

What controls stratospheric water vapor?

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Water Vapor, -20- 20lat, 80hPa

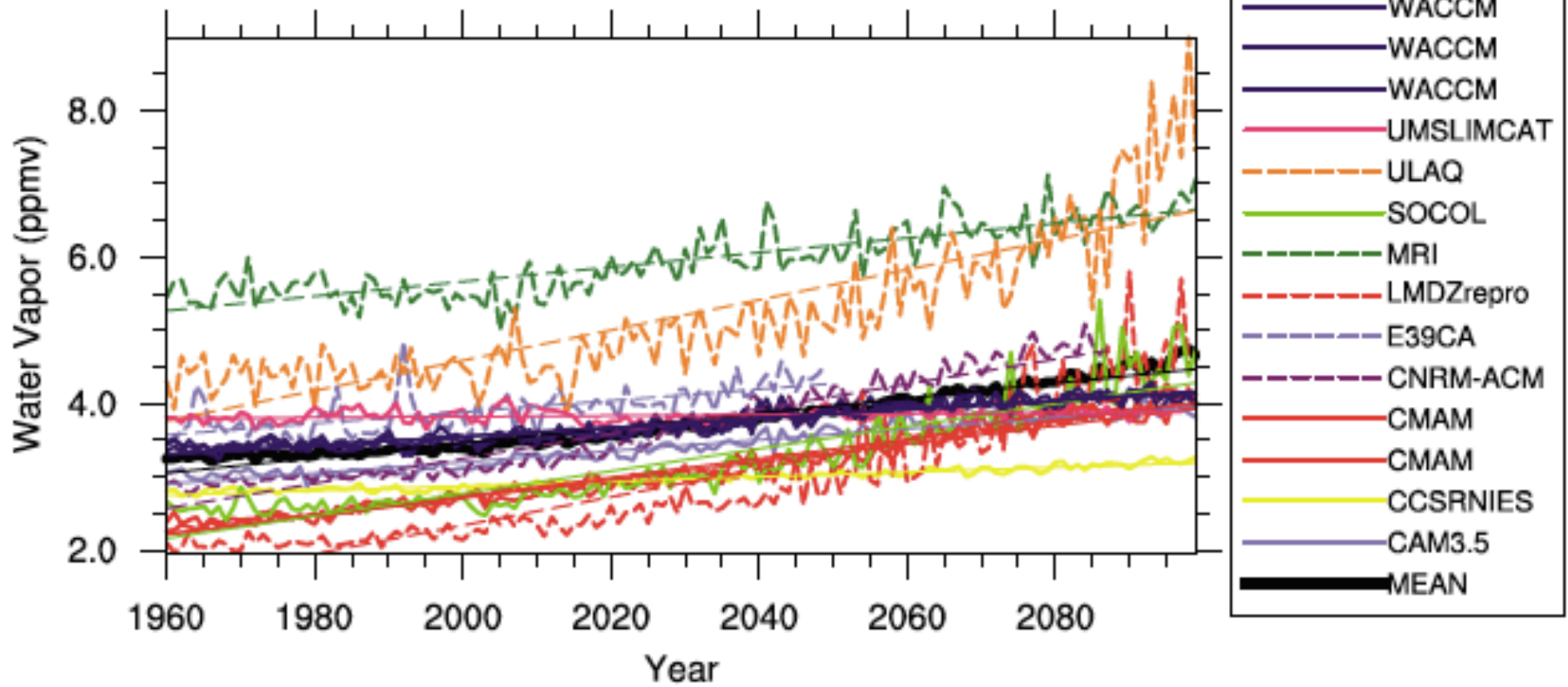


Figure 17. The 80 hPa Water Vapor time series from 20S–20N for future REF-B2 scenarios. Thin lines are linear fits. Multimodel mean (MEAN) is the thick black line.

Gettelman et al., JGR, 2010



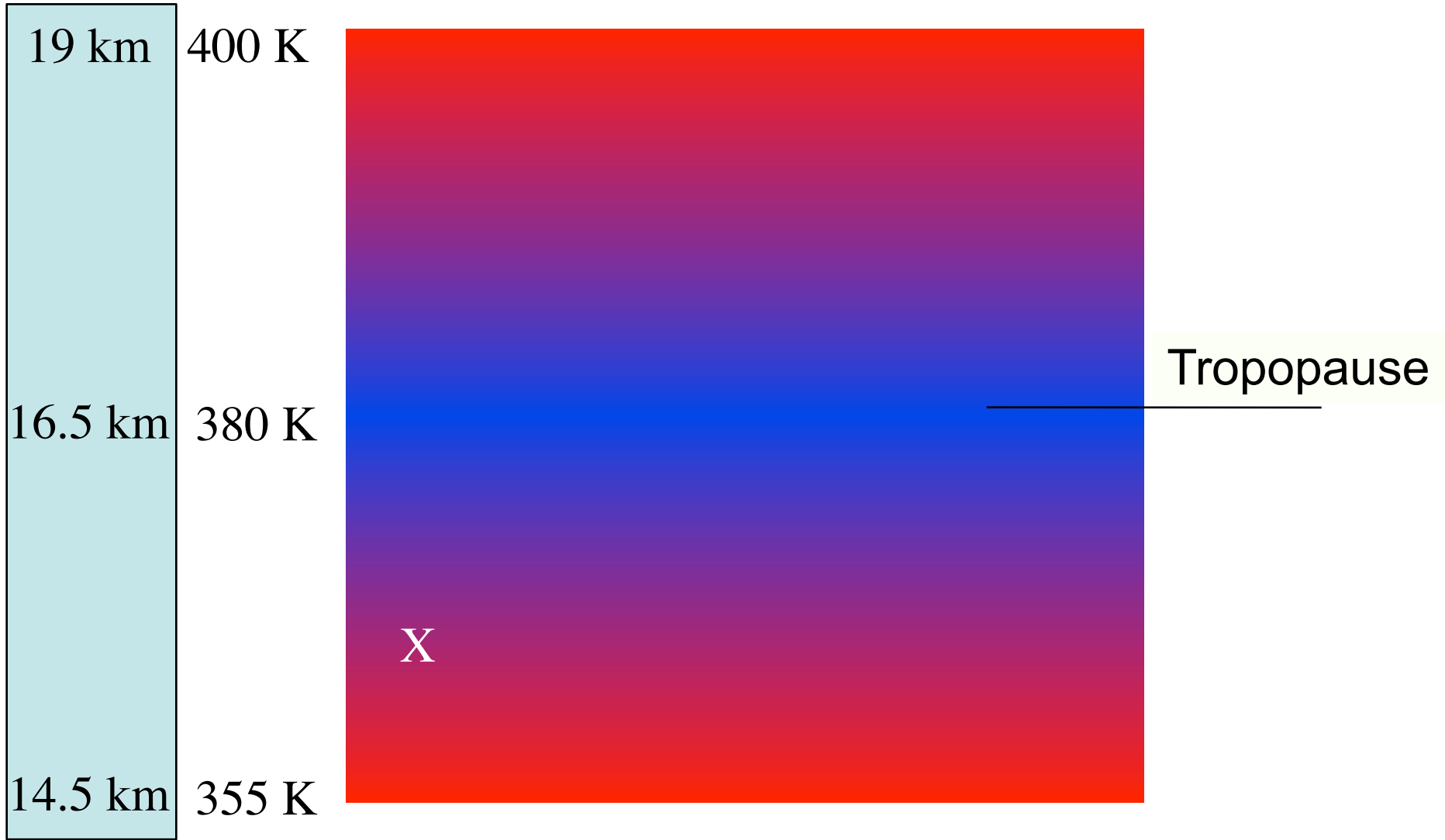
Mark imagines great thoughts emanating from his head

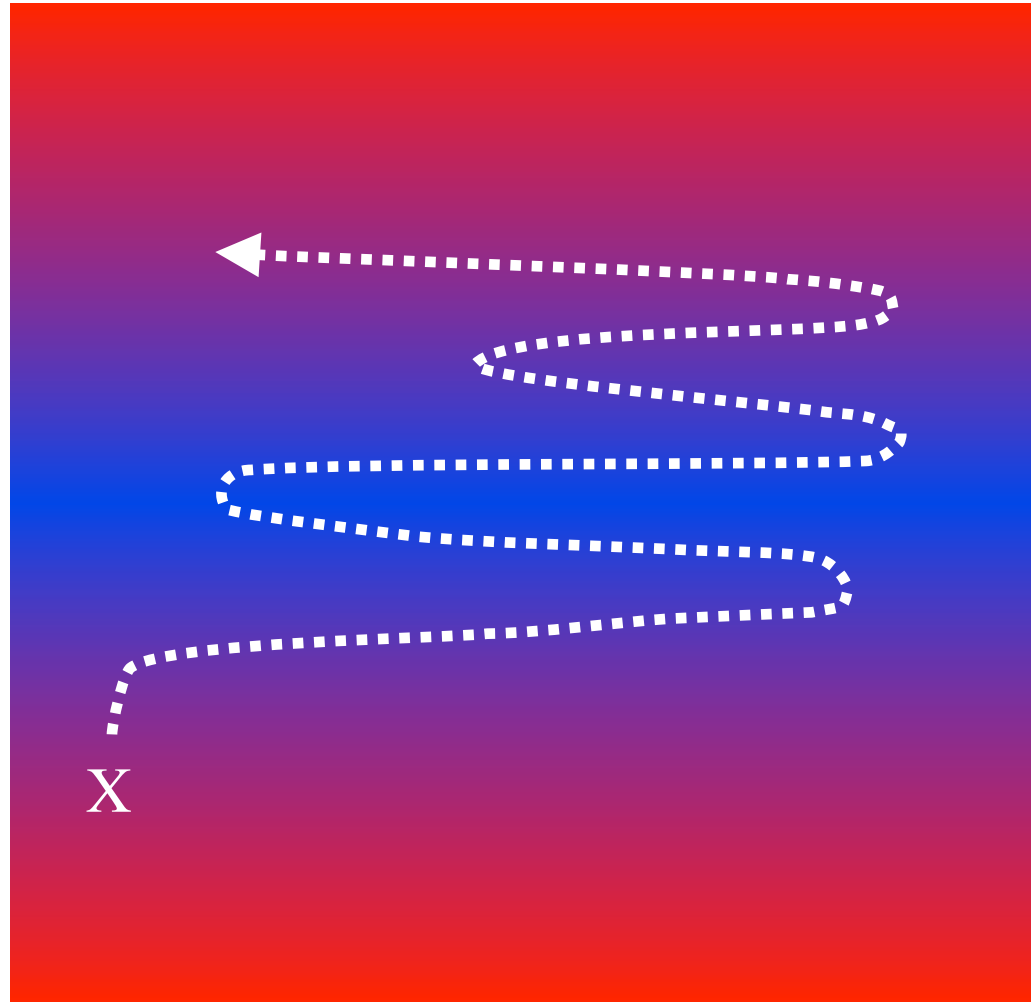
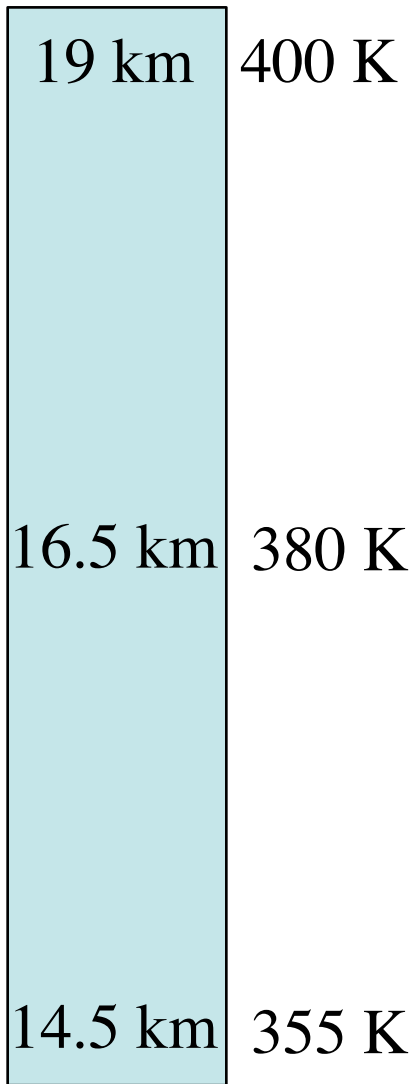


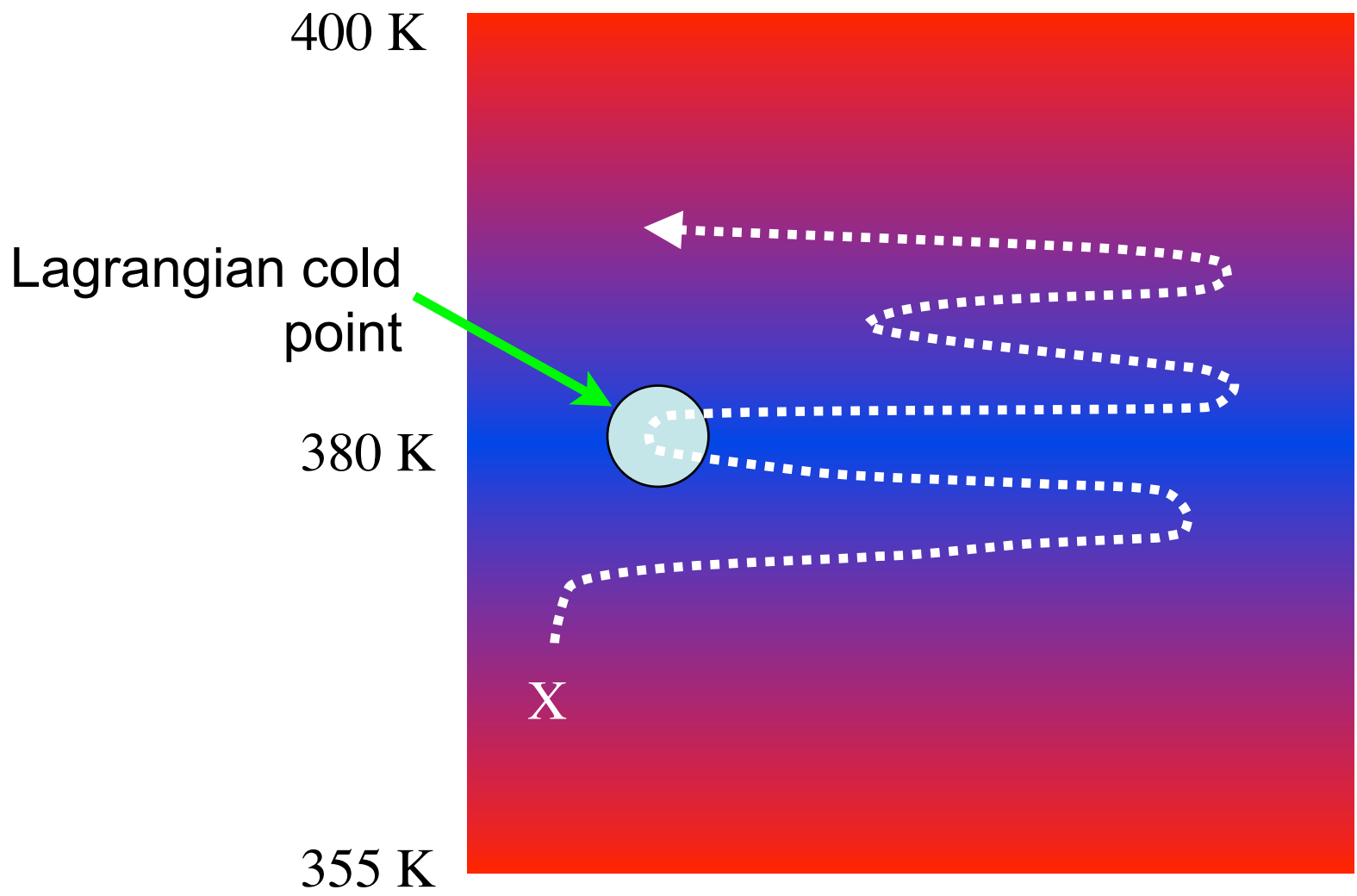
The model

- Bowman trajectory model
- Uses horizontal winds and heating rates from MERRA and ERA-interim





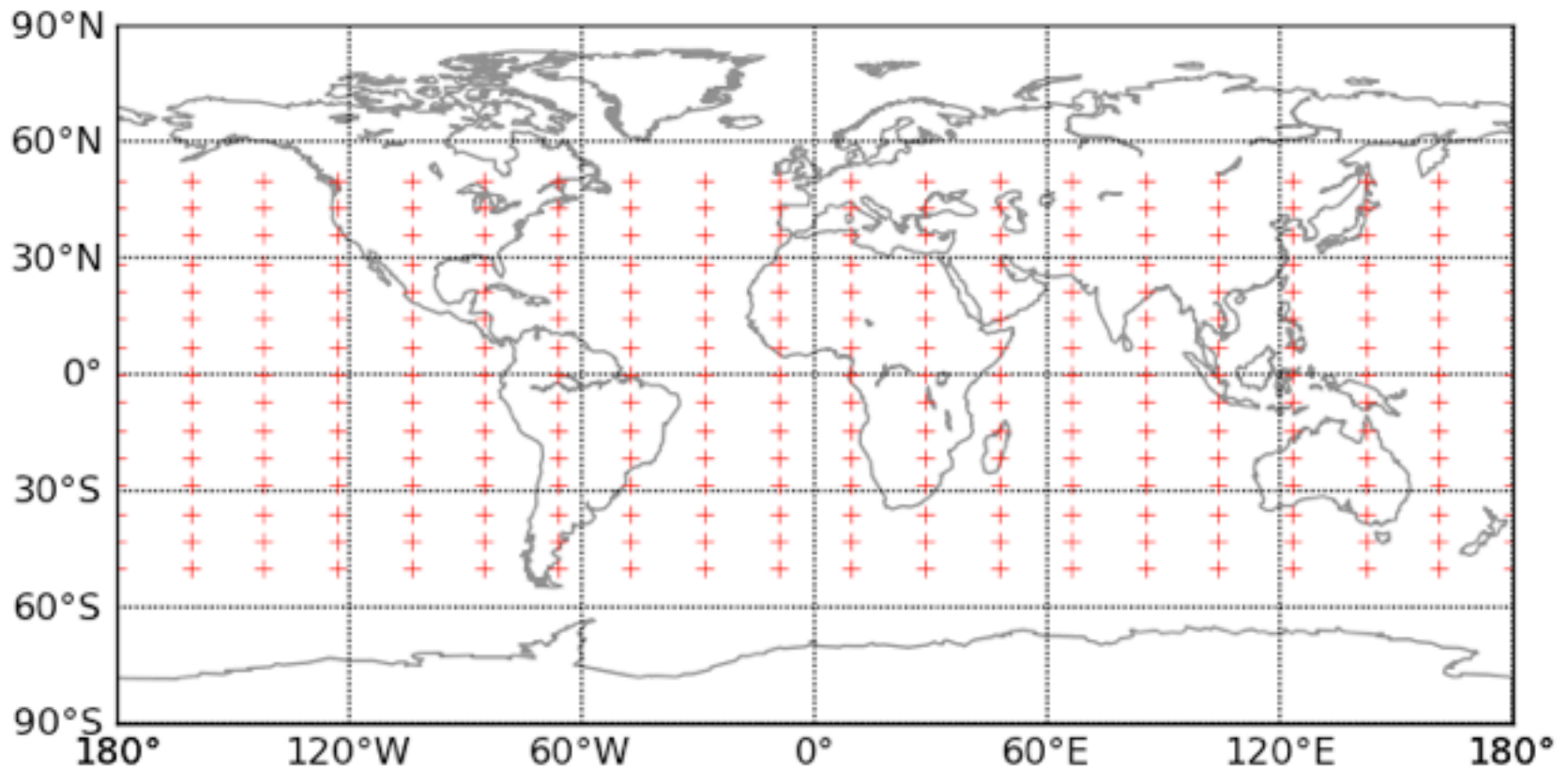




The model

- Bowman trajectory model
- uses horizontal winds and heating rates from MERRA and ERA-interim
- initialize grid of parcels every day @ 365 K

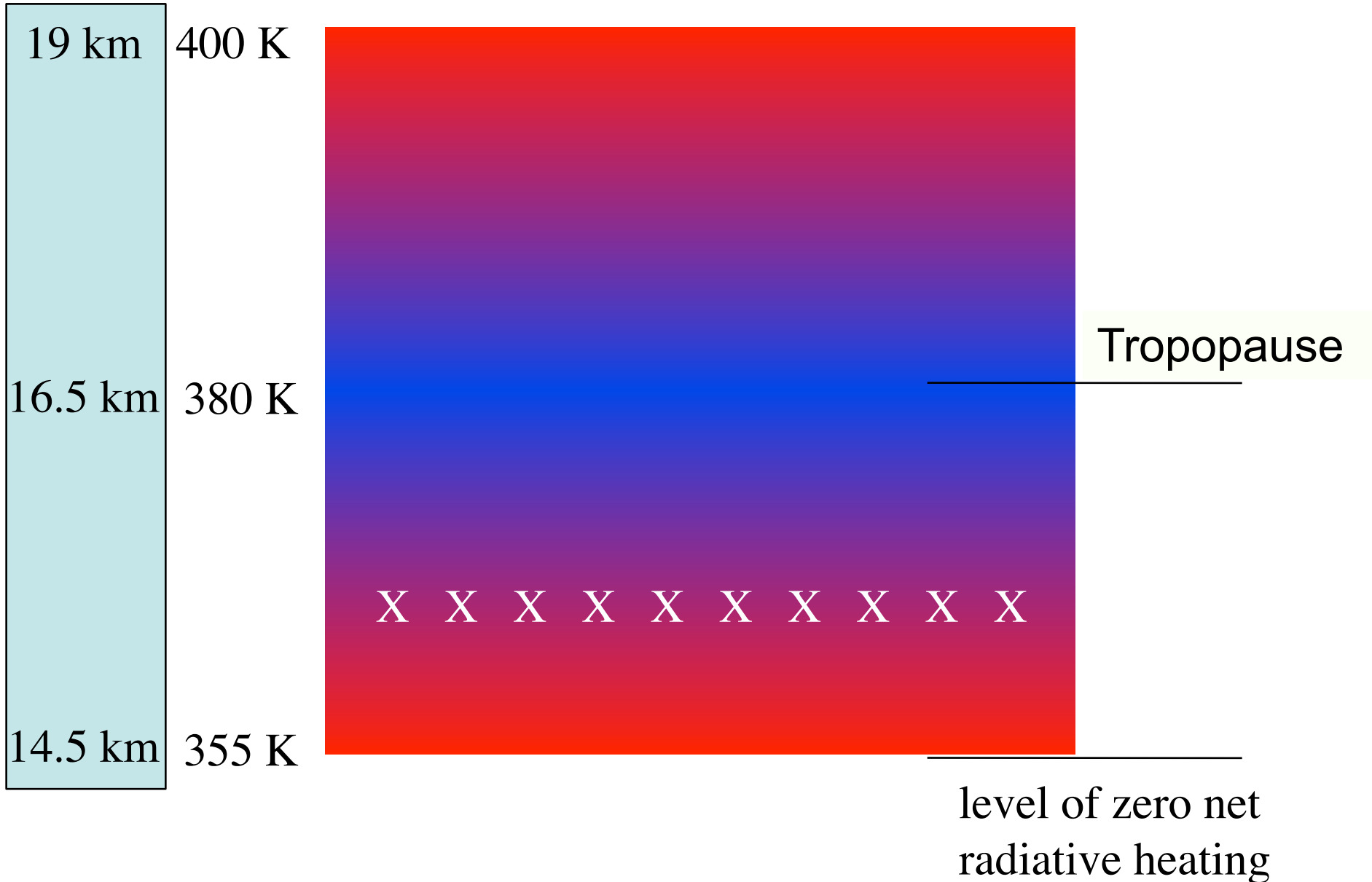


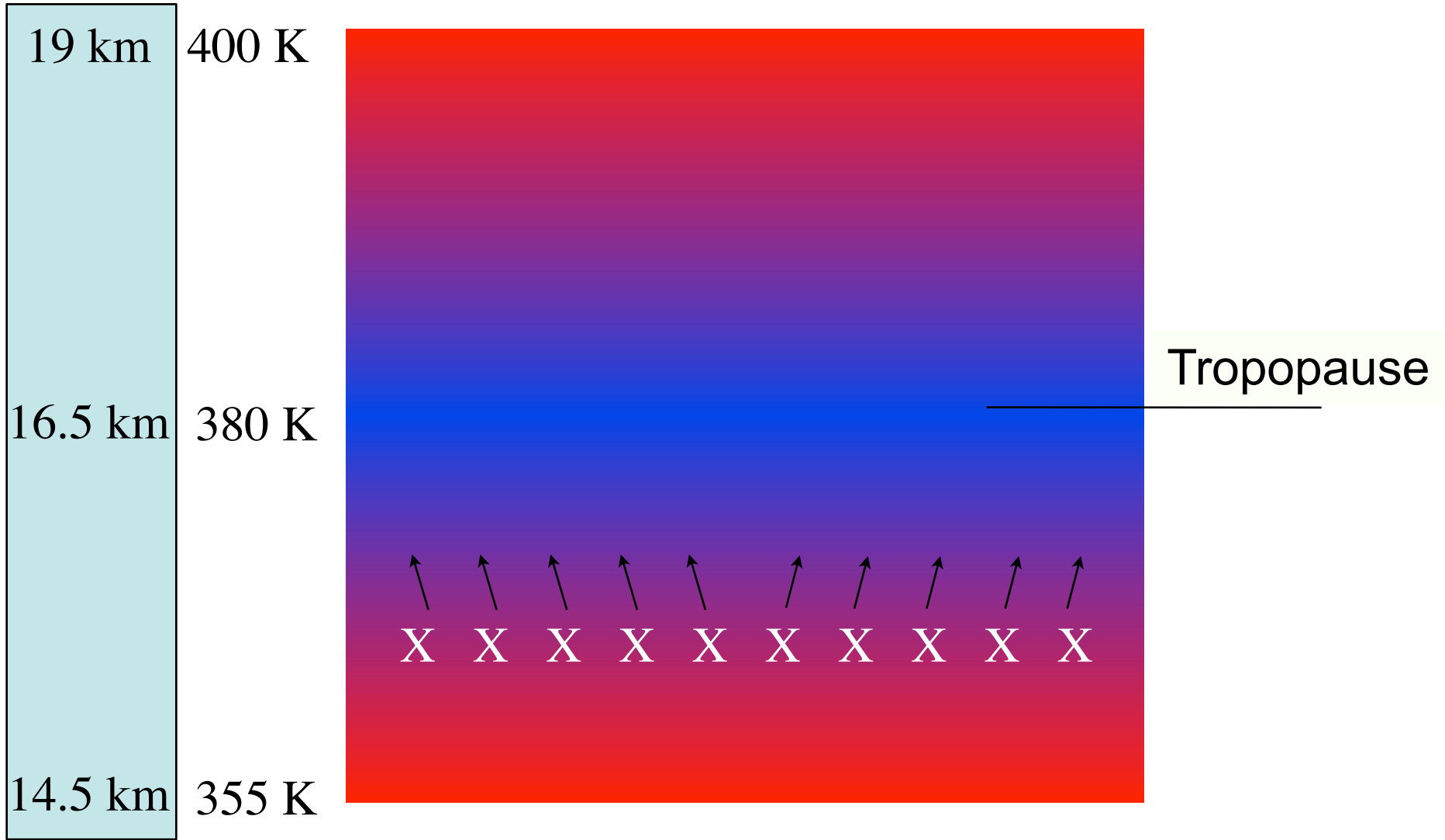


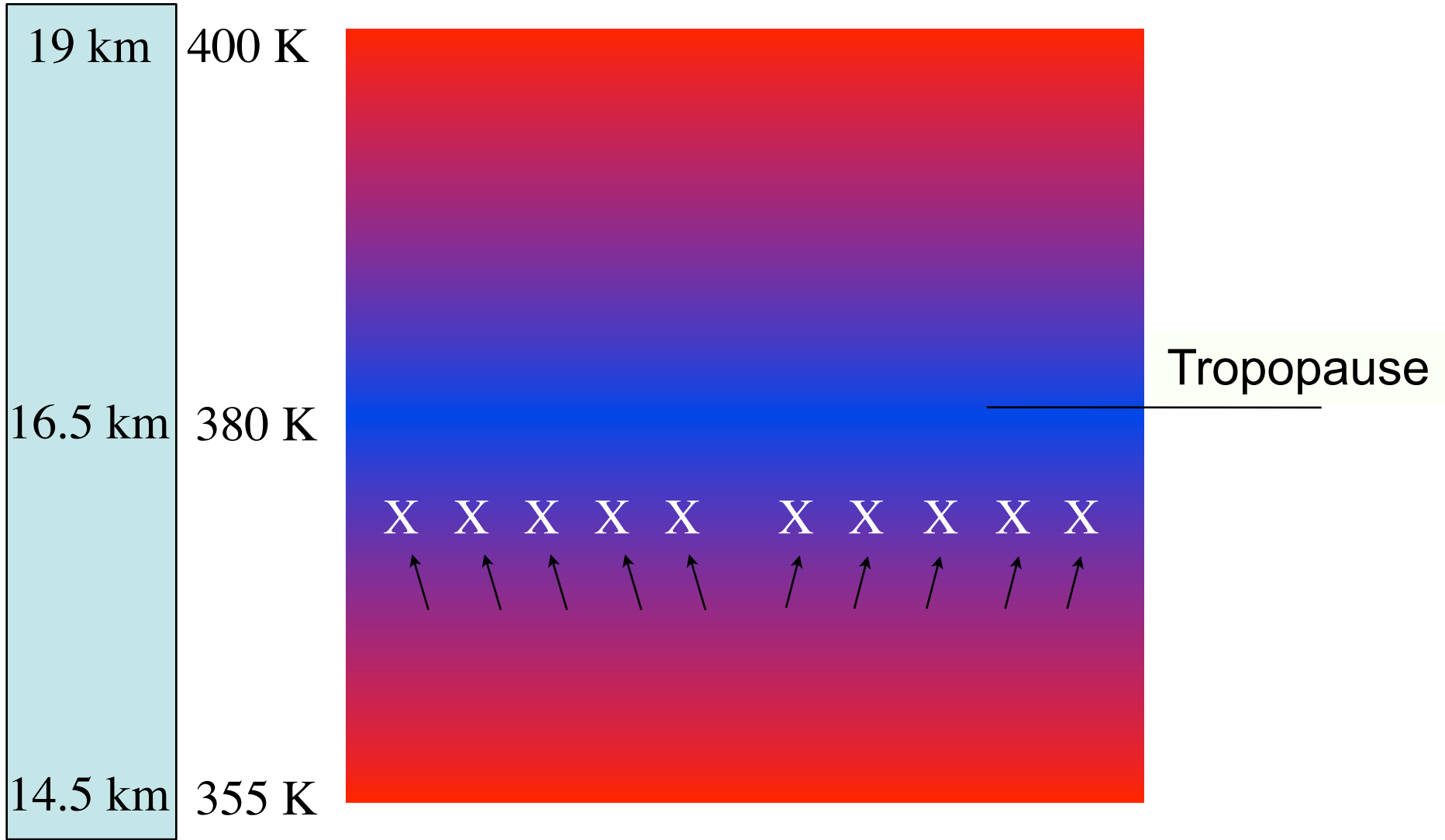
Parcels initialized at 365-K potential temperature

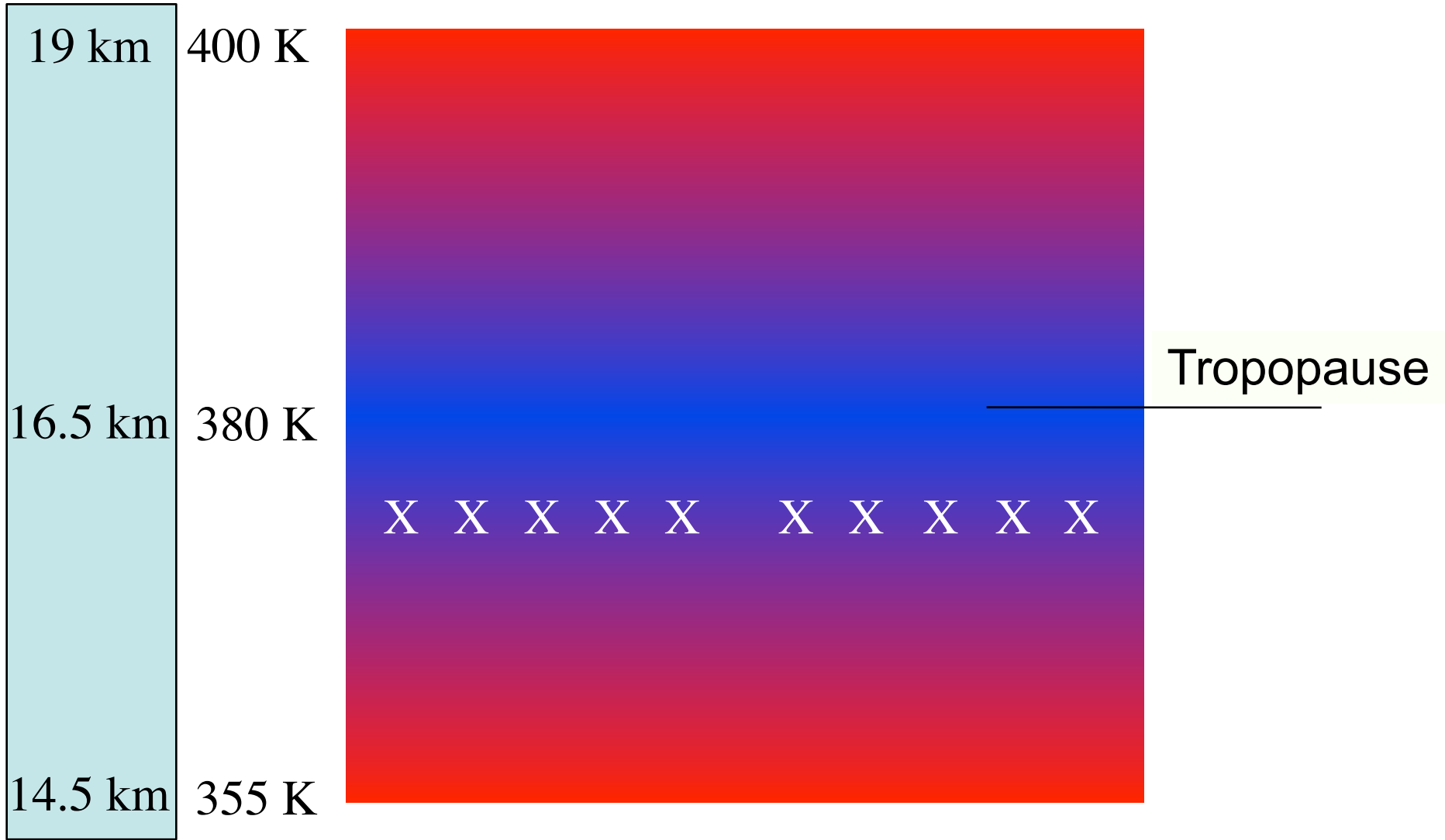
The model

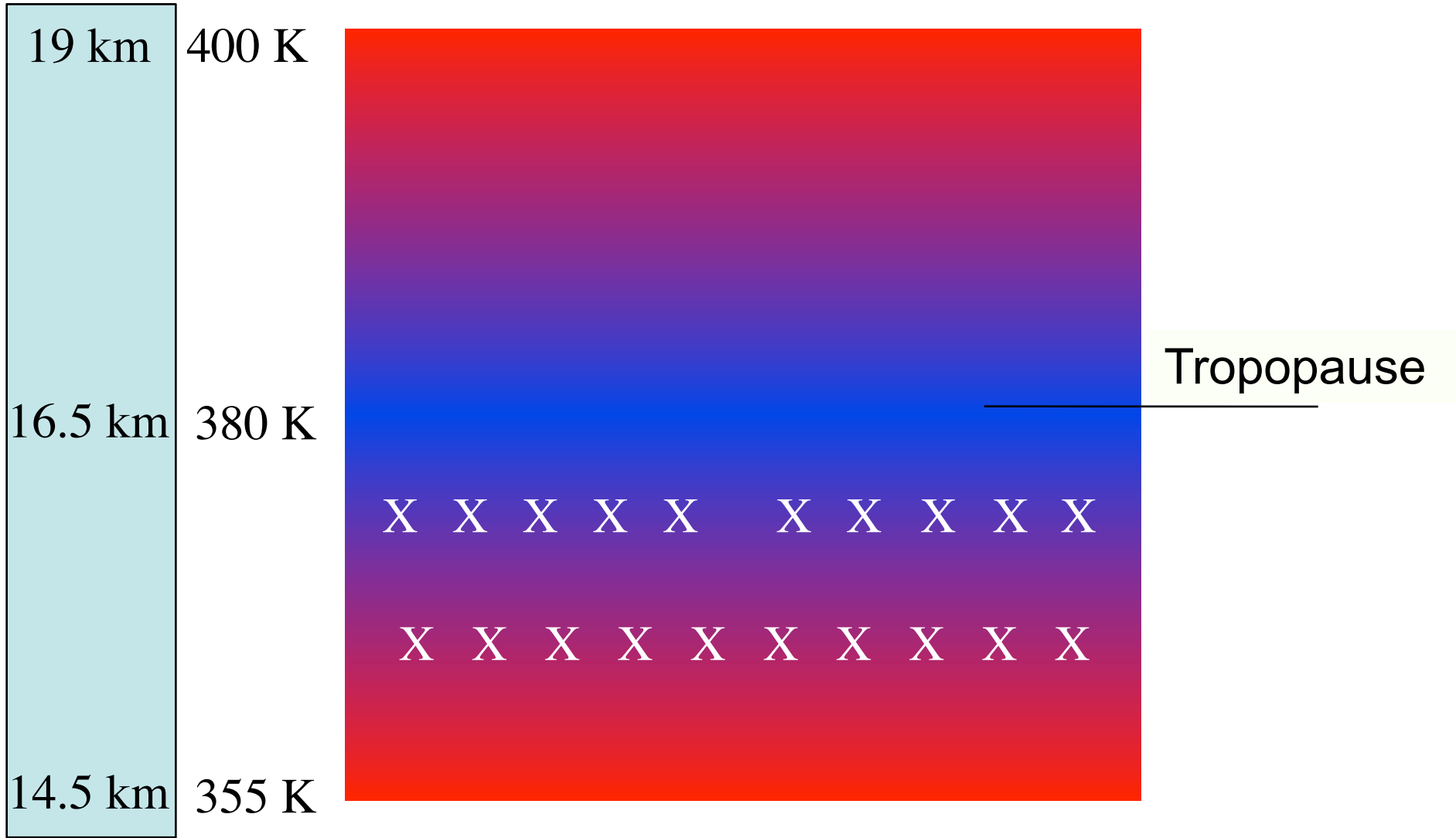
- Bowman trajectory model
- Uses horizontal winds and heating rates from MERRA and ERA-interim
- grid of parcels initialized every day
- parcels advected forward in time; most head into the stratosphere
- removed when they reenter the troposphere or age > 10 years



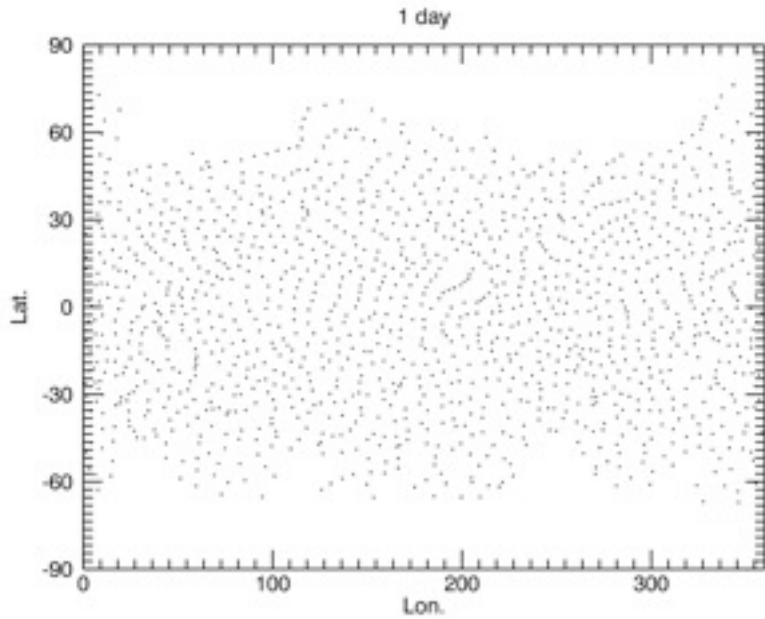




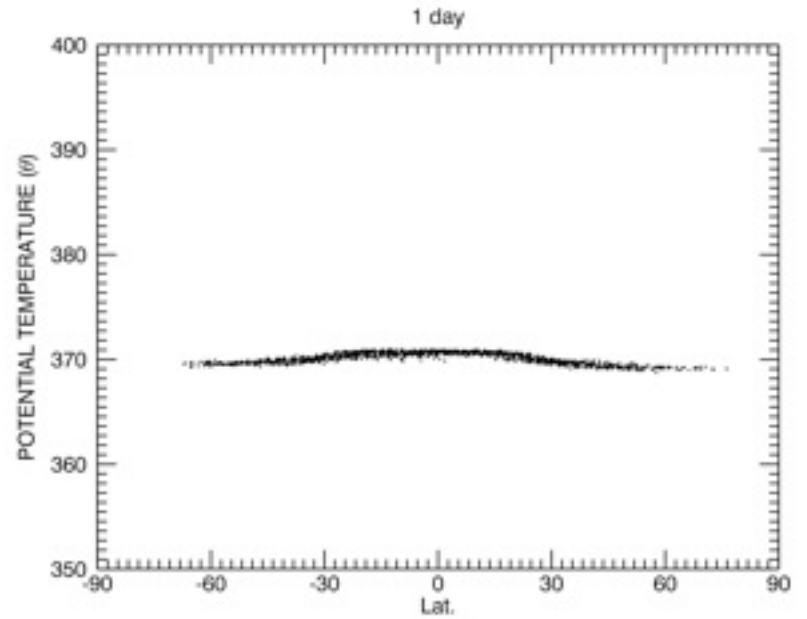




1 day

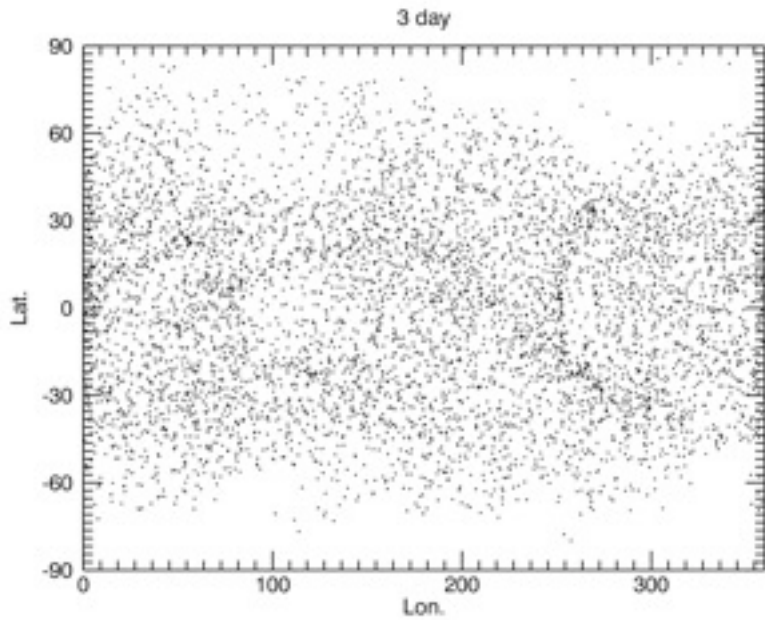


Horizontal view

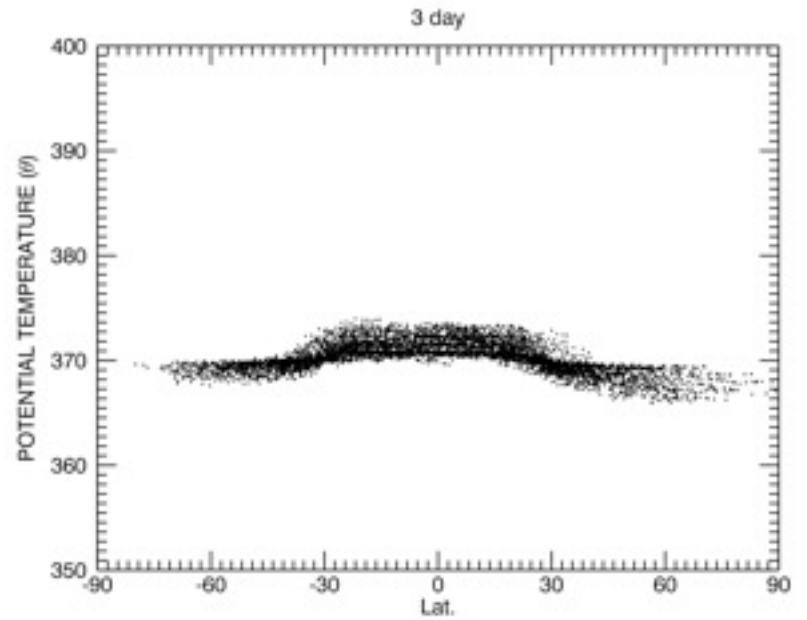


Vertical view

3 days

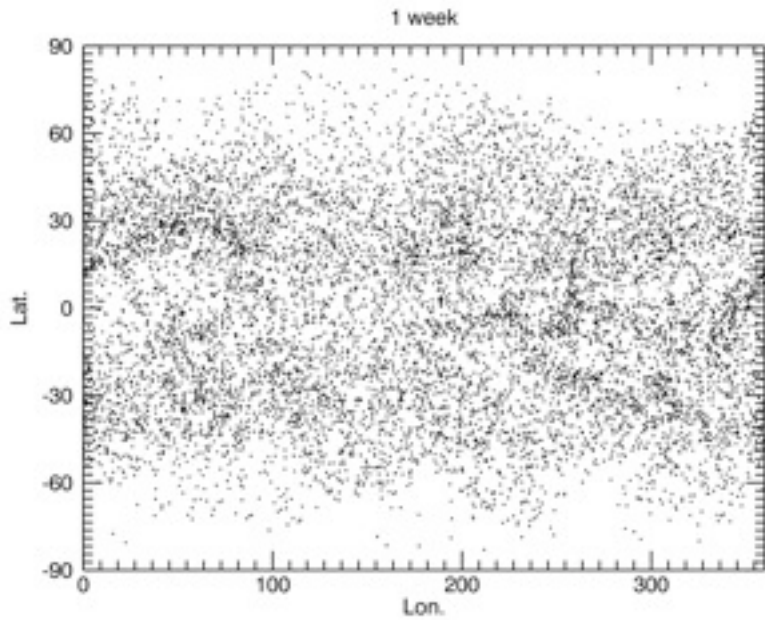


Horizontal view

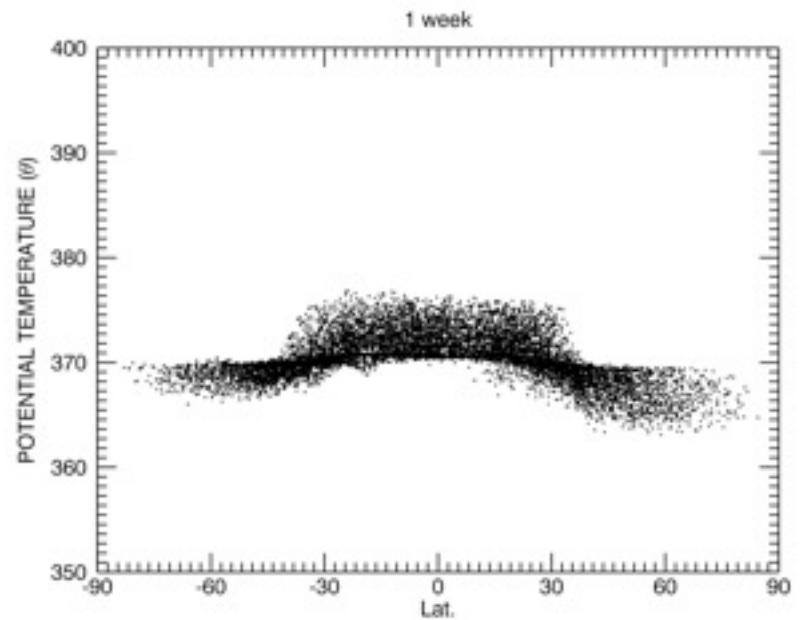


Vertical view

1 week

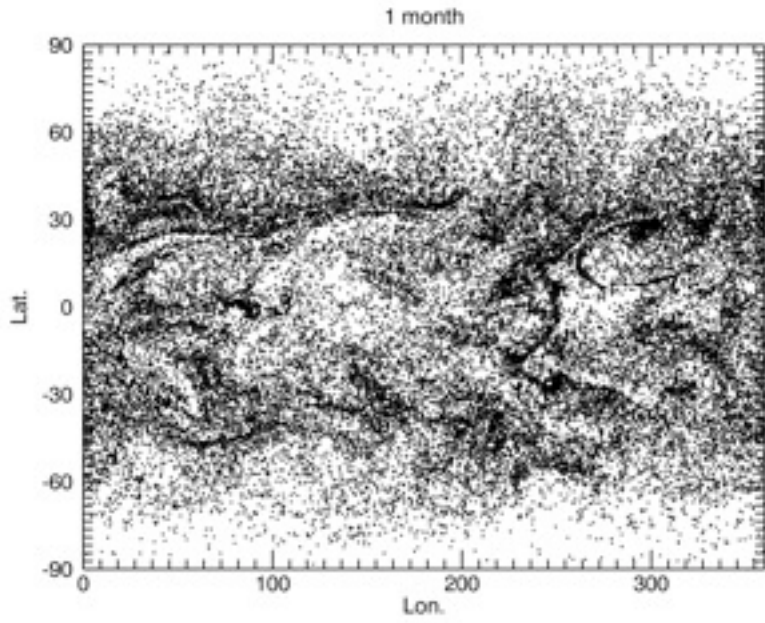


Horizontal view

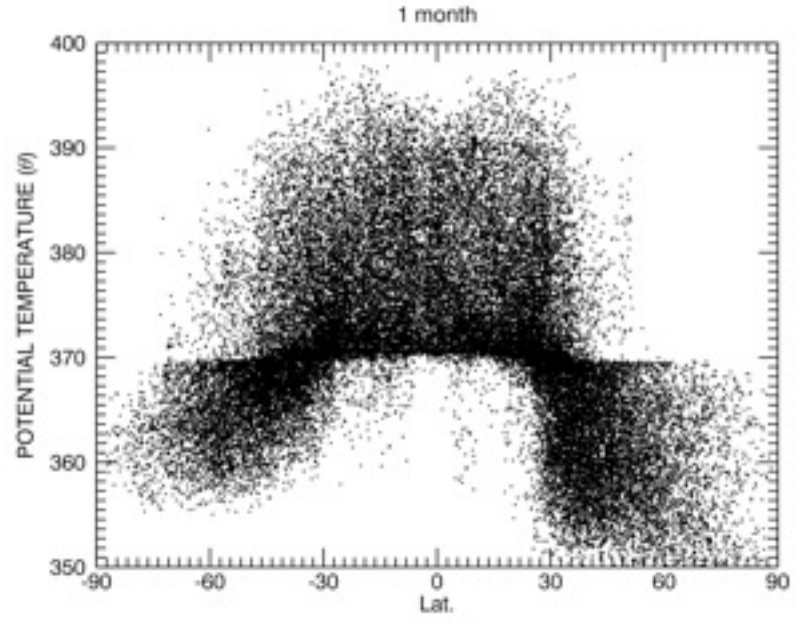


Vertical view

1 month

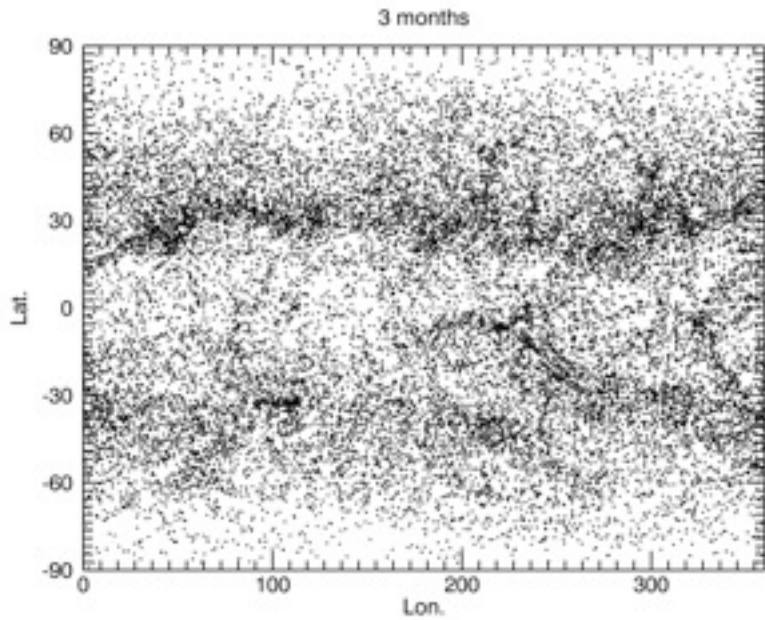


Horizontal view

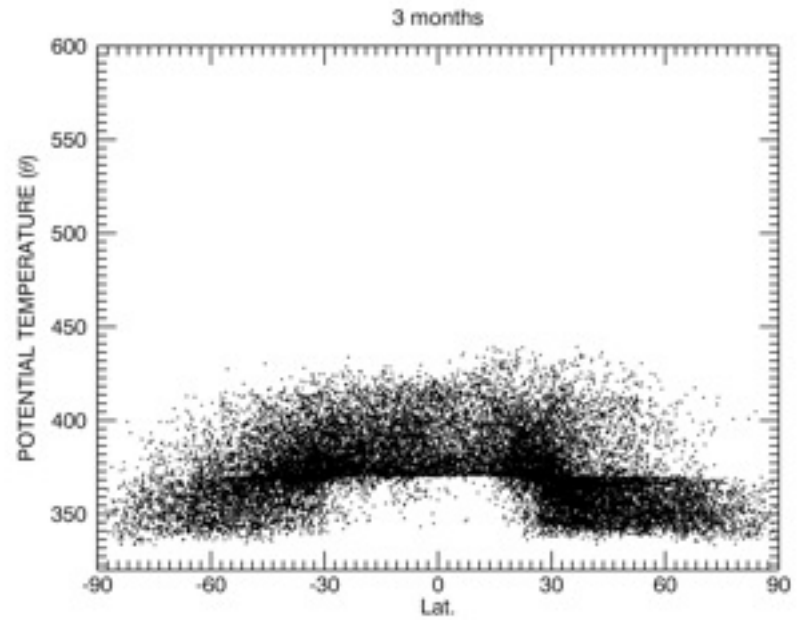


Vertical view

3 months



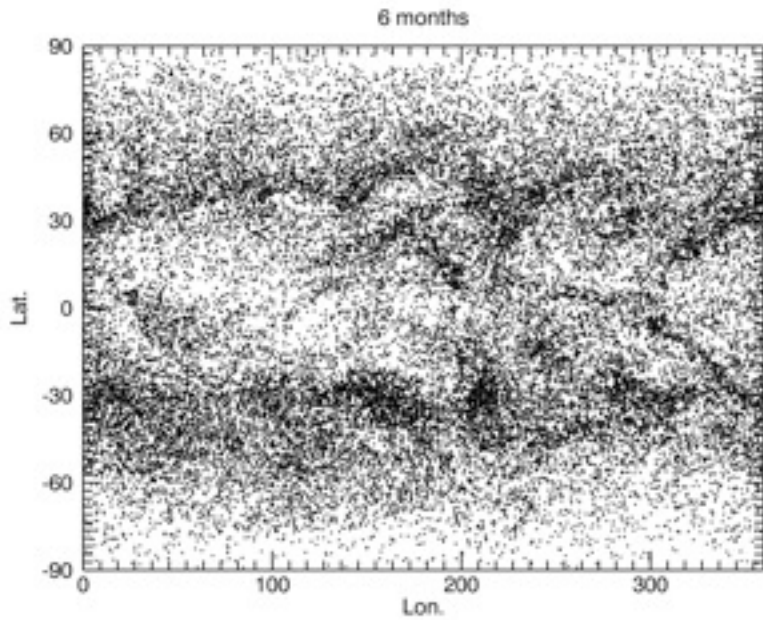
Horizontal view



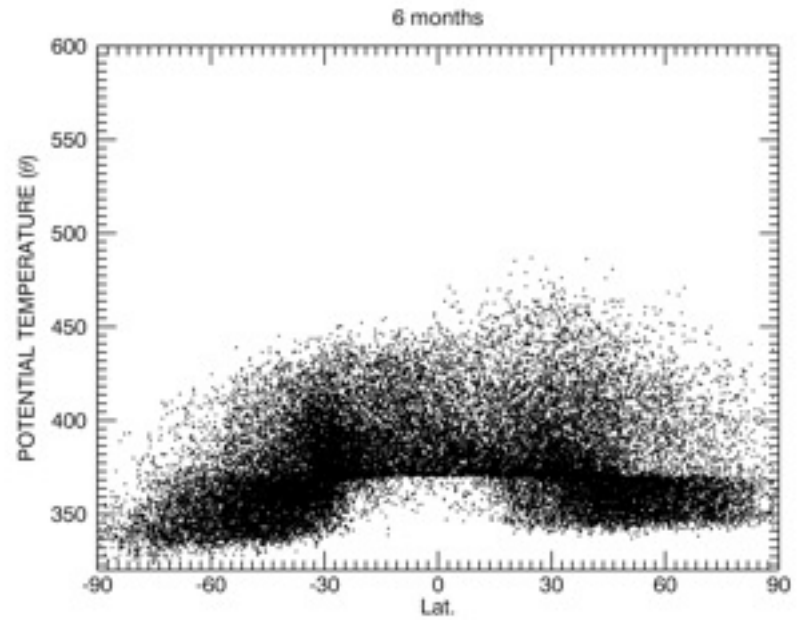
Vertical view

Parcels have been thinned out by a factor of 10

6 months



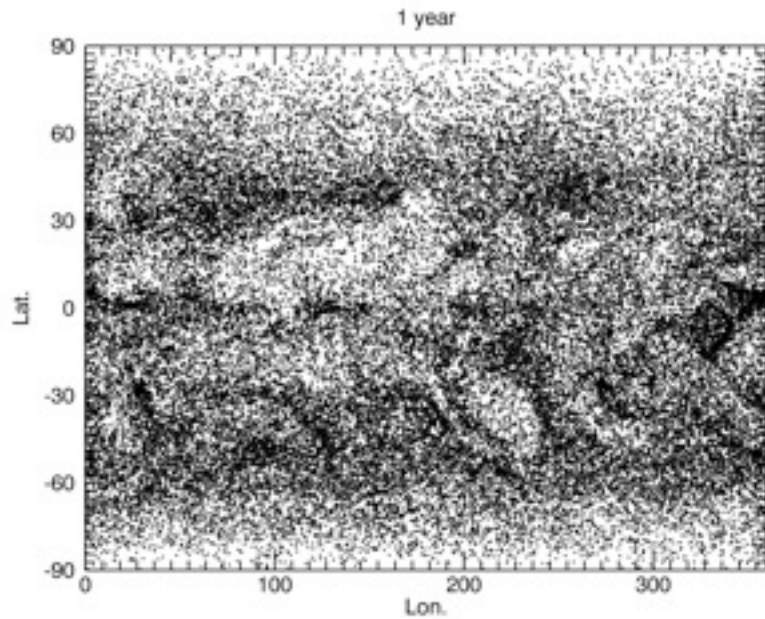
Horizontal view



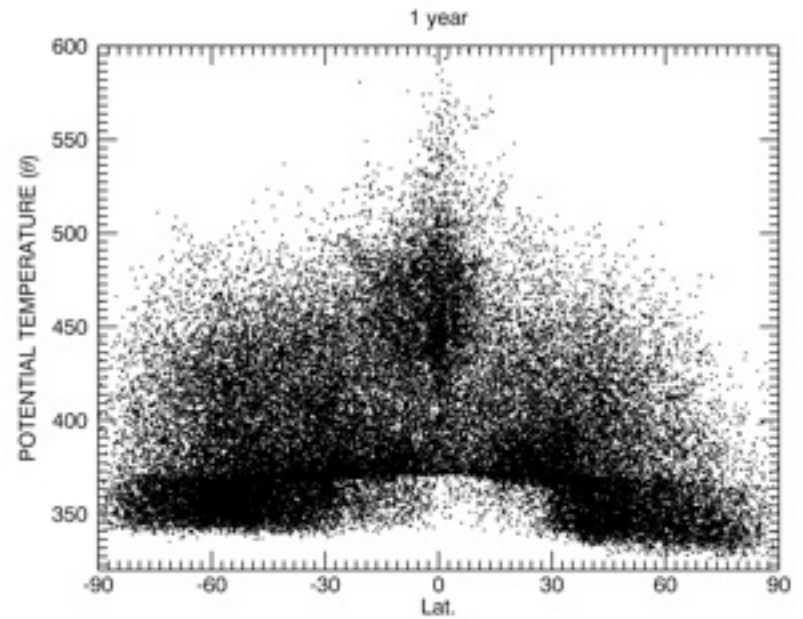
Vertical view

Parcels have been thinned out by a factor of 10

1 year



Horizontal view

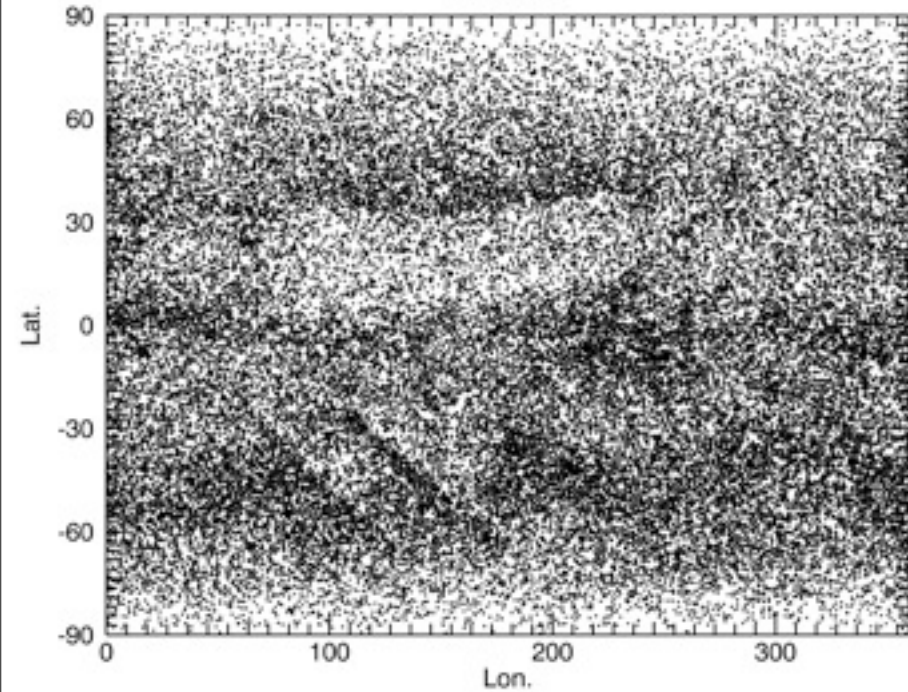


Vertical view

Parcels have been thinned out by a factor of 10

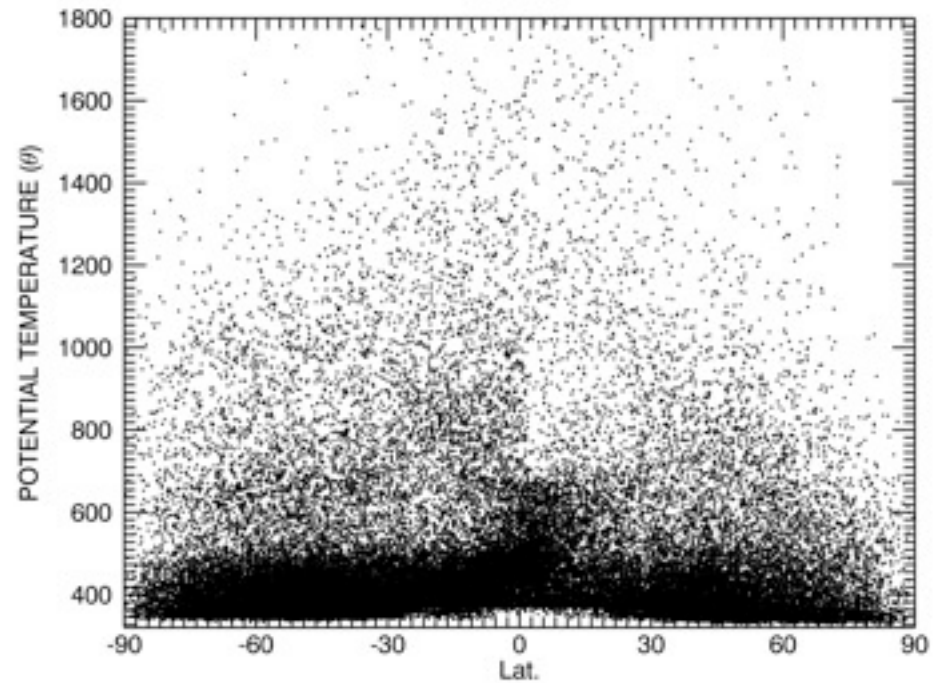
12/31/2005

20051231



Horizontal view

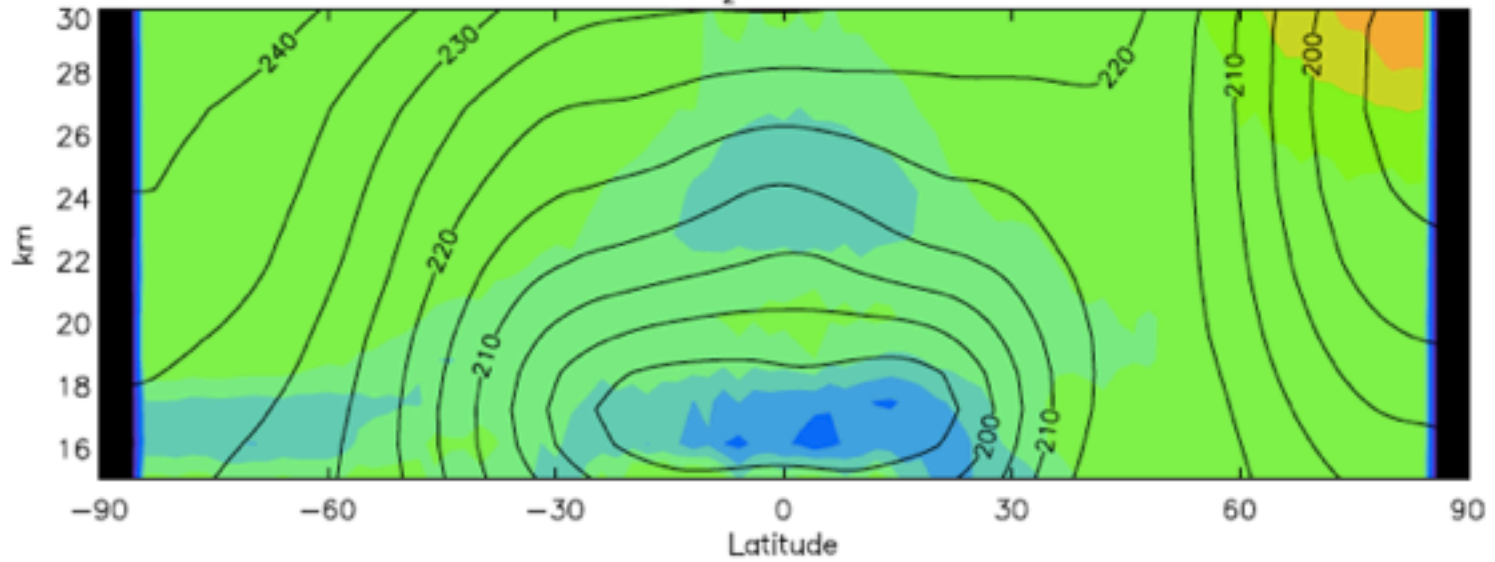
20051231



Parcels have been thinned out by a factor of 10

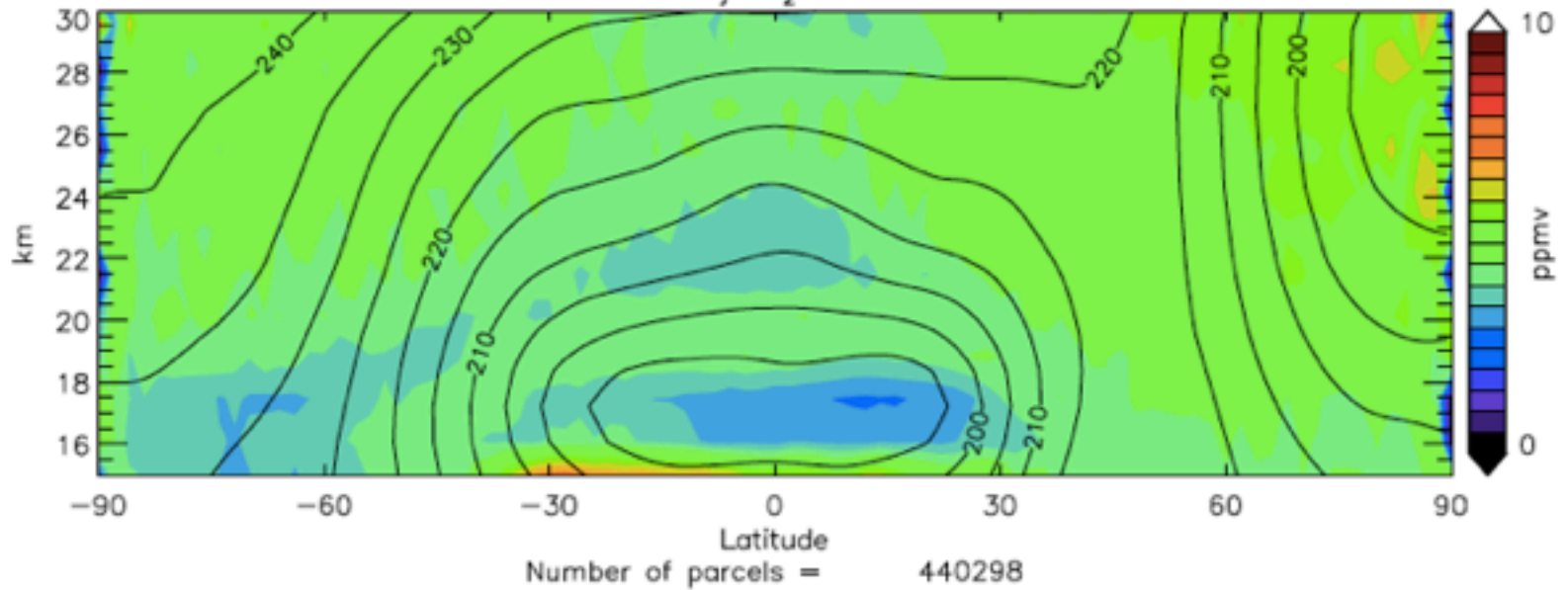
MLS

MLS H₂O 20091230

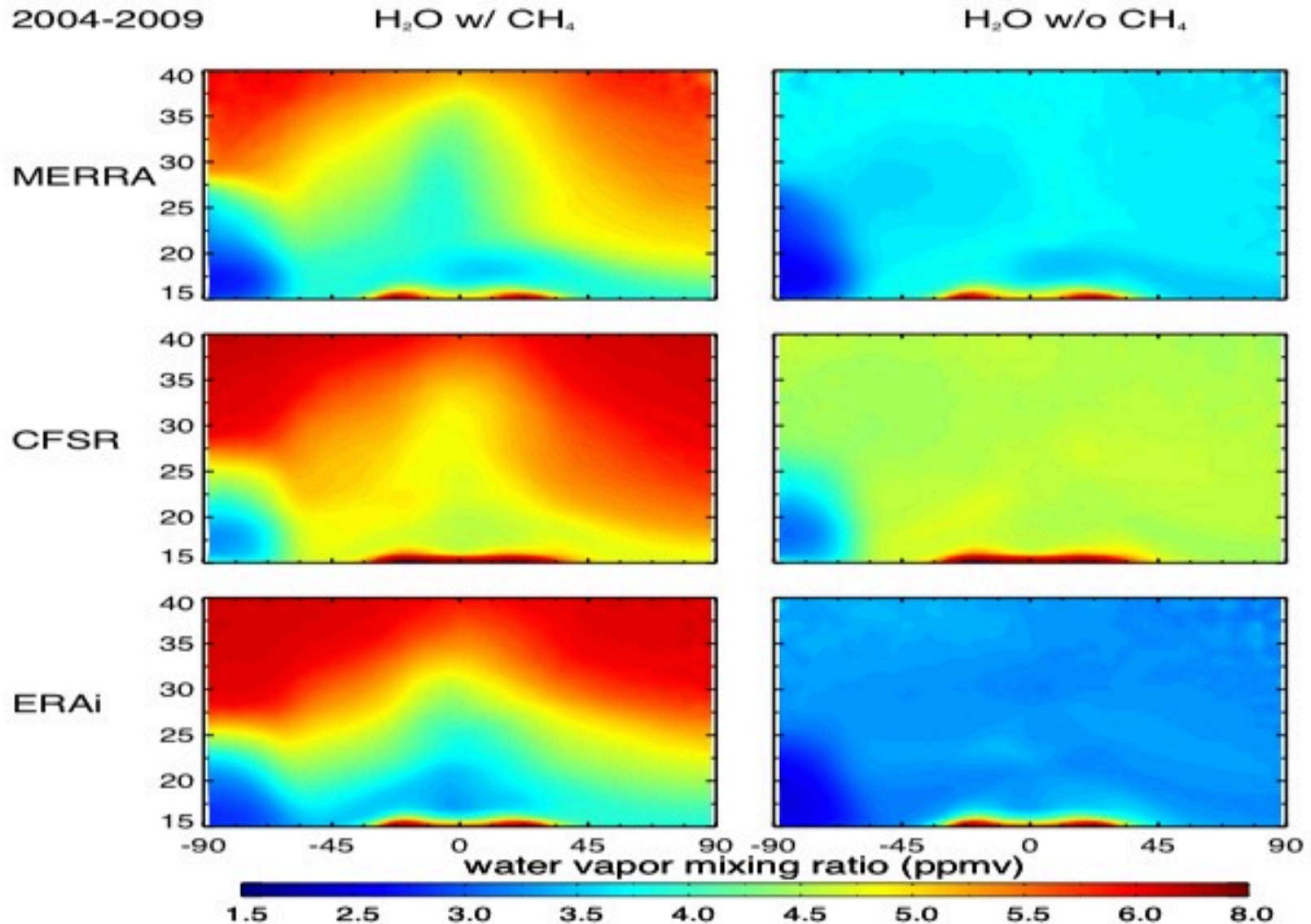


MERRA

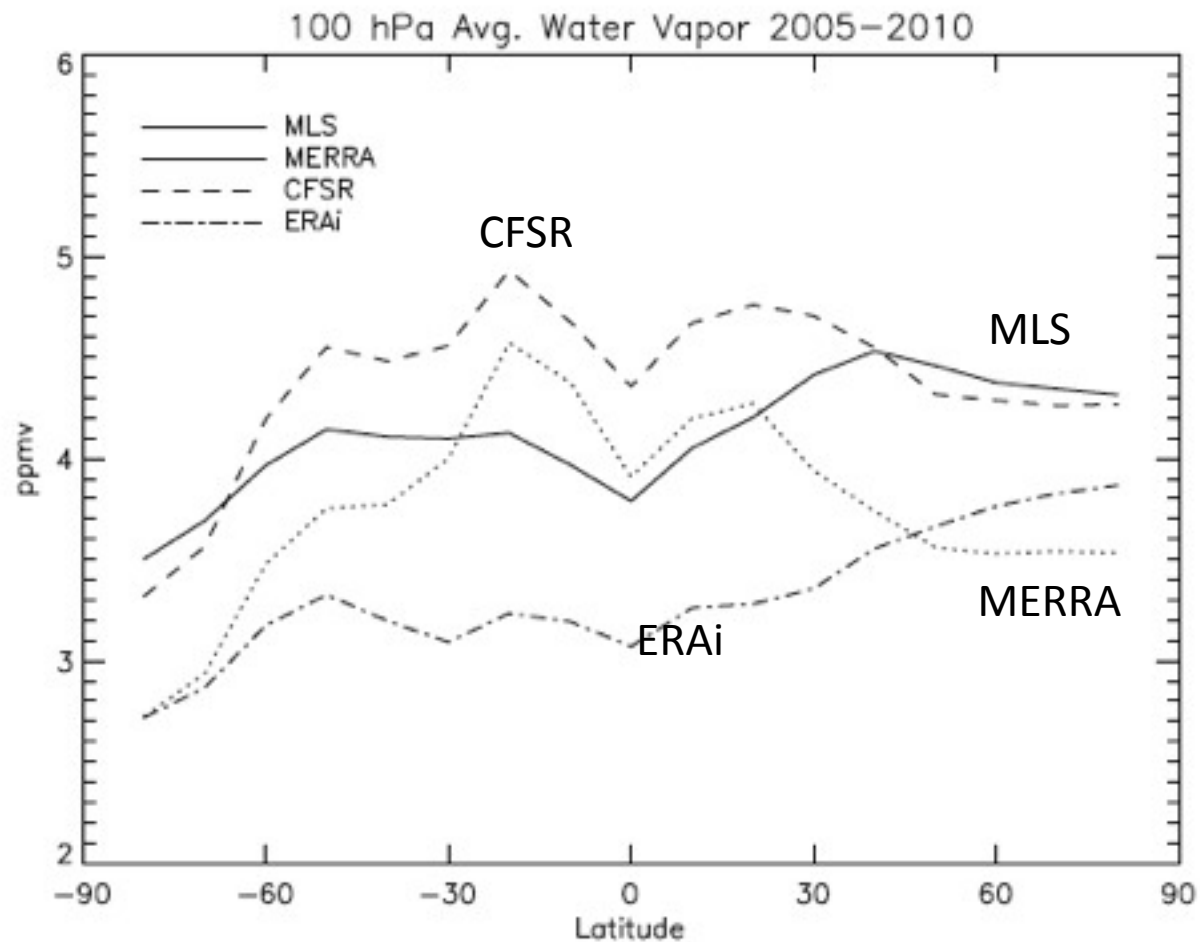
MERRA Traj. H₂O 20091230



Role of Methane Photolysis

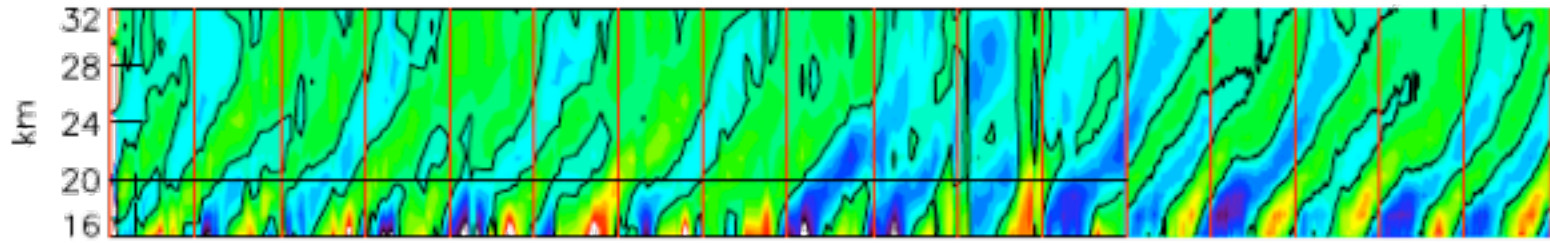


Zonal Mean H₂O at 100 hPa



Tropical Tape Recorder

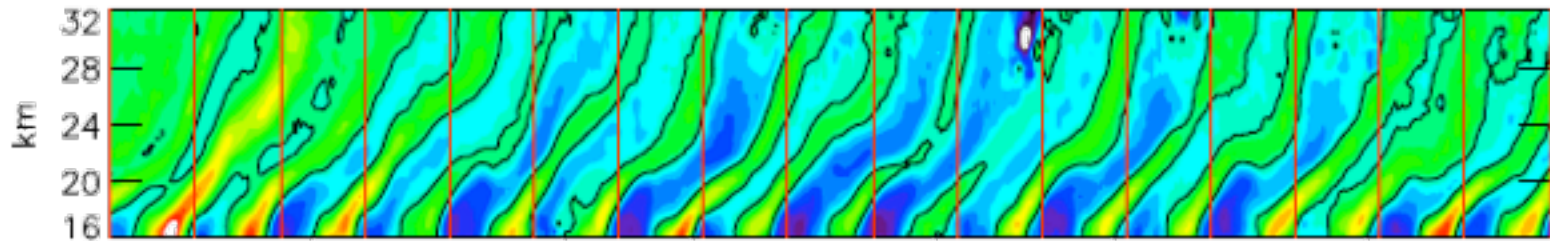
HALOE & MLS



1993

MERRA

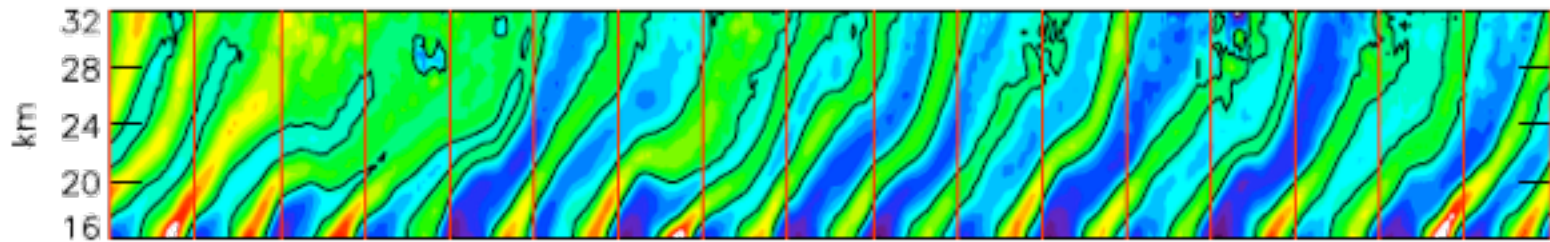
2010



1993

CFSR

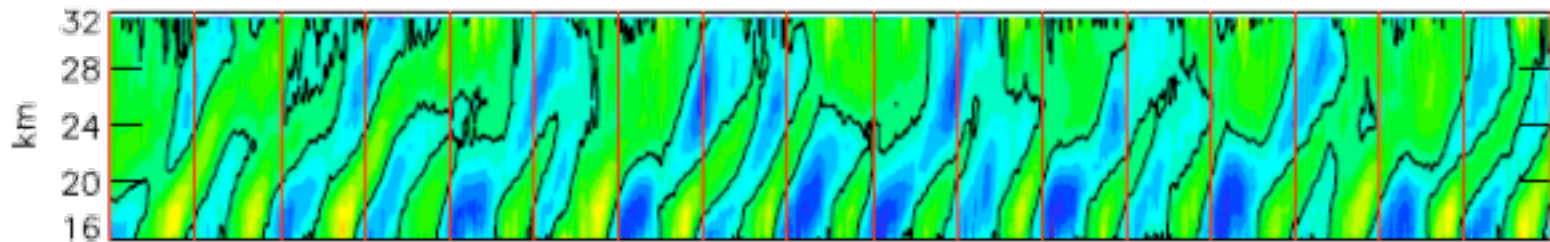
2010



1993

ERAi

2010



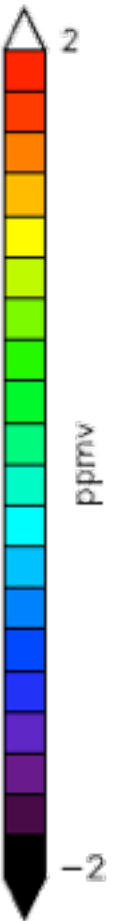
1995

2000

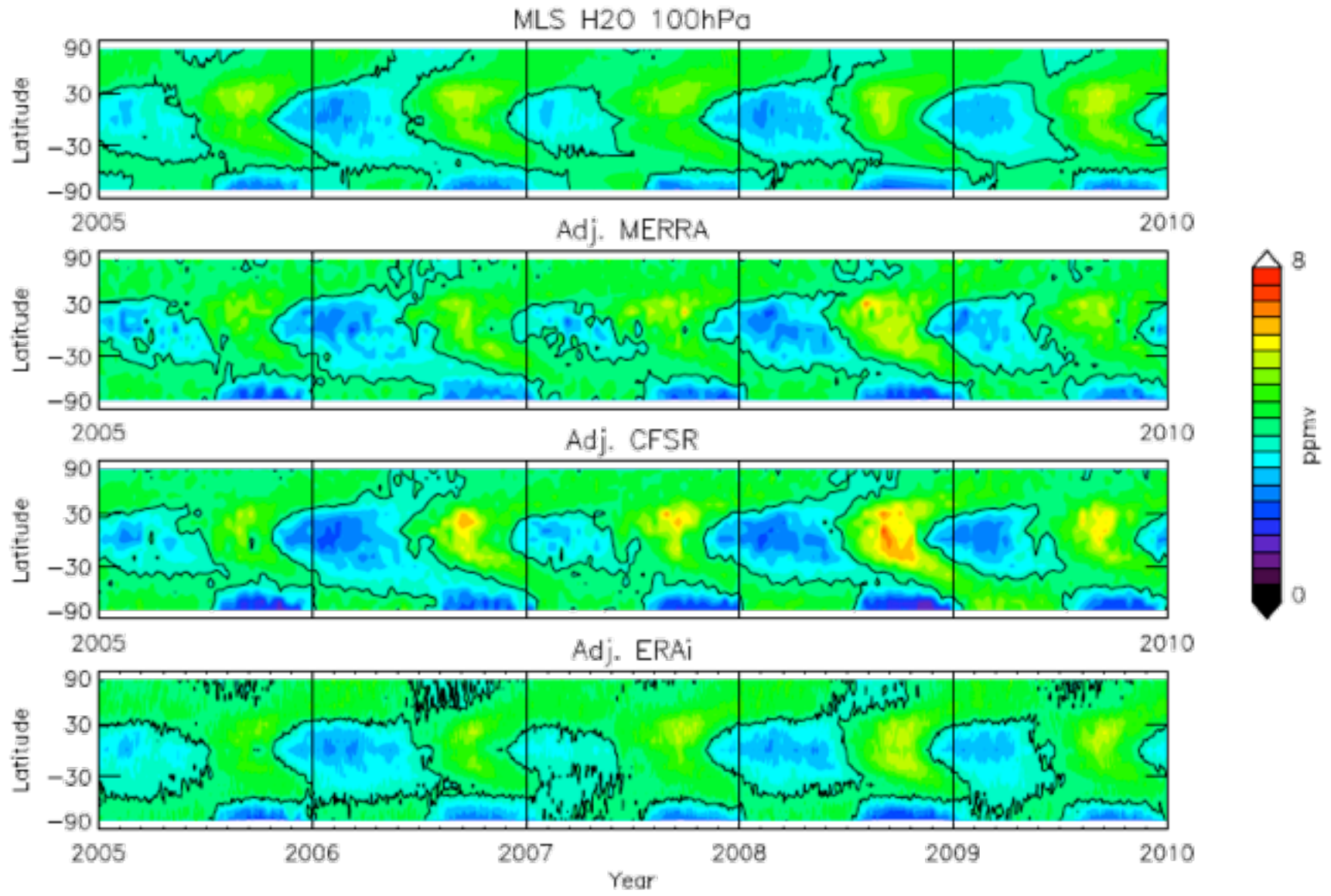
2005

2010

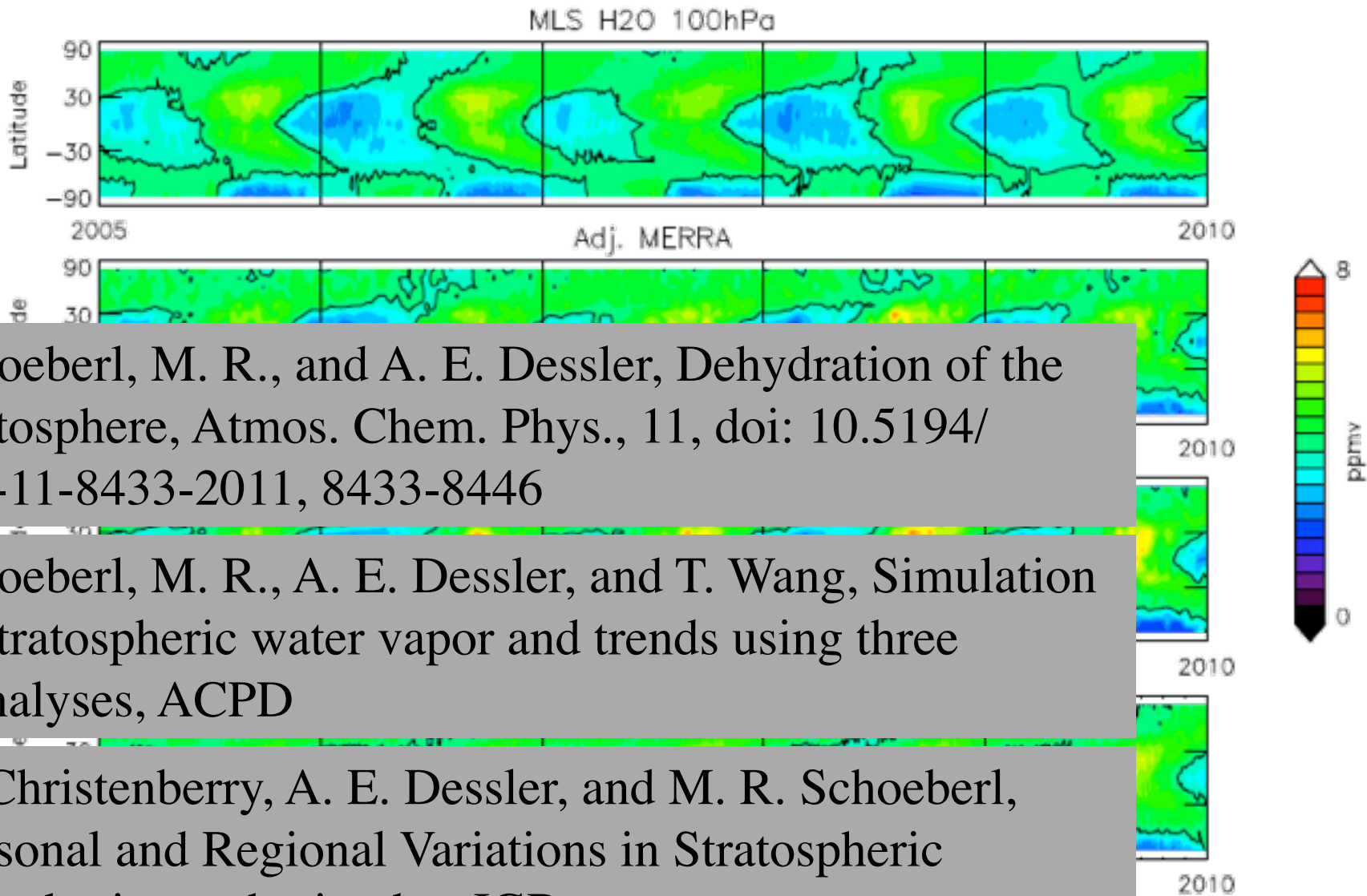
Year



Normalized to MLS Zonal Mean



Normalized to MLS Zonal Mean

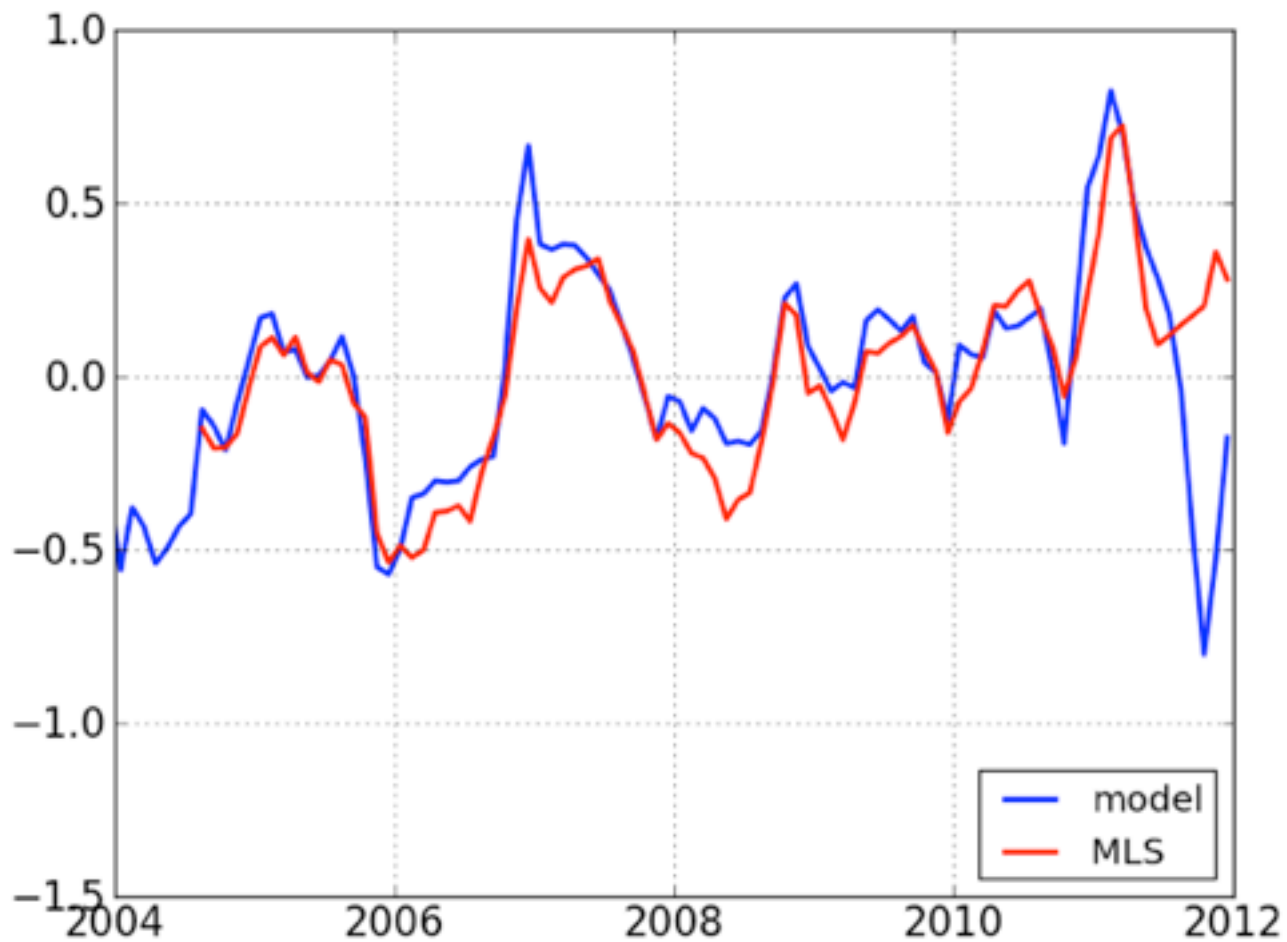


Schoeberl, M. R., and A. E. Dessler, Dehydration of the stratosphere, *Atmos. Chem. Phys.*, 11, doi: 10.5194/acp-11-8433-2011, 8433-8446

Schoeberl, M. R., A. E. Dessler, and T. Wang, Simulation of stratospheric water vapor and trends using three reanalyses, *ACPD*

A. Christenberry, A. E. Dessler, and M. R. Schoeberl, Seasonal and Regional Variations in Stratospheric Dehydration, submitted to *JGR*

H₂O
anomaly
(ppmv)



82 hPa, 30°N-30°S average

SWOOSH/Aura MLS v3

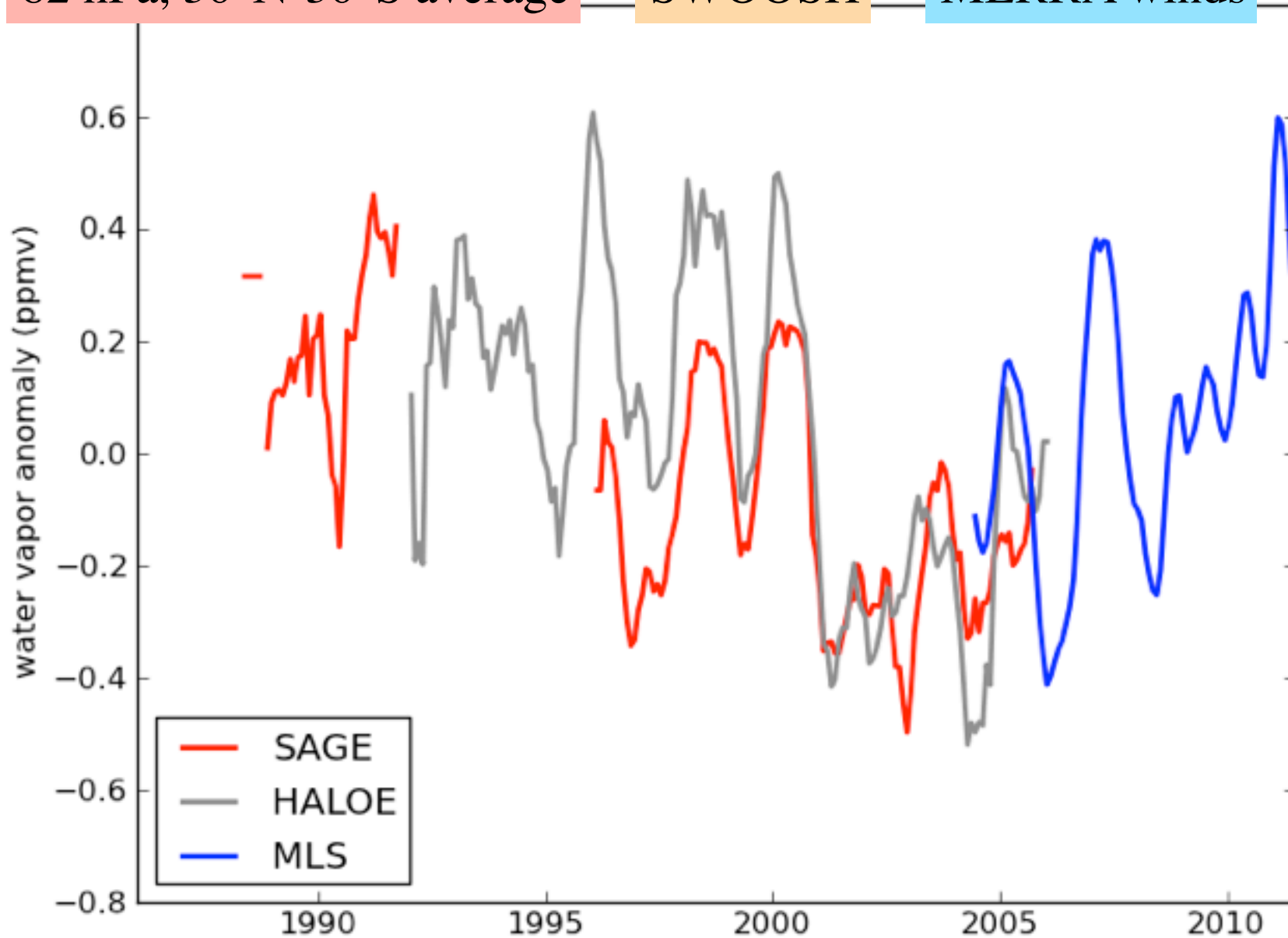
MERRA winds



82 hPa, 30°N-30°S average

SWOOSH

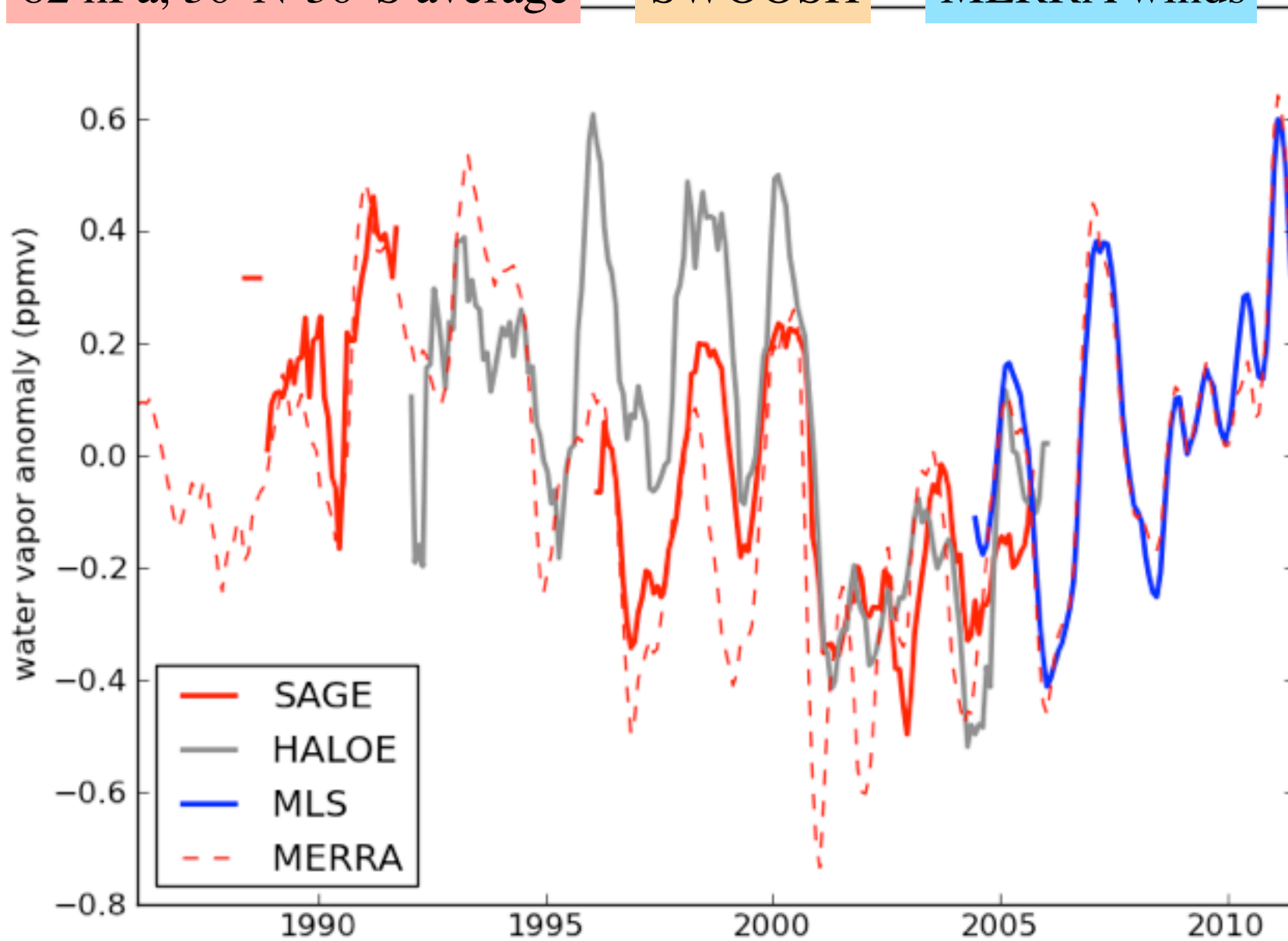
MERRA winds



82 hPa, 30°N-30°S average

SWOOSH

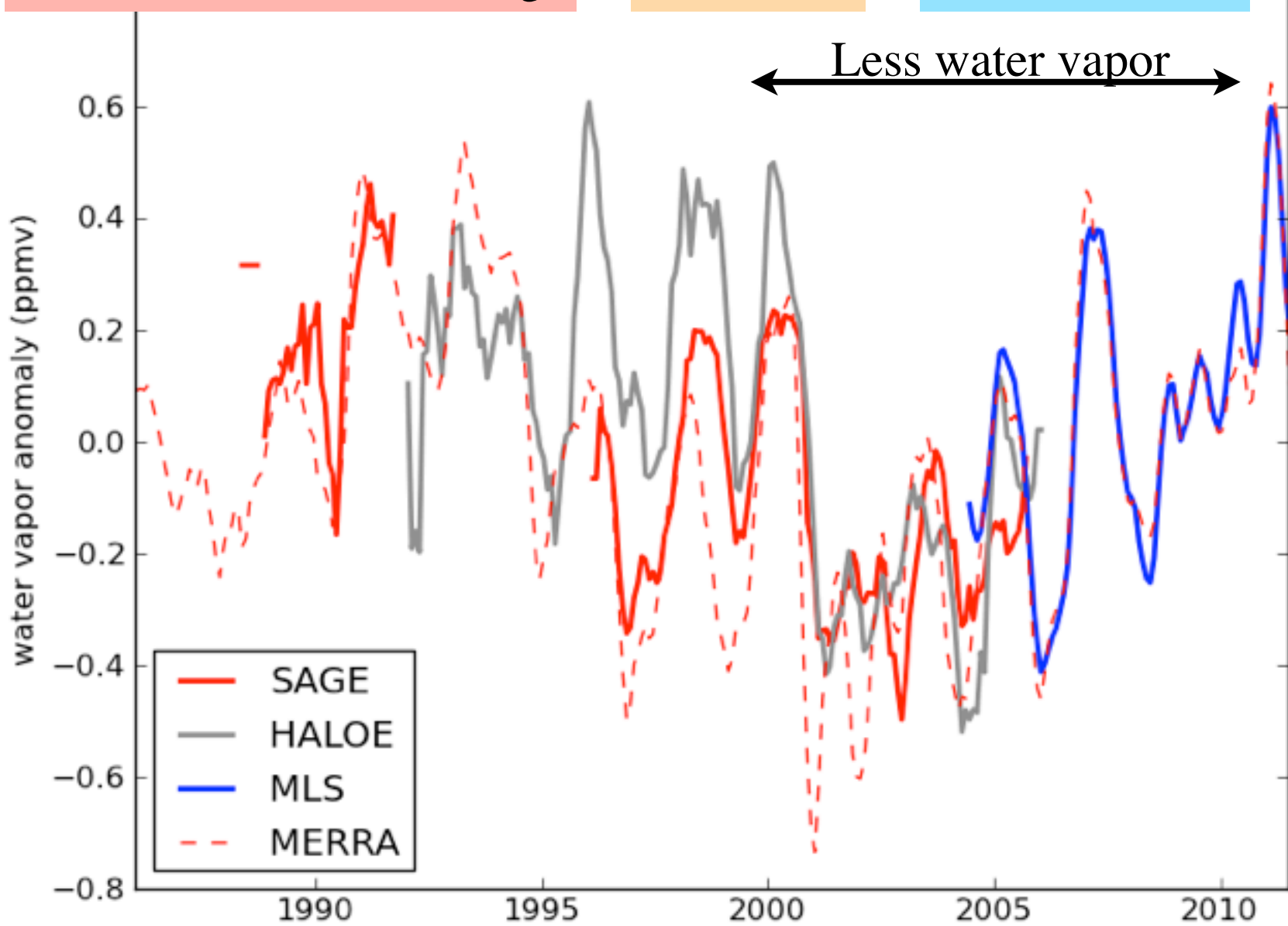
MERRA winds



82 hPa, 30°N-30°S average

SWOOSH

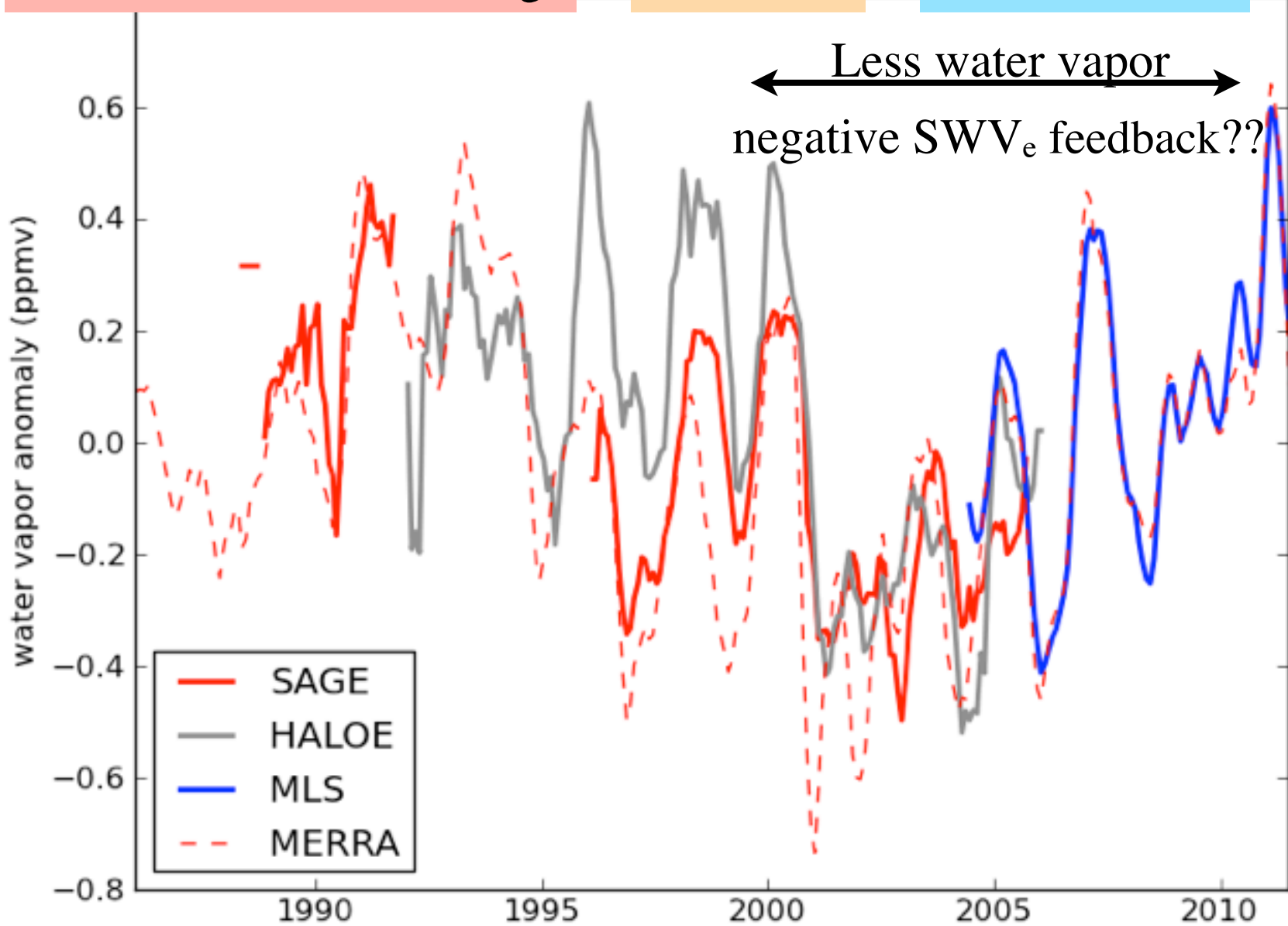
MERRA winds



82 hPa, 30°N-30°S average

SWOOSH

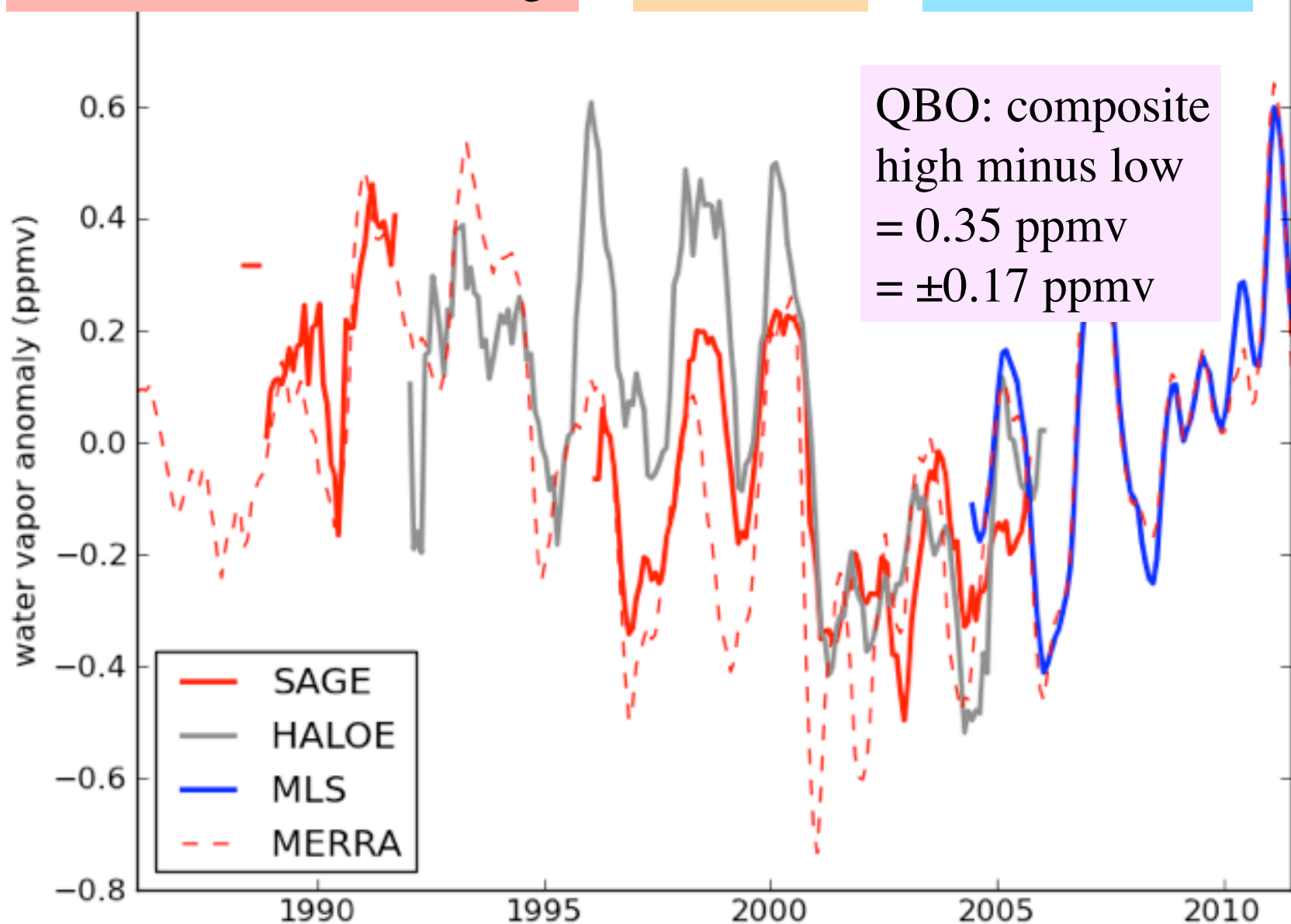
MERRA winds



82 hPa, 30°N-30°S average

SWOOSH

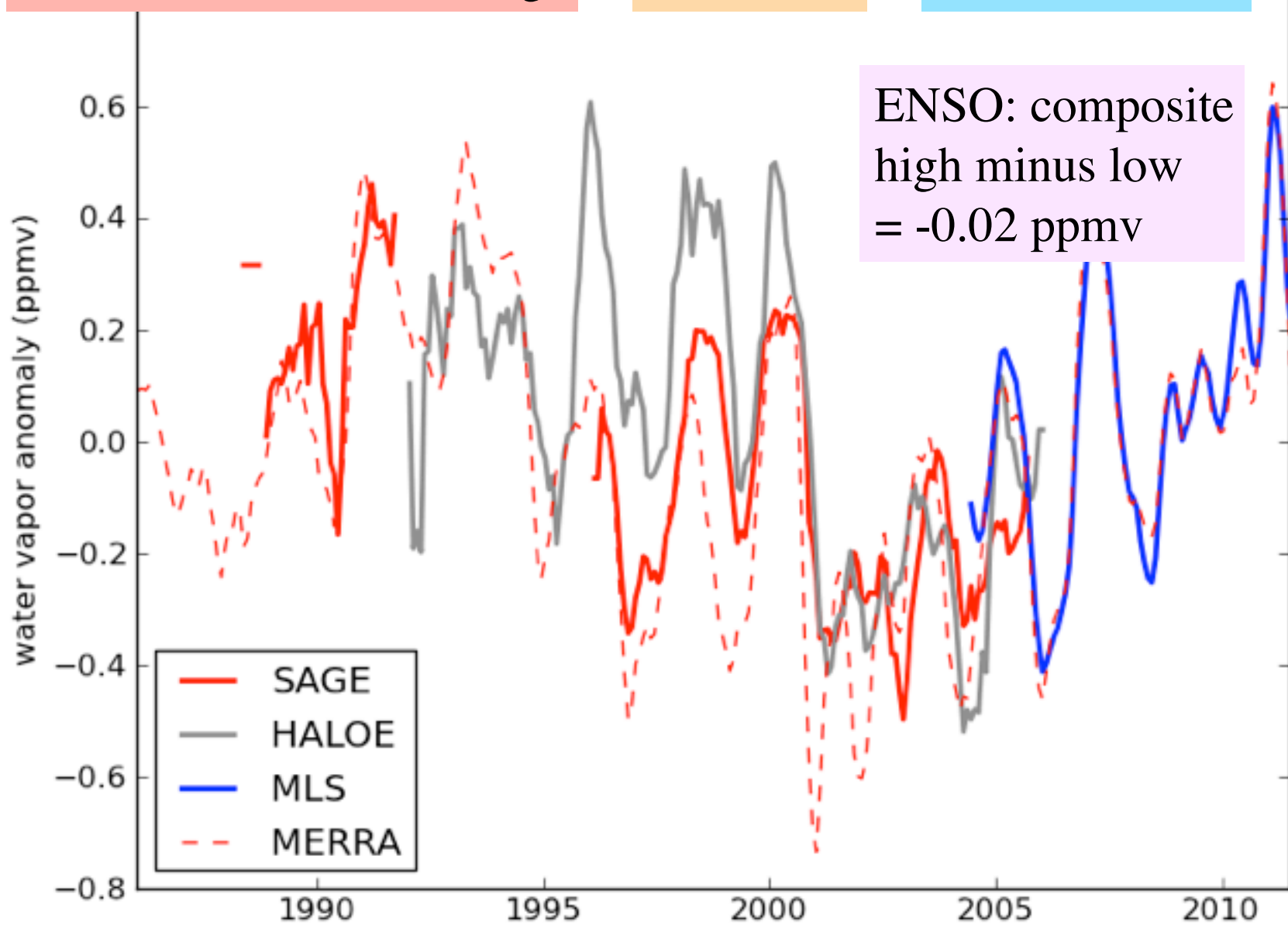
MERRA winds



82 hPa, 30°N-30°S average

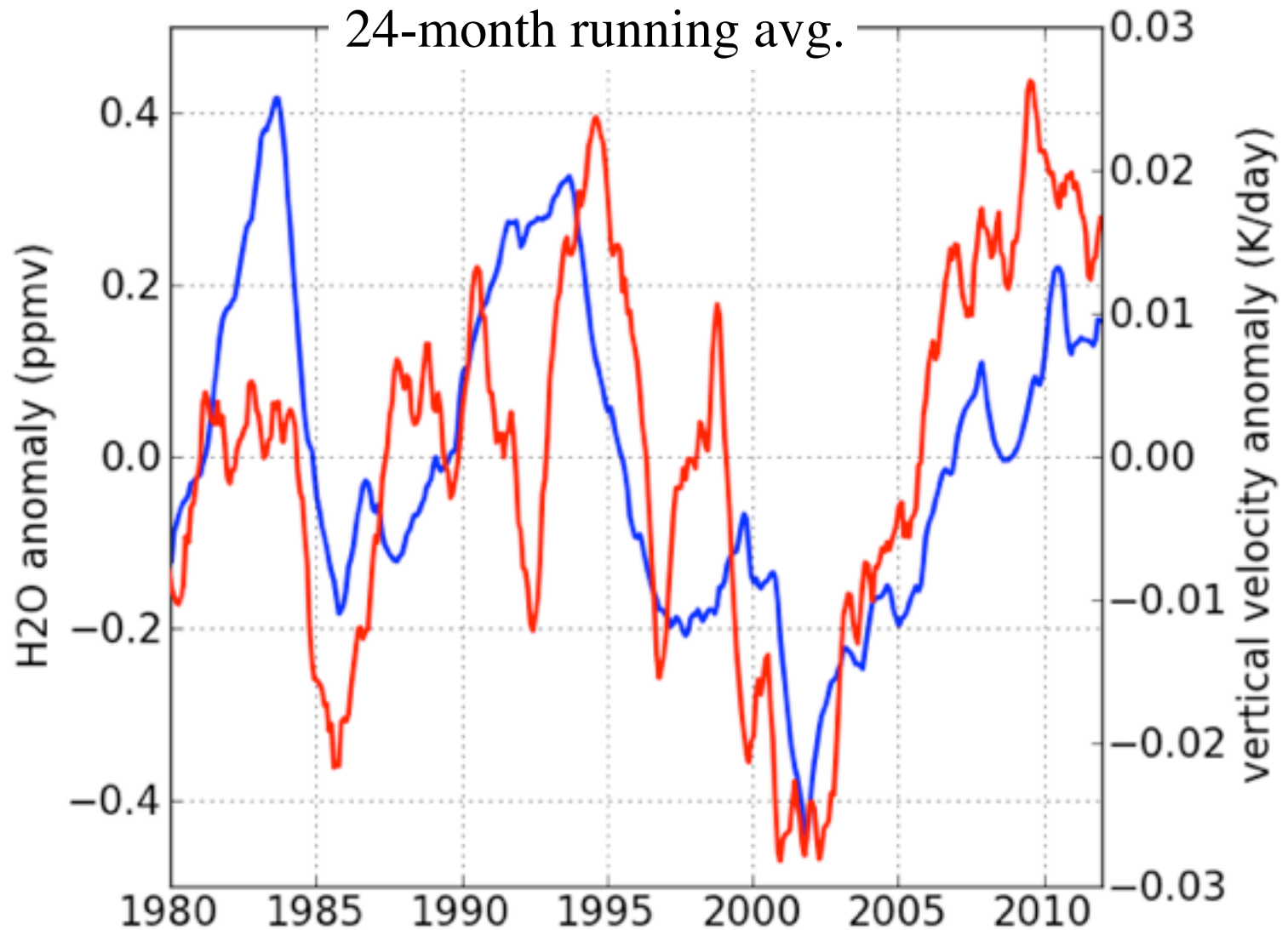
SWOOSH

MERRA winds



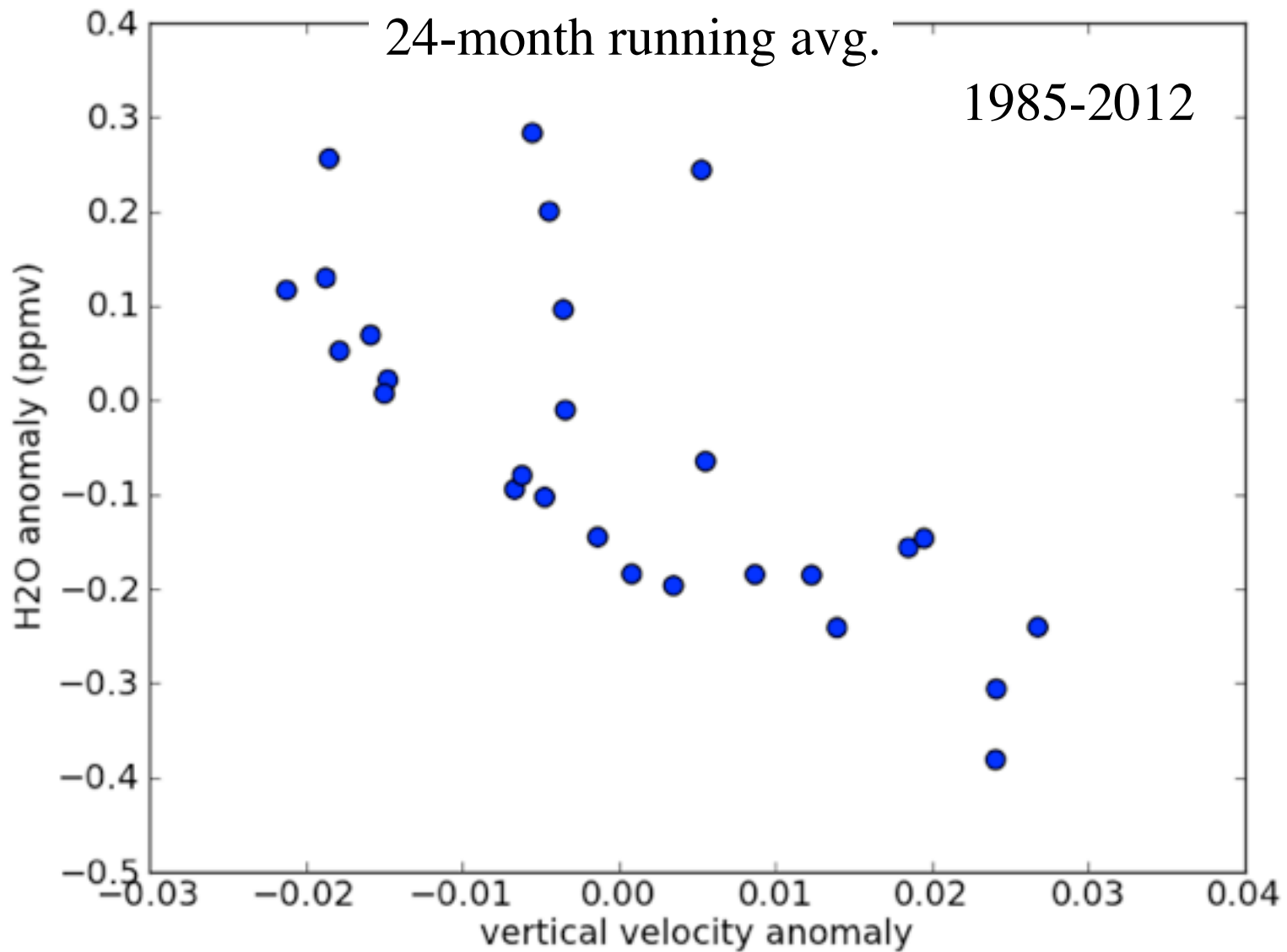
ENSO: composite high minus low = -0.02 ppmv

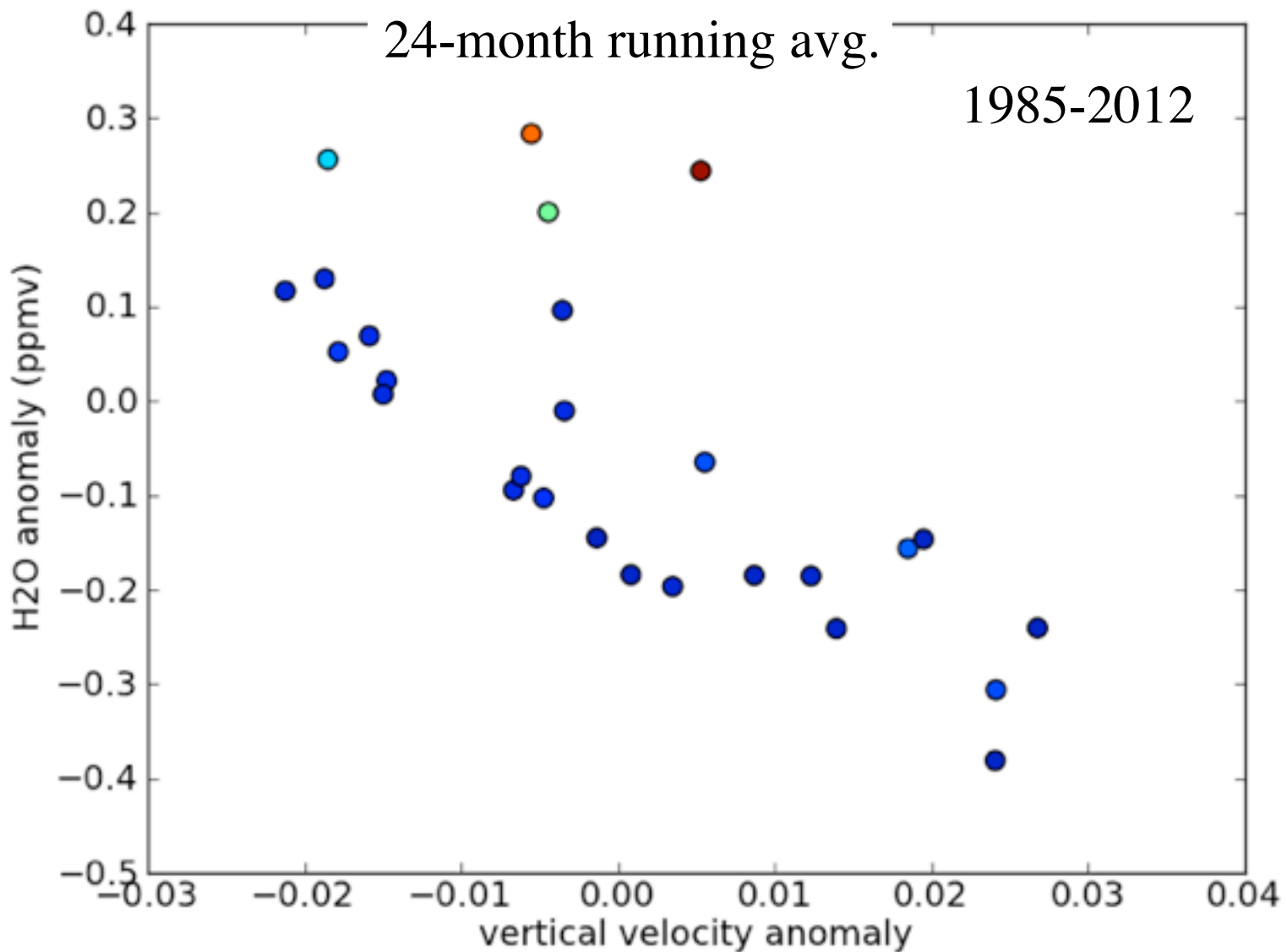
- SAGE
- HALOE
- MLS
- MERRA



blue = 82 hPa water vapor from the model, 30N-30S
 red = negative of 100 hPa heating rate, 30N-30S

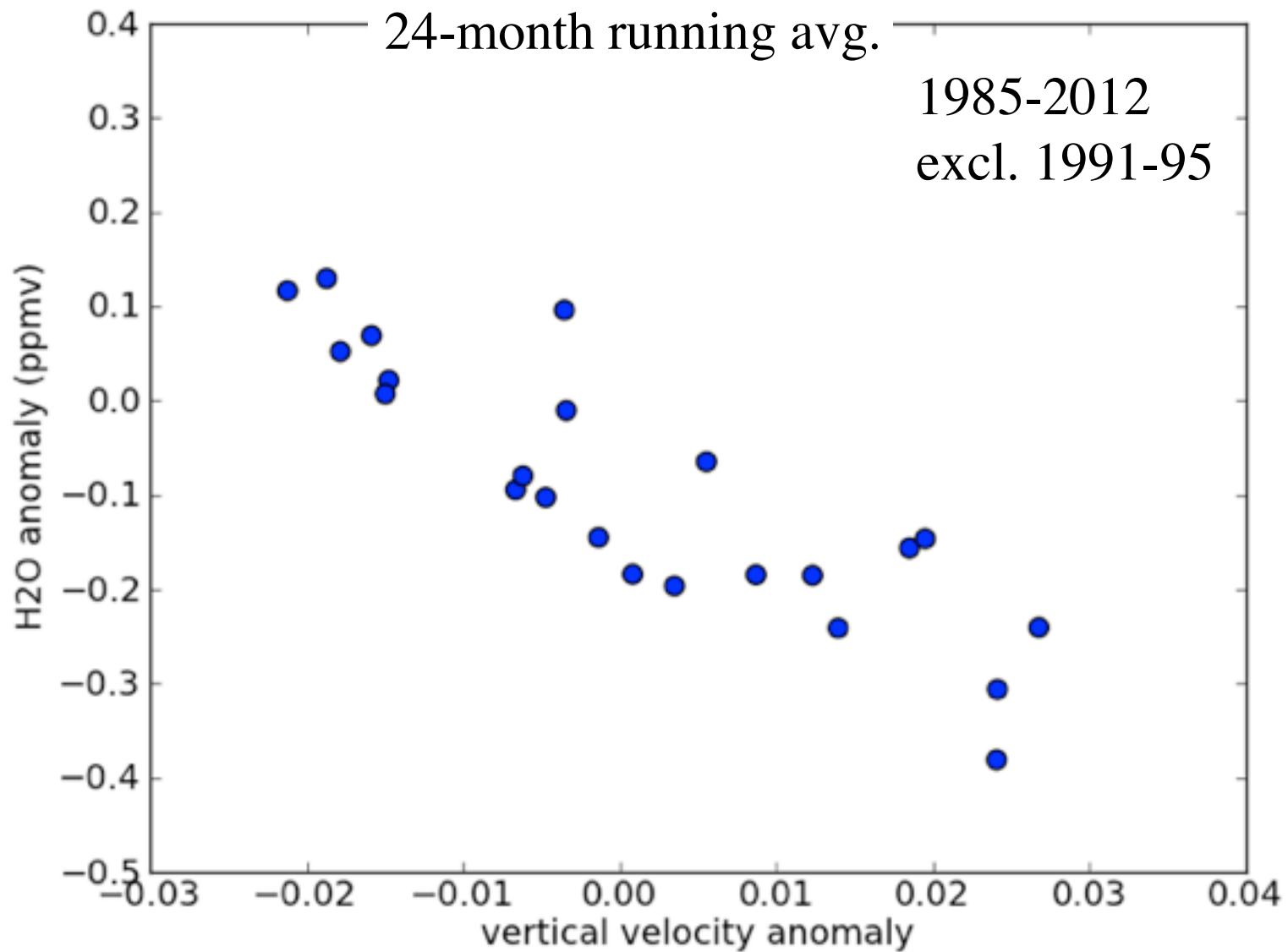


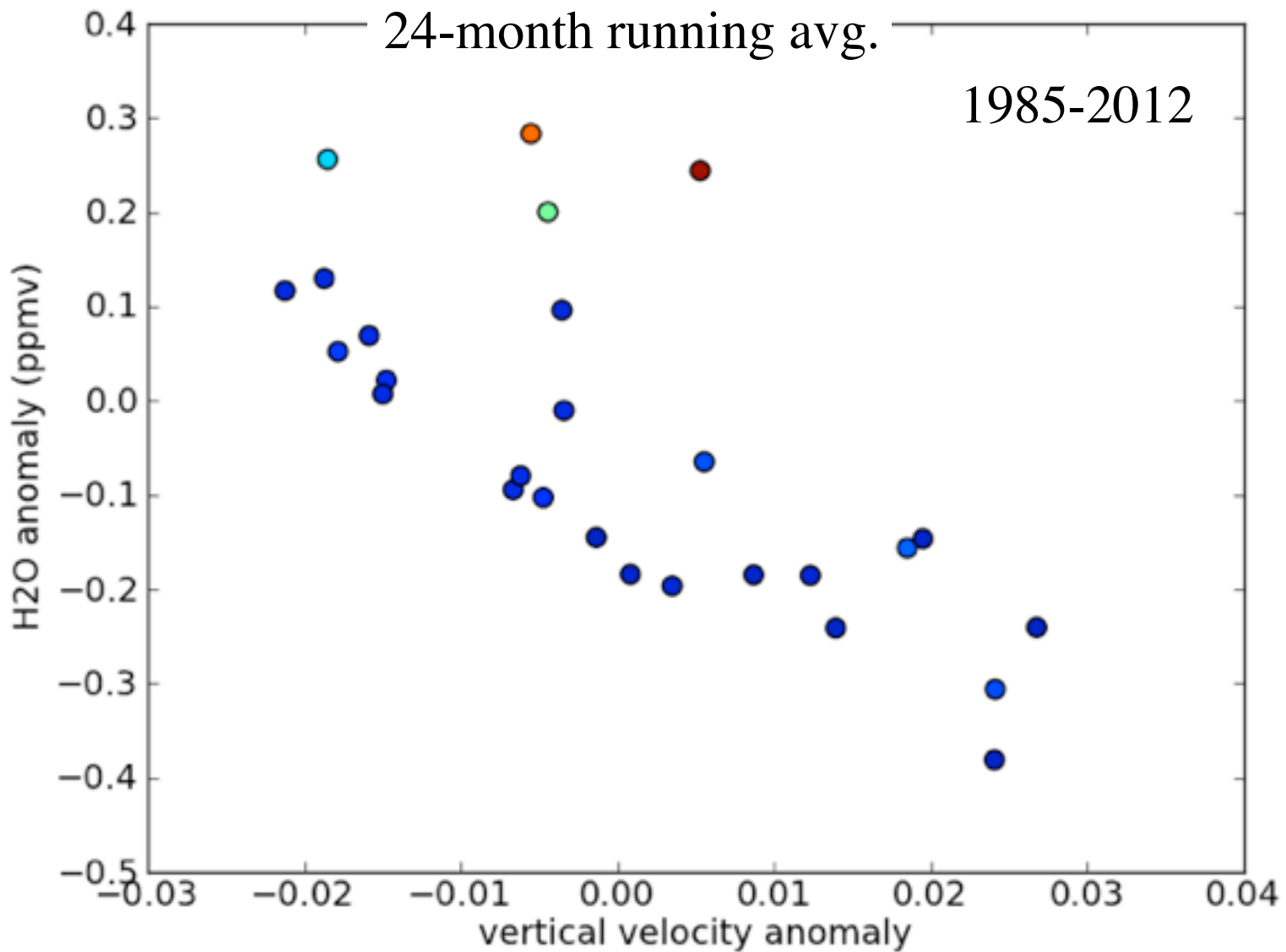




Color coded by aerosol optical depth (15-40 km)

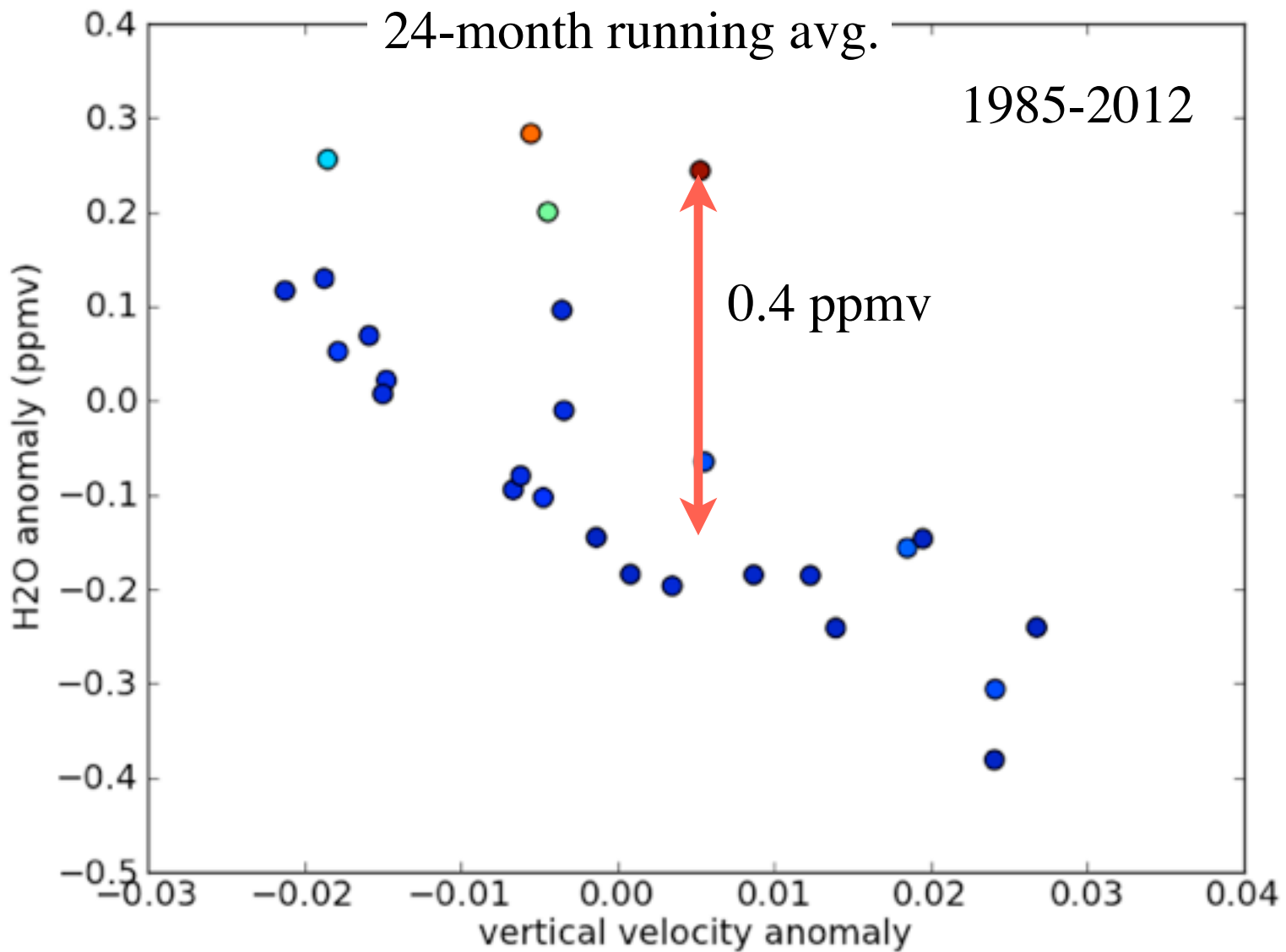






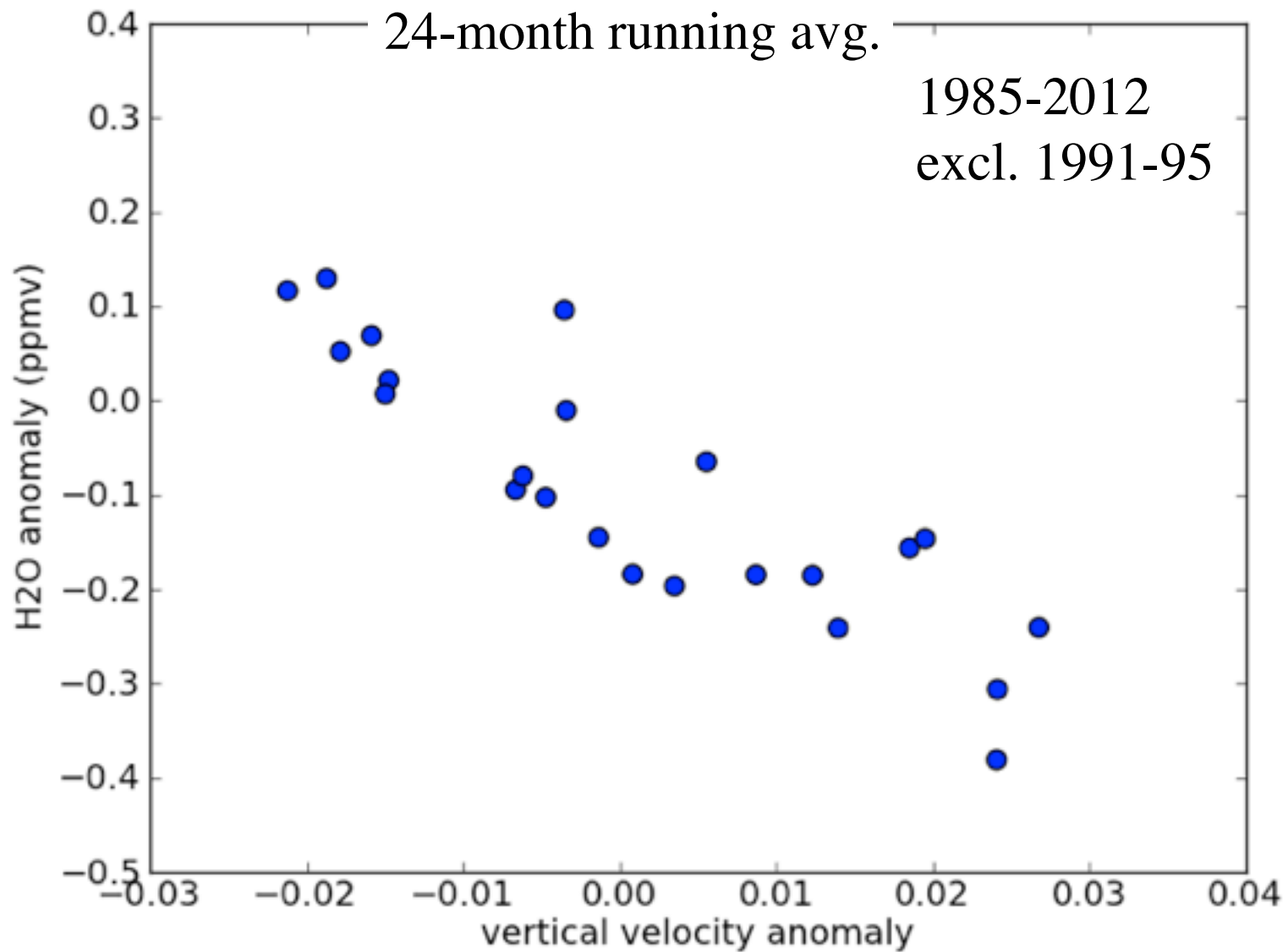
Color coded by aerosol optical depth (15-40 km)





Color coded by aerosol optical depth (15-40 km)





Conclusions

- Strat. H₂O can be accurately simulated over the last 25 years with a trajectory model using a simple microphysical assumption
- Analysis shows no increase in strat. H₂O for either long-term warming or ENSO warming
- peak-to-peak variations:
 - QBO: 0.3 ppmv
 - ENSO: ~0 ppmv
 - decadal: 0.9 ppmv
- Decadal variations due to variations in the BD circulation
- Let us know if you want to analyze our model

