WACCM Studies at CU/LASP

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Outline

Introduction of the Direct vs. Indirect effect of EPP

Randall et al. (2015) – Ongoing Challenges in Simulating the Indirect Effect of EPP on the Atmosphere

CU/LASP assisting with the "Sathist" capability

RAISE - Response of the Atmosphere to Impulsive Solar Events

Josh Pettit is the LASP point-of-contact for WACCM simulations in support of RAISE

Challenges in Simulating the Indirect Effect of Energetic Particle Precipitation on the Atmosphere

Cora Randall, et al. (2015), Simulation of energetic particle precipitation effects during the 2003-2004 Arctic Winter, JGR Space Physics, in press.

Energetic Particle Precipitation (EPP)

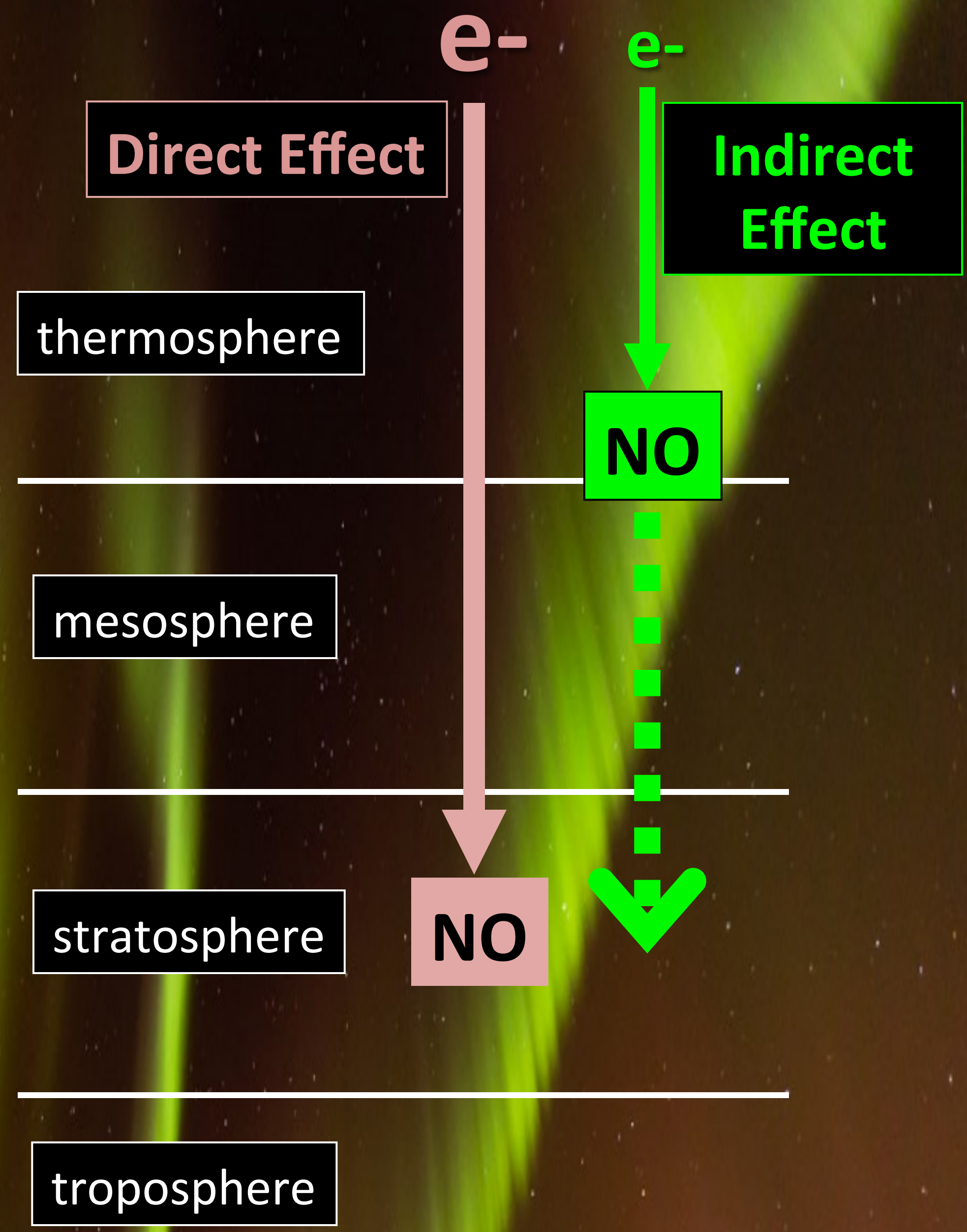
↓↓↓

Ionization & Dissociation

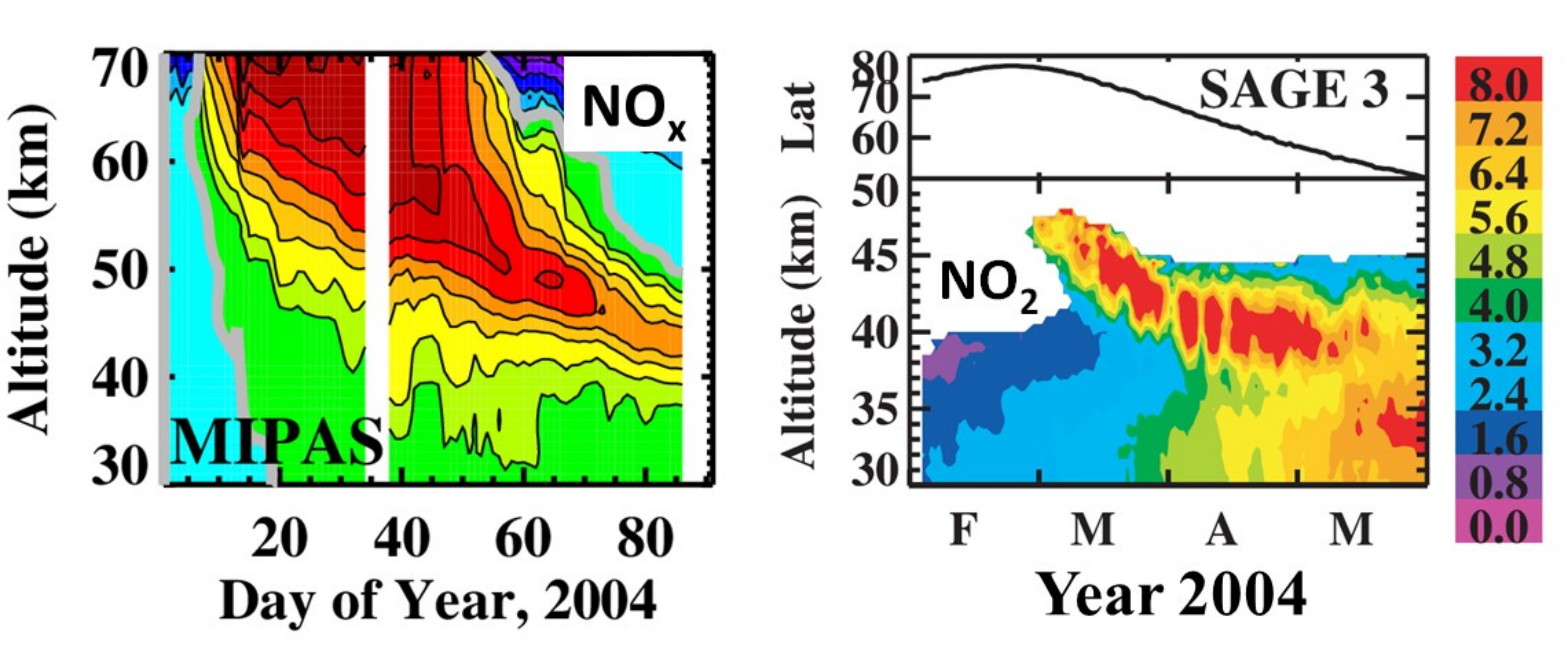
↓↓↓

NO_x and HO_x

NO_x and HO_x Destroy Ozone

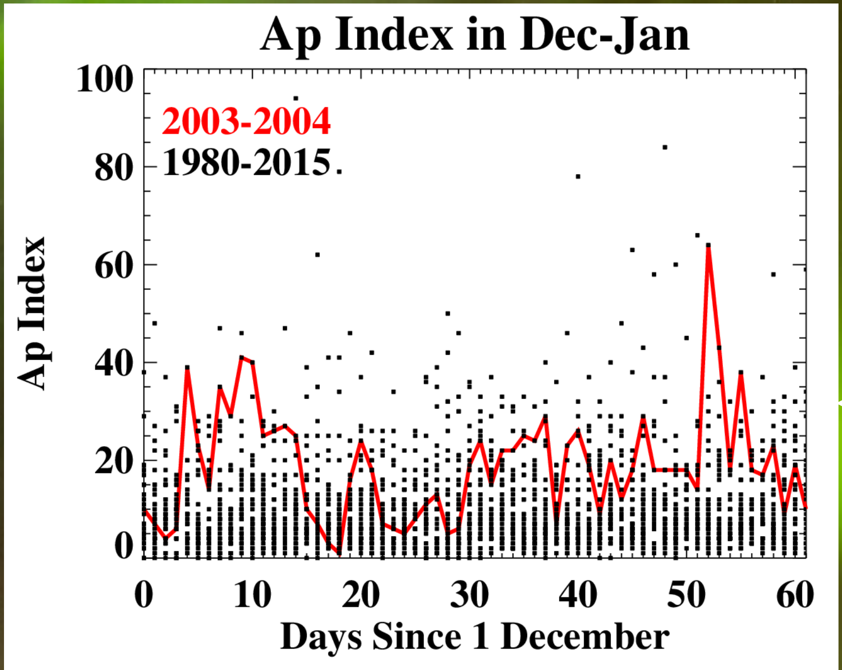


Largest EPP Indirect Effect ever observed in the NH was in winter/spring of 2004



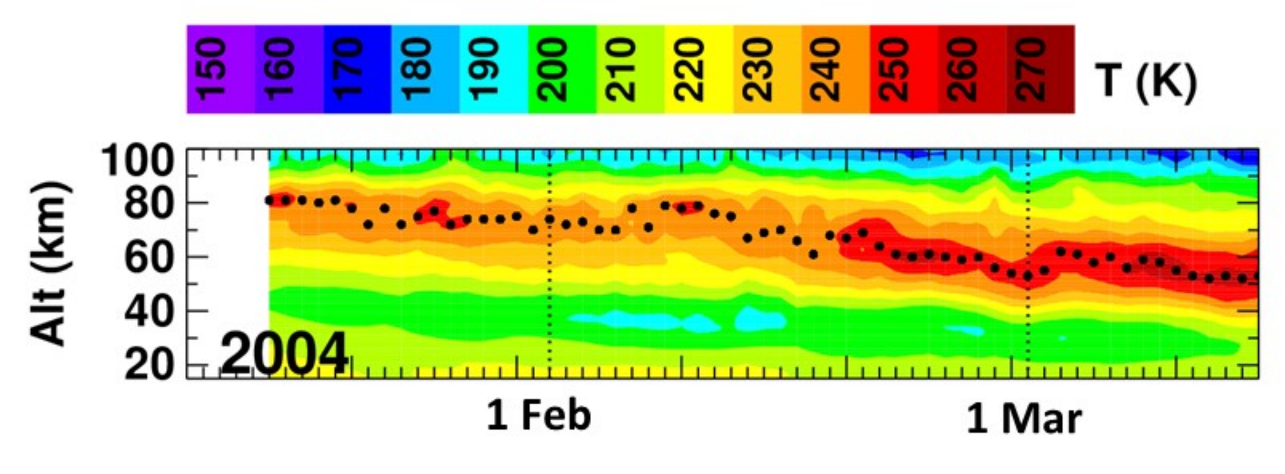
Caused 60% reductions in O_3

Contributing factors in 2004

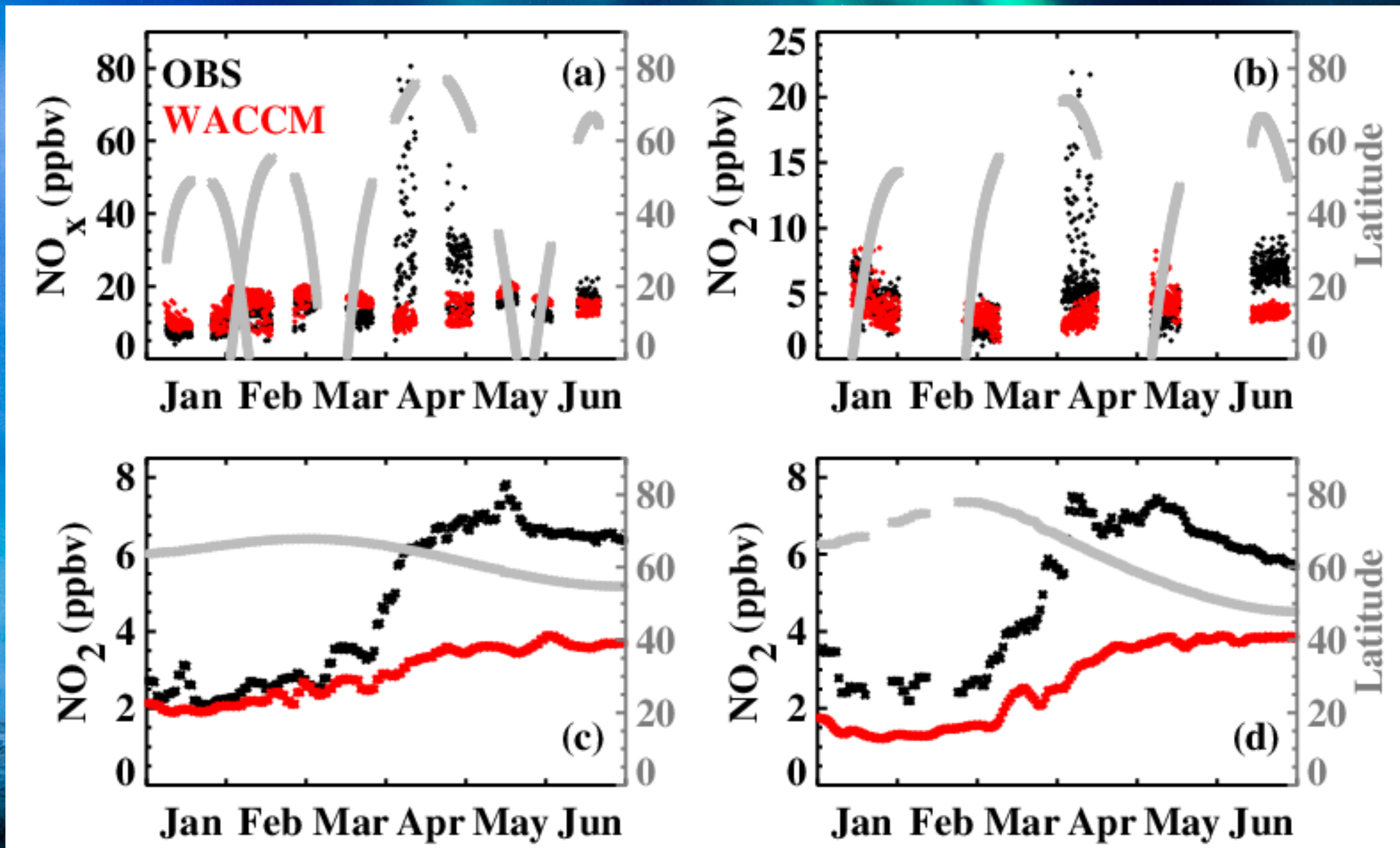


High level of EPP

Enhanced Descent

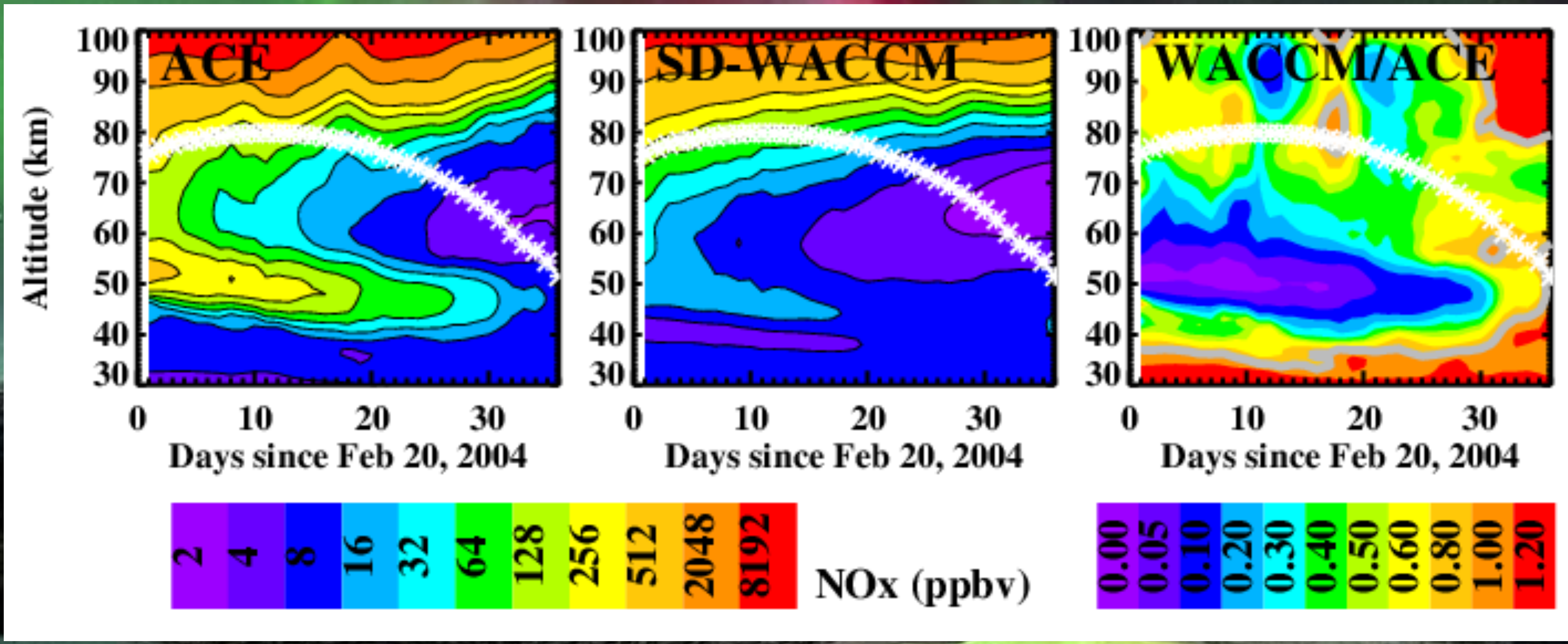


SD-WACCM underestimates NO_x in 2004



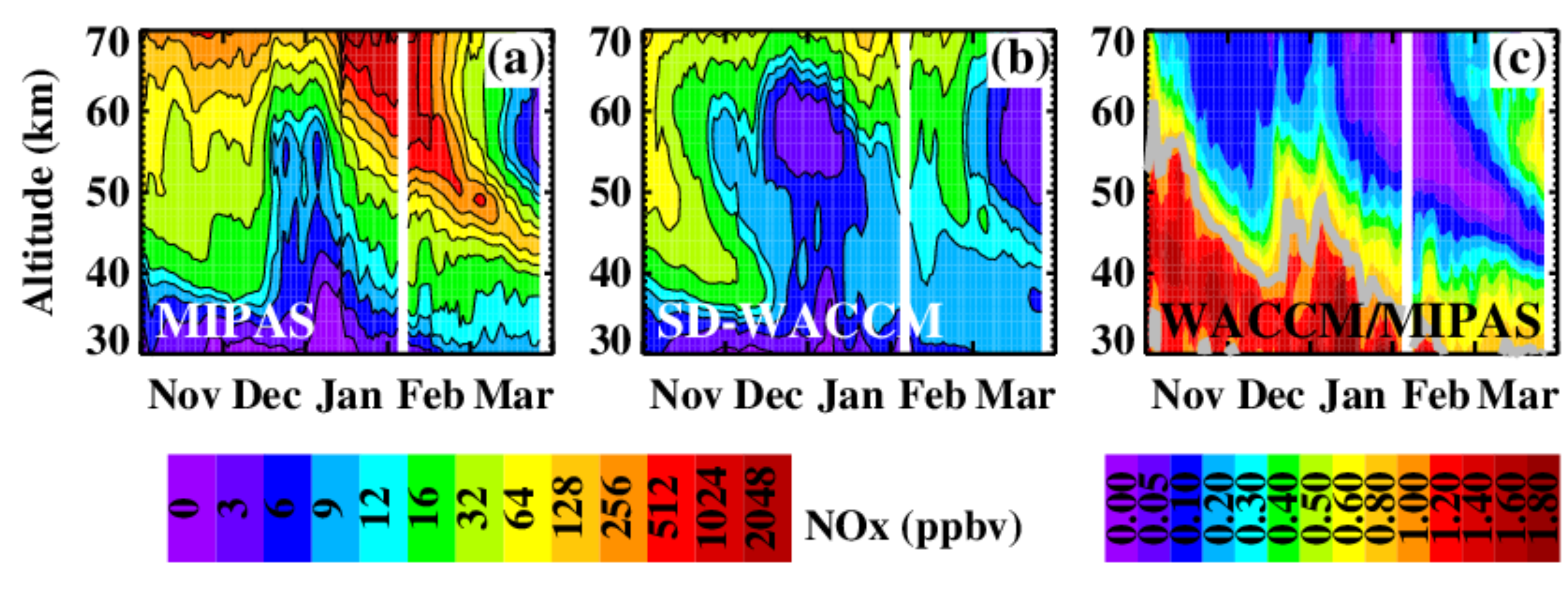
- CCMI REFC1SD model output is at satellite locations.
- Nudged to MERRA below 50 km. Transition to free-running between 50-60 km. Pr=4
- Model underestimates 3-fold April enhancements in Arctic NO_x at 40 km from HALOE, SAGE II, POAM III, SAGE III.

ACE and SD-WACCM Arctic NO_x in 2004



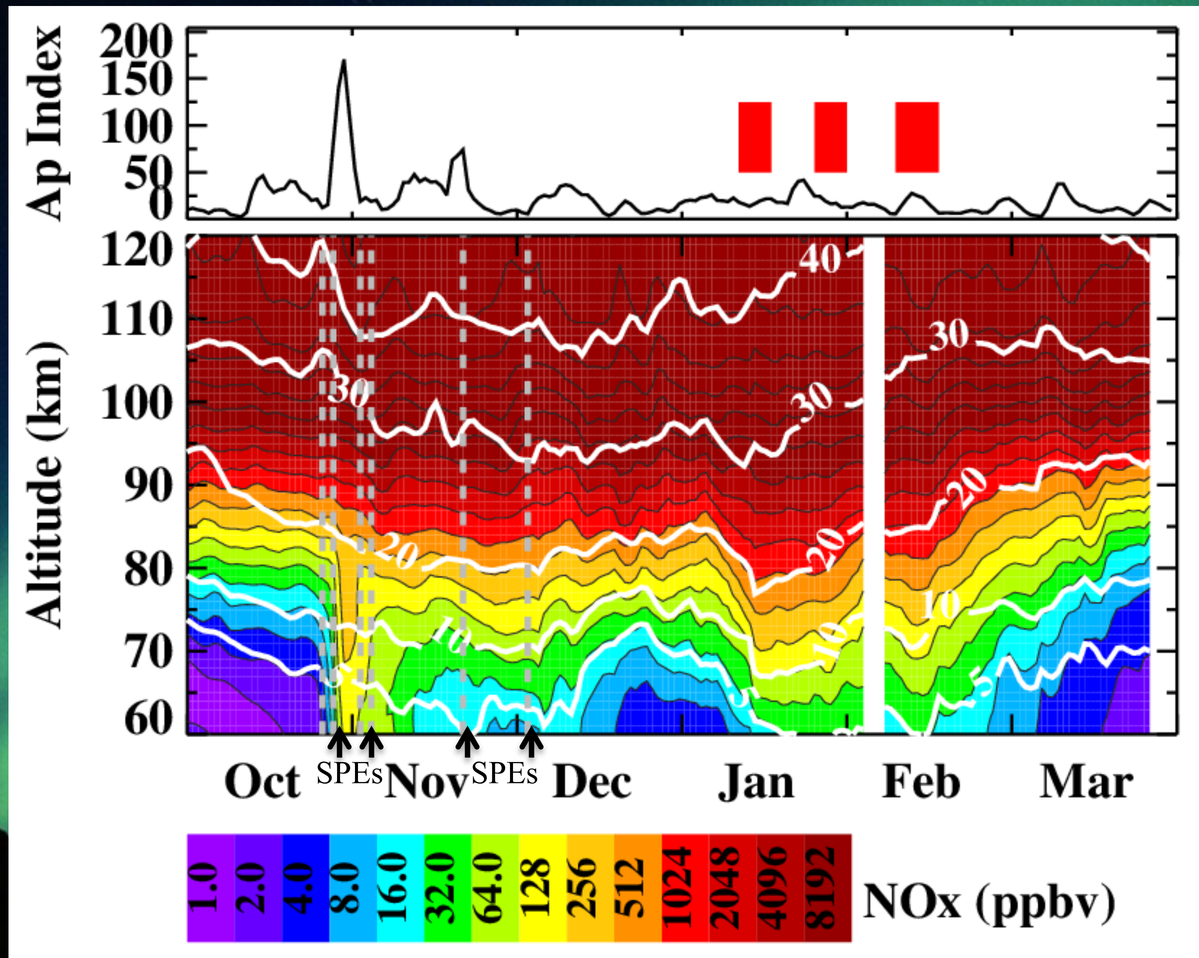
- ACE poleward of 50°N.
- Model underestimates NO_x "tongue". NO_x is <20% of ACE.

MIPAS and SD-WACCM Arctic NO_x in 2003/2004



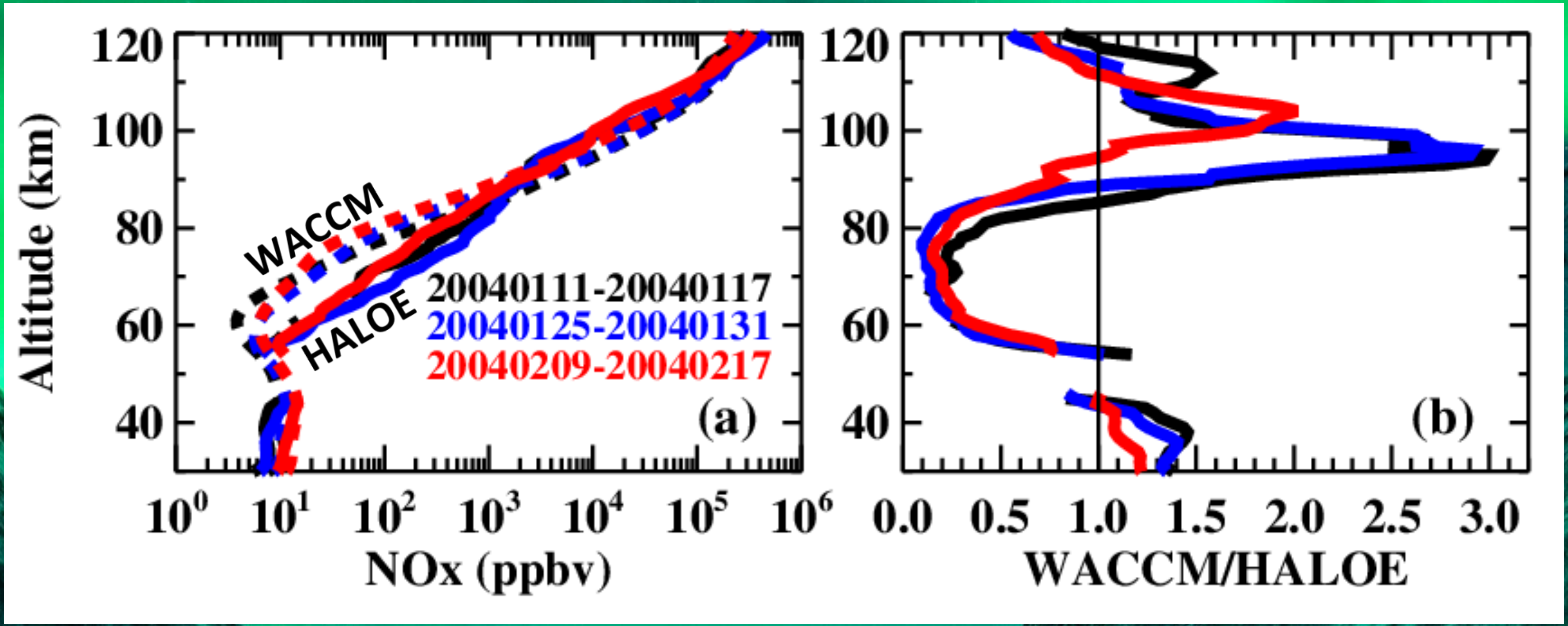
- MIPAS daily averages > 70°N.
- In November, the model underestimates mesospheric NO_x and overestimates stratospheric NO_x. Due to errors in ionization rates?
- Feb/Mar differences consistent with HALOE, SAGE, POAM, ACE.
- Are differences due to NO_x source or descent?

SD-WACCM NO_x in the MLT



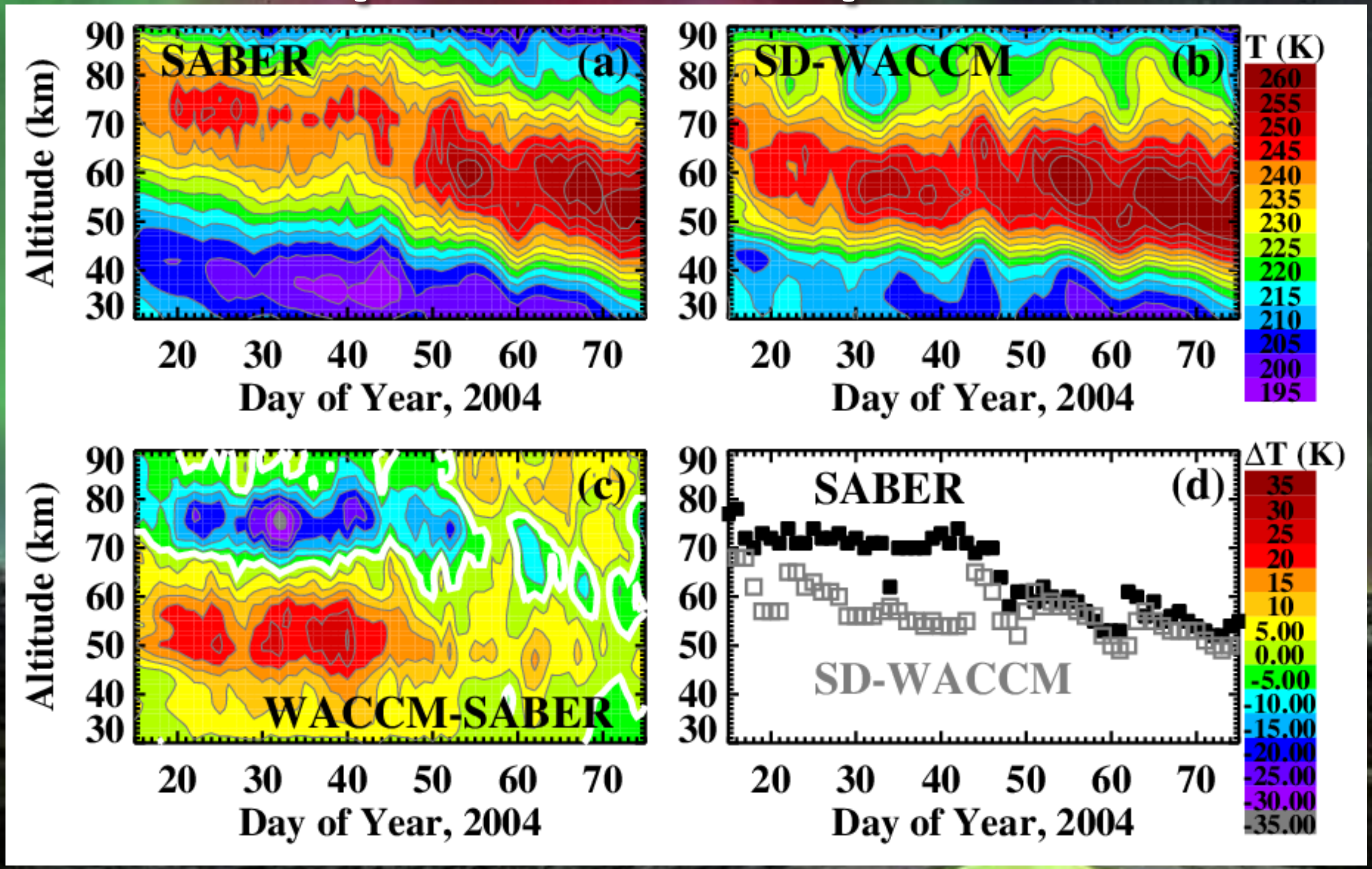
- Rough correlation between the Ap index and NO_x variations in the thermosphere.
- Above 85 km variations due to SPEs are no larger than other times without SPEs.
- **No discernible connection between SPE NO_x and the second tongue.**

HALOE and SD-WACCM: Exploring the Source Region of Arctic NO_x in 2004



- Poleward of 40°N during 3 time periods in January and February.
- SD-WACCM actually overestimates NO_x from ~90 km to 110 km or higher.
  -> An underestimate of the EPP source in SD-WACCM is unlikely.
- SD-WACCM significantly underestimates NO_x values from 60-85 km in all three time periods.
  -> Missing high energy particles or errors in transport.

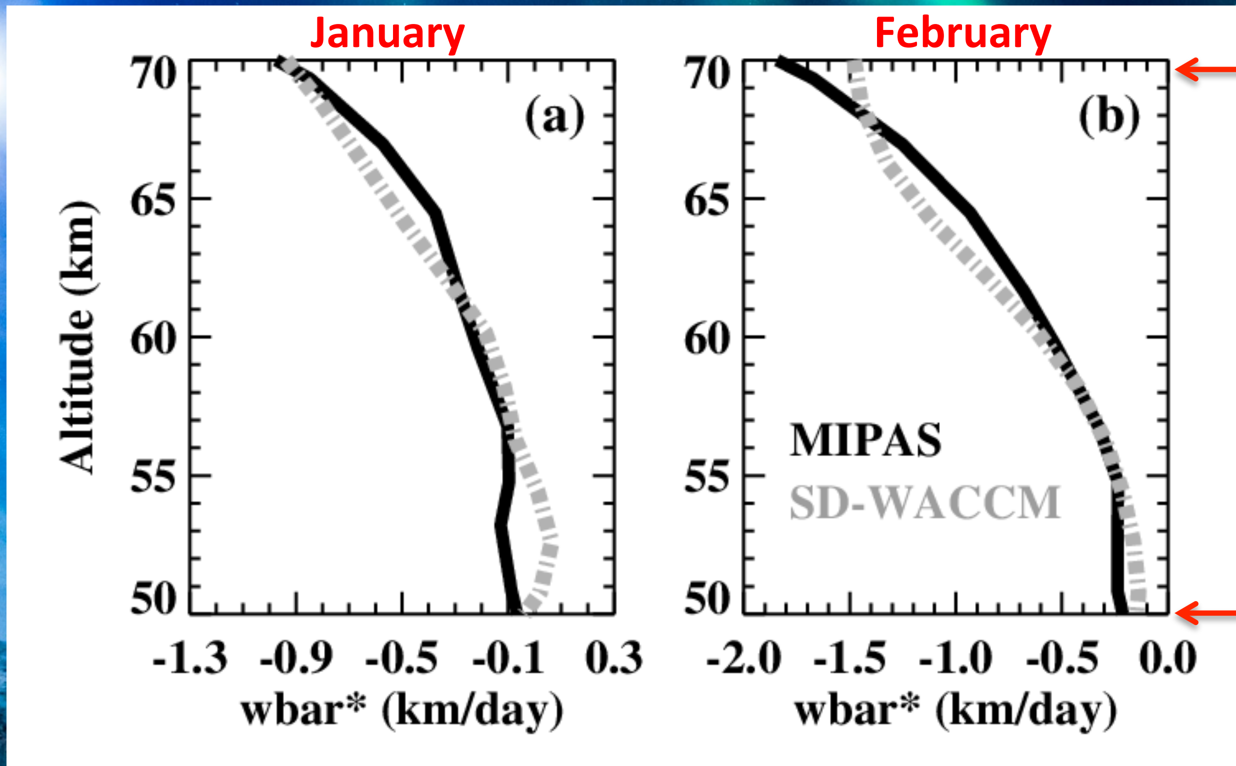
SABER and SD-WACCM: Exploring Arctic Mesospheric Transport in 2004



Clear signature of a displaced stratopause

- SD-WACCM at SABER times and locations poleward of 70°N.
- Prolonged SSW followed by enhanced descent at mesospheric altitudes.
- SD-WACCM elevated stratopause reformed ~10 km lower than SABER.
- Descent in SD-WACCM above 80 km was not enhanced as much as obs.

MIPAS and SD-WACCM: Exploring Arctic Mesospheric Transport in 2004



Top of MIPAS

Top of nudging

- SD-WACCM at MIPAS times and locations poleward of 70°N.
- Wbar* from MIPAS temperatures and diabatic heating rates from O_3, H_2O, and the radiative transfer model MODTRAN.
- Good agreement (increases with height and time)

-> Below 70 km SD-WACCM descent rates are reasonable.

Updated Instruments for "Sathist" Output Option

- WACCM is output at observation locations and times.

- Original functionality created by Matthias Brakebusch. Current archives and scripts maintained by Chuck Bardeen and CU/LASP.

- >38 observation sources from 1978-Present

- Create files containing geo-location and profile information: DATE, TIME, LATITUDE, LONGITUDE, ORBIT_NUMBER, PROFILE_NUMBER

- Ongoing observations need updating: ACE, SOFIE, EOS-MLS, SABER, SBUV/2
- Update with newest data versions
- Add additional observations: SNOE, OSIRIS
- Bug fixes: GOMOS, SME

Updated SPE file

Response of the Atmosphere to Impulsive Solar Events (RAISE)

Four main science questions:

(1) How well do models simulate effects of recent ISEs?

(2) What factors control the atmospheric response to ISEs?

(3) What is the range and sensitivity of the atmospheric response?

(4) Are there long-term, cumulative effects of ISEs on the atmosphere and climate, and with what certainty can these effects be modeled?

We will use WACCM, SD-WACCM, and WACCM-X to simulate recent ISEs (CMEs, SPEs, flares) and quantify the atmospheric response.

Josh Pettit is the LASP point-of-contact for WACCM simulations in support of RAISE

From the table of planned RAISE simulations Josh is first focusing on the Halloween Storms.

ISE Time Period	Reasons to Study
14-16 July 2000	3rd largest solar proton event (SPE) in past 50 years, X5 flare. Southern Hemisphere winter.
19 Oct to 5 Nov 2003	4th largest SPE in past 50 years. X17 flare plus overall high flare activity. Many atmos. obs. Early Northern Hemisphere (NH) winter.
15-17 Jan 2005	13th largest SPE in past 50 years and hard spectrum. X2 flare. Many atmospheric observations. NH winter.
7-11 Sep 2005	Moderate SPE. X17 flare. ISR electron density data. Many atmospheric observations.
15 Feb to 9 Mar 2011	X1,X2 and many M-class flares. Very small (50 pfu) SPE. SDO data.
4-9 Aug 2011	X6 flare. Very small (<100 pfu) SPEs. SDO data.
7-13 Mar 2012	10th largest SPE in past 50 years. X5 flare. SDO data.

He is using SD-WACCM to answer the following 3 questions:

1. What is the medium/high energy electron influence on middle atmosphere chemistry?

2. Can CO be used as an accurate dynamical tracer during an EPP event?

3. How accurate is the "reference date subtraction" technique used to compare obs to models?

PhD Dissertation

- Correctly input medium and higher energy electrons into WACCM

Summary

Randall et al. (2015) - The EPP-NO_x underestimate in SD-WACCM is attributed to too little NO_x production by high energy precipitation and/or insufficient transport from the MLT.

We will continue to keep the Sathist datasets and the SPE files up-to-date.

Stay tuned for more exciting results from Josh Pettit.