Building OSSE at JCSDA

Michiko Masutani[1,2,$],Jack S. Woollen[1,#], Sean Casey [2,3,$], Isaac Moradi [2,$],
Tong Zhu [2,3,%], Narges Shahroudi [2,3,$] , Yan Zhou[2,3,$],
Sid Boukabara[2,3], Kayo Ide[6], Ross Hoffman[5,@]

[1]NOAA/National Centers for Environmental Prediction (NCEP)
[2]Joint Center for Satellite and Data Assimilation (JCSDA)
[3]NOAA/ NESDIS/STAR, [4]NOAA/ESRL, *[5]NOAA/OAR/AOML*
[6]Dept. of Atmospheric and Oceanic Science, Univ. of Maryland
[$] Earth System Science Interdisciplinary Center,
Cooperative Institute for Climate and Satellite, Univ. of Maryland
IMSystem Group, Rockville, MD
@*Atmospheric and Environmental Research, Inc. (AER), Lexington, MA*
%Cooperative Institute for Research in the Atmosphere (CIRA)/CSU, CO

Observing System Simulation Experiment

Full global OSSE is conducted at JCSDA

- A Nature Run (NR, proxy true atmosphere) is produced from a free forecast run using the highest resolution operational model which is significantly different from the NWP model used in Data Assimilation Systems.

- Calibrations is performed to provide quantitative data impact assessment. Data impact on analysis and forecast will be evaluated.

- A Full OSSE can provide detailed quantitative evaluations of the configuration of observing systems.

- A Full OSSE can use an existing operational system including diagnostic tools and utilities. OSSE can also help the development of an operational system
  - **No special OSSE system**

Observing System Simulation Experiment

Collaboration

- Full OSSEs are expensive
  - Sharing one Nature Run and simulated observation saves costs
  - Sharing diverse resources
  - Regional OSSE can be done with less resource at other institutes.
- OSSE-based decisions have international stakeholders
  - Decisions on major space systems have important scientific, technical, financial and political ramifications
  - Community ownership and oversight of OSSE capability is important for maintaining credibility
- Independent but related data assimilation systems allow us to test the robustness of answers

List of references are available at
http://www.emc.ncep.noaa.gov/research/JointOSSEs/references

JCSDA played the leading role for International Joint OSSE Since 2006

Joint OSSE Nature Run by ECMWF

ECMWF Nature run used at NOAA
Spectral resolution : T511
13 month long. Starting May 1st,2005
Vertical levels: L91, 3 hourly dump

Andersson, Erik and Michiko Masutani 2010: Collaboration on Observing System Simulation Experiments (Joint OSSE), ECMWF News Letter No. 123, Spring 2010, 14-16.

Simulated observation for Control experiments are available from NASA/NCCS and NCAR

Data distribution
NASA/NCCS
Contact:
Ellen Salmon Ellen.M.Salmon@NASA.gov

NCAR
Currently saved in HPSS Data ID: ds621.0
Contact:
Chi-Fan Shih chifan@ucar.edu

Joint OSSEs at JCSDA and collaborators

Evaluation of Infrared sounders on the geostationary Hyperspectral Environmental Suite (HES)
Evaluation of Future configuration of GNSS-RO
Evaluation of OAWL and WISCCR DWL
Evaluation of DWSS and JPSS
Simulation of DWL planned from NASA (GWOS, ISS)
Simulation and assimilation of Cloud Motion Vector, ASCAT
Evaluation of Wind Lidar (GWOS, ISS) impact and configuration experiments for NASA
Evaluation of Impact of GWOS on monsoon,

Joint OSSEs conducted by other organizations

PREMIER InfraRed and MicroWave Limb Sounder measurements by ESA/ESTEC (Environment of Canada)
Polar Communications and Weather mission (PCW)(Environment of Canada)
ADM-Aeolus and follow up mission (KNMI, NASA/GSFC/GMAO)
Studies of Observational errors (NASA/GSFC/GMAO)
Regional OSSE to Evaluate DWL data on Hurricane forecast (Univ Utah)
Rigional OSSE on severe storm (Mississippi State University)
Global OSSE forUnmanned Aircraft System (NOAA/AOML, NOAA/ESRL)
Evaluation of Hybrid Data assimilation system (NOAA/EMC, UMD)
Global OSSE for WISDOM balloons (NOAA/ESRL, NOAA/AOML)
Evaluation of RAOB over India (National Centre for Medium Range Weather Forecasting (NCMRWF))
Analysis and Evaluation of Observing System Simulation Experiments (OSSEs) forecast data for Indian Summer Monsoon (ISM), Indian Institute of Tropical Meteorology

OSSE with New Nature runs at JCSDA

GOES-5 Nature Run
By NASA/GSFC/GMAO
(G5NR)

GOCART model with full aerosol, full chemistry

Non-Hydrostatic

Global, 7 km, 72 level model from May 16, 2005-June2007

Data are available in 0.5deg and model resolution with 30min write up.

Pressure level data are provided in 0.5 deg

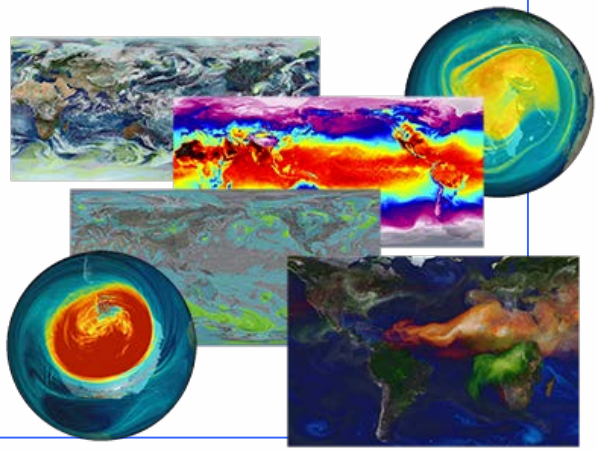
Various time mean data are also provided

Data are available through OPeNDAP to registered users.

For more detail visit:

http://gmao.gsfc.nasa.gov/projects/G5NR/

Comprehensive evaluation is posted.



G5NR image by NASA/NCCS

Transient Eddy Kinetic Energy (tEKE) in G5NR and NCEP reanalysis

by Michiko Masutani

Motivation

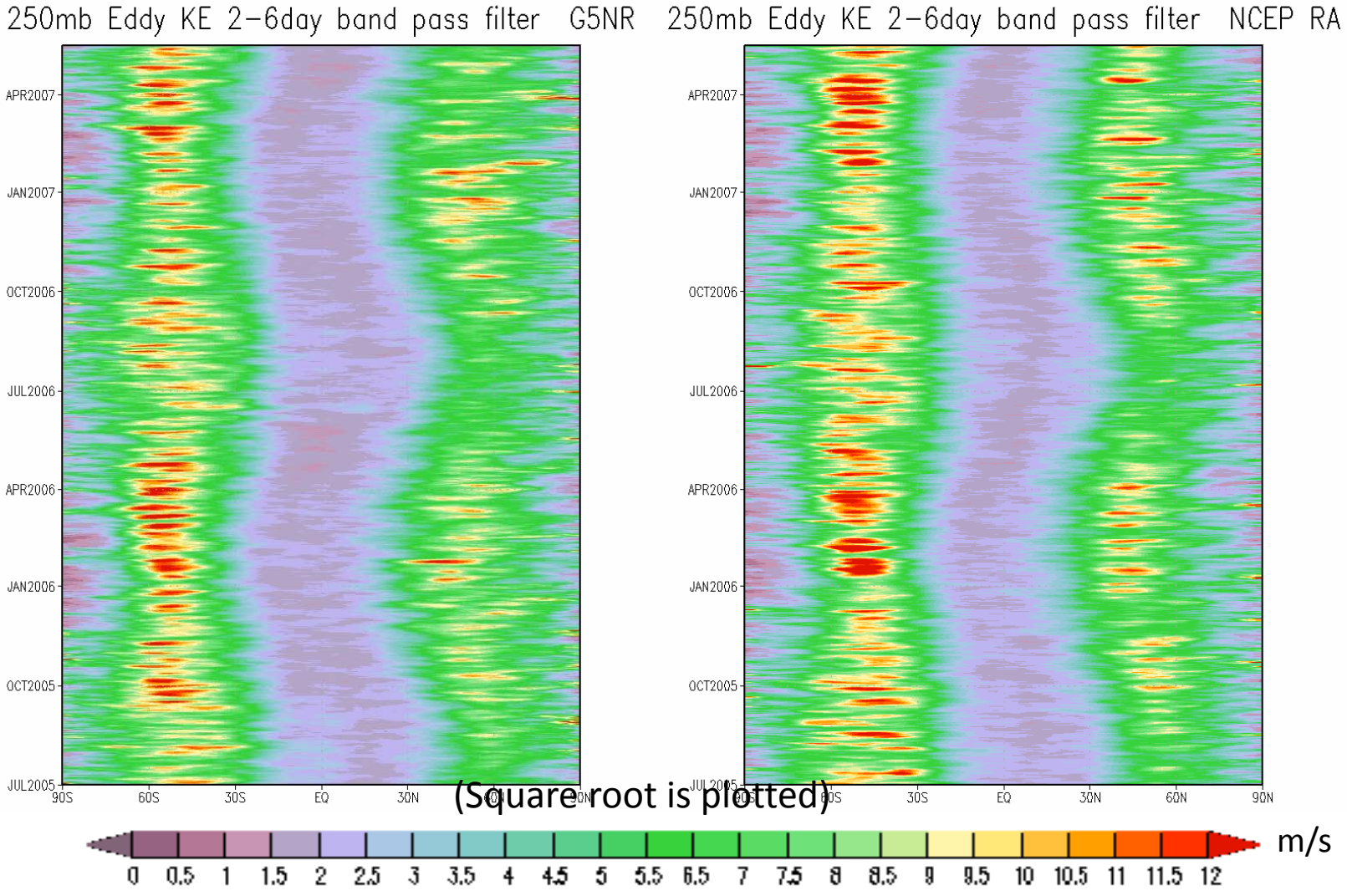
- Transient eddy kinetic energy (tEKE) is one of the standard fields included in the ECMWF atlas. (Kallberg, P. *et al.*, 2006: ERA-40 Atlas, ERA-40 Project Report series No 19)
- tEKE clearly revealed a drift away from reality in the T799 ECMWF nature run (NR)

Here tEKE at 250 hPa at three time scales is presented

- 2-6 day: Synoptic scale
- 6-30 day: Large scale events such as blocking
- 30-90 day: Intraseasonal variability such as MJO

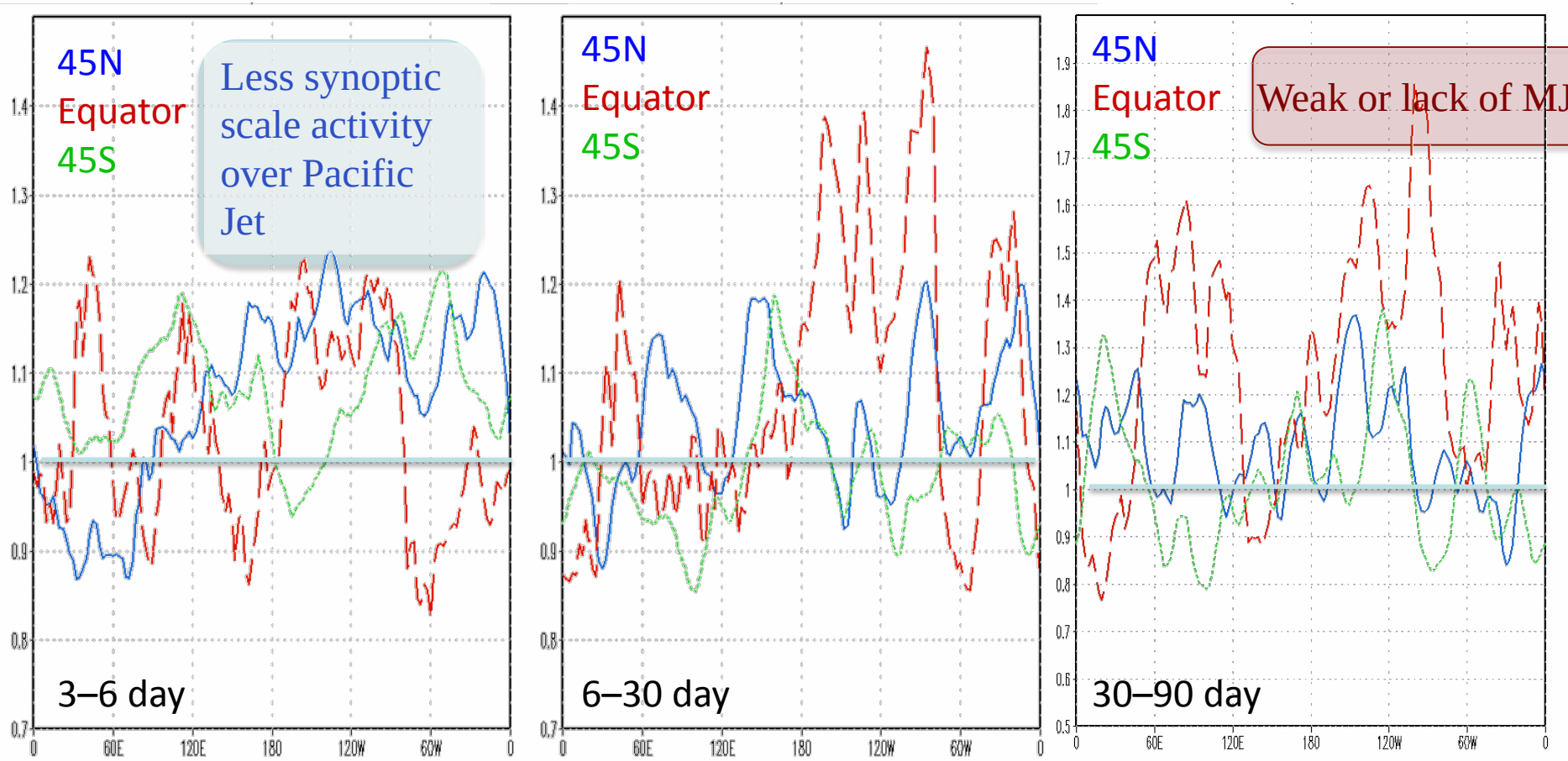
2–6 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution



Time mean (Jul 2005 – Jun 2006), and zonal average

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution

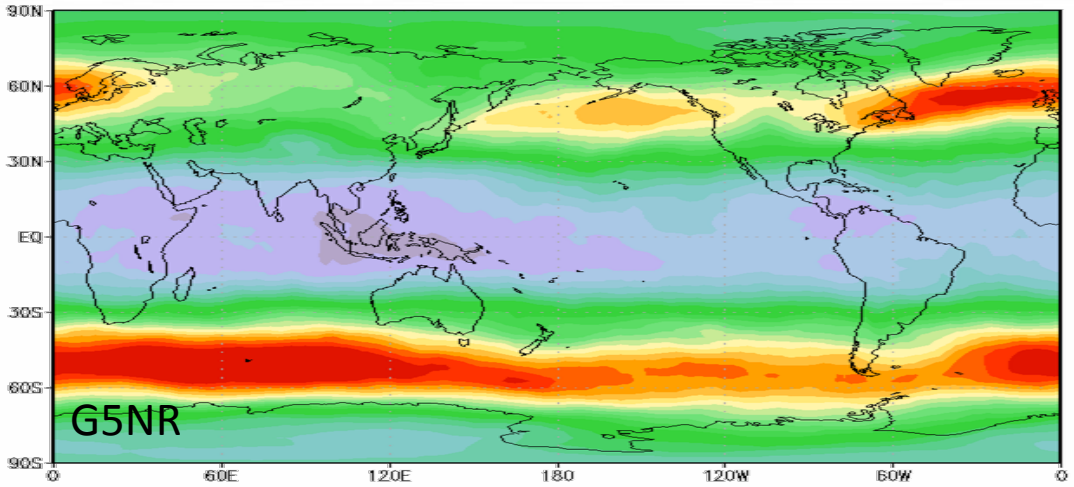


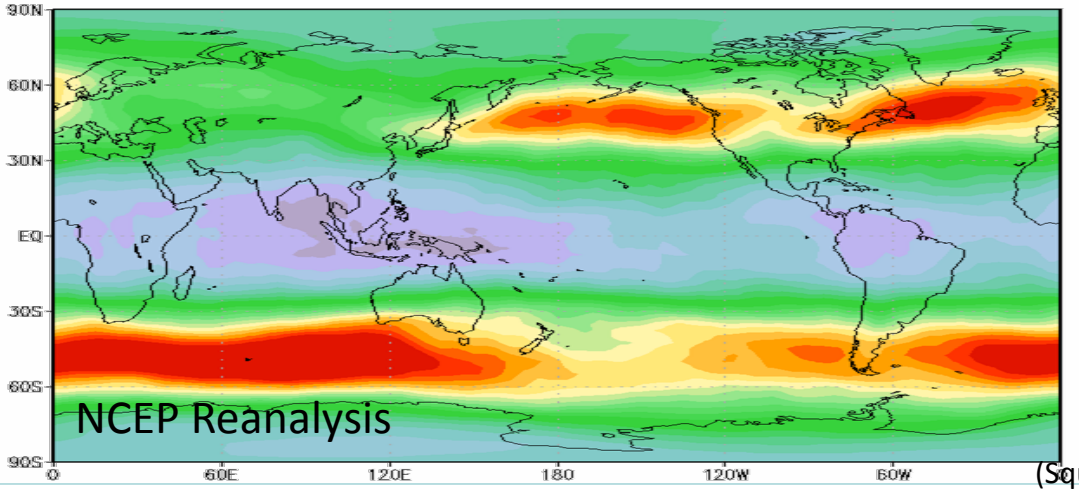
(Square root is plotted)

Ratio of the NCEP reanalysis to the G5NR

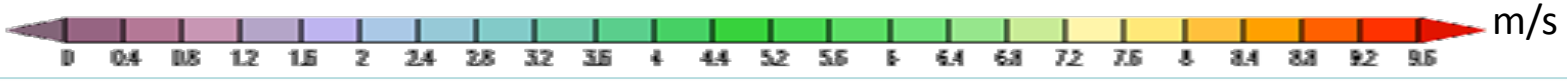
Time mean (Jul 2005 – Jun 2006), 2–6 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution



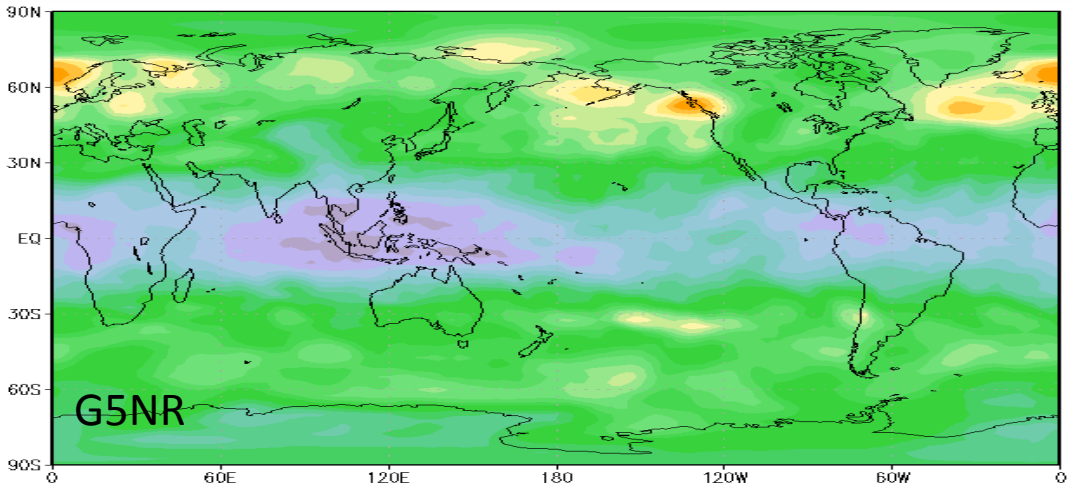


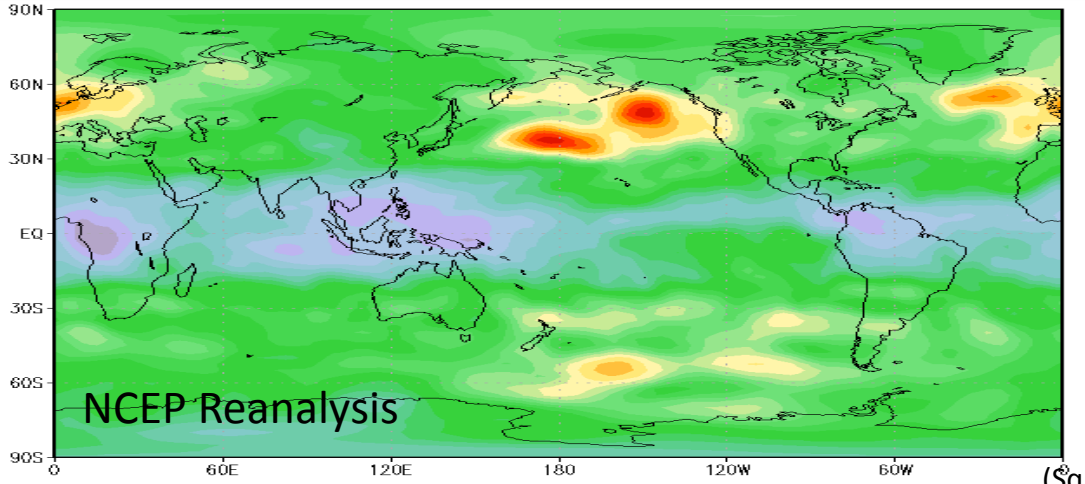
(Square root is plotted)



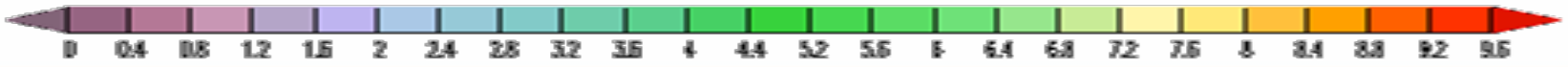
Time mean (Jul 2005 – Jun 2006), 30–90 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution





(Square root is plotted)



Summary of the results

On all time scales, the G5NR zonally averaged tEKE does not show any serious drift away from that of the NCEP reanalysis.

One year time mean tEKE are similar in Atlantic sector on all time scales but slightly weaker on the 6–30 day time scale.

In 30–90 day band, in tropics and in the North Pacific region the G5NR has reduced tEKE compared to the NCEP reanalysis.

On synoptic time scales (2–6 day band) G5NR tEKE is much weaker in the North Pacific jet region compared to the NCEP reanalysis.

Further analysis is required to explore seasonal differences region by region.

Relevance to OSSEs

- Gross features of the G5NR climatology of tEKE are reasonable. No temporal drift is apparent. This is a positive validation of the G5NR for use in OSSEs.
- On a regional basis the G5NR climatology of tEKE seems consistent with the NCEP reanalyses over the Atlantic and Southern Hemisphere, but is weaker in other areas. These features may have an impact on how the results of G5NR OSSEs are interpreted. Two examples are:
    - There is substantially lower (8 vs. 10 m/s) synoptic activity (2-6 day time scale) in the North Pacific jet region of the G5NR relative to the NCEP reanalysis.
    - This will be especially important to consider when OSSEs are used to evaluate observation and weather systems that involve the North Pacific jet and in examining data impacts on weather forecasting for the U.S. West Coast and Alaska.
    - The large scale 30-90 day pattern of jet variability in the central North Pacific and Gulf of Alaska (which may be associated with the Tropical-Northern Hemisphere (TNH) pattern) in the NCEP reanalysis is largely absent in the G5NR.
    - This is potentially important for OSSEs that include extended range and seasonal forecasting.

Another Nature Run in preparation

ECMWF Nature Run

[Proposed configuration]
ECMWF IFS T1279 91 Level
March 1st, 2005- April 30th, 2006 (year of most active Atlantic hurricane)
High time resolution for selected period

[Sample data]
Sample data provided for hurricane period and midlatitude storm period.
[Status]
Still waiting for updated sample data and initial NR

We need ECMWF Nature Run to confirm the OSSE results using G5NR. Particularly tropical and midlatitude interaction.

Simulation of observation at JCSDA

Conventional observation

- Conventional observation based on operational usage.
- Satellite wind is still simulated based on real observation. Considering to simulate at Nature run cloud location.
- Random error added

GPSRO (JCSDA and ESRL)

- GPSRO has simulated for refractivity. Being simulated for bending angle. Plan to upgrade forward model in 2015.
- Current GPS, Add 6 sat over equator, Additional 6 satellite in polar orbit, GPSRO by PlanetiQ are being simulated and tested.

Simulation of Radiance

- Currently clear sky radiance for control experiments are simulated using CRTM
- Type of radiance data location used operation in 2014
- Random error was added.
- Bias will be added based on bias in real observation
- Plan to use cloudy simulation of radiance
- Coefficients for hyperspectral infrared radiances from geostationary orbit were generated. JCSDA will simulate with CRTM. (SSEC will simulate with SARTA)

Evaluation of Simulated Radiance
At the beginning of the Nature run

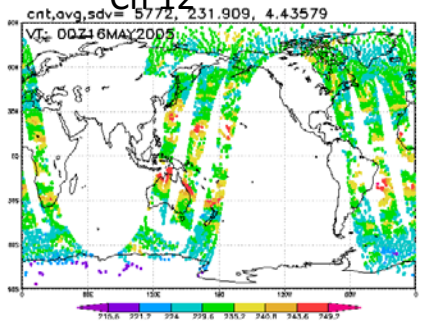
Compare simulated radiance an d real radiance at initial time of the Nature Run 00z May 16, 2005, the GMAO analysis is very close to real atmosphere.

After a few steps Nature run will diverge from real atmosphere.
Observations are assimilated by NCEP GSI at 00Z May 16 with same guess fields.

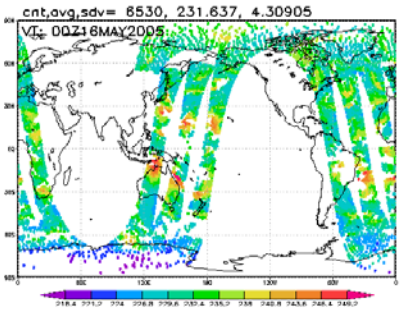
For this evaluation only instrument available in May 2005 can be used.

HIRS3 NOAA17
Ch 12

Real



Simulated



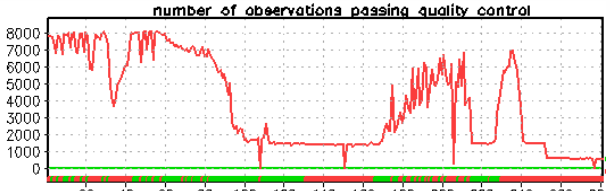
Evaluation of Simulated Radiance
At the beginning of the Nature run

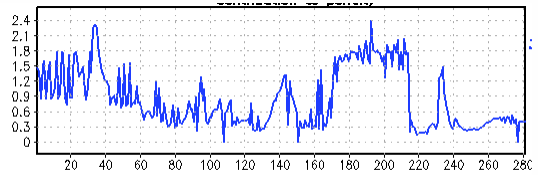
Number of observations passing quality control

Contribution to the penalty

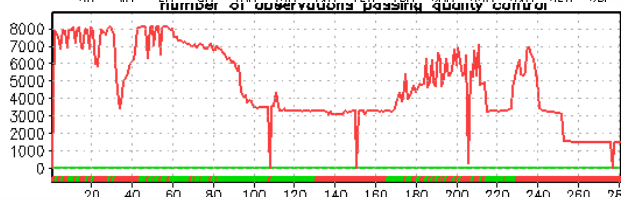
AIRS AQUA

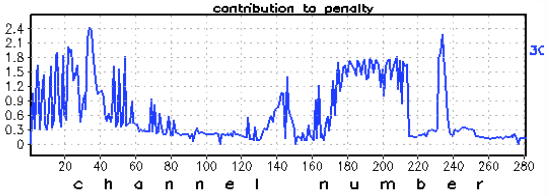
Real





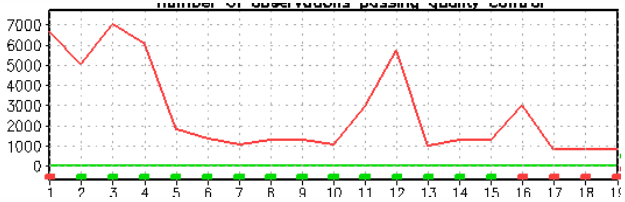
Simulated

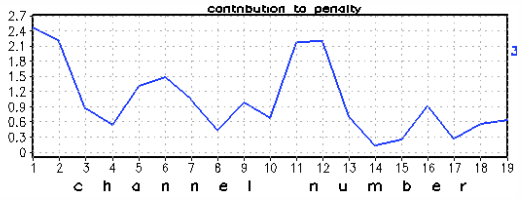




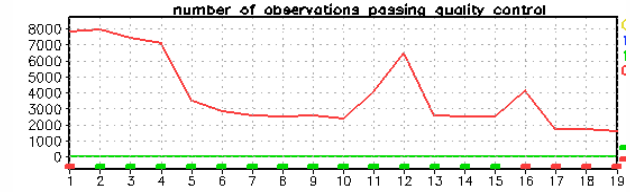
HIRS3 NOAA17

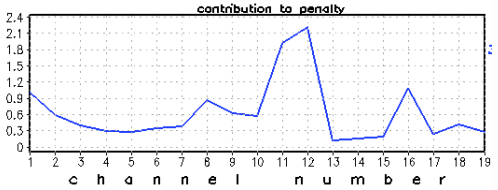
Real





Simulated

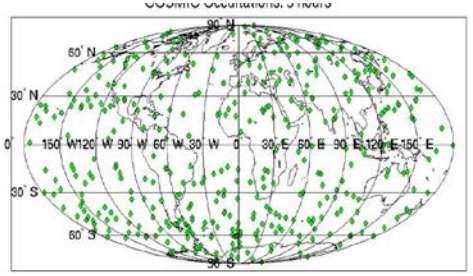




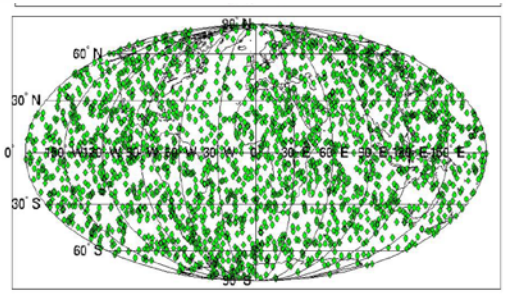
Current OSSE efforts at JCSDA

- Conduct OSSE to Evaluate of Infrared sounders on the geostationary Hyper-spectral Environmental Suite (HES).
- Collaborating with ESRL and NOAA/AOML, JCSDA plan to conduct a series of global OSSE experiments to assess the impact of additional future Global Navigation Satellite Systems (GNSS) Radio Occultation constellations.
- Add various observational errors to control observations and study data sensitivity to the data impact. Use template from real observation.
- Upgrade OSSE system to current operational data assimilation and beyond.
- OSSE for further more instruments are being considered
- JCSDA is putting together the state of the art OSSE package together based on the different existing tools.
- Code and scripts will be available from EMC SVN

COSMIC



COSMIC-2



Simulation of observation at JCSDA

Plan to use two Polar satellite scenario as control configuration

2polar = a more reasonable data-gap scenario

Control	3polar	2polar (PM Gap)	polar (Mid-AM Only)	Orbit
F16 (SSMI/S)	F16	F16	16	Early-AM
F17 (SSMI/S)	F17	F17	17	Early-AM
F18 (SSMI/S)	F18	F18	18	Early-AM
Metop-A (AMSU/MHS/IASI/HIRS)	Metop-A	Metop-A	Metop-A	Mid-AM
Metop-B (AMSU/MHS/IASI)	Metop-B	Metop-B	Metop-B	Mid-AM
N15 (AMSU)	N15	N15	N15	Late PM
N18 (AMSU/MHS)	N18	N18	N18	PM
N19 (AMSU/MHS)	N19	N19	N19	PM
SNPP (ATMS/CrIS)	SNPP	SNPP	SNPP	PM
Aqua MODIS IR Winds	Aqua MODIS IR*	Aqua MODIS IR	Aqua MODIS IR	PM
Aqua AIRS	Aqua AIRS	Aqua AIRS	Aqua AIRS	PM
Aqua MODIS WV Winds	Aqua MODIS WV	Aqua MODIS WV	Aqua MODIS WV	PM
Terra MODIS IR/WV Winds	Terra MODIS	Terra MODIS	Terra MODIS	AM
WindSat	WindSat	WindSat	WindSat	Early-AM
GOES Sounder, AMVs	GOES	GOES	GOES	GEO
JMA AMVs	JMA AMVs	JMA AMVs	JMA AMVs	GEO
METEOSAT AMVs	METEOSAT AMVs	METEOSAT AMVs	METEOSAT AMVs	GEO

By NOAA/NESDIS

Progress

[The first OSSE period is selected]
From August 1,2006 to September 30,2006 of G5NR is selected as a first OSSE period.
This is the period for most land fall tropical cyclone activities

Real data distribution and statistics from August 1,2014 through September 30,2014 are used to generate control observation.

[Progress in simulation]
Radiance data are simulated for 45 days. To be completed soon.
perfect and with random error. No bias
Simulation of conventional data are in progress
Simulation GPSRO with bending angle is ready

[Preliminary OSSE]
Experiments for GPSRO was conducted using T511 NR with refractivity with T574.
Could not show improvement more than 18 satellite

Possible Future OSSEs

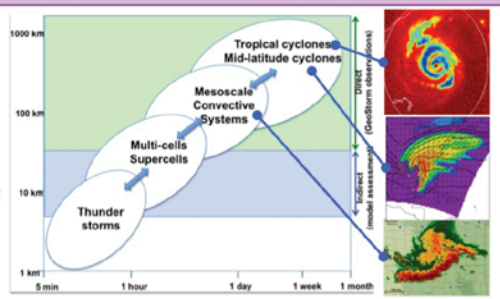
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

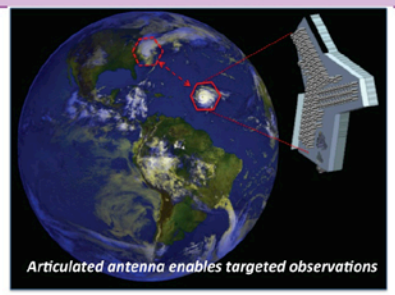
"GeoStorm": A pre-PATH mission

A GEOSTATIONARY MICROWAVE SOUNDER MISSION FOCUSED ON THE EVOLUTION OF SEVERE STORMS

Improve our understanding of sudden and unpredicted change in intensification and motion of destructive storms:

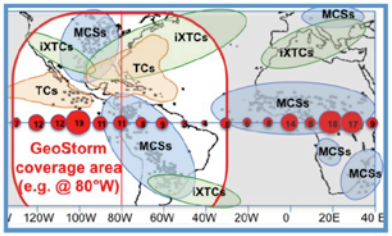
- *hurricanes*
- *severe thunderstorms and mesoscale convective systems*
- *mid-latitude cyclones and winter storms*





Low cost as a hosted payload

Many hosting opportunities in GEO:



There are more than 80 GEO comm-sats that provides a view of the Americas, being replaced at a rate of 5-6 per year

GeoStorm Highlights	
Targeted observations	Life cycle storm tracking
Time-continuous	Capture dynamic processes; diurnal cycle fully resolved
Multiple simultaneous key parameters	Temperature, humidity, precipitation, wind
All-weather	Cloud/rain-penetrating
3-D observations	1000 km dia x 15 km vert. (volume); 25 km dia x 3 km vert. (resolution)
Wide coverage	All storms visible from GEO

GeoStorm covers a substantial subset of the PATH science objectives at a greatly reduced cost (~ $100M vs. ~ $500M), using all key PATH technologies and flying as a hosted payload.
Proposed as a Venture EV-I hosted-payload mission

Figure produced by NASA/JPL

Possible Future OSSEs

OSSEto improve Arctic observing system

Masutani, M., L. Garand, W. Lahoz, L.-P. Riishojgaard, E. Andersson, Y. Rochon, M. Tsyrulnikov, J. McConnell, L. Cucurull, Y. Xie, S. Ishii, R. Grumbine, G. Brunet, J. S. Woollen, and Y. Sato, 2013: Observing System Simulation Experiments: Justifying new Arctic Observation Capabilities, White paper on OSSE Optimized Modelling, National Centers for Environmental Prediction Office Notes No 473. http://www.lib.ncep.noaa.gov/ncepofficenotes/files/on473.pdf

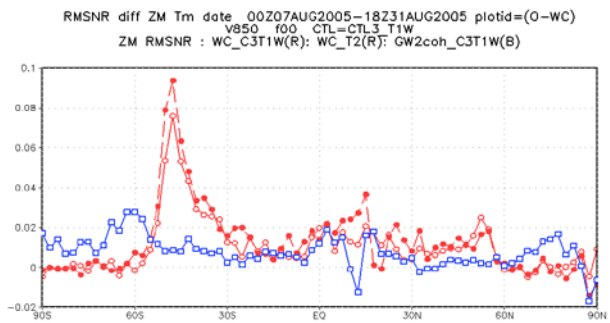
Space based Doppler Wind Lidar (DWL) in ISS orbit

Optical Auto covariance Wind Lidar(OAWL) is planned to use International Space Station (ISS) orbit.

ISS allow heavier instruments but just more data to area to data rich area. Current interests are focused on ISS orbit only.

Need to improve assimilation of DWL on ISS orbit

Impact on V 850 hPa



Analysis impact (reduction of RMS Diff from NR, compared to control experiment (existing obs only). Only results from coherent Lidar are presented.

DWL with two looks to produce vector wind measurement.

Red, Solid line,open circle:ISS orbit T126 experiment

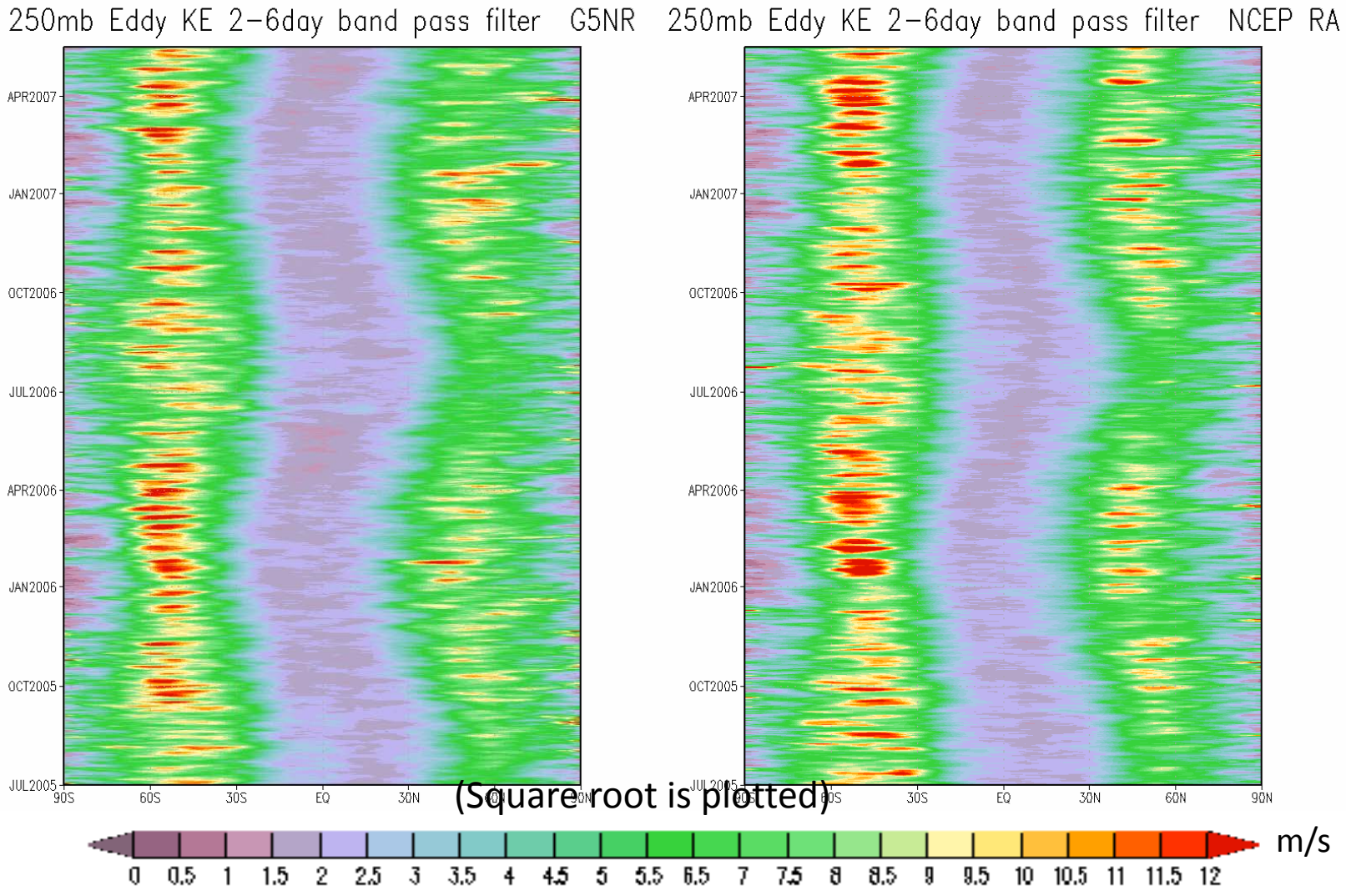
Red, Dashed line, closed circle: ISS orbit T254 experiment

Blue, Solid line, open circle: Polar orbit T126 experiment

END

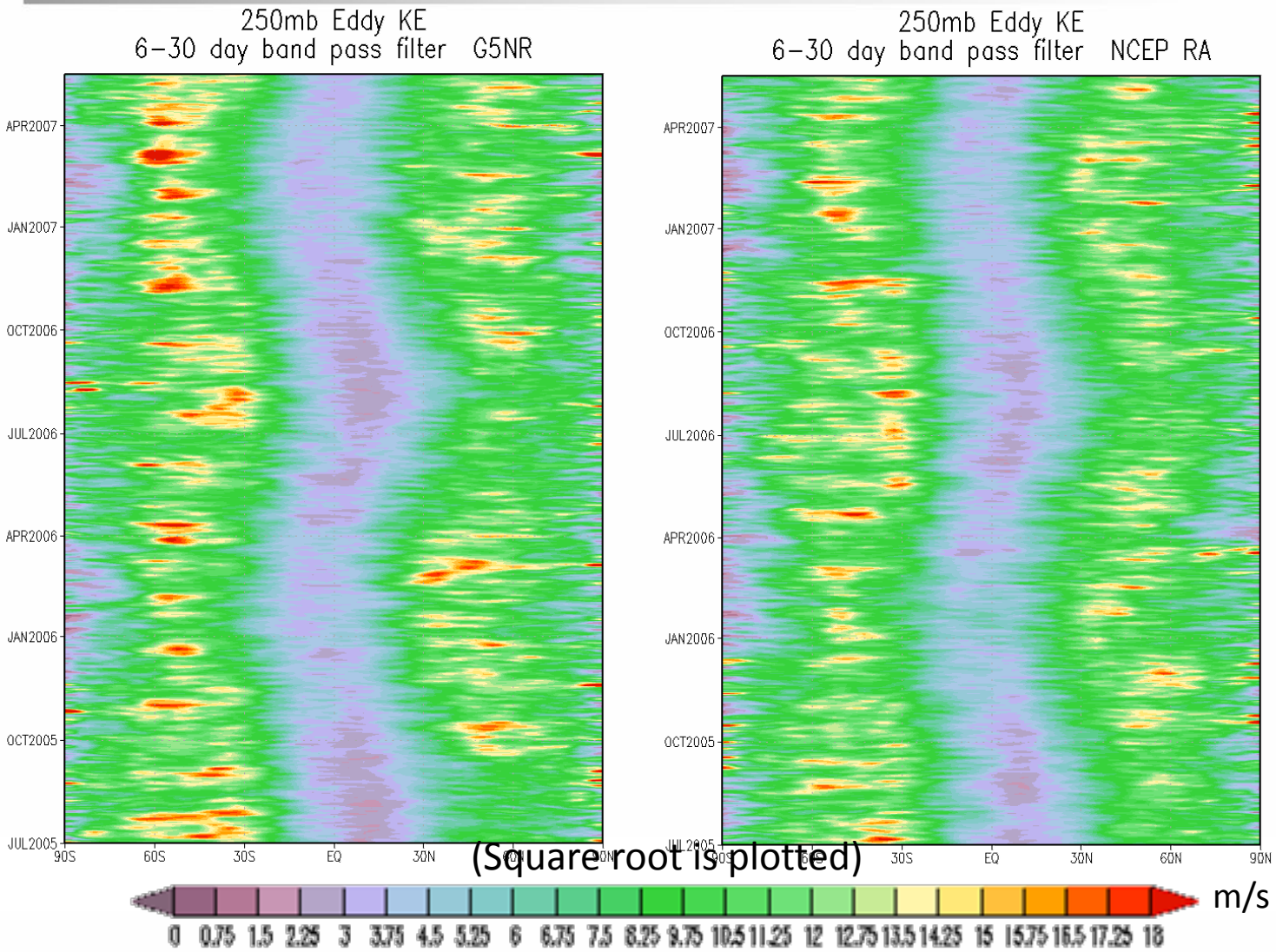
2–6 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution



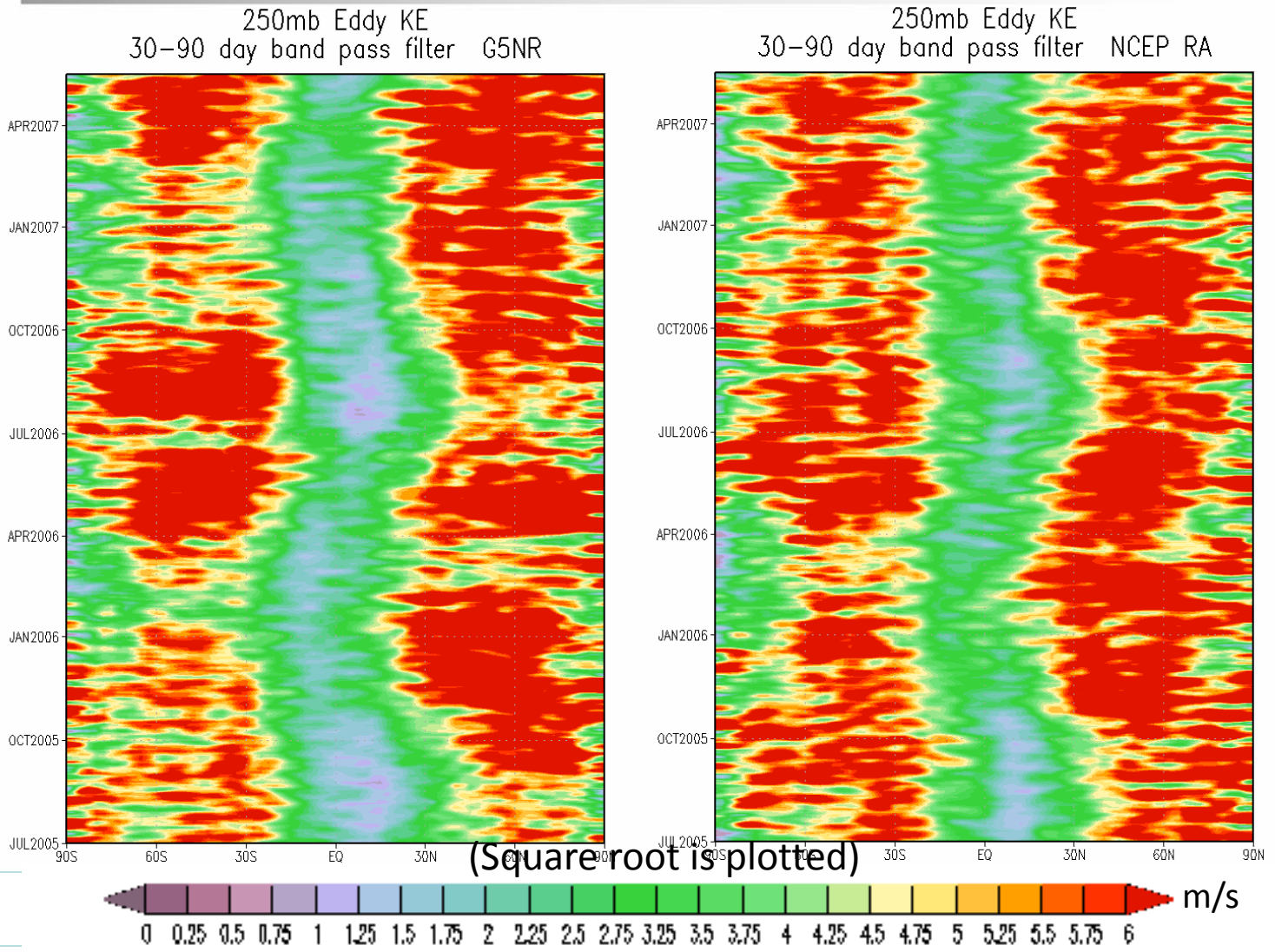
6–30 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution



30–90 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution

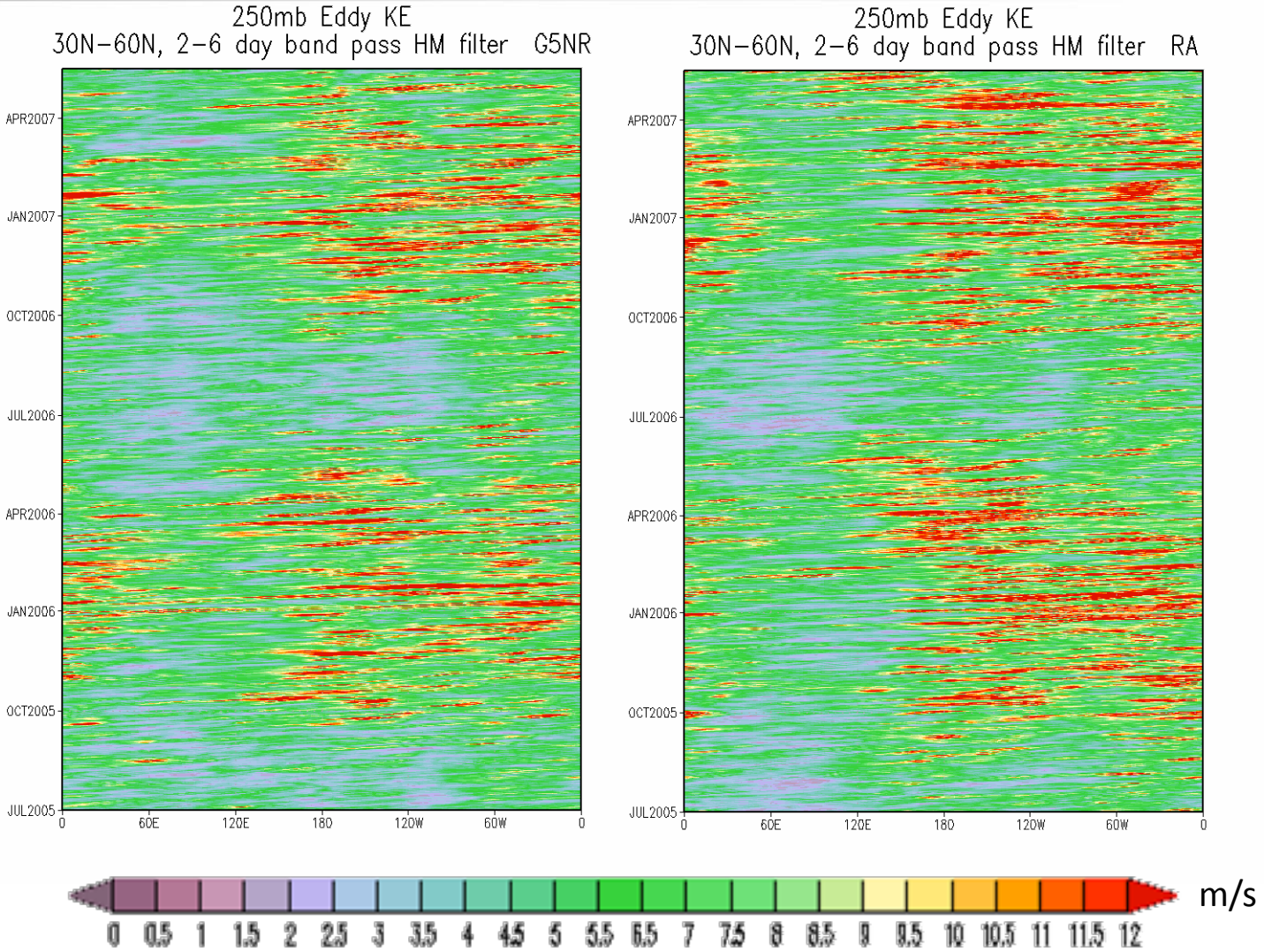


Time series of latitude averaged tEKE (Hovmöller diagrams)

In the NH (30N–60N), in the 2–6 day band it appears that the reanalysis is more active than the G5NR.
In the tropics (10S–10N), in the 30–90 day band it appears that the reanalysis is much more active than the G5NR.
Conclusion: The G5NR 250 hPa 30–90 day band tEKE is substantially lower than that of the NCEP reanalysis in the tropics.
The MJO amplitude should be reflected in this band pass, The MJO in the G5NR may be weak or some other phenomena at these time scales is responsible.

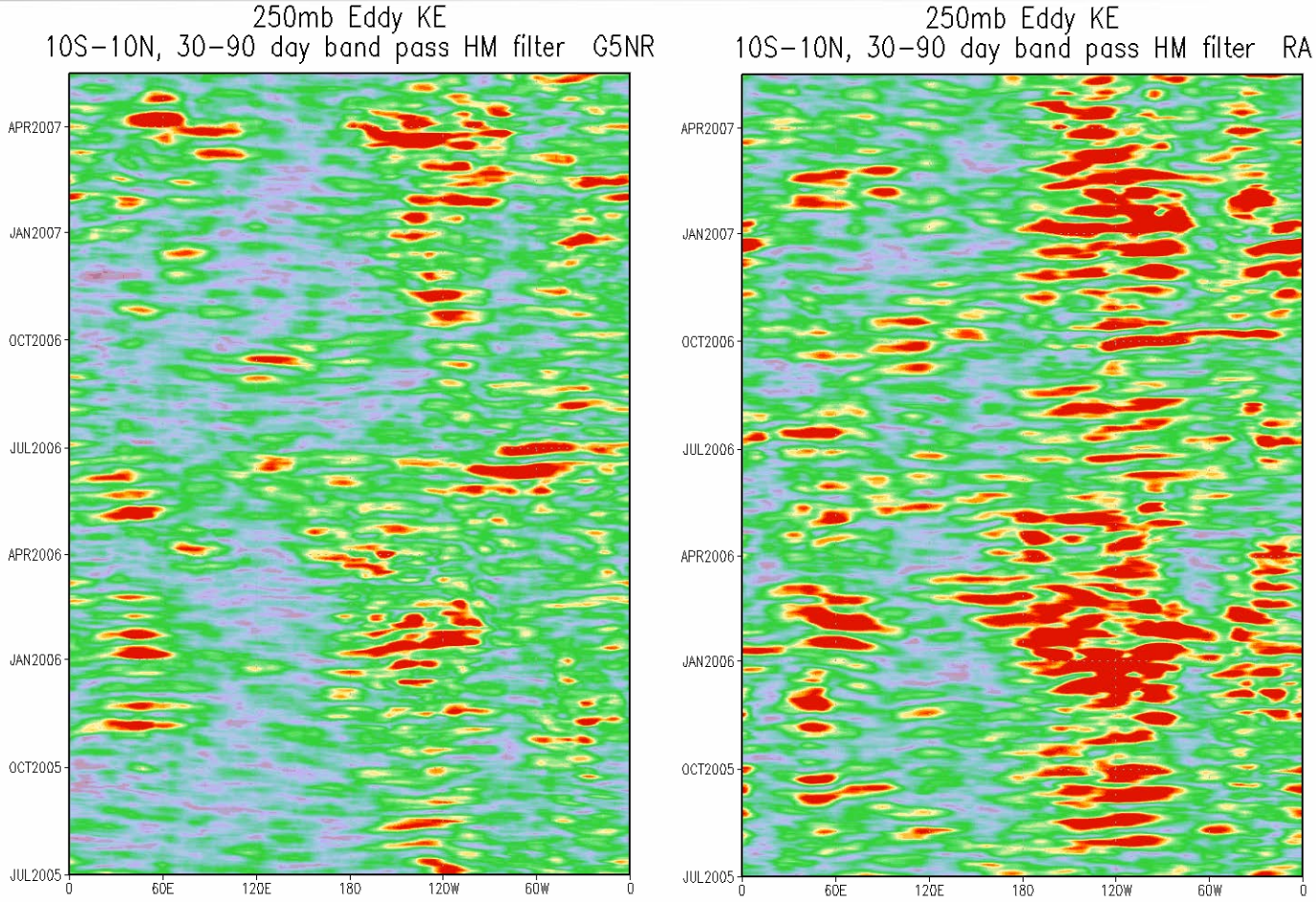
30N–60N, 2–6 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution



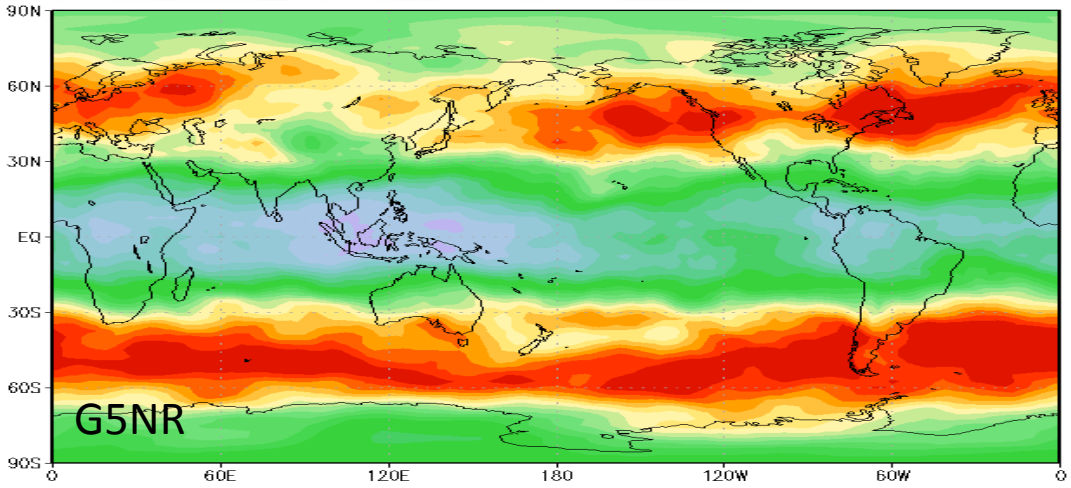
10S–10N, 30–90 day band pass

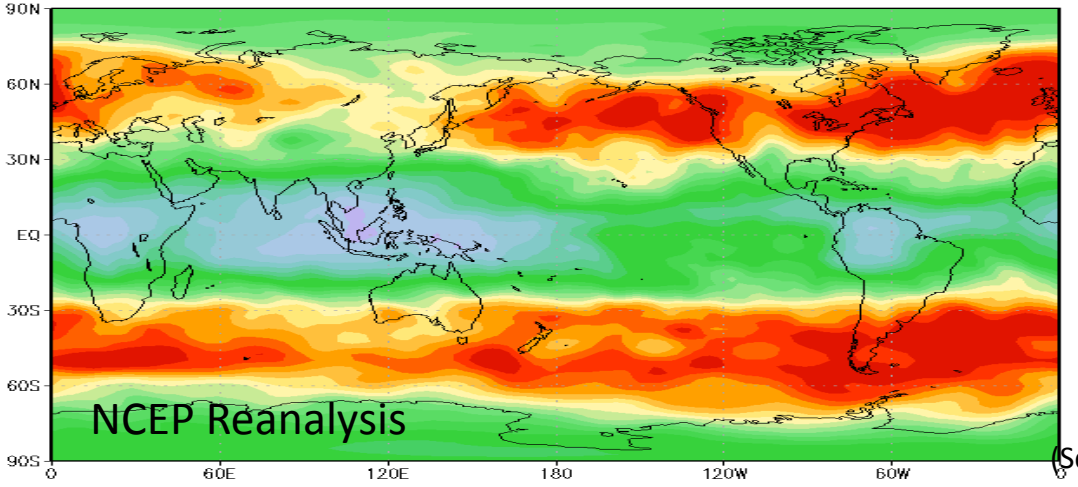
Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution



Time mean (Jul 2005 – Jun 2006), 6–30 day band pass

Comparison between 250 hPa tEKE of the G5NR and NCEP reanalysis
Based on data sampled at 6-h, 2.5 degree resolution





(Square root is plotted)