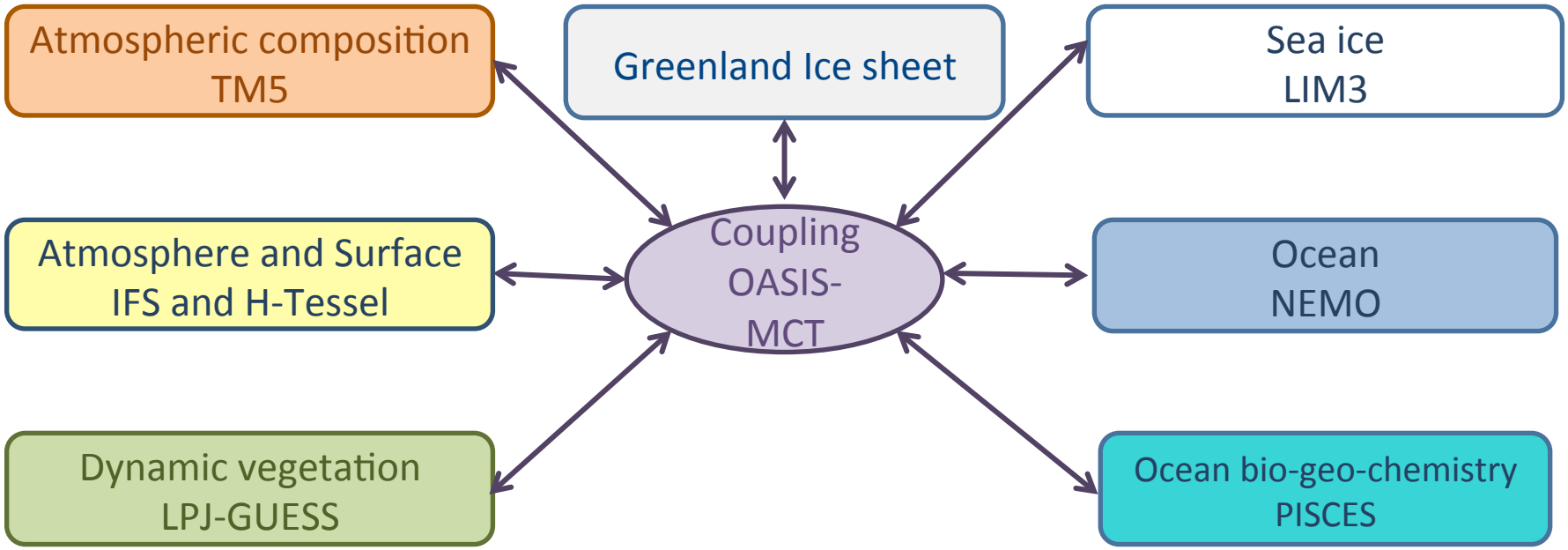
EC EARTH in CMIP6

- A community ESM in different resolutions and configurations
- V3.2:
  - GCM
  - ESM with on/off
    - chemistry/aerosol
    - dynamic vegetation
    - ocean biochem
    - ice sheet

The maximum system

(not used)



Model components

- Atmosphere: IFS cy36r4,
- Ocean: NEMO 3.6
- Sea ice: LIM3 (as part of NEMO3.6)
- Atmospheric composition: TM5
- Dynamic vegetation: LPJ-GUESS
- Ocean biogeochemistry: PISCES (as part of NEMO3.6)
- Two resolutions:
  - T255L91/ORCA1 and T511L91/ORCA025

Differences CMIP5-CMIP6 Atmosphere

- CY31R1 → CY36R4
  - Updated convection scheme
  - New radiation scheme with McICA
  - New microphysics scheme with prognostic ice
  - dynamic lake temperature and ice concentration
  - Updated humidity conservation
  - Changed gravity wave drag parameterization (better QBO at resolutions other than T255)
  - Updated treatment of snow on ice sheets
  - CMIP6 forcing incl. MACv2-SP aerosol optical properties

Differences CMIP5-CMIP6
Ocean

- NEMO3.6
  - tri-polar grid with poles over North America, Siberia and Antarctica
  - 1° (ORCA1) or 0.25° (ORCA025); 42 → 75 vertical levels
  - major changes in the TKE schemes, runoff, surface wave breaking, tidal mixing
  - time discretization made energetically consistent
  - partial step representation of bottom topography
  - PISCES
- LIM3
  - multiple sea ice categories
  - new thermodynamics including bulk ice salinity
- I/O management: NEMO in now interfaced with XIOS

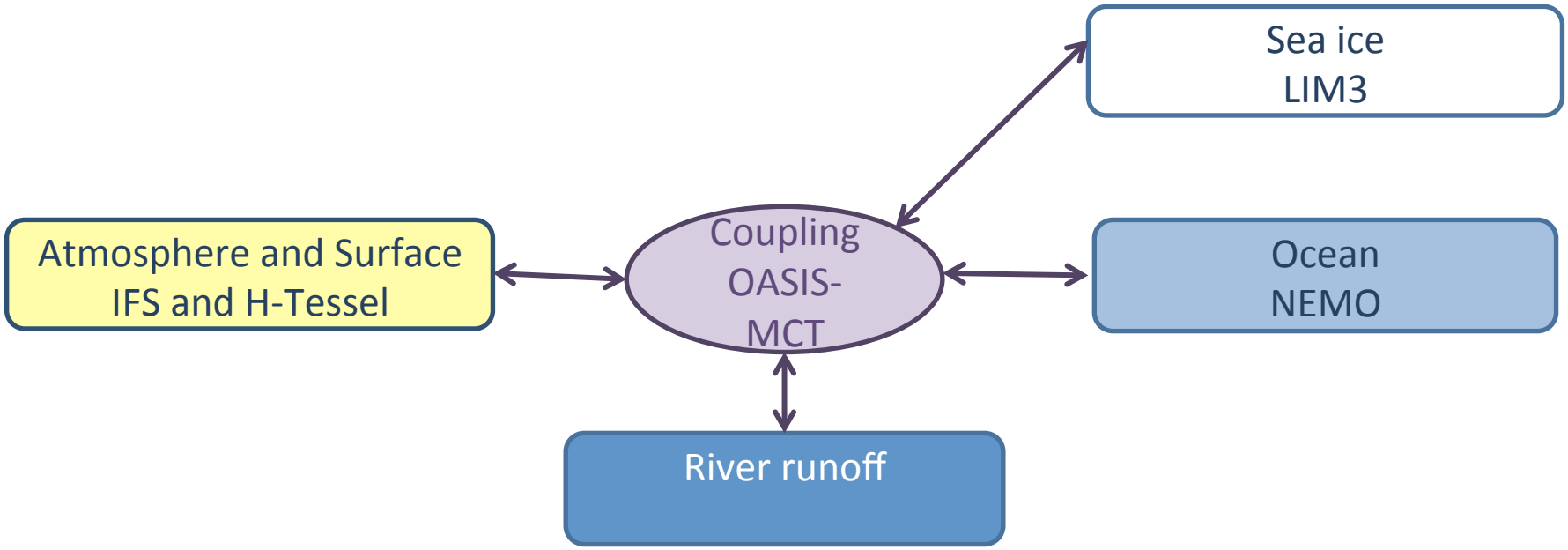
Differences CMIP5-CMIP6
Aerosols and chemistry (TM5)

- Sources/sinks
  - New secondary organic aerosol scheme
  - Updated particle nucleation scheme
  - Revised wind speed dependence of sea spray source; online calculation of mineral dust source
  - Revised scavenging efficiencies for removal of aerosols by large-scale clouds
  - Updated forcing data sets to CMIP6
- Aerosol properties
  - Revised black carbon refractive index
  - Revised carbonaceous aerosol properties
  - More consistent treatment of ammonium nitrate and MSA
- Processes
  - Updated photolysis scheme
  - Revised chemical reaction kinetics based on CB05
  - Included aerosol-radiation interactions (both SW and LW)
  - Included aerosol-cloud interactions (first and second indirect effects), cloud activation scheme
  - Included additional diagnostics (incl. double radiation call)
- Improved performance and scalability: domain decomposition and parallel exchange of fields via OASIS-MCT

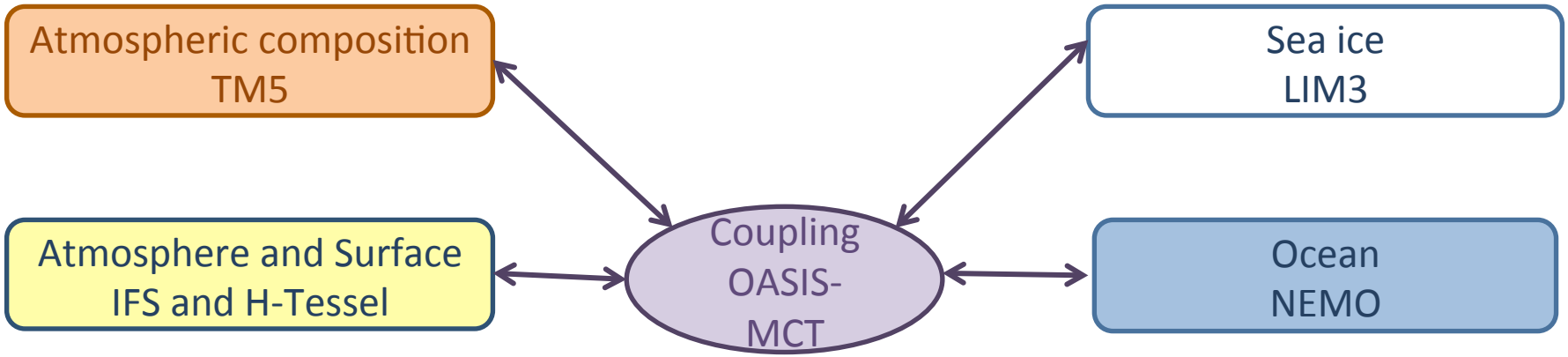
Differences CMIP5-CMIP6
Land surface/vegetation and paleo

- Land surface and vegetation
  - Static → Dynamic natural vegetation, both phenology and biome distribution (LPJ-Guess)
  - Some updated physics in HTESSEL (snow, veg. cover, desert identification, background albedo)
  - Terrestrial carbon cycling, interactive carbon and nitrogen cycling
  - Uses CMIP6 nitrogen deposition forcing data set
  - N_2O emission is directly related to daily soil N mineralisation (Smith et al., 2014)
- Paleo-simulations
  - Orbital forcing
  - Surface process of ice-sheet (land-ice mask, snow accumulation, snow albedo)
  - Model configuration tbc (likely the lowres vegetation config)

overview of your CMIP6 model

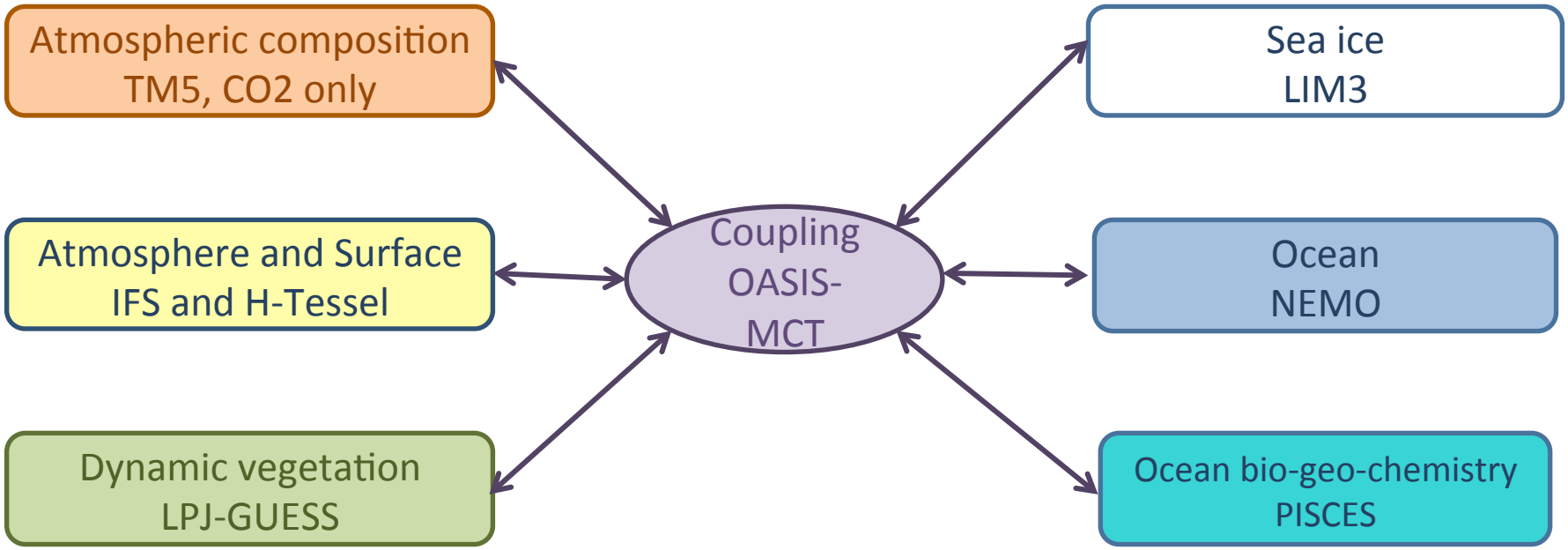


EC-Earth3-AerChem



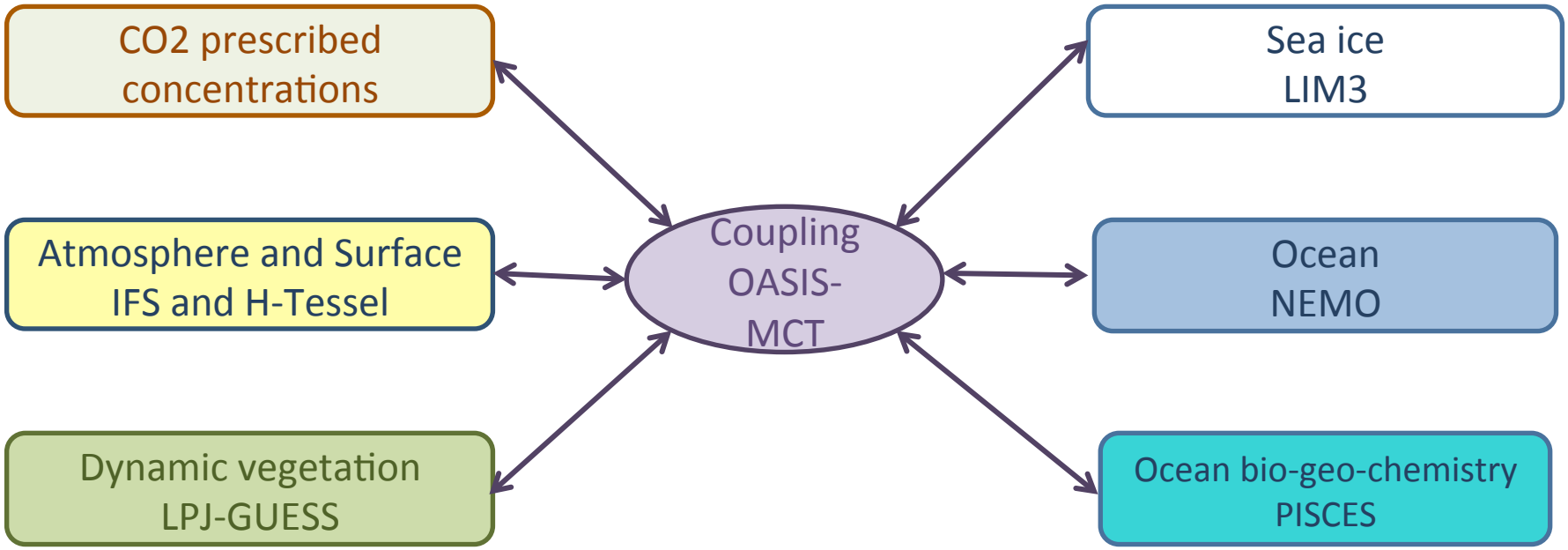
for AerChemMIP

EC-Earth 3 CC



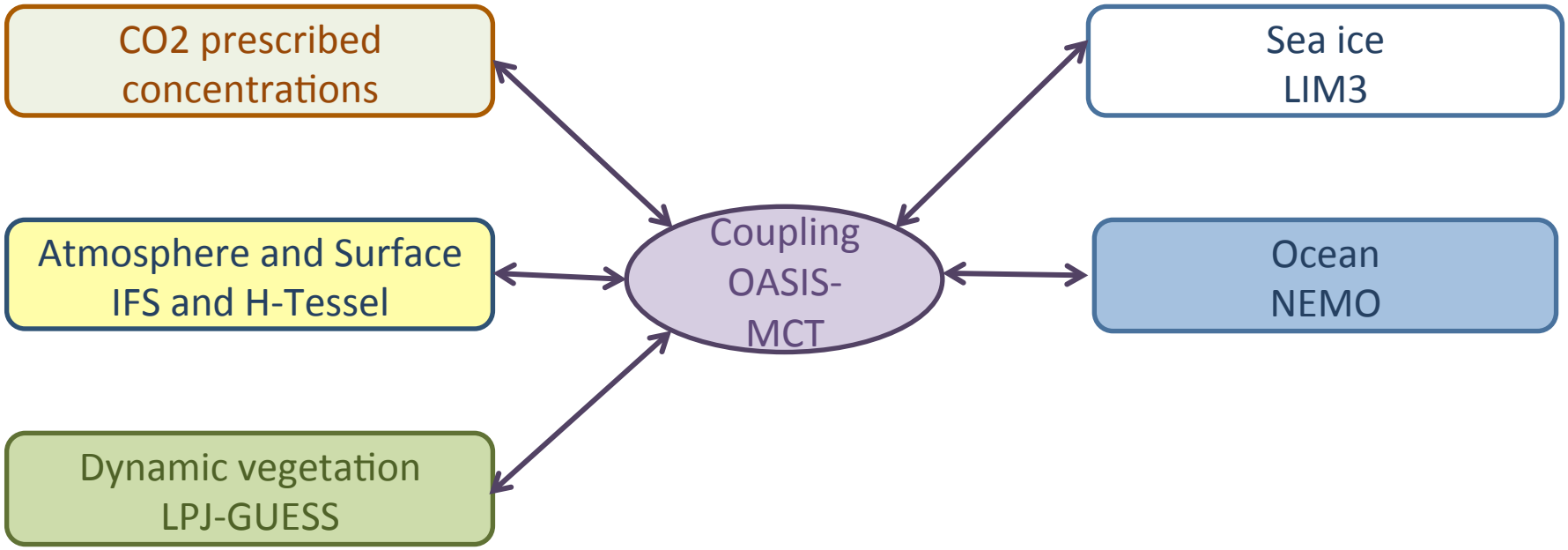
for C4MIP

EC-Earth 3 conc



for ScenarioMIP

EC-Earth 3 veg



for LUMIP and ScenarioMIP

Status

- EC-Earth version 3.2.2 (GCM) released for coupled tuning
- Tuning ongoing
- Remaining challenges
  - AMOC strength
  - Finalization of forcing implementation
  - Coupling of vegetation
- Status of ESM configurations
  - (at least) technically running
- To run CMIP6 and data issues
  - work load distribution over partners
  - Workflow, CMOR output to ESGF

Tuning

- Tuning in atmosphere-standalone mode (AMIP) for present day climate
  - reproduce the observed imbalance of the atmosphere-ocean fluxes (~0.5 W/m2) as starting point for coupled tuning.

- A long coupled present-day simulation
  - GHG forcing from one specific year, to be compared to present day obs
  - estimate the model climate sensitivity
  - verify and tune the realism of the ocean state (transport, sea ice, surface temperatures and their distribution etc.)
  - aim at realistic combination of surface temperatures/net surface fluxes (Gregory plot passing through 14.5 ° / 0.6 W/m^2)

- A Pre-Industrial (PI) spin-up
  - fine tuning for transient runs between 1850 and 2010.
  - adjusted land-use fields

Tuning atmosphere

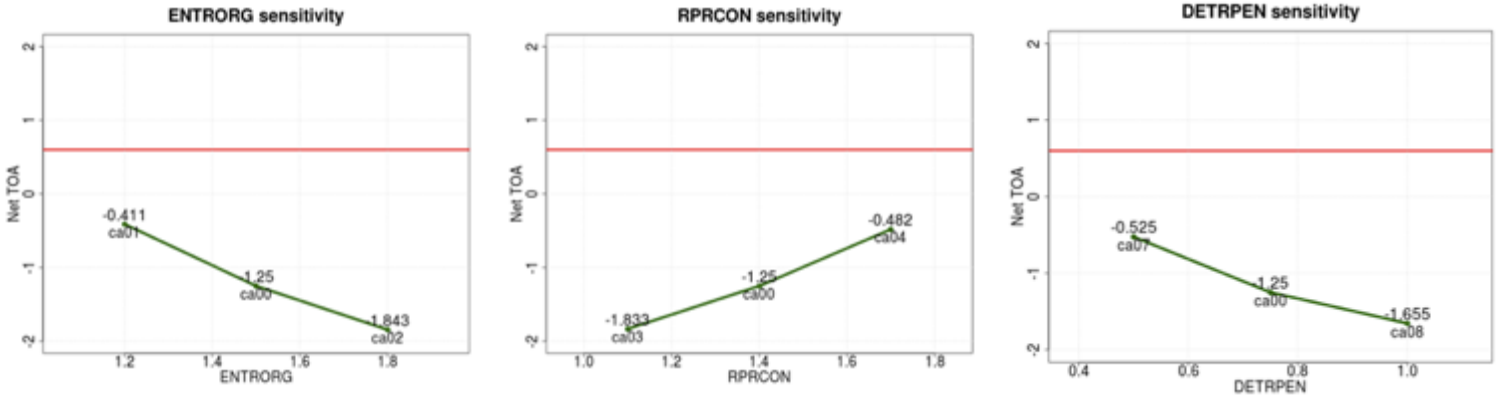
- Optimize:
  - Radiative fluxes (Net SFC, Net TOA, LW, SW, LHFL, SHFL, cloud forcing
    - TOA-SFC imbalance reduced to -0.27 W/m^2
  - P-E and SSH changes
    - imbalance P-E = -0.016 mm/day
  - Specific fields, e.g. t2m temperatures
  - Performance indices (Reichler and Kim 2008)
  - Regional properties of specific fields
  - model variability (e.g. QBO)

- Tune atmosphere at both resolutions (T255 and T511)

Sensitivity tests

parameters affecting convection, entrainment rates, precipitation, and other water-cycle-related features:

ENTRORG : organized entrainment in deep convection
1.RPRCON : rate of conversion of cloud water to rain
2.DETRPEN : detrainment rate in penetrative convection
3.ENTRDD : average entrainment rate for downdrafts
4.RMFDEPS : fractional massflux for downdrafts
5.RVICE : fall speed of ice particles
6.RLCRITSNOW : critical autoconversion threshold for snow in large scale precipitation
7.RSNOWLIN2 : snow autoconversion constant in large scale precipitation.
8.RTAUMEL : relaxation time for the melting of falling solid particles for large scale precipitation
9.RALBSEAD : albedo for diffusive radiation over the ocean
10.RCLDIFF : Mixing coefficient for turbulence , controls cloud cover

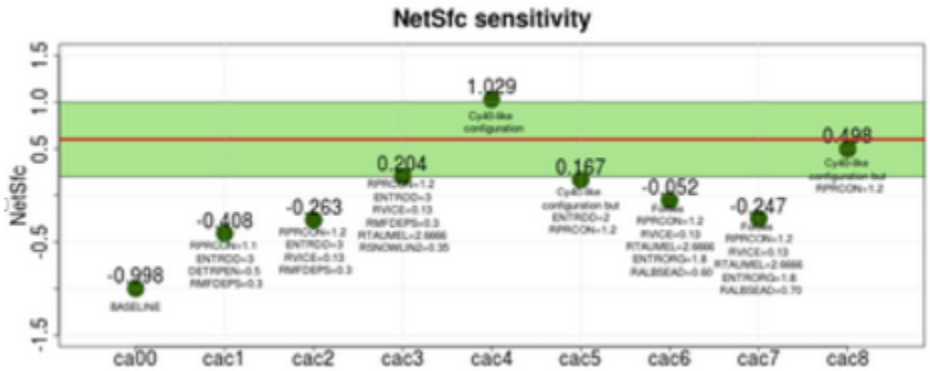


(linear) Sensitivity of radiative fluxes

	Toa Net LW	TOA Net Sw	LWCF	SWCF	NetSFC
RPRCON	-4.70	6.96	-3.59	7.30	2.24
RVICE	-36.17	18.03	-35.28	19.83	-18.40
RLCRITSNOW	0.56	-0.37	0.61	-0.39	0.19
RSNOWLIN2	140.00	-97.00	148.50	-101.90	40.00
ENTRORG	-0.55	-1.84	-0.25	-1.80	-2.47
DETRPEN	1.14	-3.40	1.23	-3.30	-2.21
ENTRDD	0.02	0.48	0.00	0.44	0.50
RMFDEPS	0.80	-6.39	0.20	-6.46	-5.52
CONDLIM	1.18	0.47	0.89	0.34	1.63

[W/m^2 per unit parameter change]

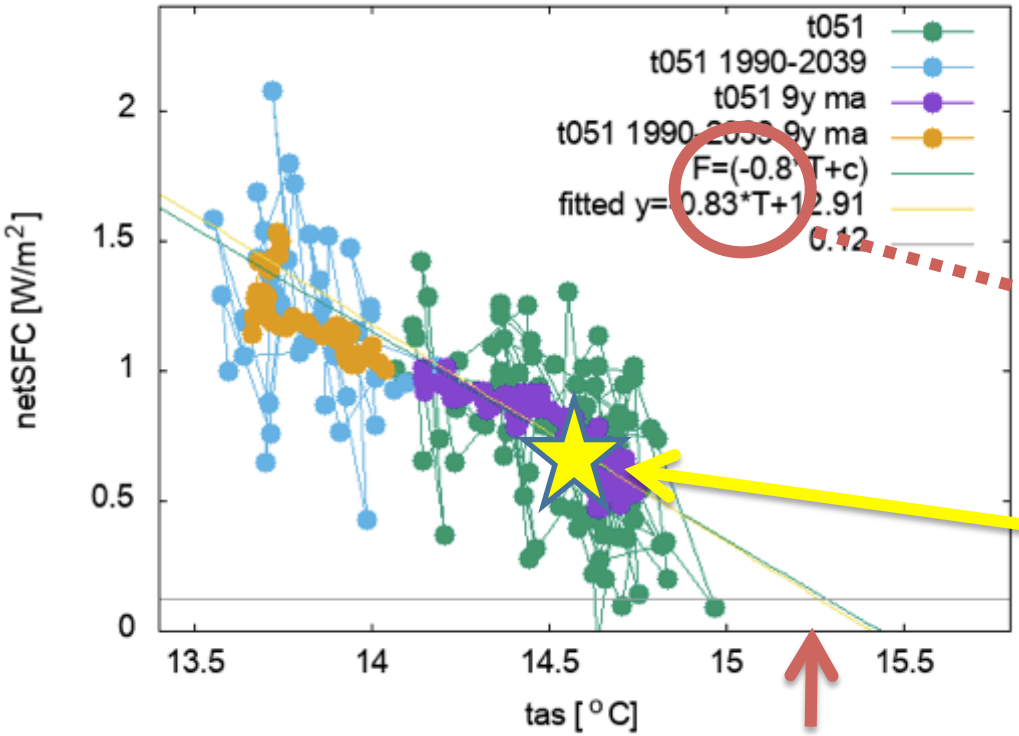
To plan new tuning parameter sets starting from an existing experiment (using a **'tuning simulator'** to compute the effect of new configurations)

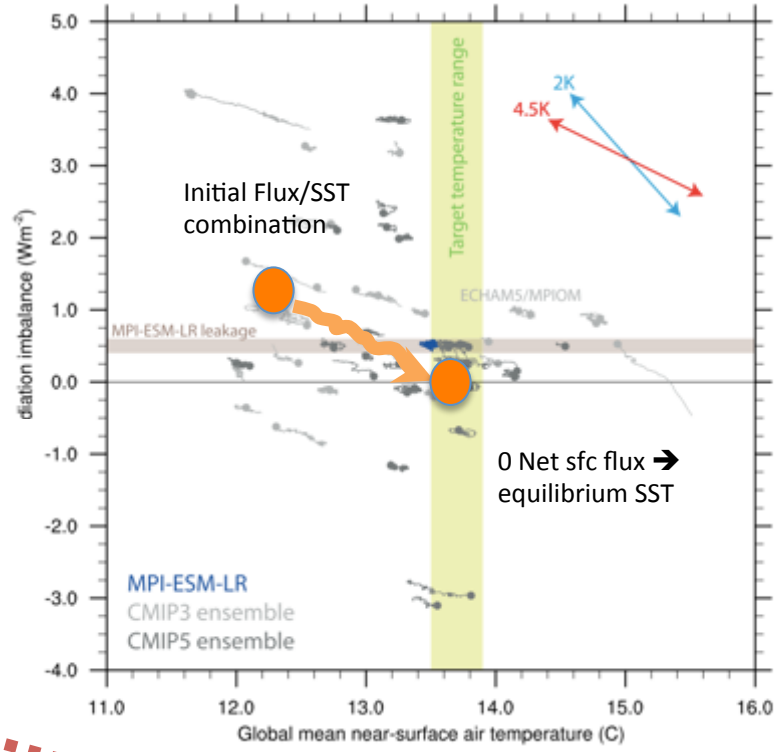


Tuning of the coupled model

Problem: need long runs (100s of years) to bring the ocean into equilibrium

Approach: First estimate of the equilibrium temperature and climate sensitivity can be obtained with a ”Gregory” plot





Climate sensitivity ~ 4.5 K for a doubling of CO2

Current climate (surface temperature and net surface energy flux)

Equilibrium SFC temperature

Questions

- experience with CMIP6 forcings
  - Mostly implemented …
- have you yet started any simulations, and if so which ones?
  - tuning only for standard resolution, AMIP HighresMIP ongoing
- first results from CMIP6 simulations
  - none
- when are you planning to submit model output from the DECK to the ESFG?
  - by mid 2018
- when are you planning to submit model output from the CMIP6 historical simulations to the ESGF?
  - by mid 2018
- when are you planning to submit CMIP6-Endorsed MIPs experiments to the ESGF
  - starting by end 2018
- have you yet started filling the ES-DOC questionnaire?
  - first inventories