Impact of satellite data assimilation in atmospheric reanalysis on the wind and wave climate

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Background and purpose

Homogeneity in marine meteorological data is essential to assess the marine wind and wave climate accurately. However, meteorological observation records suffer from temporal inhomogeneity due to changes in observational instruments or methods.

Observations

- Inhomogeneity in marine wind speeds from ship reports due to changing measurement methods and measurement heights (Thomas et al. 2005; 2008)

Background and purpose (cont.)

<u>Atmospheric reanalysis</u>

- Inhomogeneity in near-surface wind speed in reanalysis (e.g. Cox and Swail 2001; Krueger et al. 2013)

<u>Wave data</u>

- Inhomogeneity in significant wave height in ERA-40 (Caires and Sterl 2005) and Voluntary Observed Ship data (Gulev et al. 2003)

Inhomogeneity potentially exists in marine meteorological data, which could lead to erroneous interpretation of a historical climate state.

Background and purpose (cont.)

- Japan Meteorological Agency produced state-of-the-art atmospheric reanalysis, JRA-55 and JRA-55C
- JRA-55C is based on the same atmospheric model and assimilation scheme as the JRA-55 but assimilates conventional data (e.g. in-situ surface observations) only.

The purpose of this study is to investigate

impact of satellite data assimilation (SDA) on the wave climate using JRA-55 and JRA-55C.

Model, experimental design, and datasets

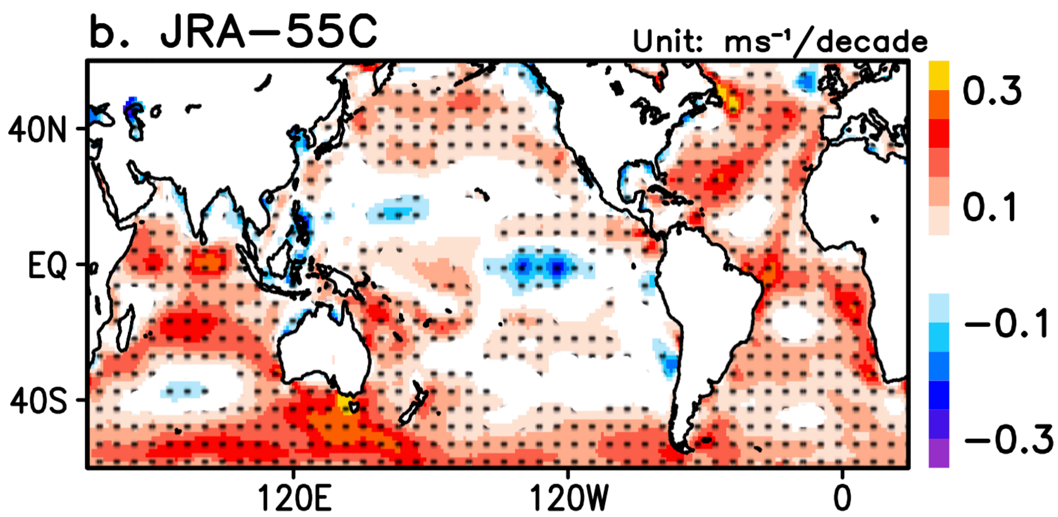
WaveWATCH III (Tolman, 2014)	
lodel domain	0-360E, 78S-78N
lorizontal nesh	1.25 deg. x 1.25 deg.
eriod	1958-2012
utputs	Wave energy flux (WEF) $=\rho_w \iint C_g E(f,\theta)d\theta df$ $\approx 0.5 H_s^2 T_e$

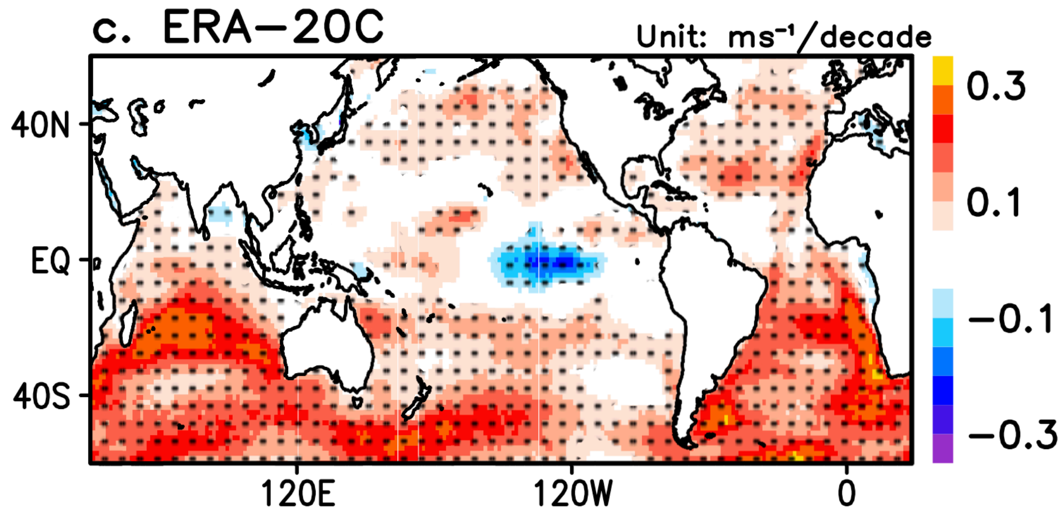
Name of experiment	Wind forcing
Exp. A	**JRA-55** (Kobayashi et al. 2015) • conventional observations since 1958 • satellite observations since 1973 e.g. IR sounders since 1973 scatterometer ocean surface winds since 1
Exp. B	**JRA-55C** (Kobayashi et al. 2014) • conventional observations since 1958 • no assimilation of satellite observations

- Near–surface wind and significant wave height in ERA-20C (et al. 2013)

Validity of JRA-55C wind

Trend of the annual mean of near-surface wind speed (1959-2012)

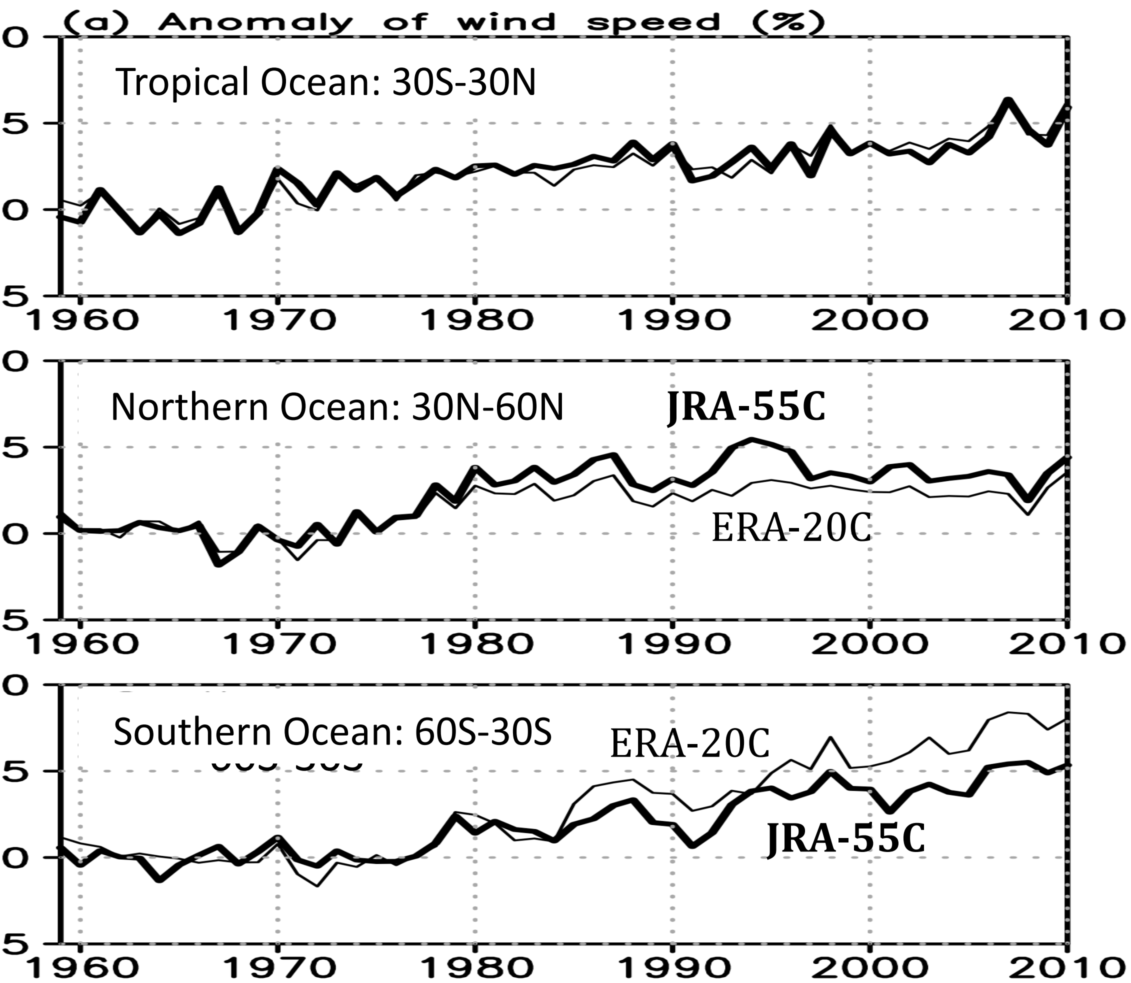




- The trend of wind speed in JRA-55C is similar to that of ERA-20C.
- Upward trend in the mid-latitudes in the Northern and Southern Hemispheres.
- Downward trend in the central-eastern equatorial Pacific

Validity of JRA-55C wind (cont.)

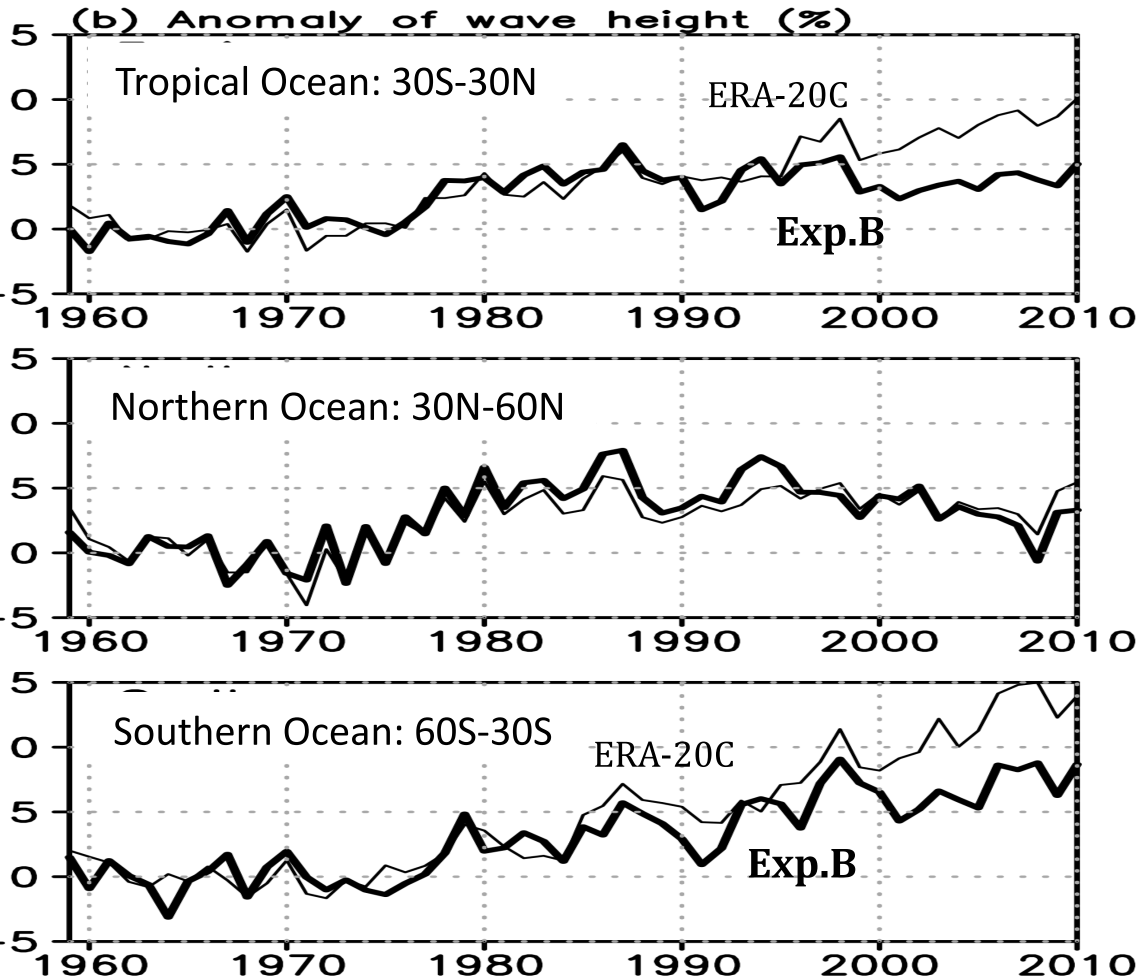
omalies of near-surface wind speed (base period: 1959-1972)



- The average wind speed of the tropical ocean has been gradually increasing since 1970.
- The wind speed in the Northern Ocean has increased since 1970, although there is stagnatio after 1980.
- The wind speed in the Southern Ocean has been increasing, although there is a difference in the wind speed between JRA-55C and ERA-20C.
- Long-term trends in the near-surface wind speed in JRA-55C are qualitatively similar to those in ERA-20C.

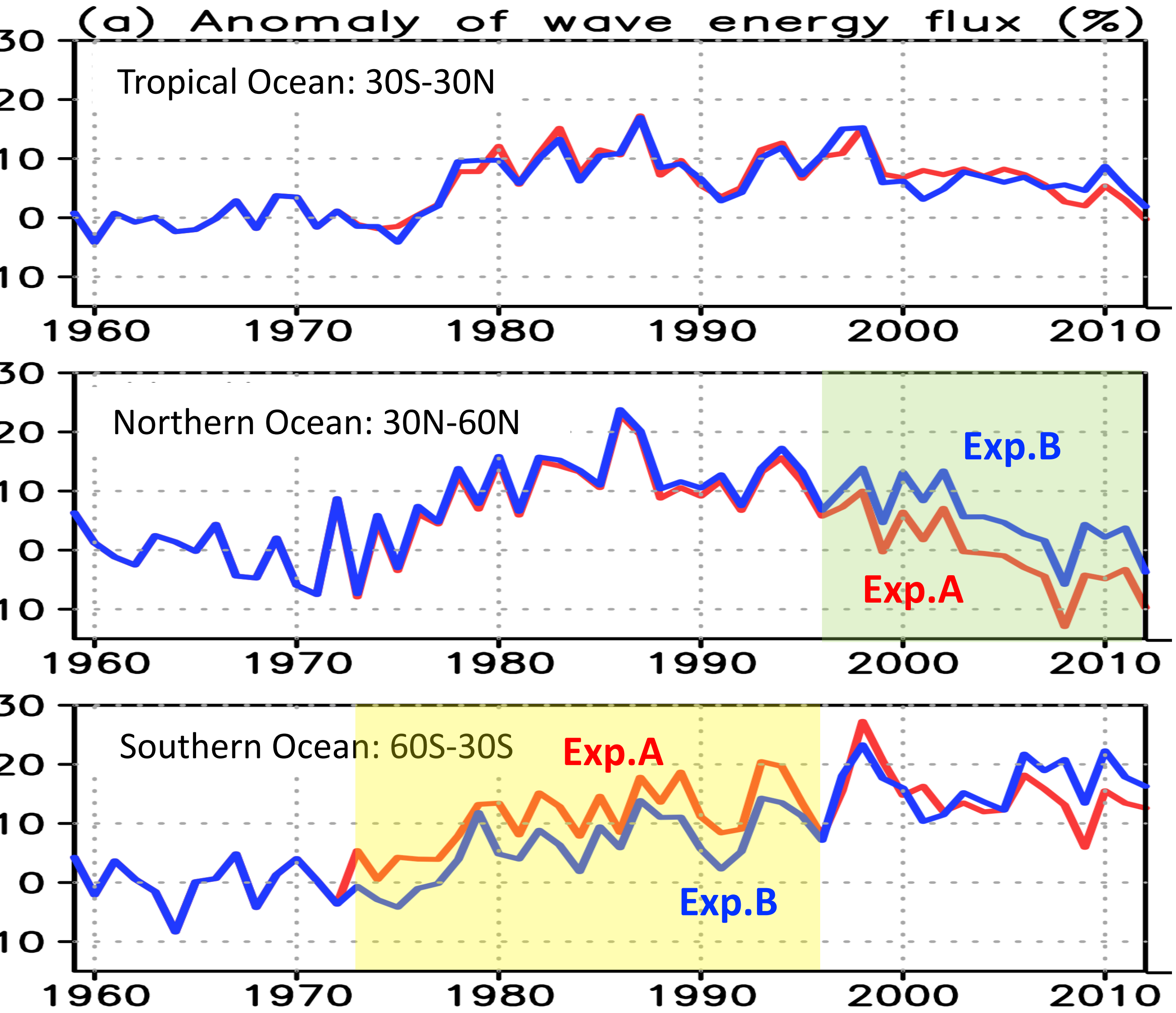
Validity of JRA-55C wind (cont.)

Anomalies of significant wave height (base period:1959-1972)



- SWH after 1980 is greater than that in the 1960s in all basins.
- Consistent with the near-surface wind speed
- The temporal variability of the near-surface wind speed in JRA-55C and SWH in Exp.B is generally consistent with that of ERA-20C.

How does SDA affect wave climate?

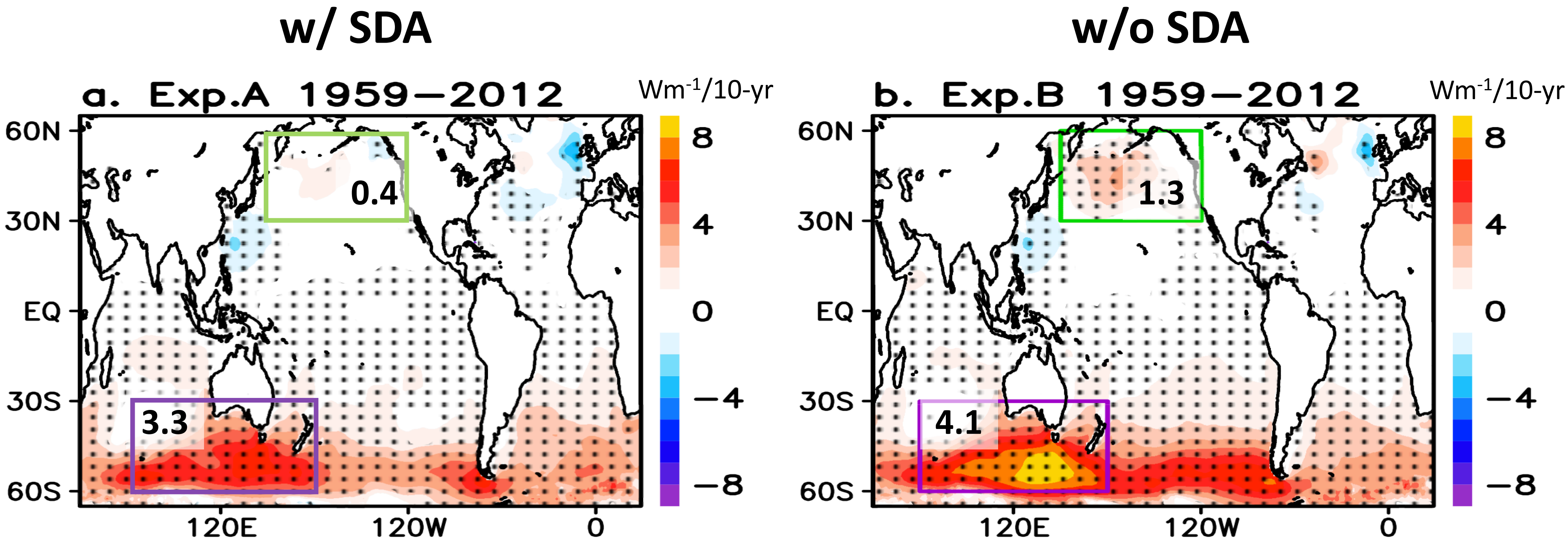


There is no significant difference in WEF in the tropical ocean due to the SDA.

WEF in the Northern Ocean is decreased after the mid-1990s due to the SDA.

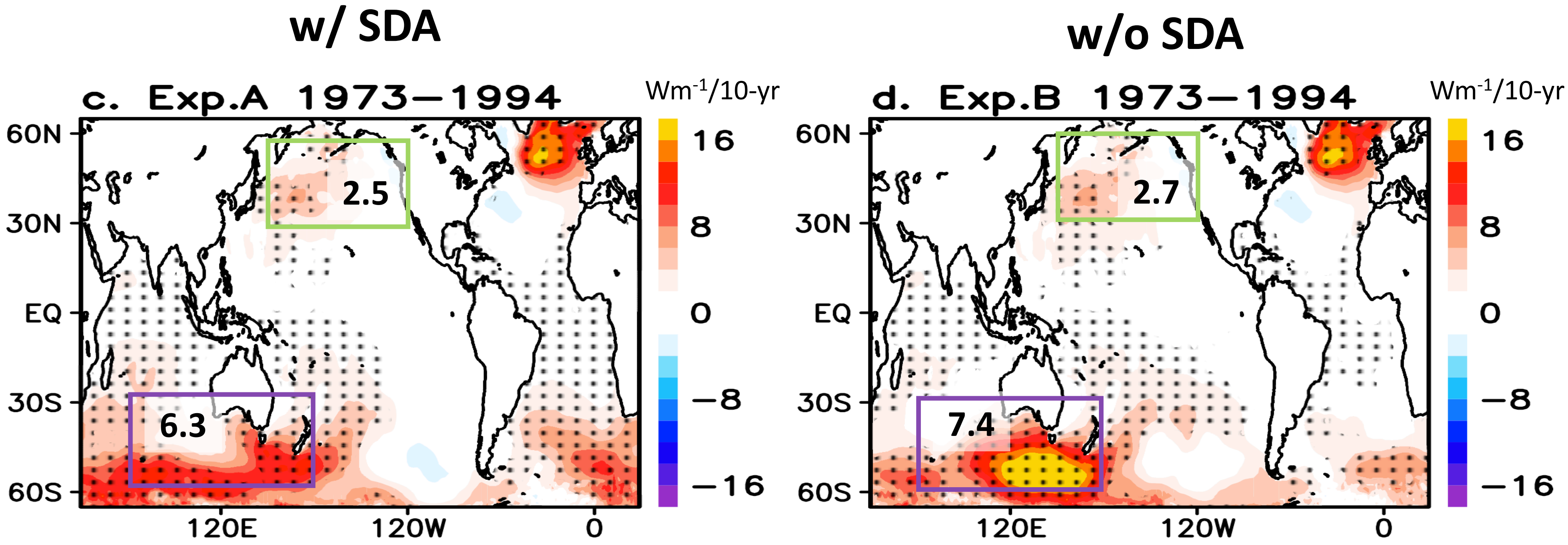
WEF in the Southern Ocean is increased from 1973 to the mid-1990s by the SDA.

SDA changes WEF trend



- Upward trends of the WEF in the mid-latitude North Pacific and Southern Ocean in Exp.B
- The upward trends are reduced.
- e.g. 18% reduction of the trend in the south of Australia

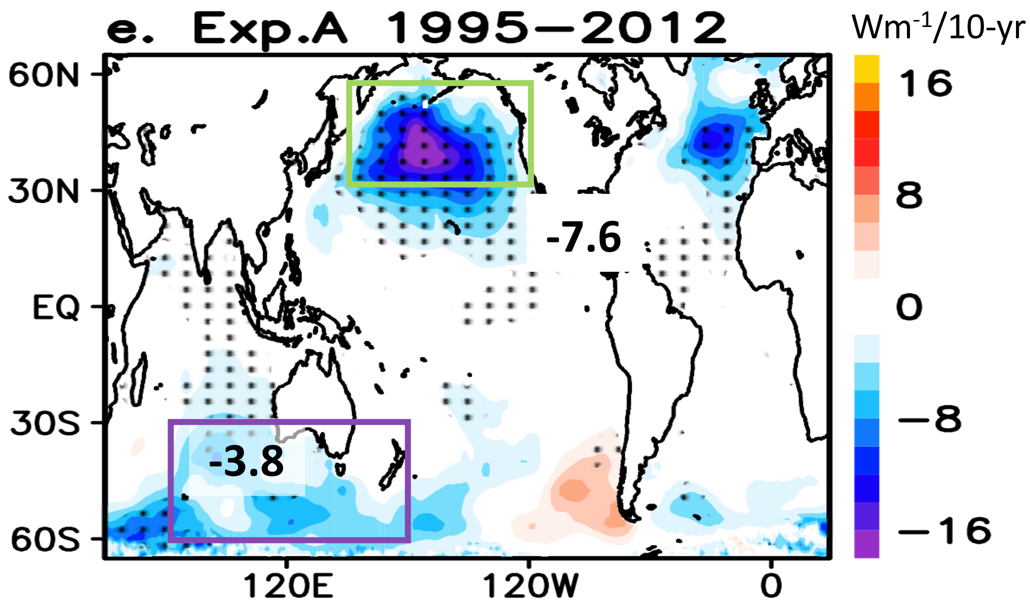
SDA changes WEF trend (cont.)



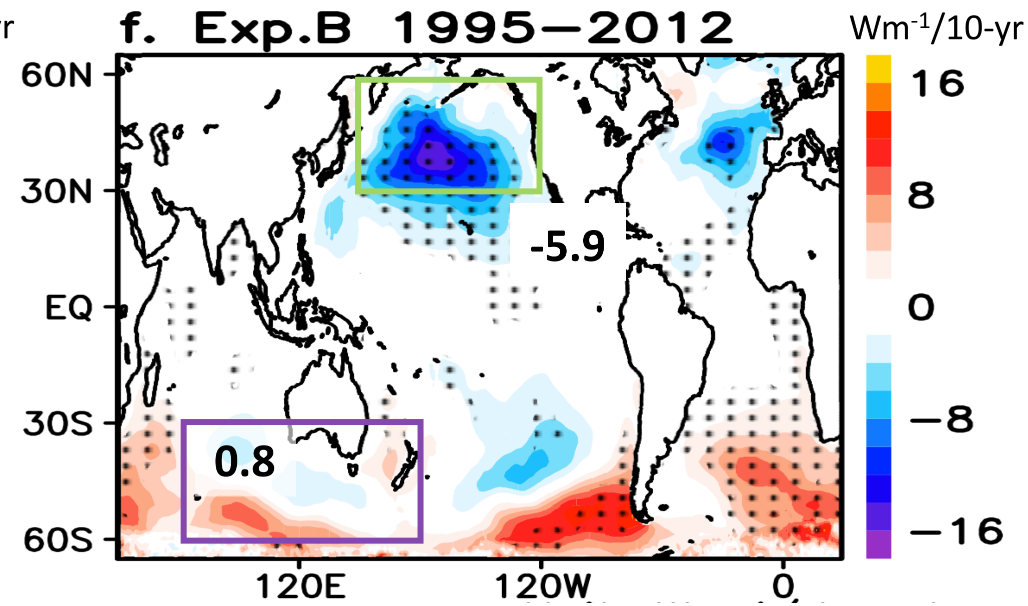
- Assimilation of satellite radiance
- The SDA has no major effect on the trend of WEF in the mid-latitude North Pacific.
- The upward trend of the WEF in the south of Australia is reduced by the SDA.

SDA changes WEF trend (cont.)

w/ SDA

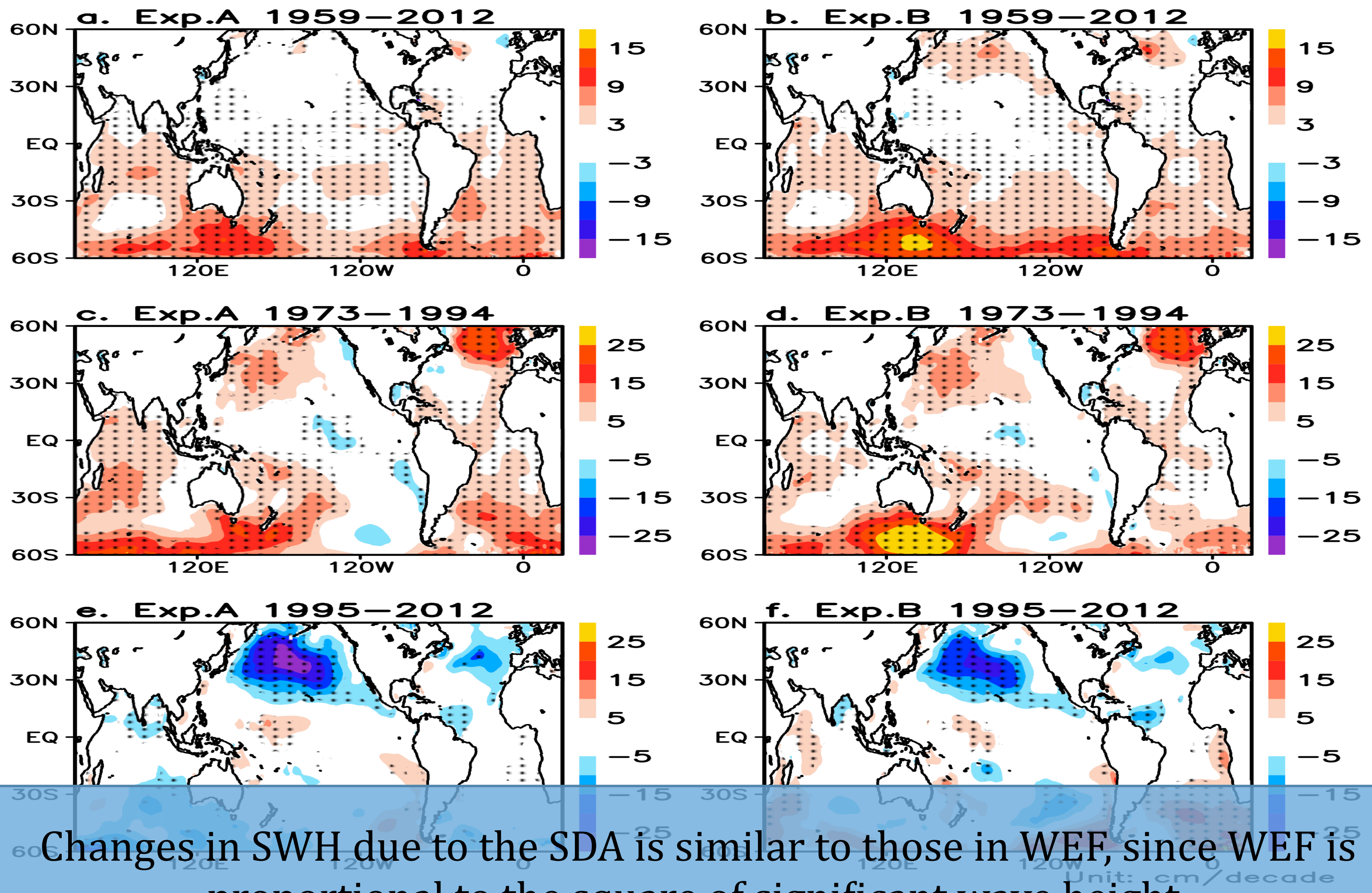


w/o SDA



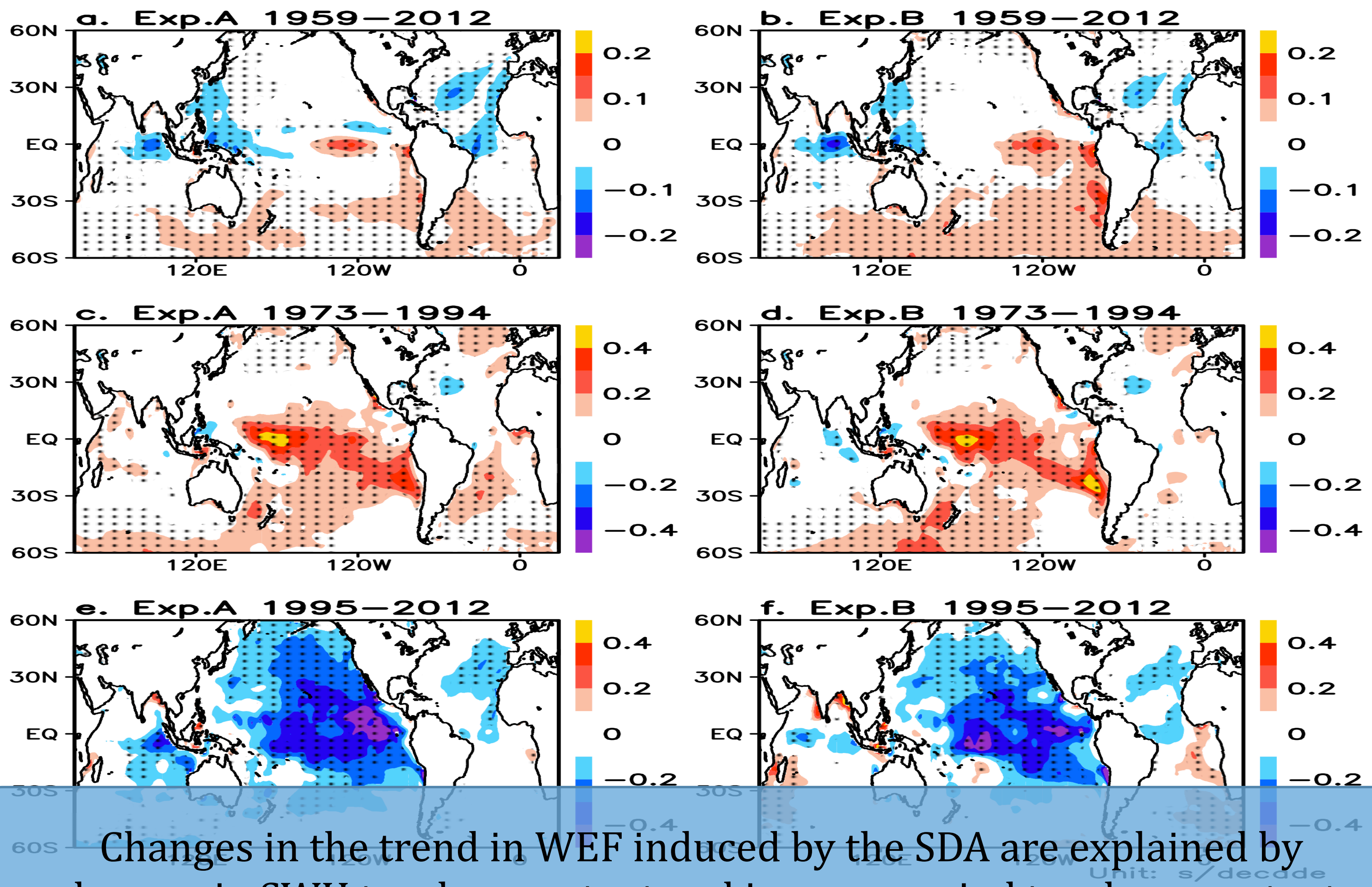
- Assimilation of satellite radiance and scatterometer winds
- The downward trend in the mid-latitude North Pacific is enhanced by 20% due to the SDA.
- The trend in the western south of Australia is reduced by the SDA.

Impact of SDA on trends in SWH



Changes in SWH due to the SDA is similar to those in WEF, since WEF is proportional to the square of significant wave height.

Impact of SDA on trends in wave period

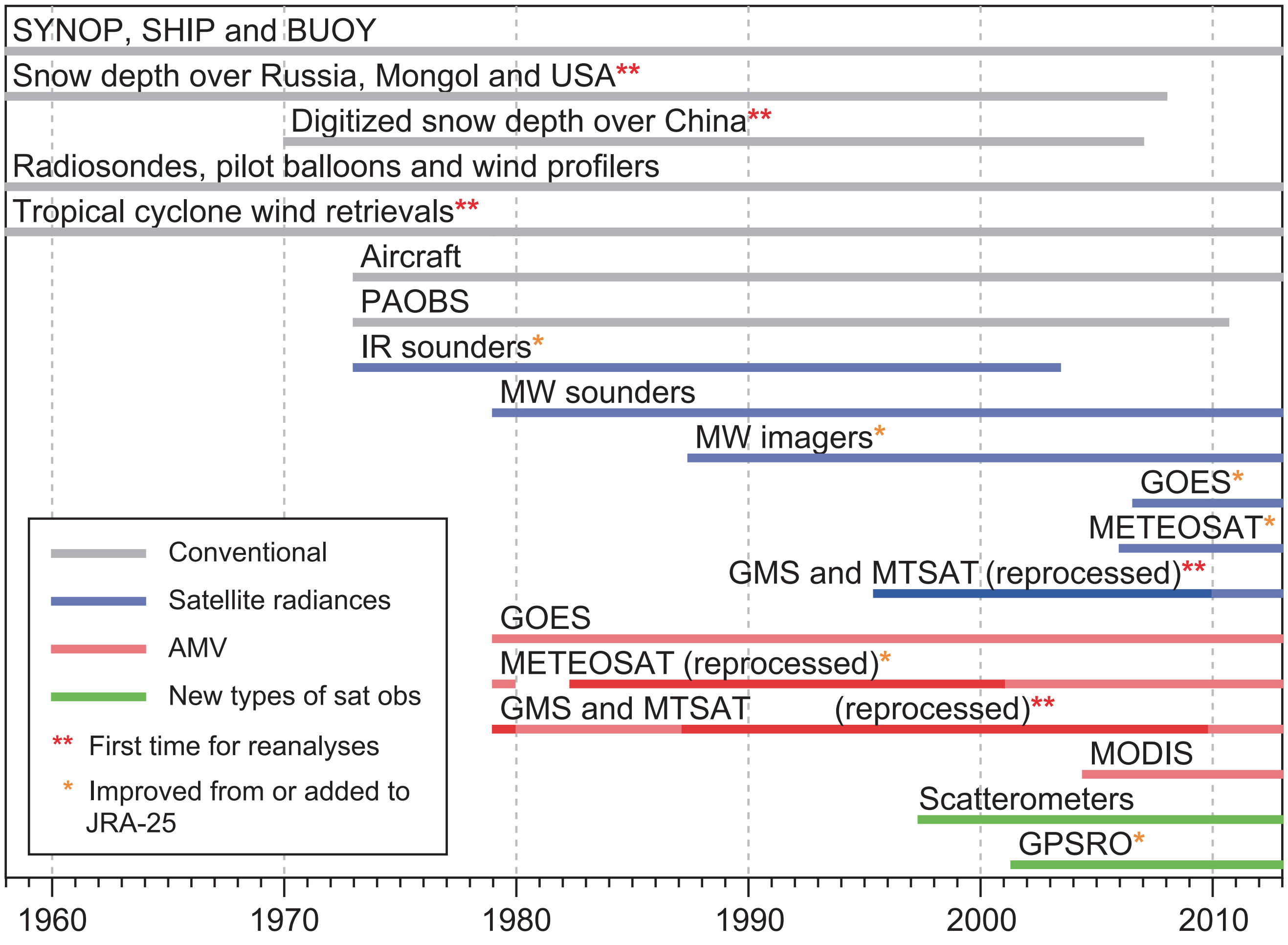


Changes in the trend in WEF induced by the SDA are explained by changes in SWH to a large extent and in wave period to a lesser extent.

Summary

- We investigated the impact of the presence or absence of the SDA after 1973 on wind and wave climate by comparing two experiments using WW3, forced by near-surface winds of the JRA-55 and JRA-55C.
- The SDA affected the trends of wind speed and WEF for two decades (1973-1994; 1995-2012) as well as for the last half century (1959-2012).
- In the mid-latitude North Pacific, the assimilation of satellite radiance from 1973 to 1994 had no major effect on the trend of WEF, while the assimilation of satellite radiance and scatterometer ocean wind measurements after the mid-1990s reduced the trend of WEF. The latter resulted in the reduced trend of the WEF during 1959-2012.
- In the Southern Ocean south of Australia, the assimilation of satellite radiance from 1973 to 1994 reduced the trend of the WEF. The SDA after the mid-1990s also reduced the trend of the WEF.

Additional slides



Ebita et al. 2011