Near-Real-Time Wave, Wind, and Sea Surface Height from CryoSat FDM/L1B data

W. H. F. Smith[1], J. L. Lillibridge[1], R. Scharroo[1,2], and E. W. Leuliette[1]

[1]NOAA Laboratory for Satellite Altimetry

[2]Altimetrics LLC

Acknowledgements to

S. Labroue & J. Dorandeu

Motivation & Overview

NOAA wanted near-real-time winds and waves from CryoSat2 in time for 2011 hurricane season (June).

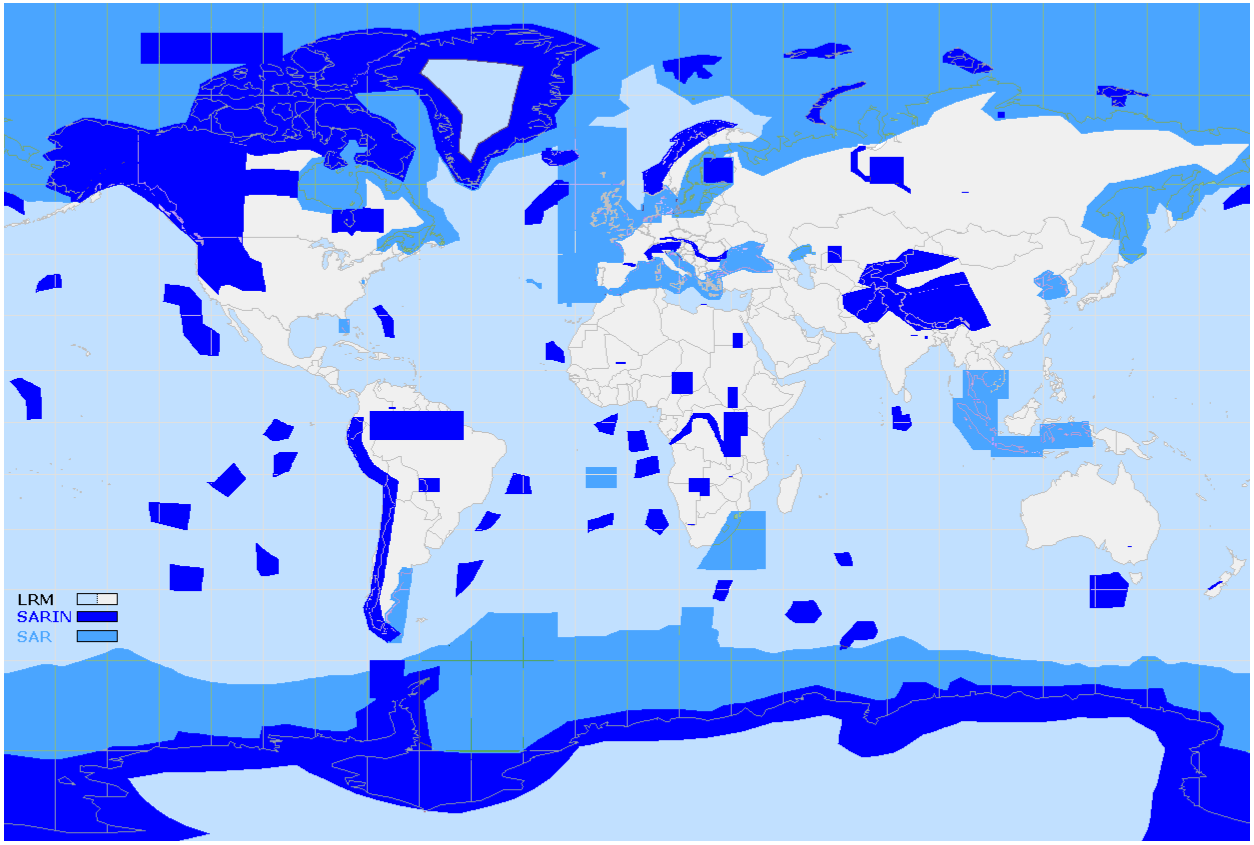
We decided to build our own product from L1b waveform data (FDM & LRM).

Our product turned out to give a good Sea Surface Height as well.

Walter’s Instrument Processing talk has details of the algorithm and its yields. Remko’s CalVal talk compares our results to other products.

This talk shows what we can produce for

CryoSat-2 LRM Mode Products



- LRM (Low Rate Mode) = Operates as a conventional altimeter.

LRM Products:

- FDM (Fast Delivery Mode) = short latency, DORIS DIODE or predicted orbit, predicted meteo & ancillary data.
- "LRM" = Final version, precise orbit, analyzed meteo, etc. (final "GDR").

Level L1b = Has waveform and geophysical corrections, but no derived quantities (range, SWH, σ^0) ➔ no sea surface height, wind speed (U_{10}), wave height, backscatter, etc.

Level 2 = No waveform; has geophysical corrections and derived quantities.

We build all our results from L1b FDM and LRM waveform products, not Level 2.

Fast Wind & Wave Recipe

① Download new FDM L1b data from ESA ftp server.
② Retrack the waveforms at 20-Hz.
③ Average the 20-Hz results to 1-Hz.
④ Remove land values and reformat SWH and U_{10} for NOAA's forecasters (N-AWIPS).
⑤ Export to NOAA forecasters via NOAA ftp sites.

SWH requires only a waveform and lat,lon.
σ_0, to within ± 1dB, requires only AGC and lat,lon.
Retracking and (crude) orbit height improve σ^0.
Nothing else needed for SWH and σ^0, U_{10}.

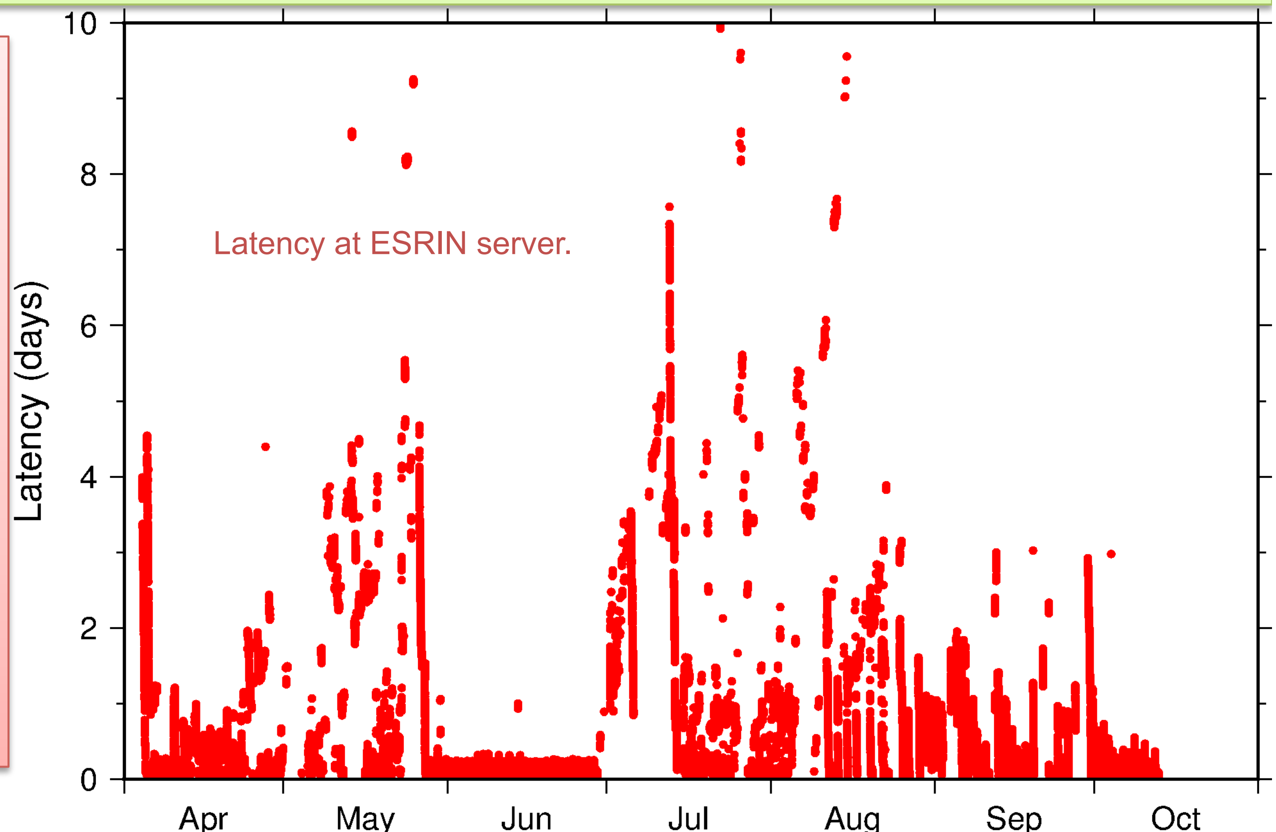
Speed & Latency

Every hour, we search ESA ESRIN ftp site for new FDM L1B data.

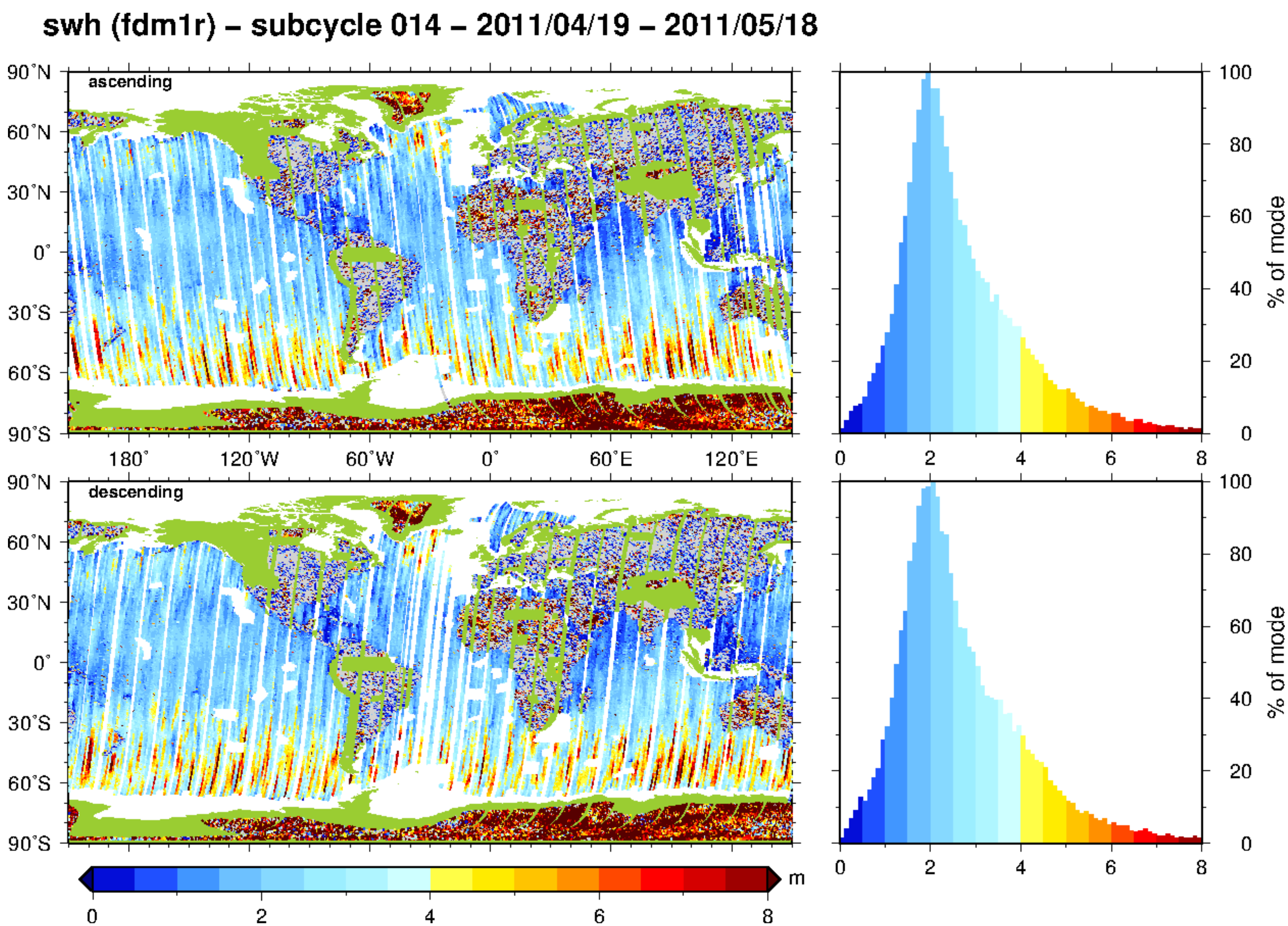
From ESRIN ftp to NOAA N-AWIPS, our process takes about 2 minutes, end-to-end. Thus latency is determined on the ESA side.

Until recently, less than 25% of FDM L1B files were available within 3 hours of real time. This has now improved.

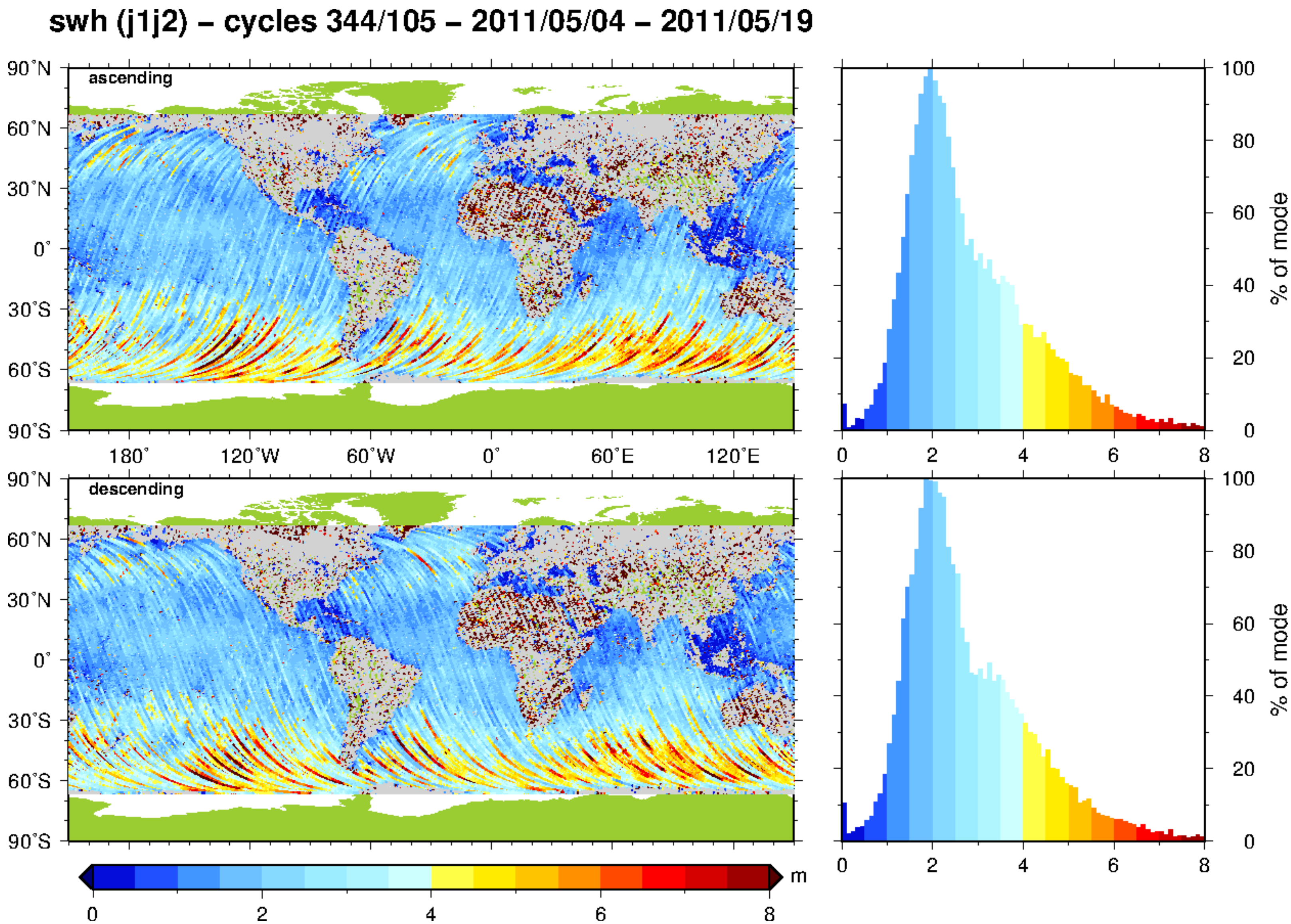
October 6-13:
34% within 3 hours;
77% within 6 hours;
all within 1 day.



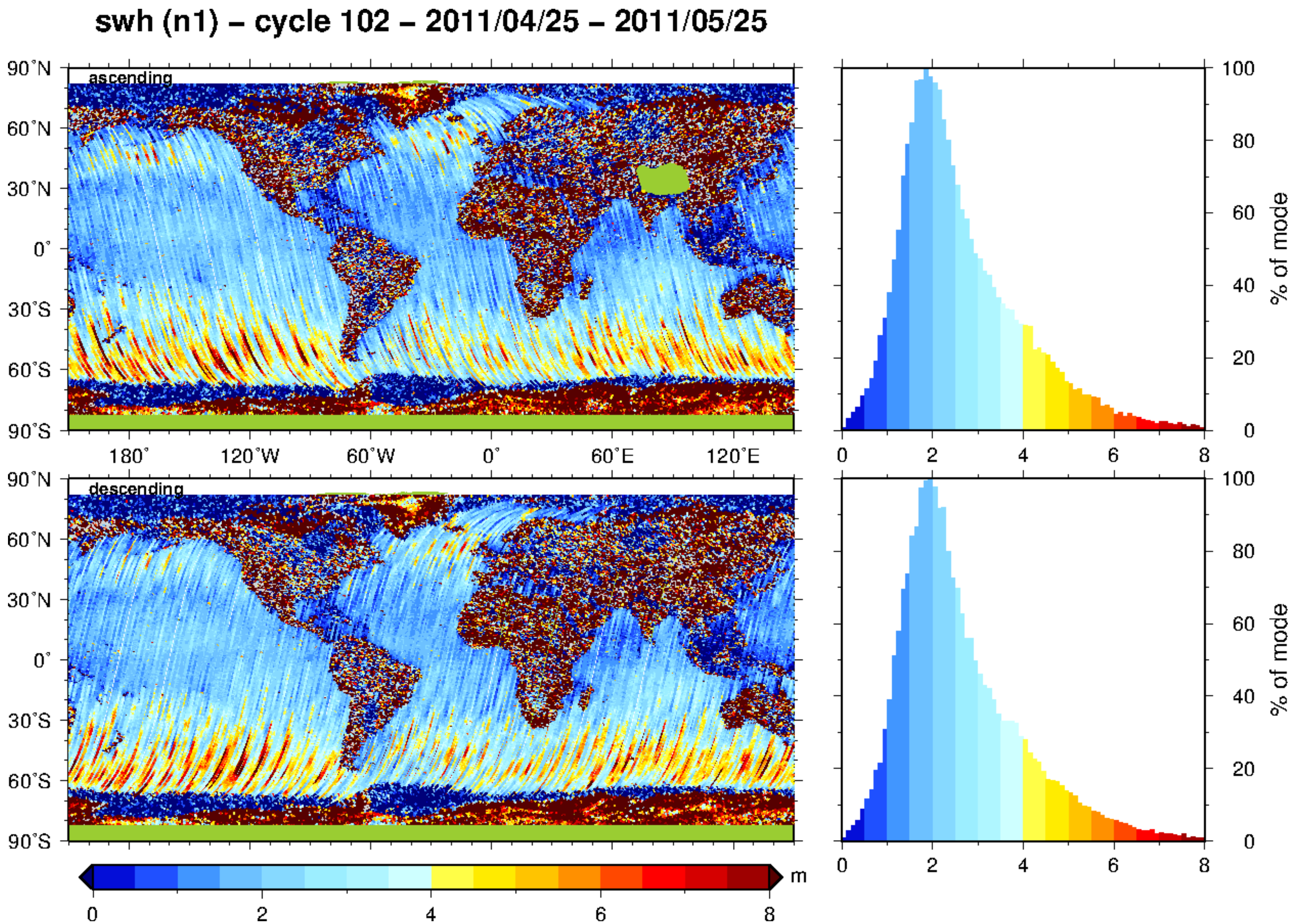
CS2 Wave Heights



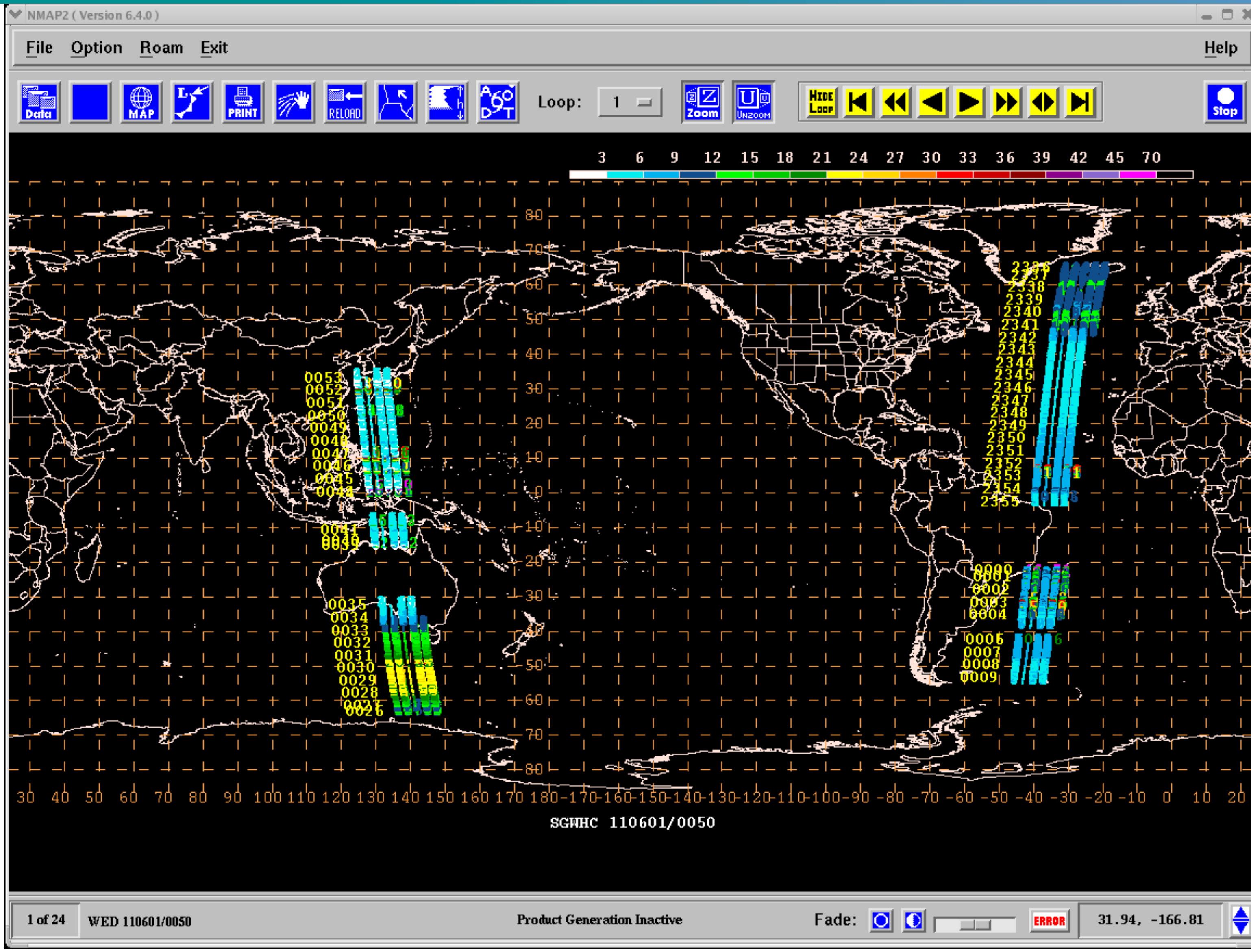
J-1 & J-2 Wave Heights



Envisat Wave Heights



CS2 SWH on NCEP N-AWIPS



NOAA Advanced Weather Interactive Processing System (N-AWIPS) display at NCEP

SWH is Easy; U_{10} is a bit harder.

Retracking yields SWH straightforwardly.

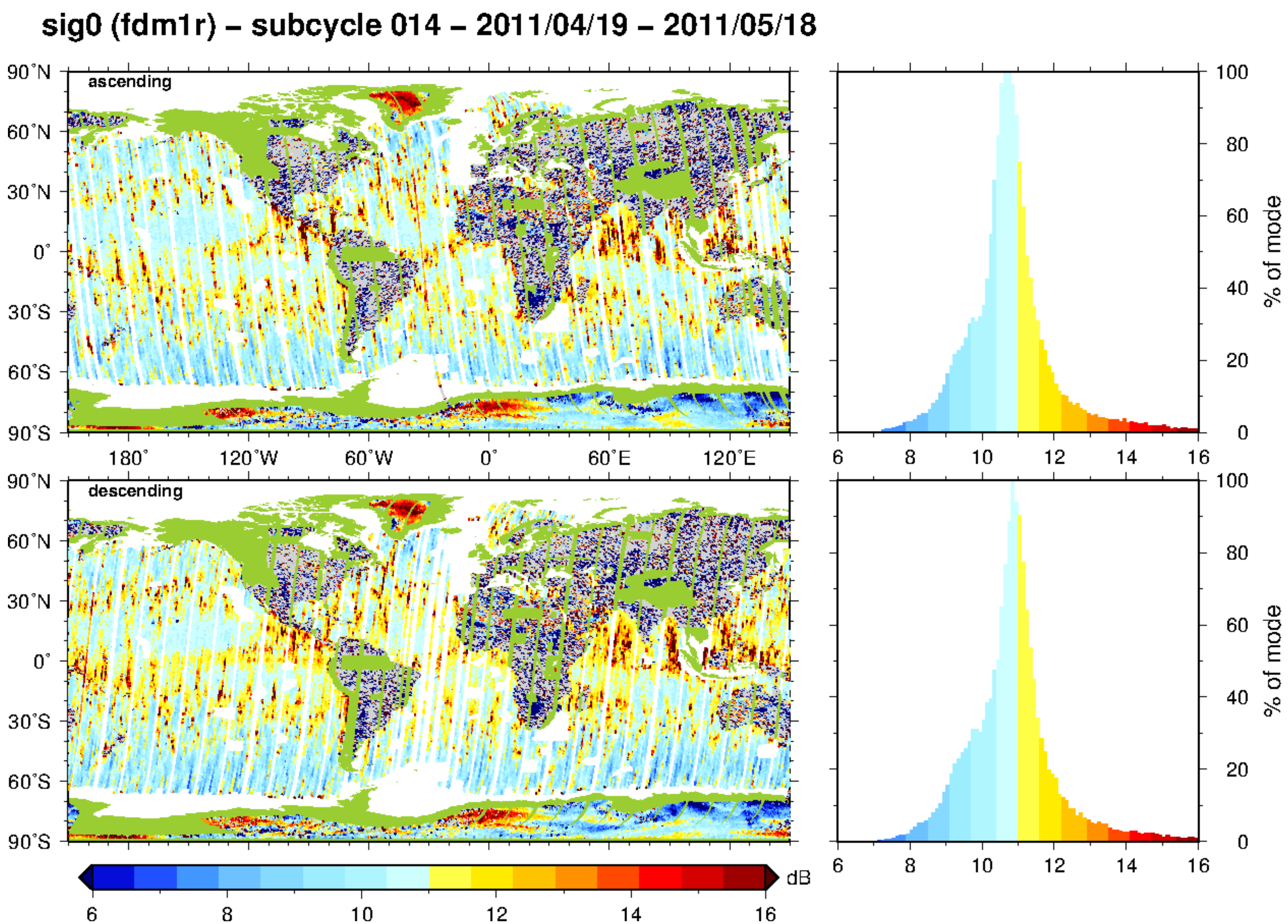
Wind speed is estimated from backscatter, σ^0, by empirical models tuned separately for each altimeter. *We don't yet have a model for CS2.*

σ^0 can be obtained by retracking, but there is an unknown (to us, at least) constant, representing $10*\log_{10}$ of the system gains and losses.

We had to guess this unknown constant.

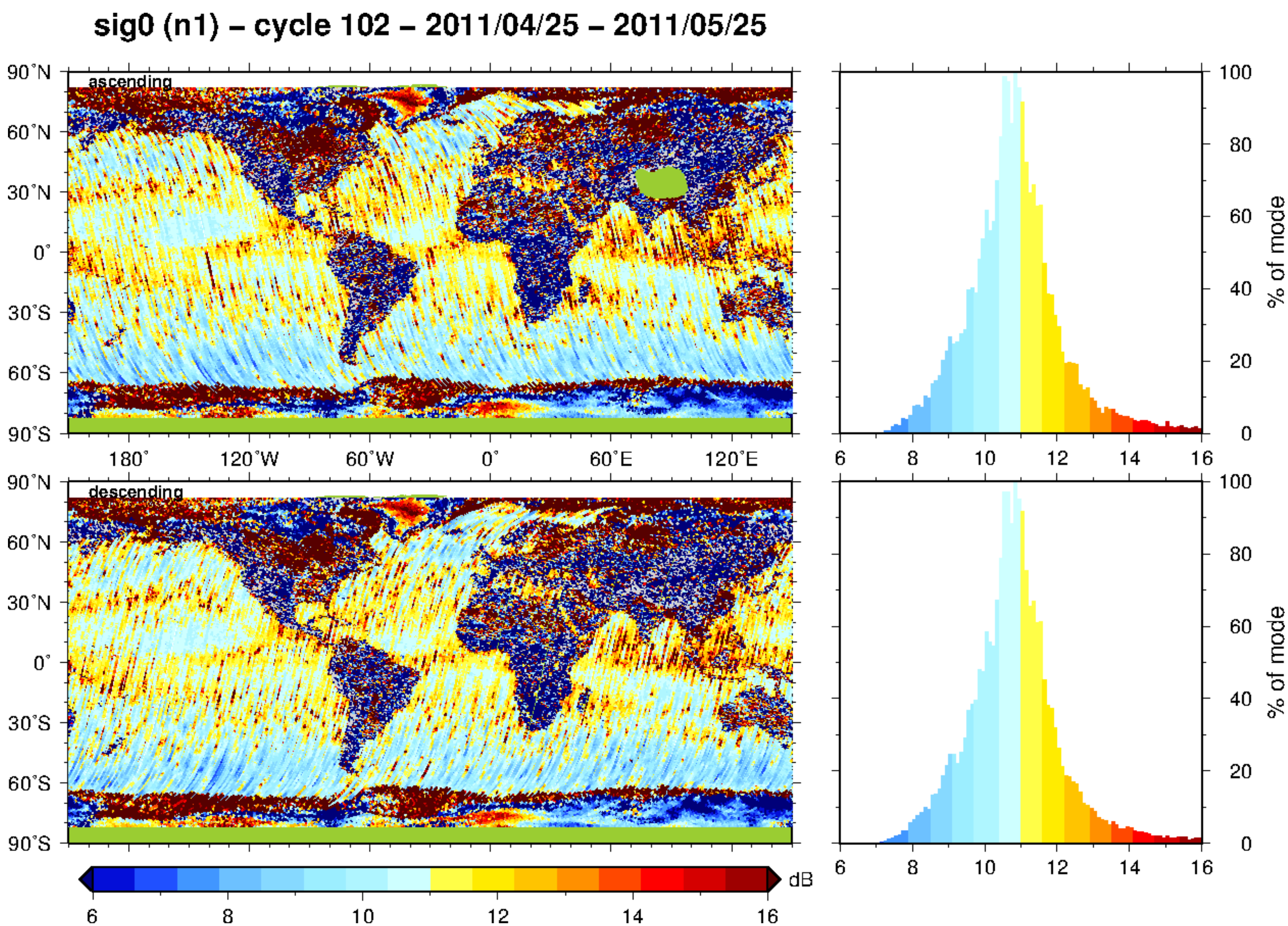
Our wind speed estimates are therefore *ad hoc* and preliminary.

CS2 σ^0

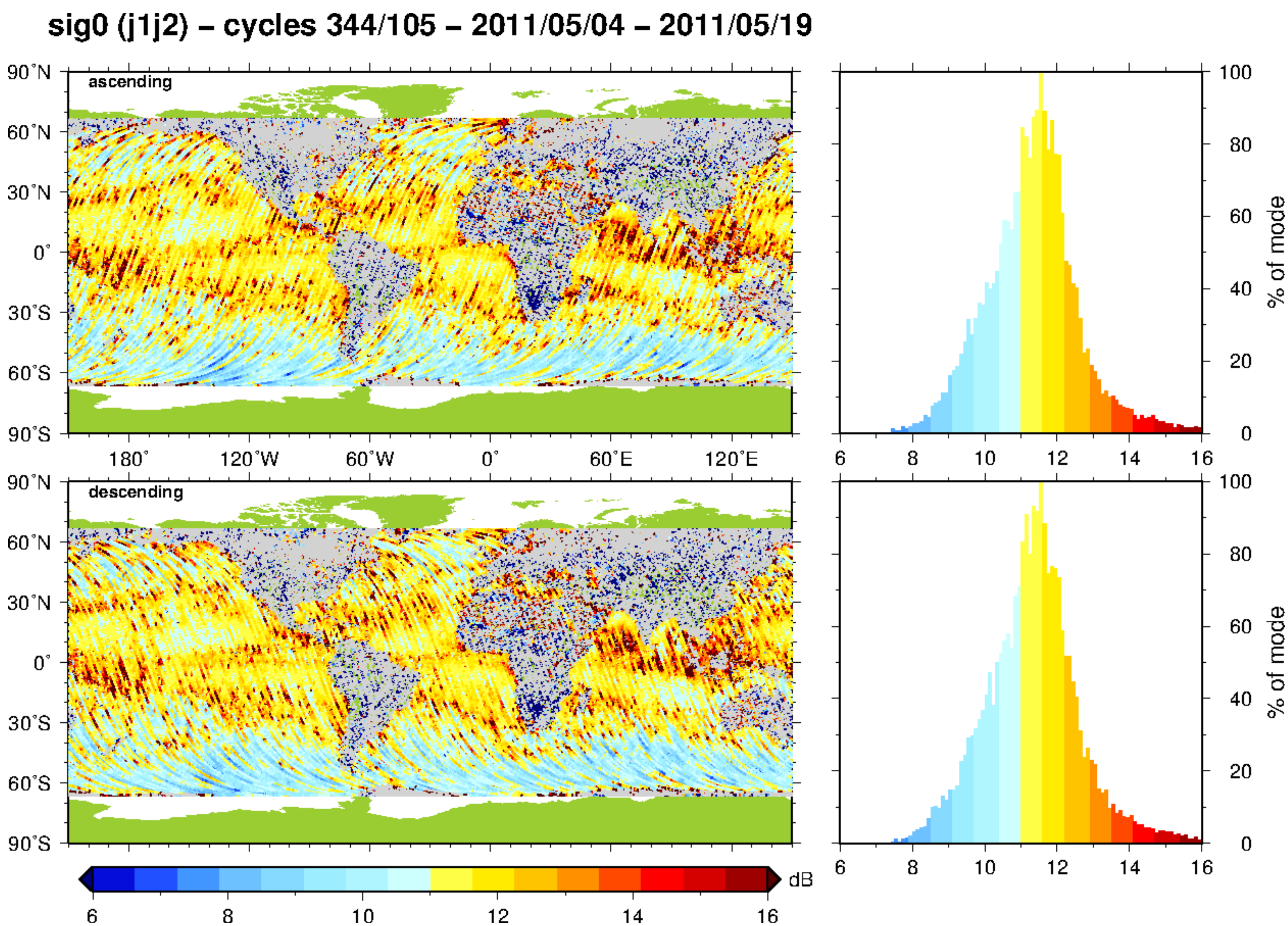


sig0 (fdm1r) – subcycle 014 – 2011/04/19 – 2011/05/18
ascending
descending
90˚N
60˚N
30˚N
0˚
30˚S
60˚S
90˚S
180˚
120˚W
60˚W
0˚
60˚E
120˚E
% of mode
100
80
60
40
20
0
6
8
10
12
14
16
dB

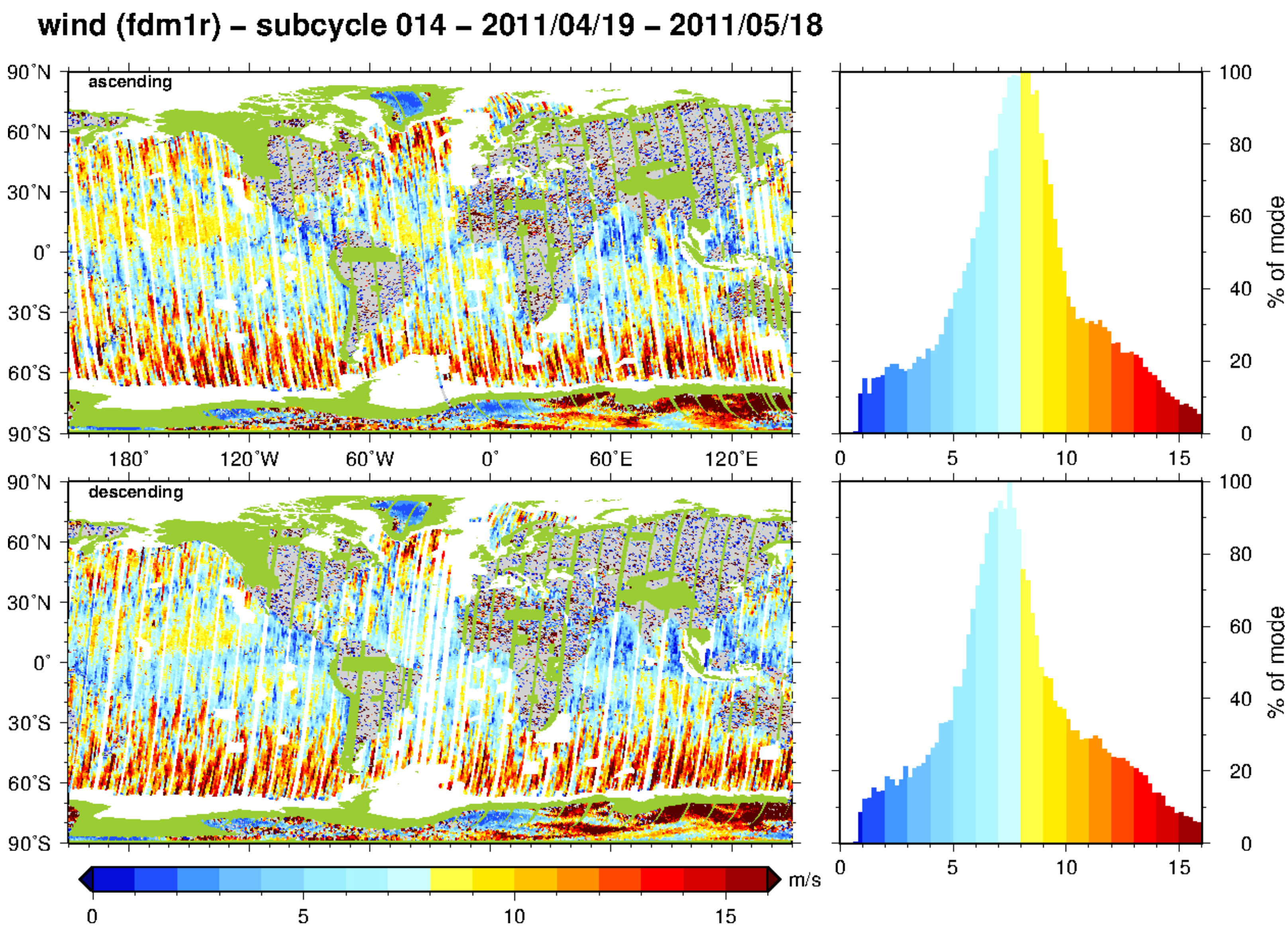
Envisat σ^0



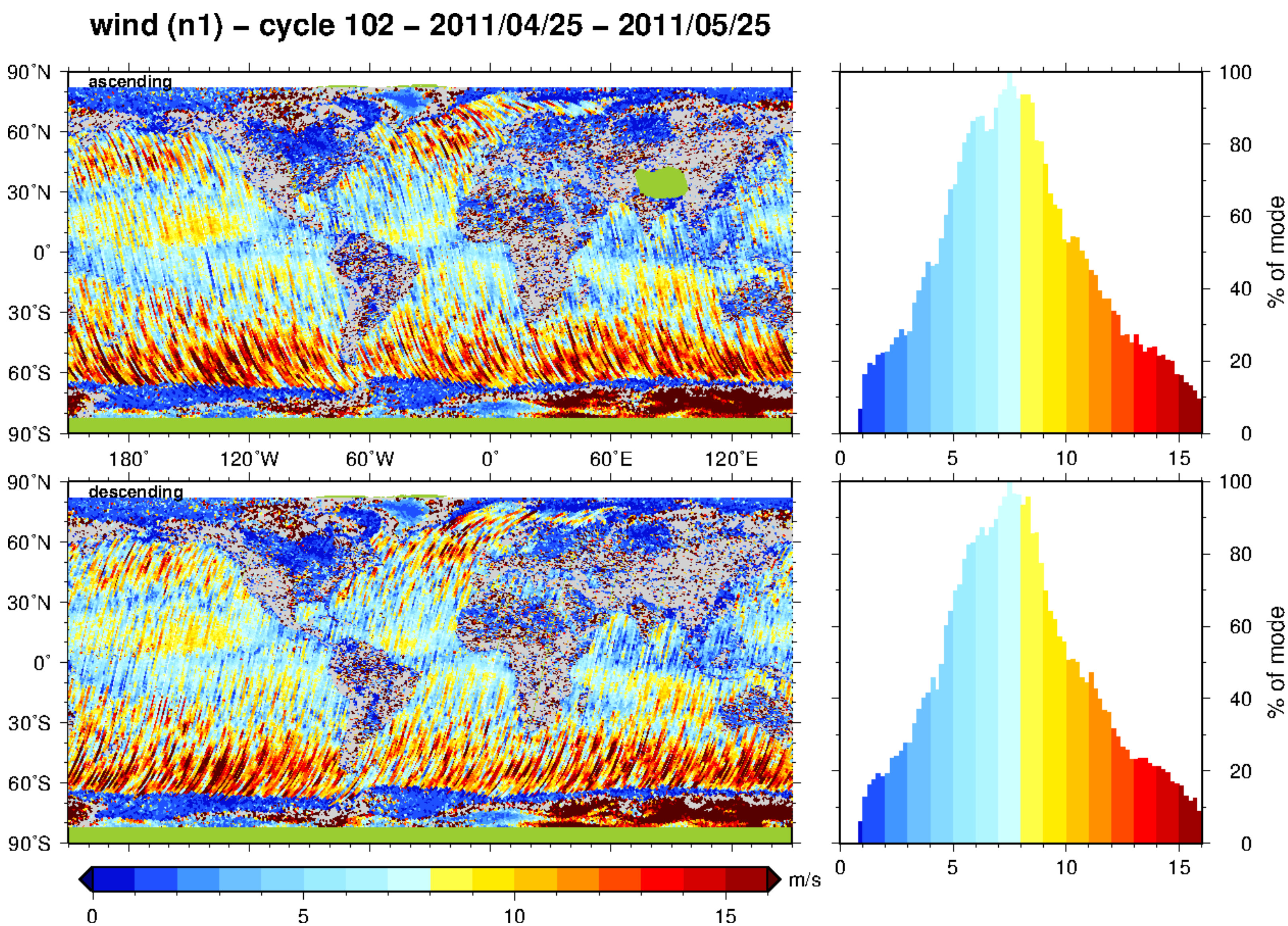
Jason-1 & Jason-2 σ^0, - 2.4 dB



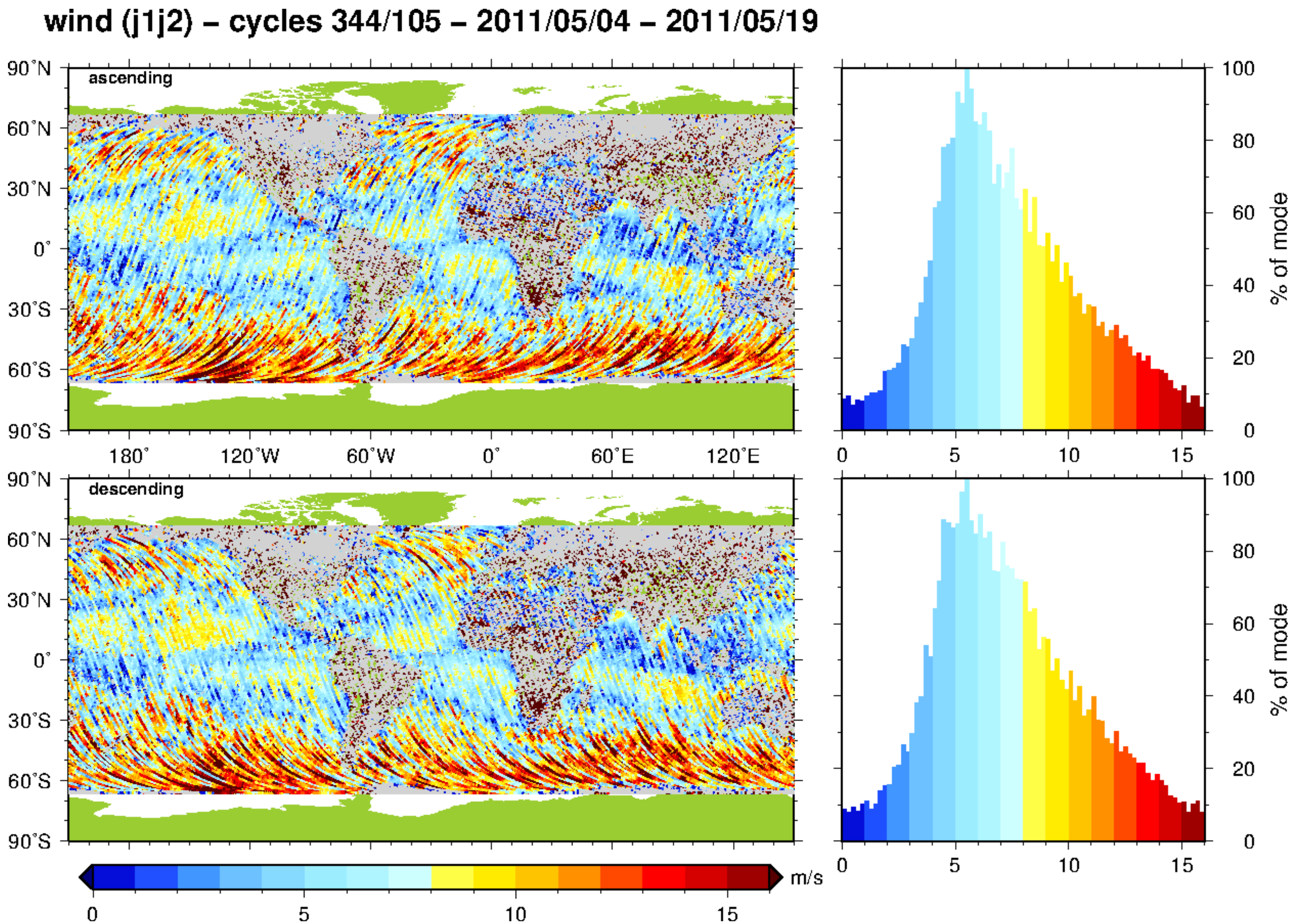
CS2 Wind Speeds (Abdalla model)



Envisat Wind Speeds (Abdalla model)



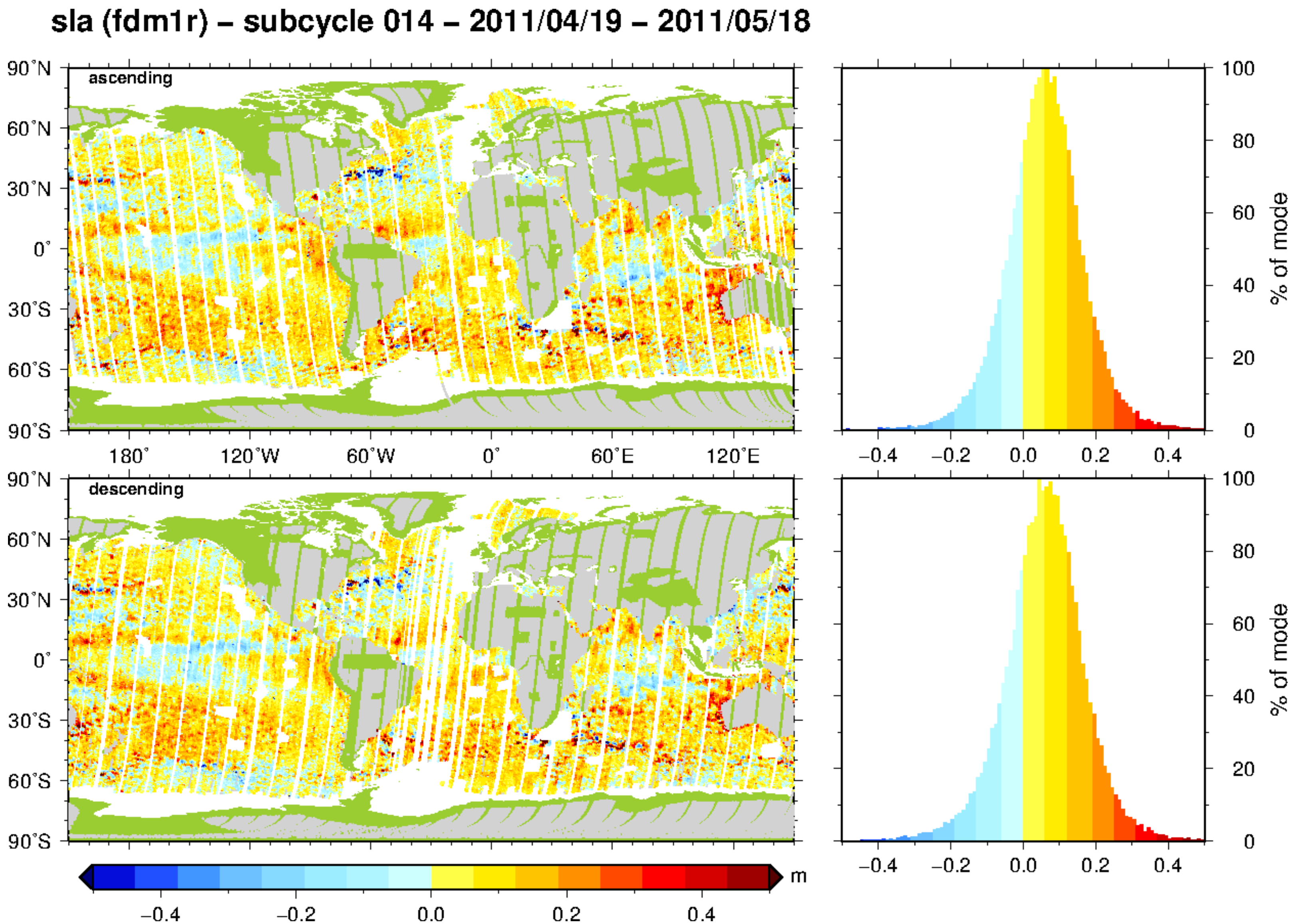
J-1 & -2 Wind Speeds (Collard model)



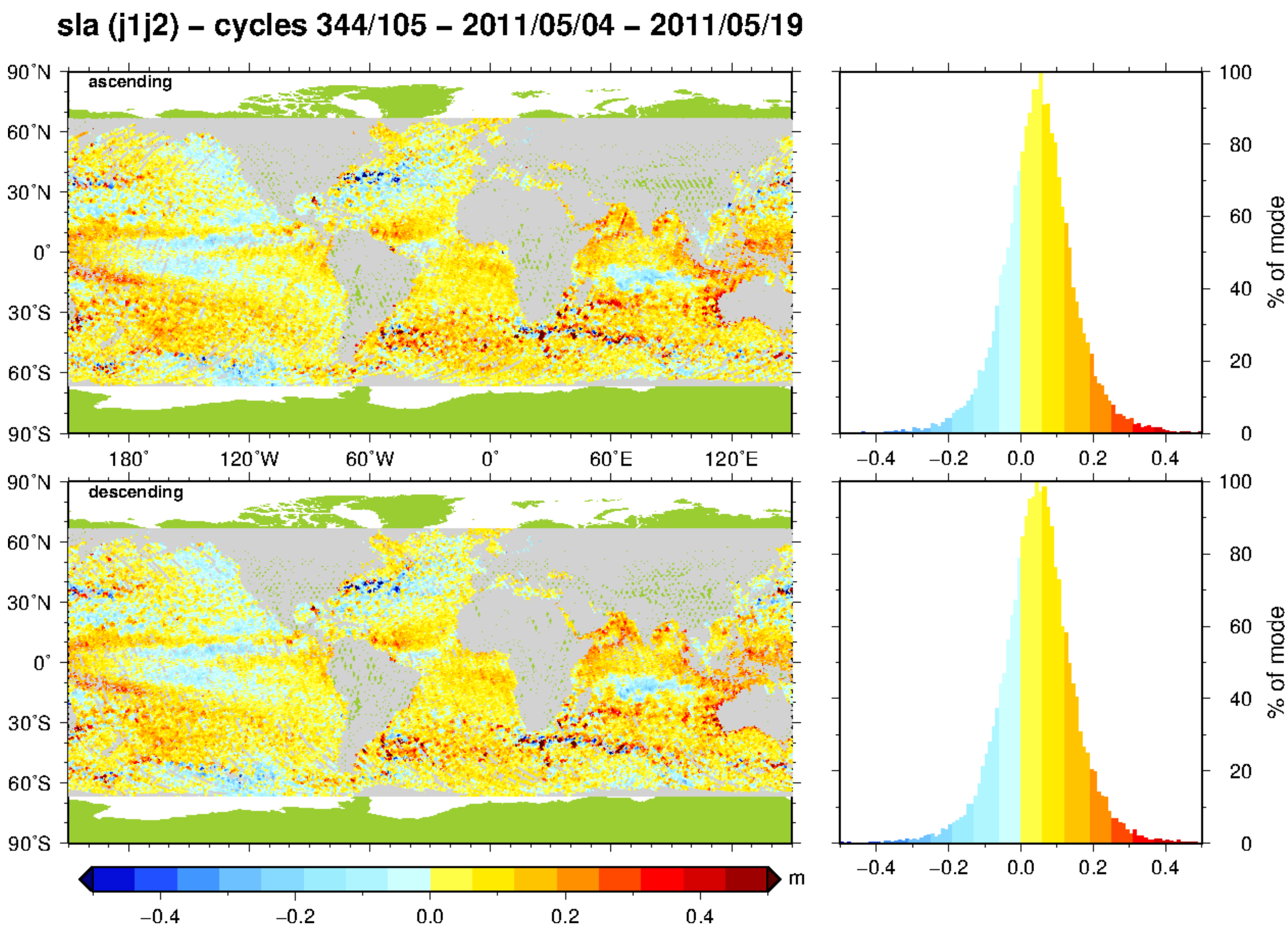
After real time Sea Height

- The LRM L1b ("GDR") has same format as the L1b FDM, so we use our 20 Hz retracker on that product as well, with averaging of (orbit height minus range) to 1 Hz.
- We ingest this product into the Radar Altimeter Database System (RADS) to verify correction fields.
- We form height anomalies by subtracting a Mean Sea Surface model.
- Currently, this product is available days to weeks after real time, because of the need for an orbit.

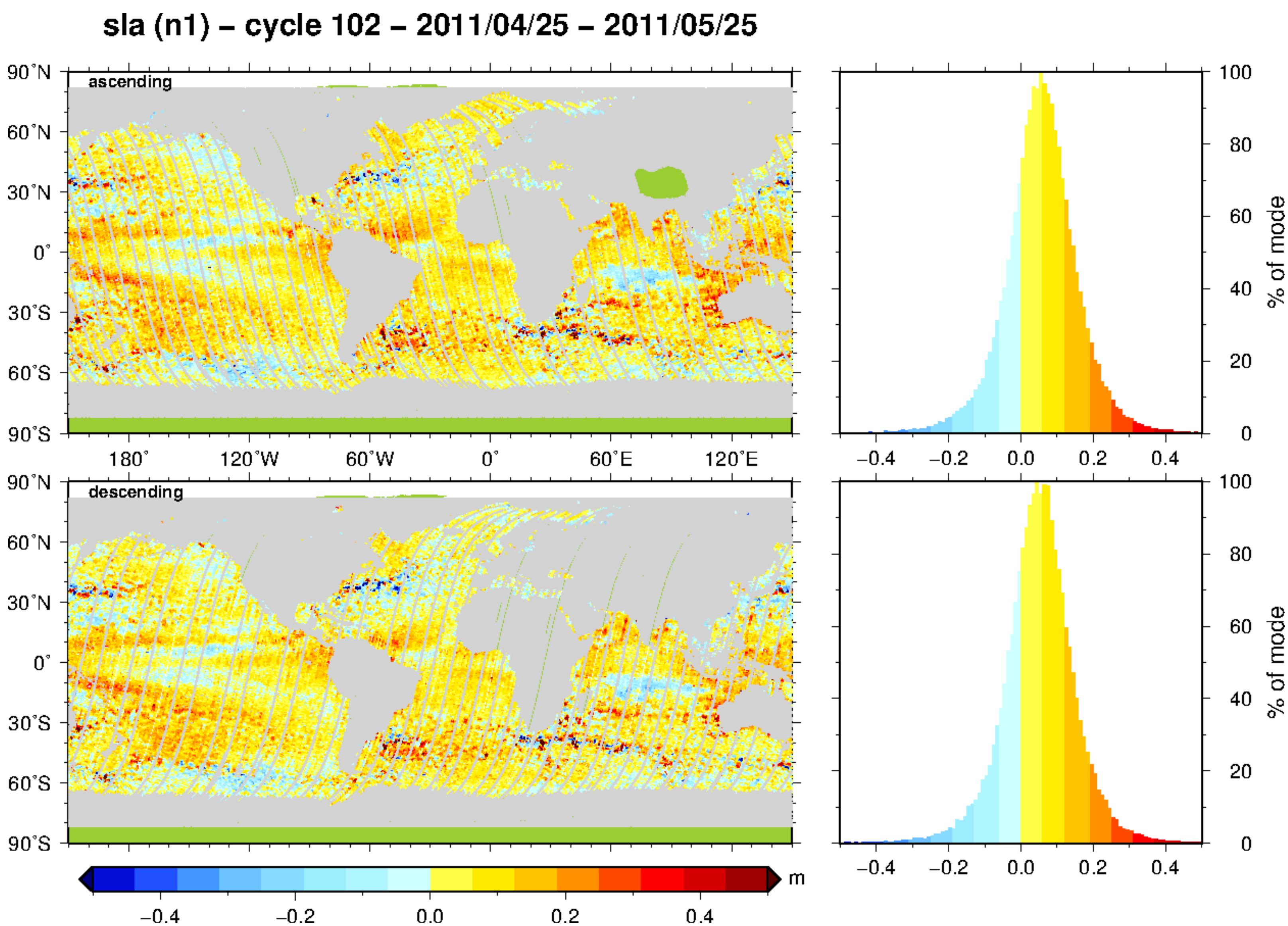
CS2 Sea Level Anomaly



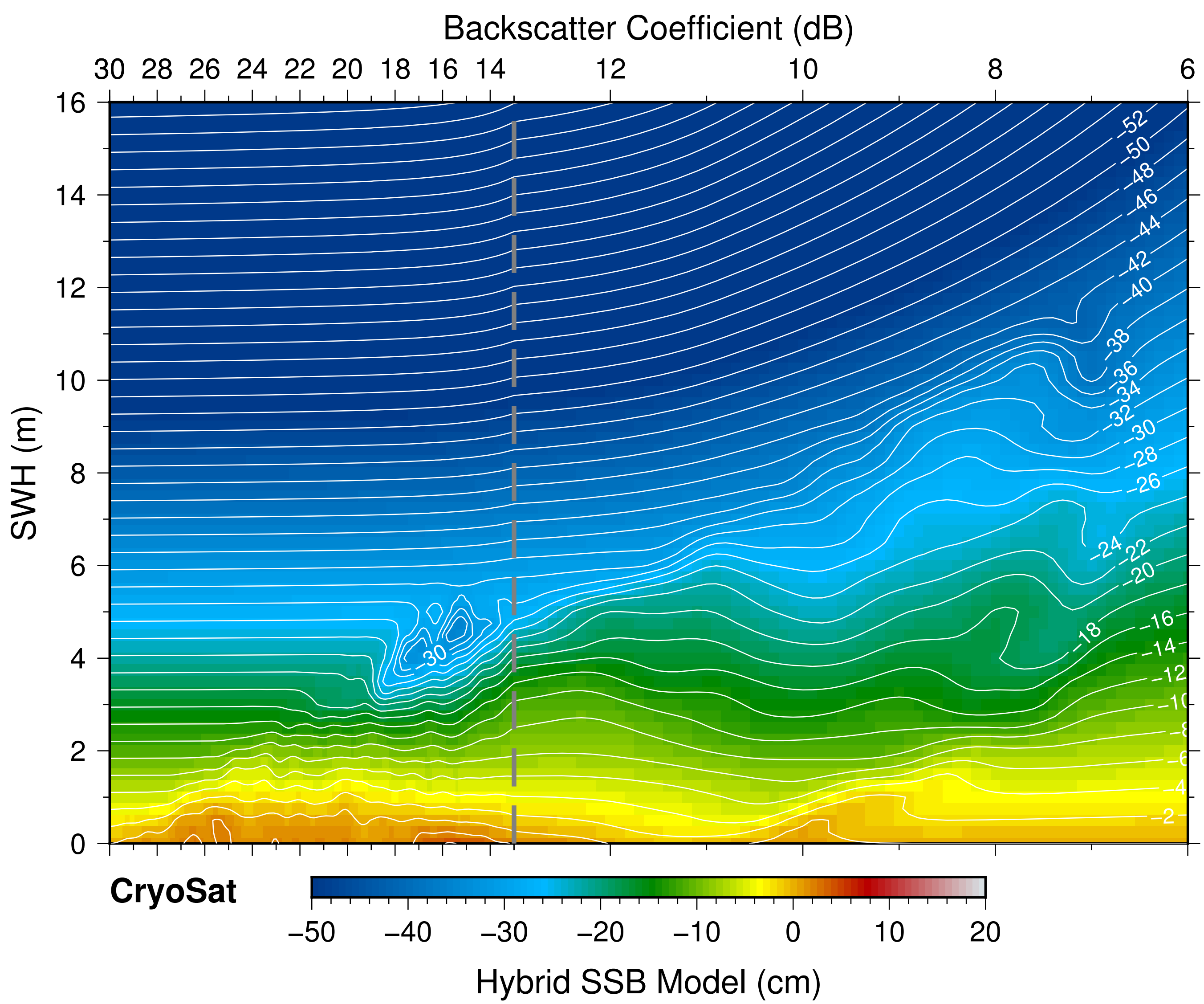
J-1 & J-2 Sea Level Anomaly



Envisat Sea Level Anomaly



CS2 SSB is typically -3.5% SWH



Direct Method; BM-4 style; relative to DTU10 Mean Sea Surface; fit to subcycles 11-17

SSH crossovers < 3 days

	Mean (mm)	Std. Dev. (mm)
Env – Jason-2	-2.8	48.9
CS2 – Jason-2	+0.2	50.8
CS2 – Env	-2.4	49.7

CryoSat2 seems as good as J-2 and Envisat

Towards a CS2 I-GDR -?-

We would like accurate sea surface height anomalies within ~1 day of real time for Ocean Heat Content, Surface Currents, and other applications. We have ***almost*** everything we need to build that from our FDM L1b retracker and RADS:

- ◆Orbit
- ✓Iono: GPS GIM
- ✓Meteo: NOAA NCEP
- ✓IB: MOG2D
- ✓Tides: FES, GOT
- ✓SSB: RADS empirical

We could distribute this through RADS if that is desired.

Conclusions, 1

CryoSat2 is an excellent altimeter for oceanography. We thank ESA for the FDM L1b Product.

We are producing SWH, σ_0, U_{10}, and SSH by retracking FDM L1b waveforms.

Our product compares well with J1, J2, E, though there are *ad hoc* values that could be tuned.

Conclusions, 2

Our product is on the NOAA-only side of RADS, but could be put on the public side if desired.

Currently, our winds and waves are adequate for NRT, but height needs a better orbit. If we had an MOE orbit within 1-3 days of real time, we could make an I-GDR for Cryosat2 LRM. Such a product would build from the FDM L1b and so would not impact the ESA ground segment.

We could offer this as an "interim", "best effort" product, until ESA's new products are ready (February 2012?).