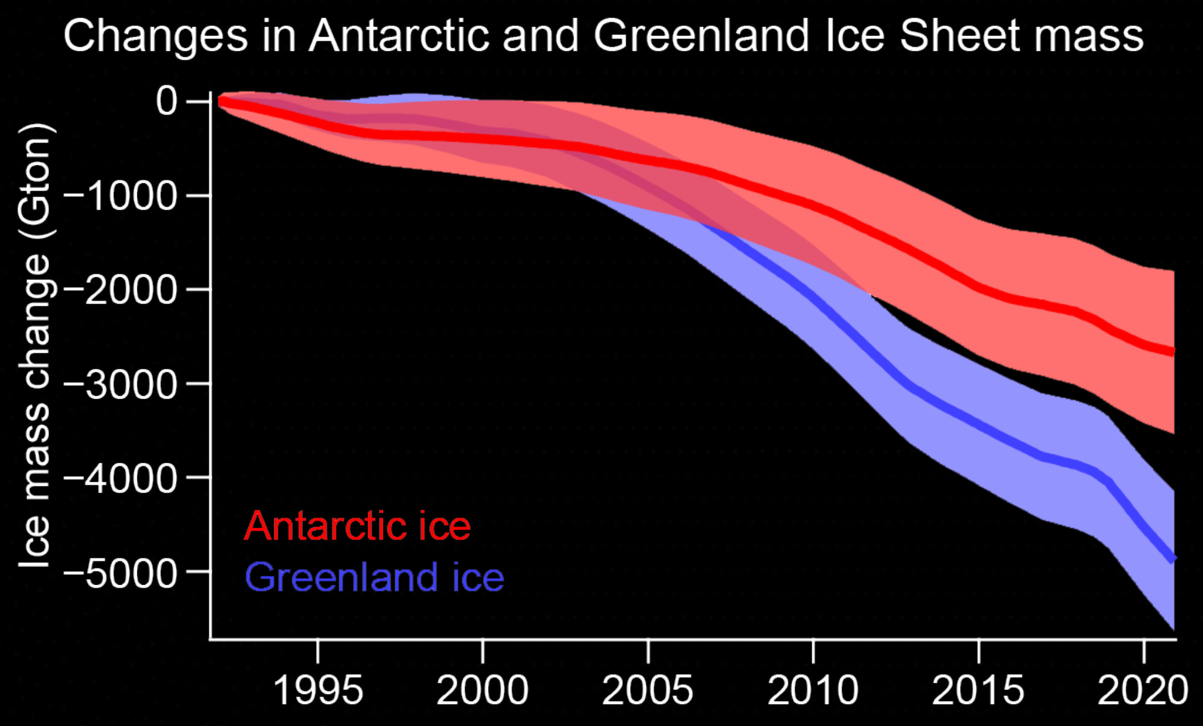
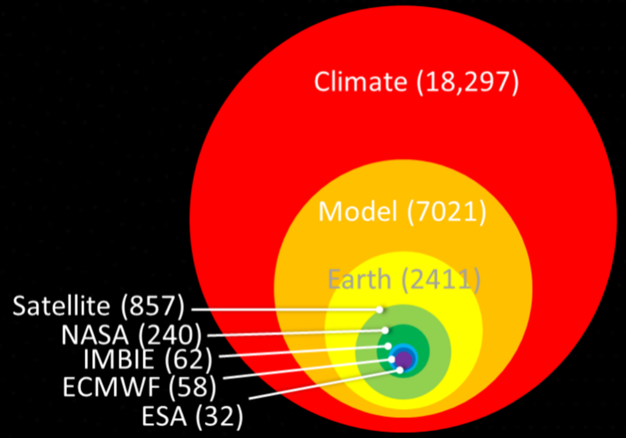
CCI+ in the WGI contribution to the IPCC 6th Assessment Report
Feedback from projects at 11th Colocation, 7 October 2021

Ordering of feedback:

IMBIE
Snow
Greenland Ice Sheet
Permafrost
Sea Ice
Sea State
Sea Surface Salinity
SST
Sea Level
Sea Level Budget Closure

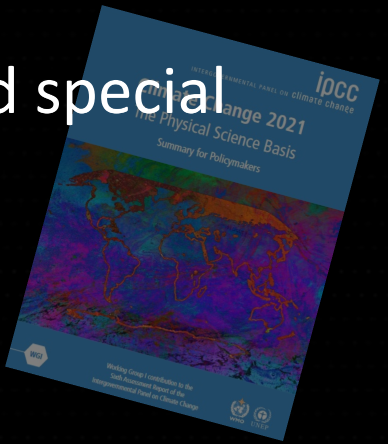
Ocean Colour
Aerosol
GHG
Cloud
Ozone
RECCAP-2
Soil Moisture
Medium Res Land Cover
Biomass





"We acknowledge the contribution of invited expert reviewers and the IMBIE Team. Their valuable input and advice have significantly improved the chapter"

- IMBIE produced an updated assessment for IPCC through to 2020
- Adopted as primary reference source for ice sheet contribution to sea level rise throughout AR6
- IMBIE cited 66 times in AR6
- IMBIE team received special acknowledgement



CCI Snow and AR6 WGI

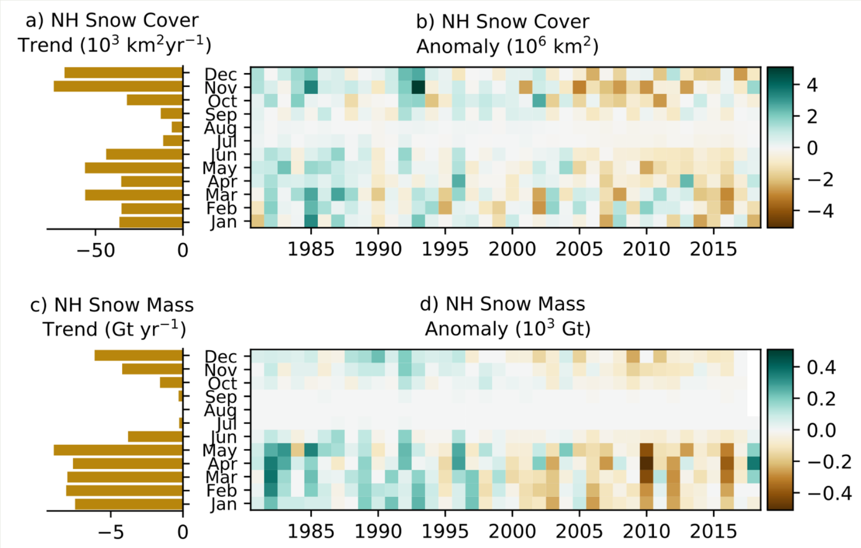


Figure 9.23 Observed monthly Northern Hemisphere snow cover and snow mass trends and anomalies.

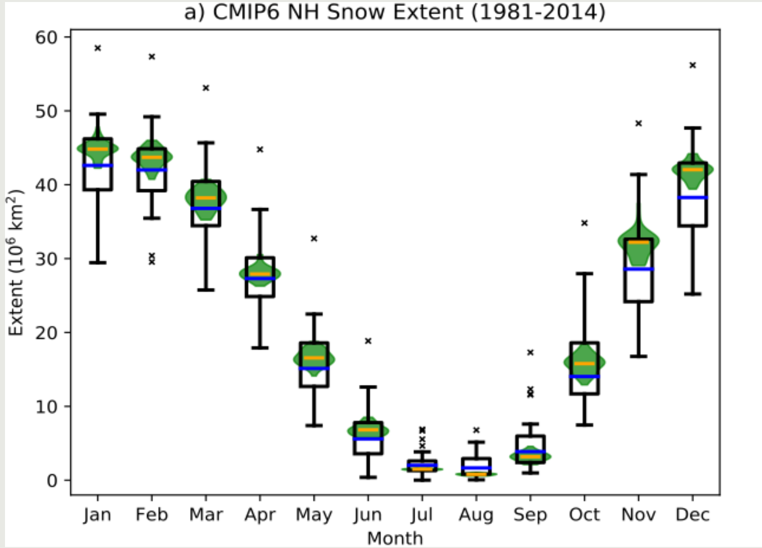


Figure 9.24a Simulated CMIP6 and observed snow cover extent (SCE; in millions of km^2) for 1981-2014.

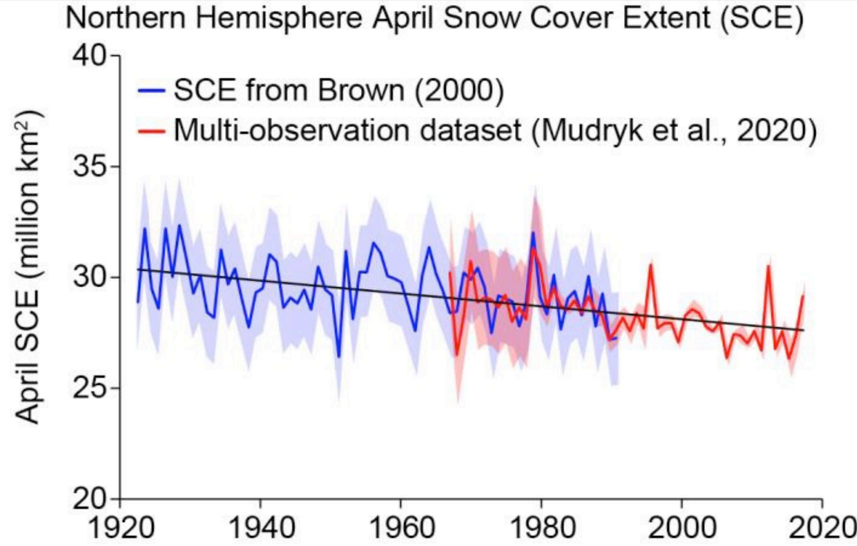


Figure 2.22 April snow cover extent (SCE) for the Northern Hemisphere (1922–2018). Shading shows *very likely* range. Trend over the entire 1922–2018 period (black line) is −0.29 (± 0.07) million km^2 per decade.

Multi-product ensemble of snow mass products (including ESA Snow-CCI) used for satellite-era and century-scale trend analysis

CCI Snow and AR6 WGI

Improved understanding of the performance of gridded snow mass datasets including GlobSnow v3/Snow CCI v1
[Mortimer, C., L. Mudryk, C. Derksen, K. Luojus, R. Brown, R. Kelly, and M. Tedesco. 2020. Evaluation of long term Northern Hemisphere snow water equivalent products. The Cryosphere. DOI: 10.5194/tc-14-1579-2020.]

Updated historical trends in Northern Hemisphere snow water equivalent based on GlobSnow v3/Snow CCI v1
[Pulliainen, J., K. Luojus, C. Derksen, L. Mudryk, J. Lemmetyinen, M. Salminen, J. Ikonen, M. Takala, J. Cohen, T. Smolander, and J. Norberg. 2020. Patterns and trends of Northern Hemisphere snow mass from 1980 to 2018. Nature. DOI: 10.1038/s41586-020-2258-0.]

Updated historical trends in Northern Hemisphere snow cover extent and CMIP6 model evaluation
[Mudryk, L., M. Santolaria-Otín, G. Krinner, M. Ménégoz, C. Derksen, C. Brutel-Vuilmet, M. Brady, and R. Essery. 2020. Historical Northern Hemisphere snow cover trends and projected changes in the CMIP-6 multi-model ensemble, The Cryosphere. 14, 2495–2514, DOI: 10.5194/tc-14-2495-2020.]

Gerhard Krinner (CRG member): Lead Author (Chapter 9)
Chris Derksen (CRG lead) and Lawrence Mudryk: Contributing Authors (Chapter 9)

CCI+ Greenland Ice Sheet. Contributions to the IPCC AR6

Insert your name, date and location,

then run the Slide Show mode

to see how it looks

IPCC AR6 WG1

From IPCC AR6 Chapter 9.4.1: Greenland Ice Sheet

"The vast increase in observational products from various platforms (e.g, GRACE, PROMICE, ESA-CCI, NASA MEaSUREs) provide a consistent and clear picture of a shrinking Greenland Ice Sheet (Colgan et al., 2019; Mottram et al., 2019; Mouginot et al., 2019; King et al., 2020; Mankoff et al., 2020; Moon et al., 2020; Sasgen et al., 2020; The IMBIE Team, 2020; Velicogna et al., 2020)."

CCI directly recognized

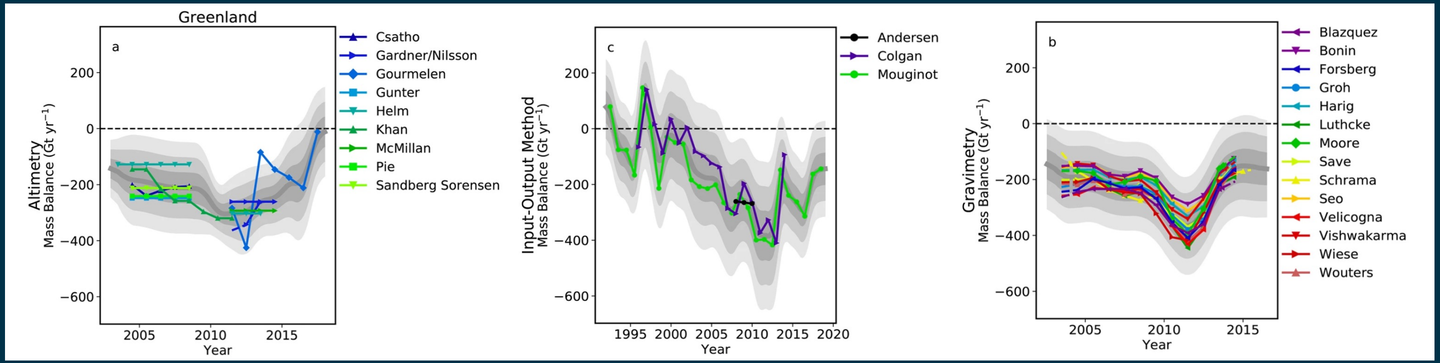
CCI partner

CCI publication.
Ruth Mottram is CRG member.

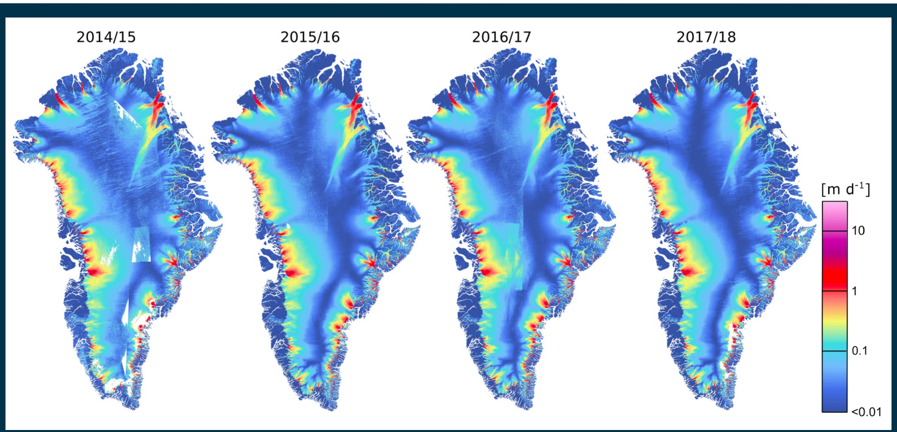
Input from several CCI partners - based on CCI data products.

Chapter Lead Author Guðfinna Aðalgeirsdóttir is CCI Greenland ice sheet CRG member.

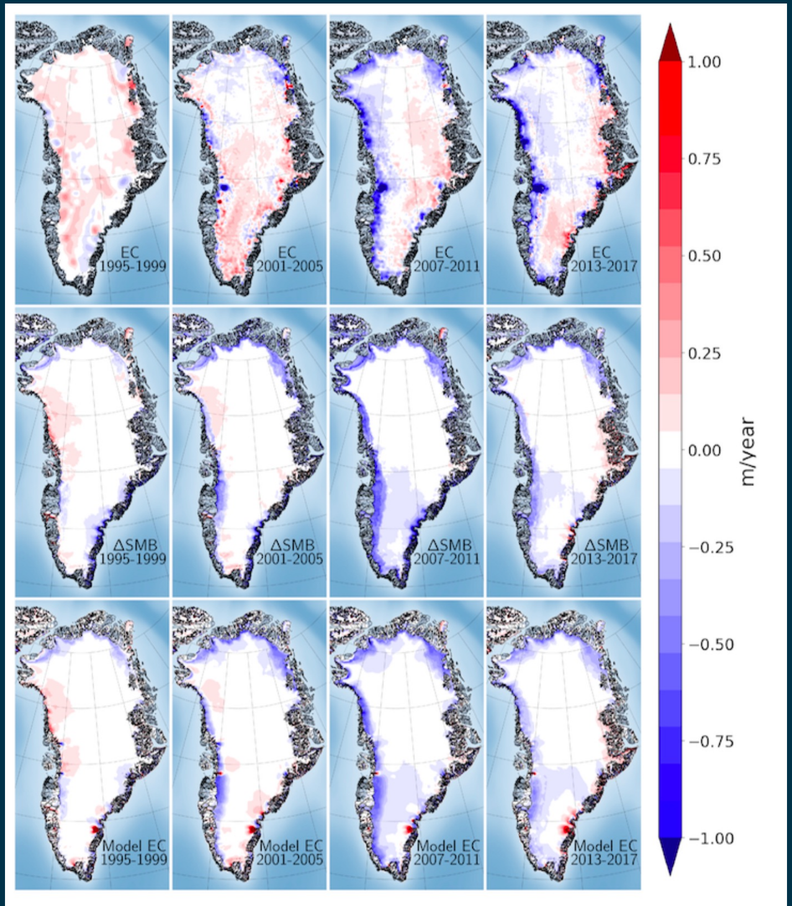
Examples of results



Greenland Ice Sheet mass balance using different methods. [The IMBIE team, 2020]



Greenland CCI annual ice velocity maps derived from Sentinel-1 SAR [Mottram et al., 2019]



Observed vs. modelled elevation changes. [Mottram et al., 2019]

Permafrost_cci contribution to IPCC session

Insert your name, date and location,

then run the Slide Show mode

to see how it looks

Permafrost_cci team contributions IPCC

- AR6 - Contributing authors to Chapter 9, cryosphere
  - Cecile Pellet, in situ observations for mountain permafrost …
  - Andeas Kääb

- Special Report on the Ocean and Cryosphere in a Changing Climate

  - Contributing authors 'Polar regions'
    - Guido Grosse
  - Lead author 'High mountain areas'
    - Andeas Kääb
  - Contributing author 'Extremes, Abrupt Changes and Managing Risks'
    - Andreas Kääb

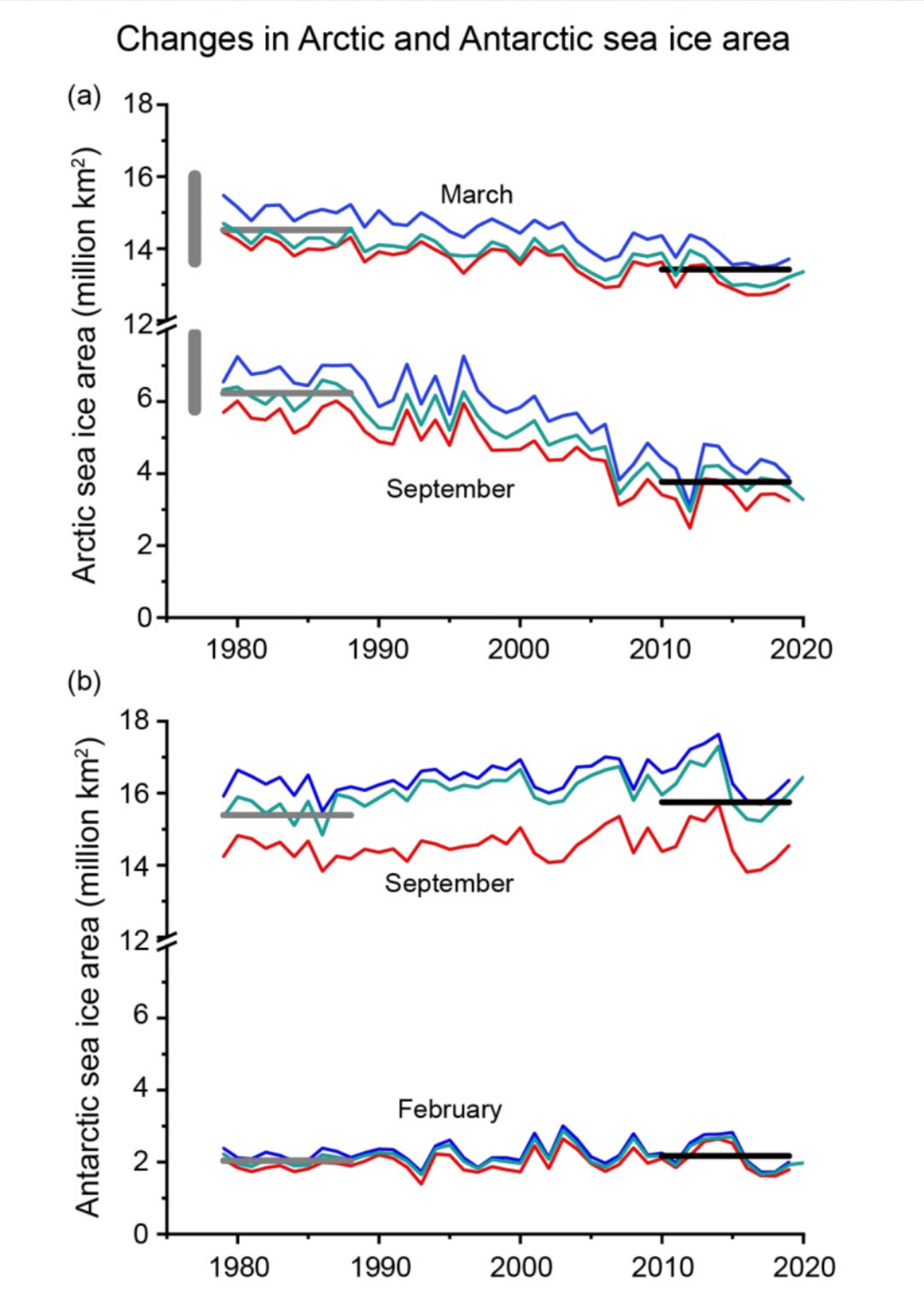
Permafrost_cci IPCC report relevant papers

- Obu, J. et al., 2019: Northern Hemisphere permafrost map based on TTOP modelling for 2000–2016 at 1 km2 scale. 35 Earth-Science Reviews, 193, 299–316
  - “The extent of the region where permafrost is simulated within the top 15 m in the Northern Hemisphere for the 1979-1998 period is characterized by very large scatter in the coupled CMIP5 and CMIP6 historical simulations compared to estimates of the present permafrost extent … Excessive simulated permafrost extent can in several cases be traced to insufficient thermal insulation by the winter snow cover (Burke et al., 2020)."
- Trofaier, A.M., S. Westermann, and A. Bartsch, 2017: Progress in space-borne studies of permafrost for climate science: Towards a multi-ECV approach. Remote Sensing of Environment, 203, 55–70, 19
  - "In spite of increasing evidence of landscape changes from site studies and remote sensing, quantifying permafrost extent change remains challenging because it is a subsurface phenomenon that cannot be observed directly (Jorgenson and Grosse, 2016; Trofaier et al., 2017)."
- Linked to Permafrost_cci activities, p 2236 “"There is medium confidence that the observed acceleration and destabilization of rock glaciers is related to warming temperatures and increase in water content at the permafrost table in recent decades (Deline et al., 2015; Cicoira et al., 2019; Marcer et al., 2019; PERMOS, 2019; Kenner et al., 2020)."

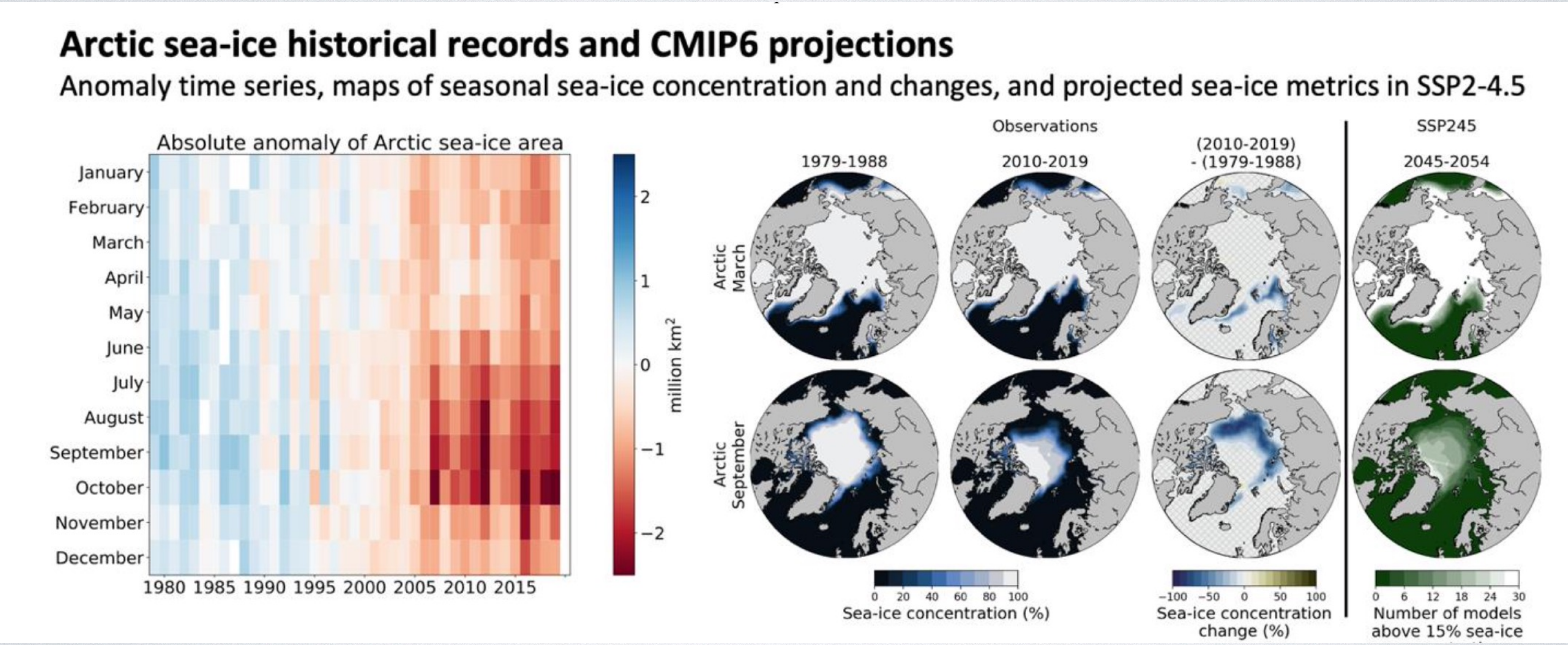
ESA CCI SEA-ICE IN AR6

CHAPTER 2: OBSERVATIONS

- ESA CCI / EUMETSAT OSISAF Sea-ice concentration was one of three sea-ice concentration products used in IPCC AR6
- The spread across the products was used as an estimate of observational uncertainty
- The sea-ice concentration data was consistently transformed into a new sea-ice area product, as part of ESA CCI work



CHAPTER 9: OCEAN/CRYOSPHERE



Sea State in IPCC AR6 Chapter 1: coastal & sea ice

esa

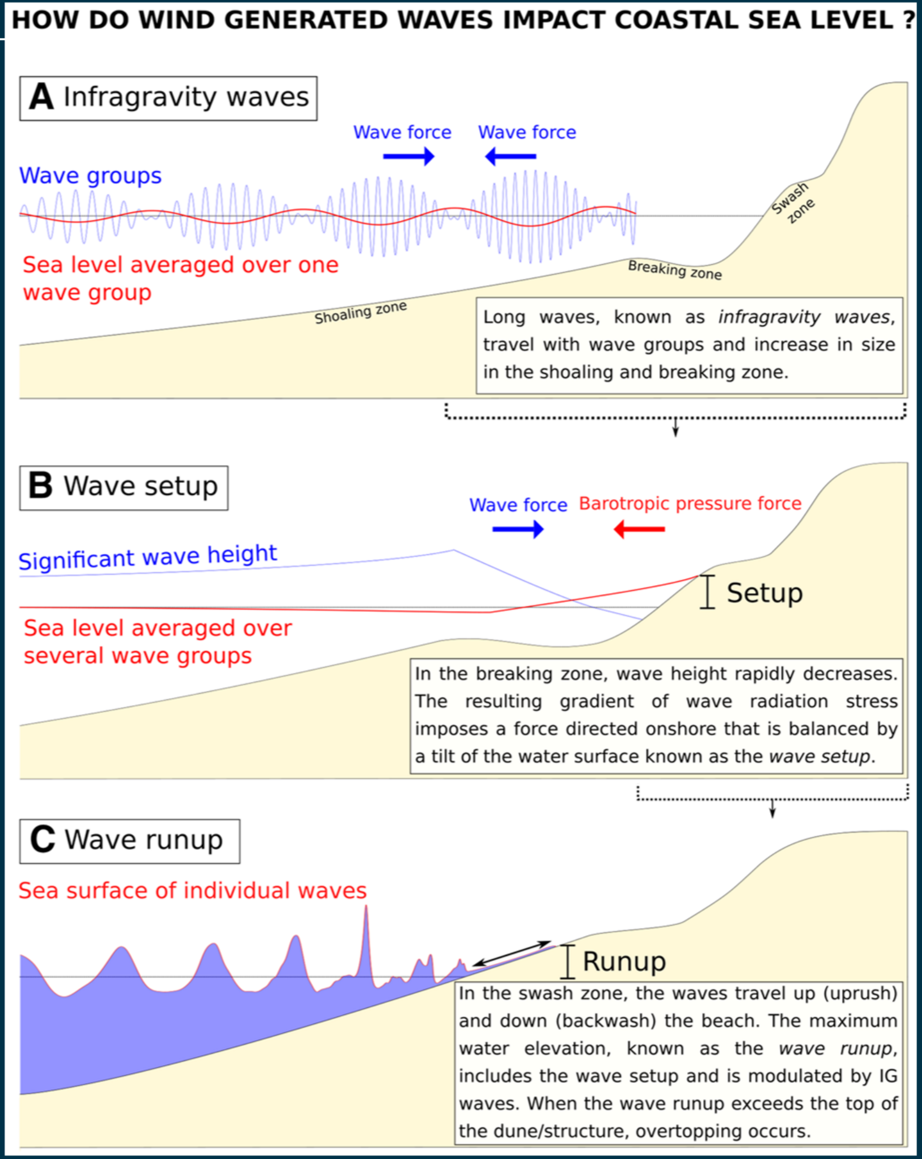
“Waves [a.k.a. Sea State] contribute to ESL via wave setup, infra-gravity waves and swash processes (Dodet et al., 2019) […] The SROCC (Oppenheimer et al., 2019) reported the dependency of these processes on **nearshore geomorphology** and **deep-water wave climate**, and thus sensitivity to internal climate variability and climate change. [...] Trends in wave contributions to ESL are typically derived from trends in wave conditions observed offshore.”

Before the Sea State CCI :

“On the basis of satellite altimeter observations, the SROCC reported increasing extreme wave heights in the Southern and North Atlantic Oceans of around 1.0 cm yr^{-1} and 0.8 cm yr^{-1} over the period 1985-2018 **(medium confidence)**. The SROCC (Collins et al., 2019) also identified sea-ice loss in the Arctic as leading to increased wave heights over the period 1992 to 2014 **(medium confidence).**

Thanks to the ongoing Sea State CCI work :

“Since the SROCC, the satellite wave record has been shown to be sensitive to alternate processing techniques, leading to important differences in reported trends (Timmermans et al., 2020).” [blabla on issues with reanalyses and hindcasts, citing Stopa et al. 2019] To summarise, satellite era trends in wave heights of order 0.5 cm yr_{-1} have been reported, most pronounced in the Southern Ocean. However, sensitivity of processing techniques, inadequate spatial distribution of observations, and homogeneity issues in available records limit confidence in reported trends (medium confidence).”



(Dodet et al., 2019) [1]

Sea State in IPCC AR6 Chapter 1: coastal & sea ice

3 papers produced by the CCI and cited in AR6 Chapter 1:

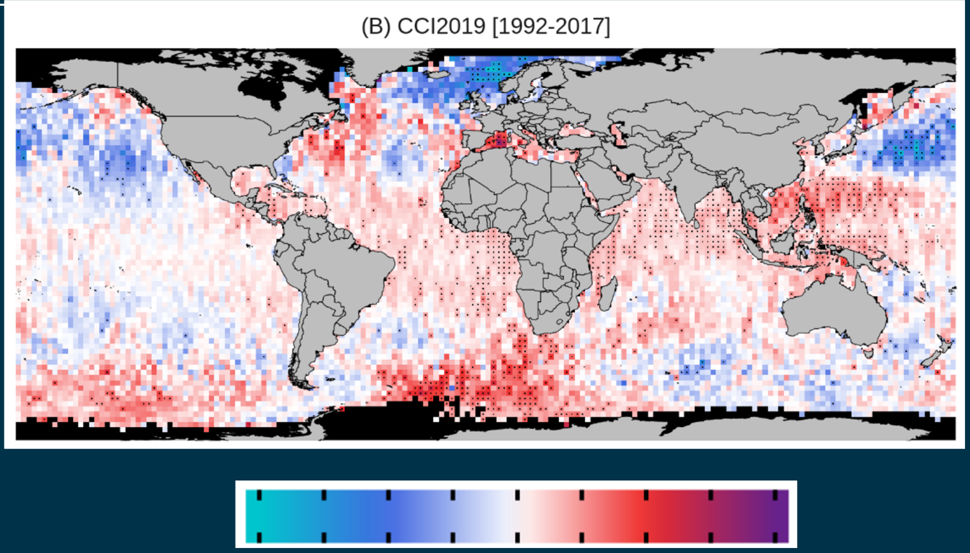
Dodet, G., Melet, A., Ardhuin, F., Bertin, X., Idier, D., & Almar, R. (2019). The Contribution of Wind-Generated Waves to Coastal Sea-Level Changes. Surveys in Geophysics. doi:10.1007/s10712-019-09557-5

Stopa, J.E., F. Ardhuin, E. Stutzmann, and T. Lecocq, 2019: Sea State Trends and Variability: Consistency Between Models, Altimeters, Buoys, and Seismic Data (1979–2016). Journal of Geophysical Research: Oceans, 124(6), 3923–3940, doi:10.1029/2018jc014607.

Timmermans, B.W., C.P. Gommenginger, G. Dodet, and J.-R. Bidlot, 2020: Global Wave Height Trends and Variability from New Multimission Satellite Altimeter Products, Reanalyses, and Wave Buoys. Geophysical Research Letters, 47(9), doi:10.1029/2019gl086880.

Timmermans, B., D. Stone, M. Wehner, and H. Krishnan, 2017: Impact of tropical cyclones on modeled extreme wind-wave climate. Geophysical Research Letters, doi:10.1002/2016gl071681.

Stopa, J.E., F. Ardhuin, and F. Girard-Ardhuin, 2016: Wave climate in the Arctic 1992-2014: seasonality and trends. The Cryosphere, 10(4), 1605–1629, doi:10.5194/tc-10-1605-2016.



(trend in wave height, cm/year, Timmermans et al., 2019)

CCI+Sea Surface Salinity : project’s involvement in IPCC process

CCI+SSS projet publicizes the use of satellite SSS for a better understanding of the processes linking the surface salinity with the freshwater fluxes and with the subsurface salinity

IPCC AR6 acknowledges:

Satellite salinity provides continuous and global monitoring of surface salinity in the open ocean and coastal areas for the first time (Vinogradova et al., 2019; Reul et al., 2020). It is now part of the salinity observing system (together with in situ observations) => study the links between surface fluxes and surface and subsurface salinity changes.

Members of the CCI+SSS projects have participated to long term trends studies based on in situ salinities (eg. in the N. Atl.: Friedman, Reverdin et al. 2017: Holliday,…, Josey…et al. 2020); these studies do not use the decade of available satellite SSS yet.

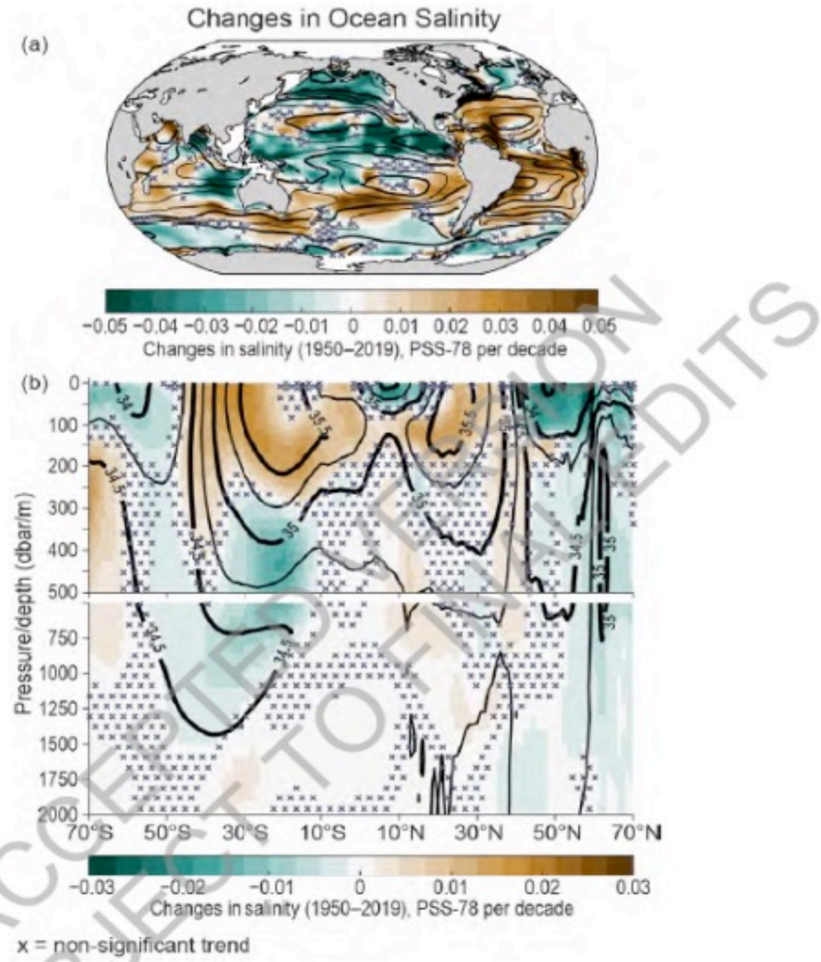

Final Government Distribution Chapter 2 IPCC AR6 WGI

Figure 2.27: **Changes in ocean salinity**. Estimates of salinity trends using a total least absolute differences fitting method for (a) global near-surface salinity (SSS) changes and (b) global zonal mean subsurface salinity changes. Black contours show the associated climatological mean salinity (either near-surface (a) or subsurface (b)) for the analysis period (1950–2019). Both panels represent changes of Practical Salinity Scale 1978 [PSS-78], per decade. In both panels green denotes freshening regions and orange/brown denotes regions with enhanced salinities. ‘x’ marks denote non-significant changes. Further details on data sources and processing are available in the chapter data table (Table 2.SM.1).

SST CCI and IPCC

- No project team authors for IPCC 6th assessment report (AR6)
- Project team support to UK government review of SPM and chapter review.
- Six SST CCI-led publications cited within AR6.
  - Actively keep authors up to date with newer papers.
- SST CDR cited and used in ESMValTool supporting AR6 model assessments.
  - More interaction on strengths and limitations of v2 data could be useful in this context
- AR6 observation synthesis tends to "marine surface temperature" approach
  - Which means including sea-ice areas
  - Key SST CCI analysis already incorporates sea ice concentration
  - Project team will consider options on ice surface temperature and SAT-over-sea-ice in future products (next phase) to further promote usage

CCI sea level project involvement in IPCC process

B.Meyssignac, 2021 oct, Toulouse

CCI Sea level project involvement in IPC process

Monitoring

Citations related to sea level estimates (time series, trends acceleration)

Legeais et al. 2018, 2020, Ablain et al. 2017: Chapter 2

Citations related to sea level uncertainty estimates (time series, trends acceleration)

Ablain et al. 2019: chapter 2

Use of the CCI sea level data for figures

Legeais et al. 2018, Quartly et al. 2017 (chapter 2, technical summary TS8)

CCI Sea level project involvement in IPC process

Science questions

Citations related to sea level budget assessment

Dieng et al. 2017 chapter 2

Citations related to evaluation of model representation of sea level variations

Meyssignac et al. 2017, Slangen et al. 2017 chapter 3 and chapter 9

Citations related to detection and attribution of the anthropogenic signal in sea level signal

Palanisamy et al. Chapter 9

Citations related to the ocean heat content and Earth energy imbalance derived from the CCI sea level data

Meyssignac et al. 2019 chapter 2, chapter 7 and TS

CCI Sea Level Budget Closure IPCC AR6 involvement

Prominent citation of single-ECV results co-funded by SLBC_cci:

- **Antarctic Ice Sheet**: Shepherd et al. 2019 (doi: 10.1029/2019GL082182)
- **Greenland Ice Sheet**: Mottram et al. 2019 (doi: 10.3390/rs11121407)
- **Glaciers**: Zemp et al. 2019 (doi: 10.1038/s41586-019-1071-0)

AR6 contributing **authors** involved in SLBC_cci (and in no other CCI project):

- Ben Marzeion (Bremen University)
- Petra Döll (Goethe University Frankfurt)

The **Land Water Storage (LWS)** change assessment by SLBC_cci (from hydrol. model and sat. gravimetry)

- Cáceres et al. 2020 (doi:10.5194/hess-24-4831-2020)

is one out of two sources for AR6's assessment of a positive LWS contribution to sea-level rise (1993-2018, 2006-2018) within the **sea-level budget**. This was an essential **revision w.r.t. to SROCC** which estimated a negative LWS contribution to sea level rise.

Ocean Colour CCI and IPCC Assessment Report of Working Group I

Shubha Sathyendranath

AR6 WGI Lead author: Chapter 2

Contributing author: Summary for Policy Makers

Author: Technical Summary

OC-CCI-related citations

- Kassi, J-B, Racault, M-F, ID , Mobio, BA, Platt, T, Sathyendranath, S, Dionysios E. Raitsos, DE, Affian, K (2018) Remotely sensing the biophysical drivers of *Sardinella aurita* variability in Ivorian waters. Remote Sensing, 10: 785. doi:10.3390/rs10050785
- Menon, NN, Sankar, S, A. Smitha, A, George, G, Shalin, S, Sathyendranath, S, Platt, T (2019) Satellite chlorophyll concentration as an aid to understanding the dynamics of Indian oil sardine in the southeastern Arabian Sea. Marine Ecology Progress Series: 617-618:137-147. https://doi.org/10.3354/meps12806 (Note: this work is cited, but reference is missing.)
- Racault, M.-F., S. Sathyendranath, N. Menon, and T. Platt, 2017a: Phenological Responses to ENSO in the Global. Oceans (2017a). Surveys in Geophysics, 38(1), 277–293, doi:10.1007/s10712-016-9391-1.
- Racault, M.-F., C. Le Qu r , E. Buitenhuis, S. Sathyendranath, and T. Platt, 2012: Phytoplankton phenology in the global ocean. Ecological Indicators, 14(1), 152–163, doi:10.1016/j.ecolind.2011.07.010.
- Racault, M.-F. et al., 2017b: Impact of El Ni o Variability on Oceanic Phytoplankton. Frontiers in Marine Science, 4, 53 133, doi:10.3389/fmars.2017.00133.
- Sathyendranath, S. et al., 2019: An Ocean-Colour Time Series for Use in Climate Studies: The Experience of the Ocean-Colour Climate Change Initiative (OC-CCI). Sensors, 19(19), doi:10.3390/s19194285.
- Sathyendranath, S. et al., 2020: Reconciling models of primary production and photoacclimation. Appl. Opt., 59(10), 37 C100––C114, doi:10.1364/ao.386252.

Data citation:

https://catalogue.ceda.ac.uk/uuid/99348189bd33459cbd597a58c30d8d10

Citable as: Sathyendranath, S.; Jackson, T.; Brockmann, C.; Brotas, V.; Calton, B.; Chuprin, A.; Clements, O.; Cipollini, P.; Danne, O.; Dingle, J.; Donlon, C.; Grant, M.; Groom, S.; Krasemann, H.; Lavender, S.; Mazeran, C.; Mélin, F.; Moore, T.S.; Müller, D.; Regner, P.; Steinmetz, F.; Steele, C.; Swinton, J.; Valente, A.; Zühlke, M.; Feldman, G.; Franz, B.; Frouin, R.; Werdell, J.; Platt, T. (2020): ESA Ocean Colour Climate Change Initiative (Ocean_Colour_cci): Global chlorophyll-a data products gridded on a sinusoidal projection, Version 4.2. Centre for Environmental Data Analysis, *date of citation*. https://catalogue.ceda.ac.uk/uuid/99348189bd33459cbd597a58c30d8d10

OC-CCI work referenced through CMEMS:

von Schuckmann, K. et al., 2018: Copernicus Marine Service Ocean State Report. Journal of Operational Oceanography, 11(sup1), S1–S142, doi:10.1080/1755876x.2018.1489208.

von Schuckmann, K. et al., 2019: Copernicus Marine Service Ocean State Report, Issue 3. Journal of Operational Oceanography, 12(sup1), S1–S123, doi:10.1080/17558

Aerosol_cci links to IPCC AR6

T. Popp / DLR and the ACCI+ team

27/09/2021

Papers cited in AR6, which acknowledge ACCI or use ACCI datasets or cite ACCI papers

Kinne, S., 2019: Aerosol radiative effects with MACv2. *Atmospheric Chemistry and Physics*, **19(16)**, 10919–10959, doi:10.5194/acp-19-10919-2019: acknowledge ACCI + use ATSR ORAC

Sogacheva, L. et al., 2018: Spatial and seasonal variations of aerosols over China from two decades of multi-satellite observations – Part 1: ATSR (1995–2011) and MODIS C6.1 (2000–2017). *Atmospheric Chemistry and* 56 *Physics*, **18(15)**, 11389–11407, doi:10.5194/acp-18-11389-2018: acknowledge ACCI + use ATSR ADV

Gliß, J. et al., 2020: Multi-model evaluation of aerosol optical properties in the AeroCom phase III Control experiment, using ground and space based columnar observations from AERONET, MODIS, AATSR and a merged satellite product as well as surface in-situ observations from GAW. *Atmos. Chem. Phys. Discuss.*, **2020**, 1–62, doi:10.5194/acp-2019-1214: acknowledge ACCI + use ATSR SU and ATSR merged (including SU + ADV + ENS) + cite de Leeuw et al 2015, Popp et al 2016 and Sogacheva et al, 2020

Gliß, J. et al., 2021: AeroCom phase III multi-model evaluation of the aerosol life cycle and optical properties using ground- and space-based remote sensing as well as surface in situ observations. *Atmospheric Chemistry and Physics*, **21(1)**, 87–128, doi:10.5194/acp-21-87-2021: acknowledge ACCI + use ATSR SU and ATSR merged (including SU + ADV + ENS) + cite de Leeuw et al 2015, Popp et al 2016 and Sogacheva et al, 2020

Inness, A. et al., 2019: The CAMS reanalysis of atmospheric composition. *Atmospheric Chemistry and Physics*, **19(6)**, 3515–3556, doi:10.5194/acp-19-3515-2019: use ATSR SU + cite Popp et al 2016

Brühl, C., 2018: Volcanic SO2 data derived from limb viewing satellites for the lower stratosphere from 1998 to 2012, and from nadir viewing satellites for the troposphere. World Data Center for Climate (WDCC) at DKRZ, https://doi.org/10.1594/WDCC/SSIRC_1: acknowledge ACCI + cite Bingen et al 2017, Popp et al 2016

GHG-CCI+ contributions to IPCC AR6

Michael Buchwitz,

University of Bremen, Germany

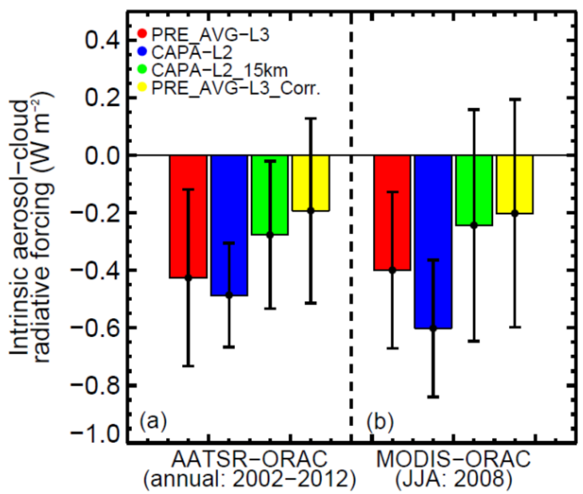
GHG-CCI+ contributions to IPCC AR6

- **GHG-CCI+ ECV products:** Satellite-based atmospheric carbon dioxide (CO_2) and methane (CH_4)
- **Main application:** To enhance our knowledge on CO_2 & CH_4 sources & sinks -> IPCC AR6 Chapter 5: Global Carbon and other Biogeochemical Cycles and Feedbacks
- **Focus of GHG-CCI+ (since 2019):** R&D on retrieval algorithm development & corresponding ECV data product generation, validation & user assessments
  - Focus is on how to optimally generate new satellite-based GHG ECV data products
  - Focus is NOT (any more) to generate long-term data sets; the long-term GHG-CCI pre-cursor project (2010 - 2018) ECV data products are now generated operationally via the Copernicus Climate Change Service (C3S)
- **IPCC** cites primarily high-level publications but typically not publications describing „lower level" publications describing how fundamental observational input data have been generated
  - Direct visibility of GHG-CCI publications is therefore low despite many publications produced (see https://climate.esa.int/en/projects/ghgs/publications/); nevertheless, some publications are cited, e.g., Houweling et al., 2015; Reuter et al., 2017; Palmer et al., 2019a
- GHG-CCI+ project team members supported AR6 by acting as reviewers (e.g., Science Lead M. Buchwitz) and experts from GHG-CCI+ institutions acted as authors (e.g., LSCE, MPI-BGC, Univ.Bremen, …)

Cloud_cci's contribution to IPCC AR6

- Numerous papers cited with Cloud_cci team members being lead or co-authors.
- One highlight paper:

Christensen et al. (2017), ACP, Unveiling aerosol–cloud interactions – Part 1: Cloud contamination in satellite products enhances the aerosol indirect forcing estimate, https://doi.org/10.5194/acp-17-13151-2017, 2017.



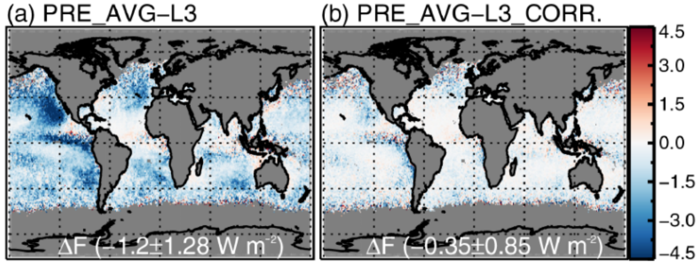


Figure 8. Extrinsic aerosol indirect radiative forcing computed using AATSR observations over oceanic $1^\circ \times 1^\circ$ regions during the period 2002–2012. Oceanic mean and standard deviation of the forcing (ΔF) are given in parenthesis.

- However, utilization of Cloud_cci data for AR6 unsatisfying. This is potentially because the late release of the final Cloud_cci Phase 2 datasets in 2020 and/or the absence of a Cloud_cci simulator in COSP, which would actually be needed in models for evaluation of models for many cloud properties.

Cloud_cci's contribution to IPCC AR6

- However, we see a lot potential in our latest, final long-term datasets for having a high impact on climate science in the future and potentially to AR7 – in particular because we enriched our cloud datasets with consistent radiative fluxes.

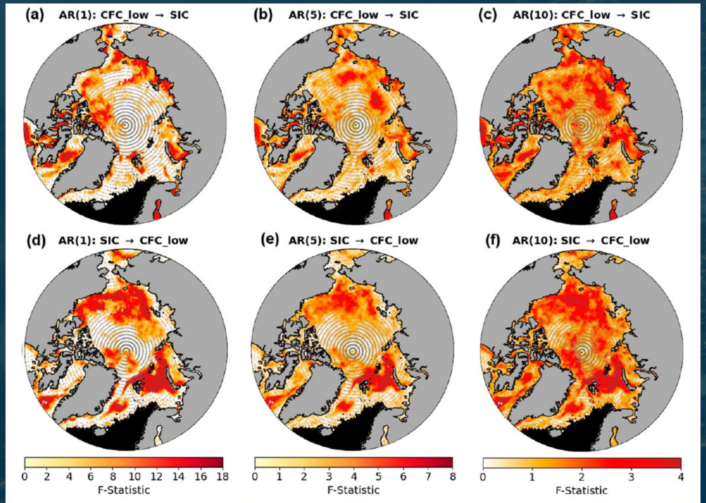
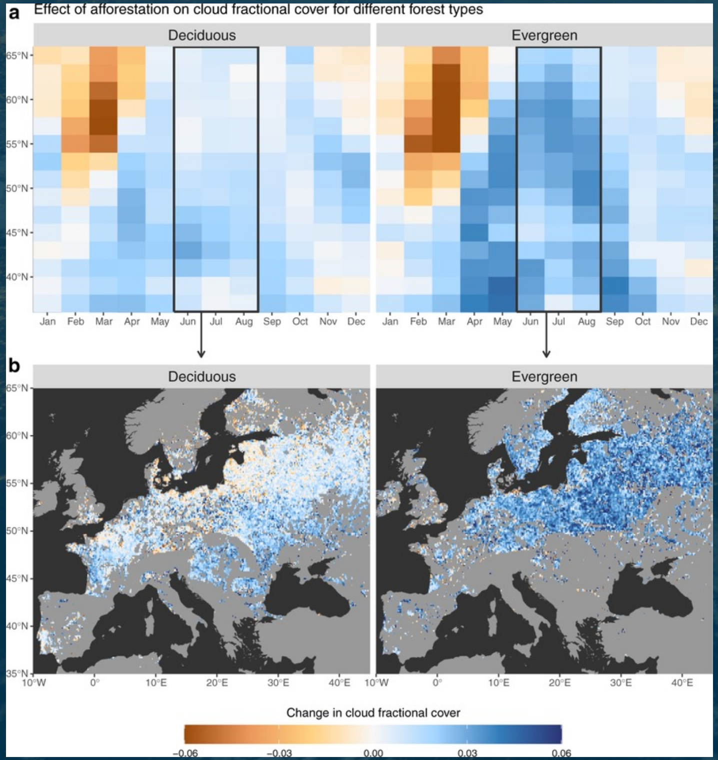


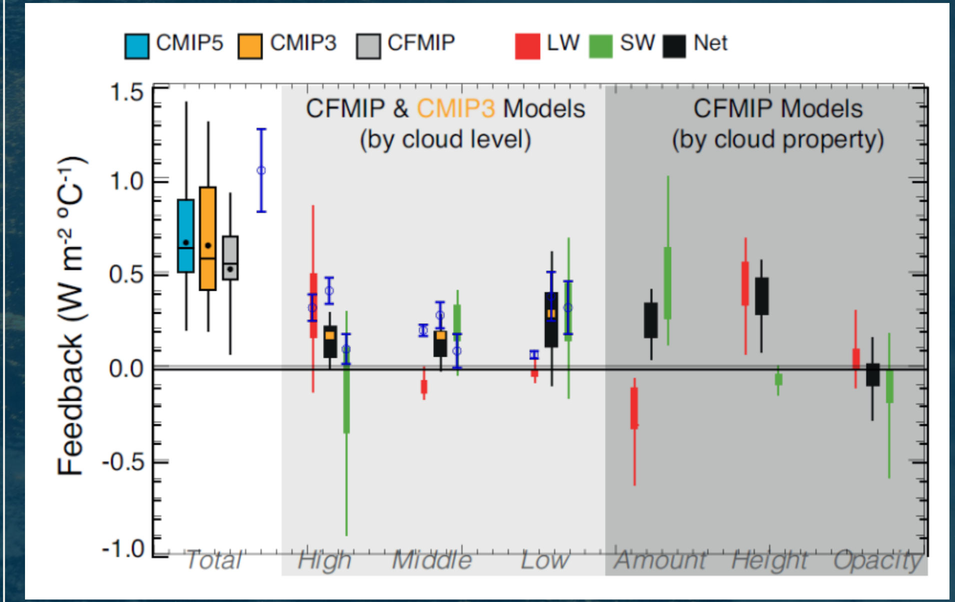
FIG. 10. Arctic year-round F statistics of GC tests for CFC_{low} and SIC. (top) Influence of CFC_{low} on SIC for an (a) AR(1), (b) AR(5), and (c) AR(10) model. (bottom) As in the top panels, but the influence of SIC on CFC_{low} is shown. Dotted areas mark statistically insignificant F statistics below a 95% level of confidence. Black shaded areas indicate where SIC was constant over the whole analysis period and thus no F statistic was calculated. Please note the different color bar ranges.

Philipp, D., M. Stengel, and B. Ahrens, 2020: Analyzing the Arctic Feedback Mechanism between Sea Ice and Low-Level Clouds Using 34 Years of Satellite Observations. J. Climate, 33, 7479–7501, https://doi.org/10.1175/JCLI-D-19-0895.1.



Duveiller, G., et al. (2021) *Revealing the widespread potential of forests to increase low level cloud cover*. Nat Commun 12, 4337. https://doi.org/10.1038/s41467-021-24551-5

Cloud radiative feedback in IPCC AR5 + our results



Stengel et al., in preparation

Ozone_cci involvement in IPCC AR6

- No direct involvement from team members in writing
- Ozone community more directly involved in WMO/UNEP Scientific Assessment of Ozone Depletion Reports (last issue 2018)
- 3 Ozone_cci data sets were used in IPCC AR6, Chap. 2

- Chap. 2, Fig. 2.7: Assessment of stratospheric ozone trends and their links to GHG and halogens (ODS)

- Chap. 2, Fig. 2.8: Assessment of tropospheric ozone trends and related radiative forcing

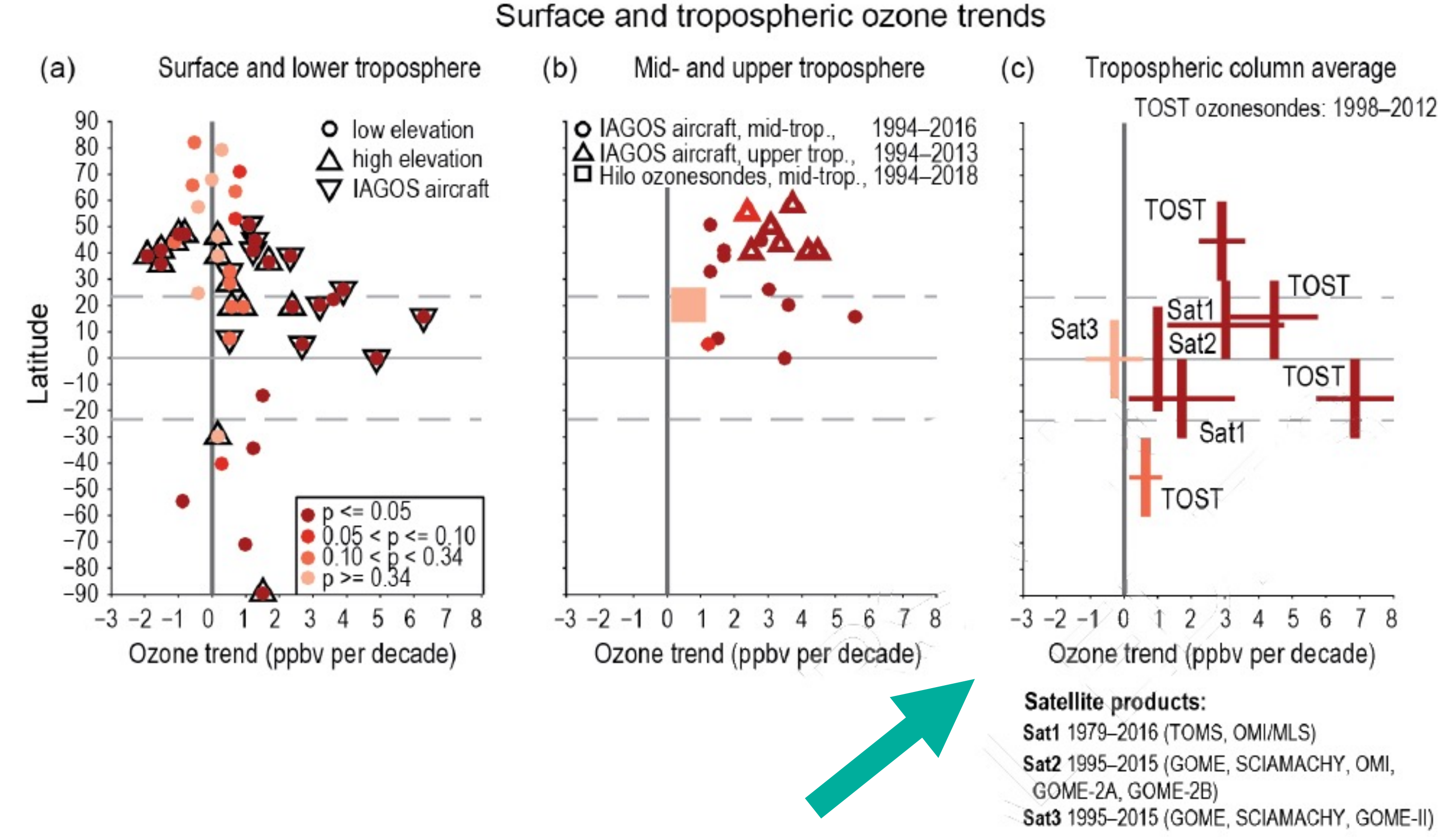


Figure 2.8: **Surface and tropospheric ozone trends.** (a) Decadal ozone trends by latitude at 28 remote surface sites and in the lower free troposphere (650 hPa, about 3.5 km) as measured by IAGOS aircraft above 11 regions. All trends are estimated for the time series up to the most recently available year, but begin in 1995 or 1994. Colours indicate significance (p-value) as denoted in the in-line key. See Figure 6.5 for a depiction of these trends globally. (b) Trends of ozone since 1994 as measured by IAGOS aircraft in 11 regions in the mid-troposphere (700–300 hPa; about 3–9 km) and upper troposphere (about 10-12 km), as measured by IAGOS aircraft and ozonesondes. (c) Trends of average tropospheric column ozone mixing ratios from the TOST composite ozonesonde product and three composite satellite products based on TOMS, OMI/MLS (Sat1), GOME, SCIAMACHY, OMI, GOME-2A, GOME-2B (Sat2), and GOME, SCIAMACHY, GOME-II (Sat3). Vertical bars indicate the latitude range of each product, while horizontal lines indicate the *very likely* uncertainty range.. Further details on data sources and processing are available in the chapter data table (Table 2.SM.1).

Tropospheric ozone

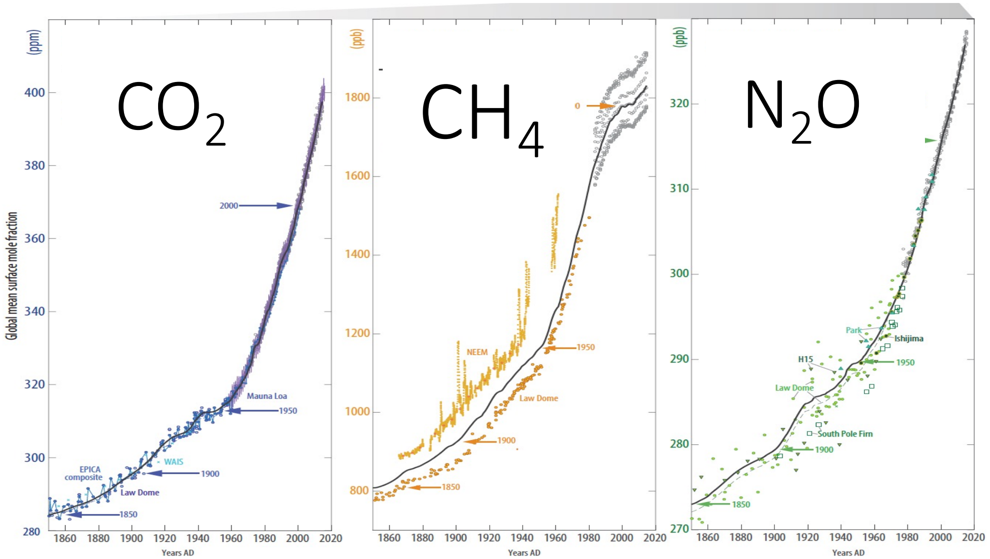
- Increase in tropospheric column ozone since 1998, but magnitude of trends still highly uncertain

  SAT 2: Heue et al. 2017 (DLR)

  SAT 3: Leventidou et al. 2018 (IUP-Bremen)

- Free tropospheric ozone related radiative forcing larger than that from stratospheric ozone

RECCAP2 products to Align with Policy Needs



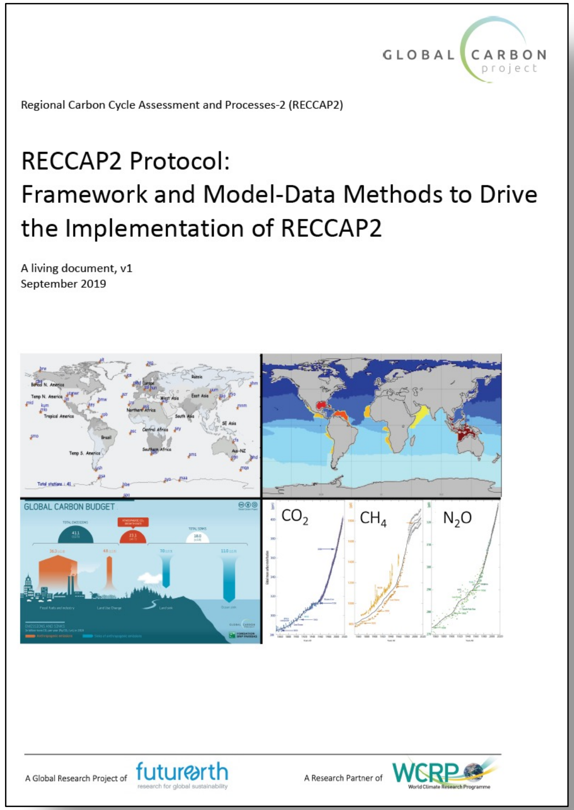
- ✓ To **quantify anthropogenic greenhouse gas emissions**
- ✓ To support the **Global Stocktake and NDCs** (Paris)
- ✓ To track regions **towards zero net emissions**, anthropogenic and natural fluxes (Paris Agreement)
- ✓ To gain understanding on the response of marine and terrestrial regional GHG budgets to climate change and direct anthropogenic drivers - **climate-biogeochemical feedbacks** and **implications for the remaining C budget** to Paris temperature targets

LSCE Laboratoire des Sciences du Climat & de l'Environnement

University of Exeter

Max Planck Institute for Biogeochemistry

Contribution to IPCC process & AR6


GLOBAL CARBON project

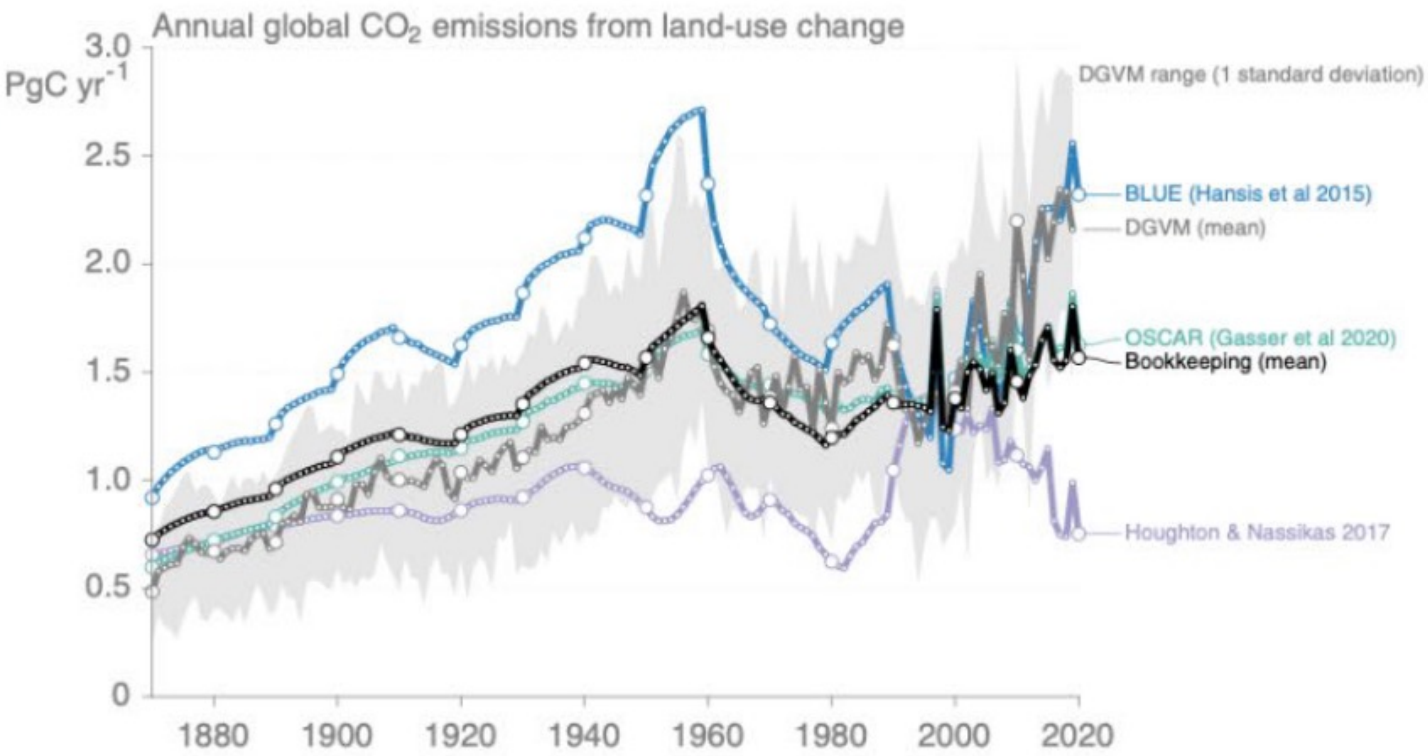
Regional Carbon Cycle Assessment and Processes-2 (RECCAP2)

RECCAP2 Protocol:
Framework and Model-Data Methods to Drive the Implementation of RECCAP2

A living document, v1
September 2019

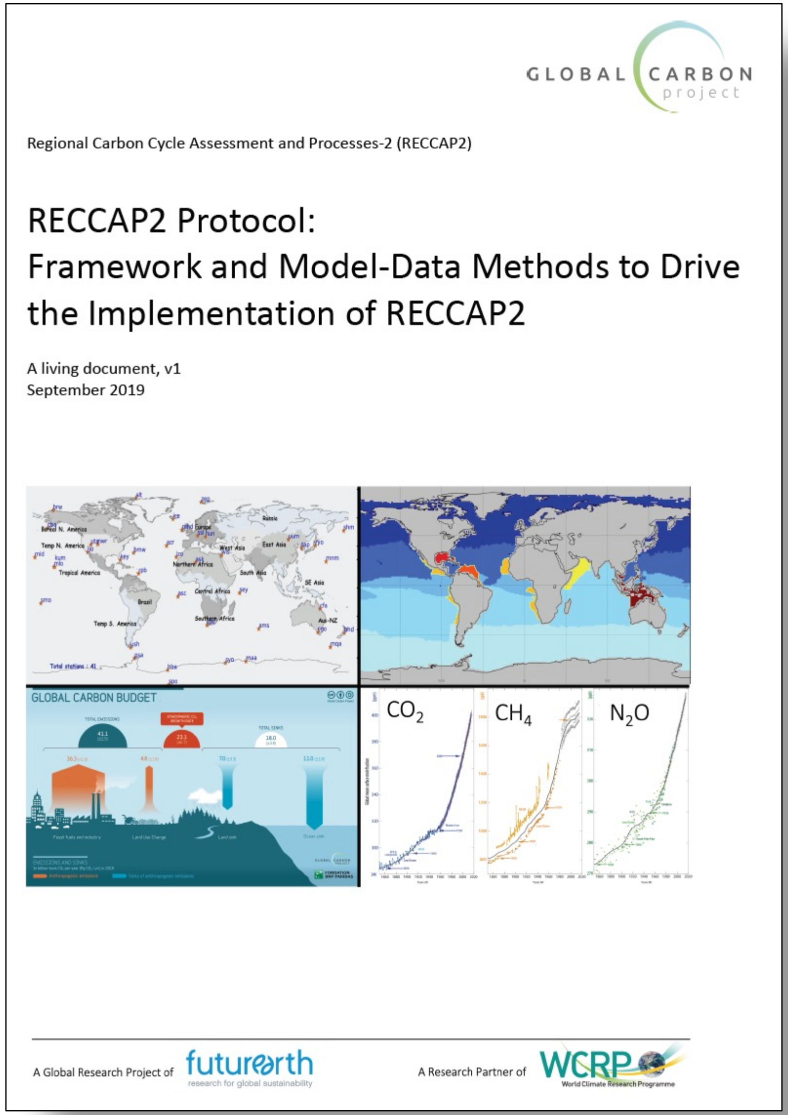
A Global Research Project of futurearth — research for global sustainability

A Research Partner of WCRP — World Climate Research Programme



✓WGIII Chp 7 AFOLU - ELUC from GCB.

Contribution to IPCC process & AR6


GLOBAL CARBON project

Regional Carbon Cycle Assessment and Processes-2 (RECCAP2)

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GLOBAL CARBON BUDGET

CO_2 CH_4 N_2O

A Global Research Project of futurearth research for global sustainability

A Research Partner of WCRP World Climate Research Programme

- ✓Budgets of the 3 GHGs used by WG1
  - Chp5 Global carbon and other biogeochemical cycles and feedbacks
- ✓ Data used in WG2 (emissions)
- ✓Work relevant to IPCC guidelines
- ✓Contribution to GST CEOS papers
- ✓WGIII Chp 7 AFOLU - ELUC from GCB.

CCI soil moisture in AR6 (relevant statements)

- Chapter 1 - Major expansions of observational capacity
  - "Observations of soil moisture are now available via SMOS and SMAP satellite retrievals, filling critical gaps in the observation of hydrological trends and variability over land"

  → included in CCI soil moisture product

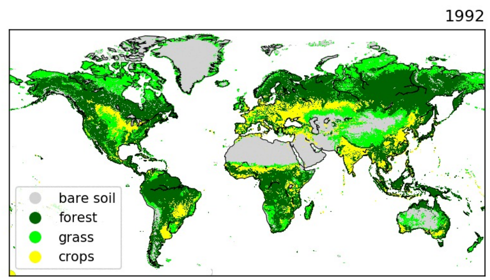
- Chapter 11 - Soil moisture deficits
  - "Microwave-based satellite measurements of surface soil moisture have also been used to analyse trends…"
  - "Although there is regional evidence that microwave based soil moisture estimates can capture well drying trends in comparison with ground soil moisture observations, there is only *medium confidence* in the derived trends, since satellite soil moisture data are affected by inhomogeneities… Furthermore, microwave-based satellites only sense surface soil moisture, which differs from root zone soil moisture."

  → root-zone soil moisture currently addressed in a CCI SM Scientific Evolution study

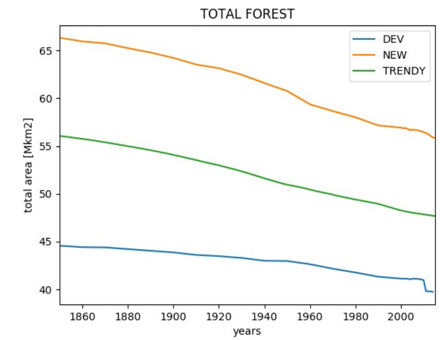
MRLC data : Contribution to IPCC from IPSL - LSCE

Land Cover Classes (2000 – 2020) → **Plant Functional Types (PFTs: 2000 – 2020)** → **Historical – future PFTs (1700– 2100)**

mapping



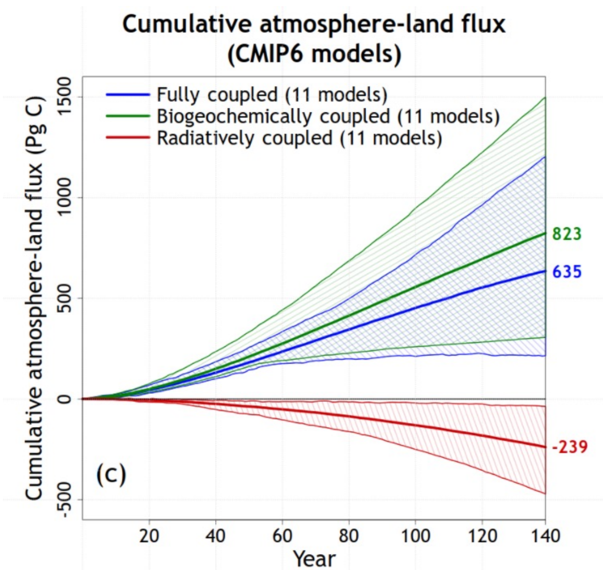
Combine with LUHv2 dataset



➔ Contribution to CMIP6 simulations (all MIPs)

<u>Ex. C-cycle</u>

Cumulated Land C uptake (Arora et al. 2020)



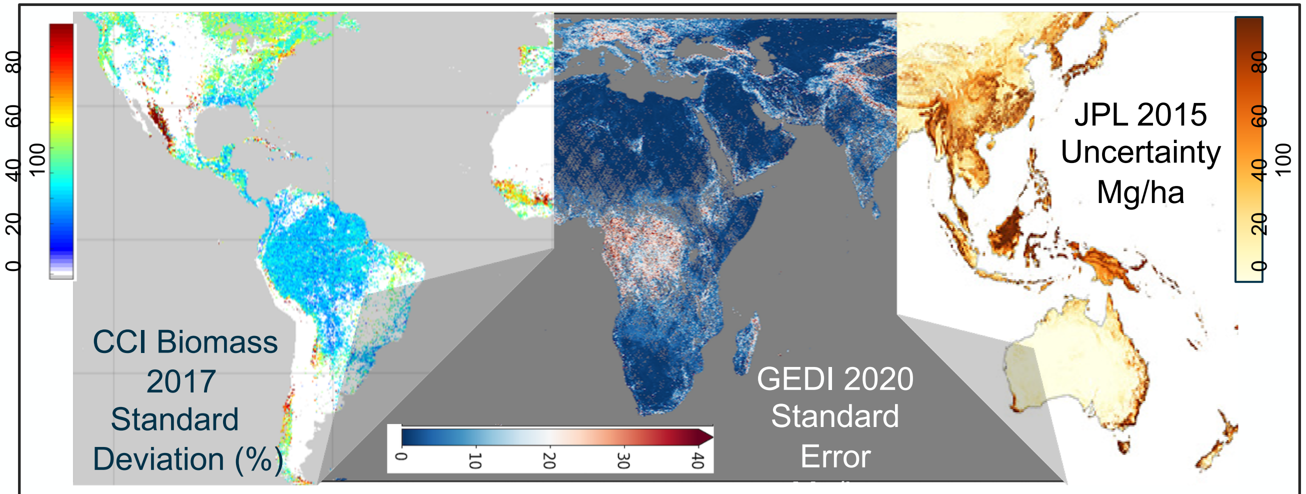
A few key papers (IPSL)

- *Boucher et al.: “IPSL-CMIP6” model evaluation*
- *Lurton et al.: “Input data stream for CM6”*
- *Cheruy et al.: “Surface – atmosphere coupling”*

Potential ways forward …

- Combine CCI-MRLandcover product with other data streams (LUH data set, …) to derive a coherent land cover historical reconstruction (from 1900 – present)
- Include a C3 vs C4 split using various proxies / data set
- Combine with the LAI ECV to derive a coherent product with combined LandCover and LAI information (same resolution)
- Same synergies with BIOMASS data ?
- …

CCI-BIOMASS CONTRIBUTION TO THE UNFCCC GST



Uncertainties and scales are calculated differently between products.

Biomass map harmonization (CEOS-led)

- **Open Science activity** using the ESA-NASA Multi-Mission Algorithm and Analysis Platform to compare and harmonize of biomass products for the GST.
- Individual and harmonized products will be assessed using **reference data** in pilot USGS Silvacarbon countries

Country engagement

- **Partnership** between national teams reporting to the UNFCCC on forest elements of their NDCs and EO AGB experts is basic to exploiting space data in the GST and improving reports through time.
- As part of the harmonization activity we are working with (initially) 10 countries identified by Silvacarbon on **concrete demonstrations** of the use of space–derived AGB data in their UNFCCC reports.
- This is a **two-way process**. Country data also provide validation of AGB products. National insight is crucial to EO experts in specifying the properties AGB products must have for them to be useful.