MLS, HIRDLS and ACE-FTS Measurements of UTLS Trace Gases in the Context of Multiple Tropopauses and Upper-Tropospheric Jets

Aura Science Team Meeting 2011

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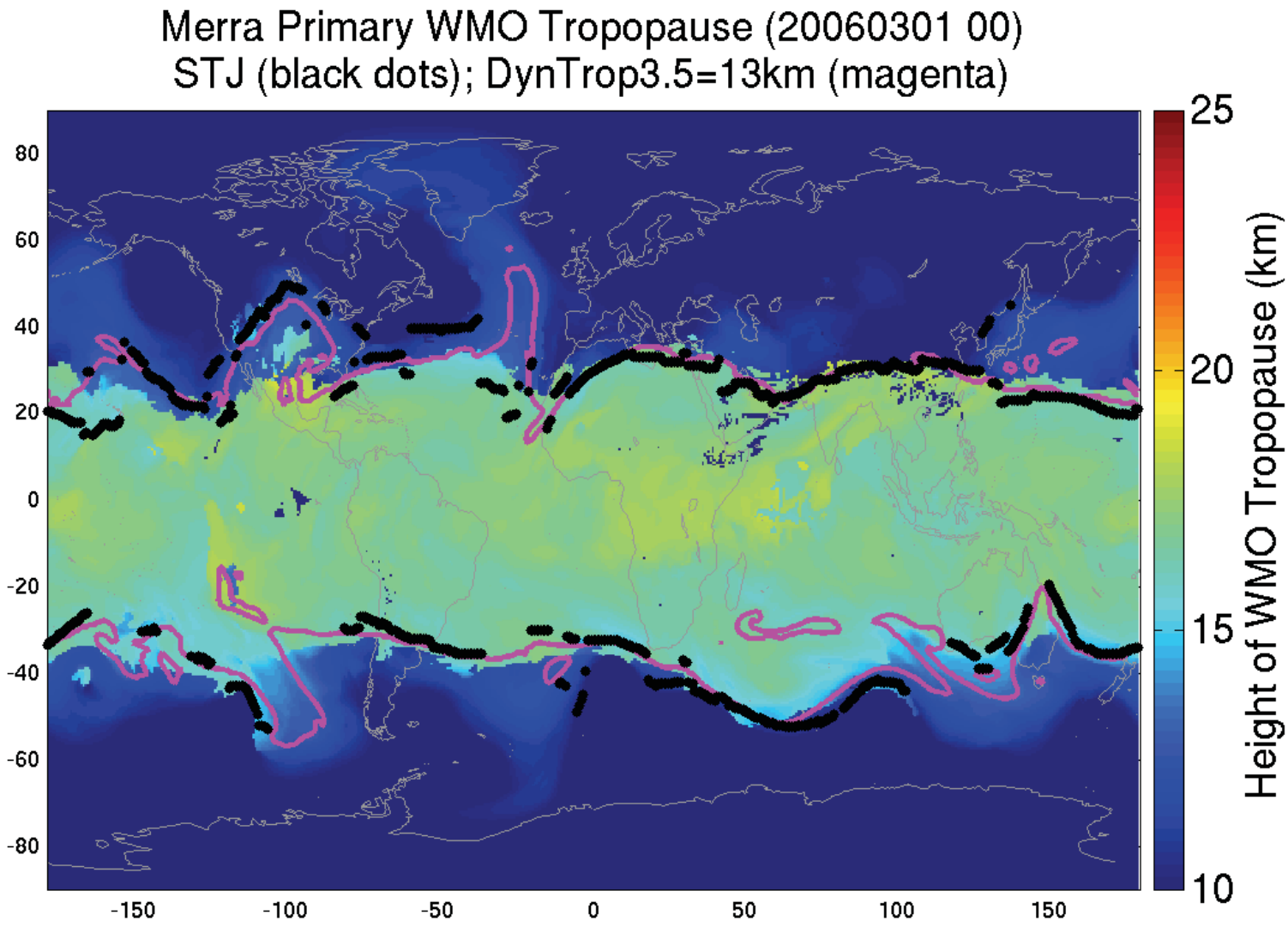
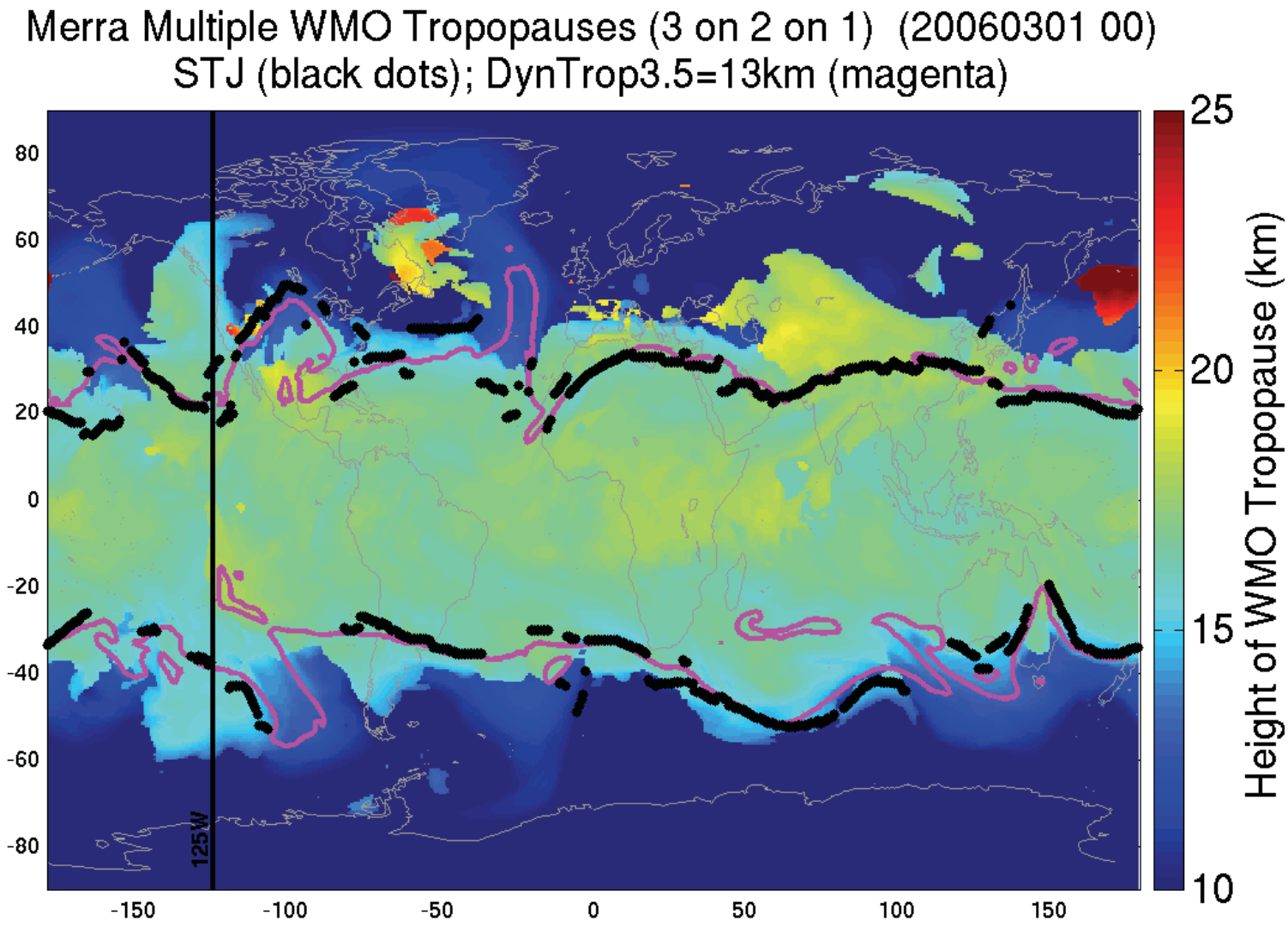
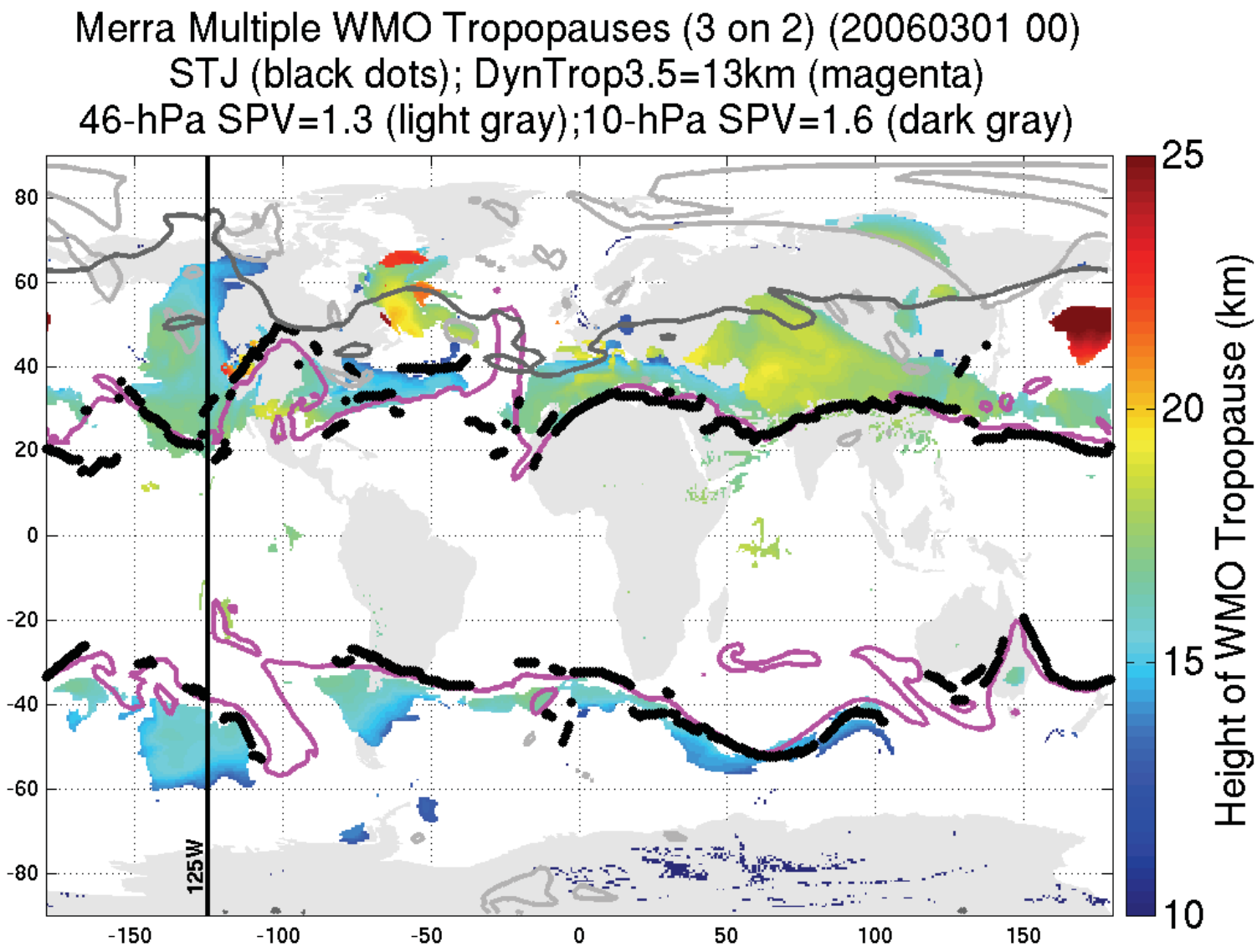
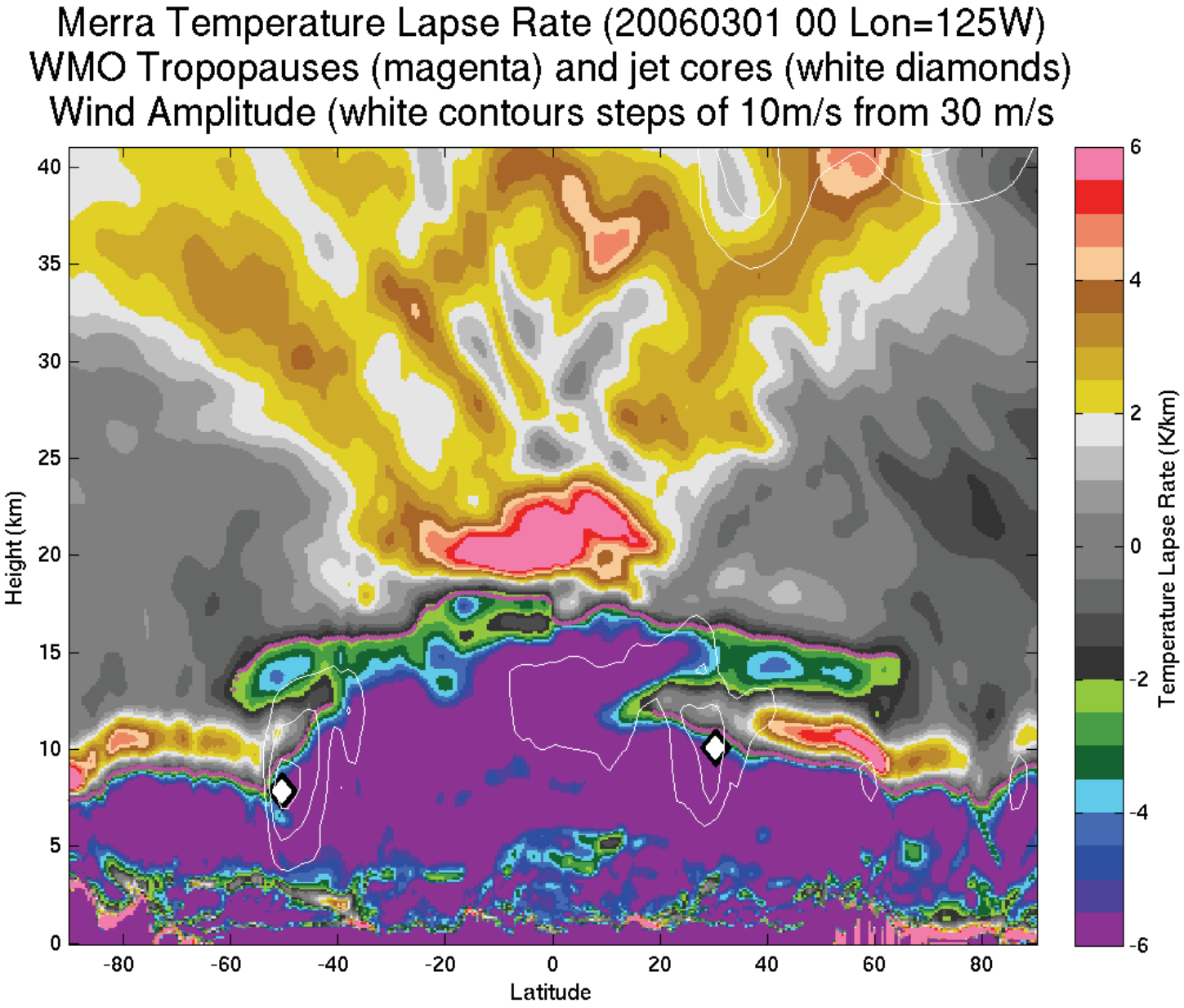
Introduction

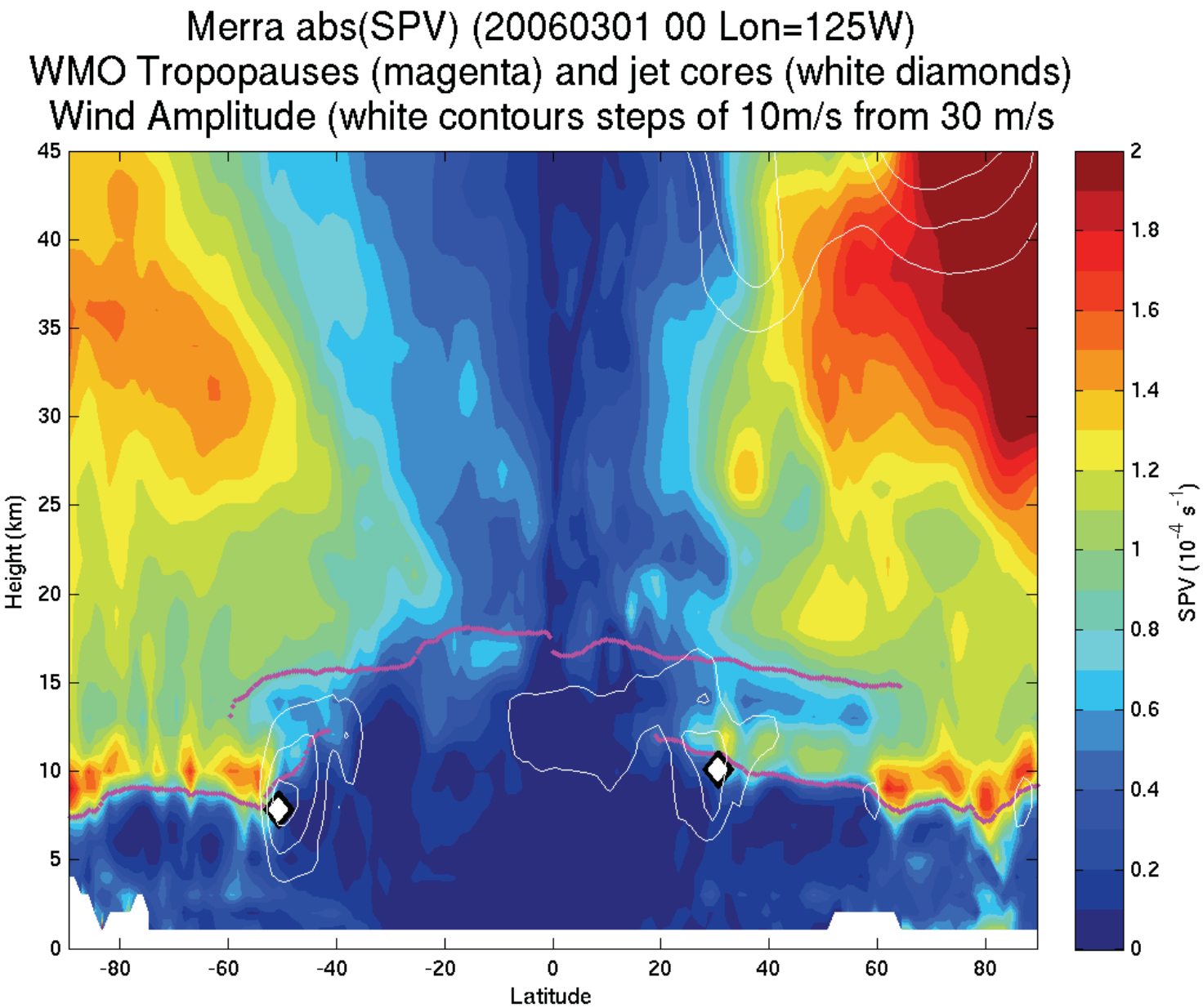
- Double thermal tropopauses in the extratropics, with the low-latitude, tropical tropopause extending over the lower, mid-latitude tropopause, are common and can extend to high latitudes (e.g. Randel et al. JGR2006).
- More recently, Pan et al. JGR2009 (HIRDLS data); Homeyer et al. JGR2011 (aircraft data) have made case studies of the injection of tropical UT air between these double tropopauses and its impact on the composition of the extra-tropical lowermost stratosphere (LMS).
- In the work described here, a more climatological view will be taken, to see whether dynamical fields from MERRA (including derived tropopause and jet locations) and composition from MLS, HIRDLS and ACE-FTS provide a consistent picture of these extratropical double-tropopause events.
- This is then a test both of the usefulness of the satellite composition measurements and of the geophysical significance of dynamical features (such as multiple tropopauses) in the MERRA (GEOS-5) assimilation.
- The lowermost stratosphere is important radiatively, so composition of the LMS (particularly abundances of H2O and O3) has significant implications for climate.


Merra Primary WMO Tropopause (20060301 00)
STJ (black dots); DynTrop3.5=13km (magenta)
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
25
20
15
10
Height of WMO Tropopause (km)

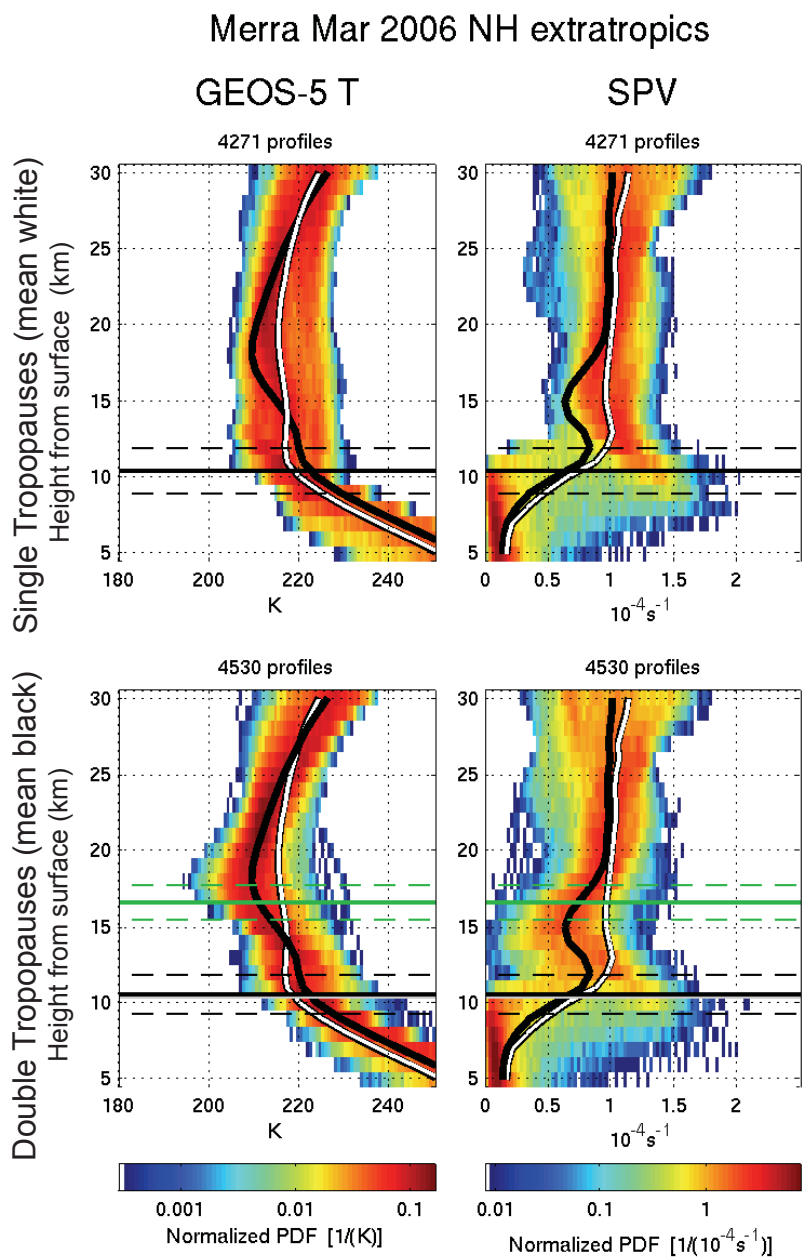

Merra Multiple WMO Tropopauses (3 on 2 on 1) (20060301 00)
STJ (black dots); DynTrop3.5=13km (magenta)
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
125W
25
20
15
10
Height of WMO Tropopause (km)


Merra Multiple WMO Tropopauses (3 on 2) (20060301 00)
STJ (black dots); DynTrop3.5=13km (magenta)
46-hPa SPV=1.3 (light gray);10-hPa SPV=1.6 (dark gray)
80
60
40
20
0
-20
-40
-60
-80
125W
-150
-100
-50
0
50
100
150
25
20
15
10
Height of WMO Tropopause (km)

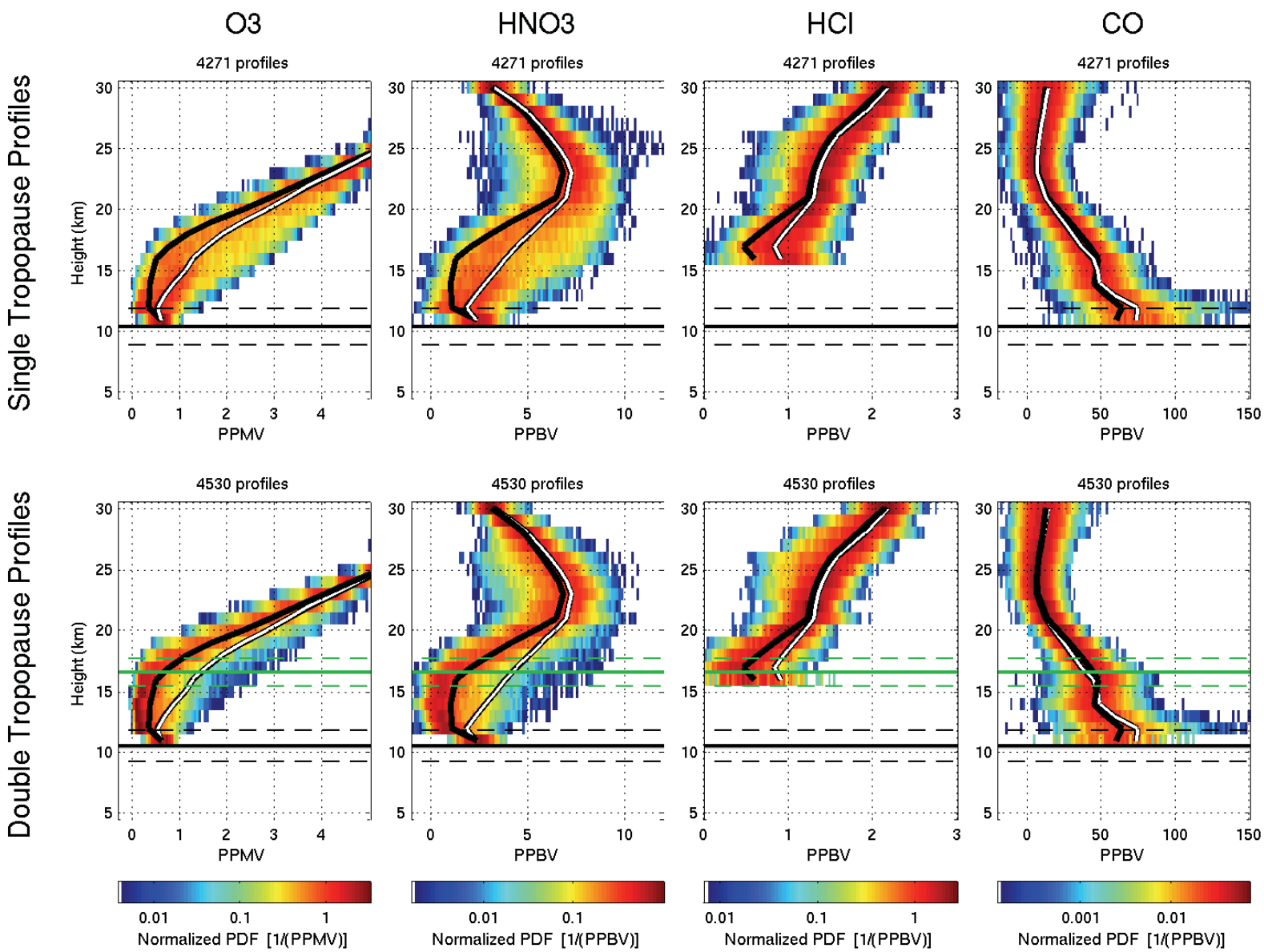

Merra Temperature Lapse Rate (20060301 00 Lon=125W)
WMO Tropopauses (magenta) and jet cores (white diamonds)
Wind Amplitude (white contours steps of 10m/s from 30 m/s
Height (km)
Latitude
Temperature Lapse Rate (K/km)
40
35
30
25
20
15
10
5
0
-80
-60
-40
-20
0
20
40
60
80
6
4
2
0
-2
-4
-6


Merra abs(SPV) (20060301 00 Lon=125W)
WMO Tropopauses (magenta) and jet cores (white diamonds)
Wind Amplitude (white contours steps of 10m/s from 30 m/s
Height (km)
Latitude
SPV (10^{-4} s^{-1})
45
40
35
30
25
20
15
10
5
0
-80
-60
-40
-20
0
20
40
60
80
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

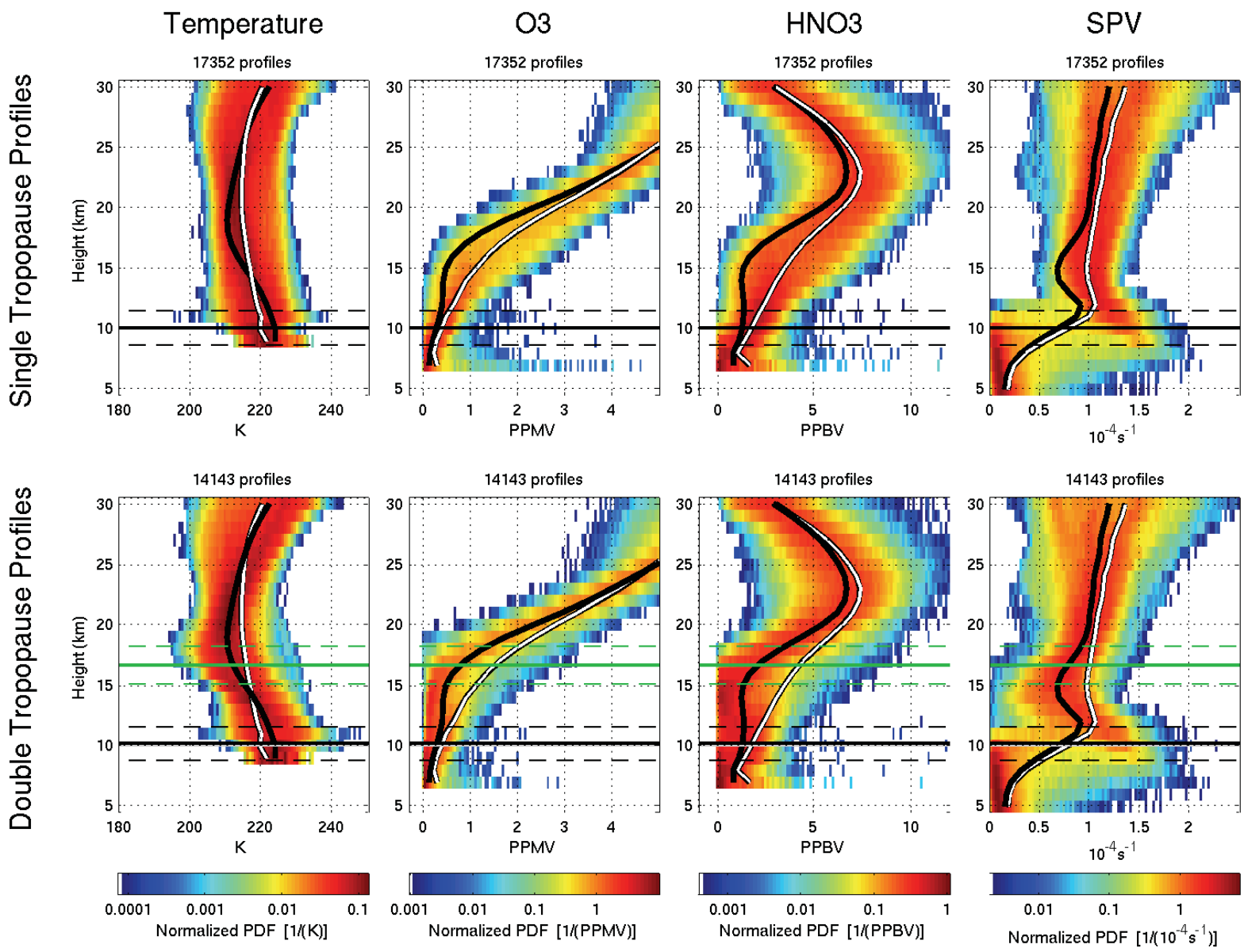
- Merra temperature and SPV are shown for single-tropopause (upper panels) and double-tropopause (lower panels) cases.
- Colors are histograms (log scale) giving an estimate of the PDFs. A tenfold drop in color would slightly more than 2 sigma for a Gaussian PDF.
- The black curves are the mean of the double-tropopause cases, the white are the single tropopause cases. They are repeated on each other's plots (underneath where they cross.)
- Black horizontal lines indicate the mean height of the primary tropopause. The secondary is in green. Dashed lines are +/- one standard deviation of the tropopause heights.



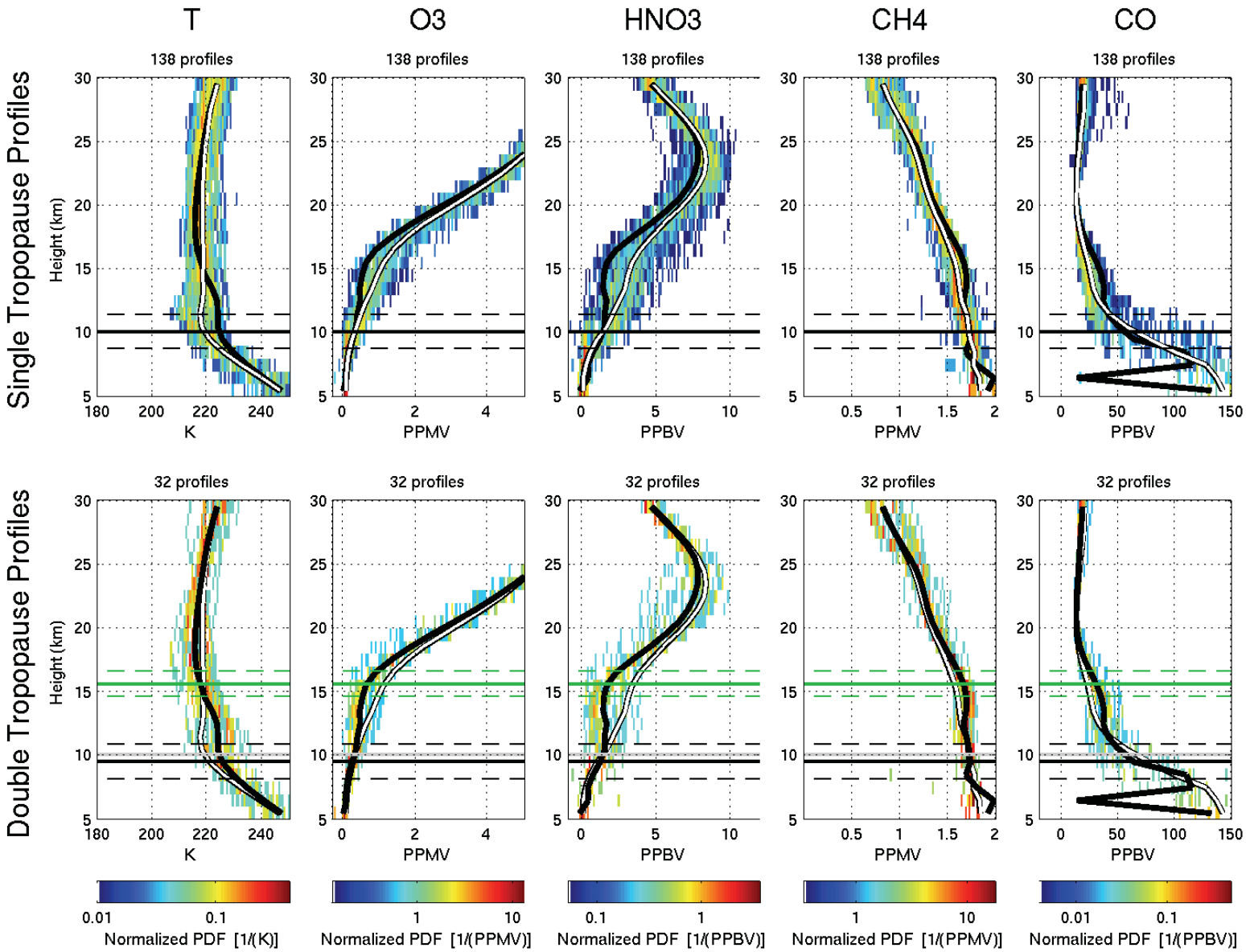
MLS fields March 2006 NH extratropics excluding sub-Vortex



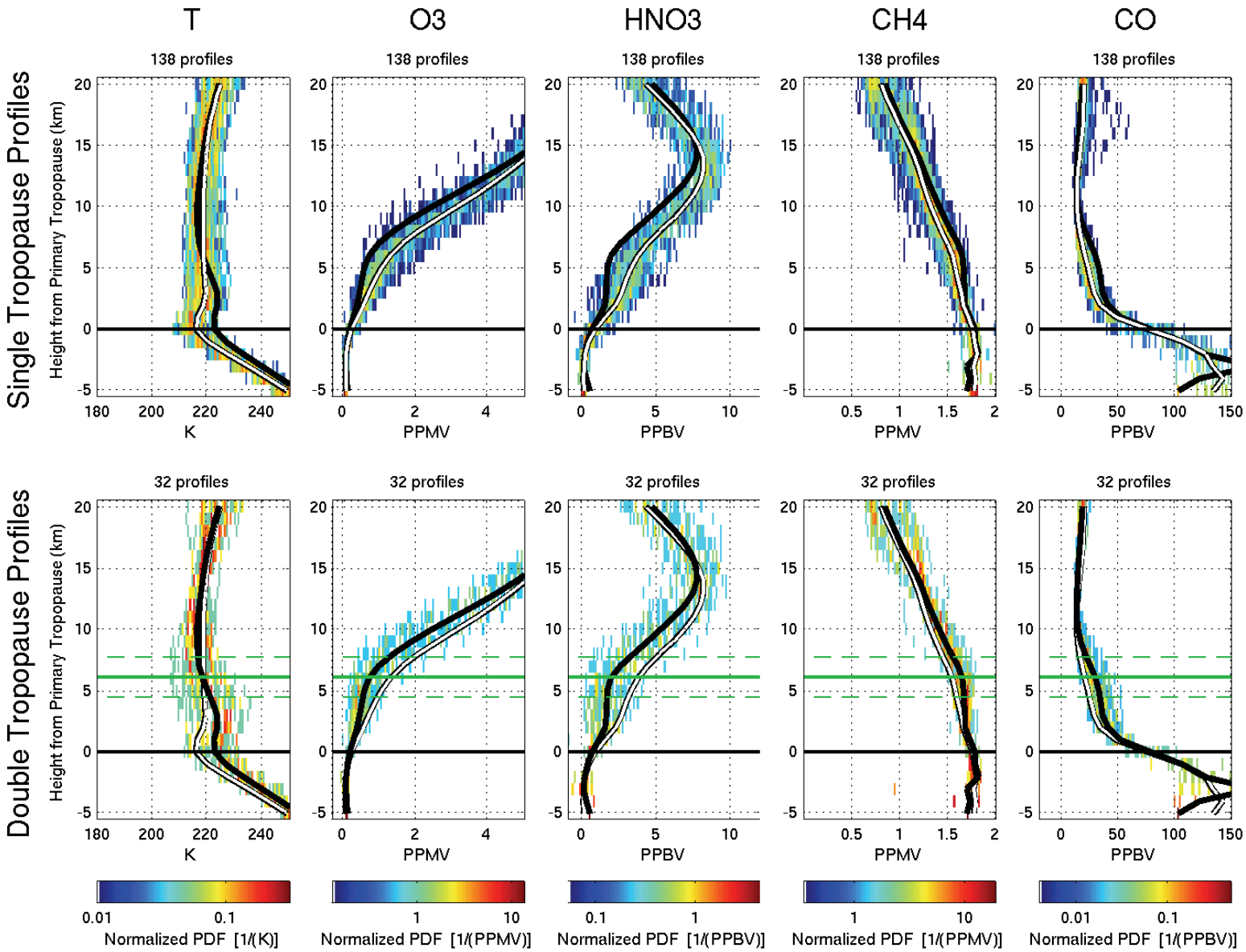
HIRDLS fields, March 2006, NH extratropics excluding sub-Vortex



ACE-FTS fields, March Climatology, NH extratropics excluding sub-Vortex



ACE-FTS fields, March Climatology, NH extratropics excluding sub-Vortex



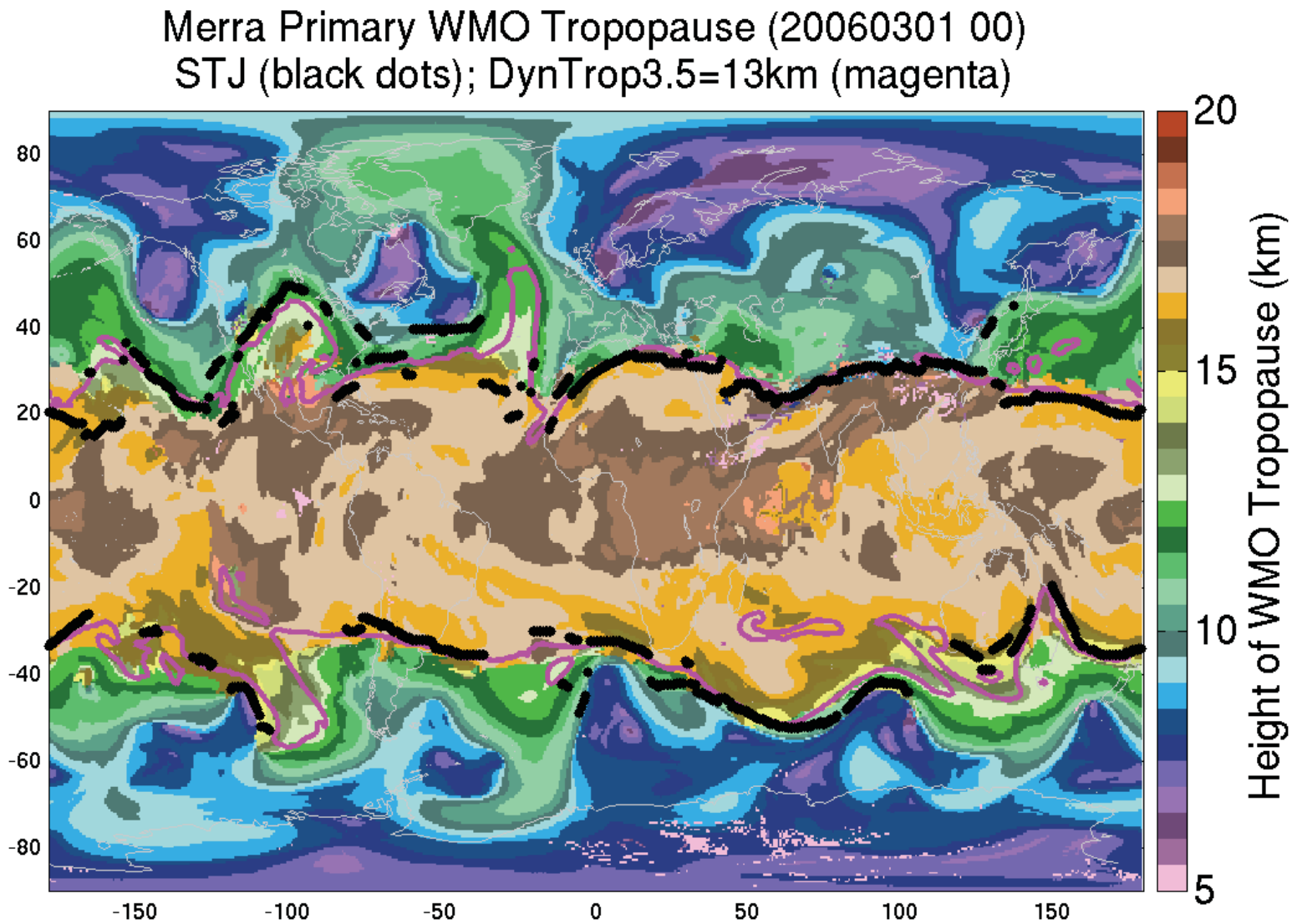
Conclusions and Further Work

- MERRA (GEOS-5) DMPs provide geophysically useful quantities, including thermal trop structure, for categorizing airmasses.
- MLS, HIRDLS and ACE-FTS provide a consistent picture of tropical tropospheric air in the layer between double tropopauses in the extratropics.
- March 2006 data have been examined in detail.
- In double-tropopause case, stratospheric source gases (O3, HNO3, HCl) have low values, characteristic of the troposphere, up to the level of the secondary tropopause.
- CO values are higher near the secondary tropopause than they are at the level of the primary tropopause and in the layer just above the primary tropopause. This morphology is in both MLS and ACE-FTS.
- MLS v3 CO still has a small high bias wrt ACE v3 CO.
- ACE-FTS sampling is weighted to high latitudes, limiting the number of profiles of interest.

Further Work

- Seasonal and inter-annual variability will be examined and a seasonal climatology will be developed.
- Routinely-processed trajectory analysis (see Livesey poster) will be used to see where parcels of interest are coming from and where they end up.

Backup Slides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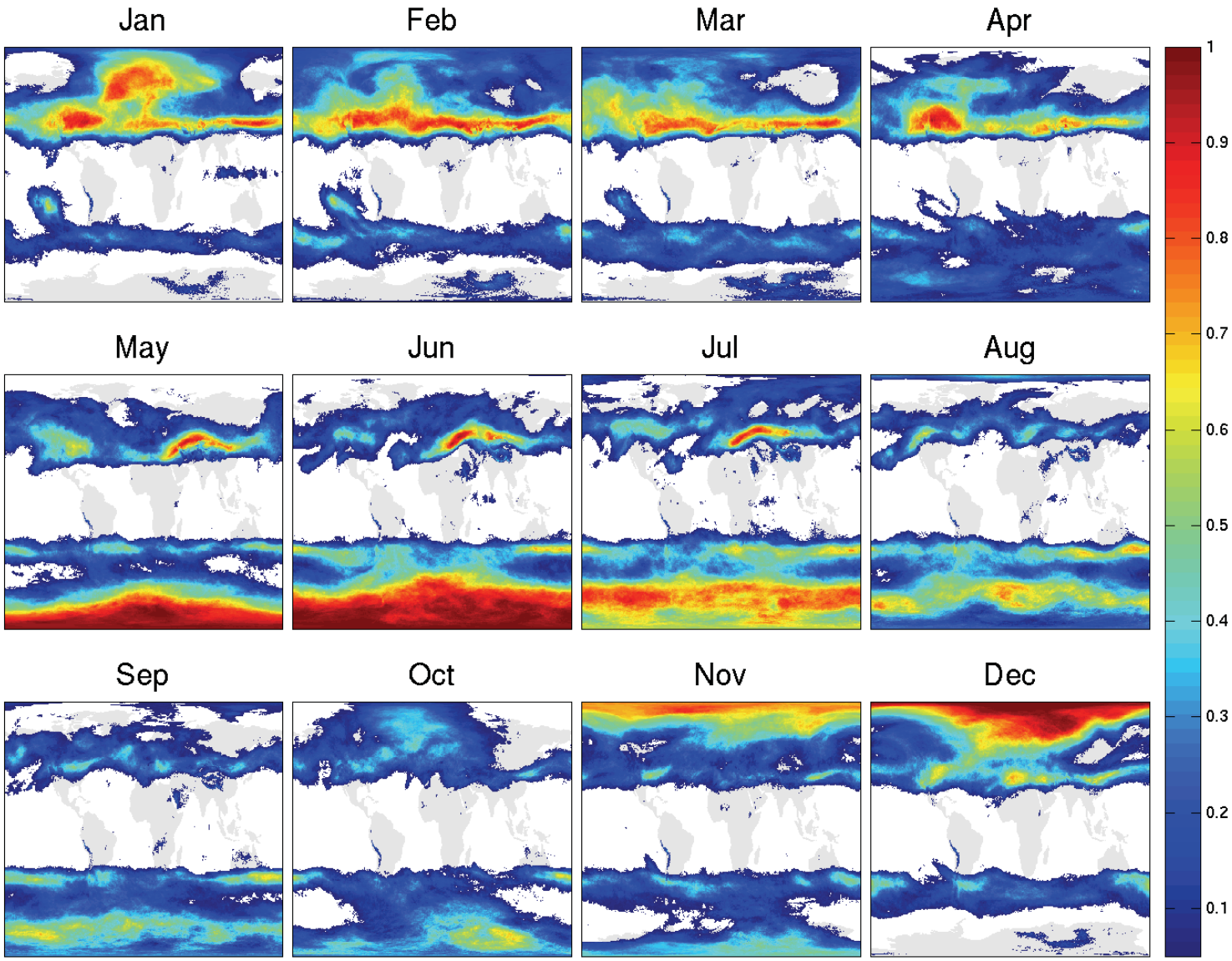
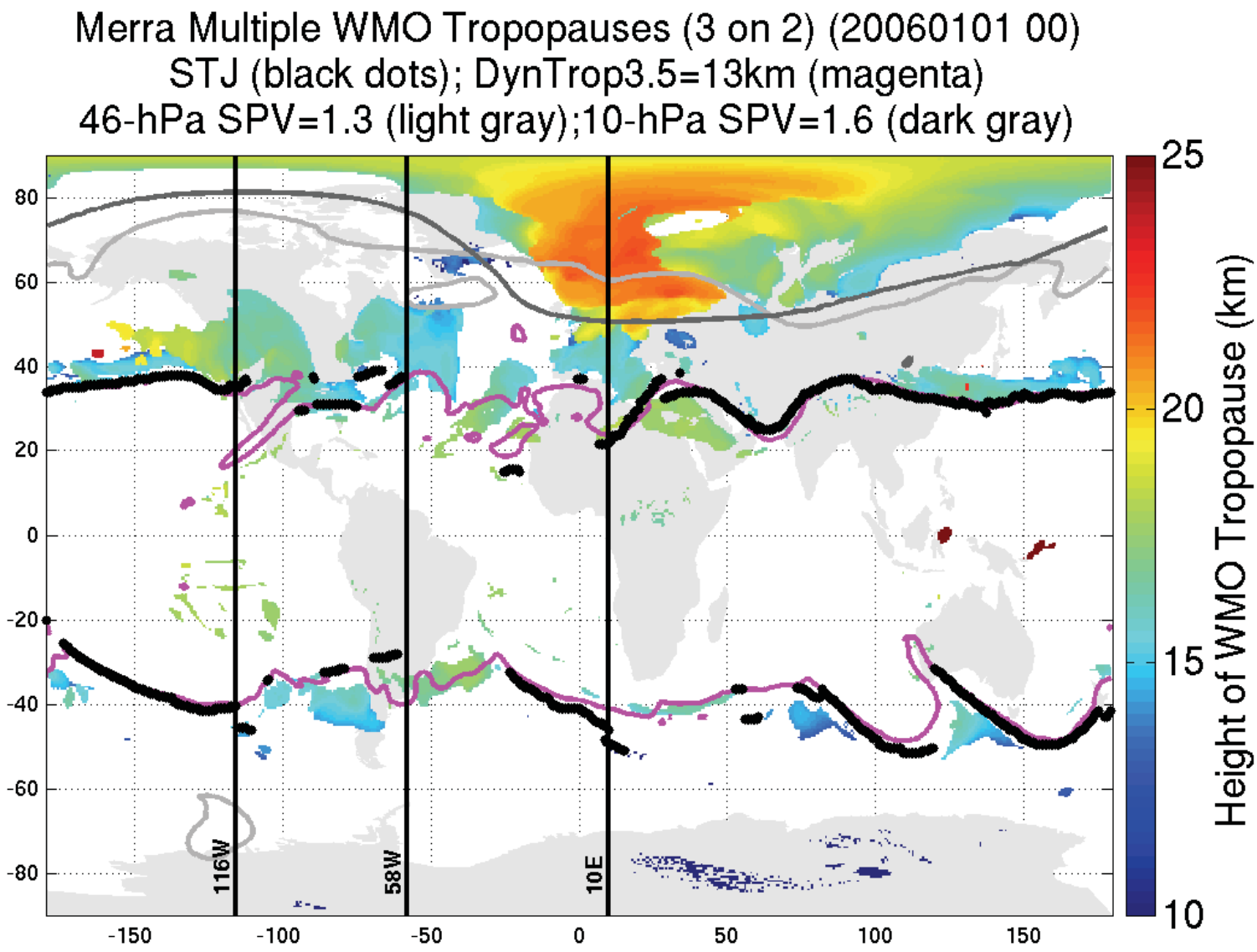
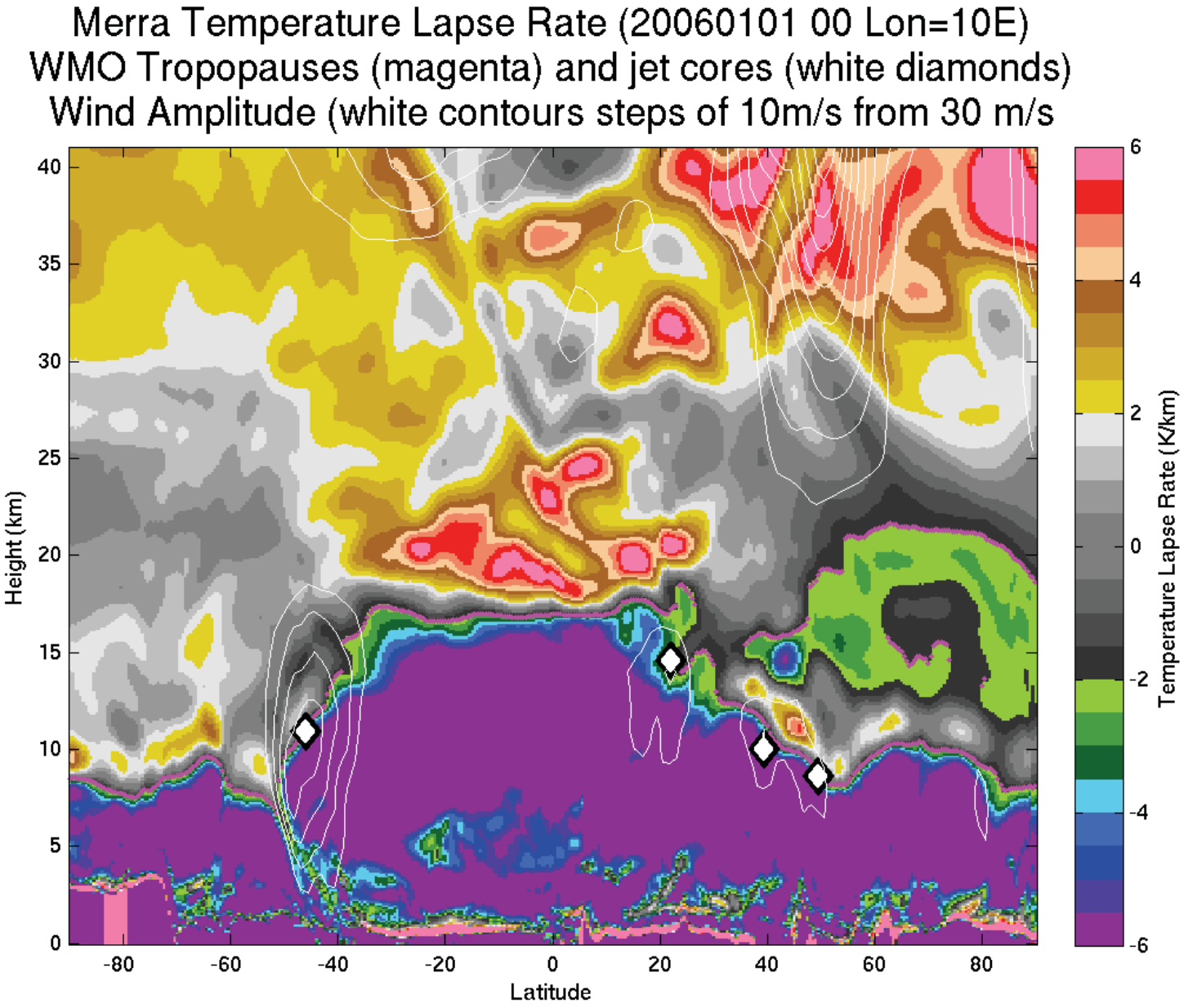
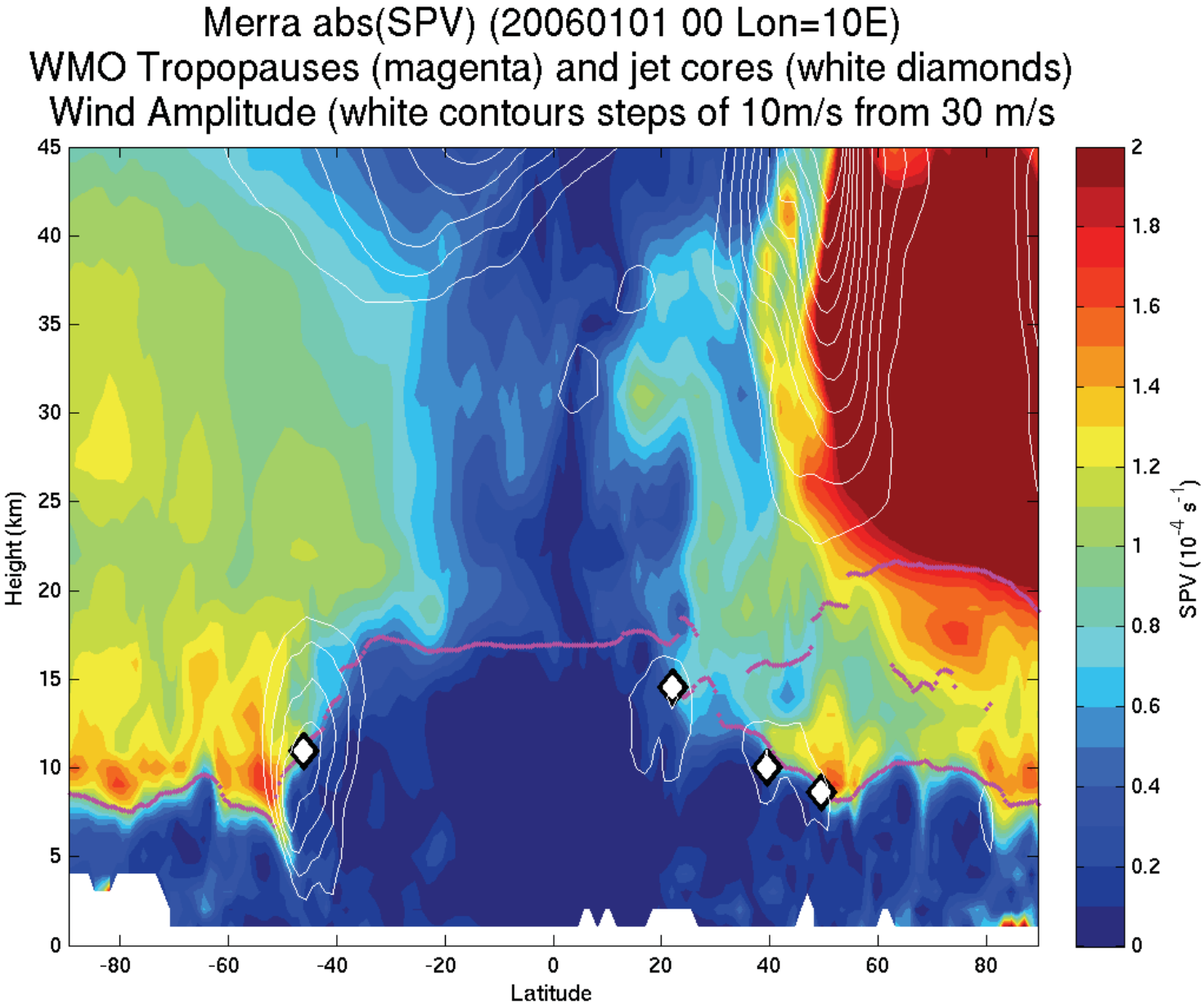
STJ (black dots); DynTrop3.5=13km (magenta)
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
20
15
10
5
Height of WMO Tropopause (km)

2006 Monthly Multiple-Tropopause Occurrence Rate




Merra Multiple WMO Tropopauses (3 on 2) (20060101 00)
STJ (black dots); DynTrop3.5=13km (magenta)
46-hPa SPV=1.3 (light gray);10-hPa SPV=1.6 (dark gray)
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
116W
58W
10E
25
20
15
10
Height of WMO Tropopause (km)


Merra Temperature Lapse Rate (20060101 00 Lon=10E)
WMO Tropopauses (magenta) and jet cores (white diamonds)
Wind Amplitude (white contours steps of 10m/s from 30 m/s
Height (km)
Latitude
Temperature Lapse Rate (K/km)
40
35
30
25
20
15
10
5
0
-80
-60
-40
-20
0
20
40
60
80
6
4
2
0
-2
-4
-6


Merra abs(SPV) (20060101 00 Lon=10E)
WMO Tropopauses (magenta) and jet cores (white diamonds)
Wind Amplitude (white contours steps of 10m/s from 30 m/s
Height (km)
Latitude
SPV (10^{-4} s^{-1})
45
40
35
30
25
20
15
10
5
0
-80
-60
-40
-20
0
20
40
60
80
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0