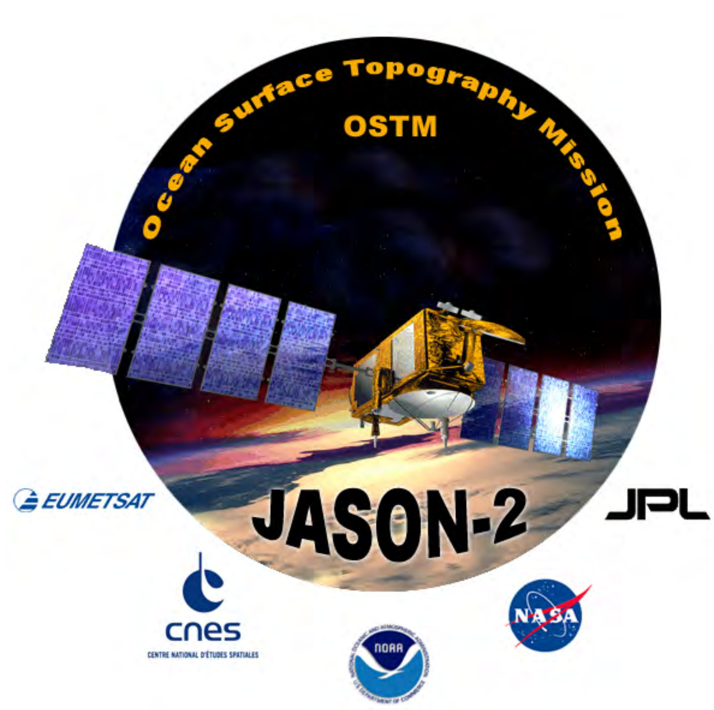
OSTM / Jason-2

Near Real-Time Data Annual Quality Report 2009-2010

September 2010



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 2009-2010* (Sept. 29, 2010 issue).

The purpose of this document is to assess the overall quality of the Jason-2/OSTM 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-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 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 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 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 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 calculation is performed for both the 3 hour / 75% requirement and the 5 hour / 95% requirement. The overall latency of OGDRs, produced by both NOAA and EUMETSAT, is accumulated over the previous week for reporting at the OCG meeting.

Figure 1 is a graphical representation of the weekly latency statistics over the second year of operations. At each weekly interval along the x-axis, the percentage of data available within 3 hours is shown by the height of the green area (on a y-axis scale of 70-100%). The percentage of data available within 5 hours is shown by the height of the combined green + yellow areas. Finally, the red areas show the percentage of data NOT available within 5 hours, as a difference between 100% and the yellow area. The target 75% and 95% requirements are shown as horizontal dashed lines.

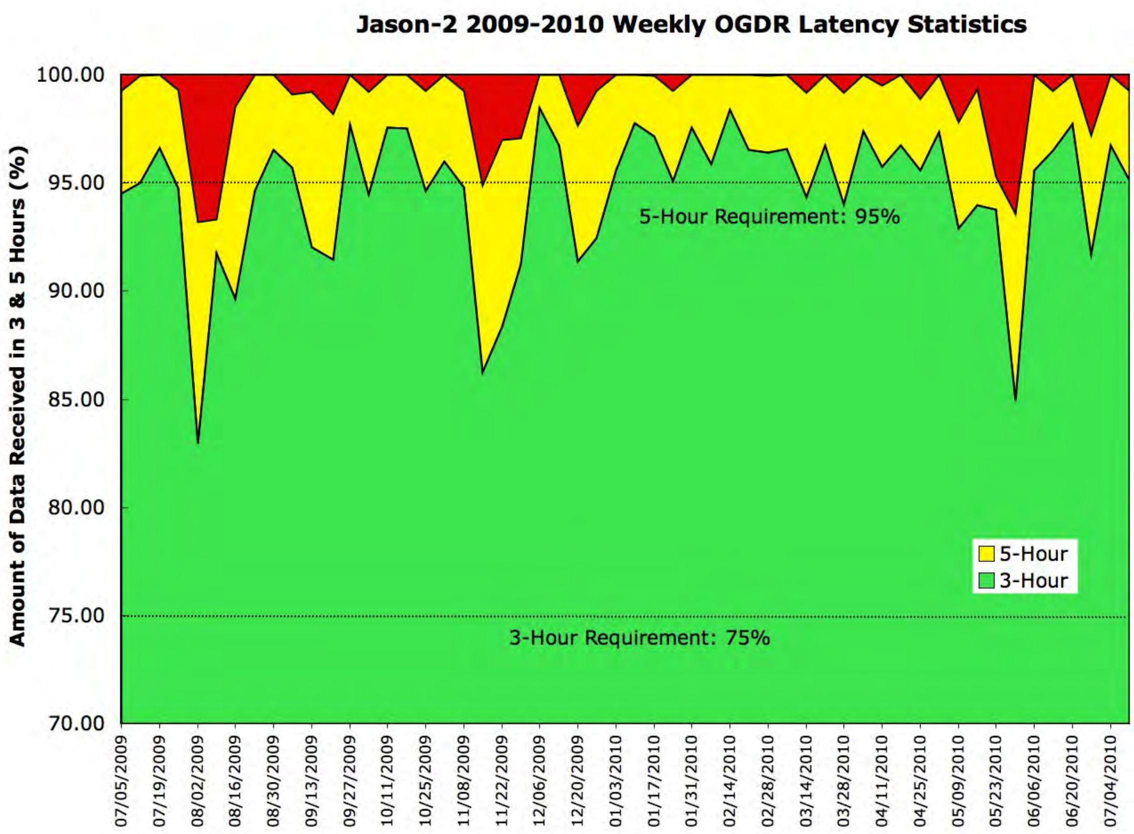


Figure 1 – Jason-2 OGDR Latency Statistics for July 2009 to July 2010

This figure demonstrates that the 3-hour requirement was satisfied 100% of the time this year, since the yellow area never falls below the 75% line. The 5-hour requirement was met for all but 4 weeks this year, for a 92.3% success rate. The requirement was NOT met at the times when the red area falls below the 95% line. Based on the information in the weekly OCG reports, those 4 failures are due to the following causes:

> 2009 Week 31 (27 Jul - 02 Aug): NOAAServer failover from primary to secondary strings required after failure of primary J2TCCS component. Issues with Usingen ground station required data re-dumps which increased latency.
>
> 2009 Week 32 (03 Aug - 09 Aug): Leap second (TAI-UTC) file automatically deleted by file aging cleanup routines on NOAA's TM-NRT, resulting in 5 OGDRs generated with time tags incorrect by one second. The 5 OGDRs were recreated the next day, leading to abnormally long latencies and low statistics.
>
> 2009 Week 46 (09 Nov - 15 Nov): Command/control issues at NOAA/SOCC and the ground stations required a large number of re-dumps which increased latency.
>
> 2010 Week 21 (24 May - 30 May): A scheduled upgrade of operating system software at the Usingen ground station resulted in station unavailability during European working hours, and many blind passes subsequently had to be dumped at the NOAA ground stations.

The yearly averaged values (over the 54 weeks shown in Figure 1) are: **94.58% of all data were available within 3 hours and 98.91% of all data were available within 5 hours**.

Section 3.0 Data Quality Analysis Plots

In this section data from the second year of operations are analyzed, covering the time period from 04-Jul-2009 to 05-Jul-2010: cycles 37-73. 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 ± 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 37-73, comprising the second 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 following sections.

Section 4.0 Anomalies Impacting Quality

Since the launch of Jason-2 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 July 2009 to July 2010 are 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.

   Two cycles were notably affected by maneuvers:

   Cycle-042: A maneuver burn was performed on 2009-08-23 from 21:12:59 to 21:13:01, affecting pass 033.

   Cycle-053: A maneuver burn was performed on 2009-12-17 from 15:55:37 to 15:55:39, affecting pass 205.

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. This includes events associated with software uploads, including Digital Elevation Model (DEM) updates, as well as calibration files.

   Two cycles were affected by software uploads and calibration updates:

   Cycle-053: Gyro calibration performed on 2009-12-11 from 20:38:19 to 21:29:43 impacting passes 057 & 058. CAL-1 calibration performed on 2009-12-18 at 16:11:32 affecting 40 seconds of data on pass 231 (over land). CAL-2 calibration performed on 2009-12-18 at 16:39:01 affecting 33 minutes of data from pass 232. CNG calibration performed on 2009-12-18 at 19:43:40 affecting 26 minutes of pass 235 (mostly over land). The result of these calibrations was that the Poseidon-3 altimeter was in DIODE/DEM mode from 2009-12-18 at 16:12:12 (pass 231) until 2009-12-19 at 01:17:40 (pass 241). This is the only data this year that is NOT in nominal median tracker mode.

   Cycle-073: CAL-1 calibration performed on 2010-07-04 at 23:42:14 affecting 40 seconds of data on pass 231 (over land). CAL-2 calibration performed on 2010-07-05 from 00:09:33 to 00:42:54 impacting pass 232 (over ocean). CNG calibration performed on 2010-07-05 from 03:14:11 to 03:40:20 impacting pass 235 (over land).

c. Instrument anomalies can result in a partial loss of data or degradation in performance of the system. Only one cycle was impacted by this type of anomaly:

   Cycle-060: An upgrade of the DORIS onboard software to V8.0 was performed, necessitating a DORIS restart on 2010-02-18 at 05:01. The impact was a data gap of 2 hours 34 minutes due to loss of DORIS time-tagging, and increased radial orbit error as the DORIS/DIODE orbit determination system converged.

d. Unavailability of auxiliary data can impact computation of SSH while not affecting the SWH and wind speed variables. One cycle was impacted due to a temporary delay in receiving ECMWF model data:

   Cycle-072: Due to an anomaly with ECMWF model update cycle-c36r2, forecast surface pressure grids were unavailable for computation of dry troposphere and inverse barometer corrections. This resulted in missing SSH data from 2010-06-23 at 12:00 to 2010-06-24 at 12:00. There was no impact on SWH or wind speed data.

e. Gaps in payload telemetry can cause (generally) small losses of data. Four cycles were affected by telemetry data gaps:

   Cycle-037: There is a small data gap for pass 054 on 2009-07-06 between 02:33:12 and 02:34:33 due to missing PLTM-1 telemetry (barely visible in the East equatorial Pacific).

   Cycle-039: There is a small data gap of approximately 20 seconds on pass 105 in the Indian Ocean due to missing telemetry (not visible in cyclic plots).

   Cycle-066: There are a few data gaps on pass 249 west of New Zealand totalling 39 seconds between 06:08 and 06:18 on 2010-04-27.

   Cycle-072: There is a small data gap on pass 199 south of Australia on 2010-06-23 from 19:15:37 to 19:16:59 due to missing PLTM-1 telemetry.

Further details on these anomalies can be found in the cyclic GDR calibration/validation reports provided by CLS under contract to CNES. These are available on the AVISO ftp server: ftp://avisoftp.cnes.fr:/AVISO/pub/jason-2/gdr_t_validation_report

Section 5.0 Summary

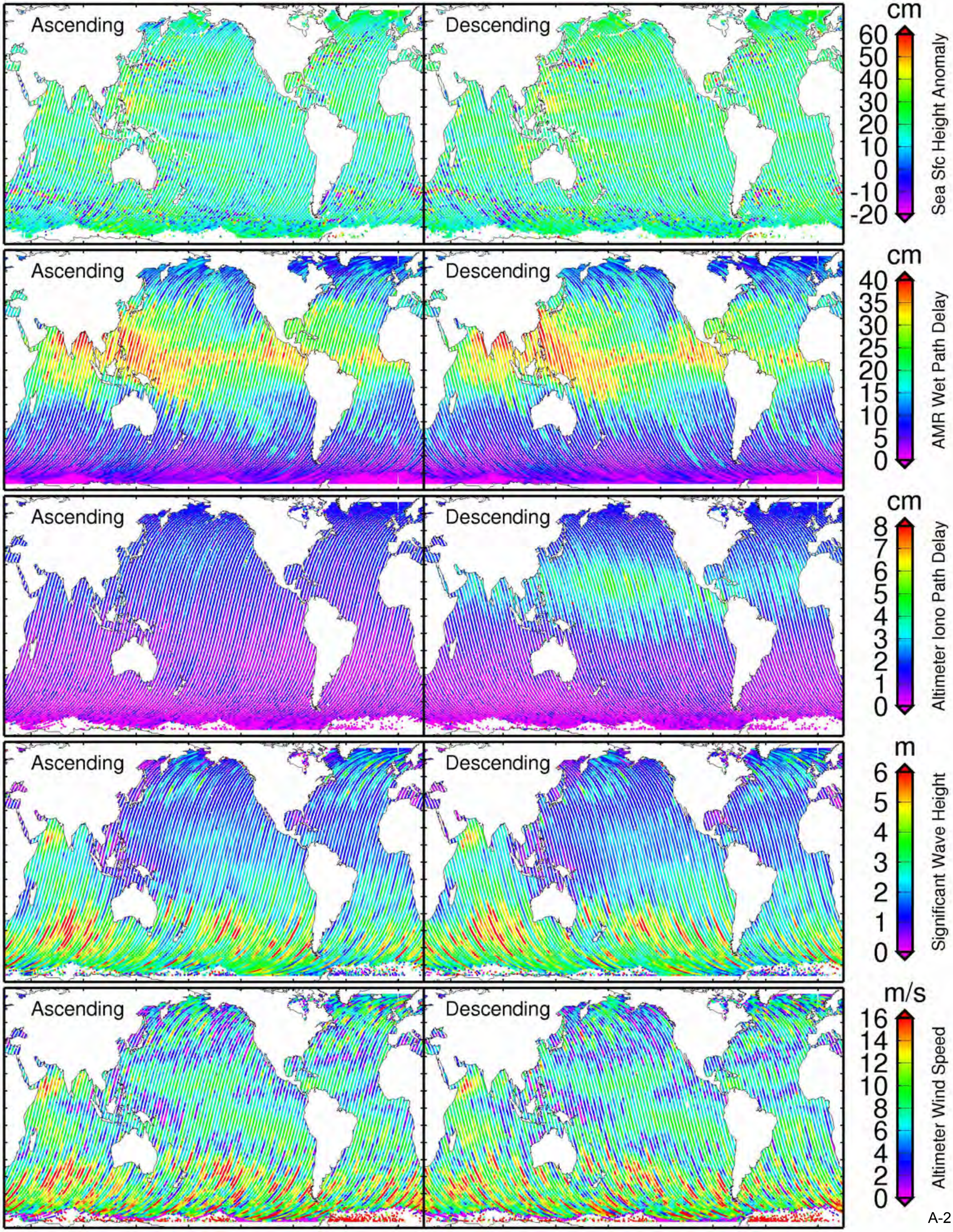
The overall quality of the Jason-2/OSTM near real-time OGDR data is extremely good. Only 5 of the 37 cycles analyzed had noticeable defects in the cyclic plots: cycles 042, 053, 060, 072, and 073. The major causes of data degradation were orbital maneuvers, calibration sequences, the DORIS system reset, and the loss of a day's worth of ECMWF pressure grids. The amount of missing data, attributed to all of the anomalies discussed in section 4, is 1d 5h 28m 57s (with one day of missing data due to the ECMWF anomaly). **This represents a data return of 99.67% over the time period analyzed (slightly more than a year). The data return for wind/wave data, which wasn't affected by the ECMWF anomaly, is 99.94%.** This value is representative of the data return for the final GDRs.

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 also provided a valuable diagnostic for monitoring the OGDR data quality in near real-time.

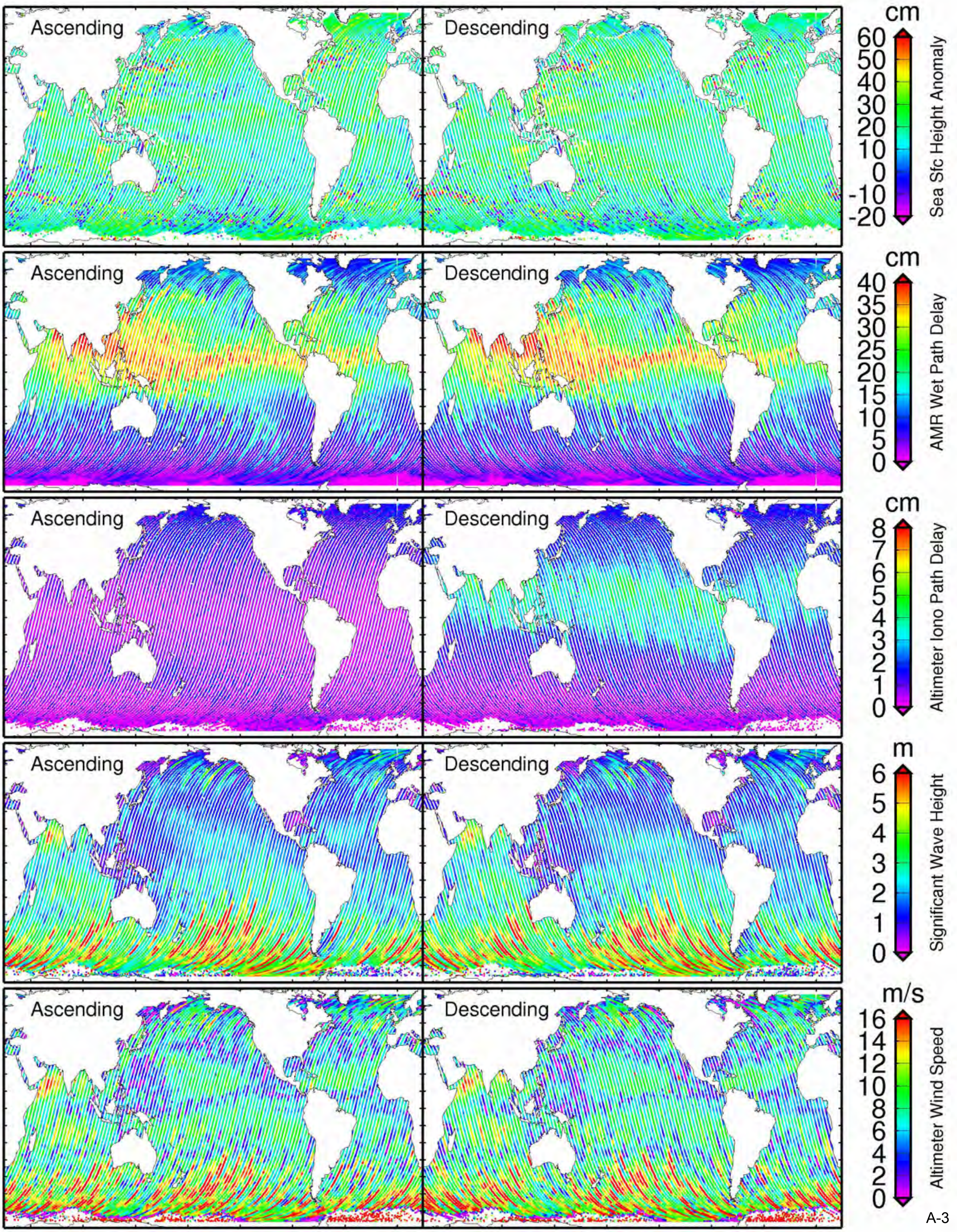
Appendix A. Cyclic Parameter Plots Cycle-037 to Cycle-073

See individual plots on the following 37 pages.

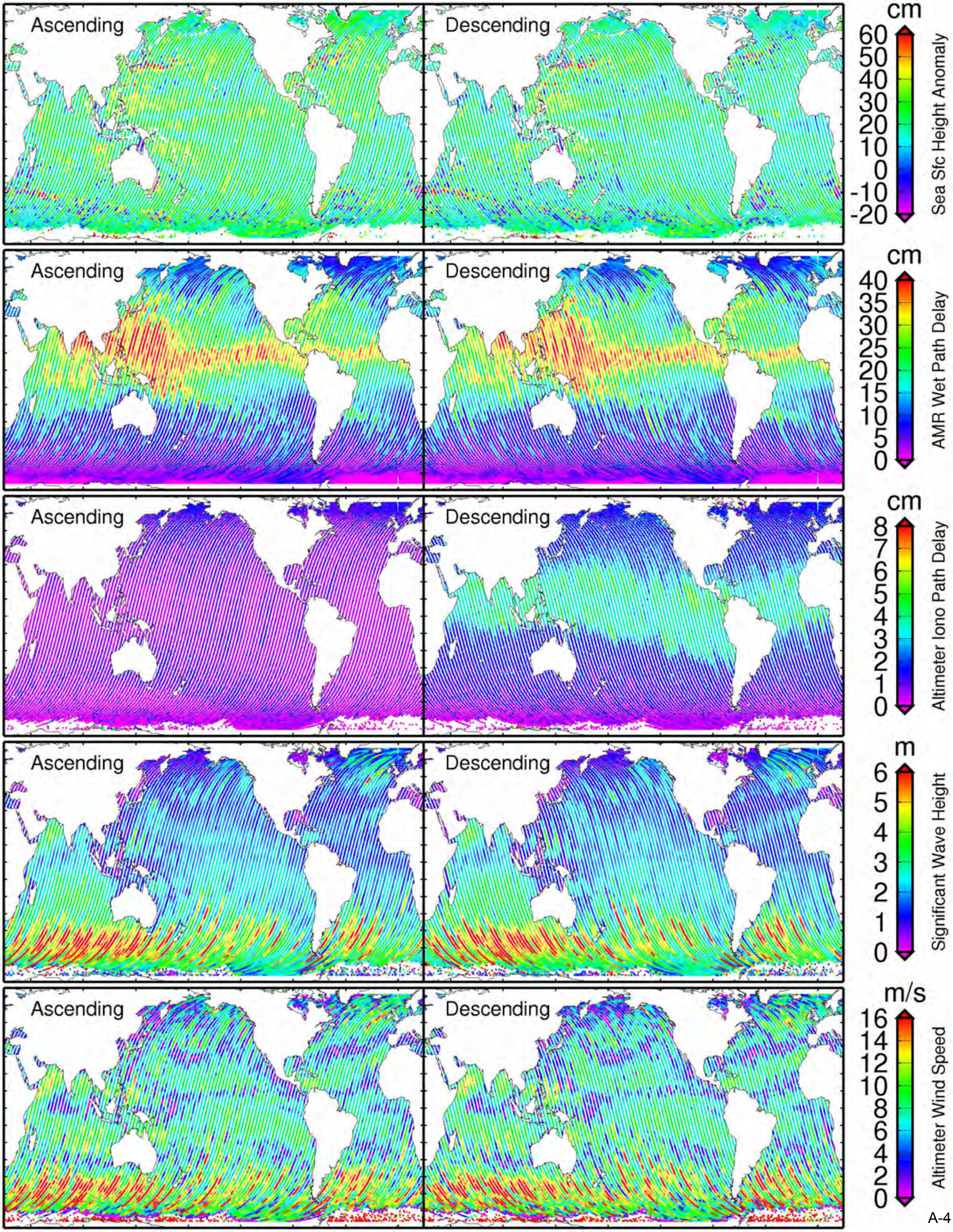
Jason-2 Cycle-037 2009-07-04 00:27:03 - 2009-07-13 22:25:35



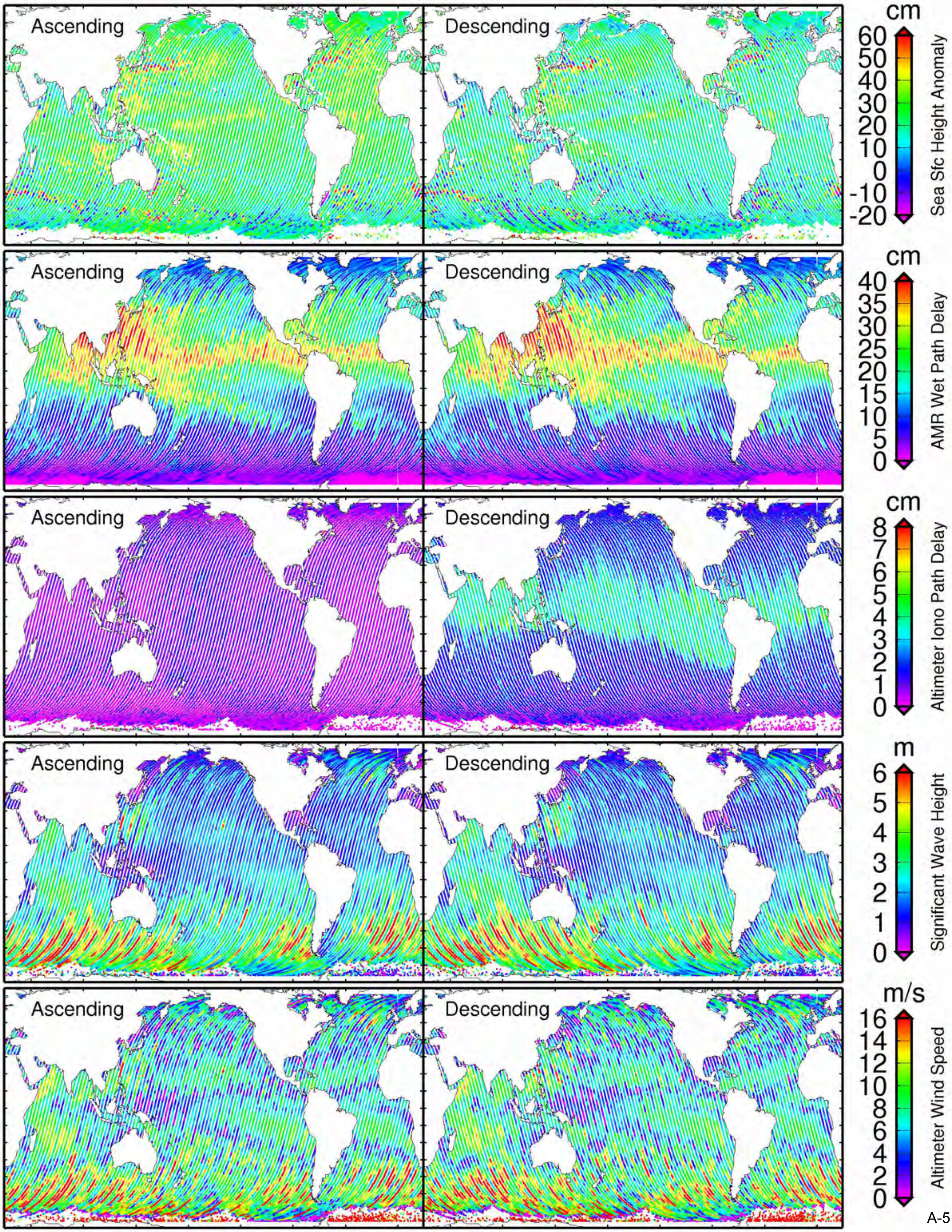
Jason-2 Cycle-038 2009-07-13 22:25:35 - 2009-07-23 20:24:06



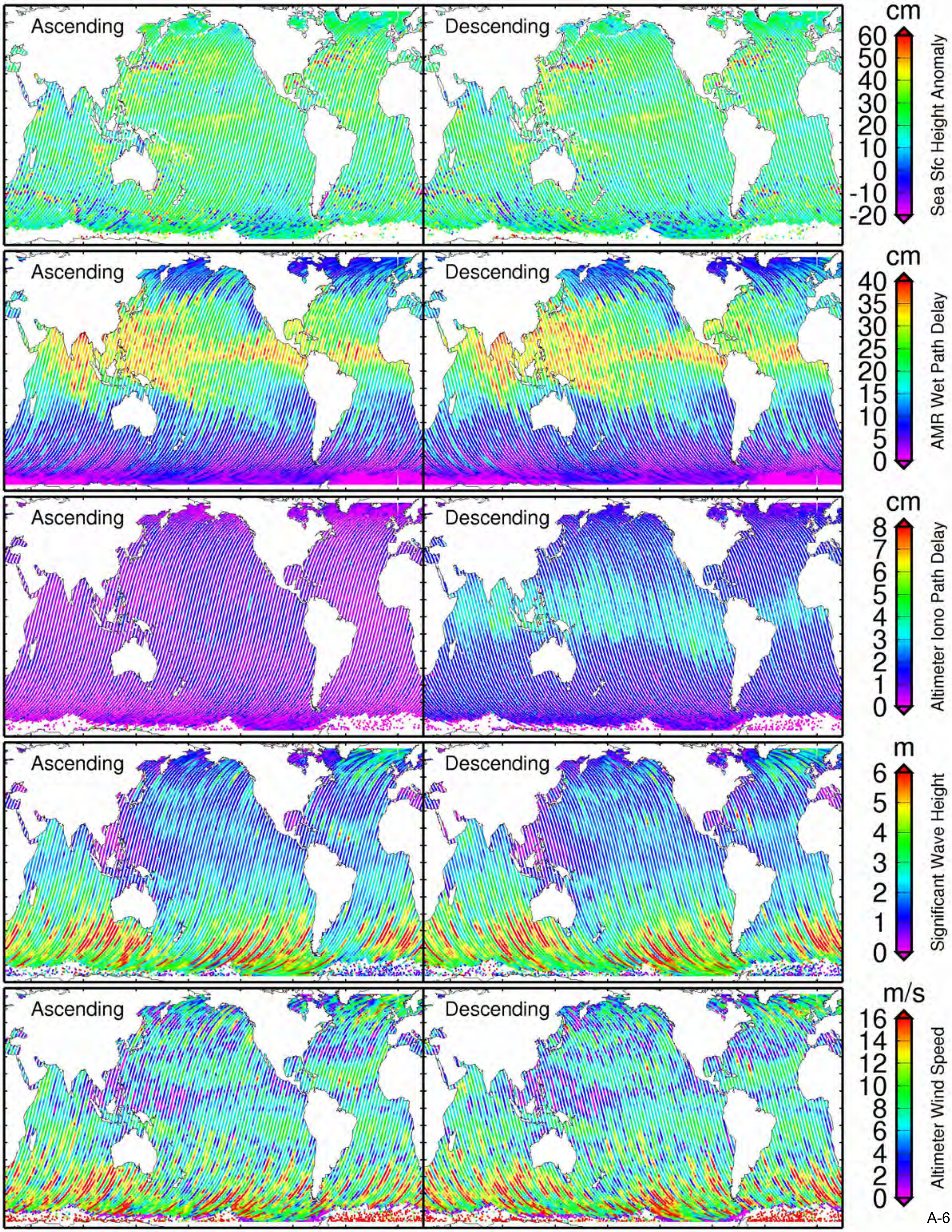
Jason-2 Cycle-039 2009-07-23 20:24:06 - 2009-08-02 18:22:38



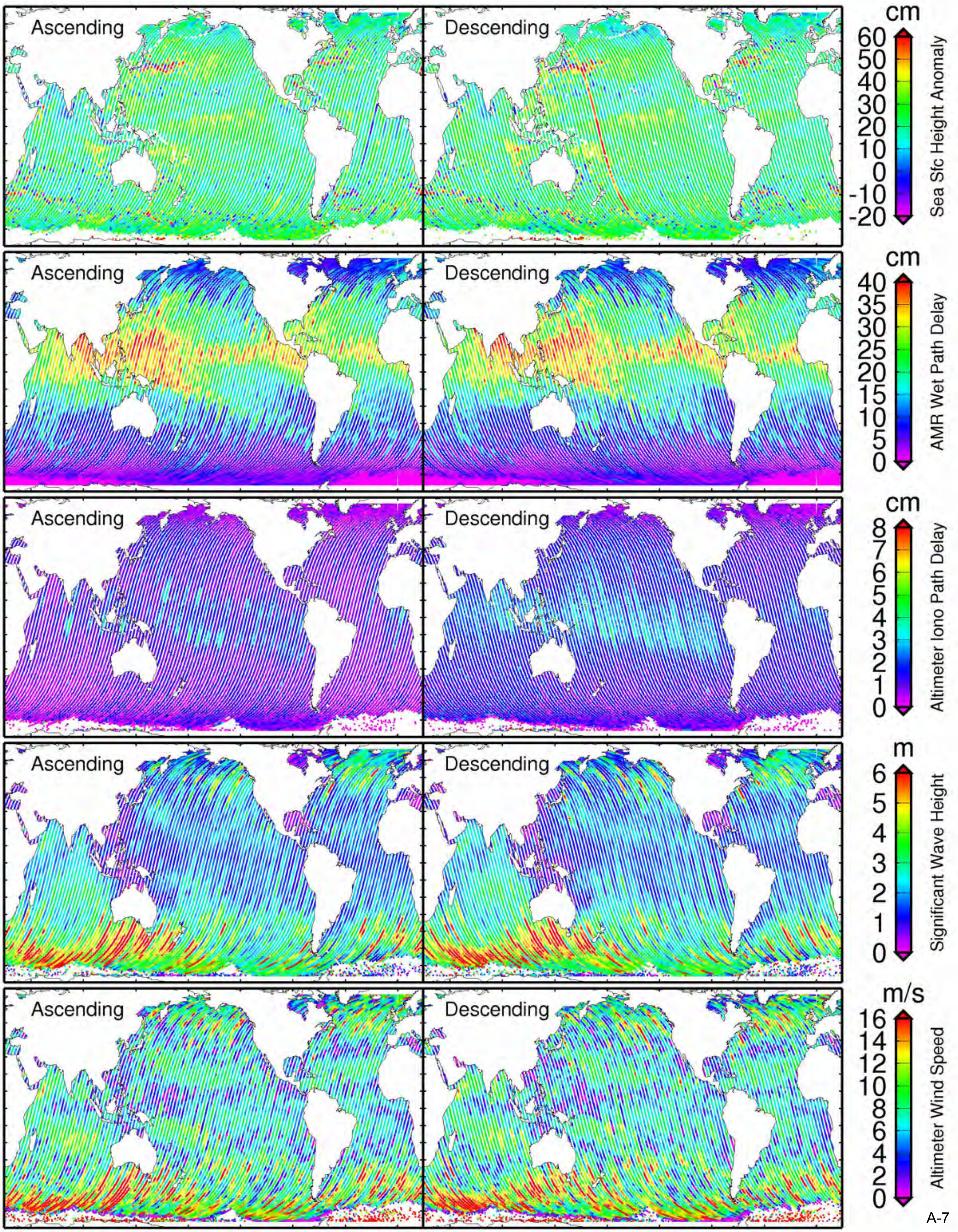
Jason-2 Cycle-040 2009-08-02 18:22:38 - 2009-08-12 16:21:09



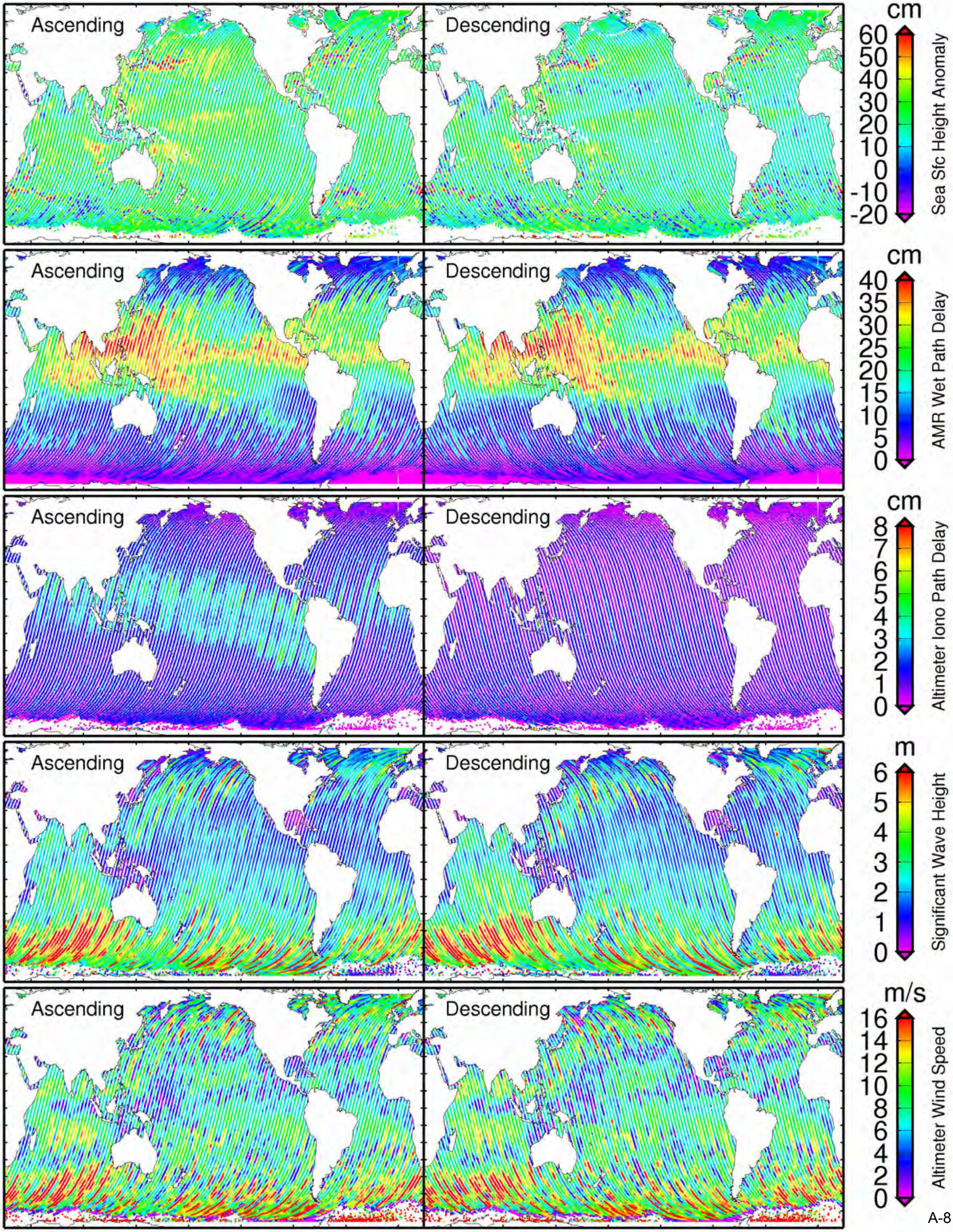
Jason-2 Cycle-041 2009-08-12 16:21:09 - 2009-08-22 14:19:41



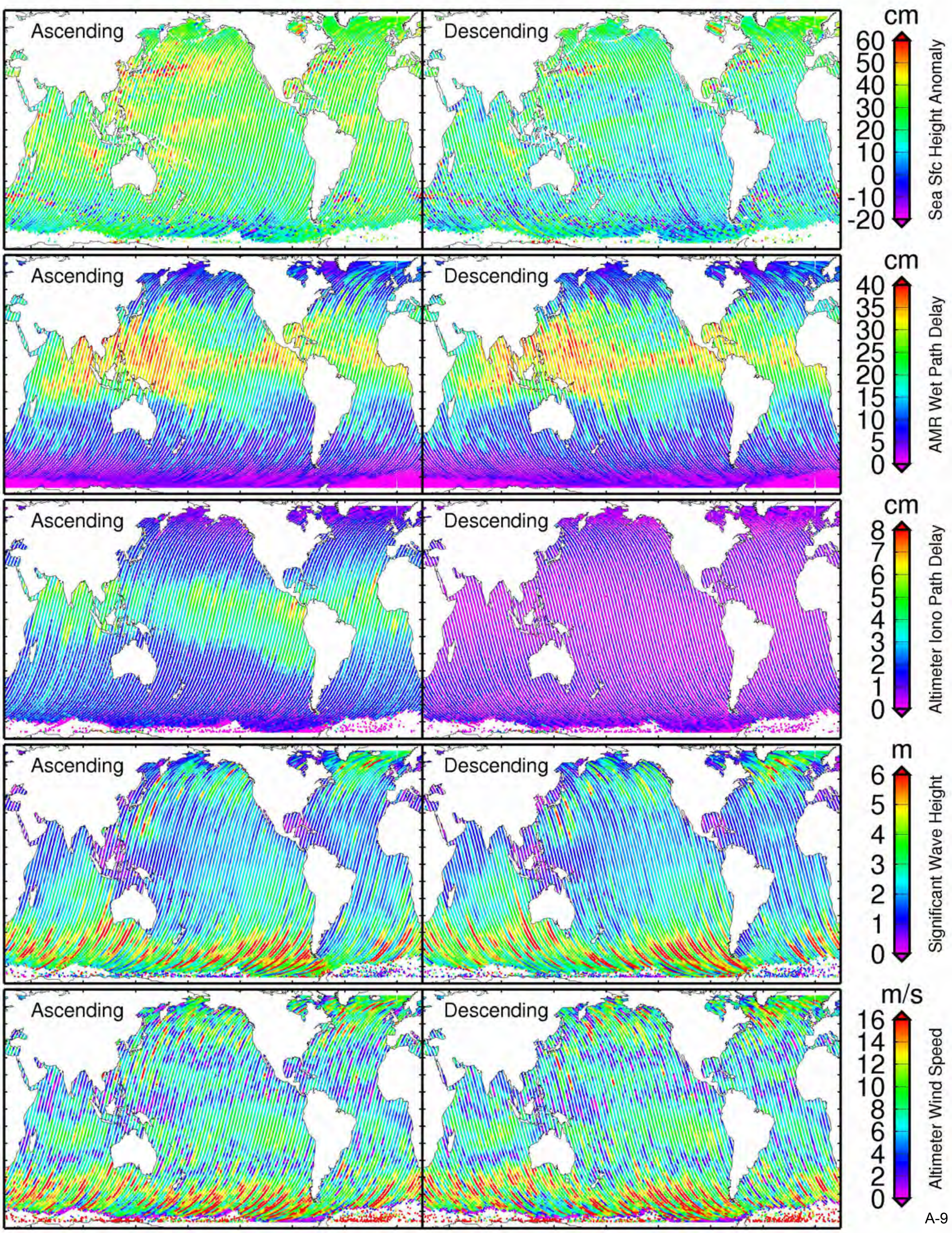
Jason-2 Cycle-042 2009-08-22 14:19:41 - 2009-09-01 12:18:13



Jason-2 Cycle-043 2009-09-01 12:18:13 - 2009-09-11 10:16:44



Jason-2 Cycle-044 2009-09-11 10:16:44 - 2009-09-21 08:15:16



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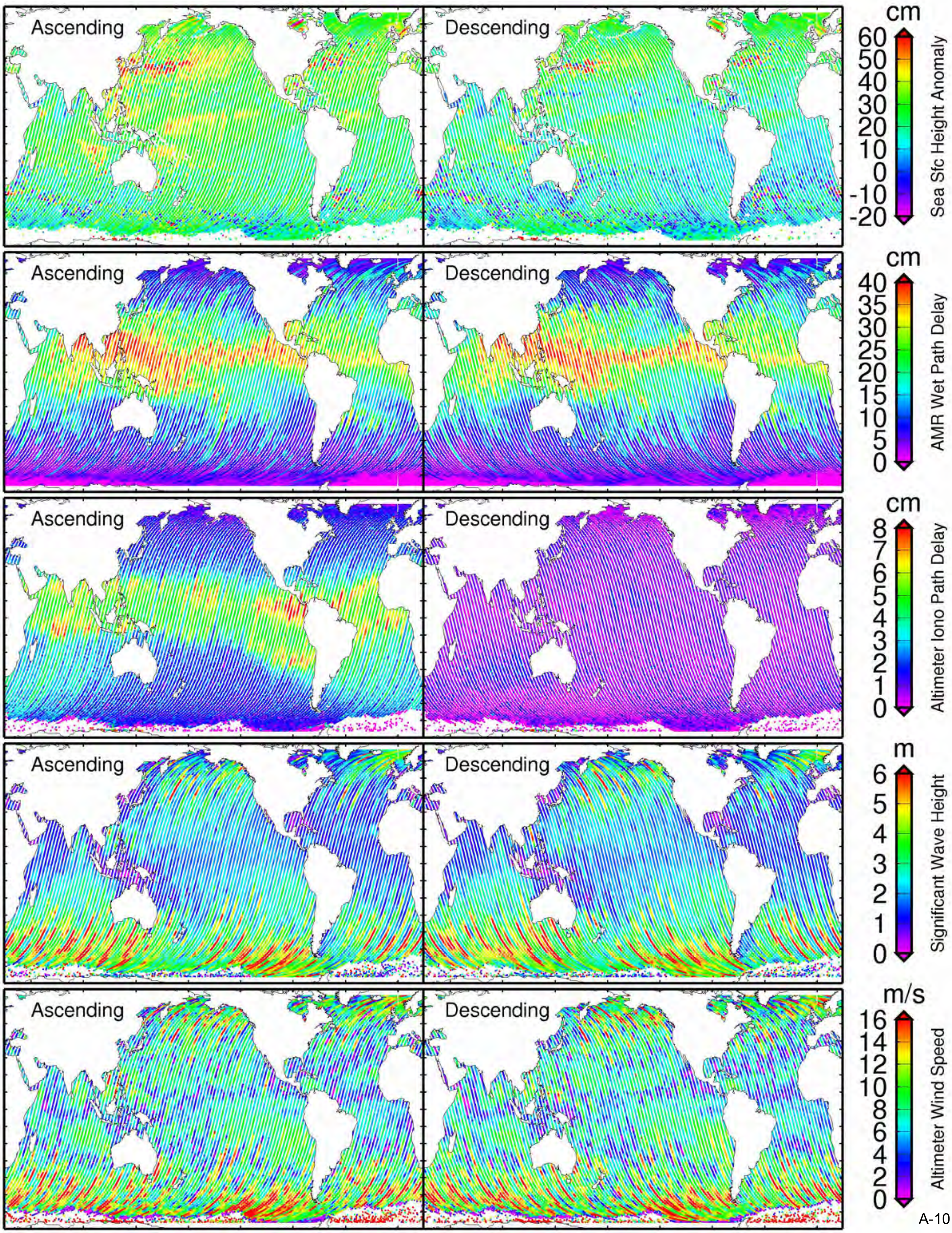
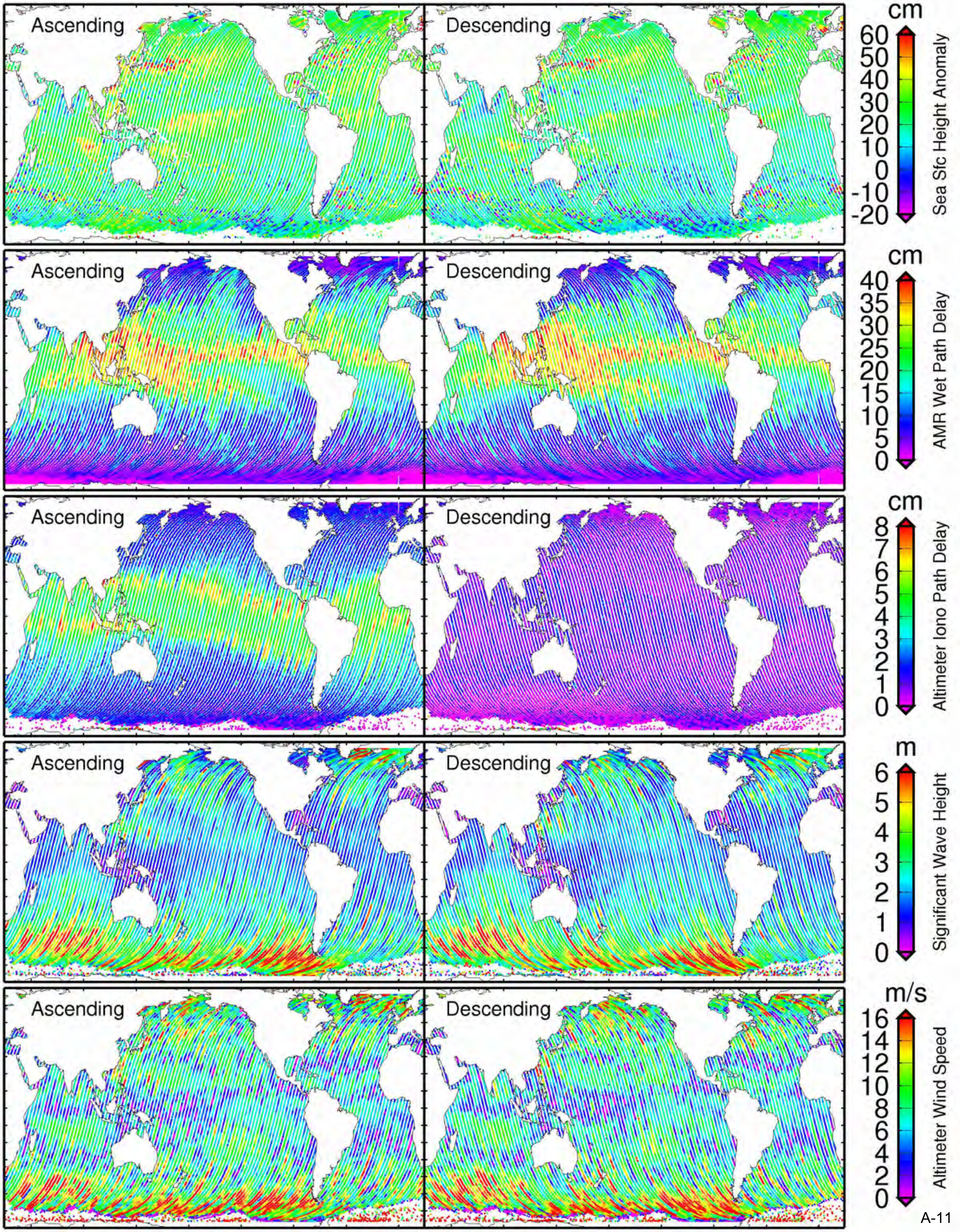
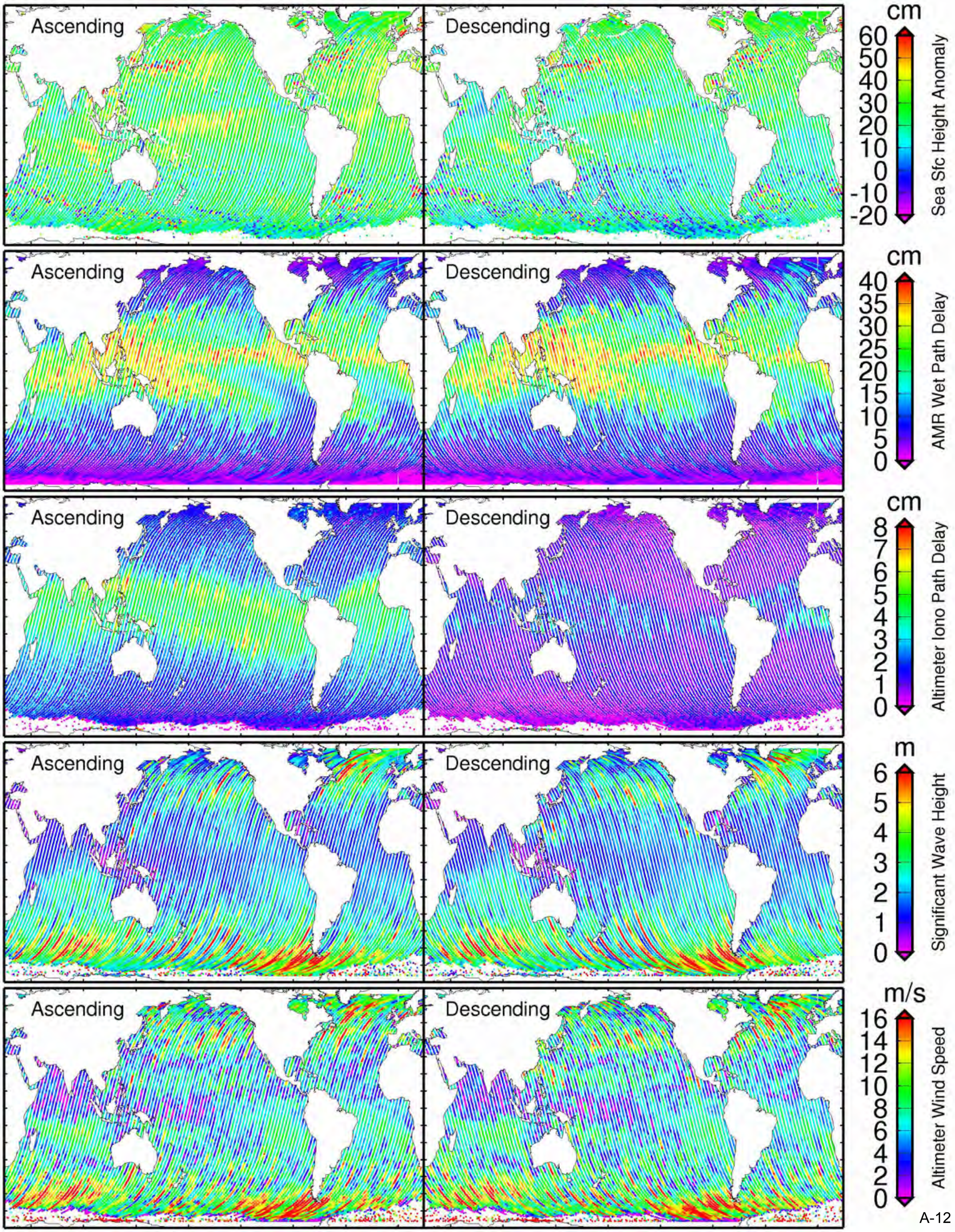


Jason-2 Cycle-046 2009-10-01 06:13:47 - 2009-10-11 04:12:19



Jason-2 Cycle-047 2009-10-11 04:12:19 - 2009-10-21 02:10:51



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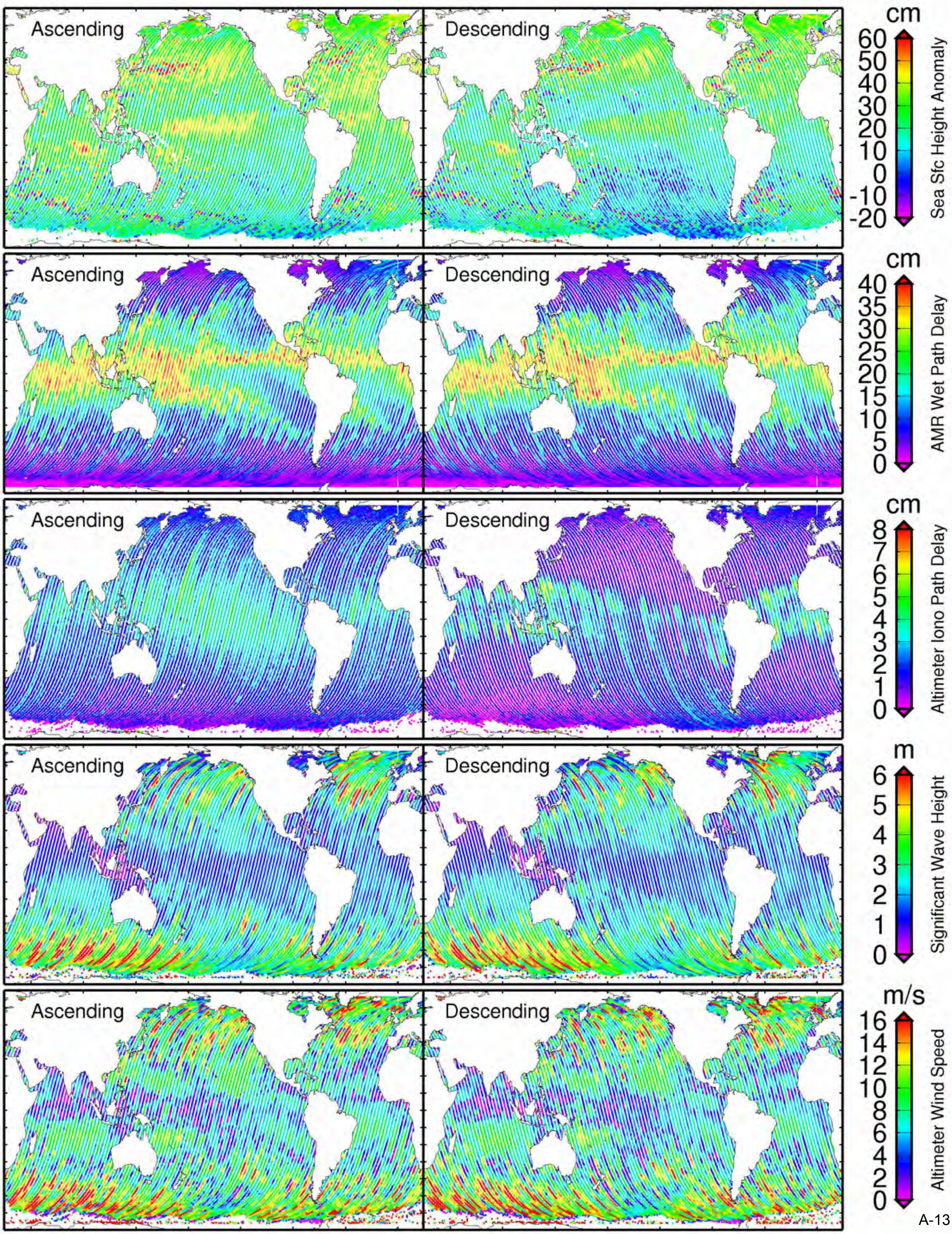

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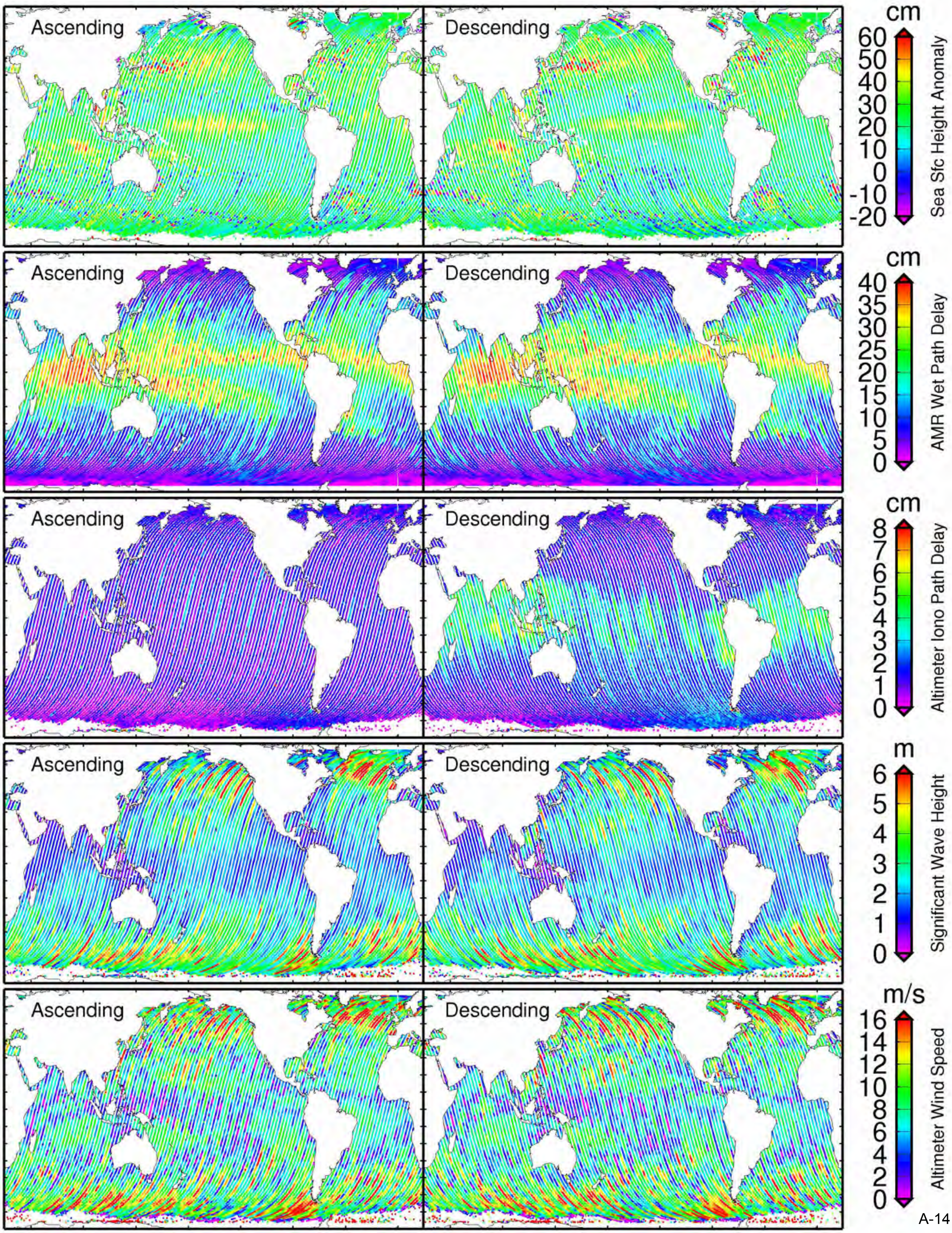

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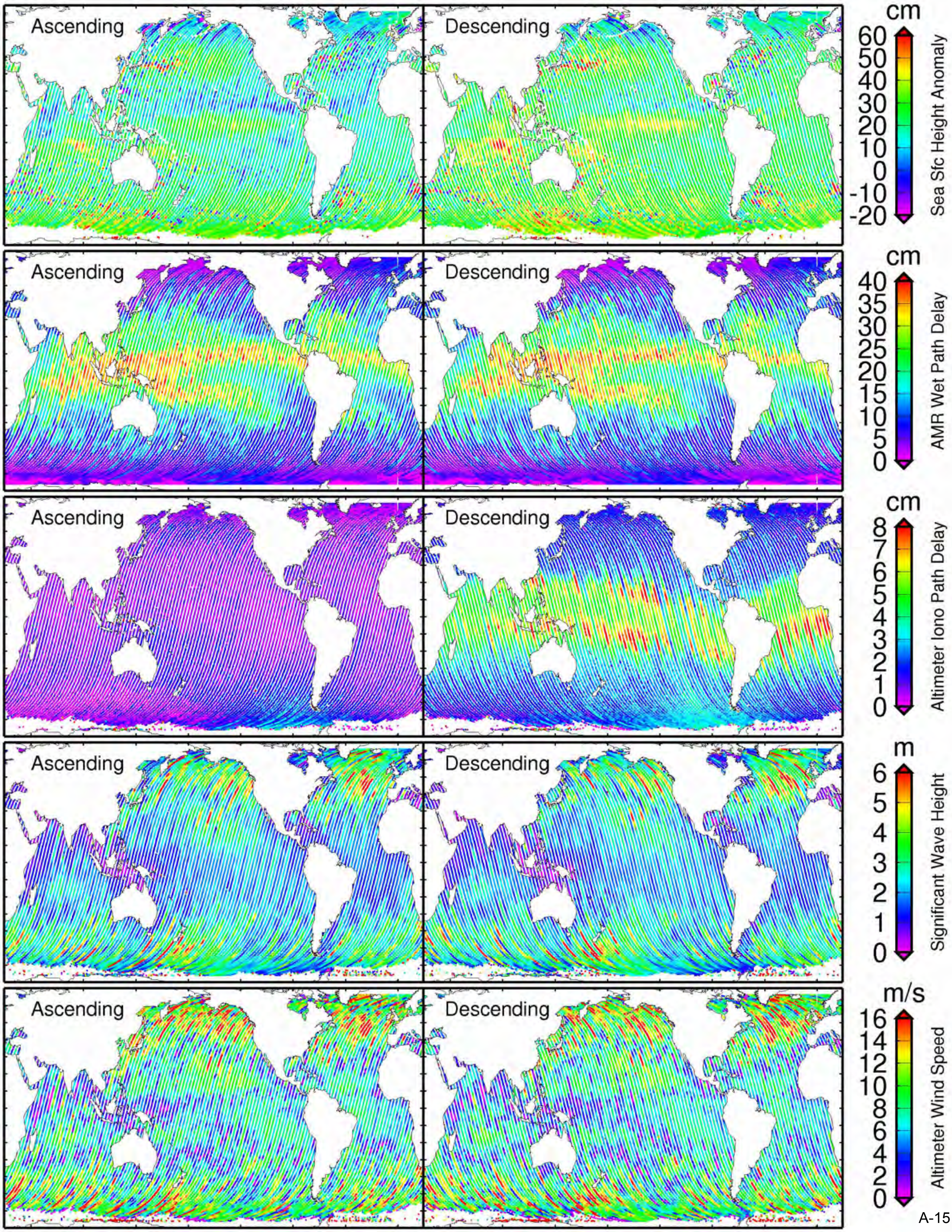
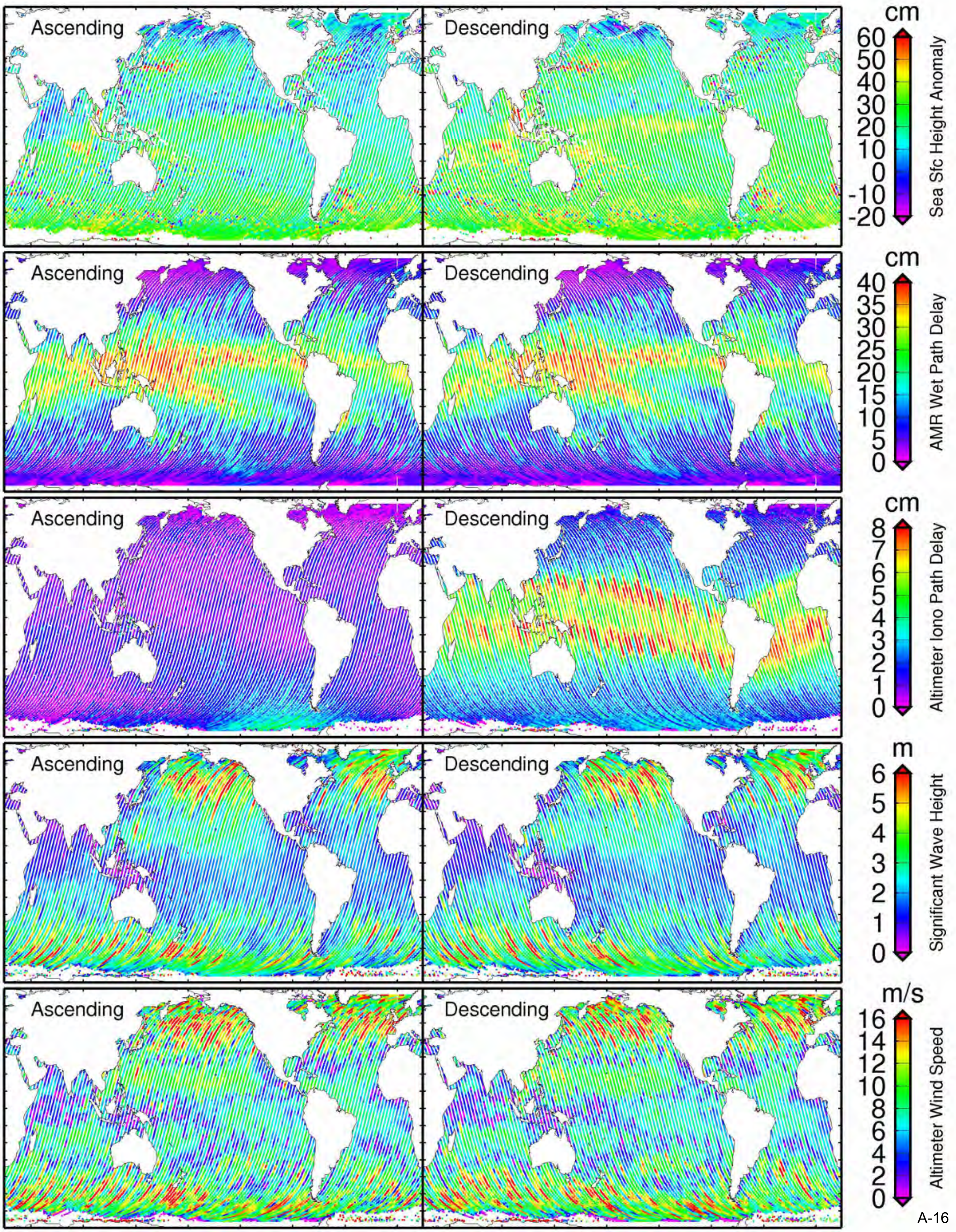
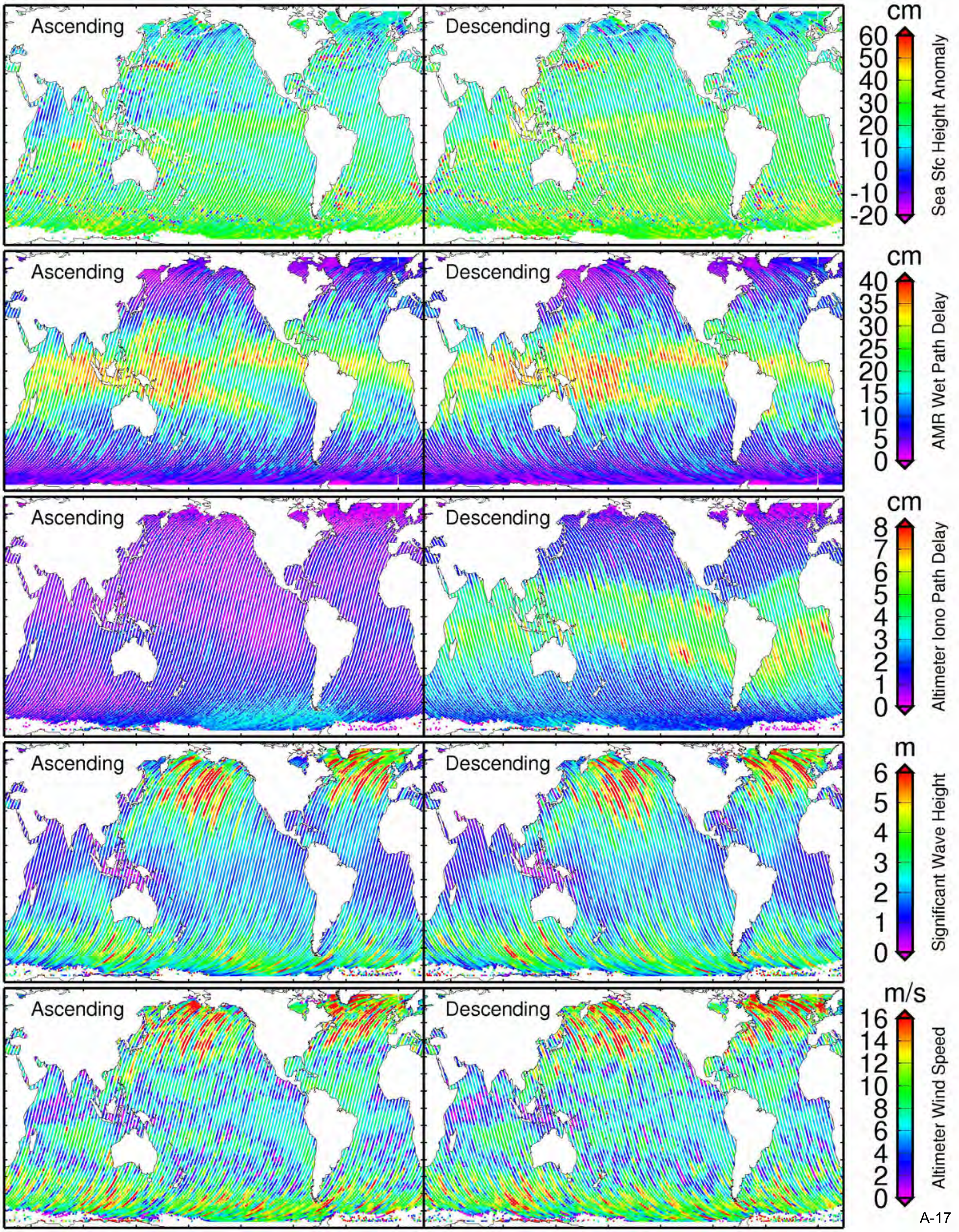
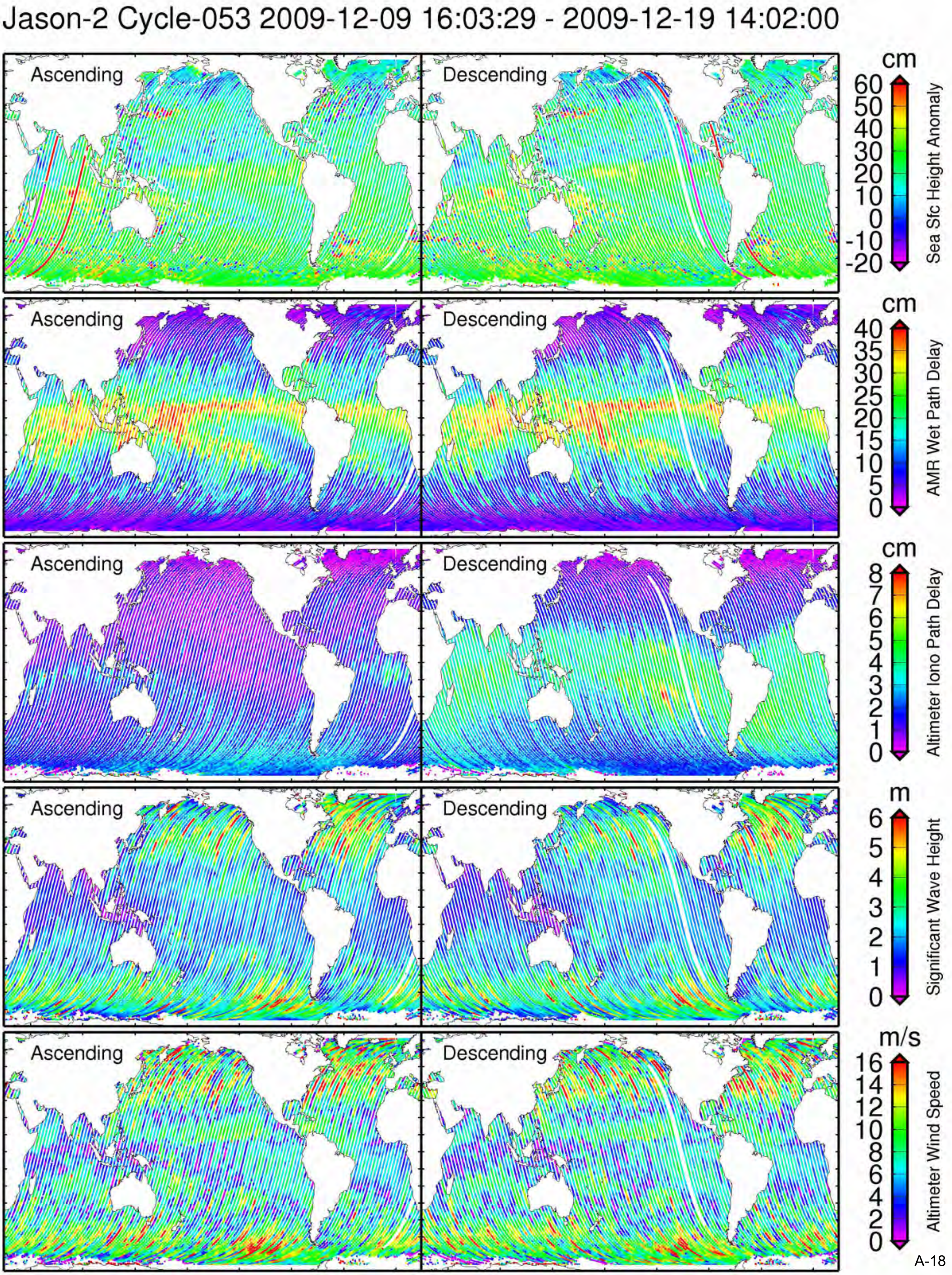


Jason-2 Cycle-051 2009-11-19 20:06:26 - 2009-11-29 18:04:57



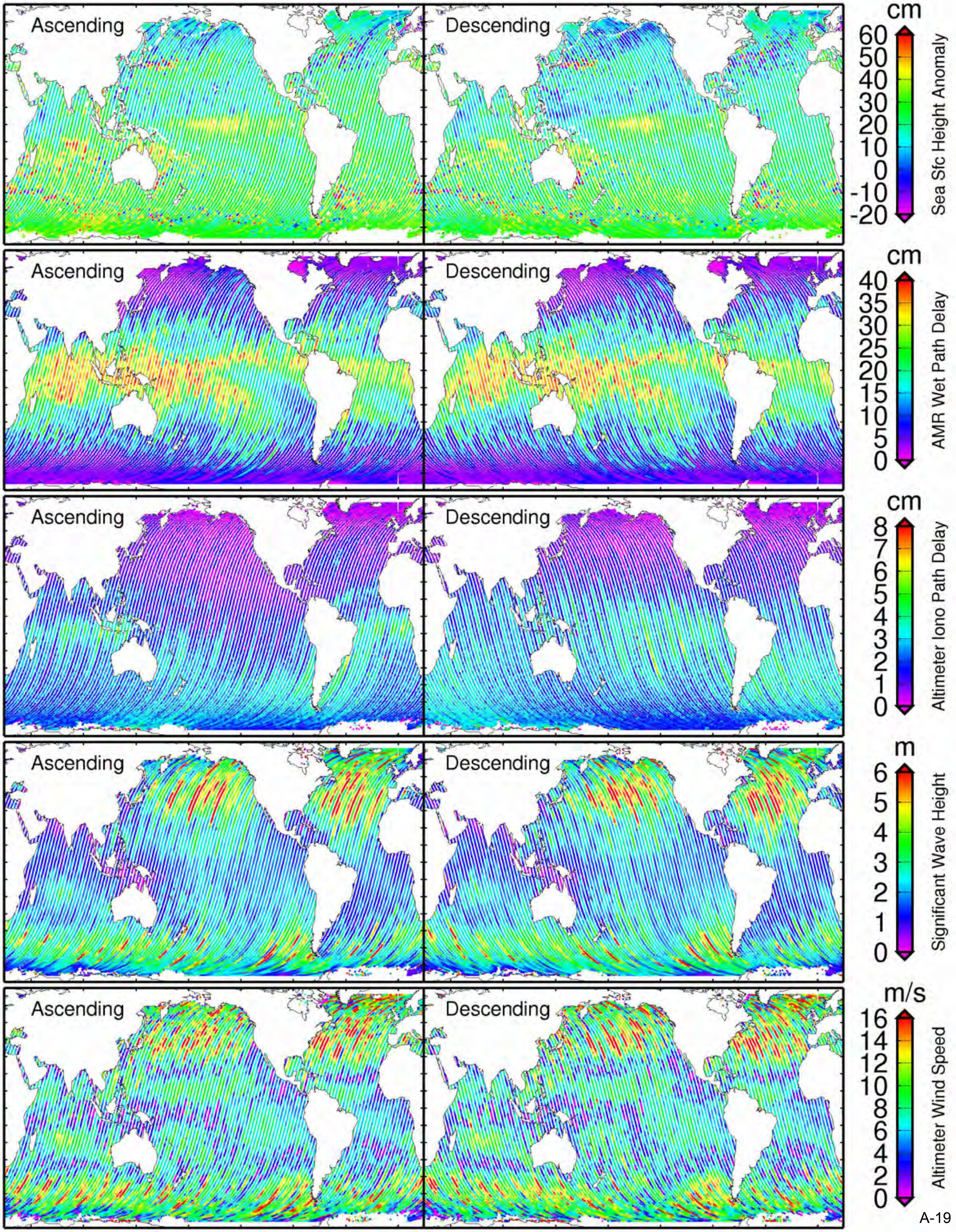
Jason-2 Cycle-052 2009-11-29 18:04:57 - 2009-12-09 16:03:29





Jason-2 Cycle-053 2009-12-09 16:03:29 - 2009-12-19 14:02:00
Ascending
Descending
cm
60 50 40 30 20 10 0 -10 -20
Sea Sfc Height Anomaly
cm
40 35 30 25 20 15 10 5 0
AMR Wet Path Delay
cm
8 7 6 5 4 3 2 1 0
Altimeter Iono Path Delay
m
6 5 4 3 2 1 0
Significant Wave Height
m/s
16 14 12 10 8 6 4 2 0
Altimeter Wind Speed

Jason-2 Cycle-054 2009-12-19 14:02:00 - 2009-12-29 12:00:32



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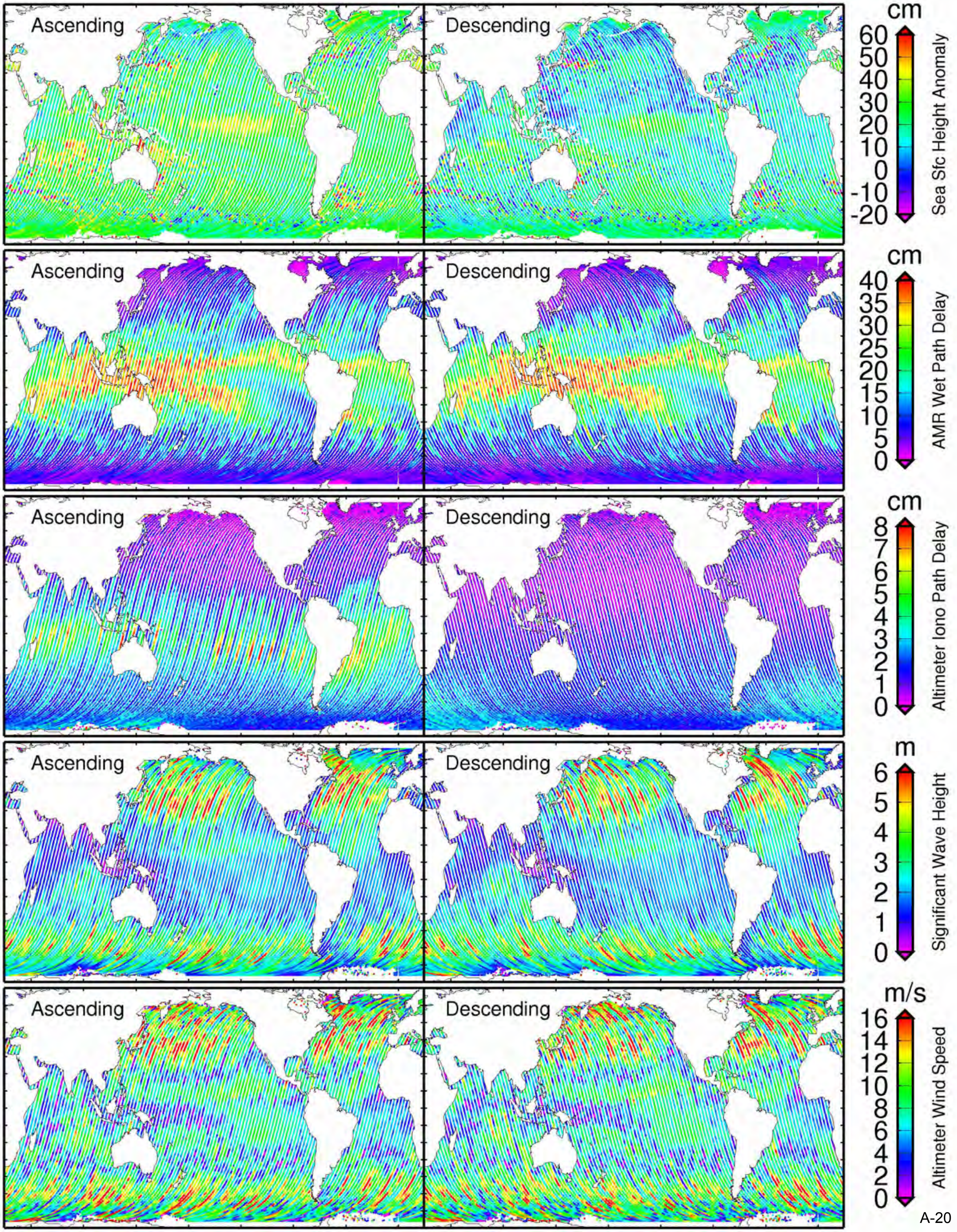

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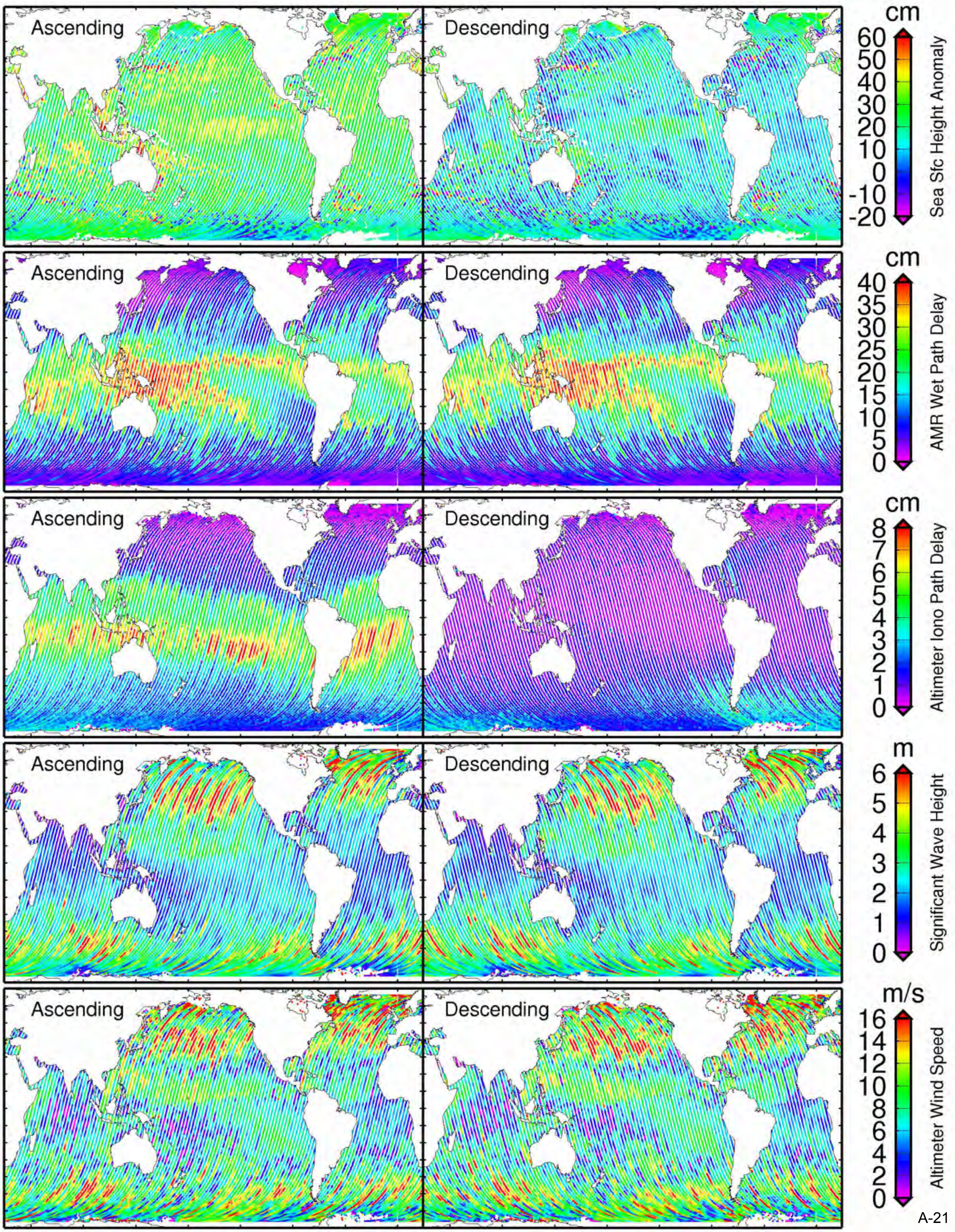

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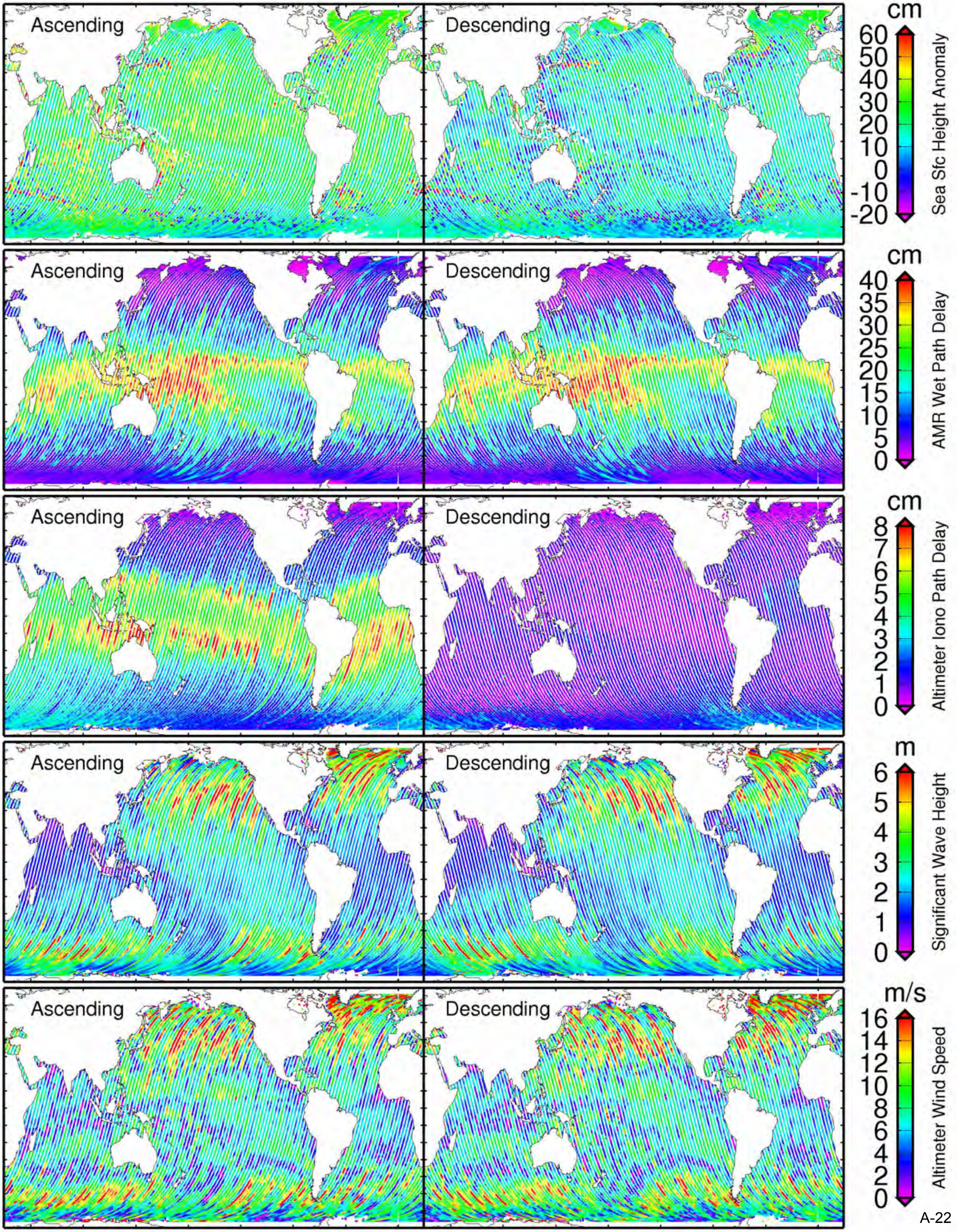

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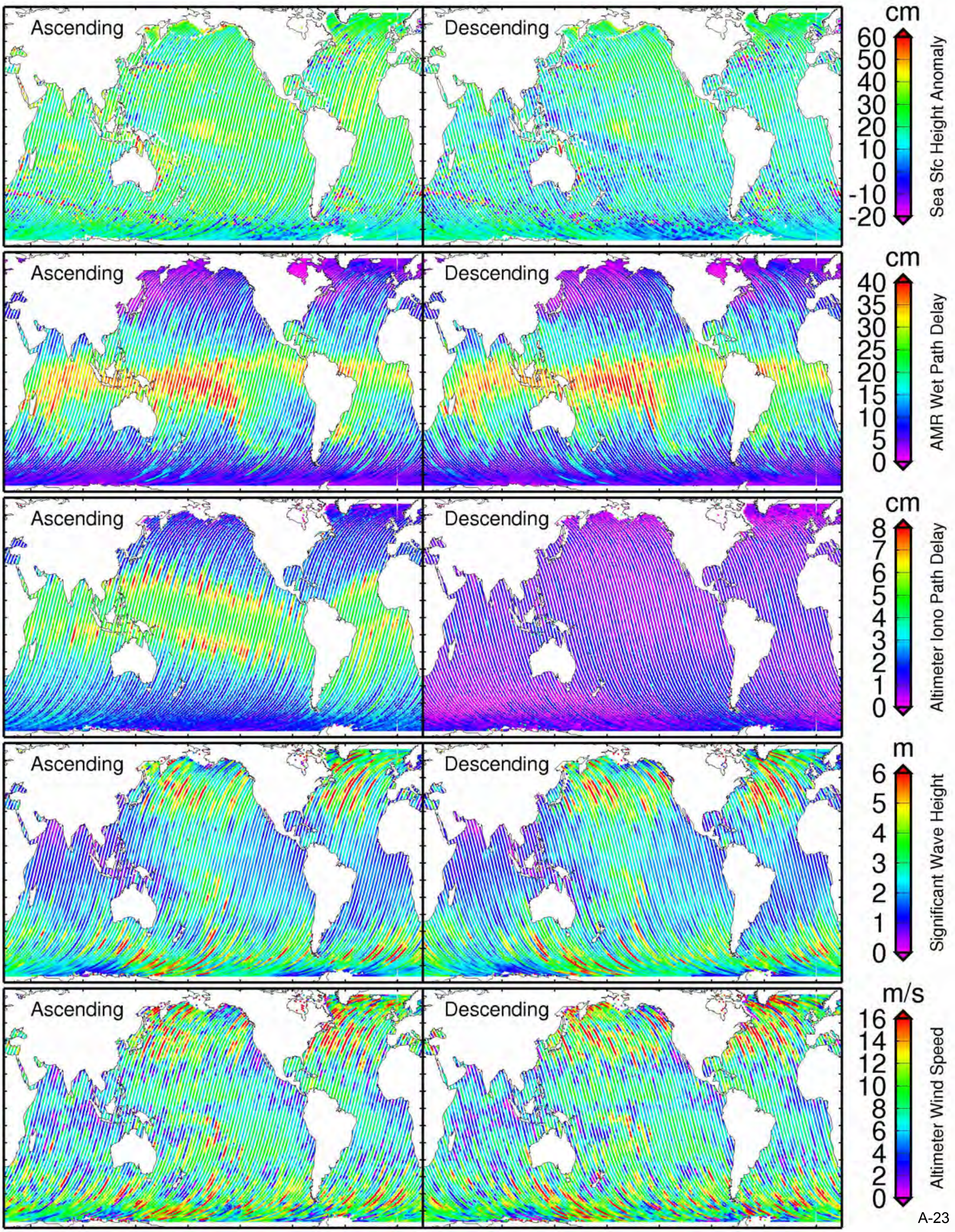

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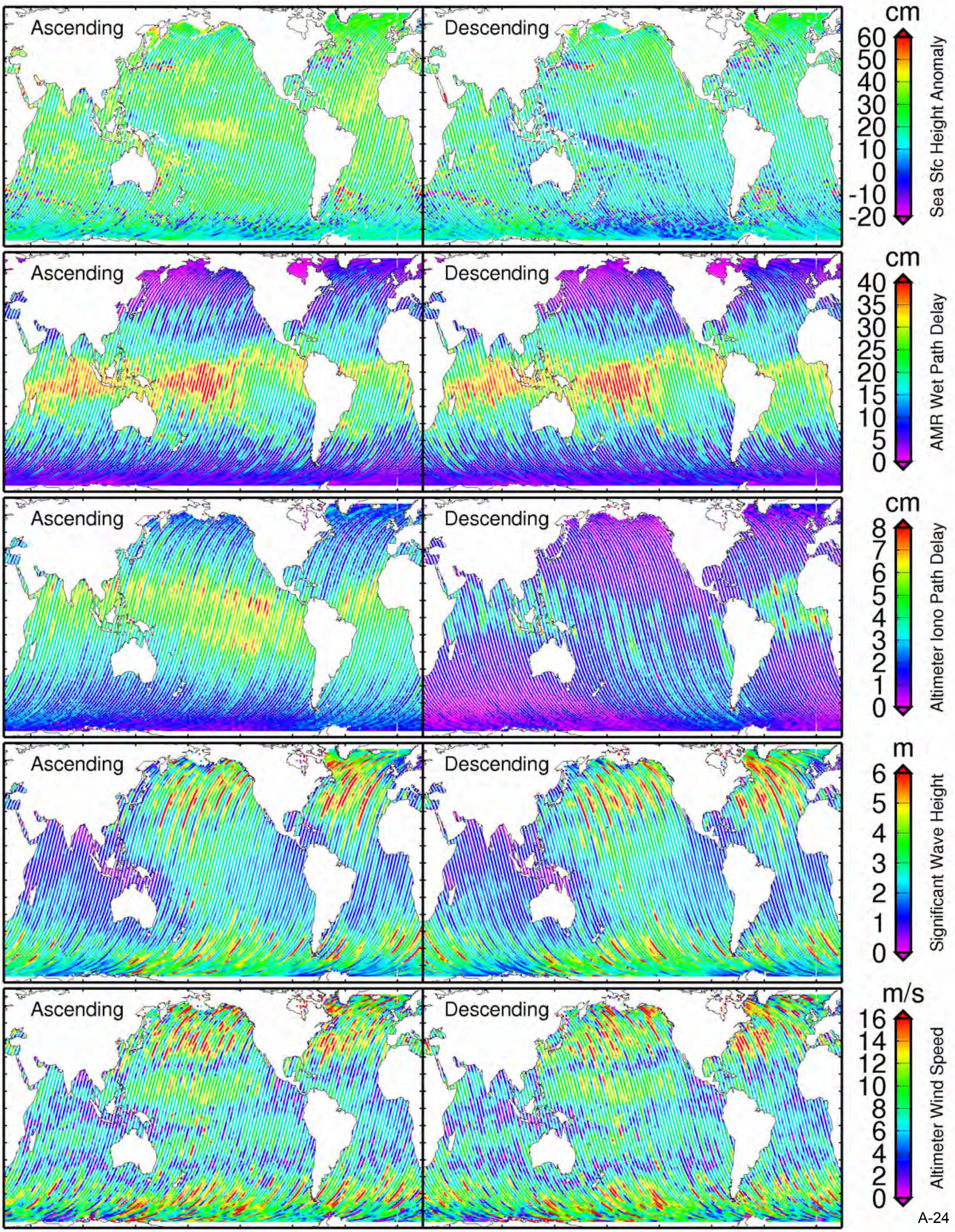

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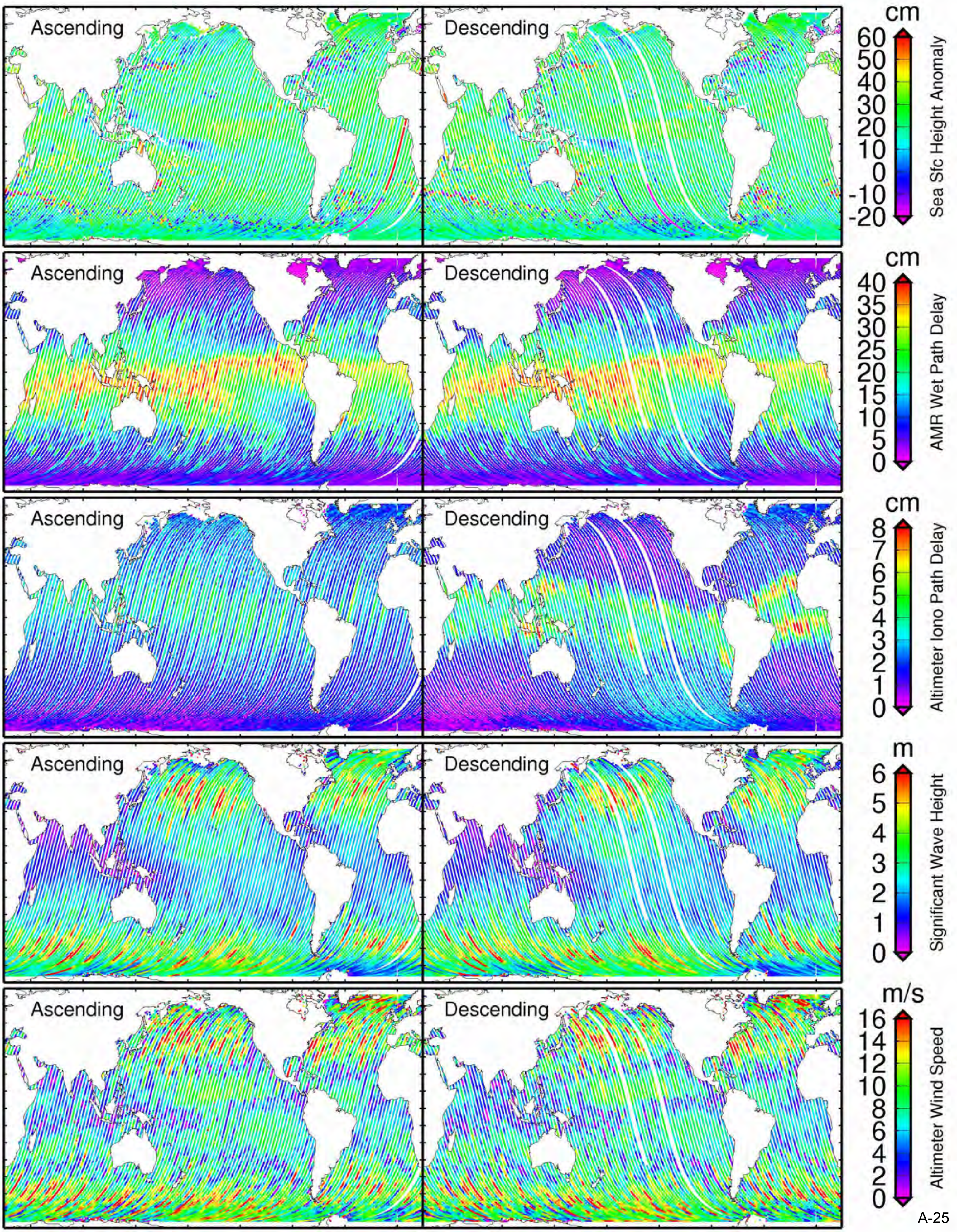

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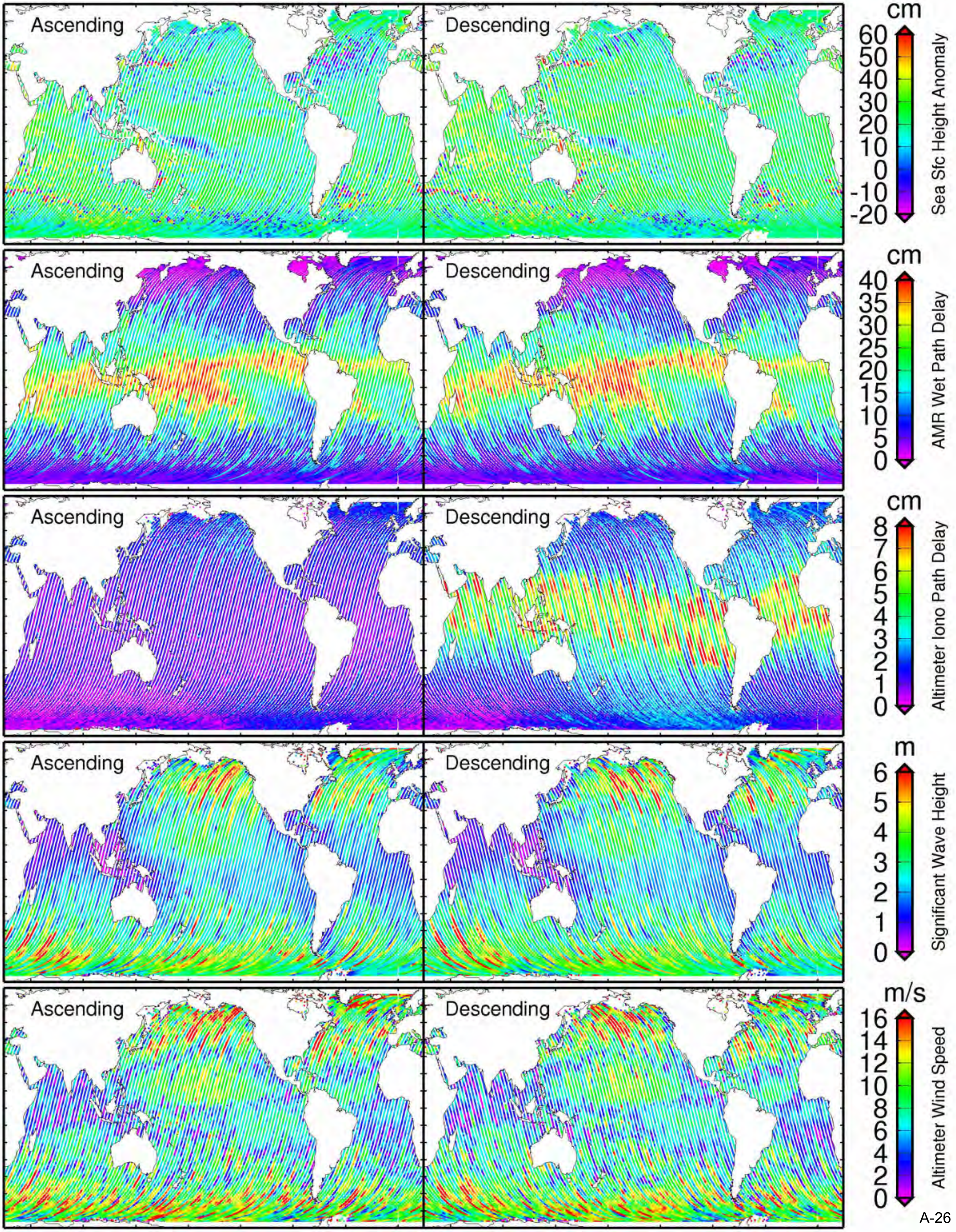

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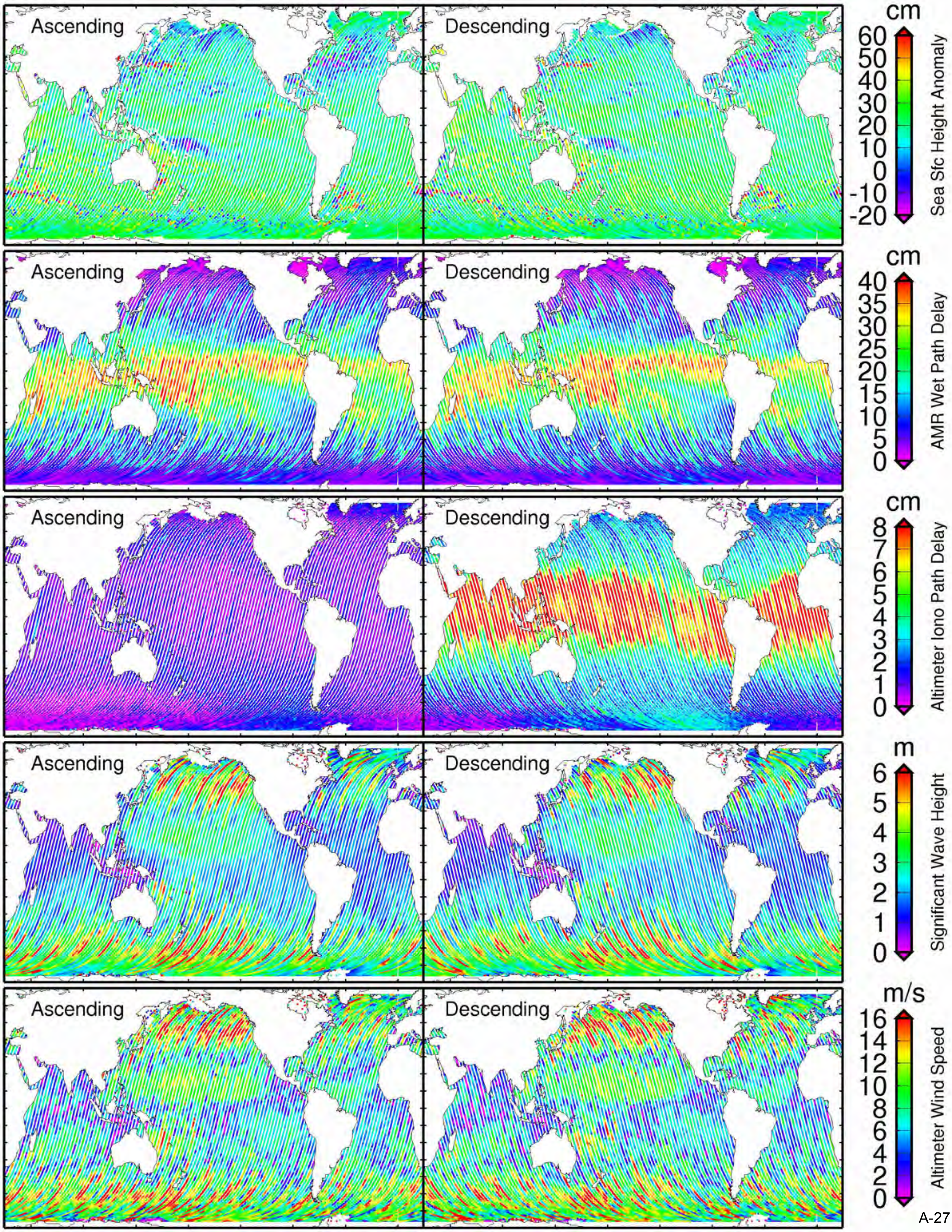

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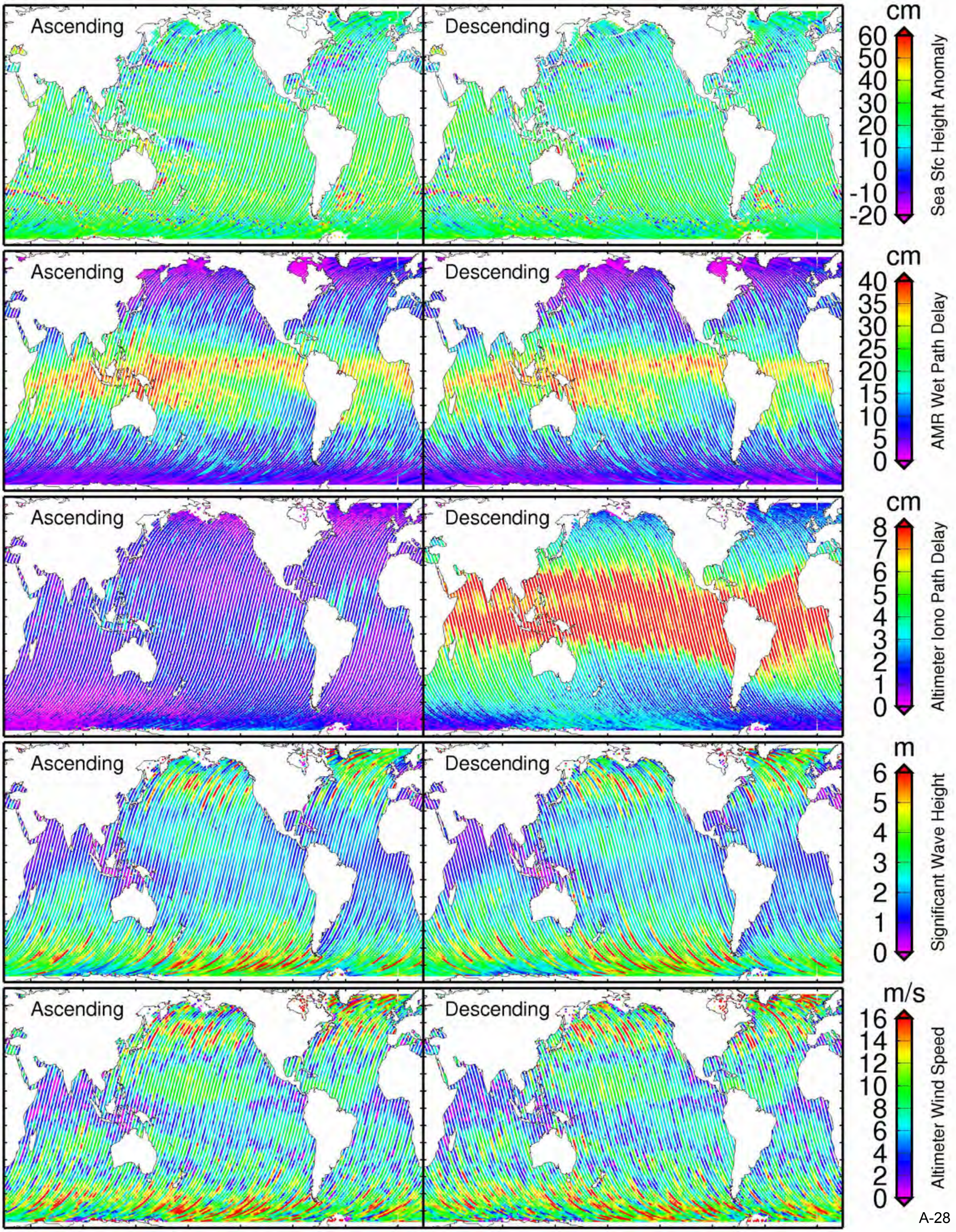

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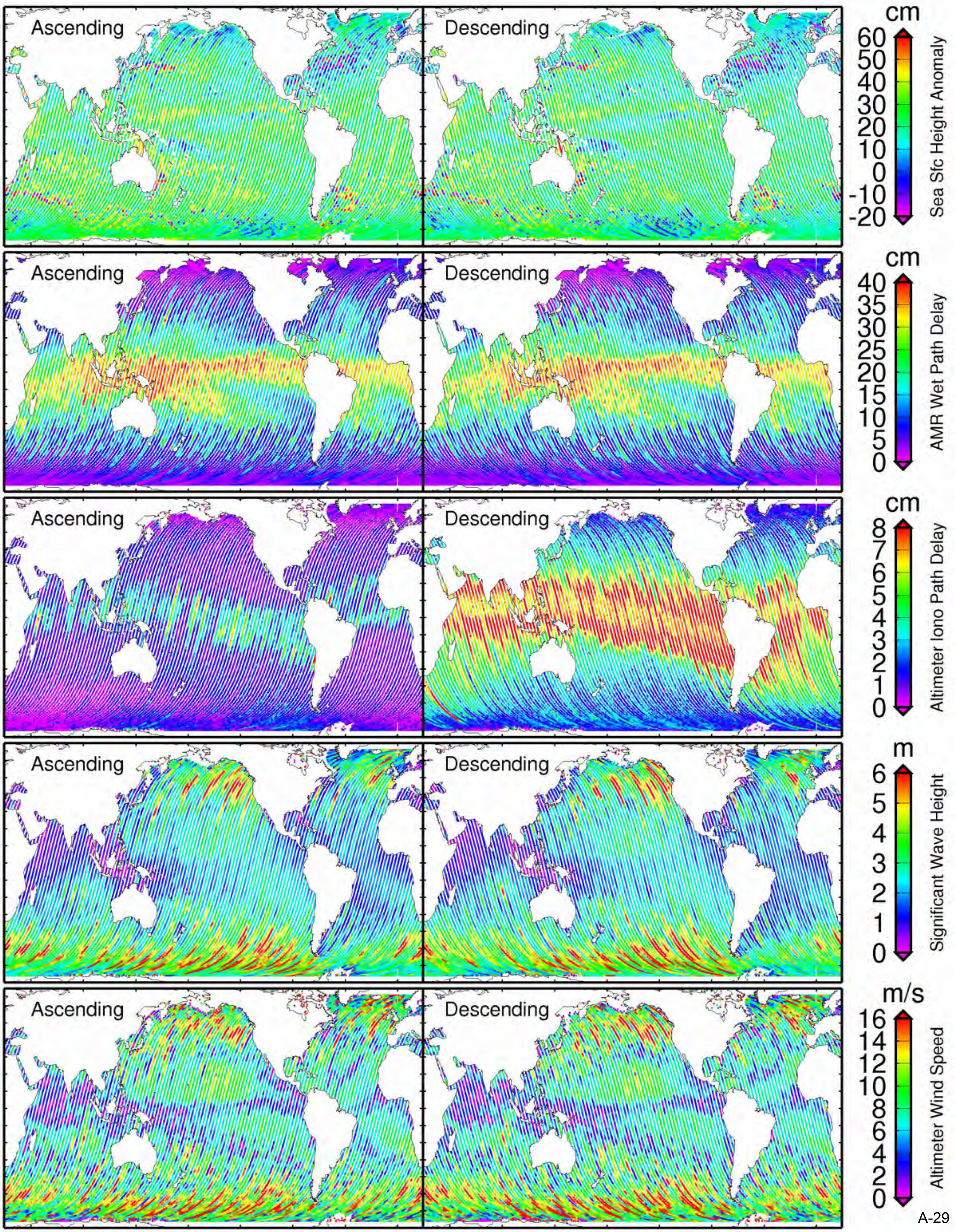

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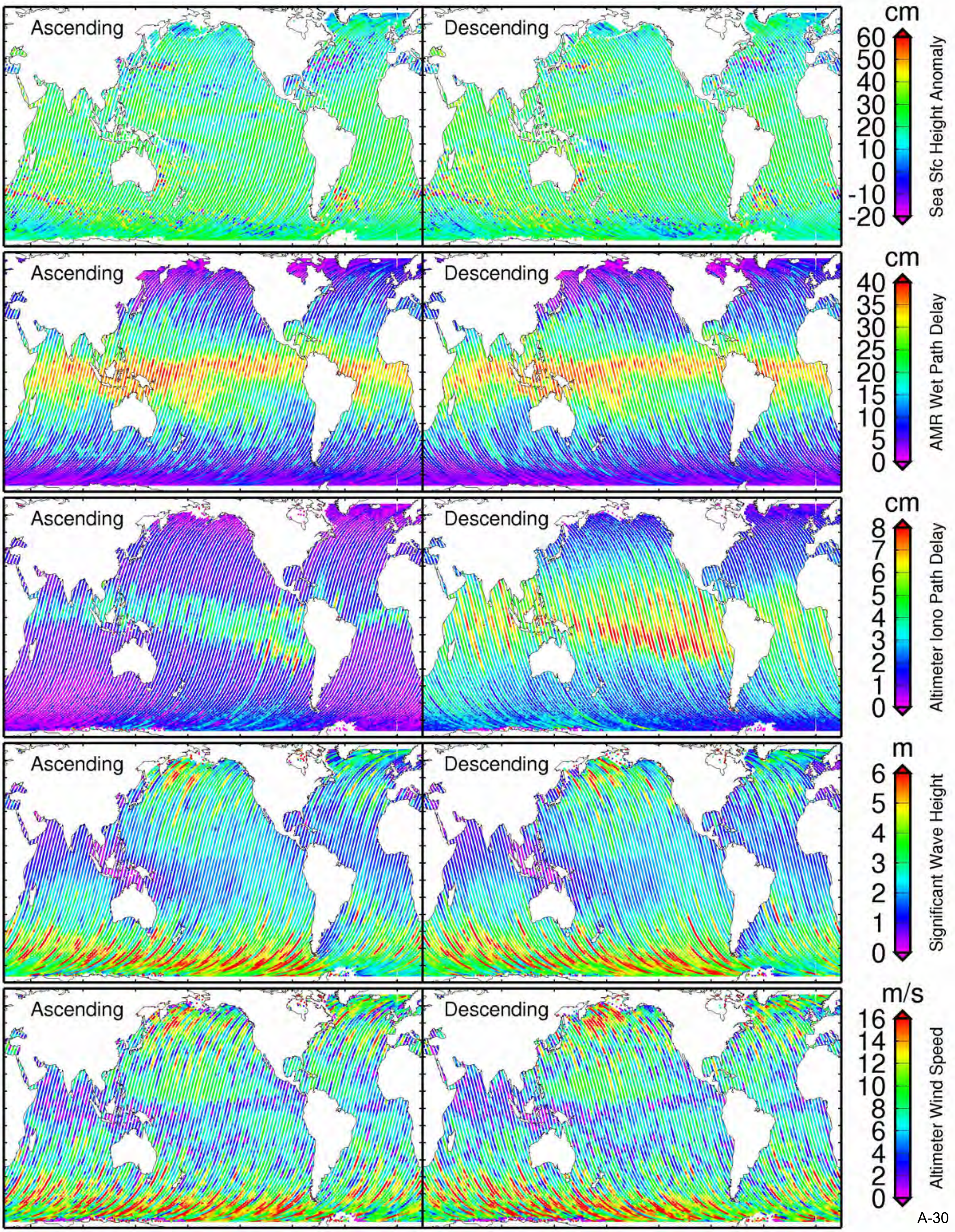

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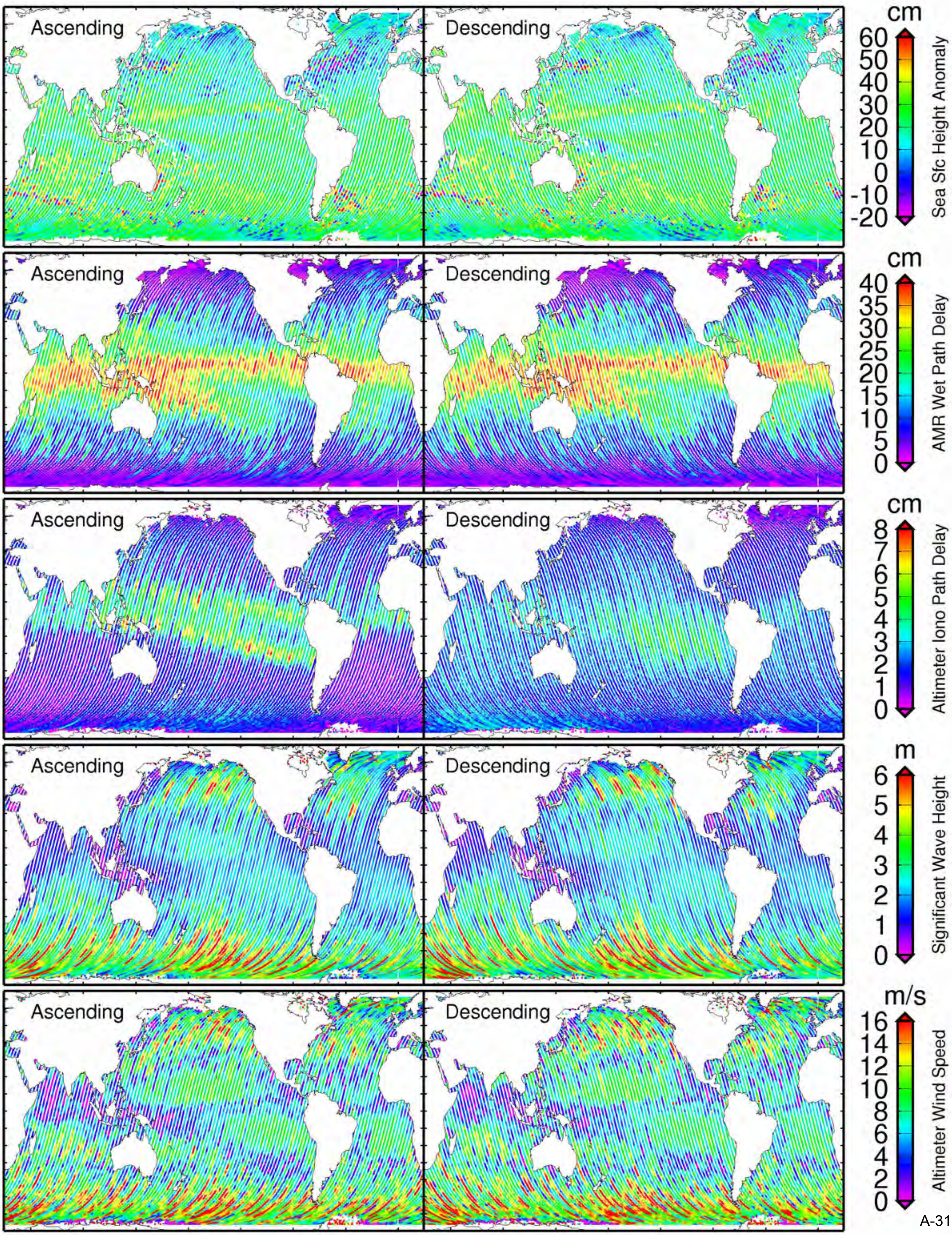

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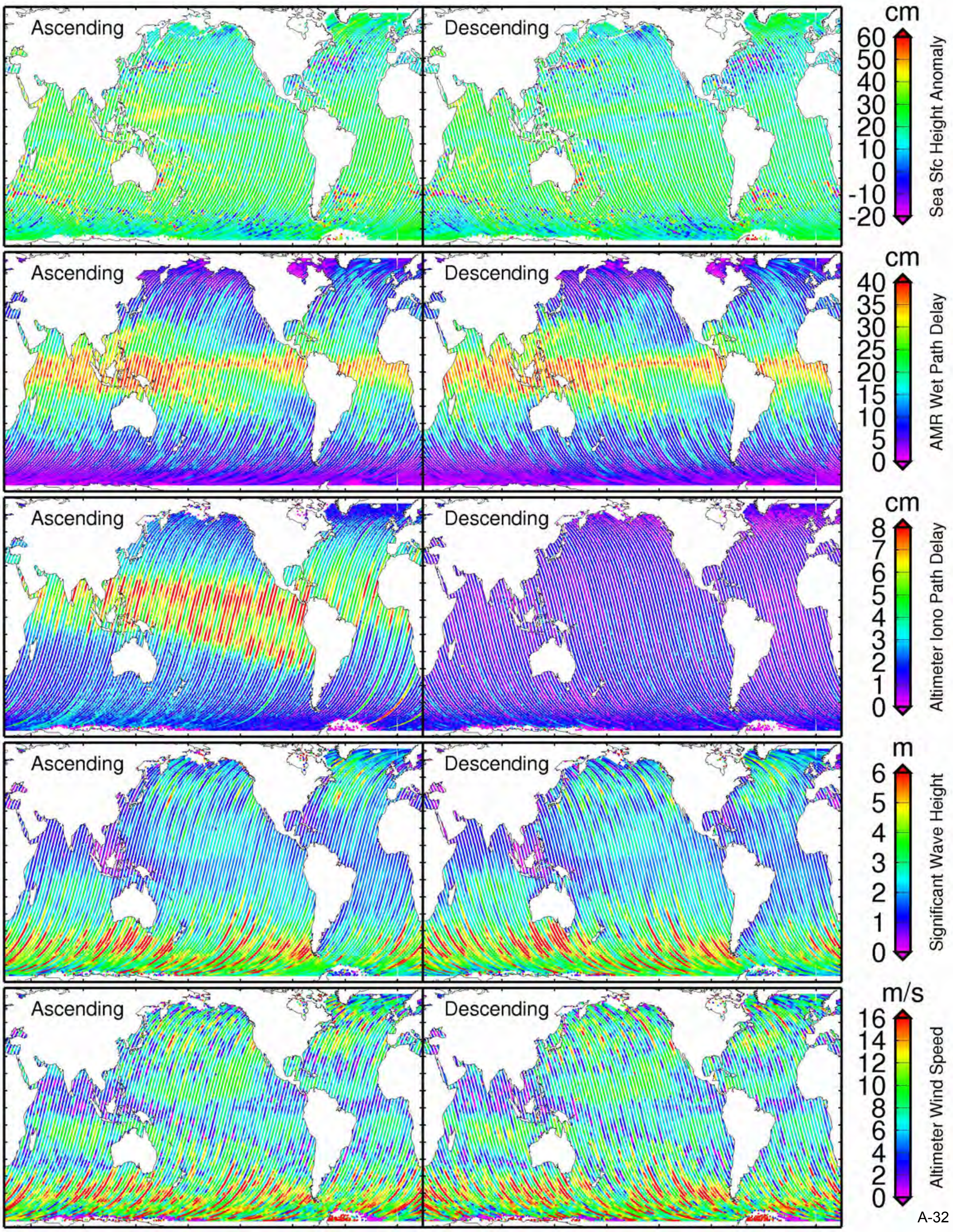

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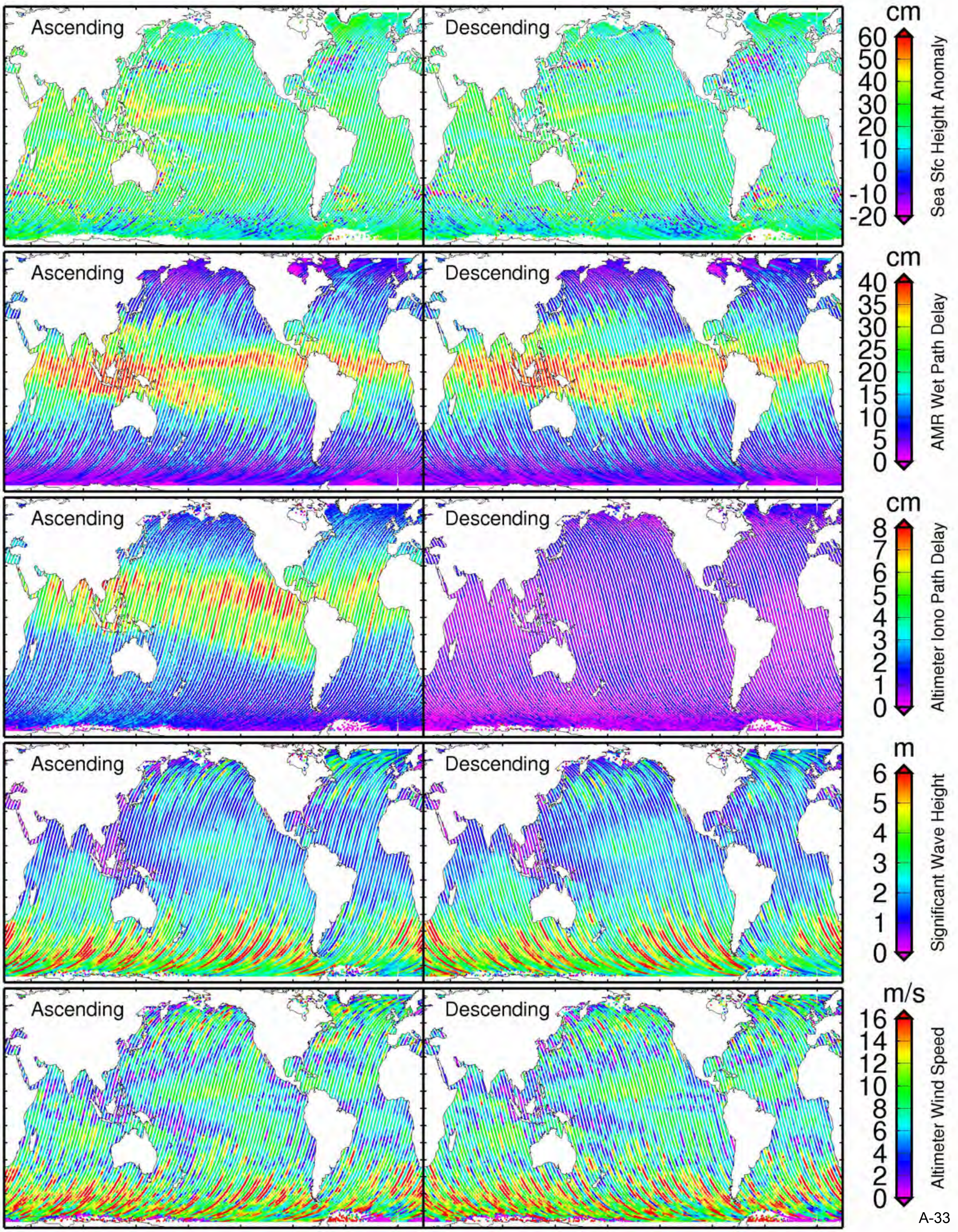

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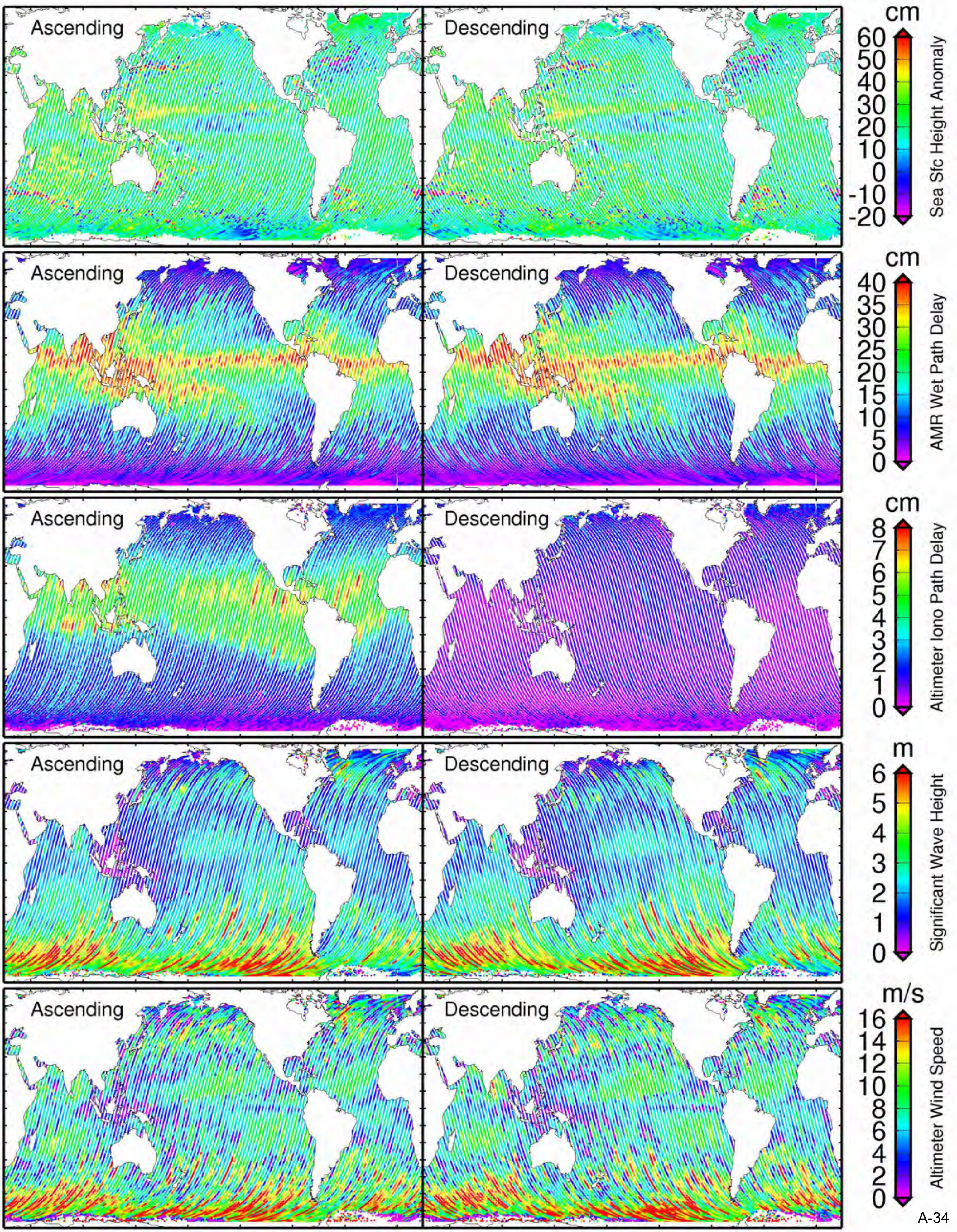

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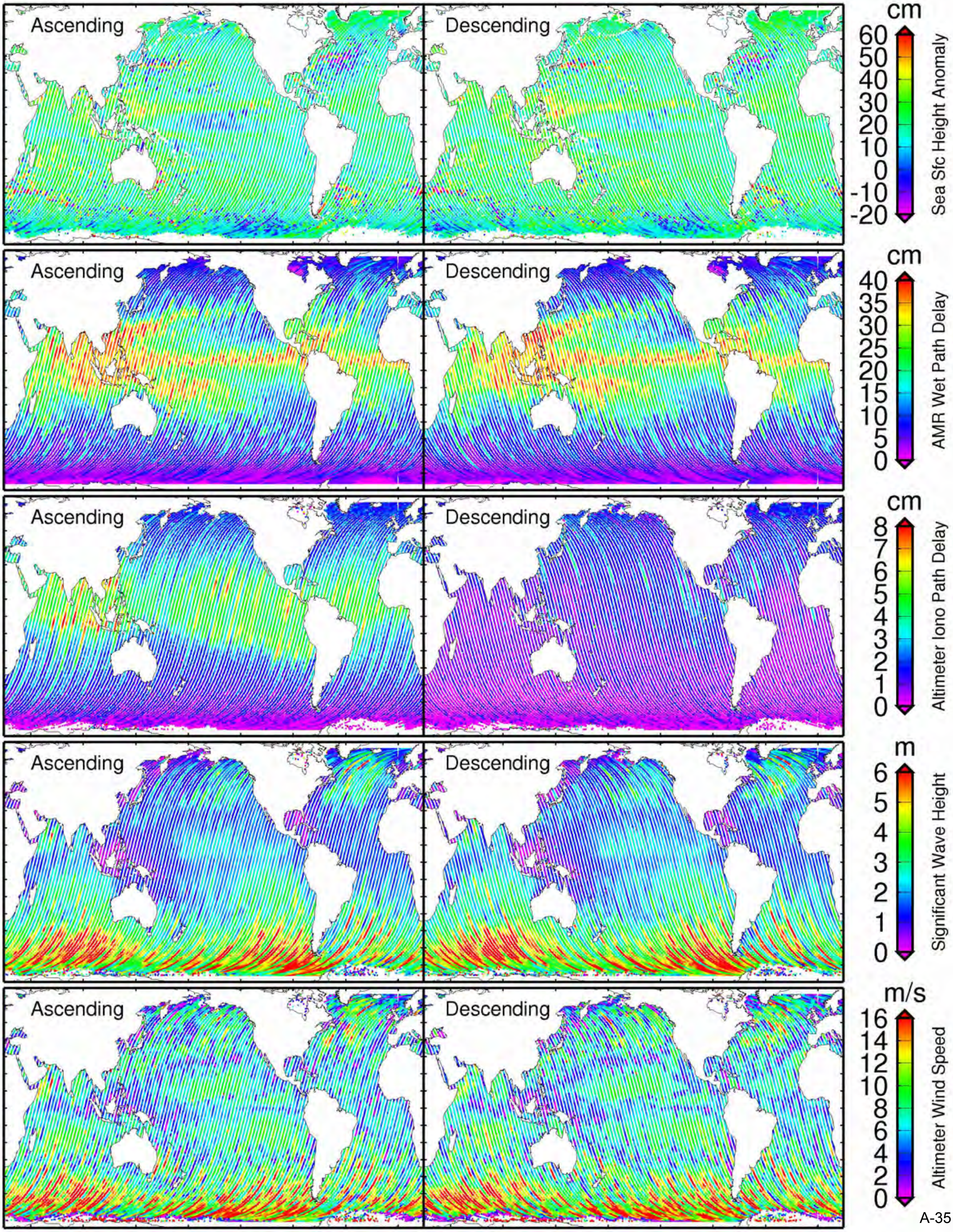

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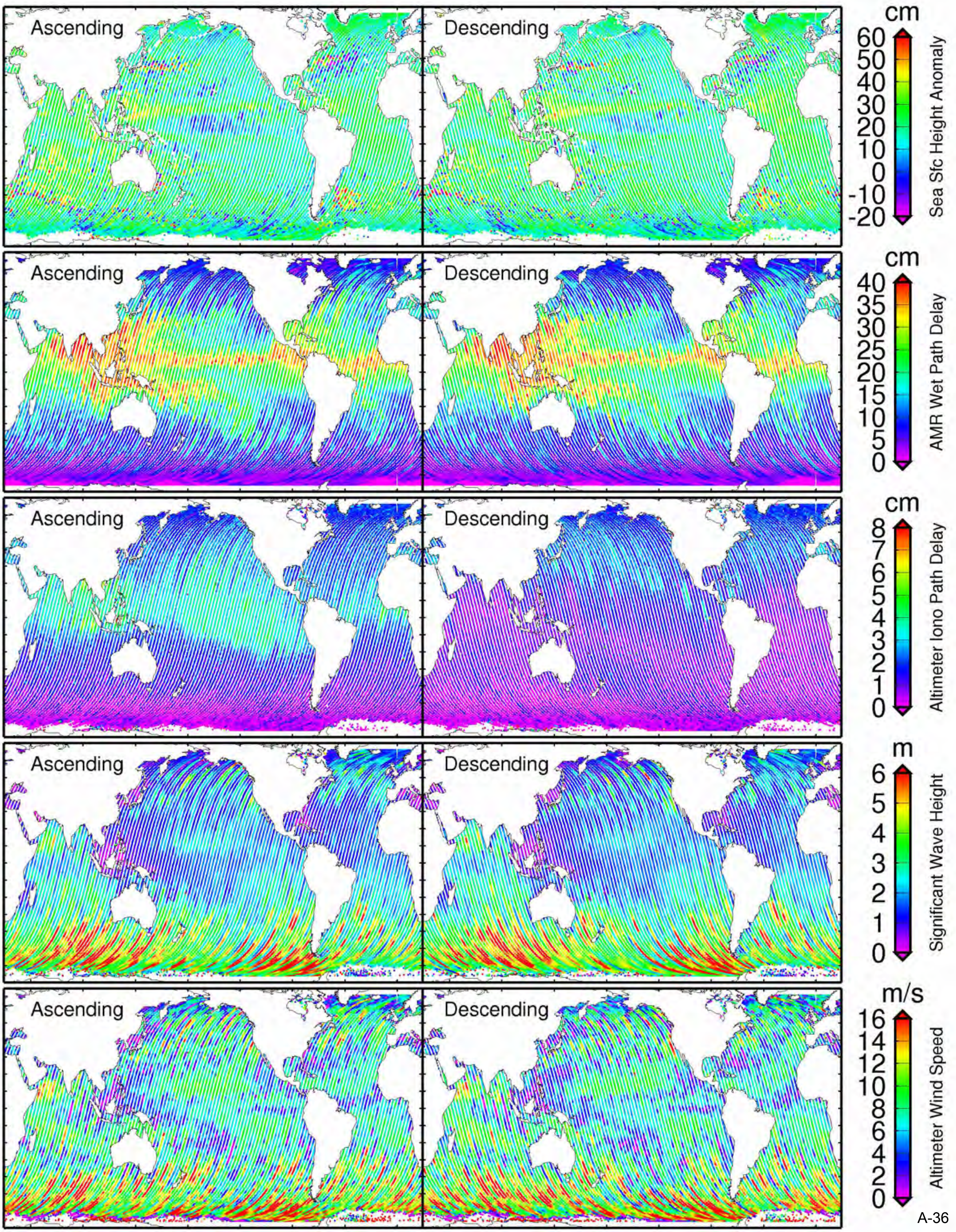

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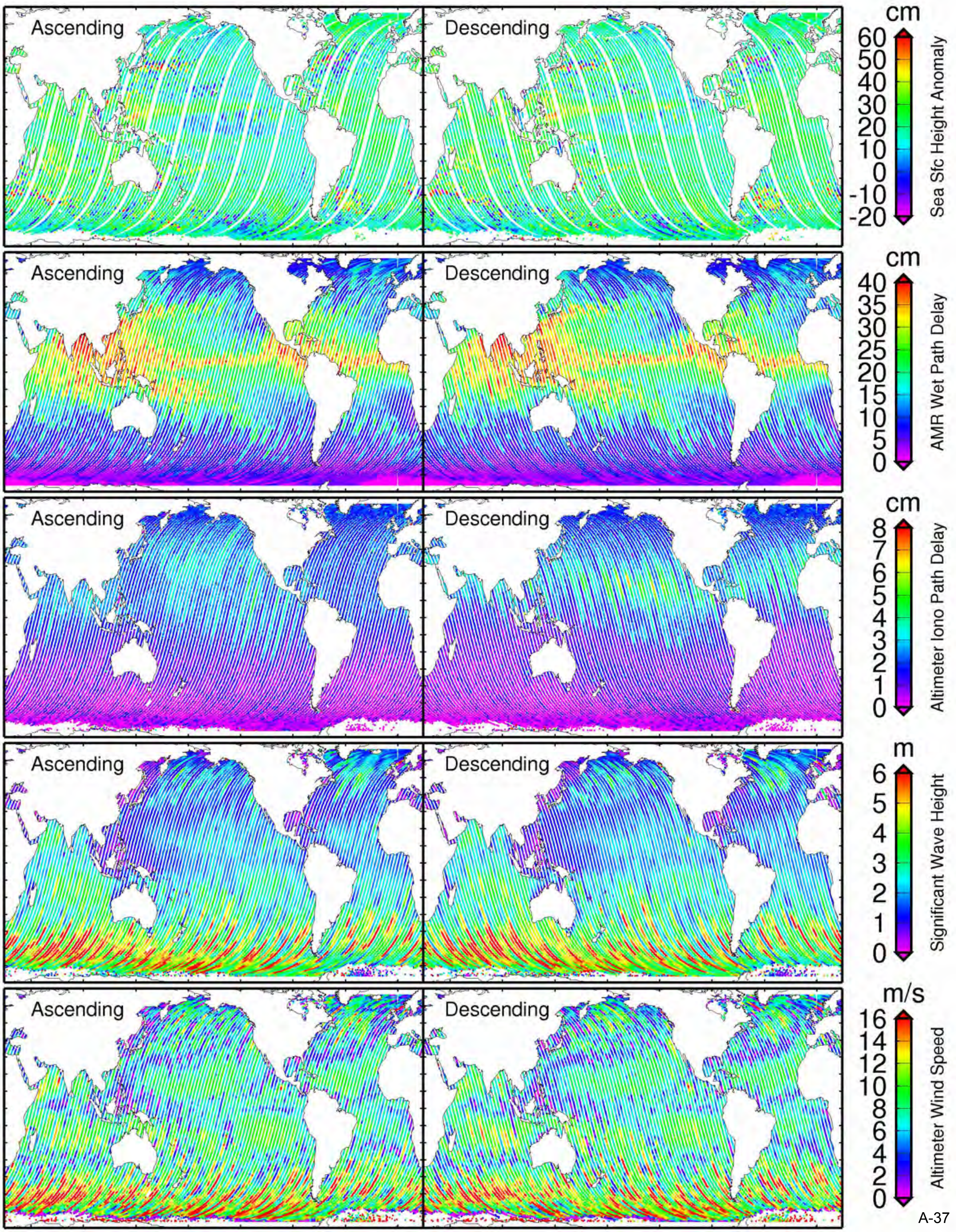

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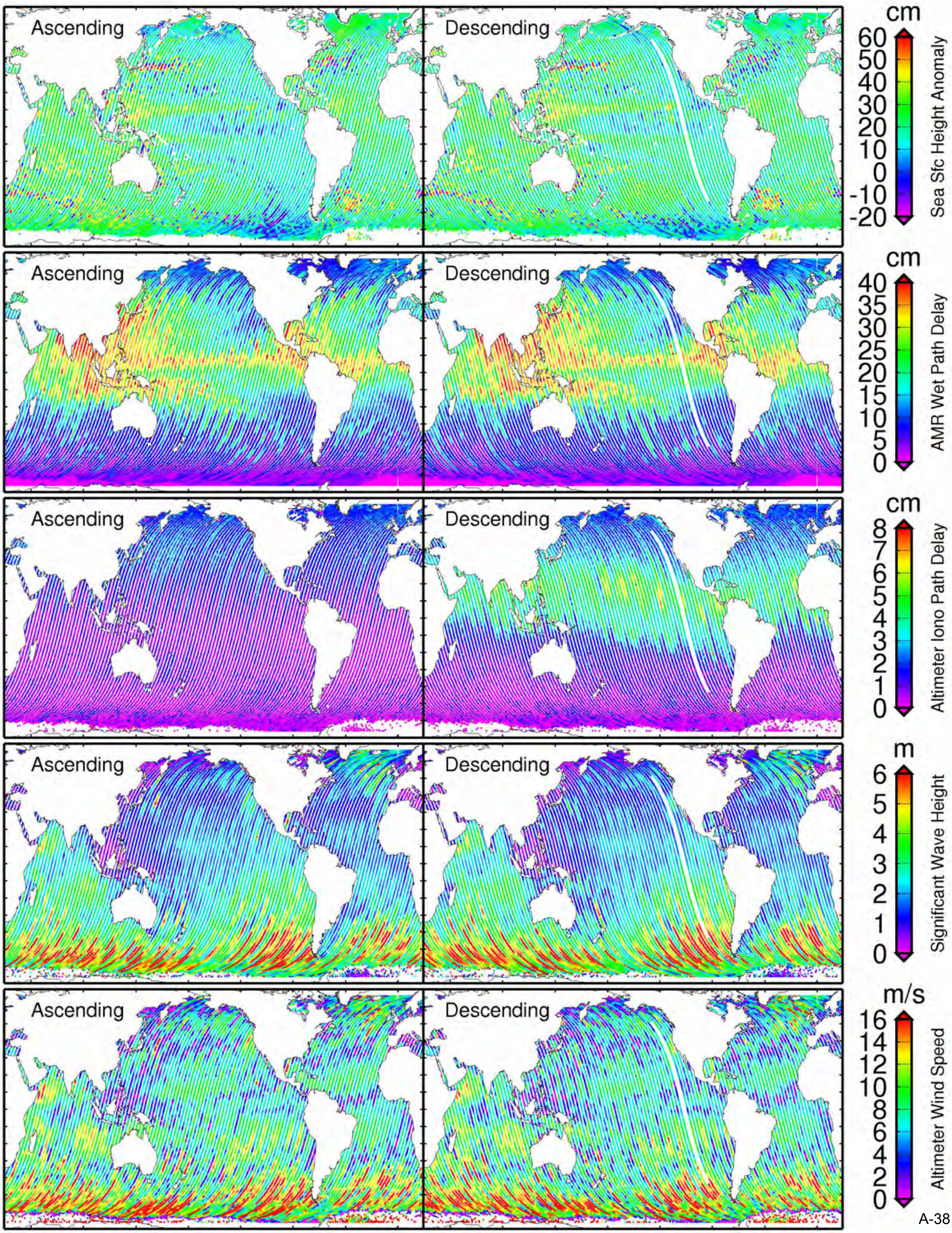

Appendix B. Acronyms

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 Forecasts
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
NOAA	National Oceanic and Atmospheric Administration
NRTAVS	Near Real-Time Altimeter Validation System
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