CAM-chem Status

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Simone Tilmes

CESM 1.2 with Chemistry

- CAM4 and CAM5, described in:
  Tilmes, S., et al., Description and evaluation of tropospheric chemistry and aerosols in the Community Earth System Model (CESM1.2), Geosci. Model Dev. Discuss., 7, 8875-8940, doi:10.5194/gmdd-7-8875-2014, 2014.

- Recent additions (not available in public version yet):
  - Neu wet dep in CAM5
  - MAM4
  - Improved dry deposition in CLM4.0 & CLM4.5 (Val Martin et al., GRL, 2014)
  - Updated volcanic heating (in CCMI ver.)
  - Removed aerosol double counting in troposphere/stratosphere (in CCMI ver.)
  - New polar chemistry (Kinnison et al., in prep., Solomon et al., in prep.) (in CCMI ver.)
  - MEGAN corrections in CLM4.5 (get CO_2 from atm, not namelist; correct LAI average for last 10 days)
  - Updated SO_2 Henry's Law coefficient (had been set to H_2O_2)

→ See bug reports

MEGAN emissions flux for species i: $F_i = \gamma_i \sum \varepsilon_{i,j} \chi_j$

$\gamma_i = C_{CE}$ LAI $\gamma_{P,i} \gamma_{T,i} \gamma_{A,i} \gamma_{SM} \gamma_{C,i}$

$\varepsilon_{i,j}$ = emission factor at standard conditions (species i, PFT j)

χ_j = area of grid box for PFT j

C_{CE} : canopy environment

LAI: **Leaf area index**

γ_P = (1−LDF) + LDF $\gamma_{P,LDF}$ -- **Light dependent** factor; depends on PAR in sun
      and shade, and current and 10-day average

γ_T − **Temperature** dependence, also includes light dependence, and
      difference from past 10-day average

γ_A − Leaf age factor (difference from **past 10-day average LAI**)
      {CLM4.0 used difference from last time step}

γ_{SM} − Soil moisture (=1)

γ_C − CO_2 inhibition (isoprene only)
      {CLM4.0 used namelist CO2 value, not actual CAM atmosphere value}

CLM/Chemistry Coupling

Impact of different land model versions on MEGAN VOC emissions and dry dep.

Model Versions: 1.9x2.5, FV, F2000, CO_2 coupling added, **10years**
- CAM5-chem, CLM4.0, prescribed LAI climatology
- CAM5-chem, CLM4.0, including CN coupling -> LAI is calculated online
- CAM5-chem, CLM4.0, including CN coupling, 10-day avg previous LAI used for VOC emission calculation (previous version uses 1-timestep for previous LAI)

F2000 10years, and FSD, 1year
- CAM5-chem, CLM4.5, prescribed LAI climatology
- CAM5-chem, CLM4.5, including CN/BGC coupling -> LAI is calculated online
- CAM5-chem, CLM4.5, including CN coupling, 10-day avg previous LAI used for VOC emission calculation

Coupling between LAI, VOC emissions and dry deposition:
1. **LAI important for MEGAN VOC emission calculation**
   - CO_2 coupling added for CO2 inhibition of isoprene emission calculation
   - VOC depends on previous LAI: emission activity factor (gamma) [unitless] includes dependence on PPFT, temperature, LAI, leaf age and soil moisture.
   - **LAI important for leaf cuticular resistance (R_{lu}) and stomatal resistance (R_{st})** and therefore deposition velocities -> changes chemistry (surface ozone)
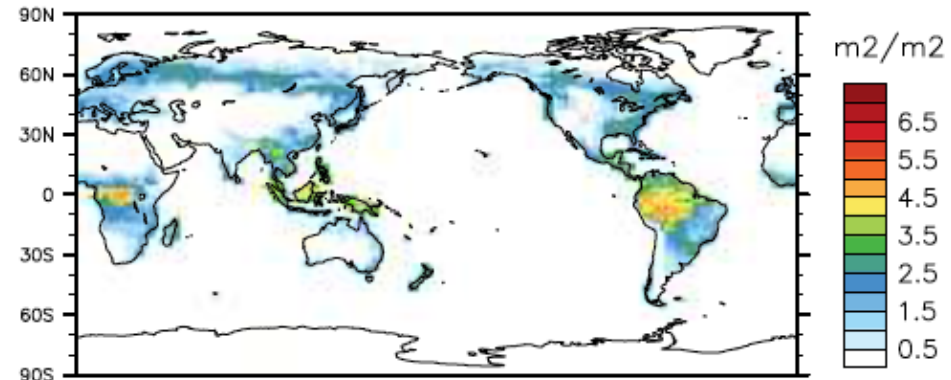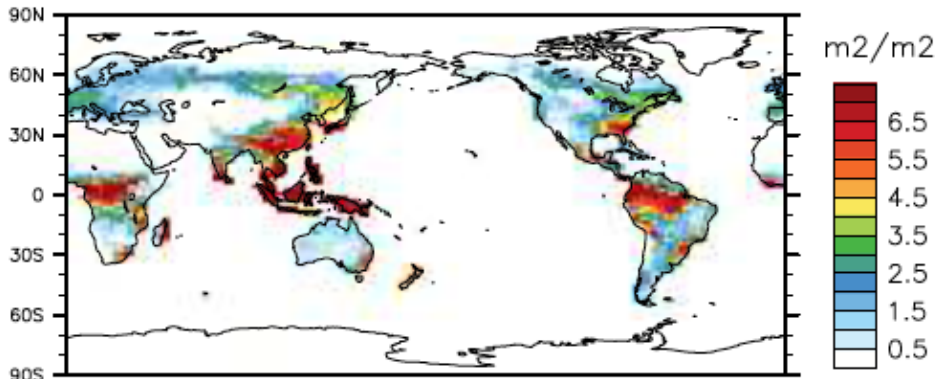
Leaf Area Index (LAI) in different versions
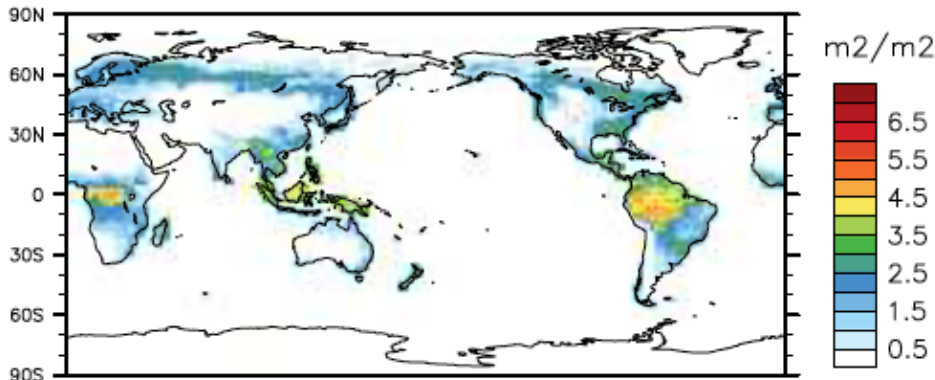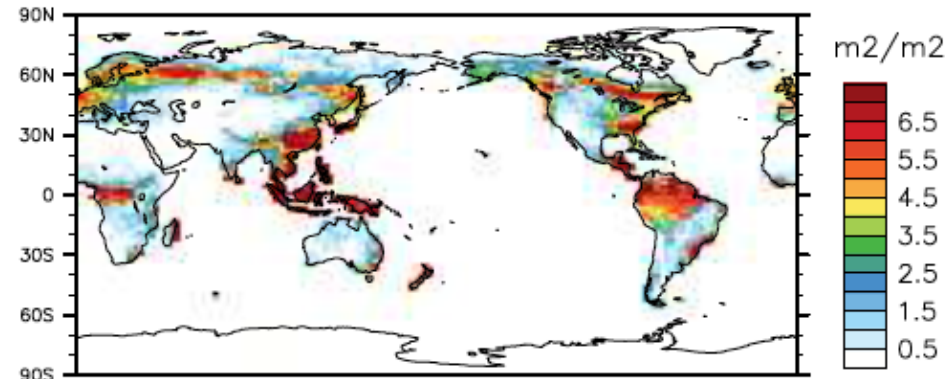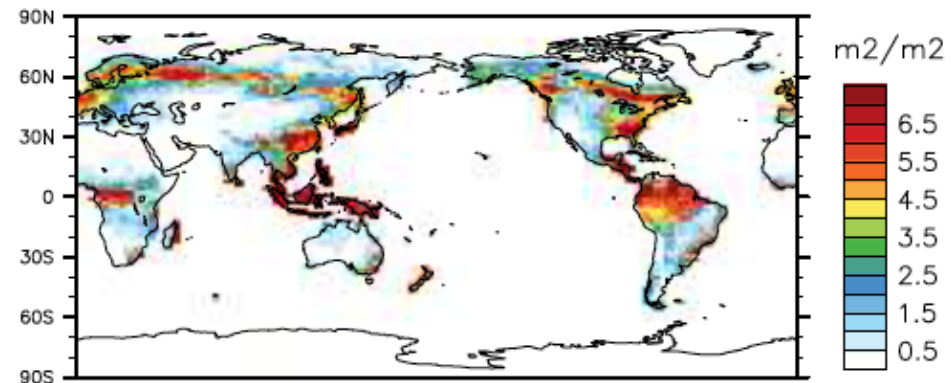
Most difference in Shaded LAI

Biogenic Isoprene Emissions
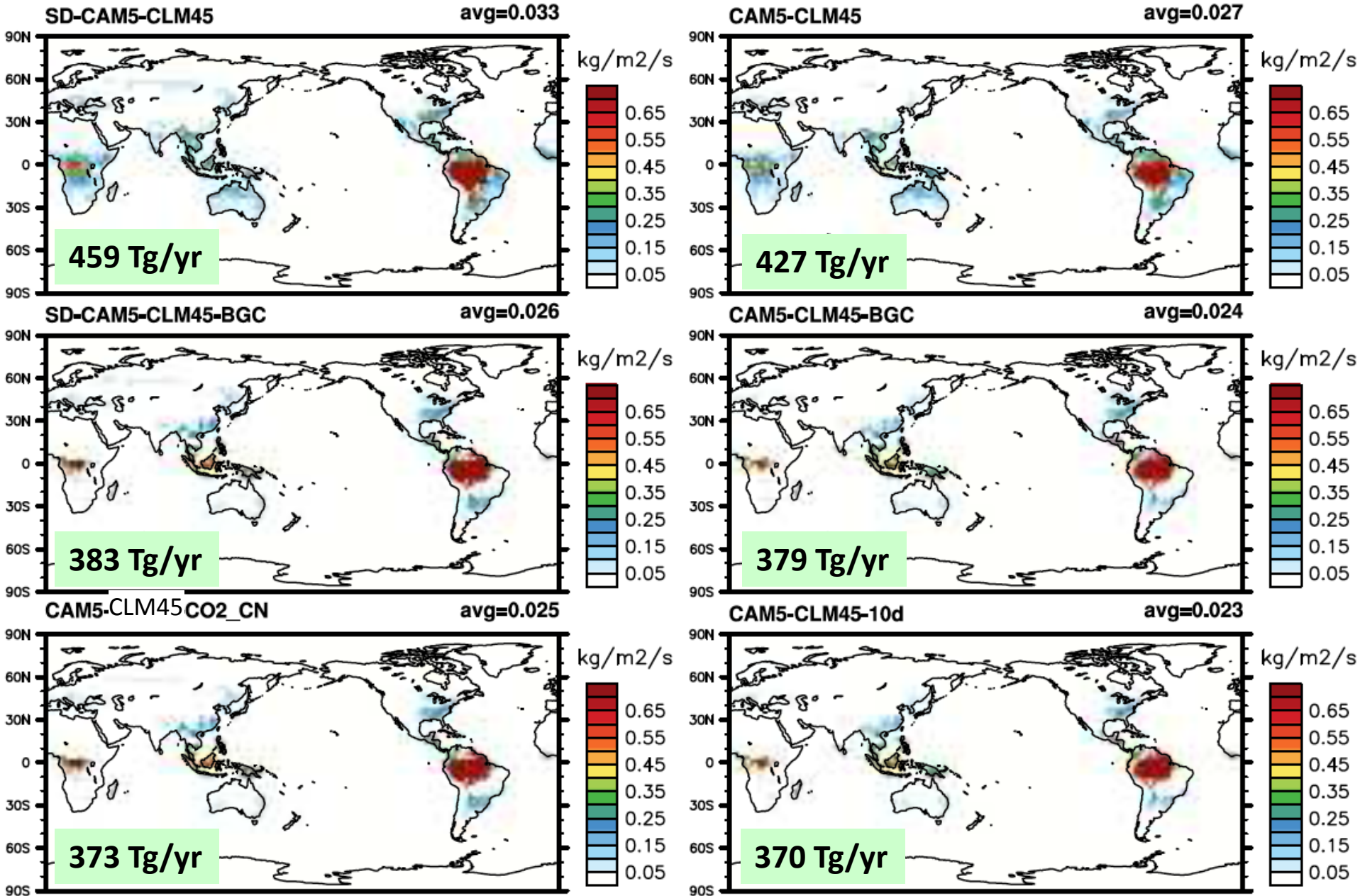
Biogenic Emissions

	F2000 Satellite LAI	F2000 BGC	F2000 BGC 10d Leaf Age	SD Sat. LAI	SD BGC	SD BGC 10d Leaf Age
CAM5-CLM4.5 Annual Emissions (Tg/yr)						
Isoprene	426.872	379.181	370.162	459.313	383.464	373.035
Monoterpene	131.451	130.501	133.021	136.741	136.219	138.526
Methanol	88.287	111.817	128.273	97.575	109.507	125.490
Acetone	41.668	47.526	47.575	43.762	48.036	48.007

F2000: 7-yr average
SD: GEOS-5 for 2000

Some differences between:
- free-running and specified dynamics
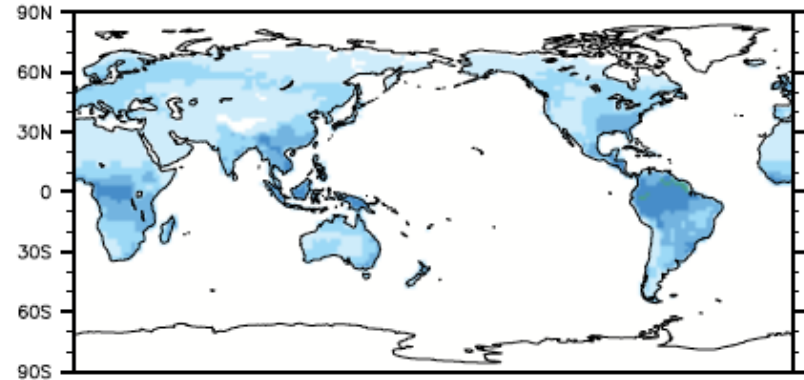- satellite LAI and CLM-BGC calculated

But all totals within expected range
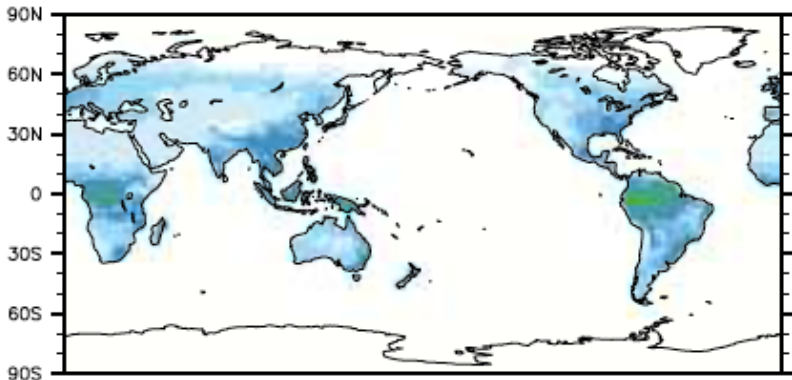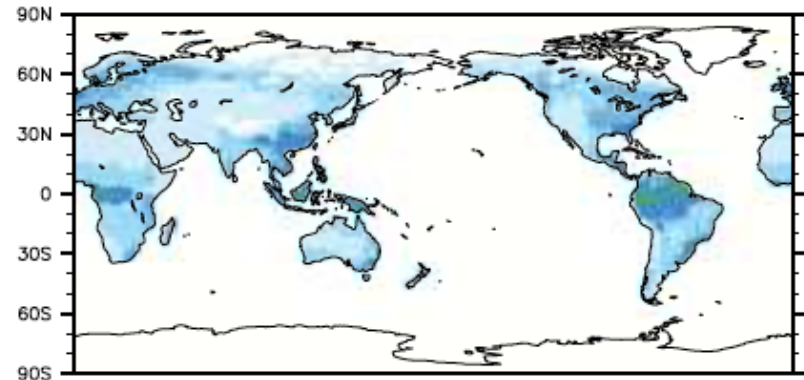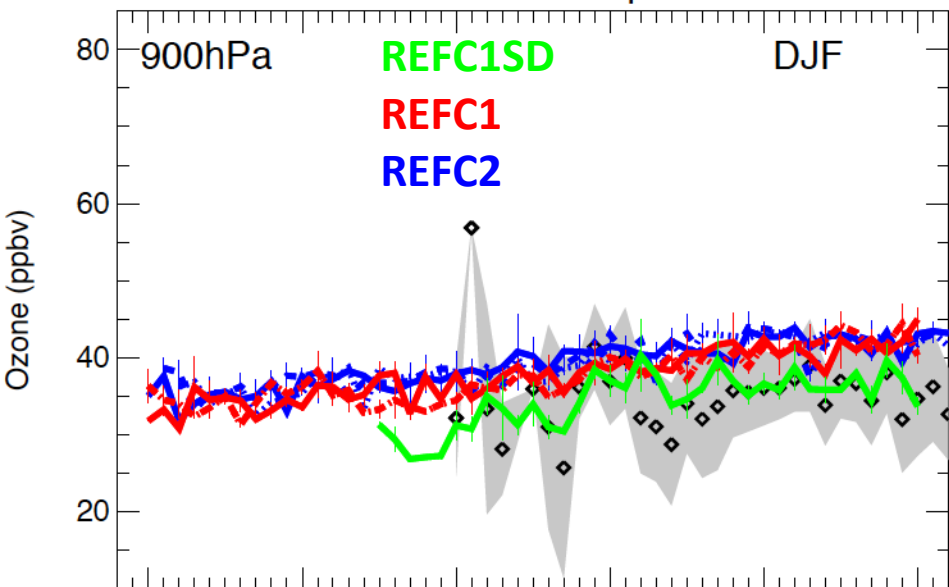
Changes in O$_3$ Deposition Velocities
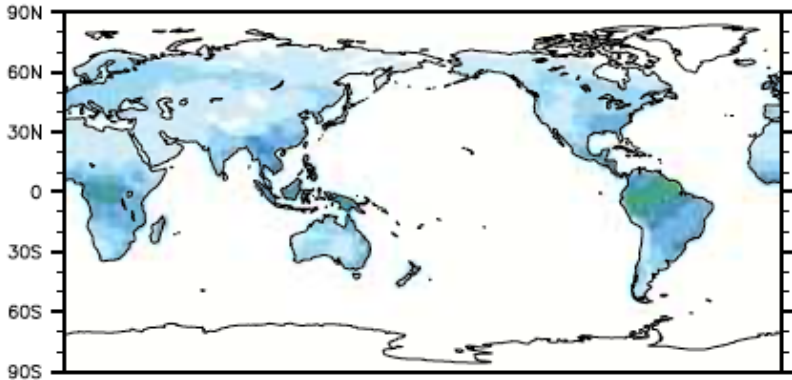
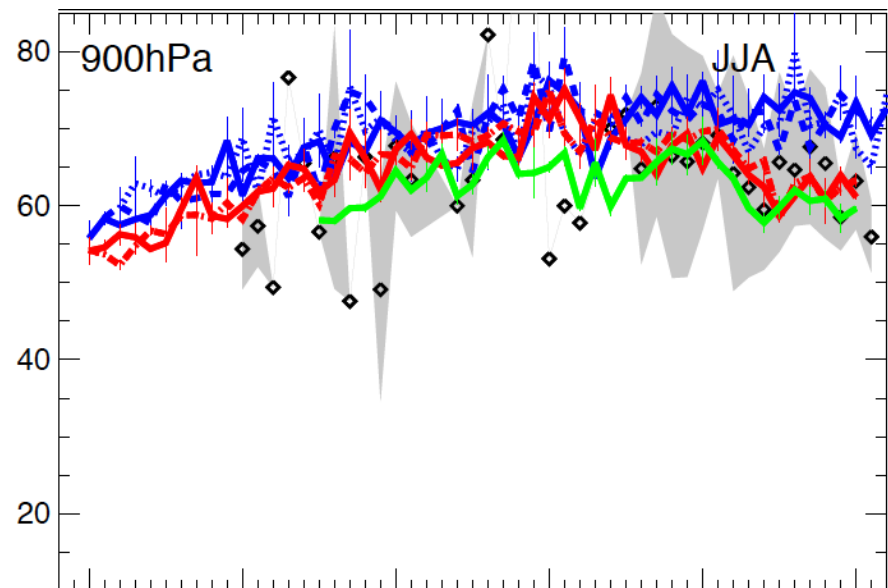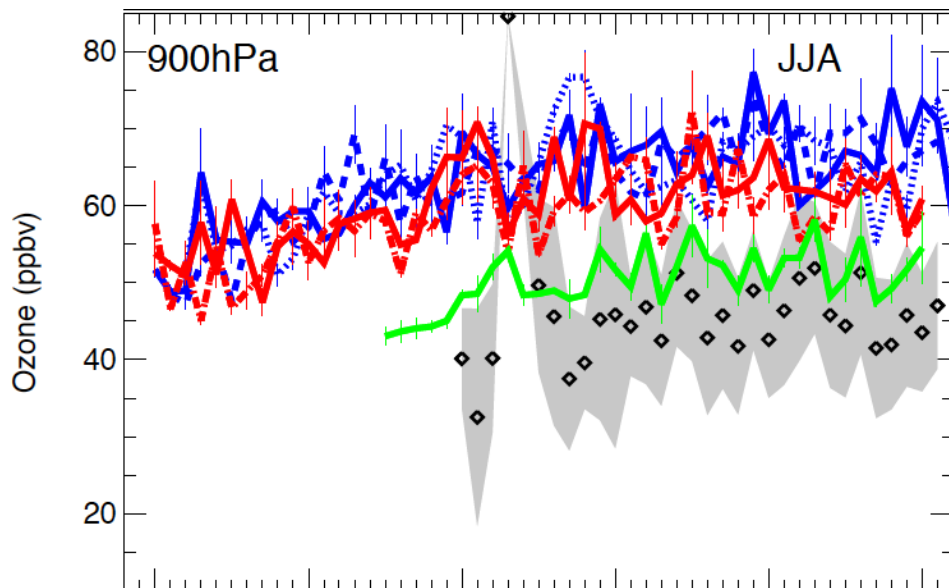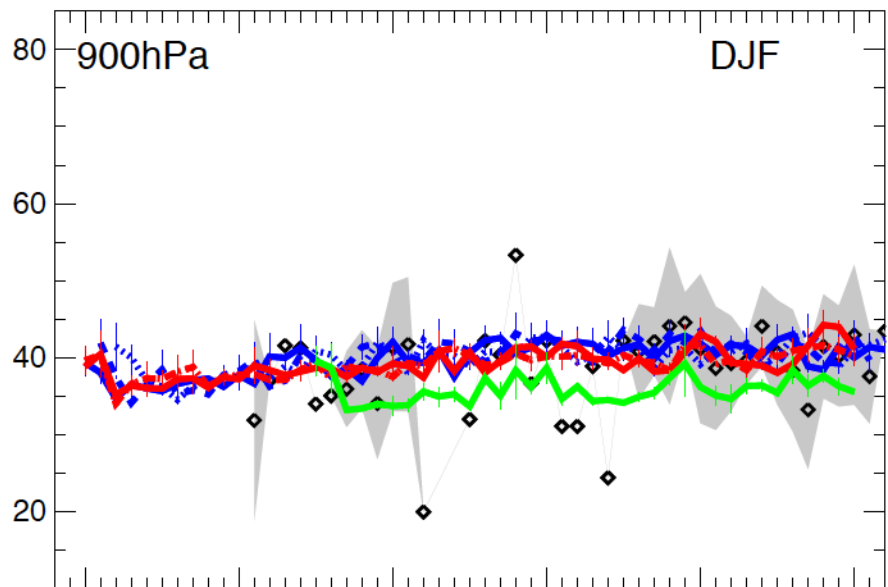Small differences between CLM 4.0 and 4.5

CESM1 CAM4-chem simulations for CCMI

Simulation	Status (not planned; about to start; running; finished data linked/ uploaded to BADC)	Priority (High, Medium, or Low)	How many ensemble members?
REF-C1	finished	high	3 members
REF-C1SD	finished	high	1 member
REF-C2 (RCP 6.0)	finished	high	3 members
SEN-C1-Emis			
SEN-C1SD-Emis			
SEN-C1-fEmis	about to start	medium	1 member
SEN-C1SD-fEmis	running	high	3 slightly diff. versions
SEN-C1-SSI			
SEN-C2-RCP2.6			
SEN-C2- RCP4.5			
SEN-C2- RCP8.5			
SEN-C2-fODS	about to start	medium	1 member
SEN-C2-fODS2000	about to start	medium	1 member
SEN-C2-fGHG	about to start	medium	1 member
SEN-C2-fEmis	about to start	medium	1 member
SEN-C2-GeoMIP (1x)	running	high	3 members
SEN-C2-SolarTrend			

Western Europe — 900hPa — DJF — REFC1SD — REFC1 — REFC2

Eastern US — 900hPa — DJF

Western Europe — 900hPa — JJA

Eastern US — 900hPa — JJA

Ozone (ppbv)

Western Europe — Eastern US

500hPa · DJF · REFC1SD · REFC1 · REFC2 · Ozone (ppbv)

500hPa · JJA
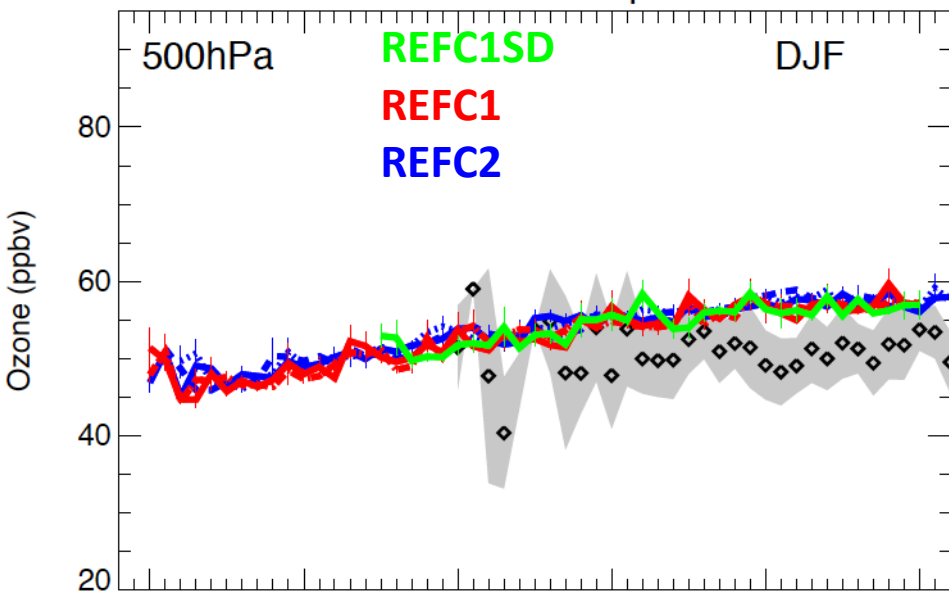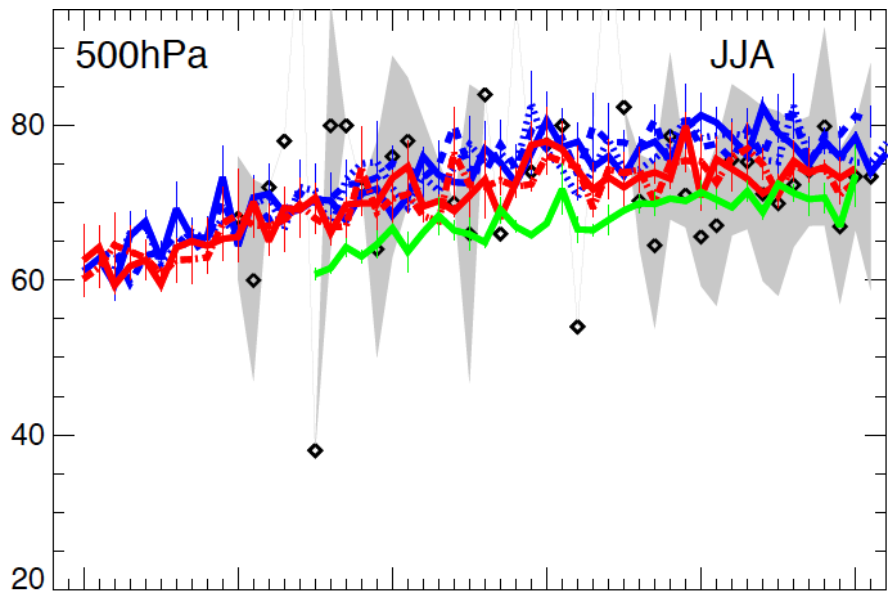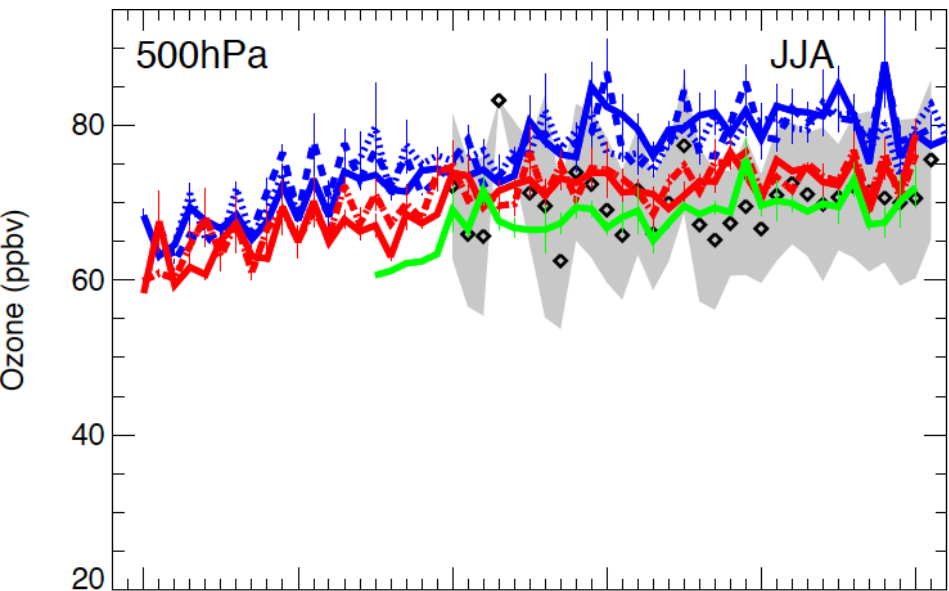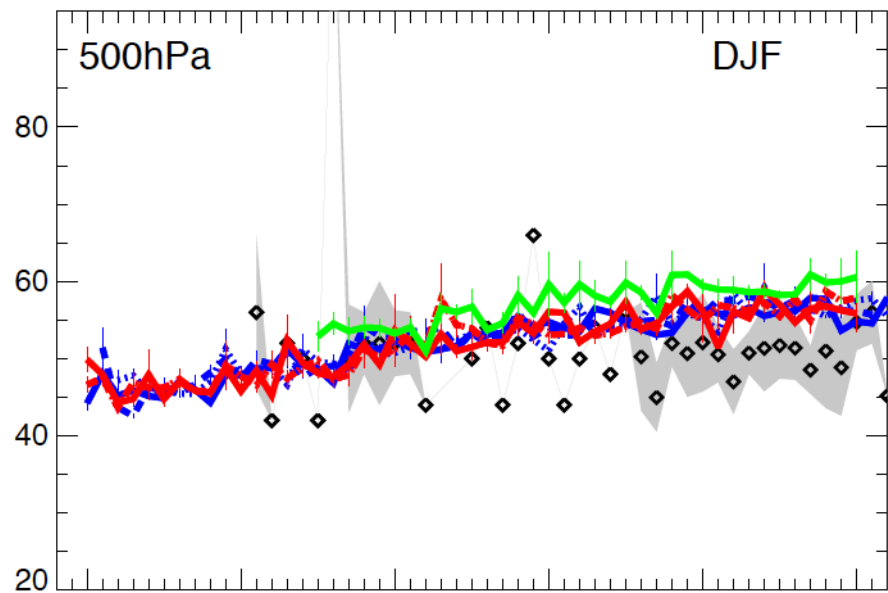
HTAP2 Simulations

Louisa Emmons, Steve Arnold, Tim Butler

- Using CCMI configuration of CAM-chem

- Emissions provided by HTAP2, 2008 & 2010

- Regional source perturbation experiments

UK CESM "Meeting"

Photo by Steve Arnold

Paul Young – Lancaster
Ryan Neely – Leeds
Maria Val Martin – Sheffield
Steve Arnold - Leeds

Setting up common model version for all on the UK machine (1.1.1 and 1.2.2)

A core theme that they may target is vegetation-composition-climate

- If you are on ReadyTalk you need to call in to hear us!!!!