Satellite Observations of Equatorial Planetary Boundary Layer Wind Shear

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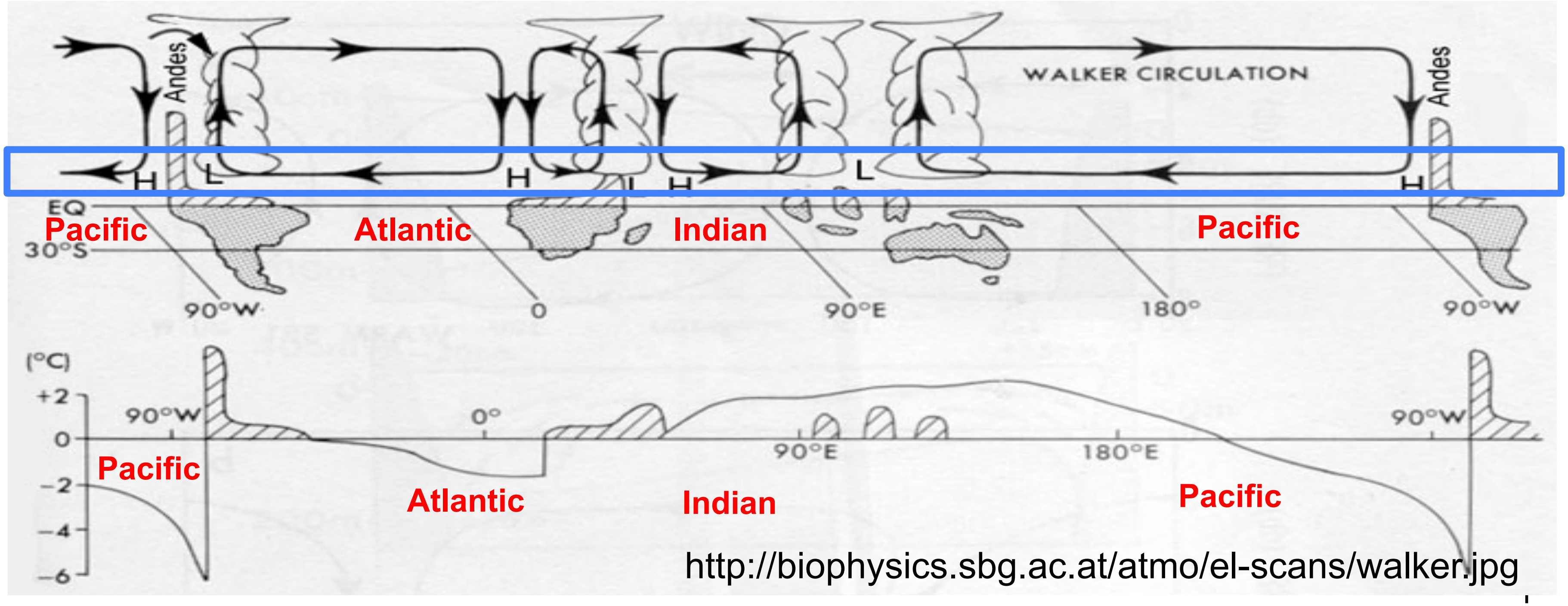
Thanks to Joshua Cheng, Caltech, for computer programming support
Thanks to Kevin Mueller, JPL, for knowing all-things about MISR

Motivation: El Niño, La Niña, and Global Walker Circulation

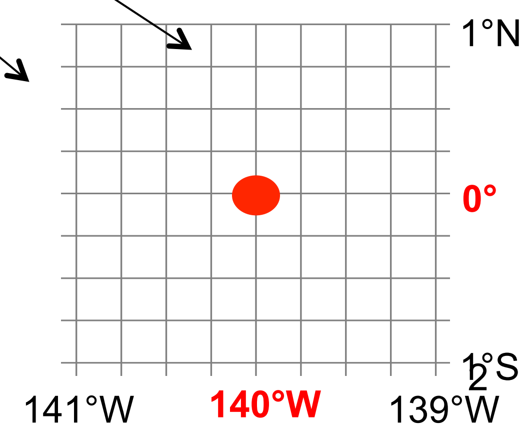


http://biophysics.sbg.ac.at/atmo/el-scans/walker.jpg

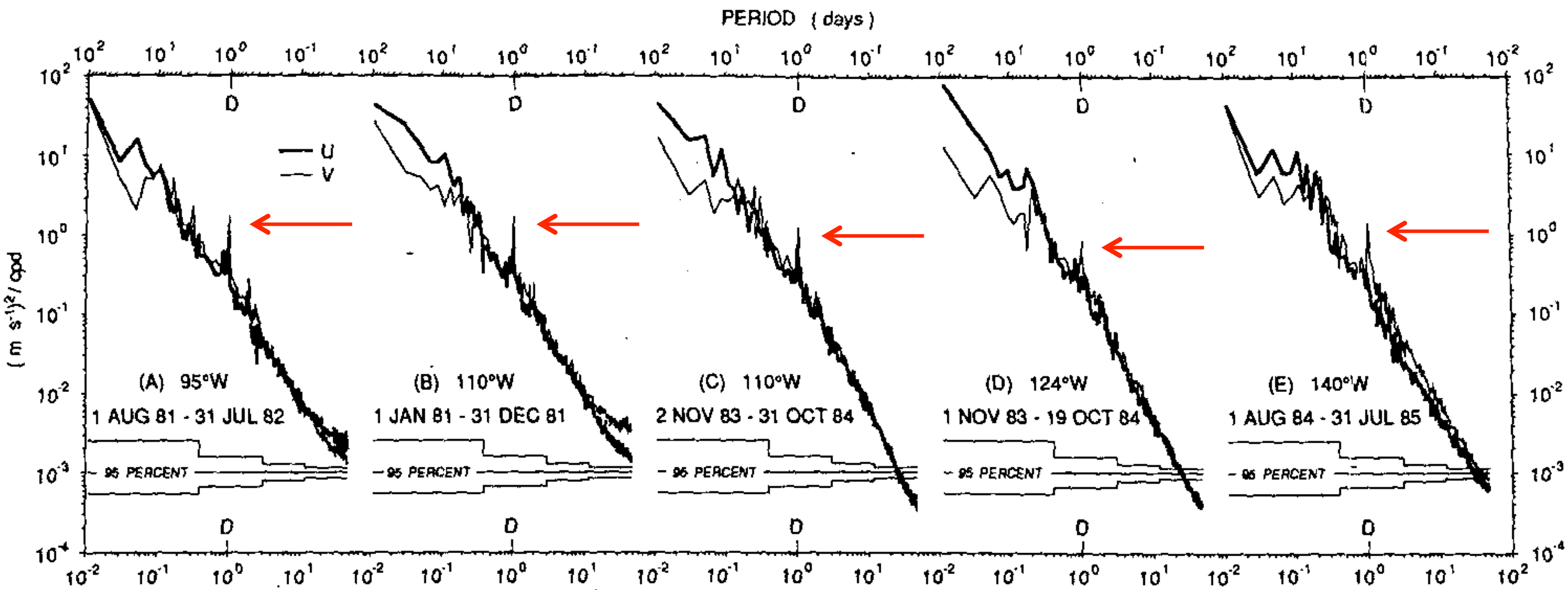
MISR, ASCAT and SeaWinds Dataset Design

	ECT		Global Coverage (days)	Horiz. Res. (km)	Height (m)
SeaWinds	06:00	**Δ diurnal**	1.0	25	10
ASCAT	09:30	**0.35**	1.5	25	10
MISR	10:30	**m s^{-1}**	7-9	17.6	many

- Remote Sensing Systems (RSS) reprocessed ASCAT and SeaWinds datasets with similar methodology and calibration target
- RSS archives ascending & descending speed and direction (U, V) retrievals in 1 day, 0.25°x0.25° cell
- We created 1-day averaged <U>, <V> in 2°x2° tile
  - No rain in 0.25°x0.25° cell
  - No rain in adjacent 0.25°x0.25° cell
- Collocated Datasets, 1 Jun 2007 – 31 Oct 2009
  - N_{TOTAL} = 884 days
  - SeaWinds ~ 550 days
  - ASCAT/SeaWinds ~ 250 days
  - MISR/ASCAT/SeaWinds ~ 30 days



3.8-m Height Wind Vector Variability Along Equator

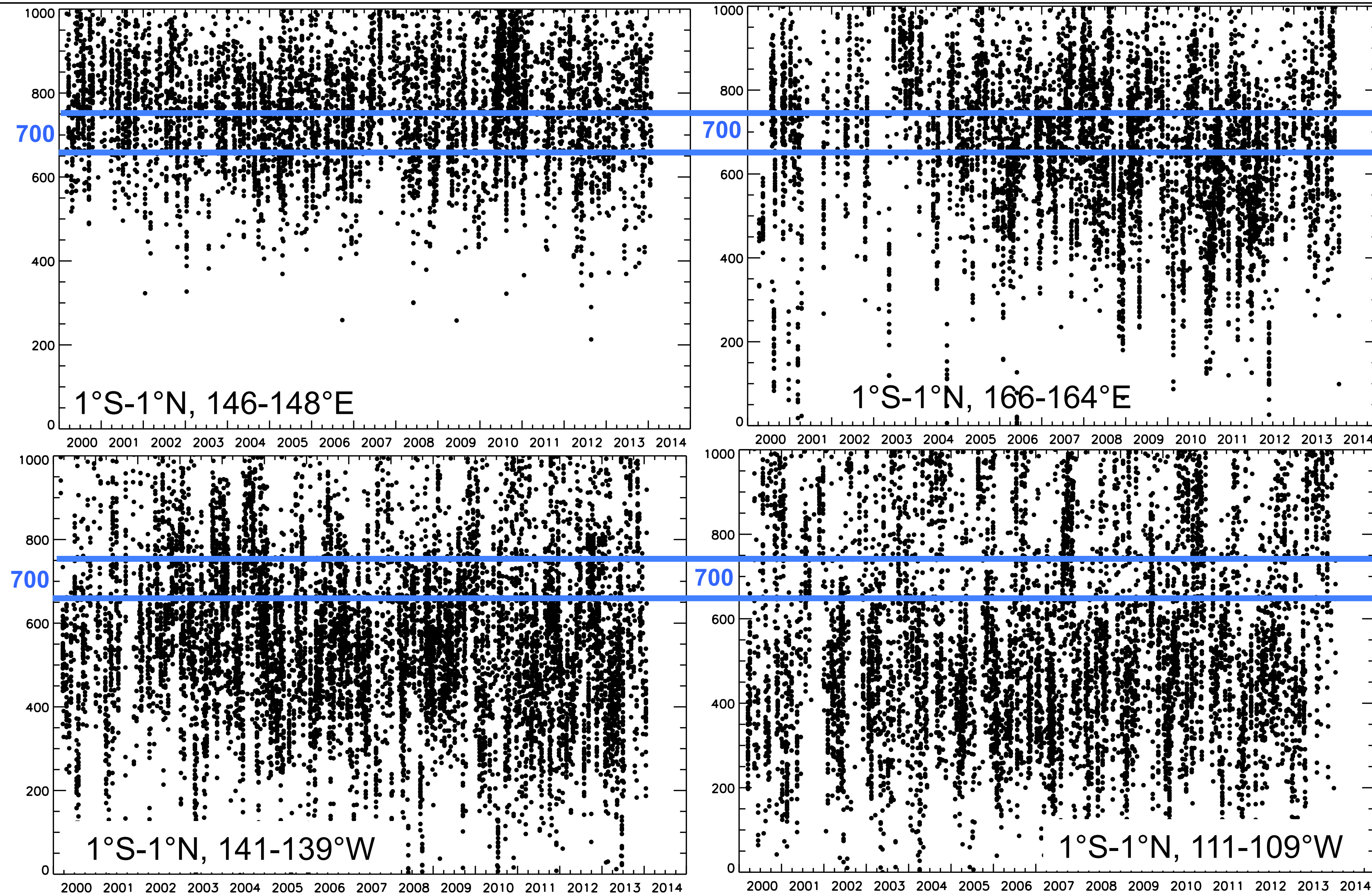


Parameter	95°W	110°W	110°W	124°W	140°W
Start	1 Aug 81	1 Jan 81	1 Nov 83	1 Nov 83	1 Aug 84
Finish	31 Jul 82	31 Dec 81	31 Oct 84	31 Oct 84	31 Jul 85
U_{mean}	−1.8	−3.9	−2.4	−3.4	−6.2
V_{mean}	4.0	2.7	1.7	0.7	0.8
S_{mean}	4.4	4.7	2.9	3.5	6.3
Steadiness	94%	94%	85%	90%	97%
$U_{std\ dev}$	1.7	1.9	1.9	2.1	1.7
$V_{std\ dev}$	1.7	1.6	1.5	1.4	1.7
Slope	−1.4	−1.4	−1.5	−1.6	−1.6
$u_{rms}, f = 1.0$ cpd	0.18	0.18	0.17	0.11	0.13
$v_{rms}, f = 1.0$ cpd	0.32	0.31	0.27	0.23	0.28
$u_{rms}, f > 0.031$ cpd	1.4	1.5	1.4	1.3	1.4
$v_{rms}, f > 0.031$ cpd	1.4	1.4	1.3	1.2	1.4

Halpern (1988)

$\langle S_D \rangle = 0.45$ m s^{-1}

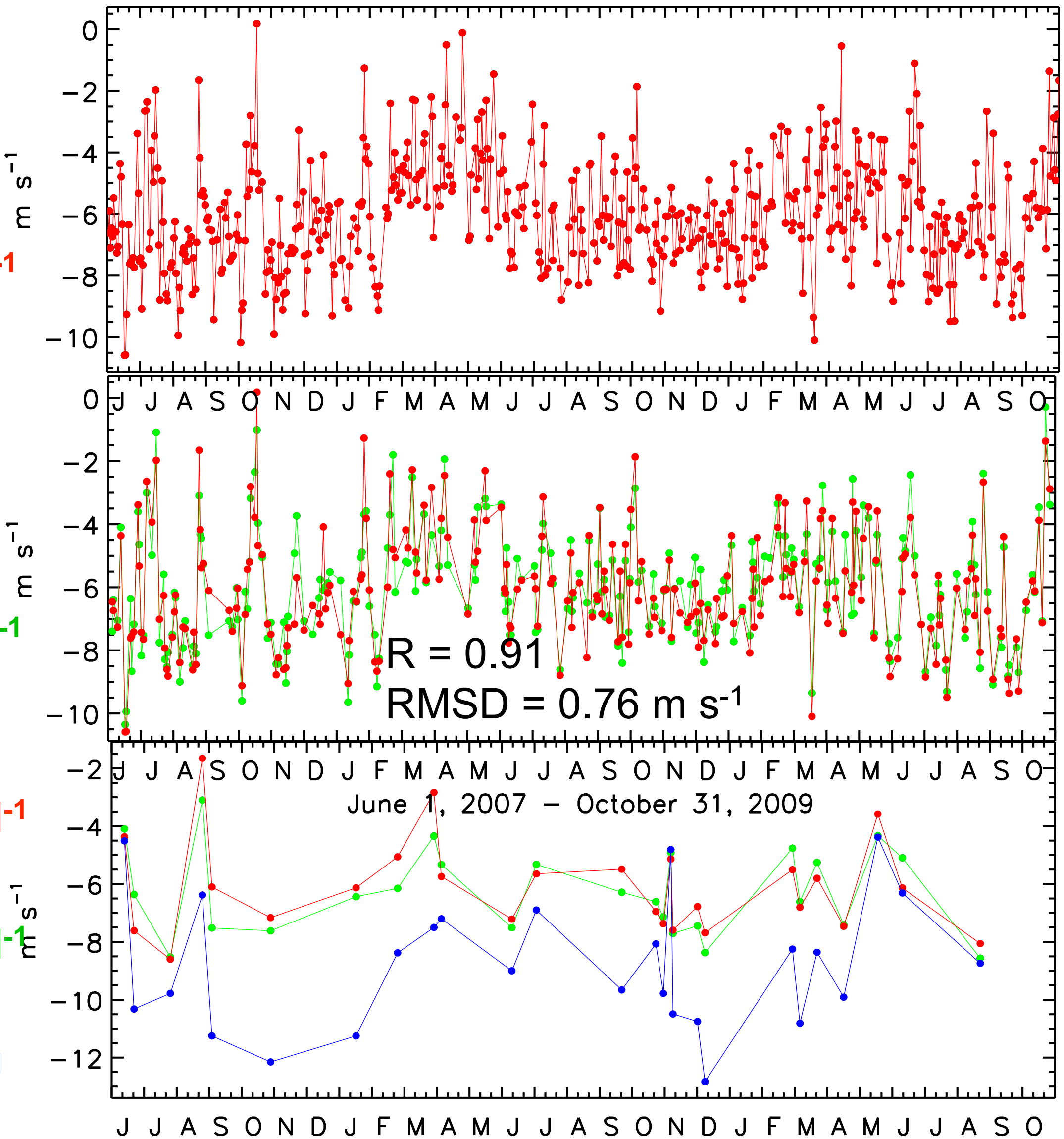
MISR Cloud Top Heights
0-1000 m, 2000-2014



Daily Collocated ASCAT, MISR and SeaWinds U, 1 Jun 2007 – 31 Oct 2009 at 0°, 140°W

SeaWinds **ASCAT** **MISR**

N_{TOTAL} = 884 days



N = 548 days
<n> = 52 retrievals d^{-1}

U = - 6.2 m s^{-1}
U_{StdDev} = 1.8 m s^{-1}

N = 252 days
<n> = 53 retrieval d^{-1}

N = 252 days
<n> = 40 retrievals d^{-1}

U = - 6.1 m s^{-1}
U_{StdDev} = 1.8 m s^{-1}

U = - 6.2 m s^{-1}
U_{StdDev} = 1.8 m s^{-1}

N = 26 days
<n> = 49 retrievals d^{-1}

N = 26 days
<n> = 41 retrievals d^{-1}

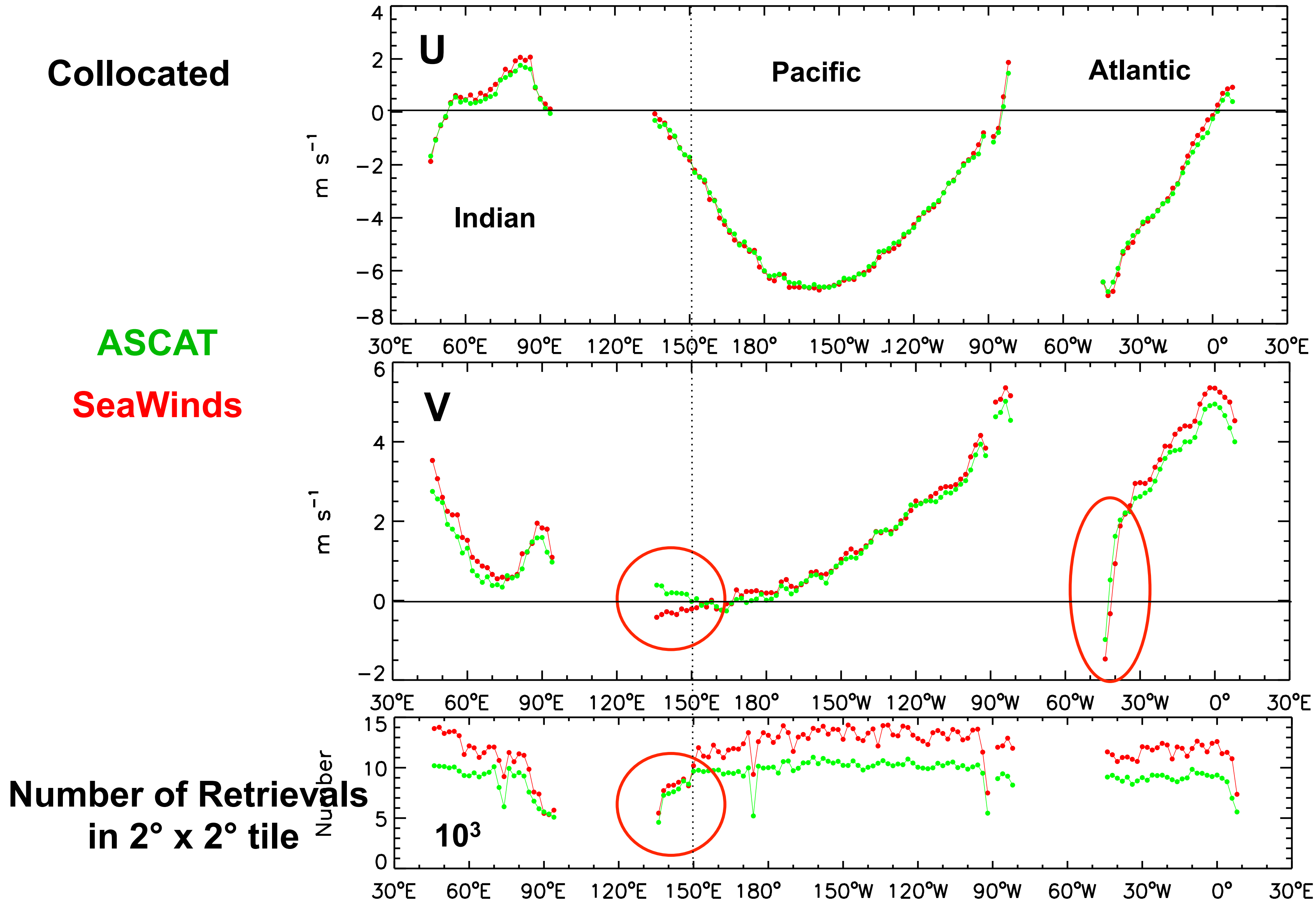
N = 26 days
<n> = 9 retrievals d^{-1}

U = - 6.1 m s^{-1}
U_{StdDev} = 1.6 m s^{-1}

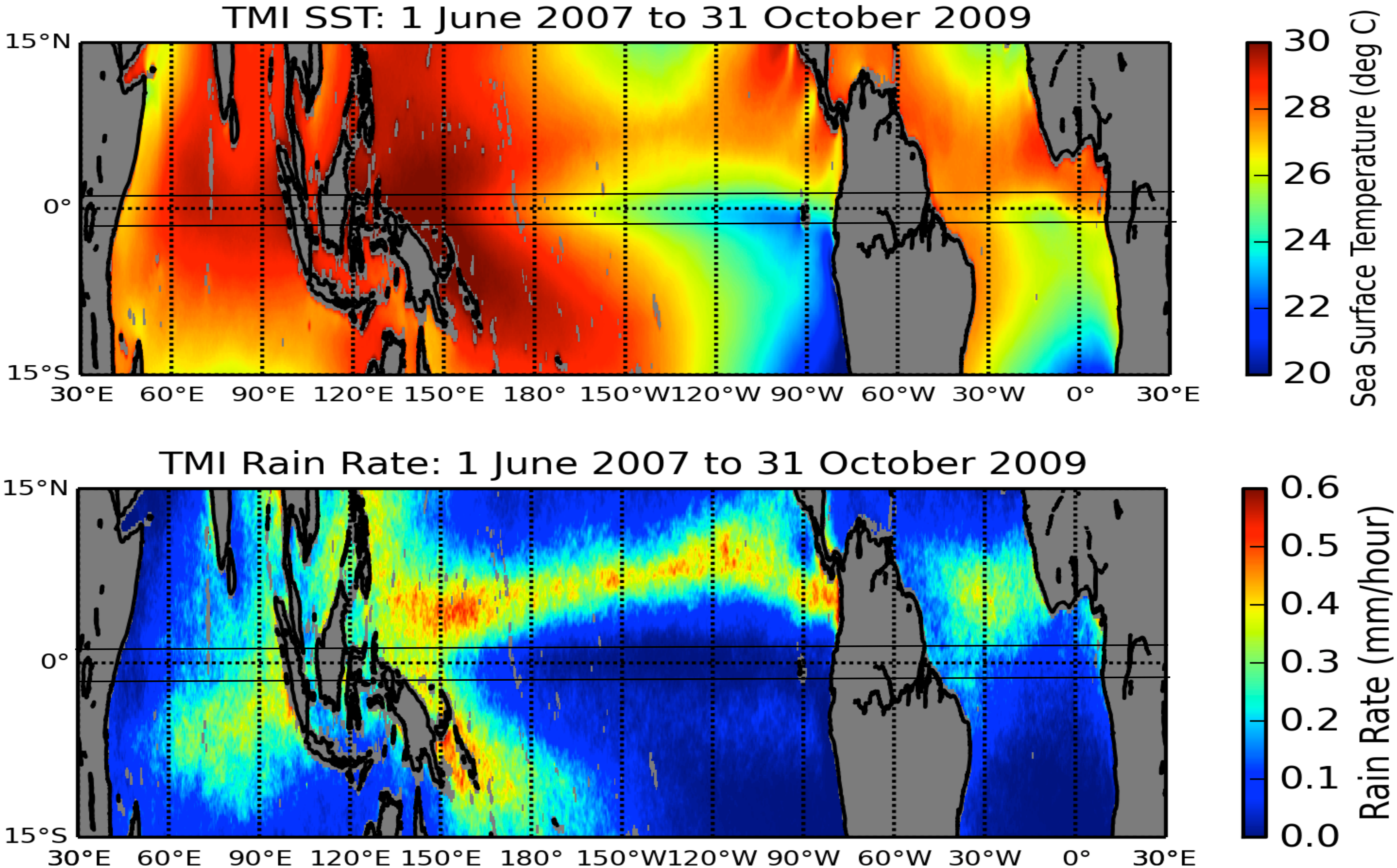
U = - 6.6 m s^{-1}
U_{StdDev} = 1.5 m s^{-1}

U = - 8.6 m s^{-1}
U_{StdDev} = 2.3 m s^{-1}

ASCAT and SeaWinds: **Mean (m s^{-1})**
1°S-1°N, 1 Jun 2007 – 31 Oct 2009



Sea Surface Temperature and Rain Rate



Courtesy of Kyle Hilburn, RSS (May 2014)

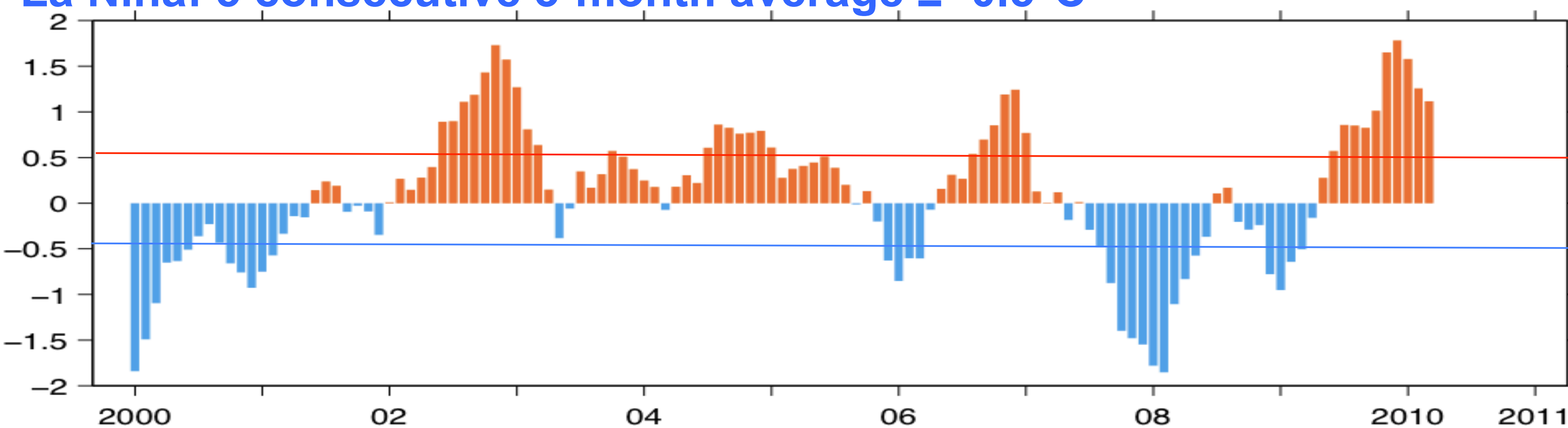
NOAA Oceanic Niño Index (ONI)
SST Anomaly Nino 3.4 (170-120°W, 5°S-5°N)

2000	**-1.7**	**-1.5**	**-1.2**	**-0.9**	**-0.8**	**-0.7**	**-0.6**	**-0.5**	**-0.6**	**-0.6**	**-0.8**	**-0.8**
2001	**-0.7**	**-0.6**	**-0.5**	-0.4	-0.2	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.3
2002	-0.2	0.0	0.1	0.3	**0.5**	**0.7**	**0.8**	**0.8**	**0.9**	**1.2**	**1.3**	**1.3**
2003	**1.1**	**0.8**	0.4	0.0	-0.2	-0.1	0.2	0.4	0.4	0.4	0.4	0.3
2004	0.3	0.2	0.1	0.1	0.2	0.3	**0.5**	**0.7**	**0.8**	**0.7**	**0.7**	**0.7**
2005	**0.6**	0.4	0.3	0.3	0.3	0.3	0.2	0.1	0.0	-0.2	**-0.5**	**-0.8**
2006	**-0.9**	**-0.7**	**-0.5**	-0.3	0.0	0.1	0.2	0.3	**0.5**	**0.8**	**1.0**	**1.0**
2007	**0.7**	0.3	-0.1	-0.2	-0.3	-0.3	-0.4	**-0.6**	**-0.8**	**-1.1**	**-1.2**	**-1.4**
2008	**-1.5**	**-1.5**	**-1.2**	**-0.9**	**-0.7**	**-0.5**	-0.3	-0.2	-0.1	-0.2	**-0.5**	**-0.7**
2009	**-0.8**	**-0.7**	**-0.5**	-0.2	0.2	0.4	**0.5**	**0.6**	**0.8**	**1.1**	**1.4**	**1.6**
2010	**1.6**	**1.3**	**1.0**	**0.6**	0.1	-0.4	**-0.9**	**-1.2**	**-1.4**	**-1.5**	**-1.5**	**-1.5**
2011	**-1.4**	**-1.2**	**-0.9**	**-0.6**	-0.3	-0.2	-0.2	-0.4	**-0.6**	**-0.8**	**-1.0**	**-1.0**

http://www.cpc.ncep/noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

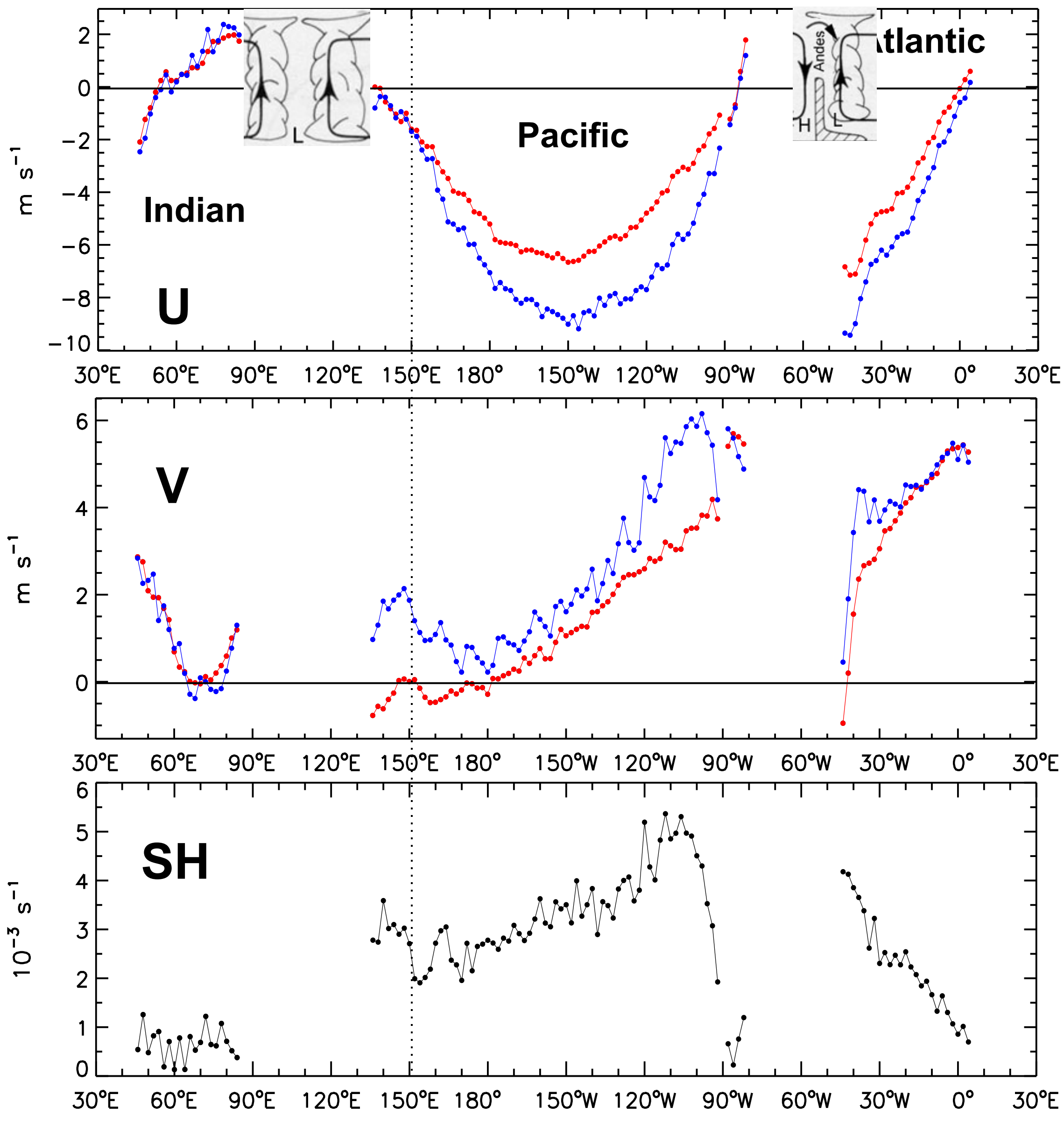
El Niño: 5 consecutive 3-month average ≥ 0.5°C

La Niña: 5 consecutive 3-month average ≤ -0.5°C



http://www.climate.washington.edu/events/2010winter/

Climatological Mean Profiles Along Equator Collocated, 2°x2°, Mar2000 – Jun2011



SeaWinds < Oct 2009
ASCAT ≥ Nov 2009
H = 10 m

MISR
H = 700 m

$SH = [(\Delta U/\Delta Z)^2 + (\Delta V/\Delta Z)^2]^{1/2}$

$\Delta U = U_{700m} - U_{10m}$

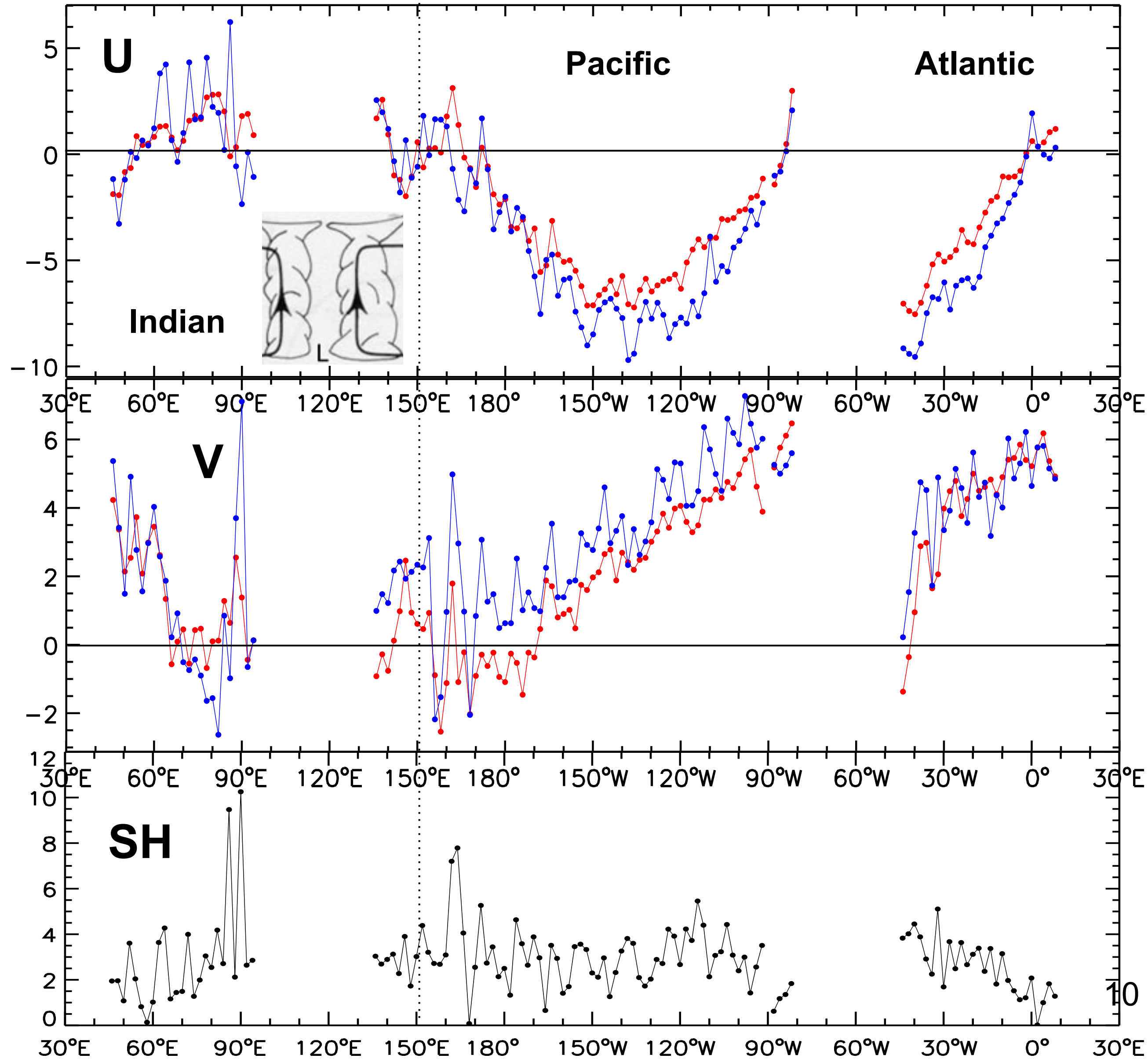
$\Delta V = V_{700m} - V_{10m}$

$\Delta Z = 690m$

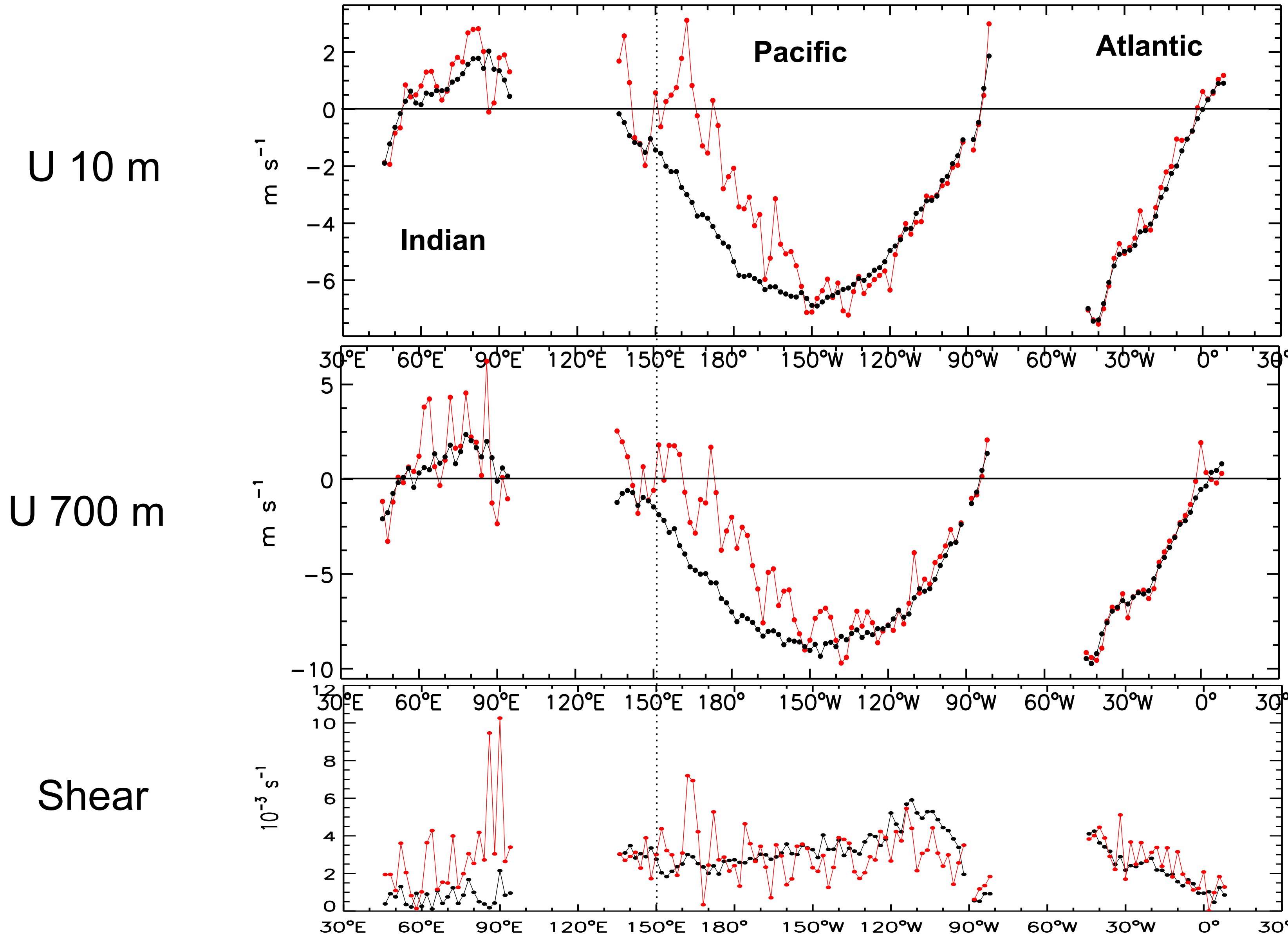
El Niño 2002-2003
<1 May 2002 – 28 Feb 2003>

SeaWinds 10 m

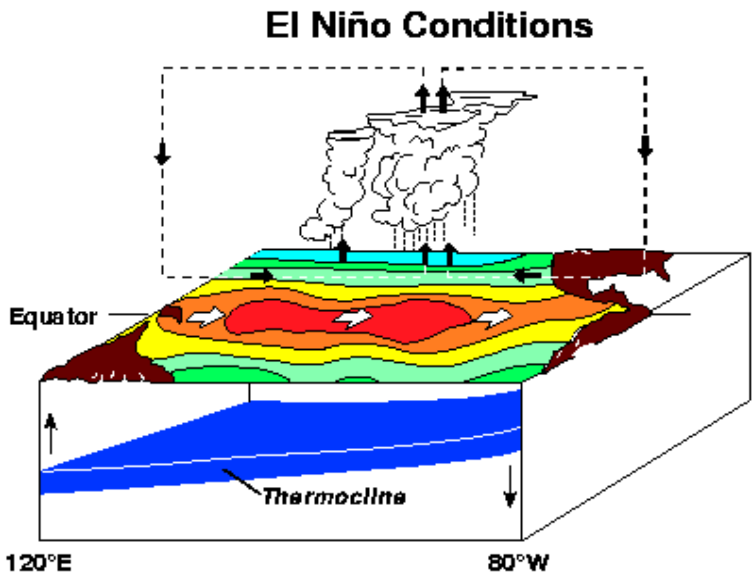
MISR 700 m

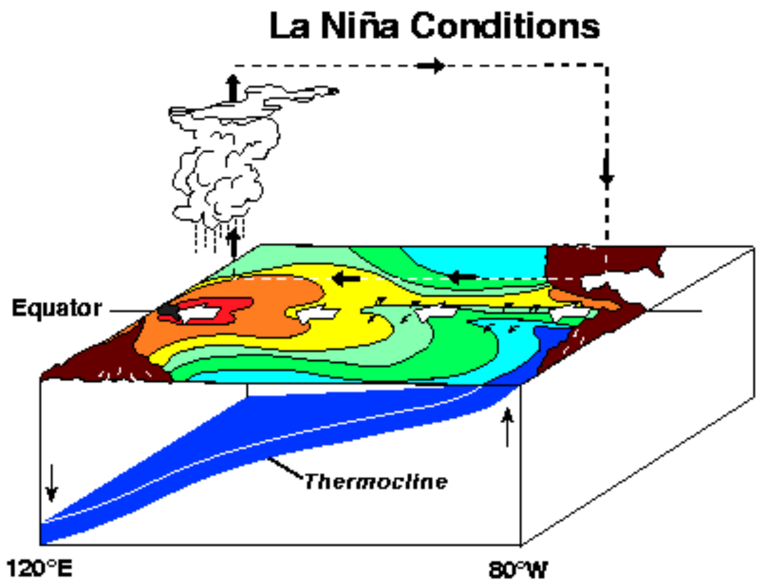


May2002 – Feb2003 El Niño
May-Feb Climatology 2000-2011



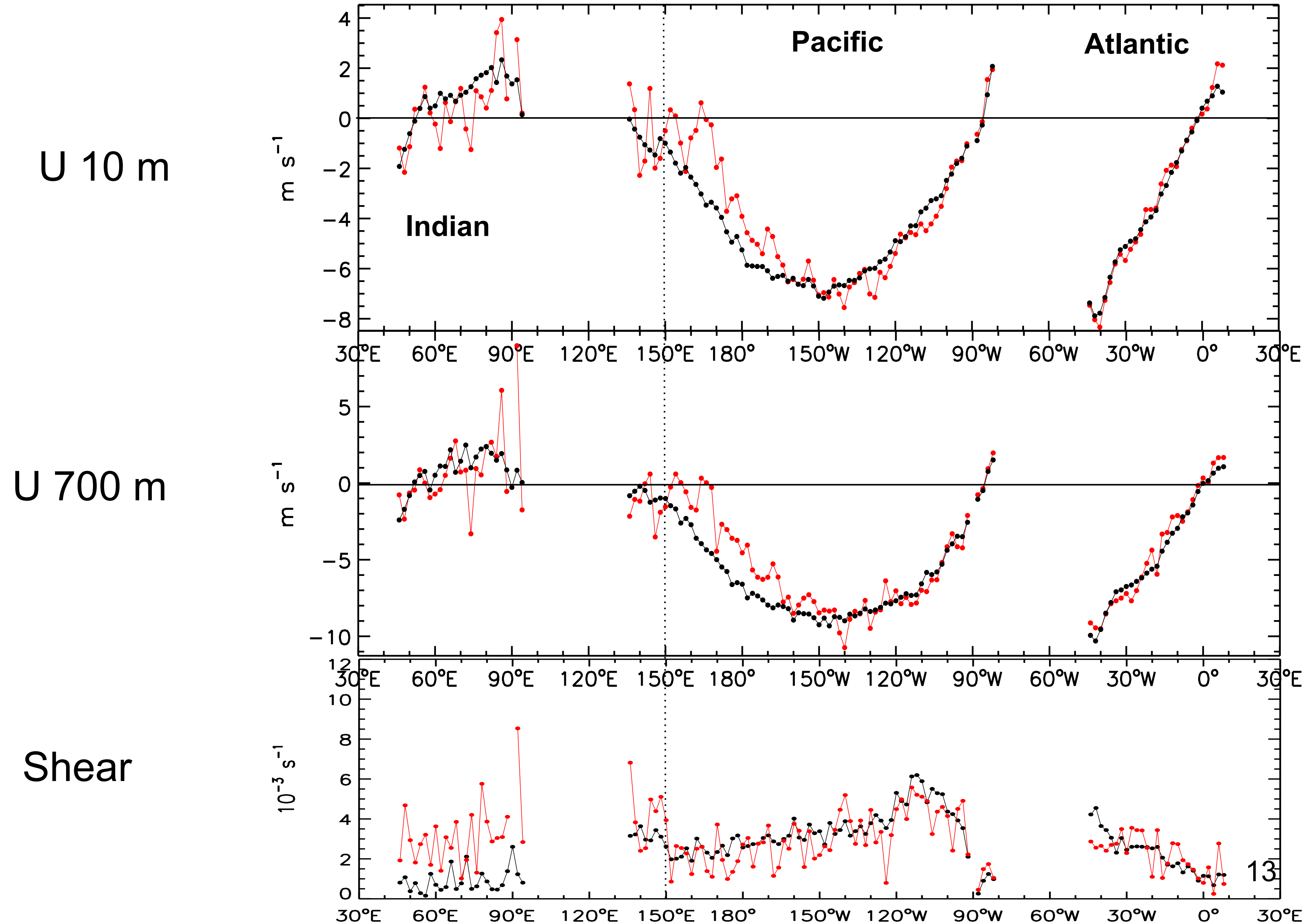
El Niño, La Niña, and Walker Circulation (Pacific)



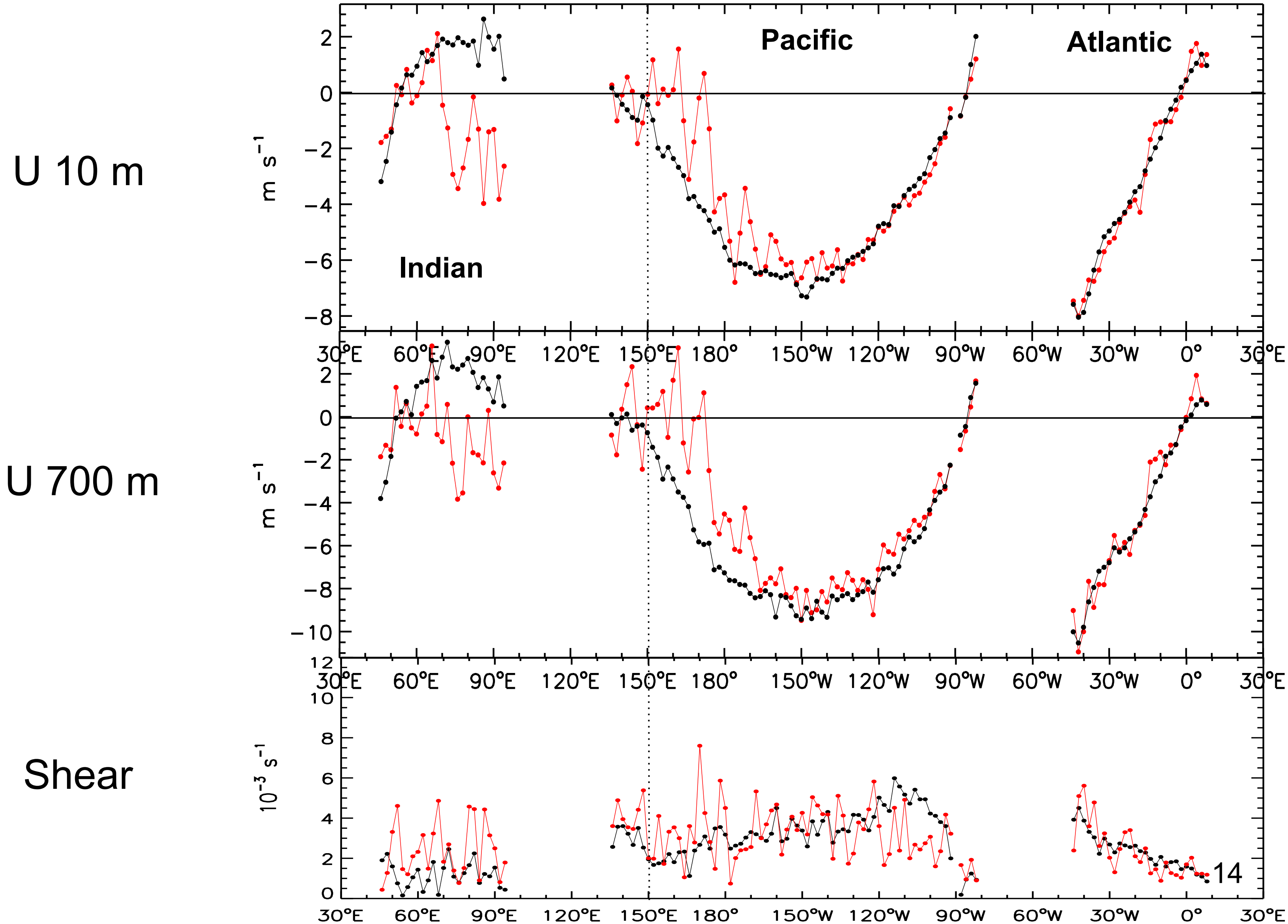


http://www.pmel.noaa.gov/tao/elnino/nino_normal.html

Jul2004-Jan2005 El Niño
Jul-Jan Climatology 2000-2011



Sep2006-Jan2007 El Niño
Sep-Jan Climatology 2000-2011



Summary and Plans

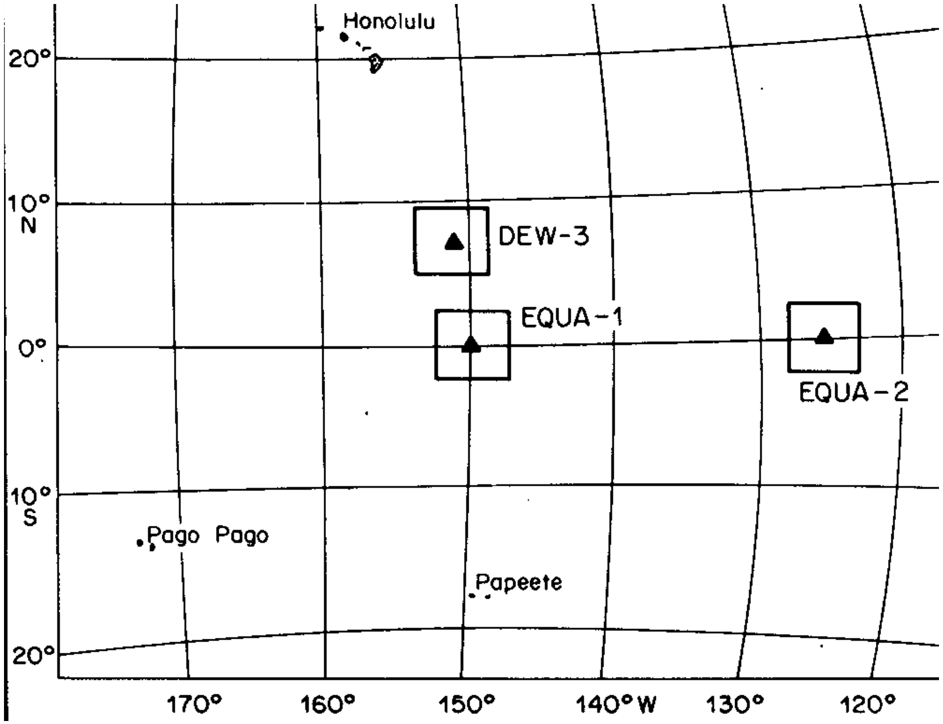
- Influence of El Niño (work in progress)
  - Similar results in each of three events
  - Reduced easterly wind over 150°E – 150°W (~ 60° in west Pacific)
  - Reduced westerly wind in Indian
  - No change in easterly wind over Atlantic and east Pacific
  - Reduced southerly wind over 150°E – 150°W (~ 60° in west Pacific)
  - Shear increased in Indian; no change elsewhere
- Analyze influence of La Niña during 2000-2011 (work in progress)
- Analyze ERS-1 (1991-2000) ocean vector wind data
  - Capture Δ longitudinal region in west Pacific of reduced easterly wind during 1997-1998 El Niño (= May 1997 – Apr 1998, 12 months)
  - Capture Δ longitudinal region in west Pacific of enhanced easterly wind during 1998-2001 La Niña (= Jul 1998 – Mar 2001, 30 months)
- Analyze upper troposphere zonal return flow of Walker Circulation
- Analyze ECMWF, NCEP, JMA, UKMO, etc.
  - Consistency with observations
  - Estimate aliasing along vertical and in time

- Analyze geostationary satellite low-level AMV

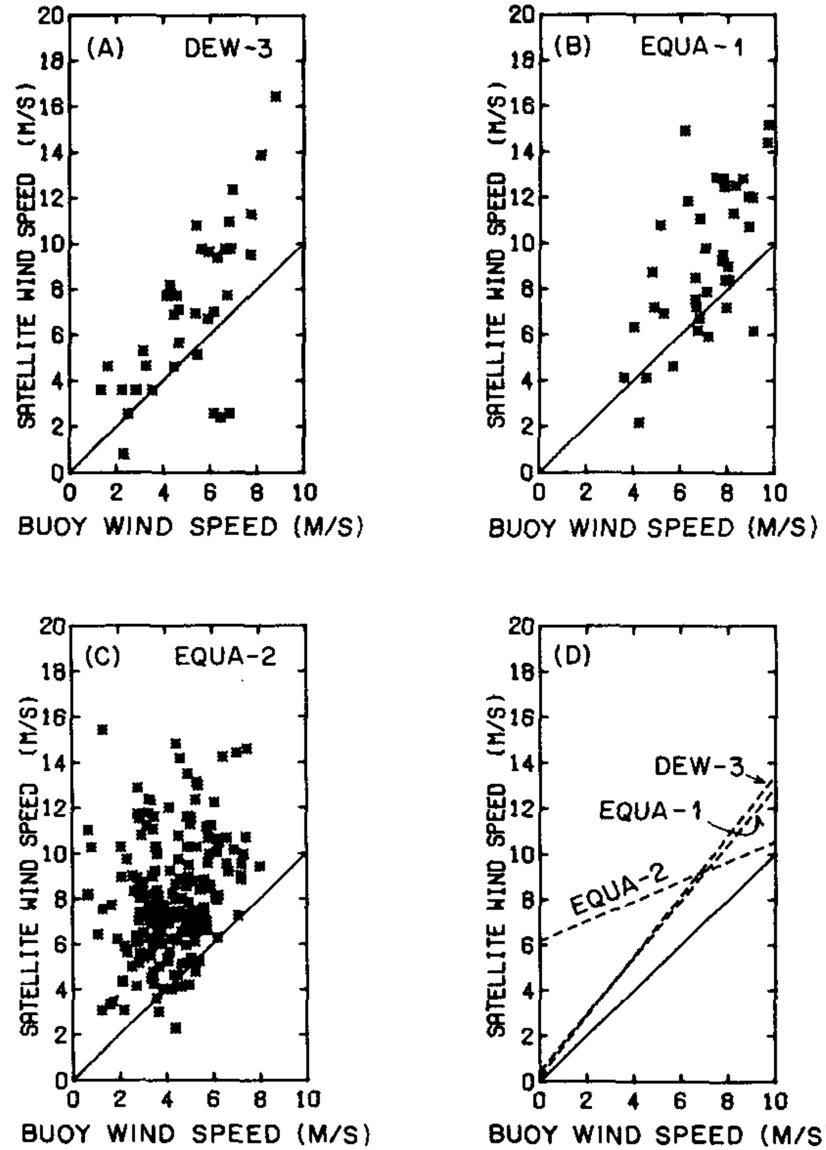
Questions?


תודה
Dankie
Gracias
شكراً
Спасибо
Merci
Takk
Köszönjük
Terima kasih
Grazie
Dziękujemy
Dėkojame
Ďakujeme
Vielen Dank
Paldies
Kiitos
Täname teid
谢谢
Thank You
Tak
感謝您
Obrigado
Teşekkür Ederiz
감사합니다
Σας ευχαριστούμε
ขอบคุณ
Bedankt
Děkujeme vám
ありがとうございます
Tack

Historical Curiosity



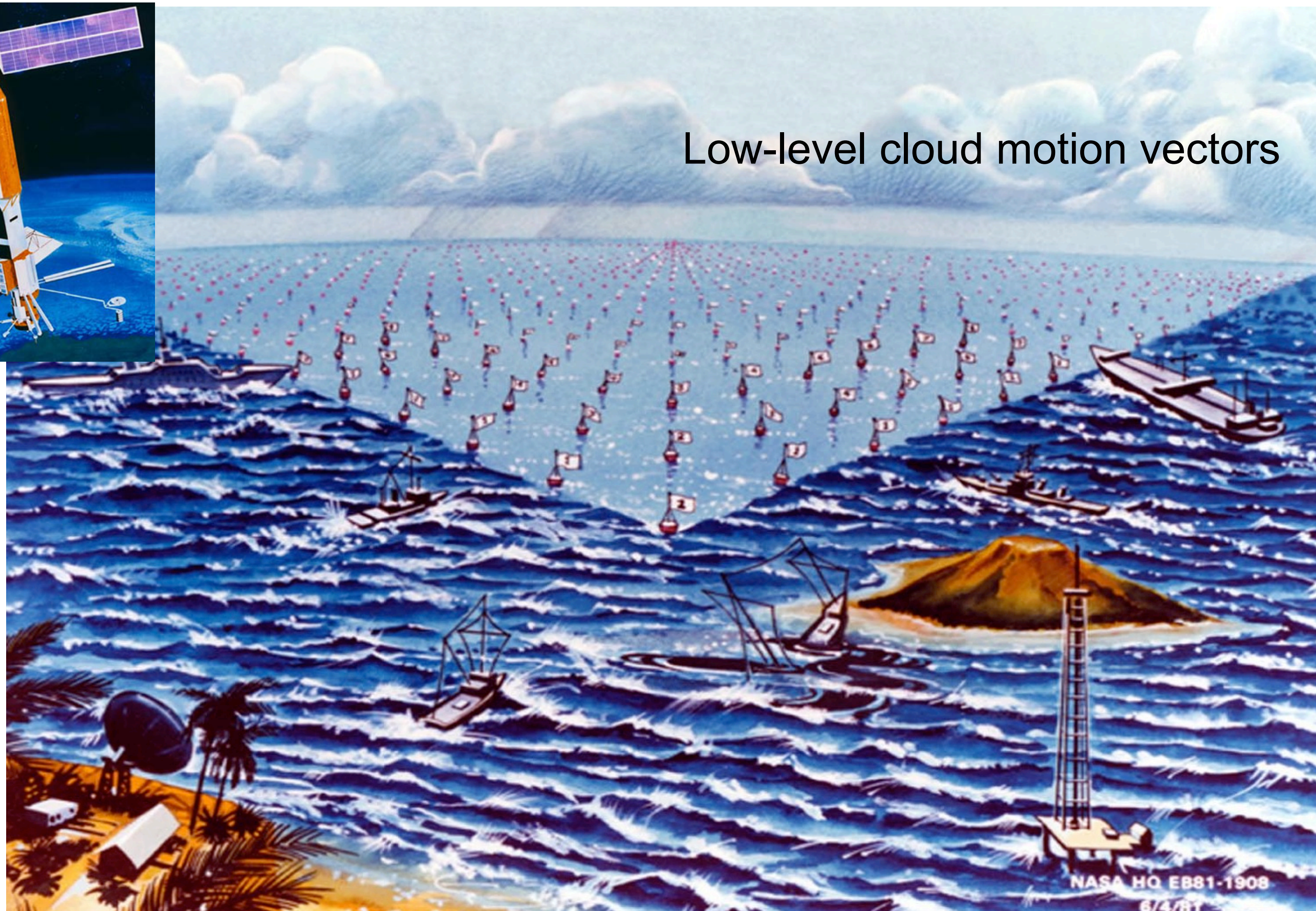
- 3-m height, 15-min vector-averaged U, V wind components
- DEW-3: 2 Aug – 29 Sep 1976
- EQUA-1: 5 Aug – 9 Sep 1976
- EQUA-2: 4 Apr – 11 Jul 1977
- 5° x 5° "search" region for NOAA NESS GOES low-level CMV



Halpern (1978)

Potential Network for Global In-situ Ocean Vector Wind Measurements (4 April 1981)

SeaSat
28 Jun –
10 Oct
1978



Buoy Diagram Courtesy of Stanley Wilson