A Comparison Between the MOZART-T1S and MOZART-T4S Chemical Mechanisms

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AMWG Winter Meeting

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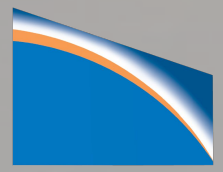

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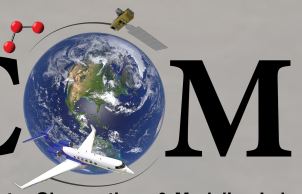
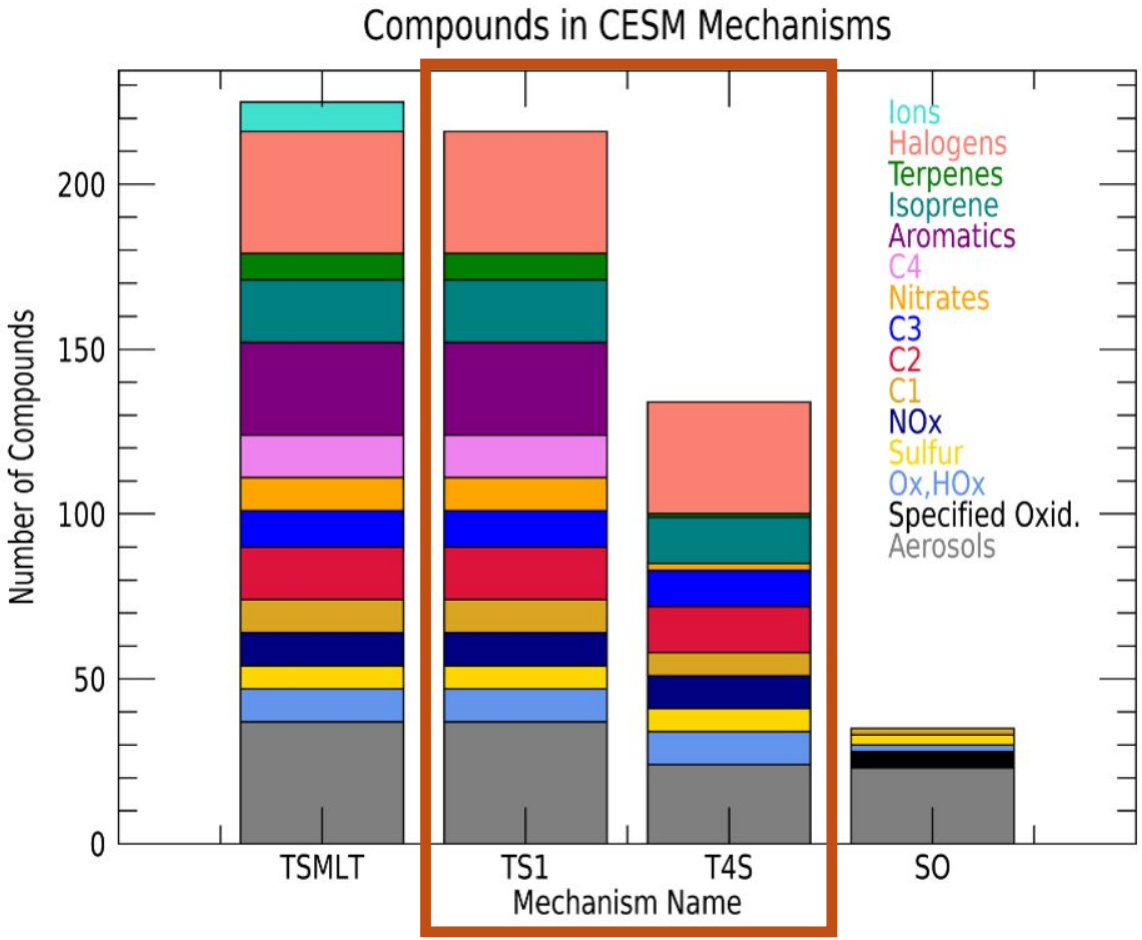


Acknowledgement: Louisa Emmons

Chemical Mechanisms



Name	Description	# tracers	# reactions
T1MA (TSMLT)	T1 with stratosphere, mesosphere, lower thermosphere chemistry	234	583
T1S (TS1)	T1 with comprehensive stratospheric chemistry and full sulfur chemistry	231	528
T4S	T4 with comprehensive stratospheric chemistry, no odd F, C>3 hydrocarbons simplified	141	364
SO	Specified Oxidants, with GHGs	31	12

1. Expectation for T4S Compared to T1S:
   - Lower cost
   - Faster running simulations
   - Similar chemistry, budgets, & biases.

2. T4S may be a better choice if Bullet 1 holds true & you don't need the species that are excluded.

Model Setup

3 Different Model Runs (T1S, T4S, T4Sr2)

Setup (T1S/T4S):

- CESM Tag: **cesm3_0_beta02**
- Free Running
- ne30.pg3
- Mid Top (80 km top)
- 93 Vertical Levels
- CAM7 Physics
- MAM5 Aerosols
- 1980– 2015 (1995-2011)

Setup (T4Sr2 Run):

- Same as the other setup with following exception:
  - CESM Tag: **cesm3_0_beta04**
    - **Updated Dust Tuning**
    - **Moving Mountain GW Scheme**

Timing, Costs, and Stability

Timing (T1S/T4S):

T1S: 2.7 simulated years per day on 26 nodes
- 2.75 sim yrs/day on 28 nodes (Default)
- 31876 pe-hrs/simulated_year

T4S: 3.9 simulated years per day on 24 nodes
- 4.0 sim yrs/day on 26 nodes (Default)
- 18569 pe-hrs/simulated year

T4S ~ 1.4 times faster than T1S

Timing (T4Sr2):

4.0 sim yrs/day on 26 nodes
19930 pe-hrs/simulated year

Stability (T1S/T4S):

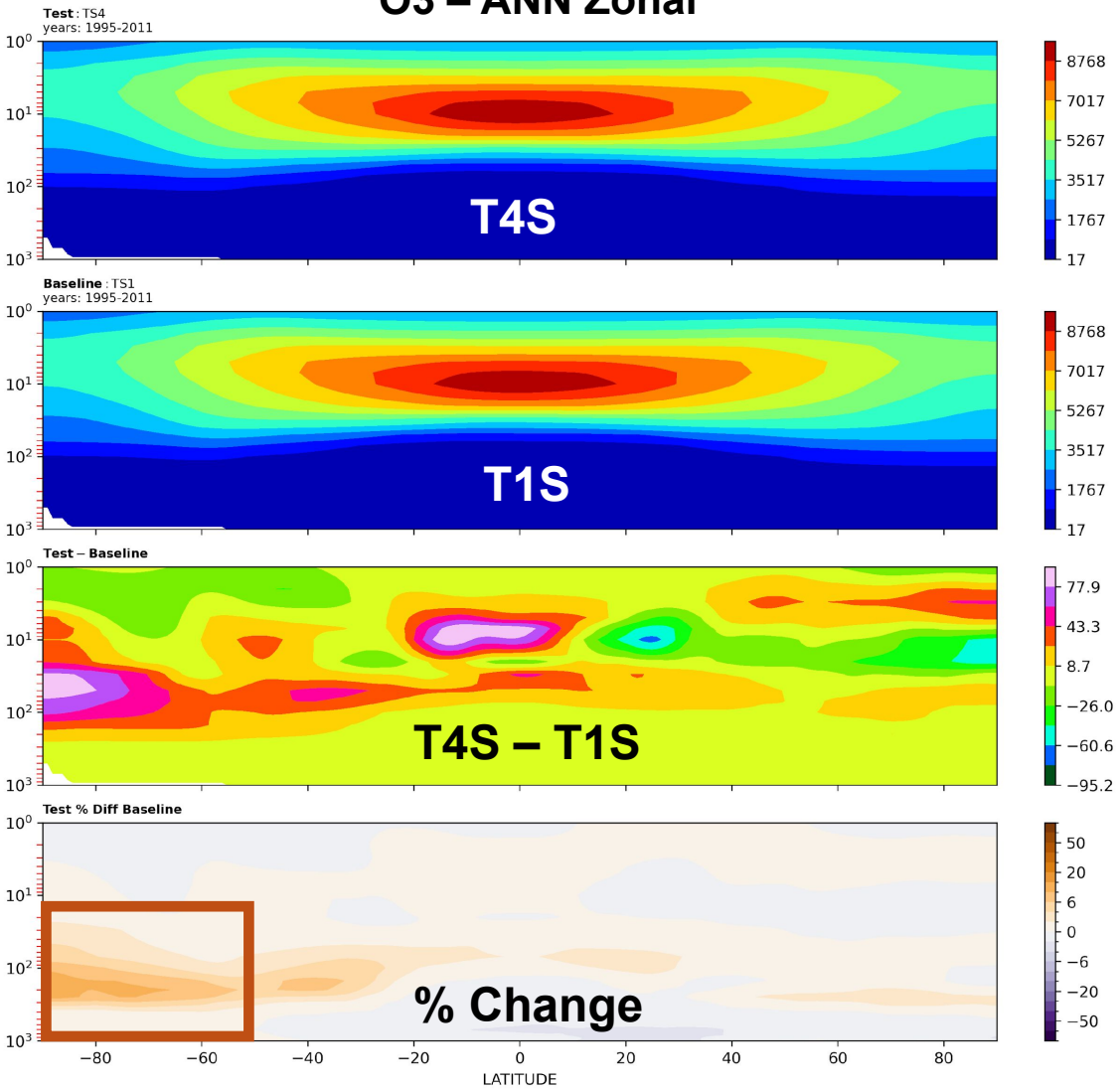
- No stability issues on T1S run
- Had to adjust time step (se_nsplit) a couple of times on the T4S run

Stability (T4Sr2):

- No major stability issues.
  - More stable than the other T4S run

Ozone – Climatology (1995-2011)

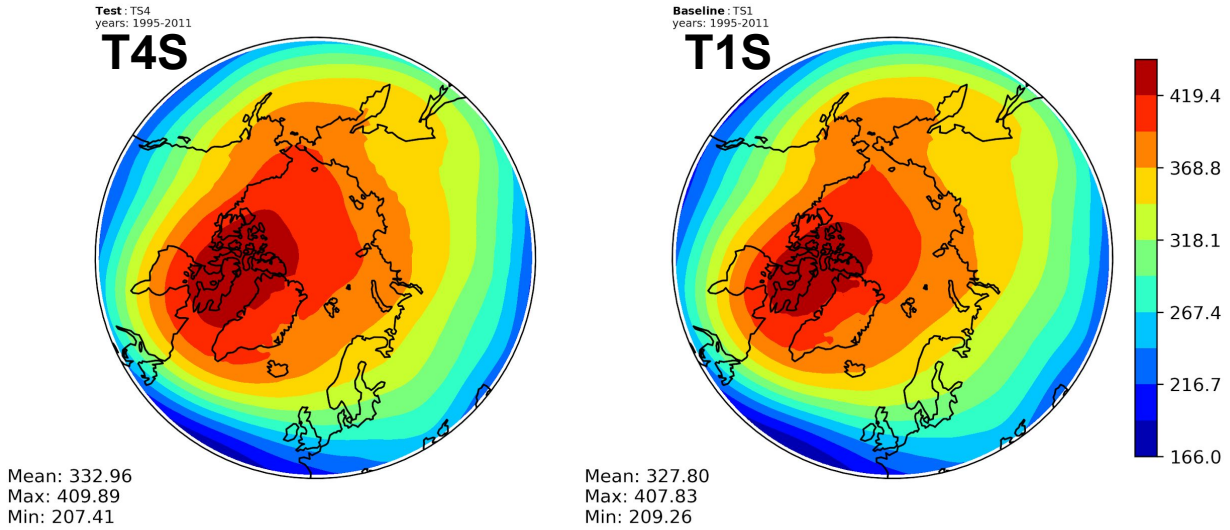
O3 – ANN Zonal



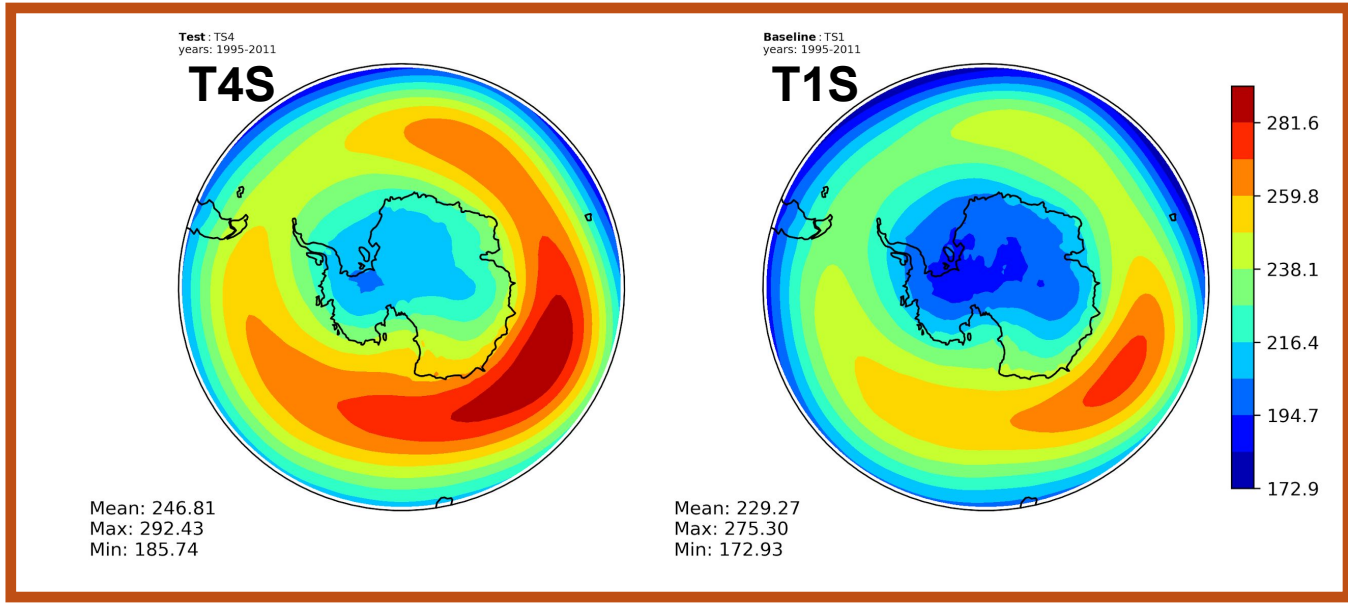
Largest deviation in the southern hemisphere polar UTLS.

- **T4S about 17 ppbv (10%) higher**

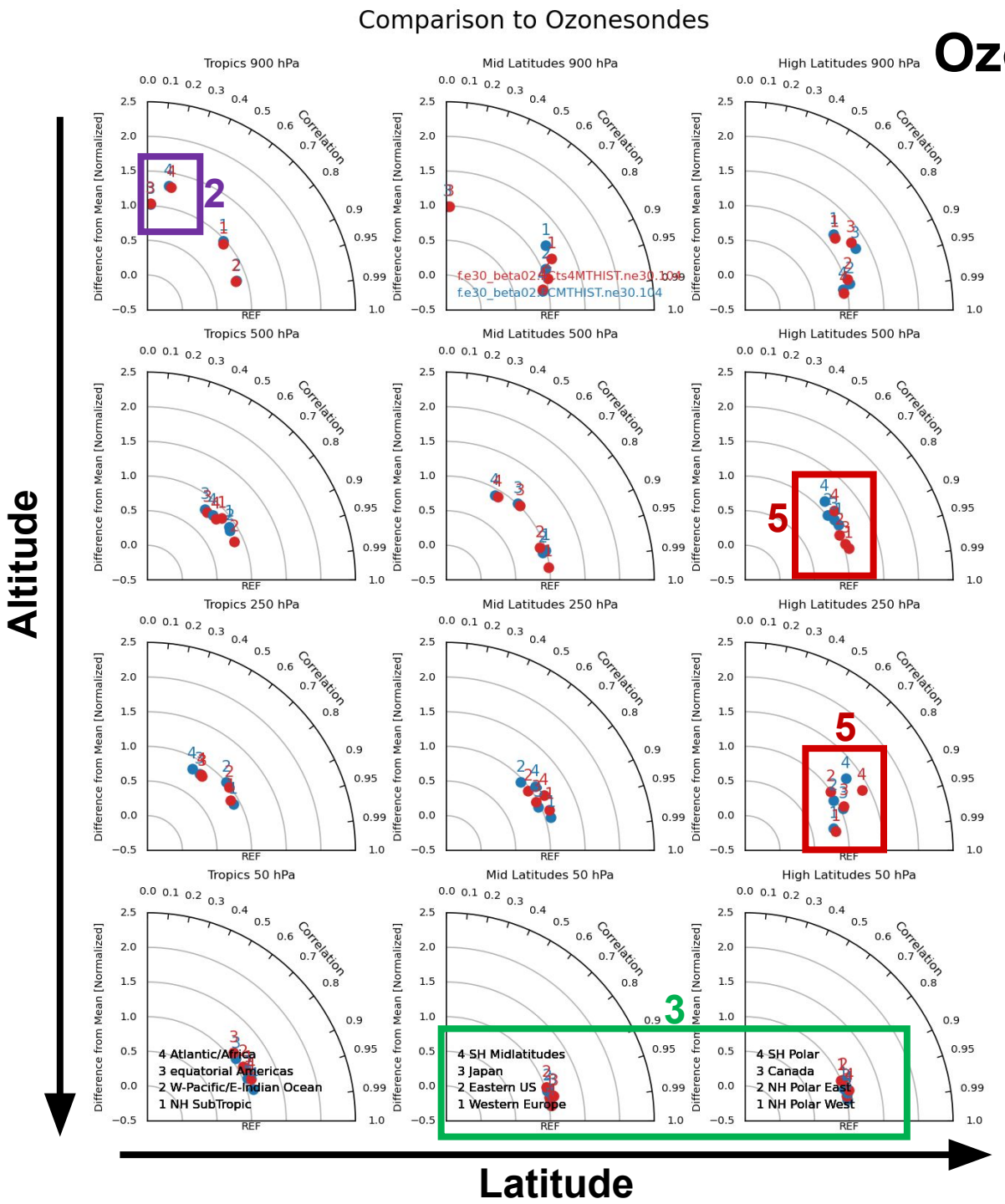
O3 – 200 hPa – ANN – NH Polar



O3 – 200 hPa – ANN – SH Polar



Ozone – Taylor Diagrams



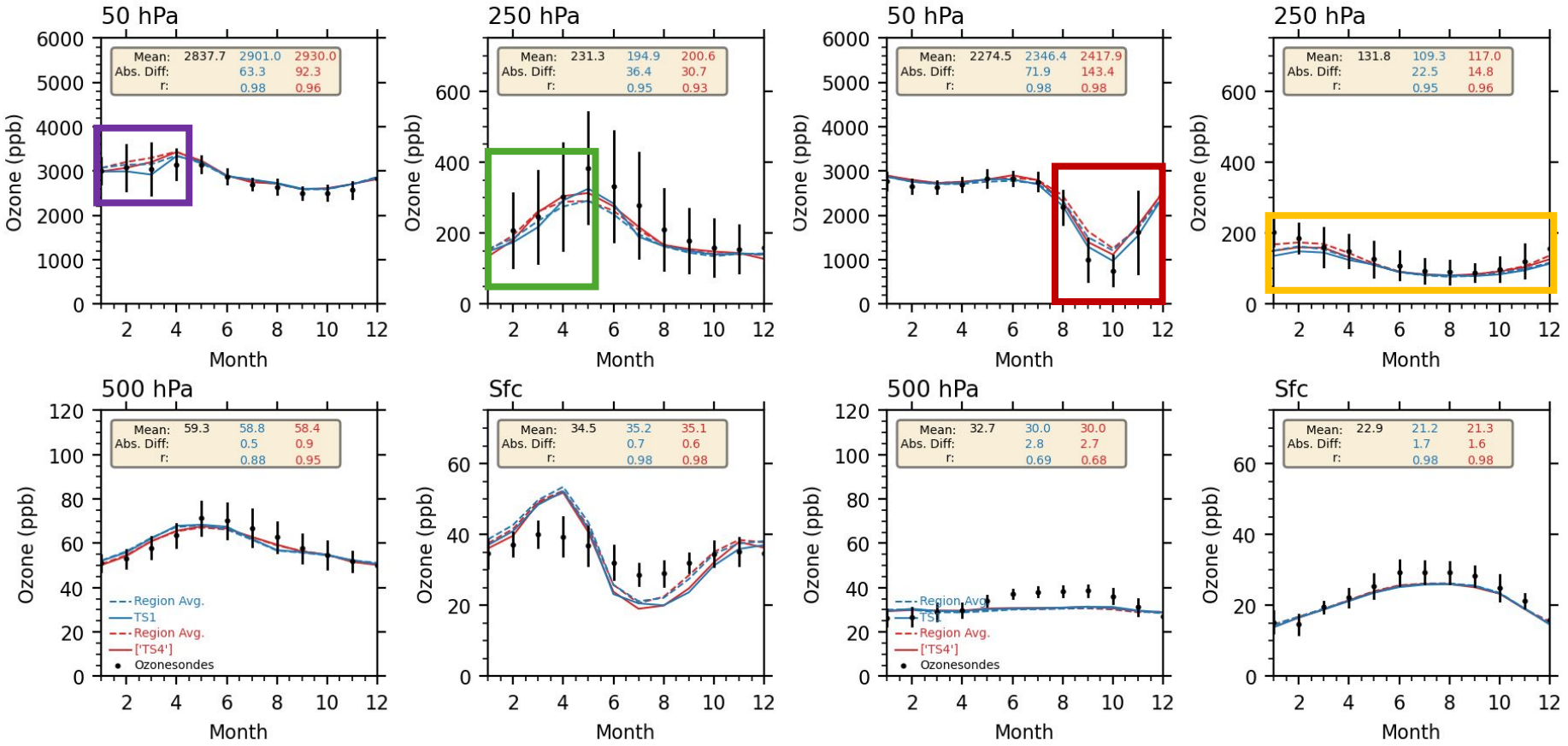
- Left to right: Tropics, Mid Lat, High Lat
- Top to Bottom: 900, 500, 250, and 50 hPa
- Red Dots: T4S
- Blue Dots: T1S

1. Correlations increase with altitude.
2. Worst correlations: **low level tropics**
3. Best correlations: **Mid/High latitude stratosphere**
4. T1S & T4S similar placements.
5. SH Polar: **T4S correlation slightly higher than T1S at 50 and 250 hPa**

Solid: Point Avg
Dashed: Regional Avg

Ozone – Seasonal Cycle

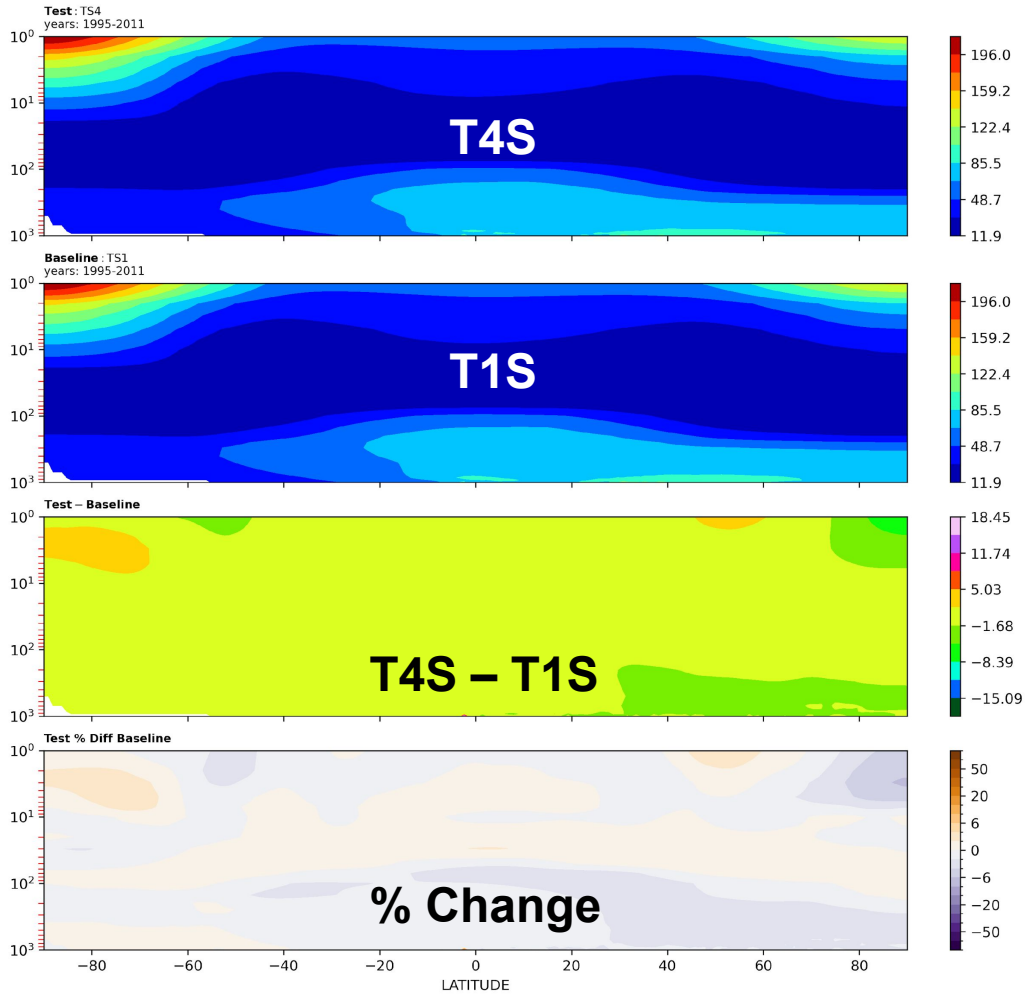
NH Polar **SH Polar**



- SH lower stratosphere departure occurs primarily in SH summer months.
- Other notable areas:
  - NH 50 hPa early part of year.
  - NH 250 early part of year.
  - SH 50 hPa end of year.

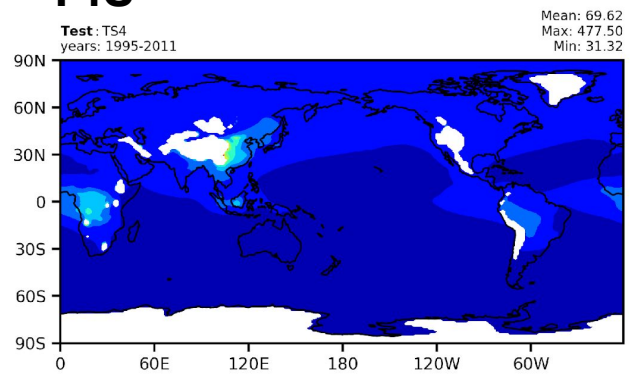
Carbon Monoxide

CO – ANN Zonal

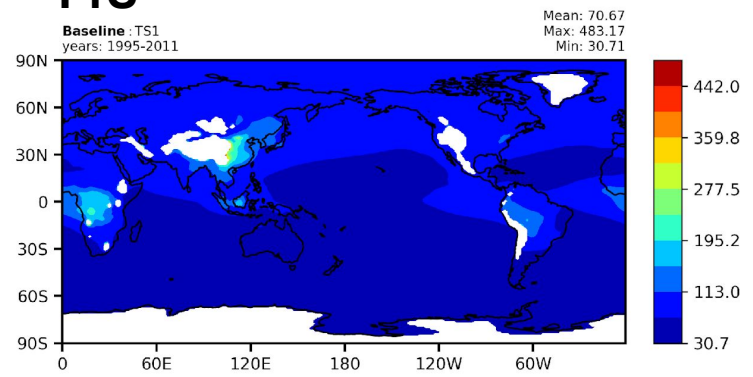


CO – 850 hPa ANN Map

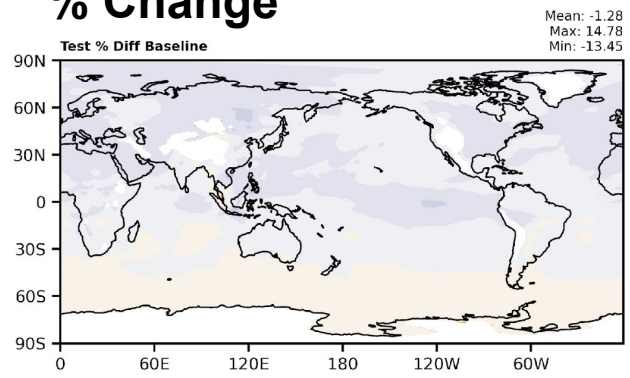
T4S



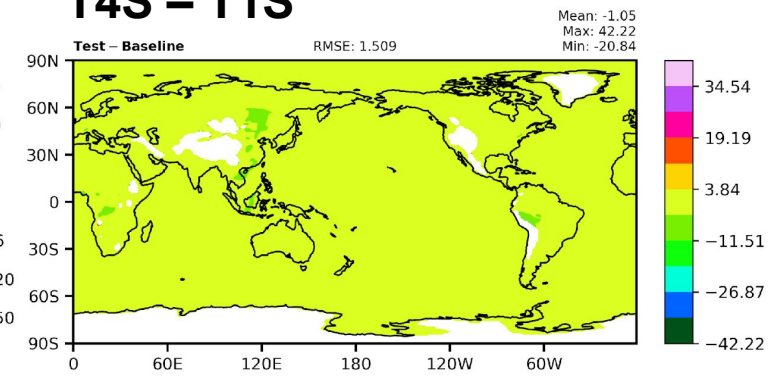
T1S



% Change

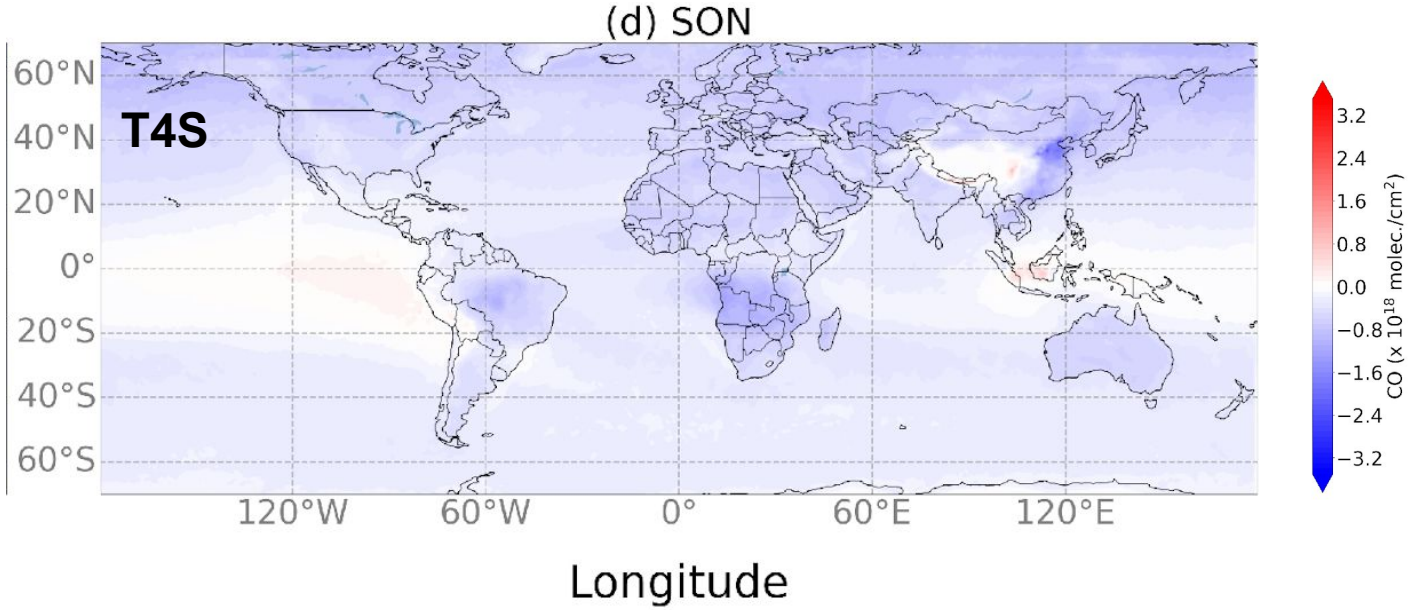


T4S – T1S



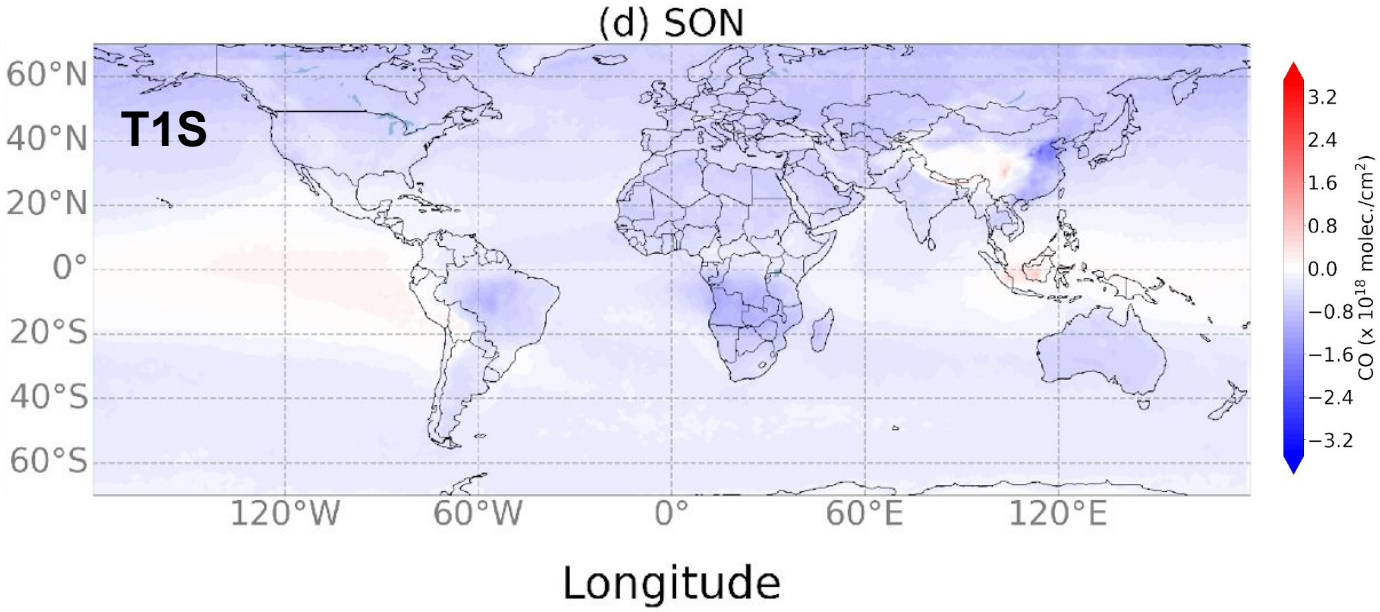
No Significant differences in CO!

Carbon Monoxide – Total Column Difference from MOPITT

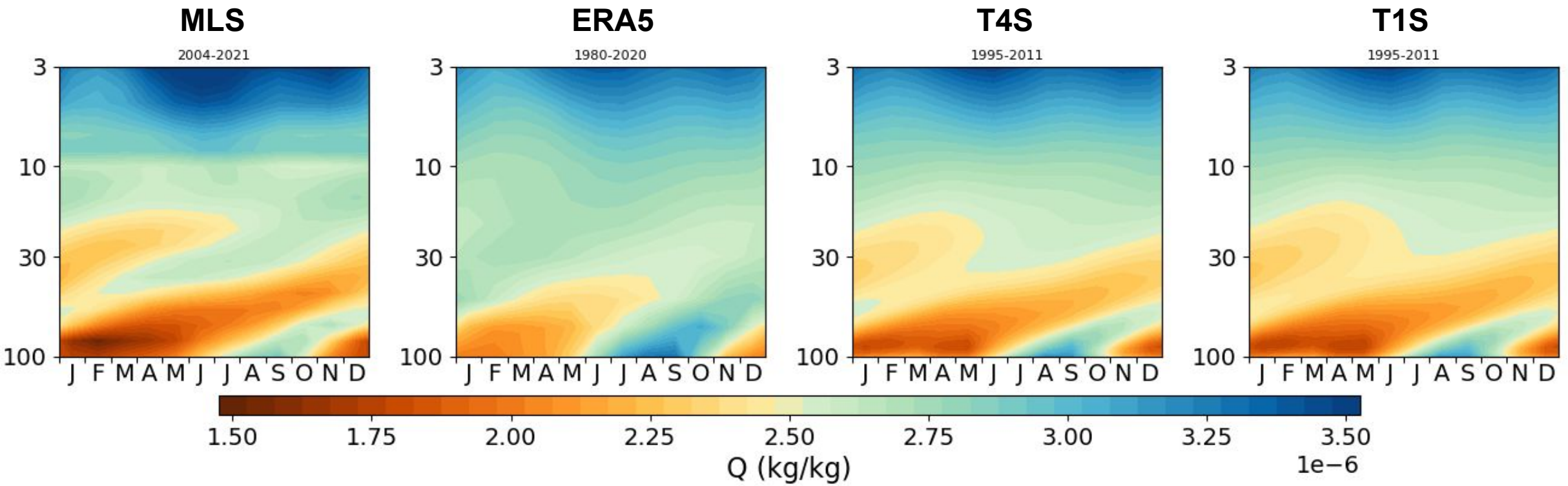


Model - MOPITT

CO low bias on both the T4S and T1S runs



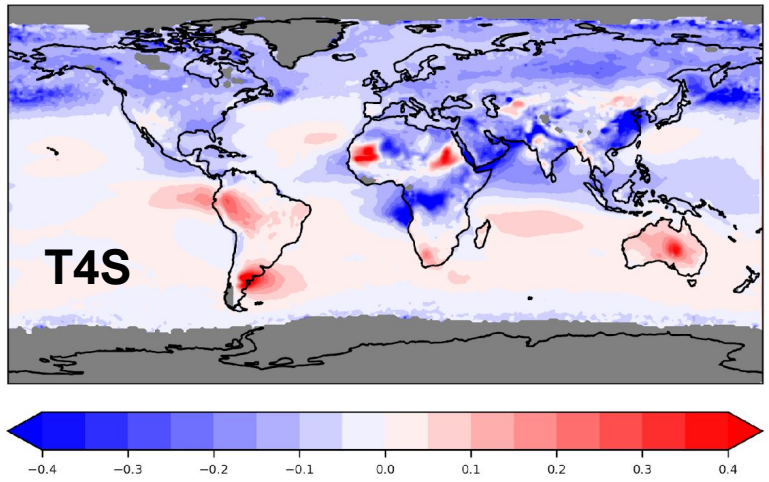
Tape Recorder



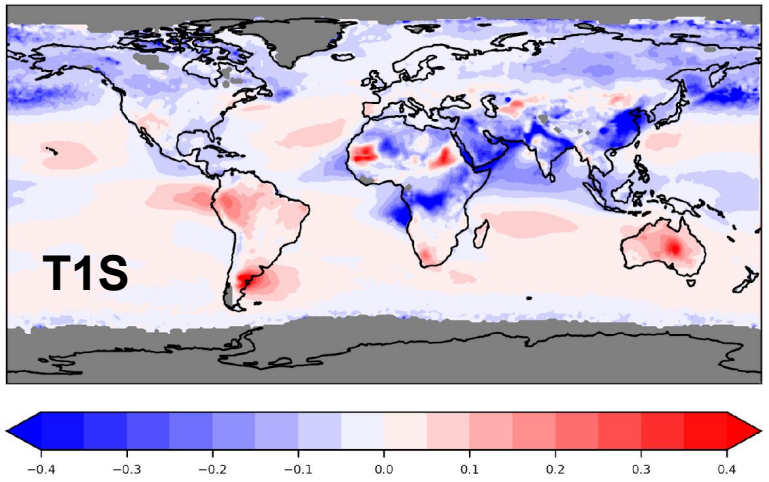
T4S & T1S No Major Differences

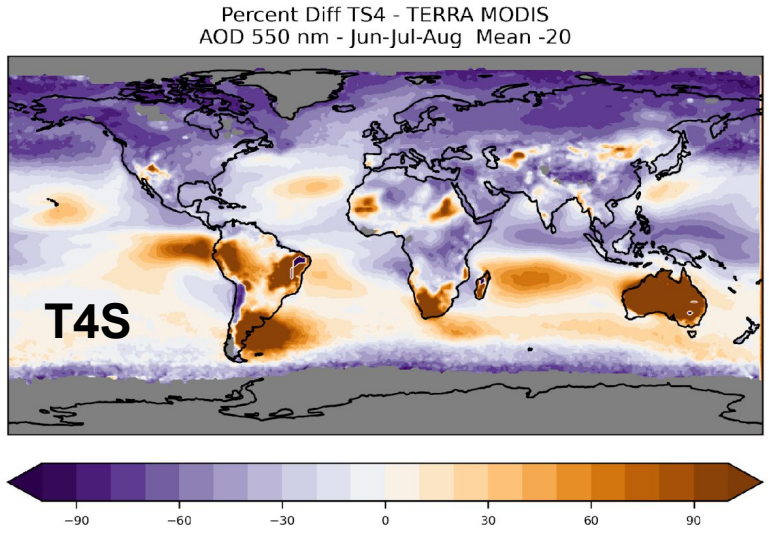
AOD – Compared to MODIS

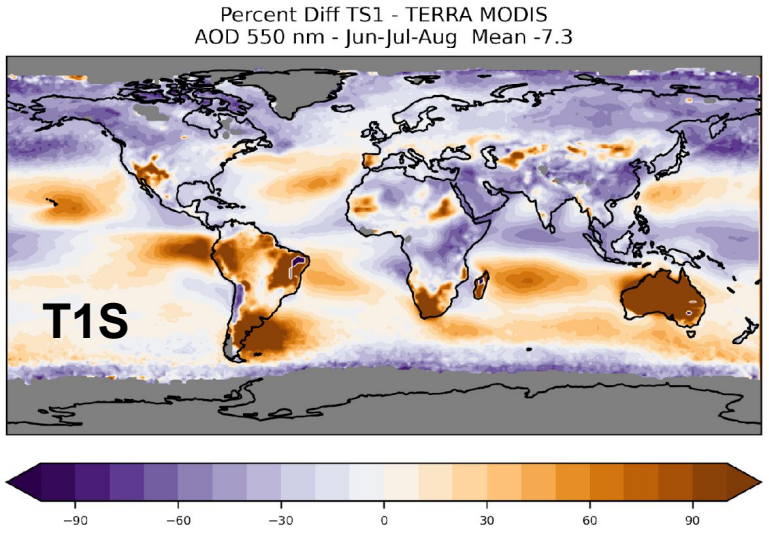
Model – MODIS, JJA



Model – MODIS, JJA

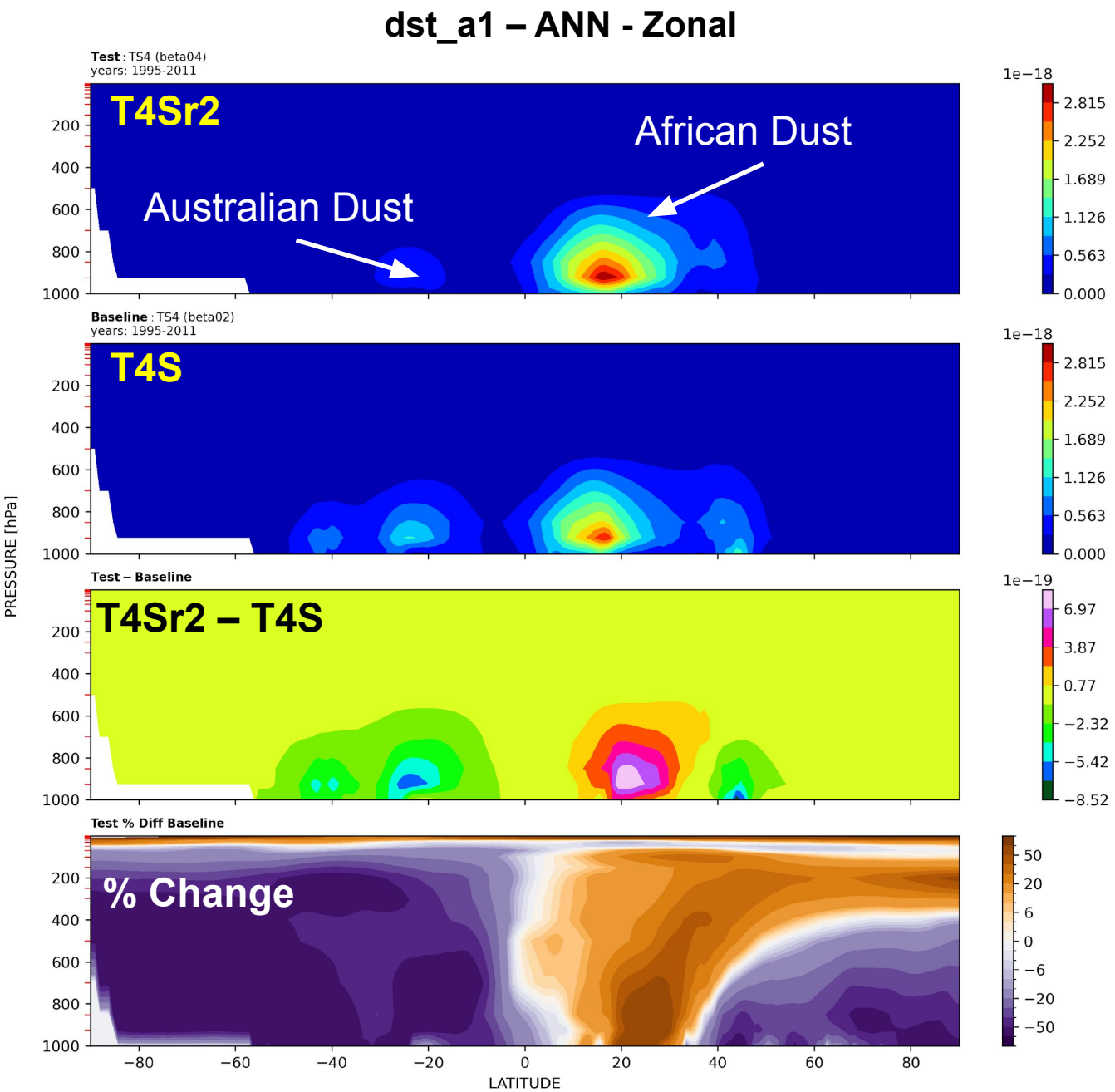






- No major difference between T4S and T1S.
- Low bias in NH
- High bias in SH

T4Sr2 – Dust (dst_a1)

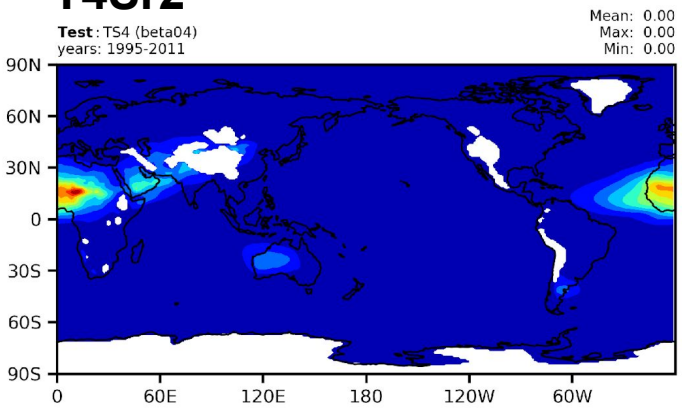


- Reminder: T4Sr2 contains updated dust tuning.
- A little more dust in NH around 20N lat
- Less elsewhere.

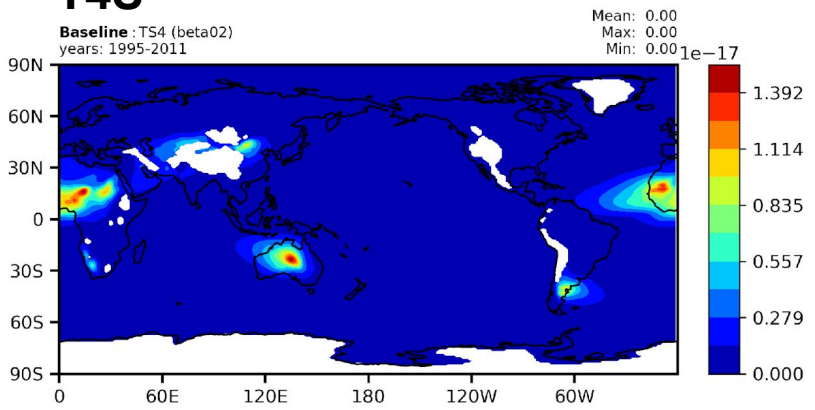
T4Sr2 – Dust (dst_a1)

dst_a1 – 850 hPa - ANN - Map

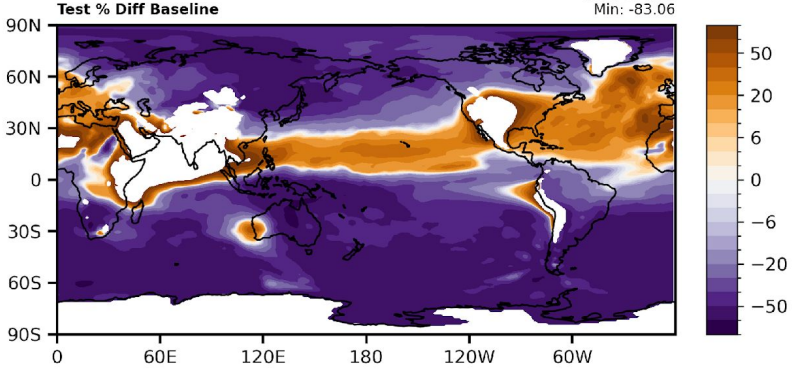
T4Sr2



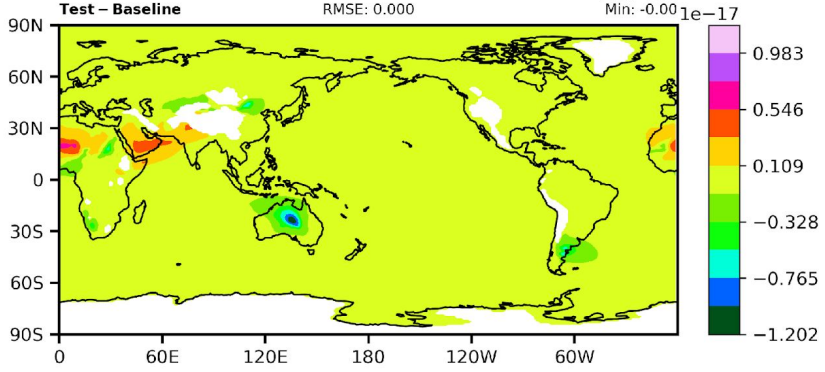
T4S



% Change



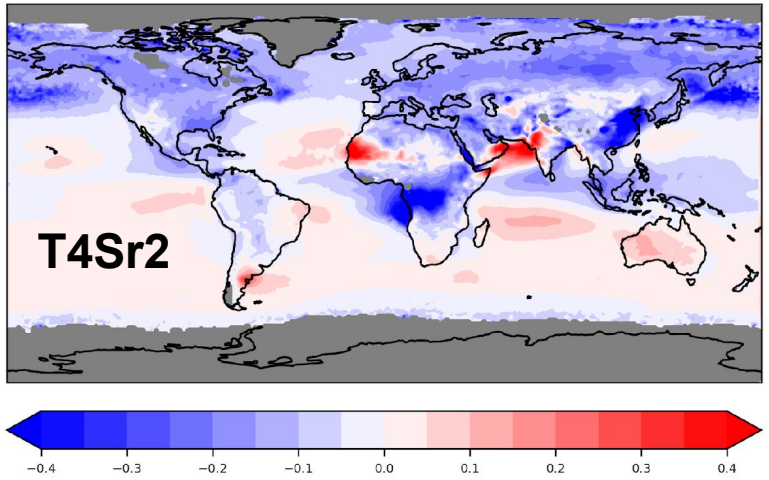
T4S – T1S



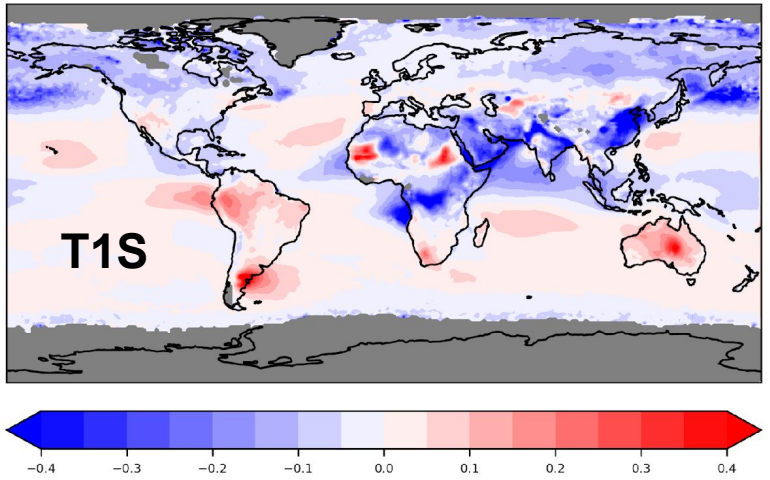
- More African Dust
- Less Australian Dust
- NH low/mid latitudes higher
- Elsewhere lower

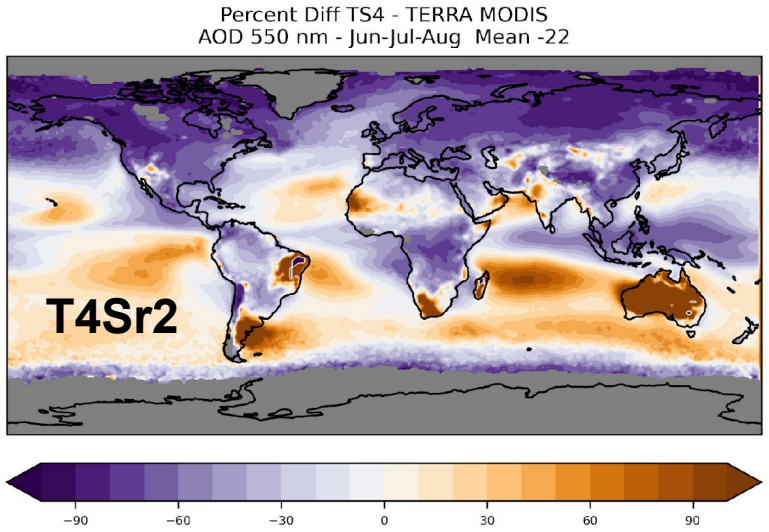
T4Sr2 - AOD

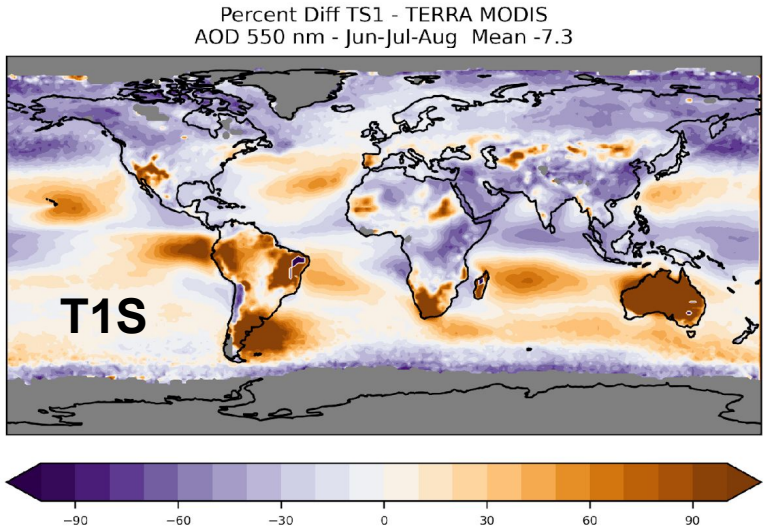
Model – MODIS, JJA



Model – MODIS, JJA





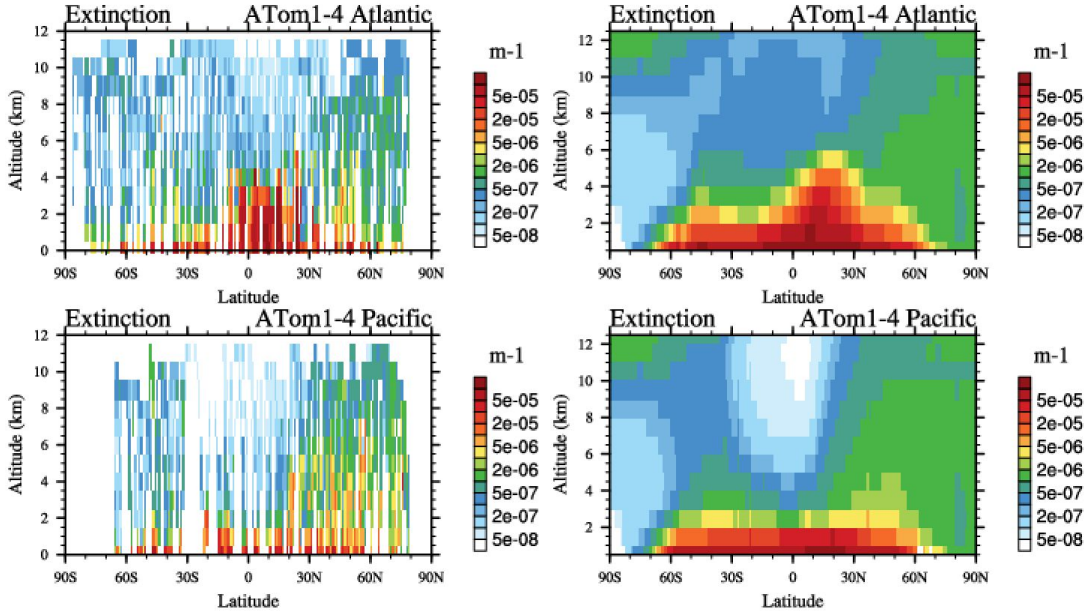


- T4Sr2 more significant low bias in NH.
- T4Sr2 SH high bias reduced

T4S MT performance: Comparisons to Aircraft Data

Extinction

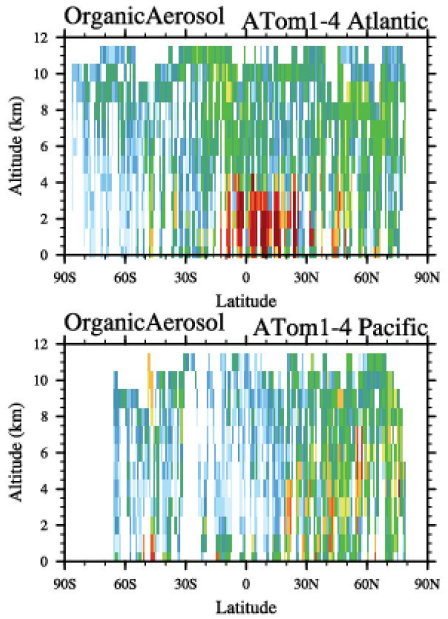
ATom data



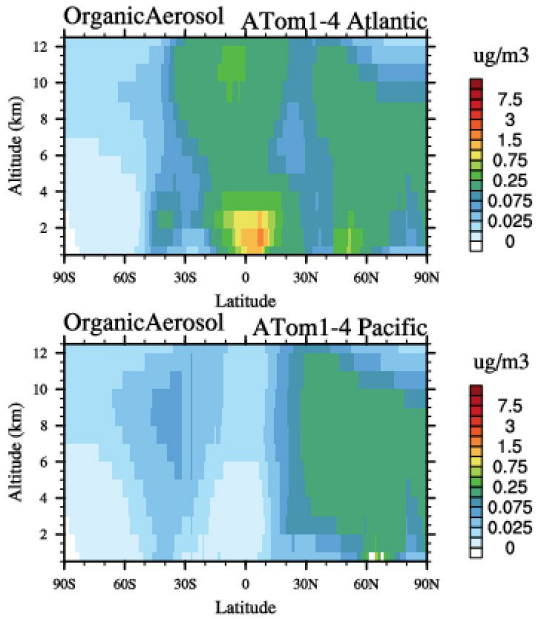
T4S MT new dust

Organic Aerosol

ATom data



T4S MT new dust



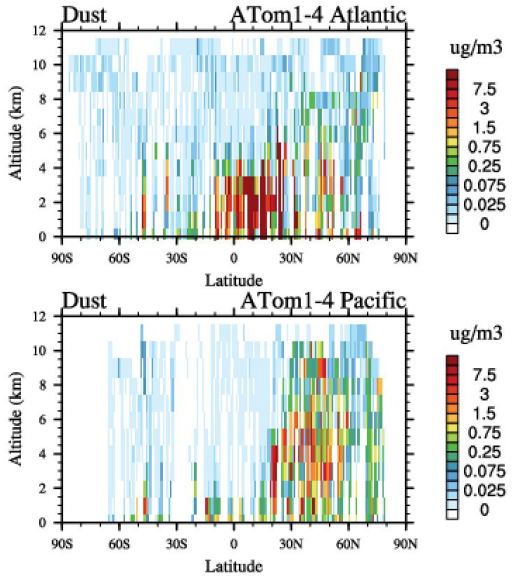
- Extinction is reasonable, some underestimation over the Pacific mid-to high latitudes
- Underestimation of Organic Aerosol (possible due to reduced biogenetic precursor emissions)

Credit: Simone Tilmes

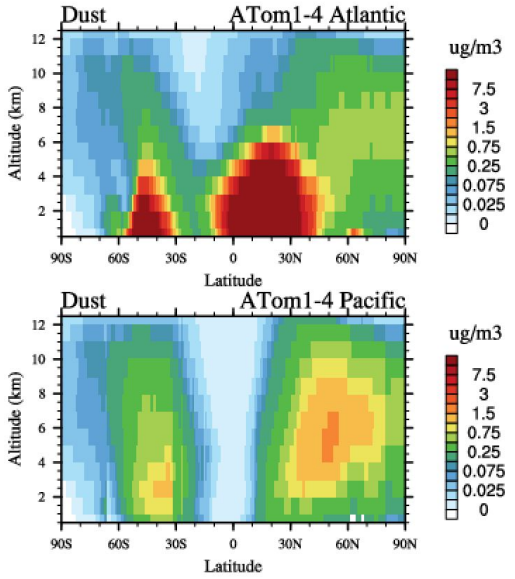
T4S MT performance: Comparisons to Aircraft Data

Dust

ATom data

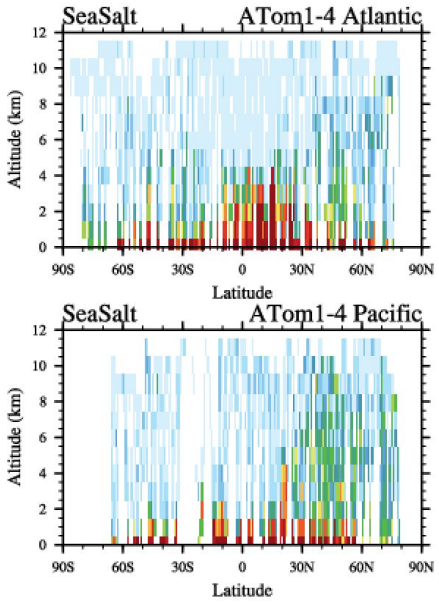


T4S MT new dust

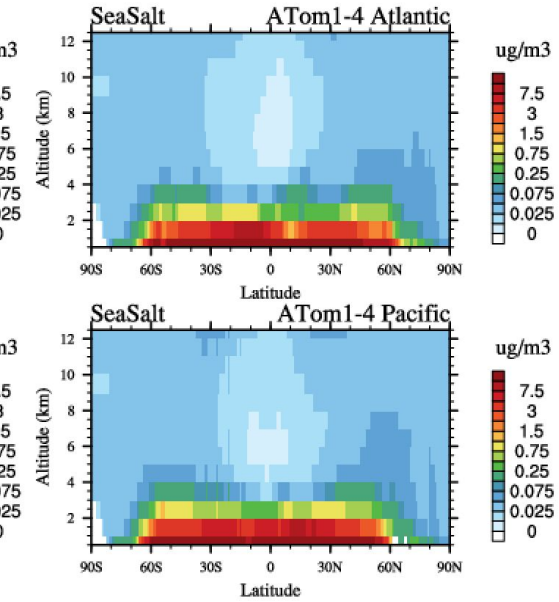


SeaSalt (factor 1.0)

ATom data



T4S MT new dust



- Dust has improved, but still a bit high compared to observations
- SeaSalt (using tuning factor 1.0) is reasonable

Credit: Simone Tilmes

Budget Tables

Variable	T1S	T4S (% diff)	T4Sr2 (% diff)
O3_BURDEN (Tg)	301.927	298.665 (-1%)	294.549 (-2.4%)
O3_CHEM_LOSS (Tg/yr)	3253.96	3190.16 (-2%)	3066.2 (-6%)
O3_CHEM_PROD (Tg/yr)	3786.55	3624.24 (-4%)	3503.55 (-8%)
O3_LIFETIME (days)	28.196	28.347 (0.5%)	28.95 (2.6%)
O3_TEND (Tg/yr)	395.981	377.67 (-4.7%)	373.244 (-6%)
O3_STE (Tg/yr)	260.995	280.272 (7%)	276.641 (6%)
CO_EMIS (Tg/yr)	766.079	765.452 (-0.1%)	748.275 (-2.3%)
DUST_EMIS (Tg/yr)	4180.63	4174.27 (-0.14%)	3573.95 (-16%)
DUST_BURDEN (Tg)	22.277	22.381 (0.47%)	21.722 (-2.5%)
DUST_LIFETIME (days)	2.332	2.344 (0.5%)	2.613 (11.4%)
SALT_BURDEN (Tg)	4.13	4.12 (-0.25%)	5.295 (25%)
SOA_BURDEN (Tg)	0.564	0.433 (-26%)	0.298 (-62%)
POM_BURDEN (Tg)	0.455	0.417 (8.7%)	0.417 (8.7%)
BC_BURDEN (Tg)	0.115	0.105 (-9%)	0.105 (-9%)
SO4_BURDEN (Tg)	0.411	0.414 (0.73%)	0.408 (-0.73%)
CH4_LIFETIME (years)	9.316	9.439 (1.3%)	9.111 (2.25%)
ISOP_EMIS (Tg/yr)	304.857	297.229 (-2.5%)	173.33 (-55%)

- T4S not significantly different from T1S with exception of SOA
- T4Sr2 shows more differences with T1S than T4S does.
- T4Sr2 dust variables show biggest difference

Takeaways

Evaluation of the differences between simulations using the MOZART-T1S and MOZART-T4S chemical mechanisms

- Findings (T4S & T1S)
  - T4S is approximately 40% cheaper and faster than T1S
  - Overall, species compare well
  - Share same biases
  - Largest differences: SH UTLS Ozone (10%) & SOA Burden (26%)

- T4S & T4Sr2
  - More African and less Australian dust in T4Sr2
  - AOD looked better in T4Sr2 with respect to Australia
  - Results in a bias shift – low bias in NH even lower, high bias in SH reduced.