OSTM / Jason-2

Near Real-Time Data Annual Quality Report 2008-2009

August 2009

Prepared by:

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

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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 OSTM / Jason-2 *Near Real-Time Data Annual Quality Report 2008-2009* (August 28, 2009 issue).

The purpose of this document is to assess the overall quality of the Jason-2/OSTM near real-time products (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-2/Ocean Surface Topography Mission is the successor to the Topex/Poseidon and Jason-1 radar altimetry missions. Jason-2 was launched from Vandenberg AFB on 20-Jun-2008, and the onboard instruments began producing data shortly thereafter, on 22-Jun-2008. Prior to achieving its final ~10-day exact repeat orbit, Jason-2 executed a series of maneuvers after injection into orbit. The exact repeat orbit was finally achieved on 04-Jul-2008. 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-2 is a dual-frequency altimeter (Ku-band & C-band) which provide measurements of sea surface height, significant wave height, and ocean surface wind speed. Three independent orbit determination systems are provided by the DORIS, GPS, 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 radar 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.

The Ocean Surface Topography Mission is 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 maximum data latencies of 3-5 hours with the normal two hours of data acquisition on board between data dumps to the ground.

In the following sections data from the first year of operations are analyzed, covering the time period from 04-Jul-2008 to 04-Jul-2009, cycles 0-36. We focus this 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, and ionospheric path delay based on dual-frequency altimeter measurements.

Section 2.0 Data Quality Analysis Plots

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 ± 2 seconds with the actual cycle boundaries. The individual 1-second data points, read from the NetCDF formatted OGDR files, are filtered with a 20-second long median filter and values are reported every 10-seconds along track. Each of these 10-second values is plotted as a filled circle, color coded by a rainbow scale 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 0-36, comprising the first year of operations of Jason-2, 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 37 plots form the basis of the quality assessment provided in the next sections.

Section 3.0 Anomalies Impacting Quality

Since the launch of Jason-2, various anomalies have occurred that 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. This section summarizes the known events which caused degradation in data quality.

This information is based on the file 'List of OSTM Events.doc', which is maintained by Nicolas Picot & Thierry Guinle at CNES and was kindly provided to the project partners. The entries in this table of events which impact data quality are presented in **Error! Reference source not found.**

The most common types of anomalies which impact data quality are grouped as follows:

a. Spacecraft maneuvers - when maneuvers are performed the accuracy of the orbital information is degraded leading to larger than normal once-per-revolution radial orbit error. This causes long wavelength errors in sea surface height anomaly, but has little impact on the other parameters. The spacecraft's attitude can also be affected, but the ground-based retracking of the radar return 'waveform' echo normally compensates for off-nadir excursions so there is minimal degradation of any of the measured parameters.

   Maneuver events are color coded by RED entries in Appendix-B, and the effects of the maneuvers can be seen in the cyclic plots in Appendix-A. The cycles affected by maneuvers are 0-2, 5-7, 11, 17, and 30.

b. Software & calibration file uploads - when new instrument calibration coefficients, or onboard software patches, are uploaded to the satellite data gaps usually result whose extent can vary from just a few seconds to hours in length. Events associated with software uploads, including Digital Elevation Model (DEM) updates, as well as calibration file uploads are indicated by PURPLE entries in Appendix-B. Cycles affected by software uploads and calibration updates are 0-1, 6-8, 16, 31, and 33-34.

c. Instrument anomalies result in a partial loss of data or a degradation in performance of the system. Two AMR outages in cycle 19, and a star tracker anomaly in cycle 23, are indicated by BLUE in Appendix-B. The AMR outages resulted in a loss of radiometer wet troposphere corrections, which led to losses of sea surface height anomaly data during cycle 19, with no impact on wind or wave data. The star tracker anomaly in cycle 23 caused unusually high attitude excursions for the Jason-2 spacecraft, but the retracking applied during on-ground processing did not introduce significant errors from this effect into the SSHA, wind speed or wave height data.

A measure of the amount of data loss from the combination of these affects comes from the calibration/validation analyses performed by CNES on the final Geophysical Data Records. The analysis presently extends to cycle-34, and we exclude the initial (partial) cycle-0. Table-1 presents the cycle-by-cycle statistics for missing data in the open ocean (defined as data between

± 50° latitude, to avoid sea-ice regions, and where water depths are great than1000m, to avoid coastal/shallow water regions).

Cycle #	Missing Data
1	1.95%
2	0.00%
3	1.85%
4	0.00%
5	2.32%
6	0.55%
7	0.01%
8	0.01%
9	0.00%
10	0.04%
11	0.05%
12	0.01%
13	0.00%
14	0.01%
15	0.01%
16	0.00%
17	0.00%
18	0.00%
19	0.00%
20	0.00%
21	0.00%
22	0.00%
23	0.00%
24	0.01%
25	0.00%
26	0.02%
27	0.00%
28	0.00%
29	0.00%
30	0.00%
31	0.35%
32	0.00%
33	4.10%
34	0.55%
Average	**0.0035%**

Table 1: Missing Data by Cycle

Section 4.0 Analysis of Cyclic Parameter Plots

This section provides a summary of data outages and data quality issues detected from a visual inspection of the parameter figures in Appendix-A. In most cases these anomalies are related to incidents reported in Appendix-B for that cycle. Only those cycles which exhibit an issue are discussed here.

Cycle-000: They large number of missing passes in this first figure of Appendix-A simply reflects the fact that this was a partial cycle. The exact repeat orbit was not attained until pass 61 of cycle-000. A portion of a pass in the NW Pacific goes off-scale, in the positive direction, in wind speed, SWH and ionosphere correction and is missing in the SSA panel at the top. This was likely caused by switching the altimeter tracking mode as the instrument's various modes were exercised during this cycle. There is also evidence of large orbit error in the ascending SSHA plot (top left) due to one of the maneuvers.

Cycle-001: Data gaps in this cycle resulted from the upload of the DEM to the onboard computer and due to ground-station acquisition problems. Another incident of bad SWH, wind, and ionosphere values associated with missing SSHA values is seen in the NW Pacific. This is attributed to a 'low signal tracking anomaly' which caused small portions of some passes coming off land to exhibit this problem. This was finally repaired via a software upload on Pass-073 of Cycle-016.

Cycle-003: Data gaps in passes 32-35 were due to ground-station acquisition problems.

Cycle-004: Large radial orbit error is observed on several passes in the SSHA plots (top) related to poor performance of the onboard determined DORIS/DIODE orbit.

Cycle-005: Data gaps in passes 236-241 were due to ground-station acquisition problems.
Some passes again exhibit higher than normal radial orbit error.

Cycle-006: The data gap observed in all parameters was associated with a long CAL-2 calibration upload.

Cycle-008: A gap in AMR data on pass-065, and thereby also SSHA data, was caused by a bug in the TM-NRT software that generates the OGDRs. The software mismanaged the radiometer brightness temperature values resulting in defaulted AMR data.

Cycle-009: A similar but much smaller gap in AMR data on pass-065 of cycle-009 (S. Pacific) was due to a separate issue with TM-NRT that was corrected in the next revision of the OGDR software.

Cycle-016: Some passes in the N. Atlantic and E. Pacific exhibit increased radial orbit error.

Cycle-017: A single pass with large radial orbit error is seen in the SSHA plots, associated with a maneuver.

Cycle-018: TM-NRT mismanagement of the 2009-01-01 leap second caused processing delays and a miniscule loss of data (few seconds) around the leap second.

Cycle-019: Two outages of the AMR instrument affects passes 24-52 and 119-161, resulting in the loss of AMR, and consequently SSHA data, on a significant number of passes in cycle-019. No data loss occurs when the AMR wet troposphere correction is replaced by the ECMWF model wet troposphere correction. SWH and wind speed were unaffected.

Cycle-023: There are several segments of missing SSHA data from passes 187-205. This was caused by late delivery of ECMWF model data, which provides the model dry troposphere and inverted barometer corrections for the OGDRs. When the altimetry data was later than the last ECMWF grid, the processing defaults the SSHA data rather than using extrapolated corrections from the ECMWF grids.

Cycle-025: A single descending pass of ionosphere correction data is unusually high. Presumably this is due to an anomaly in the secondary altimeter C-band data, since there is no evidence in the SSHA data based on the primary Ku-band.

Cycle-030: A single revolution of SSHA data exhibit high radial orbit error due to a maneuver.

Cycle-031: Short segments of missing data, primarily in the far N. Pacific, are due to uploads of a new DEM.

Cycle-033: Passes 204-213 were impacted by the upload of new onboard software associated with the new DEM upload that occurred in cycle-031.

Cycle-034: A segment of pass 235 is missing due to a long Cal-2 calibration upload.

Section 5.0 Summary

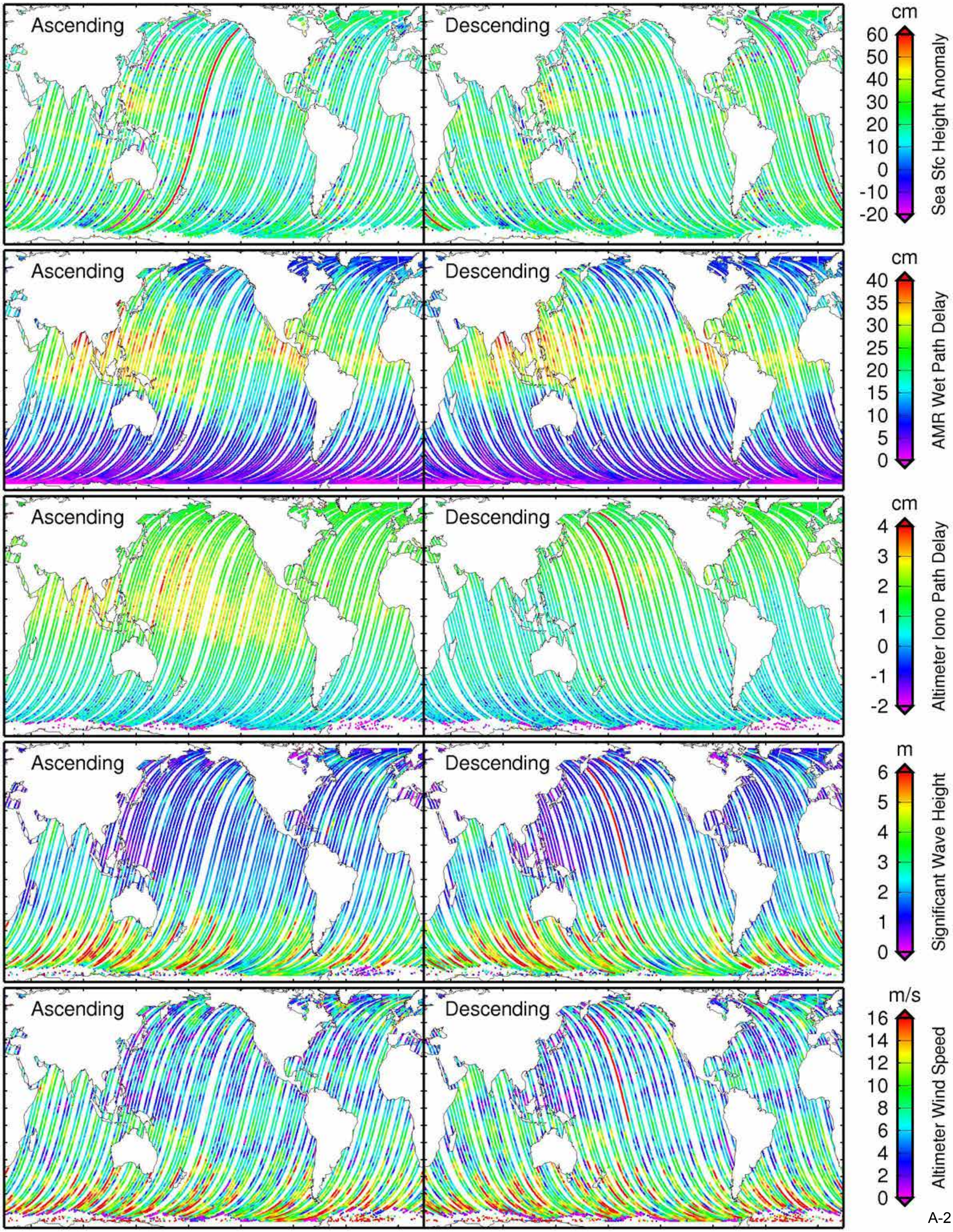
The overall quality of the Jason-2/OSTM near real-time OGDR data is extremely good. The major cause of data degradation is when orbital maneuvers are performed, resulting in larger than normal radial orbit errors and degraded sea surface height anomaly data. In the early phases of the mission there were a few data outages caused by ground station anomalies, but none have occurred since cycle 5. Two significant AMR instrument anomalies caused the loss of wet troposphere data during cycle 19, but those were the only occurrences of AMR problems. The remaining data gaps are associated with uploads of DEM, software, or calibration information to the onboard computer, which are unavoidable. The overall data return exceeds 99.99%.

Operational monitoring of the OGDR data quality is ongoing with the NRTAVS system developed under contract to NOAA by JPL. This monitoring tool generates plots similar to those in Appendix-A as each new OGDR is processed by NOAA or received from EUMETSAT. This tool has provided a valuable diagnostic for monitoring the OGDR data quality in near real-time.

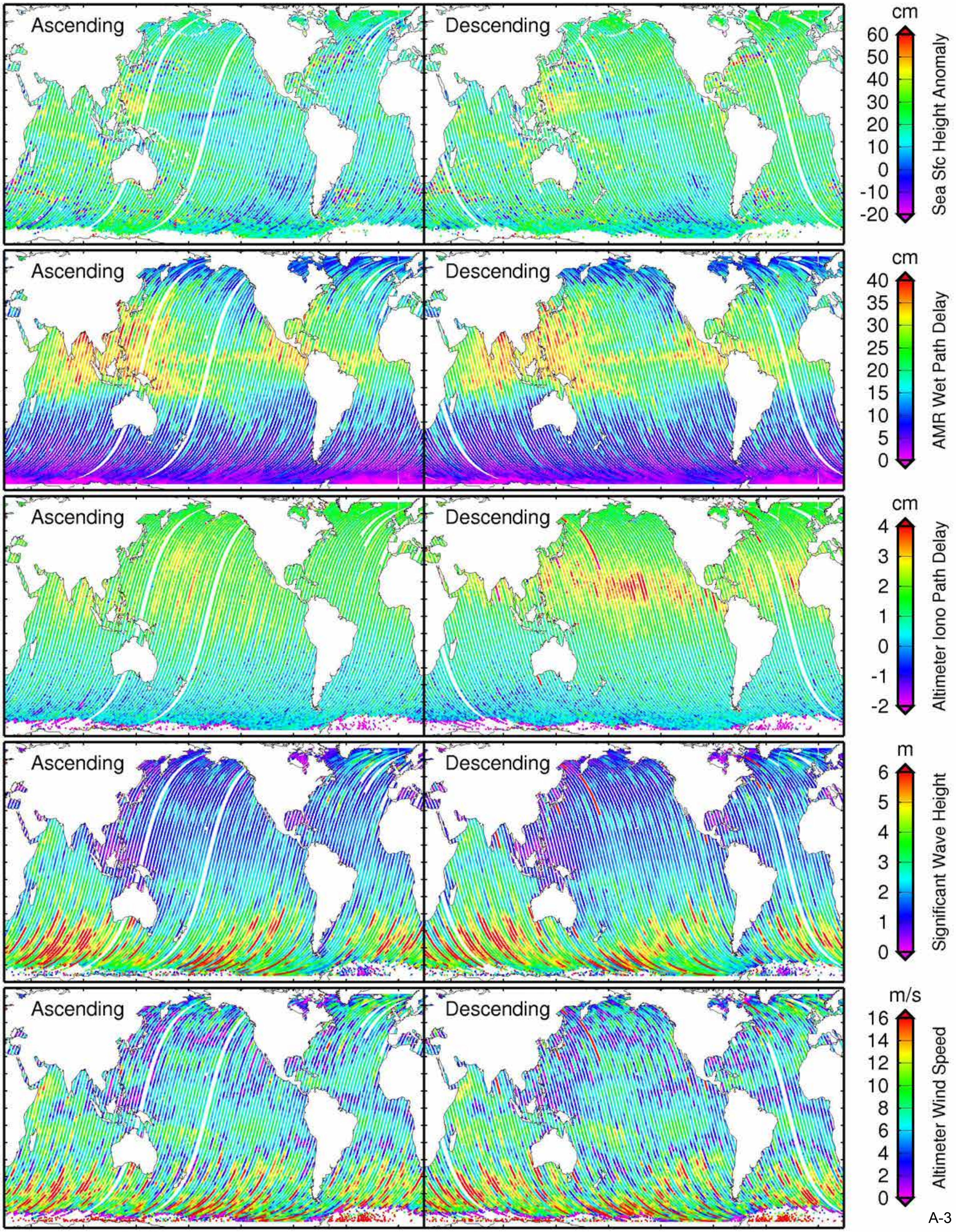
Appendix A. Cyclic Parameter Plots Cycle-000 to Cycle-036

See individual plots on the following 37 pages.

Jason-2 Cycle-000 2008-07-04 12:19:19 - 2008-07-12 01:20:05



Jason-2 Cycle-001 2008-07-12 01:20:05 - 2008-07-21 23:18:37



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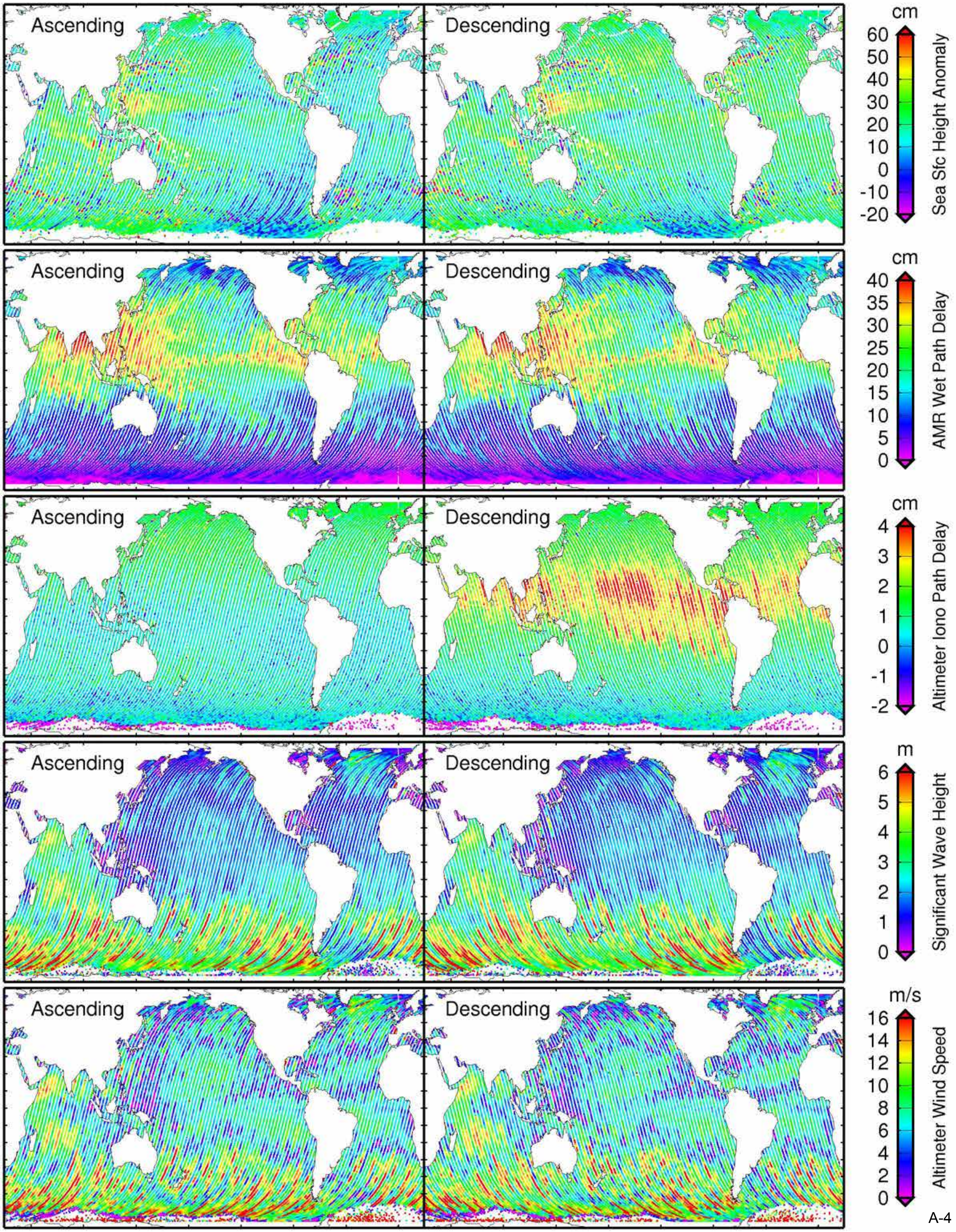
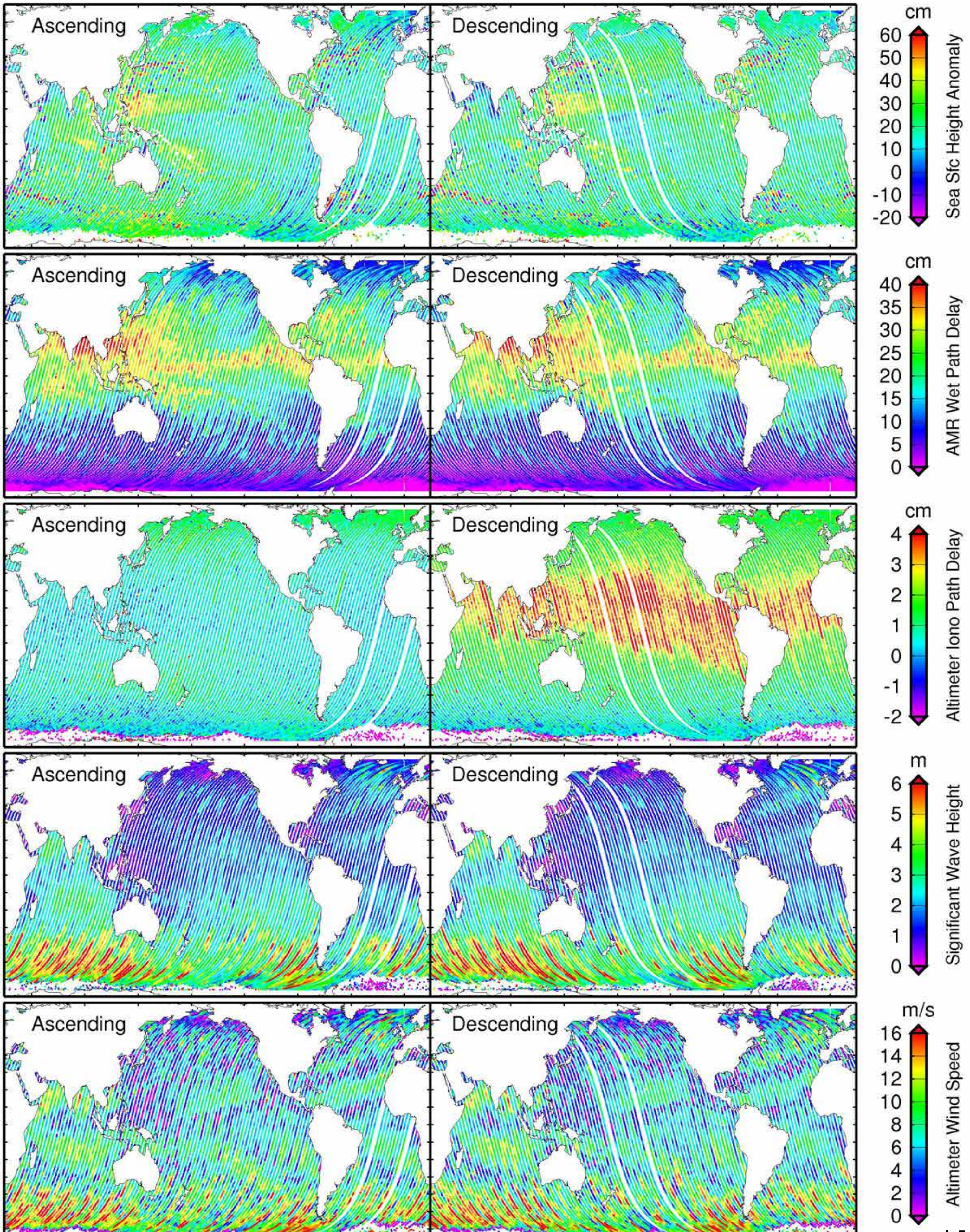
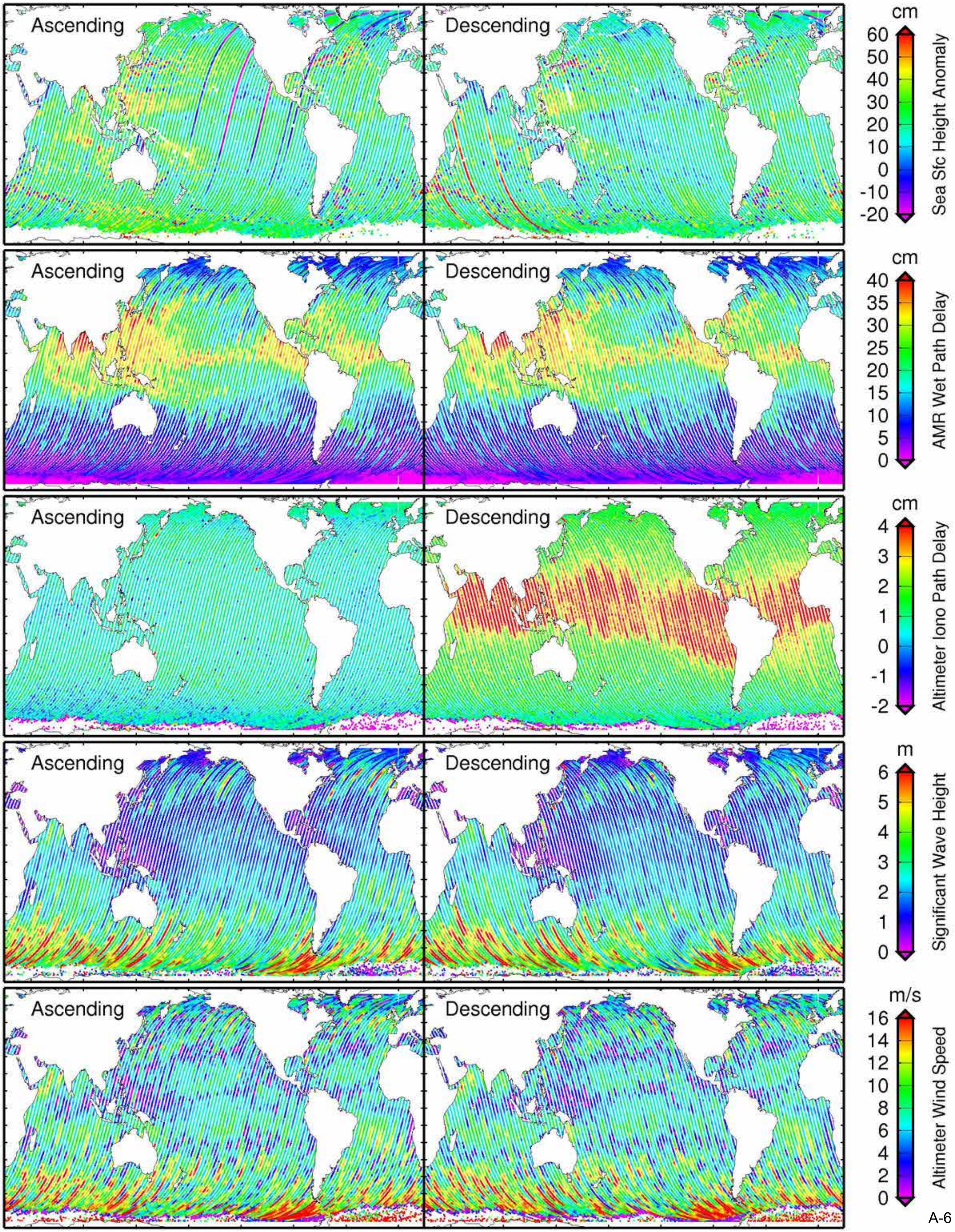


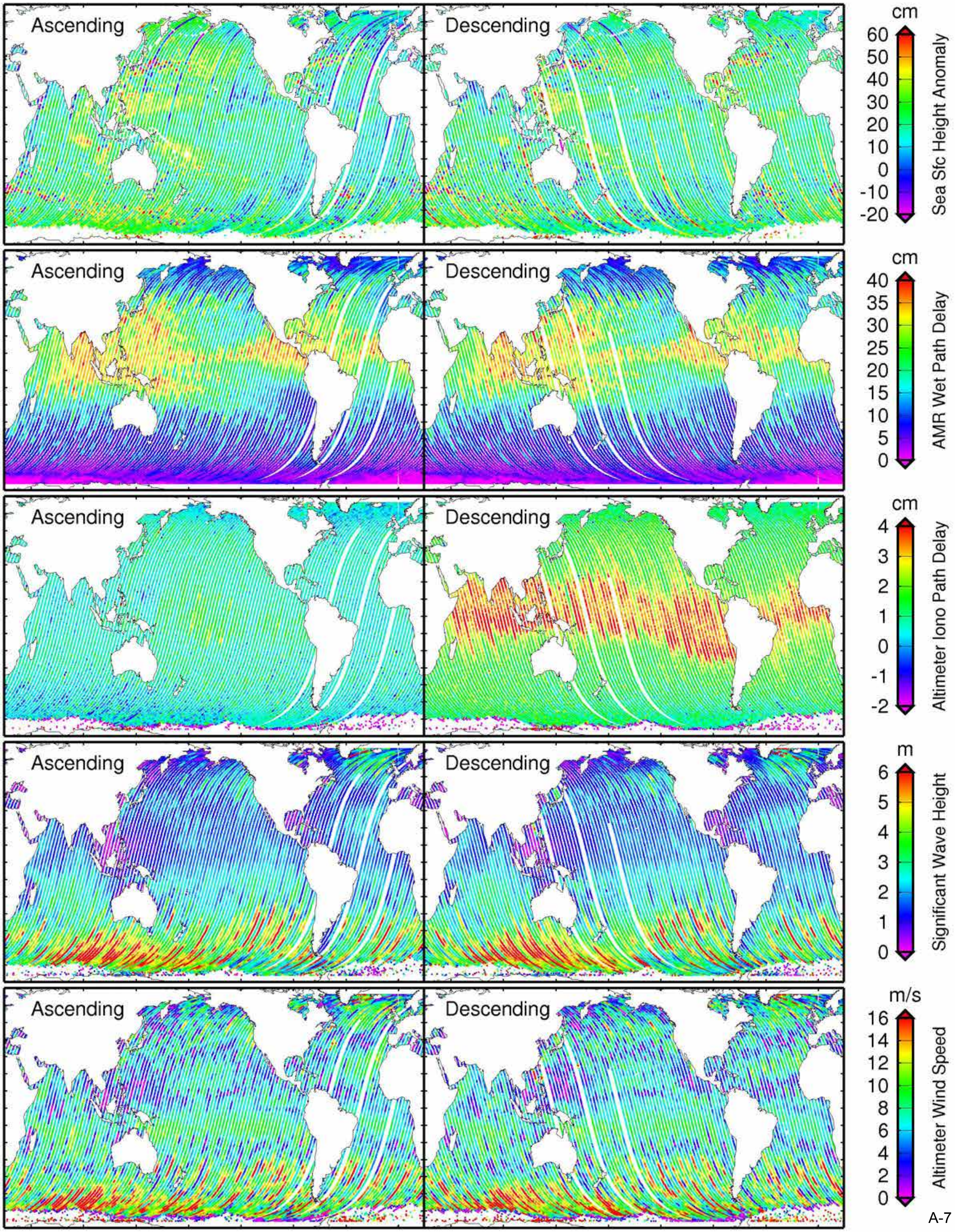
Jason-2 Cycle-003 2008-07-31 21:17:08 - 2008-08-10 19:15:40



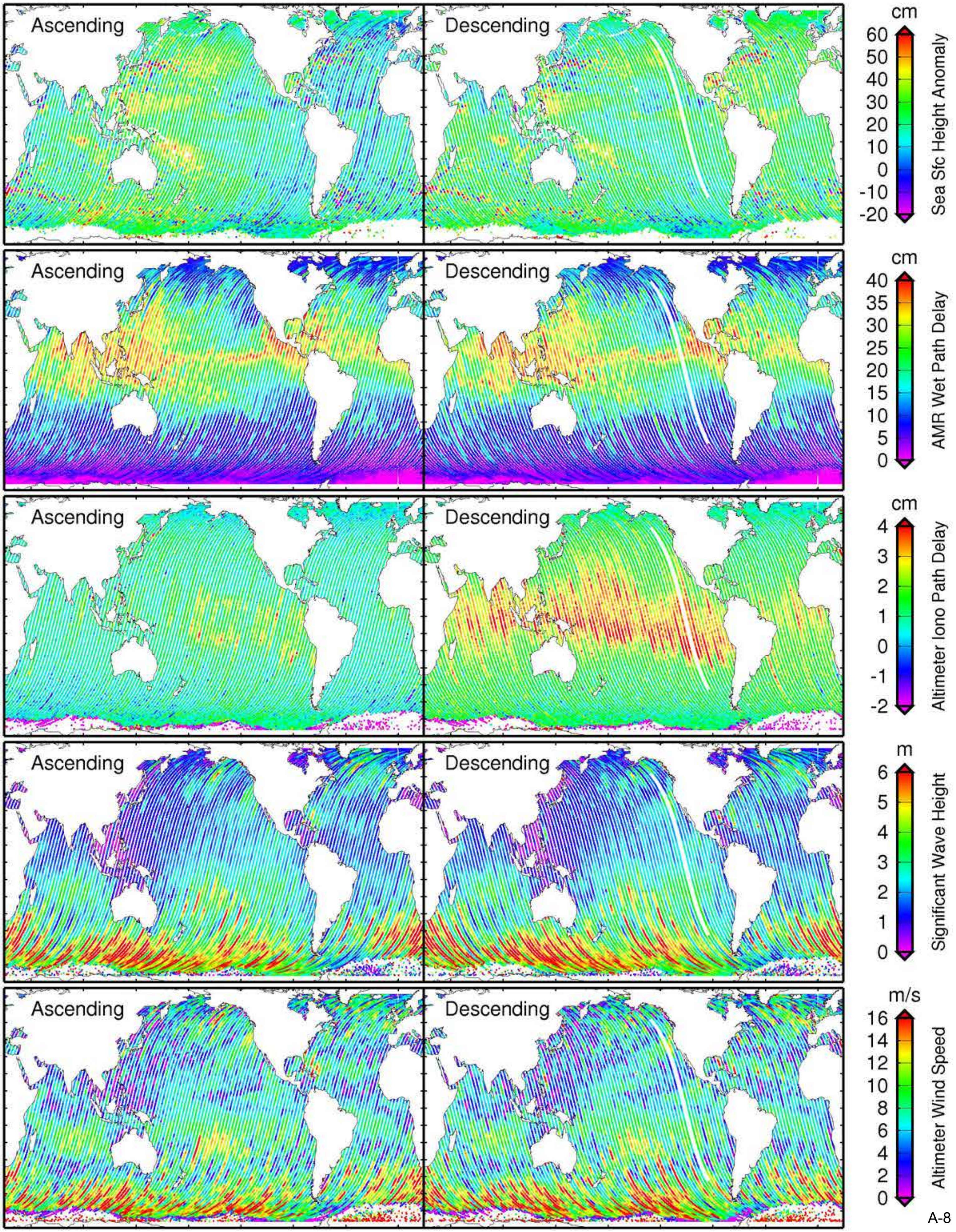
Jason-2 Cycle-004 2008-08-10 19:15:40 - 2008-08-20 17:14:11



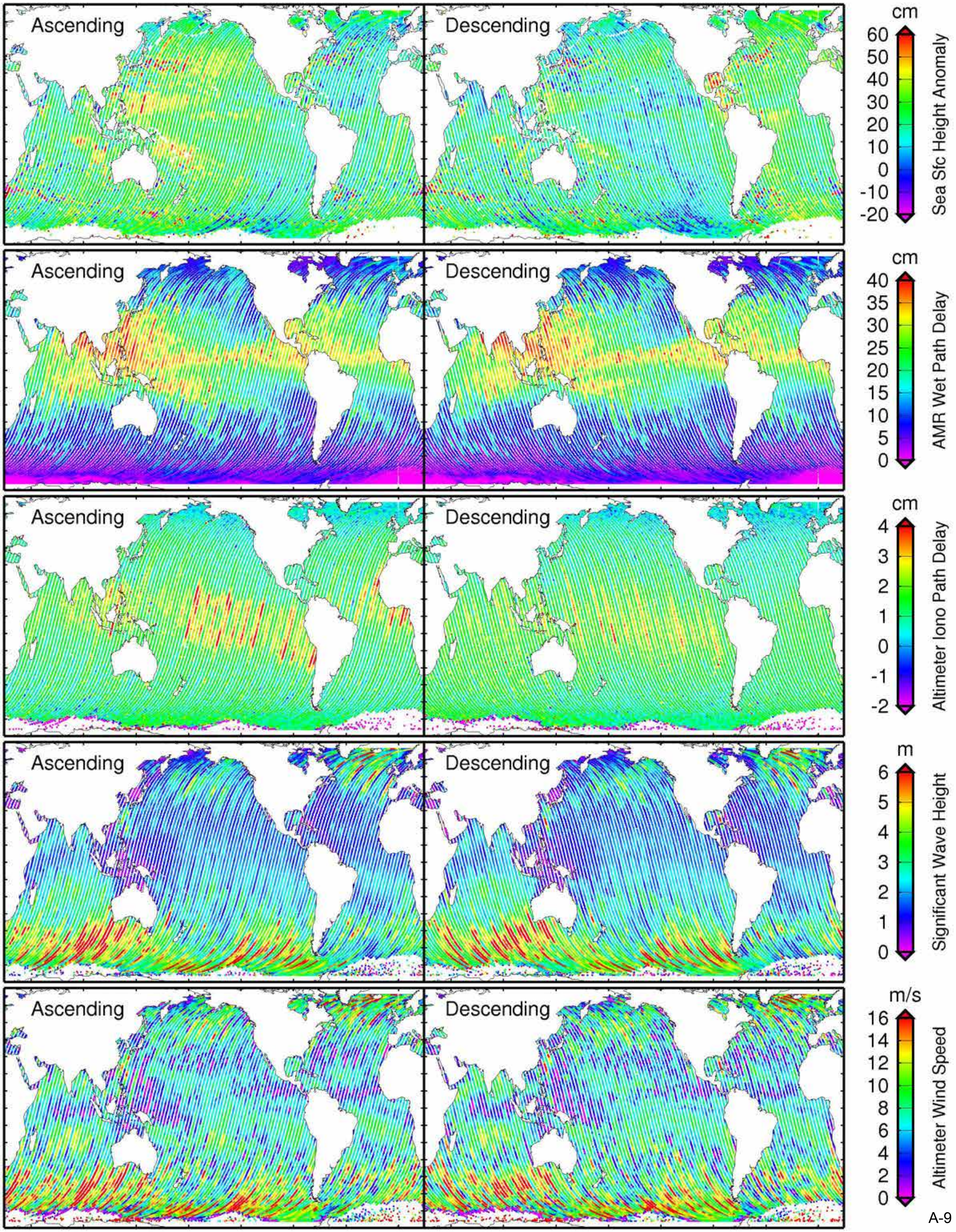
Jason-2 Cycle-005 2008-08-20 17:14:11 - 2008-08-30 15:12:43



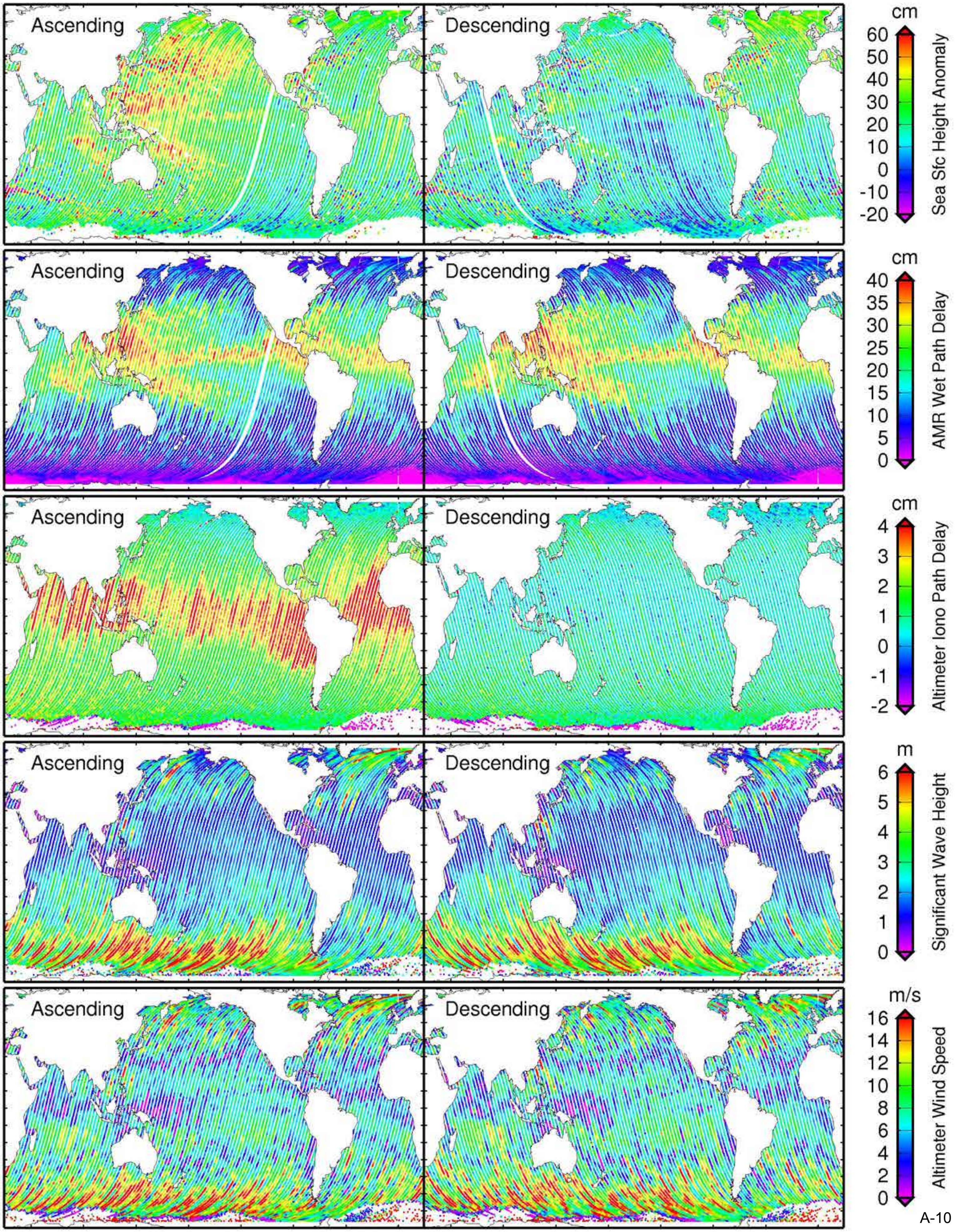
Jason-2 Cycle-006 2008-08-30 15:12:43 - 2008-09-09 13:11:15



Jason-2 Cycle-007 2008-09-09 13:11:15 - 2008-09-19 11:09:47



Jason-2 Cycle-008 2008-09-19 11:09:47 - 2008-09-29 09:08:19



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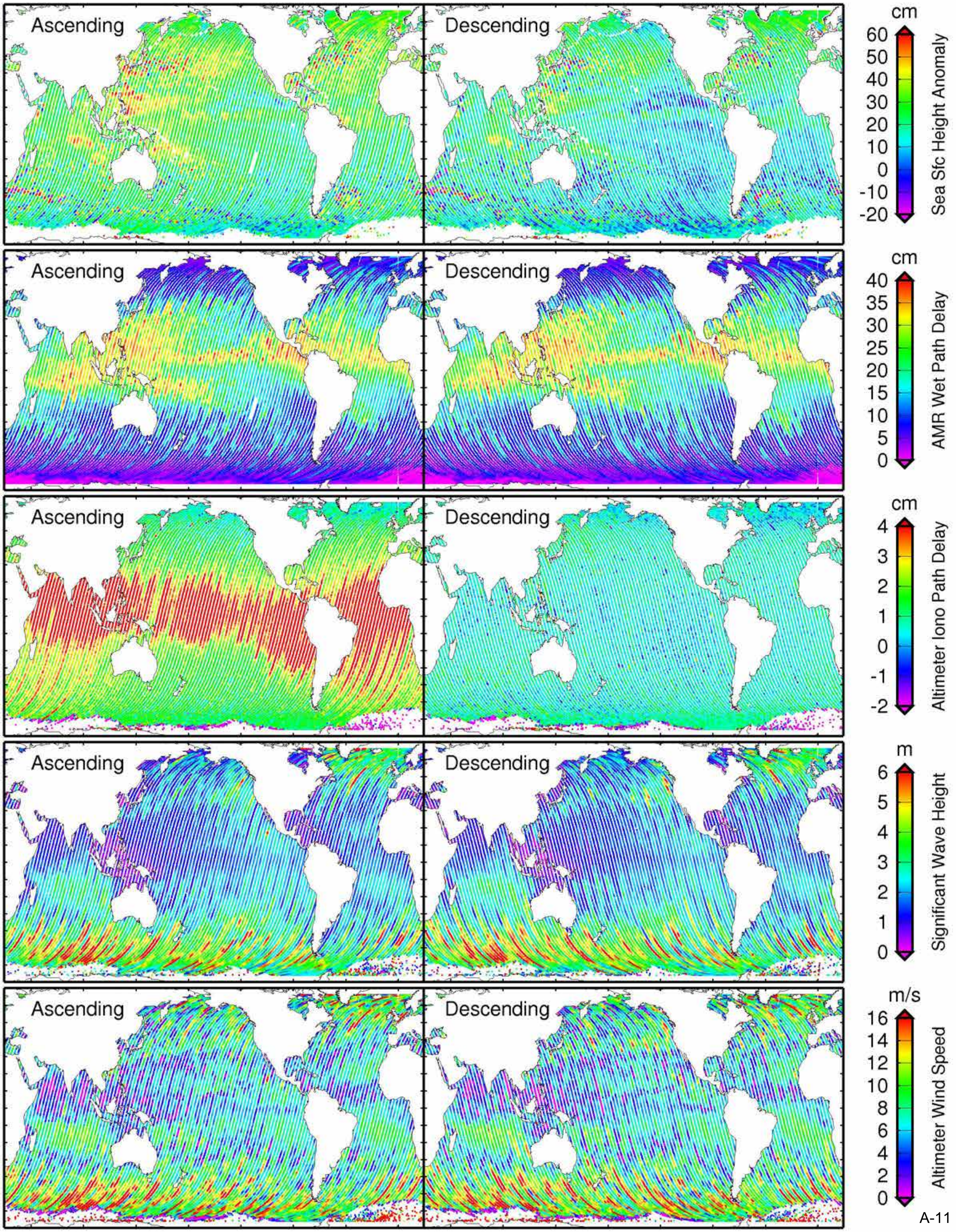

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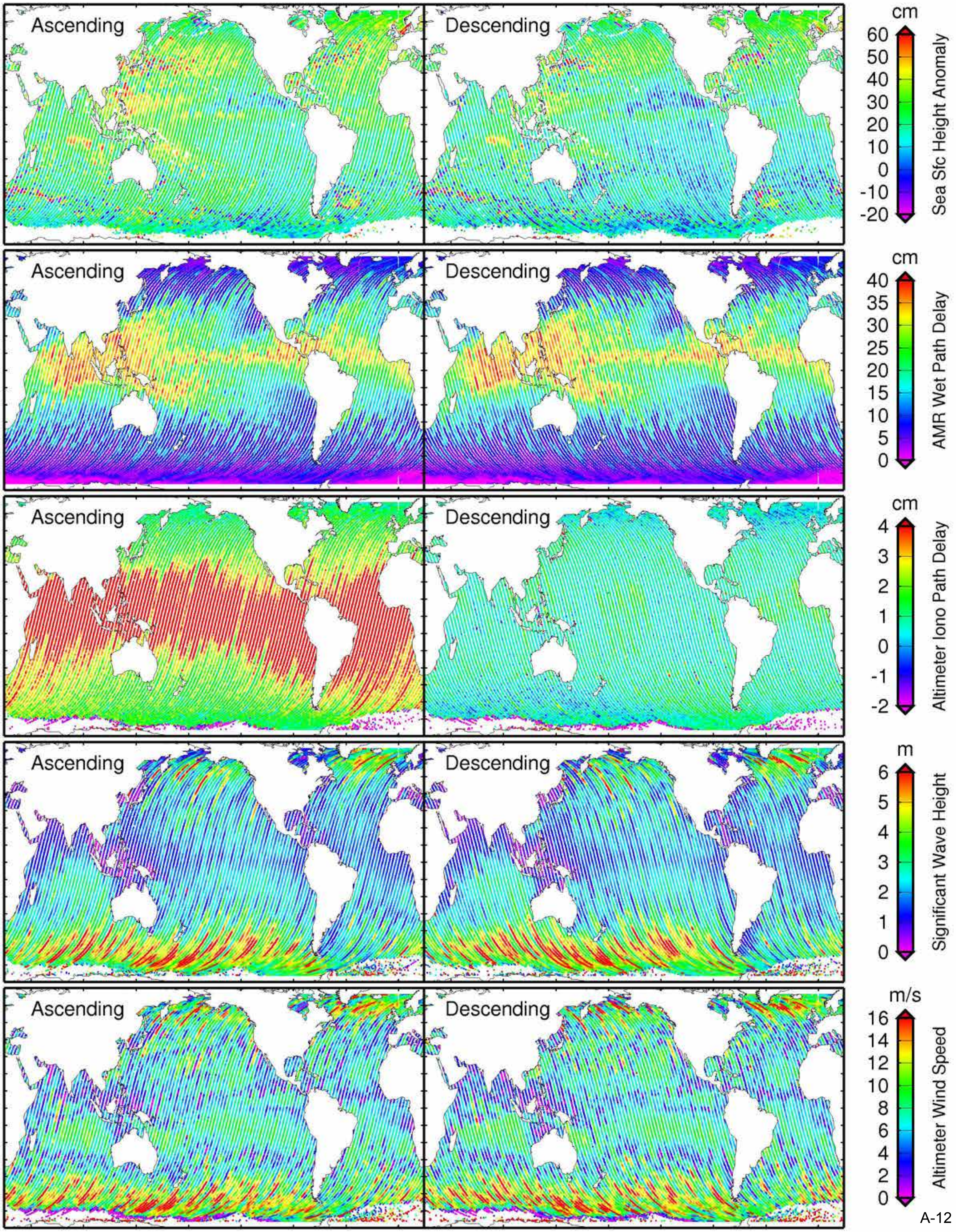

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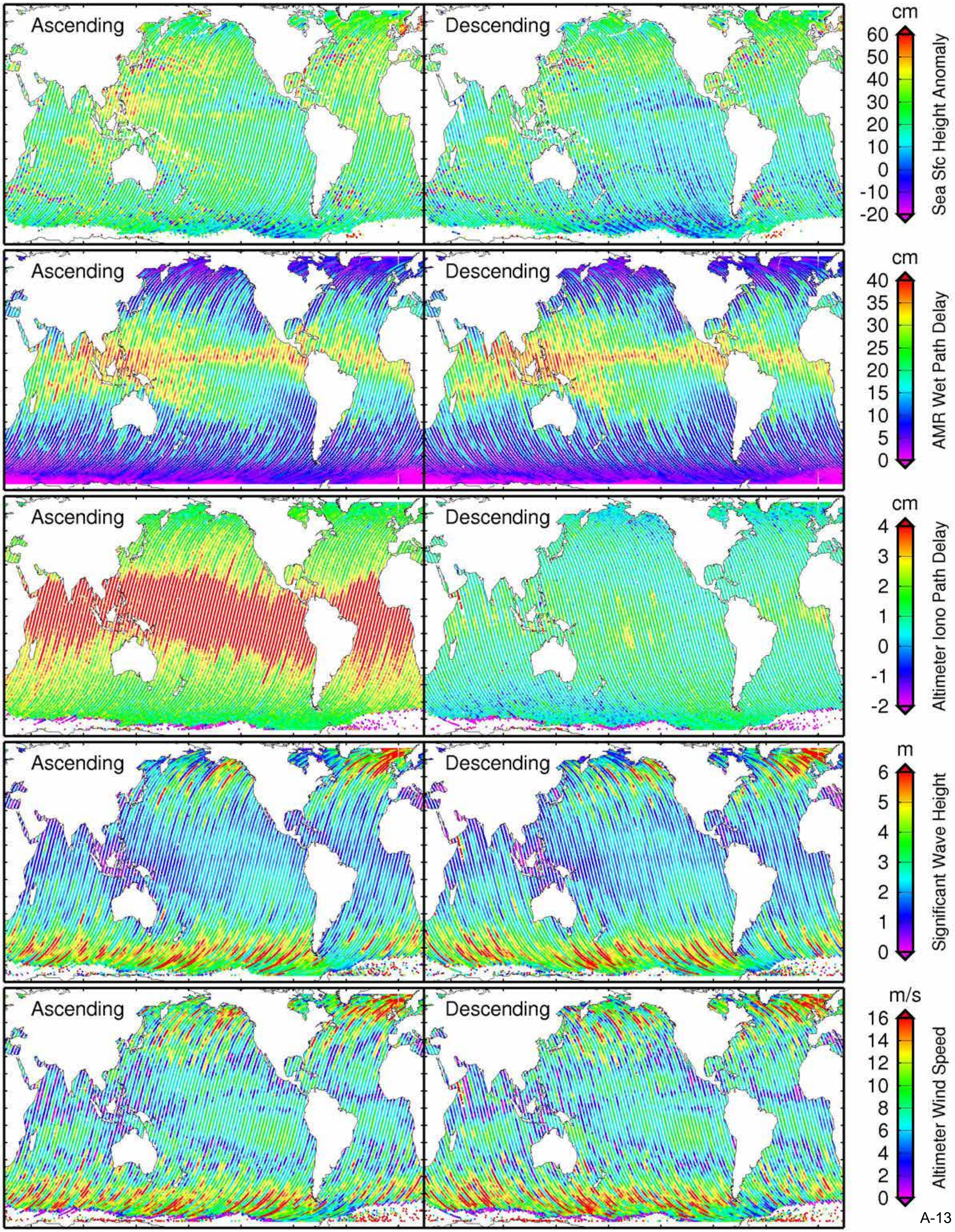

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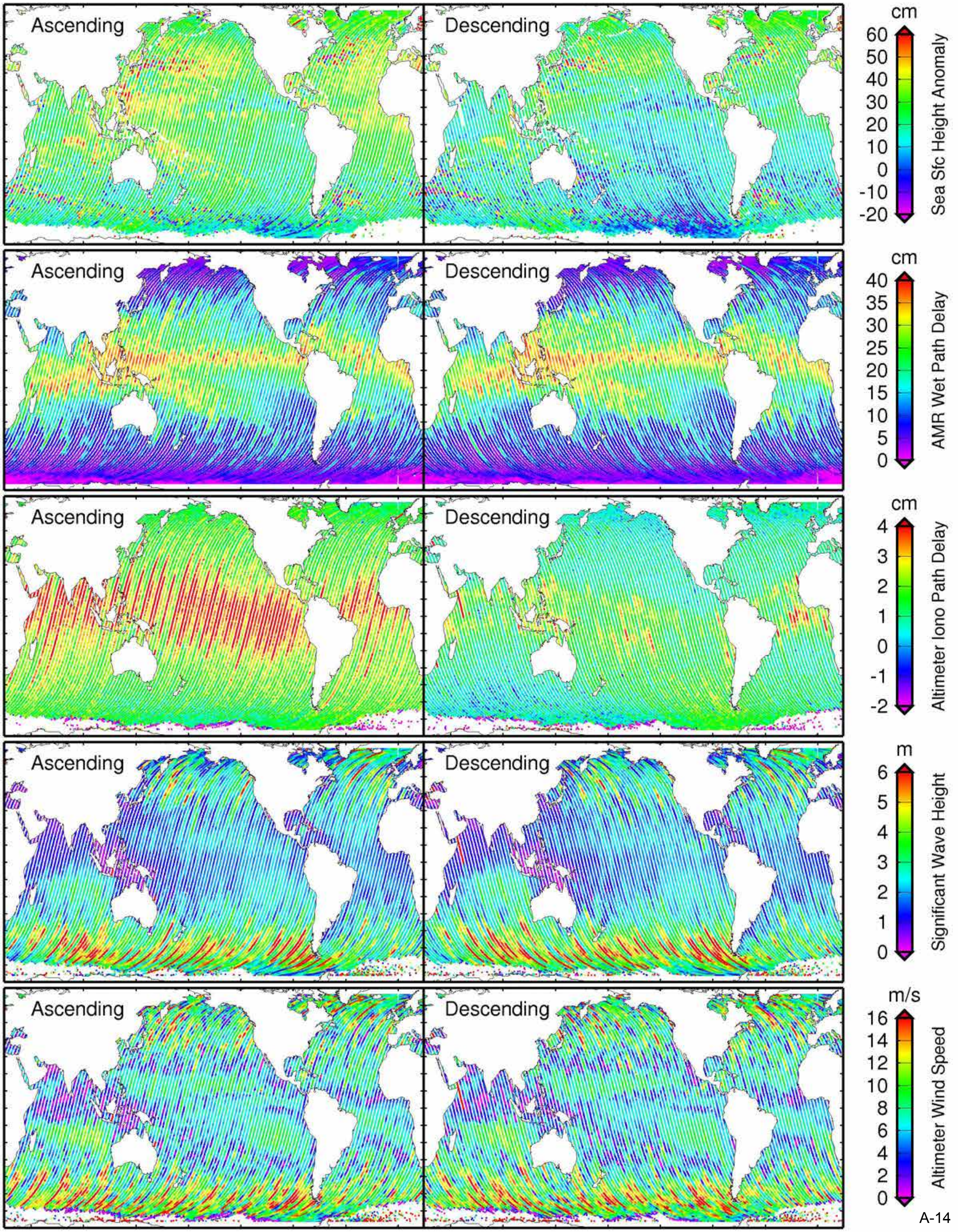

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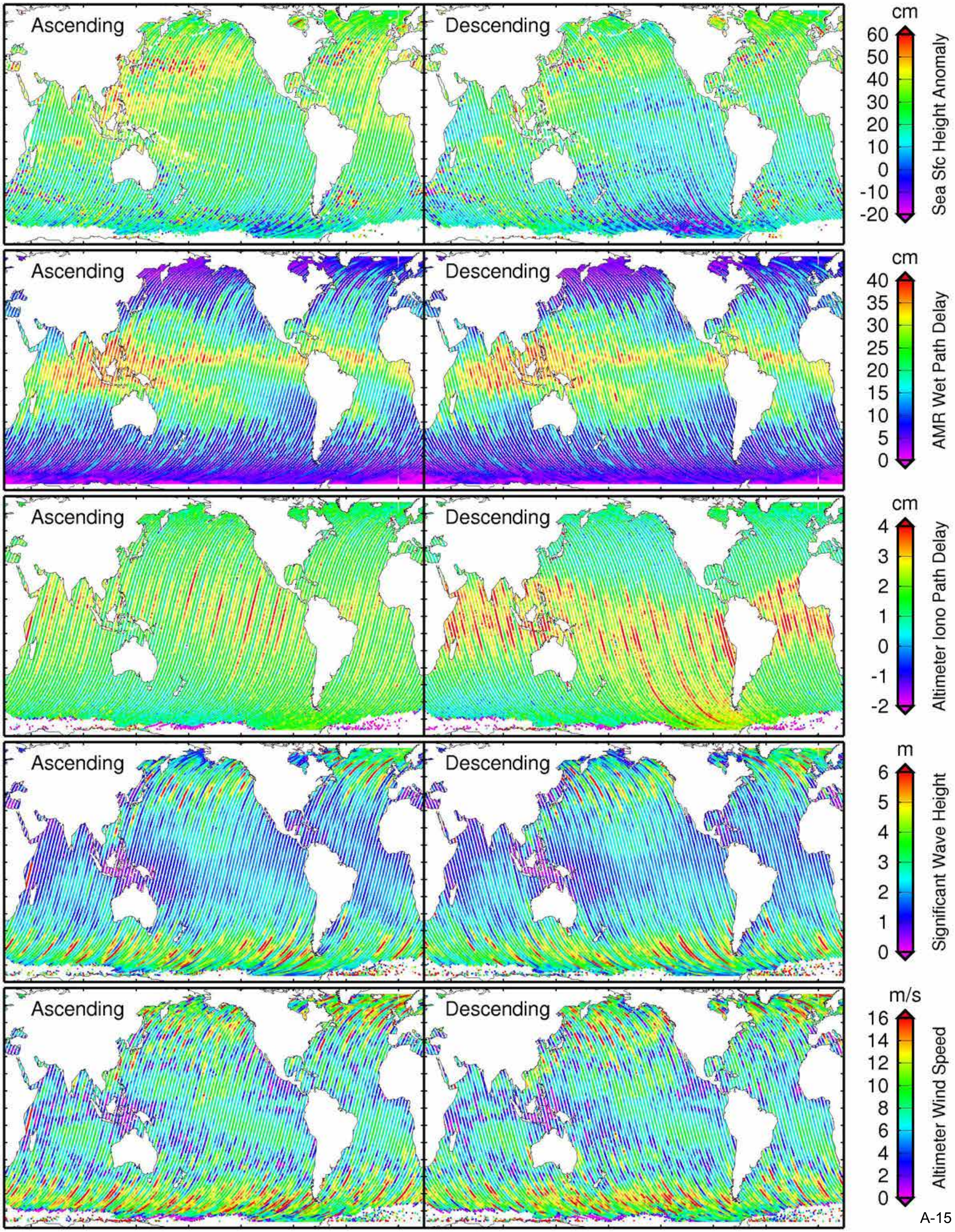

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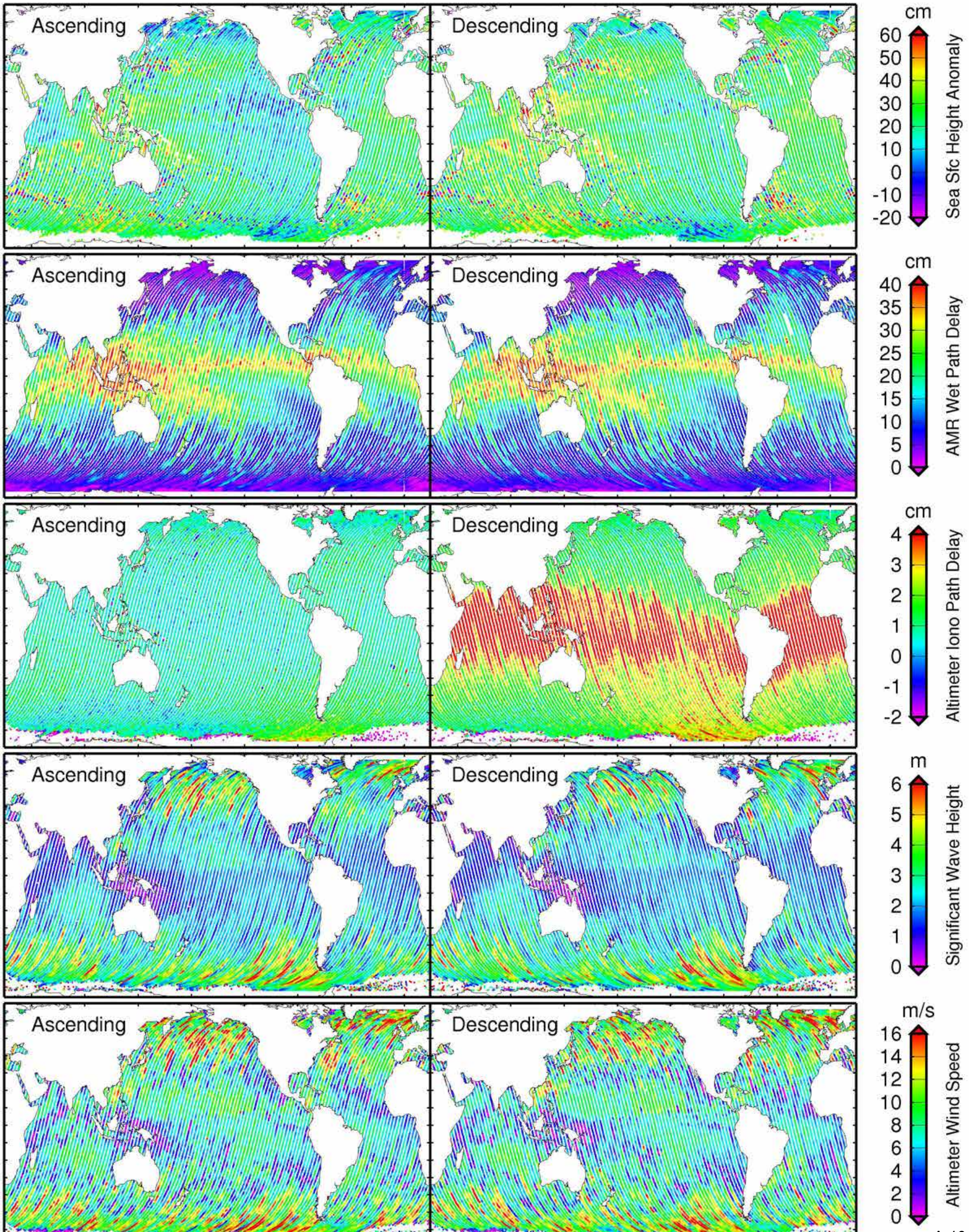

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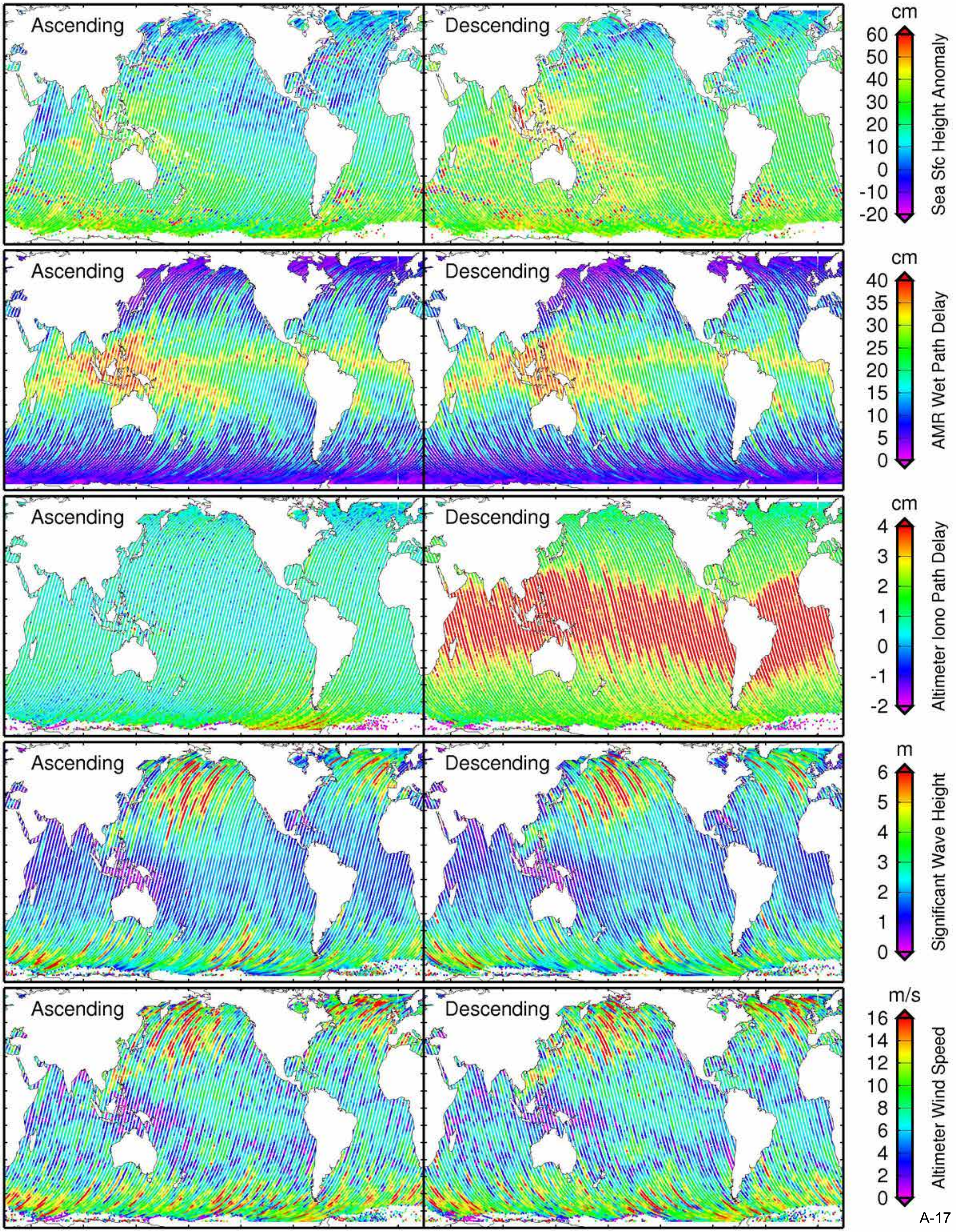

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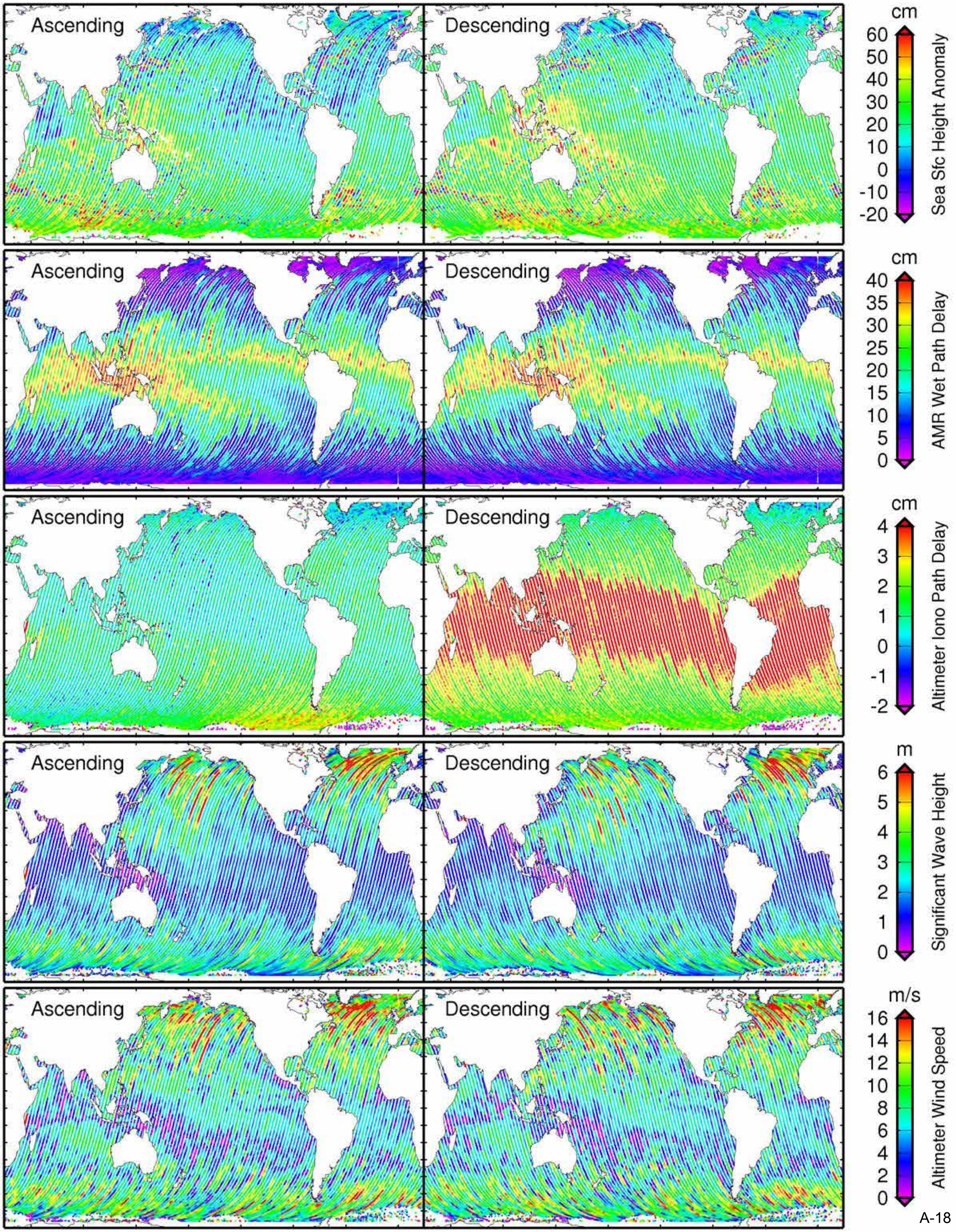

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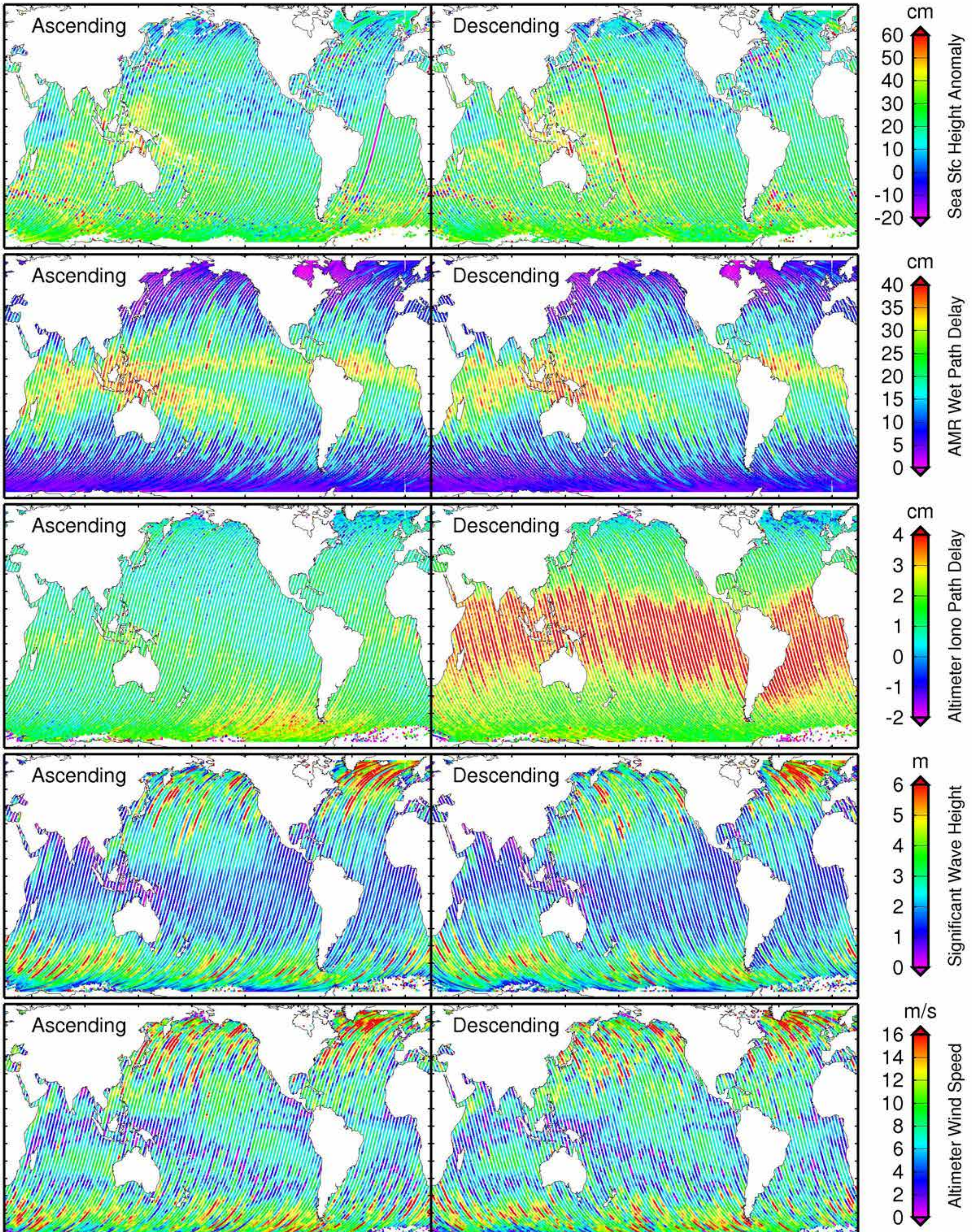

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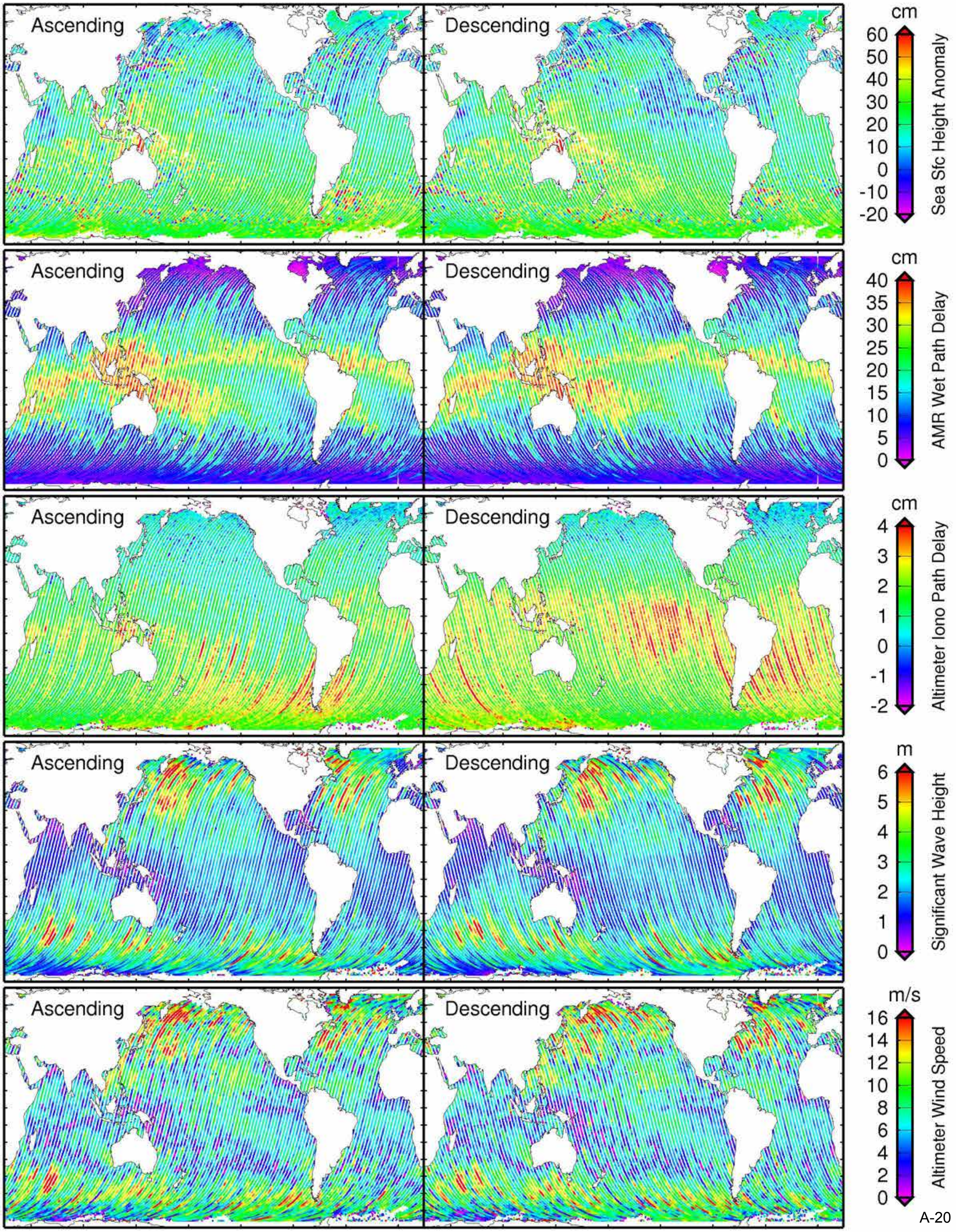

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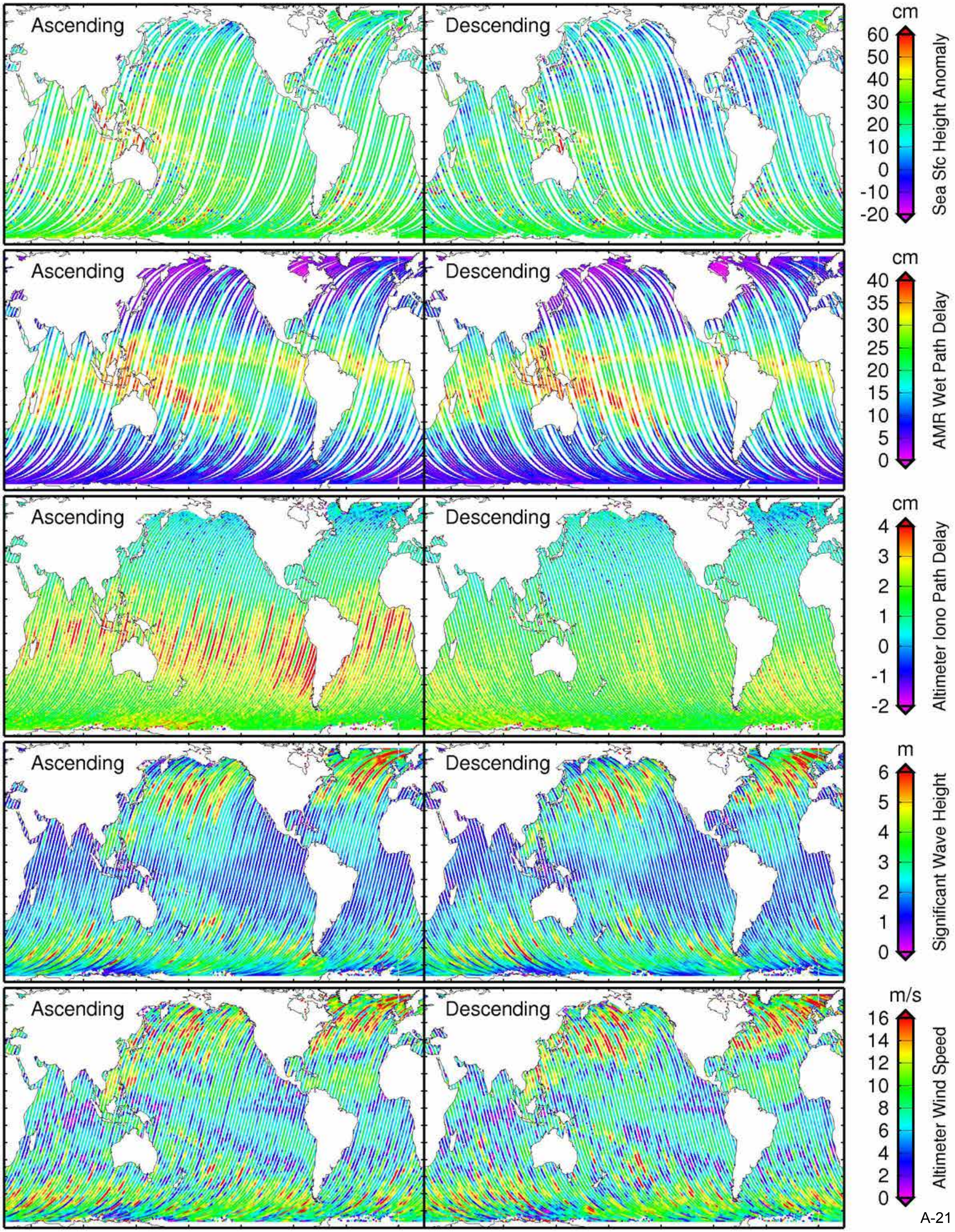

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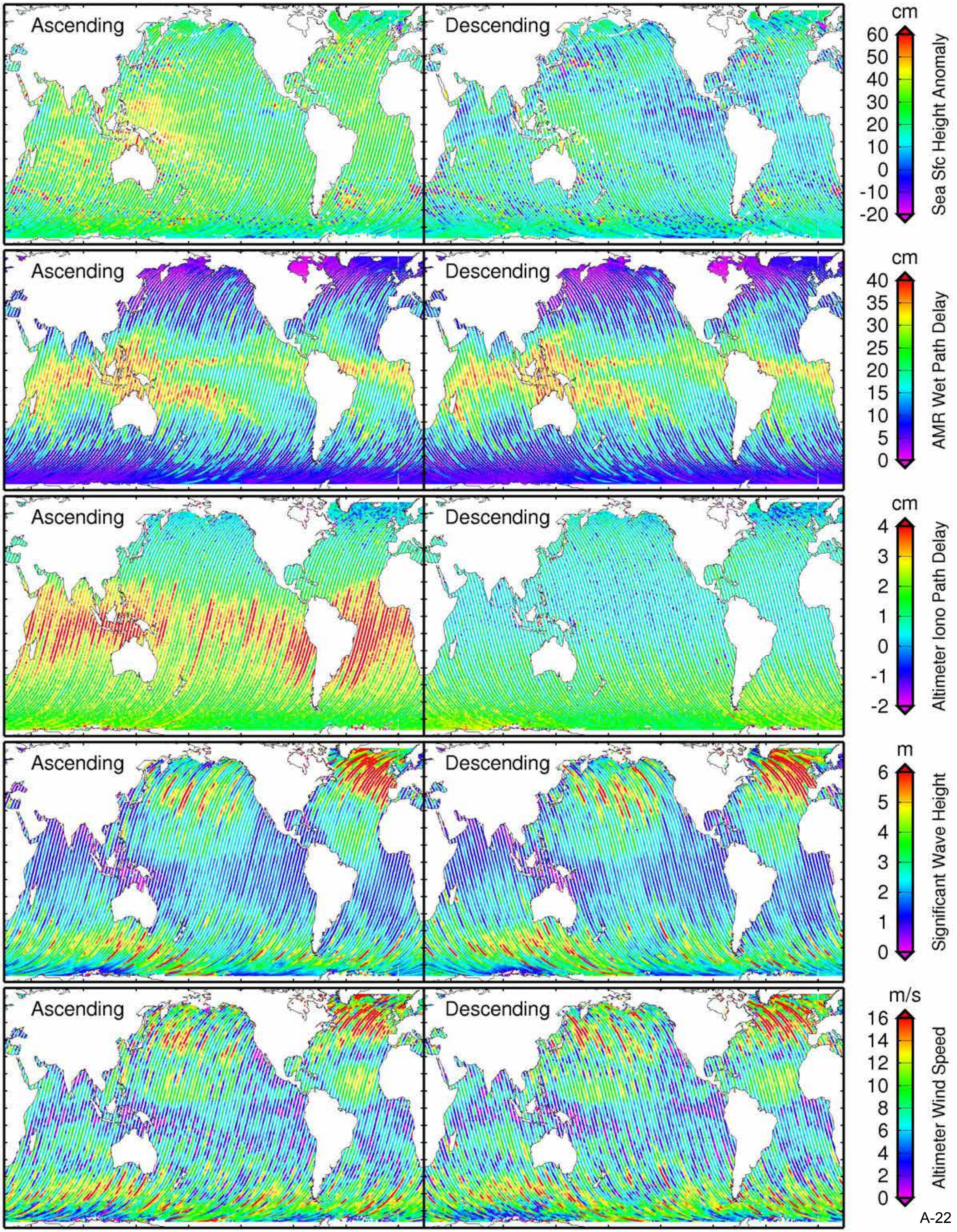

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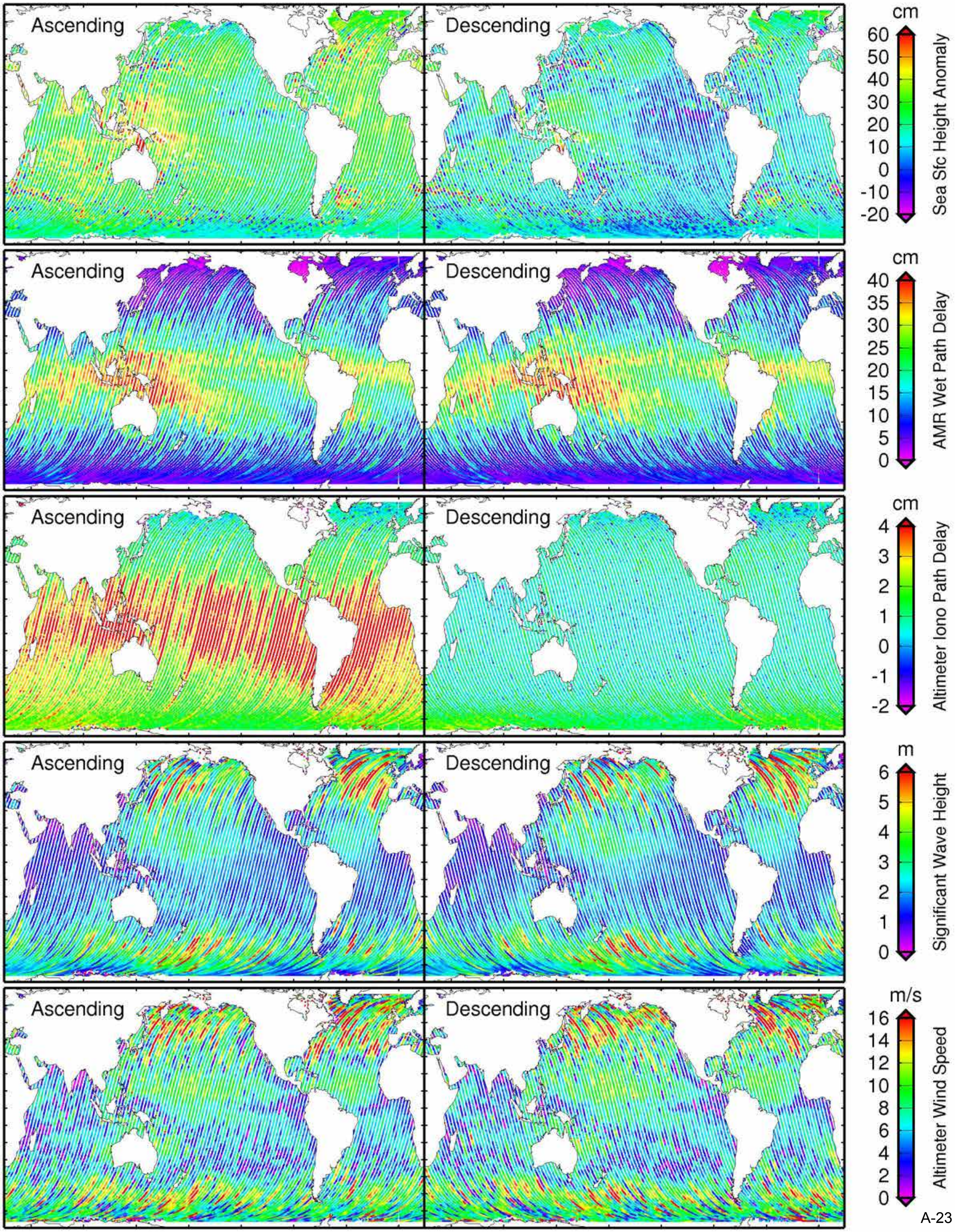

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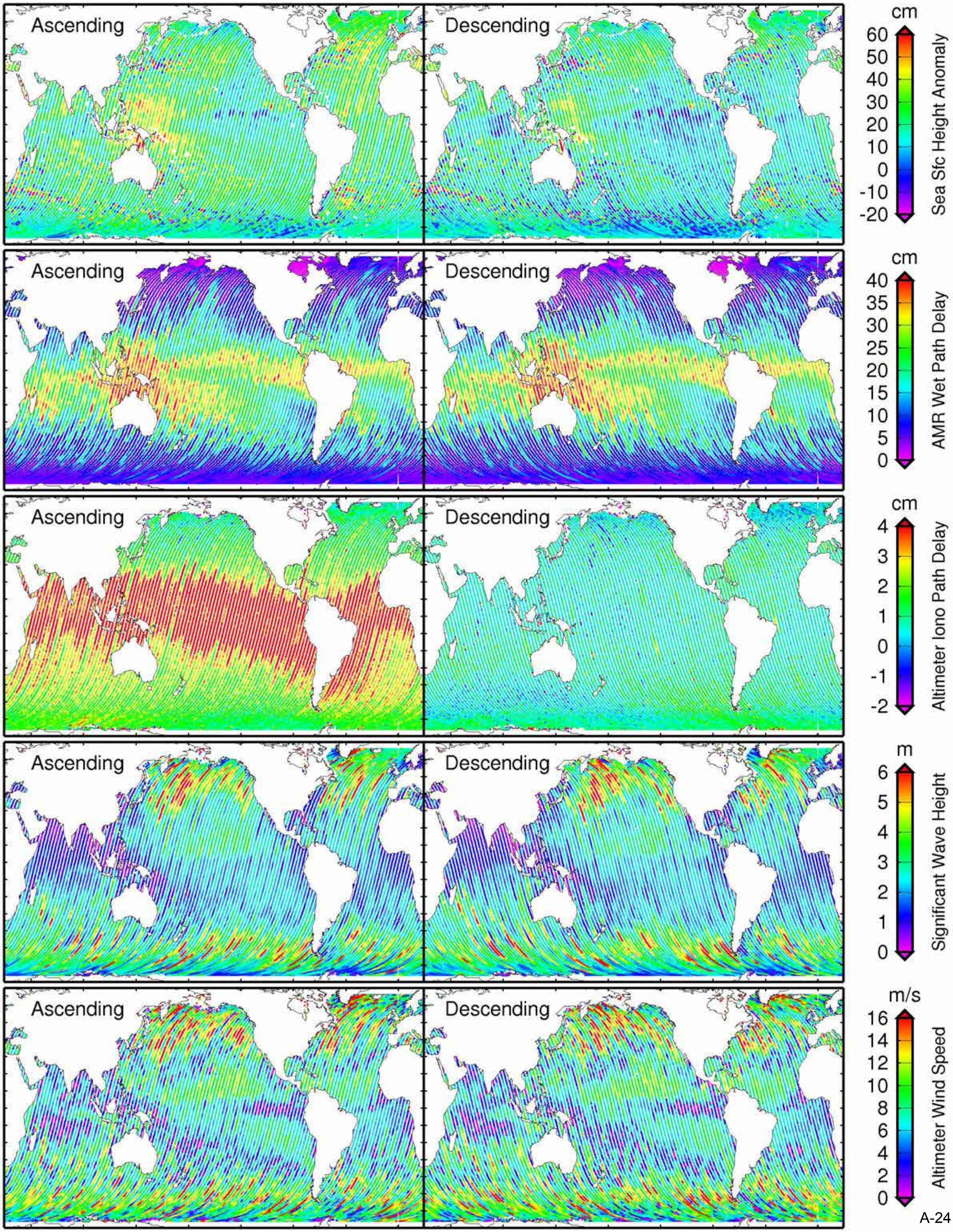

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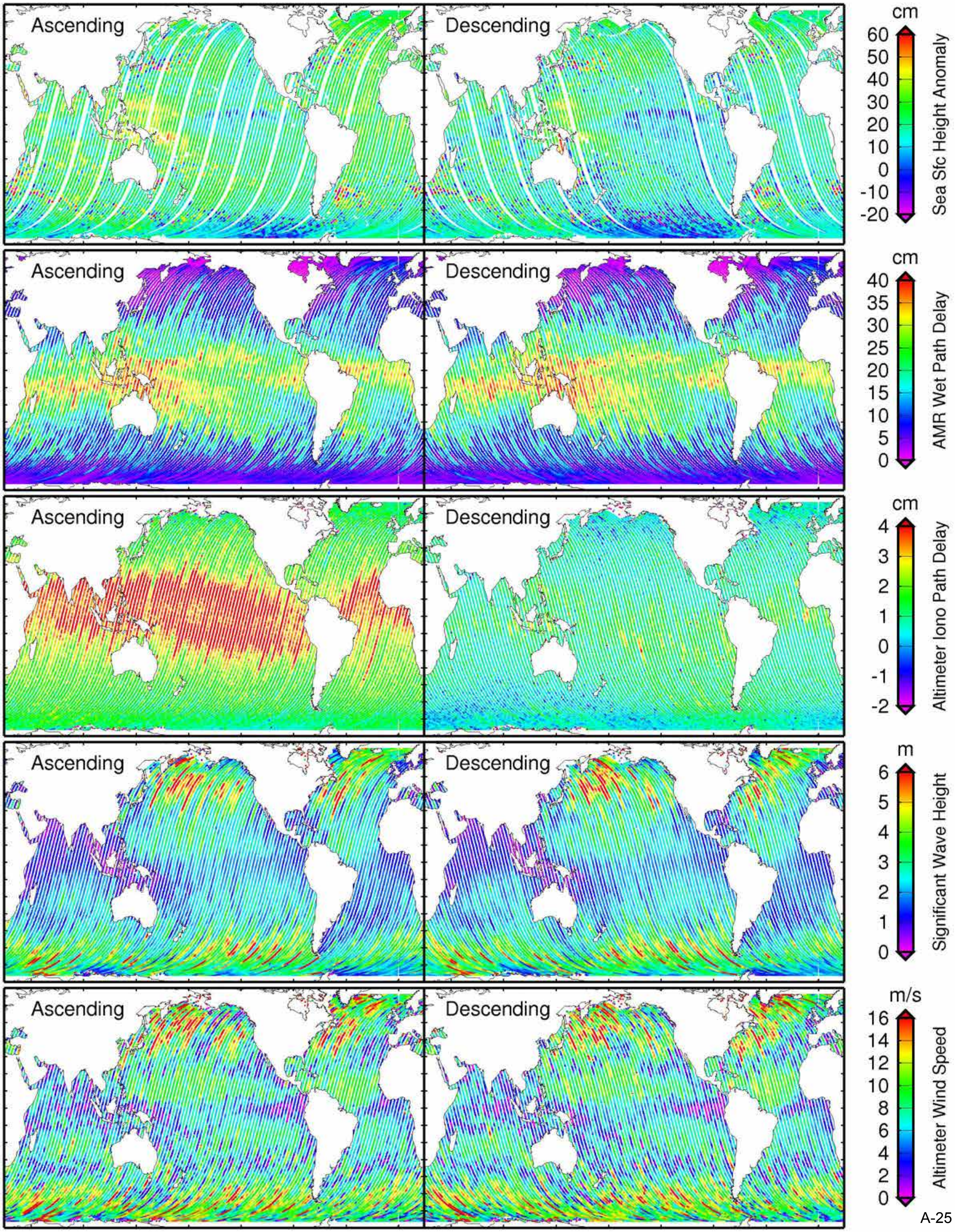

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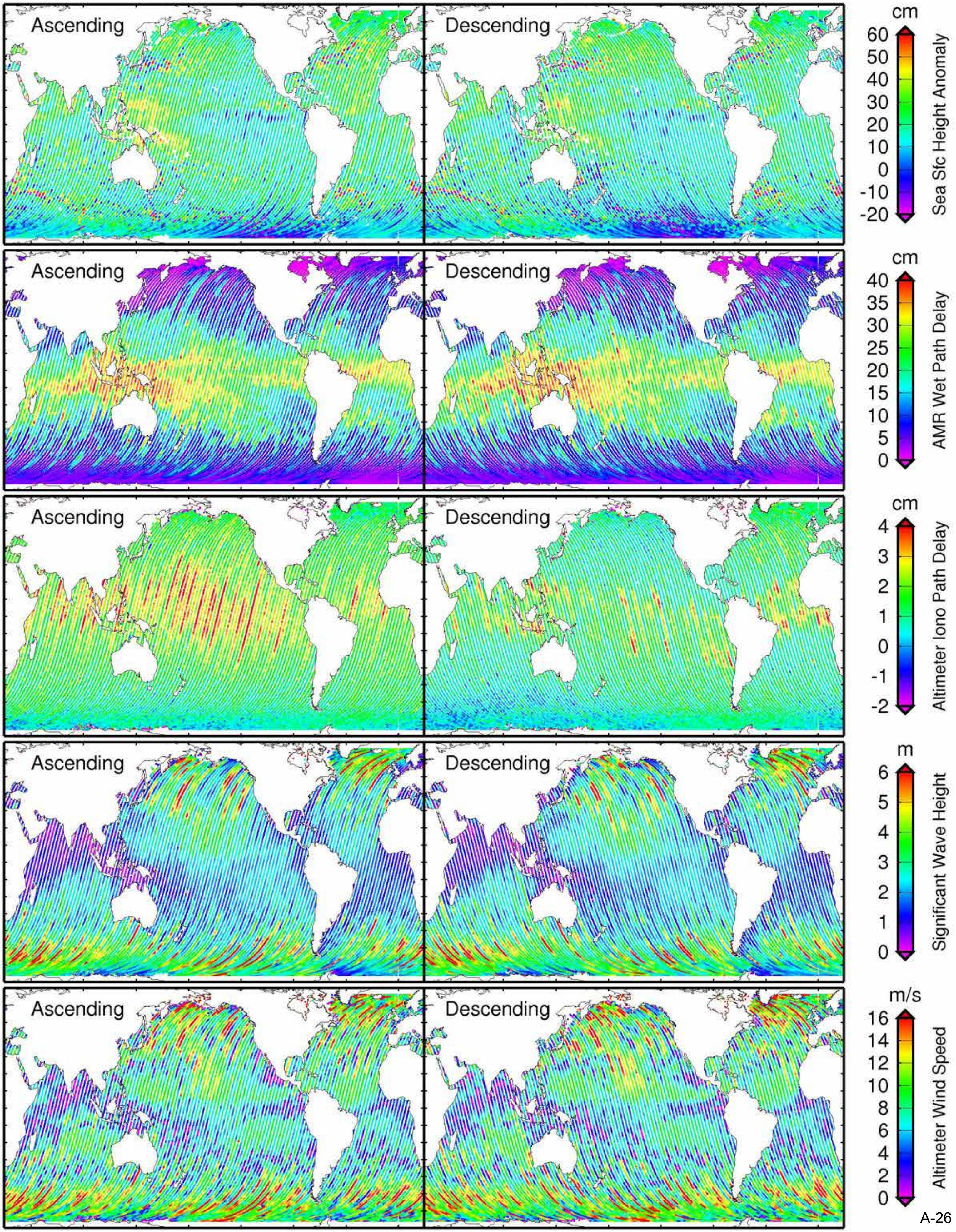

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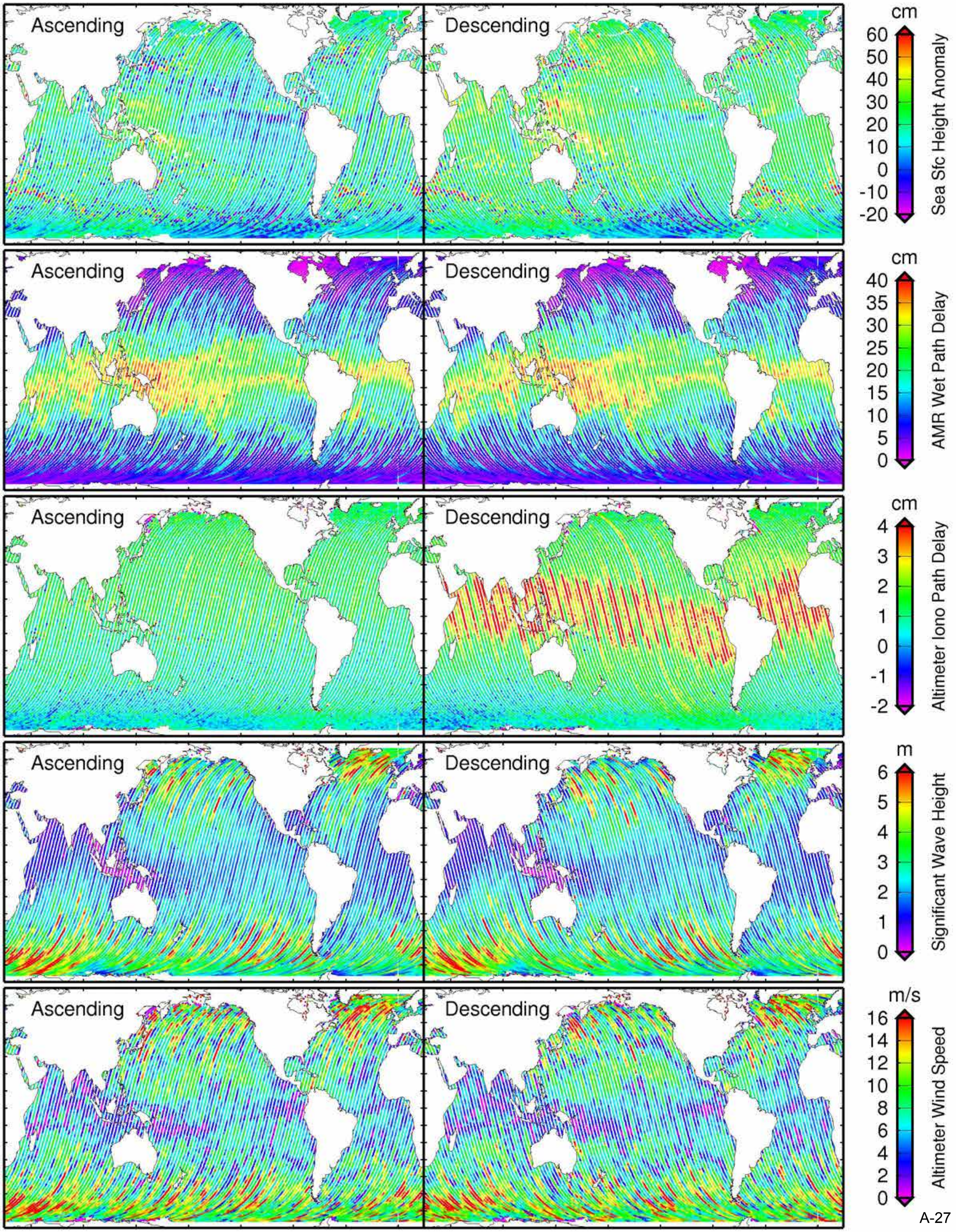

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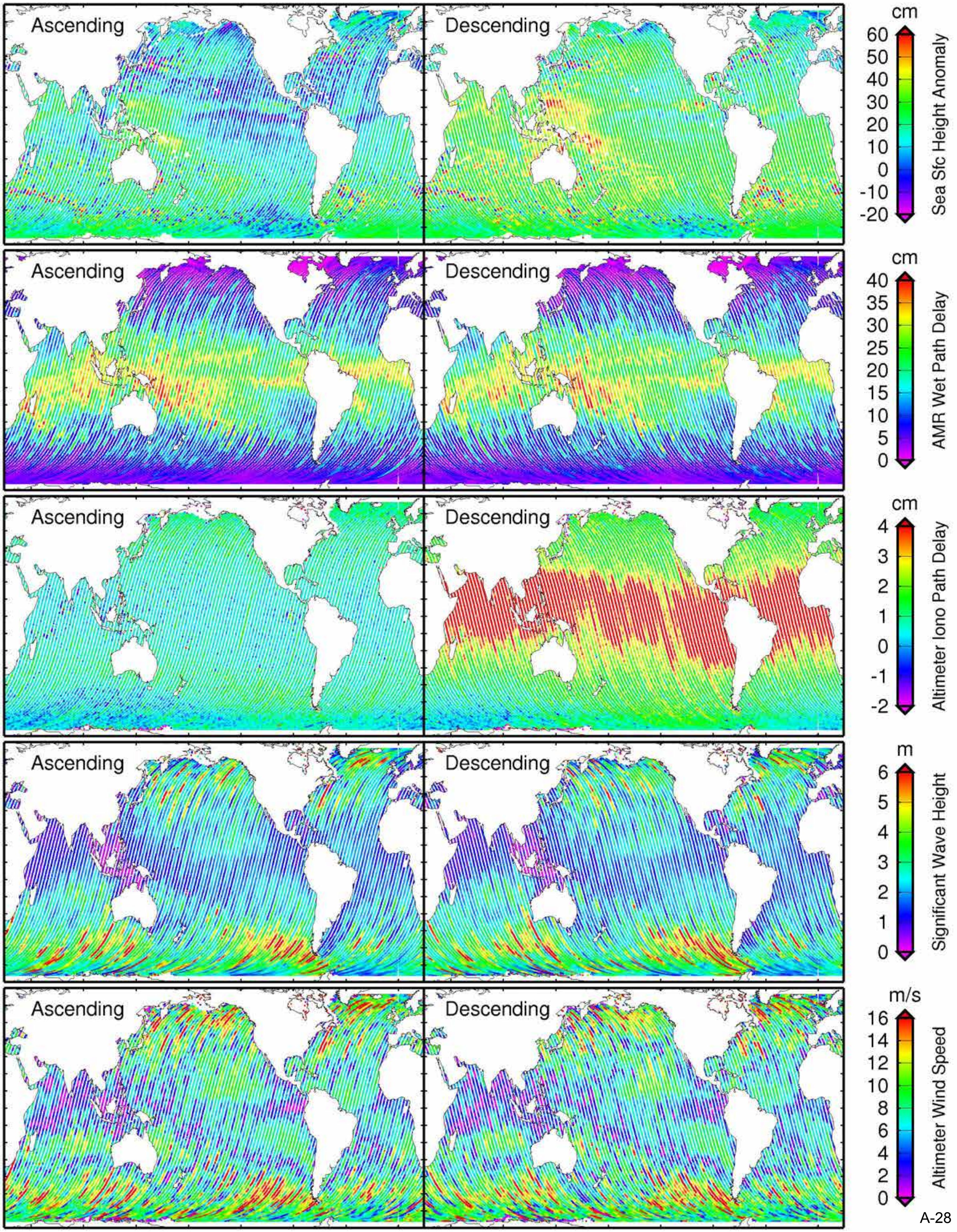

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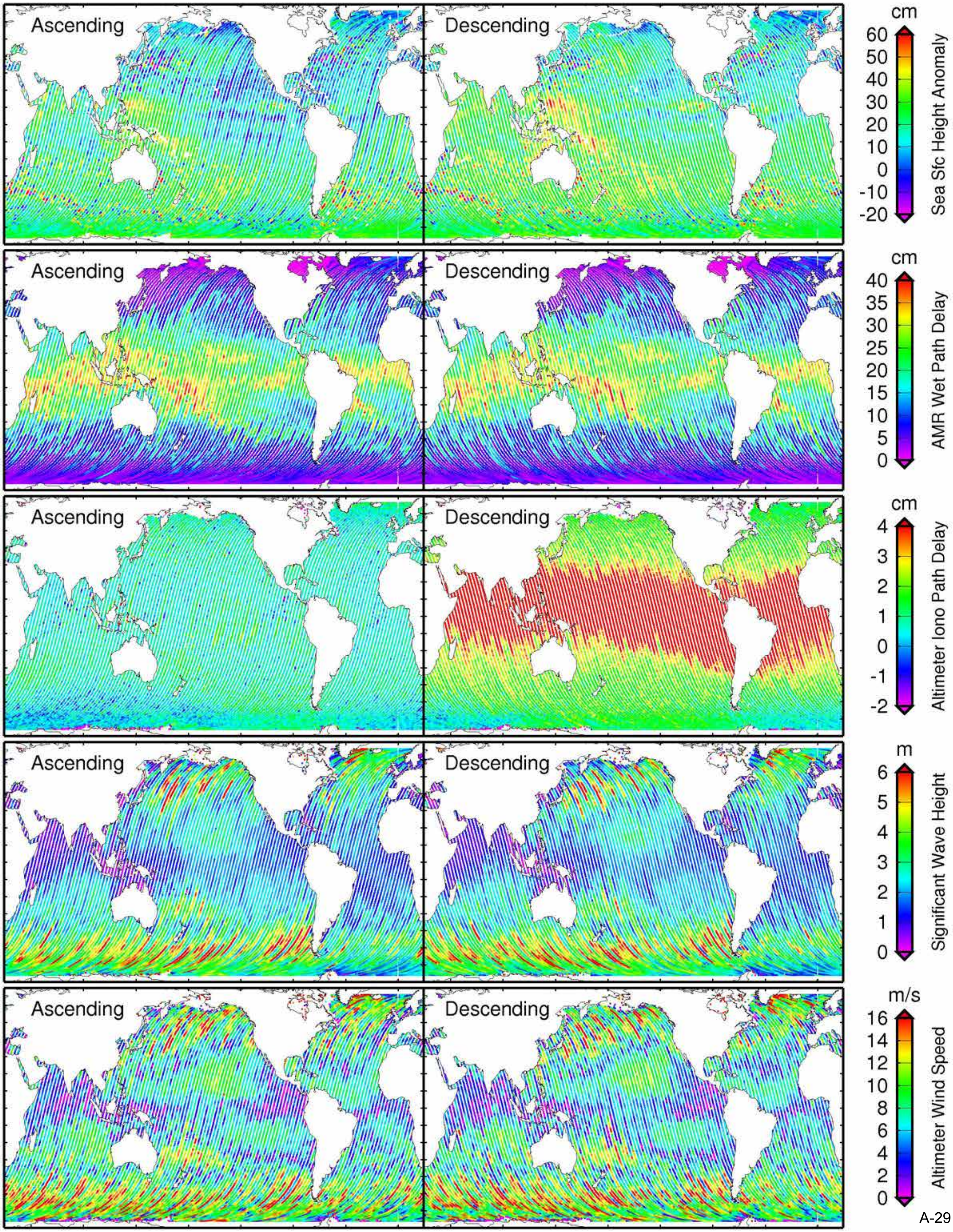

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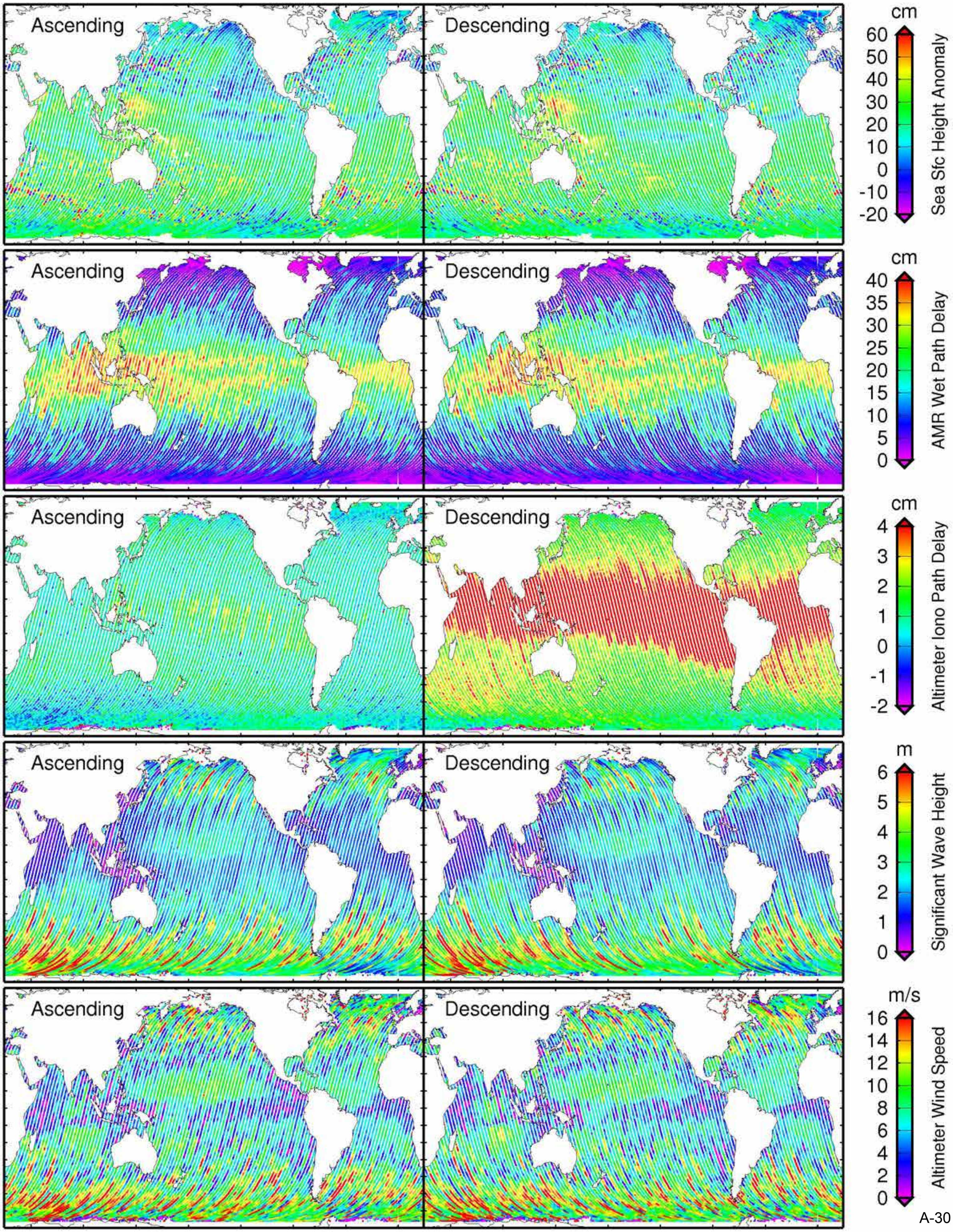

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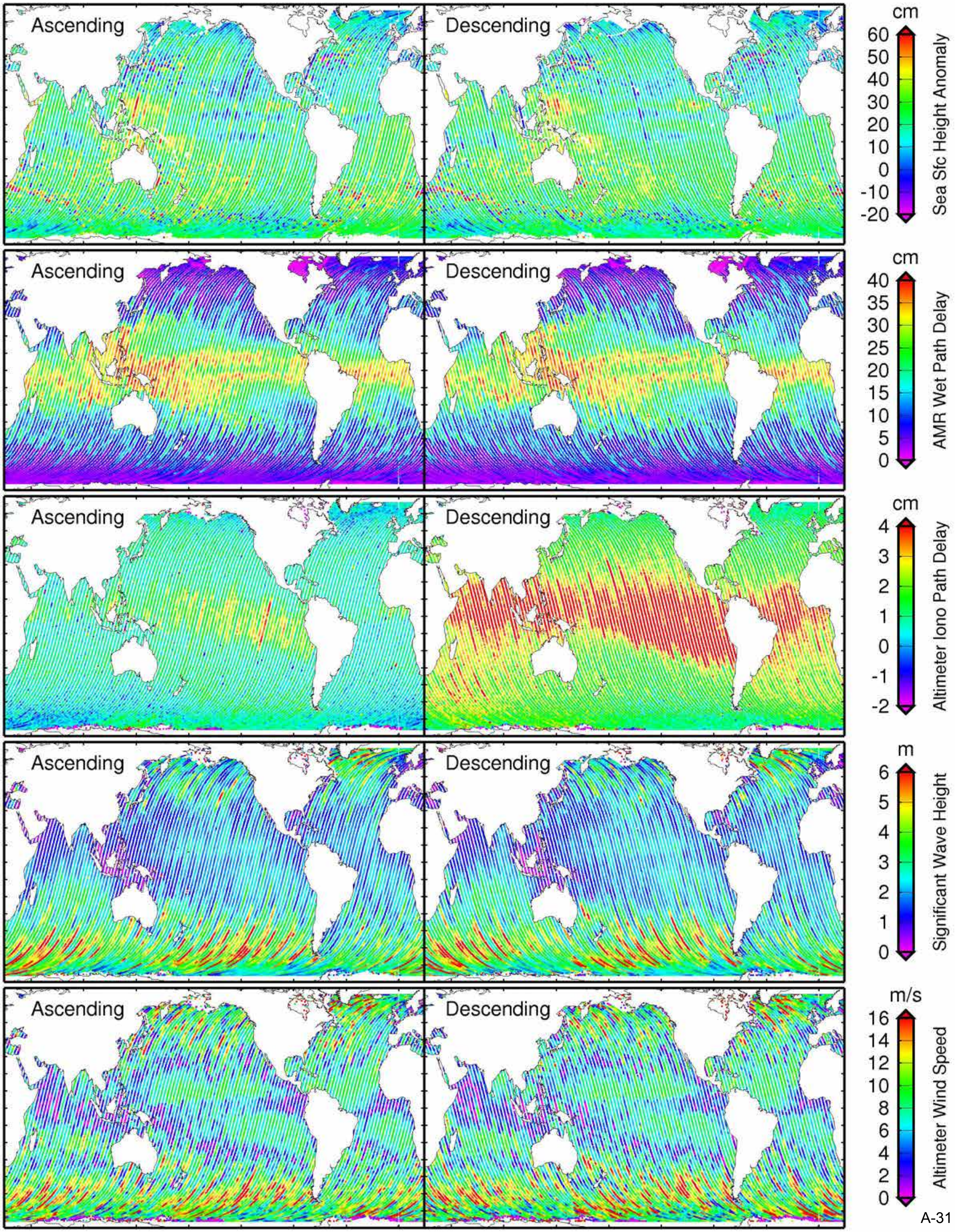

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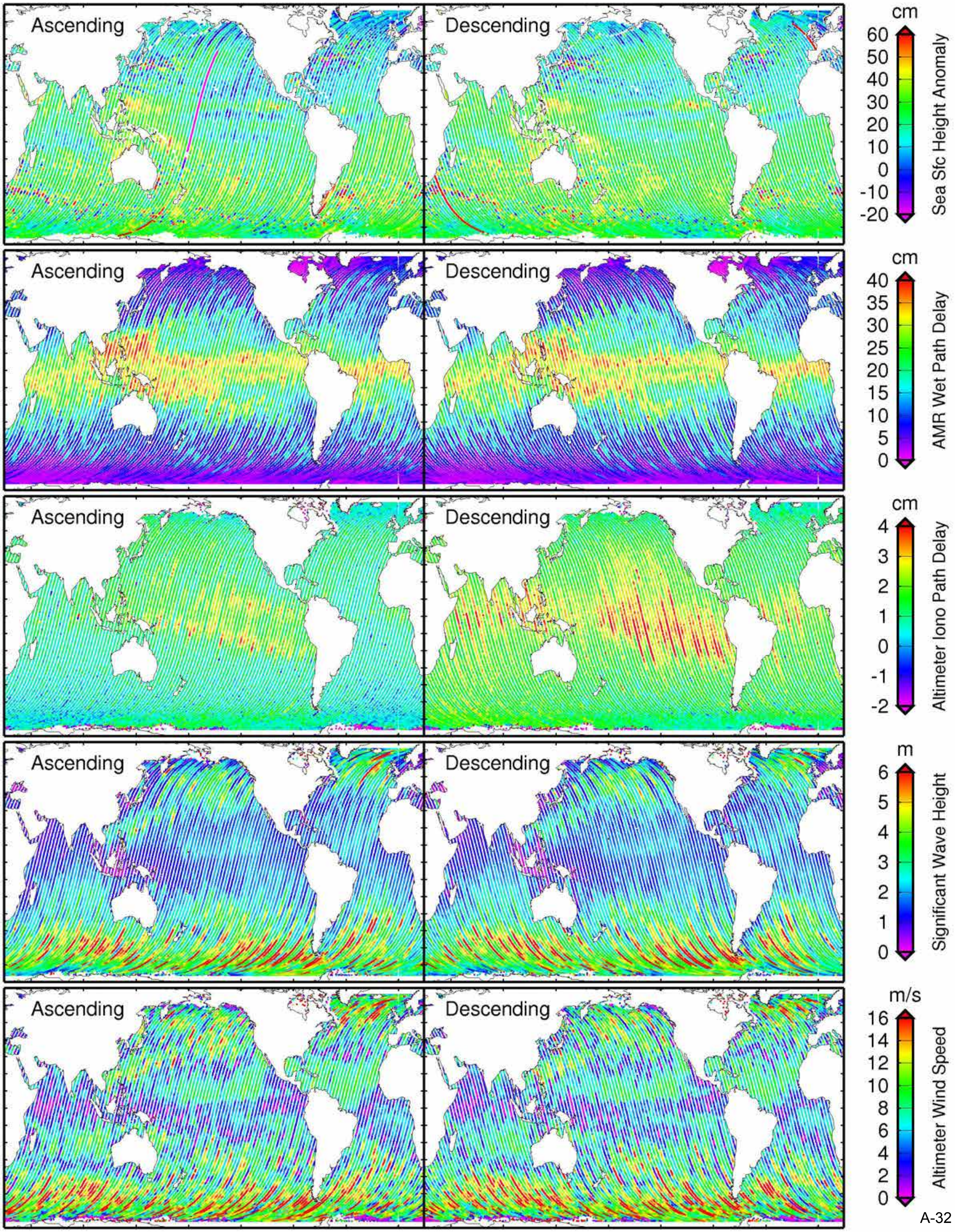

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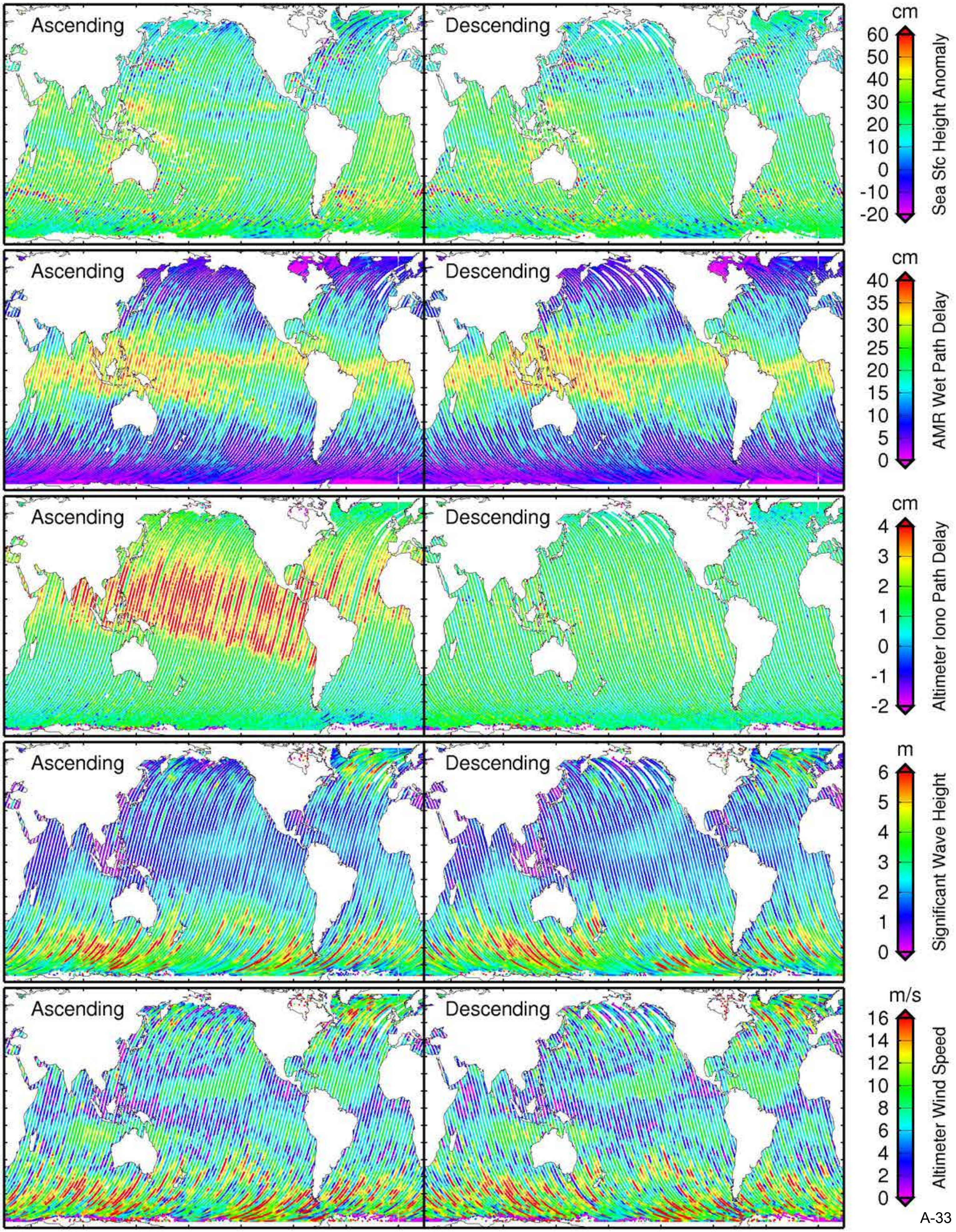
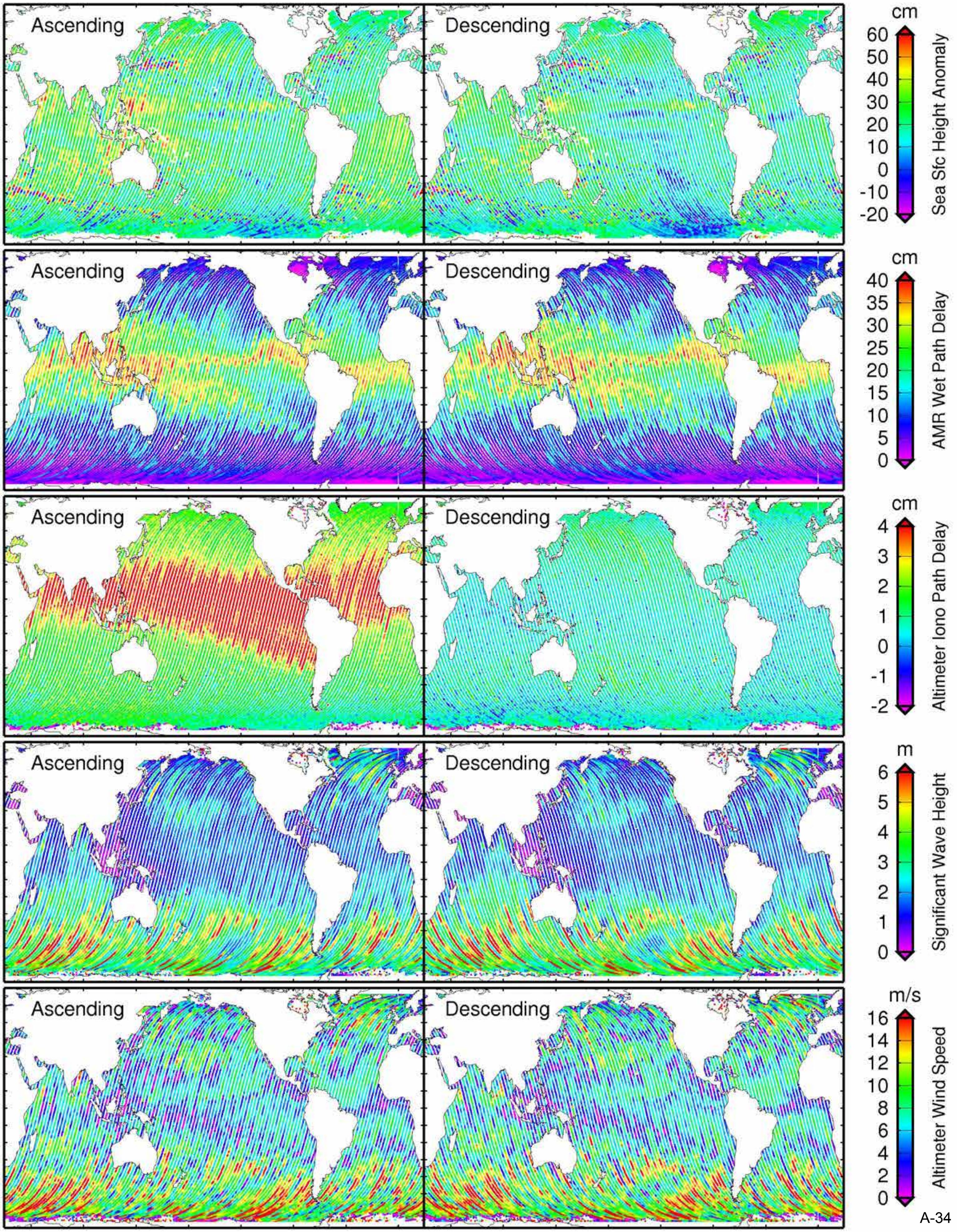
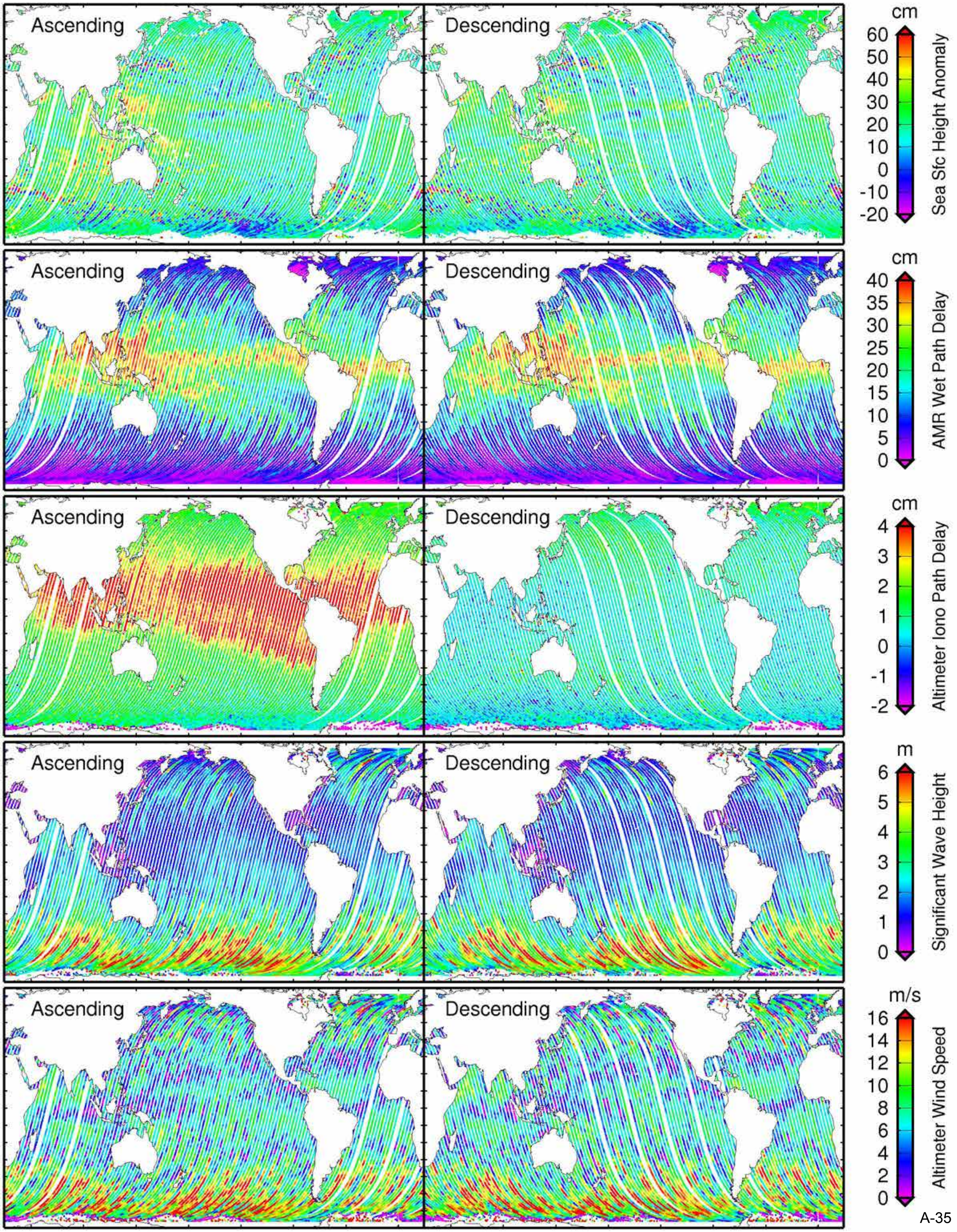


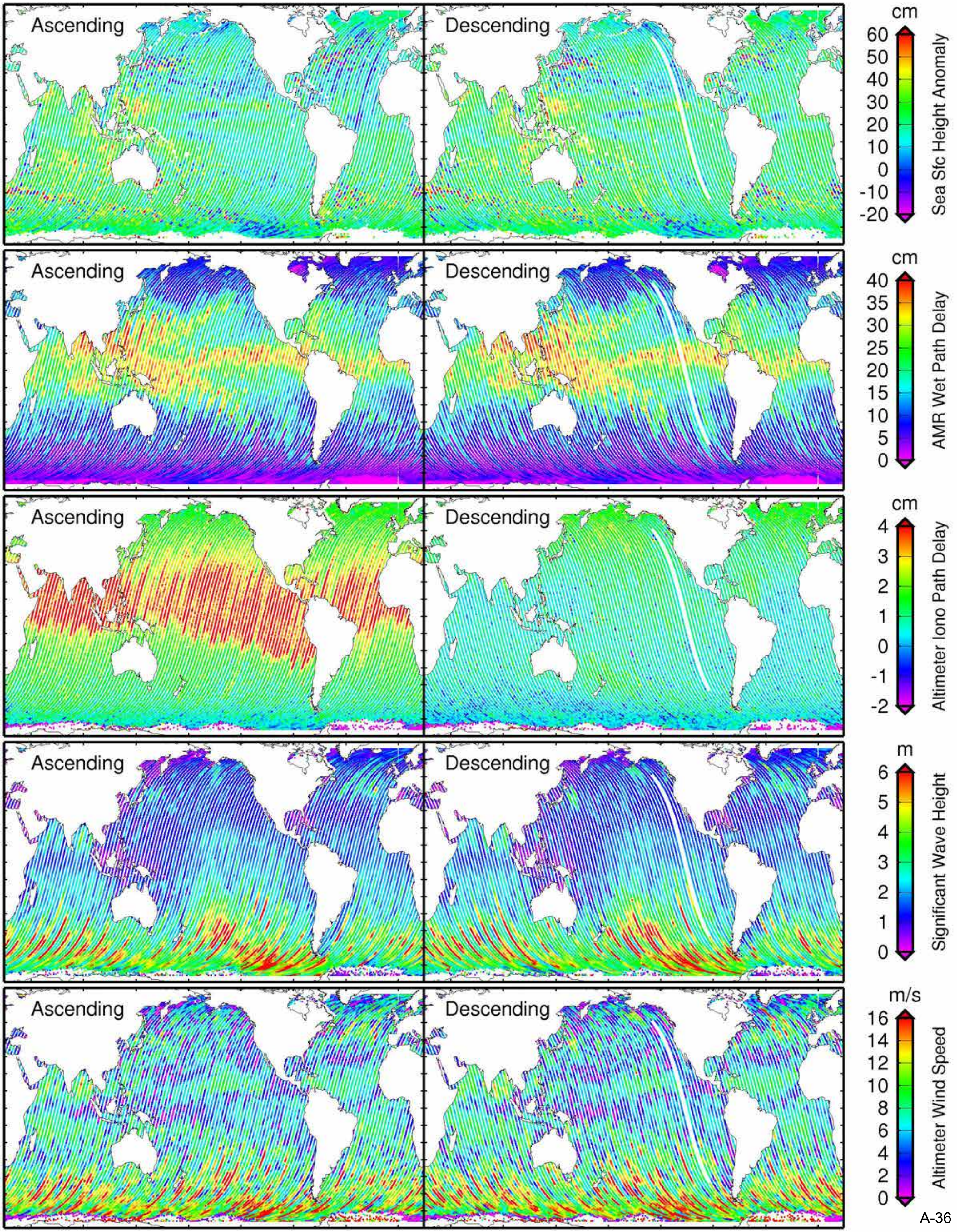
Jason-2 Cycle-032 2009-05-15 10:34:24 - 2009-05-25 08:32:56



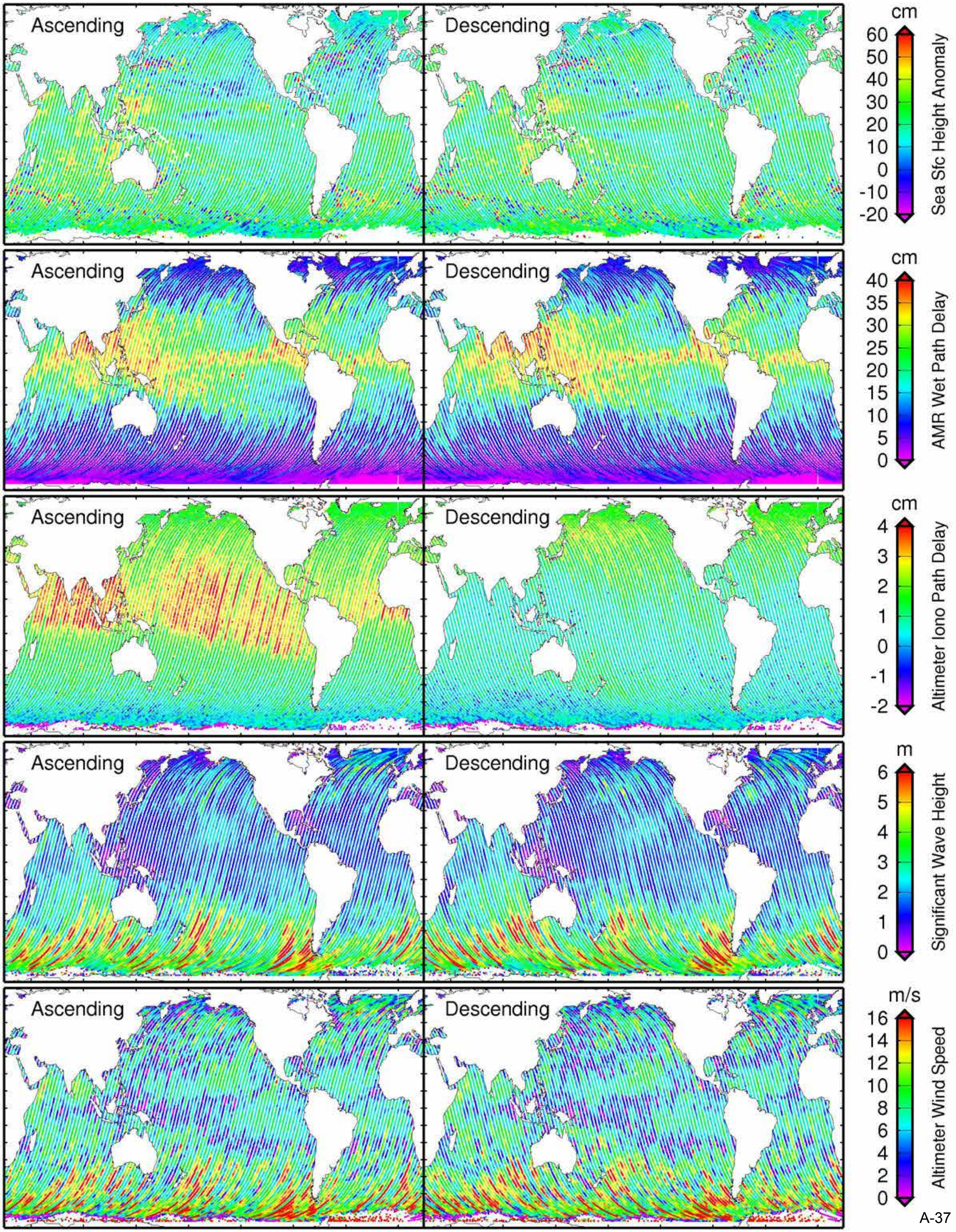
Jason-2 Cycle-033 2009-05-25 08:32:56 - 2009-06-04 06:31:28



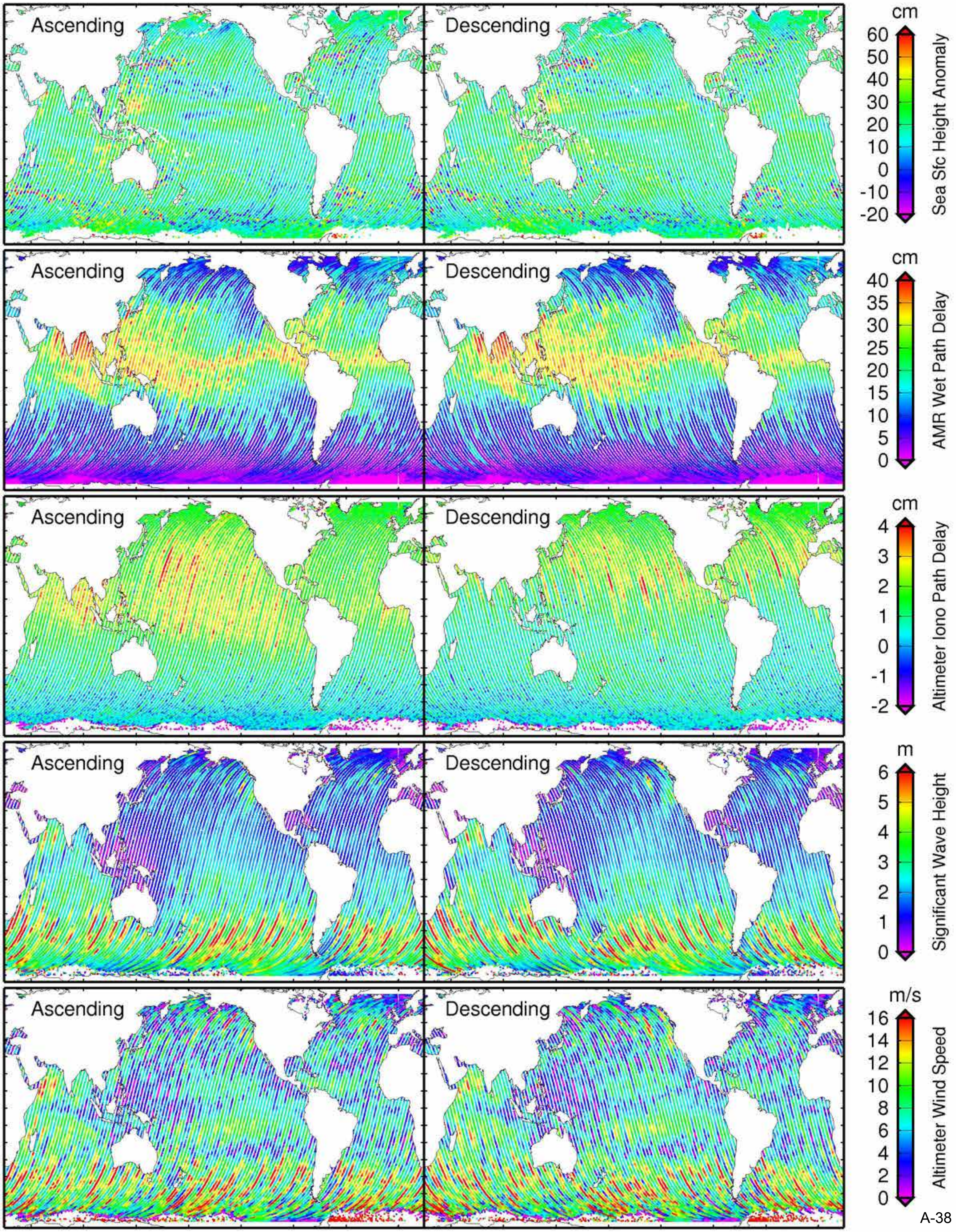
Jason-2 Cycle-034 2009-06-04 06:31:28 - 2009-06-14 04:30:00



Jason-2 Cycle-035 2009-06-14 04:30:00 - 2009-06-24 02:28:32



Jason-2 Cycle-036 2009-06-24 02:28:32 - 2009-07-04 00:27:03



Appendix B. List of OSTM Events Logfile

Date	Event	Impacts
2008/07/04 05:57	**Start of Jason-2 Cycle 0**	
2008/07/04 22:32	inclination maneuver 1st thrust	Degraded orbit quality
2008/07/05 01:20	inclination maneuver 2nd thrust	Degraded orbit quality
2008/07/08 03:12	OCM2 maneuver (Station keeping) single thrust	Degraded orbit quality
2008/07/08 04:45 - 05:25	Poseidon3 altimeter Dedicated period for validation of tracking mode performances	See note 1 and small data gaps on corresponding passes [Cycle 0, …]
2008/07/10 17:43-18:01	X-Maneuver	Off nadir up to 0.3 degrees
2008/07/11 03:57-04:29	Poseidon3 altimeter Specific calibration long CAL2 (onboard low pass filter)	Data gap on corresponding pass [Cycle 0, Pass 232]
2008/07/11 07:01-07:28	Poseidon3 altimeter Specific calibration long CAL1 (onboard amplifier)	Data gap on corresponding pass [Cycle 0, Pass 235]
2008/07/11 13:00-13:01 and 13:04-13:12	Poseidon3 altimeter Tracking mode : Diode-DEM (functional)	Functional test of DIODE-DEM tracking mode while onboard DEM was not correct, leading to wrong waveforms and so impacts on altimeter retracking outputs.
2008/07/12 01:20	**Start of Jason-2 Cycle 1**	
2008/07/16 07:10-17:08	upload POS3 – DEM	Data gap on corresponding passes [Cycle 1, Pass 108-144]
2008/07/16 18:05-18:25	X-Maneuver	Off nadir up to 0.3 degrees
2008/07/17 07:29-11:30	upload POS3 - DEM	Data gap on corresponding passes [Cycle 1, Pass 108-144]
2008/07/21 23:18	**Start of Jason-2 Cycle 2**	
2008/07/23 14:10-14:28	X-Maneuver	Off nadir up to 0.3 degrees
2008/07/31 21:17	**Start of Jason-2 Cycle 3**	
2008/08/10 19:15:40	**Start of Jason-2 Cycle 4**	
2008/08/20 17:14:11	**Start of Jason-2 Cycle 5**	
2008/08/25 17:19-17:35	X-Maneuver	Off nadir up to 0.3 degrees
2008/08/27 16:45	OCM2 maneuver (Station keeping) single thrust	Degraded orbit quality
2008/08/29 16:51-17:08	X-Maneuver	Off nadir up to 0.3 degrees
2008/08/30 15:12:43	**Start of Jason-2 Cycle 6**	
2008/09/08 15:48-16:21	Poseidon3 altimeter Specific calibration long CAL2 (onboard low pass filter)	Data gap on corresponding pass [Cycle 6, Pass 232]
2008/09/08 18:53-19:19	Poseidon3 altimeter Specific calibration long CAL1 (onboard amplifier)	Data gap on corresponding pass [Cycle 6, Pass 235]
2008/09/08 19:44-20:03	X-Maneuver	Off nadir up to 0.3 degrees
2008/09/09 13:11:15	**Start of Jason-2 Cycle 7**	
2008/09/17 18:33:15	Upload ZQS DORIS DIODE Change of source for attitude values (model instead quaternions)	Improvement of DORIS NAV ephemeris quality (improvement in OGDR products)

Date	Event	Impacts
2008/09/18 15:50-16:08	X-Maneuver	Off nadir up to 0.3 degrees
2008/09/19 11:09:47	**Start of Jason-2 Cycle 8**	
2008/09/25	Upload ZQS DORIS DIODE Update of pole covariance model	Improvement of DORIS NAV ephemeris quality (improvement in OGDR products)
2008/09/29 09:08:19	**Start of Jason-2 Cycle 9**	
2008/10/09 07:06:51	**Start of Jason-2 Cycle 10**	
2008/10/19 05:05:23	**Start of Jason-2 Cycle 11**	
2008/10/23 21:51-22:07	X-Maneuver	Off nadir up to 0.3 degrees
2008/10/29 03:03:54	**Start of Jason-2 Cycle 12**	
2008/11/08 01:02:26	**Start of Jason-2 Cycle 13**	
2008/11/17 23:00:57	**Start of Jason-2 Cycle 14**	
2008/11/27 20:59:28	**Start of Jason-2 Cycle 15**	
2008/12/07 18:57:59.748	**Start of Jason-2 Cycle 16**	
2008/12/10	tuning for POSEIDON-3 parameters : uploaded in RAM (avoid the cases of acquisition of “ghost echoes” with a secondary signal acquisition inducing the loss of helpful data)	
2008/12/17 16:56:30.868	**Start of Jason-2 Cycle 17**	
2008/12/18 23:46	OCM2 maneuver (Station keeping) single thrust	Degraded orbit quality
2008/12/27 14:55:03.062	**Start of Jason-2 Cycle 18**	
2009/01/06 12:53:34.289	**Start of Jason-2 Cycle 19**	
2009/01/07 11:00 to 18:00	AMR-H ceased transmitting telemetry packets to the S/C bus controller. Nominal operation resumed at 18h after the AMR was power cycled and commanded into its nominal operational mode.	No radiometer data.
2009/01/11 03:56:00 to 19:26:01	AMR-H experienced an autonomous reset due to an internal watchdog (WD) timeout. Nominal communications were restored within six seconds of the WD reset. AMR produces brightness values equal to default. At 19:26:01 AMR-H was back to nominal.	No radiometer data.
2009/01/16 10:52:06.403	**Start of Jason-2 Cycle 20**	
2009/01/26 08:50:38.480	**Start of Jason-2 Cycle 21**	
2009/02/05 06:49:10.566	**Start of Jason-2 Cycle 22**	
2009/02/15 04:47:42.596	**Start of Jason-2 Cycle 23**	
2009/02/23 13:58 to 16:10:18	Star tracker problem (STR1) An expertise mode was planned but the upload of the TCs went wrong, leading to a standby of STR regarding the AOCS loop. During that period, pointing was insured by gyro wheels. As a consequence some mispointing MAY occur.	off nadir reached about 0.27 degrees (0.075 deg^2) so fully compatible to our ground retracking software
2009/02/25 02:46:14.360	**Start of Jason-2 Cycle 24**	
2009/03/07 00:44:45.802	**Start of Jason-2 Cycle 25**	
2009/03/16 22:43:17.002	**Start of Jason-2 Cycle 26**	

Date	Event	Impacts
2009/03/26 20:41:48.100	**Start of Jason-2 Cycle 27**	
2009/04/05 18:40:19.209	**Start of Jason-2 Cycle 28**	
2009/04/15 16:38:50.280	**Start of Jason-2 Cycle 29**	
2009/04/25 14:37:21.199	**Start of Jason-2 Cycle 30**	
2009/05/05 6:26	OCM2 maneuver (Station keeping) single thrust	Degraded orbit quality
2009/05/05 12:35:51.929	**Start of Jason-2 Cycle 31**	
2009/05/11 12:05 to 2009/05/14 12:56	Poseidon3 DEM upload	Altimeter stopped ONLY during fly by over Earth Terminals (uploads) no altimeter data during those periods
2009/05/15 10:34:23.948	**Start of Jason-2 Cycle 32**	
2009/05/25 08:32:55.881	**Start of Jason-2 Cycle 33**	
2009/06/02 06:56 to 15:58	Poseidon3 on-board software upload. The mission interruption as been of about 9:03 hours.	No altimeter data during the period Passes 205 to 212 are missing
2009/06/04 06:31:27.810	**Start of Jason-2 Cycle 34**	
2009/07/13 07:07:02 to 07:40:24	Exceptional POSEIDON-3 calibration (long CAL2 LPF)	No altimeter data during the period
2009/07/13 10:11:41 to 10:37:51	Exceptional POSEIDON-3 calibration (on board amplifiers)	No altimeter data during the period
2009/06/14 04:29:59.753	**Start of Jason-2 Cycle 35**	
2009/06/24 02:28:31.549	**Start of Jason-2 Cycle 36**	

Appendix C. Acronyms

Acronym	Definition
AMR	Advanced Microwave Radiometer
CNES	Centre National d'Etudes Spatiales
DEM	Digital Elevation Model
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
ECMWF	European Centre for Medium-Range Weather Forecasts
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
OGDR	Operational Geophysical Data Records
OSTM	Ocean Surface Topography Mission
SSH(A)	Sea Surface Height (Anomaly)
SWH	Significant Wave Height
TM-NRT	Telemetry analyzer Near Real-Time