Australian SAR Waves Dataset and Its Validation

2nd International Workshop on Waves, Storm Surges and Coastal Hazards

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IMOS

CSIRO

Outline

- Objective
- Australian SAR Waves Dataset
- Validation Against WW3 Hindcast
- Conclusions, Challenges and Outlook

Objective

Objective

- Develop a long-term, open-access database of well-calibrated satellite SAR wave observations
- Support Australian marine scientific and industrial community
- Feedback our Australian efforts into global initiatives

SAR Database of directional ocean swell spectra and partitions: swell Hs, period and direction

Australian SAR Waves Dataset

Australian SAR Waves Dataset

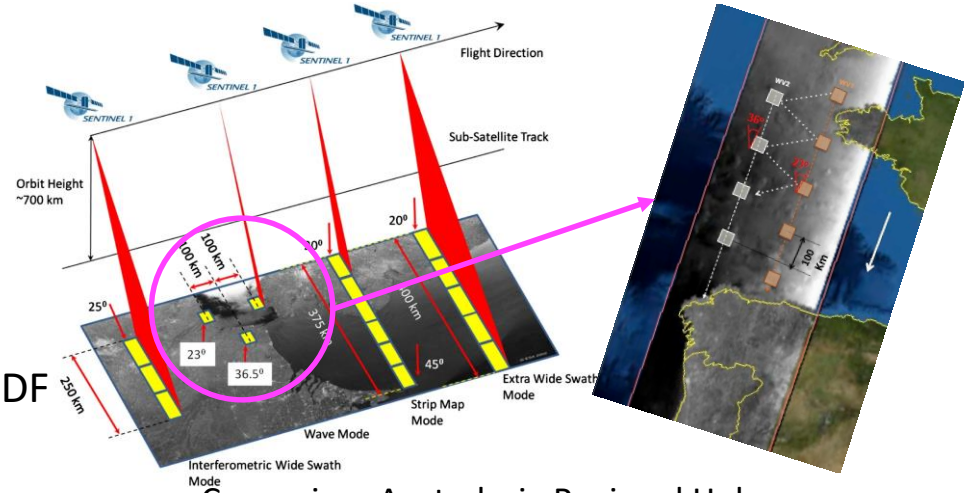
Satellites: Sentinel-1 A and B
Source: ESA Level-2 OCN wave mode data - http://www.copernicus.gov.au/ Copernicus Australasia regional hub

Delayed Mode Dataset

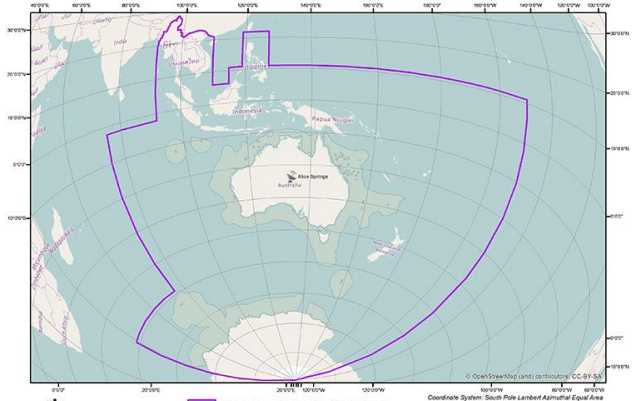
- Duration: July-2015 to May-2019
- Format: Daily/monthly along-track netCDF
- CF 1.6 & IMOS 1.4 compliant
- Processing time: ~1 day

NRT Dataset

- Latest 24 hours of SAR waves 6-hourly
- Same format and conventions
- Previous files archived
- Processing time:~few minutes



Copernicus Australasia Regional Hub



QA/QC Highlights

- Source data inconvenient: 1 netCDF/obs (~15k obs/month/plat.)
- Source data inconsistent: netCDF file structure changes such as:
  - Var missing, data type changes, dimension changes, var attributes partially defined

  All inconsistencies handled via trial and error
- Not CF compliant
- No consistent time variable
- WAVNUM coord changes over time
- Both WAVNUM and DIR coords sometimes exhibit floating point imprecisions
- Some erroneous measurements over land even after using land flag

Format of netCDF files

Dec 2016 monthly file

```
Dimensions:                (DIRECTION: 72, PARTITION: 5, TIME: 18807, WAVNUM: 60)
Coordinates:
  * DIRECTION              (DIRECTION) float32 0.0 5.0 10.0 ... 345.0 350.0 355.0
  * PARTITION              (PARTITION) int8 0 1 2 3 4
  * WAVNUM                 (WAVNUM) float32 0.005235988 0.00557381 ... 0.2094395
  * TIME                   (TIME) datetime64[ns] 2016-12-01T07:40:56 ... 2016-12-31T22:57:46
Data variables:
    AMBI_FAC_PART          (TIME, PARTITION) float32 ...
    AZ_CUTOFF              (TIME) float32 ...
    AZ_CUTOFF_DIR          (TIME, DIRECTION) float32 ...
    BOT_DEPTH              (TIME) float32 ...
    DP_PART                (TIME, PARTITION) float32 ...
    EKTH                   (TIME, DIRECTION, WAVNUM) float32 ...
    EKTH_PART              (TIME, DIRECTION, WAVNUM) int8 ...
    EKTH_quality_control   (TIME, DIRECTION, WAVNUM) int8 ...
    HEADING                (TIME) float32 ...
    HS_PART                (TIME, PARTITION) float32 ...
    HS_WIND_SEA            (TIME) float32 ...
    INC_ANGLE              (TIME) float32 ...
    INV_CONF_PART          (TIME, PARTITION) int8 ...
    INV_WAVE_AGE           (TIME) float32 ...
    LAND_COVERAGE          (TIME) float32 ...
    LATITUDE               (TIME) float32 ...
    LONGITUDE              (TIME) float32 ...
    NRCS                   (TIME) float32 ...
    POLARISATION           (TIME) object ...
    RG_CUTOFF              (TIME) float32 ...
    SNR                    (TIME) float32 ...
    SOURCE_NETCDF          (TIME) object ...
    SOURCE_SAFE            (TIME) object ...
    WDIR_ECMWF             (TIME) float32 ...
    WDIR_SAR               (TIME) float32 ...
    WP_PART                (TIME, PARTITION) float32 ...
    WSPD_ECMWF             (TIME) float32 ...
    WSPD_SAR               (TIME) float32 ...
```

Concat data along TIME

- Daily
- Monthly
- Yearly
- All data

All consistent vars from OCN Level-2 included

Wavenumber spectra

```
Dimensions:                (DIRECTION: 72, PARTITION: 5, TIME: 18807, WAVNUM: 60)
Coordinates:
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  * WAVNUM                 (WAVNUM) float32 0.005235988 0.005573
  * TIME                   (TIME) datetime64[ns] 2016-12-01T07:4
Data variables:
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    AZ_CUTOFF_DIR          (TIME, DIRECTION) float32 ...
    BOT_DEPTH              (TIME) float32 ...
    DP_PART                (TIME, PARTITION) float32 ...
    EKTH                   (TIME, DIRECTION, WAVNUM) float32 ...
    EKTH_PART              (TIME, DIRECTION, WAVNUM) int8 ...
    EKTH_quality_control   (TIME, DIRECTION, WAVNUM) int8 ...
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    HS_WIND_SEA            (TIME) float32 ...
    INC_ANGLE              (TIME) float32 ...
    INV_CONF_PART          (TIME, PARTITION) int8 ...
    INV_WAVE_AGE           (TIME) float32 ...
    LAND_COVERAGE          (TIME) float32 ...
    LATITUDE               (TIME) float32 ...
    LONGITUDE              (TIME) float32 ...
    NRCS                   (TIME) float32 ...
    POLARISATION           (TIME) object ...
    RG_CUTOFF              (TIME) float32 ...
    SNR                    (TIME) float32 ...
    SOURCE_NETCDF          (TIME) object ...
    SOURCE_SAFE            (TIME) object ...
    WDIR_ECMWF             (TIME) float32 ...
    WDIR_SAR               (TIME) float32 ...
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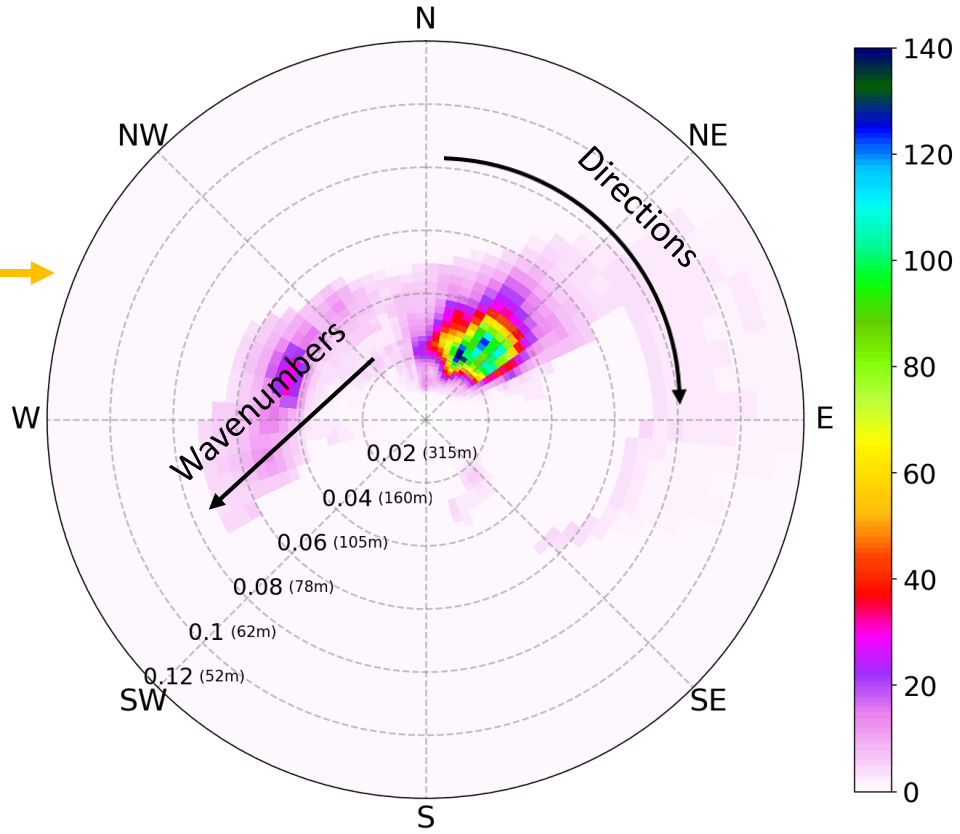
    WSPD_ECMWF             (TIME) float32 ...
    WSPD_SAR               (TIME) float32 ...
```



Partition Bulks

```
Dimensions:                (DIRECTION: 72, PARTITION: 5, TIME: 18807, WAVNUM: 60)
Coordinates:
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    BOT_DEPTH              (TIME) float32 ...
    DP_PART                (TIME, PARTITION) float32 ...
    EKTH                   (TIME, DIRECTION, WAVNUM) float32 ..
    EKTH_PART              (TIME, DIRECTION, WAVNUM) int8 ...
    EKTH_quality_control   (TIME, DIRECTION, WAVNUM) int8 ...
    HEADING                (TIME) float32 ...
    HS_PART                (TIME, PARTITION) float32 ...
    HS_WIND_SEA            (TIME) float32 ...
    INC_ANGLE              (TIME) float32 ...
    INV_CONF_PART          (TIME, PARTITION) int8 ...
    INV_WAVE_AGE           (TIME) float32 ...
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    LATITUDE               (TIME) float32 ...
    LONGITUDE              (TIME) float32 ...
    NRCS                   (TIME) float32 ...
    POLARISATION           (TIME) object ...
    RG_CUTOFF              (TIME) float32 ...
    SNR                    (TIME) float32 ...
    SOURCE_NETCDF          (TIME) object ...
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    WDIR_ECMWF             (TIME) float32 ...
    WDIR_SAR               (TIME) float32 ...
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    WSPD_ECMWF             (TIME) float32 ...
    WSPD_SAR               (TIME) float32 ...
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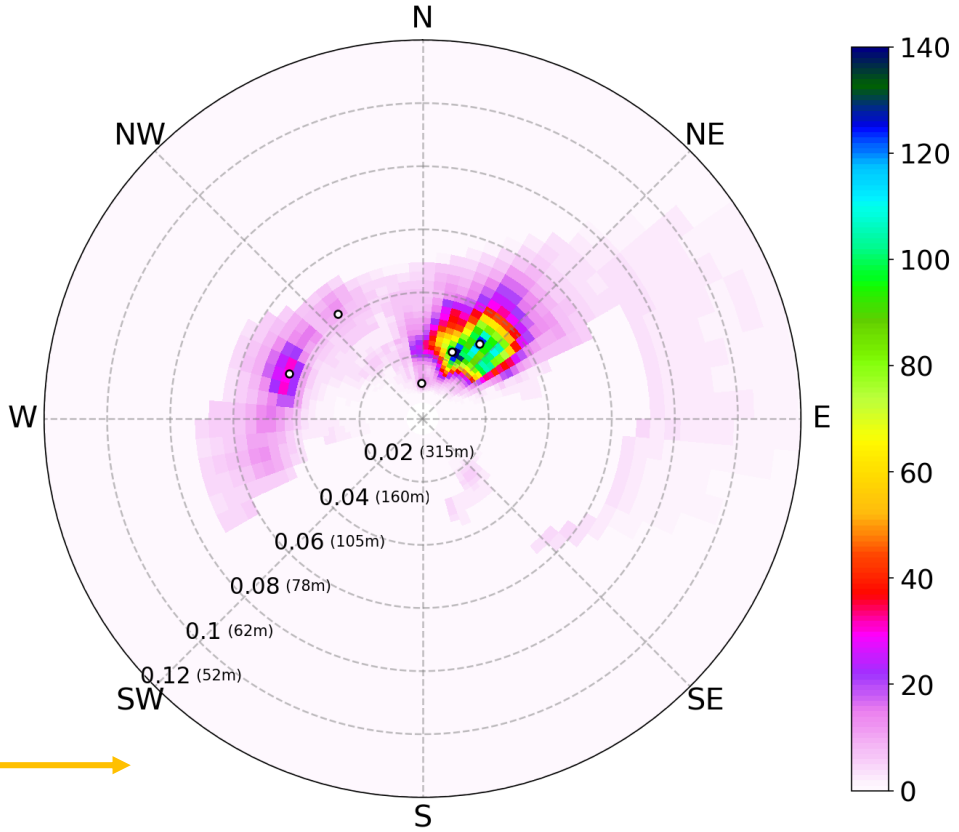

180° Directional Ambiguity

```
Dimensions:                (DIRECTION: 72, PARTITION: 5, TIME: 18807, WAVNUM: 60)
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  * WAVNUM                 (WAVNUM) float32 0.005235988 0.005573
  * TIME                   (TIME) datetime64[ns] 2016-12-01T07:4
Data variables:
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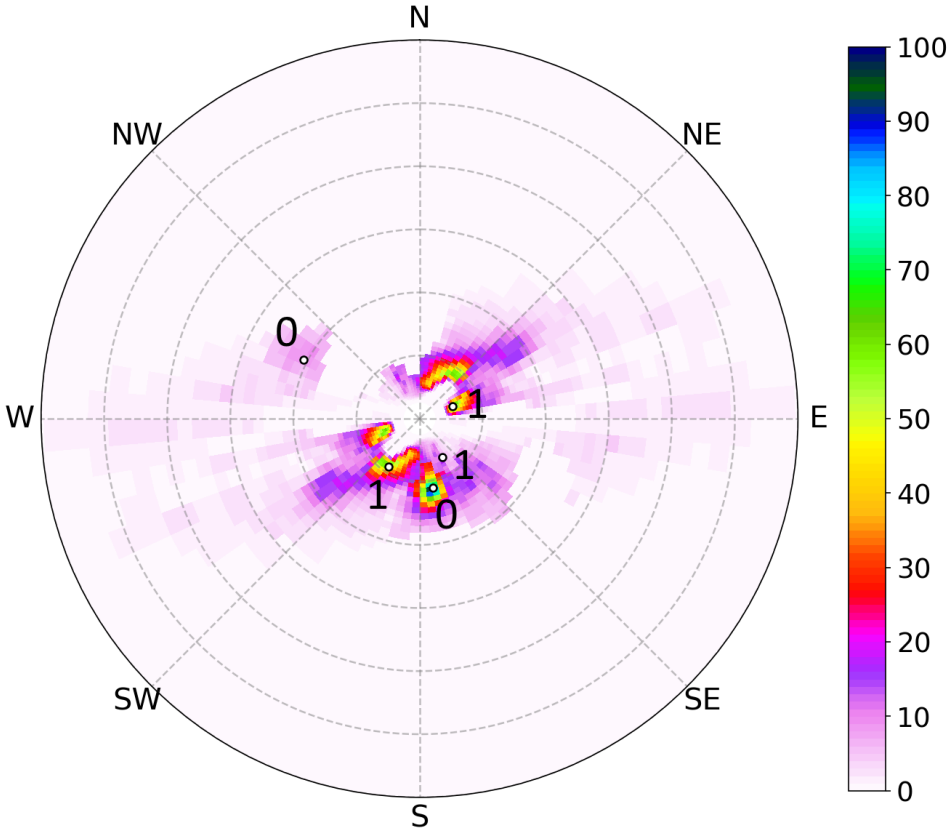
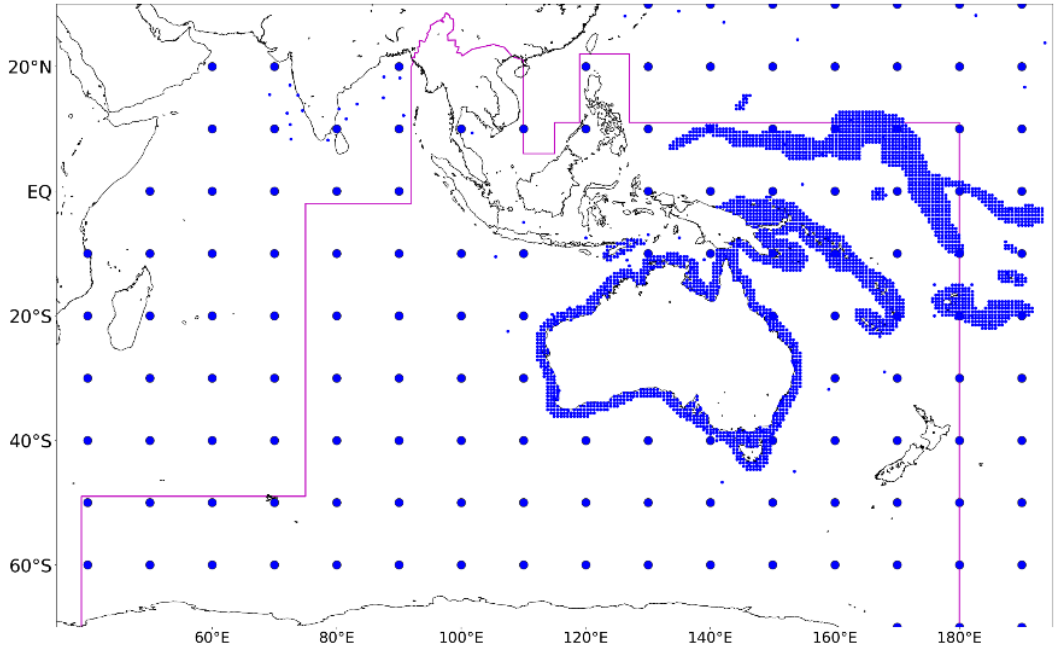
    AZ_CUTOFF              (TIME) float32 ...
    AZ_CUTOFF_DIR          (TIME, DIRECTION) float32 ...
    BOT_DEPTH              (TIME) float32 ...
    DP_PART                (TIME, PARTITION) float32 ...
    EKTH                   (TIME, DIRECTION, WAVNUM) float32 ...
    EKTH_PART              (TIME, DIRECTION, WAVNUM) int8 ...
    EKTH_quality_control   (TIME, DIRECTION, WAVNUM) int8 ...
    HEADING                (TIME) float32 ...
    HS_PART                (TIME, PARTITION) float32 ...
    HS_WIND_SEA            (TIME) float32 ...
    INC_ANGLE              (TIME) float32 ...
    INV_CONF_PART          (TIME, PARTITION) int8 ...
    INV_WAVE_AGE           (TIME) float32 ...
    LAND_COVERAGE          (TIME) float32 ...
    LATITUDE               (TIME) float32 ...
    LONGITUDE              (TIME) float32 ...
    NRCS                   (TIME) float32 ...
    POLARISATION           (TIME) object ...
    RG_CUTOFF              (TIME) float32 ...
    SNR                    (TIME) float32 ...
    SOURCE_NETCDF          (TIME) object ...
    SOURCE_SAFE            (TIME) object ...
    WDIR_ECMWF             (TIME) float32 ...
    WDIR_SAR               (TIME) float32 ...
    WP_PART                (TIME, PARTITION) float32 ...
    WSPD_ECMWF             (TIME) float32 ...
    WSPD_SAR               (TIME) float32 ...
```



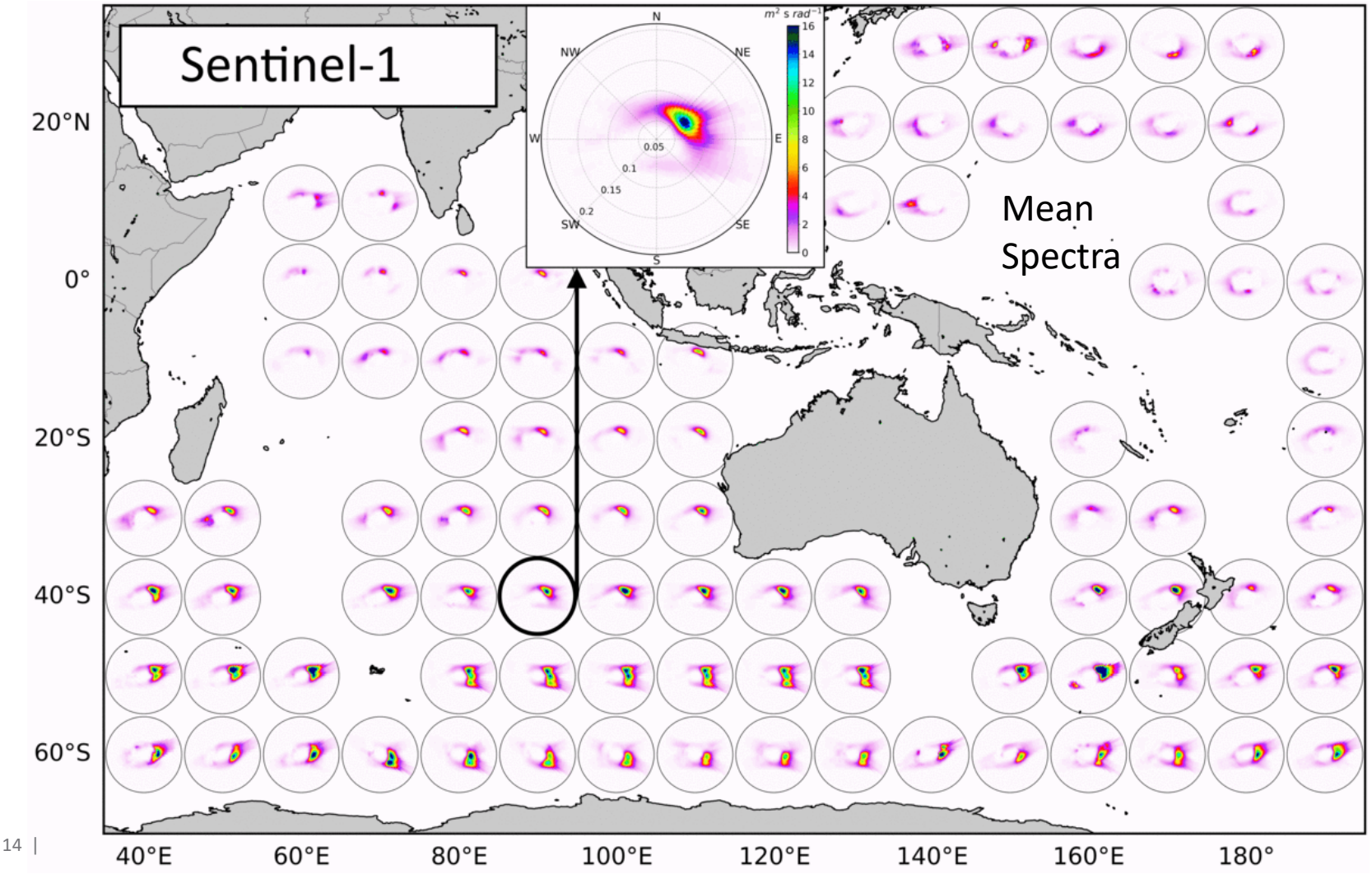
Validation against WW3 hindcast

WW3 CAWCR Hindcast (1979-present)

WW3 – Centre for Australian Weather and Climate Research (CAWCR) Hindcast (Durrant et al. 2014)



- WAVEWATCH III v4.18 model
- Forced using CFSR winds and ice concentration (0.2°, hourly winds and 6-hourly ice)
- Australian part of 10^{o} global grid, hourly spectra
- 4’ nested grid, hourly spectra around Australia and Pacific Islands

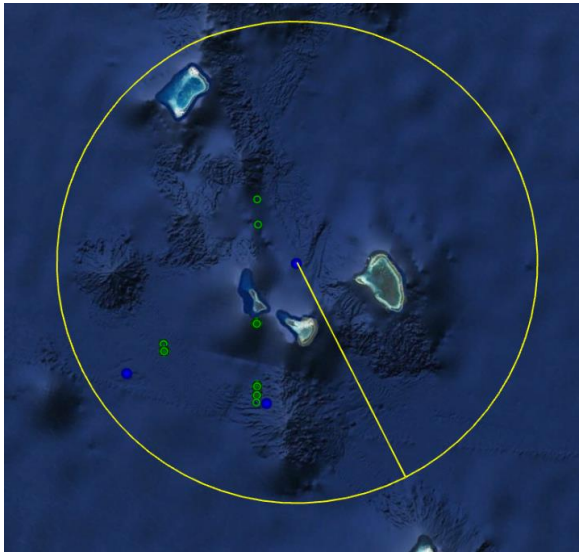

Sentinel-1
Mean
Spectra
N
NE
E
SE
S
SW
W
NW
0.05
0.1
0.15
0.2
m^2 s rad^{-1}
16
14
12
10
8
6
4
2
0
20°N
0°
20°S
40°S
60°S
40°E
60°E
80°E
100°E
120°E
140°E
160°E
180°

Collocations

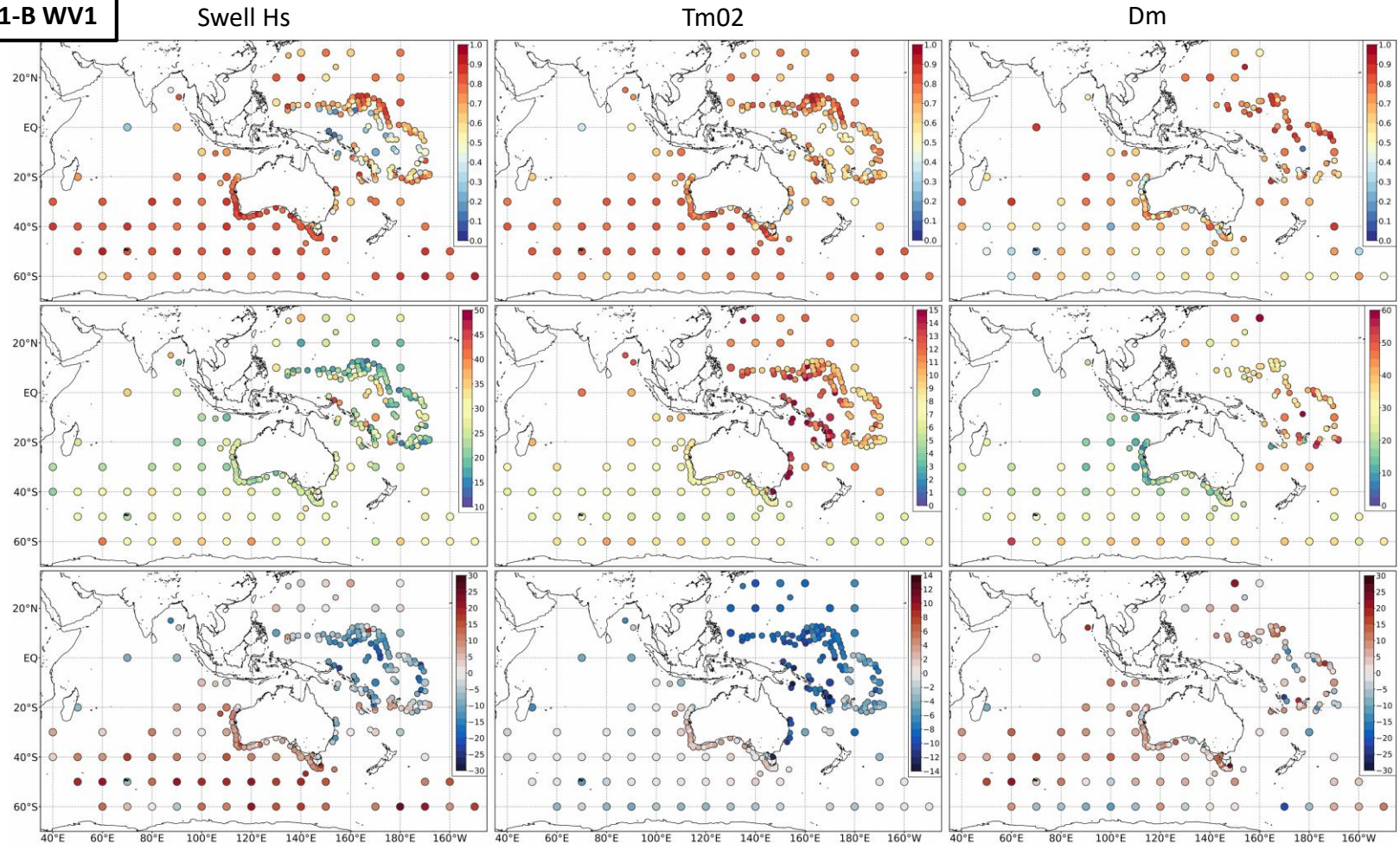
Criteria: distance ≤ 100km, +- 30 min, depth > 30m, swell Hs > 1m

At least 30 collocations to compute statistics

Most problematic island collocations removed



Sentinel 1-B WV1



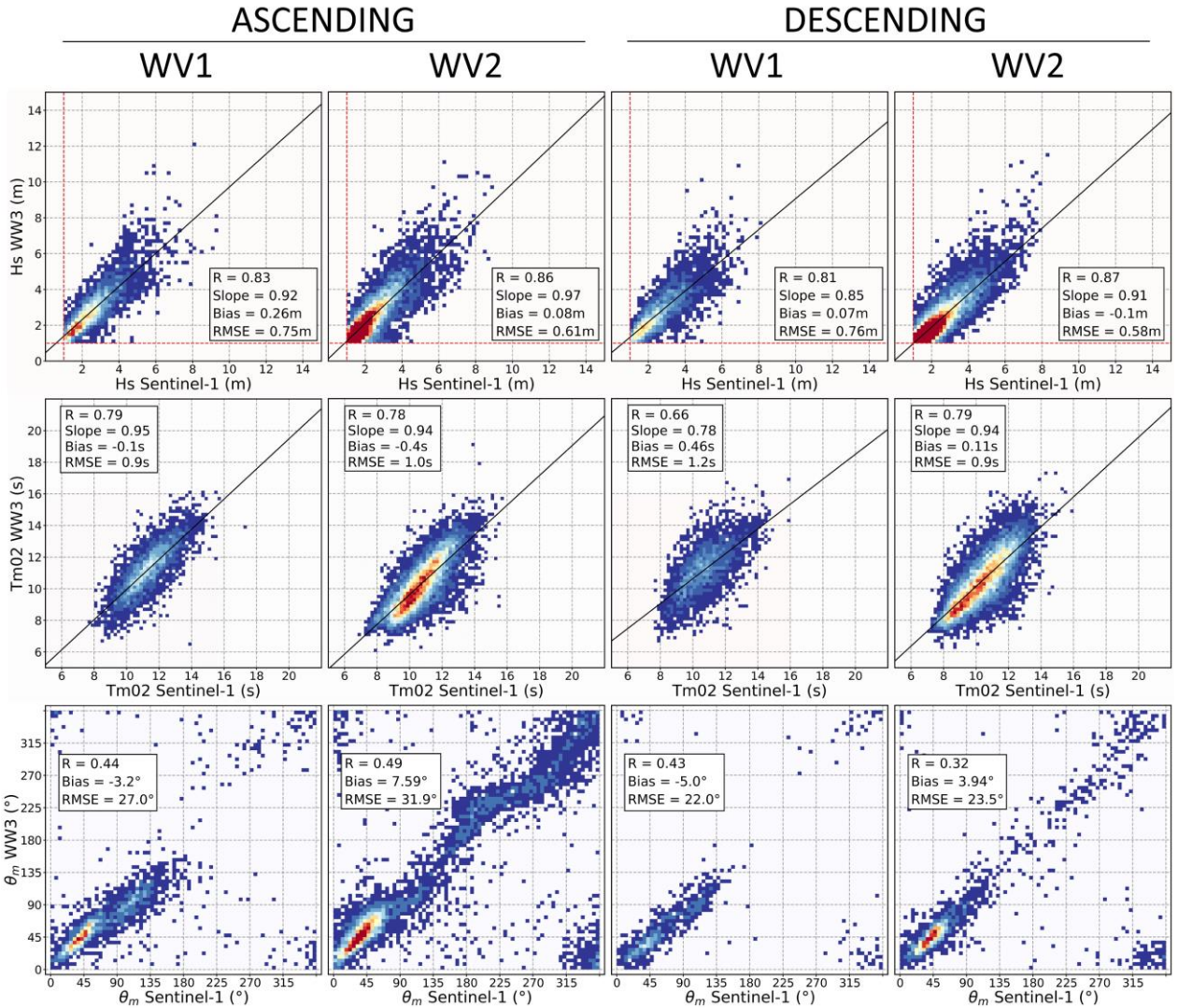
Similar results for other combinations, but slightly better for S1-B

Sentinel1-B

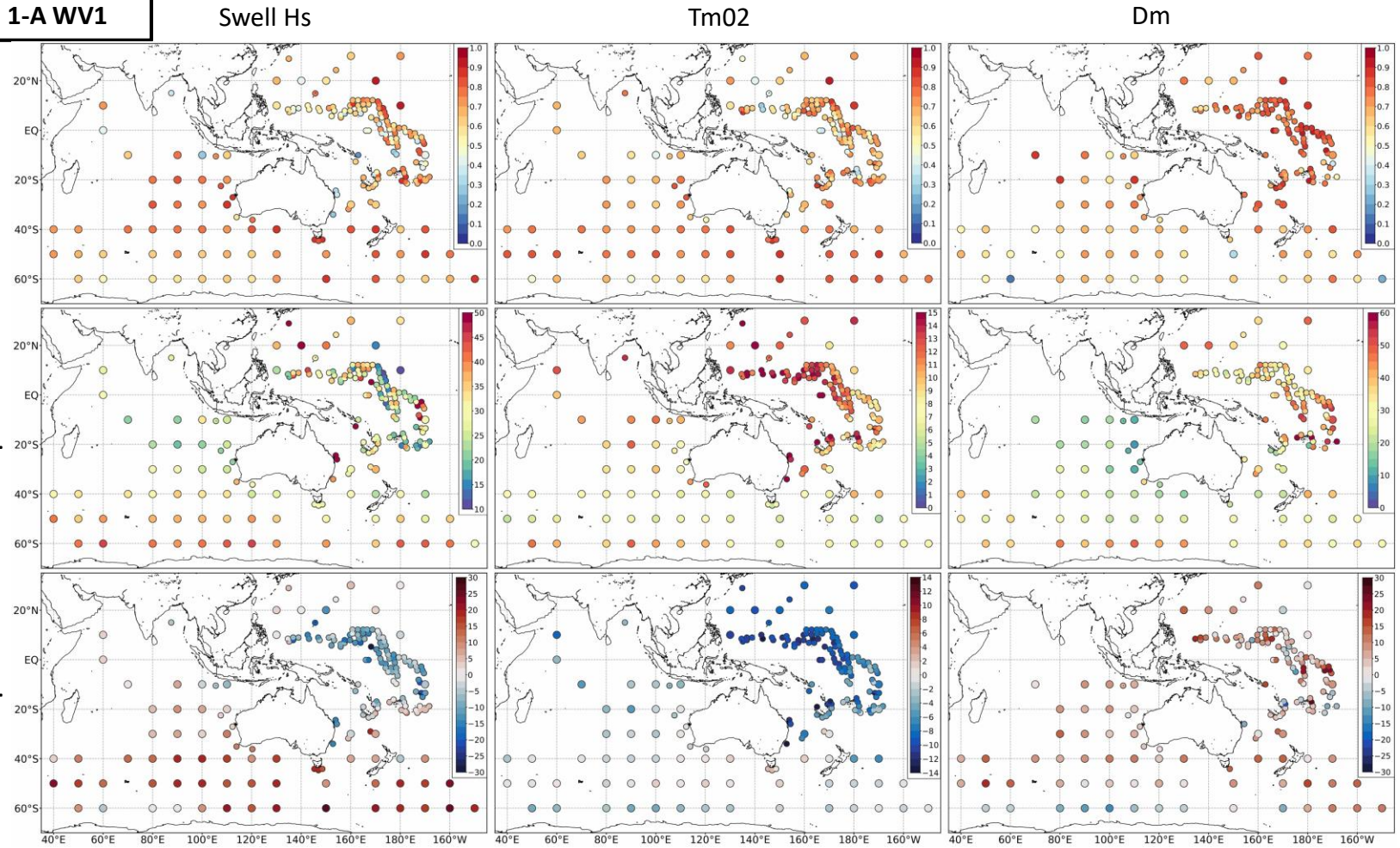
Swell Hs

Tm02

Dm



Sentinel 1-A WV1

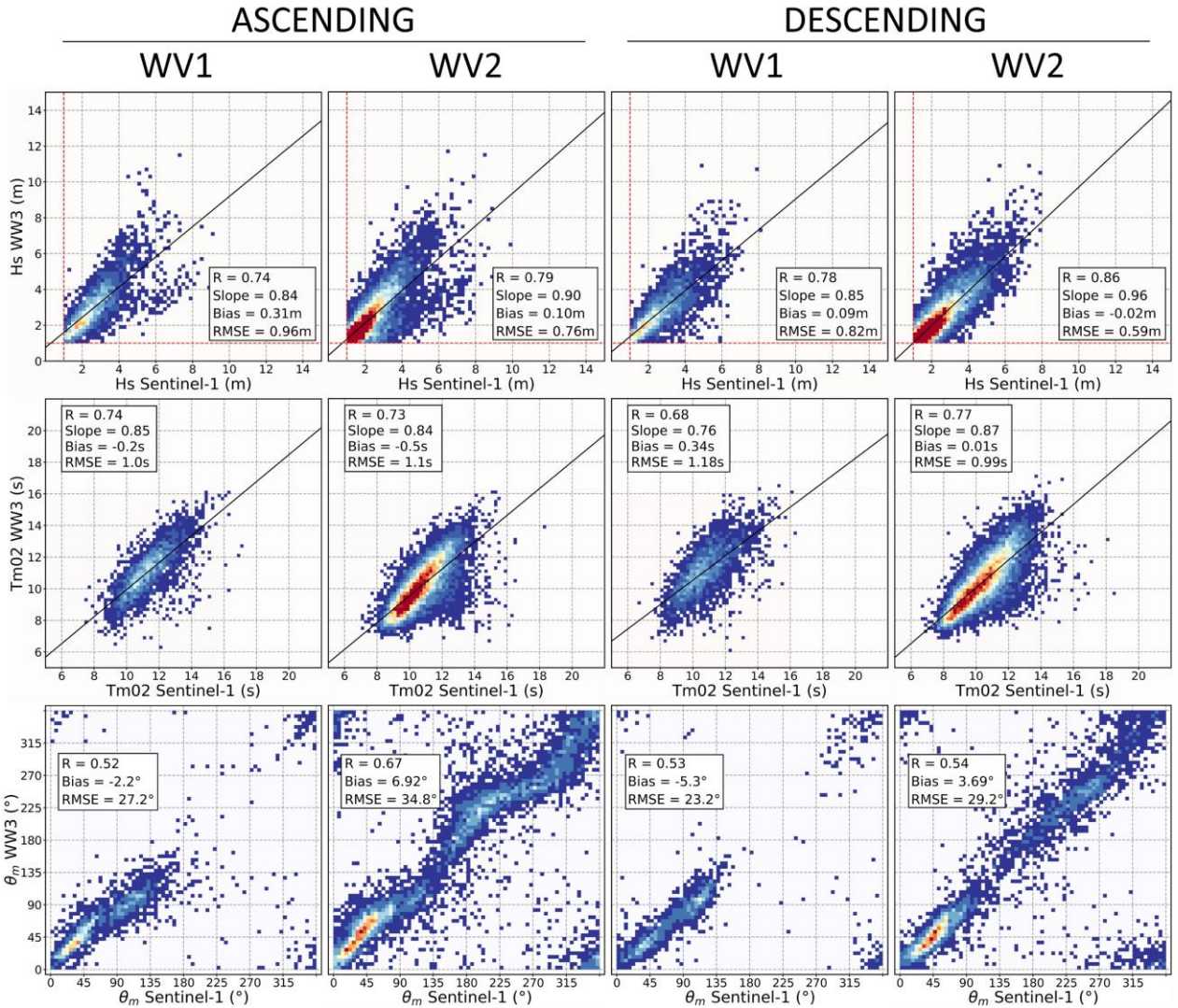


Sentinel1-A

Swell Hs

Tm02

Dm



Conclusions, Challenges and Outlook

Conclusions and Challenges

Conclusions:

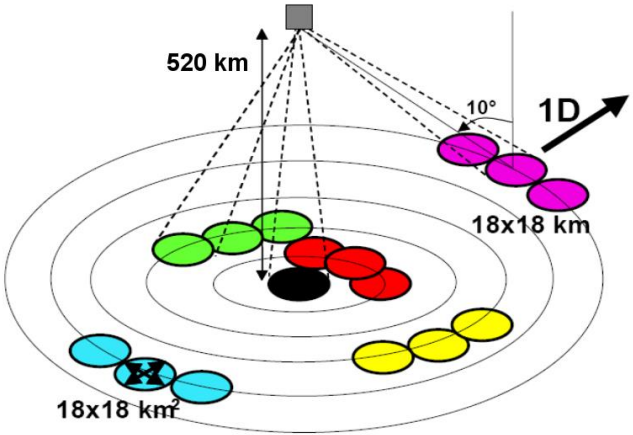
- Model and SAR bulks match reasonably well. Dm, less so
- Database suitable for full-duration analysis: CAL/VAL, potentially trends
- Database suitable for analysing extreme events and case studies
- Database (Jul-2015 to Oct-2019) in process of being published at AODN

Challenges:

- Lack of in-situ, reference directional buoy data
- Complex island collocations

Outlook

- CFOSAT SWIM instrument measuring nadir and off-nadir waves and scatterometers winds simultaneously for the first time
- Initial calibration and validation performed
- Full directional wave spectra to be included in database in future
- Measures between 70m – 600m wavelengths



Courtesy CNES

- Copernicus continuation Sentinel-1 C & D > 2021
- Inclusion of historical ENVISAT waves obs

Questions?

Thank you

Oceans and Atmosphere
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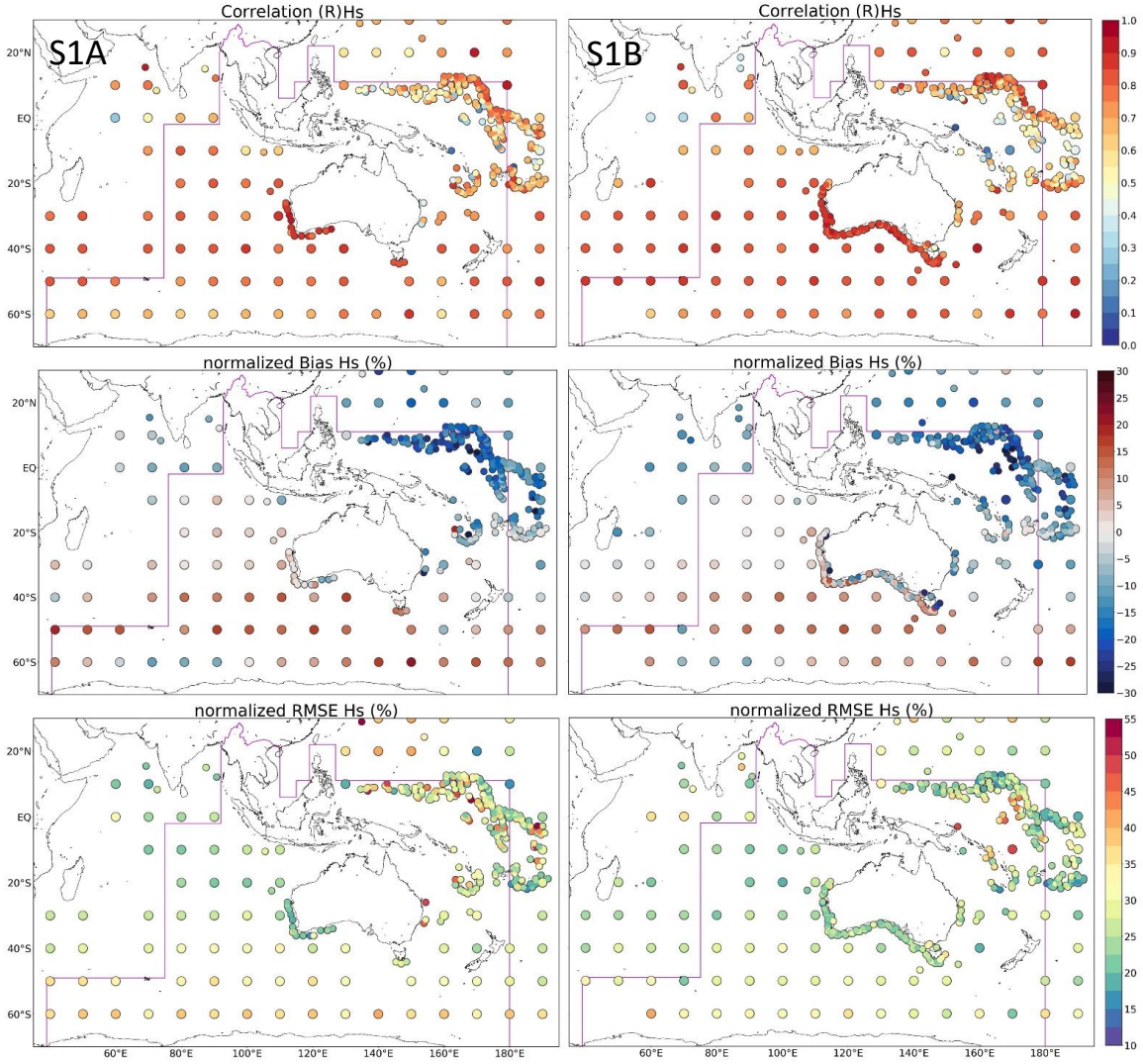
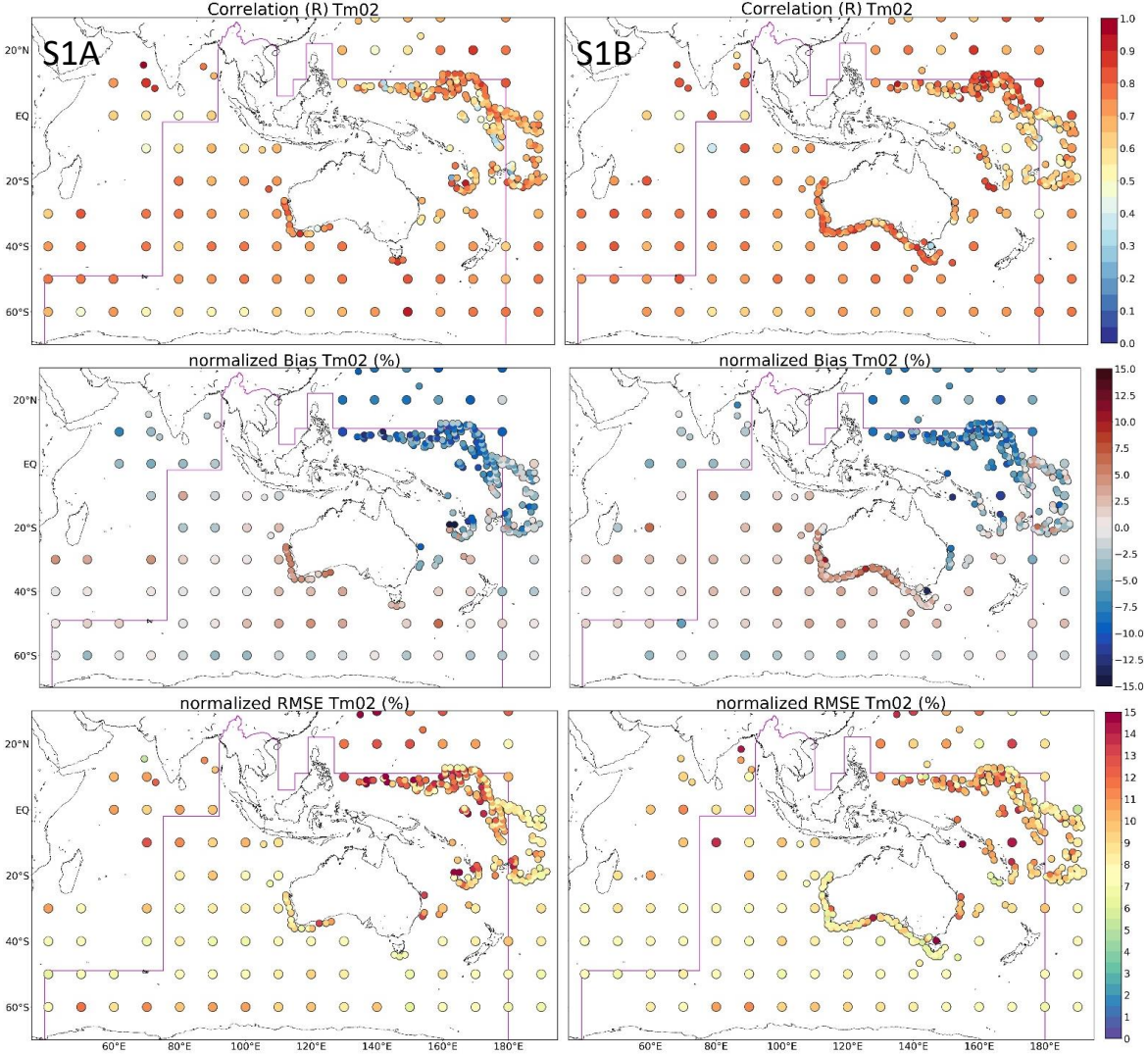
Extra slides

Hs stats by location



Tm02 stats by location



Dm stats by location