Jason-3

Near Real-Time Data Annual Quality Report 2017-2018

February, 2019

Prepared by:

U.S. Department of Commerce
National Oceanic and Atmospheric Administration (NOAA)
National Environmental Satellite, Data, and Information Service (NESDIS)

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National Environmental Satellite, Data, and Information Service (NESDIS)

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Preface

This document comprises the initial National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) baseline publication of the Jason-3 *Near Real-Time Data Annual Quality Report 2017-2018* (February 1, 2018 issue).

The purpose of this document is to assess the overall quality of the Jason-3 near real-time products, Operational Geophysical Data Records (OGDRs), which are produced by NOAA and EUMETSAT. For each 10-day cycle, five primary parameters are displayed, divided into ascending and descending passes: sea surface height, significant wave height, ocean surface wind speed, altimeter-based ionosphere correction, and radiometer-based wet troposphere correction. All anomalies evident in these plots, such as orbital maneuvers or data gaps from calibration exercises, are described and documented based upon operational processing logs, etc. Statistics for data latency and data return are presented to demonstrate that high-level mission requirements have been met.

Future updates and revisions to this document will be produced and controlled by NOAA/NESDIS.

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Section 1.0 Introduction

The Jason-3 mission is the successor to the TOPEX/Poseidon, Jason-1, and Jason-2/OSTM radar altimetry missions. Jason-3 was launched from Vandenberg AFB on 17-Jan-2016, and the onboard instruments began producing data shortly thereafter. Prior to achieving its final ~10-day exact repeat orbit, Jason-3 executed a series of maneuvers after injection into orbit. The exact repeat orbit was finally achieved on 12-Feb-2016. Since this resulted in a partial 10-day cycle, it was dubbed cycle-0. All subsequent cycles (beginning with cycle-1) are comprised of 254 half-revolution 'passes' with odd-numbered ascending passes extending from south to north, and even-numbered descending passes going north to south.

The primary instrument on-board Jason-3 is a dual-frequency radar altimeter (Ku-band & C-band) that provides measurements of sea surface height, significant wave height, and ocean surface wind speed. Three independent orbit determination systems are provided by the DORIS, GPSP, and passive laser retro-reflector instruments. Sea surface height is computed from the difference in orbital altitude from these systems and the fundamental range measurement (from round-trip travel time) made by the altimeter. Finally, a three-frequency passive microwave radiometer provides measurements of integrated total precipitable water, which is used to correct the sea surface height measurements for path delays due to atmospheric water vapor. Path delay corrections for the ionosphere are based on the dual-frequency altimeter measurements, and for the dry troposphere based on ECMWF model surface pressure fields. Finally, sea surface heights are corrected for signals not associated with large-scale ocean circulation (tides, inverse barometer, and sea state bias).

The Jason-2 and Jason-3 missions are a four-partner collaboration between NOAA, NASA, CNES and EUMETSAT. As partner operational agencies, NOAA and EUMETSAT share responsibility for production of near real-time data sets. These data, the Operational Geophysical Data Records (OGDRs) are the focus of this quality assessment report. OGDRs are typically produced 1-3 hours after the telemetry are received from the spacecraft, leading to nominal data latencies of 3-5 hours after accounting for two hours of data acquisition on board between data dumps to the ground. The data latency statistics over the second year of mission operations are discussed in the next section.

Section 2.0 Data Latency Statistics

The four project partners hold Operational Coordination Group (OCG) meetings weekly, and NOAA routinely reports statistics for near real-time product latency. The latency is computed for each OGDR, based on the time difference between the data itself (measurement time) and the time of availability of the product to end users. The overall latency of the OGDRs, produced by both NOAA and EUMETSAT, is accumulated over the previous week for reporting at the OCG.

In this year's report we use the same methodology as in recent Jason-2 and 3 analyses, for reporting data latency: the "PROPRO-005" algorithm[1]. Each OGDR is evaluated to determine if 75% of the 1-Hz data records inside the file have a latency of < 3 hours. If so, that OGDR is "good". If not (< 75% of data < 3 hours old) that OGDR is considered "bad". Each week the percentage of files that are good is reported, compared to the algorithm goal of 90%.

Figure 1 illustrates the weekly latency statistics during the second year of operations. At each weekly interval along the x-axis, the percentage of files meeting the 75% < 3 hours criteria is plotted. As can be observed from the plot, the data latency performance was remarkable; there are only two instances in which the OGDR data latency fell below the 90% goal, and only one instance when it was below the 75% requirement. This corresponds to the week of June 19th 2017. On June 16th, the FTP service on FileManager1 became irresponsive and data stopped flowing through the system. Unable to resolve the problem, the NOAA Environmental Satellite Processing Center (ESPC) idled the TM-NRTs and requested EUMETSAT to go into Emergency Backup Mode (EBM). The system recovered early Sunday morning June 18 and NJGS ESPC processing and data flow resumed. 21 OGDRs showed up at the time of system recovery, with a latency much greater than the 3 hours requirement, hence negatively impacting on the weekly latency statistics.

The overall percentage of low-latency OGDRs from 2017-02-13 to 2018-02-12 was 97.1%.

[1] Algorithms About Jason-3 Telemetry Data Availability And OGDR Data Latency: TP4-J0-NT-86-CNES, Christophe Jouan & John Lillibridge, 2011.

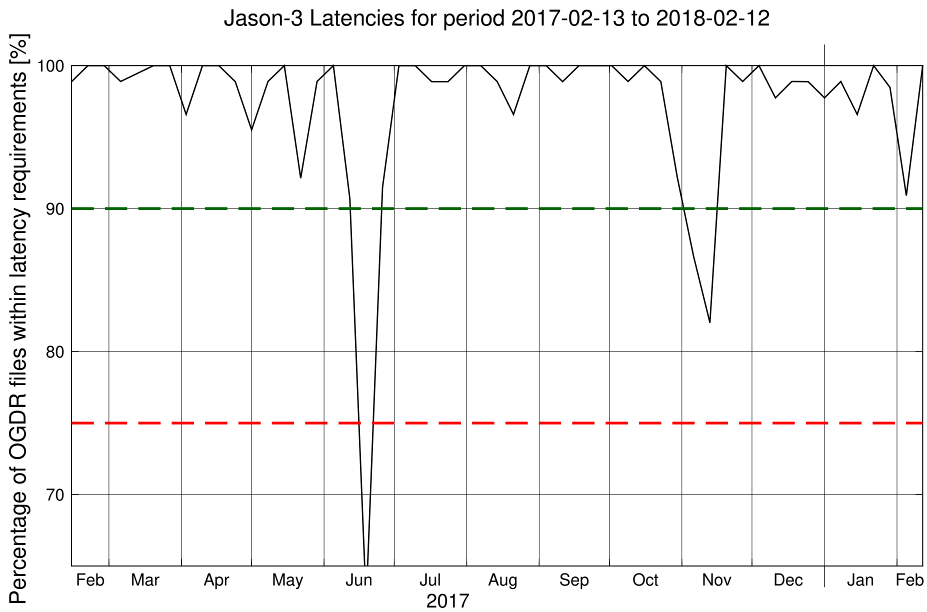


Figure 1 – Jason-3 OGDR Latency Statistics for February 2017 to February 2018

Section 3.0 Data Quality Analysis Plots

In this section data from the first year of operations are analyzed, covering the time period from 2017-02-08 to 2018-01-31: cycles 37-72. We focus the analysis on five primary geophysical parameters measured by the on-board instruments: sea surface height anomaly (relative to a multi-year altimetric mean sea surface), significant wave height, ocean surface wind speed, wet tropospheric path delay from the radiometer, and ionospheric path delay based on dual-frequency altimeter measurements.

Each of the five geophysical parameters are analyzed on a per-cycle basis, with data from ascending and descending portions of the ground track plotted separately to prevent overlapping points. The start and end times of each cycle are based on an average cycle duration of 9d 21h 58m 31.612s (856711.612 seconds). The start and end times in the plot labels are rounded to the nearest second, and agree within a few seconds with the actual cycle boundaries. The individual 1-second data points, read from the NetCDF formatted OGDR files, are reported every 10-seconds along track. Each of these 10-second values is plotted as a filled circle, color coded by the vertical scale bar, which is based on a prescribed maximum-minimum range for that variable. For each ~10-day cycle, the five parameters are plotted on a single page as ten subplots (separate ascending/descending data) in Appendix-A. Each cyclic subplot represents a map view of a single variable, over the region 22°-382° longitude, ± 70° latitude. The longitude axis is offset by 22° to split the plots at Cape Agulhas, where there is minimal oceanic latitudinal extent between the Atlantic & Indian basins.

Plots for cycles 37-72 are contained in Appendix-A. These plots provide an excellent means of assessing the overall data coverage (or data gaps) as well as anomalies in the data values of the five analyzed parameters. If a parameter map has long stretches of data that are 'off-scale' in either the positive (red) or negative (blue) directions, there is a clear indication of degraded quality. These 36 plots form the basis of the quality assessment provided in the following sections.

Section 4.0 Anomalies Impacting Quality

Since the launch of Jason-3 a variety of anomalies have occurred which impact the quality of the data. These can be related to spacecraft maneuvers, instrumental problems, telemetry transmission difficulties, ground station anomalies, or data processing errors. The anomalies impacting data quality from February 2017 to February 2018 are presented in chronological order below, including the names of the impacted OGDR files. The detailed explanations are based on the cyclic GDR reports kindly provided by CNES, as well as the weekly OCG reports.

Jason-3 Cycle-043 2017-04-08 21:26:55 - 2017-04-18 19:25:26

Station Keeping Maneuver performed, but no impact is observed in the OGDR cyclic plots.

Jason-3 Cycle-045 2017-04-28 17:23:58 - 2017-05-08 15:22:30

During this cycle a slight deviation from the normal sea surface height (SSH) anomaly is observed in one of the passes over the North Atlantic, starting off the Northern coast of South America and extending up to 60 degrees North.

For that time period, a yellow alarm was reported stating the loss of track of star patterns by the star-tracker:

> NSTVALMEAGC 02/05/2017 04:22:25 02/05/2017 04:27:45
> STR tracking loss at 04:12 in SAA (Lon= –74.1°, Lat= –17.9°). Error message = "No star Pattern Recognition"

The pass when this star pattern loss occurred corresponds to the one that exhibits anomalous SSH. (STR is the Star Tracker; SAA is the South Atlantic Anomaly.)

Jason-3 Cycle-049 2017-06-07 09:18:04 - 2017-06-17 07:16:36

Missing orbit in OGDR:

On Friday June 16 the FTP service on FileManager1 became unresponsive and data stopped flowing through the system. Unable to resolve the problem, NOAA ESPC idled the TM-NRTs and requested EUMETSAT to go into Emergency Backup Mode (EBM). The system recovered early Sunday morning June 18 and NJGS ESPC processing and data flow resumed. 21 OGDRs showed up at the time of system recovery. EUMETSAT came out of EBM on Monday June 19. On June 20, four OGDRs that were processed but never got transferred from TM-NRT to FileManager were pulled off the TM-NRT and copied to the upload directory on FileManager for distribution. There was one unprocessed frame file NOAA ESPC tried to process but it produced an error in TM-NRT.

However, the data were not lost, since no missing pass is reported in the final GDR report for this cycle.

Jason-3 Cycle-057 2017-08-25 17:06:17 - 2017-09-04 15:04:49

The cyclic plots show two full missing passes. Those were attributed to the upload of a new POSEIDON3B/JASON3 Digital Elevation Model (DEM), which took place from Tuesday 29/08/17 to Thursday 31/08/2017. The missing passes corresponds to pass 124 and 125, the former one being completely missing, and the latter with no available data over the ocean.

The GDR reports show two additional missing passes, corresponding to passes 152 and 153. However, this is not observed in the OGDR data. The CNES GDR report mentions that the following passes are missing:

Due to DEM upload:
- Pass 123 has 23.91% of missing measurement (15.44% over ocean).
- Pass 124 is missing.
- Pass 125 has 96.16% of missing measurement (100% over ocean).

Due to DEM upload:
- Pass 151 has 12.40% of missing measurement (8.57% over ocean).
- Pass 152 is missing.
- Pass 153 has 98.40% of missing measurement (100% over ocean).

Due to calibration:
- Pass 159 has 56.17% of missing measurement (10.54% over ocean).

The JPL GDR validation shows essentially the same thing, with the exception of pass 152, that is not reported as missing, however it has 0% available data over ocean.

```
Exception 1  : Pass 124 is missing and passes 123, 125, 151, 152,
               and 153 have 83.28%, 0%, 89.64%, 0%, and 0%,
               respectively of over ocean data available.
               Cause: DEM onboard upload from 2017-08-29 13:41:14 to
               2017-08-31 16:24:07.
Exception 2  : Pass 159 has 88.10% of over ocean data available.
               Cause: CAL CNG.
```

The fact that passes 152 and 153 are available and showing consistent data on the OGDRs is a discrepancy with the GDRs. This is not well understood at this moment, and will need to be further investigated.

Jason-3 Cycle-059 2017-09-14 13:03:21 - 2017-09-24 11:01:52

The cyclic plots show some missing altimeter data off the South African coast, and along the coast of South East Africa, all the way up to the Gulf of Aden and the Persian Gulf. The AMR wet tropospheric correction is available though. However, no data gap was reported by NOAA ESPC nor SSALTO for that time period.

The CNES GDR report reveals that after a GYRO calibration performed on 14/09/2017 from 16:54:56 to 17:52:18, pass 5 has 47.22% of missing measurements and 89.6% of altimeter measurements set to a default value. The OGDR impacted is:

JA3_OPR_2PdS059_003_20170914_155037_20170914_174536

Jason-3 Cycle-069 2017-12-22 16:48:37 - 2018-01-01 14:47:08

On 2017-12-26 at 22:33:30, due to a JTCCS-3 ground element failure, NOAA SOCC was unable to connect to Usingen-2 in time to command on revolution 9083. The controller failed over to JTCCS-1, and a full support was possible on the following revolution. However, the Payload Telemetry 1/2 read on that support was 98%, which possibly originated the data gap that is observed in the cyclic plot off the Northern coast of Japan, across the Sea of Okhotsk. The OGDR impacted is:

JA3_OPR_2PdS069_108_20171226_210619_20171227_003106

The data gap for this OGDR amounts to 168 seconds.

Jason-3 Cycle-071 2018-01-11 12:45:40 - 2018-01-21 10:44:11

Missing OGDR data for passes 214-254.

From the NOAA ESPC OCG report:

> Shortly after 00UTC on January 20, EUMETSAT contacted ESPC notifying us that Jason-3 TM-NRT began failing and requesting that ESPC activate Emergency Backup Mode. We [entered] EBM for Jason-3 at 0147UTC. At 0221UTC, Jason-3 TM-NRT began failing at ESPC as well. ESPC confirmed with EUMETSAT that the errors we were seeing were the same as those being observed at EUMETSAT. At 0325UTC, ESPC received another email from EUMETSAT stating that Jason-2 TM-NRT had now begun failing, so we entered EBM for Jason-2 at 0346UTC, but Jason-2 TM-NRT began failing as well.

Processing logs and error dumps were provided to the TM-NRT programmers at CNES for analysis. CNES investigated the anomaly and determined that the root cause was an overflow of the counter used by TM-NRT to measure the time when it reached a maximum value of 2^31.

A software patch was developed by CNES, that solved this issue. This was solely a TM-NRT data processing issue. No data was lost, as the pass is reported in the CNES and JPL GDR reports for that cycle.

Jason-3 Cycle-072 2018-01-21 10:44:11 - 2018-01-31 08:42:43

Missing OGDR data for passes 001-058.

The cause for the missing OGDRs is linked to the issue described above, that had originated in cycle071. The TM-NRT patch was provided by CNES on January 23rd, successfully installed on the TM-NRTs and the OGDR production was resumed soon after. The system was restored to operation on at 1920 UTC and NESDIS came out of Emergency Backup Mode on January 24 at 1355 UTC. The OGDR outage was 89 hours, 12 mins, 2 secs.

Section 5.0 Analysis of Data Gaps in the OGDRs

There is a high-level Jason-3 mission/system requirement that is relevant to the anomalies discussed in the previous section:

The GDR shall contain 95% of all possible over-ocean data (acquisition and archive) during any 12 month period, with no systematic gaps.

To assess our performance with regard to this requirement, based on the near real-time OGDRs, all of the data for cycles 37-72 were checked for data gaps between measurements (and between files) when either of the two measurements was over the ocean. Using a nominal inter-record spacing of Δt = 1.02 seconds, a gap is identified whenever two measurements are separated by more than $2*\Delta t$. Duplicate data, associated with re-dumping of data stored on-board Jason-3 (i.e. when two OGDRs have the same start time) were skipped during gap detection.

The cumulative result over the 4498 analyzed OGDRs is a total of 21,237,946 over-ocean records (out of a total 30,406,709 records) with data gaps totaling 334,997 records. This equates to 93h 3m 17s of missing data over the course of the year, and an over-ocean data return of 98.42%. Over 95% of this data gap, however, is associated with the one-time TM-NRT software issue, where the time counter overflowed the maximum predefined value of 2^31, and therefore OGDRs could not be produced during a period of 89 hours. It should be stated that no data was lost during this period.

The following OGDRs had cumulative data gaps (both internally and relative to the previous file) in excess of 100 seconds. OGDRs are not reported in this list if the data were re-dumped on a subsequent pass, but they are included in the statistics reported above.

```
JA3_OPR_2PdS072_059_20180123_174225_20180123_193738 323607
JA3_OPR_2PdS057_125_20170830_141033_20170830_141122  7252
JA3_OPR_2PdS039_127_20170305_042527_20170305_062112  2276
JA3_OPR_2PdS057_152_20170831_144013_20170831_162247   723
JA3_OPR_2PdS069_108_20171226_210619_20171227_003106   168
```

Section 6.0 Summary

The overall quality of the Jason-3 near real-time OGDR data is extremely good. The amount of missing OGDR data, attributed to all of the anomalies discussed in sections 4 and 5 is about 100 hours 14 minutes. **This represents an over-ocean data return of 98.4%, over the time period of 360 days analyzed in this report.** 90% of that missing OGDR data was attributed to a TM-NRT software error, which was resolved. No data was lost during that time period.

It is also remarkable that during the current period of analysis, there is not a single missing pass that can be attributed to an operator error.

In addition to the high overall data return, the data availability in terms of latency is also meeting the weekly 90% goal, with an **overall percentage of low-latency OGDRs of 97.1%.**

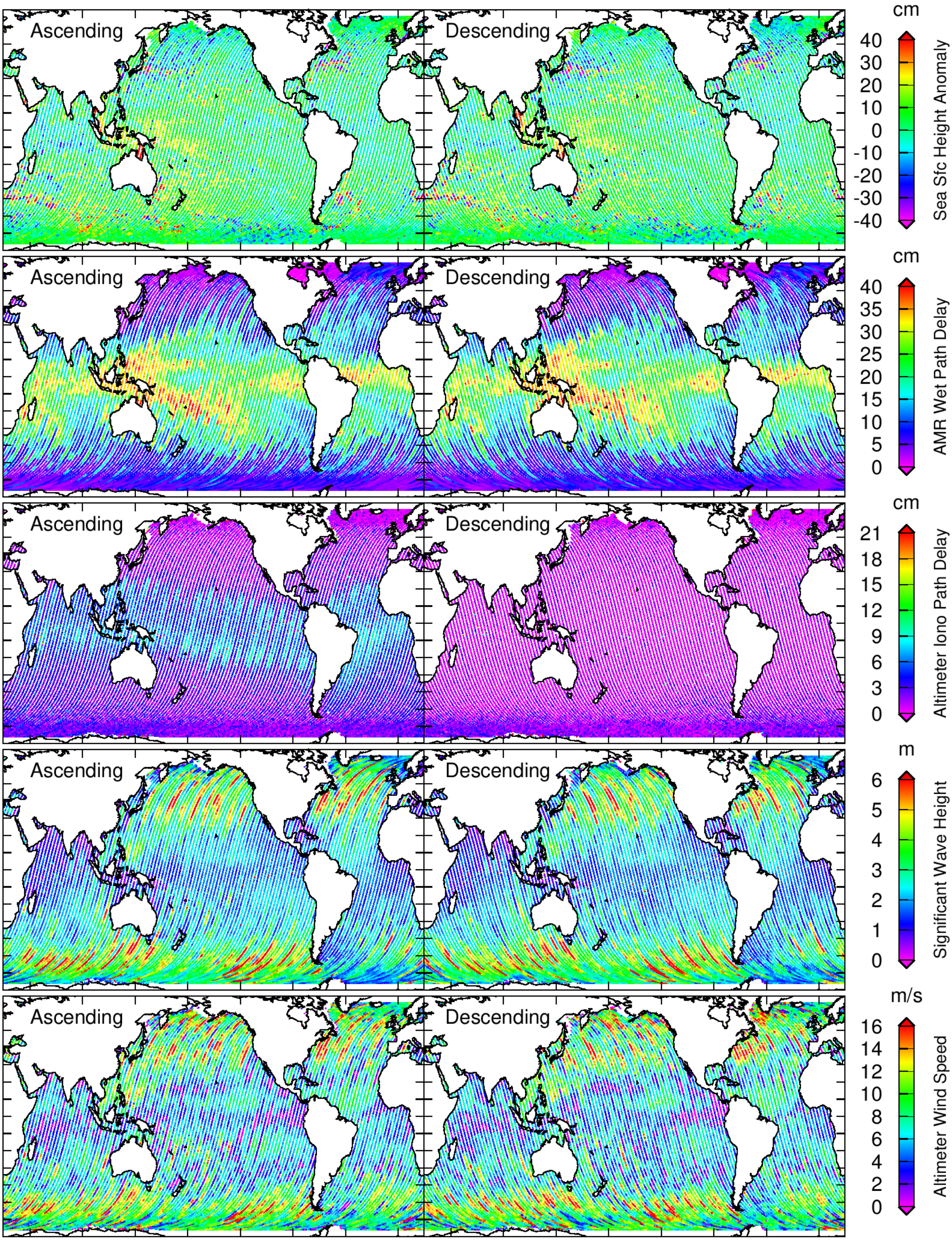
Appendix A. Cyclic Parameter Plots Cycle-037 to Cycle-072

See individual plots on the following 36 pages.

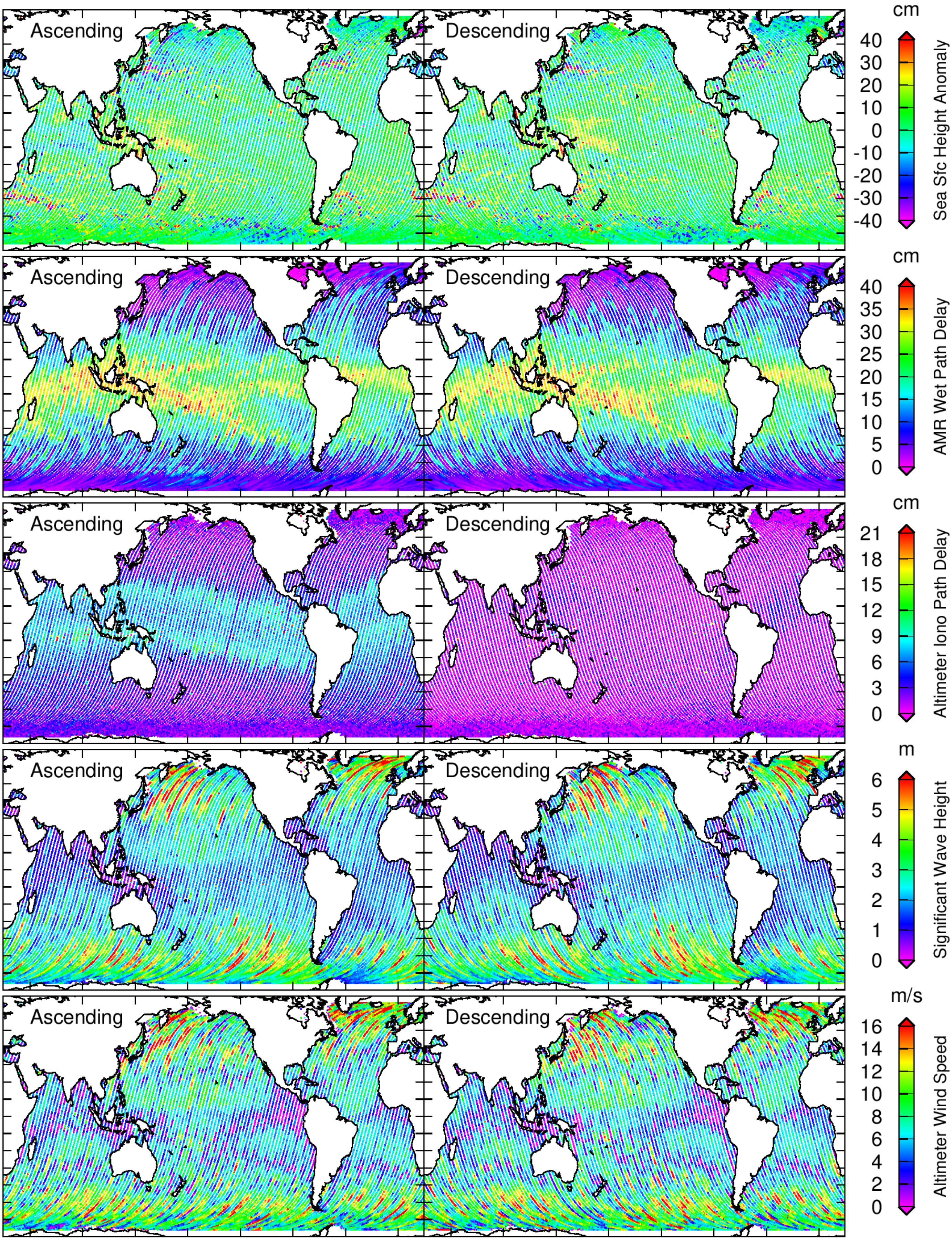
Appendix B. Acronyms

Acronym	Definition
AMR	Advanced Microwave Radiometer
CLS	Collecte Localisation Satellites
CNES	Centre National d'Etudes Spatiales
CNG	Consigne Numerique de Gain (altimeter gain calibration)
DEM	Digital Elevation Model
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
ECMWF	European Centre for Medium-range Weather Forecasting
EBM	Emergency Backup Mode
ESPC	NOAA NESDIS Environmental Satellite Processing Center
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GPSP	Global Positioning System Payload
J2TCCS	Jason-2 Tele-Command and Control System
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite Data and Information Service
NJGS	NOAA Jason Ground System
NOAA	National Oceanic and Atmospheric Administration
NRTAVS	Near Real-Time Altimeter Validation System
OCG	Operational Coordination Group
OGDR	Operational Geophysical Data Records
OSTM	Ocean Surface Topography Mission
SOCC	Satellite Operations Control Center
SSH(A)	Sea Surface Height (Anomaly)
SWH	Significant Wave Height
TM-NRT	Telemetry analyzer Near Real-Time

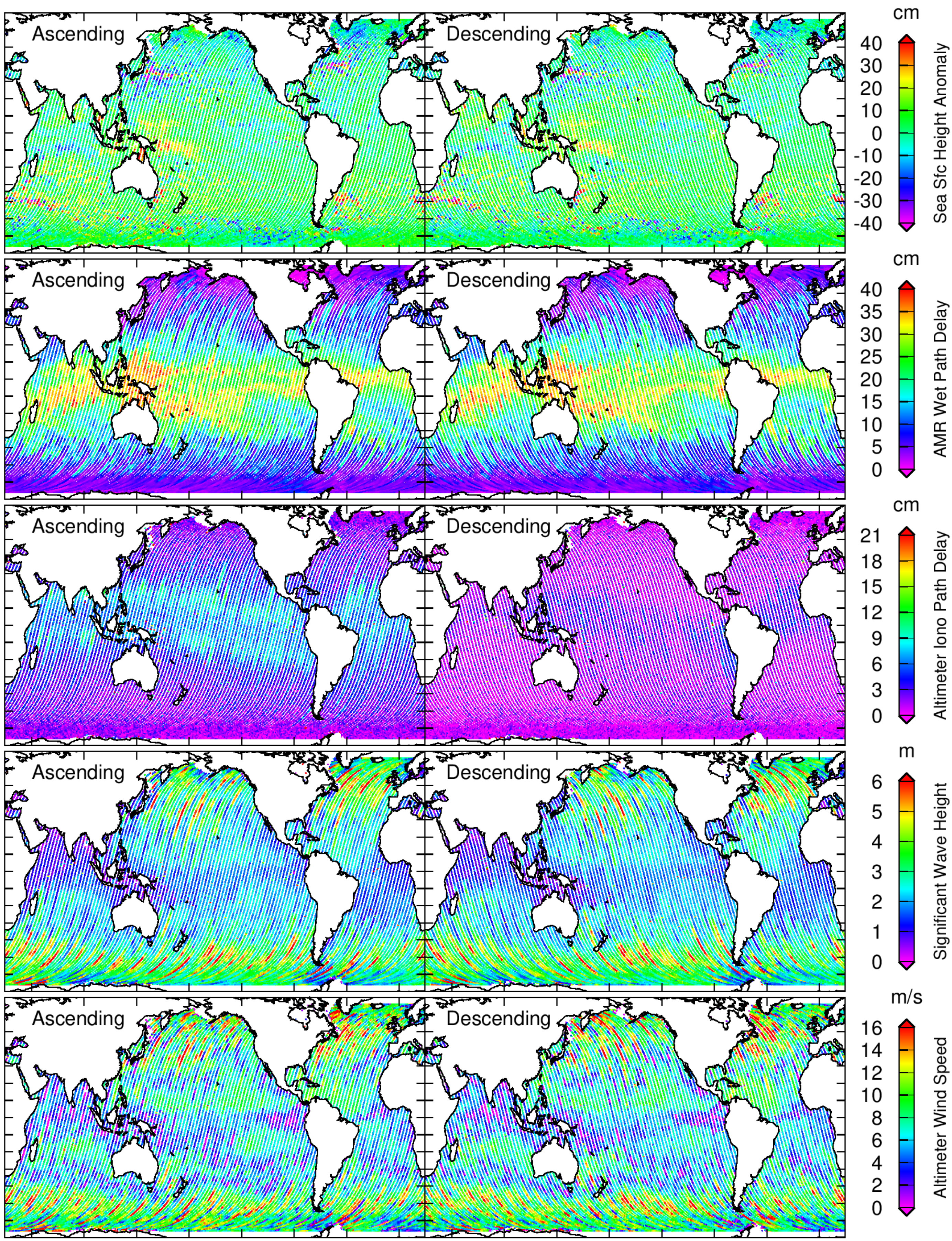
Jason-3 Cycle-037 2017-02-08 09:35:45 - 2017-02-18 07:34:17



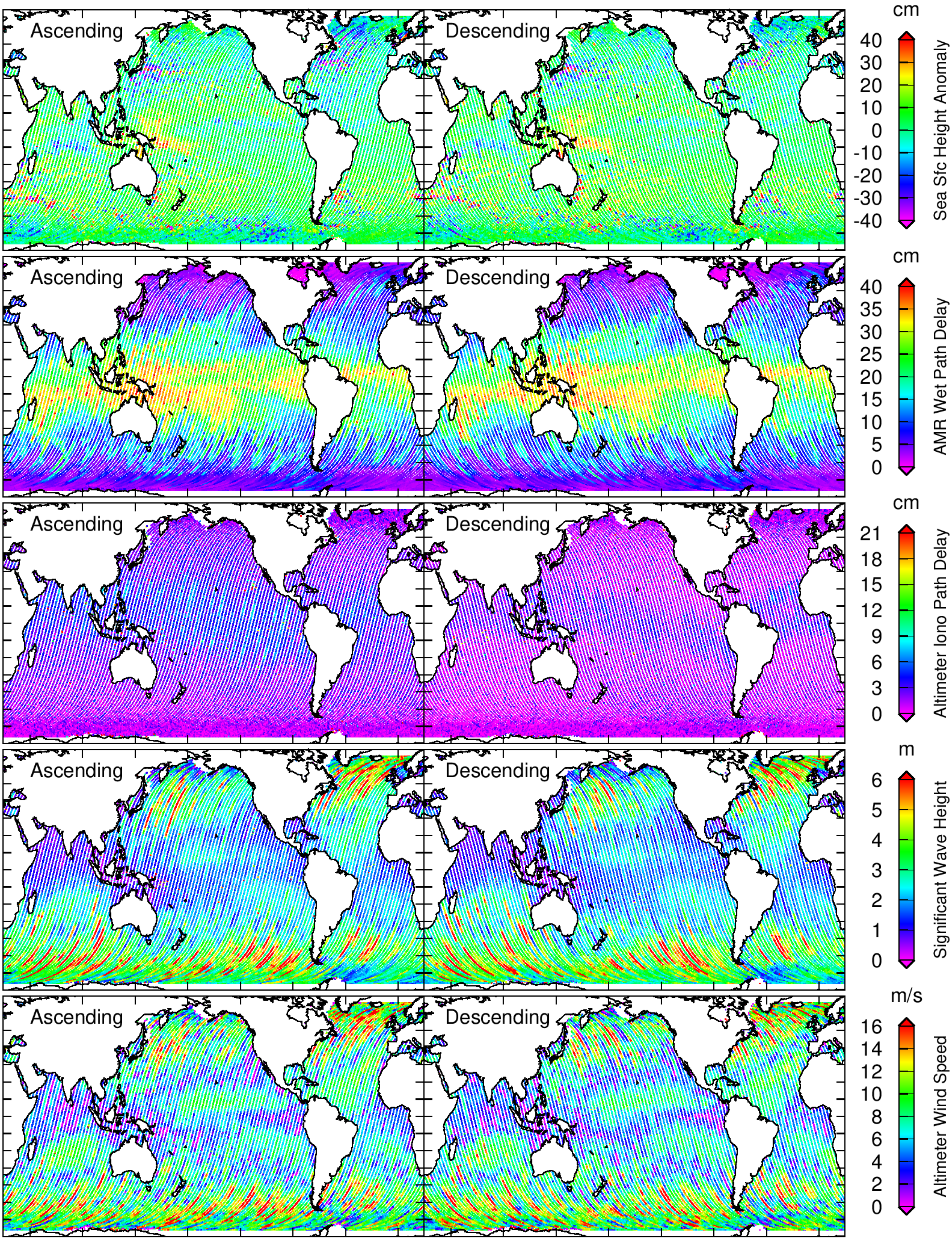
Jason-3 Cycle-038 2017-02-18 07:34:17 - 2017-02-28 05:32:48



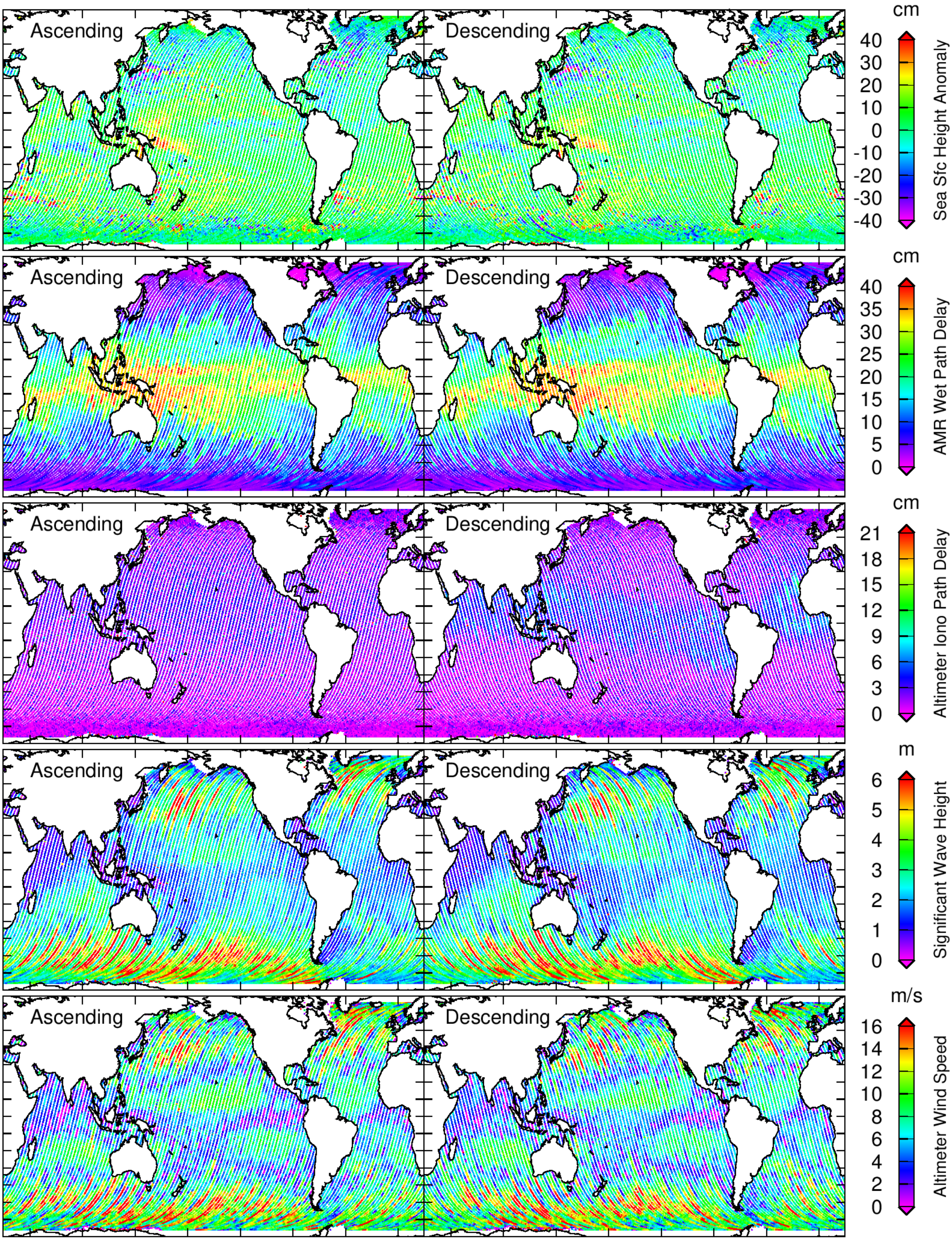
Jason-3 Cycle-039 2017-02-28 05:32:48 - 2017-03-10 03:31:20



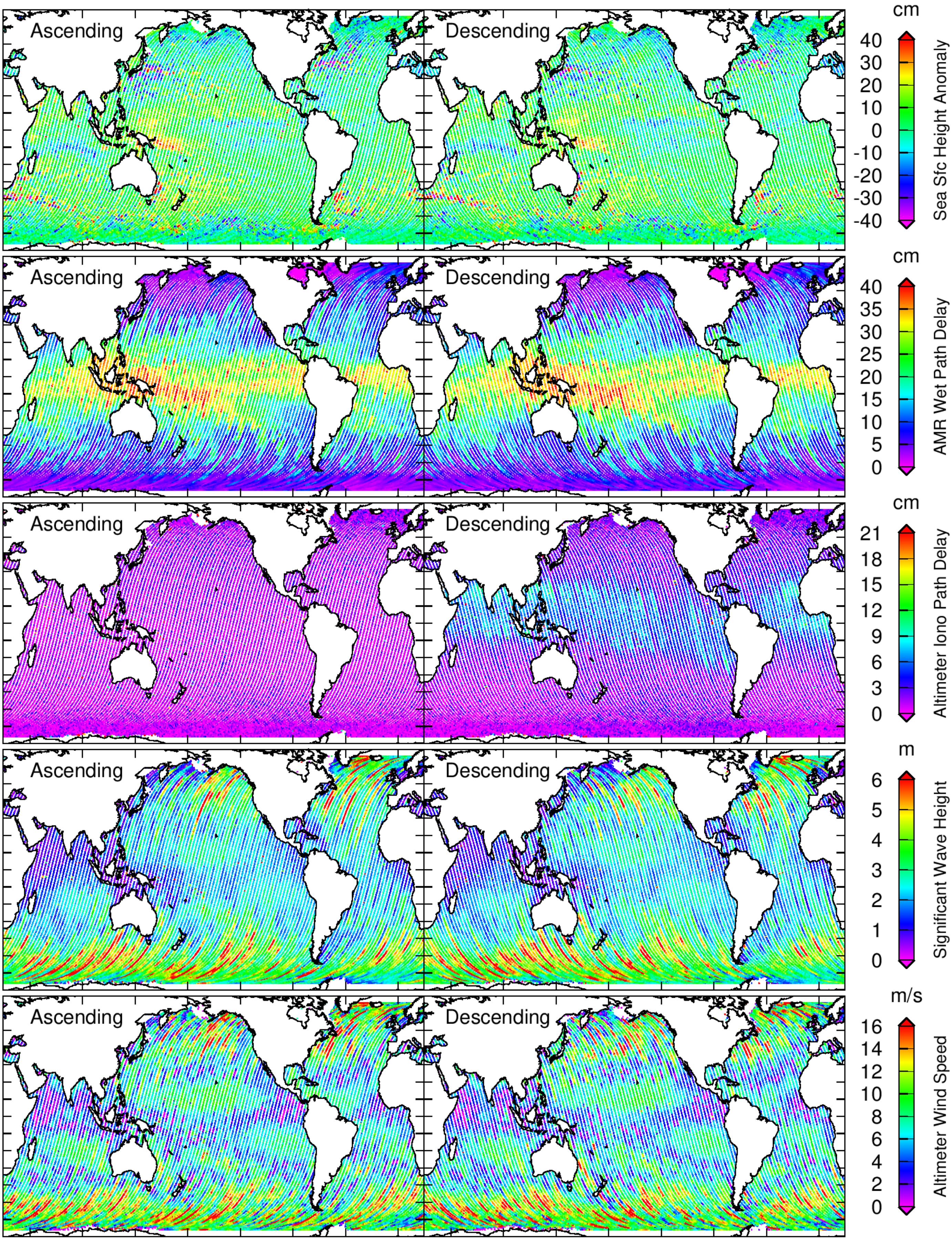
Jason-3 Cycle-040 2017-03-10 03:31:20 - 2017-03-20 01:29:52



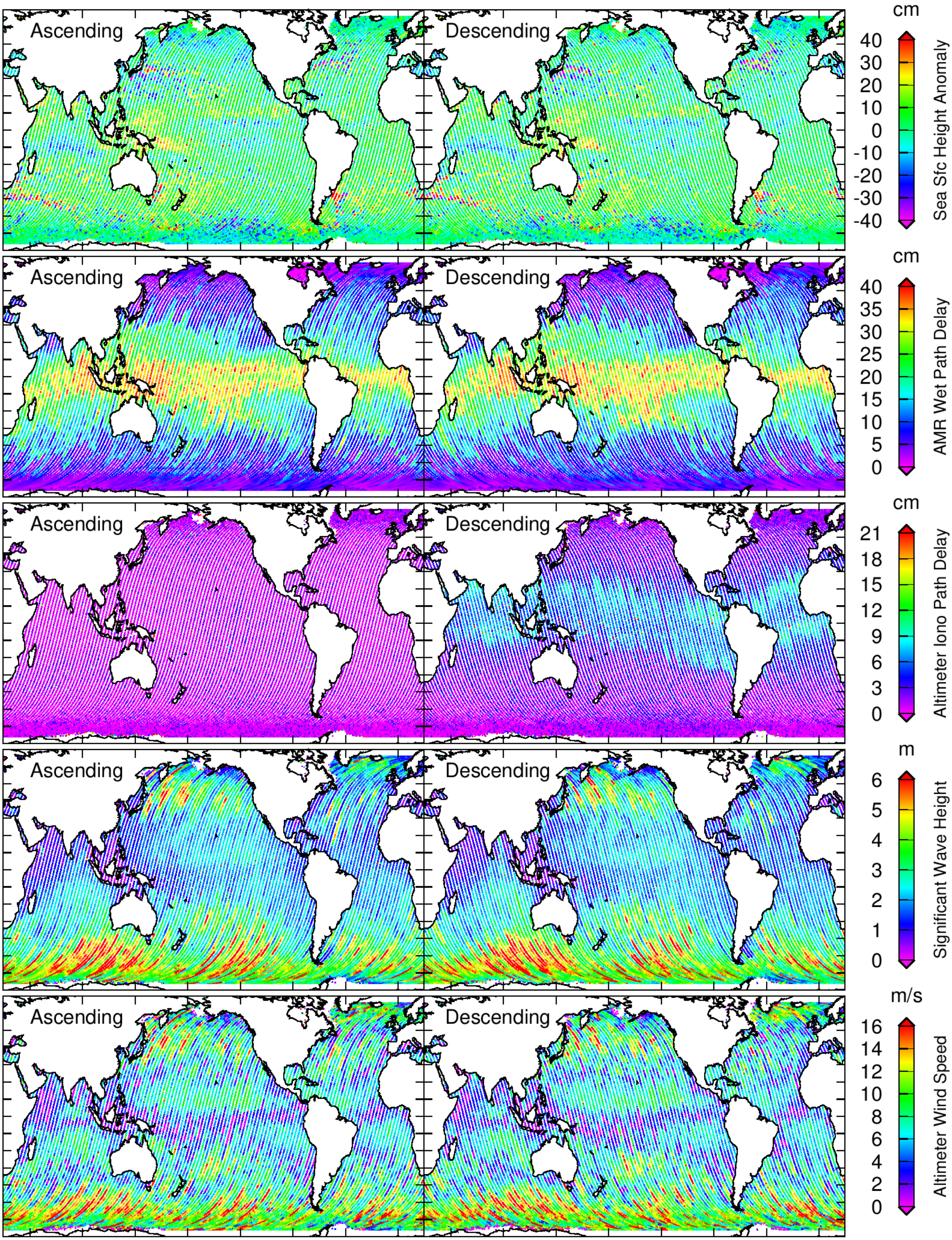
Jason-3 Cycle-041 2017-03-20 01:29:52 - 2017-03-29 23:28:23



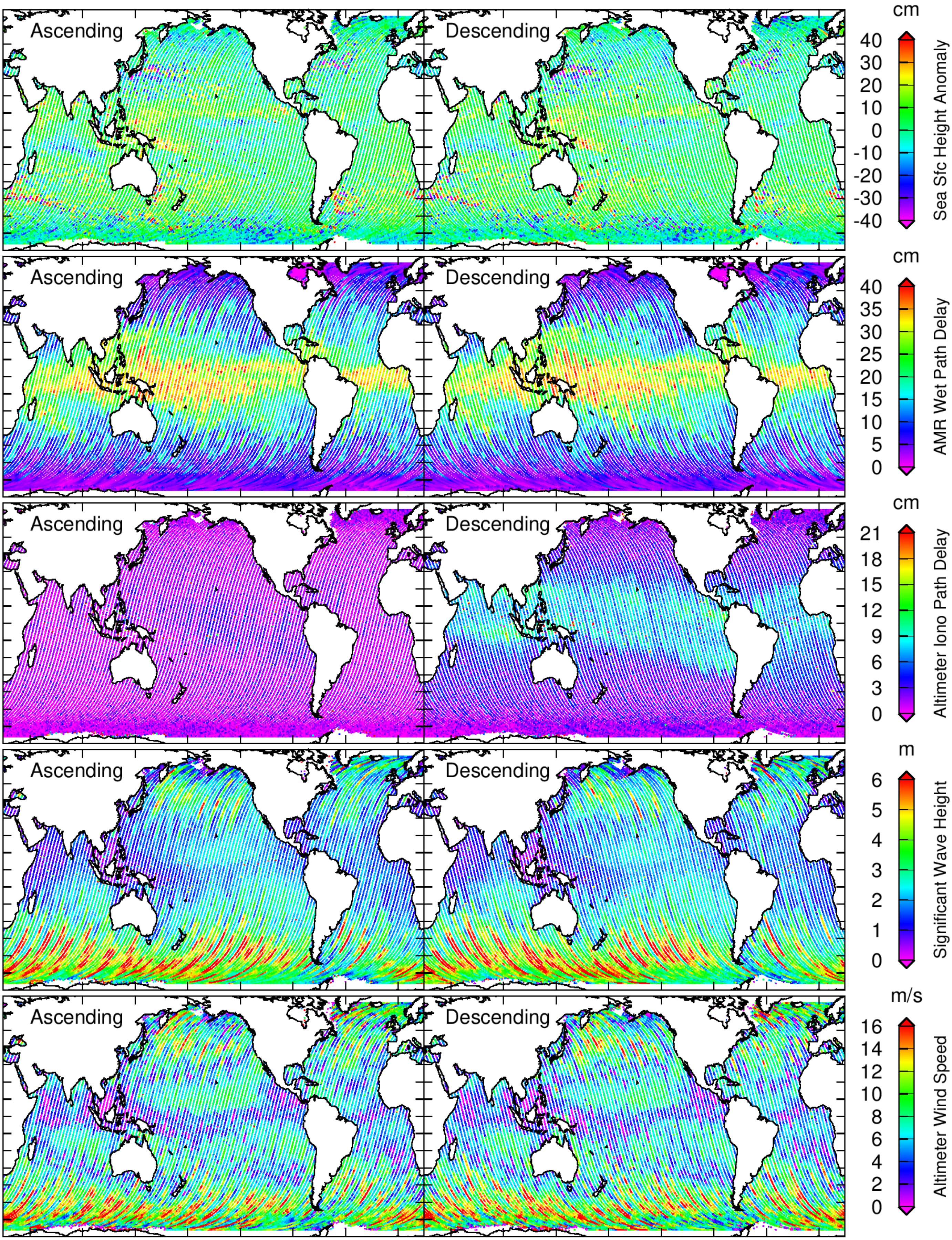
Jason-3 Cycle-042 2017-03-29 23:28:23 - 2017-04-08 21:26:55



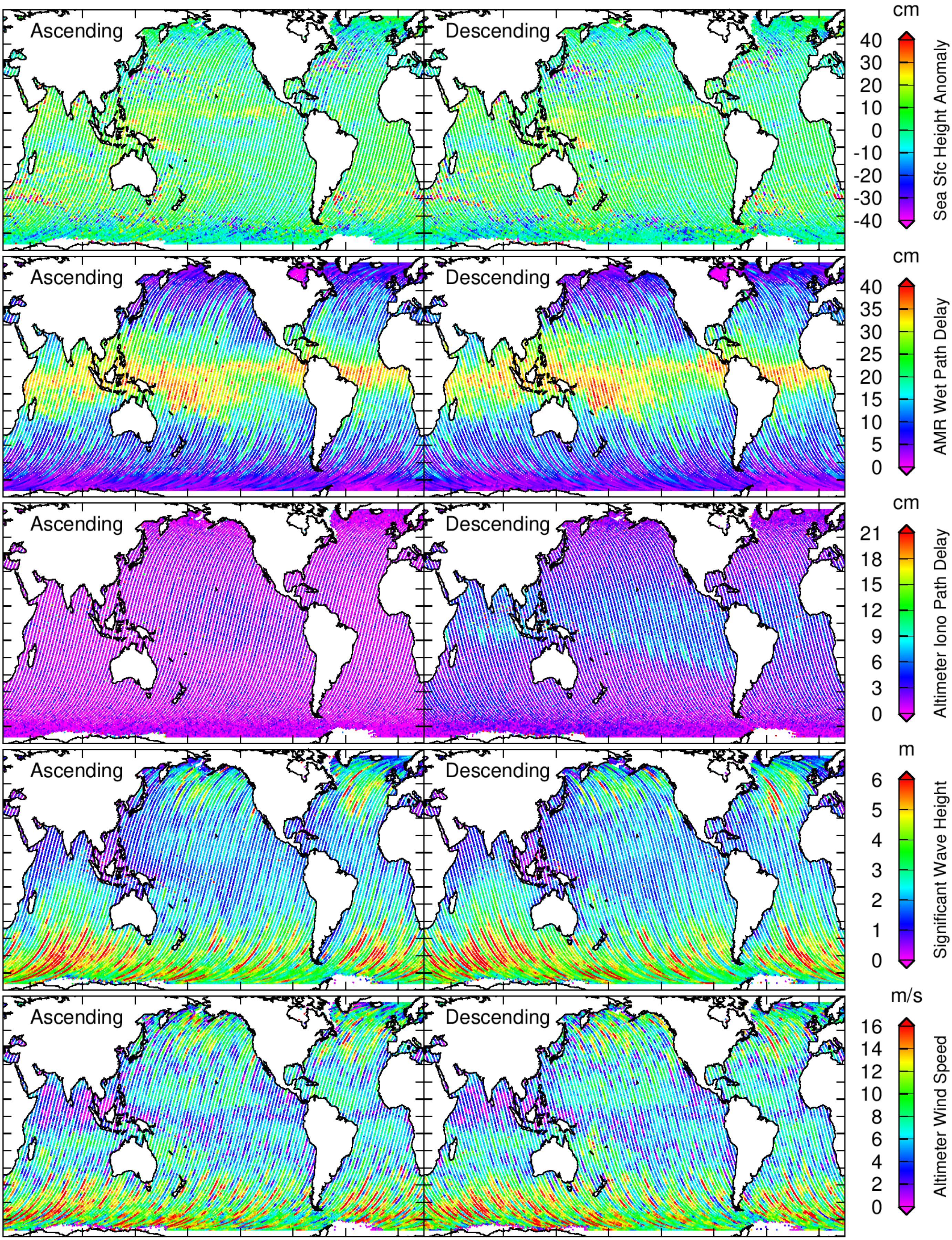
Jason-3 Cycle-043 2017-04-08 21:26:55 - 2017-04-18 19:25:26



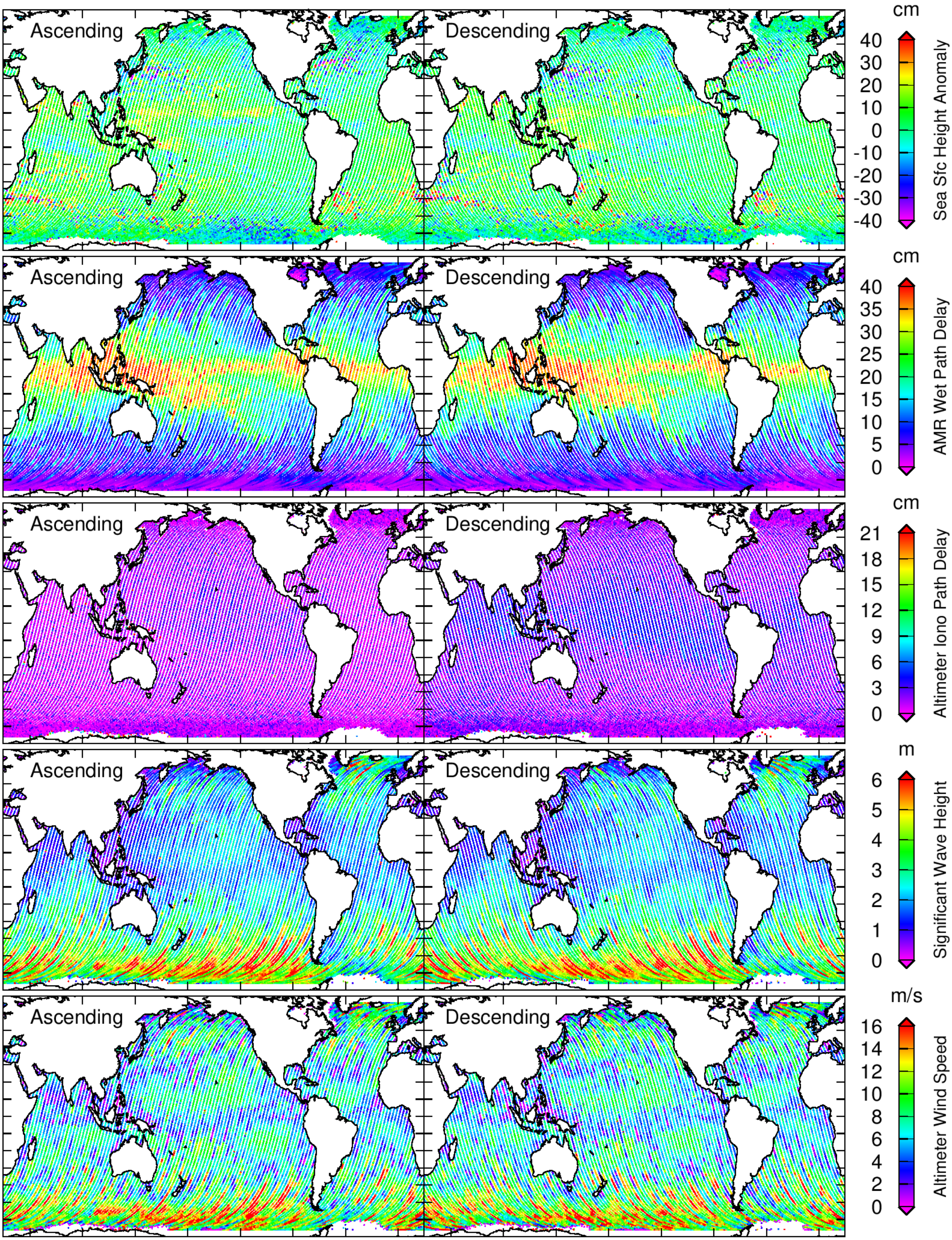
Jason-3 Cycle-044 2017-04-18 19:25:26 - 2017-04-28 17:23:58



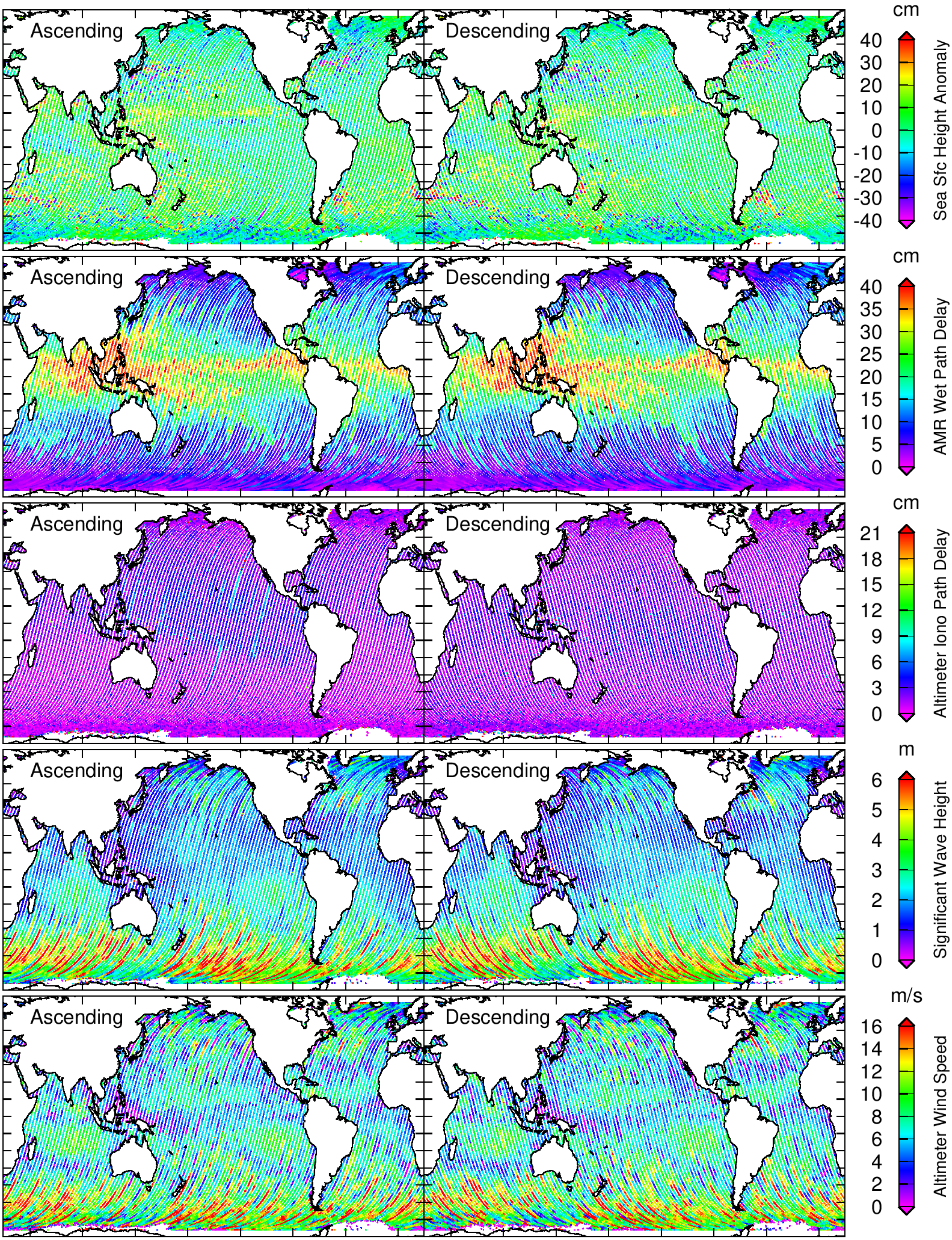
Jason-3 Cycle-045 2017-04-28 17:23:58 - 2017-05-08 15:22:30



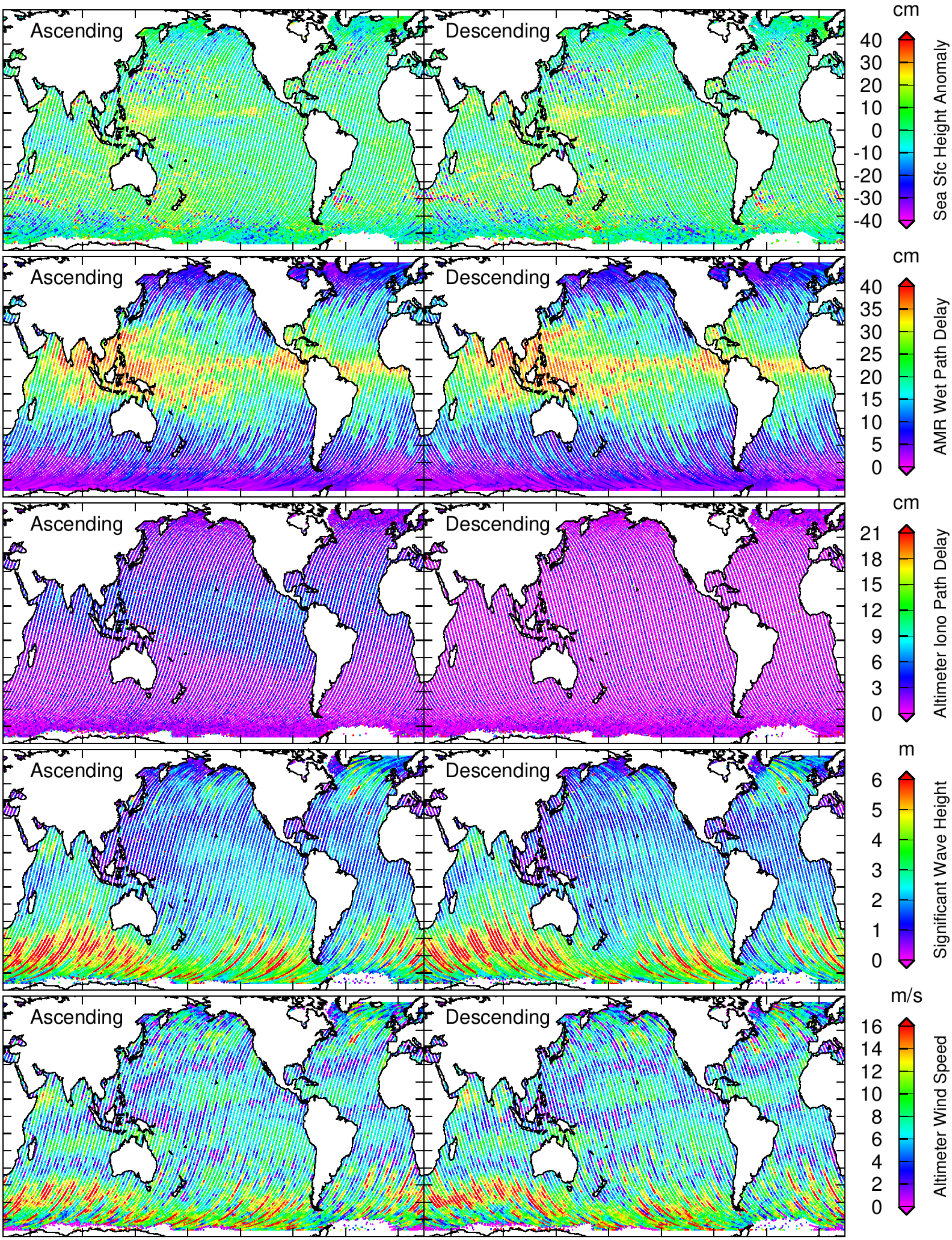
Jason-3 Cycle-046 2017-05-08 15:22:30 - 2017-05-18 13:21:01



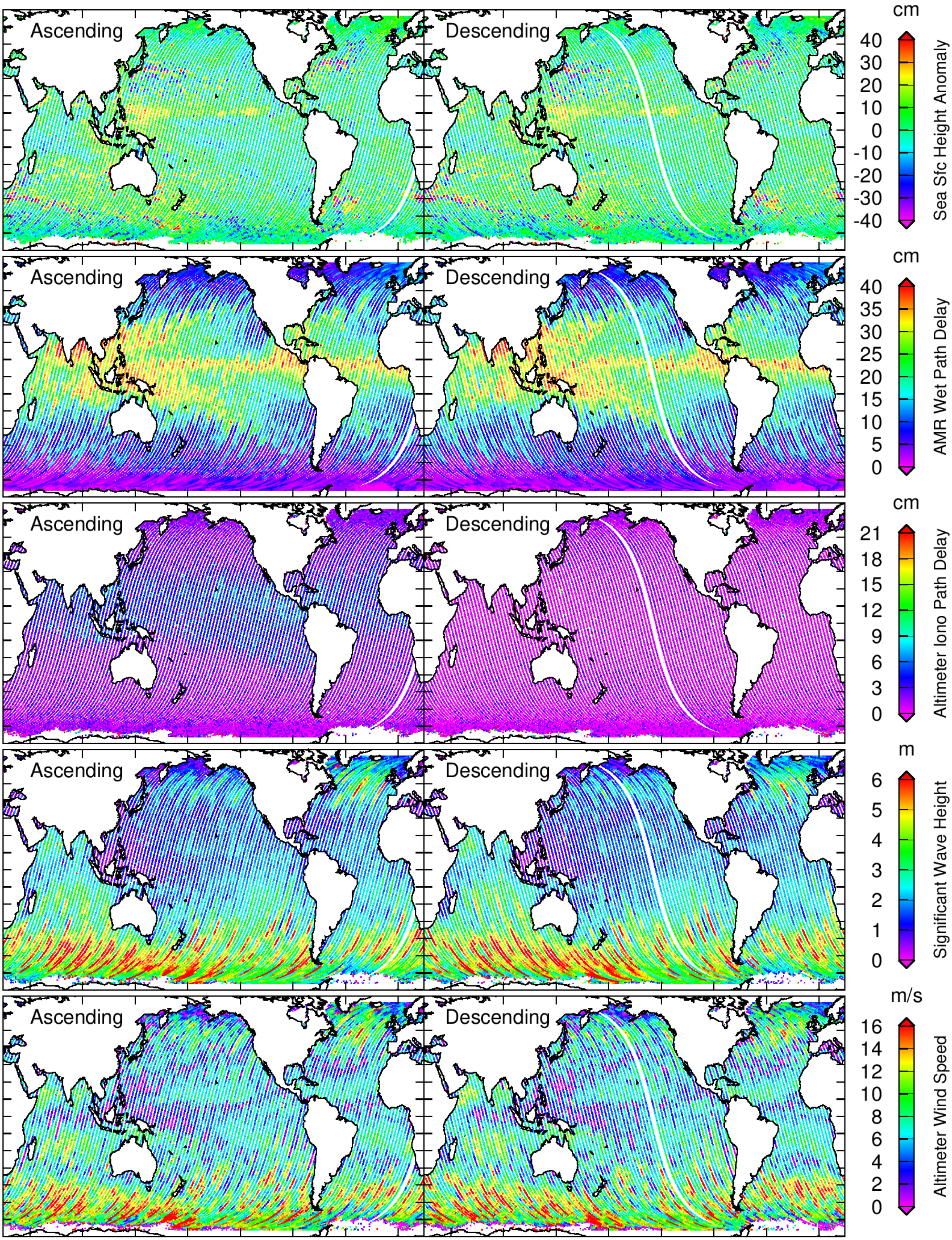
Jason-3 Cycle-047 2017-05-18 13:21:01 - 2017-05-28 11:19:33



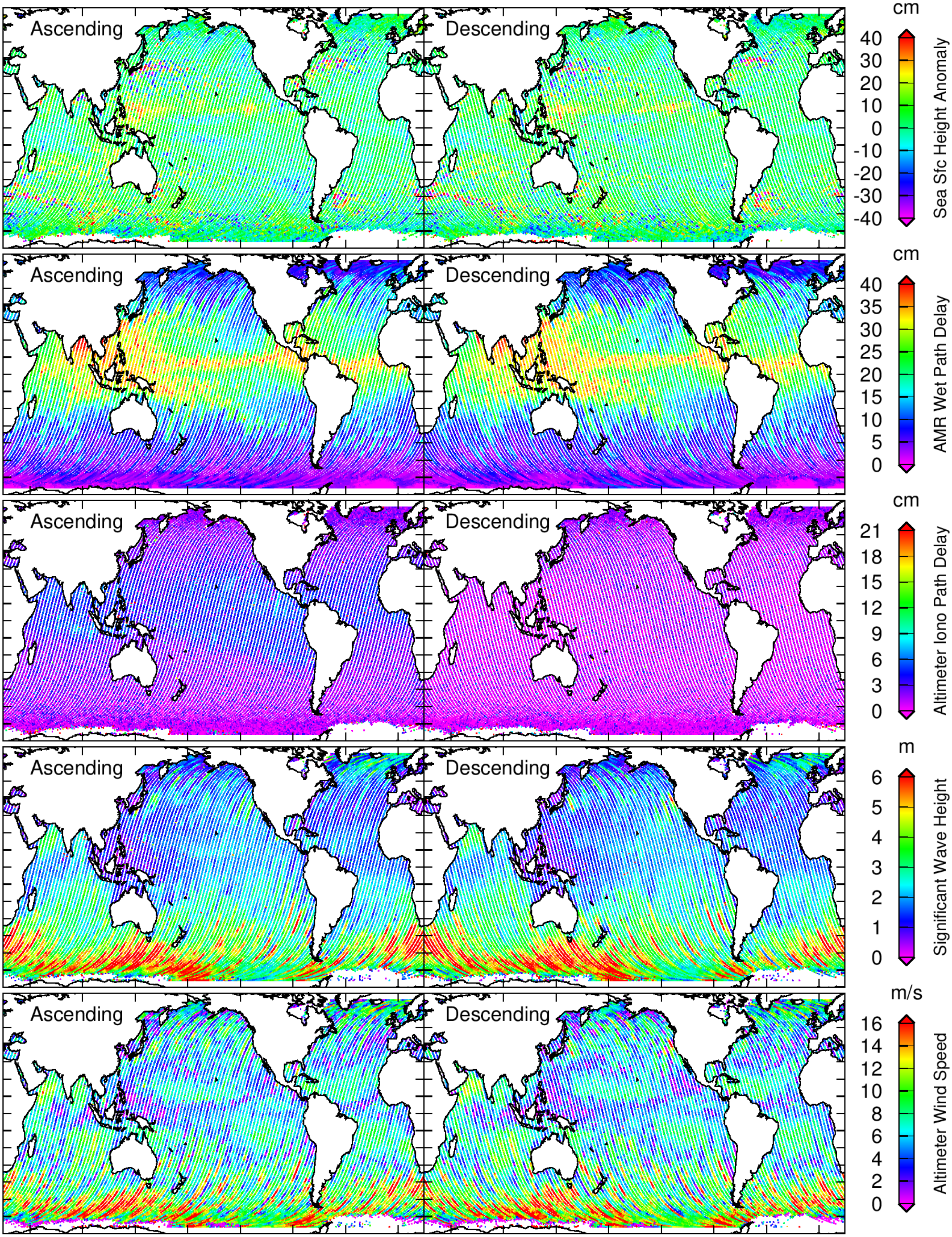
Jason-3 Cycle-048 2017-05-28 11:19:33 - 2017-06-07 09:18:04



Jason-3 Cycle-049 2017-06-07 09:18:04 - 2017-06-17 07:16:36



Jason-3 Cycle-050 2017-06-17 07:16:36 - 2017-06-27 05:15:08



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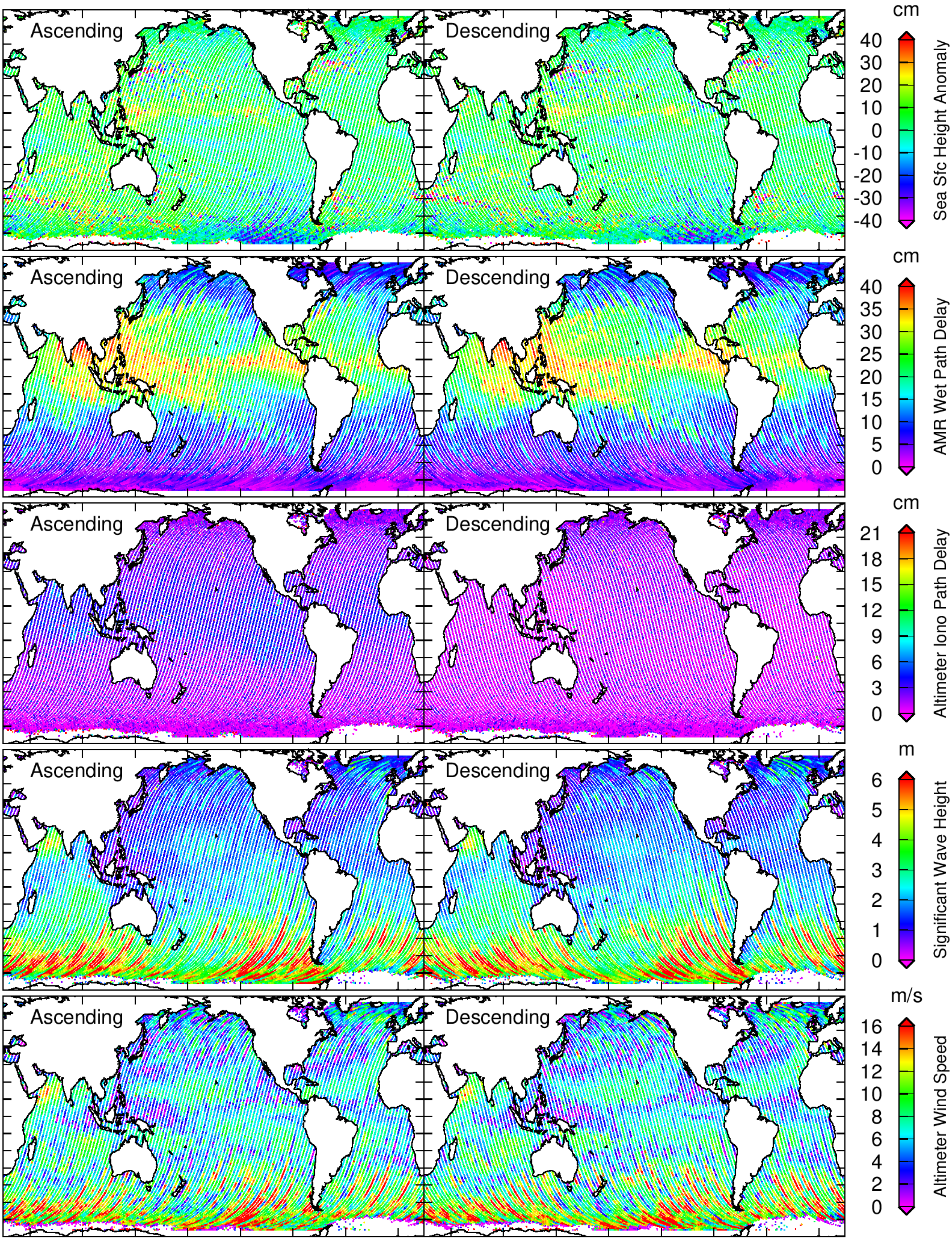

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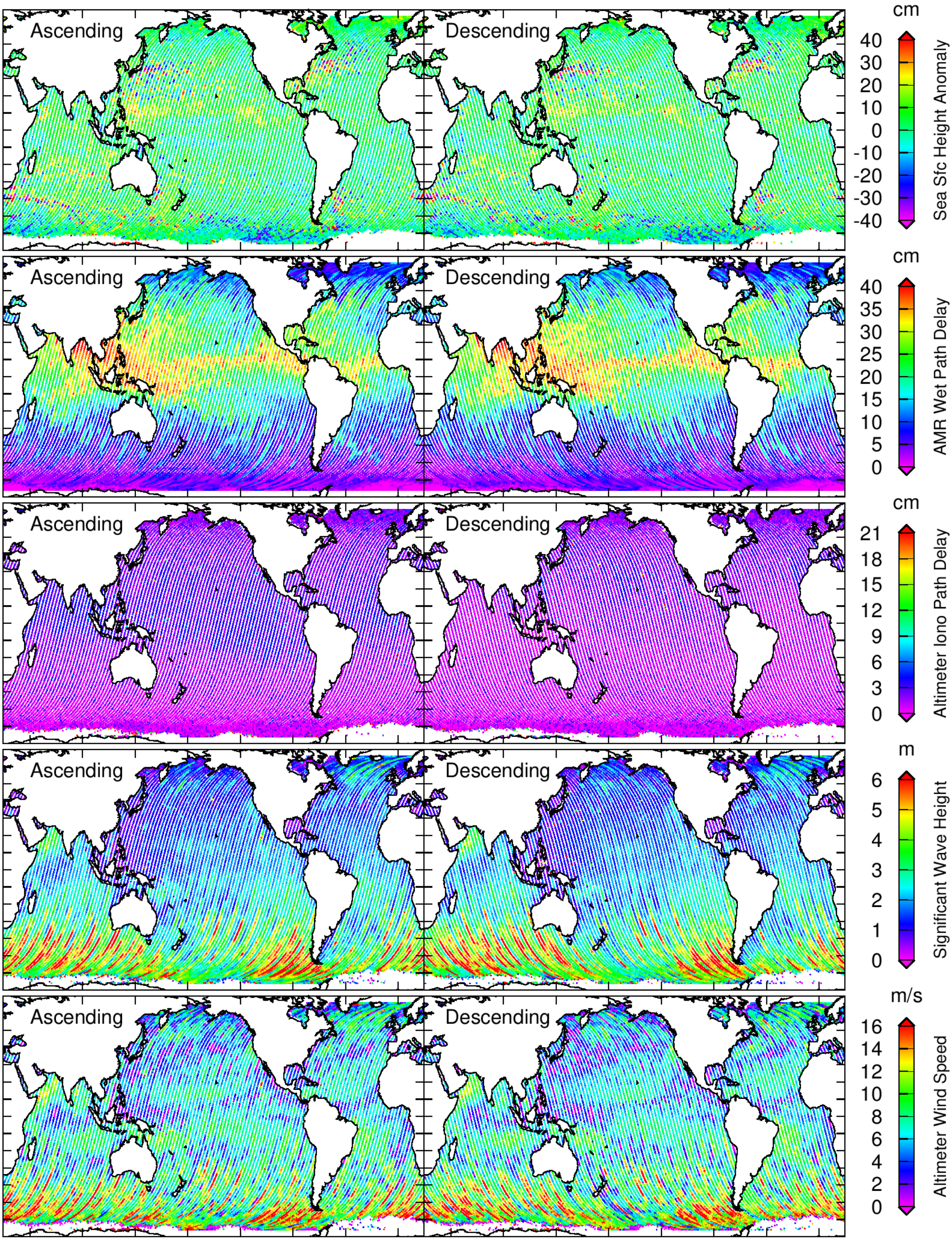

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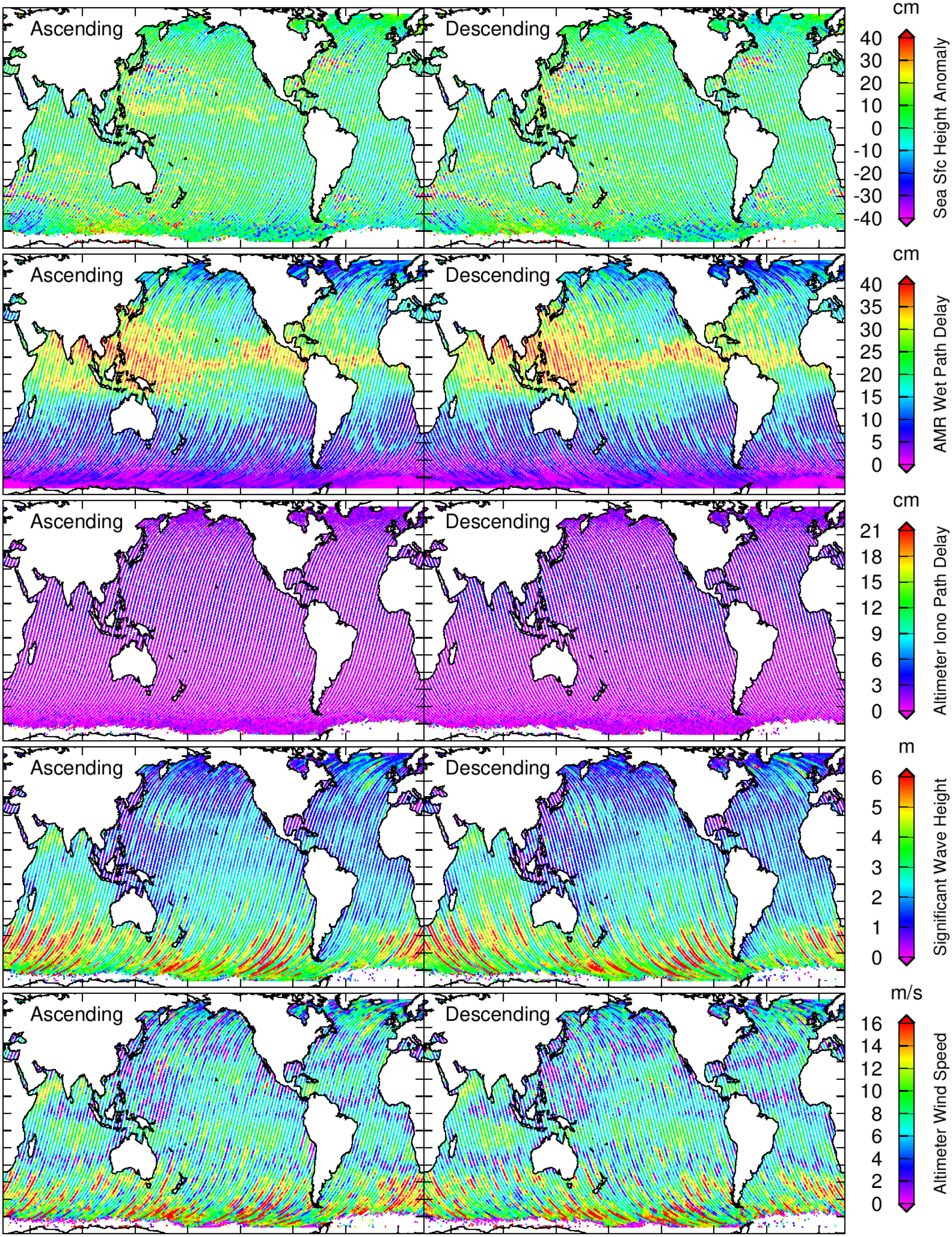

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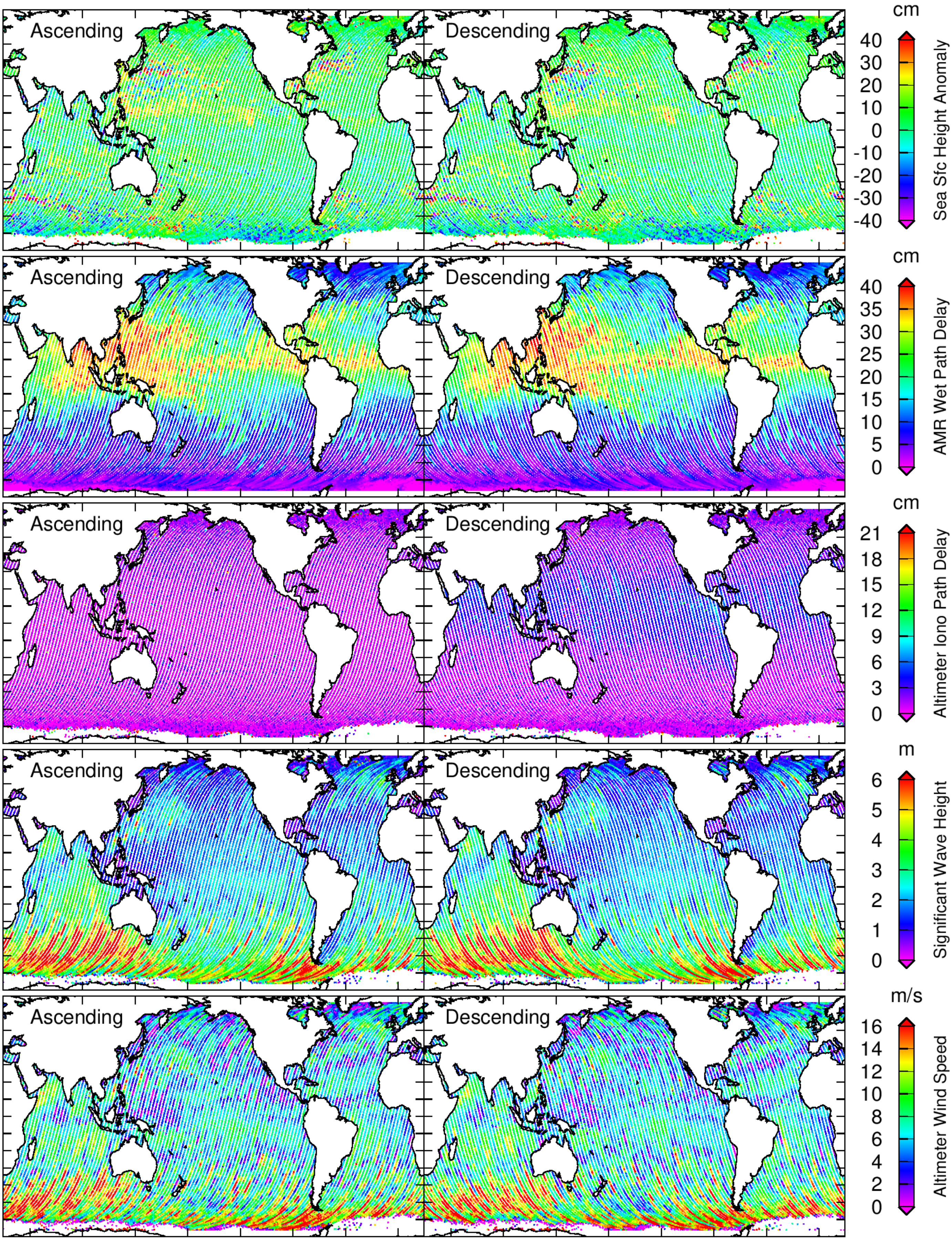

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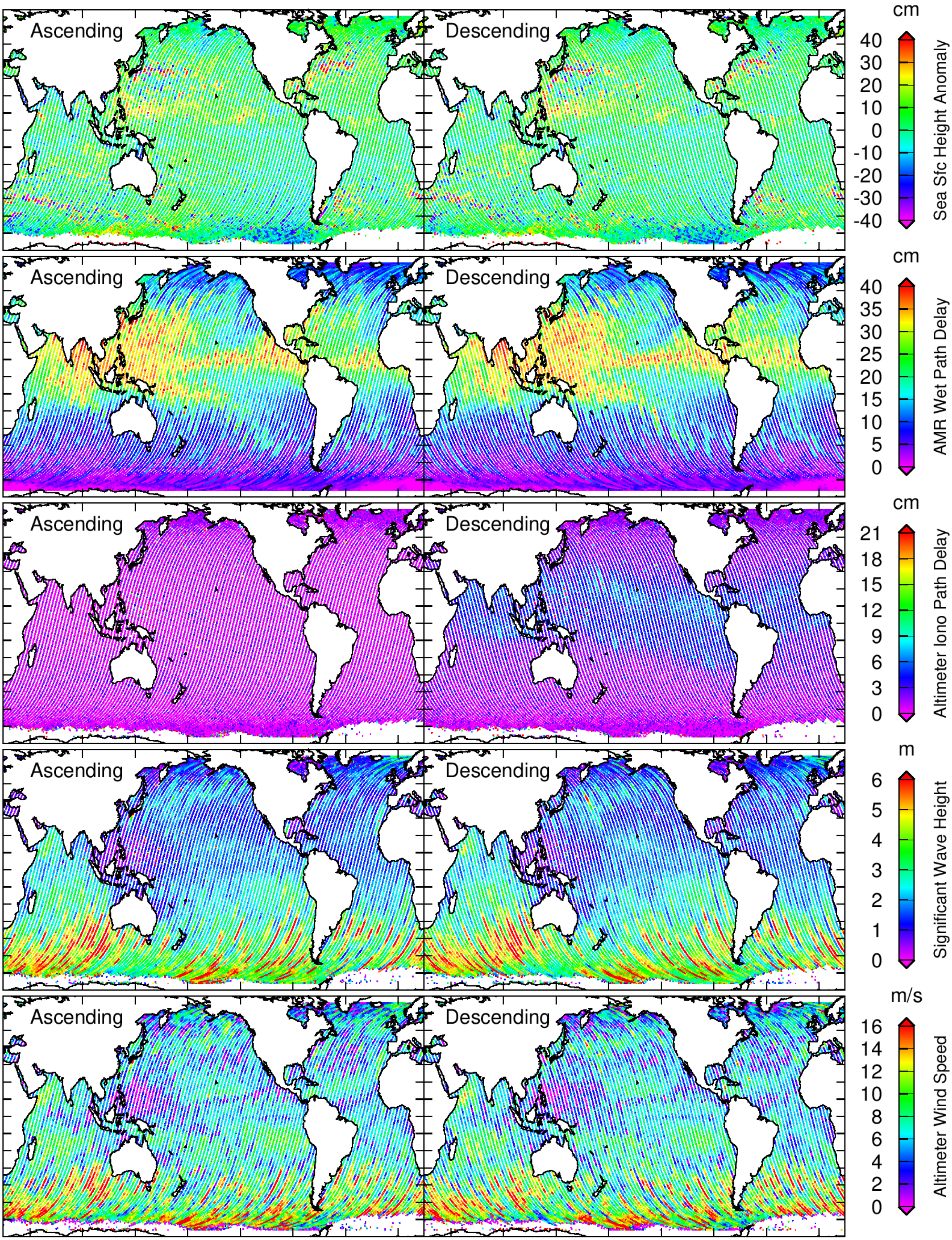
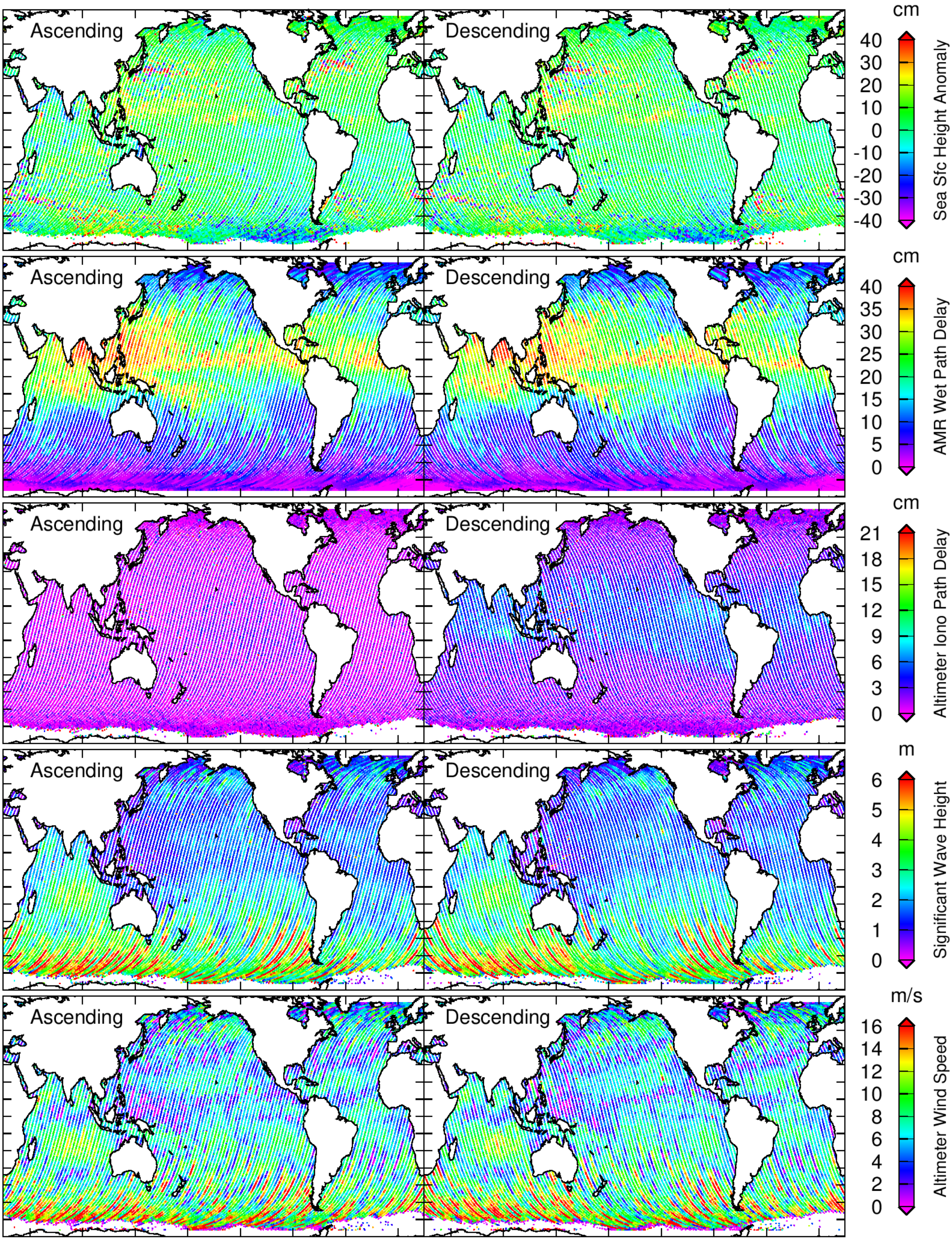
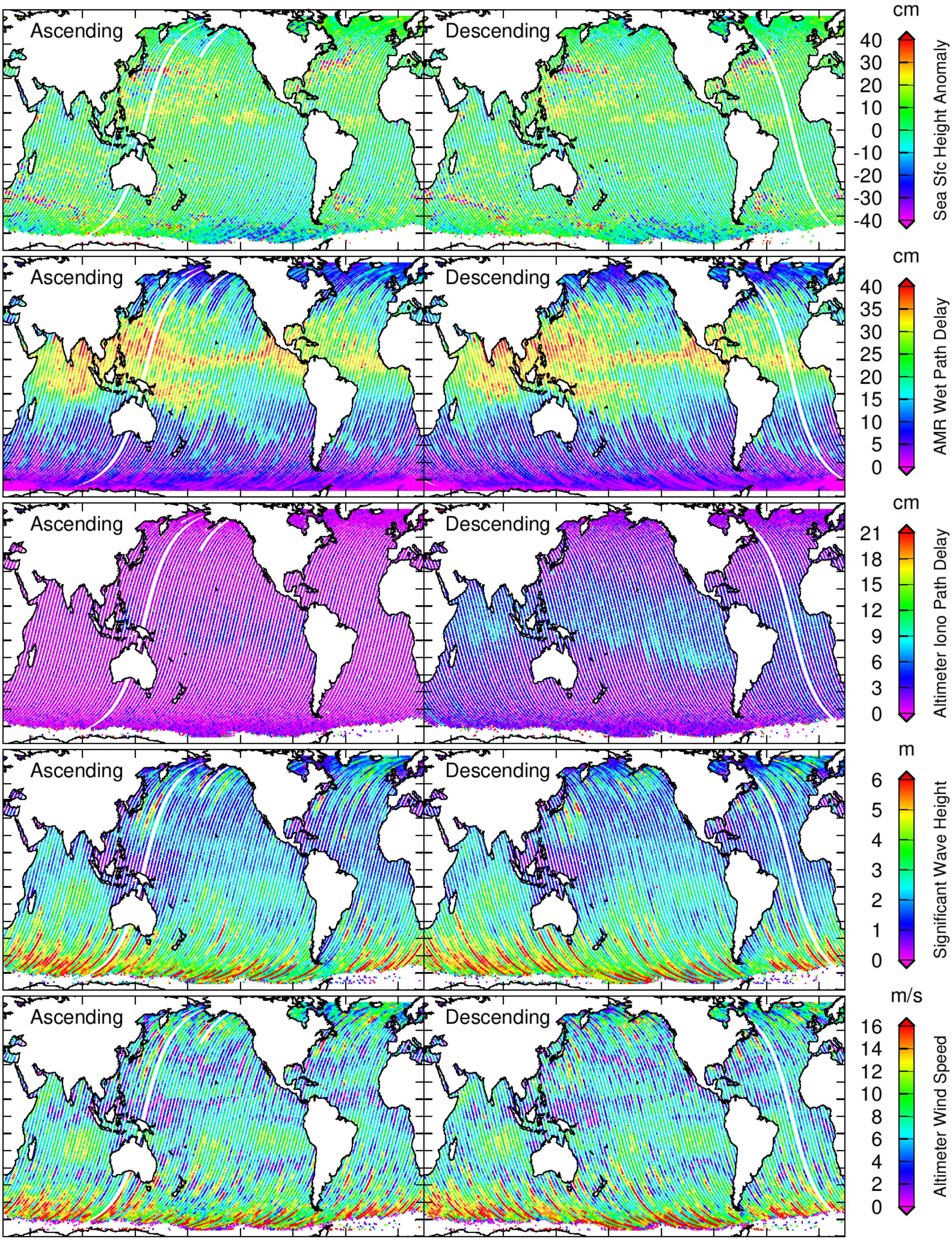


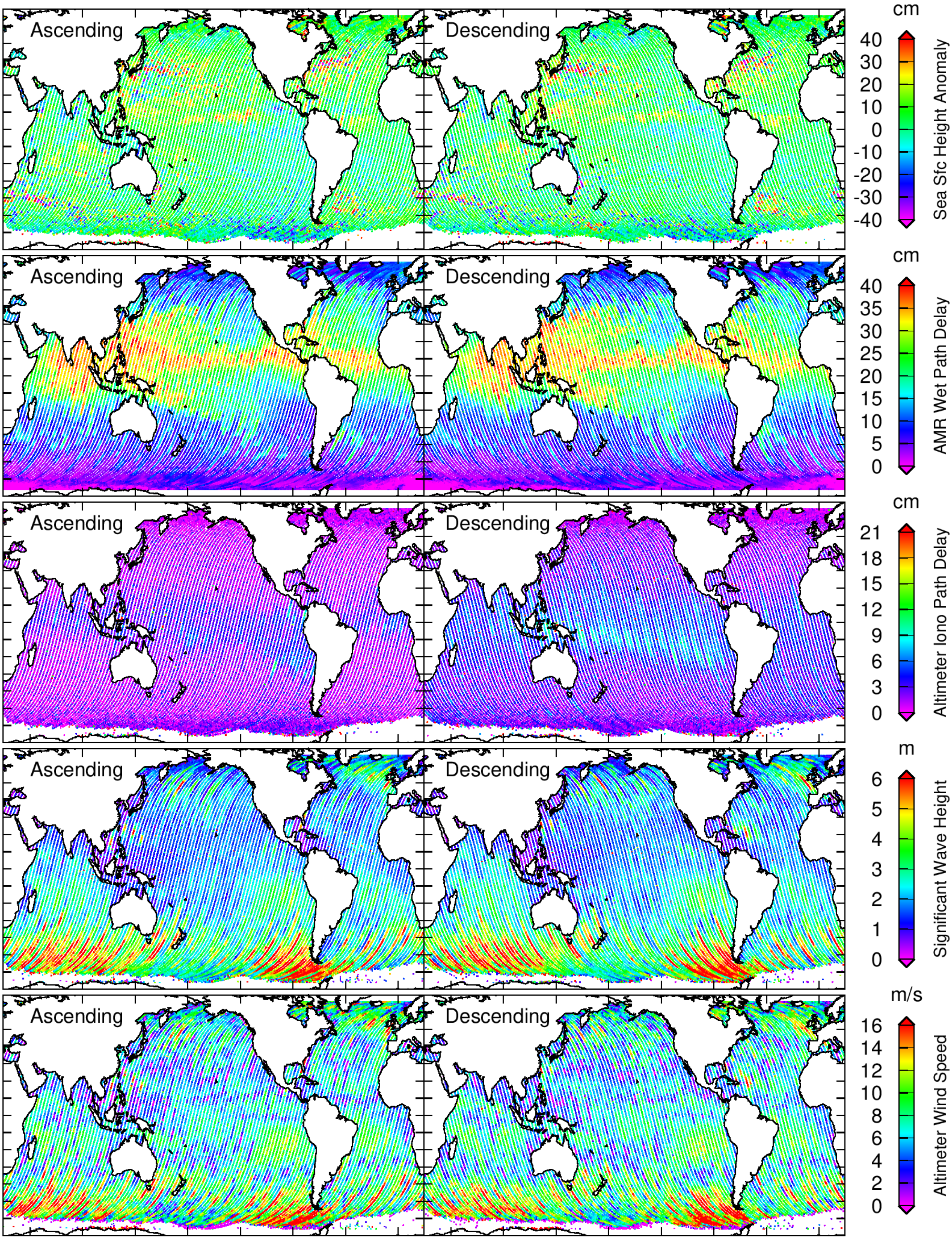
Jason-3 Cycle-056 2017-08-15 19:07:46 - 2017-08-25 17:06:17



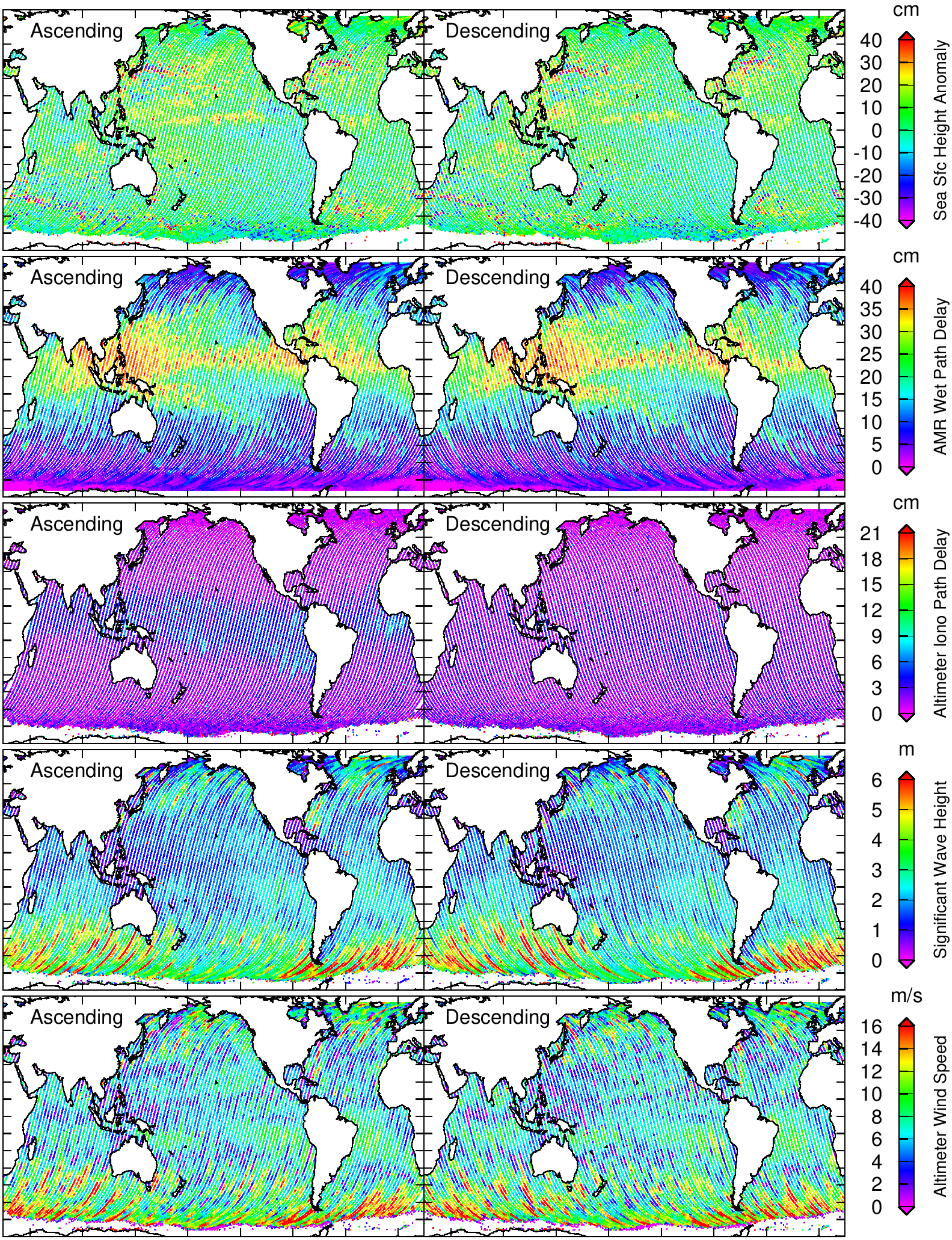
Jason-3 Cycle-057 2017-08-25 17:06:17 - 2017-09-04 15:04:49



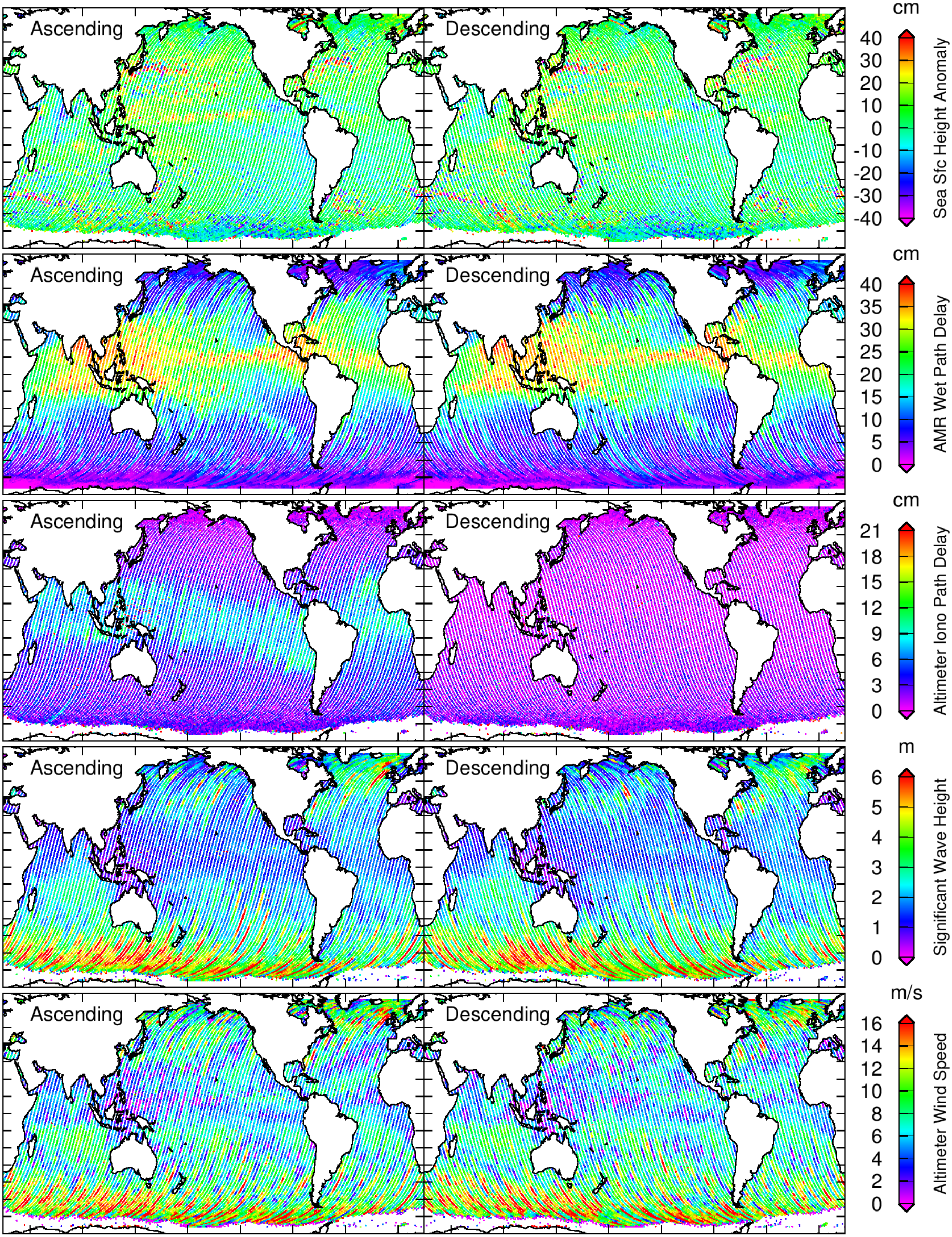
Jason-3 Cycle-058 2017-09-04 15:04:49 - 2017-09-14 13:03:21



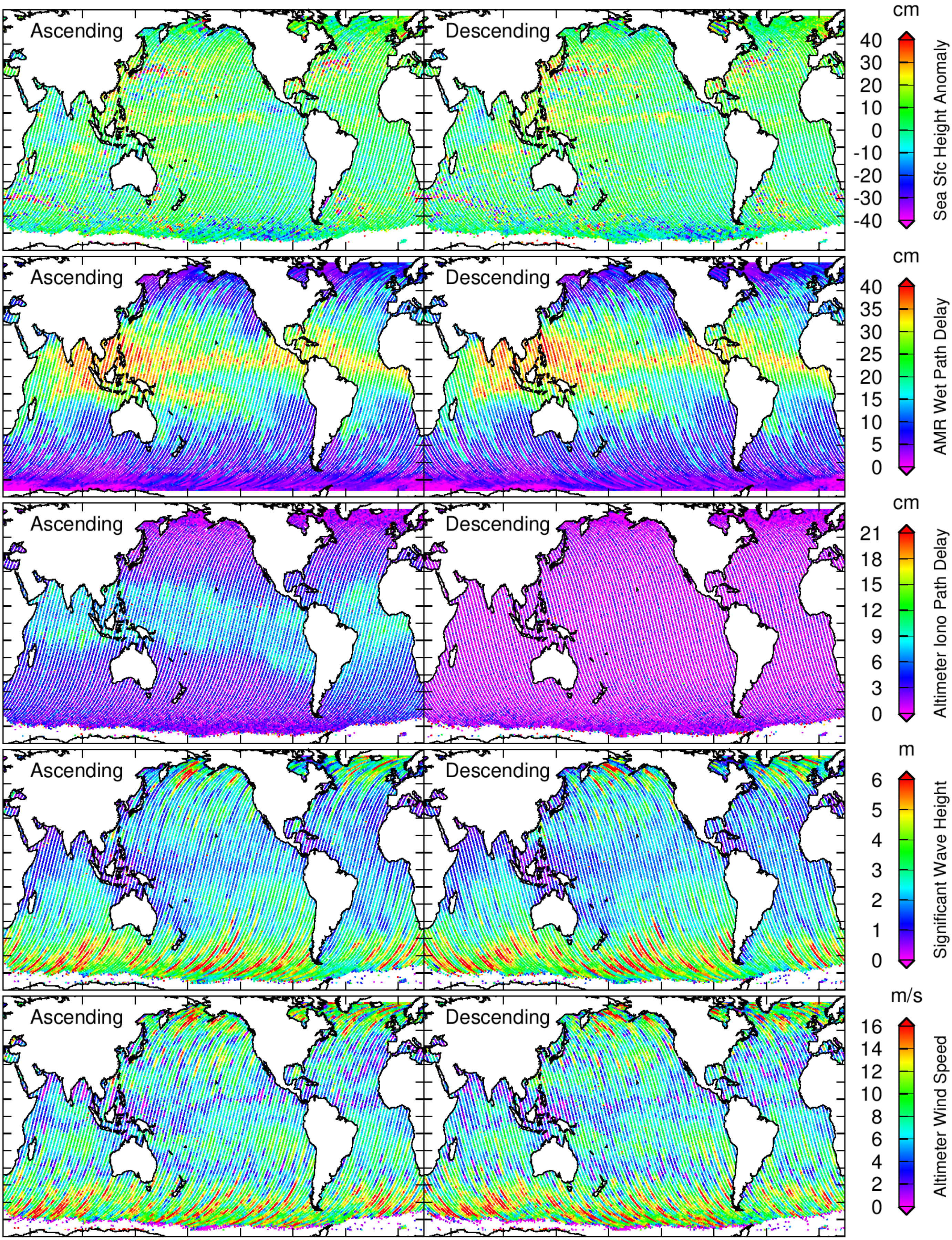
Jason-3 Cycle-059 2017-09-14 13:03:21 - 2017-09-24 11:01:52



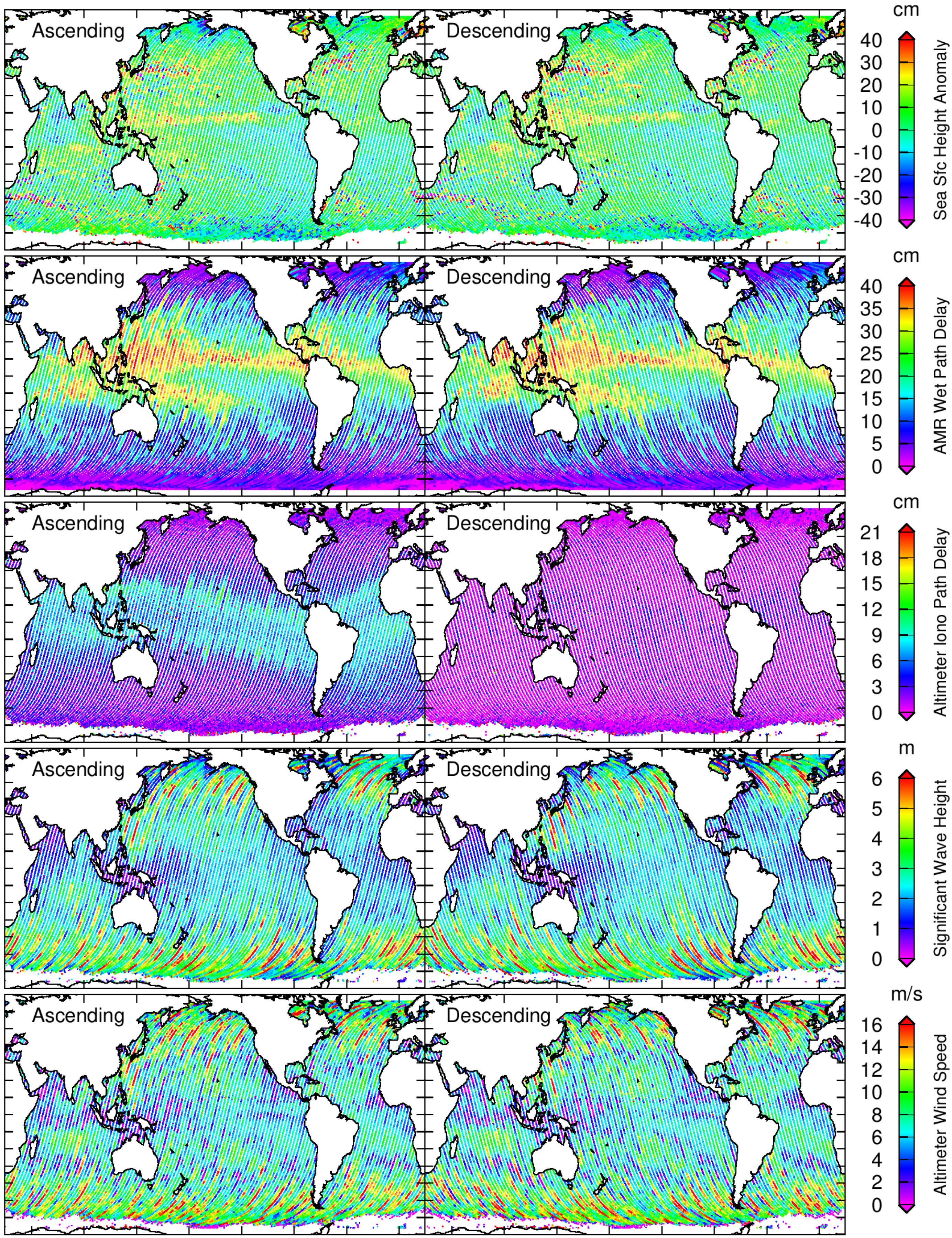
Jason-3 Cycle-060 2017-09-24 11:01:52 - 2017-10-04 09:00:24



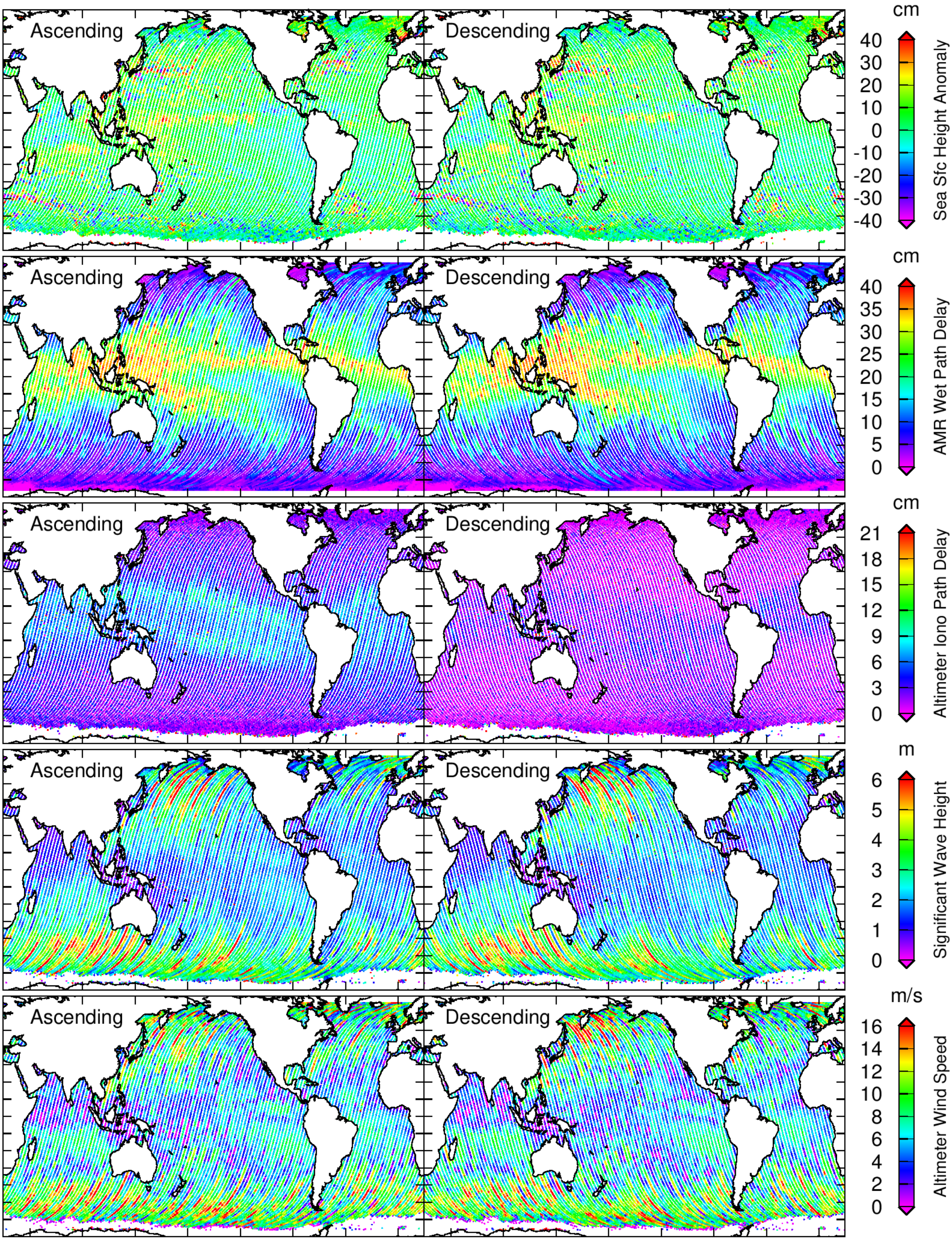
Jason-3 Cycle-061 2017-10-04 09:00:24 - 2017-10-14 06:58:55



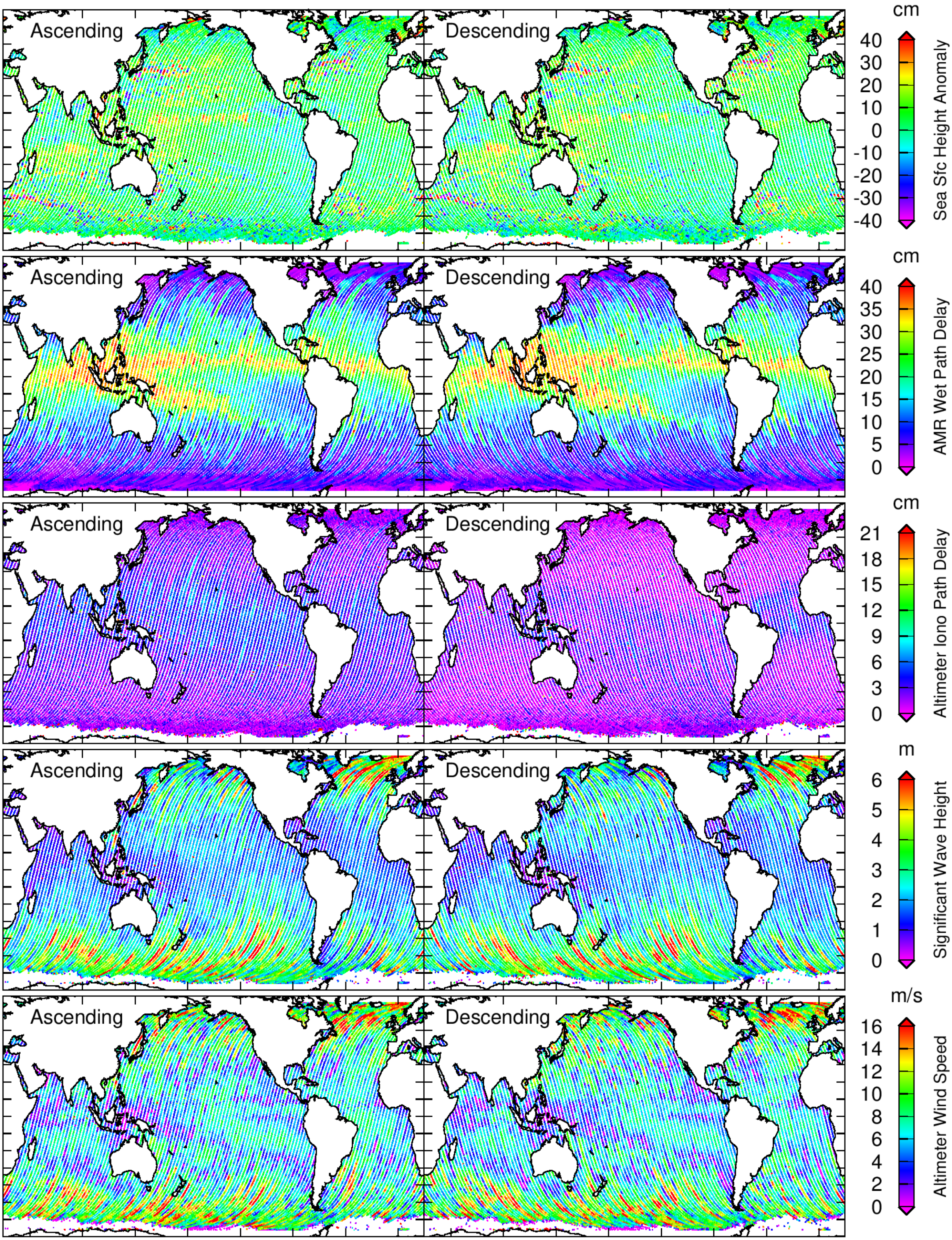
Jason-3 Cycle-062 2017-10-14 06:58:55 - 2017-10-24 04:57:27



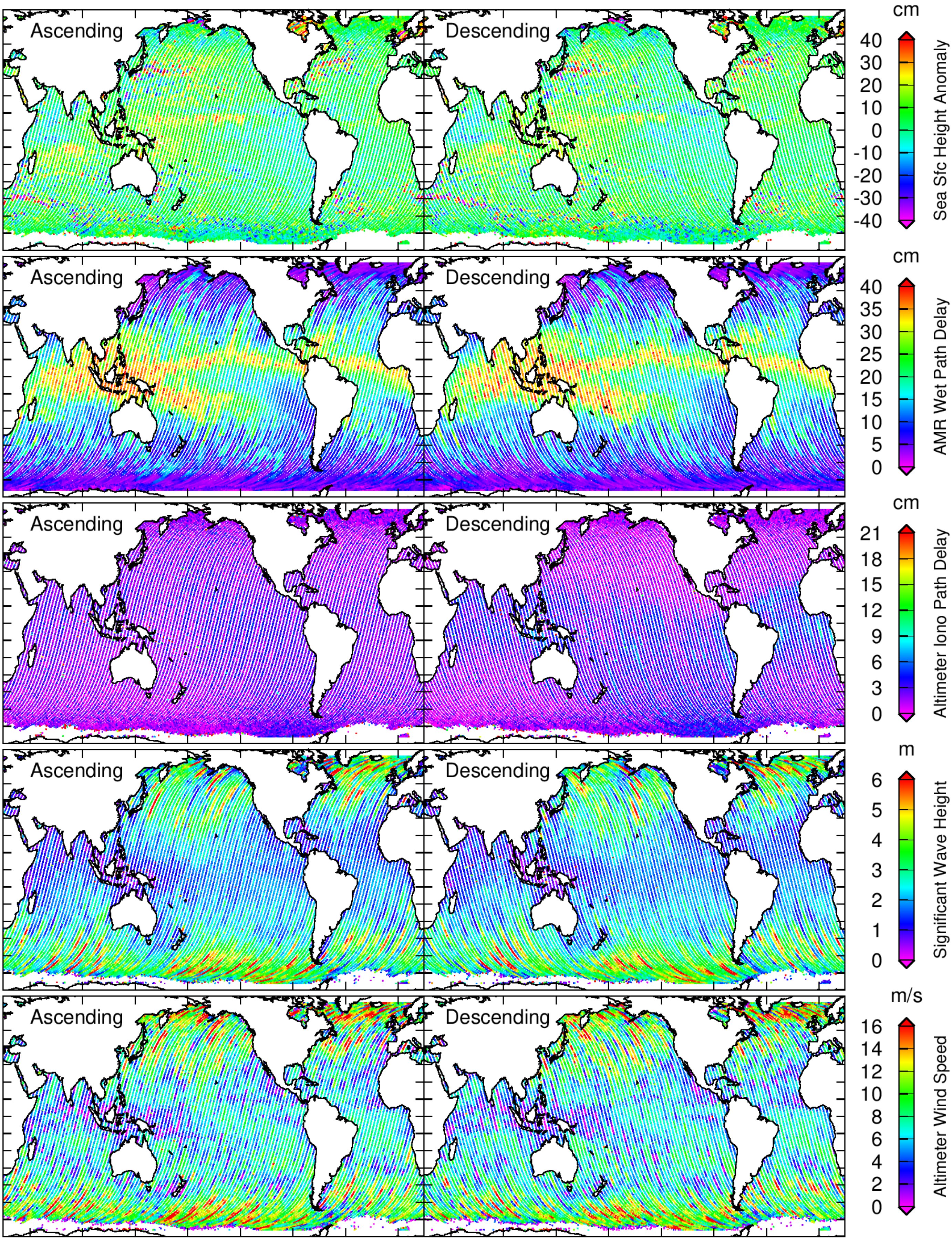
Jason-3 Cycle-063 2017-10-24 04:57:27 - 2017-11-03 02:55:59



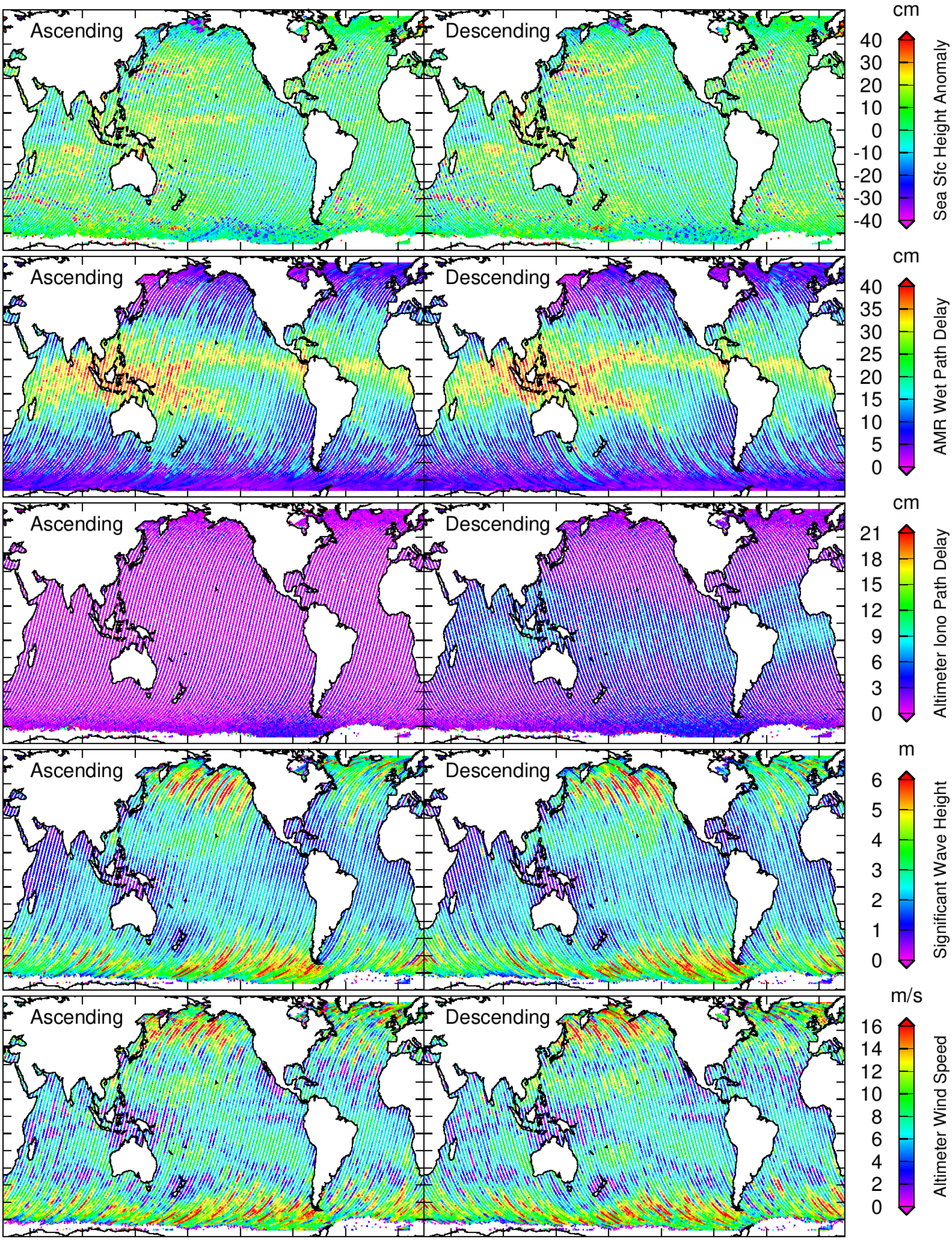
Jason-3 Cycle-064 2017-11-03 02:55:59 - 2017-11-13 00:54:30



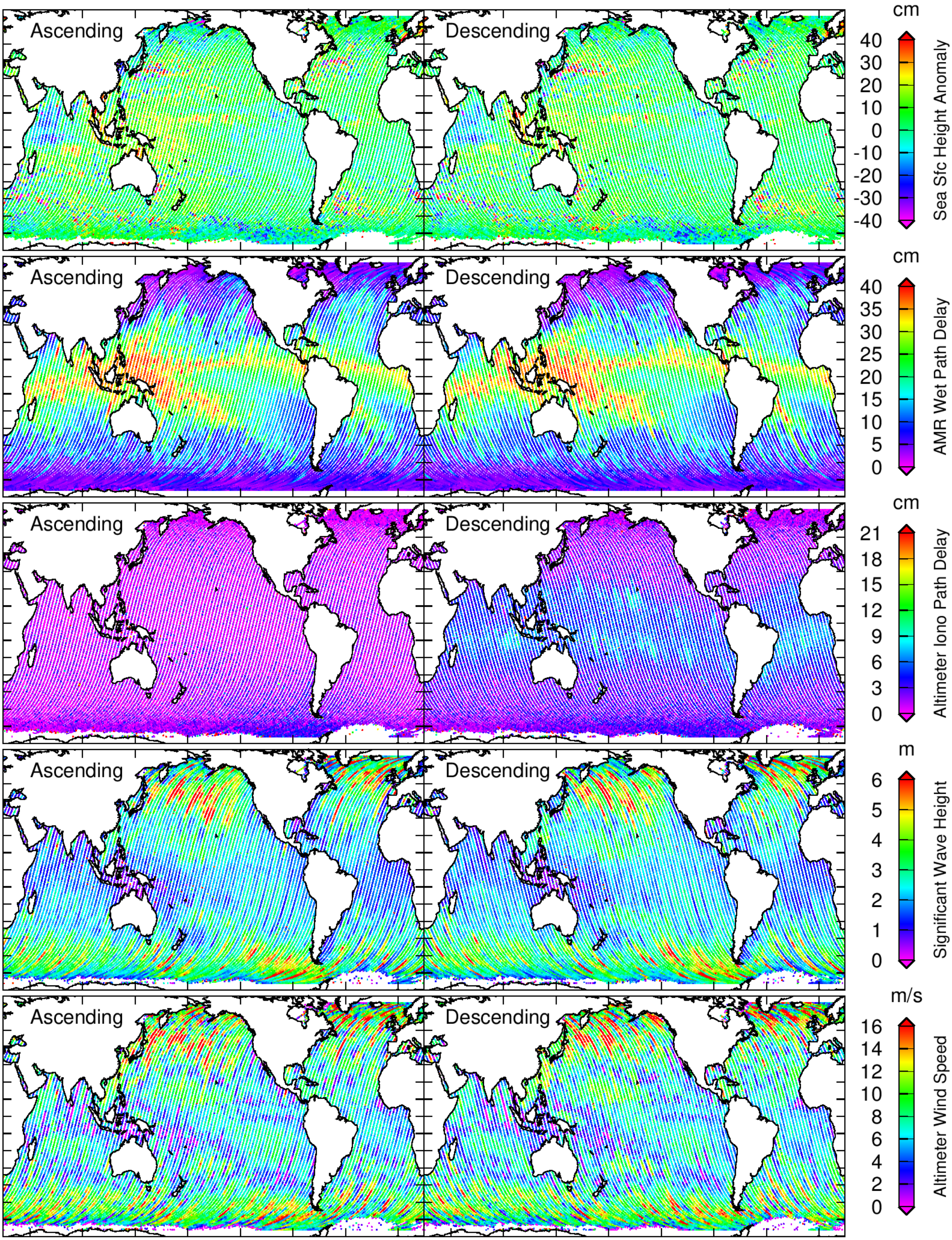
Jason-3 Cycle-065 2017-11-13 00:54:30 - 2017-11-22 22:53:02



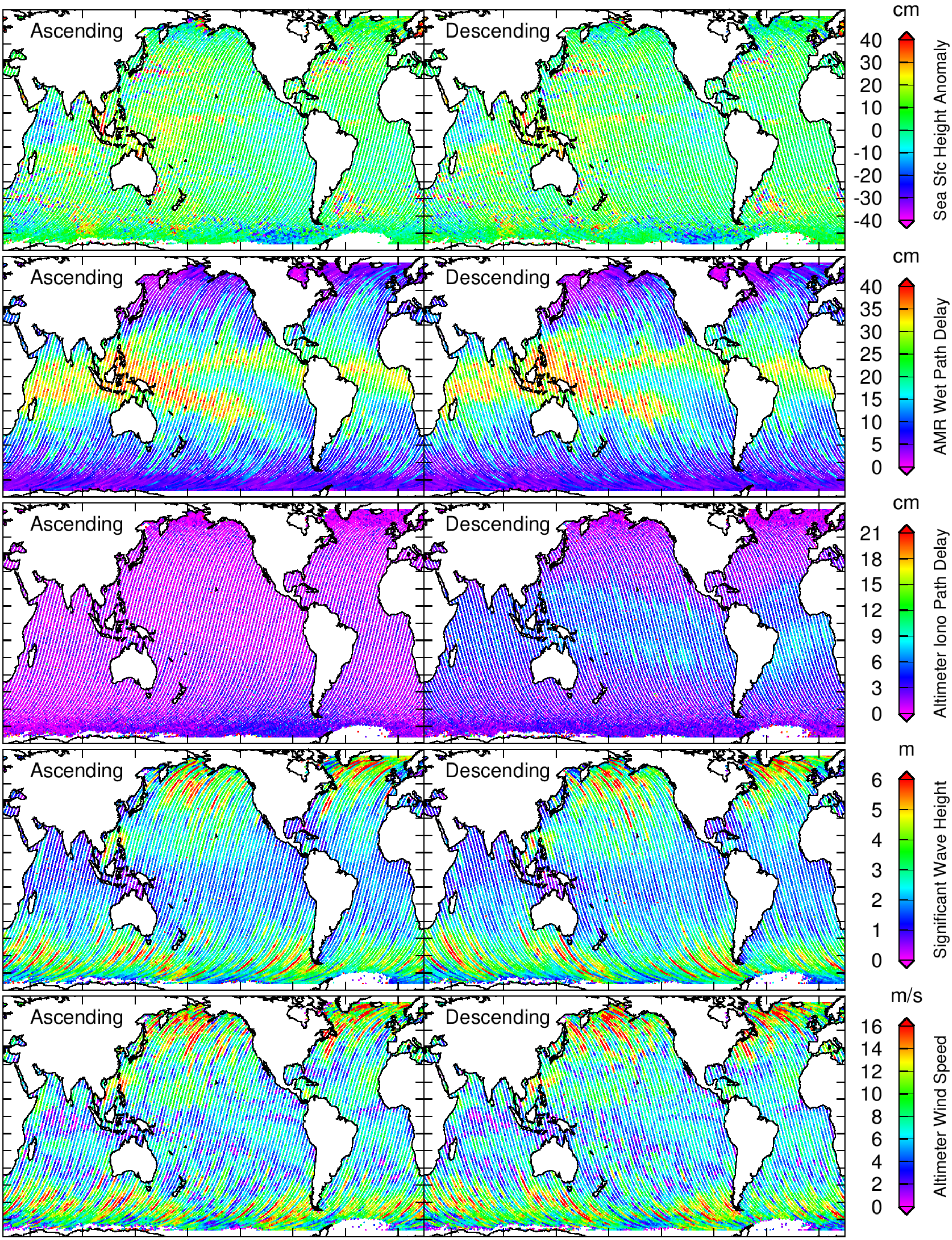
Jason-3 Cycle-066 2017-11-22 22:53:02 - 2017-12-02 20:51:33



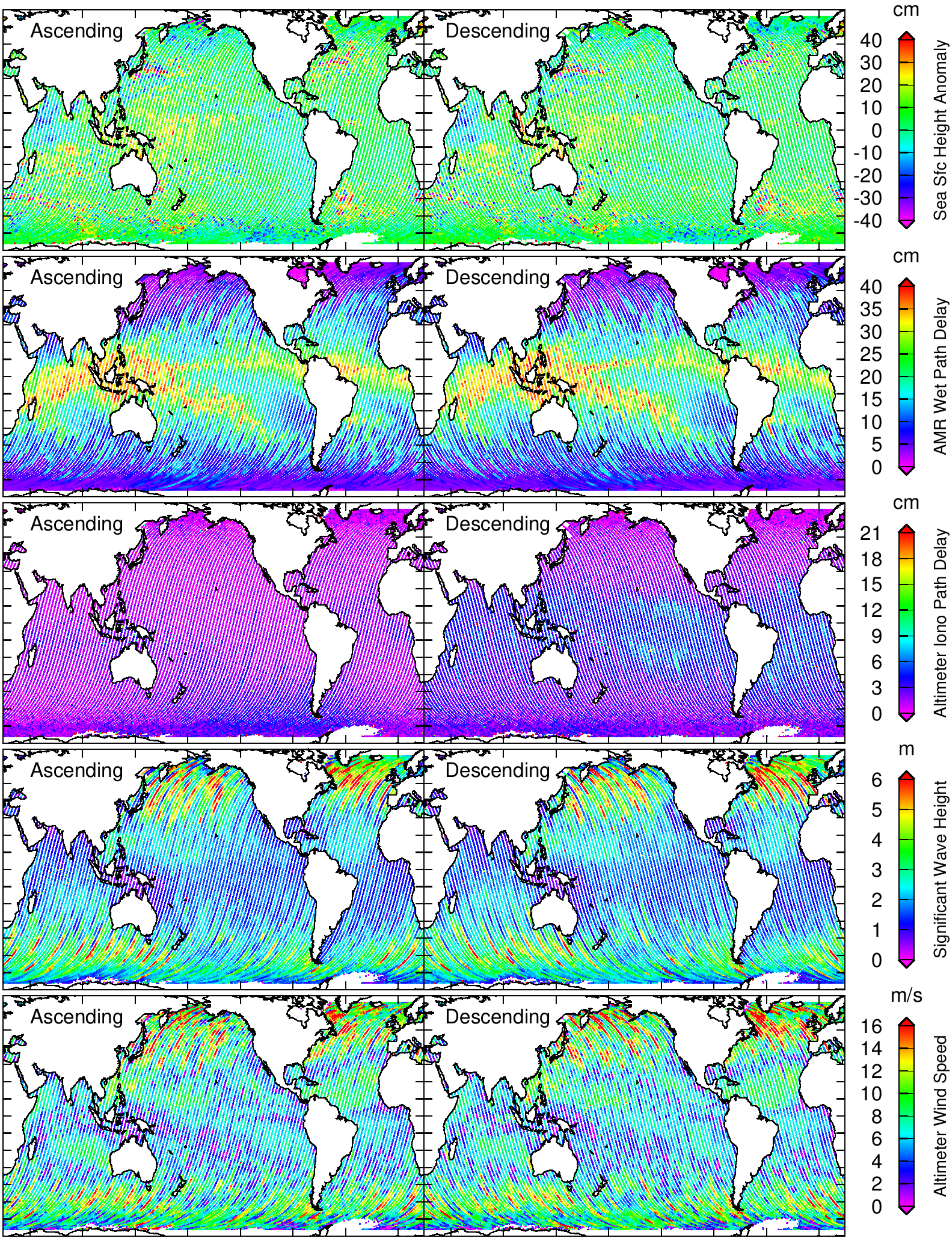
Jason-3 Cycle-067 2017-12-02 20:51:33 - 2017-12-12 18:50:05



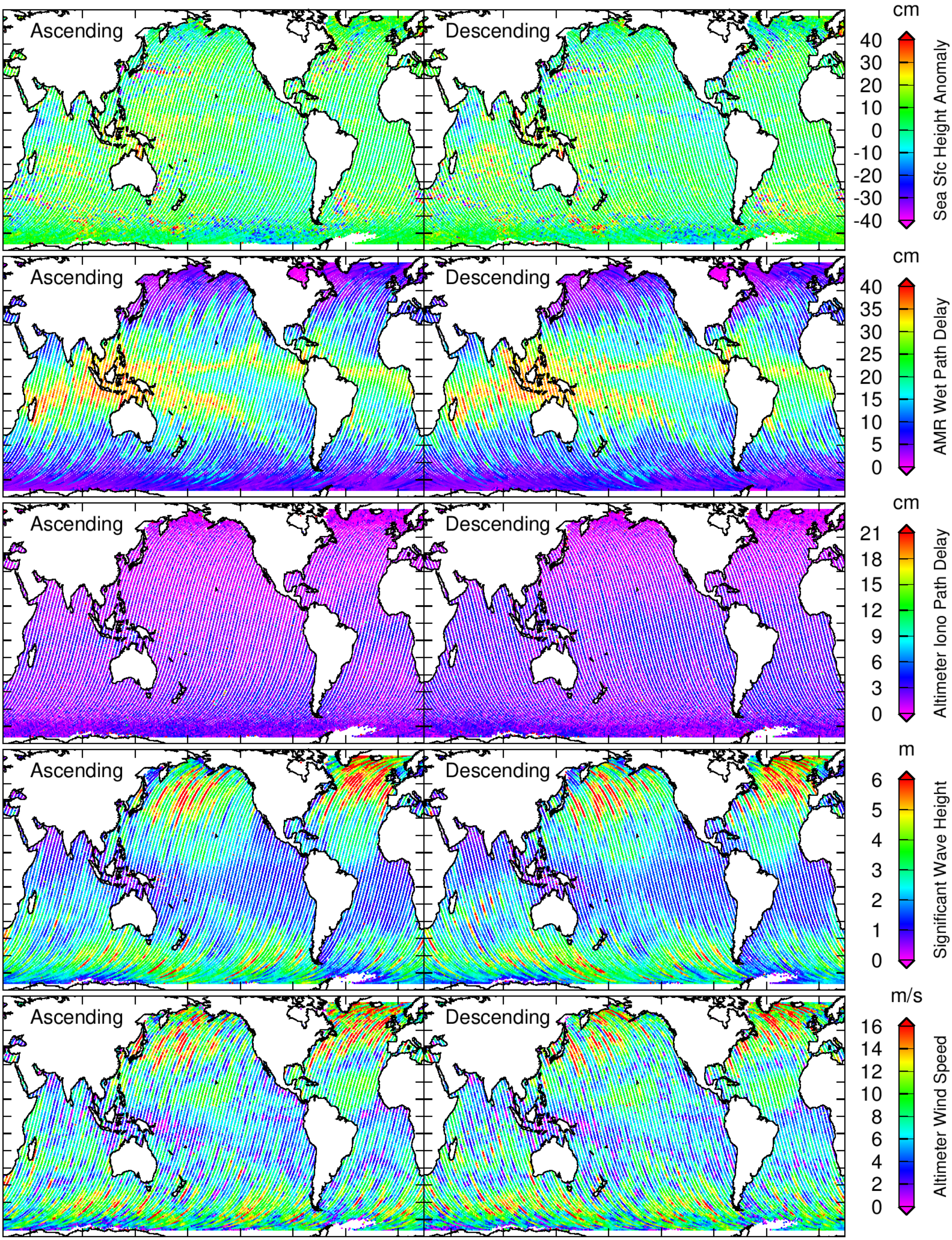
Jason-3 Cycle-068 2017-12-12 18:50:05 - 2017-12-22 16:48:37



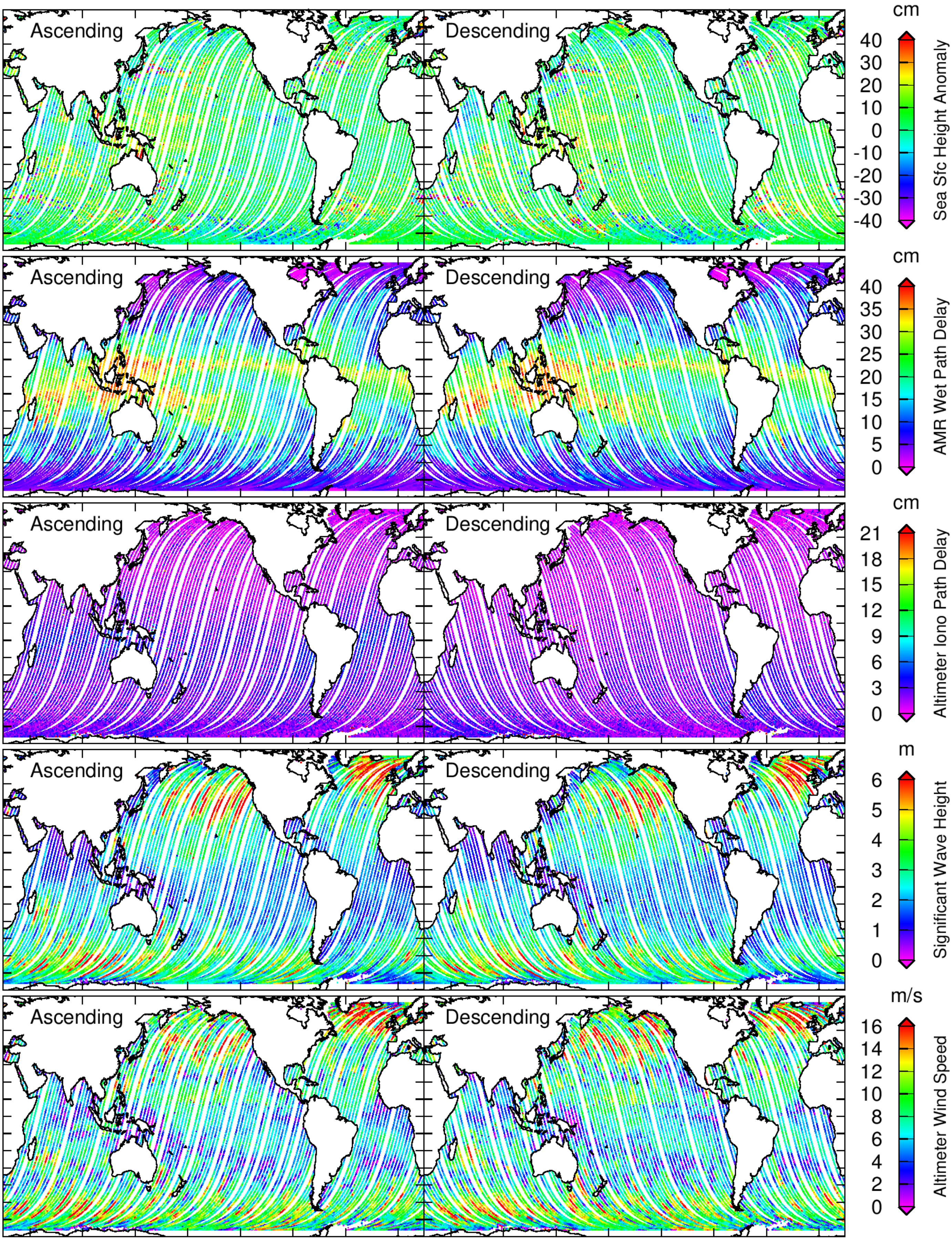
Jason-3 Cycle-069 2017-12-22 16:48:37 - 2018-01-01 14:47:08



Jason-3 Cycle-070 2018-01-01 14:47:08 - 2018-01-11 12:45:40



Jason-3 Cycle-071 2018-01-11 12:45:40 - 2018-01-21 10:44:11



Jason-3 Cycle-072 2018-01-21 10:44:11 - 2018-01-31 08:42:43