Long Term Temperature and Density Variations from Initial Transient Runs of CESM/WACCM-X

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WACCM-X: WACCM-eXtended
WACCM: Whole Atmosphere Community Climate Model
CESM: Community Earth System Model
Background: Model, Runs, Analysis

WACCM-X model:
- A comprehensive numerical whole atmosphere model
- 1.9x2.5 lat/lon, 0 to ~500km, simple ionosphere, no E-region dynamo
- Available in CESM release (cesm.ucar.edu)

Performed two simulations:
- First: 1955-2010, time varying CO2, data ocean and land, realistic solar forcing
- Second: Same as first but for 1944-1971

Global annual mean temperature and density put through multi-linear regression analysis, independent variables F10.7 and ap index, trends derived from linear fit to analysis residuals
1970-2010 Upper and Lower Thermosphere Temperature Trends

WACCM-X Temperature 3.3E-09 hPa
-2.62 K/decade

WACCM-X Temperature 1.2E-04 hPa
-1.82 K/decade

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Vertical Structure of Temperature Change

Cnossen, 2012 Temperature Trends K/decade

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Density: Comparison With Other Results

- Emmert and Picone, 2011: -1.94 %/decade
- WACCM-X 310 km: -2.08 %/decade

Emmert and Picone, 2011: -1.94 %/decade

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Vertical Structure of Density Change

Cnossen, 2012 Density Trends %/decade

WACCM-X 1970-2010 %/decade
Full Time Range (1955-2010) Temperature and Density

WACCM-X Temperature Residuals

-1.32 %/decade

WACCM-X Density at 310 km

-1.32 %/decade

WACCM-X T 3.3E-09 hPa

+4.3 K/decade

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Temperature 1955-2010 and 1944-1971

Temperature Residuals

Year

WACCM-X T 3.3E-09 hPa

+4.3 K/decade

Temperature Residuals

Year

WACCM-X T 3.3E-09 hPa

-0.14 K/decade

T Change = 24.1131 K
(4.30591 K/decade)

T Change = -0.780630 K
(-0.139398 K/decade)

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Main Points

• WACCM-X 1970-2010 temperature and density compare reasonably well with previous studies

• But when including first 15 years (1955-2010), temperature trend of opposite sign and smaller density trend – Analysis - large solar cycle?

• WACCM-X 1944-1971 temperature and density show different trend in period of overlap with 1955-2010

• 1944-1971 relatively small thermosphere temperature trend coinciding with a small surface temperature trend
WACCM-X Development

• A recent preliminary version with:
  - Energetics: produce electron and ion temperature
  - Vertical ion diffusive transport

Liying’s talk next includes some initial results from this preliminary version of WACCM-X

• Under development is WACCM-X with electrodynamics

• Also developing horizontal ion diffusive transport