Ozone structure and variability in the UTLS as seen by Envisat and ESA Third-party mission limb profiling instruments

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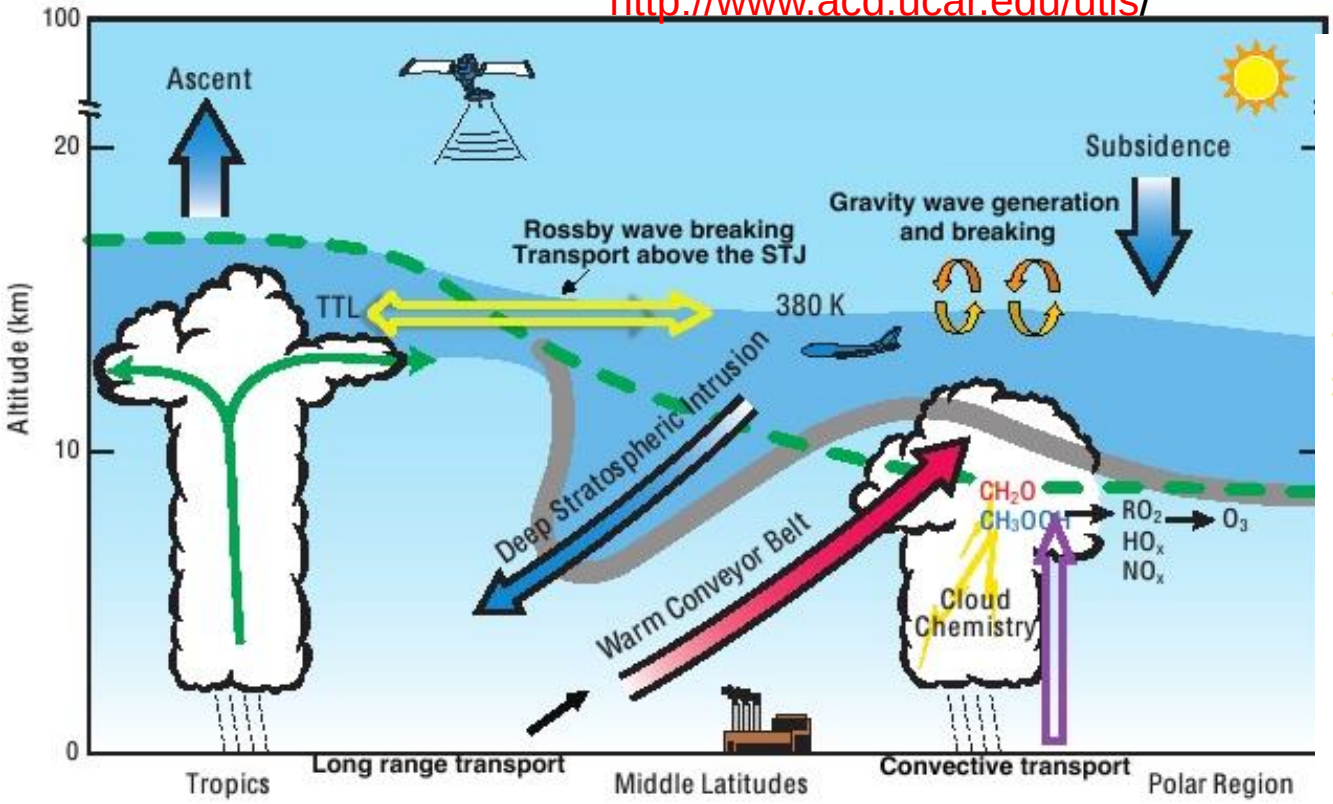
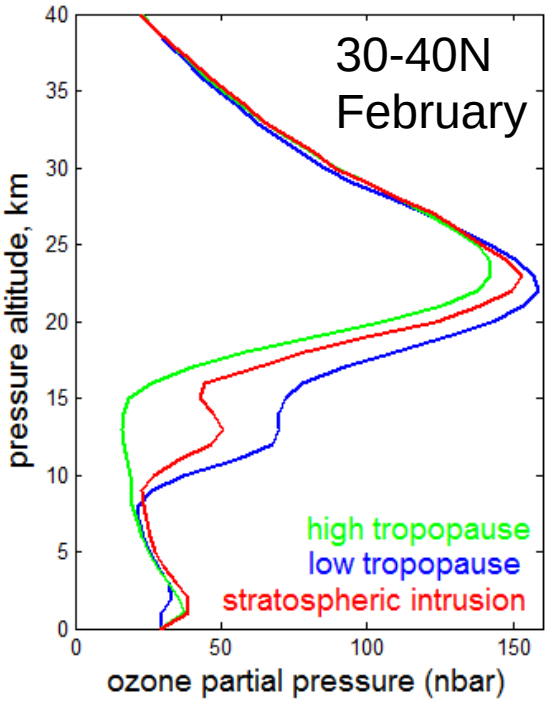
UTLS variability and ozone

http://www.acd.ucar.edu/utls/



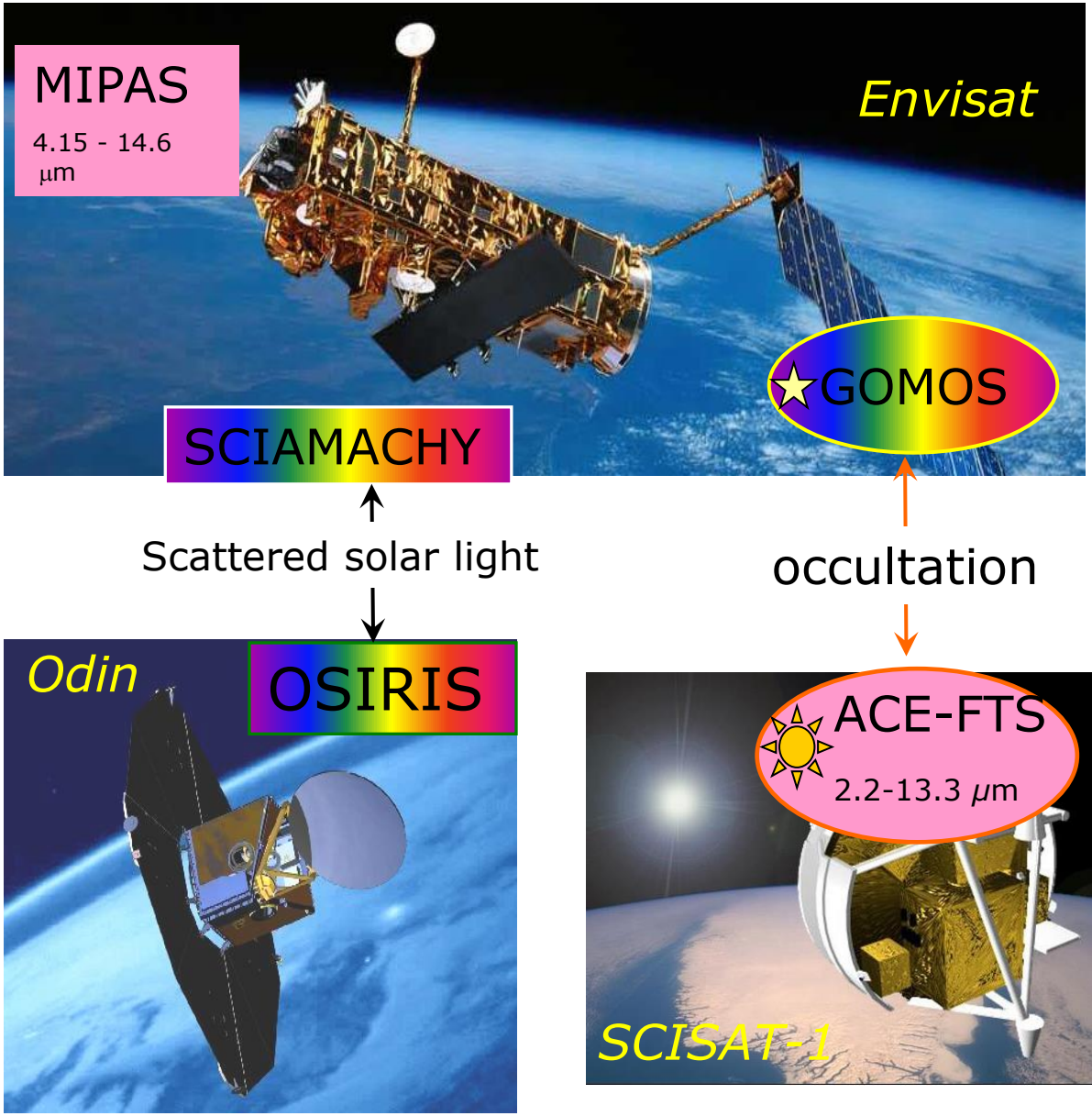
TpO3 climatology, (Sofieva et al., 2014)



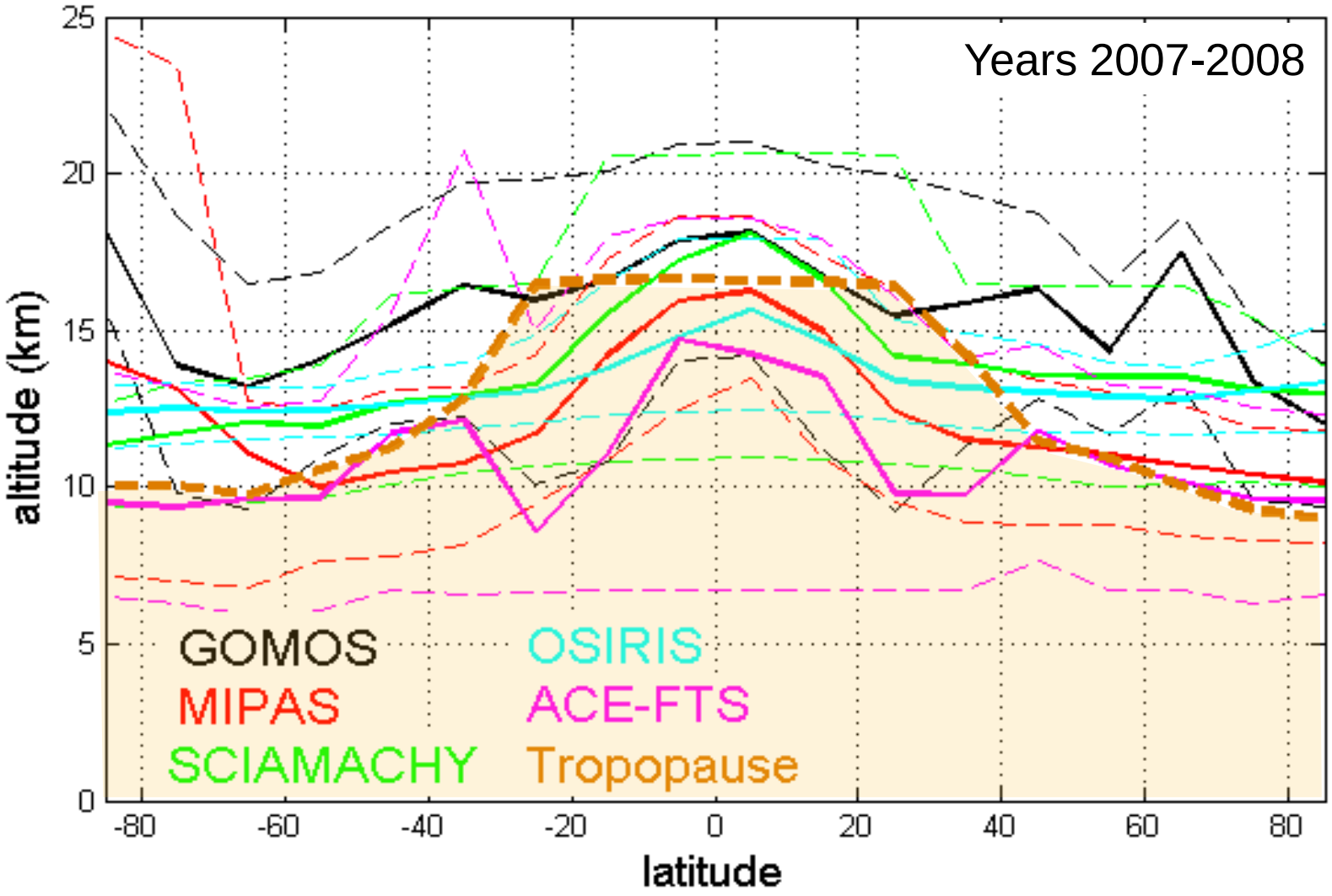
- Dynamical, chemical and radiative coupling between the stratosphere and troposphere are among the important processes that must be understood for prediction of global trends, including climate change
- Ozone in the UTLS is highly variable:
  - processes related to variations in the tropopause height
  - stratosphere-troposphere exchange

UTLS observations from space

- Nadir instruments
  - not sufficient vertical resolution
- Limb instruments
  - Low signal-to-noise ratio
  - Presence of clouds
  - UV-VIS instruments: aerosol modelling
- Instruments participating in the Ozone_CCI



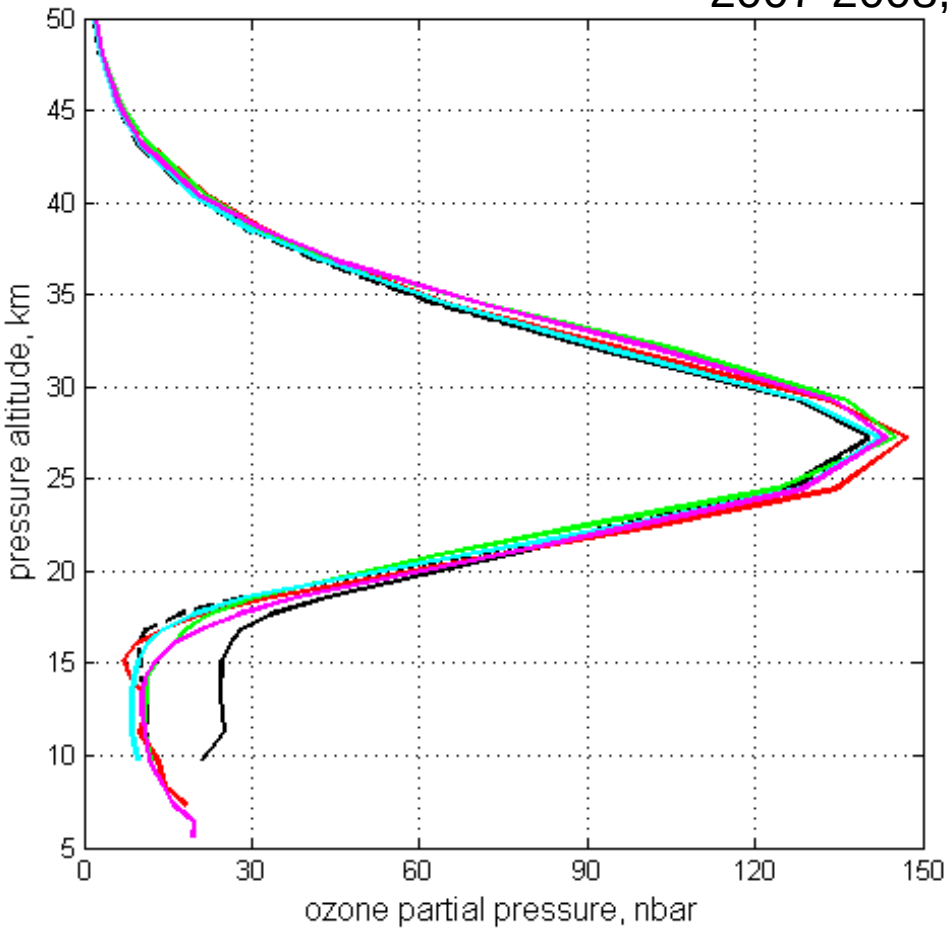
The lowest altitude of ozone profiles

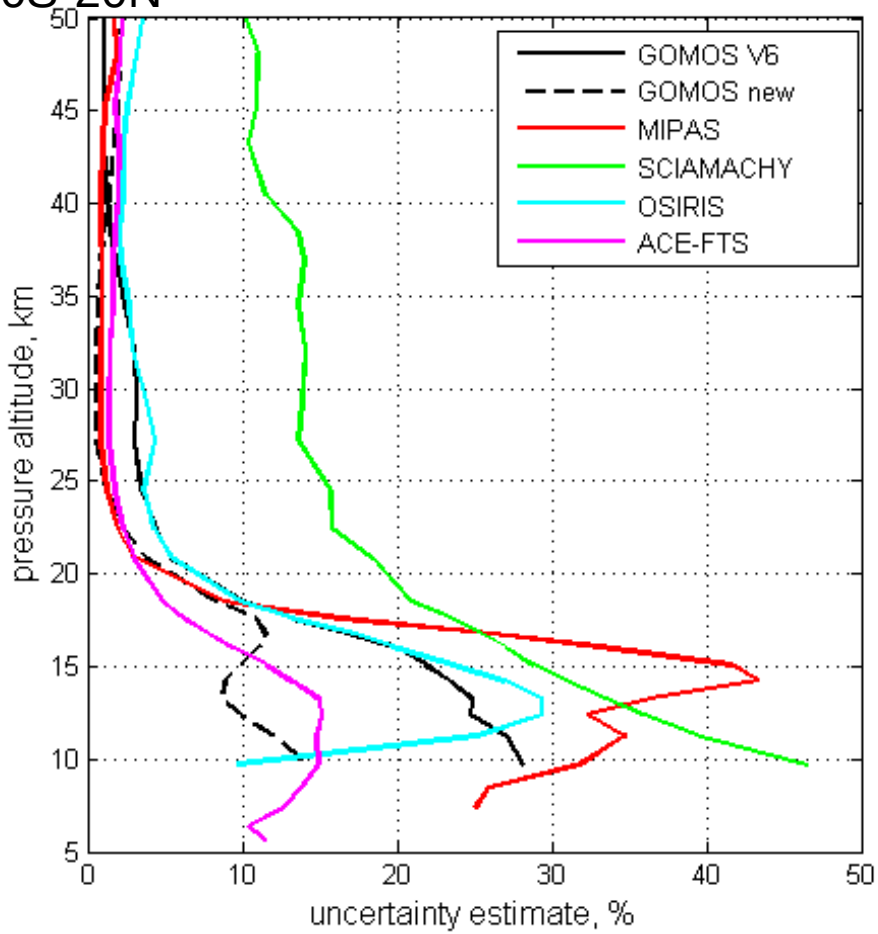


- The UTLS region is usually well covered by the Ozone_cci limb sensors
- The lowest altitude depends on presence on clouds

Profiles and estimated retrieval uncertainty in the UTLS

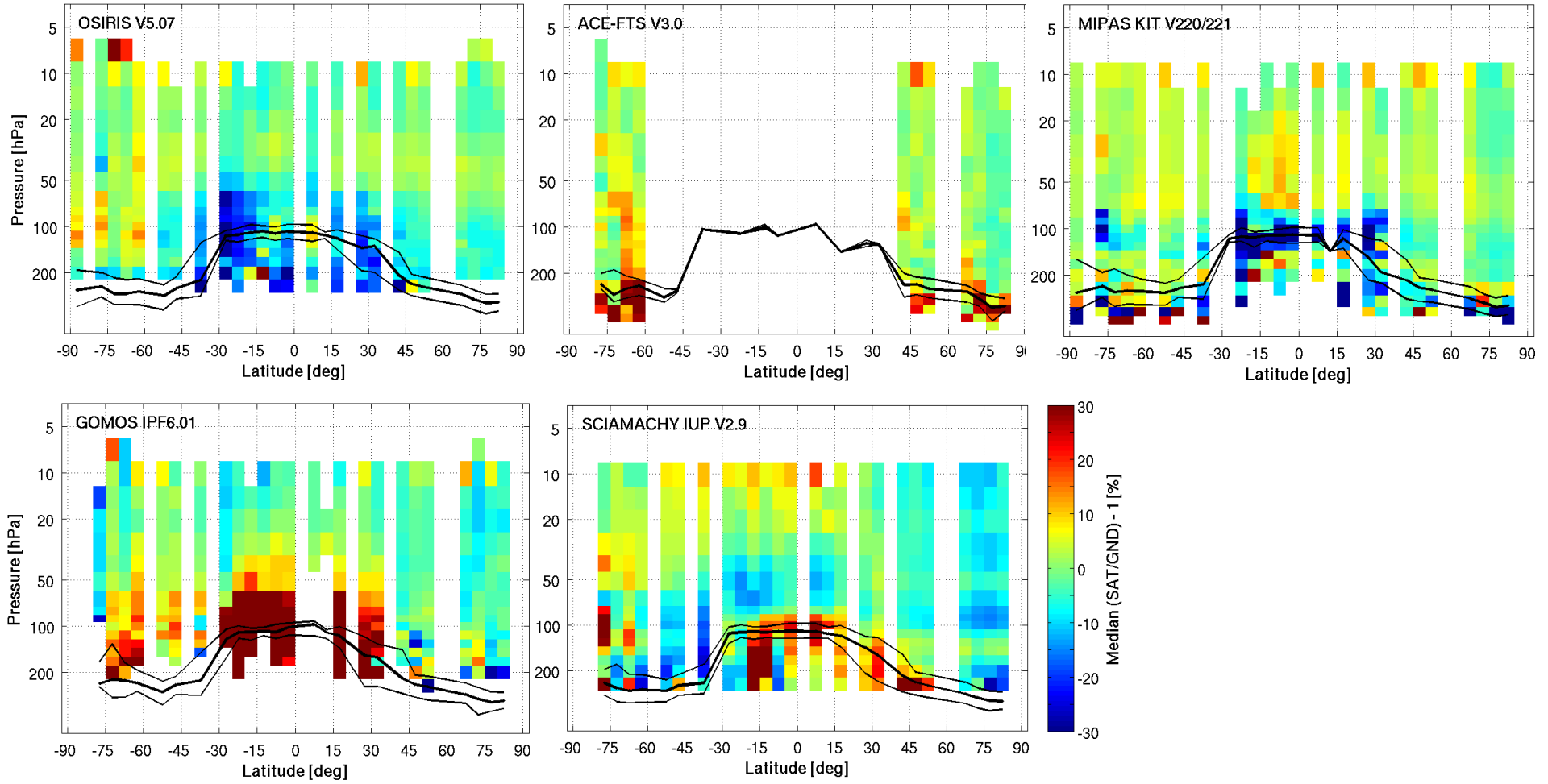
2007-2008, 20S-20N





- Large reduction of bias for the alternative GOMOS processing - more details in poster 25
- Uncertainties for SCIAMACHY contain also smoothing error

Summary of the validation against ozonesondes



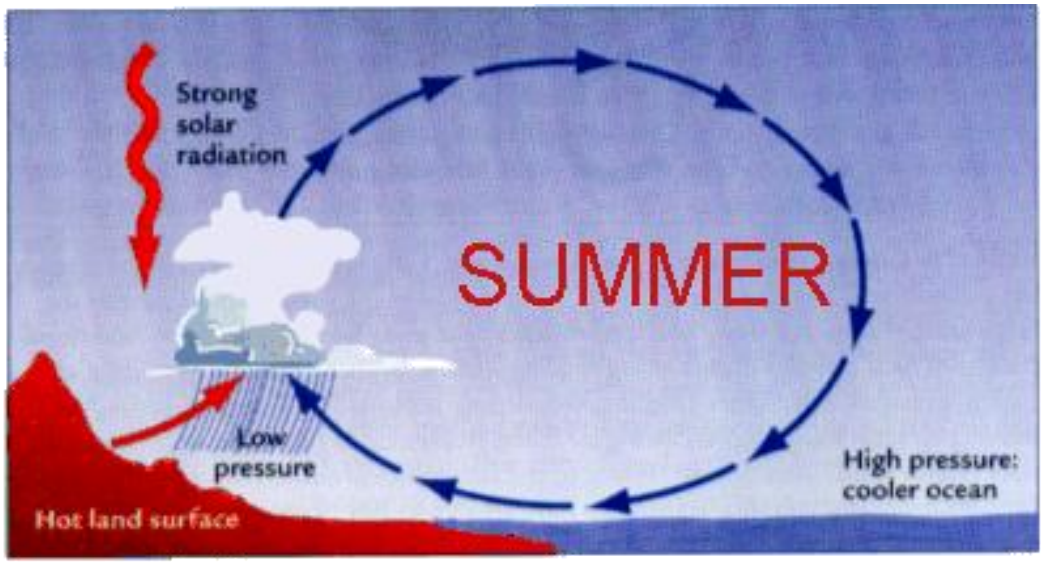
- Usually, biases are within ± 20%
- Large positive bias for GOMOS V6 is not observed in advanced (alternative) retrievals
- Data from OSIRIS, ACE-FTS and MIPAS have already been used for scientific studies in the UTLS

Hubert et al., AMTD, 2015
Hubert et al., Ozone_cci PVIR, 2014

Geophysical phenomena as observed by Ozone-CCI instruments

UTLS response to Asian Summer Monsoon

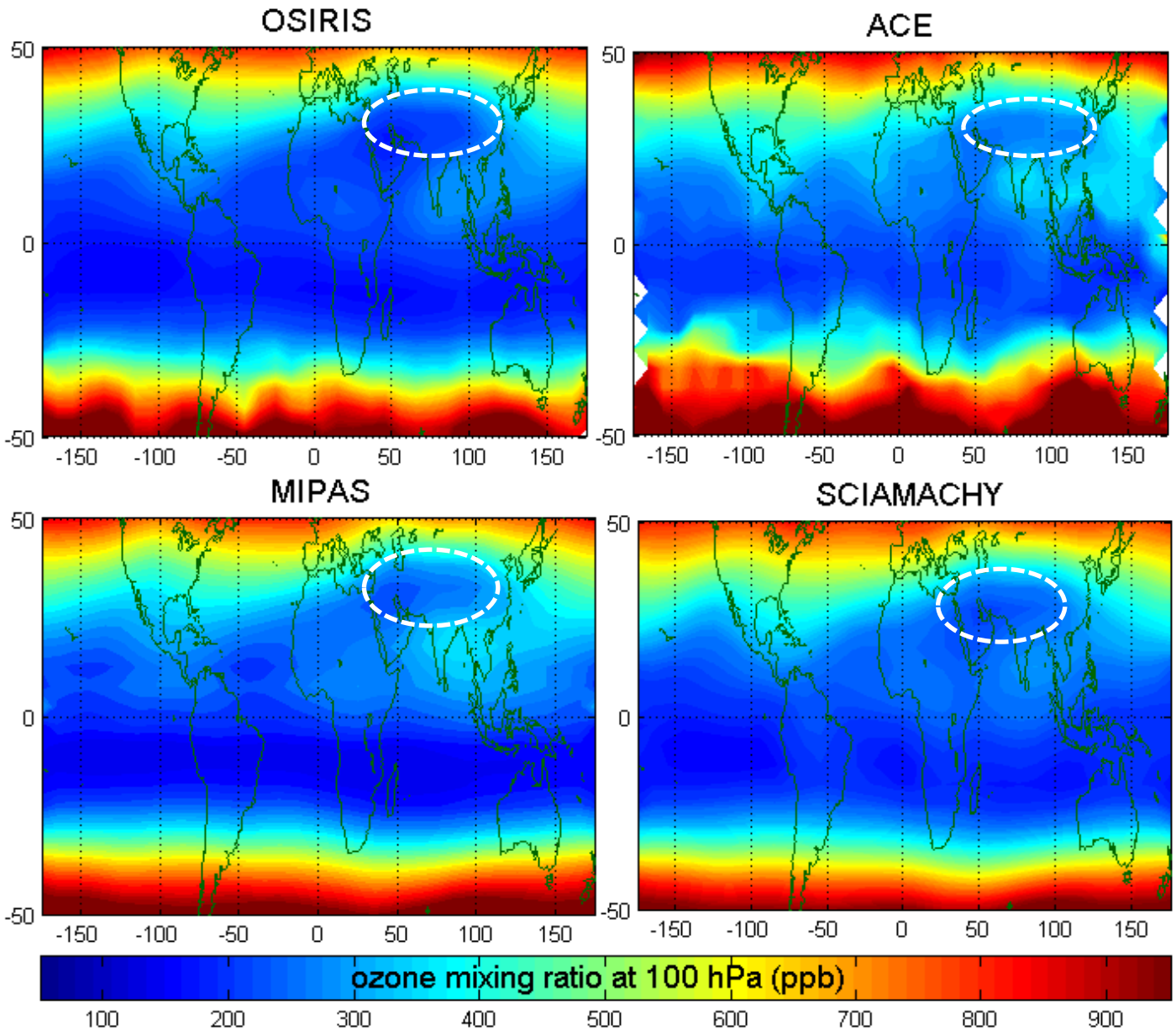
www.nc-climate.ncsu.edu



http://www.sciencedaily.com

- The ASM contains a strong anti-cyclonic vortex in the UTLS, spanning from Asia to the Middle East
- The ASM has been recognized as a significant transport pathway for water vapor and pollutant to enter the stratosphere
- Open questions
  - What is the structure of chemical composition and aerosol in the UTLS
  - Water vapor budget and aerosol cirrus cloud interaction
  - Troposphere-stratosphere exchange
  - How well is the transport pathway represented in the chemistry-climate models?
  - Trends?

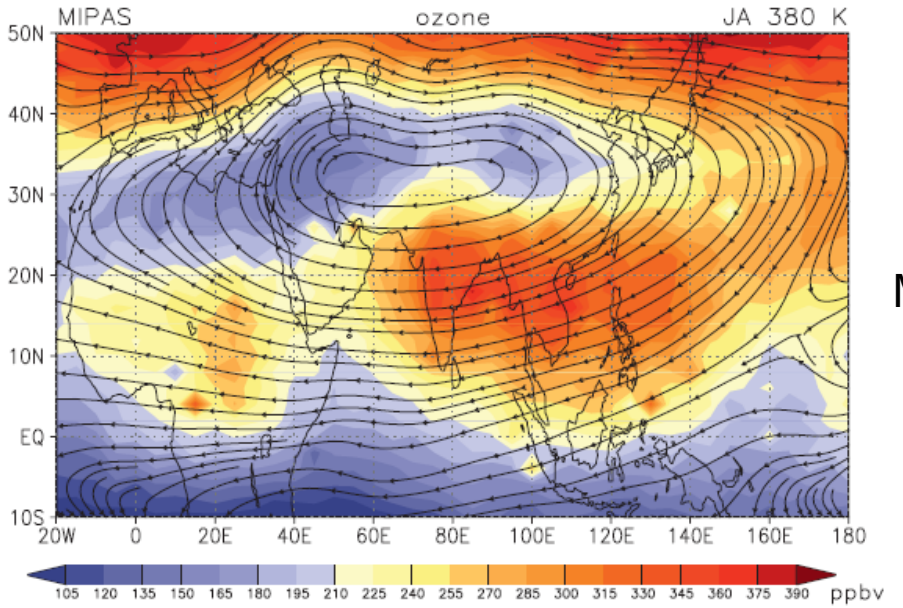
ASM influence on ozone as seen by Ozone_cci instruments



Ozone mixing ratio (ppb) at 100 hPa in Jun-Aug, all available years

ASM structures: comparison with models

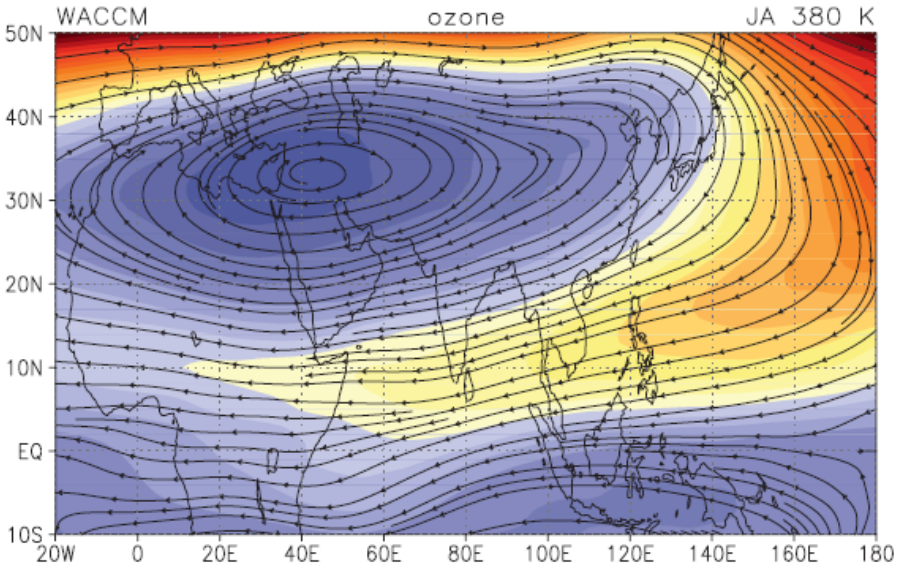
Kunze et al., 2010



380 K potential temperature level, July & August

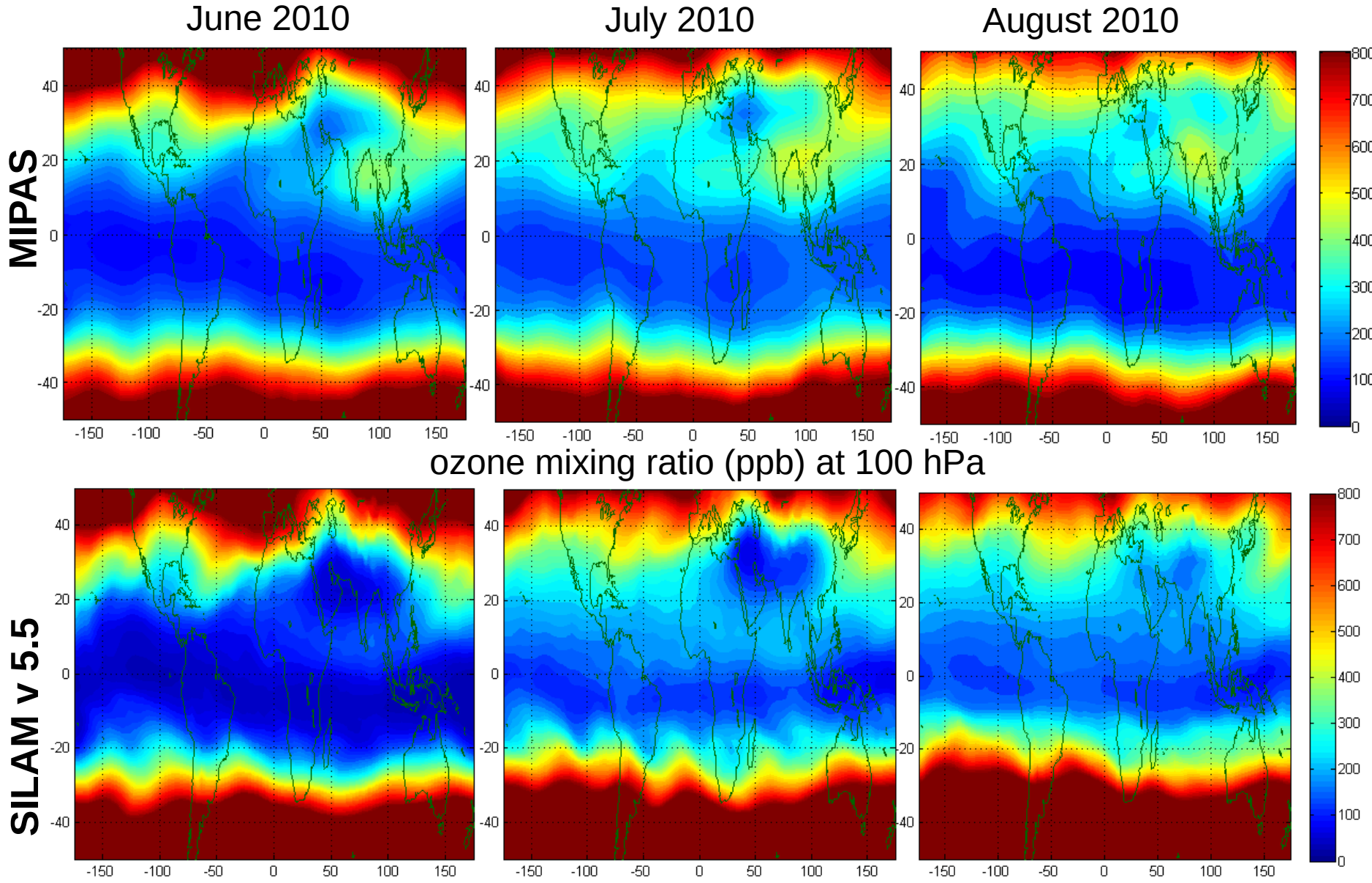
MIPAS

Models capture the associated impact on ozone to some degree

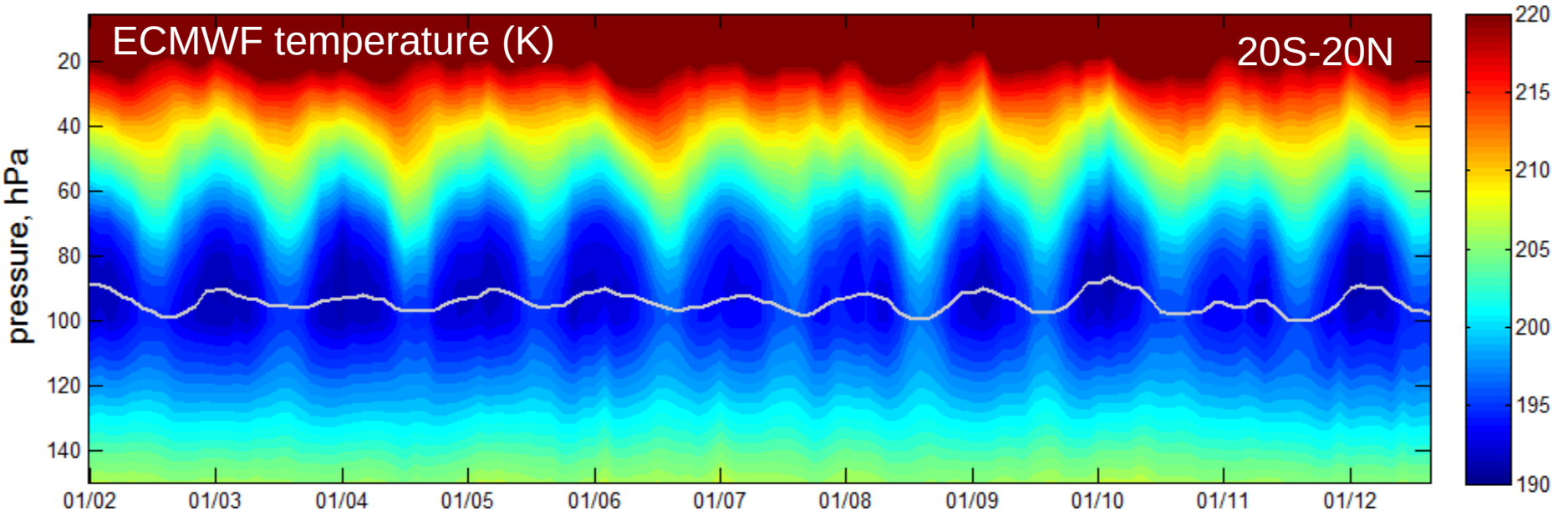


WACCM

Comparison with new models covering the troposphere and the stratosphere

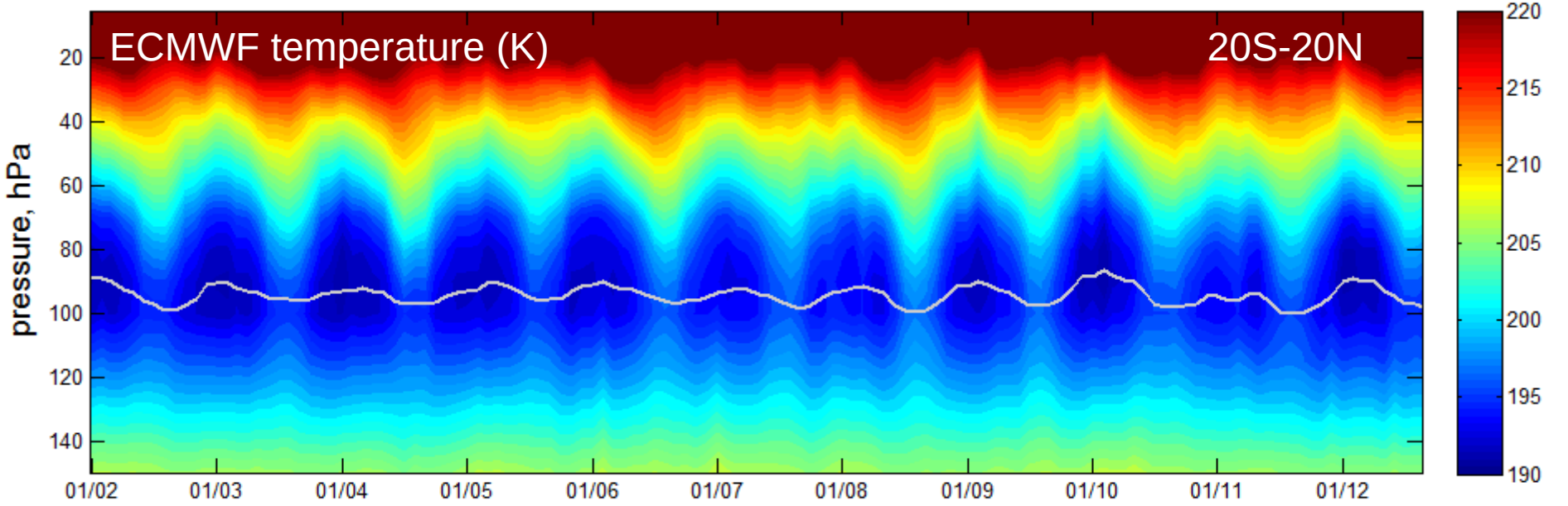


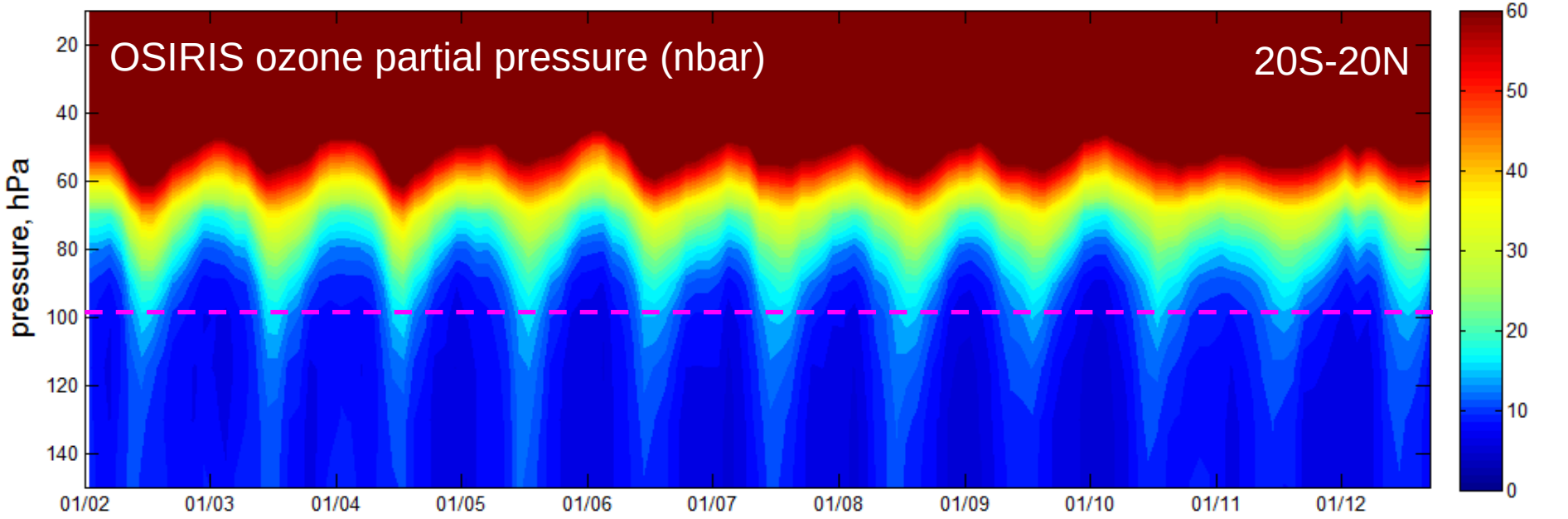
Seasonal cycle in the tropical UTLS



- Approx. factor-of-two variations in strength of upwelling and temperature changes up to 8 K
  - Faster upwelling and colder temperatures during boreal winter
- Annual cycle is observed exclusively above ~15 km
- Original explanation:
  - Tropical cycle is a response to the annual cycle of the stratospheric planetary wave forcing in winter-spring high latitudes
- Recent analyses
  - Importance of extratropical waves dissipating in subtropics
  - Planetary waves generated within the tropics
- Important consequence: vertical transport of trace constituents
  - Especially important for ozone having a strong gradient across TTL

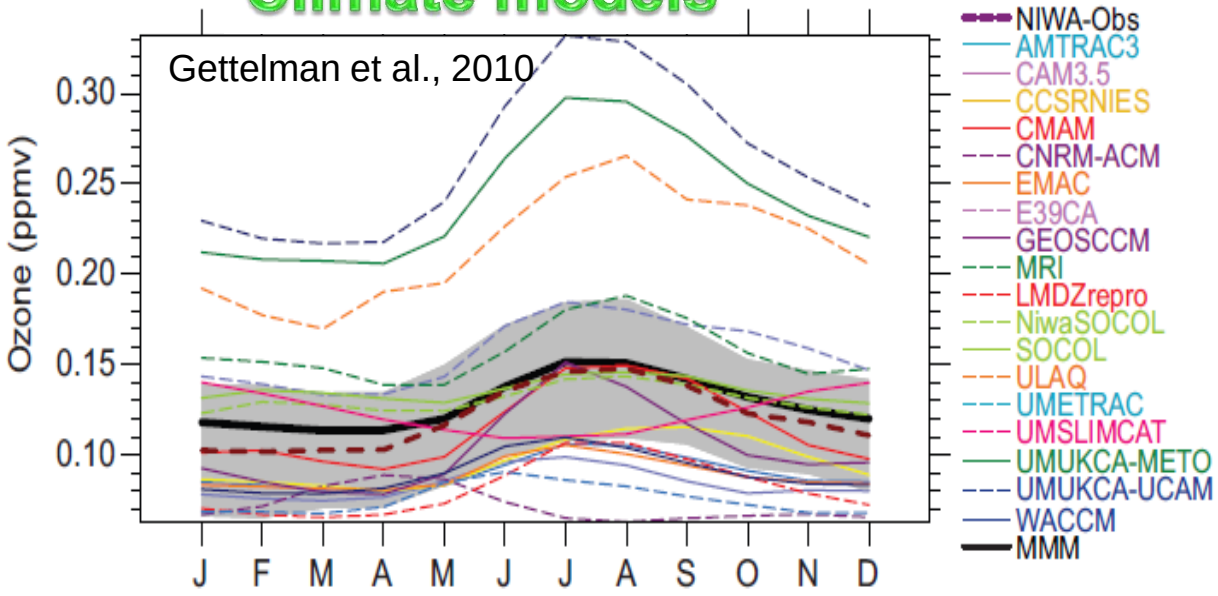
Seasonal cycle in the tropical UTLS





Ozone seasonal cycle in the tropical UTLS

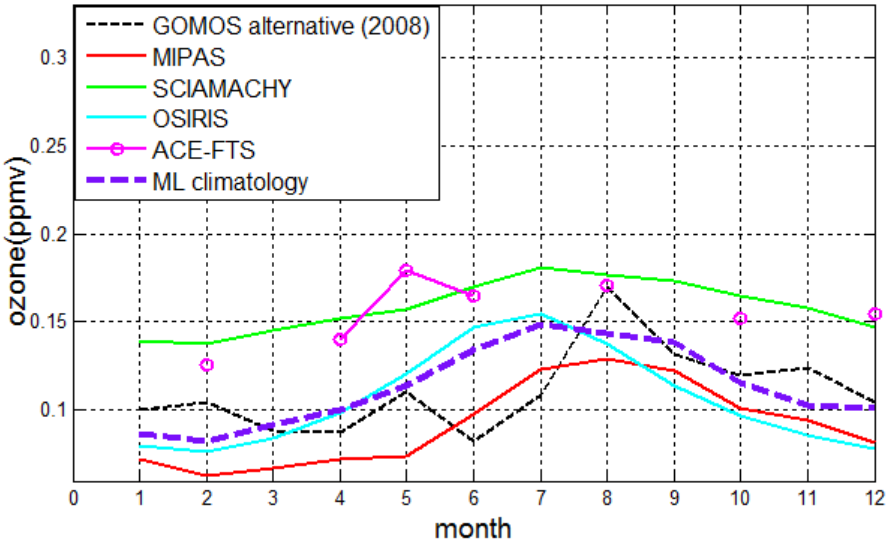
Climate models



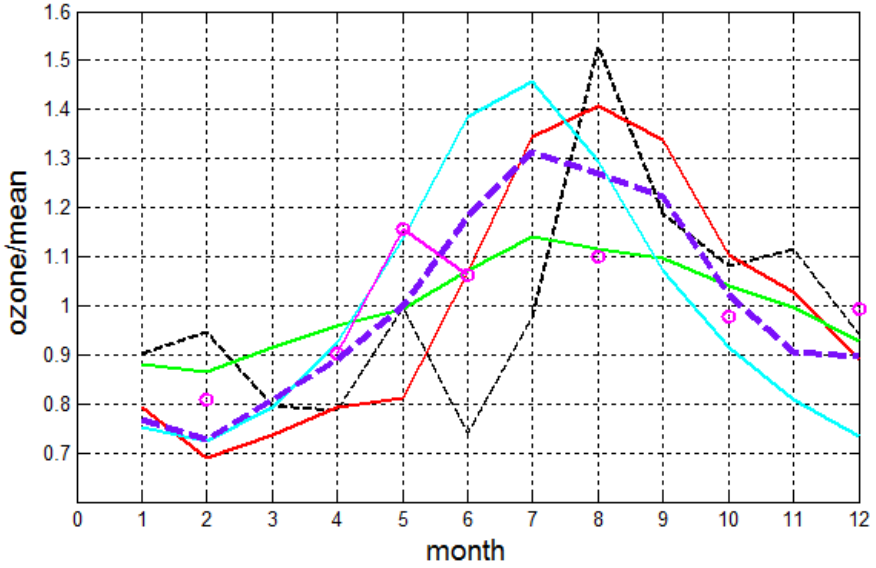
- Reproducing the seasonal cycle is the test for climate model intercomparison
- The figure is adapted from CCMVal report

20S-20 N, 100 hPa

Ozone_cci limb instruments



Amplitude of annual cycle

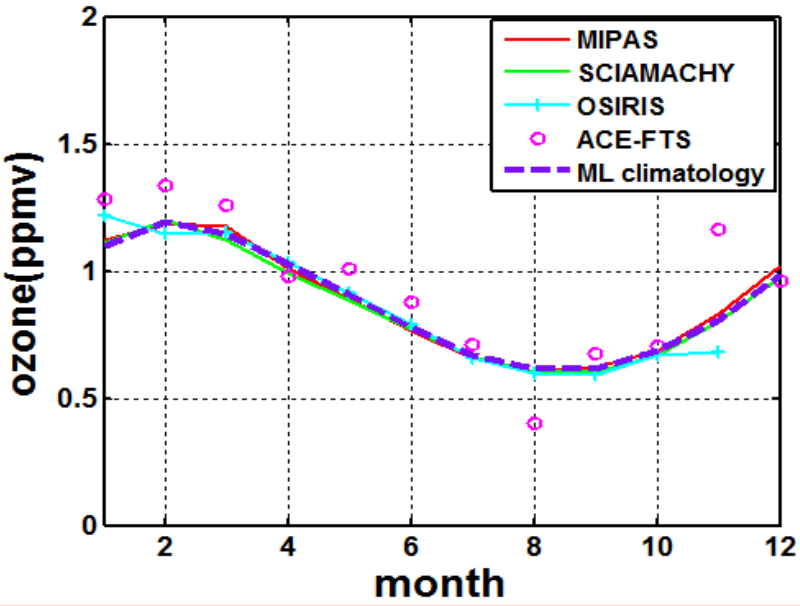


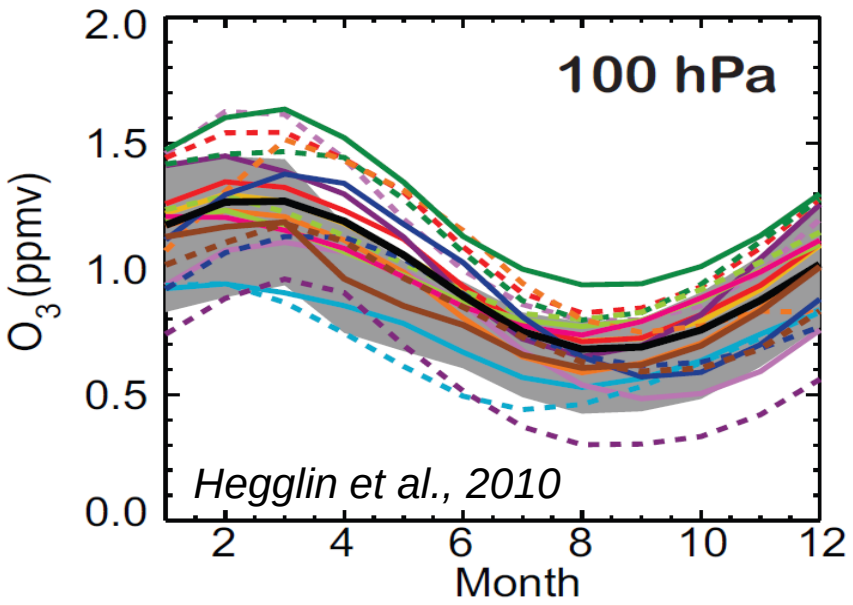
Ozone seasonal cycle in the extra-tropical UTLS

Ozone_cci limb instruments

Climate models

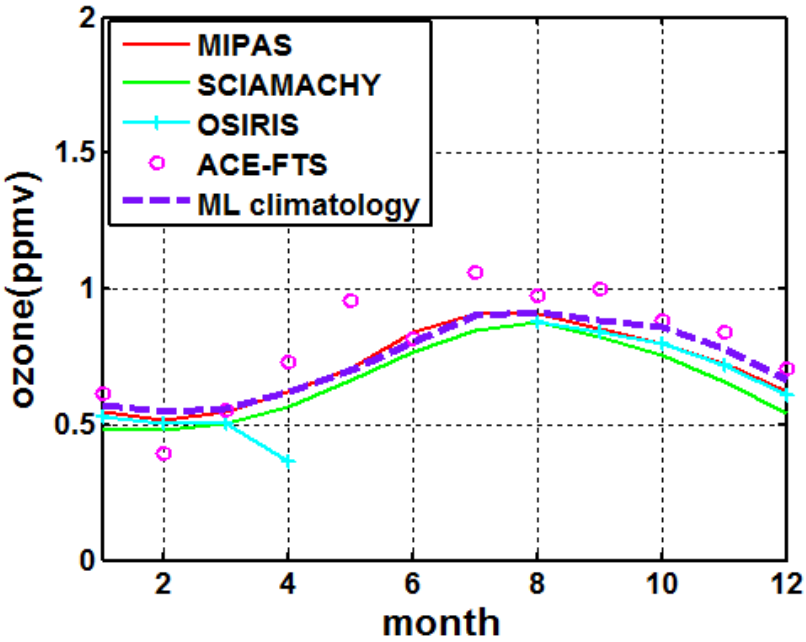
40- 60 N

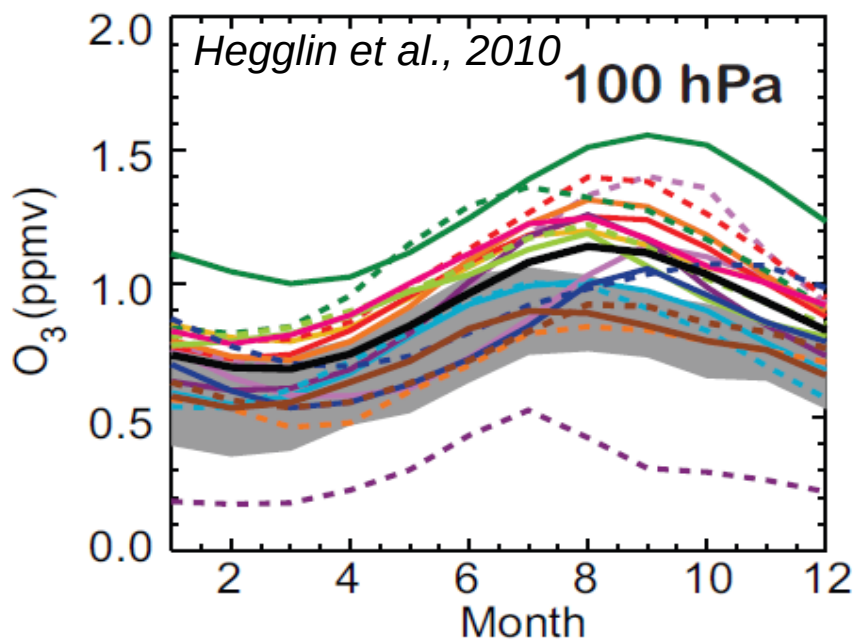




Hegglin et al., 2010

40- 60 S





Summary : data quality

- Ozone limb profiles by Ozone_cci instruments have been extensively validated and inter-compared
  - In general, data are of good quality
  - Further data improvements are foreseen in the new processing versions
- The patterns of geophysical phenomena and variations observed by different instruments are in a very good agreement
- The ozone profile data in the UTLS provide very useful information
  - For testing the chemistry-transport models
  - For research

Summary: scientific highlights

- The ozone profile data by Ozone_cci instruments have been used in the UTLS related research
- Some examples
  - Influence of Indian Summer Monsoon (Kunze et al., 2010)
  - Composition during the southern hemispheric biomass burning season in 2003 (von Clarmann et al., 2007)
  - Jet characterization in the UTLS (Manney et al, 2011)
  - low ozone events in the tropical upper troposphere and links with convection (Cooper et al., 2013)
  - Madden-Julian oscillation (Liu et al., 2009)
  - Intercomparison of UTLS climatologies in the framework of the SPARC Data Initiative (Neu et al., 2014)
  - Ozone variability and trends in the tropical lower stratosphere (Sioris et al., 2014)

Nearest and future plans

- In the Ozone_cci project, dedicated UTLS datasets will be created (Level 2 and Level 3)
- First study of ozone trends in the UTLS using merged SAGE II & OSIRIS data
- The trend analyses will be continued using Ozone_cci limb profiles