Intraseasonal air-sea fluxes in reanalyses and observations during the DYNAMO period

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Dynamics of the Madden-Julian Oscillation (DYNAMO)

Observational objectives:

- Vertical profiles of moistening and heating
- Structure and evolution of cloud and precipitation processes, surface fluxes, atmospheric boundary-layer and upper-ocean turbulence and mixing

Motivations

- Reanalyses are widely used in the diagnostics and prediction of MJO
- Assessment of uncertainties in reanalyses is important for understanding MJO dynamics and its prediction
- In situ observations are highly valuable for the validation of reanalyses

Objectives

- Analyze surface fluxes, rainfall, and SSTs during DYNAMO period in reanalyses (CFSR, MERRA, and ERAI)

- Assess differences in fluxes between reanalyses and observational estimates

Data

- Period
  - October 1 to December 31, 2011
- Reanalyses (0.5° x 0.5°)

- CFSR (Climate Forecast System Reanalysis)

- MERRA (Modern Era Retrospective-analysis for Research and Applications)

- ERA-I (ECMWF Re-Analysis Interim)

- Observations
  - CMORPH rainfall (0.5° x 0.5°)
  - DYNAMO Surface fluxes from the Revelle near (0°N, 80°E)

Analysis

- Seasonal mean in reanalyses
  - SW, LH, q2m
- Intraseasonal anomalies in reanalyses
  - Time evolution of (10°S-10°N, 75°E-85°E) average
- Comparison with DYNAMO observation
  - DYNAMO observation from the Revelle near (0°N, 80°E)

Seasonal mean in reanalyses

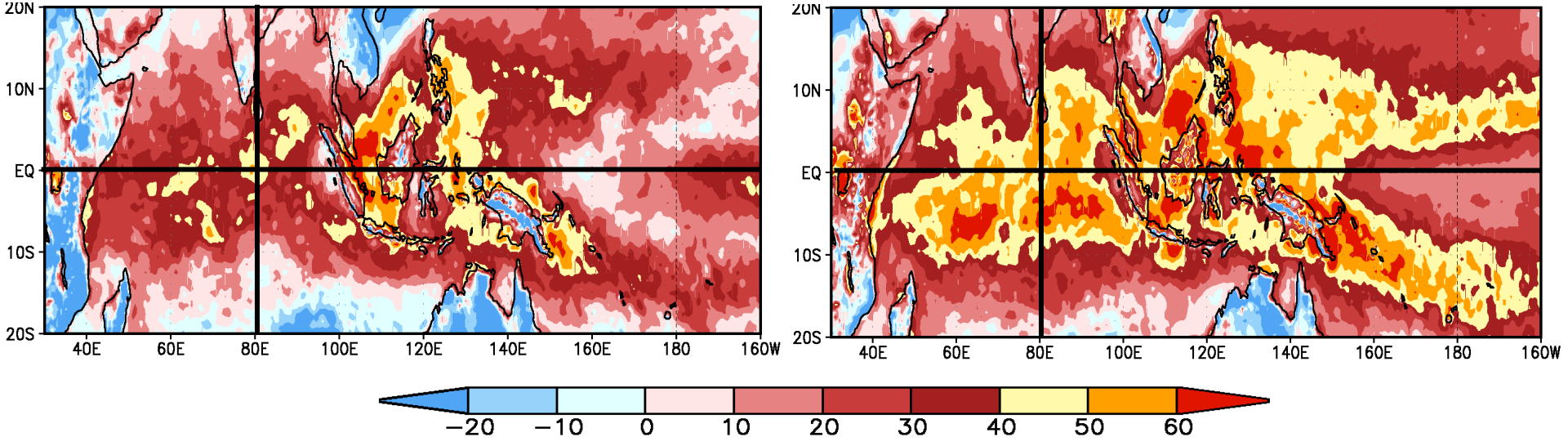
Oct-Dec 2011

Oct-Dec 2011 Average Difference [W m^{-2}]

Net Short-wave Radiation (NSW)

CFSR - MERRA

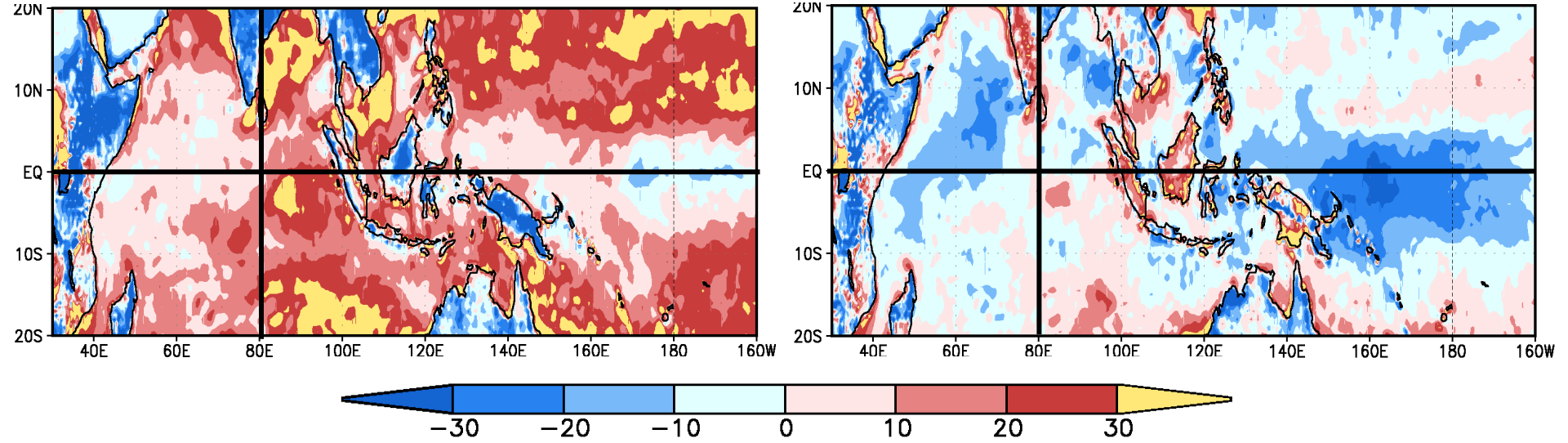
CFSR - ERAI



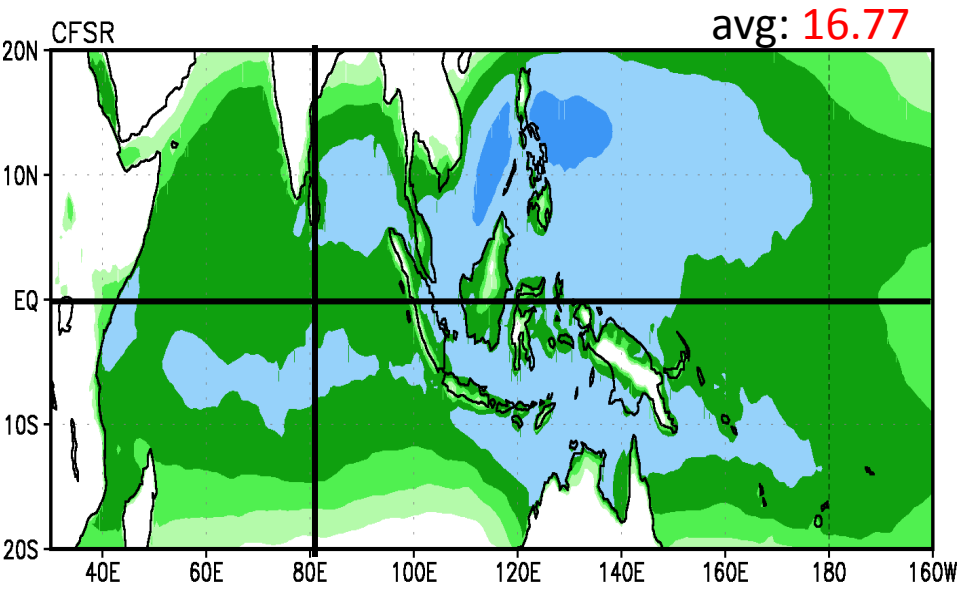
Latent heat flux (LH)

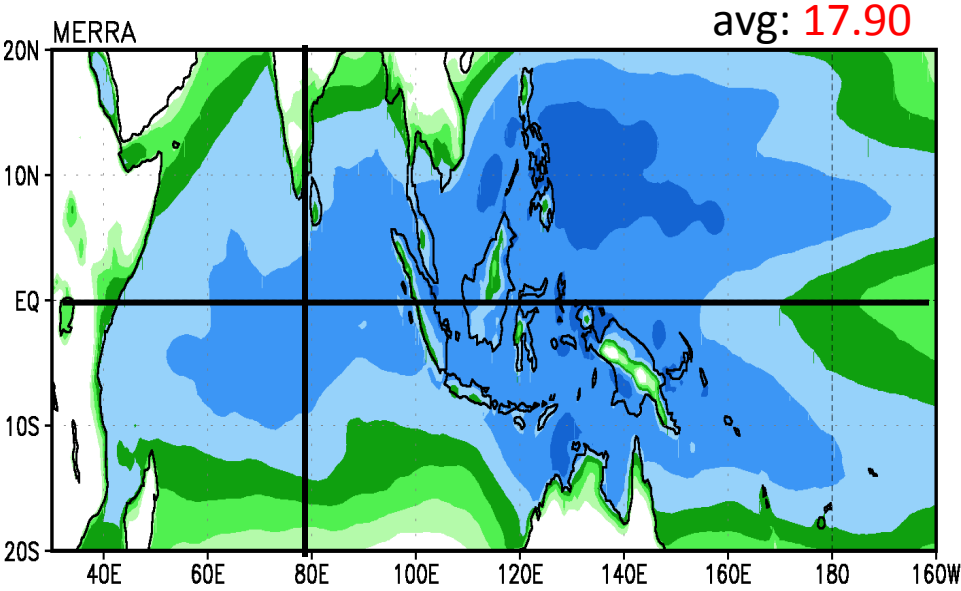
CFSR - MERRA

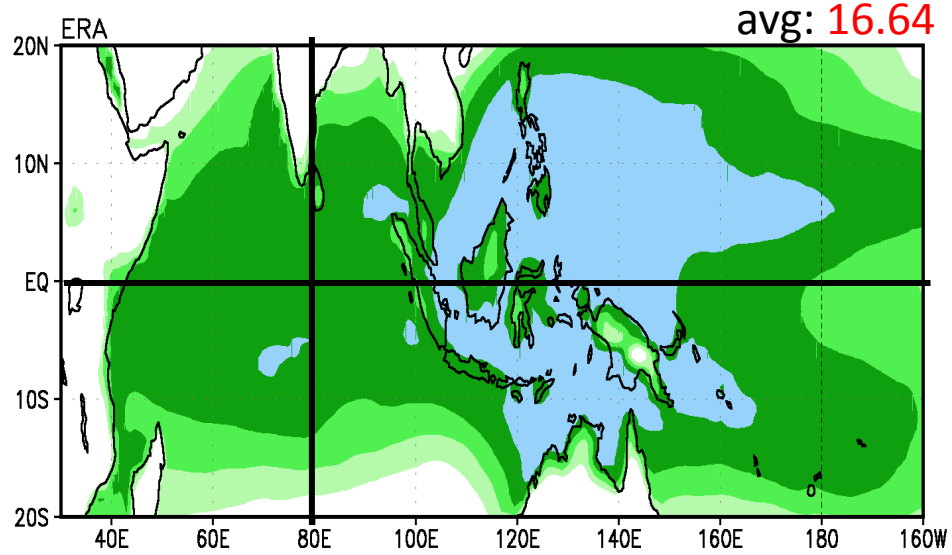
CFSR - ERAI



3-month Average of Specific Humidity [g Kg^{-1}]







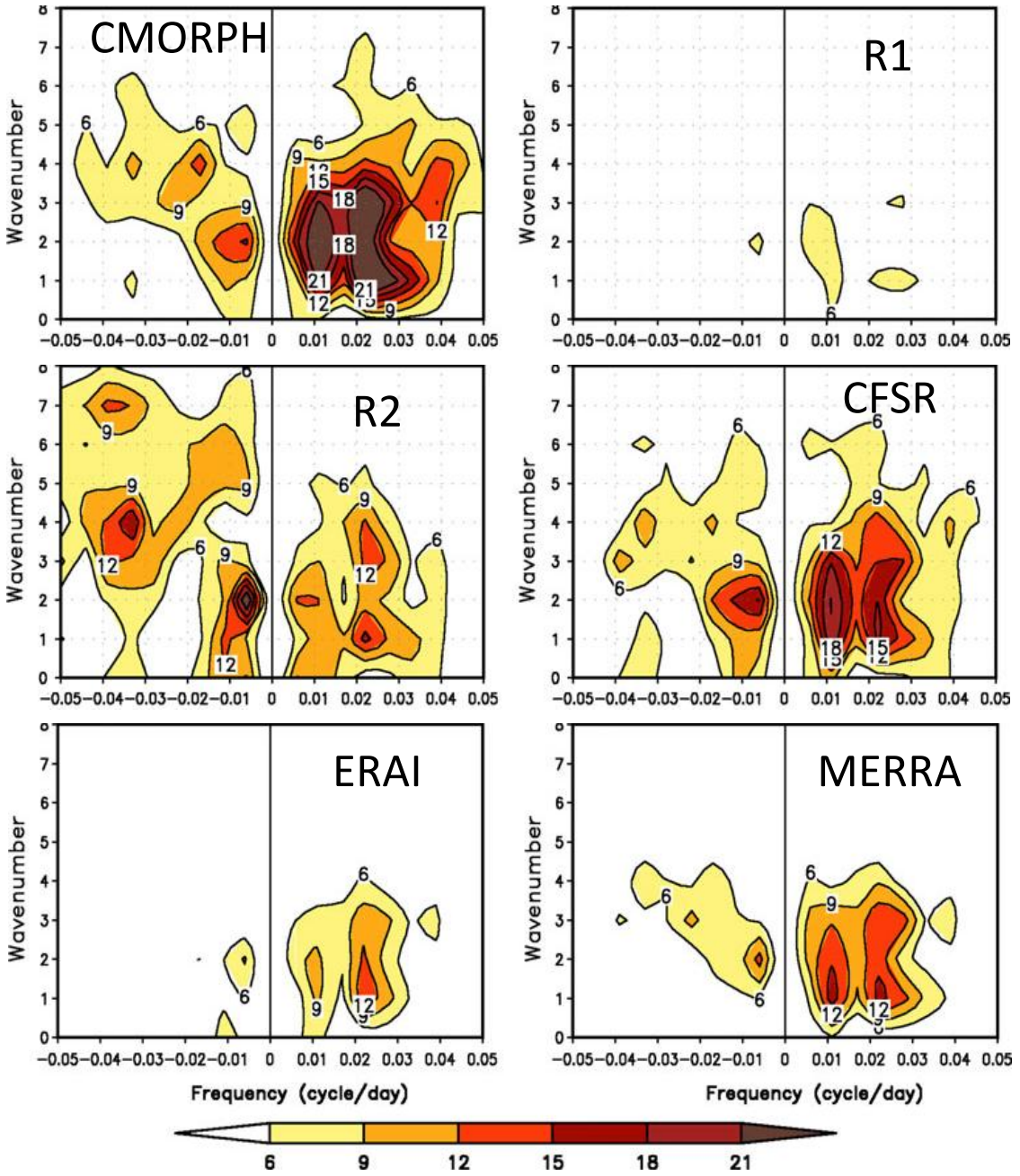
CFSR and ERAI are drier than MERRA

Intraseasonal anomalies in reanalyses

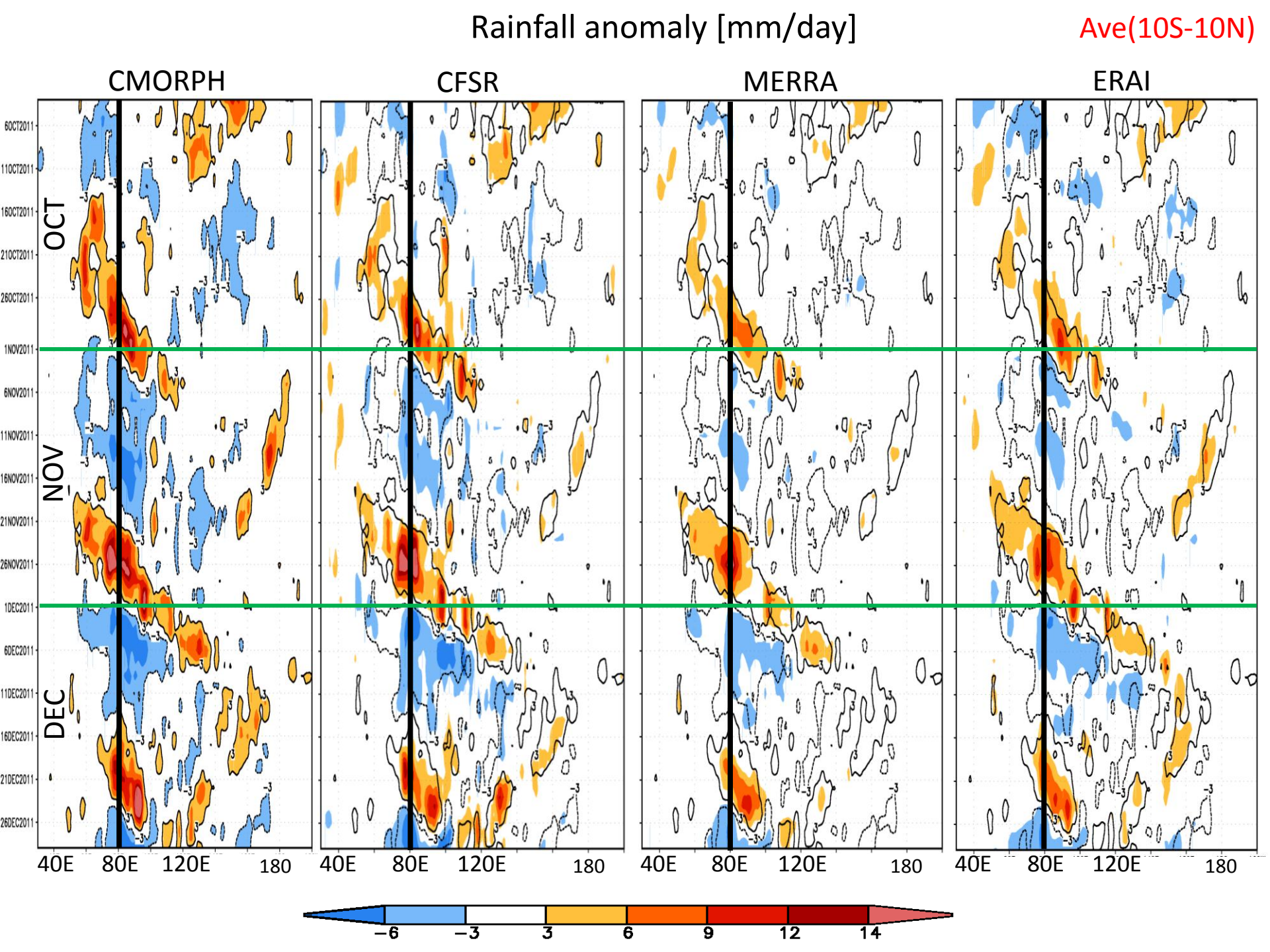
Anomaly = Total – Linear Fit

Rainfall wavenumber-frequency spectra (10S–10N average)

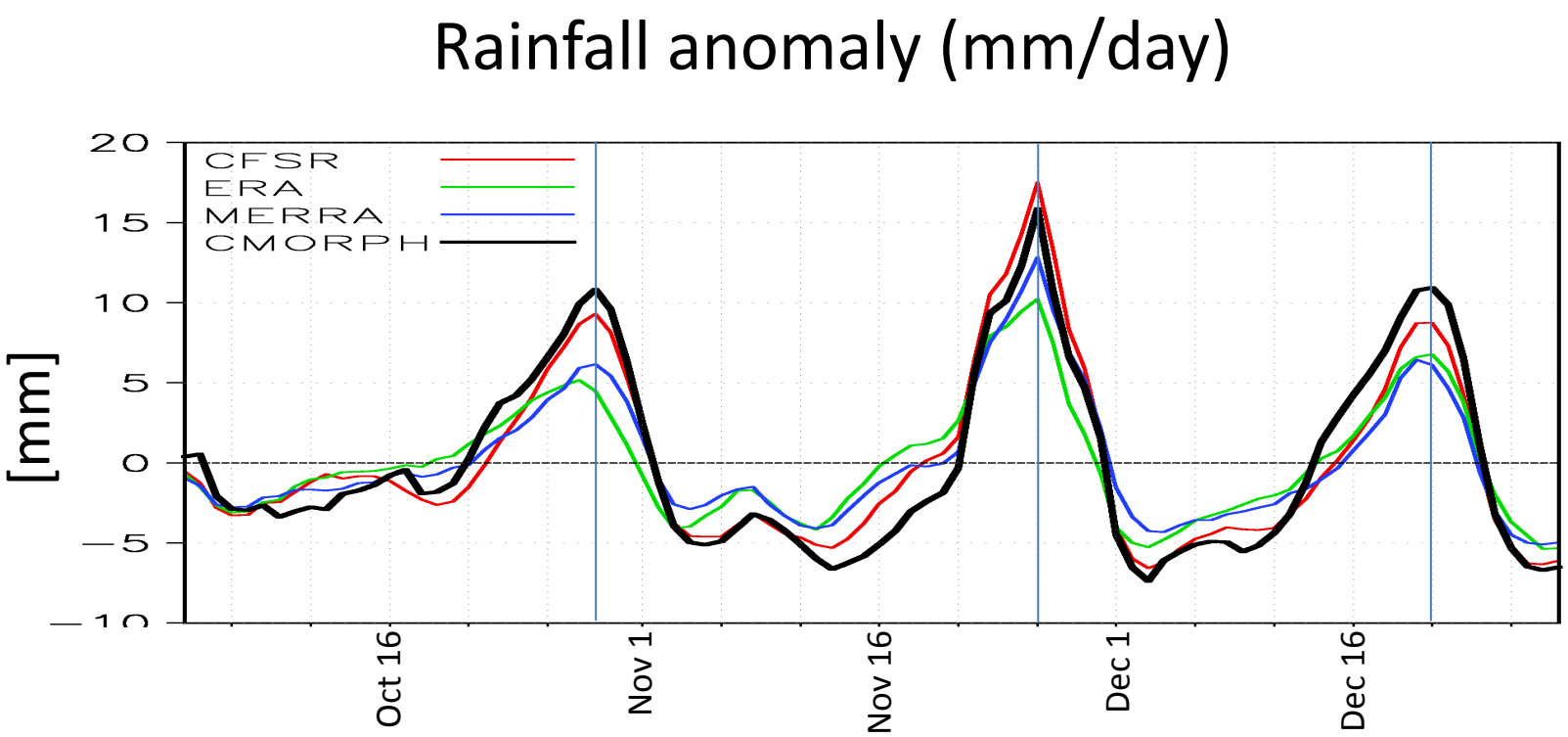
The new reanalyses (CFSR, MERRA, ERAI) produced better eastward/westward contrast



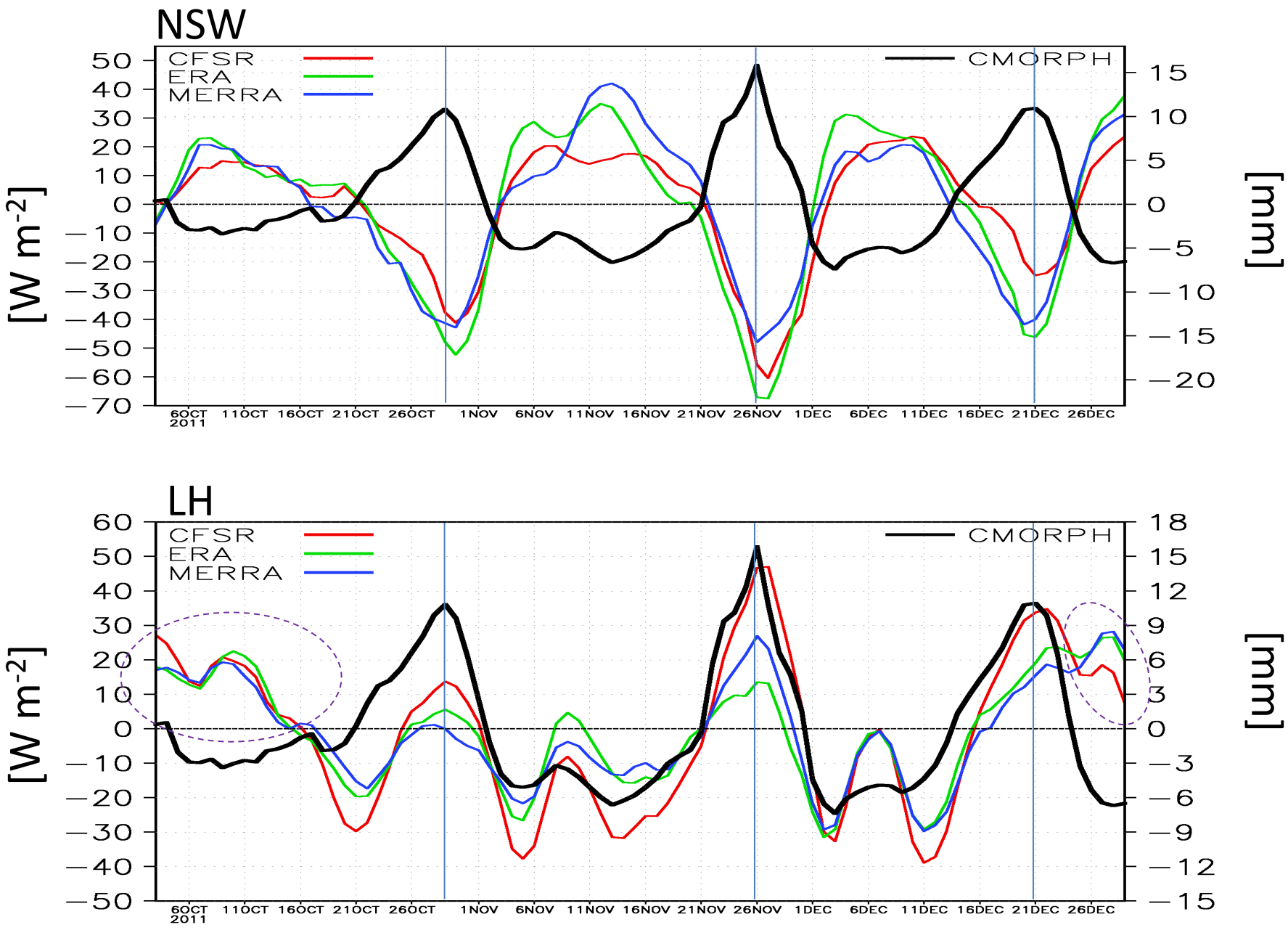
Wang et al. 2011 in Climate Dynamics


Rainfall anomaly [mm/day]
Ave(10S-10N)
CMORPH
CFSR
MERRA
ERAI
OCT
NOV
DEC
6OCT2011
11OCT2011
16OCT2011
21OCT2011
26OCT2011
1NOV2011
6NOV2011
11NOV2011
16NOV2011
21NOV2011
26NOV2011
1DEC2011
6DEC2011
11DEC2011
16DEC2011
21DEC2011
26DEC2011
40E
80E
120E
180
−6
−3
3
6
9
12
14

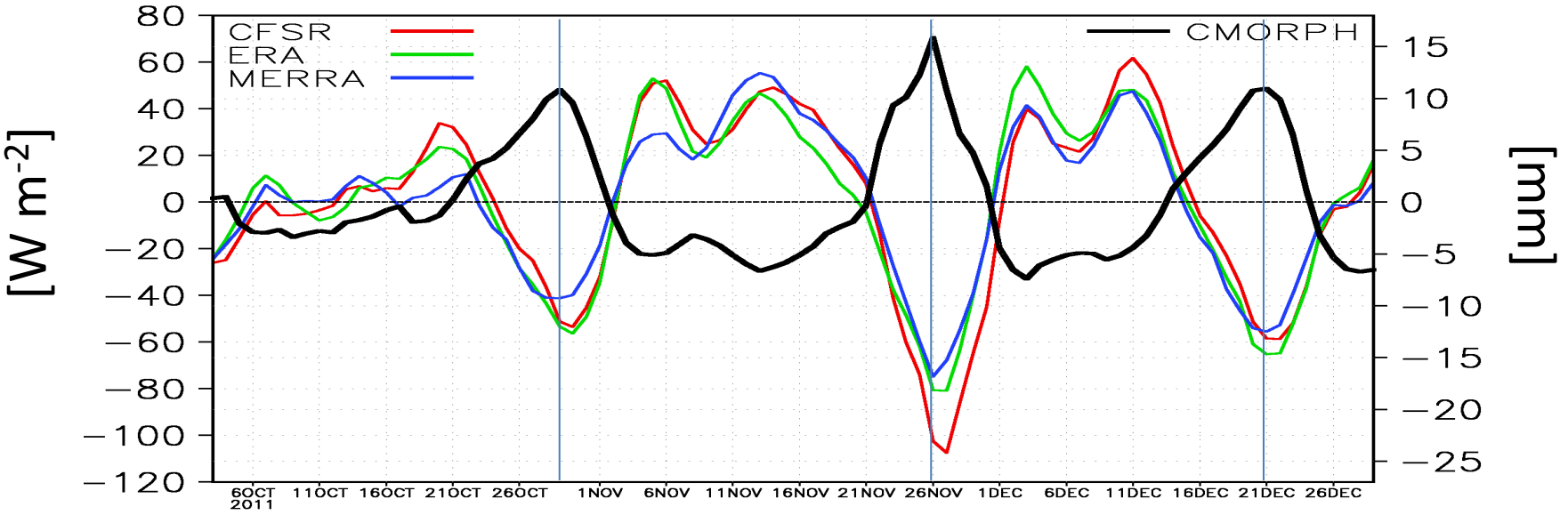
Ave(10°S-10°N, 75°E-85°E)



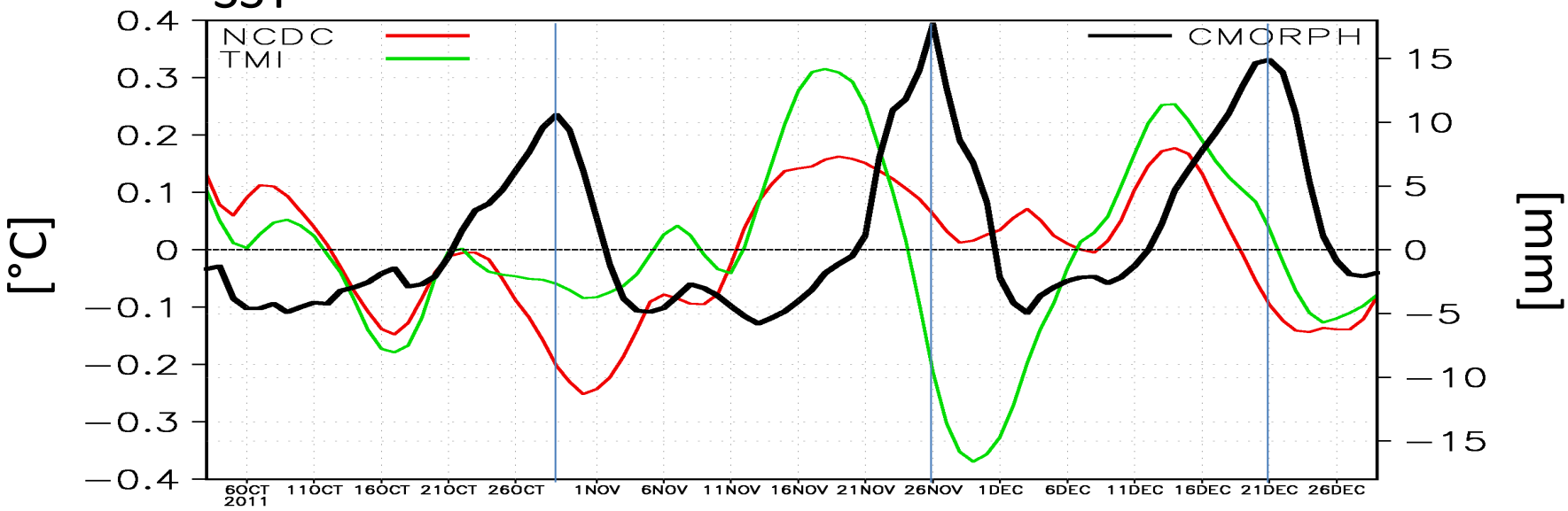
Intraseasonal anomalies

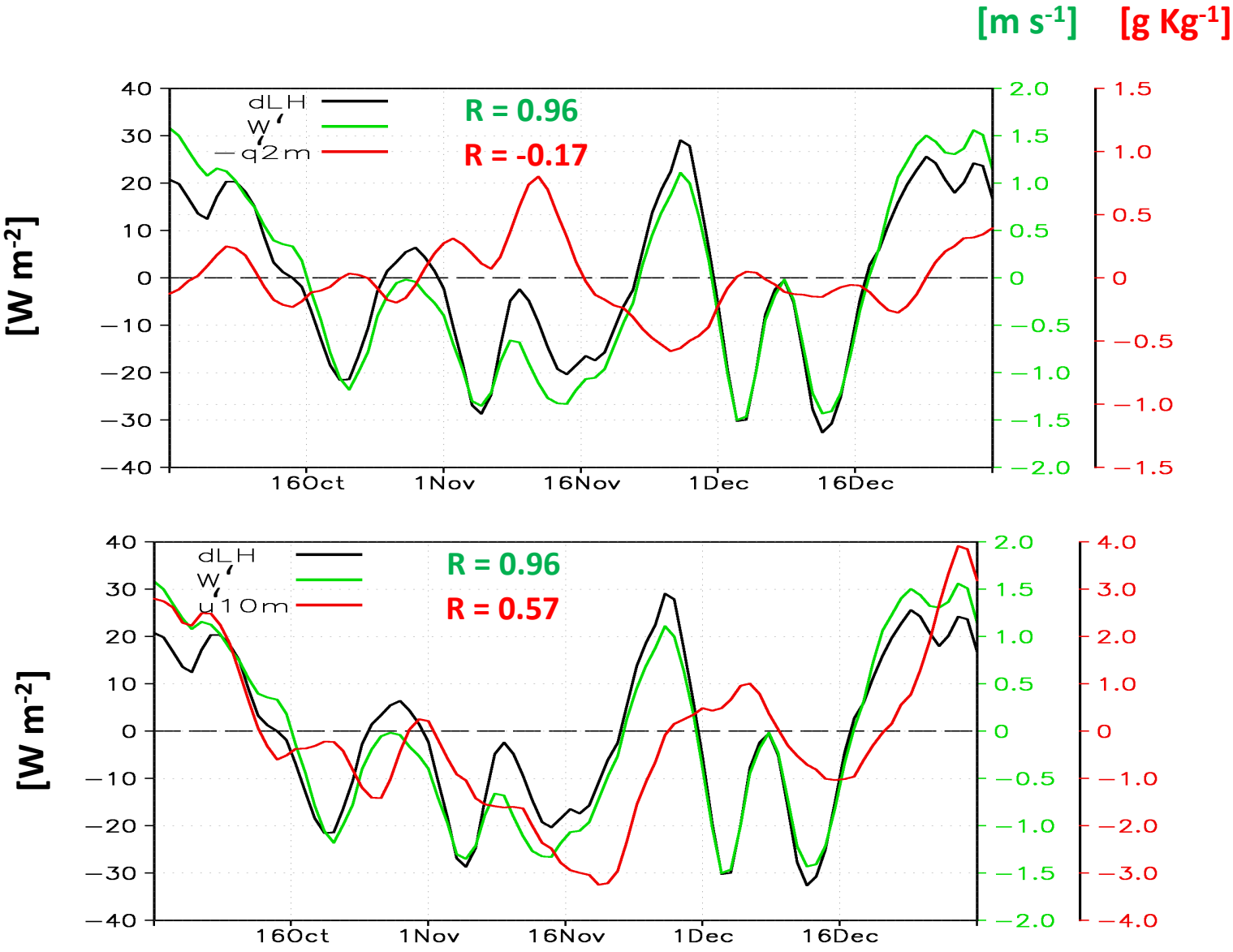


NSW - LH


CFSR
ERA
MERRA
CMORPH
[W m-2]
[mm]
80
60
40
20
0
−20
−40
−60
−80
−100
−120
15
10
5
0
−5
−10
−15
−20
−25
6OCT 2011
11OCT
16OCT
21OCT
26OCT
1NOV
6NOV
11NOV
16NOV
21NOV
26NOV
1DEC
6DEC
11DEC
16DEC
21DEC
26DEC

SST


NCDC
TMI
CMORPH
[°C]
[mm]
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
15
10
5
0
−5
−10
−15
6OCT 2011
11OCT
16OCT
21OCT
26OCT
1NOV
6NOV
11NOV
16NOV
21NOV
26NOV
1DEC
6DEC
11DEC
16DEC
21DEC
26DEC


[m s-1]
[g Kg-1]
[W m-2]
dLH
w'
−q2m
R = 0.96
R = -0.17
16Oct
1Nov
16Nov
1Dec
16Dec
[W m-2]
dLH
w'
u10m
R = 0.96
R = 0.57
16Oct
1Nov
16Nov
1Dec
16Dec

Comparison with DYNAMO observation

from R/V Roger Revelle near (0°N, 80.5°E)

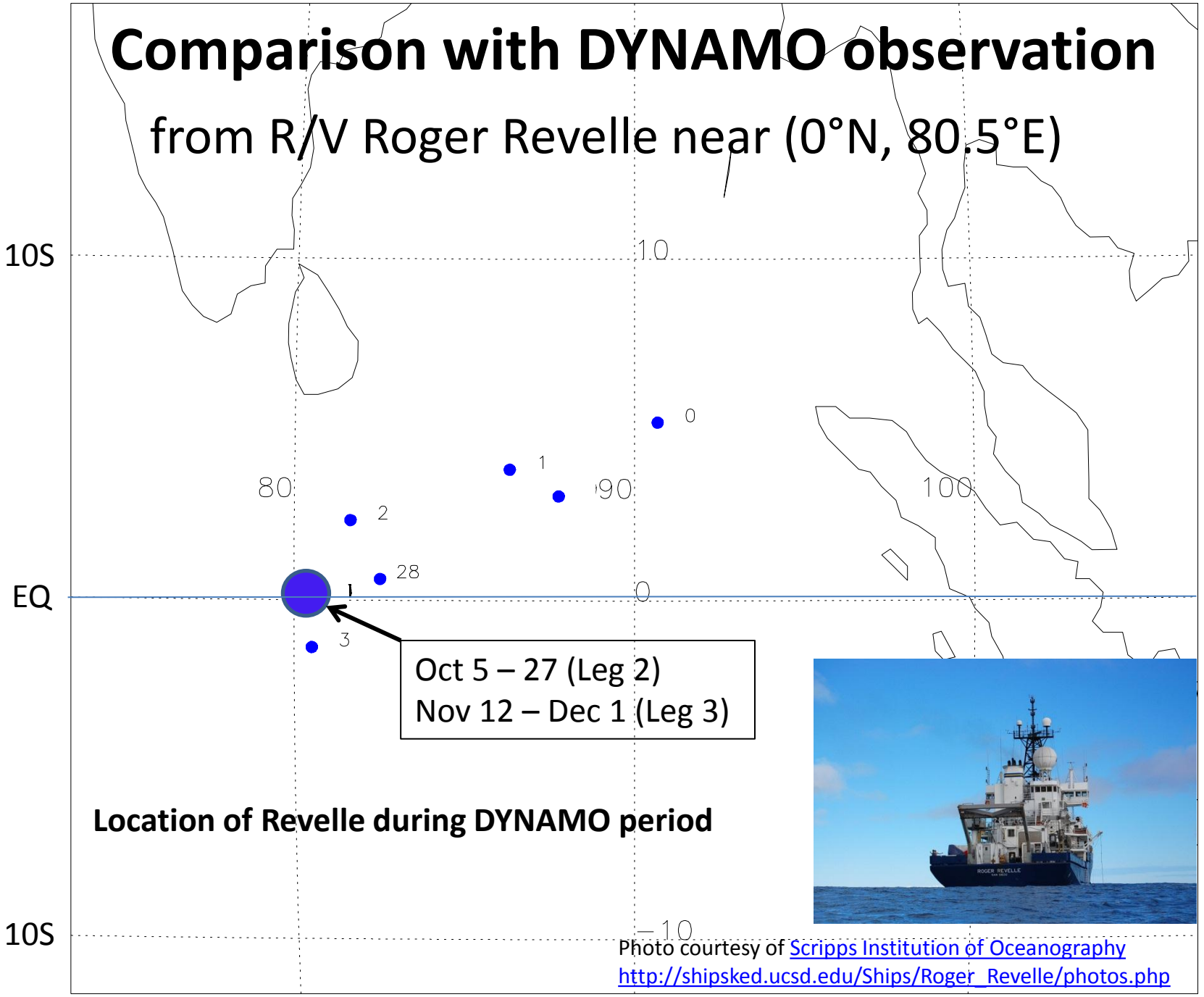
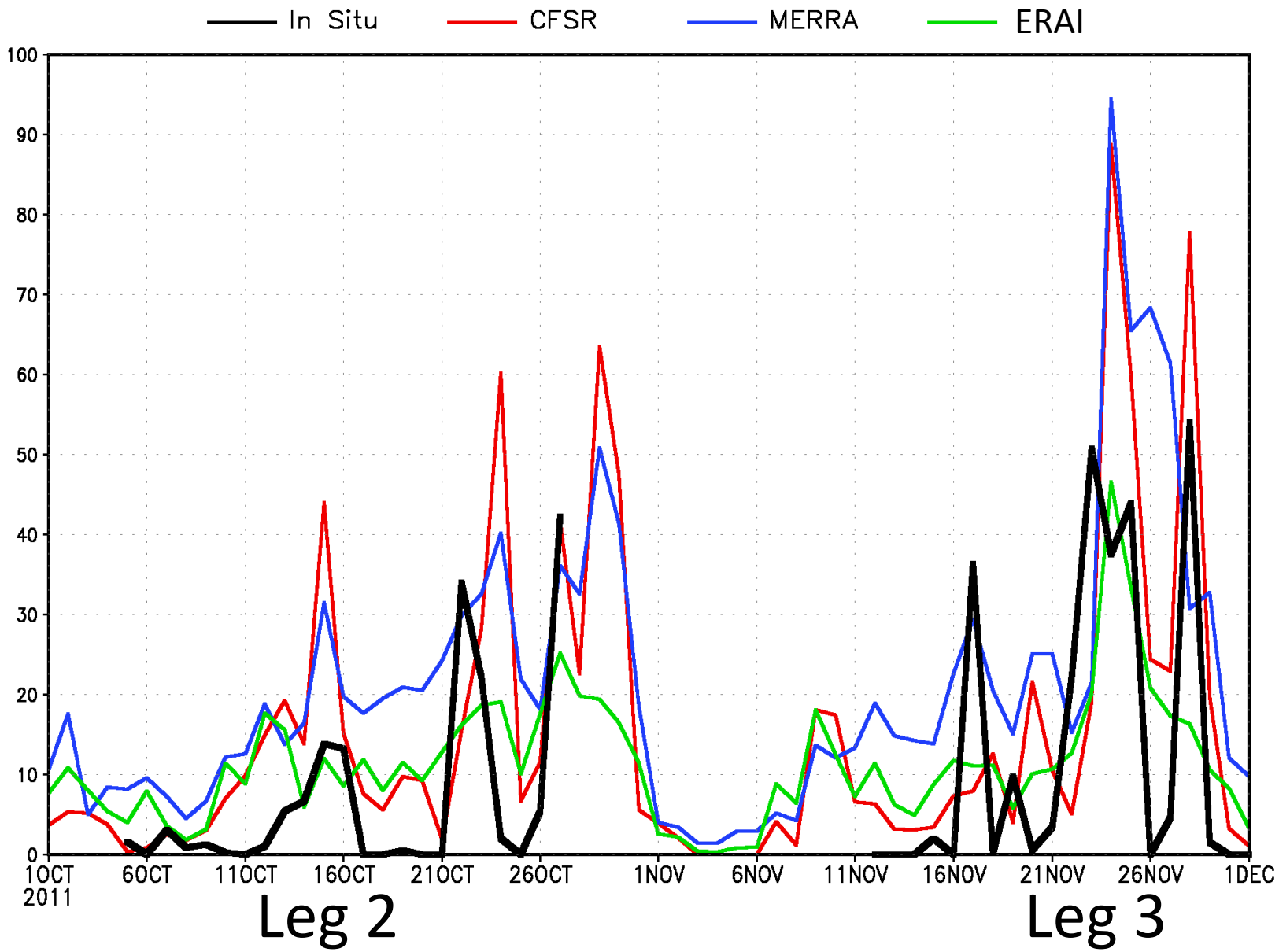
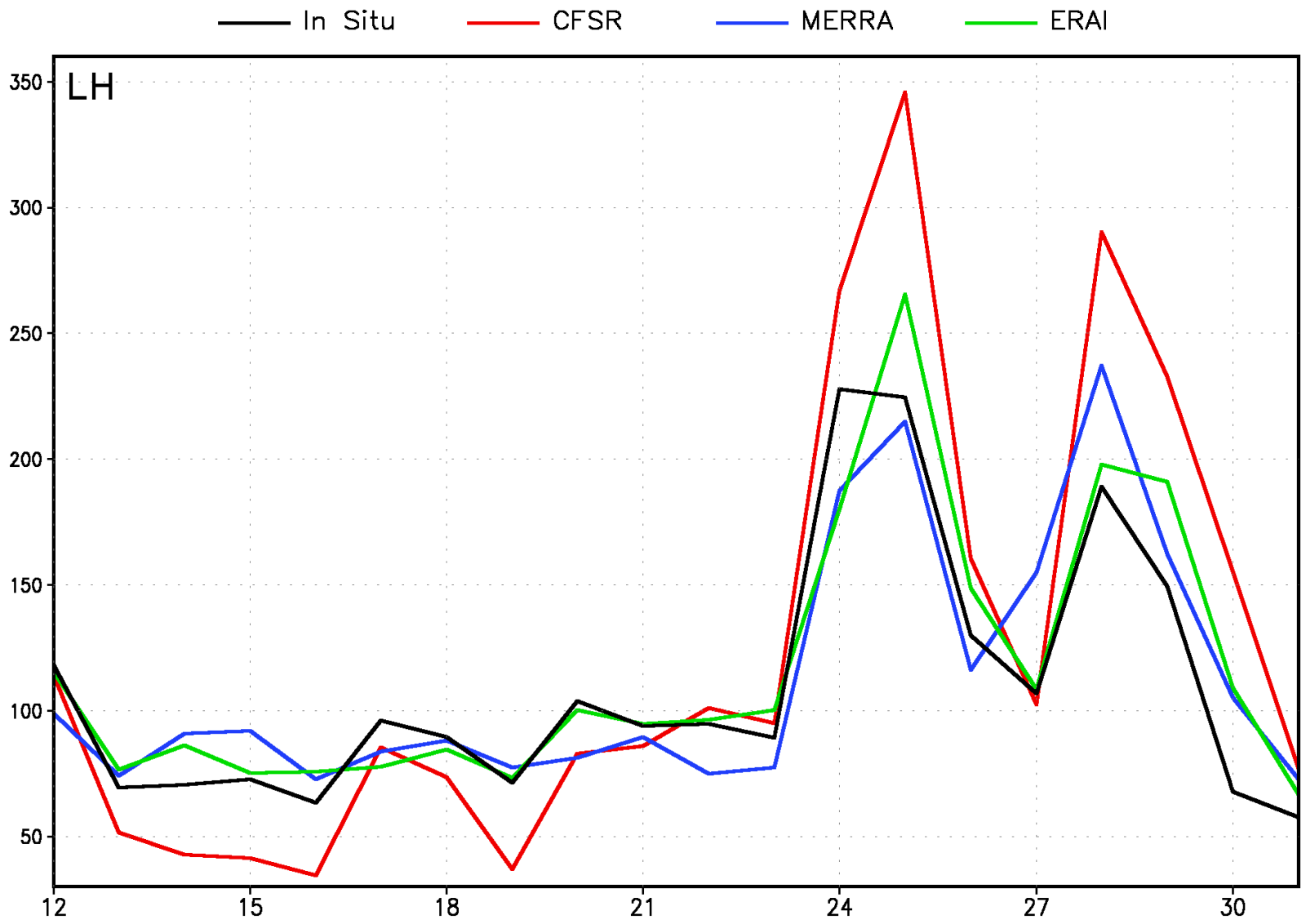


Photo courtesy of Scripps Institution of Oceanography
http://shipsked.ucsd.edu/Ships/Roger_Revelle/photos.php

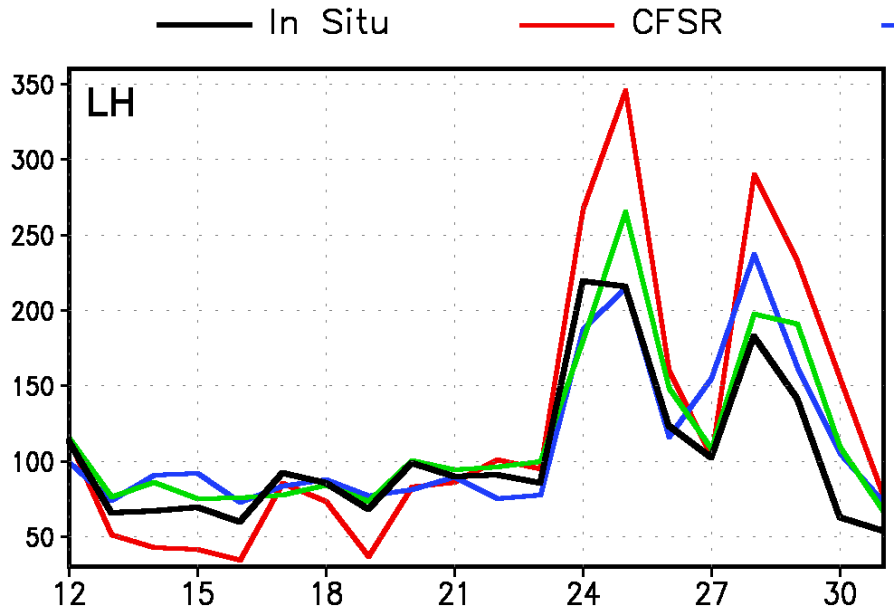
Total rainfall rate (mm/day)

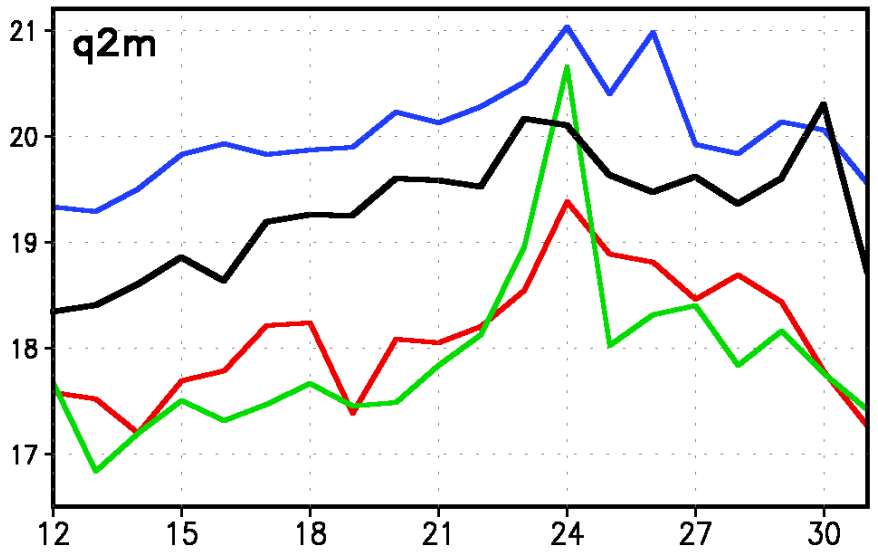


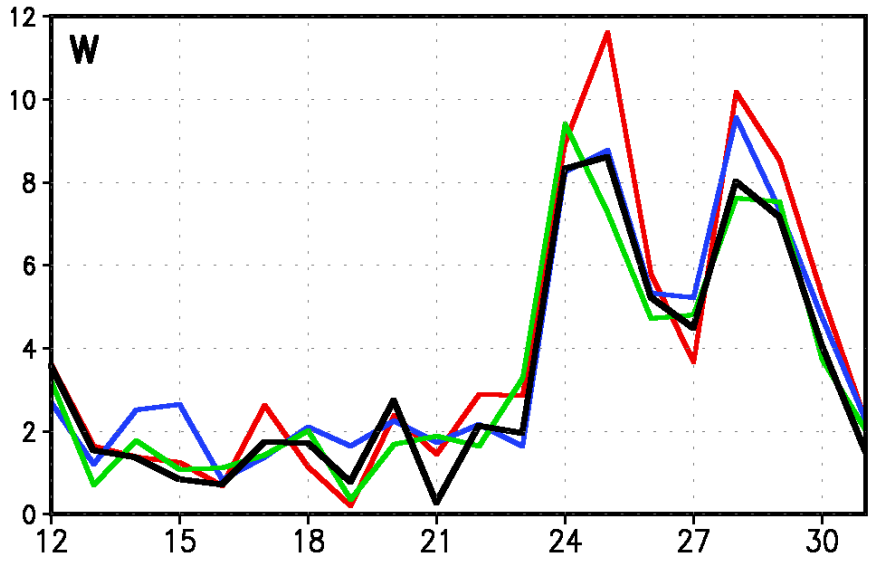
Leg 3 (Nov 12 – Dec 1)



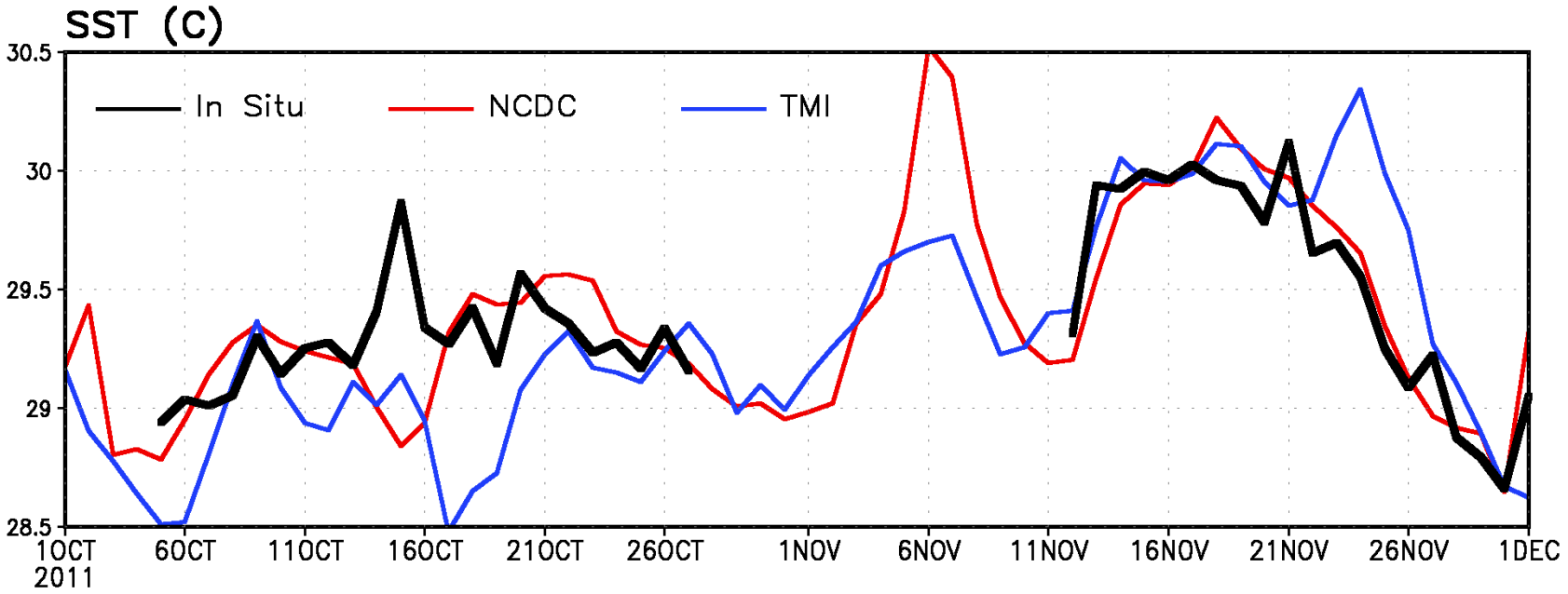
Leg 3 (Nov 12 – Dec 1)







SST at (0N, 80.5E)



Summary

- Large differences in mean state (e.g., q2m, SW, LH) but similar in anomalies among reanalyses
- All three reanalyses produce quite realistic rainfall variability
- Confirmation of previous findings: Positive downward SW, less evaporate cooling, and positive SSTs ahead of convection.
- LH is largely controlled by surface winds; both zonal and meridonal components are contributing .
- Compared to DYNAMO in situ observation, CFSR and ERAI are too dry near the surface, while MERRA is too wet.
- NCDC SSTs appear to be more consistent with in situ observation than TMI retrieval.