# Tropospheric Ozone at the CTA sites

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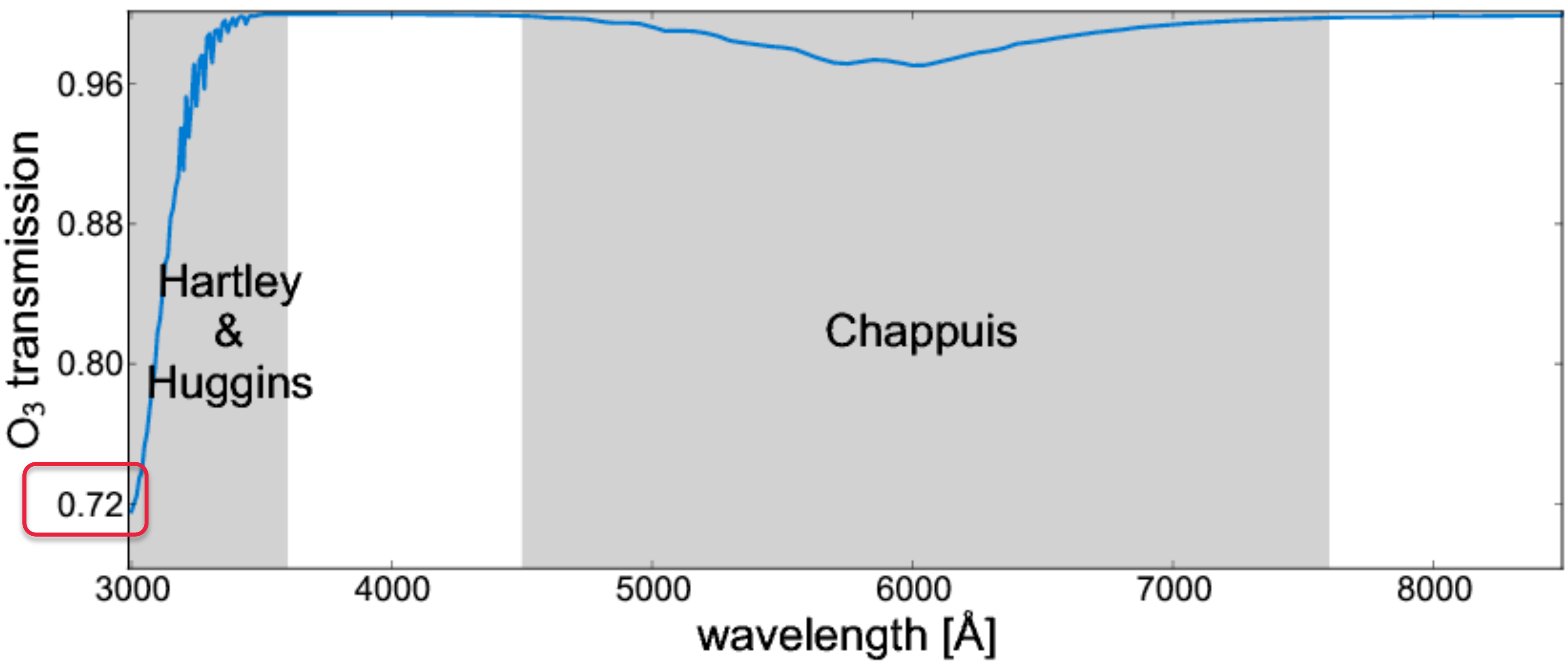
# Characterization of observed field-of-view

## Requirements for systematic uncertainties on energy scale, due to atmospheric effects, are very ambitious

| Part | currently achieved | goal for CTA | comments |
|---|---|---|---|
| Simulation codes | 5% | 1-2% | MC working group |
| Simplifications in MC | 2% | 2% | |
| Cherenkov light creation | 5% | 2% | mainly molecular profile |
| Ozone absorption | 3% | 1% | Potential vorticity, spectrometer |
| Molecular extinction | 2% | 1% | Radio sondes and GDAS |
| Cirrus layers extinction | 5-10% | 1-2% | Raman LIDARs and FRAM |
| Boundary layer extinction | 5-10% | 1-2% | Raman LIDARs and FRAM |
| Scattered Cherenkov light | <1% | <2% | |

# Ozone absorption spectrum

- Relatively small (but non-negligible) effect for Cherenkov spectrum
- Cannot absorb Cherenkov light completely, but may introduce small systematic biases



# Ozone absorption spectrum:

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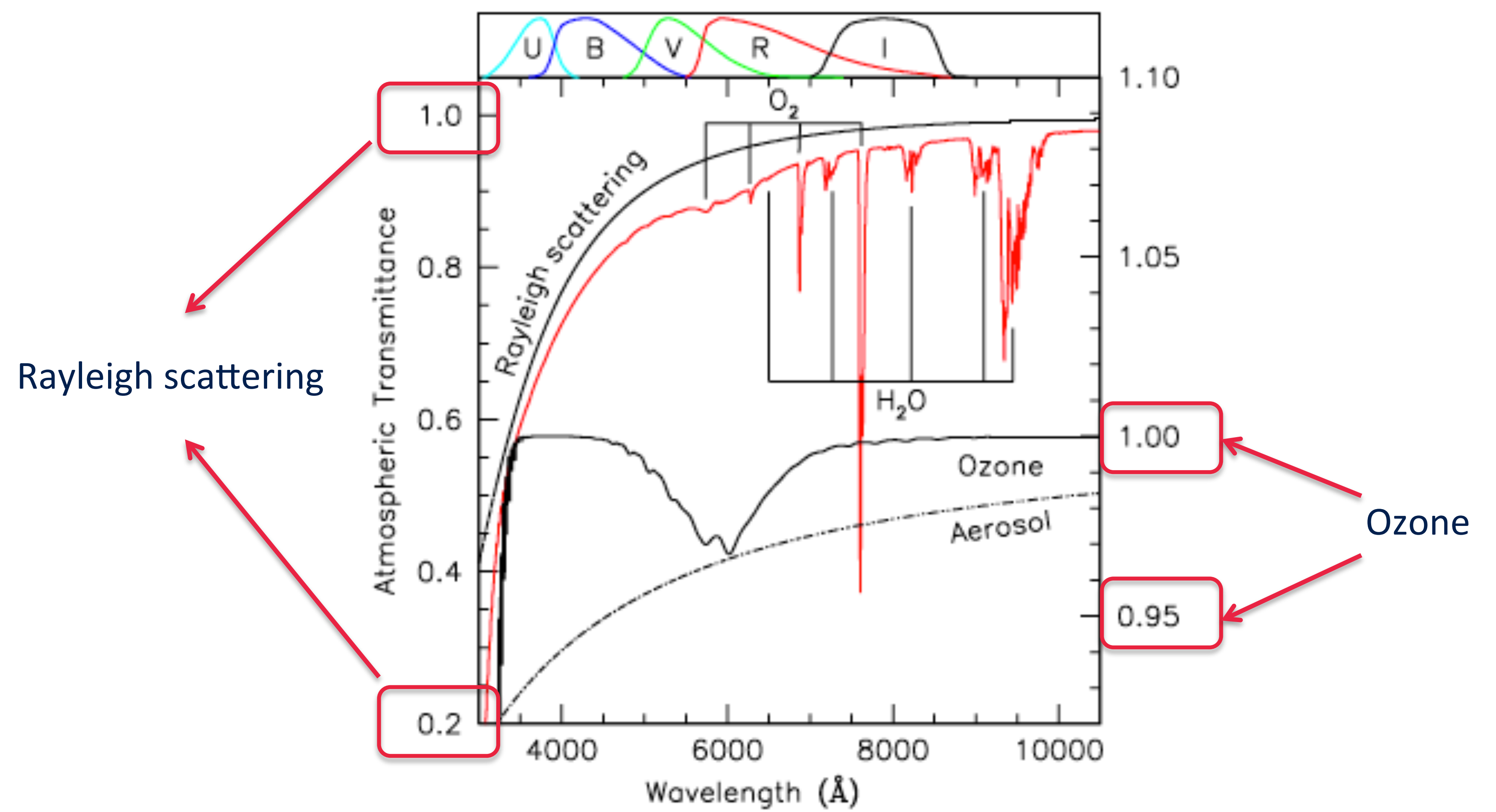
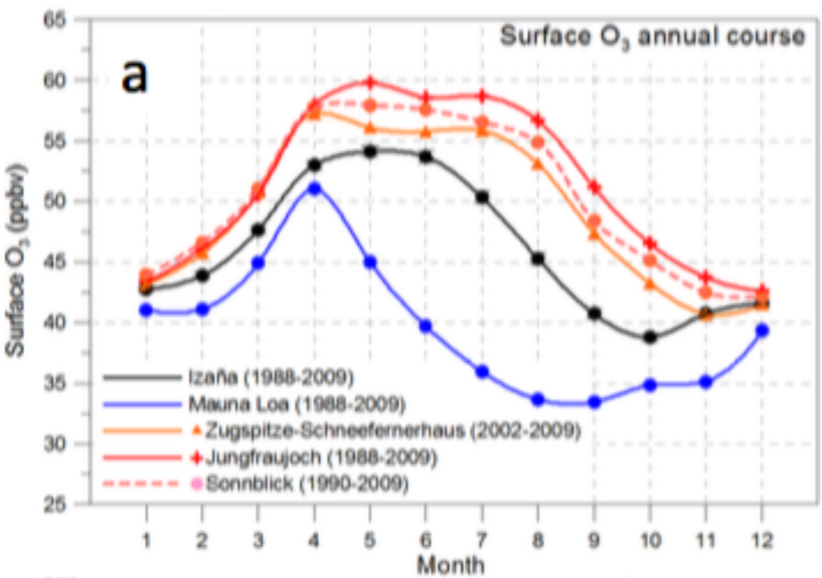
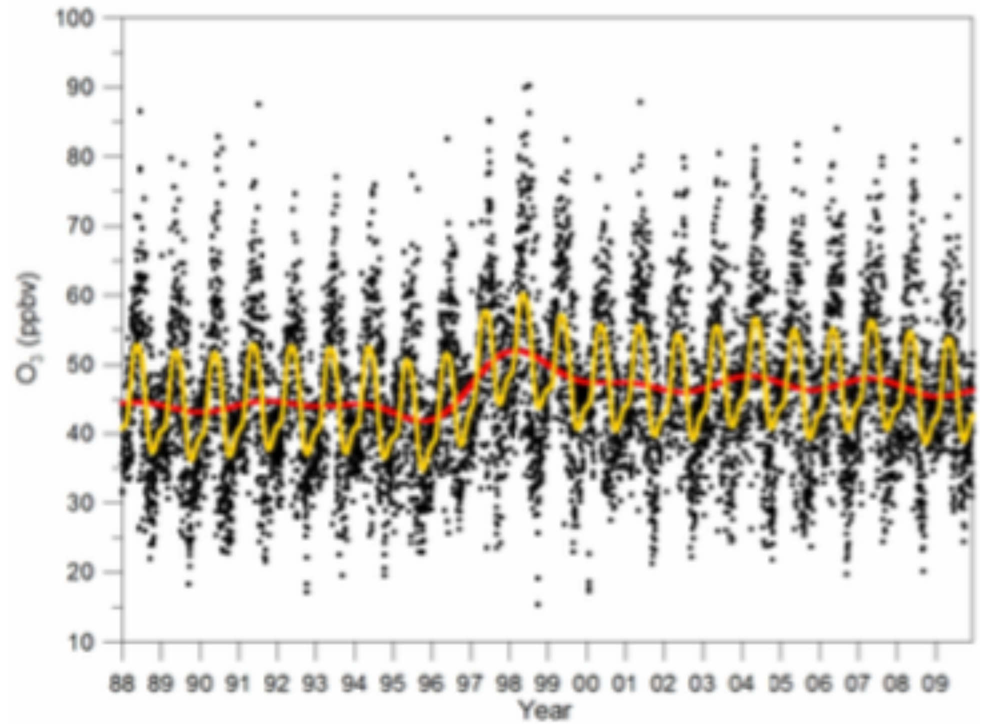



Markus Gaug, Universitat Autònoma de Barcelona, CCF, general meeting, Oct. 2017

# Ozone profile (CTA-N)

## Ozone has been studied in detail at Izaña (Tenerife), 2400 m a.s.l.




E. Cuevas et al., "**Assessment of atmospheric processes driving ozone variations in the subtropical North Atlantic free troposphere**", Atmos. Chem. Phys., 13, 1973–1998, 2013

**Fig. 2.** Surface $O_3$ daily night means (black dots), interannual trend (red line) and interannual trend plus annual cycle at IZO from 1988 to 2009.

# Ozone profile (CTA-N)

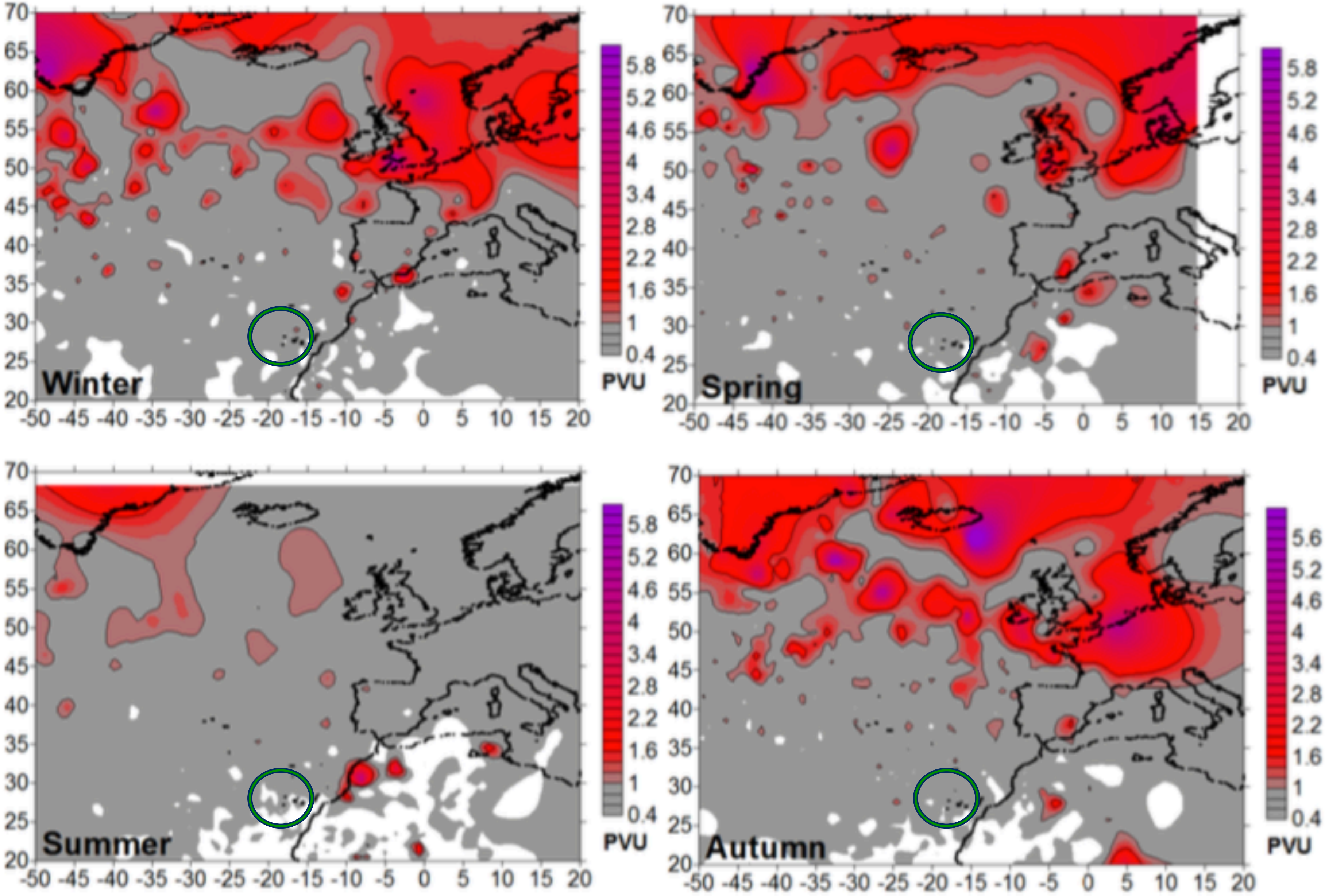
Ozone can suddenly "drop" from stratosphere deep into the troposphere through "Stratosphere-Troposphere-Exchange" (STE) processes.

Ozone at high troposphere is correlated with a parameter called "Potential vorticitiy" (PV), measured in units of PVU.

Situations with PVU>1.0 indicate stratospheric intrusions into the upper troposphere and hence high $O_3$ concentrations.

E. Cuevas et al., "**Assessment of atmospheric processes driving ozone variations in the subtropical North Atlantic free troposphere",** Atmos. Chem. Phys., 13, 1973–1998, 2013

# $PV_{max}$ maps for winter (JFM), spring (AMJ), summer (JAS) and autumn (OND) in the period 1988–2009.



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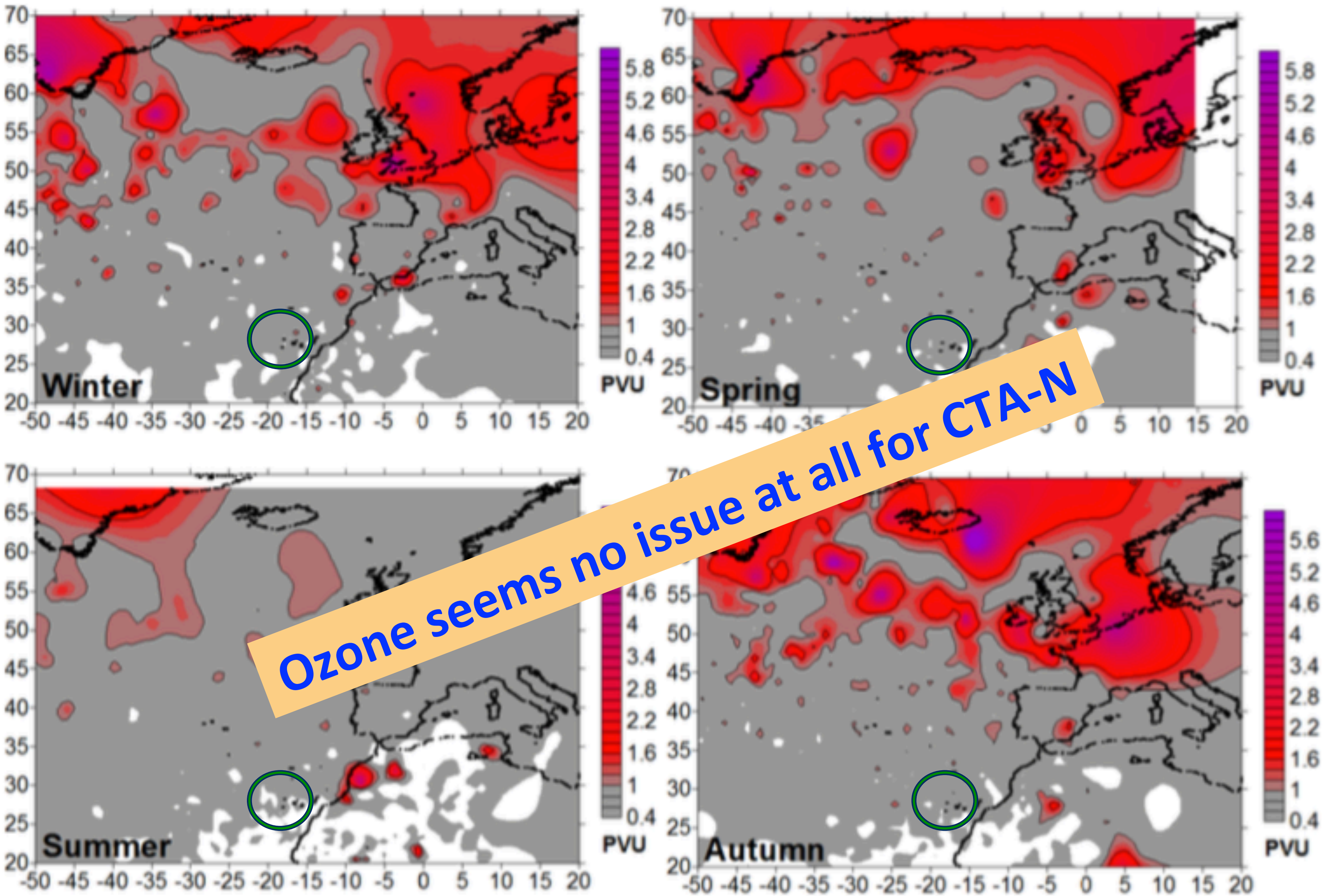


# Ozone profile (CTA-S)

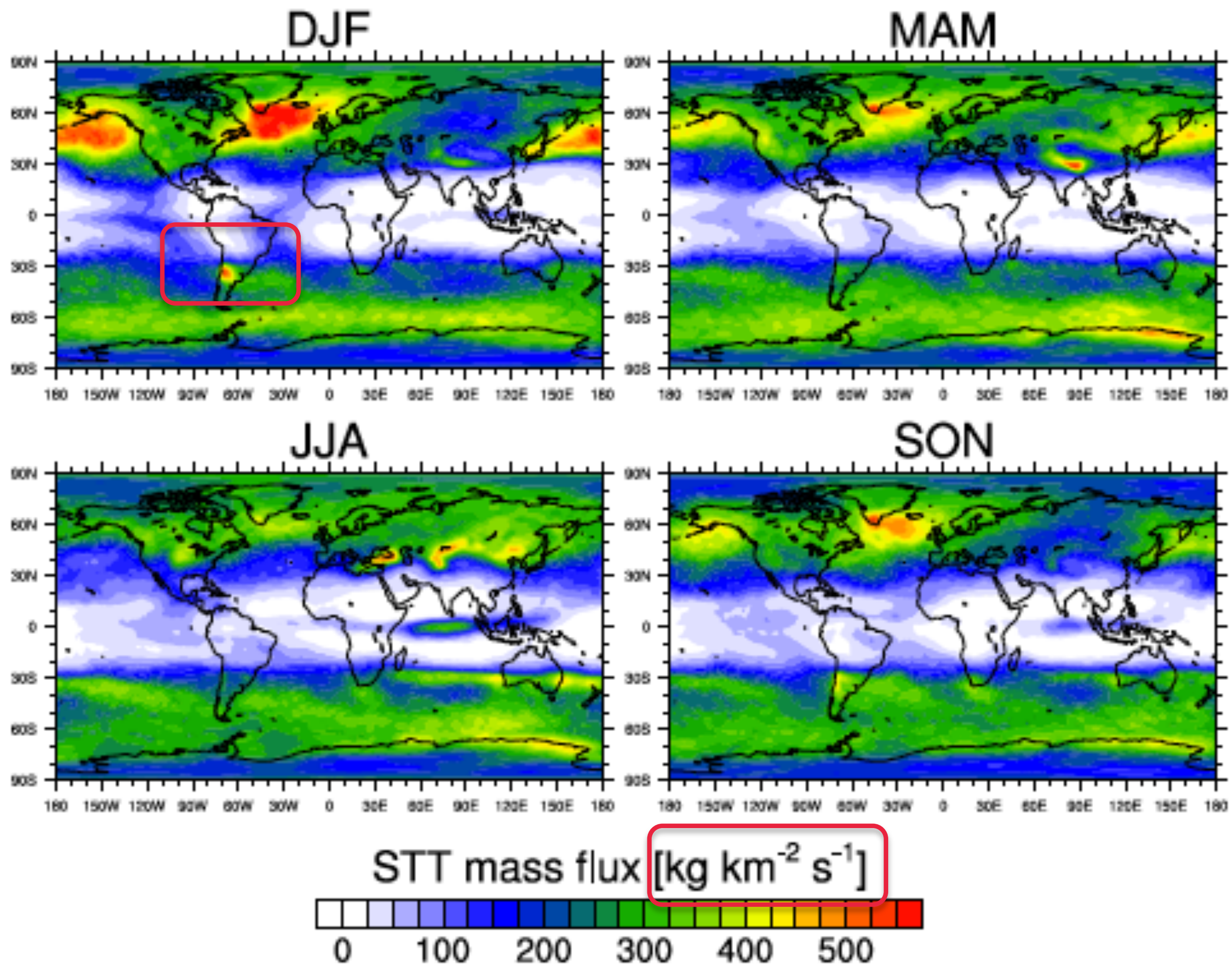
Very deep STE processes seem to occur predominantly above high mountain (chains), above all "STT" (Stratosphere to Troposphere) processes.

Chilean andes are strongly affected by very deep ozone intrusions.

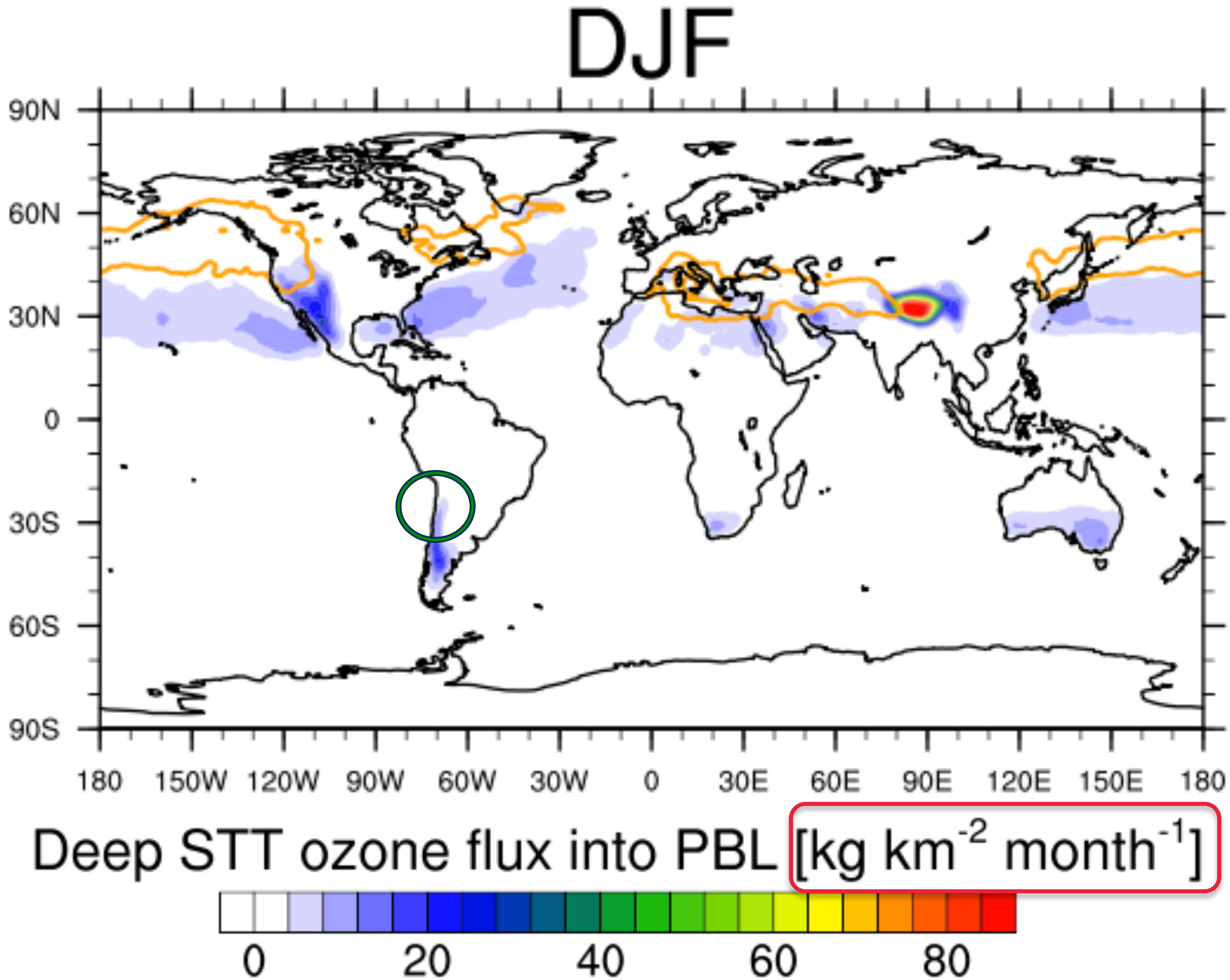
For the moment, have only direct measurements from Cerro Tololo (10° further South, and maybe not representative enough) and reanalysis of global data assimilation data (ERA-interim analyses).

Škerlak B. et al. ***A global climatology of strato- sphere–troposphere exchange using the ERA-Interim data set from 1979 to 2011***, Atm. Chem. Phys. 14 913 (2014)

# Seasonally averaged STT mass flux



# Deep tropospheric ozone intrusions (Škerlak et al. )



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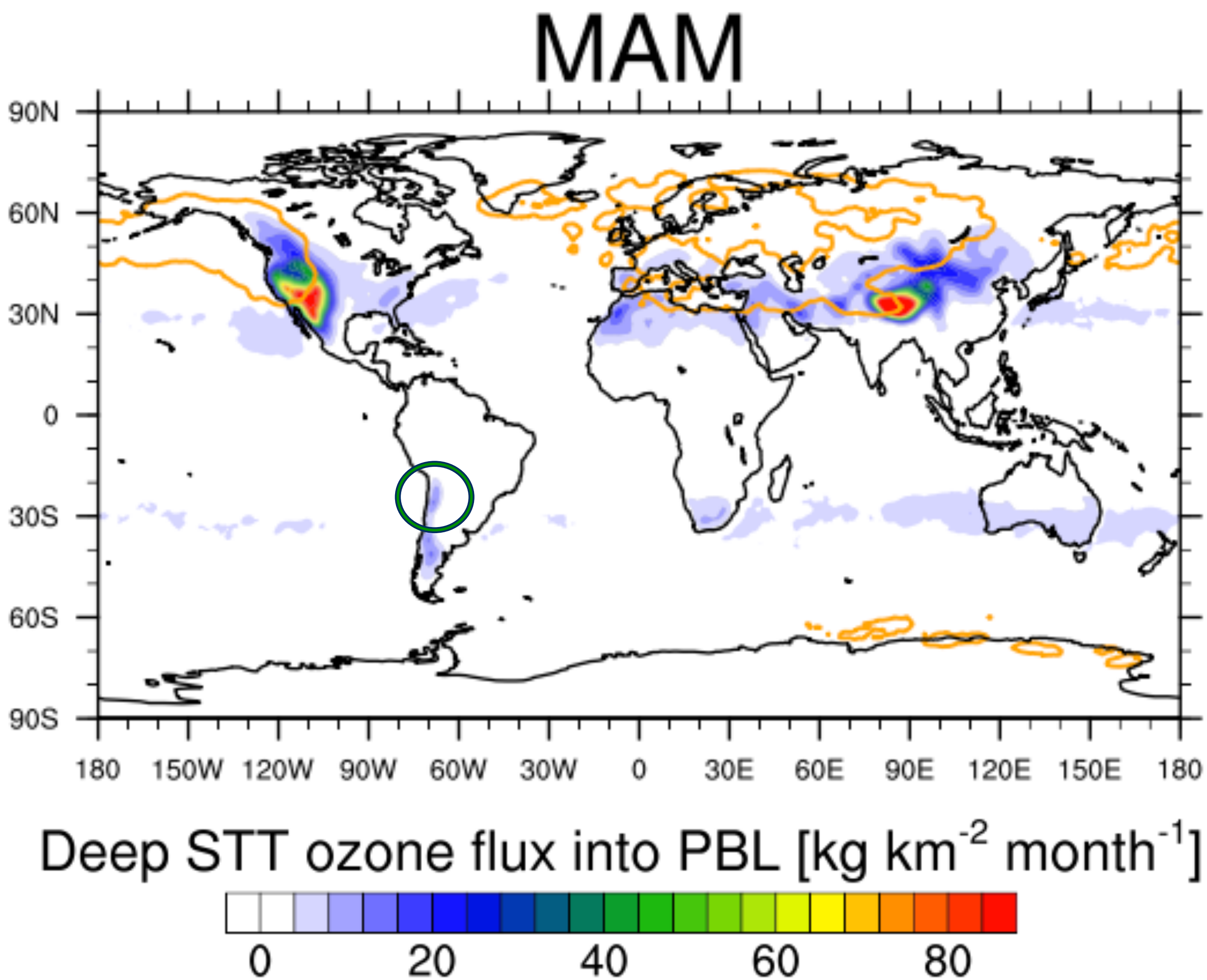

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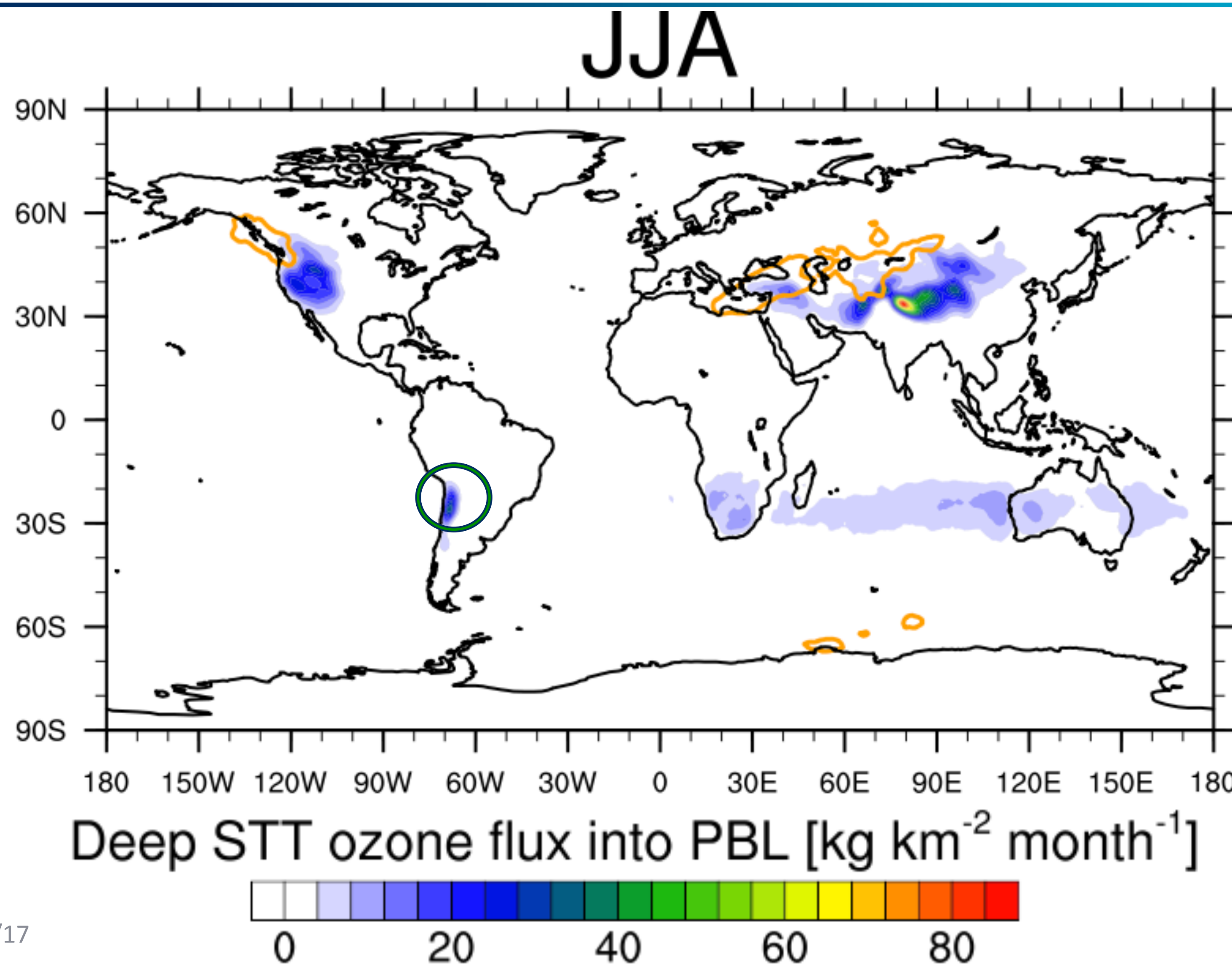

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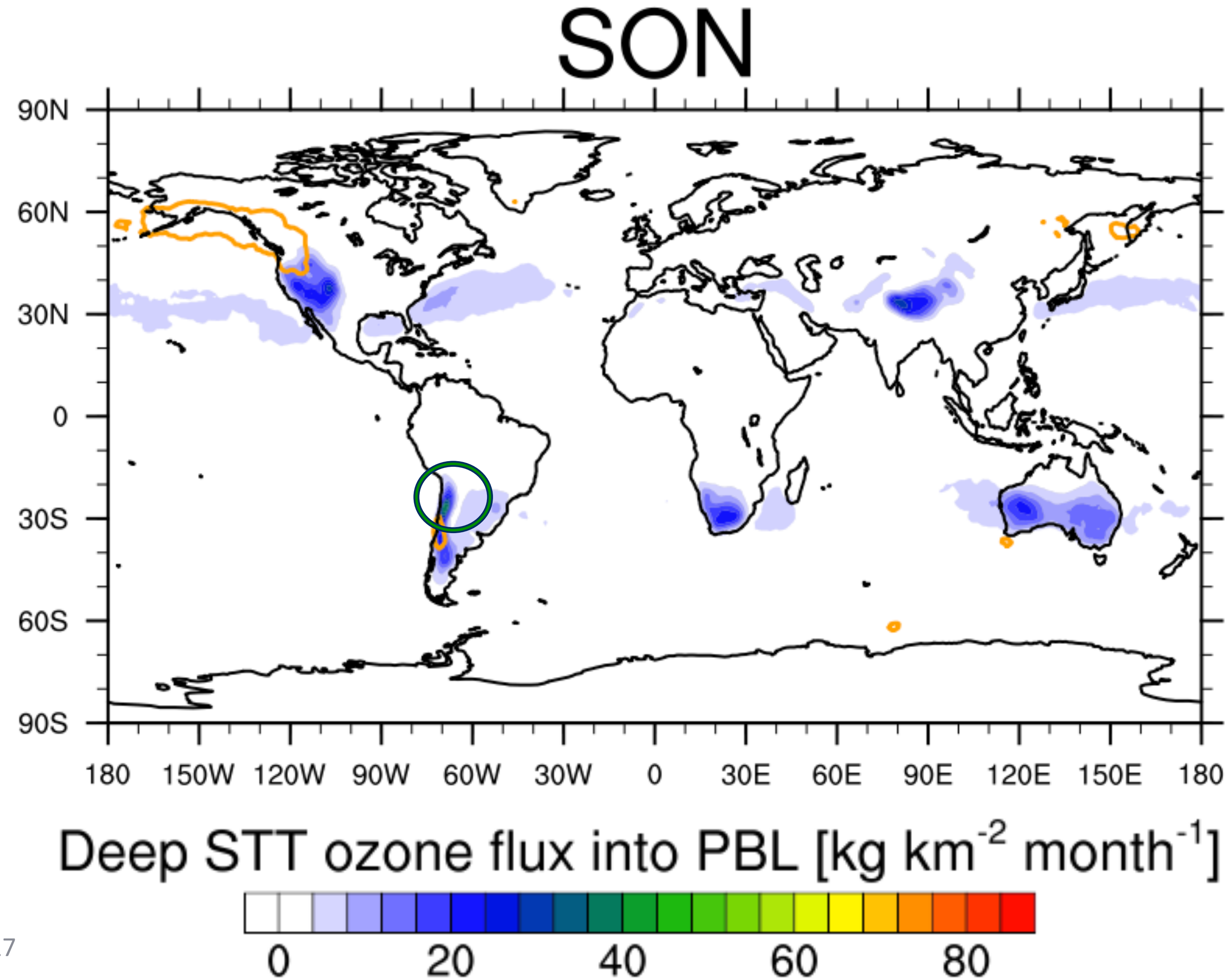

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