National Aeronautics and Space Administration

Trace Gas Evolution in the Lowermost Stratosphere from Aura MLS and ACE-FTS Data: Subvortex Processing and Transport

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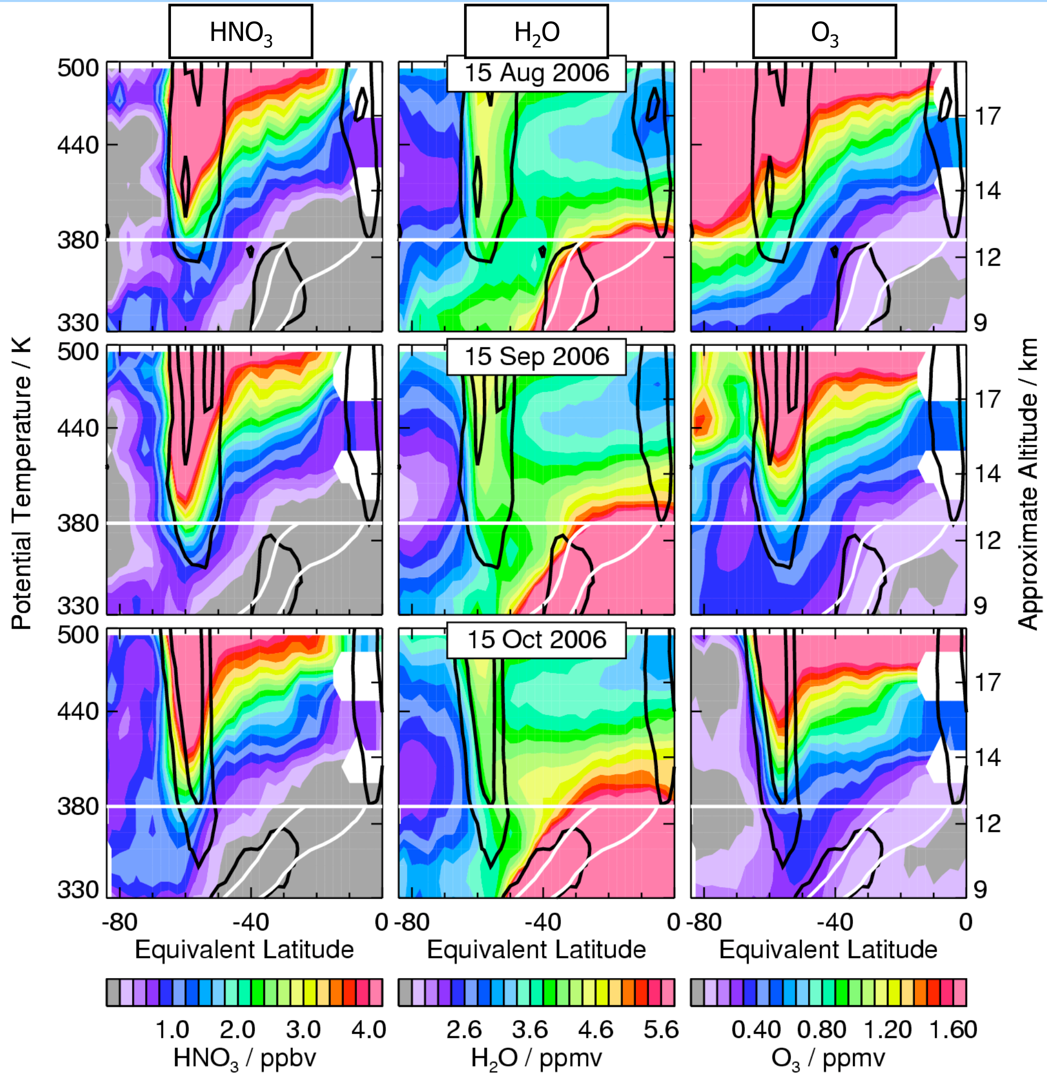
Overview of Subvortex / Extratropical UTLS Study

- Export of chemically-processed and ozone-depleted air from the polar vortex in late winter / spring can significantly affect extratropical trace gas distributions
- Chemically-perturbed air is largely confined within the vortex until it breaks down, but the degree of containment varies with altitude
- **Subvortex:** Region below strong confinement of the vortex proper
- Low temperatures and chemical processing occur in the subvortex, but it experiences more vigorous exchange with lower latitudes
- Vortex / subvortex transition varies throughout the season from ~350 to 380 K in the Antarctic and from ~400 to 450 K in the Arctic
- We investigate the seasonal, interannual, and interhemispheric variations in chemical processing in the lowermost stratosphere with:
  - Aura MLS v2.2 measurements of HNO_3, H_2O, O_3, HCl, ClO
  - ACE-FTS v2.2 measurements of HNO_3, H_2O, O_3, HCl, $ClONO_2$
- Trace gas variations are compared with the evolution of transport barriers from GMAO GEOS-5 meteorological analyses

Seasonal "Snapshots" of the Antarctic Vortex & Subvortex – I

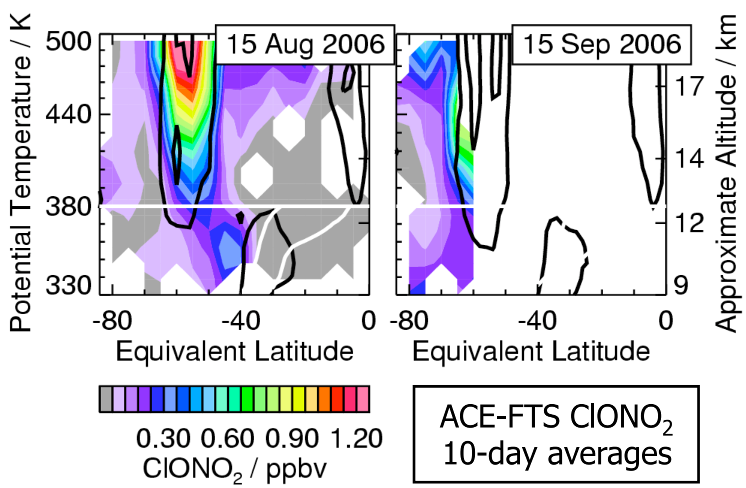
- Mid-August: HNO_3 and H_2O depleted down to bottom of vortex, O_3 still high throughout vortex / subvortex
- Mid-September: HNO_3 slightly recovered, H_2O more depleted, polar O_3 loss substantial
- Mid-October: HNO_3 & H_2O significantly recovered, O_3 severely depleted throughout vortex & subvortex
- 2006 record O_3 hole: partly due to large losses in the subvortex

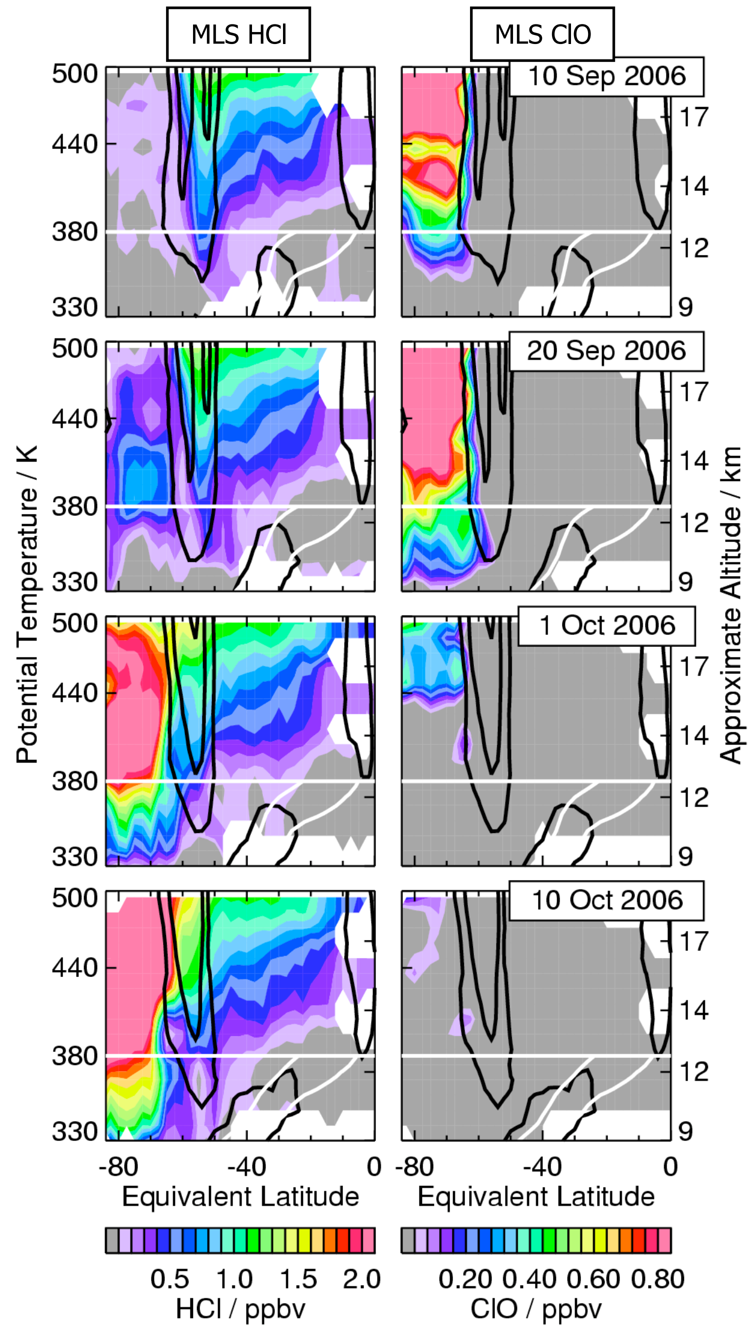


White contours: Tropopause (1.5, 4.5 PVU)
Black contours: Vortex edge, Subtropical jet

Chlorine Activation in the Antarctic Lowermost Vortex & Subvortex

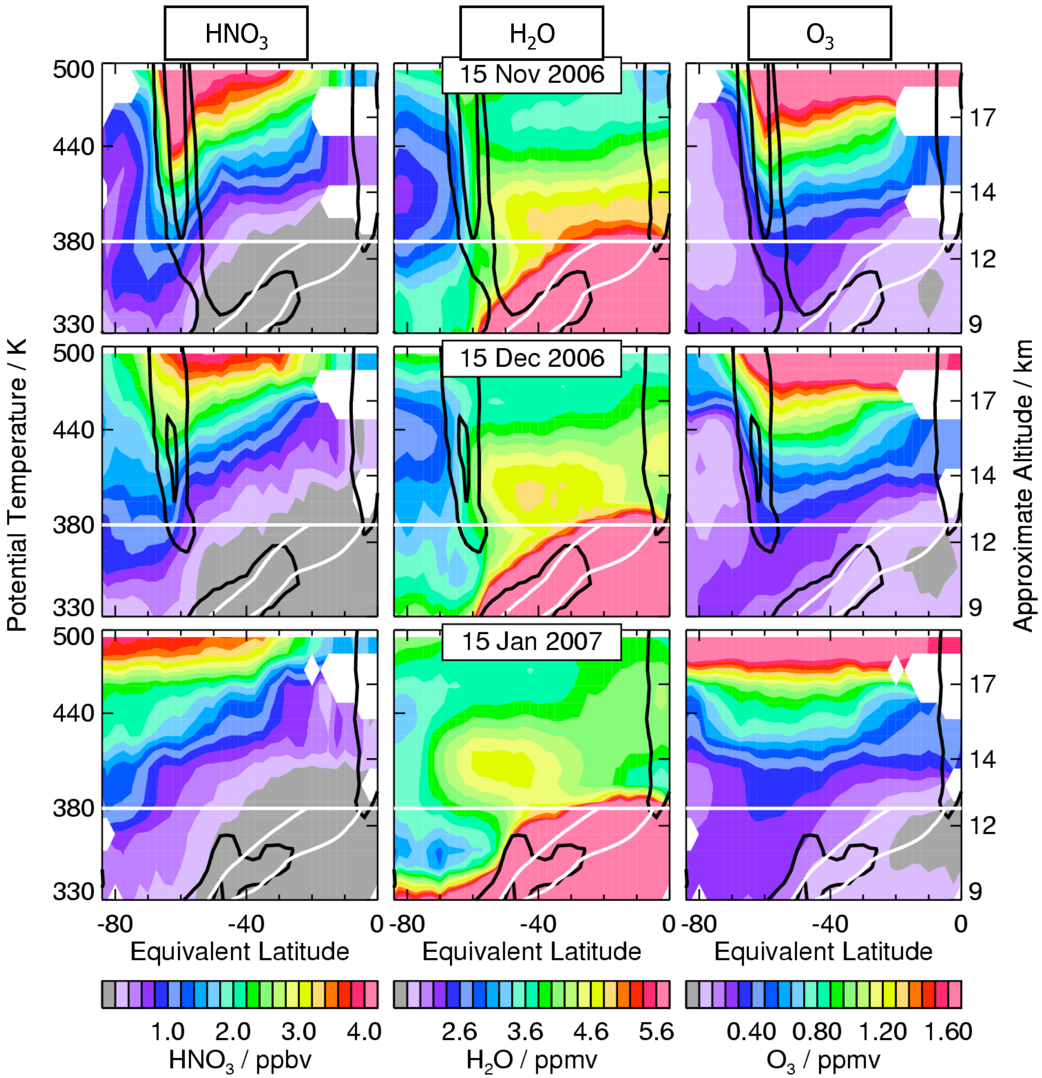
- CALIPSO observed PSCs at the 10–15 km level from late June through mid-September in 2006 [Pitts et al., ACP 7, 2007]
- HCl and $ClONO_2$ are depleted and ClO is greatly enhanced — thus substantial chlorine activation is widespread inside the Antarctic lowermost polar vortex / subvortex



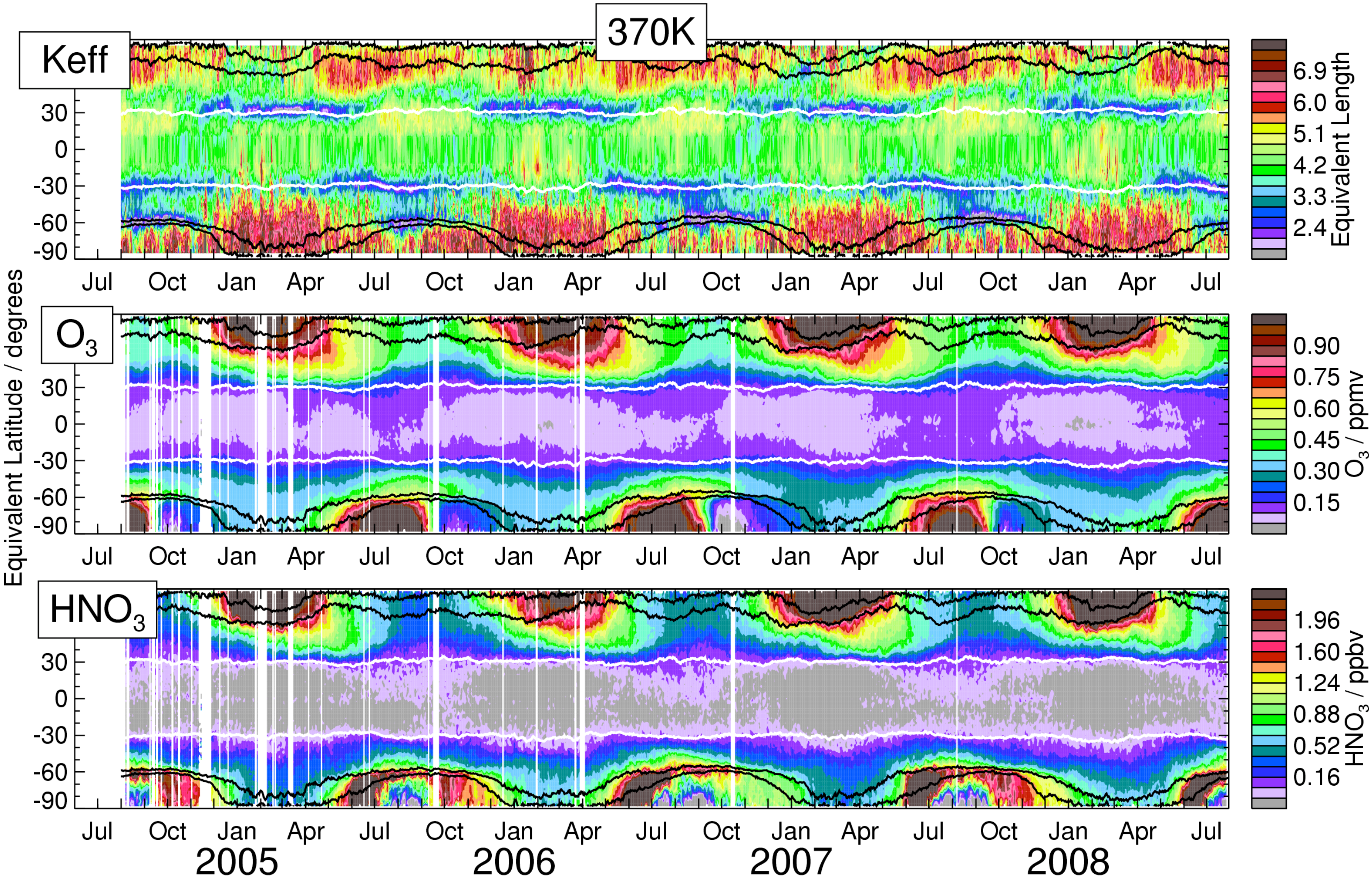


Seasonal "Snapshots" of the Antarctic Vortex & Subvortex – II

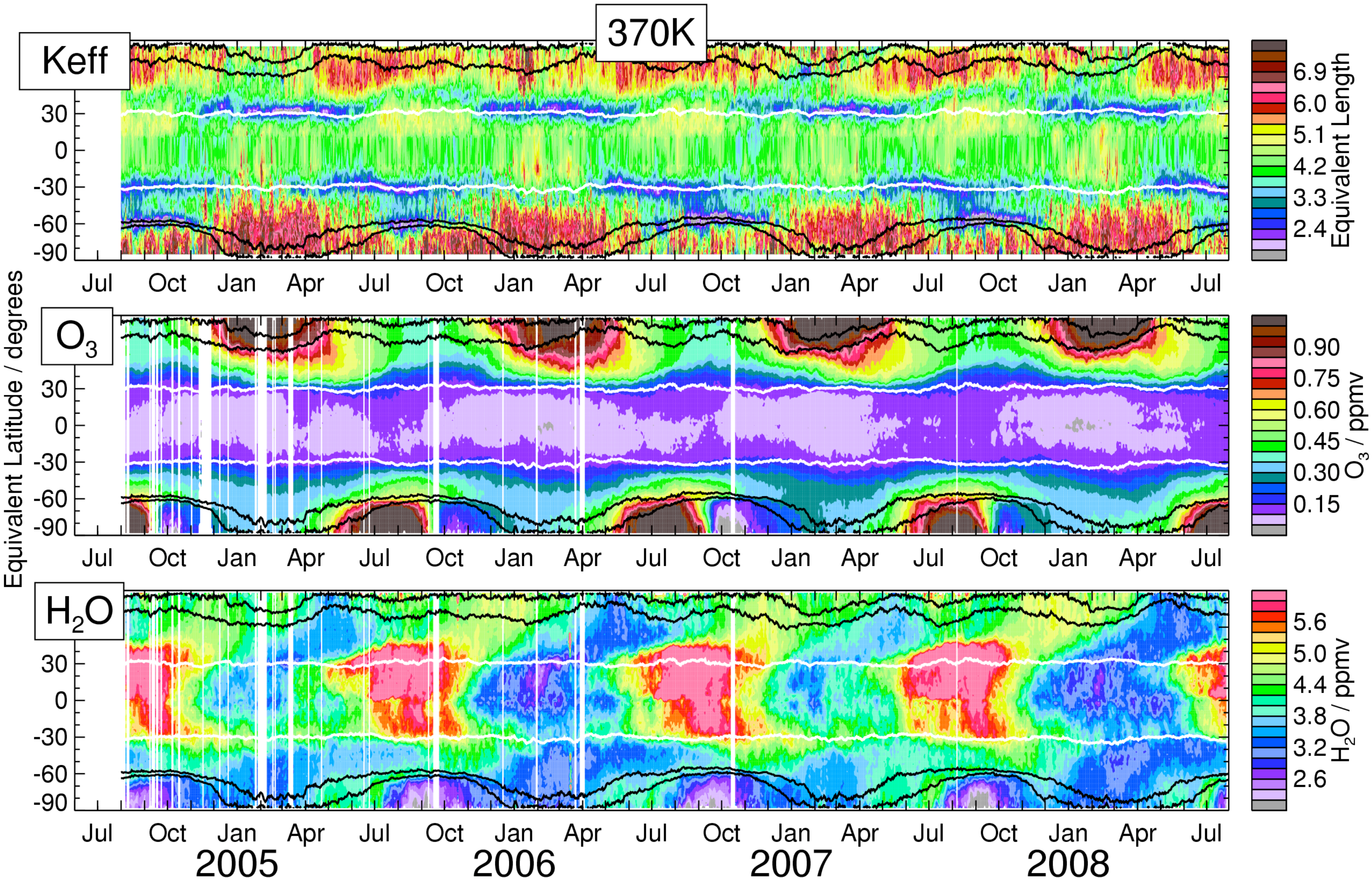
- **Mid-November:** Low HNO_3 & H_2O imply denitrification & dehydration, O_3 recovery significant
- **Mid-December:** Vortex starting to erode, homogenization of trace gas contours suggests exchange of polar & midlatitude air
- **Mid-January:** With the vortex broken down, the subtropical jet / tropopause is the major transport barrier



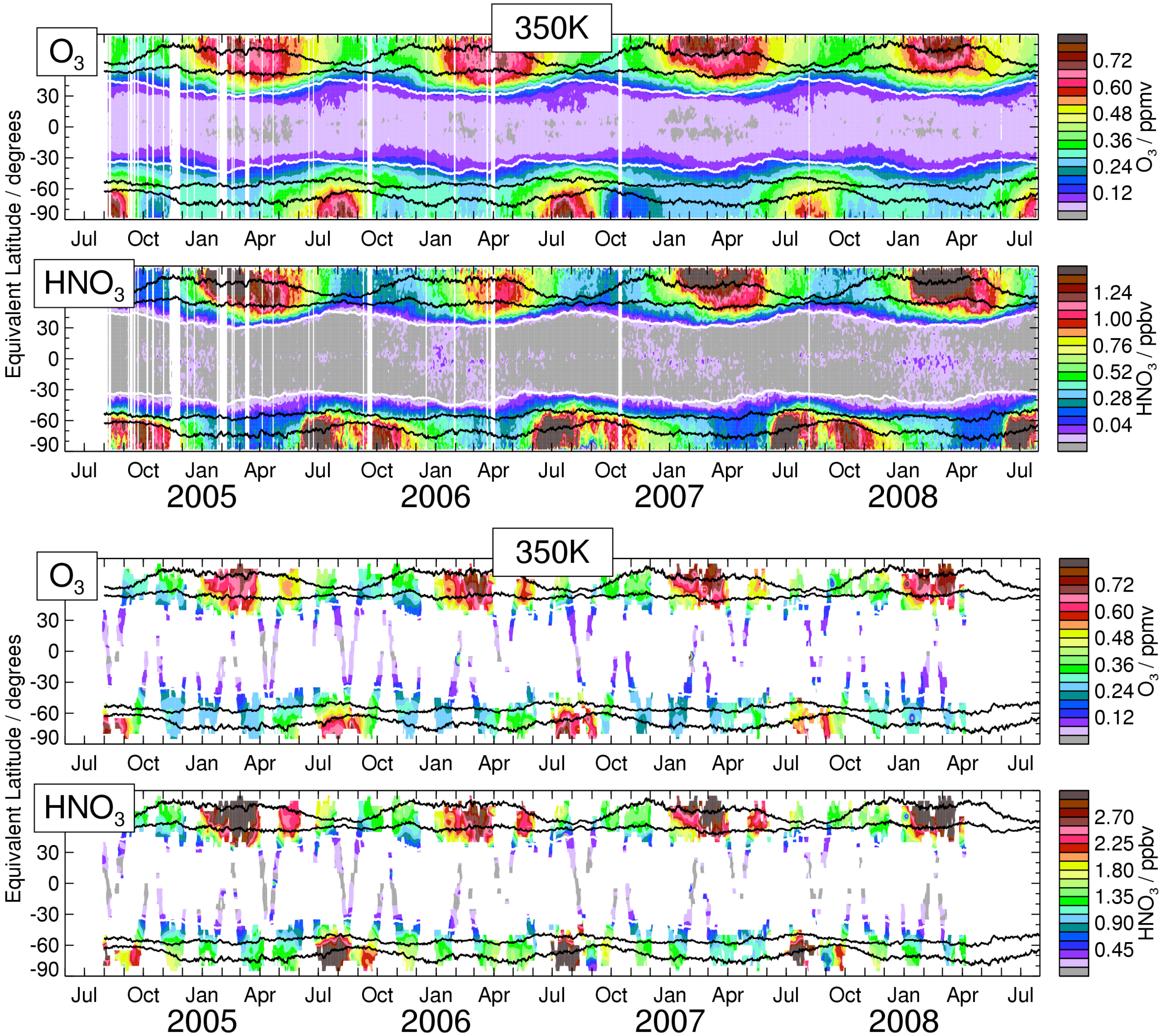
Evolution of Transport Barriers & MLS Trace Gases – I



Evolution of Transport Barriers & MLS Trace Gases – II



Comparison of Aura MLS and ACE-FTS Measurements



Aura MLS

- ✦ Aura MLS and ACE-FTS data generally show very consistent features

ACE-FTS

Summary & Conclusions

- ✦ Four years of Aura MLS and ACE-FTS v2.2 measurements were analyzed along with GEOS-5 meteorological data to investigate interhemispheric and interannual variations in chemical processing and transport barriers in the lowermost stratosphere
- ✦ Chemical processing — denitrification, dehydration, chlorine activation, and ozone loss — occurs throughout the lowermost polar vortex and down into the subvortex in the Southern Hemisphere
- ✦ The breakdown of the vortex at the end of Antarctic winter (mid-December or January depending on the year) allows mixing between polar-processed and lower-latitude air
- ✦ At this time a transition takes place from the vortex to the subtropical jet / tropopause being the major transport barrier
- ✦ Observed changes in trace gas distributions are consistent with the evolution of transport barriers diagnosed from meteorological data