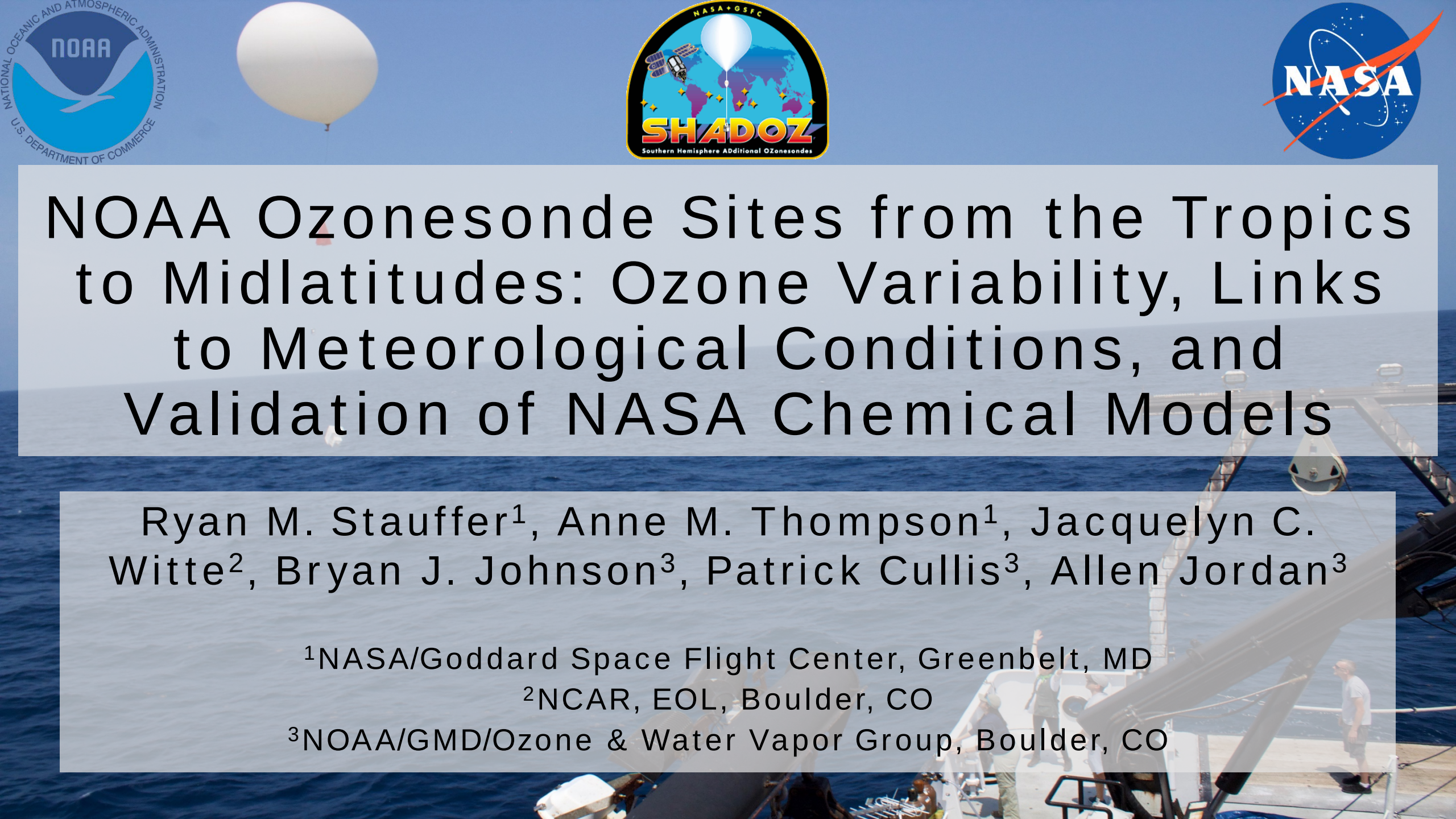

NOAA Ozonesonde Sites from the Tropics to Midlatitudes: Ozone Variability, Links to Meteorological Conditions, and Validation of NASA Chemical Models

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Talk Roadmap

- Compare/contrast example NOAA ozonesonde profile sites:
  1. Midlatitude (Boulder, CO – Operationally >40 years old!), 1979-present, >1600 profiles
  2. Subtropical (Hilo, HI), 1982-present, >1500 profiles
  3. Subtropical/Tropical (Fiji), 1998-present, >400 profiles

- Using statistical clustering to link ozone profiles to meteorological conditions: MERRA-2 Reanalysis Meteorology
  1. Synoptic-scale dynamics (Boulder, CO)
  2. Convective activity (Fiji)

- Comparisons with the latest NASA MERRA-2-based chemical model simulations at Hilo, HI and Fiji

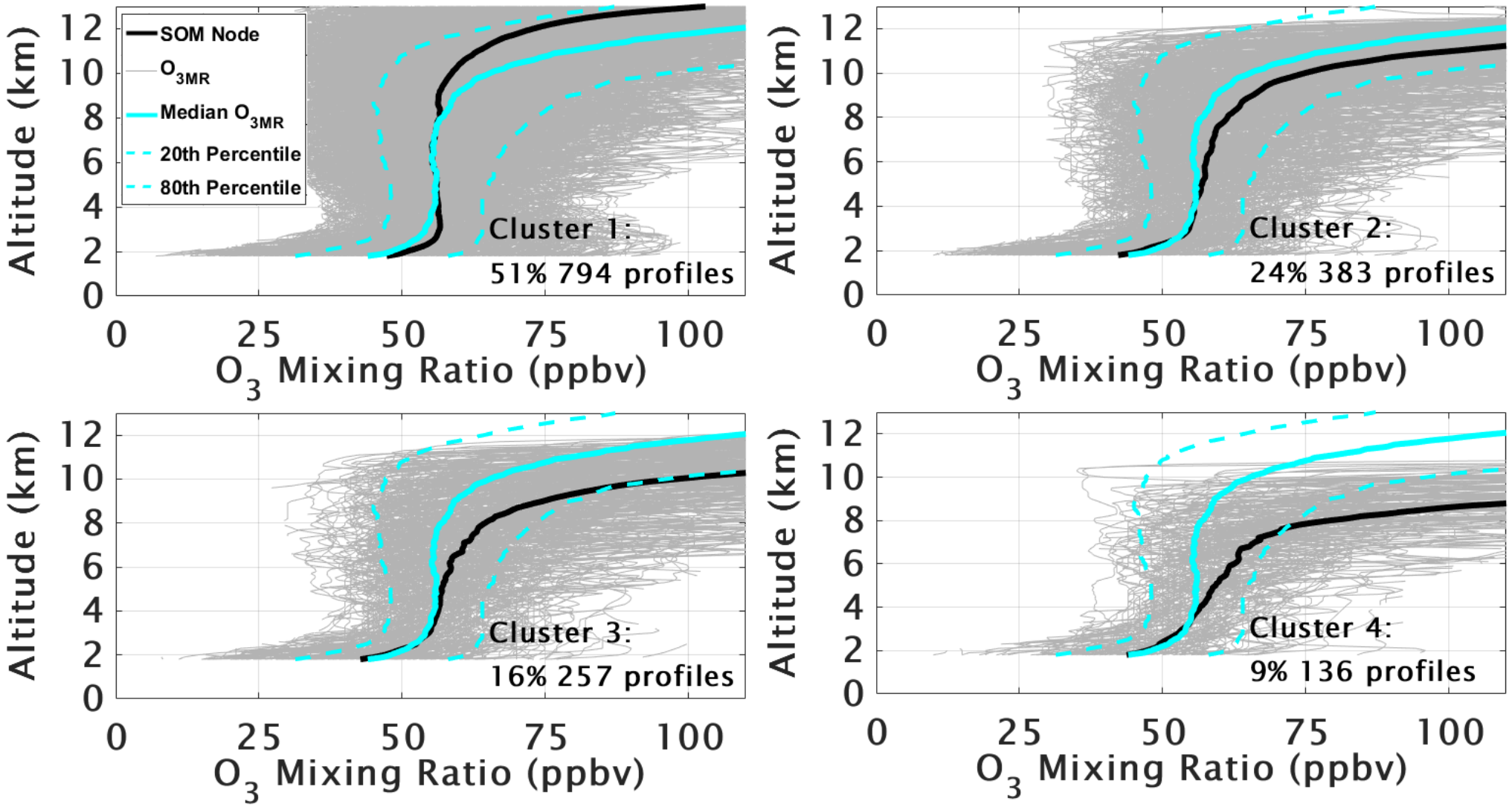
We need to analyze thousands of ozonesonde profiles, so let's start with a cluster analysis…

Boulder, CO (40°N, >1600 profiles)

Boulder O_3 mixing ratio profile clusters. Compare profiles in each plot to overall median and variability

Cluster mean is black line

Clusters from mid- and high-latitude sites depend mostly on UT/LS O_3, tropopause height



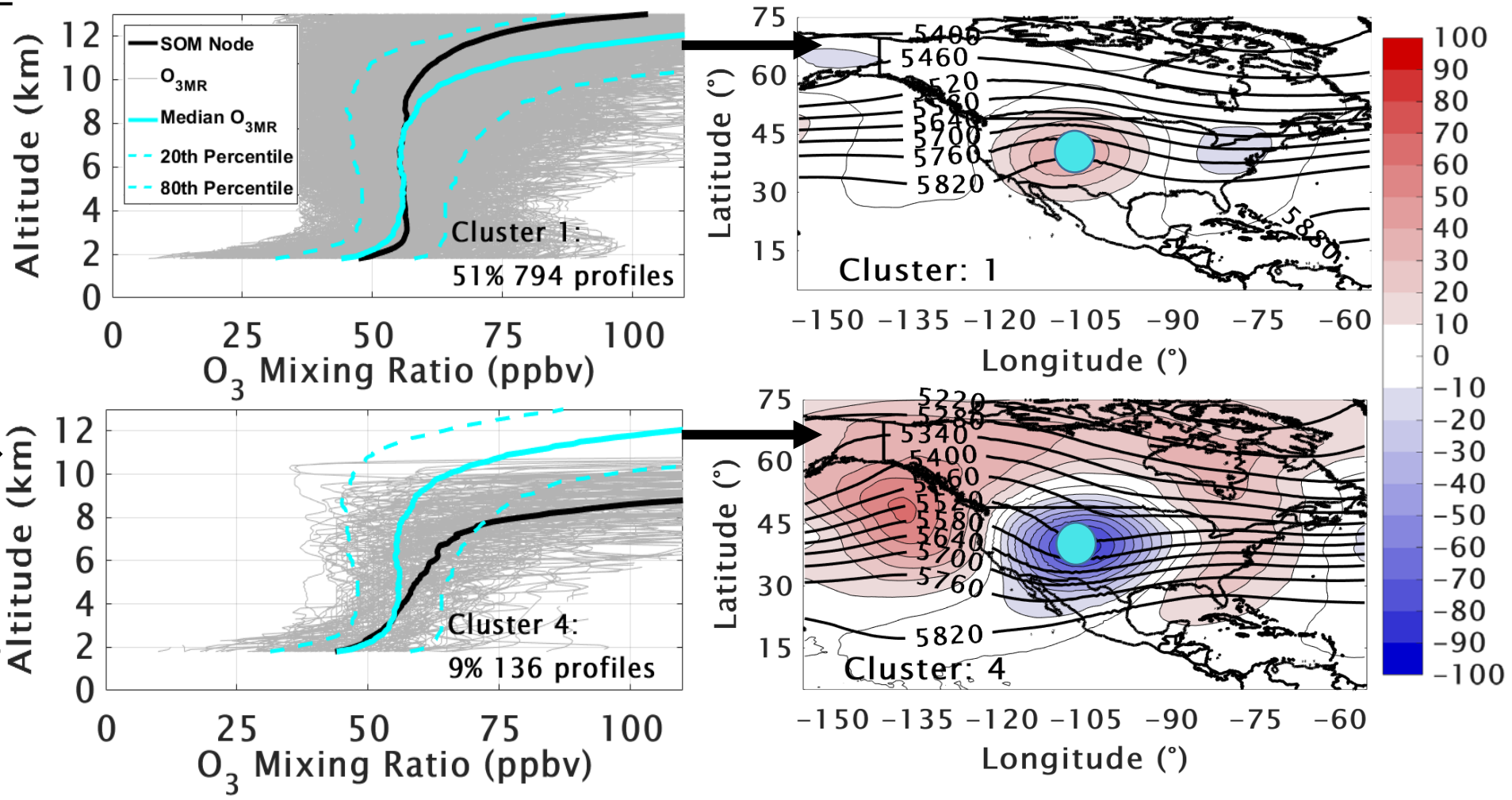
MERRA-2 500 hPa Height Composites

MERRA-2 500hPa Z anomaly (Boulder = blue dot)

High Z →High Tropopause, Subtropical Air → Low O_3 amounts

Low Z → Dynamic, Low Tropopause → High O_3 amounts

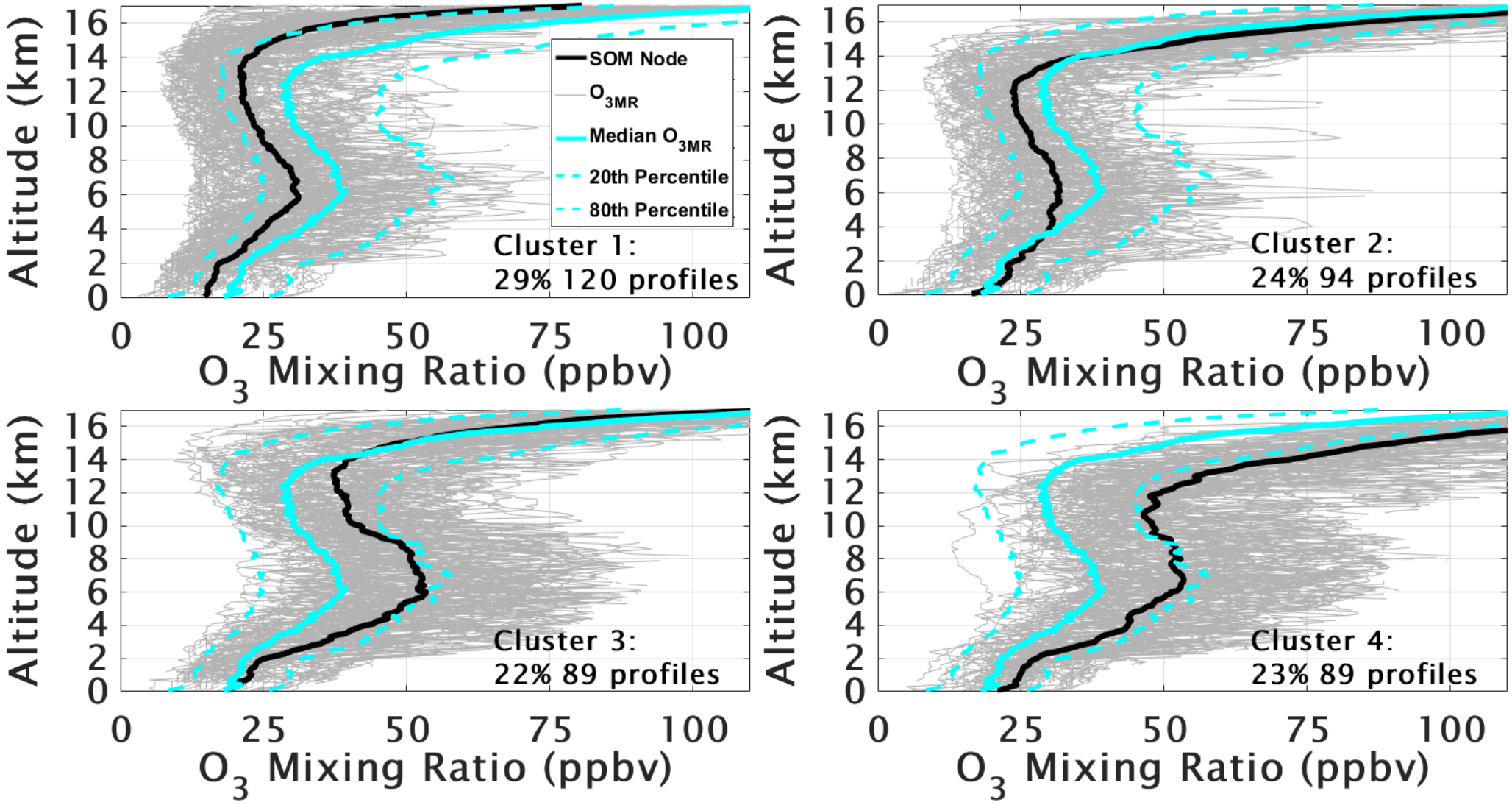
500 hPa Z is an excellent proxy for O_3 profile shape and UT/LS O_3 gradients



Fiji (18.1°S, >400 profiles)

Fiji O_3 mixing ratio profile clusters. Compare profiles in each plot to overall median and variability

Tropical sites have less UT/LS and tropopause variability. Low to mid-tropospheric features are more prominent in clusters



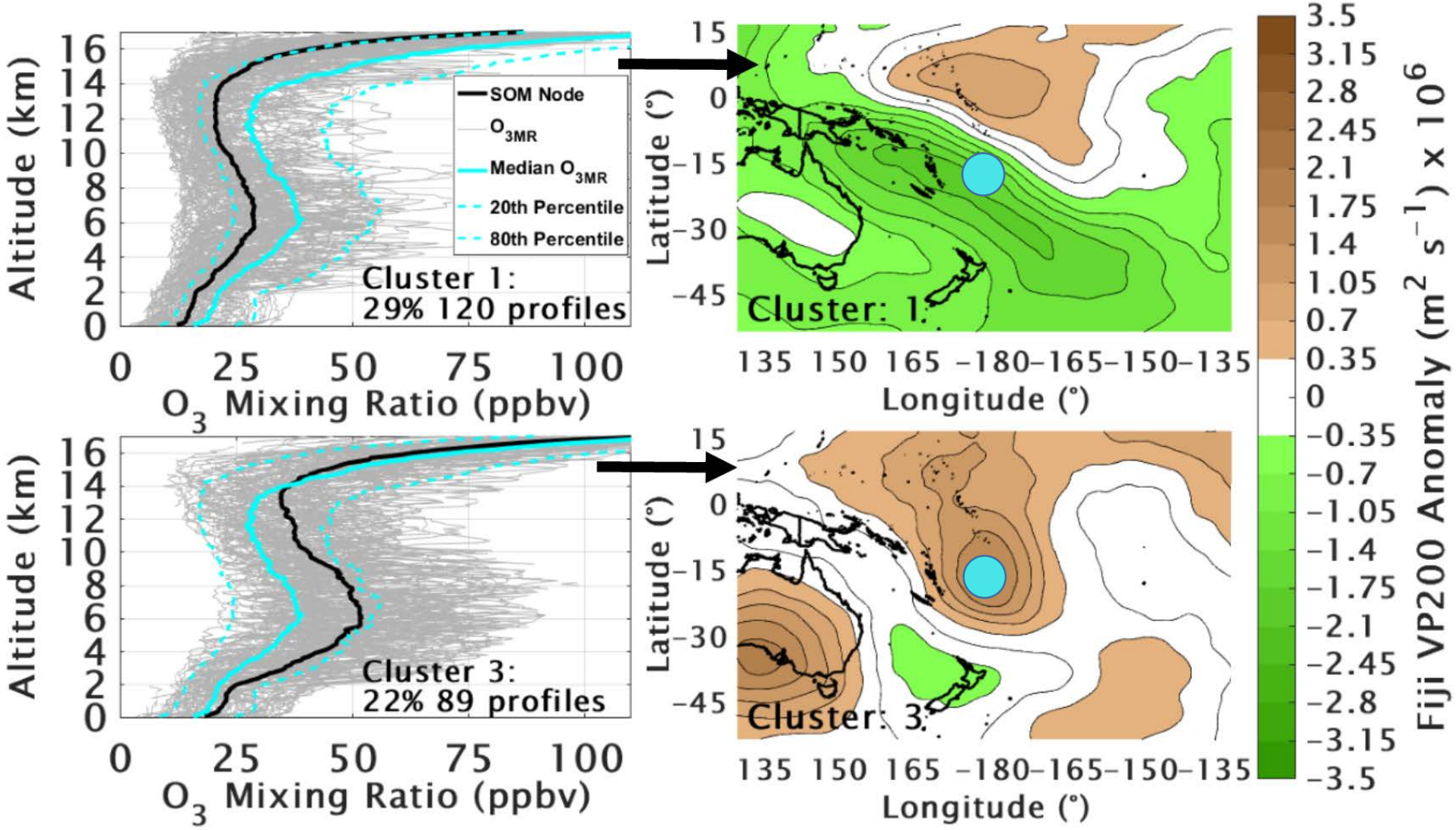
MERRA-2 Velocity Potential Composites

MERRA-2 200hPa velocity potential (VP, proxy for convection; Fiji = blue dot)

Divergence → Enhanced Convection → Low O_3 amounts

Convergence → Suppressed Convection → High O_3 amounts

VP is an excellent proxy for tropical UT/LS O_3



See A. Thompson poster on SHADOZ O_3 profile links to convection

Takeaway: Clustering helps identify major modes of variability in the O_3 profile

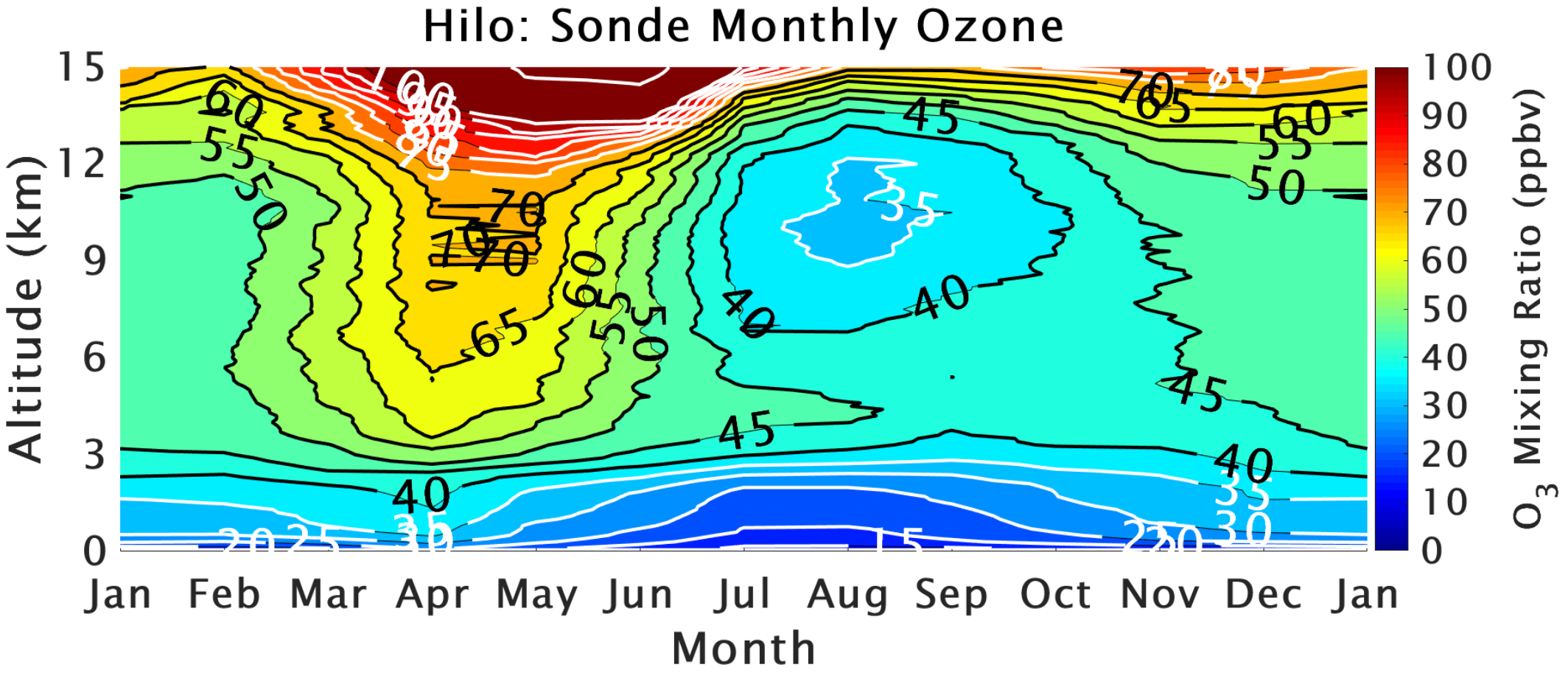
Long-term NOAA ozonesonde sites also provide excellent data sets to evaluate historical chemical model output. We will look at NASA's MERRA-2 GMI (M2 GMI) model at Hilo and Fiji

Monthly Sonde O_3 at Hilo, HI (1982-present)

Monthly O_3 climatology at Hilo shows a prominent seasonal cycle

O_3 maximum in spring, minimum in late summer/fall

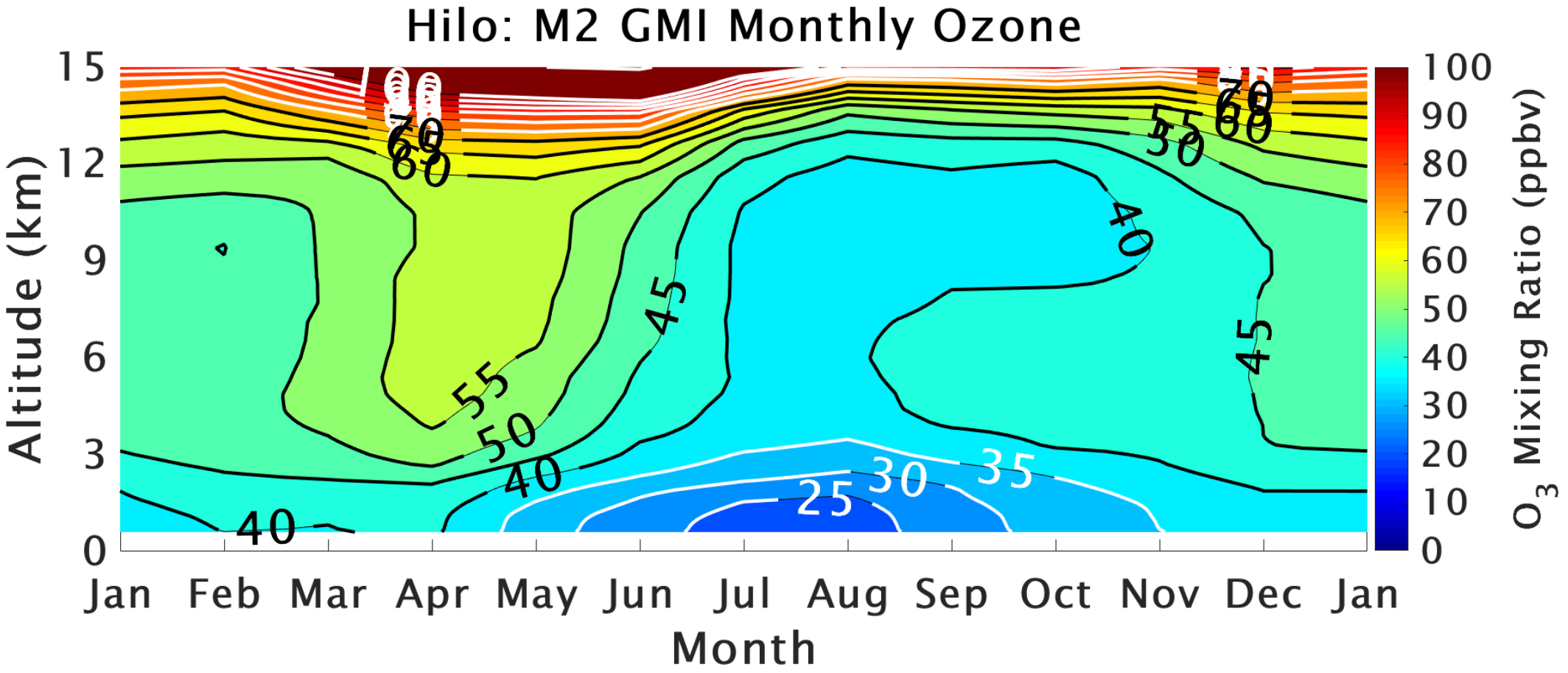
Low surface O_3 all year



M2 GMI at Hilo, HI (1982-present)

M2 GMI model seems to reproduce the seasonal cycle at Hilo

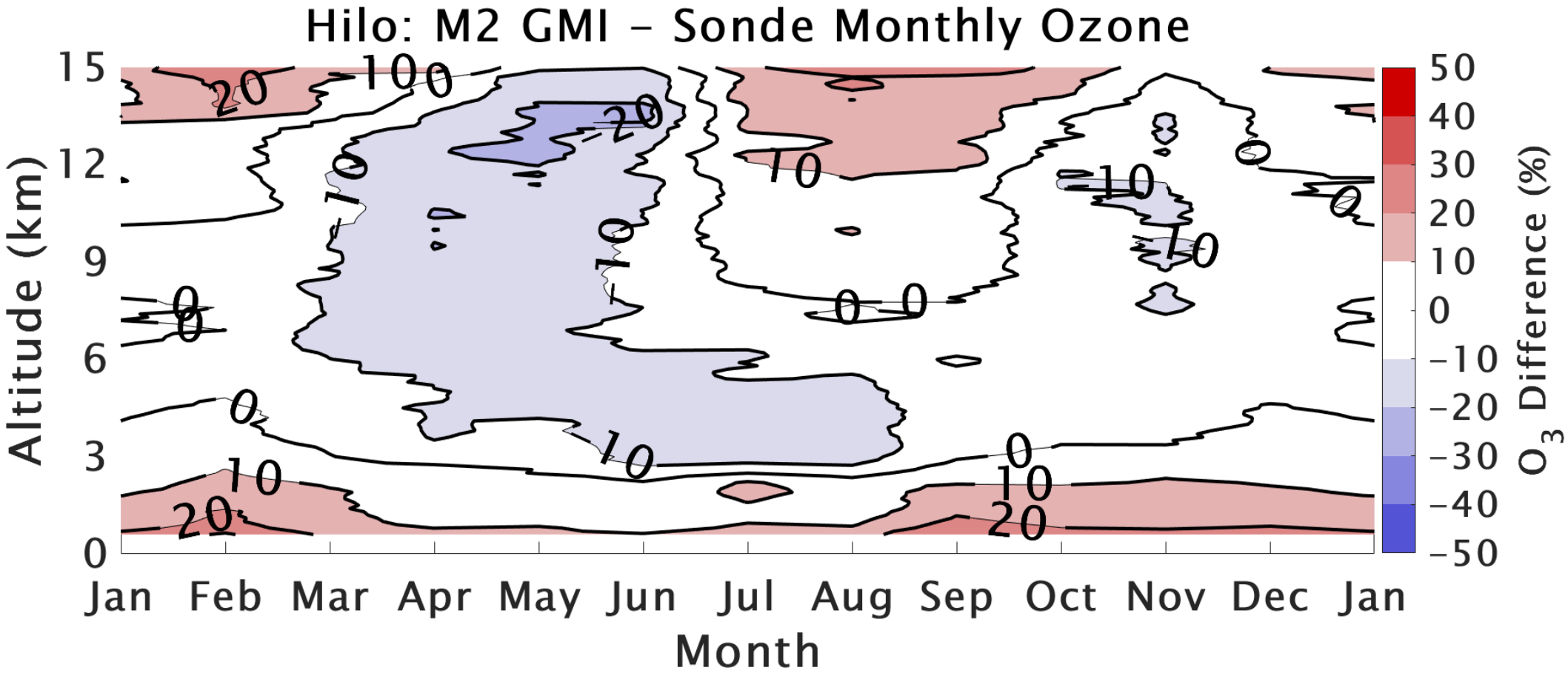
However… surface O_3 appears to be too high, a common problem in chemical models



M2 GMI at Hilo, HI (Model - Sonde)

Model minus sonde O_3 differences show that surface O_3 is indeed 20% too high in M2 GMI

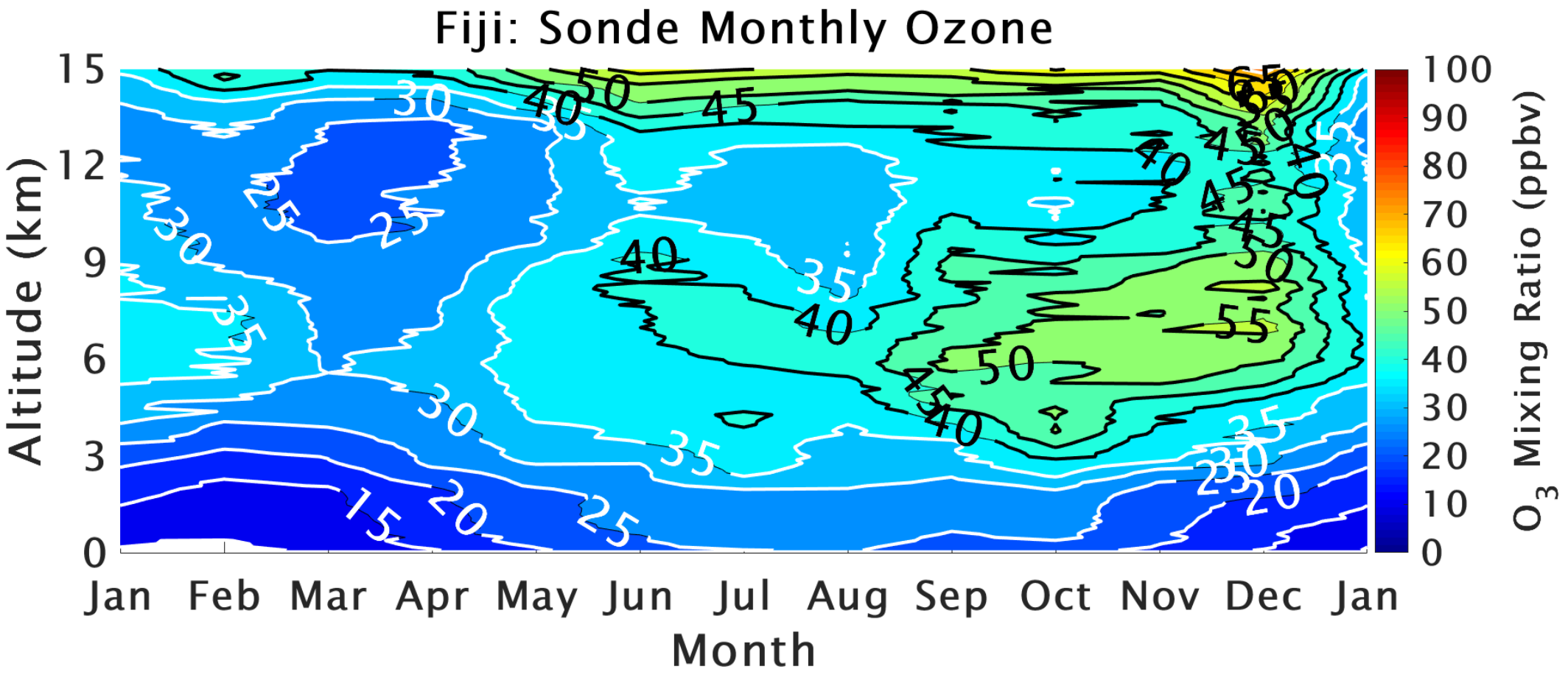
The O_3 maximum is not quite reproduced. UT/LS O_3 in spring is 20% too low in the model



Monthly Sonde O_3 at Fiji (1998-present)

Monthly O_3 climatology at Fiji shows similarities to Hilo, with a seasonal maximum in austral spring, and a minimum in autumn

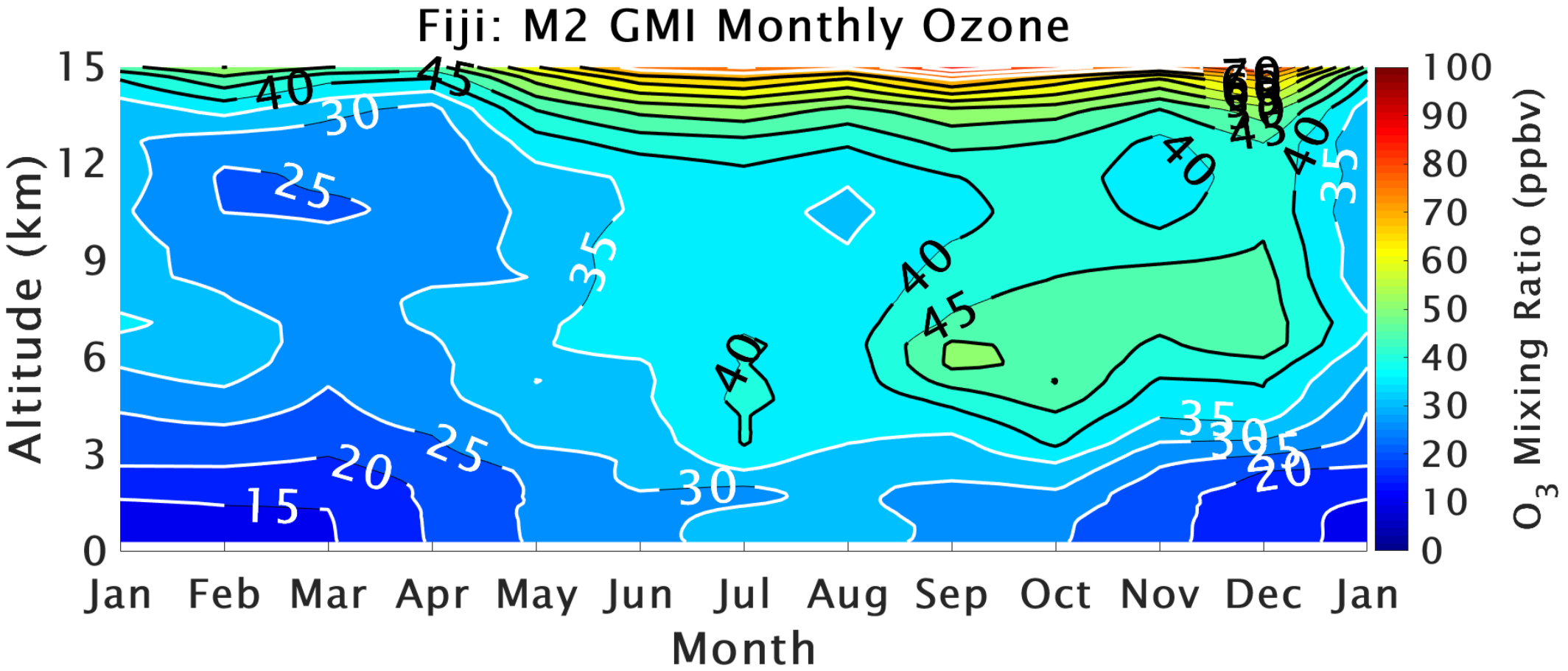
Surface O_3 is very low all year



M2 GMI at Fiji (1998-present)

Again, M2 GMI model seems to reproduce the seasonal cycle at Fiji

Model problems at Fiji are similar to Hilo (any many other tropical sites; Stauffer et al., 2019, in review)



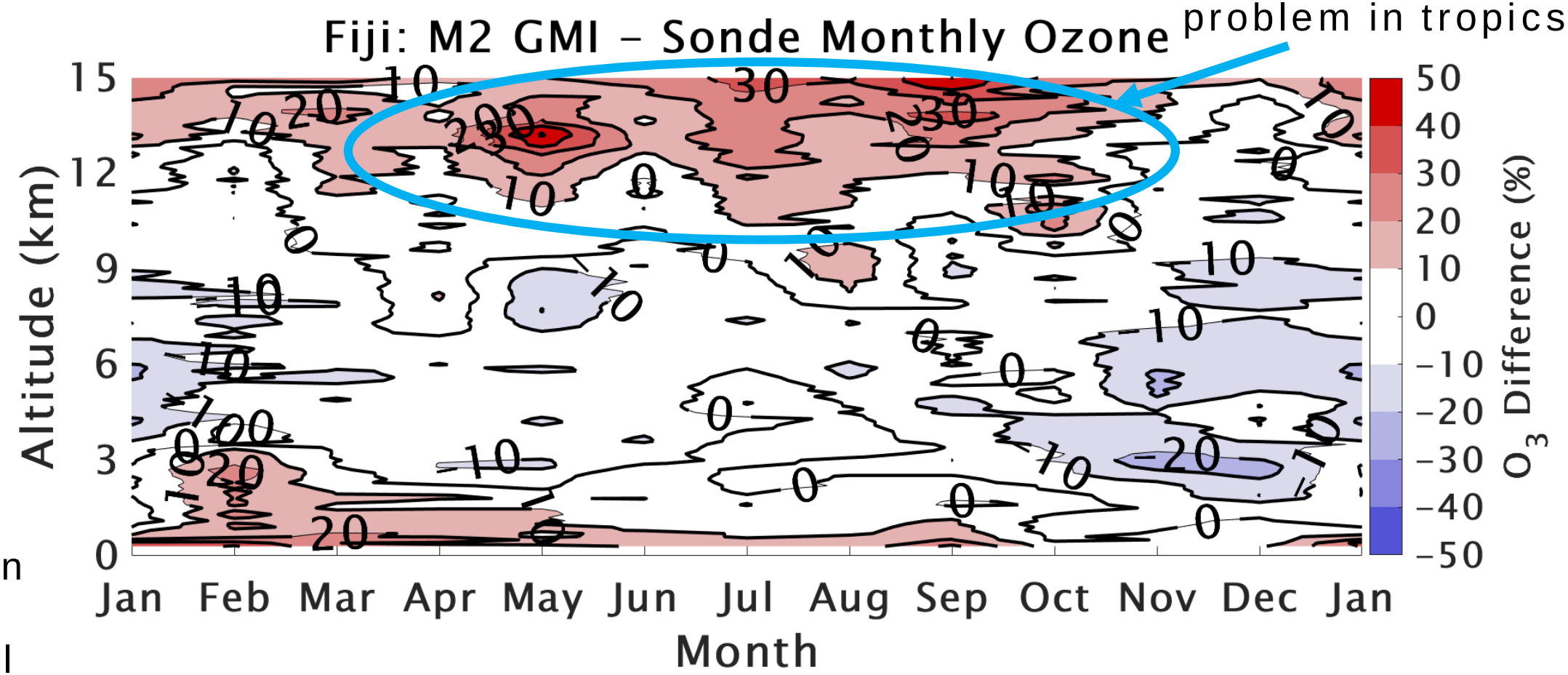
M2 GMI at Fiji (Model - Sonde)

UT/LS high bias is also a common problem in tropics

Modeled surface O_3 is 20% too high at Fiji

Seasonal maximum in Oct-Dec is too low in model

Note: See E. Hall poster on GMI CTM, a similar model that also uses MERRA-2 meteorology



Summary

- The thousands of ozonesonde profile measurements over several decades at NOAA-led sites are a valuable climate record

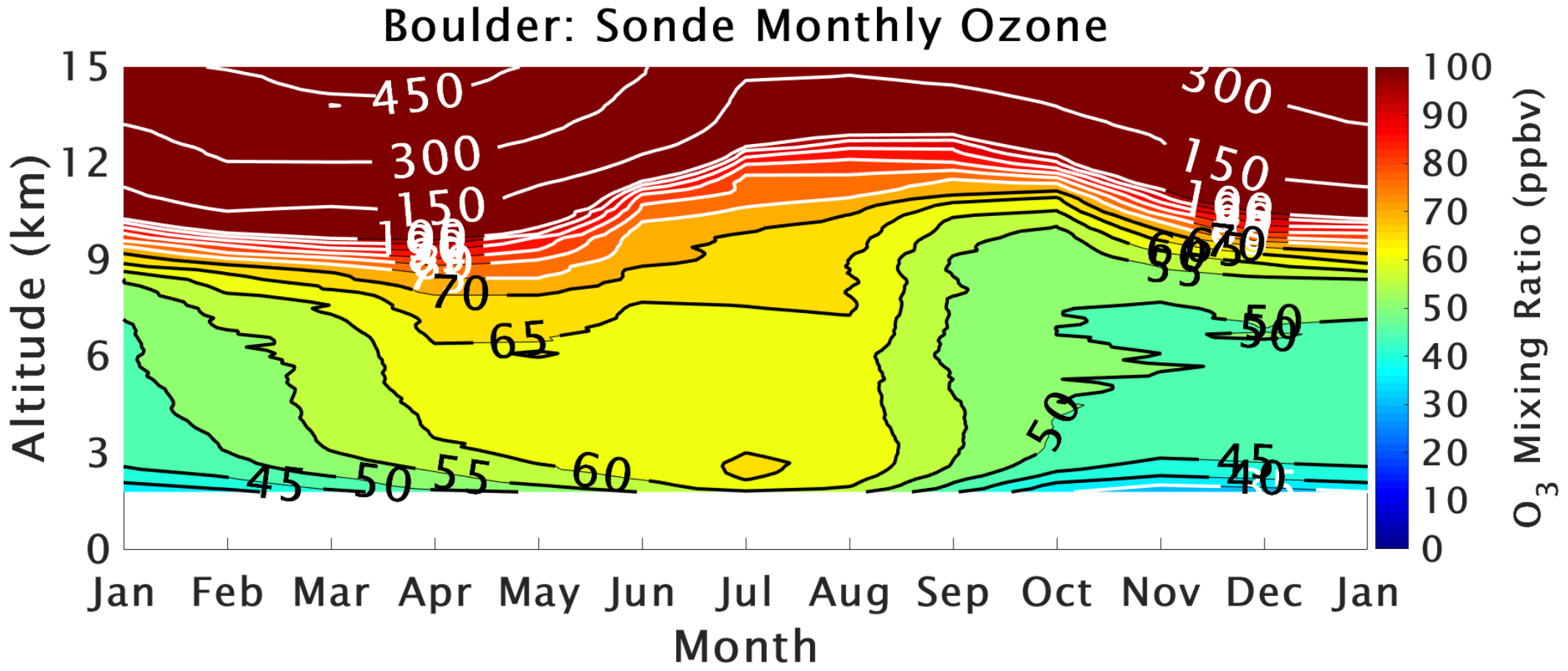
- Techniques like statistical clustering allow easy identification of meteorological controls on O_3 variability

- NOAA sonde profiles are important assets for model evaluation:
  - M2 GMI surface O_3 is ~20% too high *at every site* (we analyzed 38 global sites in Stauffer et al., 2019)
  - Model O_3 is too low during Hilo and Fiji spring O_3 maxima

Thank You!

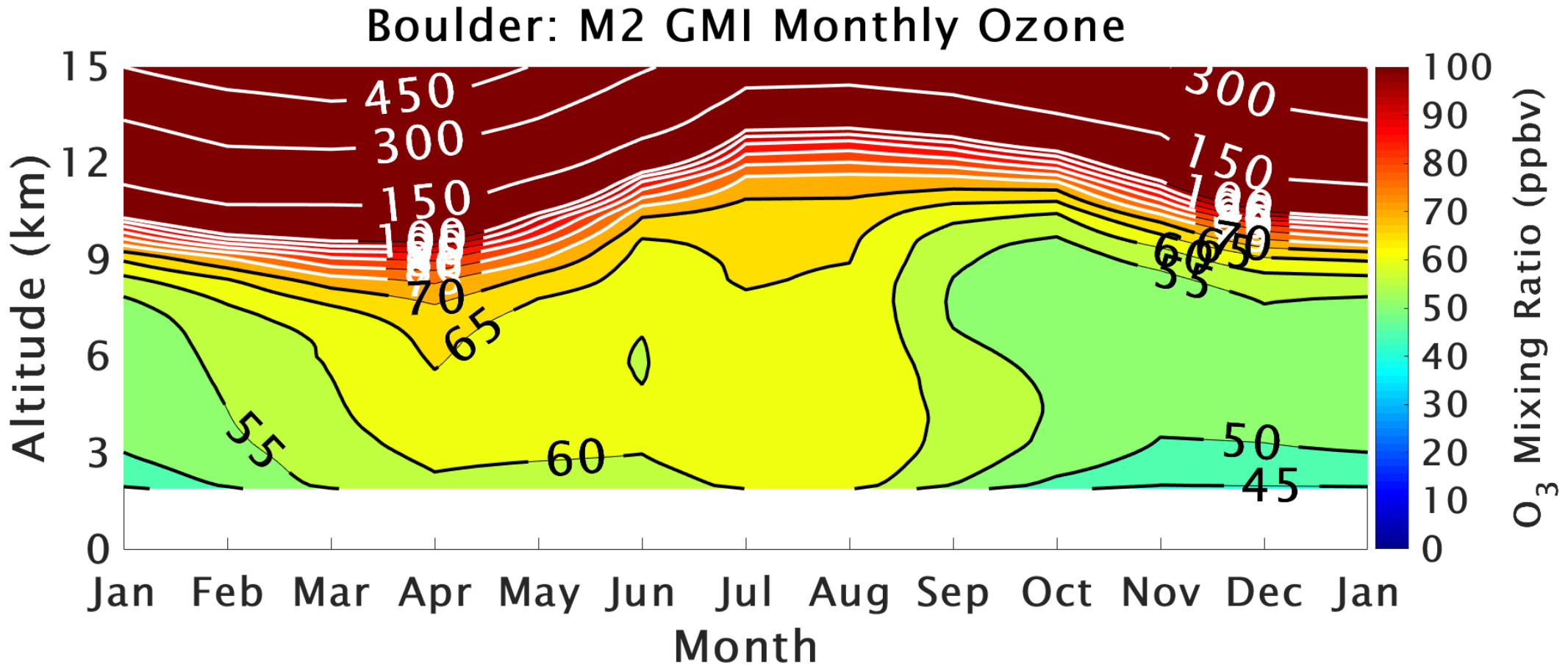
- Our NOAA colleagues for excellent SHADOZ support, high quality data, wonderful technical help, and user-friendly software
- NASA Postdoctoral Program (NASA/GSFC) administered by USRA and NASA Project Funding (SHADOZ, Upper Atmosphere Research Program)
- Contact: ryan.m.stauffer@nasa.gov
- Select References:
  - Stauffer, R. M., A. M. Thompson, L. D. Oman, S. E. Strahan (2019), The effects of a 1998 observing system change on MERRA-2-based ozone profile simulations, in review, *J. Geophys. Res. Atmos.*
  - Stauffer, R. M., A. M. Thompson, and J. C. Witte (2018), Characterizing global ozonesonde profile variability from surface to the UT/LS with a clustering technique and MERRA-2 reanalysis, *J. Geophys. Res. Atmos.*, 123, 6213-6229, https://doi.org/10.1029/2018JD028465

Monthly Sonde O_3 at Boulder, CO (1980-present)



Stauffer – NOAA Ozonesonde Sites, GMAC, 21 May 2019 3pm

M2 GMI at Boulder, CO (1980-present)



M2 GMI at Boulder, CO (Model - Sonde)