

Earth System and Climate Modeling

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2) Research Professor, Finnish Meteorological Institute

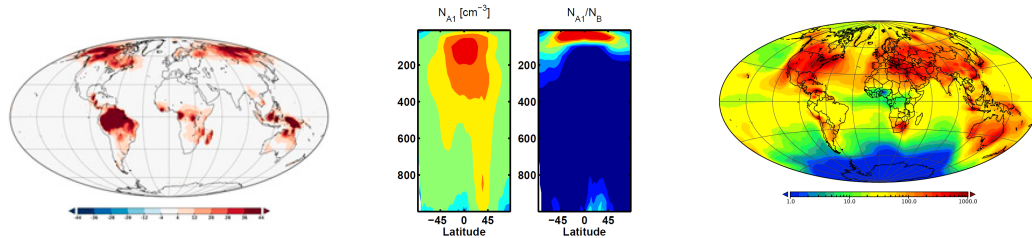
INAR

INSTITUTE FOR ATMOSPHERIC AND
EARTH SYSTEM RESEARCH

RSHU & UHEL
meeting, 23.4.2020

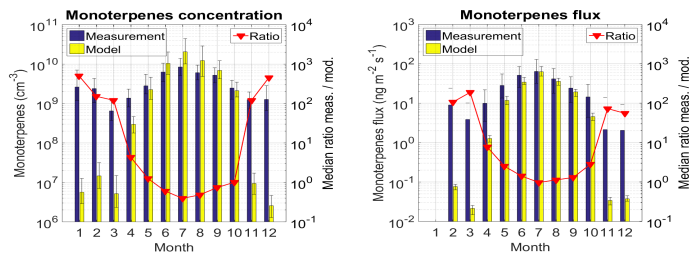
Examples of Earth System and Climate Modeling during recent years

Nucleation and growth in Earth System Models



New particle formation modules in three different models:
 ECHAM-HAM (2007 →)
 NorESM (2012 →)
 EC-Earth (2016 →)

Secondary organic aerosols in global models



SOA modules in three different ESMs:
 ECHAM-HAM (2008 →)
 NorESM (2012 →)
 EC-Earth (2016 →)

→ SOA interactions in Siberia (2016) and Tibet (2015)
 → Effect on aerosol forcing
 → Detailed analysis against supersite observations

Marine Organic Aerosol (MOA)

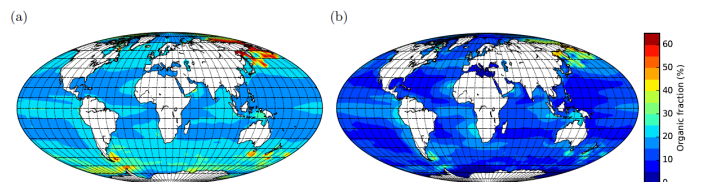
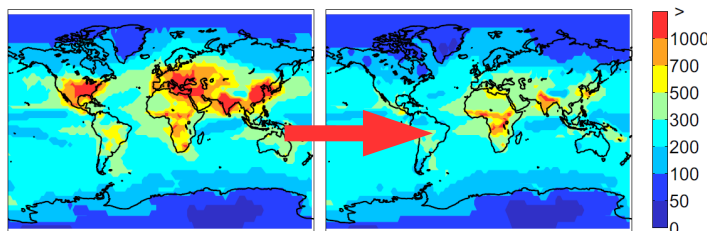


Figure 1: Organic fraction during the months September, October, and November (SON) of the SSA as calculated using (a) the parametrization of Vignati et al. (2010) and (b) the parametrization of Burrows et al. (2014).

Two models of MOA emission have been implemented in EC-Earth, with varying complexity in e.g. ocean precursors (chlorophyll vs. lipids/polysaccharides/DOC/...)

→ potential future coupling to ocean biogeochemistry (PISCES)

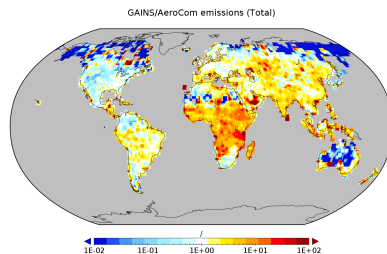
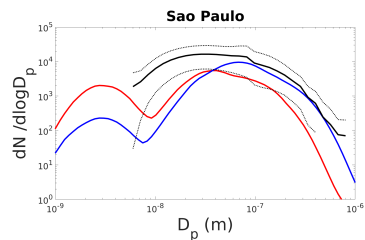
Linking air pollution to amplification of climate change



→ Effect of nitric acid co-condensation on cloud formation, impact on anthropogenic forcing
 → Impact of nucleation on CCN and aerosol forcing during 1750 - 2100
 → Aerosol forcing uncertainty

Examples of Earth System and Climate Modeling during recent years

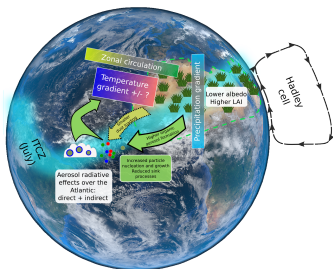
Novel methods for primary anthropogenic aerosol sources



Moving from traditional mass-based emission inventories to detailed size-segregated data

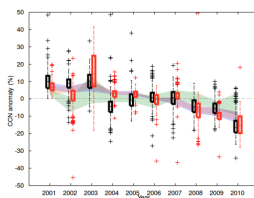
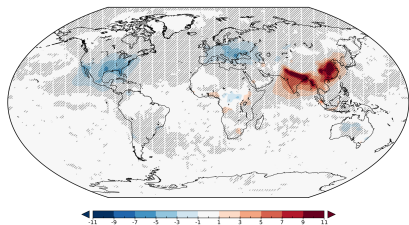
→ Potential for a strong effect on anthropogenic forcing

Aerosol-climate interactions and feedbacks during Green Sahara



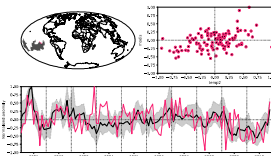
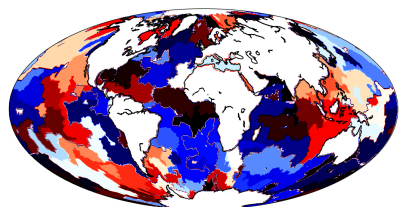
- Reconstruct mid-Holocene aerosol fields in an Earth System Model
- Quantify the effect of aerosols on West African Monsoon intensification and spatial distribution
- Pursue holistic understanding of vegetation-climate Earth System feedbacks

Cloud condensation nuclei concentration hindcasts



Assessing the trends and variability of global CCN concentrations during 2000-2010
Attributing changes to natural and anthropogenic aerosols

Big data, data mining

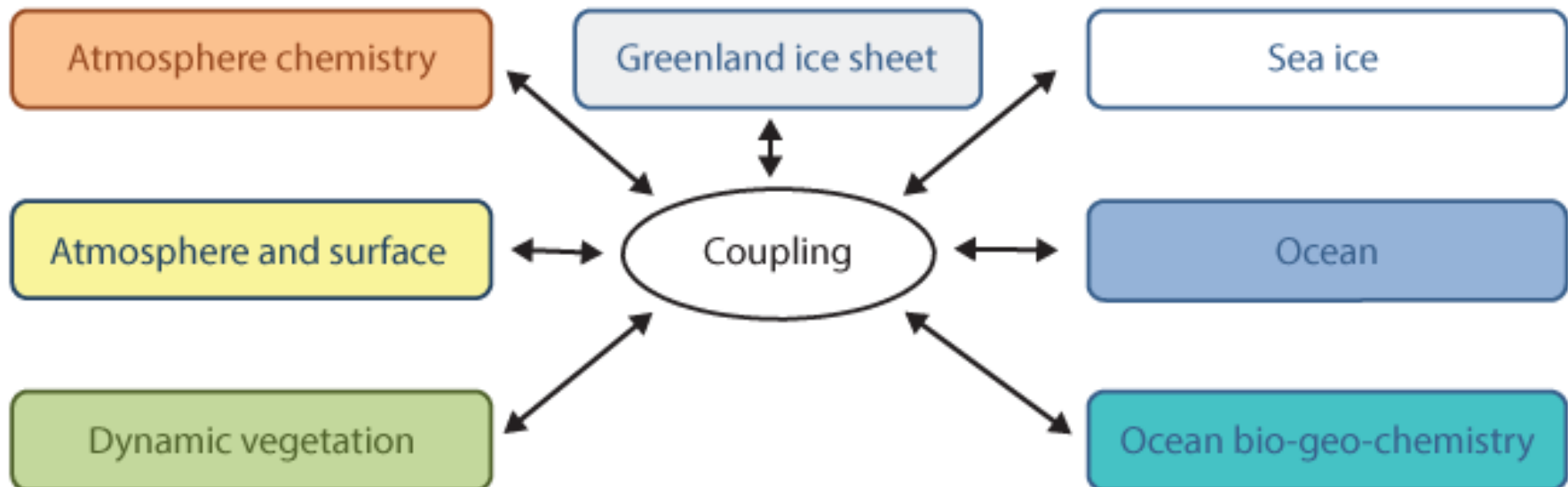


Automatic processing of big datasets: generic tools for clustering of geospatial data and network detection.

→ Can be applied to e.g. aerosol-climate interactions, teleconnections

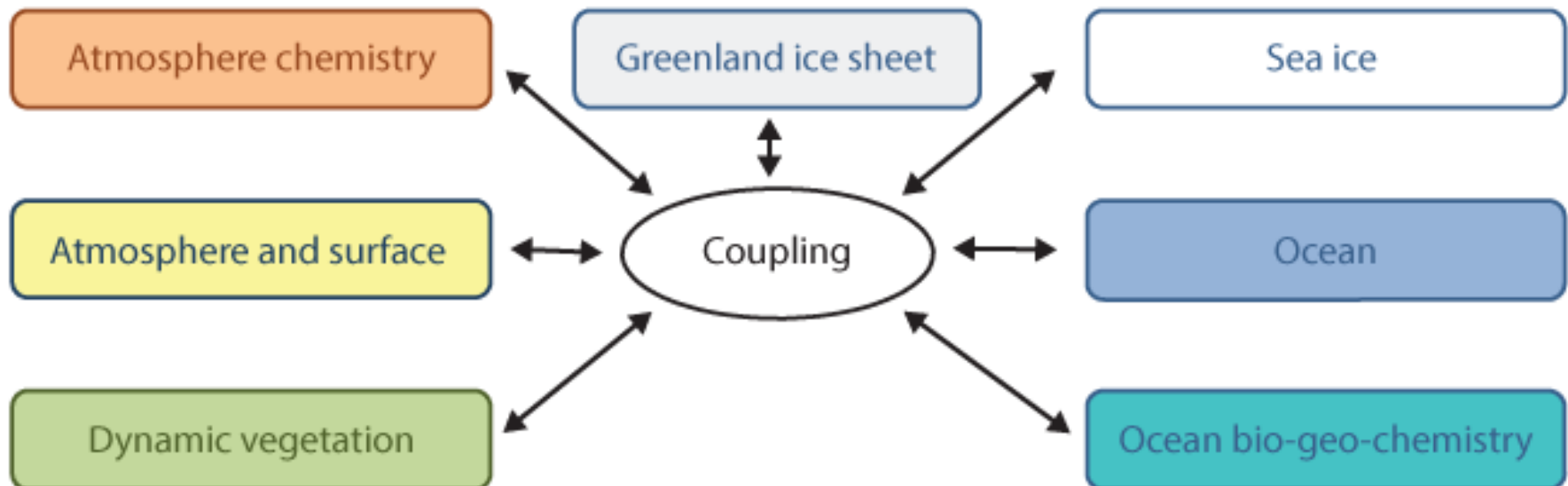
EC-Earth3

- Earth System Model, several model configurations
- UHEL participating in CMIP6 with EC-Earth3
(Atmosphere+Ocean+Aerosols/Chemistry)
- Finnish groups have participated model development



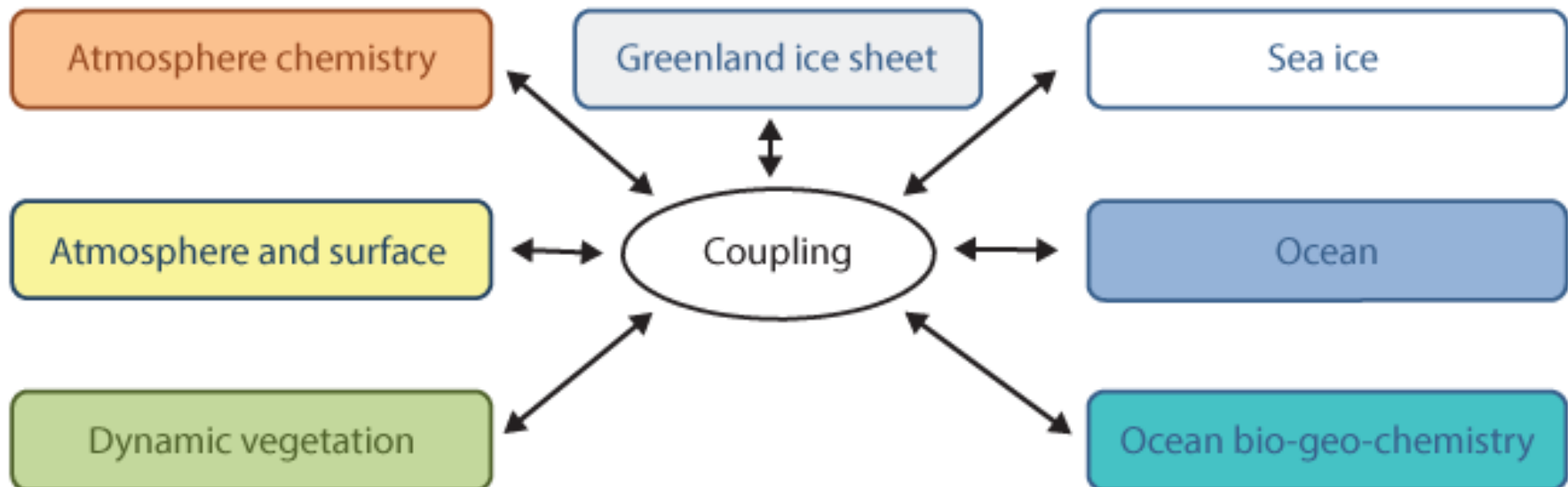
EC-Earth3

- **Atmosphere:** IFS (from ECMWF)
- **Atmospheric transport and chemistry:** TM5
 - Carbon bond (CB05) mechanism (51 species, 156 reactions)
- **Ocean:** NEMO, **sea-ice:** LIM, **biogeochemistry:** PISCES
- **Dynamic vegetation:** LPJ-GUESS
- **Ice sheets:** PISM



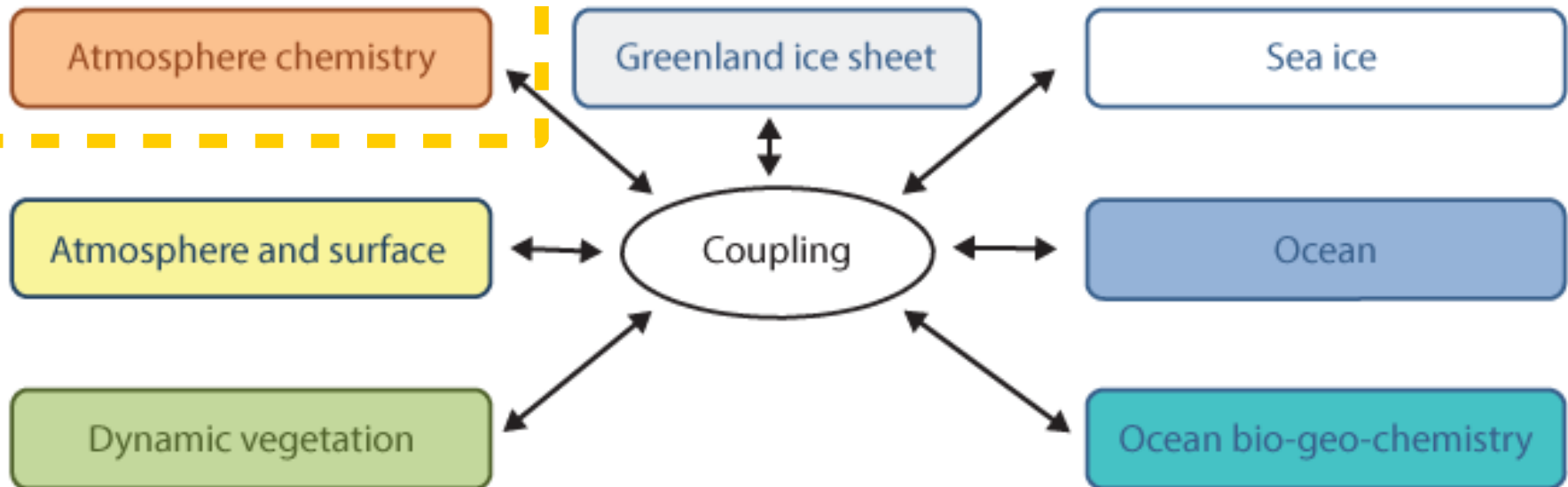
EC-Earth4 and OpenIFS

- In EC-Earth4, the atmospheric model of EC-Earth will be OpenIFS
 - OpenIFS widely used in education and training
 - OpenIFS license allows more open collaboration outside ECMWF member countries
- UHEL course “Introduction to Earth System Modelling”
 - In addition, Earth System Modeling integrated to several courses



EC-Earth3

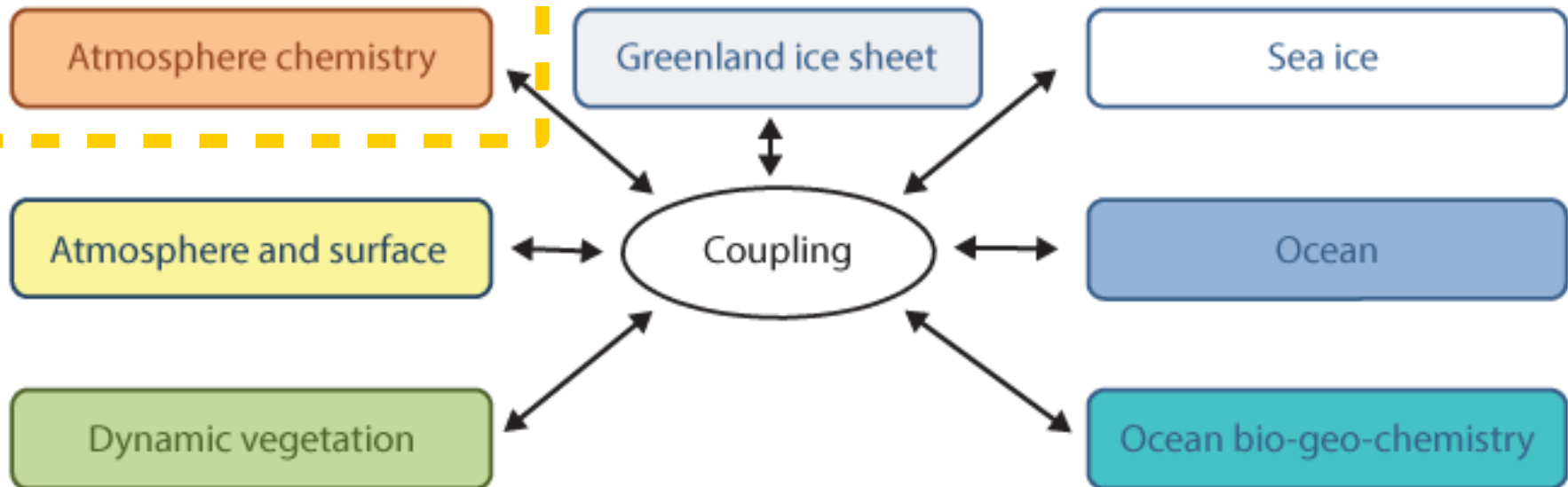
Recent Finnish developments



EC-Earth3

Recent Finnish developments

**Marine Organic
Aerosol (MOA)**
(UHEL, U. Oulu,
FMI, ...)

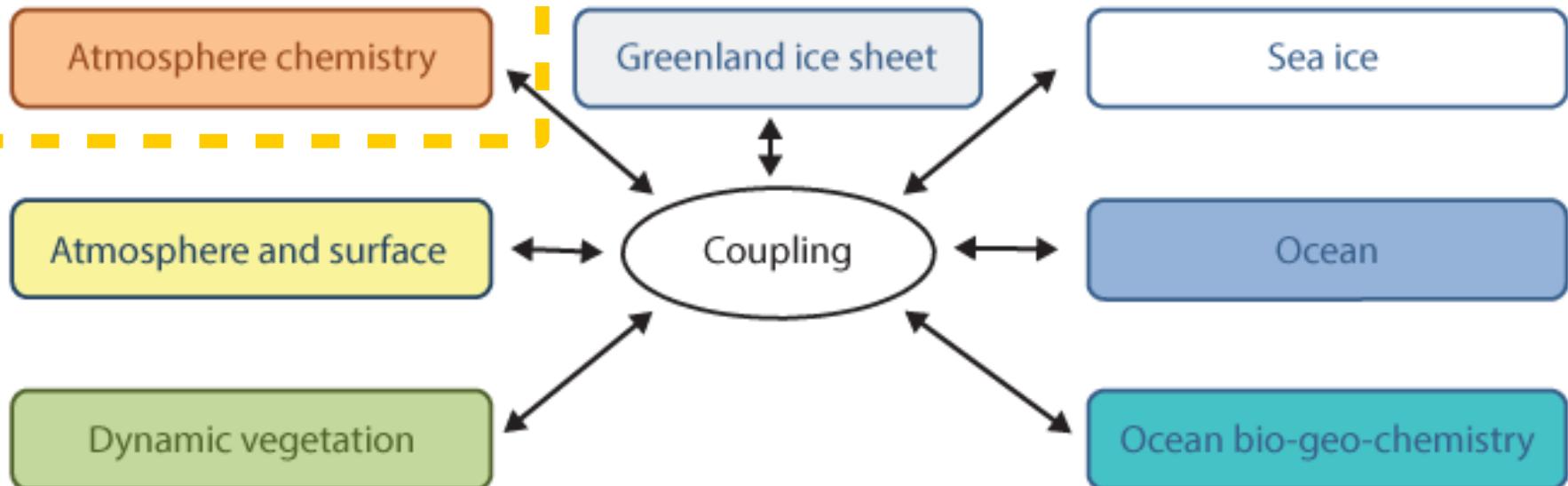


EC-Earth3

Recent Finnish developments

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Secondary Organic Aerosol (SOA)
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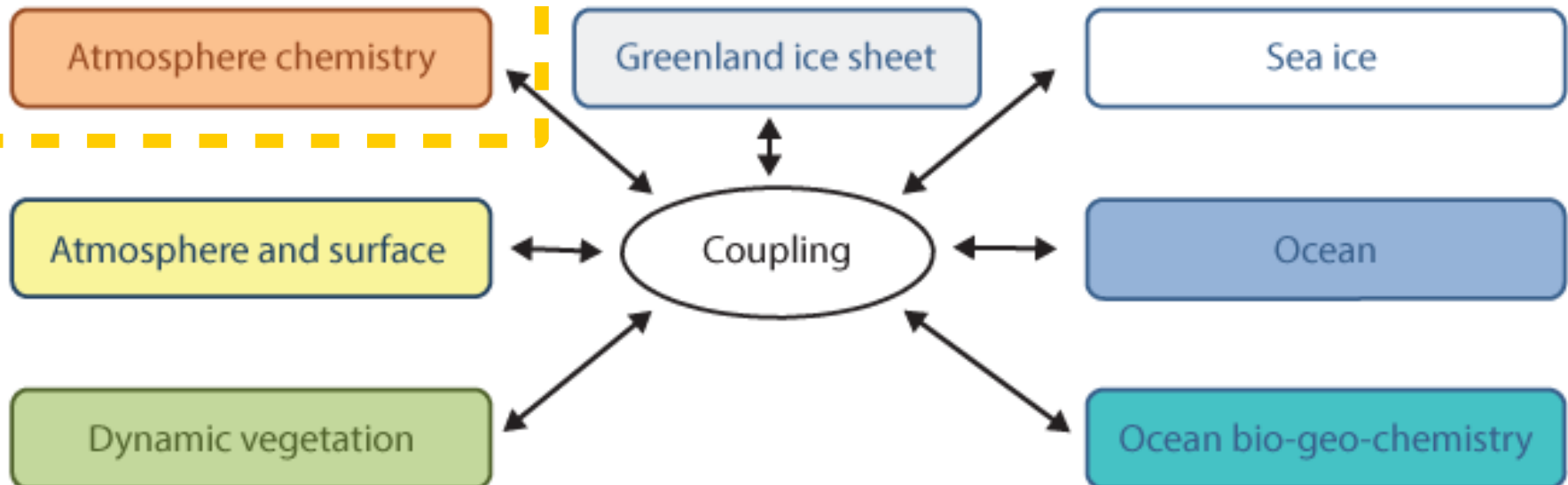
EC-Earth3

Recent Finnish developments

Marine Organic Aerosol (MOA)
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Secondary Organic Aerosol (SOA)
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Primary Biological Aerosol Particles
(U. Lund, UHEL, ...)



EC-Earth3

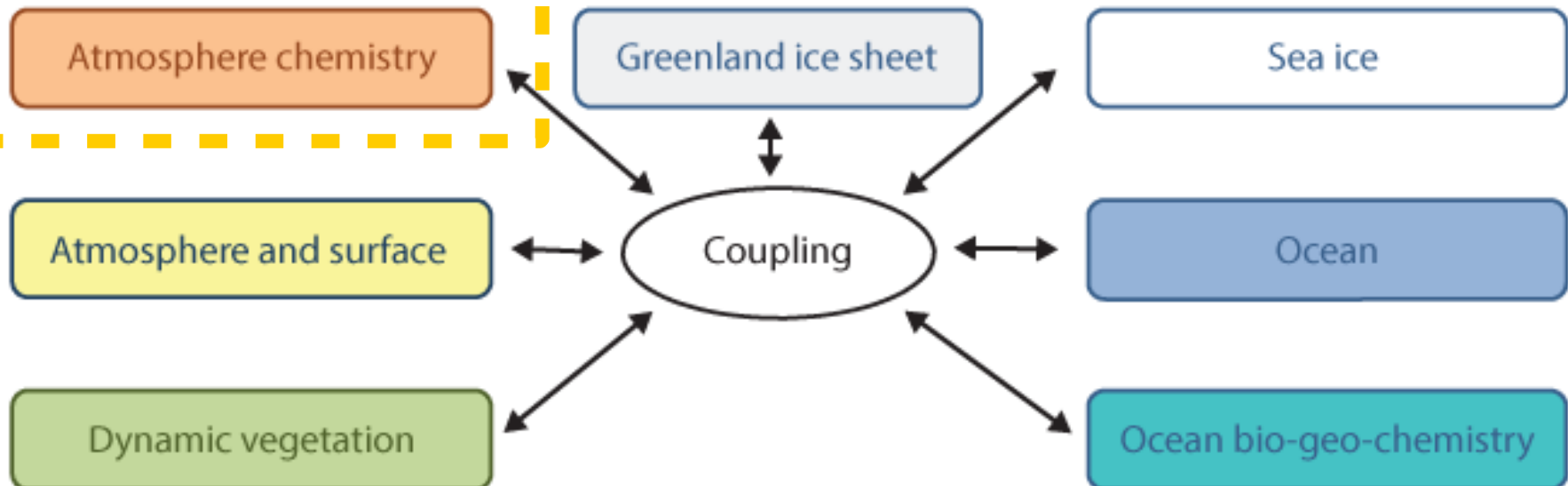
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(U. Lund, UHEL, ...)

Aerosol nucleation
(UHEL, U. Lund, KNMI)



EC-Earth3

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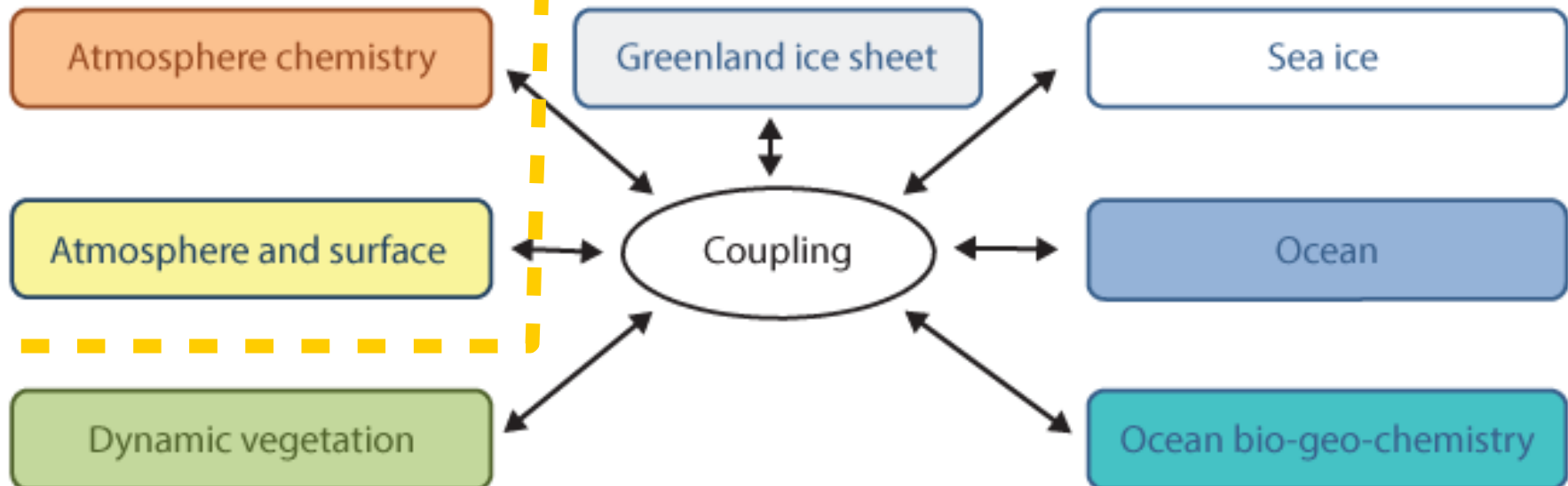
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(UHEL, U. Oulu, FMI, ...)

Secondary Organic Aerosol (SOA)
(UHEL, FMI, KNMI, U. Lund, ...)

Primary Biological Aerosol Particles
(U. Lund, UHEL, ...)

Aerosol-cloud interactions
(FMI)

Aerosol nucleation
(UHEL, U. Lund, KNMI)



Future projections

From pathways to climate projections

Finnish groups participating in CMIP6 for the first time

→ Climate model results towards 6th IPCC Assessment report

Coupled Model Intercomparison Project Phase 6
= CMIP6

