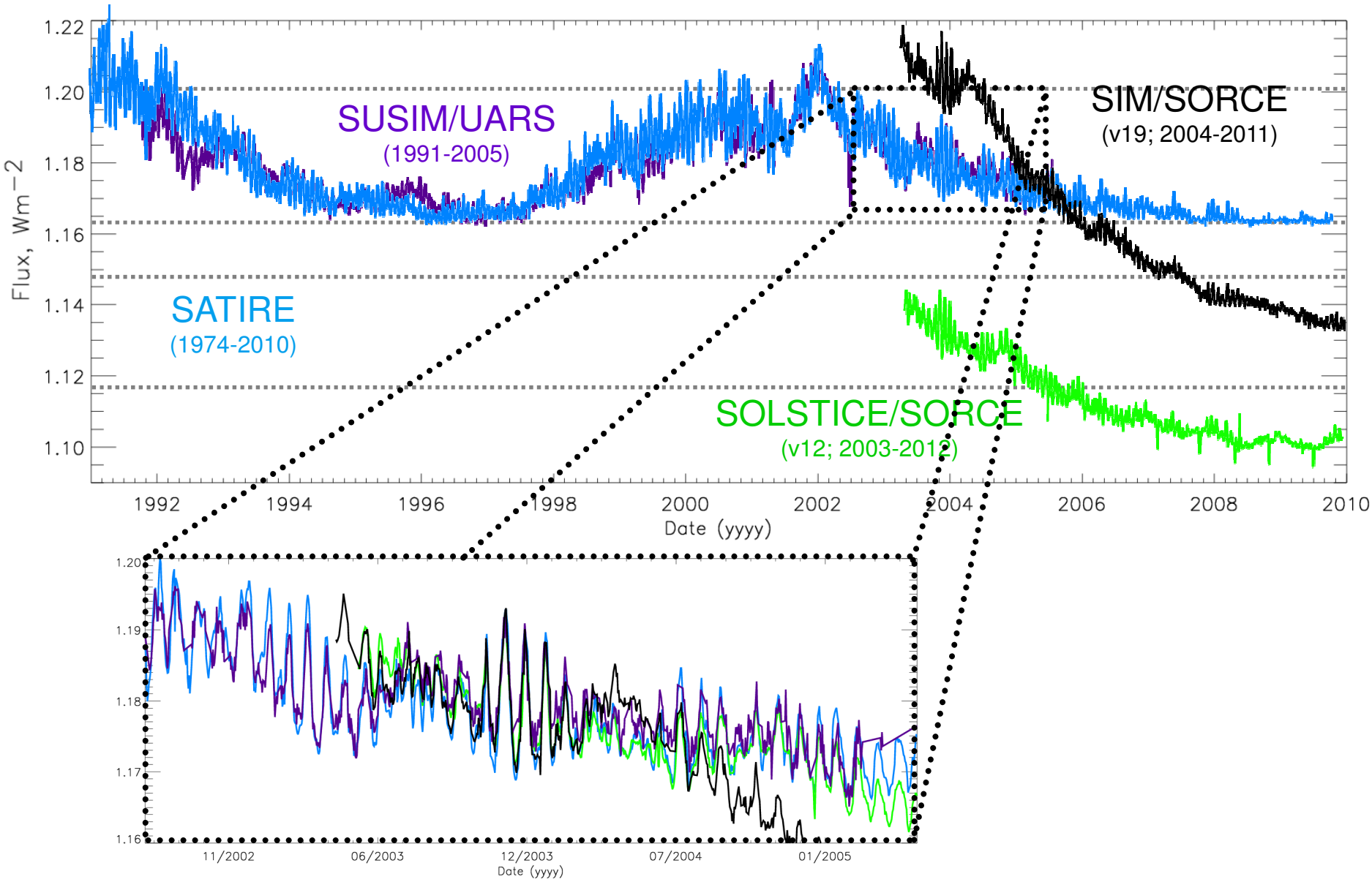
the problem with real data

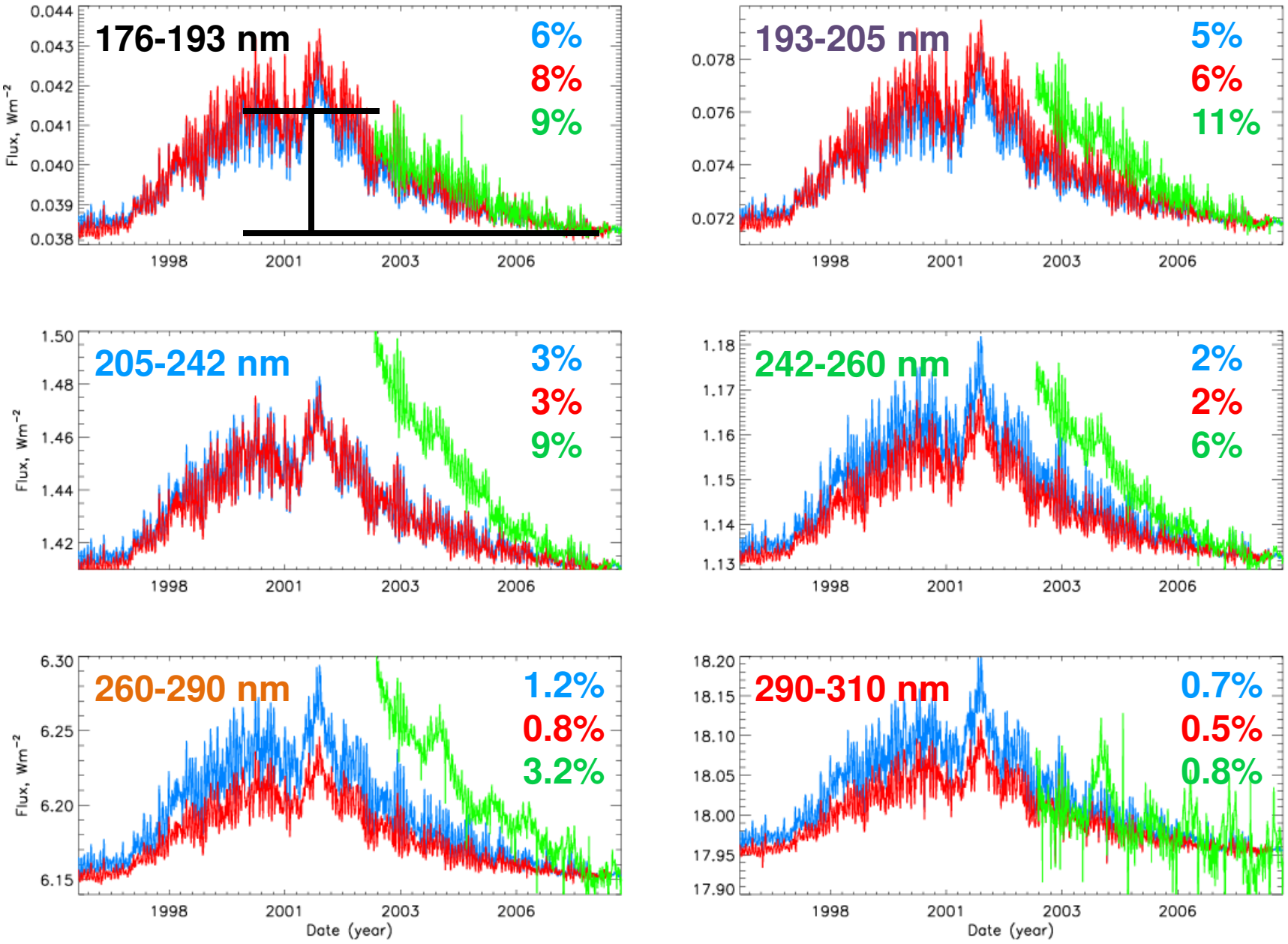
Ermolli et al. 2013



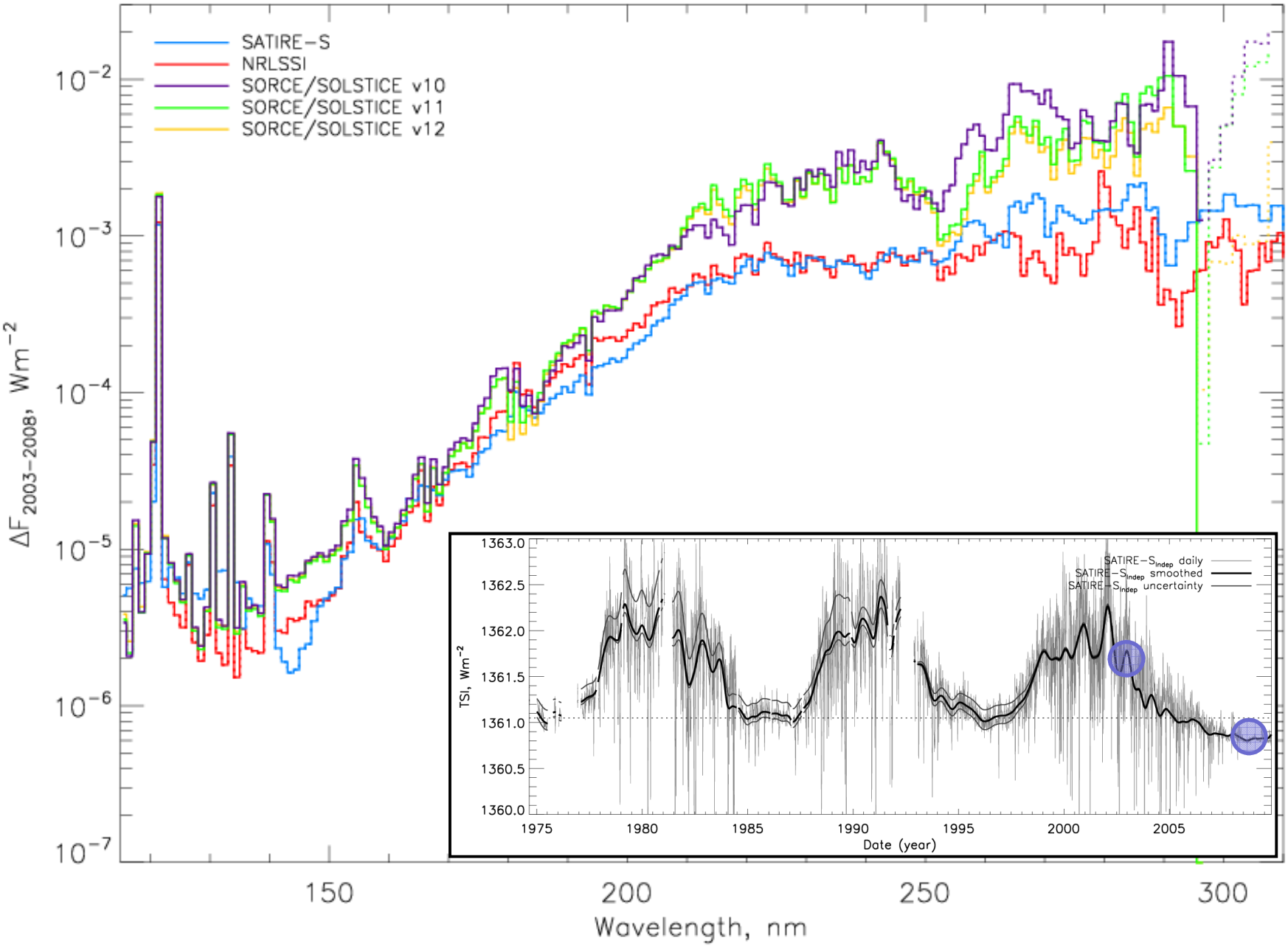
SSI observations do not agree

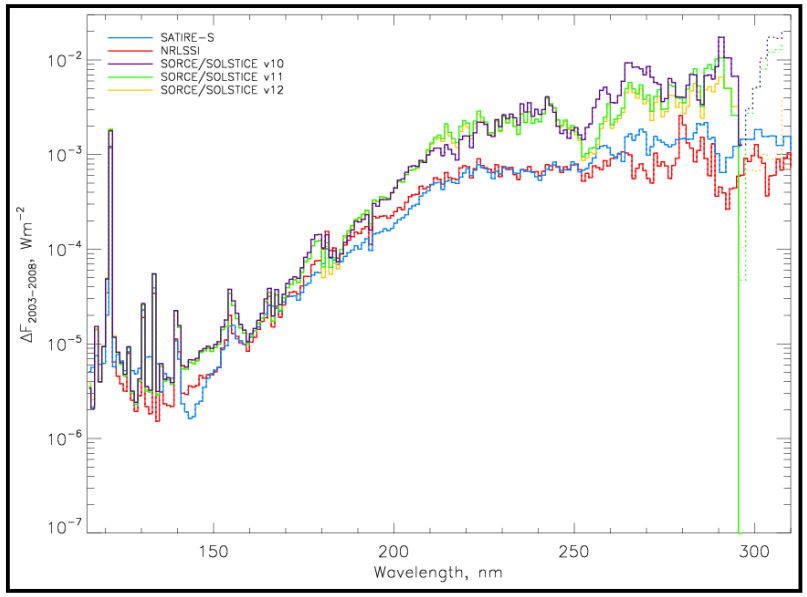
SSI: 242-260 nm

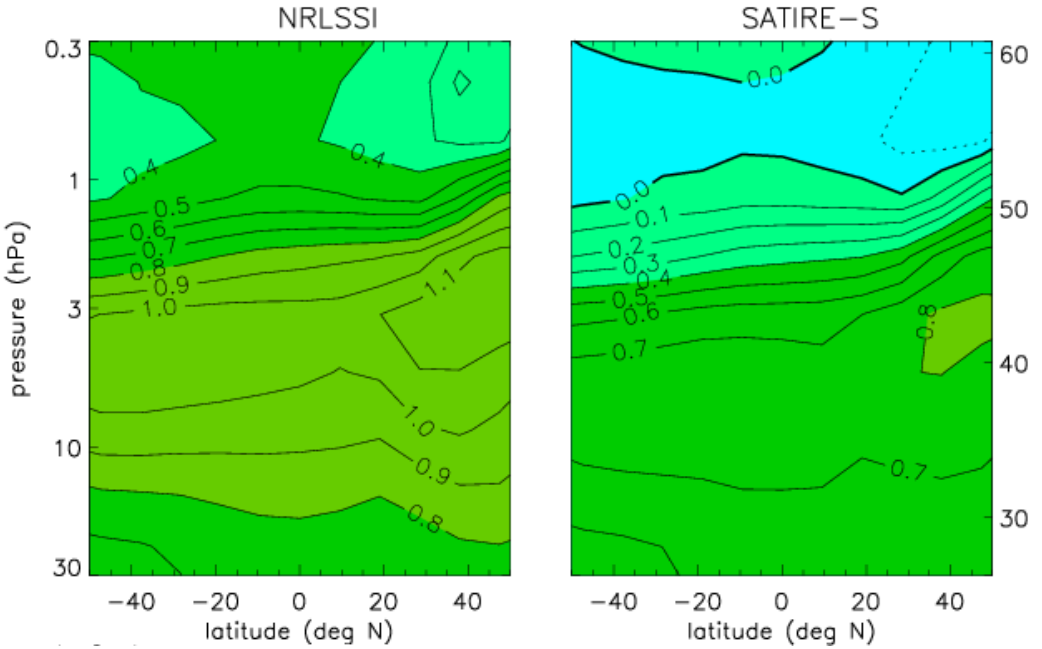


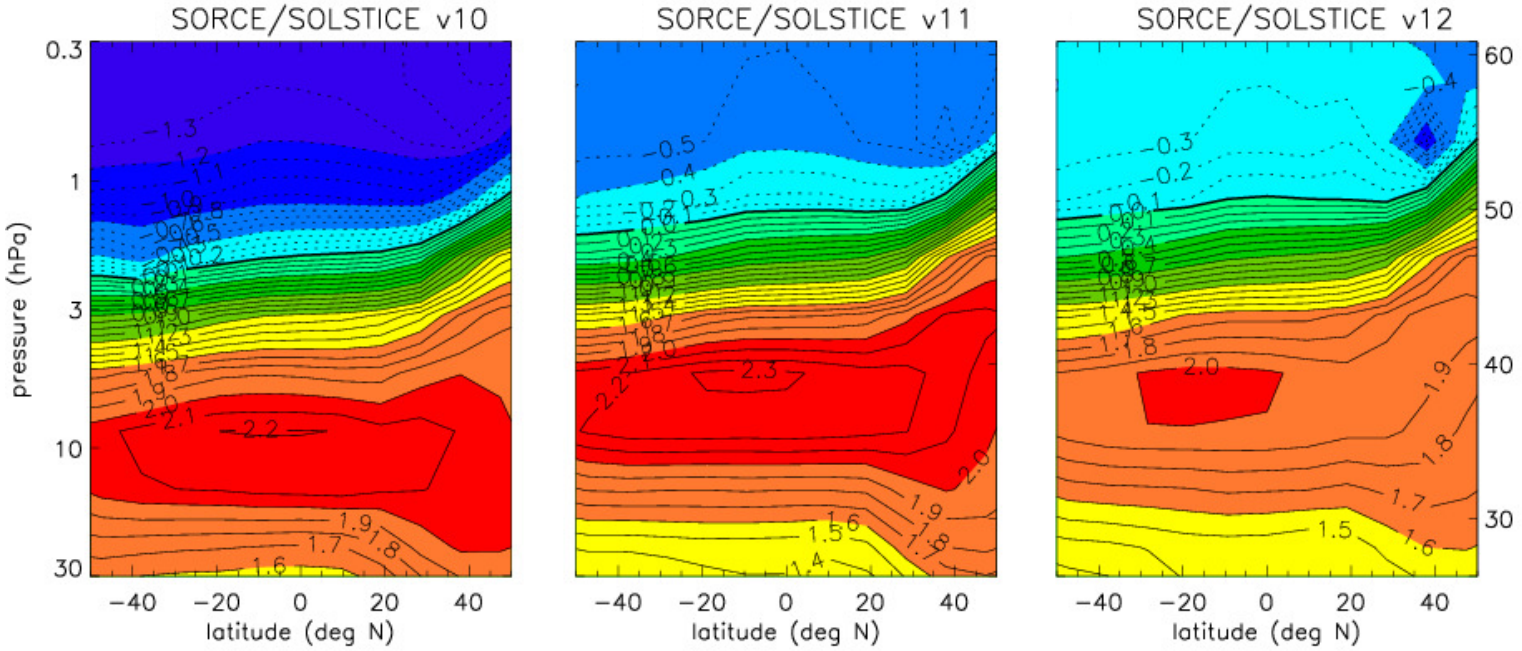

176-193 nm
6%
8%
9%
193-205 nm
5%
6%
11%
205-242 nm
3%
3%
9%
242-260 nm
2%
2%
6%
260-290 nm
1.2%
0.8%
3.2%
290-310 nm
0.7%
0.5%
0.8%
Flux, Wm⁻²
Date (year)
1998
2001
2003
2006
SATIRE-S Model
NRLSSI Model
SORCE/SOLSTICE
Observations

Ball et al., 2014a, JAS



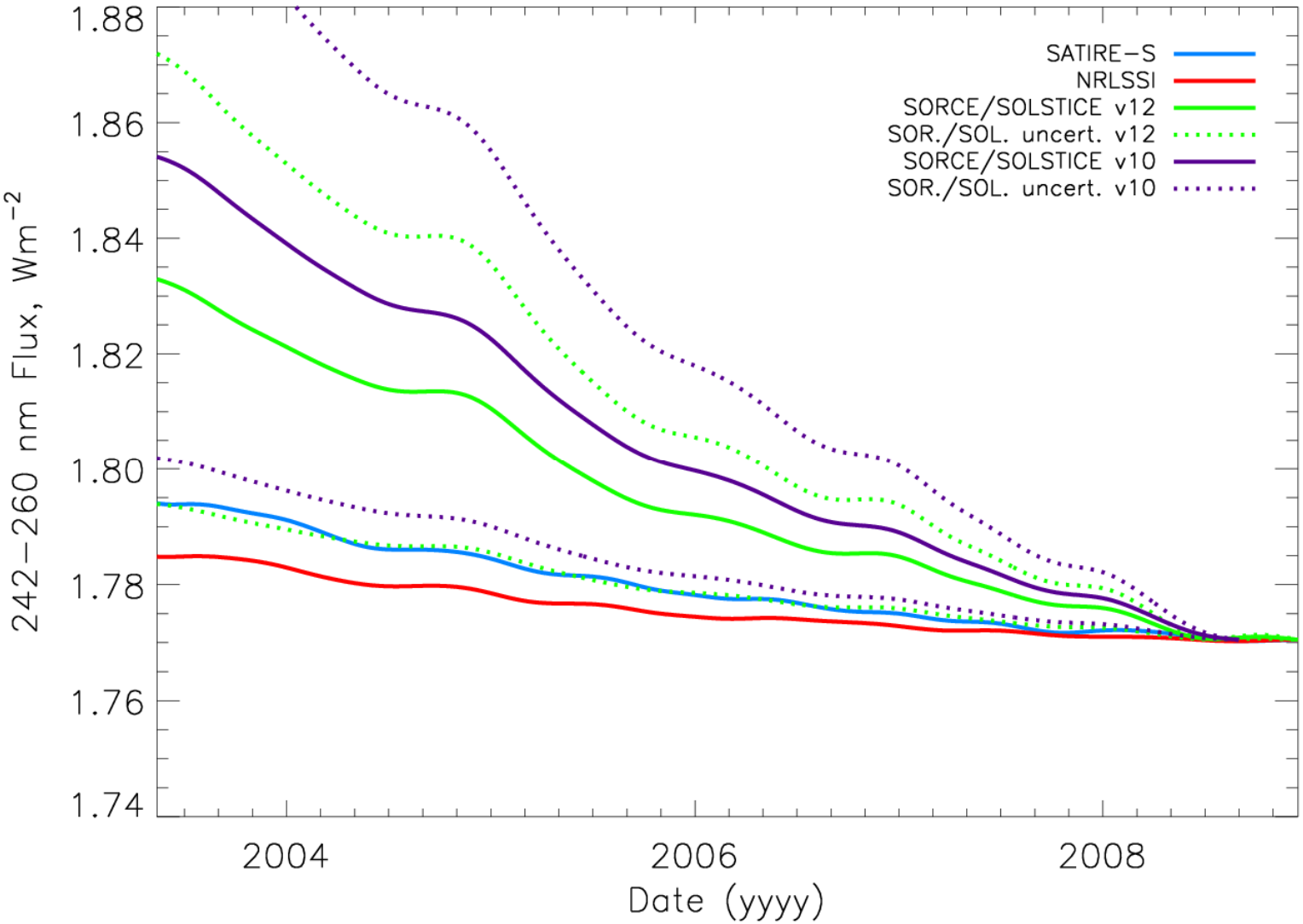






Ball et al., 2014a, JAS

Ball et al., 2014b, SWSC



Take away points:

i) UV variability >> TSI varb.
ii) More UV → more strato. O_3
iii) Changes in NH weather?
iv) UV variability uncertain

The end

pmod wrc IACETH