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Atmosphärenchemie im Erdsystem – AerChemMIP mit EMAC

CMIP6 Jahrestreffen

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Knowledge for Tomorrow

DLR

CMIP6 AerChem MIP model requirements

- **AGCM / AOGCM** → atmosphere or atmosphere/ocean GCM

- **AER** → models should at least calculate tropospheric aerosols driven by emission fluxes.

- **CHEM^T** → at least tropospheric chemistry is required

- **CHEM^S** → at least stratospheric chemistry is required.

- Models should always be run with the maximum complexity available.

EMAC (ECHAM MESSy Atmospheric Chemistry) v2.53
(Jöckel et al., 2016)

Configuration: T42L47MA
AOGCM   – EMAC-MPIOM   (Pozzer et al., 2011)
CHEM^T, CHEM^S, AER – EMAC/EMAC-MPIOM with
- MECCA (gas phase)   (Sander et al., 2011)
- GMXE (aerosol)   (Pringle et al., 2010)
- SCAV (aqueous phase)   (Tost et al., 2006)

Solar forcing for CMIP6 (Matthes et al., 2017)

Total solar irradiances and spectral solar irradiances:

• CMIP6 TSI/SSI dataset – created as a combination of NRLSSI2 and SATIRE.

Energetic particle precipitation (EPP):

• EPP as Ap and Kp indices available from 1850 – 2300

• Ap is used in the upper boundary condition for NO_x (UBCNOX submodel) (Funke et al., 2016).

ΔO_3 [%] $A_{p,max} - A_{p,min}$ 70-90°S
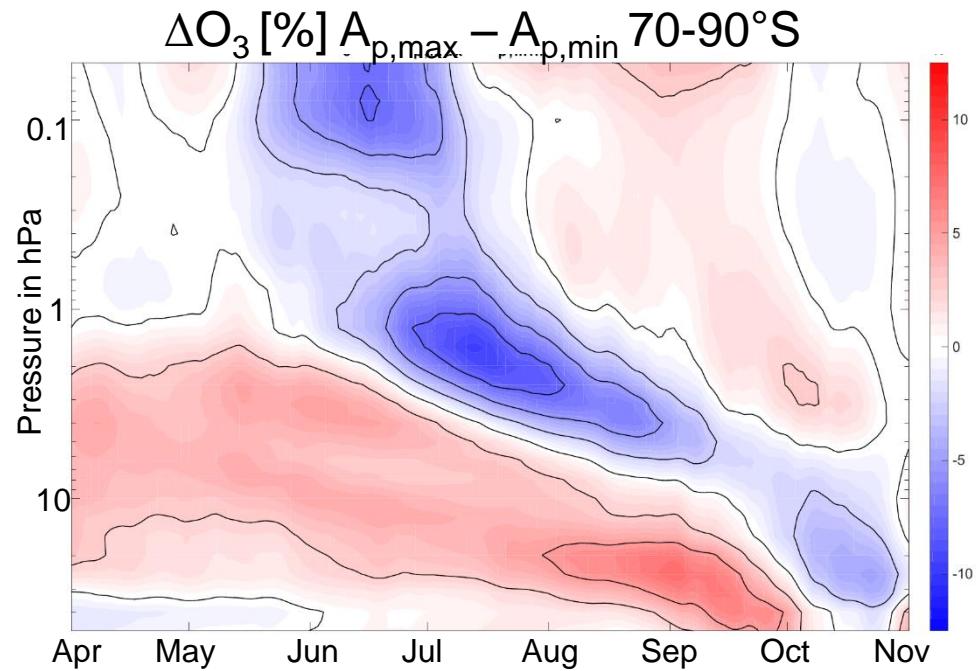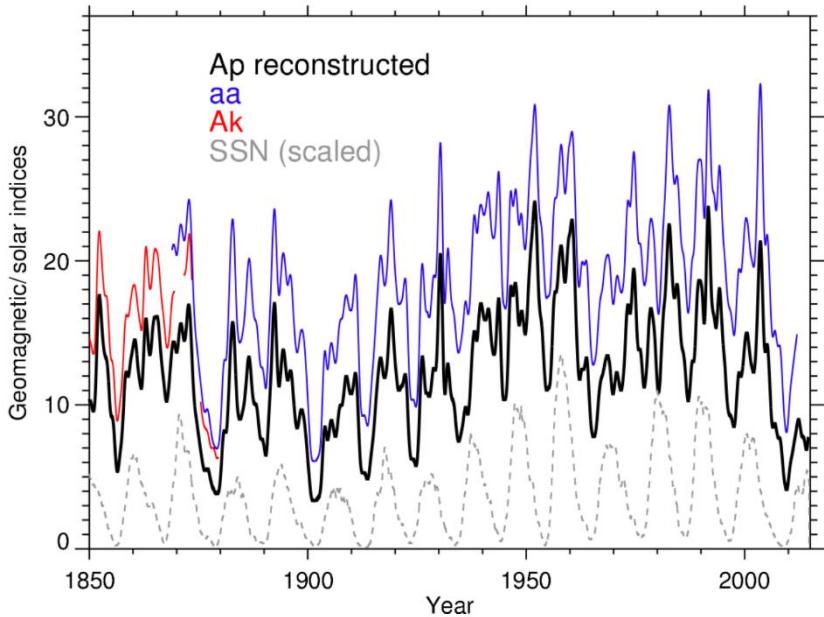
Matthes et al. (2017)

Scientific questions in AerChem MIP (Collins et al. 2017)

(1) How have anthropogenic emissions contributed to global radiative forcing (RF) and affected regional climate over the historical period?

(2) How might future policies (on climate, air quality and land use) affect the abundances of NTCFs (near term climate forcers) and their climate impacts?

(3) How do uncertainties in historical NTCF-emissions affect RF estimates?

Simulations (only Tier 1):

hist-piNTCF: (1850 – 2014, 3 ensemble members)   → (1)

hist-1950HC   (1950 – 2014, 3 ensemble members)

histSST, histSST-piNTCF, histSST-piCH4, histSST-1950HC

ssp370, ssp370-lowNTCF   (2015 – 2055, 3 ens. mem.)   → (2)

ssp370SST, ssp370SST-lowNTCF (2015 – 2055)

piClim-control, piClim-NTCF, piClim-CH4, piClim-HC   → (1, 3)

　　　(30 years time slices, fixed SSTs)

Preparation of DECK and historical simulations

## Requirement for CMIP6 AerChem MIP participation

I.   DECK (Diagnosis, Evaluation, and Characterization of Klima)

1. AMIP simulation (prescribed SSTs/SICs ~1979 – 2014
2. Pre-industrial control simulation (1850 conditions, time slice 500 years)
3. 1%/yr CO_2 increase   (150 years)
4. 4xCO_2 abrupt increase   (150 years)

II.   CMIP6 historical simulation with CMIP6 forcing (1850 – 2014)

First step: pre-industrial equilibrium state

- With CMIP6 solar forcing (Matthes et al., 2017) TSI is lower:
  1361±0.5 W m^{-2} (Kopp and Lean, 2011) compared to
 1365 W m^{-2} (Lean et al., 2005) solar forcing of CMIP5.

piControl - Preparation: 2 m temperature

13.9±0.2, 0.019±0.005, n=500   14±0.2, 0.004±0.005, n=533

global mean 2 m temperature
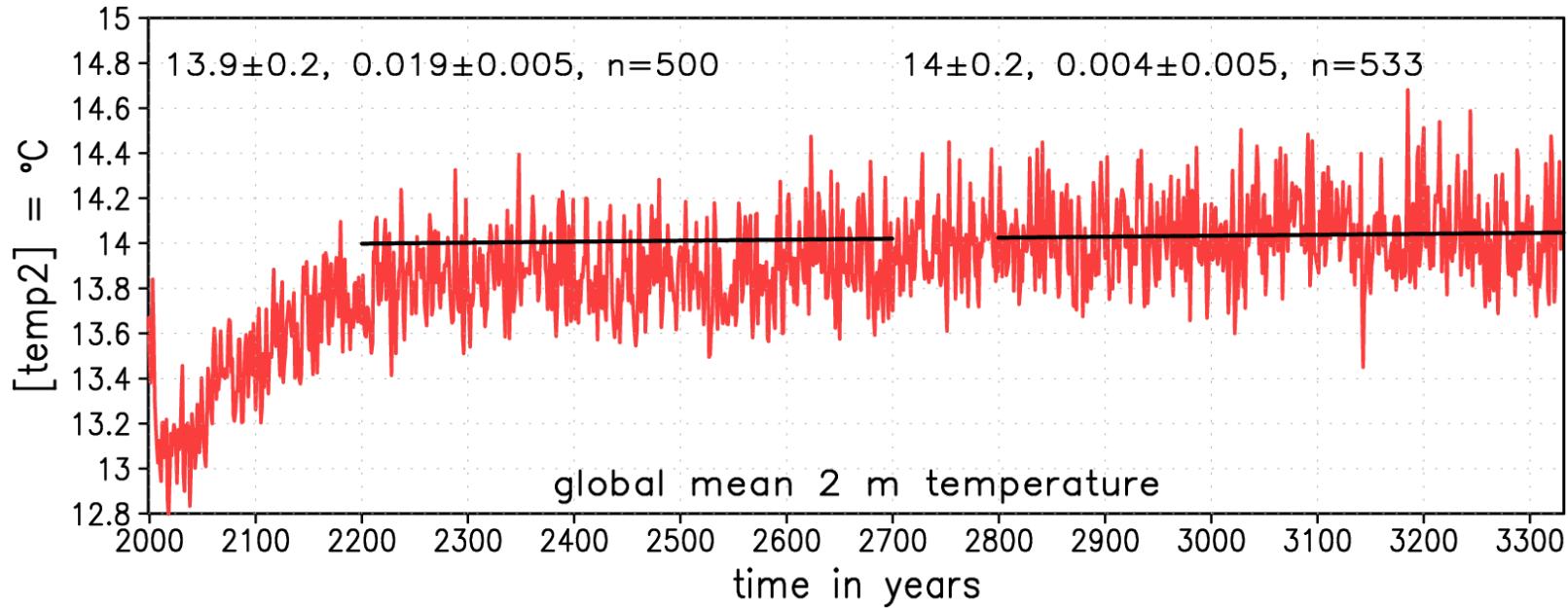
- Target value: 13.7± 0.2 °C
- Current value: 14.0± 0.2 °C, insignificant, slightly positive trend 0.004°C/century

piControl - Preparation: radiation balance TOA
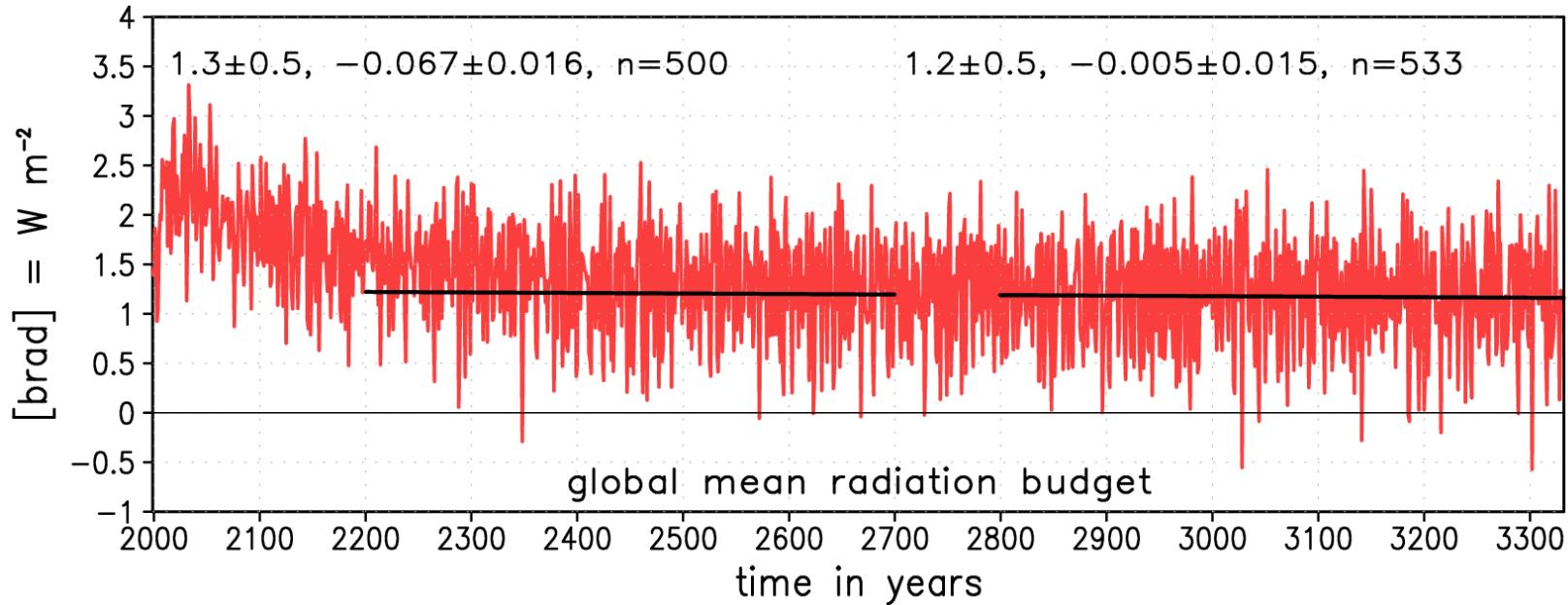
- Target value: 0.5± 1.0 W m-2
- Current value: 1.2± 0.5 W m-2, insignificant, slightly negative trend
                 0.005 W m-2/century

piControl - Preparation: total cloud cover
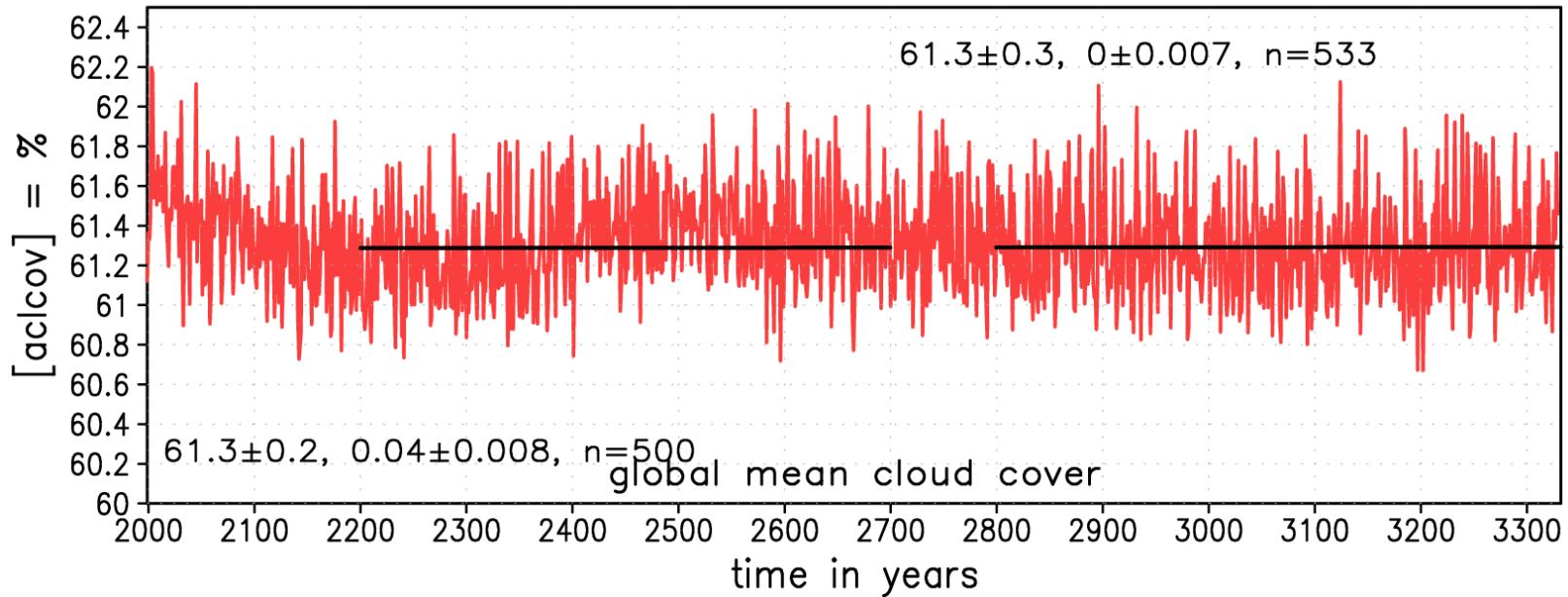
- Target value: > 60%
- Current value: 61.3± 0.30%, no trend detectable

Preparation of DECK simulation: AMIP

PCMDI-AMIP-1.1.2 (20 April 2017; Data coverage 1870-1-1 to 2016-12-31)
   Two versions of SSTs/SICs:
   ➤ observations (Hurrell et al., 2008)
   ➤ boundary conditions (BCS) (method as described in Taylor et al., 2000)

   Original horizontal resolution: 1°x1°

- Preparation for usage in EMAC:
  - ➤ Regrid to T42 and adapt to T42 land-sea mask

- Test runs with prescribed SSTs/SICs:
  - ➤ check the resultant SSTs/SICs
 - ➤ Is the AMIP-II climatology reproduced?

Boundary conditions AMIP-II SICs, January (1980 – 1992)

- **Questions**: Do the regridded boundary conditions reproduce the AMIP-II climatology?

boundary condition original   **% boundary condition for EMAC T42**
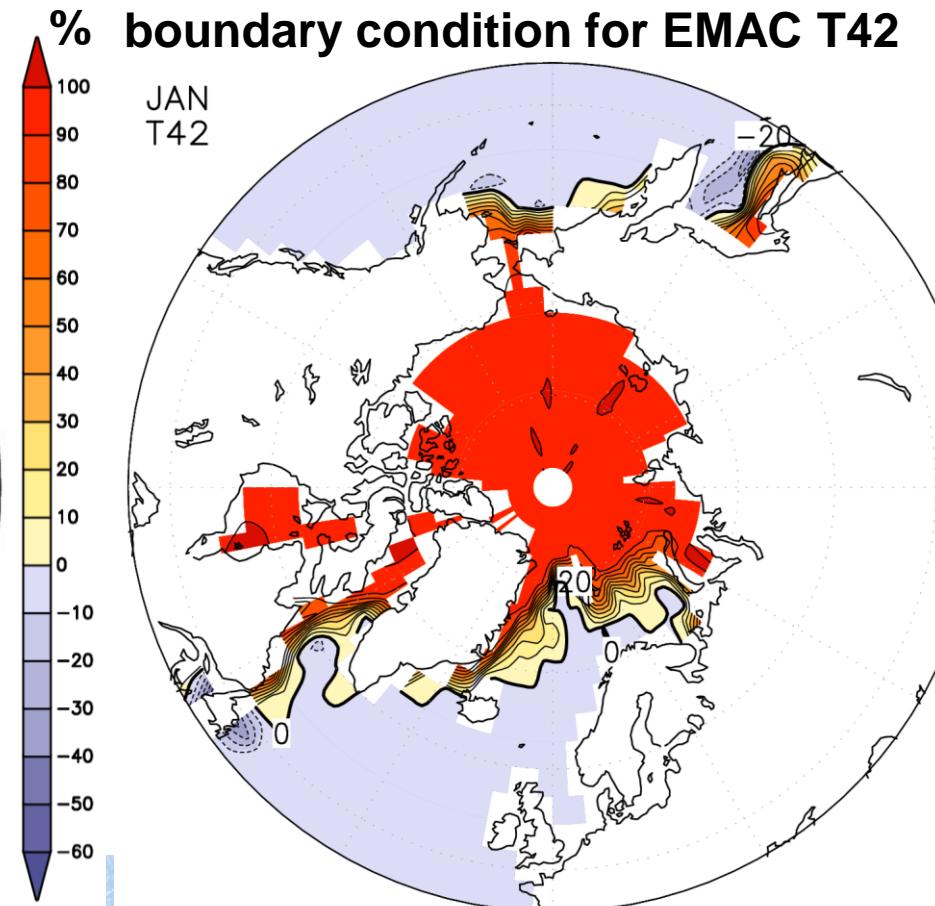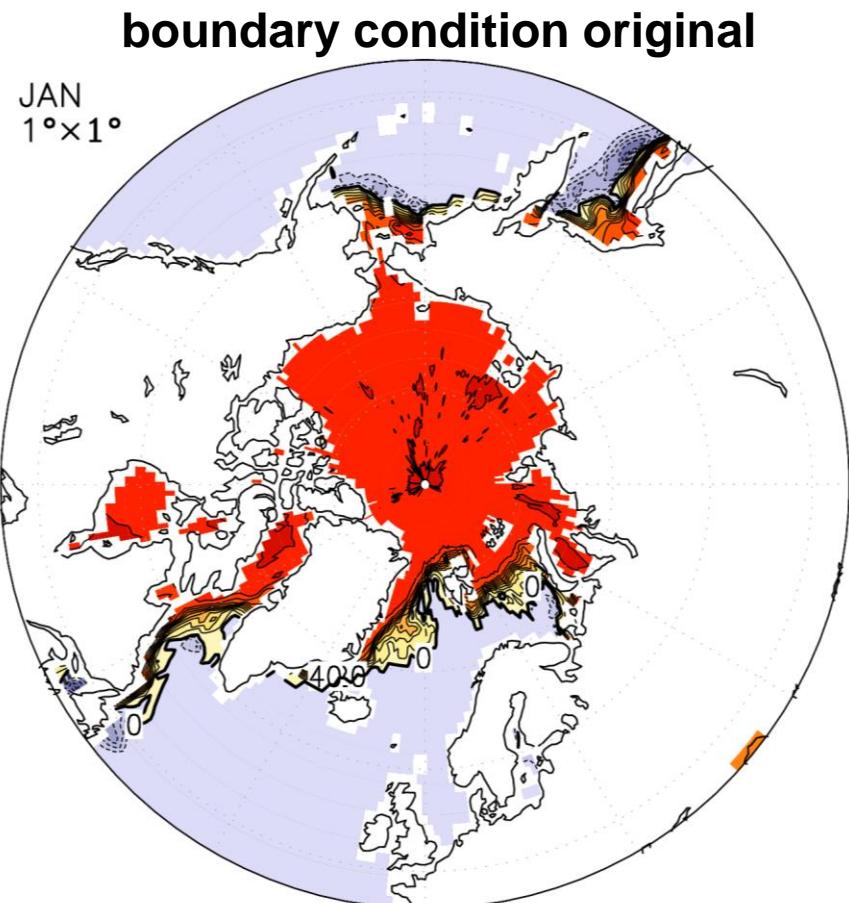
Test of prescribed AMIP-II SICs, January (1980 – 1992)

- EMAC output reproduces the AMIP-II climatology
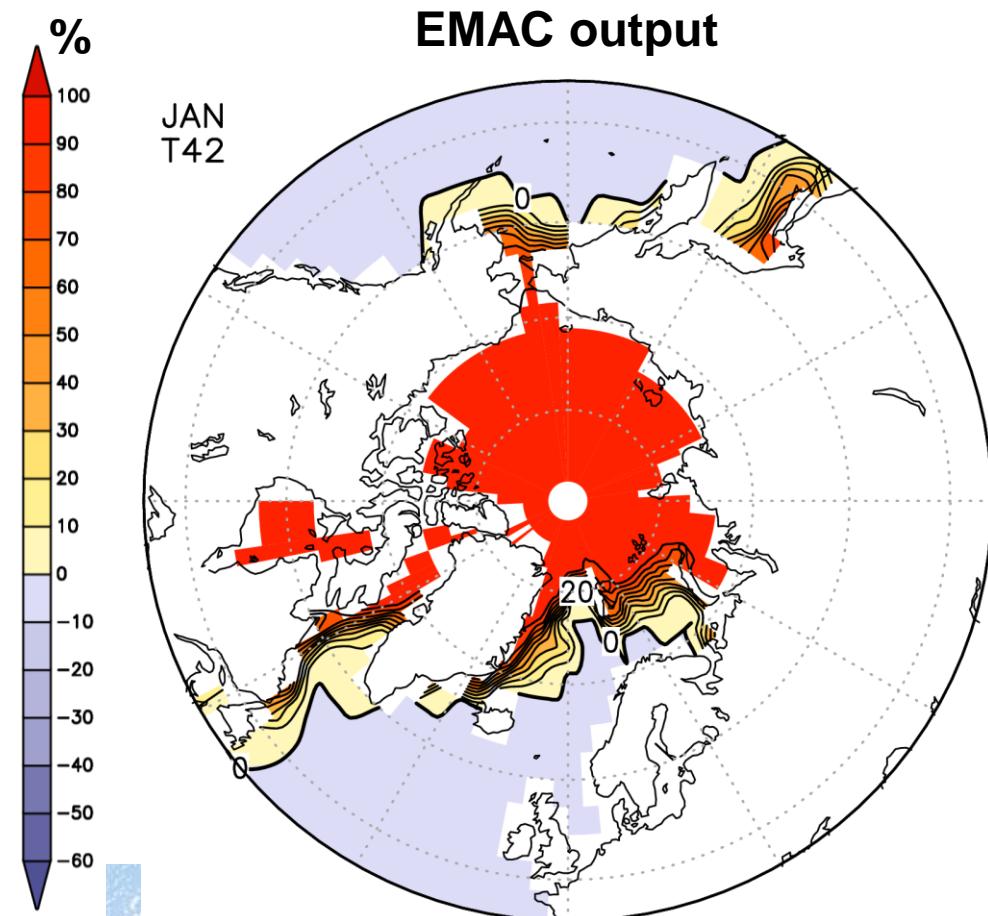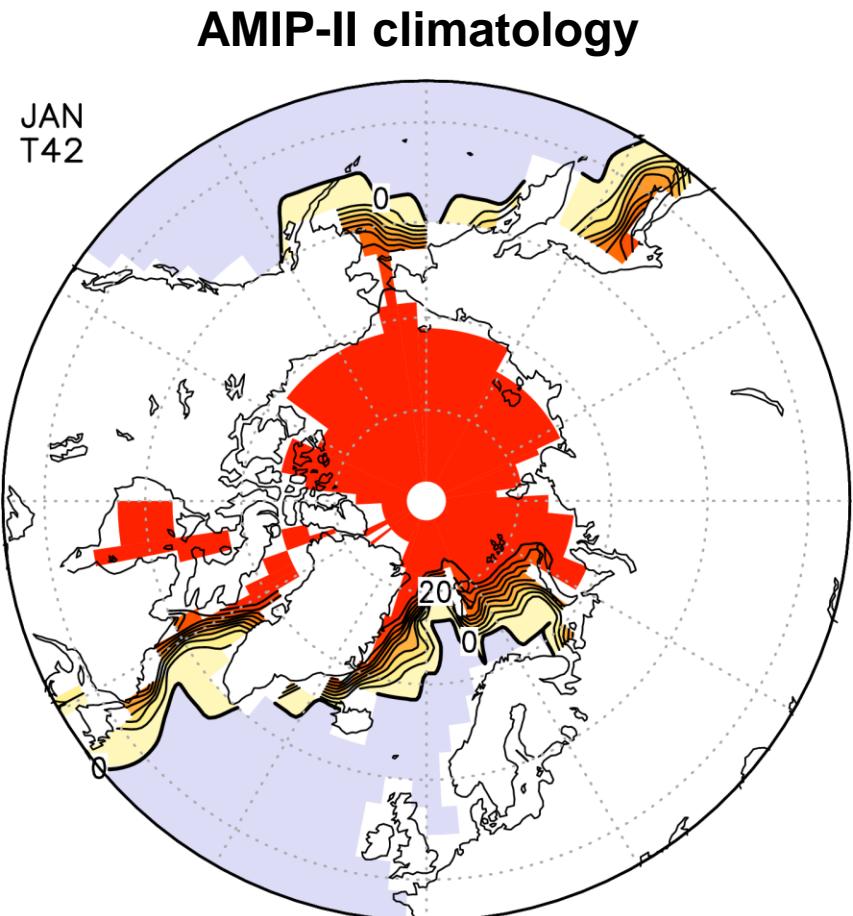
Status

- AerChem MIP simulations   – not yet started.
- Preparation of DECK simulations   – work in progress.
- CMIP6 data request   – nearly finished
- CMIP6 forcings, emissions, etc.   – finished for historic period

Next steps

DECK simulations:

➢ start *piControl* (500 yrs) and *amip*

➢ start *1pctCO2* and *abrupt-4xCO2* (need to be started from *piControl*)

CMIP6 historical simulation

➢start *historical* from *piControl*

AerChem MIP simulations

➢start *hist-piNTCF* from *piControl*

➢start simulations with prescribed SSTs/SICs:
piClim-control, piClimNTCF, piClim-CH4, piClimHC