THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

MISR
Multi-angle Imaging SpectroRadiometer

MISR CMVs

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Acknowledgements: MISR Science and Data Processing Team
(especially Catherine Moroney and Mike Garay)

From the AGU Fall Meeting 2009

MISR and the multi-angle remote sensing of clouds: *before the launch of Terra, over 10-years ago…*

- albedos from multi-angle measurements would be nice …
  - *but these measurements must be co-registered to the same dynamic reference height*
- dynamic cloud-top heights would be nice …
  - *but it takes 7 minutes to measure all angles, and clouds move*
- cloud-tracked winds would be nice …

At the 9th IWW

- showed improvements due to sub-pixel matching
  - Davies et al, *Remote Sensing of the Environment,* 2007
- preliminary comparisons between MISR and NCEP
  - also with ECMF (Claire Delsol, Niels Bormann, and Lueder von Bremen)

overview

- comparison of the MISR standard product with 10-years of NCEP reanalysis
  - *more to follow on this from Dong Wu*
- known problems with/improvements to the MISR standard product
  - *more to follow on this from KatrinLonitz*
- 10-years of global CMV wind fluctuations

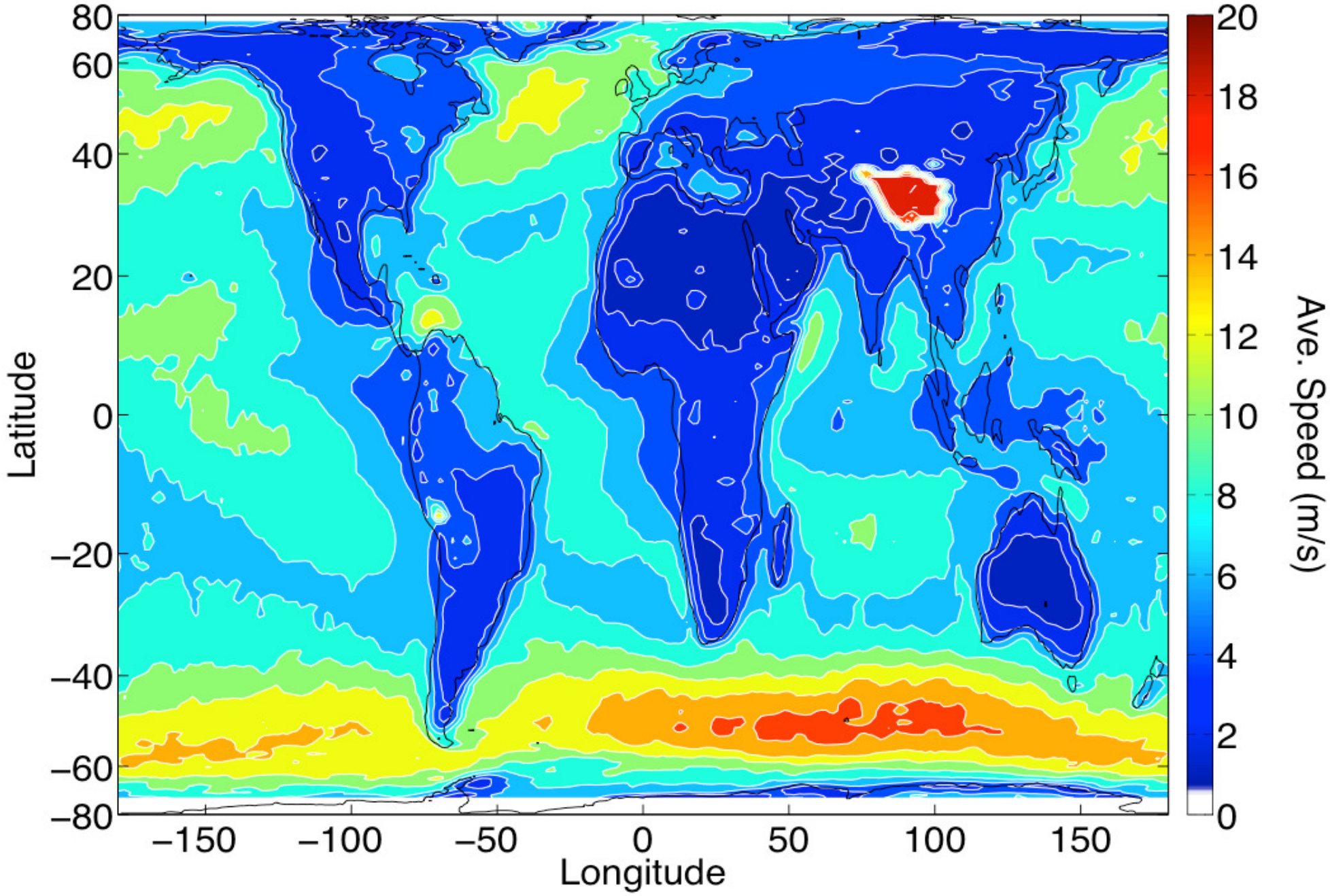
MISRCMVsfrom Stereo Processing

- conventional stereo techniques ⇒ far too slow
  - new techniques of pattern matching had to be developed
  - initially quite noisy (averaged over 70.4 km domain), but unbiased
- 0°, 45°, and 70° triplet of views needed for along-track wind
  - works because the Earth is not flat
- many improvements since then
  - image navigation (< 275 m)
  - sub-pixel enhancement
  - fore and aft redundancy provides quality control
- faster computers have helped
  - less noisy techniques
  - complete reprocessing of stereo data record is practical

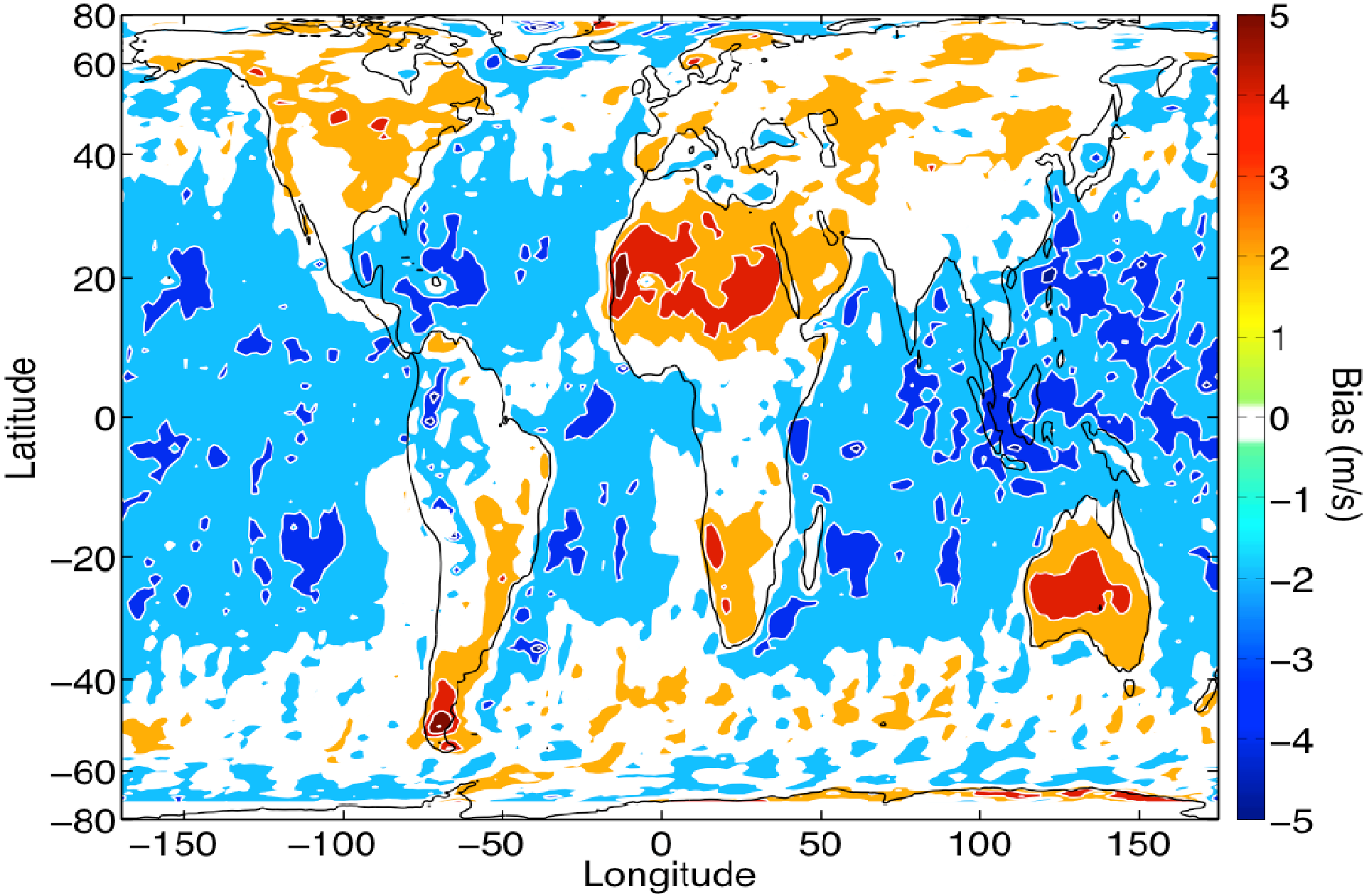
MISR-NCEP Comparison

- Analyzed entire data set of MISR winds at version 17
- Compared against NCEP/NCAR reanalysis
    - matched in time, space (area weighted) and height
    - over 22 x 10^6 matches in10 years

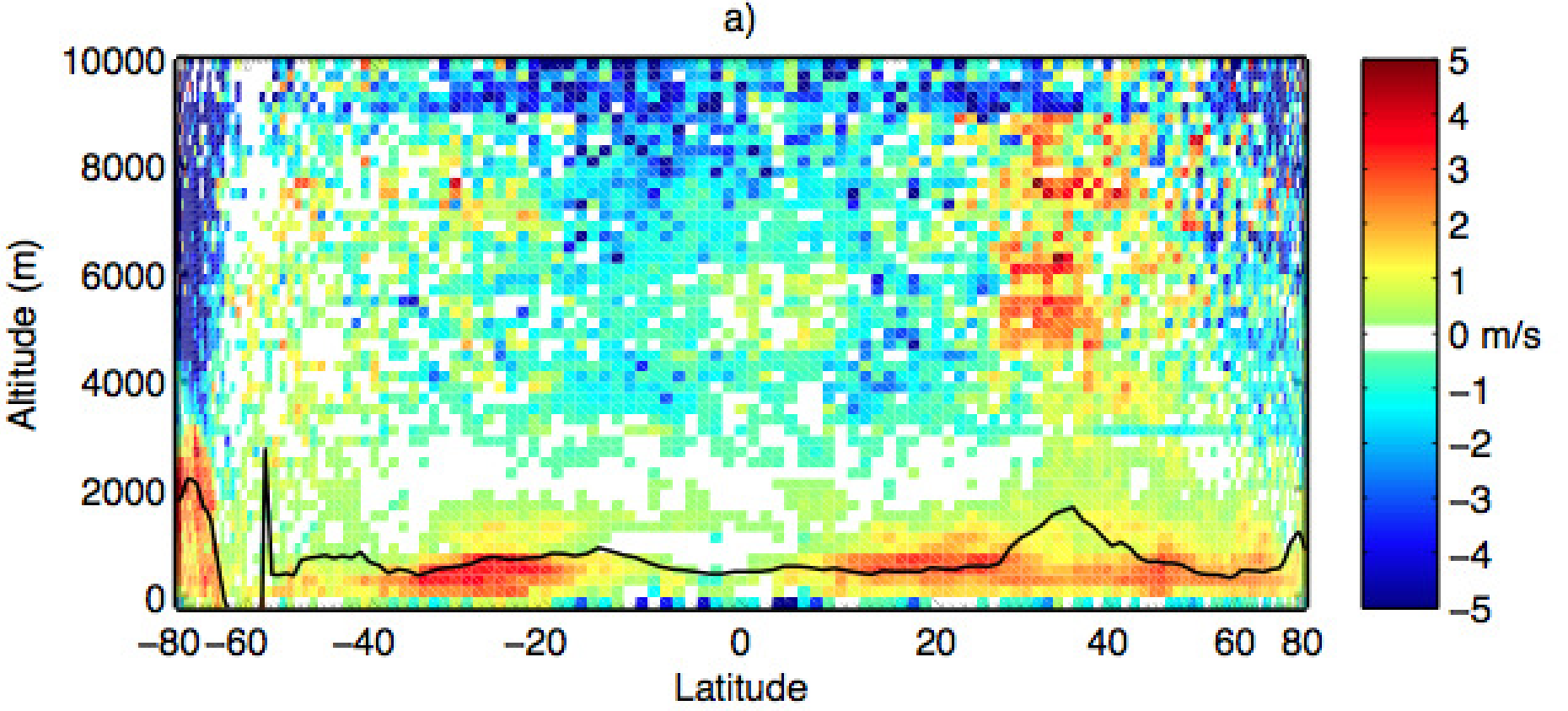
MISR average winds below 3 km



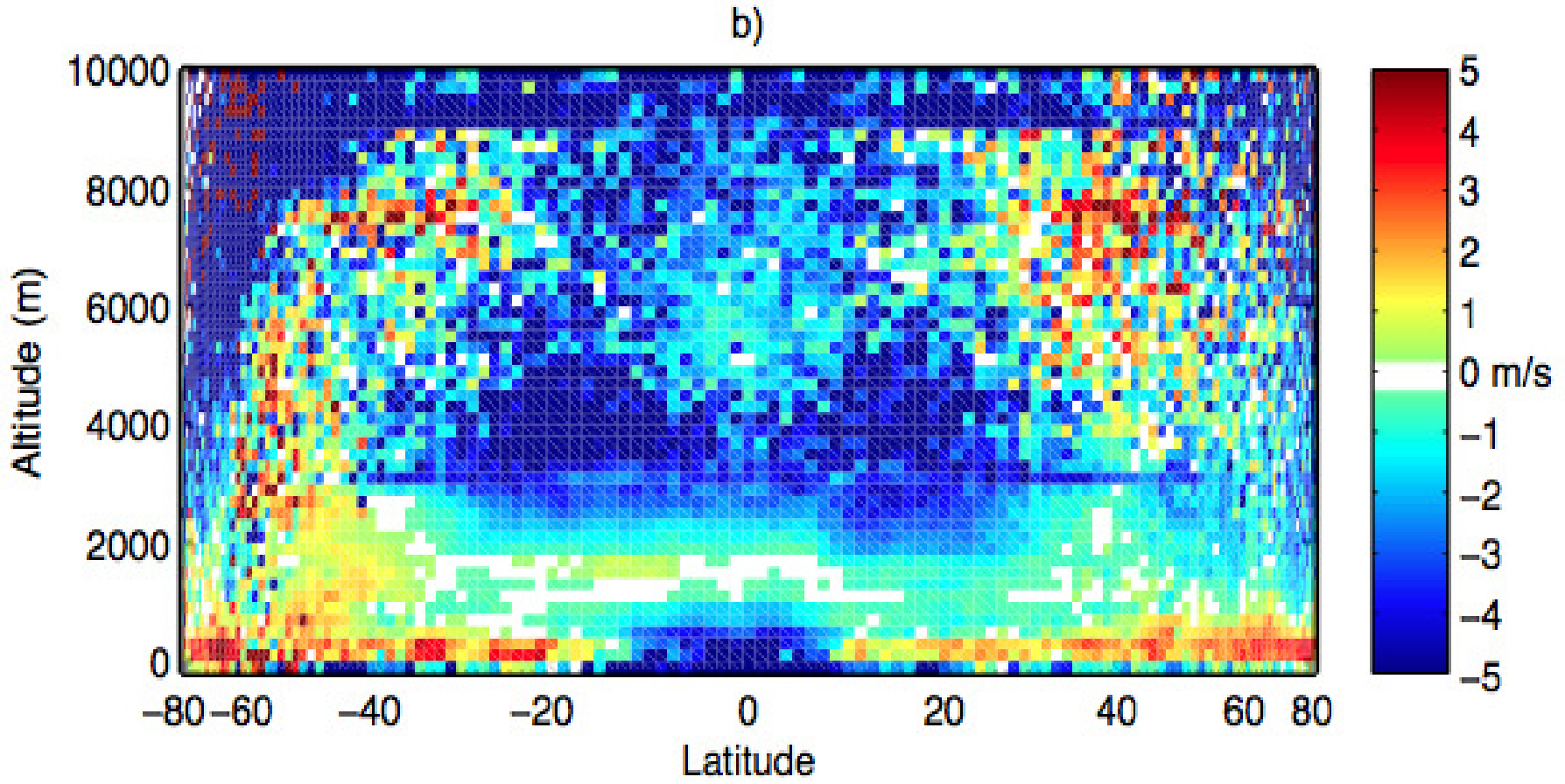
Average reanalysis–MISR scalar wind difference, z<3 km



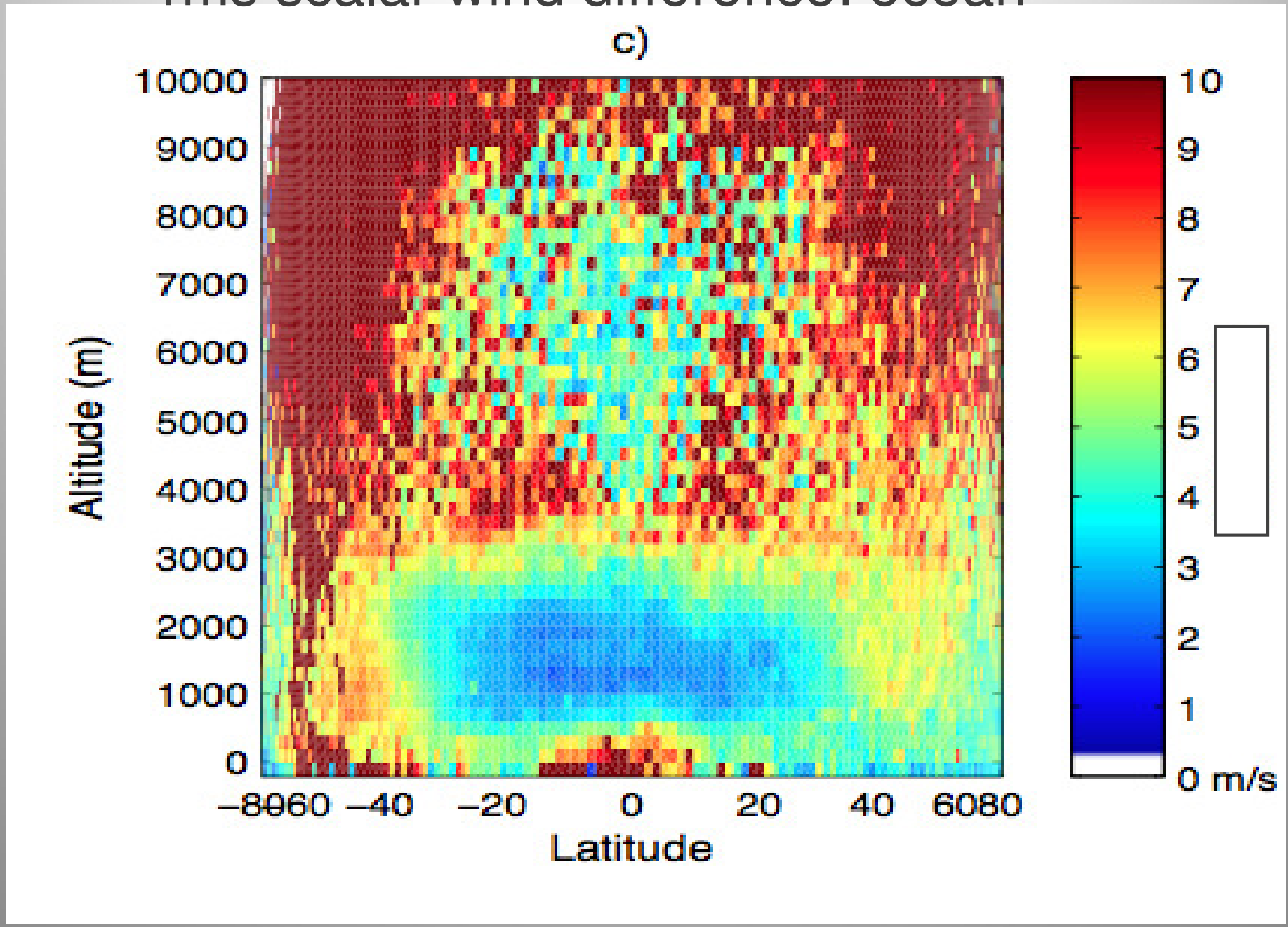
Reanalysis—MISR scalar bias: land



Reanalysis—MISR scalar bias: ocean



rms scalar wind difference: ocean

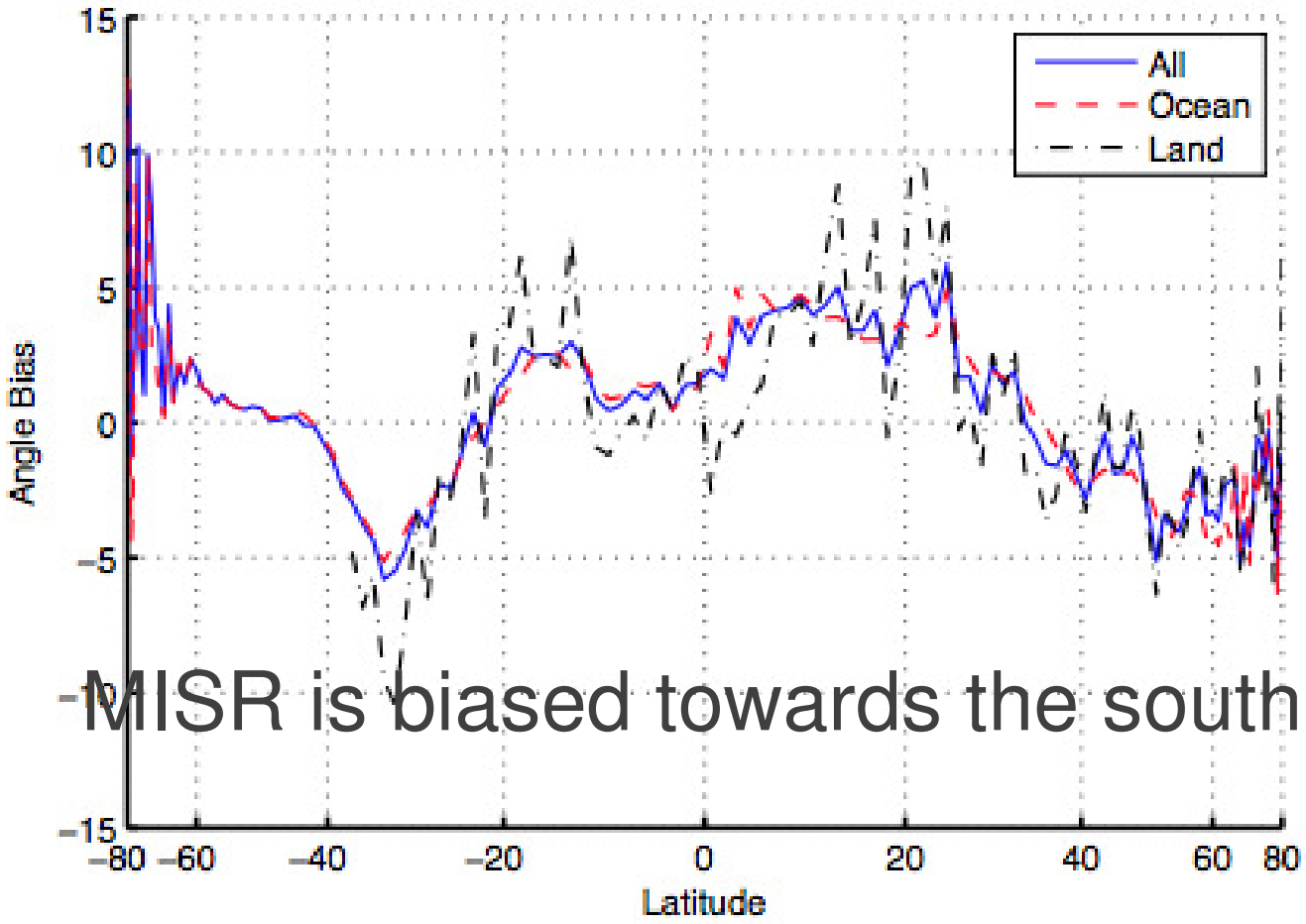


Summary of standard product-reanalysis

Height Range(m)	Over Land	Over Ocean
	Mean Vector Difference (ms^{-1})	
1000-3000	5.8	6.1
3000-7000	8.0	10.9
7000-20000	15.8	15.6
	Standard Deviation (ms^{-1})	
1000-3000	3.3	3.3
3000-7000	6.0	9.0
7000-20000	15.8	16.2
	RMSE (ms^{-1})	
1000-3000	6.7	6.9
3000-7000	10.0	14.1
7000-20000	25.2	22.5

Table 6.4: MISR-NCEP Comparison

directional bias by latitude



MISR is biased towards the south

Figure 6.6: Directional bias by latitude - Plot of angular bias over land and ocean against latitude for winds sub $3km$

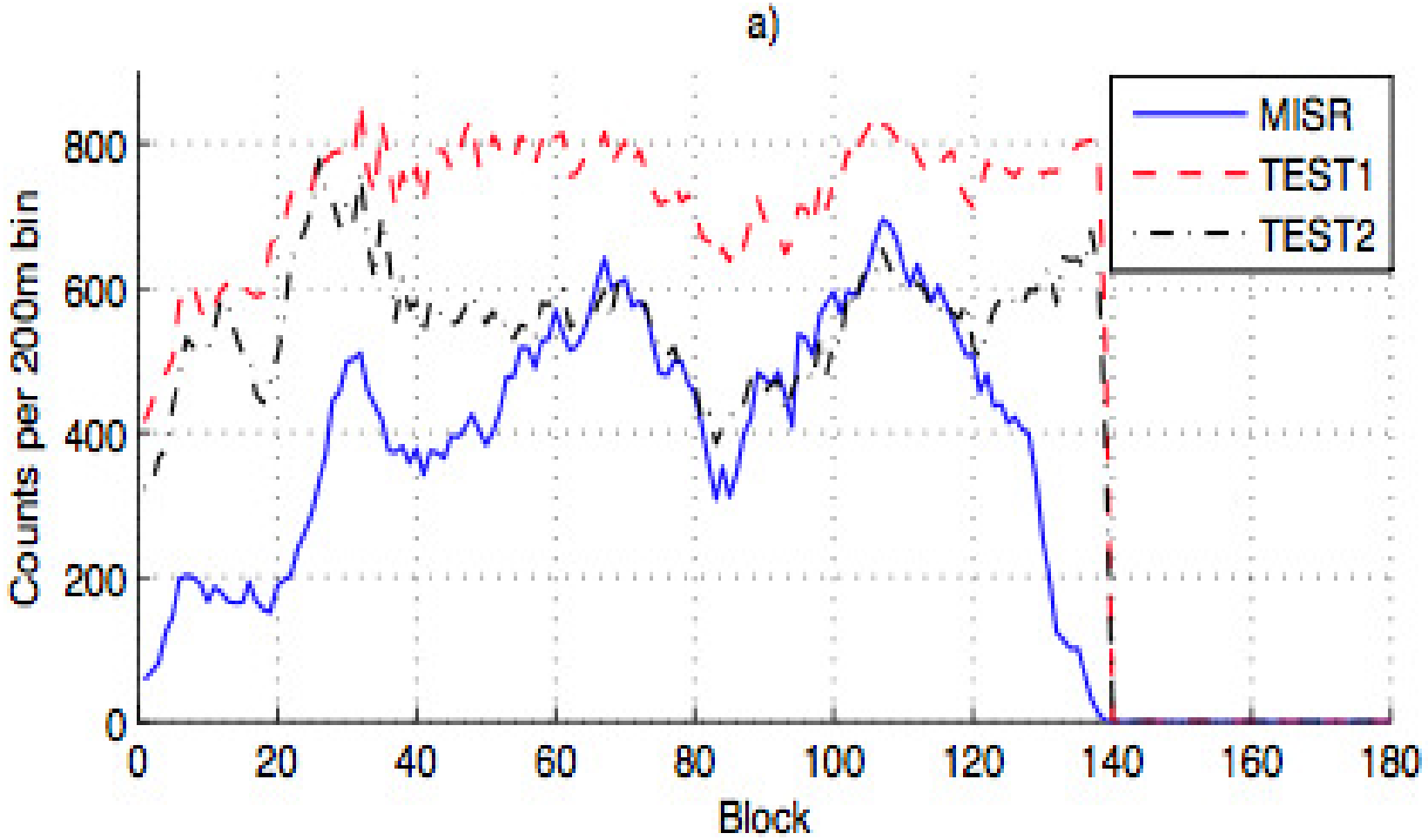
Latitude Range	1 - 3km	3 - 7km	7km +
	Over Land		
$25°N - 60°N$	$-11.16°$	$-5.86°$	$-0.26°$
$25°S - 25°N$	$6.99°$	$5.96°$	$9.18°$
$60°S - 25°S$	$-10.10°$	$-23.60°$	$-15.09°$
	Over Ocean		
$30°N - 60°N$	$-5.35°$	$-0.46°$	$-2.02°$
$30°S - 30°N$	$9.50°$	$9.86°$	$2.70°$
$60°S - 30°S$	$-4.06°$	$-18.92°$	$-24.26°$

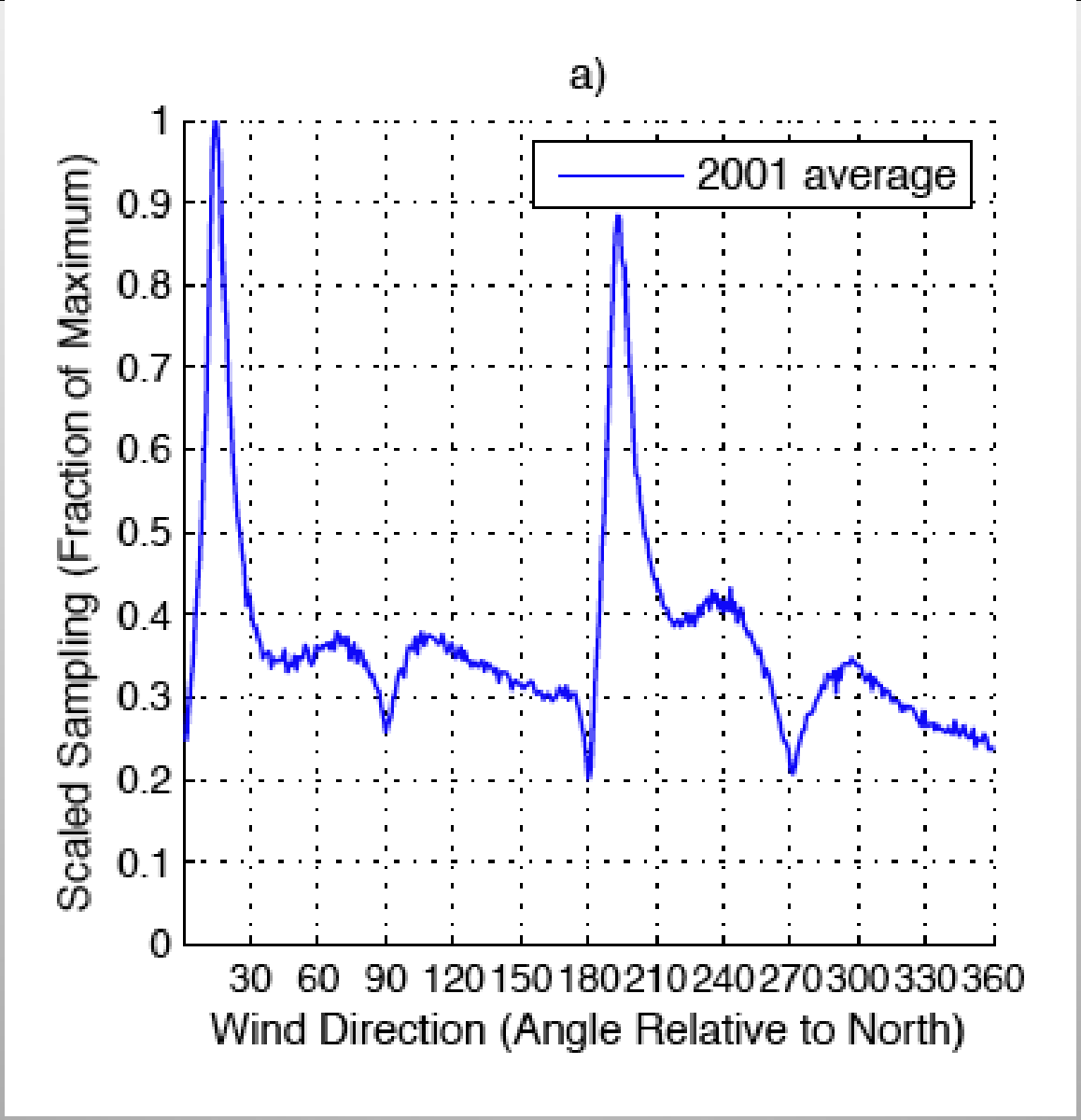
Table 6.3: Directional Bias measured as reanalysis-MISR

Improvements

- more exhaustive matcher
  - greater coverage ≈70% more winds than original method
  - increased coverage at high latitudes
  - double the number of high altitude winds
  - eliminates drop-outs at East-West cardinal points
  - Improves ascending-descending differences

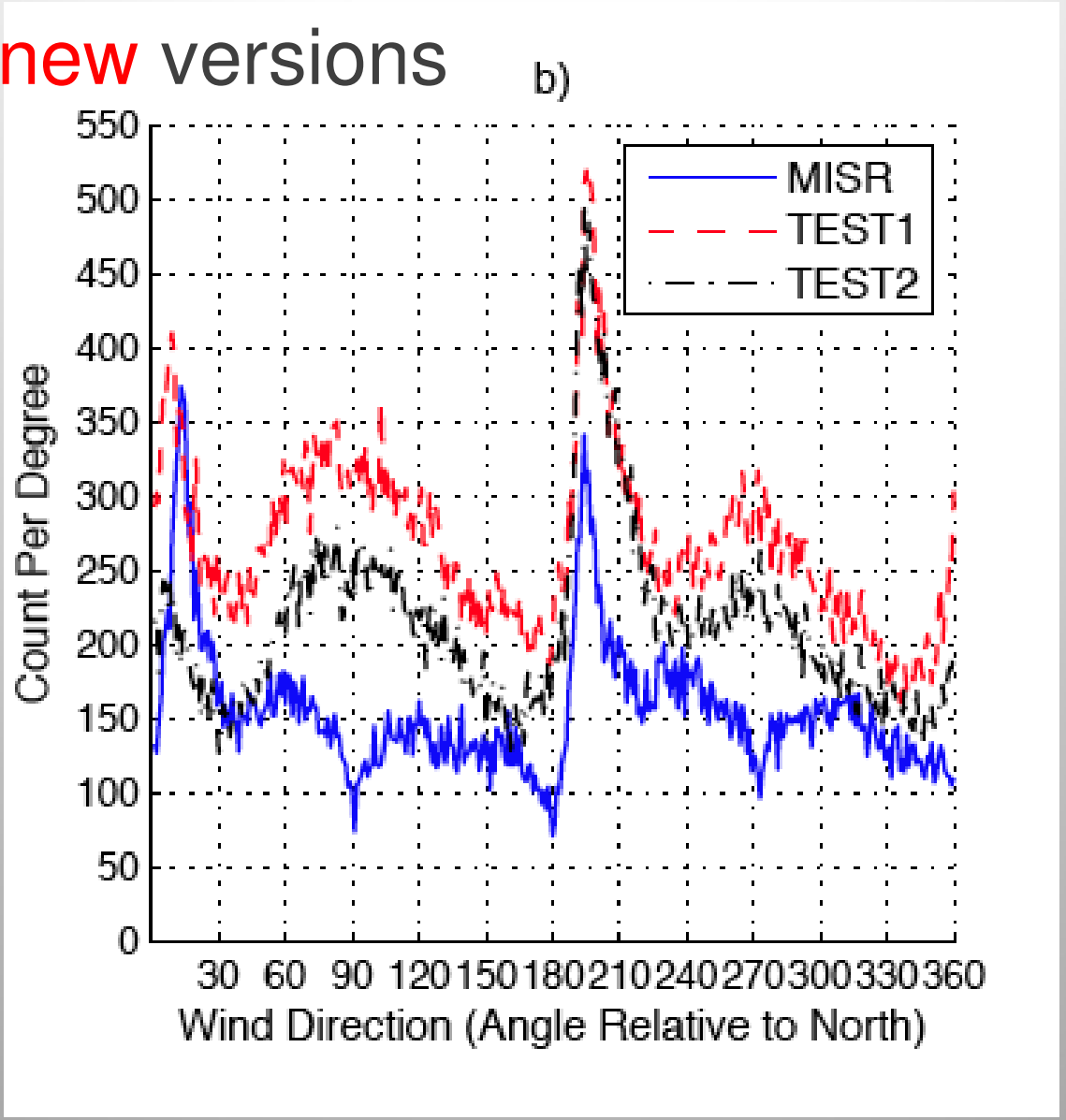
new versus old coverage



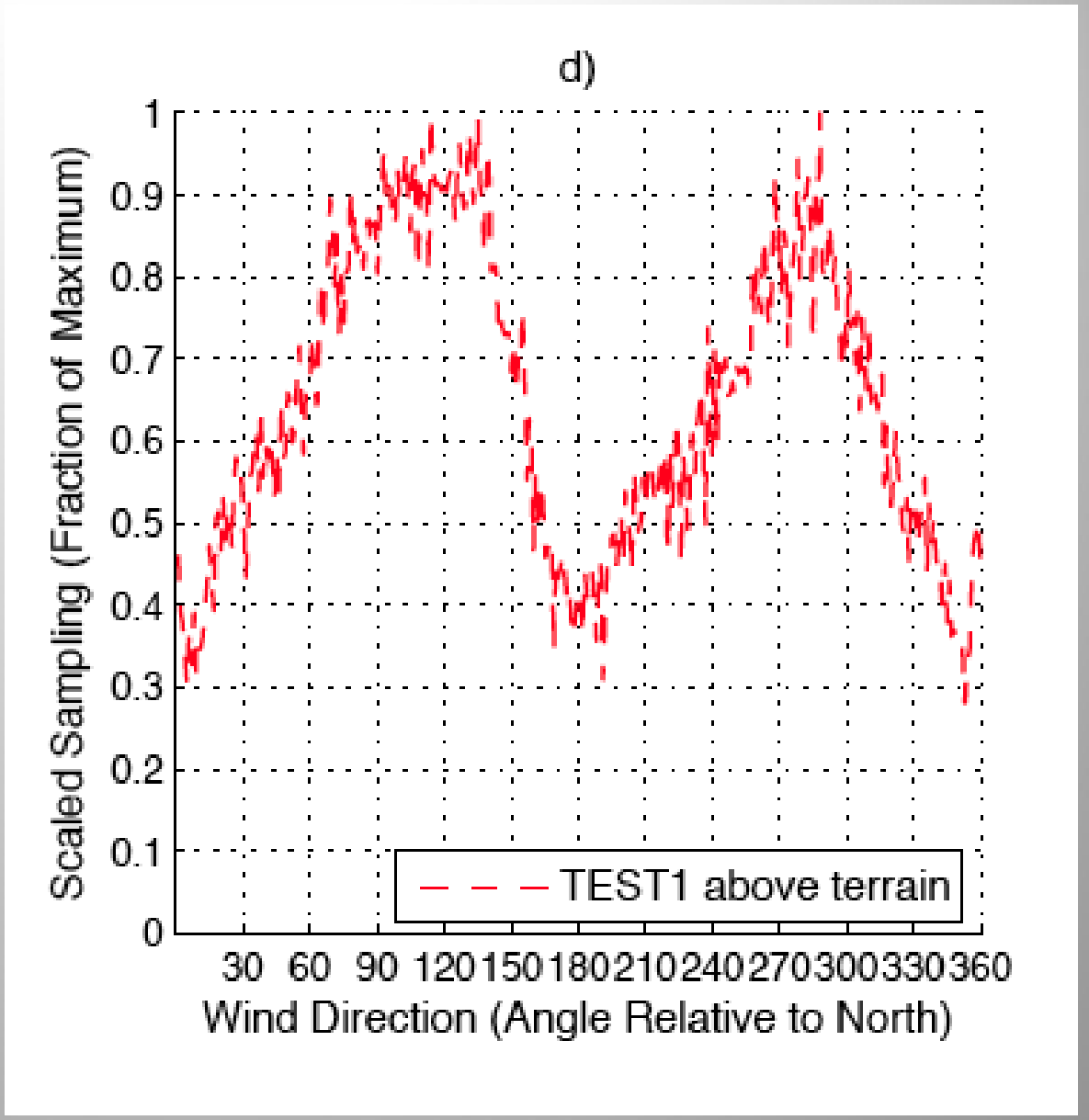


Standard Product

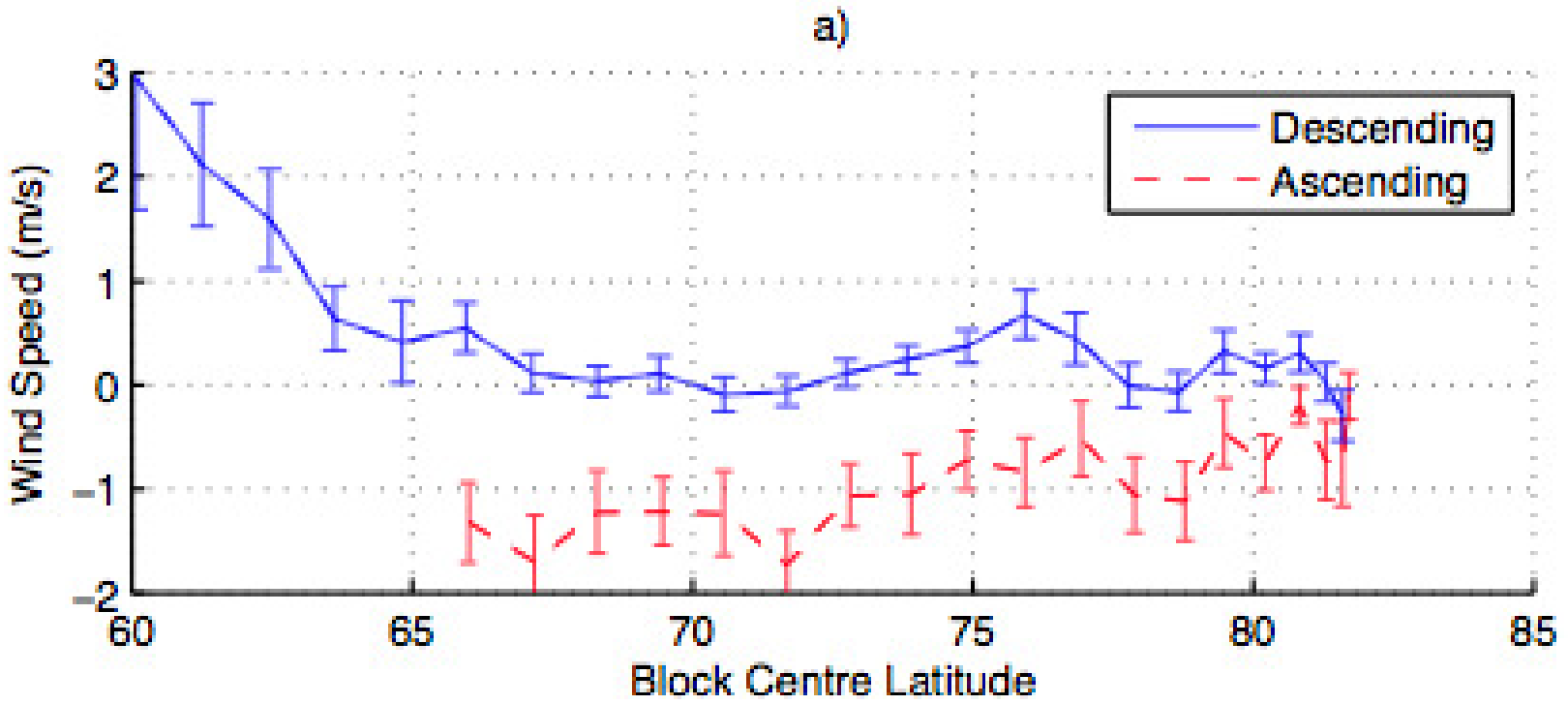
Old and new versions



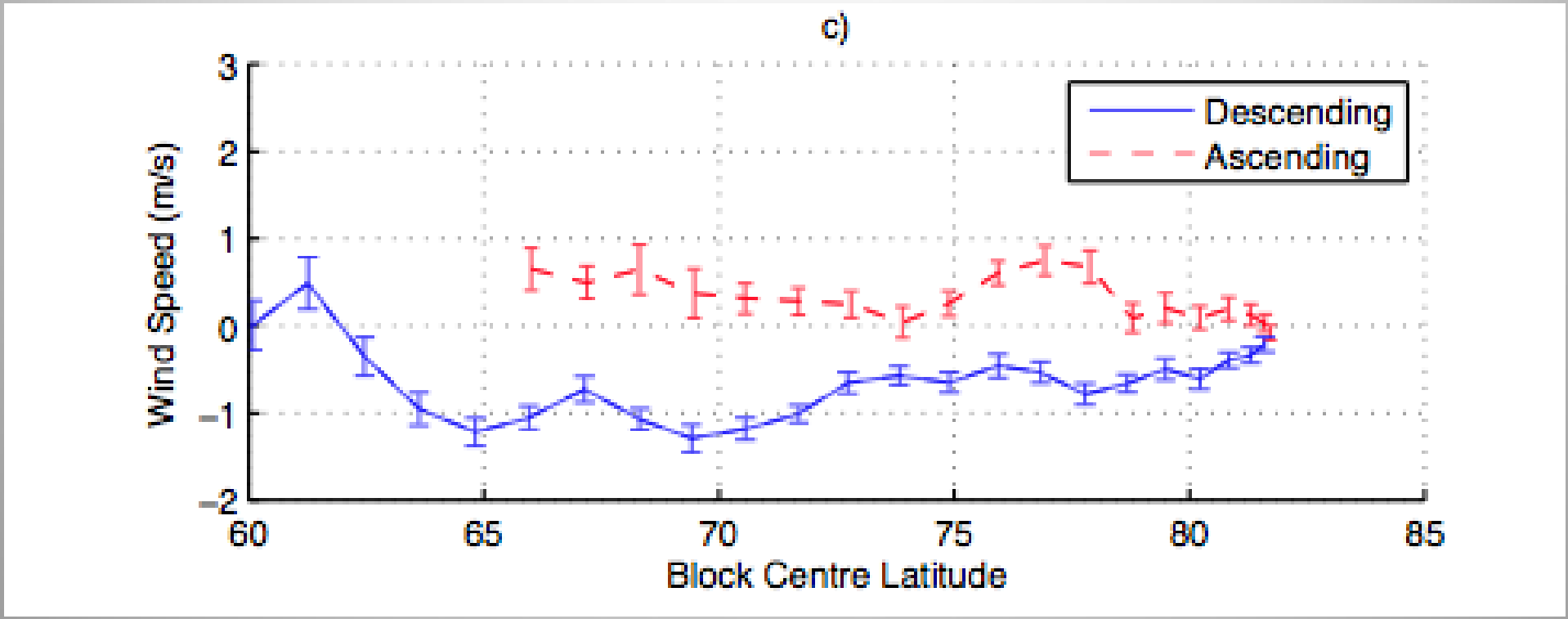
New version,
with land mask
100 orbits, global



Polar surface wind speeds: standard product



Polar surface wind speeds: new product

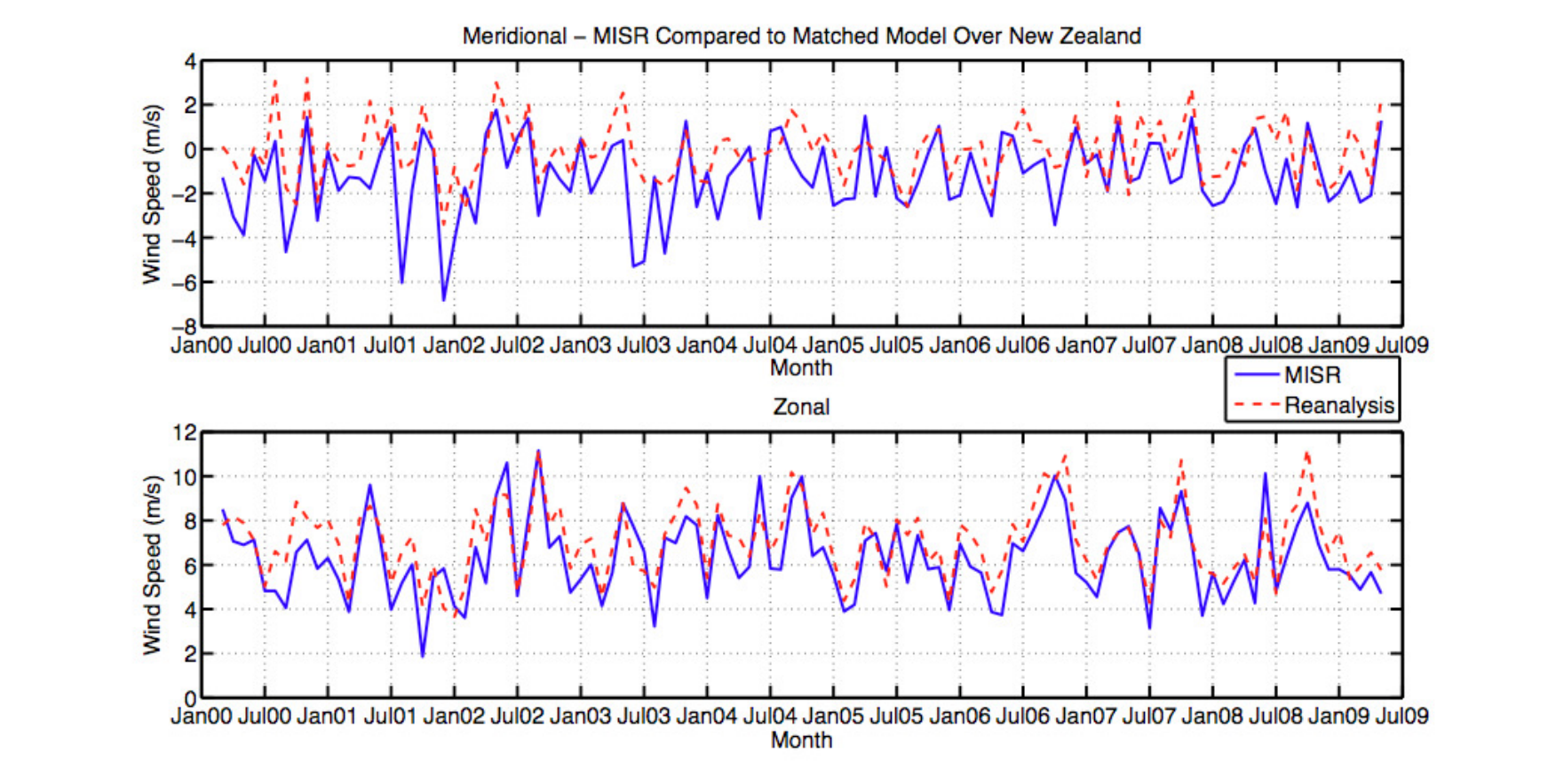


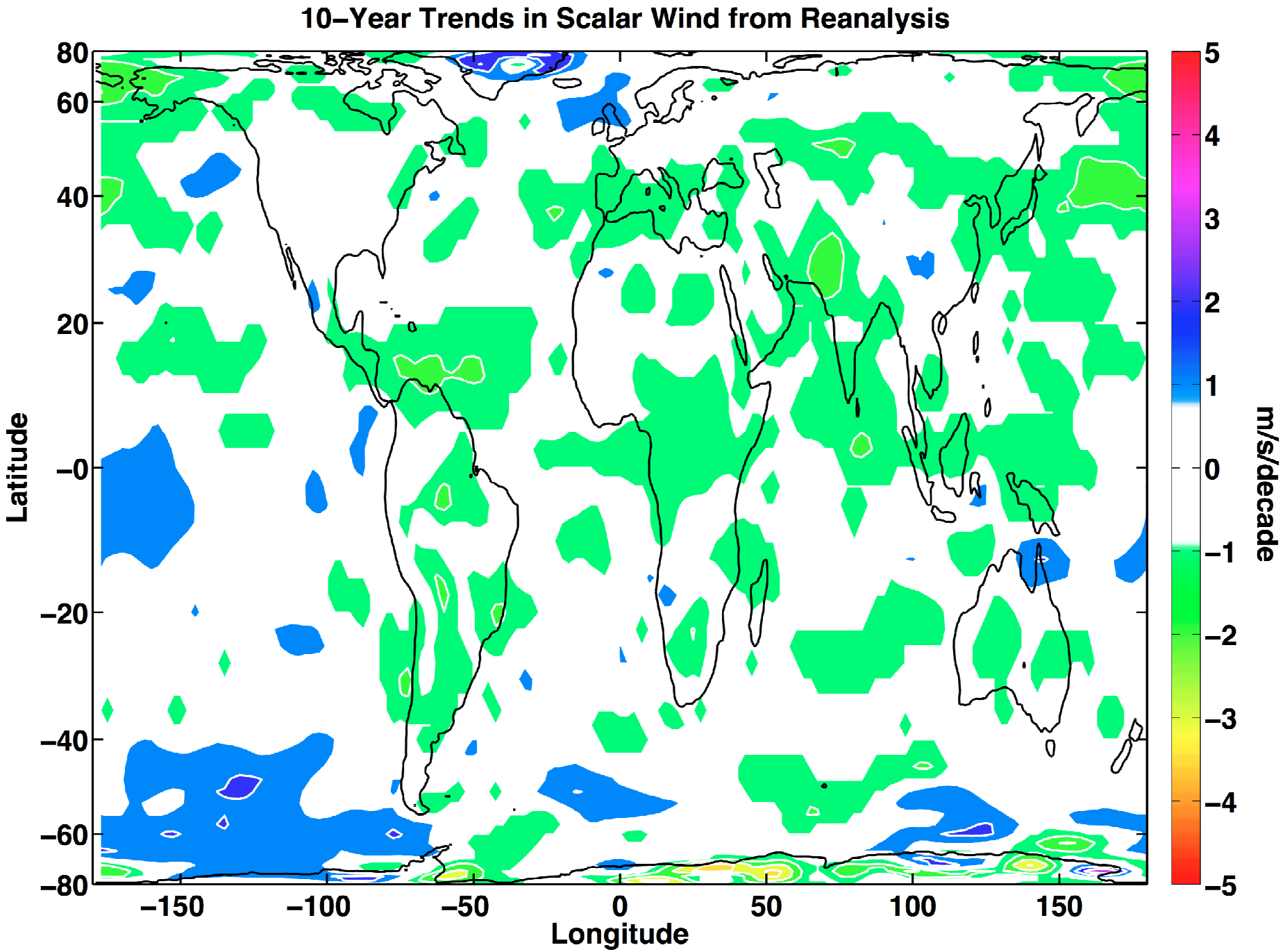
since have found a systematic bias in the along-track wind, ranging from 0 at centre of swath to 3 m/s at swath edge (see Lonitz and Horváth)

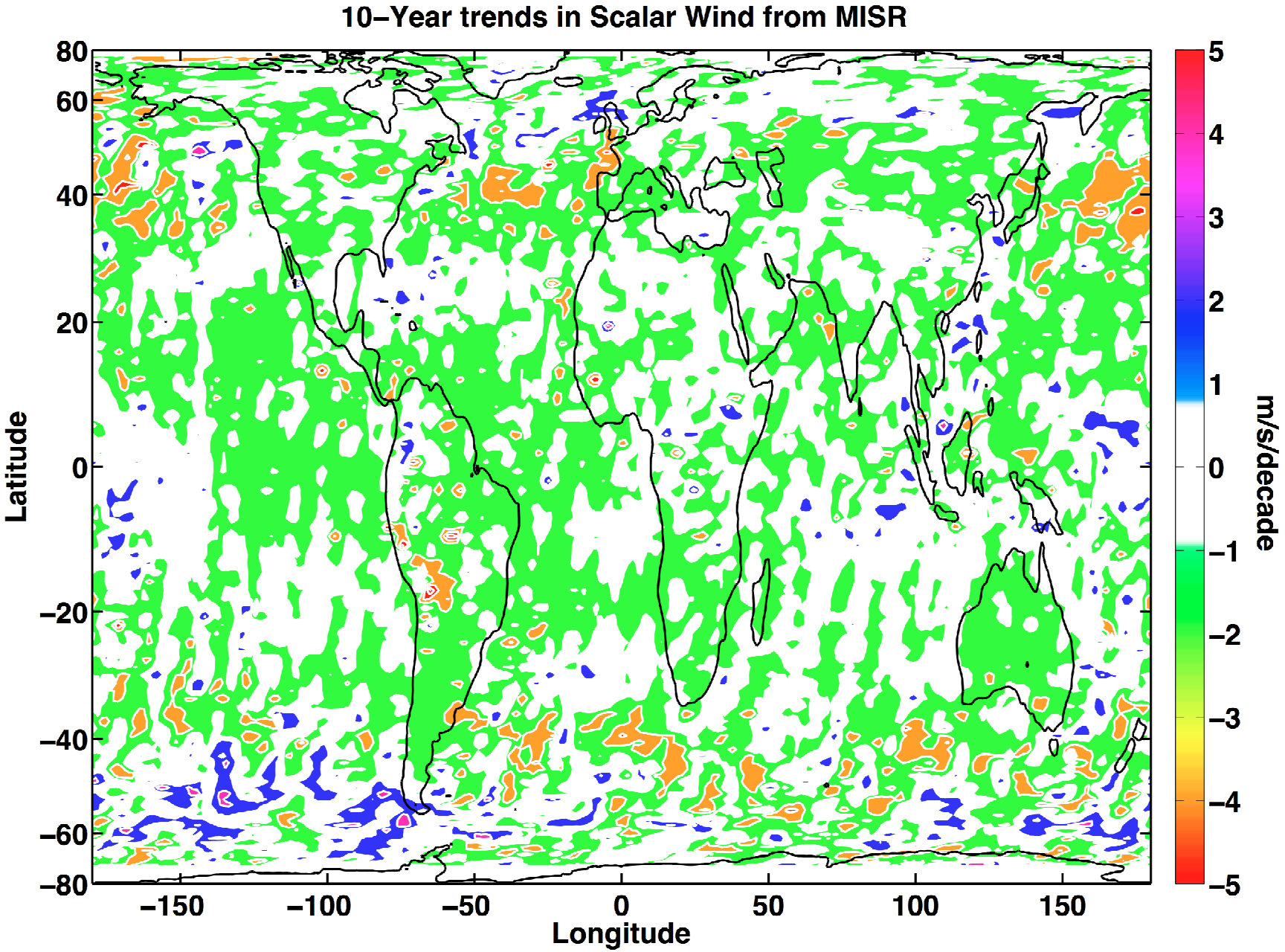
Terra/MISR: 10-year Climate Data Records

- cloud-top heights (from March/2000)
  - cloud fraction by height
  - at 1.1 km
- height-resolved cloud motion vectors (from March/2000)
  - at 70.4 km
- top-of-atmosphere albedos (from May/2000)
  - spectral, equivalent broadband, local, restrictive or expansive too
  - at 35 km
- summarized into 140x300 km blocks, ≈140blocks/orbit, ≈420 orbits/month

New Zealand Average Winds Over Ten Years




10–Year Trends in Scalar Wind from Reanalysis
Latitude
80
60
40
20
–0
–20
–40
–60
–80
–150
–100
–50
0
50
100
150
Longitude
5
4
3
2
1
0
–1
–2
–3
–4
–5
m/s/decade


10−Year trends in Scalar Wind from MISR
Latitude
Longitude
m/s/decade
80
60
40
20
0
−20
−40
−60
−80
−150
−100
−50
0
50
100
150
5
4
3
2
1
0
−1
−2
−3
−4
−5

Summary

- MISR and reanalysis winds differ
  - physical reasons
    - land effects (-3 m/s MISR below 3 km)
    - tropical wind divergence, thunderstorms (-5 m/s reanalysis)
    - resolution (-1.4 m/s reanalysis)
  - model/algorithm deficiencies
    - MISR still has a weak meridional bias depending on swath position (0-3 m/s), turns wind to the South by 5-10° in descending branch of orbit
    - the reanalysis winds appear 2-3 m/s too fast in the Southern Ocean
- Low level (<3 km) winds agree well
  - overall scalar wind speed bias <0.4 m/s
  - vector rms ≈6 m/s

Summary

- MISR algorithms will likely be changed and reprocessed to correct the swath bias
  - then perhaps repeat this study using high resolution ECMWF reanalysis
- the global fluctuation analysis seems to be useful as is, and of interest to climate change studies
  - a lower background wind speed (-1 m/s/decade) is a reasonable consequence of polar warming
  - with less surface wind over ocean, expect higher Bowen ratios
  - the decrease is greater (up to -4 m/s/decade in North Pacific)
  - an increase 2-3 m/s/decade in Southern Oceans
  - MISR and reanalysis generally agree on this, with MISR showing more regional detail