Useful Arctic-centered mailing lists for jobs, summer schools, conference announcements, etc

- ArcticInfo: https://www.arcus.org/arctic-info
- CLIMLIST: http://climlist.wku.edu/
- CRYOLIST: http://cryolist.org/

Useful career advice & often a good read: Science careers http://www.sciencemag.org/careers

CMIP6

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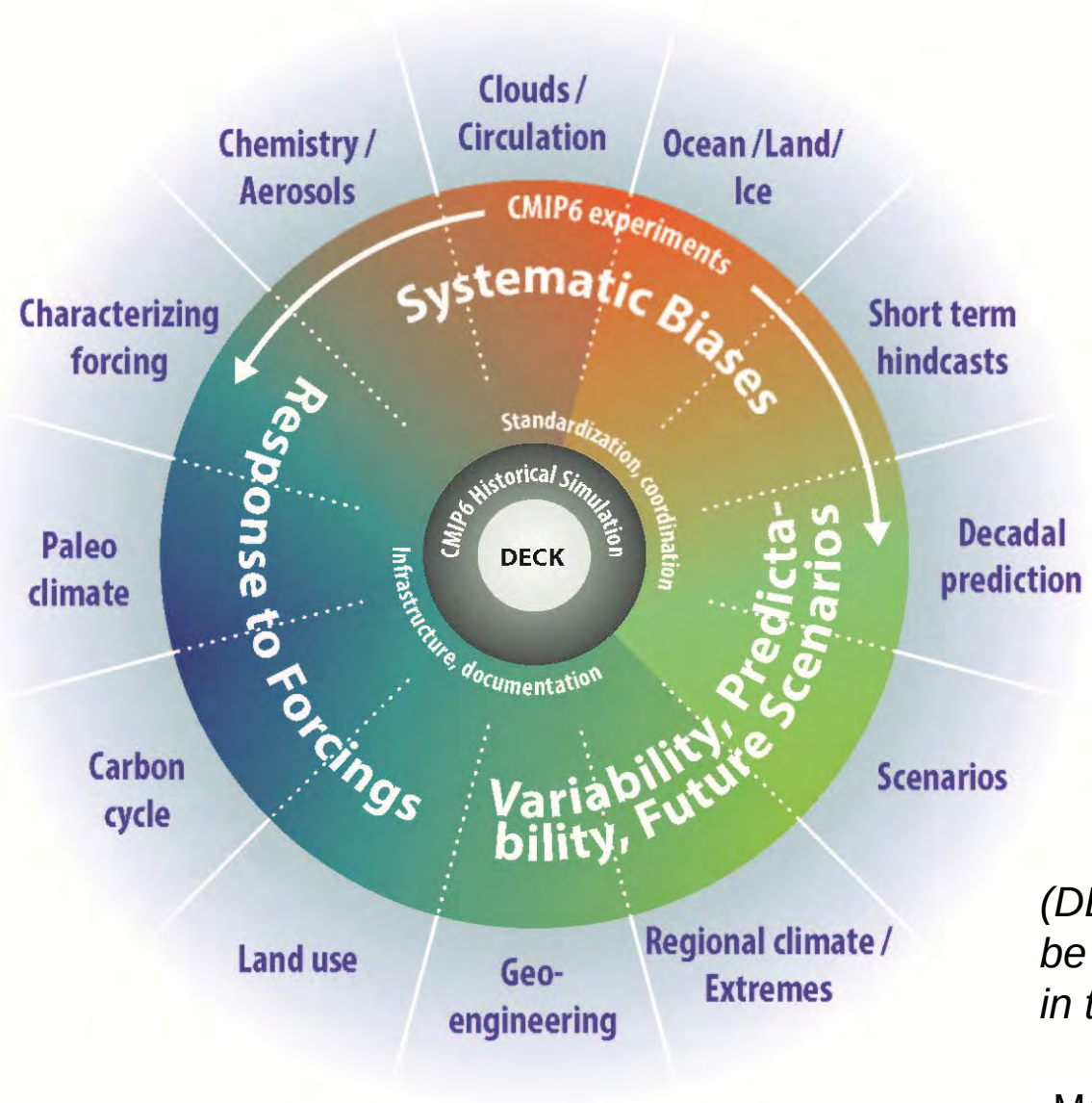


DECK (entry card for CMIP)

i. AMIP simulation (~1979-2014)
ii. Pre-industrial control simulation
iii. 1%/yr CO_2 increase
iv. Abrupt 4xCO_2 run

CMIP6 Historical Simulation (entry card for CMIP6)

v. Historical simulation using CMIP6 forcings (1850-2014)

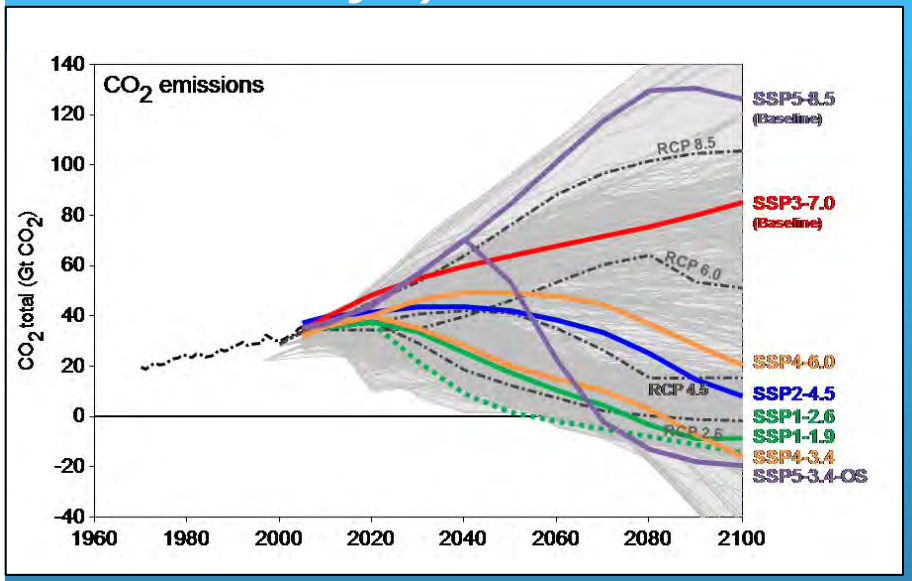
(DECK & CMIP6 Historical Simulation to be run for each model configuration used in the subsequent CMIP6-Endorsed MIPs)

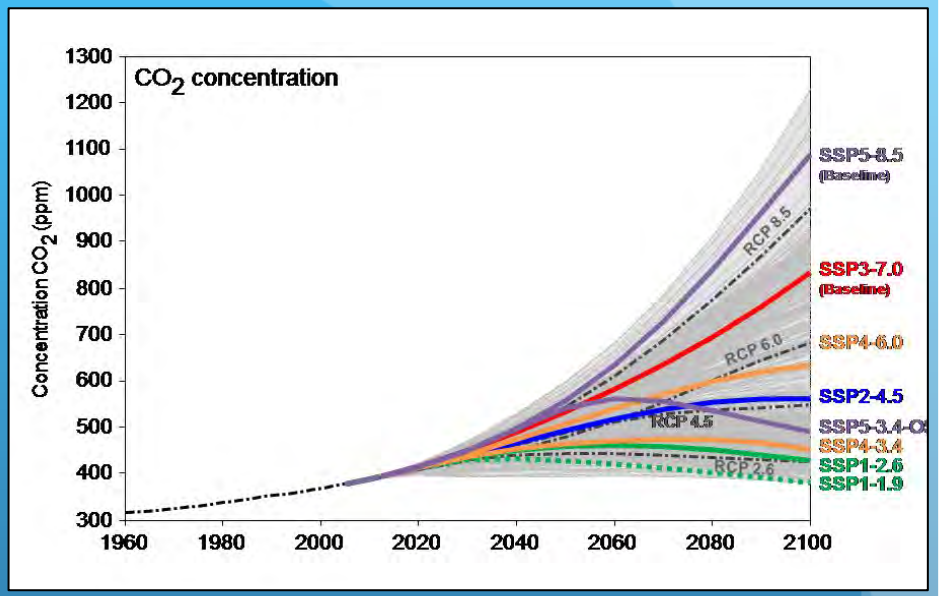
Meehl et al., 2004, EOS

Note: *The themes in the outer circle of the figure might be slightly revised at the end of the MIP endorsement process*

CMIP6 special issue: https://www.geosci-model-dev.net/special_issue590.html

CMIP6 scenarios: SSP (Shared Socioeconomic Pathways)

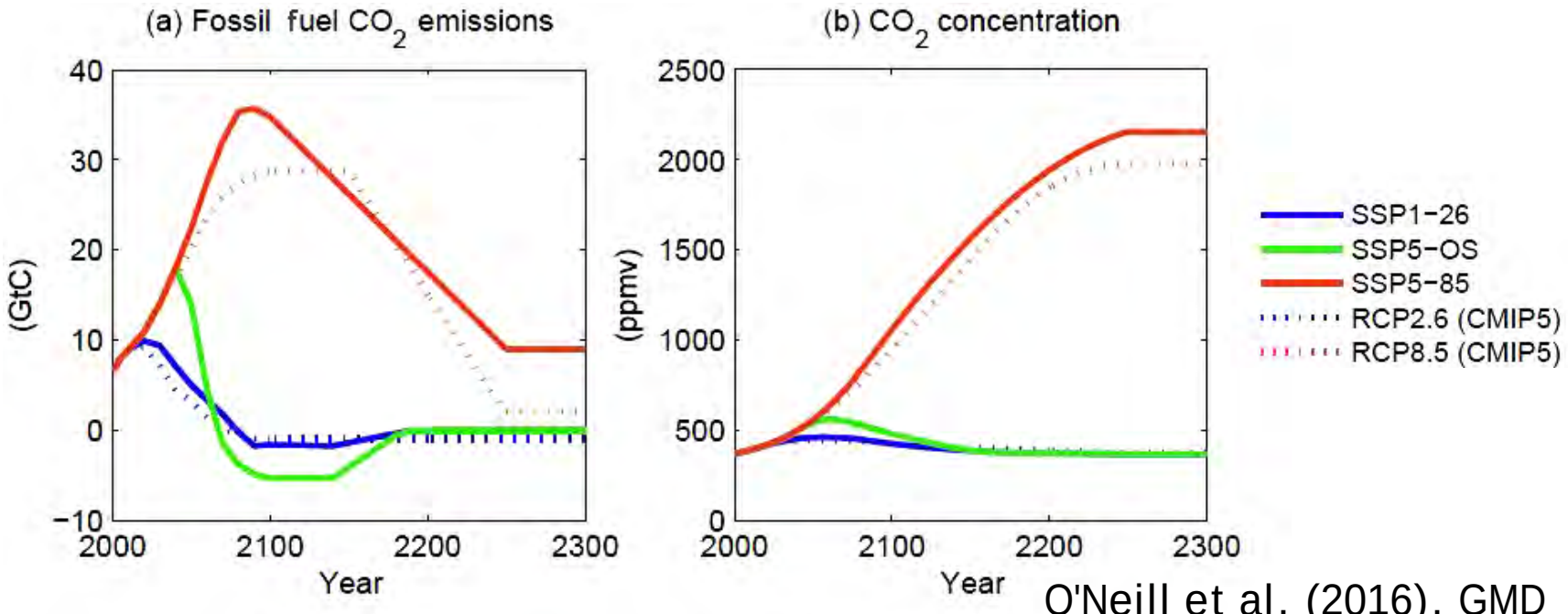




- Tier 1: Four 21st century scenarios: SSP-8.5, SSP-7.0, SSP-4.5, SSP-2.6
- Tier 2:
  - 4 additional scenarios: SSP4-6.0, SSP4-3.4, SSP5-3.4-OS, SSPa-b
  - 9 additional ensemble members of SSP-7.0, SSP-6.0
  - Three Long term extension to 2300 (SSP5-8.5, SSP1-2.6, SSP5- 3.4-OS)
- SSP start in 2015, RCPs started in 2005

O'Neill et al. (2016), Geosci. Model Dev., https://doi.org/10.5194/gmd-9-3461-2016.

CMIP6 extension simulations



O'Neill et al. (2016), GMD

CMIP6 special issue: https://www.geosci-model-dev.net/special_issue590.html

CMIP6 Sea Ice Model Intercomparison Project (SIMIP)

Co-chairs: Dirk Notz (MPI) and Alexandra Jahn (CU)

Aim: To better understand the role of sea ice for the changing climate of our planet

Website: www.climate-cryosphere.org/simip

SIMIP paper: Notz, Jahn et al. (2016), GMD

Three major goals:

- Define new sea ice variable request that allows more process based and budget analysis of sea ice (done for CMIP6)
- Coordinate some of the CMIP6 sea-ice related analysis through a number of dedicated sub-groups, encouraging earlier process-based sea ice analysis for CMIP6 simulations (see website)
- Serve as forum for identifying the best possible use of observations for the evaluation and improvement of model simulations (see website)

CliC Climate and Cryosphere

Understanding the changing cryosphere and its climate connections

WCRP World Climate Research Programme

ICSU

The challenge of assessing sea ice simulations from climate models with observations

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Real world and models

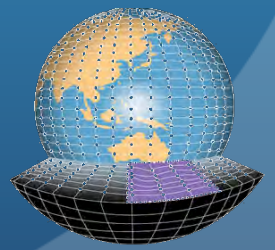
Real world

Model

How and what can we compare? And what does it mean if they do not agree?

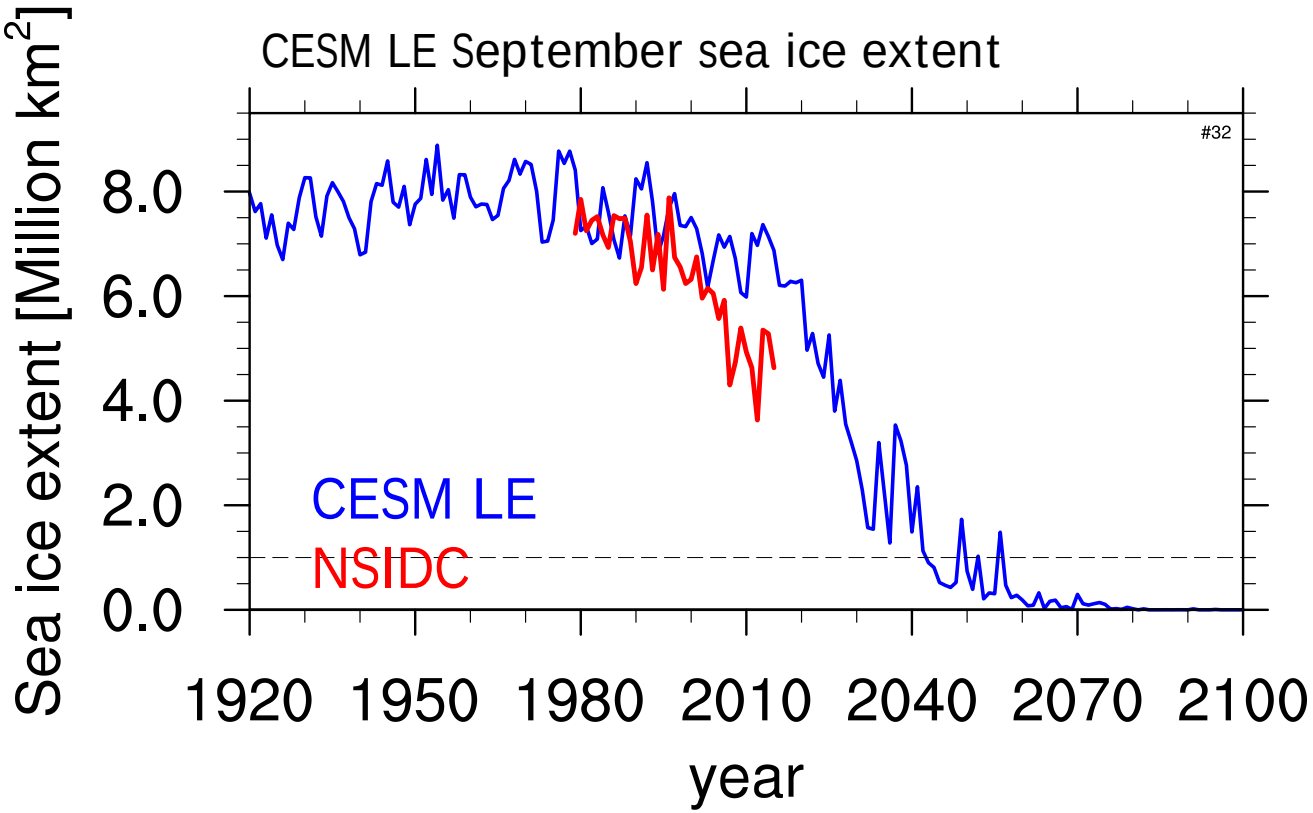
Impact?

Not measured the same way



Nice paper on this: “How well must climate models agree with observations?” (Notz, 2015, Phil. Trans. R. Soc. A)

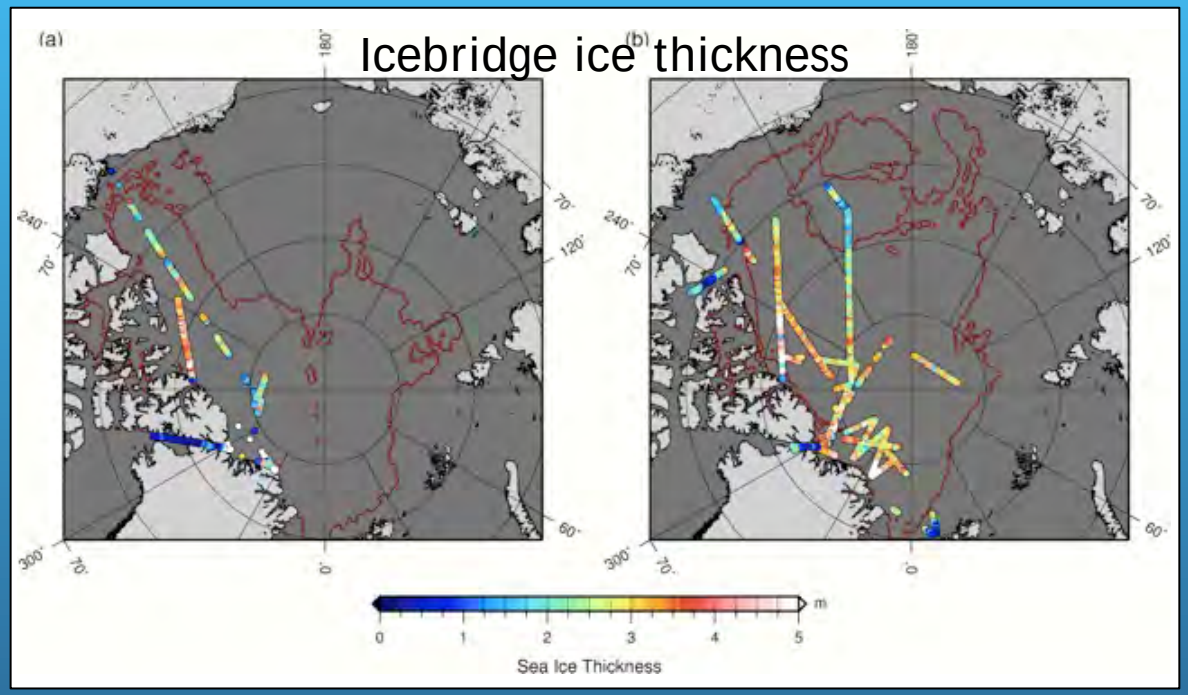
Review: Internal variability



Jahn et al., 2016, GRL

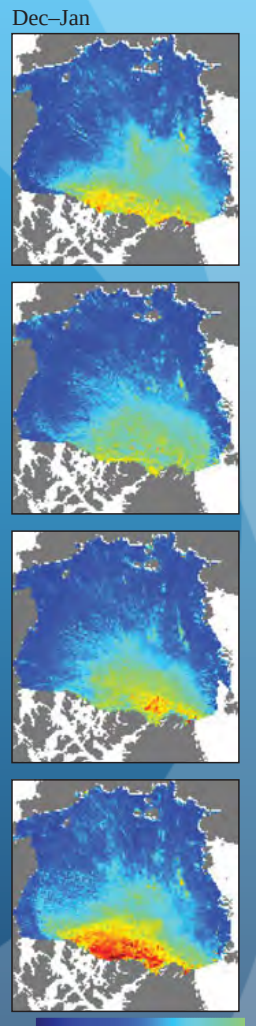
Can't compare year-to-year evolution with observations

Internal variability



Icebridge ice thickness

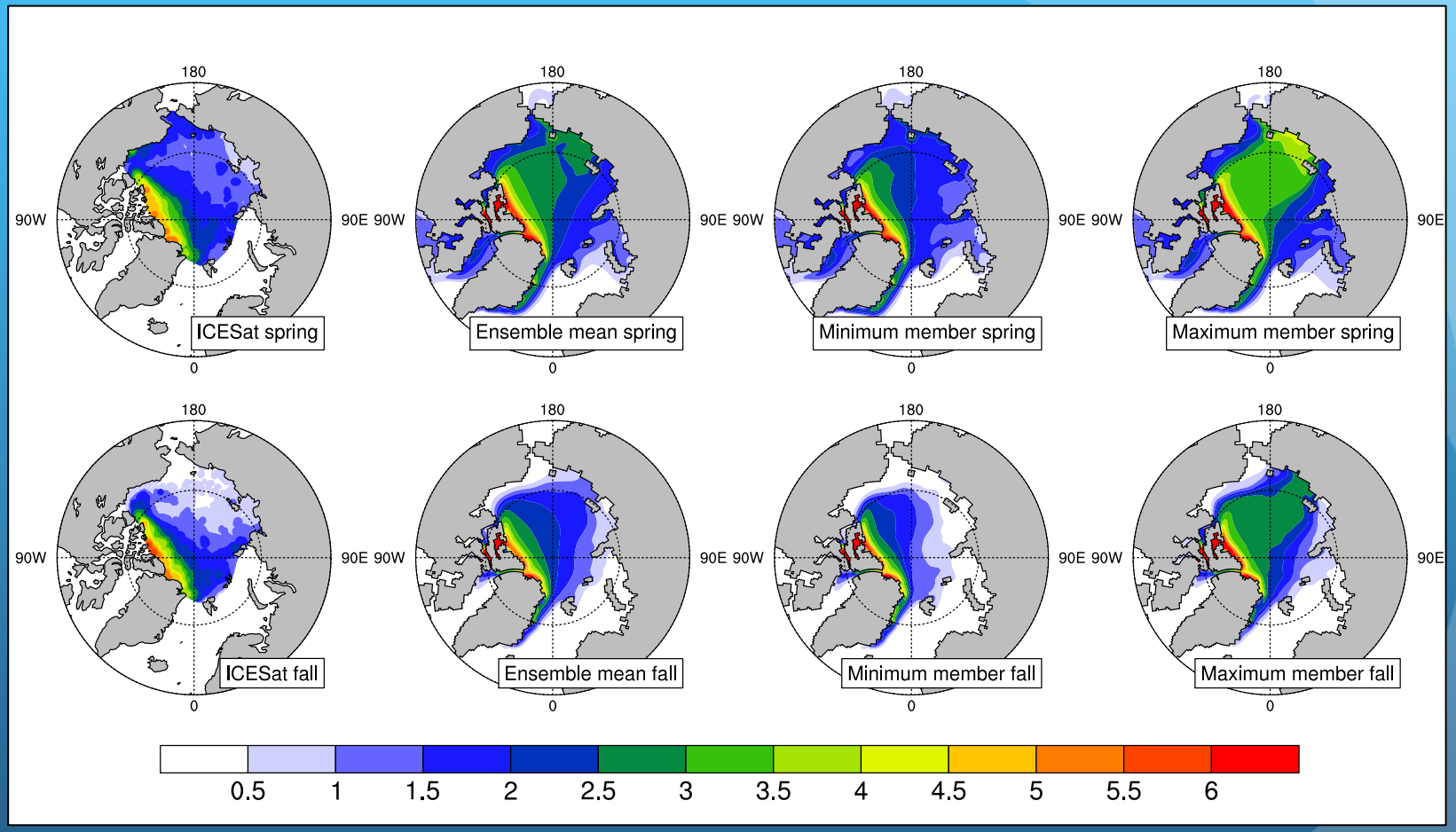
Kurtz et al., 2013



Kwok and Cunningham, 2015

Can't directly compare in-situ/remote sensing observations on a given day/month/season with models

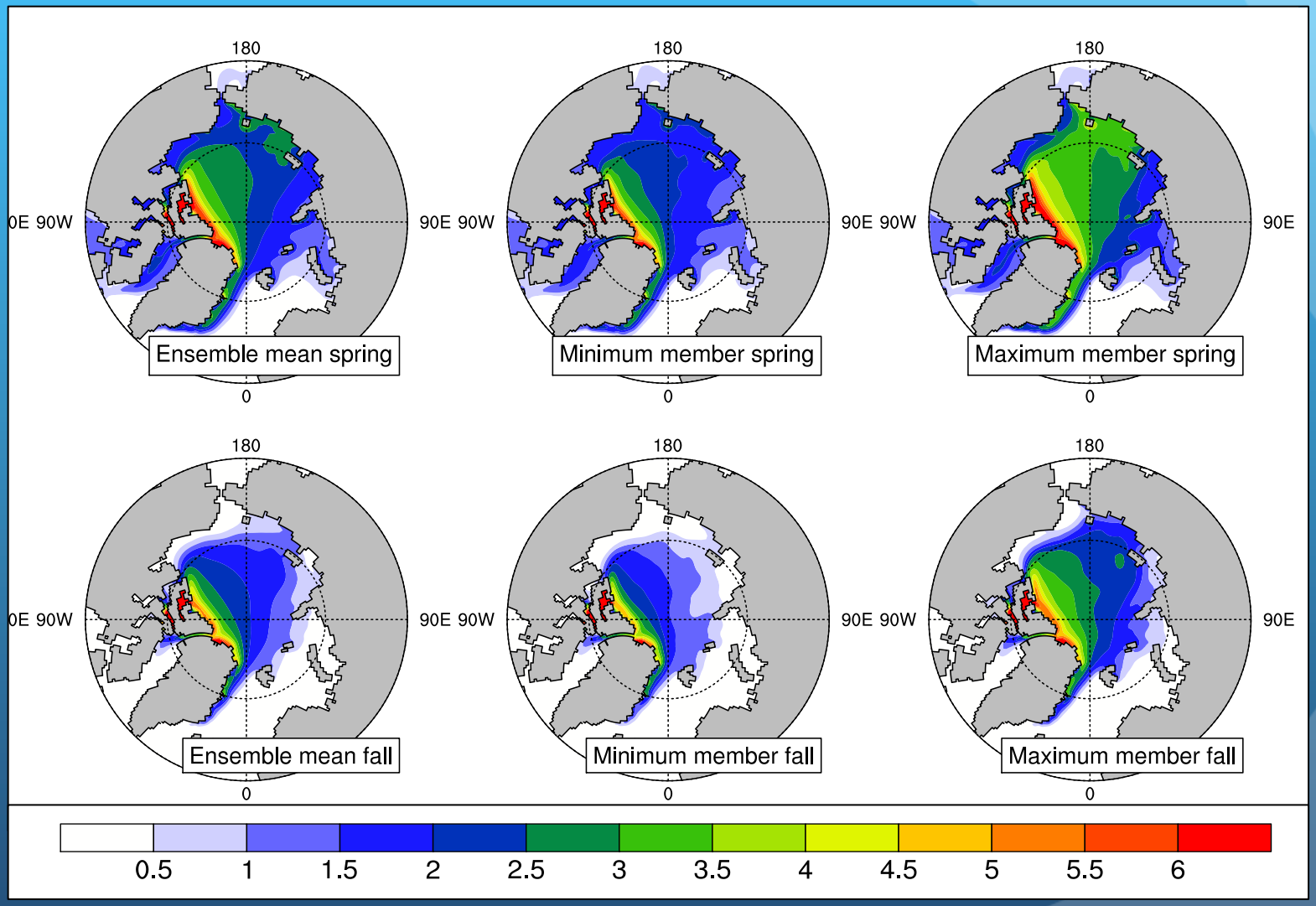
Internal Variability - Sea ice thickness– 5 yr average (2003-2007)



Internal variability has a large impact on sea ice thickness for 5 year averages

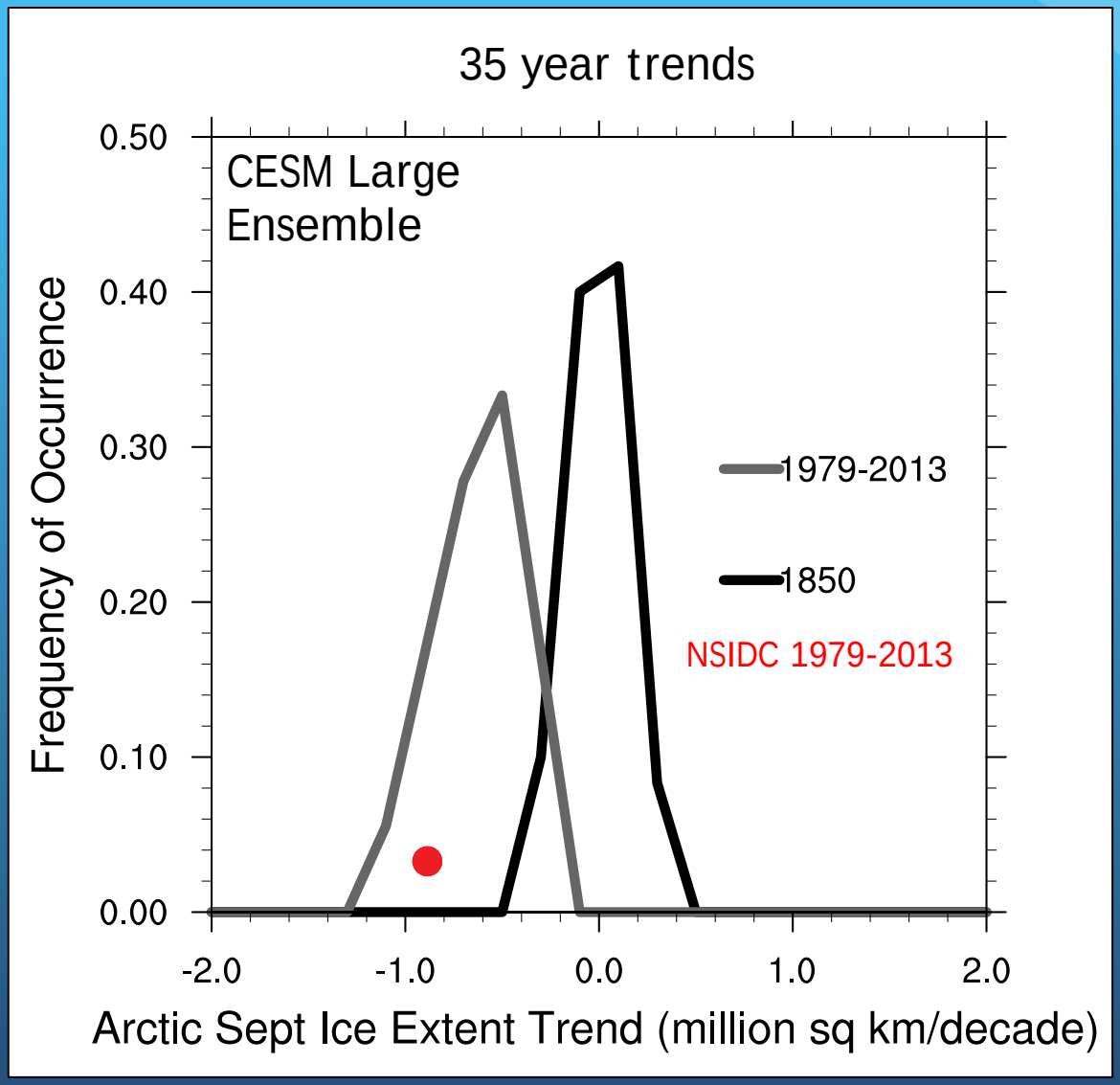
Jahn et al., 2016, GRL

Internal variability - Sea ice thickness – 10 year average



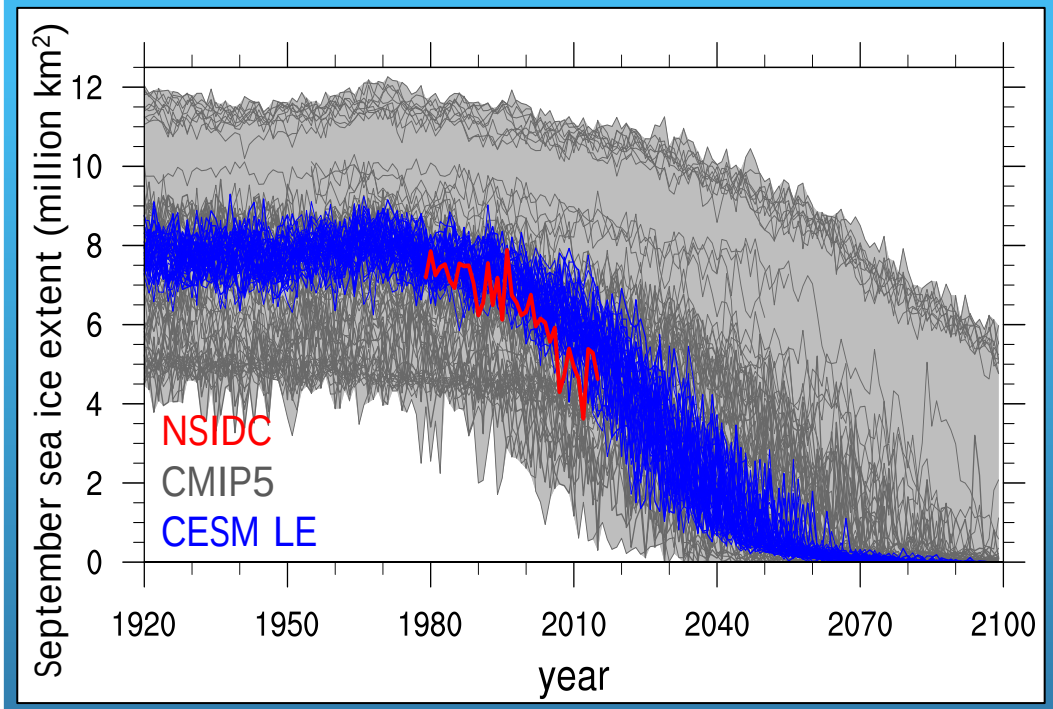
Internal variability has a large impact on sea ice thickness even for 10 year averag

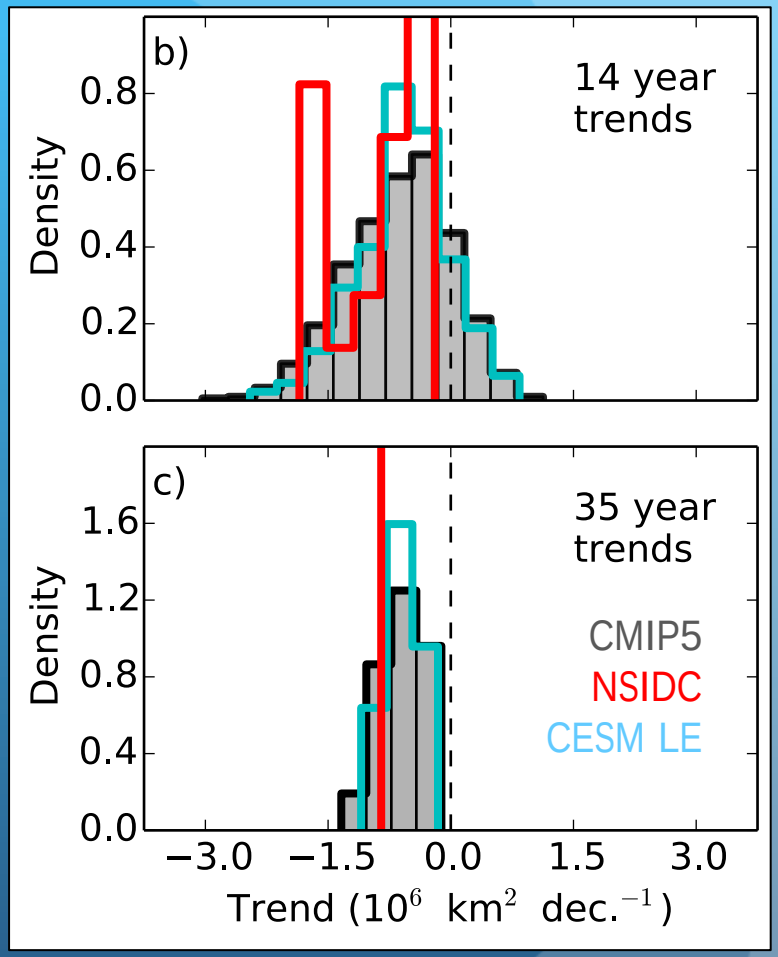
Role of internal variability: trends



Even 35 year trends can be strongly affected by internal variability

Role of internal variability: CMIP5 trends



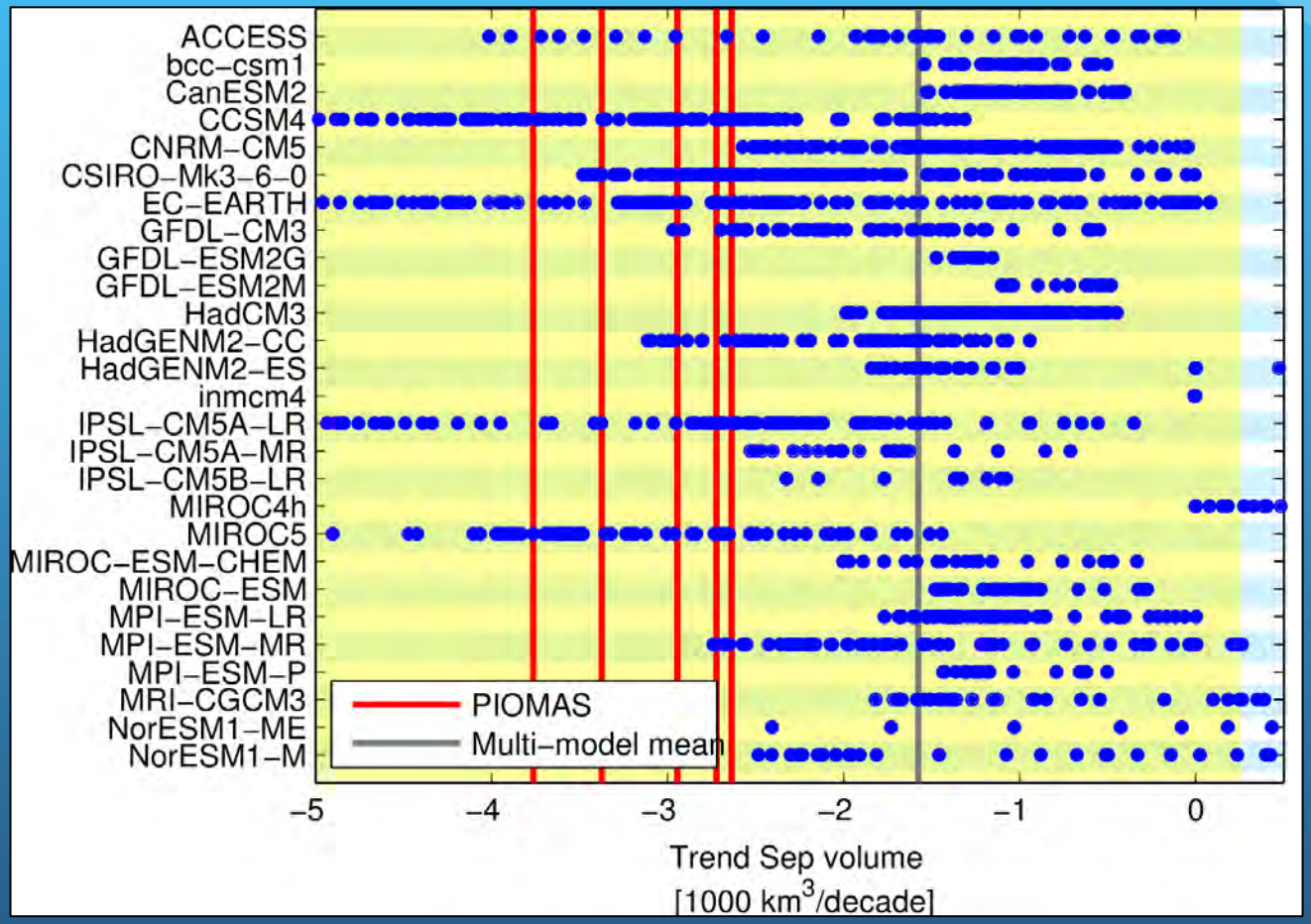


Almost all 14 & 35 year trends from CMIP5 can be explained by internal variability as simulated by the CESM LE

→ These trends alone should not be used to subset the CMIP5 models into "good" and "bad" models

Swart et al. 2015, Nature Climate Change

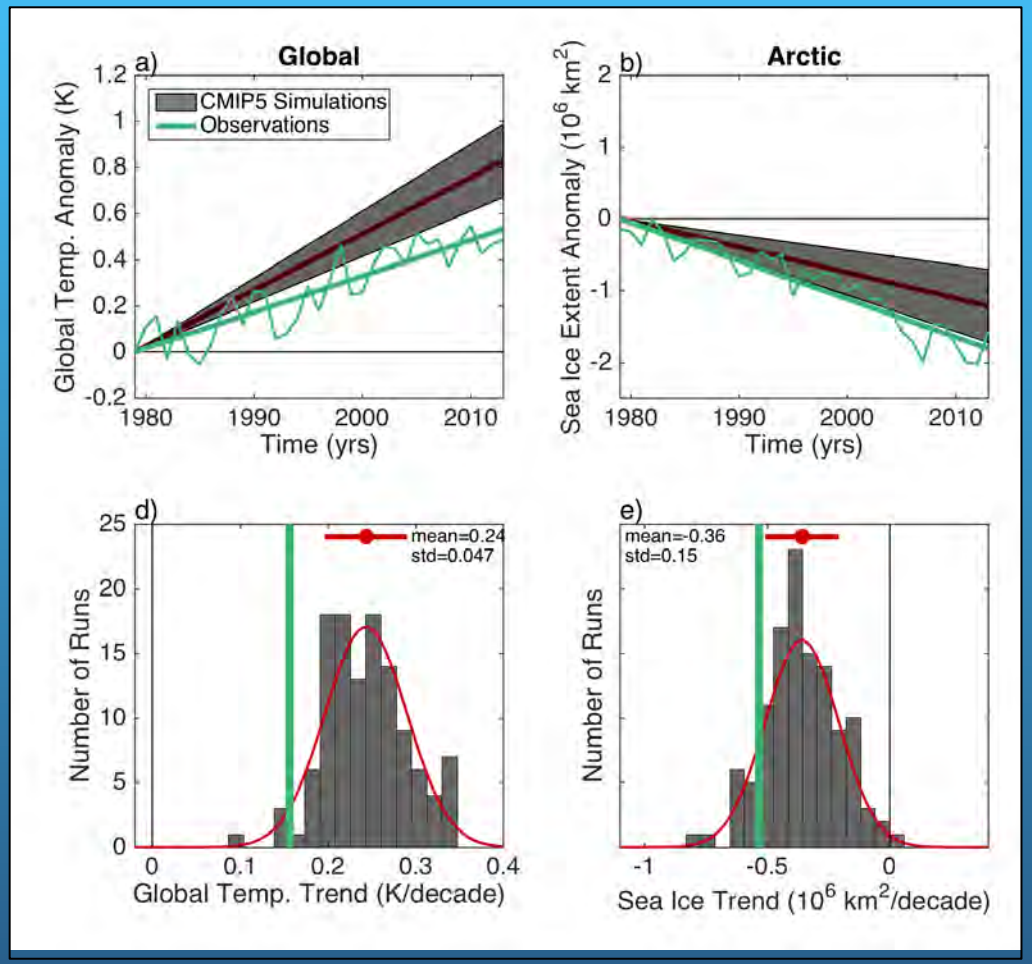
Sea ice volume trends are also very variable

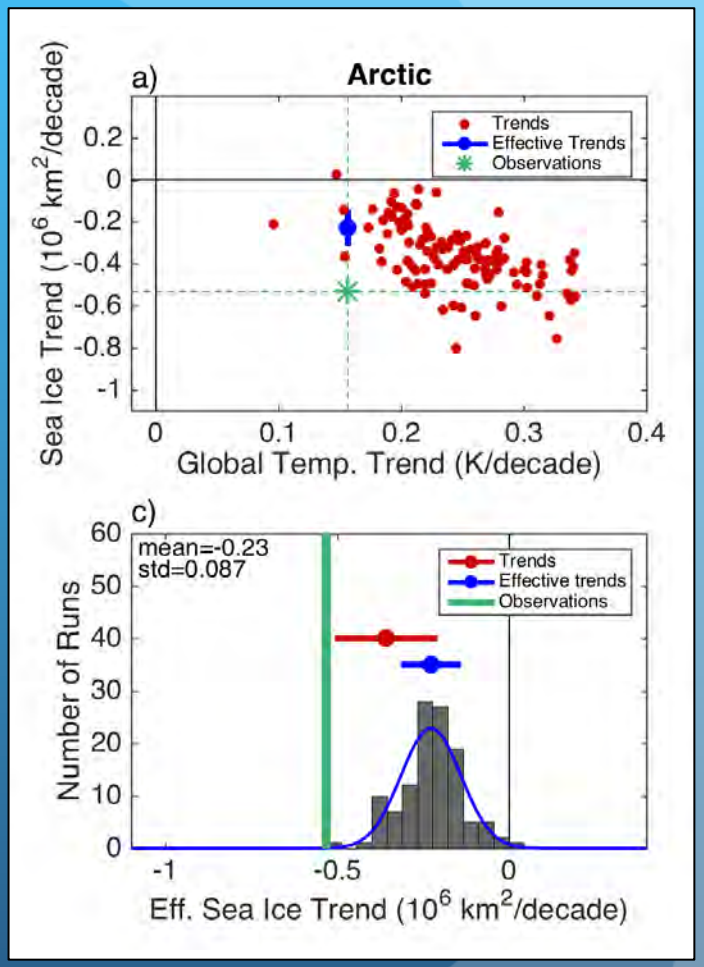


Recent 30-year trends of Arctic sea-ice volume in CMIP5 simulations.

Notz, Phil. Trans. Roy. Soc. A, 2015

Detecting a biases despite large internal variability: CMIP5





35 year CMIP5 sea ice trends larger than observed only occur in CMIP5 model runs with larger than observed global warming trends

Rosenblum and Eisenman, 2017, J. Clim, in press

Spatial and Temporal Resolution

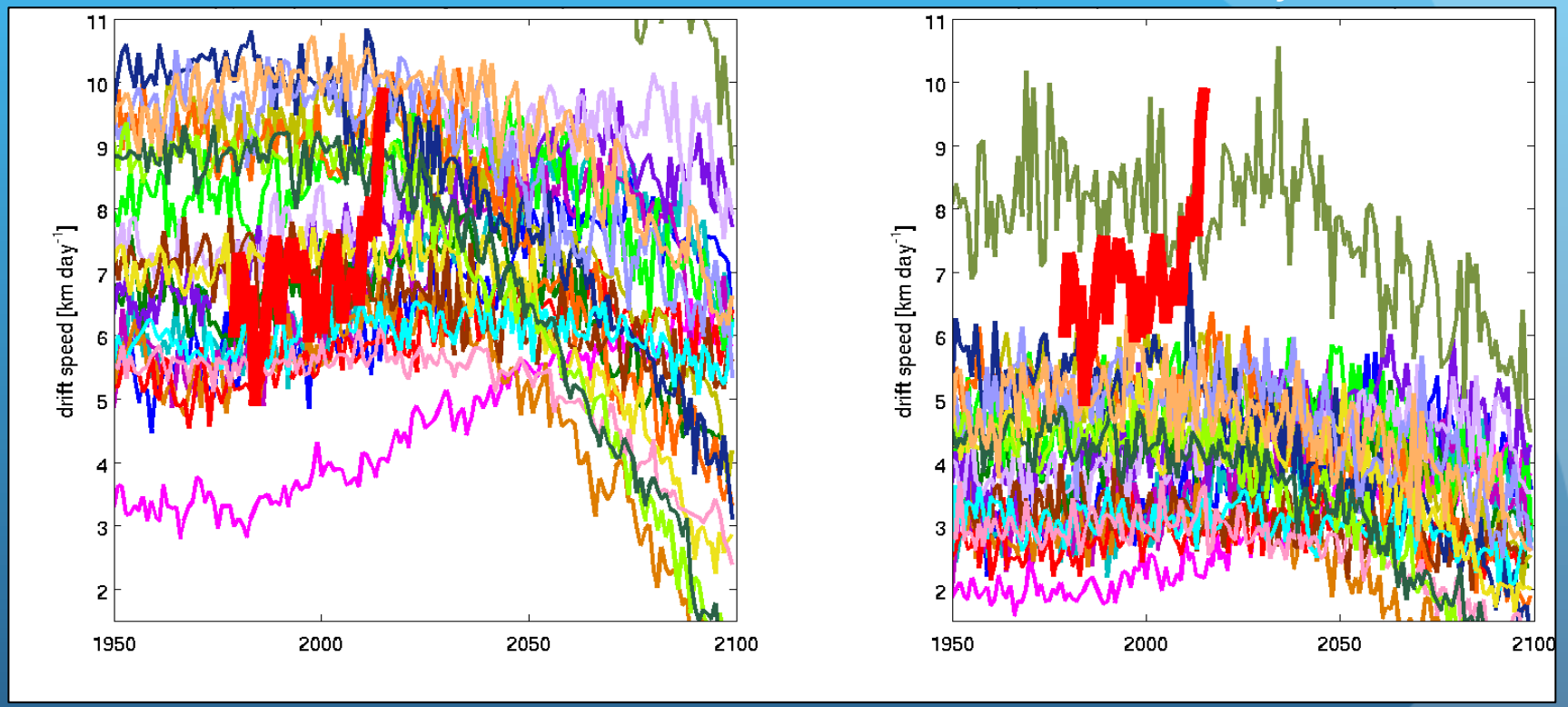
- Spatial: Observations are largely at a higher spatial resolution than global models
- Temporal: Observational timeseries in the Arctic are often short (e.g., ice thickness), often have high temporal resolution, while model variables are often monthly means
- Another issue: Often averaging in space and time is not done the same way for observations and models

Time Sampling Has a Big Impact

Annual Mean CMIP5 Drift Speeds (away from coasts)

Computed from daily means for models and observations

Computed from monthly means in the models, daily in the data



→ Always make sure to average models and observations the same way!

N. F. Tandon, P. J. Kushner, D. Docquier, J. J. Wettstein, and C. Li, 2017: Reassessing the role of sea ice drift in Arctic sea ice loss. In preparation.

Sea ice extent versus area

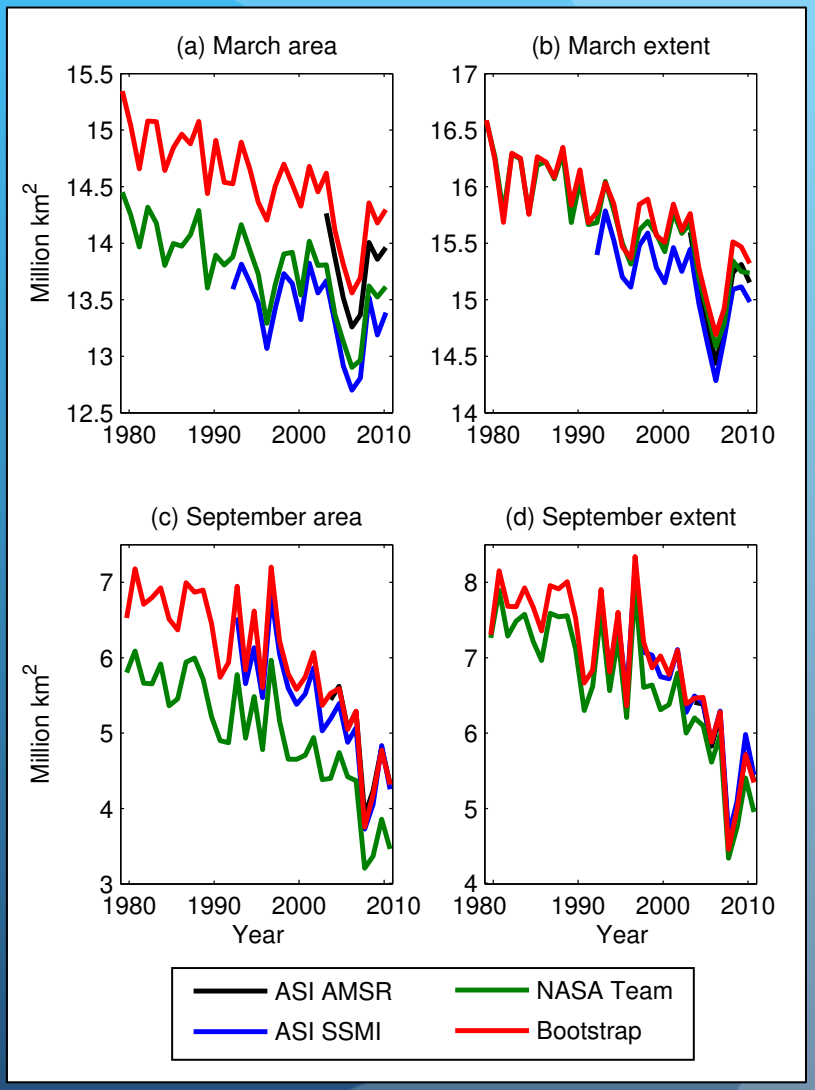
What is sea ice extent?

Grid cell ice covered >15%?

- Yes, ice extent =1
- No, ice extent =0

Why do we use sea ice extent instead of area?

- Satellite algorithms have larger differences in concentrations, and hence area, than extent
- Makes it easy to deal with polar hole in satellite data (assume ice covered >15%)

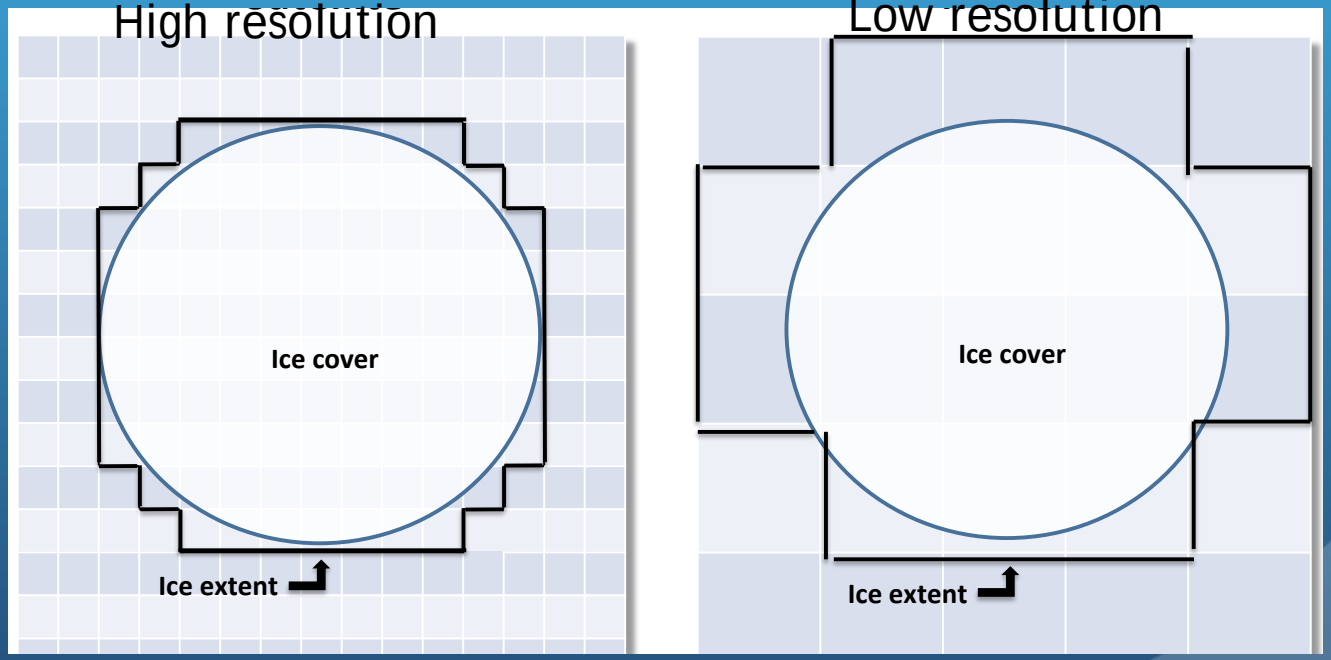


Notz, 2014, Cryosphere

What is the “problem” with ice extent?

- Ice extent is more variable than ice area
- Ice extent is very sensitive to grid size.
  - Generally, higher grid resolution results in a lower sea ice extent.
  - At very high resolution, sea ice extent and area are very similar

→Impacts model-observation and model-model intercomparisons

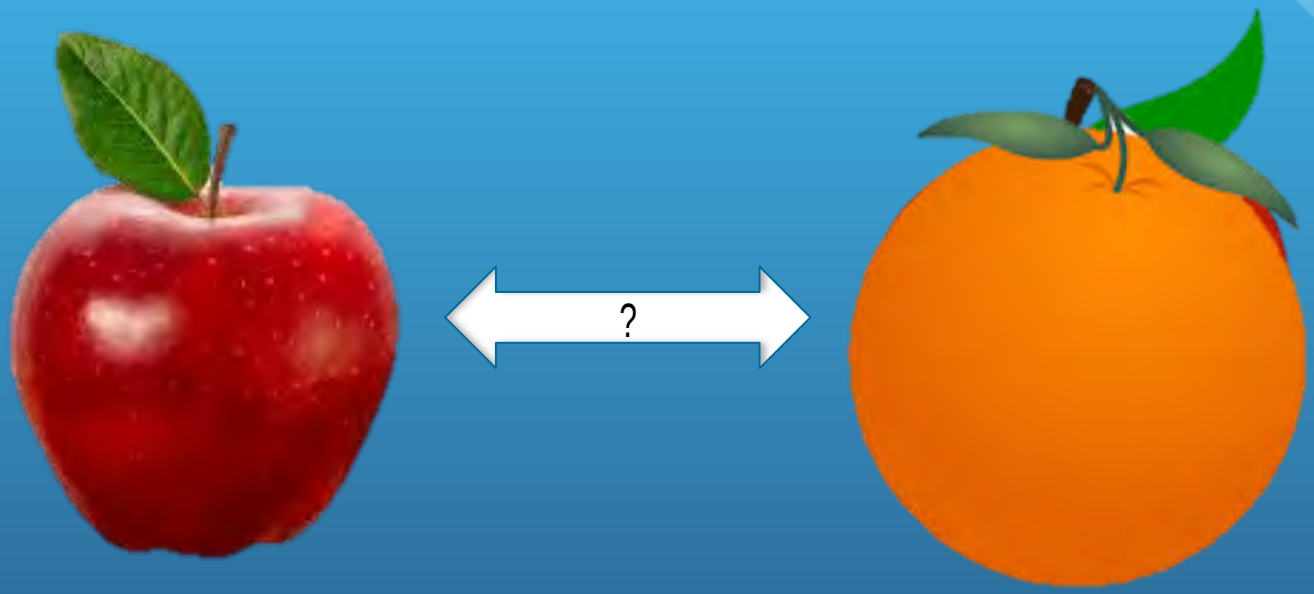


Smaller ice extent

Larger ice extent

Slide courtesy of A. Ahlert

Inconsistent variable definitions



Observations
(in situ/remote sensing)

Model simulations

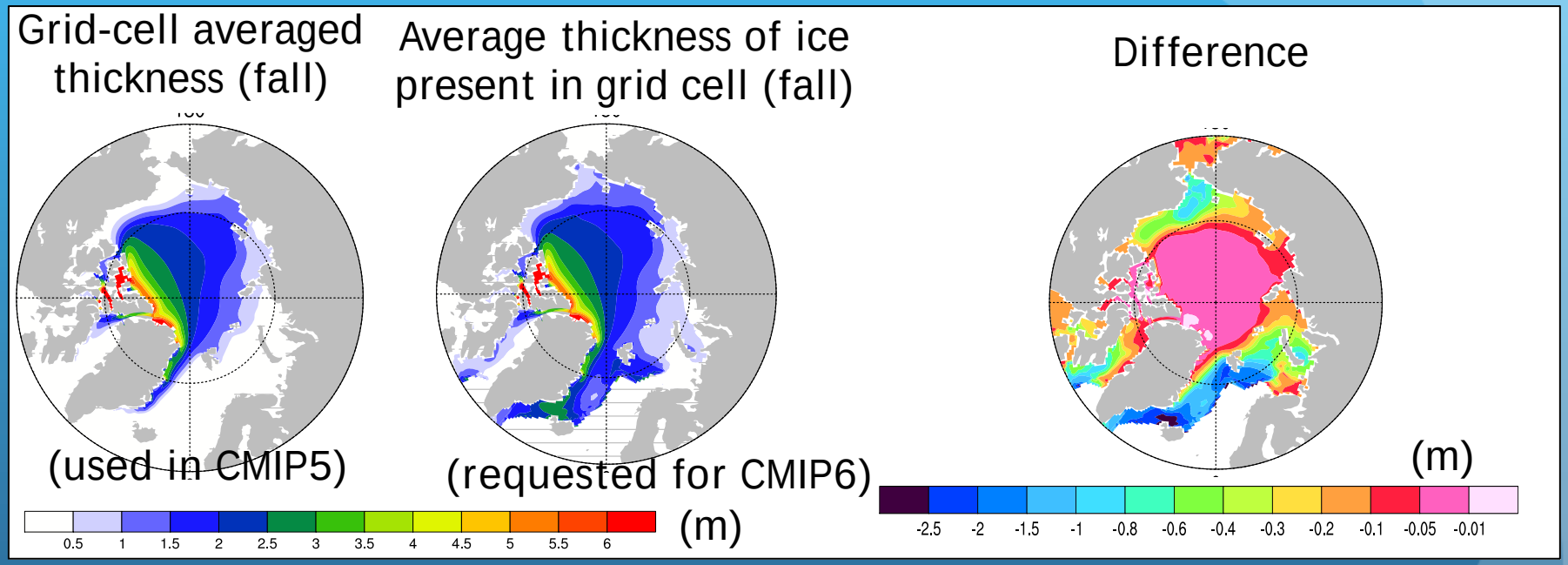
Ice thickness definitions: To average in zeros for no ice or not?

- A) We should average in zeros for grid cells not 100% covered by sea ice when calculating ice thickness
- B) We should report the ice thickness only for the part of the grid cell that has ice present (no zeros averaged in for ice concentrations <100%)

- Simple example: 50% ice cover, ice present is 2m thick

  → What is the ice thickness for this grid box?
  - Method A) → 1m
  - Method B) → 2 m

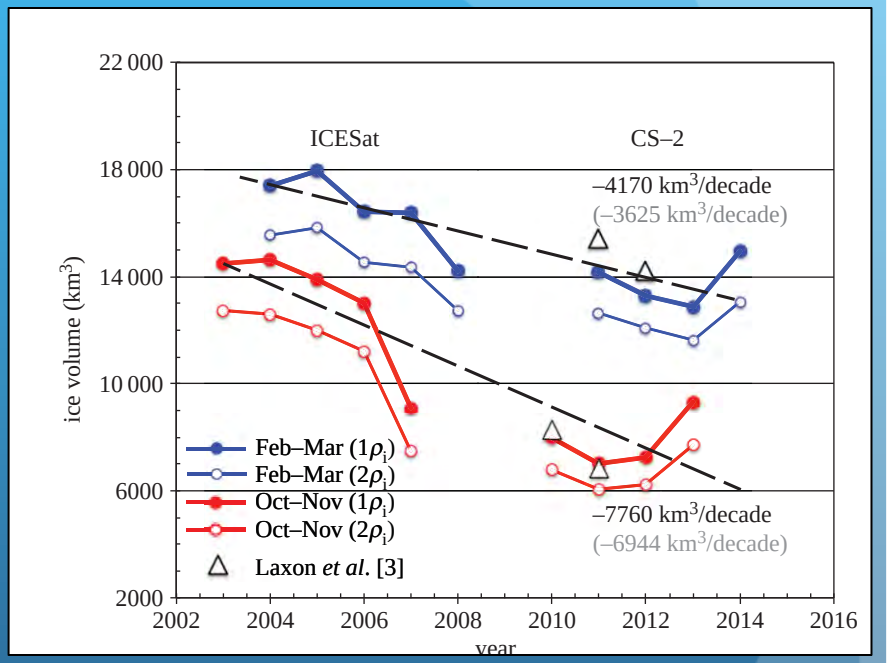
Ice thickness definitions: To average in zeros for no ice or not?



- In low ice concentration areas in the Arctic differences can be up to 50-100 cm
- Difference in the central Arctic are small (1-5cm)
- For CMIP6, SIMIP requested the actual floe ice thickness from models (Notz, et al, 2016 GMD)

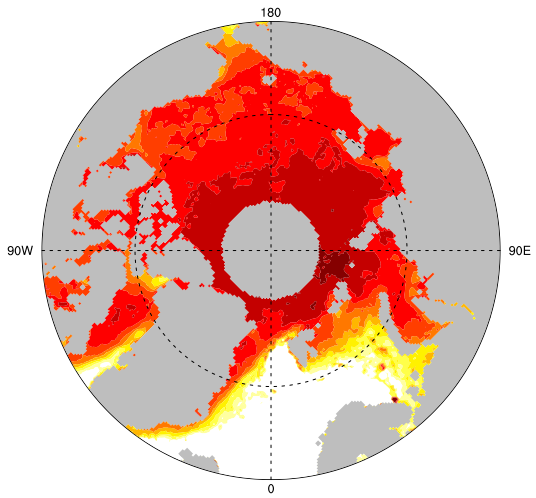
Freeboard versus ice-thickness

- Overall, MYI thickness is reduced by approximately 0.25 m in October and by approximately 0.5 m in May when using average MY ice density in satellite retrievals
- (Constant ice density in CICE is typical FW ice density: 917 kg/m³)
- CMIP6: Asking for freeboard, for more direct comparisons with satellite data, taking away the ice density uncertainly (snow uncertainty remains)



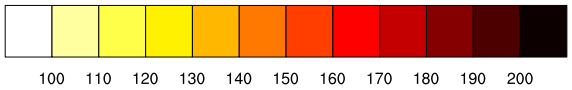
(Kwok and Cunningham , 2015)

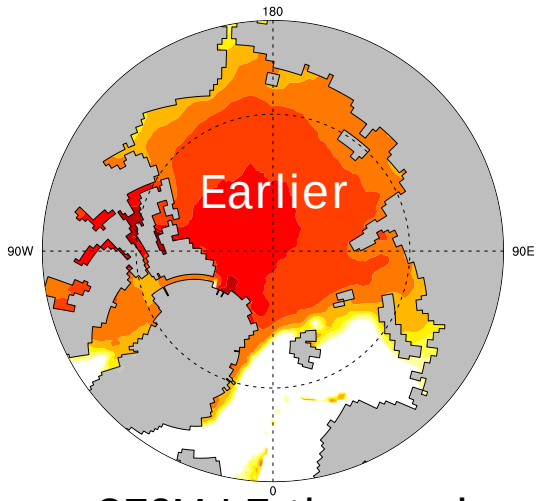
Melt onset definitions



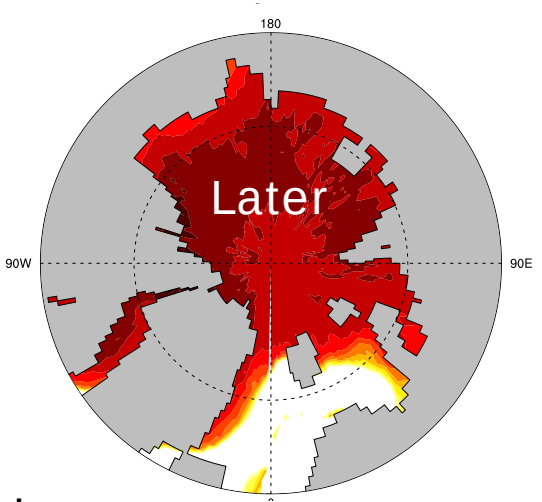
Stroeve et al., 2014 satellite observations

Days





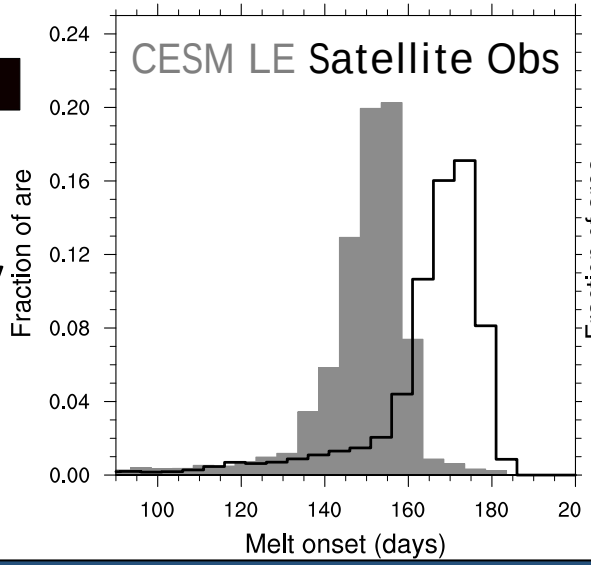
CESM LE thermodynamic volume tendency

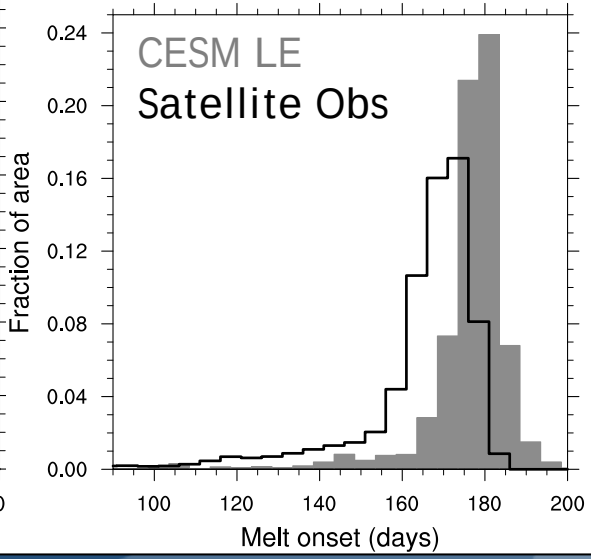


CESM LE surface temperature (-1 ºC)

Differences in definition/ measurement complicate comparisons

Ahlert and Jahn, in prep





Many more definition issues: Always compare the definitions before you do a comparison!

- Sea ice “break-up”
- Sea ice age (Lagrangian versus Eulerian tracking)
- Multiyear ice coverage can differ substantially depending on whether it is calculated as an extent or area
- Melt onset/freeze up
- etc

Ways forward:

- More variables requested for CMIP6 for Arctic sea ice (SIMIP), allowing process based analysis of model biases and spread (and a few more daily variables)
- Development of process based metrics (e.g., SIMIP, http://www.climate-cryosphere.org/activities/targeted/simip) → beyond detecting biases, by thinking about what they tell us about our understanding of the processes and/or their representation in models
- New automated model evaluation tools for CMIP6 (https://www.esmvaltool.org/), to allow scientists to focus on in-depth analysis (sooner) rather than standard analysis already done for previous model simulations
- Development of sea ice emulators (Roberts, Jahn, Notz), to improve the gap between variable definitions
- More communication between modelers and observers, so we learn each others language!

The purpose of models is not to fit the data but to sharpen the question.

How can I make my data useful for models?

- Publish your data and put your data out there, with good metadata and error bars.
- If possible, use your data to test model sensitivity to change → sensitivity is a lot more important to get right than the mean, as mean biases can be more easily corrected
- Ask a modeler which parameters are most uncertain/ would benefit from more understanding of the physics/refinement of parameterizations