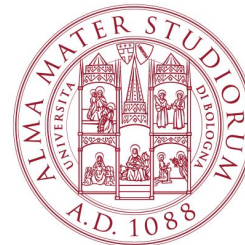


Antarctic sea ice in global ocean reanalyses

Julia Selivanova¹, Doroteaciro Iovino²

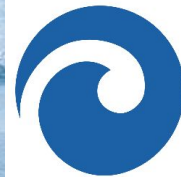
*1 - University of Bologna, Italy; 2 - Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy
iuliia.selivanova@unibo.it*



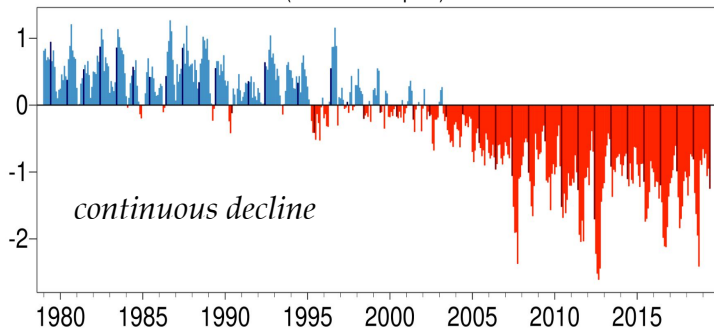
cmcc
Centro Euro-Mediterraneo
sui Cambiamenti Climatici



Background



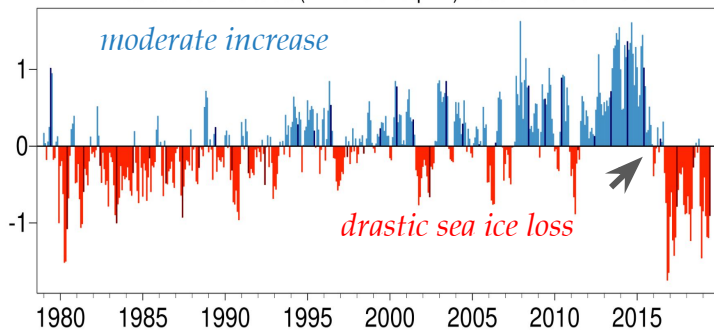
Arctic sea ice area (millions of sq km) relative to 1981-2010



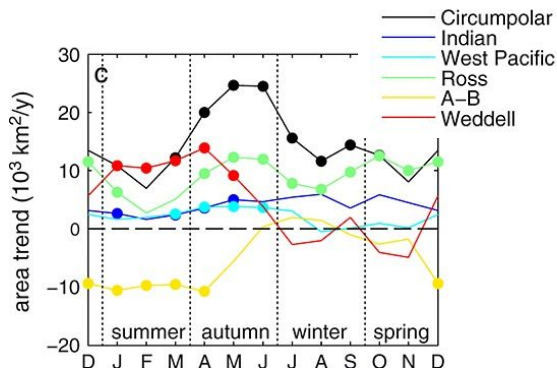
In contrast to the Arctic, the Antarctic has not witnessed a stable sea ice loss. The reasons of such variability in the Antarctic sea ice area are still not completely clear.

Net circumpolar sea ice area conceals the spatial and seasonal heterogeneity and different types of ice

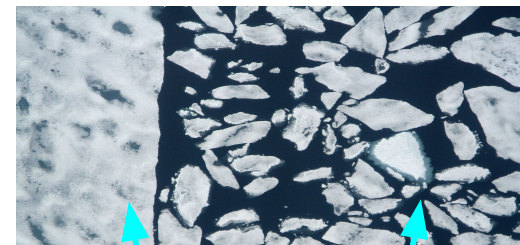
Antarctic sea ice area (millions of sq km) relative to 1981-2010



ECMWF Copernicus Climate Change Service



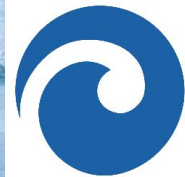
W. Hobbs et al., 2016



different response to the external forcing



Methods



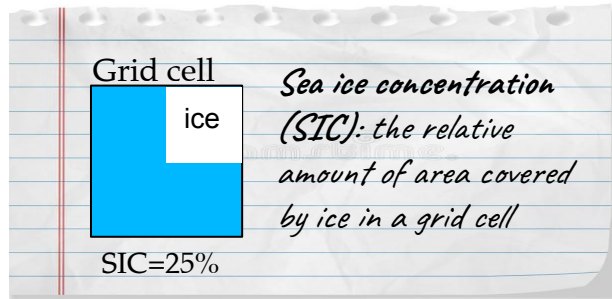
The focus on different sea ice types can enhance our knowledge about sea ice area variability.

Hence we distinguish sea ice classes based on sea ice concentration (SIC) thresholds:

pack ice (80-100%)

marginal ice zone (MIZ; 15-80%)

sparse ice (0-15%)



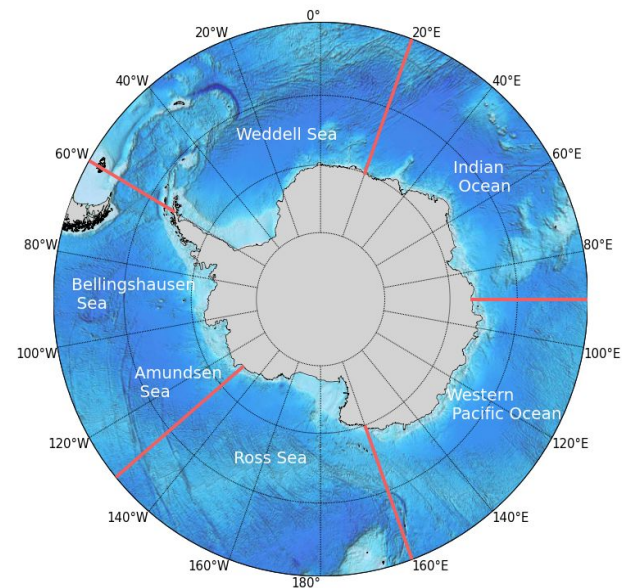
Extent or area?

Sea ice extent (SIE) - the total area of sea ice coverage with a SIC greater than some threshold value (typically 15%)

Sea ice area (SIA) - total area of ice coverage for a given domain i.e., $\sum SIC(x,y) \times A(x,y)$, where A is the area of each grid cell

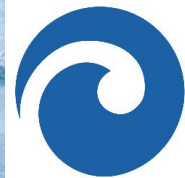
We describe here sea ice variability in terms of **SIA**

Opposite signal in different parts of the Southern Ocean → 5 sectors for regional analysis





Data



Ensemble mean (GREPv2) of four ORA-IP reanalyses produced by CMEMS (GLOBAL_REANALYSIS_PHY_001_031)

global eddy-permitting configuration (0.25° horizontal resolution and 75 vertical levels)

Atmospheric forcing: ECMWF ERA-Interim

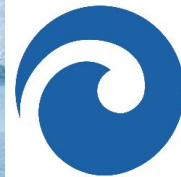
Analyzed time period: 1993-2019

<i>Name</i>	CGLORSv7	GLORYS2v4	ORAS5	GLOSEA5v13
<i>Institution</i>	CMCC	Mercator Ocean	ECMWF	UK Met Office
<i>Ocean-ice model</i>	NEMO3.6-LIM2	NEMO3.1-LIM2	NEMO3.4-LIM2	NEMO3.2-CICE4.1
<i>Sea ice data assimilation method</i>	Linear nudging	Reduced order KF	3DVAR-FGAT	3DVAR
<i>DA sea ice data</i>	OSISAF	IFREMER/ Cersat	OSTIA(reprocessed before 2008, analysis from 2008)	OSISAF

SIC from set of satellite datasets:

{ NOAA/NSIDC CDR (<https://nsidc.org/data/g02202>)
EUMETSAT OSISAF (<ftp://osisaf.met.no/>)
Ifremer/CERSAT (https://wwwz.ifremer.fr/cersat_fr)

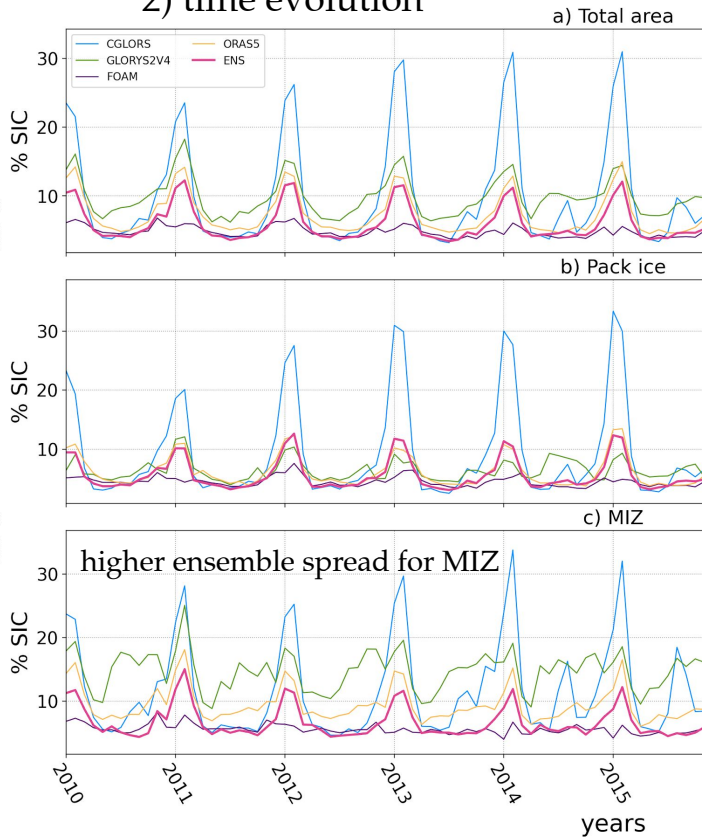
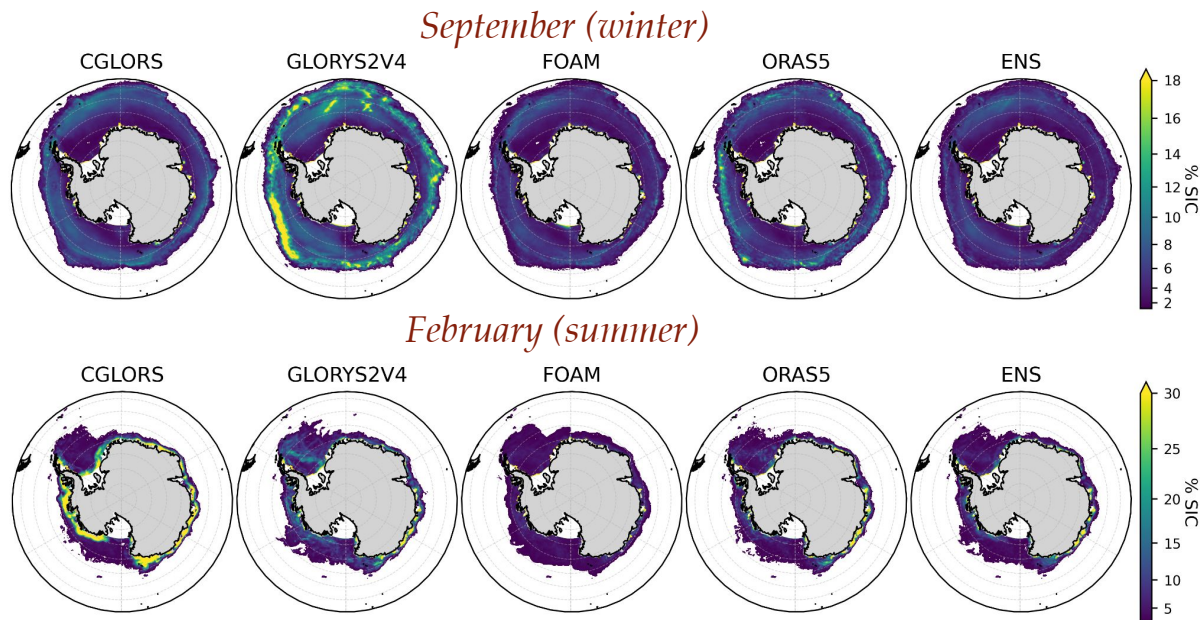
ORAs accuracy in SIC representation



1) spatial distribution

RMSE for SIC against observations

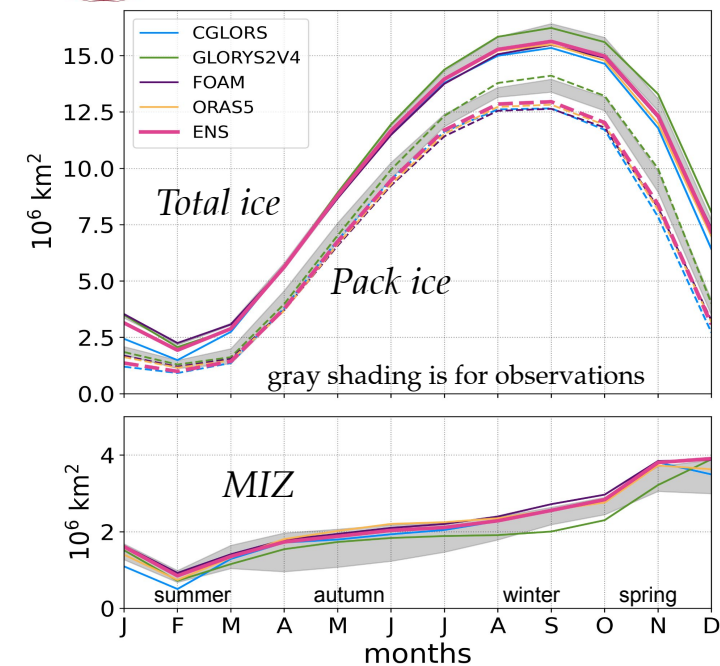
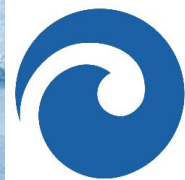
2) time evolution



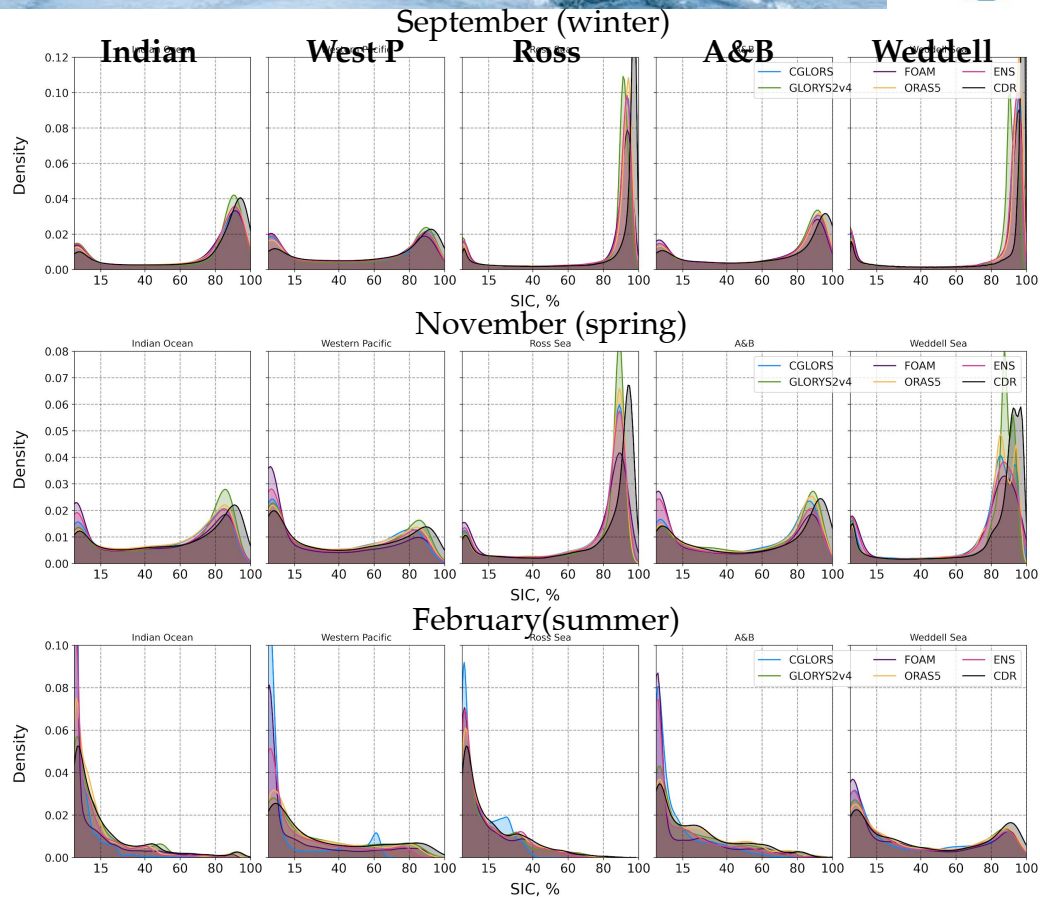
- GREP minimizes individual errors and performs fairly well (except for coastal areas in summer)



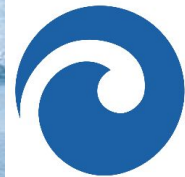
Seasonal variability of SIA and SIC distribution



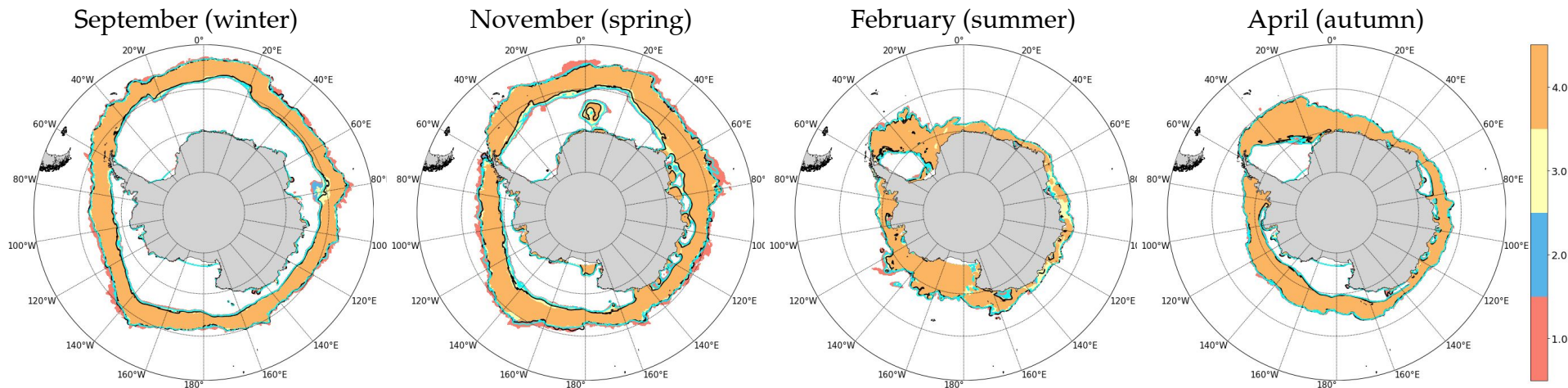
- Strong asymmetry of the MIZ seasonal cycle;
- MIZ area peaks when pack ice retreats;
- Underestimation of pack ice in all seasons and the MIZ in summer



Seasonal evolution of the MIZ location

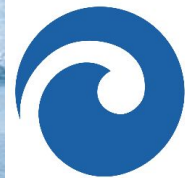


Number of ORAs per grid cell where $15\% \leq \text{SIC} < 80\%$.
CDR and GREP are marked by black and cyan, respectively.



- Importance to examine the location of sea-ice edge with 80% SIC (not only 15%);
- High consistency among ORAs but the agreement is worse in spring and summer;
- GREP agrees well with CDR in all seasons.

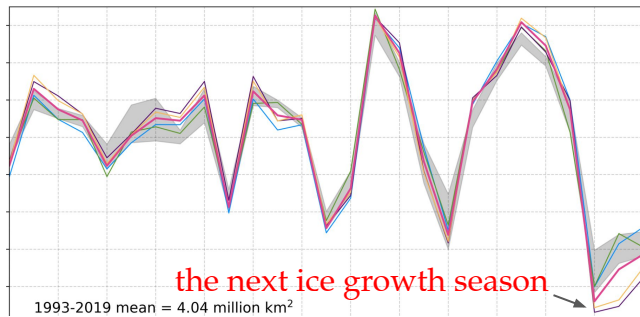
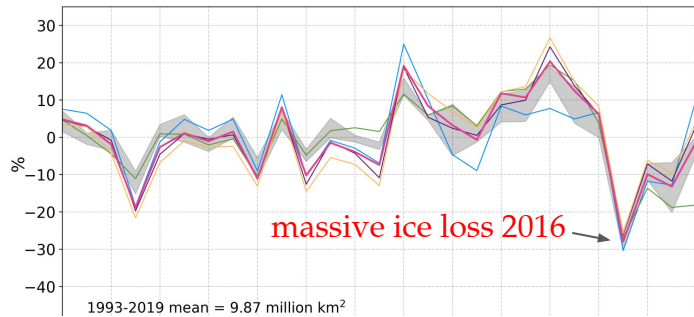
Interannual variability



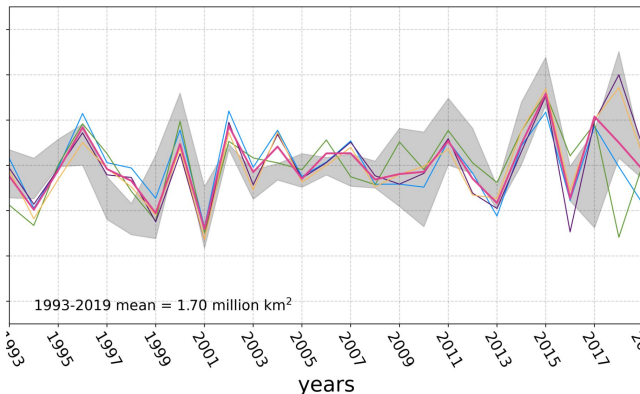
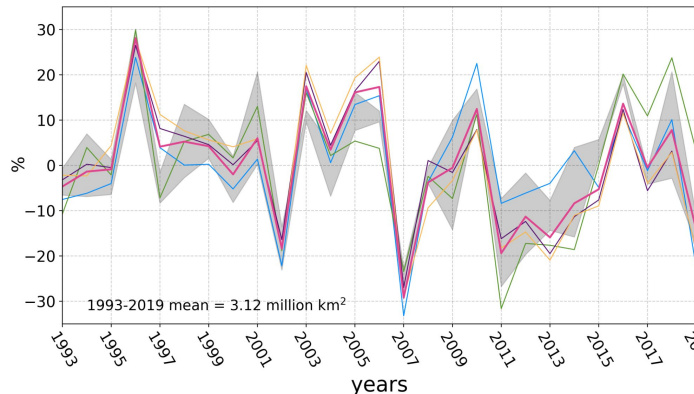
November (spring)

April (autumn)

Pack ice area



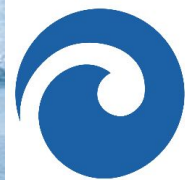
MIZ area



- difference between sea ice classes in long-term variability and its amplitude;
- higher observational uncertainty for the MIZ;
- less agreement between ORAs and observations for the MIZ;
- The biases are not constant throughout the period;
- less agreement between ORAs and observations when looking at the ice classes rather than total ice area.

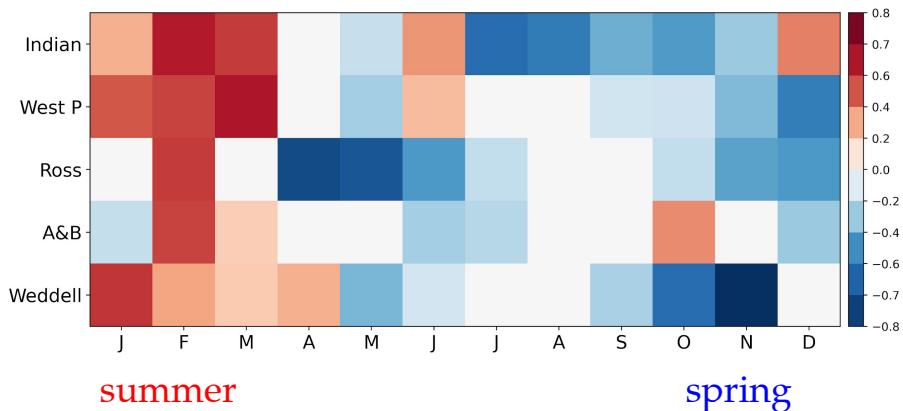
Anomalies expressed as a percentage of the mean value over the period. Gray shading is for observations.

Relation between MIZ and pack ice area on interannual scale



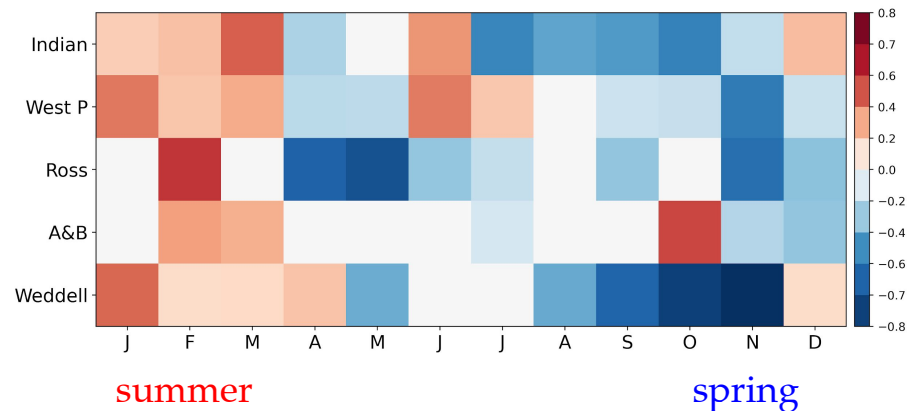
Correlation between time series of the pack ice and the MIZ area

CDR



(up to 0.65 in the Western Pacific) (up to -0.86 in the Weddell Sea)

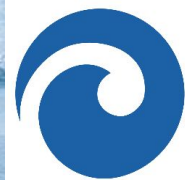
GREP



(up to 0.57 in the Ross Sea) (up to -0.91 in the Weddell Sea)

- Predominance of positive correlation in summer and negative in spring;
- Correlation depends on season and sub-region;
- Time-lagged correlation (up to 4 months) is the evidence of ice-ocean feedbacks;
- GREP reproduces stronger correlation in the Weddell Sea in winter-spring and weaker in summer.

Sea ice area trends 1993-2019 (lon x month)

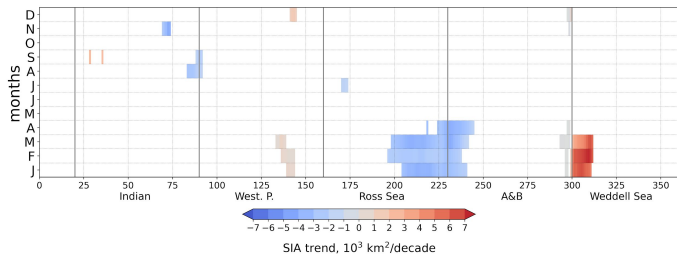


Total sea ice area

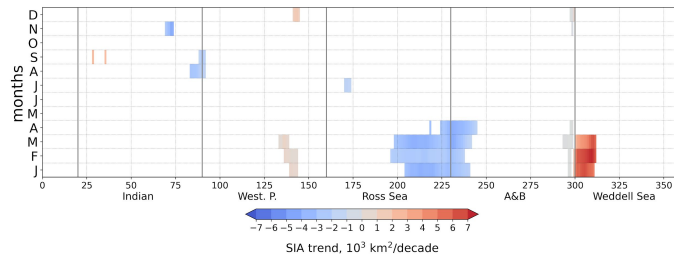
Pack ice area

MIZ area

CDR



GREP

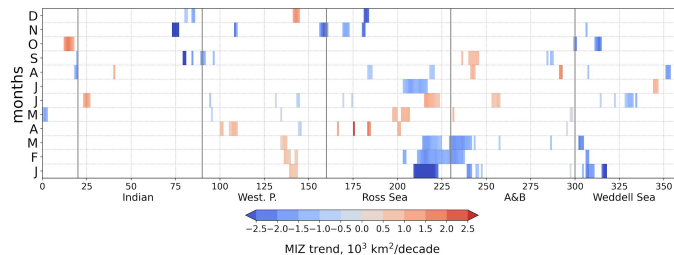
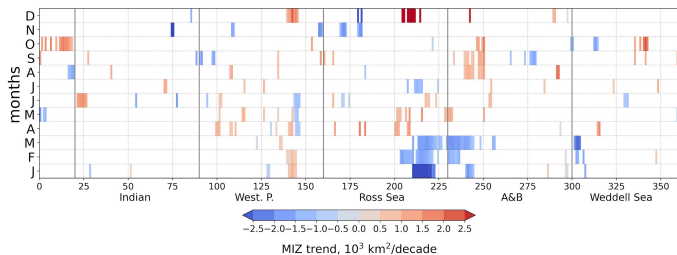
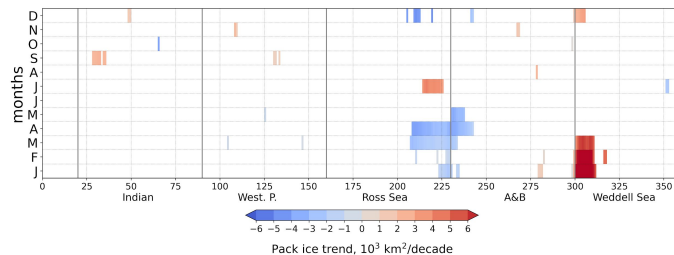
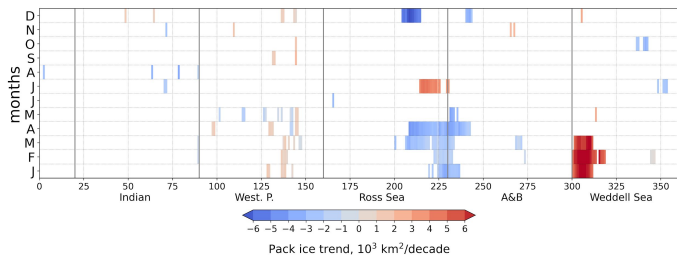


- GREP is well agreed with CDR in trends for total sea ice area;

- Inconsistency appears when looking at the ice classes;

- Total ice area conceals changes inside the ice cover;

- Different timing of trends for the MIZ and pack ice;





Conclusions



- GREP (and ORAs) reproduce well the hemispheric variability of sea ice area and generally agree with satellite estimates; further benefits from improvements in sea ice data assimilation and in the quality of remote sensing algorithms;
- the difference between pack ice and MIZ area variability on seasonal and interannual scale;
- predominance of positive correlation between pack ice and MIZ area in summer and negative in spring;
- time-lagged correlation and different timing of linear trends for ice classes indicate ice-ocean feedbacks.

Thank you for your attention!