Swedish climate modeling research
-
the Beskow perspective

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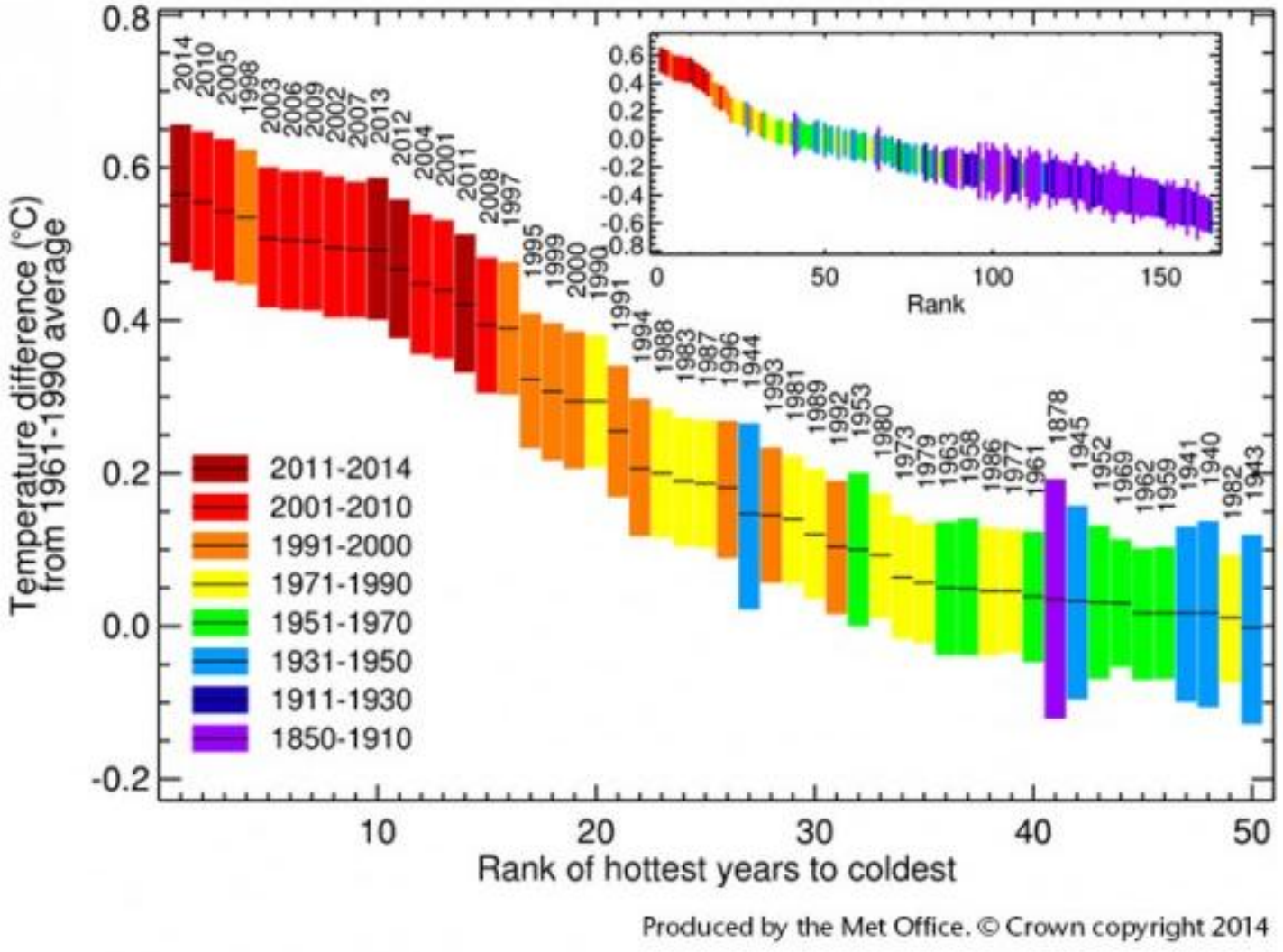
SeRC

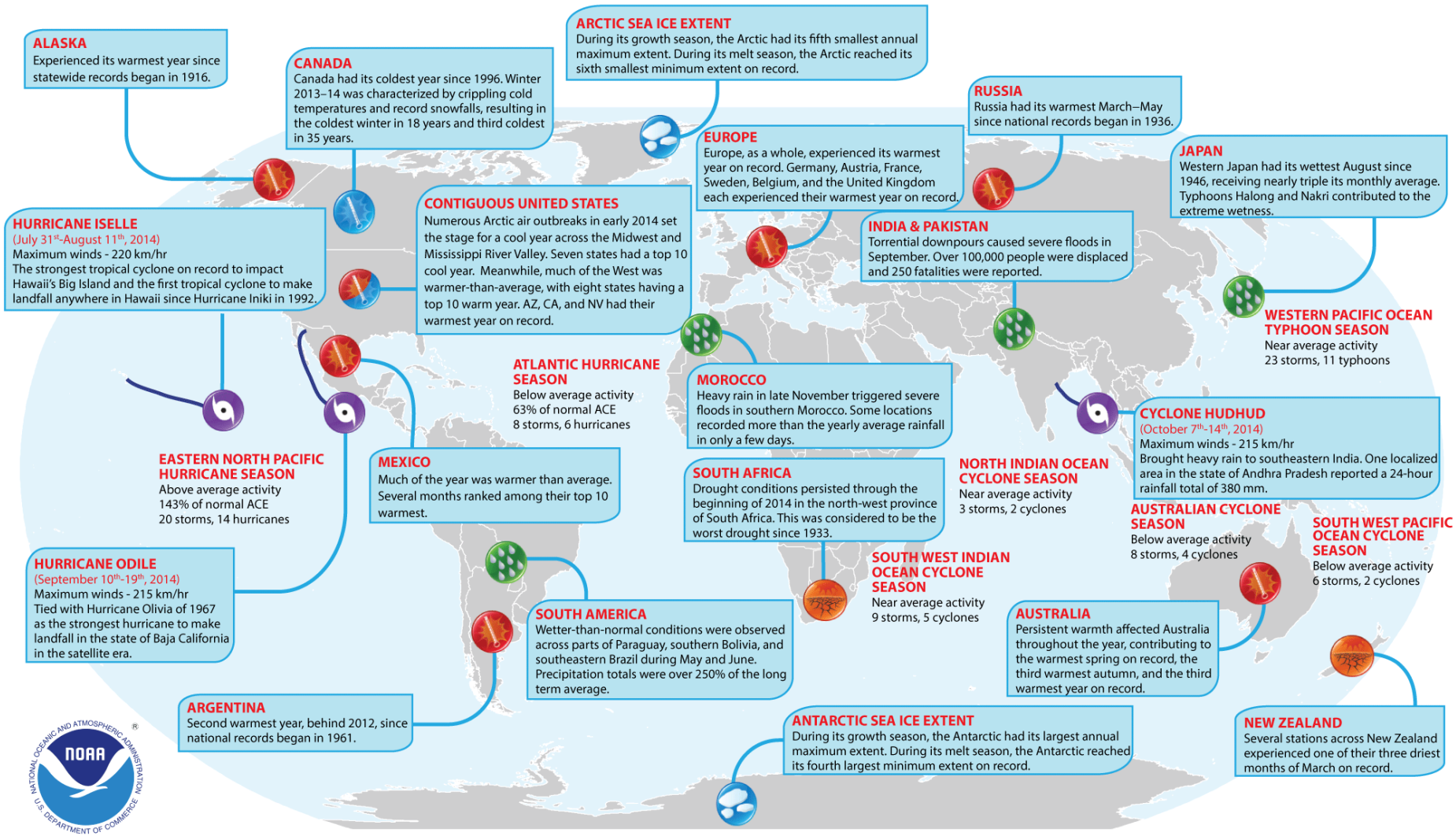
Our earth is getting warmer...

Stockholm University



Is it getting more extreme?

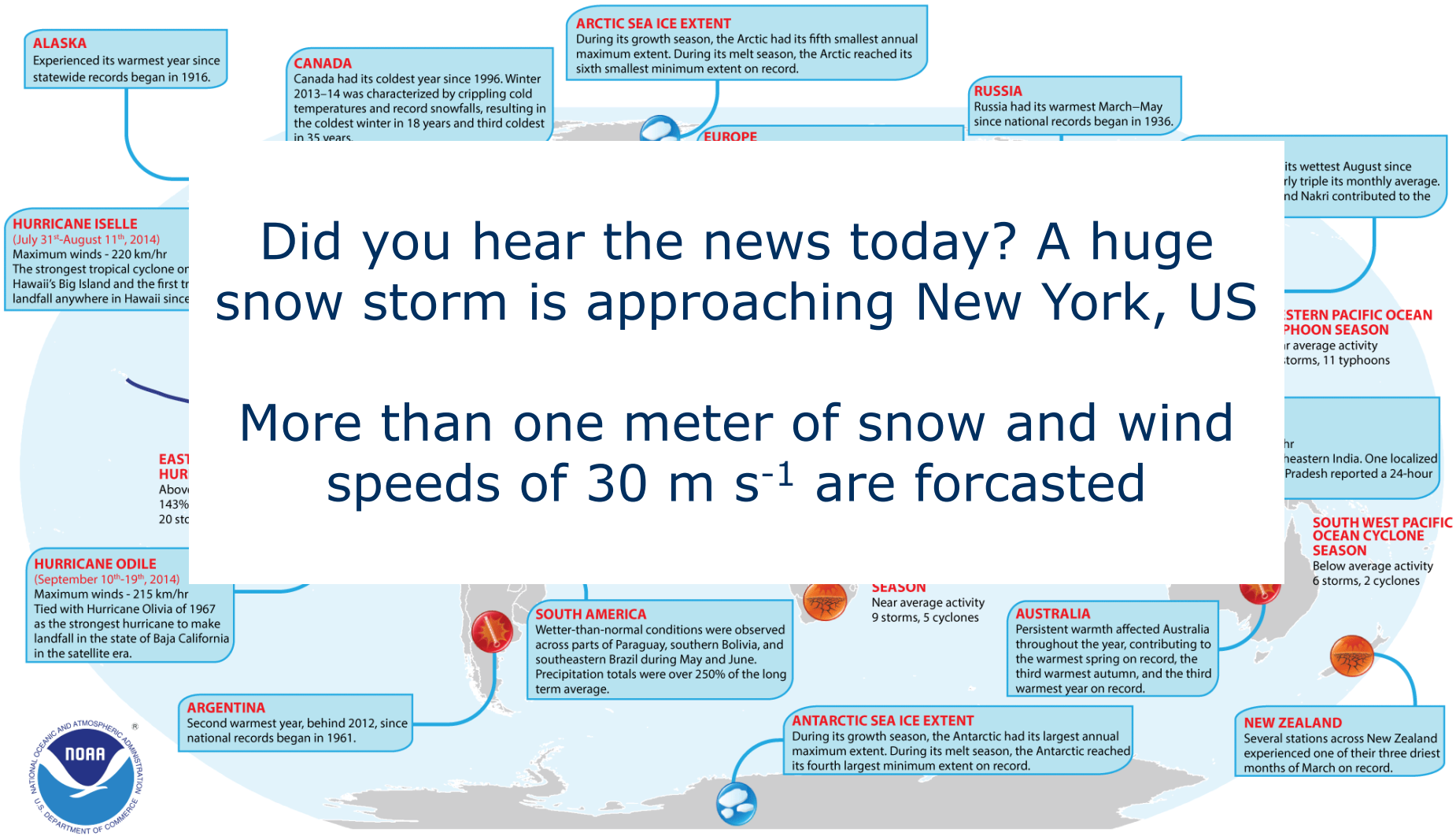
Selected Significant Climate Anomalies and Events in 2014



Please Note: Material provided in this map was compiled from NOAA's NCDC State of the Climate Reports and the WMO Provisional Status of the Climate in 2014.
For more information please visit: http://www.ncdc.noaa.gov/sotc

Is it getting more extreme?

Selected Significant Climate Anomalies and Events in 2014



Did you hear the news today? A huge snow storm is approaching New York, US

More than one meter of snow and wind speeds of 30 m s^{-1} are forcasted

Please Note: Material provided in this map was compiled from NOAA's NCDC State of the Climate Reports and the WMO Provisional Status of the Climate in 2014.
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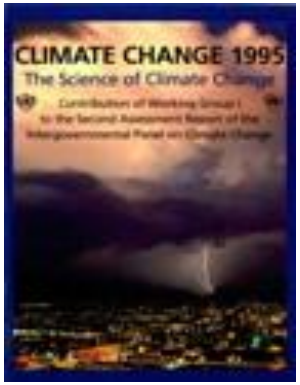
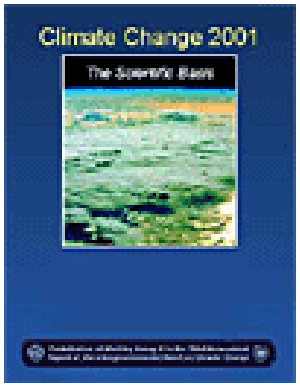
Is man responsible?

Stockholm University



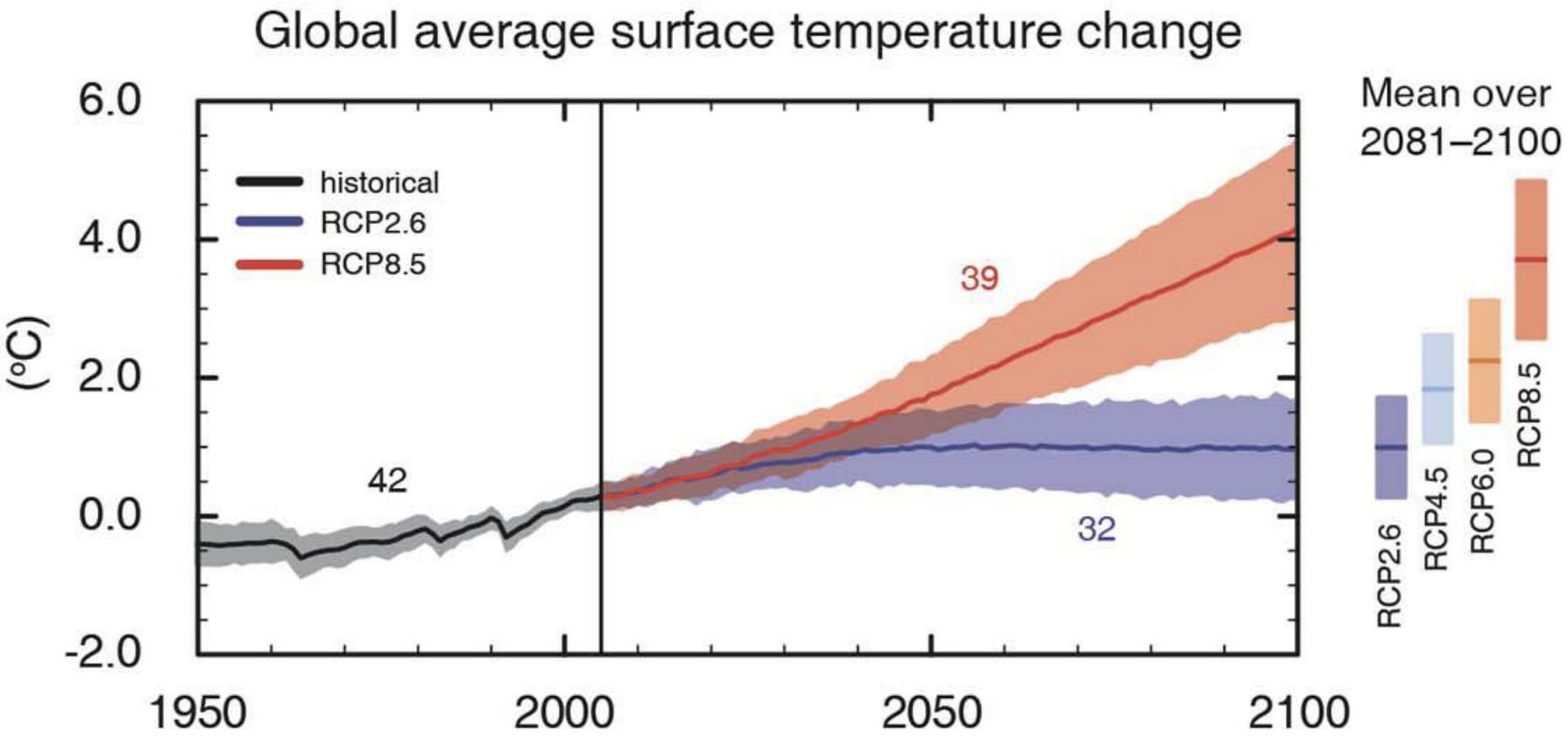


FAR	SAR	TAR	AR4	AR5
1990	1995	2001	2007	2013
	Suggests	Likely	Very likely	Extremely likely

IPCC - Intergovernmental Panel on Climate Change
Working Group I: The Physical Science Basis

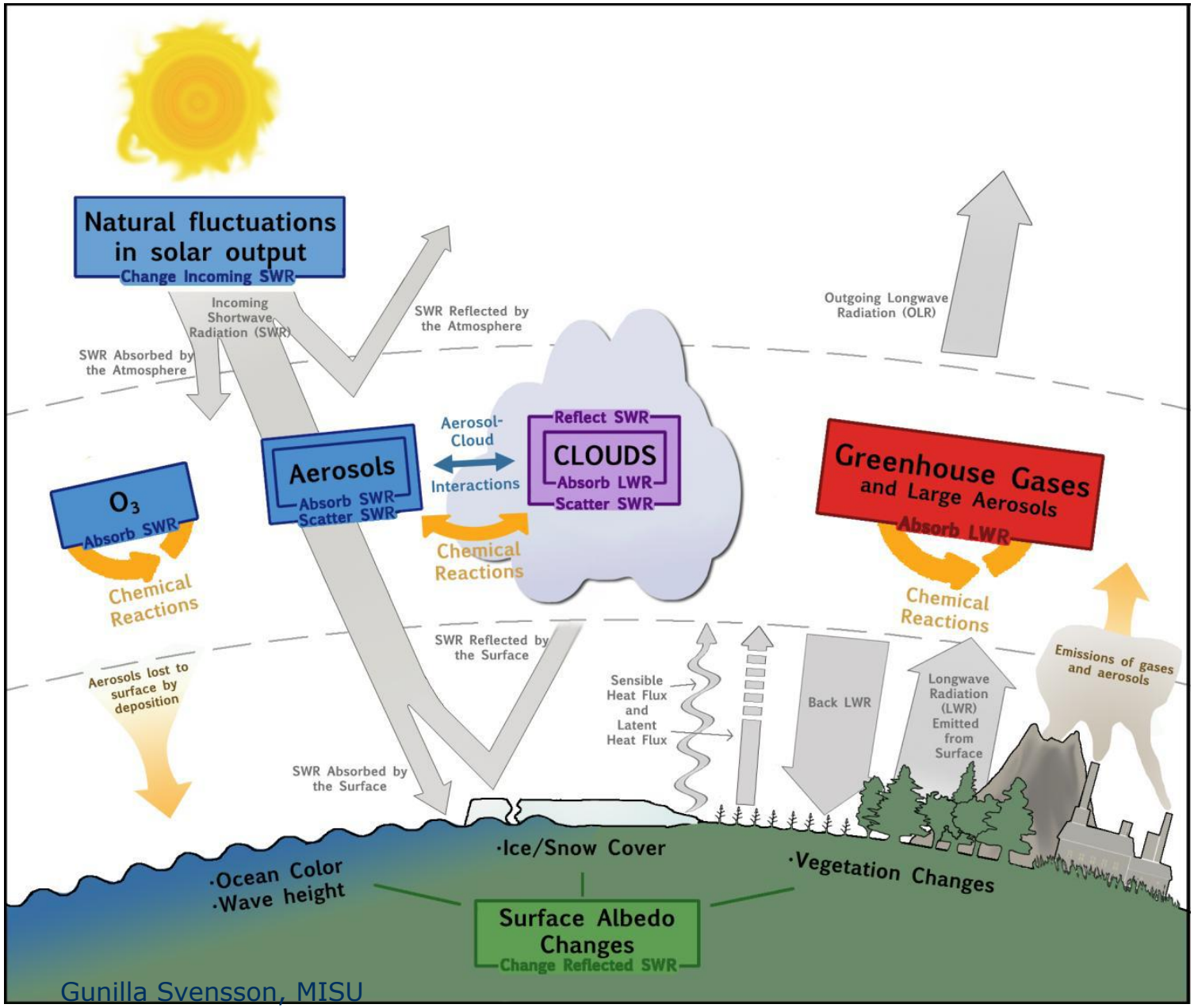
Global change (AR5)

Stockholm University



IPCC, 2013

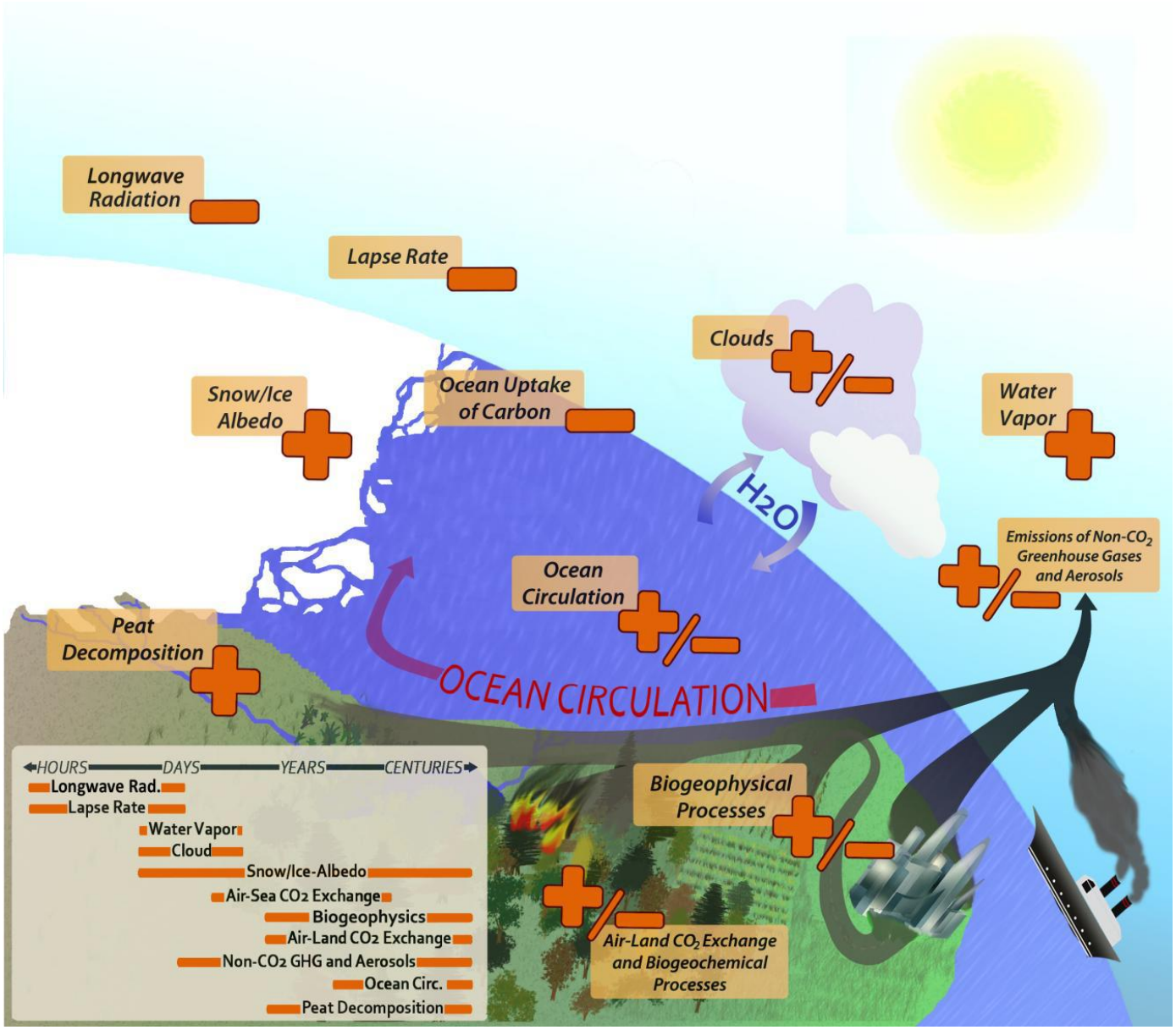
Main drivers of climate change



Gunilla Svensson, MISU

IPCC, 2013

Feedbacks in the climate system



IPCC, 2013

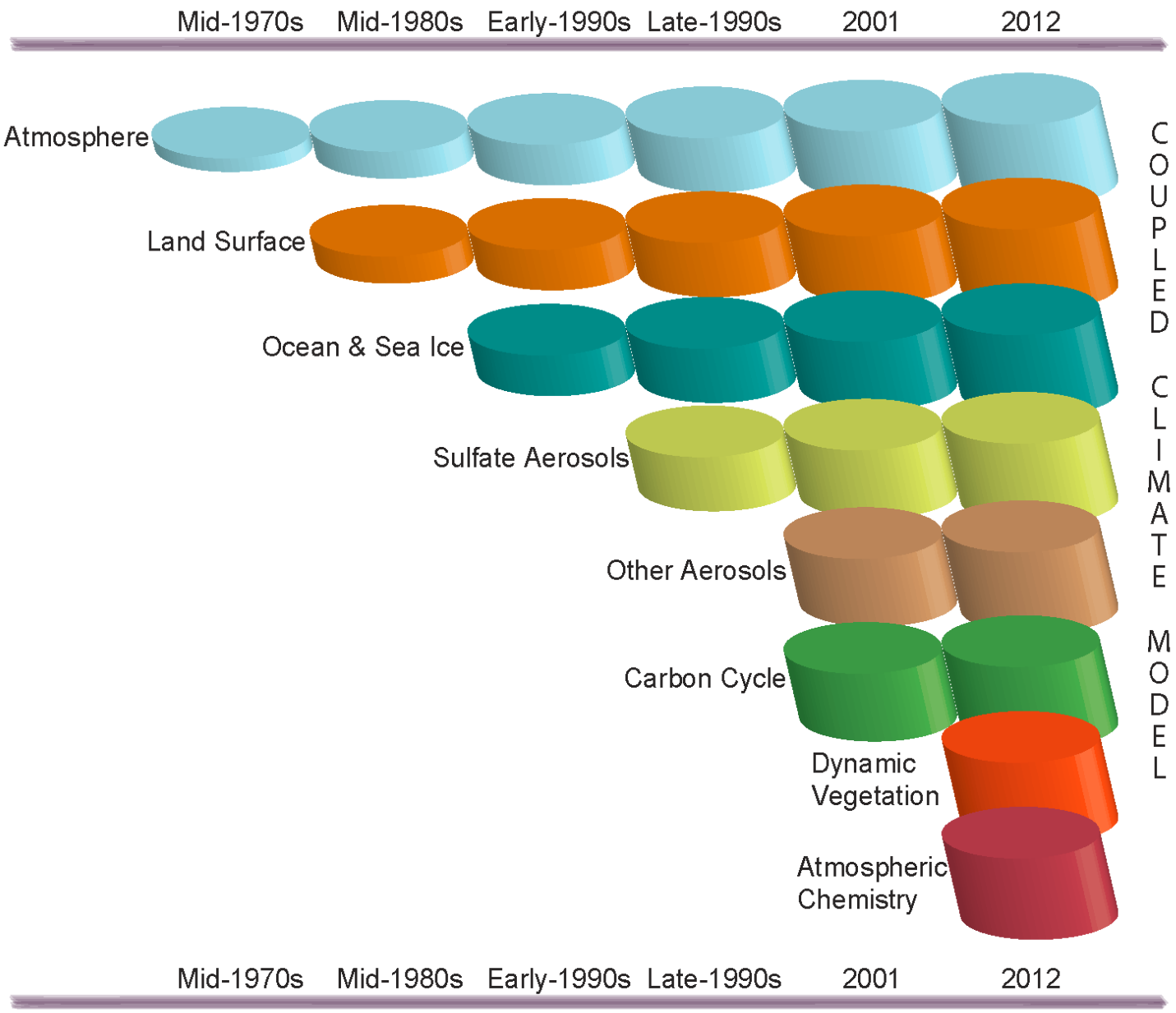
Climate models are the only scientific tool available to say something about future climate

Stockholm University

Courtesy Christian Jakob

Climate model development

Stockholm University

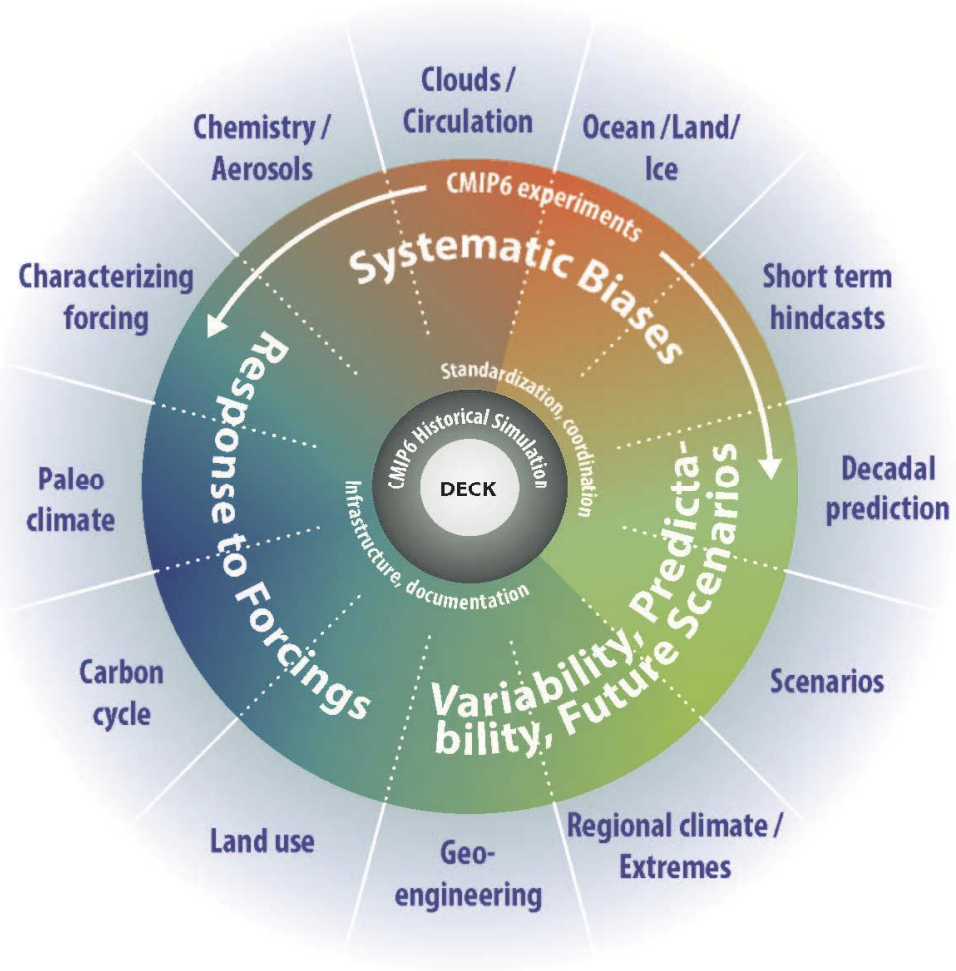


?

IPCC, 2013

International climate research

Stockholm University



cmip Coupled Model Intercomparison Project

DECK - Diagnostic, Evaluation and Characterization of *Klima*

WCRP World Climate Research Programme

Coupled Model Intercomparison Project phase 6

Stockholm University

The specific experimental design is focused on **three broad scientific questions:**

1. How does the Earth System respond to forcing?

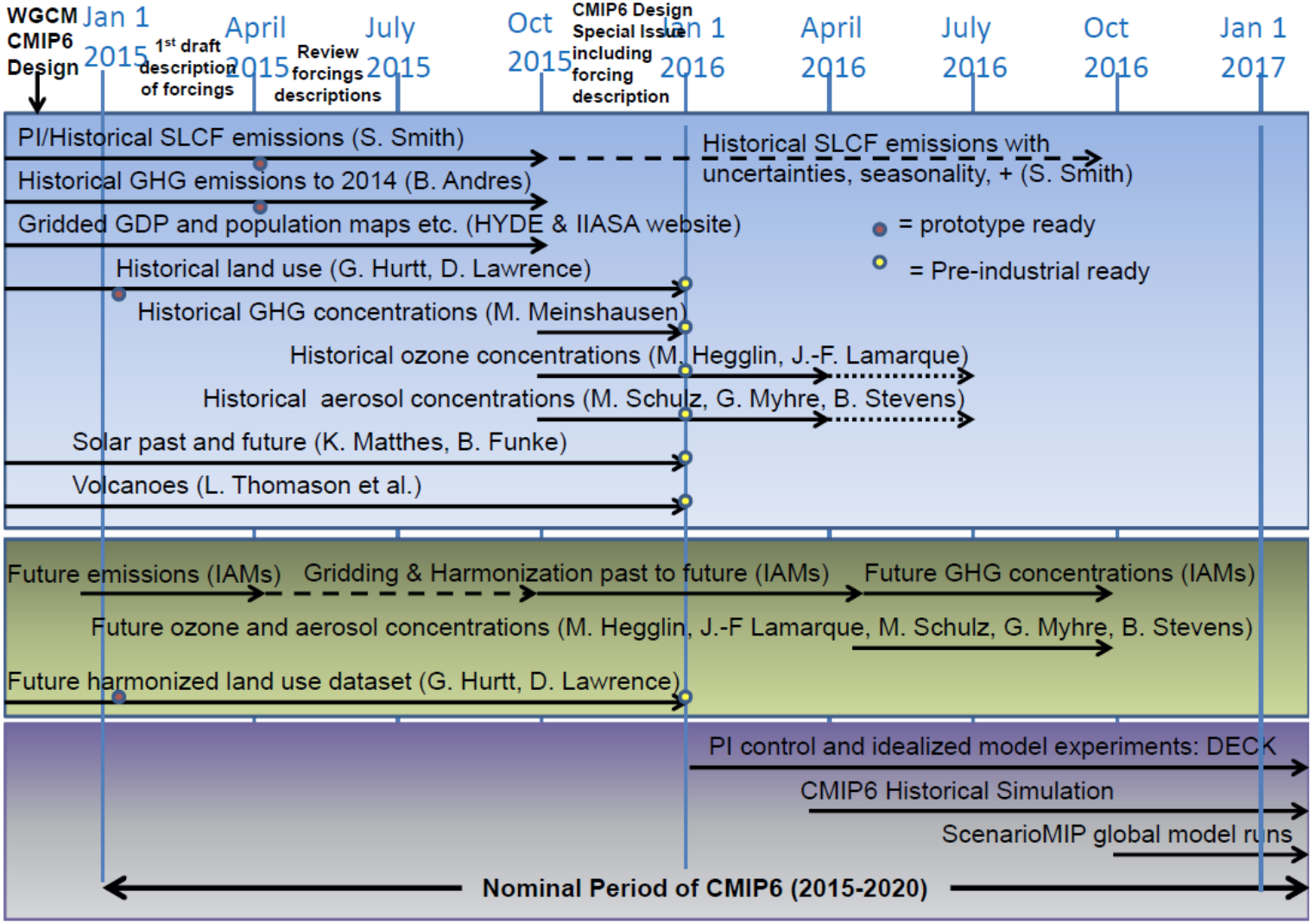
2. What are the origins and consequences of systematic model biases?

3. How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?

CMIP6 experiment timeline

Defining experiment protocols

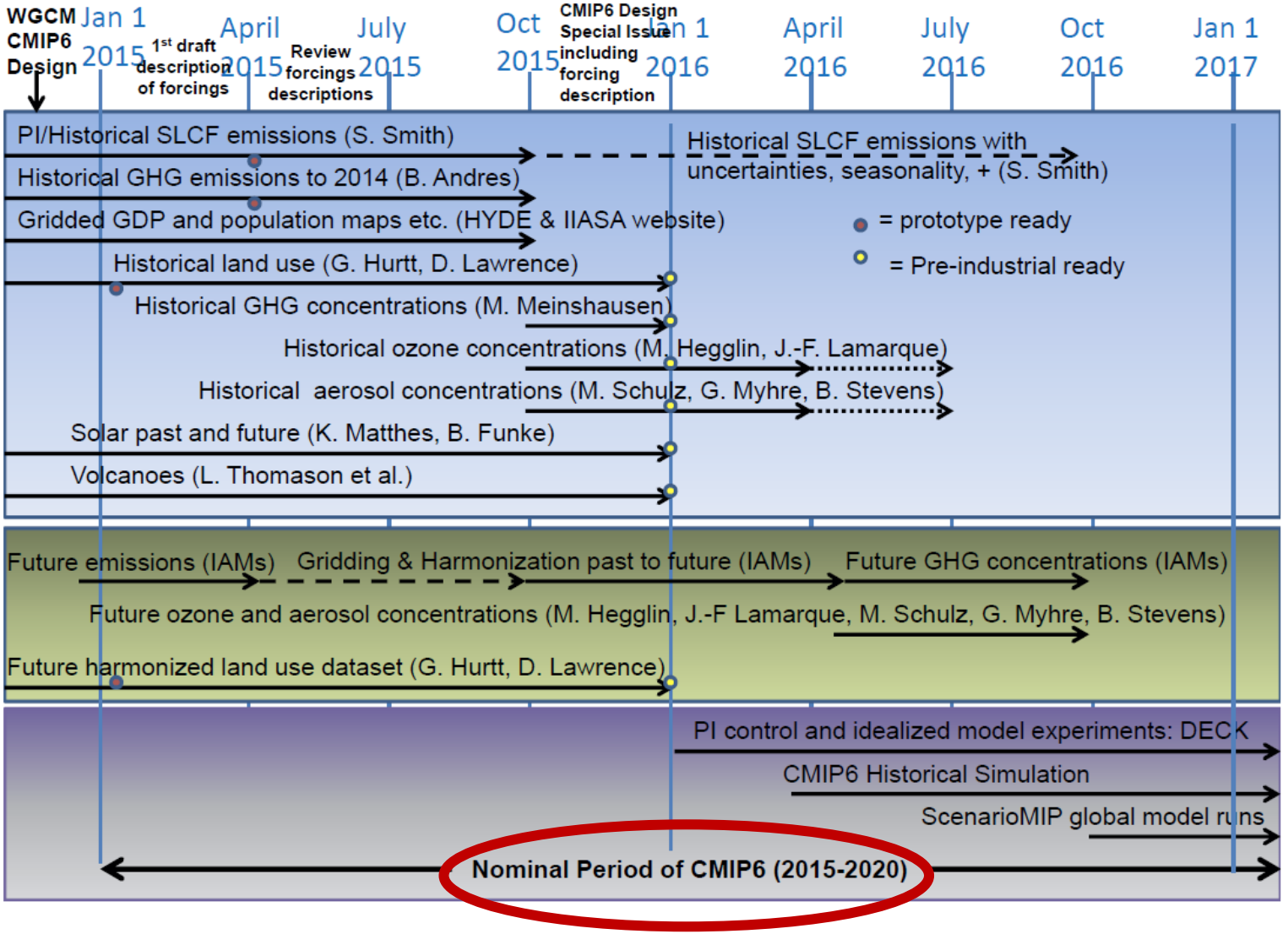
Stockholm University



CMIP6 experiment timeline

Defining experiment protocols

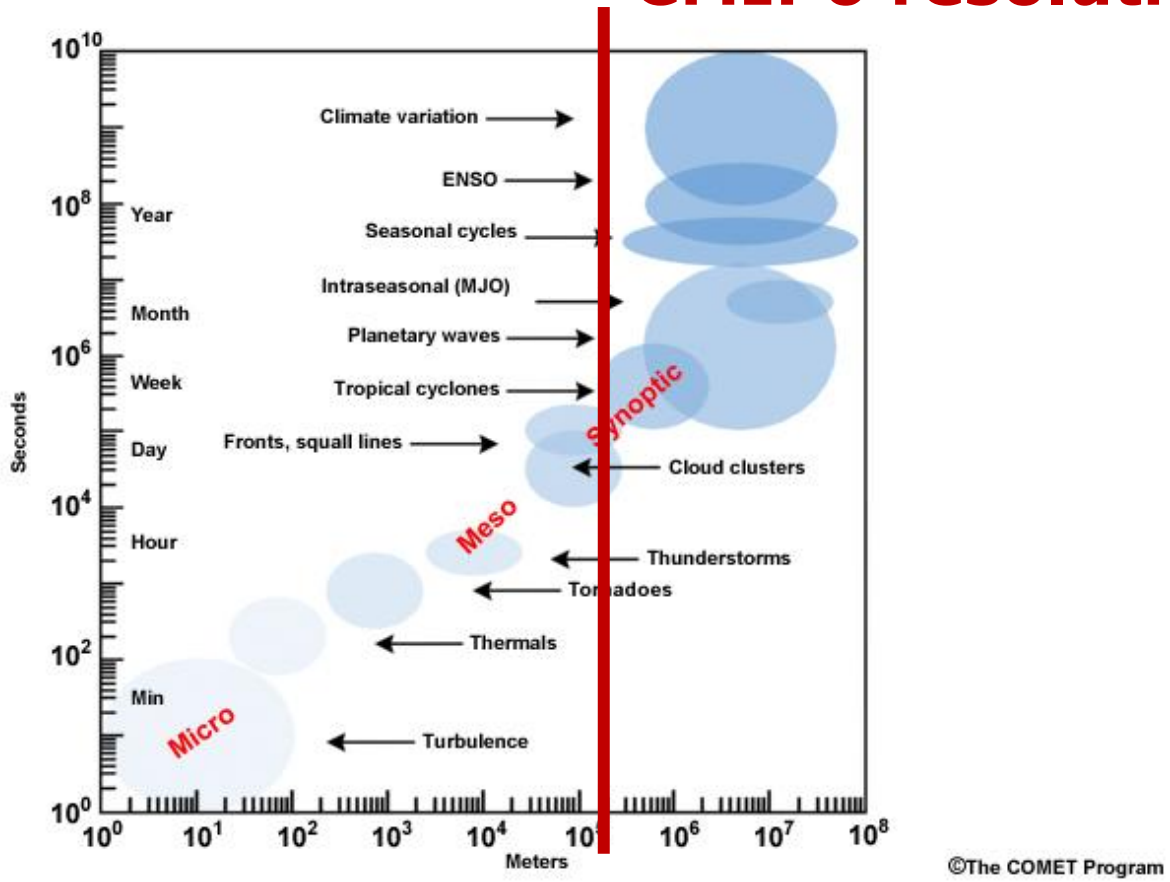
Stockholm University



Scales in the climate system

Stockholm University

~CMIP6 resolution



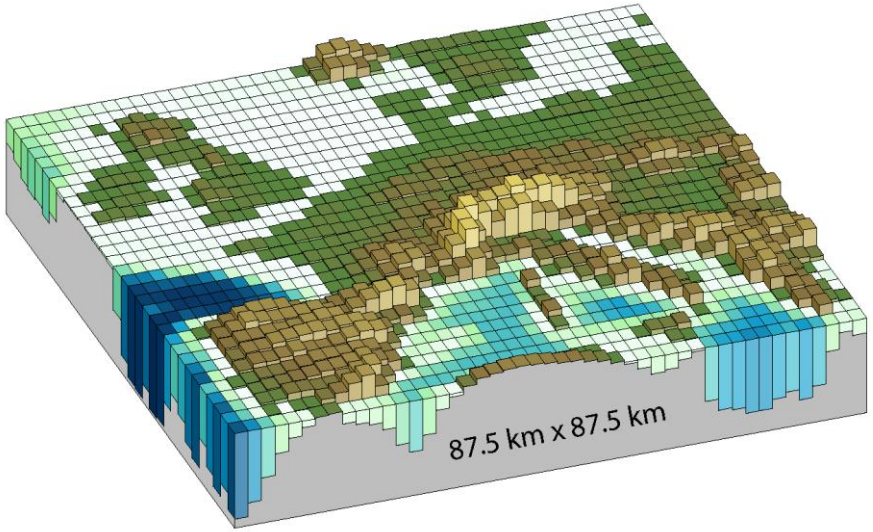
DNS **LES** **CRM** **GCM** **ESM**

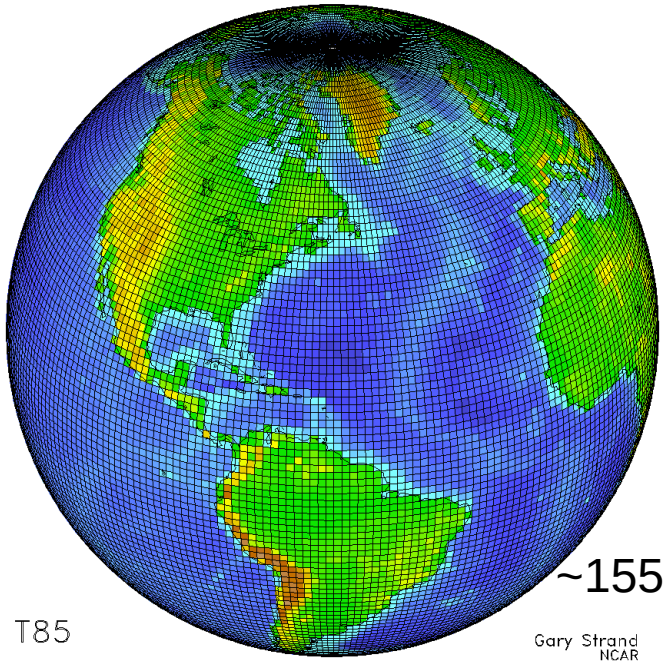
Scales

Length
Time
Complexity

Horizontal grid

Stockholm University

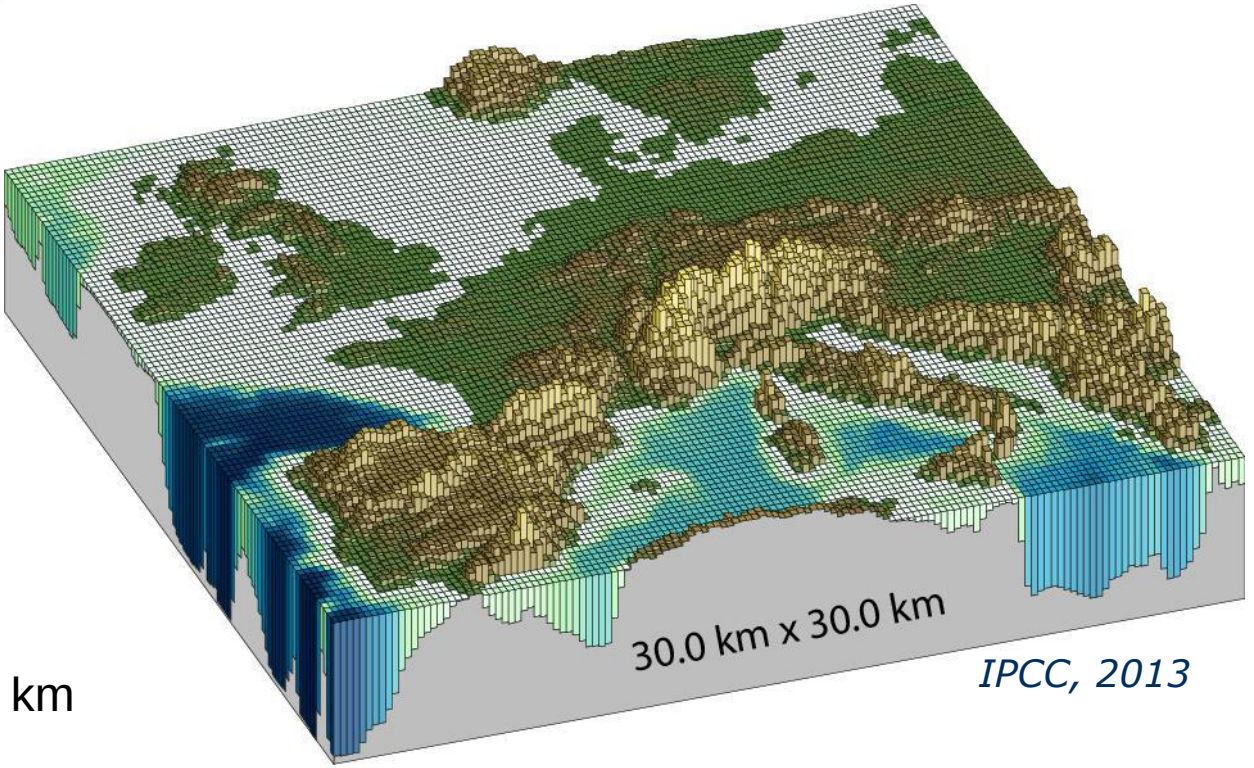




~155 km

T85

Gary Strand
NCAR



IPCC, 2013

Swedish climate modeling research

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CLOUD MACROSCALE

Thermodynamic forcing
Supersaturation development

CLOUD MICROSCALE

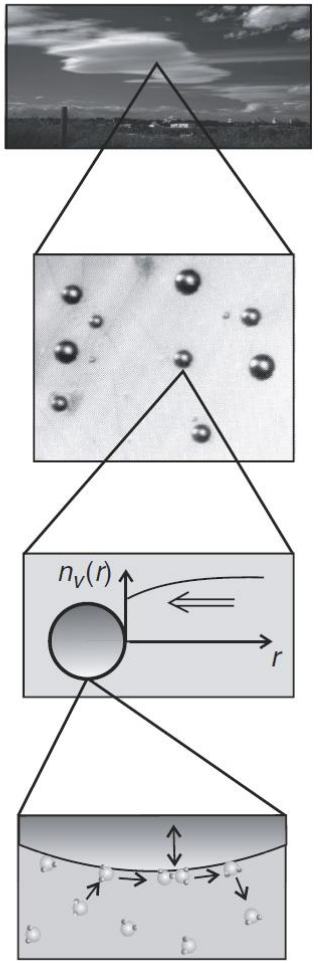
Competitive vapor depletion
Interstitial supersaturation

PARTICLE SCALE

Vapor, heat transport
Mass growth / evaporation

MOLECULAR SCALE

Surface kinetics
Condensation coefficient



ESM

DNS **LES**

Scales

Length
Time
Complexity

Swedish climate modeling research

Stockholm University

DNS **LES** **CRM** **GCM** **ESM**

Scales

Length
Time
Complexity

Swedish climate modeling research

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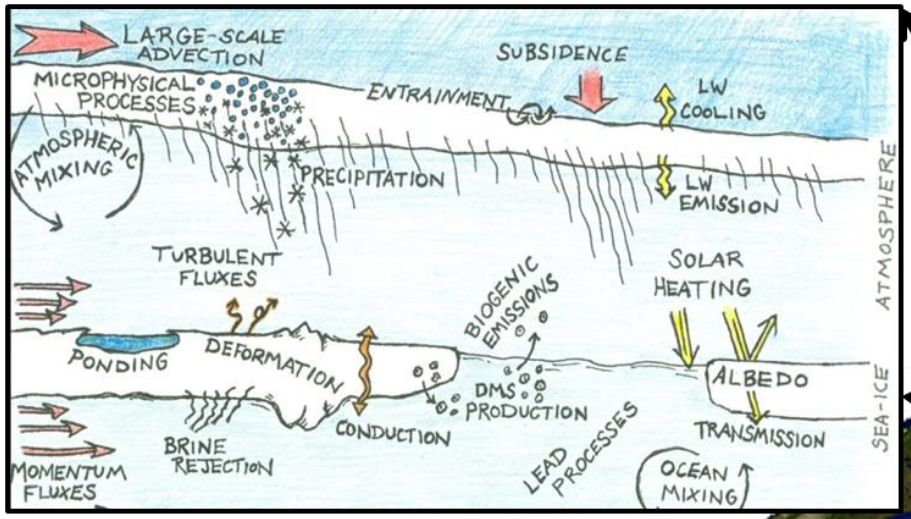
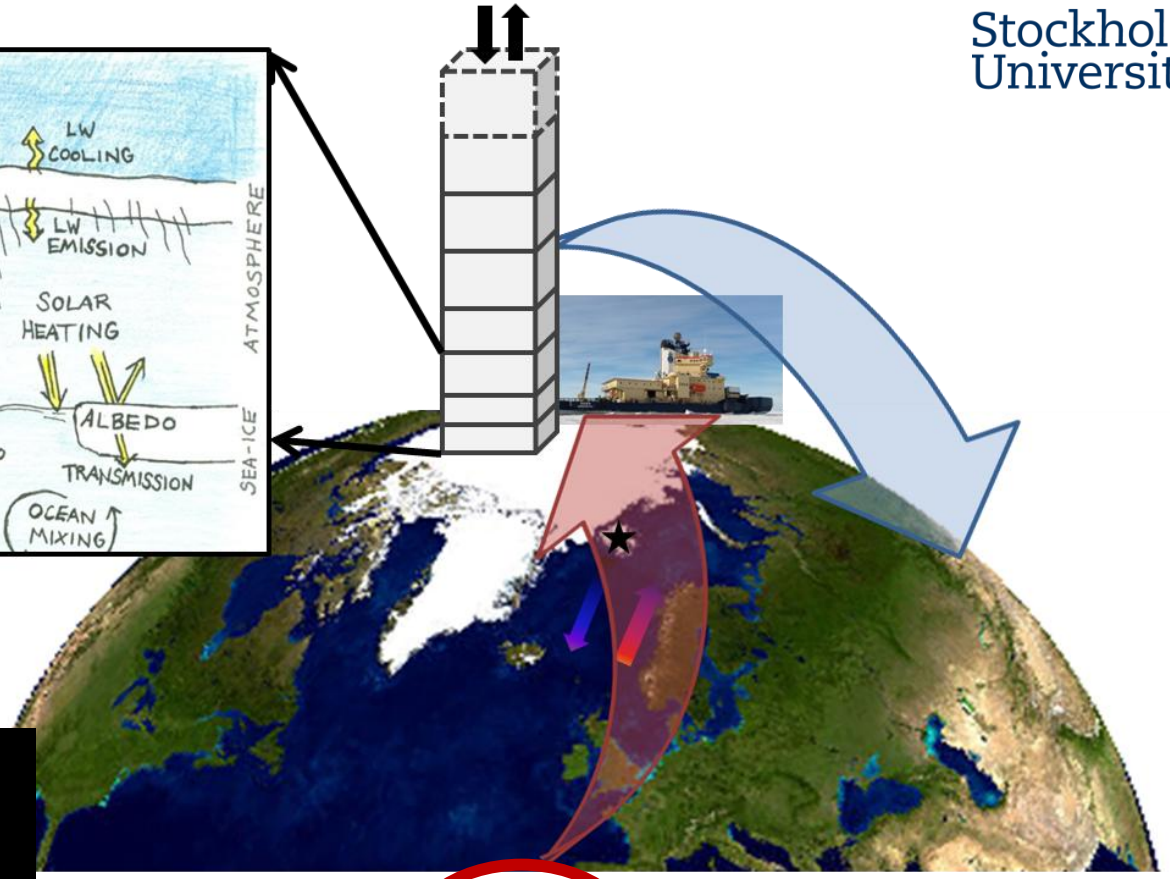




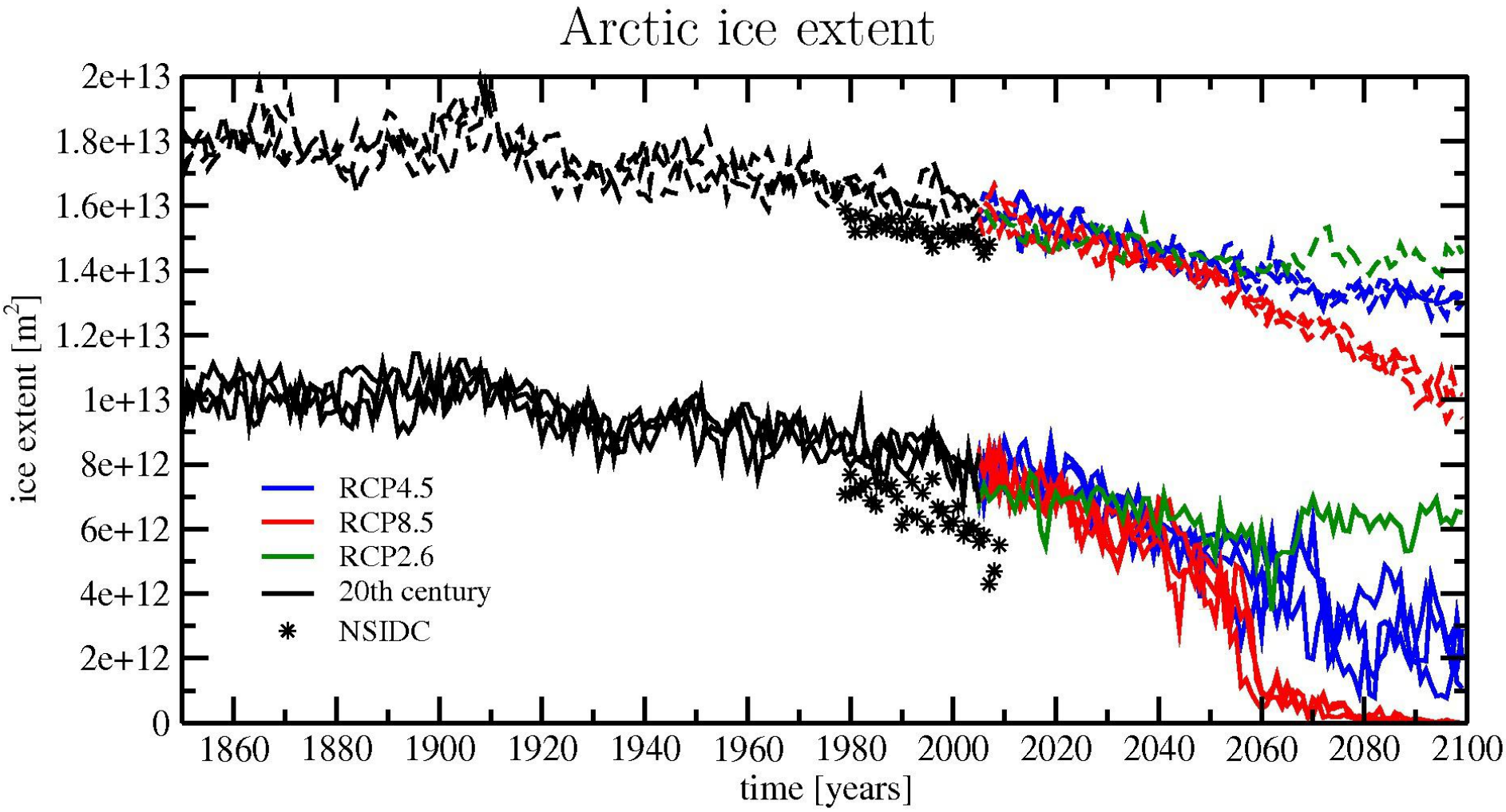
[redacted]

CRM **GCM** **ESM**

Length
Time
Complexity

Arctic climate change

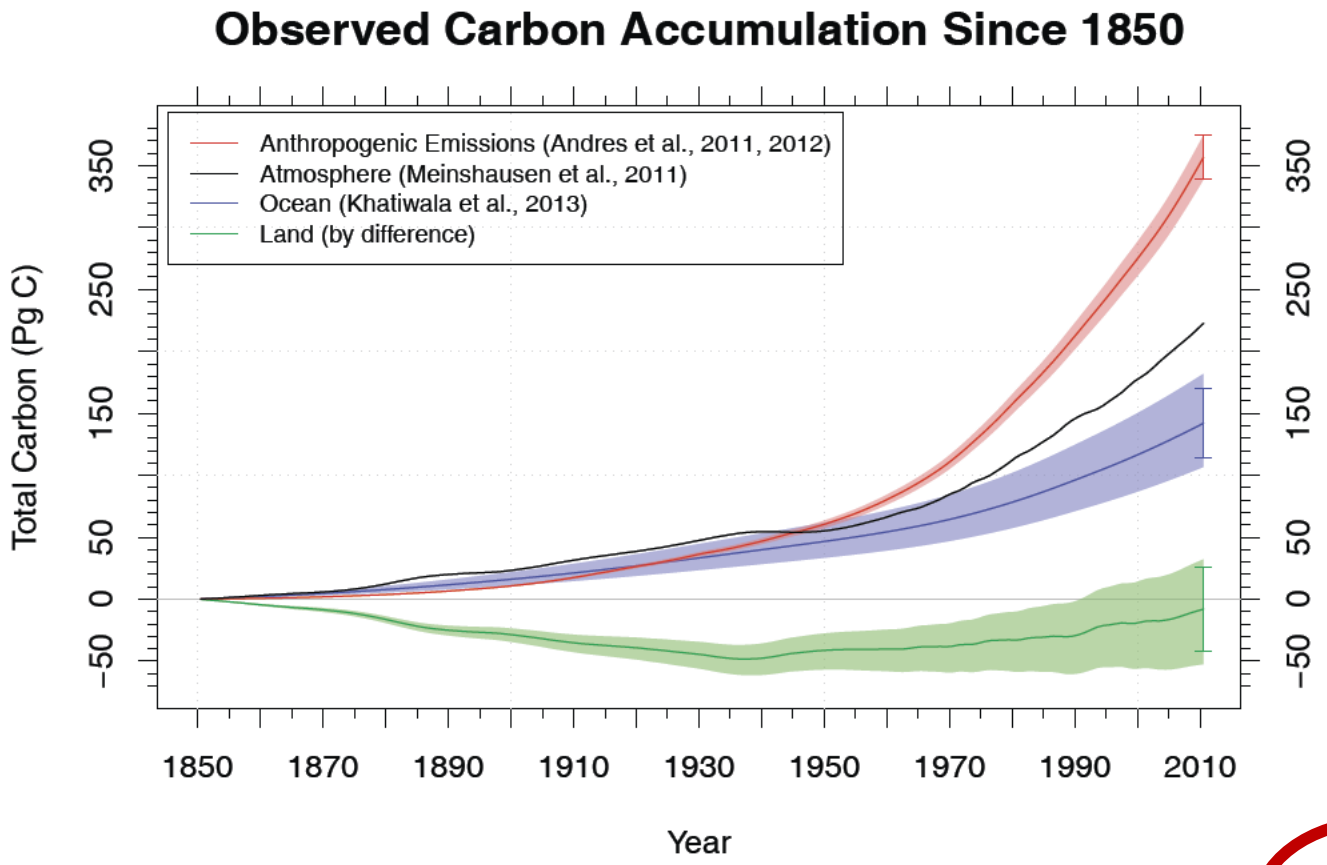
Stockholm University



Koenigk et al., 2013

Swedish climate modeling research

Stockholm University



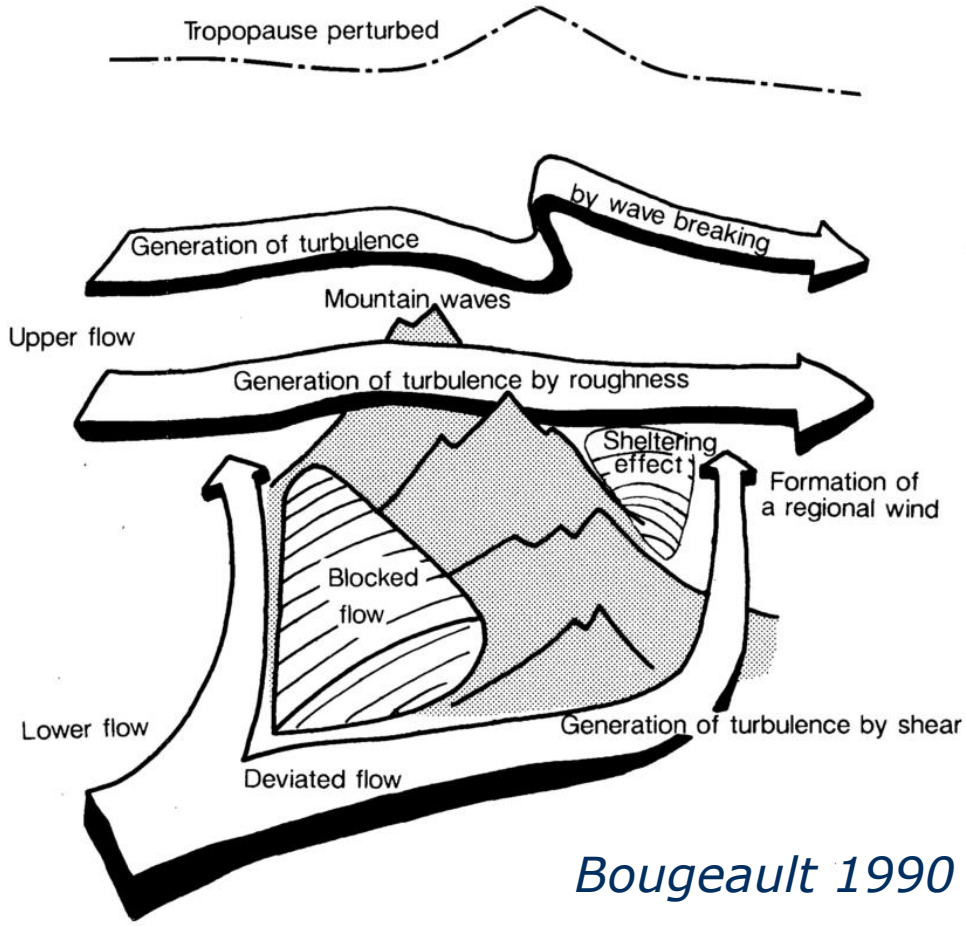
DNS **LES** **CRM** **GCM** **ESM**

Scales →

Length
Time
Complexity

Subgrid-scale terrain effects in GCM

Stockholm University

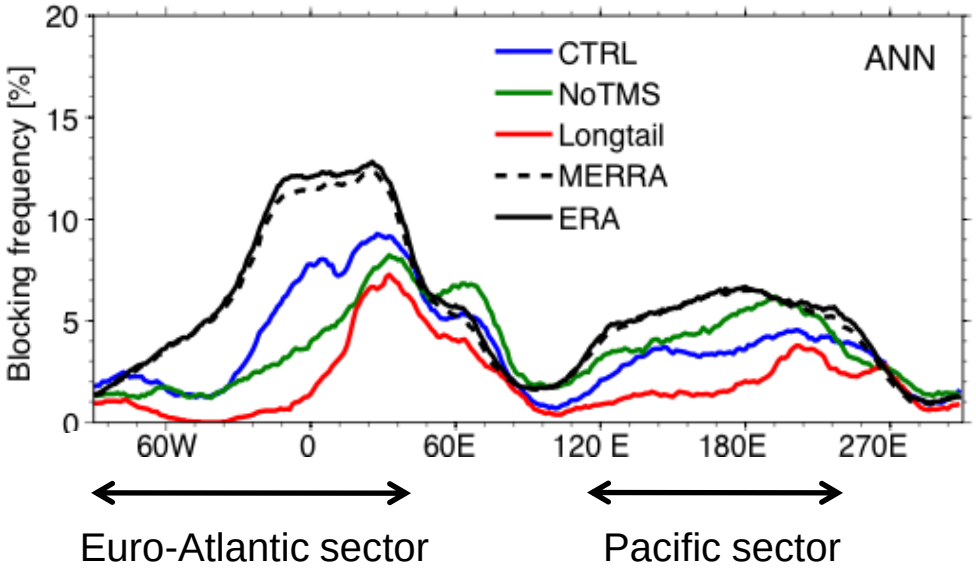


Bougeault 1990

Atmospheric blocking frequency

Stockholm University

All model versions have too few blockings, specially for the Euro-Atlantic sector

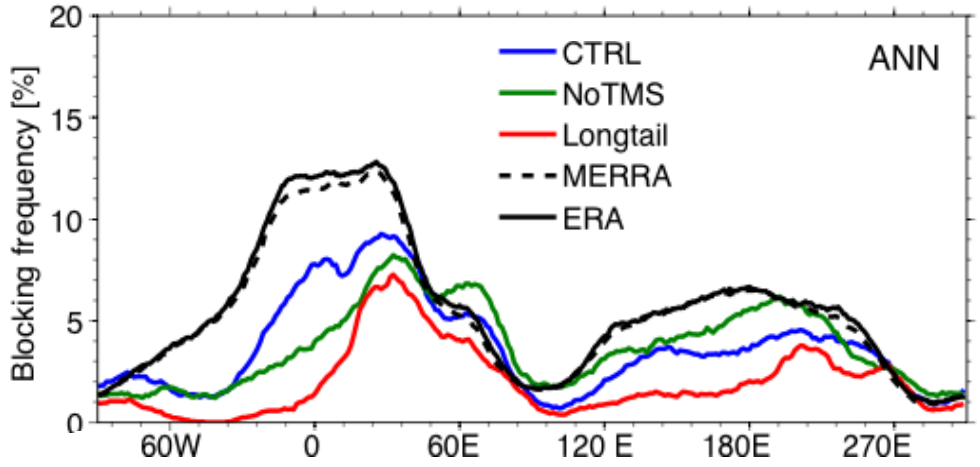


Lindvall, Svensson and Caballero, 2015

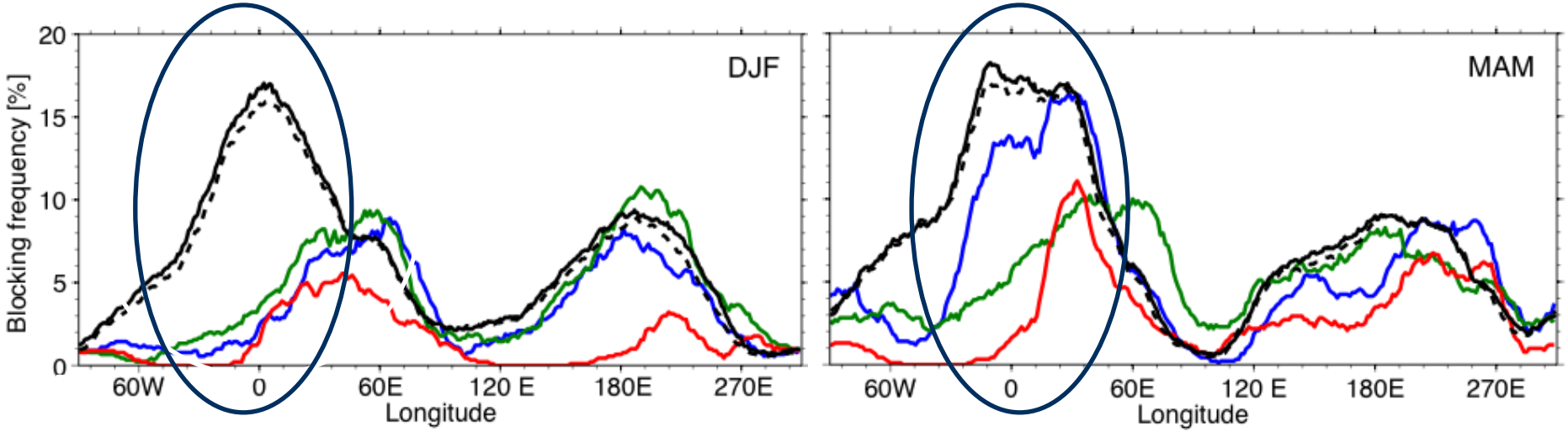
Atmospheric blocking frequency

Stockholm University

No version captures the Atlantic blockings in winter



Control is closer to observations than both NoTMS and Longtail in spring



CONTROL – With TMS (subgrid scale turbulent orographic drag)

NoTMS - Without TMS (no subgrid scale turbulent orographic drag)

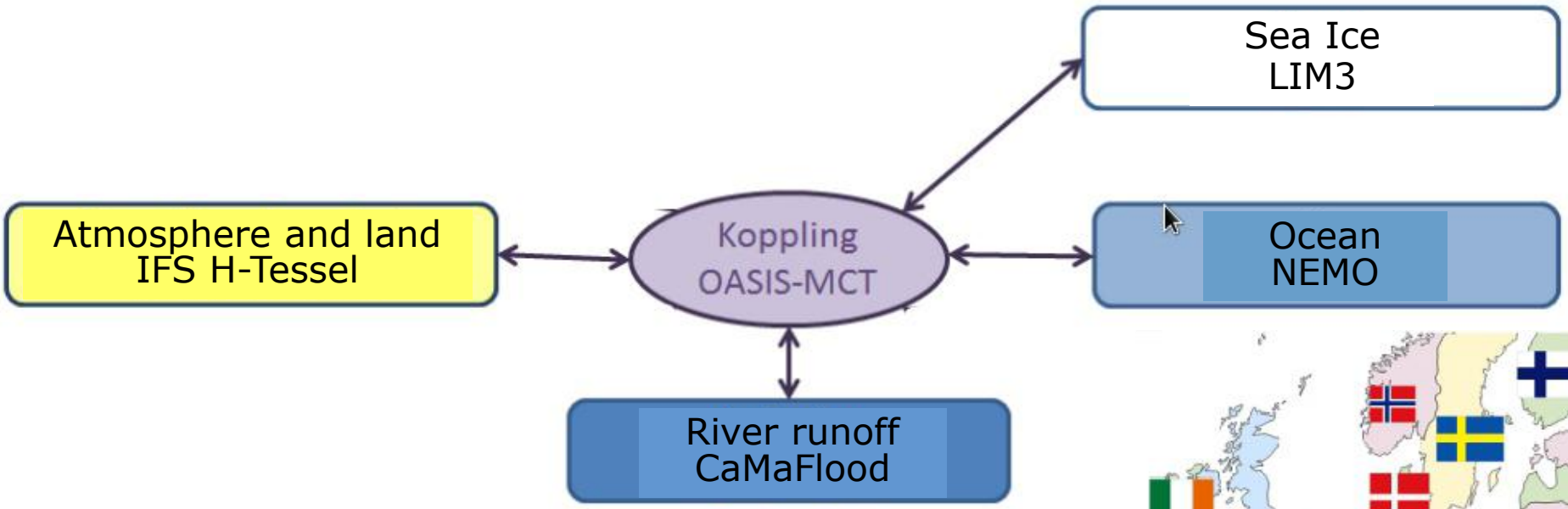
LONGTAIL - Higher diffusivity in stably stratitified conditions + no turbulent orographic drag

Lindvall, Svensson and Caballero, 2015

EC-Earth

GCM Global Climate Model

Stockholm University

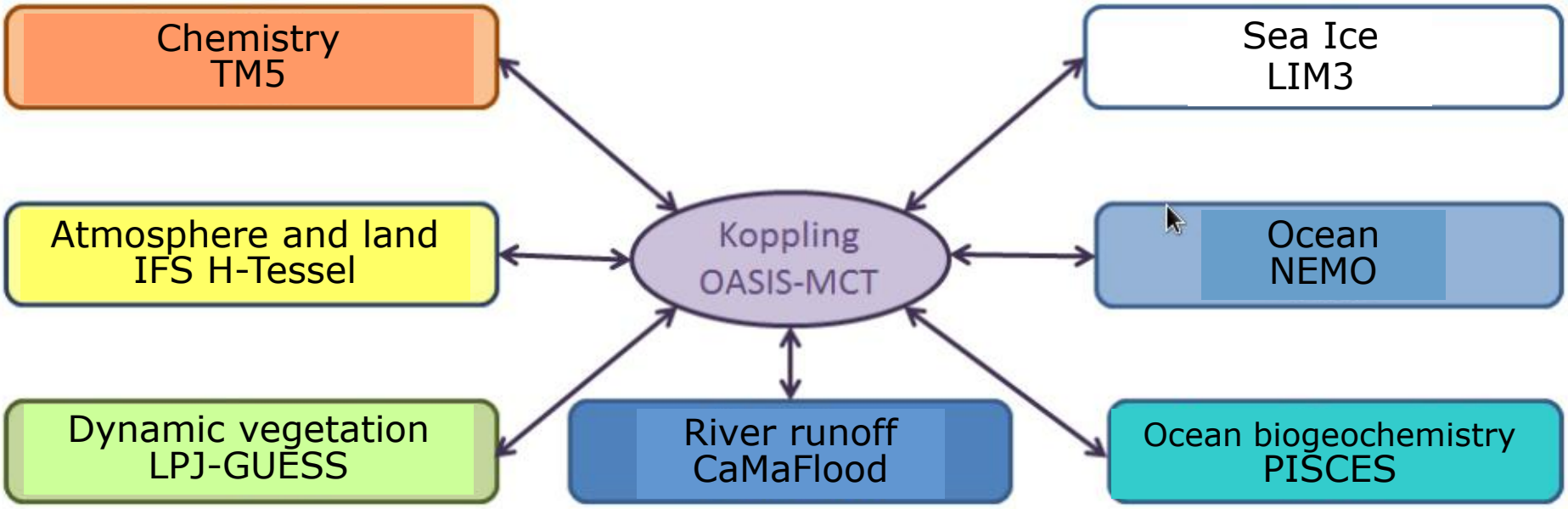


EC-EARTH

EC-Earth

ESM Earth System Model

Stockholm University



EC EARTH

The Beskow perspective so far… AMIP experiments

- Atmosphere-only simulation
- Prescribed SST and sea-ice concentration

- Standard method for testing climate models
- AMIP experiments have been done for CMIP5 and are planned for CMIP6 (part of the DECK runs)

First set of runs that we are doing on Beskow

Klaus Wyser, Rossby Centre

AMIP experiments at PDC

Ekman (CMIP5):

- EC-EARTH v2.3
- Performance: 4 simulated years per day

Beskow (CMIP6):

- EC-EARTH v3.1
- Performance: 6 simulated years per day

Is the only gain 2 more simulated years per day when going from Ekman to Beskow?

But…

Ekman (CMIP5):

- EC-EARTH v2.3
- Horizontal resolution T1
- 62 vertical layers
- Timestep 1 hour

Beskow (CMIP6):

- EC-EARTH v3.1
- Horizontal resolution T511 (~0.35 degrees)
- 91 vertical layers
- Timestep 15 minutes

- EC-EARTH has higher resolution on Beskow, horizontally and vertically, and a shorter timestep
- Roughly speaking the model is 60 times more complex
- *Performance of Beskow is 50% better compared to Ekman yet the model is 60 times more complex model*

Summary

- The Swedish climate community contributed to CMIP5 and take part in CMIP6, currently leading the European consortium on EC-Earth
- For CMIP6 simulations we currently estimate an overall amount of **340 mio core-hours** over a period of 5 years (2015-2019).
- Climate science is a huge and challenging flow problem, a turbulent flow that range from the micrometer to the global scale
- The Earth is rotating and we have moist diabatic processes (clouds) that affect the flow and the subsystems are interacting
- Much science is not understand on a fundamental physical level where climate models is a indispensible tool

Swedish climate modeling research is performed at KTH, Stockholm, Lund, Gothenburg and Uppsala University in collaboration with the Rossby Centre at SMHI

Stockholm University

KTH VETENSKAP OCH KONST

LUNDS UNIVERSITET

Rossby Centre SMHI

GÖTEBORGS UNIVERSITET

UPPSALA UNIVERSITET