The Madden–Julian Oscillation and Equatorial Waves in Upper Tropospheric Water Vapor

Carl J. Schreck, III (CICS-NC)
James Kossin (RSAD)
Lei Shi (RSAD)

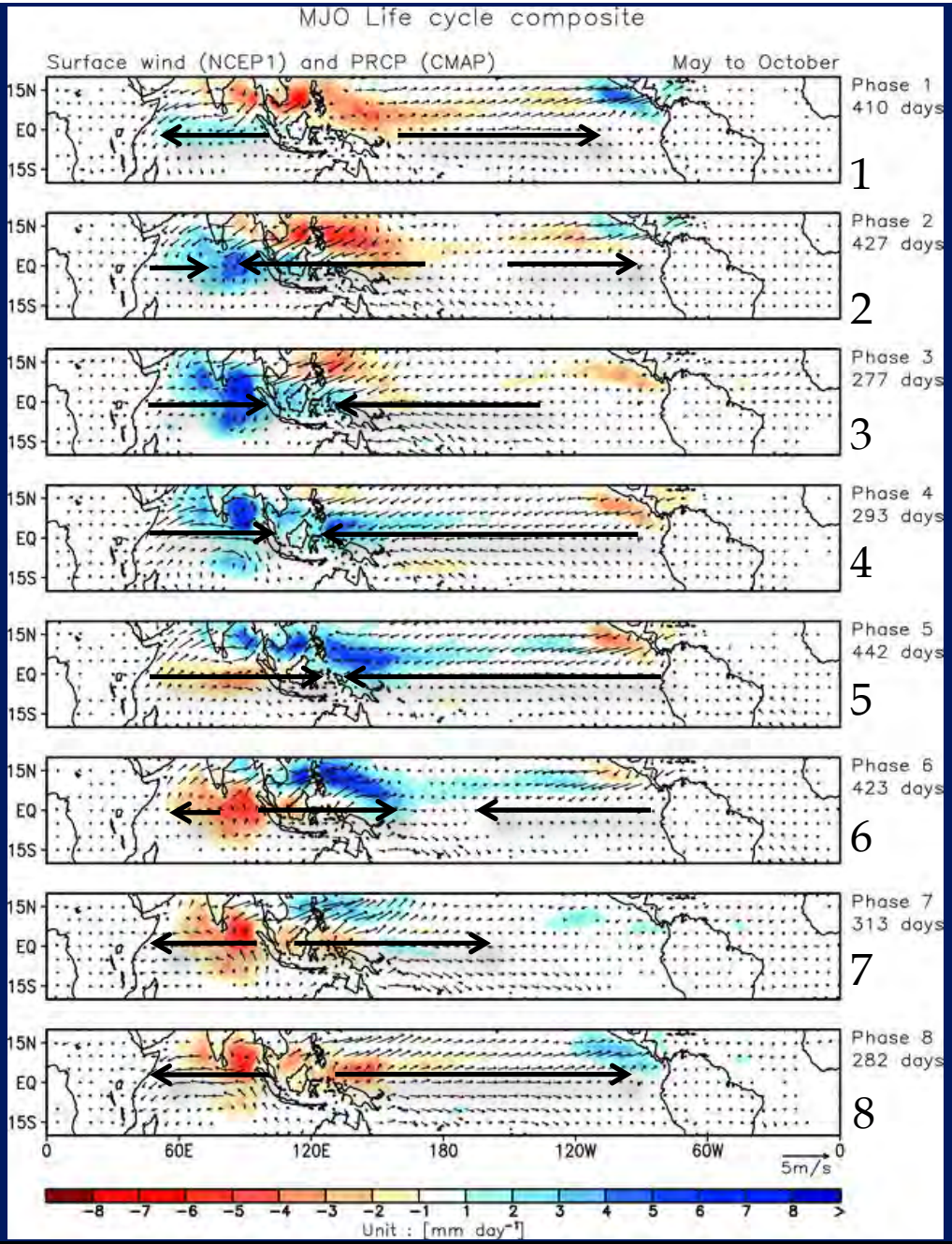
Outline

- Background on dominant modes of tropical intraseasonal variability:
  - The Madden–Julian Oscillation (MJO)
  - Kelvin waves
  - Equatorial Rossby (ER) waves
- Comparison between upper tropospheric water vapor (UTWV) and outgoing longwave radiation (OLR)
- Monitoring and Prediction

The Madden Julian Oscillation

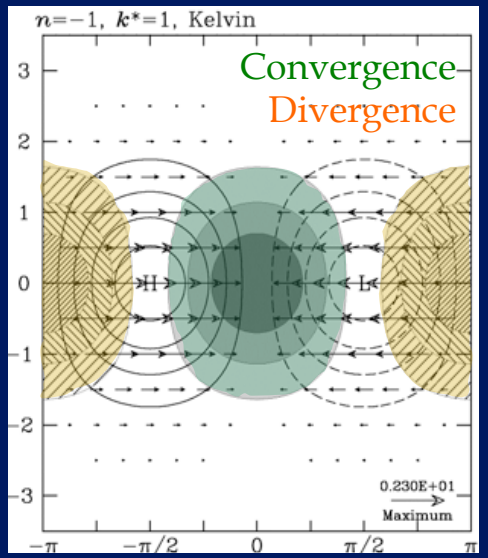
- Each phase is ≈6 days apart
- Eastern Hemisphere dominates
- Weaker signal in eastern North Pacific
  - But important for hurricanes!

Propagation:	Eastward
Phase speed:	3–6 m s^{-1}
Period:	30–60 days
Wavelength:	Planetary

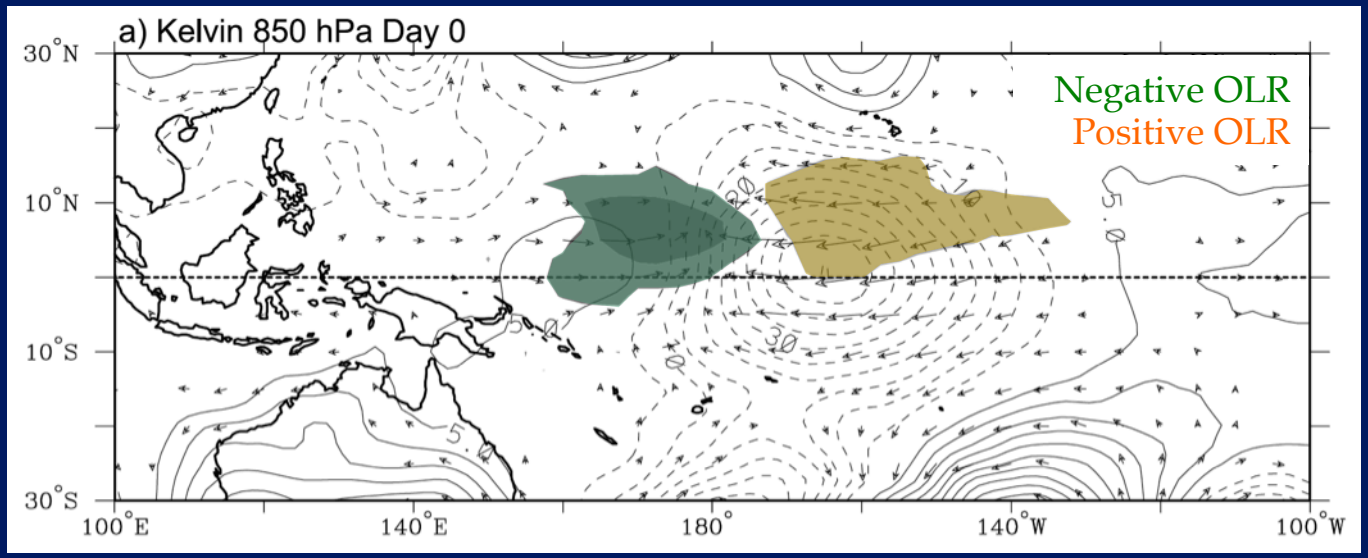


Anomalies of rainfall (shading) and surface winds (CLIVAR MJO Working Group 2009, J. Climate)

Kelvin Waves



Matsuno (1966)

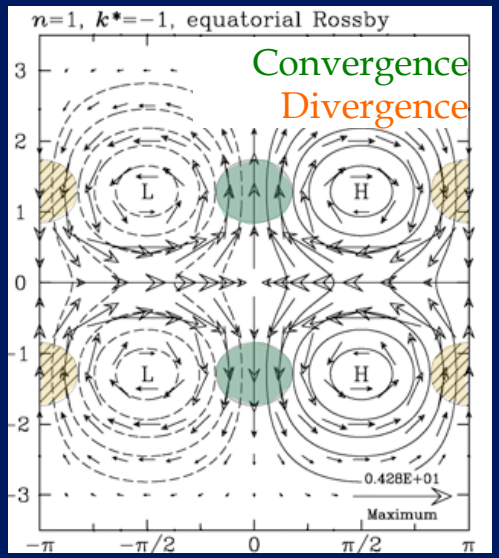


Kiladis et al. (2009)

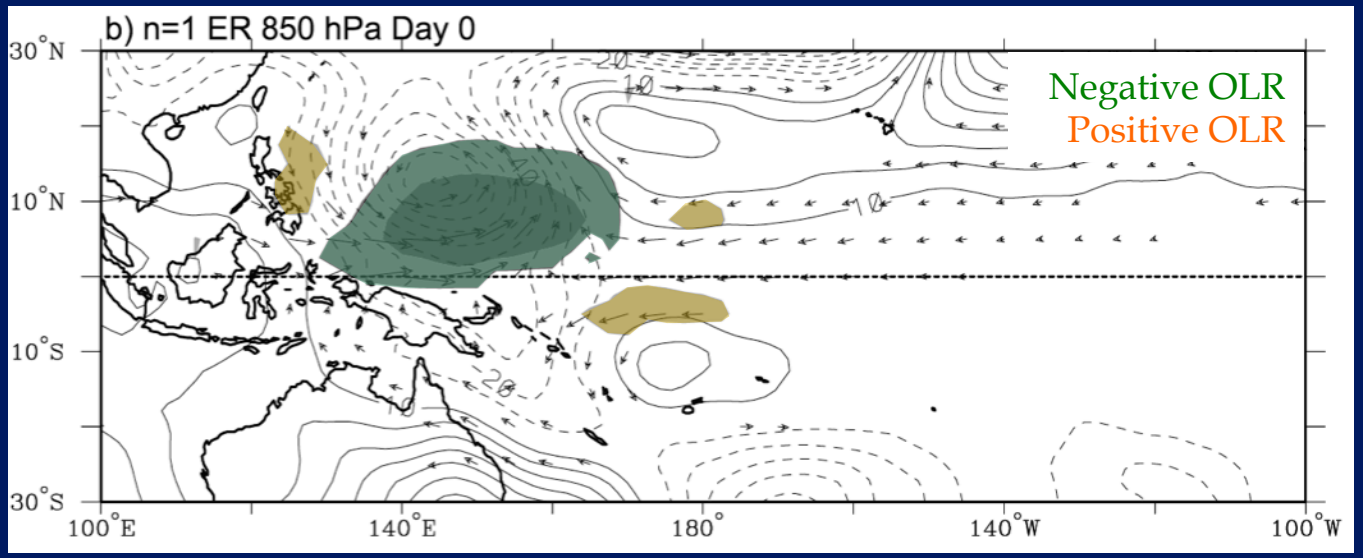
- Alternating westerlies and easterlies on the equator
- Enhanced convection where low-level winds converge

Propagation:	Eastward
Phase speed:	10–20 m s^{-1}
Period:	3–10 days
Wavelength:	2000–4000 km

Equatorial Rossby (ER) Waves



Matsuno (1966)



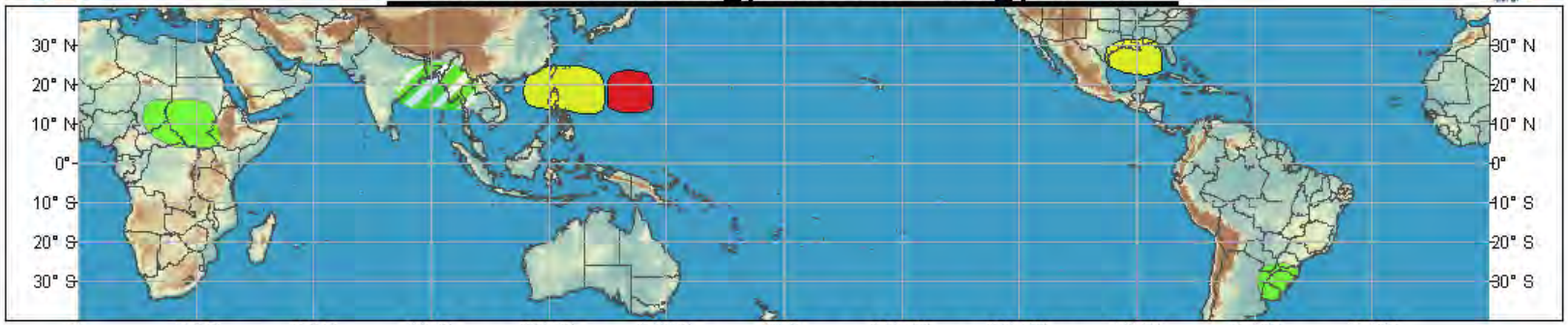
Kiladis et al. (2009)

- Twin circulations straddle the equator
- Enhanced convection in low-level poleward flow and near equatorial westerlies

Propagation:	Westward
Phase speed:	4–10 m s^{-1}
Period:	10–40 days
Wavelength:	4000–15 000 km

Global Tropical Hazards/Benefits Assessment - Climate Prediction Center

Week 1 - Valid: Aug, 10 2011 - Aug, 16 2011



Week 2 - Valid: Aug, 17 2011 - Aug, 23 2011

Produced: 08/09/2011

	Confidence: High	Confidence: Moderate	
Tropical Cyclone Formation			Development of a tropical cyclone that eventually reaches tropical storm strength.
Above-average rainfall			Weekly total rainfall in the upper third of the historical range.
Below-average rainfall			Weekly total rainfall in the lower third of the historical range.
Above-normal temperatures			7-day mean temperatures in the upper third of the historical range.
Below-normal temperatures			7-day mean temperatures in the lower third of the historical range.

Product is updated once per week. The product targets broad scale conditions integrated over a 7-day period for US interests only. Consult your local responsible forecast agency.

中央氣象局 Central Weather Bureau · UNIVERSITY AT ALBANY State University of New York · Australian Government Bureau of Meteorology · NPS

The UNIVERSITY of NORTH CAROLINA A Multi-Campus University · NC State University · cics.nc

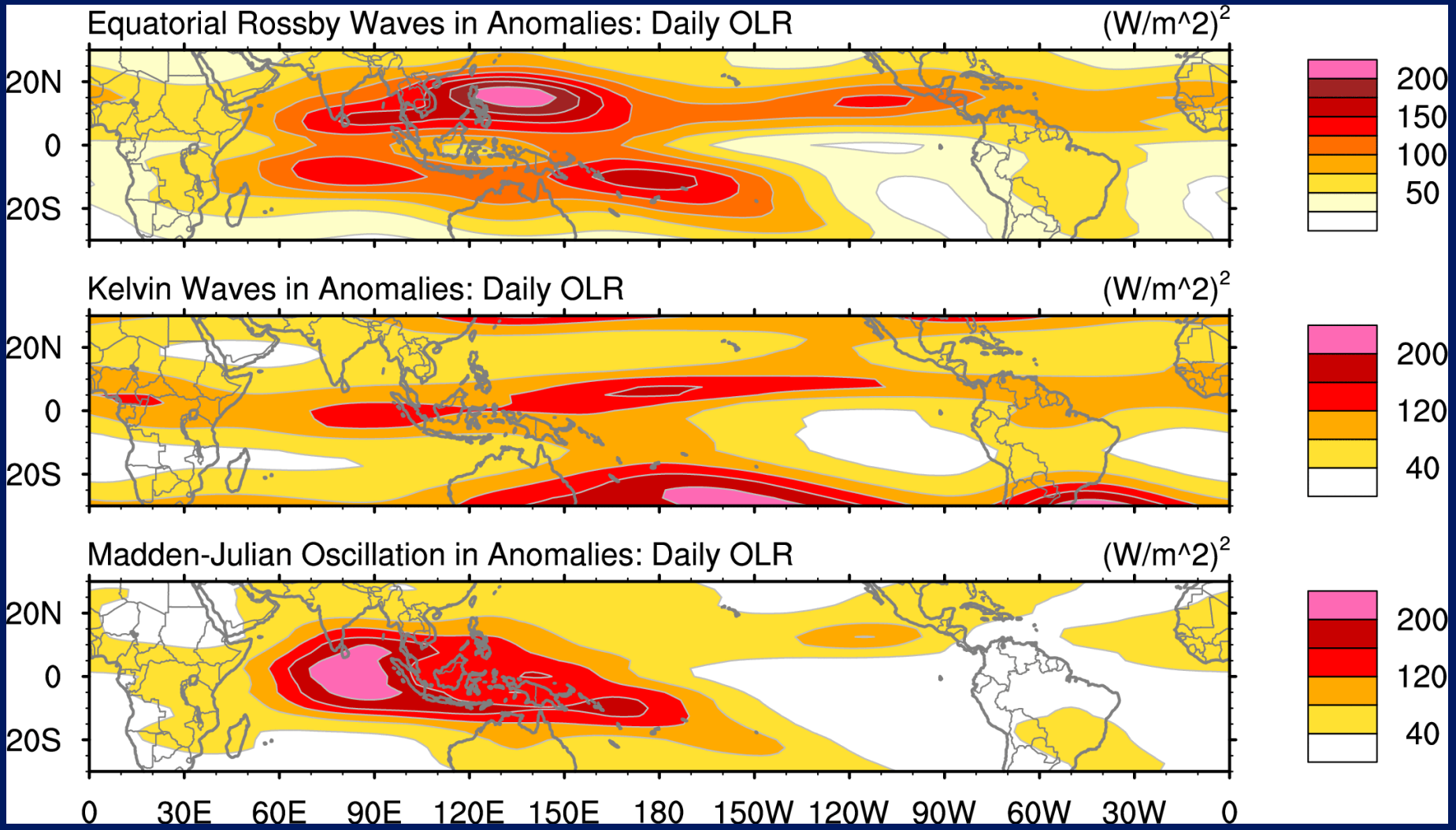
http://monitor.cicsnc.org/mjo/

Data

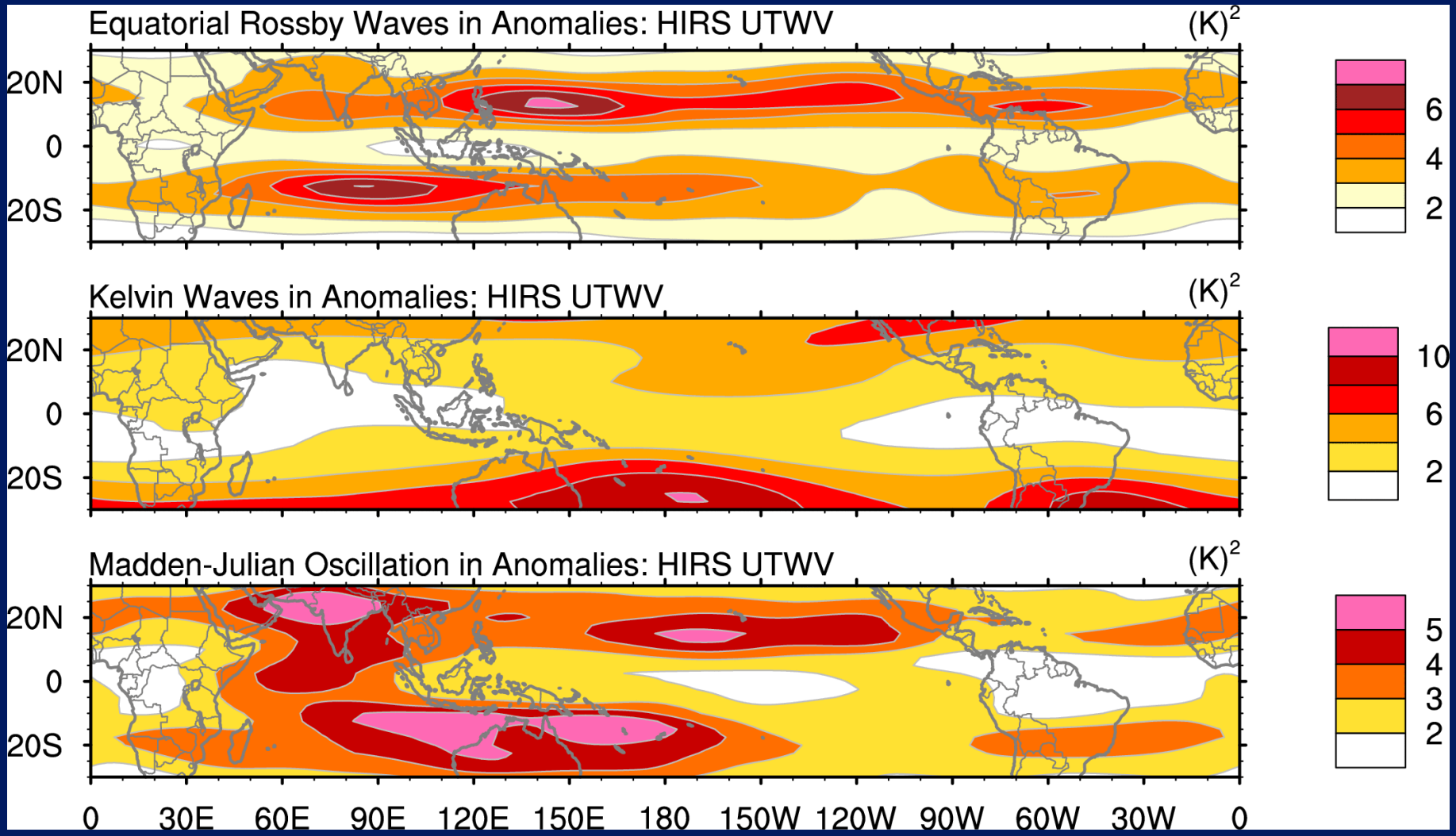
- Outgoing Longwave Radiation (OLR)
  - Lower OLR associated with deep clouds
  - Observed with AVHRR sensor on NOAA polar-orbiting satellites
  - Daily 2.5° gridded values obtained from NOAA/OAR/ESRL/PSD
  - 32-year *heterogeneous* dataset

- Upper Tropospheric Water Vapor (UTWV)
  - Lower brightness temperatures indicate more moisture
  - Observed with HIRS sensor on NOAA and MetOp polar-orbiting satellites
  - Orbital swath data obtained from NOAA/CLASS
  - Inter-satellite calibration developed by the Climate Data Record (CDR) program (Shi & Bates 2011)
  - 32-year *homogenized* dataset

Wave Variance: OLR

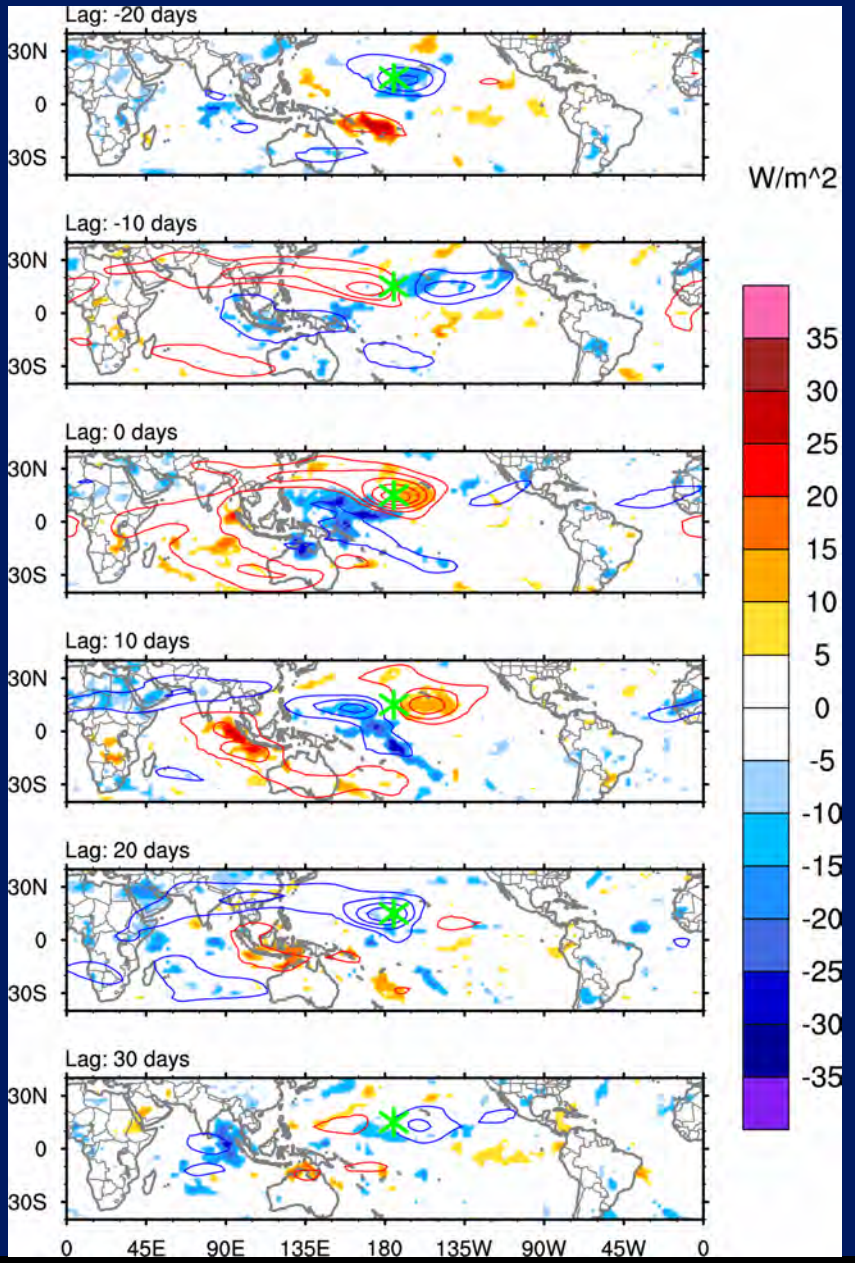


Wave Variance: UTWV



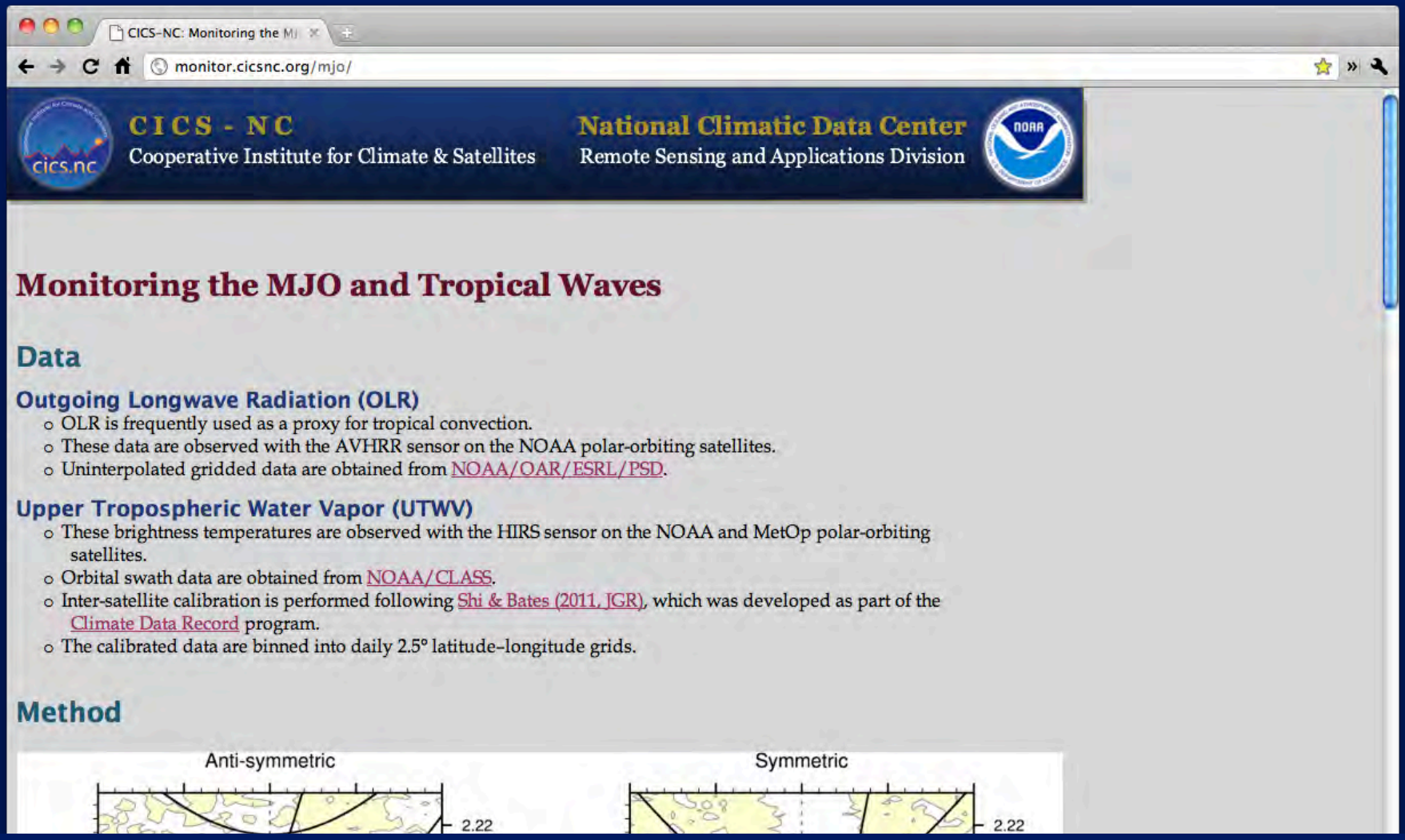
Composite MJO based on UTWV

- UTWV identifies compensating vertical motion
- Moistening UTWV precedes convective initiation over the Indian Ocean
- Redeveloping convective signal at +30 days suggest long-range predictability



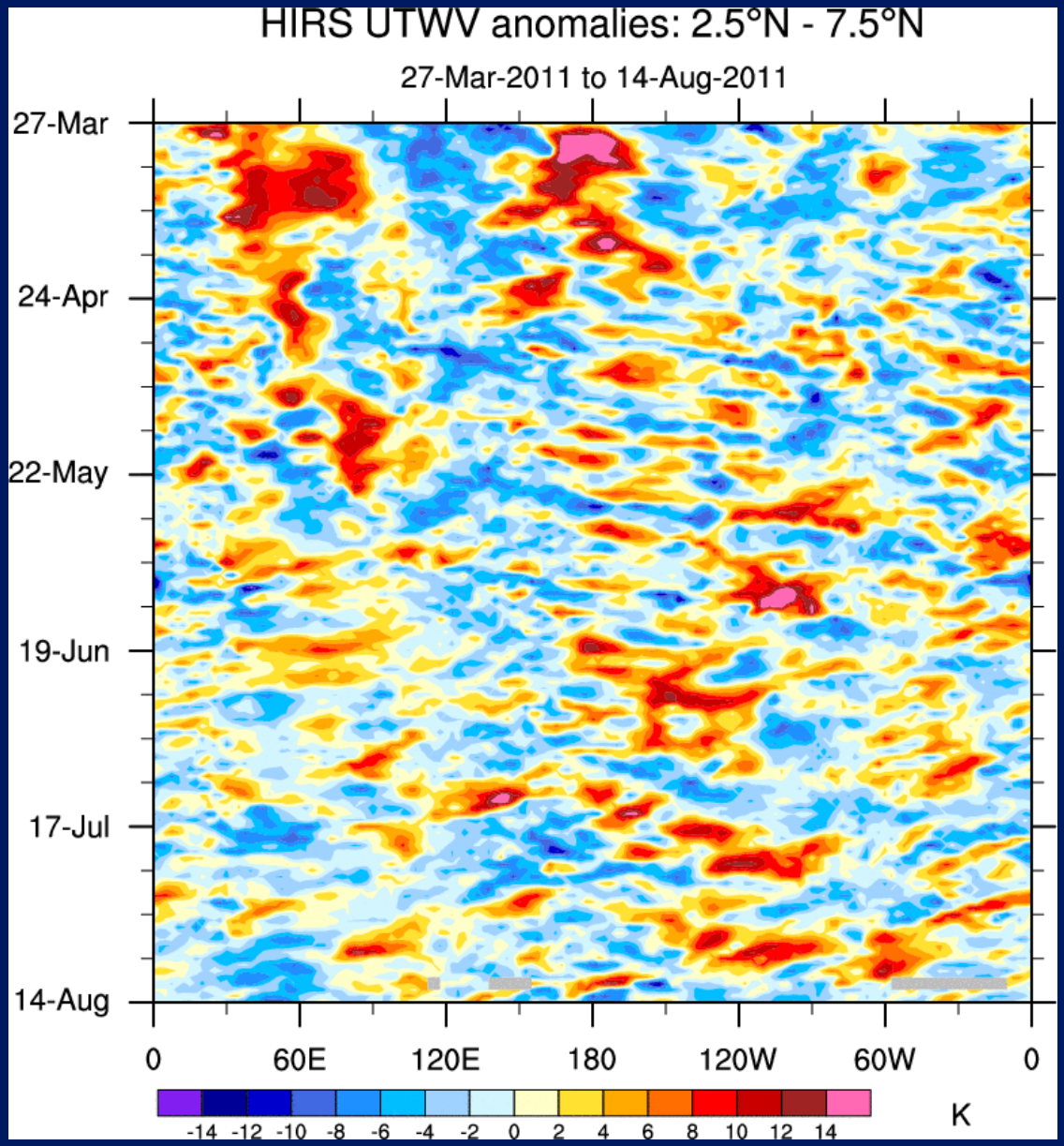
DJFMAM Composite of MJO-filtered UTWV (contoured every 1 K) and unfiltered OLR (shaded) based on 27 events with a $+2\sigma$ MJO-filtered UTWV anomaly at 15°N, 175°W

monitor.cicsnc.org/mjo/



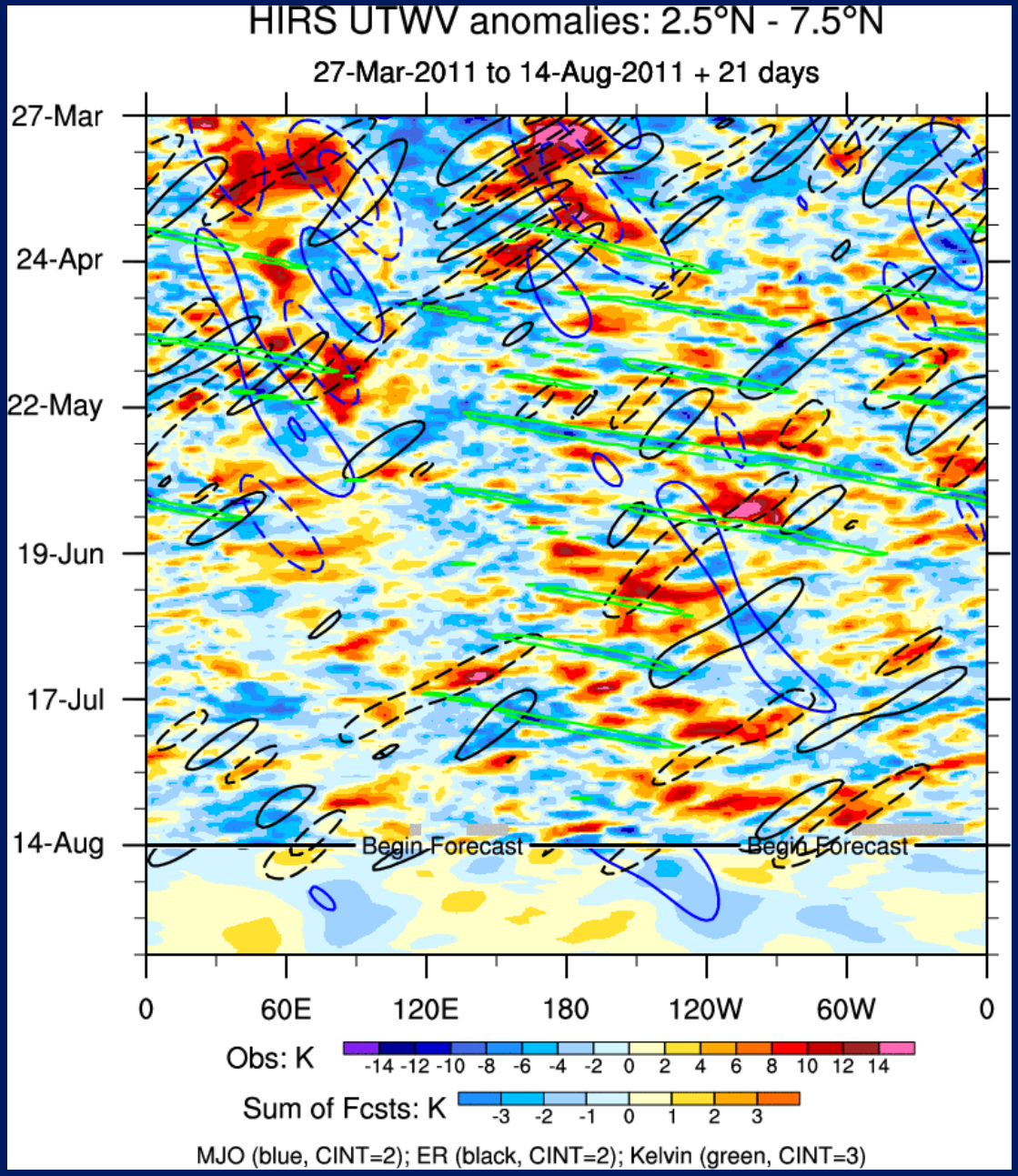
Monitoring UTWV

- Longitude–time plots (Hovöllers) monitor the MJO and waves



Monitoring UTWV

- Longitude–time plots (Hovöllers) monitor the MJO and waves
- Filtering identifies features more clearly
- Filters can also predict wave movement



Summary

- Three dominant modes of tropical intraseasonal variability:
  - The Madden–Julian Oscillation (MJO)
  - Kelvin waves
  - Equatorial Rossby (ER) waves
- Each are traditionally identified in proxies for convection (e.g., OLR)
- In the Western Hemisphere, UTWV is more useful
- Monitoring these features assists NOAA/CPC in their Global Tropical Hazards Assessments