Efforts to develop climate models and to reflect the knowledge in the adaptation plans

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representing the research team in MRI for modeling and understanding climate change from global to regional scale

TOUGOU

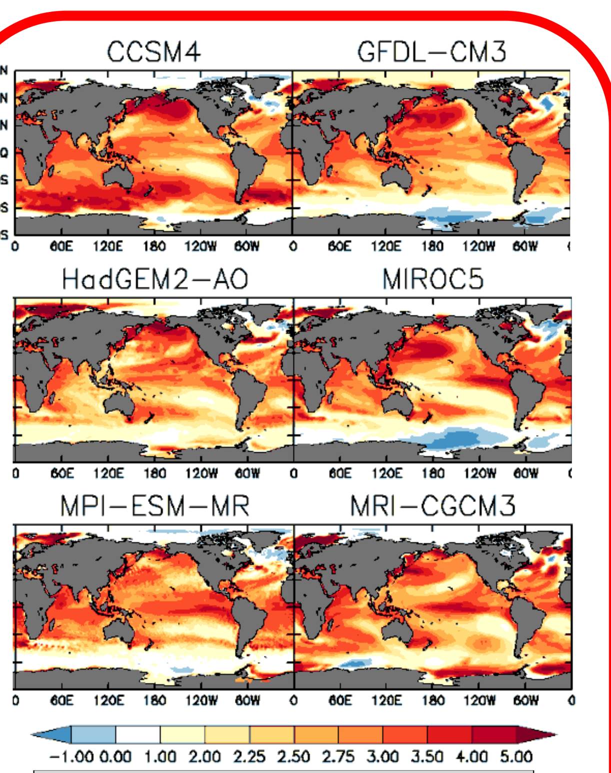
Abstract. *The Meteorological Research Institute (MRI) of the Japan Meteorological Agency has been involved in research themes that use high-resolution and precise global and regional climate models to describe "possible future scenarios" which include probability information on climate change and weather phenomena in and around Japan by developing methods for statistical analysis and assessment. In this study, we aim to contribute to formulating countermeasures against future weather/climate-related disasters, in particular adaptation plans at national and local levels. In this regard, we introduce and demonstrate recent outcomes under the above research themes, such as event attribution for extreme weather phenomena and climate projections by the Atmospheric/Oceanic (TSE-C) model. Then, we exchange views on expectations and prospects with users and policymakers.*

Database for policy decision making for future climate changes (d4PDF)

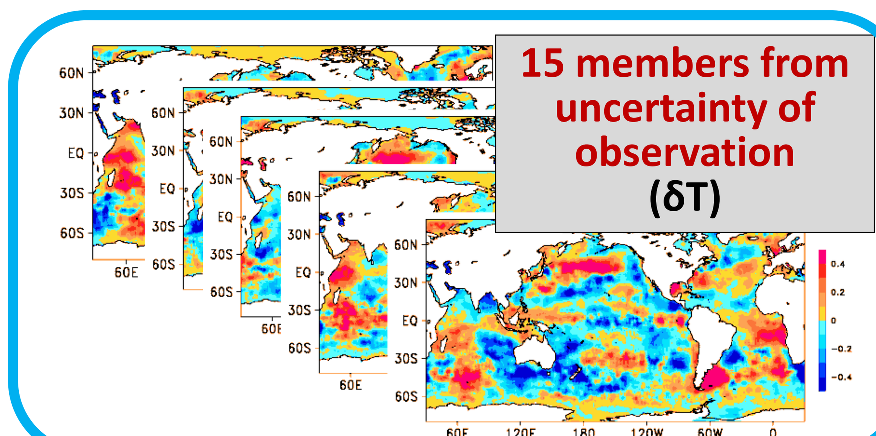
Mega ensemble dataset based on global/regional atmospheric models

- historical past, warming (+1.5, +2, +4°C), non-warming (1850 condition)
  - Each has 60-year duration, 90–100 ensemble members.
  - historical: observed SST, GHG, 3-d distributions of modeled ozone and aerosols
  - warming: blended CMIP5-SST increase + observed SST product (see below)
    GHG and aerosol/ozone at 2030(+1.5°C), 2040(+2°C), 2090(+4°C) of RCP8.5
  - non-warming: SST (1900-1919), GHG/aerosol (1850), ozone (1960-1962)
- Present climate is reproduced well by prescribing sea surface temperature and sea ice.

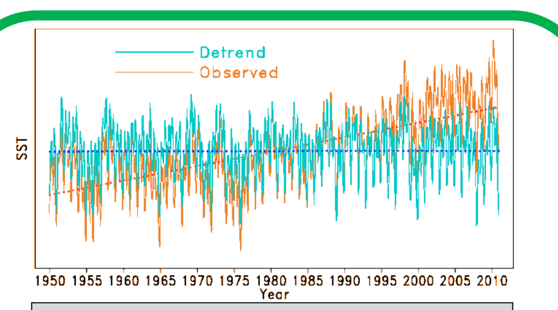
Mizuta et al. (2017)
Fujita et al. (2019)
Nosaka et al. (2020)
Ishii and Mori (2020)



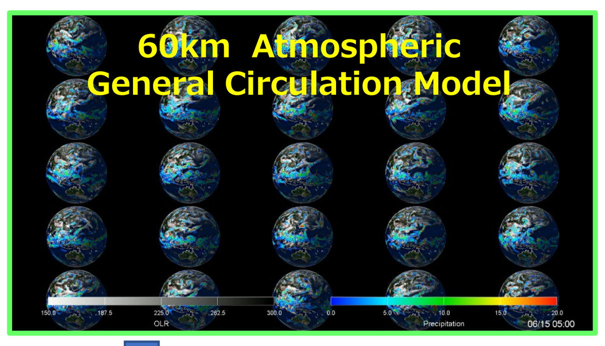
6 CMIP5 models sea surface temperature increase pattern (ΔT)



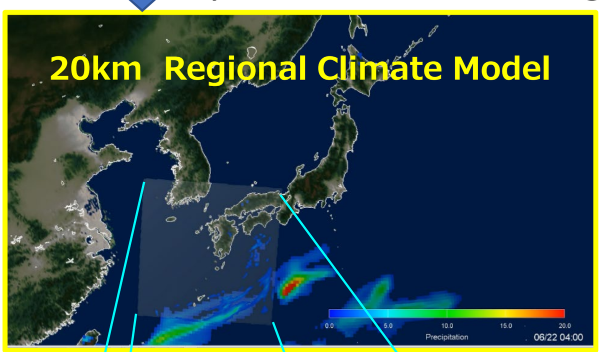
15 members from uncertainty of observation (δT)



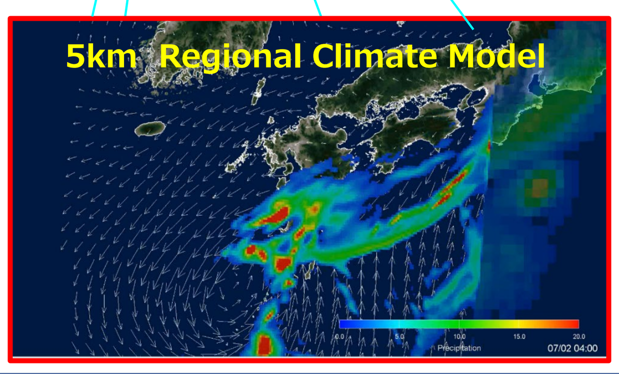
Added to detrended COBE-SST2 observation (blue line)



dynamical downscaling

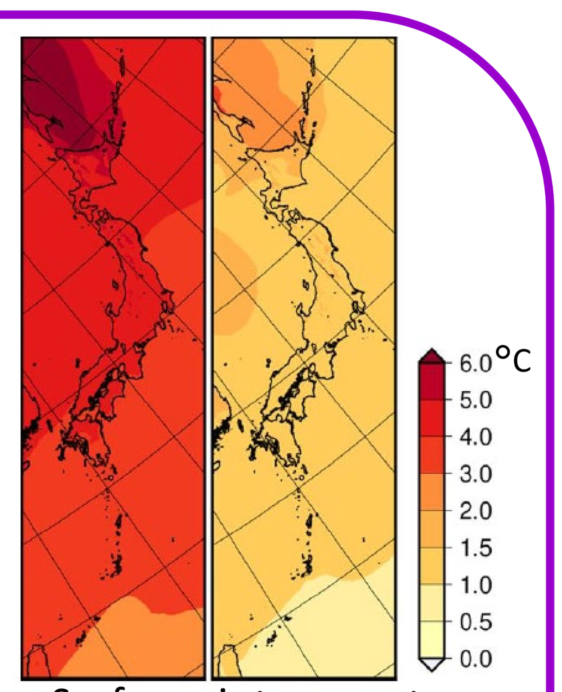


further downscaling for some cases

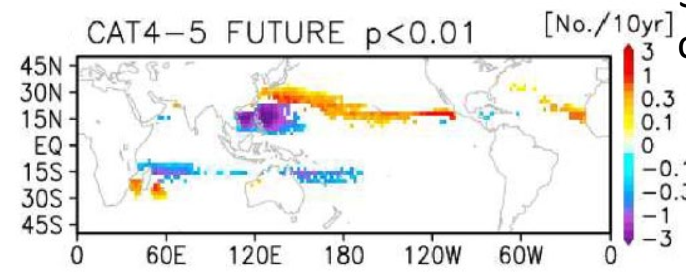


Used in the national assessment report for climate change

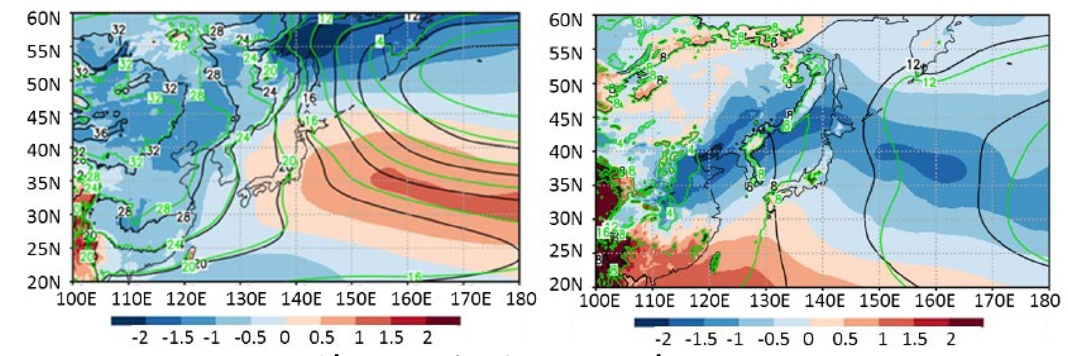
"Climate Change in Japan 2020"



Surface air temperature change: +4°C and +2°C



← Change in occurrence frequency of intense Tropical Cyclones (Yoshida et al., 2017)



Change in Sea Level Pressure in winter (left) and summer (right)

Event attribution
for developing adaptation plans

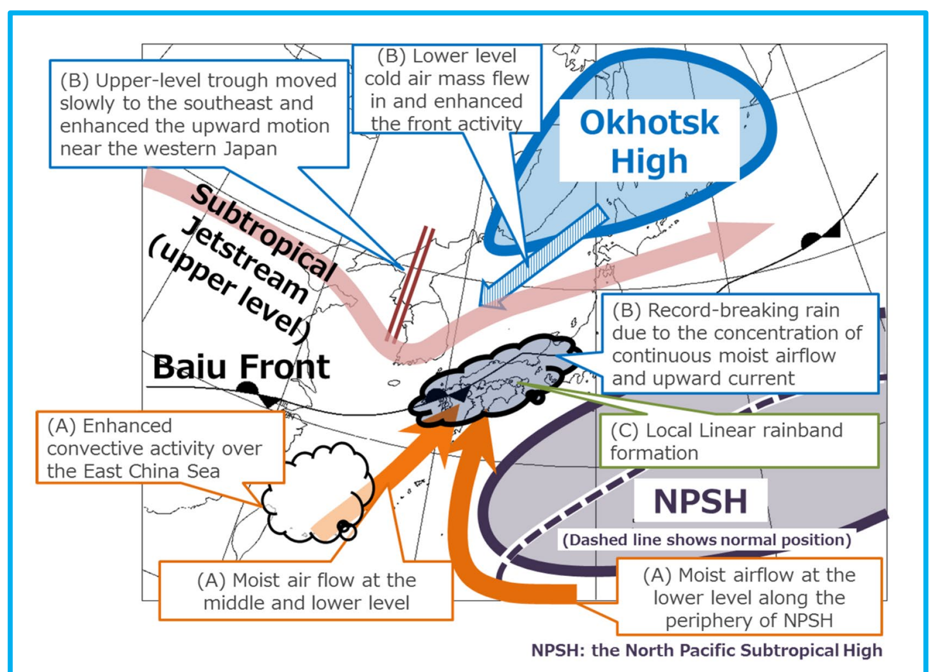
Here we introduce two types of approach to produce information of climate hazard using two recent devastating rainfall events.

- **Risk based EA**: **Mega ensemble simulation** (such as d4PDF) is used to evaluate how anthropogenic climate change has altered the **probability of occurrence** of specific extreme events.
- **Storyline EA**: **Pseudo global (non-)warming (PGW)** approach is used to simulate specific extreme events in detail (e.g., by using reanalysis and regional climate model (RCM)) and to evaluate how anthropogenic climate change has altered **severity (i.e., magnitude or intensity)** of those events.

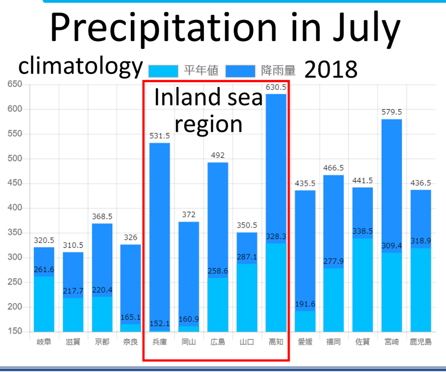
Risk based approach

Heavy rain event of July 2018 in Japan (Imada et al., 2020)

Statistical analysis for 100-member ensemble historical/non-warming simulation of **d4PDF (GCM 60km and RCM 20km)** for summer 2018.

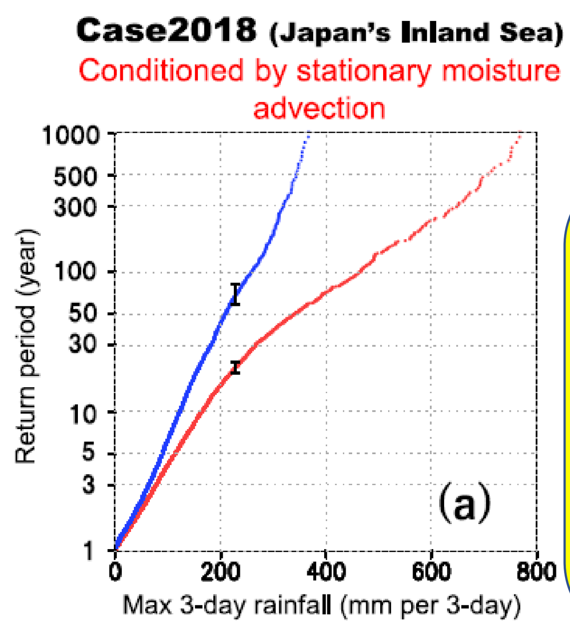


Precipitation in July



Record breaking casualties and damages!

Event	Jul 2018 heavy rain	Hagibis 2019
deaths	237	104
missing	8	3
total damage (billion USD)	9.6	14.7



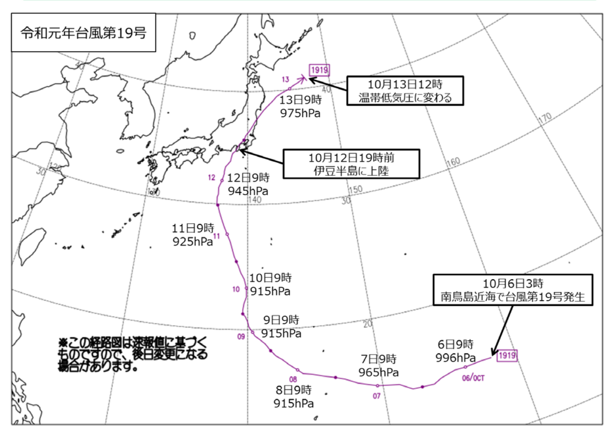
Return period of heavy rainfall. historical (red) vs non-warming (blue)

Both approaches are useful to clarify effect of climate change and thus are able to provide relevant data for users who intend to do risk assessment on climate change.

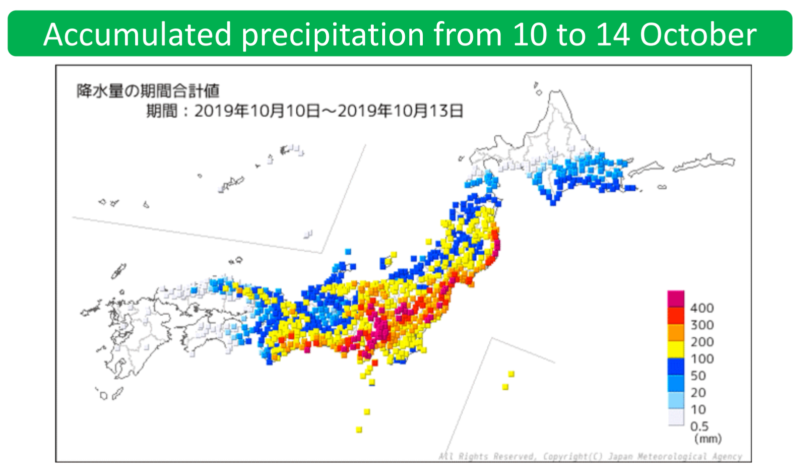
Storyline approach

Typhoon Hagibis (2019) (Kawase et al., 2021)

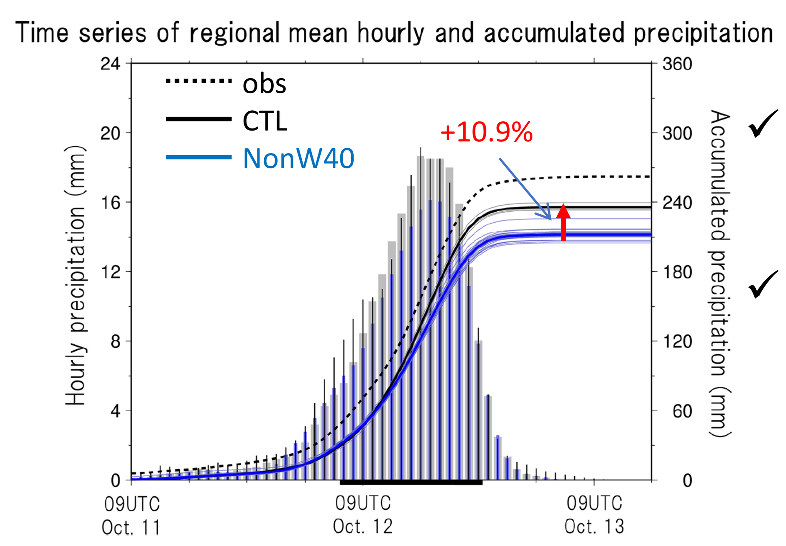
Typhoon's best track



Accumulated precipitation from 10 to 14 October



PGW approach: hindcast vs non-warming with 5 km RCM



- ✓ Each of CTL and NonW40 has 8 members differing in initial condition.
- ✓ Background environment for NonW40 is generated by detrending reanalysis data by 40 years.

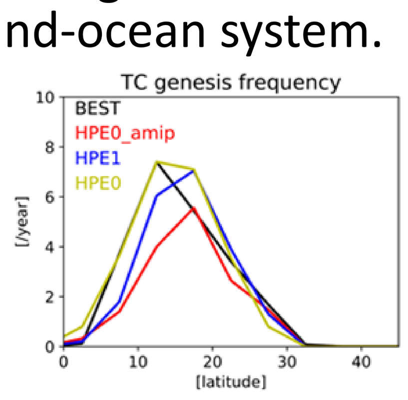
New framework for producing a next generation database

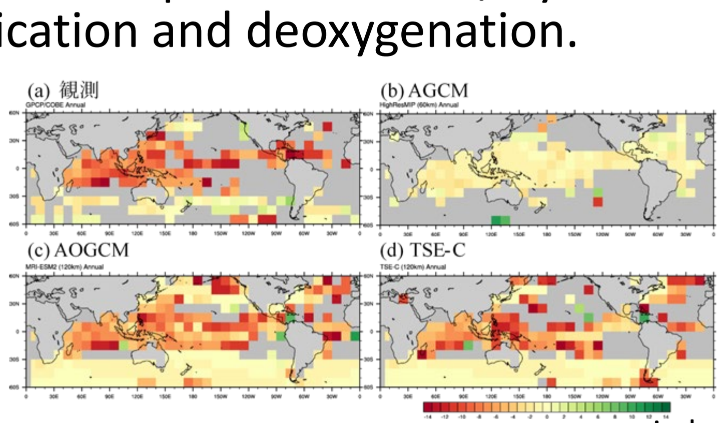
Goals

- More robust and actionable climate information.
- Time-sequential experiments with coupled model (TSE-C), that is, with **interactive ocean.**
- Detect overshooting and tipping points in the near future.
- Ocean downscaling with 10 km and 2 km resolutions, which can express Kuroshio/Oyashio.
- Ocean bio-geochemical variables for assessing ocean acidification and deoxygenation.
- Consistent changes in the atmosphere-land-ocean system.

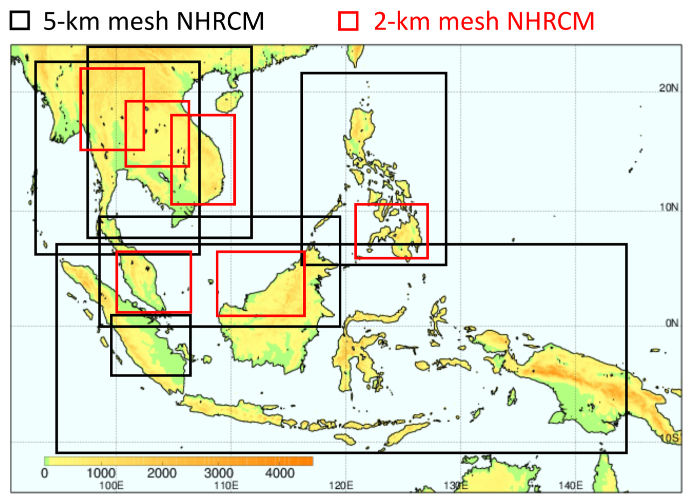
By introducing an interactive ocean, we have,

- ✓ higher genesis frequency of Tropical Cyclones in the lower latitudes as observed.
- ✓ more realistic lead-lag correlation between SST and precipitation anomalies.





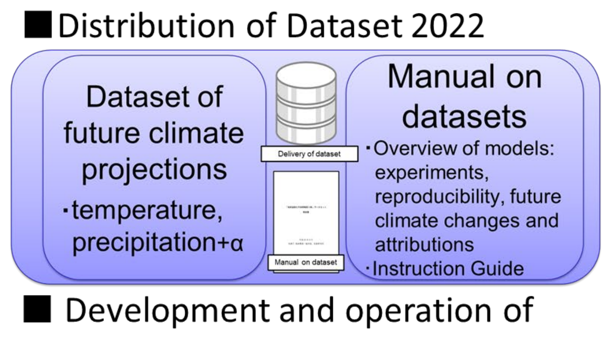
Application of the system to other regions by collaborating with experts from developing countries



Systematic promotion for use of datasets

A) Data distribution, tool development and operation

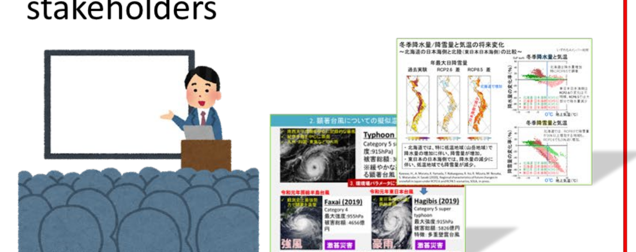
■ Distribution of Dataset 2022



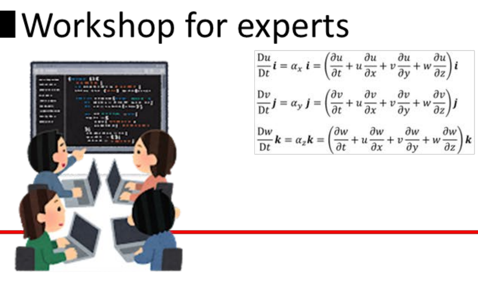
■ Development and operation of usage promotion tools

B) Communication promotion

■ Opinion exchange meeting for stakeholders



■ Workshop for experts



References:

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Yoshida et al. (2017)	doi:10.1002/2017GL075058
Fujita et al. (2019)	doi:10.1029/2018GL079885
Nosaka et al. (2020)	doi:10.1186/s40645-020-00341-3
Ishii and Mori (2020)	doi:10.1186/s40645-020-00367-7
Imada et al. (2020)	doi:10.1038/s41612-020-00141-y
Kawase et al. (2021)	doi:10.2151/sola.17A-002