

# The CESM1.0.3 public release: What's new in WACCM

Mike Mills  
WACCM Liaison

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- Updated Chemistry
  - New CMIP5 Compsets
  - Satellite and aircraft tracking
  - Local time history averaging
  - WACCM driven by specified dynamics (SD-WACCM)
  - WACCM with specified chemistry (SC-WACCM)
  - Additional new compsets
  - Bug fixes
  - Known issues
  - Ongoing & future developments



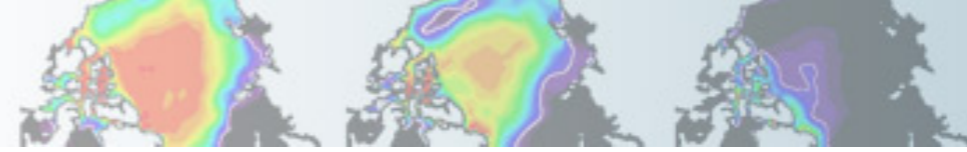
NCAR



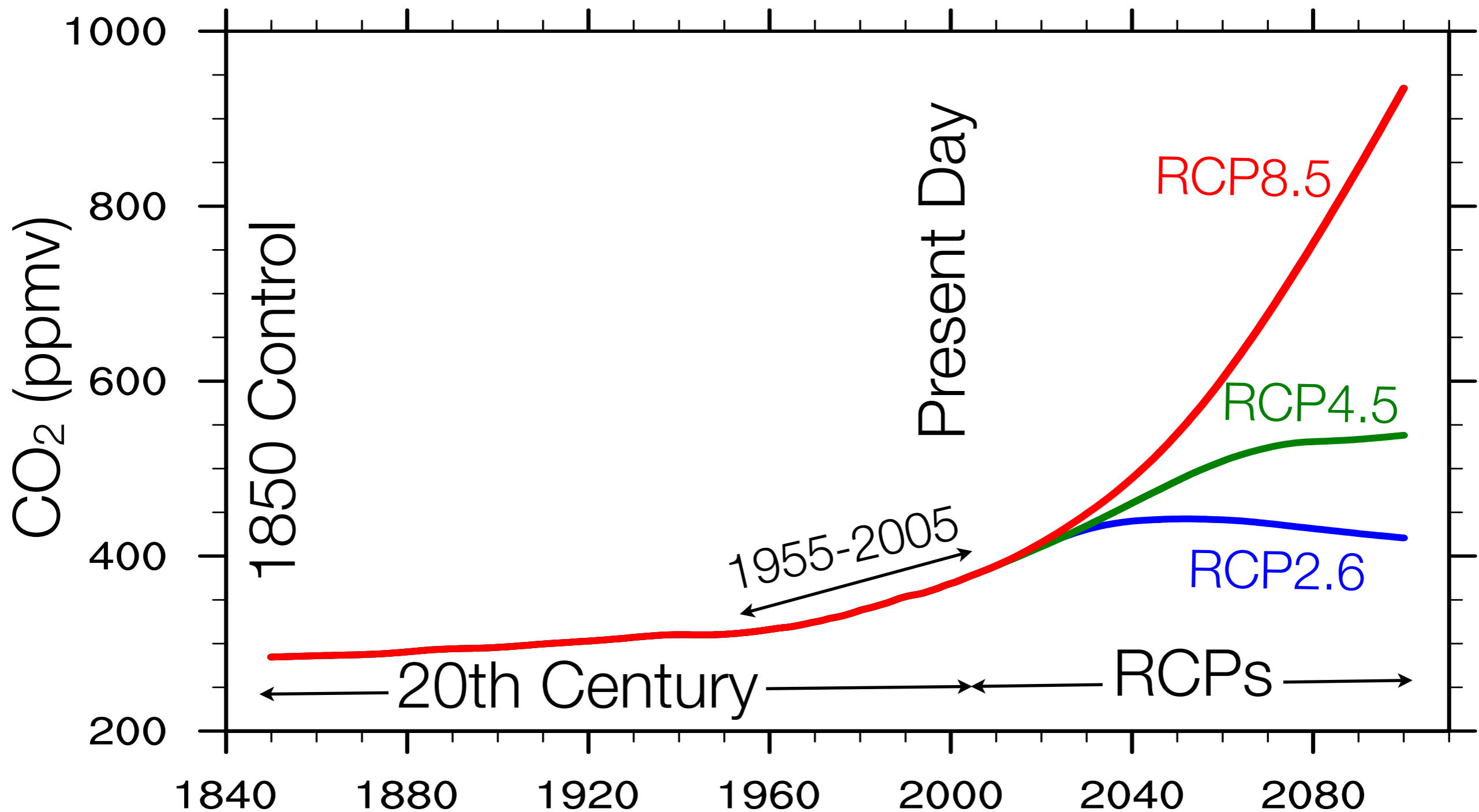
# WACCM

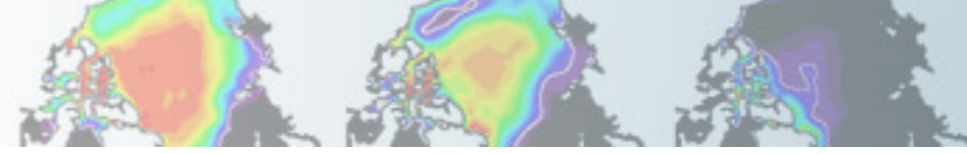
Whole Atmosphere  
Community Climate Model





# Transient and static WACCM configurations



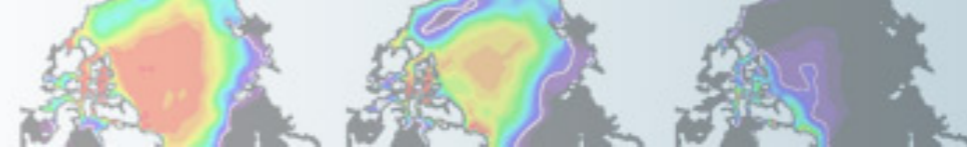


## Previously released WACCM compsets (CESM1.0.{0,1,2})

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- **B Compsets:** Full interactive ocean/ice
  - **B\_1850\_WACCM** (short name **B1850W**): Pre-industrial (perpetual year 1850AD)
  - **B\_1850\_WACCM\_CN** (**B1850WCN**): Pre-industrial with carbon-nitrogen cycle in CLM. **Scientifically validated at 1.9x2.5\_gx1v6.**
  - **B\_1850-2005\_WACCM\_CN** (**B20TRWCN**): 20th Century (1850-2005 transient) with carbon-nitrogen cycle in CLM. **Scientifically validated at 1.9x2.5\_gx1v6.**
- **F Compsets:** Prescribed sea ice, data ocean (SST data mode)
  - **F\_1850\_WACCM** (**F1850W**): Pre-industrial (perpetual year 1850AD)
  - **F\_2000\_WACCM** (**FW**): Present-day (perpetual year 2000AD). **Scientifically validated at 1.9x2.5\_1.9x2.5.**



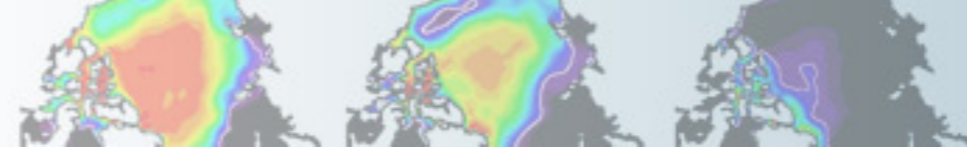


# Newly released WACCM compsets (CESM1.0.3)

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- **B Compsets:** Full interactive ocean/ice
  - **B\_2000\_WACCM\_CN (BWCN):** Present-day (perpetual year 2000AD)
  - **B\_1955-2005\_WACCM\_CN (B55TRWCN):** 1955 to 2005 transient, with daily solar data and SPEs. **Scientifically validated at 1.9x2.5\_gx1v6.**
  - **RCP future scenarios:** 2005 to 2100 transient, with daily solar data and SPEs. **Scientifically validated at 1.9x2.5\_gx1v6.**
    - **B\_RCP2.6\_WACCM\_CN (BRCP26WCN)**
    - **B\_RCP4.5\_WACCM\_CN (BRCP45WCN)**
    - **B\_RCP8.5\_WACCM\_CN (BRCP85WCN)**
- **F Compsets:** Prescribed sea ice, data ocean (SST data mode)
  - **F\_1955-2005\_WACCM\_CN (F55WCN):** 1955 to 2005 transient, with daily solar data and SPEs.
  - **F\_2000\_WACCM\_SC (FWSC):** Specified chemistry, perpetual year 2000
  - **F\_SD\_WACCM (FSDW):** Specified dynamics



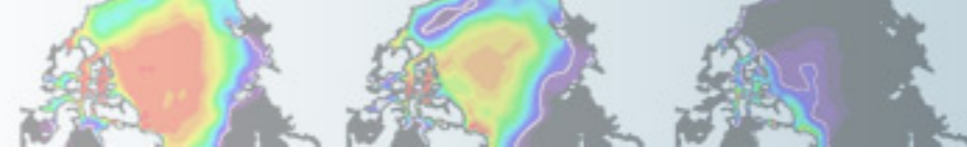


# Updated Chemistry

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- **mo\_sad.F90:** Sulfate and PSC surface area density scheme has been updated to improve science and stability (Doug Kinnison). This update changes climate. Configure with “chem -**waccm\_mozart**” for the latest updates.
- To preserve the ability to reproduce our CMIP5 runs, we created the configure option “chem -**waccm\_mozart\_v1**”, which is configured out-of-the-box in:
  - B\_1850\_WACCM\_CN
  - B\_1850-2005\_WACCM\_CN
  - B\_1955-2005\_WACCM\_CN
  - B\_RCP2.6\_WACCM\_CN
  - B\_RCP4.5\_WACCM\_CN
  - B\_RCP8.5\_WACCM\_CN
- **Bug fix:**  $O(^1D) + CCl_4 \rightarrow 4 Cl$  reaction was previously not producing chlorine. This has been fixed in both versions of the chemistry (**waccm\_mozart** and **waccm\_mozart\_v1**). Because photolysis is the dominant loss for  $CCl_4$ , the impact on chemistry should be very minor (number changing, not climate changing).

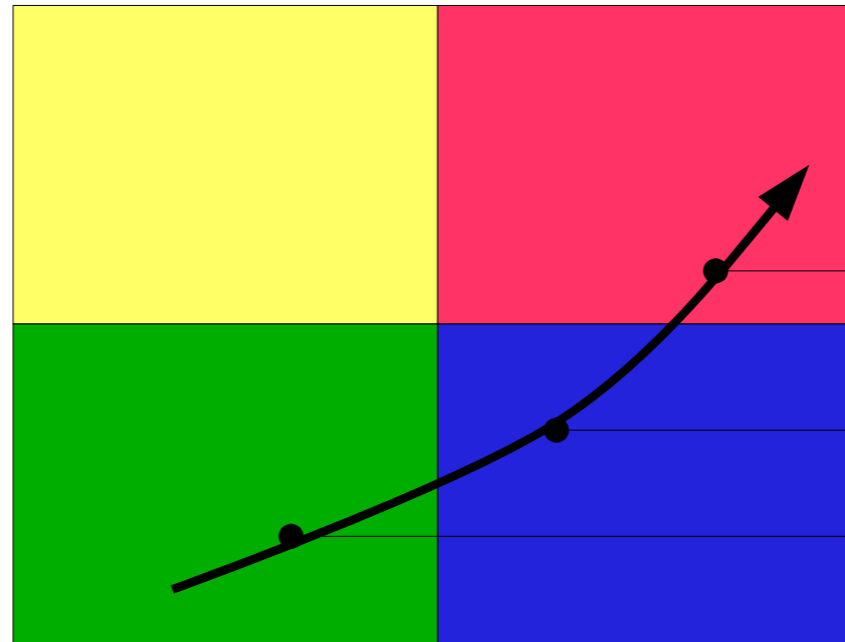




# History Column Sampling

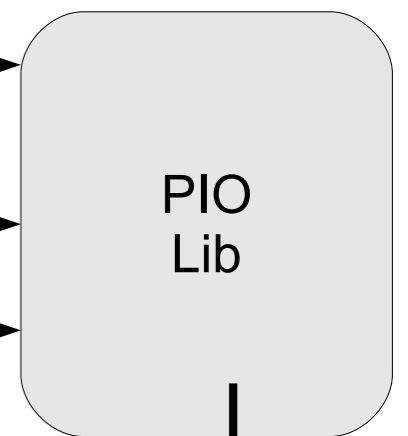
- Sample the CAM history buffer along a specified path (satellite, aircraft)
- All history variables can be sampled
- At each timestep, output stream of model columns nearest to specified coordinates for +/- half a timestep in a sequence specified via a tracking file

Horizontal grid distributed across MPI tasks

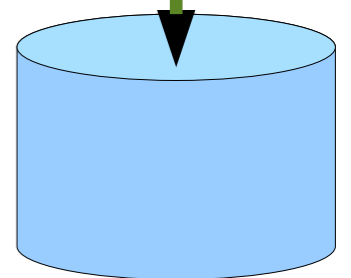


Output individual columns along the flight path

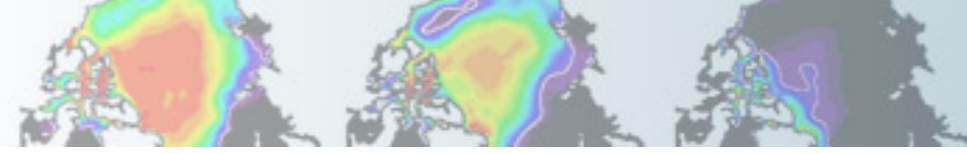
The corresponding model columns along the flight path are extracted and output in the same sequence as the input tracking file



Stream columns to Netcdf file



Courtesy Francis Vitt



# History Column Sampling

## Namelist options:

```
sathist_fincl      = 'PS','Q','T','U','V','O3',...
sathist_track_infile = '../satellite_profilelist.nc'
sathist_mfilt      = 500000
sathist_hfilename_spec = '%c.cam2.sat.%y-%m-%d-%s.nc'
```

input file

output file format

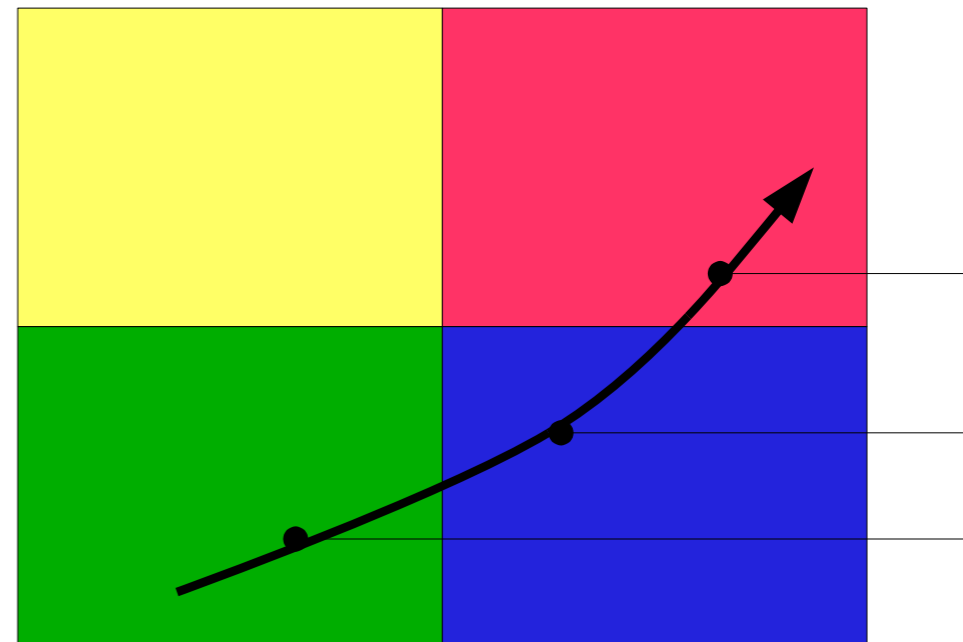
## Tracking file:

Required variables:

```
int time(profs) ;
   time:long_name = "time of day" ;
   time:units = "s" ;
int date(profs) ;
   date:long_name = "date[yyyymmdd]" ;
   date:units = "yyyymmdd" ;
float lat(profs) ;
   lat:long_name = "latitude" ;
   lat:units = "degrees" ;
float lon(profs) ;
   lon:long_name = "longititude" ;
   lon:units = "degrees" ;
```

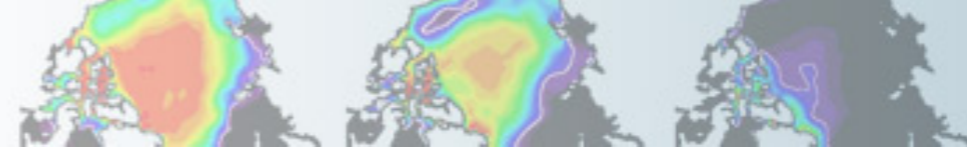
profiles

Horizontal grid distributed across MPI tasks



Courtesy Francis Vitt

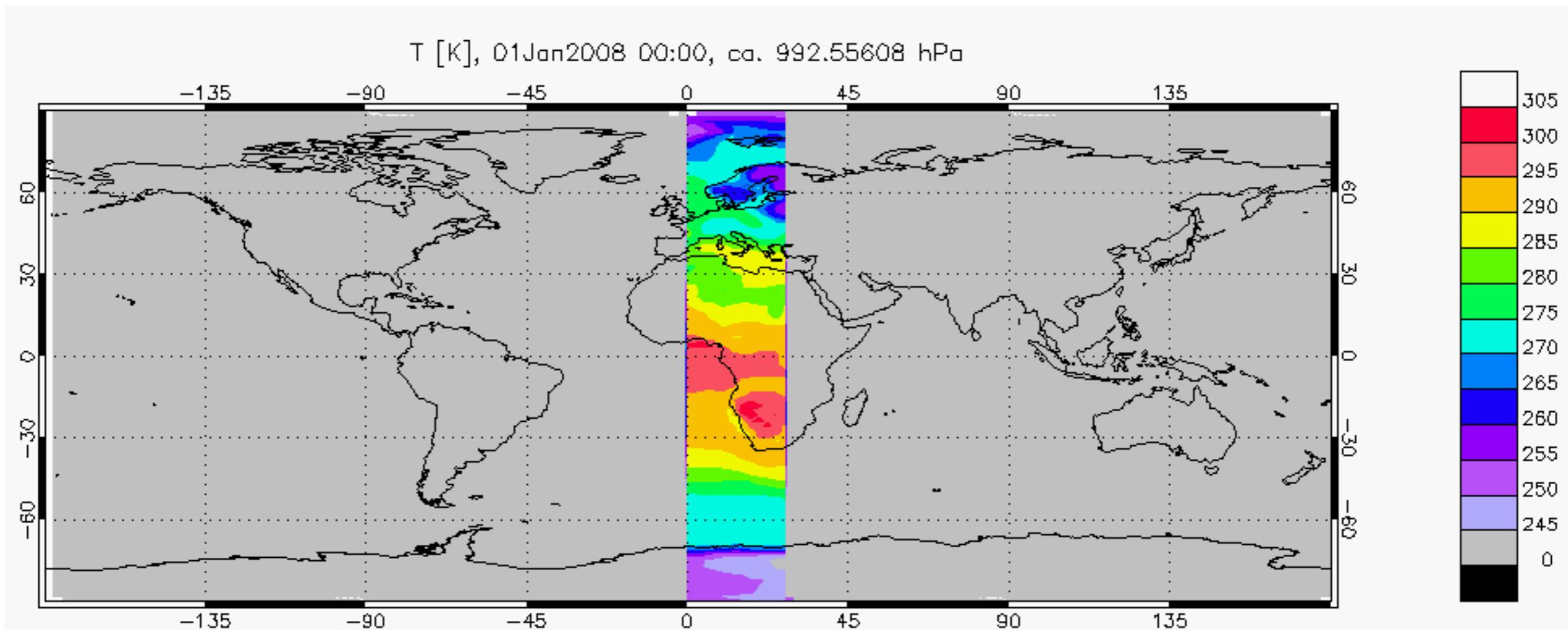


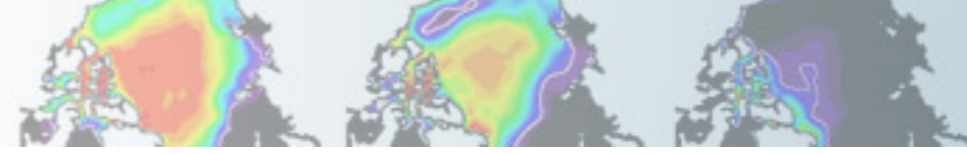


# Local time history averaging

Namelist settings:

```
avgflag_pertape = 'A', 'L'  
fincl2          = 'Q', 'T', 'PS'  
lcltod_start   = 0, 0  
lcltod_stop    = 0, 7200
```



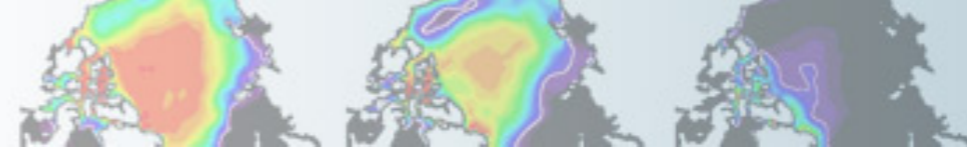


# Specified Dynamics: SD-WACCM

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- Reproduce winds and temperatures from specific periods in analyses.
- Meteorological fields from NASA GMAO [GEOS5.1] available for 1 Jan 2004 - 1 Oct 2010. **F\_SD\_WACCM** compset starts on 1 Jan 2005 out of the box.
- GEOS5.1 resolution:  $0.5^\circ \times 0.66^\circ$ , 72 levels ( $\leq 80\text{km}$ )
- SD-WACCM resolution:  $1.9^\circ \times 2.5^\circ$ , 88 levels ( $\leq 140\text{km}$ )
- Nudge T, U, V, PS by 1% at every dynamics timestep below  $\sim 50\text{ km}$ , fully interactive dynamics aloft.
- Chemistry: standard **waccm\_mozart** middle atmosphere mechanism (57 species, 230 photochemical reactions)
- Ongoing developments for future release:
  - MERRA meteorological fields to cover 1979-2010.
  - MOZART4 troposphere mechanism (122 species, 380 reactions)





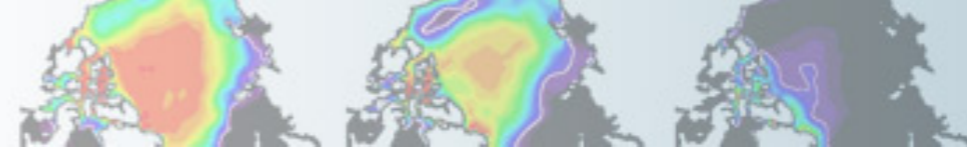
# Specified Chemistry: SC-WACCM

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- Requested at February WACCM Working Group for significantly faster throughput in dynamical studies.
- Run WACCM using limited chemistry, specified from zonally averaged output of a previous WACCM run: CO<sub>2</sub>, H, NO, O, O<sub>2</sub>, O<sub>3</sub>, QRS\_TOT (merged SW heating)
- Namelist variables:

```
ghg_chem           = 'true'  
cam_chempkg       = 'waccm_ghg'  
waccm_forcing_datapath= '/path/do/forcing/file'  
waccm_forcing_file  = 'ghg_forcing_2000_c110321.nc'
```
- **F\_2000\_WACCM\_SC** compset repeats year 2000 out of the box. May be modified for transient runs.
- Runs ~2.5 times faster than WACCM with full middle atmosphere chemistry





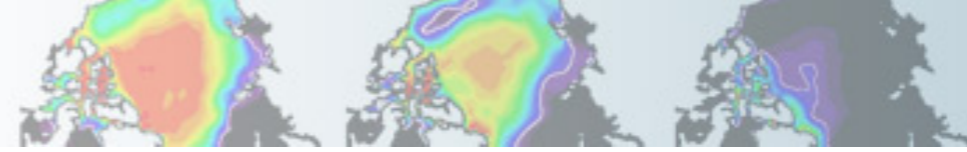
## Known Issues

- Gravity waves amplitudes were turned down to increase the mesopause altitude (was ~80 km previously). This strengthens and extends the stratospheric polar vortex jet, causing it to persist too late in the season. May be a problem for all FV dynamical cores.

## Ongoing and Future Model Development

- WACCM5
  - WACCM4 + RRTMG radiation scheme: ✓
  - WACCM with all CAM5 physics: in progress
  - climate and gravity wave tuning with new physics
- CESM-CARMA: public release within a few months?
- Self-generating QBO
- WACCM-X
- Spectral element (SE, or HOMME) dynamical core and CSLAM



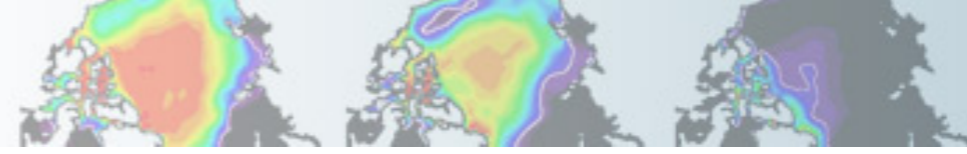


# Summary

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- Updated Chemistry
  - new mo\_sad
  - CMIP5 version available as waccm\_mozart\_v1
  - Bug fix: O(<sup>1</sup>D) + CCl<sub>4</sub>
- New CMIP5 Compsets
  - 1955-2005 with daily solar
  - RCP2.6, 4.5, & 8.5
- WACCM driven by specified dynamics (SD-WACCM)
- WACCM with specified chemistry (SC-WACCM)
- Additional new compsets
  - Present-day with full ocean
  - 1955-2005 with data ocean
- Satellite and aircraft tracking
- Local time history averaging
- Known issues: polar vortex
- Ongoing & future developments
  - WACCM5
  - CESM-CARMA
  - WACCM-X
  - Self-generating QBO
  - Spectral element core

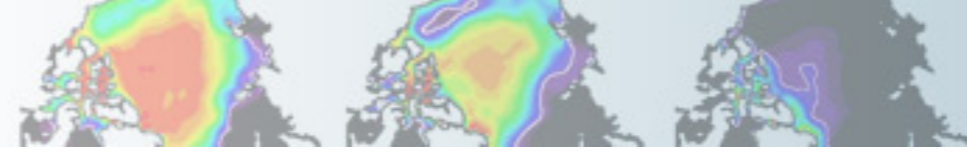




# Additional Slides

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# History Column Sampling

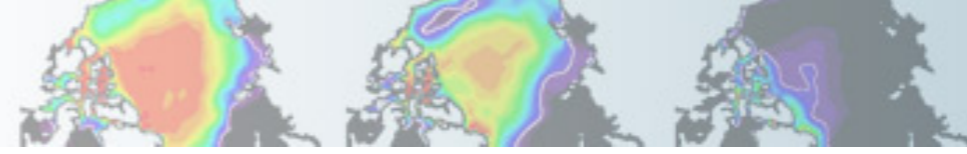
## History copied to output file as optional variables

Optional variables:

```
int instr_num(profs) ;
    instr_num:long_name = "MLS=1, ACE-FTS=2, HIRDLS=3, SABER=4" ;
    instr_num:units = "1" ;
float instr_sza(profs) ;
    instr_sza:long_name = "solar zenith angle" ;
    instr_sza:units = "degrees" ;
float local_time(profs) ;
    local_time:long_name = "local solar time" ;
    local_time:units = "1 = sunrise, -1 = sunset, 0 = N/A" ;
short occ_type(profs) ;
    occ_type:long_name = "type of occultation" ;
int orbit_num(profs) ;
    orbit_num:long_name = "orbit number" ;
    orbit_num:units = "1" ;
int prof_num(profs) ;
    prof_num:long_name = "profile number" ;
    prof_num:units = "1" ;
```

Courtesy Francis Vitt





# History Column Sampling

The output file is unstructured with column sequenced in the same order as the input tracking file:

dimensions:

```
lev = 26 ;  
ilev = 27 ;  
ncol = UNLIMITED ; // (100018 currently)
```

variables:

```
double lat(ncol) ;  
    lat:long_name = "latitude" ;  
    lat:units = "degrees_north" ;  
double lon(ncol) ;  
    lon:long_name = "longitude" ;  
    lon:units = "degrees_east" ;  
double lev(lev) ;  
    lev:long_name = "hybrid level at midpoints (1000*(A+B))" ;  
    lev:units = "level" ;  
    lev:positive = "down" ;  
    lev:standard_name = "atmosphere_hybrid_sigma_pressure_coordinate" ;  
    lev:formula_terms = "a: hyam b: hybm p0: P0 ps: PS" ;  
double time(ncol) ;  
    time:long_name = "time" ;  
    time:units = "days since 2005-01-01 00:00:00" ;  
    time:calendar = "noleap" ;  
int date(ncol) ;  
    date:long_name = "current date (YYYYMMDD)" ;  
int datesec(ncol) ;  
    datesec:long_name = "current seconds of current date" ;  
float Q(ncol, lev) ;  
    Q:units = "kg/kg" ;  
    Q:long_name = "Specific humidity" ;  
....
```

Courtesy Francis Vitt

