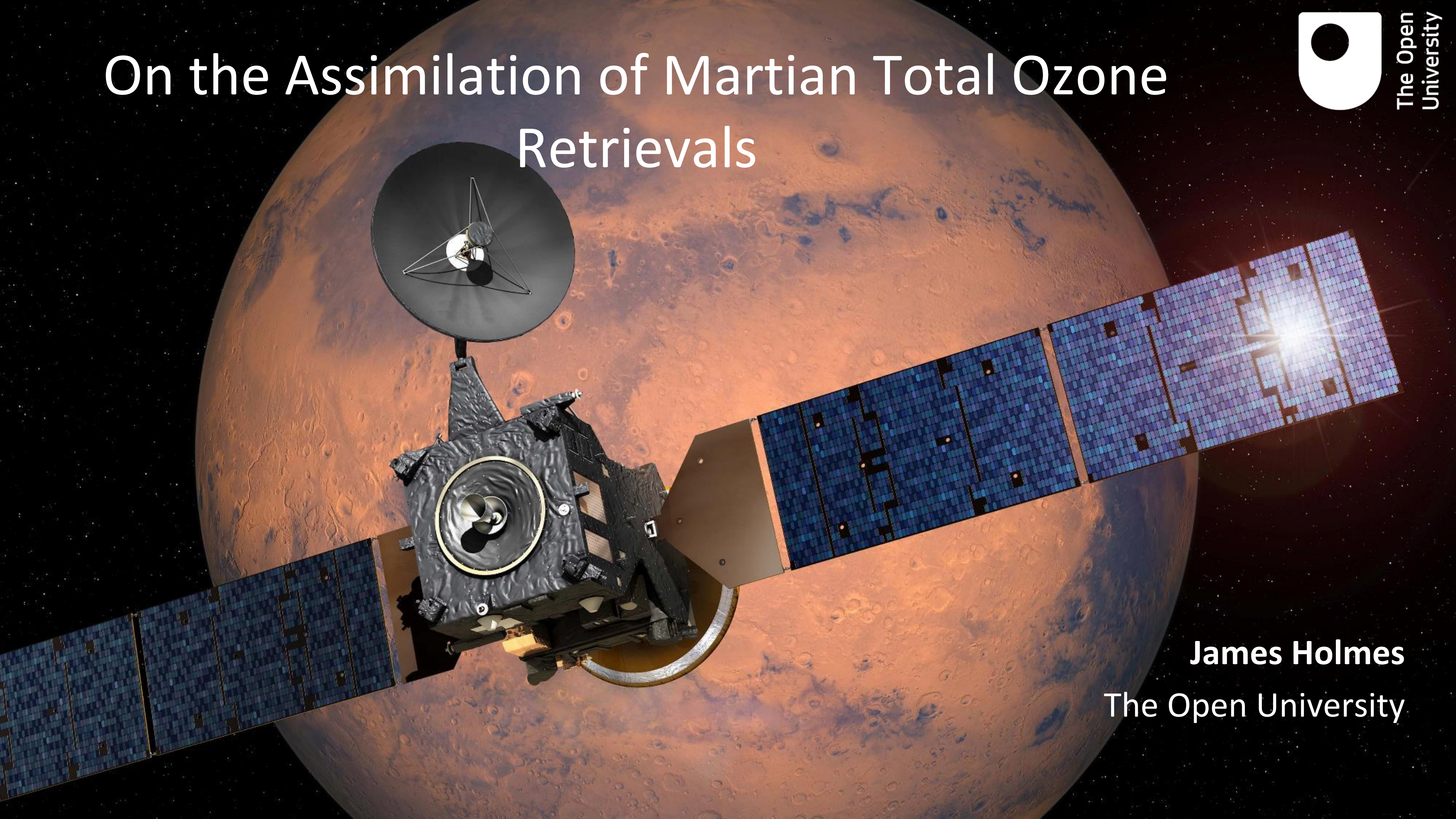
On the Assimilation of Martian Total Ozone Retrievals



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Motivation

- Still much to learn about chemical cycles on Mars (OH,methane?)

- Ozone has been measured for multiple Mars years by multiple instruments, providing an ideal dataset to test created chemical assimilation technique

- We are combining retrievals of multiple meteorological variables with the UK version of the LMD Mars GCM through data assimilation to investigate chemical and dynamical processes linked to the trace gas cycles

On the assimilation of total-ozone satellite data

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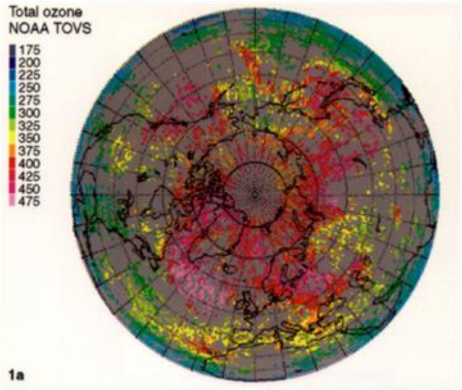
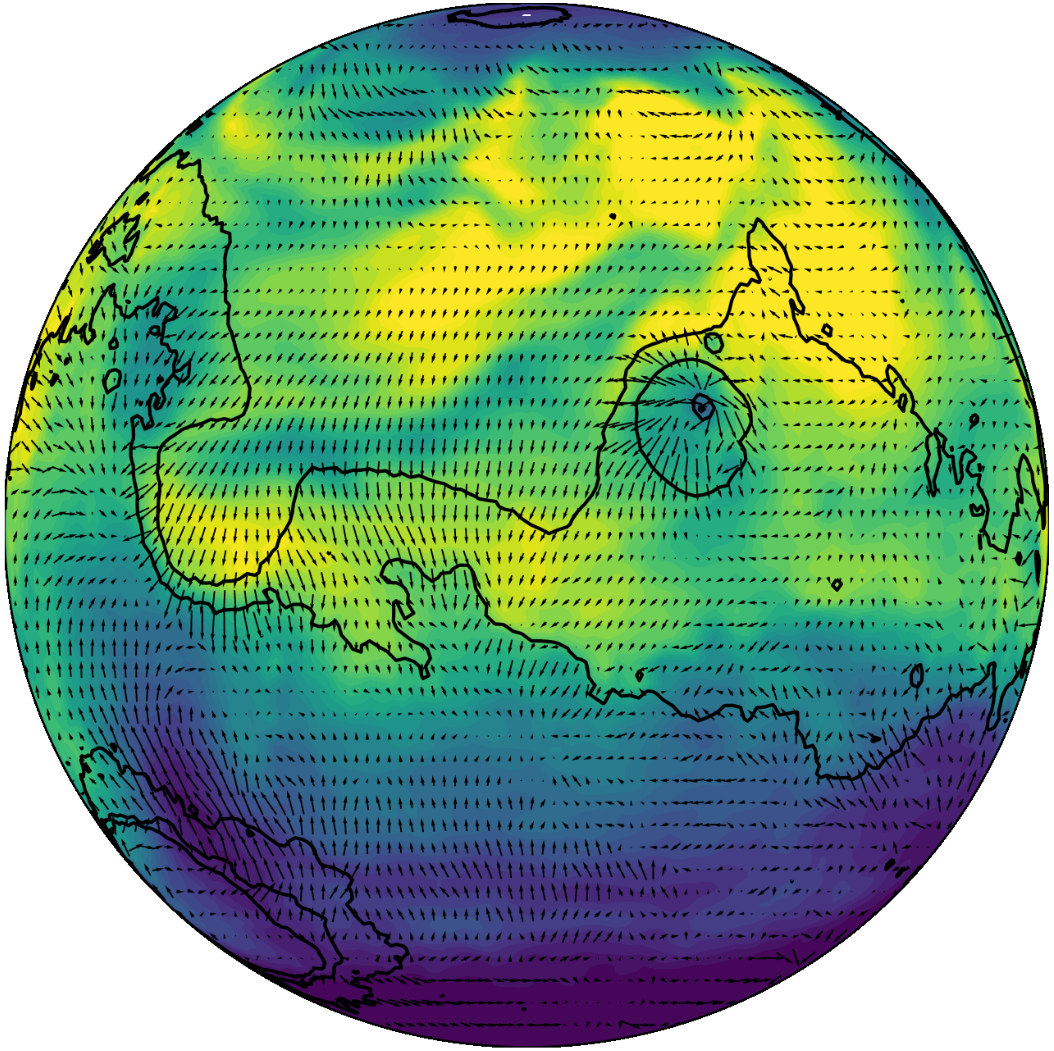
Abstract. A two-dimensional model for advection and data assimilation of total-ozone data has been developed. The Assimilation Model KNMI (AMK) is a global model describing the transport of the column amounts of ozone, by a wind field at a single pressure level, assuming that total ozone behaves as a passive tracer. In this study, ozone column amounts measured by the TIROS Operational Vertical Sounder (TOVS) instrument on the Na-



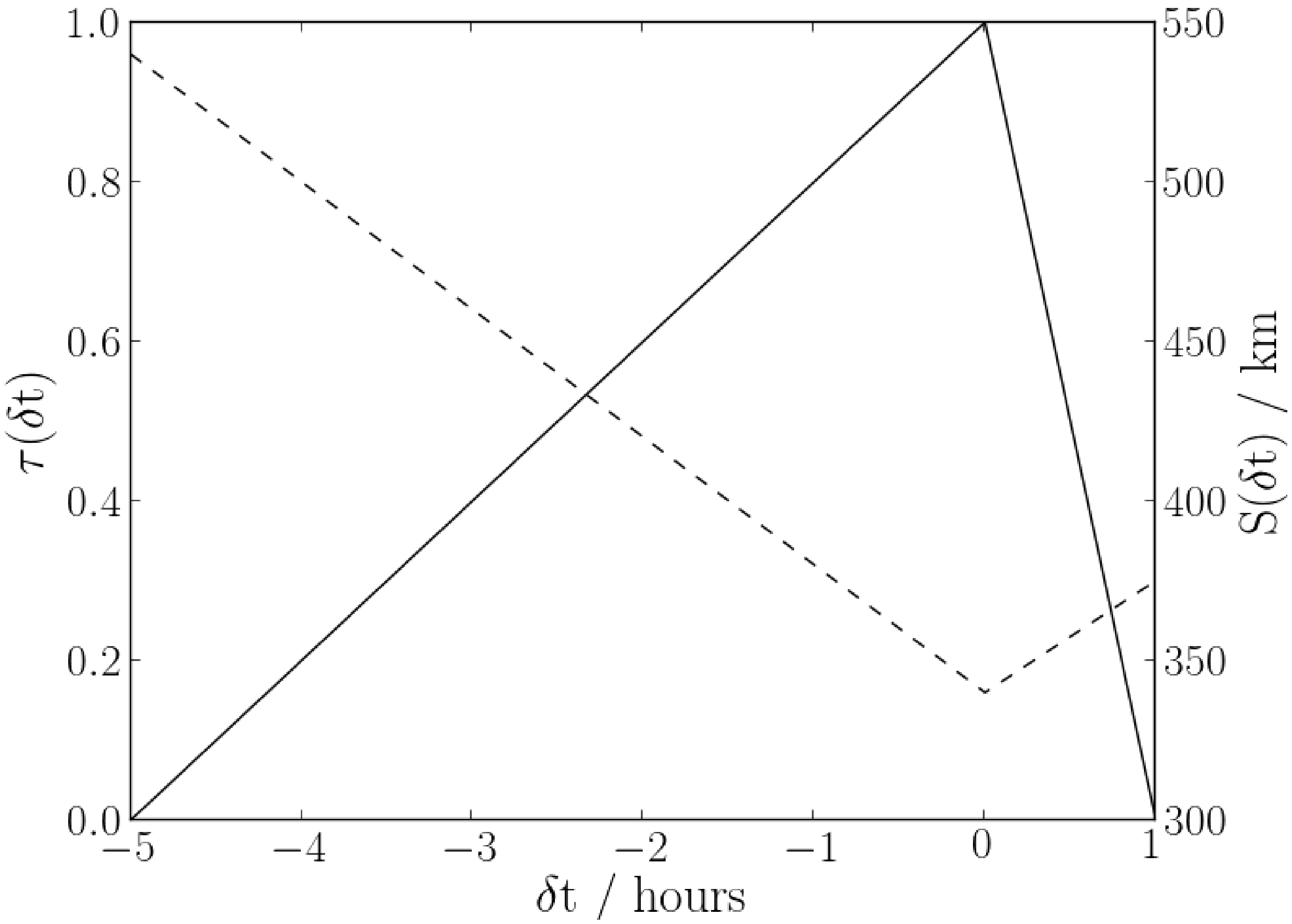
Global Circulation Model & Data Assimilation

- UK version of LMD Mars GCM
  - Physical parameterisations shared with LMD
  - UK-only spectral dynamical core
- Typical resolution of T31 (5^{o} resolution for physical/chemical processes) from 0-110 km
- Interaction and transport of 16 chemical species by LMD photochemical model and UK-only semi-Lagrangian advection scheme
- Analysis Correction assimilation scheme

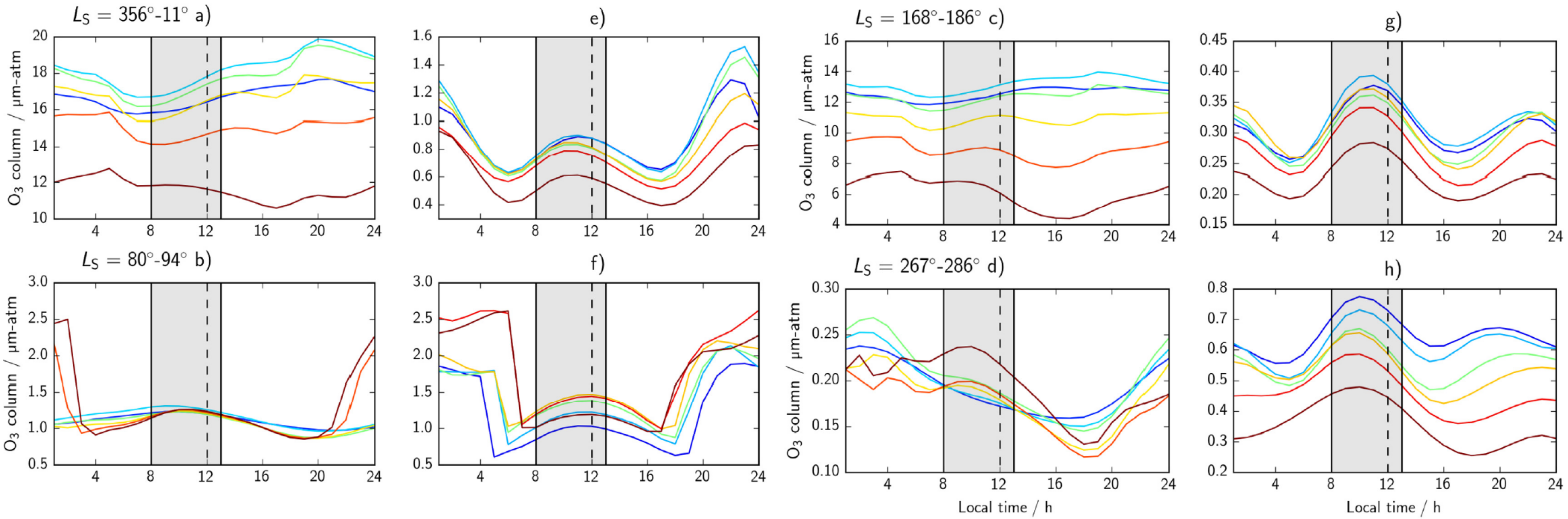


Overview of the data assimilation method

- Time window and radius of influence are adjustable parameters



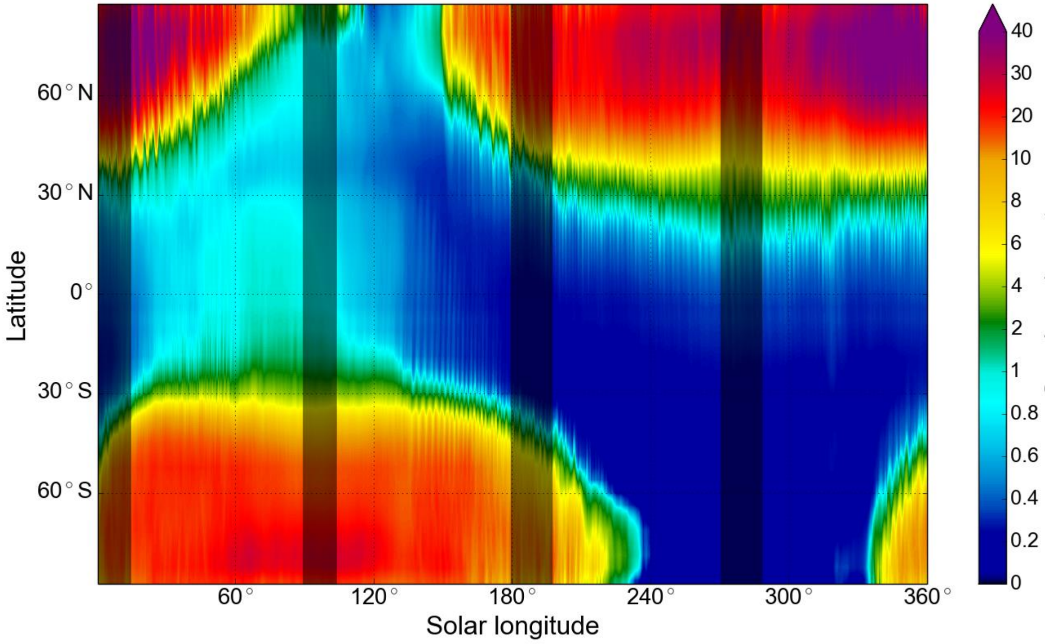
Diurnal cycle of ozone on Mars

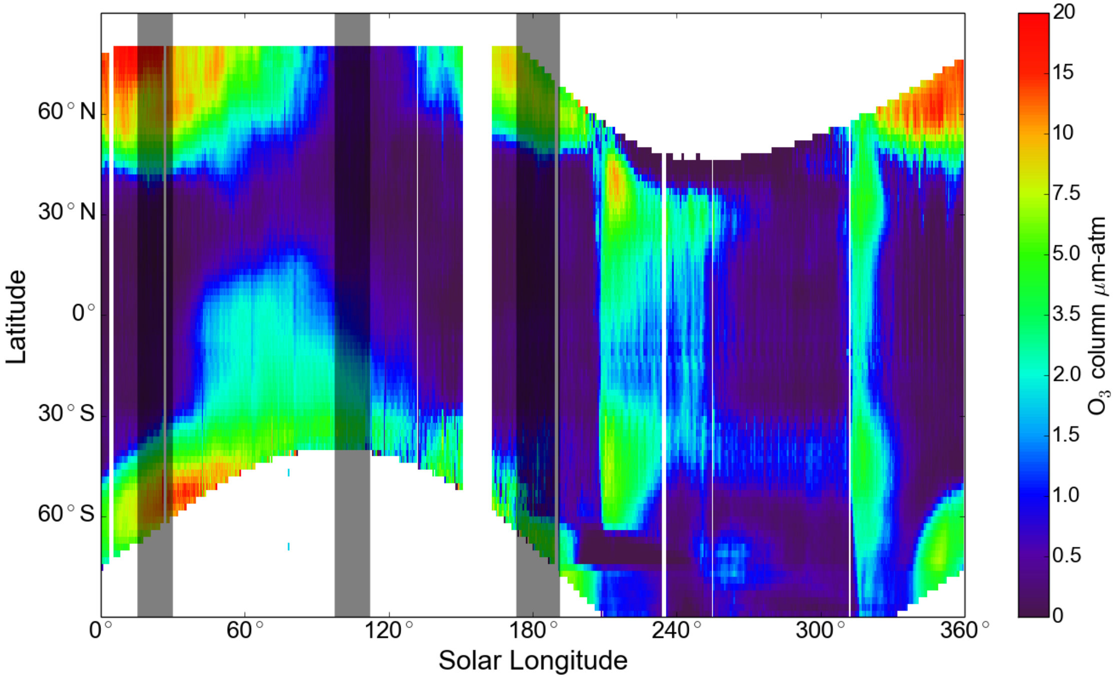


- Optimal parameters are likely to change for different datasets…

Tuning assimilation parameters

- Tested parameter space using OSSE and MARCI retrievals, with best fit chosen based on minimising RMS error in assimilation



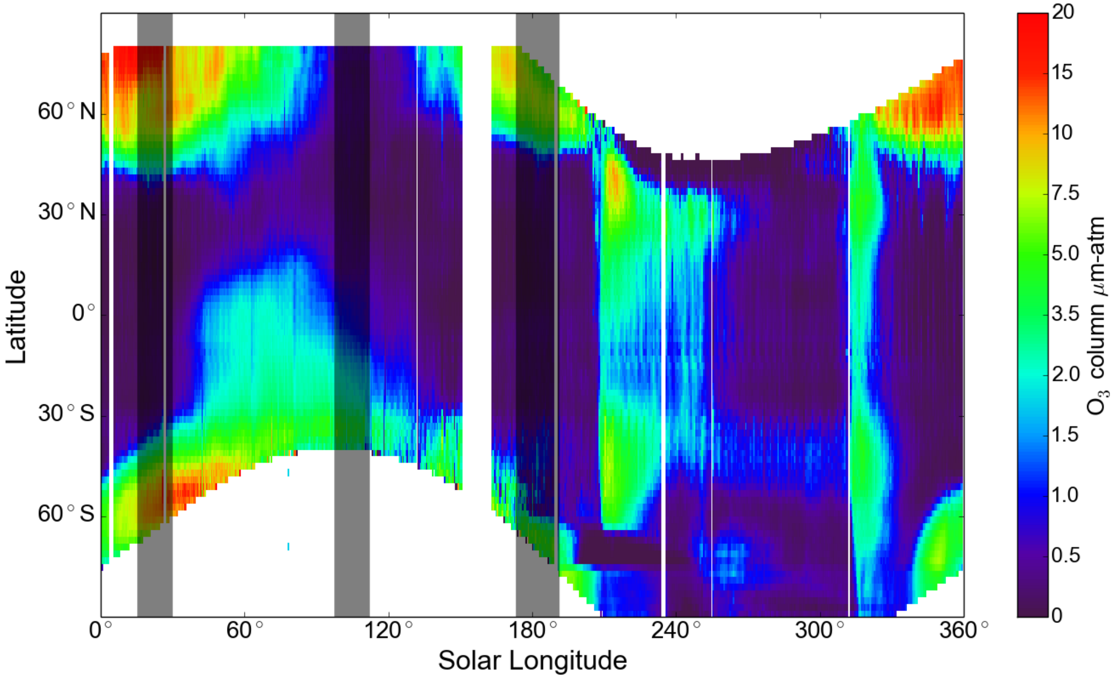


Tuning assimilation parameters

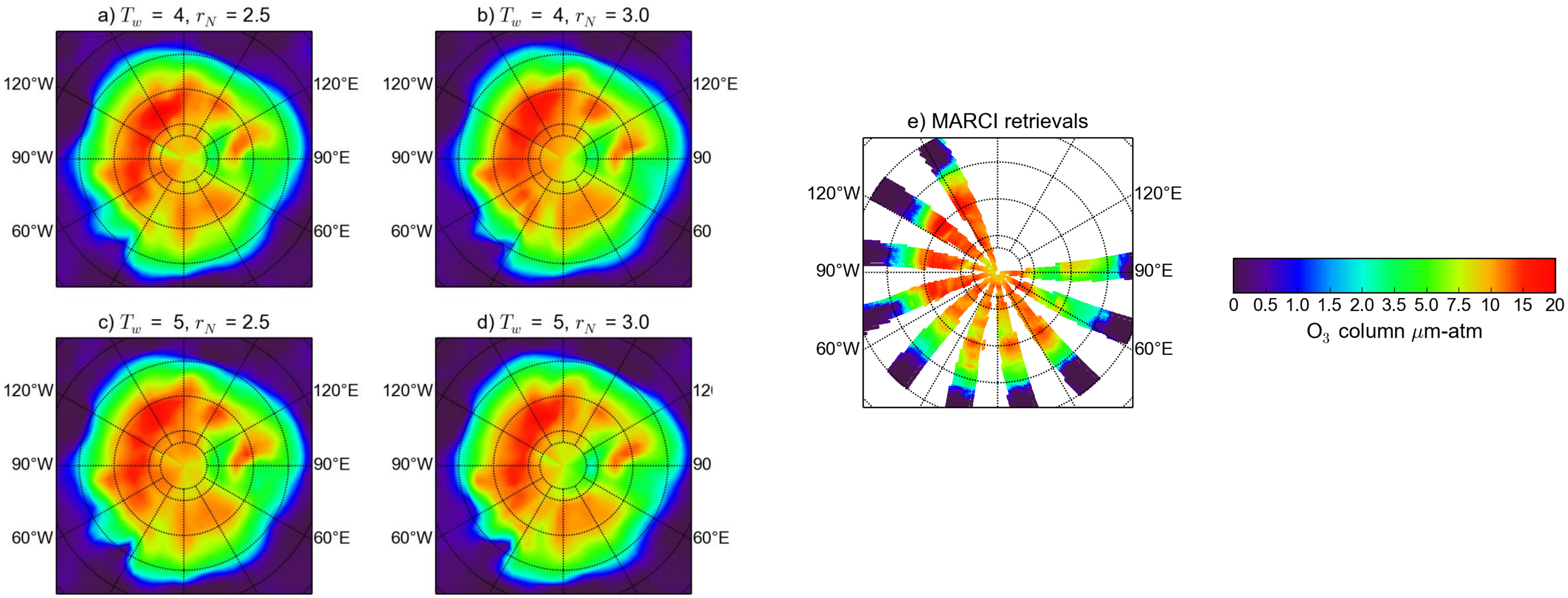
- Tested parameter space using OSSE and MARCI retrievals, with best fit chosen based on minimising RMS error in assimilation

$r_N = r_{inf}/S$	$T_w = 3$	$T_w = 4$	$T_w = 5$	$T_w = 6$
1.5	1.541	1.379	1.351	1.347
2.0	1.418	1.200	1.199	1.348
2.5	1.350	1.109	1.123	1.327
3.0	1.350	1.175	1.191	1.326
3.5	1.341	1.317	1.325	1.348
4.0	1.288	1.389	1.406	1.368

Table 4.5: Mean average RMS error in total ozone for the MARCI assimilation test periods. The four smallest RMS error values are highlighted in red.



Finalising assimilation parameters



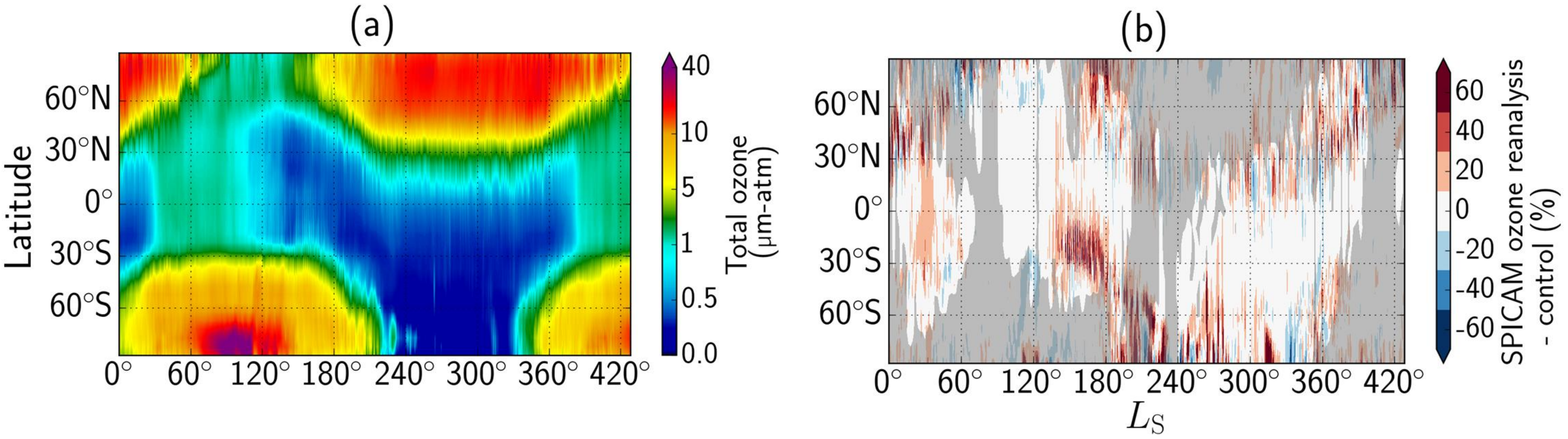
Total ozone retrievals: filtering process

- For SPICAM ozone assimilation (Holmes et al., 2018), we used a buddy check algorithm to filter the retrieval data

- Discussion point: Are better methods available?

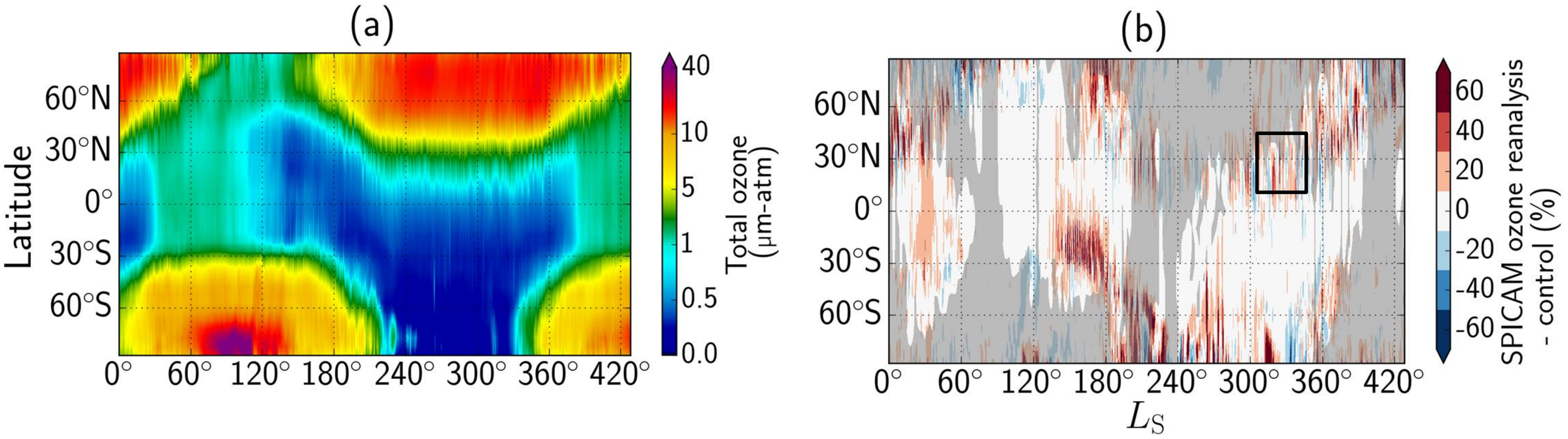
- Assimilation method allows for adjusting the error ratio (model/retrieval) based on chi-square fit of supplied observations

Case study: SPICAM total ozone assimilation



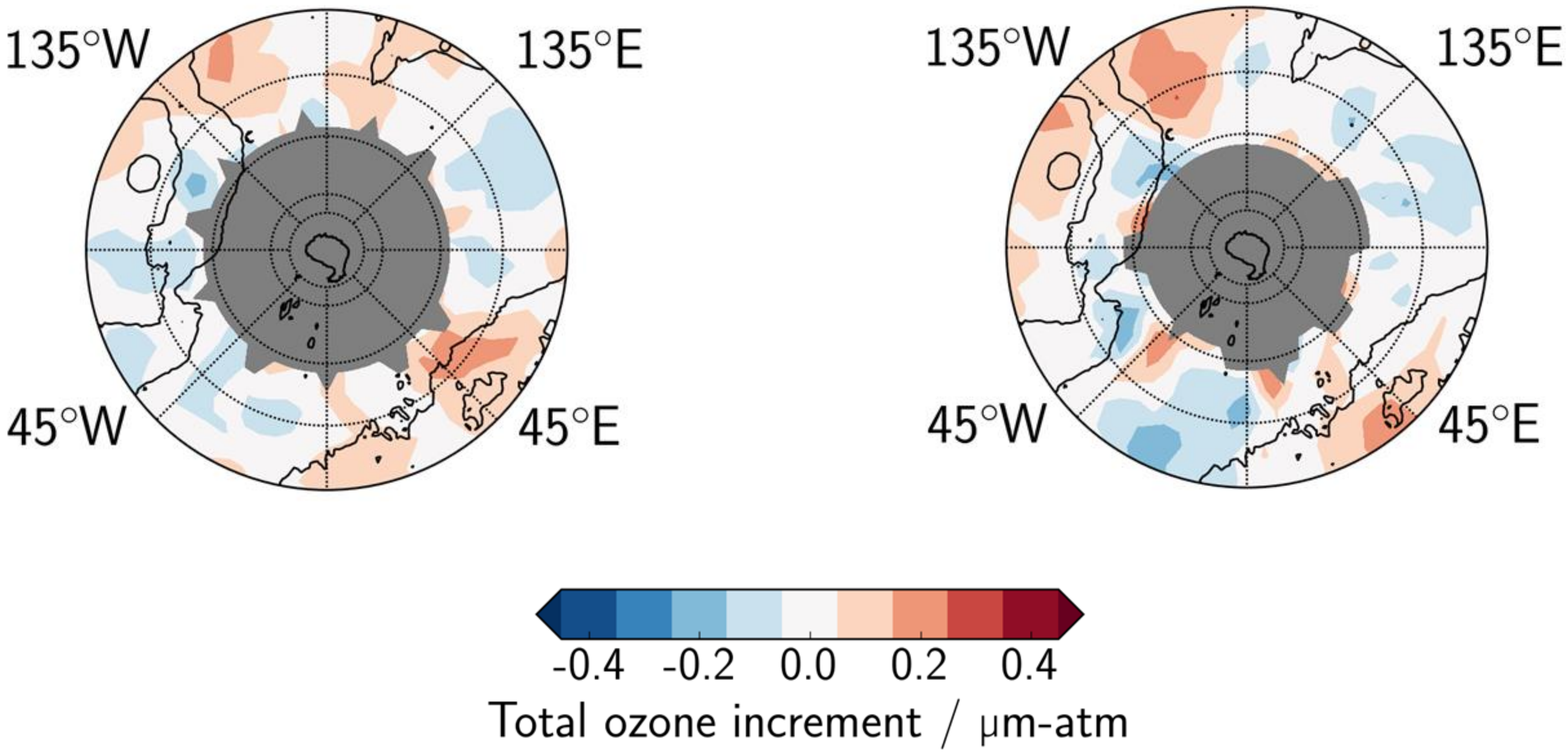
- Reanalysis allows us to investigate mechanisms which lead to total ozone disagreement

Case study: SPICAM total ozone assimilation

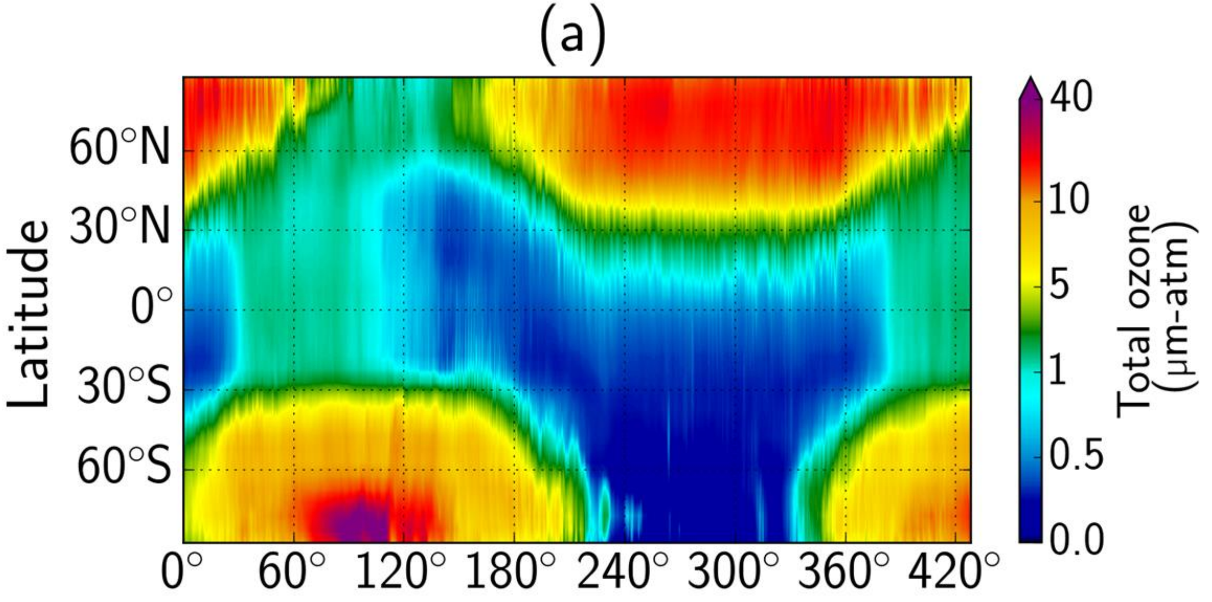


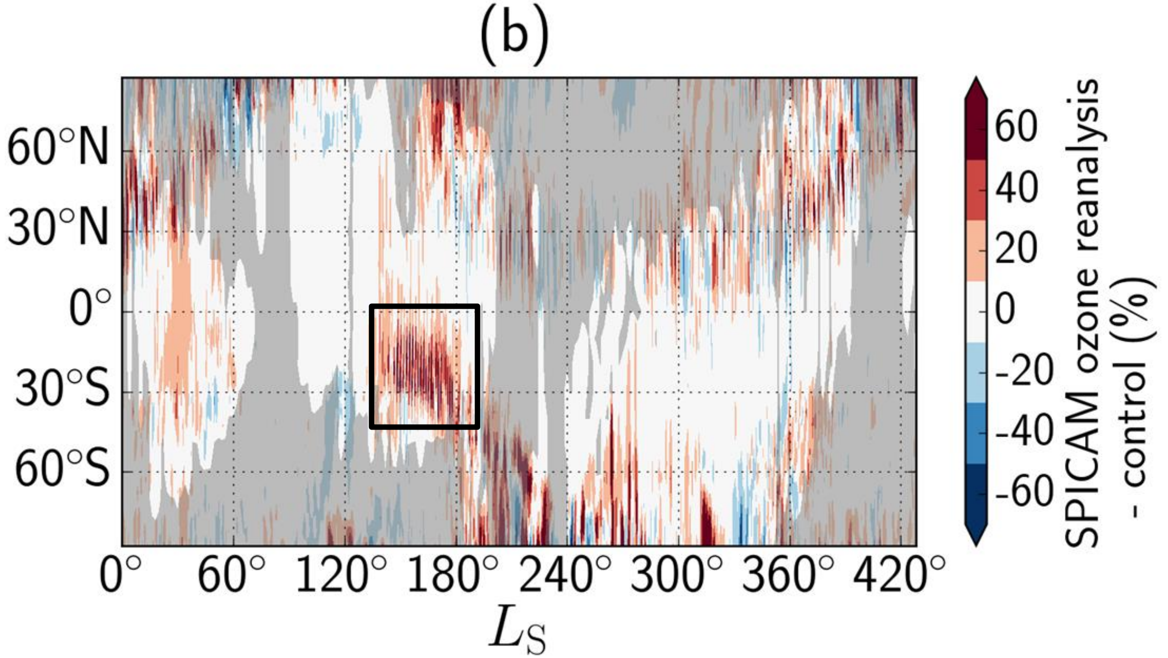
Case study: Data assimilation increments

$L_S = 310^o$ $L_S = 325^o$

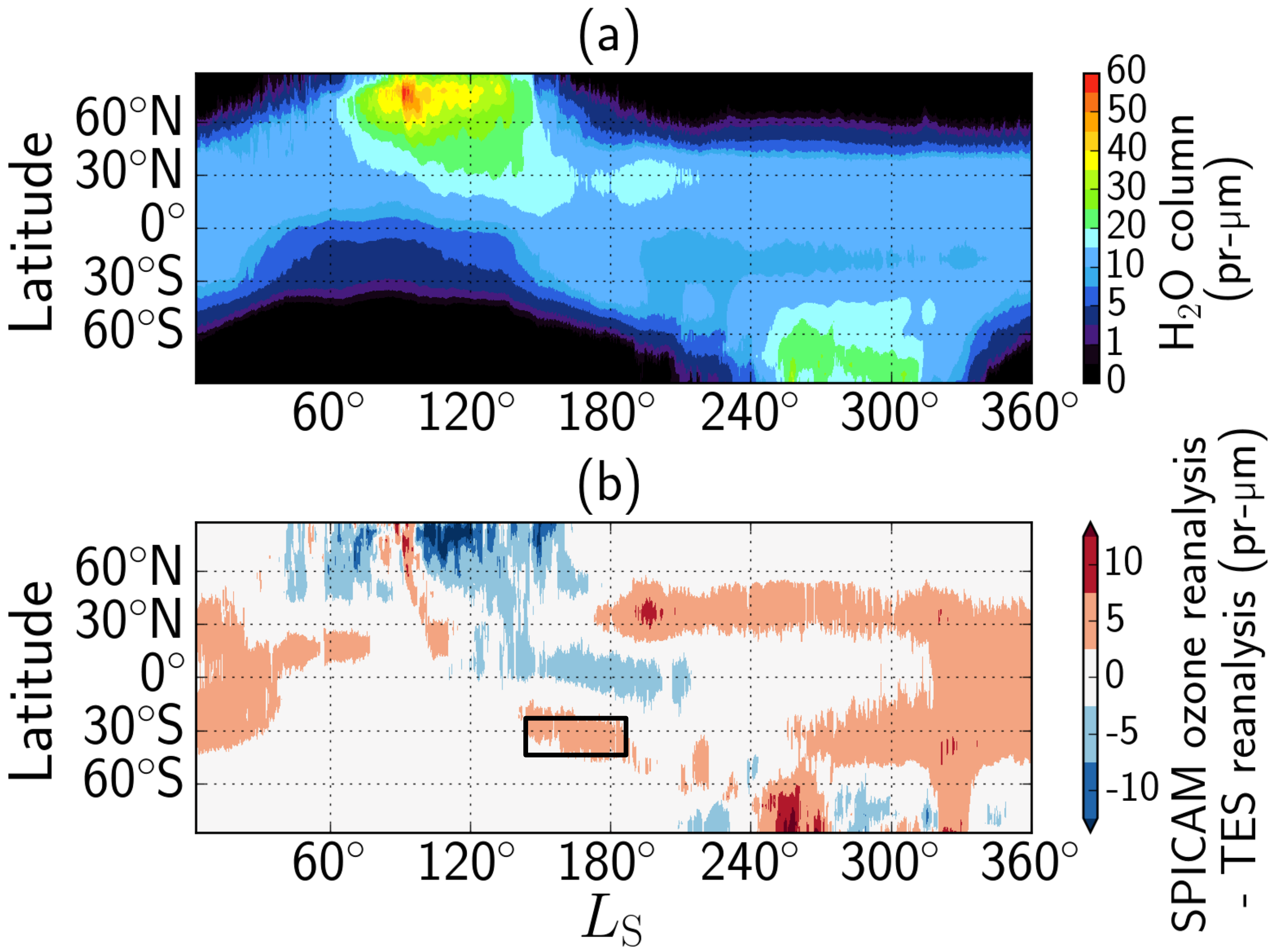


Case study: SPICAM total ozone assimilation





Linking the water vapour and ozone cycles



- Wet bias in the free-running model in the same location of total ozone underestimation

- Discussion point: vertical profile could explain other differences?

Assimilation of multiple chemical species: current progress

- Upgrading water vapour/ice assimilation (Steele et al., 2014a, 2014b) by turning into an active species
- CRISM CO assimilation complete
- Progress with MARCI total ozone assimilation (combine with MCS and MAVEN?)
- Framework set up for assimilation of ExoMars Trace Gas Orbiter data
- OSSE experiments using artificial methane observations

The effect of temperature assimilation on the water cycle

- Assimilation of TES temperature retrievals leads to increased water vapour at higher altitudes

- **Discussion point**: Should GCM parameterisations be tuned after temperature profiles have been assimilated into the model?