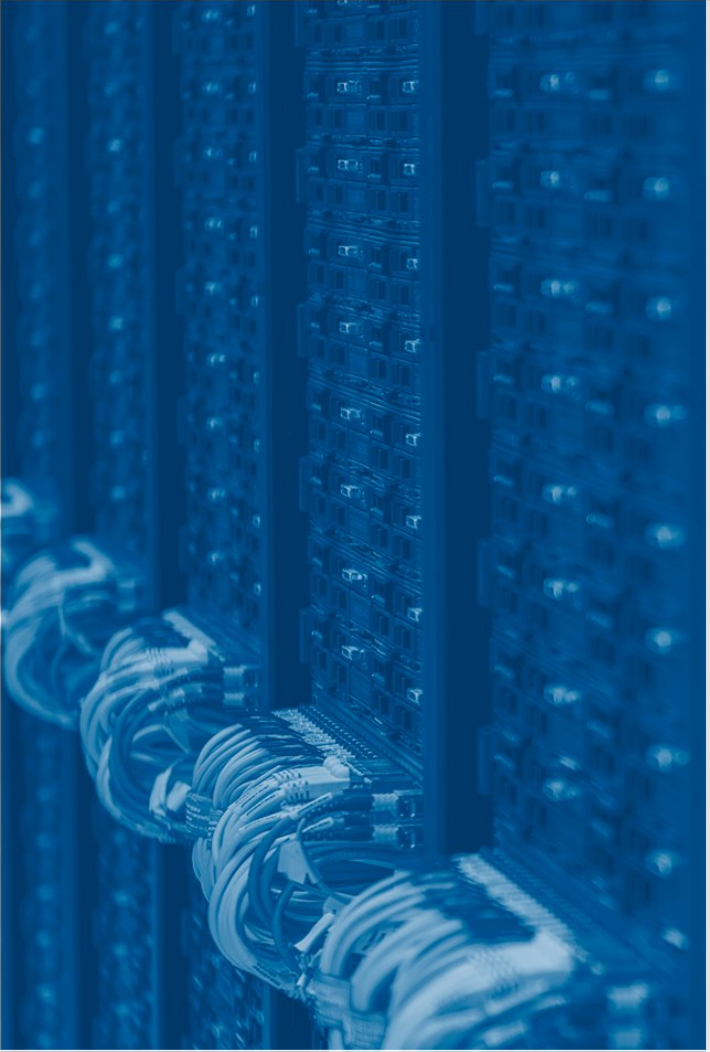

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

FORCeS

Trends in dust, clouds and radiative fluxes with the EC-Earth3 model updated within FORCeS

BSC: Montserrat Costa Surós, Maria Gonçalves Ageitos, Gilbert Montané Pintó, Carlos Pérez-García Pando
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Univ. of Crete/CSTACC: Maria Kanakidou, Marios Chatziparaschos
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EPFL
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National Observatory of Athens
University of Crete
Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management
UPC
SMHI

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ICREA
MARIE CURIE ACTIONS
STARS POST-DOCTORAL PROGRAMME

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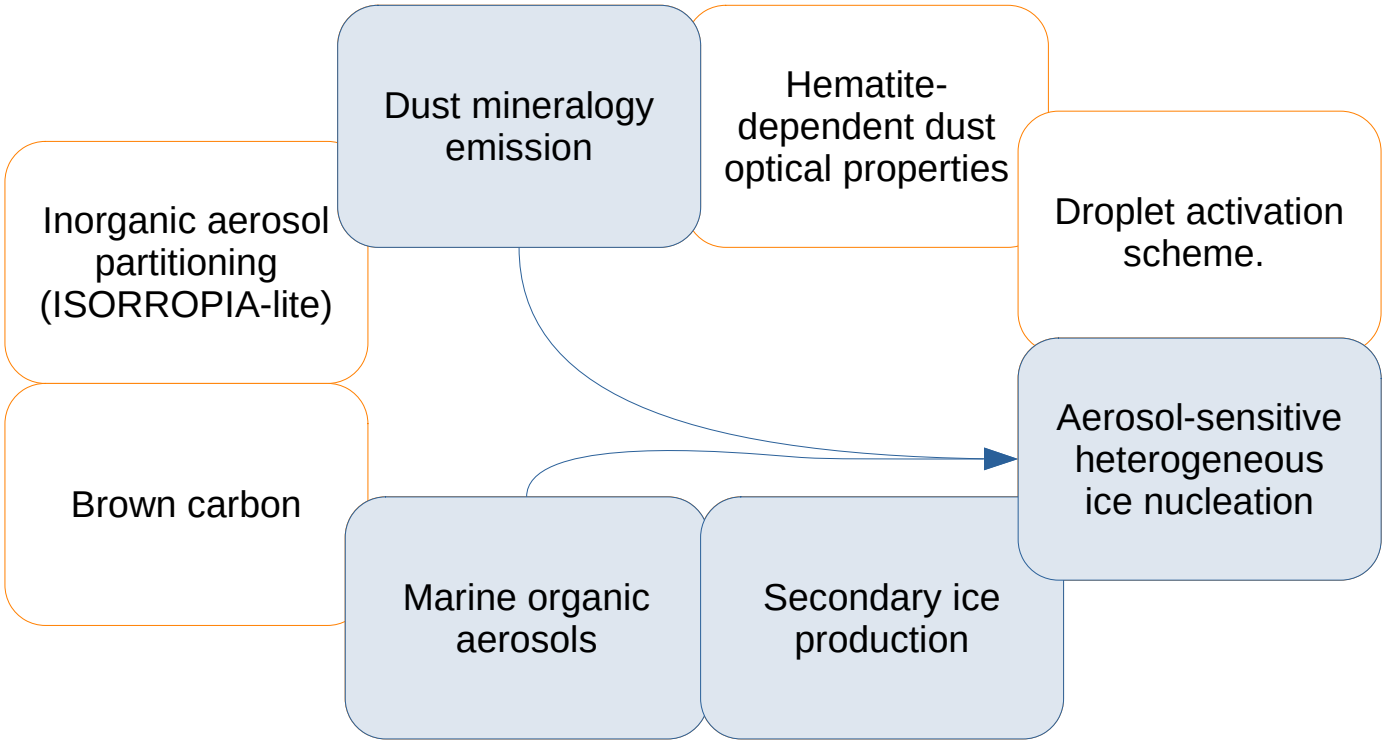
20/09/2023

EC-Earth3-FORCeS model updates



Ice nucleation experiments

Source: FORCeS-D5.3-Three revised ESMs

New heterogeneous ice nucleation param.

ICNC estimation

Temperature-sensitive ice nucleation parameterization

Meyers et al. (1992): deposition-condensation freezing

Aerosol-sensitive ice nucleation parameterization

PRIMARY ICE PRODUCTION

Immersion freezing

Atkinson et al. (2013): K-fedlspar
or
Ullrich et al. (2017): soot and dust
or
Harrison et al. (2019): K-feldspar and quartz

+

Wilson et al. (2015): of marine organic aerosols

SECONDARY ICE PROCESSES

Georgakaki et al. (under rev.): RaFSIP, considers:
- Hallet-Mossop process
- Droplet shattering during freezing
- Fragmentation due to collisional break-up

v1
v2

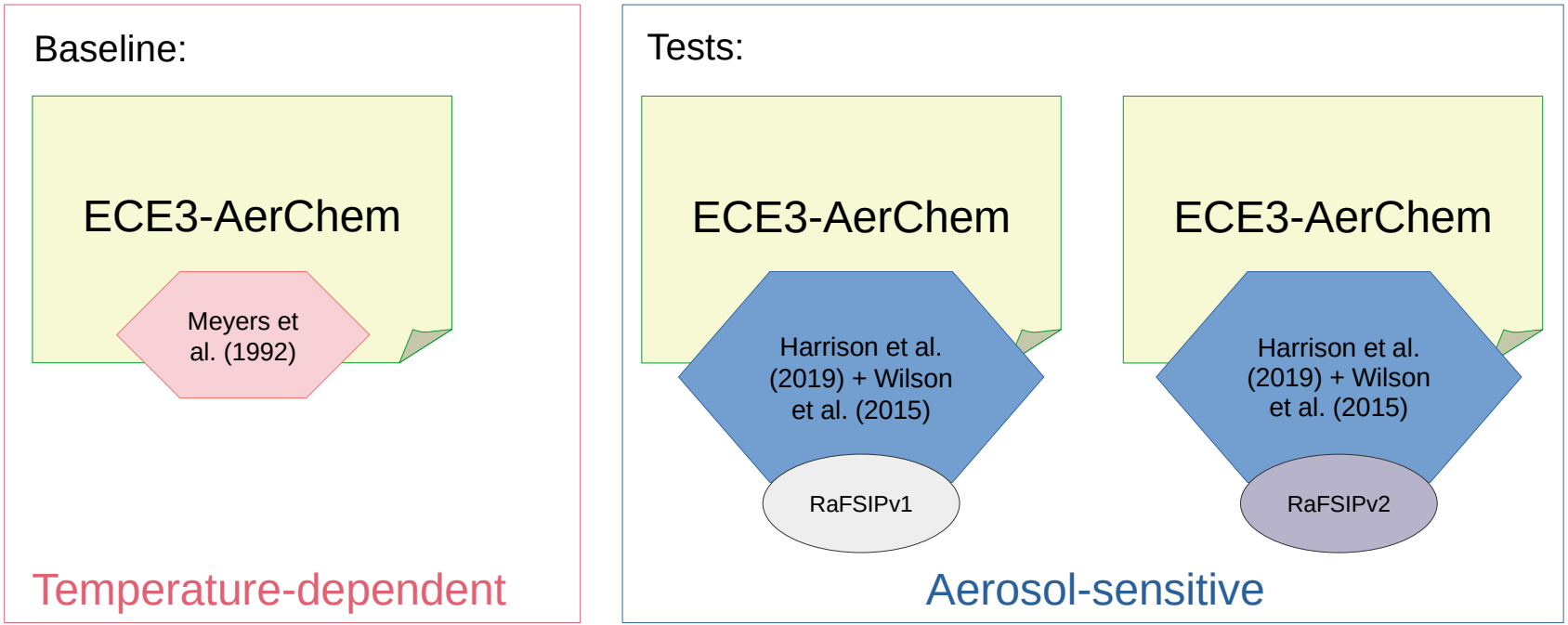
Ice crystal growth by vapor deposition

Depositional growth parameterization

Following Pruppacher and Klett (1997) and Rotstayn et al. (2000)

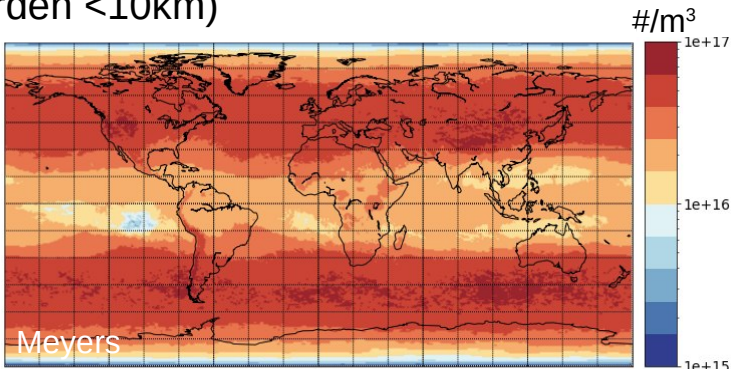
Simulations with aerosol-sensitive ice nucleation parameterization

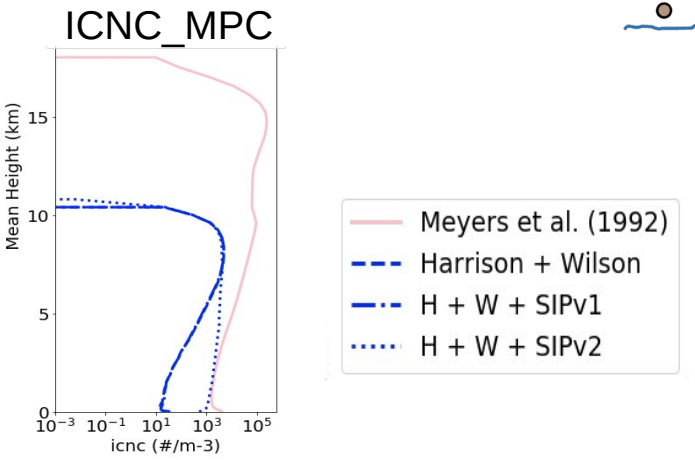
1-year simulations (07/1990-06/1991), with atmospheric circulation nudged towards ERA5:

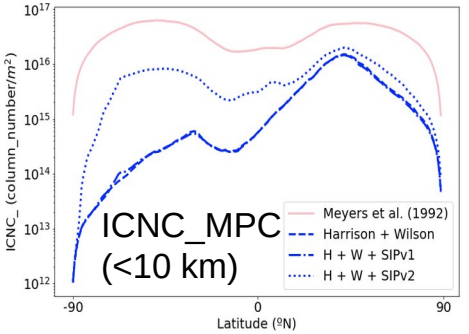


ICNC results for 1-year nudged simulations

Ice crystal number concentration (mixed-phase clouds)
(column burden <10km)

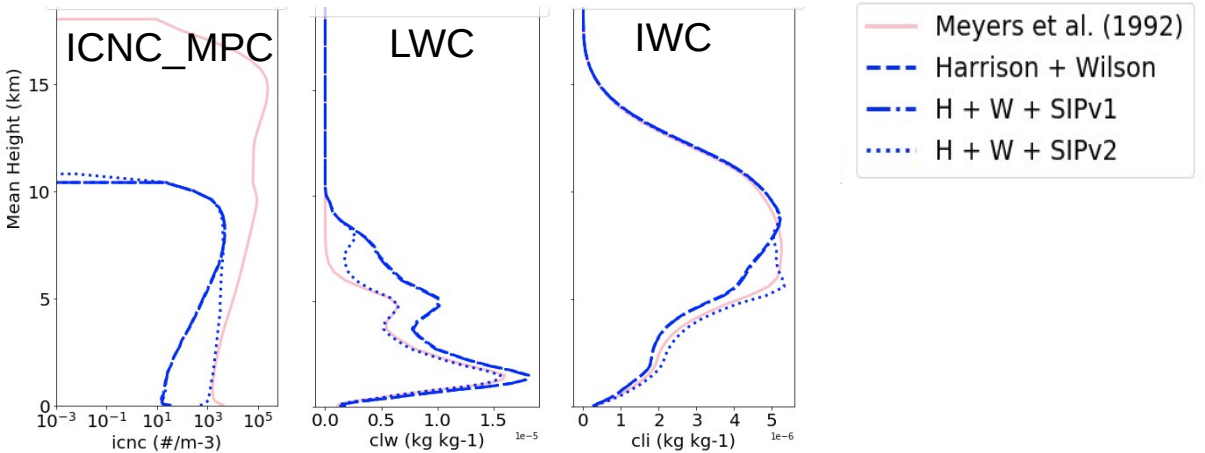




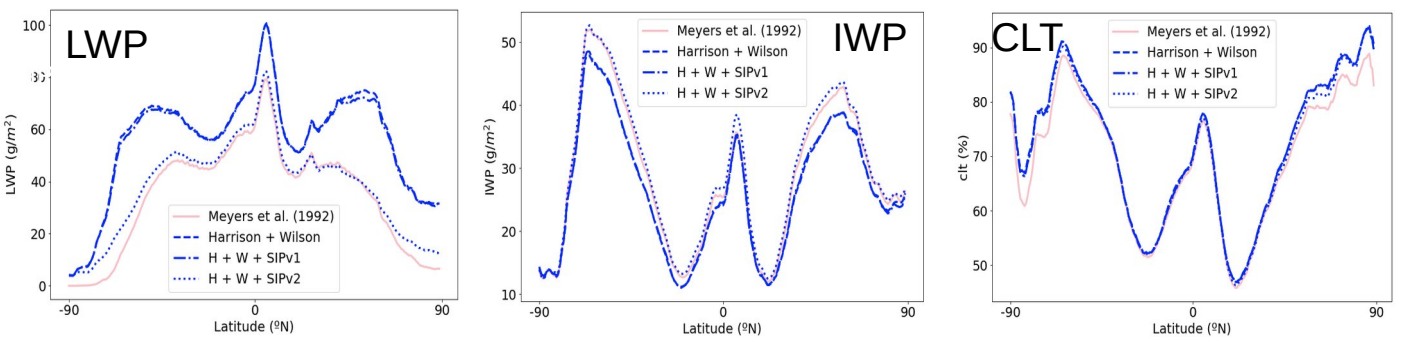


Distribution follows trends on dust compared to the baseline simulation

Results for 1-year nudged simulations

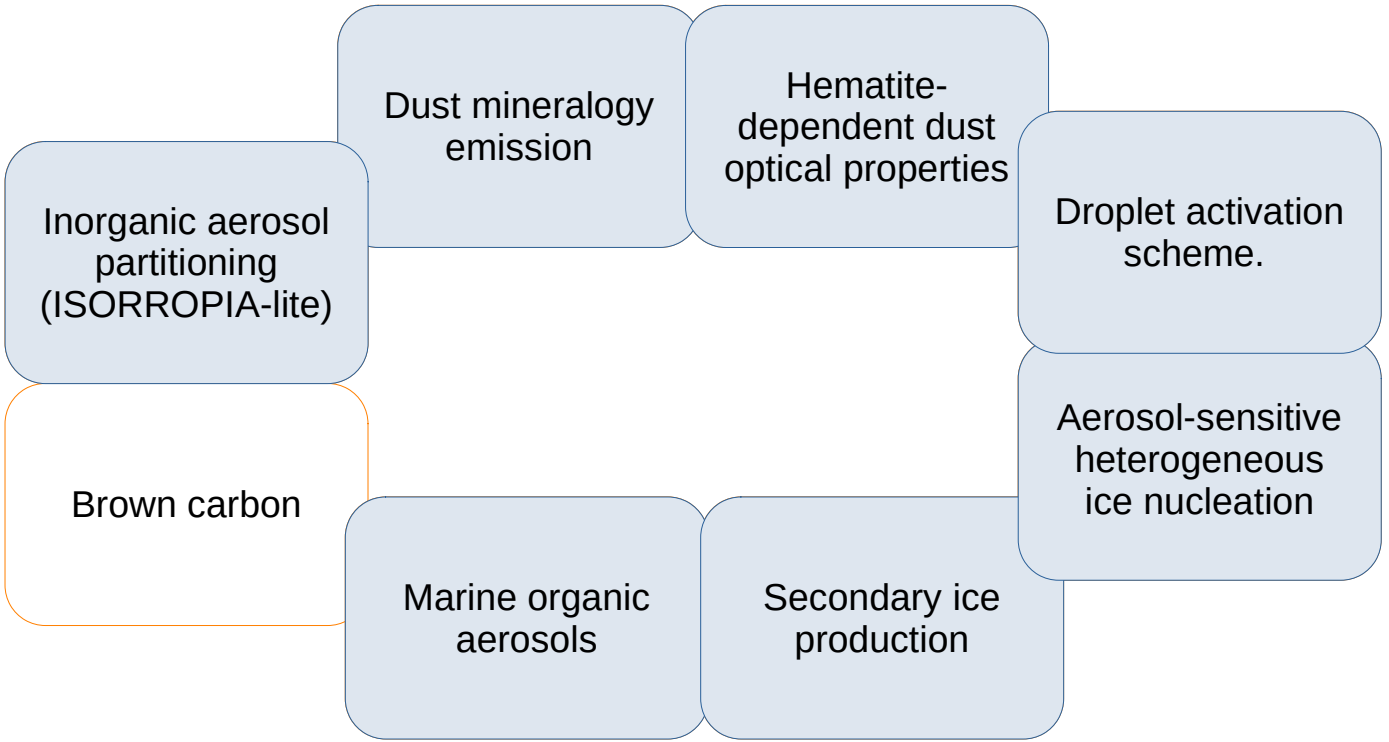


Global mean difference with respect to Meyers	LWP	IWP	Cloud cover
SIPv1	+19.4 g/m^2	-2.1 g/m^2	+1.5 %
SIPv2	+2.4 g/m^2	+1.0 g/m^2	+0.9 %



Aerosol-sensitive param. impact: tendency to cool the system

EC-Earth3-FORCeS model updates

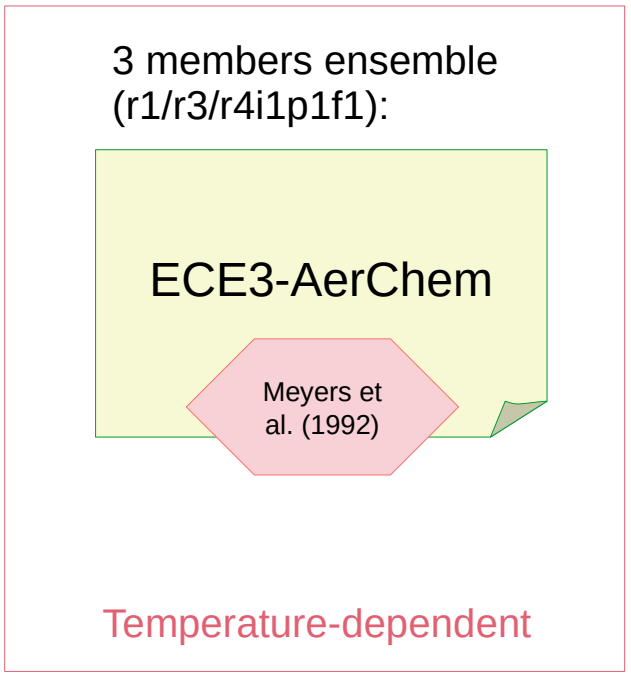


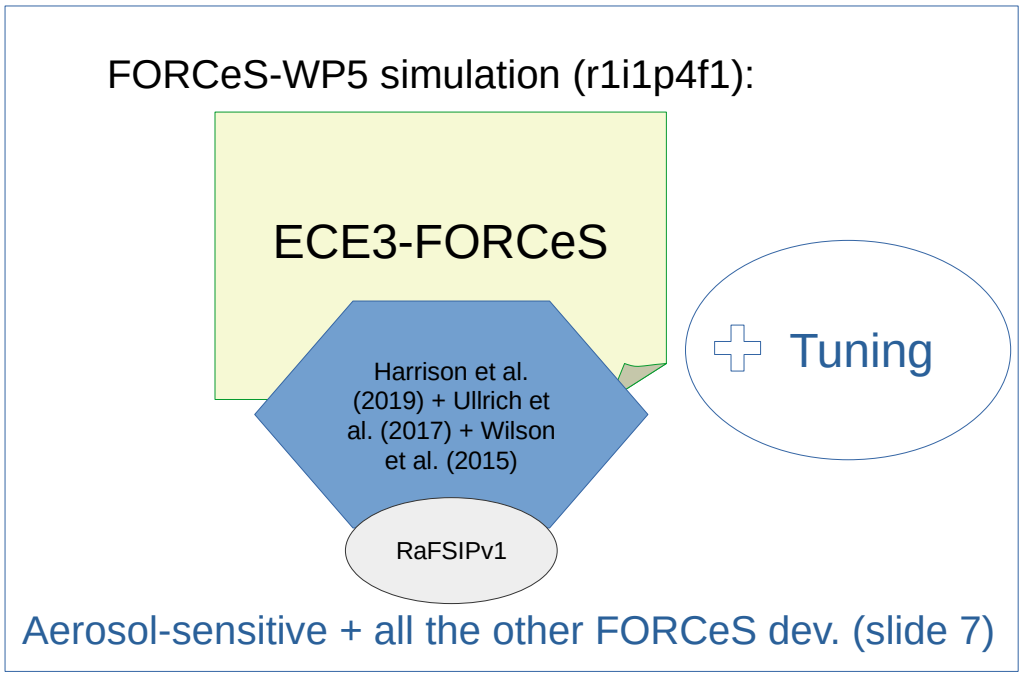
FORCeS WP5 simulations

Source: FORCeS-D5.3-Three revised ESMs

EC-Earth3 WP5 simulations

CMIP6-historical simulations (analysis of the last 65-year (1950-2014), where anthropogenic emissions where higher):

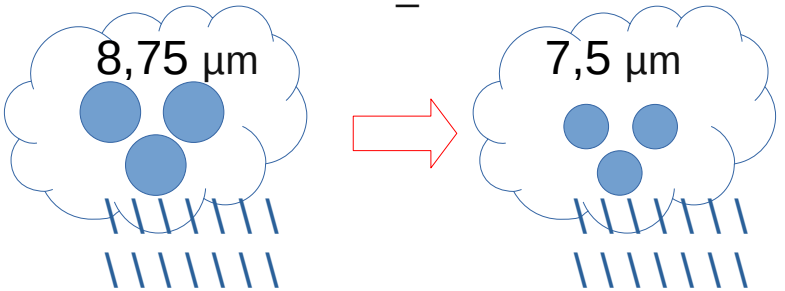




New tuning parameters

- To reduce the cloud forcing in the new configuration, we have reduced the **threshold radius for autoconversion**. Rain is formed at smaller droplet sizes.

RLCRIT_UPHYS



- Increased coeficient for determining **conversion from cloud water to rain**

RPRCON

1.34e-3 ⇨ 1.4e-3

- Reduced the standard deviation of the **updraft velocity distribution** (by reducing it by 0.2 m/s reduced the cloud forcing by ~ 1 W/m2)

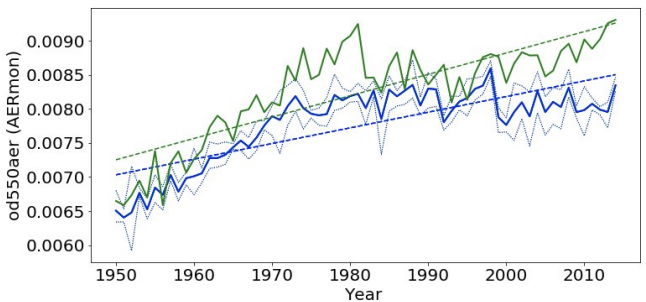
SIGW

0,8 m/s ⇨ 0,6 m/s

Aerosol and dust trends 1950-2014

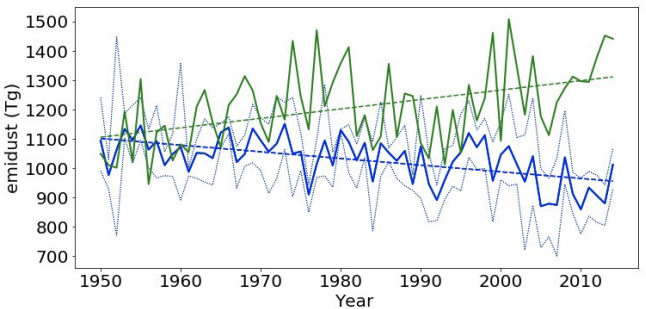
ECE3-AerChem 3 members ensemble (+min&max)
ECE3-FORCeS

Ambient Aerosol Optical Thickness at 550nm



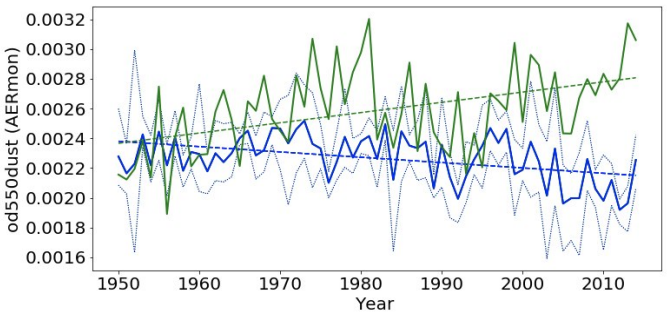
AerChem ensemble trend: 2.30e-05 AERmon
FORCeS trend: 3.13e-05 AERmon

Total dust emission



AerChem ensemble trend: -2.27e+00 Tg
FORCeS trend: 3.21e+00 Tg

Dust Optical Thickness at 550nm

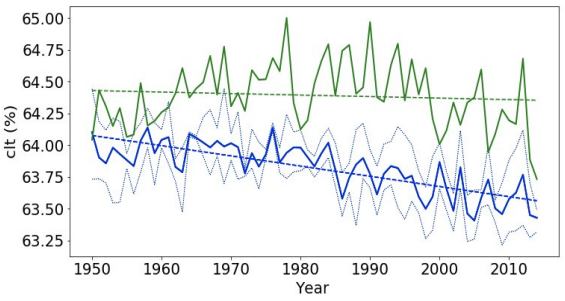


AerChem ensemble trend: -3.58e-06 AERmon
FORCeS trend: 6.88e-06 AERmon

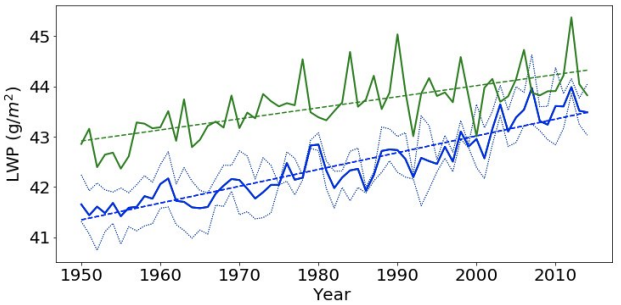
Global trends 1950-2014

ECE3-AerChem 3 members ensemble (+min&max)
ECE3-FORCeS

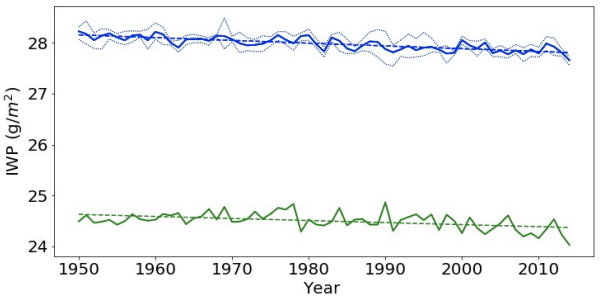
Cloud cover



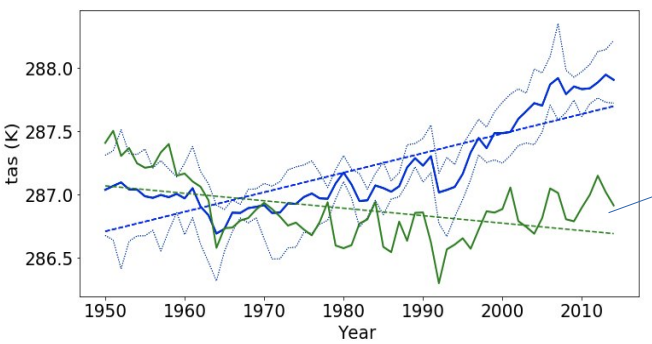
LWP



IWP



Near-surface temperature

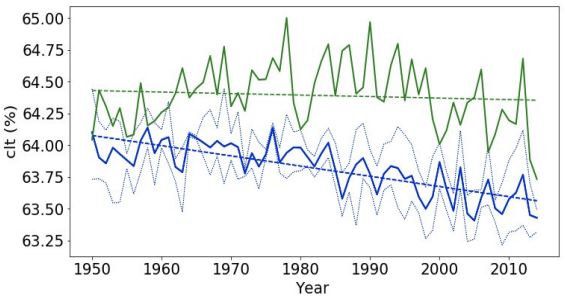


Historical experiment with the first EC-Earth3-FORCeS model version show an unrealistical cooling

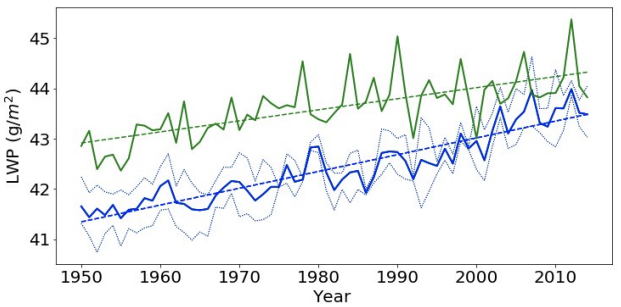
Global trends 1950-2014

ECE3-AerChem 3 members ensemble (+min&max)
ECE3-FORCeS

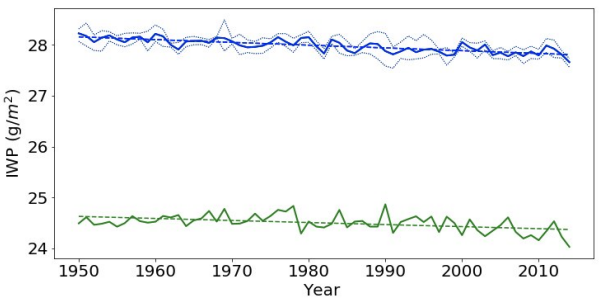
Cloud cover

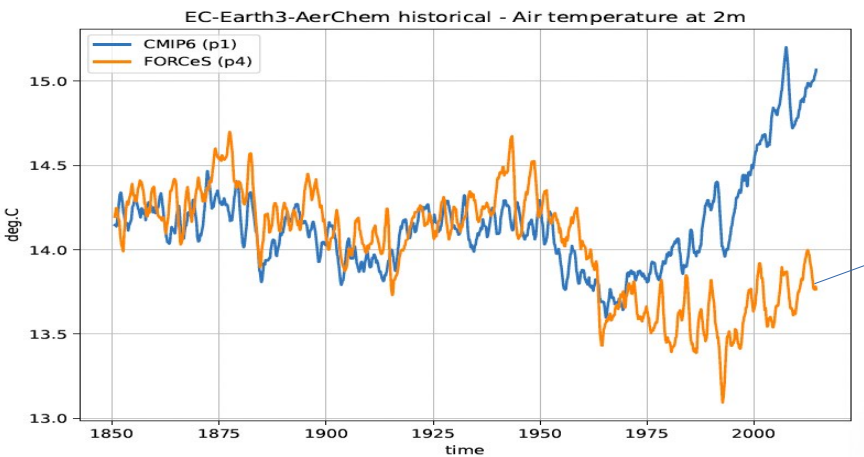


LWP



IWP

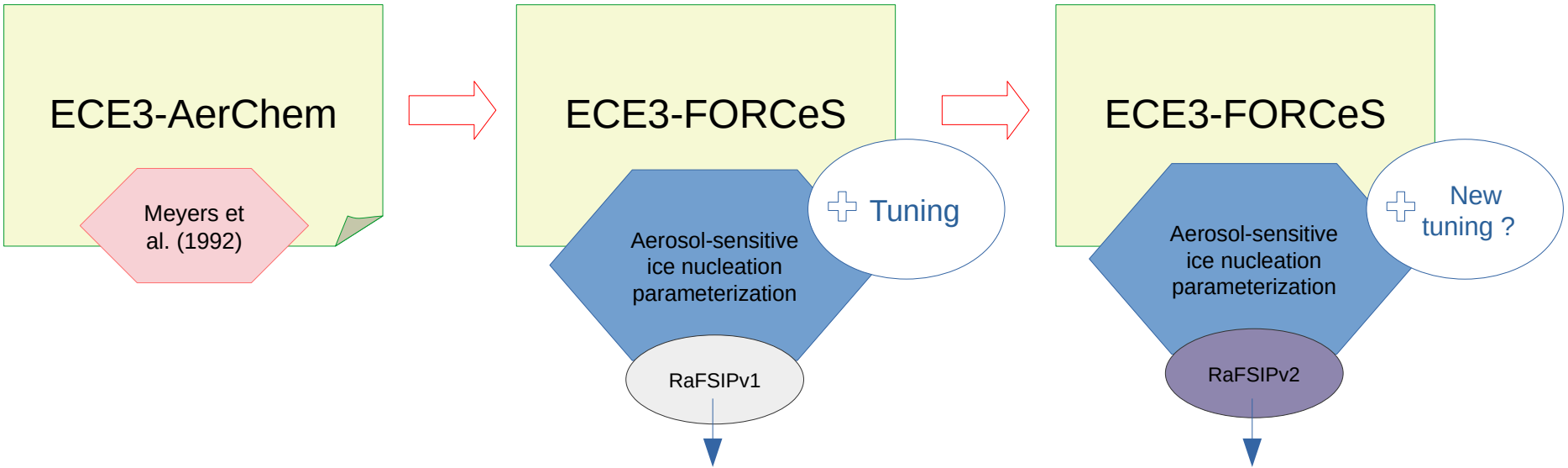




Source: Philippe Le Sager (initial FORCeS-historical experiment analysis in comparison to the CMIP6-AerChem ensembe).

Temperature evolution for the complete historical run (164 years) shows that the model starts cooling from the 60´s.
Has the model become overly sensitive to sulfate/anthropogenic aerosols increases?
Could it be due to the tuning?
Further investigation is needed!

Conclusions and future plans



High LWP enhancement and IWP reduction compared to the baseline, which tends to cool down the climate system unrealistically

Tests show that with the recent v2 the results are closer to those from the baseline.

Historical sim. + evaluation with obs.

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Centro Nacional de Supercomputación

montserrat.costa@bsc.es

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Atmospheric Composition
EC-Earth3 Working Group

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